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Welcome to the 2006/2007 Annual Report for the National Center for Atmospheric Research (NCAR)



I am delighted to present the *2006/2007 NCAR Annual Report*, and to share my enthusiasm for the recent accomplishments of our staff and collaborators in the key areas of facilities, science, and service.

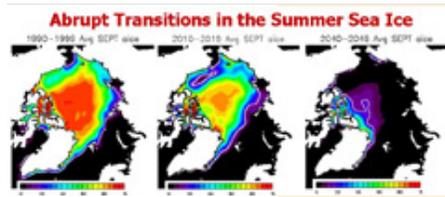
Through generous support from the *National Science Foundation*, NCAR continues to be dedicated to exploring and understanding our atmosphere in the broadest terms, including interactions with the sun, the oceans, the biosphere, and human society. As a federally funded research and development center, it is our mission to pursue these studies in collaboration with federal sponsors, universities, industry and private sector partners, and governments and research institutes around the world.

This year, we published our new strategic plan, [NCAR as an Integrator, Innovator and Community Builder](#). With our collaborators, we've been moving forward aggressively to implement our strategic goals, to:

- [Improve understanding of the atmosphere, the Earth system, and the Sun](#)
- [Increase societal resilience to weather, climate, and other atmospheric hazards](#)
- [Cultivate a scientifically literate and engaged citizenry and a diverse and creative workforce](#)
- [Provide robust, accessible, and innovative information services and tools, and](#)
- [Provide world-class ground, airborne, and space-borne observational facilities and services.](#)

In pursuing these goals NCAR will continue to serve as NSF's strategic partner in addressing issues of national concern, including understanding climate change, advancing weather and severe storm forecasting, and securing U.S. competitiveness in science and engineering, all for the benefit of society.

This report describes NCAR's major accomplishments in 2006 and our plans for 2007. As you will see, our efforts continue to benefit enormously from pervasive community interactions, ranging from the many and growing research collaborations to active community leadership of our field campaigns.

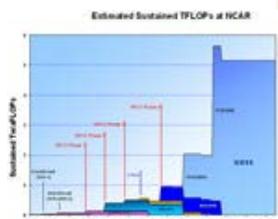


[NOTE: Click Images for reports](#)

Beyond the scientific work itself, the need for effective communication, public outreach, and education is urgent, perhaps most notably in the context of anthropogenic climate change. As the evidence builds that climate change is under way and having visible consequences, the need for concerted responses intensifies. NCAR is working to improve society's ability to respond to the challenges faced by our leaders and decision makers, from computer modeling, to studying the genesis of hurricanes, to developing early warning systems and other effective communication tools.

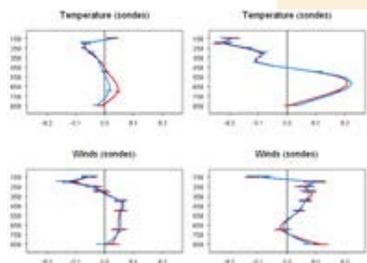


Through our world-class observational facilities, we are improving weather models and instruments for researchers. In 2006, NCAR conducted the first scientific missions with the new NSF High-Performance Instrumented Airborne Platform for Environmental Research (HIAPER), a Gulfstream V specially adapted as a research jet. The culmination of 20 years of planning and development, HIAPER can fly up to 51,000 feet with a range of 7,000 miles and can carry 5,600 pounds of scientific sensors. Following a year of progressive science missions, HIAPER saw its first major field deployment in the spring, during the successful Terrain-Induced Rotor Experiment (T-REX). This experiment brought scientists, technicians, and students from across the United States and Europe to the Owens Valley of California to study rotors, huge rolling-pin-shaped zones of high turbulence that form near mountains. The formations and associated turbulence are not only scientifically challenging, they threaten aircraft safety.

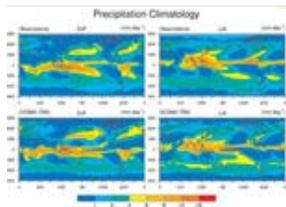


Complex models and increasing amounts of observational data require that NCAR meet exponentially growing computational needs in the geosciences research community. Our short-term goal is to augment supercomputing capacity by a factor of 25 in five years, from our starting point in early 2005. We recently completed the first and only Integrated Computing Environment for Scientific Simulation (ICESS) procurement. We will install the new ICESS machine in early 2007, increasing the total production computing capacity at NCAR to over 2.2 teraflops sustained, thereby providing our community with secure, leading-edge computing capabilities for the next several years. Our even-more-ambitious goal is to reach petascale computing for all the geosciences, and we recently hosted a major community workshop to outline steps for achieving that vision.

Our computational resources have allowed NCAR to conduct research and develop community models that improve our understanding of the atmosphere, the Earth system, and the Sun. With these models scientists are able to provide national and regional decision-makers with the most advanced science in weather and climate modeling.

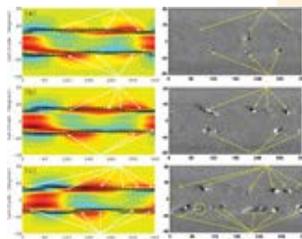


In August, the high-resolution Weather Research and Forecasting model (WRF) became the first model to serve as both the backbone of the nation's public weather forecasts and a tool for cutting-edge weather research. The model was adopted for use by NOAA's National Weather Service as the primary model for its one-to-three-day U.S. forecasts and as a key part of the NWS's ensemble modeling system for short-range forecasts. The U.S. Air Force Weather Agency also used WRF for several areas of operations around the world. Because the model fulfills both research and operational functions, it is easier for research findings to be translated into improved operational models, leading to better forecasts.



NCAR's Community Climate System Model (CCSM) served as one of three U.S. models in the

Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. NCAR scientists were notably active participants in the IPCC, with seven convening and lead authors and many more contributing authors. In June, a special issue of the *Journal of Climate* was devoted to the CCSM's contributions to the IPCC, with articles featuring 51 NCAR authors and 49 external collaborators.



This year, NCAR scientists Mausumi Dikpati, Peter Gilman, and Giuliana de Toma published breakthrough research results that indicate the next sunspot cycle will be 30-50% stronger than the last one and begin as much as a year late. The model, called the Predictive Flux-transport Dynamo Model, draws on new understandings of solar dynamics showing that the evolution of sunspots is caused by a current of plasma that circulates between the Sun's equator and its poles over a period of 17 to 22 years. This current acts like a conveyor belt of sunspots. The model has been 98% accurate in simulating the past eight solar cycles. Better prediction of solar cycles would provide advance warning of increases in space weather activity, thermospheric density, and ionospheric disruptions that can disrupt communications satellites, commercial flight patterns, and power systems.



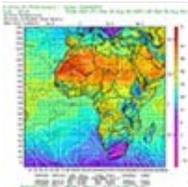
In another breakthrough with important practical applications, field researchers this summer tested a technique for the first time that uses multiple Doppler weather radar to track water vapor in the lower atmosphere. During REFRACT (Refractivity Experiment For H₂O Research And Collaborative operational Technology Transfer) researchers measured changes in the speed of radar signals caused by refraction, which in turn revealed the presence or absence of atmospheric moisture. The proof-of-concept experiment demonstrated that such measurements can help forecasters pin down the locations and timing of storms that might rage a few minutes to a few hours later.



NCAR and its university partners share a commitment to professional development in atmospheric and related sciences. In 2006, NCAR implemented a new Faculty Fellowship Program that promotes professional exchanges between NCAR and UCAR member universities. We augmented our graduate fellowship program, held two graduate research colloquia, and completed our fourth annual Early-career Faculty Forum on Future Scientific Directions.



As NSF's strategic partner, we continue to augment our efforts in education, outreach, and diversity, and I have committed special NCAR funds toward this effort. Of particular note are the annual NCAR Undergraduate Leadership Workshop, which brings promising future leaders from around the country for a week of exposure to NCAR scientists and facilities.



On the international front, we are conducting a special African Initiative in association with the American Association for the Advancement of Science (AAAS), which builds collaborations with African institutions. These and other ongoing activities are aimed at engaging more people from underrepresented minority groups in NCAR's programs.

NCAR's activities as an integrator, innovator, and community builder are contributing to the development of predictive Earth system science that can help sustain Earth's habitability, improve environmental quality, safeguard human health, reduce the impacts of natural disasters, and increase economic productivity. We look forward to working with you to make these goals a reality.

- Tim

NCAR Director's Message

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NCAR's Strategic Goals

NCAR's 2006 Strategic Plan, [NCAR as an Integrator, Innovator and Community Builder](#), outlines five Strategic Goals, and the priorities for achieving each. In the following sections we report on progress made in FY 2006 toward each scientific goal and priority, and on our plans for the coming year.

NCAR's five Strategic Goals are to:

1. Improve understanding of the atmosphere, the Earth system, and the Sun,
2. Increase societal resilience to weather, climate, and other atmospheric hazards,
3. Cultivate a scientifically literate and engaged citizenry and a diverse and creative workforce,
4. Provide robust, accessible, and innovative information services and tools, and
5. Provide world-class ground, airborne, and space-borne observational facilities and services.



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Strategic Goal 1

Improve Understanding of the Atmosphere, the Earth System, and the Sun

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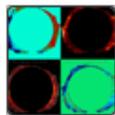
The National Science Foundation supports the National Center for Atmospheric Research (NCAR) to advance basic research in the United States in the atmospheric and related sciences in support of the university community. As a federally-funded research and development center, NCAR is able to sustain a long-term commitment to this scientific enterprise. Our research and understanding of the atmosphere, the Earth System, and the Sun and their environments is essential to fulfilling our other strategic goals. We pursue this basic research to advance our knowledge. Concurrently, we also are able to improve the modeling, computing, and observational facilities we provide; and, to transfer the results of our work to the public and private sector.

Our research includes atmospheric chemistry; meteorology, solar physics, solar-terrestrial interactions, and the Earth's upper atmosphere; climate research; societal impacts of climate change and severe weather; biogeochemistry; water cycle; geophysical turbulence; and applied mathematics and statistical analysis. We conduct our research in close collaboration with university partners; local, state and federal agencies; and with strategic international partners and private sector sponsors. Our goal is also to make our research accessible and widely available.

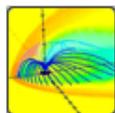
NCAR addresses four broad priorities within this goal:

[Priority 1: Exploring Atmospheric, Earth System, and Solar Processes, Variability and Change](#)

Exploring atmospheric, Earth system, and solar processes, and the variability and change of these processes, are critical components to reaching NCAR's Strategic Goal #1. Exploration into these areas will focus on three key activities: simulation of natural Earth system variability, research on magnetic-flux eruptions from the sun, and understanding the effects of gravity waves, including the coupling between the upper troposphere and lower stratosphere.... [Read more about this priority](#)



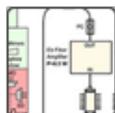
Coronal Magnetometry (CoMP and COSMO)



Space Weather

[Priority 2: Investigating the Interactions of the Atmosphere, the Broader Earth System and Human Society](#)

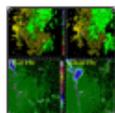
Whereas in the past, meteorology and climatology were separate fields, be it only because of disparate time (and length scales as well), it appears today that the two fields are strongly coupled, not only as the climate gives the boundaries for investigating the weather, but also because localized events can influence the larger climatological scales.... [Read more about this priority](#)



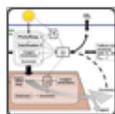
INTEX-B



MIRAGE-MILAGRO



Short-term Weather Forecasting: The Colorado REFRACTT Demonstration



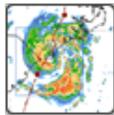
Impacts of Ocean Acidification on Coral Reefs

[Priority 3: Improving Prediction of Weather, Climate, and Other Atmospheric Phenomena](#)

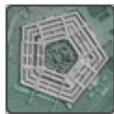
Understanding of the Earth system is a prerequisite to predicting its behavior, the latter being however of a more direct use to many components of society. In that context, the key activities within the laboratory deal with improving climate models, exploring new approaches to prediction across scales and global and local weather prediction.... [Read more about this priority](#)



THORPEX support with Hurricane Genesis Research



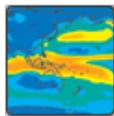
WRF-ARW



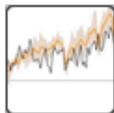
Model Development and Enhancement

Priority 4: Developing Community Models

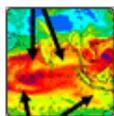
Developing numerical models and making them available to the scientific community is at the heart of NCAR's research and service to the community. Key activities in this priority are community models, research models, and progress toward an Earth system model. Leading the way in the key activity of community models are the CCSM and the WRF... [Read more about this priority](#)



CCSM and IPCC



IPCC Scientific Contributions



Nested Regional Climate Modeling

Science: Strategic Goal 1

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Increase Societal Resilience to Weather, Climate, and Other Atmospheric Hazards

Please enjoy selected scientific highlights by clicking on the thumbnail images below the "overview", or by using the arrows above to move page-by-page.

Scientific understanding of weather and climate has expanded dramatically, but the application of that knowledge to societal needs remains a grand challenge. Decision makers face an increasingly complex world as human population continues to grow and its associated impacts on the environment escalate. They need better information, tools, and systems to understand, and address, the effects of weather and climate. As the NSF's federally-funded research and development center, NCAR is in a unique position to partner with federal and state agencies to identify and pursue high priority weather and climate information needs for decision-making and to develop the tools decision makers need to plan for hazardous weather events, to improve operational weather forecasting, and to adapt to subtle but long-lasting changes in our climate.

NCAR efforts in this area include:

[Priority 1: Investigating Weather and Climate Information Needs and Decision Making](#)

While decision makers in virtually all sectors of the economy could benefit from improved weather and climate information, they often have little idea of what is currently available and how it could benefit them.... [Read more about this priority](#)



Societal Impacts Program



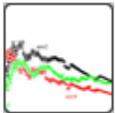
Incorporating Climate Change Information in Water Utility Planning

Priority 2: Building Capacity for Coping with Weather and Climate Hazards

NCAR scientists work in partnership with their stakeholder communities to research, build, and transfer state-of-the-art decision support information, tools and systems.... [Read more about this priority](#)



REFRACTT



Developmental Testbed Center



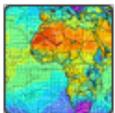
Climate Change, Seasonality and Environmental Hazards

Priority 3: Establishing New Connections with Researchers from Developing Nations

Many of the most interesting and important Earth system processes are global in scale and can only be effectively pursued with cooperation among nations and collaborative research efforts among institutions from many countries.... [Read more about this priority](#)



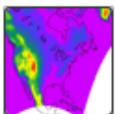
ISTP (International Symposium on Tropospheric Profiling)



Building Capacity in Developing Countries

Priority 4: Supporting and Conducting Regional-Scale Investigations of Climate and Weather

As climate change and societal vulnerability to severe weather becomes more apparent, decision makers want to know what changes are likely to occur in particular places... [Read more about this priority](#)



NARCAPP



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Cultivate a Scientifically Literate and Engaged Citizenry and a Diverse and Creative Workforce

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Our nation is facing a significant challenge in educating the next generation of scientists. As an NSF strategic partner, NCAR contributes to national efforts to improve science literacy, inspire students, educate teachers, inform policy makers, and build a diverse workforce. At NCAR, we recognize that the health of our institution depends on ensuring that those with aptitude and determination have opportunities in the atmospheric sciences and that they are welcomed and nurtured, regardless of gender, ethnic background, nationality, or physical ability.

To achieve this goal, NCAR researchers work with students and teachers in the lab, in the field, in real and virtual classrooms, and via our Web sites to engage them in the exciting research we do. With our own staff and visitors, we are committed to providing ongoing professional development and to creating a workplace environment that allows our employees to flourish.

As a national center, NCAR can catalyze efforts and provide critical leadership in its areas of expertise.

NCAR addresses four broad priorities within this goal:

Priority 1: Engaging a Broader and More Diverse Community

At NCAR, diversity extends beyond "vital statistics" to include diversity of disciplines, ideas, scientific background and approaches to problem solving. With a rich array of disciplines and a broad outreach component... [Read more about this priority](#)



Inter-American Institute for Global Change Research

Priority 2: Enhancing Science Education

In FY2006, NCAR advanced this priority through expanded collaborations and relationships with visiting scientists, faculty fellowship appointments, and professional development programs. NCAR scientists organized and carried out numerous national and international conferences and workshops... [Read more about this priority](#)



Student Field Project Support



Graduate Visitor Program

Priority 3: Improving Public Awareness and Understanding

This strategic priority and the previous one (enhancing formal science education) are not mutually exclusive and overlap in significant ways. Conferences, colloquia, and workshops enhance public awareness and understanding of the atmospheric sciences by building human and institutional capacity to deal with climate issues... [Read more about this priority](#)



VisLab Outreach Program



Climate Affairs

Priority 4: Maintaining an Innovative and Creative Workplace

Our scientific aspirations cannot be achieved without capable, intelligent, dedicated, and effective personnel. NCAR has increased the number of its early career scientists by 34 since 2001, and has successfully worked to improve the representation of women in the atmospheric sciences ... [Read more about this priority](#)



Science and Engineer Visitor Program



New, State-of-the-Art Chemistry Building and Mesa Lab Refurbishment



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Strategic Goal 4

Provide Robust, Accessible, and Innovative Information Services and Tools

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NCAR's scientific research programs work to provide more accurate advance warning of extreme weather, more skillful prediction of space weather events, and better prediction of the regional impacts of global climate change.

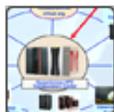
NCAR provides cyberinfrastructure on behalf of the National Science Foundation to enable rapid scientific progress in these areas of the atmospheric and related sciences. NCAR is continually expanding and upgrading its networking, high-end computing, and data management infrastructure and the related portfolio of services it provides to help achieve these advances. NCAR designs, develops, and maintains community models, modeling frameworks, and data analysis and visualization tools that are all made openly available to the community. NCAR collaborates with the community on research activities in computational science, applied mathematics, and geostatistics, with the goal of developing novel, improved techniques for attacking these key scientific problems and providing meaningful results for society.

NCAR has identified four key priorities for this goal:

[Priority 1: Enhancing Capability and Capacity of NCAR Supercomputing](#)

NCAR provisions, operates, and maintains supercomputing facilities and cyberinfrastructure to advance our understanding of the

atmospheric and related sciences... [Read more about this priority](#)



Workshop on High Performance Computing for Geosciences Research

Priority 2: Developing and Providing Advanced Services and Tools

For nearly 50 years, NCAR has provided a computational environment to satisfy the institution's overall mission of providing robust, reliable, accessible, innovative, and advanced services to the university community and the broader scientific community... [Read more about this priority](#)



TeraGrid Integration



FODM Integration into EOL

Priority 3: Conducting Research in Computer Science, Applied Mathematics, Statistics, and Numerical Methods

NCAR's research in computational science and math applied to geophysics enhances NCAR's computational resources and produces more efficient scientific simulations... [Read more about this priority](#)



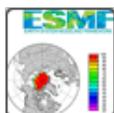
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| Ave median intensity | Max median intensity |
|----------------------|----------------------|
| 34.7 | 41 |
| 33.8 | 40 |
| 34.5 | 40 |
| 33.3 | 45 |

Verification Research

Priority 4: Creating an Earth System Knowledge Environment

NCAR continues to develop an Earth System Knowledge Environment that fosters knowledge sharing and accelerates scientific workflow.... [Read more about this priority](#)



Earth System Modeling Framework



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Provide World-Class Ground, Airborne, and Space-Borne Observational Facilities and Services

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Observations of our atmosphere, Earth system, and Sun are the basis for many scientific discoveries. The ability to make these observations is fundamental to meeting the science goals of NCAR and the community we serve.

On behalf of NSF, NCAR develops and deploys world-class ground, airborne, and spaceborne observational facilities and services that range from technical assistance on instrument deployment to the organization of field campaigns with hundreds of participants and multiple locations.

We operate the exciting NSF-owned High-performance Instrumented Airborne Platform for Environmental Research (HIAPER), a Gulfstream V (GV) and the world's most advanced research aircraft, along with the NSF/NCAR C-130 and a suite of airborne radars, lidars, and radiometers. Surface-based systems include several mobile radars, an eye-safe lidar, and a wide variety of in situ instruments. We operate the Mauna Loa Solar Observatory, which includes a coronagraph, polarimeter, and photometer, and we have polarimeters and a telescope at the National Solar Observatory in New Mexico.

NCAR priorities in this area include:

Priority 1: Enabling Innovative Field Experiments and Measurement Campaigns

The accuracy, robustness, and performance of weather, climate, and chemistry models depend on sound theory and accurate measurements. NCAR leadership in the area of field program planning and implementation is considered a critical service to the community... [Read more about this priority](#)



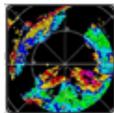
Virtual Operations Center

Priority 2: Developing New Instrumentation

NCAR is tasked with developing a new generation of robust, inexpensive, easily deployable, and versatile instruments to address observational requirements for weather, climate, water cycle, chemistry and dynamics of the upper troposphere/lower stratosphere, space weather, solar models, and the biogeosciences... [Read more about this priority](#)



CAPRIS



Radar Development and Enhancement



Instrument Development at Mauna Loa Solar Observatory

Priority 3: Installing Initial Instrument Suite and Beginning Operations of the NSF/NCAR HIAPER Aircraft

The year 2006 heralded the debut of nation's most advanced research aircraft, the NSF/NCAR GV. This cutting edge observational platform will meet the scientific needs of many disciplines and user communities... [Read more about this priority](#)



Installing the Initial Instrument Suite and Beginning Operations for the NSF/NCAR Gulfstream-V (GV)

Science: Strategic Goal 5

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NCAR Metrics

The following sections provide another method for viewing NCAR's contributions to the research community, over the past fiscal year. By providing concise "metrics" on a number of our outreach activities, it is easy to see just how much NCAR supports the greater research and education community.

We report on metrics in the following categories:

1. Education & Outreach
2. Honors & Awards
3. Community Service
4. Publications
5. People & Organization

Metrics

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