2014 NCAR ANNUAL REPORT

TABLE OF CONTENTS

Message from the NCAR Director ›

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research

NCAR Earth System Laboratory

Research Applications Laboratory

STRATEGIC PLANS

NCAR Strategic Plan

PREVIOUS NCAR REPORTS

Select year

Printer-friendly version

Login

MESSAGE FROM THE NCAR DIRECTOR

The National Center for Atmospheric Research (NCAR) is one of the world's premier scientific institutions, with an internationally recognized staff and research program dedicated to advancing knowledge, providing community-based resources, and building human capacity in the atmospheric and related sciences. In this Annual Report, as well as the accompanying Laboratory Reports, I invite you to learn more about how our staff are collaborating with the broader research community, nationally, and internationally, to produce impressive advances in our understanding of fundamental atmospheric processes and how the atmosphere interacts with and is influenced by other components of the Earth and Sun system. This progress is being driven, in part, by new technologies and their effective utilization at NCAR, including advanced observing facilities for field studies, powerful supercomputing capabilities, valuable research data sets that describe the Earth and the Sun, and widely used state-of-the-science community models that are providing improved capabilities for predictions of weather (including catastrophic events), air quality, hydrology, climate variability and change, and space weather. Moreover, educational and technology transfer activities at NCAR continue to encourage outstanding young scientists into the field and bring new research and technical achievements into the public and private sectors. Although only a small sampling of the many notable accomplishments of the past year, these aspects are illustrated through the accompanying set of 10 highlights of our work.

A major focus of my first full year as director was the completion of NCAR's new strategic plan, which is easily accessible from our main web page. I thus also invite you to review this strategic plan, which will steer NCAR's direction over a period of time that will present significant opportunities and challenges for the atmospheric, geospace, and related sciences. Despite impressive gains in knowledge, our understanding and predictive capabilities remain insufficient for many societal needs. The reality of human-induced climate change is established, but the current generation of weather and climate modeling systems is inadequate to provide the accurate and reliable predictions of regional changes in climate and high impact weather required for adaptation and mitigation strategies. An increasingly sophisticated and technological society remains vulnerable to atmospheric and space weather hazards, air quality remains a major health issue, and we are witnessing the global stresses of food and water shortages.

The new strategic plan lays out a vision for NCAR to help tackle these challenges by focusing on the development, application and analysis of next-generation numerical models, the development and deployment of new observing systems, and the development of new capabilities for extracting useful information from "Big Data." Ultimately, NCAR will only be successful in addressing these challenges by continuing to work synergistically with the broader academic community. This includes relations with university researchers coming to NCAR as both short- and long-term visitors, serving on NCAR advisory committees and working groups, and working as principal investigators on field campaigns. In so doing, NCAR will continue to embrace a leadership role in delivering objective information in support of national and international decisions on mitigation, adaptation, resiliency, and sustainability, and it will continue to actively engage with the stakeholders and the consumers of its science.

For now, please enjoy this Annual Report as but a snapshot of NCAR competencies, facilities, and scientific accomplishments achieved over the past year. In addition, please accept my sincere thanks for your ongoing support and your hard work.

With best wishes for 2015,

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NCAR Strategic Plan

PREVIOUS NCAR REPORTS

Select year

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Jim Hurrell

‹ 2014 NCAR Annual Report up FRAPPÉ tracks Front Range pollution ›

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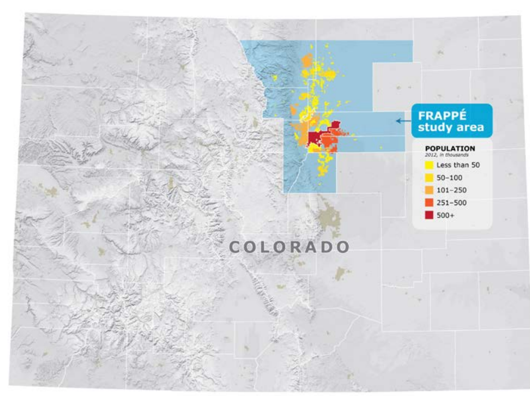
FRAPPÉ TRACKS FRONT RANGE POLLUTION

NCAR and its research partners successfully conducted a landmark field project last summer to track the origins of summertime ozone pollution over the Front Range of Colorado. The month-long study, known as the Front Range Air Pollution and Photochemistry Éxperiment (FRAPPÉ), tracked emissions from both human-related activities and natural sources.



FRAPPÉ sampled and examined the atmospheric conditions pertaining to air quality north of Fort Collins, Colorado. Study area is indicated in blue.

Summertime air pollution on the Front Range, including Denver, often exceeds federal standards for safe levels of ground-level ozone pollution despite efforts to reduce emissions. Ozone can lead to increased asthma attacks and other respiratory ailments. It also damages vegetation, including crops.

FRAPPÉ focused on the urban corridor from south of Denver to north of Fort Collins, as well as the adjacent plains and mountains. Scientists also measured pollution from upwind areas, including other states and countries. "Our goal is to produce an accurate and detailed view of all the diverse sources of ozone pollution along the Front Range," said ACD's Gabriele Pfister, a principal investigator on the project. "We want to fingerprint where the pollution comes from and analyze what happens when it mixes in the atmosphere."

The researchers used specially equipped aircraft on a total of 15 flights, as well as networks of ground-based instruments and sophisticated computer simulations. "The flights were generally successful in addressing the project goals, even in light of the unusually cool summer," said ACD's Frank Flocke, a principal investigator. "The data coverage and instrument reliability was excellent."

FRAPPÉ was funded by a state-federal partnership, with support from both the Colorado Department of Public Health and Environment and the National Science Foundation.

The NSF/NCAR C-130 aircraft, one of the aircraft involved in FRAPPÉ, is based at NCAR's Research Aviation Facility (RAF) at Rocky Mountain Metropolitan Airport in Broomfield, Colorado. RAF

Two major projects converge

To provide additional detail across the region, scientists closely coordinated FRAPPÉ with a second air quality mission taking place on the Front Range at the same time. DISCOVER-AQ (Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality) was a major study led by NASA seeking to improve the ability of satellites to

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PREVIOUS NCAR REPORTS

Select year

Printer-friendly version

usefully assess our air quality.

develops and operates instrumented research aircraft for the atmospheric science community.

The DISCOVER-AQ flights and ground observations focused on the northern Front Range, while FRAPPÉ also gathered measurements from the surrounding region. In all, approximately 200 scientists, technicians, pilots, and students from around the country converged on the Front Range for the combined projects.

The researchers quantified emissions from industrial facilities, power plants, motor vehicles, agricultural operations, oil and gas drilling, fires, and other sources. They also measured naturally occurring emissions from trees and other plants that then combine with emissions generated by human activity to form ozone and other pollutants.

Colorado, like other states, relies on a limited number of ground-based stations to monitor air quality and help guide statewide policies and permitting. But a full, three-dimensional picture of the processes that affect air quality, including conditions far upwind and high up in the atmosphere, requires a three-pronged approach with measurements from aircraft, satellites, and the ground. “By bringing together aircraft, satellites, and ground-based instruments, we can analyze the amounts and types of pollutants that are emitted in the Front Range as well as transported from other places, how they evolve, and how air circulation patterns near the mountains move them around,” Flocke said.

“[The research] will help us more fully understand complex questions such as the factors contributing to ozone formation in the region,” said Will Allison, director of the Colorado Department of Public Health and Environment’s Air Pollution Control Division. “And that will help us continue to implement effective measures to reduce air pollution.”

FRAPPÉ and DISCOVER-AQ used similar payloads for their aircraft. The teams conducted wingtip-to-wingtip intercomparison flights during the project, sampling air in the same place to make sure the instrument readings are comparable.

A network of in-situ instruments deployed on the ground, on towers, rooftops, and mobile vans continuously monitored ozone and the gases that reacted to form it. These as well as the aircraft flights were also closely coordinated with measurements from tethered balloons and from lidars (laser-based radars).The researchers drew on forecasts and nowcasts of both weather and air quality from a large number of computer models to assess daily conditions and make final decisions on when to fly and where to gather atmospheric samples.

The data gathered by the projects are going through a quality assurance process before becoming publicly available early January 2015. There will be a FRAPPÉ /DISCOVER-AQ science team meeting in Boulder from May 4-8, 2015 to discuss first results.

In addition to NCAR and the Colorado Department of Public Health and Environment, the FRAPPÉ team includes scientists from the National Oceanic and Atmospheric Administration; Cooperative Institute for Research in Environmental Sciences; National Park Service; Regional Air Quality Council; Global Ozone Project; Western Regional Air Partnership; Environmental Protection Agency; University of Colorado Boulder; Colorado State University; University of California, Berkeley; University of Wisconsin; University of Cincinnati; Georgia Institute of Technology; University of California, Riverside; Aerodyne Inc.; U.S. Naval Academy; University of Rhode Island; University of California Irvine; and Princeton University.

‹ Message from the NCAR Director   up   CONTRAST: Scientists examine Pacific’s “global chimney” ›

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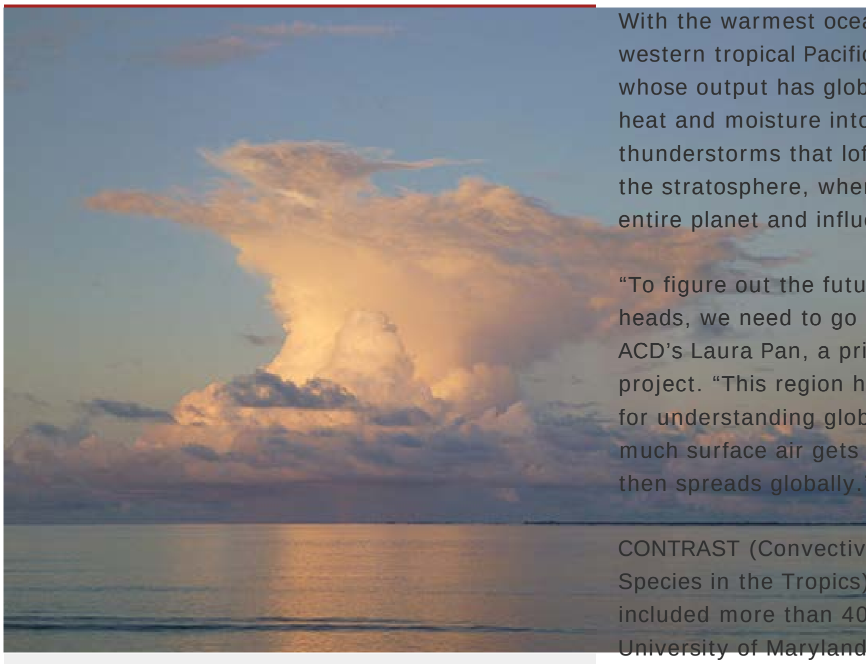
CONTRAST: SCIENTISTS EXAMINE PACIFIC'S "GLOBAL CHIMNEY"

Even though few people live in the western tropical Pacific Ocean, these remote waters affect billions of people by shaping climate and air chemistry worldwide. By conducting a successful field project there last year known as CONTRAST, scientists hope to better understand the region's influence on the atmosphere, including how that may change in coming decades if storms over the Pacific become more powerful with rising global temperatures.



Showers and thunderstorms over the tropics can grow from isolated systems, as shown here in the Maldives, to larger complexes that loft vast quantities of air from the lower atmosphere to the stratosphere. CONTRAST examined how such circulations evolve over the western tropical Pacific, where they can influence atmospheric chemistry over wide areas.

With the warmest ocean waters on Earth, the western tropical Pacific fuels a sort of chimney whose output has global reach. The region feeds heat and moisture into huge clusters of thunderstorms that loft gases and particles into the stratosphere, where they spread out over the entire planet and influence the climate.

"To figure out the future of the air above our heads, we need to go to the western Pacific," said ACD's Laura Pan, a principal investigators on the project. "This region has been called the holy grail for understanding global air transport, because so much surface air gets lifted by the storms and then spreads globally."

CONTRAST (Convective Transport of Active Species in the Tropics) was based in Guam. It included more than 40 scientists from NCAR, the University of Maryland, the University of Miami, other universities across the country, and NASA. It was funded by NSF.

Pan said the 16 flights succeeded in gathering important data. The research team was able to get information on the structure of ozone, the movement of bromine compounds, and other important air chemistry processes. "The field phase measurements were very successful," she said. "We had many good case studies of convective transport."

CONTRAST was coordinated with two other field projects in order to give researchers an especially detailed view of the air masses over the Pacific with a vertical range spanning tens of thousands of feet.

One of these projects, NASA's Airborne Tropical Tropopause Experiment (ATTREX), used a Global Hawk, a robotic aerial vehicle, to study upper-atmospheric water vapor, which influences global climate. The other, CAST (Coordinated Airborne Studies in the Tropics), was funded by Britain's Natural Environment Research Council Facility. CAST deployed a BAe146 research aircraft that will focus on air near the ocean surface.

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Research Applications Laboratory

STRATEGIC PLANS

NCAR Strategic Plan

PREVIOUS NCAR REPORTS

Select year

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Together, the sensor-laden research flights provided a comprehensive view of the atmosphere from the ocean surface, where gases produced by marine organisms enter the air, to the stratosphere, more than 60,000 feet above.

Gateway to the stratosphere

As trade winds flow across the tropical Pacific, they push warm water to the west, where it piles up in and near the CONTRAST study region. The waters around Guam have the world's highest sea surface temperatures of open oceans. They provide heat and moisture to feed clusters of thunderstorms that lift air through the troposphere (the lowest level of the atmosphere) and the tropopause (a cold, shallow region atop the troposphere) and then up into the stratosphere.

Once in the stratosphere—where the air tends to flow horizontally more than rising or sinking—the gases and particles spread out around the world and linger for years or even decades.

Some of the gases, such as ozone and water vapor, affect the amount of energy from the Sun that reaches Earth's surface. The amount of these gases in the stratosphere is important for the planet's climate. Other chemicals, such as bromine compounds, have indirect effects by destroying ozone or otherwise altering the chemistry of the stratosphere. And the gases produced by ocean organisms create a signature of marine biology in the stratosphere.

As atmospheric patterns evolve and sea surface temperatures warm further due to climate change, the storm clusters over the Pacific are likely to influence climate in ways that are now challenging to anticipate. "Understanding the impact of these storms will help us gain ground truth for improving the chemistry-climate models we use to project future climate," Pan said.

The CONTRAST team deployed the NSF/NCAR HIAPER aircraft. Using spectrometers and other instruments on board, the researchers measured various chemicals and took air samples across a wide region, both in storm clouds and far away from them. They targeted both both towering storms that loft fresh air into the stratosphere as well as collapsed storms to examine the composition of the air that remains lower down, in the troposphere.

Researchers from the three coordinated projects met in October to discuss preliminary findings. They are planning a workshop next year, jointly sponsored by SPARC (Stratospheric-Tropospheric Processes and Their Role in Climate) and IGAC (International Global Atmospheric Chemistry), which will involve a broader community to focus on science questions targeted by the field projects.

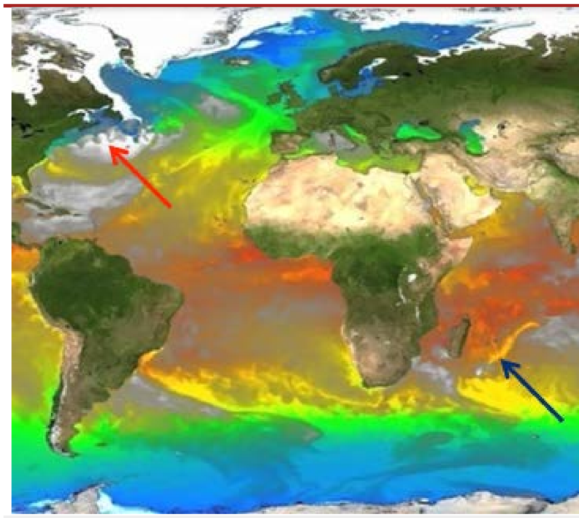
‹ FRAPPÉ tracks Front Range pollution   up   A new class of global climate models ›

A NEW CLASS OF GLOBAL CLIMATE MODELS

In FY14, NESL/CGD scientist Justin Small and colleagues analyzed the most comprehensive high-resolution simulation ever carried out with an NCAR climate model. It took the power of the Yellowstone supercomputer, based at the NCAR/Wyoming Supercomputing Center (NWSC), to carry out the project. The simulation spanned a century's worth of climate, including critical exchanges between atmosphere, ocean, sea ice, and the land surface.

Ultimately, the new high-resolution version of the Community Earth System Model (CESM-H)—which saw its first century-scale usage in Small's project—is well positioned to generate many new insights into the workings of our past, present, and future atmosphere. First, though, scientists must evaluate the overall quality of the CESM-H, as well as a handful of other, similarly upgraded models around the world. Their goal is to verify how well these new models depict the intricacies of climate, making sure that the advantages are well understood and any flaws are recognized and accounted for. These models are likely to inform the next assessment from the Intergovernmental Panel on Climate Change (IPCC), expected to take place in the late 2010s.

From the earliest days of climate modeling, the biggest constraint has been the finite nature of computing hardware itself. Today, hugely powerful machines and vast data-storage facilities are used to carry out and archive the enormous number of calculations involved in a single century-scale simulation. With this in mind, the NWSC was built to accommodate not only a modern-day supercomputing system on par with Yellowstone, but also the still more massive and complex systems that will be needed years from now.



This image from the century-long simulation produced by the high-resolution Community Earth System Model (CESM-H) shows latent heat flux (gray, with bright white indicating the greatest heat transfer from ocean to atmosphere) overlaid on sea surface temperature (colors, with the coldest in blue and the warmest in red). The arrow at top left highlights the influence of eddies along the Gulf Stream on cold air streaming out to sea from from eastern Canada, while the arrow at lower right shows cooler waters left in the wake of a tropical cyclone in the Indian Ocean. Both types of phenomena are not well simulated by standard-resolution climate models.

Even with Yellowstone, hardware-based limits on climate modeling remain a factor, and every method for dealing with them has its pros and cons. For example, the output from lower-resolution global models can be further refined across specified areas, a technique called downscaling. And some global models now include variable meshes that allow for zoomed-in regions within the larger grid. However, these and similar approaches all require that careful attention be paid to how phenomena on smaller and larger scales interact with each other.

When a high-resolution model grid straddles the entire globe, many of these potential problems are erased. The CESM-H includes a horizontal resolution of 25 km in its atmospheric component, more than 10 times more data points than the standard CESM. Oceans are depicted at resolutions of 10 km or less, also far sharper than in standard

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PREVIOUS NCAR REPORTS

Select year

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global models. However, all this requires many more calculations—and, as Small reiterates, "there are real limits on computing power and data storage."

The petabyte-scale Yellowstone can carry out more than 1.5 quadrillion calculations per second, but the CESM-H still gave it quite a workout. The century-long CESM-H simulation was conducted over several months in late 2012 and early 2013, shortly after the supercomputer's installation, as part of the NSF-sponsored Accelerated Scientific Discovery (ASD) program. ASD allowed a carefully chosen set of cutting-edge projects to run their course before routine operations on Yellowstone began.

Some benefits of high-resolution global modeling were already known before the CESM-H project. These include

- more realistic timing and strength of El Niño–Southern Oscillation (ENSO), the single biggest shaper of year-to-year climate variations worldwide;
- more accurate depiction of ocean circulation along west-facing shores, such as the California coast;
- and improved portrayal of heavy rain and snow across land areas, particularly over large mountain-dominated areas such as the Rockies, where topography must be simplified in lower-resolution models.

CESM-H confirmed many of these strengths. In particular, the overly intense El Niño and La Niña events found in many models were much more realistically captured in CESM-H—although Small and colleagues have found it a challenge to prove exactly why the ENSO portrayal had gotten better.

"Myriad processes govern the amplitude of ENSO events," notes Small, "so attributing the cause of the improved ENSO simulation is not straightforward." Small is collaborating with peers at NCAR, NOAA, and the University of Hawaii to unravel the factors at work.

The CESM-H also appears to be the first high-resolution global model to accurately depict the preferred location of the Atlantic intertropical convergence zone, the east-west band where northern and southern trade winds collide and generate showers and thunderstorms. Small and colleagues are now sorting out how much of the improvement is due to the higher model resolution and how much can be attributed to a set of new formulations of atmospheric physics employed in the model. Their strategy includes mixing and matching various model resolutions in a suite of experiments to tease out the important elements.

A number of the world's leading centers for climate modeling are now examining how the new generation of high-res global models could feed into the next IPCC assessment, which will be the sixth in a series of major reports that began in 1990. A key goal will be to make the best use of the limited number of century-scale simulations that computing and funding constraints will allow. Colleagues around the world will craft a common set of guidelines for these simulations. One proposed idea is to focus on the period 1950–2050, which would meet two goals at once: simulating several decades of recent climate, thus allowing model performance to be compared to observations, while also venturing into the middle part of the 21st century, when some of the more worrisome impacts of climate change may become more noticeable.

‹ CONTRAST: Scientists examine Pacific's “global chimney” | up | Sharpening our view of hurricanes, future and present ›

Login

Home Annual Reports: NCAR ACOM ASP CGD CISL EOL HAO MMM RAL

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Home » 2014 NCAR Annual Report

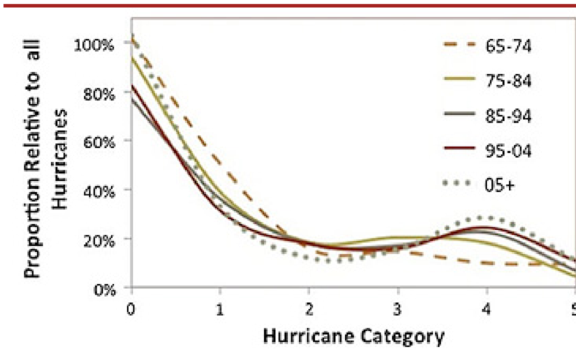
SHARPENING OUR VIEW OF HURRICANES, FUTURE AND PRESENT

For centuries, tropical cyclones have been among the most feared weather phenomena on Earth. Although the behavior of specific tropical cyclones can vary wildly, there's a surprising consistency to the global distribution of these massive storms (the strongest of which are called hurricanes in the North Atlantic and Northeast Pacific and typhoons in the western North Pacific).

Well-defined tropical "genesis regions" produce tropical cyclones each year; many of these storms sweep into midlatitudes, with a few striking such areas as the U.S. East Coast or East Asia. Although some genesis regions may be more productive and others less so in a given year, the action tends to average out. All told, the planet usually sees somewhere between 40 and 60 tropical cyclones reaching hurricane strength (winds of 74 mph) in a given year.

What are the odds that a warming planet will tamper with these long-established patterns? Scientists at NCAR have monitored trends in tropical cyclone (TC) behavior, and simulated the potential influence of increased greenhouse gases, for more than a decade. Research in FY14 bolstered a growing consensus—reflected in the 2013 report of the Intergovernmental Panel on Climate Change—that the world of the late 21stcentury will most likely see slightly fewer tropical cyclones, but a greater proportion of intense ones.

The record onslaught of Atlantic hurricanes in 2005 (including the horrific Katrina) helped spur a number of studies by Holland and others establishing that recent decades have seen a global jump in the number of Category 4 and 5 TCs, those with winds exceeding 130 mph. Although most modeling work indicates this trend should continue, Holland and Bruyere suggest that we might actually hit a ceiling over the next several decades. The concept is straightforward: once almost every hurricane with the potential to reach Category 4 status now makes the grade, there can be little further growth in the number of those behemoths.



Normally, the strongest hurricanes would be expected to be least numerous. However, as conditions allow for more tropical cyclones to intensify dramatically, recent years have seen a bimodal distribution, with a local minimum in hurricane frequency in the Category 2–3 range and a growing peak at the Category 4 level. (Image courtesy Greg Holland and Cindy Bruyère, used with permission from the 2014 Climate Dynamics paper "Recent intense hurricane response to global climate change," doi 10.1007/s00382-013-1713-0.)

Signs that our planet is already moving in this direction emerge from recent work by NCAR's Greg Holland and Cindy Bruyere (NESL Mesoscale and Microscale Meteorology Division). Interested in the link between rising global temperatures and TC behavior, the scientists calculated how each degree Celsius of global warming attributable to greenhouse gases has already affected the mix of TCs that attain various strengths.

"The implication here is that climate change is not just something in the future—we have already experienced substantial change in Category 4 and 5 hurricanes," said Holland. He adds that the efforts to assess how long this observed increase will continue, and whether a limit is appearing, have fundamental implications for community planning and development.

When Kevin Reed joined NCAR's Advanced Study Program in 2013, he brought a keen interest in future tropical cyclones with him. Reed used NCAR's Community Atmosphere Model (CAM) for

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PREVIOUS NCAR REPORTS

Select year

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his dissertation work at the University of Michigan. At UM, Reed explored how well the CAM simulated tropical cyclones across the globe when the model was configured at high resolution—with around 25 kilometers between grid points, compared to the typical resolution in global models of closer to 100-km.

While 25 km isn't quite sharp enough to capture the showers and thunderstorms that feed an individual hurricane, Reed found that this resolution still managed to portray the climatology of a season's worth of tropical cyclones (TCs) fairly well, while cutting back on the expense that a even higher-resolution approach would require.

"Since the 25-km CAM does a reasonable job in the current climate, it suggests that the model is a good tool to study how tropical cyclones may change in our future climate," said Reed.

The next step, after Reed arrived at NCAR, was carried out in collaboration with a number of colleagues in NESL's Climate and Global Dynamics Division. They zeroed in on a two-decade-long slice of climate (2070-2089), using the 25-km CAM together with two different scenarios of how greenhouse gases might increase this century: a middle-of-the-road option, RCP4.5, and the most intense scenario, RCP8.5 (RCP stands for representative concentration pathway).

The globe-spanning experiments produced a crop of tropical cyclones whose characteristics are in line with those found in several other recent studies. The average total annual count of TCs dropped by close to 10% in the RCP4.5 scenario and by almost 20% in the RCP8.5 scenario. Although the CAM's future planet doesn't generate as many TCs as we see today, a higher fraction of those that do form are in the most dangerous range, with sustained winds topping 130 mph (Categories 4 to 5 on the Saffir-Simpson scale).

Even as the world inches toward an uncertain climatic future, attention zooms back to the here and now with the approach of each year's hurricane season. Millions of people scrutinize the seasonal outlooks that are issued at several points in advance of the Atlantic season. Among the groups that issue such outlooks are forecasting teams based at NOAA, Colorado State University, and University College London (tropicalstormrisk.com).

Seasonal hurricane outlooks are based largely on the correlations between sea-surface temperatures, and other features that can persist for months, and the subsequent occurrence of hurricane formation. While the tools used by each group vary somewhat, these outlooks have a common enemy: internal variability, or processes that unfold without being dictated by larger-scale features. Work led by NCAR's James Done (NESL Mesoscale and Microscale Meteorology Division) suggests that such variability can make one season twice as active as another, even when El Niño and other large-scale hurricane-shaping elements are unchanged.

Done and colleagues zeroed in on a single hurricane season (1998) using an NCAR-based version of the Weather Research and Forecasting model. They incorporated the role of internal variability by introducing minor variations in the atmosphere, too small for seasonal forecast models to capture, at the beginning of each model run. The team simulated the 1998 season 16 times, each time with different but equally likely atmospheric features at the start of the key study period (May 1).

Despite the similarity of their starting points, the 16 simulations produced as few as 6 and as many as 12 tropical cyclones in the deep North Atlantic tropics, where a total of 7 TCs actually formed. The wide range of equally plausible outcomes suggests that a large dose of uncertainty may be unavoidable in any particular seasonal outlook.

"It appears there is an upper limit on how well we can predict hurricane frequency in advance of a season," Done said. With more research, he added, it's possible that tools that explicitly include the amount of natural uncertainty could be developed for use in seasonal hurricane prediction. This would help give stakeholders and the public a better idea of each outlook's margin of error.

‹ A new class of global climate models   up   Guiding rescue helicopters: New NCAR tool highlights weather conditions for emergency medical flights ›

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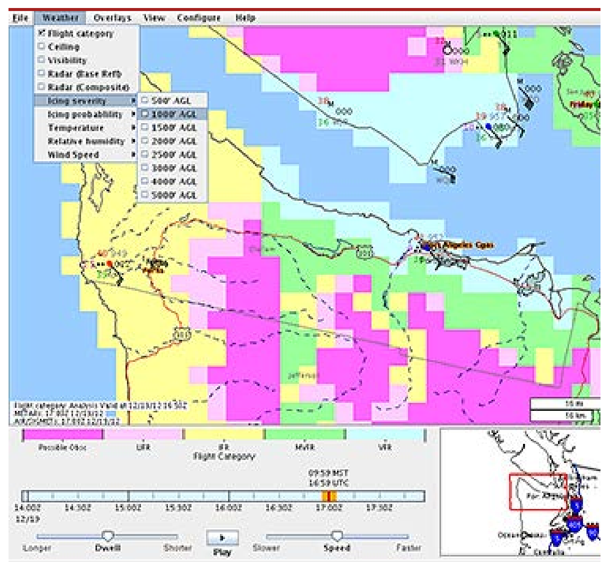
GUIDING RESCUE HELICOPTERS: NEW NCAR TOOL HIGHLIGHTS WEATHER CONDITIONS FOR EMERGENCY MEDICAL FLIGHTS

For many years, NCAR has provided an experimental tool for helicopter rescue pilots who must decide quickly whether weather conditions are safe enough to attempt a low-altitude flight. Recently the NCAR team has made key upgrades to the Helicopter Emergency Medical Services (HEMS) tool that enables it to be more widely used in rescue situations.

The HEMS Tool provides important information for rescue pilots. It runs on a desktop application and gives users a seamless graphical compilation of reported and forecasted winds, visibility, clouds, temperatures, and radar data for the continental United States.

But HEMS is particularly notable in that it creates an "intelligent interpolation" of low-altitude visibility and ceilings (the height of the lowest cloud layer) between observation stations by using algorithms that take into account the terrain, forecasting models and technical assessments. That allows users to view an area as small as 5 kilometers by 5 kilometers anywhere in the country and get actual or estimated data about its visibility and cloud heights. In addition, it presents the data measured in feet above ground level instead of mean sea level, which is generally used by pilots but is less helpful to those who only fly at low altitudes.



HEMS enables rescue pilots to view atmospheric conditions, including ceiling, visibility, wind speed, and icing potential, at various altitudes above ground level.

Since its creation in 2006, HEMS has been available on an experimental site hosted by NCAR. It is expected to become an approved flight planning tool supported by the National Oceanic and Atmospheric Administration (NOAA) at some point next year, increasing its visibility to those engaged in emergency evacuations.

The program's recent updates, which are available on NCAR's site, allow users to track visibility and ceiling trends in order to better determine if conditions are improving or deteriorating. It also adds important topographical data such as contoured elevation lines and enables users to locate landmarks to help with navigation, such as heliports or hospitals. Without that information, the Federal Aviation Administration (FAA) found that helicopter rescue pilots have too often flown from safe conditions on takeoff into unanticipated areas of poor visibility, resulting in crashes into obstacles or terrain.

The HEMS Tool is now used by every major air medical operator in the U.S. and has a potential economic benefit of over $50 million year, according to Christopher Eastlee, president of the Air Medical Operators Association. "Other tools didn't provide high enough resolution and didn't show conditions exactly where HEMS pilots were flying to pick up patients," said Arnaud Dumont, a senior software engineer in NCAR's Research Application Laboratory, which developed the application.

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NCAR Strategic Plan

PREVIOUS NCAR REPORTS

Select year

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NCAR has a long and successful history with the FAA, NOAA, and other agencies with primary missions focused on safety, protection of life and property and efficiency. Its decades-long collaboration with the FAA goes back to the early 1980s when groundbreaking research was conducted on deadly microbursts that were taking airplanes down around airport terminals.

The HEMS tool is an extension of NCAR's Aviation Digital Data Service (ADDS) program that provides pilots with easy-to-use web access to a variety of critical aviation weather information. It was developed at the request of the FAA after a 2006 review of rescue helicopter crashes revealed that a lack of detailed weather information was often a factor. While good weather information is usually available near airports and large cities, no data are available for many other areas.

‹ Sharpening our view of hurricanes, future and present up Scientists help repel mosquito-borne disease with models ›

Login

Home | Annual Reports: | NCAR | ACOM | ASP | CGD | CISL | EOL | HAO | MMM | RAL

NCAR UCAR National Center for Atmospheric Research 2014 Annual Report

Home » 2014 NCAR Annual Report

SCIENTISTS HELP REPEL MOSQUITO-BORNE DISEASE WITH MODELS

Every year about 400 million people contract dengue virus, primarily from bites of *Aedes aegypti* mosquitoes, which live in tropical and subtropical regions. Dengue virus can cause dengue fever, also known as "breakbone fever," which has symptoms that may include high fever, severe headache, rash, and pain in the eyes, joints, muscles, and bones. With roughly one percent of dengue fever cases developing into the more severe hemorrhagic fever and no approved vaccine available to treat the disease, healthcare officials are looking for a way to better predict and, in doing so, preventing dengue outbreaks.

Aedes aegypti are daytime biting mosquitoes and prefer human-blood meals. They live where people live, developing in water-filled containers in and near homes. These containers provide perfect habitat for mosquito eggs, larvae, and pupae.

To better predict and monitor dengue outbreaks, researchers in NCAR's Research Applications Laboratory (RAL) and Science and Technology in Atmospheric Research (STAR) developed a prototype risk-mapping framework with a team of scientists from Mexico, Arizona, Colorado, and Virginia. The system utilizes a series of geospatially diverse data sets that characterize weather, likelihood of mosquito habitats, and human and mosquito populations. The data sets are used in a sequence of models, including a newly developed algorithm that approximates mosquito habitat, in order to produce dengue risk maps.

"We combined a variety of models, including the Weather Research Forecasting model, mosquito population and virus transmission models, and an energy balance model that estimates water temperature and water height in containers, which are critical factors in larvae development," says Paul Bieringer, a scientist in RAL and at STAR.

The regions highlighted in orange on the map are primarily at risk from dengue outbreaks. The red lines show the 10-degree C isothermal line, which are the potential geographical limits of the Northern and Southern Hemisphere for year-round survival of *Aedes aegypti* mosquitoes.

To create the algorithm, the team used human population data and satellite images of the study site located near the town of Orizaba in central Mexico. The group turned to Oak Ridge National Laboratory's national database of urban and regional population to obtain the population data. To get an idea of what the environment looked like near Orizaba, the researchers used very high-resolution satellite imagery. Merging the population and environmental data, the algorithm helps researchers estimate the number of containers that could be used by immature mosquitoes for development.

The resulting data and modeling framework generates a map that provides an initial estimate of the rate of mosquito reproduction and the prevalence of transmission of disease from mosquitoes to humans in near-real time.

The geography of this first study site will aid the researchers in assessing the mapping system. The region's hilly geography results in large variations in rainfall rates and temperature across the landscape, making obvious differences in conditions favorable to mosquito survival and reproduction, and therefore dengue outbreaks, easily identifiable. The project's next step is moving forward with validation of the mapping system's accuracy. If deemed accurate, a similar approach will be used to test the system's utility in other regions where dengue is endemic, Bieringer says.

"The goal of this project is to predict for a given month how mosquitoes respond to changing weather patterns and the related effects on disease prevalence," says Bieringer. "Validating our initial mapping effort will require looking at the available records of dengue incidence in the region to see if our mapping estimations are accurate."

‹ Guiding rescue helicopters: New NCAR tool highlights weather conditions for emergency medical flights

up

HCR: HIAPER Cloud Radar ›

HCR: HIAPER CLOUD RADAR

As scientists work to improve climate models, one of the biggest uncertainties that they need to resolve is a clear understanding and treatment of cloud processes. Observations are critical to achieving this end. The Earth Observing Laboratory (EOL) develops and operates many of the instruments that the U.S. research community relies on to obtain the required high-quality environmental observations for model validation. Among the latest of these is EOL's HIAPER Cloud Radar (HCR), which is providing researchers with detailed observations of cloud dynamics.

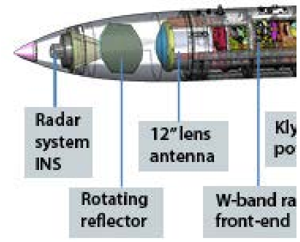
The HCR is one of a suite of instruments developed for the NSF/NCAR Gulfstream V (GV or HIAPER) research aircraft. Before instrument development began, EOL polled the community to identify conceptual design of the HCR to support their climate and weather research. They requested an narrow beam radar capable of detecting and quantifying small amounts of liquid and ice with a second wavelength and/or dual-Doppler capability. The scientists estimated that such a design would significantly extend the utility of radar observations by further reducing uncertainty in radar-based measurements of cloud properties.

EOL built the HCR based on this input, but also had to factor in size and weight restrictions because the instrument would fly in a pod attached beneath the GV's wing. As a result, the HCR became a small, compact radar built in three phases, beginning with the pod-based W-band radar system with scanning capability. In the second phase, which the team estimates will be completed in 2016,a pulse compression will be added for improved sensitivity and polarimetric capability to the W-band system operating at 95 GHz. The third and last phase will add the complementary K_a-band radar operating at 35 GHz; completion of this last phase is estimated to occur in the next two to three years.

The HIAPER Cloud Radar (HCR) sits in the high-tech pod especially developed to house instrumentation during research flights; the pod sits beneath the wing of the NSF/NCAR Gulfstream V.

The HCR, which operates both on the GV and as a ground-based sensor, opens up new observational opportunities for the NSF research community, says Jothiram (Vivek) Vivekanandan, a senior scientist at EOL and the lead scientist on the HCR development. "The radar's millimeter-wavelength, dual-polarization, Doppler remote sensing capabilities generate measurements that provide the most complete picture of cloud physics available to the atmospheric science community."

The HCR precisely detects drizzle, and thin ice and liquid clouds, estimates their microphysical and radiative properties and takes detailed wind measurements. It can also distinguish between ice, water, and super-cooled water droplets (droplets that exist as a liquid at temps below freezing). Data collected by the HCR sensors offer unique observations on the formation and evolution of clouds that will provide critical understanding about the effects of clouds on global and regional climate.



The instrument pod has a diameter of 20 inches (0.5 meters), and a length of 160" (4.1 meters). The HIAPER Cloud Radar, contained within the pod, weighs 420 pounds (191 kg). The cartoon above shows the details of the HCR's current and soon-to-come components.

The HCR also complements existing airborne narrow-band radar available to the research community. The two other airborne radar – used on the University of Wyoming's King Air and NASA's ER-2 – have different characteristics, making the HCR's third set of instrument options useful to climate researchers. The Wyoming King Air and ER-2 have a similar radar that uses the same frequency, but these instruments do not have scanning and a dual-wavelength radar ability. Moreover, when used in combination with the High Spectral Resolution Lidar (HSRL), another instrument developed for use on the GV, the HCR and HSRL mimic the sensing capabilities of the CloudSat and CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) satellites. This may prove useful for validating satellite observations and deriving scientific products from remote measurements.

The HSRL and the HCR remain operational between deployments, living in a seatainer at NCAR's Foothills campus, where both instruments will run continuously. In addition to keeping an expensive instrument in use, it gives the team an opportunity to continue learning about the HCR's capabilities, including its accuracy. With this information, laboratory researchers will continue to improve the data product/output.

Especially when flying on the GV (because of the plane's extended distance and altitude capabilities), the HCR opens up exciting observational opportunities for climate researchers. Already, scientists are lining up to include the HCR in field campaigns to attain high-fidelity cloud observations. The Cloud-System Evolution in the Trades (CSET) campaign is scheduled to launch in summer 2015; CSET researchers will look at cloud-system evolution in Pacific trade-wind regions. Other field-campaign HCR requests made for 2016 and beyond include DOWNSTREAM (Dynamics and Observations of the Waveguide: North-South Transport and Rossby Wave Excitation over Atlantic Midlatitudes) and SOCRATES (Southern Ocean Cloud Rain/Radiation, Aerosol Transport Experimental Study). DOWNSTREAM proposes to look at the polar vortex and how jet streams are controlled and affected by clouds and radiation, while SOCRATES aims to observe ocean/atmosphere processes occurring in the remote Southern Ocean.

"Observations, whether day-to-day, or collected during future and proposed field campaigns generate observations that provide critical information that will help us better understand the interplay between climate and weather systems," says Vivekanandan. "Measurements using remote sensing instruments – namely, lidars and radars – not only depict current climate, they offer a means to evaluate climate models' performance. Obtaining these measurements are critical for advancing predictive skills of climate models."

‹ Scientists help repel mosquito-borne disease with models | up | Big data: Glade and Globus+ ›

BIG DATA: GLADE AND GLOBUS+

The National Center for Atmospheric Research (NCAR) has recently implemented an enhanced data sharing service that allows scientists increased access to data as well as improved capabilities for collaborative research. In addition to data sharing, NCAR has significantly upgraded its centralized file service, known as the Globally Accessible Data Environment (GLADE).

Managed by NCAR's Computational and Information Systems Laboratory (CISL), both GLADE and the data sharing service are important upgrades for the high-performance computing (HPC) user community, allowing faster and better access to data and a more flexible virtual workspace.

The Globally Accessible Data Environment (GLADE) is the centralized file service located at the NCAR-Wyoming Supercomputing Center in Cheyenne.

The data sharing service leverages the capabilities of Globus Plus to increase customization options for storage as well as data sharing. Globus, a project of the Computation Institute (a partnership of The University of Chicago and Argonne National Laboratory), is a software service that has been described as a dropbox for big data. It is broadly used in the scientific community. "Plus" refers to a new feature that allows researchers to share data with colleagues outside of their home institutions, greatly improving ease of collaborative work.

"Scientific collaborations are global endeavors, and researchers need to share data with colleagues around the world. As data sets have grown in size and number, the process of moving and managing access to them has become a significant challenge," said Pam Gillman, manager of NCAR's Data Analysis Services Group. "Globus Plus is a robust and user-friendly service that eases the workflow, and it allows users to be more productive by spending less time on the minutiae of data transfers."

NCAR users have been accessing the Globus transfer service for many years. In addition to making data available to external colleagues, the upgrade now allows users of CISL's HPC environment to control the users or groups of users to which the data are accessible. With the sharing service, outside users need only a free Globus account, not a UCAR username/token, to access shared data.

The Globus Plus service has a 1.5-petabyte capacity, and most users can take advantage of the Globus web interface to transfer data. Advanced users or service developers can leverage the Globus Plus features via a command-line interface.

CISL recently added 5 petabytes of high performance storage to the GLADE environment, bringing the total to 16.4 petabytes. GLADE is based on the GPFS file system and provides over 90 GB/s of sustained bandwidth across HPC, analysis, and visualization resources. GLADE file spaces are intended as work areas for day-to-day tasks and are well suited for managing software projects, scripts, code, and data sets.

"We strive to meet the growing needs of our user community, which expand as the data sets grow and require greater and more efficient resources," said Gillman. "These major upgrades are part of CISL's

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PREVIOUS NCAR REPORTS

Select year

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ongoing commitment to giving users the tools and services they need to carry out cutting-edge computational research.”

‹ HCR: HIAPER Cloud Radar up Grassroots efforts address the diversity issue for high-performance computing ›

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GRASSROOTS EFFORTS ADDRESS THE DIVERSITY ISSUE FOR HIGH-PERFORMANCE COMPUTING

Given the inherently dynamic, ever-evolving environment of high-performance computing (HPC), having a diversity of ideas and perspectives in this arena is critical to advancing the field. The Computational & Information Systems Laboratory (CISL) therefore puts a strong focus on training a variety of future HPC experts early in their studies and careers.

Dr. Richard Loft, director of CISL's Technology Development and head of the lab's diversity and outreach team, leads the lab's successful diversity recruitment effort, along with CISL diversity coordinator Stephanie Barr. Loft, Barr, and the education team have created programs that are developing next-generation HPC expertise to serve the nation's coming exascale-computing needs. In addition to benefitting the lab and NCAR's scientific community, these programs have notable positive impacts on individual students.

One of the lab's longest-running training and diversity efforts is the 11-week-long Summer Internship for Parallel Computational Science (SIParCS). Launched in 2007, this program brings bright, motivated undergraduates interested in HPC to NCAR. Since the inauguration of SIParCS, CISL has made minority-serving institutions (MSIs) aware of this and its other programs. By regularly meeting with MSIs, the lab actively – and successfully – seeks out women, minority, and other underrepresented populations as program applicants. The result: a mix of student interns that has grown increasingly diverse over the past several years. These programmatic efforts have also led to a change in the lab's focus on, and awareness of, diversity issues.

"The most notable changes in our program and recruitment efforts are the result of hiring Stephanie Barr as CISL diversity coordinator in 2012," explained Loft. "Stephanie has led CISL's diversity efforts in relation to intern and employee recruiting, in the process making CISL and NCAR more attractive to populations that historically have been less actively engaged in the computational sciences."

Barr regularly speaks to professors and administrators at MSIs and other universities about NCAR and CISL training and internship opportunities, as well as discussing student career and educational opportunities that could result from such hands-on program experience. She works at a grassroots level to identify what might work best for MSI students and how CISL programs could be modified to better suit these students' needs. In addition to targeted visits to science, technology, engineering, and mathematics (STEM) departments, Barr supports CISL scientists and staff as they carry out the lab's mission to actively seek, train, mentor, and integrate diverse new talent at NCAR.

One example of recent progress in CISL's internship training opportunities originated from an informal interaction between Loft, Barr, and several professors teaching at MSIs. In August 2013, Barr invited a number of MSI-based professors to attend the Rocky Mountain Advanced Computing Consortium's (RMACC's) High Performance Computing Symposium. RMACC is a group of HPC-focused western academic and research institutions. The Symposium enables them to network, attend tutorials, and learn about the latest HPC technology trends. "Inviting the MSI professors seemed like a good way to build collaborative relationships," said Loft.

At the Symposium, the informal conversation turned to the issue of engaging non-traditional students, who make up about two-thirds of the U.S. student population. "Non-traditional" students in this context

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STRATEGIC PLANS

NCAR Strategic Plan

PREVIOUS NCAR REPORTS

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refers to those going to school on a part-time basis, working full-time, supporting dependent relatives, etc. Often these students can't attend internships that take them away from home for long periods, which means that talented students fall through the cracks because they cannot take advantage of programs that offer potentially life-changing benefits.

In response, the CISL team and MSIs professors came up with the idea of transforming some SIParCS positions into externships. In the 2014 prototype of this model, students spent only four weeks of the 11-week program in Boulder. During the first three weeks at NCAR, the externs learned new technology and skills they would need to succeed with their projects. They then returned home for seven weeks, working at their home institutions with a team of remote and local mentors. During the last week of the externship, the students returned to present their final project to their peers and NCAR leadership.

For a student like Justin Moore, who attends Salish Kootenai College, a tribal college in Montana, the externship proved life-changing. After the initial training in Boulder, he returned to his family, job, and academics. His project entailed building and administering a small cluster of Linux machines that, from a software point of view, are as complex as running a supercomputer. In addition to learning practical skills, his experience led to a new job: Moore now administers the college's recently purchased computer cluster, a job that puts Moore solidly in the IT field.

With the first year of externships deemed a success by CISL and the students, externships will likely be offered again in 2015.

Many of the contributors to the Workshop on Diversity in the Computational Geosciences at NCAR. DCG provided a forum and ample time for vigorous discussion and brainstorming.

CISL's 2014 diversity efforts also included a summer workshop on "Diversity in the Computational Geosciences." The workshop was created as a way to develop and sustain a robust national community dedicated to broadening participation in the geosciences. A workshop report summarizing the shared vision, knowledge, and experiences of the participants will be shared with the National Science Foundation, and help define the research, curricula, and best practices needed to increase diversity within the geosciences.

Other 2014 highlights include participation by 10 students from four institutions – Universidad del Turabo in Puerto Rico, Salish Kootenai College, and two historically black universities, Elizabeth City State University and Prairie View A&M University – in UCAR's Software Engineering Assembly (SEA) conference. A technical conference to update software engineers on HPC practices, this meeting fostered collaboration between participants, and offered hands-on computing tutorials for students. The students also had the chance to have lunch and learn from NCAR professionals working in their future industry.

"By working directly with MSIs students and faculty, the team is making inroads on addressing the diversity issue for HPC and meeting the needs of the computational community that CISL and NCAR serve – a win-win for all in terms of interest, time, and energy," Loft said.

‹ Big data: Glade and Globus+ up Keying in on the atmosphere's vertical reverberations ›

Login

2014 NCAR ANNUAL REPORT

- Message from the NCAR Director
- FRAPPÉ tracks Front Range pollution
- CONTRAST: Scientists examine Pacific's "global chimney"
- A new class of global climate models
- Sharpening our view of hurricanes, future and present
- Guiding rescue helicopters: New NCAR tool highlights weather conditions for emergency medical flights
- Scientists help repel mosquito-borne disease with models
- HCR: HIAPER Cloud Radar
- Big data: Glade and Globus+
- Grassroots efforts address the diversity issue for high-performance computing
- Keying in on the atmosphere's vertical reverberations
- ASP turns 50 years old
- 2014 Metrics

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

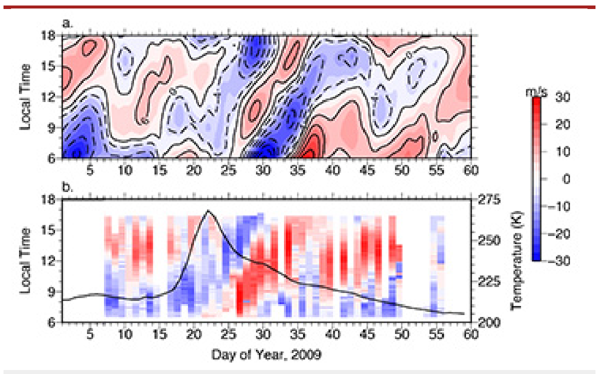
- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research

KEYING IN ON THE ATMOSPHERE'S VERTICAL REVERBERATIONS

All of the everyday weather events that we find pleasing, annoying, or terrifying take shape in the troposphere—the atmosphere's lowest layer, extending anywhere from 7 to 20 km (4–12 miles) high depending on season and latitude. Earth's weather doesn't stop there, though. Atmospheric tides, solar storms, and other phenomena play out at much higher altitudes, far from our curious eyes. Now, a range of modeling and observing tools is helping researchers at NCAR and elsewhere discern previously unmapped links between weather events in various layers of the atmosphere, with implications for aviation, GPS, and other critical aspects of society.

A linchpin in this growing field of study is the Whole Atmosphere Community Climate Model, or WACCM. Originally developed at NCAR more than a decade ago, WACCM pulls together elements of preexisting lower- and upper-atmosphere models into a unified whole. A special version of the model, WACCM-X, extends up to the bottom of the exosphere (around 500 km), allowing it to simulate the rarefied realm of the upper thermosphere where air temperatures can soar above 900°C (1,620°F).

Tools such as WACCM and a NOAA counterpart called Whole Atmosphere Model allow researchers to replicate particular weather events and study how their effects propagate both horizontally and vertically. By comparing these simulations with observations—especially for major weather events with extensive vertical reach—the researchers gain further insight.



Model simulations (top) and observations (bottom) of the impacts of a sudden stratospheric warming (SSW) in January–February 2009, as shown in the vertical movement of plasma at 300 km altitude above the geomagnetic equator (Jicamarca, Peru). Speeds on the right-hand legend are in meters per second, with red indicating upward motion and blue downward motion. The black trace on the bottom panel indicates temperatures at the 10-hecopascal pressure surface between 70°N and 80°N, with a warm spike associated with the SSW in late January. The simulations were produced by an extended high-altitude version of the NCAR-based Whole Atmosphere Community Climate Model (WACCM) and Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Model (TIME-GCM). (Image courtesy Nicholas Pedatella, UCP/COSMIC.)

For an investigation-worthy event, it's hard to do better than a sudden stratospheric warming (SSW). SSWs develop as large-scale atmospheric waves propagate upward, then act to compress and warm a portion of the polar stratosphere. Over a period of days to weeks, usually in wintertime, the resulting chain of events can disrupt the infamous "polar vortex," causing it to split into two pieces and occasionally triggering dramatic cold air outbreaks in midlatitudes. In the stratosphere, an SSW can produce warming near the North Pole of as much as 50°C (90°F) over several days. A strong SSW can reverse the usual north-south temperature gradient in stratospheric temperature and force the winds encircling the polar vortex at this height to switch direction, with wind-speed changes of up to 50-mph observed.

"SSWs were quite rare in the 1990s, but over the last decade we've seen a major event almost every year," says Hanli Liu, one of the primary NCAR developers behind WACCM. This kind of multidecadal variability in SSWs also shows up when WACCM simulates long periods of climate. Scientists aren't yet sure why the frequency of SSWs varies from decade to decade in nature or in

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models.

One of the best tools for observing high-altitude weather from the ground is a device known as an incoherent scatter radar. A dozen of these are now stationed at major research centers scattered around the globe. Although SSWs can occur anytime from December to March, these radars can only be coordinated for relatively short observing periods of a few weeks, usually centered on the peak of SSW season in January and February.

Happily for researchers, several of the radars managed to capture significant SSWs in 2008, 2009, 2010, and 2013. These years span the interval from the minimum to maximum of the roughly 11-year solar activity cycle, which will allow researchers to delineate how SSWs influence the upper atmosphere under varying solar conditions (although the current solar maximum is on the weak side). The data will also be valuable for helping models such as WACCM replicate the effects that cascade from lower to upper atmosphere as an SSW evolves.

"We're finding that if you get a solid representation of the lower and middle atmosphere, you can get a good, clear signal for the upper atmosphere," said Liu. "It's a step forward for space weather and ionosphere predictability."

Nicholas Pedatella focused on high-altitude impacts of SSWs during his two-year term as an NCAR Advanced Study Program postdoctoral researcher at the center's High Altitude Observatory. Now a scientist at UCAR's COSMIC program, Pedatella continues to study how SSW impacts manifest themselves in the upper atmosphere.

"Model such as WACCM have been essential for this research," said Pedatella. He and NCAR colleagues have pioneered the use of WACCM and related models to examine how the SSW interacts with semidiurnal tides in the mesosphere and lower thermosphere. As these tides wax and wane twice each day—powered by daily variations in solar heating and the orbit of the moon—weak updrafts and downdrafts work their way through the upper atmosphere.

Pedatella and colleagues found that SSWs can temporarily boost the strength of some semidiurnal tides by up to 70%. In turn, these tidal shifts affect the behavior of the electrified ionosphere above, including the flow of plasma and the number of electrons. Radio signals typically bounce off the ionosphere before returning to Earth, while GPS signals pass through the region. Both types of signals can be affected by variations in plasma flow, electron density, and other ionospheric components. The new findings could eventually help satellite operators anticipate how the ionosphere might be affected by an unfolding SSW, thus providing a crucial heads-up of possible short-term irregularities in radio and GPS transmission.

While SSWs are rare but powerful, there are smaller-scale, more-frequent phenomena that also make their mark across multiple layers of the atmosphere. Strong winds flowing over mountain ranges often generate gravity waves that propagate dozens of kilometers upward. Though smaller and shorter-lived than the planetary-scale waves that kick off SSWs, these gravity waves can still influence the atmosphere at heights of up to 100 km.

In June and July 2014, the NSF/NCAR HIAPER aircraft joined several ground-based radars to sample gravity waves arising from strong winter winds slamming into the peaks of New Zealand's South Island. The DEEPWAVE project, involving several universities and laboratories, examined how the gravity waves evolve and how their influences can be better predicted.

“We devised DEEPWAVE to take advantage of new measurement capabilities,” said David Fritts (GAT Inc.), one of the project's four principal investigators. “If we can use our knowledge from DEEPWAVE to better understand gravity waves arising from sources over the entire planet, it will contribute to better weather and climate forecasting in the future.”

‹ Grassroots efforts address the diversity issue for high-performance computing   up   ASP turns 50 years old ›

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ASP TURNS 50 YEARS OLD

There's no pomp and circumstance on the agenda, but the staff and alumni of NCAR's Advanced Study Program (ASP) are taking quiet pride this autumn in the program's 50th anniversary. What began as a novel idea just four years after the founding of NCAR has become a renowned launch pad for the careers of hundreds of young scientists, many of whom are now leaders in weather, climate, and solar research.

ASP offers a unique two-year postdoctoral program that combines intensive mentoring and access to a wide range of experts with the freedom to explore innovative topics. More than 500 alumni of the ASP Postdoctoral Fellowship Program now occupy prominent positions within the atmospheric sciences community. These scientists can be found practicing in a broad range of disciplines at UCAR member universities; government, nongovernmental, and private organizations; and NCAR itself.

Along with its postdoc program, ASP offers graduate students the opportunity to make 3- to 12-month visits to NCAR in support of their university-based thesis research. In addition, ASP's Faculty Fellowship Program paves the way for university faculty to take NCAR-based sabbaticals and for NCAR scientists to do likewise in academia.

Supported by the National Science Foundation, ASP addresses mission-critical education and training goals of both NCAR and the foundation. Benefits accrue not just to the participants but also to NCAR and the science community, which gain highly trained researchers and an infusion of new ideas that emerge with each cohort of fellows.

According to ASP alumnus Russ Schumacher (Colorado State University), the program's focus on independent research is fundamental to its success. "The program puts a lot of power in the hands of a young scientist, which is invaluable. ASP fellows are encouraged to explore new ideas and allowed to find their own way to a large degree, but can also turn to some of the world's top atmospheric scientists as needed," he said.

MEETINGS OF THE MINDS

In the course of fostering emerging scientists, ASP promotes the examination of particularly timely topics, as well as areas that seem underemphasized relative to their importance. Toward this end, almost every year since 1966, ASP has hosted a summer colloquium that brings together graduate students and expert researchers in a given field for an intensive set of lectures. The colloquia foster interactions between scientists and graduate students and also provide an opportunity for professional peers working on similar issues to come together, typically for several days, midway through the multiweek agenda.

Uncertainty in climate change research was the focus of the 2014 ASP Summer Colloquium, held from July 21 to August 6. Although the basic role of human-produced greenhouse gases in raising global temperature is unquestioned, there remains a wide range of possibilities as to how future climate change will unfold, especially on local and regional scales. Sessions at this past summer's colloquium focused on the need to understand strands of uncertainty throughout the climate

Julio Herrera Estrada (Princeton University) and Elizabeth Lewis (Newcastle University) discuss one of the research projects featured at a dinnertime poster session during the ASP 2014 Summer Colloquium on Uncertainty in Climate Change: An Integrated Approach.

change problem in order to maximize the effectiveness of research focused in any one area, such as regional climate change or societal vulnerability.

"Research quality on any related topic is enhanced by having a more well-honed understanding of the bigger climate picture," explained Linda Mearns, an NCAR senior scientist and lead organizer of the 2014 colloquium on uncertainty. "We aimed to train up-and-coming scientists in interdisciplinary thinking, illuminate both the certainties and uncertainties related to climate change, and provide tools for dealing rigorously with the uncertainties."

"ASP colloquia provide a real service to the community by training the next generation of scientists," said Lance Bosart (University at Albany, State University of New York), who co-led ASP's 2012 colloquium on the intersection of weather and climate. "Organizing and running colloquia is a difficult thing for a university to do. NCAR has the resources and experience and knows how to do it right."

Another tradition is the Thompson Lecture Series, launched in 1998 in honor of ASP founder Phil Thompson. The series brings prominent scientists to NCAR for short visits that feature interaction between the lecturer, ASP fellows, and other early career scientists at NCAR. Thompson Lecturers have included Nobel Prize winner Paul Crutzen (Max Planck Institute for Chemistry), Susan Solomon and Kerry Emanuel (both at Massachusetts Institute of Technology), Robert Rosner (University of Chicago), and the late Jerry Mahlman (who spent most of his career at NOAA's Geophysical Fluid Dynamics Lab and Princeton) among others.

In addition to giving a formal presentation, Thompson Lecturers offer research advice to the ASP postdocs and share their perspectives on scientific trends and priorities. In turn, they're briefed on emerging areas of research being investigated by the postdocs.

AT THE HELM

Leadership has been a critical part of ASP's half century of success. Alumni praise the lineup of past and present ASP directors for their excellent mentoring and listening skills, dedication to fostering early career scientists, and strong advocacy on the part of fellows during the program and beyond, as the fellows launch their careers.

Mary Hayden, an ASP alumna now working on health and climate issues at NCAR's Research Applications Laboratory, credits ASP leadership for ensuring strong, ongoing ties between NCAR and program alumni.

"During my tenure as an ASP postdoc, I knew I had Director Maura Hagan's full support for the work I was doing then, and to this day – although my postdoc has ended, and Maura is no longer the program director – she continues supporting the work I do," Hayden said. "This abiding interest from Maura is not unique to me, but is true for other ASP postdocs that Maura mentored, and likely contributes to the enduring connections between NCAR and its ASP postdocs."

Current ASP director Chris Davis sees the ongoing interaction as essential for keeping NCAR strong and

relevant.

“Outgoing ASP postdocs form an important part of the web connecting NCAR and universities,” said Davis. “We look forward to the research and career development possibilities that those ties represent, both for ASP alumni and successive generations of students and postdoctoral fellows.”

‹ Keying in on the atmosphere's vertical reverberations | up | 2014 Metrics ›

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2014 METRICS

The metrics featured below offer qualitative and quantitative measurements and assessments of the productivity, quality, and impacts that NCAR staff, programs and activities have on our research community, sponsors, and society in general.

LAB/OBSERVATORY/PROGRAM-LEVEL METRICS

NCAR-Hosted Community Events

Each year, events are hosted by labs, divisions, and programs. These include colloquia, conferences, symposia, tutorials, and workshops.

A total of 96 events were hosted: 38 workshops, 20 tutorials, five symposia, nine conferences, and 24 colloquia. Event co-sponsors included government entities such as the Air Force Weather Agency and the Department of Energy; non-profit organizations like the Statistical and Applied Mathematical Sciences Institute and the Molina Center for Energy and the Environment; and universities including The Pennsylvania State University and Newcastle University.

Facility Tours

Each year, NCAR facilities host a number of participants for tours organized for a specific organization or group. This year, NCAR hosted a total of 63 tours.

The NCAR-Wyoming Supercomputer Center hosted 46 tours in FY14, for groups ranging in size from 2 to 80 people. Fourteen tours were by K-12 groups, including the Boys and Girls Club of Douglas, Wyoming. Ten groups took science- or technical-related tours, including the Hydro and Agro Informatics Institute group from Thailand. There were seven college or university groups, ranging from a Colorado State University atmospheric chemistry class to the Laramie County Community College. Five tours were green building and design-related, including a tour made by a rotary club convention. Four tours were in the engineering category, including the Wyoming Army National Guard. There were five tours by political/sponsor groups, including IBM. There was also one tour by the peer center Penn State Data Center Project Team.

The Rocky Mountain Metropolitan Airport hosted a total of 19 tours in FY14. Thirteen tours were by college and university groups, including Indiana University and University of Vienna. Four tours were by science and technical groups, including South Dakota School of Mines. One tour was made by NASA, and a K-12group from St. Louis Catholic School also toured the facility.

Field Campaigns

NCAR's geosciences research facilities, instrumentation and field support services support field campaigns around the globe.

In FY14, NCAR participated in 14 field campaigns ranging in duration from 30 to 1,500 operational field days. A total of 173 institutions, including 72 UCAR member institutions participated in these campaigns. The projects involved 200 investigators, 95 undergraduate students, and 154 graduate students.

For example, the Biogenic Aerosols-Effects on Clouds and Climate (BAECC) field campaign is a

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STRATEGIC PLANS

NCAR Strategic Plan

PREVIOUS NCAR REPORTS

Select year

Printer-friendly version

collaboration with Finnish scientists to measure biogenic aerosols emitted from forests in order to determine their effects on clouds, precipitation, and climate. BAECC placed the second ARM Mobile Facility (AMF2) in a Scots pine forest in southern Finland from February through September 2014 to obtain surface-based measurements of biogenic aerosols and gases. These measurements will be augmented by aircraft observations of aerosol microphysics, as well as measurements from the University of Helsinki's Station for Measuring Ecosystem-Atmosphere Relations (SMEAR-II).

NWSC Walk-In Public Tours

The NCAR-Wyoming Supercomputing Center (NWSC) is based in Cheyenne, Wyoming. The Center provides advanced computing services to scientists studying a broad range of disciplines, including weather, climate, oceanography, air pollution, space weather, computational science, energy production, and carbon sequestration. The Center is open to the public for self-guided tours, field trips for school groups, and non-school group special tours.

In FY14, the Center received 839 walk-in public visitors, and averaged 70 visitors per month.

INDIVIDUAL STAFF METRICS

Contributions to Individual Graduate Student Education

NCAR staff serve as research advisors and committee members for graduate students around the world.

Of the 208 graduate students that have NCAR staff serving as graduate advisors or committee members, 31% hail from Colorado institutions; 43% attend schools in 27 other states. The remaining 26% study at schools in 22 countries around the world, including a student from The University of the South Pacific who is advised by Cindy Bruyere.

Editorships

NCAR staff serve as publication editors. These positions recognize the appointee's leadership in the field and serve a critical role in developing a given field's future focus.

Seventy-three NCAR staff served in 102 different editorial roles on 74 different publications or journals. Publications included top-tier journals such as *JGR-Atmosphere*, and *Solar Physics*.

External Awards

Each year a number of NCAR Staff are honored for their work and contributions to the Atmospheric and related sciences.

Twenty-seven staff received special recognition for their work. William Mahoney, Sue Ellen Haupt, and Brako Kosovic (Principal Investigators) and the Windpower Forecasting Team (RAL) received the 2014 Colorado Governor's Award for High-Impact Research for their project "Optimizing Integration of Renewable Energy into the Power Grid in Colorado." This award was in the in the Sustainability category as well as an honorable mention in Public-Private Partnerships, for work on a cutting-edge wind and solar energy forecasting system. The Governor's Award is given each year by CO-LABS, a nonprofit that works to inform the public about the breakthroughs and impacts from Colorado's 30 federally funded labs and research facilities.

Vanda Grubisic (EOL) was awarded a American Meteorology Society Fellowship. The AMS Fellowship honors outstanding contributions to the atmospheric or related oceanic or hydrologic sciences or their applications during a substantial period of years.

Lisa Kaser (ASP) received an Award of Excellence for outstanding Dissertations from the Austrian Federal Ministry of Science and Research. During her work as a PhD student at the University of Innsbruck, she participated in the NCAR/ACD-led BEACHON ROCS and ROMBAS field campaigns at the Manitou Experimental Forest (close to Woodland Park, Colorado). She studied the biosphere-atmosphere exchange of volatile organic compounds (VOCs) in this Ponderosa Pine ecosystem using the eddy covariance technique and a newly developed instrument (PTR-TOF-MS).

Fellowships

A fellowship is typically a special appointment granting support for a term in order to support advanced

research or study.

Nine NCAR staff received fellowships in 2014. Among the highlights: Mari Tye (MMM) was awarded a visiting research associate position by Colorado State University (CSU). At CSU, she is working with two Professors in the Statistics department at CSU, on research covering statistical analysis and research relating to tropical cyclones, and extreme. The goals of the research include developing spatial statistical techniques applicable to extreme precipitation and of use in adaptation planning and resilient design.

K-12 Outreach

Staff across NCAR work directly with classes and groups of K-12 students to develop or deliver lectures, conduct tours, and lead or participate in field trips and other educational activities.

Forty-three NCAR Staff worked with K-12 students from 65 schools. Activities included a career fair, helping teachers, mentoring, and field trips reaching 29 different communities. Examples range from a career fair at North High School in Denver, Colorado to giving a talk at Dannevirke High School in Tararua, New Zealand, to conducting a weather balloon launch demonstration at Ponderosa Elementary School in Loveland, Colorado.
Among the highlights: Joey Comeaux (CISL) conducted a third grade science show on dry ice and polymers at Tarver Elementary School in Thornton, Colorado; Jamie Wolff (RAL) served as an exam writer and proctor at the North Region Science Olympiad Event in Fort Collins, Colorado; and Jim Moore (EOL) participated in the CONTRAST Project Education Outreach at Notre Dame High School in Agana, Guam.

Talks and Posters

NCAR Staff give presentations about data, models, theories, hypotheses, reviews, and results around the world in talks and posters to audiences ranging from scientists and engineers to the general public.

Many thousands of people were in the audience when 253 NCAR staff gave more than 1,100 talks across the country and around world, from Norfolk, Virginia to Rio de Janeiro, Brazil. Examples range from Qian Wu's (HAO) talk on "Upper Atmosphere Observation" at Embry-Riddle Aeronautical University in Daytona, Florida to Bette Otto-Bliesner's (CGD) talk "Working Group Report: Quaternary Interglacials" in Namur, Belgium. Sheldon Drobot gate a TEDx talk in Boulder, "The Promise of Connected Vehicles," to 2200 people.

One hundred and five NCAR staff made more than 170 poster presentations across the country and around world, from Potomac, Maryland to The Hague, Netherlands. Examples include Don Stott's (EOL) poster "The Pacific Marine Arctic Regional Synthesis (PacMARS) Data Archive" in Anchorage, Alaska at the Alaska Marine Science Symposium and Joseph Plowman's (HAO) poster "Automated Coalignment of Multi-instrument Data" in La Roche-en-Ardenne, Belgium at the 7th Solar Information Processing Workshop.

External Committee Service

NCAR staff are called upon to participate in and often lead external scientific, technical, policy, and educational committees. These committees are instrumental to advancing and promoting the work of the scientific and technical community.

This year, 169 NCAR staff served in a multitude of roles on 437 external committees for national and international scientific, education, and governmental organizations, including entities such as the Green Enterprise IT Awards for the Uptime Institute, the Committee on Probability and Statistics for the American Meteorological Society, and the Committee on Solar and Space Physics for The National Research Council. More than 65 % served on more than one committee.

Staff Collaboration Visits to Universities

NCAR staff take leaves to visit other institutions for two weeks or more for intellectual growth, professional development, collaboration with research community peers, community support, teaching, or sabbatical. Examples of work include teaching courses or workshops, lecturing, giving tutorials, working with graduate students on dissertation-focused research, student mentoring, collaborative research, and participating in the host institution's outreach to community colleges, minority-serving institutions, and high schools.

This year, 12 NCAR staff members took leaves at 12 different institutions, ranging from Max Planck Institute for Meteorology to the University of Puerto Rico. Among the highlights: Steven Massie (ACD), a Scientist III, visited Florida State University to teach a graduate course in atmospheric chemistry, and engage in collaborative research with the chemistry programs of the geology and oceanography departments.

Teaching in University/College Classrooms

NCAR staff make important contributions through teaching appointments at institutions of higher education in positions ranging from Graduate Faculty to Professor.

Teaching appointments at institutions of higher education currently number 66. Twenty percent of these appointments occur in 9 countries around the world; 80% took place in 17 U.S. states, including Lyndon State College. The longest term is 29 years, by Grant Branstator (CGD) who is an Adjunct Professor at Iowa State University.

Teaching or Training at Workshops/Tutorials/Colloquia

NCAR staff teach classes and offer training in workshops, tutorials, and colloquia to students ranging from model users, to scholars, to fellow researchers.

During this year, 69 staff members taught at a total of 100 workshops, tutorials, and colloquia. In all, 613 individual classes were taught, with class sizes ranging from five to 171 people. Twenty-five percent of these events occurred in 17 countries around the world including Nigeria and India; 75% took place in eight U.S. states, including Maine and Kansas. Examples range from Simone Tilmes' (ACD) contributions at the "1st West African Workshop on Air Quality" in Abuja, Nigeria to Qian Wu's (HAO) teaching at the CEDAR workshop in Seattle, Washington.

Special Appointments

NCAR Affiliate Scientists: Select university and research-community scientists are invited to carry out long-term, highly interactive, collaborative work with UCAR scientists and are appointed as Affiliate Scientists with three-year terms. This appointment is particularly suitable for parties who desire an extended, close-working relationship on scientific problems of mutual interest. Currently, 36 hold appointments including Dr. Elisabeth Lloyd of Indiana University. Dr. Lloyd is collaborating with scientists in the Computational and Informational Systems Laboratory on climate science and uncertainty quantification.

Emeritus/Emerita: Scientific and Research Engineering staff who have made significant contributions to NCAR through long and distinguished service in senior positions in research may be granted emeritus or emerita status. This designation confers a life-long honorary distinction. Approval of the President and the Board of Trustees is required. Currently the ranks of Emeritus/Emerita number 23 with the recent appointment of CGD scientist David Williamson who is continuing his development and validation of numerical methods for global atmospheric models.

Scientific and Technical Visits to NCAR

Each year students, scientists, engineers, weather forecasters, and other professionals from around the country and world receive special visitor appointments from labs and programs across NCAR to collaborate with scientific, educational, or technical staff; conduct independent research; or participate in and/or oversee a professional project. Many receive financial support for their visits and some visitors temporarily join the NCAR staff.

This year, colleagues visited NCAR 865 times and hailed from 379 institutions, located in 44 different U.S. states and 43 different countries.

Visit Length - Number of Scientific and Technical Visits in FY14

1 day to 1 week: 196

8 days to 2 weeks: 113

>2 weeks to 2 months: 249

>2 months to 6 months: 130

> 6 months to 1 year or more: 177

Total: 865

Scientific and Technical Visit Types - FY14

Visits by Visitors on Payroll: 46

NCAR funded Visits: 293

Externally funded Visits: 526

Total: 865

Publications in the UCAR Open Sky Institutional Repository

NCAR's publication records are curated in the UCAR Open Sky Institutional Repository. OpenSky is the open access institutional repository supporting UCAR, NCAR, and UCP, extending free and open access to our scholarship for the benefit of research and education.

OpenSky is operated by the NCAR Library, with the goal of providing free and open access to the scholarship of UCAR, NCAR, and UCP. Founded on the principle that public access to the scholarly record is essential to the advancement of science and society, the vision of OpenSky is to support the broad mission of UCAR to foster science, support its community, and facilitate the transfer of knowledge.

In support of this vision, OpenSky will provide long-term storage, preservation, access to scholarly works and the products of scientific research created by UCAR, NCAR, and UCP authors.

A publication is an academic or technical work of writing containing original research results, reviews of existing results, or scholarship. "Refereed" publications undergo an editorial "blind" or anonymous process of peer review by one or more referees (who are experts in the same field) in order to check that the content of the paper is suitable for publication in the journal. A paper may undergo a series of reviews, edits and re-submissions before finally being accepted or rejected for publication. "Non-refereed" articles have been reviewed by editors or boards before being accepted for publication but have not gone through a formal blind review. Attached are NCAR's refereed lists for the period October 1, 2013 to September 30, 2014 . To search for recent NCAR publications by author, date, keyword or status please visit the NCAR Publications database.

For excellent library resources please go the NCAR Library Web site.

699 Total Publications (download bibliography)

Refereed: 699
UCAR and Other: 76
UCAR and University: 207
UCAR only: 82
UCAR, University and Other: 334

UCAR Outstanding Publication Award:

Stephen Yeager (NESL/CGD), Alicia Karspeck (NESL/CGD), Gokhan Danabasoglu (NESL/CGD), Joe Tribbia (NESL/CGD), and Haiyan Teng (NESL/CGD) received the Outstanding Publication Award for 2014 for their paper "A decadal prediction case study: Late Twentieth-Century North Atlantic Ocean heat content," published in the Journal of Climate, 25, 5173–5189, doi: 10.1175/JCLI-D-11-00595.1.

Predicting climate change in the near-term, over time horizons of up to a few decades into the future, is a relatively new and rapidly evolving field of climate science. Such “decadal prediction” research is aimed at bridging the gap between seasonal-to-interannual forecasting carried out by many operational weather services worldwide, and the centennial timescale future climate change projections that are the mainstays of the periodic IPCC assessments. Decadal time scales and regional spatial scales are particularly relevant to policy makers and other climate stakeholders. Skillful decadal predictions have the potential to confer tremendous benefits to society by providing advance warning of climate changes such as prolonged droughts, severe heat waves, and increased hurricane activity. This publication distinguishes itself as an outstanding publication on the topic of decadal prediction in several respects:

- This study has provided impetus for continued and expanded decadal prediction efforts at NCAR, and influenced the latest Strategic Plans of NCAR, NESL and CGD that now highlight decadal climate prediction as a Grand Challenge objective (NCAR Strategic Plan: 2014-2019).
- It demonstrates that significant decadal prediction skill is possible today using community models developed by NCAR.
- It goes beyond simply documenting predictive skill by providing a clear explanation of the physical processes that give rise to that skill through a rigorous and innovative analysis of a relevant case study.

Its immediate and lasting impact on the international research community is evidenced by a high and accelerating citation rate.

For a copy of the metrics data, click here.   Please visit the Metrics Database for details on these metrics categories, and the database dashboard for charts and graphs.

For questions on metrics, contact Helen Moshak (moshak@ucar.edu).

2014 ASP ANNUAL REPORT

- Directors Message
- Postdoctoral Fellowships
- Building Partnerships with University Faculty
- Providing University Students Access to the Resources of NCAR
- ASP Summer Colloquium
- Spotlights in Science

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- ASP Strategic Plan
- NCAR Strategic Plan

PREVIOUS ASP REPORTS

Select year

2014 ASP ANNUAL REPORT

TABLE OF CONTENTS

Directors Message ›

Printer-friendly version

Login

DIRECTORS MESSAGE

The Advanced Study Program (ASP) helps NCAR and the scientific communities that it serves to prepare for the future by engaging in human, institutional and broad intellectual capacity building. ASP entrains a broad community of scholars, encourages the exchange of information and the development of new perspectives, and provides unique hands-on educational experiences and many opportunities for students, advisors, and early career scientists to collaborate with a wide variety of NCAR scientists and engineers engaged in research, modeling, and observational activities.

The two-year ASP Postdoctoral Fellowships encourage the development of early career scientists in the field of atmospheric and related sciences and direct attention to timely cutting-edge scientific areas. Approximately 10 new appointments are made annually for positions across NCAR. Fellows' research advances are reported separately in the NCAR Laboratory Annual Reports.

Through its remaining components, the Graduate Visitor Program (GVP), the Faculty Fellowship Program (FFP), and the Summer Colloquium, ASP promotes research activities, fosters graduate education, and develops partnerships between NCAR scientists and their colleagues in universities and other institutions.

Accomplishments

The ASP awarded 10 new postdoctoral fellowships in spring 2014. These new fellows have already begun to arrive and to participate in ASP activities, providing a boost to the ongoing program. Between the FFP and the GVP, the ASP supported 70 months of long-term visits to NCAR in FY14. While no new Faculty Fellowship Program Awards were offered in FY14, 11 GVP awards were given as a result of the 2014 GVP search. Most of the GVP awards also include an advisor visit.

Finally, the ASP supported the second Software Engineering Assembly (SEA) conference on scientific computing and software development that included 130 participants from NCAR, other scientific agencies in the area and several students from Minority Serving Institutions (MSIs).

More on all of these programs can be found in this report.

Printer-friendly version

FY2015 Plans

ASP will continue to engage and develop the scientific workforce of the future through its core visitor and fellowship program elements that engage all graduate students and postdoctoral fellows in residence at NCAR, including monthly seminars, weekly Postdoc Teas, the annual ASP retreat and ongoing mentoring opportunities. Through the highly successful Thompson Lecture Series, ASP will bring two prominent scientists to NCAR for extended interactions with this cohort. Dr. Ulrike Lohmann from the Institute for Atmospheric and Climate Sciences in Zürich, Switzerland will be here in December and Dr. Chris Barker, a professor at New York University will be visiting in February.

The annual ASP Colloquium series will focus on the topic of Climate, Space Climate, and the couplings Between. Students will stay for two weeks to participate in lectures and hands-on activities.

ASP will support the NCAR Software Engineering Assembly's third conference and also provide organizational support for the activities of the Early Career Scientists Assembly (ECSA).

ASP will continue to promote diversity in the atmospheric sciences by supporting travel of NCAR scientists to give seminars at MSIs, supporting teaching opportunities of NCAR postdocs at MSI's and encouraging participation in ASP programs of individuals from underrepresented groups.

Additional details along with other ASP plans are included in this report.

ASP Postdoctoral Fellows, Faculty Fellows, and Graduate Visitor Program Participants with Director, Chris Davis

‹ 2014 ASP Annual Report up Postdoctoral Fellowships ›

Login

POSTDOCTORAL FELLOWSHIPS

ASP serves as a catalyst for burgeoning research that spans NCAR activities. The most important ASP component is the Postdoctoral Fellowship Program, which has been a part of NCAR for forty-five years and has sponsored over 450 postdoctoral scientists' research. The ASP appoints approximately 10 new postdoctoral scientists each year. During their two-year NCAR appointments, fellows benefit from the opportunity to work with NCAR scientists, from exposure to the breadth of science at NCAR, and from the independence they are encouraged to develop. Many former fellows now occupy prominent positions at UCAR universities or at NCAR, and many of the present collaborations between NCAR and university scientists derive from associations that developed in the postdoctoral program.

In FY14, the ASP appointed 10 new fellows (from over 120 applications) in a diversity of disciplines spanning the NCAR activities. In addition to the diversity of disciplines, the new fellows represent a diversity of population including gender and ethnicity. Also in FY2014, the ASP scheduled several events that included an education or career development aspect including a panel discussion entitled "How to get a faculty job" at our annual retreat. These activities not only brought members of ASP together, but also included any postdoctoral fellow or graduate student within the organization who wished to attend.

The ASP aims to create a meaningful experience not only for ASP fellows, but for all fellows at NCAR. As part of this plan, NCAR/ASP is a sustaining member of the National Postdoctoral Association.

In FY2015, ASP plans to continue the core elements of the program, including monthly seminars, regular research reviews, regular career development activities, and the Thompson Lecture Series along with the annual research planning sessions and on-going mentoring that ASP postdocs receive.

Printer-friendly version

NCAR Postdocs with Thompson Lecture Series invited speaker Ruth DeFries of Columbia University

‹ Directors Message up Building Partnerships with University Faculty ›

Login

2014 ASP ANNUAL REPORT

- Directors Message
- Postdoctoral Fellowships
- Building Partnerships with University Faculty
- Providing University Students Access to the Resources of NCAR
- ASP Summer Colloquium
- Spotlights in Science

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- ASP Strategic Plan
- NCAR Strategic Plan

PREVIOUS ASP REPORTS

Select year

BUILDING PARTNERSHIPS WITH UNIVERSITY FACULTY

The ASP established the Faculty Fellowship (FFP) program in 2005 with the goal of funding medium-to long-term collaborative visits between the NCAR scientific staff and the university community. The program provides opportunities for university faculty to spend three to 12 months at NCAR, and for NCAR scientific staff to spend three to 12 months at a U.S. university. University faculty may also bring graduate students with them to NCAR. The FFP provides support for travel costs, temporary living per diem, and graduate student expenses.

Due to funding limitations in FY14, we were unable to make any new FFP offers. However, several faculty members and their students from the FY13 search were at NCAR finishing up their visits. In fact, **we supported 30 months of faculty/scientist visits through this program in FY14.**

The program gives university faculty an opportunity to take advantage of their National Center in a meaningful and productive way, while providing unique research opportunities for the accompanying graduate students.

‹ Postdoctoral Fellowships up Providing University Students Access to the Resources of NCAR ›

Printer-friendly version

Login

PROVIDING UNIVERSITY STUDENTS ACCESS TO THE RESOURCES OF NCAR

The Advanced Study Program provides university graduate students and their advisors with access to NCAR resources through the Graduate Visitor Program (GVP). The program, now in its seventh year, was created in response to multiple requests from NCAR scientific staff for graduate student support. It was also developed in response to university community requests for access to NCAR resources and facilities that are not available at a university. ASP recognized the need to establish a program that would sponsor a significant number of meaningful visits and collaborations with graduate students and their advisors. The GVP responds to that need.

The Graduate Visitor Program provides NCAR scientific staff with opportunities to bring graduate students to NCAR for three- to 12-month collaborative visits. These visits are undertaken with the endorsement and complementary support of the graduate students' thesis advisors. While residing at NCAR, the students conduct research in pursuit of their thesis requirements. The students receive support to cover their travel and living expenses in Boulder. Funding is also provided to allow the students' advisors to visit NCAR for a period of up to two weeks. The students' home institutions continue to pay the students' salary, benefit, and tuition expenses while they are in residence at NCAR.

The ASP made 11 awards in the GVP program as a result of our FY2013 GVP competition. ASP supported 40 months of GVP visits and 10 advisor visits in 2014.

The Graduate Visitor Program is becoming more popular every year. The ASP recognizes that students and their advisors are the bridge builders between NCAR and the university community. The ASP contends that the Graduate Visitor Program will seed significant and long-term collaborations. This program helps to extend NCAR capabilities by bringing students on-site to work on research of mutual interest and by providing NCAR scientific staff with the opportunities to participate in graduate student research and education. Through this program, NCAR increases its contribution to the education of the next generation of scientists, researchers, and faculty. In turn, the graduate students help invigorate NCAR and their home institutions. Finally, the Graduate Visitor Program provides opportunities to partner with universities and engage Ph.D. students from underrepresented groups in NCAR research activities. The ASP anticipates that the program will help diversify the future workforce at NCAR and in the geosciences professoriate and research communities.

GVP TESTIMONIALS, 2014

Yang Zhang, Advisor, North Carolina State University

This is an excellent program that will have long-lasting impacts on the next generation of scientists as well as their advisors The close interactions with NCAR staff and weekly meetings with NCAR colleagues not only enhanced the students' research skills and experience but also their communication skills. Further, the visit allowed my student to develop a professional network with her hosts and other colleagues at NCAR that will benefit her future career.   As an advisor of the ASP student, I enjoyed very

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much my short visit to NCAR during which I gave a seminar, met a number of scientists for collaborative projects, and explored potential areas of collaboration. Such a visit also offered me a great opportunity to learn the research priorities and direction at NCAR, which will greatly benefit my own research in the near future.

Galen McKinley, Advisor, University of Wisconsin – Madison

The ASP graduate visitor program was a fantastic opportunity for my graduate student and my research program. My student spent 3 months at NCAR and learned how to analyze the NCAR Large Ensemble for ocean biogeochemistry. This has initiated two publications and an NSF proposal, thus it is the start of a promising new research direction for myself and my lab, and also the start of a new set of collaborations between myself and NCAR. Without the ASP visit, the speed at which we've moved these ideas forward would have been far harder and slower. The program also benefited my student enormously by allowing him to make valuable career-strengthening connections to NCAR scientists, to add the NCAR CESM model to his repertoire of modeling tools, and to get to know a scientific community outside his home Department. These experiences have helped him to understand better the landscape within which he needs to make choices about his postdoctoral pursuits. Thank you ASP for this opportunity!

Jian He, Student, University of North Carolina

It was a great opportunity for me to work with a passionate group of people at the Atmospheric Chemistry Division, NCAR. My participation in the Advanced Study Program broadens my perspective and deepens my knowledge in the work I'm doing.

Darren Pilcher, Student, University of Wisconsin - Madison

The three months that I spent at NCAR as an ASP visiting student were very helpful towards furthering my graduate research. During my stay, I was able to accomplish the majority of my research analysis. My host was extremely helpful in providing technical and scientific support for my project. This enabled me to immediately get to work when I arrived at NCAR, and helped me accomplish my research goals during the stay. I thoroughly enjoyed the group of people that I worked with and came away with an excellent opinion of the community at NCAR.

Anders Jensen, Student, The Pennsylvania State University

What I enjoyed about NCAR's graduate visitor program was the working environment NCAR provided. In fact, I never felt like a visitor while I was there; I felt like part of a scientific community. My Ph.D. work involves building and testing a new microphysics parameterization for ice in clouds. The graduate visitor program provided the opportunity to work with several other microphysics modelers who have experience testing and running models in the Weather Research and Forecasting (WRF) model. This provided an invaluable opportunity to not only make substantial progress on my Ph.D. work, but to meet new colleagues in the modeling community. With the help of my graduate visitor host, Hugh Morrison, and several others, I was able to get my parameterization working in WRF. This progress would have been significantly delayed without being at NCAR. Finally, coming from a University, the program allowed me the experience of working at a research center. This experience will be useful when I eventually decide on my career.

Hannah Huelsing, Student, University of Albany

The ASP Graduate Visitor Program contributed greatly to the research I am working on for my Master's Thesis. Through participation in this program, I was able to advance my knowledge of the topic of my thesis by working with, and learning from, scientists with varying areas of expertise. This helped to improve my research techniques and show me different ways to look at problems. The various analysis techniques, problem solving skills, and other research-related skills they demonstrated will aid me in current and future research projects. Participating in this program also helped to develop professional skills and allowed me to have a sufficient amount of high-quality research which I presented at a Geo-Navigational Satellite System workshop in Bulgaria almost immediately after completing the ASP program. Without the program, I am positive my research would not have been of the same caliber. Also, from the program I gained mentors and collaborators who I hope to continue working with throughout much of my career.

Prasanth Meiyappan, Student, University of Illinois at Urbana-Champaign

My work at NCAR represents the culmination of my PhD thesis work, allowing me to implement the new spatial land use model I had developed and apply it within an integrated economic-biophysical model. It represents the culmination of earlier work in my PhD, carried out partly in collaboration with NCAR scientists.

This visit to NCAR helped my research (and contributed to the goals of NCAR IAM group) in the following ways: (1) played a key role in completion of the my PhD thesis; (2) increased the capacity for the NCAR integrated assessment model to carry out integrated economic-biophysical analysis of land use issues; (3) increased my capacity, and our research group at the University of Illinois in general, to carry out integrated land use analyses; and (4) most importantly, improved our understanding of the importance of land use change to climate change, and the potential impacts of climate change on land use and agriculture.

The development of the integrated modeling framework achieved from our collaboration would be used to explore the implications of global land use patterns for future emissions, and of climate change for regional land use decisions. This work also constitutes a key step toward linking the NCAR integrated assessment model to earth system models, in particular CESM, and help further strengthen existing interactions within NCAR between the integrated assessment modeling group and others in CGD, particularly in the Terrestrial Sciences Section.

We anticipate the work accomplished during my visit with NCAR scientists will result in one or more publications in peer reviewed journals, co-authored by NCAR collaborators, my thesis advisor, and myself. Results will also be presented at the winter meeting of the CESM Societal Dimensions Working Group, therefore contributing to the research community represented by that group. This collaboration also provided me with the necessary knowledge to build strong foundations in this research area and further strengthened existing relations between NCAR and the research group at the University of Illinois.

Overall, I had a wonderful experience as an NCAR ASP fellow. It gave me the opportunity to work closely with both economic and climate modelers at NCAR, to receive invaluable feedback about my research, and most importantly, to meet other interdisciplinary scientists visiting NCAR with whom I started collaborating with and will continue to collaborate in the future.

Maria Eugenia Frediani, Student, University of Connecticut

The opportunity of being a long term visitor at NCAR, facilitated by the ASP visitors program, has been valuable and enriching for my career development. In my particular case, I am a graduate student in an engineering department where the atmospheric science-related research is limited. Being at NCAR is my chance for moving my PhD research into a subject that would not have been possible at the university without collaboration.

The visitors program gives me the chance to work closely with my co-advisors from NCAR and to expand

my network of potential collaborators. Today, communication does not require physical presence, so being away from the university is not a problem. From my experience, the major advantage of being here is the networking, the learning opportunities, and in many cases, the combination of both.

The constant flux of visitors triggers professional interactions that would not happen otherwise. I cannot count the number of people I've met during lunch or through someone I also met at NCAR. In the seminars I'm always learning something new, catching up with research in fields other than mine, and getting ideas for applications and alternative solution to problems.

NCAR gave me the means to redirect my research to atmospheric science and offered me the support of the top scientists in the field. I am thankful for this chance and I hope other visitors appreciate it as much

David Gagne, Student, University of Oklahoma

The Graduate Visitor Program has given me the opportunity to work with NCAR scientists on exciting projects with real-world impact. I have met with experts in modeling and verification to discuss ways to improve my doctoral research on hail forecasting. Through a solar energy forecasting project, I have been able to help develop a new system that will be deployed operationally to major utility companies across the country. I have experienced the challenges and issues that come with working on a large team, delivering an operational product, and producing valuable science at the same time. These interactions have exposed me to a wider array of future career possibilities and allowed me to network with the people that could make those possibilities happen.

‹ Building Partnerships with University Faculty up ASP Summer Colloquium ›

ASP SUMMER COLLOQUIUM

For several decades, the ASP has hosted at least one 2-week colloquium every summer on an emerging science topic of interest to the NCAR community. The colloquia are designed for graduate students in new or rapidly developing areas of research for which good course materials may not yet be available. In recent years, the colloquia have had both a lecture component and a hands-on tutorial component. NCAR Scientific staff members in partnership with one or more university collaborators write proposals for colloquia topics, and in the event that their proposal is selected, organize the colloquium curriculum with logistical support provided by the ASP.

In 2014, the summer colloquium was titled "Uncertainty in Climate Change Research: An Integrated Approach"

The 2014 ASP summer colloquium was three weeks long and was attended by 25 Ph.D. students and 10 Postdoctoral Fellows. Linda Mearns of NCAR was the key organizer along with co-organizers Hailey Fowler (University of Newcastle, UK), Chris Forest (The Pennsylvania State University), and Rob Wilby (Loughborough University, UK)

Uncertainty is present in all phases of climate change research and applications, from the physical science (e.g., projections of future climate) to the impacts through to the effort to make decisions regarding mitigation and adaptation across different temporal and spatial scales. While there have been attempts to integrate all facets of uncertainty in the problem of climate change, there remain important gaps that were addressed during the Colloquium. Such gaps include: 1. methods that facilitate consistent treatment of uncertainties in different parts of the climate change problem, 2. how to account for additional factors outside quantifiable ones that contribute to uncertainty in decision making, 3. accounting for the effect of cognitive biases that prevent consistency from one discipline to the next, and 4. critical differences in the end-to-end academic process vs. reality (i.e., practical application vs. theoretical approaches).

The colloquium focused on decision making under uncertainty, and the assessment of the other uncertainties (in impacts, vulnerability, the physical climate system, and projections of future concentrations of greenhouse gases and aerosols) were brought into the mix based on the landscape of decision making. Therefore, this theme embraced all aspects of uncertainty in climate change research

Printer-friendly version

helping to provide a pedagogic whole for graduate students interested in any and all aspects of climate change.

‹ Providing University Students Access to the Resources of NCAR
up
Spotlights in Science ›

Login

SPOTLIGHTS IN SCIENCE

Atmospheric Science, From Research to the Real World

Scale-Aware Vertical Transport Parameterization in the Convective Boundary Layer

Spatial Variability of Snow Interception in Forest Canopies

Vortices and Waves in geophysical turbulence

‹ ASP Summer Colloquium up Atmospheric Science, From Research to the Real World ›

2014 ASP ANNUAL REPORT

- Directors Message
- Postdoctoral Fellowships
- Building Partnerships with University Faculty
- Providing University Students Access to the Resources of NCAR
- ASP Summer Colloquium
- Spotlights in Science
  - Atmospheric Science, From Research to the Real World
  - Scale-Aware Vertical Transport Parameterization in the Convective Boundary Layer
  - Spatial Variability of Snow Interception in Forest Canopies
  - Vortices and Waves in geophysical turbulence

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

ASP Strategic Plan

NCAR Strategic Plan

PREVIOUS ASP REPORTS

Select year

Printer-friendly version

Login

ATMOSPHERIC SCIENCE, FROM RESEARCH TO THE REAL WORLD

ATMOSPHERIC SCIENCE, FROM RESEARCH TO THE REAL WORLD - MINGHUI DIAO

What is the reason that you chose atmospheric science as your PhD study area?

When I applied for grad school, I was actually looking more into the field of environmental chemistry and microbiology. My undergraduate work was more related with decomposing air/water pollutants and most of the applications were targeted toward research projects on these topics. However, when I did my campus visit to Princeton University, my PhD adviser showed me a project related to measurements of water vapor on a research aircraft, trying to understand how clouds form in the higher altitudes (at that time I didn't even know what cirrus clouds and ice supersaturation were...) and what their roles are in the climate system. Being an undergrad at that time, I was unsure of which direction to head, especially since the area was brand new to me. But this project really caught my eye, and the saying of "follow your heart" helped me make a decision on my future career path. Learning about this research project in combination with doing aircraft measurements pushed me to the front lines of atmospheric observations. I am grateful to be able to do this fascinating work and at the same time have fun.

What is the most amazing part of a field campaign?

Because part of my PhD work was to maintain and calibrate the water vapor hygrometer (VCSEL hygrometer) on the NSF/NCAR HIAPER Gulfstream-V aircraft, I was involved in several flight campaigns. One of the campaigns, HIAPER Pole-to-Pole Observations (HIPPO), was the campaign I was involved with from the first year of my PhD to the fourth year. This campaign is quite special, because it sampled from about 87°N to 67°S over the North American continent and the central Pacific Ocean. The flights were scheduled to have several stops, and it usually took about a month to finish the round trip. There were very limited seats onboard and most of the space was dedicated to instruments. But luckily I got to fly for one special flight, from Christchurch, New Zealand to about 63°S over the Southern Ocean. This flight was in August 2012 for the fifth deployment of HIPPO. Because it was wintertime in the Southern Hemisphere, there was floating sea ice observable as we flew over the Southern Ocean. The plane was generally scheduled to do a vertical profile for every 3 degrees in latitude, that is, from the surface (doing a miss approach) to ~14 km in altitude. For about 9 hours, I was gazing behind the window looking at this amazing picture in front of me, one moment being so close to the sea ice that I could see the dark blue of the ice deep in the crevices, to the next moment when we were in the lower stratosphere, where the curvature of the Earth could be seen. It was a peaceful and quiet time, with no other aircraft or boats around us. Time seemed to be frozen, giving me a long pause to look at this beautiful Earth, look back into the past, look into oneself and think about the future. It is during these moments that I understood the importance of my work and the positive impact it has on everyone and every living thing around the world. Atmospheric science is a rewarding job, and I feel so very fortunate that my career will have me doing work for the good of society.

STRATEGIC PLANS

ASP Strategic Plan

NCAR Strategic Plan

PREVIOUS ASP REPORTS

Select year

Printer-friendly version

View from the NSF/NCAR HIAPER Gulfstream-V research aircraft during the HIAPER Pole-to-Pole Observations (HIPPO) Global campaign over the Southern Ocean around 63°S.

Why does cloud research matter?

Clouds are a unique subject in atmospheric research. They are observable, seen almost every day by everyone, and people can feel the difference that clouds can make to daily weather. One moment it is sunny, the next cloudy, then the next minute there might be a heavy rain. Clouds can transport water, change water from gas to liquid phase and back again, and they play other important roles in the hydrological cycle. To me, working on clouds is tangible, and sometimes also artistic. It is interesting to learn how many things we still don't understand about clouds, though they are around us every day. When working on the HIPPO campaign, it was an amazing experience to see vast differences of shapes and components of clouds as we traveled from the deep tropics to the midlatitudes and polar regions, as well as from the lower troposphere to the upper troposphere. In order to understand how these different types of clouds form, it requires accurate, precise and fast measurements, which actually has been a challenging task to resolve for several decades. For example, the clouds may look homogeneous to the human eye, but when measured in-situ, their structure is actually very heterogeneous for the distributions of droplets, ice crystals and water vapor. In addition, there is more than one phase of water existing in clouds, which requires different measurements of these phases. Due to the fast speed of the aircraft, which is generally ~250 m/s for HIAPER, the instruments have to be able to make fast measurements. Combining these measurements of clouds with modeling studies ultimately helps improve our understanding of the roles that clouds play in weather and climate systems.

How does atmospheric research link to the real world?

Each flight campaign that I participated in has specific scientific goals. For example, the 2011 PREDICT campaign was focused on understanding how tropical disturbances develop into tropical depressions, storms and hurricanes; the 2012 DC3 campaign was designed to help understand the formation of deep convective clouds and their impact on upper tropospheric chemistry and dynamics. When sitting in front of my computer, coding, making figures, and writing up results, sometimes it is easy to forget what is beyond all the details. But when involved in the flight campaigns, I usually get to learn how the research I do every day plays a part in the bigger picture. In general, the research could take years and decades to fully understand certain features. But once in a while we need to be reminded how each of our steps is contributing to this big puzzle of the real world.

The webpages of the NSF HIPPO, PREDICT and DC3 campaigns are:
http://hippo.ucar.edu
https://www.eol.ucar.edu/field_projects/predict
https://www.eol.ucar.edu/field_projects/dc3

‹ Spotlights in Science
up
Scale-Aware Vertical Transport Parameterization in the Convective Boundary Layer ›

Login

SCALE-AWARE VERTICAL TRANSPORT PARAMETERIZATION IN THE CONVECTIVE BOUNDARY LAYER

SCALE-AWARE VERTICAL TRANSPORT PARAMETERIZATION IN THE CONVECTIVE BOUNDARY LAYER - HAILEY SHIN

An accurate modeling of turbulent transport in the planetary boundary layer (PBL) is essential for reliable weather and climate predictions, as it determines the states of the lower atmosphere through transmitting surface forcing to the upper atmosphere. In weather and climate models, the transport has been modeled using so-called PBL parameterization. The PBL parameterization has been developed based on the assumption that none of turbulent processes in the PBL are resolved at given model resolution (Δ), and the assumption is valid when the model resolution is much coarser than the scale of large eddies (*l*) in the PBL (i.e., when Δ >> *l*).

On the other hand, recent advance in computing power makes meso-scale modeling at Δ ~ *O*(0.1–1 km) feasible. The resolution is comparable to large-eddy scale (Δ ~ *l*) in certain types of PBL, e.g., the convective boundary layer (CBL), and falls into the "gray zone" in parameterizing the vertical transport. The traditional PBL parameterization is no longer valid in the gray zone, and it is required to design a new vertical transport parameterization for the high-resolution modeling.

Two important features characterize the gray zone, and they have to be represented in the new parameterization. First of all, the vertical transport in the CBL is partly resolved by vertical advection term, while partly subgrid-scale (SGS) and yet to be parameterized. Secondly, as model resolution gets higher in the gray zone, the amount of the parameterized SGS transport has to decrease. The second feature makes the concept of "scale-aware" parameterization under the spotlight for the recent decade.

My research involves (1) to investigate scale (or resolution) dependency of the SGS vertical transport in the CBL and find out on which key factors the dependency depend, and (2) to quantify the scale dependency and apply it to a scale-aware parameterization.

Figure 1 presents a reference resolution dependency of vertical heat transport derived from a large-eddy simulation. The reference can be used as "truth", and it is expected that a good scale-aware parameterization would follow the reference. The reference scale dependency shows that ratio of the parameterized transport (blue lines) decreases to 80% at 1-km horizontal grid size, implying that the traditional PBL parameterization is invalid even around at 1-km resolution as well as finer resolutions. Different lines in Fig. 1 indicate different stability cases: ratio of shear forcing (u_*) to buoyancy forcing (w_*), u_*/w_*, is different. It is apparent that as relative importance of the shear forcing increases (as u_*/w_* increases), the ratio of resolved transport increases. Therefore, given a same grid size, more turbulent transport is resolved in stronger shear case and less transport has to be parameterized.

By considering the reference resolution dependency, a simple scale-aware vertical transport parameterization has been designed. Figure 2 presents that the scale dependency simulated by the new algorithm (solid lines with closed circles) well follows the reference (thick solid lines), while the traditional PBL parameterization (dotted lines with open circles) hardly depend on the resolution.

STRATEGIC PLANS

- ASP Strategic Plan
- NCAR Strategic Plan

PREVIOUS ASP REPORTS

Select year

Printer-friendly version

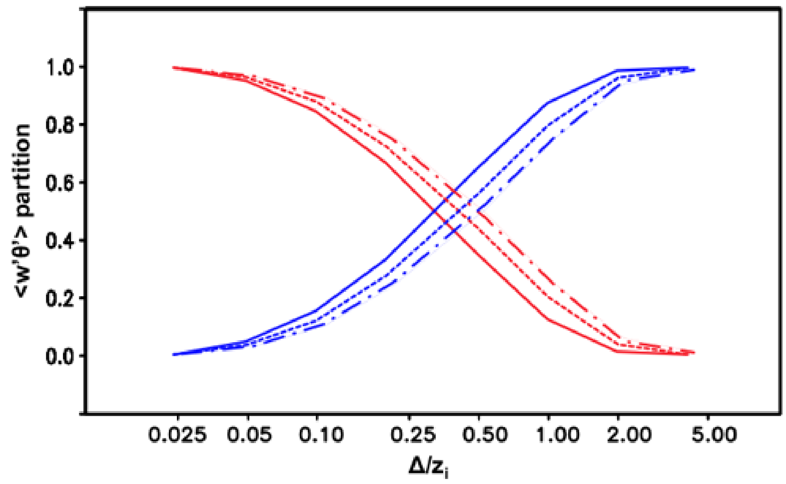

Fig. 1. Reference scale dependency of vertical heat transport in the middle of the CBL: ratio of resolved (red) and SGS (blue) transport to corresponding total (resolved plus SGS) transport as functions of dimensionless grid size (Δ/z_i: z_i, the PBL height, ~ 1 km). Different lines indicate different CBL stability: u_*/w_* = 0.097 (solid), 0.278 (dotted), and 0.417 (dot dashed).

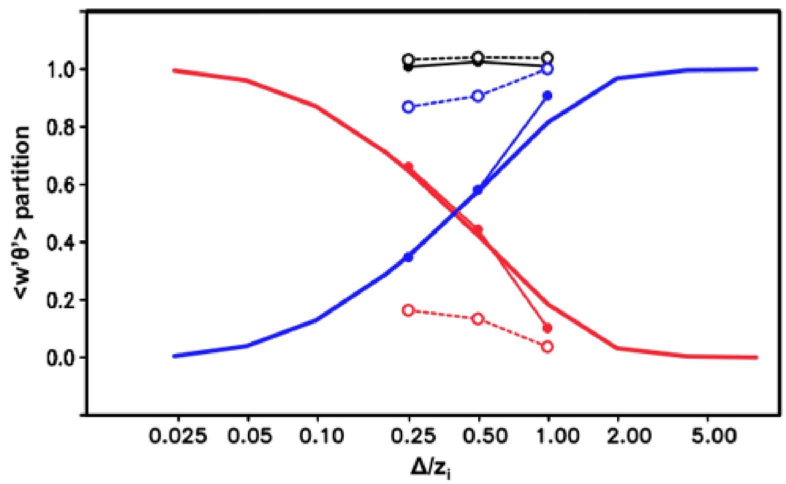

Fig. 2. Thick solid lines indicate the reference for u_*/w_* = 0.278 (dotted lines in Fig. 1). Solid lines with closed circles present the scale dependency modeled by the scale-adaptive scheme, and dotted lines with open circles are for a conventional PBL scheme.

‹ Atmospheric Science, From Research to the Real World up Spatial Variability of Snow Interception in Forest Canopies ›

Login

SPATIAL VARIABILITY OF SNOW INTERCEPTION IN FOREST CANOPIES

SPATIAL VARIABILITY OF SNOW INTERCEPTION IN FOREST CANOPIES - MARK RALEIGH

Snow falling in forested mountain watersheds is prone to interception in the forest canopy, resulting not only in iconic winter landscapes but also in important hydrologic implications. Namely, the forest canopy is a major factor in how much snow sublimates back to the atmosphere versus how much ultimately ends up in streams from snowmelt. In the water-limited, snow-dominated mountain watersheds of the western United States, snowpack is “white gold” and thus from a water management perspective it is critical to understand the impact of forest canopies on the snowpack “reservoir”.

The prevalence of snow interception and the fate of snow in the canopy varies with forest characteristics (e.g., species, canopy density), as well as climatic and meteorological factors (e.g., wind regime, turbulent fluxes, temperature, new snow density and liquid water content), with 30% to 80% reductions in snowpack due to interception [Martin et al., 2013]. Snow is more prone to sublimate in the canopy than from the snowpack because of windier conditions and greater exposed area to the atmosphere. Estimates of sublimation from flux tower measurements at Niwot Ridge (near Nederland, CO) indicate that sublimation rates are about 75% higher when snow in the canopy versus snow on the ground [Molotch et al., 2007]. Hence, an important consideration is the spatial and temporal variability in canopy interception processes across a watershed, which influence sublimation rates, snowpack development, and streamflow.

Despite this importance, it remains difficult to quantify and measure snow interception. A variety of methods have been utilized, including indirect methods (e.g., comparing snow accumulation in clearings versus under sub-canopy areas) and direct methods (e.g., cutting a coniferous tree and continuously weighing it over the winter) [Friesen et al., 2014]. Unfortunately, these measurements are typically only made at specialized research sites and are often constrained to local scales. As a result, it is usually not possible to test simulations of canopy processes in land surface and hydrology models.

To provide improved understanding of snow interception variability, I am currently studying the dynamics of snow residence in coniferous canopies across an elevational transect in the mountains west of Boulder, including the Boulder Creek Critical Zone Observatory (CZO) and the Niwot Ridge Long Term Ecological Research area. I am pursuing an integrated approach that uses common data collection methods (e.g., a network of time-lapse cameras and snow depth sensors) and develops new methods for obtaining snow interception information (e.g., determining intercepted mass from frequency measurements of canopy sway, satellite-based remote sensing of interception). A network of time-lapse cameras (supported by an ASP equipment grant) was strategically deployed to examine differences in snow interception with respect to elevation, terrain aspect, side of tree, and spatial scale. While the cameras do not yield quantitative information on the mass of the intercepted snow, they provide valuable information about the timing, extent, and spatial variability of snow interception. Image analysis using thresholding across the blue channel provides one avenue for systematically extracting objective data about snow from the image sequences [Parajka et al., 2012; Kerr et al., 2013].

Examples of two interception events captured with time-lapse cameras at the Boulder Creek CZO and

STRATEGIC PLANS

ASP Strategic Plan

NCAR Strategic Plan

PREVIOUS ASP REPORTS

Select year

Printer-friendly version

Niwot Ridge are shown in Figure 1. The sites exhibit contrasting levels of snow interception due to elevation (500 m difference) and aspect effects (CZO camera is facing S/SW while the Niwot camera faces W/NW). Future work will apply these new interception datasets to evaluate model parameterizations of canopy interception and unloading. Specifically, the new camera and remote sensing datasets will permit evaluation of the spatial extent, timing, and duration of interception events, while in-situ measurements of intercepted mass (from tree sway frequency) will be applied to assess the modeled snow mass in the canopy.

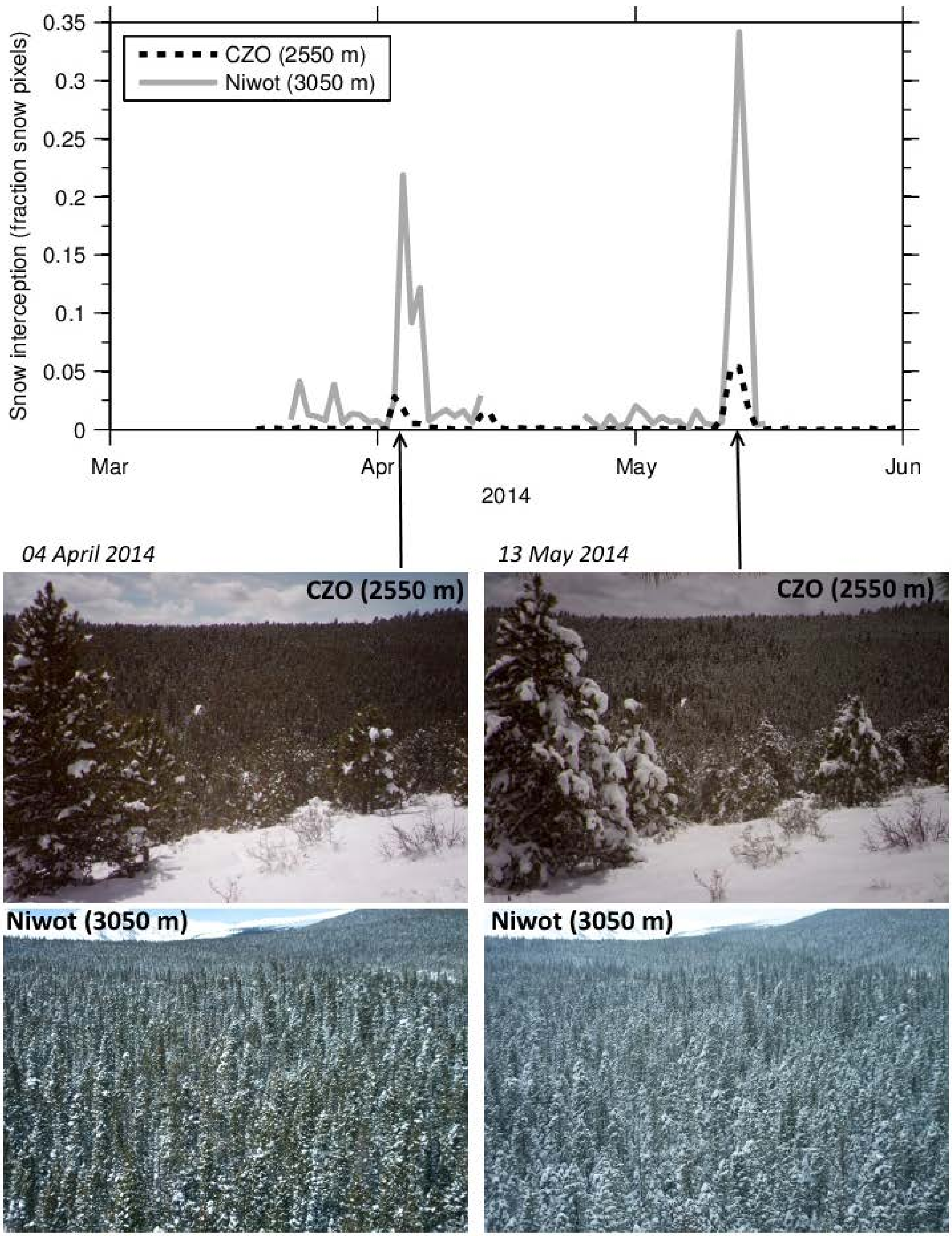

Figure 1: Daily time series of snow interception (i.e., fraction of canopy pixels covered in snow) derived from time-lapse imagery at the Boulder CZO site (2550 m) and Niwot Ridge (3050 m). Two prominent spring interception events are highlighted with photos from each site.

REFERENCES

Friesen, J., J. Lundquist, and J. T. Van Stan (2014), Evolution of forest precipitation water storage measurement methods, Hydrol. Process., doi:10.1002/hyp.10376.

Kerr, T., M. Clark, J. Hendrikx, and B. Anderson (2013), Snow distribution in a steep mid-latitude alpine catchment, Adv. Water Resour., doi:10.1016/j.advwatres.2012.12.010.

Martin, K. A., J. T. Van Stan, S. E. Dickerson-Lange, J. A. Lutz, J. W. Berman, R. Gersonde, and J. D. Lundquist (2013), Development and testing of a snow interceptometer to quantify canopy water storage and interception processes in the rain/snow transition zone of the North Cascades, Washington, USA, Water Resour. Res., 49, doi:10.1002/wrcr.20271.

Molotch, N. P., P. D. Blanken, M. W. Williams, A. A. Turnipseed, R. K. Monson, and S. A. Margulis (2007), Estimating sublimation of intercepted and sub-canopy snow using eddy covariance systems, Hydrol. Process., 21(12), 1567–1575, doi:10.1002/hyp.6719.

Parajka, J., P. Haas, R. Kirnbauer, J. Jansa, and G. Blöschl (2012), Potential of time-lapse photography of snow for hydrological purposes at the small catchment scale, Hydrol. Process., doi:10.1002/hyp.8389.

‹ Scale-Aware Vertical Transport Parameterization in the Convective Boundary Layer | up | Vortices and Waves in geophysical turbulence ›

Login

VORTICES AND WAVES IN GEOPHYSICAL TURBULENCE

VORTICES AND WAVES IN GEOPHYSICAL TURBULENCE - CORENTIN HERBERT

Both the atmosphere and the ocean are fully turbulent flows spanning a very broad range of length scales. The ocean for instance supports a thermohaline circulation at the planetary scale, on the order of ten thousand kilometers, western boundary currents such as the Gulf Stream and the Kuroshio, stretching over thousands of kilometers and surrounded by mesoscale rings of about 100 km diameter, as well as overturning and internal mixing occurring at scales as small as the centimeter (Fig. 1).

A fundamental question in geophysical fluid dynamics is to understand the energy pathway across this range of scales: how are large-scale circulations maintained? How do coherent structures such as mesoscale rings form? How are small-scale mixing and dissipation fed and how should we represent them in atmosphere and ocean models?

A major difficulty is that different processes dominate at different scales. This is at variance with more idealized turbulent flows, such as 3D homogeneous isotropic turbulence, for which the Kolmogorov theory predicts that large vortices break up into smaller vortices, and so on and so forth, down to the dissipation scale. In geophysical turbulence, the joint effect of the Coriolis force and the buoyancy force puts strong constraints on the large scales of the flow. They are dominated by vortices which maintain a balance between the aforementioned forces and the pressure gradient. The behavior of these so-called 'geostrophic' vortices is very similar to that of a fluid on a two-dimensional surface: they tend to merge to form large-scale coherent structures. On the other hand, at very small scales, neither the Coriolis force nor the buoyancy force is felt any longer, and we expect the Kolmogorov theory of 3D turbulence to apply. In between, there exists a grey zone where the balanced motion mentioned above coexists with much faster oscillatory motion referred to as inertia-gravity waves. The non-linearity of the equations leads not only to coupling between vortices of different size, as in geostrophic turbulence, but also between waves of different wavelength, and to interactions between vortices and waves.

My recent work focuses on disentangling the role of vortices and waves in the energy transfer across the scales. An important goal is to understand if, under certain circumstances, the range of scales can be divided into well-defined sub-ranges which could be haracterized by their energy spectrum and energy fluxes, like in the Kolmogorov theory, but also by geometrical structures. To do so, I use a combination of numerical simulations and theoretical methods. On the numerical side, together with Annick Pouquet (IMAGe) and Raffaele Marino (IMAGe), we analyze high-resolution direct numerical simulations of the Boussinesq equations using a pseudo-spectral code called GHOST ('Geophysical High-Order Suite for Turbulence'). We focus on the intrinsic behavior of the equations of motion and use an idealized setting: periodic boundary conditions, no bottom topography, isotropic forcing, no moisture/salinity,...

The theoretical approach is based on ideas of statistical mechanics: the individual interactions between different modes are not very meaningful. What is interesting is to be able to predict the average behavior due to the very large number of modes and their interactions. It is possible to do so by using techniques from probability theory.

STRATEGIC PLANS

ASP Strategic Plan

NCAR Strategic Plan

PREVIOUS ASP REPORTS

Select year

Printer-friendly version

The analytical computations provide a theoretical explanation for a phenomenon seen in the numerical simulations (Fig. 2): when the system is not rotating, both the vortices and the waves tend to transfer energy towards smaller scales on average, while when rotation is present, the vortices tend to transfer energy upscale on average, while the waves still transfer it downscale.

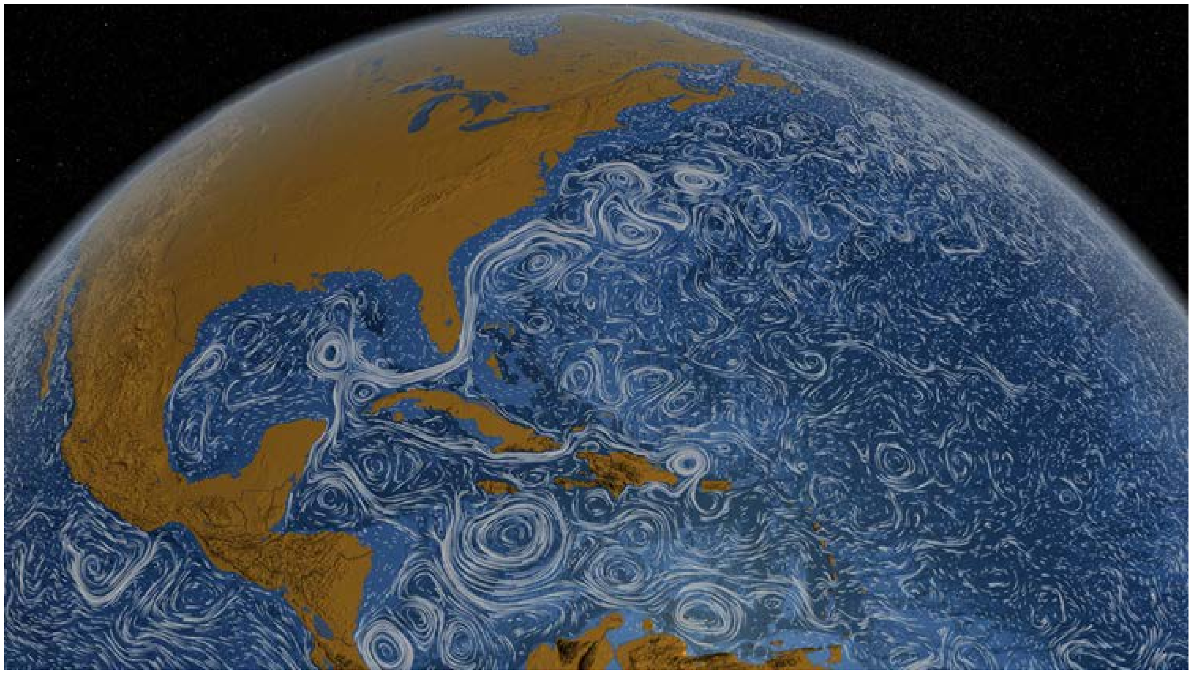

Fig 1: Snapshot from the "Perpetual Ocean" visualization made by NASA (see http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=3827) based on altimetric observations and the MIT ocean model, showing the range of scales in the Gulf Stream region.

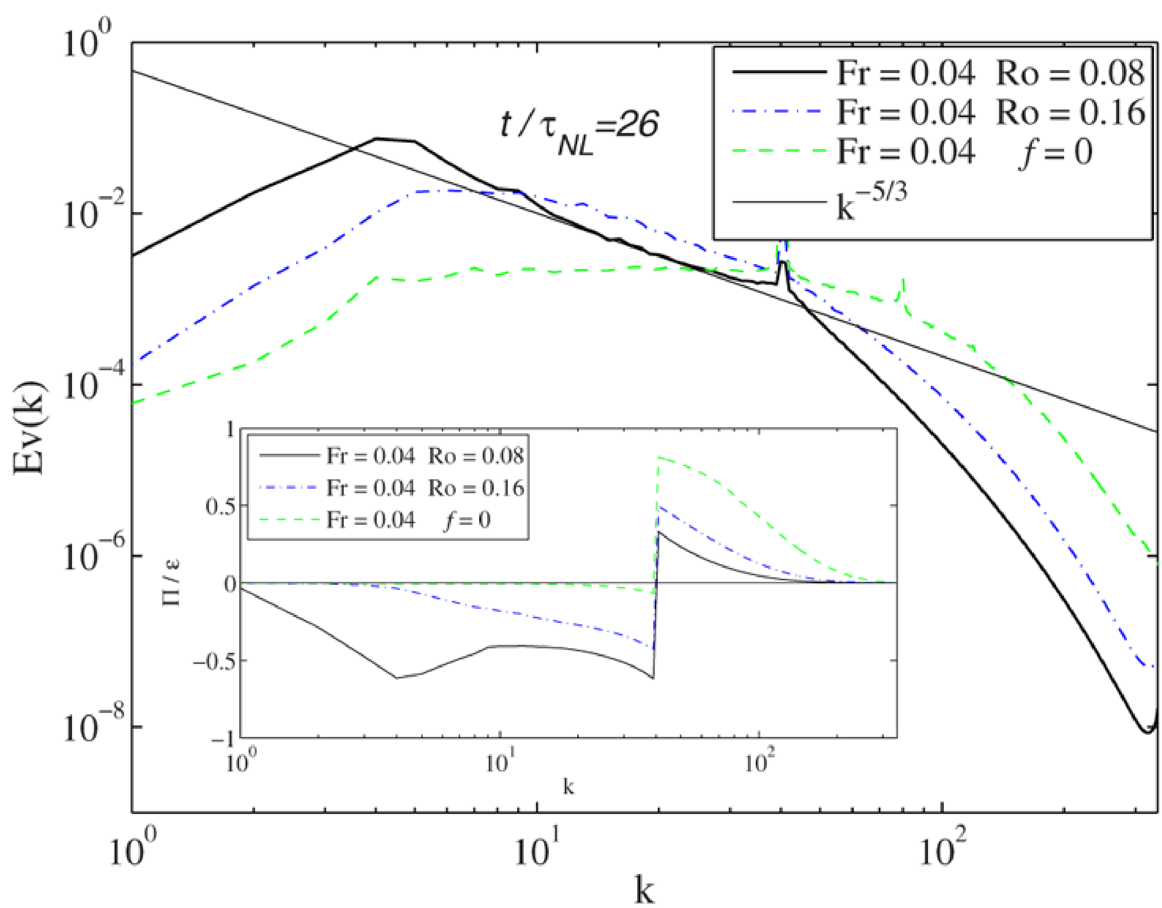

Fig 2: Energy spectrum and energy flux (inset) for direct numerical simulations of density stratified turbulence, with rotation (Ro=0.08 and Ro=0.016) and without rotation (f=0). When there is no rotation, the energy flux is positive at all scales (downscale energy cascade) while in the presence of rotation there is a large range of negative constant flux (upscale energy cascade) and a small (but not constant) positive flux. Figure from Marino et al. (2013).

References:

- R. Marino, P. Mininni, D. Rosenberg, A. Pouquet, Inverse cascades in rotating stratified turbulence: fast growth of large scales, Europhysics Letters, 102, 44006 (2013).
- C. Herbert, A. Pouquet, R. Marino, Restricted Equilibrium and the energy cascade in rotating and stratified flows, Journal of Fluid Mechanics, 758, 374 (2014).

‹ Spatial Variability of Snow Interception in Forest Canopies   up

2014 CISL ANNUAL REPORT

- CISL Director's message
- CISL Services
- CISL Science
- CISL Education, Outreach, and Training
- Broader Impacts

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- CISL Strategic Plan
- NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

Printer-friendly version

2014 CISL ANNUAL REPORT

TABLE OF CONTENTS

CISL Director’s message ›

CISL DIRECTOR'S MESSAGE

CISL Director Al Kellie

Welcome to the FY2014 CISL Annual Report. This collection of highlights from our service, science, and education portfolios includes an overview of CISL's broader impacts on the research community.

This was a busy year of significant progress in CISL along several fronts. In its second year of operation, Yellowstone continues to provide scientists in the atmospheric and related sciences with the computing resources necessary to advance our understanding of the Earth System. This year we also expanded the GLADE disk storage systems to 16 petabytes to keep up with the insatiable demand for data storage resources. Our Big Data analysis and visualization tools, like VAPOR and NCL, have continued to evolve to support ever larger and more complex data sets, and new parallel tools, like LatticeKrig and PyReshaper, have helped accelerate data-intensive scientific workflows.

Perhaps surprisingly to those not familiar with the supercomputer lifecycle, we've begun planning the deployment of a larger and even more powerful successor to Yellowstone, scheduled to start operations in January 2017. And last but not least, we continue to work hard in the education and outreach area, where a highlight included hosting the Diversity in the Computational Geosciences Workshop at NCAR, a unique forum that brought together educators, computational scientists, and diversity advocates from government, academia, and national laboratories.

This annual report describes numerous changes we have implemented in the past year to our hardware, services, tools, and methods to stay at the forefront the needs of atmospheric sciences. This year we handled more data than ever in our history and made significant upgrades to NCAR's HPSS archival facility, increasing its capacity to 160 petabytes.

CISL's scientific research also focused on big data initiatives this year. Numerically simulating the Earth System requires many forms and differing volumes of data to be managed very efficiently. These data sets range from small but vital historical observations to very large data sets from satellite and radar observations and from model outputs. CISL led the way by enhancing the Data Assimilation Research Testbed (DART) that integrates observational data with simulations. This year, DART's efficiency with Community Earth System Model (CESM) components was increased dramatically via new software that enables multiple DART/CESM assimilation cycles in a single job, significantly reduces the core hours spent archiving, and reduced queue waiting time by an order of magnitude. More FY2014 CISL research advances include new NARCCAP data service capabilities that allow users to access only the data they need from very large data sets via spatial and temporal subsetting, file spanning, aggregation, and format conversion.

CISL launched several new forward-looking services this year. Based on Globus software, one offers researchers a simple way to transfer and share large data sets. Another is the HPC Futures Lab to extend CISL’s exploration of emerging high performance computing (HPC) technologies. A third new service, the Strategic Parallel and Optimization Computing (SPOC) initiative, is an NCAR-wide effort to increase the performance and efficiency of NCAR’s community codes – CESM, WRF, and MPAS – on Yellowstone, and to prepare these codes for future supercomputing architectures.

Also in FY2014, CISL and the University of Colorado at Boulder received funding from Intel, Inc., to form an Intel Parallel Computing Center focused on Weather and Climate Simulation (IPCC-WACS). Participation in this IPCC program will enable NCAR and CU to develop ways to increase the performance of atmospheric applications using advanced microprocessor technologies, and this work will help train the next generation of scientists and engineers who will apply these new technologies.

CISL continued to offer progressive and well-targeted education programs to enrich and expand our research community. SIParCS, TOY, and RSVP are mature programs that encourage young scientists and engineers to plan for and succeed at careers in the computational and Earth System sciences. CISL now offers a selection of webinars and online training for HPC, NCL, and VAPOR users. The visitor center at the NCAR Wyoming Supercomputing Center (NWSC) continues to exceed expectations for the ongoing visitor load: in FY2014, the NWSC hosted 47 large groups and a total of 1,713 visitors. Further, the NWSC visitor center now serves as a preferred venue for regional STEM events.

As part of its diversity program, CISL conducts mission-appropriate outreach to integrate education and research, broaden participation in Earth System sciences, and develop the future STEM workforce. CISL again reached out to various sites through visits, conferences, job fairs, and presentations to tribal colleges and minority-serving institutions. CISL employs multiple communication methods to connect the work of NCAR scientists and engineers with interested students in minority groups, EPSCOR states, and two-year colleges. This year, our collaborations with computational science faculty members from Hampton University, Salish Kootenai College, and Alabama A&M University led them to become project mentors for CISL’s first summer externship program. These faculty joined CISL staff to teach parallel computing concepts to nontraditional students who have obligations that do not allow them to spend an entire summer in Boulder for an internship. Engaging nontraditional students through an externship program and via webcasting allows CISL to redefine its definition of diversity and better understand the resources and needs of partner students, faculty, and communities.

It is my pleasure to present our FY2014 CISL Annual Report. As you read it, I hope excitement about our recent progress comes through. These and many more accomplishments appear in the following pages. Enjoy!

‹ 2014 CISL Annual Report up CISL Services ›

CISL SERVICES

From CISL's services and support web pages, users can access CISL's help desk and consulting services, as well as complete information about HPC systems, storage systems, data analysis and visualization systems, data collections, user documentation, and training. CISL has a proud tradition of providing world-class supercomputing and data services to its user community. The quality of these services is and will remain a core value of the laboratory. However, the makeup of these services is not static: they continually change in concert with rapid changes in the underlying technologies and the scientific demands of our users. CISL:

- Maintains and operates the physical facilities and cyberinfrastructure needed to support the atmospheric and related sciences.
- Curates, manages, and archives a rich set of data collections to which it provides free and open access.
- Creates essential, widely used software cyberinfrastructure such as data analysis and visualization tools and frameworks for modeling and science gateway construction.
- Provides user support and training for all of these services.
- Strives to better integrate its resources and services with regional and national cyberinfrastructure and services, and with the organizations that maintain them, such as the Front Range GigaPoP (FRGP), the Rocky Mountain Advanced Computing Consortium (RMACC), and NSF's eXtreme Science and Engineering Discovery Environment (XSEDE).

In FY2014 CISL operated the data-centric petascale Yellowstone supercomputing environment at the NWSC, including the 1.5-petaflops IBM iDataPlex supercomputer, the 16-petabyte GLADE central disk storage system, two data analysis and visualization systems, the HPSS data archive, and high-speed wide-area networking. A wide range of computing projects pursued the research frontiers of weather phenomena, climate change, space weather, solar physics, and more. CISL has started to shift its focus to NWSC facility enhancements that will be required for the next supercompting system to be delivered through the NWSC-2 procurement effort. The NWSC Visitor Exhibit was completed in early FY2013 and has attracted over 3,000 visitors in its first year of operation, hosting a number of student STEM education programs such as Wyoming's GEAR UP and the Wyoming Cowboy Challenge.

CISL's software CI capabilities continued to make important advances in FY2014 as well, including the deployment of a novel multiple-component interface between the Data Assimilation Research Testbed (DART) and the CESM that enables climate predictability experiments; a major new release of the NCAR Command Language (NCL) that included a major overhaul of its display model; and improvements to the Visualization and Analysis Platform for Ocean, Atmosphere, and Solar Researchers (VAPOR), such as adding support for ocean modeling data and refactoring VAPOR's architecture to facilitate third-party code enhancement. All of these tools are heavily used – for instance, in FY2014, VAPOR's user community increased to nearly 7,000 users and NCL's software was downloaded almost 22,000 times.

This work is supported by NSF Core funding and other sources as specified in the following individual reports.

NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

Printer-friendly version

‹ CISL Director’s message up CISL computing facilities ›

Login

CISL COMPUTING FACILITIES

Former Wyoming Governor Dave Freudenthal (left) and current Wyoming Governor Matt Mead filming the introduction to the NWSC video segment.

From the NCAR Strategic Plan, "High Performance Computing (HPC) is one of the foundational elements of NCAR's scientific research and publications." Within CISL, providing capable, flexible, and efficient facilities is the cornerstone of this foundation. Consistent with NCAR's environmental mission, CISL regularly enhances the capability and capacity of NCAR's supercomputing facilities while maximizing their efficiency and usability. FY2014 marks a transition year as CISL shifted focus from tuning and optimization to new planning phases for both the ML and NWSC facilities. This ensures that NCAR will not only be home to many generations of supercomputing systems for the Earth System sciences but also the associated systems and capabilities required for data.

At the NWSC, efforts continue to tune and optimize the facility – a continuous process – ensuring that NCAR gets optimum performance and minimized operating costs. However, focus has shifted and FY2014 was spent in the very early phases of scoping and determining the best options to prepare for the next supercomputing system. The Mesa Lab Computing Facility (MLCF) moved solidly into its role as a colocation facility with the closure of a computer room at CG2: four divisions and F&A moved equipment to MLCF. Similar to the NWSC, the MLCF is also in a planning and design phase where the facility will be upgraded and refurbished to fulfill its new mission as a colocation facility for the organization. This also allows NCAR to better manage operating costs while enhancing capabilities.

NSF Core funds support this work along with other funding as described in the following sections.

‹ CISL Services up NCAR-Wyoming Supercomputing Center ›

STRATEGIC PLANS

CISL Strategic Plan

NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

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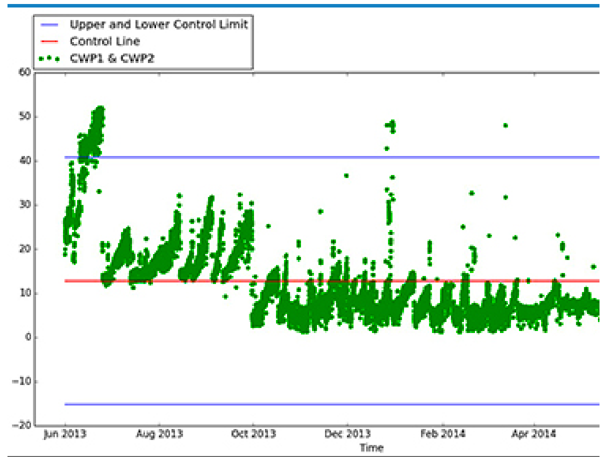

SIParCS summer students Theophile Nsengimana and Ademola Olarinde pored through two years of building sensor data looking for sub-optimal performance of NWSC systems. The chart illustrates some of their work which identified a problem with the condensing water pumping system at NWSC. The root cause has been further investigated and requires periodic purging of air from the system improving the energy efficiency of the facility.

The NCAR Wyoming Supercomputing Center (NWSC) entered its second full year of production in FY2014. The NWSC is designed to meet the rapidly growing high-performance computing (HPC) needs of Earth System scientists and to encourage broader participation in this scientific enterprise. Earth System scientists need petascale computing, data analysis, and visualization resources combined with exascale data management capabilities to support greater model resolution, increased model complexity, better statistics, more predictive power, and longer simulation times. NWSC has been designed and built with a focus on sustainability and energy efficiency consistent with NCAR's and the University of Wyoming's strong commitment to environmental stewardship.

The NWSC is fully aligned with NSF's vision for 21st-century cyberinfrastructure and directly contributes to the creation of a national petascale computing capability. The facility is a peer with other NSF facilities and serves as a “stepping stone” for Earth System science investigators to fully utilize the largest systems available, such as NCSA's Blue Waters. CISL's first strategic imperative is to provide HPC facilities for the Earth System sciences: “A foundational element of CISL's mission is to deploy and operate the physical and virtual computational facilities needed to support the science community. Essential to this mission is the design, construction, and operation of a new data center capable of meeting future scientific computing challenges in the atmospheric sciences.”

CISL continually optimizes and improves the efficiency and operability of the facility. This summer's SIParCS students analyzed facility data from nearly two years of operations and identified anomalies in the energy used for pumping coolant through the computing systems. As a result of their work, CISL has identified operational maintenance actions that eliminated the anomalies. CISL has also started the initial project scoping, schedule coordination, and a process for NWSC infrastructure upgrades that will likely be required to support NWSC-2.

The operational expenses for NWSC during FY2014 were met using NSF Core funds.

‹ CISL computing facilities up Mesa Lab Computing Facility ›

STRATEGIC PLANS

CISL Strategic Plan

NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

Printer-friendly version

Login

MESA LAB COMPUTING FACILITY

These UCAR Finance and Administration (F&A) servers provide vital business services to NCAR and all other organizations managed by UCAR. These UCAR servers have been relocated to the MLCF because it provides multiple backup power sources and other redundant site infrastructure.

The Mesa Lab Computing Facility (MLCF) has been repurposed to house the majority of the enterprise-class IT equipment for NCAR and UCAR. It will therefore continue providing significant value to researchers for many years into the future.

At present, the MLCF hosts servers and services for NCAR divisions and UCAR programs ACD, CGD, CISL, COSMIC, F&A, Globe, HAO, IIS, JOSS, and RAL.

CISL, along with UCAR Facilities Management and Sustainability (FM&S), followed up earlier efforts to develop a design and master plan to refurbish the MLCF. The contract and selection effort was completed in FY2014 along with initial design work. This design work will continue into FY2015.

During FY2014 CISL worked with FM&S and IT groups across UCAR to finalize plans and complete the relocation of computer equipment from the Center Green 2 facility. The CG2 computer room was inadequate, expensive, and problematic for the building structure. This allowed UCAR to consolidate services, reduce the energy requirement for the CG campus, and provide better quality of service including fully redundant electricity backup at the MLCF facility. This also allowed for more focused computer system operations and maintenance in fewer computer facilities. The move of equipment was completed in July 2014 with only a 48-hour weekend interruption of services.

Funding for the MLCF is supported by UCAR overhead funding out of the UCAR Communications pool.

‹ NCAR-Wyoming Supercomputing Center | up | CISL hardware cyberinfrastructure services ›

STRATEGIC PLANS

CISL Strategic Plan

NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

Printer-friendly version

Login

CISL HARDWARE CYBERINFRASTRUCTURE SERVICES

Yellowstone systems delivered over 480 million computing core hours during FY2014.

CISL deploys and operates NCAR’s high performance computing (HPC) systems on behalf of the atmospheric and related science community. The integrated petascale computing, analysis, visualization, networking, and storage resources constitute a world-class HPC resource for about 2,500 researchers from institutions throughout the U.S. and abroad. More details about the hardware cyberinfrastructure managed by CISL appear in subsequent sections of this report. The primary systems include:

- 1.5 PFLOPS Yellowstone compute cluster based on IBM’s iDataPlex architecture, composed of 4,536 two-socket Intel Sandy Bridge nodes connected by a full fat-tree FDR InfiniBand interconnect.
- 16.4 PB high-performance parallel file system capable of over 90 GB/s of sustained bandwidth.
- 1.5 PB data sharing environment based on Globus Plus software.
- High performance data archival system based on IBM’s High Performance Storage System (HPSS). Current holdings of 35 PB, with a capacity of 160 PB.
- 16-node Caldera GPU computation and visualization cluster based on the same two-socket Sandy Bridge architecture as Yellowstone, and augmented with two NVIDIA K20X graphics processing unit (GPU) accelerators per node.
- 16-node Geyser data analysis and visualization cluster based on the Intel Westmere processor and featuring 1 TB of DRAM per node and NVIDIA K5000 GPUs.
- 84-node Erebus cluster based on the same node-level architecture as Yellowstone. Erebus is operated by CISL on behalf of the U.S. Antarctic Program's Antarctic Mesoscale Prediction System (AMPS) project.
- 16-node Pronghorn system based on the same node-level architecture as Yellowstone, but augmented with two Intel Xeon Phi Knight’s Corner accelerators per node.
- A range of smaller systems for pre-production testing and the evaluation of future HPC technologies.

Yellowstone and its associated complex of HPC systems operated in full production status throughout FY2014. For FY2014, the Yellowstone environment supported over five million production computing jobs,

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totaling over 480 million core hours. As noted elsewhere in this report, there were also significant upgrades to GLADE, HPSS, Caldera, and Geyser that resulted in performance improvements and new capabilities.

CISL also inaugurated the HPC Futures Lab at the Mesa Lab facility. The HPC Futures Lab is a testbed where CISL can experiment with new HPC hardware and software to better understand how current and future technologies can best be deployed on behalf of the community.

NCAR's supercomputers are managed by CISL under the UCAR/NSF Cooperative Agreement and are supported by NSF Core funds.

‹ Mesa Lab Computing Facility up Yellowstone data-intensive computing environment ›

STRATEGIC PLANS

CISL Strategic Plan
NCAR Strategic Plan

PREVIOUS CISL REPORTS

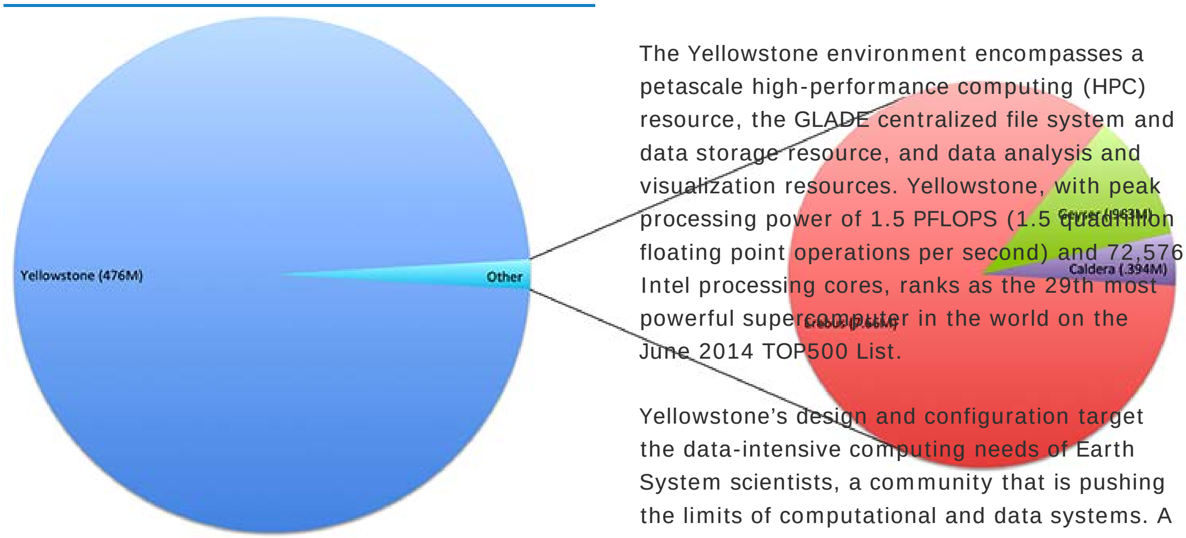
Select year

Printer-friendly version

Login

YELLOWSTONE DATA-INTENSIVE COMPUTING ENVIRONMENT

FY2014 was a highly productive year for the Yellowstone data-intensive computing environment. The systems have been in production for nearly two years following their inauguration in December 2012, and by all measures, have been overwhelmingly successful in enabling new science and discovery in the atmospheric and related sciences. Over the past year these systems have supported over five million production computing jobs, totaling over 480 million core hours of computing.



Yellowstone computing environment supported over 480M core hours of computing.

The Yellowstone environment encompasses a petascale high-performance computing (HPC) resource, the GLADE centralized file system and data storage resource, and data analysis and visualization resources. Yellowstone, with peak processing power of 1.5 PFLOPS (1.5 quadrillion floating point operations per second) and 72,576 Intel processing cores, ranks as the 29th most powerful supercomputer in the world on the June 2014 TOP500 List.

Yellowstone's design and configuration target the data-intensive computing needs of Earth System scientists, a community that is pushing the limits of computational and data systems. A centerpiece of NWSC's data-centric supercomputing environment is NCAR's Globally Accessible Data Environment (GLADE), which provides a shared, high-speed, central file system connecting all the computing and support systems required for scientific computation and associated workflows. This design improves scientific productivity and reduces costs by eliminating the expense (time and energy) of moving and maintaining multiple copies of data.

Rounding out the resources of Yellowstone's environment are the Data Analysis and Visualization (DAV) systems Geyser and Caldera. Specially configured for DAV tasks and equipped with NVIDIA graphics processing units (GPUs). The 16-node Geyser cluster, with 1 terabyte of memory per node, was designed for data synthesis and analysis tasks, while the 16-node Caldera cluster, with two GPUs per node, was designed for computationally intensive parallel data analysis and visualization tasks.

As described in other sections of this report, there were several major upgrades to the computing environment, including: 5.5 PB added to the GLADE file system, bringing the total to 16.4 PB; upgrades to the GPUs on both Caldera and Geyser; an upgrade of the tape technology in the NCAR HPSS Archive, which brings the capacity of the system to 160 PB; and a full system software stack upgrade to all computing systems. And CISL, IBM, and Mellanox replaced all of the more than 4,600 optical InfiniBand cables in Yellowstone in early October 2013, a change necessitated by a manufacturing defect in the cables. Thanks to the efficient teamwork of NCAR, IBM, and Mellanox, the project was completed 10 days ahead of schedule.

- Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- CISL Strategic Plan
- NCAR Strategic Plan

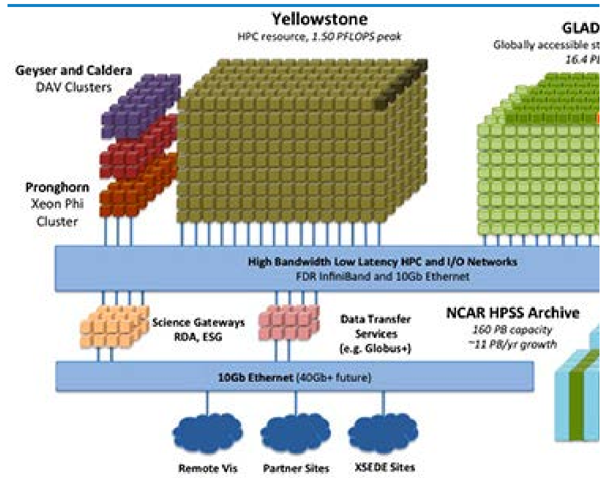
PREVIOUS CISL REPORTS

Select year

Printer-friendly version

The NCAR Data Sharing Service was piloted and formally launched in FY2014. Based on the Globus Plus software (a tool that came out of a partnership between the University of Chicago and Argonne National Laboratory), the NCAR Data Sharing Service provides researchers a way to share large datasets with collaborators around the world using a simple web-based interface. The service provides 1.5 PB of storage, data movement servers, and high-speed network connectivity to external research networks.

CISL's commitment to a data-intensive computing strategy extends beyond the Yellowstone environment and includes a full suite of science gateway and data portal services. CISL continues to lead the community in developing data services that can address the future challenges of data growth, preservation, curation, and management. CISL also leads in supporting NSF's new requirement for data management plans. Our disk and tape-based HPSS storage systems provide an efficient, safe, and reliable environment for hosting datasets. CISL has streamlined and improved its data services through the data-centric design of the Yellowstone environment.



Yellowstone's data-intensive computing environment.

CISL continued to operate Erebus, an 84-node supercomputing cluster that is based on the same architecture as Yellowstone. Erebus is used exclusively by the Antarctic Mesoscale Prediction System (AMPS) for producing twice-daily numerical weather predictions over the Antarctic continent. Primary users of these simulations are forecasters who support the U.S. Antarctic Program flight operations and polar observatory, and to support research and education activities involving Antarctic meteorology.

This past year also saw the launch of the procurement process for the follow-on Yellowstone system. CISL, along with colleagues from NCAR, started the early steps of defining the key science and technology drivers for "NWSC-2". NCAR anticipates releasing a formal Request for Proposals in early 2015, with an award to be made in late 2015. The new system is planned for production availability in January 2017.

The Yellowstone environment, including HPC, GLADE, and DAV resources, was made possible through NSF Core funds.

‹ CISL hardware cyberinfrastructure services   up   Production supercomputing status ›

Login

PRODUCTION SUPERCOMPUTING STATUS

In FY2014, CISL focused its efforts on ensuring that Yellowstone and related systems – GLADE, Erebus, Caldera, and Geyser – were operated at the highest levels of performance and availability. Although the year kicked off with a two-week downtime for a replacement of all of Yellowstone's fiber optic cables, the year was characterized by adding new capabilities and services to the HPC environment and achieving higher levels of availability and utilization. This section describes some major events and highlights from FY2014.

Internal cable replacement

The Yellowstone InfiniBand recabling project was completed in under half the expected time. Here Mellanox employees are dressing the cables at Yellowstone's nine core InfiniBand switches after new cables had been laid to Yellowstone's 63 racks.

The year began with Yellowstone, GLADE, Caldera, and Geyser being taken out of service to replace all the Mellanox InfiniBand fiber-optic cables. A previously undetected defect in the fabrication of the silicon circuitry in the cables' connectors had induced significantly higher failure rates than were expected during the first year of Yellowstone production. During the second half of FY2013, CISL, IBM and Mellanox agreed that the best remediation strategy was a wholesale cable replacement, so they meticulously planned and prepared for this effort. The replacement started with the combined CISL, IBM, and Mellanox teams beginning the demolition and removal of the existing cables. The demolition was completed in less than half the expected time and the laying of new cables started late that afternoon. By Friday morning, all cables had been replaced, Caldera and Geyser had been returned to service, and system testing of Yellowstone had begun. Yellowstone was returned to production service on Wednesday 9 October, 10 days ahead of the original schedule. The outcome reflected the thorough planning and superb teamwork of CISL, IBM, and Mellanox staff. Following this cable replacement, Mellanox identified a new defect that has the potential to impact approximately 1,200 of the more than 4,500 new cables. CISL is now using a proactive error-detection process to identify faulty cables before they fail. CISL and Mellanox have subsequently replaced an additional 600 cables. CISL is closely monitoring the situation, the rate of errors is dropping, and all 1,200 of the potentially affected cables are not expected to require replacement.

System software upgrades

Motivated by both end-of-life support from IBM and a desire to provide improved systems performance, an upgrade to Yellowstone's LSF resource manager and parallel runtime environment (PE) was conducted in February, and a full systems software upgrade was carried out in April. Yellowstone and related systems were shut down on the morning of April 7 and returned to user community production on the morning of April 14 after an upgrade of the operating system to Red Hat Enterprise Linux 6.4, a complete reinstallation and upgrade of the IBM HPC software stack, and firmware upgrades to GLADE's disks and controllers, Yellowstone's nodes, InfiniBand, and Ethernet switches. This was followed by a similar upgrade of the software stack on Erebus, the cluster used for the Antarctic Mesoscale Prediction System

STRATEGIC PLANS

PREVIOUS CISL REPORTS

Select year

Printer-friendly version

(AMPS), an experimental, real-time numerical weather prediction capability that provides support for the United States Antarctic Program, Antarctic science, and international Antarctic efforts.

Expansion and upgrade of GLADE, Yellowstone, Geyser, and Caldera

During the operating system downtime, the hardware comprising the Phase II disk storage expansion of GLADE was added to the storage subsystems. The new storage, adding 5.5 petabytes to GLADE and bringing its total capacity to 16.4 petabytes, completed its acceptance testing on April 30. IBM staff carried out the GLADE expansion per the previously negotiated contract. This additional storage is being used to expand the project space available to Yellowstone users. As noted in NCAR's data-sharing service on Globus Plus, CISL also launched a new service based on the Globus software to provide researchers with a simple way to transfer and share large data sets via national and international high-performance networks.

In addition to the GLADE expansion, an additional 18 nodes were added to Yellowstone's rack 63, and the GPUs on Geyser and Caldera were upgraded. The additional nodes made Yellowstone's InfiniBand interconnect a symmetric full fat tree and brought the total Yellowstone node count to 4,536. Geyser's GPUs were upgraded to Kepler-based NVIDIA Quadro K5000 graphics cards in July, and Caldera's GPUs were upgraded to NVIDIA Tesla K20X accelerators in September. Work continued with IBM and Intel on Pronghorn, CISL's Intel Xeon Phi test cluster.

System specifications

This table provides the technical details for the supercomputing systems maintained by CISL.

	Yellowstone	Caldera	Geyser	Pronghorn	Erebus (AMPS)
Peak FLOP Rate (TF)	1509.6	21.8	14.4	37.7	28.0
Total Number of Nodes	4536	16	16	16	84
Primary Node Architecture	IBM dx360 M4	IBM dx360 M4	IBM x3850 X5	IBM dx360 M4	IBM dx360 M4
CPU Type	Intel Xeon E5-2670	Intel Xeon E5-2670	Intel Xeon E7-4870	Intel Xeon E5-2670	Intel Xeon E5-2670
CPU Microarchitecture	Sandy Bridge EP	Sandy Bridge EP	Westmere EX	Sandy Bridge EP	Sandy Bridge EP
CPU Frequency (GHz)	2.6	2.6	2.4	2.6	2.6
CPU Count per Node	2	2	4	2	2
Core Count per Node	16	16	40	16	16
Node Memory Capacity (GB)	32	64	1024	64	32
Node Memory Type	DDR3-1600	DDR3-1600	DDR3-1066	DDR3-1600	DDR3-1600
Interconnect Network	InfiniBand 4x FDR	InfiniBand 4x FDR	InfiniBand 4x FDR	InfiniBand 4x FDR	InfiniBand 4x FDR-10
Interconnect	3-tier full fat	1-tier full fat tree	1-tier full fat tree	1-tier full fat	2-tier full fat

Topology	tree			tree	tree
Network Ports per Node	1	1	2	1	1
System Bisection Bandwidth (GB/sec)	31,100	109	104	109	407
Accelerator	-	NVIDIA K20X	NVIDIA K5000	Intel Phi 5110P	-
Accelerator Peak Single-Precision FLOP Rate (GF)	-	3,950	2,150	-	-
Accelerator Peak Double-Precision FLOP Rate (GF)	-	1,310	90	1,011	-
Accelerator Count per Node	-	2	1	2	-
Accelerator Memory Capacity (GB)	-	6	4	8	-
Accelerator Memory Type	-	GDDR5	GDDR5	GDDR5	-
Number of Compute Racks	63	0.5	2	0.5	1

HPC Futures Laboratory

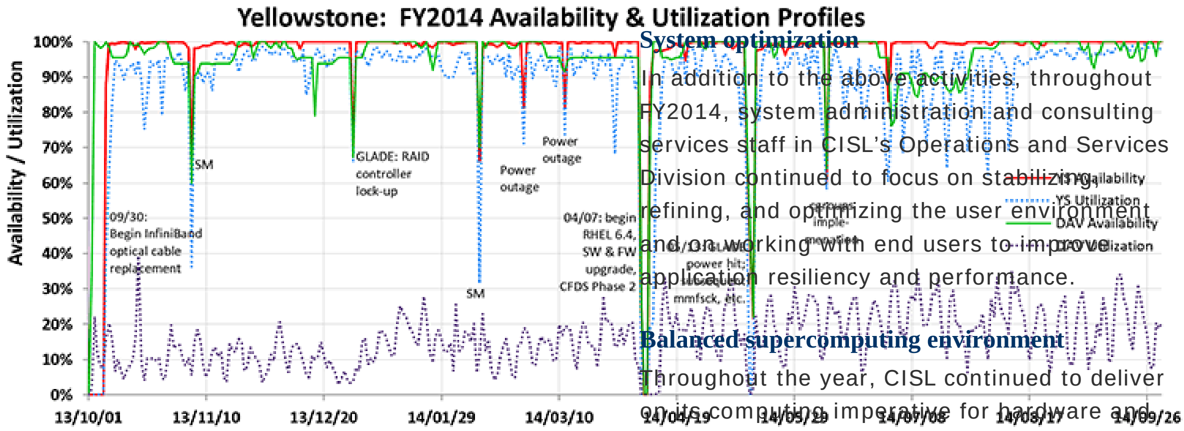
CISL also launched and deployed the HPC Futures Lab this year to continue its focus on research in high performance computing (HPC), something that is relevant for improving the current environment and helping CISL assess technology that may be present in future systems. The HPC Futures Lab provides system administration, consulting staff, and scientists with a ready-to-use environment where cutting-edge technology can be deployed and tested. Some of the current research is examining areas such as heterogeneous architectures, GPGPUs, coprocessors, resource managers, job schedulers, Message Passing Interface (MPI) software, benchmarks, performance tuning, file systems, and a variety of computation-intensive applications.

System availability

During FY2014, Yellowstone had an average scheduled availability of 99.6% and user utilization of 91.6%, while the Data Analysis and Visualization systems (Caldera and Geyser) averaged 97.3% scheduled availability and 16.3% user utilization.

FY2014 Availability Metrics	GLADE	Yellowstone	DAV
Total User Availability	97.8%	96.1%	95.2%
Downtime: Scheduled Maintenance and Environmental	1.6%	3.4%	2.1%
Scheduled Availability	99.4%	99.6%	97.3%

Stability and utilization of Yellowstone and the DAV resources trended upward throughout the year as shown by the figure below.



The availability and utilization profiles for the HPC (Yellowstone) and DAV (Caldera and Geyser) resources during FY2014, showing downtimes for the internal recabling (October), software stack upgrade (April), other maintenance activities, and a couple power interrupts.

System optimization

In addition to the above activities, throughout FY2014, system administration and consulting services staff in CISL's Operations and Services Division continued to focus on stabilizing, refining, and optimizing the user environment and on working with end users to improve application resiliency and performance.

Balanced supercomputing environment

Throughout the year, CISL continued to deliver on its computing imperative for hardware and software cyberinfrastructure. CISL's efforts remained substantially focused on providing robust, reliable, and secure high-performance computing resources in a production research environment, and on supporting that environment for thousands of users and hundreds of projects spanning NCAR, UCAR member universities, and the University of Wyoming in a wide variety of disciplines related to the atmospheric sciences. CISL resources empower the research community to pursue more innovative investigations, and CISL itself provides the organizational focus, capabilities, and skill sets to support these investigations along with the field campaigns and computational projects of other NCAR laboratories.

CISL's production supercomputing environment is designed, administered, and managed to provide data-centric computational resources that are balanced to meet the needs of its numerical simulation and data-analysis communities. Further, CISL strives to provide the most effective and useful combination of computational and data storage capability and capacity, augmented by scientific data analysis, visualization, and archival services. CISL works to provide equitable access to these computing and storage resources while achieving high reliability, minimizing job wait times, and maximizing resource throughput and utilization. These objectives require CISL to continuously monitor system usage and performance and to continuously work to balance resource allocation with priority-based intelligent job scheduling, a well-tuned job queue structure, and single-job resource limits.

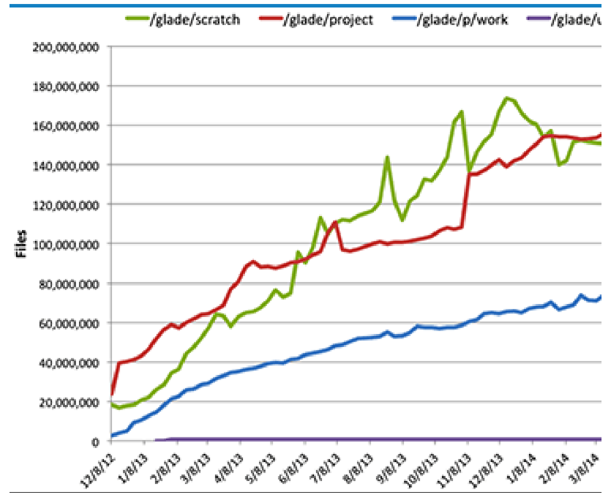
Funding support

This work is made possible through NSF Core funds, including CSL funding, and NSF Special Funds were used for the AMPS resources.

‹ Yellowstone data-intensive computing environment | up | Globally Accessible Data Environment ›

Login

GLOBALLY ACCESSIBLE DATA ENVIRONMENT



Growth profile of the GLADE file systems showing total number of files stored based on weekly snapshots from November 2012 through June 2014.

The GLobally Accessible Data Environment (GLADE) provides centralized high-performance file systems spanning supercomputing, data post-processing, data analysis, visualization, and HPC-based data transfer services. GLADE provides computation, analysis, and visualization work spaces common to all CISL HPC resources. Project space is allocated through NCAR's allocation panels, while scratch and user space is available to all users of NCAR HPC resources. GLADE also hosts data from NCAR's Research Data Archive (RDA), NCAR's Community Data Portal, and the Earth System Grid which curates CMIP5/AR5 data.

GLADE's architecture shifts scientific workflows from a design that centers on serving the supercomputer to a more efficient design that facilitates the flow of data. Through a globally accessible storage infrastructure, users now arrange their workflows to use stored data directly without first needing to move or copy it. Additional services like high-performance data transfer protocols enhance CISL's ability to bring computational data from other sites to NCAR for post-processing, analysis, and visualization.

In FY2014 GLADE resources continued to provide stable centralized file services for all CISL HPC resources. An expansion of the capacity was completed during FY2014 which added 5.5 PB to GLADE, bringing the total available space up to 16.4 PB. This additional space was made available for project allocations. Data transfer services were enhanced with the addition of new features in the Globus online interface made possible in part through collaboration with the Globus development team at the University of Chicago.

This work supports CISL's computing imperative for hardware cyberinfrastructure by provisioning storage and networking systems customized to support efficient workflows for the atmospheric and related sciences. Specifically, GLADE facilitates typical user workflows plus special efforts like supporting data flows for the IPCC AR5. GLADE also advanced CISL's computing imperative for facilities by demonstrating high-performance data services that were critical for the next-generation resources that now operate at NWSC.

GLADE equipment was purchased with NSF Special funds, and it is supported by NSF Core funds including CSL funding.

‹ Production supercomputing status | up | Archival systems ›

- Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- CISL Strategic Plan
- NCAR Strategic Plan

PREVIOUS CISL REPORTS

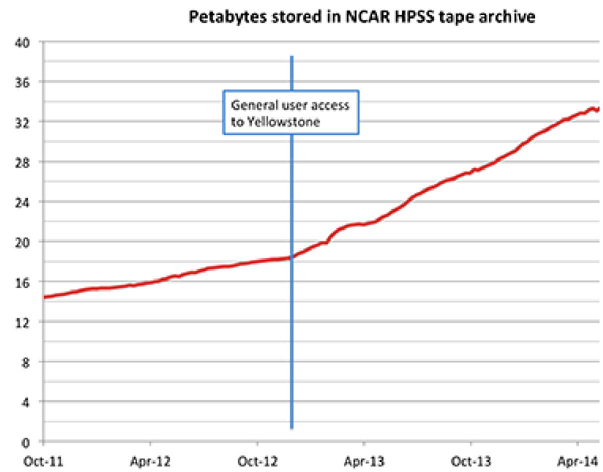
Select year

Printer-friendly version

Login

ARCHIVAL SYSTEMS

The HPSS (High Performance Storage System) provides data archive services for the high performance computing (HPC) system Yellowstone, as well as for other NCAR laboratories and UCAR programs for their divisional servers. HPSS usage grew throughout FY2014 with over 11 PB of new data and 32 million files added to the archive during the year.



HPSS growth in petabytes.

Based on the business continuity plan developed in FY2013, CISL supported offsite duplication for CISL's Research Data Archive (RDA). The primary data copy is resident at the production NWSC facility while the second copy is stored at the Mesa Lab Computing Facility (MLCF) in Boulder. This ensures both data replication and geographic separation for disaster recovery support. CISL anticipates that more labs will use this service in 2015, particularly for high-value, irreplaceable data collections.

In December 2013, CISL completed a major upgrade effort that included the migration of data from the legacy NCAR Mass Store format to HPSS native format and a migration of data from older Oracle T10K-B tape technology. Completed in July 2014, this milestone improved overall performance of the archive and paved the way for capacity growth based on newer T10K-D tape technology. It also represents the last stage of primary data relocation from the MLCF to the NWSC in Wyoming.

After carefully analyzing the growth rates and performance of the archive and assessing the technology landscape, CISL decided to postpone the release of the tape library procurement until 2016. In lieu of this, CISL exercised options to extend the current AMSTAR subcontract and upgrade the tape drives from Oracle's T10K-C to T10K-D technology. T10K-D tapes have an 8 TB capacity, which increases NCAR's total HPSS capacity by at least 60% without replacing any media already in the library. The subcontract extension is anticipated to meet NCAR's projected needs through 2016, after which the equipment from the NWSC Archive RFP is expected to be deployed. The additional extension did not result in any additional hardware requirements since the overall data growth from Yellowstone turned out somewhat lower than originally projected (currently 1 PB/month).

In addition to tape technology upgrades, CISL implemented and currently executes new policies for orphaned file processing to ensure that older data either leaves the system or is adopted by funded projects to cover the cost of keeping them.

The HPSS effort supports CISL's computing imperative for hardware cyberinfrastructure by deploying a production HPSS instance that supports NWSC Archival Services Requirements. The NCAR HPSS is managed by CISL under the UCAR/NSF Cooperative Agreement and is supported by NSF Core funds and CSL funding.

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‹ Globally Accessible Data Environment up Data analysis and visualization environment ›

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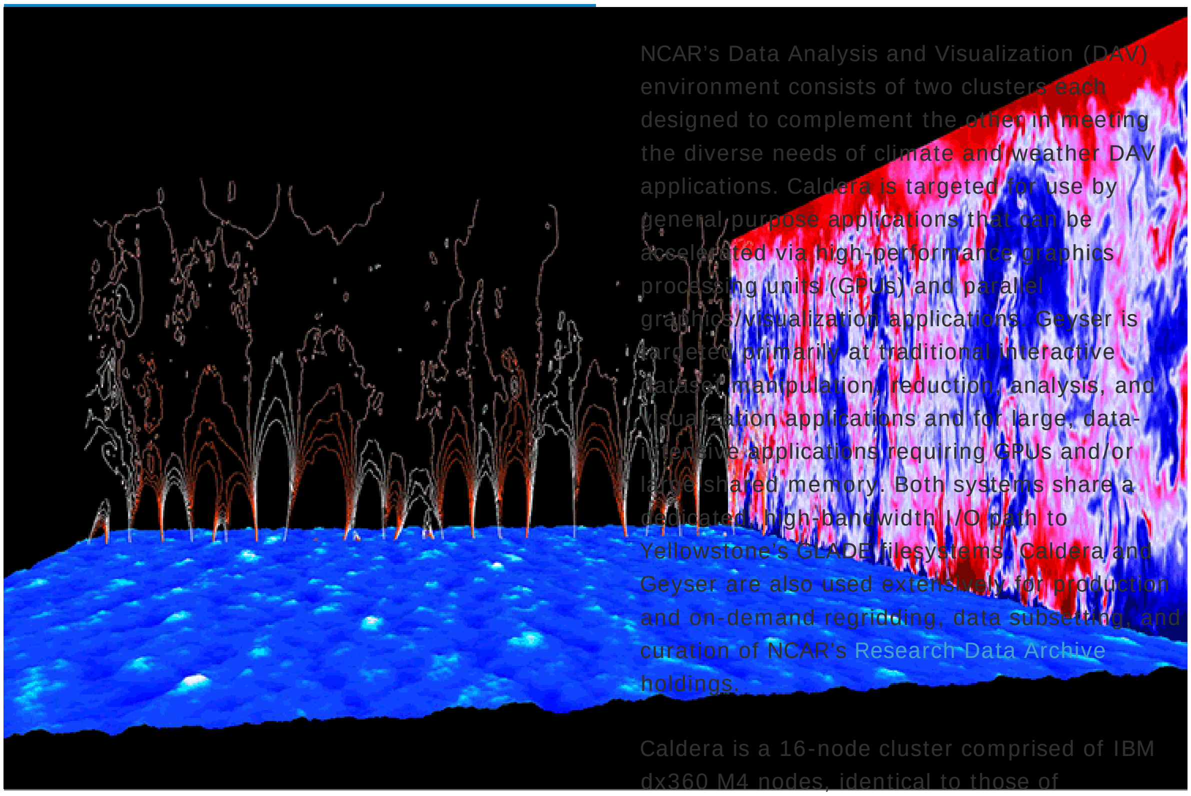
Home » 2014 CISL Annual Report » CISL Services » CISL hardware cyberinfrastructure services

DATA ANALYSIS AND VISUALIZATION ENVIRONMENT

The Data Analysis and Visualization environment enables scientific workflows by providing UCAR's research community with state-of-the-art systems tailored for the specialized needs of parallel data post-processing, analysis, and visualization. This environment also supports the research community by developing algorithms for relevant visualization and analysis methods and by producing animations and imagery in collaboration with and on behalf of scientific staff.



It is conventionally understood that the winds in the atmosphere are what generate ocean waves, such as those seen on the shore before a hurricane makes landfall. The forces that the ocean waves exert on the atmosphere are more subtle and not as well understood. In this simulation, 12 million compute hours on Yellowstone were used to help understand how the effects of ocean waves ripple up into the atmospheric boundary layer. The enormous datasets were visualized on CISL's Geyser cluster using VAPOR.

NCAR's Data Analysis and Visualization (DAV) environment consists of two clusters each designed to complement the other in meeting the diverse needs of climate and weather DAV applications. Caldera is targeted for use by general purpose applications that can be accelerated via high-performance graphics processing units (GPUs) and parallel graphics/visualization applications. Geyser is targeted primarily at traditional interactive dataset manipulation, reduction, analysis, and visualization applications and for large, data-intensive applications requiring GPUs and/or large shared memory. Both systems share a dedicated, high-bandwidth I/O path to Yellowstone's GLADE filesystems. Caldera and Geyser are also used extensively for production and on-demand regridding, data subsetting, and curation of NCAR's Research Data Archive holdings.

Caldera is a 16-node cluster comprised of IBM dx360 M4 nodes, identical to those of Yellowstone except that they augmented with two general purpose graphics processing units (GPGPUs). Each Caldera node contains two 8-core Intel Sandy Bridge processors, 64 GB of memory, and two NVIDIA Tesla K20X accelerators. Each K20X accelerator is capable of 1.31 TFLOPS double-precision calculations or 3.95 TFLOPS single-precision calculations, giving Caldera a peak double-precision floating point rate of over 47 TFLOPS. The same peak computation rate requires over 140 Yellowstone nodes.

Geyser is a 16-node cluster comprised of IBM x3850 X5 nodes, each equipped with four 10-core Intel Westmere processors, one terabyte of memory, and one NVIDIA Quadro K5000 graphics adapter. The K5000 accelerator is designed for high-speed graphics rendering, with a single-precision floating point rate of 2.1 TFLOPS. Additional details of the Geyser and Caldera systems are contained in a table in the

Production supercomputing status section.

In addition to supporting CISL's computing imperative for hardware cyberinfrastructure (CI), the DAV environment supports CISL's software CI computing imperative by supporting, developing, and enhancing software specific to the simulation, analysis, and forecasting needs of the atmospheric and related sciences. Furthermore, the DAV resources help to advance CISL's science frontier in understanding large and heterogeneous data sets by developing new methods and tools such as VAPOR to extract and visualize information from such data sets.

NCAR's DAV environment and services are supported by NSF Core funds including CSL funding.

2014 CISL ANNUAL REPORT

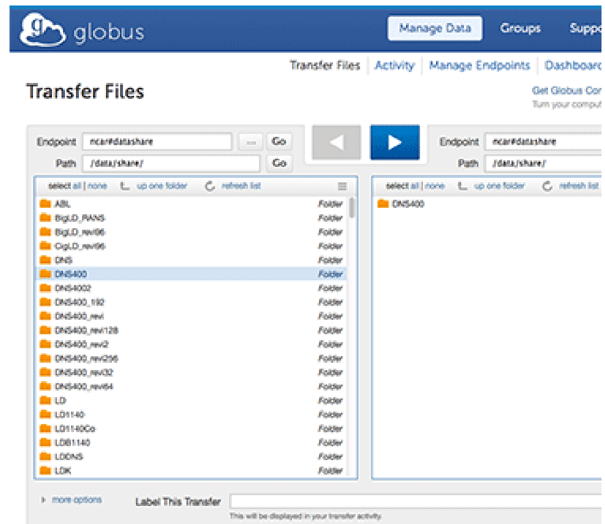
- CISL Director’s message
- CISL Services
  - CISL computing facilities
  - CISL hardware cyberinfrastructure services
    - Yellowstone data-intensive computing environment
    - Production supercomputing status
    - Globally Accessible Data Environment
    - Archival systems
    - Data analysis and visualization environment
    - NCAR’s data-sharing service on Globus Plus
  - CISL supercomputer user services
  - CISL’s Big Data services and software tools
  - CISL’s enterprise architecture
- CISL Science
- CISL Education, Outreach, and Training
- Broader Impacts

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information

NCAR’S DATA-SHARING SERVICE ON GLOBUS PLUS



The Globus user interface provides an easy way to manage data across multiple sites. Users can choose to transfer data between any two Globus endpoints for which they have authorization. As part of the Globus Plus data sharing services, NCAR users can now easily share data with external collaborators. The Globus Plus service also enhances the ability of NCAR researchers to bring computational data from other sites into NCAR's GLADE central file system for post-processing, analysis, and visualization.

The GLobally Accessible Data Environment (GLADE) provides centralized high-performance file systems spanning supercomputing, data post-processing, data analysis, visualization, and HPC-based data transfer services. Additional services like high-performance data transfer protocols, including a new data-sharing service, enhance CISL’s ability to bring data from other sites to NCAR for post-processing, analysis, and visualization and to share data easily with external collaborators.

The data sharing service leverages the capabilities of Globus Plus to increase customization options for storage as well as data sharing. Globus, a project of the Computation Institute (a partnership of The University of Chicago and Argonne National Laboratory), is a software service that has been described as a “Dropbox for big data.” It is broadly used in the scientific community. “Plus” refers to a new feature that allows researchers to share data with colleagues outside of their home institutions, greatly facilitating collaborative work.

In FY2014 CISL dedicated 1.5 PB of GLADE storage to host the new data-sharing service as part of the Beta launch of Globus Plus. As part of this evaluation, CISL staff worked closely with Globus staff to ensure that the service was production ready. CISL launched the production service in mid FY2014. In addition to making data available to external colleagues, Globus Plus now allows users of CISL's HPC environment to control the users or groups of users to which the data are accessible. With the sharing service, outside users need only a free Globus account, not a UCAR username/token, to access shared data.

This work supports CISL’s computing imperative for hardware cyberinfrastructure by provisioning storage and networking systems customized to support efficient workflows for the atmospheric and related sciences. GLADE also advanced CISL’s computing imperative for facilities by demonstrating high-performance data services that were critical for the next-generation resources that now operate at NWSC. GLADE equipment was purchased with NSF Special funds, and it is supported by NSF Core funds including CSL funding.

‹ Data analysis and visualization environment up CISL supercomputer user services ›

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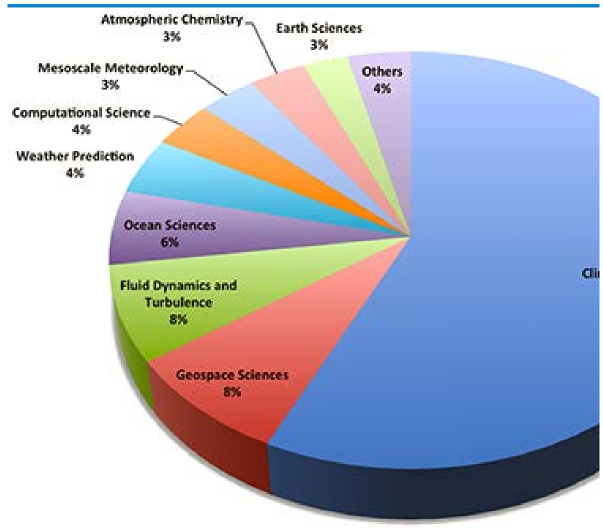
CISL SUPERCOMPUTER USER SERVICES



The petascale Yellowstone system was used by various Earth System science disciplines in FY2014. User Sciences staff provide computational and data management support services tailored to needs of this research community.

CISL has a strategic commitment to provide robust, accessible, and innovative services and resources to researchers in the atmospheric and related sciences, including the broad university community, Climate Simulation Laboratory (CSL) users, NCAR researchers, and University of Wyoming users. As part of that commitment, CISL works to provide its users with responsive and knowledgeable support services. CISL's success in supporting scientific goals and enabling scientific impact depends in equal measure on understanding the needs and research objectives of its user community, and on integrating CISL's resources, capabilities, and services in response to those needs. Our success can be measured in part by the high demand for current and future CISL resources in FY2014.

NCAR is one of only a small number of institutions with the resources and support services necessary to conduct high-end climate research, model development, and support for field campaigns. As a discipline-specific computing center, CISL is able to provide the capabilities and skill sets required to support important computational campaigns with on-demand resources that include those driven by unfolding natural disasters.

In FY2014, CISL user services worked to enhance and stabilize the production Yellowstone environment, supported Yellowstone users as the system achieved ongoing daily utilization in excess of 95%, and increased training opportunities to help users make effective use of this powerful resource.

This work supports CISL's computing imperative to provide hardware cyberinfrastructure customized for the atmospheric and related sciences. This ongoing service for users is supported by NSF Core funds including CSL funding.

‹ NCAR's data-sharing service on Globus Plus | up | User community overview ›

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

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- CISL Strategic Plan
- NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

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National Center for Atmospheric Research
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Research Applications Laboratory

STRATEGIC PLANS

CISL Strategic Plan
NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

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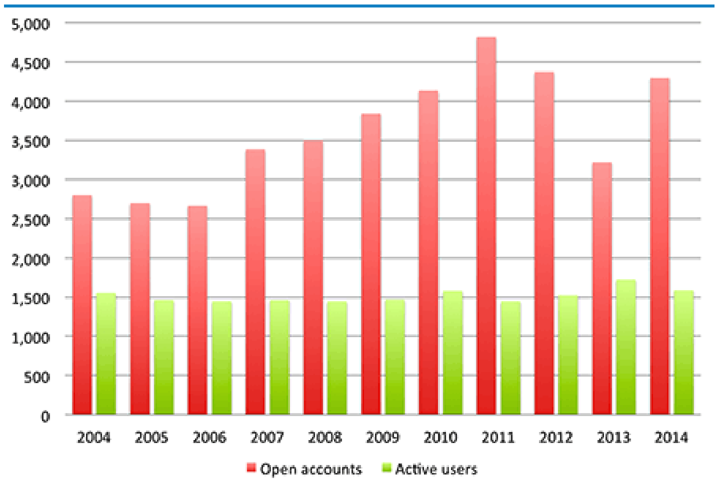
USER COMMUNITY OVERVIEW

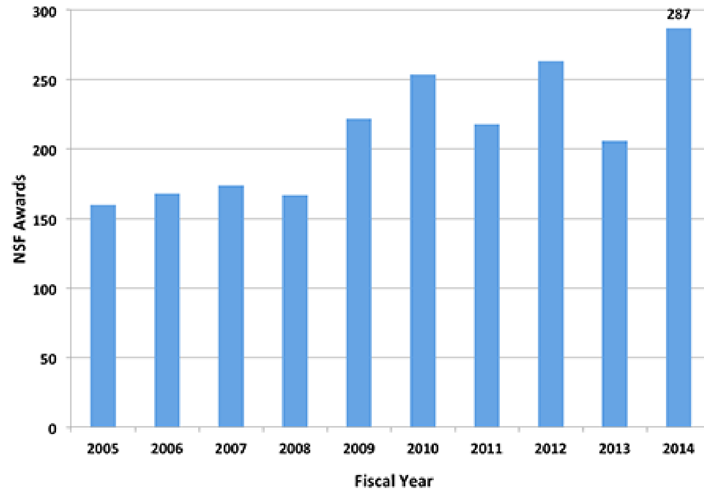
CISL's success in supporting scientific goals and enabling scientific impact depends in equal measure on understanding the needs and research objectives of its user community, and on integrating CISL's resources, capabilities, and services in response to those needs. In FY2014, that user community included more than 1,500 users at more than 200 universities and other institutions who benefited from using CISL's high-performance cyberinfrastructure (CI) and services. These active users represented nearly 40% of the more than 4,200 users who had computing or storage accounts during that year. In FY2014, more than 550 new users joined the CISL computing community.



CISL has retained a consistently large number of active HPC users (including HPSS and MSS users) over the past 10 years. The number of open user accounts rebounded as the Yellowstone user community continued to grow.

A discipline-specific approach to supercomputing allows CISL to tailor system design and services for our user community and to satisfy the highly specialized technical requirements of scientific applications such as climate system models. A well-defined workload allows CISL and NCAR scientists to optimize the most heavily used models and applications on current and future systems. It also ensures that model development and research in Earth System processes can occur in a controlled yet responsive environment where researchers can prepare complex models and perform the computationally demanding tests required to validate them.

The size, breadth, and disciplinary pursuits of the CISL user community offer perspectives on the scientific impact enabled by CISL's HPC, data analysis, and archival resources. This user community reported more than 350 publications and 44 dissertations and theses resulting from CISL HPC support in



CISL allocations to university researchers have supported the scientific objectives of more than 150 different NSF awards each year for the past decade. In FY2014, active projects supported nearly 300 unique NSF awards.

FY2013 (the timeframe of our most recent survey). More than 70% of CISL's HPC system use is related to running NCAR-provided climate and weather applications.

Scientifically, our user community spans more than 17 areas of interest in the atmospheric and related sciences. In geographic scope, the user community for CISL's HPC environment spans hundreds of different universities and collaborating institutions, primarily in the U.S. as defined by our HPC mission. In serving the NSF research community, CISL allocations to university researchers have supported the scientific objectives of more than 150 different NSF awards each year for the past decade. In FY2014, active projects supported nearly 300 unique NSF awards, and 706 university projects were open during the year on CISL resources (a 50% increase over FY2013), along with a new set of NCAR and large-scale Climate Simulation Laboratory (CSL) projects.

This work is a crucial part of CISL's computing imperative to provide hardware cyberinfrastructure customized for the atmospheric and related sciences. This ongoing service for users is supported by NSF Core funds including CSL funding.

‹ CISL supercomputer user services   up   Special computational campaigns ›

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CISL Strategic Plan
NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

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SPECIAL COMPUTATIONAL CAMPAIGNS

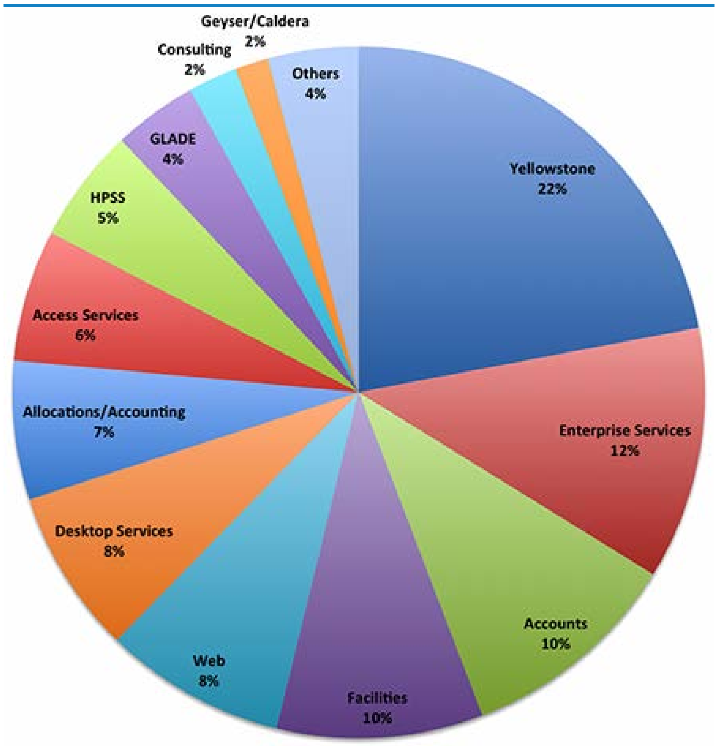
The CISL production supercomputing environment supports special computational campaigns for ongoing and short-term computational projects, all via a priority-based and near-real-time job scheduling mechanism.

These campaigns are managed to minimize the impact on the production computing delivered to NCAR, university, and CSL scientists.

The table below lists the special computational campaigns supported by CISL during FY2014.

The efforts included support for three field campaigns as well as real-time hurricane forecasts.

In addition, several Accelerated Scientific Discovery (ASD) projects completed some computing runs early in the fiscal year.



This chart shows the monthly usage of Yellowstone for special computational campaigns during FY2014. CISL works to accelerate scientific discovery through numerical simulation by providing a portion of the Yellowstone system to special campaigns.

FY2014 Special Campaign	Project Lead	Begin	End
Evaluating Lossy Data-Compression within the Large Ensemble Project	J. Dennis	10-Apr-14	31-Dec-14

STEP Hydromet experiment 2014	J. Sun	01-Apr-14	30-Sep-14
MPAS Hurricane Forecasts	C. Davis	10-Jul-13	31-Oct-14
Impacts of climate change on coral reef ecosystems of the Coral Triangle Region	J. Kleypas	17-Jun-14	30-Sep-14
WRF Forecasting for CONTRAST Field Operations	J. Bresch	17-Oct-13	31-Aug-14
FRAPPE Field Program Regional Forecasting Project	A. Mizzi	12-Jun-14	30-Sep-14
Testing and Applying WRF-Solar for Irradiance and Solar Power Prediction	S. Haupt	16-Jun-14	30-Sep-15
ASD: Turbulence in the Heliosphere: The Role of Current Sheets and Magnetic Reconnection	M. Shay	01-Aug-12	31-Jan-14
ASD: Global Cloud-Permitting Atmospheric Simulations Using MPAS	W. Skamarock	01-Aug-12	31-Jan-14
ASD: Direct numerical simulation of cumulus cloud processes over larger volumes and longer times	L. Collins	01-Aug-12	31-Oct-13
ASD: PetaScale Simulation of Physics and Dynamics of Turbulent Clouds	A. Wyszogrodzki	01-Aug-12	31-Oct-13
ASD: Turbulence modification in the spray-laden atmospheric marine boundary layer	D. Richter	01-Aug-12	30-Sep-14

The STEP Hydromet experiment was conducted from 7 July to 15 August 2014. The experiment was led by NCAR's STEP (Short Term Explicit Prediction) program with participation by NCAR scientists and engineers from RAL, MMM, and EOL, as well as scientists from NOAA. The main objective of the experiment was to demonstrate the capability of high-resolution data assimilation systems in producing short-term quantitative prediction forecasts (QPFs) and the impact in hydrological streamflow prediction. Seven state-of-the-art high-resolution data assimilation systems with rapid update cycles were run with hourly or 3-hourly updates. QPFs from some of the data assimilation and WRF forecast systems were used as input to drive a hydrological model coupled with WRF to produce real-time streamflow prediction over the Rocky Mountain Front Range region. The STEP Hydromet experiment was successfully conducted thanks to the dedicated effort of the participating scientists and engineers as well as CISL computing. CISL supported the experiment by assigning dedicated cores and storage on Yellowstone, both essential for the successful completion of the STEP Hydromet experiment.

Yellowstone also supported weather forecasting essential for two other field campaigns. The Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ) field campaign also took place in July and August 2014, in conjunction with the NASA DISCOVER-AQ project. This collaborative effort involved the Colorado Department of Public Health and the Environment, the University of Colorado, Colorado State University, the University of California at Berkeley, NASA, NOAA, and NCAR, and

other university and local collaborators. The FRAPPÉ forecasts supported a campaign that coordinated the deployment of four NASA aircraft, the NSF/NCAR C-130, and ground-based instrumentation. In support of the campaign, NCAR's Atmospheric Chemistry Division (ACD) issued real-time weather forecasts using the Weather Research and Forecast Model (WRF-ARW) for the FRAPPÉ study region, which stretched north from the east, west, and south borders of Colorado to central Wyoming. ACD issued two 48-hour deterministic forecasts per day and output graphics were made available in the Earth Observing Laboratory (EOL) FRAPPÉ field catalog. The WRF forecasts included inert tracers for different source types to provide information on pollution transport and mixing, and FRAPPÉ/DISCOVER-AQ scientists used those forecasts to plan the research aircraft flight and measurement patterns. To facilitate forecast availability, CISL reserved 256 nodes on Yellowstone, which consistently issued its forecasts in a timely manner. The success of the FRAPPÉ/DISCOVER-AQ field campaigns can be attributed in part to the computing and support services provided by CISL.

The CONvective TRansport of Active Species in the Tropics (CONTRAST) campaign targeted a better understanding of how convection redistributes atmospheric gases in the tropical atmosphere. The effort collected observations with the NSF/NCAR Gulfstream-V aircraft from a deployment in Guam during January and February 2014, in concert with NASA and British aircraft.

These special computing campaigns serve CISL's computing imperative to provide on-demand and real-time services support for hardware cyberinfrastructure. This work is made possible through NSF Core funds, including CSL funding.

‹ User community overview | up | Help desk and consulting ›

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Select year

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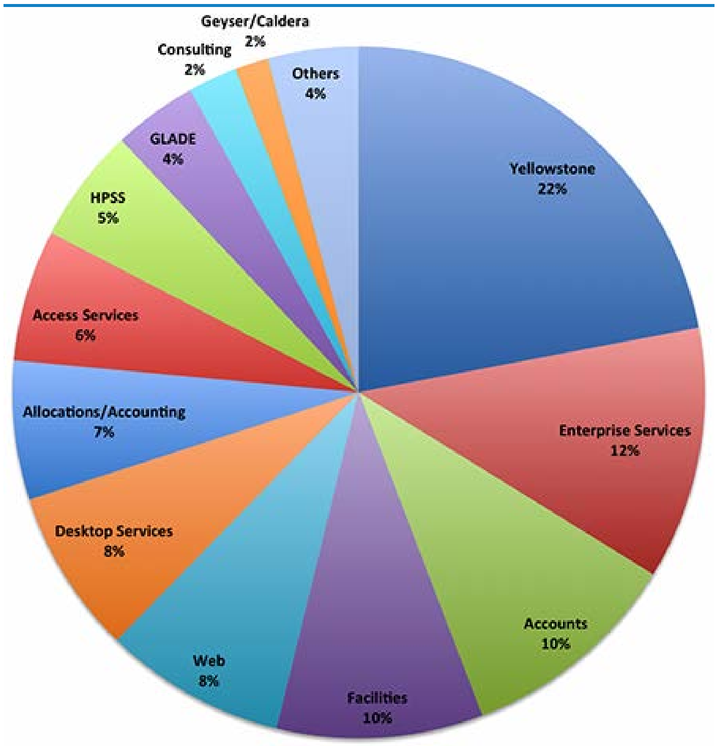
HELP DESK AND CONSULTING

CISL's strategic commitment to provide robust, accessible, and innovative information services and tools to our customers includes end-to-end services for NCAR's supercomputer users with both 24x7 frontline user support and consulting services for providing in-depth expertise. CISL's User Services Section unites four functions – the CISL Help Desk, Consulting Services, Documentation, and Accounts and Allocations – under the User Services Section to streamline and coordinate user-oriented procedures and support activities.



In FY2014, CISL staff fielded more than 12,000 help requests to the CISL Help Desk, which are grouped into the general categories shown here. (CISL's Network Engineering and Telecommunications Section (NETS) fielded an additional 1,400 help requests not shown here.)

For the Consulting Services Group, user support efforts in FY2014 focused on helping the user community make full use of the system's capability. During FY2014, CISL user services staff shepherded an expanding user community through a number of significant updates and changes to the Yellowstone system at the NCAR-Wyoming Supercomputing Center (NWSC), including a major re-cabling in October 2013 and a system software upgrade in April 2014. In addition, CISL's consulting staff provided expertise and customized, one-on-one service for special campaigns, including workshops and field campaigns, and benchmarking, testing, and troubleshooting related to the Yellowstone HPC environment.

As Yellowstone fully entered into production mode, the Consulting Services Group re-targeted some staff expertise to a CISL-wide effort aimed at improving the performance of NCAR flagship models on Yellowstone with an eye toward preparing the models for future systems. These models included the Community Earth System Model (CESM), the Weather Research and Forecasting model (WRF), and Model Prediction Across Scales (MPAS). The Consulting Services Group also

continued to support users of these models on the Yellowstone system and taught training courses for users of CISL's supercomputing, storage, and data analysis and visualization resources.

CISL tracks user support activity for this growing community using an ExtraView trouble ticket system. In FY2014, the ticket system recorded 12,335 tickets to the CISL Help Desk, a 6% decrease from the FY2013 total. The average number of log entries per ticket was 4.38, and communication with users was highest on complex cases. Of the total tickets submitted, the Help Desk team closed 2,991 tickets in an average of 3.56 days (median, 0.90 days), or 250 per month on average. The increase from FY2013 is largely due to increased responsibilities related to allocation requests. In the same interval, Consulting Services staff resolved 1,774 more complex requests with an average response time of 13.2 days (median, 5.72 days). An additional 545 user support tickets were fielded related primarily to managing allocations and accounting, with an average response time of 7.62 days (median, 0.79 days).

This work supports CISL's computing imperative to provide hardware cyberinfrastructure customized for the atmospheric and related sciences. This ongoing service for users is supported by NSF Core funds including CSL funding.

‹ Special computational campaigns up User documentation ›

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Select year

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USER DOCUMENTATION

Preparing new documentation, reviewing and updating other content, and communicating changes to help the user community compute efficiently on Yellowstone and other CISL-managed systems continued to be a major focus of the User Services Section (USS) staff in FY2014.

While documenting new systems such as Pronghorn and systematically reviewing other content to ensure its continued accuracy, relevance, and timeliness, USS staff created or updated more than 120 web pages in FY2014. In addition to those activities, USS reviewed and revised approximately 320 documentation pages to accommodate a new site design that was introduced. The website pages that support users' computation and data management efforts received 117,000 unique page views in FY2014.

Queue	Wall clock	Job size (# cores)	Priority	Queue factor	Notes
geyser	24 hours	1-39	2	1.0	Interactive and batch use; shared nodes
bigmem	6 hours	1-640	2	1.0	Interactive and batch use, exclusive; jobs charged for all 40 cores on each node used; daytime limit of four nodes
caldera	24 hours	1-15	2	1.0	Interactive and batch use; shared nodes
gpgpu	6 hours	1-256	2	1.0	Interactive and batch use, exclusive; jobs charged for all 16 cores on each node used; daytime limit of four nodes
hpss	24 hours	1	1	0	For HPSS and external data transfer only
The geyser and bigmem queues use nodes in the Geyser cluster. The caldera and gpgpu queues use nodes in the Caldera cluster.					

This table shows which job-submission queues are available to users of the Geyser and Caldera clusters. The details help them determine which queues are most appropriate for their visualization and analysis jobs. Such documentation contributes to efficient use of the users' allocations.

USS introduced new and enhanced documentation to support users' work on each system in the Yellowstone environment, from computing to file systems to long-term data storage. Examples of new content development include:

- Launching coarray programs for parallel computing
- Using the NCAR Data Sharing Service
- Transferring files to Google Drive and Dropbox archives
- Using the Pronghorn computing cluster and the Colorado School of Mines BlueM system

USS continued efforts that were initiated in FY2012 to increase awareness of the many information and training assets that

it provides to users. Significant updates or additions to documentation and training resources are publicized routinely in the CISL Daily Bulletin, an important tool for keeping the user community informed. USS also extended its communications reach by repurposing Daily Bulletin announcements and other web content for distribution to community members via CISL and UCAR social media accounts on platforms including Twitter, Google+, and Facebook.

This work supports CISL's computing imperative to provide hardware cyberinfrastructure customized for the atmospheric and related sciences. This ongoing service for users was supported by NSF Core funds including CSL funding.

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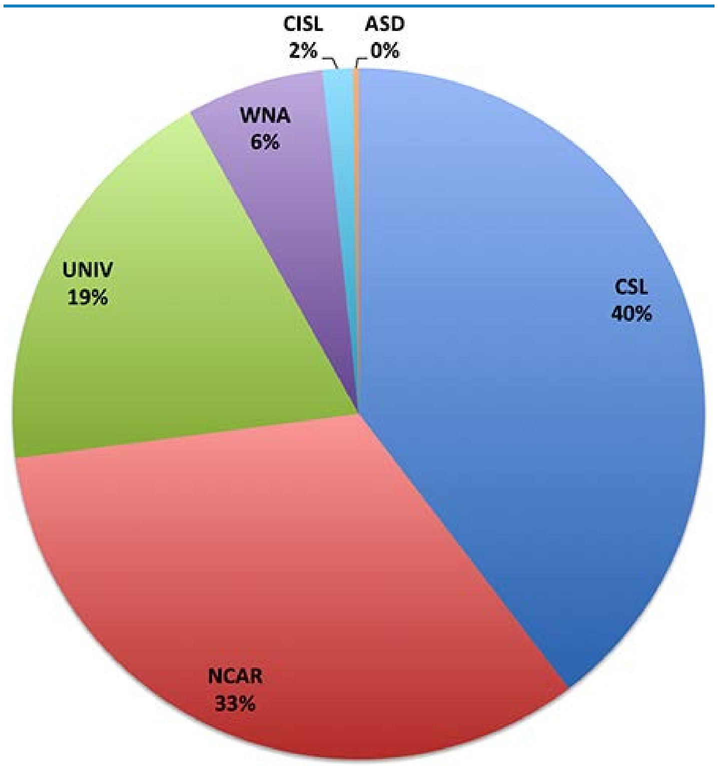
ALLOCATING SUPERCOMPUTING RESOURCES

CISL works to provide equitable and efficient access to reliable computing resources for several distinct communities of researchers in the atmospheric and related sciences, including the broad university community, Climate Simulation Laboratory (CSL) users, NCAR researchers, and with the arrival of Yellowstone, University of Wyoming researchers. CISL manages several allocation processes to distribute resources and ensure access by the most meritorious projects, and FY2014 represented a full year of Yellowstone running in production mode and supporting a growing user community with rapid turnaround for their research efforts.



The FY2014 usage of Yellowstone by CISL's major user communities showed a slight drop in University usage with the end of the Accelerated Scientific Discovery program. The portion identified as "CISL" represents a significant reduction in use by CISL and IBM staff to evaluate performance and troubleshoot system problems.

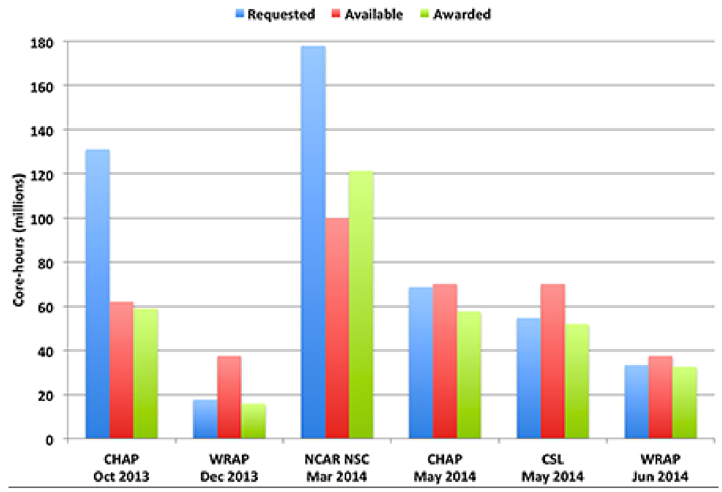
About 28% of Yellowstone is available to the CSL at NCAR; in FY2014, the CSL review process was integrated into the responsibilities of the CISL HPC Allocation Panel (CHAP), which continued to review University allocation requests. CSL projects engage researchers funded by NSF awards to pursue climate-related science questions requiring large-scale simulations of Earth's climate system.

Approximately 29% of Yellowstone is available to U.S.-based University researchers with NSF awards in the atmospheric or related sciences. University requests are reviewed twice per year by the CHAP. In October 2013 and May 2014 combined, the CHAP reviewed 70 requests for 200 million core-hours on the Yellowstone system. University researchers also submitted more than 230 small allocation requests during FY2014, indicating growing interest in the new system. CISL also offers the university community access to the Janus cluster, which was deployed as part of a collaboration between the

University of Colorado and NCAR.

A comparable portion (29%) of Yellowstone is also allocated to NCAR researchers in support of the computational needs of the NCAR laboratories. NCAR activities include NCAR Strategic Capability (NSC) projects, which are reviewed by a panel of NCAR computational scientists and approved by the NCAR Executive Committee. The inaugural NSC projects completed in April 2014, and the second round of projects began in May.

The Wyoming-NCAR Alliance (WNA), which targets geosciences collaborations among the University of Wyoming, NCAR, and institutions in other EPSCoR states, convened the Wyoming Resource Allocation Panel (WRAP) in December 2013 and June 2014. In FY2014, the WNA established eight large projects for 48 million core-hours, along with seven small allocations; 22 different WNA projects used nearly 30 million Yellowstone core-hours.



The FY2014 allocation opportunities showed the user communities' strong demand for the Yellowstone system. Core-hours available to the University community reflect modestly reduced availability due to prior allocations made before Yellowstone's arrival.

This work supports CISL's computing imperative to provide hardware cyberinfrastructure customized for the atmospheric and related sciences. This ongoing service for users is supported by NSF Core funds including CSL funding. The Janus cluster is supported by NSF MRI Grant CNS-0821794, with additional support from the University of Colorado and UCAR non-federal funds. The Wyoming Resource Allocation Panel (WRAP) is supported by funding from the University of Wyoming.

‹ User documentation up Earth System Model support ›

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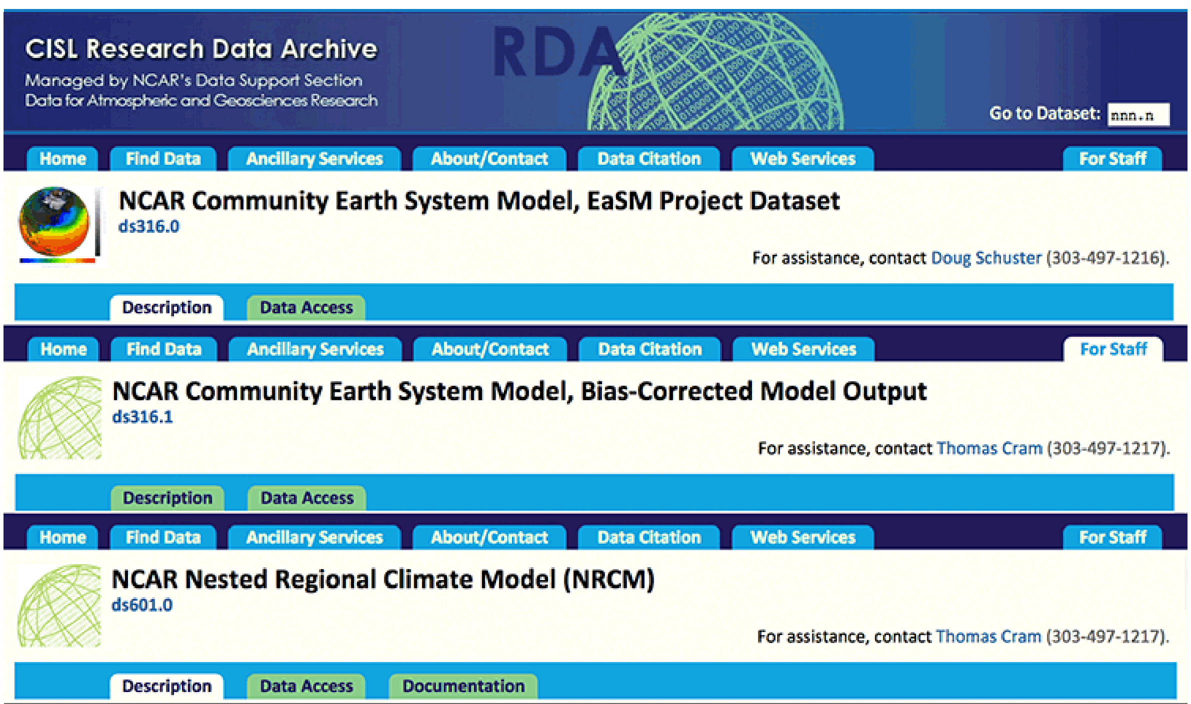
EARTH SYSTEM MODEL SUPPORT

To support NSF grant winners from the Decadal and Regional Climate Prediction Using Earth System Models (EaSM) program, CISL partnered with the NCAR Earth System Laboratory (NESL) to offer enhanced data and modeling support to this community, and CISL provides a coordinated EaSM entry point for this service.



This figure is an image of three Research Data Archive data sets that support the NSF-funded EaSM projects. First, the NCAR Community Earth System Model (CESM) has global 3D atmospheric and surface data grids coverage, with simulations for 20th Century (1950–2005) and three concomitant Representative Concentration Pathway future scenarios spanning 2005–2100. Second is the NCAR CESM dataset after refinements that help the model output agree more closely with observational datasets. Third, the NCAR Nested Regional Climate Model combines the strength of NCAR's Weather Research and Forecasting (WRF) model and the Community Climate System Model to make climate change simulations for the North Atlantic Ocean and

Following guidance from NCAR scientists, a selection of global and regional model outputs have been identified and are available as datasets in the Research Data Archive (RDA). The datasets are:

- The NCAR Community Earth System Model (CESM) output with 6-hourly data for a 20th Century run (1950–2005) and three Representative Concentration Pathway (RCP) future scenarios spanning 2005–2100.

USA in periods 1995–2005, 2020–2030, and 2045–2055.

- A bias-corrected version of the CESM dataset.
- The NCAR Nested Regional Climate Model (NRCM) data output that covers the North Atlantic Ocean and the U.S. with greater fidelity than CESM and for periods 1995–2005, 2020–2030, and 2045–2055.

All these data are offered as downloadable filesets, through GUIs that allow users to make spatial, temporal, and parameter selections, and interoperably into analysis tools that support access from Thematic Realtime Environmental Distributed Data Services (THREDDS) Data Servers (TDS). The CESM and NRCM collections are supporting user activities: cumulatively, 46 unique users have downloaded files with a total size of 17 terabytes, and 19 unique users have submitted 89 requests for customized subsets. To fill these requests, CISL has processed 35 terabytes of data to produce 1.5 terabytes of needed products, indicating the value of server-side data processing in advancing research work. The bias-corrected CESM dataset is in the early stages of preparation and will be online soon.

In FY2014, the CISL Consulting Services Group (CSG) and NESL development teams for CESM and NRCM continued to offer user support for EaSM awardees. Through EaSM support, CSG was able to offer individualized help for porting and installing community codes at or outside NCAR. Through Yellowstone allocations, CISL also supported the science objectives associated with 17 different EaSM awards. In FY2015, CISL's EaSM support will transition to focus on the optimization and performance of the CESM and WRF models in an effort to improve the scientific productivity of all model users on CISL's current and future HPC systems.

The EaSM support effort received one-time NSF funding to augment NWSC resources and is receiving NSF Core funding.

‹ Allocating supercomputing resources up Optimizing model performance for current and future supercomputer architectures ›

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OPTIMIZING MODEL PERFORMANCE FOR CURRENT AND FUTURE SUPERCOMPUTER ARCHITECTURES

In recent years, the amount of performance that can be extracted from supercomputers through optimization has become at least as important as the continued shrinking of transistor size or improvements in the packaging and networking performance of high-performance systems. Significant trends driving this trend include the stagnation or even reduction of the speed of a single thread of execution, the aggressive introduction of vector/SIMD instruction sets, the increased core-count per processor socket which requires careful parallel programming to properly utilize, and the introduction of heterogeneous architectures composed of both conventional processors and accelerator coprocessors.

In FY2014 CISL responded by significantly augmenting its efforts to optimize NCAR codes, focusing first on NCAR's community models. This strategic optimization thrust is two-pronged, with one effort (called SPOC) aimed at optimizations for Yellowstone-like systems (i.e., conventional processors) and a second (called IPCC-WACS) housed in TDD's ASAP group focused on the future challenges of the accelerator space.

Strategic Parallel and Optimization Computing (SPOC) initiative

In FY2014 CISL launched the Strategic Parallel and Optimization Computing (SPOC) initiative. SPOC is an NCAR-wide effort to increase the performance and efficiency of NCAR's community codes – CESM, WRF, and MPAS – on Yellowstone and prepare these application for future architectures. CISL is identifying additional resources for this work and embedding them directly with the model development teams. Key activities this year include:

- Chartered the SPOC initiative with broad support from NCAR scientific and executive leadership.
- Allocated a member of CISL's Consulting Services Group group to work directly with the CESM team in CGD on a systematic profiling and benchmarking effort aimed at identifying modules that are targets for optimization.
- Brought in an external optimization expert to work with the MPAS/WRF development team. The effort had a measurable, positive impact on model performance.
- Acquired licenses for the Allinea DDT debugger and profiling tool, and provided two training workshops. This was identified as a key requirement in advancing the NCAR optimization tool chain.

The SPOC initiative is supported by NSF Core funds.

Intel Parallel Computing Center focused on Weather and Climate Simulation (IPCC-WACS)

Also in FY2014, CISL and the University of Colorado Boulder (CU Boulder) received funding from Intel, Inc. to form an Intel Parallel Computing Center (IPCC) focused on Weather and Climate Simulation (IPCC-WACS). Participation in the IPCC program will enable NCAR and CU to develop methods to increase the performance of atmospheric applications that use advanced microprocessor technologies, such as Xeon Phi, and will help train the next generation of scientists and engineers who will apply these new technologies to challenges of societal importance. The Indian Institute of Science in Bangalore, India, will also collaborate with the NCAR/CU Boulder team on the project.

The NCAR/CU team is focused on weather and climate applications, including the Community Earth System Model (CESM), the Weather Research and Forecasting model (WRF), and the Model for Prediction Across Scales (MPAS), three of the most widely used applications in the field. All three are large Fortran-based simulation codes – for instance, CESM is estimated to have about 1.5 million lines. One of the primary focuses of the project is on the development of a performance enhancement methodology to accelerate application refactoring. This methodology will consist of automated porting and optimization tools designed to speed up the code refactoring process, such that it can keep up with science-driven model developments. In the first year of IPCC-WACS, funding has been used to develop (1) the Kernel Generator, an automated unit test generator written in Python and based on the F2PY Fortran parsing tool, and (2) the OpenCase tool, a generator of optimized source code that performs source code translation, compiler flag selection, logs performance results, and provides automatic case generation to encapsulate expert optimization knowledge.

The IPCC-WACS project is currently hiring another computational scientist to work with students newly hired by CU to begin applying these refactoring tools to key subcomponents of NCAR applications.

The IPCC-WACS project is funded by a donation from Intel Corporation.

‹ Earth System Model support | up | CISL's Big Data services and software tools ›

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2014 CISL ANNUAL REPORT

- CISL Director's message
- CISL Services
  - CISL computing facilities
  - CISL hardware cyberinfrastructure services
  - CISL supercomputer user services
  - CISL's Big Data services and software tools
    - Research Data Archive
    - Science gateway services
    - Data Assimilation Research Testbed software
    - NCL data analysis and visualization software
    - VAPOR visualization software for very large datasets
  - CISL's enterprise architecture
- CISL Science
- CISL Education, Outreach, and Training
- Broader Impacts

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
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CISL’S BIG DATA SERVICES AND SOFTWARE TOOLS

CISL provides our research community with “Big Data” tools and services for locating, accessing, and analyzing a variety of observational and model research data collections. These data are served through data gateways over high-speed wide-area networks and are also accessible from disk and tape storage on the Yellowstone computing complex. These tools and services combine to support our communities’ efforts to extract scientific knowledge from the petabytes of data available on NCAR’s cyberinfrastructure. These tools and services include:

- Research Data Archive (RDA) – The climate and weather research communities’ data needs continue to grow, so CISL adds new content and access features to the RDA. More than 11,000 unique users acquire 1.1 petabytes of data yearly through the RDA web portal. In addition, hundreds of internal users access substantial amounts of data directly from GLADE.
- Data Gateways – Data gateways expand scientific collaboration by connecting research communities and new climate data consumers with data products and tools. The Science Gateway Framework (SGF) is a unified portal for scientific data users, and it helps researchers use new supercomputing environments. The SGF underlies CISL’s NCAR Earth System Grid, the ACADIS Arctic Data Repository, and the Community Data Portal.
- Data Assimilation Research Testbed (DART) software – DART supports community researchers and improves their prediction skill for and understanding of the Earth System by collaboratively developing and applying data assimilation methods across a wide range of geophysical problems.
- Data Analysis Tools – CISL’s portfolio of data analysis tools provides an ever-growing community of scientists with unique capabilities tailored to the disciplines we serve. The scalability and performance of these tools are increasingly important in the era of Big Data. The Visualization and Analysis Platform for Ocean, Atmosphere, and Solar Research (VAPOR) offers the capability to efficiently explore enormous or complex 3D data sets. The NCAR Command Language (NCL) is an open source scripting language for geoscientific data analysis and visualization. NCL reads and writes several geoscientific data formats and creates publication-quality graphics. PyNIO and PyNGL are Python modules built on top of NCL’s component libraries, providing Python users with the same file I/O and visualization capabilities as NCL. PyAOS is an atmospheric and oceanic-based computational library with contributing partners from universities, national laboratories, and commercial enterprises.
- NCAR Data Sharing Service via Globus Plus – NCAR’s Data Sharing Service uses Globus Plus to augment CISL’s existing Globus-based data transfer services with user-managed big-data sharing capabilities.

Through parallelism, end-to-end workflows employing these tools and services are used by scientists to produce results more quickly and to a broader audience of researchers.

The funding for each of these efforts is specified in the sections below.

‹ Optimizing model performance for current and future supercomputer architectures | up | Research Data Archive ›

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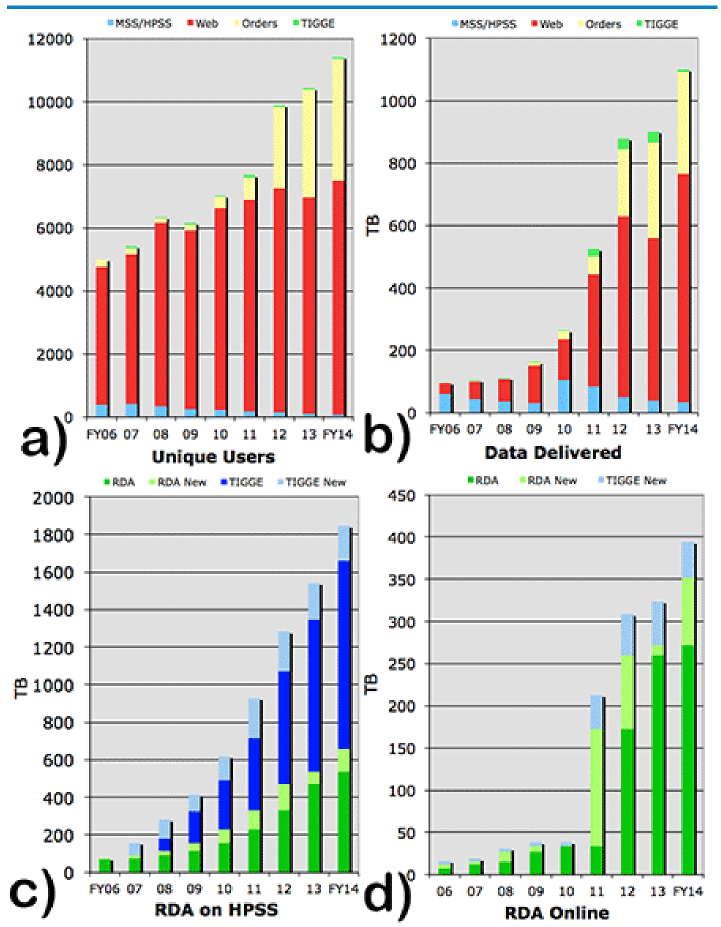
RESEARCH DATA ARCHIVE

The Research Data Archive (RDA) is a key part of CISL's computing imperative for data curation and provision. It provides a rich information resource through a large and growing collection of datasets that support scientific studies in climate, weather, Earth System modeling, and increasingly, other related sciences. The RDA is developed to serve the research needs at NCAR and in the associated UCAR community, but since it is an open resource, the global community also uses it. RDA activities can be viewed from two different perspectives: user data access and archive content development, both of which are equally important.



These charts show the data access and growth metrics for the Research Data Archive during FY2006-FY2014. a) The number of unique RDA users specified by access pathway: the NCAR HPSS, publicly available web servers, one-time special requests (orders) prepared for individual users, and TIGGE. b) The amount of data delivered to customers, by access pathway. c) The amount of data in the HPSS archive, showing annual growth and not including backups. d) The amount of data on public web servers, showing annual growth.

In FY2014, over 11,000 unique persons were provided about 1.1 petabytes of data through various primary access pathways: the NCAR HPSS, public servers on the web, one-time special requests prepared for individuals, and the THORPEX (THe Observing system Research and Predictability EXperiment) Interactive Grand Global Ensemble (TIGGE) archive (see charts a and b). The number of unique users increased steadily from 2012 through 2014. One-time requests (subsetting, format conversion, and HPSS file restaging to disk) and full file downloads increased. CISL is making it easier for users to access terabyte-sized archives on their own. Orders were automatically prepared for over 3,800 individuals, and they received 328 terabytes of data. Web users form the largest group, with 7,400 people downloading 730 terabytes of data. There are fewer users of the HPSS (88 requesting 32 terabytes) and TIGGE (57 requesting 7 terabytes) services. The newest and most-used RDA collections are directly available from GLADE to the HPC environment. We currently cannot estimate the metrics for this pathway, but it is substantial because the access from the HPSS (tape-based) has dropped, and anecdotally, our local users are pleased. These metrics indicate that the RDA is an

important growing data resource for a broad community.

Charts a) and b) indicate the RDA's significance to the community, and charts c) and d) show the annual progress toward building more valued content into the RDA.

The RDA content expanded by over 118 terabytes in FY2014 (see chart c). TIGGE is part of the RDA, but it is shown separately because it alone added about 186 terabytes. The complete RDA is now over 1.8 petabytes, and over 390 terabytes of it is readily available via GLADE (chart d), a 70-terabyte increase relative to the previous year. TIGGE is shown separately, and although it is capped at a rolling three-month archive, it is about 50 terabytes. NCAR users can access the portion of the RDA not available on GLADE directly from the HPSS, and the Data Support Section provides automated procedures to assist outside users with data access from HPSS.

The RDA is constantly changing. Curation extends and adds to existing datasets, and stewardship improves the documentation, creates systematic organization, applies data quality assurance, and develops user access. Many routine tasks and background infrastructure developments are necessary to maintain the RDA. Major accomplishments for FY2014 include:

- Operated and maintained the TIGGE archive and access on a 24×7 basis, and updated over 70 ongoing observational, operational model, and reanalysis dataset collections.
- Expanded automated systems that use CISL HPC and GLADE to give users better access to terabyte-sized datasets. More than 38,000 individual data requests were processed.
- Further supported NSF grant winners from the Decadal and Regional Climate Prediction Using Earth System Models (EaSM) program by adding the NCAR Bias-corrected 6-hourly Community Earth System Model data to the RDA.
- Improved the NCAR Upper Air Database by publishing four distinct global products spanning 1924-2014 and initiated a monthly update cycle.
- Added significant reanalysis data assets to the RDA:
  - The 30-kilometer Arctic System Reanalysis dataset (2000-2012).
  - The Japanese Meteorological Agency 55-year Reanalysis.
  - NCAR Global Climate Four-Dimensional Data Assimilation 40km Reanalysis.
- Expanded Thematic Realtime Environmental Distributed Data Services (THREDDS) Data Server (TDS) to over 16 popular GRIB and NetCDF-formatted datasets, creating metadata and data access with scientific tools using standard interoperable protocols such as Open-source Project for a Network Data Access Protocol (OPeNDAP).
- Increased formal data citation potential by assigning and maintaining DOIs on 17 RDA datasets.
- Broadened the RDA Geoportal search to include data discovery simultaneously with assets from ArcGIS.com, NODC, NGDC, and NCDC.
- Finalized a new data distribution agreement with ECMWF: except for the high-resolution operational analysis, all products can now be provided worldwide.

The RDA is nationally and internationally respected for its staff, data management practices, consulting services, and ability to positively affect outcomes in the data arena. This position is advantageous to building collaborations that continually strive to provide better scientific data resources and access.

RDA maintenance and development within CISL are almost entirely supported by NSF Core funding. A small NOAA grant supplemented development of ICOADS.

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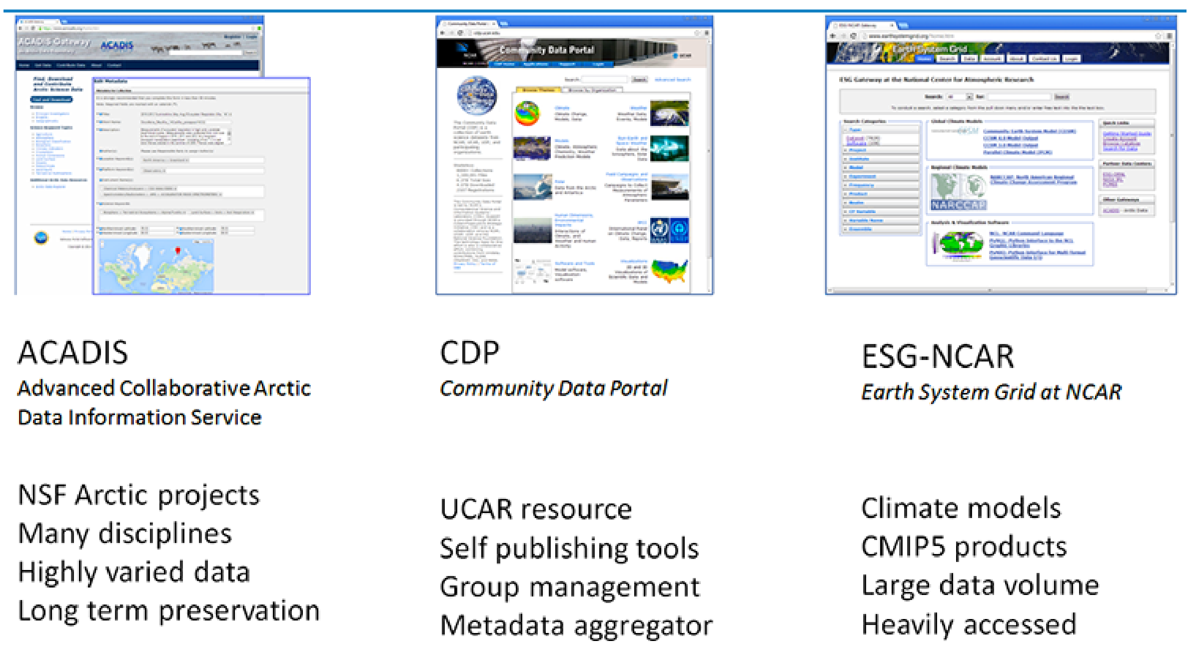
SCIENCE GATEWAY SERVICES

CISL builds and operates science gateways that provide sustainable access to shared cyberinfrastructure for diverse scientific communities. Our projects and initiatives span climate science, regional climate change, Arctic science, solar science, digital preservation, and international efforts to develop metadata and knowledge infrastructure. Many of these efforts are tied to major interagency, national, and international initiatives, including, for example, the World Meteorological Organization (WMO), the Intergovernmental Panel on Climate Change (IPCC), the International Polar Year (IPY), the World Climate Research Program (WCRP), and the Library of Congress' National Digital Information and Infrastructure Preservation Program (NDIIPP). Most of these projects use open-source web-portal infrastructure called the Science Gateway Framework (SGF -- see CISL FY2013 Annual Report for details). CISL's contributions to this suite of science gateway services is supported through NSF Core funding and augmented by special funding as noted below.



Shown here are three prominent science gateway services operated by CISL. These operational systems provide access to shared data management cyberinfrastructure for diverse scientific communities from petascale "big head science" to small individual investigator-based projects. Combined, these services support over 1,000 active users monthly with annual downloads of over 1.5 petabytes.

Our contributions to science gateways support CISL's computing imperative for software cyberinfrastructure by maintaining, operating, and supporting software specific to the simulation, analysis, and forecasting needs of the atmospheric and related sciences. They also address CISL's computing frontier for center virtualization by operating science gateways and other Grid-based

technologies that provide critical cyberinfrastructure (CI) to broad communities. Finally, operational services provided for the NCAR Earth System Grid gateway (ESG-NCAR), ACADIS, WMO, and other collaborations address CISL's strategic action item to meet the challenges posed by large and heterogeneous environmental data, and to establish metadata standards for diverse collections of data and models.

Detailed updates on our portfolio of science gateway services follow:

Earth System Grid Gateway at NCAR (ESG-NCAR)

CISL operates the ESG-NCAR gateway that provides data discovery and access services for global and regional climate model data, knowledge, and software. The ESG-NCAR gateway participates in the Earth System Grid Federation (ESGF), which is a globally distributed petascale data management environment for CMIP5/IPCC-AR5 and U.S. climate science. The ESG-NCAR gateway supports community access to data products from many of NCAR's modeling efforts, including IPCC-AR4, IPCC-AR5, PCM, AMPS CESM, and the NARCCAP data products. The ESG-NCAR gateway is heavily used, has over 43,000 registered users, and each month delivers over 60 terabytes of scientific data to the community.

In FY2014, the ESG-NCAR gateway capabilities were extended primarily to support simpler end-user data product access, openly available data collections, performance of data publication, and use metrics capture. CISL also provided considerable end-user support through the ESG-NCAR help desk, answering over 200 end user inquiries in FY2014. We continued to refine our Agile software development process in FY2014, with frequent releases enabling more continuous user feedback, with 25 software versions. Other 2014 accomplishments include adding OpenDAP and NetCDF Subsetting services to open data collections, refactoring many URLs to RESTful forms, and streamlining data download scripts and simplifying end user access to secured data.

In FY2014, CISL installed an Earth System Grid Federation Index Node to extend CMIP5 and related data collection access to the ESGF. The ESGF Index Node provides an alternative access point to on-disk data collections by participating in the federated search mechanism of the ESGF, and it expands access to an even larger community of international users.

CISL continued to work closely with NESL and other data managers to process and publish data products from the AMPS, CESM, CCSM3/4, NARCCAP, and NMME projects. Over 400 terabytes were published to ESG-NCAR during FY2014, raising the full volume of ESG-NCAR to 2.7 petabytes and 3.8 million files.

NSF Core funds support the operational ESG-NCAR gateway as well as special funding from the National MultiModel Ensemble (NMME) project.

Advanced Cooperative Arctic Data and Information Service (ACADIS)

ACADIS is a collaboration between CISL and NCAR's Earth Observing Laboratory, the National Snow and Ice Data Center, and Unidata. ACADIS is a community data service that provides project data management planning, data archival, preservation, and access for all projects funded by NSF's Arctic Science Program (ARC). CISL's contributions to ACADIS include the ACADIS gateway, which provides an end-to-end service where NSF-supported data providers can publish their data collections and make them available to the broad community of researchers.

Accomplishments in FY2014 include adding REST-based file management APIs, extending ISO-19115 metadata record support, integrating the Unidata Rosetta metadata authoring tool, and augmenting search results with harvested metadata records from the ACADIS Arctic Data Explorer metadata aggregator. Also in FY2014, the data provider workflow was significantly enhanced based on end user feedback and usability studies to provide easier and faster metadata authoring, bulk file upload, and efficient re-edit of metadata records. The ACADIS gateway supports a community of over 200 principal investigators and receives an average of 50 provider-self-published datasets monthly.

The ACADIS project is supported by NSF Core and NSF Special funds.

Community Data Portal (CDP)

The CDP offers a broad range of scientific data collections that includes observations, climate, atmospheric chemistry, space weather, field programs, models, analyses, and more. Many programs and projects at NCAR, UCAR, and UCAR

Community Programs (UCP) are represented in the portal. CDP provides a self-publishing model that offers data management tools directly to projects and PIs. Roughly 2,100 registered CDP users are discovering, accessing, and using 8,000 collections representing over 6.5 terabytes of managed data holdings. Data discovery is enhanced worldwide by automatically sharing these metadata with other portals and international centers.

In FY2014 we identified high-use data collections that we plan to migrate to the actively developed ESG-NCAR science gateway, providing a forward support path for this important service. In FY2014 we continued to provide operational support and critical bug fixes for CDP.

CDP is supported by NSF Core funding.

North American Regional Climate Change Assessment Program (NARCCAP)

This project shares regional climate simulation data with a community of over 800 users via the ESG-NCAR gateway. NARCCAP is an international program that supports regional climate assessments for the U.S. and Canada. The assets are nine high-resolution regional model outputs forced by various global models and provided by multiple PIs. The core software CI is now mature, and the archive continues to grow as experimental runs are completed and published via the ESG-NCAR gateway.

In FY2014, NARCCAP-published data volume grew from 33 to 39 terabytes in managed holdings. The data collections were made openly available, with OpenDAP and NetCDF Subsetting web services added. CISL contributed by supporting operations, data publication, and implementing user interface enhancements.

CISL’s contributions to NARCCAP are supported by NSF Core funding.

Chronopolis: Federated Digital Preservation over Space and Time

There is a critical and growing need to organize, preserve, and make accessible the increasing number of digital holdings that represent vital intellectual capital, much of which is precious and irreplaceable. Chronopolis is a strategic collaboration among the San Diego Supercomputing Center (SDSC, lead organization), NCAR/CISL, the University of California Library System, and the University of Maryland. It is aimed at developing national-scale digital preservation infrastructure that has the potential to broadly serve any community with digital assets for science, engineering, humanities, and more. In addition to community collections, Chronopolis CI is being used to provide digital preservation services for the ACADIS project.

In FY2014, CISL established a second Chronopolis node for system integration testing of the next major revision of the Chronopolis CI software stack. CISL continued to provide operational support of the NCAR storage node which currently manages 52 terabytes and over 2.3 million managed objects.

This gateway data preservation service is supported by the Chronopolis project.

WMO Information System (WMO-WIS)

CISL contributes to developing the World Meteorological Organization (WMO) Information System (WIS). Under the auspices of the United Nations, the WMO is designing, developing, and deploying WIS as a next-generation globally federated information system for weather, climate, hydrology, oceanography, and many other disciplines. CISL plays a strong role in the management and technical direction of WIS and has contributed ideas, strategies, and services developed through our work with CDP, ESG, ACADIS, and TIGGE. CISL staff have served on several WIS committees, recently including the Expert Team on WIS Centres (ET-WISC), the Task Team of Data Centres (TT-DC), and the Task Team on WIS Centre Audit Certification (TT-CAC).

In FY2014, CISL extended the Science Gateway Framework capabilities to support rich WMO-ISO metadata records for ingest into the WMO Global Information System. CISL science gateway metadata is harvested by the U.S. National Weather Service (NWS) Global Information System Center (GISC) nodes via the WMO Information System (UN/WMO WIS).

CISL’s WMO-WIS efforts are supported by NSF Core funding.

‹ Research Data Archive | up | Data Assimilation Research Testbed software ›

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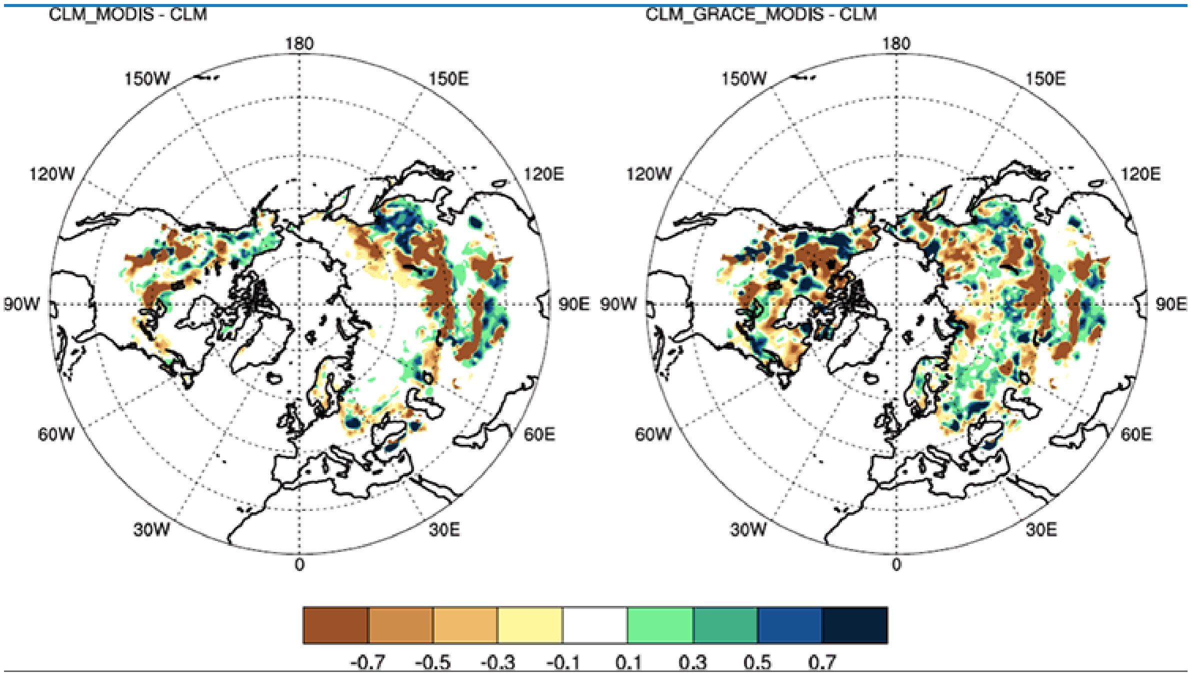
DATA ASSIMILATION RESEARCH TESTBED SOFTWARE

Data assimilation is providing rapid advances in geophysical studies. The Data Assimilation Research Section (DAReS) of IMAGe develops and maintains the Data Assimilation Research Testbed (DART), a software facility for ensemble data assimilation. DAReS also provides support to a growing community of NCAR, university, and government laboratory partners who apply ensemble data assimilation methods with DART.



The changes in normalized bias of the total snow water equivalent from DART/CLM assimilations using MODIS snow cover fraction observations (left panel) and using MODIS and total water storage observations from the GRACE satellites (right panel) for March 2003. The bias is compared to independent estimates of snow cover from the Canadian Meteorological Centre. GRACE provides information for all regions, while MODIS observations only provide information in regions near the snow cover boundary. Recent enhancements to DART software allow scientists like graduate student Yongfei Zhang at the University of Texas (who provided these figures) to assimilate a variety of remote sensing observations with CLM.

CISL's data assimilation research supports CISL's computing imperative for software cyberinfrastructure. Further, developing and supporting the capabilities of the DART facility is specified as a strategic action item in the CISL Strategic Plan.

The efficiency of DART assimilations with Community Earth System Model components was increased dramatically in FY2014 by developing software to enable multiple DART/CESM assimilation cycles in a single job. Time spent waiting in the queue was reduced by an order of magnitude, and the core hours spent archiving were reduced from 10-35% of the total job cost to approximately 1%.

Software interfaces between DART and several land surface and hydrology models were completed or enhanced in collaboration with the model development teams. New interfaces were created for the Community Atmosphere Biosphere Land Exchange (CABLE) model and for the WRF-Hydro hydrological modeling system. The software interfaces to the Community Land Model component of CESM were enhanced to allow observations to impact a more comprehensive set of model variables.

In collaboration with the Naval Research Laboratory, an interface between DART and the Navy Atmospheric Aerosol Prediction System (NAAPS) was completed and initial assimilation tests have been performed. Enhancements were also made to the DART interface to the CAM/CHEM chemistry model component of CESM.

A DART interface to the ROMS regional ocean model was developed by scientists at Rutgers University in collaboration with DAReS scientists. The DART interfaces to the TIEGCM upper atmosphere model were revised to allow enhanced functionality.

Data assimilation research in IMAGe is supported by NSF Core funding, National Oceanographic Partnership Program Grant G0776112, and NSF Grant CNS1035250.

‹ Science gateway services | up | NCL data analysis and visualization software ›

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- CISL Director's message
- CISL Services
  - CISL computing facilities
  - CISL hardware cyberinfrastructure services
  - CISL supercomputer user services
  - CISL's Big Data services and software tools
    - Research Data Archive
    - Science gateway services
    - Data Assimilation Research Testbed software
    - NCL data analysis and visualization software
    - VAPOR visualization software for very large datasets
  - CISL's enterprise architecture
- CISL Science
- CISL Education, Outreach, and Training
- Broader Impacts

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research

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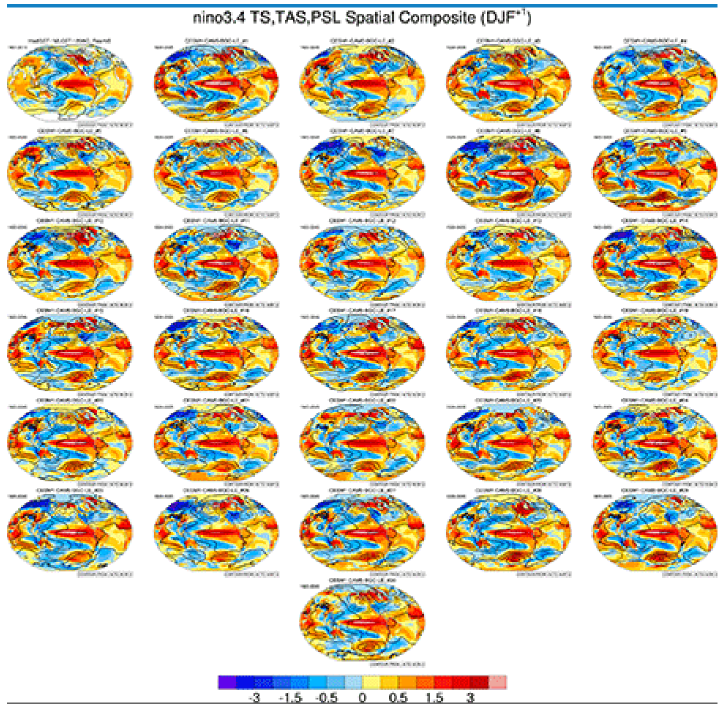
NCL DATA ANALYSIS AND VISUALIZATION SOFTWARE



This figure (click for full size then click again to magnify) is from the Climate Variability Diagnostics Package (CVDP) which is developed and maintained by NCAR's Climate Analysis Section. The CVDP provides quick-look plots of the major modes of climate variability in models and observations. A unique feature of the CVDP is the ability to specify both CESM and non-CESM models for comparison, as well as the ability to choose particular observational data sets and time periods for analysis. This particular figure shows ENSO spatial composites of sea level pressure (contours) and temperature (shaded) comparing observations (upper left panel) to the 30-member CESM1 (CAM5) Large Ensemble Community Project. NCL scripts written by Adam Phillips are used to generate all of the CVDP figures.

The NCAR Command Language (NCL) is a data analysis and visualization environment developed primarily at CISL in deep collaboration with a number of core scientific groups. NCL enables scientists to easily and effectively read, analyze, and visualize their geoscientific data on platforms ranging from personal laptops to high performance computers. PyNIO and PyNGL are Python modules based on NCL's file input/output and visualization capabilities, thereby offering NCL's software components to a wider and more mainstream user base. The NCL and Python tools have been embraced broadly across the international Earth System sciences community spanning research, education, operational, military, government, and commercial organizations.

NCL, PyNIO, and PYNGL are used for data analysis and display to generate publication-quality visualizations for journals, for post-processing and comparing data from a wide range of Earth System models, for real-time data access and display at operational centers, and by hundreds of graduate students as the primary tool for their research. Critical to the importance of these tools is that they are free, well supported, and run across a wide variety of UNIX systems, allowing students and scientists to continue their research uninterrupted as they change organizations.

In FY2014, the NCL team released two versions of NCL. One was a major release that contained significant speedup for internal visualization routines via OpenMP and code refactoring, better contouring of the hexagonal MPAS grid (a component of CESM and WRF), and better support for complex NetCDF-4 file features and large GRIB2 files. Major enhancements to PyNGL and PyNIO were incorporated to add a suite of WRF computational functions, to incorporate NCL's new color capabilities, and to support complex NetCDF-4 and HDF5 structures. PyNIO was successfully coupled with MPI4PY

to provide file read parallelism for several CESM-based files (CAM FV/SE, CICE, POP, CLM). Beta versions of future releases of PyNIO and PyNGL were given to users for early testing. A test version of an interactive tool, which uses NCL for file I/O and OpenGL for graphics, was released to CESM researchers for rapid look at large CAM spectral element grids.

A three-year joint project (ParVis) with Argonne National Laboratory and several other organizations to parallelize components of NCL for ultra-large climate datasets (ParNCL) reached its final year, and a beta version was released to friendly testers in summer 2014.

There were 21,791 downloads of NCL, PyNGL, and PyNIO software in FY2014 by 4,472 unique users. Our email lists had 4,045 total postings in FY2014 on 1,363 unique subjects.

This work advances one of NCAR's goals to support, enhance, and extend the capabilities of the university community and the broader scientific community both nationally and internationally. It also addresses CISL's strategic imperative for software cyberinfrastructure through developing and supporting software specific to the simulation, analysis, and forecasting needs of the atmospheric and related sciences. Specifically, this effort fulfills CISL's strategic action item to continue the support and development of community data analysis and visualization software.

Our core development and maintenance of NCL and Python tools is primarily supported by NSF Core funding, while the ParVis project was supported by the U.S. Department of Energy Office of Science's Biological and Environmental Research Division under grant DE-SC0005358.

‹ Data Assimilation Research Testbed software   up   VAPOR visualization software for very large datasets ›

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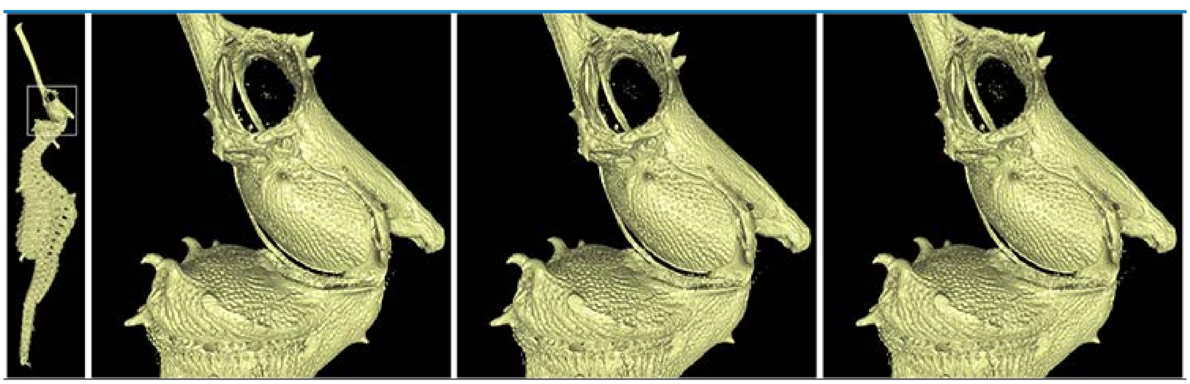
VAPOR VISUALIZATION SOFTWARE FOR VERY LARGE DATASETS

The Visualization and Analysis Platform for Ocean, Atmosphere, and Solar Researchers (VAPOR) project is an open source software development effort aimed at improving the ability of researchers in the Earth System sciences to analyze and interpret results from some of the largest numerical simulation outputs. The genesis of this work was an NSF-ITR research grant that supported CISL as well as collaborators at the University of California at Davis and the Ohio State University. VAPOR has transitioned into production from a research project, and it has become a strategic priority for CISL. Though VAPOR's origins are strongly rooted in geophysical turbulence, recent work on VAPOR has focused on expanding its capabilities to support the needs of the broader Earth System sciences community, particularly in the areas of numerical weather prediction and ocean modeling.



This image demonstrates VAPOR's wavelet-based, progressive-access data model applied to a high-resolution (1000x1000x5482) microCT scan of a new species of sea dragon. Shown from left to right are isosurfaces of the sea dragon's head using data compressed 100:1, 10:1, and the original full-resolution data. In partnership with UCSD, NCAR has won a two-year NSF SSE grant that would fund enhancements to the VAPOR progressive-access data format to make the data model suitable for use with biological imaging data as well as improve its usability with Earth sciences simulation outputs.

Development of VAPOR is closely guided by a steering committee comprised of Earth scientists from around the world that sets development priorities, dictates software requirements, and serves as friendly users for testing and evaluating new software features.

VAPOR's unique features include its use of a multi-resolution data model that permits exploration of some of the largest simulation outputs using only desktop computing resources – a feature set and user interface that is focused on the needs of the Earth System sciences community – and a strong emphasis on supporting quantitative data analysis.

The goals of the VAPOR project are strongly aligned with the cyberinfrastructure components of CISL's strategic plan in the areas of:

- Developing and supporting software infrastructure specific to the simulation, analysis, and forecasting needs of the

atmospheric and related sciences.

- Preparing for petascale computing by developing visualization and analysis capabilities in support of extremely large data sets.

VAPOR's FY2014 efforts were focused on meeting the contractual obligations of a grant from the Korea Institute of Science and Information Technology (KISTI), as well as on developing and enhancing core capabilities. The KISTI award funded the development of data readers for the widely used GRIB data format, outputs from NCAR's CAM model, as well as the development of isoline display capability. Other highlights include:

- The number of registered VAPOR users worldwide has reached nearly 7,000, and VAPOR was cited by over 20 scholarly journals in FY2014.
- Release 2.4 of VAPOR was completed in February. Major new features for version 2.3 include a simplified data conversion wizard, discrete color maps, and numerous usability improvements.
- A fourth year of funding to support further enhancements was secured from KISTI.
- A two-year NSF SSE grant was awarded to extend and generalize VAPOR's wavelet-based data format.

This project is supported by NSF Core funds, NSG grant NSF-14-40412, and KISTI grant C14009.

‹ NCL data analysis and visualization software | up | CISL's enterprise architecture ›

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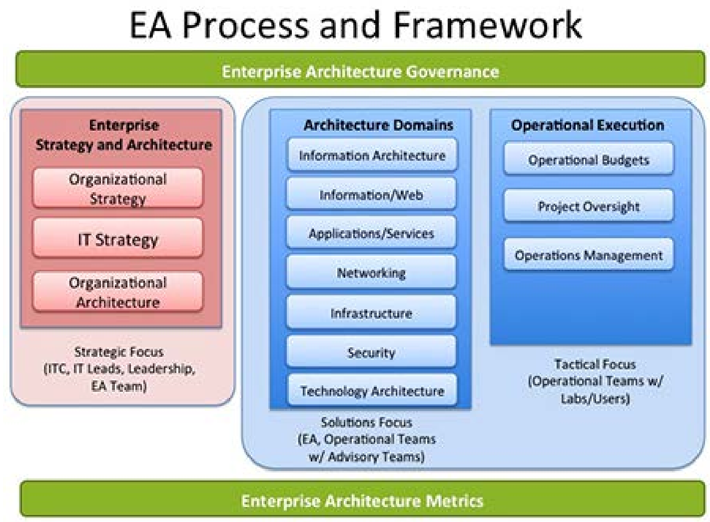
CISL'S ENTERPRISE ARCHITECTURE



The diagram illustrates the components, processes and framework that was developed for UCAR's approach to Enterprise Architecture.

Enterprise Architecture (EA) is the name of the discipline of translating an organization's vision and strategy into effective business practices and information technology (IT) infrastructure to support those practices. EA is a relatively young and still-evolving discipline, but it has been adopted by a wide variety of public and private organizations. The U.S. Government has developed a set of reference models called the Federal Enterprise Architecture.

Under the auspices of the UCAR Information Technology Council (ITC), co-chaired by Anke Kamrath (OSD director) and Shawn Winkelman (Finance and Administration IT Director), and at the direction of the UCAR President's Council, a UCAR-focused Enterprise Architecture Team (EA Team) was formed at the beginning of FY2013. The team meets weekly to discuss IT topics of significance to the institution and recommend courses of action.

During FY2014, the EA Team monitored and advised UCAR's Google Apps for Government rollout project, and received requests for consideration of a number of IT-related initiatives. As the number of initiatives for consideration rose, the EA Team adopted a wiki-based method of Project Portfolio Management (PPM) to help with prioritization. At the end of FY2014, the highest-priority projects in the EA Team portfolio were identity management, security strategy, and IT governance. To assist the EA Team with prioritization and implementation of initiatives, an Enterprise Architecture Technical Advisory Board (EATAB) is being convened for FY2015 and beyond.

A major event during FY2014 was an IT Assessment carried out by Deloitte. The Deloitte report was released to UCAR staff at the end of FY2014, and UCAR is now considering what actions to take in response to recommendations. This will significantly influence the activities of the EA Team during FY2015.

Development of an EA for UCAR supports the Science and Collaboration Fabrics of the CISL Strategic Plan, and is a joint effort between CISL/OSD and UCAR Finance and Administration IT. This effort is supported by UCAR indirect funds.

‹ VAPOR visualization software for very large datasets   up   Network engineering and telecommunications ›

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NETWORK ENGINEERING AND TELECOMMUNICATIONS

Networking infrastructure is essential technology vital to UCAR's ability to function and prosper in a rapidly evolving scientific and technical environment. Networking infrastructure enables many aspects of the scientific enterprise to flourish: business processes, scientific investigations and analysis, communication, global collaborations, and educational and outreach missions. Network infrastructure is literally the backbone of all other IT infrastructure and services. A sound and reliable network infrastructure is critical to building stable IT infrastructure at the higher levels. It is the goal of the networking infrastructure to provide this fast, robust, and flexible infrastructure to support all other IT services.

Networking is a critical component of cyberinfrastructure. Networks are interconnected and interoperate at the campus, metropolitan, regional, national, and international levels. Networking is a global endeavor. Being well connected has become a requirement for successful business operations but is especially important for a national research center such as NCAR/UCAR. Networking provides a vital service enabling all functions at UCAR. UCAR's scientific mission is enabled and supported by networking. UCAR's business operations, including interactions with funding agencies, also depend on networking. Collaborative science would not happen today without networks, just as UCAR's business operations would not function.

The Network Engineering and Telecommunications Section (NETS) plans, engineers, installs, operates, maintains, develops strategy, and performs research for NCAR and UCAR's state-of-the-art data networking and telecommunications facilities. NETS provides a vital service to NCAR's research communities by linking scientists to supercomputing resources and each other. These activities are essential for the effective use of NCAR/UCAR's scientific resources, and they foster the overall advancement of scientific inquiry. This work supports CISL's computing imperative to provision hardware cyberinfrastructure for the atmospheric and related sciences. It also supports CISL's computing frontier of center virtualization by providing infrastructure for science gateways and other Grid-based technologies.

NETS pursued these LAN projects in FY2014:

- UCAR network infrastructure re-cabling
- WASP inventory system
- NWSC Infiniband cabling (major replacement effort)
- ArcGIS
- Plookup
- ITC Strategic Plan participation (networking, collaboration, security, collocation)
- Softphones
- ML Room 034 remodel and NETS shop relocation
- Cellular phone support
- Network monitoring
- CISL Nagios centralization transition
- Netflow – lcmynetflow
- Archibus
- Extraview
- Multicast support activities
- Business continuity
- Everbridge Emergency Notification System (ENS) participation
- UPS, grounding, wireless networking, IPT, Collocation Facilities Management (CFM)
- ML 29 infrastructure design
- IPT server replacement
- Spring and Fall power downs

- Cisco 6500 to 4500 replacement plan and order
- NETSDB replacement and redundancy
- UIS database project (PeopleDB)
- Contact list conversion
- Telecommunication closet cooling
- Vidyo® expansion
- CG2 colocation shutdown and move to ML 29
- BiSON Boulder Node B implementation
- Network Time Protocol (NTP) server and service

NETS pursued these MAN projects in FY2014:

- Boulder Point-Of-Presence (BPOP)
- Boulder Research and Administration Network (BRAN)
- I2 Dynes project completed
- City of Boulder CG4 inter-building cabling

NETS pursued these WAN projects in FY2014:

- Front Range GigaPoP (FRGP) ongoing management and engineering
  - New FRGP cost model
  - Thirty-two new or renewed Five-year agreements effective 7/1/14 – 6/30/19
  - Five participants left the FRGP (STAR, ARTstor, DenverHealth, CARL, and UCH)
  - 1850 Pearl Street colocation relocation
  - Expanded ESnet peering to 20 Gbps
  - UCAR Point of Presence (UPoP) merged with FRGP
- New FRGP Participants: NEON, NREL, State of Wyoming, JeffcoSD, Colorado College, CSU-Pueblo, I2/USDA (pending)
- National LambdaRail (NLR) shutdown
- Internet2
  - Diversity Initiative Co-chair
  - Network/Connector Liaison
  - Frictionless Science Networking
- Bi-State Optical Network (BiSON)
  - Design and order for Golden ring
  - Design and order for SCONE path
  - CSM BiSON hardware configuration implementation
  - UW NSF CC*NIE proposal support and network design
  - CU–B NSF CC*NIE proposal support
  - Boulder BiSON Node B network resiliency
- XSEDE
- Western Regional Network (WRN)
  - 100G Upgrade design and infrastructure and equipment order
- NOAA Research Network (NWAVE)
- The Quilt Project – National Regional Networks Consortium
  - Jeff Custard - Executive Committee
  - Jeff Custard - CIS Committee
  - Marla Meehl - Nominations Committee
  - Marla Meehl - Finance Committee
  - Marla Meehl – Research Working Group
  - Marla Meehl – CC*IIE Regional Collaboration Working Group
  - Fabian Guerrero – Spring and Fall travel grants
- SC'13 SCinet Participation
- RMCMOA proposal and award
- Westnet Meeting Support
  - January 2014
  - June 2014

In FY2015, NETS will continue to provide support and enhancements for all of these essential networking services. NETS activities are primarily supported through UCAR Communications Pool indirect funds, the FRGP, and NSF Core funds.

Detailed project descriptions appear below for four of these projects: 1850 Pearl Colocation Move, FRGP Agreement and Cost Model, BiSON Expansion: Golden, Southern Colorado (SCONE), State of Wyoming, and the CG2 colocation move to ML and NWSC.

1850 Pearl colocation move

The Front Range GigaPoP (FRGP), the Bi-State Optical Network (BiSON), and the Western Regional Network (WRN) are critical wide area networking (WAN) infrastructure for

UCAR and for all the FRGP, BiSON, and WRN participants in Colorado, Wyoming, California, New Mexico, and Washington. The FRGP and BiSON are managed by UCAR. The Level3 colocation space at 1850 Pearl Street in Denver is the primary hub for the FRGP, BiSON, and WRN WAN services.

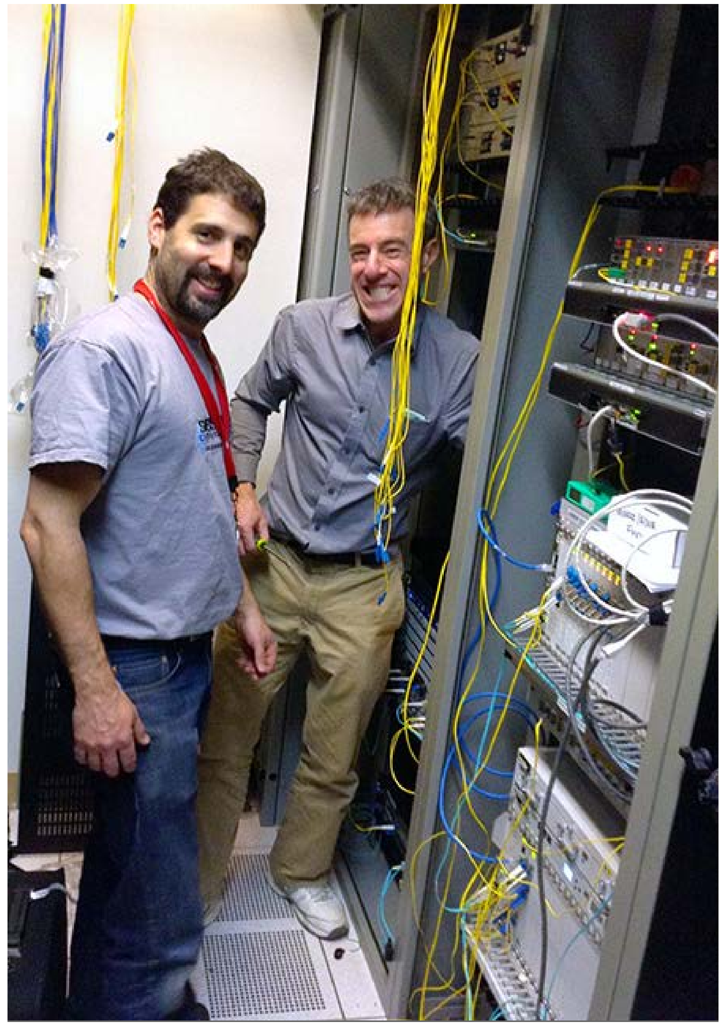
The criticality and breadth of impact made this project particularly visible, and the effect was broad and large. As the contracting agent and manager of the FRGP and BiSON, UCAR was notified in mid-January 2014 that National LambdaRail (NLR) would be ceasing services with less than 30 days notice on 17 February 2014. The NETS FRGP team immediately starting working on contingency plans to avoid services shutdown. One of those critical services was the FRGP Level3 colocation services shared in NLR space. Ultimately, the NLR shutdown was on 17 March 2014, but this was still less than 60 days notice to move critical and complicated services.

Led by Pete Siemsen, the team of Bryan Anderson, Armando Cisneros, Scot Colburn, Susan Guastella, John Hernandez, and Carlos Rojas-Torres put in the long hours and hard work on this project and documented their accomplishments on a wiki page.

This team successfully led a multi-component move process under tight timeframes and off-hours to relocate one of the main colocation facilities for the FRGP in Denver. The FRGP had sub-contracted space in an NLR suite at 1850 Pearl Street in Denver for approximately 10 years, affording the FRGP significant cost savings over this time. Given the NLR shutdown, NETS was required to move out under short notice or face possible power down of all the key gear and connectivity this location provided. All FRGP equipment and cross connects moved from the existing Level3 NLR Suite to new cabinets on a different floor at the Level3 Denver Gateway at 1850 Pearl Street. NLR shutdown was confirmed for 17 March 2014, so there was no flexibility in the date or time due to the urgency and extreme nature of the hard power down of this facility. This project was successfully completed on 15 March 2014, two days before the deadline.

Through adept planning and efficient teamwork, this very complex project was completed in a very short amount of time. It was accomplished with great skill, professionalism, communication, and attention to detail on the part of all team members and also many outside organizations that had to be involved and coordinated including Level3, Internet2, ESnet, NOAA, and FRGP participants.

Due to efficiencies gained, the resulting cost of the new colocation is no more expensive than the shared NLR colocation that benefits all of the FRGP. The FRGP has also gained independence from shared colocation. We decided on this path in an attempt to avoid this type of exercise in the future.



John Hernandez (left) and Scot Colburn, FRGP Network Engineers, are activating the FRGP equipment in the new colocation space.

Carlos Rojas Torres (left) and Armando Cisneros test fiber optic cabling in the new colocation space.

FRGP agreement and price model

Every five years the FRGP agreements expire and must be renewed, and 2014 was one of those years. This was a major effort in that there were significant revisions to the agreement dictated by recommendations from a UCAR internal audit of the FRGP and changing conditions in the network usage and services environment. A number of costs shifted from UCAR to the FRGP and had to be codified. In addition, it was decided to create a new, very different, and hopefully more equitable, cost model. Again this required major changes to the FRGP Agreement. Lastly, it was decided to eliminate the concept and organization known as the UCAR Point of Presence, and merge those functions and participants into the FRGP. Again, this required changes to the FRGP Agreement.

The development of the new cost model required multiple iterations, extensive discussion and meetings, and a lot of patience. The new model is simpler, fairer, and more flexible. However, it is somewhat complex to explain so a document was created to detail the model, and a calculator was developed to easily and quickly run scenarios. As a result of increased FRGP costs, five FRGP participants left the FRGP and that process had to be managed. Thirty-two participants remain with the FRGP, which is starting its 16th year of successful operation.

The FRGP is functioning very effectively and efficiently under the new agreement structure and cost model.

BiSON expansion: Golden, Southern Colorado, State of Wyoming

The BiSON team has been working to expand the BiSON footprint to Golden, Southern Colorado, and the State of

Wyoming in Cheyenne, Wyoming. The FRGP team has worked to design the ADVA Wave Division Multiplexing (WDM) network that will use existing and new fiber to construct a multi-10 Gbps network to connect these new FRGP participants. This year the focus has been on building the relationships and partnerships, establishing the FRGP agreements, the network design, the hardware order, and working to make the fiber optic path whole.

The BiSON team has been working to expand the BiSON footprint. This expansion includes the Colorado School of Mines (CSM), Jefferson County School District (JeffcoSD), and the National Renewable Energy Lab (NREL) in Golden. CSM has been connected to BiSON for over a year using Colorado Department of Transportation (CDOT) fiber optics. Partnerships have been developed to leverage CSM fiber optic paths to expand the reach to NREL and JeffcoSD with minimal fiber construction. A non-redundant network has been installed and activated for CSM and NREL. JeffcoSD is pending a final fiber optic path installation. The next phase will be to install and implement the fully redundant fiber optic and WDM ring.

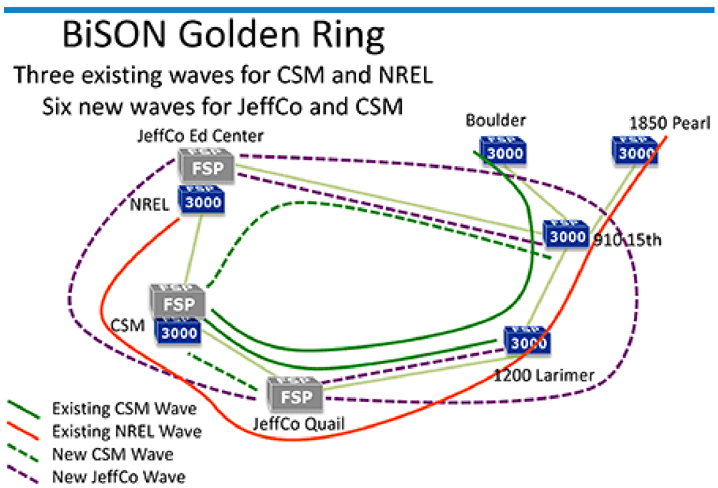
The BiSON team has also been working to expand the BiSON footprint to include Colorado College (CC) and the University of Colorado at Colorado Springs (CU-CS) in Colorado Springs, and Colorado State University at Pueblo (CSU-P). CU-CS and CSU-P have been connected to the FRGP using Colorado Department of Transportation (CDOT) fiber optics sharing a 1 Gbps path for a number of years. However, with increasing bandwidth demands and to include CC and optimize routing, it was decided to integrate this path into BiSON and for UCAR to assume engineering and management. The next phase will be to install and implement the full fiber optic WDM network.

Finally, the BiSON team expanded BiSON to connect the State of Wyoming government offices in Cheyenne, Wyoming and

New FRGP Cost Calculator

Commodity CALCULATOR Enter bandwidth of your choosing to see cost impacts		Intial 2015 Shared Costs and I2 Tiers	Shared Costs & I2 CALCULATOR Enter Pipe Size and see cost impacts: Pipe Size (Gig)	Tier
30.00	AHEC	1.0	1	1.0
20.00	CARL	1.0	1	1.0
	CC	0.0		
500.00	CCCS	3.0	4	3.0
10.00	CDHE	1.0	1	1.0
40.00	CMC	1.0	1	1.0
30.00	COMCD	1.0	1	1.0
350.00	CSM	4.5	11	4.5
1,265.00	CSU-FC	5.9	30	5.9
0.00	CSU-P	0.0		
50.00	CTN	1.0	1	1.0
100.00	CtyBldr	1.0	1	1.0
100.00	CityDenv	1.0	1	1.0
400.00	CU-B	5.3	20	5.3
175.00	CU-CS	1.0	1	1.0
300.00	CU-D	4.5	11	4.5
20.00	CU-UIS	1.0	1	1.0
0.00	Unassigned	0.0	0	
400.00	DU	5.3	20	5.3
750.00	EN	4.5	11	4.5
100.00	FLC	1.0	1	1.0
160.00	MSUD	2.0	2	2.0
20.00	NEON	1.0	1	1.0
330.00	NOAA	4.8	14	4.8
0.00	NREL			
500.00	StateCO	4.3	10	4.3
300.00	StateWY	1.0	1	1.0
330.00	UCAR	6.8	54	6.8
50.00	UNAVCO	1.0	1	1.0
200.00	UNC	1.0	1	1.0
10.00	USAP	1.0	1	1.0
0.00	I2-USDA	0.0	0	0.0
500.00	UW	5.2	19	5.2
0.00	JeffcoSD	0.0		
7,040.00		72.1	222.0	72.1

The new FRGP cost model is simpler and more equitable, and the Cost Calculator allows participants to estimate costs for changing services.



The BiSON Golden ring will connect CSM, NREL, and JeffcoSD in a high-speed and highly

enable the State to become a FRGP participant. The State of Wyoming's direct connection to the FRGP using BiSON greatly benefits the State of Wyoming as well as the other FRGP members who work with the State of Wyoming. This partnership strengthens and expands the existing relationship between UCAR/NCAR and the State of Wyoming. As part of the FRGP/BiSON, the State of Wyoming provides connectivity to approximately 400 K-12 schools that they are responsible for as part of the State CIOs office.

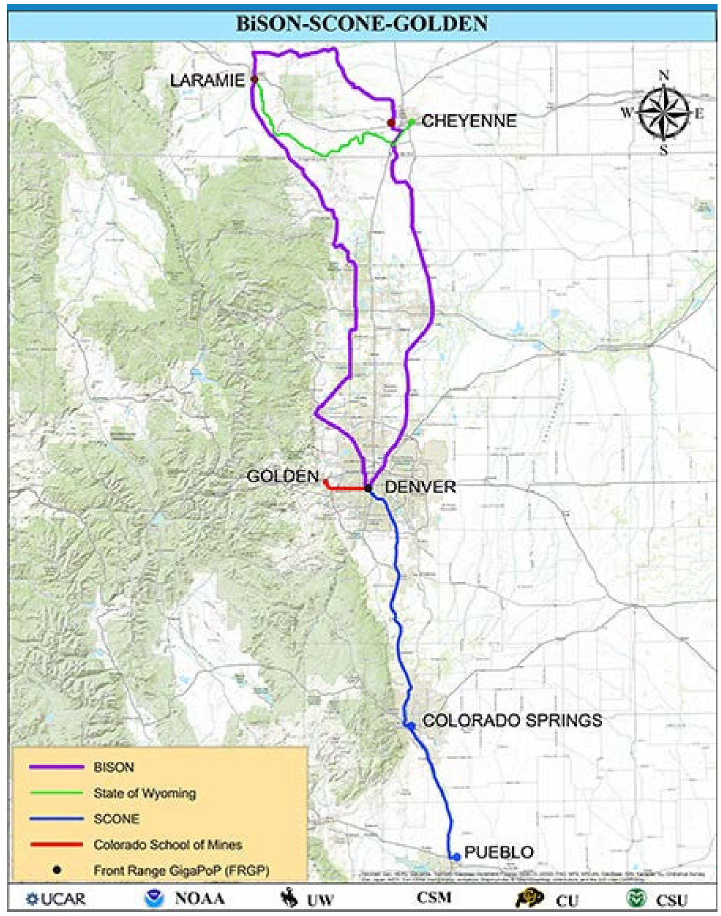
The State of Wyoming is dual-connected using fiber via the NWSC to the University of Wyoming as well as Bresnan/Level3 fiber via Stateline, and then to the FRGP/UPoP via the Bi-State Optical Network (BiSON). Intra-FRGP participant traffic stays within the FRGP network providing optimal direct connectivity.

CG2 colocation move to ML and NWSC

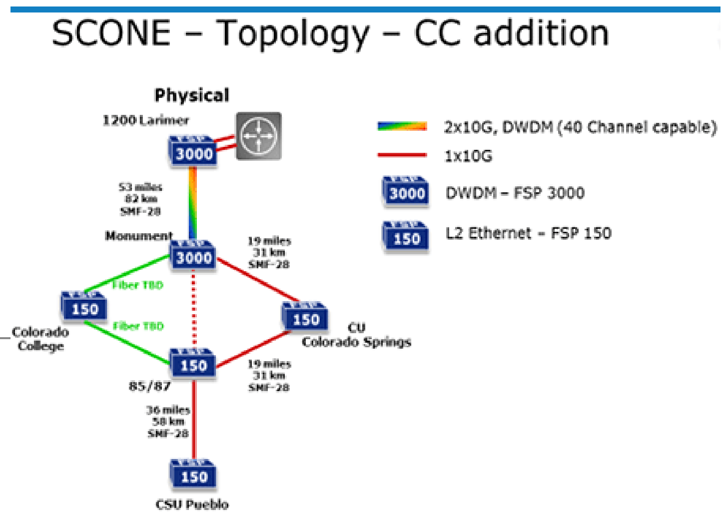
The Colocation Facilities Management (CFM) team has been tasked with consolidating colocation facilities across UCAR for efficiencies and cost savings. As part of that effort, it was decided to consolidate equipment from CG2 2042 into the Mesa Lab room 29 (ML29) and the NWSC data center (NWSC Room CM-31). After many months of planning and documentation, this effort was successfully completed in July 2014.

NETS played a major and lead role in the planning, design, ordering of racks and components, installation of the colocation areas and network in advance, and in the actual move to the NWSC on 14 June 14 and to ML29 on 11 July – 13 July 2014. At the NWSC, as part of a pilot program between NETS and CISL, KVM and remote console connectivity was provide to each server relocated to the NWSC. At ML, NETS technicians upgraded and standardized the physical cabling to each server's primary network, intra-network, and out-of-band connectivity. Each relocated server's cable was standardized to Category 6A (F/UTP) cable, color coded for ease of management, electronically documented, and physically labeled. Both of these moves were implemented successfully and gracefully.

reliable fiber optic ring.

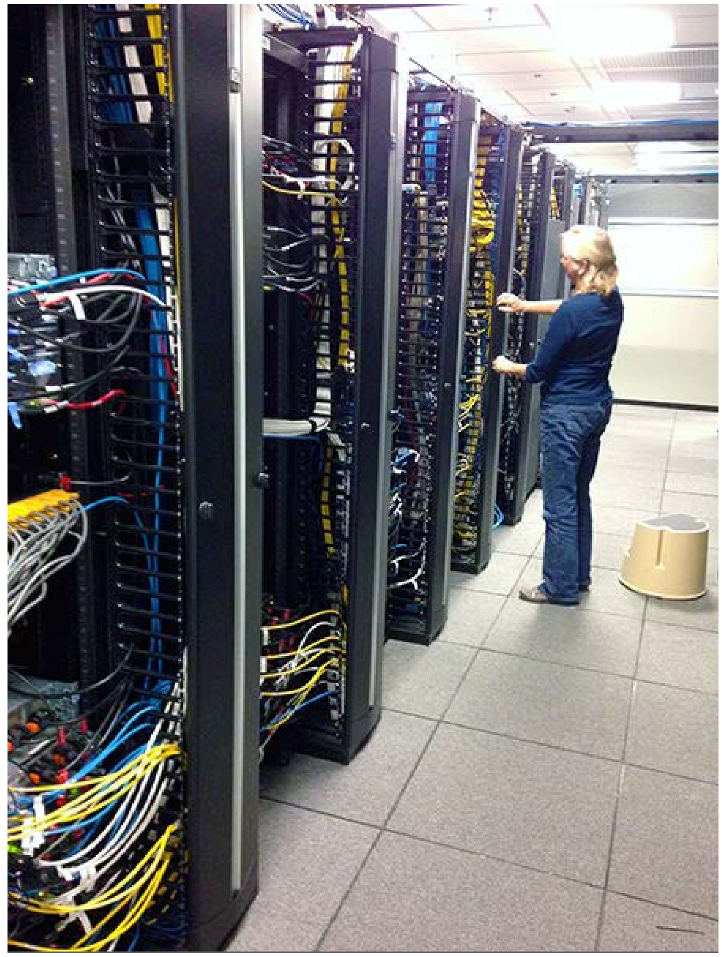


BiSON now reaches west to Golden and south to Colorado Springs and Pueblo to connect six new FRGP participants.



The SCONE BiSON fiber optic network will provide over 10 times the current bandwidth available to CC, CSU-P, and CU-CS.

‹ CISL's enterprise architecture
up
Cybersecurity ›



Teresa Shibao puts the final touches on the new colocation racks in ML 29 after the move from CG2.

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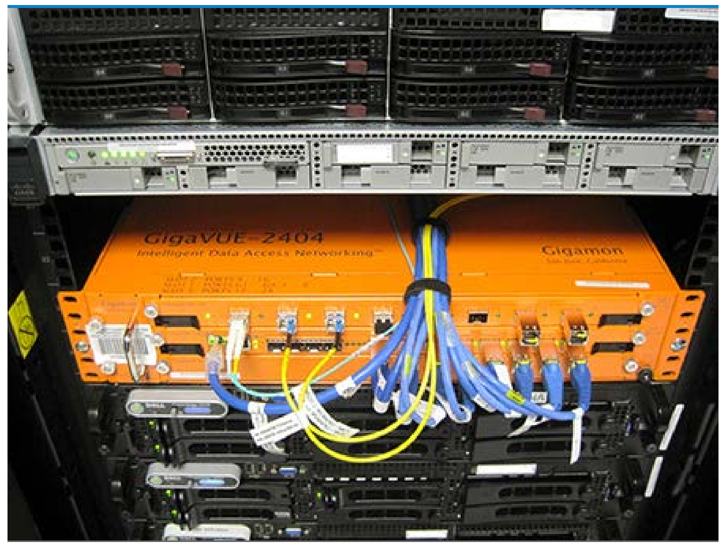
CYBERSECURITY

UCAR manages and maintains a large and diverse set of compute, data, email, web, and network servers that form the core information technology (IT) within the institution. Not only are these systems valuable monetarily, they comprise vital scientific research tools and business continuation systems used throughout UCAR and the university communities. To pursue the scientific mission of the organization without hindering the free exchange of information, CISL is committed to maintaining a security posture that appropriately balances usability with the security of the systems.



This is an upgraded network traffic distribution node. It takes a 40 Gbps optical feed and distributes the packets to a number of computers that examine each byte that transits the Mesa Lab. The upgrade was needed to keep pace with both the increasing traffic volume and threats from outsiders.

Providing secure information technology systems within CISL and across UCAR supports CISL's computing imperatives to provision hardware and software cyberinfrastructure for the atmospheric and related sciences. Cybersecurity is also critical to CISL's computing imperative for data curation and to its computing frontier of center virtualization. The security strategy we employ must be balanced by the goals of openness and ease of access. CISL proactively strives for zero security incidents on its systems, and CISL responds and reports an incident analysis if one occurs.

It is vital to the organization that we take appropriate measures to ensure the confidentiality, integrity, and availability of intellectual property, data, and systems. Appropriate measures balance the needs for availability and usability with those for integrity and confidentiality.

During FY2014, the following activities were vital to the continued security of IT systems at UCAR:

- Architected and assisted with the implementation of the colocation private access networks at the Mesa Lab and the NWSC.
- Expanded our network scanning and penetration testing capabilities.
- Created the synchronization method for the Google Apps for Government migration.
- Coordinated consistent security policies and procedures across UCAR by the Computer Security Advisory Committee (CSAC), with the goal of maintaining reasonable protection in support of the institution's scientific mission.
- Consulted with various internal groups on how best to implement computer security for their applications and needs.
- Continued to expand the capabilities of the four-person Security Engineering Group (SEG) though numerous

professional development activities.

- Continued to encourage UCAR staff to engage with SEG early in the process of developing or purchasing systems internal to UCAR, that will be accessible across the UCAR network security perimeter, that are in the cloud, or that will require UCAR authentication.
- Maintained UCAR-wide token authentication using one-time password (OTP) tokens.
- Continued to provide ongoing information to UCAR system administrators about newly found compromises for a wide variety of relevant operating systems and applications.
- Engaged in collaborative efforts with peer and XSEDE centers to share cybersecurity information, best practices, and incident notification.
- Expanded the capabilities and uses for our Kerberos authentication infrastructure.
- Upgraded both security hardware and software to increase capabilities.
- Collaborated with peers to develop and refine policies and procedures for secure operation of high-performance computing resources at the NWSC.
- Enhanced our network and host monitoring tools to support increased traffic loads and provide redundancy using our other campuses.

Cybersecurity at NCAR is supported by a combination of NSF Core funding and UCAR Communications Pool indirect funds.

‹ Network engineering and telecommunications up Distributed services and web engineering ›

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2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

STRATEGIC PLANS

CISL Strategic Plan

NCAR Strategic Plan

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DISTRIBUTED SERVICES AND WEB ENGINEERING

Current hardware infrastructure being used to provide enterprise services at NCAR.

The CISL Enterprise Services Section (ESS) provides the hardware and software infrastructure – including development, deployment, configuration, monitoring, and maintenance – for a variety of Information Technology (IT) services used across UCAR. Examples of these services include organization-wide DNS and DHCP, incoming and outgoing e-mail via SMTP, web content hosting, development and production instances of the Drupal web Content Management System (CMS), and distributed software revision control systems, among others. ESS also provides systems administration support for other CISL groups such as the Data Support Section and the Visualization and Enabling Technologies Section.

Like last year, FY2014 saw a good deal of transition for ESS. A major effort was participation in the rollout of the Google Apps for Government solution for the organization. This involved integration of the UCAR LDAP instances with Google Apps for account and group provision, establishing a link between UCAR's Kerberos infrastructure and Google for password synchronization, and a major effort coordinating the migration of existing e-mail content for all UCAR staff from over a dozen different organizational mail servers into Google Apps – in addition to learning how to configure and support Google Apps for the enterprise. At the same time, ESS maintained its existing infrastructure and services, and commissioned a distributed replicated storage back-end to improve the robustness of its virtualized systems. With the successful adoption of Google Apps for Government, ESS should be able to simplify its infrastructure in the years to come.

Also during FY2014, the Web Engineering Group (WEG) expanded its purview to include the application and promotion of modern software engineering practices, and as such has been renamed the Software and Web Engineering Group (SWEG). The SWEG performed major work improving the SAM software in support of CISL/USS, particularly in the areas of stability and reporting.

ESS provides enterprise services in support of the Service, Innovation, and Collaboration Fabrics of the CISL Strategic Plan. Support comes from NSF Core and CSL funding, as well as from UCAR indirect funds because the services provided are available to all UCAR/NCAR labs and programs.

‹ Cybersecurity   up   CISL Science ›

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- CISL Director's message
- CISL Services
- CISL Science
  - Data-centric research
  - Scalable algorithms for massively parallel computers
  - Computational research and development
- CISL Education, Outreach, and Training
- Broader Impacts

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- CISL Strategic Plan
- NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

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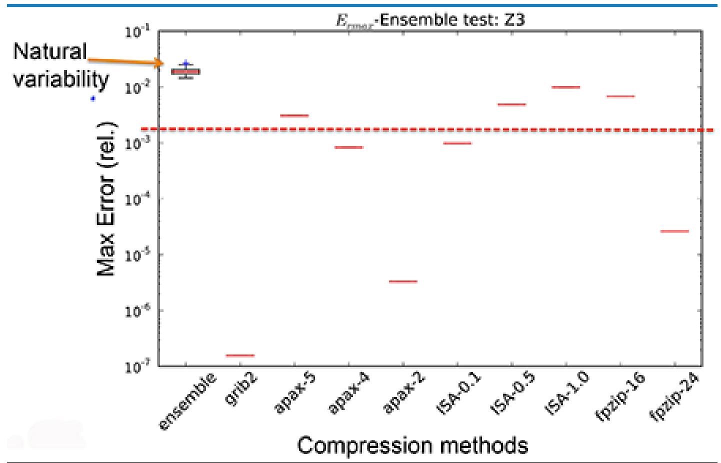
CISL SCIENCE

CISL research activities support scientific computation, numerical methods, geophysical modeling, and the analysis of geophysical data and model experiments. These activities are chosen to lead the geophysics community in adopting new computational methods and mathematical tools to improve research.

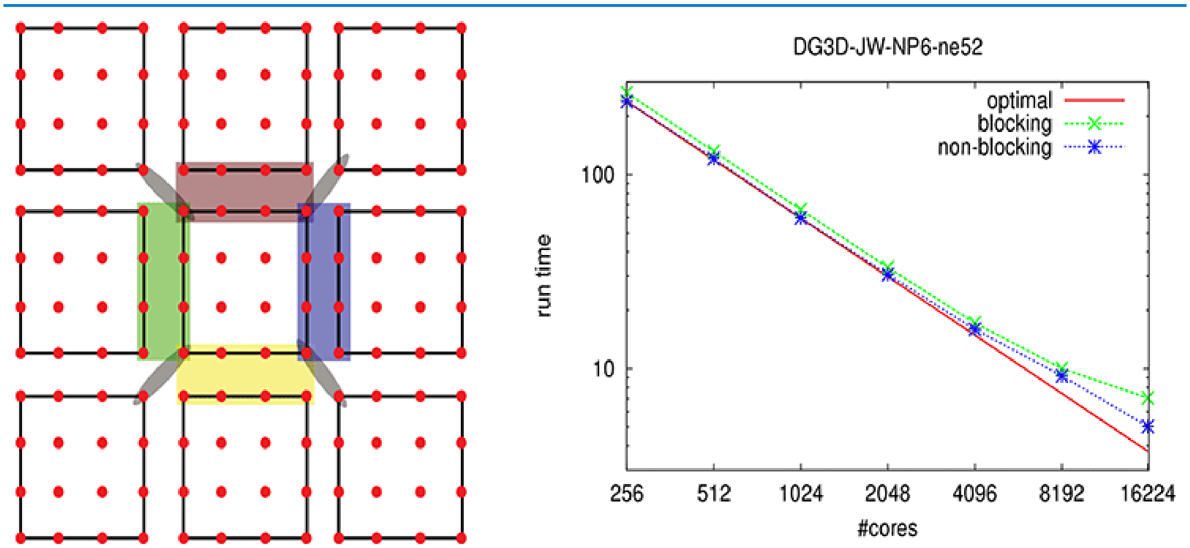
Diverse scientific disciplines often share common tools and numerical methods. The kind of mathematical, computational, and physical sciences housed in CISL focus on general mathematical tools, models, and algorithms that have broad application across NCAR. Hallmarks of this research are innovative and standout contributions that not only have relevance for the overall NCAR scientific program, but also are significant in their specific area of mathematical, physical, or computational science.

The figures shown here illustrate some of the diversity of scientific research in CISL and also suggest some unifying themes. The compression of model output (top figure) not only draws on computer science but must also address the particular requirements of the geophysical application. Any solution should not compromise the scientific value of the model output and also should fit into the standard workflow of model analysis used by the community.



A comparison of compression methods for reducing the size of climate model output. This figure is an example of applying different methods of data compression to one of the primary output fields from the Community Earth System Model (CESM). In this case the variable being compressed is geopotential height and each method is effecting a lossy compression. A useful benchmark is comparing the maximum error that is incurred by the compression to natural variability among ensemble members from the same simulation The red horizontal line on the plot indicates a factor of 10 decrease in variability relative to the ensemble. Besides the image-based method supported by NCEP (grib2) there are two other compression algorithms that have a small error. Of note is the performance of fpzip (24) an open source tool that does not require additional information about the field's geometry. Initial findings for CESM output suggest that the amount of compression will vary among variables but overall one can achieve an average compression ratio of 1:5 using fpzip while controlling the amount of error. This kind of reduction in the output size could be important to maximize the amount of storage available for archiving climate model experiments.

The development of HOMME (second figure) is part of the next generation of numerical methods for CESM. Anticipating future computing architectures, these algorithms must be designed to be highly scalable but also must limit communication between cores. Moreover, to be scientifically relevant, the algorithms must also give an accurate solution of the dynamical equations. Thus the numerical development is tied to the end goals of the communities who will use CESM.



Improvements in parallel communication for large numerical codes. The left figure shows the connectivity in two versions of the HOMME, a dynamical core of the NCAR Community Atmospheric Model. The main overhead in communication for this algorithm is between tiles (spectral elements) in this plot

The final two figures indicate some of the breadth involved in CISL research. Here a statistical model is applied to observational data not directly related to the time series of interest. These kinds of reconstructions will have benefit for forcing model simulations, but will also give insight into the natural variability of CO_2 before

and is indicated by the color blocks around the central tile. The grey lines are additional connectivity that is required by the spectral element method but not the discontinuous Galerkin (DG) method. Using this connectivity and also implementing a strategy where additional computation is done during periods of communication latency the run time for DG has improved. The figure on the right shows the speedup in run time for a standard test case and the DG version of HOMME. Note that, as expected, the improvement becomes more pronounced for larger number of processors (cores).

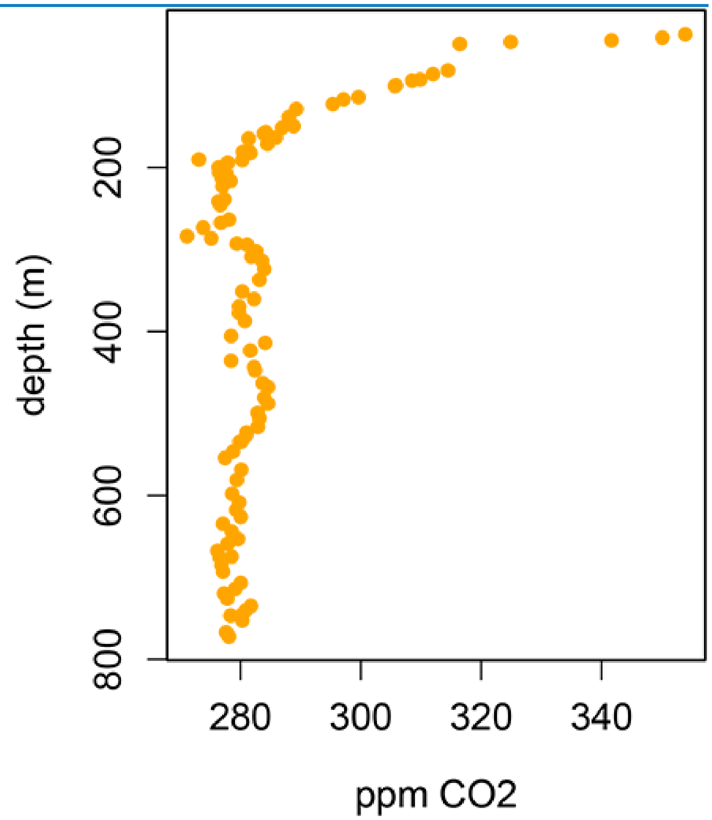
industrialization. The hierarchical statistical models used for this application are general and have wide applicability to interpreting climate model experiments, data assimilation, and the impacts of climate change.

In summary, the seemingly diverse nature of CISL research is motivated and has impact on the core mission of NCAR to support research with both Earth System models and observations.

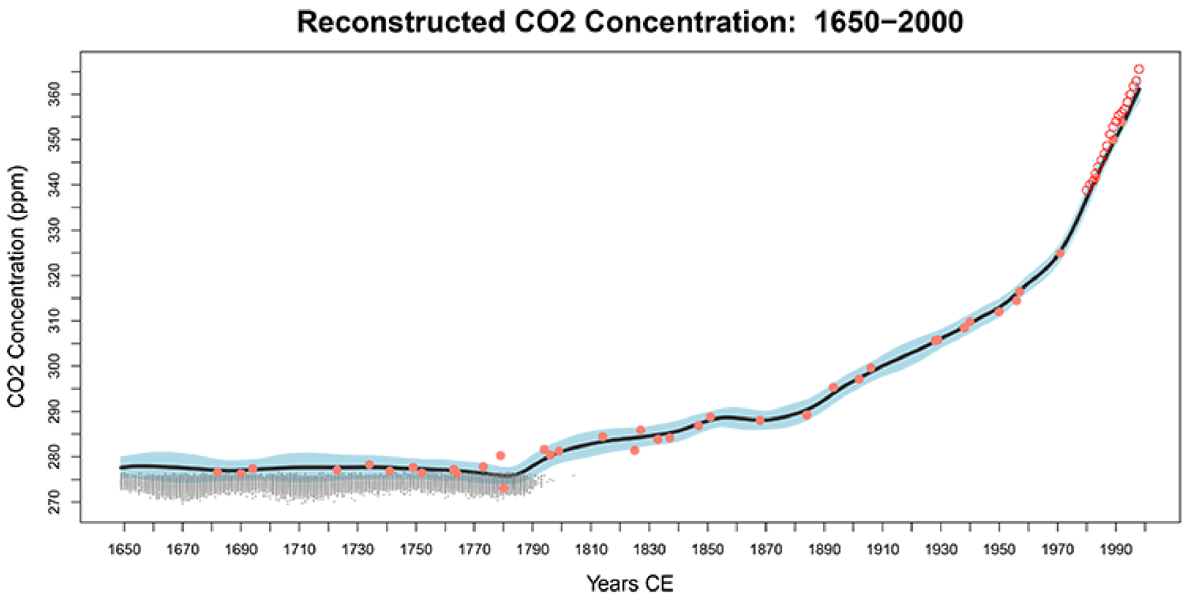
Some notable highlights in CISL research during FY2014 include:

- Data centric research that extends tools for data assimilation and data analysis of complex observational data, processing of large simulations, and visualization of model output.
- Algorithm developments that accelerate the simulation of geophysical processes and make better use of computational and storage resources.
- Developing and evaluating computational strategies for new architectures to anticipate how codes and workflow may have to adapt to future systems.

This work is funded as specified in the following individual reports.



A reconstruction of atmospheric carbon dioxide concentrations using ice core measurements from Law Dome, Antarctica. This figure plots the CO_2 concentrations measured in bubbles trapped at different depths in a core sample from Southern Antarctica. Although deeper ice layers tend to represent older air samples, the exact relationship is more complicated due to diffusion of air within the layer as snow from the surface becomes consolidated into ice. Here a combination of a physical model for the ice core trapping process and a statistical model to handle measurement errors and to constrain the CO_2 time series is used to reconstruct concentrations of atmospheric CO_2 for the past 2,000 years.



This figure further illuminates the reconstruction of atmospheric carbon dioxide concentrations using ice core measurements from Law Dome, Antarctica. It reports the reconstructed concentration time series (black) with estimates of the uncertainty (blue envelope). The solid points are the depth measurements placed at the average times associated with depth, and the open circles are direct measurements of the atmosphere from recent time. The gray points are based on a statistical sampling method to indicate the uncertainty in where the minimum value of CO_2 occurs during this period. Although uniformly distributed up to approximately 1790, there is no evidence for a minimum occurring beyond 1795. This is a useful, objective measure of determining the onset for the increase in CO_2 due industrialization. Besides being a contribution to paleoclimate, this example is also a testbed for developing statistical methods for inverse problems that arise for many kinds of remotely sensed data.

‹ Distributed services and web engineering up Data-centric research ›

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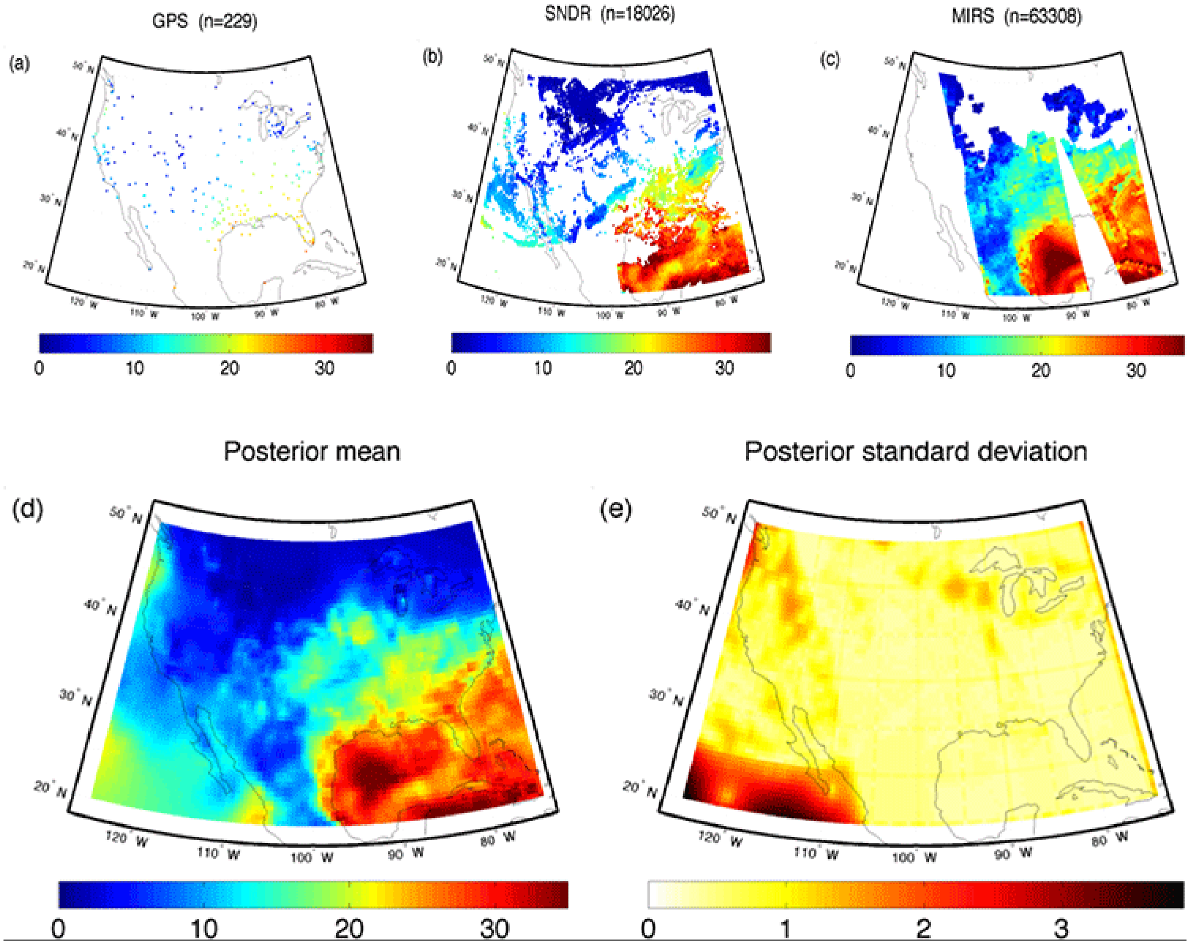
DATA-CENTRIC RESEARCH

CISL's strategy to support progress in the geosciences focuses on the grand challenges of numerically modeling the Earth System, and efficiently managing data in its many forms is critical to these efforts. These forms range from the "Big Data" problems associated with remotely sensed observations and model output to the wide range of small but vital historical data sets that document past climate and important geophysical processes. Historical data is used to study past variability, for insight into processes, and for reanalysis projects. Geophysical models depend on data for initial fields and forcing variables, and typically models generate substantial and complex data objects for interpretation. Finally, data assimilation seeks to combine models and observations to produce predictions, reanalysis products for past weather, and also to diagnose model shortcomings. To meet the varied needs of our research communities, CISL research takes an interdisciplinary approach where collaboration with scientific teams within and outside NCAR helps to motivate new software tools and analysis methods.

CISL's data-centric view has helped to integrate research on several different aspects of computational and mathematical science. For example, data compression for the efficient storage of model output is also related to statistical methods for evaluating geophysical fields as well as to strategies for verifying model codes on new computing architectures. Data assimilation has traditionally been the mainstay of numerical weather prediction, but it is



An example of using a statistical model to synthesize different measurements of precipitable water in the atmosphere. This work is part of a project to provide tools for rapidly creating a combined data product for short-term prediction. Top row: Hourly observations of total precipitable water using (a) a ground-based GPS system (b) GOES infrared sounders, and (c) MIRS microwave sounder over North America in January 2011. Bottom row: Filtering (d) posterior means and (e) posterior standard deviations of total precipitable water based on all three data products. All units are in millimeters. The statistical method takes advantage of prior estimate of precipitable water from earlier time points and also the fact that these observational data sets may be distributed across several computing systems. Also to make the computations efficient the field is expanded in a reduced set of basis functions that help to extract the salient information from the large remotely sensed observations. The advantage of a statistical model for data fusion is availability of companion measures of uncertainty. In this case the large prediction standard deviations in the lower corner of (e) reflect the lack of observations over this region and rely on extrapolation from the analysis at previous time points.

also emerging as tool for confronting models with observations and improving numerical models. Statistical methods that quantify uncertainty in an analysis through an ensemble are also useful for creating gridded data products. Moreover, some statistical analyses are only feasible for large data problems using the improvements in workflow from implementing parallel data algorithms.

These are some highlights from CISL's FY2014 research that illustrate contributions in this area:

- Assimilation of unique measurements of fast neutron counts to determine soil moisture and the use of radiative transfer models to infer brightness temperature of the land surface.
- Studying adaptation of climate change to local and regional scales. This work used, in part, the NARCCAP suite of regional climate experiments and studied decision making and risk management under uncertainty in the future climate.
- Parallel data processing tools were developed to handle time series and time slice model output, and statistical methods were extended to analyze large spatial datasets.

Funding for these activities is indicated at the end of each of the following sections.

‹ CISL Science up Data assimilation research ›

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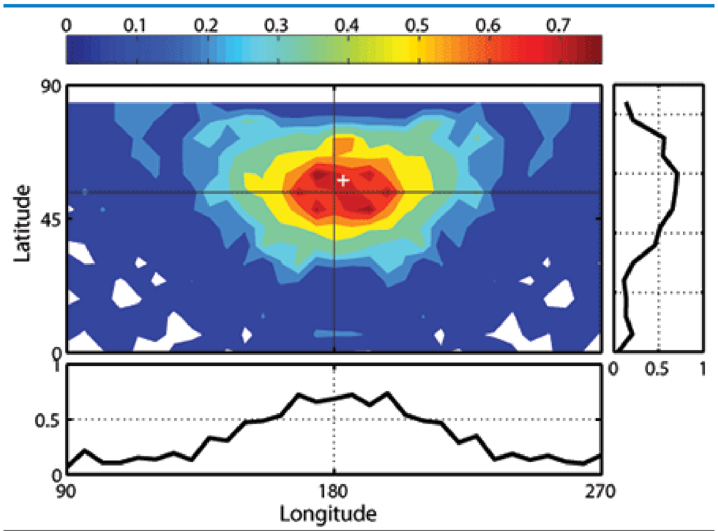
DATA ASSIMILATION RESEARCH



An adaptively estimated localization field for the impact of an east-west wind observation located at the white cross on north-south wind variables. The lower and right plots show cross sections of localization along the black lines in the main panel. This is the result of an assimilation in an atmospheric model that did not require any empirical tuning of localization and produced an analysis of unprecedented quality for this model.

Data assimilation is providing rapid advances in geophysical studies. The Data Assimilation Research Section (DAReS) of IMAGe performs fundamental research on ensemble data assimilation methodologies for application across a wide range of geophysical problems. DAReS develops and maintains a software facility for ensemble data assimilation called the Data Assimilation Research Testbed (DART). DAReS also provides support to a growing community of NCAR, university, and government laboratory partners who are applying ensemble data assimilation methods.

CISL's data assimilation research advances CISL's strategic imperative to produce scientific excellence. Specifically, this work leads the mathematics and geophysical communities in ways that accentuate the contributions of mathematical methods and models to scientific progress in the geosciences. Further, DAReS research advances CISL's science frontier for understanding large and heterogeneous data sets by assimilating strategic, heterogeneous, and nonlinear observations into Earth System models.

A primary goal of DART is to provide data assimilation tools that require as little tuning and expert knowledge as possible. However, the DART tools still require that localization (a method to reduce the impact of spurious correlations between observations and model state variables) be tuned empirically. Algorithms that can replace localization by explicitly estimating the correlation distributions in the assimilation are being explored to eliminate the need to tune localization. Initial assimilations in a simple atmospheric model have produced improved assimilations with no tuning (see figure).

DAReS scientists and software engineers provided support to enable multi-year CESM coupled model reanalyses of the climate system being performed by CGD scientists and postdocs. Output from these reanalyses has been examined to improve understanding of coupled phenomena like the Madden Julian Oscillation.

High-energy neutrons from cosmic rays produce low-energy neutrons in the Earth's soil, where moisture modulates the number of neutrons that escape the soil to reach the recording instrument. This process can be measured on scales comparable to flux tower footprints. Rafael Rosolem of Bristol University collaborates with DART scientists to investigate how effectively the information from above-ground cosmic-ray neutrons is propagated to individual soil moisture layers in the NOAH land surface model and to assess the benefits and limitations of high-frequency retrievals. We find that more frequent assimilations (on the order of 1 hour) are superior to infrequent assimilations, particularly for soil moisture in the

upper 40 cm.

DAReS has provided software and scientific support to ACD scientists doing assimilations with the CAM/Chem and WRF/Chem models. Improved forward operators to increase the amount of information extracted from remote sensing observations of carbon monoxide (CO) have been developed. Appropriate localizations for the DART data assimilation process have also been tested, leading to improved analyses of CO and other trace gases.

The use of radiative transfer models (RTMs) to estimate brightness temperature (Tb) observations from land surface models can help guide the development of land surface models. The RTMs are also useful in the context of data assimilation in that Tb observations are readily available globally. Since Tb observations are influenced by several key processes represented in land surface models (e.g., vegetative cover, snow cover, soil moisture, soil temperature), a multi-sensor assimilation system can help constrain the ecological state. DAReS staff members are working in close concert with researchers at NASA GSFC and the University of Texas at Austin in support of multi-sensor Tb assimilation.

Data assimilation research in IMAGe is supported by NSF Core funding, National Oceanographic Partnership Program Grant G076112, and NSF Grant CNS1035250.

‹ Data-centric research up High-resolution research data for climate change studies ›

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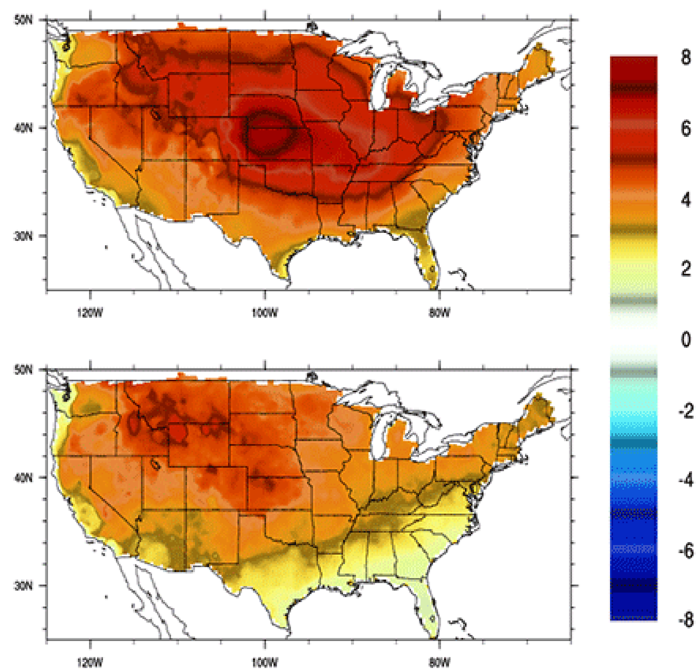
HIGH-RESOLUTION RESEARCH DATA FOR CLIMATE CHANGE STUDIES



Bias in climate change. Both figures show the change (in degrees C) in the summer average daily maximum temperature for the HRM3-GFDL simulations from NARCCAP. The top figure shows the climate change for uncorrected (raw) data; the bottom figure shows the climate change after bias correction.

In collaboration with a broad range of public and private laboratories and universities, the mission of the Regional Integrated Science Collective (RISC) is to generate high-quality regional-scale scenarios of projected climate change, then develop tools and methods for analyzing impacts, vulnerability, and adaptation options. RISC's placement in IMAGe shows the close ties between evaluating climate models and quantifying uncertainty using statistics. RISC also reaches out to the broader decision-making and policy communities by integrating mathematical analyses into a more immediate and pragmatic realm. RISC has responsibility for serving large and multifaceted numerical experiments, so it is well aligned with CISL's mission of data support to the climate science community.

A centerpiece of RISC's activity has been its leadership of the North American Regional Climate Change Assessment Program (NARCCAP). NARCCAP is systematically investigating the uncertainties in regional-scale projections of future climate. It is unique in its balanced design that allows for isolating the influence of individual regional and global models on the resultant climate simulations. The overall goal of NARCCAP is to produce high-resolution (50 km) climate change scenarios using six regional climate models (RCMs) nested within four atmosphere-ocean general circulation models (AOGCMs) forced with the A2 SRES emission scenario, over a domain covering the conterminous U.S., northern Mexico, and most of Canada. The project also includes an evaluation arm whereby the participating RCMs are forced by reanalysis data sets. The resulting regional climate model runs and time slices form the basis for multiple high-resolution climate scenarios that can be used in climate change impacts assessments in the U.S. and Canada. In FY2014, work related to NARCCAP has entailed completing archiving of data and applying the data sets to a number of climate and impact analyses.

Further analyses and data products development using NARCCAP

RISC's activities include the development of a number of data products and services to support the users of data from NARCCAP. These will also be useful for future anticipated high-resolution regional climate simulations such as those to be developed in North American CORDEX. Seth McGinnis has been collaborating with CISL's VETS group and NOAA's NCPP project to help guide the development of next-generation data services that will enable users of output from “Big Data”

projects like NARCCAP to access the data they need without downloading large volumes of unwanted data to get it. These new service capabilities include spatial and temporal subsetting, file spanning, aggregation, and format conversion.

Simulation data bias correction

Having identified bias correction as an important need of NARCCAP users, especially for impacts analysis, RISC has been working to bias-correct NARCCAP output using distribution mapping techniques. This work breaks new ground by applying the methods to daily data rather than monthly or seasonal climatologies. Seth McGinnis has developed a novel technique for distribution mapping called Kernel Density Distribution Mapping (KDDM). KDDM makes use of well-established statistical methods to perform distribution mapping using non-parametric estimates of the probability distributions underlying the data sets to be bias-corrected. This technique has been evaluated against existing techniques by use of an oracle analysis, wherein each technique is used to bias-correct synthetic data and the result is compared to a perfect correction, or "oracle." KDDM performs very well according to multiple metrics, and has the best performance on non-idealized data. It is also fast, robust, flexible, and conceptually straightforward. These results will be published in the proceedings volume for the 2014 Climate Informatics Workshop, and plans are in development for KDDM to be used in collaborations with Brian O'Neill's group in CGD and Katherine Hayhoe's group at Texas Tech University. The application of bias correction to climate model data affects the degree of climate change that is seen. The figure above shows the results for one model pair for NARCCAP, and indicates that the climate change determined from the raw model output is considerably larger than that from the bias-corrected data. Of course applying bias correction to both the current and future simulations implies that we believe the "correction" for the future will be the same as that for the current period. This assumption is difficult to verify.

Development and testing of Regional Climate Model Evaluation System (RCMES)

In collaboration with NASA JPL and UCLA, RISC has contributed to the development of RCMES, which combines observations (especially from satellite remote sensing) and Information Technology (IT) to establish core climate model assessment capabilities. The NARCCAP data set has served as the testbed for RCMES, which is also being used to evaluate many of the simulations of CORDEX. An important added value of RCMES is its establishment of uncertainty related to multiple observation data sets. RISC's MICA project will contribute the final daily temperature and precipitation data sets with measures of uncertainty for use in RCMES.

Evaluation of the North American Monsoon in the NARCCAP simulations

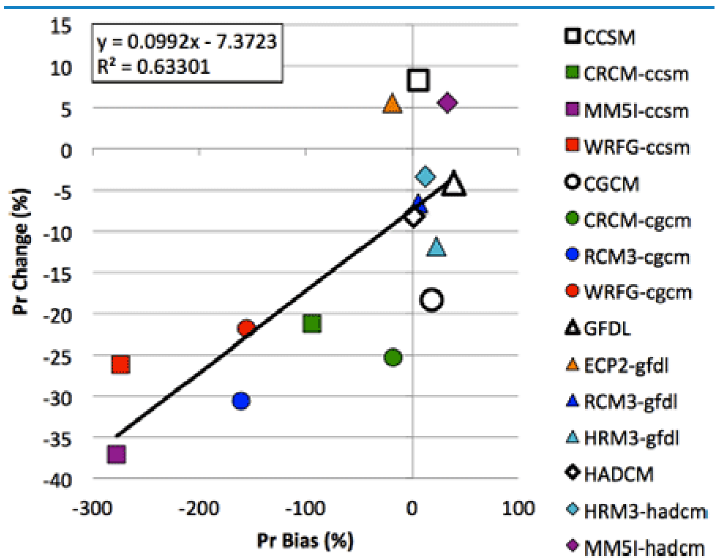
Melissa Bukovsky has led, in collaboration with Dave Gochis in RAL, the evaluation of how well the NARCCAP models reproduce characteristics of the North American Monsoon (Bukovsky et al., 2013, *J. Climate*) and has pursued an investigation of the effect of model errors on the future projections of climate in this area. New findings this year (Bukovsky et al., 2014) include the fact that the least credible models produce the largest decreases in precipitation, whereas the "best model" produces little change in precipitation (see figure below). This result is particularly noteworthy since strong relationships between biases in current period simulations vs. changes in precipitation in the future are rarely seen.

Heat stress and exposure to heat

RISC scientists are collaborating with scientists from the IAM group in CGD to produce analyses of the combined distribution of heat and population based on the NARCCAP simulations and downscaled population distributions. This gives an indication of how many people are exposed to different levels of heat stress. The study finds that U.S. population exposure to extreme heat increases four- to six-fold over observed levels in the late 20th century, and that changes in population are as important as changes in climate in driving this outcome. A manuscript has been submitted to *Nature Climate Change* (Jones et al., 2014).

Development and provision of climate information including uncertainty measures for adaptation research

RISC is currently engaged in three different research projects concerning adaptation to climate change at local and regional scales. These projects include one funded from NSF EaSM, "Informing Climate Related Decisions with Earth System Models," led by RAND; and two funded through the DoD Strategic Environmental Research and Development Program (SERDP): "Decision-Scaling: A Decision Framework for DoD



July-August average precipitation change (%) from the current to the future period vs. the precipitation bias (%). Bias is defined as the model current period average (1971–1999) simulation minus North American Regional Reanalysis (NARR) (1980–2003). Values are the average of land points only over the core North American Monsoon Area. The linear fit applied to the points does not include the driving global climate model (GCM) results. Model

pairs indicate the regional model (capital letters) and global model (lower case) that drove the regional model.

Climate Risk Assessment and Adaptation Planning," led by U. Massachusetts, and "Understanding Data Needs for Vulnerability Assessment and Decision-making to Manage Vulnerable DoD Installations to Climate Change," led by PNNL. All three concern decision-making and more specifically risk management under various conditions of uncertainty, including that of climate. All three projects rely to some degree on the use of the NARCCAP simulations in various resource management contexts. The EaSM project specifically considers ecological and water resources in the U.S. East and West, while the two SERDP projects consider a range of resources and climate conditions relevant to U.S. military bases (in the Southeast, mid-Atlantic, Texas, the Front Range of Colorado, and southern California) such as heat stress, flooding, changes in available water resources, etc. The analysis of changes in snowpack, number of days of snow cover, etc., are relevant to a number of resources, particularly water resources. These results, analyzed by Rachel McCrary, are being used in one of the SERDP projects for the location along the Front Range of Colorado as well as in the EasM water resource segment in California. Particular attention has also been devoted to developing a Climate Outlook for the mid-Atlantic region, which is relevant to four of the sites being investigated. It is a challenging area for the development of future climate scenarios, since it is a region of transition between wetter future scenarios to the north and drier scenarios farther south.

WCIASP

RISC also maintains and develops the Weather and Climate Impacts Assessment Science Program (WCIASP). WCIASP has three primary thrusts: investigating uncertainty in climate change research, studying extreme weather and climate events and their impacts, and supporting the Climate and Health Workshop series. WCIASP funds projects throughout NCAR, particularly in CGD, RAL, and other sections in IMAGe.

Funding

The Regional Integrated Science Collective (RISC) has been supported by NSF Core funding as well as interagency support for NARCCAP and the use of NARCCAP results for adaptation planning from NSF, NOAA, NASA, EPA, and DoD.

‹ Data assimilation research | up | Parallel data processing ›

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NCAR Strategic Plan

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Select year

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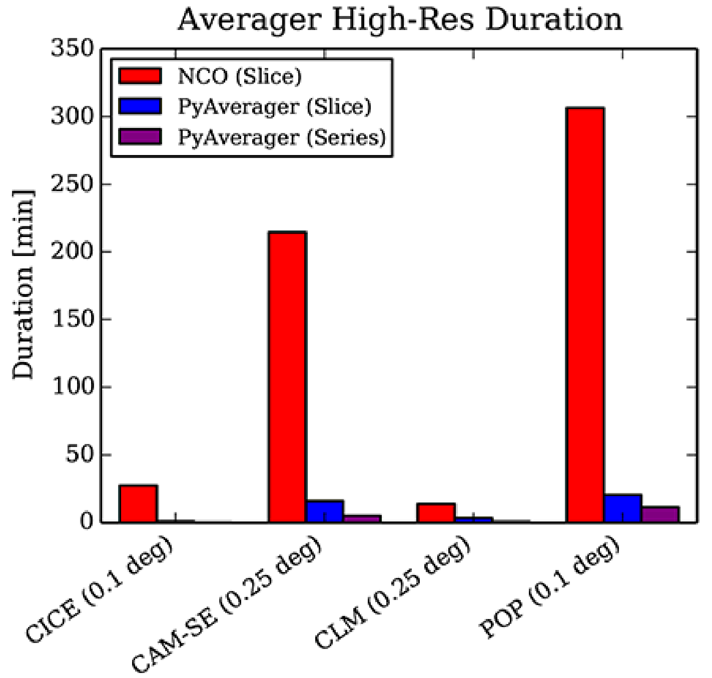
PARALLEL DATA PROCESSING



The time in minutes to perform temporal averaging using the existing serial NCO methods and pyAverager operating on either time-slice or time-series data. Note that time for POP at 0.1 degree has been decreased from 5 hours to 21 minutes for the time-slice data and and 12 minutes for the time-series data.

The parallel data processing project is critical to the objectives of NCAR for several reasons. While the rate at which it is possible to generate simulation data from the CESM has increased rapidly over the last 5 years, our ability to analyze it has not due to the serial nature of the post-processing workflow. The impact of a serial post-processing workflow was apparent during the CMIP5 project when the post-processing took as long to perform as the initial simulations. This project will increase the scientific discovery rate by removing post-processing bottlenecks.

During FY2014, CISL's Technology Development Division (TDD) added a new software engineer and project scientist within the Application Scalability and Performance (ASAP) Group to accelerate the post-processing workflow for Earth System modeling. We focused on accelerating the post-processing workflows used in both the Community Earth System Model (CESM) and the Community Model Inter-comparision Project (CMIP5).

Also in FY2014, ASAP collaborated with NCAR's Climate and Global Dynamics Division to develop a parallel data post-processing capability based on Python and Message Passing Interface (MPI). Currently this capability consists of two software applications: pyReshaper converts time-slice to time-series format, and pyAverager performs temporal averaging. The pyAverager code is written in Python and uses MPI and pyNIO (the I/O library from NCL) to calculate temporal averages over a collection of climate data in parallel. A number of different types of climatologically important averages are supported including annual, monthly, seasonal, and yearly. The duration to perform temporal averaging necessary for the standard post-processing diagnostic packages for 10 years of high-resolution CESM data is illustrated in the figure above.

This work on parallelizing the post-processing workflow was supported through NSF Core and NSF Special funds.

‹ High-resolution research data for climate change studies   up   Scientific data compression and visualizing large datasets ›

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2014 CISL ANNUAL REPORT

- CISL Director's message
- CISL Services
- CISL Science
  - Data-centric research
    - Data assimilation research
    - High-resolution research data for climate change studies
    - Parallel data processing
    - Scientific data compression and visualizing large datasets
    - Statistics for geophysical data and model experiments
  - Scalable algorithms for massively parallel computers
  - Computational research and development
- CISL Education, Outreach, and Training
- Broader Impacts

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

CISL Strategic Plan

NCAR Strategic Plan

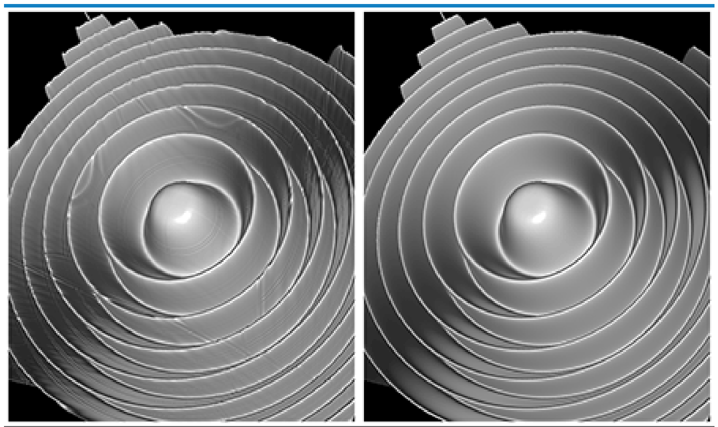
PREVIOUS CISL REPORTS

Select year

Printer-friendly version

SCIENTIFIC DATA COMPRESSION AND VISUALIZING LARGE DATASETS

CISL is exploring a variety of hardware- and software-based approaches for addressing the challenges of storing, visualizing, and analyzing large data sets. CISL is also exploring two interrelated approaches to the challenges of large data sets. The first major software thrust in this area has been research, development, and experimentation with wavelet-based progressive-access data models for structured scientific data sets. Wavelets are the basis for numerous, ubiquitous multimedia compression technologies such as the JPEG 2000 image compression standard. However, unlike the "lossy" compression strategies used in consumer entertainment, our efforts are focused on level-of-detail techniques that offer perfect reconstruction of the original data while allowing the user to make speed/quality tradeoffs when performing interactive work. The second focus is to develop a method for determining how much information can be lost without impacting the results of typical climate analysis. The goals of all this work are to:



This figure qualitatively compares the current VDC compression scheme (left), with results from the SPIHT encoder (right) using a synthetic data set that has been compressed 64:1. The image on the left exhibits artifacts, while the one on the right is visually indistinguishable from imagery generated using the original data. Exploring data reduction strategies that are suitable for scientific data sets is a key component of CISL's Big Data research agenda.

- Determine whether, and to what degree, scientific data sets can tolerate information loss.
- Investigate a variety of compression methods and their suitability for geoscience data.
- Develop user tools for data compression and improved, more general, progressive data access.

Exponential growth in transistor density is producing ongoing increases in computer processing power. These increases enable computational scientists to create numerical simulations of physical phenomena at unprecedented scales, thus generating extraordinary amounts of data. Yet while microprocessor performance continues to advance in accordance with Moore's Law, other computing technologies are improving at much more modest rates. In particular, storage and networking bandwidths have lagged behind. As a result, the challenge of storing, analyzing, managing, and sharing large simulation data sets is becoming ever more problematic. Moreover, large data visualization is a central component in petascale computing and making large and heterogeneous data sets understandable. This is a science frontier specified in CISL's strategic plan, which specifies these tasks:

- Deploy and investigate parallel visualization clusters.
- Partner with peer institutions and combine efforts to develop and enable visualization of large data.

In FY2014, CISL continued development of VAPOR's open source progressive data access model, the VAPOR Data Collection (VDC). This year we completed an effort to refactor the VDC API to better support the Earth sciences communities, particularly those with data adhering to the widely used NetCDF Climate Forecast (CF) Metadata conventions. The new "version 3" API removes many of the constraints imposed by the old API and should facilitate greater adoption by the Earth sciences modeling communities. The refactoring effort wrapped up at the end of FY2014. The software will be publicly released in FY2015.

CISL partnered with the DOE's National Renewable Energy Lab and the University of Oregon on a DOE proposal that would explore state-of-the-art compression encoding techniques (such as SPIHT), preparing the VDC software for exascale environments, and using GPGPUs and many-core processors. The proposal was highly reviewed, but not funded.

This data compression and visualization research is supported by NSF Core funds.

‹ Parallel data processing | up | Statistics for geophysical data and model experiments ›

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STRATEGIC PLANS

CISL Strategic Plan

NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

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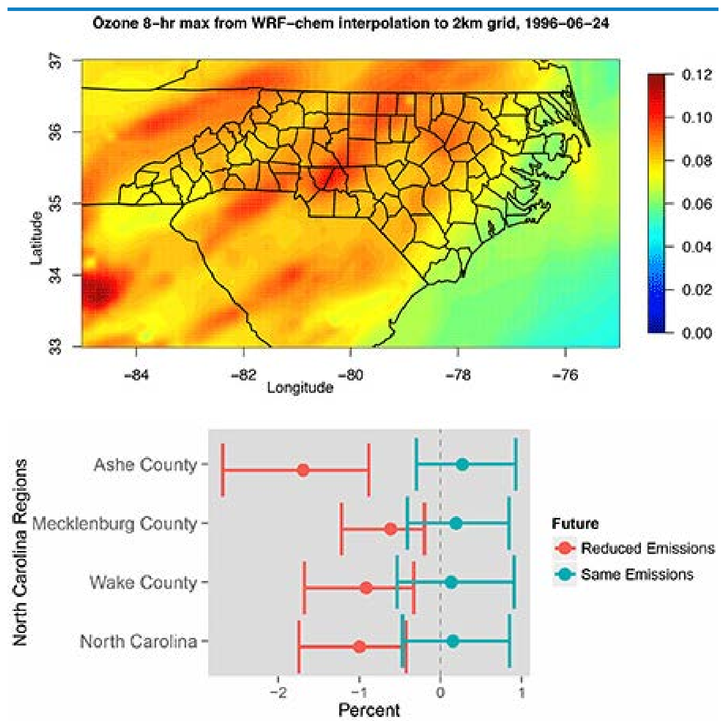
STATISTICS FOR GEOPHYSICAL DATA AND MODEL EXPERIMENTS

From its unique position within CISL and IMAGe, the Geophysical Statistics Project (GSP) has been a leader in research and training emphasizing the synergy between the geosciences and the statistical sciences. In addition to basic methodological and theoretical statistical research for scientific problems arising in the geosciences and at NCAR, GSP is focused on developing algorithms and tools to harness multi-core and high-performance computing environments to enhance capabilities for analyzing large datasets, and in particular, those involving spatial and spatial-temporal dependence. Further, GSP has a strong interdisciplinary training component supporting graduate students and postdoctoral visiting scientists. These young researchers are immersed in research activities that not only focus their skills as applied statisticians but also expose them to important geophysical applications.



An assessment of the impact of climate change on air quality and public health. The upper figure is an example of the surface ozone field simulated by the WRF-CHEM regional model which was in turn driven by the global information from the NCAR climate model. Shown in this subregion over North Carolina is the maximum value of 8-hour averages over a specific day. This particular statistic for ground-level ozone is related to the regulations formulated by the Environmental Protection Agency to determine if ozone levels are in violation of standards. High ozone levels are accepted to cause respiratory problems and also contribute to increased mortality in exposed populations. These simulations were carried out over 13 simulated years for current and future conditions for the entire U.S. The lower figure is a summary of the expected change in mortality between our current climate and a future climate (IPCC SRES A2 scenario). The mortality computation is based on a meta analysis that relates mortality to ozone levels and where the ozone levels are taken from the numerical simulations. A novel feature of this analysis is the statistical ranges in these estimates that integrate not only uncertainty in the ozone/mortality relationship but also the variability in ozone pollution over time and from year to year. Results for several counties and for the entire state are given for two different ozone emissions scenarios (no controls and RCP 8.5).

GSP also has an active visitor program providing research opportunities for visiting faculty members from across the nation and abroad. Our goal is to foster collaboration between graduate students, postdocs, the permanent and visiting GSP and IMAGe staff, and more broadly, NCAR scientists. These programs – as well as the research and training aspects of GSP that emphasize the interaction between statistics and the geosciences – embody the tenets of integration, innovation, and community building within the CISL Strategic Plan. This program advances CISL's strategic imperative to produce scientific excellence by leading the scientific community in adopting new computational methods and mathematical tools that enhance scientific research. More specifically, GSP supports CISL's science frontier of developing innovative statistical design and analysis techniques to improve the efficiency and accuracy of model development and testing. During FY2014, GSP researchers have been involved in numerous projects including NCAR staff and also university collaborators. Some highlights are:

- Validating computer experiments of the upper

atmosphere and the magnetosphere that focus on coherent features in the fields. These features are compared to observations using image warping – a technique from image analysis – and object-oriented validation – a technique from forecast evaluation.

This shows that under these simulations, there is no evidence for a change in mortality if no controls are placed on ozone pollution. If emissions are restricted, however, we see a reduction in mortality rates for North Carolina as a whole and in these selected counties.

- Estimating impacts of climate and climate change on public health. These include estimates of heat stress for the Houston metropolitan area and the impact on public health due to future levels of surface ozone. The statistical results that link mortality to changing levels of ozone for the U.S. is the most comprehensive study to date that integrates high-resolution atmospheric chemistry simulations under present and future climates with a meta-analysis of the link between ozone levels and mortality. (See example from figure.)

- Building software tools to analyze large spatial datasets. This includes LatticeKrig, a contributed package in the R statistical language, that can accelerate spatial analysis by factors of 10 or more using sparse matrix methods. This software was used as a testbed for estimating regional temperature trends during the Surface Temperature Initiative Workshop.

More broadly, GSP continues to develop theory and methodology for analyzing spatial and spatial-temporal data (including large datasets, nonstationary covariance models, and multivariate spatial observations). These include an extension of statistical models to a spherical domain for the analysis of global geophysical fields.

This project is made possible through NSF Core funding, as well as grants through NSF’s Division of Mathematical Sciences (DMS0707069), NSF’s Division of Atmospheric Sciences (ATM0934488), NSF’s Collaboration in Mathematical Geosciences (AGS0934488), and the National Aeronautics and Space Administration (NNX10AK79G).

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2014 CISL ANNUAL REPORT

- CISL Director’s message
- CISL Services
- CISL Science
  - Data-centric research
  - Scalable algorithms for massively parallel computers
    - High Order Method Modeling Environment
    - Meshless numerical methods for geophysical modeling
  - Computational research and development
- CISL Education, Outreach, and Training
- Broader Impacts

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- CISL Strategic Plan
- NCAR Strategic Plan

SCALABLE ALGORITHMS FOR MASSIVELY PARALLEL COMPUTERS

NCAR models of the Earth System and for solar physics motivate CISL's scientific research on algorithms, numerical methods, and computational performance. A priority in geophysical modeling is to increase resolution to resolve important processes and uncover unexpected interactions within the physical system. This goal must be pursued within the context of massively parallel computational resources.

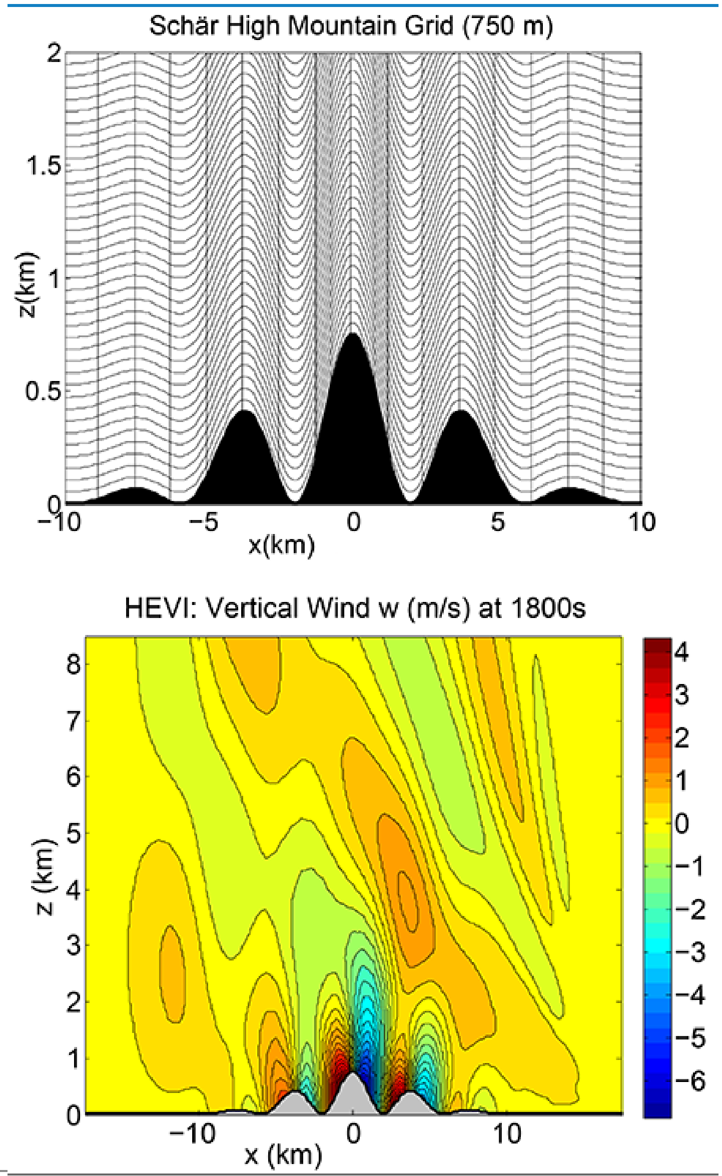
Given these two elements, CISL research focuses on areas to increase model resolution through methods that scale to large numbers of processing cores. It is well understood that to take advantage of the unique characteristics of large systems, improvements in simulation speed depend on better numerical algorithms and innovative computer science.

Accurate and highly scalable numerical methods were developed to discretize partial derivatives in geophysical equations. The innovation is the use of a local set of radial functions to generate the differentiation weights without being tied to a regular mesh. Moreover, these computations are well suited to take advantage of graphics accelerators and other kinds of coprocessors.

During FY2014 there was further progress on a developing a discontinuous Galerkin and nonhydrostatic dynamical core that will support the next-generation numerics for the NCAR community atmosphere model.

In addition, radial basis function methods were extended to a nonhydrostatic model relevant to convective scale meteorology.

This work is funded as specified in the following individual reports.



Simulation of orographic waves for a nonhydrostatic model for atmospheric flow that employs the terrain-following height-based vertical (z) coordinates. The upper panel shows a non-uniform mountain which has a maximum height of 750 meters and is used for the simulation with a grid spacing of dx=2 dz=250 meters. The lower panel shows the vertical velocity field (m/s) after 1/2 hour and is computed using a time-stepping algorithm (HEVI) that is both accurate and more efficient than slower alternatives (such as an explicit Runge-Kutta scheme). These model scales are important to simulate the effect of terrain. As climate models resolve finer scales, accounting for detailed terrain has the potential to provide more realistic simulation of atmospheric flows and the resulting climate.

‹ Statistics for geophysical data and model experiments
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High Order Method Modeling Environment ›

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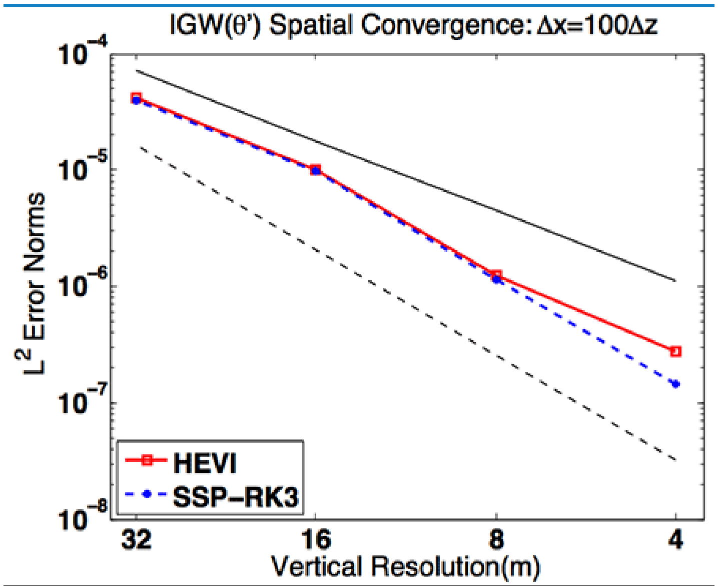
HIGH ORDER METHOD MODELING ENVIRONMENT



Convergence plots with split (horizontally explicit vertically implicit HEVI) and explicit Runge-Kutta (RK) scheme used in the Discontinuous Galerkin Nonhydrostatic (DGNH) model for a test case where the horizontal and vertical grid-spacing aspect ratio is 1:100. The operator-split HEVI scheme (red line) maintains second-order accuracy. Because of the implicit treatment in the vertical direction, the HEVI scheme can effectively take a time-step 100 times larger than that of the fully explicit Runge-Kutta scheme (blue line), without degrading the quality.

The High-Order Method Modeling Environment (HOMME) is a hydrostatic framework to investigate using high-order element-based methods to build conservative and accurate dynamical cores. Currently, HOMME employs the Spectral Element (SE) and Discontinuous Galerkin (DG) methods on a cubed-sphere tiled with quadrilateral elements. HOMME can be configured to solve the shallow water or the dry/moist primitive equations with explicit time-stepping. The objective of this project is to extend HOMME to a framework capable of providing the atmospheric science community with a new generation of atmospheric general circulation models (AGCMs) for the CESM (Community Earth System Model). Currently the SE version of HOMME is the default dynamical core for NCAR's Community Atmosphere Model (CAM), and HOMME-SE can efficiently scale hundreds of thousands processors on a supercomputer. With the emergence of petascale computing resources, it is now possible to develop high-resolution (cloud-resolving) global models at non-hydrostatic (NH) scales.

For a typical NH global model, the vertical grid spacing (dz) is several magnitudes smaller than the horizontal grid spacing (dx). A major computational challenge is to find an efficient time-stepping scheme for the NH model. The maximum stable time step for explicit time discretizations is dictated by the Courant–Friedrichs–Lewy (CFL) stability limit. At a higher resolution (smaller grid spacing), the CFL limit requires extremely smaller time steps, and is not practical for global NH models simulating climate. However, the stringent CFL limit associated with vertical high resolution can be remedied by treating the vertical component of the equations an in implicit manner and the horizontal components explicitly, using a dimension-splitting procedure. This method is often called "horizontally explicit vertically implicit" (HEVI). To evaluate the time-stepping scheme, a prototype NH Euler model in 2D (x-z plane) based on the DG method was developed in FY2013, and used as a testbed that essentially mimics the vertical aspects of a fully 3D model. The vertical discretization for the DG-NH parallel model relies on terrain-following height (z) coordinates, with an explicit or HEVI time-stepping scheme. Extending the hydrostatic HOMME framework for the NH model development was a major research effort in FY2014 – with main focus on the development of efficient time-stepping schemes.

The figure above shows the convergence rate of the DG-NH model using the HEVI and explicit Runge-Kutta (RK) time steps, for a benchmark test case where dx = 100dz. The dimension-split HEVI scheme shows a second-order convergence, close to the theoretical limit for a split scheme. Since the vertical grid spacing is independent of the time stepping used for the HEVI scheme, it can potentially take a time step 100 times larger than permitted by the explicit RK scheme and produce results of the same quality. The DG-NH model is capable of handling complex orography and successfully simulates the orography-induced waves. No visually distinguishable difference is observed between the results of the explicit RK scheme and the HEVI scheme. There is no unphysical distorted wave pattern shown in the upper level of the domain. This shows that the HEVI approach is a viable option for the time integration in 3D NH model based in the HOMME framework.

This work supports CISL's science imperative to develop mathematical research codes that improve modeling. Specifically,

it fulfills the strategic action item to further develop the HOMME dynamical core. Primary support for HOMME is provided by NSF Core funding. The validation of the HOMME dynamical core and HOMME/DG development are supported by U.S. Department of Energy grant DOE BER SciDAC 06-13194 and funded through subaward 1548727 from the University of Colorado at Boulder, with additional funding from the Korean Institute of Atmospheric Prediction Systems of Seoul, South Korea.

‹ Scalable algorithms for massively parallel computers | up | Meshless numerical methods for geophysical modeling ›

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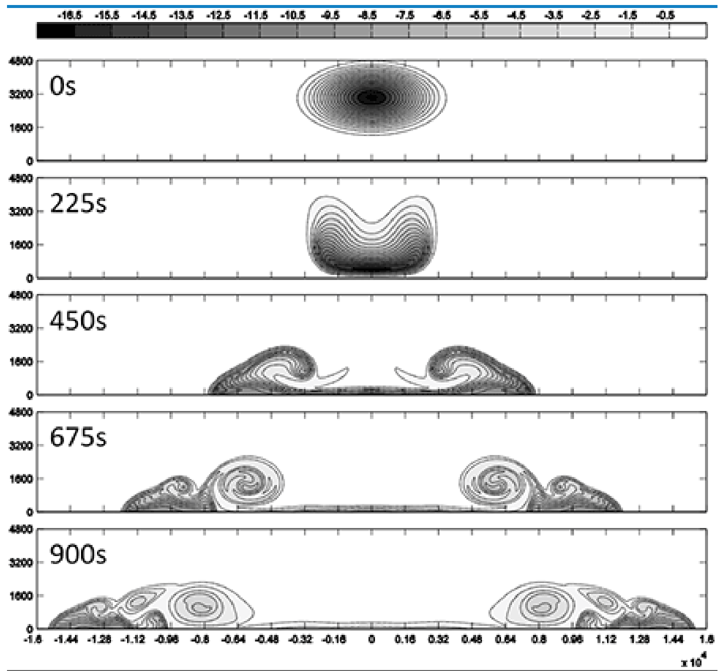
MESHLESS NUMERICAL METHODS FOR GEOPHYSICAL MODELING



The time evolution of the potential temperature for the Straka density current test case using a hexagonal node layout at 100m resolution.

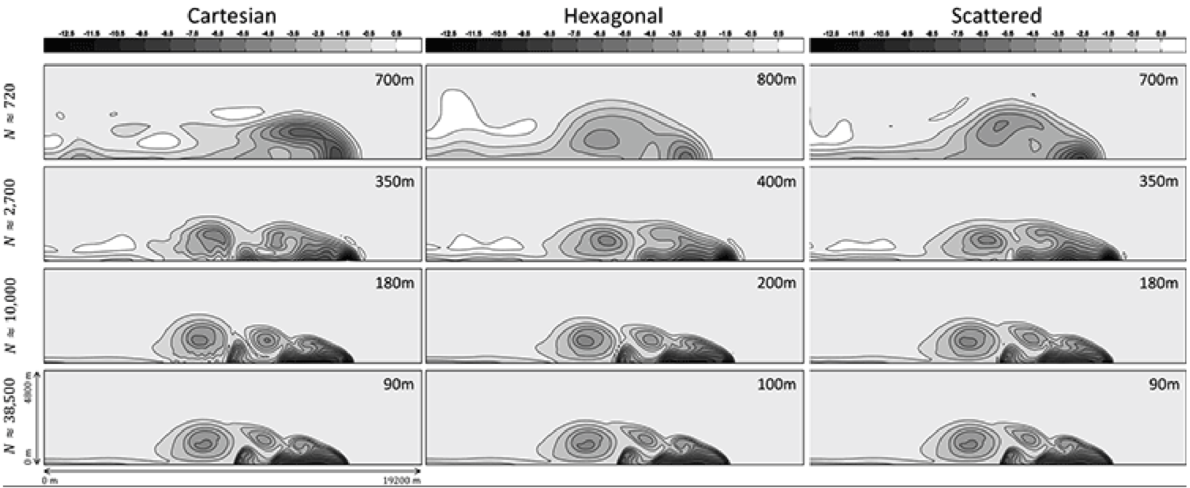
While computer architectures have advanced rapidly in recent years, numerical schemes currently used for geoscience modeling have not kept pace with these technological developments. Radial basis functions (RBFs) offer a novel numerical approach for solving partial differential equations to high accuracy. Being a meshless method, RBFs excel in solving problems that require geometric flexibility, local refinement for small features, and minimal increase in programming complexity when extended to higher dimensional spaces. In particular, the RBF-generated finite differences (RBF-FD) approach has allowed the RBF method to become computationally cost-effective in terms of scalability, memory, and runtime for solving systems of PDEs. The localized and accurate nature of the RBF-FD method:

- Leads to matrices that are 99.8% empty.
- Allows it to scale as O(*N*) per time step, with *N* being with the total number of nodes.
- Makes it highly suitable for parallelization on accelerator-based computer architectures.

The fact that they do not depend on any grid, mesh, or coordinate system, but only the Euclidean distance between node locations in any dimensional space, makes it particularly easy to test how different node distributions influence the extent to which the physics is captured.

The figure above shows the time series for the Straka density current test case where a bubble of cold air descends and develops three smooth and distinct rotors due to shear instability as it spreads sideways. The figure below examines how three different node layouts, Cartesian, hexagonal, and quasi-uniformly-scattered, affect the extent to which the rotors are clearly formed. Under refinement, the solution is the same in all cases, as seen in the highest resolution displays (bottom row of subplots). However, in the coarsest cases shown, 700m-800m (720 nodes in domain), the hexagonal and scattered nodes give clearer evidence of the first rotor being formed. At the next highest resolution (about 400m), they provide a better picture of the formation of subsequent rotors. Cartesian nodes are more prone to spurious oscillations or overshoots.

This test case shows that by building on the accomplishments of FY2012 and FY2013, FY2014 produced further development of the RBF-FD method with the extension to an RBF-FD model for



The potential temperature for the Straka density current test case at the final time t = 900s, shown as a function of the total number of nodes when using the RBF-FD method on different node sets. For plot clarity, only half of the solution is displayed.

the 2-D fully compressible nonhydrostatic equations relevant to atmospheric modeling. These advancements were made possible by the successful collaborations of the IMAGe Computational Mathematics Group working together with the University of Colorado-Boulder and the NOAA National Severe Storms Lab to continue research in the promise of using RBFs for geoscience modeling.

This work advances CISL's scientific efforts to develop scalable algorithms for atmospheric modeling on massively parallel and accelerator-based computer architectures. This development effort at NCAR is supported by NSF grant DMS-0934317.

‹ High Order Method Modeling Environment | up | Computational research and development ›

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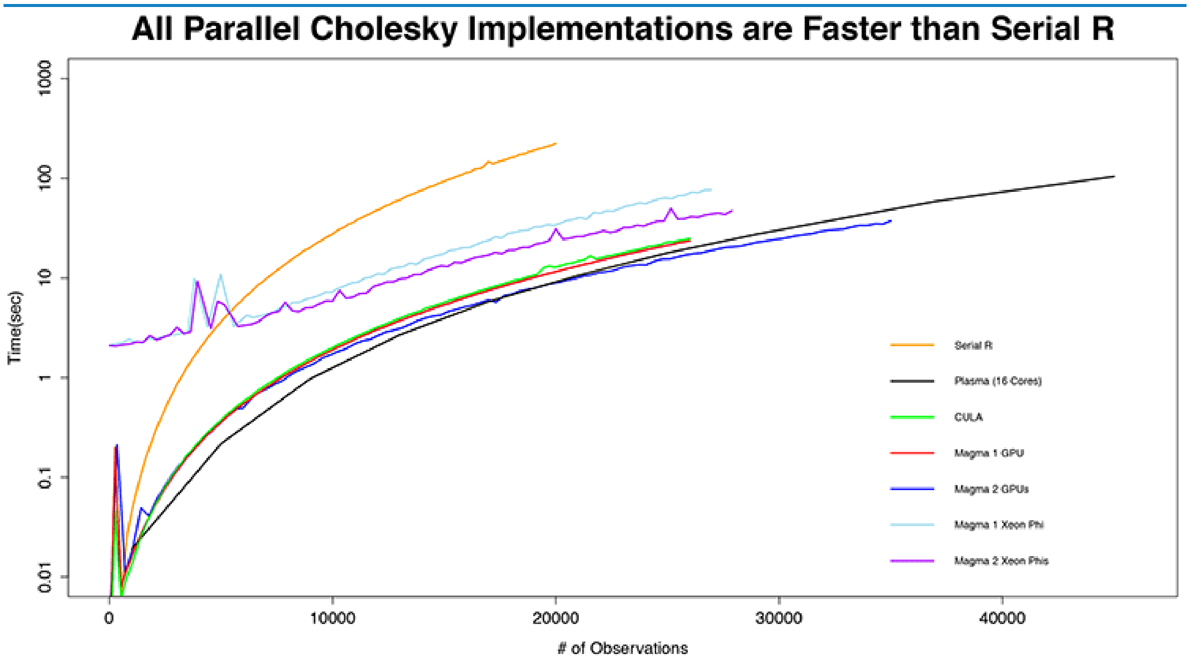
COMPUTATIONAL RESEARCH AND DEVELOPMENT

Meeting the grand challenges in simulating the Earth System requires much more than just migrating standard algorithms to larger computational platforms. New hardware, parallel computational approaches, and more efficient algorithms are all needed to reach the resolution and complexity levels necessary to support scientific breakthroughs in modeling. The research in this section focuses on CISL's mission to anticipate new computational technologies and determine their fit for geoscience applications. These activities also adapt software tools and numerical methods to emerging technologies.



A comparison of timing for the Cholesky matrix decomposition as a function of matrix size. The Cholesky decompostion – finding the triangular square root of a matrix – is the main computational step in many kinds of data analysis, so it is important to accelerate its computation based on possible advantages from different kinds of coprocessors, multiple cores, and numerical libraries. This figure reports some research from a collaboration between a summer intern and CISL computational scientists and statisticians. Plotted are the times for a decomposition as function of the matrix size (number of observations) for a single core and high-level implemetation in the R language (orange), a parallel version using 16 cores and the PLASMA libraries (black), and for one and two coprocessors. The results indicate that that using 16 cores is comparable to one or two GPUs, and both of these choices are better than using Xeon Phi coprocessors. As expected, the serial R timings are more than an order of maginitude slower and so suggest that parallel or GPU implements could be advantageous. These results are important because a spatial data analysis can involve many decompositions for matrices on the order of 10,000 observations rather than decompositions for a few very large matrices. So acceleration for this problem will have a significant impact.

CISL research activities support scientific computation, numerical methods, geophysical modeling, and the analysis of geophysical data and model experiments to improve research through new computational methods and mathematical tools. Diverse scientific disciplines often share common tools and numerical methods. The types of mathematical, computational, and physical sciences housed in CISL focus on general mathematical tools, models, and algorithms that have broad application across NCAR and are also significant in their specific area of mathematical, physical, or computational science. The activities outlined in this section reflect the breadth and quality of this scientific research.

CISL derives its research priorities from the computational science challenges in the NCAR strategic plan with emphasis on innovation and collaboration. Based on these priorities, CISL focuses its applied scientific research and development activities in these areas:

- Exploiting many-core and accelerator-based architectures: The Technology Development Division's ASAP group is enhancing the scalability and performance of key kernels extracted from climate and weather models on various many-core architectures, including GPUs and Intel's Xeon Phi architecture, using a variety of languages, compilers, source-to-source translation tools, and directive-based methods.
- Accelerating data analysis: TDD is conducting research to develop end-to-end parallel data analysis and visualization technologies intended to accelerate scientific discovery on large or complex data sets.
- Accelerating applications algorithmically: Goals for the next generation of global atmosphere models include accommodating regional grid refinement, resolving fine-scale convective processes that occur on scales on the order of a few kilometers, taking relatively large implicit or semi-implicit time steps, and conserving physical quantities such as mass and energy to machine precision. We are developing several novel numerical methods to tackle these challenges.

This work is supported by NSF Core funding, with supplemental funding supplied by other sources as noted in the following reports.

‹ Meshless numerical methods for geophysical modeling   up   Evaluating many-core and accelerator-based architectures ›

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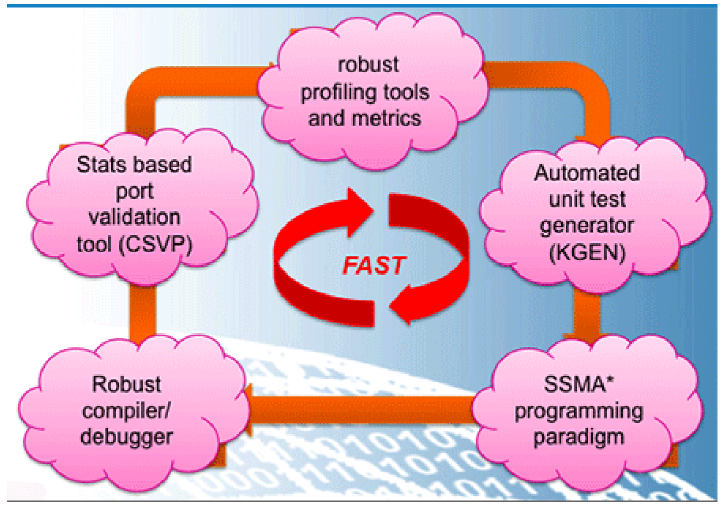
EVALUATING MANY-CORE AND ACCELERATOR-BASED ARCHITECTURES



The proposed Performance Enhancement Methodology (PEM) is a virtuous cycle that involves identifying poorly performing sections of code, extracting the target sections of code into a kernel, followed by subsequent optimization. We are targeting a single source/multiple architecture capability for software maintainability and portability.

In FY2014, members of the Application Scalability and Performance (ASAP) group within CISL's Technology Development Division (TDD) explored the use of accelerator technology within existing weather and climate model codes. This group is evaluating the two main accelerator architectures: general-purpose graphics processing units (GPGPUs) from NVIDIA and Intel's Xeon Phi processor.

During a FY2014 collaboration between ASAP, CGD, and IMAGe, this group advanced the development of two important tools that will enable the evolution of existing code base toward many-core architectures. The tools include a Python-based Kernel Generator (KGEN) which easily extracts blocks of code from large applications into small kernels, and the CESM Statistical Verification Package (CSVP) which simplifies the verification of answer-changing code modifications. Along with robust performance-profiling tools, these new tools have allowed us to develop a Performance Enhancement Methodology (PEM). This PEM, illustrated in the figure above, is composed of several synergistic capabilities that will allow for the systematic evolution of our large existing code bases toward higher performance many-core architectures.

Members of ASAP and the Community Software Engineering Group within NESL have successfully ported and verified the entire CESM Version 1.3.0 application on two Intel Xeon Phi-based clusters, one at the Texas Advanced Computing Center and another at the National Energy Research Scientific Computing Center. While CESM on Xeon Phi is not currently competitive with CESM on Xeon, we have made a number of advances. In particular we have identified improvements to the CESM code base that enhance vectorization and increase thread parallelism. We have also identified and worked with Intel to address a significant correctness problem in their compiler.

In mid-September 2014, NCAR's Technology Development Division hosted, for the fourth year, the "Programming Weather, Climate, and Earth System Models on Heterogeneous Multi-core Platforms Workshop." This workshop brought 40 experts in the field of programming accelerators to NCAR to discuss the state of the art in programming weather and climate models on many-core systems. This workshop allowed computational science teams at numerical weather prediction centers and national laboratories, who often work in isolation, to share experiences and compare best practices.

This work on the use of accelerators is supported by NSF Core funds.

‹ Computational research and development   up   Accelerating data analysis ›

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ACCELERATING DATA ANALYSIS

NSF and other agencies now broadly recognize "Big Data" as a paramount challenge across science and engineering. Models such as the Community Earth System Model (CESM) have seen dramatic improvements in their performance and in the associated volume of data they produce. At the same time, we have not seen nearly the same progress from our processing, analysis, and visualization tools, which are generally single-threaded and sometimes limited to 32-bit addressing. In addition to emphasizing the hardware cyberinfrastructure (CI) side of the data analysis problem with NWSC resources, CISL is engaged in several activities aimed at exploring the requirements and developing new strategies for the software CI side of the equation.

A three-year joint project (ParVis) with Argonne National Laboratory and several other organizations to parallelize components of NCL for ultra-large climate datasets (ParNCL) reached its final year, and a beta version was released to friendly testers in summer 2014. As discussed in this annual report's NCL data analysis and visualization software section, the DOE-funded Parvis project is aimed at providing data and compute-parallel NCL capabilities to the broad community. The basic goal is to use very large machines to efficiently analyze supercomputer output. During FY2012, we advanced task-level parallelism via Swift, completed a full conversion of the ocean diagnostics package to NCL, and completed most of the development work needed to make the first community release of ParNCL in early FY2013.

CISL continued to explore the area of web-based services for supporting very large climate datasets with new and complex grids. We prototyped REST-based web service access to the 64-bit version of NCL using a Java-based interface layer. Such services can be layered on top of, for example, CMIP5 data or much higher-resolution ocean model output. ParNCL can serve as the back-end processing engine and take advantage of using much larger-scale computers to service gateway users.

CISL was heavily involved in the CGD-led process of preparing CMIP5 data for publication into the Earth System Grid for subsequent community use. The existing tools and workflows currently in use are fundamentally serial and seriously inadequate. To address these deficiencies, CISL secured partial funding and has developed several Python-based parallel post-processing tools. A joint project between CGD, IMAGe, and ASAP developed a method to evaluate the use of lossy data compression. Our method is based on analyzing the internal variability of a large ensemble of CESM runs. We discovered that it is possible to achieve a 5-to-1 compression of climate simulation data without being statistically distinguishable from natural variability.

An FY2013 SIParCS project provided another opportunity to research web-based access to visualization and analysis of large collections of model output data stored on a centralized file server. The SIParCS intern prototyped a web service that allows a user to select from a set of model runs, and based on the options selected, produce a tailored suite of output diagnostics. For instance, the user might choose to compare two model runs over a selected time period. The service consists of a modular and extensible Python framework that achieves scalable performance using the Swift task-parallel scripting tool to control the parallel execution of the user-selected and parameterized elements of the diagnostic suite.

CMIP5, SIParCS, and data services R&D are supported by NSF Core funds. The new NSF-supported work in model data processing is supported by a special award under AGS-0856145. The ParVis project is supported by the U.S. Department of Energy Office of Science Biological and Environmental Research Division under grant DE-SC0005358. The FY2013 SIParCS program supported the 10-week project by the intern, and her CISL mentor was supported by NSF Core funds.

‹ Evaluating many-core and accelerator-based architectures | up | Accelerating applications algorithmically ›

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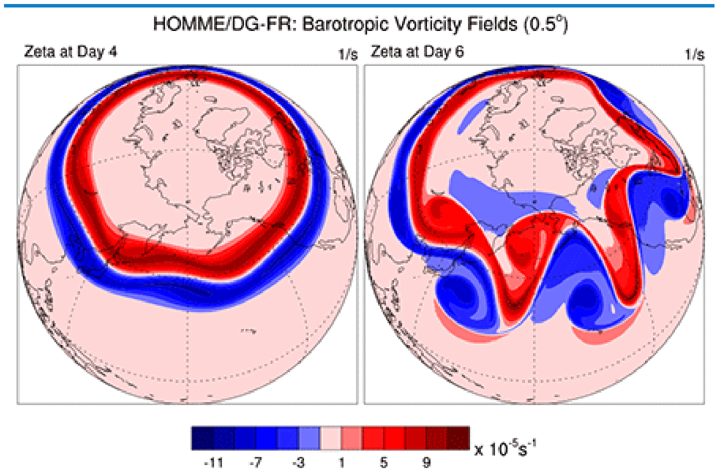
ACCELERATING APPLICATIONS ALGORITHMICALLY

New high-performance computing algorithms are needed to produce increasingly ambitious simulations for the Earth System sciences. Because each doubling of spatial resolution requires a 16-fold increase in computational cost, increases in raw computing power alone will not be sufficient to address the grand-challenge problems we face. To address this issue, CISL is developing new numerical methods, solvers, and time-integration schemes for the algorithms used for Earth System simulations. Another approach is to reduce the computational complexity of the simulation by taking longer time steps or by using fewer grid points.

CISL is reporting two highlights in this area for FY2014. The discontinuous Galerkin (DG) method shows promising acceleration potential when used with a new approach to high-order accuracy called the Flux Reconstruction (FR) procedure. Second, meshless methods such as Radial Basis Functions-generated finite differences (RBF-FD) techniques have been developed to generate computational grid points (node locations) in variable-density patterns that can produce optimal solutions to diverse problems for any given computing resource.

Discontinuous Galerkin (DG) method using the Flux Reconstruction (FR) procedure



Simulation of the relative vorticity fields at model day 4 (left) and day 6 (right) at a horizontal resolution of 0.5 degree, using the shallow-water DG-FR model in the HOMME framework. The new DG-FR algorithm produces same result as the conventional DG algorithm but with 24% more computational efficiency.

The discontinuous Galerkin (DG) method is considered to be a prominent candidate for atmospheric modeling, due to its multiple computationally attractive features such as local and global conservation, high-order accuracy, geometric flexibility, and excellent parallel efficiency. In addition, the DG method offers positivity-preserving transport for tracer advection – only a few high-order schemes can satisfy these requirements. The High-Order Method Modeling Environment (HOMME) developed at CISL employs DG spatial discretization as an option.

The DG methods use an integral (weak) formulation of the hyperbolic conservation law (i.e., governing partial differential equations) in the solution process. This leads to the evaluation of several surface and line integrals in the spatial discretization of a multi-dimensional problem, and results in a robust but computationally expensive scheme. Recently Huynh (2007) introduced a new approach to high-order accuracy called the Flux Reconstruction (FR) procedure, where the governing equations are solved in differential form. The FR philosophy can be adopted to improve the computational efficiency of the DG method. The discontinuous fluxes at the DG element edges are corrected by correction functions, which maintain flux continuity across the element edges, and the integral formulation is avoided altogether. The resulting DG-FR method (or quadrature-free version) has been implemented and successfully tested in the HOMME framework for the shallow-water (SW) model.

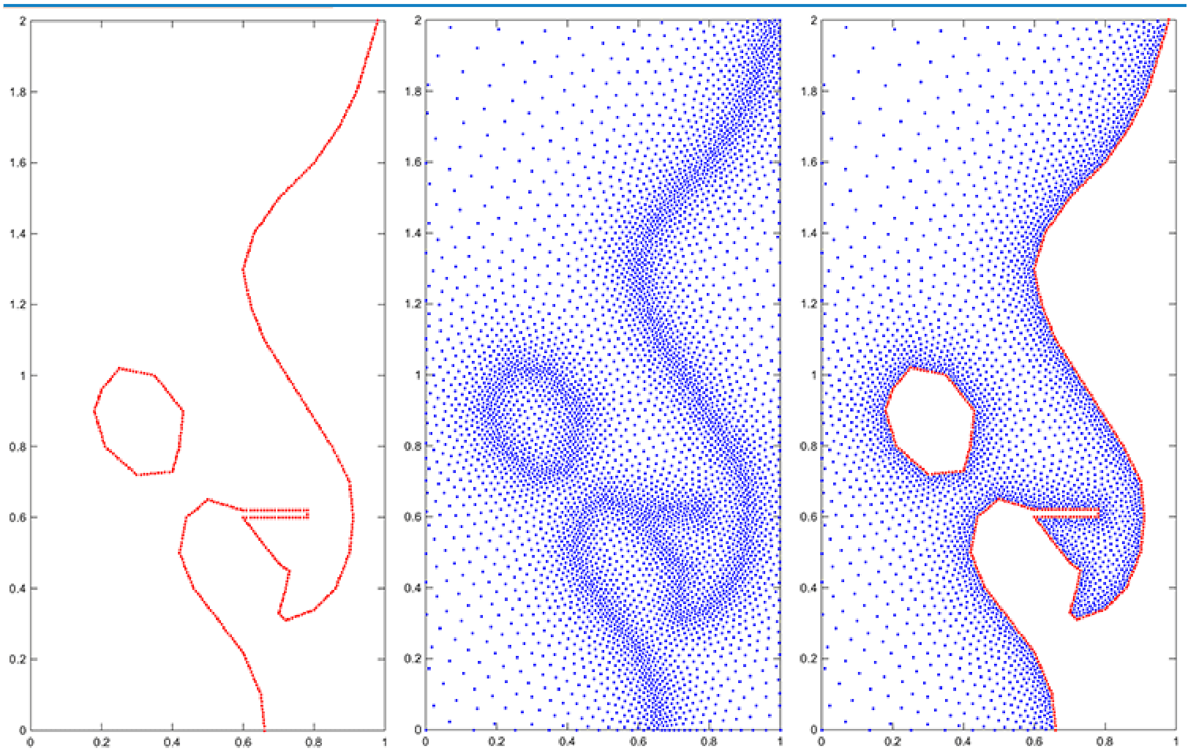
The figure above shows the barotropic instability benchmark test with the DG-FR version of the SW model at a horizontal resolution of 0.5 degree. The test describes the evolution of a barotropic wave in the Northern Hemisphere and exhibits continuous nonlinear transfer of energy at the midlatitudes from large to small scales. The initial conditions are zonally symmetric and introduce a strong zonal jet along the midlatitudes. The left and right panels of the figure show relative vorticity fields at days 4 and 6 of the simulation, respectively. The DG-FR scheme produces results that are visually

identical to those produced with the standard DG scheme, but the DG-FR algorithm has been shown to be about 24% more efficient when using viscous fluxes (diffusion process). The DG-FR approach is therefore very promising for future HOMME development, and this conversion would require only a nominal change in the existing code base.

This work advances CISL's science frontier in algorithmic acceleration by developing new algorithms and computational approaches to produce simulations capable of addressing grand challenges. Specifically, it fulfills a strategic action item to accelerate applications algorithmically by developing new numerical methods, AMR, new solvers, and new time integration schemes. This work is supported by NSF Core funding.

Radial Basis Functions use optimal node generation and placement techniques

To capture evolving features in atmospheric flows, such as vortices or moving fronts, adaptive refinement provides a numerical mechanism to accomplish this in a computationally efficient manner. For mesh-based spatial discretizations – such as finite volume, spectral element, or discontinuous Galerkin – refinement is generally achieved by subdividing the volume or element into smaller polygons, either with a structured (in which they have the same shape) or an unstructured (in which the polygonal shape varies) technique. In either case, it is necessary to define both the nodes and the connectivities between the nodes that form the sides of the polygon.



This figure illustrates the computational steps for creating a variable-density coastline node set. First, the nodes are placed at equal-length increments along a shoreline (left panel shown in red). The center panel shows the next step of distributing nodes (shown in blue) from the bottom of the rectangle to the top edge. These nodes are separated according to their distance from the nearest shoreline node. The right panel shows the result of overlaying the shore points, removing all nodes on land, and executing a local repel only in the immediate vicinity of the shores. This algorithm is another step toward accelerating applications using meshless methods such as Radial Basis Functions-generated finite differences (RBF-FD).

In contrast, meshless methods such as Radial Basis Functions-generated finite differences (RBF-FD) only require the node locations, and these can be scattered in any arbitrary fashion. As a result, a node refinement scheme only needs to scatter the nodes with a variable density that corresponds to a given measure such as the vorticity.

To accomplish adaptive node refinement for meshless methods in a fast and effective manner, a novel node generation (placement) algorithm has been developed in FY2014 that will aid in accelerating future developments of meshless numerical methods for geophysical modeling. As opposed to an iterative scheme, where, for a given number of nodes, the quality of the distribution depends on how soon the iteration is stopped, this algorithm uses advancing-front schemes. These schemes start at a boundary and advance forward until the domain is filled according to some predetermined criteria for node separation. The concept is directly related to the well-developed processes of dithering half-tone images in the field of image processing.

The algorithm is illustrated in the figure above and has the following key properties:

- Computationally fast -- placing 11,000 nodes/second in two dimensions (non-parallelized)
- Total geometric flexibility

- Any level of local refinement directly available
- At every spatial scale, the nodes have a hexagonal-like layout
- The algorithm is easily parallelizable on multi-core architectures

This work advances CISL's scientific efforts to develop algorithms for computationally accelerating applications of NCAR-wide science. This development effort at NCAR is supported by NSF grant DMS-0934317.

‹ Accelerating data analysis | up | CISL Education, Outreach, and Training ›

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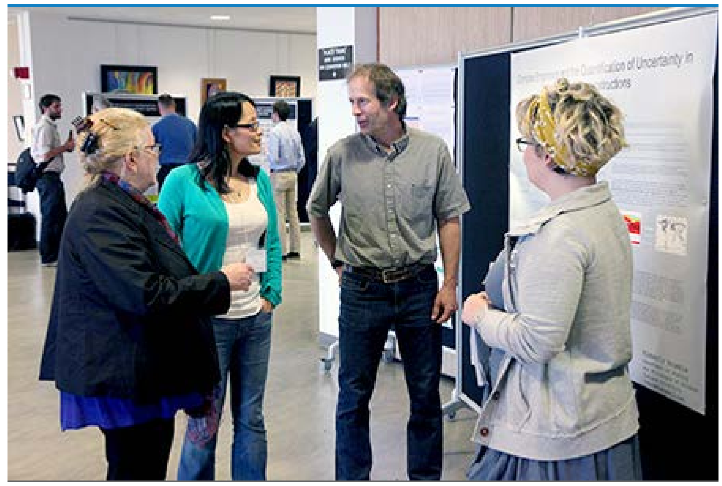
CISL EDUCATION, OUTREACH, AND TRAINING

CISL's education programs integrate research and education and teach the technical skills that students and faculty need to make effective use of advanced cyberinfrastructure. These programs also promote diversity, enhance CISL's culture of teaching and mentorship, and stimulate collaborations with the university community. These objectives are accomplished through internship, visitor, workshop, and training programs.



A lively discussion during the poster and reception for the SAMSI/IMAGe Summer Program: The International Surface Temperature Initiative. Here (from left to right), Elisabeth Lloyd (University of Indiana), Bo Li (University of Illinois), Doug Nychka (CISL), and Kimberly Brumble (University of Indiana) discuss how past climate before the existence of instrument records is inferred from proxy data. This workshop is typical of many sponsored by CISL that bring a broad group of scientists and researchers to NCAR with a common interest in the scientific programs at NCAR. In this case, the expertise of Lloyd and Brumble is in the philosophy of science, and Li and Nychka are statisticians. The overall theme of this workshop was to bring different groups together to confront the inherent uncertainties and biases in climate observations and find ways to quantify their accuracy. Solutions to these problems will also involve CISL Data Support Services and data analysis tools developed in CISL.

A supercomputing laboratory in a national research center is a unique place to help integrate research and education between disciplines. CISL focuses on the computational and atmospheric sciences, and has a math institute dedicated to education and advancing research using applied mathematics and statistics. CISL's educational efforts are designed to complement and supplement programs at universities and other centers.

CISL manages two principal training thrusts: one for HPC systems and another for CISL-developed data analysis and visualization tools. NCAR and CISL also provide cyberinfrastructure resources and user support for community workshops, tutorials, and summer schools in the atmospheric and related sciences.

This work is supported by NSF Core funding, with supplemental funding supplied by other sources as noted in the following reports.

‹ Accelerating applications algorithmically   up   Integrating research and education ›

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INTEGRATING RESEARCH AND EDUCATION

Michael Angus (left), a graduate student at North Carolina State University presents his research poster to Kevin Trenberth, Distinguished Senior Scientist in the Climate Analysis Section at NCAR, during IMAGe's Fourth Workshop on Understanding Climate Change from Data held in June 2014 at NCAR's Mesa Lab. More than 90 participants exchanged ideas during this event sponsored by NSF Expeditions in Computing.

As a supercomputing laboratory embedded in a national center focused on the atmospheric and related sciences, CISL provides resources to integrate research and education between the disciplines of the computational and atmospheric sciences. This unique interdisciplinary focus enables CISL's educational efforts to complement and supplement related programs at universities and other centers.

CISL's inter-supporting programs that foster the integration of research and education include:

- The Summer Internships in Parallel Computational Science (SIParCS) program offers graduate and undergraduate students significant hands-on opportunities in computational science, applied mathematics, and geostatistics to help build a workforce that can exploit petascale computers. CISL budgets for approximately 10–12 SIParCS interns each year.

- The Theme-of-the-Year (TOY) is held in IMAGe as a series of year-long programs, each focused on a specific aspect of mathematics applied to the geosciences; it is designed to advance research, education, and collaboration between the mathematics and geosciences communities. The TOY program establishes collaborations around potentially rewarding research activities and encourages contributions from talented young investigators in a variety of disciplines.

- The Research and Supercomputing Visitor Program (RSVP) facilitates prolonged engagement and collaboration between our staff, the university community, and researchers at peer centers around the world, and offers special travel support for training classes and workshops to faculty and students from minority-serving and EPSCoR-state institutions.

CISL's education imperative for integrating research and education is primarily supported by NSF Core funding, with supplemental funding supplied by other sources as noted in the following reports.

‹ CISL Education, Outreach, and Training up Summer Internships in Parallel Computational Science ›

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SUMMER INTERNSHIPS IN PARALLEL COMPUTATIONAL SCIENCE

The Summer Internships in Parallel Computational Science (SIParCS) program seeks to develop students with a background in computational science, applied mathematics, computer science, or the computational geosciences. The 11-week internships provide opportunities for exceptional students to gain practical experience with a wide variety of parallel computational science problems by working with the HPC systems and applications related to NCAR's Earth System science mission. The ultimate goal of SIParCS is to address shortages of trained scientists and engineers capable of using and maintaining these high-end systems to achieve the goals of 21st-century computational geoscience research. SIParCS supports NCAR's and CISL's core missions in education and directly contributes to CISL's strategic imperative to integrate research and education. CISL is teaching the mathematical and computational science concepts and skills that students will need to make effective use of advanced cyberinfrastructure.

2014 SIParCS extern Justin Moore of Salish Kootenai college in Pablo, Montana working with mentor Rich Loft (left standing) and teacher assistant Ragu Raj Prasanna Kumar on performance benchmarking on a Raspberry Pi cluster system (shown in foreground).

In FY2014, the eighth annual SIParCS program included seven graduate and five undergraduate students from 12 U.S. colleges and universities, including three from Minority Serving Institutions (MSIs) and two from an EPSCoR-state institution. Seven of the 12 students were from underrepresented groups in STEM. Student research topics covered diverse problems in applied mathematics, numerical algorithms, information science, software engineering, HPC system administration, and computer science. Two engineering interns participated in the program and worked on a project at the NCAR-Wyoming Supercomputing Center (NWSC). Ten were supported by NSF Core funds including one by CISL Diversity funds, one was partially funded by external partner University of Wyoming, one by an NSF special award. The ongoing development of the SIParCS program can be credited to CISL's comprehensive and aggressive outreach strategy.

In FY2014 SIParCS began a new externship program, funded in part by NCAR's Diversity Committee and CISL Diversity funds that hosted two externs as part of a two-year pilot program for nontraditional undergraduate students from U.S. MSIs who are unable to work full-time at NCAR in Boulder, Colorado for the entire summer program. The pilot program is designed to teach parallel computing concepts using inexpensive Raspberry Pi (R-Pi) computers running full Linux operating systems. Paired with both professional mentors and higher-level teacher assistants at NCAR, the two students gained access to resources afforded to students enrolled in the traditional SIParCS summer program, while taking into account barriers that non-traditional students face, such as other work and family responsibilities. The externs spent three weeks immersed in the internship culture and onsite work environment at NCAR learning the technology and gaining the hands-on experience of building the R-Pi computers, then spent the duration of the summer working on their projects at their home institutions, returning for the final week of the 11-week SIParCS program to present their research results to their peers and mentors.

‹ Integrating research and education up IMAGe Theme Of the Year ›

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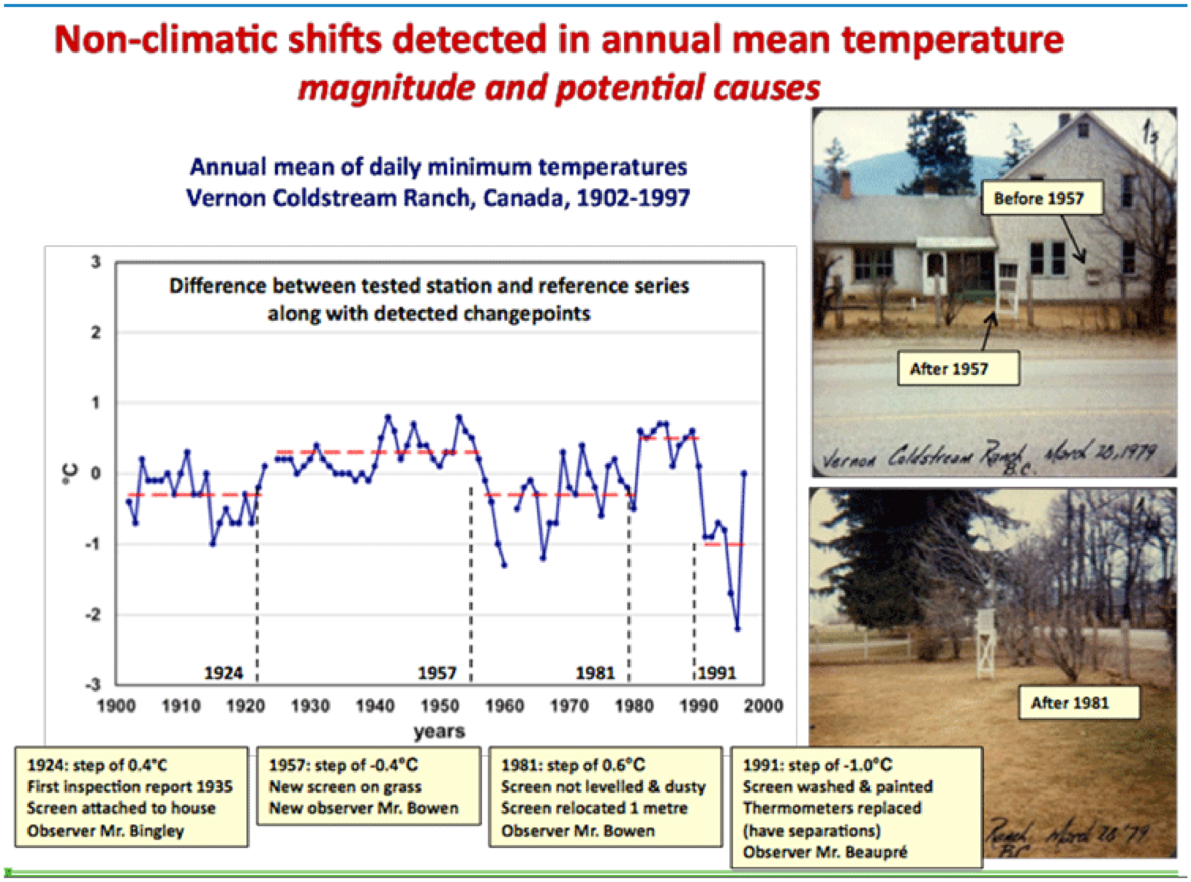
PREVIOUS CISL REPORTS

Select year

Printer-friendly version

IMAGE THEME OF THE YEAR

IMAGe's Theme Of the Year (TOY) is a series of activities that explores the opportunity to enrich both applied mathematics and the geosciences through a common scientific topic. TOY is designed to advance research and education between the mathematical and geosciences communities; it uses targeted projects for building interdisciplinary communities. The topics are selected by the IMAGe external advisory panel and coordinated by one or more visiting co-directors. The yearly TOY programs support CISL's education imperative to integrate research and education, sparking collaborations between the mathematics community and Earth System scientists.



This figure is a slide from the talk by Lucie Vincent, (Environment Canada) given at the TOY workshop on Surface Temperature Analysis. It shows how surface temperature measurements are affected by even modest changes in the instrument location or the shelter (screen). The station is located in the southern interior of British Columbia, Canada and has been maintained for more than 100 years. Here we see clear level shifts in the annual mean temperatures based on documented events by the station observer. The challenge for data science is to infer level shifts and other biases when the information about changes at a station are incomplete or nonexistent, then attempt to adjust for biases so that regional trends can be estimated accurately. It is also a caution to the statistical community that the analysis of surface temperature measurements should be done in collaboration with climate experts who are familiar with the many kinds of biases that can enter into the observations.

The 2014 TOY was concerned with new ways of teaching data analysis and disseminating cutting-edge statistical techniques to the geoscience community. It was proposed partly as a response to the growing interest in data science as a discipline and the distinct challenges for working with "big data" problems.

Statistics is the science of interpreting data through mathematical models with an emphasis on quantifying the uncertainty in any analysis. Typically, part of a statistical analysis will also involve the use of graphics to communicate complex relationships and patterns. Traditional courses in statistics focus on developing the mathematical basis of statistical

concepts, for example sampling from a population, using probability models for testing hypotheses and setting error bounds for parameter estimates. However, this view may miss the rich set of tools that can be applied to different kinds of data. Moreover, the rapid increase in computing power and the advent of the R statistical language has made statistical methods accessible to a broad scientific and engineering community. With these advances, the ability to interpret large and complex data sets has improved dramatically.

TOY's FY2014 education activities involved teaching courses on data analysis with a focus on the kinds of methods used for weather and climate research. Besides the direct benefit of these courses for the participants, there is an added product in lecture materials, software, and data sets that will be used in future activities. The data analysis course taught by IMAGe staff during summer term A at the University of Colorado in Boulder was intended to reach both undergraduates in the mathematical and physical sciences and also graduate students in engineering and science. The course was successful in engaging students on problems that involved large data sets. For example, a subset of the NARCCAP regional climate model output was used for projects. The second event was a short course, Ecological Informatics, that focused on spatial statistical methods for ecology graduate students. This was team-taught by several outside statistics faculty members and emphasized the use of R for the analysis of large spatial data.

Developing curricula and teaching was complemented by an intensive data analysis-oriented meeting: Workshop on Surface Temperature Analysis, which was cosponsored by NCAR, the Statistical and Applied Mathematical Sciences Institute (SAMSI), and the International Surface Temperature Initiative (ISTI). The meeting brought together about 40 climate scientists and statisticians to address issues in the analysis of land surface air temperature observational records in support of the International Surface Temperature Initiative.

Participants spent the majority of time working in breakout sessions and working groups that were charged with undertaking distinct analyses of the recently released databank holdings of 32,000+ station records. This meeting was an experiment to confront climate data specialists with new statistical methods for determining station biases and inferring regional trends. It was also an opportunity for the statistical scientists to understand the unique needs of interpreting surface temperature station records. One success of these meetings was a new approach to identifying regional trends using the R package LatticeKrig, a spatial analysis method designed for large data sets. Another synergy was a statistical formulation for detecting inhomogeneities in station records by looking for change points but also adjusting for temporal correlation in the temperature series.

Other significant events hosted by IMAGe's TOY include:

- The Fourth International Workshop on Climate Informatics
- Uncertainty in Climate Change Research: An Integrated Approach
- Pattern Scaling, Climate Model Emulators, and their Application to the New Scenario Process
- PDEs, The Workshop on Partial Differential Equations on the Sphere

Outreach activities of the Theme of the Year are supported by NSF Core funding.

‹ Summer Internships in Parallel Computational Science   up   Research and Supercomputing Visitor Program ›

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Search

2014 CISL ANNUAL REPORT

- CISL Director's message
- CISL Services
- CISL Science
- CISL Education, Outreach, and Training
  - Integrating research and education
    - Summer Internships in Parallel Computational Science
    - IMAGe Theme Of the Year
    - Research and Supercomputing Visitor Program
    - Visualization Laboratory outreach
  - Workforce training and development
  - Outreach activities
- Broader Impacts

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

CISL Strategic Plan

NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

Printer-friendly version

RESEARCH AND SUPERCOMPUTING VISITOR PROGRAM

The Research and Supercomputing Visitor Program (RSVP) is designed to bring university faculty, researchers, and students to NCAR to foster collaboration with CISL staff and to provide training opportunities for underrepresented groups. The program pays for travel and living expenses for stays of up to three months.

These extended visits help establish stronger relationships that lead to long-term collaborations. For many visitors, this program represents a unique opportunity to interact with CISL and NCAR scientists and staff on topics ranging from high-performance computing and Earth System modeling to applied mathematics and statistics.

In FY2014, CISL used some RSVP funds to attract students from minority-serving and EPSCoR-state institutions to participate in the SEA Conference and Scalable Profiler Workshop, and to partially support travel expenses for students from EPSCOR states to attend NCL workshops in Boulder.

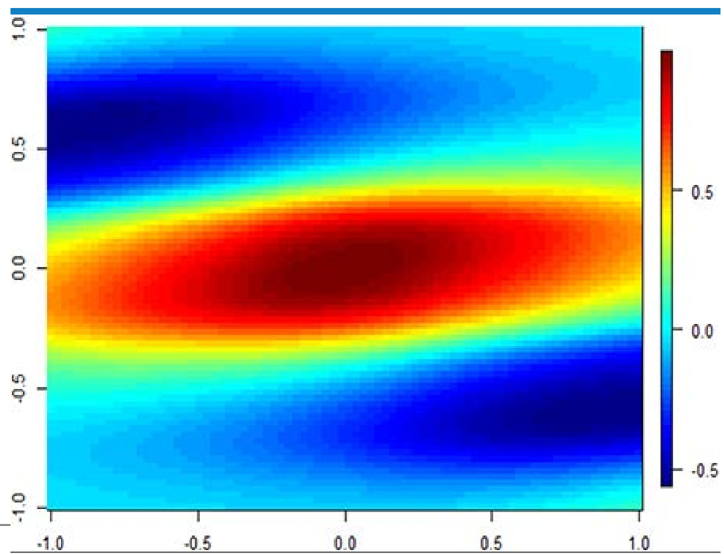
This program supports CISL's education imperatives of integrating research and education and broadening participation by being a key component that integrates CISL's education, outreach, and training efforts.

RSVP has sponsored graduate students, junior faculty, senior faculty, and scientist visitors from around the U.S. and the world.

Visitors in FY2014 included applied mathematicians to work with staff on numerical methods for geophysical models (e.g., new dynamical cores) and also graduate students in statistics to expand their mathematical research by including more focused methods for large geophysical data sets.

This program is made possible through NSF Core funding.

RSVP visitor Siddartha Nandy, a statistics graduate student at Michigan State University, talks with Doug Nychka, a scientist in IMAGe, who hosted his RSVP visit. When one considers how physical variables are correlated it is often the case that the strength of the dependence between measurements depends not only on how far apart they are but also on the direction. Siddartha's research at NCAR was concerned with creating models that represent correlation patterns that are not the same in all directions. The plot below illustrates a way to measure this.



This figure illustrates how a hypothetical measurement in the center of this region is correlated with surrounding observations. Were there no preference for direction, the pattern would indicate circular contours for regions of equal correlation. The elliptical contours

‹ IMAGe Theme Of the Year up

Visualization Laboratory outreach ›

indicate longer range (or stronger) correlations in roughly an east-west direction with less dependence in a north-south direction. Moreover this example also illustrates a pattern that is slightly tilted from a horizontal alignment. Although this kind of anisotropic pattern for correlation is standard in spatial statistics, Siddartha Nandy has implemented this idea in a new statistical method that scales to large problems and is described in a novel way by three statistical parameters. In this way he is helping to make statistical tools more appropriate for analyzing large geophysical data sets. Moreover, this work ties into his dissertation research on parameter selection.

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2014 Annual Report

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Search

2014 CISL ANNUAL REPORT

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

STRATEGIC PLANS

CISL Strategic Plan

NCAR Strategic Plan

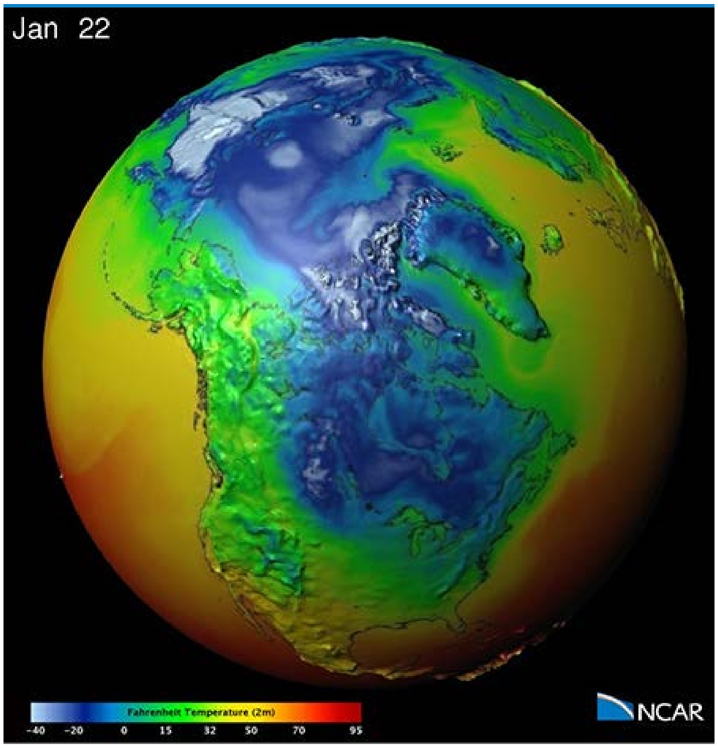
PREVIOUS CISL REPORTS

Select year

Printer-friendly version

VISUALIZATION LABORATORY OUTREACH

CISL's Scientific Visualization Services Group (SVSG) operates the Vislab, a visual computing center that is used to conduct many of CISL's education, outreach, and collaboration efforts. The 1,000-square-foot facility supports video conferencing technologies, data analysis and visualization, and theater-style presentations in a widescreen, high-resolution, 3D format. The facility is equipped with a collaborative touch-screen interface, a high-definition 3D 1920×1080-resolution active stereo projector, and a 12×7-foot screen. This system displays imagery and presentation materials simultaneously from multiple sources including user laptops, digital media systems, and high-definition video conferencing platforms.



VisLab staff produced significant new visualization material in FY2014, including an animation of January-February 2014 surface temperatures across North America. The animation depicts the multiple surges of frigid air that swept across eastern North America during the 2013–2014 winter. Hourly images are based on data generated by the NOAA Climate Forecast System model and visualized using NCAR Command Language software. The animation was featured in a UCAR AtmosNews feature article about the 2013–2014 winter.

The Vislab serves as an important resource for CISL's education and outreach efforts, fulfilling the strategic action item for CISL to tell NCAR's story to the world. Vislab activities serve hundreds of staff and visitors each year and include support for advanced collaboration environments that foster geographically distributed research and communication. The Vislab operates a sizable outreach program that provides 3D presentations to a wide range of student, governmental, and scientific visitors. The Vislab's implementation and support of collaborative technologies help enhance communication while minimizing the need for travel by geographically distributed teams collaborating on cross-institutional projects. The Vislab is also routinely used as an important presentation venue by UCAR staff for general meetings, conferences, and classes.

The Vislab continued serving as a venue for demos to many high-level visitors and a meeting space for conferences and classes to help engage a broad and diverse community, increasing awareness and understanding of science, high-performance computing (HPC), and environmental issues. In collaboration with the UCAR Office of Government Affairs and UCAR's Science Education Program, demonstrations of NCAR science were provided to diverse visitors and groups including U.S. Congressman Jared Polis, the Weather Channel, commercial interests such as Chevron, and many K-12 and university student groups, to name a few. Additionally, the VisLab was used as a recording venue for an NBC interview with NCAR scientist Dr. Kevin Trenberth.

HPC training classes addressing topics such as Fortran and Python programming, Yellowstone supercomputer access, performance tools, data processing, and visualization techniques were offered through collaborations with the Pittsburg Supercomputing Center, the CISL Consulting Group, and the NCL and VAPOR projects. In all, the VisLab supported over 2,100 participants in 145 meetings (a 45% increase over last year).

The VisLab also continues to help CISL embrace green technologies and reduce its environmental footprint. Technologies for video, web, and telephone conferences were used to support meetings and classes for approximately 500 remote users at NCAR Boulder campuses, the University of Wyoming, and other institutions around the country. Additionally, the VisLab supported multiple collaboration technologies to record, deliver, and post-process interactive webinars for NCL and VAPOR visualization tutorials and the CISL Consulting Group's training seminars.

Unplanned accomplishments this fiscal year included the hiring of a software engineer I to replace an outgoing multimedia technician.

This project is supported by NSF Core funds.

‹ Research and Supercomputing Visitor Program up Workforce training and development ›

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Select year

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WORKFORCE TRAINING AND DEVELOPMENT

CISL provides training opportunities for researchers in the atmospheric and related sciences to help them effectively use NCAR's petascale high-performance cyberinfrastructure. CISL delivers educational content synchronously through workshops and training classes, and asynchronously through Internet-based content such as webinars, recorded lectures, and online documentation.

CISL's education imperative for workforce training and development is supported primarily by NSF Core funding, with supplemental funding supplied by other sources as noted in the following reports.

CISL now offers a selection of webinars and online training for HPC, NCL, and VAPOR users. This screenshot introduces an NCL webinar that was first released in FY2014.

‹ Visualization Laboratory outreach up Training users and interns in computing at NCAR ›

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2014 CISL ANNUAL REPORT

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

STRATEGIC PLANS

TRAINING USERS AND INTERNS IN COMPUTING AT NCAR

By delivering timely training and educational content, CISL helps prepare researchers to answer questions in the atmospheric and related sciences using high-performance cyberinfrastructure. CISL delivers this content synchronously through workshops, webinars, and training classes, and asynchronously through its website.

CISL instructors provided training classes in high-performance computing to approximately 300 local and national HPC users. CSG instructors presented the following courses in FY2014: Introduction to Yellowstone, Introduction to Python for Scientists, Python for Scientists, Fortran Workshop, and Yellowstone User Seminar. CSG also organized training events taught by outside experts including an HPSS Best Practices tutorial; a webcast about using CISL's VAPOR package to visualize 3D model data; and two Allinea DDT debugger workshops.

```
import argparse
parser = argparse.ArgumentParser()
parser.add_argument("n",
                    type = int,
                    help = "prints the N-th Fibonacci number")
args = parser.parse_args()

class MyMath(object):           # this is how to make a class
    def fibonacci(self, n):     # note the use of 'self' argument
        a,b = 0,1
        for i in range(n):
            a,b = b,a+b
        return a,b

x,y = MyMath().fibonacci(args.n)
print "x=", x
print "y=", y
```

A slide from the training course "Python for Scientists" shows an example of Python code. CISL training typically provides hands-on activities and demonstrations in addition to lectures, slides, and video presentations. Many courses and webcasts are recorded and published on the CISL website.

The NCAR Command Language (NCL) team taught six workshops in Boulder, Kansas, Maine, and Hamburg, Germany in FY2014. The NCL team also began augmenting its onsite training workshops with webinars in FY2014. The six webinars offered between February and September 2014 have proved a popular addition to its training portfolio.

In addition to the regular curriculum, CSG personnel also coordinated the 2014 UCAR Software Engineering Assembly conference, which included five days of talks and tutorials on high-performance computing; HPC profilers, debuggers, and optimization tools (Eclipse, GPTL, TAU); Data analysis; Modern Fortran; Unit testing for Fortran developers; Software Carpentry; Productivity tips; and Scientific data management.

CSG staff also supported NCAR user training events that were delivered by others: Weather Research and Forecasting (WRF) model workshops; Community Earth System Model (CESM) workshops; and the RAL-taught Gridpoint Statistical Interpolation (GSI) Data Assimilation System Community Tutorial.

In FY2014, CISL began serving as a satellite site for select events in the XSEDE HPC Monthly Workshop Series. CISL further leverages its participation in the national XSEDE cyberinfrastructure to expand the training opportunities available to users by cross-posting XSEDE training opportunities via CISL's website and Daily Bulletin.

CISL's user and intern training is supported by NSF Core funding.

‹ Workforce training and development   up   Training in geoscientific tools ›

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PREVIOUS CISL REPORTS

Select year

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TRAINING IN GEOSCIENTIFIC TOOLS

Staff in CISL/TDD and NESL/CGD have collaborated for 14 years to provide a series of training workshops for the NCAR Command Language (NCL) – a free, interpreted language designed specifically for geoscientific data analysis and visualization. NCL workshops are 3-1/2 days in length with morning lectures and intensive hands-on labs in the afternoons. At end-FY2014, a total of 74 workshops have been taught to 1,159 students at universities and research centers worldwide. Four workshops were taught in FY2014 to 78 students at the University of Maine, Kansas State University, and NCAR. Deutsches Klimarechenzentrum (DKRZ) offered two first-ever NCL visualization workshops in Germany to 40 students, with staff support from the NCL team. Twelve webinars on various NCL file I/O and visualization topics were given in FY2014.

Participants attending the April 2014 NCL workshop at the University of Maine included students from Dartmouth College, the University of New Hampshire, Plymouth State University, and the University of Connecticut. Areas of research included regional climate change, bird migration studies, glaciology, and coastal ecology.

The VAPOR team has been offering tutorials on interactive 3D visualization and analysis with CISL's VAPOR package. VAPOR tutorials were held in FY2014 at the Korean Supercomputing Conference, and the annual WRF meeting held in Boulder. The first-ever VAPOR webinar was also held in FY2014, with over 90 students participating.

The NCL and VAPOR hands-on labs are targeted toward students' specific needs by encouraging students to use their own datasets for analysis and visualization rather than using canned datasets and examples. The instructors work with students individually during the labs, and by the end of the workshop most students have developed nearly complete NCL programs or VAPOR "sessions" that produce meaningful results from their data.

A core NCAR value is partnership with the university community. We proactively reach out to U.S. university students by offering at least one fully or partially funded NCL workshop at a U.S. university each year, and by covering some of the travel expenses for qualified students from EPSCoR universities and minority-serving institutions (MSIs) to attend workshops. (EPSCoR universities are located in states that are deemed to be underserved by federal research and education funding. The goal of the Experimental Program to Stimulate Competitive Research – EPSCoR – is to balance national research and education support by strengthening it in these states.)

In FY2014, we partially funded the NCL workshops at the University of Maine and Kansas State (both EPSCoR states), and we partially funded 11 EPSCoR/MSI students to attend workshops at NCAR and these two universities.

These workshops and webinars advance CISL's strategic education imperative to provide workforce training and development. The VAPOR tutorial at the Korean Supercomputing Conference was funded by the Korea Institute for Science and Information Technology. All other VAPOR tutorials and the NCL workshops were supported by NSF Core funds.

‹ Training users and interns in computing at NCAR up Support for community workshops, tutorials, and summer schools ›

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2014 CISL ANNUAL REPORT

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

STRATEGIC PLANS

NCAR Strategic Plan

PREVIOUS CISL REPORTS

Select year

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SUPPORT FOR COMMUNITY WORKSHOPS, TUTORIALS, AND SUMMER SCHOOLS

CISL supports a variety of workshops, tutorials, and summers schools designed to build community awareness of and make progress on a variety of complex technical problems. Two noteworthy examples of these included below are a workshop designed to tackle the challenge of many-core processors, and a workshop focused on understanding climate from data, two very hot topics in computational science.

Norbert Agana from North Carolina A&T University (right) presents his poster, Analysis of Extremes of Precipitation Events, to Forrest Hoffman (Oak Ridge National Laboratory) at the Fourth Workshop on Understanding Climate Change from Data. This activity is noteworthy because it brings together the two distinct communities of computer science and Earth System science. Agana is based in an Electrical and Computer Engineering Department while Hoffman is affiliated with a Climate Change Science Institute.

Heterogeneous Multi-core Workshop

A small group of computational experts familiar with weather and climate applications, along with representatives from industry, gathered at the NCAR Mesa Lab September 17-18, 2014 at the fourth Heterogeneous Multi-core Workshop to discuss latest findings and developments in programming emerging disruptive computing technologies.

Over the past few years, a new architectural paradigm has appeared in high-performance computer design: coprocessors, also known as accelerators, with a large amount of computing power in the form of many SIMD/vector processing elements. Typically, these coprocessors are installed in a computing node with conventional microprocessors that host these computationally powerful accessories.

This many-core architectural approach has arisen because as transistors are reduced in size, quantum tunneling effects begin to affect their accuracy. In response, the many-core design holds down power density by lowering clock speeds and dramatically increasing the number of processing elements per unit area. The result is a system that is potentially much faster and more energy efficient per floating point calculation, but that can also be much more difficult to program.

The NCAR workshop provided a forum for experts to share experiences and have open discussion, thus leading to an improved collective understanding of the utility of these new technologies. The workshop specifically focused on the algorithms, programming models, design strategies, and tools that will be needed to create a new generation of applications capable of efficiently exploiting the disruptive computing power of heterogeneous multi-core platforms. In addition, the workshop sought to create a community of developers that can work together to provide technical feedback to vendors, develop necessary software standards, and further develop programming models for weather and climate applications.

Most workshop participants started from the premise that the trends driving the many-core paradigm shift will continue and that the future of scientific progress in computational weather and climate simulation will profoundly depend on their ability to adapt or develop and then optimize methods for exploiting massive levels of parallelism. However, the apparent consensus from the meeting was that the size and complexity of weather and climate applications make adoption of radically new technology difficult, as does the current maturity of these architectures and their compilers. This reality for the community was reflected in both the rate of progress in many-core application development as well as the relatively modest performance gains (two to four times faster in many cases) achieved so far. Thus, significant challenges remain to

the widespread adoption of many-core systems.

Understanding Climate from Data

Earlier this summer, NCAR hosted the Fourth Workshop on Understanding Climate Change from Data, an event organized by CISL's IMAGe in conjunction with the University of Minnesota, and a result of an NSF-funded program known as Expeditions in Computing, which explores data-driven approaches to understanding climate change. This workshop brought together researchers who are advancing computational and data analysis methods necessary for addressing the key challenges in climate change science.

Among the keynote speakers were Jim Hurrell, Director of NCAR, Warren Washington, Senior Scientist and National Medal of Science recipient, Clara Deser, Head of the Climate Analysis Section of the Climate and Global Dynamics Division, and Kevin Trenberthm Distinguished Senior Scientist. The workshop also included panel discussions and a poster session.

A major focus of the workshop was to explore computational data science tools that can extract the achievable predictive insights from climate data and capture the complex dependence structures among climate variables. Because climate change and its consequences are among the most significant challenges of our time, it is critical to develop improved assessments including global and regional changes, extreme events, and stresses on environment and society. Among those are questions relating to food security, water resources, biodiversity, and other socio-economic issues.

Climate and Earth sciences have recently experienced a rapid transformation from a data-poor to a data-rich environment. In particular, climate-related observations from remote sensors on satellites and weather radars, or from *in situ* sensors and sensor networks, as well as outputs of climate or Earth System models from large-scale computational platforms, provide terabytes of temporal, spatial, and spatio-temporal data. In addition, the rapid growth of geographical information systems leads to the availability of multi-source data. These massive and information-rich datasets offer a huge potential for advancing the science of climate change and its impacts.

James Faghmous, from the University of Minnesota, discussed data mining in the context of ocean eddies as observed from space. Mesocale ocean eddies are dynamic phenomena that propagate across the global oceans and play a critical role in the transport of heat, momentum, and nutrients. They are also instrumental in balancing the planet's energy. Faghmous described the results from the OpenEddy project, a theory-guided data mining effort to catalog daily ocean eddy activity on a global scale using satellite altimeter data, as well as preliminary results of the impact of ocean eddies on tropical cyclones on a global scale.

Colorado State University's Imme Ebert-Uphoff presented her preliminary findings on causal discovery: learning potential causal relationships from data using machine learning algorithms. By applying causal discovery to climate science, generating new hypotheses about causal relationships between different climate variables, as well as generating "graphs of information flow" around the globe, Ebert-Uphoff seeks to help climate scientists better understand certain dynamical processes of our planet's climate.

Dimitris Giannakis, from New York University, explored methods for spatio-temporal decomposition of large-scale data from climate models and observations. This work has applications in the detection and forecasting of climate patterns on seasonal to interannual timescales.

The workshop presentations and panel discussions were geared toward finding new and transformative approaches to understand the potential impact of climate change using data-driven approaches that have been highly successful in other scientific disciplines. Methodologies developed as part of this project will be used to gain actionable insights and to inform policymakers.

A proper role for a national center such as NCAR is to serve as a forum for discussion and a catalyst for progress for scientists working on the toughest and most impactful problems of the day. A robust and energetic portfolio of workshops, tutorials, and summer schools offers this function to the community.

Funding

Workshops are typically funded through NSF Core funds (as in the Heterogeneous Many-Core Workshop) or via small NSF grants (Understanding Climate from Data).

‹ Training in geoscientific tools up Outreach activities ›

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OUTREACH ACTIVITIES

Outreach is a gateway activity: it is the conduit through which other goals are reached. Examples include integrating education and research, broadening participation, and workforce development. Enhancing these activities offers opportunities to better connect with our user community, students, and future employees at all levels. In general, the goals for enhancing our outreach programs include:

- Reach a larger and broader audience.
- Develop our message to be more impactful and compelling.
- Communicate our accomplishments and the benefits of working in CISL more effectively.

In addition to being a petascale supercomputing facility, the NCAR-Wyoming Supercomputing Center was designed with ample space to host visitors and exhibits to explain how NCAR's research benefits people and society. A key educational goal of the NWSC visitor center was to include content that conveys the basics of computational thinking. The NWSC visitor center now serves as a preferred venue for regional STEM events.

CISL's outreach program supports CISL's education imperative for outreach: to actively attract qualified candidates, particularly those from diverse backgrounds. This work fulfills CISL's strategic action item to expand outreach activities at conferences that enable CISL to effectively interact with our user community, students, and potential employees. Conference outreach also contributes to CISL's educational imperatives for workforce training and development, and for broadening participation. These efforts are supported by NSF Core funds, with supplemental funding supplied by other sources as appropriate.

‹ Support for community workshops, tutorials, and summer schools | up | NWSC visitor center exhibits ›

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NWSC VISITOR CENTER EXHIBITS

A key goal of the NWSC facility project was to broaden its impact through an active public visitor program. The primary element of that program was a planned NWSC visitor exhibit to explain the science goals of NCAR and the University of Wyoming, as well as the technology employed at the NWSC to realize these goals. The NCAR-Wyoming partnership's NWSC education and outreach strategic goals are derived from an understanding of the national and regional challenges of STEM education and are designed to leverage the unique strengths of the founding NWSC partners. In October 2012, the NWSC opened its doors to the public, and inaugurated its Educational Visitor Center.

A young visitor and his mother explore the exhibits in the NWSC visitor center. The center has several interactive elements as well as short videos, games, and information about supercomputing and science. The visitor center provides an opportunity for the public to learn about NCAR science and its relevance to society.

CISL OSG staff, in collaboration with advisors from the UCAR Center for Science Education, the University of Wyoming (UW), and the Laramie County Public Library, worked to create a visitor experience at the NWSC that would engage and educate audiences of all ages and backgrounds in NCAR's and UW's science, the facility's state-of-the-art green design, and the capabilities of the supercomputers it houses. The educational goal of the exhibit was to explain how the NWSC's research and science mission benefit people and society while providing visitors with a fun and memorable experience.

In total, the content includes 16 professionally produced video segments, three short animated films, two touchscreen interactive games, two kinesthetic interactive elements, multiple question-and-answer displays, and science and technical content and accompanying vivid "story-telling" imagery for the six focus-area themes. This year, a new animation that describes the infrastructure of the NWSC was added to the exhibits.

The NWSC visitor center has exceeded initial estimates for community interest, total visitors, organized group tours, and school group visits. Since opening in October 2012, the visitor center has hosted over 5,000 visitors, which is approximately 8% of the population of Cheyenne, Wyoming, where the NWSC is located. Since January 2013, when school groups first began visiting, visits have averaged 2-3 school groups per month in sizes ranging from 12 to 226. In addition, the center has received 33 non-school groups. Currently, relatively few American students pursue studies in the fields of science, technology, engineering, and mathematics (STEM), and STEM education for both students and teachers has become a national priority. The NWSC exhibit has served as the nexus for regional STEM events tackling this problem, hosting groups like the Boys and Girls Clubs of Douglas, Wyoming, school field trips, and summer activity groups.

In short, the NWSC Visitor Center has yielded rich opportunities for outreach and education about NCAR science, scientific computing, mathematics, and engineering. The STEM disciplines come to life at the NWSC, where visitors can explore interdisciplinary yet related topics like extreme weather, climate change, energy, water resources, supercomputing, facility design, energy efficient technologies, and human health.

The NWSC visitor center is intended for self-guided tours for individuals and groups of all ages and backgrounds, and it can also be used for presentations and special events. The visitor center consists of a theater for watching a video overview; two science displays, each with a different science focus area on each side; a young scientist display that includes a tornado simulator and an interactive computer speed demonstration; and a supercomputer display at which visitors can see

inside the supercomputer and interact with an exhibit that connects the concepts of electrical power with computing power through a hand-crank “generator.” A key educational goal of the visitor center was to include content that would convey elements of computational thinking. These include interactive activities that explain the concept of speedup in parallel computing and identify other kinds of parallel systems in everyday life. To engage diverse audiences, the videos in the exhibits also include Spanish-language subtitles.

The NWSC visitor center was financed using NWSC construction funds from the NSF, and it is maintained using NSF Core funds.

‹ Outreach activities up NWSC education and outreach ›

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NWSC EDUCATION AND OUTREACH

The Wyoming-NCAR partnership's NWSC education and outreach strategic goals are derived from an understanding of the national and regional challenges of STEM education and are designed to leverage the unique strengths of the founding NWSC partners. NWSC's high-level strategic EOT goals are to:

A group of high school students learn about the NWSC and NCAR science during a field trip to the facility. Visitors of all ages enjoy the educational exhibits, and school groups in particular are able to combine group play and learning at the NWSC. Such activities expose students to STEM disciplines and careers, broadening the impact of NCAR's science mission through education and outreach.

- Integrate university research with K-16 education.
- Build cyberinfrastructure and computational science capacity in Wyoming, regional EPSCoR states, and Front Range institutions.
- Train the next generation of computational scientists.
- Complement and enhance programs at community colleges to prepare students for careers in related technical fields.
- Broaden participation by enhancing the capabilities of community colleges to train students in technical fields that better prepare them for careers in HPC-related technical fields.
- Broaden diversity by engaging minority-serving institutions, particularly regional tribal colleges and historically black colleges and universities.
- Build strong foundations and foster innovation to improve K-12 computational thinking, mathematics, and computational geosciences.
- Engage and inform the public about NWSC science through informal education.

In FY2014, CISL's Outreach Services Group collaborated with the University of Wyoming and UCAR's Center for Science Education (SciEd) to materially advance each of these goals. For example, CISL's Outreach Services Group supported K-12 STEM enrichment by participating in the Wyoming State Science Fair for the fourth consecutive year. This summer, as part of the Boys and Girls Clubs of Douglas, Wyoming's "Brain Gain" summer activities, nearly 70 members participated in hands-on activities to learn about extreme weather and related topics at the NWSC. Since opening, the NWSC has hosted over 35 school groups and more than 60 adult professional organizations, and received a total of over 5,000 visitors. In FY2014, the NWSC has hosted 15 school groups, 32 adult professional organizations, and a total of 1,713 visitors.

CISL's contributions to the Wyoming-NCAR partnership's NWSC education and outreach strategic goals are supported by NSF Core funding.

‹ NWSC visitor center exhibits   up   Outreach at regional, national, and international levels ›

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OUTREACH AT REGIONAL, NATIONAL, AND INTERNATIONAL LEVELS

Students learn about facility infrastructure from an interactive exhibit at the NWSC visitor center that lets them study the electrical, mechanical, and computing systems installed at the center. Such activities allow students to explore STEM disciplines and careers, demonstrating real-world applications for their school studies.

Since 1989, CISL has deployed a series of exhibit booths for a variety of scientific and technical conferences. In these booths, CISL staff demonstrates supercomputing capabilities, scientific visualization, and NCAR research in science, computational science, computing technology, and applied mathematics and statistics for the geosciences. CISL also invites NCAR scientists to present their current findings in the CISL exhibit booth. At the height of its conference outreach program, CISL staff provided demonstrations and presentations at many conferences each year, including Supercomputing, the American Meteorological Society, the American Geophysical Union, and others. In recent years, CISL has focused its energy and resources on providing NCAR outreach at the annual Supercomputing and XSEDE conferences and on local Visualization Laboratory presentations and outreach activities. CISL also hosts and provides planning and logistics support for mission-appropriate conferences and workshops.

CISL's outreach program supports CISL's education imperative for outreach: to actively attract qualified candidates, particularly those from diverse backgrounds. This work fulfills CISL's strategic action item to expand outreach activities at conferences that enable CISL to effectively interact with our user community, students, and potential employees. Conference outreach also contributes to CISL's educational imperatives for workforce training and development, and for broadening participation.

CISL's outreach activities at SC13 in Denver included science and technology presentations in the exhibit booth. CISL invited NCAR scientists to give daily science talks in the exhibit booth. Also at SC13, CISL staffed a table at the Supercomputing Student Job Fair with computational scientists and the coordinator of SIParCS, CISL's internship program. They provided young people interested in careers in computational science and engineering with information about SIParCS and CISL's employment opportunities.

As part of its diversity program, CISL conducts outreach in mission-appropriate diversity-oriented venues. CISL staff described NCAR research careers, encouraged faculty members to nominate students for NCAR programs, and distributed printed information about internship opportunities and professional development programs including SOARS and SIParCS.

CISL does outreach through site visits and presentations to universities and tribal colleges as a key strategic element of our recruiting activities. For instance, CISL helped re-establish a UCAR presence at the SACNAS conference with the CISL Diversity Coordinator. CISL was an exhibitor at the American Indian Science and Engineering Society (AISES) from 31 October – 2 November 2013. The CISL Diversity Coordinator performed outreach at the NSF EPSCoR annual meeting in November 2013. CISL exhibited at the Student Job Fair at Supercomputing 2013 in Denver, Colorado. The Diversity Coordinator made outreach contacts in the Houston-area MSIs on 2-6 October 2013: Prairie View A&M University, University of Texas at San Antonio, St. Mary's University, and Texas Tech University.

CISL supported the March 2014 Wyoming State Science Fair at the University of Wyoming in Laramie. CISL and UCAR Spark supplied three volunteers as judges, presented four awards for top junior and senior computational and Earth System science projects, presented atmospheric science demonstrations, and exhibited information about the NWSC facility

in Cheyenne. CISL's outreach efforts are part of the NWSC partnership with the State, University, and business community of Wyoming. CISL encourages students to embark on careers in computational science and engineering, and our efforts at this venue demonstrate our long-term commitments to outreach, workforce development, and broadening participation in the sciences.

CISL's Outreach Group developed and maintains the public visitor area at NWSC. This NWSC education exhibit informs K-12 students and the public how high performance computing supports and advances scientific research and discoveries. CISL collaborates in this effort with staff at the University of Wyoming, the Laramie County Library System, and UCAR Education and Outreach efforts. The NWSC Education and Outreach Strategic Plan, which was written in a collaboration between directors of CISL and the University of Wyoming, calls for NWSC education efforts to support diversity and in particular to serve tribal colleges and community colleges throughout the intermountain west.

CISL has provided mentors for UCAR's Significant Opportunities in Atmospheric Research and Science (SOARS) program for 19 years, every year since its inception. CISL's SIParCS program collaborates with SOARS in outreach activities, and has established a reciprocal arrangement for referring candidates between the programs.

These efforts are supported by NSF Core funds, with supplemental funding supplied by other sources as appropriate.

‹ NWSC education and outreach up Broader Impacts ›

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BROADER IMPACTS

CISL engages in a spectrum of activities designed to broaden the laboratory's impact through outreach, collaboration, and community engagement, and through capacity building at regional, national, and international scales. These activities have two main thrusts. First, CISL does outreach and provides training and education opportunities aimed at broadening participation and encouraging the development of the trained and diverse workforce necessary to continue advancing the scientific use of high performance computing resources. Second, CISL encourages collaboration and exchanges of information and expertise for developing shared cyberinfrastructure and standards that will advance high-performance computing, not only in the atmospheric and related sciences, but also in the general HPC community.

This interactive plenary session of the Fourth International Workshop on Climate Informatics brought together over 90 researchers with experience levels ranging from undergraduate students to senior scientists for knowledge sharing and networking. Climate informatics broadly refers to any research combining climate science with approaches from statistics, machine learning, and data mining. This workshop series stimulates discussion of new ideas, fosters new collaborations, grows the climate informatics community, and accelerates discovery across research disciplines.

Clear examples of how CISL's education efforts broaden the laboratory's impact on the U.S. STEM workforce arise yearly from CISL's internship program SIParCS and IMAGe's Theme of the Year (TOY) interdisciplinary education series. Numerous interns and early-career scientists have redirected their career plans in response to their positive research experiences in CISL. Students often come to CISL for a specific SIParCS or TOY session, return as postdoc collaborators, take jobs as university faculty, then send their students here to enrich their development. This process keeps refreshing our workforce with new talent, it reinvigorates others at the universities, and it is a healthy model for a national center.

This work is supported by NSF Core funding.

‹ Outreach at regional, national, and international levels | up | Diversity-focused activities ›

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DIVERSITY-FOCUSED ACTIVITIES

The CISL Outreach Services Group organized the first Workshop on Diversity in the Computational Geosciences (DCG) on 23–25 June 2014. This workshop was created to develop and sustain a robust national community dedicated to broadening participation in 21st century geoscience. The photo shows Dr. Juan Gilbert presenting his keynote address about how the University of Florida's Human-Experience Research Lab produced results for its clients and the participating students. The DCG workshop brought together 30 diversity leaders from 21 different U.S. research universities and national laboratories. The workshop's organizing committee was led by Stephanie A. Barr (CISL Diversity Coordinator at NCAR), and included Dr. Richard D. Loft (CISL Director of Technology Development and Outreach at NCAR), Dr. Shela Aboud (Senior Research Scientist at Stanford University), Dr. Denise Barnes (NSF Section Head for EPSCoR), and Dr. Linda Hayden (Professor of Computer Science at Elizabeth City State University). Presenting keynote addresses were Dr. Diane A. Baxter, Associate Director for Education at the San Diego Supercomputer Center (SDSC), and Dr. Juan E. Gilbert, Associate Chair of Research in the Computer and Information Science and Engineering Department at the University of Florida and head of the Human-Experience Research Lab. A second NSF contributor was Marilyn J. Suiter, a program director in the Education and Human Resources Directorate. In plenary sessions and breakout groups, the participants drew on their personal and professional experiences to illustrate the principle that people having diverse world-views enrich the quality of research in the computational geosciences.

CISL supports multiple thrust areas to enhance staff diversity in the laboratory and at NCAR. The mission of CISL's Outreach Services Group (OSG) is to integrate education and research, broaden participation in Earth System sciences, and develop the future STEM workforce. OSG focuses on communication methods to connect the work of scientists and engineers with the research community, funding agencies, and the general public. This effort is sustained at local, regional, national, and international levels.

In FY2014, CISL, through its Diversity Coordinator, continued implementing successful outreach strategies to enrich computational science, mathematics, and statistics projects by aggressively building a collaborative network for expanding participation by underrepresented groups. CISL continued to encourage diversity by leveraging its Research and Supercomputing Visitor Program (RSVP) to lower access barriers to training for students and staff from U.S. minority-serving and EPSCOR-state institutions. (EPSCoR universities are located in states that are determined to be underserved by federal research and education funding. The goal of the Experimental Program to Stimulate Competitive Research – EPSCoR – is to balance national research and education support by strengthening it in these states.)

For example, CISL used some RSVP funds to attract, for the second year in a row, students from minority-serving and EPSCoR-state institutions to participate in the SEA Conference and Scalable Profiler Workshop, both CISL-sponsored annual technical conferences at NCAR. Using new connections made in recent months, CISL's Diversity Coordinator enrolled 10 students from four institutions – Universidad del Turabo in Puerto Rico, Salish Kootenai College, a tribal college in Montana, Elizabeth City State University, and Prairie View A&M University – to participate in the SEA Conference. The meeting offered hands-on computing tutorials and opportunities for students to meet and make connections with professionals in attendance. In addition, Stephanie coordinated and co-facilitated participation by students in internship opportunities and in an informal lunch with NCAR scientists and engineers.

OSG also did face-to-face outreach and training at an expanded portfolio of institutions and conferences in FY2014. For the second year running, CISL OSG staff participated in the Association of Computer and Information Science and Engineering Departments at Minority Institutions (ADMI) symposium held at Virginia Beach, Virginia in April 2014. ADMI draws students from eight historically black colleges and universities, and it is devoted to computing issues relevant to minority students, education, and institutions. This close-knit organization is composed of hundreds of individuals ranging from undergraduates to department heads. Richard Loft delivered a presentation on "Big Data" in climate and weather and spoke at a panel discussion on student internships at the ADMI event. In a related outreach, Dr. Loft also lectured on Weather

and Aviation Safety at Elizabeth City State University in North Carolina.

CISL staff followed up on connections made with four computational science faculty members from Hampton University, Salish Kootenai College, and Alabama A&M University at the August 2014 Rocky Mountain High Performance Computing Symposium in Laramie, Wyoming to create a new educational program. CISL recruited two of these faculty members (one from Salish Kootenai College and one from Hampton University) to serve as project mentors for CISL's experimental summer externship program that taught parallel computing concepts with low-cost Raspberry Pi clusters.

This and related work is funded as specified in the following individual reports.

‹ Broader Impacts up Outreach ›

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OUTREACH

Undergraduate and graduate students share their experiences and interests with NCAR scientists, engineers, and other Software Engineering Assembly (SEA) attendees during a conference luncheon. For the second year in a row, CISL's Diversity Coordinator (Stephanie Barr, far right) brought new computing and engineering students to NCAR for UCAR's SEA conference in April 2014. Part of the SEA mission is to foster a sense of community for software engineering professionals. CISL is actively working to broaden diversity among staff in our technical and scientific research community.

CISL conducts outreach by integrating education and research, broadening participation in Earth System sciences, and developing the future STEM workforce. (STEM stands for Science, Technology, Engineering, and Mathematics, and the National Science Foundation funds a variety of education efforts for these disciplines.) Enhancing these activities offers opportunities to better connect with our user community, students, and future employees at all levels. This year, CISL outreach goals centered on strategies to increase reach, impact, and clarity of mutually beneficial endeavors for targeted populations including, but not limited to:

- Higher education institutions serving large sections of minority students historically underrepresented in STEM fields.
- EPSCoR states.
- Students in community colleges and two-year colleges.
- Non-traditional students.
- Faculty and students dedicated to pursuing research in enhancing K-12 education. (Engagement with the K-12 community is a key element of the NWSC EOT partnership and strategic plan.)
- The general public.

For CISL's exhibit at the SC13 conference held in Denver on 16-22 November, Aaron Andersen (CISL) presented "Dialing it in: A Year of Tuning the NCAR-Wyoming Supercomputing Center" where he described how three engineering interns conducted detailed investigations to identify ways to improve the facility's energy efficiency.

CISL continued its outreach activities at the ACM/IEEE supercomputing conference SC13 held in Denver, Colorado. These included presentations in CISL's exhibit booth, disseminating information to participants, targeted dissemination of SIParCS internship information to university booths on the show floor, and a CISL-staffed table at the SC13 Student Job Fair to provide information about the SIParCS internship program and other employment opportunities at NCAR for young people interested in careers in computational science and engineering. CISL staff also focused on augmenting communication and interaction with fellow exhibitors who have complementary outreach, education, and diversity goals.

CISL also engaged in numerous activities to foster education and outreach collaborations with the state of Wyoming, including at the University of Wyoming, Wyoming Community Colleges, and Wyoming EPSCoR programs. These include working with the Strategic Diversity Initiatives Committee

(SDIC) to recruit and create mutually beneficial partnerships between MSIs, HBCUs, NCAR, and the University of Wyoming (UW). CISL also supports the Wyoming State Science Fair held each year at UW.

Conference outreach also contributes to CISL’s educational imperatives for workforce training and development, and for broadening participation. These efforts are supported by NSF Core funds with supplemental funding supplied by other sources as appropriate. The Diversity Coordinator position is funded 25% by the University of Wyoming, 25% by NCAR Directorate NSF Core funds, and 50% by CISL NSF Core funds.

‹ Diversity-focused activities up Education ›

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EDUCATION

Sunni Ivey presenting the results of her SIParCS research project, “Visualization of Air Quality Data in VAPOR” at the SIParCS symposium on 31 July 2014.

CISL is committed to NCAR’s core education mission, offering opportunities for students and recent graduates to hone their skills in mathematical and computational science concepts through programs such as the Summer Internships in Parallel Computational Sciences. This year, CISL focused on nontraditional students through the creation of a pilot externship program. This program enables students who, because of their life situation, cannot spend a full summer in an internship away from their home institution. Externships provide this growing population of students an opportunity to work on a research project remotely, spending only short periods at NCAR at the start and end of their summer projects.

CISL is also dedicated to attracting and retaining a diverse and talented staff that can meet supercomputing and computational science needs in the decades to come. To this end, CISL has also developed a Diversity Coordinator position to support its transformative vision of increasing diversity in the computational geosciences. This vision has several focal points, one of which emphasizes building a collaborative network to increase student and educator awareness of and participation in CISL programs, another is to support and develop educational opportunities centered on the intersection of the computational sciences with NCAR’s traditional atmospheric science disciplines.

By integrating research and education, CISL education efforts contribute to CISL’s educational imperatives for workforce training and development, and for broadening participation. These efforts are supported by CISL NSF Core funds, with supplemental funding supplied by other sources as appropriate. The Diversity Coordinator position, which played a critical role in the development of CISL’s externship program piloted this past summer, is funded 25% by the University of Wyoming, 25% by NCAR Directorate NSF Core funds, and 50% by CISL NSF Core funds.

Highlights: CISL interns shine in 2014

Four CISL summer students from the class of 2014 made their mark in the research community during their first summer in the program. Sunni Ivey, of the Georgia Institute of Technology, earned an Alfred P. Sloan scholarship to support her studies in Environmental Engineering. Two externs, Justin Moore of Salish Kootenai College and Lauren Patterson of Hampton University, used inexpensive Raspberry Pi clusters to learn concepts in high performance computing in a new CISL program designed to appeal to non-traditional students. Both externs presented posters at the August 2014 Rocky Mountain High Performance Computing Symposium. And SIParCS intern Ye Feng of the University of Wyoming won best poster there for her work on accelerating a part of the Data Assimilation Research Testbed (DART) on Graphics Processing Units (GPUs). The three posters were all based on research conducted over 11 weeks in the summer.

Sunni Ivey’s Alfred P. Sloan UCEM Scholarship will facilitate and complement her studies in the Environmental Engineering program at the Georgia Institute of Technology University Center of Exemplary Mentoring (UCEM). The funds will be used to cover personal and professional development activities that will accelerate and catalyze her success in graduate school. She also received Sloan Foundation support to attend the annual Institute on Teaching and Mentoring twice over the course of her graduate school career. The purpose of the Institute is to provide scholars with the skills necessary to succeed in graduate study and to prepare them for success as faculty members at colleges and universities. This four-day conference has become the largest gathering of minority doctoral scholars in the country. Sunni earned this honor after completing two

undergraduate degrees, a Master's degree, four teaching assignments, three internships, and having begun work on her Ph.D.

Three CISL students presented posters at the August 2014 conference organized by the Rocky Mountain Advanced Computing Consortium (RMACC). Held August 12-13 on the Boulder campus of the University of Colorado, the Rocky Mountain High Performance Computing Symposium focused on the continuing growth and future of high-performance computing in the Rocky Mountain region. Recognized as one of the top regional events on high-performance computing, the fourth annual symposium drew participants including designers and users of high-performance computing systems from universities, government laboratories, and industry from Colorado, Wyoming, Idaho, New Mexico, Utah, and Montana. The symposium featured nationally recognized speakers, group breakout sessions, a variety of tutorials covering many aspects of high-performance computing system design and use, and a student research poster competition. The winner of the poster presentation competition was awarded a trip to the Supercomputing 2014 conference in New Orleans.

Justin Moore presenting the results of his SIParCS research project, "Performance Benchmarking a Raspberry Pi Cluster" at the SIParCS symposium on 1 August 2014.

Lauren Patterson presenting the results of her SIParCS research project, "Raspberry Pi Hadoop Cluster" at the SIParCS symposium on 31 July 2014.

Justin Moore's research involved benchmarking a four-processor Raspberry Pi cluster with standard techniques used to evaluate and rank supercomputer performance internationally. Specifically, Justin optimized the parallel performance of the numerically intensive matrix-matrix multiply algorithm, comparing the performance of parallel versions built from basic linear algebra subprograms (BLAS), machine-optimized ATLAS libraries, and a hand-coded method for multiplying matrices of his own design.

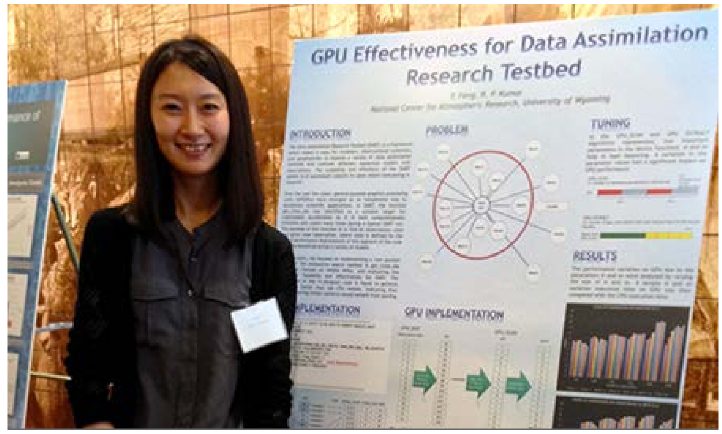
Justin went on to compute derived metrics of efficiency such as price-performance and power-performance, then compared his Raspberry Pi cluster with NCAR's Yellowstone supercomputer in Wyoming using these.

Lauren Patterson's research used the Raspberry Pi cluster to compare ways of analyzing supercomputer interconnect topology to understand and improve parallel job performance. Lauren wrote graph traversal scripts using both the Hadoop MapReduce and message passing paradigms that converted interconnect configuration files and a list of nodes used in a parallel job into lists of network pathways taken between all possible pairs of nodes.

She prepared a poster about this research after her SIParCS presentation on the topic, and just over a week later she gave a talk and presented her poster at the RMACC symposium. Along with her mentor, Amogh Simha, she joined Justin, Raghu Raj, and a new faculty member at the University of Colorado, professor Karina Hauser for another talk where they described their research experiences using Raspberry Pi components to study supercomputing performance issues.

Raghu Raj Prasanna Kumar, a student assistant in CISL's Technology Development Division who worked with the students on their summer projects said, "Justin and Lauren took advantage of many networking and public speaking opportunities at the RMACC conference. They each gave talks about their work with a Raspberry Pi cluster they personally built, and they also presented at the poster session. They were excited to take part in the conference and to compete for a trip to SC14 in New Orleans. Between the SIParCS program and the RMACC conference, Justin returned to Salish Kootenai College and learned that his summer experience helped him earn an offer for a computing internship at his college. He accepted the offer and is well prepared to begin his new research project."

Ye Feng's research explored ways to accelerate the performance of the Data Assimilation Research Testbed



Ye Feng of the University of Wyoming presenting her award-winning poster from her SIParCS research project, “Evaluating Coprocessor Effectiveness for the Data Assimilation Research Testbed” at the SC14 Conference in New Orleans, Louisiana on 19 November 2014.

(DART) using graphics processor hardware (general-purpose graphics processing units – GPGPUs). GPU technology is becoming an increasingly popular way to accelerate application performance by harnessing the massive amounts of parallelism inherent in GPU architecture. DART is a community facility developed and maintained at NCAR that offers powerful, streamlined tools that help researchers assimilate observational data into geophysical models.

Ye and her mentor, Helen Kershaw in IMAGe, combined the two concepts in her summer research by applying the GPGPU acceleration to a computationally intensive DART function that performs nearest neighbor lookups. By implementing a new algorithm better suited to GPGPUs, she was able to obtain a 10.9 times speedup relative to the original code running on a conventional Xeon processor. Judges at the HPC Symposium in Boulder awarded her poster top honors, including an all-expenses-paid trip to New Orleans for the November SC14 conference.

‹ Outreach up Training programs that broaden participation ›

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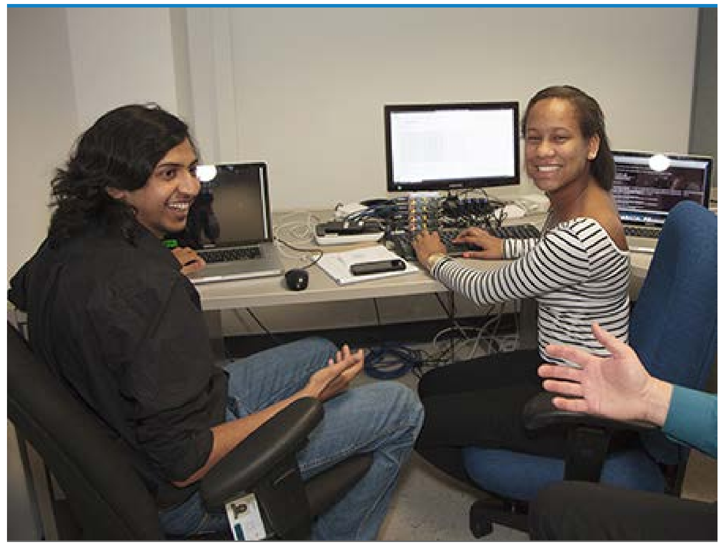
TRAINING PROGRAMS THAT BROADEN PARTICIPATION

This section details activities dedicated to expanding diversity and inclusion-related training efforts in CISL.

CISL is lowering access barriers to training for students and staff from U.S. minority-serving and EPSCOR-state institutions by providing travel support from its Research and Supercomputing Visitor Program (RSVP). The types of classes covered include CISL HPC training such as Fortran 90 and MPI/OpenMP, and its Data Analysis and Visualization Workshops. RSVP also encourages university visitors from diverse backgrounds to visit CISL and NCAR for extended periods.



Lauren Patterson (right, Hampton University) and her mentor, Amogh Simha (University of Colorado at Boulder) studied ways to improve parallel job performance on high-performance cluster computers using a five-node Raspberry Pi cluster. CISL's new externship program allowed Lauren to fulfill her summer commitments at home while also exploring supercomputing technology at NCAR in Boulder, Colorado. During her return visit to present her results at the SIParCS colloquium, she prepared a research poster and presented her findings at the Rocky Mountain High Performance Computing Symposium at the University of Colorado, where she also participated in a panel discussion and described her studies of cluster computing performance issues.

Beyond travel support, CISL has been particularly focused on opening avenues of inclusion to those from nontraditional backgrounds, for example students at community/two-year colleges, and people from rural areas. (The term “nontraditional student” refers to those who have one or more of the following characteristics: delayed enrollment into postsecondary education, enrolled part time, have financial independence, work full time while enrolled, have dependents, are a single parent, or didn’t obtain a high school diploma.)

Engaging nontraditional students by webcasting courses and through its externship pilot program provides opportunities for CISL to redefine its definition of diversity and to better understand the resources and needs of partner students, faculty, and communities.

CISL efforts to broaden participation in training activities such as RSVP, externships, and web-based training offerings are supported by NSF Core funding and NCAR diversity funds.

‹ Education up CISL leadership in cyberinfrastructure ›

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CISL LEADERSHIP IN CYBERINFRASTRUCTURE

CISL participates in a broad portfolio of activities intended to further the advancement of computing, data storage, and networking technology and the improvement of regional, national, and international cyberinfrastructure. These activities are consistent with NCAR's leadership role as a national Federally Funded Research and Development Center (FFRDC), and are supported by NSF Core funding.

‹ Training programs that broaden participation up Regional CI engagement ›

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REGIONAL CI ENGAGEMENT

CISL has a strong presence in regional cyberinfrastructure (CI) development, including both the high performance computing (HPC) and networking communities. Working with regional entities broadens NCAR's impact by fostering the maturation of regional HPC CI, leverages unique regional resources and partnerships to tackle regional problems, and is a natural and mutually beneficial component of a national center's role.

Owned by the Colorado School of Mines, this hybrid-architecture supercomputer is hosted at NCAR in the Mesa Lab Computing Facility. CISL is collaborating with CSM on a computational science research project using this unique system that is small in both size and energy consumption. Its three compute racks contain 10,496 cores that have a peak performance rating of 154 teraflops, yet the entire system consumes only 85 kilowatts. This is one of many compute servers now colocated at the MLCF.

Contributions to metropolitan and regional networks

CISL's Network Engineering and Telecommunications Section (NETS) is a recognized leader and participant in many regional networking projects that are tightly integrated with national networks. CISL's involvement with regional networking consortia includes FRGP, BiSON, WRN, EAGLE-Net, CHECO, BRAN, and the Quilt.

These are all designed to provide NCAR/UCAR and other institutions in the region with robust regional and wide-area data pathways. CISL designs, plans, engineers, installs, operates, maintains, develops strategy, and performs research for NCAR and UCAR state-of-the-art data networking and telecommunications facilities, providing a vital service to NCAR, UCAR, and UCP research communities by linking scientists at partner institutions throughout the western U.S. to NCAR's supercomputing resources. NETS hosted ADVA/BiSON training and separately, an Operating Innovative Networks workshop (with NOAA, Internet2 and ESnet), which also included a Bro regional workshop in 2014.

On behalf of UCAR, CISL continues to lead and participate in several important metropolitan, regional, and national networking initiatives. The tangible benefits of such participation include economical, diverse, high-performance networking for UCAR and its member universities. However, the intangible benefits are at least as important: participating in these initiatives reinforces UCAR's public mission of providing services to its members while simultaneously fostering cooperative ventures, collaborations, and relationships among these institutions. As a leading participant in such community alliances, NETS contributes to strengthening UCAR's value as an institution and helps UCAR fulfill its leadership and outreach obligations for NSF funding.

Commitment to HPC partnerships

CISL is actively engaged with regional and national high performance computing partnerships.

Wyoming-NCAR Alliance

Perhaps the most important is the Wyoming-NCAR Alliance (WNA), which governs the joint activities of NCAR and the State and University of Wyoming related to the NWSC facility, the Yellowstone environment, and NWSC's Education, Outreach, and Training activities. CISL also continues its collaboration with the University of Colorado at Boulder and the University of

Colorado at Denver on a Major Research Instrumentation (MRI) project that brought Janus, a 184-TFLOPS Intel-based Dell supercomputer to the CU Boulder campus. NCAR controls a 9.8% portion of this system and used more than 4.1 million core-hours across 15 allocated projects. Access to Janus' computing resources were used to support a number of new startup research projects, thus serving as an important staging area for scientists preparing for the Yellowstone supercomputer.

Colorado School of Mines supercomputing collaboration

In collaboration with the Colorado School of Mines (CSM), CSM's new IBM supercomputer named "BlueM" was installed in the Mesa Lab Computing Facility in FY2014. CISL is collaborating with CSM on a computational science research project related to this novel hybrid computing system that combines IBM's iDataPlex and Blue Gene/Q platforms. CISL has also supported several University of Wyoming-focused STEM education activities and proposals including a recently funded NSF ITEST proposal related to robotics and computer gaming. These regional HPC activities allow CISL to gain hands-on experience in collaborating with campus IT staff through the processes of CI acquisition, deployment, and resource federation.

Intel Parallel Computing Center for Weather and Climate Simulation

This year, a partnership of CISL and the University of Colorado at Boulder received an Intel award to become the Intel Parallel Computing Center for Weather and Climate Simulation. The objective in creating this collaborative center is to promote the discovery of new methods for optimizing the performance of weather and climate models on Intel Xeon and Xeon Phi hardware, and to accelerate the adoption of these optimizations in key weather and climate community models. Additional details of this work are discussed in the section Optimizing model performance on NCAR supercomputers.

Rocky Mountain Advanced Computing Consortium

CISL also participates in the activities of the Rocky Mountain Advanced Computing Consortium (RMACC) – formerly the Front Range Consortium for Research Computing – a consortium of regional HPC organizations including Colorado State University, the University of Colorado, Colorado School of Mines, the University of Wyoming, NCAR, the Department of Energy's National Renewable Energy Laboratory, and NOAA's Boulder Earth System Research Laboratory. RMACC was recently expanded to include R&E organizations from Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming.

RMACC representatives meet monthly to discuss and organize joint training, education, and outreach activities. They also consider other collaborative measures to benefit the regional development of HPC. In August 2014, RMACC organized and hosted the fourth annual RMACC Symposium, which attracted about 100 registered participants to a two-day series of lectures, tutorials, and affinity group discussions at the CU Boulder campus. The RMACC also planned its booth presence at the ACM/IEEE Supercomputing 2014 trade show in New Orleans, Louisiana, where CISL staff will provide outreach services.

Rocky Mountain Cyberinfrastructure Mentoring and Outreach Alliance

CISL was awarded an NSF Collaborative Research CC*IIE Region Proposal titled the "Rocky Mountain Cyberinfrastructure Mentoring and Outreach Alliance (RMCMOA)." Colorado State University (CSU), the Idaho Regional Optical Network (IRON), the University Corporation for Atmospheric Research (UCAR), the University of Colorado at Boulder (UCB), and the University of Utah (UU) have a long and fruitful history of collaboration, leadership, and innovation in regional and state networking, cyberinfrastructure (CI), and high performance computing (HPC) technology and infrastructure operations. These partners will leverage their expertise and organizational structures to lead and manage an outreach effort to better inform, educate, and drive adoption and expansion of advanced networking and CI technologies to small colleges and universities in the western region of the United States, specifically those in the states of Colorado, New Mexico, Idaho, Utah, and Wyoming.

During the two-year award term, the project team will conduct four regional workshops targeted at smaller institutions focused on High Performance Networking (HPN) as an enabler of scientific discovery through computational modeling and simulation, data-driven analysis, collaboration, and community building. The team will make site visits and consult with smaller institutions in the region to mentor, educate, and support proposal development and campus investment for research infrastructure and related funding opportunities. Engineering support will be provided to smaller institutions on the approaches and benefits of HPN performance measurement, performance troubleshooting and optimization, use of Science DMZs, enhanced information security protection, IPv6, and network interactions with HPC data nodes. Finally, strategies for preparing and submitting CI-related proposals will be addressed for administrators and faculty leaders. The outcome of this proposal will benefit many students and faculty in the geographically challenged Intermountain region and enhance the deployment, utilization, and access of advanced CI.

Purpose and funding

These efforts advance CISL's strategic computing imperatives in hardware cyberinfrastructure, software cyberinfrastructure, and facilities. Further, this work also addresses CISL's education imperative to broaden participation. CISL's work in this area is supported by NSF Core funding, NSF MRI grant CNS-0821794, and UCAR non-federal funds.

‹ CISL leadership in cyberinfrastructure | up | National CI engagement ›

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NATIONAL CI ENGAGEMENT

CISL has a strong presence in national CI development, including both the HPC and networking communities. Working with national entities broadens NCAR's impact by fostering the maturation of national HPC CI, leverages national resources and partnerships to tackle national problems, and is a natural and mutually beneficial component of a national center's role.

XSEDE Federation contributions

Building on its participation in the TeraGrid as a Resource Provider since 2007, CISL continues to be engaged as an active member of the Extreme Science and Engineering Discovery Environment (XSEDE) Federation and Service Provider (SP) Forum as a Level 2 Service Provider. NCAR supports XSEDE cyberinfrastructure by integrating the networking, data transfer, and science gateway services at the NCAR-Wyoming Supercomputing Center (NWSC) with XSEDE resources. Although NCAR does provide allocable resources to XSEDE, NCAR provides a dedicated 10-Gbps networking link to XSEDEnet, with which NCAR provides high-performance access to the 16-petabyte central file system at NWSC to users having both NCAR and XSEDE source and destination accounts. This year, CISL became one of the first adopters of the open-source release of the XD Metrics on Demand (XDMoD) application. Developed by the University of Buffalo through the NSF-supported XSEDE program, XDMoD is a web-based application for querying and reporting on supercomputing job and user statistics. Following the installation of XDMoD at NCAR, all historical Yellowstone, Geyser, and Caldera data were imported, and scripts were implemented for ongoing ingestion of this data. A primary use of the tool within CISL is to analyze job statistics in support of the next supercomputing procurement, NWSC-2.

As part of its work on the Service Provider Forum, CISL helped rewrite the SPF Charter and governing documents to help clarify the mission and procedures governing the SPF.

NCAR is also active in coordinating training, education, and outreach goals with other XSEDE SPs, including participating as a satellite site for an XSEDE "Big Data" training workshop in September 2014. CISL staff contributed to paper reviews for and as part of the program committee for XSEDE '14 in Atlanta, and several staff attended the conference. XSEDE is funded through a five-year grant from the NSF Office of Cyberinfrastructure.

Contributions to national networks

CISL is a recognized leader and participant in a number of national networking projects that are tightly integrated with regional networks. Active participation helps guide and set strategic direction for these national organizations, which helps ensure that UCAR has access to the national network connectivity and services required to carry out its mission. CISL's involvement with national networking consortia includes Internet2 (I2), NOAA's science network NWAVE, and the Department of Energy (DOE) Energy Science Network (ESnet). These are the United States' premier networks in research and education. On behalf of UCAR, CISL/NETS maintains high-speed connectivity to these national networks to ensure the required connectivity between researchers that enables collaboration and access to local and remote computing, data, and instruments.

CISL has continued to be heavily engaged with NSF's EarthCube initiative. CISL staff served on the Architectural Advisory Panel for the SDSC-led EarthCube Conceptual Design Award, a steering committee responsible for forming the EarthCube Council on Data Facilities (CDF). CISL's service included working to form a draft charter.

ACM/IEEE Supercomputing conference participation

CISL is also an active participant in the ACM SIGARCH and IEEE Computer Society Supercomputing conferences, which attract thousands of HPC experts from government, academia, and industry every year. CISL staff members serve each year on the infrastructure committee, present technical papers, and operate an NCAR exhibit booth on the conference floor. CISL is also active each year at the Supercomputing Student Job Fair, which is an opportunity to reach a broad population

of students and other job candidates. CISL also participates in the design, implementation, and operation of SCinet.

CISL staff members serve on a number of advisory panels, including the Science Gateways Institute, the Petascale External Advisory Committee of the NSF Blue Waters Project, and the Technical Evaluation Panel of the Department of Defense HPC Modernization Office.

Purpose and funding

These efforts advance CISL's strategic computing imperatives in hardware cyberinfrastructure, software cyberinfrastructure, and facilities. With the exception of CISL's participation in XSEDE, CISL's national leadership activities are funded by NSF Core funds.

‹ Regional CI engagement   up   International impacts ›

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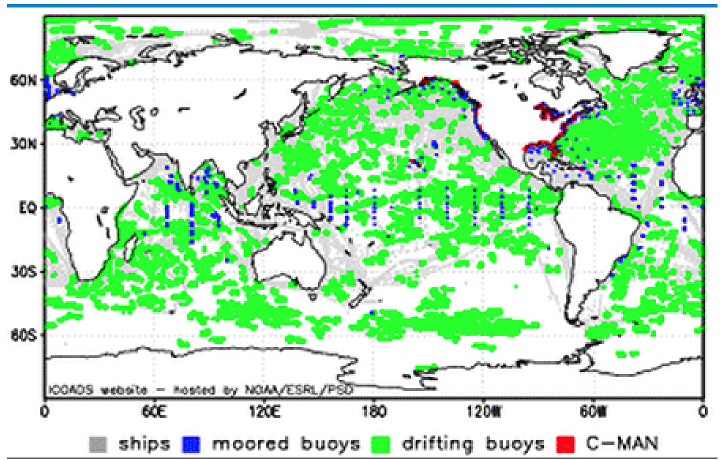
INTERNATIONAL IMPACTS

CISL is highly visible on the international front and engages with international climate and weather organizations, programs, peer supercomputing centers and laboratories, and international projects. Our international impact spans data services and exchanges, analysis and visualization tools, computational support, strategic advisory functions, training, capacity building, and participation in international conferences.



Global distribution of marine surface measurements for September 2014 in the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). ICOADS collects and distributes environmental observations from merchant and research ships, moored and drifting buoys, and coastal stations. In collaboration with NOAA partners at the National Climatic Data Center and Earth Systems Research Laboratory, NCAR processes data and adds them to ICOADS on a monthly basis. The data are openly shared with the international community.

CISL contributes to developing the World Meteorological Organization (WMO) Information System (WIS). Under the auspices of the United Nations, the WMO is designing, developing, and deploying WIS as a next-generation globally federated information system for weather, climate, hydrology, oceanography, and many other disciplines. CISL plays a strong role in the management and technical direction of WIS and has contributed ideas, strategies, and services developed through our work with CDP, ESG, ACADIS, and TIGGE. CISL staff have served on several WIS committees, recently including the Expert Team on WIS Centres (ET-WISC), the Task Team of Data Centres (TT-DC), and the Task Team on WIS Centre Audit Certification (TT-CAC). At the request of the U.S. National Weather Service (NWS), CISL attended the WMO WIS Centre Audit for NWS. CISL data collections are now being harvested by GISC-Washington into WIS as part of production operations. In addition, CISL operates the U.S. archive and portal for the WMO THORPEX Interactive Grand Global Ensemble (TIGGE), an international weather forecast multimodel intercomparison collaboration with the European Centre for Medium-range Weather Forecasts (ECMWF) and the China Meteorological Administration (CMA).

There are several noteworthy formal international data exchange agreements associated with the development of the NCAR Research Data Archive (RDA). ECMWF and JMA routinely share data under longstanding Memoranda Of Understanding with NCAR. Moreover, in 2014 ECMWF agreed to allow NCAR to distribute nearly all of their products worldwide and to the commercial sector; previously it had been only within the U.S. academic and government communities. These reanalyses and operational model outputs add to the RDA and are important because they are not available anywhere else in the U.S. CISL reciprocates by preparing observational datasets and delivering them to support future reanalysis efforts.

CISL's analysis and visualization tools (e.g., NCL, PyNGL, and VAPOR) are widely used in centers and universities around the world. VAPOR, for example, is currently expanding ocean visualization capabilities under support from the Korea Institute of Science and Technology Information. NCL is used in 114 different countries, and CISL has conducted NCL data analysis training workshops in Australia, Turkey, Germany, Korea, and Switzerland.

CISL is very active internationally in the area of data services. The RDA is an extremely valuable international scientific data resource, providing important collections to the global community and making EU collections available to U.S. scientific communities. CISL's Science Gateway Framework (SGF) federates with the global Earth System Grid Federation (ESGF), sharing catalogs and security protocols such that CCSM, CESM, WCRP/CMIP5, and other data collections are accessible via the ESGF environment. Similarly, CISL is a primary partner in the ACADIS effort. CISL provides the SGF-based ACADIS Gateway that offers data management support for NSF-sponsored Arctic research including Arctic Observing Network

(AON) data for the International Polar Year (IPY). CISL also provides computing and data management support for the Antarctic Mesoscale Prediction System (AMPS), an experimental, real-time numerical weather prediction capability that supports the United States Antarctic Program, Antarctic science, and international Antarctic efforts. Finally, CISL staff have contributed to the development of the UK's National Environment Research Council (NERC) Big Data program.

CISL continues to participate in international collaborations designed to grapple with the challenges of emerging exascale technologies. The NCAR/CU Intel Parallel Computing Center for Weather and Climate Simulation includes a collaboration with the Indian Institute of Science focused on improving the scalability of CESM's radiation code. The G8 Exascale Climate Science (ECS) project, completed this year, was a collaboration between CISL's Technology Development Division and computer scientists and climate experts from Inria (France), the University of Illinois at Urbana Champaign (USA), the German Research School for Simulation Sciences (Germany), Tokyo Institute of Technology (Japan), University of Tennessee at Knoxville (USA), University of Tsukuba (Japan), Victoria University (Canada), and Barcelona Supercomputing Center (Spain). Over three years, this collaboration studied various aspects of the exascale climate modeling challenge, including application scalability, node performance, and system resilience. The project uses CESM as one of the target applications, and relied heavily on NCAR staff for technical support of the project. In FY2014, CISL representatives attended G8 ECS project meetings in Denver, Colorado and Kobe, Japan, as well as the final program review at Princeton University. Finally, CISL staff were invited to present at the joint workshops on “Exascale Technologies” & “Innovation in HPC” for Climate Models in Hamburg, Germany which is supported by the EC-funded project IS ENES2. This was the third in a series of workshops that brought together leading climate scientists and developers of state-of-the-art climate models to discuss common challenges and strategies.

CISL hosts and organizes the popular international Computing in Atmospheric Sciences (iCAS) workshop every other year in Europe, with the most recent event taking place in September 2013. iCAS is a forum where scientists, industry experts, and computing professionals from around the world can attend and discuss challenges and new approaches to advance climate and weather research. Finally, CISL staff members collaborate with many more foreign institutions and serve on various international committees and advisory panels, including the German Climate Computing Center (DKRZ) Advisory Committee.

These efforts advance CISL's strategic computing frontier in center virtualization and strategic computing imperatives in software cyberinfrastructure and data curation. Further, this work also addresses CISL's science imperative for scientific excellence and CISL's imperative to broaden participation. This work is supported by NSF Core funding.

‹ National CI engagement up Interactions with industry ›

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INTERACTIONS WITH INDUSTRY

CISL maintains close contacts with High Performance Computing (HPC), networking, and related vendors as a way of providing information to vendors regarding the computational requirements of the atmospheric and related sciences and to track technology. To this end, CISL has up-to-date nondisclosure agreements (NDA) with HPC-related vendors that allow CISL to keep abreast of the latest technical developments and plans in this fast-moving industrial space. CISL also routinely receives loaner equipment and new software products from vendors for evaluation and testing under these agreements. For example, in FY2014, computer scientists in CISL continued to optimize code for the latest-generation Intel Xeon Phi many-core processor called Knights Corner.

Research using Microsoft cloud resources

CISL also wrote a successful proposal to the Microsoft Azure for Research program to obtain access to Microsoft cloud resources to evaluate their ability to perform big data computations. As part of this project, a cross-cutting team of CISL staff in IMAGe, TDD, and the Data Support Section in OSD worked with NOAA reanalysis datasets as well as other climate data to benchmark standard workflows, comparing the performance of Azure to the Yellowstone infrastructure. On the plus side, it proved surprisingly easy to port NCAR workflows to the cloud. Performance was another matter, however: cloud data access bandwidths were significantly lower than those achievable on GLADE. As part of this project, staff attended the EScience in the Cloud Conference in Redmond, Washington to build collaborations with other researchers exploiting cloud resources.

Shawn Strande leads the NWSC-2 procurement effort and updates vendors with numerous presentations to fully inform them of NCAR’s next-generation supercomputing needs. These presentations help vendors optimize their proposals for supplying the best mix of equipment and software for our research requirements through the next five to seven years. Shawn manages CISL’s High End Services Section, and he is also a founder of CISL’s new HPC Futures Lab.

Preparing vendors to bid on upcoming supercomputer procurement

As part of the planning for the Yellowstone follow-on procurement named NWSC-2, CISL began an extensive series of NDA briefings with HPC vendors to better understand the technology landscape in 2016-2017, which is when the new system is planned for deployment. These briefings are critical to understanding the maturity, performance, and risk in adopting these new technologies.

Developing the HPC Futures Lab

In FY2014, CISL launched the HPC Futures Lab at the Mesa Lab facility. The HPC Futures Lab is a testbed where CISL can test emerging hardware and software that may be present in future systems. This is both a risk mitigation activity and an opportunity for staff to gain valuable experience in using these technologies. Examples of technologies we are testing now and planning to in the near future include, for example the Lustre parallel file system, EDR InfiniBand, next-generation processors, and new accelerator and many-core technologies.

Interactions with networking equipment vendors

Likewise, CISL’s Network Engineering and Telecommunications Section (NETS) interacts with many networking companies. NETS provides them with feedback on feature requests and keeps them informed about services that would benefit UCAR, the Front Range GigaPop consortium

(FRGP), and our research and education community. In turn, NETS receives product road maps and other information about products and services we utilize in running and maintaining the networks we manage. NETS interacts with many vendors, professional associations, and consortia including ADVA Optical Networking, BICSI, Cisco Systems, EDUCAUSE, Internet2, Juniper Networks, North American Network Operators' Group (NANOG), National LambdaRail (NLR), and The Quilt coalition.

NETS staff provides input and receives product information on ADVA equipment through their Research and Education Technical Advisory Group. NETS technicians are RCDD certified through the BICSI professional association. UCAR has a non-disclosure agreement with Cisco Systems that keeps NETS appraised of product road maps, and NETS participates in special-purpose discussions with Cisco about future purchases and product requirements for UCAR and the FRGP. UCAR is a member of the higher-education information technology association EDUCAUSE and participates in training and conferences. UCAR is a participating member and represents the FRGP as a network member of the Internet2 research and education networking consortium. NETS participates in special-purpose discussions with Juniper Networks about future purchases and product requirements for UCAR and the FRGP. NETS network engineers participate in NANOG engineering meetings to improve the Internet's networking technologies and operational practices. NETS assistant manager Jeff Custard serves on the Board of Directors for the FRGP to influence the national agenda on information technology infrastructure, with particular emphasis on networking for research and education.

Workshops featuring HPC vendors

CISL also routinely invites vendors to attend and present at HPC-related conferences and workshops that it holds, such as the Fourth Programming Weather, Climate, and Earth System Models on Heterogeneous Multi-core Platforms workshop held in September 2014, which included vendor presentations from Intel and NVIDIA. CISL maintains an active collaboration with Intel to optimize code for both the Intel Xeon and Xeon Phi technologies. This collaboration involves regular weekly teleconferences consisting of participants from NCAR, Intel, NREL, and TACC. This working group has explored a wide range of issues associated with the Intel Phi, including the efficiency of the Intel vectorization compiler, coding structures that may inhibit vectorization, OS jitter, and MPI performance.

Service on vendor advisory boards

In FY2013, CISL staff members also continued to provide advice to industry, for example through service on the IBM Deep Computing Advisory Board and the Intel HPC Round Table. As a result of the work done by CISL on the design and construction of the NCAR-Wyoming Supercomputing Center facility, CISL staff also served on the Uptime Institute's Oversight Board. The Uptime Institute is an unbiased, third-party data center research, education, and consulting organization focused on improving data center performance and efficiency through collaboration and innovation.

Funding

This collaborative work with industry is supported by NSF Core funds, as well as resource allocations and gifted funds from industrial partners. In addition, NETS activities are supported by UCAR Communications Pool indirect funding.

‹ International impacts | up | CISL participation in the HPC community ›

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CISL PARTICIPATION IN THE HPC COMMUNITY

As part of its leadership role in the High Performance Computing (HPC) community, CISL organizes, hosts, or participates in several large-scale conferences. Through this participation, CISL fosters the interchange of ideas, technical information, best practices, and research findings. In addition to participation in relevant conferences when topics and CISL interests intersect, CISL regularly engages the HPC community via the following conferences:

Dave Hart, manager of CISL's User Services Section, presented the talk “Yellowstone: Capability and Capacity for the Atmospheric and Related Sciences” at CISL's SC13 exhibit in Denver on 16-22 November 2013. Dave also plays an active role in the NSF's XSEDE program and speaks at the biennial iCAS conference.

- SC conferences: CISL is a longtime participant in the IEEE and ACM-sponsored Supercomputing (SC) conference series, the premier HPC event in the United States. CISL staff members participate on organizing and event committees, organize Birds of a Feather sessions, and routinely submit technical papers to this conference. CISL also participates in the SC Student Job Fair, a prime venue for meeting employee candidates from a variety of backgrounds who are interested in careers in HPC and related scientific fields.
- XSEDE Annual Conference: CISL participates in the XSEDE program’s annual conference by attending, presenting papers, and participating on committees where appropriate.
- iCAS conference: To foster international dialogue by peer centers, CISL hosts the International Computing in Atmospheric Sciences (iCAS) conference every two years under NSF sponsorship. CAS brings together international colleagues to discuss information technology advances and the transformative infrastructure that allows scientists to investigate atmospheric research as part of understanding the Earth System.
- RMACC HPC Symposium: As a member of the Rocky Mountain Advanced Computing Consortium (RMACC), CISL engages with students and researchers from other HPC providers in the region by attending, participating in the conference organization, and presenting posters and invited talks.
- HPSS Users Forum: The HPSS Users Forum is the annual gathering for the HPSS community, bringing together new and existing HPSS users from around the globe to discuss best practices, new implementations, and future directions and releases. HUF 2013 in November 2013 was hosted by CISL at the NCAR Mesa Lab.
- IBM SPXXL Meetings: SPXXL is a user group for sites with large installations of IBM equipment. The SPXXL group focuses on a wide range of issues that are important to achieving petascale scientific and technical computing on scalable parallel machines.

Ye Feng worked as an intern in CISL's 2014 SIParCS program and is shown presenting her research results at the SIParCS symposium on 31 July 2014. Ye and two CISL externs (Justin Moore of Salish Kootenai College and Lauren Patterson of Hampton University) presented posters at the August 2014 RMACC Symposium. Their posters were based on their research conducted over 11 weeks in the summer. Ye's work on accelerating the Data Assimilation Research Testbed (DART) with Graphics Processing Units (GPUs) won best poster at the

This work is supported by NSF Core funding and augmented by registration fees and sponsor donations.

‹ Interactions with industry

up

RMACC Symposium and earned her a trip to present it at the SC14 conference in New Orleans.

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2014 EOL ANNUAL REPORT

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

STRATEGIC PLANS

PREVIOUS EOL REPORTS

Select year

Printer-friendly version

2014 EOL ANNUAL REPORT

TABLE OF CONTENTS

Director's Message ›

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2014 Annual Report

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2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

STRATEGIC PLANS

PREVIOUS EOL REPORTS

Select year

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DIRECTOR'S MESSAGE

Vanda Grubišić, EOL Director

It is my pleasure to present to you the Earth Observing Laboratory annual report for FY 2014. It has been another successful year for EOL that is reflected in the high quality of service the Laboratory has provided to the atmospheric observational science community. In addition, EOL staff, postdocs, students and visitors have contributed to advancing the observational-data-based physical discovery and developments of a next generation of observational systems and data services to be placed in service of the observational science community in the years to come.

In the past year, EOL supported a number of field campaigns and investigator teams by providing our end-to-end service that extends from the field program planning and guidance through the operation of facilities and instruments in the field to data services in the course of a field campaign and afterwards. In FY 2014, EOL teams supported seven traditional, small and large, field campaigns that took place in a wide range of locations, from Guam to New Zealand in the Pacific and from the Colorado Rockies and the Front Range to the Arizona Meteor Crater in the Continental US. In addition to the traditional campaigns, this past year we introduced a new type of field campaign – a 20-hr research project – and supported two of these via operation of our S-band Dual Polarization Doppler radar (S-Pol) at the Front Range Observational Network Testbed (FRONT). In FY 2014, EOL's work on these campaigns entailed direct support of over 60 principal investigators from 30 US universities, 10 European universities, and 11 federal agency entities and organizations. A total of 88 students undergraduate, graduate and postdoctoral – were directly involved in these field campaigns as well.

With support of field campaigns worldwide, we have continued to place heightened emphasis on safety of our operations and in FY 2014 expanded the Safety Management System (SMS) – a comprehensive set of policies and procedures covering all aspects of safety related to flight operations – at the Research Aviation Facility (RAF). In August 2014, the RAF Safety Management System underwent a Stage 2 third-party audit and successfully obtained the certification for compliance with the protocols under the International Business Aviation Council (IBAC) International Standard for Business Aircraft operations (IS-BAO) SMS. Having a certified and registered SMS is becoming a worldwide requirement for international aviation operations and having the IS-BAO Stage 2 certification will allow us to operate easily worldwide.

The end-to-end service that EOL provides to our scientific community includes not only the deployment of instrumentation to the field but also data processing, quality control, and archival and stewardship of field project data. In FY 2014, EOL updated its data policy to insure that our data policy follows the open data guidelines set forth by the US Office of Science and Technology Policy while at the same time addressing the needs of our community. Also, we have continued our efforts to locate older field project datasets in NCAR and EOL archives and bring that data online. 487 projects that EOL (ATD) has participated in, or have data for, have been identified to date, going back to the NCAR Line Islands Experiment in 1967.

In conjunction with support of field campaigns, we have continued to provide help to the investigators to implement targeted and tailored outreach activities via education and public engagement. During last five years EOL has attracted close to 3,000 visitors during 9 Open Houses and arranged visits to more than 60 schools reaching close to 5,500 students. Another 1,000 students were reached through tours and hands-on demonstrations.

Finally, I would like to highlight some of new and innovative instrumentation developments in EOL. Our highest new instrumentation development priority is the Airborne Phased Array Radar (APAR), a new and unique C-band airborne radar with dual-Doppler and dual-polarimetric capabilities designed for a large fuselage aircraft such as the NSF/NCAR C-130. In FY 2014, we have started working on a prototype "brick" Line Replacement Unit (LRU), the basic element of the APAR antenna. In addition to APAR, teams of EOL scientists and engineers having been busy advancing, among others, the

HIAPER Cloud Radar (HCR), the Water Vapor Differential Absorption Lidar (WV DIAL), Laser Air Motion System (LAMS) and the Advanced Vertical Profiling System (AVAPS).

As in the past years, this annual report is organized around the Imperatives and Frontiers of the EOL Strategic Plan. I invite you to enter the following pages and read more about the Laboratory's remarkable activities and accomplishments in FY 2014.

Vanda

‹ 2014 EOL Annual Report up Executive Summary ›

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EXECUTIVE SUMMARY

The ability to make observations of the atmosphere, Earth System, and Sun is fundamental to achieving the science goals of NSF, NCAR, and the scientific community. When established, NCAR was charged with providing for the community of atmospheric scientists observing facilities and services that are too large and expensive to be operated by a single university group and are thus best managed and operated centrally. A significant portion of this charge to NCAR now rests with the Earth Observing Laboratory (EOL), which defines its mission to be:

To develop and deploy observing facilities and provide data services needed to advance scientific understanding of the earth system.

EOL's activities are framed in the context of our mission statement, and are further encapsulated in our "Four Ds": Deployment, Development, Data Services and Discovery. This annual report describes the efforts we undertook in Fiscal Year (FY) 2014 to carry out the objectives described in our Strategic Plan.

Deployment

The NSF-funded Lower Atmosphere Observing Facilities (LAOF) that EOL manages include research aircraft, ground-based and airborne remote sensing systems, vertical profiling systems, in situ sensing systems, and a number of individual instruments that can be deployed in conjunction with these larger systems. EOL works continuously to maintain and improve these NSF LAOF with which we are entrusted, and to ensure their safe and reliable operation for deployment. Several of these activities are described in Imperative I: *"Maintain the EOL facilities that are deployed using NSF "deployment pool" funds so that they are ready for reliable and safe operation in anticipated field programs."*

Deployments of those LAOF are encompassed in our Imperative II: *"Support observing needs of research programs at a level that serves NSF, university, and NCAR program needs."* In FY 2014, EOL supported nine NSF-funded and one NASA/NOAA-funded research campaigns. These campaigns included over 60 principal investigators from 30 US universities, 10 European universities, and 11 federal agency entities and organizations, and direct involvement by 88 students (undergraduate, graduate and postdoctoral). EOL's deployments of the NSF LAOF in FY 2014 are described in the Imperative II section of this report.

Development

EOL's Strategic Plan Imperative III encompasses most of our Development activities: *"Anticipate future needs resulting from changing priorities, aging equipment or emerging opportunities, and develop new technology (instrumentation, software, and infrastructure) to meet those needs."* In FY 2014 EOL conducted work on several high priority developments: CentNet, the 449 MHz wind profiler system, the Water Vapor Differential Absorption Lidar (WV-DIAL), the Airborne Phased Array Radar (APAR), and the EOL Field Catalog.

Other, longer-term and emerging EOL development efforts are contained in our Frontiers, which focus on promising opportunities or developing needs in the atmospheric science community that EOL could address. In FY 2014, EOL addressed some of our Frontiers by turning our attention to the potential offered by Unmanned Aerial Vehicles (UAVs); pursuing data activities related to the EarthCube Initiative; progressed with remote control of instrumentation; continued work on the Laser Air Motion Sensor (LAMS); further utilized the testbed capabilities of FRONT and investigated other calibration/testing facilities; and improved our remote sensing capabilities from aircraft with the HIAPER Cloud Radar (HCR).

Data Services

The end-to-end service that EOL provides to our scientific community includes data processing, quality control, and archival for field project data, and these facets of that service are expressed in our Imperative IV: *"Provide comprehensive data services, open access, and long-term stewardship of data."* This includes further development of the Field Catalog into versions 2.1 and 2.2; enhancements to operating software for instrumentation; increased data stewardship activities; and collaboration with NCAR's Computational Information Systems Laboratory (CISL) for improved data access.

Discovery

Activities under EOL's Imperative V, to *"Attract and inspire new generations of scientists, engineers and the general public to atmospheric science, conveying the excitement and intrinsic value of observational research,"* show our commitment to promoting curiosity about atmosphere and Earth sciences and to inspiring the next generation of observational scientists and engineers. In FY 2014, EOL was active in a number of education and outreach activities for several field campaigns, an educational deployment, and training and entraining new LAOF users. EOL also continued two internship programs: the Summer Undergraduate Program for Engineering Research (SUPER), which focuses on undergraduate students in various fields of engineering as a complement to existing NCAR programs that primarily target students in geosciences; and our Technical Internship Program (TIP II), which establishes and increases interactions with two-year college and technical school faculty and students in order to spark interest in technical and support careers in the geosciences.

‹ Director's Message up Imperative I ›

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IMPERATIVE I

Maintain the EOL facilities that are deployed using NSF "deployment pool" funds so that they are ready for reliable and safe operation in anticipated field programs

State-of-the-art, accurate observations and measurements of the atmosphere and other parts of the Earth system continue to be the driver for scientific discovery and impetus for advances in geosciences. Such observations are also critical inputs for the robust performance and continued development of weather, climate, and chemistry models. Therefore, our first Imperative is the maintenance of NSF-funded Lower Atmosphere Observing Facilities (LAOF) for research in atmospheric science, with emphasis on systems that are beyond the capabilities of most universities or smaller groups.

In this endeavor, EOL conducts countless day-to-day efforts to preserve and consistently improve the NSF LAOF resources that are entrusted to NCAR, and to maintain readiness for a vigorous deployment schedule (see Imperative II). In the run-up to each field campaign, all instruments undergo exhaustive testing by EOL engineers and technicians to ensure optimal campaign performance. After the field phase commences, it often becomes necessary to make adjustments or upgrades to overcome difficult or unforeseen environmental conditions in order to meet scientific objectives. Then, upon completion of the field phase, calibrations, repairs and reconditioning are often required to maintain instrumentation readiness state for the next activity. The activities described below are a sampling of these efforts for FY 2014.

HIGH-SPECTRAL RESOLUTION LIDAR (HSRL) IMPROVEMENTS

EOL upgraded the High-Spectral Resolution Lidar with a new laser control developed by University of Wisconsin, and installed a new laser seed (quantum dot laser). The new laser control improves the stabilization feedback loop between the main and seed lasers, and the new laser seed is less susceptible to optical feedback with a wider spectral tuning range. These upgrades improve wavelength accuracy and allow more robust instrument calibration.

HSRL in the downward-looking position aboard the NSF/NCAR GV.

We also took steps to address a safety issue that first arose during the Tropical Ocean Troposphere Exchange of Reactive Halogen Species and Oxygenated VOC (TORERO) experiment in 2012. While in TORERO, EOL observed that under certain conditions (e.g., during zenith pointing around midday at the equator), direct sunlight can fall on the HSRL telescope primary mirror. When the primary mirror is fully illuminated, the reflected solar power can reach 150 W, which is focused down to a ~1 cm spot that can land on the black carbon-fiber struts. These in turn absorb the solar power, heat up, and create smoke, creating a hazard within the aircraft cabin. To remedy this issue, we changed the reflective coating of the primary mirror from aluminum to a dielectric in FY 2014. The new coating reflects ~1/3 of the solar power thereby reducing the maximum power ~50 W. For additional safety, an aluminum mask was installed on the underside of the telescope struts to protect them from the remaining ~50 W in the reflected spot.

The improvements made to HSRL in FY 2014 increased the reliability of HSRL data in low latitude regions of the Earth, while also improving the overall safety of airborne operations.

RAF SAFETY MANAGEMENT SYSTEM AUDIT

EOL continued to expand its Safety Management System (SMS) at our Research Aviation Facility (RAF) in FY 2014. An SMS is a comprehensive set of policies and procedures covering all aspects of safety related to flight operations. Certification of Safety Management Systems is done to assure that the policies and procedures adequately cover the specific flight activities of the organization, and that the policies and procedures are in fact being followed by the aircraft operators. Having a certified and registered SMS is becoming a worldwide requirement for international aviation operations.

In August 2014 the RAF Safety Management System underwent a Stage 2 third-party audit for compliance with the protocols under the International Business Aviation Council (IBAC) International Standard for Business Aircraft operations (IS-BAO) SMS. The requirement for the audit stems from a directive issued in 2005-2006 by the International Civil Aviation Organization (ICAO) in Annex 6; Annex 6 directed member countries to adopt SMS for their aviation activities. The audit was conducted under the auspices of the General Services Administration (GSA) Interagency Committee for Aviation Policy

(ICAP). The audit committee was comprised of aviation professionals from the GSA Office of Aviation Management, NOAA's Aircraft Operations Center, the Department of Energy's National Nuclear Security Administration and the Department of Interior Office of Aviation Services.

The audit committee strongly endorsed the performance of EOL/RAF in complying with the policies and procedures, and the SMS certification was approved. The audit verified that our SMS contained all of the standards and recommended practices required under ICAO Annex 6, including management's commitment to safety, flight operations, aircraft maintenance, training, hazard identification and mitigation, safety change management, emergency response planning, and security. As a result, we have a certified SMS that is approved and recognized for international operations.

This represents a major milestone for EOL/RAF and for the UCAR/NCAR aviation safety program. We were especially pleased by the firm support the audit committee provided of our SMS and for other helpful comments that will help us to continue to improve the safety of our aircraft operations. The outcome of this audit is a robust acknowledgement of the commitment made by all of EOL's staff to safety.

IMPROVEMENTS TO THE ADVANCED VERTICAL ATMOSPHERIC PROFILING SYSTEM (AVAPS) FOR THE NSF/NCAR GV

During the 2013 Mesoscale Predictability Experiment (MPEX) project, a number of dropsonde fast falls from the NSF/NCAR GV were observed. In FY 2014, EOL attempted to reduce this number by testing a manufacturing process that uses molds rather than machining for the dropsonde parachute cap and nose piece. This solution was tested during the 2014 DEEPWAVE-NZ field project on the NSF/NCAR GV and was shown to need additional adjustment. A slightly modified version was also tested during the NASA HS3 field project in 2014 on the NASA/NOAA Global Hawk. While results to date show that further modification may be needed, we are confident that we will soon converge on a robust solution.

‹ Executive Summary up Imperative II ›

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IMPERATIVE II

Support observing needs of research programs at a level that serves NSF, university and NCAR program needs

Field program planning and implementation is a critical community service, and EOL's efforts under our Imperative II are part of NCAR's Strategic Imperative to provide observational facilities that meet the science community's needs. EOL employs and trains project staff, assists principal investigators (PIs) with project planning and preparation, supports observing programs by operating facilities and instruments, and preserves quality of collected data for decades in support of research and field programs worldwide. EOL enables science for each campaign's PIs through this support, and, when we are a science lead or participant, directly engages in that science. EOL provided field program planning and implementation nine NSF-funded and one NASA/NOAA-funded research campaigns in FY 2014; seven of these were "traditional" campaigns, while two were 20-hour research programs, a new type of project for EOL.

Traditional small and large campaigns:

- CONTRAST
- DEEPWAVE-NZ
- FRAPPÉ
- FRONT-DE
- HS3 (NASA/NOAA)
- IDEAS IV
- IFRACS
- METCRAX II

20-hour projects:

- LATTE
- STEP Hydromet

EOL's work on these campaigns entailed direct support of over 60 principal investigators from 30 US universities, 10 European universities, and 11 federal agency entities and organizations. A total of 88 students (undergraduate, graduate and postdoctoral) were directly involved in these field campaigns as well.

CONTRAST

EOL conducted the Convective Transport of Active Species in the Tropics (CONTRAST) field project during winter 2014. This campaign had a major chemistry payload on the NSF/NCAR GV and collaboration with the NASA Airborne Tropical Tropopause Experiment (ATTREX) and the British-led Coordinated Airborne Studies in the Tropics (CAST) project.

Led by Elliot Atlas (University of Miami), Laura Pan (NCAR/NESL) and Ross Salawitch (University of Maryland), the project tracked organic gases and particles emitted by marine organisms as they rise from the ocean surface into the stratosphere. Based out of Guam, the NSF/NCAR GV conducted research flights over the Western Pacific Warm Pool, an area characterized by some of the highest open-ocean surface temperatures on Earth. Aided by widely abundant convective systems including towering thunderstorm clouds, components such as bromine and iodine are funneled through a powerful chimney effect from the ocean surface into the upper atmosphere, where they are chemically processed and react with man-made pollutants, potentially accelerating the thinning of the ozone layer.

The CONTRAST team in front of the NSF/NCAR GV.

The NSF/NCAR GV operated in the 25,000-49,000 feet altitude range during the project and was joined by the British BAe-146 aircraft, flying as low as 50 feet above the ocean, and the NASA Global Hawk, which surveys the stratosphere at close to 65,000 feet.

The CONTRAST PIs collected an excellent dataset that will help to further quantify how convection redistributes atmospheric gases in a tropical environment. Data collected include profiles in and around the Inter Tropical Convergence Zone, in the outflow anvil of storms up to 50,000 feet tall, and in some moderately active regions. Some of the most exciting data were seen during the sampling of tropical convection, and a suite of GV instruments supported by EOL, NESL, CU Boulder and NASA sampled a range of convective influences in and around the storms. The CONTRAST data will be invaluable for the scientific research for years to come.

DEEPWAVE-NZ

The Deep Propagating Gravity Wave Experiment over New Zealand (DEEPWAVE-NZ) campaign in summer 2014 used the NSF/NCAR GV, NCAR Integrated Sounding System (ISS), and the GV AVAPS systems to study characteristics and factors influencing gravity waves (GW), which are major contributors to atmospheric dynamics and affect the atmosphere at essentially all altitudes and across all spatial and temporal scales. DEEPWAVE-NZ focused on the dynamics of gravity waves from the surface of the Earth to the mesosphere and lower thermosphere. From a decade of satellite observations of temperature fluctuations in the stratosphere, a few consistent regions with concentrated GW energy have been identified. New Zealand, one of the “hotspots” in the southern hemisphere, is a prolific generator of waves due to its reliable westerly jet climatology.

Internal gravity waves are widely recognized to play central roles in a broad range of dynamical, chemical, microphysical, and plasma processes extending from Earth’s surface upward into the thermosphere and ionosphere. The dominant GW sources are in the troposphere and lower stratosphere, but their upward propagation, transport of energy and momentum, amplitude growth with decreasing mean density, and diversity of interactions and instabilities cause them to play important roles at all altitudes. DEEPWAVE-NZ examined how tropospheric winds and storms modulate the generation of GWs, how GWs propagate across the tropopause into the stratosphere, and how tidal winds influence GW propagation and breakdown in the middle atmosphere.

For this campaign, EOL deployed the NSF/NCAR GV for a six week period to the NSF Polar Programs Facility in Christchurch, New Zealand. The GV was outfitted with several user-supplied instruments as well as the EOL’s relatively new GV automated dropsonde (AVAPS) system. The GV AVAPS deployed 279 dropsondes over both land and water, with very few fast falls and the majority of data reaching the Global Telecommunication System (GTS). This was the second field project to deploy the new mini dropsonde from the GV and data quality was very good, with a success rate for DEEPWAVE-NZ similar to past dropsonde programs.

The NSF/NCAR GV on the tarmac in Christchurch, New Zealand during DEEPWAVE-NZ.

On the ground, EOL deployed the 7-module version of the 449 MHz wind profiler in Hokitika, New Zealand, and launched approximately 145 radiosondes. This was the first field project use of the 7-module profiler and first use of the 449 MHz technology (3-module or 7-module) overseas. The new wind profiler operated well through all Intensive Observing Periods (IOPs) and these data were used in real time by the PIs for aircraft flight track planning. EOL was responsible for the successful overall coordination of this complex field campaign, which also involved participation of the German DLR Falcon aircraft.

Preliminary results from this project include excellent observations of wave horizontal and vertical structure both in the lower and upper atmosphere. The data from aircraft, dropsondes and radiosondes, ground-based wind profilers, and airborne lidar measurements are being combined to get an almost complete temperature profile in the GW environment from 0 to 105 km. The lidar and dropsonde data are especially complementary in covering altitudes below and above the aircraft. On the ground, DEEPWAVE-NZ was the first opportunity to evaluate performance of the 7-module 449-MHz wind profiler in true field conditions, and through an overseas deployment. This has allowed EOL to better understand the strengths, weaknesses, and current performance of this system. Adjustments and improvements based on this understanding will lead to a more robust system for future projects. In addition, the GV-AVAPS was operated fully from the ground during one IOP, and this successful experience is a step towards future routine reliable remote operations.

FRAPPÉ

The Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ) took place in July and August 2014, and successfully collected data with a wide range of chemistry instruments on the NSF/NCAR C-130 to characterize and understand summertime air quality (AQ) in the Northern Front Range Metropolitan Area (NFRMA). Despite efforts to limit emissions, the NFRMA still experiences air quality problems and exceeds the National Ambient Air Quality Standard for ozone on a regular basis in summer. The complex meteorology and the mix of diverse pollution sources present challenges with respect to characterizing, modeling and forecasting the transport and photochemical processes contributing to local air quality. In addition, long-range transport of pollution into the area and its impact on surface air quality is poorly characterized, as is the effect of NFRMA outflow on its surroundings.

Funded by NSF, NCAR, NASA and the State of Colorado Department of Health and Environment, the FRAPPÉ campaign involved a series of coordinated NSF/NCAR C-130 flights and ground-based measurements to determine what factors control NFRMA surface ozone and whether current emission controls are sufficient to reduce ozone levels below standards. FRAPPÉ was closely linked to the NASA DISCOVER-AQ (DAQ) project, which was aimed at improving satellite capability to interpret AQ conditions near the earth's surface by deploying two instrumented NASA aircraft, as well as remote sensing and in-situ ground equipment.

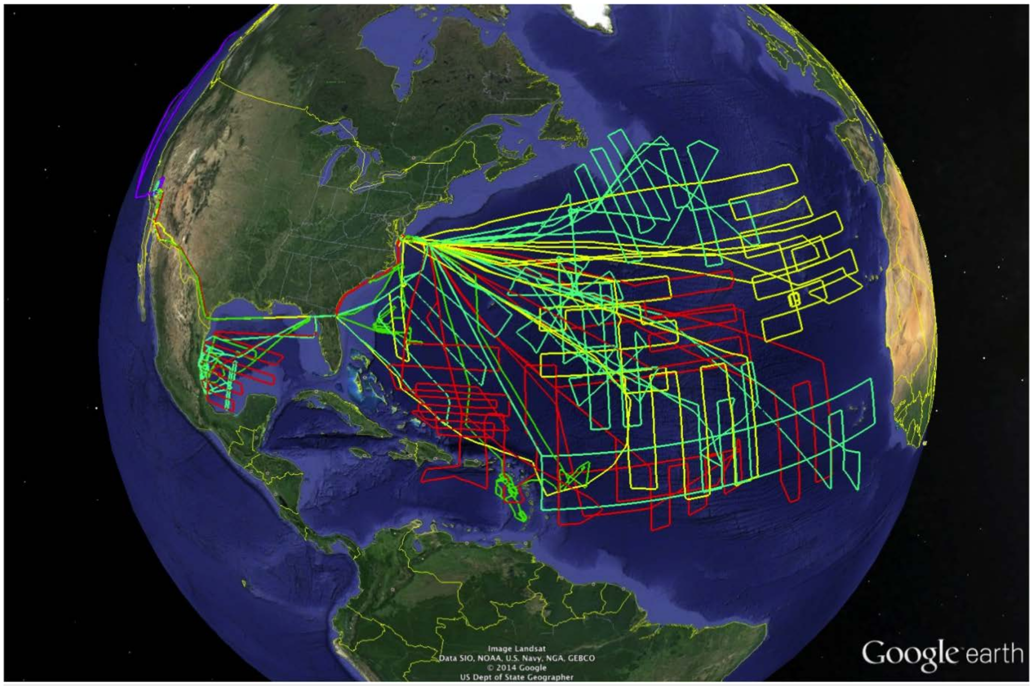
FRAPPÉ was one of the more challenging projects in EOL's recent history. The project had higher-than-usual visibility because of the $2 Million contribution by the Colorado Department of Public Health and Environment (CDPHE). The low altitude flight operations required a dedicated spotter in the NSF/NCAR C-130 cockpit to avoid close encounters with smaller aircraft and gliders, while afternoon thunderstorms and a week of monsoon-like rain hampered flight operations on several occasions. Cabin heat issues due to high summer temperatures, a full payload with a large number of heat-emitting instruments, and problems with the aircraft's air conditioning unit made for some tough working conditions, especially in the back of the aircraft. However, the project was a success and initial data analysis shows some promising and surprising results.

The view from the NSF/NCAR C-130 during FRAPPE flights over the Colorado Front Range.

See: AtmosNews article "Scientists launch far-ranging campaign to detail Front Range Air Pollution".

HS3

In August/September 2014, EOL supported the third field phase of NASA's five-year Hurricane and Severe Storm Sentinel (HS3) project, which investigates the processes that underlie hurricane formation and intensity change in the Atlantic Ocean basin, with AVAPS on NASA's Global Hawk (GH) platform. EOL's AVAPS was one of the most important instruments on this high-altitude aircraft as sounding data are essential to the science goals of this project.



Flight tracks during the 3-year HS3 campaign.

Flying from NASA's Wallops Island facility in Virginia, the GH-AVAPS operated during HS3 with a higher overall reliability than in past years, with less telemetry disruption from aircraft noise sources, good performance of the automated launcher, and improvements integrated into the software. From mid-August to late September, the EOL AVAPS on NASA GH AV-6 flew a total of 236 hours, targeting three named storms, the Saharan Air Layer, and a tricky intercomparison with sondes dropped from NOAA's GIV. Of particular scientific interest, 282 sondes were dropped into the initial disturbance, rapid intensification to a Category 3, and subsequent final decay of storm Edouard during research flights 5 to 8. Paul Newman, one of the two chief PIs for HS3, elatedly described Edouard as the type of system that HS3 had envisioned to sample when the original proposal was formulated. Furthermore, research flights 9 and 10 heavily sampled the equatorial Atlantic and were described as historic because this was the first time that a major part of the Main Development Region was systematically sampled since the GATE experiment in 1974.

All in all, ISF launched 649 sondes during the final two month installment of the three year campaign with a total of 1425 sondes deployed over the campaign lifetime. Robbie Hood, the Director of NOAA's Unmanned Aircraft Systems Program, described the NCAR Global Hawk dropsonde system as a "game changer to hurricane research."

IDEAS IV

In early FY 2014, EOL conducted the fourth installment of the Instrument Development and Education in Airborne Science (IDEAS) program. IDEAS IV included further testing of the HIAPER Cloud Radar (see Imperative I) and Laser Air Motion System, testing of new community instrumentation, as well as testing of the Holographic Detector for Clouds (HOLODEC II), which is a joint development effort between NCAR and Michigan Technological University (MTU). LAMS tests determined that some modifications to the placement of the beam "sweet spots" will be required for the best characterization of three dimensional turbulence. A paper describing the use of LAMS for calibration of temperature and pressure written in FY 2014 has been accepted for publication (http://www.atmos-meas-tech.net/7/3215/2014/). HOLODEC II also completed a shakedown on the NSF/NCAR GV in its latest configuration, and EOL has confirmed that improved measurements of small ice and water droplets are possible with the instrument.

EOL also tested improvements to the inlet system to reduce possibility of contamination from cabin air. Those tests provided a much better characterization of the boundary layer contamination profile at various inlet locations. The contamination profile was also better than expected. This improved information on the GV boundary layer contamination profile will expand the usefulness of the aircraft and reduce the possibility of inaccurate data.

IFRACS

In January/February 2014, EOL supported the Isotopic Fractionation in Snow (IFRACS) project at Storm Peak Laboratory (SPL) in northwestern Colorado. The experiment used the Global Positioning System (GPS) Advanced Upper-Air Sounding

system (GAUS) to infer the nature of snow growth processes which occur higher up in the atmosphere, and, for the first time, measured the concurrent water isotopic composition of vapor, cloud, and snow phases when SPL is cloud-covered and it is snowing.

Led by Doug Lowenthal (DRI), IFRACS examined the origin of water in snow using isotopic analysis. Similar to previous years, one of EOL's GAUS operated near the base of the mountain, providing thermodynamic profiles through the clouds, while a range of additional instruments including isotopic, aerosol and cloud droplet samplers operated on top of the mountain. The project investigated the relationships among pollution aerosols, snow growth by riming, and snowfall amounts until the end of the month.

A sonde launch during IFRACS.

IFRACS expectations were exceeded during the second part of the campaign, when a series of snowstorms hit the mountains of the Park Range. Staff at SPL collected a record number of droplet and snow samples on the roof of the laboratory, while the EOL team launched a total of 68 radiosondes to provide vertical profiles of each storm. Operations were often carried out in freezing weather conditions with instrumentation showing heavy riming, and balloons frequently dropping in flight due to icing.

The results of this study have important implications for water resources in the inter-mountain West, which of course depend on a sizeable snow pack every year. Previous experiments suggest that most of the snow mass is formed within 1 km above the Lab. Continuing analysis will refine this result and will test simulations of snow formation with an isotopologue-enabled version of WRF.

As part of the campaign, ISF carried out a focused E&O program with the MGAUS, visiting five schools scattered among three towns along the Yampa Valley (see Imperative V).

METCRAX-II

The ISFS tower set up on the rim of Barringer Meterorite Crater during METCRAX II.

In early FY 2014, EOL conducted the second Meteor Crater Experiment (METCRAX-II) to study downslope windstorm flows in and near the Barringer Meteorite Crater in Arizona. EOL's Integrated Surface Flux System (ISFS) and Integrated Sounding System (ISS), along with PI-operated instruments, measured near-surface turbulence and radiation, and height-resolved boundary layer properties within the crater and upwind.

EOL successfully deployed tower-based in-situ and ground-based remote sensors in and around Barringer Meteor Crater, and collected a nearly continuous high-quality data set throughout the METCRAX-II project. The 50 m instrumented tower deployed approximately 1 km upwind of the Crater is the highest Rohn tower EOL has installed to date. The 40 m tower near the Crater rim used a unique deadweight anchor system to meet the location requirement of the experiment. Three other 10 m instrumented towers were deployed outside the Crater, and 10 sites inside the Crater measured the pressure gradient and other properties through a transect of the Crater. In addition, EOL deployed an ISS including the new 3-module 449 MHz wind profiler and SODAR, and released over 50 GAUS radiosondes. METCRAX-II was the first deployment of the 449 MHz wind profiler as an LAOF. It was also the first use of RASS temperature profiling with the 449 MHz wind profiler and the first use of Range Imaging (RIM) in a field project. EOL also leased and deployed a Leosphere Doppler lidar to support METCRAX-II science data collection needs.

The scientific goals of METCRAX-II were to determine the characteristic atmospheric structure and evolution associated with downslope windstorm flows, and the controlling parameters in the katabatic winds that drive them. The towers and remote sensors collected a wealth of data. Preliminary findings show the temporal evolution of drainage flow outside of the crater topography, flow splitting as the flow approaches the crater, and development and evolution of downslope-wind-storm type intrusions into the crater basin. The EOL deployment extended our capabilities by demonstrating deployment of a 50 m instrumented tower, and use of new tower anchoring techniques including deadweight anchors. The project was also the first field use of 449 Radio Acoustic Sounding System (RASS) with the modular profiler, and the first use of RIM (Range Imaging), which greatly improves the vertical resolution from the wind profiler. The deployment to METCRAX-II also

uncovered a list of changes to improve the mechanical robustness of new wind profiler.

FRONT-DE

The FRONT Demonstration Experiment (FRONT-DE) took place in summer 2014. This 20-hour project was EOL's first external, remotely operated NSF-funded FRONT project at the Firestone Site (see Imperative I). During the first portion of the project, Dr. Sandra Yuter and four of her undergraduate students from North Carolina State University remotely operated both NCAR's S-Pol radar and CSU's CHILL radar from Raleigh, NC as storms over the Front Range evolved and moved. Students remotely powered on the radars prior to operations, implemented real-time decisions on how to scan the radars, and shut them down once done. The project collected radar data from several thunderstorms and hail storms as well as mini-supercells and a supercell storm that produced tornadoes, and data from this project will be used to develop a series of case study examples of commonly observed storm structures.

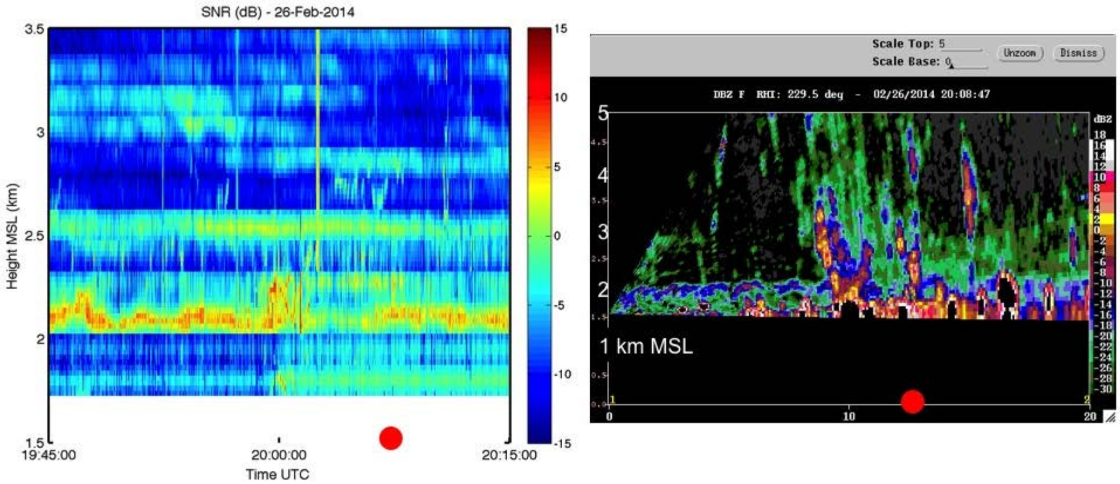
During second half of this project, NCAR/EOL PI John Hubbert used FRONT to understand and quantify the biases in the simultaneous transmission and reception of horizontal (H) and vertical (V) polarized waves (called SHV mode) of polarimetric radar data. While this has become a very popular way to achieve dual polarization for weather radars, the simultaneous transmission of the H and V signals results in cross-coupling, which causes biases to the polarimetric measurement variables. These biases have been documented but are not well-understood and documented. The July FRONT-DE operations were an opportunity to investigate these biases with unprecedented polarimetric radar coverage with S-Pol, CSU-CHILL and the Denver NEXRAD, KFTG. Radar data was collected using these three radars from common regions in order to do an inter comparison study.

20-HOUR PROJECTS: LATTE AND STEP-HYDROMET

In February 2014, EOL supported its first 20-Hour Project: the Lower Atmosphere Thermodynamics and Turbulence Experiment (LATTE), led by Dr. Phil Chilson from the University of Oklahoma. Twenty-hour projects are a new category of requests that were introduced to allow for small-scale testing and data collection without having to go through the Observing Facilities Assessment Panel process. A primary motivation behind LATTE was the testing and validation of the NCAR 449 MHz wind profiler. However, the scope of the experiment expanded to include 15 different instruments from eight different groups including the University of Oklahoma, NOAA, Lawrence Livermore National Laboratory (LLNL), the University of Colorado and North West Research Associates (NWRA). Participants conducted turbulence measurements using lidar and other sensors motivated by wind energy applications; intercompared various remote and in situ sensors; and studied Bragg scatter using radars, sodars, in situ probes, soundings and models. Most of the instrumentation was located at the BAO tower in Erie, CO while S-Pol operated at the FRONT site.

While the primary objective of LATTE was to compare Bragg scatter from the ISF 449 MHz wind profiler with that from S-Pol, it was unknown whether S-Pol would even be able to detect Bragg scatter in winter conditions. Bragg scatter echo is produced by gradients in the refractive index due to small-scale moisture and temperature gradients that occur at one-half of the radar's wavelength. For LATTE, S-Pol's sensitivity was maximized to conduct RHI scans along a radial corresponding to the location of the wind profiler. Signals from S-Pol indicative of Bragg scatter were then used to compare with enhanced backscatter from the 449 MHz profiler. Both the 449 MHz wind profiler and S-Pol collected excellent datasets, with S-Pol revealing wintertime Bragg scattering signatures previously not documented.

The two figures below show the 449 MHz wind profiler data for a 30-min period on 26 February 2014 on the left, and the corresponding S-Pol RHI over the profiler site (which is in the ground clutter echo region at 12.5 km from S-Pol) on the right. The data show enhanced echo (purple colors) at ~500 m AGL and correspond to the height of the boundary layer as determined through radiosonde data. These measurements were collected under clear sky conditions, and the enhanced reflectivity corresponds well with the enhanced return from the wind profiler. S-Pol data from a light precipitation case will also be used to help calibrate the 449 MHz profiler. Numerous other diverse datasets collected during LATTE provide a unique opportunity to cross-validate various sensor technologies developed for lower atmospheric observations and to investigate the structure and evolution of the planetary boundary layer. Undoubtedly these new capabilities in EOL will greatly benefit NSF community.



The Short Term Explicit Prediction (STEP) Hydromet experiment was the second 20-hour project supported by EOL in FY14. Jenny Sun and Rita Roberts (both NCAR/RAL) were PIs for this opportunity, and used it to test the predictive skill of the STEP Hydromet Rainfall Prediction System. Centered over the Colorado Front Range, RAL ran this system in real-time to improve short–term prediction of high–impact weather. The long-term goal of STEP is to advance the prediction of heavy rainfall, flash floods and streamflow prediction through the integration of state-of-these art components into one seamless system.

‹ Imperative I up Imperative III ›

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IMPERATIVE III

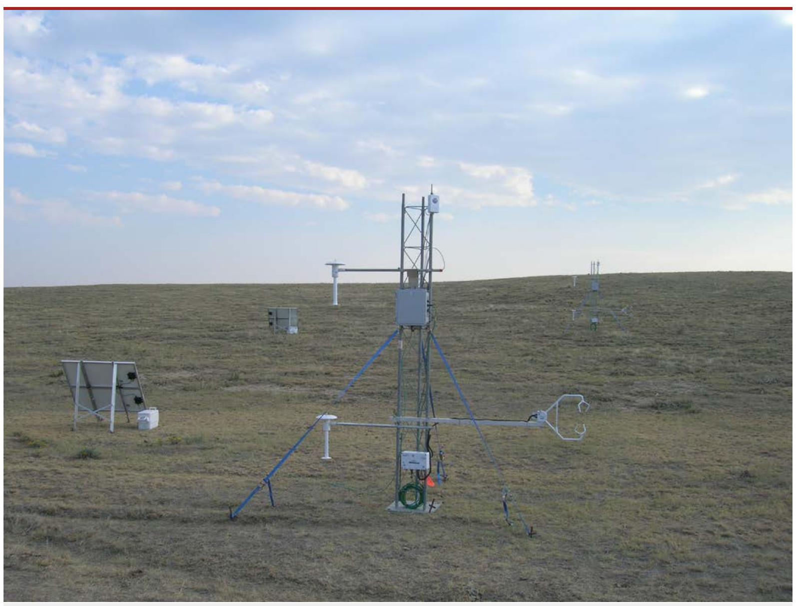
Anticipate future needs resulting from changing priorities, aging equipment or emerging opportunities, and develop new technology (instrumentation, software, and infrastructure) to meet those needs.

The NSF LAOF maintained and deployed by EOL are of vital importance to the community's scientific interests, and these systems continue to be in high demand. However, community priorities and technological opportunities also call for ongoing development to ensure that EOL's observing systems and support matches evolving community needs. There is also a constant, ongoing process of acquiring new capabilities, and retiring and replacing those that become outdated. In addition to such evolutions, it is necessary to plan for the replacement or end-of-life of systems that become obsolete or too costly to maintain. Thus, Imperative III calls upon EOL's scientific and engineering leadership and expertise for a healthy development effort, and for the retention and training of staff who can conduct that research and development. It also requires the development of life-cycle and end-of-life plans for major facilities, instruments and software (see Imperative IV for more information on data services and software developments).

The shift toward an emphasis on studies that contribute to the support of climate process study research, on both local and global scales, can be well served by new or developing EOL facilities such as the planned CentNet sensor array and FRONT. The attendant shift in the use of observing facilities features increased aircraft use in collection of global-scale observations, longer-term deployment of observing systems and sensors, repeated observations to cover seasons and broader areas, networks that provide a larger number of measuring stations, and development of reliable, easily deployable sensors.

Our development efforts in FY 2014 included continued work on the prototyping of CentNet; deployment and incremental improvements to the 449 MHz wind profiler system; further development of the Water Vapor Differential Absorption Lidar; work on the Airborne Phased Array Radar; improvements to the Airborne Vertical Atmosphere Profiling System for HIAPER; the Laser Air Motion Sensor; and the Lidar Radar Open Software Environment (LROSE). Plans for other, emerging developments are discussed in our Frontiers.

SURFACE EXCHANGE: CENTNET



CentNet towers set up during SCP.

In FY 2014 EOL continued progress on CentNet development. CentNet is envisioned to be a deployable 100-station network for surface exchange research. To make this number of stations manageable, CentNet's design to minimizes set up and maintenance time. With the majority of sensor selection complete, EOL focused in FY 2014 on a transition of existing sensors toward the CentNet platform by upgrading interfaces and data systems.

The data system interface was redesigned based on experience in the FY 2013 Shallow Cold Pools (SCP) field project, and the improved interface has been applied to the NR01 radiation sensor and a variety of soil sensors, improving their capabilities as smart-sensors. We also completed evaluation of the 10 m telescoping tower as a candidate for CentNet infrastructure, but unfortunately found it would not be robust enough for repeated field use, and other options are therefore being considered. Significant effort in FY 2014 also went into seeking collaborations that could lead to funding opportunities to build CentNet.

CentNet's large deployable sensor network is expected to facilitate research in the biogeosciences, hydrology, and urban meteorology over seasons and is therefore a capability that can be employed for climate process studies. CentNet will address many research topics including understanding turbulent flow over complex terrain, predicting convective

initialization, and characterizing the exchange of trace gases within a vegetative canopy.

TROPOSPHERIC WIND PROFILING: 449 MHZ WIND PROFILER

The 449 MHz wind profiler system deployed twice during FY 2014: first to METCRAX II and next to DEEPWAVE-NZ. Thanks in large part to the experiences and information collected during these campaigns, EOL made significant progress in the continuing development of both the 3-module and 7-module configurations of the 449 MHz modular wind profiler.

The 449 MHz profiler set up during DEEPWAVE-NZ.

The prototype 3-panel 449-MHz wind profiler was deployed to METCRAX II in early FY 2014 (see Imperative II). This system has improved altitude coverage and better time resolution compared to EOL's 915 MHz wind profilers. METCRAX II was be the first use of the 449 system and the first field use of radio acoustic sounding system (RASS) virtual temperature profiling and range imaging (RIM) for better range resolution of winds. Then in summer 2014, the 7-panel 449 profiler was successfully deployed to Hokitika, New Zealand during DEEPWAVE-NZ (see Imperative II). This was the profiler's first international field campaign in any configuration, first use with 4 kW transmit power, and first use of the newly designed 7-module frame. During DEEPWAVE-NZ, the profiler accurately profiled the wind and structure of the atmospheric boundary layer and troposphere, and extended the capabilities of the current Integrated Sounding System. The deployment also allowed us to field-test this larger wind profiler configuration, and test system improvements, including the new frame and higher transmitter power. Knowledge of this configuration's strengths and weaknesses will lead to future improvements in the design.

TROPOSPHERIC WATER VAPOR PROFILING: WV DIAL

EOL continued its partnership with Montana State University (MSU) in FY 2014, to upgrade the prototype water vapor differential absorption lidar (WV DIAL) for field deployment. The upgrades include: a unique shared telescope design that allows expansion of the outgoing beam for eye-safe operation with opto-mechanical and thermal stability; multi-stage optical filtering enabling measurement during daytime bright-cloud conditions; rapid spectral switching between the online and offline wavelengths enabling measurements during changing atmospheric conditions; and enhanced performance at lower ranges by the introduction of a new filter design and the addition of a wide field-of-view channel.

The improved WV DIAL was deployed at the Boulder Atmosphere Observatory (BAO) tower near Erie, Colorado as part of the FRAPPÉ project to be collocated with other water vapor profiling systems, such as University of Wisconsin Atmosphere Emitted Radiance Interferometer (AERI), rawinsonde, and Unmanned Aerial Vehicles (UAVs), in order to intercompare the performance of the WV DIAL with these established water vapor measurement systems. Evaluation of the results is underway.

NEXT-GENERATION AIRBORNE DOPPLER RADAR: APAR

EOL's work on a phased plan for a state-of-the-art, electrical scanning, fuselage conforming, airborne phased array radar (APAR) on board the NSF/NCAR C-130 to replace the ELectra DOppler RAdar (ELDORA) continued in FY 2014 with the beginning design, fabrication and assembly of a prototype "brick" Line Replacement Unit (LRU). We also completed and submitted to NSF a White Paper outlining development steps beyond the LRU.

More information about APAR can be found in the APAR White Paper and a peer reviewed publication in the interactive open access journal of the European Geosciences Union called *Geoscientific Instrumentation, Methods and Data Systems.*

"The next generation airborne polarimetric Doppler weather radar", J. Vivekanandan, W.-C. Lee, E. Loew, J. L. Salazar, V. Grubišić, J. Moore, and P. Tsai; *Geosci. Instrum. Method. Data Syst. Discuss.*, 4, 1-42, doi:10.5194/gid-4-1-2014, 2014

DEEP IN SITU ATMOSPHERIC PROFILING: AVAPS ADVANCEMENTS

One of the innovations implemented in FY 2014 for the AVAPS dropsonde sounding system was a technique called GPS Aiding. The GPS receiver in the dropsonde provides horizontal wind speed and direction data as the sonde descends on its parachute to the surface. In some instances it is desirable to make a series of soundings in rapid sequence, e.g., when soundings are dropped into the eye and eyewall of a hurricane. Any improvement that can shorten the preparation time before a drop will therefore permit a more rapid release rate. The new GPS Aiding technique in AVAPS did exactly that and has cut the overall prelaunch preparation significantly.

When a dropsonde is powered up, it must first identify and track all GPS satellites above the horizon. GPS satellite

acquisition typically takes anywhere from 35 to 60 seconds from a "cold start." AVAPS GPS Aiding leverages the continuous satellite tracking of the GPS receiver mounted in the AVAPS telemetry chassis to provide "warm start" satellite data to the dropsonde prior to release. With GPS Aiding, typical dropsonde satellite acquisition time during prelaunch is now 10 to 15 seconds. Other aircraft-dependent physical handling factors such as loading the sonde into the launcher determine the overall prelaunch preparation time. By reducing the time required to get the dropsonde to flight readiness, all AVAPS users have benefited from the GPS Aiding change.

The new technique was first tested and perfected this spring on a series of flights of opportunity on the NOAA GIV jet. Shortly after, the update was first used operationally on the NSF/NCAR HIAPER during DEEPWAVE-NZ. This summer the technique was implemented system-wide including the U.S. Air Force and NOAA Hurricane Hunters for the 2014 hurricane season, the NASA Global Hawk UAV for the HS3 2014 hurricane research program and to other AVAPS users in the research community.

‹ Imperative II   up   Imperative IV ›

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IMPERATIVE IV

Provide comprehensive data services, open access, and long-term stewardship of data

NSF policy requires data set preservation and availability to users pursuing research questions apart from those that justified the original project, and NSF requires that grant proposals include comprehensive data management plans. Additionally, one of NSF's core expectations in the NSF - UCAR Cooperative Agreement focuses on data issues, specifically calling for NCAR to "serve as stewards of high quality scientific data on behalf of the community through maintenance, enhancement and curation." For EOL, this charge falls primarily on the Computing, Data and Software Facility (CDS). CDS is responsible for developing and maintaining EOL's data and metadata services, collaborative tools, and software engineering, all of which are integral to EOL Imperative IV.

Data sets collected and preserved by EOL have value that extends far beyond immediate project-team use. Modern data-access mechanisms increase the importance and utility of data set preservation, and improve data access by the scientific community. Leveraging these mechanisms, EOL has enlarged the scope of its data services to include service provision from mission planning stages, to data collection and quality control and long-term archives. EOL also provides stewardship for a select set of data not collected by its observational facilities. These efforts directly feed into NCAR's Strategic Plan Imperative to develop and provide state-of-the-art data services that meet the needs of NSF, NCAR, and the science community.

EOL DATA POLICY

EOL updated its data policy in FY 2014. The main goal of this effort was to make sure that EOL's data policy follows the open data guidelines set forth by the US Office of Science and Technology Policy while at the same time addressing the needs of our community. EOL continues to be committed to the collection of high quality, research-grade observational data on behalf of NSF and its user community; the timely release of quality-controlled EOL data and associated metadata and documentation; and full and open data sharing of all EOL data with the scientific community and public.

Several changes were made to the policy:

(1) PIs will be granted access to preliminary data in a centralized, password protected location at the conclusion of each field campaign.

(2) Quality-controlled EOL data, associated metadata and documentation will be released within no more than six months after the conclusion of a field campaign unless otherwise indicated.

(3) While generally discouraged, EOL will continue to grant exclusive rights to the use of data collected by EOL instrumentation for up to one year. The data restriction period will start on the first day after the end of a campaign.

The new data policy is posted on the EOL website at https://www.eol.ucar.edu/content/eol-data-policy.

DATA STEWARDSHIP

EOL continues to locate older field project datasets in NCAR and EOL archives and is working with other Agencies and the University Community to coordinate additional contributions to project archives. 487 projects that EOL (ATD) has participated in, or have data for, have been identified to-date going back to the NCAR Line Islands Experiment in 1967. For the complete on-line list, see: https://www.eol.ucar.edu/all-field-projects-and-deployments

As project documentation is located and becomes organized, project web pages are created which contain a short scientific project descriptions, facilities and participants involved, links to available datasets (both at EOL and externally), digitized documentation and reports, photos, aircraft flight videos, publication lists, and other related items. EOL continues to organize, inventory, and document our off-line archives for improved access and future media migration. As older datasets are migrated, they are reviewed and corresponding software is either located, modified, or created to convert these older data into readable formats. In some cases additional "browse" datasets (e.g. imagery) are created during this process. Once these datasets are completed, metadata are created and submitted to the EOL Data Management System (EMDAC) and data are made available to the community through project web pages.

FIELD CATALOG

EOL continued development of the Field Catalog and deployed two new versions of this tool in FY 2014: 2.1 and 2.2. Below is a sampling of the enhancements offered by these new versions:

- a redesigned catalog navigation paradigm vetted by PIs
- a multi-author instrument status form that pushes information to a database, allowing viewing of status by day or by project period
- the ability to field a Catalog server to a remote site for poor bandwidth situations
- deployment of a dedicated MySQL server to improve performance
- the ability to show aircraft position and heading on a rapid update cycle (5-10 sec) for real-time use

The Field Catalog is in high demand by the research community, and in FY 2014 this tool supported five field campaigns and one project dry run:

- the Ontario Winter Lake-effect Snow study (OWLES, December 2013 - January 2014 in Oswego, NY);
- the High Altitude Ice Crystals – High Ice Water Content campaign (HAIC-HIWC, January – March 2014 in Darwin, Australia);
- the Convective Transport of Active Species in the Tropics Project (CONTRAST, January - February 2014 in Guam);
- the Deep Propagating Gravity Wave Experiment over New Zealand (DEEPWAVE-NZ, May - July 2014 in Christchurch, NZ).
- the Plains Elevated Convection at Night (PECAN) Dry Run (June 2014 in Boulder, CO);
- the Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ, July - August 2014 in Broomfield, CO).

FY 2014 was the first time the Field Catalog supported three simultaneous projects: CONTRAST, OWLES and HAIC-HIWC.

EMDAC

The EOL Metadata Database and Cyberinfrastructure (EMDAC) long-term archive relies on NCAR's Computational Information Systems Laboratory (CISL) hardware, but certain project datasets are hosted on EOL servers. In FY 2014, EOL migrated its most recent (e.g., three to five years old) data holdings to high-speed disk hosted by CISL. Moving these more recent datasets to CISL-hosted hardware will greatly improve access times and allow EOL to better serve the community in the future. Consolidating our data holdings on a small list of sequential tapes also allows us to quickly make backup copies of our complete holdings.

EOL also worked with CISL to create a consolidated set of field project data, resident on a reserved set of high performance storage system (HPSS) tapes. Such a consolidated set will allow simple copying for backups and more reliable migration of observational data upon future upgrades of the HPSS system. The consolidated tape set (referred to as a "file set") will consist of about 200 TBytes and over 3 million files of data. Consolidation of data on fewer tapes will help speed future access to data, as only a single tape will need to be mounted to recover a full data set.

SOFTWARE ENHANCEMENTS FOR CORE INSTRUMENTATION

EOL made significant software enhancements for core instrumentation in FY 2014. Improvements to NIDAS, the flagship EOL time-series data acquisition system, including building real-time javascript displays for browsers, and completion of a user guide and white paper to enhance the documentation. Development also continued on merging the NIDAS "syncserver" with the Nimbus processor; this will complete integration of NIDAS with the legacy aircraft data processor, and will greatly streamline the airborne data processing procedures.

The Range Imaging Method (RIM) was added to the Software Defined Digital Down-Converter (SD3C) Field Programmable Gate Array (FPGA) firmware and the wind profiler software, bringing sub-range gate resolution to the winds observations. The 449 MHz Wind Profiler also received enhancements to the user interface, data communications, and overall system robustness. These upgrades met essential needs for the LATTE and DEEPWAVE-NZ field programs, and the RIM capability was successfully deployed for those projects as well (see Imperative II).

The HIAPER Cloud Radar flew during IDEAS IV, employing new software to use high-frequency attitude information in real time to maintain very precise nadir and/or zenith pointing. Software refactoring improved the integration of recently added hardware sub-systems, which increased overall system performance and robustness.

Improvements were also made in the RAF sensor calibration infrastructure. In collaboration with end users, the "calibration editor" received significant usability and functional improvements. EOL software engineers took the lead in developing new

calibration management processes, and the calibration database and algorithms were refactored to provide more consistent and robust functionality. The automated NAGIOS monitoring system was also integrated with the aircraft database, to provide real-time detection of sensor anomalies and faults during NSF/NCAR GV and C-130 flight operations.

The Aspen radiosonde software Q/C package received significant modifications, as a result of collaborations among EOL, Air Force, National Hurricane Center, and Hurricane Research Division scientists. This has impacts on hurricane surveillance (message formatting), science results (quality control algorithm improvements), efficiency (user interface usability improvements), and research frontiers (support for upward travelling dropsondes, and contiguous up/down soundings from a single radiosonde).

‹ Imperative III | up | Imperative V ›

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2014 Annual Report

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Search
Search

2014 EOL ANNUAL REPORT

- Director's Message
- Executive Summary
- Imperative I
- Imperative II
- Imperative III
- Imperative IV
- Imperative V
- Frontier I
- Frontier II
- Frontier III
- Frontier IV

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- EOL Strategic Plan
- NCAR Strategic Plan

PREVIOUS EOL REPORTS

Select year

Printer-friendly version

IMPERATIVE V

Attract and inspire new generations of scientists, engineers and the general public to atmospheric science

The promotion of atmospheric science is crucial to inspire the development of the next generation of observational scientists and engineers, and is an institutional charge that is important to EOL. EOL's commitment to both continuing and expanding the Laboratory's portfolio of education and outreach (E&O) contributions is reflected in EOL's Strategic Plan Imperative V. This Imperative aligns with NCAR's goal to attract a diverse group of university students and early career scientists and engineers, and to provide exciting educational and professional opportunities. The EOL-managed LAOF, EOL's mission and the Lab's E&O activities and visitor programs offer excellent and unique opportunities for education and training for undergraduate and graduate students interested in observational meteorology, and the integration of traditional engineering fields with areas of science. These opportunities can also motivate students to pursue careers in observational meteorology. EOL also strives to educate the public on the value of observational atmospheric science, through demonstrations of direct atmospheric measurements combined with explanations of what scientists learn from such observations.

Students pursuing education in science, technology, engineering and mathematics (STEM) can be motivated to seek careers in observational meteorology through exposure to NSF LAOF, and EOL outreach activities. EOL can also help the public understand better the value of observational atmospheric science by demonstrating direct measurements of the atmosphere and explaining what scientists learn from these observations. The mechanisms EOL provides to support and inspire undergraduates and graduates, high school students, teachers, and faculty will ensure the field of atmospheric science remains vibrant well into the future.

In FY 2014 EOL conducted education and outreach activities for several field campaigns; participated in an educational field deployment; and conducted the 14th year of EOL's Summer Undergraduate Program for Engineering Research (SUPER) internship.

PUBLIC ENGAGEMENT AND E&O FOR FIELD CAMPAIGNS

Field campaigns are excellent opportunities to carry out public engagement in parallel with the conduct of science itself. Therefore, EOL staff works closely with the PIs of funded research projects on dedicated education and outreach efforts during field campaigns to increase the understanding of and public appreciation for observational research in the atmospheric sciences and its relevance to society.

Over the last few years, EOL has significantly enhanced its efforts in reaching out to various sectors of the public. The activities that EOL undertook as part of the FY 2014 field campaigns significantly increased the number of activities related to broader impacts as required by NSF, and raised the visibility of NSF-funded and NCAR-supported field work. School visits in particular provide support and inspiration to high school students and teachers, undergraduate and graduate students and faculty, and will help ensure the field of atmospheric science becomes even more diverse and vibrant well into the future.

For CONTRAST, EOL conducted a focused education and outreach campaign that included school visits, media events and a public Open House. In a two-week period, 3,921 middle and high school students in Guam heard a total of 24 presentations describing the objectives of CONTRAST and the various facilities. EOL's E&O Coordinator and participants from CONTRAST and the concurrent UK CAST and NASA ATTREX projects were available to interact with students from all ages to share their passion for science and technology.

During the DEEPWAVE-NZ campaign, EOL organized an Open House and Media Event on the US Antarctic Program premises, which was attended by at least 200 enthusiastic visitors, including the mayor of Christchurch. Several media pieces were created for the project. One is a report by Radio New Zealand called "Our Changing World," and

EOL E&O Coordinator Alison Rockwell conducts educational activities during the CONTRAST open house.

another includes three individual, short movie clips as well as some rather amazing pictures put together by NIWA Science, one of the collaborators in DEEPWAVE-NZ.

The E&O portfolio for FRAPPE included a media day and a large Open House, where the public was allowed to tour the NSF/NCAR C-130 and the two NASA Discover AQ aircraft. This Open House attracted over 1,200 interested visitors and involved 52 volunteers from 12 organizations. Visitors were able to get on board the two NSF/NCAR research aircraft, watch real-time flight operations and tracking of the NASA P3, explore three mobile research vehicles, and peruse the educational air quality materials and activities at exhibits sponsored by the partner organizations.

North Carolina A&T State University students pose in front of the NSF/NCAR GV during the FRAPPE open house.

In another outreach activity for FRAPPE, EOL welcomed three students from North Carolina A&T State University to work on research projects related to the campaign. The students participated in a series of citizen science research hikes with Boulder Open Space Mountain Parks (OSMP) and Rocky Mountain National Park (RMNP) rangers, using small hand-held air quality pods designed by the CU Engineering Department.

The FRAPPÉ Blog, which was maintained by the project PIs, can be seen here: http://frappecolorado.wordpress.com

Two major graduate student projects were included during IDEAS IV. The first was a continuation of the study of the effects of shattering on the measurements of cloud hydrometeors, by a student from the University of Illinois at Urbana-Champaign. That work has now been accepted for publication and will be a major part of her Ph.D. thesis. The second study, by a student from Colorado State University, evaluated the concentrations of biogenic aerosols above the Front Range. The work is expected to be part of her thesis work. The students that participated in IDEAS IV were able to conduct high impact research, which will, for example provide improved understanding of the performance of EOL GV cloud instrumentation for future users and, in another case, will provide some of the first measurements of the incorporation of biogenic aerosol into cloud hydrometeors.

Finally, and similar to previous years, EOL carried out several E&O events at the beginning of IFRACS, taking a mobile GAUS system to various elementary schools in the Steamboat Springs area and launching weather balloons. This effort reached approximately 300 schoolchildren.

TRAIN AND ENTRAIN WORKSHOPS

In order to entrain the next generation of users of its facilities, EOL, in conjunction with other LAOF partner organizations, offered a short course on how to request the observing facilities for use in field campaigns at the 2014 American Meteorological Society (AMS) Annual Meeting and the American Geophysical Union (AGU) Annual Meeting in late 2013. The main focus of the course is to describe in detail the available NSF Lower Atmosphere Observing Facilities and EOL services that are available to the NSF User Community, and to provide an overview on the request process.

In addition to the public overview presentations describing available facilities and services provided by EOL and its LAOF partner organizations, EOL staff was also available for one-to-one interactions as part of its booth set-up during exhibit times.

EOL expects that workshops at annual meetings of the AGU and AMS will remain valuable entrainment tools and reach a new set of LAOF users.

EDUCATIONAL DEPLOYMENTS FOR EOL LAOF

EOL continues support for deployment of observing facilities for education through NSF's Deployment Pool. On average, four to six educational deployments are approved by NSF per year, involving primarily the Center for Severe Weather Research's Doppler on Wheels (DOW) platforms.

In FY2014, the NSF Deployment Pool supported four educational deployments, which were carried out by NCAR, the Center for Severe Weather Research and the University of Wyoming. The projects were:

- The Hawaiian Education Radar Opportunity (HERO) - M. Bell, University of Hawaii - DOW
- NCAR Technical Internship Program (TIP) outreach - M. Daniels, NCAR - MISS, DOW
- Student Training in Airborne Research and Technology (START14) - M. Wetzel, Embry-Riddle Aeronautical University - UWY King Air
- The Plymouth State Meteorology DOW Project (PSUMET) - Sam Miller, Plymouth State University – DOW

INTERNSHIPS

In FY 2014, EOL once again offered undergraduate engineering students with interest in the atmospheric sciences an opportunity to participate in the EOL Summer Undergraduate Program in Engineering Research (SUPER) Internship. SUPER provides hands-on experience with atmospheric observing systems to students by teaming them with lead engineers. SUPER focuses on engineering problems directed at scientific advancement and EOL typically receives resumes from mechanical, electrical and computer, aerospace, optical, environmental, chemical, and industrial engineering students.

EOL hosted three SUPER interns in FY 2014. Julian Quick (Humboldt State University, environmental resources engineering) worked with EOL/RAF software engineer Chris Webster on live data monitoring via quality control metadata. Brandon Butterfield (Arizona State University, mechanical engineering) worked with EOL's Design and Fabrication Services manager and engineer Jim Ranson on a redesign of the automated Giant Nuclei Impactor system. Jose Diaz (University of Puerto Rico, electrical engineering) worked with EOL/RSF ASP postdoc Jorge Salazar on multilayer radome design and experimental characterization of scattering and propagation properties for atmospheric radar applications. Jose Diaz's work resulted in him submitting a paper, "Multilayer Radome Design and Experimental Characterization of Scattering and Propagation Properties for Atmosphere Radar Applications" to the 2015 AMS Annual Meeting.

In addition, Darin Baker, who was a SUPER intern in summer 2013, worked on an engineering capstone project at his home institution of Embry Riddle Aeronautical University, with EOL/RAF Associate Scientist Pavel Romashkin as his mentor.

EOL also held its Technical Internship Program during summer 2014 using remaining funds from the program's successful NCAR Diversity proposal. TIP hired Derek Higgins to be an aircraft mechanic intern, and when that internship term ended, he returned to us as a temporary mechanic.

Our SUPER and TIP internship programs provide solutions to EOL engineering and science support problems, while at the same time educating students on career opportunities of which they might not otherwise be aware.

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FRONTIER I

Improve observing capabilities for weather and climate phenomena with high socio-economic impact

AIRBORNE PHASED ARRAY RADAR (APAR)

EOL's highest new instrumentation development priority is the Airborne Phased Array Radar (APAR), a new and unique C-band airborne radar with dual-Doppler and dual-polarimetric capabilities designed for a large fuselage aircraft such as the NSF/NCAR C-130. After the decommission of the Electra Doppler Radar (ELDORA), the scientific community has strongly voiced the need for an airborne radar for studies of clouds over open ocean or other hard-to-access parts of the Earth. APAR is our response to that need. This frontier development takes advantage of significant in-house scientific and engineering expertise and is an exceptional opportunity for EOL to make significant contributions to a next-generation radar capability in collaboration with current and future development partners.

In FY 2014, EOL continued work to develop a novel APAR with dual-Doppler and polarimetric capabilities to be operational on the NSF/NCAR C-130 aircraft. APAR presents an opportunity to provide simultaneous measurements in kinematics, microphysics, water vapor and chemical species from aircraft, in time and space. The plan is to use four removable, flat C-band Active Electronically Scanned Arrays (AESAs) strategically placed on the fuselage, which requires some modest airframe modifications. The large surface area on fuselage permits a C-band radar with a beam width comparable to ELDORA. This design could also be adapted to other agencies' C-130s, including the US Air Force hurricane reconnaissance fleet. The potential to improve hurricane track and intensity forecasts by continuously assimilating APAR data from those reconnaissance missions into operational numerical models may provide even greater societal impacts for the general public beyond the benefits to be gained by the scientific research community.

As described in Imperative III, the APAR team worked in FY 2014 to develop, build up and test the APAR brick Transmit/Receiver (T/R) module. This included specifying, designing and implementing the field-programmable gate array (FPGA) controller and transmit/receive module firmware systems for the prototype. A novel approach allowed the transmit/receive firmware to be tested and verified on surrogate FPGA hardware even before the actual hardware was constructed.

Development of APAR requires substantial effort and resources and is a multi-disciplinary effort, requiring the skills of scientists, technicians, instrument makers, and mechanical, electrical, antenna, RF and software engineers. Input from the community is a critical part of APAR development and EOL will seek collaborative partners for it.

HIAPER CLOUD RADAR (HCR)

In FY 2014, EOL continued work on the HIAPER Cloud Radar (HCR). We implemented a steerable reflector for zenith to nadir operation; a real-time antenna stabilization for nadir-pointing observations; and an algorithm for antenna steering. We tested these and developed operation limits and procedures for HCR during the Instrument Development and Education in Airborne Science (IDEAS) IV program. The antenna pointing has a bias of 0.1 degree and the attitude correction error is approximately 0.05 degree. HCR can now be operated in nadir-pointing mode at a minimum altitude 10,000 ft Above Ground Level (AGL) and 4,000 ft AGL in attenuated mode. In FY 2014, the instrument achieved sensitivity of -37 dBZ at 1 km and also observed -29 dB linear depolarization ratio (LDR). HCR is also now temperature- controlled to ensure receive stability, and electromagnetic interference issues with the NSF/NCAR GV have been mitigated.

However, tests during IDEAS IV revealed suboptimal sealing of the instrument's pressure vessel. As a result, EOL designed and implemented an active pressurization system to provide supplemental pressure. Initial testing on the ground indicates that the radar will maintain needed pressurization levels for the full 10-hour flight duration of the NSF/NCAR GV.

The work completed in FY 2014 allows EOL to offer a fully-functioning, state-of-the art, airborne radar that can be flown on the NSF/NCAR GV to the NSF user community.

LROSE

In conjunction with the development of new remote sensors, EOL is leading a community effort to develop the next general radar and lidar analysis software suite. This suite adopts an open software framework to encourage and enable community

contribution in developing next-generation software, and is an effective way for software sharing. LROSE will replace the suite of legacy radar and lidar software that is mostly maintained by EOL.

For LROSE in FY 2014, EOL continued development of the new netCDF-based common radar and lidar data exchange format (CfRadial) and updating of Solo, the aging interactive editing software. We also partnered with the University of Hawaii to submit a proposal on LROSE to NSF in FY 2014 to accelerate the activity's progress. This proposal and the work leading up to it have allowed EOL to develop a clear roadmap on how to replace outdated software in an efficient manner.

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2014 Annual Report

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FRONTIER II

Provide new or significantly strengthened capabilities to support observational research in key areas where support needs are growing in importance

EOL's support of climate research has a deep history and we have much to offer in this realm; however, as needs and opportunities change, so is there motivation to change the nature of our support. The opportunities for global-scale observations provided now by HIAPER (e.g., during the HIPPO campaigns) are significant, and we see potential for longer-term observations through FRONT and CentNet. These build on EOL's history and experience in process studies, and we will continue to serve the needs of the climate community for such observations.

The weather forecasting and climate research communities also have a clear need to obtain improved measurements of water vapor, as accurate, high-resolution, continuous measurements of water vapor are a key observational gap. EOL's collaboration with Kevin Repasky (EOL Affiliate Scientist) of Montana State University (MSU) on the development of a Water Vapor Differential Absorption Lidar (WV DIAL) will help address this need. The WV DIAL will provide measurements of water vapor from the surface to 6 km and of aerosols to 12 km, and system will have a relatively low cost due to the use of commercial off-the-shelf components.

EOL, partnering with MSU will continue to upgrade the prototype low-cost, eye-safe diode laser-based micro-pulse WV DIAL to profile water vapor and aerosols in the lower troposphere. These upgrades will include design and implementation of a shared transmit- and receive-path telescope, as well as a shorter pulse to reduce the minimum range. EOL will also add an etalon filter to significantly reduce the background solar radiation and improve daytime performance. EOL and MSU are working together to enhance the system for operating in the field and for long periods of time that would be required for use in a field campaign.

This instrument will fill a national long-term observing facility gap and greatly benefit studies of micro- and meso-scale meteorology, water cycle, carbon cycle and, generally, biosphere-hydrosphere-atmosphere interaction research at weather and climate variability time scales. In FY 2014, the WV DIAL was tested in the field for 50 continuous days at the BAO tower during the FRAPPÉ experiment (see Imperative III). Extensive inter-comparisons were performed between radiosondes and other instrumentation (including an infrared radiometer). The instrument was shown capable of autonomous long term field operation under a broad set of atmospheric conditions.

UNMANNED AERIAL VEHICLE (UAV) WORKSHOP

Examples of UAVs

In summer 2014, EOL staff met with Prof. V. Ramanathan (Scripps Institute of Oceanography) and Prof. Mark Askelson (University of North Dakota), both of whom are experienced in UAV-based research and operations, to discuss whether and how EOL could most effectively contribute to Unmanned Aerial Vehicles (UAVs) and associated developing technologies in atmospheric observation. At issue was the future availability of UAV-based measurements and related services to prospective investigators as part of the NSF-AGS Lower Atmosphere Observing Facilities (LAOF) program. The discussions were robust and evolved around four main themes (1) UAV Platforms; (2) Science Priorities; (3) Instrumentation Emphasis; and (4) Data Issues. The group agreed that next steps should include on-site consultations and demonstration with several experienced platform operators, followed by a broad consultation with LAOF users at an open workshop, and EOL will be undertaking such steps in FY 2015

LASER AIR MOTION SYSTEM

EOL implemented, tested, and evaluated improvements to the Laser Air Motion System (LAMS) in FY 2014 during IDEAS IV. These test determined that some modifications to the placement of the beam "sweet spots" will be required for the best characterization of three-dimensional turbulence. A paper describing the use of LAMS for calibration of temperature and pressure was written and accepted for publication in FY 2014 (http://www.atmos-meas-tech.net/7/3215/2014/).

LAMS will allow wind velocity measurements using a continuous-wave laser that in undisturbed air is focused about 20 meters ahead of the NSF/NCAR GV, which should, for the first time, allow for measurements of turbulence in the air

unaffected by the presence of the aircraft. LAMS has already demonstrated a major capability to improve the calibration of temperature and pressure in the difficult flight environment. It may prove to be an alternative to calibrations using the cumbersome trailing cone technique.

NEW DATA INITIATIVES

EOL is participating in activities under NSF's EarthCube programs, a goal of which is "to transform research and data management practices within the geosciences community." EOL is working with partners both inside and outside of UCAR to a) enhance the role of real-time data within the geosciences through cloud hosting, and b) to use case studies to demonstrate how semantic web and linked data technology can play an essential role in the coordination and organization of scientific virtual organizations and their products, thereby accelerating the pace of scientific discovery and innovation. These efforts feed into the EarthCube community and will help inform the ongoing Initiative.

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FRONTIER III

Develop new capabilities that focus on processes at interfaces in the atmosphere

Understanding processes at interfaces continues to grow in importance and is prominent in many assessments of needs for the future. The air-sea interface, the air-land interface, and the tropopause have diverse observational needs, and there are many possible measurement tools and observational opportunities for these interfaces. These could include: controlled towed vehicles to extend the reach of research aircraft closer to the surface; ocean sensors like Airborne eXpendable BathyThermographs (AXBTs) for studies of the upper layer of the ocean; measurements of fluxes of trace gases to or from the lower surface (land or sea); new sensors on dropsondes for characterizing the chemistry of the tropopause region; the development of remote sensors that measure profiles of trace gases and for measurement of fluxes (e.g., via combining a DIAL with a Doppler lidar); and development of large arrays of sensors to increase coverage and resolution of measurements. Other areas with potential include using Unmanned Autonomous Systems (UASs) for boundary-layer studies, the remote measurement of 3-D wind, tethersonde capability to increase the altitude range of boundary layer measurements, and higher-response measurements from research aircraft to measure fluxes and probe the fine-scale structure of turbulence. To address some of these needs, EOL is developing CentNet and FRONT for greater boundary layer coverage through longer timeframes, broader areas, and complex terrain. Sensor simplification and miniaturization are leading to new opportunities in this area and FRONT will be an excellent testbed for these sensors (see Frontier IV).

There is also now broad recognition within the geosciences that the multi-scaled features characterizing landscapes present unique challenges that hinder progress in multiple fields connected to climate, air quality, atmospheric composition, surface hydrology, and ecology. To make scientific progress on these challenges requires measuring and modeling spatial gradients in state variables and their concomitant fluxes at unprecedented spatial scales.

A large network of ground-based sensors would help address these challenges and would facilitate research in the biogeosciences, hydrology, and urban meteorology, in addition to the mesoscale meteorological research traditionally supported by tower networks. EOL therefore is designing and prototyping CentNet, a network of up to 100 stations that can be deployed on spatial scales from 1 m to 100 km in support of surface exchange research and a wide variety of bio-geophysical field studies – more of this development is described in Imperative III. CentNet would allow direct research-quality measurements of all components of the surface energy and water budgets, complemented by measurements of key elements of the carbon budget. The CentNet system could also be used for both weather and climate process studies. This development builds on EOL's current Integrated Surface Flux System (ISFS), expanding it to include an array of semi-autonomous sensor stations that can be deployed in a variety of spatial patterns and for a wide range of time periods.

CentNet is designed to minimize set up and maintenance time, with Radio Frequency (RF) communications used as much as possible to reduce cabling, and two-way communication via the Internet for each station for real-time data display and control. The system is also designed to have the ability to cycle power on any sensor, e.g. one that is not reporting.

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FRONTIER IV

Develop new calibration and testing facilities, including testbed capabilities, for the community, either in collaboration with other agencies or specifically for NSF-supported research

FRONT

The most prominent test-bed development area in EOL is the Front Range Observational Network Testbed (FRONT), and in October 2013, the S-band Dual Polarization Doppler Radar (S-Pol) was relocated and set up at the Front Range Observational Network Testbed (FRONT) site in Firestone, CO. FRONT has substantial potential to serve community needs, as it integrates Colorado State University's (CSU) CHILL and EOL's S-Pol radar systems to streamline engineering development and operations for expanded science, research and education opportunities. FRONT will provide the scientific community with opportunities to conduct target-of-opportunity scientific field experiments; maintain a long-term mesoscale test bed for assessing instruments, data quality procedures, sensor integration, numerical models, networking capabilities and derived products; provide a framework for local field campaigns; and provide hands-on education. FRONT will be an easily accessible, cost-efficient, observational infrastructure for the collection of comprehensive data sets for hydro-meteorology, mesoscale meteorology, climate process studies, and for the advancement of technology.

FRONT's technical goals are to establish common system software, data formats and data processing environment; share common receiver and system control hardware; and remote-control both radars for unattended operations. With the radar's move to Firestone, EOL staff successfully designed new hardware and software, and implemented automated diagnostic and calibration procedures, that allow remote operation of S-Pol. Remote operations, including turning the transmitter on and off, can now be done from anywhere in the world with a better-than-DSL internet connection. This provides new operational flexibility and savings in staffing requirements.

This capability became fully operational in FY 2014, allowing scientists to completely control and monitor S-Pol over the Internet. Since February 2014, S-Pol has been remotely operated in two 20-hr projects (the Lower Atmosphere Thermodynamics & Turbulence Experiment (LATTE)) and Short Term Explicit Prediction (STEP) Hydromet experiment) and during the two-month, NSF-funded FRONT Demonstration Project (FRONT-DE). As part of FRONT-DE, graduate students from the University of North Carolina successfully operated S-Pol remotely from their home institution with guidance from EOL staff in Boulder, CO. University instructors across the US can take advantage of the educational opportunities that FRONT offers and provide hands-on learning experiences to students interested in observational research with little to no cost to their program. See Imperative II for further information on these projects.

CALIBRATION FACILITIES

Beyond the testbed capabilities of FRONT, there are also needs for calibration facilities for water vapor sensors; an environmental chamber with precise pressure and temperature control for testing instruments over a wide range of these parameters; and a wind tunnel test facility for aircraft inlets to which EOL would have access, perhaps operated by EOL. Associated with these needs, is the need for more attention to measurement science: calibration, uncertainty characterization, and documentation of instrument characteristics. In FY 2014, EOL investigated several possible environmental chambers and has plans to move forward with purchase and installation of a chamber in FY 2015.

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2014 HAO ANNUAL REPORT

- Director's Message
- Scientific Discovery & Innovation
- Developing Predictive Solar Capabilities & Understanding Their Impacts
- Community Modeling & Diagnostic Tool Development
- Observational Facilities & Data Service
- Research to Application
- Education & Outreach

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- HAO Strategic Plan
- NCAR Strategic Plan

PREVIOUS HAO REPORTS

Select year

Printer-friendly version

2014 HAO ANNUAL REPORT

TABLE OF CONTENTS

Director's Message ›

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DIRECTOR'S MESSAGE

Scott W. McIntosh, HAO Director

It is my pleasure to present the 2014 Annual Report of the High Altitude Observatory (HAO), the solar-terrestrial physics laboratory of the National Center for Atmospheric Research (NCAR). As an integral part of NCAR—through its research, leadership, and service to the community—HAO strives toward an understanding of the Earth's ongoing interaction with the Sun's atmosphere in which we are immersed.

HAO has a broad group of stakeholders: the National Science Foundation (NSF) and other government agencies; the world-wide solar-terrestrial physics community (including the solar physics, heliospheric physics, magnetospheric physics, and upper-atmospheric physics communities); higher education facilities; the rest of NCAR and UCAR; our own staff, visitors, and students; and the wider public. In support of these stakeholders, HAO has a number of goals: to perform world-leading science; to provide scientific leadership and facilities to the wider community; to support the education and training of early-career researchers; and to provide advocacy for solar-terrestrial physics, promoting its results, and articulating its societal importance.

A perennial strength of HAO lies in its broad program—conducting essential studies of solar radiative, particulate, and eruptive phenomena and their interaction with the terrestrial atmosphere. Our domain straddles the deep solar interior and the origins of heliospheric magnetism, through the Sun's photosphere and chromosphere, into the corona and interplanetary space, to the magnetosphere and the upper atmosphere of the Earth—more than 93 million miles of parameter space. This report showcases just some of the outstanding work that has been accomplished by our team over the past year in these areas and, while it is not intended to be comprehensive, it covers the spectrum of education, instrumentation, modeling, and observational efforts that we pursue.

Over the past year HAO has seen a transition in leadership. Following Michael Thompson's promotion to NCAR Deputy Director (and Chief Operating Officer) in October of 2013, Gang Lu took over as interim HAO director and continued in that role until the end of September 2014. Gang's selfless dedication, fairness, and wisdom in leadership and oversight of HAO during the directorial transition is appreciated by all and especially by me. Having been chosen as the ninth director of HAO, I can honestly say that it is truly an honor and a privilege, and I am greatly excited about the opportunities that we have ahead of us as we stride the path forward together.

Also over the reporting year, several colleagues have gained promotions: Roberto Casini was promoted to senior scientist; Qian Wu was promoted to project scientist IV (the first in HAO); Giuliana de Toma and Wenbin Wang were promoted to project scientist III; and Ben Berkey was promoted to Associate Scientist II. I pass on my sincere congratulations to each of these staff members in recognition of their effort and commitment to the Observatory, the Center, and to the broader community.

Sadly, it is also time to say farewell (for now) to Vic Tisone and Teresa Rivas. These two characters have been part of the HAO family for 46 and 39 years, respectively, and have contributed an immeasurable amount in all aspects of what we do. Both will be greatly missed around the halls (and around the lunch table), although they are welcome to visit any time that they want.

There are many landmark activities in the coming year, but two are very prominent in my eyes. Early in the new year we will revise our strategic plan with goals to push forward on scientific frontiers and to build even stronger connections between HAO and its sister laboratories within NCAR. More importantly, it is also a year where we celebrate our 75th birthday! We are planning a three-day symposium September 1–3, 2015, in which we will celebrate HAO's people, its considerable accomplishments, embrace its relationship with the U.S. solar-terrestrial community, and lay the foundations for our solar-terrestrial physics laboratory of the future. It promises to be a tremendous opportunity to renew old friendships and build new ones as we push for the century. I am already looking forward to providing an overview of our new strategic plan and the year's landmark festivity in next year's annual report.

Finally, I will add that the endeavors described herein would not have been possible without the tremendous effort put into the laboratory by our Administrative Team, Computer Systems Management Team, and others who unfalteringly work in service of the laboratory, center, and stakeholders.

‹ 2014 HAO Annual Report up Scientific Discovery & Innovation ›

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2014 HAO ANNUAL REPORT

- Director's Message
- Scientific Discovery & Innovation
  - The Dance of the Solar Dynamo
  - The Seasons of Space Weather
  - Ubiquitous Twist in the Solar Atmosphere and Its Release
  - Combining Ionospheric Observations for Better Measurement
  - Possible Evidence for (Alfvenic) Turbulence Onset in Coronal Loops
  - Understanding the Role of Tides in Sudden Stratospheric Warmings
- Developing Predictive Solar Capabilities & Understanding Their Impacts
- Community Modeling & Diagnostic Tool Development
- Observational Facilities & Data Service
- Research to Application
- Education & Outreach

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications

SCIENTIFIC DISCOVERY & INNOVATION

HAO conducts a comprehensive program of solar-terrestrial physics. This program encompasses the physics of the Sun, Heliosphere, and Geospace to that of the Earth's Magnetosphere, Ionosphere, Thermosphere, and upper atmosphere. Research in these areas areas is pursued using a combination of state-of-the-art numerical models, theoretical, and observational efforts that study the response of the terrestrial system to electro-magnetic, particulate, and impulsive phenomena.

The following are some of our scientific highlights from fiscal year 2014.

‹ Director's Message up The Dance of the Solar Dynamo ›

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HAO Strategic Plan

NCAR Strategic Plan

PREVIOUS HAO REPORTS

Select year

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THE DANCE OF THE SOLAR DYNAMO

Researchers have long known that the seething turbulence that lies below the visible surface of the Sun, known as “solar convection,” acts as a dynamo to beget magnetism and with it solar eruptive activity. New solar dynamo studies are illustrating how magnetic fields can have an equally profound influence on convection—reshaping the motions that sustain them.

Motions of the solar plasma act like colossal ocean currents, carrying warm plasma upward and cool plasma downward, and bringing the energy to the solar surface that makes the Sun shine. These convective currents also alter the rotation of the Sun, causing the equator to spin faster than the poles (25 vs. 35 days per rotation). This is the phenomenon of differential rotation, first discovered by the British astronomer Richard Carrington more than 150 years ago.

Convection, magnetism, and differential rotation in the Sun are intimately linked. Although solar physicists observe all three at the solar surface, we must rely on sound waves to reveal internal plasma flows, much as an ultrasound reveals the shadowy features of a baby before birth. Meanwhile, supercomputer simulations create virtual suns by solving the equations that govern plasma motions, providing a framework for interpretation of these observations. The difficulty lies in reconciling the vigorous convection that arises in simulations with observed flows.

In order to reproduce observations, simulations have historically had to either artificially reduce the solar luminosity or artificially increase the rotation rate of the Sun (which alters convection much as the Earth's rotation diverts air currents into swirling hurricanes). Recent research at HAO has demonstrated that a better representation of the third member of the triumvirate, magnetism, may solve the problem.

By achieving higher-resolution models with lower magnetic dissipation, Fan & Fang produced stronger magnetic fields than in previous models (Fig. 1). The differential rotation in the new models matched solar observations without the need to drastically reduce the solar luminosity artificially. The beneficial effects of magnetism were further clarified in distinct supercomputer models by Hotta, Rempel, and Yokoyama. By focusing on smaller domains without rotation and by focusing on time intervals short compared to the solar cycle, these models achieved even higher spatial resolution. The result was that the magnetic field on small scales possessed an energy that rivaled the energy contained in the convection itself. The overall conclusion? Magnetism essentially saps the vigor from convection, making it an equal partner in the dance of flows and fields that drives solar activity.

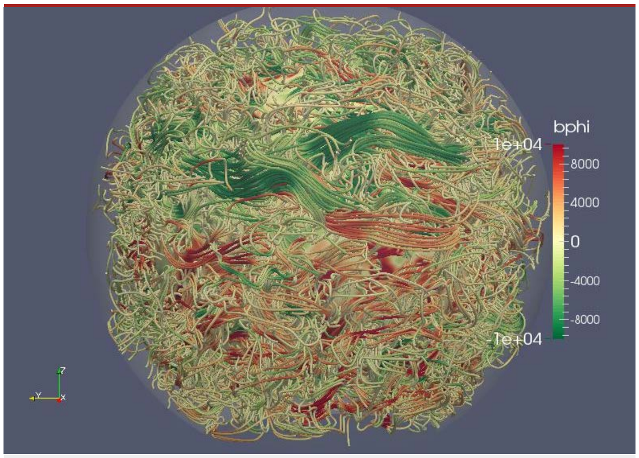

Figure 1. A snapshot of 3D magnetic field lines in the solar convective envelope, showing the emergence of strong coherent magnetic bundles

This work was supported by NASA grant No. NNX13AJ04A and base

funding.

among otherwise turbulent fields. From the solar convective dynamo simulation by Fan and Fang (2014).

‹ Scientific Discovery & Innovation up The Seasons of Space Weather ›

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THE SEASONS OF SPACE WEATHER

It has always been a “given” that the Sun’s eruptive, radiative, and particulate output are modulated by the evolution of the magnetic field inside the star. Solar magnetism displays a host of variational timescales of which the enigmatic 11-year sunspot cycle is the most prominent and best known. This research points now to a shorter timescale evolution of our star’s magnetism that has a strength that gets very close to that of the solar cycle. We have dubbed these shorter periods of strong solar variability the “seasons” of the solar atmosphere. Better understanding of this seasonal variability can help better predict space weather, which can have enormous impacts on life on Earth.

Recent observational work performed at HAO has demonstrated that the sunspot cycle can be explained in terms of the intra- and extra-hemispheric interaction of activity bands that belong to the 22-year magnetic polarity cycle (discussed in last year’s annual report). It was deduced that those activity bands are driven by the rotation of the Sun’s deep interior —its radiative zone—and that sunspots are a signature of its influence on the convective envelope and atmosphere above.

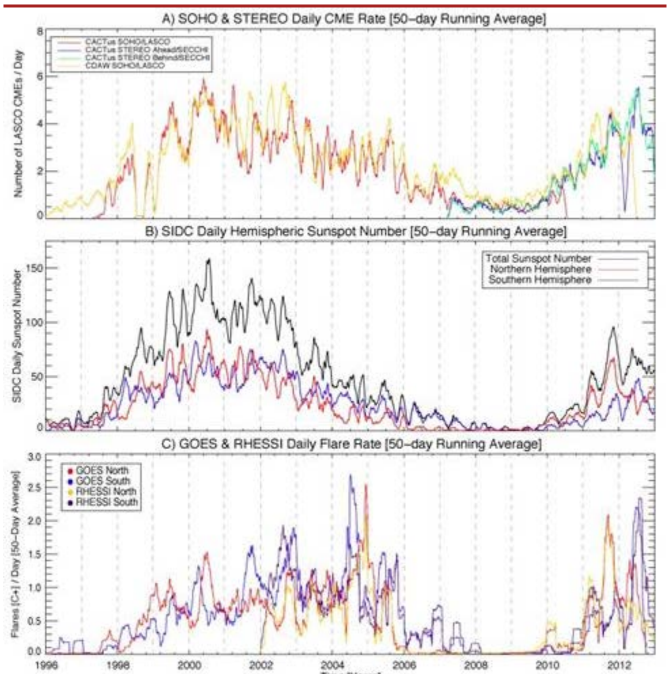

Figure 1. From top to bottom the daily the coronal mass ejection, sunspot and flare production rates over solar cycle 23 and into the start of solar cycle 24. In addition to the high frequency quasi-annual pattern - most easily seen in the hemispheric sunspot numbers and flare rates - the we see the “Gnevyshev Gap” or the time offset between the peak in flare activity and that of the sunspot number some three years earlier.

This work demonstrates that the interaction of the long-lived magnetic activity bands can naturally explain the “Gnevyshev Gap.” The gap is an observational phenomenon where the peak in the number of flares occurs *after* the peak in the sunspot number. This “gap” can range from months to several years (Fig. 1).

In addition to explaining the gap, the work presents a suite of observations (from energetic flares to the density of the solar wind) that strong quasi-annual variability—the period of the variability in each solar hemisphere peaks around 330 days. This short-term variability in solar output appears to be driven by surges of solar magnetism. Those surges appear to originate in the 22-year activity bands and drive magnetic field upwards through the Sun’s surface into the pre-existing structures (see “Ubiquitous Twist in the Solar Atmosphere and Its Release”). These forced changes in surface magnetism drive a strong variability in the number of flares and coronal mass ejections along with the radiative output of our star and in the particulate environment of the heliosphere. For example, over the course of a year the flare and CME rate can almost double and recede. It is expected that understanding the detailed interaction of the 22-year activity bands and the origin of the (quasi-periodic)

instability responsible for the seasons of space weather will considerably improve our ability to forecast the range of solar activity on the annual and decadal scale.

This work is supported by NSF award No. M0856145.

‹ The Dance of the Solar Dynamo up Ubiquitous Twist in the Solar Atmosphere and Its Release ›

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UBIQUITOUS TWIST IN THE SOLAR ATMOSPHERE AND ITS RELEASE

Understanding why magnetic fields play a crucial role in the formation and manifestation of solar eruptions is key to deeper understanding of something we can care about on earth—space weather. The relentless emergence of magnetic field from the Sun's interior created a constantly evolving hierarchy of structures and scales. One of the most abundant structures appear as columns of hot plasma, or jets, which occur when newly emerging magnetic flux interacts with pre-existing structures. The old and new magnetic environments intertwine and eventually reconfigure into one with the release of energy and ejection of the jet material occurring as result of the (forced) relaxation. The heating associated with the jets is often in excess of one million degrees Kelvin, and the ejecta can reach speeds well in excess of 100 km/s. The resulting hot mass flow associated with these jets has been suggested as a possible source of heated mass for the outer solar atmosphere and solar wind. Initial results from the Interface Region Imaging Spectrograph (IRIS) illustrate an abundance of these structures in magnetized regions of the solar atmosphere (Fig. 1).

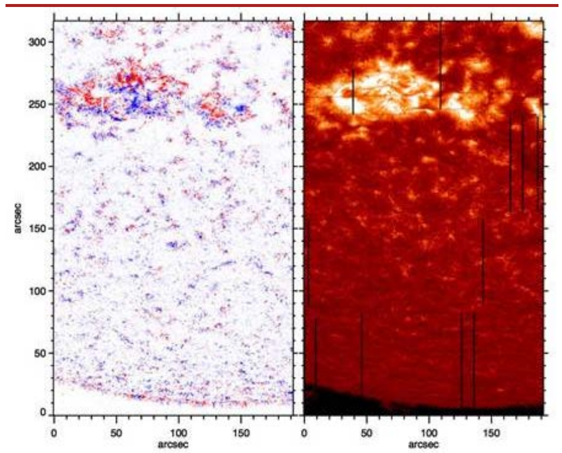

Figure 1. Full solar disk IRIS observations of the solar disk are used to demonstrate the ubiquity of twist in the upper chromosphere. Differencing high velocity components of the Mg II lines in the chromosphere (left) show a smattering of intermingled.

Those IRIS observations indicate that these small dynamic structures are twisted, or twisting. New magneto-hydrodynamic simulations of jet formation by magnetic flux interaction in an environment closer to solar conditions show violently outflowing jets that rotate very much like their observed counterparts (Fig. 2). It is found that the unleashing of the magnetic field twist after the magnetic collision and relaxation drives the spinning outflow in the jet column. The simulated jet (Fig. 2b) is comprised of "spires" of untwisting fields that are loaded with a mixture of cool and hot plasma and exhibit rotational motion of order 20 km/s (Fig. 2c), in good agreement with the observed characteristics of coronal jets.

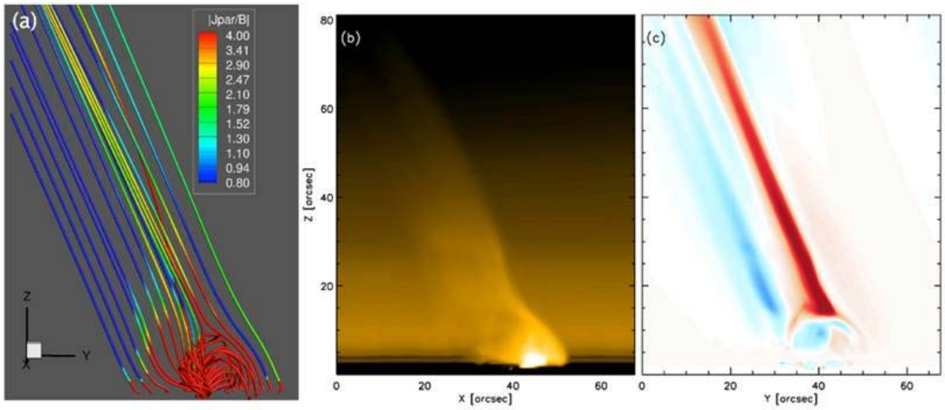

Figure 2. (a) 3D structure of the magnetic field lines with color showing the twist (b) Modeled synthetic emission in AIA 171Å channel. (c) Line of sight velocity representing the rotation of the jet.

This work is supported by NASA contract NNG09FA40C (IRIS). The simulations described here were carried out on the Yellowstone Supercomputer at NCAR and Stampede system in the Texas Advanced Computing Center (TACC) at the University of Texas at Austin.

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Select year

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COMBINING IONOSPHERIC OBSERVATIONS FOR BETTER MEASUREMENT

As the electrically charged particles of the solar wind flow toward the Earth and interact with the Earth's magnetic field, electric fields and currents are generated that extend down from space into the high-latitude ionosphere. The electric fields and currents are highly variable and have strong influences on space weather, affecting GPS signals, satellite communications, and the orbits of satellites and space junk. The international Super Dual Auroral Radar Network (SuperDARN) observes electric fields over large areas of the high-latitude ionosphere. The Active Magnetosphere and Planetary Electrodynamic Response Experiment (AMPERE) collects magnetic measurements from the 66 Iridium telecommunication satellites to infer the intensity and pattern of current flowing into the ionosphere. Each of these data sets is spatially incomplete, but by combining them with a model of ionospheric electric conductivity we can continually map out the electric fields and currents and the electrical heating they produce in the upper atmosphere. In order to do this accurately, new data-assimilation tools were developed by HAO scientists that optimally use knowledge from earlier analysis of the temporal and spatial variations of the fields and their relations with each other. These new tools will help us develop better monitoring techniques for these important sources of space weather.

This work was sponsored by NSF FESD grant AGS-1135466.

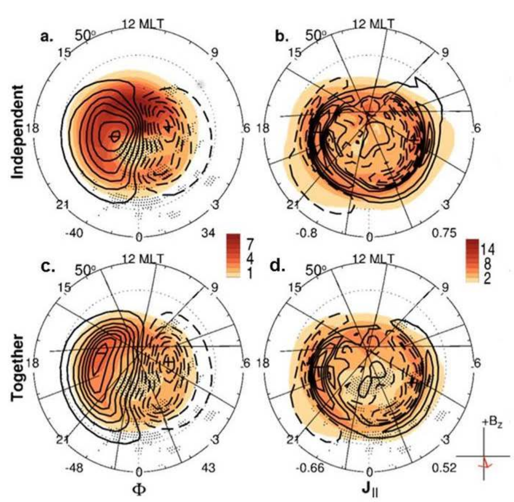

Figure 1. An example of the improvement obtained by using both data sets together. All quantities are shown at 7:45 GMT on 2011 November 29 over the polar ionosphere. The top row shows results when the data sets are used separately. Segment (a) shows the electric potential (or voltage), Φ, estimated from SuperDARN alone, while segment (b) shows the intensity of electric current flowing into the top of the ionosphere, J obtained from AMPERE. Contour

II

lines are used to indicate increasing intensity levels, with solid contours denoting positive potentials and currents, and dashed contours denoting negative potentials and currents. The background color indicates the amount of uncertainty in the estimates in both measurements, caused by areas with no measurements. The bottom row shows results when the two data sets are used jointly. The patterns of (c) potential and (d) current are somewhat modified, and the errors are reduced.

Source: Cousins, E.D.P., T. Matsuo, and A.D. Richmond, Mapping high-latitude ionospheric electrodynamics, submitted to Journal of Geophysical Research.

‹ Ubiquitous Twist in the Solar Atmosphere and Its Release up Possible Evidence for (Alfvenic) Turbulence Onset in Coronal Loops ›

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POSSIBLE EVIDENCE FOR (ALFVENIC) TURBULENCE ONSET IN CORONAL LOOPS

Over the last decade observations have revealed an abundance of waves, oscillations, and other (quasi-periodic) disturbances that travel through the solar atmosphere. Many of these observed waves and oscillations contain substantial amounts of energy—often comparable to the energy requirements of the quiet Sun corona and/or fast solar wind. However, the question of how this wave energy is released into the solar plasma remains a real mystery. Understanding the fate of these waves, and their impact on the solar atmosphere, can provide a clearer picture of how the light that bathes the Earth's atmosphere and impacts things like stratospheric ozone chemistry (for example) arises. In addition, investigations such as this can help us to build a physical picture of what drives the solar wind leading to considerably improved space weather forecasts.

Recent analysis of Coronal Multi-channel Polarimeter (CoMP) observations from the Mauna Loa Solar Observatory reveals tantalizing clues about how this wave dissipation process may work.

"Time-distance" analysis (Fig. 1) of the Doppler shifts along the outlined loop structure shows a "herringbone pattern," which indicates disturbances propagating up from both ends of the massive coronal loop. Doppler shift oscillations with a broad range of frequencies were found to propagate along the loop with speeds of about 500 km/s. An estimate of the energy contained in the waves (~350 erg cm^{-2} s^{-1}) is enough to power the quiet solar atmosphere and drive the solar wind.

Analysis of the power in the waves travelling up from both ends of the loop system shows that they are remarkably symmetric (the "chevron" pattern in Fig. 1C) except that the waves do NOT always appear to reach the other side of the loop (this would produce a complex crisscross pattern). A comparison of the loop footpoints and apexes revealed that there was an excess of high-frequency power in the latter (Fig. 1D). This high frequency power is far more than one might expect if the waves were running through the outer solar atmosphere without interacting. It is suggested that this signature is evidence of ("Alfvenic") turbulence in the corona as the oppositely directed waves near

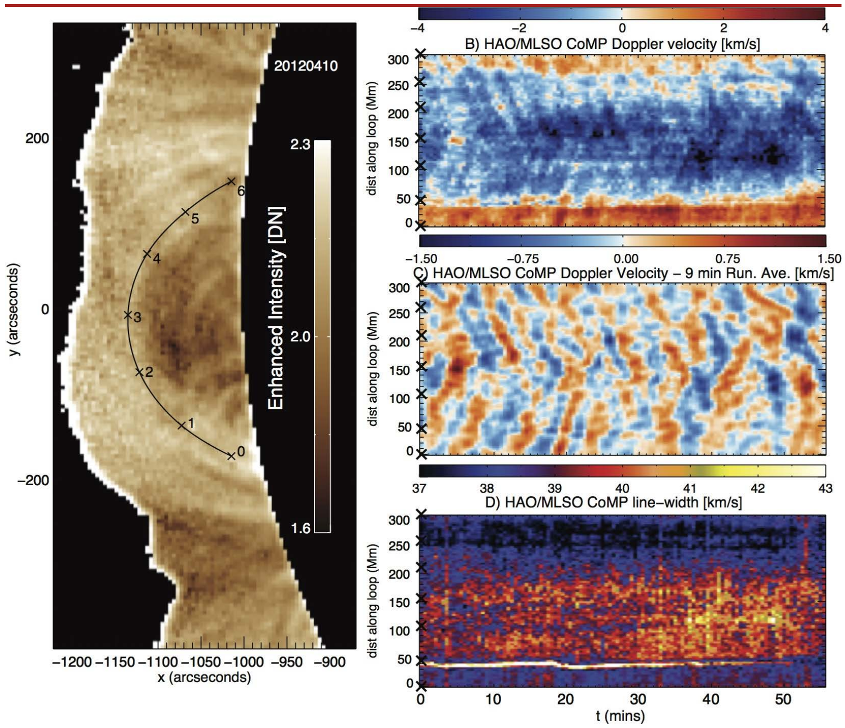

Figure 1. CoMP observations of transequatorial coronal loops (A). The Doppler shifts along the loop reveal a herringbone pattern of counter-propagating Alfvenic waves roaring through the corona at speeds in excess of 500km/s (B and C). Near the loop apex there is a notable increase in the broadening

the apex run into each other.

of the coronal emission lines that CoMP observes (D) and the Fourier power at high frequencies.

A further study of a large number of CoMP observations, conducted by graduate student Jiajia Liu, revealed that this phenomenon is present near the apex of most coronal loops. The behavior appears to depend on loop length and the wavelength of the observed oscillations. The relationship between the loop length, wavelength and enhanced apex wave power strengthens the assertion that (Alfvenic) turbulence is present in coronal loops.

Funding for this project was provided by the National Science Foundation and the European Commission Seventh Framework Programme (FP7/ 2007- 2013) under the grant agreement SOLSPANET (project No. 269299, www.solspanet.eu/solspanet).

‹ Combining Ionospheric Observations for Better Measurement | up | Understanding the Role of Tides in Sudden Stratospheric Warmings ›

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UNDERSTANDING THE ROLE OF TIDES IN SUDDEN STRATOSPHERIC WARMINGS

Sudden stratospheric warmings (SSWs) are dynamical disturbances in the high-latitude stratosphere during wintertime. SSWs are associated with significant changes in the high-latitude stratospheric zonal mean winds and temperatures. Though the dynamical disturbances during SSWs are most pronounced in the high-latitude stratosphere, recent observations and modeling results have demonstrated that SSWs can generate considerable variability in the low-latitude ionosphere.

Several mechanisms for producing the variability in the ionosphere have been proposed, including variability in the solar and lunar atmospheric tides. To assess the impact of the migrating semidiurnal lunar tide on the ionosphere response to SSWs, HAO postdoctoral scientist Nick Pedatella performed model simulations of the 2009 SSW by combining the NCAR Whole Atmosphere Community Climate Model eXtended version (WACCM-X) and the Thermosphere-Ionosphere- Mesosphere- Electrodynamics General Circulation Model (TIME-GCM) (Fig. 1).

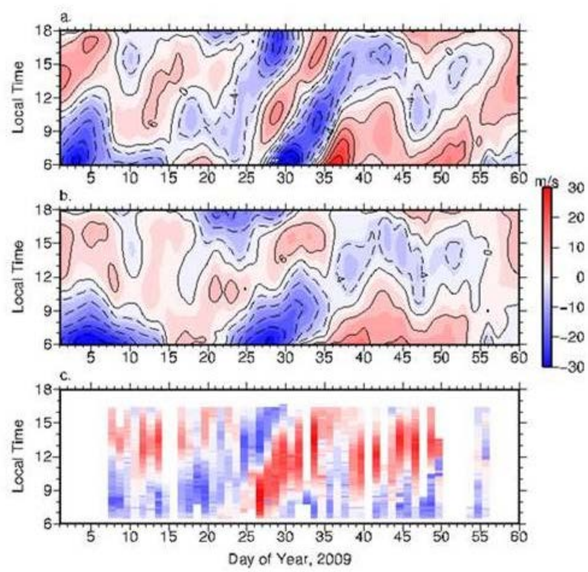

Figure 1. The top panel shows the effect of the SSW on the plasma drifts in a TIME-GCM simulation with lunar tides. The middle panel shows the lack of this effect in a TIME-GCM simulation without tides. As a reference, the bottom panel shows measurements of the plasma drifts obtained from Jicamarca Radio Observatory.

The simulations reveal notable enhancement effects of both solar and lunar tides during the SSW. The importance of the lunar-driven tides on the ionosphere variability during the 2009 SSW was demonstrated by comparing simulations with and without the lunar tides. The TIME-GCM simulations that incorporate the lunar tides were found to be in good agreement with Jicamarca Incoherent Scatter Radar vertical plasma drifts and Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) observations of the ionospheric electron density. The agreement with observations is worse if the lunar tide is not included in the simulations, demonstrating that it is an important contributor to the ionosphere variability during this SSW event likely during other SSWs.

The sources of the ionospheric electron density variability during the 2009 SSW were also investigated. It was found that the primary driver of the electron density variability is changes in electric fields, with additional contributions from changes in thermospheric neutral winds and composition. The electron density variability during the 2009 SSW is therefore not solely due to variability in electric fields as previously thought.

This work was supported by the following grants: NSF/AGS 1138784, NSF/ATM 0836386, NASA 08AQ916, NASA 09AN576, and NASA NNX09AJ83G.

‹ Possible Evidence for (Alfvenic) Turbulence Onset in Coronal Loops up Developing Predictive Solar Capabilities & Understanding Their Impacts ›

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DEVELOPING PREDICTIVE SOLAR CAPABILITIES & UNDERSTANDING THEIR IMPACTS

One of HAO's key activities is to develop an understanding of solar phenomena to the point where forecast skill and predictive capability can be realized. We study how a broad range of these phenomena—from electromagnetic radiation that is continuously emitted by the Sun, to the energetic particles in the solar wind, and the large eruptive events like flares and CMEs—impact the Earth. Understanding the state of the solar and terrestrial atmospheres will ultimately allow us to forecast how these "space weather" phenomena impact the Earth and how the Earth responds on scales of minutes to centuries.

‹ Understanding the Role of Tides in Sudden Stratospheric Warmings | up | Record Lows in the Outer Atmosphere and Ionosphere ›

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RECORD LOWS IN THE OUTER ATMOSPHERE AND IONOSPHERE

The solar cycle minimum period during 2008–2009 was the longest and quietest such period since the advent of space-based measurements, and probably the longest and quietest in a century. Additionally, the first half of the following solar cycle, starting in 2010, has also been the weakest the early 1900s. During 2008–2009, the temperature and density of the outer atmosphere were lower than during previous solar cycle minima, and the lowest they have been during the space age. This was caused by a reduction in solar extreme-ultraviolet irradiance (EUV), with lower geomagnetic activity and cooling from increased carbon dioxide levels also playing a role. Similar effects were observed in the ionosphere, with measurements showing that the ionosphere was unusually low in density, and the altitude of its peak also decreased. Model simulations of the outer atmosphere and ionosphere conducted by HAO scientists (Stan Solomon, Liying Qian, and Alan Burns*) demonstrated good agreement with observations of the atmospheric density at 400 km altitude throughout the solar cycle. Comparison of the ion density from these simulations with ionospheric measurements also showed consistent agreement. The global average peak ionospheric density was estimated to have declined by about 15 percent from the solar cycle minimum period in 1996 to the solar cycle minimum in 2008–2009 (Fig. 1). These changes on the Sun could be indicative of an extended period of lower-than-usual activity, or they could be confined to a single cycle, but in either event they have important effects on the ionosphere and on near-Earth space.

Funding for this work was sponsored by NASA SR&T NNX10AF21G.

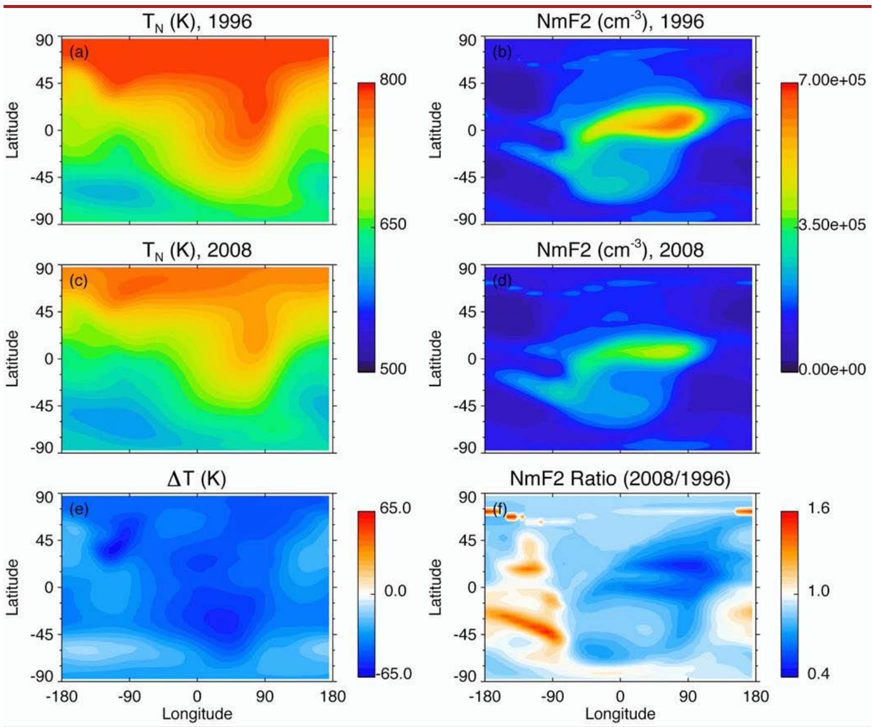

Figure 1. Thermospheric temperature and density modeled by the NCAR TIE GCM for 1996 and 2008, on June 30. (a) Model temperature at 400 km altitude for 1996. (b) Model peak electron density of the F2 region NmF2 for 1996. (c) Model temperature at 400 km for 2008. (d) Model NmF2 for 2008. (e) Temperature difference, 2008-1996. (f) NmF2 ratio, 2008/1996.

*Solomon, S. C., L. Qian, and A. G. Burns (2013), The anomalous ionosphere between solar cycles 23 and 24, J. Geophys. Res. Space Physics, 118, 6524–6535, doi:10.1002/jgra.50561.

‹ Developing Predictive Solar Capabilities & Understanding Their Impacts   up   Data Assimilation ›

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DATA ASSIMILATION

Being able to predict the impact of a single storm is important, but it is also important to predict when we are in for a particularly stormy season. This is true for hurricanes, and it is also true for solar storms. In the case of the sun, the number of storms is directly connected to the number of sunspots – which we know varies with a roughly eleven-year cycle. The trouble is that the sun sometimes surprises us – as in the case of the last solar cycle which ended up lasting nearly 13 years. Not only is it difficult to predict exactly when solar activity will reach a maximum, but it is also a challenge to predict just how active a maximum is likely to be.

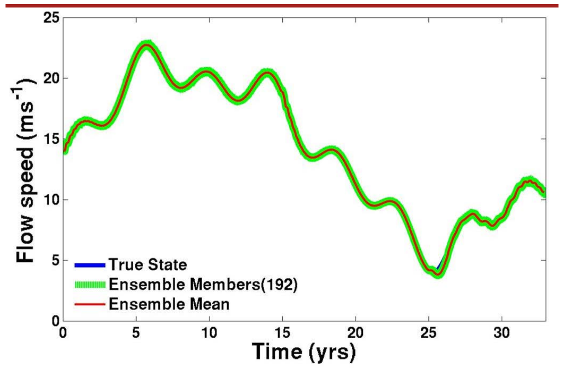

Figure 1. An optimum reconstruction of time-variation in meridional flow-speed by employing Ensemble Kalman Filter (EnKF) data assimilation method for 180 magnetic field observations. Green curves denote 192 reconstructed flow-speeds for 192 ensemble members and red curve denotes the ensemble mean; note that the true flow-speed, plotted in blue, is invisible because it is hidden behind the red and green curves.

A necessary step in improving our predictive ability is to combine observations with a physical model of the solar cycle. Just how to do this is a problem unto itself, and leads us to the realm of data assimilation. Data assimilation is a means by which models incorporate observations to improve forecasting, and is widely used in meteorological and climate studies.

Recent work by HAO scientist M. Dikpati and CISL scientist J. Anderson used data assimilation to examine several questions at the heart of solar cycle prediction, including the number and type of observations needed to constrain the problem, and the implications of using incorrect model ingredients.

By specifying a test pattern of large-scale flow within the sun (the meridional circulation), the authors created a time series of synthetic observations of solar magnetic fields in accordance with these flows. They then ran a set, or ensemble, of models that each started from an initial guess for the flow and sequentially updated the guess to yield magnetic fields that better matched the synthetic observations. They found optimal values for the size of the ensemble and the number of observations required, for which the correct characteristics of the model-ingredient were reproduced (Figure 1).

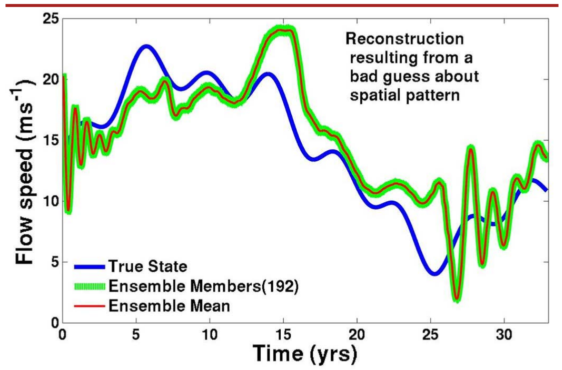

Figure 2. Reconstructed time variation in meridional flow-speed for an incorrect assumption about the spatial structure of the flow. The poorer reconstruction in this case compared to that in Figure 1 demonstrates the power of this method in deriving accurate spatio-temporal variations of the Sun's meridional flow.

However, for an inaccurate initial guess of model ingredients (two-celled instead of one-celled meridional circulation flow), the reconstruction was not nearly as good (Figure 2). This result motivates future work that would incorporate flows that vary in time as well as in space. The ultimate goal is to determine how well the assimilation of real solar observations into models could help improve forecasts of solar activity.

This work is supported by NSF award No. M0856145 and NASA LWS No. NNX08AQ34G.

‹ Record Lows in the Outer Atmosphere and Ionosphere | up | Community Modeling & Diagnostic Tool Development ›

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COMMUNITY MODELING & DIAGNOSTIC TOOL DEVELOPMENT

One of the cornerstones of HAO's activities lies in the development and support for a series of numerical models that are freely available to the broad research community. Among the models supported are the Thermosphere-Ionosphere-Electrodynamic General Circulation Model (TIE-GCM), the Coupled Magnetosphere Ionosphere Thermosphere Model (CMIT), and the Extended Whole Atmosphere Community Climate Model (WACCM-X). HAO's staff support these models and welcome the community to collaborate on research projects, participate in development, or use them in independent research. This year's report will update you on improvements to our existing complement of models, introduce you to FORWARD (a coronal modeling and analysis package), and provide an update on the Community Spectropolarimetry Analysis Center (CSAC).

‹ Data Assimilation up Moving FORWARD! ›

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MOVING FORWARD!

New data, like those from HAO's Coronal Multichannel Polarimeter(CoMP), take some getting used to. For the first time we are able to obtain daily observations that measure the effects of magnetism on the solar atmosphere, giving us insight into where built-up magnetic energy is likely to burst forth in a Coronal Mass Ejection (CME). However, our actual measurements depend in rather complicated ways upon how the magnetized plasma is distributed in the solar atmosphere. At first viewing, CoMP linear polarization data may appear like so many dark splotches (Fig. 1, right-hand image). This is why **forward modeling** is so valuable—it allows us to see what we expect to observe given a model of the 3D distribution of magnetized coronal plasma (Fig. 1, left-hand image).

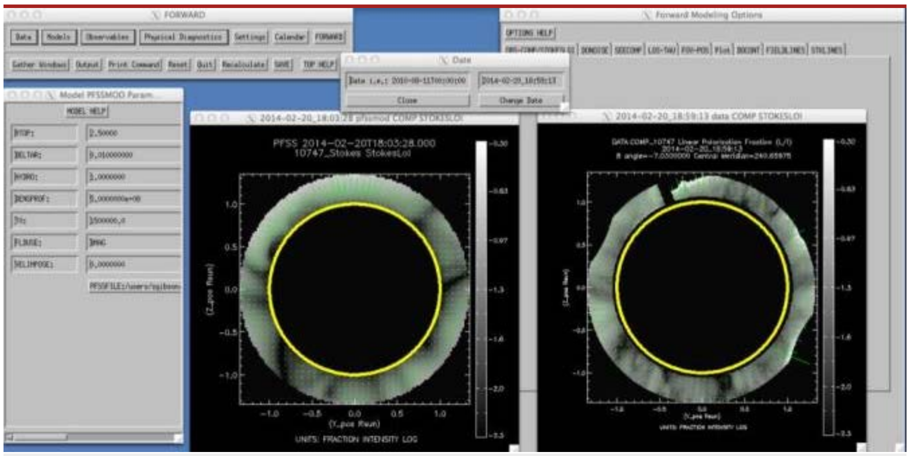

Figure 1: A screen capture of the FORWARD widget interface. The user can access online data as well as magnetic models of the solar corona and compare observations and the same quantity synthesized from the model. Shown here are linear polarization data from the CoMP telescope (right), and synthetic data from a potential field source surface model of the coronal magnetic field for the same day (left). Differences between model and data indicate the presence of stored magnetic energy.

Enter the ***FORWARD*** codes—a suite of *SolarSoft* IDL software designed as a community resource for model-data comparison, with a particular emphasis on analyzing coronal magnetic fields. *FORWARD* enables "forward-fitting" of specific observations and helps to build intuition into how the physical properties of coronal magnetic structures translate to observable properties.

FORWARD continues to grow. Originally developed by a team led by HAO scientist S. Gibson, over the years more than a dozen community scientists have contributed modules that enable the reproduction of solar observations at wavelengths ranging from radio to soft X-ray. *FORWARD* interfaces with the *CLE* Fortran polarimetry code of HAO scientists P. Judge & R. Casini, allowing the reproduction of CoMP-type data, and with other community SolarSoft IDL software such as the *CHIANTI* atomic database for spectroscopy (E. Landi, Univ. Michigan) and the Potential Field Source Surface model (M. De Rosa, LMSAL). Both analytic and numerical models can be employed; the widely used *Predictive Science Inc.* coronal magnetohydrodynamic simulations can be accessed automatically by date. Finally, FORWARD connects to the *Virtual Solar Observatory* and other web-served observations to download data in a format directly comparable to model predictions.

FORWARD is gaining in popularity, particularly with students. In the past twelve months, three graduate students have visited HAO with the express purpose of using *FORWARD* in their thesis work, and several others have been in communication with Gibson via email. The students have begun to write their own modules and adaptations of *FORWARD*, so its development continues!

This project is supported by the International Space Science Institute (ISSI) and base funds.

‹ Community Modeling & Diagnostic Tool Development | up | New Capabilities Added to Community Models ›

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NEW CAPABILITIES ADDED TO COMMUNITY MODELS

Throughout this year HAO staff has continued to develop and encourage community utilization of several numerical models that are freely available for use by members of the scientific community. The Thermosphere-Ionosphere-Electrodynamic General Circulation Model (TIE-GCM), the Coupled Magnetosphere-Ionosphere- Thermosphere Model (CMIT), and the Extended Whole Atmosphere Community Climate Model (WACCM-X) are the three primary models supported by HAO. The upper atmosphere TIE-GCM and related models allow scientists to model the interactions between the mesosphere, ionosphere, and thermosphere. CMIT couples the TIE-GCM to the Lyon-Fedder-Mobarry (LFM) magnetohydrodynamic model of the Earth’s magnetosphere, allowing investigations of the coupling between the magnetosphere and ionosphere. The WACCM-X model is an extension of the WACCM model and is part of the Community Earth Model (CESM) framework that allows for studies of the lower and upper atmospheres. HAO scientific and software engineering staff remains committed to allowing the community to collaborate in model development, collaborate on research studies, or to conduct independent research.

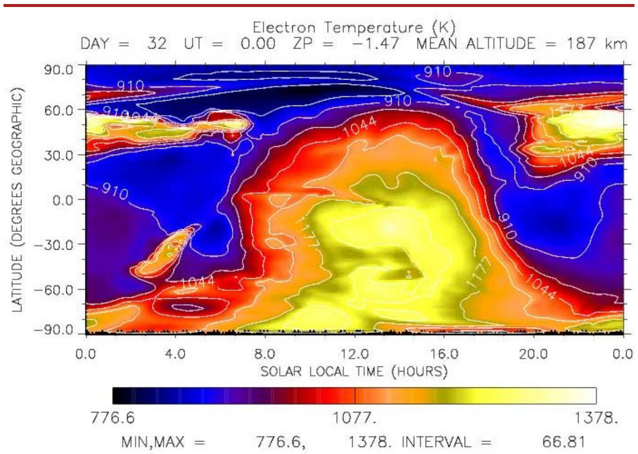

Figure 1. Electron temperature on February 1 from a WACCM-X simulation.

As a part of the WACCM-X ionosphere development, HAO staff has developed and tested a module to calculate the vertical component of O+ transport in the F region, as well as a module to solve the time-dependent electron and ion temperatures (Fig. 1). The test has been conducted in a column physics setting, so that well-controlled comparisons could be made with TIE-GCM results. Both modules have been integrated in WACCM-X, and extensive simulations have been made. This will soon be incorporated into the CESM model and released to the community as a functional capability.

Additional work has been done to test coupling framework between the WACCM-X model and the TIME3D plasmasphere model developed by Dr. Zhinpeng Ren of the Chinese Academy of Sciences. This framework has been designed to easily accommodate other plasmasphere models to foster collaborations with other members of the scientific community. HAO staff has also done work to support running WACCM at 25-km resolution, a factor of 8 times higher than typical, to further studies of coupling between the lower and upper atmosphere.

Over the past year development of the TIE-GCM model has advanced significantly. As a result of collaboration with Dr. Eric Sutton at the Air Force Research Laboratory (AFRL) two additional species, argon and helium were added to the TIE-GCM. The addition of helium was major since it could not be treated as tracer gas in the TIE-GCM framework. This capability has been added to the code repository and will be available to entire TIE-GCM user community with the next release of the model. HAO software engineering staff has also been working on improving the computational core of the model. This includes supporting model runs 2.5° x 2.5° mode with a parallel electric dynamo calculation. As Fig. 2 shows, the inclusion of the parallel electric dynamo increases computational performance by a factor of two across a broad range of processor counts. The work on the parallel dynamo has been done in a very modular fashion so that this technology can be transferred into the WACCM-X model.

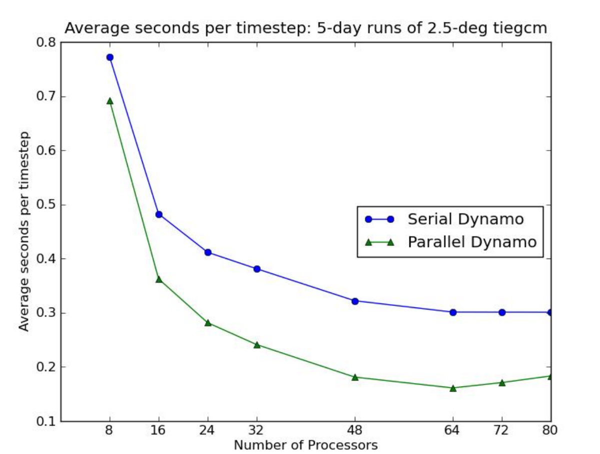

Figure 2. The parallel dynamo (green line) results in significantly faster computation times than the serial dynamo (blue line) across a broad range of processor counts.

A major focus of work with the CMIT model has been to develop tools to facilitate investigations that involve mass coupling between the magnetosphere and ionosphere. In collaboration with Dartmouth graduate student Sheng Xi a new framework for more robust boundary condition coupling at the inner edge of the magnetospheric domain was developed and is being incorporated into the model repository. Additionally, we are now testing multi-fluid extensions of the LFM magnetosphere model, and it is expected that this version will become the new baseline for all future CMIT studies.

A growing pathway for community utilization of our models is through our collaboration with NASA's Community Coordinated Modeling Center (CCMC). HAO provided CCMC with updates to both the TIE-GCM and CMIT models and supported users' investigations with these models. Well over 300 model runs have been completed at the CCMC. In addition, HAO scientists participated in several inter-model metric studies lead by the CCMC with broad participation by the scientific community.

This work was supported by base funds and the following grants:

NSF AGS 1335432/UNH 12-033 (sub-award from the University of New Hampshire), NSF AGS 1400985, NSF AGS 1138784, NSF AGS1135446 (sub-award from CU 1548648), NASA NNH12AU10I, NASA NNX09AJ83G (in collaboration with ACD), NASA NNXX12AD26G (sub-award from CU 1549222).

‹ Moving FORWARD! up The Community Spectropolarimetric Analysis Center ›

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- Developing Predictive Solar Capabilities & Understanding Their Impacts
- Community Modeling & Diagnostic Tool Development
  - Moving FORWARD!
  - New Capabilities Added to Community Models
  - The Community Spectropolarimetric Analysis Center
- Observational Facilities & Data Service
- Research to Application
- Education & Outreach

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
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STRATEGIC PLANS

- HAO Strategic Plan
- NCAR Strategic Plan

PREVIOUS HAO REPORTS

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THE COMMUNITY SPECTROPOLARIMETRIC ANALYSIS CENTER

The Community Spectropolarimetric Analysis Center (CSAC) has its roots in HAO's rich heritage in the remote sensing of magnetic fields in the Sun's atmosphere—the field of spectropolarimetry.

CSAC provides a centralized access point for all polarization data and derived products that are produced by instruments built with HAO participation. CSAC is also home to a comprehensive collection of diagnostic tools for the manipulation, calibration, and analysis of spectropolarimetric data. The well-documented analysis methods available cover data reduction, spectral line inversion, magnetic field disambiguation, and data visualization.

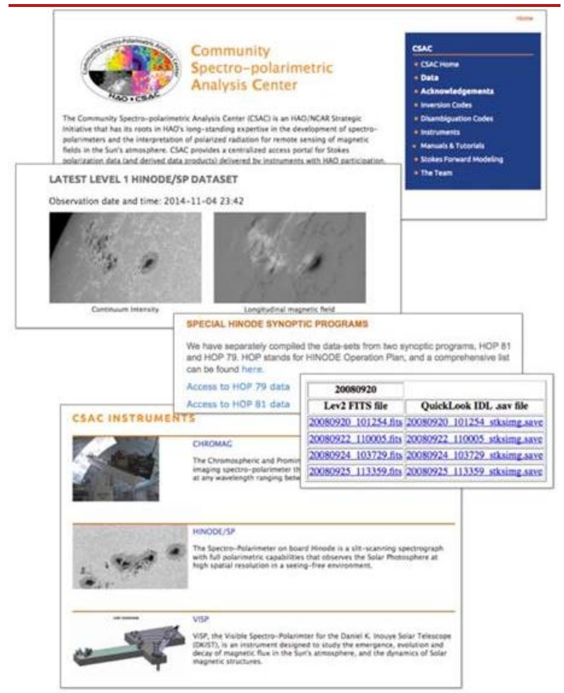

Figure 1. Snapshots of the new CSAC website illustrating some of the features incorporated from data service to data visualization.

The CSAC website—our main interface with the community (Fig. 1)—is being redeveloped to accommodate the data streams of instruments that are scheduled to come online in the near future, such as the Chromospheric Magnetograph (ChroMag) and the Visual SpectroPolarimeter (ViSP) of National Solar Observatory's Daniel K. Inouye Solar Telescope (DKIST).

CSAC, in partnership with colleagues at the National Solar Observatory, will lead the national effort in the interpretation of polarized radiation from the Sun's chromosphere—the crucial interface between the Sun's surface and its outer atmosphere. Capturing the magnetic field characteristics and dynamics of the chromosphere has become a cornerstone of our community and places a heavy burden on the success of the next generation of solar polarimeters and diagnostic tools.

To complement its research efforts, the CSAC team is also investing effort to develop a training program for the next generation of solar physicists in the detection and understanding of polarized radiation. By mentoring graduate students and postdocs in house, organizing community polarization workshops, and by creating/participating in undergraduate/graduate materials in partnership with universities around the country, we hope to broaden the accessibility of spectropolarimetric data.

This work is supported by NSF award No. M0856145. Data available through this interface are supported by multiple sponsors, including NASA and Lockheed.

‹ New Capabilities Added to Community Models   up   Observational Facilities & Data Service ›

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OBSERVATIONAL FACILITIES & DATA SERVICE

Observations and observationally driven science are central to the vision and mission of HAO, as is the delivery and utility of products from those observations. To this end, HAO maintains the Mauna Loa Solar Observatory (MLSO) on Hawaii and a network of Fabry-Perot Interferometers (FPI), which provide daily information on the state of the solar atmosphere and Earth's upper atmosphere, respectively. Over the last year, several upgrades have been made to the MLSO, and new nodes have been added to the FPI network and are highlighted in this report, in addition to observationally driven research from sources outside of HAO.

‹ The Community Spectropolarimetric Analysis Center | up | The COSMO Chromospheric Magnetograph (ChroMag) Progress ›

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THE COSMO CHROMOSPHERIC MAGNETOGRAPH (CHROMAG) PROGRESS

The solar chromosphere is a complex and poorly understood part of the solar atmosphere that is integral to the mass and energy balance of the outer solar atmosphere, particularly as it relates to the energetic events and processes collectively known as space weather. Magnetism is key, yet we lack instrumentation to accurately diagnose magnetic field in the solar chromosphere in a synoptic fashion. The ChroMag instrument was conceived to provide the community with regular observations of the chromospheric magnetic field.

Testing in the summer of 2013 revealed several design issues with the prototype. The instrument consequently underwent a significant redesign this year. ChroMag was deployed to the NCAR Mesa Lab spar late in the summer of 2014, where testing revealed that the design issues had been mitigated. The instrument will undergo further testing and commissioning this winter at the Mesa Lab spar. We plan to conduct high-resolution observations with the instrument at the Dunn Solar Telescope of the National Solar Observatory and the New Solar Telescope at the Big Bear Solar Observatory before installing the prototype at the Mauna Loa Solar Observatory (MLSO) in late summer 2015.

With the instrument approaching operational status at MLSO, we are turning our attention toward data handling, reduction, and interpretation. The instrument will produce data at a rate of about 300 GB/hour, and we expect a total data volume of about 1 TB/day. Current network bandwidth at MLSO is inadequate to transfer all data. High-priority data will be transferred over the network, while lower priority data will be transferred to HAO by shipped hard disks. The ChroMag data will be archived on the NCAR High-Performance Storage System. While several diagnostic codes and analysis techniques exist that will be readily applicable, the interpretation of ChroMag data requires a significant effort in theory, modeling, and code development and will be large focus of the Community Spectropolarimetric Analysis Center (CSAC) moving forward.

This work is supported by NSF award No. M0856145.

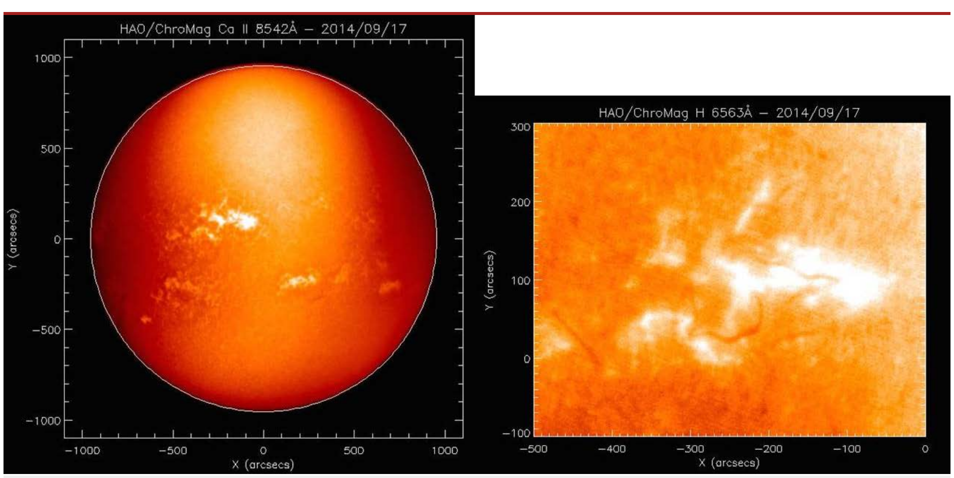

Figure 1. (left) ChroMag first light image in the chromospheric H-alpha line at 656.3 nm. Active regions are visible as brighter areas while the filaments are dark lanes (right).

‹ Observational Facilities & Data Service up Global-Scale Observations of Limb and Disk Mission ›

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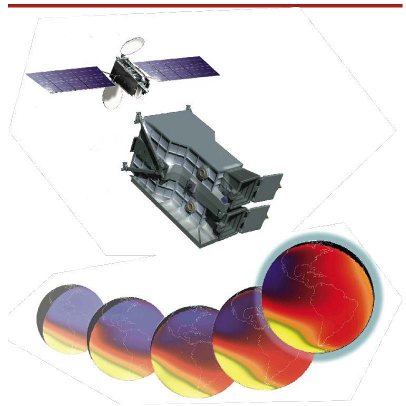
GLOBAL-SCALE OBSERVATIONS OF LIMB AND DISK MISSION

The Global-scale Observations of the Limb and Disk (GOLD) is a NASA-funded mission of opportunity that is designed to study how the "weather" of the Thermosphere-Ionosphere system responds to external forcing from the Sun and the lower atmosphere. HAO staff members are playing a significant role in this mission. Dr. Alan Burns is the Project Scientist and Drs. Art Richmond and Stan Solomon are Co-Investigators. All three investigators are tasked with developing simulations to aid in instrument design and development and addressing GOLD's science goals once the instrument is in orbit.



The Earth's thermosphere and ionosphere is a region on the edge of space that constitutes a dynamic system that varies rapidly in response to these energy inputs from above and below, as plasma and fluid processes compete to control its temperature, composition, and structure. It is where energetic radiation from the Sun and charged particles from the magnetosphere are absorbed, and where waves propagating from the lower atmosphere finally dissipate. Determining how the thermosphere-ionosphere (T-I) system responds to these drivers on a global scale is essential to our physical understanding of coupling between the space environment and the Earth's atmosphere.

GOLD is an imaging Far Ultra Violet (FUV) spectrometer that will fly on board a commercial communication satellite in geostationary orbit as a hosted payload. GOLD will measure FUV emissions to provide disk images on the neutral composition and temperatures at about 150 km above the Earth's surface during the day and O^+ densities near at night. Stellar occultations will be used to measure O_2 profiles on the limb.

The GOLD mission is framed by four science questions: how do geomagnetic storms alter the temperature and composition structure of the thermosphere; what is the global-scale response of the thermosphere to solar extreme-ultraviolet variability; how significant are the effects of atmospheric waves and tides propagating from below on the thermospheric temperature structure; and how does the nighttime equatorial ionosphere influence the formation and evolution of equatorial plasma density irregularities?

The mission is currently in Phase B, having passed its System Readiness Review in January and is heading for its Preliminary Design Review in December.

GOLD is funded under NASA contract NNG12PQ28C to the University of Central Florida.

‹ The COSMO Chromospheric Magnetograph (ChroMag) Progress | up | Expansion of the NCAR Upper Atmosphere Observations ›

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EXPANSION OF THE NCAR UPPER ATMOSPHERE OBSERVATIONS

While NCAR HAO is using a variety of models to study the mesosphere and thermosphere, it is important to have observational results to validate these simulations. At the same time, observations can often lead to new discoveries, requiring more modeling investigations. NCAR HAO operates optical remote sensing Fabry-Perot interferometers (FPI) to measure nighttime mesospheric and thermospheric winds. These observations are supported by National Science Foundation Regular/CORE funding contract No. M0856145.

Over the years, the FPI observations expanded from a single station in northern Canada to mid and lower latitudes. In February 2014, in collaboration with the Korean Polar Research Institute under grant No. HAO11518, an FPI was deployed at a new Korean Antarctic station called Jang Bogo (74.6S, 164.2E) (Fig. 1, left). This station, with magnetic latitude close to 80 degrees, is ideally located to monitor geomagnetic substorm activities inside the polar cap. Moreover, this new station complements the existing northern polar cap station in Canada because FPI operates only during long polar winter nights. The Canadian station operates from October to March, while Jang Bogo operates from April to September. Thus the two stations can provide polar cap coverage throughout the year.

HAO is also expanding its northern polar cap observations to Eureka, Canada (80N, 86W), in collaboration with University of New Brunswick, to measure thermospheric winds (Fig. 1, right). The Eureka observatory further enhances the existing NCAR capability inside the polar cap and allows us to examine thermosphere structure inside the polar region. The thermospheric responses to the geomagnetic substorm inside the polar cap can have a profound impact on the ionosphere and thermosphere from the high to mid latitudes. The polar region is usually the first impacted by the geomagnetic activity because the geomagnetic field lines from this region are directly connected to the magnetosphere with the solar wind from the sun. The HAO observation network will further support the science objectives of NCAR to understand the solar impact on the terrestrial environment.

Figure 1. Jang Bogo Fabry-Perot interferometer Sky Scanner with Mt. Melbourne near Terra Nova Bay in Victoria Land of Antarctica (left). The sky scanner is a rotating mirror system, which allows the instrument to point any direction in the sky. Eureka Station in northern Canada is shown on the right.

‹ Global-Scale Observations of Limb and Disk up MLSO Upgrades and Data ›

Mission

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2014 Annual Report

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Search
Search

2014 HAO ANNUAL REPORT

- Director's Message
- Scientific Discovery & Innovation
- Developing Predictive Solar Capabilities & Understanding Their Impacts
- Community Modeling & Diagnostic Tool Development
- Observational Facilities & Data Service
  - The COSMO Chromospheric Magnetograph (ChroMag) Progress
  - Global-Scale Observations of Limb and Disk Mission
  - Expansion of the NCAR Upper Atmosphere Observations
  - MLSO Upgrades and Data
- Research to Application
- Education & Outreach

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

HAO Strategic Plan
NCAR Strategic Plan

PREVIOUS HAO REPORTS

Select year

Printer-friendly version

MLSO UPGRADES AND DATA

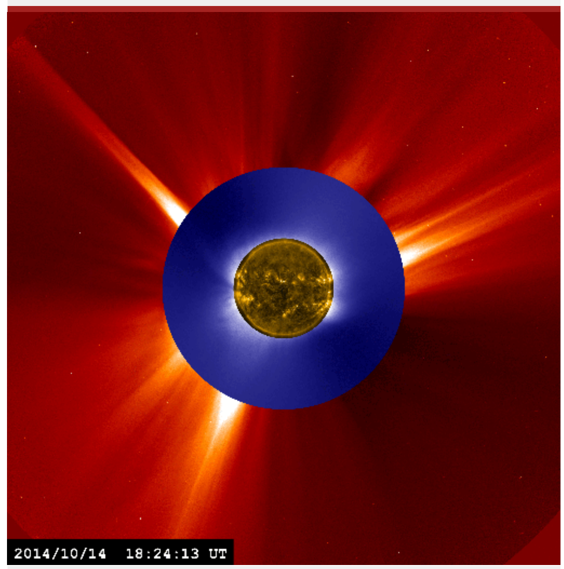
Several upgrades were made to the Mauna Loa Solar Observatory (MLSO) over the past year. The instrument package was upgraded in the fall of 2013 with the successful deployment of the COSMO K-Coronagraph (KCor). Scientific images and movies of all KCor data became available in 2014 from the MLSO web page. KCor provides the only white light observations of the very low corona with a very high time cadence (15 seconds) that are ideal for studying the formation and early propagation of coronal mass ejections (CMEs), which are the primary driver of large space weather events at Earth.

KCor is able to observe CMEs many minutes before they are visible in space-based coronagraphs. KCor can also detect the rapid acceleration of CMEs in the very low corona that is strongly associated with solar energetic particle events. These capabilities are important for space weather forecasting.

Mauna Loa Solar Observatory

In 2014, HAO upgraded the MLSO web page and added a number of new data products. The MLSO web page now provides the Community Forward Modeling Tools package, a community-developed tool for comparing coronal models with observations from MLSO, NASA, and other observatories. This unique tool allows users to select from a variety of coronal models and compare model output such as magnetic field and plasma properties with space- and ground-based observations.

HAO has also added a community observing campaign request form for scientists to specify the types of observations they would like to acquire with MLSO instruments to meet specific science goals. HAO has received and fulfilled a number of Coronal Multi-channel Polarimeter (CoMP) observing campaign requests by the community. Examples are provided on the MLSO web page. The web page was expanded in 2014 to include MLSO gallery and news pages, and the MLSO data calendar was upgraded to provide a quick and easy display of MLSO observations containing CME and related solar activity.



A composite image of a CME on October 14, 2014, as seen in

A number of repairs were made to the facility by UCAR over the past year, including roof resealing to prevent leaks and the replacement of an aging staircase to the upper dome. Internet bandwidth to the observatory was tripled in October to provide better realtime data access for space weather forecasting and related science. HAO added new computing systems and a control station to allow observers quicker and easier monitoring of solar activity from all MLSO instruments.

MLSO is suported by NSF #M0856145.

coronal observations from NASA AIA (yellow), Mauna Loa KCor (blue) and NASA LASCO (red). KCor observed the start of the CME in the very low corona 24 minutes before it was visible in the LASCO observations. KCor observations are useful for space weather forecasting and studying the causes of CME formation.

‹ Expansion of the NCAR Upper Atmosphere Observations

up

Research to Application ›

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2014 Annual Report

National Science Foundation
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Search
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RESEARCH TO APPLICATION

HAO's mission includes efforts to foster the transfer of knowledge and technology from its origins in fundamental research for the benefit of society—the research-to-application path. In the study of space weather, HAO staff have developed partnerships with the Community Coordinated Modeling Center (CCMC) at NASA's Goddard Space Flight Center and NOAA's Space Weather Prediction Center (SWPC) here in Boulder. In this year's report we highlight the recent collaborative efforts related to satellite tracking and collision avoidance related to space junk and how research developed at HAO is being "hardened" for day-to-day operational use.

‹ MLSO Upgrades and Data up Satellite Tracking and Collision Avoidance ›

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Search

2014 HAO ANNUAL REPORT

- Director's Message
- Scientific Discovery & Innovation
- Developing Predictive Solar Capabilities & Understanding Their Impacts
- Community Modeling & Diagnostic Tool Development
- Observational Facilities & Data Service
- Research to Application
  - Satellite Tracking and Collision Avoidance
- Education & Outreach

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- HAO Strategic Plan
- NCAR Strategic Plan

PREVIOUS HAO REPORTS

Select year

Printer-friendly version

SATELLITE TRACKING AND COLLISION AVOIDANCE

Space debris poses serious risks to a wide array of satellites critical to society. The U.S. Air Force tracks roughly 20,000 pieces of space debris, but there's nothing that can be done to change any of their paths. Instead, satellite operators have to adjust spacecraft orbits to steer around them. NCAR is part of a collaborative effort, commissioned by the U.S. Air Force and currently being tested, that takes into account real-time information on satellite tracks and space weather to predict future satellite paths as much as 72 hours in advance. Once finalized, the system, called the Atmospheric Density Assimilation Model (ADAM) project, could eventually be used in both military and commercial settings.

Even though the upper atmosphere is tenuous, it exerts drag onto space objects, particularly in low-earth orbits (LEO, below ~1000 km). In this region, atmosphere density changes greatly, responding to changes in the Sun's emissions, from space weather events such as solar flares and coronal mass ejection, to the 11-year solar cycle. This density change alters drag, which in turn changes orbits. Consequently, low-earth orbits are the most difficult to predict. To aggregate the problem, the greatest concentration of debris is also found in LEO. Variable upper atmosphere density is the main uncertainty for orbit prediction and collision avoidance, satellite lifetime prediction, re-entry prediction, and on-board fuel requirements.

Despite the many advances in understanding the atmosphere, upper atmosphere density specification for space operations are still based on simple empirical methods as opposed to physics-based numerical models. These simple empirical methods cannot adequately capture atmospheric responses to space weather events.

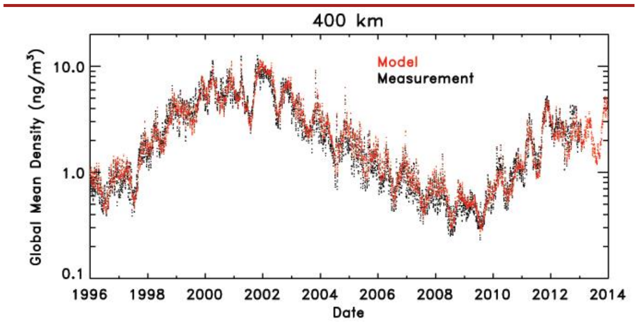

Figure 1. Global average atmosphere mass density over time.

Due to significant advances in physics-based models, advances in data assimilation techniques, and sophisticated modern computer systems, it is now possible to nowcast and forecast upper atmosphere density using modern physics-based numerical models. The NCAR Thermosphere Ionosphere Electrodynamics General Circulation Model (TIE-GCM) community model is one such physics-based numerical model. It is one of several physics-based models that will be used in the ADAM project to predict future satellite paths as much as 72 hours in advance. Figure 1 shows comparisons of model-calculated and measured global average atmosphere mass density at 400 km, which is a typical LEO altitude, over an 18-year period from 1996 to 2014. The model is able to simulate mass density and its changes in consistent with the data, from short impulsive changes due to solar storms, to changes caused by the seasons, as well as long-term variations driven by the solar cycle.

This work is being conducted in collaboration with our colleagues at ASTRA under subcontract 1211-02 and is supported by AFOSR award FA9453-14-C-0061.

‹ Research to Application | up | Education & Outreach ›

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2014 HAO ANNUAL REPORT

- Director's Message
- Scientific Discovery & Innovation
- Developing Predictive Solar Capabilities & Understanding Their Impacts
- Community Modeling & Diagnostic Tool Development
- Observational Facilities & Data Service
- Research to Application
- Education & Outreach
  - CISM Summer School

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- HAO Strategic Plan
- NCAR Strategic Plan

PREVIOUS HAO REPORTS

Select year

Printer-friendly version

EDUCATION & OUTREACH

In the following section we highlight two of HAO's projects in the area of Education over 2014. Education and pro-diversity activities are vital to the future of our community. HAO is committed to developing and using existing engagement opportunities to foster STEM (Science Technology Engineering and Mathematics) awareness and to cultivate greater "diversity of thought" in the general public when it comes to the Sun and its interaction with our planet.

‹ Satellite Tracking and Collision Avoidance up CISM Summer School ›

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Search

PREVIOUS HAO REPORTS

Select year

Printer-friendly version

CISM SUMMER SCHOOL

Figure 1. 2014 CISM Summer School participants and staff.

In 2014 the High Altitude Observatory (HAO) held the second CISM Space Weather Summer School. The goal of this intensive two-week program is to provide participants with a broad overview of the sun-earth system—how space weather effects arise, and how models can be used to help understand, investigate, and predict the space weather system.

This year we had we 29 students, including 9 female students, 9 from international universities, and 2 space weather professionals (Fig. 1). The intimate setting provided a unique learning environment that is not possible at a typical university.

Funding included support for students to travel to HAO in Boulder, CO, to attend the program. Lectures were given by experts in all areas of heliosphere and geospace, and students participated in an interactive laboratory session using model output for exploring the high coupled space weather system. In addition to these sessions, experts from industry and government discussed how space weather impacts our technological systems. The students left the school with a broad understanding of the entire Sun-to-Earth chain that makes up the space weather system.

As part of the laboratory portion of the school, the students had the opportunity to predict the arrival time of Coronal Mass Ejections (CME) at earth. One of the students said about the experience, “I love it, very interesting to play with the CME arrival model. I felt like I was at the prediction center exercises.” Initially, the students were broken up into expert groups and given observational data from one area. These groups were then rearranged to assemble a complete team that produced a concept map of the space weather event they were examining. A member of class felt this exercise was “...the best we've had. I liked how it brought all the concepts we learned together and showed how interrelated they were.”

This activity is supported by NSF Award No. 1220626 and will continue for another three years.

‹ Education & Outreach up Into Africa, A Scientist's Journey to the Classroom and the Savannah—by Mark Miesch ›

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Select year

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INTO AFRICA, A SCIENTIST'S JOURNEY TO THE CLASSROOM AND THE SAVANNAH—BY MARK MIESCH

“Chui” was the word on the radio; Swahili for leopard. The Masai are still the best wildlife spotters on the Mara, but they are not averse to using modern technology when it suits them. The report was from another guide letting us know about a leopard feasting on a buffalo carcass near a well-known creek. This was good fortune for the feline, nothing more. A leopard can't take down a buffalo—not even a young one. By the time we arrived he was just finishing his lunch, leaving the rest for the vultures. He took refuge from the Kenyan sun in the shade of a leafy shrub, yawned a big kitty yawn, and stretched out for an afternoon nap, momentarily tamed by the soporific sway of a full belly.

Mark with Nigerian student Oluwadre T. Seun

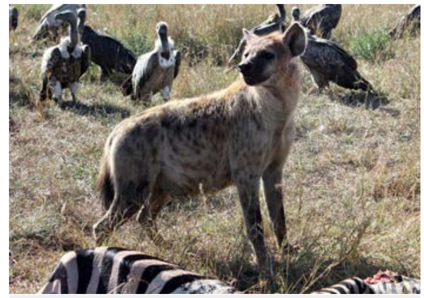
I had come to Africa to share the wonders of solar magnetism with a group of 39 bright and eager students from Ethiopia, Kenya, Uganda, Tanzania, Rwanda, Malawi, and Nigeria. The occasion was one of a series of advanced schools on space science sponsored by the International Space Weather Initiative (ISWI) and the Scientific Committee on Solar Terrestrial Physics (SCOSTEP). This one was held in Nairobi in October 2013, hosted by the Technical University of Kenya (TUK). I was one of 17 international lecturers on a range of topics, including the solar interior, the solar dynamo (my contribution), the solar atmosphere, coronal mass ejections, solar flares, the solar wind, solar energetic particles, cosmic rays, the Earth's magnetosphere and ionosphere, space weather, atmospheric physics, and the influence of the Sun on climate. There were also lectures and a hands-on workshop on instrumentation and data analysis techniques for space physics research.

The school was organized by Nat Gopalswamy (NASA GSFC/SCOSTEP) and Paul Baki (TUK), with local help from Andrew Oduor (Maseno University) and Harrison Amwayi (TUK). The goals were to promote space science research and education in Africa and to provide opportunities for the students and their mentors to participate in hosting ground-based instruments such as solar telescopes, GPS receivers, magnetometers, and ionospheric monitors, each as components of larger networks. Students were selected based on academic merit, research interests, and research experience. It was a lively and diverse crew! Each lecture was accompanied by a hands-on activity that fostered interactions between the students and lecturers. We all lived and dined together buffet-style in the education complex that served as a conference center, and we shared our triumphs and tribulations on such erudite matters as the water temperature and pressure (or lack thereof) in the morning's shower.

To complement the school, which was targeted at graduate students, Deborah Scherrer of Stanford University organized a one-day teacher workshop at the University of Nairobi, about 5 miles from the ISWI/SCOSTEP school. I was fortunate to participate in that as well. The idea was to teach teachers, and we expected to find a group of practicing elementary school teachers who were interested in incorporating solar science and space weather into their curriculum. What we found instead were mainly undergraduate astronomy and physics students from the University of Nairobi! Still, it was very well received. After an introductory address by Nat and Paul, I gave a presentation on solar science and space weather. Then the fun really began! Deborah had a full agenda of hands-on activities, from building a cardboard spectrograph (a student favorite) to active demonstrations of lunar phases and magnetism, to training on the use of Sudden Ionospheric Disturbance (SID) monitors, which were given to the participants for use in their classrooms.

Before returning home to Boulder I took the opportunity to go on a five-day safari in the Masai Mara game reserve, one of the world’s greatest wildlife refuges, in the southwest corner of Kenya, across the border from Serengeti National Park in Tanzania. Relative to some African countries, Kenya does an outstanding job of keeping poaching under control, so the density of wildlife is incredible.

I have lived in Colorado for nearly 20 years and I have never seen a mountain lion in the wild. In the Mara I went on seven game drives (morning and evening each day) and saw lions every time, along with a stunning abundance and variety of other fauna that reads like a who's who of African animals or a guest list for Noah's ark: elephants, giraffes, ostriches, impalas, wildebeests, hartebeests, topis, zebras, leopards, cheetahs, servals, Thompson's gazelles, warthogs, hyenas, hippos, crocodiles, mongooses, hornbills, baboons, vervet monkeys, bush babies, African swallows (a must for every Monty Python fan!), storks, eagles, guinea fowl, a secretary bird, termites, dik dik, waterbuck, bush duiker...the list goes on.



Hyena with vultures and zebra kill

To my host's surprise, I rounded out the complete list of Mara cats by spotting a wild cat and a caracal, known as the ghost of the savannah. We saw lions sleeping, hunting, feeding, and even mating (complete with a satisfied roar that stirs the depths of your soul unlike any other sound on Earth). We saw a pack of hyenas vying for a zebra carcass with a flock of impatient vultures. We saw one of the famous wildebeest migration river crossings spanning the croc-infested Mara River, though it was the wrong time of the year to witness the migration itself. Many employees of the bush camp, including our guides, were Masai tribesmen, and they took us to their village one afternoon. A woman and child kindly let a few of us into their home, a small thatched hut with a warm, dark, cozy interior filled with the scented smoke of the central fire. The child was calm but eyed us suspiciously.

Kinfe Teweldebirhan visiting HAO

One of the lasting rewards of such a trip is the new friends you make along the way and the unexpected paths where those new connections can lead. Soon after returning from my trip I was contacted by email by a PhD student in the physics department of Addis Ababa University (AAU) in Ethiopia. His name was Kinfe Teweldebirhan. Although Kinfe had not attend the ISWI/SCOSTEP school, many of his friends and colleagues had, and it was through them that he obtained my contact information. Kinfe is an exceptional student with a passion for astrophysics and space science, but due to circumstances beyond his control, he recently found himself without a PhD advisor. Faced with the possibility of giving up his passion for other areas of physics that are better represented among the AAU faculty, he was reaching out for a new advisor. After several email exchanges with Kinfe and those who know him, I agreed to serve as an external advisor, in collaboration with a local advisor at AAU. Promoting expertise in astrophysics and space science in Ethiopia through education has become particularly pressing in recent years with the opening of the new Entoto Observatory, Ethiopia's first, located in the highlands north of the capital, Addis Ababa. Studying the origins and manifestations of solar variability is not only of practical relevance to our technological society, but it is also a link to the cosmos, with 100 billion other stars in our galaxy alone waiting to be explored.

With generous support from the HAO visitor's program, Kinfe is now visiting Boulder (April–May 2014) and we are beginning to shape a research direction for his PhD thesis. Several of us at HAO, including myself and Mausumi Dikpati, have recently developed a novel 3D Babcock-Leighton dynamo model of the solar cycle. Kinfe will help us improve the theoretical foundations of the model and make closer contact with solar observations through calibration and data assimilation. This model forms the dynamo core of the broader Space Climate Initiative (SCI), which seeks to investigate the causes and extremes of long-term solar variability and its influence on the Earth's climate system and space environment. Kinfe is enjoying the intellectual stimulation of NCAR and is reveling in the adventure of the entire experience. This is his first trip out of Ethiopia, and last week marked the first time he had ever seen snow. He also had his own memorable wildlife encounter: he had never before seen a squirrel. The world never ceases to amaze.

Editor’s note: If you buy Mark a beer sometime he’ll tell you even more; so while this article is longer than what we usually publish on the web, I think it is worth a five-minute break to settle in and imagine this amazing experience.

‹ CISM Summer School   up   Grad Student Cohort ›

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GRAD STUDENT COHORT

Staff at HAO are devoted to mentoring and supporting students seeking careers in upper atmospheric and solar science. This past year's list of HAO staff-mentored graduate students include:

Jesse Lord – Matthias Rempel
Maria Weber – Yuhong Fan
Bernadett Belucz – Masumi Dikpati
Junfeng Wang – Mark Miesch
Kinfe Teweldebirhan – Mark Miesch
Ricky Egeland – Phil Judge
Jiajia Liu – Scott McIntosh
Sheng Xi – Mike Wiltberger
Josh Murphy – Mike Wiltberger
McArthur “Mack” Jones – Maura Hagan

Recent Ph.D.’s

Jesse Lord received his Ph.D. from the University of Colorado (CU), Boulder, in October 2014. His primary adviser was Mark Rast at LASP, a close collaborator with HAO, and he was mentored at HAO by Matthias Rempel. Jesse's Ph.D. work was on the topic of "Deep Convection, Magnetism and Solar Super Granulation." His work was funded primarily through a NASA SR grant; in 2014 he was supported for half a year through HAO. In addition, his work benefited heavily from an NCAR Strategic Capability (NSC) computing project on Yellowstone. Jesse is currently taking a break from science while he explores different career avenues.

Jesse Lord and Maria Weber

Maria Weber was a Ph.D. student from the Physics Department at Colorado State University in Fort Collins. She worked at HAO from June 2010–July 2014 as a graduate research fellow on her Ph.D. thesis, "The Dynamic Evolution of Active Region Scale Magnetic Flux Tubes in the Turbulent Solar Convection Zone." Her research has been published in three refereed journal articles. One of her publications, "The Rise of Active Region Flux Tubes in the Turbulent Solar Convective Envelope," published in the Astrophysical Journal, vol. 741, won the HAO John W. Firor Publication Award in 2013. She has also twice won the "Outstanding Student Paper Award" at the Four Corners American Physical Society meetings, and won the "Outstanding Student Paper Award" at the 2011 Fall AGU meeting. Maria successfully passed her oral dissertation defense in May 2014. After obtaining her Ph.D. in Physics, she left HAO to join Department of Physics and Astronomy at the University of Exeter, England, as an Associate Research Fellow working on MHD modeling of solar and stellar dynamos. Maria’s HAO mentor was Yuhong Fan.

Active Graduate Students

Bernadett Belucz is a Ph.D. student in the Department of Astronomy at Eötvös University in Budapest, Hungary. She is investigating North-South asymmetry in a Babcock-Leighton solar dynamo model and plans to graduate by the end of 2015. Bernadett is supported by the Hungarian Science Research Fund (OTKA grants no. K83133 and 81421) and has been partially supported by the Graduate Study Program of ASP, NCAR, and ASA's LWS grant with award number NNX08AQ34G. Bernadette’s HAO mentor is Mausumi Dikpati.

Ricky Egeland is HAO’s newest Newkirk Fellow. He is a Ph.D. student in the

Ricky Egeland, Jiajia Liu, Josh Murphy, and Mack Jones

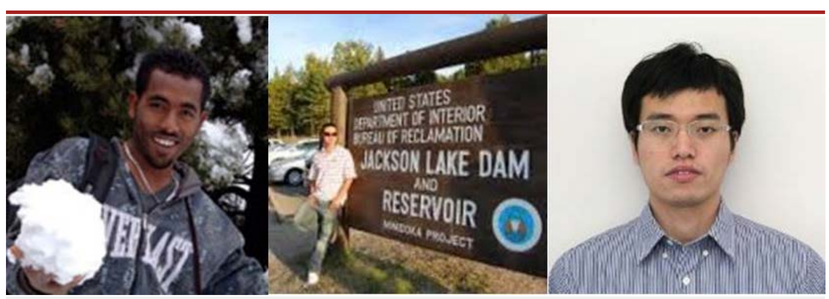
Physics Department of Montana State University. His advisors include Profs. Dana Longcope and Piet Martens, and his HAO advisor is Phil Judge. Ricky is trying to identify some of the basic ingredients in the solar dynamo through examination of solar behavior in the context of stars. He is studying novel ways of measuring the solar irradiance over centuries, and very long timescale variations of Sun-like stars.

Jiajia Liu is a Ph.D. student from the Earth and Space Science School at the University of Science and Technology of China. He visited HAO from September 2012 to August 2013 where he worked with Scott McIntosh on the analysis of propagating Alfvénic signatures in the solar corona as observed by the Coronal Multichannel Polarimeter (CoMP) at MLSO. The collaboration resulted in three peer-reviewed articles on the possible onset of wave turbulence in the (magnetically) open and closed regions of the outer solar atmosphere. Jiajia hopes to defend his Ph.D. in the spring of 2015. His visit to HAO was supported by a grant from the Chinese Academy of Science.

McArthur “Mack” Jones Jr. is a Ford Foundation fellow and Ph.D. candidate (anticipated May 2015) in Aerospace Engineering Sciences at CU Boulder. His thesis advisor is Professor Jeff Forbes (CU), and his co-advisor is Maura Hagan (NCAR/HAO). Mack's research is focused on quantifying and better understanding the role that atmospheric tides play in determining the mean state, longitudinal, seasonal, and solar cycle variability of the ionosphere-thermosphere system, with specific attention to the responsible physical mechanisms. Mack is conducting numerical experiments with the NCAR TIE-GCM and TIME-GCM models and diagnosing the results in pursuit of his research objectives. During the past year his research led to two scholarly publications.

Josh Murphy is a graduate student at CU Boulder, working on his Ph.D. within the Laboratory for Atmospheric and Space Physics (LASP). Currently, his research is focused on developing tools for providing 3D visualizations of the forecast of solar wind at Earth from numerical simulations of the heliosphere. He is currently completing the coursework requirements and will begin focus on research full time in the coming year. His research efforts are supported by NASA, and his HAO mentor is Mike Wiltberger.

Kinfe Teweldebirhan is a Ph.D. student in the Physics Department at Addis Ababa University in Ethiopia. For his master's thesis, Kinfe studied the contribution of magnetic stresses to the "core bounce" that follows after a massive star explodes as a supernova. He is now busy learning about solar physics, scientific computing, and parallel programming in preparation for a Ph.D. thesis that will investigate the origins of solar magnetism. Kinfe is working with the BASH (Babcock-Leighton Anelastic Spherical Harmonic) code, which was developed at HAO/NCAR by Mark Miesch and Mausumi Dikpati by adapting the previously-existing ASH code (of which Miesch is also a co-author). BASH is a numerical model of the solar activity cycle based on the so-called Babcock-Leighton paradigm by which poloidal magnetic field is generated by the destabilization, emergence, and dispersal of toroidal magnetic flux structures that give rise to sunspots and related active regions. Kinfe will help to improve the realism of the BASH model by implementing nonlinear feedbacks on large-scale flows (differential rotation and meridional circulation) due to Lorentz forces and enhanced cooling in active regions. This will allow Kinfe to address issues such as dynamo energetics, saturation, and cycle amplitude variation that cannot be captured by means of a purely kinematic (linear) treatment.



Kinfe Teweldebirhan, Junfeng Wang, and Sheng Xi

Junfeng Wang is a Ph.D. student in the Mechanical Engineering Department at George Washington University (GWU). His main expertise is on leading-edge numerical methods in computational fluid dynamics (CFD). His thesis research focuses on applying these numerical methods to study convection and differential rotation in stars. He, together with advisors, Chunlei Liang (GWU) and Mark Miesch (HAO/NCAR), are co-authors of the Compressible High-ORder Unstructured Spectral difference (CHORUS) code, a description of which is now being reviewed by the Journal of Computational

Physics.

Sheng Xi is a graduate student at Dartmouth College, pursuing his Ph.D. from the Thayer School of Engineering. He has been working with Michael Wiltberger and members of the CMIT development team on improvements to the low latitude boundary conditions used within the magnetosphere portion of the simulations. His first paper was just accepted for publication in the Journal of Geophysical Research, and he expects to graduate in fall 2015. His research efforts are supported by grants from NASA.

‹ Into Africa, A Scientist's Journey to the Classroom and the Savannah—by Mark Miesch up

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2014 NESL ANNUAL REPORT

TABLE OF CONTENTS

NESL Director's Message ›

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NESL DIRECTOR'S MESSAGE

The 2014 NESL Annual Report highlights some examples of the exceptional work carried out by Laboratory staff during the last fiscal year. This research

significantly furthers the NESL mission of advancing our understanding of weather, climate, atmospheric composition and processes, and providing facility support for such advancements to the wider community, in particular the atmospheric science programs at UCAR member institutions.

This year, the Annual Report is organized under the headings of the six Laboratory-wide priorities described in the new NESL Strategic Plan that was published in Spring 2014, and which broadly illustrates how NESL's research program is advancing Earth System knowledge and serving the broader community. Essential to addressing these priorities is a cutting-edge scientific program of discovery-oriented research, balanced and integrated among theory, observation and modeling. The work described here has been accomplished within NESL's three major research divisions (Atmospheric Chemistry Division (ACD), Climate & Global Dynamics (CGD), and Mesoscale and Microscale Meteorology (MMM)), through substantial cross-divisional and cross-NCAR interactions, and through collaboration with the US and international research community.

The three Interdisciplinary Science Challenges described in the first part of the Annual Report are *Identify and model the processes responsible for hazards related to weather and air pollution, and project the influences of climate change*; *Determine the inherent predictability of the Earth system with respect to weather, climate and air quality*; and *Identify and model the processes and interactions that govern climate variability*. Research into each of these Challenges is illustrated by examples of the work performed and ongoing across NESL and within our community. NESL also provides specialized research, observing facilities and support for field programs, valuable research data sets, and widely used state-of-the-science community models. These services motivate the three strategic priorities described in the second part of the Annual Report under Enabling World Class Community Science. These priorities are: *Continued development and support of NCAR community models*; *A unified strategy toward model and data assimilation system development for weather-chemistry-climate prediction*; and *Expand community access to instruments, models and data sets*. Examples of NESL model and observational facility development and support are presented under each of these headings.

Over the coming year, NESL will continue work on its six strategic priorities, motivated by increasing evidence that the environmental issues we face are not theoretical or potential futures, but are already having significant impacts on society. There also will be new opportunities for collaborative research across NCAR and the wider community, prompted by the vision of the newly published NCAR Strategic Plan. This NCAR Plan emphasizes Grand Challenges associated with prediction of hazards and their impacts, and understanding the consequences of natural and anthropogenic climate and global change. These are both areas where the research conducted in NESL will make a leading contribution.

‹ 2014 NESL Annual Report | up | 1. Interdisciplinary Science Challenges ›

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STRATEGIC PLANS

NESL Strategic Plan

NCAR Strategic Plan

PREVIOUS NESL REPORTS

Select year

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1. INTERDISCIPLINARY SCIENCE CHALLENGES

While core disciplines necessarily remain an emphasis, NESL programs have become increasingly interdisciplinary to address the challenges of studying the atmosphere and the Earth as a system.

‹ NESL Director's Message up 1.a. Identify and model the processes responsible for hazards related to weather and air pollution, and project the influences of climate change ›

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Pollutants from Open Waste Burning

1.a.10. REACCTING - Research of the Emissions, Air Quality, Climate and Cooking Technologies In Northern Ghana

1.a.11. The Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ)

- 1.b. Determine the inherent predictability of the Earth system with respect to weather, climate and air quality
- 1.c. Identify and model the processes and interactions that govern climate variability on timescales long enough for forcing to dominate over initial conditions
- 2. Enabling World Class Community Science

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- NESL Strategic Plan

NCAR Strategic Plan

PREVIOUS NESL REPORTS

Select year

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1.A. IDENTIFY AND MODEL THE PROCESSES RESPONSIBLE FOR HAZARDS RELATED TO WEATHER AND AIR POLLUTION, AND PROJECT THE INFLUENCES OF CLIMATE CHANGE

NESL scientists, in collaboration with university colleagues and international research organizations are conducting research aimed at understanding the causes of such hazards and how they change over time. An overarching goal is to improve our capabilities to predict them.

‹ 1. Interdisciplinary Science Challenges up 1.a.1. Improve understanding of climate change contributions to extreme events, associated environmental and societal impacts ›

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2014 Annual Report

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NCAR Strategic Plan

PREVIOUS NESL REPORTS

Select year

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1.A.1. IMPROVE UNDERSTANDING OF CLIMATE CHANGE CONTRIBUTIONS TO EXTREME EVENTS, AS WELL AS THE ASSOCIATED ENVIRONMENTAL AND SOCIETAL IMPACTS

Considerable work has taken place with regard to the purported hiatus in global warming and the associated details on consequences around the world manifested in regional extremes in climate. By sorting out the changes in atmospheric circulation by season, teleconnections emanating from the tropical Pacific ocean in association with the negative phase of the Pacific Decadal Oscillation (PDO) have been linked to Arctic amplification of changes there, such as cold winters in Europe, extremes of precipitation in association with storm track changes, Antarctic sea ice changes, and West Coast drought. The tropical Pacific seems to be a key player in the extremely cold winter over the eastern US in 2013-14 also.

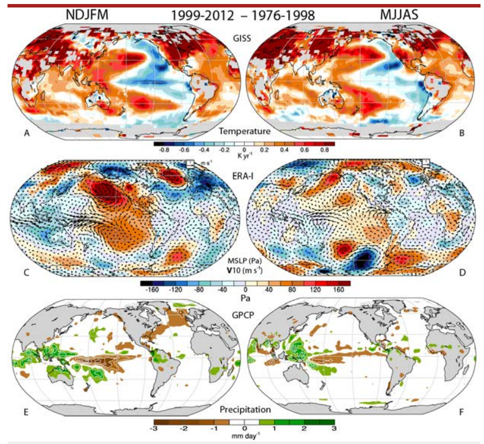

Figure: *Mean differences between 1999–2012 and 1979–1998 for NDJFM (left) and MJJAS (right) for surface temperature from GISS (a,b), mean sea-level pressure (MSLP) differences from ERA-I (colours) and surface wind vectors (arrows) with the key at the top right (c,d), and precipitation from GPCP truncated to T63 resolution (e,f). (Image courtesy Justin Small.)*

‹ 1.a. Identify and model the processes responsible for hazards related to weather and air pollution, and project the influences of climate change

up

1.a.2. Hurricane Prediction ›

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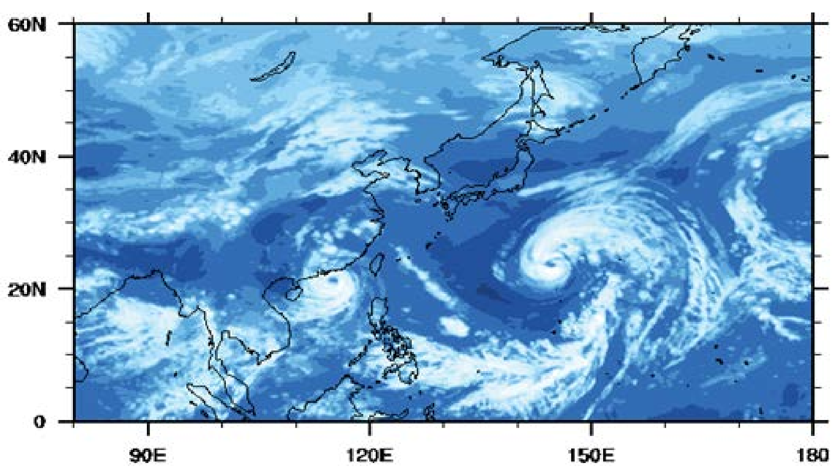
1.A.2. HURRICANE PREDICTION

The first experimental, hurricane-specific forecasts using WRF-ARW (Advanced Research WRF) were conducted for hurricane Isabel in 2003. This model is referred to as the Advanced Hurricane WRF (AHW). The purpose of these forecasts was to see if the same model used for mesoscale weather prediction was also capable of predicting hurricanes. Encouraging results has led to more extensive and comprehensive hurricane-prediction work each year since then, building toward a reliable quasi-operational system that could also be used for research.

NESL/MMM scientists continued work on WRF-ARW in an effort to improve its representation of tropical convection and its effects on moisture distributions that are known to strongly influence hurricane intensity changes. This work is being carried out in collaboration with the University at Albany SUNY. In FY2014, the ability to include full-resolution terrain and land-surface characteristics into moving nests was completed and released in WRF V3.6. Previously, moving nests had been used for a variety of simulations of weather phenomena, especially hurricanes. However, the nest would acquire the terrain and land character of the coarse domain as it moved along. This made coastlines too coarse and mountains too low, thus limiting the accuracy of the prediction of the effects of hurricanes at landfall, particularly for wind and rainfall near the coast and over higher terrain inland. The new modifications now allow more realistic predictions with moving nests.

In addition, real-time forecast experiments with MPAS were conducted during the 2013 hurricane season. The purpose was to test the representation of tropical-cyclone track and intensity anywhere on the globe, the effect of variable resolution in the global model and a comparison of similarly configured ARW hurricane forecasts for the Atlantic basin. A total of 134 MPAS forecasts were integrated out to 10 days during the period August 12 to September 30, 2013. There were 3 different configurations; a uniform grid of 15 km horizontal spacing on the sphere, and two regionally refined grids, one centered over the Atlantic, the other centered over the Western Pacific in which a 15-km grid spacing transitioned to 60 km over the rest of the earth. Fifty-two forecasts were made with the uniform and Atlantic configurations. It was found that through day 6, the skill of forecasts in the tropical Atlantic with variable resolution was comparable to the skill of the uniform-resolution forecasts in that region. The uniform MPAS configuration was also able to produce good forecasts of many of the cyclones over the Western Pacific (see attached images). MPAS was noted to have a positive bias in the number of tropical cyclones, although in a homogeneous comparison, it produced track errors indistinguishable from the operational Global Forecast System (GFS) of the National Centers for Environmental Prediction (NCEP). The NCEP GFS performed slightly better in the Atlantic.



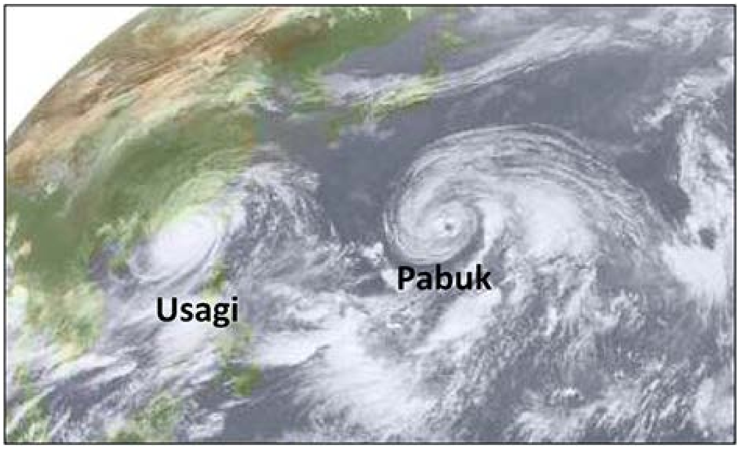


Figure. Outgoing longwave radiation from MPAS at 12 UTC 22 September (top) compared with infrared satellite image valid 03 UTC 22 September, 2013.

‹ 1.a.1. Improve understanding of climate change contributions to extreme events, associated environmental and societal impacts
up
1.a.3. Communicating Weather- and Climate-Related Risk for Use in Decisions ›

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1.A.3. COMMUNICATING WEATHER- AND CLIMATE-RELATED RISK FOR USE IN DECISIONS

To enhance the use and value of weather-related information, NESL scientists conduct research to understand and improve the communication, interpretation, and use of weather forecasts and warnings and of information about weather in the context of climate variability and change. This includes investigating how information about weather and climate risks are communicated, interpreted by various groups, and used in decisions. It also includes building understanding of people's perceptions of weather-related risks and the underlying vulnerabilities and other contextual factors that influence weather and climate decision making. The research applies social-science concepts and methods to atmospheric-science issues, facilitating interdisciplinary work by the broader community.

In FY2014 NCAR scientists continued investigating how different members of the public perceive and respond to different test-hurricane forecasts and warning messages, using analysis of data from a survey of residents of coastal south Florida areas that are at high risk from storm surge. They also analyzed how individuals' protective actions for approaching hurricane threats vary with their individual characteristics, perceived hurricane risks and vulnerabilities, motivations and barriers to actions, and other factors, using public survey data from the Miami, FL and Galveston, TX areas (Lazo et al. 2014).

Staff also completed analysis of data from stakeholder interviews in south-central Oklahoma to examine how cultural values inform drought-risk perceptions and management preferences. The study finds that drought-risk perceptions are complex and often conflicting, and while community members largely agree water management is important, they disagree about who has authority to enact management measures (Lazrus 2014). Scientists also continued work to develop and implement a framework that integrates knowledge about locally significant drought impacts and cultural risk perceptions with advances in climate research to enhance drought-risk information and decision making.

Other work in FY2014 included NESL/MMM staff and collaborators building on discussions at the Rising Voices I workshop to complete a manuscript that examines lessons learned from experiences with engagement of Indigenous communities in weather and climate research and policies. The manuscript also synthesizes recommendations for meaningful, successful engagement, with the goal of understanding and responding to the many challenges that climate change poses to communities (Lazrus et al. 2014). A follow-on workshop (Rising Voices II: Adaptation to Climate Change and Variability: Bringing Together Science and Indigenous Ways of Knowing to Create Positive Solutions) was held at NCAR 30 June-1 July, 2014, with an emphasis on identifying action-oriented activities for developing positive climate-adaptation solutions and building capacity in, for, and with Indigenous communities.

The results of this work have been disseminated to the public through the following publications.

Lazo, J. K., A. Bostrom, R. E. Morss, J. L. Demuth, H. Lazrus, 2014: Factors affecting hurricane evacuation intentions. Submitted to *Risk Analysis*.

Lazrus, H., 2014: “Drought is a relative term”: Drought risk perceptions and water management preferences among diverse community members in the Arbuckle-Simpson Aquifer. Submitted to *Current Anthropology.*

Lazrus, H., B. Gough, J. K. Maldonaldo, R. S. Pulwarty, E. Shea, and M. K. Souza, 2014: Rising Voices: The move to more fully engage indigenous perspectives in climate science and policy. Submitted to *Nature Climate Change.*

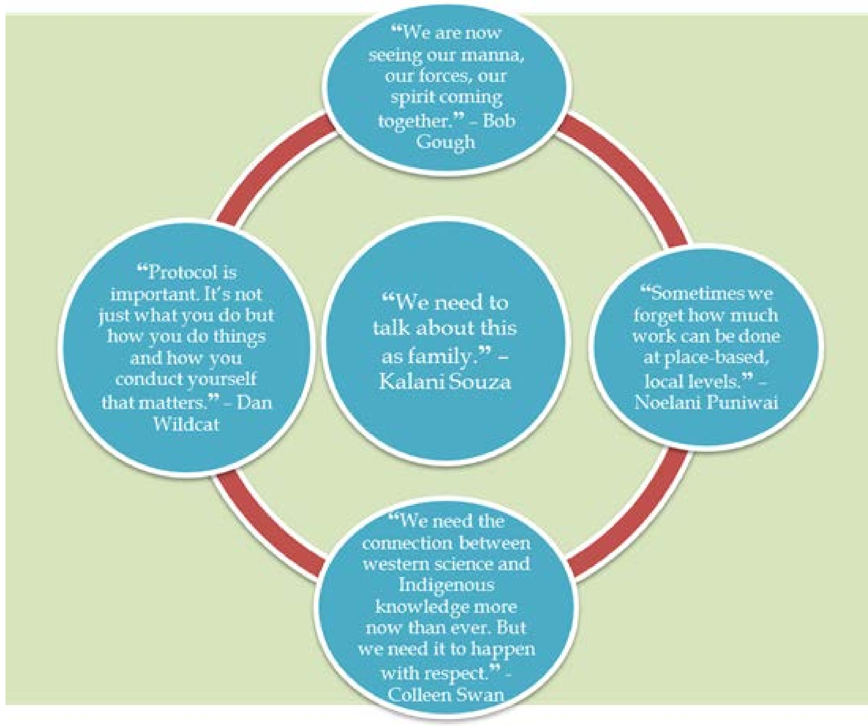

Figure. Quotes from participants of the Rising Voices II workshop illustrating the need to support hearing and valuing Indigenous knowledge in the context of co-production of knowledge and adaptation decisions to extreme weather and climate variability and change.

‹ 1.a.2. Hurricane Prediction up 1.a.4. Clouds and Precipitation ›

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1.A.4. CLOUDS AND PRECIPITATION

NESL has organized a group of university investigators in the United States and abroad to study the role of dust in ice production in clouds. The experiment, called the Ice in Clouds Experiment-Dust (ICE-D), is a successor to two earlier ICE field programs. Dust is considered to be a primary ice nucleus in clouds globally, and its activity has been studied primarily in the laboratory but only cursorily in natural clouds. Additional study of this important component of natural-ice production processes is central to understanding the glaciation process in convective clouds.

A workshop to advance the ICE-D effort was held during the week of October 14th, 2013, at NCAR. About 25 university faculty and students, and corporate members, attended the workshop. There were some excellent discussion and presentations demonstrating significant progress in analyzing and applying the data from the earlier field campaign, ICE-T.

NESL/MMM scientists have nearly completed an article on the microphysical processes that occur from just above, through, and just below the layer where ice melts to snow—the so-called melting layer. Accurate information on the properties of this layer is essential if the two radars onboard the Global Precipitation Measurement mission satellite (GPM), launched in February 2014 to provide snow and rain precipitation measurements worldwide every two to three hours) is achieved. A major impetus for the development of this satellite was to identify snow precipitation falling to the ground, or close to it, and to derive the snow precipitation rates. This is obviously important if researchers are to characterize the water budget of the earth.

Working together with investigators in the MMM and RAL Divisions at NCAR, and faculty and students at the University of North Dakota and McGill University, scientists have identified several key processes operative within this layer of clouds. Slow spiral descents, descending at about the fall velocity of the largest particles while drifting with the wind (Figure), were used to characterize the growth followed by melting through the melting layer.

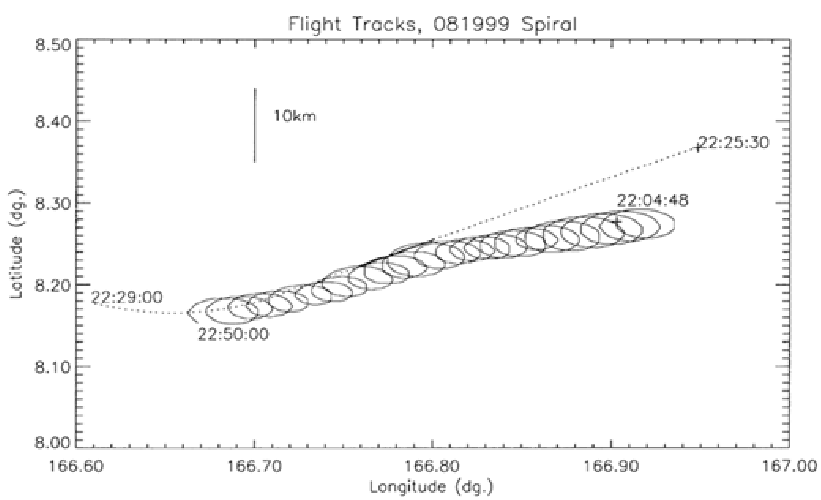

Figure: Position of the University of North Dakota Citation aircraft during spiral descent lasting 46 minutes with the goal of characterizing ice hydrometeors as they descended from a temperature of -14C to +7C. Data are from the NASA Kwajalein Experiment, KWAJEX.

Collection of the small ice particles by the larger ones-the process of aggregation, is responsible for the observed increase in the size of the largest ice within the melting layer (Figure below). Algorithms to retrieve snowfall rate above and within the melting layer are being developed to characterize this process.

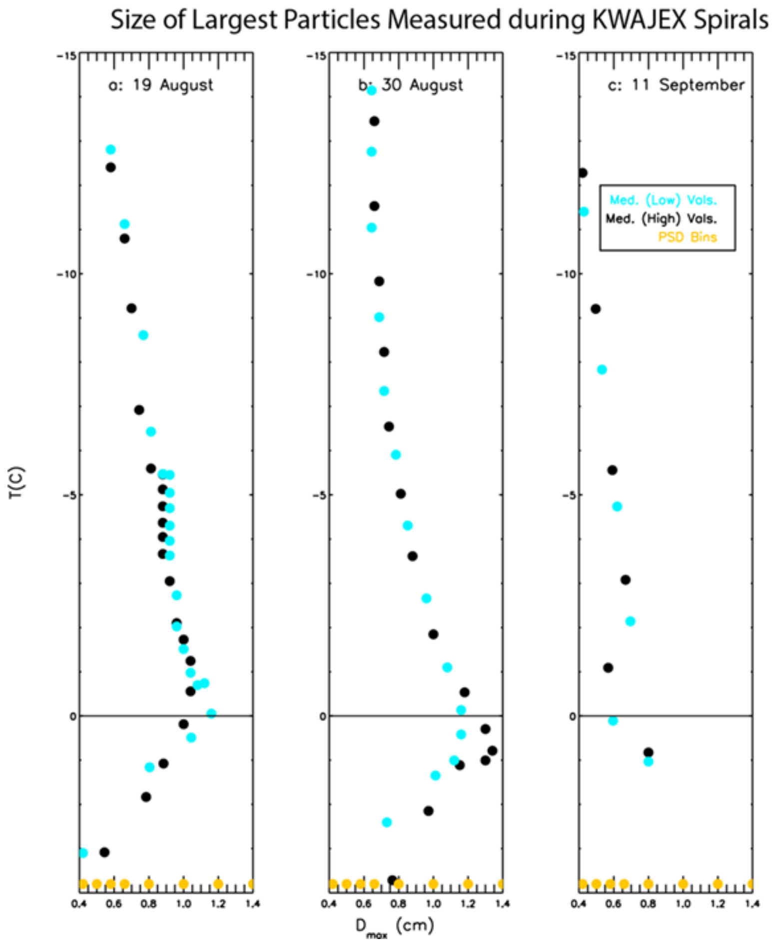

Figure: Dimension (diameter) of largest particle (Dmax) sampled during slow spiral descents

‹ 1.a.3. Communicating Weather- and Climate-Related Risk for Use in Decisions | up | 1.a.5. Boundary-Layer Turbulence and Surface Exchange ›

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1.A.5. BOUNDARY-LAYER TURBULENCE AND SURFACE EXCHANGE

Boundary layers and, at a more fundamental level, boundary-layer turbulence, are an essential component of weather and climate as they regulate the crucial fluxes of momentum, heat and scalars between the atmosphere and land surfaces, the atmosphere and ocean, and at stably stratified interfaces separating the more turbulent boundary layers from the overlying less turbulent troposphere. NESL's boundary-layer turbulence research continues to emphasize an increased understanding of the coupling between 3D, high-Reynolds-number turbulence and a variety of physical processes with a goal of improved parameterization.

In FY2014, NESL scientists continued to develop and apply large-eddy simulations to further improve fundamental understanding of the connections between atmospheric turbulence and the wavy ocean surface. The interaction between winds, buoyancy and surface gravity waves were investigated using a large-eddy simulation model with the ability to impose a broadband spectrum of time-varying finite-amplitude surface waves at its lower boundary. Weakly unstable boundary layers are simulated with geostrophic winds varying from 5 to 25 m/s. The simulations illustrate cross-scale coupling as wave-impacted near-surface turbulence transitions into shear-convective rolls with increasing distance from the water. In a regime with swell, low winds, and weak heating, wave-induced vertical velocity and pressure signals are readily observed well above the standard reference height of 10 m. At wind-wave equilibrium, the small-scale wave-induced signals are detectable only near the water surface. Below 10m a nearly constant-flux layer is observed where the momentum flux carried by turbulence, form stress, and subgrid-scale motions shifts with varying wave age and distance above the water. An archival manuscript was written and accepted for publication in the *Journal of Atmospheric Sciences*.

Related to this work, NESL/MMM scientists and colleagues were able to simulate turbulent winds over incipient and active breakers similar to those generated in a wind-wave tank. Mean winds computed from LES are found to be in good agreement with the observations, and the simulations show a pronounced enhancement in surface drag as the wavy surface transitions from incipient to active breaking. Overall, they found that the wave shape is more important than the surface wind drift in determining the onset of flow separation.

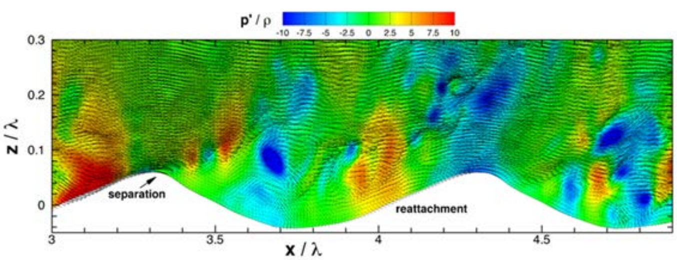

Figure: Flow vectors over a spilling laboratory breaking wave overlaying contours of pressure fluctuations from large-eddy simulation. The flow separates near the wave crest, exhibits a dead zone with slow re-circulating winds in the wave trough and reattaches on the face of the downstream wave; note the region of high pressure (red contours) near the point of reattachment.

‹ 1.a.4. Clouds and Precipitation up 1.a.6 Chemical and Biological Meteorology ›

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1.A.6 CHEMICAL AND BIOLOGICAL METEOROLOGY

Chemical and biological interactions are important parts of the Earth System, resulting from their close connection with the ecosystem, water cycles, boundary-layer meteorology, land-surface changes, precipitation, cloud systems, fire, air pollution, and urbanization. These interactions control energy partitioning at the Earth surface, which in turn influences the planetary boundary layer and drives the weather-climate system. With the increasing concern surrounding the potential impacts of global warming, understanding transport and effects of chemical constituents and particulates and their coupling with atmospheric transport and convection is becoming increasingly important.

Research in FY2014 included efforts to improve the ability of coupled weather-wildland fire models to simulate the evolution of wildland fires, their phenomenology, and their impacts on the land surface and air quality. The Coupled Atmosphere-Wildland Fire Environment (CAWFE) model has been adapted to ingest a gridded fire map to simulate a wildland fire already in progress. Using satellite active fire detection remote sensing data from the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument to initialize fire extent, this model/assimilation system has been shown to accurately simulate fire growth for the next 12-24 hours. A sequence of these simulations can be applied to accurately predict a wildfire's growth from first detection until it is extinguished, a previously unattainable goal. CAWFE has been applied to several high-impact wildfires, including the 2012 High Park fire, the 2012 Little Bear Fire, and the 2013 Yarnell Hill fire.

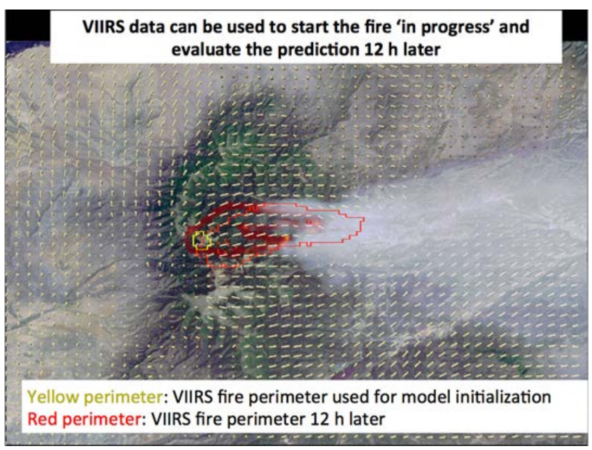

Figure: CAWFE model simulation of the 2012 Little Bear Fire, initialized in progress with satellite active fire detection data from the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard the Suomi/NPP satellite and evaluated 12 h later with the satellite's next pass. The arrows indicate the simulated near-surface wind speed and direction and the colored contour indicates the heat flux (in W m^-2) produced by the fire. The misty white field is the simulated smoke concentration, where darker and thicker smoke indicates higher concentrations.

‹ 1.a.5. Boundary-Layer Turbulence and Surface Exchange   up   1.a.7. Dynamics of Mesoscale Weather Systems ›

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1.A.7. DYNAMICS OF MESOSCALE WEATHER SYSTEMS

A particular emphasis in NESL has been high-impact convective weather systems such as squall lines, hurricanes, and tornado-producing thunderstorms. In a recent series of studies, NESL scientists showed how numerical models could produce hurricanes with intensity greater than that ever observed, despite very realistic initial conditions. The reason is that the particular combination of thermodynamics and flow structure in hurricane eyewalls acts as a form of atmospheric front in which mesoscale gradients are enhanced. Turbulent phenomena like eyewall mesovortices can limit this tendency to enhance gradients, but NESL scientists showed that extraordinarily small horizontal grid spacing (< 100 m) is needed to accurately simulate this process. Because these research studies are not constrained by limited timeframes to which operational forecasts must abide, they are free to utilize higher resolution that can reveal additional insights.

Research on the dynamics and predictability of Derecho events (large wind-producing convective systems) revealed fundamental differences between two recent notable events: the 8 May 2009 ‘’Super Derecho” in Kansas and Illinois and the 29 June 2012 Derecho, which produced an extensive swath of damaging winds from Chicago through Washington, DC. The former case organized ahead of a large mesoscale vortex in the mid-troposphere, while the latter was fueled by an unusually strong pool of cool air at the surface.

Other work conducted within NESL in FY2014 included three-dimensional large eddy simulations of tornadoes using the CM1 numerical model on yellowstone. A postdoc at the University of Miami is now leading the analysis of results with input from scientists at MMM. The simulations elucidate the influence of turbulent eddies (i.e., "suction vortices") on the maximum windspeed within the tornado. In addition, analysis of large eddy simulations of hurricanes continued and higher resolution simluations (with 31-m grid spacing) were begun. Maximum wind gusts continue to increase as grid spacing decreases and are associated with kilometer-scale vortices in the hurricane eyewall. A NSF-PRF postdoc working at NCAR has processed more than 15 years of dropsonde observations and identified dozens of cases with 100+ m/s wind gusts, which are being used to evaluate the model simulations.

‹ 1.a.6 Chemical and Biological Meteorology   up   1.a.8. Reductions in India’s crop yield due to ozone ›

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1.A.8. REDUCTIONS IN INDIA’S CROP YIELD DUE TO OZONE

A collaborative study between the Institute of Tropical Meteorology in Pune, India, the Scripps Institute of Oceanography and NCAR has looked into the impacts of high surface ozone on India’s crop yields. The study used crop production data and hourly surface ozone estimates to assess the agricultural effects of high levels of ozone, which damages plants and affects human health as well.

Despite air quality standards passed in the 1980s that were designed to curb industrial and vehicle emissions, pollution remains a major challenge for India. Rising emissions are causing severe ozone pollution in some of India’s most populated regions. Pollution in Delhi, the nation’s capital, has reached levels comparable to Beijing, one of the most polluted cities in the world, according to India’s Air Monitoring Center. Long-term measurements of surface ozone across India—measured on the ground or by aircraft—are not available, making it difficult to get a clear picture of how levels of the pollutant have changed. But satellite-based studies show ozone has increased in the last two decades. Due to the ability to acquire accurate crop production data, the year 2005 was chosen as a year representative of the effects of ozone damage over the first decade of the 21st century.

The study adopts the European matrix-accumulated exposure of vegetation to ozone above a threshold of 40 ppbv (AOT40) over the growing season for assessing ozone damage to crops. Hourly surface ozone was simulated with the regional Weather and Forecasting Model with Chemistry (WRF-Chem). To account for uncertainties in anthropogenic emission inventories, six different sets of simulations were conducted using multiple emission estimates.

The study estimated that surface ozone pollution damaged 6 million metric tons (6.7 million U.S. tons) of India’s wheat, rice, soybean and cotton crops in 2005, which would be enough to feed 94 million people living below the poverty line for one year. Taking into account the variability within the emission inventories considered, the uncertainty on combined economic losses can be as much as 36%.

Wheat – one of the country’s major food sources – saw the largest loss by weight of the four crops studied, with ozone pollution damaging 3.5 million metric tons (3.8 million U.S. tons) of the crop in 2005. Another major food source, rice, saw losses of 2.1 million metric tons (2.3 million U.S. tons). Cotton – one of India’s major commercial crops — lost more than 5 percent of its 3.3 million metric ton (3.6 million U.S. tons) annual output in 2005, costing the country $70 million.

This study has been the first to quantify how much damage India’s ozone pollution has caused the country’s major crops on a national level and can help policymakers craft new ozone pollution standards. It can also help India, a country with a high rate of poverty, as the country implements a new law that subsidizes grain for two-thirds of the country’s residents. The new food security bill requires the country to provide 61.2 million metric tons (67.5 million U.S. tons) of cereal grains – that include wheat and rice – to India’s poor each year at a subsidized rate. The estimated loss of wheat and rice due to ozone pollution is equal to 9.2 percent of the new law’s subsidized cereal requirement.

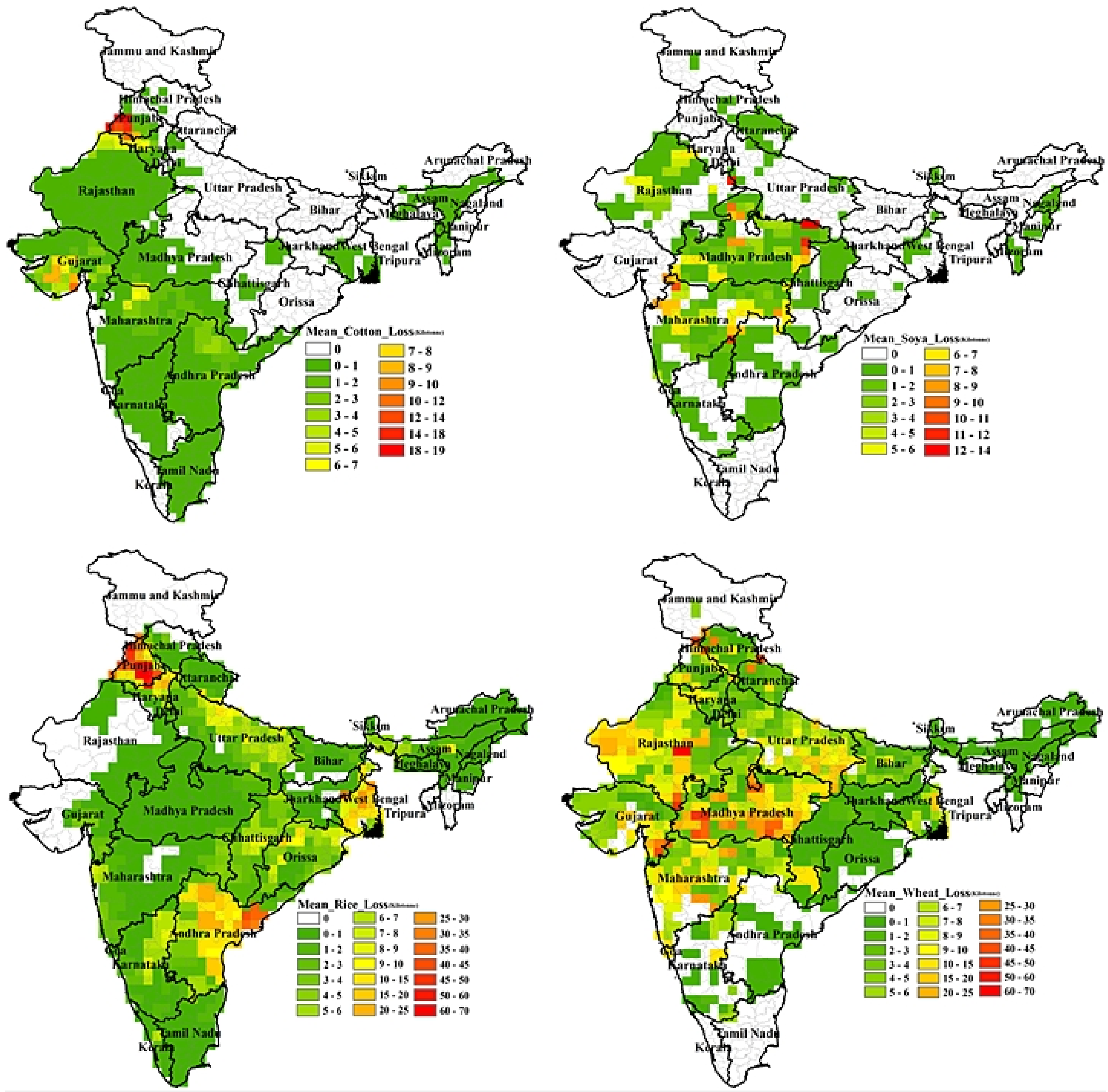

Figure 1: Average ozone-induced crop production loss from AOT40 metrics for rice (left) and wheat (right) during 2005. The production loss numbers are given in kilotons/grid box. (Figure adopted from Ghude et al., GRL. 2014)

‹ 1.a.7. Dynamics of Mesoscale Weather Systems up 1.a.9. Emissions of Particulates, Greenhouse Gases, and Air Pollutants from Open Waste Burning ›

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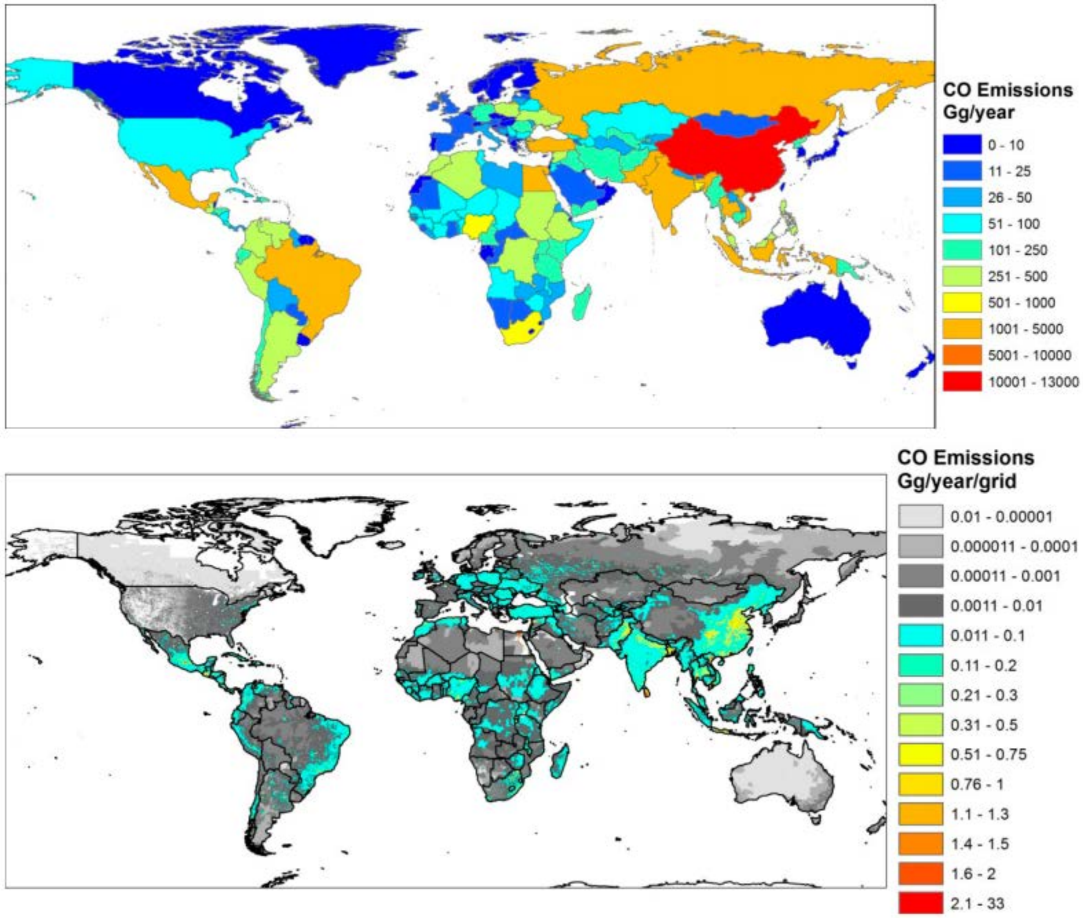
1.A.9. EMISSIONS OF PARTICULATES, GREENHOUSE GASES, AND AIR POLLUTANTS FROM OPEN WASTE BURNING

The uncontrolled open burning of waste is a common method for waste disposal, particularly in developing countries. This type of burning occurs at residences as well as at dump sites. The burning of waste produces substantial emissions of air pollutants; yet, despite this common occurrence, emissions from open waste burning are not well constrained and are often omitted from inventories used for regional and global chemical and climate model simulations.

Trash burning at a dump site.

Together with colleagues at the University of Montan and the U.S. Environmental Protection Agency, NESL ACD has developed a global open waste burning emissions inventory of air pollutants. The method developed follows greenhouse gas inventory guidelines from the IPCC, available population metrics and waste production information from the World Bank, and emissions factors from laboratory and field measurements.

Approximately 40% of all municipal solid waste produced globally is burned, with the majority in heavily populated developing countries. The countries with the most uncontrolled waste burning are China, India, Brazil, Mexico, Pakistan, and Turkey. Globally, emissions of greenhouse gases, criteria air pollutants, particles, and toxics are substantial; however, they become increasingly important on regional scales. Open waste burning is estimated to emit 1400Tg CO_2, an amount equivalent to 5% of the CO_2 emissions from anthropogenic sources. Air pollutants, such as particulate matter and dioxins, are emitted in large quantities. Results from this study suggest that anthropogenic emissions of particles are underpredicted in many regions of the world, particularly in Asia; particulate emissions in China could be underpredicted by as much as 20%.



Emissions of Carbon monoxide.

The emission estimates have been produced on a 0.1° grid resolution and are available as part of the Fire Inventory from NCAR (FINN) open burning emissions at http://bai.acd.ucar.edu/Data/fire/. These emissions will next be used as inputs to regional and global model simulations to assess their accuracy, importance and impacts.

Reference

Wiedinmyer, C., R. Yokelson, B. Gullet (2014) Global emissions of trace gases, particulate matter and hazardous air pollutants from open domestic waste burning. *Environmental Science & Technology*, **48**, pp. 9523-9530, doi: 10.1021/es502250z/

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1.A.10. REACCTING - RESEARCH OF THE EMISSIONS, AIR QUALITY, CLIMATE AND COOKING TECHNOLOGIES IN NORTHERN GHANA

According to recent reports, nearly three billion people in the developing world cook food and heat their homes with open fires or cookstoves that are fueled by solid biofuels. The smoke exposure from these activities is estimated to lead to approximately four million premature deaths each year. The emissions from these processes also add significantly to global emissions of greenhouse gases, short-lived climate forcers, and air pollutants. However, emission estimates from these processes, and their atmospheric impacts, are still highly uncertain. Furthermore, stove technologies exist that enable reductions in the amount of fuel used for cooking, and in emissions. Yet, the extent to which these technologies will be utilized, change emissions, and impact health and atmospheric composition is unclear.

REACCTING study area within Ghana.

Many studies are being performed worldwide to try to understand the use of various stove technologies, their emissions, and their impacts. One such study is being led by the NCAR Atmospheric Chemistry Division and has begun in the northern region of Ghana. This region, impacted by strong dry and wet seasons, is one in which biomass is a dominant source of cooking fuel. Two different stoves, one low-emitting gasifier stove and one locally made “efficient” stove, will be tested through a randomized intervention in rural communities of the Kassena-Nakana District of the Upper East Region. The value that households place on these technologies and their various characteristics will be evaluated; the emissions, resulting personal exposure to smoke, and health outcomes will be measured. A component of this multi-disciplinary project includes the design and application of sensors that will be used to monitor emissions, ambient air quality, and personal exposures. Stove use and emissions will be scaled up through emissions and chemistry-climate models, including WRF-Chem, to investigate the impact of cooking and other sources on air quality and regional climate.

Two hundred rural households were selected for participation in REACCTING, which was officially launched in November 2013 with the initial baseline survey and stove distribution. Since that time, four rounds of surveys have been completed, as well as regional ambient measurements, in-home microenvironment measurements, exposure measurements of carbon monoxide and particulate matter, and in-field emissions measurements have been completed. The study will continue through 2015, with the inclusion of 50 additional urban households and emissions measurements from cooking and other important emission sources.

This project includes a multi-disciplinary team from many institutions, including NCAR ACD and RAL, the Mechanical Engineering and Mathematics Departments of the University of Colorado-Boulder, and the Navrongo Health Research Center in Ghana. The research includes the intersection of air quality and

health, climate, economics, and engineering. The work is funded by NSF Award # 1211668 and a second grant has been approved for funding by the U.S. EPA.

Cooking in a rural household.

‹ 1.a.9. Emissions of Particulates, Greenhouse Gases, and Air Pollutants from Open Waste Burning
up
1.a.11. The Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ) ›

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1.A.11. THE FRONT RANGE AIR POLLUTION AND PHOTOCHEMISTRY EXPERIMENT (FRAPPÉ)

The Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ) was successfully carried out between July 15 and August 18, 2014. NASA conducted their fourth DISCOVER-AQ intensive concurrently in the Colorado Front Range between July 15 and August 11, 2014. Six instrumented ground sites (including an instrumented elevator carriage at NOAA's Boulder Atmospheric Observatory), six mobile laboratories, two tethered balloons, and a large number of additional ground-based monitors were deployed by the State of Colorado, EPA, NOAA, and NASA. An very comprehensive data set, unprecedented in scope and magnitude, was collected and final quality controlled data will be available by the end of the year.

The C-130 conducted flights on 15 days, with dual sorties including a refueling stop on three of these days. About half of the flights were aimed at characterizing local emission sources such as transportation, oil and gas extraction and processing operations, agricultural emissions including large animal feeding operations, emissions from energy generation units, and contributions from the biosphere. There was no major influence on Front Range air quality from wildfire emissions during the study period. The other half of the flights were aimed at characterizing transport of Front Range pollution into the mountains to our west and possible recirculation of processed air driven by thermal upslope/downslope winds, as well as outflow to rural areas in the east and south of the Front Range, and large scale inflow, such as from oil and gas operations on the Colorado western slope or from other western states. Significant transcontinental transport affecting the Front Range was not observed during the study.

Below we show preliminary results from two flights highlighting two typical meteorological situations, which are frequently encountered in the Colorado Front Range and have a profound influence on local air quality. Figure 1 shows measurements taken during a Denver Cyclone event, where large scale southeasterly surface winds create a gyre, often centered over the northern end of the Denver Metro Area, keeping local emissions concentrated and recirculating over the region. Shown are the flight tracks colored by ethane mixing ratio. Ethane is an excellent tracer for oil and gas operation emissions and this shows the accumulation of these emissions in the closed, counterclockwise circulation pattern. Figure 2 shows a transport event of ozone produced over the Front Range urban areas being pushed westward into the mountains by thermally driven upslope. The flight included a low approach into Granby Airport, located west of the Continental Divide in the Fraser Valley. The measurements clearly show how Front Range ozone can impact remote areas up to the divide and into the adjacent valleys on the west side.

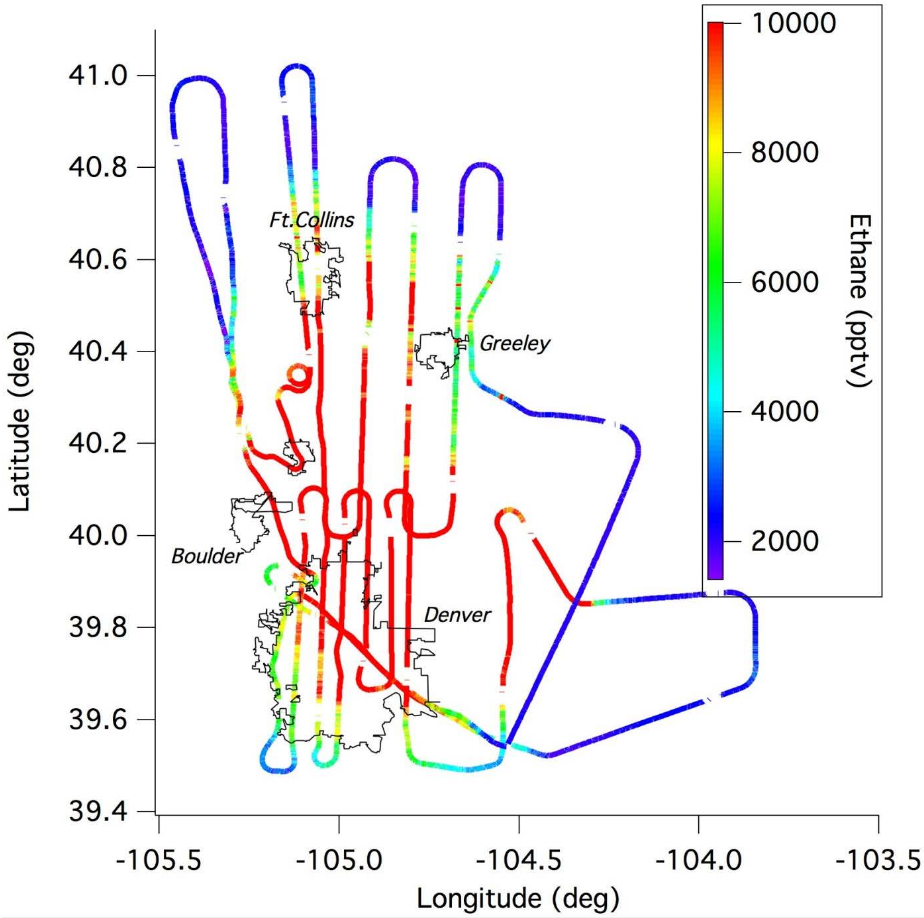

Figure 1: Ethane data obtained from the C-130 during a Denver Cyclone event.

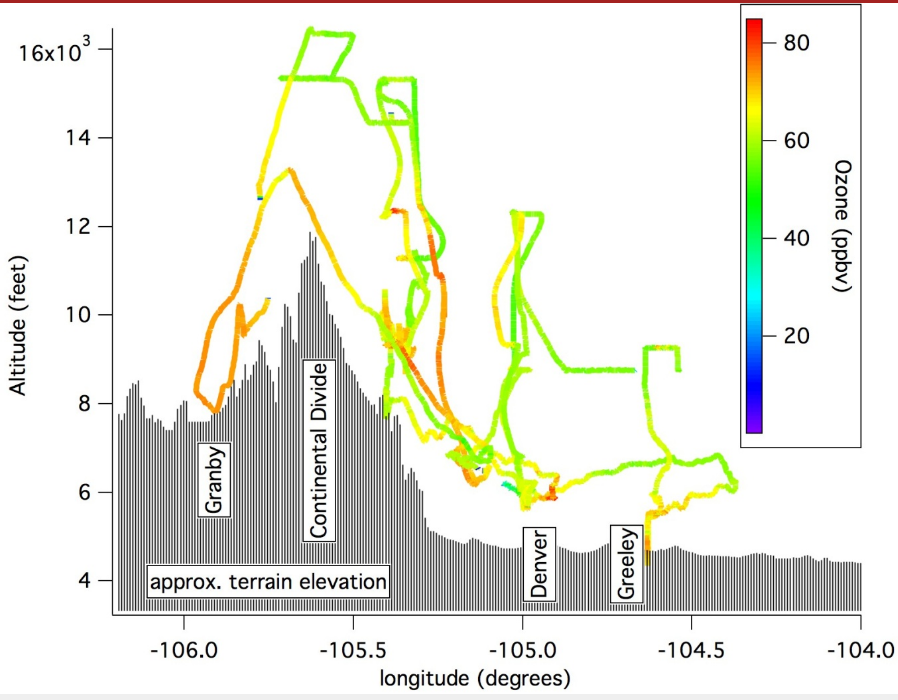

Figure 2: Ozone mixing ratios obtained from the NSF/NCAR C-130 during an 'upslope' event. The data provide evidence for transport of urban ozone to more remote areas west of the Continental Divide.

Air Quality, Climate and Cooking Technologies In Northern Ghana

Earth system with respect to weather, climate and air quality ›

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1.B. DETERMINE THE INHERENT PREDICTABILITY OF THE EARTH SYSTEM WITH RESPECT TO WEATHER, CLIMATE AND AIR QUALITY

Society continues to desire better predictions related to weather, air quality, and regional and global climate change. Further gains in prediction skill can only be assessed with the knowledge of the inherent predictability (the time beyond which the marginal benefit of forecast-error reduction relative to the cost of forecast-system improvement is negligible) of the Earth system with respect to specific predictions.

‹ 1.a.11. The Front Range Air Pollution and Photochemistry Experiment (FRAPPÉ) up 1.b.1. Identify and Model the Physical, Chemical, Biological, and Human Components that Govern the Climate System ›

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1.B.1. IDENTIFY AND MODEL THE PHYSICAL, CHEMICAL, BIOLOGICAL, AND HUMAN COMPONENTS THAT GOVERN THE CLIMATE SYSTEM

A chemistry mechanism including very short-lived (VSL) halogen species was developed to assist in the analysis of observations of ozone and halogenated compounds particularly in the marine boundary layer. A set of historical and future experiments designed to assess the potential range of permafrost-carbon feedback were simulated and found that enhanced vegetation growth due to warmer climate and CO2 fertilization will dominate Arctic terrestrial carbon response for early part of this century and that the future carbon balance of the permafrost region is highly sensitive to the decomposability of deeper carbon.

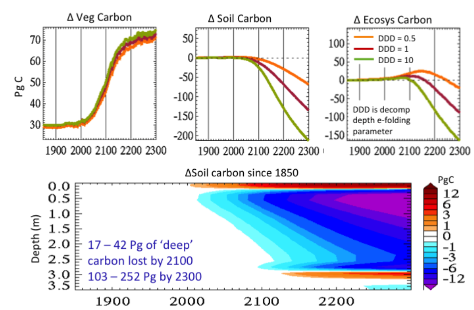

Figure: *Trajectories of changes in total ecosystem carbon, vegetation carbon, and soil carbon averaged over the 1850 permafrost domain as simulated by CLM4.5BGC. Top panels show three different curves on each plot representing differences in the key and uncertain depth decomposition parameter that controls the decomposibility of deep soil carbon. Bottom panel shows the soil carbon losses as a function of depth and time for the central decomposition parameter. CLM4.5BGC is forced with observed meteorological data for 1850-2005 and by CCSM4 RCP8.5 climate anomalies for the period 2005-2300.*

‹ 1.b. Determine the inherent predictability of the Earth system with respect to weather, climate and air quality

up

1.b.2. Understand and Model How Human Systems Influence, and are Influenced by, the Physical Climate System ›

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1.B.2. UNDERSTAND AND MODEL HOW HUMAN SYSTEMS INFLUENCE, AND ARE INFLUENCED BY, THE PHYSICAL CLIMATE SYSTEM

Substantial progress has been made on development of THESIS, a Toolbox for Human-Earth Systems Interaction and Scaling, which aims to facilitate the linking of integrated assessment and impact models to CESM to facilitate interdisciplinary research. Progress has included completion of tools for producing spatial population and land use scenarios, published in Environmental Research Letters and Ecological Modeling, respectively. An updated tool for defining building types for urban areas within the Community Land Model has also been completed. In addition, a coding and documentation design has been established in order to ensure comparability across tools, provide for interactions among them, and facilitate eventual use by the research community.

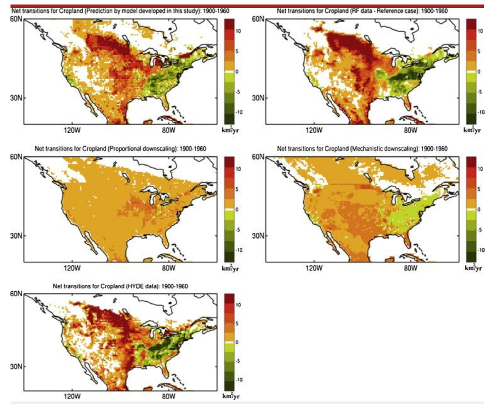

Figure: *Net transitions for cropland over the US, averaged over the period 1900–1960 based on: our land use allocation model (top-left), RF data (top-right), proportional downscaling approach (mid-left), mechanistic downscaling approach (mid-right), and HYDE 3.1 data (bottom).Units are in km^2/yr.*

The Climate and Human Systems Project (CHSP, https://chsp.ucar.edu/) has been established, has decided on goals, and has begun work on a cross-cutting interdisciplinary project comparing physical and societal impacts between two different climate change scenarios. This project now includes contributions from more than 40 NCAR researchers and eight external partners. A special issue of a journal is planned for 2015 to publish work from this project. A new multi-member ensemble of CESM climate simulations for the RCP4.5 scenario has been created in order to support impacts analysis.

‹ 1.b.1. Identify and Model the Physical, Chemical, Biological, and Human Components that Govern the Climate System   up   1.b.3. Regional Climate Research ›

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1.B.3. REGIONAL CLIMATE RESEARCH

The goal of the Regional Climate Research is to improve understanding, assessment, projection and prediction of regional climate with emphasis on the two-way effects of climate variability and change on high-impact weather and societal consequences.

Making a prediction is only part of the way to a successful outcome, as the prediction is interpreted by users within their own frameworks of risk perception and action. Our researchers are thus working with a range of communities, from Native Americans to industry and commerce, to adapt NCAR research and predictions in ways that improve the usability and use of weather and climate information. This research therefore supports community use of data and tools and directly informs climate-change-vulnerability assessments and adaptation and mitigation planning.

In FY2014, NESL scientists developed combined dynamical-statistical tools to assess potential future changes in high-impact weather. Specifically, WRF regional climate-model output was combined with extreme-value distributions to obtain future changes to the most extreme winds in the climate system. This technique was also applied to assess extremes of hurricane-damage potential for a range of societal groups. To assess uncertainty an ensemble of 24 different versions of the WRF model was used to assess credible bounds on current climate. In addition, the first successful regional climate simulations using the Model for Prediction Across (MPAS) were completed.

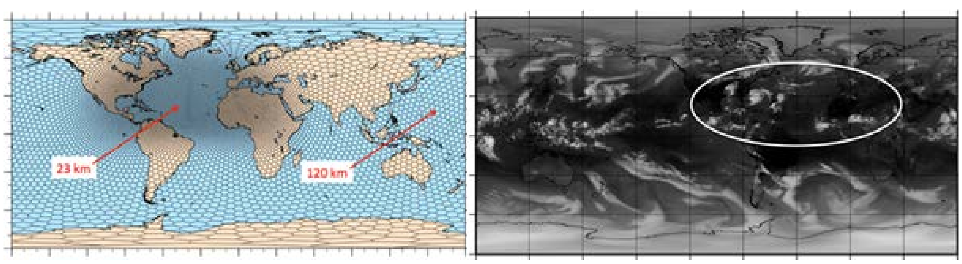

Figure: Variable global MPAS mesh (left panel, Bill Skamarock, NCAR) used for the simulation of the 2005 North Atlantic hurricane season (snapshot in right panel, source: Atsushi Hashimoto, CRIEPI).

To provide community support for regional climate modeling along the lines of the WRF support effort, a regional climate tutorial was held at NCAR on July 30, 2014. This daylong event covered dynamical modeling, statistical modeling, data visualization and applications, and attracted approximately 40 participants from diverse backgrounds including academia, governmental organizations and for-profit industries. A help desk fielded technical questions from the community on running WRF for regional climate research. A new suite of bias corrected driving data for regional climate models has been released to the community and made freely available to download from the NCAR research data archive.

‹ 1.b.2. Understand and Model How Human Systems Influence, and are Influenced by, the Physical Climate System | up | 1.b.4. The effect of dry and wet deposition of condensable organic gases on SOA regional mass ›

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1.B.4. THE EFFECT OF DRY AND WET DEPOSITION OF CONDENSABLE ORGANIC GASES ON SOA REGIONAL MASS

Removal of secondary organic aerosols (SOA) from the atmosphere has been studied far less than its counterpart, production. In current regional and global chemistry models rainout is the dominant loss of SOA. Here we show the importance of a less direct pathway, in which large-scale evaporation of SOA particles occurs as a re-adjustment to gas-particle partitioning when semi-volatile organic gases are lost by dry deposition to the Earth's surface. Our work also illustrates the unique benefits of explicit aerosol modeling for improving NCAR regional and climate models.

The SOA particles are formed from the condensation of oxidized low-volatility organic gases that are intermediates in the atmospheric oxidation of biogenic and anthropogenic hydrocarbons. This complex chemistry is being mapped with the Generator of Explicit Chemistry and Kinetics of Organics in the Atmosphere (GECKO-A) model built collaboratively at NCAR and the University of Paris. The GECKO-A model uses chemical reaction pathways and their kinetics from compilations of laboratory measurements where possible, and extends these with estimations based on structure-activity relations for molecules where no measurements exist. The explicit chemical nature of the molecules is retained, and can be used to estimate additional properties including chemical reactivity, optical properties, and thermodynamic properties such as vapor pressures, and Henry's law solubility coefficients.

In particular the water solubility of organics is poorly constrained in 3D models, although it is a key parameter for the estimation of gaseous dry deposition. Dry deposition actually refers to the deposition of a (dry) gas onto a surface which is often wet (e.g. surface waters, stomata and moist vegetation), and so the Henry's law solubility often determines the fate of the molecules striking the surface. Using GECKO-A, we were able to calculate Henry's law solubility coefficients for the myriad of semi-volatile organic products, and showed that they correlate well with vapor pressures. These correlations were implemented in a regional chemistry model, WRF-Chem, to examine the influence of SOA dry deposition. The results are shown in Figure 1, separately for anthropogenic and biogenic hydrocarbon precursors. For the case studies, dry deposition was found to be a major loss pathway for SOA, indicating that a large fraction of the SOA is removed well before encounter with cloud and eventual rainout. Averaged over the contiguous U.S., dry deposition accounts for about a factor of two reduction in surface SOA particle concentrations, while wet deposition is far less important than previously assumed.

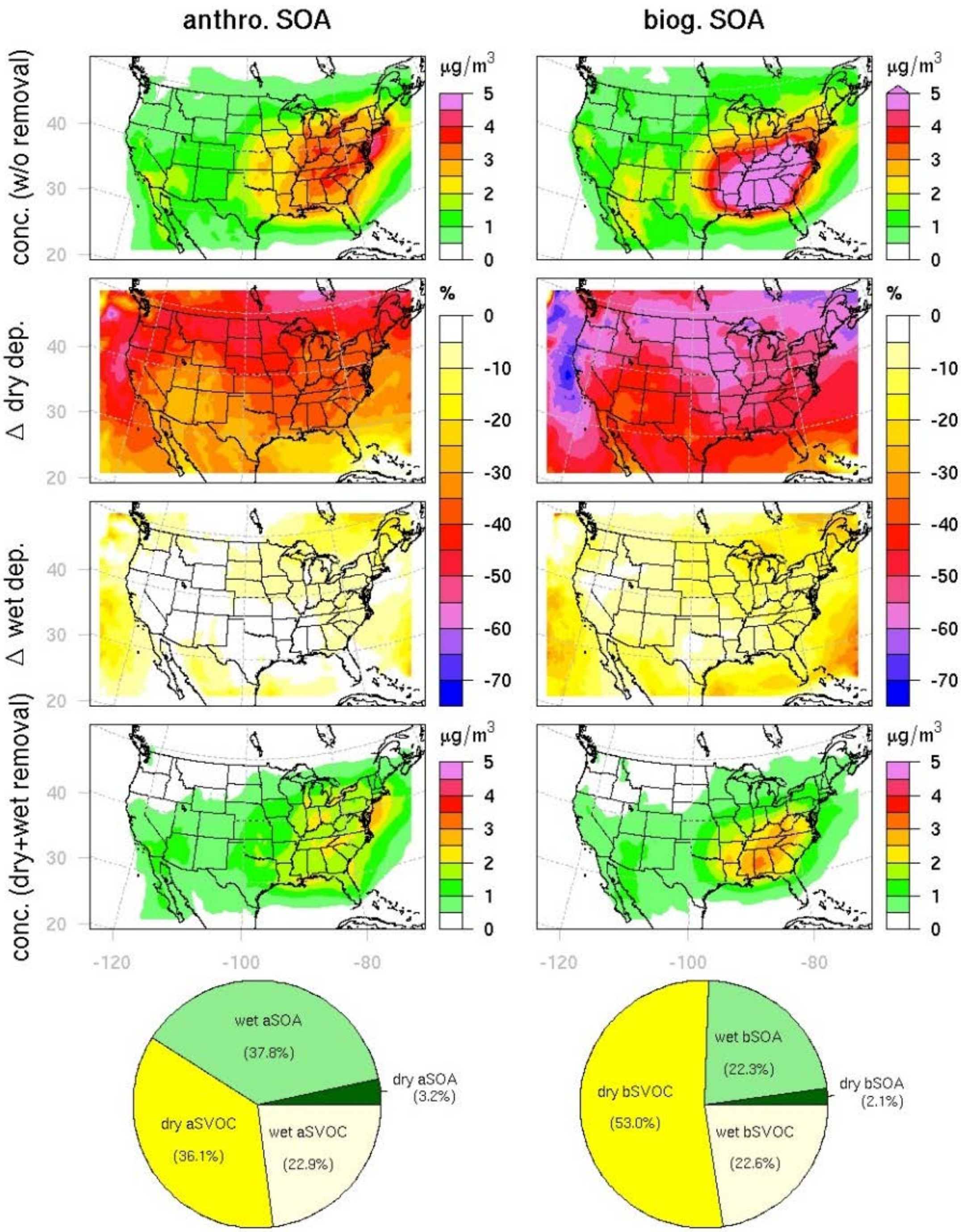

Figure 1: Contribution of different depositional processes to the budget of SOA over the United States. Top and bottom maps show surface SOA concentrations, before and after including dry deposition of the gases. The relative importance of dry and wet deposition is shown in the four middle maps and is also summarized in the pie charts.

REFERENCES:

Hodzic A., et al, 2014. "Volatility dependence of Henry's law constants of condensable organics: Application to estimate depositional loss of secondary organic aerosols." *Geophys. Res. Lett.*, **41**, doi: 10.1002/2014GL060649.

Knote, C., et al., 2014. The effect of dry and wet deposition of condensable vapors on secondary organic aerosols concentrations over the continental US, *Atmos. Chem. Phys. Discuss.*, **14**, 13731-13767, doi:10.5194/acpd-14-13731-2014.

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1.B.5. HIGHLIGHTS FROM THE DEEP CONVECTIVE CLOUDS AND CHEMISTRY (DC3) FIELD CAMPAIGN

The DC3 field campaign, co-led by investigators from NCAR, Penn State University and Colorado State University, took place is spring/summer 2012. The campaign, involving both instrumented aircraft flights and ground-based measurements, investigated the impact of deep, mid-latitude continental convective clouds on upper tropospheric (UT) composition and chemistry. A primary motivation of DC3 is in determining the role of these convective events on the concentration of ozone in the UT, where ozone acts as a greenhouse gas. The aircraft (NSF/NCAR G-V, NASA DC8 and DLR Falcon) were based in Salina, Kansas, while networks of ground-based instrumentation were deployed in Colorado, Oklahoma and Alabama in support of the project. Analysis of campaign data analysis has highlighted the following results.

One of the goals of DC3 is to characterize the processing of chemical constituents by thunderstorms. The 22 June 2012 case study in northeastern Colorado provided the opportunity to contrast the composition of the anvil outflow from a storm ingesting a wildfire smoke plume to that without fresh smoke emissions. Figure 1 shows the satellite imagery of the two storms and the smoke plume as well as the flight tracks of the GV and DC-8 aircraft. A biomass burning tracer of fresh smoke emissions, acrolein, is shown to have very high values in the outflow of the northern storm (purple oval area) compared to the southern storm. CO mixing ratios are also generally higher in the northern storm outflow, but NO mixing ratios are much higher in the southern storm outflow because of the greater lightning activity of the southern storm. Box model calculations were done to examine the potential ozone production, and show that the two storms produced about the same amount of ozone, 7 ppbv over 24 hours and 11-12 ppbv over 48 hours, despite the greater concentrations of volatile organic compounds in the northern storm outflow compared to the southern storm. These results suggest that the additional VOCs in the outflow were not enough to generate more ozone, and that the amount of NOx in the storm outflow regions is also very important.

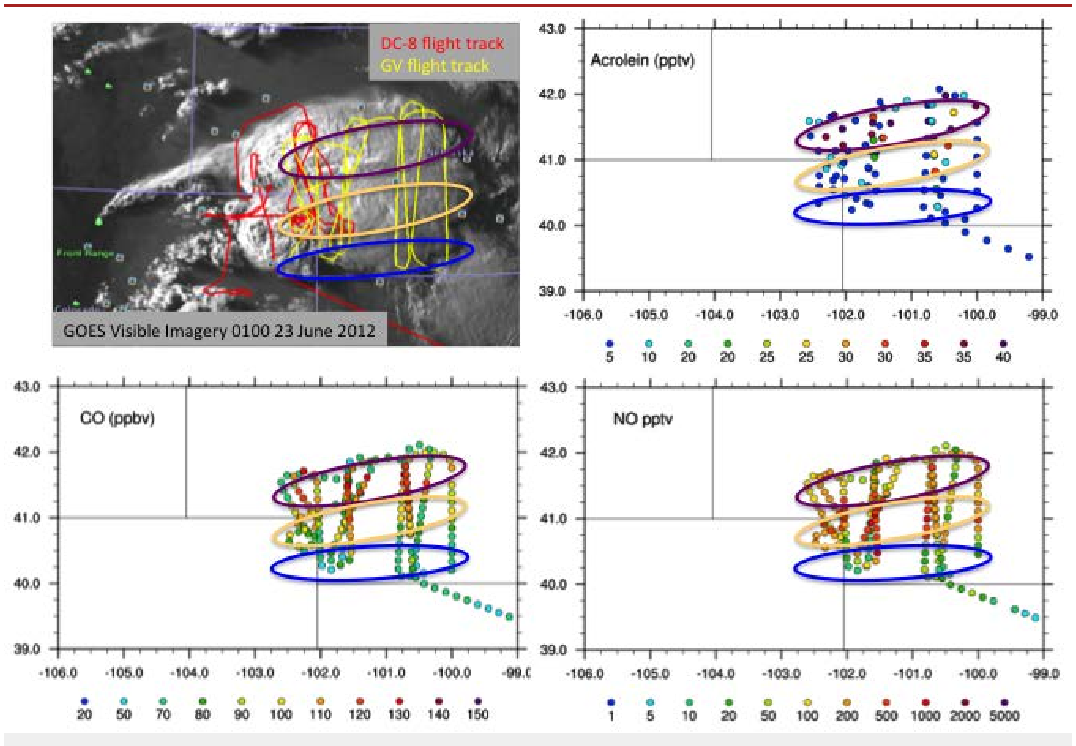

Figure 1. Flight tracks from the 22 June 2012 DC3 Smoke Ingestion Case. Top left panel shows the DC-8 (red) and GV (yellow) flight tracks overlaid on the visible satellite imagery (the smoke plume originates at the green dot). Two thunderstorms are evident, the northern storm in western Nebraska ingesting the smoke plume, and the southern storm in northeast Colorado. Top right panel shows mixing ratios from a biomass-burning marker of fresh emissions, acrolein, with high mixing ratios measured from the northern storm. Lower left panel shows CO mixing ratios with generally higher values from the northern storm. Lower right panel shows NO mixing ratios with higher values from the southern storm, which had more lightning occurring during this time period. The region outlined in purple is the outflow area of the northern storm, in gold is the outflow area of the southern storm, and in blue the background upper troposphere.

Another DC3 highlight is the unequivocal evidence of stratospheric air wrapping around anvils of mesoscale convective systems. Airborne lidar observations (Figure 2) show that deep convective thunderstorms over the central US enhance tropospheric ozone by entraining ozone-rich air from the stratosphere. The fine-scale transport from the stratosphere may be a significant source of upper troposphere ozone complementing the in situ production of ozone in convective outflow regions. However, this fine-scale transport poses a significant challenge to global models that do not resolve storm scale dynamics, yet it is important to include such a representation because of the effect of ozone in the upper troposphere on the atmospheric radiation budget and on the oxidizing potential of the troposphere since ozone is the source of highly reactive oxidants.

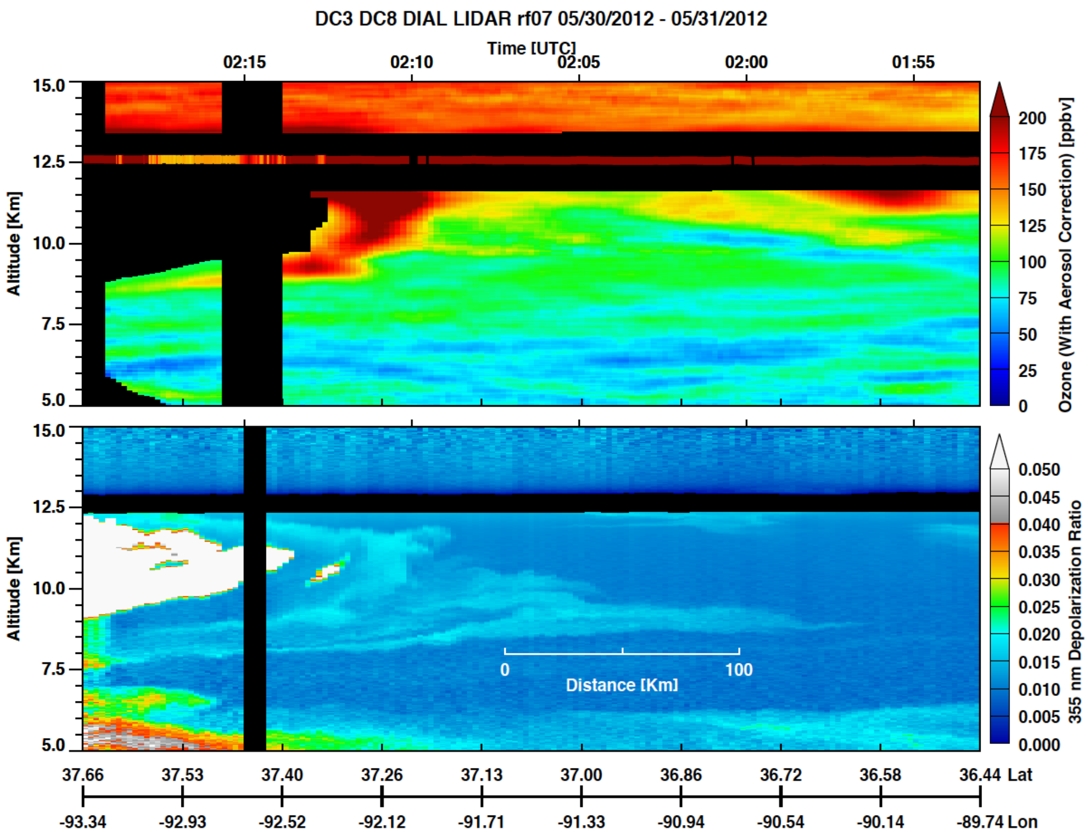

Figure 2. The vertical distribution of upper tropospheric ozone mixing ratio (upper) measured by DIAL along approximately 30 minutes (~ 400 km in distance) of the DC-8 flight. Note the cross section is shown in reversed time scale to illustrate the cross section from west to east. The black color indicates the region when the DIAL ozone channel produced no data due to cloud attenuation. In situ ozone is shown by the color of the flight track. The depolarization ratio (lower panel) from the DIAL 355 nm wavelength channel provides a signature of cloud/storm edge and outflow pattern in the neighborhood of the storm. The outflow structure shown in light blue is most consistent with low number density of ice particles, which complements the stretching and shedding shown in the ozone structure (upper panel).

‹ 1.b.4. The effect of dry and wet deposition of condensable organic gases on SOA regional mass   up   1.b.6. CONvective TRansport of Active Species in the Tropics (CONTRAST) Experiment ›

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1.B.6. CONVECTIVE TRANSPORT OF ACTIVE SPECIES IN THE TROPICS (CONTRAST) EXPERIMENT

In collaboration with colleagues from six universities, NCAR ACD scientists successfully conducted a large field campaign over the western Pacific in early 2014, using the NSF/NCAR Gulfstream V (GV) research aircraft. The airborne study was operated from Guam, and included the coordinated participation of two other research aircraft, the NASA Global Hawk (GH) and the UK BAe146. The three research aircraft each focused on its preferred sampling altitude range. The NASA GH targeted the upper troposphere and lower stratosphere between 15 and 20 km. The BAe164 mainly sampled from the marine boundary layer (100 meters above sea level) to around 8 km. The GV targeted the full altitude range between 100 meters to 15 km above sea level. Together, the three aircraft obtained unprecedented chemical information from the oceanic boundary layer to the lower stratosphere over the western pacific during the NH winter, at the time and location where the most massive deep convection on Earth occurs. This convection acts as a global chimney, imparting a global impact to the local marine boundary layer emissions.

Figure 1 gives an example highlighting the success of the coordinated flights. The figure shows the total short-lived organic bromine (a combination of bromoform, $CHBr_3$ and dibromomethane, CH_2Br_2) measured by the TOGA instrument on the GV and three Whole Air Samplers (WASs), one on each platform. These organic bromine species are products of oceanic biology. They are relatively short-lived, and their abundances decrease with altitude in general. If lifted to the upper troposphere, they will play a significant role in chemically destroying ozone, as shown by recent study using NCAR CAM-Chem model (Saiz-Lopez et al., 2011). The observed significant enhancement at 12-15 km level indicates the impact of deep convection on the distribution of these active species. The example highlights that persistent deep convection is a key process (“elevator”) connecting oceanic biology to global ozone chemistry.

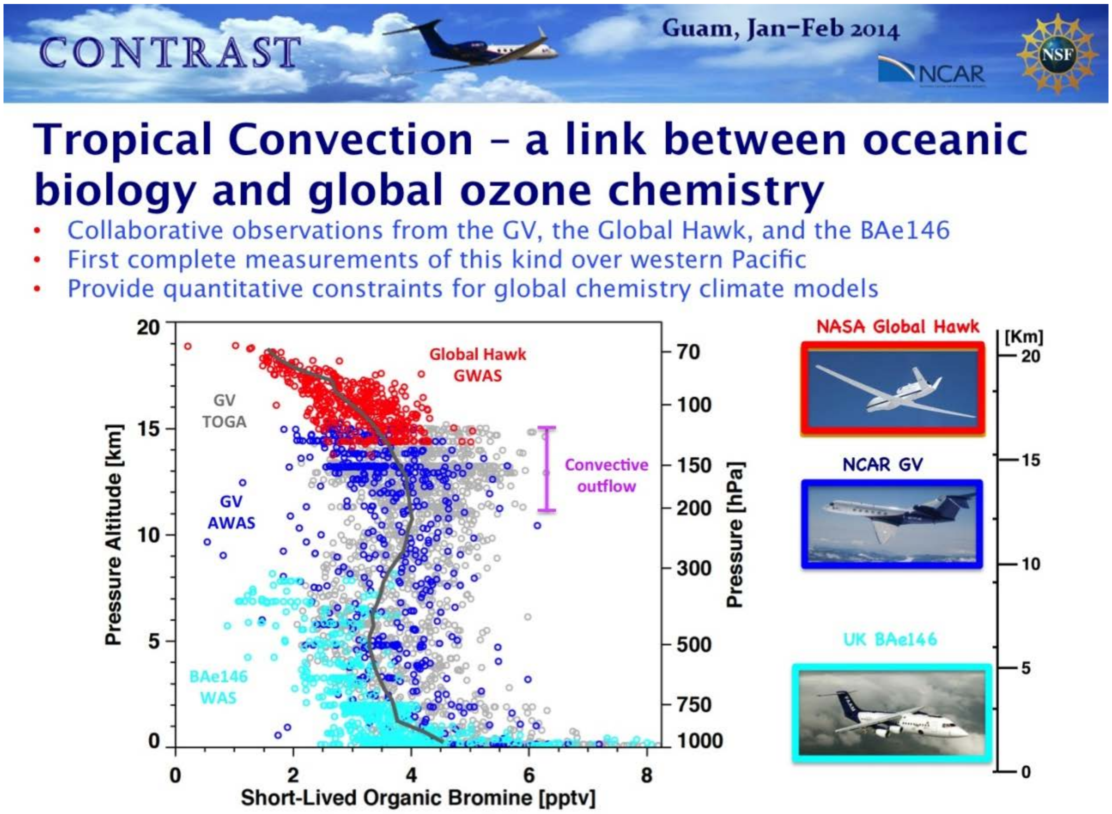

Figure 1. Composite profile of the total short –lived organic Bromine, defined as 2 x CH_2Br_2 + 3 x $CHBr_3$. The data are from four different instruments on three platforms, as labeled and color-coded. The gray line shows the median of all data points.

To predict the impact of climate change on ozone chemistry, these processes need to be represented correctly in chemistry-climate models (CCMs). The CONTRAST experiment obtained a significant dataset for evaluating and constraining the CCMs.

REFERENCE

Saiz-Lopez, A., et al., Estimating the climate significance of halogen-driven ozone loss in the tropical marine troposphere, Atmos. Chem. Phys., 12, 3939-3949, doi:10.5194/acp-12-3939-2012, 2012.

‹ 1.b.5. Highlights from the Deep Convective Clouds and Chemistry (DC3) Field Campaign | up | 1.b.7. Simulation of the chemistry of very-short lived halogen species with CAM-Chem during CONTRAST ›

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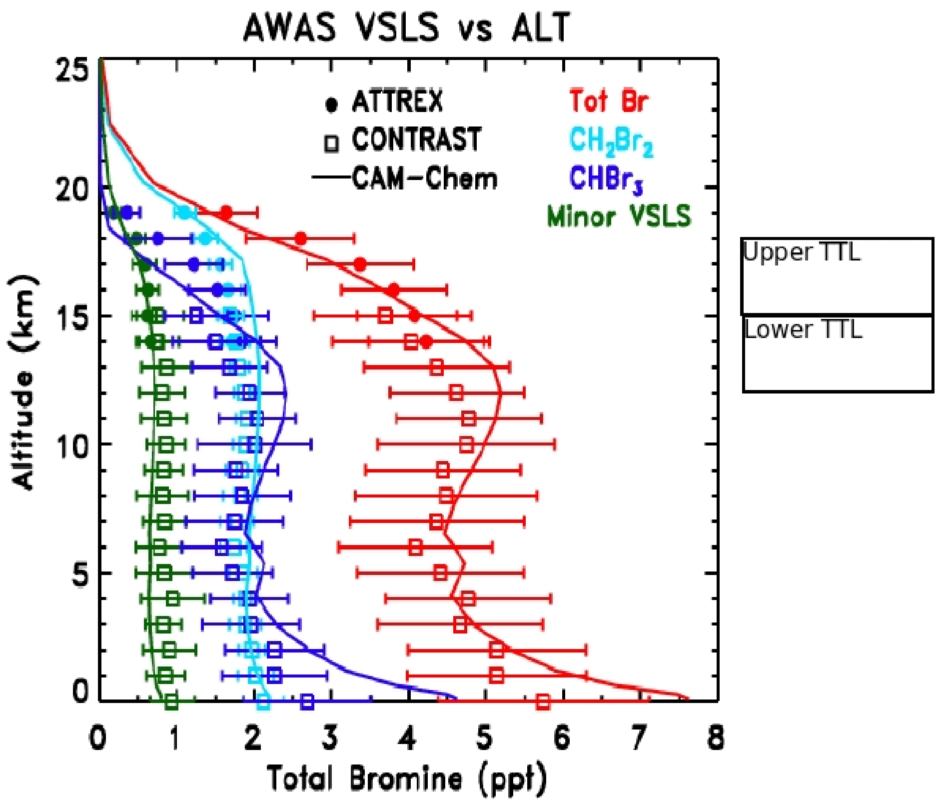
1.B.7. SIMULATION OF THE CHEMISTRY OF VERY-SHORT LIVED HALOGEN SPECIES WITH CAM-CHEM DURING CONTRAST

In support of the CONTRAST campaign, the CAM-Chem model (which is the version of CESM in which chemistry is explicitly computed and interacts with the generated meteorology, Lamarque et al., 2012) has been extensively modified to include the representation of short-lived halogens species. This work, done in collaboration with scientists from Spain (see below), includes a representation of their emissions (mostly in association with biological processes in the ocean, Ordonez et al., 2012) and their chemistry (Saiz-Lopez et al., 2012; Fernandez et al., 2014; Prados-Roman et al., 2014; Saiz-Lopez et al., 2014). As a result, during the whole CONTRAST campaign, the CAM-Chem team at NCAR provided 3-day forecasts of the full chemical state of the atmosphere, including distributions of halogens that would eventually be measured. This capability was used extensively for flight planning and flight re-routing to maximize the opportunities of flying through air masses of interest. The analysis of the CAM-Chem results (see Figure) indicates the overall validity of the model and supports their use for complementing the new understanding provided by the observations.



AWAS VSLS vs. ALT

This comparison is the result of the collaboration of three teams:

1. AWAS Data: Elliot Atlas, Richard Lueb, Maria Navarro, Valeria Donets (U. Miami), Sue Schauffler (NCAR)

2. CAM-Chem Model: Rafael Fernandez, Alfonso Saiz-Lopez, Xavier Rodriguez (Madrid, Spain), Doug Kinnison, Jean-François Lamarque, Simone Tilmes, and Francis Vitt (NCAR)
3. Data/Model Analysis: Julie Nicely, Ross Salawitch (U. Maryland)

REFERENCES

Lamarque, J.-F., et al., *Geosci. Mod. Dev.*, **5**, 369-411, doi:10.5194/gmd-5-369-2012, 2012.

Ordóñez, C., et al., Bromine and iodine chemistry in a global chemistry-climate model: Description and evaluation of very short-lived oceanic sources. *Atmos. Chem. Phys.*, **12**, 1423-1447, 2012.

Saiz-Lopez, A., et al., Estimating the climate significance of halogen-driven ozone loss in the tropical marine troposphere. *Atmos. Chem. Phys.*, **12**, 3939–3949, doi:10.5194/acp-12-3939-20122012, 2012.

Fernandez, R. P., et al., Bromine partitioning in the tropical tropopause layer: implications for stratospheric injection. *Atmos. Chem. Phys. Disc.*, 14, 17857-17905, 2014.

Prados-Roman, C., et al., A negative feedback between anthropogenic ozone pollution and enhanced ocean emissions of iodine. Submitted for publication in *Atmos. Chem. Phys. Disc.*, 2014.

Saiz-Lopez, A., et al., Iodine chemistry in the troposphere and its effect on ozone, *Atmos. Chem. Phys. Disc.*, 14, 19985-20044, doi:10.5194/acpd-14-19985-2014, 2014.

‹ 1.b.6. CONvective TRansport of Active Species in the Tropics (CONTRAST) Experiment | up | 1.b.8. Climate change threatens to worsen U.S. ozone pollution ›

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1.B.8. CLIMATE CHANGE THREATENS TO WORSEN U.S. OZONE POLLUTION

High resolution simulations of current and future air quality over the contiguous U.S. have been conducted as part of an NCAR Accelerated Scientific Discovery (ASD) project to estimate changes in surface ozone over the summertime U.S. between present and a 2050 future time period under the A2 climate and Representative Concentration Pathway (RCP) 8.5 anthropogenic precursor emission scenarios.

Using the fully coupled regional chemistry-transport model WRF-Chem, thirteen summers for each of present time and two future time scenarios were simulated. The two scenarios allow for separation of the impacts of changes in climate from changes in emissions. In one scenario, emissions of nitrogen oxides and volatile organic compounds from human activities were assumed to continue at current levels through 2050. In the other, emissions would be cut by 60-70 percent. Both scenarios assumed continued greenhouse gas emissions with significant warming.

Predicted changes in regional climate and globally enhanced ozone are estimated to increase surface ozone over most of the U.S.; the 95th percentile for daily 8 h maximum surface ozone increases from 79 ppb to 87 ppb. The analysis suggests that changes in meteorological drivers likely will add to increasing ozone, but the simulations do not allow separating meteorological feedbacks from that due to enhanced global ozone. Stringent emission controls can counteract these feedbacks; if implemented as in RCP8.5, the 95th percentile for surface ozone is reduced to 55 ppb. A comparison of regional to global model projections with similar emission projections shows that the global model is biased high in surface ozone compared to the regional model and compared to observations. On average, both the global and the regional model predict similar future changes but reveal pronounced differences in urban and rural regimes that cannot be resolved at the coarse resolution of the considered global model.

This study confirms the key role of emission control strategies in future air quality projections and demonstrates the need for considering degradation of air quality with future climate change in policy making. It also illustrates the need for high-resolution modeling when the objective is to address regional and local air quality or establish links to human health and society.

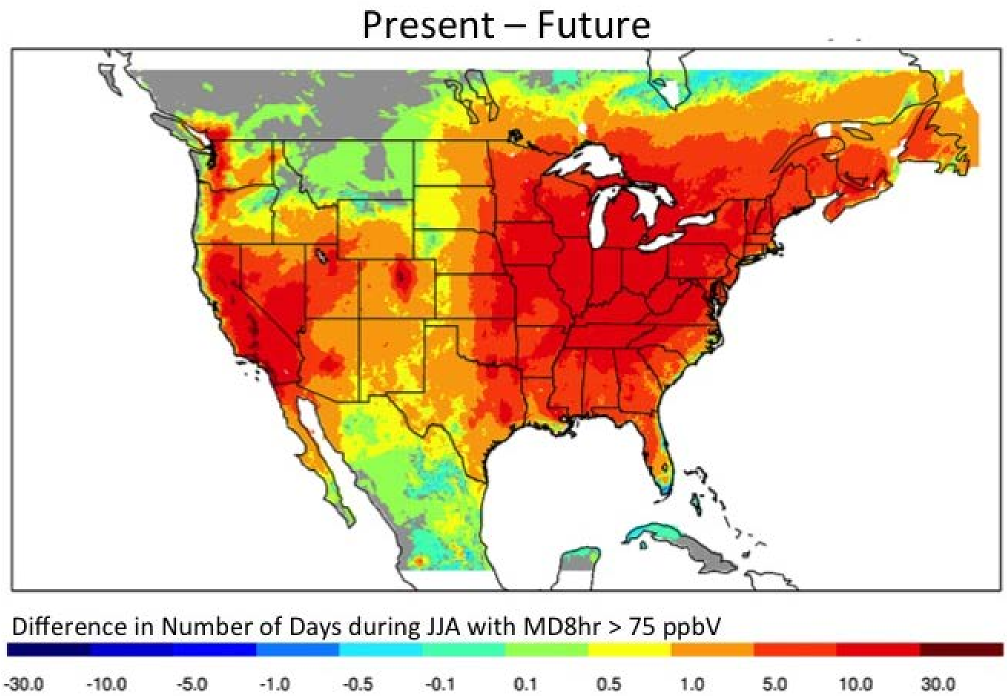

Figure 1: Change in number of days during June-August with 8-hour maximum surface ozone exceeding the current National Health Standards of 75 ppbV between present and future due to changes in climate only.

‹ 1.b.7. Simulation of the chemistry of very-short lived halogen species with CAM-Chem during CONTRAST   up   1.b.10. Determining the source of new aerosol particles in the Amazon rainforest ›

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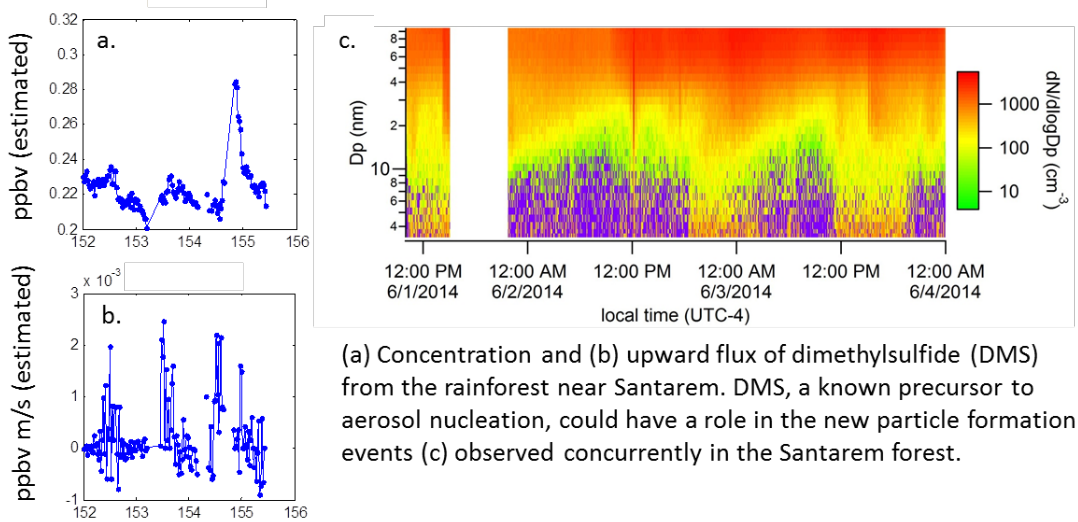
1.B.10. DETERMINING THE SOURCE OF NEW AEROSOL PARTICLES IN THE AMAZON RAINFOREST

Scientists from the Ultrafine Aerosols group in ACD have been spending most of the past year in the Amazon basin of Brazil as participants in the Green Ocean Amazon (GOAmazon) Experiment. GoAmazon is the largest field study devoted to the understanding of atmospheric composition in the Amazon, with several ground sites as well as deployments of the Department of Energy's G-1 and the German Aerospace Center (DLR) HALO GV aircraft. ACD scientists are part of research team that is focusing on understanding the processes that control the source of aerosol particles in the Amazon. They are currently operating instruments for measuring gas-phase organic compounds, sulfuric acid and OH, and nanoparticle size and chemical composition.

One of the most interesting preliminary results is the observation that dimethylsulfide, or DMS, is emitted from the forest canopy (Figure 1a and 1b). If additional analysis of our data shows this to be correct, it could explain the relatively weak but frequent new particle formation events, such as those shown in Figure 1c from the same days as these DMS observations. DMS, a compound commonly associated with ocean emissions, is a precursor for sulfuric acid - a powerful agent for producing new particles in the atmosphere.



(a) Concentration and (b) upward flux of dimethylsulfide (DMS) from the rainforest near Santarem. DMS, a known precursor to aerosol nucleation, could have a role in the new particle formation events (c) observed concurrently in the Santarem forest.

Figure 1. Emissions from the forest canopy.

‹ 1.b.8. Climate change threatens to worsen U.S. ozone pollution

up

1.c. Identify and model the processes and interactions that govern climate variability on timescales long enough for forcing to dominate over initial conditions ›

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1.C. IDENTIFY AND MODEL THE PROCESSES AND INTERACTIONS THAT GOVERN CLIMATE VARIABILITY ON TIMESCALES LONG ENOUGH FOR FORCING TO DOMINATE OVER INITIAL CONDITIONS

The long term evolution of climate is influenced both by the response of the climate system to anthropogenic forcing and also by a wide range of Earth system feedbacks involving, for instance, interactions between the marine and terrestrial biosphere and the changing atmospheric composition. NESL scientists are working to reduce uncertainties by improving the simulation of the response of the climate system to altered radiative forcing by greenhouse gases and aerosols.

‹ 1.b.10. Determining the source of new aerosol particles in the Amazon rainforest | up | 1.c.1. Predict the Time-Evolution of Global and Regional Climate by Considering More Climate-System Components than just the Atmosphere ›

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1.C.1. PREDICT THE TIME-EVOLUTION OF GLOBAL AND REGIONAL CLIMATE BY CONSIDERING MORE CLIMATE-SYSTEM COMPONENTS THAN JUST THE ATMOSPHERE

A CESM Large Ensemble (CESM-LE) was run with the explicit goal of enabling assessment of climate change in the presence of internal climate variability. All CESM-LE simulations use a single CMIP5 model (CESM with the Community Atmosphere Model version 5). The core simulations replay the 20-21st century (1920-2100) 30 times under historical and Representative Concentration Pathway 8.5 external forcing with small initial condition differences. Two companion 1000+-year long pre-industrial control simulations (coupled, atmospheric) allow assessment of internal climate variability in the absence of climate change.

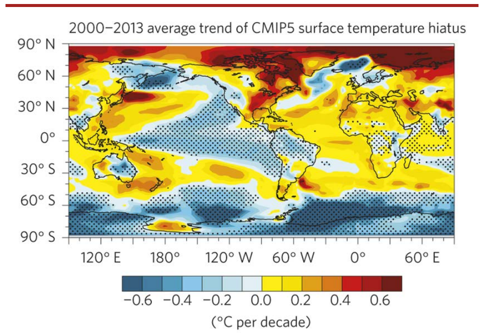

Figure: *A set of 262 model simulations for the last century that were assessed in the most recent IPCC report show the long-term warming trend produced by greenhouse gases, along with short-term trends produced by natural variability. A total of 10*

Early results from the Large Ensemble demonstrate the substantial influence of internal climate variability on 20th-21st century climate trajectories. Global warming hiatus decades occur, similar to those recently observed. Internal climate variability alone can produce projection spread comparable to that in CMIP5. The slow-down in the rate of global warming in the early-2000s is not evident in the multi-model ensemble average of traditional climate change projection simulations. However, a number of individual ensemble members from

that set of models successfully simulate the early-2000s hiatus when naturally-occurring climate variability involving the Interdecadal Pacific Oscillation (IPO) coincided, by chance, with the observed negative phase of the IPO that contributed to the early-2000s hiatus. The hiatus has also been linked to heat being deposited deeper into the oceans, especially in the Atlantic and southern oceans both observationally and in climate models, with clear indications that initialized coupled models might have predicted the hiatus.

simulations randomly produced variations for the period 2000–2013 that were similar to those actually observed during this period. Above is a map showing trends in sea surface temperature for those 10 model runs, with the characteristic cooling evident across the tropical Pacific. (Image courtesy Nature Climate Change.)

If the recent methodology of initialized decadal climate prediction could have been applied in the mid-1990s using the CMIP5 multi-models, both the negative phase of the IPO in the early 2000s as well as the hiatus could have been simulated, with the multi-model average performing better than most of the individual models. The loss of predictive skill for six initial years prior to the mid-1990s points to the need for consistent hindcast skill to establish reliability of an operational decadal climate prediction system. Compared to uninitialized climate change projections, a multi-model ensemble from the CMIP5 ten-year decadal prediction experiments produces more warming during the mid-1970s climate shift and less warming in the early 2000s hiatus in both the tropical Indo-Pacific region and globally averaged surface air temperature. One contributing factor for the improved climate simulation is the bias adjustment, which corrects the models' systematic errors and higher-than-observed decadal warming trend. Another factor is the constraint of the ocean conditions through initialization with observations.

‹ 1.c. Identify and model the processes and interactions that govern climate variability on timescales long enough for forcing to dominate over initial conditions

up

1.c.2. Data Assimilation ›

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1.C.2. DATA ASSIMILATION

Data assimilation provides initial conditions for forecasts and thus is an essential component of any forecasting system. Because it routinely and systematically compares model predictions to large and diverse observational data sets, data assimilation also has a central role in the continued improvement and refinement of the forecast model, for example by identifying model biases. Moreover it can inform improvements to the observational network through observing-system simulation experiments. NESL is recognized for its unique expertise in modeling, assimilation and observing of mesoscale and convective processes and for advancing high-resolution prediction.

In FY2014, NCAR staff continued to support WRFDA and WRF/DART for the community, with WRFDA support including a help desk answering email questions and covering both the four-dimensional variational (4DVar) capabilities and a full suite of radiance observations. The interfaces for an MPAS ensemble Kalman filter are now available to the community in the latest DART release.

In addition, the WRFDA 4DVar was tested successfully for real-time radar data assimilation during the STEP Hydromet Prediction Experiment during August 2014. Development continued for novel approaches to cloud analysis, such as first analyzing a set of displacements that will align the clouds in the background forecast with those observed. Initial assimilation experiments using the variable-resolution capability of MPAS were completed.

NCAR scientists also continued fundamental research in data assimilation. This included techniques that account for nonlinearity and non-Gaussianity, which provide bias correction and parameter estimation and account for forecast-model error. Particle filters offer a fully non-parametric and non-Gaussian approach to data assimilation. Existing bounds on the performance of particle filters were extended to show that even particle filters employing importance sampling in its cleverest form still suffer from the need for ensemble sizes that grow exponentially with the problem size. It appears that some form of spatial localization, similar to that used in the EnKF, will be essential if particle filters are to be successful in many geophysical applications.

‹ 1.c.1. Predict the Time-Evolution of Global and Regional Climate by Considering More Climate-System Components than just the Atmosphere   up   1.c.3. Convective Weather Prediction ›

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Select year

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1.C.3. CONVECTIVE WEATHER PREDICTION

An important component of WRF development has been experimental explicit convective weather forecasts (3km grid resolution, extending to forecast lead times of 48h) covering much of the continental United States to better establish the capabilities and limitations of such high-resolution numerical guidance. These forecast exercises have been instrumental in documenting forecast sensitivities and biases for the wide range of physics options generally applied for convective applications, and have especially highlighted initial condition uncertainty as a major contributor to significant convective forecast errors. In light of this, modeling efforts have expanded to develop improved sets of analyses and subsequent forecasts using the ensemble Kalman filter (EnKF) data assimilation system from the CISL WRF/DART system. The use of such high-resolution (3km grid interval) ensembles for convective applications also allows for the development of probabilistic approaches to severe weather forecasting.

During FY2014, efforts were focused on convection-permitting ensemble forecast system design, emphasizing the improvement of 1) the ensemble initial state, 2) specification of lateral boundary conditions, and 3) the representation of model error. For this study, the ensemble initial state and boundary conditions were drawn from a WRF/DART analysis. The sufficiency of the WRF/DART ensemble analysis as a foundation for ensemble forecasts was demonstrated in Schwartz et al. (2014). Additionally, Romine et al. (2014) found that the inclusion of a model error scheme can significantly improve the reliability of convection-permitting ensemble forecasts, with the Stochastic Kinetic Energy Backscatter Scheme (SKEBS)

having the most consistent contribution to increasing ensemble spread while preserving ensemble mean skill.

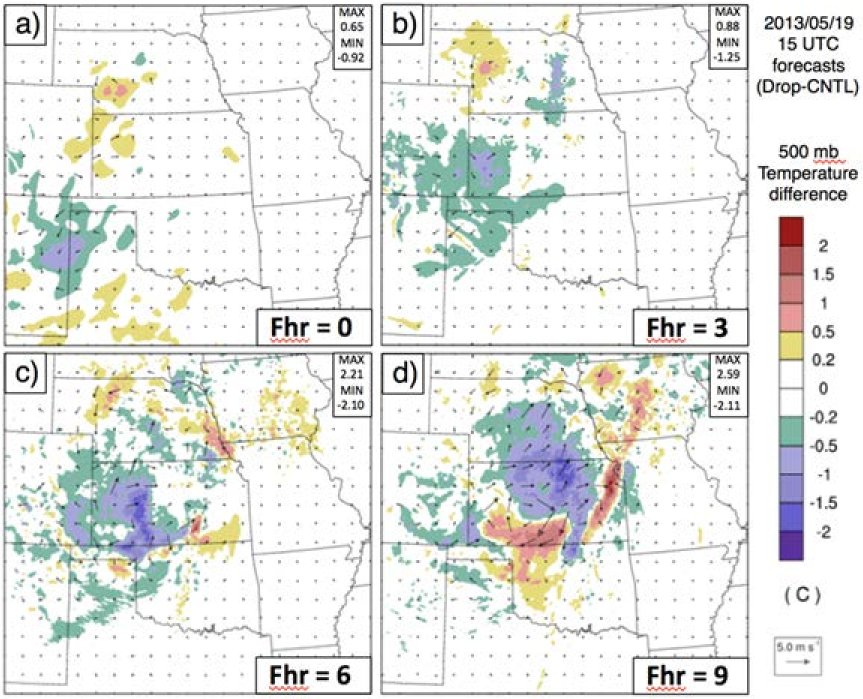

Figure: Difference in ensemble mean temperature (contour fill) and winds (vectors) at 500 mb between the analysis (a) and ensemble forecasts (every 3 h; b-d) with and without assimilating dropsondes via the WRF/DART analysis system. The initial cold perturbation in eastern New Mexico is shown to amplify in spatial extent and perturbation magnitude as the forecast evolves, highlighting the sensitivity in forecast evolution from changing the initial condition state by assimilating dropsonde observations

‹ 1.c.2. Data Assimilation | up | 1.c.4. WACCM Model Simulates Global Environmental Effects of a Regional Nuclear War ›

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1.C.4. WACCM MODEL SIMULATES GLOBAL ENVIRONMENTAL EFFECTS OF A REGIONAL NUCLEAR WAR

The NCAR Community Earth System Model with the Whole Atmosphere Community Climate Model (WACCM) was used to simulate a regional nuclear conflict between India and Pakistan. In the modeled scenario, the resulting firestorms would generate 5 Tg of smoke in the form of black carbon (BC) which self-lofts to the stratosphere and spreads globally. The BC would remain in the stratosphere, reducing solar fluxes to the surface for nearly 2 decades, much longer than previous studies of the same scenario with other models, due to interaction of the radiation, chemistry, and dynamics calculated in the coupled model. Surface temperatures and precipitation are reduced for more than 25 years, due to thermal inertia and albedo effects in the ocean and expanded sea ice. At the same time, intense heating of the stratosphere would cause global ozone losses of 20%-50% over populated areas. The summer enhancements in damaging ultraviolet radiation of 30%-80% over mid-latitudes, suggest there would be widespread damage to human health, agriculture, and terrestrial and aquatic ecosystems.

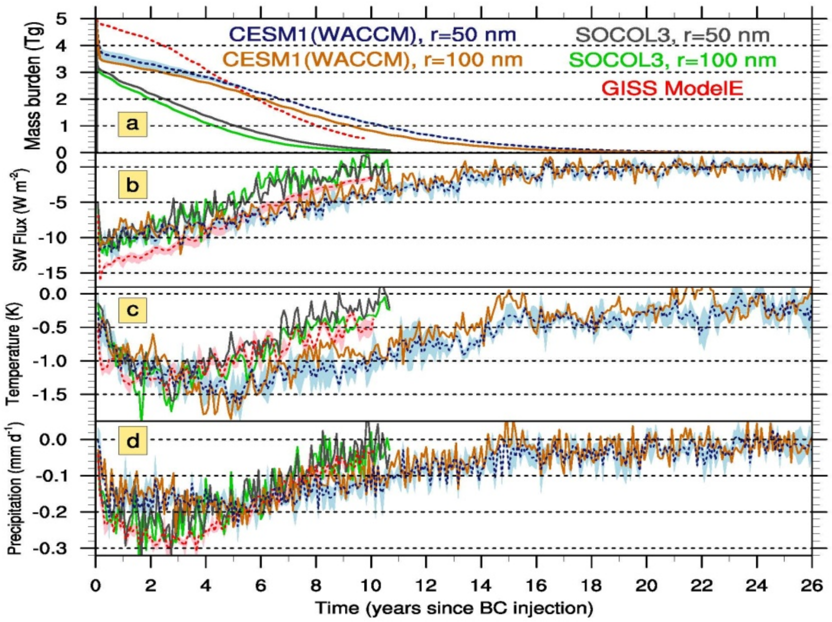

Figure 1: a) Globally averaged mass burden of BC. The dark blue dashed line and light blue shading show the average and range of an ensemble of 3 CESM1 (WACCM) simulations assuming BC has a 50 nm radius. The gold line shows a simulation assuming a 100 nm radius. Red, grey, and green curves show results from two previous studies of the same scenario, which used two independent climate models. b) Reduction in global average shortwave net flux at the surface (W m-2) due to BC absorbing sunlight in the stratosphere. c) Reduction in global average surface temperatures (K), which lag solar forcing responses in CESM1 (WACCM) due to the thermal inertia of oceans and sea ice. d) Reduction in global precipitation (mm/day), which responds to both changes in temperature and changes in solar flux at the surface.

REFERENCE:

Mills, M. J., O. B. Toon, J. Lee-Taylor, and A. Robock (2014), Multidecadal global cooling and unprecedented ozone loss following a regional nuclear conflict, *Earth's Future*, **2**, doi:10.1002/2013EF000205.

‹ 1.c.3. Convective Weather Prediction | up | 2. Enabling World Class Community Science ›

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2. ENABLING WORLD CLASS COMMUNITY SCIENCE

Through an easy-to-use infrastructure NESL provides researchers our modeling facilities such as the Community Earth System Model (CESM) and the Weather Research and Forecasting (WRF) model, their various components (including WACCM in CESM), and specialized modules, along with model and observational datasets. NESL also provides an advanced chemical measurement capability, ranging from satellite observations to in-situ measurements. In particular, NESL is a leader in the development and use of chemistry instrumentation in support of the scientific needs of the broader academic community, as exemplified through support for large field campaigns.

‹ 1.c.4. WACCM Model Simulates Global Environmental Effects of a Regional Nuclear War up 2.a. Continued development and support of NCAR community models ›

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2.A. CONTINUED DEVELOPMENT AND SUPPORT OF NCAR COMMUNITY MODELS

Computer models are powerful tools for meeting the intellectual challenge of understanding the Earth system, and they are the only scientific tool capable of integrating the myriad physical, chemical and biological processes that determine the evolution of the atmosphere as well as past and future climates. Models are essential for testing and confirming understanding, and for making predictions of use to society and policy makers. The international-scientific and user community is widely utilizing NESL community models at a level far in excess of any comparable activities, with more than 20,000 registered users of the Weather Research and Forecasting (WRF) model and the Community Earth System Model (CESM) worldwide.

‹ 2. Enabling World Class Community Science up 2.a.1. Community Earth System Model ›

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2.A.1. COMMUNITY EARTH SYSTEM MODEL

A key achievement during FY14 has been the completion of the Large Ensemble simulations and release to the community of all data (through ESGF). This includes a very long control experiment (1500+ years). In addition, Last Millennium Ensemble simulations with the transient evolution of the natural and anthropogenic forcings, together and individually, have been performed and will be released soon. GeoMIP simulations were completed and used in published papers. TOGA and GOGA (specified observed SSTs within the tropics and the globe, respectively) ensemble simulations over the period 1900-present have been performed with and without radiative forcing.

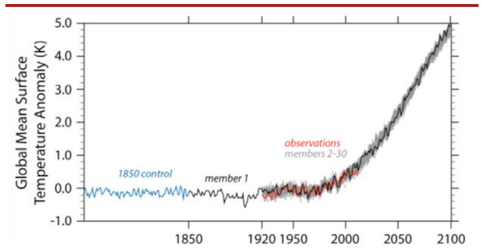

Figure: *Global surface temperature anomaly (1961-1990 base period) for the1850 control, individual ensemble members, and observations (HadCRUT4; Morice et al., 2012). From Kay et al. (2014).*

The CESM testing and scripting infrastructure has been greatly enhanced to permit the introduction of out-of-the box capability for newer component configurations and model resolutions, including the new capability to provide users the ability to specify their own grid configurations.

We have performed numerous simulations to compare the accuracy of the spectral element dynamical core with other transport schemes in representing tracer transport. CAM-SE was shown to perform well in diagnostics such as filament preservation, which is of particular importance for chemistry representation.

Significant progress was made in the implementation and development of a new gridding infrastructure in the CAM spectral element dynamical core (CAM-SE) that permits the physics and dynamics grid to no longer be co-located. Simplified validation runs were performed in preparation for using this capability to utilize the Conservative Semi-Lagrangian Multi-tracer transport scheme (CSLAM) in CAM.

The following releases were provided to the CESM community and account for out-of-the-box support for new computational platforms, bug fixes, and new support for model configurations, both for the CMIP5 release code base and for new development versions of the model.

CESM 1.0.z series – code base used for the CMIP5 simulations

- CESM 1.0.6 - May 2014

CESM 1.2.z series - targeting new development versions leading to CESM2

- CESM 1.2.0 - June 2013
- CESM 1.2.1 - December 2013
- CESM 1.2.2 - June 2014

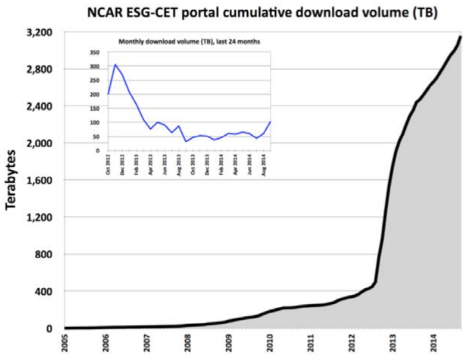

Figure: *CESM data downloads from the NCAR data portal from January 2005 through September 2014.*

Special release versions only supported on Yellowstone for these specific community projects

- CESM1_1_2_LENS - Large Ensemble Community Project special release
- CESM1_1_2_LM - Last Millennium Community Project special release

We reduced a backlog in student demand for the CESM Tutorial by increasing the number of attendees by 15% while maintaining a high quality attendee experience, and convened a Community Land Model Tutorial to further facilitate community use of the CESM land model and reduce the backlog of interest in the general CESM Tutorial.

382 attended the CESM workshop this year, and 73 people attended the CESM tutorial.

‹ 2.a. Continued development and support of NCAR community models   up   2.a.2. The WRF Modeling System ›

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2.A.2. THE WRF MODELING SYSTEM

The WRF efforts in NESL support an extensive user community that spans academic, operational, and commercial interests. To effectively manage and safeguard the WRF system, NESL is responsible for maintenance of the WRF code repository and new releases. WRF personnel also conduct model-based research and applications, provide support for field projects with real-time WRF forecasts, and perform fundamental research and development in mesoscale modeling and data assimilation. NESL's weather research activities and direct model development are integral and imperative to the continuous evolution of the WRF.

The number of registered users of WRF continues to grow and is currently almost 27,000. About 70% of these are foreign, and 156 countries are represented. These user figures reflect registrations made through the WRF download site, and the figure below shows the breakdown. It also charts the increase in the number of WRF registered users over the years. The number of subscribers on the WRF e-mail list is over 8,200. E-mail inquiries to wrfhelp (the WRF user assistance service) average about 350/month, and the servicing of these over the year has been a significant effort.

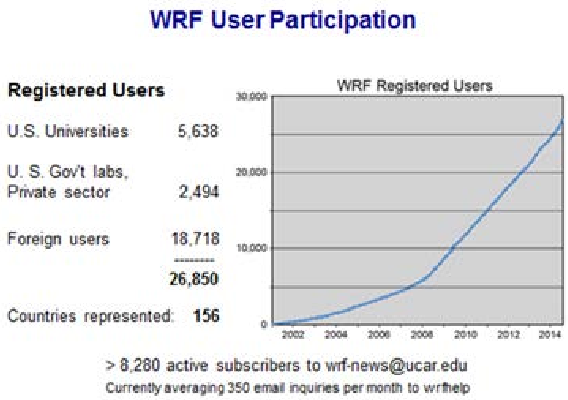

Figure: WRF registered users by user group and plot of number of registered users by year. Number of WRF mailing-list subscribers is also shown.

In support for the community, in FY2014 MMM conducted two tutorials in Boulder, one in January and the other in July. Both were attended by about 60 people, the capacity of the practical sessions. The July session included a basic WRF tutorial, a WRFDA tutorial, a WRF-Chem tutorial, and a WRF regional climate tutorial. Details on the 2014 winter and summer tutorials and their materials may be found here: http://www2.mmm.ucar.edu/wrf/users/supports/tutorial.html. In February 2014, NCAR also delivered a WRF tutorial at the University of New South Wales in Sydney, Australia.

NESL/MMM staff also organized and hosted the 15th WRF Users' Workshop in Boulder on June 23–27 with over 220 attendees. The first day presented a continuation of the model fundamentals lecture series, with the topic being WRF modeling best practices. The core of the workshop featured talks on a range of WRF topic areas (new development, physics, data assimilation, chemistry, regional climate modeling), while the final day offered instructional talks on WRF-related tools and applications.

Community support efforts also included the major WRF release of Version 3.6 in April 2014. This included WRFDA 3.6 and WRF-Chem 3.6. WRF V3.6 offered many new features and improvements that reflect contributions from throughout the WRF community, and they reflect WRF as a community model.

Research efforts in FY2014 included running real-time WRF from WRF/DART analyses in support of the 2014 Storm Prediction Center Spring Forecast Experiment and the 2014 Atlantic hurricane season. Owing to the wealth of excellent cases obtained during the Mesoscale Predictability Experiment (MPEX), efforts were directed to assimilation of MPEX observations and analysis of those results.

Other research efforts included running the Antarctic Mesoscale Prediction (AMPS) System, a real-time WRF system that provides guidance for the weather forecasters of the United States Antarctic Program (USAP). AMPS employs WRF in this, and the system completed its support of the 2013 2014 USAP field season. In addition, AMPS supports NSF-funded and other field campaigns. This has included supplying guidance for the 2ODIAC (Two-season Ozone Depletion and Interactions with Aerosols Campaign) and SCINI-Penguin studies. 2ODIAC is measuring and studying aerosols at Ross Island, and SCINI-Penguin is examining the Antarctic food web, from microalgae to top predators. AMPS also continued to support the Antarctic missions of the NSF research vessels R/V Nathaniel B. Palmer and R/V Laurence M. Gould. In this it delivers tailored, regional products directly to on-ship personnel. The figure below shows an example for the Palmer for a recent voyage in the South Atlantic, between the Falkland Island (upper-left of plot) and South Georgia Island (lower-middle of plot).

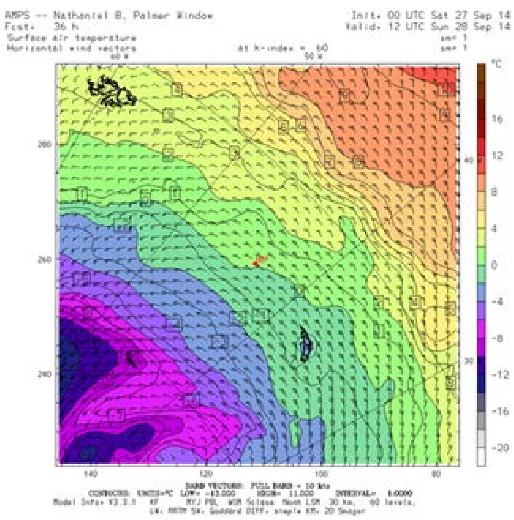

Figure: AMPS window for R/V Nathaniel B. Palmer with 36-hr forecast of surface temperatures and winds. Forecast valid 1200 UTC 28 Sept 2014 (initialized 0000 UTC 27 Sept). Temperatures shaded (C; scale to right); winds= barbs (full barb= 10 kt). Red "NBP" in center of plot marks location of the Palmer.

‹ 2.a.1. Community Earth System Model   up   2.a.3. The Antarctic Mesoscale Prediction System (AMPS) ›

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2.A.3. THE ANTARCTIC MESOSCALE PREDICTION SYSTEM (AMPS)

AMPS is a real-time, experimental WRF system run at high resolution over Antarctica in support of the U.S. Antarctic Program (USAP) and funded by NSF GEO's Division of Polar Programs. This activity provides guidance for USAP weather forecasting and various scientific and logistical efforts over the continent and Southern Ocean. The work is vital to USAP activities, as the forecast meteorologists depend on a well-maintained, robust, tailored, and upgraded system. AMPS also lends support to international scientific bases and activities across Antarctica. AMPS employs the WRF Model and has incorporated polar modifications to the physics, a planned effort on an ongoing basis.

AMPS provided NWP guidance to the USAP forecasters through the 2013–2014 field season. This was delivered through the AMPS web page (http://mmm.ucar/edu/rt/amps/) as well as the Antarctic IDD (internet data distribution) service. As noted in the WRF section of this annual report, in FY2014 AMPS efforts were also continued to support the NSF research vessels R/V Nathaniel B. Palmer and R/V Laurence M. Gould in their southern Ocean and Antarctic missions in the 2013–2014 season. AMPS provided ship-following model plot windows to give WRF forecast information to the vessels directly on a continuing basis.

Other research efforts in FY2014 focused on updating polar modifications in the WRF modeling system used in AMPS. AMPS began to run an ensemble forecast suite over its Antarctic domains. The ensemble uses output from the NCEP Global Ensemble Forecasting System for the first-guess fields of its WRF members and currently provides plots for key bases. Plots were generated for McMurdo Station that included individual ensemble members, ensemble mean, ensemble envelope, and main AMPS run forecasts of surface temperature, pressure, wind speed, and precipitation.

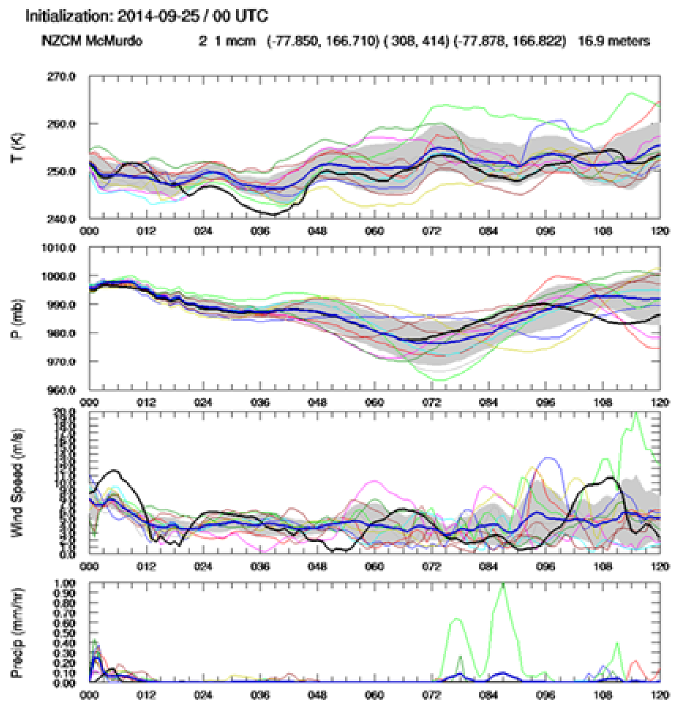

Figure: AMPS ensemble forecast time series plots for McMurdo Station. Forecast initialization: 0000 UTC 25 Sept 2014. Length: 120 hrs. Top to bottom: (i) surface temperature (K); (ii) pressure (mb); (iii) surface wind speed (ms-1); and (iv) precipitation rate (mm hr-1). Thin lines: Ensemble members. Thick blue line: Ensemble mean. Thick black line: AMPS forecast. Gray zone: Range of 1 standard deviation around ensemble mean.

‹ 2.a.2. The WRF Modeling System up 2.b. A more unified strategy toward model and data assimilation system development for weather-chemistry-climate prediction ›

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2.B. A MORE UNIFIED STRATEGY TOWARD MODEL AND DATA ASSIMILATION SYSTEM DEVELOPMENT FOR WEATHER-CHEMISTRY-CLIMATE PREDICTION

The Earth system contains features and processes that operate on a wide range of time and space scales, from detailed cloud and chemical processes to meso- and synoptic-scale weather systems, basin-scale ocean circulations, and continental-scale ice sheets. Climate and weather share many of the same underlying physical processes, so more unified approaches to model development and application could have many advantages. NESL scientists will engage with the broader community in development efforts focused on high- and variable-resolution models, the development of across scale parameterizations, new approaches to model testing and evaluation utilizing data assimilation, and new modeling initialization strategies.

‹ 2.a.3. The Antarctic Mesoscale Prediction System (AMPS) up 2.b.1 Ensure that all CESM Components use Scale-Adaptive Techniques so that Regional and Global Climate can be Simulated Concurrently ›

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- NESL Director's Message
  - 1. Interdisciplinary Science Challenges
  - 2. Enabling World Class Community Science
    - 2.a. Continued development and support of NCAR community models
    - 2.b. A more unified strategy toward model and data assimilation system development for weather-chemistry-climate prediction
      - 2.b.1 Ensure that all CESM Components use Scale-Adaptive Techniques so that Regional and Global Climate can be Simulated Concurrently
      - 2.b.2. The Model for Prediction Across Scales (MPAS)
    - 2.c. Expand the community use of and access to instruments, models and data sets

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

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- Earth Observing Laboratory
- High Altitude Observatory

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PREVIOUS NESL REPORTS

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2.B.1 ENSURE THAT ALL CESM COMPONENTS USE SCALE-ADAPTIVE TECHNIQUES SO THAT REGIONAL AND GLOBAL CLIMATE CAN BE SIMULATED CONCURRENTLY

Extended, high-resolution (~25km) simulations with CAM show improvements compared to the standard ~100km CAM configuration, in particular in areas where topographic effects may be playing a role. Another benefit of high resolution is realistic tropical cyclone distributions.

Long high uniform resolution coupled simulations (~25km atmosphere, ~10km ocean) show improvements in the annual mean sea surface temperature (SST) in the Equatorial Pacific, and El-Niño Southern Oscillation variability (see Figure 1). Tropical and Southern Atlantic SST also had much reduced bias compared to previous versions of the model. In addition, the high resolution of the model enabled small-scale features of the climate system to be represented, such as air-sea interaction over ocean frontal zones, mesoscale systems generated by the Rockies, and tropical cyclones.

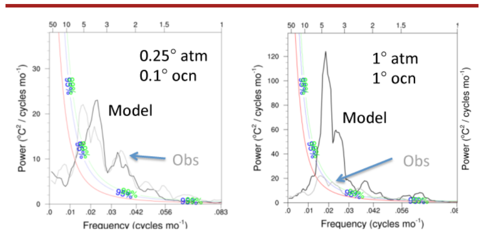

Figure: *Power spectrum of Nino3.4 index from (left) CESM high resolution, and (right) from CESM standard resolution. 95% significance levels are overlaid. The corresponding spectrum for the last 90 years of HadISST observations is overlaid as thin grey line. Note change of ordinate range between the plots. (Image courtesy Justin Small.)*

CAM-SE dynamical core has been validated in a mesh-refined configuration. Idealized simulations of baroclinic waves show that CAM-SE can reproduce the uniform high-resolution (~25km) results inside the high-resolution region. Interestingly, averages of dynamical quantities outside of the high resolution in a variable mesh simulation (where the resolution is low; ~100km), resemble high resolution, not low resolution simulations, indicating that downstream effects of high resolution can be captured at variable resolution. This demonstrates that the CAM-SE dynamical core is well suited for scale adaptivity.

The representation of sub-grid scale processes across scales, however, is a significant challenge. Simulations with resolution refinement down to ~25 km in the tropics (Figure 2) using CAM5 physics exhibits significant sensitivity in the response of cloud and precipitation processes. This response is dominated by

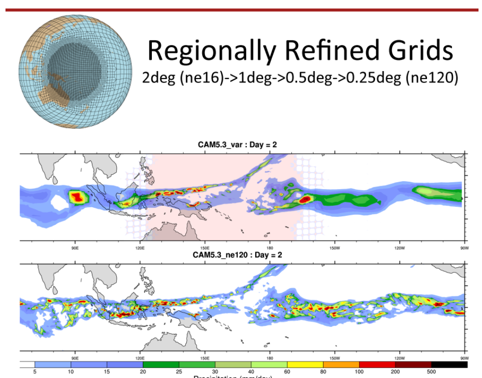

Figure: *Power spectrum of Nino3.4 index from*

(left) CESM high resolution, and (right) from CESM standard resolution. 95% significance levels are overlaid. The corresponding spectrum for the last 90 years of HadISST observations is overlaid as thin grey line. Note change of ordinate range between the plots. (Image courtesy Justin Small.)

changes in the deep convection response with increased precipitation in the refinement region. The localized heating from this increase also leads to modifications of the circulation pattern within the non-refined tropics and at higher latitudes. With an equivalent refinement region in the mid-latitudes the sensitivity of the moist processes is much less, due mainly to the reduced role of deep convection at these latitudes. Similar simulations have been conducted with the new CAM-CLUBB physics (using a multivariate probability density function closure for moist turbulence) which seems to perform stably across resolutions, with consistent cloud forcing and winds inside and outside a region of higher resolution.

‹ 2.b. A more unified strategy toward model and data assimilation system development for weather-chemistry-climate prediction | up | 2.b.2. The Model for Prediction Across Scales (MPAS) ›

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Research Applications Laboratory

STRATEGIC PLANS

NESL Strategic Plan

NCAR Strategic Plan

PREVIOUS NESL REPORTS

Select year

Printer-friendly version

2.B.2. THE MODEL FOR PREDICTION ACROSS SCALES (MPAS)

NESL is collaborating with Los Alamos National Laboratory (LANL) to develop the Model for Prediction Across Scales (MPAS), which includes a global nonhydrostatic atmosphere solver and an ocean solver. NESL is responsible for the atmospheric component, LANL the ocean component, and the development of the infrastructure is shared between the two partners. The MPAS solvers are based on spherical centroidal Voronoi meshes (nominally hexagons) that are unstructured and allow for variable resolution meshes that seamlessly transition between fine and coarse mesh regions. Increasing computer capabilities, along with the need to address problems with fixed-resolution traditionally nested models, are the motivating factors behind this development effort.

Recently scientists completed the implementation of the MPAS nonhydrostatic atmosphere core in CESM/CAM (Community Earth System Model/Community Atmosphere Model). Scientists have also begun testing MPAS in CESM/CAM in AMIP (multi-year climate) simulations and NWP (10 day weather) simulations. NESL scientists performed daily real-time MPAS global forecasts for the 2013 Atlantic tropical cyclone season (August through October) testing both variable-resolution and uniform resolution meshes.

Other MPAS research included the initial analysis of the Advanced Scientific Discovery simulations, accomplished during FY2013, that including the 3 km global mesh simulations covering severe weather events and tropical convection. In addition, the initial testing of the coupled MPAS-DART ensemble data assimilation system on uniform-resolution meshes has been completed. This MPAS-DART system has been released to the community.

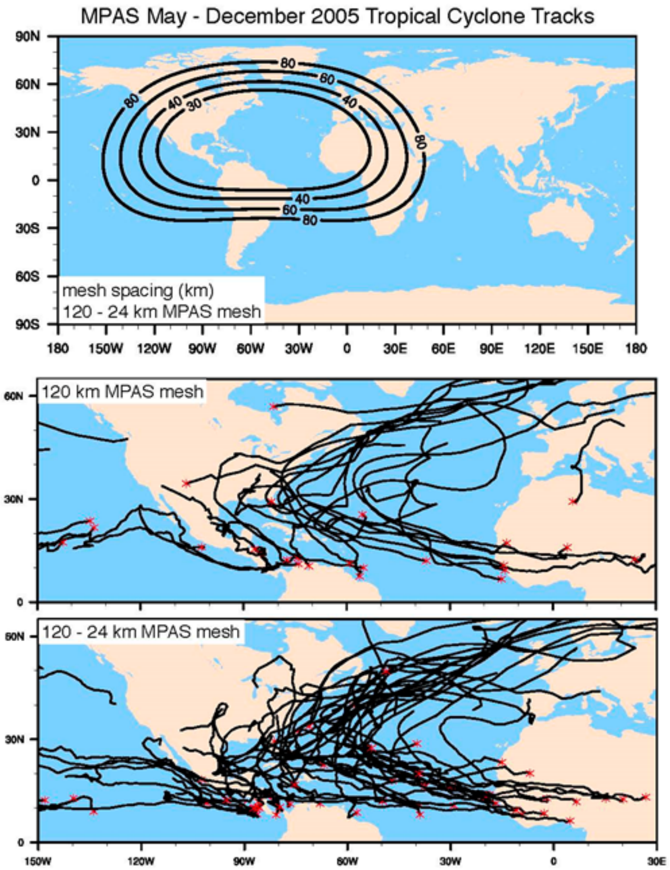

Figure: Tropical cyclone tracks for 2005 generated from two global MPAS year-long simulations. The top panel shows the cell-center spacing on the variable-resolution MPAS Voronoi mesh. The middle panel shows cyclone tracks from a 120 km uniform mesh simulation, and the bottom panel shows cyclone tracks from the variable-mesh (120-24 km cell-center spacing) simulation. The variable mesh has higher-resolution in the Atlantic basin, and the higher-resolution simulation produces a similar number of tropical cyclones compared to those observed during the 2005 season whereas the coarse uniform mesh simulation produces far fewer than observed.

‹ 2.b.1 Ensure that all CESM Components use Scale-Adaptive Techniques so that Regional and Global Climate can be Simulated Concurrently

up

2.c. Expand the community use of and access to instruments, models and data sets ›

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2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

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Computational & Information Systems Laboratory
Earth Observing Laboratory
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NCAR Earth System Laboratory
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STRATEGIC PLANS

NESL Strategic Plan
NCAR Strategic Plan

PREVIOUS NESL REPORTS

Select year

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2.C. EXPAND THE COMMUNITY USE OF AND ACCESS TO INSTRUMENTS, MODELS AND DATA SETS

A central feature of NESL's mission is to provide to the broader community data, models and instruments and related expertise. Within the community, datasets encompass output from climate model experiments, post-processed model data, observations from satellites, field programs and laboratory experiments, and value-added observationally based datasets. Community model codes, as well as information on model configurations, experimental designs, and on-line diagnostics are made available through frequently updated web pages. NESL conducts tutorials to train university students and other community scientists in the development and application of NESL community model. NESL has started a major activity to foster the development of a strong and linked atmospheric chemistry observational community; to provide an intellectual meeting ground for the discussion and prioritization of scientific problems and for the development of community-wide observational capabilities to address these problems; and to provide a vehicle for community guidance into the prioritization of the observational facilities maintained and developed within NESL in collaboration with the NCAR Earth Observing Laboratory (EOL).

‹ 2.b.2. The Model for Prediction Across Scales (MPAS) up 2.c.1. Participation in Collaborative Chamber Studies ›

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2.C.1. PARTICIPATION IN COLLABORATIVE CHAMBER STUDIES

ACD scientists were involved in two large, coordinated studies which used environmental chambers to study the chemistry of isoprene and its oxidation products. In the first study [Thalman et al., under review, AMTD, 2014] measurement techniques for glyoxal and methyl glyoxal were compared. Experiments at NCAR were used to precisely calibrate the University of Colorado Cavity Enhanced Differential Optical Absorption Spectrometer. The NCAR instruments used were FTIR and PTRMS, and glyoxal and methyl glyoxal were produced photochemically in the NCAR 50-liter photoreactor. The CU instrument was then used at a large chamber study in Switzerland where 5 groups provided 7 instruments to measure these species. The study provided a unique opportunity to compare the performance of the individual instruments, and to identify improvements to the techniques for future use in field deployments. A further result of this study was the measurement of the yields of some minor species (glyoxal, methyl glyoxal, glycolaldehyde and hydroxyacetone) produced as direct products of isoprene oxidation. While the production of these molecules from isoprene had been inferred, this was the first time that all 4 had been measured simultaneously. These newly detected oxygenated species can participate in photochemistry and aerosol growth in isoprene-rich areas.

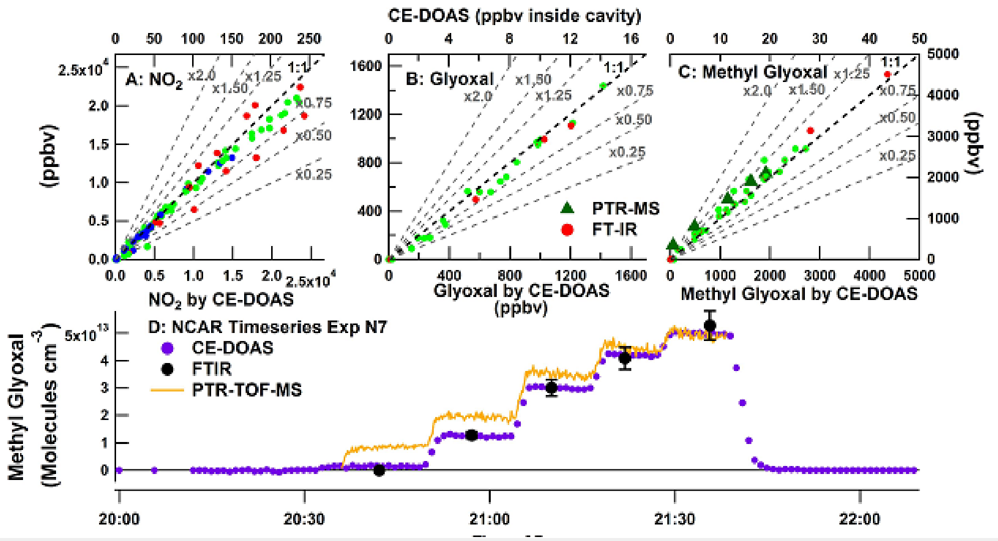

Figure 1 shows (lower panel) time traces of methylglyoxal measured in the NCAR chamber using 3 independent techniques, and (upper panel) correlation plots of 3 of the molecules studied.

ACD scientists also participated in the FIXCIT study at the California Institute of Technology, which was a follow-on to the very successful SOAS field study in summer 2013. The FIXCIT study brought together 16 different instruments to sample from the CalTech chamber with the goal of understanding calibration issues and interferences encountered in the field [Nguyen et al., under review, ACPD 2014]. In addition to sampling pure standards of various isoprene oxidation products, numerous experiments were conducted to study the oxidation of isoprene and alpha-pinene. NCAR provided a highly sensitive NO-chemiluminescence detector to characterize the levels of nitrogen oxides in the chamber. The study enabled the measurement of gas-phase isoprene oxidation products, and their partitioning to aerosols, under close to ambient levels of NO. The exact product distributions obtained from isoprene are very sensitive to the NO levels, and these experiments will provide a wealth of information which will be used to interpret measurements from SOAS and to improve isoprene oxidation mechanisms for use in regional models.

‹ 2.c. Expand the community use of and access to instruments, models and data sets | up | 2.c.2. Lab studies capture the first moments of the birth of a new particle ›

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- Advanced Study Program
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- Earth Observing Laboratory
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- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- NESL Strategic Plan
- NCAR Strategic Plan

PREVIOUS NESL REPORTS

Select year

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2.C.2. LAB STUDIES CAPTURE THE FIRST MOMENTS OF THE BIRTH OF A NEW PARTICLE

LAB STUDIES CAPTURE THE FIRST MOMENTS OF THE BIRTH OF A NEW PARTICLE

Understanding the processes by which nanometer-sized atmospheric aerosol particles (aka “nanoparticles”) form and grow is of critical importance for assessing their role of in climate and for improving air quality controls. A key quantity describing the formation of nanoparticles is the rate at which particles of certain size are formed per unit volume of air. The quantification of nanoparticle formation rates requires rapid measurement of particle number concentrations; normal techniques used to measure the particle size distribution do not have high sufficiently high time resolution.

In order to address the need for rapid measurements of nanoparticle formation rates, the Ultrafine Aerosols research group in ACD developed the “Differential Mobility Analyzer (DMA) train,” an instrument capable of providing sensitive, size-resolved nanoparticle concentrations at frequencies of one per second. This system, developed in collaboration with colleagues at the University of Vienna, was recently used in lab experiments at ACD’s biogenic aerosol chamber facility. Figure 1 shows the configuration for these experiments. The DMA train uses five commercial DMAs (model 3085, TSI Inc), together with four commercial ultrafine particle counters (UCPC; model 3025, TSI, Inc) and one diethylene-glycol (DEG) based UCPC, the latter of which is currently the state-of-the-art in detecting and counting particles as small as 1.5 nm in diameter (for reference, a molecule of water measures about 0.2 nm in size).

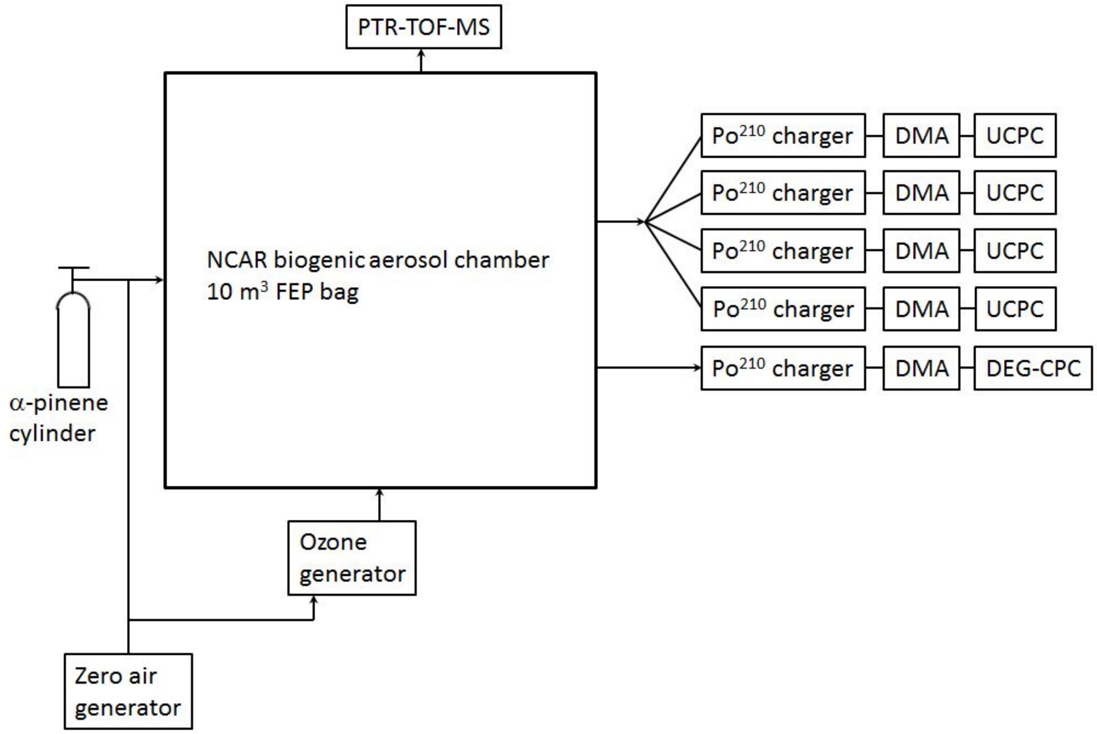

Figure 1. Experimental set-up for particle formation studies at the NCAR biogenic aerosol chamber.

Figure 2 illustrates the time evolution of different particle sizes as measured by the DMA train. The particle sizes shown were obtained from two consecutive chamber runs under identical conditions but monitoring different particle sizes. The reproducibility of size distribution data clearly indicates stable conditions in the chamber and supports the reliable operation of the DMA train. As can be seen, all particle sizes show a steep increase in concentration from basically zero to full appearance within 7-8 minutes. It is remarkable that for particle diameters above 5 nm, particle concentrations seem to increase. Although data evaluation is still in-process, this observation appears to be robust and cannot be explained by differences in the detection efficiencies of the individual components of the DMA train. This observation suggests a minimum in the concentration of particles in the 3-5 nm size range; however, more analysis is needed to completely understand the mechanisms that are responsible for this behavior.

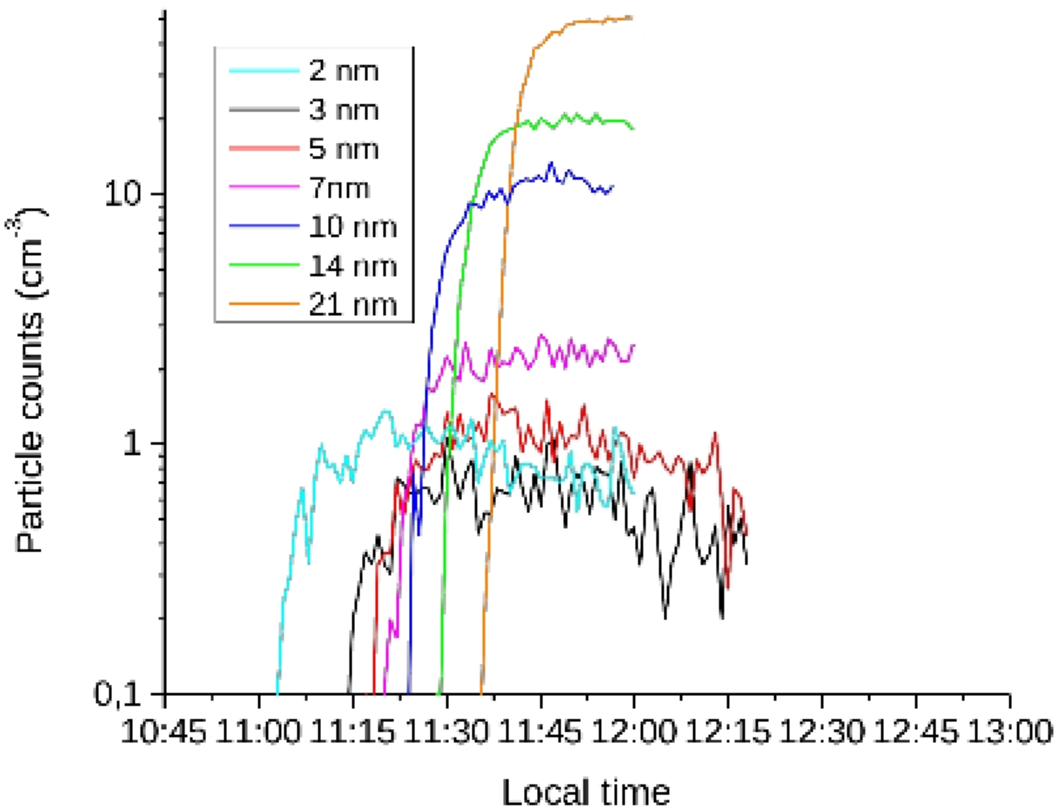

Figure 2. Data showing the size-evolution of nanoparticle number concentrations from the reaction of a-pinene with ozone. Chemical reaction was initiated at 10:45.

‹ 2.c.1. Participation in Collaborative Chamber Studies | up | 2.c.3. Drought-Amplified CO Emissions in Amazonia ›

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2.C.3. DROUGHT-AMPLIFIED CO EMISSIONS IN AMAZONIA

Because of the potential of forests to either mitigate or exacerbate climate change, "Reducing Emissions from Deforestation and Degradation" (or REDD) is an internationally recognized long-term strategy to control atmospheric concentrations of greenhouse gases. The Amazon Basin, in particular, is critical to the success of REDD. Although there has been a significant decrease in deforestation in Brazil since 2004, the future of Amazonia as a global carbon reservoir is highly uncertain because of the sensitivity of the region's carbon emissions to both future land-use practices and climate change. Fire has long served as a simple and ubiquitous tool for agriculture throughout Amazonia but could decline generally as "fire-free" land management strategies become more prevalent. With respect to climate change, however, models forecast an overall drying trend in Amazonia which could amplify emissions from future wildfires.

The MOPITT ("Measurements of Pollution in the Troposphere") group in ACD has analyzed records of MOPITT CO total column averaged over the Amazon Basin for the last 14 years. Long-term averages of MOPITT CO for the burning season are shown in Figure 1. Such observations reveal the actual atmospheric impact of biomass burning, unlike satellite records of deforestation or burned area. Analysis of MOPITT CO data along with annual averages of deforestation and burned area also can constrain the relative strengths of emissions from post-deforestation fires and accidental "understory" wildfires (i.e., fires in standing forests which mainly consume leaf litter, yet cause substantial long-term damage to the tropical forest ecosystem). Such an analysis of MOPITT data indicates that, per unit area, understory fires yield more than twice the CO emissions compared to post-deforestation fires. Ultimately, results from this project should significantly reduce uncertainties in biomass burning emissions inventories, which currently vary by more than a factor of two.

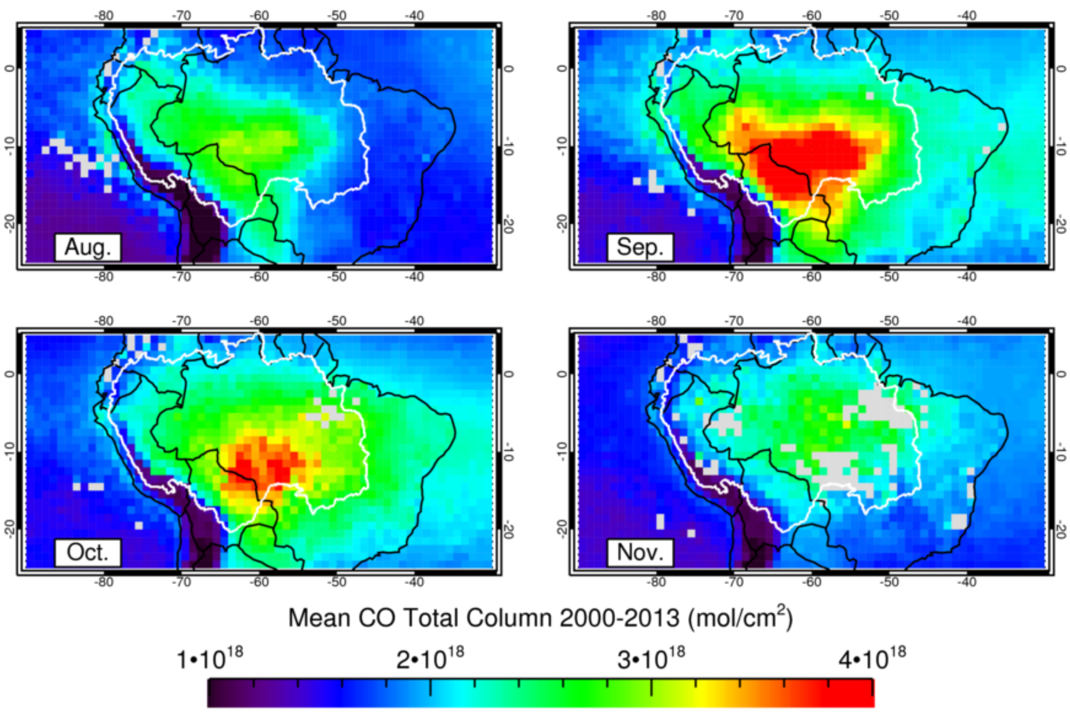

Figure 1. Long-term mean maps of MOPITT CO total column for the main burning season months (August to November).

‹ 2.c.2. Lab studies capture the first moments of the birth of a new particle
up
2.c.4. Stratospheric chlorine species rising in the Arctic ›

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2014 Annual Report

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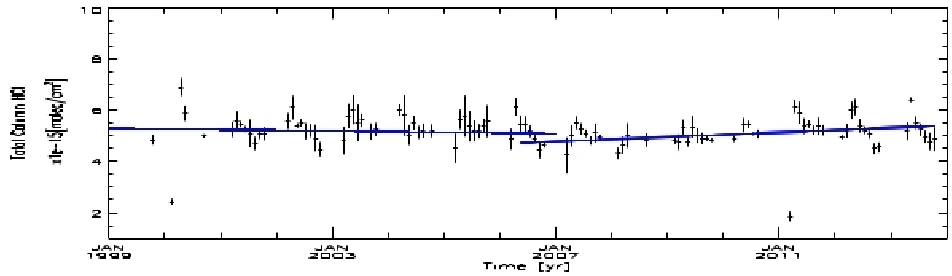
2.C.4. STRATOSPHERIC CHLORINE SPECIES RISING IN THE ARCTIC

Current analysis of the FTS (Fourier Transform Spectrometer) NCAR / NDACC (Network for the Detection for Atmospheric Composition Change) data show secular increases in several stratospheric species. Focusing on HCl, the largest reservoir of chlorine in the stratosphere, the 1990's total column amounts were observed to be decreasing starting in 1997-1998 [Rinsland et al, 2003] due to reduced anthropogenic emissions. This continued until about 2006-2007, when that trend appeared to be reversing. Now with the benefit of several years of observations the secular increase is quite evident. The upper panel in Fig 1. shows monthly averaged HCl total column amounts at Thule Greenland (76ºN, 68ºW). HCl shows an annual cycle dominated by high amounts in the spring due to descent during the polar night, although this in turn can be greatly decreased by activation of Cl resulting in catalytic ozone destruction. For instance note the very low value in the spring of 2011.

Another Cl containing species, carbon tetrachloride (CCl_4) exhibits similar trends that may have different or multiple drivers – see lower panel of the figure. Note that CCl_4 is close to the detection limit of the measurement technique, giving rise to larger uncertainty and in turn the higher apparent variability. Nevertheless the stratospheric loading was decreasing at Thule at a fairly high rate of 8.4%/year to about 2006-2007. There have been recent revisions in emission estimates upwards that is in contrast to HCl and the time lag for surface emissions coupled with fluctuations in transport dynamics can cause short term discrepancies between surface and stratospheric observations. Regardless, the total loading of potential ozone depleting Cl has been on the increase in the northern polar stratosphere. In the case of HCl this is believed to be dynamics driven and transient. In the case of CCl_4 our understanding is not so clear at this time.



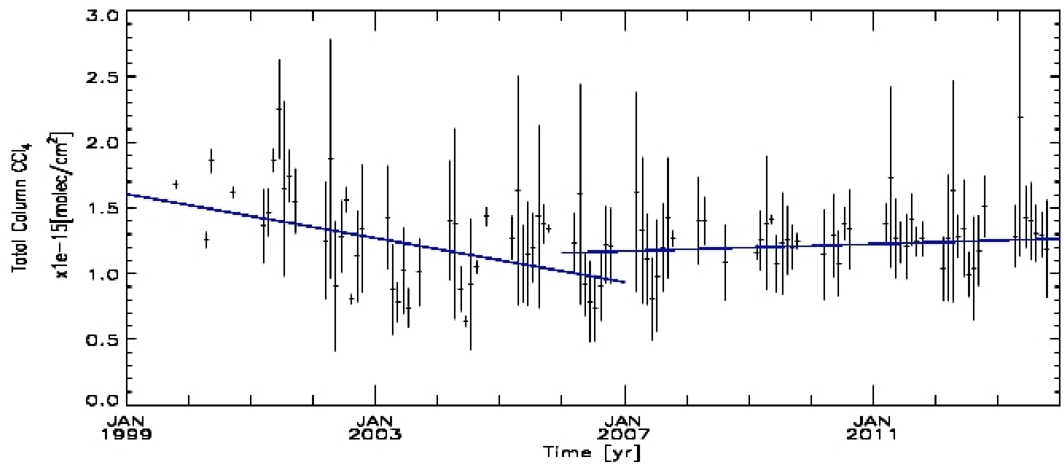


Figure 1. HCl upper panel, CCl_4 lower, total column amounts versus time from 1999 - 2013 measured at Thule Greenland. Average monthly mean values where the vertical bars represent a 1 standard deviation of the measurements during the month. Blue lines are linear trends 1999-2007 and 2006-2013 using the less perturbed months of May-October. No observations are made from November-February.

‹ 2.c.3. Drought-Amplified CO Emissions in Amazonia | up | 2.c.5. Actinic Flux measurements during the CONTRAST field campaign ›

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- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- NESL Strategic Plan
- NCAR Strategic Plan

PREVIOUS NESL REPORTS

Select year

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2.C.5. ACTINIC FLUX MEASUREMENTS DURING THE CONTRAST FIELD CAMPAIGN

The CONvective TRansport of Active Species in the Tropics (CONTRAST) aircraft campaign in February 2014 deployed to Guam to examine deep convection in the western Pacific Ocean. The goal was to understand the processes and impact of powerful storms able to pump surface chemical species high in the atmosphere and even beyond the tropical tropopause. The radiative and chemical impact of these systems extends globally as the convected species rapidly expand through the upper atmosphere.

As part of the NCAR G-V aircraft payload, the Atmospheric Radiation and Measurements (ARIM) group in ACD deployed the HIAPER Airborne Radiometer Package (HARP) actinic flux instrumentation for the determination of spectrally resolved actinic flux radiation and calculation of atmospherically important photolysis frequencies. Many atmospheric chemicals are photochemically active, meaning they can be dissociated by sunlight. The HARP measurements allow understanding of their chemical evolution as they are exposed to the complex radiative environments associated with storm clouds. The resulting oxidative chemistry at high altitudes is strongly tied to photodissociation of atmospheric species where ozone greenhouse forcing is strongest. The measurement is sensitive to cloud, aerosol, albedo and composition dynamics and is critical to understanding the evolution of ozone, greenhouse gases, and both natural and anthropogenic emissions.

The figure shows the flight tracks from Guam during the CONTRAST deployment. The colors indicate cloud impacts on the chemistry shown as the ratio of nitrogen dioxide photolysis calculated from the HARP measurement to clear sky values from the NCAR Tropospheric Ultraviolet and Visible (TUV) radiative transfer model. Red colors indicate high altitude flight legs with enhanced photolysis above clouds while blue colors indicate shading by clouds. Yellow colors show agreement under relatively cloud and aerosol-free skies. Data analysis continues on this project to examine the chemical processes

and evolution in this remote environment.

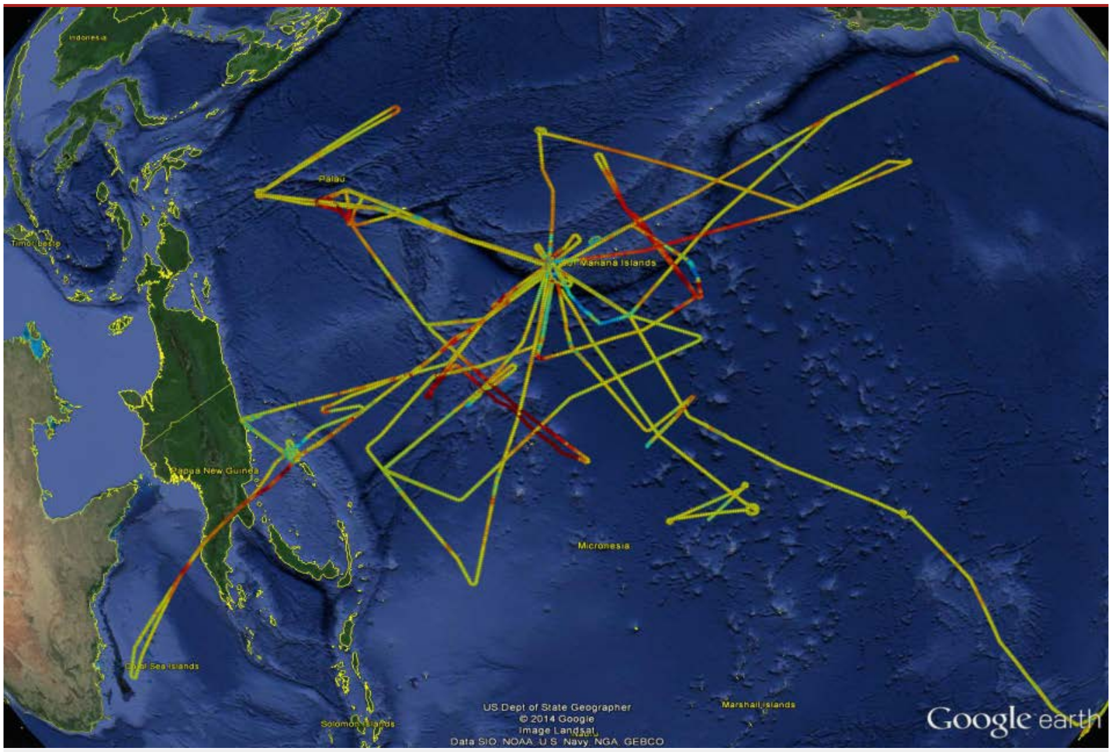

Figure 1. Flight tracks from Guam during the CONTRAST deployment.

‹ 2.c.4. Stratospheric chlorine species rising in the Arctic
up
2.c.6. Climate Data Sets ›

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2.C.6. CLIMATE DATA SETS

We continue to make available new value-added data sets via ftp and the web. These include the most recent Tropical Rainfall Measuring Mission (TRMM) Version 7 in netCDF files consolidated for easier usage; up-to-date energy budget analyses derived from the ERA-Interim reanalysis; and climate variability diagnostics from CAM ensembles.

Selected products include:

(a) High temporal resolution (3 hour) TRMM precipitation estimates using the most up-to-date TRMM processing algorithm (V7);

(b) Daily Global Precipitation Climatology Project (GPCP) spanning 1996-2013;

(c) Energy budgets spanning 1979-2013 using the ERA-Interim analyses.

These datasets facilitate model development and evaluation and provide the basis for analyzing recent weather and climate related events.

‹ 2.c.5. Actinic Flux measurements during the CONTRAST field campaign up

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2014 RAL ANNUAL REPORT

- Director's Message
- Table of Contents
- Next Generation Air Transportation
- New and Emerging Applications
- National Security Applications
- Numerical Systems Testing and Evaluation
- Hydrometeorological Applications
- Climate, Weather and Society

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- RAL Strategic Plan
- NCAR Strategic Plan

PREVIOUS RAL REPORTS

Select year

Printer-friendly version

2014 RAL ANNUAL REPORT

TABLE OF CONTENTS

Director's Message ›

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DIRECTOR'S MESSAGE

Brant Foote - RAL Director

Welcome to the Research Applications Laboratory's Annual Report for FY2014. Our mission is to conduct directed research that contributes to the depth of fundamental understanding of the atmosphere and its interaction with society, and to develop and transfer knowledge and technology that expands the reach of atmospheric science and contributes to the betterment of life on Earth. We are, at present, an organization with annual expenditures of approximately $30M and a staff comprised of nearly 200 scientists, software engineers, and management/administration personnel.

This year I am very pleased to acknowledge receipt of the Colorado Governor's Award for High-Impact Research for Sustainability. This award recognized the work of more than 20 of our staff members in developing the NCAR/RAL Wind Power Forecasting System. The system enables utilities to integrate large amounts of wind energy into the power grid by providing wind energy forecasts every 15-minutes out to three hours and on an hourly basis out to 168 hours. Implementation of the system has resulted in a 40% reduction in wind energy prediction error, improving the integration of wind power into the electric grid and, since 2009, saved Xcel Energy rate payers at least $37.5M.

I hope you will enjoy reading this year's Annual Report. As in the past, it follows the outline of our current strategic plan, providing details on our many accomplishments over the past year and our plans for the future. Below, I highlight a number of significant accomplishments of the past year:

Aviation Program

RAL staff working on the FAA-sponsored High Ice Water Content (HIWC) project joined with members of the European High Altitude Ice Crystals (HAIC) project to conduct a field study in Darwin, Australia, in spring 2014. Our staff travelled to Darwin to run the ALPHA (Algorithm for Prediction of High Ice Water Content Areas) workstation and collaborate with Australian Bureau of Meteorology staff to forecast HIWC conditions in the area. The HAIC Falcon 20 research aircraft was instrumented to sample high ice crystal environments, mostly in the outflow of deep convection. The data will be used to assess ALPHA skill in identifying these regions. The ALPHA concept uses NWP output combined with satellite and radar data to diagnose cold cloud tops, warm atmosphere (compared to a standard sounding), high radar reflectivity below typical flight cruise altitudes, and other factors to determine regions conducive to the high ice water content hazard.

Weather, Climate and Health

The System for Integrated Modeling of Metropolitan Extreme heat Risk (SIMMER), an interdisciplinary NASA-funded study conducted by RAL scientists in 2010-2014, focused on extreme heat, human health, and urban vulnerability in present and future climates. The project quantified the importance of explicitly characterizing urban properties to improve urban meteorological simulations, and the role of adaptive capacity in understanding vulnerability to extreme heat. Climate model simulations from SIMMER suggest high heat stress days and nights in cities across the U.S. will increase substantially by the mid-21st century. New statistical methods for modeling risk of heat related mortality and morbidity at the neighborhood scale advance our understanding of heat risk factors, as well as the spatial and temporal distribution of vulnerability within cities. Research findings have been discussed in the context of public health policies and interventions through a stakeholder engagement process in Houston, Texas and Toronto, Canada. Decision-support tools with usable, actionable information have been developed for the stakeholders, researchers and the public.

Hydrometeorology

In 2014 our scientists concluded a ten-year effort to assess the feasibility of increasing Wyoming water supplies through winter orographic cloud seeding in the state's Medicine Bow, Sierra Madre, and Wind River Ranges. The analysis approach followed recommendations from the 2003 National Research Council report on Weather Modification that any evaluation of weather modification programs involve physical, statistical and modeling components. NCAR high-resolution cloud model, developed and used in real-time for this program, was found to be capable of forecasting the likelihood of seeding

conditions over the three mountain ranges studied, aided in the placement of ground-based seeding generators, and assisted in the evaluation of amount and location of seeding-enhanced precipitation and in stratification of the randomized seeding experiment data. High-resolution, quality-controlled snow gauges were used to evaluate the effectiveness of cloud seeding and validate the performance of the model used during the project. RAL scientists participated in a recent briefing to the Wyoming Legislature Select Water Committee and reported that the accumulation of evidence suggested a 5-15% increase in precipitation over the target mountain ranges leading to the conclusion that *cloud seeding is a viable technology to augment existing water supplies* for the Medicine Bow and Sierra Madre Ranges. More detail on results from this program may be found at:
http://wwdc.state.wy.us/weathermod/WYWeatherModPilotProgramExecSummary_v7_final_draft_12-10-14.html

Model Evaluation Tools (MET)

Version 5.0 of MET (http://www.dtcenter.org/met/users/) was released to the community in 2014. MET is a freely available software package for forecast evaluation with more than 2550 registered users, about half of whom are university researchers. METv5.0 includes a new package for evaluation of Tropical Cyclone (TC) predictions, called MET-TC and many enhancements to capabilities for evaluating model predictions (e.g., for ensembles). MET is supported to the community through an email help facility along with on-line and in-person tutorials.

Probabilistic Predictions and Uncertainty Quantification

Uncertainty quantification is central to cost-effective decision-making. In the last few years RAL's scientists have introduced a new approach to generate accurate probabilistic predictions and reliable uncertainty quantification, called the analog ensemble (AnEn). The AnEn technique has been successfully implemented for short-term predictions of several weather parameters, wind and solar power, and for climate downscaling for wind resource assessment applications and precipitation. The AnEn is a computationally efficient technique that is outperforming other state-of-the-science post-processing techniques for the prediction of rare events.

Taiwan

2014 marks the end of the third and possibly final phase of the Advanced Operational Aviation Weather System (AOAWS) project. For the past 18 years RAL and Taiwan's Civil Aeronautics Administration (CAA) have worked together to create an aviation weather warning system for the Taipei Aeronautical Meteorological Center (TAMC). The AOAWS project has substantially improved the ability of the Taiwan CAA to provide critical aviation weather services to the aviation community flying into or through Taiwan airspace. The AOAWS has provided Taiwan with a state-of-the-art capability that improves aviation safety, efficiency, and capacity. Over the duration of the project several technologies developed for the Federal Aviation Administration's (FAA) Advanced Weather Research Program (AWRP) such as the Current Icing Producnt (CIP), Forecast Icing Product (FIP), Graphical Turbulence Guidance (GTG), and NEXRAD Turbulence Detection Algorithm (NTDA) have been adapted and incorporated into the system. As is the case with any partnership over a long period, the friendships and trust built over such a longtime has enriched all. We are hopeful that this collaboration will renew itself in the near future.

‹ 2014 RAL Annual Report   up   Table of Contents ›

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NEXT GENERATION AIR TRANSPORTATION

Play a leadership role within the atmospheric research community to provide the necessary scientific underpinning and technology to support the weather and climate–related needs of the Next Generation Air Transportation System (NextGen).

- InFlight, Ground and Engine Icing
- Prediction of Storm Hazards for Aviation
- Turbulence
- Integration of Weather Information into Air Traffic Management
- Dissemination of Aviation Weather Information
- Oceanic Weather

‹ Table of Contents | up | InFlight, Ground and Engine Icing ›

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INFLIGHT, GROUND AND ENGINE ICING

ICING

For the past two decades RAL scientists have worked to improve diagnoses and forecasts of icing conditions that impact aviation. Much of this work is accomplished as part of the FAA's Aviation Weather Research Program which provides operationally-available, automated in-flight icing forecasts over the CONUS and Alaska. At this time, the Current and Forecast Icing Products (CIP and FIP) developed at RAL are running at the National Weather Service's Aviation Weather Center (AWC) and are approved for unrestricted supplementary use. The outputs include expected icing severity, probability of encounter, and potential for supercooled large drop (SLD, those drops with diameters exceeding 50 microns) at 13-km resolution over the CONUS for 0-18 h. RAL also works as part of the NASA Icing Remote Sensing System which aims to convert NIRSS from an upward-looking system to a scanning system, providing potential support for an airport terminal area.

FY2014 ACCOMPLISHMENTS

In 2014 RAL continued work on a number of FAA projects: 1) MICRO (Model for Icing Conditions in Real-time Operations), which will incorporate a high-resolution NWP model and improved use of sensor data to output the full drop size distribution (DSD) for icing prediction and severity calculations, 2) IPA (Icing Product-Alaska) which will revise CIP and FIP for the Alaska weather and data environments, and 3) evaluations of improvements to icing diagnosis using NEXRAD dual-polarization data. An initial dual-polarization Radar Icing Detection Algorithm, RaDIA, was implemented locally on data streams from several NEXRAD systems. This new algorithm combines RAL’s Icing Hazard Level (IHL) algorithm, tested on research radars, and new work that identifies glaciated areas using ZDR information.

RAL staff working on the High Ice Water Content (HIWC) project joined with members of the European High Altitude Ice Crystals (HAIC) project to conduct a field study in Darwin, Australia in spring 2014. Staff travelled to Darwin to run the ALPHA (Algorithm for Prediction of High Ice Water Content Areas) workstation and collaborate with Australian Bureau of Meteorology staff to forecast HIWC conditions in the area. The HAIC Falcon 20 research aircraft was instrumented to sample high ice crystal environments, mostly in the outflow of deep convection. The data will be used to assess ALPHA skill in identifying these regions. The ALPHA concept uses NWP output combined with satellite and radar data to diagnose cold cloud tops, warm atmosphere (compared to a standard sounding), high radar reflectivity below typical flight cruise altitudes, and other factors to determine regions conducive to the high ice water content hazard.

The Terminal-Area Icing Weather Information for NextGen (TAIWIN) continued work on assessing freezing drizzle detection instruments and algorithms, and on determining variability of winter precipitation around airports. Additionally, the NextGen Surface Observing Capability (NSOC) project, also sponsored by the FAA, was initiated. This grew out of a previous project that sought to evaluate the appropriate sensors, in terms of type and quantity, needed to detect and report weather conditions affecting aviation. The highest priority from this evaluation was the detection of winter precipitation at the surface at airports. The approach is to determine what suite of instruments provides the most accurate measurements. A market survey was completed to gather information from industry on current capability and determine a suite of instruments to be tested. A test site was set up at the NCAR Marshall test facility, as well as Volpe Transportation Center in Massachusetts and at the FAA’s Technical Center at Atlantic City, New Jersey. Additional sites will be set up next winter to ensure enough data are collected to make a meaningful evaluation of instrument and algorithm capabilities.

In support of NASA, RAL staff added additional features to NIRSS, notably a Radar Estimated Size product. NIRSS was an important part of a field study conducted in March 2014 near NASA Glenn Research Center in Cleveland OH. RAL supported the campaign which used the NASA Twin Otter research aircraft to gather in situ cloud data for icing algorithm evaluation.

PLANS FOR 2015

In 2015 a version of MICRO will be ready to support the NASA GRC field effort; the data collected from the research aircraft will be used for verification of NWP model cloud parameters and MICRO icing output. During this field study RAL scientists will also run RaDIA on Cleveland NEXRAD data and use the aircraft data to verify its performance.

TAIWIS will move the snow variability study from Denver International Airport to the Boulder-Marshall area. This will include shielded snowgauges with data collection at 1-min intervals. The NSOC field test site at Marshall will be fully operational with data sent to staff at Volpe for evaluation.

A second field project for HIWC/HAIC is planned for Cayenne, French Guyana in May 2015. NCAR will again provide ALPHA and field project data cataloging services. Modifications to ALPHA, based on analysis of the Darwin data sets, should be in place for this second part of the field effort.

‹ Next Generation Air Transportation up Prediction of Storm Hazards for Aviation ›

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PREDICTION OF STORM HAZARDS FOR AVIATION

BACKGROUND

The Next Generation Air Transportation System (NextGen) is a national priority designed to meet the air transportation needs of the United States in the 21st century—in particular, a significant growth in demand for air traffic services, possibly on the order of two to three times today's demand levels. Since weather conditions can seriously restrict aircraft operations and levels of service available to system users, the manner by which weather is observed, forecast, disseminated, and used in decision-making is of critical importance.

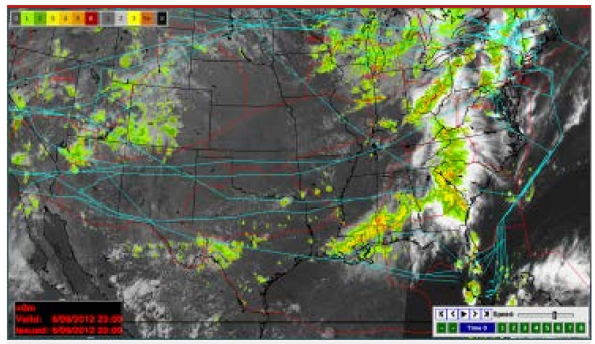

Figure 1. Analysis and forecast products made available to aviation planners via a web-based display.

For the past several years, NCAR's Research Applications Laboratory (RAL) has been engaged in multiple FAA-funded research and development efforts geared toward improved convective weather support for air traffic management en route and in/out of terminals, as well as, more recently, for improved airport operations safety for outdoor workers. In addition, efforts aimed at enhancing understanding of numerical weather prediction model performance, which enables effective harvesting of model predictions for convective storm initiation and probabilistic forecasting, have continued.

FY2014 ACCOMPLISHMENTS

Figure 2. Average gate pushback delays, taxi-out and taxi-in times (in minutes) of flights caught in a lightning ramp closure (left) versus not (right) for various safety procedures and lightning sources (color coded).

The 0 – 8 hour forecasts using the Consolidated Storm Prediction Algorithm (CoSPA), jointly developed and maintained by MIT Lincoln Laboratory, NOAA Earth System Research Laboratory, and RAL, continue to be made available to aviation planners (i.e., select FAA and airline industry partners) via a web-based display from April through October (i.e., convective weather season). The display allows users to overlay airports and associated arrival and departure fixes, route structures, and sectors on current and forecast weather facilitating the product's utility (Figure 1). This past summer, like previous years, only a reduced operational evaluation was conducted by the FAA that primarily relied on surveys and interviews with select groups of users. The analyses convey sustained interest and usage of the CoSPA forecast products by the aviation planners. An initial version of CoSPA is currently undergoing acquisition by the FAA's NextGen Weather Processor. Additional research has been conducted to improve the performance of the CoSPA forecasts, especially with regard to a smoother blending of the heuristic and model-generated storm predictions.

Another major research effort has been focused on the safety risks of personnel working outdoors at airports (e.g., baggage handlers, food

and fuel suppliers) and the impact on operational efficiency when thunderstorms are in the vicinity that may generate cloud-to-ground lightning strikes. This ongoing collaborative effort with various airport and airline stakeholders has revealed substantial uncertainty associated with the decision-making process for ramp closures (i.e., pulling people inside for safety reasons) due to thunderstorms and lightning in close proximity to concourses/gates. This uncertainty is caused by the various sources of lightning information, differences in procedures applied by the various stakeholders, human cognition and behavior, and the way information is communicated. Moreover, detailed analyses of air traffic data in conjunction with lightning data suggests that lightning-induced ramp closures, especially for prolonged duration or if multiple closures happen in succession, can exert notable impacts on traffic in/out of an airport (Figure 2) and potentially cause ripple effects through the national airspace system.

Unexpected initiation of large-scale convective storms can exert substantial impacts on air traffic as well. Using data mining approaches and ensemble forecasts, our research this past year has focused on early identification of areas prone to develop large-scale storms, including assessment of how well numerical weather prediction models capture those storm initiation areas. Unfortunately, numerical weather prediction models continue to experience difficulty in grasping whether a storm will initiate or not in a particular area, as well as how it will evolve given the timing of initiation and whether the storm system remains organized long enough. Notable regional differences in model skill have been observed. The lessons learned from the assessment of model performance are helping to improve the blending of heuristic and model-generated forecasts for CoSPA.

This substantial prediction uncertainty is reason for developing probabilistic convective storm guidance products using ensemble forecasts. Two probabilistic prediction efforts are underway, one focused on developing a probabilistic storm impacts product based on ensemble forecasts for the United States, while the other aims at creating a probabilistic convection guidance product based on global ensemble forecasts for strategic trans-oceanic air traffic planning (see oceanic weather). Work in both of these areas is being conducted in close collaboration with the NWS Aviation Weather Center (AWC).

FY2015 PLANS

Research and development focused on improving the CoSPA forecast system is expected to continue. Particular foci include: calibration of model storm intensity, correction of model storm position errors, and treatment of storm initiation in the blending algorithm. CoSPA forecasts will be provided again to aviation planners during the next convective summer season.

It is expected that new capabilities and products will be periodically demonstrated to users as technologies mature. A lightning hazard synthesis capability may be developed during the next year and additional air traffic impact analyses conducted in collaboration with AvMet Applications. Development of ensemble-based probabilistic storm impact predictions will continue for both domestic and international flight domains.

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TURBULENCE

BACKGROUND

Turbulence encounters by general and commercial aviation pose significant safety and flight efficiency concerns. Almost anyone who has flown commercially has had an unpleasant experience with turbulence and has a tale to tell about it. In fact, turbulence encounters account for well over 75% of all weather-related injuries on commercial aircraft and amount to at least $200M annually in costs, according to some estimates. Consequently, there is an urgent need to provide better turbulence information to pilots and route planners so that the number of encounters can be minimized, or at least provide adequate warnings so that passengers and crew can prepare for an expected encounter.

For more than twenty years, a group of scientists and engineers at the National Center for Atmospheric Research's Research Application Laboratory (NCAR/RAL) has led efforts to address these needs. Working under the sponsorship of the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the Taiwan Civil Aeronautics Administration (CAA) and in collaboration with several universities and private companies, the team has conducted research aimed at improving our fundamental understanding of the nature and causes of turbulence and has developed new techniques for better observing and forecasting turbulence.

Efforts have been focused in four areas: (1) Development and implementation of new techniques for obtaining automated *in situ* reports of turbulence encounters from commercial aircraft; (2) development of an automated system for detecting in-cloud turbulence using Doppler weather radar data; (3) development and implementation of an automated turbulence diagnosis, nowcasting and forecasting system called Graphical Turbulence Guidance or GTG; and (4) high-resolution simulation studies of observed turbulence events to better characterize the nature and genesis of free atmosphere turbulence. The products developed at RAL have reached a level of maturity that allows them to be used operationally by pilots and route planners in tactical and strategic planning for avoiding turbulence or mitigating encounters. One important aspect of all products is that they provide an aircraft-independent measure of atmospheric turbulence known as the energy (or eddy) dissipation rate or EDR ($m^{2/3}/s$).

AUTOMATED *IN SITU* MEASUREMENTS

Despite the continued reporting of the frequency and severity of turbulence encounters, our understanding of the nature and genesis of this complex atmospheric phenomenon remains limited. Research into the nature and causes of free atmosphere aviation-scale turbulence has been limited in part by a lack of reliable data. Verbal pilot reports (PIREPs) have typically been the only source of information about the location and severity of turbulence at flight levels. These reports are, unfortunately, incomplete (reporting is voluntary), and highly subjective (what one pilot views as "moderate" might be perceived as "light" or "severe" by another). Further, recent investigations into the accuracy of PIREPs have indicated an average position error of about 50 km, or several grid points with current operational numerical weather prediction (NWP) model grid spacings. While NWP models are very useful in

forecasting other atmospheric hazards, they are of limited value for turbulence given that turbulence exists for short periods of time and in small geographical areas. In order to improve the detection and forecasting of turbulence, it is clearly essential to upgrade the turbulence observation and reporting system and to create empirical means for obtaining more abundant, reliable data. In pursuit of this goal, we are in the process of augmenting, and eventually replacing, the PIREPs with *in situ* observations from selected commercial aircraft. These observations and dissemination of them are completely automated, and provide a measure of atmospheric turbulence intensity levels (EDR). The *in situ* EDR system consists of a simple software upgrade to the aircraft's ACMS (Aircraft Condition and Monitoring System), and no hardware changes are required.

Figure 1. In situ EDR observations of turbulence automatically reported by UAL 757, DAL737, DAL767, and SWA737 aircraft for the 24hr period on 25 Aug 2014. The color scale is the EDR intensity ($m^{2/3}$ s^{-1}).

FY2014 Accomplishments

Currently the *in situ* EDR software package is implemented on about 50 United Airlines (UAL) 757-200 aircraft, 80 Delta Air Lines (DAL) 737-700 and -800 aircraft, 80 DAL 767 (-300ER and -400ER) and 165 Southwest Airlines (SWA) 737-700 and -800 aircraft. An example of the coverage by these aircraft is given in Fig. 1. This algorithm is expected to be implemented on other aircraft in the coming years; the highest priority is implementation on international aircraft to enhance global coverage. Commercial vendors are also beginning to provide automated *in situ* EDR estimates, and one work area this year was to develop EDR estimation standards to insure that all EDR estimation methods provide similar results, at least within the operational needs.

FY2015 Plans

Discussions with Air France, British Airways, Lufthansa, Korean Airlines and DAL to implement the in situ EDR algorithm on all or parts of their fleets will be conducted.

REMOTE SENSING MEASUREMENTS

In order to give pilots better information about potentially hazardous regions of turbulence in thunderstorms before they encounter them, RAL scientists developed the NEXRAD Turbulence Detection Algorithm (NTDA) to use ground-based Doppler radar data to remotely detect turbulence within clouds. The algorithm runs on data from each radar, processing each "tilt" or "sweep" independently to obtain estimates of EDR. The results are merged with measurements from other radars and mapped to chosen flight altitudes. The initial version of the NTDA was adopted by the National Weather Service and implemented on all of its radar systems in 2007 and 2008. Since then, a number of advancements have been made to the NTDA to increase its coverage, accuracy, speed and maintainability, and to accommodate NEXRAD changes like the adoption of dual-pol and the implementation of a new spectrum width estimator (also developed by RAL staff). Recently, the NTDA has been modified to run on radars in Taiwan, as well.

FY2014 Accomplishments

In 2014, the NTDA continued to be modified to run in Taiwan on four Doppler weather radars, including three Gematronik radars and one NEXRAD. This new version of NTDA—called the NCAR Turbulence Detection Algorithm in Taiwan—required simulating the Gematronik signal processing and operational modes to update the NTDA's quality control configuration, as well as adapting for differences between the Gematronik and NEXRAD radars and their data. The NTDA processing and 3-D mosaic system is currently being integrated into the operational version of the Advanced Operational Aviation Weather System (AOAWS) that supports the Taiwan CAA (see Figure 2).

The NTDA-2.5 processing and mosaic system continued to run in real-time at RAL, using data from about 155 NEXRADS to produce 3-D grids of in-cloud EDR over the CONUS, Alaska, Hawaii, and Puerto Rico every 5 minutes at a resolution of 2 km horizontally and 3,000 ft vertically.

NTDA data were also used to analyze the development of turbulence inside thunderstorms and relate turbulence intensity and volume to the occurrence of lightning. The correlation between these quantities may be used in conjunction with future geostationary satellite lightning mapping data to help diagnose likely regions of turbulence in regions not served by Doppler radar.

FY2015 Plans

RAL scientists plan to investigate the possibility of using the newly-available NEXRAD dual-polarization data to further improve the NTDA's data quality. NTDA will continue to run as a real-time prototype over the CONUS, Alaska, Hawaii and Puerto Rico, providing data used for the development of turbulence nowcast products and scientific investigations

of the development of convective storms. It will be adapted as needed to accommodate changes to the NEXRAD radars.

NOWCASTING/FORECASTING TURBULENCE

RAL has been developing and testing aviation-scale turbulence forecast algorithms that provide forecasts out to 18 hours. These algorithms are based on operational NWP model output and are updated hourly. The version that is used over the CONUS is termed the GTG (Graphical Turbulence Guidance product). It relies on the WRF RAP NWP model (http://rapidrefresh.noaa.gov/) output and provides what amounts to an ensemble weighted mean of various turbulence diagnostics output as EDR ($m^{2/3}$ s^{-1}) on designated flight levels. The output is available to interested users on NOAA's ADDS web site (http://www.aviationweather.gov/adds/). An example is shown in Fig. 3.

In addition to the GTG *forecast* system (forecasts updated hourly), RAL is currently developing a *nowcast* system, GTG-N, which will provide rapid (every 15 min) updates and make heavy use of the latest available turbulence observations from the *in situ* EDR estimates, PIREPs, NTDA, and other sources (e.g., satellite-based inferences) on a GTG background. This will tremendously enhance pilot situational awareness, especially for turbulence associated with thunderstorms (convectively-induced turbulence or CIT). Special diagnostics (Diagnose Convectively-Induce Turbulence or "DCIT") have been developed to predict areas of likely near-cloud turbulence. DCIT has been developed by using statistical learning techniques in conjunction with a large database of *in situ* EDR reports and collocated radar, satellite, lightning, and NWP model-derived data fields.

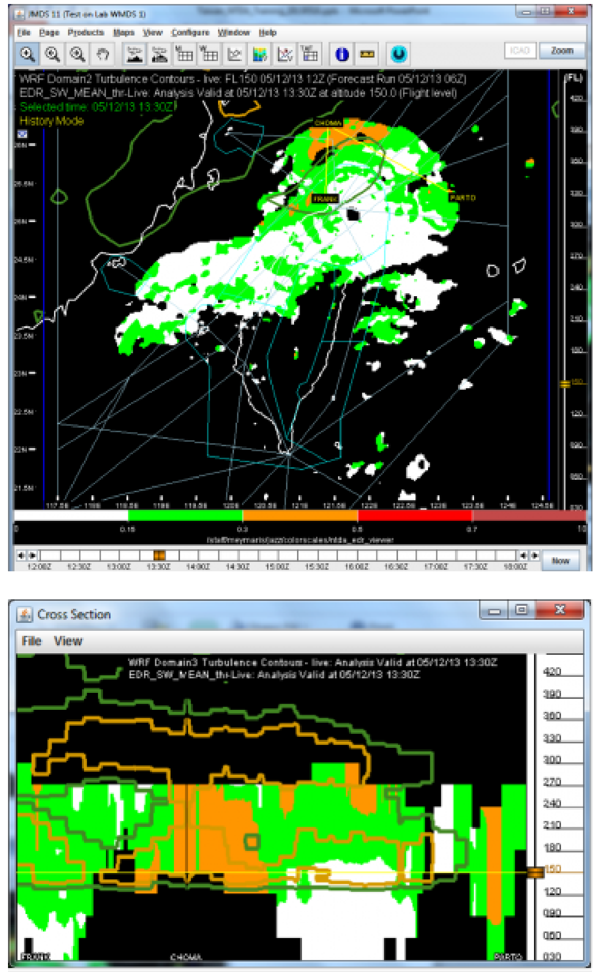

Figure 2. (Left) Plan view of Taiwan AOAWS NTDA EDR at 15,000 ft, 13:30 UTC on 5/12/13, with GTG/ITFA 6-hour forecast contours valid at 12:00 UTC overlaid. (Right) A cross-section view. NTDA complements the GTG forecast by supplying real-time, high-resolution detection of in-cloud turbulence.

FY2014 Accomplishments

The Graphical Turbulence Guidance version 2.5 (GTG2.5), which provides WRF RAP–based forecasts of turbulence, was developed and became "operational" on 1 May 2012 when the WRF-RAP replaced RUC at NCEP. In 2014 a major upgrade to the GTG product (GTG3) was prepared for release in mid-2015. The upgrades include (1) the inclusion of specific mountain-wave turbulence (MWT) predictive algorithms to better forecast this source of clear-air turbulence over the mountainous regions of the western U. S. and (2) the prediction of turbulence at low levels, i.e., below 10,000 ft MSL (the current GTG2.5 version provides predictions only at or above 10,000 ft MSL). Work also began on an Alaska turbulence prediction system, as well as on development of a global forecast system.

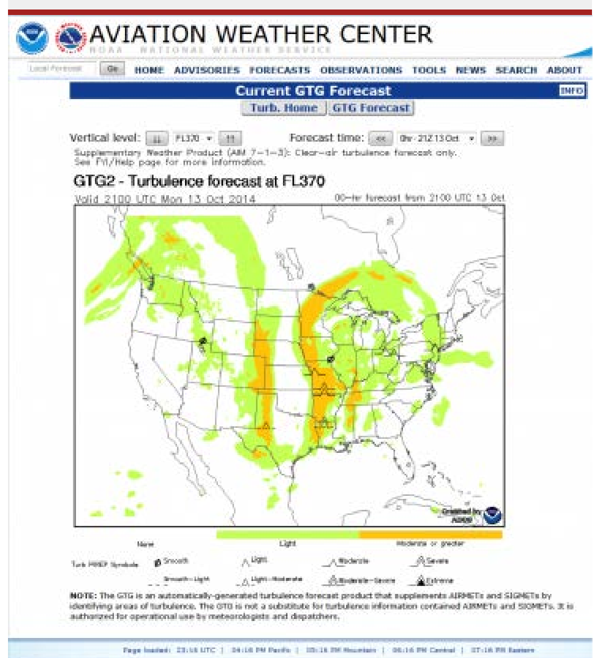

Figure 3. Example GTG2.5 output as it appears on NOAA's Experimental ADDS website.

FY2015 Plans

An update to the GTG forecast component will include a nowcast component (GTGN), which uses observations merged with short-term forecasts to provide EDR maps updated at 15 min intervals. GTGN will be independently evaluated by NOAA's GSD verification group. This new version of GTG will become available on NOAA's ADDS website sometime in late 2015. Testing and evaluation of the Alaska and global products will continue. Research on developing algorithms for forecasting convectively-induced turbulence (CIT) will also continue. These CIT

forecast algorithms will become part of GTG4.

CHARACTERIZATION EFFORTS

Substantial effort has been invested in developing a better physical understanding of the mechanisms responsible for CIT and CAT with the long-term goal of providing better operational turbulence forecasts. These studies make use of high-resolution nested (WRF) numerical simulations that have outer computational domains large enough to capture the relevant large-scale processes and inner domains fine enough to capture the turbulence generating mechanisms. An example turbulence case related to banded structures in anvil cirrus associated with a winter-time storm is shown in Fig. 4. In this case there were many reports of turbulence in the vicinity of the bands.

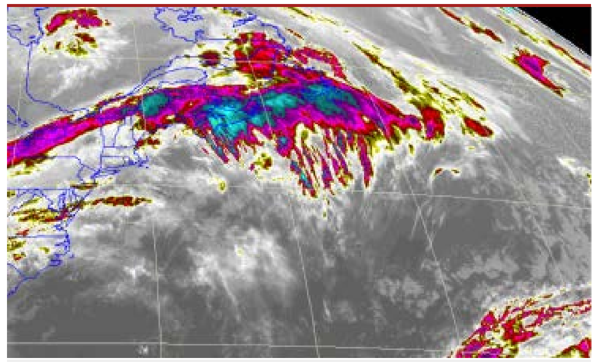

Figure 4. Example (16 UTC 15 Nov 2011) of turbulence associated with banded structures in a N. Atlantic storm.

FY2014 Accomplishments

By careful examination of observations (PIREPs and *in situ* EDR reports) compared to satellite imagery RAL scientists have isolated several cases where banded structures in the anvil cirrus of convective storms seem to be highly correlated to regions of elevated turbulence. The relation of the bands to the turbulence has been investigated for summer-time storms and the bands seem to have the character of planetary boundary layer rolls. Other cases involving banded structures in winter-time storms are being investigated. Preliminary results indicate the same mechanism is at play, but regions of negative absolute vorticity are also present, so this makes the turbulence generation processes more difficult to isolate. These studies are ongoing.

FY2015 Plans

Efforts to isolate cases and resolve turbulence sources will continue. This will lead to a better understanding of turbulence in the free atmosphere which in turn should suggest improved forecasting strategies. Since this work is unique and original we anticipate several publications to be forthcoming on the results.

‹ Prediction of Storm Hazards for Aviation   up   Integration of Weather Information into Air Traffic Management ›

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INTEGRATION OF WEATHER INFORMATION INTO AIR TRAFFIC MANAGEMENT

BACKGROUND

Since weather conditions can seriously restrict aircraft operations and levels of service available to system users, the manner in which weather is observed, forecasted, disseminated, and used in making air traffic management (ATM) decisions is of critical importance to the operation of the United States' National Airspace System (NAS) and international airspaces, especially oceanic domains. As the United States moves toward significantly increasing the capacity of the NAS through implementation of the Next Generation Air Transportation System (NextGen), integrating weather information (and associated uncertainty) into ATM decision-making processes is critical. Moreover, harmonization around the globe with partners such as the Single European Sky ATM Research (SESAR) plays an important role as well.

METHODOLOGIES FOR ESTIMATING PROBABILISTIC WEATHER-RELATED IMPACTS ON AVIATION

Daily ATM planning utilizes weather predictions with forecast horizon of 12 hours and longer for high-impact weather systems, such as hurricanes and winter storms, and for transoceanic flights. Strategic ATM planners look for detailed information about weather systems, including storm structure and organization, intensity and echo tops, location and timing, and associated forecast uncertainty.

RAL has been developing advanced concepts of using ensemble model forecasts to create probabilistic weather-related impact predictions for use today by ATM planners and for future incorporation into largely automated decision support tools. One such approach make predictions of the potential reductions in airspace capacity due to the presence of convective storms that pilots will deviate around. The probabilistic capacity reduction estimates are derived based on utilizing the 10-member Mesoscale Ensemble Prediction System (MEPS) run twice per day by the Air Force Weather Agency (AFWA) and using a methodology developed by Steiner et al. (Air Traffic Control Quarterly, 2010).

FY2014 Accomplishments

Significant effort was devoted this past year under NOAA sponsorship to the calibration of these capacity reduction predictions, and notable improvements have been achieved in terms of the prediction reliability. Unfortunately, we are lacking continued support to further this particular effort.

FY2015 Plans

We will continue to use ensemble-based approaches to provide improved guidance for convective weather hazards for transoceanic flights. This FAA-sponsored effort considers exploring the concept described above to highlight potential capacity impacts due to convective storms in oceanic airspace.

ATM – WEATHER INTEGRATION ACTIVITIES WITHIN NOAA

Under an Aviation Weather Cooperative Agreement (AWCA) with NOAA, RAL continued to facilitate collaborative work on weather integration and to transition that work from research to operations across federal agency lines for NextGen interim capabilities. During this past year the collaborative effort has been focused primarily on advancing a technology transfer of the turbulence and icing hazard guidance products to global forecast models in support of the World Area Forecast Centers (WAFCs).

FY2014 Accomplishments

For turbulence: A global version of the Graphical Turbulence Guidance (GTG) product was developed that uses input data from the United States' Global Forecast System (GFS) and numerical weather prediction models run by the UK MetOffice and ECMWF. Much of the effort was devoted to calibrating the generated levels of turbulence intensity, as they are significantly depending on the underlying numerical weather prediction model used. Work has also been conducted toward implementing a global GTG nowcast product based on utilizing in-situ aircraft-based turbulence information, satellite and model data.

Moreover, work continued on simulating aviation turbulence events over the North Atlantic Ocean like the one of 14 thru 15 November 2011 when reports of moderate-or-greater turbulence at cruising altitudes were widespread within regions of banded cirrus south of Newfoundland (Figure 1a). The widespread cirrus banding with horizontal wavelengths on the order of 50 km is particularly well simulated by ARW-WRF using a horizontal grid spacing of 3 km within the inner nest of a multi-domain run (cf. Figure 1b). Sensitivity experiments suggest a critical role of remote deep convection in the development of these cirrus bands and related turbulence. Continued analysis will examine the possible synergistic relationship between thermal and inertial instabilities on the formation of the simulated bands.

In-flight Icing

The work this past year focused on assessing the global Forecast Icing Product (FIP) to the FIP generated for the CONUS. In particular, the GFIP severity and probability fields were compared to the operational FIP over the CONUS for 6, 9, 12, 15 and 18-hour forecasts. The assessment method considered the distribution of severity numbers (0 – 1) for each forecast hour for both GFIP and FIP to note differences between the two data sets and determine, if these differences can be reconciled by a simple transfer function applied to the GFIP output. A similar technique was used to calibrate the Current Icing Product (CIP) for night/day differences (arising from the lack of visible satellite data) and for FIP when changes were made to the input model (from RUC to RAP).

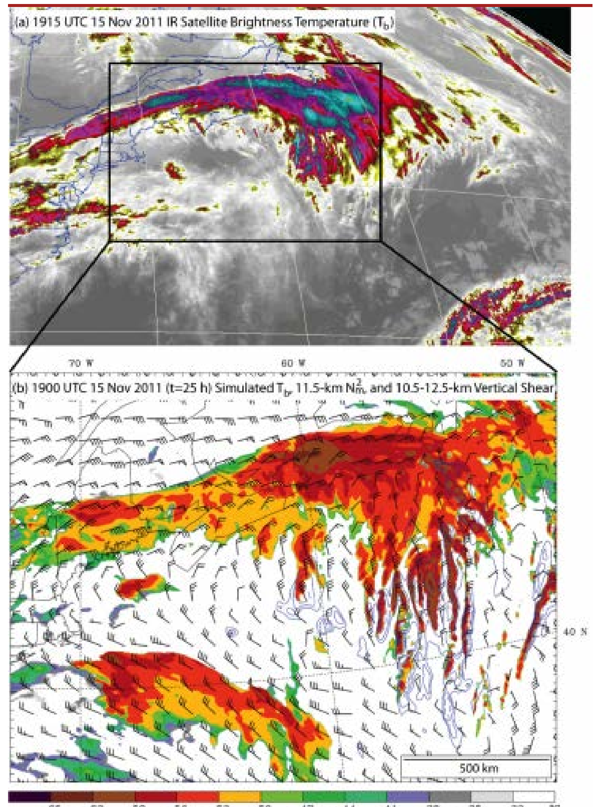

Figure 1. (a) Satellite depiction of brightness temperature, and (b) WRF-simulated depiction of brightness temperature, moist static stability with respect to ice (contours of 1×10^{-5} s^{-2} from -2×10^{-5} s^{-2} to 1×10^{-5} s^{-2}, negative values dashed) and vertical shear through the approximate cloud depth. The IR image at 1915 UTC on 15 November 2011 shows obvious bands in the vicinity of the diagonal line.

Comparison of Two Key Convective Storms Products

It is important to understand the similarities and differences between the radar analysis products and associated forecasts, which are used for operations at the NWS and those used at the FAA. The focus of this limited effort has been on objectively comparing the Multi-radar Multi-sensor (MRMS) convective storm analysis and forecast products generated by the National Severe Storms Laboratory (NSSL) to the Corridor Integrated Weather System (CIWS) products developed by the Massachusetts Institute of Technology (MIT) Lincoln Laboratories (LL). Notable differences have been identified so far that vary by time of day, season, and geographical location. This work will be completed in a few months with the release of a detailed report.

Ceiling and Visibility

R&D was directed toward forecast methods that could be used in an automated ceiling and visibility forecast system (CVF), including work focused on development of a self-adjusting method to determine optimal probability thresholds needed to derive deterministic forecasts from probabilistic forecast data. The advantage of such an algorithm will be its ability to self-adjust to accommodate seasonal and year-to-year variability. Better thresholds are expected to yield better deterministic forecasts.

FY2015 Plans

The period of performance for the NOAA Aviation Weather Cooperative Agreement will end soon and at this time no continued funding is available.

ATM/WEATHER INTEGRATION OUTREACH ACTIVITIES

RAL continues to participate in many outreach venues to further weather R&D, harmonization, and integration into ATM decision support tools. Notable events this past year included workshops sponsored by the FAA, NASA, and the Air Traffic

Control Association (ATCA). Moreover, the Friends and Partners in Aviation Weather (FPAW) meeting organized by RAL and hosted by the National Business Aviation Association (NBAA) at its Annual Convention & Exhibit continues to serve as an excellent venue to share and discuss latest developments with industry, government and research partners. RAL staff is represented on several ICAO, FAA and industry advisory committees such as the RTCA and SAE G-10 (weather displays on the flight deck), and professional organizations such as AMS and AIAA.

‹ Turbulence up Dissemination of Aviation Weather Information ›

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DISSEMINATION OF AVIATION WEATHER INFORMATION

BACKGROUND

The Next Generation Air Transportation System (NextGen) is now taking shape on the design boards of several federal agencies. NextGen has been parsed into several components, each with its own associated R&D and acquisition effort. One such effort is dedicated to developing the weather information needs of NextGen and providing common weather-related decision information to all stakeholders within the system. The NextGen System is a national priority to meet the expanding air transportation needs of the U.S. in the 21st century. Since weather conditions can seriously restrict aircraft operations and levels of service available to system users, the manner by which weather is observed, forecast, disseminated, and used in decision–making is of critical importance.

RAL's activity in dissemination of aviation weather information is concentrated in three areas:

1. Common Support Services – Weather (CSS-Wx), developing next generation technology and infrastructure for dissemination of weather data to US Government and other users;
2. Aviation Digital Data Service (ADDS), delivering weather data and support services to the aviation community using the Internet; and
3. Weather Technology in the Cockpit (WTIC), developing methods for making the best weather information available to pilots for decision-making in the cockpit.

COMMON SUPPORT SERVICES – WEATHER (CSS-WX) PROGRAM

For several years RAL has been engaged in developing standards and technology for the FAA research and acquisition programs focused on weather in the Next Generation Air Traffic Control System (NextGen) . The CSS-Wx program is developing next generation technology and infrastructure for dissemination of weather data to FAA and other aviation users. CSS-Wx's goal has been to enable ubiquitous access to aviation weather data anywhere an appropriate network connection is available. This program is part of the FAA's NextGen acquisition process, and is part of a larger related program called Common Support Services that encompasses flight, aeronautical, and weather data.

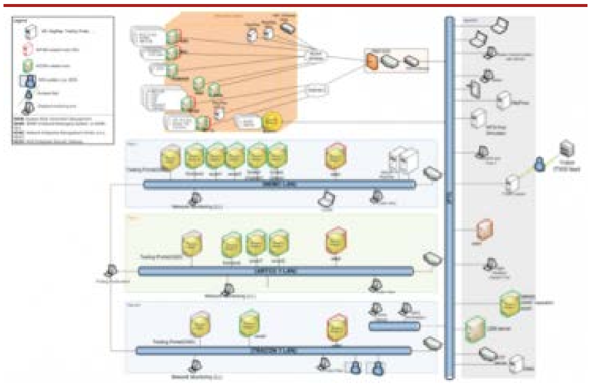

Figure 1. Diagram of Capability Evaluation with tiered data distribution.

CSS-Wx achieves its goal by using a service-oriented architecture (SOA) approach in which existing Internet technology is leveraged to build weather data directory and delivery services that conform to international standards. CSS-Wx is combining a data directory service using OASIS ebXML Registry/Repository (Reg/Rep) standards with data servers based on the Open Geospatial Consortium (OGC) Web Feature Service (WFS) and Web Coverage Service (WCS) standards. Using these technologies, it is possible to build complex, dynamic weather systems in which data sources and clients can be developed and modified independently but remain compatible while optimizing data latency and network bandwidth. RAL's participation in this program is sponsored by the FAA CSS-Wx Program Office and work is conducted collaboratively with the FAA's William J. Hughes Technical Center, MIT/Lincoln Laboratories, the MITRE Corporation, and NOAA.

FY2014 Accomplishments

In FY2014, RAL updated the Web Coverage Service Reference Implementation (WCSRI) capabilities to address needs identified by a FAA program that is acting as a pre-production user of the weather data dissemination technologies of NextGen. RAL also continued to assist the FAA in refining technical materials for a Request for Proposal for a commercially provided CSS-Wx system. A final version of the WCSRI reference implementation software was delivered to the FAA in September. In addition, RAL acted as the FAA’s technical expert and worked with experts from the International Civil Aviation Organization (ICAO) and the World Meteorological Organization (WMO) to establish new XML-based weather data standards.

FY2015 Plans

The focus for FY15 is supporting the FAA's acquisition process for CSS-Wx, including providing technical guidance to the FAA and the CSS-Wx commercial vendor. RAL will also continue its work on XML-based weather data standards in concert with ICAO and the WMO.

AVIATION DIGITAL DATA SERVICE (ADDS) PROGRAM

ADDS is a dissemination program that uses web pages to distribute aviation weather data. There are two instances of ADDS web pages: Experimental ADDS which is run at NCAR and Operational ADDS which runs at the NWS Aviation Weather Center in Kansas City. RAL uses Experimental ADDS to expose new prototype weather products to aviation users and gather feedback on the products' utility. Operational ADDS provides weather products that have been through the full review and approval process for operational use in aviation.

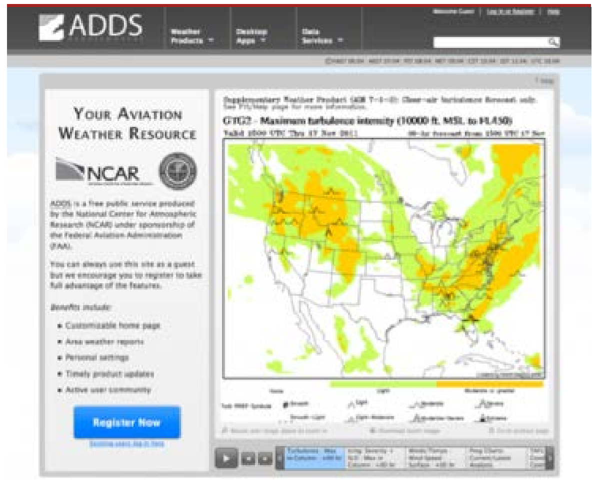

Figure 2. The Experimental ADDS Web site.

FY2014 Accomplishments

In FY2014 ADDS continued to provide critical weather information to a broad cross-section of the aviation community, 24 hours a day, 7 days a week. NCAR’s ADDS web site delivered real time aviation weather information to 500,000 different users every month.

FY2015 Plans

In FY2015, RAL will continue to serve the needs of the aviation community by providing the latest weather information.

WEATHER DISSEMINATION TO THE FLIGHT DECK - WEATHER TECHNOLOGY IN THE COCKPIT (WTIC) PROGRAM

One of the programs led by the FAA's Aviation Weather Office (AWO) is Weather Technology in the Cockpit (WTIC). RAL engaged in an effort for WTIC to study the requirements and technologies that would enable pilots to gain the advantages inherent in the rapidly emerging world of mobile technologies, including both tablets and phones. In this project, referred to as MobileMet, RAL provided a comprehensive technology assessment of mobile devices for use in delivery of weather information to the cockpit. RAL also conducted a broad survey of the needs and expectations of users in relation to mobile devices for aviation weather delivery. In addition, RAL developed and delivered prototype application based on the user needs survey.

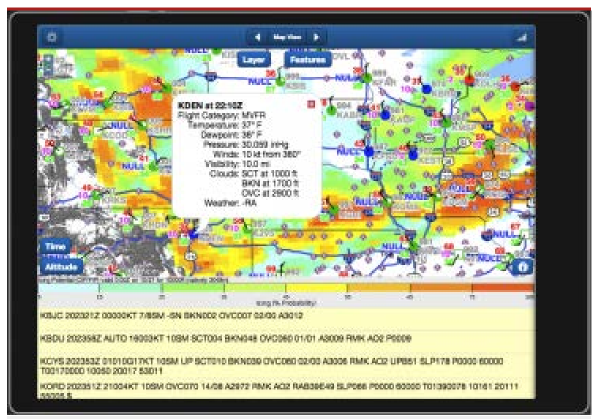

Figure 3. WTIC MobileMet Application Prototype screen

FY2014 Accomplishments

RAL enhanced the Mobile Met application in support of a cognitive walkthrough evaluation by the FAA technical Center. In response to the results of the evaluation, RAL modified the application in preparation for a part task simulation evaluation by the FAA.

FY2014 Plans

RAL will support the FAA during the part task simulation evaluation. RAL will also research and develop extensions to the MobiileMet application that are decision support tools aimed directly at safety critical pilot decisions.

‹ Integration of Weather Information into Air Traffic Management | up | Oceanic Weather ›

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OCEANIC WEATHER

BACKGROUND

Weather conditions can seriously restrict aircraft operations and levels of service available to system users. Thus, the manner by which weather is observed, forecasted, disseminated, and used in decision-making is of critical importance. Aviation users operating within oceanic and remote regions have limited access to high-resolution (temporal and spatial) weather products that depict the current and future locations of deep convection and turbulence.

To address these needs, RAL scientists develop weather products related to the oceanic/remote occurrence of deep convection and turbulence from clear air (CAT) and convectively-induced (CIT) sources. For convection, the Oceanic Convection Diagnosis and Nowcasting system is being developed to detect and forecast deep convection using satellite-based methodologies in combination with numerical model results. These methods have been implemented both regionally (i.e., the Gulf of Mexico/Caribbean area), as well as globally. For turbulence, a methodology developed for the continental U.S. (CONUS) Graphical Turbulence Guidance (GTG) and GTG Nowcast (GTG-N) products is being extended to produce estimates of CAT and CIT over a global domain. In addition, a recent effort has begun to investigate the utility of global ensemble forecasts for providing probabilistic guidance for convective storms. Accomplishments and plans related to the ongoing research and development of convection and turbulence weather products are discussed below.

GLOBAL TURBULENCE

Under funding from NASA, NOAA and the FAA, the GTG algorithm and software developed for use in CONUS airspace under the FAA Aviation Weather Research Program (AWRP) have been adapted to utilize global numerical weather prediction (NWP) forecast model data and create forecasts for use in global turbulence decision support. Additionally, satellite-based diagnostics are being incorporated to develop global turbulence nowcasts. These nowcasts use the observation data to provide an improved snapshot of current global turbulence, similar to the CONUS GTG Nowcast product developed under FAA AWRP funding.

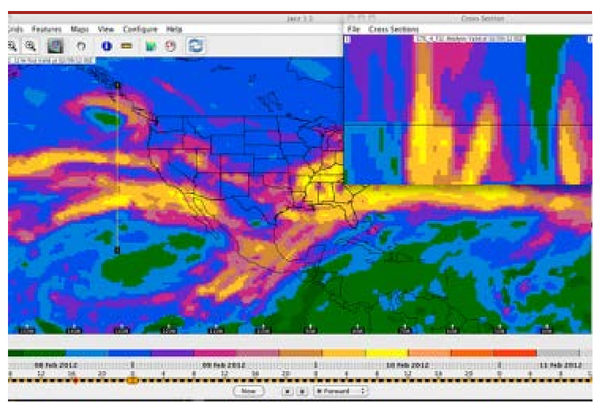

Figure 1 . Prototype Global GTG 12-hour forecast valid 9 February 2012 00 UTC, displayed via a web-accessible Java display tool. A vertical cross-section along the north-south transect depicted in the western Pacific appears in a separate window and is overlaid in the upper right.

FY2014 Accomplishments

A Global GTG prototype based on the NCEP Global Forecast System (GFS) NWP model continued to run in real time, and its global 0 – 48 hour gridded turbulence forecasts were provided to the Aviation Weather Center (AWC) for evaluation (Figure 1). A database of GFS model data, model-based diagnostics, satellite imagery, and satellite-derived turbulence diagnostics was collected to support data mining and development of an empirical data fusion approach to turbulence nowcasting. The GTG software was tested on a number of case studies using the full native resolution GFS model data, as well as on data from the ECMWF and UK Met Office global NWP models. RAL personnel continued to interface with colleagues at the UK Met Office and the World Area Forecast Center (WAFC) coordination group.

FY2015 Plans

With funding from NOAA and the FAA, work in FY2015 will continue on harmonization of the global turbulence forecasts produced by the Washington and London WAFCs via development of a GTG product that uses both the GFS and UK Met Office models. A prototype global GTG Nowcast product that fuses NWP and satellite-derived turbulence diagnostics will be developed, with real-time output provided to the AWC. The turbulence nowcasts and forecasts will address clear-air, mountain-wave and convectively-induced turbulence sources in a unified fashion for global aviation users, providing a replacement of the current World Area Forecast System (WAFS) gridded turbulence product, the Ellrod Index. RAL will continue collaborating with NOAA and UK Met Office personnel to facilitate the further development and ultimate transition to operations of this technology.

PROBABILISTIC GUIDANCE FOR CONVECTIVE HAZARDS

Prediction of convective storms continues to be a difficult problem. Ensemble forecasts are now being used to better characterize forecast uncertainty. Effort is focused on development of a forecast product that provides probabilistic guidance on convective storm hazards for transoceanic flights with lead times of 24 – 36 hours. A methodology has been developed that can be utilized to facilitate global harmonization of World Area Forecast System (WAFS) products.

FY2014 Accomplishments

This past year the initial methodology to characterize oceanic convection based on fusing global ensemble forecasts has been further developed. The current real-time prototype utilizes global ensemble forecasts from the United States and Canada's numerical prediction centers; ensemble data from European centers are being explored in an offline mode as well. Model-predicted precipitation is used as a proxy for convective storms, and early assessments are being conducted using CMORPH data. The initial domain has been focused on the northern Pacific (Figure 2), and this year a Caribbean domain has also been added. Further expansions will follow with future upgrades. Significant effort is going into development of a "truth field" based on satellite and global lightning data to enable assessment and calibration of the probabilistic guidance on convective storm hazards. The truth field development is largely based on previous NASA-funded efforts for the detection and nowcasting of oceanic convection that can be viewed at http://www.rap.ucar.edu/projects/ocn/realtime_sys.

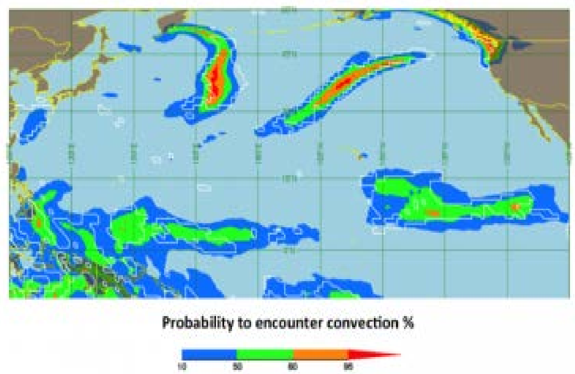

Figure 2. Probabilistic guidance for encountering convection (in colors). Shown is a 24-hour forecast for the Pacific domain based on harmonizing four global ensemble prediction models. The white contours represent observed convective storms.

This effort is conducted in close collaboration with the NWS Aviation Weather Center (AWC), which receives first-generation products from RAL's prototype system and provides feedback based on evaluations conducted as part of the Aviation Weather Testbed.

FY2015 Plans

During the coming year, the prototype capability will be further enhanced based on performance assessment and feedback received from AWC forecasters. In particular, a cloud/echo top product will be added and the domain coverage expanded to include the Atlantic basin. In addition, the truth field will be enhanced; this is critical as the performance assessment hinges on this. The collaboration with AWC will continue, as the product suite continues to be enhanced and additional domains added.

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- Renewable Energy
- Weather Prediction Statistical Optimization
- International Aviation
- Use and Value of Weather Information

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SURFACE TRANSPORTATION WEATHER

BACKGROUND

RAL is a key contributor to the research and development of the weather component of the Federal Highway Administration's wireless Connected Vehicle program. RAL also continues to support the adoption of the winter Maintenance Decision Support System (MDSS) technology across the nation.

In the coming year, RAL will continue to expand its efforts by enhancing our transportation decision support systems in preparation for the United States Department of Transportation (USDOT) Connected Vehicle Deployment Pilot Program and by exploring new uses for our technology.

FY2014 ACCOMPLISHMENTS

Pikalert® Vehicle Data Translator

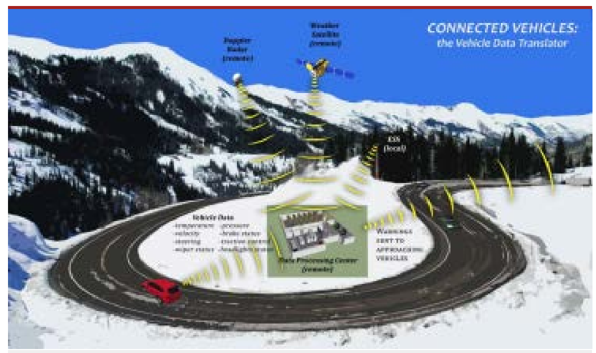

Figure 1. Schematic of the connected vehicle concept.

The Connected Vehicle program has three main goals: to increase safety, mobility, and environmental efficiency. This program will ultimately provide vehicle probe data (including weather data) from millions of vehicles that will be available to the weather community to support the diagnosis and short-term prediction of weather and road conditions (Figure 1). With funding and support from the USDOT Research and Innovative Technology Administration (RITA) and direction from the Federal Highway Administration's (FHWA) Road Weather Management Program, RAL conducted research in FY14 to continue development of the prototype Pikalert Vehicle Data Translator (VDT). Pikalert incorporates vehicle-based measurements of the road and surrounding atmosphere with other, more traditional weather data sources, and creates road and atmospheric hazard products for a variety of users. Analysis in FY14 focused on two key areas: improving the Pikalert Enhanced Maintenance and Decision Support System (EMDSS), which incorporates Connected Vehicle technology into the EMDSS, and refining the Pikalert Motorist Advisory and Warning (MAW) System, which provides hyper-local and rapid-update road weather warnings to the travelling public.

The Pikalert EMDSS represents the latest innovation in snow control. Building on years of MDSS development, the Pikalert EMDSS incorporates Connected Vehicle data into the forecast and decision process. As a result, end users can obtain information along the entire stretch of roadway, and not just at Road Weather Information System (RWIS) sites. This enables maintenance providers to better monitor and react to changing road conditions. They will be better equipped to make spot treatments on the road, improving safety, mobility, and reducing the environmental impact of de-icing chemical.

The Pikalert MAW is a revolutionary approach to providing hyper-local, near real-time road weather information for the travelling public. Incorporating Connected Vehicle data, the MAW provides current inferences for visibility, road condition, and road precipitation. It also blends the Connected Vehicle data with a forecast engine to provide 24-hour forecasts of road weather conditions. Using the MAW, drivers will be able to plan routes in advance of their travel, including knowing which way to go and whether to delay travel. While on the road, a phone application keeps drivers abreast of changing road weather conditions.

Maintenance Decision Support System (MDSS)

The federal prototype MDSS deployment over the State of Alaska continued to further some much needed road weather

research in a high-latitude and extreme-cold region of the world. Along with a deployment of the MDSS, Connected Vehicle research was also performed with Alaska Department of Transportation vehicles equipped with weather instrumentation. The MDSS project at Denver International Airport (DIA) continued in FY14 and is now an instrumental tool for the ground operations personnel at DIA. Research on improving the very short-term forecast and treatment recommendations was accomplished, improving operator's ability to keep the runways open as long as possible.

FY2015 PLANS

Pikalert® Vehicle Data Translator

RAL will work with state partners in Minnesota, Michigan, Colorado, and Nevada to create enhanced functionality for the Pikalert System. This will include expanding the road network to include areas beyond interstates and major state highways, adding a new email alert function, improving the road weather hazard algorithms, and implementing more features into the Pikalert display, including RWIS camera imagery.

Forecasting and Vehicle Data

RAL will conduct research to explore the scientific and technical challenges associated with using vehicle probe data for weather diagnosis and prediction. Technical challenges include data quality, metadata, data representativeness, data collection architectures, and understanding the potential impact of vehicle data on surface weather forecast skill. RAL will conduct a study of the impact of vehicle probe data on short-term (0 to 6 hour) weather forecast skill. RAL will also oversee four university partner white papers on critical topics related to road weather use.

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RENEWABLE ENERGY

BACKGROUND

Since 2009 RAL has collaborated with university researchers, DOE labs, commercial partners, and other NCAR entities to develop methods to more accurately analyze and predict wind and solar power in support of the renewable energy industry. Projects have focused on resource assessment, analysis of the interaction between atmosphere and operating wind turbines, and real time wind, solar, and load forecasting to improve operations and economics of incorporating renewable energy into the power mix, and characterization and quantification of variability in wind and solar energy.

FY2014 ACCOMPLISHMENTS

Xcel Energy Variable Energy Forecasting System Project

In FY2013, RAL commenced a two-year collaborative project with Xcel Energy Services, Inc. with the goal to extend existing wind power forecasting capability developed in the previous phase of the collaborative effort. The renewable prediction technology summarized in Figure 1 helps operators make critical decisions about powering down traditional coal- and natural gas–powered plants when sufficient winds are predicted, enabling increased reliance on alternative energy while still meeting the needs of customers. Utilization of the initial day-ahead forecasting system resulted in significant savings for the utility and the rate payer (Mahoney et al. 2012, Haupt et al. 2013). NCAR is now extending these capabilities to address a wide range of forecasting needs related to efficient wind power integration: enhancing the short-term forecasting for energy dispatching and forecasting extreme events. New forecasting capabilities also include probabilistic estimates of wind power via an analog ensemble approach, extreme events, potential power, ramping (rapid changes in wind energy), and load forecasting. To better forecast loads distributed solar energy production forecast system is also under development (Williams et al. 2014).

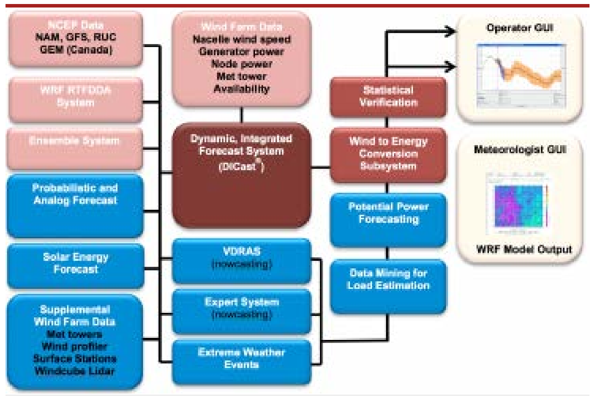


Figure 1. Schematic diagram of the comprehensive wind power forecasting system.

The numerical weather prediction portion of the forecasting system incorporates observations of current atmospheric conditions from satellites, aircraft, weather radars, ground-based weather stations, and even sensors on the wind turbines. The information is then utilized by the Real-Time Four-Dimensional Data Assimilation System (RTFDDA), which continuously updates the WRF model simulations with the most recent observations.

Initial forecasting capabilities developed by RAL focused on day-ahead forecasting. The goal was to minimize root square error in wind power forecast for energy trading purposes. This was accomplished using our own Dynamic Integrated Forecasting System (DICast®). DICast® statistically optimizes the forecasts based on current observations, climatological data, and real-time validation of the model predictions while customized displays provide grid operators with a best forecast that includes error estimates as well as meteorological plots to visualize the weather graphics.

The current project emphasizes improving short-term forecasting capability, which is designed to improve forecasts of wind energy ramp events. One aspect of the system is NCAR's Variational Doppler Radar Analysis System (VDRAS, Sun and Crook, 1997; Sun and Zhang, 2008; Sun et al., 2010). VDRAS is designed to use all available weather data:

surface and upper observations, NEXRAD data, and aircraft observations, as well as any supplemental weather observations including meteorological tower data, nacelle winds, wind profilers and surface stations in proximity to wind parks. VDRAS has also been used to analyze and forecast wind fields at wind plants in Eastern Colorado (Figure 2). The short-term forecasting system based on VDRAS provides wind forecasts within the first two hours, and thus, it is particularly useful for wind ramp forecasting. Integrating VDRAS output with an expert system based on surface observations and the DICast forecast is leading to better estimates of rapid wind speed changes.

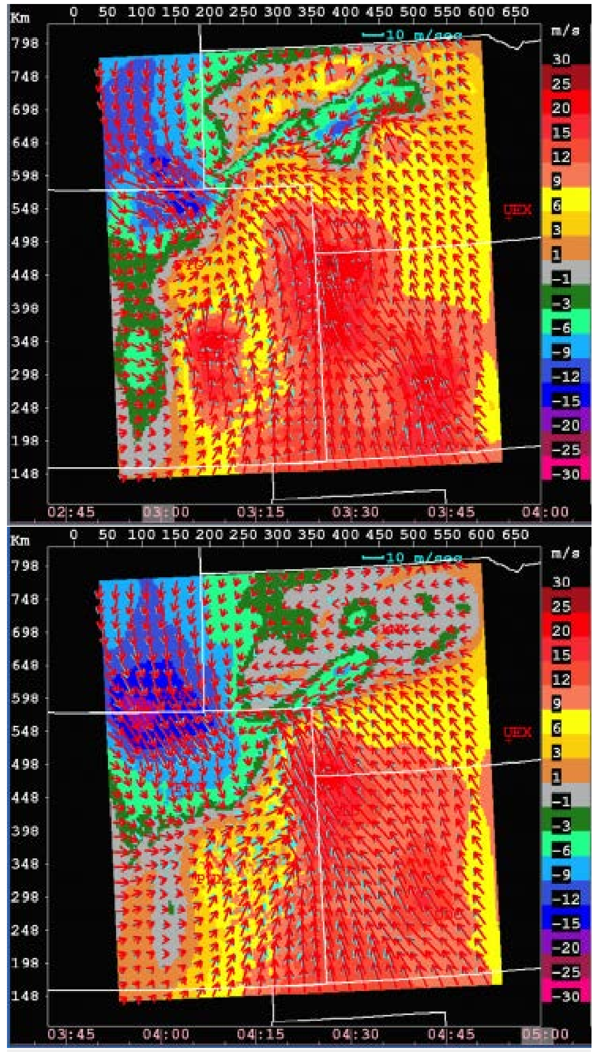


Figure 2. VDRAS analysis (left panel) and two-hour forecast (right panel), shown are results obtained using two vertical resolutions, dz=300m (color contours) and dz=200m (vectors).

Another novel capability being added to Xcel Energy's forecasting system is icing prediction. In cold climates icing can significantly reduce wind power production even under very favorable wind conditions. Ice accretion on turbine blades reduces the effective lift and therefore reduces the rotor torque, resulting in significantly reduced performance that can lead to cut-outs. Freezing precipitation including snow, freezing drizzle and ice accretion is poorly observed by standard surface observation systems and by radar. A freezing drizzle algorithm that uses air temperature and the raw vibration frequency of a freezing precipitation sensor has been developed and successfully demonstrated at several airports in support of deicing services (Politovich et al, 2010). This algorithm, and others developed at NCAR over the past 20 years for aircraft anti-icing programs for the FAA, are now being adapted for application to wind turbine operations. Data from icing sensors at wind parks is being integrated with collocated air temperature data to generate ice accretion information for turbines. Freezing precipitation and icing alerts can then be generated to avoid engine damage due to ingestion of ice, improve the efficiency of deicing operations, and produce more accurate wind power forecasts under adverse weather conditions.

RAL is also collaborating with Pennsylvania State University scientists who are conducting laboratory and numerical experiments on ice accretion on turbine blades. These experiments are designed to determine the effect of blade rotation speed and pitch angle on ice accretion and consequently the effect of ice accretion on power output. This work is expected to enable improved wind power forecasts in icing conditions.

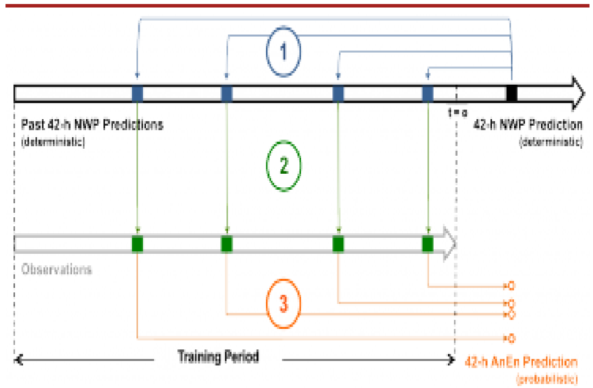


Figure 3.Schematic representation of the process for finding four members of the analog ensemble (AnEn) at one forecast lead time.

Another new capability that is being provided is advanced diagnosis and warning of high speed cut-outs, which will enhance overall forecast system performance. High-speed cut-outs are predicted through analysis of standard practices at wind parks of interest and development of a diagnostic algorithm to determine when high speed cut-outs are occurring.

An ongoing challenge in wind power prediction is the quantification of uncertainty in any given forecast. The accuracy of wind power forecasts depends on a number of factors, including boundary and initial conditions, accuracy of parameterizations of physical processes, as well as inherent limits to predictability (Haupt and Delle Monache 2014). For that purpose a novel technique based on the analog ensemble described by Delle Monache et al. (2011, 2013) is used. The analog ensemble approach combines real-time and historical data from state-of-the art numerical weather prediction models and extensive records of wind power observations to provide reliable quantification of the forecast uncertainty and accurate power forecast of day-ahead lead times (Figure 3).

The analog method has shown great value for improving the best prediction and quantifying its uncertainty.

Finally, the DICast system will be applied and enhanced for load forecasting by synthesizing weather forecasts and observed (historical) load data to provide more accurate forecasts of future loads based on past behavior.

Solar Power Forecasting

In 2013, RAL embarked on a major DOE-funded effort to advance the state-of-the science of solar power forecasting. This work is in partnership with the National Renewable Energy Laboratory, Brookhaven National Laboratory, National Oceanographic and Atmospheric Administration; universities – Penn State, Colorado State, Hawaii, Washington, and University of Buffalo; utilities – Long Island Power and Light, Public Service of Colorado, Sacramento Municipal Utility District, Southern California Edison, and the Hawaiian Electric System; independent system operators (ISOs) – New York Power Authority, Xcel Energy, California ISO, and Hawaiian Electric; and commercial forecast providers – Telvent DTN, Atmospheric and Environmental Research, Global Weather Corporation, and MDA Information Systems.

The primary objective of this project is to develop a solar power forecasting system that advances the state-of-the-science through cutting edge research, tests it in several high penetration solar utilities and ISOs, and disseminates the research results widely to raise the bar on solar power forecasting technology (Haupt and Drobot 2014). To reach this goal requires basic and use-inspired research in targeted core areas. Metrics have been developed in collaboration with DOE, the other DOE-funded team led by IBM, and thoroughly vetted by the stakeholders. These metrics measure improvements in solar forecasts, the resulting power predictions, and value to the utility or ISO. The value chain is depicted in Figure 4.

Advances are also being made in solar radiation measurement and cloud observation and tracking techniques, as well as in their use for short-range prediction. This includes working with BNL on total sky imaging (TSI) technology. Three TSIs have been deployed in Xcel Energy's solar farms in the San Luis Valley of Colorado. NCAR is also working with NOAA and CSU on advancing the use of satellite data in models. A new method for integrating multiple satellite inputs and using that information to project cloud shadows onto the earth's surface and advects the clouds using cloud vectors has been developed. A second new technology has been developed to fully assimilate these multiple sources of cloud data (satellite data and TSI images) into a rapid update version of WRF that advects the diagnosed clouds using the WRF dynamical core and computes the resulting irradiance (see Figure 4). Finally, new methods are being devised to statistically predict irradiance that includes identifying regimes and also predicting variability (Figure 5) (McCandless et al. 2014).

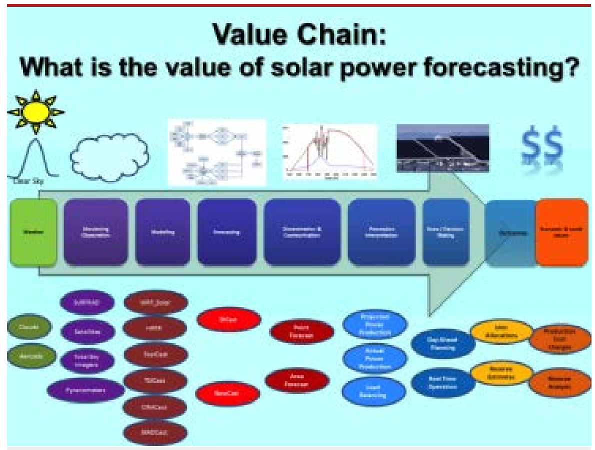
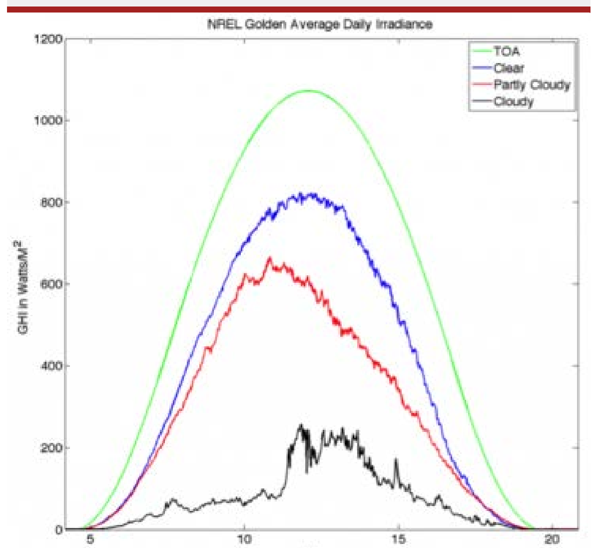


Figure 4. Value chain of implementing a weather decision support system for solar power. At the bottom are the components of the NCAR team's system that build toward providing an economic impact of this system.

Methods to quantify and track aerosols that affect cloud formation and radiative transfer, including the prediction of aerosols, haze, and contrails, are being investigated. Radiative transfer through distinct types of clouds and aerosols, NWP modeling capabilities tuned for solar radiation at specific locales, and a new shallow convective scheme are resulting in a new version of the Weather Research and Forecasting (WRF) model tuned to solar irradiance prediction – WRF-Solar. The team is working closely with scientists at NOAA to translate the research toward operational use in the High Resolution Rapid Refresh (HRRR) system. WRF-Solar is being run in two test modes: a rapid-update 6 hr forecast run hourly at 9 km resolution, and a "next day" forecast run twice a day out to 48 hours at 3 km resolution with 1 km nested domains over the target solar farms.



These new technologies must be blended seamlessly and delivered to the utilities and ISOs. Thus, statistical learning methods are needed to blend the disparate forecast models, and real-time learning techniques are needed to optimize irradiance forecasts under dynamic conditions. Irradiance-to-power conversion methods are also important in providing the users with the type of data that they require. Finally, economic

analysis is assessing the value of the forecast improvements.

Research in FY14 has focused on deploying a prototype solar forecasting system that is being tested in collaboration with utilities and ISOs in geographically diverse areas, including Long Island, New York; Colorado; and coastal California. Each component of the system is in the process of being verified and validated using evaluation techniques developed specifically for the project through in-depth interactions with stakeholders. The quasi-operational forecasts will be provided for a full year to allow sufficient time for full assessment of their value. The results are being widely disseminated through publications, workshops, and software. The impact of this effort will be enhanced solar forecasting that is integrated into utility operations, advancing the potential penetration of renewable energy.

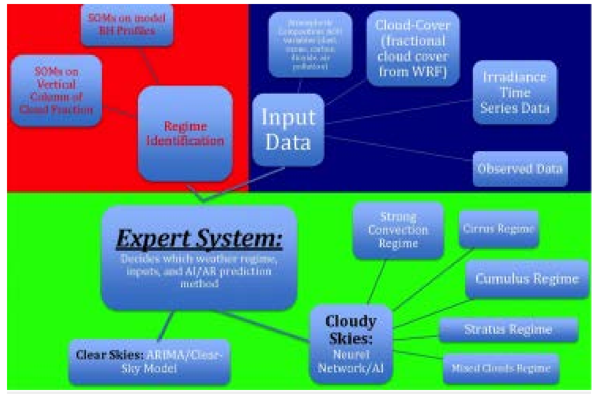


Figure 5. Composite plot of the average irradiance for days defined as cloudy (black line), partly cloudy (red line), clear (red line), and the top of atmosphere expected Global Horizontal Irradiance (left plot). The location of these observations is Golden, Colorado. Right figure: Statistical learning system for short-range prediction that includes pattern analysis for cloud regime identification (top left) based on multiple source of data (top right) that combine to produce an expert system based on cloud regime (bottom).

Off-Shore Wind Energy Projects

RAL staff have been working on several DOE-funded projects aimed at advancing offshore wind energy. These projects are focused on enhanced understanding and characterization of the interactions between the ocean and the atmosphere in order to better predict winds over rotor disks for both locating wind plants and for forecasting power for plant operations. Analysis of available offshore observations is combined with modeling efforts to develop improved marine boundary layer parameterizations, as well as improved ocean-atmospheric coupling techniques, with a goal to reduce market barriers to offshore wind energy. One of the projects, in collaboration with Penn State University, is developing a "Cyber Wind Facility", a computational facility akin to a field wind turbine test facility that blends models across scales. In 2013, NCAR and PSU worked together to integrate time varying mesoscale forecasts with large eddy simulations (LES) of the atmosphere in the vicinity of a wind farm. A second project combines the efforts of staff in RAL and MMM seeks to characterize the coupling between wind, wave states and stratification toward reducing errors and uncertainties in hub-height wind speed and rotor-plane shear prediction. A third project expects to improve understanding of the complex interactions between the atmosphere and the ocean surface. This knowledge will be used to develop improved marine boundary layer (MBL) parameterizations, as well as improved ocean-atmospheric coupling techniques. These projects will lead to better modeling capability to reduce market barriers to developing offshore wind energy.

Lidar Support for Wind Energy

RAL researchers worked closely with faculty and students from the University of Colorado and the Nation Renewable Energy Laboratory's National Wind Technology Center to deploy lidars during 2014. RAL's lidar was deployed at the NWTC and in other experiments to better characterize wind for renewable energy.

Wind Turbine and Turbine Array Wake Characterization

The effects of operating wind turbine rotors on atmospheric flows can be represented using a generalized actuator disk model. To further study these effects, RAL scientists have implemented a generalized actuator disk model in the Weather Research and Forecasting (WRF) model to examine wind turbine wakes, their structure and interaction in wind turbine arrays, as well as their effect on transport processes in atmospheric boundary layers using the large-eddy simulation (LES) approach. In collaboration with the Lawrence Livermore National Laboratory (LLNL), RAL scientists have validated the generalized actuator disk model in WRF-LES using the data from the Turbine Wake and Inflow Characterization Study (TWICS) experiment (Figure 6). The TWICS experiment took place at the National Wind Technology Center (NWTC) test site of the National Renewable Energy Laboratory (NREL) in the spring of 2011 and involved measuring a 2.3 MW turbine wake using National Oceanic and Atmospheric Administration's (NOAA's) High Resolution Doppler Lidar (HRDL). The validated generalized actuator disk model implemented in WRF will advance the capability to model details of flow through wind turbine arrays under a wide range of atmospheric conditions and thus will become an advanced tool for wind resource assessment and wind turbine array performance evaluation as well as turbine

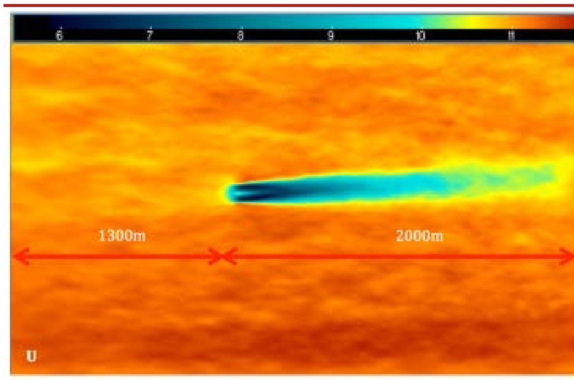


Figure 6. Turbine wake simulated using WRF-LES with a generalized actuator disk model.

load calculations.

Wind Resource Assessment in the Developing World

In 2014, NCAR embarked on a project with the National Renewable Energy Laboratory (NREL) to assess and quantify the wind resource in Bangladesh. NREL deployed sodars on site as well as several meteorological observation towers (Figure 7). NCAR's role is to use modeling capabilities to assess the resource and to assimilate data from the new observational network to calibrate the models. The first step was to compare the wind resource from three separate historical reanalyses, which blend information from historical observations with models. The next step will be to work closely with NREL to downscale and assimilate the observations using the Real Time Four Dimensional Data Assimilation (RTFDDA) of RAL.

Figure 7. Partners deploying a sodar in Bangladesh.

Analog Ensemble for Wind Resource Assessment

As part of an NREL-funded project, a new method has been proposed and demonstrated for the long-term estimate of the wind speeds at a target site, a key step in wind resource assessments. Analog ensemble (AnEn) techniques have been used with success previously for short-term weather predictions (e.g., Delle Monache et al. 2013). In the context of the wind resource assessment, the analog-ensemble method draws on the information contained in the historical data of multiple physical quantities over the period these data overlap with the observations (known as *training period*; typically 365 days) of the quantity of interest (known as *predictand*; the wind speed in this study). The relationships derived within the training period are then applied to reconstruct the on-site wind speed over the period for which there are no observations (hereafter referred to as *reconstructed period*, e.g., the past 20 years before the measurement campaign started).

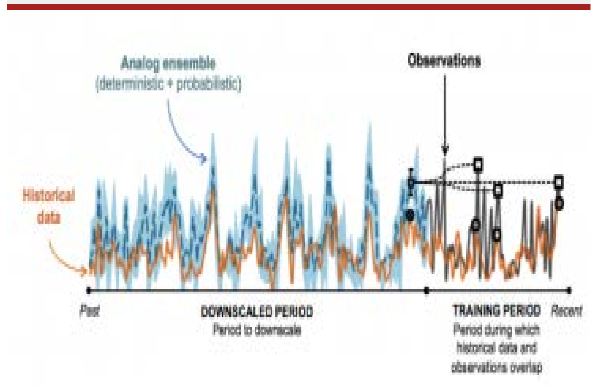


Figure 8. Sketch of the functioning of the analog ensemble method for one analog predictor, the analog trend reduced to one time step, and when retaining the best three analogs.

More precisely, this is a three-stage process that is executed independently at every target site for every hour, *t,* of the reconstructed period, as sketched in Figure 8. First, the historical value of multiple physical quantities (known as *analog predictors*; e.g. wind speed itself, wind direction, pressure, etc.) is retrieved for a time window (known as an *analog trend*) centered around time *t* (black dot in Figure 8). The analog predictors are selected beforehand based on their known or anticipated correlations to the predictand. Second, other historical cases with conditions similar to those in the target window are identified (known as *analogs*) by looking at a time window (known as the *analog search window*) centered around the same hour of the day for every day in the training period, and ranked by closeness of the match. Analogs may therefore come from any day in the training period. Using multiple predictors helps distinguish the analogs by identifying specific weather regimes relevant to the predictand. Third, the *K* best analogs (*K* is the *number of analogs*; black circles) are selected, and the corresponding observed values of the predictand are retrieved (black squares). The latter are the *ensemble members* for hour *t*.

The final result is the *analog ensemble*, i.e., a set of *K* wind speed values for every hour *t* of the reconstructed period. The assumption is that if analogs are found, their errors will likely be similar to the error of the historical time step used to reconstruct, and thus, the error that can then be inferred and corrected. It has been demonstrated that:

- The AnEn can be used effectively for wind resource applications;
- The AnEn provides an accurate long-term wind resource estimate at target sites;
- The AnEn reliably quantifies the uncertainty allowing for cost-effective decision making;
- The AnEn is a computationally inexpensive method.

We are in the process of testing AnEn for 15 locations provided by NREL, assessing its statistical consistency, reliability, spread-skill relationship, and resolution.

PLANS FOR FY2015

FY2015 will continue to be an exciting time for renewable energy research at RAL. New collaborations with national

laboratories, university scientists, and private companies will advance the state-of-the-science necessary to make a large penetration of renewable energy capacity feasible. In FY2015 significant efforts will be focused on developing comprehensive wind power forecasting capabilities that, in addition to current wind power forecasting system will include capabilities for short-term forecasting, forecasting of extreme events, and load forecasting. An emphasis will be on porting the research to other regions of the world. RAL and its partners will also continue implementing a new solar forecasting system for both utility scale and distributed solar facilities. In addition analog ensemble methodology will be further advanced and applied to a range of renewable energy related projects to quantify uncertainty.

Other plans include:

- Continued collaboration with Xcel Energy to enhance the Wind Power Prediction System, including predicting icing, high speed cutouts, load forecasting, short range forecasting, enhancing power conversion algorithms, etc.
- Continued collaboration with many partners under DOE funds to implement, deploy, and test a solar power forecasting system.
- Collaboration with NREL and the University of Colorado to deploy a vertically pointing lidar to study wind turbine wakes and to model those wakes using LES techniques.
- Continuing to work with NREL with resource assessment and developing measurement programs in developing countries, including Bangladesh.
- Expansion of the wind forecasting capability into new areas, including international, complex terrain and dessert sites.
- Work with partners at the University of Colorado to study the impact of atmospheric stability and shear on wind power production.
- Work with partners at Penn State to include mesoscale model data in a coupled multi-scale cyber wind facility
- Work with partners at Penn State to adapt icing algorithms to wind energy applications
- Expand calibration of the uncertainty in wind forecasting systems in conjunction with other laboratories and with commercial partners
- Downscale model solutions for resource assessment
- Apply new artificial intelligence techniques to renewable energy and load prediction problems
- Work on improving offshore hub-height wind speed and wind shear prediction
- Improve marine boundary layer parameterization to better account for the interaction between the sea surface and the atmosphere.

References

Delle Monache, L., T. Nipen, Y. Liu, G. Roux, and R. Stull, 2011: Kalman filter and analog schemes to post-process numerical weather predictions. *Mon. Wea. Rev.*, ***139**, 3554–3570.*

Delle Monache, L., F. A. Eckel, D. Rife, B. Nagarajan, and K. Searight, 2013: Probabilistic weather predictions with an analog ensemble. Mon. Wea. Rev., 141, 3498–3516.

Haupt, S.E. and L. Delle Monache, 2014: Understanding Ensemble Prediction: How Probabilistic Wind Power Prediction can Help in Optimizing Operations, *WindTech*, **10** (6), pp. 27-29.

Haupt, S.E. and S. Drobot, 2014: New Irradiance Models for Solar Energy, Solar 2014 sponsored by the American Solar Energy Society, San Francisco, CA, July 7.

Haupt, S.E., W.P. Mahoney, and K. Parks, 2013: Wind Power Forecasting, in *Weather Matters for Energy*, Troccoli, Dubus, and Haupt, eds, Springer, in press.

McCandless, T.C., S.E. Haupt, and G.S. Young, 2014: A Model Tree Approach to Forecasting Solar Irradiance Variability, submitted to *Solar Energy*.

Mahoney W. P., K. Parks, G. Wiener, Y. Liu, W. L. Myers, J. Sun, L. Delle Monache, T. Hopson, D. Johnson, S. E. Haupt, 2012: A Wind Power Forecasting System to Optimize Grid Integration. IEEE Trans. Sustain. Energy, **3**, 670-682.

Politovich, M. K., C. A. Wolf, F. McDonough, J. Haggerty, 2010: Potential Upgrades to the Current and Forecast Icing Algorithms. AIAA paper 2010-81111 presented at the AIAA Atmospheric and Space Environments Conference, 2-5 August, Toronto, Ontario Canada.

Sun, J. and N. A. Crook, 1997: Dynamical and microphysical retrieval from Doppler radar observations using a cloud model and its adjoint: Part I. model development and simulated data experiments. J. Atmos. Sci., **54**, 1642–1661.

Sun, J., and Y. Zhang, 2008: Assimilation of multiple WSR_88D Radar observations and prediction of a squall line observed during IHOP. *Mon. Weather Rev.*, **136**, 2364–2388.

Sun, J., M. Chen, and Y. Wang, 2010: A frequent-updating analysis system based on radar, surface, and mesoscale model data for the Beijing 2008 forecast demonstration project. *Weather Forecast.*, **25**, 1715–1735.

Williams, J.K., J. Pearson, S.E. Haupt, and T.C. McCandless, 2014: Distributed Solar and Net Load Forecasts for Utilities, Solar 2014 sponsored by the American Solar Energy Society, San Francisco, CA, July 8.

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NCAR Strategic Plan

PREVIOUS RAL REPORTS

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WEATHER PREDICTION STATISTICAL OPTIMIZATION

BACKGROUND

RAL is a leader in the development of intelligent weather prediction systems that blend data from numerical weather prediction models, statistical datasets, real time observations, and human intelligence to optimize forecasts at user–defined locations. The Dynamic Integrated Forecast System (DICast®) and Location Optimized Gridded & Integrated Forecast System (LOGICast™) are examples of such technology. DICast® is currently being used by three of the nation's largest commercial weather service companies. There is a growing desire in industry to have fine–tuned forecasts for specific user–defined locations. This trend is clear in the energy, transportation, agriculture, and location–based service industries. RAL's expertise in meteorology, engineering, and applied mathematics and statistics is being utilized to address society's growing need for accurate weather information.

FY 2014 ACCOMPLISHMENTS

During this year the statistical improvements in DICast's short-term precipitation forecasting have been significant. One particular enhancement has included probabilistic prediction using two different techniques: Bayesian Model Averaging (BMA) and Analog Ensemble (AnEn) prediction.

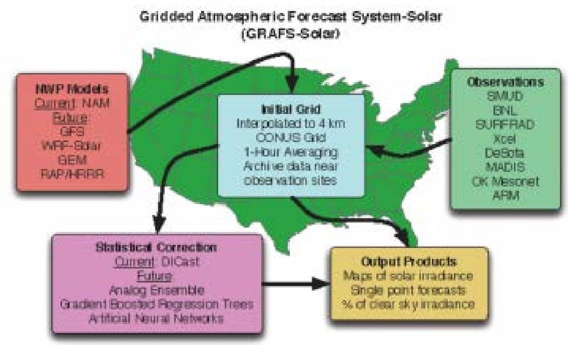

Figure 1. NCAR RAL's new GRidded Atmospheric Forecast System (GRAFS).

DICast's impact on wind energy forecasting has led to its use in other renewable energy arenas. In particular, it is currently being used as the forecast integration module for a DOE-funded solar energy forecasting project. In this project DICast has been modified to make forecasts of Global Horizontal Irradiance (GHI), Direct Normal Irradiance (DNI), and diffuse irradiance at locations where partnering utilities are providing observational data. Additionally, a separate Nowcasting blending system brings together forecasts from statistical models (StatCast), from total sky imagers (TSICast), satellite cloud advection algorithms (CIRACast), the Multi-Advective Diffusive foreCast (MADCast) system, and a rapid update version of WRF (WRF-SolarNow).

Internal to DICast, precipitation forecast methods continue to evolve. The use of observed lightning data has led to iterative improvements in the short-term probability of thunder forecasts. The quantity and probability of precipitation forecasts was reviewed based on user feedback and algorithm improvements due to inclusion of NOAA's High Resolution Rapid update (HRRR) model integration are currently being evaluated.

RAL also began an effort to develop a new gridded forecast system that is open to the university community for research (Figure 1). This system is modular in nature, allowing choices in base numerical weather prediction models that are included, as well as consensus forecasting techniques. This GRidded Atmospheric Forecast System (GRAFS) is first being tested for solar energy, allowing utilities to assess production of distributed solar power.

Simplifying and optimizing the implementation of the road temperature model, METRo, has led to a 100x speedup in the DICast-driven Maintenance Decision Support System (MDSS) which produces road condition forecasts and treatment recommendations. The MDSS is currently being used in several states and Canadian provinces by various Departments of Transportation to aid in winter road maintenance decision making. This simplification and optimization of METRo has allowed us to incorporate considerably more sites for timely road condition and treatment forecasts.

FY 2015 PLANS

Areas of development for the next fiscal year include:

- Continued training of the new Nowcast blending algorithm
- Continued evaluation of DICast's skill in solar energy forecasting
- Evaluation of alternative wind power forecasting techniques
- Expansion of GRAFS to other consensus blending methods and other variables

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NCAR Strategic Plan

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INTERNATIONAL AVIATION

ADVANCED OPERATIONAL AVIATION WEATHER SYSTEM (AOAWS)

Since 1998, RAL and MMM have collaborated in the development of an Advanced Operational Aviation Weather System (AOAWS) for the Civil Aeronautics Administration (CAA) of Taiwan. The AOAWS provides the CAA, the airlines, and the flying public with state-of-the-art aviation weather technology to detect and forecast hazardous weather phenomena that affect aviation operations, airspace efficiency, and capacity and safety at Taiwan's major hub airports. In 2010, NCAR's local Taiwan technology partner became International Integrated Systems, Inc. (IISI).

Major components of the AOAWS include: Low-Level Wind Shear Alert Systems (LLWAS Phase III) at Songshun and Taoyuan International Airport; the WRF model which provides regularly-updated forecasts on two domains with grid spacing of 20km, and 4km; the Java-based Multi-dimensional Display System (JMDS), which integrates all available real-time observational data and displays the information automatically to aviation forecasters and flight planning specialists; a web-based display system (WMDS) that displays most of the data available on the MDS on a CAA website for users (e.g., pilots and dispatchers) to view the AOAWS weather products remotely; and an AOAWS System Monitor Display (SMD) that provides system and networking activity information and alerts to the operators if any one of the sub-systems is not running smoothly. Since 2010, the WRF modeling enhancements have been developed by NCAR/MMM under a separate research agreement with the Taiwan Central Weather Bureau (CWB).

AVIATION WORK IN AFRICA AND THE MIDDLE EAST

NCAR/RAL is often requested to apply its aviation weather expertise to assist foreign governments in addressing weather hazards specific to their airports or airspace. In 2014 RAL worked with Advanced Radar Corporation (ARC) to develop a microburst detection algorithm and system tuned to ARC's radar technology for deployment at the airport in Kigali, Rwanda. Another project, also sponsored by ARC, studied the rainfall-storm and wind shear phenomena exposure at airports in west Africa.   A third effort focused on advising the government of Brunei in its acquisition of a Low-Level Windshear Alert System.

FY2014 ACCOMPLISHMENTS

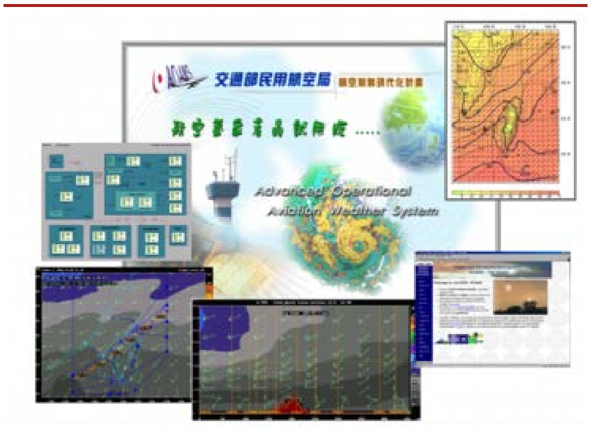

Figure 1 Composite image showing several AOAWS end-user display components

The development of the Nexrad Turbulence Detection Algorithm (NTDA) and display application upgrades were completed, and the new capabilities were integrated, tested, and became operational in the AOAWS in 2014. Verification and tuning of the Current Icing Product (CIP) and NTDA products were conducted through a series of case study analyses to ensure that the product performance skill was appropriate for the climate of Taiwan compared to North America. Enhancement of the ceiling and visibility product was performed by applying and testing a variety of artificial intelligence methods to the model and observational data. In addition, a real-time verification component was designed, developed, and implemented. A user-configurable external data server was developed that allows the Taipei Aeronautical Meteorological Center (TAMC) additional independence and control of sharing data products with its various aviation industry collaborators and partners. Collaboration with the TAMC to further develop the AOAWS will be suspended in 2014 to give the TAMC forecasters time to gain experience with the new products and assess their future needs. It is anticipated that the research and development partnership with

the TAMC will resume in one to two years.

In west Africa RAL works with ASECNA (L'Agence pour le Sécurité le la Navigation Aérienne en Afrique et à Madagascar), the primary multinational West African aviation authority, assisting the agency in planning for future acquisitions of wind shear detection systems and long-range weather radars across 16 African countries.

RAL is also supporting ARC in implementing and enhancing RAL-developed wind shear warning software for installation on a new radar that will protect airports in Rwanda.

In Brunei RAL advises the Department of Civil Aviation on its procurement and installation of a Low-Level Windshear Alert System (LLWAS) for the country's main international airport at Bandar Seri Begawan.

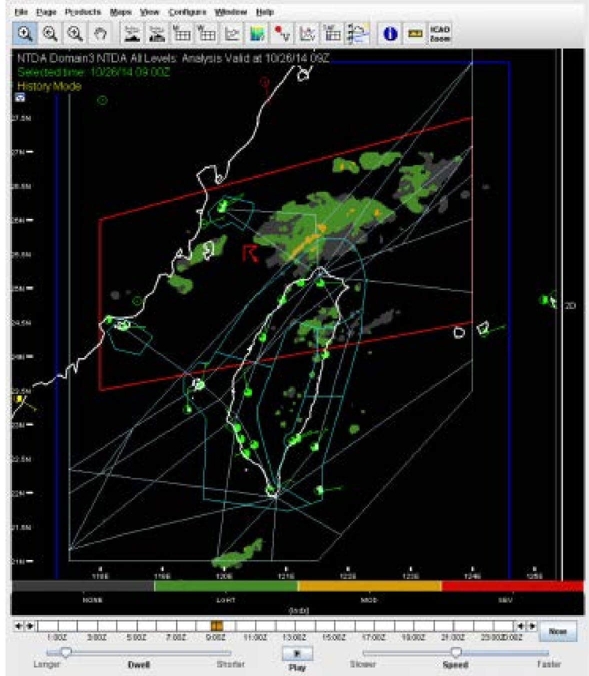

Figure 2 Image showing the NCAR Turbulence Detection Algorithm (NTDA) on the AOAWS end-user display screen.

FY2015 PLANS

The final release of AOAWS13 for use in the operational system will be made in the first quarter, and RAL staff will travel to Taiwan in December for the system acceptance meeting. Discussions are underway for a resumption of the program in the future.

International program development efforts will continue, focused on applying RAL's aviation weather expertise to airports with specific weather needs as well as to efforts to modernize aviation operations in foreign countries.

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USE AND VALUE OF WEATHER INFORMATION

BACKGROUND

Weather and climate affect all economic sectors, regions, individuals and communities. Improved weather forecasts – and better use of current forecasts – could save lives and hundreds of millions of dollars annually. To realize the potential benefits associated with improved weather forecasts and stakeholder decision making, in 2004 NCAR established the Collaborative Program on the Societal Impacts and Economic Benefits of Weather Information (aka Societal Impacts Program or SIP) to create a dedicated focal point for assembling, coordinating, developing, and synthesizing research and information on the societal impacts and economic benefits of weather information.

The SIP aims to improve the societal gains from weather information by infusing social science research, methods, and applications throughout the weather enterprise and to be the premiere focal point for integrating social science and societal impacts understanding into the weather enterprise through cutting-edge research and capacity building. The SIP endeavors to:

- Advance knowledge on the socio-economic impacts of weather and the communication, use, and value of current and improved weather information.
- Build a multi-disciplinary, multi-stakeholder community of researchers and practitioners engaged in developing and applying knowledge on societal aspects of weather information.
- Enhance social science aspects of policy-making, development, and use of related weather information

FY2014 ACCOMPLISHMENTS

Socio-Economic Benefit (SEB) Guidance Document

A first complete draft was developed of the USAID-funded and WMO/World Bank-supported socio-economics benefits (SEB) guidance document entitled “Forecast value: Economic Assessment of Meteorological and Hydrological Services.” This collaborative effort also involved conducting week-long regional training sessions on economic analysis for national hydro-met services in Brunei (Oct 2013) and South Africa (November 2013), a working group meeting and presentation in Jamaica (December 2013), a presentation at AMS (February 2014), and hosting a writing-team working group meeting in Boulder (April 2014).

Assessing the Economic Value of Improving Weather, Water, and Climate Information in Mozambique

Building on work supported by the World Bank, analysis and reporting continued on a survey of 576 members of the public in Mozambique on the sources, perceptions, uses, preferences, and values for current and improved weather, water, and climate information. Three non-market valuation methods for eliciting economic values were implemented to determine the current value of weather information as well as the potential value of improved forecast information. Related work entailed the development and implementation of an expert elicitation of 26 stakeholders in specific public and private sectors of Mozambique assessing their perceptions of the value of current services and potentially improved hydrometeorological information.

Assessment of Hurricane and Flash Flood Warnings

Efforts to examine decision processes employed by institutions, organizations, and individuals in analyzing, disseminating, and interpreting warnings of for hurricanes and flash floods continued. This work, conducted by balanced research teams representing the fields of meteorology, sociology, economics, public policy analysis, and decision sciences, is a critical piece in the evaluation of warning processes and systems. In-depth interviews and observational sessions with NWS forecasters, emergency managers, and the media from the Greater Miami area with respect to hurricanes and from the Boulder-Denver,

Colorado area with respect to flash floods were analyzed to examine their roles, goals, and interactions, and to identify strengths and challenges in how they communicate with each other and with the public. Analysis of a survey conducted in Miami and Galveston examined factors affecting stated evacuation likelihood under scenarios communicating information in two different ways. Differences in evacuation intentions were found to be related to differences in culture, vulnerability, experience, information, motivations, and barriers. People who hold more egalitarian worldviews are more likely to evacuate while those with more individualist worldviews are less likely. Having an evacuation plan, wanting to keep one's family safe, and viewing one's home as vulnerable to wind damage predict increased evacuation intentions overall, while other factors vary by context. Results reinforce the value of focusing hurricane information efforts on evacuation plans and residential vulnerability and suggest avenues for future research on how hurricane contexts shape decision making.

A Public-Private-Academic Partnership to Advance Solar Power Forecasting

For this DOE-funded project, primary research continued with a focus on identifying methods for assessing the economic value of improved solar irradiance information. Working with utility partners and stakeholders, "Production Cost Modeling" was selected as the common valuation approach and will be undertaken by four of the utilities as a contribution to the project. Implementation will be coordinated by NCAR personnel and the feasibility aggregation of results to national benefit estimate will be assessed.

FY2015 PLANS

Work will continue on several projects on communication, understanding and use of hydrometeorological information particularly with respect to the creation, communication, and value of hurricane and flash flood forecasts and warnings.

Analysis of primary survey data and in-depth interviews will continue to further develop an integrated understanding of warning systems and processes with a focus on hurricanes in Miami, Florida, and flash floods in Boulder, Colorado by:

- Identifying more completely the suite of factors influencing organizational and public decision making and action during extreme weather events
- Characterizing public preferences for different attributes of forecast and warning information
- Assessing the relationship between factors affecting evacuation decision making and individuals stated values for improved hurricane forecasts.

The World Bank, World Meteorological Organization, and USAID supported guidance document for National Hydro-Meteorological Services on best practices for socio-economic benefit (SEB) assessment is scheduled for publication in late FY2015. Plans are being developed to supplement this effort with three international workshops to develop specific socio-economic research projects building on the document.

Analysis and reporting will be completed on the public survey and expert elicitations of the World Bank hydro-meteorological improvement program efforts in Mozambique. Results from the study will be used as documentation in support of and as a case study for the SEB guidance document.

Production Cost Modeling results from stakeholder partners will be coordinated and aggregated as part of the DOE funded project "A Public-Private-Academic Partnership to Advance Solar Power Forecasting." This analysis will estimate the value to improved solar irradiance forecasts in the day-ahead unit-commitment decision making of four partner utilities. If feasible this will be aggregated to a national benefit estimate based on considerations of the significant differences in utility institutional and physical structures.

Working with Betty Morrow, faculty emeritus Florida International University, a review paper will be written as a contribution to the WMO International Workshop on Tropical Cyclones. The paper will be presented at the meeting in Seoul, Korea and published in the conference proceedings. A primary recommendation of the paper is to develop an ongoing socio-economic focus in conjunction with WMO tropical cyclone efforts.

‹ International Aviation up National Security Applications ›

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NATIONAL SECURITY APPLICATIONS

Significantly advance our understanding of mesoscale and urban-scale weather and climate processes, especially in the boundary layer, and our ability to forecast these atmospheric conditions operationally for the purpose of providing forecasters, decision makers, and emergency managers with accurate information to save lives and property.

- Operational Numerical Weather Prediction and Improved Data Assimilation
- Statistical and Dynamical Mesoscale Climate Downscaling
- Atmospheric Transport and Dispersion of Hazardous Materials Research and Development

‹ Use and Value of Weather Information up Operational Numerical Weather Prediction and Improved Data Assimilation ›

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NCAR UCAR Research Applications Laboratory
2014 Annual Report

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OPERATIONAL NUMERICAL WEATHER PREDICTION AND IMPROVED DATA ASSIMILATION

Over the past several decades, RAL has developed and deployed complex computer-based operational systems for analyzing and forecasting climate and weather at high resolution worldwide. This development is built upon the Laboratory's deep foundation of applied scientific research and engineering. Systems and their products are tailored to each project to maximize the benefit to the sponsors and end-users. For example, improved analyses and forecasts at Army test ranges saves millions of tax dollars by identifying when weather suitable for testing will occur, and improves safety by predicting conditions that would be hazardous to personnel and materiel. Other domestic and international projects include forecasting for wind farms at resolutions that can approximate large eddies within the atmosphere's boundary layer; new, innovative ways to supply models with current observations from radar ; and exploring how urban development affects the weather, and how that weather in turn affects the health of people living in urban areas. In this section of the Annual Report, we describe our work in the following areas:

- Four-Dimensional Weather System (4DWX)

Real-Time Four-Dimensional Data Assimilation (RTFDDA) and Forecasting Advances

- Operational RTFDDA
- Mesoscale Ensemble Data Assimilation and Prediction System
- Fine-Scale Precision NWP: WRF-RTFDDA-LES
- Analog Ensembles
- Ensemble Data Assimilation for Wind Prediction and Model Error
- High Performance Computing for Operational Modeling
- RTFDDA-3DVAR Hybrid System for the Middle East

‹ National Security Applications up Four-Dimensional Weather System (4DWX) ›

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- Numerical Systems Testing and Evaluation
- Hydrometeorological Applications
- Climate, Weather and Society

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2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- RAL Strategic Plan
- NCAR Strategic Plan

PREVIOUS RAL REPORTS

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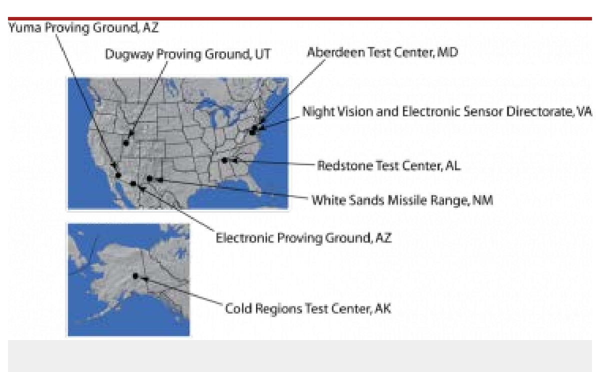
FOUR-DIMENSIONAL WEATHER SYSTEM (4DWX)

BACKGROUND



Since the middle 1990s, the U.S. Army Test and Evaluation Command (ATEC), then known as TECOM, has sponsored RAL to conduct research, development, and technology-transfer of the Four-Dimensional Weather (4DWX) system. 4DWX is an advanced numerical weather prediction (NWP) system that analyzes current weather and makes detailed predictions of weather over the next several days. 4DWX's NWP core is the Weather Research and Forecasting (WRF) Model, the current industry standard. 4DWX ingests observations into the NWP core through NCAR's Real-Time Four-Dimensional Data Assimilation (RTFDDA) scheme. 4DWX is used by ATEC forecasters at eight test ranges (Fig. 1) across five major climate zones. RAL improves 4DWX

regularly, updating software and/or hardware for ATEC several times per year.

Fig. 1. Army test ranges that use 4DWX.

4DWX provides ATEC forecasters the technology and expertise they need to produce weather forecasts and analyses at the scales, and with the accuracy and utility, required to support safe and cost-effective testing by the Department of Defense (DoD). For NCAR one of the most attractive elements of the 4DWX project is that the ATEC test ranges serve as natural laboratories for atmospheric research, complete with dense observing networks and specialized data that permit study of mesoscale and microscale phenomena in complex terrain. Continual improvements to 4DWX and to community numerical weather prediction models, such as the WRF Model, are made possible through this collaboration.

FY2014 ACCOMPLISHMENTS

Improvements to 4DWX NWP core

Collaboration with the University of Utah has uncovered one source of a pervasive positive bias in the WRF Model's forecasts of nighttime temperature near the ground in some semi-arid regions. The problem stems from poor initialization of soil moisture and how the model represents thermal conductivity in silt loam and sandy loam soils (Massey et al. 2014). 4DWX is now being updated to incorporate the needed improvements.

Advanced Data Assimilation

The project continues to rely on RTFDDA as one way to ingest observations and define the atmosphere's current state for 4DWX's NWP core, the WRF Model. RTFDDA involves modifications to an NWP model's predictive equations so the model can be gently adjusted, or nudged, toward observed conditions during the model's analysis stage, before the forecast stage begins. The scheme is computationally efficient and preserves the precise timing of observations, which gives 4DWX a particularly accurate depiction of the weather at any instant. RTFDDA continues to show itself superior to, or the equal of, many alternative methods of data assimilation in operational systems. It has recently been upgraded to include several new features. RTFDDA now assigns quality flags to observations within the analysis and forecast cycling, rather than as a pre-processing step, providing more accurate and stable assessments of each observation's usefulness in data assimilation. RTFDDA also has an improved means of dealing with cases when an observing site's actual elevation differs significantly from the simulated terrain height in the model.

At Aberdeen Test Center, MD, 4DWX is now operationally ingesting observations from radars. The method is based on coupling RTFDDA with NCAR's Variational Doppler Radar Assimilation System (VDRAS), and it includes the effects of the latent heating that can be inferred from radar reflectivity. VDRAS assimilates series of real-time radar observations (radial velocity and reflectivity) from single or multiple Doppler radars, then uses a fast numerical model to make frequently updated short-term forecasts of dry flow in the planetary boundary layer.

RAL has been working with the University of Virginia to study how assimilation of airborne lidar data into NWP systems might improve analyses and forecasts. The initial work uses data collected from the Twin Otter Doppler Weather Lidar (TODWL) that was flown during the MATERHORN field campaign at Dugway Proving Ground (Fig. 2). Initial results show promise but also point to the importance of understanding how differences in the scales of motion that are well resolved in the observations and in gridded output from the model can affect data assimilation.

Ensemble Forecasting

Since 2007, Dugway Proving Ground (DPG) has used an ensemble version of 4DWX (called E-4DWX) developed by RAL. E-4DWX provides a suite of 30 forecasts valid at the same place and time, each producing slightly different but similarly realistic forecasts. Differences among ensemble members are induced by varying initial conditions, boundary conditions, and model physics. All members are based on the WRF Model. The ensemble captures the forecasts' probability information that varies with changes in weather regime. In 2014, E-4DWX was expanded to include three additional ranges in the intermountain West: White Sands Missile Range, MD; Yuma Proving Ground, AZ; and the Electronic Proving Ground, AZ.

A subset of output from E-4DWX is calibrated—that is, made statistically consistent with observations so that the probability of E-4DWX's forecasts being realized represents the observed probability. By using a method known as quantile regression, the distribution of ensemble

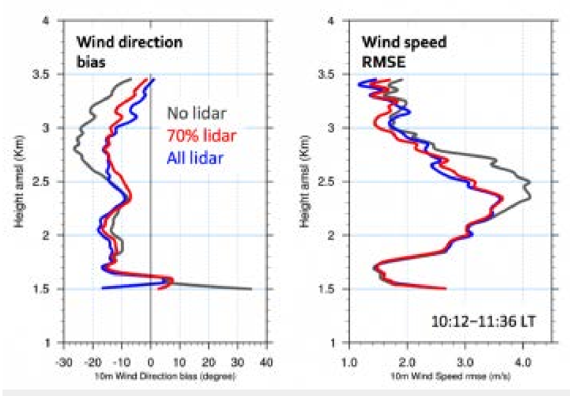


Fig. 2. Domain-averaged profiles of bias in wind direction (on the left) and RMSE in wind speed (on the right) over nearly 90 minutes of three 2-hr 4DWX simulations (10 Oct 2012 over Dugway Proving Ground) during which varying amounts of TODWL lidar were

assimilated. In this case, assimilation does generally improve the model's gridded wind speed and direction through the lower part of the troposphere. There isn't much difference between the complete and incomplete assimilations of lidar data, which suggests that, from the model's perspective, some of the lidar data are redundant or superfluous, which is partly a function of the model's resolution and the length scales in the observations.

forecasts (i.e., quantified by the mean, spread, and higher moments) is adjusted toward the actual probability distribution of weather as determined through observations. The benefits of calibration include: 1) reducing forecast error and biases, producing a calibrated ensemble mean that has on average one half the error variance of any single ensemble member; 2) predicting accurate likelihoods of extreme and potentially devastating weather; and 3) providing a measure of forecast uncertainty through the dispersion among ensemble members. Calibration is performed on moments of the overall probability distribution function, no matter the size of the ensemble membership from which the distribution is created, as opposed to calibrating output from specific ensemble members. This makes E-4DWX particularly robust, even if individual members of the ensemble fail at some point during the forecast.

Experimental Very Large-Eddy-Scale (VLES) Simulations

On several projects, including this one funded by ATEC, RAL is experimenting with very-large-eddy (VLES) simulations in a real-time framework. Current experiments are focused on Granite Peak at Dugway Proving Ground and on the Chesapeake Bay and surrounding area at Aberdeen Test Center (Fig. 3).

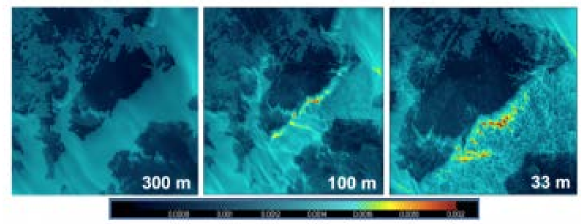


Fig. 3. Mixing ratio of water vapor (shaded in kg kg^{-1}) at 2 m (AGL) from a simulation by 4DWX-VLES over the northern Chesapeake Bay at 00 UTC on 4 January 2014. The heterogeneity of the low-level humidity and the character of the vertical mixing above the relatively warm water are highly sensitive to grid spacing.

Forecasts of Severe Weather

The 4DWX system has components that predict severe weather on two scales: the next few hours, based on both observations and model predictions blended via the AutoNowcaster, and the next few days, based on model predictions alone. The AutoNowcaster now employs the dual polarization data newly available from the NEXRAD network. Soon, Level 3 symbolic products will be added: hail index, tornado vortex signature, mesocyclone, and melting layer. Terminal Doppler Weather Radar (TDWR) data have also being added to the system. Finally, RAL continues to refine its algorithms for short-term and longer-term prediction of lightning at the ATEC ranges by sharpening the forecasts, accounting for lightning in the anvil cirrus clouds of storms, and refining displays.

Coupled Applications

Direct weather analyses and predictions from 4DWX and E-4DWX are the core of the weather information used by forecasters at the ATEC ranges, but that information can be made even more valuable when it is supplied to decision support systems (DSSs) that simulate how the weather affects other processes and conditions, such as sound propagation and the transport and dispersion of airborne hazards. Examples of DSSs that have been linked to 4DWX and/or E-4DWX include:

- Noise Assessment and Prediction System (NAPS)
- Second-order Closure Integrated Puff (SCIPUFF) model
- Lewis Rocket Trajectory Model
- Open Burn / Open Detonation Model (OBODM)

In 2014, RAL continued to collect observations and predictions for verifying the skill of a new version of the lab's Graphical Turbulence Guidance (GTG), which has been modified for application to unmanned aircraft systems. The results so far are promising (Fig. 4). RAL intends to deploy to ATEC a prototypical version of the GTG in 2015–16.

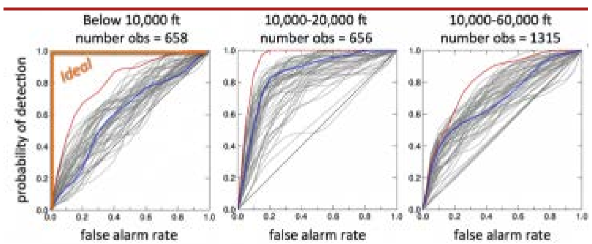


Fig. 4. ROC curves from a limited test of the modified GTG. These plots are a measure of the algorithms' abilities to differentiate between turbulent and non-turbulent conditions. Data were drawn from 4DWX simulations (dx = 10 km) and pilot reports from test cases over the Front Range of Colorado. The number of observations and the ranges of altitudes used to calculate probability of detection are indicated above the panels. Curves show forecasts from individual algorithms (gray), the National Weather Service's Ellrod 1 algorithm (blue), and the ensemble mean (red). A hypothetical ideal (perfect) forecast is shown in orange on the first panel.

4DWX Web Portal

The primary interface to the 4DWX system at all ATEC ranges continues to be the 4DWX Portal (Fig. 5). The portal's flexibility, accessibility, modularity, and extensibility are ideally suited to the customized weather support that RAL provides to forecasters who have eagerly welcomed how the Portal improves their workflow. Weather maps and related graphics from 4DWX include optional color palettes that can be seen by the color-blind (Fig. 6). By using web forms designed in RAL, forecasters can more efficiently customize their weather maps. The

Fig. 5. Front page of the 4DWX Portal at three ranges: Electronic Proving Ground in AZ, White Sands Missile range in NM, and Dugway Proving Ground in UT. From each page, forecasters can access model output, current and historical observations at the stations shown in red on the maps, a tool for issuing weather warnings, radar displays, and more.

Portal's dashboard has a flexible, configurable layout, with streamlined access to portlets for coupled applications. The list of output formats that the Portal supports includes the third-party BUFKIT and RAOB applications. In 2014, the version of Liferay (the software on which the Portal is built) was upgraded, improving the look, feel, and functionality for users. Upgrades were also made to many of the portlets, such as Weather Alert, Weather Warning, Observation List, Verification, Almanac, and Forecast Creator.

Integrated Data Viewer (IDV)

RAL collaborates with UCAR's Unidata program to include among 4DWX's display options the Integrated Data Viewer (IDV), which is a sophisticated, flexible, Java-based application for analyzing and displaying geophysical data. IDV is the primary means by which range forecasters explore in greater depth the weather analyses and forecasts from 4DWX. This more complex and flexible exploration complements the "virtual map wall" that is available through the 4DWX Web Portal, whose purpose is to provide the easiest and quickest interface to a standard suite of pre-generated weather maps. IDV is also a research tool and is employed by scientists and engineers during their testing, development, and refinement of 4DWX.

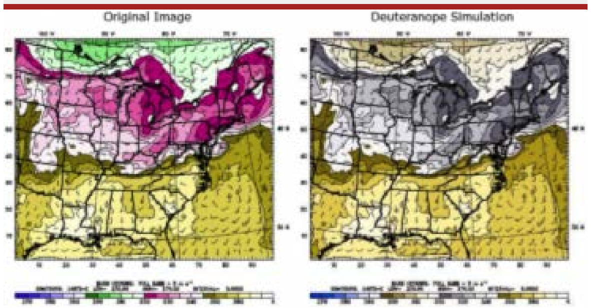


Fig. 6. Examples of the two color palettes available through the 4DWX Portal. Each panel is a map of near-surface potential temperature. The left panel shows the map's appearance to those with no color-blindness. The right panel simulates how the map appears to those with deuteranope color-blindness (courtesy of vischeck.com).

SELECTED KEY PLANS FOR FY2015

- Customize RAL's highly successful GTG technology to support tests that involve unmanned aircraft systems, which have become a mainstay at several ranges. Pending more tests and tuning, a first operational version of the system will be deployed in 2015–16.
- Generate for several ranges a multi-decadal archive of mesoscale reanalyses to create a detailed climatography for use by forecasters to help with long-range scheduling of the optimal time, day, season, and location for testing under specific weather conditions. With lessons learned from this initial climatography, RAL will do the same for the other ranges, provided sufficient computer time is available.
- Implement a set of algorithms to evaluate the quality (often called-quality control or quality-assurance) of each observation in the long-term and rich datasets collected at each of the ATEC ranges. This is a key step to enabling 4DWX and coupled applications to read and respond to quality-control flags so that observations can be used in the manner most appropriate for the model or application.
- Deploy at Aberdeen Test Center, MD and Cold Regions Test Center, AK a set of algorithms for producing probabilistic forecasts that relies on archives of observations and model predictions to collect an ensemble of prior forecasts made under analogous weather patterns. Predictions from analog-based methods are inherently calibrated, so an extra calibration step is not required.
- Continue to emphasize outreach and training as a core component of the 4DWX project through the conduct of forecaster training at NCAR, and through teleconferences, on-line documentation, and visits to ranges.
- Continue to support the MATERHORN field campaign, providing data and advice to investigators and, in return, receive datasets and other material from the field campaign to aid model development and technology transfer to ATEC.
- Make a prototype of 4DWX-VLES available to forecasters at one or more ATEC ranges.
- Continue to find solutions to the WRF Model's biases in near-ground temperature and deploy these in 4DWX.

References

Massey, J. D., W. J. Steenburgh, S. W. Hoch, and J. C. Knievel, 2014: Sensitivity of near-surface temperature forecasts to soil properties over a sparsely vegetated dryland region. *J. Applied Meteor. Climatol,* 53, 1976-1995. DOI:10.1175/JAMC-D-13-0362.1.

‹ Operational Numerical Weather Prediction and Improved Data Assimilation | up | Real-Time Four-Dimensional Data Assimilation (RTFDDA) and Forecasting Advances ›

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2014 RAL ANNUAL REPORT

REAL-TIME FOUR-DIMENSIONAL DATA ASSIMILATION (RTFDDA) AND FORECASTING ADVANCES

BACKGROUND

Many applications, including military tests and operations, renewable energy assessment and prediction, weather-related emergency response etc., desire high-resolution, rapid-update, high-accuracy, and customized weather information for focused regions. RTFDDA is a Real-Time, Four-Dimensional, Data Assimilation and forecasting system that has been developed particularly for such applications. It differs from other contemporary data assimilation approaches in that the observations are assimilated at their observation time rather than binned by time window. It is also blind to model inadequacy; no formal treatment is needed, making it a good choice particularly for forecasting

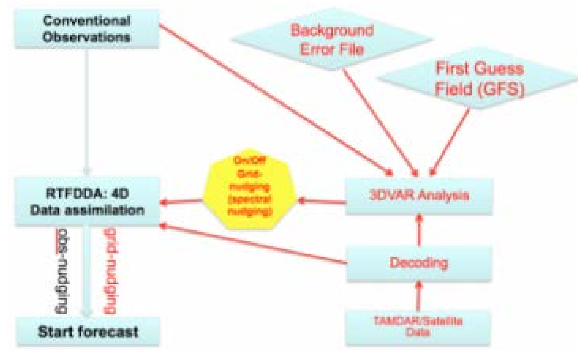


Fig. 1. Schematic diagram of the RTFDDA-3DVAR hybrid data assimilation system.

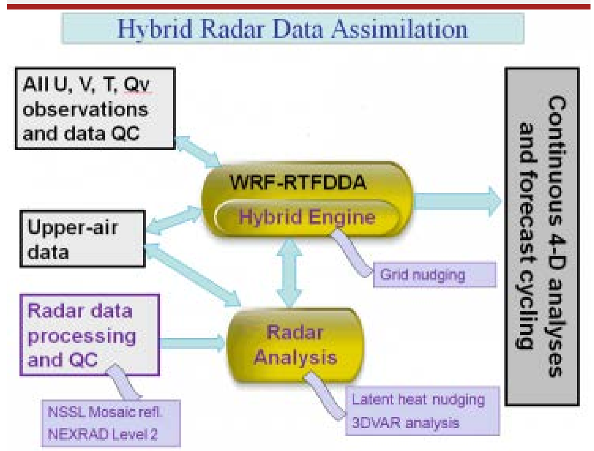


Fig. 2 Schematics of the coupled system of radar data assimilation and RTFDDA.

sensible weather near the Earth's surface.

The overarching goal is providing the best-possible weather information for target applications and regions. This requires timely processing of all available observations, and assimilating them into advanced mesoscale WRF and/or MM5 models that have been tuned for the regions. The WRF RTFDDA allows for smooth and uninterrupted assimilation of diverse weather observations and produces physically consistent and dynamically balanced 4D weather analyses and "cloud/precipitation "spun-up" predictions. In the past 13 years, RTFDDA has been applied to over 40 weather-critical applications across the US and the globe.

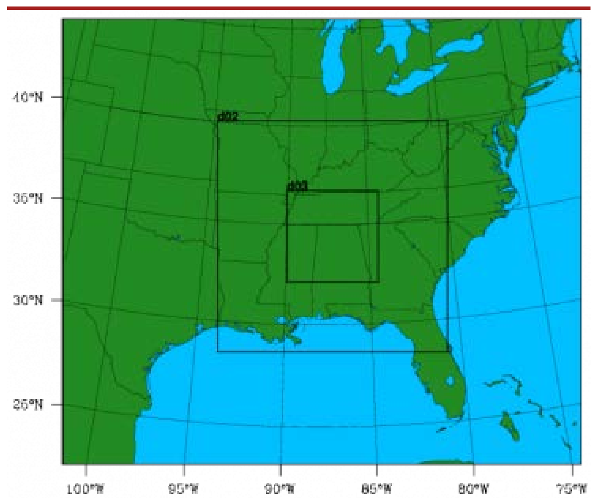
The RTFDDA data assimilation technologies include Newtonian relaxation based "observation-nudging" and "analysis-nudging" FDDA schemes, WRF-DA (3/4DVAR), DART-EnKF, GSI, and the development of a new 4-dimensional relaxation ensemble Kalman filter (4D-REKF) FDDA scheme, and a hydrometeor-latent-heat-nudging (HLHN) radar data assimilation scheme. These technologies are configured to formulate a hybrid data-assimilation engine to meet the specific requirements for each application.

Significant research and engineering has been put into advancing the science, accuracy, and capabilities of the RTFDDA system. In the last 5 years, RTFDDA has evolved from a single mesoscale deterministic analysis and forecasting system to a modeling capability suite that integrates ensemble prediction technology (Ensemble-RTFDDA), regional climate downscaling with four-dimensional data assimilation (Climate-FDDA) and microscale NWP with refined LES model grid with spacing order 10-100 meters (RTFDDA-LES). The advanced RTFDDA suite produces customized, high-resolution and ultra-high-resolution precision weather analysis and forecasts, probabilistic weather forecasts, and multi-year/multi-decadal microclimatology analyses for a given target region. In addition, WRF-Chem has been assessed and is being added to RTFDDA for forecasting sand and dust storms.

FY 2014 ACCOMPLISHMENTS

RTFDDA-3DVAR Hybrid Data Assimilation

One of the challenges for numerical weather prediction in weather data sparse regions (e.g., over oceans, the Middle East, Africa etc.) is the lack of in-situ observations needed to properly initialize models. An RTFDDA-3DVAR hybrid data assimilation scheme (Fig. 1) has been developed for incorporating unconventional observations, especially remote-sensing measurements such as satellite radiance, for model initialization. RTFDDA-3DVAR hybrid data assimilation also works to assimilate Doppler radar radial velocity observations in RTFDDA. A major characteristic of the RTFDDA-3DVAR hybrid data assimilation technology is that it inherits the full advantage of the RTFDDA ability to generate 4-D dynamically consistent and physically spun-up analysis and forecasts. In FY2014 we continued to focus on applying and testing this technology for the development of operational NWP systems in the Middle East.



Hydrometeor and Latent Heat Nudging (HLHN) and 3DVAR Radar Data Assimilation

Incorporating radar data assimilation (RDA) capability into the real-time operational framework of RTFDDA has been one of the major undertakings of RTFDDA development. To assimilate radar radial winds and reflectivity into the WRF-based RTFDDA system, a hybrid approach that couples RTFDDA and 3DVAR with a hydrometeor and latent heat nudging (HLHN) technique has been developed (Fig. 2). During FY2014, extensive research and testing of the RTFDDA-3DVAR/HLHN hybrid radar data assimilation system continued. Retrospective case studies were conducted for domains centered at three locations: the Colorado Front Range, the Army Aberdeen Test Command (ATC) range and Redstone Test Command (RTC) range. Several alternative configurations of 3DVAR and latent heating adjustment have been tested through the retrospective studies (Figs. 2, 3). Through verification and parallel testing, this advanced radar data assimilation scheme continues to be refined. A prototype RTFDDA-3DVAR/HLHN hybrid system was run locally in real-time environment for the ATC domain. Monitoring and assessment are on-going with the objective to tune the code and configuration parameters for the ATC domain. Code was released to ATEC ranges in 2014.

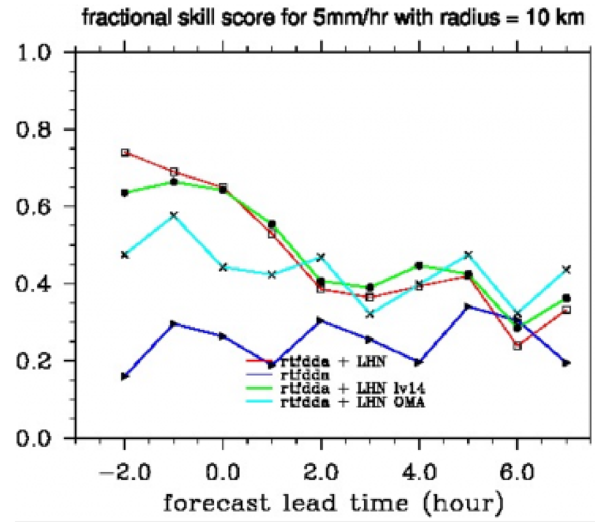


Figure. 3 Evaluation of radar data impact from a case study for the RTC domain. The event consists of several episodes of convection during November 26-27, 2012. The skill scores are calculated for 7 forecasts from RTFDDA run without RDA (blue), and RTFDDA with RDA using three different LHN options: lowest heating level at 900 mb (red), lowest heating level at 800 mb (green) and nudging heating rate based on the observation-model differences (cyan) instead of the observed heating rate.

Sand and Dust forecasting with WRF-Chem

During FY2013, an initial dust forecast capability for Saudi Arabia based on the fully coupled WRF-Chem was explored. In FY2014 major steps were taken to establish this capability including (a) assessing the modern technologies for dust forecasting in Saudi Arabia, (b) designing proper algorithms and a system for implementation, and (c) producing sample dust forecasting results through a case study to demonstrate feasibility and capability. Fig. 4 shows the observed and simulated AOD (aerosol optical depth) at Solar Village during the March 2009 severe dust storm over Saudi Arabia, compared to observed AOD.

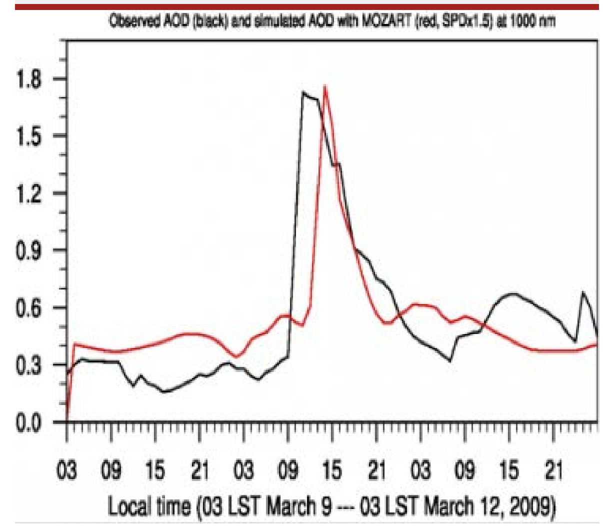


Fig. 4. Observed AOD (black line) and WRF-Chem simulated AOD (red line) at 1000 nm at Solar Village (24.91°N, 46.40°E) driven by the Final Analysis (FNL) with using the WRF-Chem default chemical background data, and with the surface wind speed in the model dust emission flux increased by a factor of 1.5 during the period of 03 LST March 9 through 03 LST March 12, 2009. The WRF-Chem model simulations were initialized at 03 LST March 9, 2009.

Advances in Observation Quality-Control and Assimilation

Quality control of observations is essential to RTFDDA. Because observations are ingested into the full physics WRF, interacting with the model dynamics and physics directly, even a few bad observations can seriously affect the model reliability and performance. To address this problem, a new online QC scheme has been developed. It corrects observation and model inconsistencies resulting from differences between model terrain heights and observation station elevations. These data-processing and quality-control procedures significantly enhance RTFDDA data assimilation and forecasting accuracy and system operation reliability (Fig. 5)

Improvements to RTFDDA Post-processing

The post-processing of model data for visualization, bias correction and verification, was improved for convenient configurations for different real-time forecast systems. Its efficiency was improved with a new data flow, a better parallelization, and running different configurations on a single computing cluster. To meet special project needs, specific products have been added with an increased frequency (every 15 minutes) to visualize and verify wind energy and surface station forecasts. Two statistical post-processing methods were implemented, an analog-based method and quantile regression, for wind production facilities and forecasts for surface observations so that the forecast pdf better matches the observed pdf.

PLANS FOR FY 2015

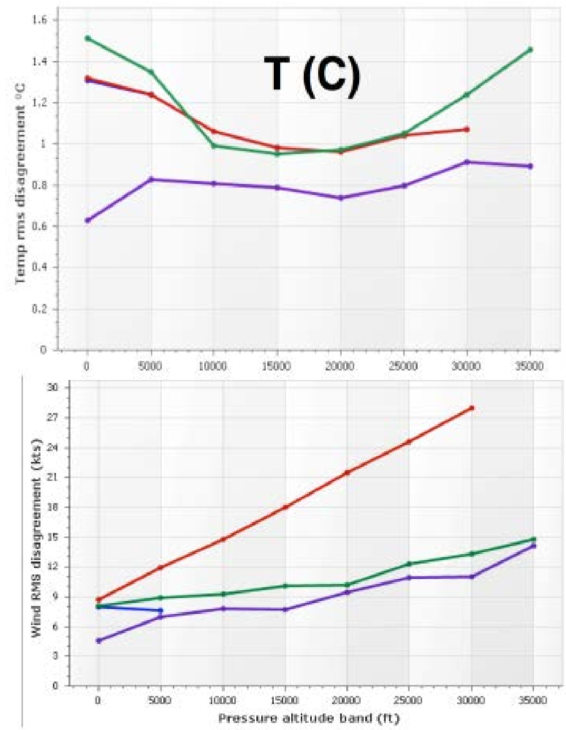


Fig. 5. Statistics of RMSE of temperature (upper) and Wind (bottom) during 10 and 17 January 2012 for the AIRDAT NAM offline QC system (red), MM5-RTFDDA off line QC system (green), and the WRF-RTFDDA online QC system (purple).

RTFDDA is a continuously evolving forecasting system. Research and development of all major RTFDDA components is ongoing. This includes tuning real-time operational forecasts for existing and new deployments. Fundamental WRF model and data assimilation advances by the RTFDDA group, and the broader community, are also continually absorbed into the RTFDDA system. In particular, the RTFDDA WRF will be upgraded to stay aligned with the WRF community updates. All operational RTFDDA systems will be upgraded to WRF Version 3.5.1.

RAL will continue to develop and test the RTFDDA-3DVAR/HLHN hybrid radar data assimilation system. The system for the Army ATC domain will be monitored and upgraded. Scientific research will be focused on improving the derivation of rain, snow, and graupel mixing ratios from radar reflectivity in the hybrid radar data assimilation system. Investigations will begin on assimilation of polarimetric radar products and lightning data in the hybrid RDA system.

The post-processing (calibration), and associated verification suite in RTFDDA will be improved to: a) produce pin-point meteograms and profiles at 5-minute time intervals, and b) develop bias-correction and calibration algorithms for station variables based on weather-pattern clustering classifications.

Sand and dust storm forecasting systems will be developed for the Middle East using RTFDDA and WRF-Chem.

‹ Four-Dimensional Weather System (4DWX) up Operational RTFDDA ›

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OPERATIONAL RTFDDA

BACKGROUND

To meet the need for high-resolution, accurate, and rapidly updated weather information for weather-critical applications directed at national defense and security, energy, and health, RAL continues to advance and deploy its Real-Time Four-Dimensional Data Assimilation (RTFDDA) and forecasting system. RTFDDA has been deployed to provide real-time operational weather services for over 50 weather-critical applications by US government agencies and international organizations over the US and other global regions. This section reviews the operational RTFDDA NWP projects during FY2014:

1. U.S. Army Test and Evaluation Commands (ATEC) test ranges
2. MAGEN for the Government of Israel
3. Ensemble wind prediction for the State Grid Corporation of China (SGCC)
4. WRF-RTFDDA for wind power prediction for Xcel Energy
5. CONUS-scale RTFDDA operation for Panasonic Weather Solutions

6. RTFDDA high-resolution reanalysis and nowcasting for Shenzhen, China

FY2014 ACCOMPLISHMENTS

1. US Army Test and Evaluation Commands (ATEC)

The RTFDDA system serves eight Army test ranges located in the US and also supports on-demand test missions of ATEC in other regions over the globe. One ensemble-RTFDDA system and a deterministic RTFDDA-LES system have been set up for operational forecasts at the Army Dugway Proving Ground, Utah. More detail on specific advances made in ATEC modeling systems can be found in the 4DWX section of this report.

2. MAGEN for Israeli Government

MAGEN (Model for Advanced GENeration of 4D Weather) employs RTFDDA and WRFDA-3DVAR hybrid data assimilation technologies to provide high-resolution weather guidance over the Eastern Mediterranean region. Scientific advances made in previous years were incorporated within the final MAGEN system, and it was delivered to the Israeli Air Force facility. The system passed the on-site acceptance test and is successfully running in its own operational environment. RAL completed the technology transfer process by providing on-site training and completing updates to the MAGEN system technical manual.

New research in FY2015 will focus on extending the capabilities of the existing MAGEN hybrid system to provide improved dust forecasting capabilities. Further enhancements will also be made to the MAGEN system to improve model resolution, cloud analysis and assimilation, ensemble data assimilation and probabilistic prediction, adaptive observation, and improved integration of the European Centre for Middle-range Weather Forecasts (ECMWF) model output.

3. Ensemble Wind Prediction for State Grid Corporation of China (SGCC)

To support wind power integration into the SGCC electric grids, RAL collaborates with the Chinese Electric Power Research Institute (CEPRI) to apply Ensemble-RTFDDA (E-RTFDDA) technologies for wind power prediction at SGCC. In 2014, RAL developed a real-time E-RTFDDA system for wind prediction at wind farms over the northwest provinces of China. One-year reforecasts for Year 2012 with 20 ensemble members have been produced. The reforecasts are used for calibrating real-time ensemble forecasts and performing training of the CEPRI ANN (Artificial Neuron Network) wind power forecasting system. To assess the E-RTFDDA system for wind prediction at a wind farm, the one-year ensemble reforecasts are compared with the observations of 18 met-towers and turbine hub-height wind reports at 4 wind farms. Figure 1 shows a sample for forecast verification for a week in September, 2012.

4. WRF-RTFDDA for Xcel Energy Wind-Power Prediction

Deterministic WRF enhancements

The NCAR-Xcel wind power prediction collaboration has moved into its third phase in which enhancements are being made to the WRF-RTFDDA system. The goal is to further improve WRF-RTFDDA's hub-height wind prediction at wind farms by improving the model's boundary layer and land surface schemes, and refining the algorithms for assimilation of turbine Nacelle wind speed (Fig. 3), wind direction, and temperature. An algorithm to assimilate wind-speed-only wind farm observations (no direction observation) has been developed, and WRF has been modified to perform the data assimilation. A next-generation RTFDDA data assimilation technology called Four-Dimensional Relaxation Ensemble Kalman Filter (4D-REKF), recently developed at NCAR, will be applied in the Xcel WRF-RTFDDA system, which is expected to improve the impact of wind farm and other data on model wind forecasts.

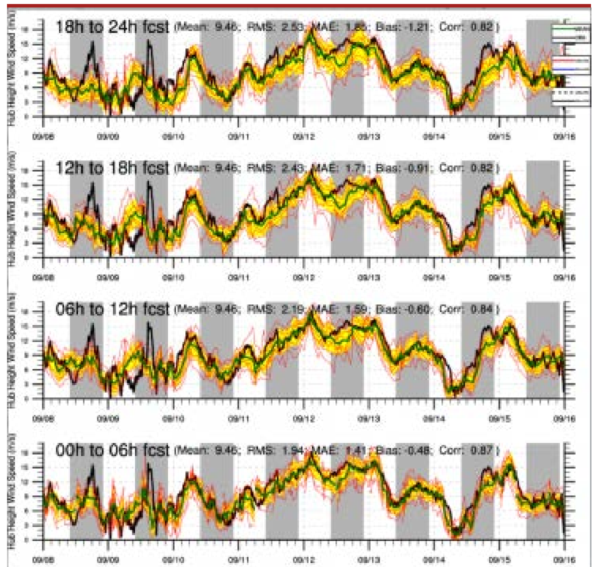

Fig. 1. Sample verification of CEPRI-NCAR Ensemble-RTFDDA forecasts of wind speed at 70m AGL at a major wind farm in Gansu Province, China. Black : Observation, Green : Calibrated 50 percentile forecasts ; Red : quantiles; and Yellow : one standard deviation.

Another major research area is focused on simulation and prediction of microphysical hydrometeors, including supercooled liquid water and wet snow in the lowest 100 – 200m layer, to support wind-turbine icing prediction. Turbine blade icing can impede power production of turbines and/or potentially damage the turbines themselves.

5. PWS CONUS-scale RTFDDA Operation

NCAR and PWS (Panasonic Weather Solutions; formerly AirDat LLC.) have been long-term partners in developing RTFDDA technology for TAMDAR (Tropospheric Airborne Meteorological Data Reporting) data

quality-control, optimization of TAMDAR impact in regional NWP, and in developing operational RTFDDA forecasting systems. A CONUS-scale operational WRF-based RTFDDA data assimilation and forecasting system at 12/4-km resolution was deployed at PWS in 2009, and has been continuously running since then. In FY2014, work focused on enhancing the PWS-NCAR 12/4km CONUS RTFDDA system with radar data assimilation. The RAL hyrdrometeor-latent-heat-nudging (HLHN) radar data assimilation scheme has been employed. Case studies for two convective storm cases have been performed to assess the impact of the radar data assimilation. Peudo-real-time tests are also conducted. The system will be implemented on a super-computing cluster, newly purchased by PWS for real-time operation before the New Year of 2015. Future work includes optimization of radar data assimilation in different regions with respect in the complex terrain areas.

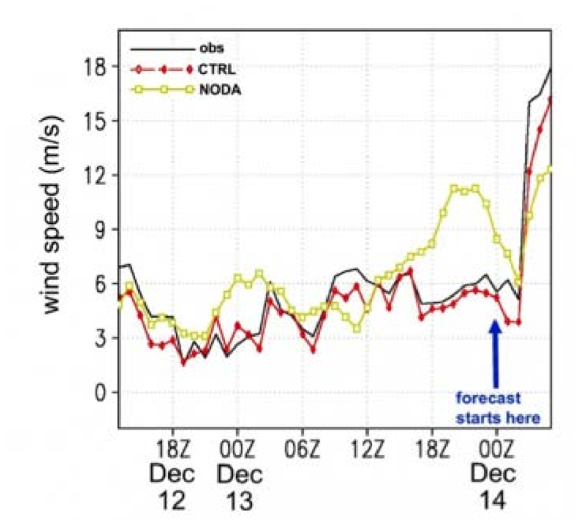

Fig. 3. Time series of farm-averaged hub-height wind speed for a wind farm in Northern Colorado from observations (black), WRF control experiment assimilating turbine observations with enhanced nudging coefficients, and WRF experiment without wind farm data assimilation (yellow). In this "idealized" experiment, the only data assimilated were the wind farm data (from 1200 UTC 12 December to 0000 UTC 14 December) with enhanced nudging coefficients to study its maximum impact with enhanced nudging coefficients. The wind farm data helped to remove the spurious wind ramp and improved the forecast of magnitude on the actual wind ramp.

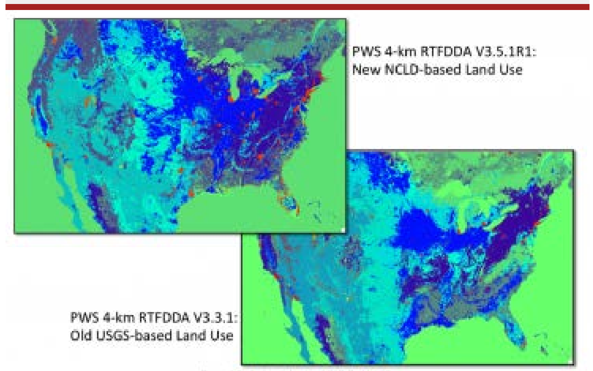

Fig. 4. Update of land uses for the PWS-NCAR CONUS 4-km grid RTFDDA land use using the new NLCD-based datasets. Many differences can be seen, especially the improved representation of the urbanization in the recent decades (red areas).

7. RTFDDA High-resolution Reanalysis and Nowcasting for Shenzhen, China

Shenzhen is a major city located in the Pearl River Delta in southern China. The municipality covers an area of 2,050 square kilometers including urban and rural areas. RAL collaborated with Shenzhen Meteorological Bureau to develop a RTFDDA modeling system for improved predictions over the Shenzhen area. The specific goal is to effectively integrate a high-density observation-network with advanced remote sensing instruments, including ultra-dense surface Automatic Weather Station (AWS), wind profilers, radiometers, met-towers, Doppler radars, the Global Positioning System (GPS), lightning, and other platforms into the RTFDDA system to provide continuous weather analysis and forecasts, and generate a five-year microclimatology for the Shenzhen metropolitan and surrounding area. The modeling system was configured with four nested domains with horizontal grid sizes at 27km, 9km, 3km and 1 km, respectively (Fig. 5). The 1-km domain covers Shenzhen municipality, Hong Kong, and the neighboring area.

The main accomplishments in FY2014 include: 1) installation of RTFDDA technologies at Shenzhen Meteorological Bureau, and optimized the model configuration including local land-surface characteristics presentation and surface-layer momentum flux computation; 2) completion of the last 5.5 year of climate-FDDA runs and verification; and 3) maintenance and continuous tuning of the real-time, rapid-updated RTFDDA microscale weather analysis and nowcasting system.

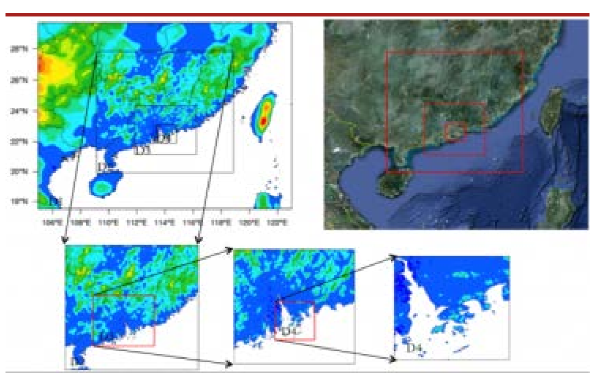

Fig. 5. The model domain configuration for real-time high-resolution weather analysis and production of 5-year microclimatology for

PLANS FOR FY2015

Research and development will continue to focus on improving RTFDDA technologies for weather-critical applications by providing high-fidelity, high-resolution 4-D weather information, including microclimatology, current weather and short-term forecasts. This work will include making advances in the core model sciences and technologies as well as enhancing the capabilities of on-going and new operational systems. Proposals are in development to create new RTFDDA systems for use in the UAE, Thailand and other countries. Specific plans for the ATEC work may be found in the 4DWX report. Below are the plans for several on-going RTFDDA projects.

China Electric Power Research Institute

Shenzhen metropolitan areas. The terrain height is shown in color shades.

RAL will collect and process the SGCC wind farm data to be assimilated into the E-RTFDDA system and to be used for E-RTFDDA forecasts calibration. The ensemble perturbation approaches will be enhanced with SKEP, EnkF and usage of more global models. Currently a proposal is under development to expand the collaboration with CEPRI to develop general NWP capabilities for broader weather service with SGCC including solar energy, electric-grid load, and power grid safety under severe weather, and support the development of SGCC intelligent grid systems.

Xcel Energy

Research will be conducted to enhance Xcel Energy's WRF-RTFDDA system by optimizing the wind farm data assimilation, including assimilating new data (wind direction and temperature measured directly by wind turbines) and refining the data assimilation weight functions. Special attention will be paid to improving WRF-RTFDDA capabilities with respect to wind ramp and turbine icing prediction.

Panasonic Weather Solutions

A major new task will examine and optimize the NCAR-PWS CONUS-scale 4-km operational RTFDDA system with assimilation of radar reflectivity in complex terrain areas.

Shenzhen Meteorological Bureau

RAL will continue to optimize the WRF-RTFDDA setting for the SZMB area to reduce the simulated wind bias, especially over the ocean. A new collaborative project will implement/improve the radar data assimilation for the real-time system at Shenzhen area and conduct local QPE based on SZMB's radar, rain-gage network, disdrometer network.

‹ Real-Time Four-Dimensional Data Assimilation (RTFDDA) and Forecasting Advances   up   Mesoscale Ensemble Data Assimilation and Prediction System ›

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MESOSCALE ENSEMBLE DATA ASSIMILATION AND PREDICTION SYSTEM

BACKGROUND

Given the chaotic nature of the atmosphere and the imperfections of numerical weather prediction (NWP) models, probabilistic forecasts are imperative for applications. To address this need, RAL has been developing an Ensemble Real-Time Four-Dimensional Data Assimilation (E-RTFDDA) and forecasting system. This WRF-based mesoscale ensemble has been deployed to support US Army test range operation and real-time wind energy prediction. Unlike most other mesoscale ensemble systems, E-RTFDDA is a multi–model, multi–scale, and rapidly cycling data assimilation and prediction system with multiple perturbation approaches. The continuous cycling mechanism of E-RTFDDA allows the model to produce accurate nowcasts and short-term

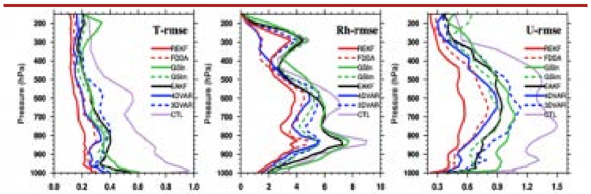

Fig. 1. Comparison of the RMSE of 12hr forecasts of temperatures (T), relative humidity (Rh), and zonal wind component (U) of WRF that are initialized from 12h data assimilation using Cressman-type observation-nudging (FDDA), 4DREKF (REKF), WRFDA 3DVAR

and 4 DVAR, DART-EnKF (EAKF), and two versions of GSI (GSIm and GSIn) for an OSSE study. The WRF Forecast without data assimilation is denoted as CTL.

forecasts. Since 2011, an innovative ensemble data assimilation algorithm known as four-dimensional relaxation ensemble Kalman filter (4D-REKF) has been under development, to replace the simpler Cressman-type “observation-nudging” FDDA in E-RTFDDA with a flow-dependent weighting. The research and development of E-RTFDDA is currently through the sponsorship of the Army Test and Evaluation Command, Xcel Energy and China State Grid projects, whose broad objectives and progress are also discussed in this annual report.

Research and development activities for the Ensemble RTFDDA (E-RTFDDA) during FY2014 were focused in three areas: 1) enhancements to the ensemble perturbation methods, 2) development of 4D-REKF, and 3) ensemble system deployment including advances in post-processing and calibration.

In FY2014, two E-RTFDDA systems, each with 15 WRF and 15 MM5 members, were continuously operated: one at the US Army Dugway Proving Ground to support routine tests and test planning, and one for Xcel Energy to provide ensemble wind forecasts at Xcel facilities located in Colorado, Minnesota, Texas and New Mexico. In addition, two new 30-WRF-member E-RTFDDA systems were implemented to provide wind forecasts to support China State Grid wind integration. Bias correction and probability calibration have been developed to produce value-added probabilistic forecast products for end users.

RAL continued to enhance the E–RTFDDA perturbations approaches, adding WRF-NMM (non-hydrostatic mesoscale model) members to the system; the Canadian GEM (Global Environment Multiscale) and Japanese Meteorological Administration GSM (Global Spectral atmospheric Model) model outputs were used to enhance E-RTFDDA boundary condition perturbations; the NCAR DART ensemble Kalman filter (EnKF) tools were also integrated with E-RTFDDA to enhance E-RTFDDA initial condition perturbations. The NCAR DART-EnKF (Data Assimilation Research Testbed-Ensemble Kalman Filter) system was integrated into E-RTFDDA to enhance the E-RTFDDA system in both member perturbations and data assimilation. The enhancement allows DART EnKF to take advantage of E-RTFDDA by means of deriving error covariance using the multiple perturbation E-RTFDDA forecasts; meanwhile, the updated EnKF means and a subset of the EnKF members are used to perturb the initial conditions in E-RTFDDA.

Major work on 4D-REKF included testing and optimizing the 4D-REKF code and algorithms, preparing for real-time operational runs. Because it is impractical to directly compute and communicate the entire Kalman gain to the nudging scheme, several more efficient approaches for computing the Kalman gain, while maintaining adequate accuracy, were tested. The schemes include a 2D mathematical fitting function, a ray-tracing method and a "nearest-point" approach. It was found that the "nearest-point" method presents the best trade-off between accuracy and efficiency for the Kalman gain computation. To handle diverse observation types, two kinds of Kalman gain computation were designed. For fixed stations, the Kalman gains are calculated at the exact station locations. For time-space changing observations such as aircraft weather reports, the Kalman gains are computed at regular grid points and then interpolated to the observation locations.

To validate the 4D-REKF data assimilation system, OSSE experiments based on perfect-model and perfect-observations assumptions were conducted. For comparison, WRF 3DVAR, 4DVAR, Gridpoint Statistical Inerpolation (GSI), and NCAR DART-EnKF have also been tested with the same OSSE framework. The verification results of this OSSE study indicate that 4D-REKF outperforms other existing WRF data assimilation technologies. Figure 1 is an example showing the bias and RMSE of various meteorological variables in 4D-REKF at the end of 6-hour data assimilation in comparison to those of WRF 3DVAR, 4DVAR, NCAR DART-EnKF, and GSI. The bias and RMSE in the standard FDDA (distance-dependent weighting) are also shown in the figure.

The 4D-REKF FDDA scheme was deployed as a component of the operational E-RTFDDA system running at the US Army Dugway Proving Ground, Utah. Assessment of the impact of 4D-REKF is on going, but the preliminary results suggest that the raw Kalman gains computed from the ensemble forecasts are not sufficiently accurate. Further refinements to the Kalman gains estimation and new hybrid Kalman gain schemes were formulated and are being tested.

FY2015 PLANS

E-RTFDDA will be further enhanced in the following areas:

- Evaluation of WRF-NMM, SKEBS, and DART EnKF components and conduct forecasting experiments to provide guidance for configuring optimal E-RTFDDA systems according to the requirements of special applications.
- Integration and assessment of more global model outputs to improve the specification of the lateral boundary conditions perturbation for E-RTFDDA.
- Continued refinement of ensemble Kalman gain computation for 4D-REKF and enhance 4D-REKF with cross-variable

(covariance) observation-nudging capabilities. In particular, this new capability will be applied to assimilate Doppler-radar radial velocities.
- Implementation of 4D-REKF for real-time operations at US Army Dugway Proving Ground, and verify the advantages.
- Continued improvement of the ensemble forecast verification and calibration algorithms. The Quantile Regression (QR) calibration approach will be reformulated to train the correction according to weather regimes. Improvement of the definition and determination of analogs for post-processing will also be considered.
- Continued E-RTFDDA technology transfer through developing new collaborations with U.S. and international agencies.

‹ Operational RTFDDA up Fine-Scale Precision NWP: WRF-RTFDDA-LES ›

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FINE-SCALE PRECISION NWP: WRF-RTFDDA-LES

BACKGROUND

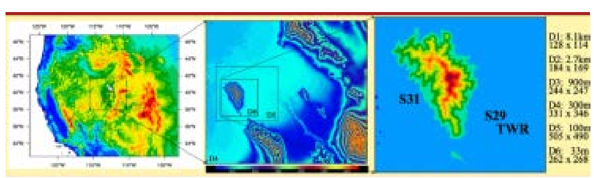

Fig. 1. Simultaneous multi-scale WRF-RTFDDA-LES simulations with six-nested-grid domains with model grid intervals varying from 33m to 8.1km.

Demands on fine-scale precision weather forecasts from weather-sensitive organizations are rapidly increasing. To meet their needs, RAL takes advantage of its advanced real-time four-dimensional data assimilation (RTFDDA) weather forecasting system and the increased computing power to start to research the feasibility of NWP capability on sub-kilometer Very-Large-Eddy Simulation (VLES) scale down to Large Eddy Simulation (LES) scale. The newly developed WRF-RTFDDA-LES system can be directly nested inside a parent mesoscale system. This fine-scale forecasting system provides detailed weather information that can be integrated to improve operational and logistic effectiveness of a multi-faceted prediction system. Fundamental research on various fine-scale weather scenarios including tornado storm

and wind farm turbulence has been conducted in the course of developing the WRF-RTFDDA-LES modeling system; this work has been adapted for research and operation by several meteorological agencies.

FY2014 ACCOMPLISHMENTS

Research on WRF-RTFDDA-LES during this year was mainly focused on an evaluation study of a real-time modeling system for the U.S. Army's Dugway Proving Ground (DPG), in Utah, and implementation of a real-time modeling system for the U.S. Army's Aberdeen Test Center, in Maryland. This included a study of multi-scale flow interactions at Granite Mountain with an LES-scale system.

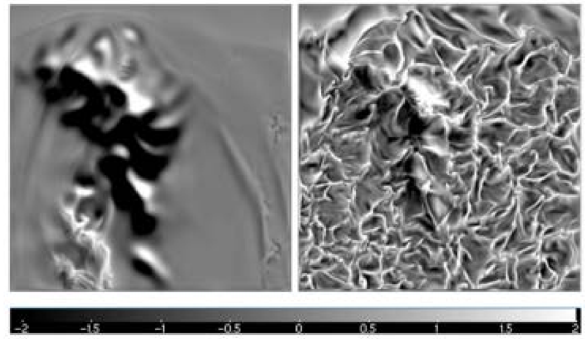

Fig. 2. Snapshots of WRF-RTFDDA-LES simulation of early morning (left panel; valid at 11:00 UTC, May 4, 2012 with stable boundary layer) and around-noon (right; valid at 17:32 UTC, May 4, 2012 with convective boundary layer) at 33 m grid intervals. The field shown is the model vertical velocity (m/s) at 200 m Above Ground Level.

During 2013, RAL staff implemented RTFDDA-LES for DPG, and configured it with four nested-grid domains, with grid sizes of 8.1, 2.7, 0.9 and 0.3 km, respectively (Fig.1). The system assimilates all available observations, including the dense network of observations at DPG. Verification of the real-time analyses and forecasts shows the benefits of the ultra-high-resolution NWP system in resolving realistic sub-mesoscale flows; it also exposes artificially amplified turbulence over broad spatiotemporal scales. To study the VLES potential w.r.t. to true LES modeling, a simulation was conducted with six nested-grid domains [two extra nested domains with grid sizes of 100 m and 33 m, respectively (Fig. 1)] were added to the DPG RTFDDA-VLES. The study focused on the Granite Mountain (~60 km^2) and neighboring areas at DPG, the site of MATERHORN. The modeling results show increasing ability of the VLES and LES model over the mesoscale resolving the fine-scale flow features, especially wind ramps (e.g. Fig. 2), and confirm the validity and value of VLES-scale NWP.

During 2014, two approaches were developed aiming at containing the artificially amplified turbulences in the VLES model. One approach is to add a TKE-based boundary layer scheme on the top of the LES sub-grid-filter, and the other is to adjust the sub-grid-filter mixing parameters. Both approaches mitigate, but do not eliminate, the artificially amplified turbulences. To benefit end-users, a wavelet-based scale separation strategy was developed to post-process the VLES meteograms, with the goal of removing the artificially amplified fast fluctuations while retaining the fine scales of interest.

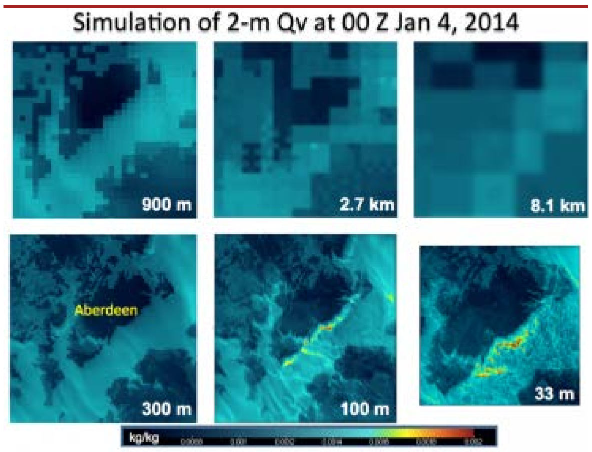

Fig. 3. A snapshot view of surface moisture (water vapor mixing ratio) structures over the Aberdeen area, simulated with models with grid sizes of 8100, 2700, 900, 300, 100, and 33m respectively.

In addition to the work at DPG, RTFDDA-VLES is also implemented for the ATC region. In contrast to the complex terrain at DPG, ATC is characterized by bay-land contrast with complex coastlines. As at DPG, RTFDDA-VLES at ATC also simulates much more accurate wind flow than the corresponding mesoscale models. A snapshot showing impact of model resolutions on wind flows and surface moisture fluxes are given in Fig.3.

FY2015 PLANS

In the coming year, work will continue to focus on the study and evaluation of the WRF-RTFDDA-LES modeling system by focusing on refinement of the fine-scale forecasting capability, as well as on development of tools to improve the use and visualization of VLES forecasts by end-users. Research will also continue on developing VLES forecast verification strategies, as well as on investigating LES-scale data assimilation algorithms.

‹ Mesoscale Ensemble Data Assimilation and Prediction System   up   Analog Ensembles ›

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ANALOG ENSEMBLES

BACKGROUND

The analog of a forecast for a given location and time is defined as the observation (or analysis grid point) that verified when a past prediction matching selected features of the current forecast was valid. A novel ensemble design, called analog ensemble (AnEn), was proposed in 2011. The best analogs of a deterministic Numerical Weather Prediction (NWP) are combined to form an ensemble and to generate skillful and reliable probabilistic predictions (Delle Monache et al. 2011, 2013).

As shown in Fig. 1, the AnEn method generates ensemble members for a prediction at a given location and forecast lead time via three main steps using a history of cases, called the analog training period, in which both the NWP deterministic prediction and a verifying observation are available. Analogs are sought independently at each location and for

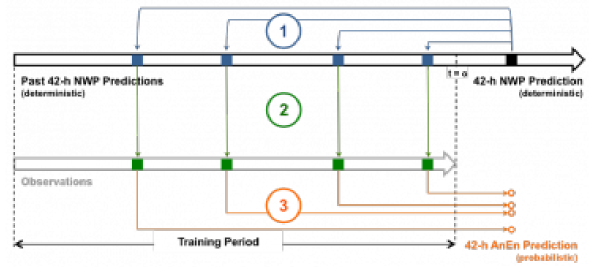

Fig. 1. Schematic representation of the process for finding four members of the analog ensemble (AnEn) at one forecast lead time.

each lead time (black square in step 1). The best-matching historical forecasts for the current prediction are selected as the analogs (blue boxes in step 1). An analog may come from any past date within the training period, i.e., a day, week, or several months ago. Next, each analog's verifying observation is selected as a member of AnEn (green boxes in step 2). Taken all together, these observations constitute the ensemble prediction for the current forecast (orange circles in step 3).

FY2014 ACCOMPLISHMENTS

An in-depth analysis of the AnEn performance for short-term deterministic and probabilistic predictions can be found in Delle Monache et al. (2001, 2013) and Nagarajan et al. (2015). The salient aspects of this technique are:

- Ability to use a higher resolution model (since only one real-time forecast is needed to generate an ensemble);
    - Reduction of both systematic and random errors of NWP-based deterministic predictions;
    - No need for initial condition and model perturbation strategies to generate an ensemble;
    - Intrinsically reliable probabilistic forecasts (i.e., no post-processing required);
    - Ability to capture the flow-dependent error characteristics;
    - Superior skill in predicting rare events when compared to state-of-the-science post-processing methods.

The analog ensemble has also been applied with success to the following applications:

- Short-term wind power predictions (Alessandrini et al. 2014, 2015). When compared to advanced power prediction systems such as the one based on the European Centre for Medium-Range Weather Forecasts (ECMWF), the AnEn exhibited superior skill using approximately 1/4 of the computational resources utilized to generate ECMWF ensemble predictions.
- Multi-year downscaling for wind resource assessment applications (Vanvyve et al. 2015);
- Short-term air quality predictions (Djalalova et al. 2015);

FY2015 PLANS

In FY15 the potential of the analog ensemble technique will be further explored for several applications, including solar power forecasting, downscaling of precipitation reanalysis, the generation of probabilistic weather predictions over a 2/3D grid, and the prediction of tropical cyclones intensity.

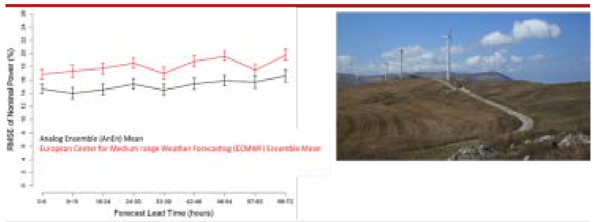

Fig. 2. RMSE of AnEn (black) and ECMWF (red) for 0-72 h wind power predictions verified over one year at a wind farm in Sicily, Italy. The vertical bars correspond to 95% confidence intervals.

References

Alessandrini, S., F. Davò, S. Sperati, M. Benini, L. Delle Monache, 2014: Comparison of the economic impact of different wind power forecast systems for producers. Advance in Science Research, 11, 49-53.

Alessandrini, S., L. Delle Monache, S. Sperati, J. Nissen, 2015: A novel application of an analog ensemble for short-term wind power forecasting. Conditionally accepted, *Renewable Energy.*

Delle Monache, L., T. Nipen, Y. Liu, G. Roux, and R. Stull, 2011: Kalman filter and analog schemes to post-process numerical weather predictions. *Mon. Wea. Rev*., 139, 3554–3570.

Delle Monache, L., F. A. Eckel, D. Rife, B. Nagarajan, and K. Searight, 2013: Probabilistic weather predictions with an analog ensemble. *Mon. Wea. Rev*., 141, 3498–3516.

Djalalova, I., L. Delle Monache, and J. Wilczak, 2015: $PM_{2.5}$ analog forecast and a Kalman filter post-processing for the Community Multiscale Air Quality model. Submitted, *Atmospheric Environment.*

Mahoney, W.P., K. Parks, G. Wiener, Y. Liu, W.L. Myers, J. Sun, L. Delle Monache, T. Hopson, D. Johnson, S.E. Haupt, 2012: A wind power forecasting system to optimize grid integration*. IEEE Trans. Sustainable Energy*, 3, 670–682.

Nagarajan, B., L. Delle Monache, J. Hacker, D. Rife, K. Searight, J. Knievel, and T. Nipen, 2015: An evaluation of analog-based post-processing methods across several variables and forecast models. Conditionally accepted*, Weather and*

Forecasting.

Vanvyve, E., L. Delle Monache, A. J. Monaghan, J. O. Pinto, 2015: Wind resource estimates with an analog-ensemble approach. Accepted, *Renewable Energy.*

‹ Fine-Scale Precision NWP: WRF-RTFDDA-LES | up | Ensemble Data Assimilation for Wind Prediction and Model Error ›

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ENSEMBLE DATA ASSIMILATION FOR WIND PREDICTION AND MODEL ERROR

BACKGROUND

Work began in FY2013 to improve understanding of the complex interactions between the atmosphere and the ocean surface. This knowledge will be used to develop improved marine boundary layer (MBL) parameterizations, as well as improved ocean-atmospheric coupling techniques, significantly reducing market barriers to offshore wind energy. Goals include more accurate predictions of turbine hub-height winds in marine environments, resulting in improved power prediction and potentially saving millions of dollars for the wind energy industry, and improved wind resource assessment techniques in marine environments. This work is funded as part of the Department of Energy effort “U.S. Offshore Wind: Removing Market Barriers”.

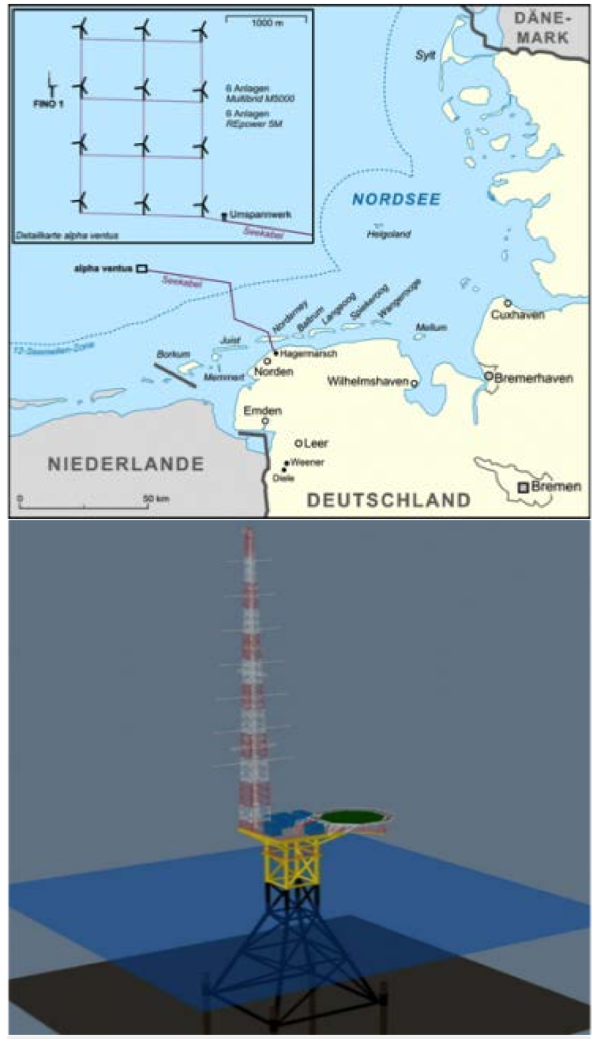

Fig. 1. Location and configuration of the FINO 1 platform. Images are from www.fino1de.

FY2014 ACCOMPLISHMENTS

The two-way coupling between WRF and the wave model WaveWatch III is nearly completed, and state estimation (SE) experiments centered over the FINO 1 tower (Fig. 1) with WRF and the Data Assimilation Research Testbed (DART) are underway. Preliminary results show a significant reduction of model error when key parameters (e.g., surface roughness length) are estimated using the WRF/DART system, resulting in more accurate hub-height off-shore wind predictions, which was one of the main goals of the project.

FY2015 PLANS

In FY15, RAL will complete SE experiments with WRF/DART, where WRF is run with both the Single Column Model and 3D configurations to study model error related to the simulation of the MBL in an ensemble data assimilation framework. The expected outcome of the project is an improved understanding of the complex interactions between the atmosphere and ocean surface. This knowledge will be used to develop improved MBL parameterizations, as well as improved atmosphere-ocean coupling techniques, significantly reducing market barriers to offshore wind energy.

‹ Analog Ensembles up High Performance Computing for Operational Modeling ›

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HIGH PERFORMANCE COMPUTING FOR OPERATIONAL MODELING

BACKGROUND

RAL's research and development in advanced, small-footprint computing is focused on providing scalable solutions to high-resolution numerical modeling with demanding data storage requirements. By keeping abreast of the increasing speed and density of rack–mounted cluster computing, RAL delivers climate analyses and real–time weather predictions that fit into an ever-decreasing footprint. As hardware vendors continue to provide higher density computing, RAL is able to move toward more green computing, with lower power and cooling requirements.

An important feature of RAL/NSAP's computing design is its ability to provide solutions across computing scales. Given the need to deploy systems that range in size from 32 cores to 832 cores, and applications that range from global climatologies to large eddy simulations, the flexibility and extensibility of the computing architecture becomes a critical component for success.

FY2014 ACCOMPLISHMENTS

Computing

In order to effectively utilize core-dense compute resources (nodes) for parallel codes (such as the WRF numerical weather prediction model) as well as serial based post-processing, various software layers have been under examination to improve performance across differing job sizes. Testing, analysis and impact measurements have included everything from Intel compilers, differing versions of openmpi, Linux kernel power features, as well as combinations of Infiniband (IB) OpenFabrics Enterprise Distribution (OFED) software stacks and Fourteen Data Rate (FDR) IB equipment. Through the evaluation of these tools, technical staff can help assess specific efficiencies that can be gained when sizing hardware architectures to varied job-type and runtime requirements, or to assess how non-local, hosted HPC centers might benefit NSAP projects by utilizing shared computing resources in the future.

Storage

RAL continues to utilize improvements in data storage management through the deployment of NAS (network attached storage) systems that are simultaneously accessible by a variety of project clusters. The transition away from RAID disks that were directly attached to a single computing cluster to NAS data repositories that are accessible across the local area network has been accompanied by greater reliability, increased data accessibility, and less time spent on storage maintenance by system administrators and users. In addition to the increased reliability, the NAS solution provides a growth path that allows for incremental additions to data storage, while maintaining consistent, logical namespace. The end result is that data users no longer have to spend time juggling datasets across individual disks, leaving it to the NAS architecture to manage the mapping between logical and physical space.

Further enhancing the scalability of application to storage performance are parallel IO access methods, which each server uses to access file systems over a dedicated gigabit to 10Gigbit network. The parallel NFS standard minimizes hot-spot contention for data sets and provides a topology where high demand IO requests are balanced over dozens of disk spindles and network ports to provide streaming of data in both write or read modes.

Monitoring

In addition to continued expansion into smaller and more-efficient use of computing and storage resources, accomplishments also include expansion in the use of network-enabled system monitoring and performance analysis tools at the data management layer. Through the deployment of these tools, technical staff receive email alerts and are able to evaluate a historical record of metrics graphically to help diagnose both system and application scalability. The extensible community-supported, plug-in architecture allows developers to easily adapt existing monitoring examples to varied applications across different computing architecture without the need to write code from the ground up.

FY2015 PLANS

With current CPU and Infiniband specifications likely to remain stable, plans are underway to improve software efficiency and scalability by utilizing the Intel compiler in operational forecasts, test and deploy vendor-specific Infiniband OFED drivers and fabric features, and construct RTFDDA and CFDDA software installations in a more portable distribution method.

The combination of these enhancements will allow NSAP to deploy, execute and benchmark various forecast configurations on remote-hosted, or cloud-based HPC environments with greater ease and flexibility. NSAP realizes that trends in hardware consolidation and secured cloud computing will put an emphasis on multiple platform and remote execution of forecast and climate codes now and in the future.

‹ Ensemble Data Assimilation for Wind Prediction and Model Error | up | RTFDDA-3DVAR Hybrid System for the Middle East ›

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RTFDDA-3DVAR HYBRID SYSTEM FOR THE MIDDLE EAST

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STATISTICAL AND DYNAMICAL MESOSCALE CLIMATE DOWNSCALING

BACKGROUND

“Climate downscaling" is a practice whereby coarse-resolution climate data -- which comes from global atmospheric reanalyses (e.g., the "NCEP/NCAR Reanalysis") or global climate models (GCMs) -- is fed to physically-based or empirically-based techniques to simulate regional- or local-scale climate at much finer spatial and temporal resolution. The need for climate downscaling has grown tremendously in the past decade, as the scientific community endeavors to address an increasing number of weather and climate impacts issues related to agriculture, water resources, human health, etc. These issues are generally local or regional in scope, and therefore require fine-scale climate datasets. Climate downscaling can be accomplished by either "statistical" or "dynamical" means or a combination of the two, as described below. It can also focus on either historical climate (reanalyses) or future climate (forecasts).

Statistical downscaling empirically relates coarse-resolution atmospheric reanalysis or GCM output to some regionally representative, observationally-based dataset from the recent past (e.g., weather station and balloon measurements, radar reflectivity, satellite radiances, regional reanalyses). These statistical relationships, which implicitly account for biases in the GCM due to inadequate resolution of terrain or deficiencies in the treatment of fine scale physical processes, can then be used to downscale both the present-day and future GCM data. Statistical downscaling has the advantage that it is computationally inexpensive, and therefore generally enables users to downscale many GCMs to obtain a probabilistic estimate of regional climate change outcomes. However, it has some important limitations, including the assumption of stationarity if applied to the future, and general ignorance of physical relationships across space and time. Dynamical downscaling, described below, can overcome some of the problems of statistical downscaling but is computationally expensive to implement.

Dynamical downscaling employs a high-resolution regional climate model (RCM) --such as the Weather Research and Forecasting Model (WRF), driven at its boundaries by larger-scale (typically global and course-resolution) climate reanalyses or forecasts, to simulate climate variability at finer spatial and temporal resolution over a region and scale of interest. Because a physical model is used, spatial and temporal relationships are preserved at the fidelity offered by the downscaling model. One common limitation that results from the computational expense is a general inability to produce probabilistic simulations or forecasts with ensembles.

Hybrid statistical/dynamical downscaling techniques developed at RAL combine dynamical and statistical methods to produce high-resolution regional climate projections that are dynamically consistent, account for non-linear climate processes, properly characterize uncertainty, and--importantly--can be relatively economical to produce. Several hybrid techniques have been developed and/or applied within RAL. These include the Monte Carlo downscaling technique ("MC"; Rife et al. 2012) and the Analog-Ensemble technique ("AnEn"; Delle Monache et al. 2011). RAL scientists work on a variety of applications that employ dynamical, statistical, and hybrid downscaling techniques, some of which are described below.

ANALOG ENSEMBLE FOR WIND RESOURCE ASSESSMENT

As part of a NASA-funded project, a new method has been proposed and demonstrated for the long-term estimation of the wind speeds at a target site, a key step in wind resource assessments (Vanvyve et al. 2013). Analog ensemble (AnEn) techniques have been used with success for short-term weather predictions (e.g., Delle Monache et al. 2013). In the context of the wind resource assessment, the AnEn method draws on the information contained in the historical data of multiple physical quantities over the period these data overlap with the observations (known as *training period*; typically

365 days) of the quantity of interest (known as *predictand*; the wind speed in this study). The relationships derived within the training period are then applied to reconstruct the on-site wind speed over the period for which there are no observations (hereafter referred to as *reconstructed period*, e.g., the past 20 years before the measurement campaign started).

More precisely, this is a three-stage process that is executed independently at every target site for every hour *t* of the reconstructed period, as sketched in Fig.1. First, the historical value of multiple physical quantities (known as *analog predictors*; e.g. wind speed itself, wind direction, pressure, etc.) is retrieved for a time window (known as an *analog trend*) centered around time *t* (black dot in Fig. 1). The analog predictors are selected beforehand based on their known or anticipated correlations to the predictand. Second, other historical cases with conditions similar to those in the target window are identified (known as *analogs*) by looking at a time window (known as *analog search window*) centered around the same hour of the day for every day in the training period, and ranked by closeness of match. Analogs may therefore come from any day in the training period. Using multiple predictors helps distinguish the analogs by identifying specific weather regimes relevant to the predictand. Third, the *K* best analogs (K is the *number of analogs*; black circles) are selected, and the corresponding observed values of the predictand are retrieved (black squares). The latter are the *ensemble members* for hour *t*.

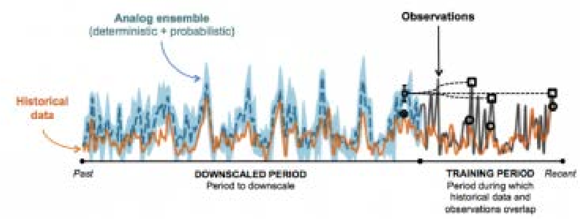

Fig. 1. Sketch of the functioning of the analog ensemble method for one analog predictor, the analog trend reduced to one time step, and when retaining the best three analogs.

The final result is the *analog ensemble*, i.e., a set of *K* wind speed values for every hour *t* of the reconstructed period. The assumption is that errors in the analogs are likely to be similar to the error in the current prediction. The result is a set of errors for inferring the current error. Vanvyve et al. (2013) showed:

- The AnEn can be used effectively for wind resource applications;
- The AnEn provides an accurate long-term wind resource estimate at target sites;
- The AnEn reliably quantifies the uncertainty allowing for cost-effective decision making;
- The AnEn is a computationally inexpensive method.

Dynamical Downscaling Computational Cost Reduction via the Analog Ensemble

The AnEn technique has been tested for the first time as a way to reduce the computational cost of dynamical downscaling over a 3-dimensional grid. The AnEn algorithm has been implemented to extend a high-resolution model estimate from one to several years. A coarser model run is assumed to be available over several years (e.g., 10), while a finer-resolution model estimate is assumed to be available over only a subset (e.g., 1 year) of that period. The period over which both coarse and fine model runs are available is called *training period*, whereas the period over which only the coarse run is available is called the *downscaling period*. For a given grid point and time of the downscaling period, the coarse run is downscaled as follows: first the best matches (i.e., similar coarse runs) are sought over the training period. Then, the fine-resolution runs corresponding to the best coarse run matches are selected as analogs. This set of best analogs forms AnEn, and they can be seen as samples of the probability density function that downscales the time considered over the downscaling period. This procedure is then repeated independently (and possibly in parallel) for every grid point and time of the downscaling period. Preliminary tests indicate the ability of this approach of reducing the cost of dynamical downscaling by a factor between 5-10, depending on the location and the required accuracy. Tests are ongoing to assess in depth the accuracy and reliability of this approach, as well as the ability of AnEn to preserve the 3-dimensional physical structure of the atmospheric flow.

Future Climate Dynamical Downscaling

Dynamical downscaling is a computationally intensive method whereby fine-scale details of the atmosphere may be portrayed by running a limited area numerical weather prediction model (often called a regional climate model, RCM) nested within a coarse resolution global reanalysis or global climate model (GCM) output. As part of a NASA-funded project, we have assessed a sampling techniques to dynamical downscale a subset of representative days such that the statistical properties of the subset of dynamically downscaled day approximate those obtained when dynamically downscaling the entire period of interest (Pinto et al. 2013). Two sampling techniques were explored: one in which days are randomly selected; the other in which representative days were chosen (or targeted) based on a set of selection criteria (example in Fig. 2). The relative merit of using random sampling versus targeted random sampling was assessed by the ability of the downscaled subset to approximate the statistical properties of daily mean 2 m air temperature (T2M). Downscaled results obtained by using a random sample that is just 5% of the entire population approximates the first two moments of T2M from the full population to within 0.3 K on average. Targeted random sampling can reduce the mean absolute of these estimates by as much as 30% locally. The estimation of more extreme values of the distribution of T2M using these

sampling techniques is more uncertain but can still be estimated to within 1 K at the 90% confidence level using just 10% of the entire population. The potential reduction in computational cost afforded by these sampling techniques could greatly benefit applications requiring high-resolution dynamically-downscaled depictions of regional climate, including cases where ensembles of regional climate simulations are required to properly characterize uncertainty.

Global Climatological Analysis Tool

RAL scientists continue to support the DoD's National Ground Intelligence Center (NGIC) in its mission of assessing the consequences of the transport and dispersion of accidental and intentional releases of hazardous materials into the atmosphere. This is done by providing the agency with access to the RAL-developed GCAT (Global Climate Analysis Toolkit) system. GCAT is a fully automated dynamical downscaling system that allows NGIC scientists to remotely generate a high-resolution 30-year climatography for any region on the Earth. GCAT is based upon Climate Four-Dimensional Data Assimilation (CFDDA) technologies.

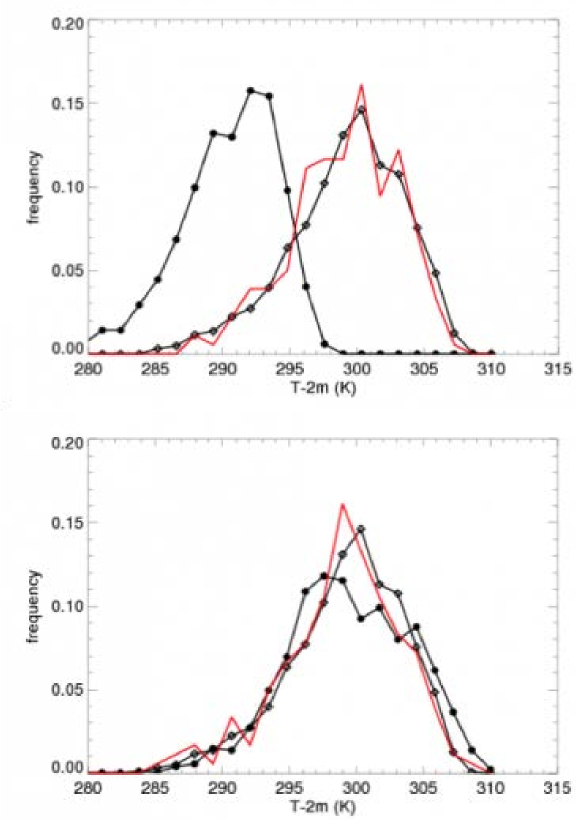

Fig. 2 Distributions of T2M obtained for the (left) Rocky Mountains (RM : 40N, 107E) training grid point and (right) Great Plains (GP: 40N, 100E) training grid point for full-period GCM (black line with filled circles), full period of dynamical climate downscaling (black line with open diamonds), and from a sub-sample obtained using targeted random sampling at the corresponding training grid point and a sample size of 180 (red).

During FY2014 several capabilities were added to GCAT. A fourth domain at 1.1-km grid increment was added to the WRF C-FDDA, enabling NGIC to conduct transport and dispersion analyses at very fine scale. The capability to automatically classify WRF output fields into climatological regimes was extended to this fourth domain. The method is based on the Self Organizing Map (SOM) artificial neural network pattern recognition technique. Figure 3 shows the results of a SOM classification, in which 30 months (May 1981-2010) of WRF 1.1km hourly outputs were used to estimate the main six regimes of the wind flow over the Energetic Materials Research and Testing Center in Socorro, NM. The six regimes that have been identified are given with their frequency of occurrence and their most representative days, which are chosen based on their Euclidian distance to each SOM node. Weather data valid for the representative days provides better forcing to NGIC's transport and dispersion climatological studies, as they didn't undergo averaging which can destroy important model physical properties (balance etc.) available with dynamical downscaling.

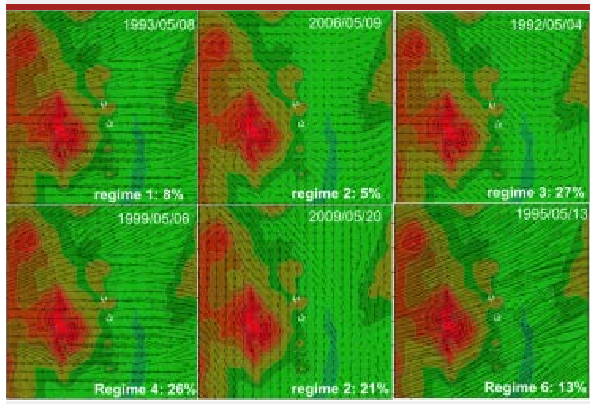

Fig. 3. Typical days based on SOM classifications for dowscaled historical flow during May over Socorro, NM.

Also during FY2014, the Second-order Closure Integrated PUFF (SCIPUFF) transport and dispersion model was implemented for execution for each dynamical downscaling simulation. This way, SOMs can be built based on plume dosage, in addition to weather variables, when analyzing the past climate.

Finally, the system began shifting from the NCAR-NCEP Reanalysis Product update NNRP2 data set to the Climate Forecast System Reanalysis data set for initial and lateral boundary conditions. The CFSR is on a 0.5-degree grid as opposed to the NNRP's 2.5 degree grid. Also, the model underlying CFSR is newer than NNRP, resulting in more accurate reanalyses.

FY2015 PLANS

While the sampling technique allows one to select a subset of representative global GCM days, the resulting dataset is necessarily discontinuous. Another technique that we will explore to downscale future climate projections is the AnEn technique (Delle Monache et al. 2011, 2013), which can be applied to efficiently extend a short, continuous dynamically downscaled dataset to a multi-decadal downscaled dataset. These increased efficiencies could allow for utilization of finer resolution and/or more complex model physics in the dynamical downscaling. Alternatively, or, in addition, the increased efficiency could allows for high resolution downscaling of multiple GCM or GCM scenarios to better estimate uncertainty due to model physics assumptions or

unknown socio-economic responses.

Figure 4 shows how the AnEn algorithm could be applied to downscale future climate projections. Given 20- and 2-year GCM and RCM estimates, respectively, the portion over which these sets overlap is the training period (which is contiguous in Fig. 4 only for illustration purposes only). The goal is to generate an ensemble of downscaled estimates of key fields for the 18-year GCM period not included in the training set. Given a GCM realization for a given point in space and time (blue square, panel 1), the best GCM matches in the training set are found (four green boxes, panel 2), where the degree of analogy is determined with the metric described in Eq. (6) of Delle Monache et al. (2011). Next (panel 3), the corresponding (in time and space) RCM estimates are selected (four black boxes). This group of four RCM estimates comprises a four-member AnEn. The procedure could be repeated independently for each variable and for each point in space and time of interest.

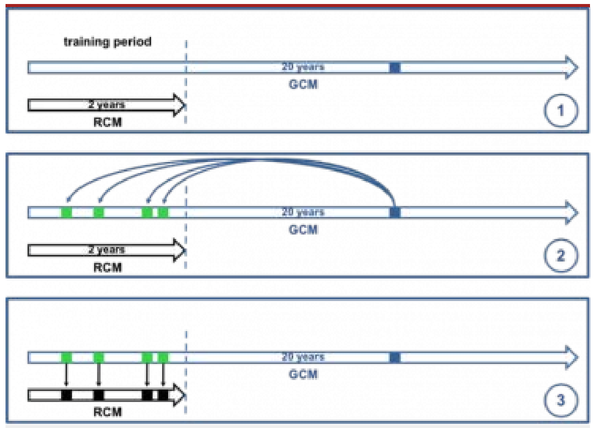

Fig. 4 Main steps of the analog ensemble (AnEn) method to downscale future climate projections.

GCAT and the underlying C-FDDA will undergo several enhancements. First, it will be updated to the latest version of WRF (v3.5.1). Initial and boundary conditions will be unified so that CFSR is exclusively used (and CFS-Forecast for downscaled foreacasts). Precipitation assimilation through a variational retrieval of moisture profiles based on observed precipitation will be evaluated. Probabilistic post-processing with surface observations and the WRF single-column model will be evaluated. Finally, the GCAT codes will be ported to DoD High-Performance Modernization Program (HPCMP) machines will reduce RAL's dependence on single-use local machines.

References

Delle Monache, L., T. Eckel, D. Rife, B. Nagarajan, and K. Searight, 2012: Probabilistic weather prediction with an analog ensemble. Submitted to Mon. Wea. Rev.

Delle Monache, L., T. Nipen, Y. Liu, G. Roux, and R. Stull, 2011: Kalman filter and analog schemes to post-process numerical weather predictions. Mon. Wea. Rev., 139, 3554–3570.

Pinto, J., A. Monaghan, L. Delle Monache, E.Vanvyve, and D. Rife, 2013. Regional assessment of a targeted random sampling technique for more efficient dynamical climate downscaling. Conditionally accepted, *Journal of Applied Meteorology and Climatology*.

Rife, D.L., E. Vanvyve, J.O. Pinto, A.J. Monaghan, C.A. Davis, and G.S. Poulos, 2012: Toward robust and efficient climate downscaling: Application to wind energy. J. Appl. Meteor. Climatol., doi:10.1175/JAMC-D-12-016.1 in press.

Wood, A.W., L.R. Leung, V. Sridhar, and D.P. Lettenmaier, 2004, Hydrologic implications of dynamical and statistical approaches to downscaling climate model outputs. Climatic Change, 62, 189-216.

‹ RTFDDA-3DVAR Hybrid System for the Middle East   up   Atmospheric Transport and Dispersion of Hazardous Materials Research and Development ›

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ATMOSPHERIC TRANSPORT AND DISPERSION OF HAZARDOUS MATERIALS RESEARCH AND DEVELOPMENT

BACKGROUND

Atmospheric releases of hazardous materials, either accidental or intentional, continue to pose a viable threat to both United States citizens, as well as troops abroad and at home. To counter this threat, RAL is actively supporting research and the development of novel techniques and systems which can be used to more accurately simulate the atmospheric state and evolution of the released material in both time and space, for planning, real-time response, and forensic purposes.

HAZARDOUS MATERIAL SOURCE TERM ESTIMATION

In addition to needing a representative description of the atmospheric state (past, present, and future), Atmospheric Transport and Dispersion (AT&D) modeling systems also require precise specifications of the material release characteristics (e.g. location, time, quantity). For most real-time response scenarios, the specifics of the material release will be unknown, with only ancillary concentration sensor measurements available.

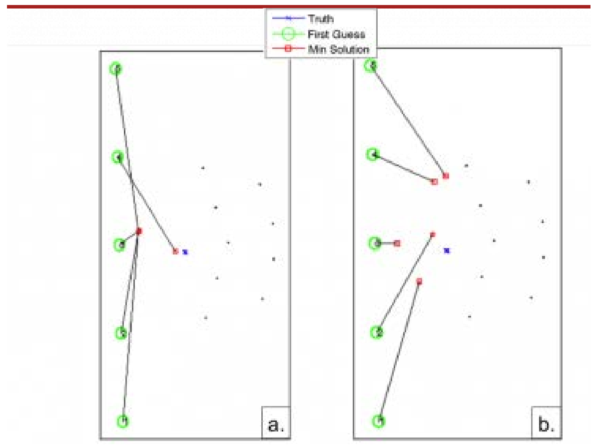

Figure 1: VIRSA test results when minimizing: (a) source location, mass, and time (Version 1.0) and (b) source location, mass, and time, plus wind speed and wind direction (Version 2.0). Black dots denote the location of material sensor observations, and the blue X denotes the true source release location. Green circles denote the first guess source release locations from which the VIRSA system initializes and converges to a minimum solution, as denoted by the red boxes.

Algorithms and techniques to characterize the source and material are actively being developed at RAL to quickly reconstruct and estimate the source release using these limited sensor observations. In particular, RAL is actively developing a tailored Source Term Estimation (STE) and hazard refinement system, called the Variational Iterative Refinement STE Algorithm (VIRSA). VIRSA is a combination of models that include: the Second-order Closure Integrated PUFF model (SCIPUFF), its corresponding STE model, a hybrid Lagrangian-Eulerian Plume Model (LEPM), its formal numerical adjoint, and the software infrastructure necessary to link them. SCIPUFF and its internal STE model are used to calculate a “first guess” source estimate based on available hazardous material sensor observations and meteorological observations. The LEPM and corresponding adjoint are then used to iteratively refine the "first guess" source and wind estimate using variational minimization techniques.

Version 1.0 of this system was successfully integrated into the US Department of Defense (DoD) emergency response modeling systems—HPAC (Hazard Prediction and Assessment Capability) and JEM (Joint Effects Model) in FY2012. This version of VIRSA includes the capability to refine the "first guess" source location, mass, and release time utilizing material sensor observations and meteorological observations provided in the North Atlantic Treaty Organization (NATO) Nuclear Biological and Chemical (NBC) messaging format. Version 2.0 is currently under development and scheduled for release in FY2014. This version will include the capability to refine the wind fields (wind speed and direction), in order to provide a better estimate of the source release characteristics and resulting downwind hazard.

Work in FY2014 continued in the following areas:

- Successfully modified the VIRSA system to include wind speed and wind direction, in addition to source mass, location, and time, in the cost function minimization procedure. Preliminary testing and evaluation has shown general improvement in the VIRSA solution, as compared to v1.0 (Figure 1).
- Made substantial progress developing an ensemble-based methodology to include and incorporate uncertainty information into the VIRSA solution. This methodology has been shown to drastically reduce the complexity of the overall cost function surface, and thus improve the overall performance of the minimization process, as illustrated in Figure 2.

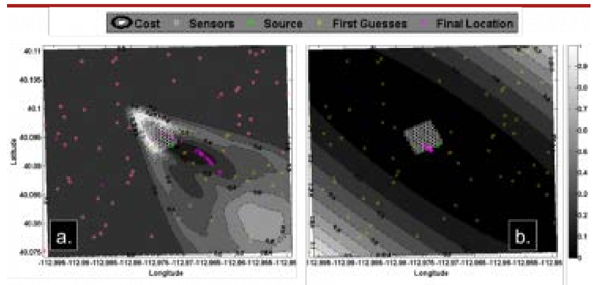

Figure 2: Cost function surface maps and VIRSA solutions when utilizing: a) no uncertainty information (unconstrained) and b) uncertainty information derived via an ensemble based method (constrained). White circles denote the material sensor locations, while a green star denotes true source release location. First guess and final estimated source release locations are highlighted in yellow and pink, respectively.

FY2015 Plans

- Continue to refine methods for incorporating wind speed and direction information into the cost-function minimization process.
- Continue to refine and evaluate methods for incorporating uncertainty information into the cost-function minimization process.
- Integrate v2.0 into HPAC and verify and validate the integrated system.
- Integrate v2.0 into JEM and verify and validate the integrated system.

VIRTUAL ATMOSPHERIC DISPERSION FIELD TESTING

In order to more robustly test and evaluate the evolving VIRSA system, RAL has developed the Virtual Threat Response Emulation and Analysis Testbed (VTHREAT), enabling simulation of physically realistic hazardous release scenarios, placement of material and meteorological sensors, and extraction of the resulting synthetic sensor readings. VTHREAT utilizes research grade Numerical Weather Prediction (NWP) and Atmospheric Transport and Dispersion (AT&D) models to generate high-resolution realizations of the turbulent atmospheric boundary layer and the resulting turbulent transport of materials released in the synthetic environment. More specifically, VTHREAT is currently leveraging the Large Eddy Simulation (LES) capabilities provided by the Weather and Research Forecast (WRF) NWP model, combined with continued advancements being made with the NCAR Lagrangian Particle Dispersion Model (LPDM). The resulting environmental simulations can then be sampled utilizing a variety of material and meteorological sensor models, which emulate the operating characteristics of the sensing modality. These tools have been incorporated into a consolidated software application, which allows a user to easily load existing virtual test simulations, visualize the 4-dimensional environment, place material and meteorological sensors within that environment, and save the sensor readings for later analysis or as input to downstream sensor information systems. The GUI architecture is currently based on the National Aeronautics and Space Administration (NASA) World Wind Java Geospatial Visualization Platform, which provides access to a variety of external web map server (WMS) services and datasets.

Work in FY2014 continued in the following areas:

- Completed the transition from EULAG (Eulerian/semi-Lagrangian fluid solver) to WRF (Weather Research and Forecasting) for providing LES generated environmental conditions.
- Developed and evaluated the Lagrangian Particle Dispersion Model (LPDM), which now utilizes a 2-particle relative dispersion modeling framework, to more accurately simulate near source dispersion.
- Added the capability to include various background aerosols, which cause detection interference, within the environmental simulation.
- Developed and integrated algorithms into VTHREAT, which predict various field test performance metrics, based on the planned test sensor makeup and layout.
- Generated a large library of synthetic environment and associated material release scenarios (21 cases), which can be used by the VTHREAT tool to generate a large quantity of synthetic sensor measurements.
- Successfully ported the VTHREAT application from the Macintosh Operating System (OS) to the Windows OS platform to better support external users.
- Delivered the VTHREAT application to the Institute for Defense Analysis (IDA) to support their ongoing third party evaluation of Source Term Estimation (STE) algorithms.

FY2015 Plans

- Continue validation of the WRF LES capability.
- Expand the VTHREAT synthetic environment and release scenario library to include urban environments/scenarios.
- Complete the testing and integration of the latest 2-particle version of LPDM, into the VTHREAT application.
- Port the LPDM to GPU's so that transport and dispersion solutions can be efficiently computed.
- Link VTHREAT with other analysis models such as health-effects models.

‹ Statistical and Dynamical Mesoscale Climate Downscaling up Numerical Systems Testing and Evaluation ›

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NUMERICAL SYSTEMS TESTING AND EVALUATION

Maintain and expand a central collaborative function within NCAR and a distributive network of collaborators for developing, testing, and validating numerical forecast systems important to operational decision makers and the international research community.

- Mesoscale Modeling Systems
- Advanced Verification Techniques and Tools
- Data Assimilation
- Tropical Cyclone
- Tailored Modeling Systems

‹ Atmospheric Transport and Dispersion of Hazardous Materials Research and Development up Mesoscale Modeling Systems ›

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MESOSCALE MODELING SYSTEMS

BACKGROUND

The Developmental Testbed Center (DTC; http://www.dtcenter.org) – a distributed facility with components in the Joint Numerical Testbed Program (JNTP; http://www.ral.ucar.edu/jnt) at NCAR's Research Applications Laboratory (RAL) and the Global Systems Division (GSD) of NOAA's Earth System Research Laboratory (ESRL) – facilitates the transfer of research results into operations and provides the research community with an easily accessible state-of-the-art Numerical Weather Prediction (NWP) system for research. At this time, the DTC's main focus is on mesoscale forecasting systems, with a goal of accelerating the rate at which new mesoscale modeling technology is infused into operational weather forecasting. The DTC meets its goals by maintaining and supporting community codes that represent the latest NWP technology, performing extensive testing and evaluation of new NWP technology, maintaining a state-of-the-art verification package, and connecting the NWP research and operational communities through its visitor program.

FY2014 ACCOMPLISHMENTS

Community Codes

Community code is a free and shared resource with distributed development and centralized support. The DTC's community code efforts are collaborative activities with developers at NCEP's Environmental Model Center (EMC), NCAR's Mesoscale and Microscale Meteorology (MMM) Division, NOAA/ESRL/GSD, NOAA's Geophysical Fluid Dynamics Laboratory, National Aeronautics and Space Administration's (NASA) Global Modeling and Assimilation Office (GMAO), the University of Rhode Island (URI), and NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) Hurricane Research Division (HRD). During 2014, the DTC worked with the following software packages:

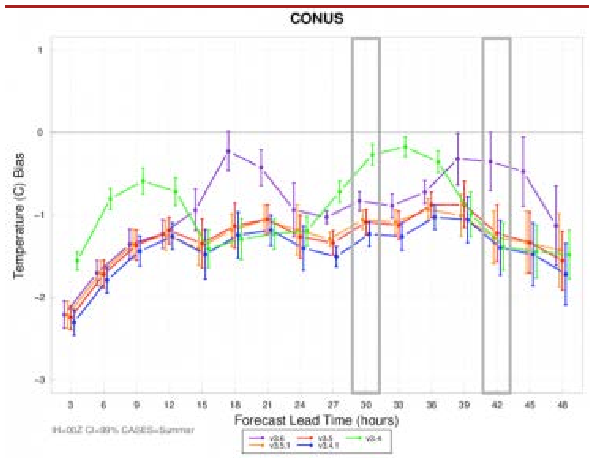

Figure 1. Time series plot of 2 m temperature (C) bias across the full CONUS domain over the warm season for WRF versions 3.4 (green), 3.4.1 (blue), 3.5 (red), 3.5.1 (orange), and v3.6 (purple). Median values of the distribution are plotted with the vertical bars representing the 99% confidence intervals. The gray boxes around forecast hour 30 and 42 correspond to the times shown in Fig. 2.

- Weather Research and Forecasting (WRF; http://wrf-model.org) – NWP model + pre- and post-processors
- WRF for Hurricanes (http://www.dtcenter.org/HurrWRF/users) – Coupled model capabilities (atmosphere and ocean) in support of tropical cyclone forecasting
- NOAA Environmental Modeling System (NEMS)
- Ensemble Kalman Filter (EnKF) DA System
- Gridpoint Statistical Interpolation (GSI; http://www.dtcenter.org/com-GSI/users) – Data Assimilation System
- Modular end-to-end ensemble system
- Model Evaluation Tools (MET; http://www.dtcenter.org/met/users) – Verification package including standard verification techniques, advanced techniques, and tools for use with tropical cyclone verification (MET-TC)

The DTC contributes to the software management of all of these systems and provides user support for the publicly-

released systems (WRF, HWRF, GSI and MET), which include the latest developments of new capabilities and techniques. Prior to each official release of software to the user community, the DTC ensures the integrity of all community code software components through a broad range of testing. The DTC also strives for system evolution, in particular through increased interoperability of existing system components, as well as adding new capabilities or techniques. In addition, the DTC provides user support for these packages in the form of Users' Guides, webpages, email helpdesks, and online and on–site tutorials.

Testing and Evaluation

The DTC provides a trusted facility that developers and the operational community can rely on for unbiased assessments of the operational prediction systems and potential new additions to those systems. Testing and evaluation undertaken by the developers of new NWP techniques from the research community are generally focused on case studies. However, in order to adequately assess these new technologies, extensive testing and evaluation must be performed to ensure they are indeed ready for operational consideration. Testing and evaluation by the DTC focuses on either extended retrospective time periods or real–time forecast experiments. These forecasts can be generated by the DTC or provided by external modeling groups. The DTC's evaluations include use of standard verification techniques, as well as new verification techniques in some cases. All verification statistics include a statistical significance (SS) and practical significance (PS) assessment when appropriate.

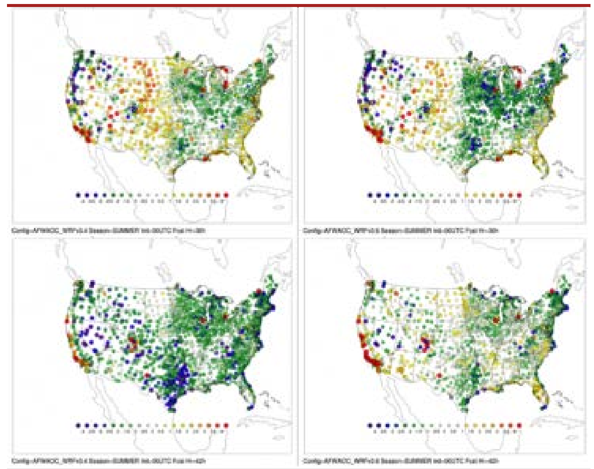

Figure 2. Average 2 m temperature (C) bias by observation station over the warm season for WRF version 3.4 (left) and 3.6 (right) at forecast hour 30 (top) and 42 (bottom).

Two mesoscale NWP systems utilized in both research and operational forecasting applications around the world include the Weather Research and Forecasting (WRF) model and the NOAA Environmental Modeling System (NEMS). Due to the increasing number of approaches developed in the NWP research community, it is necessary to rigorously test select techniques and evaluate the performance for specific applications to assess their contributions. During 2014, the DTC performed evaluations for a variety of testing activities including model inter-comparisons and stand-alone “Reference Configurations (RCs)”. Results associated with model inter-comparisons can be accessed on the DTC website at http://www.dtcenter.org/eval and RC results can be found at http://www.dtcenter.org/config. Information distributed on each website includes a description of the model configuration and the extensive testing that was performed. An executive summary of the results is provided, along with the full set of verification plots, which include additional spatial and temporal breakdowns.

Comprehensive test and evaluation activities performed during 2014 included:

- WRF v3.5.1 (see: http://www.dtcenter.org/eval/meso_mod/afwa_test/wrf_v3.5.1) in a functionally similar environment to Air Force Weather Agency (AFWA) operations, including a 6-hour "warm-start" spin up and data assimilation. Impacts when substituting AFWA’s current operational land surface scheme (Noah LSM) with the Noah scheme with multi-parameterization options (Noah-MP LSM; Niu et al. 2011) were assessed for one full year.

- WRF (v3.4, v3.4.1, v3.5, v3.5.1, v3.6) (see: http://www.dtcenter.org/eval/meso_mod/version_tne) version testing for one particular configuration of the Advanced Research WRF (ARW) dynamic core to monitor forecast performance through time. The testing spanned a warm season and a cold season to capture the model performance over a variety of weather regimes. (See Figs. 1 and 2)

Mesoscale Model Evaluation Testbed

To assist the research community with detailed case study testing of newly developed techniques, the DTC has established and is maintaining the Mesoscale Model Evaluation Testbed (MMET; http://www.dtcenter.org/eval/meso_mod/mmet). The motivation of MMET is to assist the research community to efficiently demonstrate the merits of a new model development or capability that could positively impact an operational configuration in the future.

MMET provides a variety of initialization and observation data sets for a number of routine, high-impact and field campaign cases. Baseline results for select operational configurations are also produced by the DTC in a functionally similar environment to operations and made available through MMET. Through the common framework provided by MMET, researchers have the ability to perform direct comparisons between multiple innovations tested by the research community

and/or against the baseline operational configurations established by the DTC.

During the summer of 2014, the DTC hosted a Significant Opportunities in Atmospheric Research and Science (SOARS) protégé to work with one particular MMET case, test several different physics schemes at different horizontal grid spacing's, and evaluate the sensitivities of those configurations. Researchers are also encouraged to work with MMET through the DTC Visitor Program (http://www.dtcenter.org/visitors/), which can provide selected candidates with financial and computation resources for their approved projects.

Another goal of MMET is to support the broader goal of streamlining the path to potential operational use for promising new science innovations developed in the research community. A testing protocol document detailing a three-stage process of testing conducted by the research community, DTC and, ultimately, operational centers, discusses the research to operations (R2O) process further. It is believed that, with better coordination among the NWP community as a whole, major benefits towards improving model physics can be realized, resulting in more accurate and reliable operational NWP forecasts.

FY2015 PLANS

In the coming year, the DTC will continue to support various community codes, including the WRF model and post–processor, coupled model capabilities, MET, and GSI. The DTC will also help organize and support tutorials on the community codes that it supports, related to mesoscale models, data assimilation, hurricanes, and forecast verification. Relevant workshops will be offered to stimulate discussion among the research and operational modeling communities on future directions of development.

While the DTC will continue WRF-based T&E activities for the foreseeable future in the context of RCs, WRF for hurricanes, and various ensemble configurations, it has become necessary to broaden the scope of internal T&E activities to include new software frameworks (e.g., NEMS) utilized by the relevant operational centers (e.g., NOAA). This effort is vital for the DTC to continue to serve as a bridge between research and operations, and work is on-going on this front.

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ADVANCED VERIFICATION TECHNIQUES AND TOOLS

BACKGROUND

Forecast verification and evaluation activities typically are based on relatively simple metrics that measure the meteorological performance of forecasts and forecasting systems. Metrics such as the Probability of Detection, Root Mean Squared Error, and Equitable Threat Score provide information that is useful for monitoring changes in performance of single aspects of forecast performance with time. However, they generally do not provide information that can be used to improve forecasts, or that can be helpful for making decisions. Moreover, it is possible for high quality forecasts– such as high-resolution forecasts – to have very poor scores when evaluated using these standard metrics, while poorer quality forecasts may score higher. In response to these limitations, the RAL Verification Group develops improved verification approaches and tools that provide more meaningful and relevant information about forecast performance. The focus of this effort is on diagnostic, statistically valid approaches, including feature–based evaluation of precipitation and convective forecasts, and distribution–based approaches that can provide more meaningful information (for forecast developers as well as forecast users) about forecast performance. In addition, the RAL Verification Group develops forecast evaluation tools that are available for use by members of the operational, model development, and research communities. Development and dissemination of new forecast verification approaches requires research and application in several areas, including statistical methods, exploratory data analysis, statistical inference, pattern recognition, and evaluation of user needs.

FY2014 ACCOMPLISHMENTS

Spatial verification methods and the spatial method inter–comparison project

The initial forecast verification methods intercomparison project focused on comparing the capabilities of newly developed spatial forecast verification methods. That project was completed in 2011 and resulted in a special collection of articles in the journal *Weather and Forecasting.* A second intercomparison project, developed in partnership with international collaborators, has been implemented and is known as the Mesoscale Verification Intercomparison in Complex Terrain (MesoVICT; http://www.ral.ucar.edu/projects/icp/). Detailed MetoVICT planning took place at the European Meteorological Society annual meeting in September 2013, and a recent kick-off meeting took place in Vienna, Austria on 2 – 3 October 2014. The meeting was well attended by key researchers and operational forecasts from various centers/institutions in Europe, as well as Russia and China. The cases for this project include more complex terrain and wind verification. Most of the test cases are already available, and are described along with the goals of the project in an NCAR Technical Note: https://opensky.library.ucar.edu/collections/TECH-NOTE-000-000-000-874.

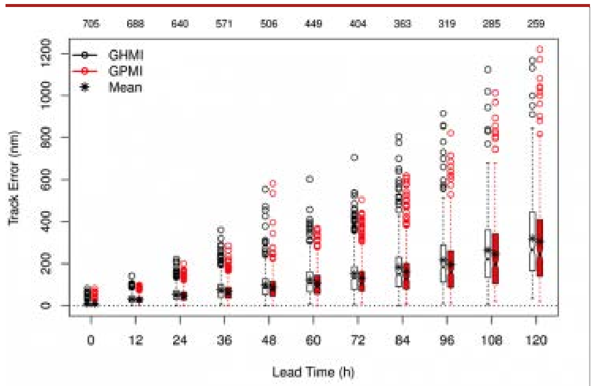

Figure 1: Boxplots of Hurricane Forecast Track Error by forecast lead time for two numerical model forecasts.

To simplify the use of many of the spatial verification methods for the MesoVICT and other efforts, the RAL verification group has developed a spatial verification methods package in the R programming language (SpatialVx; http://www.ral.ucar.edu/projects/icp/SpatialVx/), which continues to be developed. The package currently includes considerable functionality for features-based verification, neighborhood methods, kernel smoothers, and many other statistical and image-based verification approaches.

The extension of object–based and other spatial verification approaches is in progress and will continue into the next fiscal year. Fields other than precipitation have been examined with promising results.

The Method for Object-based Diagnostic Evaluation (MODE) tool has been extended to include the time dimension and

The Model Evaluation Tools (MET)

The Model Evaluation Tools (MET) (http://www.dtcenter.org/met/users/) is a freely available software package for forecast evaluation that was developed and is supported by RAL/JNT staff. MET Version 5.0 was released to the community in September 2014 and Version 5.2 will be released during summer 2015. Currently MET has more than 2550 registered users, with about half of them from the university community. MET Version 5.0 contains many enhancements, including the autoconf capability to make configuring and compiling MET easier, fourteen new statistics, and enhanced capability for MET-TC (the MET Tropical Cyclone forecast verification package), including a more flexible definition of rapid intensification and weakening of storms and the use of a global distance to land dataset The METViewer system, a capability for storing MET verification statistics in a database and analyzing and displaying the results, was redesigned and released as Version 1.0 in September. The new interface has created increased interest in both MET and METViewer. METViewer plots are highly configurable, based on MET or other verification results contained in a database. METViewer is used by the Developmental Testbed Center (DTC) for testing and evaluation activities, and has also been installed at the NWS's National Centers for Environmental Prediction (NCEP).   In preparation for the next release, development has focused on reading in diagnostic files from the Gridpoint Statistical Interpolation (GSI) data assimilation system, development of an automated regridding capability, and innovative application of MET's masking capability to evaluate rainfall forecasts and related 5-day accumulated swaths from the Hurricane WRF modeling system. MODE-Time Domain is also under development for use across all temporal and spatial scales, ranging from climate data (e.g., areas of drought) to convective supercells. This extension of MODE will be implemented in a future release of MET.

A new application of MODE is in the evaluation of ensemble and probabilistic forecasts. As an example, an investigation was performed to look at how to evaluate an ensemble of MODE precipitation objects and attributes diagnosed from individual ensemble members. By evaluating the individual members and looking at a compilation of all MODE objects identified in each solution it is evident that a simple ensemble mean may not be the best way to provide a single-value solution. Figure 2 shows an example of an ensemble of MODE objects utilized for testing performed in the DTC. In this figure the thick black lines represent the ensemble means. It should be noted that an ensemble mean was calculated for only three of the five areas of observed precipitation. The ensemble mean would not have alerted the user to the possibility of rain over the upper peninsula of Michigan or off the coast of Georgia and South Carolina. This method of evaluating ensembles will be explored further during the coming year.

A new approach to testing (univariate) forecast predictive accuracy

Two new techniques have been proposed by the RAL verification group in a recently accepted paper by Gilleland and Roux to *Meteorological Applications* (Gilleland and Roux 2014). One is a prediction comparison test first introduced in a seminal paper in the economics literature by Diebold and Mariano (1995); the so-called Diebold-Mariano (DM) test. The test directly accounts for temporal correlation in order to obtain accurate standard errors, or subsequently confidence intervals, for the differences in loss functions (when compared to the same observation). A recent paper by Hering and Genton (2011), who introduced a modification of the procedure (which is also adopted in the RAL paper by Gilleland and Roux (2014)), also established that the test is robust to contemporaneous correlation (i.e., if the two forecasts are correlated with each other).

In addition to the application of the DM test, Gilleland and Roux employ dynamical time warping (DTW) in order to adjust and account for timing errors in the test procedure. The DTW method can also be used in conjunction with the DM test. These procedures are univariate analogues to the spatial prediction comparison test and image warping procedures that have also been previously proposed by the RAL verification group.

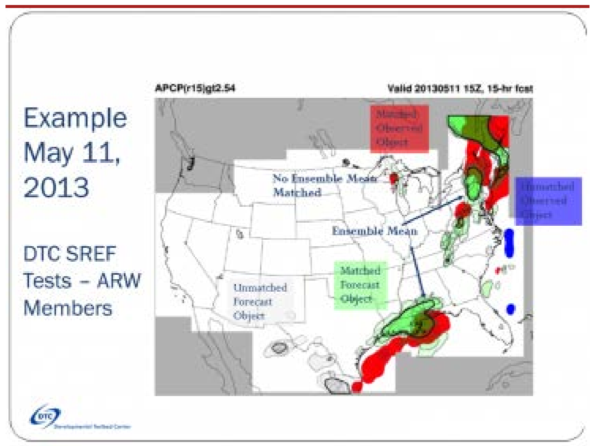

Figure 2. Example of use of MODE to diagnose objects from a precipitation field based on seven members of an ensemble. The mean field was computed using the Ensemble Stat tool in MET. If a mean object was matched, it is shown by the thick black line. Matched forecast objects are shown in green, matched observed objects are in red. Unmatched forecast objects are gray and unmatched observed object are in blue.

Evaluating revised forecasts

It is desirable for revised forecasts, which are particularly important in the context of severe weather events such as hurricanes or high wind days, to be consistent. It is hoped, of course, that a forecast revision

reflects new and improved information so that the resulting forecast will be better than earlier forecasts with longer lead times. However, if the forecasts are not consistent (e.g., they change radically as they are updated), then users may lose trust in them, which is especially crucial for decision makers who create plans based on early forecasts (e.g., emergency managers), and may need to change those plans depending on the revised forecast. The verification team prepared a report on consistency measures of forecast revision time series (e.g., Figure 3), along with various extensions to the methods to more complex forecasts, using examples from hurricane forecast tracks and accumulations of multiple time series for the *Mausam* Special Issue on Forecast Verification. The paper also gives much detail on consistency scores for competing forecasts (Fowler et al. 2014).

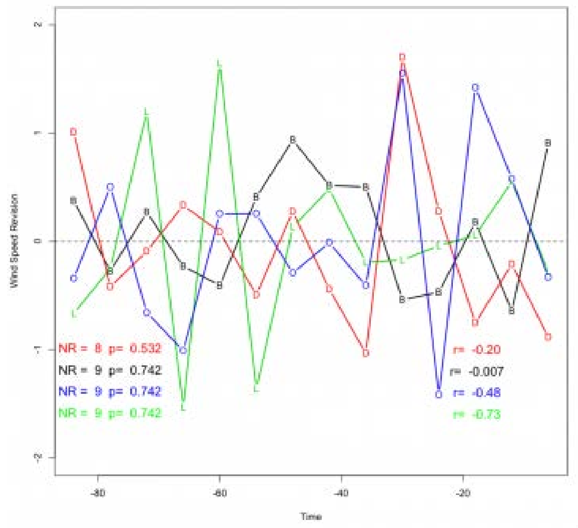

Figure 3: Revision series for surface wind speed forecasts in Boston (B), Denver (D), Chicago (O), and Los Angeles (L). Autocorrelation values (r) and number of runs (NR) along with associated p-values (p) are noted on the figure. Time is listed in hours prior to the event time.

Information contained in the paper includes diagnostic tools (e.g., Figure 4) as well as comparisons with a reference forecast in order to acquire knowledge about relative uncertainty, consistency and magnitude.

FY2015 PLANS

The MET release in 2015 will include updated tropical cyclone verification capability, new data formats, and enhanced cloud and ensemble verification methods. The capability to handle additional satellite observations will also be included in a future MET release. Further research on appropriate methods for evaluating forecasts through time will be conducted and included in a later MET software release if appropriate. Further, the object time tracking extension to MODE will be made operational and included in the next release of MET. Experimental use of MODE on fields other than precipitation will continue. The METViewer software GUI redesign will be completed, to increase usability and user friendliness.

Implementation of MesoVICT will be a major focus, in collaboration with international members of the verification community. The image warping and MODE tools will be included in this project, along with a host of other methods included in the SpatialVx package.

Only three primary methods remain to be added to SpatialVx: (i) contiguous rain area (CRA), (ii) image warping and (iii) displacement amplitude score (DAS). It is hoped to have the basic package completed in the next year or two along with documentation.

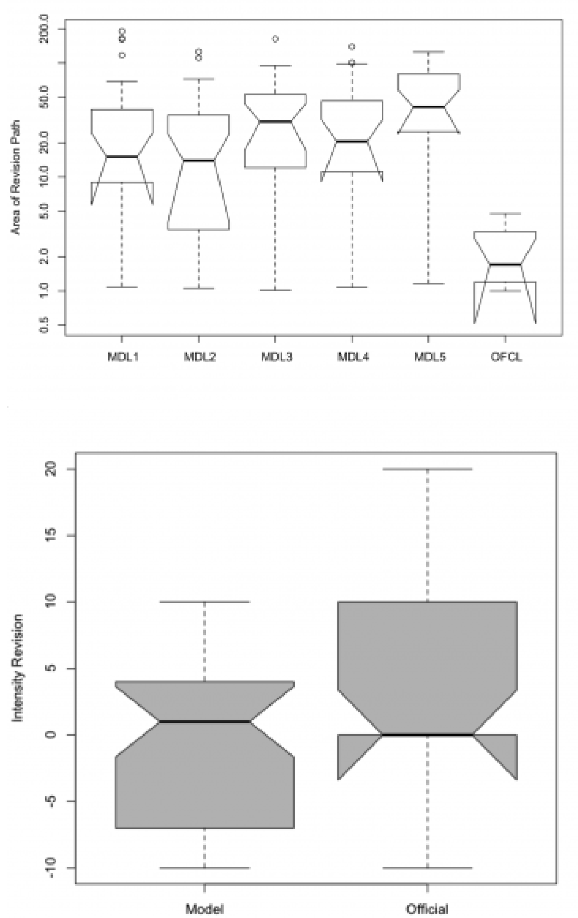

Figure 4: Boxplots showing (top) areas of the revision series paths and (bottom) distributions of intensity revision values from different sources of tropical cyclone forecasts.

References

Diebold FX and Mariano RS. 1995. Comparing predictive accuracy. *J. Bus. Econ. Stat*., **13**, 253—263.

Fowler, T.L., B.G. Brown, J. Halley Gotway, and P. Kucera, 2014: Spare Change: Evaluating revised forecasts. Accepted, *Mausum*.

Gilleland, E., 2013. Testing competing precipitation forecasts accurately and efficiently: The spatial prediction comparison test. *Mon. Wea. Rev*., **141**, 340 - 355, http://dx.doi.org/10.1175/MWR-D-12-00155.1.

Gilleland, E. and G. Roux, 2014. A New Approach to Testing Forecast Predictive Accuracy. *Meteorol. Appl*., in press.

Hering AS and Genton MG. 2011. Comparing spatial predictions. *Technometrics*, **53**, 414—425.

‹ Mesoscale Modeling Systems up Data Assimilation ›

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2014 RAL ANNUAL REPORT

- Director's Message
- Table of Contents
- Next Generation Air Transportation
- New and Emerging Applications
- National Security Applications
- Numerical Systems Testing and Evaluation
  - Mesoscale Modeling Systems
  - Advanced Verification Techniques and Tools
  - Data Assimilation
  - Tropical Cyclone
  - Tailored Modeling Systems
- Hydrometeorological Applications
- Climate, Weather and Society

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- RAL Strategic Plan

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DATA ASSIMILATION

BACKGROUND

The goal of the Data Assimilation Team (DAT) is to provide a pathway between the data assimilation research and operational communities to help accelerate transitions from research to operations. Working closely with research and operational centers [e.g., the NOAA National Centers for Environmental Prediction (NCEP)], the DAT builds and maintains a code management framework for distributed development of new capabilities and advances in data assimilation. Under the same code management plan applied to both the operational and research communities, the DAT provides operational data assimilation capabilities to the research community in a timely manner, with complete user support and annual training opportunities. By setting up a functionally similar operational environment, the DAT conducts testing and evaluation of state-of-the-art data assimilation techniques and therefore provides a rational basis for enhancement of data assimilation techniques and systems; and, eventually, improvement of numerical weather forecasts and analyses. Much of this works is done under the auspices of the Developmental Testbed Center (DTC).

FY2014 ACCOMPLISHMENTS

Code Management and Community Support

The DAT currently maintains and supports a version of the Gridpoint Statistical Interpolation (GSI) data assimilation (DA) system with community features (http://www.dtcenter.org/com-GSI/users/index.php). The GSI system is an operational data assimilation system used for various forecasting and analysis systems and applications. As NCEP and other operational centers are moving forward to apply hybrid ensemble-variational techniques to their operational forecasts, the DTC is working to transition the NOAA Ensemble Kalman Filter system (EnKF) into a community DA system. Working with code developers, the DAT set up an EnKF code management framework following the protocol used for the GSI effort. Both the EnKF and GSI code are managed under the same code repository and reviewed by a joint EnKF/GSI Review Committee. The DTC continued to be responsible for maintaining the code management plans, coordinating code development, and organizing code review activities. The DAT continued to provide code releases and community support. In a joint effort with NCEP and other code developers, the DAT released the GSI community code in June, 2014 and hosted the Annual GSI tutorial at NCAR in July 2014.

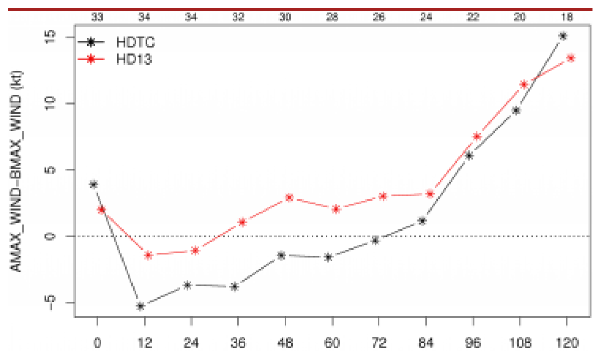

Figure 1. Mean errors of the maximum wind speed from the DTC HWRF-GSI-hybrid runs using the HWRF 2014 (black) and HWRF 2013 (red) operational systems.

Testing and Evaluation

Since FY2013, the DAT has focused on two major activities: GSI-based hybrid variational and ensemble (GSI-hybrid) tests for the hurricane WRF (HWRF) modeling system and GSI 3D-Var tests for the Air Force Weather Agency (AFWA). Both activities were geared toward providing further diagnostics for the operational systems. The DAT also has ongoing efforts to evaluate the impacts of new data types for the AFWA GSI system. These tests provided a good evaluation of the GSI/GSI-hybrid system by applying GSI in regional areas outside the U.S. domain, which is the primary domain for most regional GSI applications

	D01 (27km)	Ghost_d02 (9km)	Ghost_d03(3km)
HWRF 2014	GFS analysis	166x336 (20°x20°) Conventional, satellite radiance, satellite wind, GPS RO, TDR	250x500 (10°x10°) Conventional and TDR
HWRF 2013	Conventional data (including TC Vital)	No DA (initial conditions for d02 from ghost_d03)	529x988 (20°x20°) Conventional and TDR

at NOAA. Such evaluations are valuable to general researchers and users, in addition to the specific sponsors.

Table 1. Data assimilation configurations for the HWRF 2013 and 2014 operational systems.

DAT 2014 testing and evaluation (T&E) activities related to the application of the GSI-hybrid system are focused on diagnostics for the Hurricane WRF (HWRF) 2014 GSI-hybrid system spin-down issue and investigation of the current two-way GSI-hybrid capabilities. The DAT was able to “reproduce” the HWRF pre-implementation results and selected Hurricane Irene (2011) as an example for more detailed study. Figure 1 shows the mean intensity errors from the HWRF-GSI-hybrid runs using the HWRF 2013 and 2014 operational systems. While both systems experienced vortex spin-down during the first 12 hours, the spin down produced by the HWRF 2014 system was much larger. Table 1 summarizes the differences between the DA aspects of the 2013 and 2014 HWRF systems. Note that the differences between these two systems also include changes to the vortex initialization and the coupled modeling system itself.

The DTC conducted a series of experiments (summarized in Figure 2 and Table 2 below) for Hurricane Irene (2011), using the HWRF 2013 and HWRF 2014 systems, respectively, to isolate the component(s) contributing to the spin-down behavior. Table 2 summarizes the mean intensity and track errors for these configurations:

HWRF 2013	HWRF 2014	Vortex Initialization	DA
HD13	HDTC	Yes	Yes
HG13	HGFS	No	No
NG13	NGSI	Yes	No
HN13	HNVI	No	Yes

Table 2 Description of experiments conducted for Hurricane Irene (2011) conducted using HWRF 2013 and 2014 systems to isolate impact of components the overall initialization system.

- HWRF 2013 runs (HD13, HG13, NG13, HN13) generated track forecast errors that were smaller than those associated with the HWRF 2014 runs (HDTC, HGFS, NGSI, HNVI).
- The full configuration runs (HD13 and HDTC) show spin-down issues regardless of the version (2013 or 2014), but the spin-down issue is more prevalent in the 2014 system (HDTC) than the 2013 system (HD13).
- The no data assimilation runs (NGSI and NG13) produced positive but relatively small (< 5 kts) intensity errors for the first 60 hours of the forecasts, indicating the vortex initialization works reasonably well for this case.
- The no vortex initialization runs (HGFS, HNVI, HG13 and HN13) generated a much weaker storm at analysis time compared with the vortex initialization runs (NGSI, NG13) and the full configuration runs (HDTC, HD13). This trend points to a possible deficiency in the data assimilation (either on the global or regional scales) for this case study. Such a deficiency could be the result of insufficient representation of the background errors in the inner core of the storm. Currently, the GFS and HWRF data assimilation systems use GFS ensembles (on an ~45 km horizontal scale), which dominates the generation of the background errors in the GSI-hybrid DA system for the inner domain.
- The spin-down behavior is only present when both the vortex initialization and data assimilation are turned on, pointing to the conclusion that the spin-down behavior stems from an imbalance between the vortex initialization and the DA steps.

Further experiments are being conducted to investigate the underlying causes of the deficiencies in the DA procedure for the HWRF system and the imbalance between the vortex initialization and DA steps.

The DAT AFWA GSI tests focus on in-house mitigation and new data type impact studies. The tests conducted at the DAT were aligned with the AFWA real-time parallel GSI runs. While the AFWA runs focused on evaluating the overall performance of GSI, the DAT tests focused on testing incremental changes. The DAT configured a functionally similar testing environment to the AFWA pre-operational configuration (POC) and the testing components were selected based on the ongoing testing results and consultation with AFWA. Results from the tests will be provided to AFWA at the end of the fiscal year.

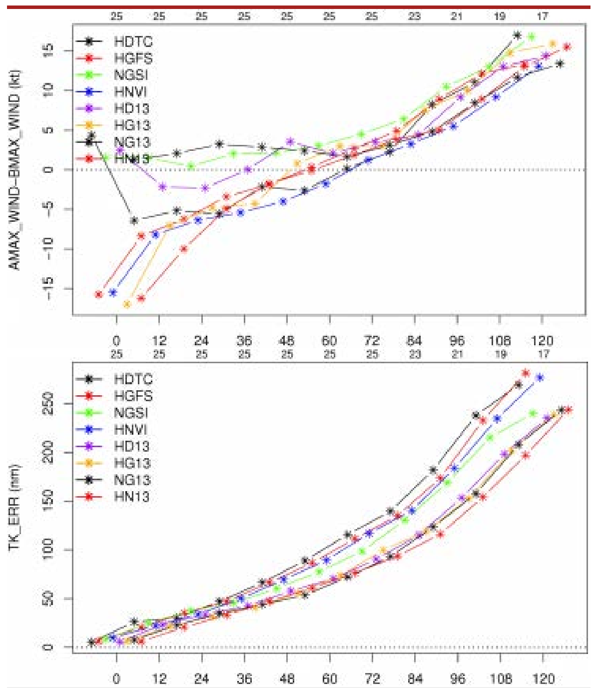

Figure 2. Mean errors of the maximum wind speed (upper panel) and mean track errors for the DTC HWRF-GSI-hybrid runs using the HWRF 2014 and 2013 operational systems. Specific experiments are listed in Table 2.

FY2015 PLANS

The DAT will continue its GSI and EnKF code management and community support efforts to facilitate the transitions from research to operations. The DAT also plans to continue testing of the GSI data assimilation system (coupled with EnKF as in the GSI-hybrid system) in applications that are relevant for sponsors and the research community to ensure the integrity and robustness of the data assimilation techniques and systems. The DAT will also continue to investigate the latest hybrid technique in regional applications in higher resolution and vortex scales.

‹ Advanced Verification Techniques and Tools up Tropical Cyclone ›

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Search
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2014 RAL ANNUAL REPORT

- Director's Message
- Table of Contents
- Next Generation Air Transportation
- New and Emerging Applications
- National Security Applications
- Numerical Systems Testing and Evaluation
  - Mesoscale Modeling Systems
  - Advanced Verification Techniques and Tools
  - Data Assimilation
  - Tropical Cyclone
  - Tailored Modeling Systems
- Hydrometeorological Applications
- Climate, Weather and Society

2014 NCAR ANNUAL REPORT

2014 LAB ANNUAL REPORTS

- Advanced Study Program
- Computational & Information Systems Laboratory
- Earth Observing Laboratory
- High Altitude Observatory
- National Center for Atmospheric Research
- NCAR Earth System Laboratory
- Research Applications Laboratory

STRATEGIC PLANS

- RAL Strategic Plan

TROPICAL CYCLONE

BACKGROUND

The focus of the JNTP's Tropical Cyclone Modeling Team (TCMT) is evaluation of experimental models for tropical cyclone forecasting (http://www.ral.ucar.edu/jnt/tcmt/) and support for the National Weather Service (NWS) operational hurricane model (the Hurricane WRF, HWRF) in facilitating transitions from research to operations. The primary sponsors of this work are NOAA's Hurricane Forecast Improvement Project (HFIP; http://www.hfip.org/) and the NOAA Office of Atmospheric and Oceanic Research (OAR).

The goals of HFIP are to improve the accuracy and reliability of hurricane forecasts; to extend the lead time for hurricane forecasts with increased certainty; and to increase confidence in hurricane forecasts. Achieving these goals requires major investments in enhanced observational strategies, improved data assimilation and numerical weather prediction (NWP) systems, and expanded forecast applications based on high resolution and ensemble-based NWP systems. HFIP's modeling efforts are organized into three development paths. Stream 1 refers to the yearly upgrades made to operational NWP capabilities, Stream 2 refers to efforts that require multiple years to enhance operations, and Stream 1.5 refers to improved models and/or techniques that the National Hurricane Center (NHC), based on prior assessments, wants to access in real-time during a particular hurricane season but that cannot be made available by the operational modeling centers in a conventional production mode. During each hurricane season, HFIP conducts an experiment, referred to as the Demonstration (Demo) Evaluation, which attempts to demonstrate model capabilities that go well beyond the current capabilities of the operational global and regional models. In addition, a Retrospective Evaluation is conducted during the pre-hurricane season for modeling systems that wish to be considered for inclusion in Stream 1.5 during the upcoming Demo.

JNTP/TCMT staff affiliated with the Developmental Testbed Center (DTC) work closely with the NCEP's Environmental Modeling Center (EMC) to support the HWRF forecast system to the research community and test new capabilities coming from the research community to determine their potential for improving the forecast skill of HWRF. The goals of this work are to accelerate the improvement in TC forecasts by providing a more timely mechanism for transitioning research into operations, and through extensive testing of new capabilities to determine their impacts on operational predictions.

FY2014 ACCOMPLISHMENTS

Experimental Forecasts

During FY2014 the TCMT (i) led the planning and evaluation of HFIP's 2014 Stream 1.5 Retrospective evaluation, (ii) enhanced the near real-time multi-model ensemble forecast and display system (http://www.ral.ucar.edu/projects/hfip/d2014/forecasts/) and (iii) provided participants with near-real-time statistical evaluations of the experimental hurricane forecast models that were included in the 2014 HFIP Forecast Demonstration (http://www.ral.ucar.edu/projects/hfip/d2014/verify/). TCMT staff also continued development of the HFIP Real-time Display System (http://www.hfip.org/products) and ongoing efforts of the HFIP data service, which provides data archival and dissemination of TC forecasts from the Demo, and retrospective analyses. The service uses RAMADDA (Repository for Archiving, Managing and Accessing Diverse DAta) to provide HFIP scientists access to hurricane track and intensity (Tier 1) forecasts and diagnostics products that are available at: https://verif.rap.ucar.edu/repository.

A specific testing and evaluation methodology was developed for the evaluation of the 2014 Stream 1.5 candidate models. This methodology includes evaluation of the uncertainty in verification measures through confidence intervals and paired statistical tests. This evaluation protocol ensures that a consistent set of results is obtained, which makes it possible to fairly evaluate and compare the performance of the forecasts from the various models. Each Stream 1.5 candidate was

evaluated based on three basic criteria: (i) performance relative to each of the 2013 top-flight operational models, (ii) performance relative to the top-flight operational models as a group, and (iii) impact on the performance of the model consensus guidance. Figure 1 shows an example of the results from the evaluation of the HWRF ensemble mean (HWMI) compared to the ECMWF baseline (HWMI-red, baseline-black) and mean pairwise differences (blue) with 95% confidence intervals. A detailed report for each candidate model provides summary results of the evaluations. These reports, which were provided to NHC and the HFIP Project Office, were used to make decisions regarding which model predictions would be designated as Stream 1.5 forecasts, and demonstrated to NHC forecasters during the 2014 hurricane season.

Information on the methodology, cases, participating modeling groups, verification results and reports is available on the TCMT 2014 Retrospective Testing website (http://www.ral.ucar.edu/projects/hfip/h2014/).

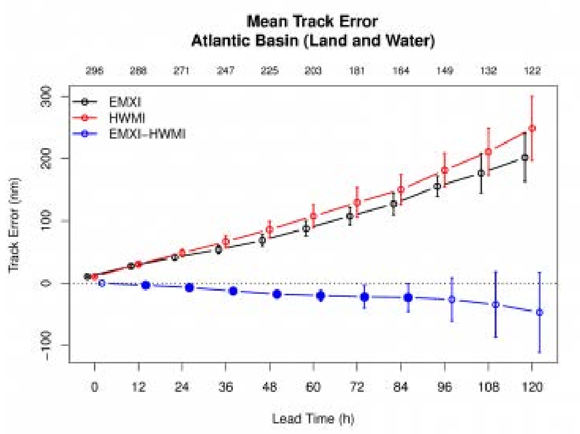


Fig. 1: Example plot of mean track errors of HWRF (HWMI-red) and the ECMWF baseline (EMXI-black) and mean pairwise differences (blue) with 95% confidence intervals for the 2014 Stream 1.5 evaluation.

During the past year, the TCMT also conducted an evaluation of a specific set of retrospective forecasts to provide an assessment of the impacts of both standard aircraft reconnaissance data and tail Doppler radar (TDR) data on the skill of hurricane forecasting systems. Each of three modeling groups provided a control forecast for which their data assimilation system did not ingest any aircraft reconnaissance data as well as retrospective forecasts for at least two additional configurations (i.e., one configuration in which only standard aircraft reconnaissance data were assimilated and a second configuration in which both standard aircraft reconnaissance data and TDR data were assimilated). The results from this study have been published as an NCAR Technical Note (http://opensky.library.ucar.edu/collections/TECH-NOTE-000-000-000-881).

The TCMT has developed a multi-model ensemble forecast product for the 2014 HFIP Demonstration. Three different ensemble forecasts were assembled: (i) Stream 1.5 forecasts only; (ii) Stream 1.5 and 2 forecasts; and (iii) all available forecasts (Stream 1.5, Stream 2, operational models). The TCMT's real-time display system was updated with improved graphics and data ingest capabilities for the 2014 Demo. The real-time system includes track, intensity, and ellipse products of forecast tracks for the three sets of forecasts, along with best track and official NHC forecasts. A new product was added for the 2014 Demo season called a revision series analysis. The revision series provide a measure of the temporal consistency of a track forecast for a given valid time. An example of the revision series product for Hurricane Odile, which formed in the Eastern Pacific, is shown in Fig. 2. All of the products are archived and made available on the TCMT Real-time website (http://www.ral.ucar.edu/projects/hfip/d2014/forecasts/).

Fig. 2: Example revision series plot for the HWRF (HWFI) for Hurricane in Eastern Pacific Ocean for the period 12 UTC 10 September – 12 UTC 17 September 2014.

Evaluations of the HFIP Stream 1, 1.5, and 2 model forecasts were produced by TCMT as part of the 2014 Demo, with results updated once per day throughout the Demo experimental period (Aug 1 – Oct 31). The graphical user interface displaying the evaluation results can be accessed through the TCMT 2014 Demo website (http://www.ral.ucar.edu/projects/hfip/d2014/verify/). The HFIP Demo verification focuses on track and intensity errors using the same methodologies applied in the retrospective analyses. The methodology includes interpolating late model forecasts, use of the MET-TC software to compute errors, use of homogeneous samples for model comarisons, and assessment of error distributions and statistical significance when applicable. Figure 3 shows an example of mean intensity skill scores computed for the experimental models for the Atlantic and Eastern Pacific Basins for storms observed during the 2014 Demo.

A prototype diagnostic hurricane display system for NHC has been developed in Java using a MySQL database and OpenLayers maps. The NHC Display tool will have the ability to plot tracks for combinations of one or more hurricane forecast models and one or more model initialization times. The user may select different options for plotting tracks – for example, color coding by the model id or by the model initialization time. An example display from this system is shown in Fig.

4.

Developmental Testbed Center

During FY2014, the DTC's Hurricane team conducted an extensive test of the impact of replacing HWRF's operational microphysics and radiation schemes with the Thompson microphysics scheme coupled to the RRTMG (Rapid Radiative Transfer Model for GCMs) radiation scheme. Retrospective forecasts for the 2012 Atlantic (AL) and eastern North Pacific (EP) basin Hurricane seasons pointed to mixed results. For the AL basin, the experimental configuration produced statistically significant (SS) improvements for track and intensity for lead times beyond 60 h, but SS degradations for intensity at shorter lead times. Conversely, for the EP basin, the experimental configuration produced SS degradations for both track and intensity. The intensity error differences, at least in part, stem from the experimental configuration producing weaker storms at longer lead times (see Fig. 5). For the AL basin, this change in intensity results in a smaller intensity bias for the experimental configuration, whereas, for the EP basin, this change results in a larger under-prediction bias.

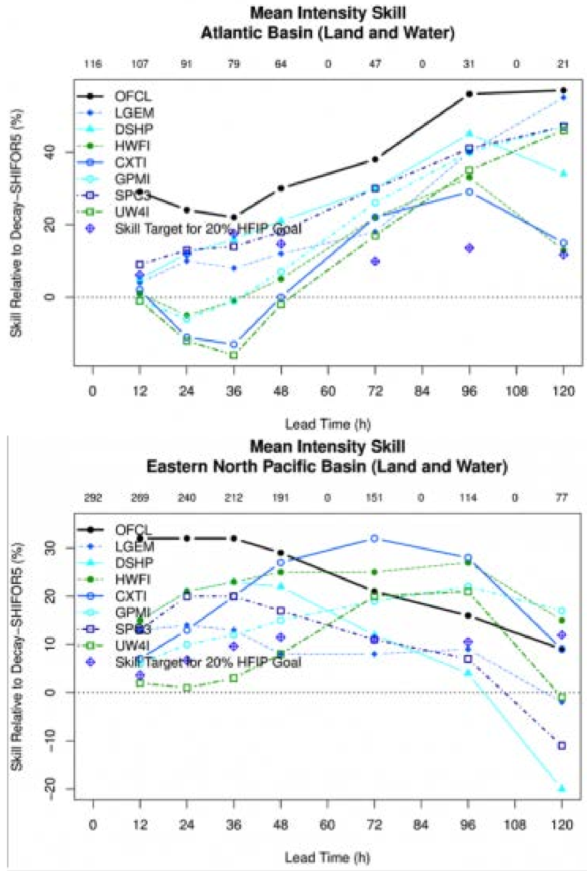
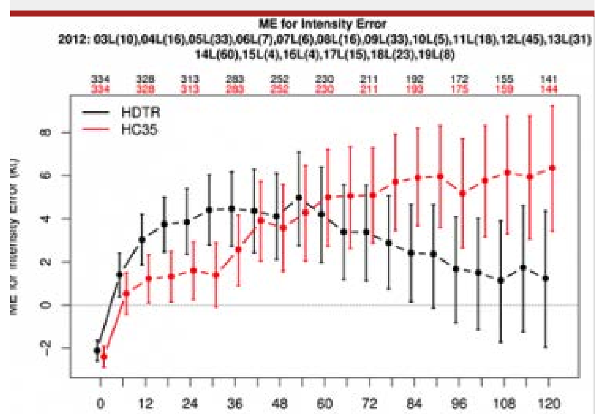


Fig 3: Intensity skill score with lead time for a homogeneous Atlantic Basin (top panel) and Eastern Pacific Basin (bottom panel) sample which includes Stream 1 and 1.5 model configurations.

NHC Display prototype

Fig. 4. Example NHC display system showing hurricane forecast tracks in an interactive open layer map display system.



In addition to looking at standard TC metrics, the Hurricane team considered differences in the forecasted large-scale environment characteristics and the precipitation forecasts. This analysis revealed a drier environment for the experimental configuration over the ocean, whereas the temperature mean errors revealed a warmer environment throughout the domain. A preliminary investigation of the storm environment indicated a drier environment in the EP basin at longer lead times in the experimental configuration, putting the storm in an unfavorable environment for further intensification. An extensive precipitation evaluation for Hurricane Sandy using the Tropical Rainfall Measuring Mission (TRMM) 3B42 product indicated both HWRF configurations over-predicted precipitation and the magnitude of the over-prediction increased as the focus moved from the parent domain to the storm-relative domain. While both configurations over-predicted the amounts of precipitation, the frequency bias was consistently higher for the experimental configuration. Further investigation of these runs by the DTC revealed inconsistent handling of sub-grid scale clouds between the two radiation schemes tested.

Work is underway to connect the SAS convection scheme with the RRTMG radiation scheme to verify the hypothesis that the lack of any sub-grid scale feedback from the SAS scheme led to degraded performance of the Thompson/RRTMG configuration. This work has the potential to impact the 2015 HWRF implementation process as EMC plans to once again test the RRTMG scheme for its 2015 upgrades.

FY2015 PLANS

Experimental forecasts

In FY2015, tropical cyclone track and intensity forecasts collected during the HFIP 2014 Demo will be evaluated using consistent tools and approaches for all models. An evaluation of the hurricane forecasts for the first five year of the HFIP program will be conducted. Retrospective

model testing and evaluation will be undertaken once again, in collaboration with NHC and a variety of research and operational modeling groups. The real-time monitoring system will continue to be enhanced with additional display graphics and evaluation products. The tropical cyclone database will continue to be enhanced with additional datasets of track and intensity, diagnostic products, and gridded fields. The NHC display and diagnostic system will continue to be enhanced and will be implemented at NHC before the 2015 hurricane season.

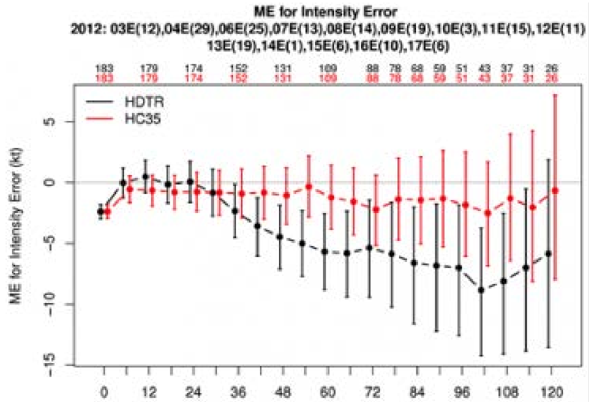


Figure 5. Intensity bias verification results for the control (red) and experimental (black) configurations of HWRF averaged over the entire 2012 season as function of forecast lead time (h) for the AL (left) and EP (right) basins. The sample size is listed above the graph.

Developmental Testbed Center

HWRF Quantitative Precipitation Forecasts

Extreme precipitation is a huge impact of land-falling TCs, which results in extensive flooding and loss of lives and property. Though progress has been made with respect to prediction of track and intensity forecasts, less attention has been focused on improving rainfall forecasts (quantitative precipitation forecasting or QPF). In 2015, NCEP's Global Forecast System (GFS) will be used as a benchmark to determine whether the high-resolution HWRF model provides additional value to QPF forecasts for TCs. The validation will be done against Stage IV datasets for land-falling storms and precipitation estimates from the Tropical Rainfall Measuring Mission (TRMM) or the CPC MORPHing technique (CMORPH) will be used for verification of QPF over the oceans. The capability to verify against TRMM 3B42 data is now available in the MET package, which will be used for this T&E activity.

Rapid Intensification and Rapid Weakening Forecasts

The HWRF track and intensity forecasts have significantly improved over the last 2-3 years, but prediction of RI/RW still remains a challenge. Understanding how RI/RW skill varies across modeling systems would provide valuable information for advancing the skill of the numerical guidance provided by NCEP. For FY2105, the DTC will develop a methodology for RI/RW verification and develop an initial tool within the MET-TC package to be made available to the community. The methodology will be applied to HWRF and other HFIP models to provide a benchmark for the current modeling capability and to work with the modeling teams to recommend avenues to improve RI/RW prediction.

Advancing the Connections between Radiation and Clouds in HWRF

For FY2015, the DTC will continue its work to verify the hypothesis that the lack of any sub-grid scale feedback from the SAS scheme led to degraded performance of the Thompson/RRTMG HWRF configuration in its retrospective testing. Upgrades to the atmospheric component of HWRF will be passed to EMC to be included in its pre-implementation testing for the HWRF 2015 implementation.

‹ Data Assimilation up Tailored Modeling Systems ›

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TAILORED MODELING SYSTEMS

BACKGROUND

As high-resolution regional numerical weather prediction (NWP) models (e.g., the Weather Research and Forecasting system, WRF) become more skillful and computing hardware becomes less expensive, the use of NWP models to meet the specialized operational needs of various stakeholders is growing rapidly. Even though the modeling software and hardware are easy to acquire, it is still very challenging to optimize the overall system performance to meet specific needs, verify the model skill on small scales, develop specialized model-output products and visualization tools, and educate users about best practices for using the high-resolution model products. RAL has developed a program to create tailored modeling systems with customized verification systems to meet the specific needs of end-users.

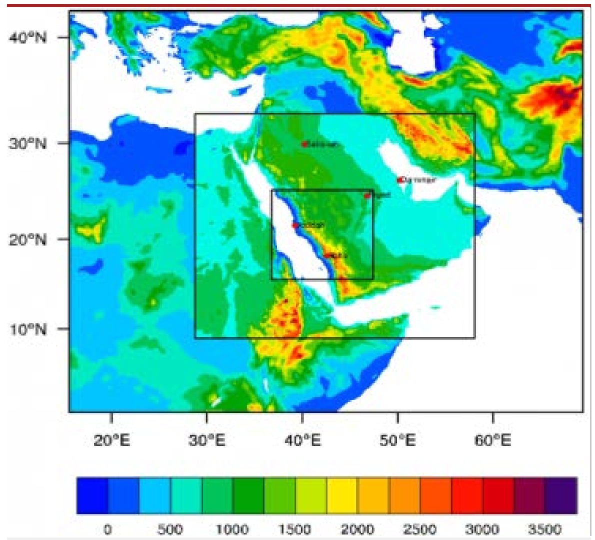
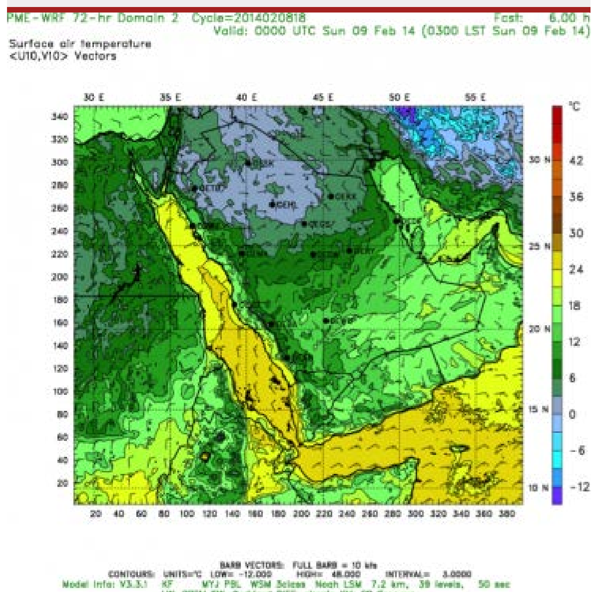


Figure 1: The forecast domains of the new PME WRF-data assimilation forecast system.



FY2014 ACCOMPLISHMENTS: OPERATIONAL FORECASTING SYSTEM FOR SAUDI ARABIA WEATHER SERVICE

In 2014 RAL completed a project for the Presidency of Meteorology and Environment (PME) to improve and modernize the NWP capabilities of the Saudi Arabia Meteorological Service. Highlights of the new modeling system include:

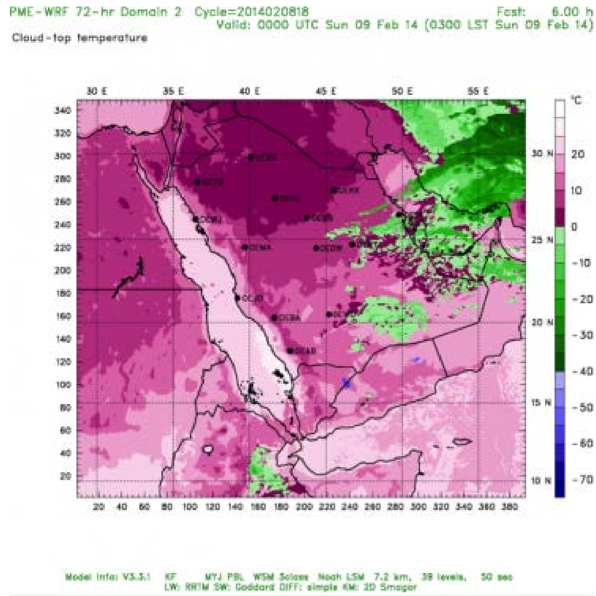
Data Assimilation: The new PME WRF system with data assimilation has been configured with three nested domains as shown in Figure 1. Note that the inner domain was configured to provide high-resolution forecasts for the major metropolitan areas (Jeddah, Mecca, Medina, Riyadh) of Saudi Arabia. The modeling system updates forecasts four times/day using a 6-h analysis (data assimilation) preceding the initialization time and provides 72/72/48-h forecasts for the three domains, with one cold-start for the 18 UTC cycle. Forecast products from the PME WRF-data assimilation system can be accessed through the project website: http://saudi-c3.rap.ucar.edu/cgi-bin/model/ugui?range=GWPME.

Visualization

A new visualization system was developed to support the display of the forecast and verification products for PME. Additionally, NCAR has implemented a monitoring system to provide a summary of model operations. The graphics are created using the NCAR Command Language (NCL) and are available through the PME forecast website. Example forecast products are shown in Figure 2.

Verification

The system's MET verification capability evaluates the new NWP



forecasts using standard WMO point surface and upper air observations and gridded radar-derived quantitative precipitation estimates as a reference and uses the METViewer visualization system to generate and display the evaluation graphics. Verification products can be viewed in real-time on the project website: http://saudi-c3.rap.ucar.edu/cgi-bin/met/ugui_met?aggregate=Week.

Figure 2: Example forecast products showing surface temperature and winds (upper panel) and cloud top temperature (bottom panel).

Dust Modeling

The project also includes an initial dust forecasting capability for Saudi Arabia using the WRF-Chem modeling system framework, a state-of-the-art system for simulation and prediction of weather, climate, air quality and dispersion of dust and pollutants. An example of a dust forecast using WRF-Chem compared to MODIS satellite observations is shown in Figure 3. The plot shows that WRF-Chem resolves the band of elevated Aerosol Optical Depth (AOD) reasonably well in terms of spatial location and temporal evolution for this case study. The daily dust forecasts are displayed on the PME dust forecast website (http://saudi-c3.rap.ucar.edu/cgi-bin/model/ugui.chem?range=GWPME).

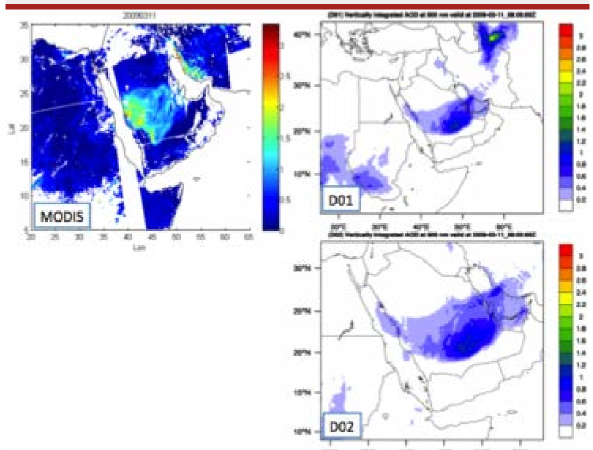


Figure 3: Aerosol Optical Depth (AOD) measured by MODIS (top left panel) and simulated by WRF-Chem (Domain 1: top right panel; Domain 2: bottom right panel) at 600 nm valid at 11 LST 11 March 2009. The WRF-Chem simulations were initialized at 03 LST 09 March 2009.

Training

A series of lectures and hands-on training was provided by NCAR staff members over three two-week training sessions. Training addressed the following topics: high performance computing system maintenance; NWP forecast system maintenance and development; verification concepts; basic concepts of NWP; dust modeling theory; introduction to data assimilation; and advanced visualization tools.

FY2015 PLANS

RAL is working with PME to plan additional development of advanced data assimilation, display, and verification capabilities. Implementation of an initial ensemble-based forecasting system along with advancements to the dust forecast capability are also under discussion. RAL is also exploring opportunities to apply knowledge gained in developing the Saudi system to meet the forecasting needs of other countries in the Middle East, Africa, and Latin America.

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HYDROMETEOROLOGICAL APPLICATIONS

Provide relevant information to water resource decision makers through directed and basic research and development in hydrometeorology, aerosol-precipitation interactions, precipitation nowcasting, microphysical modeling, and winter weather.

- Water System Research Program
- Short-Term Explicit Prediction (STEP) Program
- Winter Weather
- Probabilistic Hydrologic Forecasting at Lead Times from Minutes to Seasons
- Multi-scale, multi-physics hydrological modeling with the Community WRF-Hydro System
- Climate Change and Water
- Climate Risk Management

‹ Tailored Modeling Systems up Water System Research Program ›

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- High Altitude Observatory
- National Center for Atmospheric Research
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WATER SYSTEM RESEARCH PROGRAM

The Water System program supported work on the following topics this year:

- High-Resolution Modeling of Current and Future Climate in North America
- Warm Season Precipitation over the U.S. Central Plains
- Hydrological Modeling with the Community WRF-Hydro System
- Improving Predictions of the Land Component of the Water Cycle
- Snow Model Inter-Comparison Studies
- Water and Agriculture Modeling
- Diagnosing the Global Water Cycle and Drought

‹ Hydrometeorological Applications up High-Resolution Modeling of Current and Future Climate in North America ›

- Multi-scale, multi-physics hydrological modeling with the Community WRF-Hydro System
- Climate Change and Water
- Climate Risk Management
- Climate, Weather and Society

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HIGH-RESOLUTION MODELING OF CURRENT AND FUTURE CLIMATE IN NORTH AMERICA

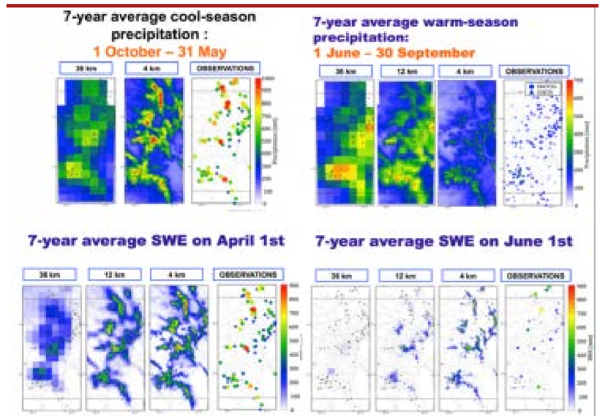

Fig. 1. High-Resolution 4 km WRF model simulations of current and future climate over North America.

The Colorado Headwaters high-resolution climate modeling effort was expanded to consider all of North America. The primary goal of this new project is to examine how key physical processes such as precipitation, snowfall, snowpack, runoff and evapotranspiration are impacted by climate change using a model with sufficient resolution to capture them. The first year of the project tested and evaluated the model configuration and parameterizations necessary to produce a faithful simulation of the current climate. To date, three years of the current climate simulation at 4 km resolution has been completed, with the expectation that the full 10 years will be finished by the end of February. The model faithfully reproduces the observed precipitation, as well as snowpack, for all months and regions. (Fig. 1). A major temperature bias occurs in the central U.S. in the summertime. This is a well-known problem with many weather and climate models and is an active research area for the Water System program and in the community.

A Pseudo Global Warming (PGW) simulation will be initiated in November using climate model monthly mean pertubations of temperature, humidity, winds, and geopotential height derived from the CMIP5 multi-model mean. The output of the model runs will be used by NCAR Water System scientists to examine western snowfall and snowpack changes in a future climate, as wall as convection in the central U.S. Scientists at the University of Saskatchewan will use the model output to examine climate change and water in the Canadian prairies. University of Quebec at Montreal scientists will examine climate change impacts on extreme winter storms, while University of Albany scientists will examine the impact of future climate change on the water cycle in the Northeast U.S.

‹ Water System Research Program | up | Warm Season Precipitation over the U.S. Central Plains ›

WARM SEASON PRECIPITATION OVER THE U.S. CENTRAL PLAINS

Stan Trier and collaborators used observations and convection-permitting simulations to study a 12-day warm-season heavy precipitation corridor over the central U.S. plains and Mississippi Valley regions (Trier et al. 2014). Such precipitation corridors, defined by narrow latitudinal widths (~3-4°) and only modest N-S drifts of their centroids (< 2° day^{-1}), often yield extreme total precipitation (e.g., >250 mm), resulting in both short-term and seasonal impacts on the regional hydrologic cycle.

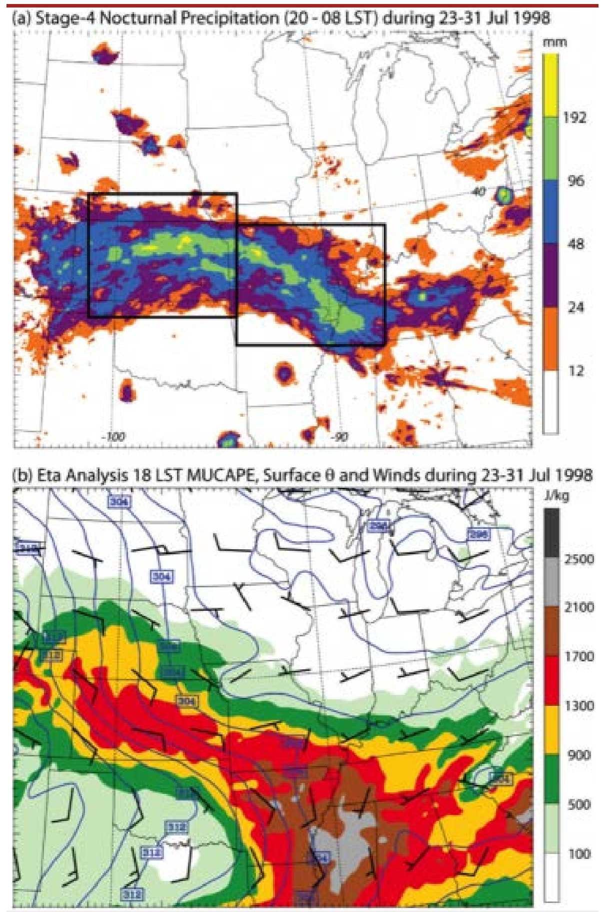

Fig. 2. (a) Nine-day total nocturnal (02-14 UTC) precipitation from Stage-4 analyses of 23-31 Jul 1998. (b) Corresponding nine-day averaged Eta model analysis of the CAPE of the most unstable (highest θe) 50-hPa averaged air parcel in a vertical column (MUCAPE), surface winds and surface potential temperature at 00 UTC.

The corridor precipitation is predominately nocturnal (Fig. 2a) and located several hundred km north of a quasi-stationary surface front (Fig. 2b). There, hot, dry air from the daytime boundary layer located underneath a persistent upper-level anticyclone requires large vertical displacements along the axis of the southerly low-level jet (LLJ) above the front to eliminate convection inhibition (CIN). Convection is favored by the large reductions in CIN along the vertical displacements and by high ambient midtropospheric relative humidity located above, which is influenced by persistent nightly convection in the region (Fig. 2d).

Though internal feedbacks resulting from the large nightly spatial coherence of convection (including enhanced mid-tropospheric relative humidities, and frontogenetic daytime sensible heat flux gradients owing to residual cloudiness) are favorable for maintaining the corridor, its persistence is most sensitive to large-scale external factors. Here, changes to the intensity and position of the large-synoptic upper-tropospheric anticyclone have significant associated changes to the frequency of strong LLJs and the surface frontal position, dramatically affecting the intensity and stationarity of the precipitation corridor. These differences can be seen by comparing a control simulation (CONTROL, Figs. 3c, d) which well replicates observations (Figs. 3a, b), to a simulation

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Climate Risk Management
Climate, Weather and Society

2014 NCAR ANNUAL REPORT

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(NESTDOM, Figs. 3e, f) where the lateral boundaries conditions have been perturbed slightly in a manner that influences the character of the upper-level anticyclone.

Reference

Trier, S. B., C. A. Davis, and R. E. Carbone, 2014: Mechanisms governing the persistence and diurnal cycle of a heavy rainfall corridor. *J. Atmos. Sci.*, **71**, 4102-4126.

‹ High-Resolution Modeling of Current and Future Climate in North America
up
Hydrological Modeling with the Community WRF-Hydro System ›

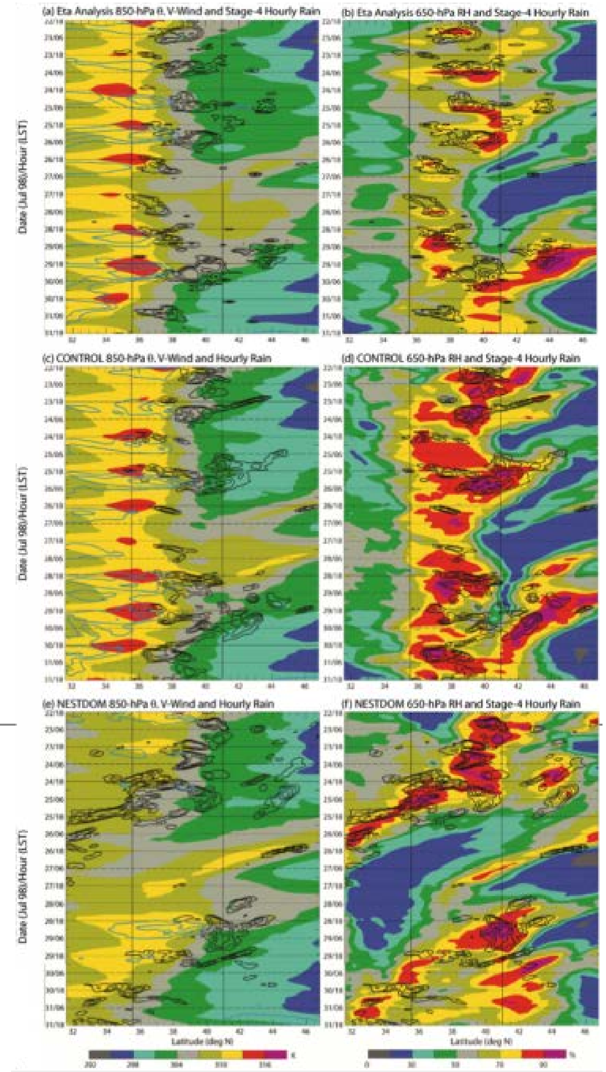

Fig. 3. Time-latitude diagrams of the (a) 850-hPa potential temperature, and (b) 650-hPa relative humidity from 3-hourly Eta analyses longitudinally averaged from approximately 100º to 95º W. The black contours in each panel indicate longitudinally averaged hourly rainfall from Stage-4 analyses exceeding 0.2, 0.6, 1.4, and 3 mm h-1 and the cyan contours (b) indicate longitudinally averaged 850-hPa meridional wind speeds exceeding 7.5, 10, 12.5 and 15 m s-1 from 3-hourly Eta analyses. (c)-(d) and (e)-(f), as in parts (a)-(b) but during a portion of the 12-day simulations CONTROL and NESTDOM, respectively, described in Trier et al. (2014).

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HYDROLOGICAL MODELING WITH THE COMMUNITY WRF-HYDRO SYSTEM

Terrestrial hydrologic processes that control the spatial and temporal distribution of water on and within the land surface are active over a large range of scales. Therefore, effective representation of these processes requires flexible, multi-scale modeling capabilities that can be adapted to meet the needs of a diversity of hydrological settings. The community WRF-Hydro modeling framework is addressing these needs by providing an extensible model structure for representing distributed hydrologic processes in both stand-alone, uncoupled and fully-coupled environmental prediction systems such as the Weather Research and Forecasting (WRF) model, the NASA Land Information System (LIS) or the Community Earth System Model (CESM). WRF-Hydro development follows the WRF modeling paradigm of relatively simple extensibility of model physics within the existing WRF modeling framework. This extensibility permits rapid integration of new model components which can be implemented for hypothesis exploration on new model formulations or for increasing the range of earth system processes being represented.

Publically released in April 2013, the WRF-Hydro modeling system is finding rapid use in the U.S. and in countries around the world by research groups and operational prediction agencies. With a growing domestic and international network of model developers, users, and increasing record of improved model skill, WRF-Hydro is becoming an important community resource for hydrometeorological and hydroclimatological prediction and earth system research. Version 2 updates to the WRF-Hydro released in April 2014 included support for the NoahMP land surface model, improved representation of lakes and reservoirs, improvements to reach-based channel routing methodologies and enhancements to the representation of groundwater processes contributing to streamflow (Gochis et al., 2014). Another major set of improvements to WRF-Hydro system includes the way in which memory is managed and support for large netcdf files which, collectively, improve model performance for large-domain, continental-scale applications. The WRF-Hydro development team also continues to produce a number of different pre- and post-processing and visualization tools to support the use of WRF-Hydro. These include ArcGIS tools for defining and attributing routing grids and stream channels, Unidata IDV and GoogleMaps applications for scalable mapping of WRF-Hydro output with other geospatial information, ncl-based scripts for rapid comparison of simulated or predicted versus observed streamflow conditions. Combined these capabilities are evolving the community WRF-Hydro system into a more robust earth system modeling capability.

FY2015 PLANS

In 2015, the WRF-Hydro team will release v2.1 of WRF-Hydro to the community. Several community-based efforts to improve the functionality and utility of the WRF-Hydro system through projects like the NSF EarthCube initiative and a joint NSF-EU program to improve cyberinfrastructure for hydrometeorological predictions between the U.S. and European countries are expected to expand. A series of new collaborations with research and operations groups in the U.S. and abroad will be initiated to address a host of water cycle prediction problems. These projects include the development of new partnerships with the U.S. Geological Survey to employ a physics-based landslide modeling capability, working with the U.S. Bureau of Reclamation dam safety team in the development of physics-based scenarios for extreme runoff events as it relates to the sustainability of aging water supply dams in the western U.S. and working with the State of Colorado to improve seasonal snowpack and streamflow predictions in the Upper Rio Grande basin. As evaluations are made and knowledge is harvested from these and other projects, continued improvement and expansion of the community WRF-Hydro system is anticipated.

More on WRF-Hydro

‹ Warm Season Precipitation over the U.S. Central Plains | up | Improving Predictions of the Land Component of the Water Cycle ›

IMPROVING PREDICTIONS OF THE LAND COMPONENT OF THE WATER CYCLE

Research in the Water System program has a strong emphasis on systematically evaluating and improving integrated hydrologic models, in order to advance capabilities to simulate the storages and fluxes of water and energy from the top of the vegetation to the depth of active groundwater (i.e., to improve predictions for the Earth's critical zone). A key research focus for the work is to directly address the major problem of compensatory model errors, where inadequacies in one model component can compensate for inadequacies in another model component. To this end we have developed a controlled approach to model evaluation, where we systematically examine the major decisions in the development of integrated hydrological models, including: (1) what schemes should we use to represent spatial variability and hydrologic connectivity throughout the model domain; (2) what parameterizations should we use to simulate the fluxes of water and energy at the spatial scale of the model discretization; (3) what values should we use for uncertain model parameters, beyond traditional curve-fitting approaches; and (4) what techniques should we use to solve the model equations, to optimize tradeoffs between numerical accuracy and computational efficiency [*Clark et al.*, 2011].

FY2014 ACCOMPLISHMENTS

In FY 2014 we completed development of an experimental modeling system, which we term SUMMA (the Structure for Unifying Multiple Modeling Alternatives) to evaluate the suitability of different approaches to simulate water and energy fluxes from the top of the vegetation to the depth of active groundwater [*Clark et al.*, 2014a; b]. SUMMA is based on a general set of governing model equations, with flexibility in the choice spatial architecture, process parameterizations, parameter values, and numerical solvers [*Clark et al.*, 2014a]. The processes considered for the initial implementation of SUMMA include radiation transfer through the vegetation canopy, within- and below-canopy turbulence, canopy interception, canopy transpiration, snow accumulation and ablation, and runoff generation. These processes have been evaluated using data from four research sites throughout the western USA [*Clark et al.*, 2014b].

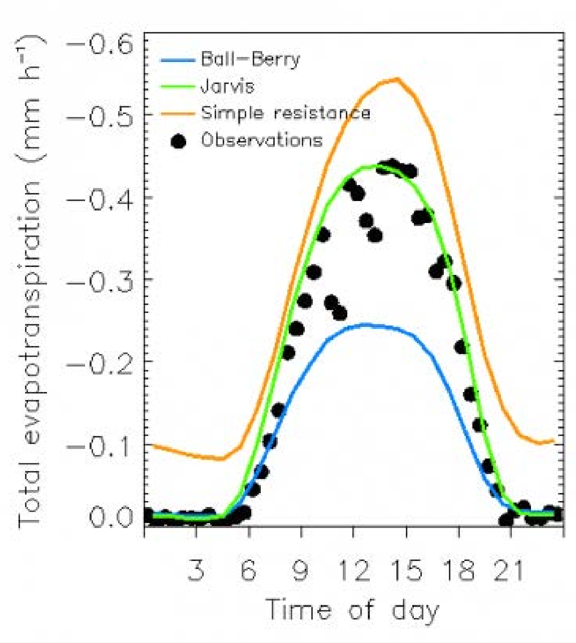

Figure 4. Impact of the parameterizations of stomatal resistance on simulations of evapotranspiration at the aspen site in Reynolds Mountain East for an intensive study period in the 2007 growing season (1 June until 20 August). These simulations are conducted using a uniform soil rooting profile, the Noah soil stress function, and uniform hydraulic conductivity throughout the soil profile, with no baseflow from the soil profile and no hydrologic connectivity among soil columns. The observations (circles) are from the eddy-correlation

Figures 4 and 5 present an example application of SUMMA to evaluate simulations of diurnal cycles of transpiration in the Reynolds Creek Experimental Watershed in southwestern Idaho, USA. Figure 1 illustrates simulations of evapotranspiration using three different parameterizations of stomatal resistance, including a simple soil stress function (orange line; common in hydrologic models), and

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Climate Risk Management
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measurements.

biophysical representations of stomatal resistance (green and blue lines, common in land-surface models). All model simulations are based on a single-column model architecture with gravity drainage at the lower boundary. The deficiencies of the simple soil stress function (orange lines) are strongly apparent in Figure 1, where transpiration is simulated to occur at night when there is no light available for photosynthesis. Figure 2 shows that simulations of transpiration have strong sensitivity to the impact of rooting profiles and the representation of lateral water fluxes – interestingly, the most sophisticated Ball-Berry stomatal resistance parameterization (blue lines) has a poor match with observations when implemented in a traditional land-surface model structure (1-d Richards), and the Ball-Berry parameterization has much closer match with observations when implemented using the dynamic TOPMODEL formulations that explicitly include lateral fluxes of water (orange lines on the right panel of Figure 2). In summary, Figure 2 illustrates that the results (and the conclusions) from a single model structure differ when using alternative process parameterizations, model parameter values, and spatial architecture.

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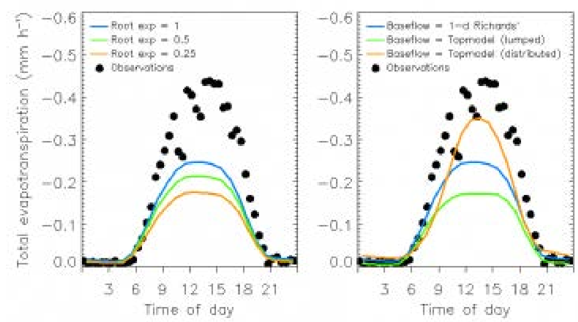

Figure 5. Impact of the choice of model soil parameters and parameterizations on simulations of total evapotranspiration at the aspen site in Reynolds Mountain East for an intensive study period in the 2007 growing season (1 June until 20 August), showing (left) the impact of the root distribution; and (right) the lateral flux parameterization. All model simulations use the Ball-Berry stomatal resistance parameterization. Note that the blue line in Figure 2 is the same as the blue line in the bottom plot of Figure 1. As with Figure 1, the observations (circles) are from the eddy-correlation measurements.

The effort in FY 2015 is focused on implementing the improved integrated hydrologic modeling capabilities from SUMMA in existing land-surface modeling frameworks. This work is proceeding on two fronts. The first work element is to include SUMMA as an option within WRF-Hydro. This work involves improving the computational efficiency of the numerical solution (obtained by experimenting with different operator-splitting approximations), streamlining the input data streams for model forcing data and model parameters, and, finally, integrating SUMMA within WRF-Hydro. The second work element is to incorporate the advanced representation of hydrologic processes from SUMMA in the Community Land Model (CLM). This work involves integrating a small subset of SUMMA modeling options in CLM, and extensive testing using CLM benchmarks, with the initial focus on improving simulations of the storage and transmission of water in the soil profile. Incorporating advanced representation of hydrologic processes in CLM will improve simulations of the land component of the water cycle for models in which CLM is embedded, especially the Community Earth System Model (CESM) and WRF-Hydro.

The effort in FY2015 is also dedicated to more extensive evaluation of model representations of hydrologic processes. This work will comprehensively evaluate sub-grid lateral flow parameterizations (i.e., topographically driven sub-surface flow on spatial scales below the grid resolution of the model) and evaluate the impact of different lateral flow parameterizations on land-atmosphere interactions, especially transpiration and the overall partitioning of precipitation between evapotranspiration and runoff. The work will also evaluate the use of multi-parameter, multi-parameterization, and multi-architecture ensembles for representing uncertainty in integrated hydrologic model simulations.

References

Clark, M. P., D. Kavetski, and F. Fenicia (2011), Pursuing the method of multiple working hypotheses for hydrological modeling, *Water Resources Research*, 47 (W09301), doi: 10.1029/2010wr009827.

Clark, M. P., B. Nijssen, J. Lundquist, D. Kavetski, D. Rupp, R. Woods, E. Gutmann, A. Wood, L. Brekke, J. Arnold, D. Gochis, R. Rasmussen, D. Tarboton, V. Mahat, G. Flerchinger, and D. Marks (2014a), A unified approach to process-based hydrologic modeling. Part 1: Modeling concept, *Water Resources Research*, (under review).

Clark, M. P., B. Nijssen, J. Lundquist, D. Kavetski, D. Rupp, R. Woods, E. Gutmann, A. Wood, L. Brekke,

J. Arnold, D. Gochis, R. Rasmussen, D. Tarboton, V. Mahat, G. Flerchinger, and D. Marks (2014b), A unified approach for process-based hydrologic modeling: Part 2. Model implementation and example applications, *Water Resources Research*, (under review).

SNOW MODEL INTER-COMPARISON STUDIES

Snowpack simulated by six land surface models (LSM: Noah, VIC, SAST, LEAF, Noah-MP and CLM) has been evaluated against one-year snow water equivalent (SWE) data at 112 SNOTEL sites in the Colorado River Headwaters region and four-year flux-tower data at two AmeriFlux sites. Results showed that evaluating only simulated SWE is deceiving and does not reveal critical deficiencies in LSMs, because the models could produce similar SWE for very different reasons. The treatment of snow albedo and its cascading effects on surface energy deficit, surface temperature, stability correction, and turbulent fluxes was a major inter-model discrepancy. Six LSMs substantially overestimated (underestimated) radiative flux (heat flux), a crucial deficiency in representing winter land-atmosphere feedback in coupled weather and climate models. Results showed significant inter-model differences in snow melt efficiency and sublimation efficiency, and models with a high rate of snow accumulation and melt were able to reproduce the observed seasonal evolution of SWE. This study highlights that the parameterization of cascading effects of snow albedo and below-canopy turbulence and radiation transfer is critical not only for SWE simulation, but also for correctly capturing the winter land-atmosphere interactions (Chen et al., 2014, JGR, in revision).

‹ Improving Predictions of the Land Component of the Water Cycle   up   Water and Agriculture Modeling ›

WATER AND AGRICULTURE MODELING

In collaboration with Purdue University and the Chinese Academy of Meteorological Sciences, RAL scientists began investigating the interactions between weather, hydrology, and crop growth. A prototype of corn growth model was implemented in the Noah-MP LSM and was evaluated against biomass data obtained at a rainfed corn site in Illinois (Liu et al., 2014, AGU Fall Meeting).

‹ Snow Model Inter-Comparison Studies   up   Diagnosing the Global Water Cycle and Drought ›

DIAGNOSING THE GLOBAL WATER CYCLE AND DROUGHT

Global water cycle research conducted by Aiguo Dai focused on historical and future changes in precipitation, drought, streamflow and continental discharge.

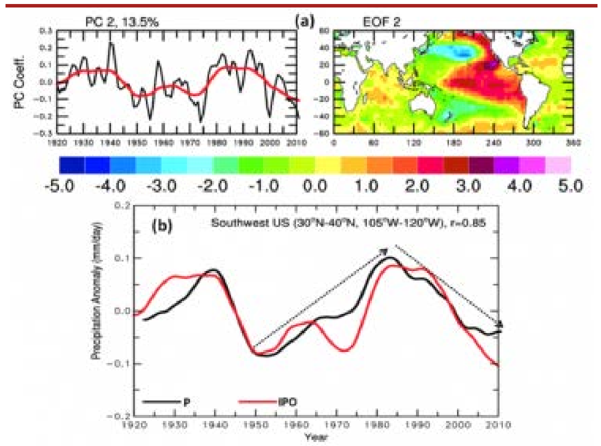

FIG. 6: Top: The 2nd EOF of global sea surface temperature (3-yr running mean) data from 1920-2011 based on the HadISST data set. The red line is a smoothed index representing the inter-decadal Pacific Oscillation (IPO). The bottom panel shows smoothed precipitation anomalies averaged over the Southwest U.S. (black line) compared with the IPO index, scaled for comparison. (Reproduced from Dai 2013b and used by Hegerl et al. 2014).

IMPACT OF NATURAL CLIMATE VARIATIONS ON CLIMATE CHANGE IMPACTS ON THE WATER CYCLE.

Natural variations associated with the Pacific Decadal Oscillation (PDO) or the Inter-decadal Pacific Oscillation significantly impact long-term trends in historical precipitation and related variables of the global water cycle, such as evapotranspiration (ET), streamflow/runoff, and soil moisture content or drought indices (e.g., PDSI). Over regions like the Southwest U.S. (Fig. 5), eastern Australia and southern Africa, recent (e.g., 1950-2013 or 1979-2013) trends in precipitation and other related variables arise mainly from the phase changes in the IPO, not from GHG-induced global warming. This is even true for the 1979-2013 trend in global-mean precipitation. This finding has very important implications for comparing model-simulated and observed changes during recent decades in precipitation and other related variables. Since the phasing of the IPO is realization dependent (i.e., varies among the observation and individual model runs), IPO-induced decadal variations and the associated apparent trends will differ from one realization (e.g., the observations or one particular coupled model run) to another (e.g., another model run). Thus, we should expect substantial inter-model spread in regional precipitation for the current and future climate averaged over a short period (e.g., <40 years). Such spreads should not be interpreted as evidence of uncertainties associated with modeling errors, since even for a perfect model some spreads among its individual runs will exist.

UPDATING OF GLOBAL STREAMFLOW AND CONTINENTAL DISCHARGE.

Aiguo Dai updated his analysis of global streamflow and continental discharge to include years after 2004 (Fig. 6). His streamflow and discharge data sets have been used by modelers at NCAR, U.K. Hadley Centre and other groups to evaluate climate models and to study the terrestrial water budget. Two new manuscripts have been written to present this recent work.

DROUGHT STUDIES

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Climate Change and Water
Climate Risk Management
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A new finding from Aiguo Dai's drought research is that not only agricultural drought, but also hydrological drought (defined using runoff) is projected to become more frequent despite increases in mean runoff over many land areas in Eurasia and northern North America (Fig. 7). This results from the flattening of the probability density function (PDF) of runoff. The PDFs also flatten for soil moisture and PDSI and this contributes to the increases in agricultural drought, which is mainly caused by increased evaporation demand (due to surface warming and increased vapor deficit) and decreased precipitation over subtropical areas. A new paper will be published in *J. Climate* on this research.

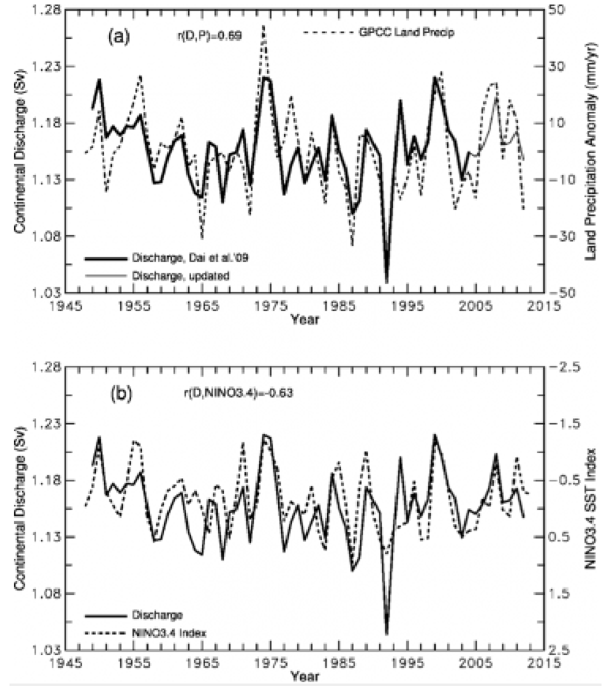

FIG. 7: (a) Yearly time series of October-September mean total continental discharge (in Sv or 1 ´ 10^6 m^3 s^{-1}, excluding that from Greenland and Antarctica) for 1949-2004 (thick solid line) estimated based on streamflow observations from 925 world's largest rivers (from Dai et al. 2009), and for 2005-2012 (thin solid line) estimated based on updated streamflow data for 264 world's largest rivers and a linear regression with the think solid line. (b) Same as (a) except the dashed line is the Nino3.4 (170^{o}W-120^{o}W, 5^{o}S-5^{o}N) SST index. [From Dai 2014a].

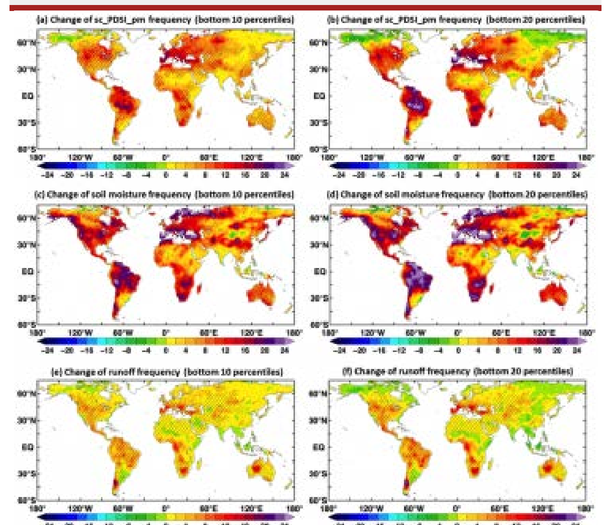

FIG. 8: Multi-model ensemble averaged changes of drought frequency (defined as the percentage of the time in drought conditions, not percentage changes) from 1970–1999 to 2070–2099 under the RCP 4.5 scenario, with drought being defined locally as months below the 10th (a, c, e) and 20th (b, d, f) percentile of the 1970-1999 period based on monthly anomalies of (a-b) sc_PDSI_pm, (c-d) normalized soil moisture (SM) in the top-10cm layer, and (e-f) normalized runoff (R) in individual model runs. The monthly anomalies of SM and R were normalized using the standard deviation over the 1970-1999 period. The stippling indicates at least 80% of the models agreeing on the sign

References

Covey, C., A. Dai, R. S. Lindzen, and D. Marsh, 2014: Atmospheric tides in the latest generation of climate models. *J. Atmos. Sci*., **71**, 1905-1913.

Dai, A., 2013: The Influence of the Inter-decadal Pacific Oscillation on U.S. precipitation during 1923-2010. *Climate Dynamics*, **41**: 633-646, doi:10.1007/s00382-012-1446-5.

Dai, A., 2013: Increasing drought under global warming in observations and models. *Nature Climate Change*, **3**: 52-58.

Dai, A., H. Li, Y. Sun, L.-C. Hong*, LinHo, C. Chou, and T. Zhou, 2013: The relative roles of upper and lower tropospheric thermal contrasts and tropical influences in driving Asian summer monsoons. *J . Geophys. Res.*, **118**: 7024-7045, doi:10.1002/jgrd.50565.

Jia, B., Z. Xie, **A. Dai**, C. Shi, and F. Chen*, 2013: Evaluation of satellite and reanalysis products of downward surface solar radiation over East Asia: Spatial and seasonal variations. *J. Geophys. Res.-Atmospheres*, **118**: doi:10.1002/jgrd.50353.

Luo, D., J. Cha, L. Zhong, and A. Dai, 2014: A nonlinear multi-scale interaction model for atmospheric blocking: The eddy-blocking matching

mechanism. Q. *J. Roy.Meteorol. Soc.*, **140,** 1785–1808,DOI:10.1002/qj.2337.

of change. (From Zhao and Dai 2014)

Rasmussen, R., K. Ikeda, C. Liu, D. Gochis, M. Clark, A. Dai, E. Gutmann, J. Dudhia, F. Chen, M. Barlage, and D. Yates, 2014: Impacts of climate change on the water balance of the Colorado headwaters: High resolution regional climate model simulations. *J. Hydrometeorol.*, doi: 10.1175/JHM-D-13-0118.1, in press.

Trenberth, K.E., A. Dai, G. van der Schrier, P.D. Jones, J. Barichivich*, K.R. Briffa, and J. Sheffield, 2014: Global warming and changes in drought. *Nature Climate Change*, **4**, 17-22.

Wang, J., L. Zhang, **A. Dai**, F. Immler, M. Sommer, and H. Vömel, 2013: Radiation dry bias correction of Vaisala RS92 humidity data and its impacts on historical radiosonde data. *J. Atmos. Oceanic Tech*. **30**: 197-214.

‹ Water and Agriculture Modeling up Short-Term Explicit Prediction (STEP) Program ›

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SHORT-TERM EXPLICIT PREDICTION (STEP) PROGRAM

BACKGROUND

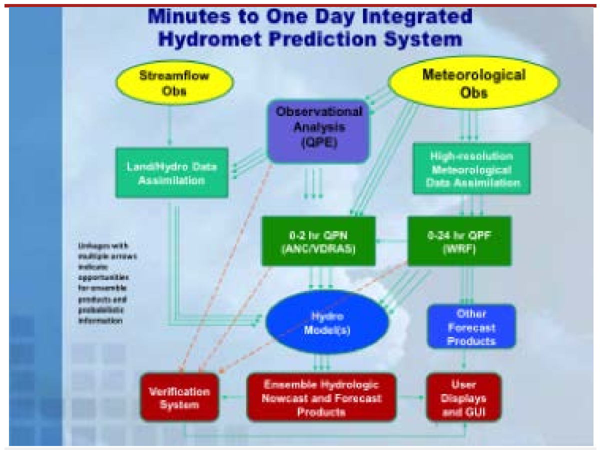

Fig. 1. Flowchart for the STEP Hydromet Prediction System.

The Short-Term Explicit Prediction (STEP) Program is a multi-NCAR Laboratory (i.e., RAL, NESL, EOL) activity with the overarching goal to improve the short-term (0-36 hours) forecasting of high-impact weather events such as severe thunderstorms (heavy rain, tornados, downburst, flash flood, lightning and hail), winter storms (snow, freezing rain and drizzle), and hurricanes. The STEP program emphasizes several research areas that are crucial for advancing the science and application of the short-term prediction of high-impact weather, through collaborative effort incorporating national and international scientists, engineers, and operational personnel from universities, government institutions and the private sector. Most of the forecasting/nowcasting systems and analysis tools developed under STEP are available to the communities for the support of research and real-time operations.

One of the major themes for STEP in FY14 was the preparation and execution of a field program to demonstrate the integrated Hydromet Prediction System (Fig. 1), developed by the STEP program in previous years with the objective to advance the prediction of heavy rainfall, flash floods and streamflow through the integration of state-of-the-art rainfall estimation, precipitation forecasting, and hydrology modeling techniques into one seamless system. This system was run in real-time this summer during the STEP Hydromet 2014 Experiment, from 7 July – 31 August, to test its predictive skill along the Colorado Front Range and to advance short-term prediction of high impact weather. Another STEP research theme led by RAL was the improvement of WRF microphysics parameterization scheme.

- Demonstration of Hydromet Prediction System
- Improving WRF Physics for Improved Prediction of High-Impact Weather

‹ Diagnosing the Global Water Cycle and Drought up Demonstration of Hydromet Prediction System ›

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DEMONSTRATION OF HYDROMET PREDICTION SYSTEM

BACKGROUND

The emphasis of the STEP Hydromet system is to provide prediction on the time scale of minutes out to one day, with particular emphasis on 0-12 hour forecasts and 0-1 hour nowcasts on very high resolution spatial grids (from 100 m – 3 km in resolution). An integral component of this system is the statistical evaluation of quantitative precipitation estimation and forecasting; this was conducted in real-time using Model Evaluation Tools (MET) and object-based evaluation tools (MODE). The primary objective for this summer was to get all components of the hydromet prediction system running in real-time. This was fully accomplished.

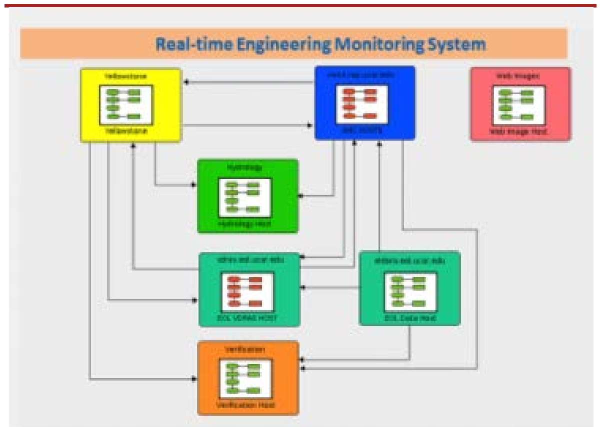

Fig. 2. SysView system for monitoring the status of all algorithms and components of the Hydromet Prediction System in realtime.

All components of the system needed to access and ingest information from some of the other components in real-time, so significant software engineering effort was directed at developing the infrastructure for data sharing and common data formats, and a system for monitoring all real-time processes and data flow was run (see Fig. 2). The Numerical Weather Prediction (NWP) forecast models and the WRF-Hydro model ran on NCAR's Yellowstone supercomputer, while the AutoNowcaster, Trident and VDRAS nowcasting systems, MET/MODE statistical tools, and the EOL QPE mosaics ran on workstations located in RAL and EOL. A dedicated web page (http://ral.ucar.edu/projects/step_hydromet) was set up for real-time viewing of precipitation accumulation fields, forecast and nowcast products, streamflow prediction, and statistical performance. The JAZZ interactive java-based display system was set up for viewing all the real-time observations (radar, satellite, surface station data), STEP nowcasts and NWP model forecast fields and was easily accessible on any workstation by clicking on a link on the dedicated STEP web site.

It was a very active summer convective season, with a high number of thunderstorm days and heavy rainfall events along the Colorado Front Range. Twenty-three days during the summer had precipitation accumulation in excess of 1 inch along the Colorado Front Range, while seven of those days had at least 2 inches of rain. Figs. 3 and 4 illustrate one of the days when high precipitation rates impacted Longmont, where 1.15 inches of rain fell between 3 and 4 pm LT. Later that afternoon 2-3 inches of rainfall fell in eastern Colorado between 4 and 6 pm. The ability of the Hydromet Prediction System to accurately predict the location and timing these heavy rainfall

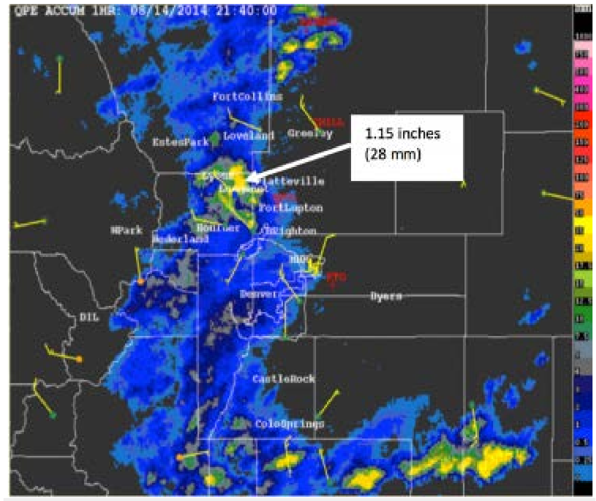

Fig. 3. Precipitation accumulation field obtained from a mosaic of NEXRAD radar data for 14 August 2014 showing heavy rainfall (yellow regions) in numerous locations including Longmont.

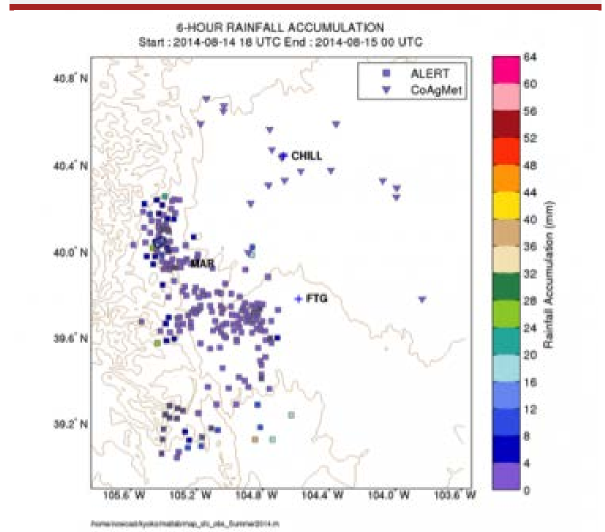

Fig. 4. Six hour rainfall accumulation measured by the ALERT and CoAgMet surface rain gauge networks for the period of heavy rainfall events in Longmont and eastern Colorado. Difficult to see but the rain gauges near Longmont recorded about 28.

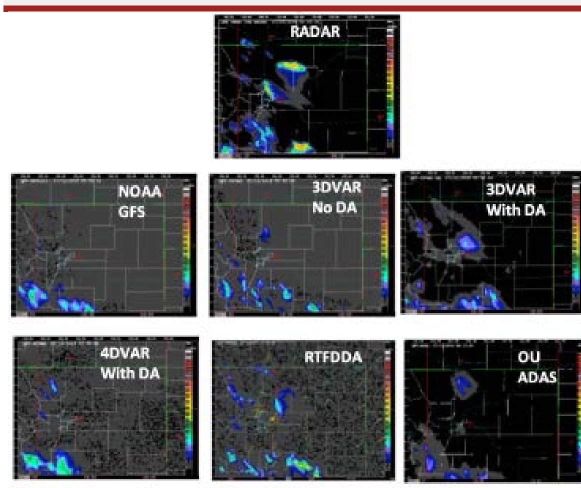

Fig. 5. The six WRF-based NWP models, using different DA schemes which were run in real-time during the 2014 summer demonstration.

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events will be assessed in great detail during the coming months.

The specific components of the Hydromet Prediction System and accomplishments are discussed in further detail in the sections below.

QUANTITATIVE PRECIPITATION ESTIMATION (QPE)

Timely and accurate Quantitative Precipitation Estimates (QPE), as shown in Figs. 3 and 4, are essential for forecasting stream flow, flash floods and localized urban flooding. A mosaic of radars and rain gauge derived QPE are being used in this system for determining “How hard is it raining” and “How much rain has fallen in the intermediate past?” and “how much more will occur in the next hour?”. Quality control algorithms are applied to both the gauge and radar datasets. The mosaic radar-based QPE products used in the Hydromet Prediction System are produced by EOL using single and dual-polarization fields from the NEXRADs, S-Pol and CHILL radars and applying two new QC algorithms: a beam blockage algorithm that computes blockage at low-elevation angles and automated discrimination of precipitation type. Six different precipitation rates were generated in real-time using combinations of Z_h, Z_{DR}, and K_{dp}. The QPE fields were ingested in realtime into the AutoNowcaster/Trident system, into the hydrology model (WRF-Hydro), and into MET/MODE for evaluation of radar-based QPE compared to rain gauge measurements of precipitation and for verification of NWP precipitation forecasts. Specific studies are underway to improve precipitation estimates in hail and very heavy rain areas.

QUANTITATIVE PRECIPITATION FORECAST (QPF)

Quantitative Precipitation Forecast (QPF) is a critical input for hydrological models in order to produce accurate streamflow prediction. Current operational NWP weather models are useful in providing guidance for precipitation forecast, but

not adequate in providing QPF with timing and location precision that is required by the hydrological models. One of the key aspects in improving the accuracy of short-term QPF is to initialize the NWP models with high density and high frequency data. Through NCAR's STEP program, data assimilation systems have been developed that have the capability to assimilate convectional as well as radar observations. Six NWP models ran during the Hydromet 2014 Experiment (Fig. 5). Three of the NCAR state-of-the-art NWP models tested were:

Evaluation activities will specifically include the approximate 300 x 300 km area along the Colorado Front Range shown in this figure.

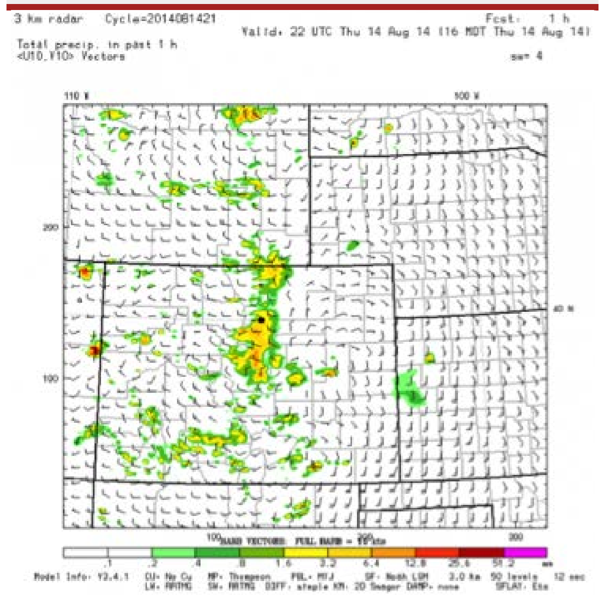
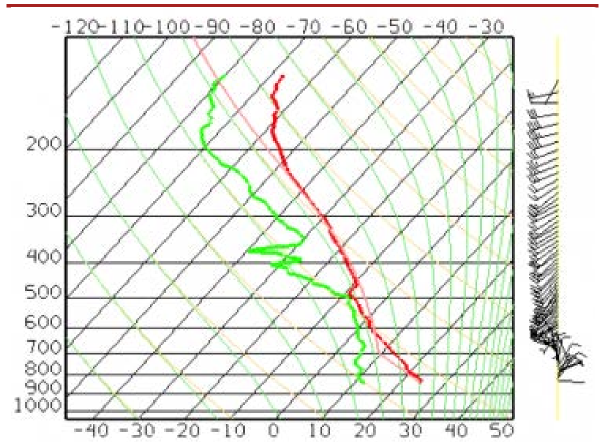


Fig. 6. WRF 3DVAR one hour precipitation forecast with radar data assimilation, valid near the time of heavy rainfall in Longmont (see Fig. 3). County (gray) and state (black) borders are shown. The black dot represents Boulder, CO.

- WRFDA 3DVar: A 3-dimensional variational data assimilation system assimilating conventional observations and radar radial velocity and reflectivity with 1-3 hourly rapid update cycles.
- WRFDA 4DVar: An extension of WRFDA 3DVar with a tangent linear model of WRF. The forward and adjoint models use simplified physics with warm-rain Kessler scheme, but the forecast model uses the Thompson microphysics (same as 3DVar and RTFDDA). Radar radial velocity and reflectivity are assimilated along with the conventional data with a 20 min window and a 3 hourly cycle.
- RTFDDA: the Real-Time Four Dimensional Data Assimilation (RTFDDA) is a system based on observation nudging. It assimilates conventional observations and mosaic radar reflectivity through latent heat nudging.

NOAA/NSSL and NOAA/GSD also participated in the QPF effort with their radar data assimilation system ADAS (Advanced Data Assimilation System) and LAPS (Local Analysis and Prediction System) respectively. These two outside systems and the three NCAR systems were in parallel with two baseline systems without radar data assimilation.

The 3DVAR one-hour precipitation forecast for the high rainfall event in Longmont on 14 August 2014, valid at 4pm LT, is shown in Fig. 6. This figure highlights the potential for NWP models with radar data assimilation to more accurately predict convective activity along the Front Range, with the specificity and timing needed for forecasting high impact weather. Detailed analysis and evaluation of performance of all of the models running this summer is ongoing. This includes comparison of techniques for 1,3 and 6 hr rainfall accumulation periods for forecast lead times of 2, 5 and 8 hr and detailed studies of failure cases to find the causes of failed precipitation forecast.



During the 2014 STEP Hydromet Prediction Experiment daily, mid-day GPS radiosonde soundings were conducted from the NCAR Foothills Laboratory. Skew-t and balloon trajectory plots of the sounding from the aforementioned storm day on 14 Aug. 2014 are shown in Fig. 7 below.Upon completion of the sounding these data were pushed onto an ftp server where they were collected and assimilated by the WRF3DVar and 4DVAR assimilation systems. In total 31 soundings were collected from late July through

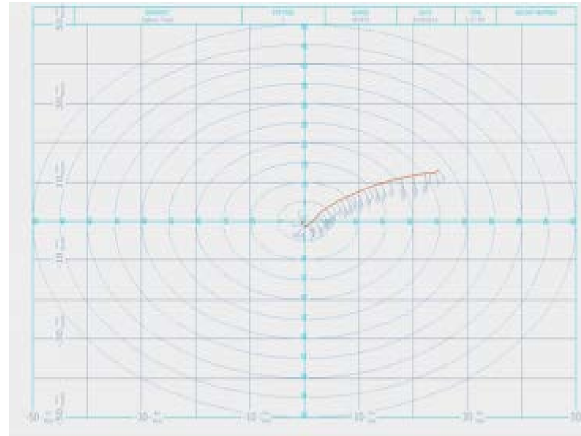


Fig. 7. (above) Skew-t plot of 18z GPS radiosonde sounding from 14 Aug 2014. Pink line indicates the lifted parcel trajectory from the lowest sounding level. (lower) track of radiosonde away from NCAR Foothills Laboratory launch site. Range rings have 5km increments. Wind barbs show wind speed from the sonde at respective horizontal ranges from launch site.

the end of August. In addition to being used by the STEP team, the soundings were also made available to the local National Weather Service Forecast Office in Boulder, CO. They reported that this supplemental information was very useful to their forecasters in the development of their forecast guidance products for afternoon convection. Thermodynamic analysis of these soundings is ongoing.

QUANTITATIVE PRECIPITATION NOWCAST (QPN)

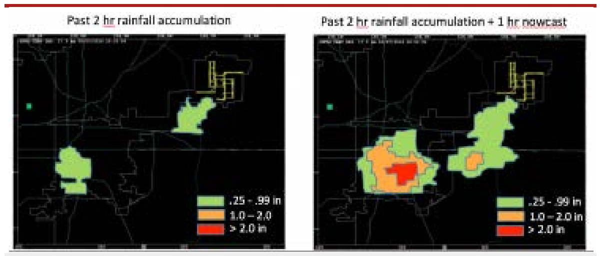


Fig. 8. Heavy rainfall that occurred over the Denver Urban area on 7 August 2014. Shown are AutoNowcaster warning guidance and nowcast maps of heavy rainfall at three precipitation accumulation thresholds (shown in green, orange and red).

The skill of Quantitative Precipitation Nowcasting (QPN) decreases very rapidly in the first hour using basic storm extrapolation techniques. In addition, NWP techniques have insufficient skill to provide suitable, accurate warnings of heavy precipitation on the temporal and spatial scales needed for flash flood forecasting. Thus, the NCAR heuristic AutoNowcaster/Trident system, that blends observations with numerical model analyses, is used to improve on simple extrapolation techniques for QPN. This system provides the specific location and timing of new storm initiation, storm growth and dissipation. It also provides 0-1 hour precipitation accumulation nowcasts and warning products updated every minute, with a spatial resolution of 1 km. In preparation for the STEP Hydromet Prediction experiment, several of the software applications that comprise the AutoNowcaster/Trident system were optimized for the Colorado Front Range, and some new applications were installed. Fig. 8 shows an example of the heavy rainfall products for the Denver Metropolitan area for 7 Aug 2014. The left side of Fig. 8 shows the accumulated rainfall for the past 2 hour and the right side of Fig. 8 the amount of rainfall in the past same 2 hr plus the amount of rainfall nowcast in the next hour. Storms that developed over the Denver metro area continued to grow and remain semi-stationary, producing significant additional rainfall over the Denver urban area in the next hour.

The AutoNowcaster/Trident rainfall accumulation nowcast fields were copied to Yellowstone in real-time for ingest and inclusion into the WRF-Hydro streamflow prediction. This was an important step in the process of running a seamless, end-to-end prediction system, for the WRF-Hydro model to mesh the QPE input, WRF 3DVAR model precipitation forecasts and AutoNowcaster precipitation nowcasts together for ingest into the hydrological streamflow prediction model. Figure 9 is an example of the WRF-hydro 1 hour streamflow prediction along the Colorado Front Range, on the day of the Longmont heavy rainfall

event, that incorporated AutoNowcaster/Trident nowcasts.

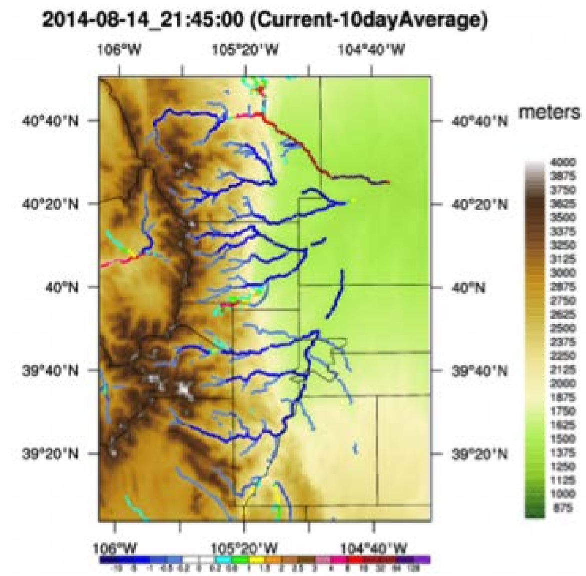


Fig. 9. WRF-Hydro with AutoNowcaster nowcasts included in the streamflow prediction. Shown is the 1 hr streamflow forecast minus the 10 day average streamflow for 14 August 2014, corresponding to the heavy rainfall event over Longmont (see Figs. 3-5).

STREAMFLOW PREDICTION FROM WRF-HYDRO

Skillful flash flood streamflow prediction is dictated by the quality of the retrospective and forecasted meteorological forcings, the quality of the hydrologic model and the ability to minimize uncertainties in hydrological model parameters. During the 2014 STEP Hydromet program we sought to move beyond existing operational 'lumped' model, point-based streamflow forecasting methodologies to provide spatially and temporally continuous analyses and forecasts of streamflow conditions throughout the entire region. To do so, we employed the NCAR community WRF-Hydro distributed hydrological modeling system in a real-time prediction capacity and implemented it in a multi-scale fashion to provide high-resolution, continuous predictions of streamflow. The WRF-Hydro model was configured calculate gridcell land-atmosphere fluxes from the community Noah land surface model on a continuous 1km grid and then calculate overland flow, subsurface flow and channel flow processes on a 100m grid. This resulted in the production of operational, real-time analyses and forecasts of streamflow conditions at over 200,000 points within the Colorado Front Range modeling domain. As noted above, the WRF-Hydro model was cycled on the real-time EOL merged QPE product to provide updated initial states of land surface and streamflow conditions for the start of each nowcast and forecast cycle. The nowcast and forecast cycles were then driven by predicted precipitation from the Autonowcaster and the WRF model (with and without data assimilation), respectively. All WRF-Hydro model runs were executed on the Yellowstone supercomputer.   Analysis of the WRF-Hydro simulated and prediction streamflow is currently underway utilizing a hydrologic model evaluation package that is concurrently being developed by the WRF-Hydro development team.

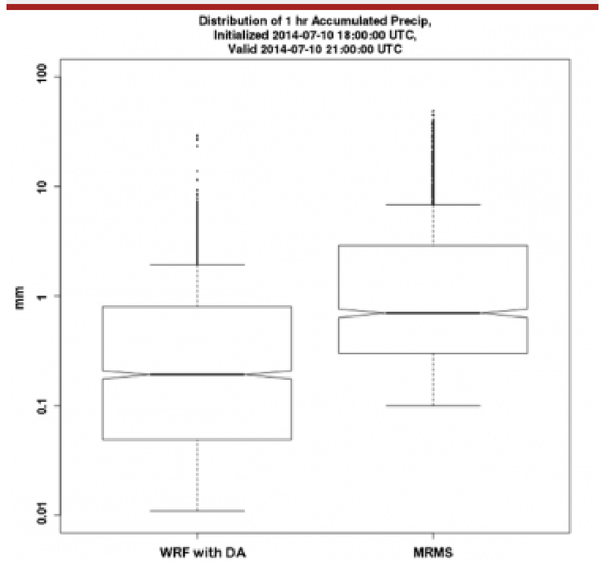


Fig. 10. Distributions of precipitation amounts for WRF with radar data assimilation forecast and MRMS observation grid, for lead time 3 hours valid on 10 July 2014 at 21 UTC. The center of the box represents the median value; bottom and top of the box are the 0.25th and 0.75th quantile values of the distributions, and lines inside an outside the boxes designate expected extremes (points beyond these "whiskers" are outliers). The notches in the boxes represent 0.95th confidence intervals around the medians.

END-TO-END VERIFICATION CAPABILITY

Forecast evaluation is a critical element of the end-to-end hydrometeorological prediction system

being developed within STEP. The evaluation component of the project focuses on the assessment of the contributions of each component of the system, from QPE to quantitative precipitation nowcasting (QPN) and QPE, to forecasting streamflow. By applying diagnostic approaches for evaluating the forecasts, it is be possible to assess the strengths and weaknesses of the particular components of the system. In addition, overall performance information provides guidance for applications of the system.

The initial verification focus has been on model-based QPF from the Weather Research and Forecasting (WRF) model, both with and without data assimilation. Two observation fields were used: the Earth Observing Laboratory (EOL) radar precipitation estimates, and the Multi-Radar Multi-Sensor (MRMS) gauge-corrected radar precipitation field. A near-real-time verification system was implemented for the project, and overnight verification runs produced both image- and text-based verification results. In all, over 31,000 statistical verification plots were produced. The project team selected both traditional and advanced spatial methods for the initial studies. While traditional verification approaches provide some useful information for evaluating and comparing model versions, especially during periods of heavy precipitation, they may suggest that some forecasts do not have much or any skill, even though those forecasts may contain some useful information. Alternative spatial methods - the Fractions Skill Score (FSS; Roberts and Lean 2008) and the Method for Object-based Diagnostic Evaluation (MODE; Davis et al. 2009) - both provided more guidance regarding which aspects of the forecasts are providing meaningful information about performance.For example, Fig. 10 shows distributions of forecast and observed precipitation for a case from near real-time operation in 2014 at lead time 3 h from a WRF forecast with radar data assimilation initialized at 1800 UTC. It is apparent that the WRF model forecast had a different distribution of predicted precipitation than was observed. In particular, the WRF predictions produced a large number of small precipitation values that were not observed, and the overall mean range of precipitation values was lower while the highest observed values were under-predicted. For this case, the MRMS precipitation analysis was used as the QPE field for the verification. Fig. 11 shows an example of a performance diagram for this case; this diagram (based on work of Roebber 2009) provides a way

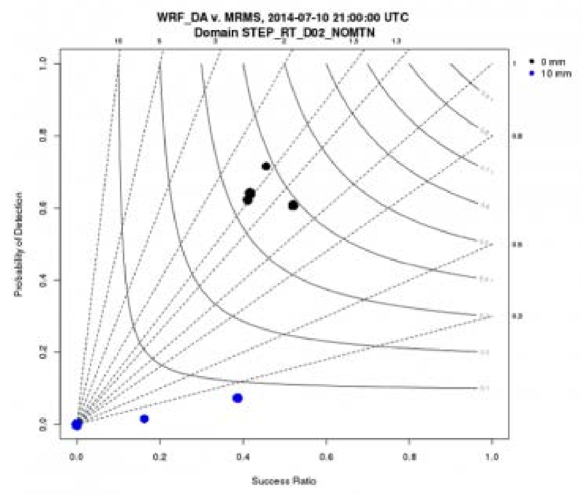


Fig. 11. Performance diagram (Roebber 2009) showing multiple verification statistics for the 10 July 2014 case valid at 21 UTC. This diagram simultaneously shows POD, 1-FAR, CSI, and Frequency Bias values for various lead times and precipitation thresholds. The different colors represent the precipitation thresholds used to define the precipitation events and individual points represent different forecast lead times. Larger points represent more weather events, smaller points represent fewer (or more null cases). The best scores are in the upper right corner; bias values close to one are typically considered optimal.

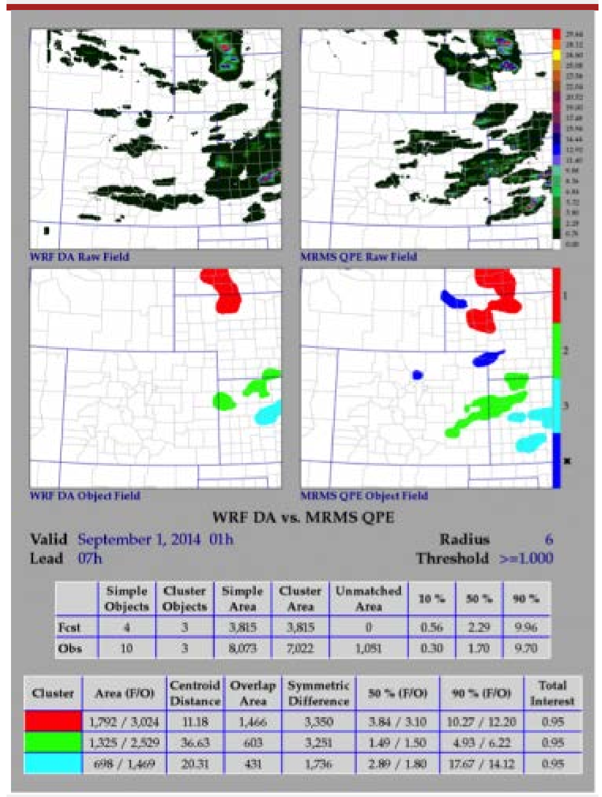


Fig. 12. Output from MODE for 1 Sept 2014 valid at 01 UTC with a lead time of 8 hours. The left column is the output from the WRF forecast with radar data assimilation, the right column is the MRMS observation grid. The top row is a plot of the raw precipitation fields and the bottom row shows the matched objects. Dark blue represents unmatched objects. Below the images are various quantitative results based on comparing the matched objects.

to visualize several different contingency table statistics simultaneously, including the Probability of Detection (POD), Success Ratio (SR, equal to one minus the False Alarm Ratio), the Critical Success Index (CSI), and frequency bias. Each dot represents a unique lead time. This diagram suggests that the best performance is associated with low precipitation thresholds and depends on the lead time of the forecast.

In contrast, Fig. 12 shows results from an application of MODE on a WRF forecast valid at 0100 UTC on 1 September 2014, initialized 7 hours earlier. This plot visually shows the differences between the forecasted (left) and observed (right) precipitation fields as well as the objects that were identified and matched between the two fields (lower plots). An additional strength of MODE is the ability to quantify these differences, which is seen in the number tables at the bottom of the figure. During the real time operations in 2014, weekly plots of object area differences were also created (Fig. 13). In this example, the precipitation area covered by the WRF both with and without radar data assimilation was less than the precipitation measured by the two QPE products (EOL and MRMS). The WRF with radar data assimilation tended to have larger object areas (more in line with what was observed) than the WRF forecasts without radar data assimilation.

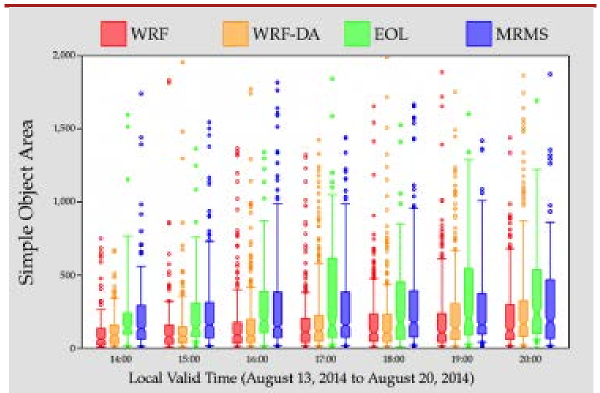


Fig. 13. Comparison of object areas for WRF with radar data assimilation, WRF without radar data assimilation, radar QPE values (EOL), and MRMS observed values for the week of 13 Aug 2014 to 20 Aug 2014. Description of boxplot features is given in the caption for Figure 10.

FY2015 PLANS

QPE

- Rain gauge QPE
    - Quality control of the surface station rain gauge data from this summer is currently being conducted. This dataset will be used by the STEP group to assess performance of the WRF models and the EOL radar-based QPE field
- Radar estimation of QPE
    - A detailed examination and qualitative assessment of the EOL QPE mosaic field, the KFTG/SPOL/CHILL dual-pol fields, and the EOL version of the PID field run on SPOL, CHILL and KFTG has been done and will be used in producing an optimized mosaic QPE field for the 2014 summer events and for the upcoming 2015 demonstration.
    - The EOL QPE mosaic field will be compared to NSSL's MRMS QPE field and to the Stage IV radar and gauge-corrected QPE field.

QPF

- Evaluate the performance of 3DVar radar DA against the baseline run and standard 3DVar run and find cases of failed precipitation forecasts
- Compare the performance of 3DVar radar DA and RTFDDA with the purpose to improve performance of both systems
- Diagnose the causes of failed precipitation forecasts for these chosen cases
- Find and evaluate cases in which 4DVar clearly outperform and underperform over 3DVar
- Improve 4DVar performance by improving the adjoint of the microphysics and continuous cycling
- Configure and run WRFDA 3DVar for PECAN

QPN

- Identification and detailed analysis of three heavy rainfall/flash flood events that occurred over a mountain watershed, over a large urban area and over Colorado highways to assess predictability.
- Examination and optimization of predictors for heavy rainfall events
- Evaluation of the accuracy of TITAN and CTREC advection vectors for the Front Range region.
- Examination and utility of diurnal PW, low-level moisture and wind relative to the Colorado Front Range for prediction of heavy rainfall events.
- Analysis on the duration and dissipation of heavy rainfall events, for improved predictability.
- Re-run the AutoNowcaster/Trident system for several of the 2014 heavy rain events using optimal set of above predictors, in preparation for 2015 summer demonstration.
- Diagnose the causes of "poor performance" cases of VDRAS, especially in terms of low-level convergence
- Configure and run VDRAS for PECAN

Streamflow prediction

- Continue enhancing a real-time WRF-Hydro analysis/evaluation package based in the open source R

scripting language
- Re-run WRF-Hydro for the entire summer with the updated EOL QPE product
- Re-run selected WRF forecast and nowcast cycles for prominent event days
- Incorporate real-time real-time land cover and vegetation information into WRF-Hydro operational cycles
- Implement a baseline streamflow data assimilation capability using the newly created Hydro-DART framework and test using selected event days from 2014
- Work with STEP team to create a blended QPF/QPN/streamflow hydromet forecast product
- Continue development on a real-time display for viewing streamflow analyses and forecasts
- Deploy WRF-Hydro model and analysis components for operational forecasting in the summer of 2015

Verification

- Set up METViewer to allow analysis of 2014 results by whole STEP team
- Create initial capability to evaluate streamflow forecasts
- Undertake more in-depth evaluation of 2014 results for specific cases
  - DA vs. no DA
  - Streamflow
  - Nowcasts
  - Apply MODE-TD (Time Domain) to one or more cases to demonstrate this capability
  - Evaluate QPEs
    - Compare MRMS and EOL QPE (e.g., as gridded products – how do they differ?)
    - Evaluate individual QPEs using rain gauges
  - Prepare for 2015 real-time exercise
    - Develop separate verification website
    - Update analysis routines
      - Incorporate new capabilities as time allows
  - Create JNT web site for verification plots.
  - Explore other advanced verification methods in addition to those implemented in the previous year. In addition, examine other system components such as streamflow.
  - In-depth analysis of system performance for select cases from 2014 season.
  - Move parts of the verification system developed for this project into the Model Evaluation Tools (MET) code.

‹ Short-Term Explicit Prediction (STEP) Program | up | Improving WRF Physics for Improved Prediction of High-Impact Weather ›

IMPROVING WRF PHYSICS FOR IMPROVED PREDICTION OF HIGH-IMPACT WEATHER

IMPACT OF MICROPHYSICS AND RADAR DATA ASSIMILATION ON SQUALL LINE SIMULATION

A case study was conducted to investigate the impact of model microphysics parameterization on short-term forecasts of convective initiation, evolution, and quantitative precipitation forecasts (QPF). The event studied was a squall line observed on 20 June 2007 in central Oklahoma. Idealized simulations of the case have previously shown the parameterization for raindrop breakup to have a strong influence on the evolution of organized convection via its impact on the cold pool (Morrison et al. 2012). New sensitivity tests were performed that varied the prescribed graupel density in the Thompson et al. (2008) bulk microphysics scheme. Results have shown that the cold pool strength and depth is impacted greatly by prescribed graupel density. In a low-density scenario, additional melting of graupel drove a stronger and faster propagating squall line due to the additional cooling from the melting process (Fig.14). Surprisingly, rain evaporation processes were not noticeably altered. Work is underway to test a diagnostic variable density graupel option. This work included the mentorship of a SOARS undergraduate student.

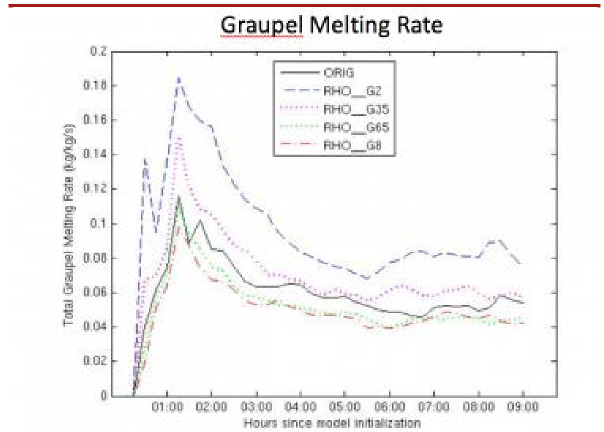


Figure 14. Time series of domain total graupel melting rate over the course of the 9-h idealized simulation of the 20 June 2007 squall line for each of the sensitivity tests that varied graupel density. The baseline simulation ("ORIG") used the default graupel density of 500 kg m^{-3} (solid black line), while the other tests varied it below that (200 and 350 kg m^{-3}, blue dashed and pink dotted, respectively) and above that (650 and 800 kg m^{-3}, green dotted and red dash-dotted, respectively).

In order to promote more accurate initiation of convective features in non-idealized simulations of this squall line, RAL's Real-Time Four-Dimensional Data Assimilation (RTFDDA) system that utilizes a latent heat nudging technique has been used and has shown that radar data assimilation (RDA) improved the squall line forecasts consistently (Fig. 15). Numerical experiments have been conducted to test the RDA technique, as well as to evaluate the effect of changes in the microphysics scheme (such as treatment of raindrop breakup and evaporation). A journal manuscript is being prepared to present the results of this study.

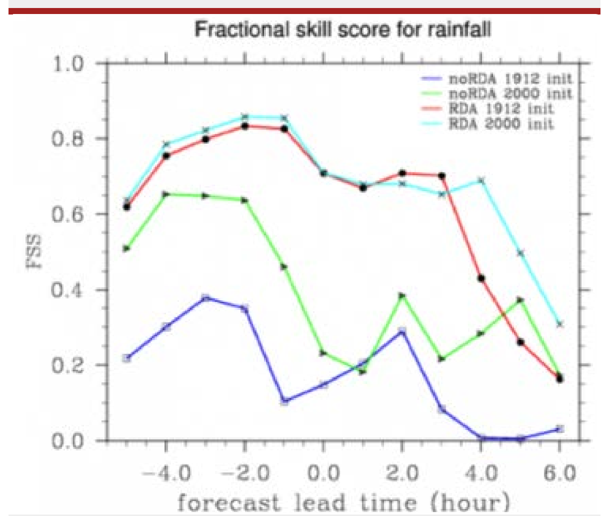


Fig. 15. Fractional skill score for rainfall for the 20 June 2007 squall line case using the RDA technique (red and cyan) compared to forecasts without RDA (green and blue) for two different model

IMPROVING THE THOMPSON MICROPHYSICAL SCHEME

During 2014, a detailed evaluation was performed

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to assess the performance and impacts of using the newly coupled Thompson et al (2008) microphysics scheme with the RRTMG radiation scheme in WRF. The newly coupled physics were tested by being included as one of the OU-CAPS Spring Experimental Forecast ensemble members during their real-time forecast exercise in May and early June 2013. An example of the impact on incoming solar radiation at the surface is shown in Fig. 16, which indicates that broad areas of less opaque clouds (i.e. more solar radiation reaches the surface) and some scattered areas of more opaque clouds are simulated in the coupled version. In 2014, the coupled scheme was included in the WRF version 3.5.1 code release and then used as the “control” member of the OU-CAPS ensemble. Analysis of 29 days of 48-hour forecasts from the 2013 OU-CAPS experiment was performed to compare the sensitivities of the coupling to surface temperature and precipitation as well as cloud and radiative properties in conjunction with surface pyranometer and geostationary satellite data. A journal manuscript is being prepared to present the methodology and results.

initialization times (19 June 12Z in blue and red, 20 June 00Z in green and cyan).

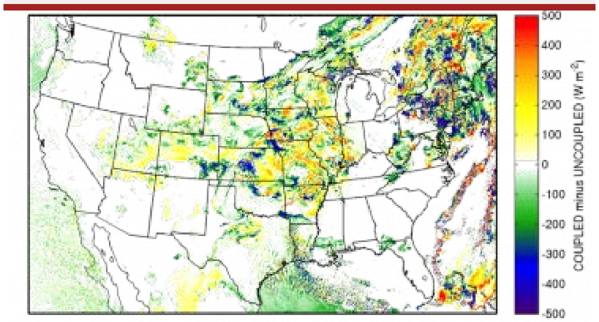

Fig. 16. Example of the difference in incoming solar radiation at the surface between the coupled and uncoupled (2013 “control”) ensemble members on 8 May 2013.

FY2015 PLANS

WRF physics improvement

- Refine the hybrid radar data assimilation system with improved mixing ratio relationships to improve forecasted convective initiation and evolution
- Develop a maximum hail size forecast metric from the Thompson microphysics scheme
- Continue development of a variable density (3-moment) graupel/hail hybrid category in the Thompson microphysics scheme to improve forecasted convective storm structure, evolution, and QPF

‹ Demonstration of Hydromet Prediction System   up   Winter Weather ›

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- Director's Message
- Table of Contents
- Next Generation Air Transportation
- New and Emerging Applications
- National Security Applications
- Numerical Systems Testing and Evaluation
- Hydrometeorological Applications
  - Water System Research Program
  - Short-Term Explicit Prediction (STEP) Program
  - Winter Weather
  - Probabilistic Hydrologic Forecasting at Lead Times from Minutes to Seasons
  - Multi-scale, multi-physics hydrological modeling with the Community WRF-Hydro System
  - Climate Change and Water
  - Climate Risk Management
- Climate, Weather and Society

2014 NCAR ANNUAL REPORT

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WINTER WEATHER

WYOMING WEATHER MODIFICATION PILOT PROGRAM

BACKGROUND

The Wyoming Weather Modification Pilot Program (WWMPP), funded by the State of Wyoming through the Wyoming Water Development Commission (WWDC), is an orographic cloud seeding research program covering three target areas (the Medicine Bow Range, Sierra Madre Range and Wind River Range; see Figure 1). It is unique among state-sponsored programs in that it includes a substantial independent evaluation component to determine the feasibility of cloud seeding and to quantify its effectiveness. The logistics, infrastructure, and operations of the program are covered under a contract with Weather Modification Inc. (WMI), while the evaluation activities fall under a separate contract with the Research Applications Laboratory (RAL) of the National Center for Atmospheric Research (NCAR).

Fig. 1. A map of Wyoming with coarse representation of topography and land use. Yellow areas denote the three mountain ranges in the winter orographic cloud seeding program: Medicine Bow, Sierra Madre, and Wind River. The randomized statistical experiment involves only the two southern ranges, the Medicine Bows and Sierra Madres.

The evaluation of the WWMPP is based on a two-pronged approach: a) a statistical experiment to collect a randomized set of seeded and unseeded cases, and b) exploratory observations to investigate the different physical processes in cloud seeding to show that the seeding hypothesis is physically-based. Collaborations with other scientists, particularly those at the University of Wyoming, have led to "piggy-back" studies applicable to the assessment of seeding impacts on precipitation formation and eventually on streamflows.

FY2014 Accomplishments

This is the final year of the WWMPP. Final analyses of program data are underway and results will be presented to the Wyoming Legislature in early December 2014. A publication on the results of the cloud seeding evaluation will be submitted soon thereafter.

Statistical Cloud Seeding Evaluation

A Randomized Statistical Experiment (RSE) was carried out over the past six winter seasons in the Sierra Madre and Medicine Bow mountain ranges in southern Wyoming (recall Fig. 1). During the six-year experiment, 154 randomized cases were seeded. High-resolution precipitation gauges were utilized to measure the precipitation at target, control, and covariate sites for each case. Three gauges were located at each site in order to assist

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with quality control measures. NCAR led an intensive and thorough quality control process of the gauge data, identifying 23 randomized cases that did not have satisfactory quality of data to be utilized in the statistical analysis. Statistical analysis was then performed on the gauge data and results of the RSE analysis will be released to the public after December 2014.

Fig. 2. GEONOR T-200B precipitation gauge at the GLEES target site in the Medicine Bow range.

Cloud Seeding Evaluation Studies with the WRF Model

One of the primary advances in the evaluation of orographic cloud seeding has been the use of high-resolution mesoscale models. The Weather Research and Forecast (WRF) model has been used in this project to evaluate seeding potential using an AgI point-source module to represent the release of AgI from ground-based generators (Xue et al. 2013a, b). The WRF model with this AgI cloud seeding parameterization was used to assess the potential impact of seeding for roughly half of the RSE cases in the Sierra Madre and Medicine Bow ranges, as well as for select cases over the Wind River Range (WRR) in Wyoming. The results of the RSE case simulations have been compared to the results from the statistical analysis to aid in the interpretation of the RSE results. The model was also utilized to assess the extra-area impacts of cloud seeding for all of the three ranges.

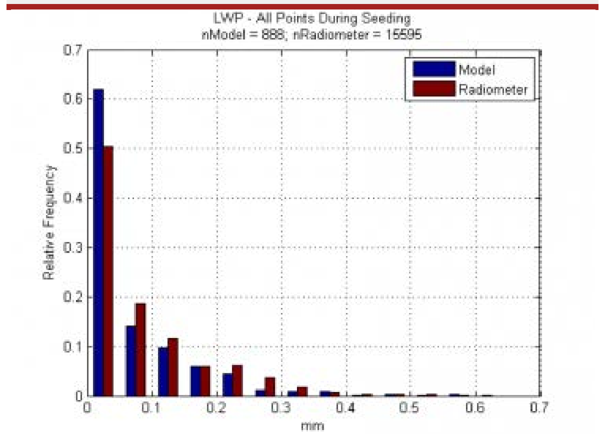


Fig. 3. Histogram comparing the modeled liquid water path (red) from RSE case simulations compared to that observed by the Savery radiometer (blue) during RSE cases.

As part of the modeling studies, a thorough evaluation of the model compared to observations has also be completed in order to provide a level of confidence in the model results. Sounding data from balloons launched for each RSE case, radiometer data, and the high-resolution precipitation gauge data have been analyzed to compare the modeled thermodynamic profile, liquid water contents (LWP), and precipitation with that which was observed. This “model validation” exercise has shown that the model is performing remarkably well, especially at being able to reproduce the conditions required for seeding (i.e. temperature, LWP) as well as for simulating observed precipitation on the ground. An example of the model versus radiometer data comparison for LWP is shown in Fig. 3. For this example, the model has a slight tendency to under predict the LWP, but performs well overall.

IDAHO POWER PROJECT

Background

Idaho Power Company (IPC) conducts a winter cloud seeding program to augment snowfall along the Snake River Basin and its tributaries for hydro-generation purposes. The program has been

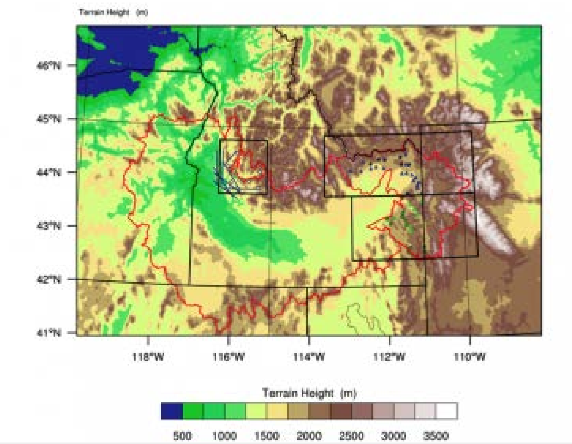


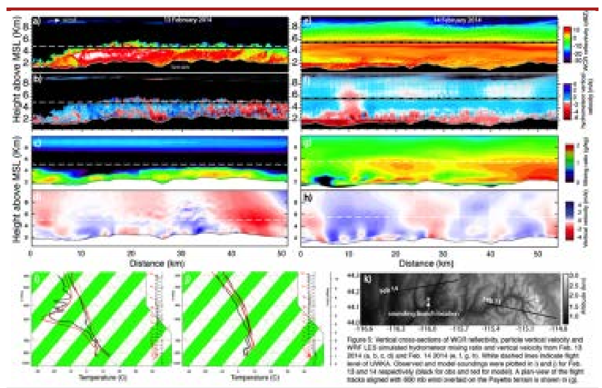
Fig. 4. Map of the Snake River Watershed in Idaho (large red outline) and existing ground generator sites on a map of terrain height (m; color shading). The Payette River Basin target area is located in the western Snake watershed, north of Boise and is also outlined in red. The Upper Snake River Basin target area is located in Eastern Idaho, also outlined in red. Ground generator locations are identified as circle and triangle symbols, and color-coded as white (Payette), blue (north Eastern Idaho), and green (south Eastern Idaho). The circles are Idaho Power owned generators, and the triangles are generators operated by Let it Snow.

focused in Payette River basin and the upper Snake River system in eastern Idaho (Fig. 4), and is now expanding into the Boise and Wood basins.

For the past two years RAL has conducted a numerical modeling “Phase Three” study (a 2-year long phase) to provide real-time and retrospective model-based guidance on the effectiveness of cloud seeding using ground generators and aircraft tracks. The primary goal of Phase Three was to develop and implement a real-time cloud seeding forecast guidance system using the Weather Research and Forecasting (WRF) model and the newly developed cloud seeding module utilized in Phases One and Two. In the first year of the Phase Three effort (2013), RAL successfully developed a prototype real-time cloud seeding case-calling algorithm, collaborated with the University of Arizona (UofA) to adapt the cloud seeding module onto the UofA real-time WRF forecast model, run a research version of WRF on a UofA computing cluster for tailored precipitation and cloud seeding forecasting relevant to the Idaho Power cloud seeding operations during the 2012-2013 winter season, and simulated cloud seeding effects for the 13 cases that were seeded by Idaho Power in that winter season (hereafter, the retrospective cases).

FY2014 Accomplishments

In 2014, the second (and final) year of the Phase Three Study was completed and a new “Phase Four” study began. The Phase Three accomplishments were that two consecutive years of real-time cloud seeding forecasts were generated (in collaboration with Univ. of Arizona) in real time between 1 November and 1 April of each winter season, the case-calling algorithm was refined in order to improve case calling in the model, and several retrospective seeding simulations were run and analyzed. Furthermore, to validate the modeling simulations, IPC observations (soundings, radiometers, and high-resolution precipitation gauges) were compared to assess the performance of the model in simulating observed temperature profiles, winds, precipitation, and supercooled liquid water.



Winter Weather

A significant accomplishment from Phase Three was that an NSF proposal was written and submitted to seek funding to conduct a field program called SNOWIE (Seeded and Natural Orographic Wintertime clouds: the Idaho Experiment). This effort involved collaboration with several universities (University of Illinois, University of Wyoming, and University of Colorado) and also included collecting, analyzing, and simulating a “pre-SNOWIE” data set with the University of Wyoming King Air cloud radar and lidar and the WRF cloud seeding module (Fig. 5). If funded, the proposal aims to conduct the program in winter 2015-2016 and would evaluate ground and airborne cloud seeding using physical and numerical modeling approaches, as well as to validate the cloud seeding module.

There are three publications from Phase Three efforts that are still underway and should be submitted within the next few months that document the results of the cloud seeding module and real-time

modeling research conducted for IPC.

The goals of Phase Four are to continue running and improving the real-time cloud seeding modeling system, expand the real-time case calling, modeling, and analysis into the Boise and Woods Basins, and build a real-time web-based display to deliver the model forecast graphics. Specific Phase Four analyses already completed are an analysis of inversion characteristics and frequency based on IPC soundings along with model simulations of retrospective case studies comparing the efficacy of manually-operated versus remotely-operated (often lower and higher elevation sites, respectively) ground generators.

Since the number of cases called by the algorithm in the first year of Phase Three was determined to be high, where several of these cases simulated weak seeding enhancements, the algorithm was refined to try to reduce the number of cases called for the second year of Phase Three. The algorithm refinements succeeded at reducing the number of cases called, but ended up calling too few cases. Therefore, additional refinements were needed, and are currently being made, in order to implement the algorithm for the Phase Four real-time modeling system. Moreover, the algorithm has been expanded to call ground and airborne cases for the Boise and Wood Basins in Phase Four, based on the newly installed ground generators and aircraft dedicated to seeding this new target region.

FY2015 Plans

- Run the newly refined and expanded seeding case-calling algorithm in real time for the 2014-2015 season.
- Complete the development of the web-based display system to display the real-time model graphics, along with IPC observations in real time.
- Conduct retrospective simulations of alternative seeding scenarios, such as investigating the potential seeding impact of current/planned seeding facilities on the Boise and Wood Basins.
- Publish three journal papers.

‹ Improving WRF Physics for Improved Prediction of High-Impact Weather | up | Probabilistic Hydrologic Forecasting at Lead Times from Minutes to Seasons ›

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PROBABILISTIC HYDROLOGIC FORECASTING AT LEAD TIMES FROM MINUTES TO SEASONS

BACKGROUND

Every day, streamflow forecasts are used to support decisions by reservoir operators and water managers in the United States, who must balance a range of competing objectives. At local scales these might include preventing floods by capturing water, maintaining cool stream temperatures for fish by releasing water, or delivering water to irrigators through scheduled releases. At large regional scales, decisions to store or release water may affect the available supply and water markets for large US cities or growing regions situated hundreds of miles from the water's headwater source, or even have international treaty implications. The need for better short-term forecasts – from minutes to seasons – is perennially raised in studies related to water management. However, identifying the research necessary to improve hydrologic monitoring and prediction products requires identifying the overlap between (i) user needs, and (ii) opportunities to improve hydrologic monitoring and prediction products.

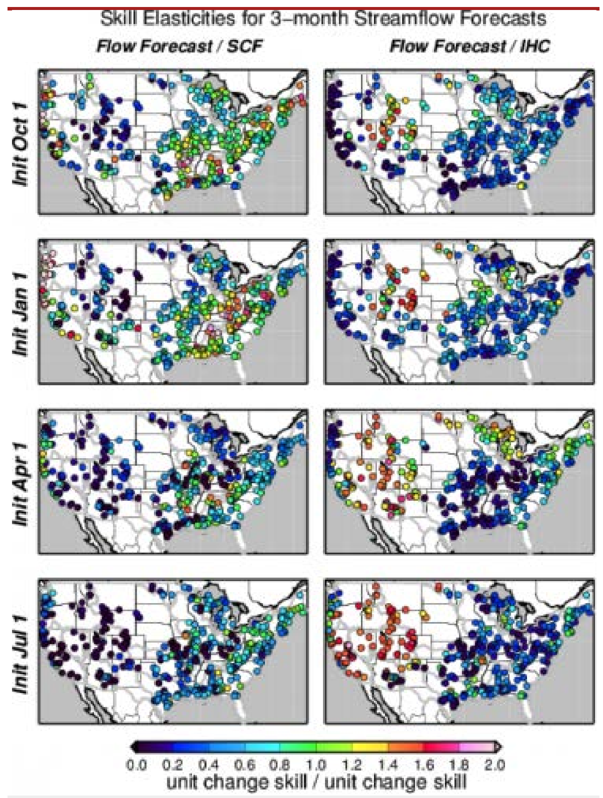

Figure 1. Skill elasticities for 3-month streamflow forecast initialized on four dates. Elasticities are the percent change in flow forecast skill relative to percent changes in seasonal climate forecast (SCF) skill (left) and to initial hydrologic condition (IHC) skill (right).

Meeting this demand requires integrating different types of quantitative meteorological analyses and forecasts with state-of-the-art models of environmental processes (e.g., hydrology, crop yield, ecosystems, etc. Essential technical capabilities include (1) ensemble methods for high-resolution meteorological analyses; (2) ensemble high-resolution meteorological forecasts from merged radar and NWP systems (lead time of 0-72 hours); (3) ensemble downscaling of global-scale numerical weather prediction forecasts (lead time of 1-14 days); (4) ensemble local-scale meteorological time series conditioned on seasonal climate outlooks (lead time of 0-12 months); (5) environmental models with advanced data assimilation capabilities; and (6) statistical post-processing methods to improve the probabilistic information content in environmental forecasts.

FY2014 ACCOMPLISHMENTS

In FY2014, NCAR undertook several studies focusing on hydrologic predictability. Through collaboration with the Bureau of Reclamation and the U.S. Army Corps of Engineers, one project

sought to quantify the major sources of skill and uncertainty in hydrologic predictions from minutes to seasons ahead, over a CONUS-wide domain. Highlights from this project included the following:

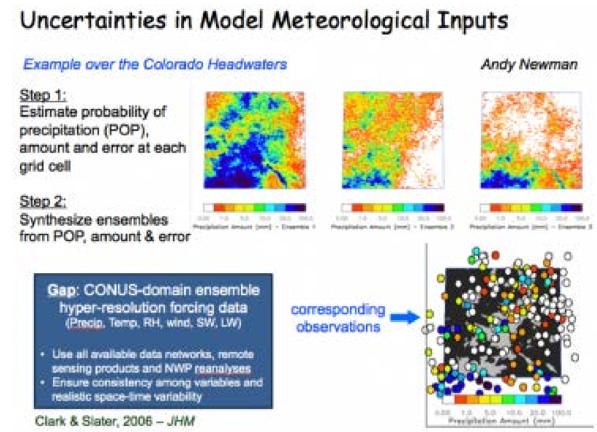

Figure 2. Input uncertainty for hydrological modeling can be represented by creating ensembles of model forcings that include uncertainties estimated from the spatiotemporal correlations between meteorological observations.

(1) A comprehensive analysis of hydrologic predictability at monthly to seasonal scales. For 424 watersheds, ensemble hindcasts were initialized on a monthly basis for a 30 year historical period, and the resulting zero-lead forecasts of streamflow for the 1, 3 and 6 month periods following the initialization are evaluated. The hindcasts supported the estimation of derivatives in predictability throughout the initial conditions and future forcing space to illustrate how science investments can improve streamflow forecasts. These flow forecast skill elasticities (relative to skill in either predictability source) depicted regional, seasonal and predictand variations in flow forecast skill dependencies (Fig 1). Among other key findings, the results suggest that climate forecast skill improvements can be amplified in streamflow prediction skill, which means that climate forecasts may have greater benefit for monthly-to-seasonal flow forecasting than is apparent from climate forecast skill considerations alone.

(2) The first large-scale CONUS-wide probabilistic meteorological forcing dataset, which forms a key building block for uncertainty-based hydrologic prediction. This study develops a gridded, observation-based 100-member ensemble of precipitation and temperature at a daily increment for the period 1980-2012. Statistical verification of the ensemble indicates it has generally good reliability and discrimination of events of various magnitudes, but has a slight dry bias for high probability events. The ensemble mean is similar to another widely used hydrometeorological dataset but with some important differences. The ensemble product is able to produce an improved probability of precipitation field, which impacts the empirical derivation of other fields used in land-surface and hydrologic modeling. Elevation lapse rates for temperature are derived directly from the observations, resulting in substantially different temperatures at high elevations in the intermountain western US. Finally, ensemble forcing allows for the estimation of forcing uncertainty through the use of the ensemble variance.

NCAR also participated in regional-scale forecasting research. The Tennessee Valley Authority (TVA) is implementing the Sacramento Soil Moisture Accounting (SAC-SMA) model for real time flood and water supply forecasting, and is interested automatic hydrologic data assimilation as an alternative to forecasters making manual modifications to keep model states and outputs in line with observations. With sponsorship from TVA, NCAR collaborated with Riverside Technologies Incorporated and Deltares on a pilot study to compare the performance of several data assimilation (DA) approaches -- ensemble Kalman filter and particle filter -- for a number of TVA watersheds. Using the Delft Flood Early Warning System (FEWS) and a data assimilation platform, OpenDA, developed by Deltares, three years of daily hindcasts (6 hour timestep, 7 day lead time) were generated and analyzed with various uncertainty parameterizations, for four watersheds. Model input precipitation and states were perturbed to improve the simulation of observed streamflow (example shown in Figure 3). Both DA approaches were able to adjust the model to reproduce observed streamflow, correcting for input precipitation errors, but the Kalman filter provided better ensemble

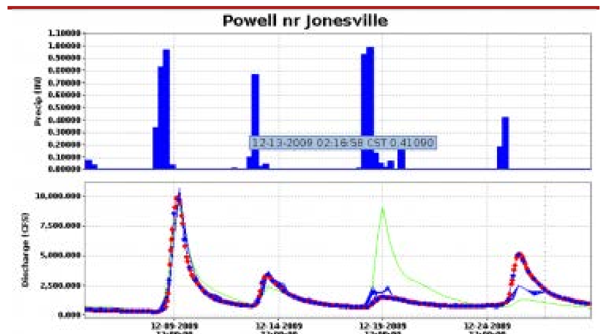

Figure 3. The particle filter ensemble analysis (blue lines) with the observations (blue and red dotted) and open-loop simulation (green). The automatic DA helped the simulation avoid errors arising from estimated meteorological inputs.

spread in the analysis. Both methods improved upon open-loop simulations for initializing forecasts, but only at the shorter lead times (out to about a day), suggesting that further constraints on model state adjustments are required.

FY2015 PLANS

The streamflow predictability project is turning toward the application of various new approaches to enhance forecast skill in a set of approximately three dozen case study basins in CONUS. In particular, weather and climate forecast ensembles will be downscaled and calibrated to watershed scales, and data assimilation (via particle filter) and streamflow post-processing will be used to improve streamflow simulation and forecasts. Several of the case studies in Colorado and the Pacific Northwest will be conducted with the involvement of water agency managers and operators to provide insight into the value of alternative forecasting strategies to support water sector decisionmaking. The predictability project will also proceed to a new phase in which new ensemble forecast methods and datasets are demonstrated and evaluated in real-time, experimental forecasting for lead times of hours to seasons.

Publications

Several papers have been submitted describing (i) the nationwide calibration effort; (ii) the predictability study; and (iii) the PQPE analysis.

- Newman, AJ, Clark, MP., Sampson, K, Wood, A, Hay, LE, Bock, A., Viger, R, Blodgett, D, Brekke, L, Arnold, JR, Hopson, T, and Duan, Q, 2014: Development of a large-sample watershed-scale hydrometeorological dataset for the contiguous USA: dataset characteristics and assessment of regional variability in hydrologic model performance, Hydrol. Earth Syst. Sci. Discuss., 11, 5599-5631, doi:10.5194/hessd-11-5599-2014.

- Wood, AW, T Hopson, AJ Newman, L. Brekke, J. Arnold, M Clark, 2014, Quantifying streamflow forecast skill elasticity to initial condition and climate prediction skill. J. Hydrometeorology (in review)

- Newman, AJ, MP Clark, J Craig, B Nijssen, A Wood, E Gutmann, N Mizukami, L Brekke, and JR Arnold, 2014, Gridded Ensemble Precipitation and Temperature Estimates for the Contiguous United States. *J. Hydrometeorology* (submitted).

‹ Winter Weather | up | Multi-scale, multi-physics hydrological modeling with the Community WRF-Hydro System ›

MULTI-SCALE, MULTI-PHYSICS HYDROLOGICAL MODELING WITH THE COMMUNITY WRF-HYDRO SYSTEM

BACKGROUND

Terrestrial hydrologic processes that control the spatial and temporal distribution of water on and within the land surface are active over a large range of scales. Therefore, effective representation of these processes requires flexible, multi-scale modeling capabilities that can be adapted to meet the needs of a diversity of hydrological settings. The community WRF-Hydro modeling framework is addressing these needs by providing an extensible model structure for representing distributed hydrologic processes in both stand-alone, uncoupled and fully-coupled environmental prediction systems such as the Weather Research and Forecasting (WRF) model, the NASA Land Information System (LIS) or the Community Earth System Model (CESM). WRF-Hydro development follows the WRF modeling paradigm of relatively simple extensibility of model physics within the existing WRF modeling framework. This extensibility permits rapid integration of new model components which can be implemented for hypothesis exploration on new model formulations or for increasing the range of earth system processes being represented.

Publically released in April 2013, the WRF-Hydro modeling system is finding rapid use in the U.S. and in countries around the world by research groups and operational prediction agencies. With a growing domestic and international network of model developers users and increasing record of improved model skill, WRF-Hydro is becoming an important community resource for hydrometeorological and hydroclimatological prediction and earth system research. Version 2 updates to the WRF-Hydro released in April 2014 included support for the NoahMP land surface model, improved representation of lakes and reservoirs, improvements to reach-based channel routing methodologies and enhancements to the representation of groundwater processes contributing to streamflow (Gochis et al., 2014). Another major set of improvements to WRF-Hydro system includes the way in which memory is managed and support large netcdf files which, collectively, improve model performance for large-domain, continental-scale applications. The WRF-Hydro development team also continues to produce a number of different pre- and post-processing and visualization tools to support the use of WRF-Hydro. These include ArcGIS tools for defining and attributing routing grids and stream channels, Unidata IDV and GoogleMaps (Figure 1) applications for scalable mapping of WRF-Hydro output with other geospatial information, ncl-based scripts for rapid comparison of simulated or predicted versus observed streamflow conditions. Combined these capabilities are evolving the community WRF-Hydro system into a more robust earth system modeling capability.

WRF-HYDRO IN SUPPORT OF NATIONAL WATER PREDICTION NEEDS

This kind of multi-scale, multi-physics earth systems modeling approach has been gaining increased interest from both operational prediction agencies and water management agencies as they seek to meet the demands of multiple user communities and as a means to integrate new research models into operations. During the latter part of 2013 the WRF-Hydro team entered into a collaboration with the NOAA Office of Hydrological Development (OHD) in an effort to evaluated the

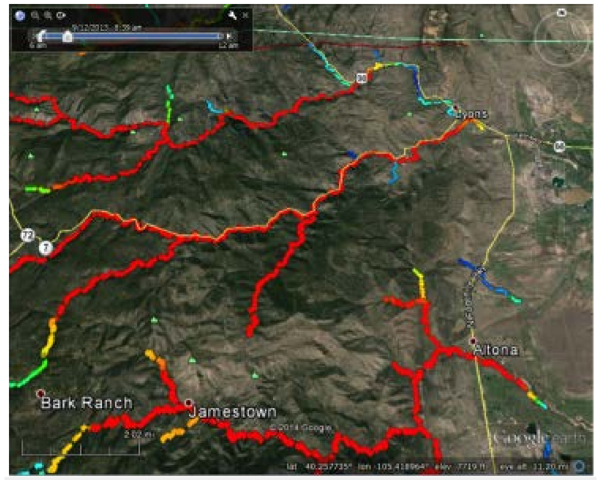

Figure 1: GoogleEarth visualization of simulated streamflow at approximately 08:40 UTC during the Sept 2013 Colorado Front Range Floods as multiple flood waves were impacting the town of Lyons, Colorado. Colored values indicate volumetric streamflow values ranging from low values (blue) to high values (red). The image shown is

WRF-Hydro system as part of a national water modeling capability for the U.S. This partnership has been extended as the WRF-Hydro system is now being deployed for the entire CONUS domain as one potential Initial Operating Capability (IOC) for the new National Water Center (NWC) in Tuscaloosa, Alabama. Benchmark tests are underway to define the computational and model quality performance and requirements for unified national streamflow prediction. Work on this effort has accelerated progress on expanding WRF-Hydro's high performance computing capabilities and the code is now being executed using 1,000s of compute cores and tested several different research supercomputers, such as the National Science Foundation's 'yellowstone' supercomputer and the University of Texas 'stampede' and 'lonestar' supercomputers.

This new CONUS capability is also being utilized to help support another community effort called the National Flood Interoperability Experiment (NFIE) which is being coordinated through the CUAHSI community and the NWC. The NFIE is being designed as research demonstration project to assess the feasibility of national scale flood forecasting and inundation mapping. Under the NFIE, CONUS domain operational cycles of the WRF-Hydro system will occur in the summer of 2015 with WRF-Hydro providing water cycle forecasts of soil moisture, runoff, evapotranspiration, snowpack and streamflow at approximately 3km grid resolution. Streamflow will be modeled using the reach-based RAPID channel routing model that was added as a new WRF-Hydro channel routing component during the summer of 2014 in collaboration with researchers from the U. of Texas at Austin. The RAPID model leverages the massive effort in data infrastructure invested in the NHDPlus version 2 data set that was developed by the U.S. Geological Survey and the Environmental Protection Agency.

WRF-HYDRO COMMUNITY APPLICATIONS AND CAPABILITIES

In a broader context, WRF-Hydro is experiencing an increasing breadth of modeling applications by its growing community of developers and users. One major innovation that is currently underway is aimed at developing and supporting a community platform for hydrologic data assimilation using WRF-Hydro. Recently, the WRF-Hydro system was coupled into the community Data Assimilation Research Testbed (DART) system. This new capability called 'Hydro-DART' provides a new, flexible and extensible framework for performing ensemble-based methodologies for data assimilation. Work with Hydro-DART is currently focusing on evaluating methods and limitations of various hydrologic data assimilation approaches and sources of data for key water cycle variables such as snowpack, soil moisture, groundwater and river stage.

During 2014, the WRF-Hydro team initiated a collaboration with the NOAA Hydrometeorological Testbed research group to explore the opportunities and limitations in ensemble hydrologic prediction using uncoupled, stand-alone and fully-coupled implementations of WRF-Hydro with the WRF atmospheric model. This work is focusing on diagnosing the limitations in forecast spread and skill under a host of different ensemble generation methodologies for an extreme rainfall event that occurred on July 27, 2013 in central-western North Carolina. In addition to time-lagging other ensemble member generation methodologies include multiple physics selections (boundary layer and cloud microphysics parameterizations), land surface model complexity and initial soil moisture state. Findings to date

suggest that while there are limitations to reproducing the exact timing, location and intensity of this extreme event, many features of the event such as the general region and timing of heavy rainfall are predictable in a probabilistic sense and that the predicted location of particular type of convective event is sensitive to specification of initial soil moisture conditions.

The WRF-Hydro system continues to attract a growing community of international users. Recent applications of WRF-Hydro include new applications in western Argentina, in Thailand, in Italy and in various locations throughout the Middle East and south Asia/Himalaya. Specific applications in these regions include studying the impact of atmospheric model data assimilation on flash flood forecasts in the Black Sea region of Turkey (Yucel et al., 2014), operational, national-scale, fully-coupled streamflow prediction for the nation of Israel (Givati et al., 2014), exploration of climate change impacts on water resources in the Himalayan/Hindu Kush region (Lu et al., 2014) and exploration of the impact of 3-dimensional groundwater representation on land-atmosphere fluxes in the pre-alpine region of the German Alps. Figure 2 shows observed versus simulated streamflow from the WRF-Hydro system.

FY2015 PLANS

Looking forward to 2015, the WRF-Hydro team will release v2.1 of WRF-Hydro to the community. Several community-based efforts to improve the functionality and utility of the WRF-Hydro system through projects like the NSF EarthCube initiative and a joint NSF-EU program to improve cyberinfrastructure for hydrometeorological predictions between the U.S. and European countries are expected to expand. A series of new collaborations with research and operations groups in the U.S. and abroad will be initiated to address a host of water cycle prediction problems. These projects include the development of new partnerships with the U.S. Geological Survey to employ a physics-based landslide modeling capability, working with the U.S. Bureau of Reclamation dam safety team in the development of physics-based scenarios for extreme runoff events as it relates to the sustainability of aging water supply dams in the western U.S. and working with the State of Colorado to improve seasonal snowpack and streamflow predictions in the Upper Rio Grande basin. As evaluations are made and knowledge is harvested from these and other projects, continued improvement and expansion of the community WRF-Hydro system is anticipated.

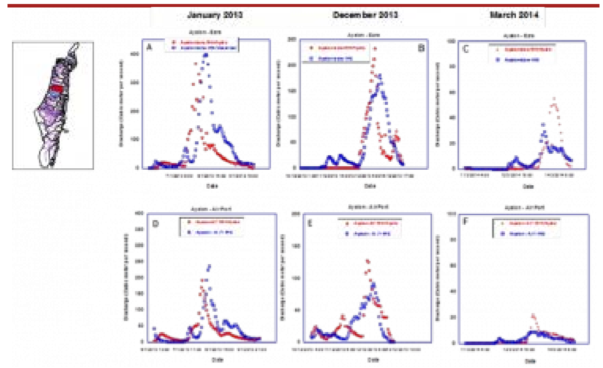

Figure 2: Uncoupled WRF-Hydro simulated river discharge (in red) vs. observed discharge (in blue) for 3 different flood events at 2 hydrometric stations within the Ayalon basin (shown in inset map) in Israel: Ayalon-Ezra station (top row, A-C) and the Ayalon basin near the Ben Guirion Airport (D-F). [From Givati et al., 2014]

References

Givati, A., E. Fredj, T. Rummler, D. Gochis, M. Silver, H. Kunstmann, W. Yu, 2014: Using the fully coupled WRF-Hydro model for extreme events flood at Mediterranean basins. *In preparation.*

Gochis, D.J., W. Yu, D.N. Yates, 2014: The WRF-Hydro model technical description and user's guide, version 2.0. NCAR Technical Document. 120 pages. Available online at: http://www.ral.ucar.edu/projects/wrf_hydro/.

Li., L. D. J. Gochis, M. d. S. Mesquita, 2014: WRF-Hydro Simulation of the Himalayan Beas River Basin. *In preparation.*

Mahoney, K., D. Gochis and W. Yu, 2014: The sensitivity of a coupled hydrometeorological flash flood forecast to model physics and initial state perturbations: A WRF-Hydro demonstration. Presentation at the 2014 Annual WRF User's Workshop, Boulder, CO, USA.

Yucel, I., A. Onen, K. Yilmaz, and D. Gochis, 2014: Calibration and Evaluation of a Flood Forecasting System: Utility of Numerical Weather Prediction Model, Data Assimilation and Satellite-based Rainfall. Accepted with revisions, *J. Hydrology*.

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CLIMATE CHANGE AND WATER

BACKGROUND

Water is a precious commodity underpinning not only the global economy, but also our quality of life. The U.S. federal agencies managing the availability and distribution of this basic necessity face a variety of challenges every year in ensuring a high-quality, always-ready resource to meet public and private demands, and to manage flood risks and drought responses around the nation. Recognizing that climate change is exacerbating these challenges, and to help managers better plan for and respond to climate change effects on water resources, the Bureau of Reclamation (Reclamation), U.S. Army Corps of Engineers (USACE), and National Center for Atmospheric Research (NCAR) are collaborating to improve our understanding of water resource-related climate effects. In addition, they are testing and improving some of the important management tools that the water resources community relies on to fulfill their federal missions to manage water resources in the best national interest.

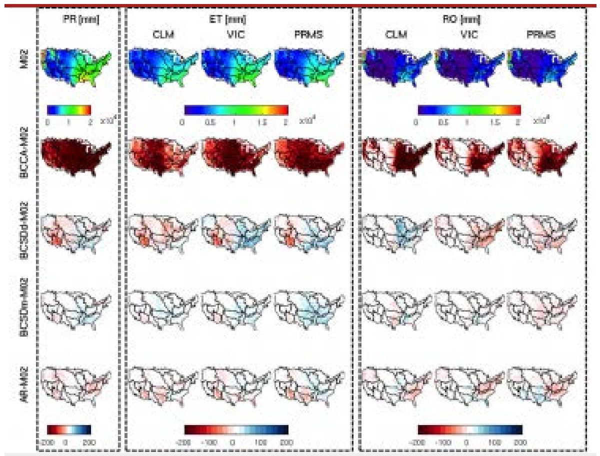

Figure 1. Bias of downscaled annual precipitation and simulated water balance (ET and Runoff) for three different hydrologic models (CLM, VIC and PRMS) forced by output from four different statistically downscaled methods (BCCA, BCSDd, BCSDm, and AR). The bias is relative to gridded observations and simulations forced by the Maurer et al. 2002 dataset (M02).

The first stage of the research addresses the question: “How does the portrayal of climate change impacts depend on the selection of downscaling methods and the selection and configuration of hydrologic models?” This comprehensive analysis of methodological shortcomings provides the user community with guidance on appropriate methods for climate impact assessments. The project helps identify limitations of the current generation of statistical downscaling methods and hydrologic modeling applications and articulates key research needs to improve assessments of climate change impacts on water resources. Ongoing research on developing new downscaling methods and new hydrologic modeling approaches will both improve the characterization of uncertainty in climate change assessments and reduce costs of individual basin studies.

FY2014 ACCOMPLISHMENTS

Reclamation, USACE, and other water management agencies have an interest in developing reliable, science-based methods for incorporating climate change information into longer-term water resources planning. Such planning assessments must quantify projections of future climate and hydrology. The common practice is to begin by developing relationships between current observed climate and climate projections over the assessment region. Because

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the spatial resolution of global climate projections is not adequate for local to regional hydrologic assessments, this step relies on some form of spatial downscaling and bias correction, which produces watershed scale weather information to drive simulations of hydrologic and other water management conditions (e.g., water demands, water quality, environmental habitat.

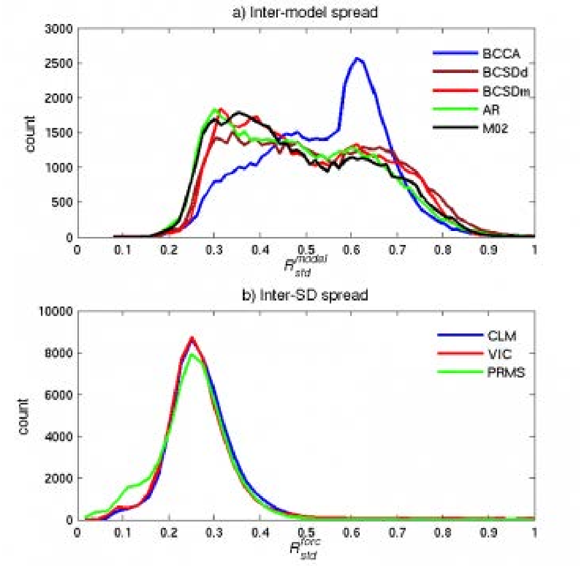

Figure 2. Histograms of inter-model spread index (a) and inter-forcing spread (b) of monthly runoff over the CONUS.

Water agencies continue to face decisions about the selection of downscaling method(s) and the selection and configuration of hydrological models, and of observational datasets. There is a critical need to understand the ramification of these methodological decisions, as they affect the signal and uncertainties produced by climate change assessments, and, thus, the effectiveness of these results to support adaptation planning and decision making.

The project has found that there is indeed reason for concern over methodological choices. In a recent paper submitted to the *Journal of Hydrometeorology* [*Mizukami et al.*, 2014] we examine the effects of four different statistical downscaling methods (Bias Corrected Constructed Analogue - BCCA, Bias Corrected Spatial Disaggregation applied at daily and monthly scales - BCSDd and BCSDm, and Asynchronous Regression - AR) on retrospective hydrologic simulations using three different hydrologic models with their default parameters (Community Land Model 4.0, Variable infiltration Capacity Model 4.1.2, and Precipitation Runoff Modeling System 3.0.4) over the contiguous United States (CONUS). Results show that each statistical downscaling method produces unique meteorological portrayals including precipitation amount, frequency and the energy input (i.e., shortwave radiation), and their interplay affects precipitation partitioning between evapotranspiration and runoff (Figure 1). The analyses show that BCCA underestimates annual precipitation by as much as 250 mm, leading to unreasonable hydrologic portrayals over the US for all models (Figure 1). Although the other three statistical downscaling methods produce smaller precipitation biases ranging from -50 to 30 mm across the US, BCSDd severely overestimates the wet-day frequency by up to 0.25, leading to different precipitation partitioning compared to the simulations with other downscaled data. Overall, the choice of downscaling method contributes to less spread in runoff estimates than the choice of hydrologic model with use of the default parameters (Figure 2).

Other key publications from this research area include:

- Gutmann et al. [2014] compared the performance of popular statistical downscaling methods across the contiguous USA. Many statistical downscaling methods that are popular in the water management community produce hydroclimate representations with too much drizzle, too small extreme events, and improper representation of spatial scaling characteristics that are relevant to hydrology. These deficiencies vary by method, significantly impacting results.

- Rasmussen et al. [2014] used 4-km dynamically downscaled simulations from the Weather Research and Forecasting (WRF) model to examine climate change impacts on the water balance in the Colorado Headwaters region. The climate sensitivities obtained from the 4-km WRF simulations differ from current statistically-based guidance being provided to water managers. WRF shows wintertime increases in precipitation in the Colorado Headwaters that are consistent with a warmer and moister atmosphere, and occur when topography is adequately resolved by the regional climate model.

- Mendoza et al. [2014] demonstrated that the choice of hydrologic model also affects projection outcomes, though less so if a hydrology model is well calibrated. Popular calibration procedures only constrain the range of climate change impacts for metrics that are closely related to the objective function used in calibration. For example, minimizing errors in simulations of observed streamflow reduce inter-model differences for mean change in the future, but does not improve model agreement on the flashiness, seasonal timing, or low flow rates. The use of uncalibrated hydrology models, as is common in regional or larger scale assessments, is ill-advised, and there is a clear need to implement more comprehensive (multi-objective) calibration schemes that consider multiple attributes of model behavior.

- Clark et al. [2014a; b] developed an experimental modeling system, termed SUMMA (the Structure for Unifying Multiple Modeling Alternatives) to evaluate the suitability of different approaches to simulate water and energy fluxes from the top of the vegetation to the depth of active groundwater. SUMMA is based on a general set of governing model equations, with flexibility in the choice spatial architecture, process parameterizations, parameter values, and numerical solvers. SUMMA is now being applied to climate risk assessments by using multi-parameter, multi-parameterization, and multi-architecture ensembles to represent uncertainty in hydrologic model simulations.

FY2015 PLANS

The project team is currently focused on efforts to develop and demonstrate improved methods for downscaling methods and hydrologic modeling. On downscaling, the effort considers advanced hybrid statistical-dynamical downscaling methods to provide a realistic depiction of physical processes at a low computational cost. These methods improve hydrologically relevant metrics, such as the spatial representation of extreme precipitation events, and can be applied to a large range of climate scenarios. On hydrologic assessment, the effort employs a multi-model approach with multiple advanced calibration strategies to reduce simulation errors and improve characterization of uncertainty in hydrologic models. Improved hydrologic models and more physically realistic downscaling implementation will lead to more dependable projections, and ultimately improve decision support.

References

Clark, M. P., B. Nijssen, J. Lundquist, D. Kavetski, D. Rupp, R. Woods, E. Gutmann, A. Wood, L. Brekke, J. Arnold, D. Gochis, R. Rasmussen, D. Tarboton, V. Mahat, G. Flerchinger, and D. Marks (2014a), A unified approach to process-based hydrologic modeling. Part 1: Modeling concept, *Water Resources Research*, (under review).

Clark, M. P., B. Nijssen, J. Lundquist, D. Kavetski, D. Rupp, R. Woods, E. Gutmann, A. Wood, L. Brekke, J. Arnold, D. Gochis, R. Rasmussen, D. Tarboton, V. Mahat, G. Flerchinger, and D. Marks (2014b), A unified approach for process-based hydrologic modeling: Part 2. Model implementation and example applications, *Water Resources Research*, (under review).

Gutmann, E., T. Pruitt, M. P. Clark, L. Brekke, J. Arnold, D. Raff, and R. Rasmussen (2014), An intercomparison of statistical downscaling methods used for water resource assessments in the United States, *Water Resources Research*, doi: 10.1002/2014WR015559.

Mendoza, P., M. P. Clark, N. Mizukami, A. J. Newman, M. Barlage, E. Gutmann, R. Rasmussen, B. Rajagopalan, L. Brekke, and J. Arnold (2014), Effects of hydrologic model choice and calibration on the portrayal of climate change impacts, *Journal of Hydrometeorology*, (under review).

Mizukami, N., M. P. Clark, E. Gutmann, P. Mendoza, A. J. Newman, B. Nijssen, B. Livneh, L. Hay, J. Arnold, and L. Brekke (2014), Implications of the methodological choices for hydrologic portrayals over the Contiguous United States: statistically downscaled forcing data and hydrologic models, *Journal of Hydrometeorology*, (under review).

Rasmussen, R., K. Ikeda, C. H. Liu, D. Gochis, M. P. Clark, A. Dai, E. Gutmann, J. Dudhia, F. Chen, M. Barlage, D. Yates, and G. Zhang (2014), Climate Change Impacts on the Water Balance of the Colorado Headwaters: High-Resolution Regional Climate Model Simulations, *Journal of Hydrometeorology*, doi: 10.1175/JHM-D-13-0118.1.

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CLIMATE RISK MANAGEMENT

BACKGROUND

A number of projects conducted within RAL focus on assisting decision and policy-makers in better understanding the impact of climate change and extreme weather events on water resources. Using the Water Evaluation and Planning (WEAP) model, co-developed by Dr. David Yates and scientists at the Stockholm Environment Institute, we are helping to address the growing need around the globe for new tools and methods to assess the impact of future climate-predicted precipitation on water availability and quality. By coupling physical hydrology and water planning and management information within a single framework, WEAP can be used by planners and managers to develop scenarios and strategies for more robust water management decision-making in their watershed, city or state. In addition to the WEAP model, RAL scientists work with stakeholders to adapt regional and global climate models and datasets to their needs. Education, training, and capacity building are fundamental components of this risk management effort.

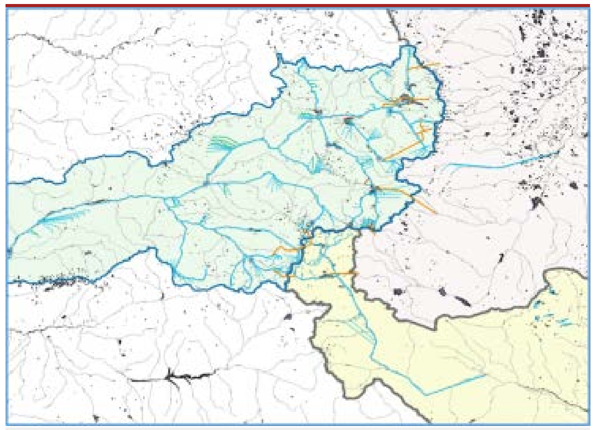

Fig. 1. West Slope WEAP model (WsWEAP), with inset showing the Upper Blue River basin, which a main water supply source for both Denver Water and Colorado Springs Utilities.

FY2014 ACCOMPLISHMENTS

Decision-centric adaptation appraisal for water management across Colorado’s Continental Divide

In collaboration with Robert Wilby, University of Loughborough U.K, and Laurna Kaatz, Denver Water, RAL scientists Kathy Miller and David Yates developed an experimental application of a decision-centric approach for evaluating climate adaptation options. The team modelled the operation of Denver Water’s Upper Colorado Basin reservoirs and transbasin water diversions as conditioned by the existing legal definitions of their water rights, and the agreements and management protocols that govern storage operations and downstream flow obligations. The model was built on the Water Evaluation and Planning (WEAP) platform, and is referred to as the ‘West Slope’ supply model (WsWEAP; Figure 1) as it is also being used for some work with Colorado Springs Utilities.

The WsWEAP model was developed and used to simulate the performance of the water management system under plausible scenarios of future climate change and associated changes in watershed conditions both with and without a specific drought mitigation policy in place. Specifically, the team illustrated its approach by simulating the performance of the Shoshone Call Relaxation Agreement (SCRA) [the adaptation measure], using the WsWEAP model [the hydrologic cycle and water systems model]; and the Statistical DownScaling Model (SDSM-DC) [the stochastic scenario generator]. Scenarios relevant to the decision community were analyzed, and results indicate that this drought management measure

would provide a very small benefit in offsetting the impacts of a shift to a warmer and drier future climate coupled with related environmental changes. The analysis demonstrates the importance of engaging water managers in the development of credible and computationally efficient decision support tools that accurately capture the physical, legal and contractual dimensions of the decision problem. A paper describing this work has been submitted to the journal *Climate Risk Management* and attached with this report.

A major accomplishment is the submission of a paper to the Journal of Climate Risk Management, (Yates, D., K. Miller, R. Wilby and L. Kaatz), *Decision-centric adaptation appraisal for water management across Colorado's Continental Divide,* which has been accepted with minor revision.

Managing Drought in the Apalachicola-Chattahoochee-Flint (ACF) River Basin through the Development of Improved Drought Indicators and Policy Alternatives

This effort, sponsored by the NOAA SARP, is conducted in collaboration with Auburn University. It addresses a key problem in the ACF Basin, rapid expansion of irrigated agriculture in the Flint River Basin, which has contributed to the depletion of streamflows during drought episodes. Such low-flow conditions both imperil a set of endangered mussel species in South Georgia's streams and contribute to inter-state conflict with Florida over the flow of the Apalachicola River at the state line. Part of the RAL work focuses on developing decision models to explain the spatial dynamics of increasing irrigated acreage in the study region under current state law, and under possible new regulations. That work will contribute to the larger project's objective of building the capacity to simulate the spatially-explicit dynamics of groundwater/surface water interactions in the basin. In addition, RAL scientists are examining the within-season temporal dynamics of irrigation demand under varying weather conditions. The models will be used to evaluate the impacts of proposed drought-year water use regulations that might be imposed in response to current inter-state litigation. Results from this project are described in a journal article, co-authored by David Yates entitled, "The Effect of ENSO-Induced climate variability on groundwater levels in the Lower Apalachicola-Chattahoochee-Flint River Basins", *Transactions of the ASABE*, which has been accepted with minor revisions.

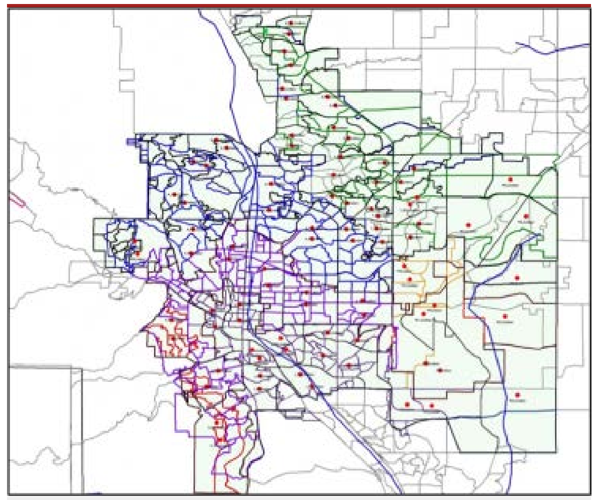

Fig. 2. The spatial extent of the Colorado Springs Utilities WEAP demand model (WEAPDemand).

Water Utilities

RAL scientists Yates and Miller have collaborated with Colorado Springs Utilities (CSU), David Groves of the RAND Corporation, and Casey Brown at the University of Massachusetts in an ongoing Integrated Water Resource Planning (IWRP) planning process being undertaken by CSU. The IWRP seeks to develop a long-term strategic plan, to provide a reliable, sustainable water supply in a cost-effective manner. It is a holistic approach to water resource planning that incorporates water supply and demand analysis, water quality aspects, infrastructure reliability, environmental protection, water reuse, financial planning, energy use, regulatory and legal concerns, and public participation. In support of the IWRP, Yates has developed models of the CSU water supply and demand systems, including a 'West Slope' supply model (WsWEAP; Figure 1 above) and a detailed spatial-multiple regression model of indoor and outdoor, residential and commercial water demand for the city of Colorado Springs (CSUDemand; Figure 2). Both models are built on the Water Evaluation and Planning (WEAP) platform, with their novelty being that both explicitly consider climate variables in simulating the water supply and demand. Since they are both climatically driven models, they can directly explore the implications of climate variability and change on important water system reliability metrics that are being defined through CSU's IWRP process. Working with Casey Brown and his graduate students, Yates is helping define future climate projections, which are considered in both models. Figure 1 shows the geographic domain of the WsWEAP model, which is the same model used in the work with Denver Water, while Figure 2 is a screen-capture of the CSUDemand model.

A major accomplishment from this work is the recently published report from the Water Research Foundation, co-authored by David Yates, Developing Robust Strategies for Climate Change and Other Risks: A Water Utility Framework [October 2014, Project #4262]

Pathways to Water Resilience in Da Nang City, Vietnam

This goal of this work is to ensure that planning for future water resource needs for Da Nang City is resilient to potential climate change impacts. This work has involved assessment of current water availability and quality, evaluation of water

access and consumption in the city, and water stresses affecting vulnerable population groups. Using this information, the P.I., Dr. David Yates has developed scenarios for future water supply and demand in the city using the Water Evaluation and Planning (WEAP) model developed by the Stockholm Environment Institute. Yates then trained a core technical group drawn from city government departments in setting up and using WEAP to simulate future water resource scenarios for Da Nang under plausible future development and climate conditions and to provide targeted input for a new Asian Development Bank-funded water supply project. The major accomplishment of this project has been the development of a useful water systems model for the evaluation of future water system planning by the City of Da Nang.

USAID: Be Secure, Philippines

RAL is a project partner in the Water Security for Resilient Economic Growth and Stability (Be Secure) Project in support of USAID/Philippines. This effort seeks to support water security in selected sites in the Philippines by increasing sustainable access to water supply services and wastewater services, and increasing resilience to climate-related water stress and hydrologic extremes. In partnership with AECOM and local groups, RAL is providing the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) with technical and training assistance to improve its ability to share, use and manage weather and climate and hydrometeorological data, forecasts, and future climate projections to improve analysis and data management capacity and enhance regional weather forecasting capabilities in the country.

This is a new project that began in the fall of 2014. A major accomplishment has been the execution of a one-week training on tropical cyclones in Manila in November 2014. PAGASA scientists will be visiting NCAR in the winter of 2015 to participate in the WRF training.

USAID: PARA-Agua, Latin America

Climate change is negatively impacting water resources, agriculture and ecosystems in the Latin America and Caribbean (LAC) region. Increasing temperatures are altering hydrological cycles, affecting crop productivity and biodiversity, changing ocean currents, and causing more frequent and extreme weather events, leading to more intense flooding and drought. Andean glaciers and *páramos*, vital sources of fresh water for tens of millions of people, are under severe threat. To meet these challenges, a new regional program has been launched by USAID entitled “Partnering for Adaptation and Resilience – Agua” (PARA-Agua) to work directly with scientists, decision-makers, and communities to strengthen watershed resilience to climate change impacts.

RAL contributes to this effort by developing climate information for pilot basin-scale applications. Regional climate data and projections from Global Climate Model results archived through the Inter-Governmental Panel on Climate Change Assessment Report-5 (IPCC-AR5) are being assembled to create a rich data set for use in the evaluation of potential adaptation actions at the watershed scale. Together, these data and data processing techniques will result in a collection of current and future climate projections that are un-biased, and suitable for use in hydrologic and water resources simulation models such as WEAP. Regional climate model results are being generated for the Northern Andes, with the datasets analyzed for their representativeness of the regional climate so that they may be adapted for use in other LAC sub-regions. In addition, RAL scientists are providing technical assistance in the use of the regional and global model scenarios and their associated data to populate WEAP models for future use by regional stakeholders.

A major accomplishment of this project is the development of a dataset that includes global bias corrected climate model output files from version 1 of NCAR's Community Earth System Model (CESM1) that participated in phase 5 of the Coupled Model Intercomparison Experiment (CMIP5), which supported the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5). The dataset contains all the variables needed for the initial and boundary conditions for simulations with the Weather Research and Forecasting model (WRF) or the Model for Prediction Across Scales (MPAS), provided in the Intermediate File Format specific to WRF and MPAS. The data are interpolated to 26 pressure levels and are provided in files at six hourly intervals. The variables have been bias corrected using the European Centre for Medium-Range Weather Forecasts (ECMWF) Interim Reanalysis (ERA-Interim) fields for 1981-2005. Files are available for a 20th Century simulation (1951-2005) and three concomitant Representative Concentration Pathway (RCP) future scenarios (RCP4.5, RCP4.5 and RCP8.5) spanning 2006-2100. An NCAR technote is being written that describes this dataset: “A description of DS316.0, Global 6-hourly Bias-corrected CMIP5 CESM Files in WRF/MPAS Intermediate Format” by A. Monaghan, D. Steinhoff, C. Bruyere, and D. Yates.

Superstorm Sandy

In 2013-14 RAL scientists examined the impact of Superstorm Sandy on the electrical power infrastructure in the northeastern U.S. This storm caused loss of electric service to over 90% of the Long Island Power Authority’s 1.1 million customers, and repair costs have approached $1 billion. This case study brought together researchers and practitioners from the atmospheric and environmental sciences, risk analysis industry, and the electric power sector to explore ways to

integrate their respective disciplines to consider how climate change science can be introduced as a design input for electric infrastructure analysis. Analysis focused on surface winds and their impact on storm surge, and on precipitation and associated flooding throughout the region after landfall. These objectives were achieved by simulating, in detail, Superstorm Sandy as it occurred and under future climate conditions, and then using modeling output to conduct hazard and impact analysis. Increased understanding and advanced computer simulation that integrates state-of-the-art weather, impact, and damage models will help in societal and economic analyses for improved storm hardening, enhancing preparedness and planning emergency responses. Results from this study were published in a special issue of the *IEEE Power and Energy* magazine devoted to climate change adaptation (Yates et al, 2014).

Public Health Benefits of Green House Gas Mitigation: Abu Dhabi

RAL is working with the Climate Change Research Group to assist the Environmental Agency of Abu Dhabi in developing a climate change research program to assess impacts, vulnerabilities and adaptation at the city, national (UAE), and regional (Arabian Gulf) scales. RAL scientists are conducting regional climate modeling studies aimed at determining how temperature, precipitation, winds, radiation and humidity are expected to change in the region due to increasing concentrations of greenhouse gases. Self-organizing map techniques are being used to identify weather systems that produce the poorest air quality in Abu Dhabi, allowing us to use a small number of highly representative inputs to the air quality model. These inputs, along with pollutant source emissions developed by CCRG, will be used to drive the Community Multi-scale Air Quality model in examining different time periods and emission scenarios. A database for meteorological conditions, source emissions and air quality attributes associated with GHG mitigation strategies is also being produced to ultimately estimate public health co-benefits from differing policy responses to changes in GHG. This project has just begun, but a workshop was held in Abu Dhabi in October 2014, where the methods of analysis were presented. The major accomplishment has been the deployment of air quality models at NCAR, and merging them.

Regional Atmospheric Modeling under Climate Change for the Arabian Gulf

This project with the CCRG is conducting a Regional Climate Modeling experiment with the goal of developing projections of regional climate for the Arabian Peninsula at fine spatial and temporal scale, that reflect the large-scale features and temporal trends from Global Climate Model (GCM) simulations (AR5), but also the historical patterns of climate variables at the regional and local scale. To achieve this, a regional climate model (RCM) was deployed that dynamically downscaled the climate of the Arabian Peninsula using GCM data for lateral boundary conditions. Improved topographic representation across the domain reflects the taller topographic features of the region, which potentially increases and re-distributes precipitation due to enhanced lifting. The taller topography also provides a cooler environment for precipitation over places like the Oman Mountains as compared to smoothed topography, which will not resolve warm season convection. The data can be used in support of the other climate change impact, vulnerability and adaptation assessments.

This Regional Atmospheric Modeling sub-project demonstrated the development of a novel, bias-corrected global climate model dataset, based on NCAR's Community Climate Systems Model (CCSM4). The CCSM4 was one the IPCC AR5 global climate models, which was bias-corrected to be statistically similar to the European Centre for Medium-Range Weather Forecasting (ECMWF) Interim Reanalysis (ERA-Interim; Dee et al. 2011) dataset. The ERA-Interm is considered to be the most accurate atmospheric reanalysis available at the present time (e.g., Lorenz and Kunstmann 2010). The bias-corrected, CCSM4 dataset was then used as the boundary and initial conditions, for simulating the NCAR Weather Research Forecast (WRF) to dynamically downscale the climate of the 20th century and the future climate based on the RCP8.5 emission pathway. The WRF model was run at spatial resolutions of 36, 12, and 4-km that included a large portion of the Arabian Peninsula. The 12 and 36 KM domains were run for a longer period, 2006 to 2100, while the 4-km domain (D3) was run for two shorter, 10-year periods.

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- Urban Futures
- Weather, Climate and Health
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‹ Climate Risk Management up Socio-ecological Systems in a Changing Climate: Governance and Adaptation ›

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SOCIO-ECOLOGICAL SYSTEMS IN A CHANGING CLIMATE: GOVERNANCE AND ADAPTATION

WATER RESOURCES

In FY 2014 Kathleen Miller led work on a book planned for publication in 2015 by Taylor and Francis entitled: *Western Water Policy and Planning in a Changing and Variable Climate.* This is an edited volume that will serve as a comprehensive resource for both students and practitioners in fields related to water policy and environmental management in the Western United States. As lead editor, Dr. Miller coordinated with her co-editors to develop a conceptual outline and organize the contributions of leading water policy experts for a comparative analysis of the interplay between climate, changing environmental and socioeconomic conditions and the processes governing water policy and planning. She also has led work with the editorial team and chapter authors to identify the key issues to be addressed, and provide editorial feedback on initial submissions. Work on this project will continue during FY 2015.

She also worked with Dr. David Yates, RAL-HAP, Dr. Robert Wilby, Loughborough University, UK, and Laurna Kaatz, Denver Water, to model the operation of Denver's Upper Colorado River Basin reservoirs and transbasin water diversions as conditioned by the existing legal definitions of their water rights, and the agreements and management protocols that govern storage operations and downstream water release obligations. Development of the model required accurately representing both: a) the spatially-explicit physical processes governing runoff in the in the complex Headwaters catchments from which Denver draws approximately 40 percent of its water supplies, and b) the interactions among a complicated set of decision rules governing water management decisions by Denver, the US Bureau of Reclamation and other entities. The model was applied under a range of plausible scenarios of future climate change and associated changes in watershed conditions to simulate the performance of the water management system with and without a specific drought mitigation policy, the Shoshone Call Relaxation Agreement, in place. It was found that while the policy would be beneficial in a warmer and drier future climate, its impact would be very small and would do little to offset the impacts of the scenario itself. A paper describing this work has been submitted to the peer-reviewed journal: *Climate Risk Management*.

That work dovetailed closely with contributions to a USDA-NSF-Water Sustainability and Climate project: "Snowpack and Ecosystem Dynamics: The Sustainability of Inter-basin Water Transfers under a Changing Climate." For that project, Dr. Miller worked on documenting the history and current institutional arrangements governing the major transbasin water diversion projects in Colorado.

In addition, Dr. Miller is working with a team of researchers at Albany State University, GA and Auburn University, GA on an application of regional economic models to estimate the impacts of alternative drought response policies on Georgia's agricultural economy. Work is focusing on irrigated cropland in Georgia's Flint River Basin, and will evaluate the pros and cons of existing drought management policies and proposed policy alternatives that could be used to more effectively manage drought in the basin. In FY 2014 Dr. Miller supervised the work of a graduate student assistant in documenting the relationship between existing water use permits in Georgia's Flint River Basin and acreage actually irrigated as identified by remote sensing. The project is primarily supported by the NOAA-SARP program, with NSF co-sponsorship of part of Dr. Miller's time.

Related Publications

Miller, K.A. and V. Belton, 2014. Water resource management and climate change adaptation: a holistic and multiple

criteria perspective, *Mitigation and Adaptation Strategies for Global Change,* 19(3): 289-308.

Yates, D., K. Miller, R. Wilby and L. Kaatz, *in review.* Decision – centric adaptation appraisal for water management across Colorado's Continental Divide. Submitted to: *Climate Risk Management.*

FY2015 PLANS

In FY 2015 Dr. Miller plans to complete work on the edited volume described above. The book, which is intended as a text for graduate-level and advanced undergraduate courses in environmental and water system management, will comprise 26 chapters including regional sections providing a comparative analysis of governance issues and drivers of change.

Work will continue on the Georgia water policy and drought risk management project. In particular Dr. Miller will work with Dr. Mark Masters, Albany State University, Georgia, in supervising the work of a graduate student assistant on irrigation demand modelling is as a function of growing season precipitation, crop prices, and crop choice. In FY 2015, research will focus on the design of incentive systems for drought year reductions and pumping that could protect streamflows in the Flint River Basin, together with economic impact analysis of such policy options.

In addition, follow-on work is anticipated that would build on the model development undertaken as part of the Denver Water drought resilience project described above, as well as the work on the Water Sustainability and Climate Project. A funding opportunity will be sought to support extension of the analysis to a broader range of paleo-conditioned climate change scenarios, and involving both Western Slope and Front Range water provider participants in defining management options to be explored.

‹ Climate, Weather and Society up Urban Futures ›

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URBAN FUTURES

BACKGROUND

Urban areas play crucial roles in the arena of climate and environmental change, not only as key sources of carbon and other air pollutants, but also as hotspots of vulnerability to water scarcity, floods, heat waves, and other hazards that climate change is expected to aggravate. These roles create a unique opportunity for urban centers to prove their talents as sources of innovations, and laboratories for responses that help transition to more sustainable and more resilient pathways of urban development. The main goal of *Urban Futures* is to integrate different disciplinary domains within NCAR and with other national and international organizations to:

- Explore the dynamics of urbanization and urban systems that shape urban emissions, vulnerabilities and risks
- Investigate urban populations' and decision makers' capacity to respond to climatic and non-climatic hazards and stresses
- Research how particular cities attempt to meet the challenges of reducing emissions (sustainability) while improving their response capacity (resilience) to environmental impacts
- Build capacity to foster urban sustainability and resilience through educational, mentoring and outreach activities at the science-policy interface

2014 ACCOMPLISHMENTS

Explore the dynamics of urbanization and urban systems that shape urban emissions

To begin bridging the gap between the natural, engineering and social sciences, and to more comprehensively focus on urbanization, urban areas and carbon, the US Carbon Cycle Science Program and Carbon Cycle Interagency Working Group (CCIWG) sponsored a workshop on Human-Carbon Interactions in Urban Systems from October 16-18, 2013, at NCAR. The main outcome of this workshop is a thematic set of four papers that synthesize contributions to the study of urbanization and the carbon cycle from the social sciences (Marcotullio et al.), engineering sciences and technology (Chester et al.) and the natural sciences (Hutyra et al), and present a new framework for the study of the urbanization and the carbon cycle that integrates multiple disciplinary perspectives and frameworks (Romero-Lankao et al.).

Independent lines of research on urbanization, urban areas and the carbon cycle have advanced our understanding of some of the processes through which energy and land uses affect carbon. The synthesis paper "A critical knowledge pathway to low carbon, sustainable futures: Integrated understanding of urbanization, urban areas, and carbon" http://onlinelibrary.wiley.com/enhanced/doi/10.1002/2014EF000258/ integrates some of these diverse viewpoints as a first step towards a co-produced, integrated framework for understanding urbanization processes, urban areas and their relationships to the carbon cycle. It suggests the need for approaches that complement and combine the plethora of existing insights into interdisciplinary explorations of how different urbanization processes, and socio-ecological and technological components of urban areas affect the spatial and temporal patterns of carbon emissions differentially over time and within and across cities. It also calls for a more holistic approach to examining the carbon implications of urbanization and urban areas as places, based not only on demographics or income, but also on such other interconnected featuresof urban development pathways as urban form, economic function, economic growth policies and other governance arrangements. It points to a wide array of uncertainties around the urbanization processes, their interactions with urban socio-institutional and built-environment systems, and how these impact the exchange of carbon flows within and outside urban areas. The paper also clarifies the importance of understanding in turn how carbon

feedbacks, including carbon impacts and potential impacts of climate change, can affect urbanization processes. Finally, the paper explores options, barriers and limits to transitioning cities to low-carbon trajectories, and suggests the development of an end-to-end, co-produced and integrated scientific understanding that can more effectively inform the navigation of transitional journeys and the avoidance of obstacles along the way.

Investigate capacity to respond to climatic and non-climatic hazards and stresses

Although mitigation and adaptation goals are, often of necessity, pursued in tandem by local governments, and urban climate policies are the product of multiscale influences, the relationship between multilevel governance and urban institutional capacity for mitigation and adaptation policies has only recently received attention, and studies focused on cities from Latin American countries are often missing altogether. The Urban Futures effort builds on work conducted through the ADAPTE project to explore some of the key factors or drivers shaping the development and implementation of mitigation and adaptation policies in the Latin American cities of Buenos Aires, Argentina; Mexico City, Mexico; and Santiago, Chile.

Our findings suggest that the level of authority provided to Mexico City within Mexico's legal framework to take steps to address climate change, and the city's extended experience with monitoring and tracking environmental hazards (e.g., air pollution), have enhanced institutional response capacity and likely help to explain why Mexico City is a regional frontrunner in responding to climate change. Buenos Aires and Santiago face greater restrictions on their authority in areas such as energy use and land use planning and are often left out of planning decisions taking place at higher levels. Regardless of Mexico City's regional frontrunner status, however, we also found many similar challenges and opportunities in their efforts to effectively respond to climate change. In all three cities, for instance, the design of climate responses was contingent upon existing growth pressures and priorities, and these conditions were often driven and perpetuated by the underpinnings of prior land use practices and housing and infrastructural investments that would be difficult and costly to change (path-dependency). Furthermore, the case studies shed light on the challenge of embedding climate considerations not only into sectoral policies such as housing and energy, but also into regional or territorial planning.

Relevant publications

Romero-Lankao, P., Hardoy, J., Hughes, S., Rosas-Huerta, A., Borquez, R., Gnatz, D., "Multilevel governance and institutional capacity for climate change responses in
Latin American cities"(forthcoming under) The Urban Climate Challenge Rethinking the Role of Cities in the Global Climate Regime, edited by Johnson, Toly and Schroeder,

Romero-Lankao, P., S. Hughes, et al. (2014). "Scale, urban risk and adaptation capacity in neighborhoods of Latin American cities." Habitat International 42(0): 224-235.

Hughes, S. and P. Romero-Lankao (2014) Institutionalization and the Science-Policy Interface in Urban Climate Change Planning: The cases of Delhi and Mexico City. Environmental Politics (forthcoming).

Romero-Lankao, P., Brutto, N., Chang, M., Hardoy, J., D'Almeida Martins, R., y Krellenberg, K., (2013) "Desarrollar capacidad de respuesta urbana a la variabilidad y el cambio climáticos" *Respuestas Urbanas al Cambio Climatico en America Latina,* edited by Sanchez, R., IAI-CEPAL, Santiago de Chile, pp.119-136.

Build capacity to foster urban sustainability and resilience

NCAR social scientist Paty Romero-Lankao served as a contributing author for the Intergovernmental Panel on Climate Change's Fifth Assessment Report. She contributed to the IPCC Working Group II's findings, reported in "Climate Change 2014: Impacts, Adaptation, and Vulnerability." This report focuses on the potential impacts of climate change and how society can adapt.

Romero-Lankao is a member of the Urban Climate Change Research Network (UCCRN) and co-editor of the Second Assessment Report on Climate Change and Cities Watch the UCCRN Video

For more info on outreach and capacity building see links to Videos and TV and radio interviews

1. http://www.pbs.org/newshour/bb/closing-window-action-climate-change-offers-conse...
2. http://ucarconnect.ucar.edu/multimedia/videos/climate-change-social-perspective#...
3. http://www.kqed.org/a/forum/R201404010900
4. "UCCRN: Preparing Local Leaders for Tomorrow" http://t.co/i2FI1mPsSd
5. Presentation IPCC-AR5 Report: Lessons Learned
   http://video.ucar.edu/mms/ral/ipcc_wg_II_seminar.mp4
6. Interview on Climate Change Adaptation, channel 8, Boulder View http://vimeo.com/97607385

PLANS FOR 2015

In 2015 Romero-Lankao will conduct further research, outreach and education in the three areas described above both at the city and global level.

‹ Socio-ecological Systems in a Changing Climate: Governance and Adaptation up Weather, Climate and Health ›

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WEATHER, CLIMATE AND HEALTH

BACKGROUND

There is widespread scientific consensus that the world's climate is changing and that there will be a broad range of impacts on health through a variety of factors, including greater heat stress, air pollution, respiratory disease exacerbation, and changes in the geographic distribution of vector-, food- and water-borne disease. The complexity of such influences requires a multi-disciplinary approach to address climate-related public health challenges. The overall goal of this work is to research the complex interactions among weather and climate processes, ecosystems, and human health in order to improve our knowledge of climate impacts on human health and the health of the planet. Through collaboration within RAL (Barlage, Bieringer, Delle Monache, Hopson, Wilhelmi), with other laboratories in NCAR (Morss - MMM, Oleson – CGD, Wiedinmyer -- ACD), UCAR (Pandya), university partners (CSU, CU, KU, U of Veracruz, U of AZ), federal agencies (CDC, NASA, NIH, Environment Canada), and state and local agencies (AZ Department of Health Services, Maricopa County Health Department, Office of Border Health (AZ),Toronto Public Health (Canada), Monroe County Health Dept. (Key West, FL) and Houston Department of Health) the research has and will continue to focus on:

- Investigating the complex relationships among weather, climate, human health and ecosystems
- Researching population vulnerability to human health threats
- Focusing on solutions-oriented scalable research with appropriate adaptation and mitigation strategies to tackle critical health issues
- Educating the next generation of scientists in these complex, yet interconnected areas

FY 2014 ACCOMPLISHMENTS

Health Risks from Extreme Heat

Our changing climate is predicted to increase the intensity and impacts of heat waves prompting the need to develop preparedness and adaptation strategies that reduce societal vulnerability. Work was completed in FY 2014 on a NASA-funded project to develop a System for Integrated Modeling of Metropolitan heat Risk (SIMMER). The project focused on understanding population vulnerability to extreme heat in Houston, TX, and on developing a more generalized framework for assessing heat-related vulnerability that could be transferred to other cites. To this end, a workshop was held in October 2013 in Toronto, Canada with our Canadian colleagues in which the SIMMER results were presented and a roadmap to implement SIMMER in Toronto was put into action. Work is ongoing to develop GIS-based maps tailored for both public health officials and the general public toward reducing vulnerability to extreme heat. Several manuscripts addressing various aspects of the SIMMER project were submitted or published in peer-reviewed journals in FY14.

Human–Environmental Interaction and Risk for Dengue Fever

Dengue is an emerging arboviral disease with worldwide impact. Increasing numbers of cases of this disease in both the Americas and Asia necessitate an examination of changing human and vector ecology in order to better understand the dynamics of dengue transmission.

RAL scientists completed the final year of a large NSF-funded project to address the human health threat of dengue virus. The project, entitled "The vector mosquito *Aedes aegypti* at the margins: sensitivity of a coupled natural and human system to climate change", was designed to investigate and model dengue fever risk along an altitudinal gradient from Veracruz to Puebla, Mexico. This has been a collaborative effort with the University of Veracruz, Colorado State University

and the Centers for Disease Control and Prevention. Accomplishments of the project included 1) repeated collections of the dengue-vector mosquito *Ae. aegypti* at an altitude 300 m higher than ever before recorded in Mexico, a likely indicator that climatic warming is making high-elevation areas more habitable to *Ae. aegypti* and other disease vectors, and 2) the development of WHATCH'EM, a state-of-the-science, physically-based energy balance model of water height and temperature in containers that may serve as development sites for mosquitoes or other container-inhabiting arthropods. WHATCH'EM is designed to be driven with field-derived meteorological data and can be used on an unlimited amount of user-specified container types. WHATCH'EM simulates the highly non-linear manner in which atmospheric conditions and container characteristics determine water temperature and height, leading to results that are not always intuitive and likely not simulated by simpler empirical models. WHATCH'EM simulations will be helpful in understanding the limiting climatic and container-related factors for proliferation of *Ae. aegypti* and *Ae. albopictus*.

In FY 2014 WHATCH'EM was employed in a now completed one-year seed project funded by the Defense Threat Reduction Agency (DTRA) in which a prototype early warning system for dengue risk was rapidly developed. A unique aspect of the work was the formulation of an automated algorithm -- led by Science and Technology in Atmospheric Research (STAR LLC) -- that employs high-resolution (sub-meter) satellite imagery to detect the types of containers that exist on premises in areas thought to be of risk for dengue. Once identified, the containers were then specified as input to WHATCH'EM to simulate the temperatures and water levels in the containers, determine the suitability of the containers for harboring the dengue virus vector mosquito *Ae. aegypti*, and finally to estimate dengue risk at the neighborhood level within cities in eastern Mexico. A final report for the prototype was submitted to DTRA in summer 2014.

A four-year NIH-funded project led by the University of Arizona continued. Efforts focused on field work and modeling along a transect from Tucson, AZ to Hermosillo, Sonora, Mexico to determine factors that account for a lack of dengue transmission in areas where the dengue mosquito vector *Ae. aegypti* is abundant. Several NCAR scientists participated in fieldwork collecting mosquito immatures and adults during August 2014, and NCAR hosted a visitor, Cory Morin, from the University of Arizona to work on a project-related paper involving meteorologically-based modeling of *Ae. aegypti.*

Finally, newly appointed Project Scientist Daniel Steinhoff procured his first ever grant, an Early Career Investigator Award from NASA, to investigate and model *Ae. aegypti* populations worldwide.

Lyme Disease in the United States

NCAR is working with CDC to better understand the meteorological drivers of Lyme disease ecology. In 2014, several models describing Lyme disease seasonality were published by former CDC-NCAR postdoctoral fellow Sean Moore. As a follow-on, Andrew Monaghan led a research effort that employed the models developed by Moore and global climate model projections to investigate the impacts of climate change on the annual onset of Lyme disease cases in the U.S. The resulting manuscript, currently in review, suggests that the Lyme disease season will become earlier in the future due to warmer winter and springtime temperatures in the U.S. (Fig. 1)

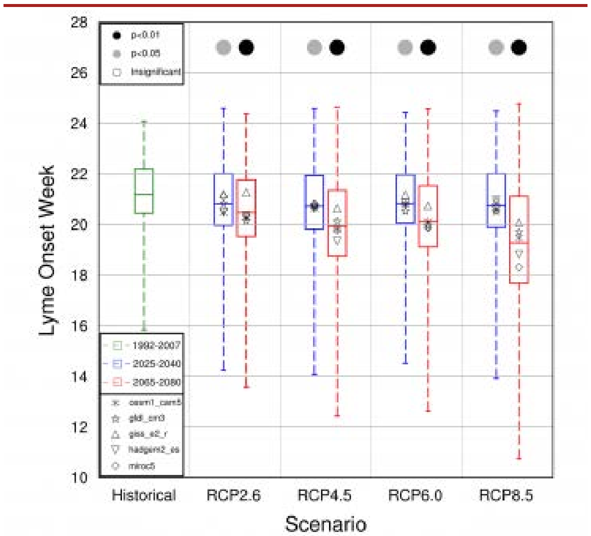

Figure 1. Box plots comparing the distributions of the national-level historical data for annual Lyme Onset Week (LOW) with the atmosphere-ocean global climate model (AOGCM) multi-model mean distributions of LOW for each of the four RCP scenarios and two future periods. Each box plot shows the values of LOW for the maximum (top of dashed line), 75th percentile (top of box), mean (line through middle of box), 25th percentile (bottom of box) and minimum (bottom of dashed line) of the distribution. All distributions are comprised of values for the 12 states where >90% of Lyme cases occur, and over 16 years (N=192). Circles along the top of each panel indicate whether the AOGCM multi-model mean is significantly different from the mean of the historical mean (see top legend). Box

CDC-NCAR Postdoctoral Fellowship

Two postdoctoral fellows entered the second year of their two-year program in fall of 2014. The goal of this program is to train the next generation of researchers in a multidisciplinary setting so that they are qualified to address the challenges of integrating health and weather/climate data. Postdoc Micah Hahn is developing an early-warning system for West Nile Virus in the United States in collaboration with CDC's Division of Vector-Borne Diseases. Postdoc Katie Conlon is investigating the impact of future changes in climate and land use on extreme heat exposure in Houston, and collaborating with CDC's National Center for Environmental Health to help prepare cities and states for climate-related risks.

Community Outreach

- This year RAL hosted Cory Morin, a postdoc at the University of Arizona, for a one-month visit. Cory and NCAR scientists ran *Ae aegypti*/dengue simulations using a ~5,000 member ensemble to determine the key drivers of dengue in San Juan, Puerto Rico. They

found that the relative influence of meteorological factors on dengue transmission varies widely from year-to-year. A paper has been drafted and will be submitted in November.

- Monaghan is working with a high-school student from Nederland on her senior year capstone project, in which she is running a mosquito model for current and future climatic conditions to determine the potential impacts of climate change on the dengue vector *Ae. aegypti* in Mexico.

plot colors indicate different time periods (see middle legend). Black symbols on each box plot indicate the mean value of LOW from each individual AOGCM that contributes to the multi-model ensemble (see bottom legend).

- Monaghan traveled to Washington, DC as part of Geosciences Congressional Visit Days to speak with Congressional delegates about the importance of the geosciences for the U.S.
- Hayden has been an invited lecturer at multiple universities along the Front Range of Colorado, as well as elsewhere in the U.S.

FY 2015 PLANS

Work will continue on the NIH-funded dengue project, as well as on new CDC research efforts focused on Lyme disease and human plague. Monaghan and Hayden will also work on a no-cost basis on an NSF-funded project led by Wiedinmyer (NESL/ACD) investigating the benefits, impacts and sustainability of implementing clean cookstoves in Northern Ghana.

Hayden and Monaghan will continue to mentor the two CDC-NCAR postdocs as well as a new ASP postdoc affiliated with this program, Leiqiu Hu.

A major focus in FY 2015 will be to continue writing proposals to secure additional grants for further climate-and-health research. Several key projects concluded at the end of FY 2014.

Hayden will put considerable effort into planning and hosting the next workshop on Climate and Health, scheduled for July 2015.

Publications

Monaghan, A.J., S.M. Moore, K.M. Sampson, C.B. Beard, and R.J. Eisen, 2014: Climate change influences on the annual onset of Lyme disease in the United States. *Ticks and Tick-Borne Diseases*, submitted.

Hayden, M.H., J.L. Cavanaugh, C. Tittel, M. Butterworth, S. Haenchen, K. Dickinson, A.J. Monaghan, and K.C. Ernst, 2014: Stakeholder perceptions of dengue preparedness and response in Key West, Florida. *Am. J. Public Health*, submitted.

Moore, S.M., A.J. Monaghan, J.N. Borchert, J.T. Mpanga, L.A. Atiku, K.A. Boegler, J. Montenieri, K. MacMillan, K.L. Gage, and R.J. Eisen, 2014: Seasonal fluctuations of small mammal and flea communities in a Ugandan plague focus: evidence to implicate Arvicanthis niloticus and Crocidura spp. as key hosts in *Yersinia pestis* transmission. *Parasites and Vectors*, submitted.

Heaton, M.J., S.R. Sain, A.J. Monaghan, M.H. Hayden, and O.V. Wilhelmi, 2014: An Analysis of an Incomplete Marked Point Pattern of Heat-Related 911 Calls. *J. Am. Statistical Assoc.*, conditionally accepted.

Moreno-Madrinan, M.J., W.J. Crosson, L. Eisen, S.M. Estes, M.G. Estes Jr., M. Hayden, S.N. Hemmings, D.E. Irwin, S. Lozano-Fuentes, A.J. Monaghan, D. Quattrochi, C.M. Welsh-Rodriguez, and E. Zielinski-Gutierrez, 2014: Correlating Remote Sensing Data with Abundance of Pupae of the Dengue Virus Mosquito Vector, Aedes aegypti, in Central Mexico. *Int. J. Geo-Info.*, 3, 732-749. doi:10.3390/ijgi3020732.

Lozano-Fuentes, S., C. Welsh-Rodriguez, A.J. Monaghan, D.F. Steinhoff, C. Ochoa-Martinez, B. Tapia Santos, M.H. Hayden, and L. Eisen, 2014: Temporal Changes in Abundance of *Aedes (Stegomyia) aegypti* and *Aedes (Ochlerotatus) epactius* in High-Elevation Communities in México. *J. Med. Entomol.*, 51, 742-751, doi:10.1603/ME14015.

Hu, L. N.A. Brunsell, A.J. Monaghan, M.P. Barlage, and O.V. Wilhelmi, 2014: How can we use MODIS land surface temperature to validate long-term urban model simulations?. *J. Geophys. Res. Atm.*, 119, 3185-3201, doi:10.1002/2013JD021101.

Monaghan, A.J., L. Hu, N.A. Brunsell, M.P. Barlage, and O.V. Wilhelmi, 2014: Evaluating the impact of urban morphology configurations on the accuracy of urban canopy model temperature simulations with MODIS. *J. Geophys. Res. Atm.*, 119, 6376-6392, doi:10.1002/2013JD021227.

Abdussalam, A.F., A.J. Monaghan, D.H. Steinhoff, V.M. Dukic, M.H. Hayden, T.M. Hopson, J. Thornes, and G.C. Leckebusch,

2014: The impact of climate change on meningitis in northwest Nigeria: an assessment using CMIP5 climate model simulations. *Wea. Clim. Soc.*, 6, doi:10.1175/WCAS-D-13-00068.1.

Eisen, L.S., A.J. Monaghan, S. Lozano-Fuentes, D.F. Steinhoff, M.H. Hayden, and P.E. Bieringer, 2014: The Impact of Temperature on the Bionomics of the Vector Mosquito Aedes (Stegomyia) aegypti, With Special Reference to the Cool Geographic Range Margins. *J. Med. Entomol.*, 41, doi:10.1603/ME13214.

Heaton, M.J., S.R. Sain, T.A. Greasby, C.K. Uejio, M.H. Hayden, A.J. Monaghan, J. Boehnert, K. Sampson, D. Banerjee, V. Nepal, and O.V. Wilhelmi, 2014: Characterizing Urban Vulnerability to Heat Stress using a Spatially Varying Coefficient Model. *Spatio-temporal Epidemiology*, 8, 23-33, doi:10.1016/j.sste.2014.01.002.

Abdussalam, A.F., A.J. Monaghan, V.M. Dukic, M.H. Hayden, T.M. Hopson, G.C. Leckebusch, and J. Thornes, 2014: Climate influences on interannual variability of meningitis incidence in northwest Nigeria. *Wea. Clim. Soc.*, 6, 62-76. DOI:10.1175/WCAS-D-13-00004.1

Moore, S.M., R.J. Eisen, A.J. Monaghan, and P.S. Mead, 2014: Meteorological influences on the seasonality of Lyme Disease in the United States. *Am. J. Trop. Med. Hyg.*, 90, 486-496. doi:10.4269/ajtmh.13-0180.

Ernst KC, Haenchen S, Dickinson K, Doyle M, Walker K, and Hayden MH. (2014) Community awareness and support of the controversial release of OX513A *Ae. aegypti* in Key West, FL. *Emerging Infectious Diseases,* accepted for publication

Pandya R, Hodgson A, Hayden M, Akweongo P, Hopson T, Adams Forgor A, Yoksas T, Dalaba M, Dukic V, Mera R, Dumont A, McCormack K, Anaseba D, Awine T, Boehnert J, Nyaaba G, Laing A, Semazzi F. (2014) Using Weather Forecasts to Help Manage Meningitis. *Bull. Amer. Meteor. Society* accepted for publication

Uejio CK, Hayden MH, Zielinski-Gutierrez E, Robles Lopez JL, Barrera R, Amador M, Thompson G, and Waterman SH. (2014) Biological Control of Mosquitoes in Scrap Tires in Brownsville, TX US and Matamoros, TM MX. *Journal of American Mosquito Control Association,* accepted for publication

Jancloes M, Thomson M, Manez M, Hewitt C, Corvalan C, Dinku T, Lowe R and Hayden M. (2014) Climate Services to Improve Public Health. *Int. J. Environ. Res. Public Health*, *11*(5), 4555-4559; doi:10.3390/ijerph110504555

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STRATEGIC PLANS

RAL Strategic Plan

NCAR Strategic Plan

PREVIOUS RAL REPORTS

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GEOGRAPHIC INFORMATION SYSTEM (GIS) PROGRAM

BACKGROUND

The Geographic Information System (GIS) program at the National Center for Atmospheric Research (NCAR) is an interdisciplinary effort to foster collaborative science, spatial data interoperability, and knowledge sharing using GIS. Working toward the definition, standards and interoperability of atmospheric information for usable science, the GIS program is: 1) conducting research integrating the Earth system and social sciences through spatial analysis and interoperability of georeferenced information; 2) supporting the use of GIS as both an analysis, and an infrastructure tool in atmospheric research; 3) improving usable science and knowledge sharing between science groups, educators and stakeholders; and 4) addressing broader issues of spatial data management, interoperability, and geoinformatics within the geosciences. Research progress in integration of geographic and atmospheric information allows GIS staff to lead and participate in a variety of research projects at NCAR, where spatial analysis and accurate georeferenced data are critical to answering complex interdisciplinary questions. With more than one hundred GIS users in all NCAR laboratories, the projects range from atmospheric chemistry to societal impacts of climate change to homeland security.

Current research activities in the GIS program occur in three thematic areas:

- Integrating physical and social science data in GIS
- Improving spatial accuracy and usability of atmospheric models for terrestrial and societal applications,
- Conducting GIS-focused educational activities at the science-society interface.

2014 ACCOMPLISHMENTS

Integrating physical and social science data in GIS

In 2014, the NASA-funded SIMMER project: System for Integrated Modeling of Metropolitan Extreme Heat Risk was successfully completed. The project addressed the critical need for information at regional to local scales that are pertinent to public health decision-making in the context of global change. Through the SIMMER project our research team advanced a methodology for assessing current and future urban vulnerability to extreme heat through integration of physical and social science models, research results, and NASA data, and developed tools for building local capacity for heat hazard mitigation and climate change adaptation in the public health sector. A series of publications highlight our research findings and new methods for integrating physical and social science data (see Publications). Several manuscripts are in preparation and will be submitted to peer-reviewed journals in 2015. SIMMER GIS tools illustrate the integration of diverse datasets and models into a platform for decision-making at various spatial scales. For example, our team developed the “Beat the Heat” online GIS tool for the general public in Houston. (Figure 1).

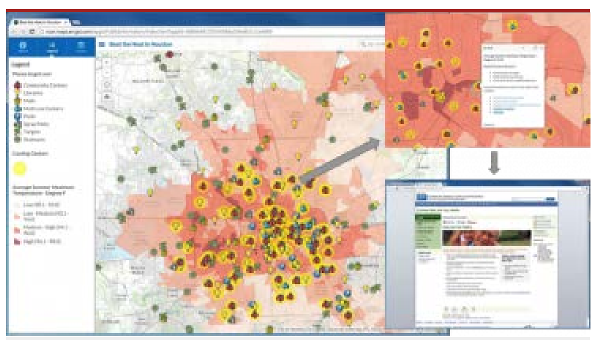

Figure 1. Beat the Heat online GIS tool provides information about average summer maximum temperature in Houston neighborhoods and guides the user to multiple strategies for staying safe and healthy in hot weather.

Publications

Hart, H., Gower S., Wilhelmi, O. and Yagouti A. 2013. Integrated Models For Heat-Health Decision Making: Linking Complex Science to Policy for Heat-Health Decision Making. SIMMER Workshop Report, Toronto (Canada), 40 pp. online at: http://ral.ucar.edu/csap/events/heat-health-decision-making/

Monaghan, A.J., Hu, L. N.A. Brunsell, M.P. Barlage, and O.V. Wilhelmi, 2014. Evaluating the impact of urban morphology configurations on the accuracy of urban canopy model temperature simulations with MODIS. *Journal of Geophysical Research: Atmospheres*, conditionally accepted.

Hu, L., N.A. Brunsell, A.J. Monaghan, M. Barlage, O. V. Wilhelmi, 2014. How can we use MODIS land surface temperature to validate long-term urban model simulations? *Journal of Geophysical Research: Atmospheres*, 119 (6): 3185–3201

Heaton, M.J., S. R. Sain, A. J. Monaghan, O.V. Wilhelmi, and M. H. Hayden, 2013. An Analysis of an Incomplete Marked Point Pattern of Heat-Related 911 Calls, *Journal of the American Statistical Association,* in review.

Heaton, M. J. , S. R. Sain, T. Greasby, C. K. Ueijo, M. H. Hayden, A. J. Monaghan, J. Boehnert, K. Sampson, D. Banerjee, V. Nepal, and O. V. Wilhelmi, 2014. Identifying vulnerability to heat-related mortality using a spatially-varying coefficient model, *Spatial and Spatio-temporal Epidemiology,* 8, 23-33.

In 2014, the GIS program contributed to an edited volume "Mapping and Modeling Weather and Climate with GIS" (Figure 2). This book is a result of a multi-year working dialog between Esri and the weather and climate research, educational and operational communities. The GIS program contributed to this community effort. Several chapters highlight examples from the GIS Program research projects and data interoperability experiments (see publications)

Publications

Wilhelmi, O., K. Sampson, and J. Boehnert, 2015 Exploring Future Climates in a GIS, In: *Mapping and Modeling Weather/Climate with GIS* (Armstrong et al. Eds.), Esri Press, Redlands, California, in press.

Wilhelmi, O., K. Sampson, and J. Boehnert, J. and O. Wilhelmi, 2015. Meteorological data in a geodatabase, In: *Mapping and Modeling Weather/Climate with GIS* (Armstrong et al. Eds.), Esri Press, Redlands, California, in press.

Boehnert, J., A. Monaghan, and O. Wilhelmi, 2015. The Shape of Earth: Spatial Referencing in Weather and Climate Models, In: *Mapping and Modeling Weather/Climate with GIS* (Armstrong et al. Eds.), Esri Press, Redlands, California, in press.

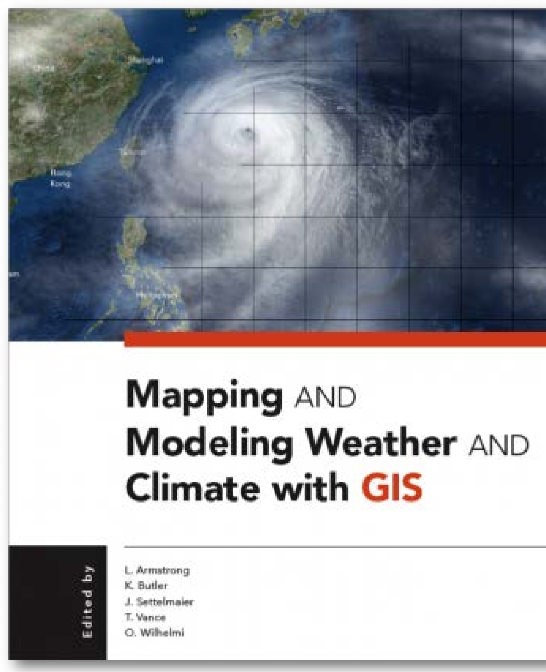

Figure 2. Book cover (draft) of the upcoming publication: Armstrong, L., K. Butler, J. Settelmaier, T. Vance and O. Wilhelmi, 2015. "Mapping and Modeling Weather/Climate with GIS". Esri Press, Redlands, CA, in press.

Improving spatial accuracy and usability of atmospheric models for terrestrial and societal applications

The NCAR GIS Program serves a large community of GIS users interested in global climate change. The GIS Climate Change Scenarios portal was the first internet gateway in which users are able to access global climate model data in GIS formats. This data portal provides access to global and downscaled data sets of climate change scenarios generated for the IPCC by the Community Earth System Model (CESM). Users can access climate change analysis products such as seasonal and annual averages, climate anomalies, and statistically downscaled climate change data for the continental United States. The model outputs can be downloaded and added to any GIS application, thus allowing for easy integration of climate projections with environmental and socio-economic datasets. The GIS Program released the Climate Inspector in 2014, which allows for the visualization of climate change in space and time through a web application. The app displays anomaly temperature and precipitation values from the IPCC AR5 runs of the NCAR CCSM4 model (Figure 3). The user interacts with the data by clicking and moving a pin on the map to change location, using a time slider to change time period, and altering the emission trajectory. Map images and data can

be downloaded for any selection while figures with captions help users interpret the information. This interface provides a rich environment from which users can assess what future climate change may occur as well as some of the model uncertainty associated with those changes.

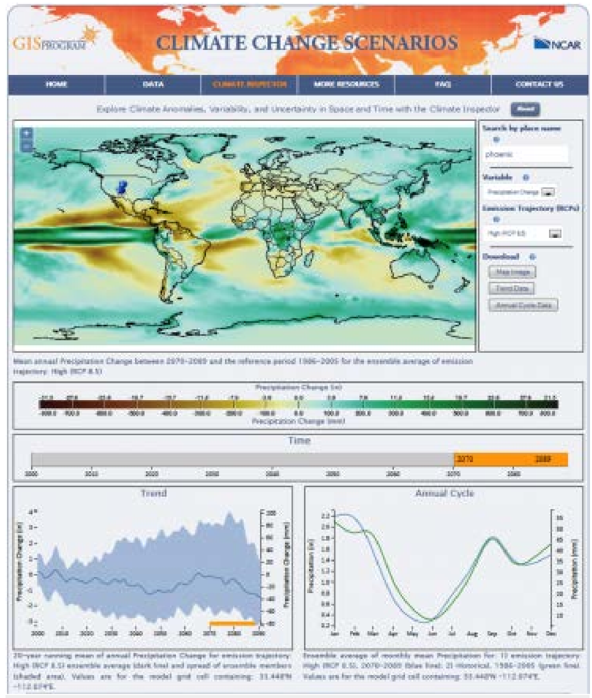

Figure 3. Climate Inspector is a new platform for climate change data visualization and downloading in user-friendly formats: http://gisclimatechange.ucar.edu/inspector.

GIS EDUCATION AT THE SCIENCE – POLICY INTERFACE

In 2014, the GIS program staff organized and hosted the USDA/NCAR-sponsored 4-day workshop, “Agriculture in a Changing Climate across Scales: Broadening Participation in Research and Decision-Making”. This workshop provided an opportunity for graduate students and early career scientists from diverse backgrounds to embrace an interdisciplinary approach to these scientific and societal challenges. A variety of sessions focused on topics ranging from fundamental climate science to vulnerability of agroecosystems and farm communities in an exploration of weather and climate-related impacts, vulnerability, and decision-making across spatial scales on agriculture in the U.S. Using geospatial technologies (i.e., GIS and remote sensing), the participants learned how to integrate spatial information about weather, climate change, agriculture, and society in a meaningful and innovative way.

Figure 4. GIS education and training workshop, "Enhancing diversity in climate change science and applications: from models to adaptation"

FY2015 Plans

Work will continue in the three focus areas described above. Progress will be made in developing research frameworks and spatial methods for integration of diverse, multidisciplinary datasets, which are both quantitative and qualitative and exist at different spatial and temporal scales. Ongoing, externally funded projects in this area of research are focused on extreme heat, air quality and human health, as well as on drought and water use, hurricanes and social vulnerability. Previously developed educational materials that link GIS, climate science and societal vulnerability and adaptation will be adjusted for a variety of training programs and workshops. A lab manual for meteorology departments on the use of GIS is currently in development.

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REGIONAL CLIMATE FOR ADAPTATION

BACKGROUND

The objective of the Regional Climate Science for Applications (RC4A) group is to deliver, evaluate and translate sound climate science to decision makers to identify and address adaptation needs, to promote sustainability, and to reduce human system vulnerability to regional climate variability/change. The activities broadly fall into four categories: (1) Perform and advance climate data evaluation looking across time scales and integrating past, present and future, (2) make climate science usable, (3) explore climate scenarios for a more comprehensive view of impacts, vulnerabilities and adaptation, and finally (4) engage in translation and climate change capacity building.

2014 ACCOMPLISHMENTS

Advanced Climate and Regional Model Validation for Societal Applications (funded by an Earth System Modeling [EaSM] grant from NSF)

In collaboration with Iowa State University (W. Gutowski and A. Abitan) and Denver Water (L. Kaatz), the EaSM project links the RAL programs of CSAP (L. Buja, C. Ammann), JNT (B. Brown, E. Gilleland, T. Fowler, J. Halley-Gotway, and R. Bullock) and HAP (D. Yates, and K. Ikeda) to develop novel methods to validate climate models. This project assesses the real world needs from the climate model predictions and projections and then tests the output for fidelity to adequately inform decision makers towards these needs. By developing informative diagnostics that are built on advanced tools originally designed for weather forecast verification, such a use-driven perspective of validation of models can also be directly incorporated into the EaSM and model development process, and in particular the community-driven NCAR CESM effort. This project is done under the auspices of NCAR's Community Earth System Model/Societal Dimensions Working Group, yet its products are more broadly applicable. Model output from sub-seasonal to seasonal or decadal forecasts can now be evaluated as readily as climate change projections. Thus the EaSM Advanced Climate and Regional Model Validation effort is forming one part of the research base for an increasing number of RAL activities.

With support from the EaSM project, MET/MODE tools (developed at RAL and in broad use across the weather forecast verification community) are undergoing an expansion into the time-domain. MET/MODE were developed to include a time-evolving perspective of weather sequences, but now they will be modified for use with climate problems. This is a welcome expansion of the more static assessment of the traditional tools that compare two states. This approach is particularly useful since climate simulations cannot reproduce specific time sequences seen in observations but rather are supposed to generate similar statistics and spatio-temporal relationships. MODE-TD will help EaSM leap into that new 3D perspective facilitating a more intuitive and engaging way of analysis and translation to users.

Direct interactions with planners at Denver Water headquarters led to a new exercise that will assess why water managers currently don't use available seasonal forecasts in their streamflow estimates but rather use the climatology of the past 30 years as a guide when planning the upcoming melt season in the Colorado high country. RAL's EaSM team is now determining the quality of these global-model-based forecasts to test if such forward looking information actually provides sufficient additional information that it would alter decisions in what is traditionally a rather risk-averse planning environment.

With supplemental funds from the NCAR Weather and Climate Impact Assessment Science Program led by L. Mearns (CISL-IMAGe), RAL scientists are evaluating the spatio-temporal behavior of extreme convective activity as represented by the

joint occurrence of high vertical convective potential energy (CAPE) and high wind shear over the lower half of the atmosphere, the key ingredients for tornadic development. A study of the field behavior conditioned on the presence of extreme conditions was based on reanalysis data. In a follow-up, the team is assessing the ability of regional climate models used in the North American Regional Climate Change Assessment Program to reproduce these observed spatio-temporal characteristics of severe convective weather events to determine the role of model resolution, the influence of boundary conditions derived from the driving models, and the robustness of changes between the present and projected future across the different model ensembles. This work is directly related to EaSM model validation as it focuses both on extreme conditions and takes into account spatio-temporal characteristics of a phenomenon with high societal impact.

Evaluation of Downscaled Climate Data

The continuation of the National Climate Predictions and Projections (NCPP) platform funded through the NOAA Climate Program Office, has advanced the access and delivery of a large set of downscaled climate data diagnostics. Led by the NCPP core team consisting of PI R. Rood (Univ. of Michigan), J. Barsugli (NOAA/Univ. of Colorado-CIRES) as well as C. Ammann and G. Guentchev (NCAR), both statistically downscaled climate dataset for the US (BCCA from Maurer et al. 2004, 2007; and ARRM from Stoner et al. 2012) and dynamically downscaled experiments from NARCCAP (Mearns et al. 2014) are analyzed. Diagnostics focus not only on climatological means of the primary downscaled fields of temperature and precipitation, but on application-oriented indices with their ranges, extremes and sequencing. This work is done in close collaboration public and private partners at the regional, national, and international levels to determine how well downscaled climate products can reproduce observations and thus how well suited these commonly used products are for application and decision-making. NCPP strives to ingest evaluation as a critical step into the data dissemination process through enriching raw climate data with diagnostics and extensive, standardized metadata.

Emerging Heat Threats in South Asia

In collaboration with ISET (Institute for Societal and Environmental Transition), a climate study was performed that focused on the emergence of heat threat to social and economic development in mid-sized cities in South Asia (i.e., India and Pakistan). The cities studied, located in the Ganges and Indus Valleys, are generally used to flooding as a potential environmental threat. But over recent years, the issue of excessively high temperatures during high humidity has risen. This project funded through a Rockefeller Foundation brought together physical and social scientists and local stakeholders to quantify current and future heat threats to largely poor populations that rely on natural ventilation and ambient cooling. Looking at projections of future heat indices in these cities, the research demonstrated how focusing on physiological thresholds might bring a different perspective and urge to the climate change problem than the analysis of changes alone. Relentless heat, where the physiological threshold for cooling of the human body is surpassed in consecutive days, weeks and months, will form a threat in regions where no active cooling through air-conditioning is available.

USDA Climate Change Support

CSAP/RC4A assisted USDA's Climate Change Program Office in carrying out assessments of the effects of climate change on U.S. Agriculture. This process includes review, analysis, synthesis of current research in climate and agricultural science, providing scientific input, holding author meetings and providing logistical support for the upcoming USDA report: "Global Climate Change, Food Security, and the U.S. Food System" and working with the new USDA Climate Hubs for risk Adaptation and Mitigation to Climate Change. In addition, a workshop associated with this project titled: "Agriculture in a Changing Climate across Scales: Broadening Participation in Research and Decision-Making", led by the CSAP/GIS group , provided an opportunity for the participants to embrace an interdisciplinary approach to these scientific and societal challenges by offering the variety of daily sessions focused on topics ranging from fundamental climate science to vulnerability of agroecosystems and farm communities. The workshop focused on topics of weather and climate-related impacts, vulnerability, and decision-making across spatial scales with an emphasis on the agricultural sector in the U.S. With the help of geospatial technologies (i.e., GIS and remote sensing) the participants learned how to integrate spatial information about weather, climate change, agriculture, and society in a meaningful and innovative way.

PLANS FOR 2015

In 2015 the RC4A effort will further develop the tools necessary for an integrated climate risk management capability. This will require expanding climate datasets and collections into useful and usable ensembles that anticipate both non-scientist and specialist use of the information. In close collaboration with the USGCRP, the research done under EaSM and NCPP will be put to use in helping advance access to and use of National Climate Assessment data by the public and decision-makers. Using this perspective, further advances in the evaluation and validation of model data and model-based ensembles of data will be embedded in work-flow capabilities that improve efficiency and flexibility to work with different user groups. Aligning, and at times embedding, these tools within the NCAR CESM effort is expected to bring clear benefits to an increasing number of model developers, application scientists and users.

‹ Geographic Information System (GIS) Program up

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