http://www.ncar.ucar.edu/archives/asr/ASR96/highlights.html Go

1996 ASR Highlights

Highlights of NCAR's FY96 Achievements

These are the most significant highlights from each NCAR division and program.

Atmospheric Chemistry Division Highlights

`data missing`

Atmospheric Technology Division Highlights

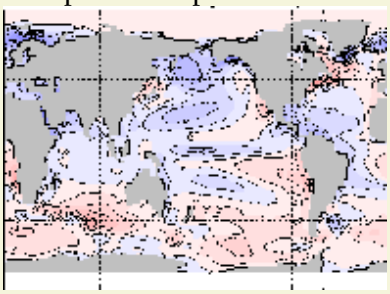
AVAPS/GPS Dropsonde System

The development of the advanced **Airborne Vertical Atmospheric Profiling System (AVAPS)/GPS Dropsonde System** was close to completion at the end of FY 96. This work has been supported by NOAA and the Deutsche Forschungsanstalt fuer Luft- und Raumfahrt (DLR, Germany). AVAPS has now progressed to the point where all the NOAA data systems (two four-channel systems plus spares for the NOAA G-IV aircraft and two four-channel systems plus spares for the NOAA P-3 aircraft) have been delivered, and the initial flight testing has been completed. Both high-level (45,000-foot-altitude) and low-level (22,000-foot-altitude) drop tests have been completed, including intercomparison tests in which sondes were dropped from both the G-IV and the P-3s. Data taken by the AVAPS system on the G-IV and by a second system installed in a leased Lear 36 aircraft are expected to play a key role in the Fronts and Atlantic Storm Tracks Experiment (FASTEX), scheduled for early 1997. The DLR four-channel AVAPS system is currently being built and will be installed on the DLR Falcon aircraft in March 1997. NCAR has transferred the technology to the public sector by licensing a commercial firm (Vaisala, Inc.) to build future GPS sondes and data systems. This effort is led by Hal Cole and Terry Hock.

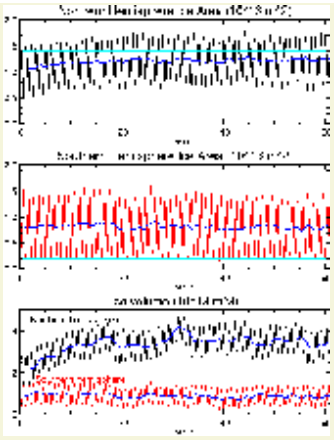
Climate and Global Dynamics Division Highlights

NCAR Climate System Modeling (CSM) Project

Completion of phase one of the NCAR Climate System Modeling (CSM) project. *(This figure*



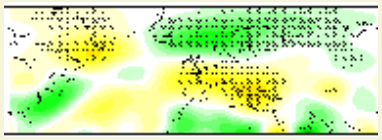
(23K) shows the difference in annually averaged sea surface temperatures (SSTs) between



the coupled model simulation (years 50 to 59) and climatology.) (This figure (21K) shows monthly time series of sea ice areas in the Northern Hemisphere (top) and Southern Hemisphere (middle) and ice volumes (bottom). Twelve-month running means are shown in blue, and observed annual minimum and maximum ice areas are shown by horizontal lines. Estimated annual mean ice volumes for each hemisphere are also indicated on the bottom panel.) This involved releasing on the World Wide Web the four independent codes that comprise the CSM. They are documented in six NCAR Technical Reports that were released at the CSM Workshop.

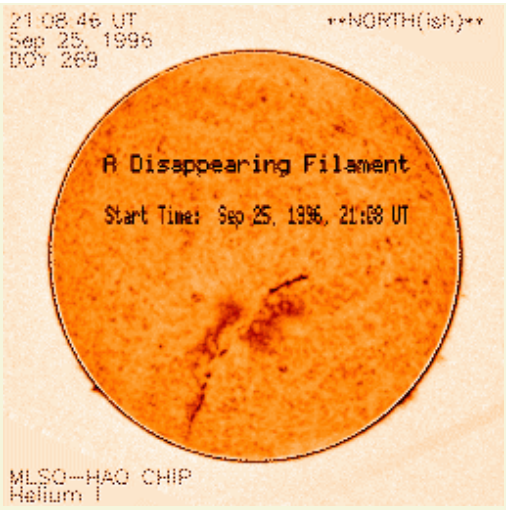
The NCAR CSM has now been integrated for 70 years without flux correction in heat or fresh water. The coupled model drifts are modest. This is the first time that a global coupled model has been run without flux correction that did not have substantial climate drift.

Studies of the North Atlantic Oscillation

Several studies have exploited the earlier work on the North Atlantic Oscillation (NAO) and its importance in explaining regional temperature and precipitation patterns. Hurrell used multivariate linear regression to quantify the effects of pronounced decadal changes in the wintertime atmospheric circulation on Northern Hemisphere surface temperatures. Nearly all of the observed cooling in the northwest Atlantic and the warming across Europe and downstream over Eurasia since the mid-1970s results from the changes in the NAO, and the NAO accounts for 31% of the hemispheric interannual variance over the past 60 winters. Hurrell and van Loon showed that NAO-related anomalies in precipitation include dry wintertime conditions over southern Europe and the Mediterranean and wetter-than-normal conditions over northern Europe and Scandinavia, consistent with that are changes in evaporation - precipitation  (*E* - *P*) between high and low NAO index values (23K). Changes in the monthly mean flow over the Atlantic are accompanied by a northward shift in the stormtracks and associated synoptic eddy activity, and these changes help to reinforce and maintain the anomalous mean circulation in the upper troposphere. Giorgi, Hurrell, Marinucci, and Beniston have shown that temperature changes over the Alps associated with the NAO show a strong elevation dependency, such that the higher the elevation the greater the warm anomaly during a high NAO index winter.

High Altitude Observatory Division Highlights

Chromospheric Helium Imaging Photometer



(Click on image for animation of this event, 503 KB mpeg.)

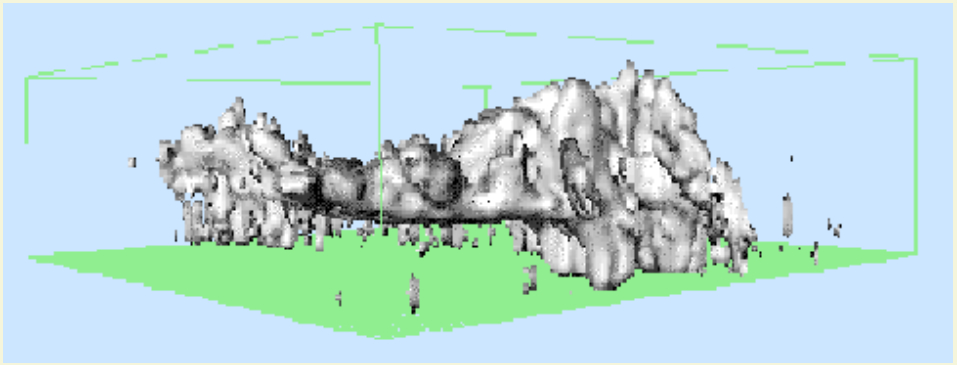
The Chromospheric Helium Imaging Photometer (CHIP) was installed at MLSO on April 15, 1996 by the HAO Instrumentation Group and is now producing full solar disk images of chromospheric structure associated with coronal activity. The CHIP is the only patrol instrument in the world capable of making HeI images at 20 images per hour. This is the first step in development of the Advanced Coronal Observing System (ACOS) at HAO.

LOWL Data Analysis

Steve Tomczyk, Paul Charbonneau (both HAO), J. Christensen-Dalsgaard (Aarhus University), R. Henning (Denver University), J. Schou (Stanford University), and M. J. Thompson (Queen Mary and Westfield College) analyzed LOWL data obtained during the period February 26, 1994 to February 25, 1996 in order to determine the location and thickness of the rotational shear layer at the base of the convection zone. They find that the shear layer has position (0.704 +/- 0.003) solar radii and width (0.050 +/- 0.012) solar radii.

Mesoscale and Microscale Meteorology Division Highlights

Cloud-Resolving Modeling



Cloud-resolving modeling by Xiaoqing Wu (long-term visitor), Wojciech Grabowski, and Mitchell Moncrieff faithfully reproduces the evolution among various types of GATE convective cloud systems in three spatial dimensions. Even shallow shear-parallel lines which are not well resolved are reproduced, demonstrating that large-scale variables (e.g., shear and forcing) are the key quantities. Also, for the first time, a squall line was shown to evolve spontaneously from a field of clouds. This is good news for deterministic parameterizations of organized cloud systems for GCMs (General Circulation Models).

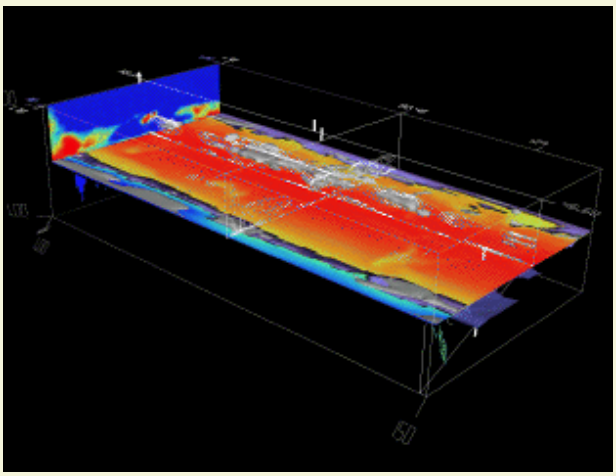
Coupled Atmosphere-Fire Modeling

A coupled atmosphere-fire numerical model developed by Terry Clark revealed the causes of common wildfire shapes and behavior and demonstrated how rotating columns near the fire front can rapidly intensify into a dangerous blowup. In agreement with observations, short-line fires bowed into a conical shape, while longer fire lines bent into multiple conical shapes due to feedback between the hot convective plumes and near-surface convergence at the fire front. Other experiments showed that when negative ambient wind shear existed, a pair of rotating updrafts at the fire front can touch down within the fire and break up the fire line.

Scientific Computing Division Highlights

USGCRP Climate Simulation Laboratory (CSL)

The CSL completed its first year of operation on July 31, 1996, and during its first year nearly 100,000 equivalent Y-MP hours were delivered to 11 projects selected by the CSL Allocations Panel in July 1996. The 11 projects have used this computer time to carry out multidecadal simulations, and to develop and/or evaluate components for use in coupled systems models.



(Click to see full-size image, 70K gif)

This image shows the output of several components from the Climate Simulation Model, including visualizations of atmosphere and ocean model data. This particular image shows global surface temperature, an ocean temperature isosurface, and a cloud fraction isosurface.

NCEP/NCAR Data Reanalysis Project

The NCEP/NCAR reanalysis project has a goal to prepare new global analyses for 40 years (1957-96), and to also do 10 earlier years if possible. Work started in February 1991 to prepare data, models, and systems. The operational production started June 1994. In September 1996, 20 years had been completed.

Example: This sequence of images (856 KB mpeg) shows the March 1993 US East Coast blizzard as represented by output from the NCEP/NCAR Reanalysis archive. The Mean Sea Level Pressure field (hPa) is shown with contour lines, and the six-hour average precipitation rate (mm/hour) is shown with color shading.

Image below: Reanalysis data is used to plot mean global temperatures and geopotential heights for December 1994 in this image.

Advanced Study Program Highlights

data missing

Environmental and Societal Impacts Group Highlights

Currents of Change Book

As a part of the focus on Usable Science, Glantz finished work on *Currents of Change: El Niño's Impact on Climate and Society*. This book presents an all-encompassing view of the El Niño phenomenon, its causes and impacts. Published by Cambridge University Press in September 1996, it includes testimonial comments by 35 researchers on their involvement in ENSO research over the decades.
Click on image to view entire cover (183k)

Research Applications Program Highlights

Data missing.

Education Highlights

Significant Opportunities in Atmospheric Research and Science

Twelve students from the U. S. and Puerto Rico participated in the first summer of Significant Opportunities in Atmospheric Research and Science (SOARS). The 12 SOARS students worked with scientific mentors from five NCAR divisions.

Clockwise from left: Christopher Castro, Carl Etsitty, Stephanie Rivale, Preston Heard, Lacey Holland, Quindi Franco, Jennifer Price, Kiesha Stevens, Paneen Petersen, Karen Mozealous, Jazmin Diaz-Lopez, and Jennifer Zabel.

Super Science Saturday

With funding from the Scientific and Cultural Facilities District, NCAR hosted Super Science Saturday, a community event at the Mesa Lab for educators, students, and parents. Over 800 people attended the event, which was staffed by volunteers from NCAR and UCAR.

(Zome tools, like the one framing this tyke, were a popular technology for bubble-making at Super Science Saturday.)

Thunderstorm Detectives

Thunderstorm Detectives, NCAR's traveling exhibit that highlights microburst research and technology transfer, completed its final year of a national tour of science museums and airports in 16 U.S. cities where millions of visitors have seen the exhibit. One copy of the exhibit is now on permanent display at the Saskatchewan Science Center in Regina, Saskatchewan, Canada.

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT
SCIENTIFIC COMPUTING

1996 SCD Annual Scientific Report

SCD's part of the NCAR Annual Scientific Report is structured according to its organizational units. You can return to this page from any file in this report by clicking on the banner at the top of any page. Navigation tools are also provided at the end of each page.

SCD's Organizational Units

- Division Office
- Computational Science Section
- Data Support Section
- High Performance Systems Section
- Network Engineering and Technology Section
- Operations and Information Support Section
- Technical Support and Development Section

Highlights

Highlights of SCD's FY96 Accomplishments

Publications

Publications list

Community Service and Educational Activities

Community Service Activities

Technical Presentations

Staff, Visitors, and Collaborators

Staff list

Visitor and collaborator list

https://web.archive.org/web/20040815083655/http://www.ncar.ucar.edu/archives/asr/ASR96/scd/[12/23/2016 12:09:25 PM]

Educational Activities Staff. Visitors and Collaborators.

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Division Office

Introduction

The Scientific Computing Division (SCD) is one of nine research and facility divisions of the National Center for Atmospheric Research (NCAR). Under a cooperative agreement with the National Science Foundation (NSF), NCAR is managed by the University Corporation for Atmospheric Research (UCAR) and its 61 member universities through the UCAR Board of Trustees. UCAR and NCAR work closely with NSF to establish priorities and plans consistent with those of the community, complementary to NSF's university grants program, and responsive to national and international initiatives and scientific opportunities.

NCAR's principal mission is twofold: to conduct research in the atmospheric and related sciences, and to support the university community by providing large computing, observational, and instrument facilities, and community models. NCAR also participates in educational programs ranging from elementary to postgraduate level, and in technology transfer to the public and private sectors.

SCD's vision is to enable the best computational, atmospheric, and related research in the world by being a recognized leader in providing, applying, and advancing high performance computing technologies and expertise. Extraordinary computational capability -- along with storage and analysis of huge datasets that are not widely available -- are required for much of this research. SCD also assists in carrying out the UCAR strategic plan. Thus, SCD's mission is to provide:

- High-performance computing resources and expertise needed for the development and execution of large, long-running numerical simulations
- An archival mass storage facility that is balanced in performance and capacity relative to computational resources
- High-speed network and data communication capabilities that are balanced with respect to computational facilities, storage facilities, and the requirements of a national and international user community
- A computing environment and support services that emphasize user productivity and cost-effectiveness
- Education and training in computing and related technologies with an emphasis on under-represented groups
- Transfer of appropriate UCAR technology to the public and private sectors in collaboration with the UCAR Foundation

To carry out its mission, SCD has a staff of about 100 Full Time Equivalents (FTEs).

Overview of SCD Facilities and Services

SCD has assembled a variety of hardware, software, and communications facilities. Functionally, these facilities consist of five major components: high-performance computers, mass store system, local and wide area networking, distributed servers, and visualization laboratories.

High-Performance Computers

The equipment delineated as "community computing" in Figure 1 is used by university scientists and NCAR scientists in support of:

- Climate
- Mesoscale and microscale meteorology
- Oceanography
- Chemistry and upper atmosphere
- Basic fluid dynamics
- Cloud physics
- Astrophysics

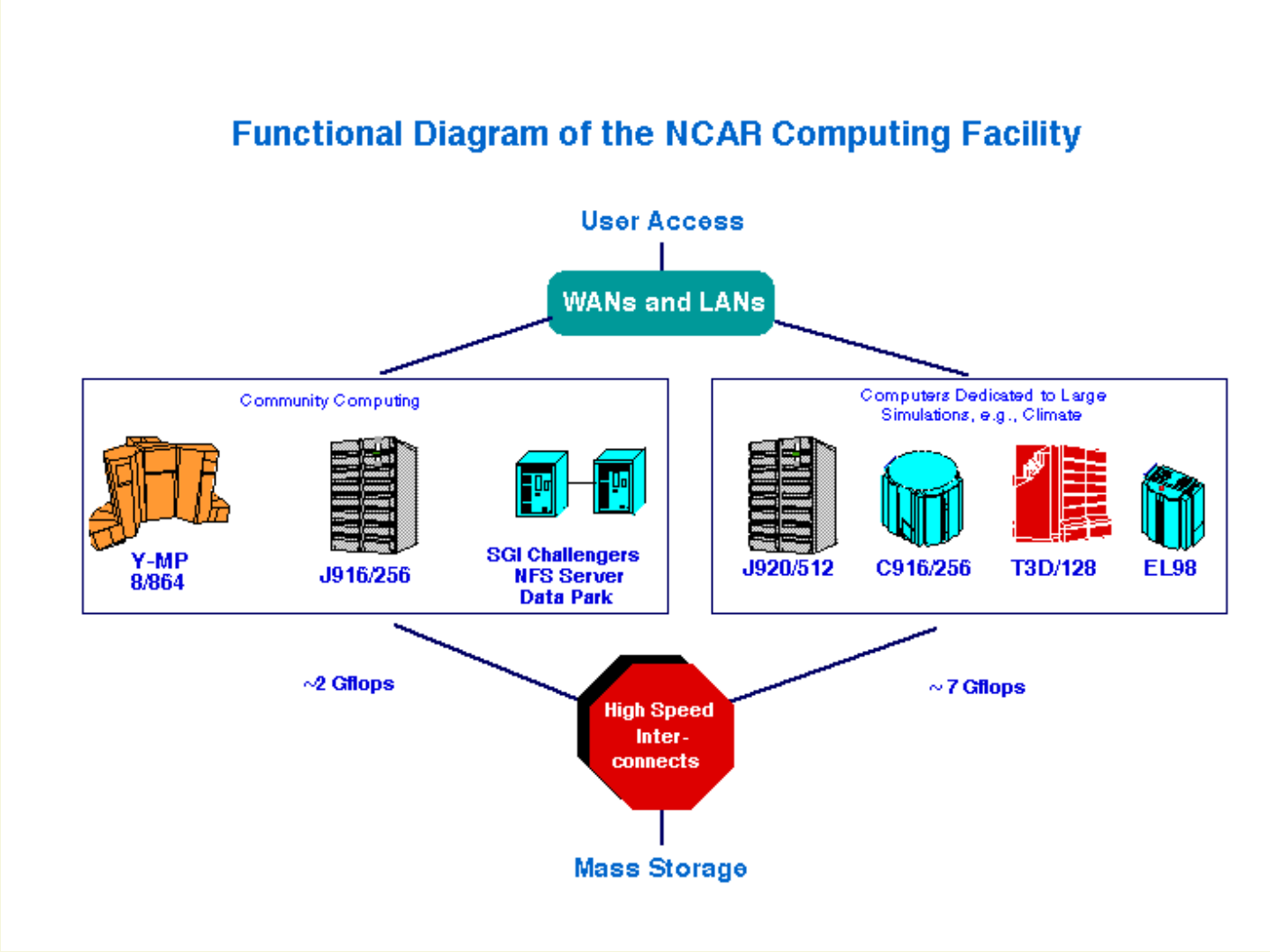


Figure 1. SCD Computing Facility Diagram, FY96

There is a growing need within the SCD user community for easy access to and computational analysis of large datasets. Such a facility must provide users with high-speed access to large datasets and/or substantial computing power for analysis of large datasets. We refer to this facility as the "Data Park." User systems that have HIPPI connectivity to SCD can take advantage of high-speed Network File System (NFS) services to access large datasets stored in the Data Park. Other users can take advantage of the computational server in the Data Park to analyze large datasets.

The equipment delineated as "computers dedicated to large simulations" in Figure 1 is used by a small number of activities that require large amounts of computing, e.g. coupled climate systems models. In particular, this equipment is used by the US Global Change Research Program (USGCRP) to support the multi-agency Climate Simulation Laboratory (CSL).

Mass Store System (MSS)

The NCAR MSS enables users to store and retrieve information (see Figure 2). The MSS is used to store model output, observational data, source files, backup files, etc. The system contained about 3 million files totaling about 80 terabytes at the end of FY96.

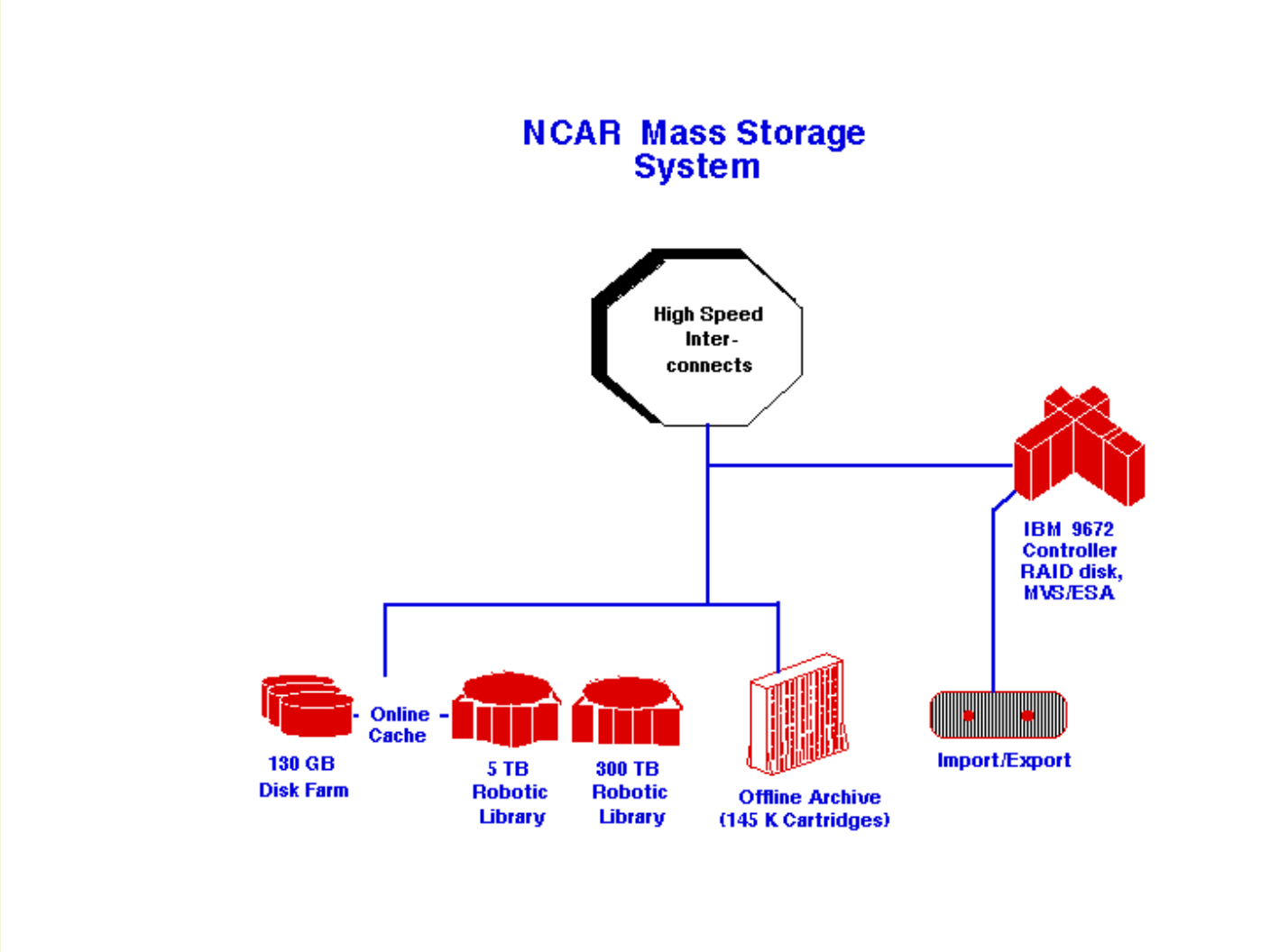


Figure 2. Mass Storage System Diagram

The MSS has two levels of storage. The first level is an online cache that provides quick access to recently referenced files. The second level consists of over 145,000 offline tape cartridges for storage of files that have not been recently referenced.

Local and Wide Area Networks (LANs and WANs)

For most scientists, desktop computers and/or departmental computers provide the primary means of software development and analysis of model output. These systems need to communicate with other computing systems including SCD high-performance computers and the MSS.

SCD is responsible for LANs throughout UCAR/NCAR and for UCARnet which integrates these LANs via state-of-the-art backbones and protocols. SCD is also responsible for interconnecting UCARnet and WANs to provide efficient access for remote users, both national and international, as well as providing UCAR staff with access to national and international networks.

Distributed Servers

By isolating functions to special servers, each server can be optimized to the function it provides, and changes can be made with minimal disruption to other servers. Functions that SCD has distributed to special servers include:

- User authentication
- Electronic mail
- Information accessible from the World Wide Web
- Job submission to supercomputers
- Weather data ingestion and distribution

Visualization Laboratory

As scientists execute increasingly complex and high-resolution 3D simulations, high-performance exploratory visualization and animation can play an important role in understanding the resulting data. SCD operates two visualization labs to address this area.

The Foothills Visualization Lab is a production, self-service facility used directly by scientists and their support staff to master single-frame animations and live visualizations to LaserDisc and professional Betacam-SP tape. The Mesa Visualization Lab is a state-of-the-art complex supporting R&D in the areas of visualization of very large datasets, volume visualization, distributed visualization, digital media development, High-Definition Television (HDTV), advanced visualization environments including virtual reality technologies, and the application of advanced networking technologies.

SCD Tools and Services

SCD makes available a suite of tools and support services that are intended to foster the scientific productivity of SCD users. These tools range from mathematical, graphical, and statistical software libraries to highly optimized job execution queues and scientific visualization of data. Support services and associated staff, e.g., programming consultants, software engineers, network engineers, computer operators, data specialists, scientific visualization experts, digital media experts, and computational theoreticians, are provided to assist users with the many aspects of computational science. SCD also provides meteorological and oceanic datasets and related data services to scientists around the world.

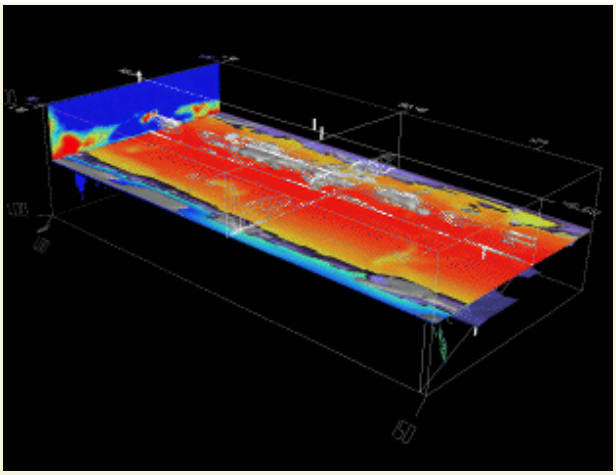
Accomplishments for FY96

We have organized our FY96 accomplishments into three categories: scientific, technical, and management. SCD either participates in or directly supports various scientific projects. Computing and communications technologies change rapidly, so one of SCD's greatest challenges is to keep pace with those changes. Finally, certain activities require careful management, so our accomplishments are organized accordingly.

Science Highlights

USGCRP Climate Simulation Laboratory (CSL)

The CSL completed its first year of operation on July 31, 1996, and during its first year nearly 100,000 equivalent Y-MP hours were delivered to 11 projects selected by the CSL Allocations Panel. The 11 projects have used this computer time to carry out multidecadal simulations, and to develop and/or evaluate components for use in coupled systems models.



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Reanalysis Project

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Portions of the output data are being written onto CD-ROMs. The larger datasets can be obtained from NCAR or used online at NCAR. Also, NOAA/CRC and NCDC have copies of the data.

Example: This sequence of images (856 KB mpeg) shows the March 1993 US East Coast blizzard as represented by output from the NCEP/NCAR Reanalysis archive. The Mean Sea Level Pressure field (hPa) is shown with contour lines, and the six-hour average precipitation rate (mm/hour) is shown with color shading.

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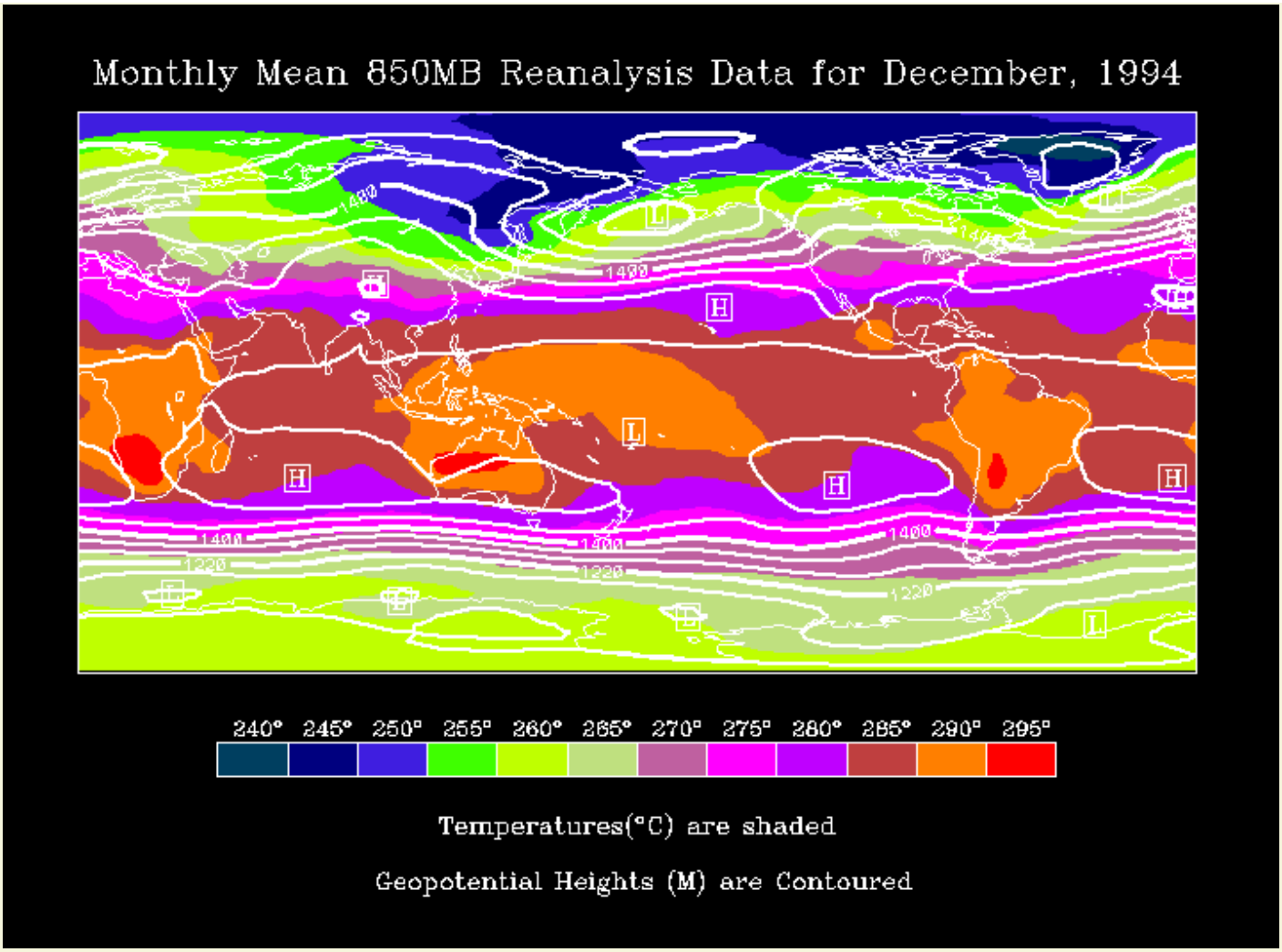

Distributed Climate Simulation Laboratory (DCSL)

Using the NSF experimental very High-Speed Backbone Network Service (vBNS), we have successfully distributed the NCAR Climate System Model (CSM) between NCAR and the San Diego Supercomputing Center. (This was not the first distribution of a climate model between two computers connected by a high-speed network. The objective of this project is to assess various capabilities of the vBNS.) A real-time visual monitor `[1.5 MB mpeg]` of the running, distributed model was developed and demonstrated at Supercomputing '95 in San Diego. This project also demonstrated that the vBNS is capable of transporting large datasets of 25 gigabytes or more. So the next generation (higher bandwidth) Internet should greatly expand the options for atmospheric scientists to collaborate.

Another component of the DCSL project focused on evaluating the use of the vBNS to transport and visualize very large (>25 GB) HPCC Grand Challenge turbulence datasets. ATM-based vBNS connectivity was established and subjected to extensive benchmarking and performance profiling. With a focus on improving scientific productivity, new tuneable high-performance file transfer tools were developed and made available to the scientific and technical community, including the University of Colorado, the University of California at Los Angeles, Argonne National Laboratory, and the San Diego Supercomputing Center.

New volume visualization software and stereo imaging techniques were developed and applied to both geophysical `[2.2 MB mpeg]` and astrophysical `[1.3 MB mpeg]` case studies, with the results being shown at the 1996 Geophysical Turbulence Program Workshop held at NCAR. The scientists working on the Grand Challenge problems reported much-improved insight into their complex simulations.

CO-OP 3D Project

SCD and MMM were involved in the CO-OP 3D project, a distributed computing research project funded by ARPA. This project used the Advanced Communications Technology Satellite (ACTS) to set up high-speed data communication links between NCAR, the Ohio Supercomputer Center (OSC), and the Great Lakes Environmental Research Lab.

The goal of CO-OP 3D was to run a nested-grid, nonhydrostatic version of the Pennsylvania State/NCAR mesoscale model -- MM5 -- on NCAR's CRAY Y-MP8/64 to model the atmosphere above Lake Erie with a grid spacing of 6-km/18-km/54-km (triple nests), while the OSC ran a 2-km MM5 model coupled with a 2-km lake model on OSC's CRAY Y-MP8/64 in a two-way interactive mode. The 2-km MM5 model was nested within the 6-km MM5 model, and the coupling of information between them was exchanged in realtime via the ACTS using the Parallel Virtual Machines (PVM) message-passing library. Interactive visualization sessions were conducted at each site as the coupled models ran, and these visualization activities were shared between sites. CO-OP 3D was successfully demonstrated at NCAR in the fall of 1995.

CO-OP 3D provided SCD and MMM with additional experience with PVM and the project pointed out some serious flaws in the ability of PVM to interconnect geographically distributed systems.

COADS

COADS is recognized worldwide as the most extensive set of surface marine data. This dataset is a result of a cooperative effort, beginning during the early 1980s, between NOAA and NCAR. NCAR contributes to the project by providing the computers for nearly all the data processing, a Mass Storage System for permanent archival, and through the Data Support Section, unrestricted distribution of these data and documentation. COADS is also the primary ocean-atmosphere boundary dataset used by the NCAR/NCEP Global Atmospheric Reanalysis project.

COADS Release 1 (April 1985) contained data for the 1854-1979 period. Release 1a (September 1993) extended the time series through the years 1980-1992. Later the 1993 data was added to Release 1a. Currently the focus is on Release 1b. This effort is a reprocessing of the post World War II portion of Release 1. During the reprocessing, previously unavailable data have been added and significant data processing improvements have been made that increase the overall quality of the archive. Release 1b now covers the 1950-1979 period. Using Release 1a and 1b, a special set of data products has been derived to support the Pan-American Climate Studies (PACS) program.

Technical Highlights

Data CD-ROM Project

The Data Support Section updated the CD-ROM that has many years of daily analyses for the Northern Hemisphere. This CD-ROM has been popular with various groups, including NWS forecasters.

Data Exchange

Under the U.S.-Russian bilateral, data exchange has been active. Two Russian PI's met with US PI's at NCAR in August 1996 to plan next year's program. In December 1995 (in Chile) and in February 1996 (at NCAR), some planning for the Inter-American IAI program continued. An exchange is starting with China.

Global Analysis

The normal and advanced analysis archives from NCEP operations were routinely updated. Forecasts are included. In addition, we archive all of the global observations from NCEP. Data also comes from ECMWF.

Datapark

During FY96, SCD developed plans for a new kind of data storage facility to better serve our user community. The proposed Datapark consists of a front-end file server capable of storing large amounts of data in a way that provides a high degree of accessibility to the researcher. The benefits to the researcher will be greater speed and access to the needed data and to the

computing power necessary for post-processing. SCD users will benefit as this post-processing is moved from the supercomputers to more economical machines. The Datapark will also allow us to provide data more rapidly by reducing the load on the Mass Storage System archive.

MSS upgrades

Several enhancements to the Mass Storage System have improved its usability and throughput. A set of POSIX-style commands was developed and successfully beta-tested in FY96. These commands create an environment where users have standard UNIX-style commands to manipulate MSS files just like UNIX files. The Mass Storage Control Processor (MSCP) was upgraded, doubling its capacity. Half of the MSS disk farm was replaced with newer disk technology. And the online storage capacity of the robotic tape cartridge handling system was increased to 300 terabytes.

Batch Priority System

SCD developed new software to introduce pre-emptive head-of-line and round-robin scheduling for supercomputing jobs. This Batch Priority System (BPS) more fairly distributes the computing resources among the various proposals on the CSL systems. It also provides better control and utilization of the resources on all machines.

Network Re-Engineering Project

NREP (Network Re-engineering Project) is a major project to fundamentally restructure the UCAR data communications networks. NREP is essentially an umbrella project that coordinates the implementation of several distinct re-engineering projects. The major goals of NREP are to:

- Restructure the conglomeration of expansionary-based legacy backbone networks and routing structures into a facility that is simpler and more rationally designed
- Replace unintelligent repeater-based shared-media end-user networks with high-speed state-of-the-art high-port-density Ethernet packet switches connected together with an ATM fabric, and utilize VLAN/ELAN (Virtual LAN/Emulated LAN) technology to simplify the host add-move-change problem by potentially allowing all logical networks to co-exist on a single physical infrastructure
- Provide each end-user computer at NCAR/UCAR with a dedicated full-duplex 10-Mbps or 100-Mbps link to an Ethernet packet switch
- Replace over 20 end-of-life-cycle routers, bridges, and ATM switches, as well as eliminate 2 of the 7 NCAR/UCAR FDDI rings
- Add 3 new Cisco 7507 routers, 4 Cisco 1010 ATM switches, and over 16 Cisco Catalyst 5000 packet switches, all tied together with an ATM fabric that will ultimately serve to replace the remaining 5 FDDI rings

Major progress was made on NREP in FY96.

Big Pipe Consortium

The BPC (Big Pipe Consortium) is NCAR/UCAR's major ATM MAN (Metro Area Network) project. SCD's Network Engineering and Technology Section spearheaded the BPC in 1995. The BPC is a loose consortium of Boulder-area institutions consisting of NCAR/UCAR, the University of Colorado, Colorado SuperNet (CSN), and Westnet.

The purpose of the BPC is to bring to NCAR a set of ATM (Asynchronous Transfer Mode) data communications links that allow BPC members to interchange information among themselves and the vBNS (very-high-speed Backbone Network Service), and more importantly, to share a single big data communications pipe to the commodity Internet.

Currently, this big pipe is a non-ATM DS-3 (45 Mbps) link provided by MCI, though at this time, BPC members are using only 10 Mbps of bandwidth. As commodity Internet access growth occurs, BPC members have the option to increase bandwidth consumption to the full 45-Mbps rate. By joining together as a group to access the commodity Internet, the BPC members save a considerable amount of money and obtain more service for the amount of money being spent.

The two major BPC ATM links consist of one ATM OC-3 link from NCAR/UCAR's Mesa Lab site to CU/Westnet at Boulder, and one fractional ATM link between ML and CSN/Westnet. A third important BPC MAN link is the ATM OC-3 link between the NCAR/UCAR ML and Foothills Lab sites.

The term "gigapop" (Gigabit Point Of Presence) has recently been coined to describe efforts such as the BPC, and Boulder is often listed as an example where a gigapop has already been built.

Machine Dependency Analysis

The objective of the committee performing this analysis is to determine the complex interrelationships between all the hardware and software in the SCD computer room. Our current analysis of this information improves SCD's ability to upgrade computers, networks, and storage systems with minimal disruption of production computing. Equally important, this information is critical to efficient restarts from unplanned shutdowns of specific systems or of the complete computer room.

Equipment Changes on The Computer Room Floor

During FY 96 several major hardware enhancements were made that increased the computing resources available in the areas of:

- Computers dedicated to large simulations - SCD upgraded a Cray J90 from 16 to 20 processors, making it the fastest machine on the floor for efficient, multi-tasked jobs.
- Computers for the general community - SCD upgraded another Cray J90 from 8 to 16 processors. With 256 megawords of memory, this is the best resource for large-memory jobs in the general user community.

Online Conference Room Reservation system

The web-based Room Reservation System, developed this year by SCD and managed by NCAR Facilities Support Services (FSS), gives UCAR staff an efficient and more convenient method for reserving UCAR conference rooms. This new system enabled FSS for the first time to manage room scheduling with part-time staff. The system design acheived these benefits without any increased costs for software in UCAR.

Model Coupling Library

The Model Coupling Library (MCL) was developed by John Dennis and Rich Loft. It is the "glue" that holds together CGD's Climate System Model (CSM). The MCL is a library of communication routines that provides a framework for building coupled climate models. It is conceptually divided into two basic functional categories: model control and data transfer. The control features of the MCL allow for initialization of the communication paths between coupled processes, fault detection, and graceful shutdown of all models if any one model crashes. The MCL has been tested under a variety of production and experimental configurations. This includes coupling supercomputers at two centers separated by 2000 km, using the vBNS and an OC3 ATM network, with a sustained data transfer rate of 4 Mbytes/sec. The MCL Version 1.0 has been released and has been used since May 1996 as an official part of CGD's Climate System Model (CSM).

ACE Benchmark suite

Steve Hammond and Rich Loft played a leading role over the prior two years in the ACE procurement process. They developed and/or assembled the elements of the NCAR Benchmark Suite which consists of 13 kernels and 3 complete geophysical simulation codes. The kernels measure specific aspects of system operation, such as accuracy of intrinsics, memory-to-memory bandwidth, processor speed, memory-to-disk I/O rates, and HIPPI transfer rates. The three applications are run at multiple resolutions. Together, these codes give a comprehensive measure of the capabilities of a computer system with respect to NCAR's computing environment as well as a computer system's performance under the anticipated computational load in the ACE. The Benchmark Suite was the cornerstone for the technical evaluation of the systems proposed under the ACE RFP and this work has been praised through the highest levels of NSF and many other agencies in

Washington.

National Geographic video

The Visualization Laboratories were instrumental in providing a filming venue and animation of simulated future climates for an upcoming educational film on climate change [4.9 MB mpeg] that is being produced by the National Geographic Society. Due to be released in January 1997, the film will show material from the Washington/Meehl sulfate aerosol study [1.8 MB mpeg] and T170-resolution clips from NCAR's Community Climate Model (CCM2) [3.2 MB mpeg]. A segment of the production was filmed in the Mesa Visualization Lab featuring Tim Scheitlin of the Visualization Group helping NCAR scientist Gerald Meehl explore simulation results and an interview with Meehl.

NetCDF optimization

NetCDF is a machine-independent, self-describing data format that is gaining wide use in scientific computing, but despite its highly useful features, its performance prohibited its use on the Cray supercomputer platforms for most applications. Jeff Kuehn, SCD's Technical Consulting Group Head, analyzed netCDF, optimized its performance on Cray systems, and led an interdivisional coordination effort to test and incorporate the improvements into simulations within the user community. Production users gained up to a factor of 100 improvement in the speed at which their codes run. UNIDATA has now folded Jeff's improvements into their distributed version, and netCDF is currently being considered for adoption into the CCM.

Management Highlights

Procurement of next-generation high-performance computers

In the spring of 1994, SCD began a competitive procurement for high-performance computers to be installed in the fall of 1996. The objective was to conduct a fair and open procurement with award based on technical merit. The associated benchmark suite and results obtained from it to evaluate the strengths and weaknesses of new computers has drawn high praise. Overall, the entire procurement -- from the drafting of the specifications through the final selection of equipment -- demonstrated considerable management and technical skill in SCD.

NSF Onsite Review

In keeping with the cooperative agreement, in FY96 NSF conducted a review of SCD activities for the previous five years. The review included documentation of activities and an onsite visit by a panel of experts in computing and communications technology. Following the report of the panel, SCD established a process for implementing recommendations from the panel in areas such as:

- NCAR Graphics development,
- Productivity tools,
- Identifying end-of-life systems, and
- Support policies for small systems.

Administration

Administration of Community Resources

Because of the partnership between NCAR, NSF, and the universities, SCD community resources and services are available to both NCAR scientists and university scientists throughout the nation. Also, a small number of projects funded by other government agencies and by the private sector use SCD resources and services (we refer to these as cost-recovery projects since they are charged actual cost of resources used).

In order to use SCD community computers, a scientist must obtain an allocation of General Accounting Units (GAUs). GAUs are the "common currency" by which SCD charges for use of supercomputers, storage, network access, etc. By the

end of FY96, 90K GAUs were available for allocation. By agreement with NSF, GAUs were distributed as follows:

Universities	40K (45%)
NCAR	40K (45%)
Joint Univ/NCAR Projects	7K
NCAR Director's Reserve	3K

Allocation to university scientists is by a peer review process. Twice each year, NSF grantees are invited to submit requests for allocation of GAUs. Proposals for less than 100 GAUs are allocated by the SCD Director subject to SCD's evaluation of the proposal. Proposals for 100 or more GAUs are sent out for peer review. Proposals for 100 GAUs to 250 GAUs are also allocated by the SCD Director subject to evaluation of the peer reviews. Finally, and again based on peer review, the SCD Advisory Panel recommends a specific allocation to proposals requesting more than 250 GAUs. Allocation to NCAR scientists is by the NCAR Allocations Committee that reports to the NCAR Director.

Administration of equipment dedicated to large simulations

The purpose of this equipment is to accelerate the completion of simulations that require hundreds and thousands of hours of computer time. In FY96, this equipment was almost totally consumed by support of the CSL and by HPCC applications. CSL and HPCC projects also have use of the MSS, the Visualization Laboratory, and SCD support services.

The CSL is a multi-agency facility of the US GCRP. Periodically announcements of opportunity for use of the CSL are issued to the climate modeling community. Associated proposals to use the CSL are reviewed by a panel of experts external to NCAR and the panel recommends allocation of CSL resources based on its review with respect to criteria that have been established for use of the CSL.

HPCC usage of this equipment is focused on development and/or execution of models that can execute on the T3D. Allocation is made by the SCD Director.

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT
SCIENTIFIC COMPUTING

Computational Science Section

Overview

The SCD Computational Science Section (CSS) provides state-of-the-art expertise in aspects of computing beneficial to the atmospheric and oceanic sciences communities. Our efforts are focused on four areas:

- Research
- Technology tracking
- Software development
- Education/outreach/knowledge transfer

We share the results of our work through collaborations, publications, software development, and seminars.

CSS conducts research in areas such as computational fluid dynamics, parallel communications algorithms for massively parallel architectures, and numerical solutions to elliptic partial differential equations using multigrid techniques. In addition, we are conducting basic research in alternate formulations of atmospheric and ocean models based on triangular (icosahedral) discretizations of the sphere.

The section engages in joint projects with groups within NCAR and from other institutions and agencies. These projects benefit the broader NCAR community. Currently, CSS is involved in projects, in conjunction with the Climate and Global Dynamics (CGD) Division of NCAR, and with support from the Department of Energy's (DOE) Computer Hardware, Advanced Mathematics, and Model Physics Project (CHAMMP) initiative, to develop a state-of-the-art coupled climate model framework that will run efficiently and effectively on distributed memory parallel computers. These projects are described below.

CSS is involved in technology tracking (performance monitoring and benchmarking studies) of both hardware and software. This work ensures the efficient use of current computing resources and is critical in selecting the most appropriate computers for the future production computing needs of NCAR and the university community. On the software side, staff play an active role in the Fortran standards effort as well as evaluating programming languages and paradigms.

We develop software packages to make use of our research results and our numerical and computational expertise. These libraries of scientific software are used by researchers in the atmospheric and related sciences community.

Finally, CSS staff are active in the area of education/outreach/knowledge transfer. We process all university requests for computing resources. We organize workshops, guest-lecture at universities, host post docs, and give seminars and talks at conferences.

Research

The Cartesian Method

Paul Swarztrauber, David Williamson (CGD), and John Drake (ORNL) have tested the Cartesian method for solving partial differential equations in spherical geometry and written a manuscript describing the method. Their codes demonstrate the viability of the method and will comprise a section of the manuscript. See the paper by Swarztrauber, Williamson, and Drake.

Cartesian coordinates are used to solve the nonlinear shallow-water equations on the sphere. The two-dimensional equations, in spherical coordinates, are first embedded in a three-dimensional system in a manner that preserves solutions of the two-dimensional system. Solutions of the three-dimensional system, with appropriate initial conditions, also solve the two-dimensional system on the surface of the sphere. The higher dimensional system is then transformed to Cartesian coordinates. Computations are limited to the surface of the sphere by projecting the equations, gradients, and solution onto the surface. The projected gradients are approximated by a weighted sum of function values on a neighboring stencil. The weights are determined by collocation using the spherical harmonics in trivariate polynomial form. That is, the weights are computed from the requirement that the projected gradients are near exact for a small set of spherical harmonics. The method is applicable to any distribution of points, and two test cases are implemented on an icosahedral geodesic grid. The method is both vectorizable

and parallelizable.

Shallow Water Equations

The accuracy of computed solutions to several formulations of the shallow water equations is compared. The shallow water equations can be written in a number of different forms that are obtained by: (a) combining terms into differential expressions; (b) raising the order of the differential equations, e.g., the vorticity-divergence formulation, and (c) transforming both independent and dependent variables. Although the exact solutions to the formulations are identical, the properties of the computed solutions vary depending on the formulation and the method of solution. Nine methods are examined, all of which provide satisfactory accuracy for a steady-state test case. The exact solution corresponds to a steady zonal wind that is tilted relative to the computational spherical coordinate system. The resulting wind passes over the north pole, providing a test of the "pole problem." Computational details are presented as well as the accuracy of a five-day computation in both 32- and 64-bit arithmetic. Stability and accuracy are shown to depend on the polar smoothing induced by resynthesis, which is also the accepted method for eliminating nonlinear aliasing. Eight of the nine methods mimic the exact solution by computing a numerical steady-state solution. See the paper by Swarztrauber.

Parallel Communication Algorithms

Transposing an NxN array that is distributed row or column-wise across P=N processors requires interprocessor communication. Its efficient implementation is of interest, particularly for use in weather and climate models where it can consume a significant percentage of the computing resource. It is also used in other fundamental computations including matrix-vector multiplication and the fast Fourier transform (FFT) of long sequences. A parallel transposition algorithm is presented for a k-ary n-cube multiprocessor with a programmable network. On a hypercube with a packet communication system, an NxN transposition requires the transmission of $\log_2 N$ packets with an average of $N/(2 \log_2 N)$ elements. If the communication system is element based, N/2 transmissions of a single element are required. The results are extended to other communication tasks including the general index-digit permutation and complementation, the case P =/= N and rectangular arrays with non-power of two dimensions. The results are also extended to mesh connected multiprocessors by embedding the hypercube in the mesh. The efficient implementation of these algorithms require certain architectural features that are listed here but not currently available in the marketplace. See the paper by Swarztrauber.

Fourier and Cyclic Reduction methods for Poisson's Equation

Computational fluid models often require the solution of Poisson's equation in models based on a stream function, velocity potential, vorticity, or the pressure of an incompressible fluid. In time-dependent models, Poisson's equation is solved at each time step and contributes substantially to the overall computing time. Here we describe the Fourier and Cyclic reduction methods for solving Poissons equation. Solutions can be computed on a rectangle in various coordinate systems including Cartesian, cylindrical, spherical or any separable coordinate system. A least-squares solution can be obtained when a solution does not exist in the traditional sense. We also discuss the availability of software and the implementation of the methods on multiprocessor computers. See the paper by Swarztrauber and Sweet.

Spherical Triangular Grids

Under the DOE CHAMMP program, we have made significant progress in our effort to understand the utility of triangular grids to atmospheric modeling in spherical geometry. Following Baumgardner's earlier work with the shallow water equations, our group at NCAR (with Baumgardner at Los Alamos National Laboratory) has implemented a triangular-grid-based, three-dimensional baroclinic atmospheric model forced by idealized Held-Suarez forcing for dynamical cores. Both three-time-level explicit semi-Lagrangian and semi-implicit, semi-Lagrangian time stepping schemes have been implemented. The semi-implicit semi-Lagrangian time stepping scheme uses Baumgardner's multigrid solver. We are working with a model resolution of 2890 quasi-equally spaced grid points on the sphere and 20 equally spaced sigma coordinate levels in the vertical. The time-step is 1080 sec. We are currently debugging the code, and anticipate having a working version soon. For comparison with current atmospheric methods of choice, we have created matching Eulerian and semi-Lagrangian spectral transform models employing the same vertical approximations and vertical levels as the triangular grid model. The triangular grid model is initialized with data spun up by the spectral semi-Lagrangian model with the Held-Suarez forcing.

Technology Tracking

The Computational Science Section (CSS) has responsibility for tracking the developments in high performance computing technology for SCD and NCAR. CSS staff assess the capabilities of the latest systems available from vendors and evaluate the performance of these these systems on problems typically found in the atmospheric sciences community. These systems, from workstations to supercomputers, are evaluated through literature, vendor presentations, and benchmarks.

The standard NCAR benchmark set was enhanced in early 1995. The earlier NCAR Community Climate Model (CCM0B) was replaced by the latest version (at the time the RFP was issued) of the model (CCM2). With the exceptions of the shallow water model (SWM) codes, the benchmark codes are benchmarks which were developed for evaluation of systems which were proposed in response to the recent UCAR/NCAR ACE Request for Proposal (RFP). These benchmarks were developed to represent the NCAR computing workload.

Description of Benchmarks

The NCAR benchmark codes are organized into three sets of benchmarks: the kernel benchmarks, the shallow water model, and the NCAR CCM2 climate model. The complete set is available through anonymous ftp and descriptions of the benchmarks are given in README files for each code. (The codes are in the UCAR ftp site, ftp.ucar.edu/css/, as kern1.tar.Z, SHAL.tar.Z, and ccm2.t42.tar.Z. The files are compressed and tarred.)

The kernels are a set of relatively simple codes which measure important aspects of the system such as cpu speed, memory bandwidth, and efficiency of intrinsic functions. These are the kernel codes:

1. ELEFUNT: elementary function test
2. PARANOIA: arithmetic operation test
3. IA: indirect addressing speed
4. XPOSE: array transpose
5. COPY: memory to memory test
6. RFFT: "scalar" FFT test
7. VFFT: "vectorized" FFT
8. RADABS: processor performance
9. I/O: memory to disk

The second benchmark set consists of different implementations and resolutions of a shallow water model. The shallow water equations give a primitive but useful representation of the dynamics of the atmosphere. The model has been used over the past decade to evaluate the high-end performance of computer systems. Finite difference approximations are used to solve the set of two-dimensional, partial differential equations. There is a single-processor version (with Cray multitasking directives), a parallel PVM version, and a Fortran 90 version of the model. The model is easily vectorized and parallelized and gives an indication of the higher-end performance of a system for moderate (64 x 64) and high (256 x 256) resolution problems.

The third benchmark is the NCAR Community Climate Model Version 2 (CCM2), which is a three-dimensional global climate model. This is the production version of the CCM in early 1994 and is computationally very close to the current production version which is widely used by the climate research community.

Systems tested

The current benchmark set was run on the following systems during the past year:

- Cray YMP
- Cray J90
- DEC 4100/EV5
- IBM SP2/590
- HP/Convex PA8000
- SGI MIPS R10000
- SUN Ultra Sparc2

Performance of these systems for the computational benchmarks shal64, shal256, and radabs is given in Figure 1 and the time to complete one day of simulation of the CCM2 on one processor of the systems is given in Figure 2. A comparison of the memory bandwidth of the systems for a copy of an array to a second array is given in Figure 3.

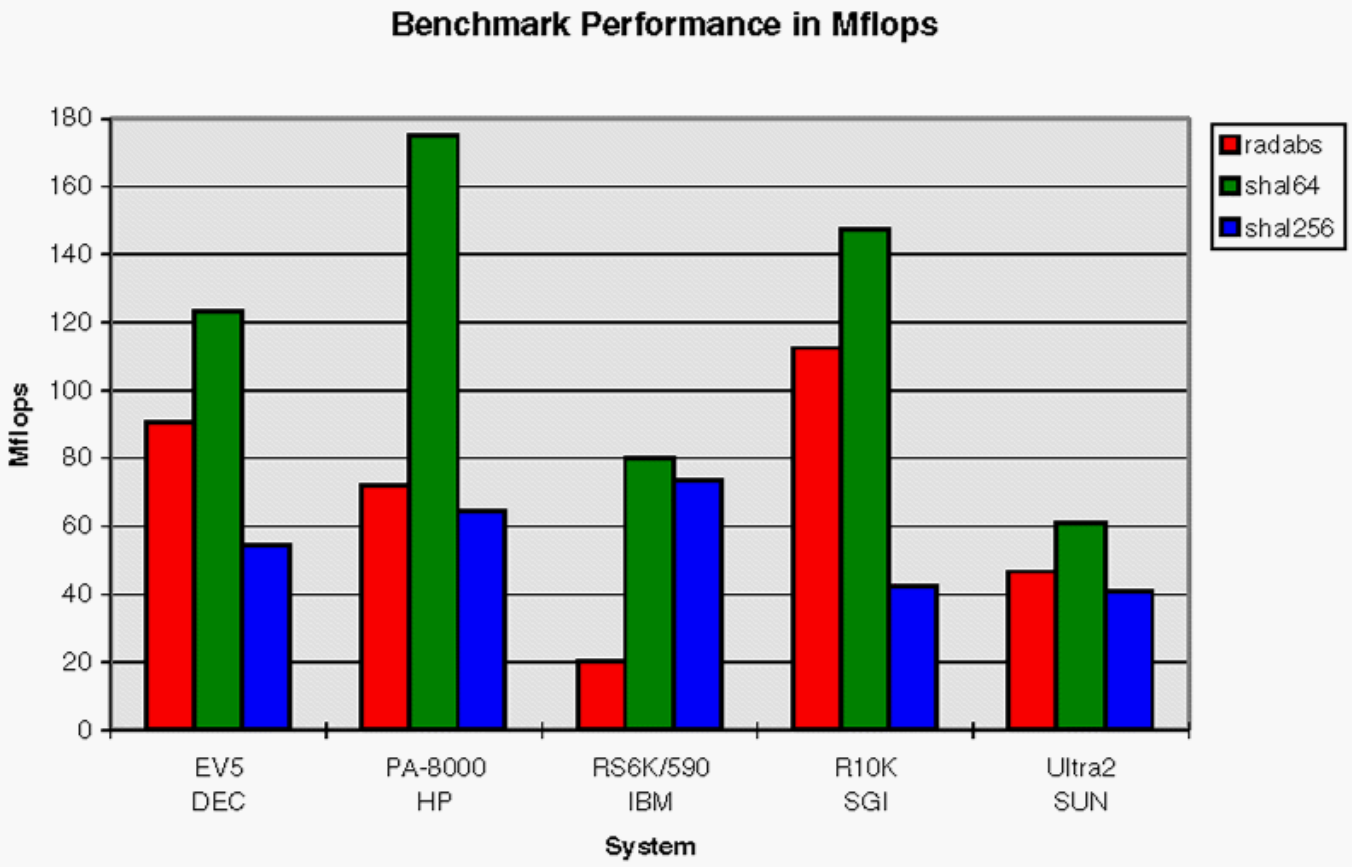

Figure 1. Bar chart showing the performance of radabs, shal64, and shal256 for each vendor

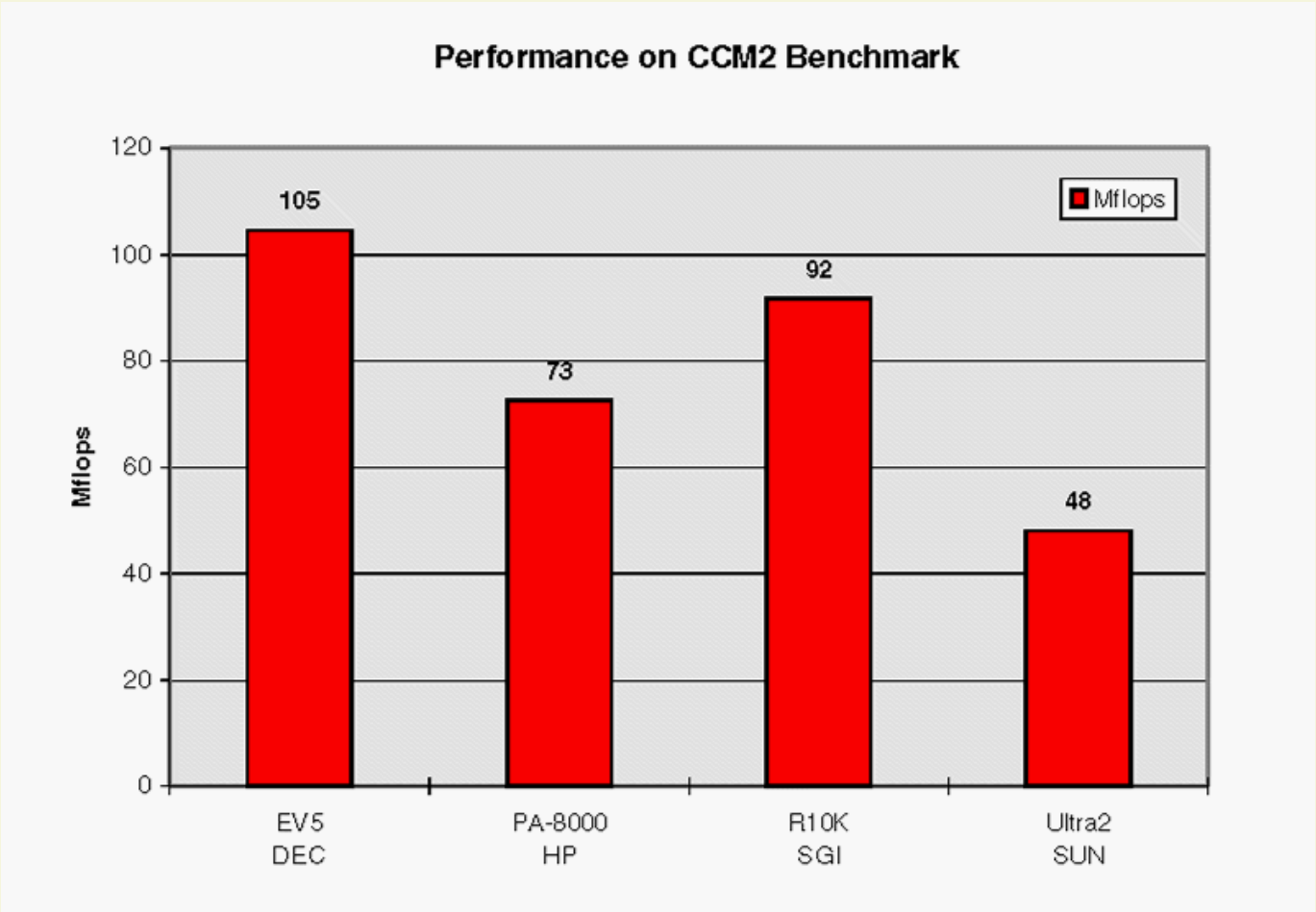

Figure 2. Bar chart showing the performance of CCM2

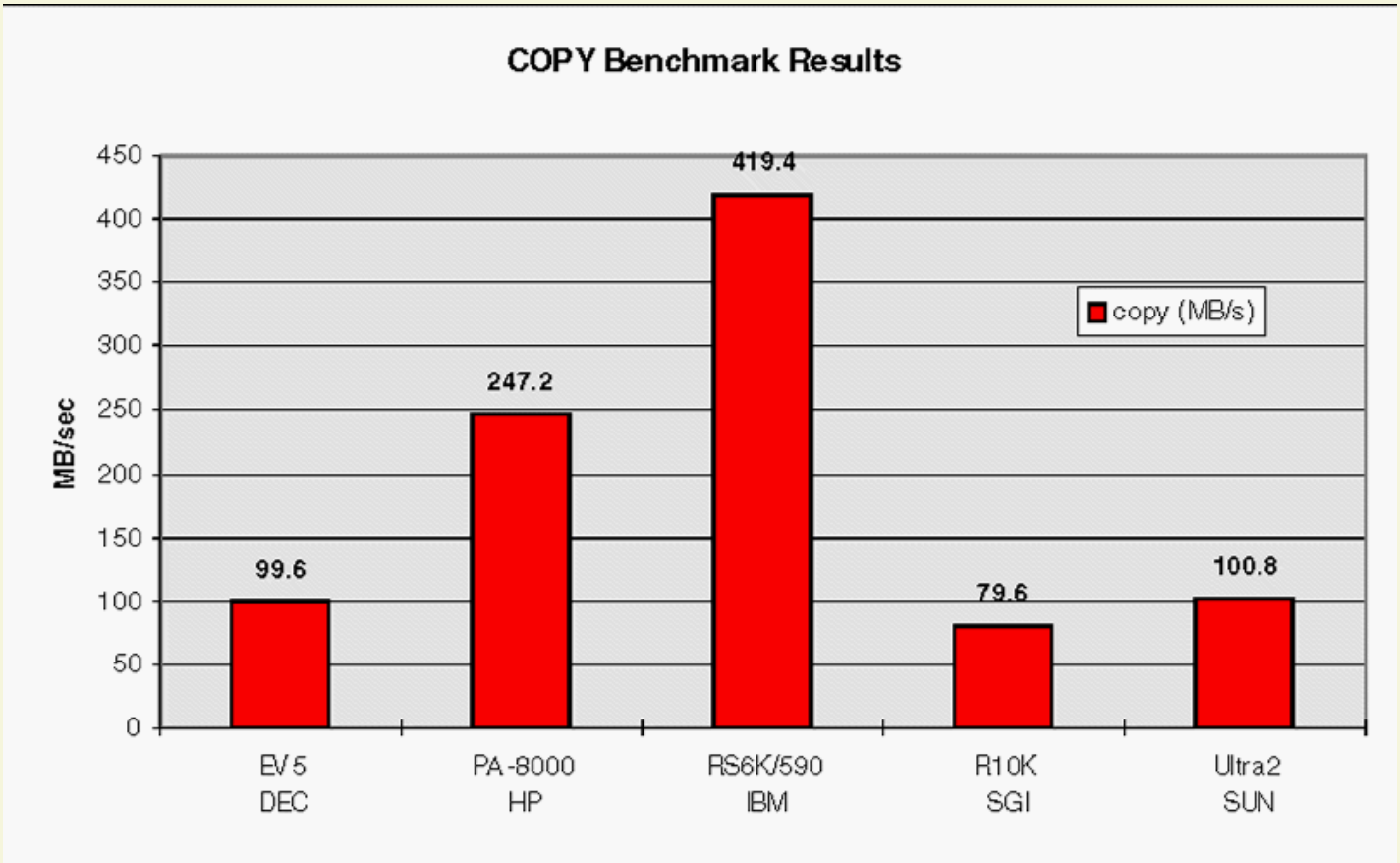

Figure 3. Plot showing the results of the COPY benchmark

Note that the computational performance in MFLOPS increases with resolution for vector machines but decreases for cache- based microprocessors. This can be attributed to the performance of the cache-based memory system of the RISC processors. As problem size increases, the cache use is less efficient. Figure 3 shows the memory bandwidth of the systems for the simple task of copying an array from one memory location to another. For raw performance, as measured by these benchmarks, for systems with comparable clock speeds, the vector architectures give better performance than the RISC microprocessors. However the price performance of the RISC-based systems is typically better than that of the vector-processor-based systems.

ACE Procurement

Hammond and Loft played a leading role over the prior two years in the ACE procurement process. They developed and/or assembled the elements of the ACE computational benchmark suite, which consists of 13 kernels and 3 complete geophysical simulation codes. The kernels measure specific aspects of system operation, such as accuracy of intrinsics, memory-to-memory bandwidth, processor speed, memory-to-disk I/O rates, and HIPPI transfer rates. The three applications are run at multiple resolutions as specified. Together these codes give a comprehensive measure of the capabilities of a computer system with respect to NCAR's computing environment as well as a computer system's performance under the anticipated computational load in the ACE. See the paper by Hammond, Loft, and Tannenbaum.

They contributed significant sections to the RFP and led the effort in evaluating the responses from each of the vendors. The future plans for this work are on hold until the international political and legal issues are resolved.

Standards

CSS continued its participation in the Fortran Standards Committee (X3J3) of the American National Standards Institute (ANSI), as well as the international group of Fortran experts (WG5) under the International Standards Organization (ISO).

Jeanne Adams reviewed and balloted on the draft Fortran 95 standard, and on various issues and clarifications. Additionally, she contributed to the Requirements for Fortran 200x. She reviewed the exception handling and the conditional compilation technical reports. See the papers and other publications by Adams.

Software Development

CHAMMP Coupled Model Framework

The CSS work for the "directed effort" portion of the DOE CHAMMP program is focused primarily on providing the coupling framework between the CCM3 (and subsequent releases) and POP. To accomplish this, Loft and Dennis will continue their development of a highly parallel version of NCAR's Flux Coupler (FC) so that it will cleanly and efficiently communicate with the NCAR CCM3 global atmospheric model. The FC provides a framework for controlling and coupling component system models such as the NCAR CCM3 and LANL POP ocean model. It is designed for model configuration flexibility, allowing each component to run with its own time stepping scheme, to have its own grid structure, and to maintain its own history and restart capability. This coupled-modeling strategy differs from other approaches in that each component model is run as a standalone model rather than as a subroutine of a single large executable. Loft and Dennis work closely with NCAR CGD staff to maximize code sharing of high level routines and to push implementation and machine specific details for the FC to a low level, thus rendering them invisible to a typical user. At the same time, the CHAMMP FC is being designed to facilitate numerical integrations in a heterogeneous environment and will be evolved to ensure that all models "gracefully" exit if one of the component models encounters an error during execution.

The present model-coupling strategy executes each model as a separate semi-autonomous MIMD process which couples to the other models by passing messages containing fluxes and other coupling information through an intermediary "hub" called the "Flux Coupler." This approach permits the coupled model to overlap model component calculations on multiple processors and avoids the software compatibility problems--such as multiple definitions of routine names--associated with the construction of a single monolithic program from pre-existing models from each discipline. Standard message formats are defined and component models that adhere to the standard can be readily interchanged.

The Flux Coupler and the component models are linked together by the "Model Coupling Library" (MCL). The MCL is a library of communication routines that provides a framework for building a coupled climate model. It was developed by John Dennis and Rich Loft. The MCL conceptually divides into two basic functional categories: model control and data transfer. Currently the model-control functions of the MCL are implemented in PVM3.3. PVM is the most natural choice for the control network because of its MIMD orientation. The control features of the MCL allow for initialization of the communication paths between coupled processes, fault detection, and graceful shutdown of all models if any one model crashes. The MCL has been tested under a variety of production and experimental configurations. This includes coupling PVPs at two centers separated by 2000 km, using the vBNS, an OC3 ATM network, with a sustained data transfer rate of 4 Mbytes/sec. The MCL Version 1.0 has been released and has been used since May 1996 as an official part of CGD's Climate System Model (CSM).

The data transfer function of the MCL is where performance is critical. The MCL supports several communication fabrics, including PVM,

transfer via DISK file, Named Pipes, AF_INET sockets, and FP-HIPPI, to provide high performance message passing under a wide variety of circumstances. Of course, details of each of each of these techniques is hidden from the user via MCL routine wrappers, and is user selectable.

Each of the component models are typically run on different grids. For example, CCM3 uses a low-resolution Gaussian latitude-longitude grid, while POP uses a high-resolution displaced pole grid. The Flux Coupler, in its role as intermediary, is responsible for the remapping fields between different grids. Our experience on the CM-5 has shown that the data remapping communication time can easily dominate the coupled model simulation time if not done efficiently.

In the past year we focused on developing a framework for coupled model execution on the Cray Research T3D using NCAR's model-coupling strategy. The T3D has certain restrictions that constrain our design of the coupled model. For instance, the T3D does not permit multiple processes on the same processors. This constraint severely impacts the performance of our implementation. Also, two processes running on different partitions cannot communicate directly via the toroidal network; instead they must communicate through the Cray Y-MP host machine. The speedup that the coupled system can achieve is limited by this serial bottleneck. A serial version of the latest Flux Coupler which is capable of coupling POP and CCM3 has been developed. It enables one to use the current MCL to couple CCM3, running on one T3D partition, to POP running on another, with the serial Flux Coupler executing on the host Y-MP.

MUDPACK

MUDPACK is a collection of subroutines that produce second- and fourth-order approximations to a variety of two- and three-dimensional elliptic partial differential equations using multigrid methods. Additions and improvements to this software package continue. Three dimension Hybrid codes which use direct methods at coarser grid levels and muligrid iteration at higher grid levels have been developed for inclusion with MUDPACK. Attempts to efficiently parallelize some of the MUDPACK routines have led to underlying code improvements for the future. A binary library for the new package MUDPACK II,
(input missing)

FFTPACK 5.0

Paul Swarztrauber and Dick Valent completed development of FFTPACK Version 5.0 this year and current efforts are directed to putting it in public domain.

Grid Data Transformation

Subroutines for transforming surface data on the sphere between Gaussian and equally spaced (co)latitude and equally spaced longitude grids of any resolution were developed and tested. This was done in collaboration with staff from SCD's Data Support Section.

Education, Outreach, and Knowledge Transfer

Allocation Of Community Resources

In the past year, CSS received 153 requests for 42,213 General Accounting Units (GAUs) and sent them out for review. In addition, we processed applications for use of the Climate Simulation Laboratory resources totalling 121,099 equivalent Cray Y-MP CPU hours. This was divided between eleven projects. Processing of requests for the year required categorizing and soliciting reviews in all areas of atmospheric and ocean science.

Post Docs

Bill Spotz (PhD from University of Texas) joined CSS in July 1996. He is doing research in high-order compact methods for fluid flow.

Workshops

Hammond and Swarztrauber (with Jim Hack and Dave Williamson, CGD) co-organized the "Joint Workshops On Numerical Methods For Global Models" which included the "Workshop On Test Cases For Dynamical Cores Of Atmospheric General Circulation Models" (Dynamical Cores) and the "Fifth Workshop On Numerical Solutions Of Fluid Flow In Spherical Geometry" (PDEs on the Sphere). The joint workshops were held June 11, 1996 and June 12-14, 1996, respectively, in Breckenridge, Colorado. There were 60 participants from the US and abroad.

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Data Support Section

The Data Support Section (DSS) maintains a large, organized archive of computer-accessible research data that is made available to scientists around the world. The archive represents an irreplaceable store of observed data and analyses and is used for major national and international atmospheric and oceanic research projects.

There are now over 480 distinct datasets in the archive, ranging in size from less than 1 MB to over 1 TB. Note below that DSS had 6.77 Tbytes of data in August 1996. This was an increase of 1.69 Tbytes during the 18 months since February 1995. We have been adding a lot of reanalysis data and other analyses. The change of data storage with time has been as shown in Table 1:

	Data Support Section		Total Mass Store		
Date	**Bit Files**	**Volume (TB)**	**Bit Files**	**Volume (TB)**	**DSS/MSS**
8/13/90	61,335	2.437	--	14.43	16.9%
8/4/91	65,518	2.689	715,000	19.4	13.9%
8/3/92	80,538	3.085	1,060,000	27.27	11.3%
8/93	103,314	4.072	1,351,271	36.28	11.2%
9/15/94	119,703	4.751	1,849,466	47.423	10.0%
2/14/95	123,877	5.085	1,966,990	52.456	9.7%
1/24/96	137,680	5.950	2,486,471	67.59	8.8%
8/28/96	143,340	6.770	2,888,639	78.964	8.6%

Table 1. Data Stored for Data Support and Total Mass Store

The DSS staff provide assistance and expertise in using the archive and help researchers locate data appropriate to their needs. Users may obtain copies of data by network access, on various tape media, or they may use data directly from the NCAR MSS. DSS staff also assist scientists by providing data access programs (to read and unpack data), other software for data manipulation, and dataset documentation.

From September 1995 through August 1996, DSS staff handled many requests for information about data, data processing tools, and online access programs. Staff handled 328 requests for data to be sent offsite. These requests required data from 477 datasets. Data were selected from 9192 archive volumes (holding 915 GB), and 750 GB were shipped to users. Users

received the data on 7 round tapes, 280 cartridges, 336 Exabyte tapes, and 42 PC floppies. In addition, at least 120 users received data by electronic transfer. We shipped 35 copies of the National Meteorological Center (NMC) gridpoint Compact Disk-Read Only Memory (CD-ROM). The University of Washington sold more of these CD-ROMs.

Table 2 shows a time history of our data requests from 1991- 1996. The amount of data that we send to users has increased from about 150 GB per year to 750 GB. The use of half-inch tapes has been decreasing a lot, while Exabyte tapes are popular. They give us a method to send large datasets at low cost, and the tape drives cost only around $2000. Many other users access the data from the NCAR computers. We help them to obtain our access software, etc. Then they run their programs, and we do not count those as data requests.

This shows the handling of user requests at DSS.

	1992 8/91 -7/92	1993 8/92 -7/93	1994 9/93 -8/94	1995 10/94 -9/95	1996 9/95 -8/96	
Requests handled	400	417	441	399		328
Data from (#) datasets	475	497				477
Read GB for user select	230	242	354	520		915
On MSS files (read for users)	6212	5099	7116	8268		9192
Select data (GB) to send	150	154	258	382		750
Sent on 1/2 inch tapes (#)	727	333	262	92		7
On 3480 cartridges	280	112	280	268		280
On Exabyte (8mm)	103	117	260	240		336
On PC floppy disks (#)	147	102	85	49		42
FTP transfers	16	80	89	190		120
Sold CD-ROM (NCEP analyses 1946-on)	15	29	35	11		35

Table 2. Data sent from NCAR DSS

Major accomplishments in FY96

NCEP/NCAR Reanalysis Project

This huge project will result in 40 or 50 years of global analyses, at 6-hour intervals. The production of analyses started June 1994. Twenty-two years were finished in September 1996. A paper was in Bull. AMS in March 1996.

1. Sent observations to NCEP for Reanalysis

   We sent more years of data to NCEP--all the world's surface, upper air, and satellite observations. As of September 1996, we have data needed to analyze 1968-1995. We are working on earlier years. It is a lot of work to prepare the data.

2. Handled the output from Reanalysis (54 Gbytes per year of analyses).

   These data arrive at NCAR at the rate of about 100 Gbytes of data per month during 1996.

CD-ROM Project

We updated the CD-ROM that has many years of daily analyses for the Northern Hemisphere. This included an update and more of the older data. NCAR sent the data inputs to University of Washington in December 1995. We started selling the CD-ROMs in July 1996. This CD-ROM has been popular with various groups, including NWS forecasters.

Ocean Data

Work on the Comprehensive Ocean-Atmosphere Data Set (COADS) led to new data for the 1960s and 1970s that includes

important new data. It is being used for reanalysis and many other projects.

Data Exchange

Under the US-Russian bilateral, the data exchange has been active. Two Russian PI's met with US PI's at NCAR in August 1996 to plan next year's program. In December 1995 (in Chile) and in February 1996 (at NCAR), some planning for the Inter-American (IAI) program continued.

NCEP data archives

The normal and advanced analysis archives from NMC operations were routinely updated. Forecasts are included. In addition, we archive all of the global observations from NCEP.

Maintain the archives and help users

We now have about 480 datasets. We updated many datasets during the year, and added some new ones.

Developed methods to obtain ECMWF Reanalysis data

The US research community needs the ECMWF reanalysis. An agreement has almost been reached under which there will be large data transfers in both directions, starting about October 1996.

More Information on selected projects

Reanalysis, benefits and staff time used

Reanalysis has been a very big project for us at NCAR (the same can be said for NCEP). There are many benefits from the project: A very good set of analyses, other output such as precipitation and radiation, and datasets of observations that are in much better quality (and easier to use). The observations can be used for future reanalyses and for all sorts of other research.

This project has a heavy impact on our time at NCAR. In late 1995, we had to speed up the work on all of the older datasets. Our Data Support Section had 7 FTE in August 1991; in October 1991 we had 10 FTE (we have also had 0.7 to 1.0 FTE of admin help). Both reanalysis and other projects have increase our workload. The time used on reanalysis has been as follows:

Feb 1991 - Dec 1992: ~2 FTE
Jan 1993 - Aug 1995: 2.5 to 3 FTE
Sep 1995 - Dec 1995: 4.5 FTE
Jan 1996 - May 1996: 6.5 FTE
Jun 1996 - Oct 1996: 5.3 FTE (1.0 of this is on output)

A brief history of the NCEP/NCAR reanalysis:

1. Some key dates in the project

   Feb 1991: The project started--prepare data, develop operational systems, and improve analysis methods (includes forecast models).

   June 1994: The production of analyses started.

   7 Sep 1995: 11.0 years were completed (1982-93, but not 1984)

   5 Jan 1996: 14.6 years (1982-95 and Jan-Jul 1979)

11 Feb 1996: 17.0 years were completed (1979-95)

Feb-Jul 1994: Run many tests; prepare for older data. Rerun some data.

26 July 1996: NCEP starts production of analyses for 1973-1977.

19 Sep 1996: 23.0 years are done (1973-1995) plus 8 months of 1996.

2. Some main texts and history of reanalysis

   We will give a short list of the texts which help to describe the history of reanalysis work, and which describe the present project.

   Oct 1988: Paper by Bengtsson and Shukla is in Bulletin of AMS.

   Oct 1988: Climate Diagnostics Workshop. Paper by R. Jenne on "A Global Reanalysis, Data Inputs and Methods." See the Workshop Publication, CAC, Mar 1989.

   Feb 1989: Reanalysis for TOGA, a workshop. See Bull. AMS, Nov 1989 for report by Kinter and Shukla.

   April 1991: Workshop for NMC/NCAR reanalysis: See Kalnay and Jenne, Bull AMS, Dec 1991.

   Bull AMS, Mar 1996: (Kalnay, et. al.) Major paper on NCEP/NCAR reanalysis

   Note: NCAR has a list of texts about the data inputs and data coverage.

Preparing Large Sets of Rawinsonde Data

For reanalysis, we are using data received in real time from world telecommunication (for 1962-1996). We also use several large sets of data prepared in past years and we use rawinsonde data received directly from a number of countries.

NCAR prepared a collection of data received from countries to send to NCEP. The recently prepared set has data for 1946-1967. Data series from Singapore, New Zealand, UK, French Islands, and permanent ships were collected. Individual years of data or short periods that were missing from the country series were collected from other data files and included. The rawinsondes were hydrostatically checked, as well as corrected for misplaced or unidentified surface, and incorrect data sources and types. The soundings for 1946-1967 were also extracted from other data series from other places: Australia, India, Hong Kong, Argentina, Brazil, South Africa, Japanese and UK Antarctic stations, Russian ships and Russian Arctic ice islands. Data for more recent years had been sent to NCEP earlier.

NCAR has a collection of all the upper air data (rawinsondes, aircraft winds, cloud winds, etc.) that were collected by NCEP from GTS communications. Data for 1968-95 has been sent to NCEP. Data for 1962-67 is in the final stages of preparation. Much work was needed to check and prepare correct locations, and do data cleanup (remove duplicates, remove extraneous data, and fix incorrect time periods offset by 12 hours.

Included in the plan for 1997-1998 are preparation of the US controlled soundings, the TD-54 set, the Canadian set, and the US marine set of raobs.

The task to update many datasets, and add new sets

NCAR has a very large archive (now about 480 datasets). Many people do not realize that the task of updating many datasets takes considerable time. We have to bring in the data, run inventories to check for problems that can be fixed, and update the information about the various archives.

During the period September 1995 through August 1996, 21 new datasets were added to the DSS archive. New sets include ocean pigment concentration estimates, the Global Historical Climatology Net, GEWEX Water Vapor set, TDF52 Air Force Pibal data, USSR surface synoptic data, hourly gridded precipitation, other new additions, and several new subsets of

existing data sets. The TOGA COARE archive is being integrated into the DSS archive and new subsets of Reanalysis products are being added. UPDATES: Over 200 different data sets were updated in the past year, with nearly 90 of these updated more than once. Three sets were updated several times each month and eight were updated monthly.

Removing errors in world station locations

There are many errors in various sources of information about the location and elevation of observing stations. When observations are used for reanalysis, it is very important that the location information be correct. Some location data has been wrong by many hundreds of kilometers. Progress in FY1996:

The general approach toward better station catalog information has been to start with the catalog of existing information most closely associated with the data set to which it would be applied. The location and elevation information is checked for internal consistency of locations over time and then checked against other sources of this same information. Many inconsistencies must be resolved by manual inspection.

For RAOBs, elevations have been calculated from the upper-air observations in order to validate the elevations reported in the catalog. Time limitations have prevented exhaustive use of this information, but it has been used to resolve discrepancies between other sources.

Station catalogs have been developed for data 1973 and later: NCEP upper-air decode files, USAF surface data decode files for 1967 through 1980, and TD13 surface data files. Work is in progress (Sep 1996) on catalogs for the pre-1973 NCEP upper-air decode files and the TD52 upper-air wind reports. TD13 and TD52 catalog information was key entered and verified from old documents. The catalogs have been used to check and correct location information on reports from other sources such as data received directly from various countries.

The comprehensive Ocean-Atmosphere Data Set (COADS)

COADS is recognized worldwide as the most extensive set of surface marine data over the past 140 years. This dataset is a result of a cooperative effort, beginning during the early 1980's, between NOAA's National Climatic Data Center and Climate Diagnostic Center (of ERL), and NCAR. NCAR contributes to the COADS project in three ways. Computers at NCAR are used for nearly all the data processing. The Mass Storage System serves as the permanent archive for all the data. The Data Support Section is responsible for a majority of the data and documentation distribution, and data access consultation. COADS Release 1 (April 1985) contained global marine data for the 1854-1979 period. Interim extensions to Release 1 added data for 1980 through 1991. Recent accomplishments have further extended the time series and made improvements to Release 1 and the interim extensions. Release 1a adds data to the time series for years 1980- 1993. Release 1b has upgraded and replaced data for the 1960- 1979 period. Figure 1 shows two time series of numbers of reports in COADS. The two curves represent the most recent part of Release 1 and the interim extensions (1960-1991) and the Release 1a and 1b collections completed to date (1960-1993). This illustrates how we have added previously unavailable data to the global COADS archive. Along with adding observations to COADS we have made data processing improvements that increase the overall quality of the data, e.g. upgraded the format to include more data fields, fixed some known data errors, and changed processing rules to achieve an improved mixture (from the many data sources) of observations. In the near future the 1950-1959 decade will be added to Release 1b and 1994-1995 will be added to Release 1a. Longer term efforts will focus on adapting our procedure for 1996 to accommodate changes being made by our source data providers, and improving the overall data quality control procedures in preparation for reprocessing the full period of record. In parallel we will continue to develop our online documentation, accessible via FTP and the WWW, so that the COADS data users can conveniently keep informed about our achievements.

Figure 1. Time series of numbers of reports in COADS Release 1 and Interim extensions, and COADS Release 1a and Release 1b as of September 1996

Data Support for Oceanographic Research

Requests for oceanographic research data at NCAR and throughout the UCAR membership are given a high priority.

Requests are filled in several ways. Data are collected from outside NCAR, documented, verified with access programs, and placed on the MSS for use on all local systems. Data products developed at NCAR, but outside of SCD, are migrated to the MSS, documented and placed under control and maintenance of the DSS. These products are then similarly available to all local systems at NCAR. Numerous data requests are also received from persons not having NCAR computing accounts. In these cases data, documentation, and access software furnished to the user by network or magnetic media transfers.

A few current achievements and forthcoming projects are now briefly described to illustrate the scope of these activities.

Improvements to COADS rely on acquisition of previously unvailable data. NCAR receives regular updates to support COADS from the Marine Environmental Data Service of Canada, the World Data Center B in Obninsk, Russian, the Inter-American Tropical Tuna Commission, the National Oceanographic Data Center (NODC), NOAA's Pacific Marine Environmental Laboratory, and Polar Science Center at the University of Washington just to mention a few. Collecting and placing these data into the permanent DSS archives insures the baseline data for COADS in the future.

Cooperative data efforts with other government agencies also provide a significant service to the research community. Two examples of this are the World Ocean Atlas (WOA) 1994 by Levitus and associates at NODC and National Centers for Environmental Prediction (NCEP) sea surface temperature analyses by Reynolds and associates. The WOA provides the most complete set of ocean profiles in existence, and a variety of analyzed grids that are useful for ocean modeling. The NCEP temperature analyses has several different data products with one, an optimum blend of satellite and marine surface observations, that is kept current to nearly real-time.

Satellite data have become more important in recent years. To support research at NCAR we receive the scatterometer surface wind data derived from measurements by the European Research Satellite 1 (ERS1). We began receiving these data in 1991 and continue to do so today. We are now preparing to receive a similar product from the NASA Scatterometer (NSCAT). The satellite was successfully placed in orbit August 1996. Preparation activities include evaluating simulated data, data format, and execution of proposed access software in the workstation and supercomputer environments.

By responding to data service needs like these mentioned above, and many other smaller activities, the DSS supports a wide variety research throughout the national and international community.

Results from user survey of August 1995

Each four years the users of the Scientific Computing Division have been surveyed to determine their satisfaction with the services. The Data Support Section looked very good in this survey We had been a little concerned that our heavy pressure to carry out the reanalysis project may have hurt support for some of our users. We still have lots of work to do to gather more data, prepare it, and give users easy access.

Data for the very high atmosphere, 70-1000 km

Since as early as 1966, NSF has funded five special radar sites to probe the upper atmosphere between about 80 and 1000 km. The main database from several radars is from 1981-on. Variables such as temperature electron density, and ion velocity are measured. In 1984, NSF began a special program involving the DSS and NCAR's HAO to establish and maintain a database at NCAR so that data from several radars can be easily used together. Under the CEDAR program, this effort has expanded to include related ground-based measurements and model output; for example, Fabry-Perot interferometer observations, Light Detection and Ranging (LIDAR) observations by the University of Illinois, Thermospheric/Ionospheric General Circulation Model (TIGCM) output from Ray Roble (HAO), and Assimilative Mapping of Ionospheric Electrodynamics (AMIE) model output from Art Richmond (HAO). Mesosphere-troposphere radar, medium-frequency radar, and high-frequency radar data have been added.

A minicomputer is maintained at NCAR for database access. Batch and interactive software and documentation have been written and installed. Internet access is maintained at two levels: Documentation and data inventories may be obtained via anonymous ftp or Web page, but a login is required to obtain data. Current plans are to add an interactive data selection capability to the Web interface. We assist data contributors by designing new record layouts, providing conversion software and verifying results. This summer, we provided these services plus an office with computer access to a visitor from Kyoto University, while he commenced conversion of the Japanese MU (Mesosphere and Upper atmosphere) incoherent scatter

radar data set (about 1 day per month from 1988 to present). DSS staff will periodically archive new data contributions, fill data and software requests, consult with users, and prepare and distribute an annual catalog.

NCAR/TN-427+PPR-CEDAR DATABASE COMMITTEE REPORT. JM Holt (MIT Haystack Observatory) and B.A. Emery. June 96.

Summary of data support provided for users

The Data Support Section helps many users obtain data they need, and it also carries out a number of special projects. There are five main ways that users obtain data and information.

Data sent from NCAR DSS

Many users request data sets from the DSS archive. These requests often involve consulting on data needs, giving price estimates, consulting on use of the data, preparing subsets to meet user needs, and delivering data to the user via ftp or on media.

Help people use data on NCAR computers

There are about 450 NCAR staff plus about 750 university staff who use the main computers at NCAR. When these users need archive data, the DSS helps them to start using the data and provides simple data access programs that makes access easy. This is 10% initial help, and 90% self-serve. This accounts for more data volume of use than the data sent to distant areas.

Users obtain data and information from self-service DSS data server

This online system became available for users in January 1992, and DSS keeps expanding the content and data volume available. Monthly use statistics are summarized below:

Monthly Activity Jan-Jul 1993

1. 3200 connects from ~800 unique sites
2. File retrieval of data & info

   11,000 total files

   8,000 of these are real time weather data

   3,000 of these are main datasets & info files

Monthly Activity Jan-Sep 1996

1. 35,000 files taken
2. Primary info & data files

   Total of about 8000 files and 1600MB (file count was 3000 in 1993)

   File counts for some institution catagories:

   Educational 2400 (105 different institutions)
   Government 500
   Foreign 2000

Data provided for major projects and exchanges

About 98% of the data in this category has not been entered in our other accounting systems. Under the NASA TOVS Pathfinder Project, DSS provided 631 GB of TOVS (Oct 78-Mar 92) to three places (Goddard, NOAA, France). So 1893 GB were sent during 1992-1996.

For reanalysis, the main work is a lot of data checking and making data fixes on many, many datasets. The volume is about 202 GB to send during 1993-1996. During 1993-95 (and earlier), we provided climate model data for the US Country Studies Program and for IPCC to make assessment studies (crops, forests, etc.). In 1994 we provided 50 copies of 7 floppies, and 200 copies of 6 floppies (IPCC). In 1995, we gave 50 copies of 10 disks, and 25 copies of 13 disks.

Consulting about data

DSS receives many email and phone messages about data. Based on spot checks, these are about 320/month (or 4000 per year). It takes about 2 or 2.5 message transactions to handle each of these. Example questions: What is the closest rawinsonde station to Kitt Peak? In addition, Ilana Stern sends a short email newsletter to ECMWF users (67 users on list in 1996), about 5 times a year.

The NCAR Data Support On-Line Data and Information

The Data Support Section has been preparing information about data for many years. Since January 1992, we have been making more of this information available online. This information system is used heavily.

This online system has catalogs of our datasets, documentation about them, selected reports and software, and some smaller amounts of data, all for quick access on-line. It was useful as soon as it became available for users in January 1992. By July 1992 another main step in adding information had been attained, and more is being added all of the time. Ilana Stern was able to gather usage statistics starting mid-Dec 1992.

Data Support provides information services, not only for our own data holdings, but to help people find data services elsewhere. One example of this is that Ilana Stern continues to maintain, update, and distribute the USENET sci.geo.meteorology Data Sources Frequently Asked Questions list. This list currently (1994) has 48 WWW sites, 26 gopher sites, 56 FTP sites, 18 telnet sites, and sources for 42 CD-ROM sets, along with information on national and international data centers, U.S. State Climatologists, and other meteorological resource information. This set of documents was cited in an article in the Summer 1994 issue of the Department of Commerce's Mariner's Weather Log as "the most extensive list of weather, oceanographic and climatic information available."

The Data Support Section Information area can be accessed by direct ftp or through the Web.

Anonymous ftp access is via:
ncardata.ucar.edu (128.117.8.111)

World Wide Web access is via:
http://www.scd.ucar.edu/dss

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT
SCIENTIFIC COMPUTING

High Performance Systems Section

The High Performance Systems Section (HPS) is responsible for the technical duties and developments related to the supercomputers, Mass Storage System, and computer workstations used by NCAR to serve the needs of researchers working in the atmospheric sciences. The three groups of the High Performance Systems Section manage, engineer, program, and administrate a host of supercomputers and workstations, and a Mass Storage System with 80 terabytes of atmospheric data.

Supercomputer Systems Group

High performance computing at NCAR is supported by the Supercomputer Systems Group (SSG), which consists of six people who install, maintain, administer and enhance vendor-supplied operating software and related software products for seven Cray Research, Inc. computing systems. The group also assists hardware engineers in diagnosing and resolving hardware problems. Additionally, the group develops software systems to handle special needs that arise which are beyond the functionality provided in standard release software. These include enhancements in the areas of scheduling, accounting, and special connections to equipment and networks. User assistance and troubleshooting are also important aspects of the group's supercomputer support role.

Four different models are evident in the seven Cray computing systems for which the group is responsible. Six of the systems are traditional shared-memory parallel vector processor (PVP) computers, and one is a distributed memory, multiple processing element computer with massively parallel processor (MPP) type architecture.

A summary of the computers and their demonstrated sustainable performance in gigaflops (billions of floating point operations per second) follows:

Cray computer model	Number of CPUs	Clock speed (ns)	Central memory size (64-bit Mwords)	Auxiliary solid-state memory (64-bit Mwords)	Approximate power (GFLOPS)
Y-MP8/864*	8	6	64	256	1.2
Y-MP8I/864**	8	6	64	256	1.0
J932/20**	20	10	512	-	1.5
J916/16*	16	10	256	-	1.0
EL98**	8	30	256	-	0.2
EL92*	2	30	64	-	0.05

T3D (MPP)	64	-	-	-	0.6
				Total Power:	**5.5**

* General community computers
** Dedicated to CSL programs

Machine Upgrades

Unlike previous years, no new major computers were installed in FY '96. However, both J9-series machines received significant upgrades in number of CPUs and memory capacity. In addition, RAID devices were attached to both J9 computers to increase disk capacity and performance.

Software Upgrades

The operating software and associated products were upgraded to the UNICOS 9.0.2 release version on four of the six PVP Crays. The two Cray Y-MPs were not upgraded, primarily because of plans for their decommissioning in the near future.

The upgrade to the UNICOS 9.0.2 release was particularly significant because, unlike previous releases, the system was distributed in binary form only, as opposed to source code. NCAR has relied on source releases principally because they allow the inclusion of local modifications, by which we have added enhancements required to meet the needs in the NCAR computing environment. Accounting and scheduling are two areas where we were particularly dependent on local modifications. Fortunately, we were able to develop alternative methods and programs to provide the same functionality as in previous releases. This did however require a significant amount of time and resources to accomplish.

Additional software capability was added to the Crays in support of PVM, ATM, DCE, and C++.

Security

Root security was enhanced on the Crays with the addition of one-time passwords using the SecureNet Key system. Many other measures were taken to improve security on the Crays by the addition of tcp wrappers, deactivation of unnecessary and vulnerable services, disallowing of remote commands by root, and discontinuation of NFS service on vBNS accessible Crays.

Job Scheduling

Batch program scheduling of supercomputers poses problems. Achieving good utilization, throughput, turnaround, and fairness for a diverse set of users and programs is a major challenge. Besides careful tuning of the vendor-supplied NQS queueing system, it has been necessary to develop additional software and strategies to meet these objectives. An additional layer of scheduling -- a batch priority system (BPS) -- was written to introduce preemptive head-of-line and round-robin scheduling. This was done to more fairly distribute the computing resources among the various proposals on the CSL machines, and to provide better control and utilization of the resources on all machines.

On the Y-MP used by the general community, a near-dedicated (ND) facility was developed to guarantee machine resources to selected climate models during specified hours of the day (usually the 11 pm to the 6 am period, plus Sunday). Models run in this time period are ones which, because of their very large resource requirements, would be unable to run with a normal, full job mix. ND does allow, however, any cycles unused by the model to be used by other work.

Support for Distributed Computing

SSG worked closely with other SCD sections in the support of two significant experiments in distributed computing. In both experiments, SSG's contribution centered around the research and experimentation involved in tuning the network and computer configurations to achieve the necessary mix of data bandwidth and computer power to effectively run the models in a distributed environment. The San Diego experiment was run as a centerpiece of the NCAR presentation at Supercomputing 95.

CO-OP 3D Project

CO-OP 3D was a distributed-computing research project funded by ARPA, which used NASA's Advanced Communications Technology Satellite (ACTS) to set up high-speed data communication links between NCAR and the Ohio State Supercomputer Center. It demonstrated the ability to create a coupled environmental modeling system encompassing weather, lake, and wave forecasting, and advanced the technology of distributed computing and high-speed networking. The models continually exchanged information via ACTS, and provided output data to local and remote visualization workstations.

Distributed Climate Simulation Laboratory

In collaboration with San Diego Supercomputer Center, the second experiment remotely linked the J9 computer at NCAR with the C90 computer at SDSC using the NSF very high-speed Backbone Network Service (vBNS). A distributed version of the Climate System Model -- the DCSM -- divided the work between the computers at the two sites. Data were exchanged in real time over the vBNS. A high-performance shared filesystem was used to store all model output.

ACE Procurement

A major project, which became one SSG member's major responsibility for much of FY '96, was the development of the ACE procurement RFP, and the benchmarking and evaluation of the responding vendors' systems.

Mass Storage System Group

The NCAR Mass Storage System (MSS) is a central, large-scale data archive that stores data used and generated by climate models and other programs executed on NCAR's compute servers. The NCAR MSS currently manages more than 2.9 million files totaling over 80 TB of stored data. Net growth rate of data in the MSS is approximately 1.5 terabytes (TB) per month. On average, 100,000 cartridges are being mounted per month, approximately half of these by operators and the other half in the StorageTek Powderhorn Automated Cartridge Subsystems (ACS), which are systems that use robotics to mount and dismount cartridges. On a daily basis, the system handles approximately 11,000 requests involving about 300 GB of data. During 1996, data transfers to and from the MSS exceeded 100 TB.

While some of the data stored on the NCAR MSS originate from field experiments and observations, the bulk of the data are generated by global climate-simulation models and other earth-science models that run on supercomputers, and SCD faces an increasing demand to archive data from ever-faster supercomputers. Essentially, the faster the supercomputer, the more data there are to be archived. Even greater demands for archiving data will result from the growing use of coupled atmospheric/oceanic simulation models.

MSS Access Methods

The NCAR MSS provides two access methods. The first method is a high-speed data fabric. The data fabric consists of host computer High Performance Parallel Interface (HIPPI) channel interfaces, non-blocking HIPPI switches capable of supporting multiple bi-directional 100 MB/sec data transfers, and protocol converters that connect the HIPPI data fabric to the IBM-style device control units. The data fabric provides data paths directly between the MSS storage devices and the client compute servers. To utilize this data fabric, SCD has written a file-transport type of interface to enable users to copy files between their host systems and the MSS. The data fabric provides the fastest access of the two methods and can support 11 independent file transfer operations between the storage devices and the compute servers, with 6 transfers sustaining 3 MB/sec each and 5 transfers sustaining 10 MB/sec each, for an aggregate total of 68 MB/sec.

The second access method uses File Transfer Protocol (FTP) to access MSS data. With FTP, any host computer attached to the Internet can access the NCAR MSS.

MSS Storage Hierarchy

The NCAR MSS currently uses two levels of storage: online and offline. The most frequently accessed data are kept on the fastest storage media, which is the online storage devices: 90 GBs of IBM 3390 Model 3 disks, 40 GBs of IBM 3380 Model E disks and two StorageTek Powderhorn ACSs. The Powderhorn ACSs utilize 3490E-based technology as well as StorageTek SD-3 (Redwood) technology. The SD-3 Powerhorn ACS expands the total online capacity to 300 terabytes. Lower in the storage hierarchy is a 3409E offline cartridge tape library holding 145,000 cartridges that can be staged with one of the 16 external IBM 3490E manually mounted cartridge drives. StorageTek SD-3 drives have been added to the offline storage level for migration of the existing data holdings. When the migration is complete, the total capacity of the offline archive will exceed 1 petabyte.

MSS Import/Export Capability

Another important capability of the NCAR MSS is the ability to import and export data to and from external, portable media. Importing data involves copying data from portable media to the MSS data archive, while exporting data involves copying data from the MSS data archive to portable media. Import/export allow users to bring data to NCAR with them, as well as take data away. Import also allows data from field experiments to be copied to the NCAR MSS archive.

In addition to 3480 and 3490E cartridge tapes, and 7- and 9-track round tapes, the NCAR MSS also offers import/export to single- and double-density Exabyte cartridge tapes.

Improvements to NCAR MSS

In FY 96, SCD made significant improvements to the NCAR MSS:

First, working with the NCAR/SCD Distributed Computing Services (DCS) project, the MSS group co-developed an interface between the MSS Master File Directory (MFD) and a set of POSIX-style commands. The MSS MFD is a metadata database that contains information for all files stored in the NCAR MSS. The command set was placed into beta test mode in FY96 and is expected to become a production interface in FY97. This command set creates an environment where the user will have standard UNIX-style commands to manipulate MSS files just as the user manipulates UNIX files today. In support of the DCS command set, a trash can feature was added to the NCAR MSS. The trash can is where deleted or purged MSS files are placed for a short period of time to allow retrieval of those files.

Second, the Mass Storage Control Processor (MSCP) was upgraded, doubling its capacity and providing state-of-the-art data channel support. At the same time, the system disks containing the MFD were upgraded to a Redundant Array of Independent Disks (RAID) system which provides fault-tolerant storage. The MSCP operating system was also upgraded to a supported version.

Third, half of the MSS disk farm was replaced with newer disk technology. The remaining half is scheduled to be replaced in FY97.

Fourth, a StorageTek Powderhorn ACS with SD-3 (Redwood) cartridge drives was purchased to increase the online storage capacity to 300 terabytes. In addition, manually mounted SD-3 cartridge drives were purchased to increase the offline capacity well beyond 1 petabyte.

Finally, the NCAR MSS Group is actively integrating state-of-the-art storage devices and is planning a migration to these new technologies in FY 97.

Distributed Services Group

Distributed Services provides the necessary infrastructure for the NCAR community to conduct daily computational

activities. For instance, DSG provides the NCAR electronic mail service and supports both Internet and Intranet World Wide Web (WWW) servers, as well as Domain Name Service (DNS) for NCAR. Most of these services are provided transparently to NCAR users. Additionally, DSG supports interactive servers on which daily activities are conducted (e.g., e-mail, text editing, MSS access), gateway servers which process 50% of supercomputer job submittals and MSS activity, text and graphical image processing, library access and queries, and computational service.

The focus of the Distributed Services Group (DSG) for 1996 was on:

- Consolidating services onto fewer servers
- Upgrading servers to the vendor's latest operating system levels
- Integrating high availability hardware and software on servers
- Increasing use of productivity tools
- Upgrading older servers to newer hardware configurations
- Using industry-standard software such as Distributed Computing Environment (DCE) to eventually replace legacy systems, e.g. Mainframe and Server Network (MASnet) and MASnet/Internet Gateway Service or MIGS
- Reducing the number of vendors that DSG supports in a production mode
- Phasing out obsolete servers and workstations
- Taking the leadership role in server security measures
- Integrating interconnection technologies such as Fiber Channel (FC) and Asynchronous Transfer Mode (ATM) into DSG servers

Infrastructure Support Services

DCE Administration

With the eventual phasing out of MASnet, Distributed Computing Services (DCS) has moved to the forefront as the next-generation MSS interface technology. DCS user-command-line interfaces have already been installed and tested on many SCD front-line servers (e.g., NCAR user server, SCD resource accounting server, Data Support Server, MIGS/IRJE server) with a high level of user satisfaction. Future plans are to include expansion onto the MIGS/IRJE complex and new supercomputers. In order for DCS to function properly, a DCE cell must exist and be maintained. Two servers, a DEC Alpha 3000/500 and a IBM RS/6000 250, are used to administer the DCE cell.

Security and DNS

The authentication servers are used for root identification on the DSG servers and supercomputers, and for DNS service. They also verify users' access on servers located outside the firewall. The security and DNS servers (two Sun Ultra1s) were configured last year in a high-availability (HA) configuration, to increase reliability and minimize system downtime. DSG also supports the DNS service at the Foothills Lab complex using a Sun 4/370 server.

Distributed Systems Management

DSG currently uses management servers primarily for administering workstations within SCD (e.g., Sun and IBM). The servers are a Sun Sparc 20 for the Sun workstations, and an IBM RS/6000 320 for IBM workstation administration.

Communication

The main communication services that DSG provides for all of NCAR is electronic mail and NetNews. This is currently being done on a Sun 4/690.

Data and Service Access Services

Network Queuing

The current gateway servers, IRJE and MIGS, provide batch and spooled access to NCAR's distributed resources. These gateways provide a buffer between the SCD computing center and the rest of the world, and allow for expected and unexpected disruptions in communications and service without loss of information. Over the last year, in a joint collaboration effort between Sun and SCD, the entire MIGS/IRJE software was ported over to Solaris 2.X from SunOS. The MIGS/IRJE system is currently a Sun 4/690 with 4 processors, although the a new MIGS machine, a Sun Enterprise 3000, is currently running in limited-user mode to test the new Sun Solaris code.

Remote Access Processing Front-ends

The connect account machine supports 1-800 account activity from remote geographical sites for NCAR users. This server is on a Sun 4/380.

Data Storage and Availability Services

File Service

A major initiative is underway to expand the file service available to users. It involves decommissioning the Auspex server and deploying a new server. An SGI Challenge XL was brought online last year, and currently supports SCD staff. It will have approximately 300 GB of data space by year end 1996. All data files on the file server, named Middlepark, are in RAID storage devices to protect data and provide continuous availability for users. To increase throughput to the MSS, a HIPPI interface was installed. To increase bandwidth to internal and external users, an ATM link was also provided.

Data and Information Processing

User Work Environment

The interactive servers (front-end computers) provide users with access to NCAR's distributed resources. These users may not have access to workstations of their own, may require 24-hour service and support, may not have good network access to NCAR, or may be away from their usual work sites. The interactive servers provide a variety of services such as editing, job submission, and output return, e-mail, and the ability to make requests of other distributed resources. There was little change in our interactive access servers. SCD supports two primary access servers: meeker, a Sun 4/670MP with 4 processors for NCAR divisional or university users; and niwot, a Sun 4/690MP for SCD's users. The SCD divisional server also doubles as the SCD divisional resource accounting machine, running Oracle database software.

Data Processing Servers

Data processing servers are those that process raw data information and convert it to some other format. This might involve data collected by weather data servers and processed into user datasets, post-processing of climate model data, or raw user accounting data which are converted into user resource accounting information. This activity is conducted on two different servers: a Sun IPX, which does the data collection; and a Sun 4/690MP 4 processor, which processes the collected data and makes them available to the outside world via the ftp service.

SCD Computation Science Server

The Computational Science Section used a Sun Sparc 20 for collecting and processing information on the ACE initiative. The machine also acts as their section's own personal server for running statistical analysis, testing and debugging code, and project tracking.

Text And Graphics System (TAGS)

TAGS lets users select an output device for processing files with various formats at NCAR. In addition to microfiche and 35mm film processing, TAGS supports video movie production. The TAGS system is frozen in the current hardware and

software configuration. TAGS was developed around the SunOS 4.1.X operating system and cannot be ported to the Solaris operating system without a great deal of effort. The TAGS complex of servers is comprised of two Sun 4/690MPs, each supporting 4 processors each.

SCD Graphics/Visualization Server

This server is used for SCD graphics code development, as well as the group's home directories and files. It is an SGI Challenge L with two processors.

Informational Service

During the course of 1996, the WWW service was split onto a internal and external WWW servers. DSG also supports the library system which provides information about articles and books to NCAR users. The WWW activity is conducted on two different servers, a Sun Server 1000 used for external Internet activity and a Sun Server 1000 used for UCAR internal Intranet activity. The library service is provided by a IBM RS/6000 320 server.

Computational Service

CM-5

A CM-5 Connection Machine with 32 processors, 128 Mwords of main memory, and 20 GB of disk storage was run for a restricted set of users who paid for maintenance on the machine. The CM5 was a solid performer from its installation of May 1993, averaging 70 to 90 percent utilization. The machine was decommissioned on July 15, 1996.

IBM RS/6000 Cluster

Over the last year, the IBM SP1 was integrated into the RS/6000 cluster to take advantage of services provided by the cluster front-end (e.g., accounting, statistics, batch processing). The SP1 at that time was used exclusively for PVM code development and processing. The SP1 was decommissioned Winter 1995. The rest of the cluster is comprised of three RS/6000 590s (one for CGD exclusively), an RS/6000 990, and a RS/6000 550 front-end.

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Network Engineering & Technology Section

The Network Engineering and Technology Section (NETS) participates in the planning, engineering, installation, operation, and maintenance of state-of-the-art networking and data communications facilities for NCAR/UCAR. The support of these facilities includes evaluating new networking methodologies and equipment, maintaining databases of the wiring plant and equipment, troubleshooting of network hardware and software problems, error and load monitoring, tuning, supporting a work-request system for networking, reconfiguration for optimal performance to meet changing needs, and consultation in the utilization of these systems.

In addition, the NETS supports all SCD networking needs and maintains and repairs certain SCD computer hardware.

The NETS Section supports special networking projects and supports the networking portion of advanced projects that are a product of outside or inter-agency funding. International networking projects are also supported by the NETS. Additionally, the NETS maintains a transit network that supports the interconnection of several major national networks.

The NETS also provides a critical service to the atmospheric research community by linking supercomputing resources (including mass storage systems and other data communication resources) to scientists at NCAR and throughout the university research community. These activities are essential to the effective use of the hardware and the overall advancement of scientific inquiry.

The Big Pipe Consortium (BPC)/very High-Speed Backbone Network Service (vBNS)

The NETS maintains a 10Mbps Commodity Internet link through MCI. This link has been in place and running successfully for over a year. The NETS implemented an innovative cost and bandwidth sharing partnership in June 1995 coined the Big Pipe Consortium (BPC). This was an effort to combine metropolitan area Commodity Internet traffic at a central location to take advantage of the economies of scale realized by shared service. This has resulted in an extremely successful partnership with Westnet and other regional area users. The NETS has also continued its support of the vBNS both for network engineering and research and for applications. The NETS helped facilitate the first NSF Connections Program attachment and application from the University of Colorado and has had members serve on two NSF Connections Program proposal review panels.

The Mesa Lab Network Access Completion (MLNAC) Project

The Mesa Lab Network Access Completion (MLNAC) project encompasses all work necessary to install all network access infrastructure at the Mesa Lab which has not already been completed. Essentially, this includes all parts of the Mesa Lab building except for the Fleischmann Building, South Tower (Tower B), and the Second Basement (2B), which have already been wired for network access. The project includes all work to complete the mechanical, wiring, termination, and equipment installation and activation. The resulting network infrastructure will be state-of-the-art Category 5 wiring and fiber optics. This project consists of three phases of which two phases were completed this year.

The Network Re-engineering (NREP) Project

The Network Re-engineering Project (NREP) is a major project to fundamentally restructure the UCAR data communications networks. The new structure will be easier to configure and maintain. The new structure is also expected to be more flexible in terms of moving, adding and changing IP subnetworks and hosts. This project consists of 15 phases of which half were completed this year. This project was largely facilitated by a lucrative trade-in program that provided a large discount for state-of-the-art equipment.

The ML Computer Room Rewire Project

The ML Computer Room Rewire Project involves a complete rewire of the ML Computer Room to state-of-the-art Category 5 and fiber optic wiring in a zonal distribution system utilizing fixed conduit.

The Foothills Lab (FL) Splicing Project

The Foothills Lab (FL) Splicing Project provides a state-of-the-art fiber optic system that will allow easy location of equipment in any of our 22 closets as well as centralized distribution of the backbone and high-speed networking services.

The FL CAT3 Retrofit Project

The FL CAT3 Retrofit Project involves retermination of existing CAT3 wiring to meet industry standards and enable the NETS to provide dedicated, switched 10Mbps ethernet service to FL users. This allows the transition from shared 10Base2 ethernet, and provides a much more robust network. The first test case involving FL2 third floor closets was successfully completed this year. A number of communications closets have been upgraded to ethernet switching hardware.

The ML WAN Distribution System Project

All US West Wide Area Networking (WAN) services were converted from copper cabling to fiber optic cabling this year. Additionally, all in-house WAN wiring was upgraded to a more easily monitorable and manageable patch panel system.

Network Wiring Projects

Ongoing wiring upgrades have occurred at the FL, UCAR North (UN), Jeffco, and UNAVCO (UV) locations including the UN backbone upgrade from ethernet (10Mbps) to FDDI (100Mbps) and the complete rewire of the UV ground and first floors.

Dial-up Modem Service

The local V.34 modem dial-up service was expanded and upgraded this year. We also began providing service for local and 1-800 Apple Talk Remote Access. We developed an algorithm for tracking and billing 1-800 PPP access.

Networking Support and Outreach

The NETS provided networking support for 27 classes, demonstrations, meetings, and conferences throughout NCAR/UCAR. The NETS also presented six seminars as part of the SCD Seminar Series. Members of the NETS prepared the following reports:

- Super HIPPI Report
- Strategic Report Regarding the Deployment of ATM within NCAR/UCAR

Committee Membership

Members of the NETS served on a number of committees this year including:

- The Network Coordination Advisory Board (NCAB)
- The Computer Security Advisory Committee (CSAC)
- The Computer Room Planning Committee (CRPC)
- The Dependencies Committee
- The Inventory Committee
- The Trouble-Ticket Committee (TTC)

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Operations and Information Support Section

The Operations and Information Support (OIS) Section focuses on managing SCD's computers and networks via:

- 24-hour-a-day monitoring and problem diagnosis
- Maintaining the necessary environmental, hardware, and software infrastructure
- Maintaining user accounts on SCD computers
- Providing an array of information to users and to SCD staff about the computing environment

The section also provides support for IBM-compatible (PC) and Macintosh (Mac) personal computers in collaboration with other sections in SCD, and applies information technologies to increase efficiency in SCD. These functions are provided by three groups within the section: the Computer Production Group (CPG), the Infrastructure Support Group (ISG), and the Information Technology Support Group (ITSG).

Computer Production Group

The Computer Production Group (CPG) monitored and maintained SCD's computing resources 24 hours a day, 365 days a year. The many system attributes monitored included system utilization, load average, job queues, status of network connections, Mass Storage System (MSS) accessibility and data transfer, memory errors, filesystems, and disk errors. Prompt diagnosis of software, hardware, and network problems of the more than thirty machines in the machine room and the hundreds of network connections led to timely resolutions and minimized interruptions to service.

Accomplishments in FY96

Mass Storage System cartridge mounts in FY96 continued to increase with over 393,000 robotic mounts. The total archive tapes mounted by the staff totaled more than 455,000 with the daily manual mounts across three shifts ranging from 350 to 2,800.

Checked hundreds of UNIX security reports for detection of electronic intrusion. CPG reported all activity which could compromise security to the Distributed Systems Group.

Collaborated with the Network Engineering and Technology Section (NETS) to consolidate the numerous network information resources into a single FrameMaker document and made this document available via the Web: http://www.scd.ucar.edu/nets/Documents/netdoc/netdoc-1.html

An index was added which facilitates finding information in the hardcopy manual. The glossary contributes to the understanding of the material, and the network typology maps provide a clear picture of network connections, network routes, and network relationships. Providing a Web version of the documentation minimizes duplication of efforts because the information can be referenced in other SCD documentation via links and also makes use of powerful search engines which can be used to quickly locate information.

Participated in the Phoenix Project which produced a Dependency Diagram depicting the priority order for booting computer and networking equipment in the SCD computer room. Critical services such as Network File System (NF S) which allows filesystems to be shared among machines, Domain Name System (DNS) which maps between hostnames and

IP addresses, and authentication servers which validates logins and passwords must be made available in a particular sequence or problems of contention will delay or prevent machine boots. CPG staff worked with other sections to determine the location of these services and to map the priority boot sequence.

Worked with representatives of other SCD sections to define criteria for the evaluation of end-of-life systems (EOLS) and wrote a procedure for proposing potential EOLS. Defining not only an EOLS, but the mechanism for proposing an EOLS creates an efficient method to produce data for management to use in making EOLS decisions.

Produced a detailed, daily report of system and network activity, problems, and steps toward resolution. This on-line documentation provided SCD with an efficient means of determining the time and cause of system and network malfunctions as well as the time equipment and systems were returned to production.

Hired and trained three operators. Instituted individual development plans for all staff to maintain technical skills in a heterogeneous and rapidly changing computing environment.

Taught the UNIX Basics Class. These were two-day classes which provided hands on training for computer users. This was a new responsibility for the CPG staff.

Infrastructure Support Group

FY 96 witnessed many changes to the computer room, computer maintenance contracts, and the management of equipment inventories. Twenty-two installations, removals, or upgrades to equipment were completed throughout the year. Infrastructure Support staff made the necessary arrangements for floor space, electrical connections and movement of equipment. The highlights for the year include the installation of a Cray J932/20, the installation of an SGI Power Challenge, installation of two RAIDs for the Crays, the installation of an STK Redwood Library for the Mass Storage System (MSS), and the removal of the IBM 3090. Also throughout the year, plans were made for the possible installation of a new supercomputer.

Hardware maintenance contracts were another big item for FY96. A large part of staff time was not only spent on keeping equipment covered under existing contracts, but also in coordinating with UCAR on a new third-party maintenance contract. A large part of ISG's effort included gathering input from SCD staff on maintenance needs, determining equipment that should be covered by a third party, and making recommendations towards the selection of a vendor.

Changes in inventory procedures by UCAR and the division created another area of emphasis for FY96. The group is now tracking computer room equipment and has taken on the responsibility of tracking workstations, home equipment, and sensitive equipment such as laptops, modems, and equipment that is easily moved. A complete internal audit of SCD was completed by ISG for the on-site and home equipment. The tracking of sensitive equipment will be a continuing project for FY97.

All of these activities were completed as well as the day-to- day tasks. Some of these include the SCD Daily Bulletin (issued online, Monday through Friday, with time-critical information), ordering supplies and equipment, and ordering and labeling of cartridges for the Mass Storage System (MSS). The invoicing and tracking of expenditures for blanket purchase awards was another focus of the group. The group also provides usage and availability statistics for the major computer systems as well as the MSS. Finally, the monitoring of the environmental conditions, electrical capacity and management of available space in the computer center are ongoing tasks.

Information Technology Support Group

The Information Technology Support Group (ITSG) applies information technologies to solve problems and increase efficiency for SCD, the NCAR Director's Office, and SCD computer users. This includes the management of user accounts for the SCD supercomputing facility, management of select UCAR/NCAR site licenses, and NCAR Graphics licensing and distribution.

Information Technology Support

Information technology support encompasses:

1. The support of IBM-compatible (PC) and Macintosh (Mac) personal computers in SCD and the NCAR executive Director's Office
2. Technical support for conferences and training
3. The application of technologies to increase efficiency in SCD

ITSG makes applications available when they have benefit to the rest of NCAR/UCAR. One goal of ITSG is to turn over maintenance of applications to the requesting group whenever possible. Focusing on Web- and Java-based technologies for multi-platform applications increases the likelihood of this goal and neutralizes the issue of software distribution and interoperability.

Accomplishments in FY96

Completed over 1,000 requests for support on Macs and PCs. Support included troubleshooting (hardware, software, and network), software installation, and purchasing guidance.

Developed Web application to capture data for analysis of the Supercomputing `95 Educational Program.

Rented high-end UNIX workstations and provided lab-setup and configuration support, an introduction to the lab computing environment, a UNIX refresher class, and technical support for the Inter-Americas Institute (IAI) conference held at NCAR February 26 to March 8, 1996.

Developed Web application to manage project registration for the Colorado Computational Science Fair held at NCAR on May 18 1996.

Collaborated with SCD's Network and Engineering Technology Section to define the network needs and layout for the SCD Training Room. After this was complete, SCD was notified by UCAR engineers that there would not be enough cooling available to the room for lab situations. As a result, the room was relocated in another area. ITSG redetermined locations for the projection system and worked with UCAR architects to draw plans for the new space.

Developed and deployed a UCAR-wide Room Reservation System (RRS) for UCAR Facilities Support (FSS). FSS had been trying for several years to implement a system that would allow easy scheduling and booking of UCAR's meeting rooms. Because only one person had authority to schedule rooms at each lab and there was only one copy of the schedule, reserving rooms was tedious and time-consuming for staff. In May 1996, ITSG deployed its beta version of the Web-based RRS, which FSS phased into production mode for the Mesa Laboratory through FY96 and early FY97 (http://www.fss.ucar.edu/rooms/). The application offered significant benefit to SCD (eliminated staff time spent playing "phone tag" and "20 questions," and gave staff access to the schedule anytime, anywhere), met the needs of FSS and enabled reasonable management of the function with less than an FTE of staff time, involved no cost associated with client machines within the organization, made the software distribution issue moot, and obtained the goal of turning over the maintenance to the requesting user.

Developed and deployed a Visual Basic Application (VBA) for Excel that enhances management of UCAR credit-card purchases on the UCAR Finance end and makes associated encumbrance information available to SCD management. Because UCAR purchase orders paid with the corporate credit card are not entered into the accounting system, there is no way for divisions to see encumbered funds for these purchase orders without this application.

User Accounting

ITSG manages all user allocations for both the general community and Accelerated Computing Environment (ACE) supercomputing facilities. Over 25,000 job accounting records a day, by more than 1800 users, are generated from the Cray computers alone. This information is then used to charge for resources used, track available allocations, control the ability of users to run jobs, and provide the basis for management reports.

Converted 46 monthly reports of gateway- and Cray-computer statistics to the World Wide Web (WWW). This eliminated a

significant amount of hardcopy distribution. Access is restricted to SCD.

Implemented charging for paiute and the connect account (effective October 1, 1995).

Implemented charging modifications for the new queueing structure on ACE machines.

Modified calculations for ACE eYhrs, ACE standby charging, and adjusted allocations among ACE machines (effective December 1, 1995).

Modified the point at which usage for joint-projects is cutoff when allocations are exceeded (changed to the entire year's allocations rather than a monthly or three-month basis).

Co-developed and implemented plans for charging for 1-800 Connect Account time for PPP (to begin November 1, 1996).

Implemented usage cutoffs for CSL users using over a certain percentage of their monthly allocation.

Generated customized user lists and reports for special purposes of user support and management information. Completed over 310 user requests for the year, including user requests for allocations information and problem resolution.

Accomplished two major updates to the database software itself, which required extensive testing and some modification to Fortran programs, makefiles, and input triggers.

Software Licensing

SCD site or volume licenses select software for UCAR as a whole and SCD as a division. In general, licensing software for the entire organization must have benefit for SCD and represent a significant savings to the organization (usually $100,000s). Examples of this are the site licenses for educational vendor programs, such as Sun's ScholarPak, SGI's Varsity Program, and IBM Higher Educational Software Consortium (HESC). Although administration of the "Big Three" is significant (upwards of 4-5 FTE-months for license, renewal, and distribution, and chargeback), estimates are that the organization as a whole saves some $600,000 annually because of it. ITSG also licenses a variety of interactive mathematical and statistical software packages for users of its front-end machine (meeker.ucar.edu) and mathematical and statistical libraries on the Cray and IBM RS/6000 computers. This licensed software includes Mathematica, SAS, S-Plus, IDL, Matlab and related toolboxes, F-lint, NAG, and IMSL.

Implemented a standardized policy for chargebacks for software and on-call support to the "Big Three." For site- or volume-licensed software, the cost is now charged back on a per-machine basis (620+ Sun systems, 120+ SGI systems, 40+ IBM RS/6000 systems), not on a per-product basis; the free on-call savings are evenly divided among all users requesting on-call support. We expect this will reduce administration time significantly for chargebacks in FY97.

Acquired MathWorks' Image Processing Toolbox for meeker.

Obtained educational pricing for Research System Inc.'s IDL product. Licensed a one-user network-floating license.

Transferred licenses among Crays, as appropriate.

Researched costs of converting current software over to platforms and adding licensed nodes and/or users as appropriate; maintained licenses for all supported software. Responded to user requests for SCD to license software for meeker and the Cray computers.

Charged back costs for non-SCD portions of Sun and SGI software, documentation, media, and on-call support;, SAS; F-lint; and NAG.

NCAR Graphics Sales and Distribution

The Information and Technology Support Group provides technical sales information, licensing, and distribution services for NCAR Graphics. Staff:

- Provide a central contact for information about NCAR Graphics' functionality and supported platforms
- Answer availability questions about the software.
- Process, distribute, and invoice all orders.

For most of 1996, the group continued to receive about 80 information contacts per month. We processed, distributed, and invoiced 241 orders. We also distributed 275 Version 4.0.1 upgrades to sites holding a Version 4.0 license. Normally, free upgrades of minor releases are not distributed because minor releases do not contain new functionality. However, Version 4.0.1 contained functionality that did not make it into Version 4.0 because of time constraints, and we felt its free distribution was appropriate this one time.

The FY95 streamlining of the licensing process (consolidating four separate licenses to one, moving from a signed license to a shrink-wrap one) and simplifying of the pricing structure (site license only), enabled ITSG in FY96 to reduce staff time needed to support the function by almost.5 FTE. Continuing the FY95 ability to accept VISA/MC payment for the package also eliminated many time-consuming wire transfers from foreign sites and responded to many years of user requests.

A market report for NCAR Graphics, conducted August 1994, suggested there was value for SCD to contact sites not upgrading to new versions. After distribution of the Version 4.0.1 upgrade, ITSG contacted all sites that had not upgraded from Version 3.2.x to Version 4.0.x. This was done through phone calls placed to U.S. sites and email or fax to non- U.S. sites. Of the approximately 150 contacts with U.S. sites, almost 15 (10%) upgraded. U.S sites not upgrading, most said the upgrade (minimum 50% discount off new license) was too costly vs. the usage at their site or new functionality in the software. We received almost no response from the foreign emailings and faxes. Twenty-six U.S. sites expressed interest in ordering, but had not ordered as of the end of FY96. Overall, 303 of 517 sites upgraded from Version 3.2.x to Version 4.0.x around the world.

Educational Activities

SCD sponsors K-12 and university-oriented projects aimed at furthering educational initiatives. In addition, numerous staff are involved in individual education activities. The projects and staff contributions are discussed below.

Colorado Computational Science Fair

For the past three years, NCAR's Scientific Computing Division has co-hosted the Colorado Computational Science Fair (CCSF) in conjunction with Colorado State University to encourage high school students to learn more about computational science. The CCSF is intended to serve as a supercomputing/information technology competition for high school students throughout the state of Colorado. In FY96 the Colorado Computational Science Fair (CCSF) was held on Saturday, May 18, 1996 at NCAR. Seventy-six students from the state of Colorado entered 45 projects into the competition. Internet connections were provided for 25 projects. Group and individual projects were submitted in four categories: (1) Computational Science: Biology/Physics, (2) Computational Science: Mathematics, (3) Visualization, and (4) Information Technology. A list of the 1996 CCSF winners is available on the World Wide Web at http://www.ucar.edu/ucargen/press/winners.html.

Classroom Computing Grants

The Scientific Computing Division continues to provide access to its supercomputers for undergraduate or graduate university classes. These computing resources are provided for classes engaged in modeling and simulations requiring high-performance computers and for classes studying new architectures, such as Cray's T3D. A few high school students have also been granted access for Colorado Computational Science Fair projects. In FY96, SCD's computing resources were used by seven classes in a variety of disciplines. Sixty students used SCD's supercomputing resources, including the Y-MP8 and T3D, accumulating over 30 CPU hours of charges.

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Technical Support and Development Section

The mission of the Technical Support and Development Section is to provide leading-edge software expertise for the climate, atmospheric, and oceanic research communities to enhance their high-performance computing endeavors.

This mission is accomplished through direct contact with the user community, technical consulting, math library support, digital information technologies, software testing and development, and both visualization and graphics software development and support.

The Technical Support and Development Section (TSD) is a gateway to SCD resources and services. The groups in this Section are designed to have a relatively high profile for direct contact from the user community. These groups have a certain amount of overlap, but more often work as independent teams due to their broad differences in functionality. The groups include:

- Vizualization Group (VG)
- NCAR Graphics Group (NGG)
- Technical Consulting Group (TCG)
- Digital Information Group (DIG)

Each group has its own mission in concert with the section and division; each has an independent set of accomplishments and plans. These will be presented below as separate sections within this document.

Visualization Group

The SCD Visualization Group's primary mission is to advance atmospheric science and the state of the art in computational science and scientific computing, with a focus on visualization, analysis, visual supercomputing, and digital media technologies. The group transfers new technology to the general scientific community and serves as an expert consulting resource in its field. Group members have expert-level skills in software engineering, animation, visualization environments and techniques, virtual environments, audio, video, digital media, WWW technologies, parallel computation, advanced networking, advanced display technologies, image processing, and user interfaces.

A primary responsibility of the group is to provide and support dedicated visualization facilities for the NCAR community of scientists and support staff. These include Visualization Labs at both the ML and FL campuses, and the TAGS Video System. The FL Visualization Lab provides a carefully-integrated, user-friendly environment where scientists and their support staff can personally produce high-quality scientific animations. The ML Visualization Lab is a cutting-edge facility supporting R&D in the areas of visualization of very large datasets, distributed visualization, digital media development, HDTV, virtual environments, and advanced networking, as well as special projects. The two labs have a combined user base greater than 100.

The group provides direct support for a number of "special projects," some of which are funded. These include, but are not limited to: MECCA, HPCC Turbulence, ACTS/CO-OP/3D, CSL, DCSL, The Visible Human Project, BATMAN, the NSF MetaCenter, SIGGRAPH VROOM, and the GII Testbed.

The group is heavily involved in advocacy for the NCAR/UCAR organization, and routinely provides technology and

science demonstrations for government officials, visitors from other research centers, and at conferences. Group members present at national and international forums.

The Visualization Group's staff are committed to engaging in a program that advances atmospheric science as well as computational science and, accordingly, NCAR's local capabilities, SCD's technical reputation among peer research centers, and public image.

Facilities

Foothills Visualization Lab

Located on NCAR's Foothills Campus, this lab provides an optimized self-service environment for producing scientific animation. A Silicon Graphics Indigo-2 system connected to special video hardware, a Sony LaserDisk system, and a Betacam-SP mastering environment coupled with custom animation and editing software comprise the hardware/software environment. The facility enables NCAR scientists and their support staff to quickly and easily produce professional-quality animations on videotape for presentations, conferences, and broadcast. In addition to day-to-day user support and training, new digital media capabilities were provided during FY96.

Mesa Visualization Lab

The NCAR Mesa Visualization Lab provides focused support for a number of special projects and a state-of-the-art environment for R&D in the general area of exploratory visualization and animation. Focus areas for the lab include volume and flow visualization, visualization of very large datasets, distributed visualization, advanced digital media, HDTV, and immersive environments. During FY96, major hardware and software upgrades were made to the lab, including a new server, new disk subsystems, high-performance graphics hardware, additional memory, digital video capability, and ATM networking.

TAGS Video

Animation is widely used in scientific research, and the Visualization Group provides both batch and interactive facilities for the production of high-quality animations. The TAGS system provides batch video printing. A user simply sends digital imagery to TAGS in any one of several formats, including Computer Graphics Metafile (CGM), and receives back the finished videotape. Users who require high-performance exploratory animation, or the ability to produce more elaborate scientific video presentations, can use the interactive facilities at one of SCD's two Visualization Labs -- one at the Foothills campus and one at the Mesa campus.

Major Projects

The first priority of the Visualization Group is to maintain and upgrade these two labs to provide scientists with the highest-functionality scientific visualization resource that current technology and our budget will allow.

The Mesa Visualization Lab provided focused support for many special projects during FY96. The most significant of these are described here.

Climate Systems

As climate modeling was a major NSF focus area during FY96, significant resources were also directed at related visualization problems. Scientific animations of CHAMMP-supported T170 CCM2 simulations [3.2 MB mpeg] were prepared and subsequently shown at conferences, seminars, and in the classroom. Also, as part of SCD participation in Supercomputing 95's GII Testbed, high-level visualizations of sulfate-aerosol-moderated global warming [1.8 MB mpeg] from Washington/Meehl simulations were developed. These were later incorporated as part of a National Geographic educational production on climate change [3.1 MB mpeg].

Both of these efforts are categorized as presentation visualization, but substantial time was also spent in developing high-performance 3D exploratory capabilities for climate modeling. These tools were applied to CCM2, CSM, and some chemistry simulations. At this point, the scientists themselves do not know if, or how, such techniques will be useful in their analysis, so this work is still categorized as an experiment. Initial results are encouraging, however.

Mesoscale Systems

The Mesa Visualization Lab was used to provide visualization and networking support for the ACTS/COOP-3D project, as well as serving as the primary demonstration venue for the project. FY96 also marked the first year where the VG had any significant efforts directed at the visualization of mesoscale systems. In particular, new visualization software was developed that allowed interactive exploration, in stereo, of MM5 simulation data. This was used to excellent effect for a particular case of east Asian cyclogenesis. Also, late in the year, efforts to visualize the complexities of the Clark Fire Model were started; detailed reports on that work will appear in the FY97 report.

DCSL Large Dataset Transport Project

This component of the NSF-sponsored Distributed Climate Simulation Lab (DCSL) project focused on evaluating the use of the new vBNS in support of large-scale distributed computation for HPCC Grand Challenge turbulence research. During FY96, a scientific and technical project team composed of staff from NCAR, CU, and PSC was organized to approach the project. ATM-based vBNS connectivity was established, and extensive benchmarking and performance profiling was conducted, relative to transferring extremely large datasets (25 GB or greater). With a focus on improving scientific productivity, new tuneable high-performance file transfer tools were developed and made available to the scientific and technical community. New volume visualization software and stereo viewing techniques were developed and applied to both geophysical [2.2 MB mpeg] and astrophysical [1.3 MB mpeg] case studies, producing, by all accounts, excellent results. These results were presented at the FY96 NCAR-hosted workshop on *Rotating and Stratified Turbulence* to a responsive scientific audience.

Visitor Program

The VG hosted a very active visitor program in FY96. Long-term visitors included:

- Dr. Kendal McGuffie; University of Tech.; Sydney, Aus., Climate modeling, 1 yr.
- Ann Maree-Hansen; Macquarrie Univ.; Sydney, Aus., Climate visualization, 1 mo.
- Dr. Hongqing Wang; Univ. of Peking, Complex model visualization, 9 mos.
- Yan Zhang, Univ. of Peking, Web technologies and databases for scientific data

Visualization Technology Development

- Complex Model Visualization: Developed expertise and extended existing tools for stereo data visualization, animation, and playback
- Virtual Reality: Constructed one-wall CAVE
- Animation: Developed stereo animation capture and playback software
- Video: Developed digital video based on motion-JPEG and MPEG-2
- Server: Deployed a batch visualization server, currently being used for HPCC Turbulence and CSM work
- Visual supercomputing: Added Infinite Reality Graphics to lab, along with many other software and hardware upgrades
- Advanced Networking: Deployed ATM technology and established vBNS connectivity
- High-end volume visualization: Developed and deployed new rendering toolkit for turbulence researchers
- Web technology: Experimented with MPEG-2 digital video and VRML for scientific applications
- Participated in Cablelab's evaluation of MPEG-2 digital video

Outreach, Education, and Service Activities, Contributions to Scientific Conferences

- Helped produce National Geographic Movie on Climate Change
- Helped produce Learning Channel Movie on Forest Fires
- Presented at SCD Advisory Panel on visualization
- Demonstrated at IAI Conference
- Hosted and presented at Geophysical Turbulence Program Workshop (120 people attending)
- Hosted and presented at IEEE Conference on Visual Languages (120 people attending)
- Presented at NSF Advisory Panel
- VG member served as judge for Colorado Computational Science Fair
- Presented at DOECGF Computer Graphics Forum DCSL/LDT/vBNS
- Presented at SIGGRAPH96 on VHP
- Hosted and presented at Wavefront/Alias User's Group Meeting
- Presented at SC96 GII Testbed Presentation on CSL
- Presented at SC96 GII Testbed Presentation on VHP
- Focus of Article in Science Now, by Caroline Chanson/Project Learn.

NCAR Graphics Group

The mission of the NCAR Graphics Group is to develop, maintain, and support the NCAR Graphics software package on behalf of scientific researchers both in the U.S. and abroad, with primary emphasis on atmospheric science support.

NCAR Graphics is oriented toward scientific visualization of meteorological, oceanographic, and other geophysical data. NCAR Graphics is currently installed at about 1000 sites worldwide including several hundred universities. It has been widely used in science and engineering for 20 years. The popularity of the package arises from its flexibility, portability through adherence to recognized standards, source code availability, ongoing compatibility with older versions, and strong customer support.

The software is supported on numerous UNIX systems including Sun OS, Sun Solaris, HP/UX, Cray/UNICOS, IBM 6000/AIX, SGI/IRIX, DECstation/Ultrix, and Digital Alpha OSF. The package contains multiple interfaces to accommodate diverse user skill levels and application needs. The NCAR Graphics Group continues to develop and add new facilities for

ease of use and enhanced functionality. Major new releases occur at approximately 2-year intervals, with minor upgrade releases every 6 to 12 months.

Software is distributed on CD-ROM and 8-mm tape. All of the software documentation is provided as hypertext on the World Wide Web. Hardcopy documentation, in the form of PostScript files, is also available via the web. Group staff currently maintain about 500,000 lines of C and Fortran code and 4,000 pages of hypertext documentation. The group provides:

- Installation consulting to all sites for all supported systems
- Technical and usage consulting backup to the SCD Consultants
- Frequent helpful posts to the ncarg-talk e-mail user group

Release of Version 4.0.1

Version 4.0.1 of NCAR Graphics was completed in June 1996, about 9 months after the Version 4.0 major release. Version 4.0.1 is more than just a bug-fix version. Since converting the NCAR Graphics documentation from hardcopy to online form, minor releases of the package have been able to include new functionality. This is true because the online documentation can be quickly updated -- hardcopy documentation changes were slow, difficult, and expensive.

Thus, a significant amount of new functionality was added including new utilities for displaying field flow including streamlines and velocity vectors. The velocity vector length indicates the field strength while the color of the vectors can be used to show another related field such as temperature or pressure. The following image illustrates much of this new functionality.

The capability to bundle the attributes of drawing primitives was also added so that it is easier to change features such as line widths, marker colors, or fill types.

The largest effort in any minor release is in porting to and testing on all the supported systems, building the binaries for all the systems, and creating and verifying the installation system.

Each new version also requires the writing of new Release Notes and an Installation Guide, as well as the update of the User Guide, Quick Start Guide, and Reference Manual to reflect modifications and new capabilites.

Two new online documents were added to Version 4.0.1 including a scientific tutorial for the NCAR Command Language (NCL), and a review of commands and tools which augment and supplement NCAR Graphics. In addition, the documentation for the NCAR implementation of the Graphical Kernel System, NCAR GKS-OA, was enhanced to take full advantage of the hypertext medium.

Version 4.1

After the release of Version 4.0.1, the NGG immediately began working on the next major release, Version 4.1, scheduled for completion in FY97. It will feature a functional Graphical User Interface (GUI) that includes features for data browsing, data processing, and visualization. Visualizations will include capabilities to do X-Y plots, contour plots, maps and mapping transformations, field flows, overlays, and annotatations. Data can be input in a number of formats including netCDF, ASCII, binary, HDF, and GRIB. Visualizations can be output in several formats including X11, NCGM, and PostScript.

UNIX Platforms Running NCAR Graphics

- Cray Y-MP
- Cray J9
- Cray C90
- Digital Equipment Alpha
- Digital Equipment DECstation

- HP9000 Series 700
- IBM RISC System/6000
- IBM PC
- Sun-4/SPARCstation
- Silicon Graphics R4 systems
- Silicon Graphics R4/R8 systems

Mirror Sites Established for NCAR Graphics Documentation

Mirror sites contain current copies of the NCAR Graphics documentation and provide backup if another site is down. The mirror sites are distributed around the globe and offer more efficient access to remote users.

- Australia: ANU Supercomputer Facility, Canberra
  NCAR Graphics version 4.0 documentation
- Europe: DKRZ (German Climate Center) Hamburg
  NCAR Graphics version 4.0.1 documentation
- U.S. East Coast: Brookhaven National Lab, New York
  NCAR Graphics version 4.0 documentation
- U.S. West Coast: Lawrence Berkeley Labs, Berkeley, CA
  NCAR Graphics version 4.0 documentation (This connection was not available at the end of FY96.)
- U.S. Central: NCAR, Boulder, Colorado
  NCAR Graphics version 4.0.1 documentation
  NCAR Graphics version 4.0 documentation

Presentations, Papers, Conferences, and Collaborations

- ECMWF 5th Workshop on Meteorological Operational Systems - Reading - 11/95
- NCL Seminar - March 1996
- DOE Computer Graphics Forum - May 1996
- NCAR Graphics demonstrations at conference exhibits Geological Society of America (GSA), New Orleans, LA, Nov. 6-9
- SC/95, San Diego Convention Center, Dec. 4-8
- American Geophysical Union (AGU), M-TH Moscone Center, San Francisco, Dec. 11-14
- American Meteorological Society (AMS), Conv Center, Atlanta, GA, Dec. 31-Jan 5
- High Performance Computing and Networking (HPCN), Brussels, Apr. 15-19

Technical Consulting Group

The Technical Consulting Group has a four-fold mission in support of the users of the NCAR supercomputing facility. We provide:

- Software Engineering Support
- Software Development
- Software Testing and Evaluation
- HPCC Community Leadership

This report describes the projects we have completed in FY96 to accomplish these aspects of our mission. Many projects overlap with several aspects of this mission. In addition to our normal daily operations, we pursue collaborations both within and outside NCAR to fulfill our mission. SCD's technical consultants' close contact with high-performance computing users puts us in a unique postion to understand and communicate the needs of this community, and to identify and evaluate trends affecting both the scientific computing users and facilities at NCAR.

Furthermore, these collaborations promote the exchange of technical knowledge with other centers of excellence, promote professional development of the employees participating, create synergy between our efforts and efforts at other centers, and

keep us up to date on advancements, future projects, and future opportunities.

Software Engineering Support

User support is the activity most people identify with the Technical Consulting Group, and it is one of our primary functions. During FY96, we had 2600 contacts split almost evenly between e-mail and telephone, with a small percentage of walk-in contacts. We resolved over 95% of the problems brought to our attention on the same day, and over 98% were resolved within one week.

Major topics of consulting expertise include all usage issues involving high-performance computing at NCAR: compilers, software tools, optimization, parallel code development and improvement, debugging, commercial and public mathematical software, operating systems, NCAR Graphics usage, and more.

In addition to our consulting work, we also engage in numerous special projects to benefit the user community. The special projects classified as software engineering support are described in this section. In pursuit of these projects, we often engage in external collaborations such as our work with climate simulation modelers on the data management committee.

Fortran 90 Initiatives

The consultants have been gradually migrating users to the Fortran 90 compilers on the Crays, though the big push cannot occur until Fortran 90 is available on all platforms. While the Fortran 77 standard is a subset of the Fortran 90 standard, there are still significant conversion issues revolving around minor changes in the standards, conflicts between vendor extensions and the new standard, and issues of old programs which are not Fortran 77 standard compliant. The level of effort applied to the conversion process can be expected to increase over the next year as the current computing platforms are upgraded.

We evaluated products that had not been used before at NCAR to determine which tools would be most beneficial to our user community, to augment our local programming environment and toolset, and to ensure that local software development efforts proceed effectively with modern tools. Some of the tools and packages investigated this year include:

- Fujitsu Fortran 90 compiler suite
- CraySoft Fortran 90 compiler suite
- Cray Programming Environment 2.0
- PSR VAST F77-to-F90 conversion utility
- CERN F77-to-F90 conversion utility

These tests include soliciting friendly users to participate in product testing and coordinating the testing and the communication of the results back to the respective vendors. In this process, TCG assembled suite of Fortran 77 test codes and acquired Unicomp Lite Fortran 90 test suite. Several benchmarks were converted from Fortran 77 and run to perform comparisons with similar code run on Crays.

TCG offered NCAR as a field test site for Cray Programming Environment 2.0. This work was supported by soliciting friendly users to participate in testing. We coordinated the testing and communicated results back to the vendor. During this work, we:

- Assembled a suite of Fortran 77 test codes and acquired Unicomp Lite Fortran 90 test suite.
- Ran benchmarks converted from Fortran 77, performed comparisons with similar code run on Crays, and ran the Unicomp Lite Fortran 90 test suite.

J90 Installation and Migration

The consulting staff assisted both the CSL user community and the general community in migrating to the Cray J90 platforms as they were installed. Though these machines were similar to the existing Cray Y-MP platforms, there were several key differences through which the users required guidance, including: lack of SSD, larger memory available, slower clock speed, higher memory latency, optimization changes, user policy changes, and queuing system differences.

Near Dedicated (ND) Queue Monitoring and Approval

The consulting staff is responsible for examining the performance codes which users would like to run in the Near Dedicated queuing system at NCAR. This screening process serves two purposes. First, it ensures that the computing resources are used efficiently, and second, it provides an opportunity for user-outreach so that the consultants can assist users in parallelizing their programs. In addition to the screening process, the consultants also review automatically generated reports on each near dedicated job to ensure that problems are handled in a timely fashion.

ConsultWeb

This year the consultants totally reorganized the ConsultWeb website and redesigned the interface for improved ease of use after exhaustive research into user interface issues. The new interface provides a simpler and more intuitive user interface for new users while preserving speed of access for experienced users. Several other sites have since begun moving to similar user interfaces for their websites. The ConsultWeb site with its new interface won an award in the Rocky Mountain Chapter Society for Technical Communication 1995 online competition.

The content of ConsultWeb also received several upgrades, including the addition of a Frequently Asked Questions (FAQ) list, a new column "This Month's Gotcha!", and a complete subsite for Fortran 90 migration and conversion issues. Future additions will include additional subsites for source code configuration management, and source code version management.

Documentation Support

Many of the technical documents produced by SCD are written by the consultants in TCG. A few of the documents produced this year (exclusive of the work on ConsultWeb) include:

- Cray's new Programming Environment
- User changes in UNICOS 9.0.2
- Fortran 90 recommended for Crays
- Reading/Writing IEEE binary data on Crays and T3D
- Introduction to IEEE and Cray floating-point formats
- MSS Migration Guide

Solaris Upgrades and Testing

The Technical Consulting Group staff has been collaborating with the staff of the Distributed Services Group (workstation and server administration) to prepare for SCD's migration to the Solaris operating system. Members of the group have been testing various Solaris installations on their personal workstations for several months now, in an effort to assist the DSG staff in correcting any problems prior to the entire division moving to Solaris. Additionally, TCG staff have been developing expertise with the new Solaris-based Common Desktop Environment, and has been providing demonstration and migration expertise to other SCD users as they begin adapting Solaris to their own desktop systems.

Distributed Computing Services Project

The Distributed Computing Services project (DCS) is an SCD effort to improve the usability and scalability of our computing environment, as well as an effort to remove several pieces of legacy software and hardware and replace them with leading-edge technology. A TCG consultant is one of the three primary developers assigned to this project. This year the following milestones have been completed:

- Completed the Queue Manager to handle queuing of requests for DCS services
- Completed several DCS client/server utilities to allow users to obtain logs of their requests. This is an entirely new feature that would have been impossible with the previous technology.
- Completed the metadata service utilities for mass storage interaction.

Work will continue on this over the next year. Currently the team is developing two servers for handling file transfer to and from the MSS: The Meta-File Request Handler, which receives requests from the queue manger, expands and formats the request into a format suitable for action by the File Mover server; and the File Mover server actually performs the file transfers to the MSS.

NetCDF Developer Support

Completion of the optimization project did not signify the end of TCG's involvement with the netCDF library code; TCG has continued supporting the netCDF developers and researchers using netCDF who want to optimize netCDF performance on the Crays using optimized code. While documentation does exist, performance tuning is a mixture of equal parts of art and science, and often requires the intuition of someone very experienced in I/O tuning. Occasionally this includes performance analysis and testing, and/or code development.

Math and Statistical Libraries

The Technical Consulting Group planned and maintained math and statistical libraries and other software on computers supported by SCD, in conjunction with SCD's Computational Science Section. The 1996 effort was a continuation of similar work in past years, but was more aggressive because of acquistion and replacement of Cray computers and UNICOS Operating Systems within SCD, along with the changing role of SCD's IBM Cluster and various other compute servers maintained by SCD and CGD. Also in 1996, TCG played a role in developing math software. Here is a summary of TCG's involvement with maintaining, planning, and developing libraries in 1996:

- Library Maintenance - TCG built and tested required binary libraries from local or externally developed source code and worked with SCD's computer system administrators to install them on SCD-supported computers in a timely fashion with respect to new hardware and OS releases.

- Library Planning - TCG collaborated with other sections in SCD--and with other divsions within NCAR--to plan libraries and software required by NCAR's computer users. Most often, this software was obtained from third-party vendors, although sometimes public-domain software was used. Preference was given to vendor-optimized software available on a variety of platforms. TCG evaluated performance, numerical accuracy, usability, and documentation of the software products.

- Library Development - In collaboration with SCD's Computational Science Section, TCG developed a library of multidimensional FFTs containing real, complex, cosine, quarter-cosine, sine, and quarter-sine transforms. The library was written over a period of 2 years, has 54 user entry points, and spans some 20,000 lines of Fortran 77 code. The library is an expansion of the one-dimensional library FFTPACK written some 20 years ago, and is intended for shared-memory systems. SCD now distributes the library freely within the public domain.

Tools Development

The consulting office also produces a wide variety of smaller utilities to enhance and simplify the SCD computing environment for the users. Some of the utilities developed this year include:

- Crayinfo utility for Crays that displays: job queue limits, machine characteristics, groups, UDB info, quota info
- Charges command that runs automatically for every Cray session and batch job
- Ncarg401.init script that allows users to more easily test NCAR Graphics beta version 4.0.1, by setting up the necessary paths and environment variables
- Craydoclist utility to dynamically display a list of manuals currently in craydoc, including the collection and the CRI manual number

UNICOS Programming Environment Testing

As operating systems and programming environments are upgraded on the supercomputers in SCD, the Technical Consulting Group performs extensive software testing prior to the new environment's exposure to our user community. This

ensures a minimal disruption to the user community's work efforts. The most significant testing efforts this year included:

- Initial installation of Cray Programming Environment 2.0 on all six Cray systems.
- UNICOS 9.0.x operating system upgrades on four of the six Cray systems.
- Reinstallation of Cray Programming Environment 2.0 on the four upgraded operating systems.
- Math and statistical library upgrades.

Vendor Collaborations

SGI/Cray Research

TCG is the primary point of contact for SGI/Cray Research for software beta-tests and field-tests. The TCG technical consultants work closely with SGI/Cray Research staff to identify and isolate compiler, library, and programming environment problems, as well as to track the resolution of those problems.

IPT

TCG is the primary SCD point of contact for IPT's FLINT product developers on a joint effort to provide their product on the Cray Supercomputer System platforms. SCD provides supercomputer access to IPT in exchange for FLINT licensing considerations. TCG consultants assist in testing and problem identification and isolation.

HPCC Community Leadership

Our mission to support users gives us opportunities to evaluate common needs and take a leadership role in developing solutions that benefit large groups of users. Our leadership in the community is sustained by and results from the large number of external collaborations that we pursue. Frequent, well-selected external contacts allow us to study efforts underway at computing facilities similar to NCAR and spot trends in the technologies and strategies for providing high-performance computing in the sciences. Our findings and insights supplement SCD's planning process.

TCG staff participate in and lead professional groups such as:

- Cray User Group (CUG)
- Parallel Tools Consortium (Ptools)
- UNIDATA
- CSM
- IAI Workshop
- NEC Users Group

TCG takes a leadership role in many of SCD's projects and community services, most of which have been discussed in detail above. Some of the most noteworthy this year include:

- The netCDF optimization project -- for which TCG provided expertise for the actual optimization as well as ongoing support for the optimized code related to use, tuning, and custom buffering schemes.

- The CSM Data Management Working Group -- which is responsible for examining all aspects of data handling and management for the CSM project. Recent issues addressed include the migration to netCDF-format model output and dataset representation and format issues. Upcoming issues will center around data analysis and visualization tools.

- Participation in the SOARS program -- for which TCG provided a technical consultant as a project mentor for one of the participating students.

- The Annual Colorado Computational Science Fair -- at which TCG techincal consultants served as judges and provided tours of the computer room for the students.

Digital Information Group

The mission of this group is to advance the dissemination, retrieval, and use of information through interactive multimedia technologies. The group designs, implements, and supports a wide range of digital information systems including interactive documents that explain how to use SCD computing resources. DIG collects, analyzes, and organizes tools and methods that add value to the information resources used by geosciences research communities. This is done by:

- Providing interactive information on using SCD computers
- Designing and constructing digital media libraries
- Developing hypermedia interfaces and navigational tools
- Providing education and training
- Assisting in outreach and public relations
- Technically supporting a digital information infrastructure for NCAR/UCAR
- Expanding interactive use of the Internet for scientist-to-scientist communication locally, nationally, and internationally.

DIG's staff is committed to enhancing SCD's role as a supercomputing center within a premier national research facility.

Providing Interactive Information on using SCD Computers

During the course of FY96, we designed and produced numerous new interactive documents for publication on the web. We also maintain and upgrade SCD's collection of user documents by adding new information and updating volatile information. Another recurring responsibility, which was fulfilled again in FY96 with the release of NCAR Graphics Version 4.0.1, is our editing and design support for NCAR Graphics online documentation.

We incorporate useful new web technology to improve the usability of the wide range of information SCD provides to the user community. In FY96, we redesigned and augmented the NCAR Home Page, the SCD Home Page, and the SCD computing newsletter (now called the SCDzine) to take advantage of the web browser format called "frames." To ensure accuracy, usability, and content richness, we make continuous improvements to all the web sites we manage.

Developing Hypermedia Interfaces and Navigational Tools

A useful tool we developed for local users is a collection of scripts and a tutorial that simplify the effort required to publish hypertext forms on our servers. This tool also maintains good security for our site by avoiding loopholes that can be exploited for unauthorized access to our web servers.

One of our popular navigation tools is the hypertext "roadmap," a hierarchy chart that reveals the structure of a website at a glance and allows users to move directly to any location at that site. This tool was developed for the NCAR Graphics Interactive Documentation, and has been applied to numerous other websites during FY96, includeing NCAR's 1995 Annual Scientific Report.

We also investigated and tested new commercial tools that allow information designers to generate hypertext and print from a single source file.

Technically Supporting a Digital Information Infrastructure for NCAR/UCAR

We reorganized the entire set of websites and supporting infrastructure for NCAR and UCAR. The new, simpler domain names (www.organization_name.ucar.edu) were instituted during this reorganization. This effort included new and faster CPU hardware, RAID storage, and access for all UCAR groups desiring a web presence at NCAR or UCAR. We developed an explanation of and request forms for web presence services offered by SCD. We helped 11 organizations within UCAR to establish their own websites on the new web server:

- UCARweb
- NCAR Director's Office
- NCAR Library
- UCAR/NCAR Housing Office

- Traffic Services
- Imaging and Design Center
- NCAR Education and Tour Program
- NCAR Archives
- Environmental and Societal Impacts Group (ESIG)
- NCAR Facilities Services
- HESS

By adding well-chosen new software applications to existing equipment, we established a new resource within SCD: the Digital Media Laboratory. We use this facility to maintain our expertise in web design and authoring technologies and to create an internal development and teaching resource center. We envision this new facility providing a fully integrated hardware and software environment where our group can train or otherwise assist NCAR staff who want to develop or upgrade their hypermedia design skills.

We continuously track developments and trends in the rapidly evolving browser and server technologies, then make recommendations to SCD, NCAR, UCAR, and various advisory committees as needed. We maintain leadership roles in UCAR-wide organizations that exist to coordinate web development efforts throughout the organization: UCAR Web Council, UCAR Web Development Group, UCAR Web Authors Group, and the NCAR Annual Scientific Report Developers.

In FY96, we supported each division's developers of the 1995 NCAR Annual Scientific Report. We designed and distributed templates for each division's front page, assisted with overall project coordination, provided website consulting support, and created graphical navigation tools for each division's report.

Outreach and Public Relations

We made significant contributions to Supercomputing 95 (held in FY96) and Supercomputing 96 (held in FY97), as DIG staff designed, developed, and staffed NCAR's research exhibits for both conferences, served as SC95 Registration Chair, SC96 Exhibits CoChair, and created a 20-minute multimedia presentation on "The Making of Supercomputing '96" for the keynote session of the convention.

Staff gave two one-half day tutorials to two different professional development groups during FY96: "Envisioning Information: the Design and Development of an Effective Web Site" to the District 6 Council for the Support and Advancement of Education (CASE), and an informal presentation to the International Business Communicators Forum dealing with "Locating Information on the Web."

We organized and staffed SCD exhibits at the AGU, AMS, and SCEurope conferences. We coordinated UCAR/UOP exhibits for GSA, AMS, and AGU. We served as judges for the Colorado Computational Science Fair and the Rocky Mountain Chapter Society for Technical Communication Online Publication Competition. And we coordinated and served on committees for CCSF, PDE Workshop, and IAI Workshop.

Providing Education and Training

We presented talks, seminars, and training classes about hypertext, the World Wide Web, and website design. We also mentored students in UCAR's SOARS program. We submitted proposals for student interns from the University of Colorado at Boulder to work on software development projects in SCD. One of these proposals was successful; in FY97, we will sponsor a group of software engineering students in their work to create a diagnostic monitor for all peripheral devices in the SCD machine room.

Staff Awards and Honors

- Award of Excellence for NCAR Graphics 4 Interactive Documentation in the regional and Award of Merit in the international STC Online Communication Competitions
- Won three regional awards (Distinguished, Excellence, Achievement) and one international award (Excellence) for

three other entries in the Society for Technical Communication Competitions
- Received IEEE Computer Society Golden Core Member Award for outstanding volunteer service to the Society over the past 19 years.
- UCAR Research Support Achievement Award for establishing a significant early presence for NCAR on the World Wide Web

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SCD Publications

Refereed

Adams, J. C., *W. Brainerd, 1996: A Little History and a Fortran 90 Summary, in *Computer Standards and Interfaces* , Aug. 96, **18,** No. 4, Amsterdam, The Netherlands, pp. 279-290.

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Swarztrauber, P. N., and *R. A. Sweet, 1996: Fourier and cyclic reduction methods for Poisson's equation, in *Handbook of Fluids and Fluid Machinery,* Schetz, J. A. and A. E. Fuhs, eds., John Wiley & Sons, New York, NY.

Other

Adams, J. C. , *W. Brainerd, and *C. Goldberg, 1996: *Programmer's Guide to Fortran 90,* third edition, Springer-Verlag, NY.

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Hammond, S. W., R. D. Loft, and *P. D. Tannenbaum, 1996: *Architecture and Application: The Performance of the NEC SX-4 on the NCAR Benchmark Suite*, August, National Center for Atmospheric Research, Boulder, CO. Also appearing in Proceedings of Supercomputing'96, November 17-22, 1996, Pittsburgh, PA.

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https://web.archive.org/web/20040820092153/http://www.ncar.ucar.edu/archives/asr/ASR96/scd/pub.html[12/23/2016 12:15:58 PM]

http://www.ncar.ucar.edu/archives/asr/ASR96/scd/service.html Go

Community Service Activities

Jeanne Adams was co-editor of the journal issue on Fortran 90 of "Computers and standards" and contributed an article. She participate in the Fortran Standards committee (X3J3) and is a member of the International Fortran Working Group under ISO.

Brian Bevirt is a member of the Association for the Advancement of Computing in Education and served as an Editor Mentor for two students in UCAR's SOARS program.

Bill Buzbee served as: Program Chair, SC96; Steering Committee for ACM/IEEE Supercomputing Conferences; and is a Member of the IEEE Supercomputing Subcommittee.

Ginger Caldwell is a Member of the Association of Computing Machinery and the American Management Association. She is also a member of the Supercomputing '95 and Supercomputing '96 Education Program Advisory Committee.

Fred Clare is a member of the ACM, SIGGRAPH, and the IEEE Computer Society.

Rachelle Daily serves as Secretary, Executive Board, IEEE Computer Society, Mass Storage Technical Committee.

Chris Fair and Marla Meehl serve on the vBNS Technical Consultation Committee (vTCC) Chris Fair and Marla Meehl served on the NSF High Performance Connection Panel.

Karen Friedman received the IEEE Computer Society Golden Core Member Award and served on SC95 (still serving on SC97) Executive Committee.

Sally Haerer served on: SC'96 Executive Committee - Technical Papers and Invited Speakers Chair; Parallel Tools Consortium Steering Committee; Cray User Group Board of Directors and Advisory Council - Vice President; is a member of IEEE Computer Society; and is a Program Committee Member of IAI Workshop, Boulder.

Steve Hammond was a member of the technical papers committee for Supercomputing 96 held in Pittsburgh, PA Nov. 1996 and was a member of the student paper award committee for Supercomputing 96.

Steve Hammond and Paul Swarztrauber were on the organizing committee for the Fifth Workshop on Numerical Solutions of Fluid Flow in Spherical Geometry, Breckenridge, Colorado, June 12, 1996.

Roy Jenne continues to serve on the following advisory panels: Academy CES satellite committee; Advisory Panel for Goddard DAAC (Data System); and the Science Council for Earth Sciences for USRA (University Space Research Association) (through November 1999). Jenne also Chaired Negotiations on Working Group VIII Data Exchange, August 1996; is Head of US side of US-Russia data exchange under Working Group VIII bilateral (1980-1996).

Jeff Kuehn is Chair, Special Interest Committee for Performance and Evaluation, Cray User Group, Inc. (elected); Advisory Council Member, Cray User Group, Inc. (appointed); Steering Committee Member, Parallel Tools Consortium (appointed); Supercomputing '96, Technical Papers Reviewer. Kuehn also is a member in IEEE Computer Society ACM (Association for Computing Machinery) Usenix Association.

Lynda Lester became the new editor of CUG.log, the international newsletter of the Cray User Group. She also served on Supercomputing 96 executive committee as photographer/producer of a multimedia documentary on "The Making of Supercomputing '96." Lester is also a Member of the Society for Technical Communication. Lester's Awards include: a Distinguished Award and an Award of Excellence at the regional level and an "Award of Excellence" at the international level from the Society for Technical Communication for "SCD Computing News" and the "SCD Information Resources Catalog." Also received Award of Achievement at the regional level from Society for Technical Communication for NCAR Graphics brochure.

Marla Meehl and Paul Hyder serve on the Westnet Steering Committee. Marla Meehl served on the US West Cell Relay Service Customer Advisory Panel.

Bernie T. O'Lear is chair of the Mass Storage Systems Technical committee for the IEEE Computer Society. He also set up and participated in the meeting of CATI (Colorado Advanced Technology Institute), the State of California GIS management group, several Colorado Universities faculty members, and Colorado State government officials. The objective is to develop distributed data bases and backups for an expanded land use information network for both Colorado and California. O'Lear also served as a reviewer for a Report of the Working Group on Large Storage I/O Issues in Large-Scale Computing.

Steve Worley served on the Steering committee for 2nd Annual Data Management Working Group Workshop, Asheville, N.C. Representing NSF November 11-15, 1996.

The NCAR Graphics Group won an Award of Excellence for NCAR Graphics 4 Interactive Documentation in the regional Society for Technical Communication (STC) Online Communication Competition. This entry then went on to STC's International Online Communication Competition, where it won an Award of Merit.

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Technical Presentations

This page lists the technical presentations SCD staff have given to groups outside the division.

Technical Presentations Outside NCAR

Buzbee, Bill, "Comments on PVPs, MPPs, NOWS, and Future Computer Architectures, ICPA '95, Wuhan, China, October 24, 1995.

Clyne, John, "The Visible Human Project", Supercomputing '95/GII Testbed, San Diego, CA, December 1995.

Clyne, John, "Distributed Visualization over the vBNS", DOE Computer Graphics Forum; Carmel, CA, May 1996.

Clyne, John, "Computer Applications of the Visible Human Dataset", SIGGRAPH96 Applications Forum, New Orleans, LA, August 1996.

Clyne, John, and Tim Scheitlin, "Visualizing Turbulence Data", Geophysical Turbulence Workshop 1996, Boulder, CO, August 1996.

Fair, Chris, "Implementation of ATM," Interop '96, Las Vegas, NV, April 1996.

Fair, Chris, "CO-OP 3D," University of Colorado, April 1996.

Hammond, Steve, "Graph Partitioning and Mapping for Parallel Computing," University of Colorado, Boulder, CO, April 1996.

Kuehn, Jeff, "Faster Libraries for Creating Network-Portable Self-Describing Datasets," 37th Cray User Group Meeting, Barcelona, Spain, March 11-15, 1996.

Jenne, Roy, "Data Exchanges in IAI," Inter-American Institute Workshop, Chile, December 3-9, 1995.

Jenne, Roy and Steve Worley, "Data Availability and Plans for IAI," Inter-American Institute Workshop on Climate Modeling, Boulder, CO, March 4, 1996.

Jenne, Roy, "Data Inputs for Future Reanalysis Projects," EMCWF Reanalysis Workshop, England, July, 1996.

Jenne, Roy, "The NCEP/NCAR Reanalysis Project," AMS Weather Forecasting Conference, August 18-24, 1996.

Jenne, Roy, Chaired session on "Reanalysis and Associated Studeis," AMS Weather Forecasting Conference, August 18-24, 1996.

Jenne, Roy, Presented five lectures: "How to Handle Data Methods and Technology," "The NCEP/NCAR Reanalysis Project," "Reanalysis Data at NCAR, River Data," "Reanalysis, Introduction to NCAR, Data Available,", "Reanalysis, NCAR, Data Access in China," IAP/LASG and CMA, China, September 13-28, 1996.

Jenne, Roy, "History of the Southern Hemisphere Climotology Project," van Loon Symposium, October, 21, 1996.

Merrill, John, "Cray Connectivity to ESCON-attached Storage Devices at NCAR," Cray User Group Meeting, October, 1996.

Middleton, Don, and Tim Scheitlin, "The Climate Simulation Lab", SuperComputing95/GII Testbed, San Diego, CA, December 1995.

Middleton, Don, "The Making of the Visible Human Movie + Visualization Lab Tour", Wavefront/Alias Front Range User's Group, Boulder, CO, April 1996.

Middleton, Don, Tim Scheitlin, and John Clyne, "Visualization at NCAR", IEEE Conference on Visual Languages 1996, Boulder, CO, September 1996.

Siemsen, Pete, WebMaker," Front Range UNIX User's Group, Boulder, CO, April 1996.

Smith, Susan, "Workstation Usage," Inter-American Institute Workshop on Climate Modeling, February 26, 1996.

Swarztrauber, Paul N., "The Role of Parallel Communication Algorithms in the Future of Computing: The Vector Multiprocessor," University of Colorado, February 26, 1996.

Swarztrauber, Paul N., "The Cartesian Method for Solving Partial Differential Equations in Sperical Geometry," Fifth Workshop on Numerical Solutions of Fluid Flow in Spherical Geometry, Breckenridge, CO, June 12, 1996.

Worley, Steve, "Availability of Ocean Data," Inter-American Institute, Bouler, CO, March 1996.

Technical Presentations at NCAR

SCD staff also gave a number of technical presentations to Review Panels, Advisory Panels, and as part of the SCD Seminar Series for SCD and NCAR/UCAR staff.

Alpert, Ethan, "Interactive Data Browsing of GRIB, netCDF, and other Formats using NCAR Graphics," SCD Seminar, March 27, 1996.

Andersen, Aaron, "Advanced HTML Concepts," SCD Seminar, January, 10, 1996.

Anderson, Dan, "Workstations Seminar," SCD Seminar, November 1995.

Buzbee, Bill, "SCD Status Report and Update," SCD Advisory Panel, March 28, 1996.

Clyne, John, "The Visible Human Project", SCD Seminar, December 1995.

Fair, Chris, "CO-OP 3D," SCD Seminar, January 1996.

Fair, Chris, "vBNS," SCD Seminar, June 19, 1996.

Fair, Chris, "SONET," SCD Seminar, August 21, 1996.

Irwin, Basil, "Introduction to Fibre Channel," SCD Seminar, August 1, 1996.

Middleton, Don, "Developments in Visualization," SCD Advisory Panel, March 28, 1996.

Middleton, Don, John Clyne, and Tim Scheitln,"A Visual Tour of Science and Computation at NCAR," NSF Review Panel, April 1996.

Poppe, Herb, "Macintosh Hardware and Software Technologies," SCD Seminar, December 21, 1995.

Siemsen, Pete, "Introduction to Computer Networking," SCD Seminar, April 1996 and May 1996.

Sloan, John L., "Distributed Climate Simulation Laboratory," SCD Advisory Panel, October 1995.

Sloan, John L., "Mass Storage: The Last Mile on the Path to UNIX," NSF Review Panel, April 1996.

Sloan, John L., "Mass Storage: The Last Mile on the Path to UNIX," SCD Advisory Panel, April 1996.

Thanhardt, Erich, "Object Oriented Thinking," NCAR Seminar, June 1996.

Woods, Greg, "Computer Security: Threats and Defenses (A User Point of View)" SCD Seminar, June 1996.

Presentations to Students

SCD staff also gave presenatations to high school and college students.

Sloan, John L., "Power Curves, the Singularity, and the Brave Newer World," keynote address for the Colorado Computational Science Fair, Boulder, CO, May 1996.

Arnold, Ed, John Clyne, George Fuentes, Gene Harano, Del Harris, Marla Meehl, Don Middleton, Peter Morreale, Dan Norman, and Tim Scheitlin, Colorado School of Mines, May 31, 1996.

Hosting Visiting Organizations

SCD hosted a number of visiting organizations during FY96 and as part of their visit SCD gave formal and informal presenatations and demonstrations. These organizations visited SCD during FY96:

80th Range Commanders meteorology Group Meeting, August 6, 1996.

Inter-American Institute Workshop on Climate Modeling, March 7, 1996.

Hitachi, September 1996.

Colorado Advanced Technology Institute, October 1996.

Air Force Global Weather Center, August 14, 1996.

Geosciences Directorate, NSF, April 1, 1996 and September 9, 1996.

Hewlett Packard Graphics Hardware Lab, Fort Collins, CO, July 1996.

Joint International Climate Projects/Planning Office, Washington, DC, June 3, 1996.

Archibus TM Computer Software Users' Committee, Colorado, June 12, 1996.

Warsaw Chamber of Commerce and Telecommunication Strategies Consultants, Warsaw, Poland, May 1996.

University of Colorado High Performance Scientific Computing I Class, Boulder, CO, April 9, 1996.

Research Organization for Information Science and Technology, and Hitachi, Tokyo, Japan, December 13, 1995.

Central Research Institute of Electric Power Industry, Tokyo, Japan, December 14, 1995.

Hughes Applied Information System, Landover, Maryland, October 6, 1995.

Rocky Mountain High School, Fort Collins, CO, June 17, 1996.

Arapahoe Ridge High School, VoTech Program, Boulder, CO, May 15, 1996.

Colorado School of Mines, Computer Science Classes, Golden, CO, May 31, 1996.

ACTS - Final demonstration to general public.

CSIRO Information Technology, Australia, Vislab demonstration.

University of Washington visitors and MMM staff - Visualization of MM5.

University of Peking, Univ. of Tapei, & Univ. of Seoul - Visualization of MM5.

Silicon Graphics, Wesley Jones, Advanced Systems Division.

National Geographic Production Team - Movie on global climate change.

Boulder Fire Department - Visualization of simulated forest fires.

Learning Channel Production Team - "Anatomy of a Disaster": Movie on forest fires, simulation thereof, and other tragedies.

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SCD Staff

Administration

Bill Buzbee (Director)
Pete Peterson (Deputy Director)
Bernie O'Lear (Associate Director)
Jonna Colacci
Linda Keyser (to 7/96)
Janice Kline
Mary Ann O'Meara

Computational Support

Steve Hammond (Section Head)
Jeanne Adams
John Adams
Rachelle Daily
John Dennis
Rich Loft
Richard Sato
Bill Spotz (ASP Post Doc)
Paul Swarztrauber

Data Support

Roy Jenne (Section Head)
Roy Barnes
Olivia Bortfeld (to 3/96)
Joey Comeaux
Robert Dattore
Dennis Joseph
Debby Novak
Chi-Fan Shih
Wilbur Spangler
Ilana Stern
Gregg Walters
Steve Worley

High Performance Networking

Marla Meehl (Section Head)
Lisa DeLeon
Chris Fair
Michael Grissom
Del Harris
Scott Hays
Ed Heitschel
Belinda Housewright
Paul Hyder
Basil Irwin
Long Moua
Dan Norman
Pete Siemsen
Ed Snyder

Jim VanDyke
Wesley Wildcat
Fred Woodley

High Performance Systems

John Sloan (Section Head)
Dan Anderson
Edward Arnold
Barbara Bateman
Mary Ann Ciuffini
Dennis Colarelli
Kris Conrad
Tom Engel
Kathy Fryberger
George Fuentes
Gene Harano
Brian Keyser
John Merrill
Andrei Rodionov
Craig Ruff
Eugene Schumacher
Erich Thanhardt
Mark Uris
George Williams
Greg Woods

Operations and Information Support

Ginger Caldwell (Section Head)
Sue Albertson
Vicky Alten
Aaron Andersen
Gregory Berman
Melissa Breedlove
Glenn Brown
Nancy Brown (to 10/95)
Mary Buck
Lee Carter (to 2/96)
Julia Chapin
Gaynez (Bo) Connell
Jeff Cowan
Sylvia Darmour
Jon Frudeger
Marlene Furmanek
Julie Harris
Roxanne Hays (to 3/96)
Gary Jensen (to 12/95)
Sue Ellen Jensen
Jana Jones (to 10/96)
Stan McLaughlin
Rosemary Mitchell
Shawn Montoya (to 4/96)
Laura Morreale (on leave)
Robert Niffenegger (to 11/95)
Herbert Poppe
James Robinson
Susan Schemel
Susan Smith

Technical Support and Development

Sally Haerer (Section Head)
Ethan Alpert
Brian Bevirt
Jeffrey Boote
Dave Brown
Frederick Clare
John Clyne
Susan Cross
Nancy Dawson
Karen Friedman
Mary Haley
Kenneth Hansen

Lynn Hermanson (to 7/96)
David Kennison
Jeff Kuehn
Robert Lackman
Lynda Lester
Gregory McArthur
Don Middleton-Link
Peter Morreale
Tom Parker
Jim Petruzzelli (to 6/96)
Juliana Rew
Tim Scheitlin
Scott Snodgrass
Richard Valent
Janie Young
David Younghans (to 1/96)

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Visitors and Collaborators

DATES	NAME	AFFILIATION	FIELD OF INTEREST	HOST
4/1/95-1/1/96	Nadia Zuljani Drmac	Unaffiliated	Applied Mathematics	Rich Loft
1/2/96-8/30/96	Hongqing Wang	Peking University	Analysis of large complex datasets	Don Middleton
6/1/95-12/1/95	Kendal McGuffie	Univ. of Technology, Sydney	Climate Modeling	Don Middleton
11/2/95-11/28/95	Ann-Maree Hansen	Macquarie University	Visualization of tropical cyclones	Don Middleton
3/11/96-3/10/97	Duane Wessels	General Atomics	Internetworking	Marla Meehl
4/19/96-8/31/96	Yan Zhang	Lab f/Severe Storm Research - Peking	Computer Visualization	Don Middleton
7/29/96-7/30/96	Reagan Moore	San Diego Supercomputing Center	Scientific data management for supercomputers	John Sloan
8/1/96-8/2/96	Michael Boettinger	Max Planck Inst. for Meteorology	Scientific Visualization	Don Middleton
8/1/96-8/2/96	Joachim Biercamp	Max Planck Inst. for Meteorology	Scientific Visualization	Don Middleton
8/3/96-8/10/96	Marsel Shaimardanov	Russian Research Inst. for Hydrometeorological Information	Data Exchange	Roy Jenne
8/3/96-8/10/96	Alex Sterin	Russian Research Inst. for Hydrometeorological Information	Data Exchange	Roy Jenne
8/5/96-8/6/96	Peter Steurer	NCDC, (NOAA) Asheville, NC	Data Exchange	Roy Jenne
8/5/96-8/6/96	Jim Slack	USGS, Office of Hydrology, Reston, VA	River Data	Roy Jenne
8/5/96-8/6/96	Mike Gillespie	Snow Survey Office of USDA, Denver	Snow Data	Roy Jenne
8/5/96-8/6/96	Roger Barry	Snow and Ice Data Center, Boulder	Snow Data	Roy Jenne
9/11/96-1/10/97	Satoshi Sekiguchi	Electrotechnical Lab Japan	Performance Modeling and Benchmarking	Steve Hammond

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STAFF, VISITORS & COLLABORATORS

- Atmospheric Chemistry Division
- Atmospheric Technology Division
- Environmental and Societal Impacts Group
- Mesoscale and Microscale Meteorology Division
- Scientific Computing Division
- Advanced Study Program
- Climate and Global Dynamics Division
- High Altitude Observatory
- Research Applications Program
- Senior Scientists
- Director's Division

Atmospheric Chemistry Division

Staff

Division Director's Office

Guy Brasseur (director)
Michael Coffey
Brad Crysel
Teresa Rivas
Donna Sanerib
Susan Solomon (acting director)
Paul Sperry

Atmospheric Odd Nitrogen

Frank Grahek
Brian Ridley (leader)
James Walega

HO_x Project

Christopher Cantrell
Fred Eisele (leader)
Richard Shetter
David Tanner

Laboratory Kinetics

John Orlando
Geoffrey Tyndall (leader)

Stratospheric/Tropospheric Measurements

Elliot Atlas (leader)
Frank Flocke
Sue Schauffler

Biosphere Atmosphere Interactions

James Greenberg
Alex Guenther (leader)
Peter Harley
Lee Klinger

Standards and Intercomparisons

Eric Apel (leader)
Timothy Gilpin

David Edwards
John Gille (manager)
Lawrence Lyjak
Steven Massie
William Randel (leader)
Fei Wu

MOPITT

Paul Bailey (leader)
John Caron
Charles Cavanaugh
John Gille (manager)
Beverly Heller
Leslie Mayer
Frederick McCloskey
Daniel Packman

Laura Rokke
Steve Shertz
Mark Smith
Charles Spaur
JinXue Wang

HIRDLS

Philip Arter
Michael Dials
John Gille (leader)

Chris Halvorson
Linda Henderson
William Howard
Joanne Loh (manager)
David Wilson
Douglas Woodard

Optical Techniques

Michael Coffey
James Hannigan
William Mankin (leader)

Tunable Diode Laser Spectroscopy

Alan Fried (leader)

Regional Process Studies

Mary Barth
John Caron
Chris Fischer
Siri Flocke
Claire Granier
Peter Hess
Sasha Madronich (leader)

Global and Stratospheric Studies

Guy Brasseur (leader)
David Erickson
Rolando Garcia
Elisabeth Holland
Anne Smith
XueXi Tie
Stacy Walters

Technical Support

William Bradley
Timothy Fredrick
Roger Hendershot
Paul Sperry (leader)

Administrative Support

Janice Powell (to July 1996)
Teresa Rivas (leader)
Donna Sanerib
Kelly Stoecklein
Marilena Stone
Jack Wainwright

Affiliate Scientists

Aaron Goldman, University of Denver
Susan Solomon, NOAA Aeronomy Laboratory
Stuart Penkett, University of East Anglia
Dieter Ehhalt, Institute for Atmospheric Chemistry

Visitors and Collaborators

Dates refer to visitor's stay at NCAR during FY95. No dates are given for collaborators who did not visit NCAR.

David Andrews; Oxford University; HIRDLS

Janet Arey; University of California, Riverside; isoprene emission studies

Robert Arnts; Environmental protection Agency; biosphere-atmosphere interactions

Roger Atkinson; University of California, Riverside; isoprene emission studies

Bradford Baker; University of Colorado at Boulder; January 1996 to December 1998; trace gas biogeochemistry

John Barnett; Oxford University; HIRDLS

Michael Bashkin; Colorado State University; December 1995 to March 1996; global modeling

F. Battin-Leclerc; NOAA Aeronomy Laboratory; ozone photochemistry studies

William Baugh; unaffiliated; July 1994 to March 1997; ecosystem studies

Karsten Baumann; NOAA/CIRES; February 1996 to April 1996; atmospheric odd nitrogen

Rachel Beaule; University of Lyon 1, France; April 1996 to May 1997; regional and process studies

William Bell; National Physical Laboratory; NDSC

Harold Berresheim; Albein-Schwaiger-Weg 10, France; 23-31 May; Ho_x measurements

Donald Blake; University of California, Irvine; PEM-Tropics
Marine Bonazzola; Univesity of Paris-sud, France; May 1996 to August 1996; global and stratospheric studies

Stephan Borrmann; University of Mainz, Germany; 29 July 1996-8 August 1996;

tropospheric and stratospheric aerosols

David Bowling; University of Colorado at Boulder; January 1996 to July 1996; biogenic emissions

Clobite Bouka-Biona; University of Brazzaville; EXPRESSO

David Bowling; University of Colorado; biosphere-atmosphere interactions

Mary Brunelle; Colorado State University; December 1995 to March

Teresa Campos; NCAR/ATD; January 1996 to January 1997; AASE-II

Simon Chabrillat; Belgian Institute for Space Aeronomy; March 1995 to July 1996; global and stratospheric studies

Julius Chang; State University of New York; 15 November 1995; regional and process studies

Martyn Chipperfield; Cambridge University; polar stratospheric chemistry

John Constable; University of Colorado; January 1996 to June 1996; biogenic emissions

to September 1996; ecosystem modeling

Robert Curran; NASA Headquarters; SUCCESS

William Custer; NOAA Aeronomy Laboratory; STERAO-A

John Daniel; NOAA Aeronomy Laboratory; November 1995 to November 1996; AASE II

Purnendu Dasgupta; Texas Tech University; 11-12 October 1995; hydrocarbon intercomparison

Douglas Davis; Georgia Institute of Technology; PEM-Tropics

Gary Davis; University of Saskatchewan; MOPITT
Tom DeFlice; University of Wisconsin-Milwaukee; aerosol/sulfur oxidation chemistry

Sara Dizick; University of Colorado; April 1995 to May 1996; trace gas biogeochemistry

Ed Dlugokensky; NOAA CMDL; UV and V radiation modeling

Mark Dombrowski; NASA Goddard Space Flight Center; July 1995 to January 2003; HIRDLS

James Drummond; University of Toronto; 18-22 November 1995; MOPITT

Ellsworth Dutton; NOAA CMDL; UV and V radiation modeling

Paul Eriksen; Danish Meteorological Institute; SESAME

Raymond Fall; University of Colorado; biosphere-atmosphere interactions

Hans Fast; Atmospheric Environment Service, Canada; NDSC

Fred Fehsenfeld; NOAA Aeronomy Laboratory; STERAO-A and other collaborations

Richard Field; Department of Chemistry; October 1995 to February 1996; regional and process studies

Francois Figarol; Institut Pierre Simon LaPlace, France; January 1995 to May 1996; global and stratospheric studies

Jean-Marc Fracheboud; Physical Chemistry Laboratory, England; September 1995; ozone photochemistry

Gene Francis; University of Colorado at Boulder; July 1992 to January 1997; global and stratospheric studies

Randall Friedl; NASA Headquarters; SUCCESS

Eric Fujita; Desert Research Institute; SOS

Kochy Fund; AtmAA; SOS

Bruce Gary; Jet Propulsion Laboratory; Microwave Temperature Profiler

modeling and other collaborations

Paul Ginoux; University of Brussels, Belgium; December 1993 to January 1998; global and stratospheric studies

Paul Goldan; NOAA Aeronomy Laboratory; STERAO-A

Arun Gopalan; Unaffiliated; December 1993 to June 1997; UARS

Peter Gray; Rutherford Appleton Laboratory; HIRDLS

David Griffith; University of Wollongong; NDSC

Sylviane Haberkorn; I.U.I. Louis Pasteur, France; September 1995 to June 1996; atmospheric kinetics
Chris Halvorson; Unaffiliated; June 1991 to March 1997; HIRDLS

Jerry Harder; University of Colorado; 11-12 October 1995; trace gas measurements

Alexis Hartz; University of Colorado; June 1996 to May 1997; ecosystem modeling

Brian Heikes; University of Rhode Island; 11-12 October 1995; hydrocarbon intercomparison

Detlev Helmig; Unaffiliated; January 1992 to June 1996; trace gas biogeochemistry

Daniel Hereid; University of Colorado; January 1995 to December 1998; ecosystem studies

Nicholas Hewitt; University of Lancaster; VOC emission modeling

James Holton; University of Washington; 31 January-2 February 1996; HIRDLS

Brian Hopkins; University of Rhode Island; SOS

Theresa Huang; University of Michigan; March 1993 to August 1997; global and stratospheric studies

Gerhard Hübler; NOAA Aeronomy Laboratory; STERAO-A

Gregory Huey; NOAA Aeronomy Laboratory; nitric acid intercomparison
Michael Hurley; Ford Motor Company; hydrofluorocarbon studies

Daniel Jacob; Harvard University; PEM-Tropics

Brian Johnson; University of Michigan; July 1995 to December 1996; HIRDLS

Nicholas Jones; National Institute for Water and Air, New Zealand; NDSC

Tørben Jørgensen; Danish Meteorlogical Institute; SESAME

John Karlik; Bakersfield Colleage; isoprene emission studies

Carla Kegley-Owen; University of Colorado; July 1993-December 1996; atmospheric kinetics

Boris Khattatov; SUNY at Stony Brook; January 1996 to January 1997; EOS studies

Rashid Khosravi; University of Colorado; January 1995 to February 1997; global and stratospheric studies

Thaddeus Kleindienst; Mantech Environmental Laboratory; 11-12 October; hydrocarbon intercomparisons

Heidi Krapfl; Metro State College; September 1995 to October 1996; stratospheric/tropospheric measurements
Brian Lamb; Washington State University; VOC emission studies

Kathleen Lantz; University of Colorado; October 1995 to January 1996; regional and process studies

Jean-François Lamarque; Catholic University of Louvain; September 1994 to August 1997; regional chemical transport models

Yin-Nan Lee; Brookhaven National Laboratory; 11-12 October 1995; SOS formaldehyde intercomparison

Conway Leovy; University of Washington; 31 January 1996-2 February 1996; HIRDLS

Jules Loemba; University of Brazzaville; EXPRESSO
William Lonneman; Environmental Protection Agency; SOS

Manuel Lopez Puertes; Institute of Astrophysics, Spain; observations of non-LTE limb radiance

Mingzhao Luo; University of California, Irvine; HALOE

Robert MacQueen; Rhodes College; atmospheric research spectrometer

Gurpreet Mand; University of Toronto; MOPITT

James Marti; Naval Research Lab, 10-14 April 1996; Ho_x measurements

Kenneth Masarie; NOAA CMDL; UV and V radiation modeling

Roy Leon Mauldin; Unaffiliated; April 1994 to April 1996; Ho_x measurements

Andrew Matthews; National Institute for Water and Air, New Zealand; NDSC

John McConnell; York University; MOPITT

Michael McIntyre; Cambridge University; HIRDLS

Richard McKenzie; New Zealand Institute for Water Research; UV and V radiation modeling

Peter McMurry; University of Minnesota; aerosol/sulfur oxidation chemistry
Demaree Michelau; University of Colorado; June 1996 to September 1996; ecosystem studies

Trine Mogelberg; RISO National Lab, Denmark; January 1996 to April 1996; atmospheric kinetics

Russell Monson; University of Colorado; biosphere-atmosphere interactions

Jean Marie Montsambote; University of Brazzaville; EXPRESSO

Denise Montzka; Unaffiliated; July 1991 to December 1996; atmospheric odd nitrogen

Michael Mozurikewich; York University; heterogeneous studies of sulfuric acid aerosols
H. G. Muller; University of Sheffield; NIRDLS

Jean-François Müller; Belgian Institute for Space Aeronomy; VOC emission modeling and other collaborations

Martin Muller; Institut für Atmospharische Chemie, Germany; February 1996 to February 1998; atmospheric chemistry

David Murcray; University of Denver; NDSC

Frank Murcray; University of Denver; NDSC

C. T. Mutlow; Rutherford Appleton Laboratory; HIRDLS

Jason Neff; Stanford University; July 1996 to August 1996; ecosystem studies

Paul Newman; NASA Goddard Space Flight Center; STRAT

Ole-John Nielsen; Ford Motor Company; hydrofluorocarbon studies

Justus Notholt; Alfred Wegener University, Germany; NDSC

Paul Novelli; NOAA CMDL; UV and V radiation modeling

Christopher Palmer; Oxford University; HIRDLS

Stella Papasavva; Tufts University; October 1995; global and stratospheric studies

Suzanne Paulson; University of California, Los Angeles; production

Jens Pedersen; RISO National Lab; January 1996 to March 1996; atmospheric kinetics

Guy Peskett; Oxford University; MOPITT

Kenneth Pickering; University of Maryland; modeling storm prediction and analyses

Thomas Pierce; Environmental Protection Agency; VOC emision modeling

Robert Portmann; NOAA Aeronomy Laboratory; November 1995 to December 1996; global and stratospheric studies

Richard Powers; University of Nebraska at Lincoln; June 1996 to

Michael Profitt; NOAA Aeronomy Laboratory; upper troposphere modeling

Joseph Prusa; Iowa State University; 7-31 July 1996; global and stratospheric studies

John Pyle; Cambridge University; HIRDLS

Evaristo Ramirez; Unaffiliated; June 1996 to September 1996; stratospheric/tropospheric measurements

A. Ravishankara; NOAA Aeronomy Laboratory; ozone photochemistry studies

Henry Reichle; North Caroline State University; MOPITT

Daniel Riemer; University of Miami; SOS

Clive Rodgers; Oxford University; HIRDLS

Michael Rodgers; Georgia Institute of Technology; PEM-Tropics
F. Sherwood Rowland; University of California, Irvine; PEM-Tropics

Nigel Roulet; McGill University; MOPITT

James M. Russell III; Hampton University; HALOE

Steven Rutledge; Colorado State University; STERAO-A

Joseph Sabutis; University of California, Los Angeles; November 1995 to April 1997; UARS

Glen Sachse; NASA Langley Research Center; Measurements of CO_2

Murry Salby, University of Colorado; January 1992-December 1997;

Fabrizzio Sassi; Unaffiliated; October 1994 to March 1997; global and stratospheric studies

Vincent Saxena; North Carolina State University; aerosol/sulfur oxidation chemistry

Niels Schonbeck; Metropolitan State College of Denver; March 1996 to August 1997; aerosols

Mark Schoeberl; NASA Langley Research Center; VOTE/TOTE

Jens Sehested; Riso National Laboratory; hydrofluorocarbon studies

Dominique Serca; Universite Paul Sabatier, France; April 1995

Christophe Seuzaret; Elf Aquitaine, Inc.; January 1996 to April 1997; global and stratospheric studies

Paul Shepson; Purdue University; SOS

Liaw Sheng-Ju; Institute of Nuclear Science, China; 2-17 February 1996; atmospheric chemistry

Christoph Spirig; Swiss Federal Institute of Technology; July 1996 to December 1996; ecostystem studies

David Starr; NASA Goddard Space Flight Center; SUCCESS

Rainer Steinbrecher; Franhoefer Institute; VOC emission modeling

Jeffrey Stith; University of North Dakota; STERAO-A

Elizabeth Stone; Iowa State University; September 1994 to August 1997; UARS

John Streete; Rhodes College; May 1996 to August 1996; optical techniques

Verity Stroud; Unaffiliated; November 1995 to January 1996; stratospheric/tropospheric measurements

James Sulzman; Unaffilaited; June 1994 to June 1997; ecosystem studies

Carine Suter; Institut Louis Pasteur, France; September 1995 to June 1996; stratospheric/tropospheric measurements

Ranajit Talukdar; NOAA Aeronomy Laboratory; ozone photochemistry studies

Pietr Tans; NOAA CMDL; UV and V radiation modeling

Frederick Taylor; Oxford University; HIRDLS
John Taylor; Australian National University; 25 March-5 April 1996; global and stratospheric studies

1. H. Taylor; Unaffiliated; May 1996 to November 1996; ecosystem studies

Brian Toon; NASA Ames Research Center, SUCCESS, VOTE

G. C. Toon; Jet Propulsion Laboratory; NDSC

Ian Tosh; Rutherford Appleton Laboratory; HIRDLS

Alan Townsend; Harvard University; May 1996 to February 1997; ecosystem studies

Adrian Tuck; NOAA Aeronomy Laboratory; STERAO-A

Andrew Turnipseed; University of Colorado; January 1996 to July 1996; biogenic emissions

Michiel Van Weele; IMAU Utrecht University; The Netherlands; November 1995 to January 1996; global and stratospheric studies

Geraint Vaughan; University College of Wales; HIRDLS

Peter Venters; Oxford University; HIRDLS

Lee Vierling; University of Colorado; May 1996 to May 1998; trace gas biogeochemistry
Timothy Wallington; Ford Motor Company; hydrofluorocarbon studies

Yonghua Wang; Georgia Institute of Technology; 22 October to 16 November 1995; stratospheric studies

Robert Wells; Oxford University; HIRDLS

Bryan Wert; University of Colorado; June 1995 to June 1999; tunable diode laser

Halvore Westberg; Washington State University; 12 October 1995; hydrocarbon intercomparisons and other collaborations

John Whitney; Oxford University; HIRDLS

Arthur Winer; University of California, Los Angeles; isoprene emission studies

Steven Wofsy; Harvard University; STRAT

Wanli Wu; University of Michigan; July 1994 to July 1996; middle atmosphere

Kuang-Ling Yang; University of Michigan; 4-17 February 1996; atmospheric chemistry

Rudolf Zander; University of Liege; NDSC

Jun Zeng; University of Alaska; May 1995 to May 1997; regional and process study

Genfa Zhang; Texas Tech University; 11-12 October 1995; trace gas measurements

Jiangfen Zheng; University of Colorado; October 1993 to September 1997; AASE-II

Xianling Zhou; ManTech Environmental; SOS

Paul Ziemann; University of Minnesota; 1-19 April 1996; Ho_x measurements

Rod Zika; University of Miami; SOS

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Advanced Study Program

ASP Staff/Visitors

William A. (Al) Cooper (Director from 6 May 1996)
John Firor (Director to 2/29/96)
Barbara Hansford (85%)
Judy Miller
Charles Cross (student assistant to 10/13/95)
Cammie Muller (student assistant from 10/10/95)
Tom Wigley 20%)

Visitors

Graduate Fellow

Steve Augustine; University of Michigan; examine block predictability and sensitivity of block development to initial condition uncertainty; Joe Tribbia, CGD.

Postdoctoral Fellows

Nolan Atkins; UCLA; Tornadoes and tornadogenesis; fine-scale structure of the dry line.

Steve Ball; Oxford Univ., England; Laboratory studies of the reactions and nucleations of sulfate aerosols.

Karsten Baumann; Univ. of Stuttgart, Germany ; Measurement of NOx produced by lightning.

Scott Braun; University of Washington; mesoscale/synoptic meteorology and modeling; frontal/convective systems and precipitation processes.

Li Chen; Princeton University; analysis of UARS (Upper Atmosphere Research Satellite) data.

Toshio Michael Chin; University of Miami; optimization, random field modeling.

Gregory Dubois-Felsmann; California Institute of Technology; atmospheric chemistry and atmospheric science policy.

Frederic Fabry; McGill University, Canada; radar meteorology and lidar research.

Regina Figge-Cannon; Univ. of Colorado; Earth's carbon cycle.

Vanda Grubisic; Yale University; Inference of critical levels on 3-D mountain airflows.

Didier Hauglustaine; Universite Paris VI, France; atmospheric chemistry modeling; atmospheric composition evolution.

Brad Hindman; Univ. of Colorado; Seismology of the Sun's active regions and outer atmosphere.

Jim Howell; Oregon State Univ.; Resolving surface flux variability.

Peter Jaumann; University of Iowa; detection of anthropogenic climate change.

Anne Jefferson; University of Colorado at Boulder; tropospheric sulfur balance and aserosol production.

Keith Julien; University of Cambridge, England; helioseismology and geophysical and astrophysical fluid turbulence.

Julia Lee-Taylor; University of East Anglia, England; whole air analysis for tropospheric and stratospheric-stable trace species.

K.D. Leka; University of Hawaii; solar magnetic fields and sunspot evolution.

Kathleen Lantz; University of Colorado at Boulder; development of a trajectory-chemistry model.

Luning Li; Indiana University; statistical analysis, turbulence and global circulation.

Jordan Powers; University of Washington; mesoscale gravity waves.

Mark Rast; University of Colorado at Boulder; compressible turbulence in an ionizing fluid.

Lynn Russell; CalTech; Atmospheric chemistry; atmospheric boundary layer dynamics; aerosol cloud interactions.

Rong-Shyang Sheu; Univ. of Colorado; Satellite retrievals and mesoscale modeling.

William Spotz; Univ. of Texas; High order methods for computational fluid dynamics.

Bjorn Stevens; Colorado State Univ.; Turbulence, warm-phase microphysics and convection.

De-Zheng Sun; M.I.T.; climate dynamics.

Robert Tomas; University of Colorado at Boulder; large-scale atmospheric disturbances with time scales from a week to a month.

Dailin Wang; University of Hawaii; ocean circulation models and geophysical fluid dynamics.

Tammy Weckwerth; University of California at Los Angeles; observational and modeling studies of the evolution of horizontal convective rolls.

Tsegay Wolde-Georgis; University of Natal, South Africa; ENSO information on food security, especially in the case of South Africa.

David Yates; Univ. of Colorado; Linkage of hydrologic processes in mesoscale climate models.

Charles Zender; Univ. of Colorado; Diagnosing the hydrologic cycle in the CCM2 using geophysical tracers.

Other ASP and GTP Visitors and Collaborators

Kenneth Davis; University of Colorado at Boulder; trace gas fluxes and transport in the boundary layer.

Myanna Lahsen; Rice University; sociology of scientific groups.

Peter Ditlevsen; University of Copenhagen; geophysical turbulence.

Ron Harris; Univ. of Charleston; behavior of lab-size tornadoes.

Jennifer Jordan; Univ. of Charleston; general atmospheric sciences.

Edward Lorenz; M.I.T.; technology, dynamic meteorology.

Graeme Mather; CloudQuest, South Africa; cloud physics.

Michael McLaughlin; Univ. of Charleston; atmospheric science.

Olivier Metais; C.N.R.S., France; rotating turbulence.

Laney Mills; Univ. of Charleston; atmospheric science education.

David Pelkey; Univ. of Charleston; atmospheric science.

Patsy Taylor; University of Wyoming; Social organization of research organizations; from 7 September 1993.

Michael Toman; Resources for the Future; sustainable development.

Irad Yavneh; Technion, Israel; geophysical turbulence.

GTP Seminar Series

Onno Bokhove; Woods Hole Oceanographic Institution.

Fausto Cattaneo; University of Chicago.

Gokhan Danabasoglu; CGD.

Victor Fernandez; Rutgers University.

Dave Fritts; University of Colorado.

Rodney Kinney; UCLA.

Alexander Lifschitz; University of Illinois at Chicago.

Victor L'vov; The Weizmann Institute of Science, Israel.

Alex Mahalov; Arizona State University.

Mu Mu; Chinese Academy of Sciences.

Basil Nicolaenko; Arizona State University.

Itamar Procaccia; The Weizmann Institute of Science, Israel.

Ye Zhou; NASA-Langley Research Center.

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Atmospheric Technology Division

Staff

Division Director's Office

David Carlson (Director)
Warren Johnson (Assistant Director)
Brigitte Baeuerle
Robert Snow
Shelley Zucker

Research Aviation Facility

Paul Herzegh (Acting Manager)
Linda Banks
Harold Barber
Keith Barr
Darrel Baumgardner
Henry Boynton
Robert Campbell
Teresa Campos
William Cooper (33%, to May 96)
John Cowan
Ray Crynkovich
Michael Daniels
James Dye (33%)
Richard Friesen
Bruce Gandrud
Lowell Genzlinger
Joanne Graham
Julie Haggerty
Michael Heiting
Gary Horton
William Irwin
Gregory Kok
Krista Laursen
Paul LeHardy
Donald Lenschow (33%)
David McFarland
Bruce Morley
Aref Nammari
George Nicoll
Robert Olson
Mary Ann O'Meara (to Sept 96)
Lawrence Radke
James Ragni
Edward Ringleman
Diana Rogers
Ronald Ruth (50%)
Allen Schanot
Richard Schillawski
Michael Spowart
Hung Viet Ta
Richard Taylor
Cindy Twohy
Judy Wade
Chris Webster
Kurt Zrubek
Norman Zrubek

Surface and Sounding Systems Facility

Harold Cole (Acting Manager)
Ed Aden (63%)

Gerald Albright
Ned Chamberlain
Steve Cohn
Forrest Cook (25%)
Celia Darnell
Anthony Delany
Terry Hock
Tom Horst
Cathy Jirak (80%)
Kurt Knudson
Errol Korn
Dean Lauritsen
Gordon Maclean
Charles Martin
Matthew Michaelis
John Militzer
Erik Miller
Larry Murphy
Santiago Newbery
Ken Norris
Steve Oncley
James Owens
Carmen Paneitz
Dave Parsons
Mary Ann Pykkonen
Michael Read (33%)
Steve Semmer
Jeff Smith
William Snyder (50%)
Michael Susedik

Remote Sensing Facility

Jeffrey Keeler (Acting Manager)
Herminio Avila
David Ecoff (66%)
Don Ferraro
Sherrie Frederick
Charles Frush
Peter Hildebrand
Jean Hurst (38%)
Wen-Chau Lee
Brian Lewis
Eric Loew
Jonathon Lutz
Ann-Elizabeth Nash
Richard Neitzel
Susan Norman
Richard Parsons
Al Phinney
Mitch Randall
Robert Rilling (50%)
Tim Rucker

Michael Strong
Margaret Taylor
Joseph VanAndel
Joseph Vinson
Craig Walther
James Wilson

Research Data Program

Jon Corbet (Manager)
Chris Burghart
Michele Case
Forest Cook (75%)
Raymond Giles
Gary Granger
Jean Hurst (38%)
Cynthia Mueller (30%)
Dick Oye
Robert Rilling (50%)
Ronald Ruth (50%)

Design and Fabrication Services

Paul Johnson (Manager)
Page Baptist (to 30 June 96)
Jeff Bobka
Jerry Dryer
James Ellis
Jack Fox
Ken Harris
Walter Hodshon
James Holt
Michl Howard
Steven Palmer
Jose Rivas (50%)
Bart Woodiel

Affiliate Scientists

Jean-Louis Brenguier; CNRM, France
James Coakley; Oregon State University, Research Aviation Facility
Richard Doviak; National Severe Storms Laboratory; Remote Sensing Facility
Gerhard Peters; University of Hamburg, Germany; Surface and Sounding Systems Facility

Visitors

James Anderson; Arizona State U., Tempe, AZ; 2 - 31 October 1995; ACE 1; Research Aviation Facility

Paul Aristo; NASA/Ames, Moffett Field, CA; 28 August - 2 September 1996; aircraft measurements; Research Aviation Facility

John Arveson; NASA/Ames, Moffett Field, CA; 16 January 1996; scientific visitor; Research Aviation Facility

David Atlas; NASA/GSFC, Greenbelt, VA; 17 July 1996; precipitation estimation; Remote Sensing Facility

Serhad Atakturk; U. Washington, Seattle, WA; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Arnold Barnes; USAF, Tampa, FL; 20 March 1996; review aircraft; Research Aviation Facility

James Belville; NWS, Operational Support Office, Norman, OK; 4 - 5 March 1996; auto-nowcaster implementation; Remote Sensing Facility

Reinhold Bergen; DLR, Oberpfaffenhofen, Germany; 6 June 1996; scientific visitor; Research Aviation Facility

Dan Berkowitz; NWS, Operational Support Office, Norman, OK; 22 April 1996; precipitation estimation discussion; Remote Sensing Facility

Pierre Bessemoulin; Meteo-France, Issy-les-Moulineaux, France; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Christopher Bishop; Penn State U., University Park, PA; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Don Blake; Georgia Tech, Atlanta, GA; 3 October 1995; atmospheric chemistry; Research Aviation Facility

John Bradshaw; Georgia Tech, Atlanta, GA; 1 - 31 October 1995; ACE1; Research Aviation Facility

Heinz Brockstieger; DLR, Oberpaffenhofen, Germany; 11 November 1995; scientific visitor; Research Aviation Facility

Heinz Brockstieger; DLR, Oberpfaffenhofen, Germany; 16 - 23 November 1995; GPS dropsondes; Surface and Soundings System Facility

Keith Browning; U. Reading, UK; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Don Burgess; NWS, Operational Support Office, Norman, OK; 4 - 5 March 1996; auto-nowcaster implementation; Remote Sensing Facility

Daniel Cadet; INSU/CNRS, Paris, France; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Jean-Pierre Cammas; Lab d'Aerologie/CNRS, Paris, France; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Jean-Pierre Chalon; Meteo-France, Issy-les-Moulineaux, France; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Sid Clough; U. Reading, UK; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

James Coakley; Oregon State U., Corvallis, OR; 18 October 1995; OFAP; Research Aviation Facility

Vickie Connors; NASA, Washington, DC; 6 March 1996; MADS; Research Aviation Facility

Barry Damiano; NOAA, MacDill AFB, FL; 26 - 29 March 1996; MADS; Research Aviation Facility

John Daugherty; NOAA/NSSL, Boulder, CO; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Roy Dixon; New Mexico Tech, Albuquerque, NM; 9 October 1995; scientific visitor; Research Aviation Facility

Bruce Doddridge; U. Maryland, Baltimore, MD; 6 March 1996; MADS; Research Aviation Facility

Paul Dubreuil; Department of the Environment, Ontario, Canada; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Kerry Emanuel; MIT, Cambridge, MA; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Chris Fairall; NOAA/ETL, Boulder, CO; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Rick Flagan; California Institute of Technology, Irvine, CA; 17 - 31 October 1995; ACE1; Research Aviation Facility

Daniel Flanagan; NOAA, Silver Springs, MD; 6 March 1996; MADS; Research Aviation Facility

Richard Fulton; NWS, Office of Hydrology, Washington, DC; 26 March 1996; precipitation estimation discussion; Remote Sensing Facility

R. Gelaro; NRL, Monterey, CA; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Herman Gerber; Gerber Scientific, Reston, VA; 27 June 1996; SUCCESS; Research Aviation Facility

Anver Ghazi; European Commission, Antwerp, Belgium; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Alan Goldstein; NOAA, Silver Springs, MD; 9 November 1995; scientific visitor; Research Aviation Facility

Warren Gore; NASA Ames, Moffett Field, CA; 7 October 1995; ACE1; Research Aviation Facility

Tom Graziano; NWS, Office of Meteorology, Washington, DC; 4 - 5 March 1996; auto-nowcaster implementation; Remote Sensing Facility

Volkert Harbers; DLR, Oberpfaffenhofen, Germany; 9 November 1995; scientific visitor; Research Aviation Facility

Tim Hewson; U. Reading, UK; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Robert Hill; Lockheed-Martin, Marietta, GA; 21 - 26 May 1996; Airman Certification; Research Aviation Facility

Alan Hills; NCAR/ACD, Denver, CO; 1 October - 28 February 1996; scientific visitor; Research Aviation Facility

Christian Hinz; DLR, Oberpfaffenhofen, Germany; 18 - 23 November, 1995; GPS dropsondes; Surface and Soundings System Facility

Barry Huebert; U. Hawaii, Honolulu, HI; 9 - 31 October 1995; ACE1; Research Aviation Facility

Genevieve Jaubert; Meteo-France, Issy-les-Moulineaux, France; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Randy Johnson; NOAA, Silver Springs, MD; 10 -31 October 1995; ACE1; Research Aviation Facility

Alain Joly; Meteo-France, Issy-les-Moulineaux, France; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Mark Kritz; U. New York, Albany, NY; 27 August - 2 September 1996; aircraft measurements; Research Aviation Facility

Rolf Langland; NRL, Monterey, CA; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Michael Lehning; ETH, Zurich, Switzerland; 12 - 15 June 1996; atmospheric chemistry; Research Aviation Facility

Yvon Lemaitre; Meteo-France, Issy-les-Moulineaux, France; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

James Lesko; NASA Ames, Moffett Field, CA; 28 August - 2 September 1996; aircraft measurements; Research Aviation Facility

Edward Lewis; NASA Ames, Moffett Field, CA; 28 August - 2 September 1996; aircraft measurements; Research Aviation Facility

Pay-liam Lin; National Central U., Taiwan; 4 - 19 September, 1996; data analysis and instrumentation, ISS and PAM-III; Surface and Soundings System Facility

Dan Lino; NOAA, MacDill AFB, FL; 25 - 29 March 1996; MADS; Research Aviation Facility

Robert Lockwood; USDA Forest Service, Riverside, CA; 19 October 1995; project planning; Research Aviation Facility

Norman Loeb; Oregon State U., Corvallis, OR; 13 September 1996; STERAO; Research Aviation Facility

Frederic Marin; Meteo-France, Issy-les-Moulineaux, France; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Lehmann Martin; U. Bern, Bern, Switzerland; 5 October 1995; scientific visitor; Research Aviation Facility

Brooks Martner; NOAA/ETL, Boulder, CO; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Randy May; NASA/JPL, Pasadena, CA; 8 July - 31 August 1996; atmospheric chemistry; Research Aviation Facility

Dieter Mayr; DLR, Oberpfaffenhofen, Germany; 16-23 November, 1995; GPS dropsondes; Surface and Soundings System Facility

James McFadden; NOAA/AOC, Silver Springs, MD; 15 November 1995; ACE1; Research Aviation Facility

James McFadden; NOAA/AOC, Tampa, FL; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Michael Morgan; U. Wisconsin, Madison, WI; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Frank Murray; U. Denver, Denver, CO; 20 March 1996; conference; Research Aviation Facility

Steve Nelson; NSF, Washington, DC; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Philip Newton; Nature Magazine; NY, NY; 17 January 1996; radar studies using insects as tracers; Remote Sensing Facility

Hung Nguyen; U. California at San Diego, LaJolla, CA; 12 - 31 October 1995; INDOEX Workshop; Research Aviation Facility

M. Osuka; DAS, Japan; 5 February 1996; scientific visitor; Research Aviation Facility

Ola Persson; CIRES/NOAA/ETL, Boulder, CO; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

John Porter; NOAA, Silver Springs, MD; 10 - 31 October 1995; ACE1; Research Aviation Facility

Guy Potvin; McGill U., Montreal; 22 - 28 August, 1996; radio acoustic sounding systems; Surface and Soundings System Facility

Juan Pradis; NOAA, Silver Springs, MD; 20 February 1996; MADS; Research Aviation Facility

Andres Prevot; Paul Scherrer Institute, Villigen, Switzerland; 1 October 1995 - 1 March 1996; scientific visitor; Research Aviation Facility

Jim Purdom; NOAA/NESDIS/CIRA, Boulder, CO; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Daniel Rendon; NASA Ames, Moffett Field, CA; 28 August - 2 September 1996; aircraft measurements; Research Aviation Facility

Frank Roesler; DLR, Oberpfaffenhofen, Germany; 18 -23 November, 1995; GPS dropsondes; Surface and Soundings System Facility

Lynn Russell; California Institute of Technology, Irvine, CA; 16 October 1995; ACE1; Research Aviation Facility

Scott Sandholm; Georgia Tech, Atlanta, GA; 1 - 30 October 1995; ACE1; Research Aviation Facility

Otmar Schmid; U. Missouri, Rolla, MO; 3 June - 3 August 1996; MMM; Research Aviation Facility

Ulli Schoenbach; DLR, Oberpfaffenhofen, Germany; 18 - 23 November 1995; GPS dropsondes; Surface and Soundings System Facility

Russ Seebaugh; Denver U., Denver, CO; 22 January 1996; scientific visitor; Research Aviation Facility

Steve Shafer; U. North Dakota, Fargo, ND; 24 June 1996; STERAO; Research Aviation Facility

Mel Shapiro; NOAA/ETL, Boulder, CO; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

David Sharp; NWS, Melbourne, FL; 4 - 5 March 1996; auto-nowcaster implementation; Remote Sensing Facility

Barkley Sive; U. California at Irvine, Irvine, CA; 26 - 30 October 1995; ACE1; Research Aviation Facility

Rainer Staeger; DLR, Oberpfaffenhofen, Germany; 16 - 23 November, 1995; GPS dropsondes; Surface and Soundings System Facility

Rainer Staeger; DLR, Oberpfaffenhofen, Germany; 10 November 1995; scientific visitor; Research Aviation Facility

Robert Stickel; Georgia Tech, Atlanta, GA; 1 - 30 October 1995; ACE1; Research Aviation Facility

Roger Stith; U. North Dakota, Fargo, ND; 24 June 1996; STERAO; Research Aviation Facility

Michael Storti; NASA Ames, Moffett Field, CA; 28 August - 31 August 1996; atmospheric measurements; Research Aviation Facility

Rikie Suzuki; U. Tsukuba, Japan; 21 - 23 March, 1996; PAM III software; Surface and Soundings System Facility

James Telford; Desert Research Institute, Reno, NV; 13 March 1996; scientific meeting; Research Aviation Facility

Jacques Testud; Meteo-France, Issy-les-Moulineaux, France; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Don Thornton; Drexel U., Philadelphia, PA; 9 September 1996; atmospheric chemistry; Research Aviation Facility

Alan Thorpe; U. Reading, UK; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Zolton Toth; EMC/NCEP/NOAA, Boulder, CO; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Roger Tubury; U. North Dakota, Fargo, ND; 24 June 1996; STERAO; Research Aviation Facility

Andrew Turnipseed; U. Colorado, Boulder, CO; 1 September, 1996 - 1 September 1997 (occasional visits); surface flux instrumentation; Surface and Soundings System Facility

Warren Ulmer; U. Hawaii, Honolulu, HI; 9 - 31 October 1995; ACE1; Research Aviation Facility

Chris Velden; U. Wisconsin, Madison, WI; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

D. Mays-Vesserling; DLR, Oberpfaffenhofen, Germany; 12 November 1995; scientific visitor; Research Aviation Facility

Peter Vogel; DLR, Oberpfaffenhofen, Germany; 18 - 23 November, 1995; GPS dropsondes; Surface and Soundings System Facility

Roger Wakimoto; U. California, Los Angeles, CA; 22 - 24 May 1996; 3rd FASTEX Meeting; Remote Sensing Facility

Dave Walgren; LSI, Moffet Field, CA; 8 January 1996; scientific visitor; Research Aviation Facility

Rodney Weber; U. Minnesota, Minneapolis, MN; 16 - 20 October 1995; ACE1; Research Aviation Facility

John William; U. Denver, Denver, CO; 20 March 1996; conference; Research Aviation Facility

Eric Woodbridge; CSD, LaJolla, CA; 12 - 31 October 1995; OFAP; Research Aviation Facility

David Wylie; U. Hawaii, Honolulu, HI; 12 - 31 October 1995; ACE1; Research Aviation Facility

Kunio Yoneyama; JAMSTEC, Yokohama, Japan; 7 March 1995 - 7 March 1996; ISS TOGA COARE and ARM Tropical Western Pacific research; Surface and Soundings System Facility

Yonghong Xil; Desert Research Institute, Reno, NV; 25 - 30 October 1995; ACE1; Research Aviation Facility

Liangzhong Zhuang; U. Hawaii, Reno, NV; 25 - 30 October 1995; ACE1; Research Aviation Facility

ATD Collaborations

RAF scientists are involved in a growing number of scientific interactions with researchers from universities, government agencies, and other institutions. These collaborations arise through such diverse activities as participation in field programs, development of instrumentation, transfer of technology, and interpretation of aircraft data. The primary interactions in FY 96 are listed in Table ATD-8.

RAF Collaborations

Investigators (Institution)

Use of aerosol data from MASP probe
D. Baumgardner, B. Gandrud (NCAR)
M. Kuhn (U. Munich)
T. Onasch (U. Colorado)

Airborne ozone measurements
G. Kok (NCAR)
M. Kritz (SUNY/Albany)

Particle measurements in contrails
D. Baumgardner, K. Barr (NCAR)

U. Schumann (DLR)
(Others from U. Missouri-Rolla,
U. Heidelberg, U. Stockholm, U. Mainz)

Flow modeling of CVI inlet
C. Twohy (NCAR)
M. Laucks (U. Washington)

Contrail and cirrus cloud studies
L. Radke, C. Twohy, B. Gandrud,
D. Baumgardner, K. Barr (NCAR),
(others from U.S. universities and government labs)

Fast-response ozone measurements for eddy correlation studies
G. Kok (NCAR)
R. Banta, C. Senft (NOAA/ETL)

Measurements of upper tropospheric aerosols in tropical and polar regions
D. Baumgardner, K. Barr (NCAR)
(others from U.S. universities and government labs)

Analysis of Hong Kong air-pollution budgets
G. Kok (NCAR)
M. Lehning, H. Richner (ETH,
Zurich, Switzerland)

Liquid water comparisons
D. Baumgardner (NCAR)
M. Wendisch (Institute for
Tropospheric Research, Germany)

Aerosol inlet development
C. Twohy (NCAR)
B. Huebert (U. Hawaii)
R. Seebaugh (U. Denver)

Contrail studies (comparison of model and measurements)
D. Baumgardner (NCAR)
R. Miake-Lye (Aerodyne Research)

Adsorbent trapping system for ion-trap mass-spectrometer
G. Kok (NCAR)
P. Hemberger (Los Alamos National
Laboratory)

Small cumulus studies
D. Baumgardner (NCAR)
S. Kreidenweis (Colorado State U.)

Measurements of liquid water content and condensation nuclei
C. Twohy, B. Gandrud (NCAR)
H. Gerber (Gerber Instruments)
D. Rogers, Paul DeMott (Colorado State U.)

Mexico City air pollution

D. Baumgardner (NCAR)
G. Raga (U. Mexico)

Attitude corrections to hemispheric radiometer data
K. Laursen (NCAR)
M. Tschudi, J. Curry (U. Colorado)

Aerosols and tropospheric ozone
D. Baumgardner (NCAR)
S. Borrmann (U. Mainz)

SSSF Collaborations

In FY 96 SSSF continued assisting universities in support of education. During the year, several students from local colleges and universities were employed at SSSF as student assistants. These students work on projects closely related to their fields of study under guidance of SSSF engineers and scientists.

Russ Monson, Dave Bowling, and Andrew Turnipseed from U. Colorado have collaborated with Tony Delany and other SSSF personnel to develop the CUFF/REA system. This program will provide Ph.D. thesis material for Bowling.

Development of a truly compact, inexpensive ozone-flux instrument suitable for use in boundary-layer research is being pursued by Tony Delany in cooperation with John Birks and John Bognar (U. Colorado).

Delany and Gordon Maclean also collaborated with faculty and students at Oregon State U. in CACHE-94 research.

David Parsons is collaborating with N.T. Giang and his graduate advisor George Young of Penn State U. in determining the vertical structure of convective wakes over the western Pacific warm pool. In addition, Parsons works closely with Brian Mapes (U. Colorado/CIRES) on the analysis of TOGA COARE data.

Parsons is also serving as an affiliate faculty member at Colorado State U. (CSU), and on Stanley Trier's dissertation committee at CSU.

Tom Horst is collaborating with Dennis Finn, doctoral candidate at Washington State U., and Brian Lamb, his advisor, on analysis of ASTER data from the Footprint-92 field program.

Steve Cohn is working with Richard Doviak (U. Oklahoma and NOAA/NSSL) on spaced-antenna wind-profiling techniques.

Cohn is also working with John Hallett (U. Nevada/Reno) on analysis of data from the Reno Basin Inversion field study, and on evaluation of the educational benefits of the program to the student participants.

RSF Collaborations

In FY 96, RSF continued assisting universities in support of education whenever possible. During the year, several students from local colleges and universities were employed at RSF as student assistants. The students worked with RSF engineers and scientists on projects closely related to their field of study.

Wen-Chau Lee is on the thesis committee of J. Li, a Ph.D. candidate at the U. of Hawaii using Doppler radar and mesonet data to study the low-level jet near the Taiwan area. In addition, Lee interacted with various university scientists including G. Barnes and D. Chen (U. of Hawaii), M. Biggerstaff (Texas A&M U.), H. Bluestein (U. of Oklahoma), B. Jou (National Taiwan U.), T. C. Wang (National Central U., Taiwan), D. Kingsmill (Desert Research Institute), Hans Verlinde (Pennsylvania State U.), Eric Rassmussen and Tom Shepherd (NOAA/NSSL), and R. Wakimoto (UCLA) on ground-based and airborne Doppler radar-analysis techniques.

Craig Walther and Jeff Keeler taught sessions of the NSF Research Experience for Undergraduate (REU) program held at Colorado State U. last summer. The topics of their sessions were design of airborne meteorological radars and remote-sensing signal-processing techniques.

Tammy Weckwerth is working with several ATD and non-ATD scientists in analyzing field data from the Small Cumulus Microphysics Study (SCMS). She is examining the evolution of boundary-layer convection. She is also examining various modes of boundary-layer convection observed with DOW and the 2-micron Doppler lidar during the LIFT project. In addition, Weckwerth has collaborated with Morris Weisman (NCAR/MMM) in a modeling study of waves on top of cold-air outflow boundaries.

Jim Wilson continues to be regularly involved with COMET education activities. He presented two days of lectures and laboratories for both the COMET Mesoscale Meteorology Course and the WMO/COMET International Workshop on Very-Short-Range Prediction. In addition, Wilson served as a mentor for COMET students Ken Falk and Dean Hazen.

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Climate and Global Dynamics Division

Staff

Division Director's Office

Maurice Blackmon (director)
David Eastman
Lydia Harper
Holly Howard
Michael Moran
Barbara Vlasity

Systems Programmers

Elizabeth Coolbaugh
Brent Halsey
Cammie Muller (to 24 October 1996)
Hester Neilan
Colleen O'Toole
Steven Sabean (joint with CCR)
Allan Walker

Global Dynamics Section

Barbara Ballard (joint with OS)
David Baumhefner
Grant Branstator
Ronald Errico (deputy head)
Sue Ellen Haupt (long-term visitor)
Akira Kasahara
Yen-Huei Lee
Andrew Mai
Thomas Mayer

Donna Moran (joint with OS)
Didier Paillard (long-term visitor)
Kevin Raeder
Ramalingam Saravanan
Lana Stillwell (joint with CCR to 30 June 1996)
Mark Taylor (long-term visitor)
Francois Thibaud (long-term visitor)
Joseph Tribbia (head)
Jun-ichi Tsutsui (long-term visitor to 29 March 1996)
Tomislava Vukicevic
Mitsuo Yamamoto (long-term visitor)

Oceanography Section

Barbara Ballard (joint with GDS)
Frank Bryan
Antonietta Capotondi (ASP long-term visitor)
Julianna Chow
Gokhan Danabasoglu (long-term visitor)
Scott Doney
Peter Gent (head and CSM co-chair)
William Holland
Brian Kauffman
William Large (deputy head)
James McWilliams
Ralph Milliff
Donna Moran (joint with GDS)
Jan Morzel
Nancy Norton
Sean Walsh
Dailin Wang
Christopher Wikle (joint with GSP)

Climate Change Research Section

James Adams
Julie Arblaster (long-term visitor)
Gary Bates
Jon Bergengren (long-term visitor)
Thomas Bettge
Penelope Boston (long-term visitor)
Esther Brady
Garrett Campbell (long-term visitor)
Robert Chervin
Anthony Craig
Charles D'Ambra (long-term visitor)
Robert DeConto (long-term visitor)
Carter Emmart (long-term visitor)
Benjamin Felzer (long-term visitor)
Filippo Giorgi
William Kellogg (Senior Research Associate)
Joan Kleypas (long-term visitor)
Elizabeth Law-Evans (long-term visitor)

Rosaria Marinucci (long-term visitor)
Renaud Mathieu (long-term visitor)
Larry McDaniel (to 20 May 1996)
Linda Mearns (to 20 May 1996)
Gerald Meehl (joint with CAS)
Keiichi Nishizawa (long-term visitor)
Dolores Olmeda (long-term visitor)
Bette Otto-Bliesner (long-term visitor)
David Pollard
Jianhua Qian (long-term visitor)
Steven Sabean (joint with System Programmers)
Anji Seth
Stephanie Shearer
Christine Shields
Gary Strand
Starley Thompson (deputy head)
Warren Washington (head)
John Weatherly (long-term visitor)
Steve Welch (long-term visitor)
Suzanne Whitman
Chris Wold (long-term visitor)
Yuxia Zhang (long-term visitor)

Climate Modeling Section

Thomas Acker (to 2 August 1996)
Gordon Bonan
Byron Boville (CSM co-chair)
Bruce Briegleb
Lawrence Buja
Steven Carson (to 30 June 1996)
William Collins (long-term visitor)
Jeremy Dunn
Brian Eaton
David Ence (to 20 July 1996)
Paula Fisher
James Hack
Jeffrey Kiehl (head)
Jerry Olson
John Pedretti
Jonathan Petch (long-term visitor)
Philip Rasch
James Rosinski
Pawel Smolarkiewicz
John Truesdale
Mariana Vertenstein
David Williamson (deputy head)
Charles Zender (to 30 June 1996)

Climate Analysis Section

David Blankinship
Lisa Butler

Christian Guillemot
James Hurrell
Douglas Lindholm
Roland Madden (deputy head)
Gerald Meehl (joint with CCR)
Chester Newton (Senior Research Associate)
Dennis Shea
Elizabeth Stephens (shared with GSP)
Christina Tidd
Kevin Trenberth (head)
Harry van Loon (Senior Research Associate)
Tom M.L. Wigley (shared with UCAR/ASP)
Robert Wilby (long-term visitor)

Geophysical Statistics Project

Mark Berliner (leader)
Barbara Bailey (long-term visitor)
Toshio Michael Chin (joint with ASP to 31 July 1996)
Timothy Hoar
Zhan-Qian Lu (long-term visitor)
Wendy Meiring (long-term visitor)
J. Andrew Royle (long-term visitor, joint with EDAS)
Elizabeth Stephens (shared with CAS)
Christopher Wikle (long-term visitor, joint with OCE)

Ecosystem Dynamics and the Atmosphere Section

Susan Chavez
Julie Cole (to 31 July 1996)
Henry Fisher
Timothy Kittel (long-term visitor)
Rebecca McKeown
Gaylynn Potemkin
Nan Rosenbloom
David Schimel (head)
Elizabeth Sulzman
Yiming Zhang (to 2 November 1995)

Affiliate Scientists

Leo J. Donner, Geophysical Fluid Dynamics Laboratory
Brian F. Farrell, Harvard University
Dale Haidvogel, Rutgers University
Steven Hostetler, U.S. Geological Survey
Karin Labitzke, Free University of Berlin
Albert J. Semtner, Jr., Naval Postgraduate School

CGD Visitors and Collaborators

(Dates refer to visitor's stay at NCAR during FY96. No dates are given for collaborators who did not visit NCAR.)

Ulrich Achatz; Institut fuer Atmosphaerenphysik; 1 September-26 October 1996; Global Dynamics Section

Richard Adams; Oregon State University; agricultural economics

John Allen; Oregon State University; Kelvin waves in balance models

Steve Archer; Texas A&M University; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Jose Ardao-Berdejo; Pennsylvania State University; 17 June-9 July 1996; Global Dynamics Section

Greg Asner; University of Colorado, Boulder; 11 October 1996 and 23 January 1996; Ecosystem Dynamics and the Atmosphere Section

Dominique Bachelet; U.S. Forest Service, Corvallis; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Ferdinand Baer; University of Maryland; 8-19 July 1996; Global Dynamics Section

Clive Baillie; University of Colorado; quasi-geostrophic multigrid code

Tim P. Barnett; Scripps Institution of Oceanography; IPCC report and climate change detection

Eric Barron; Pennsylvania State University; paleoclimatic modeling with GENESIS GCM

John Baumgardner; Los Alamos National Laboratory; numerical analysis

Martin Beniston; University of Fribourg; development of a high-resolution regional climate model for the western alpine region and coupling of model to the Hamburg GCM and atmospheric dynamics

James Berger; Purdue University; 8-9 July 1996; Geophysical Statistics Project

Roger Bilisoly; Ohio State University; 2 October 1995-10 September 1996; Geophysical Statistics Project

Robert Black; Georgia Institute of Technology; diagnosis of low-frequency flow in NCAR CCM's

Claus Boening; Institute fur Meereskunde an der Universitat Kiel; eddy-resolved ocean circulation

Bobby Braswell; University of New Hampshire; 10 September 1995-31 January 1996; Ecosystem Dynamics and the Atmosphere Section

Francis Bretherton; University of Wisconsin; global climate observation system

Keith Briffa; Climatic Research Unit, University of East Anglia; paleoclimate

John Bullister; NOAA/Pacific Marine Environmental Laboratory; freon tracer studies in the global ocean and ocean tracer observations

Steve Businger; University of Hawaii; global positioning system

Garrett Campbell; Colorado State University; 1 January-31 December 1996; Climate Change Research Section

Gregory Carbone; University of South Carolina; crop modeling and climate change

Xavier J. Carton; EPSHOM/CMO, France; baroclinic vortices

Robert Cess; State University of New York, Stony Brook; clouds and radiation

William Chameides; Georgia Institute of Technology; coupling regional climate-chemistry models

Stanley A. Changnon; University of Illinois; water resources and climate change

Yi Chao; NASA's Jet Propulsion Laboratory (JPL); ocean modeling and analysis of a high-resolution simulation of the North Atlantic carried out at JPL with emphasis on the dynamics and variability of the Gulf Stream system

F. Stuart Chapin III; University of California, Berkeley; arctic terrestrial surface fluxes

Eric Chassignet; University of Miami; intercomparison of z-coordinate and isopycnal-coordinate primitive equation model simulations of the North Atlantic in the non-eddy resolving regime

Dudley Chelton; Oregon State University; observations and modeling of the transient general circulation in the North Pacific Basin

Jau-Ming Chen; Iowa State University; tropical meteorology and climate dynamics

Tsing-Chang (Mike) Chen; Iowa State University; 8-12 July 1996; Global Dynamics Section

Steve Cherry; Montana State University; multivariate statistics in climatology

P. Chylek; Dalhousie University; atmospheric radiation and aerosols

Phillipe Ciais; Direction des Sciences de la Matiere, Paris, France; 18 October 1995; Ecosystem Dynamics and the Atmosphere Section

Emil Cienciala; Swedish University of Agricultural Sciences, Uppsala, Sweden; 15 March 1995-15 March 1996; Ecosystem Dynamics and the Atmosphere Section

Allyn Clarke; Bedford Institute of Oceanography; CLIVAR

Julie Cole; University of Colorado; GENESIS global climate model

Dean Collins; Monash University; climate change

William Collins; Center for Clouds, Chemistry and Climate; 1 August 1996-31 July 1997; Climate Modeling Section

Stephen Colucci; Cornell University; analysis and prediction of blocking events

Gilbert Compo; University of Colorado; intraseasonal climate variability

Philippe Courtier; European Centre for Medium-Range Weather Forecasts; 24-26 January 1996; Global Dynamics Section

Wolfgang Cramer; Potsdam Institute for Climate Impact Research, Potsdam, Germany; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Noel Cressie; Iowa State University; 26-27 October 1995 and 8-21 June 1996; Geophysical Statistics Project

Thomas Crowley; Texas A&M University; paleoclimatic modeling

Paul Crutzen; Max-Planck-Institute; atmospheric chemistry

Chris Daly; Oregon State University; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Arthur Dempster; Harvard University; continuing visits; Geophysical Statistics Project

Robert E. Dickinson; University of Arizona; Biosphere-Atmosphere Transfer Scheme (BATS) and EOS

Peter Ditlevsen; University of Copenhagen; 30 October 1995-1 May 1996; Global Dynamics Section

Leo Donner; Geophysical Fluid Dynamics Laboratory; development of an initialization method for numerical weather prediction incorporating cumulus convection schemes

John Drake; Oak Ridge National Laboratory; computer science

Ray Drapek; U.S. Forest Service, Corvallis; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

John Dukowicz; Los Alamos National Laboratories; DOE/CHAMMP Modeling

William Easterling; University of Nebraska; global climate observation system, crop climate modeling, and climate change

Martin Ehrendorfer; University of Vienna; 19 January-18 February 1996; Global Dynamics Section

Steve Ellner; North Carolina State University; nonlinear time series, chaos, and dynamical systems

Bill Emanuel; University of Virginia; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Kerry Emanuel; Massachusetts Institute of Technology; cumulus parameterizations

Ian G. Enting; CSIRO, Division of Atmospheric Research; IPCC report and the carbon cycle

Paul Epstein; Harvard University; climate change

Jay Famiglietti; University of Texas-Austin; 7-28 July 1996; Ecosystem Dynamics and the Atmosphere Section

Johann Feichter; Max-Planck-Institute for Meteorology; 15 April 1996-28 June 1996; Climate Modeling Section

D. Feng; University of Arizona; global positioning system

Susan Ferguson; USDA Forestry; effects of climate on U.S. forestry and climate change scenario development

Chris Field; Stanford University; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Luc Fillion; Division de Recherche en Prevision Numerique; 16-23 December 1995; Global Dynamics Section

Alberte Fischer; CESBIO, Toulouse, France; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Jonathan Foley; University of Wisconsin at Madison; GENESIS climate model and paleoclimate modeling

Michael Fosberg; USDA Forest Service; forest fire frequency and climate change

Susan Fox; U.S. Forest Service, Raleigh; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

William Frank; Pennsylvania State University; cumulus convection

Jorgen Frederiksen; CSIRO, Australia; 8 April-12 July 1996; Global Dynamics Section

Congbin Fu; Chinese Academy of Sciences; 19 August-13 October 1996; Climate Change Research Section

Lee Fu; Jet Propulsion Laboratory; ocean modeling

Boris Galperin; University of South Florida; parallel ocean climate model and eddy viscosity parameterization

A. Gangopadhyay; Jet Propulsion Laboratory; high-resolution in North Atlantic circulation

Sarah Gille; Scripps Institution of Oceanography; 13-14 May 1996; Climate Change Research Section

David Glover; Woods Hole Oceanographic Institution; 1-3 July 1996; Oceanography Section

M. Gorbunov; Russian Institute of Atmospheric Physics; global positioning system

Hans Graber; University of Miami; underwater acoustic noise measurements of wind

George Grabheer; Vienna University; climate change

Hartmut Grassl; World Meteorological Organization; IPCC and climate change

Paul Graves; University of California, Los Angeles; 22 July-2 August 1996; Oceanography Section

Gary Grunwald; previously with the Melbourne University Department of Statistics; 3 September-31 December 1996; Geophysical Statistics Project

Peter Guttorp; University of Washington; heterogeneous space-time correlation modeling

David Gutzler; University of New Mexico; intraseasonal climate variability

Danielle Haas; Georgia Tech; 11-13 December 1995; Climate Modeling Section

Dale Haidvogel; Rutgers University; 3 July-23 August 1996; Oceanography Section

Kenneth Hardy; Lockheed Martin Missiles and Space; global positioning system

Edward Harrison; NOAA/Pacific Marine Environmental Laboratory; freon tracer studies in the global ocean; Climate Change Research Section; and 12-14 August 1996; Oceanography Section

Melanie Hartman; Colorado State University; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Dennis Hartmann; University of Washington; clouds and climate

Sue Ellen Haupt; University of Colorado; empirical-dynamical models of the atmosphere

William Hay; University of Colorado; paleoclimatic modeling with GENESIS global climate model

Matthew Hecht; Los Alamos National Laboratory; 12-16 August 1996; Oceanography Section

Martin Heimann; Max-Planck Institut fur Meteorologie; IPCC report and the carbon cycle

Benjamin Herman; University of Arizona; global positioning system

Kathy Hibbard; University of Montana; 12-19 January 1996; Ecosystem Dynamics and the Atmosphere Section

Hiromaru Hirakuchi; Central Research Institute Electric Power Industry (CRIEPI); 13-21 May 1996; Global Dynamics Section

Darryl D. Holm; Los Alamos National Laboratory; Kelvin waves in balance models

Kim Holmen; Stockholm University; atmospheric chemistry

Rollin Hotchkiss; University of Nebraska; watershed hydrology and climate change

Peter Houtekamer; Division de Recherche en Prevision Numerique; 22-27 October 1995; Global Dynamics Section

Phil Hsueh; Florida State University; 1 October-30 November 1995 and 1 May-31 July 1996; Oceanography Section

Bach Lien Hua; IFREMER, France; 3-31 August 1996; Oceanography Section

Mohamed Iskandarani; Rutgers University; integration and analysis of a spectral-element shallow water model in reduced-gravity and barotropic modes focusing on the general circulation effects of high-wavenumber and high-frequency wind forcing

Anthony Janetos; NASA; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Peter Jaumann; NCAR ASP postdoc; climate change detection

Bill Jenkins; Woods Hole Oceanographic Institution; ocean tracer observations

Greg Jenkins; Pennsylvania State University; GENESIS global climate and regional climate modeling

Bhaskar Jha; Florida State University; 26 February-1 March 1996; Climate Modeling Section

Phil Jones; Los Alamos National Laboratories; DOE/CHAMMP Modeling

Phil D. Jones; Climatic Research Unit, University of East Anglia; climate change detection

Richard Jones; University of Colorado, Denver; continuing visits; Geophysical Statistics Project

Fortunat Joos; Climate and Environmental Physics, KUP; IPCC report and the carbon cycle

Jed Kaplan; U.S. Forest Service, Corvallis; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Thomas Karl; National Climatic Data Center; climate change

David Karoly; CRC for Southern Hemisphere Meteorology, Monash University; climate change detection

Arie Kattenberg; KNMI, The Netherlands; IPCC report and climate modeling

Jack Katzfey; CSIRO, Australia; regional climate modeling nested in Australian CSIRO GCM

Ralph Keeling, Jr.; Scripps Institution of Oceanography; 8-12 July 1996; Ecosystem Dynamics and the Atmosphere Section

Robin Kelly; Colorado State University; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

David Kicklighter; Marine Biological Laboratory, Woods Hole; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

John Kidson; National Institute of Water and Atmospheric Research Ltd.; long-range predictability

George Kiladis; NOAA; intraseasonal climate variability

Tony King; Oak Ridge National Laboratory; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Rodney Kinney; University of California, Los Angeles; stability of magnetic vortices with flow in anisotropic magnetohydrodynamics

Gary Klaassen; York University; gravity waves

Rob Kramer; Colorado State University; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Jon Egill Kristjansson; University of Oslo; modeling of cloud processes

Atsushi Kubokawa; Hokkaido University; topographic ocean gyres

Arun Kumar; National Centers for Environmental Prediction; TOGA

Yoshi Kurihara; Geophysical Fluid Dynamics Laboratory; 8-10 April 1996; Global Dynamics Section

John Kutzbach; University of Wisconsin; 28 July-10 August 1996; Climate Change Research Section

Upmanu Lall; Utah State University; 9-13 September 1996; Geophysical Statistics Project

Rolf Langland; Naval Research Laboratory; targeting of observations for FASTEX using adjoint models

Ray Lassiter; U.S. Environmental Protection Agency; GENESIS global climate model

Gabriel Lau; Princeton University; TOGA

Mark Lawrence; Max-Planck-Institute fur Chemie; 6-8 November 1995; Climate Modeling Section

Sonya Legg; University of California, Los Angeles; localization of deep ocean convection

Harald Lejenas; University of Stockholm; 15-26 April 1996; Climate Analysis Section

Manual Lerdau; State University of New York at Stony Brook; 2 October 1996; Ecosystem Dynamics and the Atmosphere Section

Roger Lukas; University of Hawaii; intraseasonal climate variability

Steven MacEachern; Ohio State University; Bayesian statistical inference

Jean-Francois Mahfouf; European Centre for Medium-Range Weather Forecasts; development of adjoints for convection schemes

Natalie Mahowald; Massachusetts Institute of Technology; 2-19 January and 24-28 June 1996; Climate Modeling Section

Merry Maisel; University of California, San Diego; 4-28 September 1996; Climate Change Research Section

Robert Malone; Los Alamos National Laboratories; DOE/CHAMMP modeling

Mathew Maltrud; Los Alamos National Laboratory; design, implementation, and preliminary analysis of a very high-resolution simulation of the North Atlantic being carried out at LANL and porting of CSM ocean model physics packages to the POP code

Nigel Marsh; University of Copenhagen; 3 December 1995-3 June 1996; Global Dynamics Section

Susan Marshall; University of North Carolina; modeling of snow albedo

James Maslanik; University of Colorado; climate modeling

Wieslaw Maslowski; Naval Postgraduate School; sea ice and polar ocean modeling

Wilhelm May; Danish Meteorological Institute; 10 July 1996; Climate Analysis Section

Bruce McCarl; Texas A&M University; agricultural economics

Trevor McDougall; CSIRO, Australia; 11-14 February 1996; Oceanography Section

Mack McFarland; United Nations Environment Programme; Intergovernmental Panel on Climate Change

David McGinnis; Pennsylvania State University; GENESIS global climate model

A. David McGuire; Marine Biological Laboratory, Woods Hole; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Steve McNaughty; U.S. Forest Service; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Carlos Mechoso; University of California, Los Angeles; 30-31 October 1995; Climate Modeling Section

Alex Medvedev; York University; gravity waves

T. Meehan; Jet Propulsion Laboratory; global positioning system

Mark Meier; Institute for Arctic and Alpine Research; IPCC report and sea-level change

G. Meira; Agencia Espacial Brasileira; Intergovernmental Panel on Climate Change

W. Melbourne; Jet Propulsion Laboratory; global positioning system

Jerry Melillo; Marine Biological Laboratory, Woods Hole; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Chris Miller; National Environmental Satellite, Data, and Information Service; global climate observation system

Norman Miller; Lawrence Livermore National Laboratories; 19 May-1 June 1996; Climate Change Research Section

John F.B. Mitchell; Hadley Centre for Climate Prediction and Research, Meteorological Office; IPCC report and climate modeling and detection

Mery Molenaar; University of Colorado; studies of the interaction of the oceans and the dynamics of the solid Earth (rotational dynamics and external gravity field) using output of global ocean models

Pascal Monestiez; Institut National de la Recherche Agronomique; heterogeneous space-time correlation modeling

Russ Monson; University of Colorado, Boulder; 29 January 1996 and 2 October 1996; Ecosystem Dynamics and the Atmosphere Section

Yves Morel; GEGI-IMG, France; 22 July-2 August 1996; Oceanography Section

Ellen Mosely-Thompson; Ohio State University; climate change

Steven Mullen; University of Arizona; simulation/prediction of blocking and regional modeling of Arizona monsoon

Chiashi Muroi; Japan Meteorological Agency; 10 June 1996; Climate Modeling Section

Lawrence Mysak; McGill University; 19-20 March 1996; Oceanography Section

Ray Najjar; Pennsylvania State University; 8-12 July 1996; Oceanography Section and Ecosystem Dynamics and the

Atmosphere Section

Tetsuo Nakazawa; Meteorological Research Institute, Japan; tropical cyclone genesis and the MJO using NSCAT winds

Ron Neilson; U.S. Forest Service, Corvallis; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section; and MAPPS ecosystem model and climate change; Climate Change Research Section

Peter Niiler; Scripps Institution of Oceanography; Labrador Sea convection and surface winds and the design and deployment of a moored array and drifter field program in support of the NSCAT calibration and validation effort

Keiichi Nishizawa; Central Research Institute Electric Power Industry; 1 June 1996-31 May 1997; Global Dynamics Section

Doug Nychka; North Carolina State University; 17 July-17 August 1996; Geophysical Statistics Project

James J. O'Brien; Florida State University; 1-2 August 1996; Oceanography Section

Wandera Ogana; University of Nairobi, Kenya, Africa; 9 July 1996; Ecosystem Dynamics and the Atmosphere Section

Dennis Ojima; Colorado State University; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Don Olson; University of Miami; hydrography and Indian Ocean

Breck Owens; Woods Hole Oceanographic Institution; sea-ice modeling for coupled climate studies

Jan Paegle; University of Utah; examination of the quality of moisture analysis for numerical weather prediction

Didier Paillard; Laboratoire de Modelisation du Climat et de l'Environment, France; 1 December 1995-30 November 1996; Global Dynamics Section

Theresa Paluszkiewicz; Pacific Northwest Laboratory; parallel ocean climate model and deep convection parameterization

Yude Pan; Marine Biological Laboratory, Woods Hole; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Lee Panetta; Texas A&M University; 1-31 July 1996; Global Dynamics Section

Marc Parlange; Johns Hopkins University; stochastic modeling

Bill Parton; Colorado State University; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Joyce E. Penner; University of Michigan; climate change detection

Philippe Peylin; Ecole Normale Superieure, Paris; land surface modeling

James Pfaendtner; National Meteorological Center and NASA/Goddard; data assimilation

Lars Pierce; Stanford University; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

R. Dale Pillsbury; Oregon State University; design and deployment of a moored array and drifter field program in support of the NSCAT calibration and validation effort

Lou Pitelka; Electric Power Research Institute (EPRI); 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Lorenzo Polvani; Columbia University; stratospheric vortex dynamics

Robert Portmann; NOAA/Aeronomy Laboratory; ozone chemistry

Mac Post; Oak Ridge National Laboratory; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Colin Prentice; University of Lund, Sweden; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

James Price; Woods Hole Oceanographic Institution; 12-18 September 1996; Oceanography Section

Ronald Prinn; Massachusetts Institute of Technology; atmospheric chemistry

Robert Quayle; Climatic Data Center; global climate observation system

V. Ramanathan; Scripps Institution of Oceanography; clouds and radiation

V. Ramaswamy; Geophysical Fluid Dynamics Laboratory; climate change detection

Brian Rizzo; University of Virginia; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Chester Ropelewski; NOAA/Climate Analysis Center; TOGA

Douglas Rotman; Lawrence Livermore National Laboratory; chemical transport modeling

Donald Rundquist; University of Nebraska; remote sensing and agriculture

Steve Running; University of Montana; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Paul D. Sampson; University of Washington; heterogeneous space-time correlation modeling

Benjamin D. Santer; Program for Climate Model Diagnosis and Intercomparison, Lawrence Livermore National Laboratory; IPCC report and climate change detection

Robert Sausen; Institut fur Physik der Atmosphare; 22-24 July 1996; Climate Modeling Section

Joe Schelling; Sandia National Laboratories; regional climate modeling

Catherine Scipione Forbes; Monash University; Bayesian statistical inference

Satoshi Sekiguchi; Electro Technical Laboratory; 11 December 1995; Climate Modeling Section

Joseph Sela; National Meteorology Center; numerical weather prediction

Alexander Shchepetkin; University of California, Los Angeles; multigrid solutions of stably stratified flows: the balance equations

Peter J. Sherman; Iowa State University; periodic spectral analysis, periodicity detection, and control theory

Stephen Sitch; University of Lund, Sweden; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Lisa Sloan; University of California at Santa Cruz; 27 August-1 September 1996; Climate Change Research Section

Eric Small; University of California at Santa Cruz; 20 February-22 March and 1 July-20 September 1996; Climate Change Research Section

Richard Smith; Los Alamos National Laboratory; design, implementation, and preliminary analysis of a very high-resolution simulation of the North Atlantic being carried out at LANL and porting of CSM ocean model physics

packages to the POP code

Richard Smith; University of North Carolina; 8-18 August 1996; Geophysical Statistics Project

Tom Smith; University of Virginia; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

S. Sokolovskiy; Russian Institute of Atmospheric Physics; global positioning system

Amy Solomon; Massachusetts Institute of Technology; 26-30 August 1996; Climate Analysis Section

Mike Spall; Woods Hole Oceanographic Institution; modeling variability in the North Atlantic Ocean

Peter Speth; University of Cologne; atmospheric angular momentum

Ronald J. Stouffer; Geophysical Fluid Dynamics Laboratory; IPCC report, climate modeling, and climate change detection

Max Suarez; NASA; 2-6 October 1995; Global Dynamics Section

Georgi Sutyrin; Russian Academy of Sciences; co-rotating stationary states and vertical alignment of geostrophic vortices with thin cores

Gordon Swaters; University of Alberta; modeled and observed interannual variability in the north Pacific Ocean

Raja Tallamraju; Boulder; 1 October-31 December 1995; Global Dynamics Section

Pieter Tans; NOAA; 20 October 1995 and 5 February 1996; Ecosystem Dynamics and the Atmosphere Section

John Taylor; Australian National University; climate modeling chemistry of the urban environment

Karl E. Taylor; Program for Climate Model Diagnosis and Intercomparison, Lawrence Livermore National Laboratory; IPCC report and climate change detection

David Thompson; Texas Tech University; hydrologic modeling and climate

Hanqin Tian; Marine Biological Laboratory, Woods Hole; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

Tatsushi Tokioka; Japan Meteorological Agency, Japan; IPCC and climate change

Ed Tollerud; NOAA; precipitation processes and precipitation data management

Steven Tracton; National Centers for Environmental Prediction; ensemble forecasting

Jun-ichi Tsutsui; Central Research Institute of Electric Power Industry; examination of the impact of global climate changes on the behavior of tropical cyclones

Elena Tsvetsinskaya; University of Nebraska; 15 July-15 December 1996; Climate Change Research Section

Gary Upchurch; Southwest Texas State University; 3-8 January and 19-30 August 1996; Climate Change Research Section

Francisco Valero; Scripps Institution of Oceanography; clouds and climate

Michel Verstraete; Joint Research Center, ISPRA; development of a coupled surface physics/biosphere/hydrology model

John Wahr; University of Colorado; studies of the interaction of the oceans and the dynamics of the solid Earth (rotational dynamics and external gravity field) using output of global ocean models

Roxana Wajsowicz; NASA/Goddard Space Flight Center; parallel ocean climate model and Indonesian throughflow

Kevin Walsh; CSIRO, Mordialloc, Australia; regional climate modeling

Elizabeth Walter-Shea; University of Nebraska; remote sensing and agriculture

Qiang Wang; University of Alberta; 17-19 April 1996; Geophysical Statistics Project

Rik Wanninkhof; NOAA/AOML; ocean CO2 observations

Richard A. Warrick; University of Waikato; IPCC report and sea-level change

Darryn Waugh; Monash University; 13-14 June 1996; Climate Modeling Section

Andrew Weaver; University of Victoria; IPCC and climate change

Robin Webb; University of Colorado; GENESIS global climate model

Klaus Weickmann; NOAA; intraseasonal climate variability

Albert Weiss; University of Nebraska; crop climate modeling and climate change

Jeffrey Weiss; University of Colorado; quasi-geostrophic multigrid code

Jeff Welker; Colorado State University; 8 February 1996; Ecosystem Dynamics and the Atmosphere Section

Mike West; Duke University; 12-22 August 1996; Geophysical Statistics Project

Melanie Wetzel; Desert Research Institute; use of satellite data for validation of model cloudiness

Matthew Wheeler; University of Colorado; intraseasonal climate variability

Peter Whetton; CSIRO, Australia; assessment of climate change in the Australian region

Aksel Wiin-Nielsen; Institute of Copenhagen; 29 September-6 October 1995; Global Dynamics Section

Rob Wilby; University of Derby, U.K.; 28 June 1996; Ecosystem Dynamics and the Atmosphere Section

Martin Wild; Polytechnic Institute of Zurich; development of a high-resolution regional climate model for the western alpine region and coupling of model to the Hamburg GCM

Sam Williamson; U.S. Forest Service-Pacific Northwest; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

G. Wolansky; Technion, Israel; stability of magnetic vortices with flow in anisotropic magnetohydrodynamics

Lara Wolfson; University of Waterloo; 8-10 November 1995; Geophysical Statistics Project

Jeff Wong; Dalhousie University; 5 January-3 May 1996; Climate Modeling Section

Ian Woodward; University of Sheffield, U.K.; 15-17 January 1996; Ecosystem Dynamics and the Atmosphere Section

George Woodwell; Woods Hole Oceanographic Institution; climate change

Donald Wuebbles; University of Illinois; stratospheric ozone changes in a global coupled GCM

Mitsuo Yamamoto; Central Research Institute Electric Power Industry; 2 August 1996-31 January 1997; Global Dynamics Section

Irav Yavneh; Israel Institute of Technology; 15 July-31 August 1996; Oceanography Section

Don Yuan; Florida State University; 1-31 May 1996; Oceanography Section

Xubin Zeng; University of Arizona; 14-17 April 1996; Ecosystem Dynamics and the Atmosphere Section

Guang Zhang; Scripps Institution of Oceanography; 8-10 November 1996; Climate Modeling Section

Zhengxin Zhu; Center for Ocean, Land and Atmosphere; 17-18 October 1995; Climate Modeling Section

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Environmental and Societal Impacts Group

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Michael Glantz (head)
Richard Katz (deputy head)

Mary Downton (80%)
John Firor
Victoria Holzhauer
Larry McDaniel (from 20 May 1996)
Linda Mearns (from 20 May 1996)
Kathleen Miller
Roger Pielke, Jr.
Steven Rhodes (to 30 June 1996)
D. Jan Stewart

ASP postdoctoral fellows:

Tsegay Wolde-Georgis (to 30 June 1997)

Visitors and Collaborators:

Dates refer to the visitor's stay at NCAR during FY96. No dates are given for collaborators who did not visit NCAR.

Orazbai Abdirakhmanov, writer, Karakalpakstan region, Uzbekistan; chapter in *Caspian, Aral, and Dead Seas: Central Eurasian Water Crisis*

Chris Adams, National Weather Service, Washington, D.C.; U.S. Weather Research Program (USWRP) Prospectus Development Team #6

Beningo Aguirre, Texas A&M University, College Station, Texas; STORMS volume

Nikolai Aladin, Zoological Institute, St. Petersburg, Russia; chapter in *Creeping Environmental Problems and*

Sustainable Development in the Aral Sea Basin

John Albertson, University of Virginia, Charlottesville, Virginia; stochastic hydrology/ statistical downscaling

Mary Anderson, Collaborative for Development Action, Cambridge, Massachusetts; STORMS volume

Melaku Ayalew, Independent Consultant on Famine, Addis Ababa, Ethiopia; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

A. Babayev, Desert Research Institute, Ashgabat, Turkmenistan; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Amir Badakhshan, Department of Chemical and Petroleum Engineering, University of Calgary, Calgary, Alberta, Canada; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Jay Baker, Florida State University, Tallahassee, Florida; STORMS volume; USWRP Prospectus Development Team #6

John W. Barrett, Asian Disaster Preparedness Center, Asian Institute of Technology, Bangkok, Thailand; participant, *ENSO and Extreme Events in Southeast Asia*

Sylvain Bayalama, Denver University, Denver, Colorado and Brazzaville, The Congo; 13 November 1995; rates and processes of deforestation in The Congo

Fekadu Bekele, National Meteorological Services Agency, Addis Ababa, Ethiopia; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Lynne L. Bennett, School of Forestry and Environmental Studies, Yale University, New Haven, Connecticut; climate and water quality

Guillermo Berri, Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Michele Betsill, University of Colorado, Boulder, Colorado; 1 October 1995 to 30 September 1996; value of El Niño-Southern Oscillation (ENSO) information to the Southern Africa Development Community (SADC); ozone depletion and global change policy

Jean Paul Boch, Elf Aquitaine, Inc., Washington, D.C.; 12 July 1996; global carbon cycle

Jariya Boonjawat, Southeast Asia Regional Committee for START (SARCS) Secretariat, Institute of Environmental Research, Chulalongkorn University, Bangkok, Thailand; participant, *ENSO and Extreme Events in Southeast Asia*

Vitalyi N. Bortnik, State Oceanographic Institute, Moscow, Russia; chapter in *Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin*

Cecilia Box, Metropolitan State College, Denver, Colorado; 11 March 1996; environmental impacts

Thomas Brennan, Senior Regional Advisor, Office of Foreign Disaster Assistance, Agency for International Development, Bangkok, Thailand; participant, *ENSO and Extreme Events in Southeast Asia*

John Brown, NOAA/ERL/FSL, Boulder, Colorado; STORMS volume

Patrice Bruneau, Elf Aquitaine, Inc., Washington, D.C.; 12 July 1996; global carbon cycle

Margaret Buchanan-Smith, Institute for Development Studies, University of Sussex, Brighton, United Kingdom; chapter

in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Roger Buckland, Food Security Technical and Administration Unit, SADC (Southern African Development Community) Regional Early Warning System, Harare, Zimbabwe; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Radford Byerly, Jr., Staff Director, U.S. Congress House Science Committee (retired), Boulder, Colorado; U.S. science policy

Mark Cane, Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño; participant, ENSO and Extreme Events in Southeast Asia*

Pedro Cardenas-Perez, Centro Nacional del Clima, Instituto de Meteorologia, Havana, Cuba; 9-11 November 1995, *ENSO impacts in the Caribbean region; participant, ENSO and Extreme Events in the Greater Caribbean Region*

Abel Centella-Artola, Centro Nacional del Clima, Instituto de Meteorologia, Havana, Cuba; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Stanley Changnon, Illinois State Water Survey (retired), Mahomet, Illinois; STORMS volume; USWRP Prospectus Development Team #6

Lian-shou Chen, Chinese Academy of Meteorological Sciences, Beijing, China; STORMS volume

Leighton Cochran, CPP, Inc., Fort Collins, Colorado; STORMS volume

Jeremy Collymore, Caribbean Disaster Emergency Response Agency, St. Michael, Barbados, West Indies; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Ila Cote, Environmental Protection Agency, Washington, D.C.; 16 January 1996; environmental impacts

Kristine Crandall, University of Arizona, Tucson, Arizona; 1 November 1995 to 30 September 1996; value of ENSO information to the Southern Africa Development Community (SADC)

L. Veiga da Cunha, Priority Area on Environmental Security, North Atlantic Treaty Organization, Brussels, Belgium; NATO Advanced Research Workshop on *Scientific, Environmental, and Political Issues of the Circum-Caspian Region*

Margaret Davidson, NOAA Coastal Services Center, Charleston, South Carolina; participant, *ENSO and Extreme Events in Southeast Asia*

Maxx Dilley, Office of U.S. Foreign Disaster Assistance, Agency for International Development, Washington, D.C.; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño;* participant, *ENSO and Extreme Events in Southeast Asia*

Leonid I. Elpiner, Water Problems Institute, Russian Academy of Sciences, Moscow, Russia; chapter in *Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin*

Kerry Emanuel, Massachusetts Institute of Technology, Cambridge, Massachusetts; hurricanes and the insurance industry

David B. Enfield, Atlantic Oceanographic and Meteorological Laboratory, Physical Oceanography Division, Miami, Florida; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Fabio Fajardo-Moros, Director, Instituto de Meteorologia, Havana, Cuba; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Shon Shan Fan, Federal Energy Regulatory Commission (FERC), Washington, D.C.; hydrologic disasters

Tibor Farag, Global Environment Office, Ministry for Environment and Regional Policy, Budapest, Hungary; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Graham Farmer, SADC Regional Early Warning System, Harare, Zimbabwe; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño* Lisa Farrow, National Oceanic and Atmospheric Administration/Office of Global Programs, Washington, D.C.; 25 April 1996; review of OGP projects

Sue Ferguson, U.S. Forest Service/University of Washington, Seattle, Washington; integrated assessment of climate change

Rob Figueroa, Faculty of Geography, University of Colorado, Boulder, Colorado; co-author (with M.H. Glantz) on "Does the Aral Sea Merit Heritage Status?"

Manuel Flores, Instituto del Mar del Peru (IMARPE), Lima, Peru; ENSO impacts in Peru

Gary Foley, Bureau of Meteorology, West Perth, Australia; STORMS volume

Gregory Forbes, Pennsylvania State University, University Park, Pennsylvania; STORMS volume

David Foster, Harvard University, Cambridge, Massachusetts; STORMS volume

Eduardo Franco, Intermediate Technology Development Group/Programa de Desastres del Peru, Lima, Peru; ENSO impacts in Peru

Quindi Franco, Harvard University Kennedy School of Government, Cambridge, Massachusetts; 17 June to 30 August 1996; societal aspects of weather prototype web site

Daniel Gamachu, Addis Ababa University, Ethiopia (on leave in San Francisco, California); 1 August 1996 to 30 September 1996; rates and processes of environmental change in Ethiopia

Michael Garstang, Simpson Weather Associates, Charlottesville, Virginia; STORMS volume

Nguyen Ngoc Giao, University of Ho Chi Minh City, Ho Chi Minh City, Vietnam; participant, *ENSO and Extreme Events in Southeast Asia*

Joseph Golden, NOAA/OAR, Silver Spring, Maryland; STORMS volume

Genady Golitsyn, Faculty of Geography, Moscow State University, Moscow, Russia; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Genady Golubev, Faculty of Geography, Moscow State University, Moscow, Russia; chapter in *Caspian, Aral and Dead Seas;* participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Igor Granberg, Institute of Atmospheric Physics, Numerical Modeling Section, Moscow, Russia; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

William Gray, Colorado State University, Fort Collins, Colorado; STORMS volume

Eve Gruntfest, University of Colorado, Colorado Springs, Colorado; STORMS volume

Robert Gunning, University of Colorado, Boulder, Colorado; 1 October 1995 to 31 May 1996; rates and processes of environmental change

John Hay, School of Environmental and Marine Science, University of Auckland, Auckland, New Zealand; participant, *ENSO and Extreme Events in Southeast Asia*

Bruce Hayden, University of Virginia, Charlottesville, Virginia; STORMS volume

Kenneth Heidemann, Phillips Laboratory, Hanscom AFB, Massachusetts; USWRP Prospectus Development Team #6

Srikantha Herath, Institute of Industrial Science, University of Tokyo, Tokyo, Japan; participant, *ENSO and Extreme Events in Southeast Asia*

Benigno Hernandez, Centro de Investigaciones Pesqueras, Ministerio de la Industria Pesqueria, Havana, Cuba; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Mark Hjelmfelt, South Dakota School of Mines, Rapid City, South Dakota; STORMS volume

Greg Holland, Bureau of Meteorology Research Centre (BMRC), Melbourne, Australia; hurricanes and the insurance industry

William Hooke, NOAA/USWRP, Washington, D.C.; STORMS volume

Rebecca Huss-Ashmore, University of Pennsylvania, Philadelphia, Pennsylvania; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Nguyen Dinh Huyen, University of Ho Chi Minh City, Ho Chi Minh City, Vietnam; participant, *ENSO and Extreme Events in Southeast Asia*

Thanongdeth Insisiengmay, Mekong River Commission, Bangkok, Thailand; STORMS volume; participant, *ENSO and Extreme Events in Southeast Asia*

Abbasgholi Jahani, Water Planning Bureau, Ministry of Energy, Tehran, Iran; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Dale Jamieson, University of Colorado, Boulder, Colorado and Carleton College, Northfield, Minnesota; 1 October 1995 to 31 August 1996; interrelationship between science and values

Manuel Jiminez, Secretaria del Consejo, Agropecuario Centroamericano, San Jose, Costa Rica; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Jose Joaquin-Chacon, Comite Regional de Recursos Hidraulicos del Centroamericano, San Jose, Costa Rica; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Ronald Keener, Duke Power Company, Charlotte, North Carolina; USWRP Prospectus Development Team #6

Gerard Kiely, University College, Cork, Ireland; stochastic hydrology/statistical downscaling

Jeff Kimpel, University of Oklahoma, Norman, Oklahoma; USWRP Prospectus Development Team #6

John Kineman, National Geophysical Data Center, NOAA, Boulder, Colorado; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Joseph H. Kinuthia, Kenya Meteorological Department, Nairobi, Kenya; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Tatuo Kira, Scientific Committee of ILEC (International Lake Environment Committee) Foundation, Kusatsu City, Shiga, Japan; chapter in *Caspian, Aral and Dead Seas*

Bo Kjelln, Ambassador, Miljdepartementet, Stockholm, Sweden; foreword for *Caspian, Aral and Dead Seas*

Iwao Kobori, Political Science and School of Economics, Meiji University, Meiji, Japan; co-editor (with M.H. Glantz) of *Caspian, Aral and Dead Seas*

T.N. Krishnamurti, Florida State University, Tallahassee, Florida; STORMS volume

Pablo Lagos, Instituto Geofisico del Peru (IGP), Lima, Peru; ENSO impacts in Peru

Robert Landis, World Meteorology Organization, Geneva, Switzerland; STORMS volume

Chris Landsea, NOAA Hurricane Research Division, Miami, Florida; hurricanes and the insurance industry; economics of hurricanes; STORMS volume

Pete Leavitt, Weather Services Corporation, Lexington, Massachusetts; USWRP Prospectus Development Team #6

Luis Lecha-Estela, Centro Nacional del Clima, Instituto de Meteorologia, Havana, Cuba; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Tran Viet Lien, Climate Application Section, Institute of Meteorology and Hydrology, Hanoi, Vietnam; participant, *ENSO and Extreme Events in Southeast Asia*

Gary Littlejohn, University of Bradford, Bradford, United Kingdom; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño,* and *Internet Journal of African Studies*

Walt Lyons, FMA Research, Inc., Fort Collins, Colorado; STORMS volume

Lawrence J. MacDonnell, lawyer and consultant, Boulder, Colorado; climate change and water allocation institutions

Victor Magana, Centro de Ciencias de la Atmosfera, Mexico City, Mexico; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Dave Malmquist, Risk Prediction Initiative/Atlantic Global Change Institute (RPI/AGCI), Hamilton, Bermuda; hurricanes and the insurance industry

Simon Mason, University of the Witwatersrand, Johannesburg, South Africa; 25-27 August 1996; value of ENSO information to the Southern Africa Development Community (SADC); assessment of the use of climate forecast information

Kishor Mehta, Texas Tech University, Lubbock, Texas; STORMS volume

Arif Mekhtiyev, National Aerospace Agency, Baku, Azerbaijan; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Anthony Michaels, University of Southern California, Los Angeles, California; STORMS volume

Dennis Mileti, University of Colorado, Boulder, Colorado; STORMS volume

Adams Miller, Office of Global Programs, NOAA, Silver Spring, Maryland; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Pirouz Mojtahed-Zadeh, Geopolitics and International Boundaries Research Centre, School of Oriental and African Studies, University of London, London, United Kingdom; chapter in *Caspian, Aral and Dead Seas*

Christopher Moore, University of Colorado, Boulder, Colorado; 17 June to 30 September 1996; global climate change surprises

Joao Morais, Programme Officer for Social Sciences, IGBP Secretariat, Royal Swedish Academy of Sciences, Stockholm, Sweden; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Betty Hearn Morrow, Florida International University, Miami, Florida; STORMS volume

Masahiro Murakami, Nippon Koei Co., Inashiki-gun, Ibaraki, Japan; chapter in *Caspian, Aral and Dead Seas*

Allan Murphy, Prediction and Evaluation Systems, Corvallis, Oregon; economic value of weather and climate forecasts; USWRP Prospectus Development Team #6

Mikiyasu Nakayama, Utsunomiya University, Utsunomiya, Japan; 23-27 June 1996, 27-29 August 1996; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*; chapter in *Caspian, Aral and Dead Seas*; co-author (with M.H. Glantz) on paper for *Journal of Japanese Society of Irrigation, Drainage and Reclamation Engineering*; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Lino Naranjo-Diaz, Centro Nacional del Clima, Instituto de Meteorologia, Havana, Cuba; participant, *ENSO and Extreme Events in the Greater Caribbean Region*; participant, *ENSO and Extreme Events in Southeast Asia*; STORMS volume

Neville Nicholls, Bureau of Meteorological Research Centre, Melbourne, Victoria, Australia; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*; participant, *ENSO and Extreme Events in Southeast Asia*

Nguyen Huu Ninh, Center for Environment Research, Education and Development, Hanoi, Vietnam; participant, *ENSO and Extreme Events in Southeast Asia*

Fielding Norton, Employers Re, Kansas City, Missouri; hurricanes and the insurance industry

Nina M. Novikova, Water Problems Institute, Russian Academy of Sciences, Moscow, Russia; chapter in *Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin*; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Alicia P. Occidental, Director, Regional Center for Graduate Study and Research in Agriculture, College Los Banos, Laguna, Philippines; participant, *ENSO and Extreme Events in Southeast Asia*

Laban Ogallo, Department of Meteorology, University of Nairobi, Nairobi, Kenya; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Munir Ozturk, Centre for Environmental Studies, Bornova, Izmir, Turkey; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Suwanna Panturat, Faculty of Science, Srinakharinwirot University, Bangkok, Thailand; participant, *ENSO and Extreme Events in Southeast Asia*

Robert Parkin, University of Colorado, Boulder, Colorado; 1 October 1995 to 31 August 1996; Institute on the Economics of the Climate Resource

Marc Parlange, Johns Hopkins University, Baltimore, Maryland; stochastic hydrology/ statistical downscaling

Luis R. Paz-Castro, Centro Nacional del Clima, Instituto de Meteorologia, Havana, Cuba; co-organizer, *ENSO and Extreme Events in the Greater Caribbean Region*

Roger A. Pielke, Sr., Colorado State University, Fort Collins; Colorado; hurricane book; STORMS volume

Orrin Pilkey, Duke University, Durham, North Carolina; STORMS volume

Thomas Potter, National Weather Service, Western Region Headquarters, Salt Lake City, Utah; *Handbook for Weather, Climate and Water*

Nico Potterat, Vassar College, Poughkeepsie, New York; 17 June 1996 to 31 August 1996; global climate change surprises

Mark Powell, NOAA Hurricane Research Division, Miami, Florida; STORMS volume

Sergei Preis, Department of Chemical Engineering, Tallinn Technical University, Tallinn, Estonia; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Gao Pronove, UN Institute for Training and Research (UNITAR), Geneva, Switzerland; participant, *ENSO and Extreme Events in the Greater Caribbean Region*; participant, *ENSO and Extreme Events in Southeast Asia*

Roger Pulwarty, University of Colorado, Boulder, Colorado; USWRP Prospectus Development Team #6

Asomitdin A. Rafikov, Department of Geography, Presidium of the Academy of Science, Tashkent, Republic of Uzbekistan; chapter in *Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin*

S. Raghavan, India Meteorological Department, Madras, India; STORMS volume

Patricia Ramirez, Oficina Costarricense de Implementacion Conjunto, San Jose, Costa Rica; participant, *ENSO and Extreme Events in the Greater Caribbean Region*

Erik Rasmussen, University of Copenhagen, Copenhagen, Denmark; STORMS volume

Humberto Rodriguez, National Politechnic Institute, Mexico City, Mexico; STORMS volume

John Rook, SADC Regional Early Warning System, Harare, Zimbabwe; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Richard Roth, CNA Insurance (retired), Chicago, Illinois; USWRP Prospectus Development Team #6

Modjtaba Sadria, Faculty of Policy Studies, Chuo University, Hachioji-shi, Tokyo, Japan; chapter in *Caspian, Aral and Dead Seas*

Deborah Saidy, Drought Emergency in Southern Africa Programme, UN Department of Human Affairs, Geneva, Switzerland; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Tatiana Saiko, Department of Geographical Sciences, University of Plymouth, Devon, United Kingdom; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Toshibumi Sakata, Tokai University Research and Information Center, Tomigaya, Shibuya-ku, Tokyo, Japan; chapter in *Caspian, Aral and Dead Seas*

Dan Sarewitz, Geological Society of America, Boulder, Colorado; U.S. science policy

Dr. Hans-Heinrich Schiesser, Atmospharenphysik ETH, Honggerboerg, Switzerland; STORMS volume

Gerhart Schneider, UN Environment Programme, Nairobi, Kenya; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Jalal Shayegan, Sharif University of Technology, Tehran, Iran; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Maria Silva Dias, Universidade de Sao Paulo, Sao Paulo, Brazil; STORMS volume

Vadim Sokolov, Interstate Coordination Water Commission, Tashkent, Uzbekistan; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Robert Southern, R.L. Southern Weather Associates, Ardross, Western Australia; STORMS volume

Ellis Stanley, Sr., Fulton County Emergency Management Agency, Atlanta, Georgia; USWRP Prospectus Development Team #6

Thomas Stewart, University of New York, Albany, New York; global climate change surprises, USWRP Prospectus Development Team #6

David Streets, Argonne National Laboratory, Argonne, Illinois; 4 September 1996; global climate change surprises; ENSO-related climate surprises

Kenneth M. Strzepek, Civil, Environmental, and Architectural Engineering Department, University of Colorado, Boulder, Colorado; climate and water quality

Umirsak Makhmutovich Sultangasin, Space Research Institute, National Academy of Sciences, Almaty, Kazakhstan; chapter in *Caspian, Aral and Dead Seas*; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

V.V. Sumarkokova, State Hydrological Institute, St. Petersburg, Russia; chapter in *Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin*

Pavel Szerbin, Division of Environmental Radiohygiene, Joliet-Curie National Research Institute, Budapest, Hungary; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Nguyen Van Tai, Geography Department, University of Ho Chi Minh City, Ho Chi Minh City, Vietnam; participant, *ENSO and Extreme Events in Southeast Asia*

Christopher Tapscott, School of Government, University of the Western Cape, Bellville, South Africa; chapter in *Using Science Against Famine: Food Security, Famine Early Warning and El Niño*

Greg Tripoli, University of Wisconsin, Madison, Wisconsin; STORMS volume

Huynh Trung, University of Ho Chi Minh City, Ho Chi Minh City, Vietnam; participant, *ENSO and Extreme Events in Southeast Asia*

Tsuneo Tsukatani, Kyoto University, Kyoto, Japan; chapter in *Caspian, Aral and Dead Seas*

K.I. Tsytsenko, State Hydrological Institute, St. Petersburg, Russia; chapter in *Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin*

Ilter Turan, Department of Political Science, Koc University, Istanbul, Turkey; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Peter Tyson, University of the Witwatersrand, Johannesburg, South Africa; STORMS volume

Juha Uitto, Environmental and Sustainable Development Office, United Nations University, Tokyo, Japan; chapter in *Caspian, Aral and Dead Seas*

Peter Usher, UNEP, Nairobi, Kenya; 14-15 September 1996; Scientific Advisory Committee for UNEP (with M.H.

Glantz); *Network Newsletter*; participant, *ENSO and Extreme Events in the Greater Caribbean Region*; participant, *ENSO and Extreme Events in Southeast Asia*

Alfredo Valverde, Peru Hydropower, Lima, Peru; ENSO impacts in Peru

Sergei Vinogradov, Centre for Petroleum and Mineral Law and Policy, University of Dundee, Dundee, Scotland, United Kingdom; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

G.V. Voropayev, Scientific Coordination Center, Moscow, Russia; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Elisabeth Vostokova, Institute of Ecology of the Russian Academy of Sciences, Moscow, Russia; chapter in *Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin*

Wang Shao-Wu, Beijing University, Beijing, China; STORMS volume; participant, *ENSO and Extreme Events in Southeast Asia*

John Weaver, Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University, Fort Collins, Colorado; STORMS volume

Benjamin Webster, University of Colorado, Boulder, Colorado; 17 June to 30 September 1996; global climate change surprises

Douglas Wesley, UCAR/COMET, Boulder, Colorado; STORMS volume

Donald Wilhite, National Drought Mitigation Center, International Drought Information Center, University of Nebraska, Lincoln, Nebraska; *Hazards and Disasters: A Series of Definitive Major Works*

Aaron T. Wolf, Department of Geography, University of Alabama, Tuscaloosa, Alabama; chapter in *Caspian, Aral and Dead Seas*

Tom Zacharias, National Crop Insurance Program, Overland Park, Kansas; USWRP Prospectus Development Team #6

Z. Zalibekov, PriCaspian Institute of Bioresources, Makhachkala, Republic of Dagestan, Russia; participant, NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

Zong-ci Zhao, Open Lab for Climate Science, National Climate Center, Beijing, China; participant, *ENSO and Extreme Events in Southeast Asia*

Xiaogu Zheng, National Institute of Water and Atmospheric Research, Wellington, New Zealand; climate variability and predictability

Iliya M. Zholdasova, Institute of Ecology and Biology, Uzbek Academy of Science, Nukus, Republic of Karakalpakstan, Uzbekistan; chapter in *Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin*

Conrad Ziegler, NOAA/National Severe Storms Laboratory, Norman, Oklahoma; STORMS volume

Alexander N. Zolotokrylin, Institute of Geography, Russian Academy of Sciences, Moscow, Russia; chapter in *Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin*

Igor Zonn, UNEP National Committee for Russia, Moscow, Russia; chapter in *Creeping Environmental Problems and Sustainable Development in the Aral Sea Basin*; co-editor of book (with M.H. Glantz) on Aral Sea; Co-Director with M.H. Glantz of NATO Advanced Research Workshop on *Scientific, Environmental and Political Issues in the Circum-Caspian Region*

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High Altitude Observatory

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Elizabeth J. Boyd, Financial Administrator
Louise A. Beierle
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Rebecca S. Ruttenberg
Margaret S. Searcy (to 10/27/95)
Janice Varney (from 4/15/96)
Cindy Worster

Computing and Research Support

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Roy M. Barnes (85%)
Joan R. Burkepile
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Barry G. Knapp
Alice R. Lecinski
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Solar Photosphere and Magnetic Fields (SPMF) Section

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Philip G. Judge
Michael Knoelker
Bruce W. Lites
Andrew P. Skumanich

Solar Interior (SI) Section

Keith B. MacGregor (Section Head)
Timothy M. Brown
Paul Charbonneau
Peter A. Fox
Peter A. Gilman
Steven Tomczyk

Mauna Loa Solar Observatory

Darryl A. Koon
Eric A. Yasukawa

Affiliate Scientists

Joergen Christensen-Dalsgaard, University of Aarhus, Denmark
Egil Leer, Institute of Theoretical Astrophysics, University of Oslo, Norway
Robert M. MacQueen, Rhodes College
Dimitri Mihalas, University of Illinois
Robert Rosner, University of Chicago
John H. Thomas, University of Rochester

Postdoctoral Fellowships

Giuliana de Toma, University of Arizona
Sarah Gibson (from 10/30/95 to 4/30/96)
Viggo Hansteen, Institute of Theoretical Astrophysics, Oslo, Norway
Brad Hindman, University of Colorado
Keith Julien, University of Colorado (Advanced Study Program)
Edward Kennelly, University of British Columbia, Vancouver, BC
K. D. Leka (Advanced Study Program)
Jianke Li, University of Sydney, Australia
Alan McAllister, Space Environment Laboratories, Boulder
William Oliver, Boston University (CEDAR Postdoc)
Scott Palo, University of Colorado
Mark Rast, University of Colorado (Advanced Study Program)
Toshifumi Shimizu, Institute of Astronomy, University of Tokyo
Aaron Sigut, University of Toronto, Ontario, Canada
John Worden, University of Colorado
Xiao-Xin Zhang, Center for Space Science and Applied Research, Beijing, China
Zhongwei Zhu, University of Washington, Seattle, Washington

Graduate Research Assistants

Christopher Balch, University of Colorado
Graham Barnes, Cornell University, Ithaca, New York
Farzad Kamalabadi, Boston University
Ward Manchester, University of Illinois, Urbana, Illinois
Aaron Ridley, University of Michigan
Colin Roald, University of Rochester, Rochester, New York
Bifford Williams, University of Colorado

Summer Undergraduate Student Visitors

Damien Chua, University of Puget Sound, Tacoma, Washington
Sarah Gasda, College of Notre Dame, Baltimore, Maryland
Reyco Henning, University of Denver, Denver, Colorado
Rubina Kotak, University of Kent, Canterbury, Kent, United Kingdom

SOARS Student Visitors

Lacey Holland, University of Virginia, Charlottesville, Virginia
Jennifer Zabel, Weber State University, Ogden, Utah

Student Assistants

Catherine Andrulis (to 8/30/96)
Frank R. DiPentino (to 12/15/95)
Robert A. Fleming (from 12/12/95)
Aaron Fromm (from 4/22/96)
William Golesorkhi (to 7/3/96)
Mark Henneberry (to 2/7/96)
Holly Higgins (from 2/27/96)
Kristin Hotaling (to 12/15/95)

Mansour A. Jarbou (to 8/25/96)
Michael W. Jones (to 5/10/96)
Susanne L. Jordan (to 5/15/96)
Kenneth J. Keelan (to 9/20/96)
Michael F. Kosenski (to 5/10/96)
Albert Lee (from 3/4/96)
Joseph L. McCormick (from 11/20/95)
Randle W. Meisner
John W. Murphy (from 7/15/96)
Vincent Palumbo (to 2/11/96)
Matthew W. Park (from 5/28/96)
Matthew Pate (from 4/22/96)
Juli Rasmussen (from 2/26/96)
Robert P. Rodgers (from 12/19/95)
Timothy Rood (from 4/22/96)
Edward L. Schrader (to 2/13/96)
Gregory R. Wilson

Visitors and Collaborators

Dates refer to visitor's stay at NCAR during FY 96. No dates are given for collaborators who did not visit NCAR.

Abdellatif Aboussaid; Universite Libre de Bruxelles; atomic physics for solar spectroscopy

B. -H. Ahn; Kyungpook National University, Taegu, S. Korea; 29 January 1996 - 12 February 1996; High-latitude ionospheric conductivities and currents

Tahar Amari; Saclay Center, France; 12 April 1996 - 17 April 1996; numerical mhd simulation

Rashid Akmaev; University of Colorado; Terrestrial Impact of Solar Output section

Maha Ashour-Abdalla; UCLA; coronal/interplanetary research

Susan Avery; University of Colorado; Terrestrial Impact of Solar Output section

Eugene Avrett; Center for Astrophysics; spectral synthesis

Fran Bagenal; University of Colorado; Modeling the interior magnetic field of Saturn

Stefan Baier; Kiepenheuer-Institut für Sonnenphysik; V-Stokes Polarimetry of small magnetic structures

Kile Baker; Applied Physics Laboratory, The Johns Hopkins University; ionospheric convection

Steve Balbus; University of Virginia; 24 April 1996 - 28 April 1996; astrophysical MHD systems

William Borucki; NASA/Ames; Precise Photometry Mission

Tomas Brage; Lund University; Atomic physics for solar spectroscopy

Paal Brekke; University of Oslo, Norway; SOHO observation planning, execution

John Brown; Glasgow University, Scotland; inversion problems related to SOHO

Mark Burrage; University of Michigan; Terrestrial Impact of Solar Output section

Paul Cally; Monash University, Victoria, Australia; 6 July 1995 - 1 January 1996; sunspot seismology

Randy Canfield; NIST; Instrument calibration

Vittorio Canuto; NASA/GODDARD INSTITUTE FOR SPACE STUDIES; compressible turbulence

Mats Carlsson; University of Oslo, Norway; radiation hydrodynamics, chromosphere, SOHO observing campaigns

Kwing Chan; National University of Science and Technology, Hong Kong; solar convection

Julie Chang; University of Colorado; Terrestrial Impact of Solar Output section

Joergen Christensen-Dalsgaard; University of Aarhus, Denmark; helioseismic inversions

Ron Clark; University of New Hampshire; Terrestrial Impact of Solar Output section

Bob Clauer; University of Michigan; ionospheric electrodynamics

B. Ruiz Cobo; IAC, Spain; vector magnetic fields

Mihail V. Codrescu; University of Colorado; Terrestrial Impact of Solar Output section

Geoff Crowley; Johns Hopkins, Baltimore, MD; 15 January 1996 - 15 February 1996; solar-terrestrial interactions

Hans De Sterck; Katholieke Universiteit, Leuven, Belgium; 6 May 1996 - 7 June 1996; numerical MHD simulation

Jose Carlos del Toro Iniesta; Instituto de Astrofisica de Canarias, La Laguna, Tenerife, Canary Islands; 19 July 1996 - 26 July 1996; diagnostics of solar magnetic fields

J. C. Del Toro Iniesta; IAC, Spain; vector magnetic fields

Doug Drob; University of Michigan; 10 June 1996 - 14 June 1996; interpretation of tidal and planetary wave signatures

Edward Dunham; Lowell Observatory; Precise Photometry Mission

Christopher Dyt; Monash University, Victoria, Australia; 28 August 1995 - 15 December 1995; supersonic turbulent convection

Joe Fedder; Naval Research Lab; ionospheric/magnetospheric electrodynamics

Katia Ferrière; Observatoire Midi-Pyrenees; galactic dynamo

Cassandra Fesen; Dartmouth, Hanover, New Hampshire; 15 January 1996 - 15 February 1996; solar-terrestrial interaction

Len Fisk; University of Michigan; coronal/interplanetary research

Juan Fontenla; Graci, Inc.; spectral synthesis, solar variability

Jeffrey Forbes; University of Colorado; Terrestrial Impact of Solar Output section

Steve Franke; University of Illinois; Terrestrial Impact of Solar Output section

Eigle Friis-Christensen; Danish Meteorological Institute; ionospheric electrodynamics

Dave Fritts; University of Colorado; Terrestrial Impact of Solar Output section

T. J. Fuller-Rowell; University of Colorado; Terrestrial Impact of Solar Output section

Mitch Furst; NIST; Instrument calibration

Tamas Gombosi; University of Michigan; Coronal/interplanetary research

Chet Gardner; University of Illinois; Terrestrial Impact of Solar Output section

Nikolai Gavrilov; St. Petersburg University, Russia; 30 March 1996 - 7 May 1996; gravity-wave effects in the upper atmosphere

Marvin Geller; State University of New York at Stonybrook; Terrestrial Impact of Solar Output section

Sarah Gibson; Goddard Space Flight Center; 19 August 1996 - 23 August 1996; white light CME structure, Three-dimensional modeling of the Coronal Mass Ejections

Ronald Gilliland; Space Telescope Science Institute; Precise Photometry Mission

Michel Godefroid; NASA Goddard Space Flight Center; atomic physics for solar spectroscopy

Ulrich Grossman-Doerth; Kiepenheuer-Institut für Sonnenphysik; numerical simulations of solar magnetic fluxtubes

W. P. Guo; University of Alabama; 1 February 1996 - 2 February 1996; coronal mass ejection data

Viggo Hansteen; University of Oslo; 7 April 1996 - 14 April 1996; excelleration of stellar winds and related flows, wave propagation in the solar atmosphere, coronal gas dynamics, SOHO observations

Karen Harvey; Solar Physics Research Corp., Tucson, Arizona; 9 September 1996 - 13 September 1996; solar variability, relationship between solar magnetism and radiative output

Siraj Hasan; Indian Institute for Astrophysics, India; overstable oscillations

David Hathaway; NASA/Marshall Space Flight Center; solar doppler velocities from GONG data

Williams Heaps; NASA/GODDARD SPACE FLIGHT CENTER; solar disk sextant

Eijiro Hiei; Meisei University, Tokyo, Japan; 19 February 1996 - 19 March 1996; Yohkoh data

Scott Horner; Pennsylvania State University, University Park, Pennsylvania; 8 July 1996 - 1 August 1996; detection of p-mode oscillations on other stars and detection of planets orbiting stars

Robert Howard; National Solar Observatory; sunspot motions

You Qiu Hu; University of Science and Technology, Hefei, China; 11 February 1996 - 17 February 1996; stability of magnetic structures

Veronika Hubeny; University of Maryland; inversion problems related to SOHO

Andrew Jones; University of Southern California; Precise Photometry Mission Per Jonsson; Vanderbilt University; atomic physics for solar spectroscopy

Eun-Jin Kim, University of Leeds, Leeds, United Kingdom; 9 September 1996 - 12 September 1996; local helioseismology, sunspot seismology

Yong-Cheol Kim; Yale University; solar convection

D. J. Knipp; US Air Force Academy; Terrestrial Impact of Solar Output section

David Koch; NASA/Ames Precise Photometry Mission

Raj Korde; IRD; Detector development

Sylvain Korzennik; Center for Astrophysics, Cambridge, MA; Advanced Fiber Optic Echelle project

Jeff Kuhn; Michigan State University and National Solar Observatory; coronal IR spectroscopy and magnetic field measurements

Robert Kurucz; Center for Astrophysics; spectral synthesis

Rosine Lallement; CNRS, Verrieres; cononal/interplanetary research

R. A. Langel; NASA Goddard Space Flight Center; Terrestrial Impact of Solar Output section

Rasmus Munk Larsen; University of Aarhus, Aarhus, Denmark; 19 August 1996 - 30 August 1996; algorithms for helioseismic inversion

Judith Lean; NRL; Solar EUV measurements

Egil Leer; University of Oslo, Norway; coronal/interplanetary research

Ruth Lieberman; University of Michigan; Terrestrial Impact of Solar Output section

Oystein Lie-Svendsen; Norwegian Defense Research Establishment, Kjeller, Norway; 3 April 1996 - 14 April 1996; excelleration of stellar winds and related flows

William Livingston; National Solar Observatory; solar variability

D. Lummerzheim; University of Alaska; Terrestrial Impact of Solar Output section

Thomas Lydon; Yale University; solar convection, structure

Larry Lyons; The Aerospace Corporation; ionosphere-magnetosphere coupling

Bob Madden; NIST; Instrument calibration

Ward Manchester; University of Illinois; 14 August 1995 - 6 October 1995; siphon flow in a twisted magnetic field

Alan Manson; University of Saskatoon, Canada; Terrestrial Impact of Solar Output section

Sara Martin; Helio Research, La Cresenta, California; 19 July 1996 - 24 July 1996; effects of prominences on coronal structure

Valentin Martínez-Pillet; IAC, Spain; vector magnetic fields

Scott McIntosh; Glasgow University, Scotland; inversion problems related to SOHO

Pat McIntosh; Heliosynoptics; solar activity

Charles McLandress; York University; Terrestrial Impact of Solar Output section

Ralph McNutt; Applied Physics Laboratory, Johns Hopkins University; coronal/interplanetary research

Chris Meek; University of Saskatoon, Canada; Terrestrial Impact of Solar Output section

Werner Mende; Institute for Meteorology, Berlin, Germany; 24 June 1996 - 16 July 1996 and 4 September 1996 - 4 October 1996; solar prediction analysis, long term solar variation

Karin Muglach; Kiepenheuer-Institut für Sonnenphysik; spectroscopy of He I 10830

Ingo Muller-Wodarg; University College London; Terrestrial Impact of Solar Output section

Takuji Nakamura; Kyoto University; Terrestrial Impact of Solar Output section

Peter Nisenson; Center for Astrophysics, Cambridge, MA; Advanced Fiber Optic Echelle project

Susan Nossal; Arecibo Observatory, Puerto Rico; 13 June 1996 - 25 June 1996 and 30 July 1996 - 4 August 1996; TIME-GCM model

Robert Noyes; Center for Astrophysics, Cambridge, MA; Advanced Fiber Optic Echelle project

Satanori Nozawa; Nagoya University, Nagoya, Japan; 13 June 1996 - 12 October 1996; TIME-GCM model

Howard Ogwa; USC; SOHO EUV measurements

W. L. Oliver; Boston University; Terrestrial Impact of Solar Output section

N. Olsen; University of Copenhagen, Denmark; Terrestrial Impact of Solar Output section

Terry Onssager; Space Environment Center, NOAA; ionosphere-magnetosphere coupling

Philippe Peters; Institute of Aeronomy, Brussels, Belgium; 6 January 1996 - 13 January 1996; SOLSTICE

Alex Pevtsov; University of Hawaii; 28 November 1995 - 2 December 1995; reduction software

Christophe Peymirat; University of Versailles; 1 July 1996 - 31 December 1996; magnetosphere-ionosphere coupling in the TIME-GCM model

Klaus Pflug; Astrophysik Institut, Germany; Solar EUV instrument

C. Westendorp Plaza; IAC, Spain; Vector Magnetic Fields

Yuri Portnyagin; TYPHOON/Obninsk, Russia; Terrestrial Impact of Solar Output section

Tujia Pulkkinen; Finnish Meteorological Institute, Finland; magnetospheric model

C. A. Raymond; NASA Jet Propulsion Laboratory; Terrestrial Impact of Solar Output section

Steffan Ritzenhoff; Kiepenheuer-Institut für Sonnenphysik, Freiburg, Germany; 2 July 1996 - 2 August 1996; solar lithium abundance with respect to nlte-effects, Li abundance in sunspots

Mark Rast; JILA, University of Colorado; numerical modeling of the magnetostatic corona with thermal conduction

Alan Rodger; British Antarctic Survey; ionospheric convection

Guenther Ruediger; Astrophysakalisches Institut, Potsdam; 18 July 1996 - 2 August 1996; turbulent viscosity and solar oscillation models

R. Rutten; Sterrekindig Instituut, Utrecht, The Netherlands; solar chromosphere

Joe Salah; MIT Haystack Observatory; Terrestrial Impact of Solar Output section

Wolfgang Schmidt; Kiepenheuer-Institut für Sonnenphysik, Freiburg, Germany; 18 June 1996 - 27 June 1996; dynamics of the transition zone, spectroscopy of He I 10830, phase diversity applied to sunspot observations, 2-D spectroscopy of flow fields around magnetic structures, Li abundance in sunspots

Gerhard Schmidtke; Frannhofer Institut, Germany; Folar EUV instrument

Jacqueline Schoendorf; University College London; 10 December 1995 - 10 January 1996; thermospheric studies

Jesper Schou; Stanford University; helioseismic inversions

Manfred Schuessler; Kiepenheuer-Institut für Sonnenphysik; numerical simulations of solar magnetic fluxtubes

Gordon Shepherd; York University, North York, Ontario, Canada; 8 April 1996 - 12 April 1996; TIME-GCM model

Marianna Shepherd; York University, North York, Ontario, Canada; 8 April 1996 - 12 April 1996; wave temperature signatures

Michael Sigwarth; Kiepenheuer-Institut für Sonnenphysik, Freiburg, Germany; 15 June 1996 - 14 July 1996; interaction of small scale magnetic elements with convective flows 2-D spectroscopy of flow fields around magnetic structures

Paul Simon; Institute d' Aeronomie, Belgium; 23 July 1996 - 31 July 1996; solar irradiance

Haward Singer; Space Environment Center, NOAA; magnetospheric electrodynamics

George Siscoe, Boston University; ionosphere-magnetosphere coupling

Herschel Snodgrass; Lewis and Clark College; solar activity

Sabatino Sofia; Yale University; solar convection, activity, variability, solar disk sextant

D. Soltaok; Kiepenheuer-Institut für Sonnenphysik, Germany; solar magnetic fields

Donald C. H. Stanchfield; University of Rochester; sunspots, oscillations

Jan Stenflo; ETH, Zurich, Switzerland; 15 October 1995 - 15 March 1996; solar magnetic fields

R. J. Stening; University of New South Wales, Australia; Terrestrial Impact of Solar Output section

Oskar Steiner; Kiepenheuer-Institut für Sonnenphysik, Freiburg, Germany; 17 January 1996 - 16 January 1998, numerical simulations of solar magnetic fluxtubes

Jack Streete; Rhodes College, Memphis, TN; 10 June 1996 - 20 July 1996; Advanced Coronal Observing System

Tomoyuki Takami; Kyoto University, Kyoto, Japan; 27 June 1996 - 31 July 1996; CEDAR database

Louis Tao; Cambridge University, London, England; 2 October 1995 - 13 October 1995; p-mode propagation through magnetic plage

Ted Tarbell; Lockheed/Martin; Precise Photometry Mission

John H. Thomas; University of Rochester; sunspots, oscillations

Michael Thompson; University of London, London, England; 9 August 1996 - 29 August 1996; helioseismology

Alan Title; Lockheed/Martin; Precise Photometry Mission

Kent Tobiska; Telos/JPL; Solar EUV Modeling

Alexandra Tritschler; Kiepenheuer-Institut für Sonnenphysik, Freiburg, Germany; 19 August 1996 - 10 September 1996; face diversity observations of sunspots

Kolya Tsyganenko; Goddard Space Flight Center, NASA; magnetospheric model

Gary Turner; Iowa State University, Ames, Iowa; 4 June 1996 - 23 August 1996; SunRISE model synthesis

Lawrence Twigg; Applied Research Corporation; solar disk sextant

Roger Ulrich; University of California Los Angeles; Precise Photometry Mission

Oleg Vaisberg; Russian Academy of Science, Moscow, Russia; 12 December 1995 - 15 December 1995; solar wind

Francois Vial; CNRS/LMD, France; Terrestrial Impact of Solar Output section

Robert Vincent; University of Adelaide, Australia; Terrestrial Impact of Solar Output section

William Ward; York University, Ontario, Canada; dynamics of the summer mesopause region; 3 June 1996 - 14 June 1995; dynamics of the summer mesopause region

Mark Weber; Montana State University, Montana; 23 October 1995 - 22 November 1995; Yohkoh and white light coronal observation

Oivind Wikstol; University of Oslo; coronal gas dynamics, SOHO observations

Peter Wilson; University of Sydney, Sydney, N.S.W., Australia; 9 April 1996 - 19 April 1996; solar polar magnetic fields

Dong Wu; Jet Propulsion Laboratory; Terrestrial Impact of Solar Output section

S. T. Wu; University of Alabama; 1 February 1996 - 2 February 1996; coronal mass ejection data

Anders Ynnerman; Universite Libre de Bruxelles; atomic physics for solar spectroscopy

Qihou Zhou; Arecibo Observatory, Arecibo, Puerto Rico; 20 May 1996 - 23 August 1996; low latitude mesospheric and thermospheric dynamics

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Mesoscale and Microscale Meteorology Division

Staff

Staff or long-term visitors with MMM appointments as of 30 September 1996

Division Director's Office

Amy Allen
Toni Biter
William Bonner (senior research associate)

Robert Gall (director)
Teresa Harris (also supports SMG)
Sudie Kelly
Kathleen Morgan

U.S. Weather Research Program (USWRP)

Richard Carbone (lead scientist)
Linda Morris

System Management Group (SMG)

William Boyd
Jody Williams
Patricia Waukau (group head)

Boundary Layer and Turbulence Group (BLTG)

Martine Bunting (also supports PMG)
Jackson Herring
Peter Hildebrand (long-term visitor; ATD)
James Howell (long-term visitor; ASP)
Donald Lenschow (group head; joint appointment with ATD)
Chin-Hoh Moeng
Ilga Paluch
Harvey Segur (long-term visitor)
Peter Sullivan
Jielun Sun (long-term visitor)
Jeffrey Weil (long-term visitor)

Cloud Scale Modeling Group (CSMG)

Olivia Bortfeld (also supports CSG and MAG)
Roelof Bruintjes (joint appointment with RAP)
Terry Clark (group head)
Janice Coen
N. Andrew Crook (joint appointment with RAP)
William Hall
Robert Kerr
Juanzhen Sun

Cloud Systems Group (CSG)

William Anderson (also supports PMG and MAG)
N. Andrew Crook (joint appointment with RAP)
Wojciech Grabowski
Changhai Liu (long-term visitor)
Mitchell Moncrieff (group head)
Piotr Smolarkiewicz
Xiaoqing Wu (long-term visitor)

Mesoscale Analysis Group (MAG)

Richard Carbone
James Fankhauser (long-term visitor)
Robert Grossman (long-term visitor)
Joachim Kuettner (senior research associate; joint appointment with UCAR Office of Programs)
Margaret LeMone (group head)
L. Jay Miller
John Pflaum (long-term visitor)
Melvyn Shapiro (long-term visitor)
Stanley Trier
John Tuttle (joint appointment with RAP)

NOAA/NSSL, Mesoscale Research and Applications Division--Boulder

Diana Bartels
David Blanchard
John Daugherty
Robert Hueftle
David Jorgensen (chief)
Sharon Lewis
Thomas Matejka
Eric Rasmussen

Mesoscale Dynamics Group (MDG)

Nolan Atkins (long-term visitor; ASP)
Scott Braun (long-term visitor; ASP)
Joseph Klemp (group head)
Ingrid Moore (also supports MPG)
Richard Rotunno
William Skamarock
Christopher Snyder
Morris Weisman

Mesoscale Prediction Group (MPG)

James Bresch (long-term visitor)
Christopher Davis (joint appointment with RAP)
Jimy Dudhia
David Gill
Yong-Run Guo
Daniel Hansen
Wei Huang
Ying-Hwa (Bill) Kuo (group head)
Alexis Lau (long-term visitor; joint appointment with RAP)
Simon Low-Nam
Kevin Manning
Jordan Powers (long-term visitor; ASP)
Francois Van den Berghe (long-term visitor)
Anyu Wang (long-term visitor)
Wei Wang
Qingnong Xiao (long-term visitor)
Dexin Zhang (long-term visitor)

Xiaolei Zou

Physical Meteorology Group (PMG)

Steven Aulenbach
Mary Barth (joint appointment with ACD and CGD)
Daniel Breed (joint appointment with RAP)
William Cooper (joint appointment with ASP)
James Dye (group head; joint appointment with ATD)
Janine Goldstein
Rick Graves
Andrew Heymsfield
David Johnson
Charles Knight
Nancy Knight
John Latham (long-term visitor)
Gregory McFarquhar
Larry Miloshevich
Roy Rasmussen (joint appointment with RAP)
Jan Rosinski (long-term visitor)

Affiliate Scientists

Jean-Louis Brenguier (Centre National de Recherches Meteorologiques, France; joint appointment with ATD)
Larry Mahrt (Oregon State University)
Richard Reed (University of Washington)

MMM VISITORS AND COLLABORATORS

Dates refer to visitor's stay at NCAR during FY 96. No dates are given for collaborators who did not visit NCAR.

STEVE ACKERMAN: University of Wisconsin, CIMMS, 25-28 February 1996, Cloud Systems Group

THOMAS ACKERMANN: Pennsylvania State University, 25-28 February 1996, Cloud Systems Group

MARK ALBRIGHT: University of Washington, 22-26 July 1996, Mesoscale Prediction Group

JAMES ALBRITTON: Lawrence Livermore National Laboratory, CA, 25-26 July 1996, Mesoscale Prediction Group

JOAN ALEXANDER: University of Washington, 23-24 January and 26 August - 15 September 1996, Physical Meteorology Group

JORGE AMADOR: University of Costa Rica, San Jose, 15-20 July 1996, Mesoscale Prediction Group

DARCY ANDERSON: University of Arizona, 5-6 August 1996, Physical Meteorology Group

STEVEN ANDERSON: Woods Hole Oceanographic Institute, MA, Mesoscale Analysis Group

NOLAN ATKINS: University of California, Los Angeles, 30 October 1995 - 29 October 1997, joint appointment with Advanced Study Program and Mesoscale Dynamics Group

JEFF BAILEY: NASA Marshall Space Flight Center, 14-29 August 1996, Physical Meteorology Group

ROBERT BALLENTINE: State University of New York, Oswego, 22-26 July 1996, Mesoscale Prediction Group

ALBERT BARCILON: Florida State University, 7 June - 19 August 1996, Mesoscale Prediction Group

CORNELIS BEETS: Utrecht University, Netherlands, 28 April - 27 May 1996, Boundary Layer and Turbulence Group

RICHARD BLAKESLEE: NASA Marshall Space Flight Center, 25 August - 9 September 1996, Physical Meteorology Group

WARREN BLIER: University of California, Los Angeles, 22-24 July 1996, Mesoscale Prediction Group

HOWARD BLUESTEIN: University of Oklahoma, 4 January - 21 August 1996, Mesoscale Prediction Group

WILLIAM BLUMEN: University of Colorado, Boundary Layer and Turbulence Group

LANCE BOSART: State University of New York, Albany, 30 June - 13 July 1996, Mesoscale Prediction Group

DONALD BOUCHER: Aerospace Corp., Los Angeles, 22-24 July 1996, Mesoscale Prediction Group

BRENT BOWER: National Weather Service, MD, 25-26 July 1996, Mesoscale Prediction Group

ALEX BRANDENBURG: Nordita University, Denmark, Boundary Layer and Turbulence Group

PETER BREITENBACH: Texas Natural Resource Conservation Commission, Austin, 16-19 July 1996, Mesoscale Prediction Group

JEAN LOUIS BRENGUIER: Centre National de Recherches Meteorologiques, Meteo-France, 5 February - 4 March 1996, Physical Meteorology Group, and Boundary Layer and Turbulence Group (joint affiliate scientist appointment with Atmospheric Technology Division)

JAMES BRESCH: University of Washington, 1 May 1994 - 1 October 1996, Mesoscale Prediction Group

KEITH BREWSTER: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

CHARLES BROCK: University of Denver, 11 January 1996, Cloud Systems Group

JOHN BROWN: NOAA Environment Research Laboratory, Boulder, 25-26 July 1996, Mesoscale Prediction Group

DANIEL BUNZLI: Swiss Federal Institute, Zurich, Switzerland, 1 August 1995 - 26 July 1996, Mesoscale Prediction Group

ZHOHAO CAO: University of Toronto, 15-20 July 1996, Mesoscale Prediction Group

WILLIAM CAPEHART: Pennsylvania State University, 16-19 July 1996, Mesoscale Prediction Group

RICHARD CARPENTER: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

FREDERICK CARR: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

CHI HUNG CHAN: Hong Kong University of Science and Technology, 15-20 July 1996, Mesoscale Prediction Group

KWING LAM CHAN: Hong Kong University of Science and Technology, 16-19 July 1996, Mesoscale Prediction Group

DONG-EON CHANG: Seoul National University, 22 July - 21 August 1996, Mesoscale Prediction Group

JEFFREY CHASNOV: University of Hong Kong, Boundary Layer and Turbulence Group

DANIEL CHAU: University of California, Davis, 3-14 June 1996, Cloud Scale Modeling Group

CHAING CHEN: NASA Goddard Space Flight Center, 22-26 July 1996, Mesoscale Prediction Group

SUE CHEN: Naval Research Laboratory, Monterey, CA, 25-26 July 1996, Mesoscale Prediction Group

SHOU-JUN CHEN: Peking University, China, 25 March - 25 November 1996, Mesoscale Prediction Group

XIN-AN CHEN: University of Hawaii, 25 October 1995 - 24 October 1996, Mesoscale Prediction Group

FANG-CHING CHIEN: University of Washington, 22-24 July 1996, Mesoscale Prediction Group

JASON CHING: NOAA National Environment Research Laboratory, NC, 22-26 July 1996, Mesoscale Prediction Group

YOUNG-DAE CHO: Korea Water Resources Corporation, Taejon, 3-14 June 1996, Cloud Scale Modeling Group

BOON CHOY: Royal Observatory of Hong Kong, 8-12 January 1996, Mesoscale Prediction Group

HUGH CHRISTIAN: NASA Marshall Space Flight Center, 23-24 January 1996, Physical Meteorology Group

PAUL CIESIELSKI: Colorado State University, Mesoscale Analysis Group

SAM CONTORNO: National Weather Service, MD, 25-26 July 1996, Mesoscale Prediction Group

BO CUI: Chinese National Meteorological Center, Beijing, 13 January - 13 April 1996, Mesoscale Prediction Group

KENNETH DAVIS: University of Colorado, CIRES, 15 May 1989 - 29 July 1996, and University of Minnesota, 21-24 August 1996, Boundary Layer and Turbulence Group

DANIEL DeBENEDICTIS: Hanscom Air Force Base, MA, 8-12 January 1996, Mesoscale Prediction Group

FRANK DeLUCCIA: Aerospace Corporation, Los Angeles, 8-12 January 1996, Mesoscale Prediction Group

PAUL DeMOTT: Colorado State University, Physical Meteorology Group

DAVID DEMPSEY: San Francisco State University, 22-26 July 1996, Mesoscale Prediction Group

JOHN DERBER: National Centers for Environmental Prediction, Washington, D.C., Mesoscale Prediction Group

GEOFF DiMEGO: National Weather Service, MD, 25-26 July 1996, Mesoscale Prediction Group

PETER DITLEVSEN: University of Copenhagen, 27 October 1995 - 3 May 1996, Boundary Layer and Turbulence Group, and NCAR Geophysical Turbulence Program

BRIGHT DORNBLASER: Texas Natural Resource Conservation Commission, Austin, 15-20 July 1996, Mesoscale Prediction Group

DAVID DOWELL: University of Oklahoma 15 July - 15 August 1996, Mesoscale Dynamics Group

KELVIN DROEGEMEIER: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

SYTSKE DRURY: Pennsylvania State University, 22-24 July 1996, Mesoscale Prediction Group

YANG DU: Ohio State University, 8-12 January 1996, Mesoscale Prediction Group

CLAUDE DUCHON: University of Oklahoma, 22-23 February 1996, Mesoscale Analysis Group

DALE DURRAN: University of Washington, Mesoscale Dynamics Group

GERHARD EHRET: German Aerospace Research Institute (DLR), Boundary Layer and Turbulence Group

KERRY EMANUEL: Massachusetts Institute of Technology, Mesoscale Dynamics Group

FRANKLIN EVANS: University of Colorado, 25-28 February 1996, Cloud Systems Group

CHIEN-HUI FANG: National Taiwan University, Taipei, 22-24 July 1996, Mesoscale Prediction Group

JAMES FANKHAUSER: NCAR, 11 June 1995 - 11 June 1997, Mesoscale Analysis Group

ROSSELLA FERRETTI: University of L'Aquila, Italy, 27 June - 18 September 1996, Mesoscale Prediction Group

JOE FOWLER: Argonne National Laboratories, IL, 3 April 1996 - 2 April 1997, Mesoscale Analysis Group

ALAN GADIAN: University of Manchester Institute of Science and Technology, England, 2-14 June 1996, Cloud Scale Modeling Group

BART GEERTS: University of Alabama, Huntsville, Mesoscale Analysis Group

ANDREAS GIEZ: German Aerospace Research Institute (DLR), Boundary Layer and Turbulence Group

RONALD GOODSON: Environment Canada, Edmonton, 16-26 July 1996, Mesoscale Prediction Group

MIKHAIL GORBUNOV: Institute of Atmospheric Physics, Moscow, Russia, Mesoscale Prediction Group

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Tom Windham (SOARS director)

Visitors

Education and Tour Program

More than 10,500 visitors took part in formal organized tours during FY 1996. Listed below is a selection of special visits, including visitor's institution name and date.

American Meteorological Society, 15 Project Atmosphere teachers, July 2, 1996

Hungarian Environmental Protection Agency, Zalatnay Laszko, director; June 3, 1996

Polish Parliament, 9 visiting members, May 7, 1996

Greek environmental scientists, 2 visitors through Boulder Council for International Visitors, March 5, 1996

Denver Museum of Natural History-sponsored visit for 39 museum members, February 28, 1996

Japanese Weather Association, Tokyo, 4 meteorologists in day-long visit to UCAR, February 5, 1996

Swedish government officials, 8 government heads visiting UCAR through Boulder Community Network, December 5, 1995

Early Educators Committee, 9 administrators with the Denver Public Schools,National Black Environmental Association-sponsored student visits, October 20, 27, 1995; March 29, 1996

Significant Opportunities in Atmospheric Research and Science (SOARS):

Included are student name, home institution, hosting NCAR division/program and project title. These students were in residence at NCAR from 3 June to 9 August 1996.

Christopher Castro: Pennsylvania State University - CGD
1996 project: Sensitivity of computer-generated forecasts to input parameters

Jazmin Diaz-Lopez: Metropolitan University of Puerto Rico - ACD
1996 project: Examination of nitrogen oxide cycle

Carl Etsitty: University of Arizona - ACD
1996 project: Biosphere-Atmosphere Interactions Project

Quindi Franco: Harvard University - ESIG
1996 project: Improving the connection of research to decision makers

1996 project: Radar hydrology

Lacey Holland: University of Oklahoma - HAO
1996 project: Upper atmosphere research

Karen Mozealous: University of Virginia - ACD/ATD
1996 project: Analysis of Upper Atmosphere Research Satellite (UARS) data

Paneen Peterson: University of Alaska - CGD
1996 project: Climate change research

Jennifer Price Florida A&M University - ACD
1996 project: Trace-gas chemistry

Stephanie Rivale: University of Rochester - ACD
1996 project: Modeling of tropospheric chemistry and ultraviolet radiation

Kiesha Stevens: Clark Atlanta University - CGD
1996 project: Exploration of the iron fertilization hypothesis

Jennifer Zabel: Weber State University - HAO

NCAR Senior Scientists

Maurice Blackmon, CGD
Thomas Bogdan, HAO
Byron Boville, CGD
Guy Brasseur ACD
Grant Branstator MMM

Richard Carbone MMM
Terry Clark, MMM
William Cooper, ASP
James Dye, MMM
Ronald Errico, CGD
Brant Foote, RAP
Robert Gall, MMM
Rolando Garcia, ACD
Peter Gent, CGD
John Gille, ACD
Peter Gilman, HAO
Michael Glantz, ESIG
Jackson Herring, MMM
William Holland, CGD
Thomas Holzer, HAO
Arthur Hundhausen, HAO
Roy Jenne, SCD
Richard Katz, ESIG
Jeffrey Kiehl, CGD
Joseph Klemp, MMM
Charles Knight, MMM
Michael Knoelker, HAO
Ying-Hwa (Bill) Kuo, MMM
Margaret Lemone, MMM
Don Lenschow, MMM
Bruce Lites, HAO
Boon-Chye Low, HAO
Keith MacGregor, HAO
Roland Madden, CGD
William Mankin, ACD
Chin-Hoh Moeng, MMM
Mitchell Moncrieff, MMM
Lawrence Radke, ATD
Arthur Richmond, HAO
Brian Ridley, ACD
Raymond Roble, HAO
Richard Rotunno, MMM
David Schimel, CGD
Andrew Skumanich, HAO
Piotr Smolarkiewicz, MMM
Paul Swarztrauber, SCD
Kevin Trenberth, CGD
Joseph Tribbia, CGD
Warren Washington, CGD
Thomas Wigley, CGD
David Williamson, CGD
James Wilson, RAP
Patrick Zimmerman, ACD

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A Message from NCAR's Director
Robert Serafin

Dear Friends and Colleagues

I am pleased to introduce NCAR's 1996 Annual Scientific Report. For the third year in a row, we are presenting a summary of the center's scientific research, community service and educational outreach via the World Wide Web. I encourage you to explore this report and follow the many links to NCAR's divisions, programs, and accomplishments.

Over this past year, NCAR has continued the pursuit of improved understanding of the atmosphere and its interactions with the sun, the oceans, the land and biosphere, and the impacts of climate and weather on our societies. NCAR has also made progress on the acquisition, design, and deployment of state-of-the-art facilities for computation, observation, and measurement. These tools are widely available to the university research community.

In 1996 NCAR's divisions and programs underwent extensive peer reviews to evaluate their contributions to atmospheric science, program planning and priority-setting, community leadership, and service. The Climate and Global Dynamics Division, High Altitude Observatory, Environmental and Societal Impacts Group, Mesoscale and Microscale Meterology Division, and Atmospheric Chemistry Division were reviewed, along with the Atmospheric Technology Division and the Scientific Computing Division. These reviews involved most of the staff of the divisions as well as a large portion of the atmospheric science research community, which served as reviewers. Each division was evaluated on the basis of past accomplishments and future plans. Without exception, all of these reviews were positive and found the activities of the divisions and programs to be of excellent quality, providing significant leadership and service to the atmospheric science research community, and appropriate for a national center. We found the exercise to be useful and informative and were very pleased with the outcome.

This year's Annual Scientific Report describes the scientific and technological activities and achievements of 1996. These efforts represent the type of work that NCAR has done over the past 35 years and is committed to continuing into the next century. We hope that you will concur with the reviewers and agree that NCAR continues to meet its mission to "plan, organize, and conduct atmospheric and related research programs in collaboration with universities and other institutions" and to "provide state-of-the-art research tools and facilities to the atmospheric science community".

Sincerely,

Bob Serafin

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT
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NCAR's educational activities include programs that reach groups at a variety of educational levels. Scientific visitor programs, graduate research assistantships, postdoctoral appointments, colloquia, seminars and workshops support university programs to educate the next generations of scientists, engineers, and scholars in general. Many of these are highlighted in division chapters elsewhere in this report. For example, the **Advanced Study Program** (ASP) and **Significant Opportnuities in Atmospheric Research and Science (SOARS)** provide students and graduates the opportunity to explore their educational and scientific interests in the laboratory setting. The Scientific Computing Division's (SCD) **Classroom Computing Grants** provide faculty and students access to high performance computing technologies in their classrooms.

NCAR also places a high priority on K-12 educational outreach, as well as on other educational programs that increase public awareness and understanding of atmospheric science issues. Because climate, pollution, and the environment are part of the everyday awareness of young people, the atmospheric sciences offer an unusual opportunity to teach science in engaging, relevant ways. NCAR's **Education and Tour Program** and **Visual Communications** and **Project LEARN** (Laboratory Experience in Atmospheric Research at NCAR) help teachers exploit this opportunity as well as reach out to students and the general public. SCD's **Colorado Computational Science Fair** encourages high school students to utilize computing resources beyond the capabilities of secondary schools.

This chapter documents formally organized programs. In addition, individual staff throughout NCAR serve as graduate advisors or adjunct faculty at universities, make presentations to classes and public groups, write textbooks or textbook chapters, judge science fairs, or tutor elementary through secondary school students in math and science.

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Education and Tour Program

Since 1986, the **Education and Tour Program** (ETP) has coordinated a program providing information and interaction between NCAR staff and the visiting public. Throughout the year students, teachers, scientific visitors and members of the general public come to NCAR for self-guided tours or to attend presentations on the Center and its research activities. During FY 1996, ETP staff provided guided tours to more than 10,500 visitors, including 6,300 students ranging from preschool through college level.

In 1996 the Education and Tour Program also inaugurated two new education activities. One is a career day for middle-school students with career aspirations in the atmospheric sciences; the activities planned for the day introduce them to individuals who have a variety of jobs in atmospheric science research. Staff in the Education and Tour Program follow these students through their schooling to provide occasional information and to record their achievements on their career paths.The second program is a hands-on day of science experiments and demonstrations for children of UCAR staff members, called Science FunDay. In May 1996 more than UCAR 50 parents and their children learned from hands-on activities and experiments in the Mesa Lab classroom.

FInally, the ETP coordinator participated in a summer teacher enhancement program focusing on environmental science. The workshop, attended by a dozen American science teachers, was held at the School of Education, University of Bath, UK. The group observed classroom science curricula, national standards, and assessment in various British schools. They also met with teachers from many other countries during the four-week-long program.

The ETP coordinator also attended the 4th International Conference on School and Popular Meteorological and Oceanographic Education (co-sponsored by the American Meteorological Society and the Royal Meteorological Society) to present a paper on the ways in which research laboratories can utilize their resources for educational purposes.

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Exhibits

Mesa Laboratory Exhibits

More than 10,500 visitors participated in formal tours and an estimated 30,000 more took self-guided tours of the exhibits in the Mesa Lab in FY 1996. The exhibits include seven interactive exhibits designed by the prestigious Exploratorium science museum in San Francisco which have greatly enhanced NCAR's capability as a regional educational resource. Since the installation of these exhibits in FY 1994, visits from students and teachers as well as the general public have increased dramatically. **Education activity sheets** with hands-on student activities for home or classroom accompany each exhibit. Other exhibits document the research and activities undertaken at NCAR and the UCAR Office of Programs.

A new brochure, **Welcome to the World of Atmospheric Research** was completed in FY 1996. The brochure introduces visitors to the research and activities of NCAR and the UCAR Office of Programs. It is distributed to local agencies and visitor's bureaus throughout the Denver metropolitan area, at conferences and workshops, and is available at the Mesa Lab.

Thunderstorm Detectives

By the end of FY 1996, NCAR's first traveling exhibit, Thunderstorm Detectives toured eleven science centers and seven airports throughout the United States. An estimated 2 million visitors have explored the exhibit at science centers alone.

An interactive exhibit, Thunderstorm Detectives documents how scientists, mathematicians, engineers, and policy makers worked together to create the Terminal Doppler Weather Radar (TDWR) system that detects and warns aircraft pilots of microbursts and other dangerous weather conditions. The exhibit is composed of five modular components and occupies roughly 132 to 150 square meters. It includes towering photomurals, a simulated air traffic control tower, video footage of dynamic weather processes, computer-aided simulations, scientific tools, hands-on devices, an activities poster and profiles of individuals who developed the TDWR system.

Two identical copies of Thunderstorm Detectives, one for airports and one for science centers, were developed in 1993 by NCAR's exhibit staff with a grant from the National Science Foundation and with additional support from the Federal Aviation Administration. Its national tour was managed by the Association of Science Technology Centers (ASTC). One copy of Thunderstorm Detectives was purchased for permanent display at the Saskatchewan Science Center, Regina, Canada when the exhibit completed its scheduled tour at the end of August 1996. Visual Communications plans to incorporate elements of Thunderstorm Detectives into the permanent exhibit collection in the NCAR Mesa Lab lobby. A possible final airport venue at DIA or the expanded Colorado Springs airport is still under consideration.

Community Art Program

Irene Watts: *Dreamers (oil)*

This program, directed by **Visual Communications**, provides opportunities for local artists to publicly display their work at the Mesa Laboratory. During FY 1996, 92 artists (including 75 student artists) displayed their work in juried shows at the Mesa Laboratory.

As a part of a grant from the Scientific and Cultural Facilities District in celebration of Earth Day and National Science and Technology Week (NSTW), a special juried show, the Student Art Showcase featured K-12 students' art during the month of April. Students from throughout Boulder County submitted artwork in various media which touched on the 1996 NSTW theme "Design Connections through Science and Technology". Seventy-five student artist pieces were showcased. An informal awards reception was held to honor the students and their work. Over 250 student artists and their families attended the 1996 reception. An estimated 3,000 visitors to NCAR took in the month-long display.

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Project LEARN

Project LEARN (Laboratory Experience in Atmospheric Research at NCAR) completed its final year of funding from the NSF Teacher Enhancement Program. This experiential program for middle- and junior-high school science teachers trained teachers from eight school districts in four states (California, Colorado, North Carolina, and Texas). In FY 96, project staff completed teaching modules developed by the LEARN teachers and NCAR and UCAR scientists and staff. LEARN teachers adapted activities they had used previously in classrooms and created new lessons to include current scientific research in their teaching. The result is three modules which include background information, hands-on activities using simple materials, and authentic assessment tools. They are not designed to replace existing curricula or textbooks. Rather, they are intended to enhance earth and physical science programs by incorporating atmospheric science concepts. Two modules, titled **Ozone in Our Atmosphere** , **Atmospheric Dynamics** were published in FY 96. The third module **Cycles of the Earth and Atmosphere** will be published in FY 97.

Other activities during FY 96 included teacher inservices and publication of science information for educators. In collaboration with **SIRS, (Social Issues Resource Series, Inc.)** project staff continued **Science Now**, a publication for educators which highlights current research in atmospheric science. During FY 96 SIRS distributed three issues of the publication to more than 7,800 schools in the U.S. and abroad. Project staff worked with local LEARN teachers to present **Science Saturdays** as an ongoing inservice opportunity for teachers in Colorado. Six Saturday workshops highlighted topics in the atmospheric sciences, and 12 scientists gave presentations. The teachers attending were able to earn graduate credit from the University of Colorado School of Education for the series of day-long workshops on geosciences topics led by scientists from NCAR, UCAR Office of Programs., NOAA, EPA, the National Earthquake Center and Geological Society of America.

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Visual Communications

The primary goal of this program is to provide information and educational resources to UCAR and NCAR staff and the external community. In FY 1996, a Visual Communications **website** was developed to provide direct access to information on services and programs provided. These include:

Images:

Visual Communications provides NCAR- or UCAR-produced visuals (slides, photos, films, and videos) and specialized services to the UCAR staff, member and affiliate universities, scientific community, educators, librarians, publishers, and the media. Access to more than 1,000 images is available on-line on the **Digital Media Catalog**. The catalog has recently been expanded to include additional image categories on environment and education. Eighty new images and two new weather phenomena stock reel tapes were added to the collection as well.

Exhibits and Informal Education Activities:

Visual Communications shares responsibility for exhibit development and maintenance and other informal education activities. **Exhibits** displayed in NCAR's facilities as well as at sites around the U. S. are developed to communicate information about NCAR's and UCAR's research and accomplishments. Staff in the Visual Communications program provide support and assistance to the museum and educational community in interpreting scientific concepts and activities for public audiences.

In FY1996, Visual Communications developed and hosted two special public events as part of a Scientific and Cultural Facilities District (SCFD) collaborative with the Denver Museum of History, Denver Zoo, Colorado State Department of Education, Denver Botanical Gardens, and Boulder's Collage Children's Museum. The events, Super Science Saturday and the Student Art Showcase, were highly successful by all measurements and will be continued in 1997 through another SCFD funded collaborative effort with Boulder's Collage Children's Museum.

Super Science Saturday, held in conjunction with Project Learn's Science Saturday, offered a day of informal science activities, exhibits, and science demonstrations for the public. Special hands-on workshops for students (grades 5-12) and their teachers were conducted in relevant areas such as scientific illustration, nature photography, computer graphics, and environmental printing. NCAR scientists Peggy LeMone and Morris Weisman gave public presentations on "The Stories Clouds Tell" and "Chasing Tornadoes". Special activity tables from the five collaborating institutions were on site to supplement the Mesa Lab's own exhibits and displays. Over 800 students, parents, and teachers participated in NCAR's Super Science Saturday with 125 students and teachers attending the hands-on workshops.

The Student Art Showcase was planned as part of NCAR and the Boulder community's celebration of Earth Day and National Science and Technology Week. For the month of April, all NCAR public galleries were devoted to student art reflecting on the NSTW theme. Students K-12 from throughout Boulder County submited artwork. Seventy-five student pieces were selected for display by the NCAR Community Art Judging Committee. All displayed works received ribbons. Twelve outstanding works received special awards. An informal awards reception honoring the students and their work closed the event. Over 250 student artists and their families attended the 1996 reception. An estimated 3,000 visitors to NCAR took in the month-long display last April.

Community Art Program:

This program provides opportunities for local artists to publicly display their work at NCAR in galleries on the second floor lobby and in the cafeteria. During FY 1996, 92 artists (including the 75 student artists mentioned above) displayed their work in juried shows at the Mesa Laboratory. Samples of work displayed and a calendar of showings is available at the **Visual Communications** website.

Site Use:

Another responsibility of the Visual Communication program is management of site use for photographic purposes by non-UCAR entities. The program frequently responds to requests from local photographers and businesses who wish to use the NCAR site as a backdrop for photgraphs or videos. These requests are carefully screened and approved in accordance with UCAR guidelines. One special event in FY 1996 was the filming of part of a television movie on the NCAR mesa. Scenes from *Dying to Be Perfect: The Ellen Hart Pena Story* were filmed primarily on the Walter Orr Roberts Trail and adjoining trails around the mesa.

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Significant Opportunities in Atmospheric Research and Science (SOARS)

During FY 1996 UCAR, NCAR and UOP staff, and the university community combined efforts to inaugurate **Significant Opportunities in Atmospheric Research and Science (SOARS)**, an education outreach program that creates a pipeline to bring ethnically diverse students into careers in the atmospheric and related sciences, including engineering, mathematics and social sciences. With primary funding from the National Science Foundation (NSF) and supplemental funds from NASA, SOARS' goal is to significantly increase the number of traditionally underrepresented students of color enrolled in master's and Ph.D. degree programs in the atmospheric and related sciences, which ultimately will lead to an increase in their representation in the scientific community of the future. SOARS provides educational, research, mentoring, career counselling and financial support to students completing undergraduate programs and enrolling in masters and doctoral programs in the atmospheric and related sciences. **Thirty-nine universities** participated in SOARS in 1996.

In the spring of 1996, 12 undergraduates and one graduate student were selected from a pool of 144 applicants to participate in the **SOARS inaugural class**. Students were selected on the strength of their academic history, field of study, faculty recommendations and personal statement of interest. Most of the 144 applicants were eligible, well prepared academically and presented strong talents and personal strengths. Four of the 13 students are alumni of the UCAR Summer Employment Program (SEP). The SOARS inaugural class is diverse with respect to ethnicity, gender, college class and college major and represent a wide variety of schools from across the United States and Puerto Rico.

The inaugural class arrived in June 1996, and spent their first summer of research at UCAR, NCAR and UOP. The ten week summer research experiences provided proteges with opportunities to partner with scientific/technical mentors in ongoing research projects at UCAR's research facilities. Prior to arriving, SOARS proteges were assigned research projects, research/technical mentors, and community mentors from a pool of NCAR and UOP staff volunteers.

Participation in ongoing research is an essential activity for SOARS proteges. Successful completion of the summer portion of the SOARS program requires proteges to write their research project and present their research at a colloquium at UCAR, NCAR or UOP. A 10-week workshop in scientific/technical writing was an important element of the summer program. Proteges were assigned individual writing mentors to help them achieve program writing objectives. Proteges also benefited from the leadership and counsel of peer mentors. Peer mentors for undergraduates were proteges who had completed their bachelor degree programs under guidance of the project manager. All mentors and proteges participated in a mentoring workshop offered on site by the program manager, Tom Windham.

As an extension to mentoring, weekly community meetings and on-site counselling were provided to assist proteges in adjusting to the UCAR and Boulder environments and help with the transition from full-time college student to full-time student researcher. Additional formal summer educational opportunities included six colloquia presented by members of the UCAR, NCAR and UOP staff, an agency-wide panel on the status of women in science produced by four members of the SOARS protege cohort, individual graduate school and career counselling provided by NCAR senior scientists and an all-day GRE preparation workshop offered at the University of Colorado, Boulder. Several members of the SOARS program have or are scheduled to present their research at national scientific conferences. The research of one protege was cited at a national conference; an article featuring four proteges of Native American ancestry is in press; and a protege research paper submission is in progress. These activities evidence the achievement of SOARS primary program objectives of providing a mechanism whereby proteges can conduct hands-on research and participate in activities viewed as prerequisites for master's or doctoral degrees and careers in atmospheric and related sciences.

The inaugural year of SOARS represents an overall success. Formal and informal responses from proteges, mentors, and members of the UCAR, NCAR, UOP and university communities indicate that SOARS met its first year goals by:

- Increasing the number of ethnically-diverse, underrepresented students enrolled in master's and doctoral degree programs in the atmospheric and related sciences. As a direct result of SOARS and its predecessor, SEP, three members of the SOARS inaugural class are currently enrolled in master's degree programs and one member is enrolled in a doctoral degree program in atmospheric and related sciences.

- Increasing the number of traditionally underrepresented people of color in the scientific community of the future. As a direct result of the program and SEP, 13 SOARS proteges have made significant progress toward becoming eligible for membership in the scientific community of the future.

These accomplishments result from identifying, recruiting, and retaining 13 talented, capable, serious proteges with high interest and motivation to advance in the atmospheric sciences partnering with accomplished, supportive staff in a sophisticated research environment where the SOARS program goals are a high organizational priority. SOARS provides "real world" research experience under the guidance of scientific and technical mentors, academic education and training, mentoring, personal growth and enrichment. These elements, when presented and experienced within the context of community provide the SOARS program with a powerful structure and the program participants with a powerful experience.

Protege participation in active, significant research that takes place in a professional research environment was most frequently reported by scientific/technical mentors as the most valuable aspect of SOARS. Several of these mentors identified a supportive community wherein protege achievements are recognized as being highly valued. Valuing research, being a researcher, and doing it [research] well represent prerequisites for membership in good standing in the UCAR, NCAR, UOP scientific community. A supportive community is viewed as important to the acquisition and development of these attributes. Also mentioned as a highly valuable aspect of the program is meeting people from different cultures.

Proteges were viewed by researchers as mostly being "somewhat to more than adequately" prepared for their research project. Two mentors saw the demands of their research projects as exceeding the abilities of the proteges working with them. One mentor found his project to be not challenging enough. These mentors adjusted their research projects accordingly.

Proteges gave very high marks to the SOARS program and to their research and mentoring experiences. Proteges remarks include, "It [SOARS] far exceeded my expectations and was an invaluable experience;" and "It [SOARS] was one of the best experiences I've ever had." Their research projects were described as interesting and challenging. While most proteges were challenged by the requirements of their research projects, a few stated that their projects did not fully capitalize on their knowledge and performance abilities. Proteges expressed that their research experience provided them with information that will be helpful in making career choices. Several plan to continue to pursue research in the area of their summer projects; a few expressed interests in different research areas. SOARS proteges continue an active correspondence with the project manager, Tom Windham, as well as mentors, UCAR, NCAR and UOP staff, and one another.

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- High Altitude Observatory
- Research Applications Program
- Scientific Computing Division

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Research Applications Program

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Mueller, C.K., and F. McDonough, 1996: Extrapolation of thunderstorm growth and decay based on storm characteristics and boundary layer convergence lines. Preprints, *15th Conf. on Wea. Analysis and Forecasting,* Norfolk, VA, 19-23 August. Amer. Meteor. Soc., Boston.

Neilley, P.P., 1996: Using anemometers to detect and forecast turbulence at Hong Kong's new airport. Preprints, *Workshop on Wind Shear and Wind Shear Alert Systems,* Oklahoma City, 13-15 November. Amer. Meteor. Soc., Boston.

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Politovich, M.K., B.G. Brown, G. Thompson, R. Bruintjes, and B.C. Brown, 1996: Toward improved aviation forecast for icing. 34th Aerospace Science Meeting and Exhibit, Reno, NV, 15-18 January. American Institute of Aeronautics and Astronautics, Washington, D.C.

Politovich, M.K., and G. Thompson, 1996: A meteorologically-based icing severity index. *Proc. FAA Int'l Conf. on In-Flight Icing, Volume II: Working Group Papers.* Springfield, VA, 6-8 May. 375-385.

Roberts, R.D., 1996: Integration of WSR-88D and GOES-8 data for detecting and forecasting storm initiation. Preprints, *15th Conf. on Wea. Analysis and Forecasting,* Norfolk, VA, 19-23 August. Amer. Meteor. Soc., Boston, 287-290.

Sun, J., and N.A. Crook, 1996: Retrieval of the dynamical and microphysical variables in observed Florida convective storms using a cloud model and its adjoint. Preprints, *18th Conf. on Severe Local Storms,* San Francisco, 21-23 February. Amer. Meteor. Soc., Boston, 555-558.

Thompson, G., R. Bruintjes, and J.F. Bresch, 1996: Comparison of numerical model simulations and satellite observations of an upslope cloud system. Preprints, *12th Int't Conf. on Clouds and Precip.*, Zurich, 19-23 August. Amer. Meteor. Soc., Boston, 892-894.

Wilson, J.W., and D.L. Megenhardt, 1996: Thunderstorm initiation, organization and lifetime associated with convergence lines. Preprints, *15th Conf. on Wea. Analysis and Forecasting,* Norfolk, VA, 19-23 August. Amer. Meteor. Soc., Boston, 451-454.

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Scientific Computing Division

Refereed

Adams, J. C., *W. Brainerd, 1996: A Little History and a Fortran 90 Summary, in *Computer Standards and Interfaces* , Aug. 96, **1**

Swarztrauber, P. N., Spectral transform methods for solving the shallow water equations on the sphere, 1996: *Mon. Wea. Rev., **124,** pp. 730-744.*

*Swarztrauber, P. N., and *R. A. Sweet, 1996: Fourier and cyclic reduction methods for Poisson's equation, in Handbook of Fluids and Fluid Machinery, Schetz, J. A. and A. E. Fuhs, eds., John Wiley & Sons, New York, NY.*

Other

*Adams, J. C. , *W. Brainerd, and *C. Goldberg, 1996: Programmer's Guide to Fortran 90, third edition, Springer-Verlag, NY.*

*Adams, J. C., *W. Brainerd, and *C. Goldberg, 1996: Programmer's Guide to F, Unicomp, Inc., Albuquerque, NM.*

*Hammond, S. W., R. D. Loft, and *P. D. Tannenbaum, 1996: Architecture and Application: The Performance of the NEC SX-4 on the NCAR Benchmark Suite, August, National Center for Atmospheric Research, Boulder, CO. Also appearing in Proceedings of Supercomputing'96, November 17-22, 1996, Pittsburgh, PA.*

return to SCD or to Top

NCAR Director's Office

Gray, Gayl H. and Richard Rotunno, 1996: "Review of International Bibliography of Meteorology: From the Beginning of Printing to 1889." Bulletin of the American Meteorological Society, 77, 570-573.

Project LEARN (Laboratory Experience in Atmospheric research at NCAR), 1996: Atmospheric Dynamics: a Project LEARN Teaching Module. NCAR, pp. 91.

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Science Now1995-1996. Three issues on weather measurement systems, lightning, and clouds.

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Atmospheric Chemistry Division
Atmospheric Technology Division
Environmental and Societal Impacts Group
Mesoscale and Microscale Meteorology Division
Advanced Study Program
Climate and Global Dynamics Division
High Altitude Observatory
Research Applications Program
Scientific Computing Division

Atmospheric Chemistry Division

Editorships of Peer-Reviewed Journals

Guy Brasseur was the Editor-in-Chief for the *Journal of Geophysical Research (Atmospheres)*, 1992-1997.

John Gille and William Mankin served as Guest Editors of the *Journal of Geophysical Research* Special Issue on the Validation of UARS Sensors, 1996.

Jinxue Wang (along with P. B. Hays) was the Editor of the *Optical Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research II*, SPIE Proceedings, Vol. 2830, published by the International Society for Optical Engineering, 1996.

External Scientific, Policy or Educational Committees or Advisory Panels

Jack Calvert, Interagency Oxygenated Fuel Assessment, U.S. Office of Science and Technology, study of the impact of oxygenated fuels on urban carbon monoxide levels, 1995-1996.

Jack Calvert, Panel on the Atmospheric Effects of Aviation (PAEAN), National Research Council, a study of the potential effects of a large fleet of supersonic jets on the Earth's ozone column, 1993-1998.

Jack Calvert, Review Panel on Atmospheric Chemistry of the Hydrocarbons (RPACH), recommendations for improved chemistry of the alkenes and other hydrocarbons in atmospheric chemistry modules of models, 1996- .

Jack Calvert, Reactivity Scientific Advisory Committee (RSAC), California Air Resources Board, advisory group on the efficacy of reformulated gasoline use in reducing smog levels in urban areas, 1996-.

Jack Calvert, Atmospheric Chemistry Education Committee (ACE), American Geophysical Union, development of courses and faculty for the training of atmospheric scientists in the developing countries, 1994-.

Jack Calvert, Member of the Scientific Council of the International Global Atmospheric Chemistry (IGAC), planning of international research programs designed to elucidate global atmospheric chemistry, 1992-.

Chris Cantrell, NASA Instrument Panel Workshop, SRI International, July 1996.

Chris Cantrell, Atmospheric Sciences Section Nomination Committee, American Geophysical Union, 1996.

Michael Coffey, Observing Facilities Advisory Panel, National Science Foundation, 1995-1996.

Fred Eisele, Coordinating Committee for Aerosol Characterization and Process Studies Activity (ACAPS), International Global Atmospheric Chemistry (IGAC), advisory panel on future aerosol research, 1996.

Fred Eisele, Chair of STERAO-C Steering Committee, help to direct a photochemical research study planned on the WB-57, 1995.

David Erickson, Panel Member, United Nations Environment Program, 1994 -.

David Erickson, Member, Steering Committee, Global Emission Inventory Assessment, International Global Atmospheric Chemistry Program.

David Erickson, Advisory Board Member, Tropical Atmospheric Science Center, University of Puerto Rico, 1995 -.

David Erickson, Chairman, Air-Sea Interaction Group, Atmospheric Sciences Section, American Geophysical Union, 1996 -.

Rolando Garcia, Steering Committee on Gravity Waves, International Commission on the Meteorology of the Upper Atmosphere Steering Committee.

Claire Granier, Panel on Atmospheric Effects of Aviation, National Research Council, 1994 -.

Alex Guenther, Panel on Critical Assessment of the Role of Natural Emissions on Ozone Management, NARSTO, 1996-1998.

Alex Guenther, UN-ECE Task Force on Emission Inventories Nature Expert Panel, 1996-1997.

Alex Guenther, U.S. National Tropospheric Ozone Research Needs Panel, 1995-1997.

William Mankin, Steering Committee for the Network for Detection of Stratospheric Change, 1989-1996.

William Randel, Chair, Middle Atmosphere Committee, American Meteorological Society (AMS), 1996.

William Randel, Chair, Reference Climatology Committee, Stratospheric Processes and Their Role in Climate (SPARC), 1996.

William Randel, Stratospheric Temperature Trends Committee, Stratospheric Processes and Their Role in Climate (SPARC), 1996.

William Randel, Ozone Trends Committee, Stratospheric Processes and Their Role in Climate (SPARC), 1996.

William Randel, Chair, Atmospheric Sciences Committee on Atmospheric Dynamics, American Geophysical Union (AGU), 1996.

Jinxue Wang, Chair of the SPIE International Conference on Optical Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research, 1996.

Jinxue Wang, Aerospace and Sensing Technical Committee, SPIE, 1996.

Jinxue Wang, Chair, Aerosol, Chemistry and Meteorology Group at the EOS Test Sites Meeting, 1996.

Patrick Zimmerman, EPA Review Panel for grants related to atmospheric chemistry, 1995 -.

Awards

Jack Calvert was elected as a Fellow of the American Geophysical Union, 1996.

Fred Eisele (with Dr. George Mount) received the NOAA Environment Research Laboratories, Research Paper of the Year Award, 1996.

Guy Brasseur and Claire Granier received the NCAR Outstanding Publication Award, 1996.

Miscellaneous Service

Elliot Atlas served as the convenor of the Global Chemistry Survey activity of the International Global Atmospheric Chemistry Program, 1996-.

Alex Guenther served as Workshop Co-Chair and Organizer of the Advances in Biogenic VOC Research, 1996.

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Advanced Study Program

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Atmospheric Technology Division

Editorships of Peer-Reviewed Journals

David Parsons, an Editor of the *Journal of the Atmospheric Sciences* (November 1994- present; Associate Editor, 1993 to November 1994).

External Scientific, Policy, or Educational Committees or Advisory Panels

Tony Delany, EPA Advisory Panel, to review proposals for EPA air pollution funding (1995-present).

David Parsons, Technical Advisor for the Federal Coordinators Office, Working Group on Atmospheric Profiling (1991-present).

David Parsons, General Co-chair for the Committee on Tropospheric Profiling (September 1994-present).

David Parsons, Panel Member and Chair for the mesoscale section of the AMS Monograph on Severe Local Storms. (Member, July 1996-present; Chair, November 1996-present).

Awards

U.S. Patent No. 5,553,508 was awarded to W.F. Dabberdt, K.D. Norris, S.R. Semmer, A.C. Delany, and J.R. Fox for their design of a "Portable Intelligent Whole-Air Sampling System."

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Climate and Global Dynamics Division

Editorships

Mark Berliner, Associate Editor, *Journal of American Statistical Association*, 1996.

Gordon Bonan, Editor, *Climatic Change*, 1992; Associate Editor, *Global Change Biology*, 1994.

Byron Boville, Editor, *Journal of Geophysical Research*, 1992.

Grant Branstator, Associate Editor, *Journal of the Atmospheric Sciences*, 1994.

Peter Gent, Associate Editor, *Journal of Physical Oceanography*, 1992.

Filippo Giorgi, Co-Lead Author of Chapter 6, *1995 IPCC Climate Change Report*; Editorial Board, *Journal of Climate Research*,1989.

Jeffrey Kiehl, Editor, *Journal of Geophysical Research*, 1992.

William Large, Associate Editor, *Journal of Physical Oceanography*, 1992.

Linda Mearns, Editorial Board, *Climatic Change*, 1990; Editorial Board, *Journal of Climate Research*, 1989.

Gerald Meehl, Lead Author Chapter 6; Contributor, Chapters 5 and 8, *1995 IPCC Climate Change Report*, updated assessment.

David Pollard, Editorial Board, *Climatic Change Journal*, 1993.

Philip Rasch, Associate Editor, *Monthly Weather Review*, 1994; Editorial Panel Member, *Tellus*, 1992.

David Schimel, Consulting Editor, *Biogeochemistry, Ecological Applications*, and *Global Change Biology*.

Kevin Trenberth, Lead Author/Convening Lead Author Chapter 1, Contributor, Chapter 3, *1995 IPCC Climate Change Report*, updated assessment; Editor, *Earth Interactions*, 1996.

Joseph Tribbia, Editor, *Journal of the Atmospheric Sciences*, 1993.

Warren Washington, Editor, *Climate Dynamics*, 1986.

Tom Wigley, Editorial Board, *Climate Dynamics, Global Climate Change Digest, Mitigation and Adaptation Strategies for Global Change*; Editorial Advisory Board, *Encyclopedia of Climate & Weather*.

Scientific, Policy, or Education Committees and Advisory Panels/Boards

Maurice Blackmon, Chair, NCAR Climate System Model (CSM) Scientific Steering Committee, 1996; Chair, Board of Governors, Colorado Alliance for Science, 1995; Member, UCAR Education Committee, 1995; Science Team Member, NASA's Clouds and the Earth's Radiant Energy System (CERES); Co-Chair, Scientific Working Group, Atlantic Climate Change Project, 1993; Chair, Working Group on Natural Variability, Model Validation and Climate Diagnostics, Climate System Modeling Program; Member, AMS Committee on Climate Variations, 1991; Member, International Commission on Dynamical Meteorology; IAMAP; Working Group D, Medium and Large-Scale Dynamics.

Gordon Bonan, Co-Chair, Modeling Working Group for the Arctic Systems Science Program, 1995; Co-Chair, Land Modeling Working Group for the NCAR Climate System Model, 1996.

Byron Boville, Member, CSM Scientific Steering Committee, 1996; Co-Chair, Modeling Working Group for the Arctic Systems Science Program, 1995; Co-Chair of the NCAR Climate System Model (CSM) Project, 1993; Member, IAMAP Commission on the Meteorology of the Upper Atmosphere, 1991; Member, IAMAP Commission on the Meteorology of the Upper Atmosphere (ICMUA) Working Group on Modeling of the Middle Atmosphere, 1988; Member, Organizing Committee for the NATO Advanced Study Institute on Climate Modeling, 1996; Member, CMAP Science Advisory Council, 1994.

Grant Branstator, Member of National Research Council's U.S. Global Ocean-Atmosphere-Land System (GOALS) Panel, 1994; Member of the Ad Hoc Research Priorities Review Panel of NOAA's Global Ocean-Atmosphere-Land System (GOALS) Panel Program, 1996.

Frank O. Bryan, Executive Committee, U.S. Working Group on Numerical Modelling.

Scott Doney, U.S. JGOFS Steering Committee, 1993; U.S. JGOFS Time-Series Oversight Committee, 1996.

Ronald Errico, UCAR Steering Committee for the NOAA Visiting Scientist Program at NCEP and NESDIS, 1989; Organizing Committee for WMO Workshop on Limited Area and Variable Resolution Models held in Beijing, China, 1995.

Peter Gent, Member, CSM Scientific Steering Committee, 1996; Co-Chair of the NCAR Climate System Model (CSM) Project, 1996; Member of the World Meteorological Organization CLIVAR Ocean Panel.

Filippo Giorgi, Member of NCAR MM5/6 Advisory Committee, 1994; Member of the Project for Intercomparison of Regional Climate Simulations (PIRCS) Scientific Advisory Committee, 1994.

James Hack, Member, DOE Computer Hardware, Advanced Mathematics and Model Physics (CHAMMP) Science Team, 1991; Member, DOE U.S. Supercomputer Performance Evaluation Team, 1991; Member, DOE Computational Science Graduate Fellowship Program Advisory Panel, 1990; Member, NASA FIRE-III Science Team, 1995; Member, DOE Atmospheric Radiation Measurements (ARM) Science Team, 1991; Member, NSF Partnership for Advanced Computational Infrastructure (PACI) Review Panel, 1996.

James Hurrell, Member, Great Plains Regional Center of the National Institute for Global Environmental Change; Advisory Panel for National Meteorological Center's CDAS/Reanalysis Project; Member of AMS Committee on Meteorology and Oceanography of the Southern Hemisphere, 1995; Member of the GPS/Meteorology Advisory Committee, 1995.

Jeffrey Kiehl, National Academy of Sciences Climate Research Committee, 1994; Member of the International Global Aerosol Chemistry Committee on Aerosol Forcing, 1993; Member, DOE Atmospheric Radiation Measurements (ARM) Science Team, 1991; Member, Scientific Steering Committee of the NSF Science and Technology Center for Clouds, Chemistry and Climate (C4), 1994; Chairman, General Circulation Model (GCM) Validation Working Group at the Center for Clouds, Chemistry and Climate (C4), 1994; Member, National Academy of Sciences Panel on Aerosol Radiative Forcing and Climate, 1993; Member, Scientific Steering Committee, NCAR Climate System Modeling Project, 1996.

Timothy Kittel, Member, National Technical Advisory Committee, National Institute for Global Environmental Change (NIGEC), Department of Energy (DOE), 1996; Member, National Science Foundation Long-Term Ecological Research (LTER) Climate Committee, 1990; Science Team Member, Vegetation/Ecosystem Modeling and Analysis Project, 1993; Member, Climate Scenario Task Force, U.S. Department of Agriculture Forest Service's Global Change Research Program, 1994; Analysis Team Member, Model Evaluation Consortium for Climate Assessment (MECCA), 1992.

William Large, International World Ocean Circulation Experiment Science Steering Group, 1996; NASA Scatterometer Science Working Team, 1988; NCAR CSM Principal Investigator Group, 1994; NOAA CORC Site Review Committee, 1996.

Roland Madden, Member of the Advisory Board for Meteorologische Zeitschrift, 1995; Chairman, Advisory Panel to the National Climatic Data Center for the Comprehensive Aerological Reference Data Set (CARDS), 1993.

James McWilliams, Scientific Advisory Council of NSF Climate Modeling, Prediction and Analysis Program, 1990; U.S. World Ocean Circulation Experiment Scientific Steering Committee, 1994; Massachusetts Institute of Technology

Corporation Visiting Committee for the Department of Earth, Atmospheric, and Planetary Sciences, 1995.

Linda Mearns, University of Nebraska, Great Plains Regional Center, National Institute for Global Environmental Change (NIGEC) Proposal Review Committee, 1993.

Gerald Meehl, NCAR Climate System Model Principal Investigator Group, 1994; Chairman, Working Group 1, WCRP, 1995; Climate Variability and Predictability Numerical Experimentation, WCRP/CLIVAR NEG-2, 1995; Chairman, Coupled Model Intercomparison Project (CMIP) Panel, WCRP/CLIVAR, 1995; Climate Simulation Laboratory (CSL) Allocation Panel, 1995; Visiting Senior Fellow, University of Hawaii Joint Institute for Marine and Atmospheric Research, 1995; NCAR Climate and Global Dynamics Division Seminar Coordinator, 1995-1996.

Philip Rasch, Member, NSF Science and Technology Center for Clouds, Chemistry and Climate (C4), 1990; Head, Chemistry Modeling Group at the NSF Science and Technology Center for Clouds, Chemistry and Climate (C4), 1994; Member, AMS Committee on the Middle Atmosphere, 1995.

David Schimel, U.S. National Academy Committee on Global Change, Working Groups on Biological Systems and Dynamics, Earth System Models, Nutrient Fluxes, and Dynamics; Member, U.S. National Academy Committee on Global Change Research; UCAR Global Change Institute, steering committee, 1990; Committee on Global Change Research in China, National Academy of Sciences; National Research Council Committee on Atmospheric Chemistry; National Research Council Committee on Global Change Research; University of Colorado's Global Change and Environmental Quality Program Committee; International Geosphere-Biosphere Program: Task Force on Global Analysis, Interpretation and Modeling; Chairman, Biogeochemistry Panel, NASA Earth Observing System Project.

Starley Thompson, Smithsonian National Museum of Natural History, "Forces of Change" Exhibit, 1995; Circumpolar Arctic PaleoEnvironments (CAPE) Steering Committee, 1995; Project GLOBE Focus Group on Scientific Visualization, 1995; Committee on Transportation and a Sustainable Environment, Transportation Research Board, National Research Council, 1994; Committee on Global Environmental Change, American Geophysical Union, 1993; Electorate Nominating Committee, Section on Atmospheric and Hydrospheric Sciences, American Association for the Advancement of Science, 1993; National Science Foundation Paleoclimate of Arctic Lakes and Estuaries (PALE) Steering Committee, 1993; Committee on Glaciology of the U.S. National Academy of Sciences Polar Research Board, 1988; Advisor to the Atmospheric Sciences Guild of Sandia National Laboratory, 1992.

Kevin Trenberth, NOAA Panel on Climate and Global Change, 1987, and Member Executive Committee, 1991; NCAR Clouds in Climate Program, 1994; ECMWF ReAnalysis (ERA) Project Advisory Group, 1993; Climate Modeling Analysis and Prediction (CMAP) Science Advisory Council, 1993; Atmospheric Observation Panel for the Global Climate Observing System, 1994; COLA (Center for Ocean-Land-Atmosphere Studies) Scientific Advisory Committee, 1994, and Chair 1995; American Association for the Advancement of Science, Council Delegate, Section on Atmospheric and Hydrospheric Sciences, 1993; Global Ocean-Atmosphere-Land System (GOALS) Panel, 1994; Member, International CLIVAR Scientific Steering Group, 1995, and Co-chair, 1996; Member Joint AMS/UCAR Committee on "Awareness" Document, 1996.

Harry van Loon, STEP (Solar Terrestrial Energy Program) of ICSU, Working Group No. 5, Project Leader of Solar Terrestrial Oscillation Project, 1995.

Warren Washington, Member, National Science Board, 1995; Member, Secretary of Energy's Health and Environmental Research Advisory Committee, 1990; Chair, Secretary of Energy's Health and Environmental Research Subcommittee on Biological and Environment Research Program in the U.S. Global Change Research Program, 1995; Member, Modernization Transition Committee of the National Weather Service, U.S. Department of Commerce, 1993; Past President, American Meteorological Society, 1994; Member, Executive Committee of the American Meteorological Society Council, 1995; Chair, Fellows Committee, American Meteorological Society, 1995; Member, Board on Sustainable Development, National Research Council, 1995; Member, Advisory Panel, National Centers for Environmental Prediction, 1995; UCAR Committee on Education, 1995; Member, National Science Board Programs and Plans Committees: CPP Task Force on the Environment; CPP Task Force on Polar Issues; and Chair of the Merit Review Criteria Task Force, 1996.

Tom Wigley, Member, Climate and Paleoclimate Committee, American Geophysical Union, Atmospheric Sciences Section, 1996; Select Expert Committee on Economic Issues of Anthropogenic Climate Change, German-American Academic Council Foundation, 1995; ACACIA (A Consortium for the Application of Climate Impact Assessment) Planning

Committee, Electric Power Research Institute, 1994.

David Williamson, Chairman of CAS/JSC Working Group for Numerical Experimentation (WGNE), 1991; Member, DOE Computer Hardware, Advanced Mathematics and Model Physics (CHAMMP) Science Team, 1991; Member, UCAR Review Team on the Environmental Modeling Center of the National Centers for Environmental Prediction (NCEP), 1996; Member, External Review Panel of the Naval Research Laboratory Marine Meteorology Division, 1996; Elected Fellow, American Meteorological Society, 1984.

Professional Society Memberships

Barbara Bailey, American Statistical Association

Gary Bates, American Meteorological Society

Mark Berliner, American Statistical Association; American Association for the Advancement of Science; Institute of Mathematical Statistics; International Society for Bayesian Analysis

Thomas Bettge, American Meteorological Society

Maurice Blackmon, American Meteorological Society

David Blankinship, American Meteorological Society

Byron Boville, American Geophysical Union; American Meteorological Society; Canadian Meteorological and Oceanographic Society

Esther Brady, American Geophysical Union; The Oceanography Society

Frank Bryan, American Meteorological Society; American Geophysical Union; The Oceanography Society; IEEE Computer Society

Robert Chervin, American Association for the Advancement of Science; American Meteorological Society; American Physical Society; New York Academy of Sciences; The Oceanography Society

Anthony Craig, American Geophysical Union

Scott Doney, American Geophysical Union; The Oceanography Society; American Meteorological Society

Benjamin Felzer, American Geophysical Union; American Meteorological Society; Geological Society of America; Society of Sigma Xi

Peter Gent, American Meteorological Society; American Geophysical Union

Filippo Giorgi, American Geophysical Union

Christian Guillemot, American Geophysical Union

Tim Hoar, American Statistical Association; American Meteorological Society; American Geophysical Union

Jim Hurrell, American Meteorological Society; American Geophysical Union

Jeffrey Kiehl, American Geophysical Union; American Meteorological Society

Timothy Kittel, American Association for the Advancement of Science; American Geophysical Union; American Meteorological Society; Association of American Geographers; California Botanical Society; Ecological Society of America; International Association for Vegetation Science

John Lu, Institute of Mathematical Statistics

Roland Madden, American Meteorological Society; American Geophysical Union

Linda Mearns, American Association for the Advancement of Science; American Geophysical Union; American Meteorological Society; Association of American Geographers; Society of Sigma Xi

Gerald Meehl, American Meteorological Society; American Geophysical Union

Wendy Meiring, American Statistical Association; Institute of Mathematical Statistics

Chester Newton, American Meteorological Society; American Association for the Advancement of Science; American Geophysical Union

David Pollard, American Geophysical Union

Jian-Hua Joshua Qian, American Geophysical Union; American Meteorological Society

Philip Rasch, American Meteorological Society

Andrew Royle, American Statistical Association; Institute of Mathematical Statistics; Biometrics Society; Institute of Mathematical Applications of Grenoble

David Schimel, American Geophysical Union; Ecological Society of America

Anji Seth, American Geophysical Union

Dennis Shea, American Meteorological Society

Christine Shields, American Meteorological Society

Starley Thompson, American Association for the Advancement of Science; American Geophysical Union; American Meteorological Society

Kevin Trenberth, American Meteorological Society; American Association for the Advancement of Science; Royal Meteorological Society of New Zealand

Warren Washington, American Meteorological Society; American Association for the Advancement of Science; American Geophysical Union

John Weatherly, American Geophysical Union

Tom Wigley, American Geophysical Union

David Williamson, American Meteorological Society; Sigma Xi

Honors and Awards

Barbara Bailey, Lucas Award for Outstanding Service to the Biomathematics Graduate Program, North Carolina State University, 1996

Akira Kasahara, Fujiwara Award from the Japan Meteorological Society

Starley Thompson and Carter Emmart, 1995 NCAR Outstanding Performance Awards: Education, Honorable Mention

Kevin Trenberth, Honorary Fellow Royal Society of New Zealand

Warren Washington, E. B. Lemon Distinguished Alumni Award, Oregon State University, 1996

Christopher Wikle, Research Excellence Award, Iowa State University, 1996

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Environmental and Societal Impacts Group

Editorships of Peer-Reviewed Journals

Michael Glantz, Honorary Editorial Advisory Board, *Encyclopedia of Life Support Systems*, February 1996-present.

Michael Glantz, Editorial Board, *Global Environmental Change* (since 1990).

Michael Glantz, Editorial Board, *Colorado Journal of International Environmental Law* (since 1989).

Richard Katz, Contributing Editor, Current Index to Statistics, 1992 - present.

Richard Katz, Editorial Board, Climatic Change, 1985 - present.

Scientific, Policy, or Educational Committees, Advisory Panels, Boards

John Firor, Fellow of the American Meteorological Society (AMS).

John Firor, Fellow of the American Association for the Advancement of Science (AAAS).

John Firor, Member of the advisory board of the Natural Resources Law Center, University of Colorado, Boulder, Colorado.

John Firor, Member of the Boards of Trustees of the World Resources Institute (Vice Chair of the Board), the Environmental Defense Fund (chair of its Rocky Mountain Advisory Board), and Zero Population Growth (chair of nominating committee).

John Firor, Advisor to the Winslow Foundation, a foundation making grants for environmental studies and activities.

Michael Glantz, invited participant at NOAA/OGP International Forum on Forecasting El Niño: Launching an International Research Institute, held 5-8 November 1995 in Washington, DC.

Michael Glantz, Member of the Independent Commission on Environmental Education, a program of the George C. Marshall Institute. Attended meeting in Washington, DC 7-9 February 1996.

Michael Glantz, invited participant at the NOAA Senior Leadership Retreat to reassess NOAA goals, activities, mission, and key future challenges, 13-15 March 1996 in Easton, Maryland.

Michael Glantz, Member of the Scientific Advisory Panel, Southeast Asian Regional Committee for START (Global Change System for Analysis, Research and Training).

Michael Glantz, Member of the Scientific Advisory Committee (SAC) for the World Climate Impact Assessment and Response Strategies Programme (WCIRP) of UNEP.

Michael Glantz, Member of the Steering Committee, Center for Environmental Journalism, University of Colorado, Boulder, Colorado.

Roger Pielke, Jr., Member of the Committee on Societal Impacts, American Meteorological Society.

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High Altitude Observatory

Editorships of Peer Reviewed Journals

Peter A. Fox, Associate Editor, *Fundamentals of Cosmic Physics*, 1993

Peter A. Gilman, Member of Editorial Board, *Geophysical and Astrophysical Fluid Dynamics*, 1980-1995; Member of Editorial Board, *Solar Physics*, 1987

Maura E. Hagan, Associate Editor, *Geophysical Research Letters*, 1993

Thomas E. Holzer, Associate Editor, *Journal of Geophysical Research* (Space Physics), 1994

Boon Chye Low, Member of Board of Editors, *Solar Physics*, 1992

Arthur D. Richmond, Member, Editorial Board, *Journal of Geomagnetism and Geoelectricity*, 1993

Gary J. Rottman, Member of the Board of Editors, *Glossary of Meteorology*, 1994

Paul Song, First Editor, "Physics of the Magnetopause", *AGU Monograph Volume 90*, 1993

Scientific, Policy, or Educational Committees and Advisory Panels or Boards

Paul Charbonneau, NASA SR&T Committee, 1995; NASA ATP Committee, 1996

Barbara A. Emery, Ionosphere-Thermosphere-Mesosphere-Stratosphere Subgroup of the NASA Space Physics Data System (SPDS), January 1994-present

Peter A. Fox, SunRISE Scientific Steering Committee, 1994-present

R. Daniel Gablehouse, Boulder Valley Public Schools Science and Engineering Fair Committee, 1985-89, 1991-1996

Peter A. Gilman, GONG Scientific Advisory Committee, 1985-present

Maura E. Hagan, NRC Committee of Solar Terrestrial Research, 1996-1999

Thomas E. Holzer, Scientific Advisory Committee, Max-Planck-Institut für Aeronomie, Lindau, Germany, 1996-98; Vice-Chair, Solar Physics Division of the American Astronomical Society, 1992-93, 1995-96; Chair, Cosmic and Heliospheric Management Operations Working Group, Space Physics Division, NASA, 1992-1995; Space Physics Subcommittee: Advisory to the Director of the Space Physics Division, NASA, 1991-1995

Michael Knölker, Association of Universities for Research in Astronomy (AURA) Solar Subcommittee, 1995-present

Bruce Lites, NASA Solar-B Science Definition Team, 1994-1996; NSO User's Committee, 1993-1996; NASA New Mission Concepts Panel Review, 1996; National Solar Observatory User's Committee, 1992

Boon Chye Low, Member of Organizing Committee for 2 Solar Magnetism Initiative Workshops sponsored by NCAR and NSF1995-96; Member of NSF/ATM Space Weather Proposal Selection Committee; Member of Center for Integrated Plasma Studies, University of Colorado

Gang Lu, Associate, Center for Integrated Plasma Studies, University of Colorado, July 1996-present

Keith B. MacGregor, NASA SR&T Panel for Solar Physics (Theory), FY 1996; NASA Review Panel for Astrophysics Data Program, FY 1996

Arthur D. Richmond, Member, NRC Committee on Solar and Space Physics, 1993-96; Member, Groupe International de Recherche en Geophysique Europe Afrique GIRGEA, 1995-present; Member, Scientific Advisory Committee, European Incoherent Scatter Scientific Association, 1995-96; Member, subgroup of the Scientific Committee on Solar-Terrestrial Physics to define the international research program "Equatorial Processes Including Coupling (EPIC)", 1996; Scientific Advisory Committee, Oersted Satellite, 1995-present

Raymond G. Roble, Advisory Board, Geophysical Institute, University of Alaska, 1985-present

Gary J. Rottman, UARS Science Team, 1980-96; EOS Science Team, 1989-96; Working Group 3 Chair of SOLERS22, 1990-96

Paul Song, AGU US/Canada Regional Advisory Committee, 1994-98

Oran R. White, NSO Users Committee, 1991-96; Association of Universities for Research in Astronomy, Inc. (AURA) Board, Solar Subcommittee, 1995-present; SunRISE Precision Solar Photometric Telescope (PSPT) Steering Committee, 1992-present; NOAA Solar Prediction Panel, Sept. 10-28, 1996

Thomas N. Woods, NASA TIMED Team, 1993-96; SOLERS22 Working Group Chair, 1990-96; NASA UARS Team, 1987-96

Honors

Thomas E. Holzer, Norwegian Academy for Science and Letters in the class of Mathematics and Natural Sciences; Fellow, American Geophysical Union

Raymond G. Roble, Fellow, American Geophysical Union; 1996 Arctowski Medal, National Academy of Science

Awards

Andrew P. Skumanich, Post-Rouge appointment by CNRS at Lab de Physique, Solaire, Obs. Meudon, France

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Mesoscale and Microscale Meteorology Division

Editorships of Peer Reviewed Journals

Christopher Davis, Associate Editor, *Monthly Weather Review*, 1994 to present.

Andrew Heymsfield, Editor, *Atmospheric Research*, 1992 to present.

Margaret LeMone, Co-Editor, Series of articles (on current status of the atmospheric sciences) in *Bulletin of the American Meteorological Society*, 1994 to present.

Donald Lenschow, Editorial Board, *Journal of Atmospheric Chemistry*, 1990; Editorial Board, *Boundary-Layer Meteorology*, 1995 to present.

Chin-Hoh Moeng, Associate Editor, *Journal of the Atmospheric Sciences*, 1992 to present.

Piotr Smolarkiewicz, Editor, *Monthly Weather Review*, 1994 to present.

Committees/Advisory Boards

Roelof Bruintjes, International Committee on Cloud Physics, 1992 to 2000; AMS Cloud Physics Committee, 1993 to 1997; American Society of Civil Engineers (ASCE) Weather and Climate Committee, 1994 to present.

Christopher Davis, Winter Icing in Storms Projects (WISP) Steering Committee, NCAR, 1995-1996; USWRP Prospectus Development Team, 1996; Chair of AMS Mesoscale Committee, 1993-1996.

James Dye, AGU Committee on Atmospheric and Space Electricity, 1994 to present.

Robert Gall, Center for Analysis and Prediction of Storms (CAPS) Advisory Panel, 1991 to present; Fronts and Atlantic Storm Track Experiment (FASTEX) Core Steering Group, 1994 to present; FASTEX Science Steering Group, 1994 to present.

Wojciech Grabowski, AMS Cloud Physics Committee, 1995-1998.

Joseph Klemp, COMET Advisory Panel, NCAR, 1990-1996; USWRP Scientific Advisory Committee, 1995-1998; Chair, COMET Scientific Review Panel, NCAR, 1995-1998; Chair, AMS Information Systems Committee, 1994-1998; AMS Publications Commission, 1987-1998; Comparison of Mesoscale Prediction and Research Experiment (COMPARE) Planning Committee, 1991-1997.

Margaret LeMone, National Academy of Sciences, Board of Atmospheric Sciences and Climate (BASC), 1992 to present; SOARS Advisory Panel, 1996 to present; UCAR Education Advisory Panel, 1996 to present.

Donald Lenschow, NASA Global Tropospheric Experiment Science Panel, 1990 to present.

Chin-Hoh Moeng, FIRE Science Team, 1989 to present.

Mitchell Moncrieff, Global Energy and Water Cycle Experiment (GEWEX) Cloud System Study (GCSS) Science Panel, 1992 to present; Chair, GCSS Working Group on Precipitating Convective Cloud Systems, 1992 to present; Atmospheric Radiation Measurement (ARM) Tropical Pacific Advisory Panel, 1994 to present; Cooperative Institute for Mesoscale Meteorological Studies (CIMMS) Review Panel, 1991 to present; Coupled Ocean-Atmosphere Response Experiment 1998 (COARE98) Organizing Committee, 1996 to present; Maritime Continent Thunderstorm Experiment (MCTEX) Steering Committee, 1993 to present.

Honors

Morris Weisman, Centennial Fellow, Penn State University.

Awards

Morris Weisman, NCAR Outstanding Performance Awards: Outstanding Publication Award, Honorable Mention.

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Research Applications Program

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Scientific Computing Division

Jeanne Adams was co-editor of the journal issue on Fortran 90 of "Computers and standards" and contributed an article. She participate in the Fortran Standards committee (X3J3) and is a member of the International Fortran Working Group under ISO.

Brian Bevirt is a member of the Association for the Advancement of Computing in Education and served as an Editor Mentor for two students in UCAR's SOARS program.

Bill Buzbee served as: Program Chair, SC96; Steering Committee for ACM/IEEE Supercomputing Conferences; and is a Member of the IEEE Supercomputing Subcommittee.

Ginger Caldwell is a Member of the Association of Computing Machinery and the American Management Association. She is also a member of the Supercomputing '95 and Supercomputing '96 Education Program Advisory Committee.

Fred Clare is a member of the ACM, SIGGRAPH, and the IEEE Computer Society.

Rachelle Daily serves as Secretary, Executive Board, IEEE Computer Society, Mass Storage Technical Committee.

Chris Fair and Marla Meehl serve on the vBNS Technical Consultation Committee (vTCC) Chris Fair and Marla Meehl served on the NSF High Performance Connection Panel.

Karen Friedman received the IEEE Computer Society Golden Core Member Award and served on SC95 (still serving on SC97) Executive Committee.

Sally Haerer served on: SC'96 Executive Committee - Technical Papers and Invited Speakers Chair; Parallel Tools Consortium Steering Committee; Cray User Group Board of Directors and Advisory Council - Vice President; is a member of IEEE Computer Society; and is a Program Committee Member of IAI Workshop, Boulder.

Steve Hammond was a member of the technical papers committee for Supercomputing 96 held in Pittsburgh, PA Nov. 1996 and was a member of the student paper award committee for Supercomputing 96.

Steve Hammond and Paul Swarztrauber were on the organizing committee for the Fifth Workshop on Numerical Solutions of Fluid Flow in Spherical Geometry, Breckenridge, Colorado, June 12, 1996.

Roy Jenne continues to serve on the following advisory panels: Academy CES satellite committee; Advisory Panel for Goddard DAAC (Data System); and the Science Council for Earth Sciences for USRA (University Space Research Association) (through November 1999). Jenne also Chaired Negotiations on Working Group VIII Data Exchange, August 1996; is Head of US side of US-Russia data exchange under Working Group VIII bilateral (1980-1996).

Jeff Kuehn is Chair, Special Interest Committee for Performance and Evaluation, Cray User Group, Inc. (elected); Advisory Council Member, Cray User Group, Inc. (appointed); Steering Committee Member, Parallel Tools Consortium (appointed); Supercomputing '96, Technical Papers Reviewer. Kuehn also is a member in IEEE Computer Society ACM (Association for Computing Machinery) Usenix Association.

Lynda Lester became the new editor of CUG.log, the international newsletter of the Cray User Group. She also served on Supercomputing 96 executive committee as photographer/producer of a multimedia documentary on "The Making of Supercomputing '96." Lester's is also a Member of the Society for Technical Communication. Lester's Awards include: a "Distinguished Award" and an "Award of Excellence" at the regional level and an "Award of Excellence" at the international level from the Society for Technical Communication for "SCD Computing News" and the "SCD Information Resources Catalog."

Marla Meehl and Paul Hyder serve on the Westnet Steering Committee. Marla Meehl served on the US West Cell Relay Service Customer Advisory Panel.

Bernie T. O'Lear is chair of the Mass Storage Systems Technical committee for the IEEE Computer Society. He also set up and participated in the meeting of CATI (Colorado Advanced Technology Institute), the State of California GIS management group, several Colorado Universities faculty members, and Colorado State government officials. The objective is to develop distributed data bases and backups for an expanded land use information network for both Colorado and California. O'Lear also served as a reviewer for a Report of the Working Group on Large Storage I/O Issues in Large-Scale Computing.

Steve Worley served on the Steering committee for 2nd Annual Data Management Working Group Workshop, Asheville, N.C. Representing NSF November 11-15, 1996.

The NCAR Graphics Group won an Award of Excellence for NCAR Graphics 4 Interactive Documentation in the regional Society for Technical Communication (STC) Online Communication Competition. This entry then went on to STC's International Online Communication Competition, where it won an Award of Merit.

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NCAR Director's Office

Editorships:

Karon Kelly
Meteorological and Geoastrophysical Abstracts, 1992-

Membership on Advisory Boards:

Linda Carbone
Rocky Mountain Discovery Center Board of Directors, 1995-1998.
Informal Science Alliance, 1996-

Leslie Forehand
Boulder Area Librarians Network, 1995-

Gayl H. Gray
Bibliographical Center for Research Board of Directors, 1995-1997.
Colorado Interlibrary Loan Committee, 1996-.

Karon Kelly
Carol McLaren
Rocky Mountain Discovery Center Board of Directors, 1994-1997
Space Science Institute Board of Directors, 1994-1998

Tom Windham
Graduate School Advisory Council, University of Colorado, Boulder, 1994-1997.

Awards:

Margaret E. LeMone (MMM)
1996 UCAR Outstanding Performance Award for Education

Guy Brasseur and Glaire Granier (ACD)
1996 UCAR Outstanding Publication Award

"Mt. Pinatubo Aerosols, Chlorofluorocarbons, and Ozone Depletion"

William Skamarock, Morris Weisman and Joseph Klemp (MMM)
Honorable Mention 1996 UCAR Outstanding Publication Award

"3-Dimensional Evolution of Simulated Long-lived Squall Lines"

Greg McArthur (SCD)
1997 UCAR Outstanding Performance Award for Administrative Support

Promotion of the use of the World Wide Web at UCAR

Mitch Baltuch, Glenn Davis, Steve Emmerson, and Robb Kambic (UNIDATA)
1996 UCAR Outstanding Performance Award for Technical Support

Development and Deployment of the Internet Data Distribution System

Chuck Frush, Peter Hildebrand, Wen-Chau Lee, Eric Loew, Richard Neitzel, Rick Parsons, Mitch Randall and Craig Walther (ATD)
1996 UCAR Outstanding Performance Award for Technology Advancement

ELDORA Radar development

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT

ATMOSPHERIC CHEMISTRY

ACD Director's Message

The overall ACD objective is to foster improved understanding of chemical processes that affect the Earth's atmosphere. This is accomplished through interdisciplinary studies that probe the complex interactions between oceans, land, ecosystems, and the atmospheric interface they share. ACD serves the broader scientific community through model development, collaborative studies, implementation of aircraft instrumentation, and development of satellite data and instrumentation. ACD maintains a balance between theoretical and experimental research techniques while developing a hierarchy of numerical models to both interpret measurements and extend our understanding to future predictions.

ACD was involved in a large number of field studies during FY96 where many new instruments were successfully applied. Our new airborne OH/H_2SO_4/MSA instrument was flown for the first time on the Aerosol Characteristics Mission (ACE-I) and later in the Pacific Exploratory Measurements (PEM-Tropics) study with great success. This instrument provided the first aircraft measurements of OH and H_2SO_4 in the lower and mid troposphere and the first real-time measurements of gas phase MSA. Another new instrument, a two-channel spectroradiometer, was also constructed, calibrated, and flown on the NASA DC-8. Participation in the Vortex Ozone Transport Experiment (VOTE) and Tropical Ozone Transport Experiment (TOTE) investigated transport from the polar vortex to mid-latitude regions and possible heterogeneous processes. Participation in Subsonic Aircraft: Contrail and Cloud Effects Special Study (SUCCESS) focused on particle formation and aerosol chemical processes in cirrus clouds, wave clouds, and aircraft contrails. An airborne TDL system was developed and first deployed in the North Atlantic Regional Experiment (NARE) where aircraft measurements of HCHO were acquired as part of a suite of photochemically-related species and parameters to study O_3 photochemistry and transport processes. A sensitive real-time selected ion chemical ionization mass spectrometric (SICIMS) measurement technique for HNO_3 was also recently developed and field tested.

This was also the year for the first Stratosphere-Troposphere: Radiation, Aerosols, and Ozone (STERAO) field intensive where a combination of aircraft, radars, lightning interferometer, and ground based field mills were involved. A four channel chemiluminescence instrument was designed and built to fly on the WB-57F. We also developed a tunable diode laser (TDL) for STERAO to simultaneously measure CO and N_2O and help distinguish between transport and chemical and physical transformations. Lower altitude regions were probed with the NOAA P-3 aircraft while the anvil region of the storms were probed with the University of North Dakota Citation jet. A variety of models from NOAA, NCAR's MMM Division, and the University of Maryland were used for storm prediction and analysis.

Experiment for Regional Sources and Sinks of Oxidants (EXPRESSO) efforts included aircraft test flights, infrastructure development, and field measurements at a field site in the Northern Congo. Multiple visits to Africa resulted in the building of a road, setting up a field laboratory, constructing a 65-m tower through the forest canopy, and characterizing the forest landscape. Initial measurements of methane fluxes, VOC emissions from vegetation, and isoprene at the field site indicated that hydrocarbon fluxes from this site are lower than expected.

Modeling studies to develop and use a range of models, from the mesoscale to the global scale, have advanced considerably in the past year, including the implementation of detailed chemistry in the Climate System Model (CSM). In addition, research studies have focused on topics such as the impact of biomass burning on tropospheric ozone, effects of subsonic aircraft, and the increases in surface radiation and changes in tropospheric chemistry due to ozone depletion.

Development of satellite instrumentation and algorithm has also advanced together with concurrent scientific analyses. A range of questions relating to the database from the Upper Atmosphere Research Satellite (UARS) have been addressed, including development of algorithms to infer information about aerosol distributions that are critical for stratospheric chemistry.

Through this coordinated research and implementation approach, ACD continues to serve the scientific objectives of a variety of national and international programs of interest to the broad community, particularly the Global Tropospheric Chemistry Program (GTCP).

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FY 1996 Science Highlights

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H I G H L I G H T S

- The OH/H_2SO_4/MSA airborne instrument with advanced design inlet was completed, test flown, and deployed with outstanding success. It flew on both the ACE-I aerosol and PEM-Tropics photochemistry studies providing the first OH and H_2SO_4 airborne measurements in the lower and mid troposphere and the first real-time measurements of gas phase methanesulfonic acid (MSA).

- Gas-to-particle conversion processes observed in the remote marine troposphere were found to be inconsistent with classical nucleation theory with particle production rates proportional to the square of the sulfuric acid concentration. This is important because it changes our view of when, where, and how new particles are formed in the majority of the troposphere.

- Modeling the response of stratospheric ozone to volcanic eruptions suggests that the temporary ozone decrease observed after Mt. Pinatubo and El Chichón appear to have been unique in history and the direct result of anthropogenic chlorine.

- Preparation for the EXPRESSO (Experiment for Regional Sources and Sinks of Oxidants) field program included French aircraft test flights, infrastructure development (road building, setting up a field laboratory, constructing a 65-m tower) and field measurements at a field site in the Congo. Early results indicate that hydrocarbon fluxes from this site are less than in the Brazilian rainforest and lower than expected.

- ACD participated in a large number of field campaigns in both oceans and on various continents. These included the Vortex Ozone Transport Experiment (VOTE), the Tropical Ozone Transport Experiment (TOTE), the Subsonic Aircraft: Contrail and Cloud Effects Special Study (SUCCESS), the North Atlantic Regional Experiment (NARE), the Aerosol Characteristics Experiment (ACE), the Experiment for Regional Sources and Sinks of Oxidants (EXPRESSO), the Stratospheric Tracers of Atmospheric Transport (STRAT), and the Stratosphere-Troposphere: Radiation, Aerosols, and Ozone (STERAO-A)

- Further progress was made in developing an accurate technique for the measurement of HNO_3. A sensitive real-time selected ion chemical ionization mass spectrometric (SICIMS) measurement technique was developed and field tested. Its intercomparison with another SICIMS technique and a filter pack technique resulted in very good agreement between the SICIMS systems, but some discrepancies with an existing filter technique.

- Comparing Total Ozone Mapping Spectrometer (TOMS) measurements with models show that stratospheric temperatures are correlated with the severity of ozone depletion. Enhanced heterogeneous conversion associated with

cold temperatures can explain part of observed northern hemisphere ozone depletions as well as strong interannual variations over Antarctica.

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT

EDUCATIONAL ACTIVITIES

ACD EDUCATION ACTIVITIES

October 1, 1995 through September 30, 1996

I. Staff Appointments to NCAR for categories below. (ASP Postdocs reported only by ASP)

A.	Postdoc Fellowships:	Institution Represented	Post Doc Program	Agency	Amount	Number
		NOAA				1
		U. of Michigan				2
		U. Catholic de Louvain, Belgium				1
		U. of Colorado				2
		U. of Alaska				1
		Unaffiliated				2

B.	Graduate Research Assistants:	Institution Represented	Competitive Program	Agency	Amount	Number
		U. of Brussels				1
		State U. of New York at Albany				1
		U. of Colorado				2
		U. of California, Los Angeles				1
		Iowa State U.				1

C.	Undergraduate Students:	Institution Represented	SOARS	Agency	Amount	Number
		Metropolitan State U.				1
		U. of Colorado				1

II. Formal Teaching Arrangements of NCAR Staff with Colleges or Universities						
A.	**Teaching Appointments:**	**Staff Member**	**Institution**	**Agency**	**Amount**	**Number**
	Lecturer	Guy Brasseur	U. of Brussels			1
	Lecturer	Elisabeth Holland	U. of Colorado			1
	Lecturer	Elisabeth Holland	Colorado State U.			1
	Adjunct Faculty	Rolando Garcia	U. of Colorado			1
B.	**Advising on Graduate Research:**	**Staff Member**	**Institution**	**Agency**	**Amount**	**Number**
	Supervising student	Guy Brasseur	U. of Brussels			1
	Supervising student	Anne Smith	U. of Colorado			1
	Supervising student	Anne Smith	U. of California, Los Angeles			1
	Supervising student	William Randel	Iowa State U.			1
	Supervising student	Elisabeth Holland	Colorado State U.			1
	Supervising student	Geoffrey Tyndall	U. of Colorado			1
	Supervising student	John Gille	U. of Colorado			1
C.	**Member of Thesis Committee:**	**Staff Member**	**Institution**	**Agency**	**Amount**	**Number**
	Thesis committee	Guy Brasseur	U. of Paris 6			1
	Thesis committee	Guy Brasseur	U. of Michigan			1
	Thesis committee	Guy Brasseur	Mass. Inst of Tech.			1
	Thesis committee	Guy Brasseur	U. of Brussels			1
	Thesis committee	Guy Brasseur	U. of Reims (France)			1
	Co-Chair, Thesis committee	Anne Smith	U. of Michigan			1
	Thesis committee	William Randel	Iowa State U.			1
	Thesis committee	Sasha Madronich	U. of Chicago			1
	Thesis committee	Alex Guenther	U. of Colorado			1
	Thesis committee	Lee Klinger	U. of Colorado			1
	Informal advisor	Elisabeth Holland	U. of Colorado			1
	Thesis committee	Elisabeth Holland	Stanford U.			5
	Thesis committee	Elisabeth Holland	Colorado State U.			1
	Thesis committee	Rolando Garcia	U. of Colorado			1
	Informal advisor	Geoffrey Tyndall	U. of Colorado			3

	Thesis committee	John Gille	U. of Colorado			1
III. Workshops and Colloquia sponsored by NCAR						
	Title/Subject	**Date**	**Sponsor**	**Agency**	**Amount**	
	TOTE/VOTE Science Team Mtg	10-12 June 1996	NASA			
	4th Int. Cloud Modeling Workshop	12-16 August 1996	WMO			
	Sulfate aerosol research	27-28 February 1996	NCAR			
	NARSTO Biogenic Emision Workshop	22-23 August 1996	EPA			
	Biosphere-atmosphere interactions	July, 1996	NCAR			
	Chapman Conference	1 September 1996	AGU			
	Gravity wave processing models	1-6 April 1996	NATO			
	Ultraviolet radiation modeling	January 1996	AMS			
	Overview of existing models	2-11 October 1995	NATO			
	Action spectra and UV calculations	2-11 October 1995	NATO			
	Ultraviolet radiation	March 1996	National Institute of Water and Atmospheric Research			
	Seminars on modeling results	December 1995	AGU			
IV. Seminars and Presentations						
A.	**Scientific or Technical Seminars and Presentations**					
	At NCAR or elsewhere for NCAR or non-NCAR audiences for less than full day. Includes Division					
	seminar series only if attended by non-employees.					
	see attached list of ACD Seminar series					
	Total Number =32 (not including division seminars)					
B.	**Non-Technical Presentations**					
	(Schools, Community groups, etc.)					

	Total Number = 2					

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT

PUBLICATIONS

Atlas, E. and B. Ridley, 1996: The Mauna Loa Observatory Photochemistry Experiment: Introduction. *J. Geophys. Res*., **101**, 14,531-14,541.

Atlas, E., B. Ridley, J. Walega, J. Greenberg, G. Kok, T. Staffelbach, S. Schauffler et al., 1996: A comparison of aircraft and ground-based measurements at Mauna Loa Observatory, Hawaii, during GTE PEM-West and MLOPEX 2. *J. Geophys. Res*., **101**, 14,599-14,612.

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Brasseur, G., J. Gille and S. Madronich, 1995: Ozone depletion. Future Climates of the world: a modelling perspective. *World Survey of Climatology*, A. Henderson-Sellers, Ed., Elsevier, **16**, 399-432.

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Springer-Young, *M., D. Erickson III and *T. Carsey, 1996: Carbon monoxide gradients in the marine boundary layer of the North Atlantic Ocean. *J. Geophys. Res*., **101**, 4479-4484.

Taylor, *J., P. Zimmerman and D. Erickson III, 1996: A 3-D modelling study of the sources and sinks of atmospheric carbon monoxide. *Ecolog. Model*., **88**, 53-71.

Townsend, *A. R., *B. H. Braswell, E. A. Holland and *J. E. Penner, 1996: Spatial and temporal patterns in terrestrial carbon storage due to deposition of fossil fuel nitrogen. *Ecolog. Appli*., **6**(3), 806-814. Xu, *Y., *A. McKellar, *J. Burkholder and J. Orlando, 1996: High-resolution infrared spectrum of the ν_1 and ν_3 bands of dichlorine monoxide, Cl_2O. *J. Molec. Spectro*., **175**, 68-72.

Non-Refereed

Apel, E., J. Calvert, *R. Zika, *M. Rodgers, *V. Aneja, *J. Meagher and *W. Lonneman, 1995: Hydrocarbon measurements during the 1992 southern oxidants study Atlanta intensive: Protocol and quality assurance. *Proceedings of Regional Photochemical Measurement and Modeling Study*, San Diego, Nov. 7-12, 1993, Air & Waste Management Assoc., 3.

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COMMUNITY SERVICE

Editorships of Peer-Reviewed Journals

Guy Brasseur was the Editor-in-Chief for the *Journal of Geophysical Research (Atmospheres)*, 1992-1997.

Alan Fried, Editor of SPIE Conference Proceedings, Vol. 2834, 1996.

John Gille and William Mankin served as Guest Editors of the *Journal of Geophysical Research* Special Issue on the Evaluation of UARS Data, 1996.

Brian Ridley served as the American Editor of the *Journal of Atmospheric Chemistry*, 1994 -.

Jinxue Wang (along with P. B. Hays) was the Editor of the *Optical Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research II*, SPIE Proceedings, Vol. 2830, published by the International Society for Optical Engineering, 1996.

External Scientific, Policy or Educational Committees or Advisory Panels

Jack Calvert, Interagency Oxygenated Fuel Assessment, U.S. Office of Science and Technology, study of the impact of oxygenated fuels on urban carbon monoxide levels, 1995-1996.

Jack Calvert, Panel on the Atmospheric Effects of Aviation (PAEAN), National Research Council, a study of the potential effects of a large fleet of supersonic jets on the Earth's ozone column, 1993-1998.

Jack Calvert, Review Panel on Atmospheric Chemistry of the Hydrocarbons (RPACH), recommendations for improved chemistry of the alkenes and other hydrocarbons in atmospheric chemistry modules of models, 1996- .

Jack Calvert, Reactivity Scientific Advisory Committee (RSAC), California Air Resources Board, advisory group on the efficacy of reformulated gasoline use in reducing smog levels in urban areas, 1996-.

Jack Calvert, Atmospheric Chemistry Education Committee (ACE), American Geophysical Union, development of courses and faculty for the training of atmospheric scientists in the developing countries, 1994-.

Jack Calvert, Member of the Scientific Council of the International Global Atmospheric Chemistry (IGAC), planning of international research programs designed to elucidate global atmospheric chemistry, 1992-.

Chris Cantrell, NASA Instrument Panel Workshop, SRI International, July 1996.

Chris Cantrell, Atmospheric Sciences Section Nomination Committee, American Geophysical Union, 1996.

Michael Coffey, Observing Facilities Advisory Panel, National Science Foundation, 1995-1996.

Alan Fried, International Advisory Committee for the Moscow, Russia TDLS-95 and TDLS-98 Conferences on Tunable Diode Laser Spectroscopy, 1995-1998.

Alan Fried, Program Committee for the Fourth, Fifth and Sixth International Topical Meetings, Laser Applications to Chemical Analysis, 1994-1996.

Fred Eisele, Coordinating Committee for Aerosol Characterization and Process Studies Activity (ACAPS), International Global Atmospheric Chemistry (IGAC), advisory panel on future aerosol research, 1996.

Fred Eisele, Chair of STERAO-C Steering Committee, help to direct a photochemical research study planned on the WB-57, 1995.

David Erickson, Panel Member, United Nations Environment Program, 1994 -.

David Erickson, Member, Steering Committee, Global Emission Inventory Assessment, International Global Atmospheric Chemistry Program.

David Erickson, Advisory Board Member, Tropical Atmospheric Science Center, University of Puerto Rico, 1995 -.

David Erickson, Chairman, Air-Sea Interaction Group, Atmospheric Sciences Section, American Geophysical Union, 1996 -.

Rolando Garcia, Steering Committee on Gravity Waves, International Commission on the Meteorology of the Upper Atmosphere Steering Committee.

John Gille, Steering Committee on Guide Development of the Stratospheric Processes and Their Role in Climate (SPARC), 1992 -.

John Gille, WMO Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, 1995 -.

Claire Granier, Panel on Atmospheric Effects of Aviation, National Research Council, 1994 -.

Alex Guenther, Panel on Critical Assessment of the Role of Natural Emissions on Ozone Management, NARSTO, 1996-1998.

Alex Guenther, UN-ECE Task Force on Emission Inventories Nature Expert Panel, 1996-1997.

Alex Guenther, U.S. National Tropospheric Ozone Research Needs Panel, 1995-1997.

Elisabeth Holland, NASA Distributed Archive Center Committee, 1995 -.

Elisabeth Holland, U.S. Trace Gas Network Committee, part of IGAC/IGBP, 1992 -.

Elisabeth Holland, Advisory Committee on Biogeochemistry, AGU, 1996 -.

William Mankin, Steering Committee for the Network for Detection of Stratospheric Change, 1989-1996.

William Randel, Chair, Middle Atmosphere Committee, American Meteorological Society (AMS), 1996.

William Randel, Chair, Reference Climatology Committee, Stratospheric Processes and Their Role in Climate (SPARC), 1996.

William Randel, Stratospheric Temperature Trends Committee, Stratospheric Processes and Their Role in Climate (SPARC), 1996.

William Randel, Ozone Trends Committee, Stratospheric Processes and Their Role in Climate (SPARC), 1996.

William Randel, Chair, Atmospheric Sciences Committee on Atmospheric Dynamics, American Geophysical Union (AGU), 1996.

Jinxue Wang, Chair of the SPIE International Conference on Optical Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research, 1996.

Jinxue Wang, Aerospace and Sensing Technical Committee, SPIE, 1996.

Jinxue Wang, Chair, Aerosol, Chemistry and Meteorology Group at the EOS Test Sites Meeting, 1996.

Patrick Zimmerman, EPA Review Panel for grants related to atmospheric chemistry, 1995 -.

Awards

Guy Brasseur and Claire Granier received the NCAR Outstanding Publication Award, 1996.

Jack Calvert was elected as a Fellow of the American Geophysical Union, 1996.

Fred Eisele (with Dr. George Mount) received the NOAA Environment Research Laboratories, Research Paper of the Year Award, 1996.

Miscellaneous Service

Elliot Atlas served as the convenor of the Global Chemistry Survey activity of the International Global Atmospheric Chemistry Program, 1996-.

Alan Fried, Conference Chair and Organizer of the Tunable Diode Laser Spectroscopy Symposia at the 1996 International SPIE Conference on Optical Science, Engineering and Instrumentation, 1996.

Alan Fried, President-Elect of the Rocky Mountain Optical Society, 1996-1997.

Secretary/Treasurer for the Rocky Mountain Optical Society, 1995-1996.

Alex Guenther served as Workshop Co-Chair and Organizer of the Advances in Biogenic VOC Research, 1996.

Elisabeth Holland is Director of the NATO Advanced Study Institute: Soils and Global Change: Carbon Cycle, Trace Gas Exchange and Hydrology, a two-week school in France with students and lecturers from all over the world, 1996-1997.

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STAFF, VISITORS & COLLABORATORS

Staff

Division Director's Office

Guy Brasseur (director)
Michael Coffey
Brad Crysel
Teresa Rivas
Donna Sanerib
Susan Solomon (acting director)
Paul Sperry

Atmospheric Odd Nitrogen

Frank Grahek
Brian Ridley (leader)
James Walega
Andrew Weinheimer

HO_x Project

Christopher Cantrell
Fred Eisele (leader)
Richard Shetter
David Tanner

Laboratory Kinetics

John Orlando
Geoffrey Tyndall (leader)

Stratospheric/Tropospheric Measurements

Elliot Atlas (leader)
Frank Flocke
Richard Lueb
Sue Schauffler

Biosphere Atmosphere Interactions

James Greenberg
Alex Guenther (leader)
Peter Harley
Lee Klinger

Standards and Intercomparisons

Eric Apel (leader)
Timothy Gilpin

UARS

John Gille (manager)
Lawrence Lyjak
Steven Massie
William Randel (leader)
Fei Wu

MOPITT

Paul Bailey (leader)
John Caron
Charles Cavanaugh
Cheryl Craig
David Edwards
John Gille (manager)
Beverly Heller
Leslie Mayer
Frederick McCloskey
Daniel Packman
Liwen Pan
Laura Rokke
Steve Shertz
Mark Smith
Charles Spaur
JinXue Wang

HIRDLS

Philip Arter
Michael Dials
John Gille (leader)
Chris Halvorson
Linda Henderson
William Howard
Joanne Loh (manager)
David Wilson
Douglas Woodard

Optical Techniques

Michael Coffey
James Hannigan
William Mankin (leader)

Tunable Diode Laser Spectroscopy

Alan Fried (leader)
Bruce Henry

Regional Process Studies

Mary Barth
John Caron
Chris Fischer
Siri Flocke
Claire Granier
Peter Hess
Sasha Madronich (leader)

Global and Stratospheric Studies

Guy Brasseur (leader)
David Erickson
Rolando Garcia
Elisabeth Holland
Anne Smith
XueXi Tie
Stacy Walters

Technical Support

William Bradley
Timothy Fredrick
Roger Hendershot
Paul Sperry (leader)

Administrative Support

Janice Powell (to July 1996)
Teresa Rivas (leader)
Donna Sanerib
Kelly Stoecklein
Marilena Stone
Jack Wainwright

Affiliate Scientists

Aaron Goldman, University of Denver
Susan Solomon, NOAA Aeronomy Laboratory
Stuart Penkett, University of East Anglia
Dieter Ehhalt, Institute for Atmospheric Chemistry

Visitors and Collaborators

Dates refer to visitor's stay at NCAR during FY95. No dates are given for collaborators who did not visit NCAR.

David Andrews; Oxford University; HIRDLS

Janet Arey; University of California, Riverside; isoprene emission studies

Robert Arnts; Environmental protection Agency; biosphere-atmosphere interactions

Roger Atkinson; University of California, Riverside; isoprene emission studies

Bradford Baker; University of Colorado at Boulder; January 1996 to December 1998; trace gas biogeochemistry

John Barnett; Oxford University; HIRDLS

Michael Bashkin; Colorado State University; December 1995 to March 1996; global modeling

F. Battin-Leclerc; NOAA Aeronomy Laboratory; ozone photochemistry studies

William Baugh; unaffiliated; July 1994 to March 1997; ecosystem studies

Karsten Baumann; NOAA/CIRES; February 1996 to April 1996; atmospheric odd nitrogen

Rachel Beaule; University of Lyon 1, France; April 1996 to May 1997; regional and process studies

William Bell; National Physical Laboratory; NDSC

Harold Berresheim; Albein-Schwaiger-Weg 10, France; 23-31 May; Ho_x measurements

Donald Blake; University of California, Irvine; PEM-Tropics

Marine Bonazzola; Univesity of Paris-sud, France; May 1996 to August 1996; global and stratospheric studies

Stephan Borrmann; University of Mainz, Germany; 29 July 1996-8 August 1996;

tropospheric and stratospheric aerosols

David Bowling; University of Colorado at Boulder; January 1996 to July 1996; biogenic emissions

Clobite Bouka-Biona; University of Brazzaville; EXPRESSO

David Bowling; University of Colorado; biosphere-atmosphere interactions

Mary Brunelle; Colorado State University; December 1995 to March 1996; global modeling

Teresa Campos; NCAR/ATD; January 1996 to January 1997; AASE-II

Simon Chabrillat; Belgian Institute for Space Aeronomy; March 1995 to July 1996; global and stratospheric studies

Julius Chang; State University of New York; 15 November 1995; regional and process studies

Martyn Chipperfield; Cambridge University; polar stratospheric chemistry

John Constable; University of Colorado; January 1996 to June 1996; biogenic emissions

Elizabeth Courter; University of Colorado at Boulder; May 1996 to September 1996; ecosystem modeling

Robert Curran; NASA Headquarters; SUCCESS

William Custer; NOAA Aeronomy Laboratory; STERAO-A

John Daniel; NOAA Aeronomy Laboratory; November 1995 to November 1996; AASE II

Purnendu Dasgupta; Texas Tech University; 11-12 October 1995; hydrocarbon intercomparison

Douglas Davis; Georgia Institute of Technology; PEM-Tropics

Gary Davis; University of Saskatchewan; MOPITT

Tom DeFlice; University of Wisconsin-Milwaukee; aerosol/sulfur oxidation chemistry

Sara Dizick; University of Colorado; April 1995 to May 1996; trace gas biogeochemistry

Ed Dlugokensky; NOAA CMDL; UV and V radiation modeling

Mark Dombrowski; NASA Goddard Space Flight Center; July 1995 to January 2003; HIRDLS

James Drummond; University of Toronto; 18-22 November 1995; MOPITT

Ellsworth Dutton; NOAA CMDL; UV and V radiation modeling

Jonathan Edwards; NOAA Aeronomy Laboratory; STERAO-A

Paul Eriksen; Danish Meteorological Institute; SESAME

Raymond Fall; University of Colorado; biosphere-atmosphere interactions

Hans Fast; Atmospheric Environment Service, Canada; NDSC

Fred Fehsenfeld; NOAA Aeronomy Laboratory; STERAO-A and other collaborations

Richard Field; Department of Chemistry; October 1995 to February 1996; regional and process studies

Francois Figarol; Institut Pierre Simon LaPlace, France; January 1995 to May 1996; global and stratospheric studies

Jean-Marc Fracheboud; Physical Chemistry Laboratory, England; September 1995; ozone photochemistry

Gene Francis; University of Colorado at Boulder; July 1992 to January 1997; global and stratospheric studies

Randall Friedl; NASA Headquarters; SUCCESS

Eric Fujita; Desert Research Institute; SOS

Kochy Fund; AtmAA; SOS

Bruce Gary; Jet Propulsion Laboratory; Microwave Temperature Profiler

Christopher Geron; Environmental Protection Agency; VOC emission modeling and other collaborations

Paul Ginoux; University of Brussels, Belgium; December 1993 to January 1998; global and stratospheric studies

Paul Goldan; NOAA Aeronomy Laboratory; STERAO-A

Arun Gopalan; Unaffiliated; December 1993 to June 1997; UARS

Peter Gray; Rutherford Appleton Laboratory; HIRDLS

David Griffith; University of Wollongong; NDSC

Sylviane Haberkorn; I.U.I. Louis Pasteur, France; September 1995 to June 1996; atmospheric kinetics

Chris Halvorson; Unaffiliated; June 1991 to March 1997; HIRDLS

Jerry Harder; University of Colorado; 11-12 October 1995; trace gas measurements

Alexis Hartz; University of Colorado; June 1996 to May 1997; ecosystem modeling

Brian Heikes; University of Rhode Island; 11-12 October 1995; hydrocarbon intercomparison

Detlev Helmig; Unaffiliated; January 1992 to June 1996; trace gas biogeochemistry

Daniel Hereid; University of Colorado; January 1995 to December 1998; ecosystem studies

Nicholas Hewitt; University of Lancaster; VOC emission modeling

James Holton; University of Washington; 31 January-2 February 1996; HIRDLS

Brian Hopkins; University of Rhode Island; SOS

Theresa Huang; University of Michigan; March 1993 to August 1997; global and stratospheric studies

Gerhard Hübler; NOAA Aeronomy Laboratory; STERAO-A

Gregory Huey; NOAA Aeronomy Laboratory; nitric acid intercomparison

Michael Hurley; Ford Motor Company; hydrofluorocarbon studies

Daniel Jacob; Harvard University; PEM-Tropics

Brian Johnson; University of Michigan; July 1995 to December 1996; HIRDLS

Nicholas Jones; National Institute for Water and Air, New Zealand; NDSC

Tørben Jørgensen; Danish Meteorlogical Institute; SESAME

John Karlik; Bakersfield Colleage; isoprene emission studies

Gabrial Katul; Duke University; biosphere-atmosphere interactions

Carla Kegley-Owen; University of Colorado; July 1993-December 1996; atmospheric kinetics

Boris Khattatov; SUNY at Stony Brook; January 1996 to January 1997; EOS studies

Rashid Khosravi; University of Colorado; January 1995 to February 1997; global and stratospheric studies

Thaddeus Kleindienst; Mantech Environmental Laboratory; 11-12 October; hydrocarbon intercomparisons

Heidi Krapfl; Metro State College; September 1995 to October 1996; stratospheric/tropospheric measurements

Brian Lamb; Washington State University; VOC emission studies

Kathleen Lantz; University of Colorado; October 1995 to January 1996; regional and process studies

Jean-François Lamarque; Catholic University of Louvain; September 1994 to August 1997; regional chemical transport models

Yin-Nan Lee; Brookhaven National Laboratory; 11-12 October 1995; SOS formaldehyde intercomparison

Conway Leovy; University of Washington; 31 January 1996-2 February 1996; HIRDLS

Jules Loemba; University of Brazzaville; EXPRESSO

William Lonneman; Environmental Protection Agency; SOS

Manuel Lopez Puertes; Institute of Astrophysics, Spain; observations of non-LTE limb radiance

Mingzhao Luo; University of California, Irvine; HALOE

Robert MacQueen; Rhodes College; atmospheric research spectrometer

Gurpreet Mand; University of Toronto; MOPITT

James Marti; Naval Research Lab, 10-14 April 1996; Ho_x measurements

Kenneth Masarie; NOAA CMDL; UV and V radiation modeling

Roy Leon Mauldin; Unaffiliated; April 1994 to April 1996; Ho_x measurements

Andrew Matthews; National Institute for Water and Air, New Zealand; NDSC

John McConnell; York University; MOPITT

Michael McIntyre; Cambridge University; HIRDLS

Richard McKenzie; New Zealand Institute for Water Research; UV and V radiation modeling

Peter McMurry; University of Minnesota; aerosol/sulfur oxidation chemistry

Demaree Michelau; University of Colorado; June 1996 to September 1996; ecosystem studies

Trine Mogelberg; RISO National Lab, Denmark; January 1996 to April 1996; atmospheric kinetics

Russell Monson; University of Colorado; biosphere-atmosphere interactions

Jean Marie Montsambote; University of Brazzaville; EXPRESSO

Denise Montzka; Unaffiliated; July 1991 to December 1996; atmospheric odd nitrogen

Michael Mozurikewich; York University; heterogeneous studies of sulfuric acid aerosols

H. G. Muller; University of Sheffield; NIRDLS

Jean-François Müller; Belgian Institute for Space Aeronomy; VOC emission modeling and other collaborations

Martin Muller; Institut für Atmospharische Chemie, Germany; February 1996 to February 1998; atmospheric chemistry

David Murcray; University of Denver; NDSC

Frank Murcray; University of Denver; NDSC

C. T. Mutlow; Rutherford Appleton Laboratory; HIRDLS

Jason Neff; Stanford University; July 1996 to August 1996; ecosystem studies

Paul Newman; NASA Goddard Space Flight Center; STRAT

Ole-John Nielsen; Ford Motor Company; hydrofluorocarbon studies

Justus Notholt; Alfred Wegener University, Germany; NDSC

Paul Novelli; NOAA CMDL; UV and V radiation modeling

Christopher Palmer; Oxford University; HIRDLS

Stella Papasavva; Tufts University; October 1995; global and stratospheric studies

Suzanne Paulson; University of California, Los Angeles; production of radicals in the troposphere, and other collaborations

Jens Pedersen; RISO National Lab; January 1996 to March 1996; atmospheric kinetics

Guy Peskett; Oxford University; MOPITT

Kenneth Pickering; University of Maryland; modeling storm prediction and analyses

Thomas Pierce; Environmental Protection Agency; VOC emision modeling

Robert Portmann; NOAA Aeronomy Laboratory; November 1995 to December 1996; global and stratospheric studies

Richard Powers; University of Nebraska at Lincoln; June 1996 to August 1996; HIRDLS

Michael Profitt; NOAA Aeronomy Laboratory; upper troposphere modeling

Joseph Prusa; Iowa State University; 7-31 July 1996; global and stratospheric studies

John Pyle; Cambridge University; HIRDLS

Evaristo Ramirez; Unaffiliated; June 1996 to September 1996; stratospheric/tropospheric measurements

A. Ravishankara; NOAA Aeronomy Laboratory; ozone photochemistry studies

Henry Reichle; North Caroline State University; MOPITT

Daniel Riemer; University of Miami; SOS

Clive Rodgers; Oxford University; HIRDLS

Michael Rodgers; Georgia Institute of Technology; PEM-Tropics

F. Sherwood Rowland; University of California, Irvine; PEM-Tropics

Nigel Roulet; McGill University; MOPITT

James M. Russell III; Hampton University; HALOE

Steven Rutledge; Colorado State University; STERAO-A

Joseph Sabutis; University of California, Los Angeles; November 1995 to April 1997; UARS

Glen Sachse; NASA Langley Research Center; Measurements of CO_2

Murry Salby, University of Colorado; January 1992-December 1997; global and stratospheric studies

Fabrizzio Sassi; Unaffiliated; October 1994 to March 1997; global and stratospheric studies

Vincent Saxena; North Carolina State University; aerosol/sulfur oxidation chemistry

Niels Schonbeck; Metropolitan State College of Denver; March 1996 to August 1997; aerosols

Mark Schoeberl; NASA Langley Research Center; VOTE/TOTE

Jens Sehested; Riso National Laboratory; hydrofluorocarbon studies

Dominique Serca; Universite Paul Sabatier, France; April 1995 to September 1996; trace gas biogeochemistry

Christophe Seuzaret; Elf Aquitaine, Inc.; January 1996 to April 1997; global and stratospheric studies

Paul Shepson; Purdue University; SOS

Liaw Sheng-Ju; Institute of Nuclear Science, China; 2-17 February 1996; atmospheric chemistry

Christoph Spirig; Swiss Federal Institute of Technology; July 1996 to December 1996; ecostystem studies

David Starr; NASA Goddard Space Flight Center; SUCCESS

Rainer Steinbrecher; Franhoefer Institute; VOC emission modeling

Jeffrey Stith; University of North Dakota; STERAO-A

Elizabeth Stone; Iowa State University; September 1994 to August 1997; UARS

John Streete; Rhodes College; May 1996 to August 1996; optical techniques

Verity Stroud; Unaffiliated; November 1995 to January 1996; stratospheric/tropospheric measurements

James Sulzman; Unaffilaited; June 1994 to June 1997; ecosystem studies

Carine Suter; Institut Louis Pasteur, France; September 1995 to June 1996; stratospheric/tropospheric measurements

Ranajit Talukdar; NOAA Aeronomy Laboratory; ozone photochemistry studies

Pietr Tans; NOAA CMDL; UV and V radiation modeling

Frederick Taylor; Oxford University; HIRDLS

John Taylor; Australian National University; 25 March-5 April 1996; global and stratospheric studies

1. H. Taylor; Unaffiliated; May 1996 to November 1996; ecosystem studies

Brian Toon; NASA Ames Research Center, SUCCESS, VOTE

G. C. Toon; Jet Propulsion Laboratory; NDSC

Ian Tosh; Rutherford Appleton Laboratory; HIRDLS

Alan Townsend; Harvard University; May 1996 to February 1997; ecosystem studies

Michael Trainer; NOAA Aeronomy Laboratory; STERAO-A

Adrian Tuck; NOAA Aeronomy Laboratory; STERAO-A

Andrew Turnipseed; University of Colorado; January 1996 to July 1996; biogenic emissions

Michiel Van Weele; IMAU Utrecht University; The Netherlands; November 1995 to January 1996; global and stratospheric studies

Geraint Vaughan; University College of Wales; HIRDLS

Peter Venters; Oxford University; HIRDLS

Lee Vierling; University of Colorado; May 1996 to May 1998; trace gas biogeochemistry

Timothy Wallington; Ford Motor Company; hydrofluorocarbon studies

Yonghua Wang; Georgia Institute of Technology; 22 October to 16 November 1995; stratospheric studies

Robert Wells; Oxford University; HIRDLS

Bryan Wert; University of Colorado; June 1995 to June 1999; tunable diode laser

Halvore Westberg; Washington State University; 12 October 1995; hydrocarbon intercomparisons and other collaborations

John Whitney; Oxford University; HIRDLS

E. James Williamson; Oxford University; HIRDLS

Arthur Winer; University of California, Los Angeles; isoprene emission studies

Steven Wofsy; Harvard University; STRAT

Wanli Wu; University of Michigan; July 1994 to July 1996; middle atmosphere

Kuang-Ling Yang; University of Michigan; 4-17 February 1996; atmospheric chemistry

Rudolf Zander; University of Liege; NDSC

Jun Zeng; University of Alaska; May 1995 to May 1997; regional and process study

Genfa Zhang; Texas Tech University; 11-12 October 1995; trace gas measurements

Jiangfen Zheng; University of Colorado; October 1993 to September 1997; AASE-II

Xianling Zhou; ManTech Environmental; SOS

Paul Ziemann; University of Minnesota; 1-19 April 1996; Ho_x measurements

Rod Zika; University of Miami; SOS

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HIGH ALTITUDE OBSERVATORY

HAO Director's Message

Michael Knölker

The FY 96 NSF Review of HAO's scientific programs and of its service to the scientific community concluded in an excellent evaluation. The panel report provided HAO with support and advocacy for extending its role in strategic research areas such as SunRISE and the National Space Weather Initiative through appropriate funding from these programs.

HAO's preparation for the Solar Magnetism Initiative as a community research program was highly commended. The preparatory phase has almost come to a conclusion now, and we expect to put forth a formal proposal for SMI in FY 97.

Ray Roble was honored for his outstanding contributions to solar-terrestrial physics by the National Academy of Sciences with the Arctowski Medal and prize. All of HAO joins in congratulating Ray.

HAO's emphasis on local and global helioseismology has increased to fully exploit the magnificent data provided by the HAO LOWL instrument, the SOHO MDI, and by the GONG network. We expect great progress in this particular area of solar research in the near future.

FY 96 was also a year of change for HAO. The group led by Gary Rottman and Tom Woods decided to move back to LASP. Therefore, HAO will concentrate in the future on the data interpretation and theoretical aspects of solar variability research in cooperation with that group. HAO's Instrumentation Group will still continue building space hardware on UV and EUV measurements of solar variability.

The following Annual Scientific Report demonstrates that HAO has been successful in many other areas of research during the fiscal year and that its staff pursues its scientific mission as part of a national center with great enthusiasm.

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HIGH ALTITUDE OBSERVATORY

II. Significant Accomplishments

- The Global Scale Wave Model has been used by the NASA UARS Science Team to investigate a variety of waves that have been observed by the WINDII, HRDI and MLS instruments on board the UARS satellite. The GSWM does an excellent job in simulating the observed diurnal and semi-diurnal tides and their seasonal variation and the two-day wave that occurs in the summer hemispheres during solstice. The model has been used to estimate the non-migrating tides and their influence on migrating tides observed in the upper mesosphere and lower thermosphere. The model simulations are also used to derive estimates of the magnitude and seasonal variations of parameters that are hard to observe but are important for determining the dynamics, such as eddy diffusion in the upper mesosphere and lower thermosphere.

- The TIME-GCM which calculates the compositional structure of the upper atmosphere from 30-500 km has been extended to include a calculation of airglow emission rates for direct comparison with observations made from ground stations, rockets and satellites. The TIME-GCM now calculates the red and green line emission from excited atomic oxygen, considering a wide variety of excitation sources, the OH emission, the O_2 Atmospheric Band Emissions, and the infrared emissions from CO_2, NO, O, and O_3. In addition to the emission rates, procedures have been developed to calculate Doppler temperatures and winds from height integrated quantities for a direct comparison with measurements made from the ground and space. The results show that dynamics have a pronounced influence on the airglow emission rates and that considerable insight into dynamic phenomena can be obtained by measuring the global distribution of airglow emissions.

- The Assimilative Mapping of Ionospheric Electrodynamics (AMIE) technique has been critically analyzed to determine its prospect for space weather specification and prediction. AMIE synthesizes diverse observations of high-latitude ionospheric electrodynamic phenomena into "snapshot" synoptic maps of conductances, electric fields, currents, and related parameters. At present, AMIE is a specification model rather than a forecast model, although its mathematical structure could allow inclusion of time as an additional dimension, which would permit temporal extrapolation. Such a specification model of ion convection and particle precipitation can be used to help initialize forecast models of thermospheric winds and composition, ionospheric electron density, and inner-magnetospheric particle populations for use in space weather forecasts.

- The Chromospheric Helium Imaging Photometer (CHIP) was installed at MLSO on April 15, 1996 by the HAO Instrumentation Group and is now producing full solar disk images of chromospheric structure associated with coronal activity. The CHIP is the only patrol instrument in the world capable of making HeI images at 20 images per hour. This is the first step in development of the Advanced Coronal Observing System (ACOS) at HAO.

- Data from the SOLSTICE UV spectrometer on UARS was substantially improved by the use of a new data reduction algorithm developed by Chris Pankratz and Barry Knapp. Changes in the operation of the spacecraft have been forced by problems with the solar power array, and these introduce unexpected effects in the spectrometer that are corrected with the new processing scheme. The record of the solar UV spectrum from SOLSTICE now extends from October 3, 1991 to date.

- Art Hundhausen and Chris Balch developed a simple source model that explains the shape of so-called "long duration events" seen in hard X-ray data from the GOES satellite. This work follows Hundhausen's identification of LDE's

with brightening of coronal arcades seen in YOHKOH soft X-ray images. This is an important finding because LDE's are classified as a flare phenomenon, but their origin is completely different to shorter lived transients associated with chromospheric flares seen in the HI 656.3 nm line.

- Oskar Steiner (visitor, Kiepenheuer Institut fur Sonnenphysik, Freiburg), Manfred Schüssler (Kiepenheuer Institut fur Sonnenphysik, Freiburg) and Michael Knölker have carried out numerical simulations of the interaction between non-steady convection and solar surface magnetic flux concentrations. The numerical code solves the primitive equations for two-dimensional magnetrohydrodynamics in concert with the equation of radiative transfer. One of the highlights of their work is the first ever simulation of the formation of a concentrated magnetic flux sheet through the action of flux expulsion forcing the magnetic field into the intergranular lane followed by further field intensification in the convective downflow.

- Using state-of-the-art observations delivered by the HAO/NSO Advanced Stokes Polarimeter, Bruce Lites, Donald Stanchfield II (University of Rochester) and John Thomas (NCAR Affiliate Scientist, University of Rochester) were able to gain important information on the magnetic fine structure within the penumbra of a sunspot. They deduced a magnetic field pattern consisting of spoke-like extensions of stronger more vertically-oriented magnetic flux tubes separated by regions of weaker, more horizontal, fields. Based on Doppler shifts measured for several absorption lines formed at different heights in the sunspot atmosphere, they could also show that the Evershed outflow is confined to the weak horizontal field channels.

- Philip Judge and collaborators Tomas Brage, Michael Godefroid (NASA Goddard Space Flight Center), Abdellatif Aboussaid, Anders Ynnerman (Universite Libre de Bruxelles), and Per Jonsson (Vanderbilt University) have identified several hyperfine-induced ($J = 0 \rightarrow J' = 0$) UV and EUV transitions of the Be (n=2) and Mg (n=3) isoelectronic sequences that may be of potential astrophysical diagnostic value in determining isotopic abundance ratios and electron number densities. Their approach was theoretical and based upon ab initio self-consistent Hartree-Dirac-Fock calculations for the expected spontaneous and induced transition probabilities. Although no positive identification of any of these hyper-fine induced transitions was possible with existing UV and EUV data, the high signal-to-noise observations made by CDS (Coronal Diagnostic Spectrometer) and SUMER (Solar Ultraviolet Measurements of Emitted Radiation) on board the SOHO spacecraft are likely to offer more promising potential for future detection.

- Steve Tomczyk, Paul Charbonneau (both HAO), J. Christensen-Dalsgaard (Aarhus University), R. Henning (Denver University), J. Schou (Stanford University), and M. J. Thompson (Queen Mary and Westfield College) analyzed LOWL data obtained during the period February 26, 1994 to February 25, 1996 in order to determine the location and thickness of the rotational shear layer at the base of the convection zone. They find that the shear layer has position (0.704 +/- 0.003) solar radii and width (0.050 +/- 0.012) solar radii.

- Tim Brown and Edward Kenelly (both HAO), along with R. Noyes, P. Nisenson, S. Korzennik (all from the Harvard/Smithsonian Center for Astrophysics), and S. Horner (Penn State University) have used the Advanced fiber Optic Echelle (AFOE) spectrograph in an effort to detect the presence of large-mass planets in orbit about nearby solar-type stars. To date, AFOE data has provided confirmation of planet detections for the Sun-like (i.e., G spectral type) stars 51 Pegasi, Tau Bootis, and Upsilon Andromedae.

- Peter Gilman and Peter Fox have investigated the magnetohydrodynamical stability of the rotational shear layer at the base of the solar convection zone. For two dimensional perturbations on spherical shells, they have demonstrated that the inclusion of a non-uniform toroidal magnetic field causes the differential rotation of the shear layer to become unstable. The peak e-folding times for growth of the instability are a few months, and occur for field strengths of order 10-100 kilogauss, consistent with estimates for the strengths of toroidal fields at the bottom of the convection zone.

- Paul Charbonneau and Keith MacGregor have extended their interface model for the solar dynamo to include a parametric description of the non-linear effect of alpha-quenching. For a spherical model with a Sun-like internal angular velocity distribution, they find that the toroidal magnetic field can reach equipartition strength within the shear layer, but remain weak enough in the convection zone to permit normal operation of the alpha effect. Because of this, mean-field, interface dynamo models remain a viable mechanism for producing the time-dependent solar magnetic field.

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ATD Director's Message

Observing and associated facilities of the Atmospheric Technology Division (ATD) include research aircraft, remote sensing systems, atmospheric sounding instruments, automated surface systems, and interactive computing facilities. These facilities are staffed with skilled engineers and technicians who operate and deploy the equipment. ATD's development capability resides primarily in its staff of scientists, engineers, and programmers. ATD is set up to be the focal point for the more complex platforms and instruments that are needed by many scientists and that can only be developed and operated by a sizeable team of technical staff. Development programs are routinely undertaken in collaboration with other NCAR divisions, universities, and other research organizations.

The ATD technical staff frequently advises and assists users of its facilities in experimental design and planning for field programs, in sampling and measurement techniques, and, in some instances, in the design and fabrication of special equipment. Field data are quality assured and processed before distribution to users. Assistance in analysis of these data is also frequently provided.

The division supports the observing component of research studies in a wide variety of scientific disciplines, including mesoscale meteorology, cloud physics, atmospheric chemistry, aerosol physics, radiative transfer, boundary-layer meteorology, and air-sea interaction. In recent years, use of the facilities by the atmospheric chemistry and oceanography communities has grown. In addition, there has been a trend in research toward the simultaneous study of phenomena and processes occurring on a multiplicity of atmospheric spatial and temporal scales. These changes have directly influenced ATD's plans for the development of new systems.

Based upon available information on science needs for observing facilities, some common themes are being addressed by ATD in its observing system development program. One recurrent need is for remote sensing from mobile platforms (mostly aircraft), together with specialized ground-based network capabilities. Measurements of atmospheric water, radiation, ozone, momentum, and sensible heat all have a high priority and require special attention. Many other gaseous chemical species need to be measured within the troposphere and lower stratosphere, as do specific aerosol and hydrometeor properties.

A recent thrust by ATD has been to develop and/or make available new remote sensors to meet some of these needs. In FY 96, development was completed on a new, highly portable, S-band dual-polarization Doppler radar (S-Pol) to replace the CP-2 system. S-Pol was successfully tested and deployed in its first field study in summer 1996. In addition, as a result of ATD's collaboration with the NOAA Environmental Technology Laboratory (ETL) in optical remote sensing, two optical systems are now available for community use: the airborne or ground-based Staring Aerosol Backscatter Lidar (SABL), and an airborne ozone Differential Absorption Lidar (DIAL). These new observing systems are described in detail in later sections of this report.

ATD's overall aim is to provide comprehensive, high-quality observational support for various studies conducted under the auspices of the U.S. Global Change Research Program and the U.S. Weather Research Program, as well as for other important atmospheric research studies. The division works closely with other NCAR divisions, universities, NSF, and other federal agencies to ensure that its current facilities and long-range plans provide for observing platforms, instruments, and services most needed by the scientific community.

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ATD Mission and Goals

The basic mission of the Atmospheric Technology Division is to provide unique, multi-user observing facilities and data services to the atmospheric and related sciences. Accordingly, the specific goals of ATD are:

- To provide high-quality, centrally administered observing facilities and associated data support services for use in research programs by the atmospheric and oceanic sciences communities.
- To continually improve these facilities and services, and to develop next-generation facilities as community requirements dictate, by means of strong internal development programs.

User Community

In FY 96, ATD provided observing support for nine field programs. A listing of supported field programs is provided in each of the succeeding sections describing the activities of ATD's Facility organizations. In summary, three of the nine field programs supported were for university investigators (including the very large, multi-facility ACE-1 program), five involved both NCAR and university scientists, and one was for a non-NSF government agency.

During the year ATD responded to 110 individual requests for field data from non-NCAR researchers at a large number of institutions, as well as to many additional requests from NCAR/UCAR scientists. In addition, a total of 132 different institutions requested and used ATD applications software. These latter requests are in addition to the usual large number from NCAR/UCAR users.

ATD also worked in FY 96 on a number of sensor and observing system developments funded by various government agencies and other organizations, in addition to those supported by NSF. Many of these development projects involved collaborative efforts with technical staff from universities and other research organizations.

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT

Research Aviation Facility

Mission and Goals

The mission of the Research Aviation Facility (RAF) is to develop and operate instrumented research aircraft for the atmospheric science community at a level of sophistication and operational complexity not generally available from university-based aircraft.

RAF goals are:

- To operate the research aircraft safely and reliably. Safety is the foremost factor guiding RAF in operation of the NCAR/NSF aircraft fleet.
- To provide research aircraft users with the technical support needed to maximize the scientific effectiveness of RAF aircraft and instrumentation. To accomplish this, RAF staff assist in planning and conducting field experiments; carry out the processing and quality control of RAF data sets; establish instrumentation characteristics and limitations; and, when appropriate, collaborate with investigators in the scientific analysis of project data.
- To track current and future scientific needs of the atmospheric science community, and to acquire and maintain research systems (aircraft, instruments, and data acquisition systems) that utilize current technology to best meet these needs.

Aircraft Development Activities

The NCAR/NSF aircraft fleet provides capability to address a variety of aircraft mission requirements within the atmospheric sciences community. The Lockheed Electra (45Kb) serves as the platform for the ELDORA Doppler Radar (71Kb), other remote sensing instruments, the SSSF dropsonde system (79Kb), and a wide variety of *in situ* instruments for application to studies of atmospheric chemistry, the structure and dynamics of weather systems, boundary-layer dynamics and fluxes, cloud and aerosol physics, and other research topics. The Lockheed C-130 (62Kb) supports similar science objectives, but provides greatly increased range and payload capability particularly valuable for missions in remote areas or missions requiring large scientific payloads. RAF continues development of the General Dynamics WB-57F (57Kb) high-altitude jet as a platform for study of radiation, aerosols, chemistry, electrification, dynamics and thermodynamics of the troposphere and lower stratosphere, and other topics. The Beechcraft Super King Air twin-engine turboprop and the Schweitzer 2-32 Sailplane are currently withdrawn from operational service to facilitate development and operation of higher-priority aircraft.

WB-57F Development. Work during the first nine months of the fiscal year yielded substantial improvements in airframe, flight systems, and research infrastructure of the WB-57F in preparation for support of its first NSF field study, the Stratosphere-Troposphere Experiments: Radiation, Aerosols, and Ozone (STERAO-A) program. However, experience during aircraft flight tests in the fourth quarter of the year lead first to a change of operations base, and then to grounding of the aircraft pending re-evaluation of the feasibility and cost of safe operations. By the end of FY 96, RAF and ATD were devoting substantial effort to this re-evaluation, while the aircraft remained unavailable for use by requestors. An outline of progress and events through the year follows below.

- An X-ray examination of the structural integrity of wing spars in March 1996 showed evidence of rapidly progressing stress-corrosion cracking in two spar sections of the right wing. To correct this, RAF elected to remove the faulty spar

sections and replace them with new spars machined from improved, crack-resistant aluminum alloy. The lengthy replacement operation was completed in mid-June.

- Work on aircraft systems and research infrastructure needed to support STERAO-A proceeded through August 1996. Tasks accomplished include complete replacement of the power distribution infrastructure, installation of an RAF-developed ADS-II data system, installation of a radome gust probe for wind and turbulence measurements, installation of a broad suite of instruments for *in situ* and state-parameter measurements, near-complete modification of wing pods for instrumentation, provision for user-supplied instrumentation, and other tasks.

- During a test flight on 3 July 1996, the left tip of the 125-foot-wide WB-57F wing struck a runway sign during a normal, centerline landing at JeffCo Airport. This lead to a decision to discontinue use of the 100-foot-wide runways at JeffCo Airport and relocate operations to Denver International Airport (DIA), where runway width is 150 feet. UCAR secured a 12-month lease of hangar space in mid-August, and flight testing resumed at that time from the new DIA base.

- In late August the trim control of the horizontal stabilizer became inoperative in flight at 50,000 feet altitude. This yielded a difficult situation for the pilot until trim control was restored at the warmer temperatures encountered during descent near 20,000 feet altitude. In consideration of this malfunction and the previous history of problems with the flight systems on the aircraft, ATD and RAF grounded the aircraft pending full review of its condition and the feasibility of ensuring the safety of future operations. This grounding precluded provision of support to the STERAO-A program in August and September 1996.

- By fiscal year-end, ATD had taken steps to establish a WB-57F Evaluation Panel with membership from several NCAR Divisions, NOAA Aeronomy Lab, and NSF. RAF, ATD and UCAR technical teams as well as non-NCAR experts and consultants will serve as resources to the Panel as it carries out its charge to determine the full operational and maintenance requirements and costs necessary to operate the WB-57F safely and reliably. The Panel will report its findings to NCAR, NSF, and the NSF Observing Facilities Advisory Panel in April 1997. NCAR and NSF will plan for the future role of the aircraft after consideration of the Panel report.

Electra Upgrades. RAF temporarily removed the Electra from operational status in FY 96 to carry out a mandated five-year recurrent airframe inspection and to upgrade the research infrastructure of the aircraft. The inspection and associated minor repairs confirmed that the airframe is in excellent condition. Upgraded cabin safety features include addition of handholds and provision for secured cabin storage. Improved scientific infrastructure features include the following: installation of an RAF-built ADS-II data system (similar to that on the C-130 and WB-57F aircraft); expansion from three to four workstation areas, and relocation of workstations to better support coordination of ELDORA missions; incorporation of an RSF-built Weather Avoidance Radar Data System to record and display data from the Electra weather avoidance nose radar; provision for multiple displays of ELDORA and nose radar data; and installation of an improved, switchable intercom system throughout the cabin.

Acquisition of C-130 Parts Aircraft. Through cooperation between NSF and NASA management, a Lockheed EC-130Q formerly based at NASA/AMES Research Center has been transferred to NSF for use as a non-flyable parts aircraft supporting the needs of NSF and NASA. Operation of the NCAR/NSF C-130 will benefit substantially from the spare parts available from this surplus aircraft.

Field Support and Test Activities

During FY 96, RAF supported three university, NCAR, or other-agency projects with its powered aircraft, flying 58 missions for a total of 410 flight hours. Research deployments of RAF powered aircraft in support of field programs is summarized in Tables ATD-1 and ATD- 2. Field programs supported during FY 96 included studies of atmospheric chemistry, cloud physics, planetary boundary-layer processes, air-sea interaction, and tests of newly developed instrumentation. These field programs are briefly described below.

Table ATD-1: Summary of Disposition of FY 96 RAF Flight Requests

Aircraft	Number of Projects		Number of Hours			Number of Flights
	Requested	Flown	Requested	Allocated	Flown	
C-130	5	2	695	395	396	55
Electra	4	0	349	0	0	0
WB-57F	2	1	130	110	14	3
Total	11	3	1,074	505	410	58

Table ATD-2: Summary of FY 96 Aircraft Use

User	Project	Aircraft	Science*	Research Period	Hours Flown
Huebert (U. Hawaii)	ACE-1	C-130	AC,BL,CP	10/31/95 - 12/22/95	297
Rogers (Scripps)	Coastal Waves	C-130	BL	05/30/96 - 07/02/96	99
Dye et al. (NCAR)	STERAO Test	WB-57F	E,AC	07/15/96 - 09/01/96	14
Total Hours					410

* *AC = Atmospheric Chemistry, E = Evaluation of Instruments, BL = Boundary Layer, MS = Mesoscale Studies, CP = Cloud Physics, R = Radiative Studies*

Aerosol Characterization Experiment-1 (ACE-1). The ACE-1 air chemistry/aerosol program utilized the C-130 aircraft during November and December 1996. The program was conducted by an international team of scientists and included operations over a broad area extending to Alaska, the central Pacific, New Zealand, and Tasmania. The program was the most complex atmospheric chemistry deployment ever supported by RAF, requiring integration of fifteen separate experiments on the C-130. As outlined under Research Activities, several members of RAF played a scientific role in the program. Research operations were divided into two parts to address the primary objectives: a "Pole-to-Pole" meridional chemistry profile through the central Pacific, and a study of clean air aerosol generation between southern Australia and Antarctica. Chemical species measured included: various sulfur gases, H_2SO_4 and MSA, NH_3, NO, CO_2, CO, H_2O_2, and O_3. Whole air samples were also collected for hydrocarbon analyses. A total of seven separate aerosol measurements were made ranging from CCN and ultra-fine CN particles through the larger marine sea salts. All aerosol samples were collected using RAF's new Community Aerosol Inlet, which is described under Development Activities. ATD's new Staring Aerosol Backscatter Lidar (SABL, 106Kb) provided maps of aerosol distributions through the lower troposphere during the program.

Coastally Trapped Waves Experiment. The C-130 was deployed to Monterey, California in support of this boundary-layer program during June 1996. The research addressed the dynamics of coastally-trapped waves, the ageostophy of the wind constrained by the coastal mountain range, the interaction of orographically-forced flow with the sea breeze circulation, the offshore variability of the marine boundary layer, and the influence of these features on the development of boundary-layer clouds. The C-130 *in situ* measurements were used to characterize the along-shore and across-shore turbulent structure of the boundary layer. ATD's SABL lidar provided maps of boundary-layer structure to supplement the *in situ* measurements.

Development Activities

Multiangle Aerosol Spectrometer Probe (MASP). Since its development at the RAF in late 1993 (by Darrel Baumgardner, Jim Dye, Bruce Gandrud, Diana Rogers and Keith Barr), and deployment on the NASA ER-2 high-altitude aircraft throughout 1994 as part of the ASHOE/MAESA campaign, the MASP has been deployed on four other aircraft in field research programs. (See Research Activities). This instrument has the unique ability to provide information about the optical

properties of individual particles. Because of the MASP's successful deployment and provision of new measurement capabilities in ASHOE/MAESA, the RAF was asked to build another instrument for the University of Mainz, Germany in collaboration with Stephan Borrmann. This second instrument, funded by the German Science Foundation, was delivered to the University of Mainz in September 1996. It will be flown on the DLR Falcon aircraft in contrail studies in January 1997, and again in June 1997 during the ACE-2 experiment in the North Atlantic.

Counterflow Virtual Impactor (CVI). The CVI samples cloud droplets or ice crystals and evaporates them, allowing the residual nuclei and volatile gases to be measured downstream by various methods. This technique has been used successfully for several years in studies of cloud nucleation, droplet chemistry, and radiative transfer. Recent work has focused on improving the CVI inlet and flow system for better aspiration efficiency and ease of use. A new CVI with a shrouded inlet was built to fly on the NASA DC-8 aircraft during the SUCCESS project. (See Research Activities.) Preliminary results indicate the new design represents a marked improvement. The new features will be incorporated into the NCAR CVI before deployment on future projects.

Airflow Studies. Recently, sophisticated software (STAR-CD) has been acquired and used to model the airflow and particle trajectories around complicated shapes, such as the inlets used for aerosol and cloud water collection. This extends the RAF flow modeling capabilities dramatically. The new code solves the full Navier-Stokes equations, and can accurately simulate transonic and unsteady flow problems. The complicated flow field inside the NCAR counterflow virtual impactor (CVI) has been modeled by Cindy Twohy, in collaboration with Mary Laucks of the University of Washington. The code was also used in designing the C-130 community aerosol inlet and in developing a shroud for the CVI. Two papers detailing the inlet modeling results are expected to be published soon in *Aerosol Science and Technology*.

Community Aerosol Inlet (CAI). The CAI (20Kb) is a major new instrument developed in a joint project between NCAR/RAF and university researchers. It is designed to be more effective than traditional inlets in collecting aerosol particles during airborne research. This sophisticated inlet system, described in detail in the 1995 Annual Scientific Report, was designed to minimize particle losses due to turbulence and deposition -- a known problem in other inlet systems. The CAI was deployed during the ACE-1 project; the results from this project are still being analyzed. An additional test program will be conducted in spring 1997 for further characterization of the flow field and aspiration efficiency of the CAI.

Radiometer Correction Algorithm. Krista Laursen has developed an algorithm to partially remove the effects of aircraft attitude from hemispheric radiometer data collected on NCAR/NSF research aircraft. The algorithm will soon be added to the RAF's Nimbus data processing package. Krista worked with Judy Curry and Mark Tschudi (University of Colorado) to reprocess data from the Beaufort and Arctic Seas Experiment (BASE) using this algorithm.

Aircraft Information Retrieval System (AIRS). A prototype, beta version of the relational database developed at the RAF to archive a broad range of information about ATD-supported field projects is now in the demonstration phase. Julie Haggerty and Gary Horton lead this effort. The system is based on commercial relational database software and can be accessed through a Motif-based GUI or from external applications, including the World Wide Web. AIRS is designed to streamline the archival and user access of all RAF flight data, as well as other information about the Facility and the projects being conducted. AIRS has also been expanded to include datasets from SSSF platforms and facility request metadata from the ATD Director's Office. It offers a highly flexible way to assimilate multi-dimensional data sets.

Air Chemistry Instrumentation. Greg Kok and Richard Schillawski have been improving the processing methods for data from the CO analyzer. They have also modified the LICOR H_2O/CO_2 sensor. The high-altitude design of the instrument developed at the University of Harvard (Kristie Boering) was adapted for use in the troposphere. Preliminary results from measurements during ACE-1 indicate that these modifications have greatly improved the resolution and sensitivity of the instrument.

Greg Kok continues his collaborative work with Phil Hemberger at Los Alamos National Laboratory (LANL) on an adsorbent trap system for an ion-trap mass-spectrometer analytical system. The results of this work were published in the November 1966 issue of the *Journal of the American Society for Mass Spectrometry*.

Research Activities

Research activities by RAF staff in FY 96 covered a wide range of topics in aerosol physics, cloud physics, radiative transfer, and atmospheric chemistry. Some of these research activities were connected with involvements in new field projects, while others utilized data sets from previous experimental studies.

NASA Subsonic Contrails and Clouds Effects Study (SUCCESS). This project focused on studying the microphysical and optical properties of contrails and cirrus clouds. RAF scientists Darrel Baumgardner, Cynthia Twohy, Teresa Campos, Bruce Gandrud, Al Cooper, and Larry Radke participated in SUCCESS by making measurements on the NASA DC-8 with the MASP, CVI, UV hygrometer, and a newly developed CCN counter. Also, in collaboration with Andy Weinheimer and Brian Ridley of NCAR/ACD, Teresa Campos measured *in situ* nitric oxide, reactive odd nitrogen species, and ozone. The RAF researchers were joined by over a hundred other scientists from universities and government laboratories during April and May 1996 in Salina, Kansas. The measurements made by the RAF scientists were crucial to the goals of SUCCESS. The CVI system measured the ice water content and number concentration of ice crystals in contrails, cirrus, and wave clouds, and was able to measure the very low water content present in many of the contrails (typically only 1-2 mg m^{-3} for particles larger than 6 microns diameter). The mean crystal size was observed to decrease and the volatility of the residual particles from the contrail ice was observed to be substantially higher when high-sulfur fuel was used, suggesting additional nucleation on sulfuric acid aerosols. The MASP was the only *in situ* sensor of aerosol size distributions on the aircraft that obtained measurements in the free air stream. All other instruments required inlets, in which larger aerosols are typically lost by deposition. The MASP provided size distributions and asphericity measurements of aerosol particles, water droplets, and ice crystals from 0.4 - 20 microns in diameter. The NO measurements provided an important indicator of aircraft exhaust encounters and allowed direct quantification of the aircraft NO emissions at cruise altitudes. The ozone measurements proved a useful indicator of air history. Measurable concentrations of particulate NO_y were observed frequently in cirrus clouds.

Aircraft Contrail Studies. In this work, Darrel Baumgardner and Bruce Gandrud are using NCAR/NSF Sabreliner aircraft measurements from the 1989 Contrails project. The data are being evaluated in collaboration with the Aerodyne Corp. for comparison with models of aircraft exhaust and wake formation. This study is funded by the NASA High Speed Research Program to assess the effects of tropospheric aircraft emissions on regional and global climate. This past year's study has culminated in a presentation at the spring 1996 AGU meeting and a *Journal of Geophysical Research* paper (currently in review) entitled "Thermodynamic and Turbulent Effects of a Jet Contrail." This study compares observed temperature, water vapor, and vertical velocity profiles with predicted profiles from the Aerodyne wake-vortex model. The excellent agreement indicates the model can be successfully applied to study other contrail processes such as particle formation. In a related study, Darrel Baumgardner and Keith Barr installed the MASP on the German DLR Falcon aircraft in March 1996, and participated in a study of the effect of fuel sulfur content on contrail formation. This project involved researchers from the DLR, University of Stockholm, University of Heidelberg, University of Missouri-Rolla, and the University of Mainz. The Falcon was flown closely behind various test aircraft, and measurements were made in their exhaust and contrails.

Stratospheric Aerosols. RAF researchers Darrel Baumgardner, James Dye, and Bruce Gandrud are analyzing measurements from the MASP to better understand the fundamental mechanisms of aerosol production, growth, and transport in the lower stratosphere and upper troposphere. The data were collected when the MASP was flown in the ASHOE/MAESA campaign during March - November 1994, and later in TOTE/VOTE in December 1995 and January-February 1996 (see next paragraph). The research team made measurements of aerosol size, concentration, and refractive index to assess the optical and microphysical properties of the particles in these stratospheric regions. (The surface area of aerosols is a critical parameter in models of stratospheric ozone loss because that is where important heterogeneous chemical reactions occur.) The ability to measure the refractive index of individual particles is a new capability not previously available. The MASP measurements will be used by modelers to better understand the mechanisms of ozone depletion. The above scientists have published a paper in *Geophysical Research Letters* on refractive index measurements in the lower statosphere and upper troposphere. The results presented in this paper challenge some current theories about the composition of stratospheric aerosols.

Tropical Ozone Transport Experiment and Vortex Ozone Transport Experiment (TOTE/VOTE). This project was flown with NASA's DC-8 aircraft in the tropics around Hawaii and in the Arctic near Fairbanks, Alaska. The purpose was to study the transport of Arctic vortex filaments into the tropics and midlatitudes. RAF researchers Campos, Gandrud, Barr, and Baumgardner participated in this experiment along with many other university and government scientists. Teresa Campos collaborated with NCAR/ACD researchers in measuring *in situ* nitric oxide, reactive odd nitrogen species, and ozone to determine transport during various experiments. Intercomparison of these measurements with similar measurements made

by the NOAA Aeronomy Lab (David Fahey, et al.) on the ER-2 aircraft yielded encouraging results. Latitudinal transects during the mission showed interesting interactions between the troposphere and stratosphere at the subtropical jets, as confirmed by seemingly contradictory measurements of temperature vertical profiles and stratospheric chemical tracers like ozone and nitrous oxide. Comparisons of odd nitrogen and ozone with MASP aerosol measurements (made by Baumgardner, Barr, and Gandrud) in sub-visible cirrus showed interesting correlations that are currently being evaluated.

Joaquin Valley Study. Teresa Campos participated in a third field experiment, in collaboration with Jeff Collett of Colorado State University, to measure gas-phase total peroxides in California's Central Valley. The California Air Resources Board sponsored this study of the interaction between photochemistry and fog. NCAR involvement was limited largely to technology transfer. The addition of vapor-phase peroxide measurements was an important enhancement to the extensive cloud chemical analyses conducted by Collett.

Small Cumulus Microphysics Study (SCMS). Darrel Baumgardner, Al Cooper, and Larry Radke are investigating the formation of precipitation through non-ice processes and the interaction of clouds and aerosols in marine and continental cumulus. These scientists recently presented papers on these topics at the 13th International Conference on Clouds and Precipitation in Zurich, Switzerland. A paper on this research is currently in preparation for a special issue of *Atmospheric Research*.

Aerosol Characterization Experiment-1 (ACE-1). RAF scientists Greg Kok, Richard Schillawski, Andre Prevot (visitor from Zurich, Switzerland), Krista Laursen, Bruce Morley, and Darrel Baumgardner participated in the ACE-1 project in November and December 1995. Kok, Schillawski, and Prevot made measurements of ozone, carbon monoxide, carbon dioxide, and hydrogen peroxide. Laursen measured spectral radiation with the Multichannel Cloud Radiometer (MCR). Baumgardner used the MASP on the C-130 to measure the microphysical and optical properties of aerosols. Morley made aerosol backscatter measurements from the C-130 with the new NCAR Staring Aerosol Backscatter Lidar (SABL). Laursen and Morley have been working with Lynn Russell (an ASP post-doctoral fellow) and Don Lenschow on wavelet analyses of ACE-1 lidar data in an effort to perform boundary-layer height retrievals for various research flights. Laursen, Baumgardner, and Morley, in collaboration with Tony Clarke of the University of Hawaii, are using a lidar inversion algorithm to derive extinction coefficients for radiative closure studies . Baumgardner is evaluating all the aerosol measurements to investigate the coupling of microphysical and optical properties in the troposphere studied during ACE-1.

Swiss Oxidant Study. Based on analysis of the data from the 1993 Swiss Oxidant Study, Kok and Prevot completed the paper, "The Milan Photo-oxidant Plume". A pollutant plume from the Milan, Italy industrial region that impacts southern Switzerland was clearly identified.

Hong Kong Air Quality Study. Kok's analysis of the data collected in this 1994 study shows that there are three distinct areas of polluted air: polluted background air extending out over the South China Sea, a plume that travels down the Pearl River from the People's Republic of China, and a fresh emissions plume from Hong Kong. A paper entitled "An Airborne Study of Air Quality Around the Hong Kong Territory" has been submitted to the *Journal of Geophysical Research*.

Lidars in Flat Terrain (LIFT) Project. In July and August 1996 Kok and Schillawski participated in the LIFT project, making fast-response measurements of ozone for eddy-correlation purposes. The LIFT project was designed to test the potential of using lidars for turbulence and chemistry measurements for deriving deposition fluxes of selected chemical species. The project was conducted both at the Boulder Atmospheric Observatory near Erie, Colorado and at the Flatland observing site near Bondville, Illinois.

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Surface and Sounding Systems Facility

Mission and Goals

The mission of the Surface and Sounding Systems Facility (SSSF) is to provide surface-based *in situ* and sounding measurements, and associated data-processing and analysis software, in support of atmospheric research. The Facility also engages in related scientific research to maintain a leadership role in the development and operation of state-of-the-art measurement systems. SSSF engages in the following major activities:

- Operation of advanced surface and upsonde/dropsonde direct-sensing systems and ground-based microwave and acoustic profiling systems to support field research of atmospheric scientists.
- Development of new *in situ* and remote surface, profiling, and sounding systems in cooperation with other ATD groups, NCAR divisions, universities, and NOAA and other government agencies.
- Development of new data-telemetry systems to support ATD's field-data communications needs.
- Development of operational and analytical techniques for optimum use of field facilities, including techniques for sensor calibration, instrument deployment, data collection, and data analysis, and transfer of these techniques to the atmospheric sciences community.
- Scientific research and engineering development to support, demonstrate, and advance these capabilities.
- Support of university educational programs by providing state-of-the-art observing systems for student training, and by providing lectures upon request pertaining to meteorological instrumentation and observational research.

The traditional emphasis of the Facility has been to support mesoscale and boundary-layer experiments in keeping with national scientific priorities for research in atmospheric chemistry, mesoscale precipitation systems, cumulus convection, boundary-layer processes, and air-surface interaction. Recent emphasis has also included process study experiments relevant to climate change studies. SSSF has focused significant resources over the past year on numerous requests for field measurements. SSSF attempts first to satisfy all approved community requests for field support. Next in priority is to optimize the use of remaining facility resources to develop new observing systems and improve existing systems to meet the field-support requirements of major experimental programs of national interest, such as the U.S. Global Change Research Program and the U.S. Weather Research Program.

Field Support Activities

SSSF field support activities in FY 96 are listed in Table ATD-3 and briefly described below.

Table ATD-3: SSSF FY 96 Field Support Activities

User (Affiliation)	Project	Location	System	Period
Huebert, et al. (U. Hawaii)	ACE-1	Tasmania	ISS, CLASS	10/01/95 - 12/14/95
Angevine, et al. (CIRES)	Flatland-II	Central Illinois	ISS, PAM-III	06/14/96 - 8/15/96

Mayor, Cohn (NCAR/ATD)	LIFT	Central Illinois	ISS, PAM-III, SABL	08/15/96 - 09/15/96
Cohn (NCAR/ATD)	BLX-96	Southern Kansas	MAPR	07/25/96 - 08/23/96
Dye (NCAR/MMM)	STERAO-A	Greeley, CO	Mobile CLASS	06/01/96 - 08/15/96
Rogers (Scripps)	Coastally Trapped Waves	Monterey, CA	LD2 Dropsonde	06/01/96 - 07/03/96
Parsons (NCAR/ATD)	ARM GPS/Water-Vapor	Oklahoma - Kansas	GPS Receivers	09/10/96 - 09/30/96
Avery (CIRES-U. CO)	NEXRAD Precipitation	Denver, CO	ISS	06/15/96 - 08/15/96

Aerosol Characterization Experiment (ACE-1). ACE-1 was conducted from 15 November to 14 December 1995 over the southwest Pacific Ocean, south of Australia. Two Integrated Sounding Systems (ISS) and one Omega Cross-Chain LORAN Sounding system (CLASS) were deployed in support of this project. ACE-1 was the first in a series of experiments that will attempt to characterize the chemical and physical processes controlling the evolution and properties of atmospheric aerosols and their role in radiative climate forcing. The data from the two ISS stations provided height estimates of the marine boundary layer and the extent of mixing with the free troposphere. One of the ISS units was deployed on the NOAA ship RV Discoverer (58Kb) and the other was located at the Cape Grim Baseline Monitoring Station (68Kb) on the northwest tip of Tasmania. The data from the ship-borne and the land-based ISS stations will be combined with on-site chemistry and aerosol measurements to complete closure calculations throughout the operational season. The CLASS system was deployed on an Australia fisheries ship, the FRV Southern Surveyor, to enhance the spatial and temporal continuity of the measurements being made during the Lagrangian experiments. The addition of soundings made south of Tasmania by the Southern Surveyor enhanced the regional measurement coverage, improved the air trajectory calculations, and assisted in forecasting and operations planning.

Boundary Layer Experiment - 96 (BLX-96). SSSF deployed the Multiple Antenna Wind Profiler (MAPR) version of the ISS, augmented with a ceilometer (provided by NOAA/ETL), to Dexter, Kansas for remote sensing of atmospheric winds and turbulence in the boundary layer. Data collection was coordinated with overflights of the U. Wyoming King Air, which measured mean flux profiles and the joint frequency distribution of the lifting condensation level and buoyancy for investigators at the U. British Columbia. The MAPR experiment was designed to test spaced-antenna techniques for measuring turbulence profiles. It also had a secondary objective of collecting high-time-resolution observations of the nocturnal low-level jet. Approximately 25 CLASS soundings were launched from Dexter during the three-week experiment. Additional measurements were obtained from other instruments located at the Atmospheric Radiation Measurement (ARM) program's Cloud and Atmospheric Radiation Testbed (CART) site (16Kb).

Coastally-Trapped Waves Experiment. The objectives of this experiment were to study the dynamics of coastally-trapped waves, the ageostrophy of the wind constrained by a coastal mountain range, the interaction of orographically-forced flow with the sea-breeze circulation, the offshore variability and turbulent structure of the boundary layer, and the influence of the orographic barrier on the development of boundary-layer clouds. The NCAR C-130 aircraft (30Kb) provided the primary *in situ* measurements of boundary-layer structure for this experiment by means of along-shore and across-shore flight segments. Down-looking lidar measurements of the deformation of the marine boundary layer inversion and *in situ* cloud microphysical measurements were also obtained from the aircraft. SSSF supported the experiment by providing a airborne Lightweight Digital Dropsonde (LD2, 79Kb) system with the capability of using either LORAN or Omega sondes (depending on the quality of the LORAN signals). The LD2 system was used to measure atmospheric profiles, including the detailed structure of the boundary layer below the aircraft. Fifteen sondes were dropped during some of the higher altitude legs of the flight pattern.

Flatland Observatory Project II. This was the second year for this boundary-layer structure and dynamics experiment. The basic intensive observation period ran from 15 June through 15 August 1996, but was extended to the middle of September

to support the Lidars in Flat Terrain (LIFT) experiment (see LIFT below for details). The primary focus for this year's experiment was to study boundary-layer height, divergence, entrainment velocity, and entrainment processes, as well as measurements of the atmospheric heat-budget terms. Two ISS stations were deployed in a triangular array with the NOAA 915-MHZ wind profiler that is permanently located at the Flatland Atmospheric Observatory (FAO). This year, three flux-measuring (Flux-PAM) versions of the SSSF Portable Automated Mesonet (PAM-III) stations were added to the experiment as "anchors" for the boundary-layer measurements from the ISS and the FAO instruments. The Flux-PAMs provided flux measurements over typical crops (corn and soybeans) found in the experimental area. In addition to the standard meteorological measurements of wind, pressure, temperature, humidity, and rainfall, the Flux-PAM stations made measurements of soil temperature and moisture, as well as flux measurements of latent heat, momentum, and radiation. Flux measurements of ozone surface deposition were also made for the last thirty days of the experiment. At one site the Flux-PAM was enhanced with components of the ASTER system (64 Kb) in order to better acquire and process the fast data for the ozone surface deposition fluxes.

ARM GPS/Water Vapor Experiment. During 10-30 September 1996, SSSF operated six ground-based GPS receivers capable of obtaining a vertically integrated estimate of atmospheric water vapor. The effort was a joint project with NOAA/ETL, which also operates a GPS receiver network over this region, and UCAR/UNAVCO, which is processing the data. During the experimental period, members of the ARM science team operated a variety of remote and *in situ* water vapor sensors, co-located with one of the receivers. This experiment was the first deployment of these GPS receivers by ATD, and, to our knowledge, the first dense mesoscale deployment of such receivers primarily for meteorological purposes. The goals of this experiment were (1) to gain experience with this instrumentation for future deployments, (2) to assess the accuracy of these instruments for water-vapor measurements at high temporal resolution (i.e., of order 5 minutes), (3) to test the ability of these instruments to provide spatial variations, through comparisons with the U. Maryland's scanning Raman lidar, and (4) in collaboration with NCAR/MMM, to determine whether these measurements improve the accuracy of the predicted water-vapor profile through use of a variational data-assimilation model.

Lidars in Flat Terrain (LIFT). SSSF also participated in the LIFT experiment, which was closely linked with the Flatland Observatory Project II in central Illinois. In addition to the two ISS (57Kb) and three Flux-PAM stations deployed for Flatland, SSSF installed ATD's Staring Aerosol Backscatter Lidar (SABL, 106KB) and one enhanced Flux-PAM for ozone flux measurements at one of the ISS sites. Other LIFT instrumentation included NOAA/ETL's 2-micron High-Resolution Doppler Lidar (HRDL) and the Ozone Differential Absorption Lidar (DIAL). LIFT's objective was to study the high-resolution structure of winds, aerosol, and ozone as the daytime boundary layer grows and decays. The data gathered during the four-week experiment will also be used to evaluate lidar and profiler techniques for quantifying fluxes, turbulence, and boundary-layer height.

NEXRAD Precipitation Study. SSSF deployed an ISS at a NWS site near Stapleton Airport during June and July 1996. This ISS was operated in a "profiler only" mode in support of a study of remote quantitative precipitation measurement conducted by CIRES-CU and the NOAA Aeronomy Lab. The ISS was operated in conjunction with the NWS NEXRAD radar and the ATD S-Band Polarimetric Radar (S-Pol, 87Kb) in an attempt to quantitatively characterize precipitation using radar measurements. The profiler was operated with every other beam in the vertical mode. Oblique beams were included to obtain the horizontal wind. The vertical velocity Doppler spectra obtained from the profiler will be used to derive precipitation rates and size distributions.

Stratosphere-Troposphere Experiments: Radiation, Aerosols, and Ozone (STERAO-A). SSSF's Mobile CLASS van (74 Kb) was used to support this field program with vertical balloon soundings. The soundings were a component of a detailed investigation of the physical and chemical nature of thunderstorm inflows and outflows. The program attempted to gauge the effects of thunderstorm circulation on the composition and structure of the lower stratosphere and upper troposphere. A total of 45 soundings were made between 17 June and 17 July 1996 from the Fort Morgan Airport near Fort Morgan, Colorado. (Soundings data and data reports are available from SSSF's Home Page.)

Development Activities

Airborne Vertical Atmospheric Profiling System (AVAPS)/GPS Dropsonde System (95Kb). The development of this advanced, GPS-based dropsonde system has been supported by NOAA and the Deutsche Forschungsanstalt fuer Luft- und Raumfahrt (DLR, Germany). AVAPS has now progressed to the point where all the NOAA data systems (two four-channel

systems plus spares for the NOAA G-IV aircraft and two four-channel systems plus spares for the NOAA P-3 aircraft) have been delivered, and the initial flight testing has been completed. Both high-level (45,000-foot-altitude) and low-level (22,000-foot-altitude) drop tests have been completed, including intercomparison tests in which sondes were dropped from both the G-IV and the P-3s. Some sonde and data-system problems were uncovered during these tests; improvements were made and verified during follow-on tests. Data taken by the AVAPS system on the G-IV are expected to play a key role in the Fronts and Atlantic Storm Tracks Experiment (FASTEX), scheduled for early 1997. The NCAR four-channel GPS Dropsonde system that was scheduled to fly on the NCAR/NSF WB-57F for FASTEX will be installed in a leased aircraft for the experiment. The DLR four-channel AVAPS system is currently being built and will be installed on the DLR Falcon aircraft in March 1997. SSSF has received a contract from the U.S. Air Force to build two four-channel AVAPS data systems for evaluation by the 53rd USAF Reserve Unit ("Hurricane Hunters" flight), based at Keesler Air Force Base, Mississippi. If this evaluation is favorable, USAF may want ten additional AVAPS systems to replace their existing Omega dropsonde systems. NCAR has transferred the technology to the public sector by licensing a commercial firm (Vaisala, Inc.) to build the GPS sondes and data systems. This effort is led by Hal Cole and Terry Hock.

Dual-Wavelength Net Radiometer. Tony Delany and Steve Semmer have developed this advanced net radiometer to increase the accuracy of single-instrument measurements of surface radiation flux. Conventional net radiometers make separate determinations of short-wave and long-wave incoming and outgoing radiation which are subsequently differenced, resulting in loss of accuracy. The new system increases accuracy by making differential net shortwave and long-wave radiation determinations. The system was designed to utilize numerically controlled machining techniques to substantially reduce manufacturing costs. Other advanced features include data acquisition and manipulation capabilities and integrated ventilation and leveling.

Infrared Water-Vapor Sensor. Steven Oncley, Steven Semmer, Chuck Frush (ATD/RSF), and Wim Kohsiek (KNMI, The Netherlands) have designed an infrared humidity sensor to be used with Flux-PAM systems. The design is similar to other systems utilizing the 1.4-micron absorption band, but has been optimized to require less power and less maintenance. A prototype is now being constructed and will be tested this winter.

Integrated Surface Radiation Measurement System. Tony Delany and Steve Semmer have developed this integrated system to measure surface radiation flux. The system employs commercially available Eppley pyranometers and pyrgeometers, modified to ensure proper ventilation and mounted on a leveling platform. A special computer algorithm provides appropriate corrections for dome heating and sensitivity of the pyrgeometer to shortwave radiation. The new system will be used with the Atmosphere-Surface Turbulent Exchange Research (ASTER, 64Kb) facility for accurate determination of the surface energy balance. It will also be used for research into the errors introduced by non-leveled radiation sensor arrays deployed over various types of vegetated surfaces.

Multiple-Antenna Profiling Radar (MAPR). MAPR uses newly developed spaced-antenna techniques to measure vertical profiles of wind velocity through the lower troposphere. The goal of MAPR is to obtain better accuracy and much higher time resolution than conventional wind profilers, which measure winds through estimating Doppler shift in multiple beam directions. A refined theoretical treatment of spaced-antenna signals is being tested with MAPR. Hardware upgrades during the past year include modifications to deploy the antenna lower to the ground for clutter reduction, and complete re-tuning and calibration of the four receiver channels. Software upgrades currently being developed will allow winds to be computed in real time, and will allow use of a UNIX operating system. MAPR's deployment during the BLX-96 program provided an opportunity for intercomparison with *in situ* aircraft data. This data base includes observations of the growing daytime boundary layer and the nocturnal low-level jet. BLX-96 data will also be used to test new ideas for spaced-antenna turbulence measurement techniques.

Ozone Sensor Development. A collaborative project was initiated in FY 96 between SSSF and the German DLR to develop a small, low-powered, lightweight and inexpensive fast ozone sensor suitable for dropsonde use. In its current state of development, the prototype sensor is housed in a small cylinder 7 cm in diameter and 18 cm long. In this form, the sensor meets the size, weight, power, and cost requirements for dropsonde applications. However, an undesirable sensitivity to humidity needs to be corrected before the ozone sensor will be fully satisfactory. Research into modification of the chemiluminescent target material for this purpose is currently being pursued in Germany. The prototype sensor has already been used for tower-based fast-ozone measurements during LIFT. Ozone fluxes were determined and compared to similar measurements from a more sophisticated instrument using gas-phase chemiluminescense. The fluxes determined using the two systems are comparable, although the data from the inexpensive sensor require more processing. The further development of a compact, inexpensive, ozone flux instrument is being pursued in cooperation with the Chemistry

Department of U. Colorado.

Portable Automated Mesonet-III (PAM-III, 55Kb). Three Flux-PAM surface stations were constructed in early 1995, field tested, and successfully deployed in support of field programs during the summers of 1995 (SCMS) and 1996 (Flatland). The measurement of turbulent ozone fluxes by a Flux-PAM surface station turned out to be a highlight of the Flatland field project. Over the past year, testing and development has continued to refine and quantify the performance of both standard meteorological and flux-measuring sensors. Particular effort has been devoted to the measurement of water-vapor fluxes. This has involved continued evaluation and development of a bandpass hygrometer, as well as a recently initiated effort to develop a low-power, low-cost, fast-response, infrared-absorption hygrometer. The Flux-PAM network will be expanded in early 1997 with the construction of two additional stations, making a total of five stations available to the scientific community. At the same time, another Flux-PAM station will also be constructed for use by the Japanese National Committee for the GEWEX Asian Monsoon Experiment (GAME).

Real-time Data Communications System for Field Projects. During FY 96 SSSF continued to expand its capabilities for real-time data dissemination during field projects. Data communication and processing systems were implemented to support data delivery to SSSF and the field project control centers. The former allow SSSF scientists and engineers to closely monitor operation of the remote field systems, while the latter make the observations available for project operational planning. In some cases data can also be delivered to the Global Telecommunications System, so that the observations can be incorporated into operational models at the numerical weather centers. Most of the SSSF observing systems deployed over the past year provided real-time data in this manner, including the ISS based on a research vessel during ACE-1. Although this remote communication capability cannot always replace technical staff in the field, it allows real-time ingest of field data into our home computers, with resultant advantages for both experimental control and data quality control.

Relaxed Eddy Accumulator (REA). A version of this original SSSF instrument, specifically designed to investigate fluxes of biogenic hydrocarbons, has been developed through a joint effort with the Environmental Population and Organismic Biology Department of U. Colorado. This Colorado University Flux Facility (CUFF) REA was designed and constructed by Dave Bowling (U. Colorado) and Tony Delany (SSSF), using the latest version of the PAM-III sensor board, plus PC-based software prepared by Bowling in cooperation with SSSF engineers.

Scientific Data Management System. Efforts have continued over the past year in exploring data management systems that will support post-processing of field data, engineering needs for instrument development, and scientific data analysis. The goal is to create a data infrastructure that is versatile and robust enough to cope with the large variety of SSSF data architectures and analysis activities. The primary focus over the last year has been the application to SSSF datasets of the new ATD Information Retrieval System (AIRS), developed by Julie Haggerty and Gary Horton of RAF. A large cross-section of SSSF datasets has been ingested into the AIRS prototype, and testing of AIRS performance and suitability is currently underway.

Sensor Calibration and Evaluation Lab. During FY 96 this lab provided calibration services for a variety of surface instruments used with the SSSF facilities. In addition to routine calibrations, the lab was also used in sensor performance tests. The lab's wind tunnel provided help in understanding the flow-distortion characteristics of a Solvent 3-D sonic anemometer. The Thunder Scientific humidity/temperature chamber in the lab was used to evaluate the time response, over a wide temperature range, of a variety of solid-state humidity devices. This chamber also was used to check the performance of an aircraft air-intake duct housing for a humidity probe.

Wind Profiler Antenna Test Range. The Marshall field station of NCAR has been selected as the site for a basic antenna test range being constructed cooperatively by researchers from SSSF, several NOAA labs, and Radian Corp. The site will initially be used for testing of clutter screens. Signal contamination by moving clutter often limits the ability of lower atmospheric wind profilers to make accurate measurements, especially at low altitudes. A variety of new clutter screen designs and edge treatments for existing clutter screens have been proposed. The new test range will be used to measure the relative radiation pattern at elevation angles near the horizontal of various combinations of screens and edge treatments.

Wind Profiler Real-Time Software Development. SSSF is developing new control and display software for the Doppler Beam Swinging Wind Profiler (56 Kb) and the MAPR (see above). The goal of this project is to develop an operational system that will provide the necessary software environment to support research and improvement in basic wind-profiling techniques. Design features of the new software include operation under a multi-tasking operating system, facility for rapid

testing of digital signal-processing algorithms, and adherence to standardized data formats and programming interfaces. The system will allow for development and incorporation of real-time data-processing algorithms, with little modification to the basic data-acquisition system. The system is now approximately 80% complete. Testing will begin in the first half of FY 97.

Research Activities

BOREAS. Analysis of data obtained using the NCAR/NSF Electra during the BOREAS field program in 1994 continued during FY 96. Steven Oncley and several people in MMM and other institutions are conducting this effort. As part of this analysis, a comparison was made of the quality of data from several flux-measuring aircraft. This was a cooperative effort using data supplied by Robert Kelly (U. Wyoming, King Air), Ian MacPherson and Ray Desjardins (Canadian National Research Council, Twin Otter), and Ron Dobosy and Tim Crawford (NOAA Atmospheric Turbulence and Diffusion Division, Long-EZ). Overall, the comparison was quite good, although several problems were identified. Noise existed at high frequencies on the King Air temperature and on the Electra carbon-dioxide measurements. However, this had little effect on the flux measurements. Errors were found in the Long-EZ velocity measurements, which has prompted NOAA to refine their wind-finding system.

Cloud and Aerosol Chemistry Experiment (CACHE-94) Data Analysis. This experiment was focused on the turbulent deposition of cloud droplets to forested irregular terrain. This mechanism is an important yet little understood pathway for the deposition of atmospheric pollutants. During the field program in 1994, the ASTER facility was deployed at the Cheek Peak cloud observatory on a ridge line above the ocean, at the northwest extremity of the Olympic peninsula of Washington. Gordon Maclean and Tony Delany completed the data analysis completed early in the year and their paper has been accepted for publication by a scientific journal. The data also formed the basis for a Ph.D. thesis by A. Kowalski and an M.S. thesis by P. Anthoni, both at Oregon State U.

Flux Measurements from Displaced Scalars. Leif Kristensen and Jakob Mann (RISO National Laboratory, Denmark), John Wyngaard (Pennsylvania State U.), and Steven Oncley (SSSF) completed their interpretation of heat-flux measurements using temperature sensors that are physically separated from the velocity sensor. Measurements were taken during SST-93 (an ASTER (64Kb) deployment at the NCAR Marshall field site in 1993), and later at a site near RISO. The somewhat surprising result of this work is that the fluxes are virtually unchanged when the measurement of the scalar is physically located below that of the velocity. These results will be used to configure sensors in future ASTER and Flux-PAM deployments.

Footprint for Measurement of Atmosphere-Surface Exchange Fluxes. The flux footprint relates the vertical flux measured at some height above the surface to the upwind spatial distribution of atmosphere-surface exchange fluxes. A quantitative description of the flux footprint is required both for the design of field experiments and to interpret micrometeorological flux measurements. In 1992-1994, Tom Horst published theoretical estimates of the eddy-correlation flux footprint that are based on an analytic model for vertical dispersion within the atmospheric surface layer. More recently, he has extended the model to calculate the footprint associated with flux estimation by concentration-profile techniques. The upwind extent of the profile footprint was found to be similar to that for eddy-correlation flux measurements, if the latter are made at a height equal to the arithmetic mean of the profile measurement heights for stable stratification or the geometric mean for unstable stratification. However, the concentration-profile flux footprint extends closer to the measurement location than does the eddy-correlation footprint, because the flux estimated from the profile is strongly influenced by the concentration measurements made at heights lower than that of the eddy-correlation flux measurement.

Integrated Data Assimilation/Sounding System (IDASS). Supported by the DOE ARM program, the IDASS program seeks to develop improved measurement and data assimilation strategies. The program includes the MAPR project (headed by Stephen Cohn), as well as joint data assimilation studies between ATD (David Parsons) and MMM (Bill Kuo, Jimy Dudhia, and Yong-Run Guo). The data assimilation effort focuses on using variational techniques and Newtonian nudging in the NCAR/Pennsylvania State U. mesoscale model (MM5) for field experiments conducted in the vicinity of the ARM/CART site in the central U.S. An example of such an effort is the recent GPS water-vapor measurements taken over northern Oklahoma and southern Kansas last fall. The MAPR work includes an examination of the mesoscale organization of a spring frontal system that produced upslope precipitation along the Rocky Mountain Front Range. This analysis demonstrated the usefulness of the MAPR-derived wind measurements.

Natural Emissions of Oxidants Precursors: Validation of Techniques and Assessment (NOVA-96). NOVA-96 represented a continuation of NOVA-95. The field program was conducted in the Tidewater region of North Carolina. It was intended to characterize the measurement of emission fluxes of oxides of nitrogen, using both enclosure techniques and eddy-correlation measurements. Preliminary findings by Tony Delany (SSSF) and project scientists at North Carolina State U. and other universities indicate that, for cropland with a well established vegetation canopy, the bare-soil emission measured by enclosure methods overestimated the net emission to the free atmosphere, compared with surface-layer measurements by eddy correlation. The investigators believe this could be due to redeposition of the oxides of nitrogen onto the plant surfaces. Analysis of the data will continue into the upcoming year.

Orographically Influenced Winds. High-time-resolution data taken by MAPR and the instrumented Boulder Atmospheric Observatory (BAO, 95Kb) 300-m tower during the Erie-95 field program have provided an excellent opportunity to study mesoscale dynamics in rain near the Rocky Mountain Front Range. Unique observations include highly resolved measurements of wave-like fluctuations in the wind speed, a persistent horizontal wind maximum during stratiform rain and associated with the melting-level height, and large pressure fluctuations and surges in wind speed at the surface. Stephen Cohn has been investigating these observations with supporting data from the Colorado mesonet, the Denver WSR88-D (NEXRAD) radar, and the regional rawinsonde network.

Spaced-Antenna Theoretical Development. Theoretical developments associated with the MAPR profiler continued during FY 96. These include estimation of the precision of spaced-antenna and Doppler-beam-swinging wind-measurement techniques, estimation of turbulence, and generalized theory treating measurements in the presence of horizontally anisotropic refractive-index irregularities. MAPR is being used to test these new ideas, using *in situ* data from the BAO tower for verification. Stephen Cohn and Stephen Oncley are participating in this research, in collaboration with Chris Holloway (NTIA/ITS), Richard Doviak (NOAA/NSSL), and Richard Lataitis (NOAA/ETL).

TOGA COARE Studies. Data obtained from several ISS stations (86 Kb) deployed during the Tropical Ocean Global Atmosphere Coupled Ocean-Atmosphere Response Experiment (TOGA COARE) have provided an excellent opportunity to examine atmospheric circulations over the tropical western Pacific on a variety of scales. Kunio Yoneyama (a visitor from the Japanese Marine Science and Technology Center) and Dave Parsons have collaborated on a study of the appearance of very dry air in the middle troposphere over the equatorial oceans. Their results indicate that the dry air intrusions are due to the horizontal advection of air from subtropical and even middle latitudes rather than simply the subsidence of tropical air. This work has led them to study the impact of these events on convective organization and the surface energy budget over this region. In addition, Parsons is collaborating with George Young (Pennsylvania State U.) and his graduate student in obtaining a more complete climatology of convective outflows over this region.

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT

Remote Sensing Facility

Mission and Goals

The mission of the Remote Sensing Facility (RSF) is to provide state-of-the-art remote sensing capabilities and associated data processing and analysis software in support of atmospheric research. RSF staff also conduct scientific research in order to maintain and support a leadership role in the operation and development of remote sensing systems. In meeting these mission requirements, RSF engages in the following five major activities:

- Development and field operation of remote sensing facilities, including Doppler weather radar and lidar systems.
- Consulting with users of RSF facilities on field project design and implementation, data analysis, and data interpretation.
- Development and operation of interactive computing capabilities, display systems, and software for the editing, display, and analysis of data collected.
- Scientific research on topics related to ATD-supported field projects and development activities.
- Collaboration with scientists and engineers at universities, other research organizations, and NCAR divisions in developing new facilities and data analysis techniques.

RSF field activities and sensor developments in FY 96 concentrated on polarimetric-radar precipitation estimation techniques, marine boundary-layer waves, and boundary-layer flux measurements. We continued to strengthen our joint optical remote sensing program with the NOAA Environmental Technology Laboratory (ETL) by deploying three lidars in collaboration with other boundary-layer instrumentation. RSF's new S-Band Dual Polarimetric Radar (S-Pol, 64Kb) was used in its first field program to obtain dual-polarimetric-radar precipitation estimates for comparison with precipitation estimates derived from older methods currently in use with the WSR-88D (NEXRAD) radars operated by the National Weather Service (NWS). A series of similar intercomparisons is planned over the next few years in various seasons and locations around the U.S.

Remote Sensors and Capabilities

In FY 96 RSF operated the new S-Pol radar, the airborne Electra Doppler radar (ELDORA), the airborne ozone Differential Absorption Lidar (DIAL), the Staring Aerosol Backscatter Lidar (SABL), and a 2-micron Doppler lidar from NOAA/ETL. RSF also took on new responsibilities for operation and maintenance of airborne radiometric sensors (formerly in RAF). Brief descriptions of these remote sensing systems are given below.

S-Band Doppler Dual Polarimetric Radar (S-Pol). A team led by Jon Lutz completed development of this advanced, highly-portable radar in FY 96. The new system has significantly improved signal-processing and polarization-measurement capabilities, compared with earlier radars. The need for S-Pol was well defined at a Polarization Radar Workshop at NCAR in 1994. The system was assembled from the basic framework of the prototype FAA Terminal Doppler Weather Radar (TDWR) radar, with the addition of components from ATD's earlier CP-2 radar. The enhanced system uses a high-quality antenna with very low sidelobes, a high- reliability transmitter built around the FAA's ASR-9 system, and parallel receivers for simultaneous co-polar and cross-polar responses. The innovative design packages S-Pol into six 20-foot shipping containers and eliminates the radome. This greatly simplifies transporting and setting up the system and significantly lowers shipping costs.

Airborne ELDORA Doppler Radar (ELDORA). The ELDORA radar is a dual-beam, X-band Doppler radar mounted on the NCAR Electra. The two radar beams spin about the longitudinal axis of the aircraft; one beam of the radar points slightly to the front and one slightly to the aft. As the aircraft flies near the atmospheric feature to be measured, the forward beam, and shortly thereafter, the aft beam, penetrates the measurement volume. This allows estimation of the vector wind field. The gate spacing on ELDORA can be as small as 37.5 meters and the antennas can spin at over 20 RPM, allowing for an along-track beam spacing as short as 300 meters. By staggering the spacing on the pulses, an unambiguous velocity range of +/- 100 m/s can be obtained.

Airborne Imaging Microwave Radiometer (AIMR). RSF took on new responsibilities for the operation and maintenance of AIMR in FY 96. This radiometer operates from the NCAR/NSF C-130 aircraft, scanning across the flight track through the nadir point. The instrument measures surface and atmospheric radiation emissions at 37 and 90 GHz. Each frequency is separated into horizontally and vertically polarized channels. To date, the instrument has primarily been used for mapping of the polar ice cap (ice and snow change their radiative properties with age). Potential may exist for mapping ground moisture content. During the next year RSF will test and upgrade the system to make it more useful for field programs.

Weather Avoidance Radar Data System (WARDS). This system successfully processed data from the forward-looking weather-avoidance radar on the C- 130 (41Kb) during the Small Cumulus Microphysics Study (SCMS), and on the Electra (45 Kb) during the Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX). It was upgraded this year by Craig Walther and Tim Rucker to synchronize with the master time signal on board each aircraft. An add-on unit, developed by Rich Neitzel, receives data from WARDS and plots it on an aircraft track display in fixed-earth coordinates. This latter display will greatly enhance the ability of the principal investigator (PI) to direct the flight, by showing weather echoes within 50 to 100 km of the aircraft in all directions. This display will be available at each of the scientific workstations on board the aircraft.

Optical Remote Sensing:

RSF's Optical Remote Sensing program, led by Mike Hardesty, continued as a joint effort with the NOAA/Environmental Technology Laboratory (ETL). RSF and ETL science and technical staff together deployed several lidar instruments in field programs during the year, as described in subsequent sections. During FY 96, NCAR and NOAA began planning for the joint development of a ground-based water-vapor profiling lidar. The following three lidar systems were offered for atmospheric research during the year:

Solid State High Resolution Doppler Lidar (HRDL). Chris Grund (NOAA) and Chuck Frush (NCAR) collaborated to optimize the performance of the NOAA 2-micron Solid State High Resolution Doppler Lidar in preparation for the LIFT experiment. The radar was installed in the NCAR mobile optical laboratory (70 Kb) having the capability of scanning and resolving 30-meter range increments. An upgraded signal processor was added to the instrument to provide accurate real-time wind and backscatter estimates.

Staring Aerosol Backscatter Lidar (SABL). The SABL lidar (72 Kb), used to measure and map distributions of relative aerosol concentrations, is a dual-wavelength system operating at 532 and 1064 nm. It can transmit up to 60 pulses per second. Each pulse contains approximately 75 mJ of 1064 nm energy and 45 mJ of 532 nm energy. The transmitted energy scattered by aerosols in the atmosphere is received by a 14-inch-diameter Cassegrainian telescope. The received signal is digitized to 12 bits at up to 40 Mhz (3.75-meter range resolution), and recorded to tape. A real-time data display allows scientists to use SABL for real-time experimental control during field studies.

Ozone Differential Absorption Lidar (O_3 DIAL). This airborne ozone lidar (61 Kb) was jointly acquired by NOAA/ETL and NCAR/ATD from EPA in FY 94. Designed for down-looking airborne operation, the lidar measures ozone and aerosol cross-sections and profiles in the layer below the aircraft. During FY 96, NCAR and NOAA staff continued to improve the lidar and its data system to provide higher sensitivity and better reliability of operation. Intercomparisons with ozone data from airborne and balloon-borne sensors are being used to improve ozone estimation algorithms.

Field Support Activities

RSF field support activities during FY 96 are listed in Table ATD-4 and briefly summarized below:

NEXRAD/S-Pol Precipitation Measurement Comparison. In its first field deployment, S-Pol was sited at the Front Range Airport (east of Denver), near the Denver WSR-88D radar, for the purpose of comparing rainfall estimates from S-Pol using polarimetric techniques with those from the WSR-88D using the standard reflectivity-based method. Scientists from Colorado State U. (Bringi and Chandresekar), NOAA's National Severe Storms Laboratory (NSSL, Zrnic, and Rhyzkov), NWS Office of Hydrology (Fulton), and NCAR (Brandes, Vivekanandan, and Wilson) participated in the project. The Urban Drainage and Flood Control District concurrently operated a network of 113 telemetering tipping-bucket raingauges, which provided an excellent precipitation data set for verification purposes. In addition, Colorado State U. operated three mobile vehicles for obtaining measurements of drop-size distribution and rainfall.

Coastally Trapped Waves Experiment. This program was conducted near Monterey, California with David Rogers of Scripps Institute as the PI. SABL was deployed on the NCAR C-130 to map aerosols in the marine boundary-layer. The lidar was mounted so it could be used for either upward- or downward-looking observations.

Lidars in Flat Terrain (LIFT). LIFT was a field experiment designed and led by visiting ATD scientist Shane Mayor. Through LIFT, the instrumentation network of the Flatland experiment (Wayne Angevine, PI) was supplemented by three additional lidar systems. The purposes of the program were to measure turbulent structures in the boundary layer and to improve measurements of vertical fluxes of momentum, heat, and trace gases. The three lidars that were fielded were SABL, operating at two wavelengths (1064 nm and 532 nm), developed by Craig Walther and Bruce Morley; an ozone UV-DIAL lidar, developed at NOAA/ETL by Yanzeng Zhao; and the 2-micron Solid State HRDL, developed at NOAA/ETL by Chris Grund. In addition, Tammy Weckwerth (NCAR/ASP post-doctoral fellow) operated the U. Oklahoma Doppler on Wheels (DOW) radar to investigate convective-roll structures in conjunction with the optical measurements.

Data were taken in July and August for a period of 5 weeks near Champaign, IL. The combined data from the co-located, vertically pointing, high-resolution lidars are expected to provide an unprecedented look at evolving boundary-layer features. Most of the data were taken in the vertically pointing mode, allowing a comparison of the capabilities of the co-located instruments to resolve small features of the boundary-layer.

Table ATD-4. RSF FY 96 Field Support Activities

User (Affiliation)	Project	Location	Sensor	Period
Brandes, et al. (NCAR/RAP and other)	NEXRAD/S-Pol Precipitation Measurement	Front Range Airport, CO	S-Pol	Jun-Aug 96
Rogers (Scripps)	Coastally Trapped Waves	Monterey, CA	SABL	Jun-Jul 96
Mayor (NCAR/ATD)	LIFT	Champaign, IL	SABL, HRDL, DOW	Jul-Aug 96

Sensor Development Activities

Considerable effort was spent by RSF staff on sensor development during FY 96. These activities spanned developments in ground-based and airborne radar systems, as well as optical systems. Several developments in the areas of data systems and signal processing were common to multiple sensor systems.

ELDORA. This year the ELDORA radar was upgraded to use SCSI-2 for higher-rate data recording. The radar is now capable of recording data at a rate of nearly 1 Mb/sec. Eric Loew added a MiniRIMS inertial reference unit inside the spinning antenna structure (rotodome) mounted in the rear of the aircraft. This device will more accurately register the ELDORA data within the earth's reference frame. A video distribution system was developed by Mike Strong that allows both of the ELDORA real-time displays to be available at all five scientific work areas on board the Electra. Improvements to the stability and usability of the user interface were also implemented.

Doppler on Wheels (DOW). In collaboration with Joshua Wurman (U. Oklahoma), RSF contributed to the construction of a new highly transportable, X-band Doppler radar. The DOW radar was deployed successfully in LIFT. RSF technical staff

are assisting Wurman with processor and recording improvements.

Cloud Physics Radar (CPR). In collaboration with Robert MacIntosh and Andrew Pazmany (U. Massachusetts), RSF is investigating a cloud physics radar that could be used for a variety of applications. The system could be deployed either on the ground, on the Electra in conjunction with ELDORA, or in a C-130 wing pod. Pazmany has delivered recommendations that are being evaluated by RSF.

Technique Development Activities

Polarimetric Rainfall Estimation. Real-time algorithms for estimating rainfall amount were implemented on S-Pol during summer 1996. For this purpose, Frederick Fabry and Mitch Randall modified computer code obtained from Colorado State U. and the NOAA/NSSL. Three algorithms were prepared. The first is based on horizontal (Z_H) and vertical (Z_V) radar reflectivity factors, the second on specific propagation phase (K_{DP}), and the third on the Z-R (radar reflectivity-rainfall rate) relationship used by the NEXRAD WSR-88D radars. Studies are underway to determine optimum procedures for applying these different relationships for different rainfall regimes. Based on these studies, precipitation estimates are expected to become a routine real-time product from S-Pol.

Airborne Radar Techniques. Wen-Chau Lee and Peter Hildebrand continued to improve algorithms for the efficient processing of ELDORA data. Lee and Susan Stringer led an effort to automate the technique of using ground echoes to validate and correct ELDORA radar beam-pointing angles and to minimize navigation errors. Hildebrand investigated retrieval of sea-surface wind direction and speed from the sea-surface returns obtained by ELDORA.

Radar Surface Refractivity Mapping. Frederic Fabry (NCAR/ ASP post doctoral fellow), with the assistance of Chuck Frush, developed a technique to measure refractive index and water-vapor concentrations near the ground using radar returns from fixed ground targets. A differential analysis of the propagation time to multiple ground targets caused by changes in index of refraction (due to changes in density and humidity) provides measurements of surface-level refractivity. Preliminary tests using data from the McGill radar in Montreal and from NCAR's S-Pol radar located south of Denver International Airport indicate good agreement with independent *in situ* measurements at selected points. The preliminary data show patterns in the refractivity field that drift through the observation area but are not always linked to observable reflectivity features. Work is continuing at McGill U. where Fabry is now employed.

SOLO Perusal and Editing Software. Dick Oye (RDP), Sherrie Smith, and Wen-Chau Lee continued their development of the SOLO program to peruse data from various research radars and lidars, including NEXRAD and TDWR. SOLO also translates a variety of data formats during ingest, for compatibility purposes. New and efficient editing and examining functions have been added. SOLO has been ported to a number of platforms including LINUX.

NEXRAD Data Quality. A team led by Frank Pratte is developing techniques that can be readily applied to the NEXRAD WSR-88D radar network. These include a procedure for consistent reflectivity calibration of the radar, an optimized approach to anomalous propagated clutter processing, an access platform for the digital Archive I (time-series) data, and an instrumentation system for testing modifications and improvements of the Operational Support Facility (OSF) testbed radar. A new effort to develop a robust range/velocity-ambiguity removal technique is being led by Chuck Frush, in collaboration with NOAA/NSSL. Under a joint agreement, RSF and the NOAA Forecast Systems Laboratory (FSL) support OSF tasks relating to radar data quality and product improvements and their application to hydrology.

PC and VME Integrated Radar Acquisition System (PIRAQ and VIRAQ). The new VIRAQ radar data acquisition system was developed in FY 96 by Eric Loew and Mitch Randall. This system extends the PIRAQ system with a dual-channel, digital, intermediate-frequency signal processor and a digital signal-processor (DSP). The principal advantage of PIRAQ and VIRAQ is that they can convert an ordinary, non-Doppler radar into a sophisticated Doppler system. The main difference in the two systems is that the VIRAQ plugs into a VMEBus and has two DSPs, while the PIRAQ requires a conventional personal computer and uses one DSP. A quad-DSP processor board allows additional DSPs to be added to increase computing power. A video display board allows more flexible and usable video displays than are provided by commercial video controllers. These boards were tested successfully as part of the S-Pol radar during the NEXRAD/S-Pol Precipitation Measurement program, and are also used in WARDS.

Research Activities

Jim Wilson continued his research into the factors affecting the initiation, organization, and decay of convective storms in Florida. A paper on the subject was prepared and accepted for publication in *Monthly Weather Review*. His research has shown that the initiation of storms is related to the magnitude and depth of boundary-layer convergence and the low-level wind-shear profile. The lifetime and organization of the convection is related to the relative motion between the storms and the convergence lines.

Wen-Chau Lee continued his collaboration with the NOAA Hurricane Research Division (HRD) and the National Taiwan U. on the VTD and GBVTD radar data-analysis techniques. These methods use a single airborne or ground-based Doppler radar to retrieve the primary circulation of a hurricane or typhoon. Mean perturbation pressure and temperature have been successfully retrieved from the mean tangential winds obtained using the VTD and GBVTD techniques.

Lee and Peter Hildebrand computed vertical profiles of momentum, apparent sensible heat source, and apparent moisture sink for several tropical convective systems using ELDORA data collected during TOGA COARE. The results showed good agreement with conventional methods using rawinsonde data.

Lee collaborated with David Chen (U. Chicago) in using TAMEX data to study the formation of a barrier jet and its relationship to heavy rainfall in northwestern Taiwan. In addition, Lee participated in planning for the use of ELDORA radar in several future field experiments.

Shane Mayor, with Raul Alvarez (NOAA/ETL) and Christoph Senff (U. Colorado), analyzed airborne lidar observations from the 1995 Southern Oxidants Study to map regional ozone and aerosol distributions over the experimental area. They also studied diurnal transport and evolution of the Nashville metropolitan ozone plume during a major air stagnation event, and characterized ozone titration in power-plant plumes. In combination with concurrent *in situ* measurements, the airborne lidar data provide important information on generation and transport of ozone in an isolated metropolitan area.

Jeffrey Keeler and Hildebrand maintained a collaboration with Robert Macintosh and Andrew Pazmany (U. Massachusetts) on dual-polarization mm-wave radar applications for the scientific community. Their goal is to provide access by NSF-supported scientists to airborne and ground-based mm-wave radar systems for application to various research topics such as cloud evolution, clouds and radiation, cloud physics, and boundary-layer processes.

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Research Data Program

Mission and Goals

The Research Data Program (RDP) supports the scientific user community and the ATD facility organizations via service and development in each of the following areas:

- Data archival and distribution: through operation of a comprehensive data archive of multi-platform ATD data sets, and timely distribution of these data via appropriate media.
- Analysis software tools: through development, maintenance, and user support of advanced software tools for editing, display, overlay, scientific processing, and analysis of ATD and other data sets.
- Networking and distributed computing: through coordination of distributed computing management within ATD to maximize connectivity and compatibility among ATD Facilities and users outside of NCAR.

Data Management Activities

RDP serves as a one-stop source for ATD data sets, associated documentation, and consulting services related to data access and analysis software. Data archived and distributed through RDP in FY 96 include those from aircraft (Electra, C-130, King Air, and Sabreliner), radar (S-POL, CP-2, CP-3, CP-4, ELDORA, and Mile High Radar), lidar (SABL, O_3-Dial), PAM, CLASS, ISS, and ASTER, as well as Zebra summary data sets.

Data Distributions. In FY96 we had 110 individual data requests from non-NCAR researchers (see Table ATD-5). In addition, data services were provided to NCAR investigators in RAP, MMM, and ATD. Data distribution was accomplished primarily via high-density 8-mm Exabyte cassettes. Network transfer continues to grow in application, particularly for data sets of a few tens of megabytes or less. Conventional nine-track tapes, DAT tapes, digital linear tapes, and PC floppy disks are used for investigators who require these media. A second TOGA COARE integrated data set release was made in FY 96. This data set was assembled by RDP in collaboration with the TOGA COARE International Project Office and UCAR's Joint Office for Scientific Support.

WWW Data Access. RDP continued work on developing methods for data documentation and distribution thorough the World Wide Web (WWW). Currently, information regarding the time, location, and mode of data collection, quick-look images of pertinent data sets, and information for ordering full data sets is available via the WWW for several projects. These include STERAO-A (1996), ACE-1 (1995), COPE (1995), SCMS (1995), VORTEX (1995), WISP (1994), TOGA COARE (1992-93), STORMFEST (1992), CAPE (1992), HaRP (1990), and a number of other, smaller projects. All project- and data-related information can be found in the ATD Data page.

Table ATD-5: Researchers Receiving Data Distributions from RDP in FY 96

Requestor	Institution	Data Type	Field Program
Rachel Ames	RAP	PAM	HaRP
---	United States Army	Satellite, Aircraft	KuDA

Nolan Atkins	NCAR/MMM	Aircraft, Radar	VORTEX
Gary Barnes	SOEST/University of Hawaii	Zebra	TOGA COARE
Alan Blyth	New Mexico Tech	Radar, Aircraft	SCMS
V. Bringi	Colorado State University	Radar	S-POL Precip
Baode Chen	UCLA	Zebra	TOGA COARE
Han-Ru Cho	University of Toronto	Zebra	TOGA COARE
Dean Churchill	University of Miami	Zebra	TOGA COARE
Carol-Anne Clayson	University of Colorado	Zebra	TOGA COARE
Judith Curry	University of Colorado	Zebra	TOGA COARE
John Daugherty	NOAA/MRD	Zebra	TOGA COARE
Peter Duynkerke	Inst. Marine and Atmos Res., Utrecht, The Netherlands	Aircraft	ASTEX
Jim Dye	NCAR/MMM	Misc.	NOLTG
Gerard Eldin	ORSTOM, New Caledonia	Zebra	TOGA COARE
J. Erdman	Colorado State University	Radar	Denver NEXRAD
Paul F. Hein	Colorado State University	Zebra	TOGA COARE
Ming Feng	University of Hawaii	Zebra	TOGA COARE
Pierre Flament	University of Hawaii	Zebra	TOGA COARE
D. Flannigan	Colorado State University	Zebra	CaPE
Jeff French	University of Wyoming	Aircraft	SCMS
Carl Friehe	University of California/Irvine	Aircraft	CODE, CODE-II, SMILE
Steve Gaddy	University of Oklahoma	Radar	VORTEX
Hermann Gerber	University of Wyoming	Aircraft	SCMS
J. Gibson	UMIST, UK	CLASS	WISP-94
Rick Graves	NCAR/MMM	Aircraft	FIRE-II
Grant Gray	New Mexico Tech	Radar	CP-2
Eric Hackert	NASA/GIS	Zebra	TOGA COARE
J. Hammer	Mitre Corporation	CLASS	Various
Steve Hill	Institute of Ocean Sciences, B.C., Canada	Zebra	TOGA COARE
Peter Hoellrigl	Division of Climate Research ETH	Zebra	TOGA COARE
Tihomir Hristov	University of California/Irvine	Aircraft	CODE, CODE-II, SMILE
Pat Hrubiak	NASA/GISS	Zebra	TOGA COARE
Huang-Hsiung Hsu	National Taiwan University	Zebra	TOGA COARE

Kelan Huang	Woods Hole Oceanographic Inst.	Zebra	TOGA COARE
James Hudson	Desert Research Institute	Aircraft	SCMS
Sam Iacobellis	University of California/SD	Zebra	TOGA COARE
Qiao-Lin Jin	SDSMT	CLASS	CaPE
Isabelle Jobard	CNRS, France	Zebra	TOGA COARE
Ben Jou	NTU, Taiwan	Radar	TAMEX
Robert Kelly	University of Wyoming	Radar	SCMS
Cathy Kessinger	NCAR/RAP	Radar	TNEXRAD90
Alexander Khain	Hebrew University	Aircraft	WISP-94
Charles Knight	MMM	Radar	SCMS
Kevin Knight	RAP	Radar	HaRP
Kevin Knupp	University of Alabama	Radar	MIST, CaPE
Paul Kucera	TRMM/NASA/GISS	Zebra	TOGA COARE
---	Government of Kuwait	Satellite, Aircraft	KuDA (entire archive)
Sonia Lasher-Trapp	University of Oklahoma	Aircraft, Radar	SCMS
David Ledvina	NASA/GISS	Zebra	TOGA COARE
Don Lenschow	NCAR/MMM	Aircraft	ACE-1
Jialin Lin	SUNY/Stonybrook	CLASS, PAM	CaPE, NDTP
Timothy Liu	Jet Propulsion Lab	Zebra	TOGA COARE
David M. Legler	Florida State University	Zebra	TOGA COARE
Leslie M. Hartten	NOAA Aeronomy Lab	Zebra	TOGA COARE
Mark J. MacLennan	CGRER, University of Iowa	Zebra	TOGA COARE
Mike Magsig	University of Oklahoma	ELDORA	VORTEX
Shane Mayor	University of Wisconsin	Lidar	LIFT
L. Jay Miller	NCAR/MMM	Radar	SCMS
Dewayne Mitchell	NSSL	Radar	CaPE
Joel Moeller	National Weather Service	Zebra	TOGA COARE
Martin Murphy	University of Arizona	Radar	CP-2
Tetsuo Nakazawa	Meteorological Research Inst., Japan	Zebra	TOGA COARE
Riko Oki	University of Tokyo	Zebra	TOGA COARE
Steve Oncley	NCAR/ATD	ASTER	BOREAS
Ilga Paluch	NCAR/MMM	Aircraft	BASE, SCMS

Michele Petrie	University of California/SD	Aircraft	ACE-1 (sample HRT data)
Bruno Piguet	Meteo-France	Aircraft	SCMS
James Pinto	University of Colorado	Aircraft	BASE
Dave Priegnitz	SDSMT	Radar	CaPE
David Raymond	New Mexico Tech	Zebra	TOGA COARE
Alfred Rodi	University of Wyoming	Radar	SCMS
Peter Roohr	Colorado State University	Radar	MHR, WISP, STORMFEST, NEXRAD
Lew Rothstein	University of Rhode Island	Zebra	TOGA COARE
Frank Roux	Universite Paul Sabatier, France	Zebra	TOGA COARE
M. Ryan	NOAA ETL	CLASS	WISP-94
Bryan Seng-Hpa	Monash University	Zebra	TOGA COARE
J. Shepherd	NASA/GSFC	Radar, CLASS	CaPE
Samantha Smith	NASA/Goddard	Aircraft	FIRE II
Donna Sueper	NOAA	Aircraft	ROSE-AIR
Jaques Testud	CETP, France	ELDORA	Various
Lin Tian	University of Chicago	Radar	SCMS
John Tuttle	NCAR/MMM	Radar	SCMS
Natty Urquizo	Atmospheric Environment Service, Canada	Zebra	TOGA COARE
Hans Verlinde	Pennsylvania State University	ELDORA	VORTEX
Dean Vickers	Oregon State University	Zebra	TOGA COARE
J. Vivekanandan	NCAR/RAP	Radar	MHR
Roger Wakimoto	UCLA	ELDORA	VORTEX
Jeanette Walters	UCAR/TCIPO	Aircraft	TOGA COARE
Qing Wang	UCLA	Aircraft	BASE, ACE-1
Tammy Weckwerth	NCAR/RSF (visitor)	Zebra	SCMS
Alastair Williams	Flinders University of South Australia	Zebra	TOGA COARE
Steve Williams	UCAR/JOSS	Aircraft	STORM-FEST
David Wolff	NASA/Goddard	Radar	SCMS
Xiaoqing Wu	NCAR/MMM	Zebra	TOGA COARE
Josh Wurman	University of Oklahoma	Radar	Ocean Reflectivity
Yuanzheng Yao	University of Colorado	Zebra	TOGA COARE
Seongsoo Yum	Desert Research Institute	Aircraft	ACE-1
Sandra Yuter	University of Washington	Aircraft	TOGA COARE

Yiping Zhao	University of Maryland/College Park	Zebra	TOGA COARE
Yong Zheng	University of Colorado	Zebra	TOGA COARE
Conrad Ziegler	National Severe Storms Laboratory	Zebra	TOGA COARE
Ed Zipser	Texas A&M University	Zebra	TOGA COARE

Software Tools and Capabilities

Applications Software. Software tools are developed and supported for community use to facilitate the display, editing, analysis, and graphical integration of observational data sets. RDP software support includes documentation, distribution, maintenance of code, and user consultation. RDP's principal community software tools are targeted for use on UNIX workstations and include:

- Radar Analysis: The SOLO program provides comprehensive, window-oriented radar data display, analysis, and editing. Additional utilities exist to support data access, format conversion, and file/disk management.
- Zebra: Comprehensive graphical integration of observational data sets (136Kb, such as those collected by satellite, radar, mesonet, and aircraft), and of analysis products (49Kb, such as model results, dual-Doppler syntheses or algorithm output, 136 Kb) for use in real-time and post-analysis.
- Reorder: 3-D interpolation and gridding of radar data.
- SUDS: Flexible display and editing of rawinsonde measurements.
- Robot: Flexible display of mesonet observations (Robot is no longer under active development, but is still used in some situations).

RDP also continues to provide support for the **radar editor** and **perusal** programs, but most new development effort is directed toward SOLO.

RDP's software runs on workstations provided by Sun Microsystems, Hewlett-Packard, and Silicon Graphics. In addition, most of the software suite is also supported on PC-class hardware under the Linux operating system.

Consultation and Other Support. Our scientific and programming staff provide extensive consultation and support to community scientists making use of RDP's analysis tools. These tools are developed and maintained to facilitate portability to users' home computing facilities. Institutions that have ported RDP software to their home machines or used the software in FY 96 are listed in Table ATD-6.

Table ATD-6: Institutions Using RDP Software in FY 96

Institution	Software Package					
	Radar	Zebra	Robot	Reorder	SOLO	SUDS
Abaconet		*				
Air Force Technical Applications Center		*				
Applied Research Corporation	*	*		*		
Argonne National Laboratory		*				
ARWC Weather Center		*				
Atmospheric & Environmental Research, Inc.	*	*				
Atmospheric Environment Service (Canada)		*				
Battelle Pacific Northwest Laboratories		*				*
Boeing Corporation	*	*				

Brookhaven National Laboratory		*				
Bureau of Meteorology Research Centre	*	*		*		
CESGA		*				
CNRM GMME/COME		*				
CRC Southern Hemisphere Meteorology		*				
Center for Innovative Computing Applications		*				
Centre de Meteorologie Spatiale		*				
Colorado State University	*	*	*	*	*	*
Columbia University		*				
Copel/Simepar		*				
Creighton University		*				
Dalhousie University	*					
Desert Research Institute	*	*				
Dipartimento Servizi Tecnici Nazionali		*				
Drexel University		*				
ENSCO, Inc.		*				
ERSA		*				
ETH		*				*
EUMETSAT		*				
Environmental Protection Agency		*				
Finnish Institute of Marine Research		*				
Flinders Institute		*				
Florida Institute of Technology		*				
Florida State University	*	*	*	*	*	*
Garstang Research		*				*
General Electric Aerospace	*	*				
Georgia Tech University		*				
German Space Research		*				*
Global Hydrology & Climate				*	*	
Hankook University of Foreign Studies		*				
Hellenic National Meteorological Service		*	*			*
Hughes Aircraft Company		*				
Hughes STX Corporation		*				
Illinois State Water Survey	*	*	*	*	*	

Inst. f. Angew. Geophysik		*	*			*
Intermountain Fire Sciences Lab	*					
Japan Meteorological Agency		*				
John Hopkins University		*				
King Mongkut's Institute of Technology		*				
Laboratoire de Meteorologie Dynamique		*				
Lawrence Livermore National Laboratory		*				
Lunar and Planetary Labs		*				
MESO, Inc.			*			
MSS		*				
MIT Lincoln Lab		*				*
MIT Weather Radar Laboratory	*					
Massachusetts Institute of Technology		*				
McGill University		*				
Meteorological Research Institute	*	*		*		
Michigan State University		*				
Millersville University		*				
Mission Research Corporation		*				
Mohr		*				
NASA/MSFC	*	*	*	*	*	*
NASA/GSFC	*	*	*	*	*	*
NOAA	*	*	*	*	*	*
National Central University	*	*			*	*
National Chung Hsing University		*				
National Research Council of Canada		*				
National Severe Storms Laboratory	*	*	*	*	*	*
National Taiwan University	*	*			*	*
National Weather Service	*	*		*	*	
New Mexico Tech		*			*	
North Carolina State University	*	*	*	*		*
Norwegian Meteorological Institute		*				
ORSTOM (New Caledonia)		*				
Oak Ridge National Laboratory		*				
Ohio State University		*				

Oregon State University		*				
Pennsylvania State University	*	*		*	*	
Phillips Lab	*		*			*
Princeton University	*	*	*	*	*	*
Reading University	*					
Rutherford Appleton Laboratory	*					
SUNY/Albany		*				
SUNY/Brockport	*					
Saint Louis University	*	*			*	
San Diego State University			*			
Sandia National Laboratory		*				
Sao Paulo State University		*			*	
Scripps Institution of Oceanography	*			*		
Soil Conservation Service		*				
South Dakota School of Mines & Tech.	*	*		*		
Southern Regional Climate Center		*				
Sutron Corporation			*			
Synap Corporation		*				
System Eng. Research Institute		*				
Technical University Graz	*				*	
Tel Aviv University	*	*				
Texas Nat. Resource Conservation		*				
Texas A&M University	*	*	*	*	*	*
Texas Tech University	*					
Universitat de Barcelona		*				
University of Adelaide		*				
University of Alabama	*	*		*		*
University of Bristol		*				
University of California/Los Angeles	*	*	*	*	*	*
University of California/San Diego		*				
University of California/Santa Barbara	*					
University of Chicago	*			*		*
University of Colorado	*	*	*	*		*
University of Essex, UK	*	*		*	*	*

University of Hawaii	*	*	*	*	*	*
University of Illinois	*	*	*	*		
University of Iowa		*				
University of Maryland		*	*			
University of Miami		*				*
University of Missouri				*	*	
University of New England		*				
University of North Dakota	*			*		*
University of Oklahoma	*	*		*	*	
University of Reading, UK	*					
University of Rhode Island		*				*
University of Tasmania, Tasmania		*				
University of Tsukuba, Japan		*				
University of Utah		*				
University of Virginia		*				
University of Washington	*	*	*	*	*	*
University of Wisconsin/Madison	*	*	*	*		*
University of Wyoming	*	*		*	*	
UCAR/COMET	*	*	*			*
UCAR/JOSS	*	*				*
Universite Paul Sabatier		*	*			

ATD-Foothills Laboratory Computing System

This computing system and its resident applications software supports ongoing needs for data processing and analysis within ATD, and serves as a resource for data users in the community. The core servers are a four-processor Sun SparcServer 670MP and a two-processor SparcStation 20/612. The network as a whole consists of approximately 80 workstations manufactured by Sun, Hewlett-Packard, and Silicon Graphics. Multiple tape drives (9-track, DAT, and Exabyte) and large disk storage capacity available to the scientific user provide for flexible ingest and manipulation of large data sets.

In FY 96, RDP took on an increased responsibility for the management of the approximately 140 personal computers in ATD. A standard hardware and software architecture has been developed, and the divisional machines are slowly being brought into compliance with this standard.

RDP is also now actively supporting the Linux operating system on PC-class computers within the division.

Field Project Support

On a cost-recovery basis, RDP is able to assist field projects in the areas of networking, communications, operations

support, and analysis support. In FY 96, the only field project supported by RDP was the Aerosol Characterization Experiment (ACE-1) in Hobart, Tasmania. RDP provided systems and networking support (69Kb), as well as operations support via the Zebra software.

Analysis Support Activities

Enhancements to Zebra. The pace of Zebra development slowed somewhat in 1996. Nevertheless, a number of portability and performance enhancements have been made, and a field-derivation capability is under development.

Enhanced Radar Translator, Perusal and Editing. The SOLO package, developed and maintained in cooperation with RSF, has moved out of the beta-test stage. It is now ATD's primary package for display and editing of radar and lidar data. During FY 96, a number of new features were added to SOLO, including:

- A wide range of editing features
- Time-series displays (mostly used with lidar data)
- Batch editing, allowing the automation of many repetitive editing tasks
- Support for a number of new platforms (S-Pol (86Kb), SABL (72Kb), 2-micron lidar (87Kb), etc.)
- A port to the Linux operating system

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Design and Fabrication Services

Mission and Goals

The primary goals of Design and Fabrication Services (DFS) are to provide engineering design service through the Mechanical Design Group, instrument and equipment fabrication service through the Machine Shop, and logistics and maintenance support through the Logistics Group. The Mechanical Design Group often participates in project efforts by contributing staff to the development team. The Machine Shop performs precision machining, welding, sheet-metal work, and assembly and repair service. The Logistics Group provides forklift, crane, and local trailer-towing services, fabrication assistance, equipment maintenance and repair, and logistical support for field projects. DFS provides service to all NCAR/UCAR divisions, as well as to the university community when appropriate.

Activities of the Past Year

Major development projects during FY 96 in which DFS played a significant role are listed below. The name of the project manager and his/her organization are also shown.

- Mass Spectrometer System (Eisele, ACD)
- S-Pol Radar (Lutz, ATD/RSF)
- WB-57F Diode Laser System (Mankin and Coffey, ACD)
- Doppler on Wheels II (Wurman, U. Oklahoma, 98Kb)
- PAM-III (Militzer, ATD/SSSF)
- WB-57F Installation of Atmospheric Chemistry Instruments (Ridley, ACD)

Machine Shop support was distributed among the various customer groups as shown in Table ATD-7.

Table ATD-7: DFS Machine Shop Support in FY 96

Organization	Hours	Percent
NCAR Atmospheric Chemistry Division	4,909.5	46.5
NCAR Atmospheric Technology Division	4,653.5	44.0
NCAR High Altitude Observatory	389.5	3.7
University of Colorado (LASP)	266.5	2.5
University of Oklahoma	149.5	1.4
University of Hawaii	54.0	0.5
NCAR Research Applications Program	37.0	0.4
Occupancy Cost Pool (UCAR)	35.5	0.3
University of New Hampshire	26.5	0.3
NCAR Mesoscale and Microscale Meteorology Division	26.0	0.2

General and Administrative (NCAR)	16.0	0.2
NCAR Scientific Computing Division	2.5	--
Total Hours Charged	10,566.0	100.0

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CLIMATE & GLOBAL DYNAMICS

Division Director's Message

Maurice Blackmon, Climate and Global Dynamics Division Director

This has been a year of major accomplishments for the Climate and Global Dynamics Division (CGD). CGD scientists have completed assembling and testing the first version of the Climate System Model (CSM) and made it available to the community. CGD sponsored a workshop in May, 1996, where a description of the model was presented together with a summary of its performance characteristics. At present, CSM is a numerical model of the coupled atmosphere-land surface-ocean-ice system. An important feature of CSM is that the coupling is done without any "flux correction." Because of inadequacies in earlier models, flux corrections were necessary to make the coupled model simulations resemble the real world. Model improvements have made this unnecessary for CSM.

As important as the first release of CSM has been, we are continuing development of the model by improving some of its components further and by adding new capabilities. For example, the sea ice component is being reformulated to improve its simulation characteristics. Also, we are modifying the model so that it can be used by scientists interested in paleoclimate studies.

An important additional development has been the appointment of a Scientific Steering Committee to guide the future development and use of the CSM. This committee consists of both NCAR and non-NCAR scientists. Several scientific working groups are forming to develop plans for work on CSM. Our goal is for CSM to become a community research tool for climate studies. We are expecting some of our university colleagues to contribute, for example, to improvements in CSM's land surface model, including hydrology, the sea ice model, and physical parameterizations in the atmosphere model.

CGD's research program extends well beyond CSM. I urge you to read through CGD's section of this Annual Scientific Report to see the breadth of our work. Because CGD scientists are highly respected within the U.S. and internationally, you will find some of our work is supportive of, and funded by, other agencies such as NASA, NOAA, DOE, and EPA. We are interested in extending the range of prediction of weather, using satellite data for a variety of geophysical purposes including oceanographic and ecological studies, and developing models for the study of climate on regional scales.

NSF-sponsored projects in which CGD is the NCAR lead division are the Climate Modeling, Analysis, and Prediction (CMAP) program, Geosystems Databases, and CLImate VARiability and Predictability (CLIVAR). CGD also participates in the Global Tropospheric Chemistry Program (GTCP) and the High Performance Computing and Communications (HPCC) program.

There is a strong relationship among CSM, CMAP, and the Climate Simulation Laboratory (CSL). *(This diagram (3K) shows that relationship.* CMAP is an NSF-funded program that studies the physical processes involved in the climate system. Research areas at NCAR and within the university community include climate model development, simulation and prediction validation, error estimation, and assessment of predictability. CSL is the computer hardware system needed to facilitate the model(s) developments and uses.

CGD plans and carries out research activities by collaborating within the division, within NCAR, with university scientists, and with other institution scientists. As we expand our knowledge of the climate system, we communicate our results through scientific journal publications (129 refereed papers in FY96, 109 in FY95, 68 in FY94, 71 in FY93), scientific seminars, workshops, positions at universities, public presentations, and cataloging information on the World Wide Web (http://www.cgd.ucar.edu). We also involve students in our research, including postdoctorate, graduate research assistants, undergraduates, and Significant Opportunities in Atmospheric Research and Science (SOARS) students. CGD is divided into six research sections and a computer support group with 91 regular and term employees (full- and part-time), including 30 Ph.D. scientists. We have about 39 long-term visitors (greater than six-month stay) annually, as well as 92 short-term visitors, whose stays are from one day to six months. The FY96 NSF budget was $5.1 million out of $57.9 million for all of NCAR.

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT

MESOSCALE & MICROSCALE METEOROLOGY

MMM Director's Message

The Mesoscale and Microscale Meteorology (MMM) Division is one of nine programs or divisions within the National Center for Atmospheric Research (NCAR). The mission of MMM is one of basic research to advance fundamental understanding of mesoscale and microscale processes and to improve the modeling, observation, and prediction of these processes. The division's research ranges from basic to applied; however, for the direct transfer of knowledge to benefit society, we rely on collaborative efforts with other NCAR divisions and University Corporation for Atmospheric Research (UCAR) programs whose missions are more directly aligned to technology transfer.

The division is organized into seven science groups whose missions relate to their approach to their science (e.g., modeling versus analysis of observations), or to scales considered (e.g., mesoscale versus microscale). It consists of about 65 staff with 27 scientists, including 15 senior scientists. Colocated with the division is a group of three scientists from the National Oceanic and Atmospheric Administration (NOAA) National Severe Storms Laboratory (NSSL) who specialize in airborne dual-Doppler observations of mesoscale systems. This group augments the MMM program in mesoscale observations.

Research within the division covers a wide range of topics related to mesoscale and microscale meteorology. Generally, we maintain a breadth of expertise so that many of the research areas currently identified (at the national and international levels) as priorities for the atmospheric and related sciences in mesoscale and microscale meteorology are represented within the division. This is, in part, to fulfill our role as a focal point for the weather research community, enabling visitors to come and interact with NCAR scientists and with each other, and enabling us to develop collaborative programs with scientists in many institutions in research areas facilitated by a coordinated approach. Also, by maintaining a broad program of research we are able to move quickly into new high priority initiatives as they are identified.

Our research can be grouped in a number of ways. Generally, there are two very broad emphases: (1) weather systems and forecasting, and (2) climate problems. While the fundamental research in MMM often relates to both, many of our programs are specific to one or the other.

On the weather side, our numerical weather prediction program centers around the NCAR/Pennsylvania State University Mesoscale Model (MM5). MMM, the National Centers for Environmental Prediction (NCEP)/NOAA, and the Forecast Systems Laboratory (FSL)/NOAA are now developing an improved replacement for MM5. This replacement will be used both as NCEP's operational model, and as a community research model maintained by MMM. Also on the weather side, we are developing our data assimilation program to cross divisions within NCAR, and to contribute to coordinated national data assimilation efforts. Several years ago a large portion of MMM's National Science Foundation (NSF) core program funding was reclassified as part of the U.S. Weather Research Program (USWRP). An additional allotment of USWRP funds will support new weather research efforts within NCAR after an internal competition which will take place in early FY97. In addition, activities of the office of the USWRP Lead Scientist are located in MMM.

On the climate side, we have the established Clouds in Climate Program (CCP), where research is providing improved parameterization schemes for cloud processes in climate models. This program is using cloud resolving models and data from field campaigns to design and test new schemes based on the fundamental physics and dynamics of mesoscale cloud systems. Several research efforts study the interaction of radiation with cirrus clouds and the fluxes of heat momentum and moisture through the boundary layer. Our research into the Tropical Ocean and Global Atmosphere Program's Coupled Ocean-Atmosphere Response Experiment (TOGA COARE) data sets contributes both to the CCP and to the work on the

tropical boundary layer. In addition to these physics efforts, we contribute to the Global Tropospheric Chemistry Program (GTCP) through efforts to model: (1) the chemical reactions, transport, and mixing of chemical species that occur within clouds; and (2) the exchange of various chemical species with the earth's surface.

Included in our support to the mesoscale and microscale research community are the maintenance of a suite of models that can be applied to a wide range of meso- and microscale problems, and the development of data analysis software for research that uses radar, surface networks, and aircraft data. We contribute to, and are leaders in, the planning and conducting of a variety of field programs in which university researchers also play a major role. We develop airborne instruments (balloon and aircraft) for measurements of microphysical properties of the atmosphere and make these instruments available to outside users. We provide a number of model workshops and tutorials to instruct new users on how to apply our models to their research needs, and to bring veteran users up-to-date on new features. Finally, we maintain a large and very popular visitor program, supporting many of our visitors with division funds.

Besides the NSF FY96 core funding, MMM received additional NSF funding for the Role of Clouds, Energy, and Water (ROCEW) program. About half of our ROCEW funding was allocated to the CCP, which is jointly overseen by MMM and NCAR's Climate and Global Dynamics (CGD) division. Additional NSF funding came via other collaborations with various NCAR divisions: GTCP, led by the Atmospheric Chemistry Division (ACD); TOGA, led by CGD; and the High-Performance Computing and Communications (HPCC) program, led by the Scientific Computing Division (SCD). Seven more projects were supported by NSF Special Funding: Taiwan Area Mesoscale Experiment (TAMEX), TOGA COARE/Fluxes, TOGA COARE/Clouds, TOGA COARE/Radiation, Global Positioning System Meteorological Satellite Program (GPS/MET), office of the USWRP Lead Scientist, and the Fuzhou International Workshop.

In addition to NSF, nine other federal agencies supported 23 MMM projects that contribute to MMM program goals agreed upon between NCAR and NSF. These agencies were: National Aeronautics and Space Administration (NASA), Department of Energy (DOE), Department of Defense (DoD), Office of Naval Research (ONR), Federal Aviation Agency (FAA), National Oceanic and Atmospheric Administration (NOAA), Air Force Office of Scientific Research (AFOSR), Air Force Phillips Laboratory (AFPL), and Argonne National Laboratory (ANL). NASA supported the FIRE/TOGA, ASHOE, PEMTropics, FIRE III, LASE, BOREAS, SUCCESS, and Convective Parameterization projects. DOE supported the Eulerian Differencing and ARM/IDASS projects. DoD supported the ARPA-NASA project. ONR supported the LES, Coastal Fog, and Numerical Studies projects. FAA supported the Data Assimilation, Modeling, GPS/MET, and Data Retrieval projects. NOAA supported the Forecasting and LES projects, as well as the office of the USWRP Lead Scientist. AFOSR supported the Data Assimilation, Contrails, and Variational Data projects. AFPL supported the Data Assimilation project. ANL supported the Test-Bed Prototype project.

Six more MMM projects received funding from seven educational/research institutions, as follows: University of Washington (Coastally-Trapped Phenomena project), University of Arizona (3D Simulation of Clouds project), University of California/Scripps Institute of Oceanography (Ice Cloud Research project), Hong Kong University Institute of Science and Technology, with Royal Observatory of Hong Kong (Terrain-Induced Turbulence project), Korea Advanced Institute of Science and Technology (Modeling of Cloud Systems project), and Utah State Water Resources (3D Simulation of Clouds project).

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FY 1996 SCIENCE HIGHLIGHTS

A high-resolution Large Eddy Simulation (LES) that utilizes a recently-developed nested grid method is being used to study entrainment processes in the capping inversion of Planetary Boundary Layers (PBLs). Recently, Peter Sullivan and Chin-Hoh Moeng have been able to identify actively entraining convective plumes in a dry, shear-free convective PBL with a weak capping inversion, and to follow the evolution of these plumes in time. The accompanying animation shows the temporal and spatial evolution of potential temperature contours and velocity vectors in a partial 2D yz plane taken from our 3D simulations. In the simulations, the entrainment mechanism is dominated by large-eddy impingement and engulfment processes. The bulk Richardson number, based on the strength of the inversion and the convective velocity scale for the present simulation, is about 20. The fine-nested grid spacing [(dx,dy,dz) = (33,33,10) m] is depicted in the upper right-hand corner of the animation.

The STERAO (Stratosphere-Troposphere Experiments: Radiation, Aerosols, and Ozone) Deep Convection Experiment conducted in northeastern Colorado in the summer of 1996 by James Dye as well as other researchers from the Atmospheric Chemistry Division (ACD), the Atmospheric Technology Division (ATD), the NOAA Aeronomy Laboratory, Colorado State University (CSU), University of North Dakota (UND), and several other institutions. The experiment combined extensive chemical, air motion, and electrical measurements of thunderstorms. This unique combination of measurements was used to examine the effects of deep convection, including transport and NOx production by lightning, on the chemical composition and vertical distribution of constituents in the troposphere and tropopause regions. Data used as forecasting aids were obtained from: (1) airborne instruments on the NOAA (National Oceanic and Atmospheric Administration) P3 and UND Citation aircraft; (2) the CSU/CHILL (University of Chicago/Illinois State Water Survey Radar) multiparameter Doppler radar; (3) the French ONERA (Office National d'Etudes et de Recherches Aerospatiales) lightning interferometer (for 3D mapping of lightning discharges); (4) surface detection of both cloud-to-ground and intra-cloud lightning; (5) NCAR mobile class soundings; and (6) output from the MM5 (NCAR/Pennsylvania State University Mesoscale Model, Version 5) model, maintained by NCAR's MMM Division, and the University of Maryland/Goddard (Space Flight Center) Cumulus Ensemble model. Results from the project will be the focus of much analysis in the next few years.

Radar measurements made during the Small Cumulus Microphysics Study led by Charles Knight in Florida in 1995 show the existence of adiabatic cores in newly formed clouds up to about 1 km above cloud base, where the maximum reflectivity factor becomes too large for just cloud droplets, indicating coalescence growth. Comparisons by Knight, William Cooper, and Jean-Louis Brenguier [MMM/ATD (Atmospheric Technology Division, NCAR) affiliate scientist from Meteo France, Toulouse] of growth rates expected for the combined effects of condensation and coalescence were in reasonable agreement with the observations of droplet size distributions during the early stages of development in these adiabatic regions. In the later stages of development in mixed regions the agreement with observations was not as good as in the ascent of unmixed parcels.

A study of the relationship of TOGA COARE (Tropical Ocean and Global Atmosphere Program Coupled Ocean-Atmosphere Response Experiment) convective structure to the environment has been completed by Margaret LeMone and Edward Zipser (Texas A&M University), with the help of Michael Dey (former MMM student assistant) and several of Zipser's A&M students. The relationship of the convective structure to the vertical shear of the horizontal wind was found to be similar to that for GATE [GARP (Global Atmospheric Research Program) Atlantic Tropical Experiment] and AMTEX (Air Mass Transformation Experiment). COARE convective soundings are deeper, and hence have higher CaPE (Convection and Precipitation/Electrification Experiment) than those for GATE, but CaPE evaluated to 500 mb is about the same.

The thermodynamic profile for the TOGA COARE 22 February 1993 squall line was used with two different wind hodographs (9 Feb, 22 Feb) to demonstrate the simulation of two distinct types of convective bands from a single cell. William Skamarock and Stanley Trier performed this demonstration using an adaptive grid model developed by Skamarock and Louis Wicker (Texas A&M University).

A 3D, non-hydrostatic, time-dependent Navier-Stokes solver has been implemented by William Anderson and Piotr Smolarkiewicz. The solver uses both HPF (High Performance Fortran) and MSG (message passing) for parallelization, and has Eulerian and semi-Lagrangian algorithms. The performances of the two parallelization methods on a Cray T3D have been compared for simulations of low Froude number flow past a mountain. The semi-Lagrangian model admits large time steps, so its overall performance is superior to the Eulerian model despite its inherent irregular communication patterns. It is to be used to simulate cloud systems in cold air outbreaks, a new project to be coordinated by the Clouds in Climate Program (CCP).

Cloud-resolving modeling by Xiaoqing Wu (long-term visitor), Wojciech Grabowski, and Mitchell Moncrieff faithfully reproduces the evolution among various types of GATE convective cloud systems in three spatial dimensions. Even shallow shear-parallel lines which are not well resolved are reproduced, demonstrating that large-scale variables (e.g., shear and forcing) are the key quantities. Also, for the first time, a squall line was shown to evolve spontaneously from a field of clouds. This is good news for deterministic parameterizations of organized cloud systems for GCMs (General Circulation Models).

Studies of flow over Lantau Island at the site of a new airport in Hong Kong have pioneered simulations of mechanical turbulence. High resolution simulations showed how, in topographically distorted flow, mean shears became dynamically unstable and broke down into transient eddies. A new visualization and analysis technique developed by Terry Clark shows the structure of separation bubbles in flow over the mountainous island.

A coupled atmosphere-fire numerical model developed by Terry Clark revealed the causes of common wildfire shapes and behavior and demonstrated how rotating columns near the fire front can rapidly intensify into a dangerous blowup. In agreement with observations, short-line fires bowed into a conical shape, while longer fire lines bent into multiple conical shapes due to feedback between the hot convective plumes and near-surface convergence at the fire front. Other experiments showed that when negative ambient wind shear existed, a pair of rotating updrafts at the fire front can touch down within the fire and break up the fire line.

Mesoscale convective vortices (MCVs) play an important role in the evolution of mesoscale convective systems as well as in the triggering of new convection. Through the use of idealized non-hydrostatic numerical cloud model simulations, Morris Weisman and Christopher Davis (joint appointment with RAP) have identified the mechanisms by which these MCVs are produced, and their dependence on the strength of the ambient vertical windshear. These results emphasize that divergent, convective motion must be included in numerical or theoretical models that are designed to study or forecast the generation of such features.

The interaction of fronts with steep coastal orography can promote a variety of cool-season weather events such as high winds associated with barrier jets and heavy orographically enhanced rainfall. Scott Braun (Advanced Studies Program (ASP) post-doctoral visitor), Richard Rotunno, and Joseph Klemp have completed a numerical study of these interactions, and found that while the front is strongly modified by the orography, the important interaction is the modification of the mountain flow by the stability perturbations of the front, rather than the development of across-frontal circulations induced by the mountain. Superposition of the barrier jet with frontal jets determines the winds in the coastal zone (e.g., a southerly, prefrontal jet can combine with the barrier jet to produce very strong winds prior to frontal passage).

An analysis of diurnally forced, anticyclonic circulations over northeastern Colorado was conducted by Christopher Davis with the aid of the WISP94 (Winter Icing and Storm Project 94) data set. Davis's results suggest that anticyclonic vorticity generation occurs within the lowest kilometer AGL (Above Ground Level) when that layer is nearly vertically mixed in both potential temperature and velocity. The mixed-layer mechanism is also favored as it naturally explains the diurnal tendency of the circulations, and may therefore explain the observed late-day snowfall maximum along the Front Range of Colorado.

Version 2 of the MM5 model was released to the user community in the summer of 1996. Developed primarily by Jimy Dudhia, Wei Wang, Daniel Hansen, and Sue Chen (former MMM associate scientist), this model contains several new options for physical parameterization. These include the Betts-Miller, Kain-Fritsch, and Fritsch-Chappell cumulus parameterization schemes; the Burk-Thompson second order, level 3 PBL scheme; and the Goddard-3 ice cloud microphysics scheme.

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EDUCATIONAL ACTIVITIES

Contributions to COMET

Morris Weisman continued to serve as a subject matter expert for a series of the Cooperative Program for Operational Meteorology, Education and Training (COMET) educational disk modules on convective storms. The first module, which was completed during FY96 and is titled ``A Convective Storm Matrix," utilizes an interactive matrix of convective simulations made for varying amounts of convective available potential energy (CAPE) and vertical wind shear. Forecasters can peruse the matrix to better understand these basic environmental controls on storm evolution. A second module, titled ``Anticipating Convective Storm Structure and Evolution," is nearing completion and covers the theoretical and observational aspects of convective storms and convective storm forecasting in much more detail. A third module, covering mesoscale convective systems, is currently in the planning stages and will be completed in 1997.

Weisman also served as a lead instructor for the fall 1995 COMET Mesoscale Analysis and Prediction (COMAP) course for weather service science operations officers (SOOs). This 8-week intensive course covered many aspects of mesoscale meteorology and its applications to forecasting, and is taught in conjunction with weather service personnel. Weisman served as the primary lecturer for the summertime-weather portion of the course.

Stanley Trier gave a lecture to National Weather Service personnel during the fall 1995 COMET COMAP course, discussing environmental factors that are responsible for the development of large nocturnal mesoscale convective complexes in the central United States.

Non-Technical and Educational Outreach Activities

Margaret LeMone, as an extension of her long-term collaboration with Project LEARN (Laboratory Experience in Atmospheric Research at NCAR), became a Co-PI on the UCAR LEARN II Proposal. She worked with LEARN personnel, Carol McLaren and Karen Hicks, to prepare and revise learning materials and plan teacher workshops to be held in several parts of the state, and plan the LEARN II summer programs for teachers. She will be participating in a number of the teacher workshops, and recruiting other scientists to participate in the program. LeMone gave a lecture on clouds to the American Meteorological Society's Project ATMOSPHERE teachers during the summer of 1996, and gave a lecture on weather hazards in the mountains for the Outdoor Education class at Fairview High School, Boulder. She also delivered a presentation on Women in Science for Significant Opportunities in Atmospheric Research and Science (SOARS).

Richard Carbone provided advice, consultation, and review for the UCAR Climate Learning Modules. Carbone also contributed to a number of science exhibits by providing general advice and specific suggestions.

Roelof Bruintjes (joint appointment with RAP) gave lectures on cloud physics to the University of Arizona.

Morris Weisman presented a lecture on Thunderstorms and Tornadoes for the Project Learn Science Saturdays program, and was also interviewed for a Learning Channel program on tornado research and storm chasing that will air in the spring of 1997.

Morris Weisman also presented a series of lectures on convective storms for a graduate-level Weather-Laboratory class at Colorado State University.

Daniel Breed was an undergraduate research advisor for 11 students from the Universidad Autonoma de Coahuila, Mondova, and Salltillo, Mexico. He also served as a judge for the 1996 Boulder Valley School District Science Fair. In FY96, Breed organized and facilitated NCAR's Sailplane exhibit at the Denver Museum of Natural History. Throughout the

year Breed conducted a number of non-technical science presentations including four in Mexico (radio, television, and print media) and six for the Boy Scouts of America.

Andrew Heymsfield was active in the University of California San Deigo Scripps Institution of Oceanography's outreach activities, specifically, the Science Teacher Program through the Center of Clouds, Chemistry, and Climate (C4) Program. Heymsfield provided materials to teachers to be used, primarily in Californian schools, in cloud and climate science classes for junior high school students.

Janine Goldstein served as a resource person for the Math & Science Teacher Hotline, a program developed at the University of Northern Colorado Mathematics and Teaching Center in partnership with the Colorado Alliance for Science. Her services include answering questions about mathematics and science from Colorado and Wyoming science teachers and helping them figure out how to best teach this information to students. Goldstein also served as a mentor for "Kids as Global Scientists" which is a program sponsored by the University of Colorado. In 1996, Goldstein was assigned to a single junior high school (in California) where students would email her directly for answers to atmospheric science questions. In 1997 the program will be expanded to the Web and Goldstein will be available to answer questions from grade school and junior high school students from around the world. Goldstein also served as a UCAR SOARS community mentor and represented NCAR at the CU Engineering Career Days, where she talked with students about student assistant opportunities at NCAR.

Terry Clark and Janice Coen participated in interviews and filming for a new television series on weather and aviation hazards, titled "Survival in the Sky." This program was aired on the Learning Channel in 1996 and will be shown on the Discovery Channel in 1997. Coen also answered questions generated from Public Relation News Releases regarding the fire modeling studies being carried out within the Cloud Scale Modeling Group.

Chin-Hoh Moeng worked on the proceeedings for the 1995 ASP Summer Colloquium on PBL and Its Parameterization. This proceeding volume will include 21 lecture notes, several student presentations, and a user manual for the PBL model evaluation software package that the NCAR PBL Model Evaluation Group developed over the past years. The proceedings are scheduled to be completed by the end of 1996.

Several MMM staff members were engaged in various formal teaching arrangements. They included

Teaching Appointments:

Roelof Bruintjes, Affiliate Professor, University of Arizona
Charles Knight, Adjunct Professor, University of Wyoming; and
Associate Professor, University of Oklahoma
Margaret LeMone, Affiliate Lecturer, University of Colorado

Advising on Graduate Research:

Roelof Bruintjes, Co-Advisor, University of Pretoria, South Africa
Terry Clark, Co-Advisor, University of Wyoming
James Dye, Co-Advisor, University of California Los Angeles; and Advisor, Colorado State University
Andrew Heymsfield, Co-Advisor, Stockholm University
Charles Knight, Co-Advisor, University of Oklahoma
Margaret LeMone, Advisor, University of Colorado

Member of Thesis Committees:

Roelof Bruintjes, University of Pretoria, South Africa
Christopher Davis, Georgia Institute of Technology
James Dye, University of California Los Angeles and Paul Sabatier University, France
Wojciech Grabowski, McGill University and University of Illinois
Andrew Heymsfield, University of Colorado
Charles Knight, University of Wyoming
Ying-Hwa Kuo, University of California Los Angeles and University of Washington
Margaret LeMone, University of Colorado
Donald Lenschow, University of Wyoming and University of Colorado
Chin-Hoh Moeng, University of California at Davis, Colorado State University, University of Colorado, and Pennsylvania State University

Richard Rotunno, Massachusetts Institute of Technology and Purdue University

Support for Post Doctoral and Graduate-level Visitors

The MMM Division hosted 33 postdoctoral-level visitors and 38 graduate-level visitors during FY96. These young scientists came from 23 different U.S. universities and 17 foreign universities and agencies. For a complete listing of the division's visitors, please refer to the Visitors and Collaborators list. The U.S. universities included:

- Arizona
- California
- Colorado
- Colorado School of Mines
- Colorado State
- Florida State
- Harvard
- Hawaii
- Illinois
- Jackson State
- Massachetts Institute of Technology
- Minnesota
- Missouri-Rolla
- Nevada, Desert Research Institute
- New York
- North Carolina State
- Oklahoma
- Ohio State
- Pennsylvania State
- Stanford
- Texas A & M
- Utah
- Washington

The foreign universities and agencies included:

- Monash University, Australia
- Swinburne University, Australia
- McGill University, Canada
- Nanjing University, China
- Peking University, China
- Beijing National Meteorological Center, China
- Danish Meteorological Institute, Denmark
- University of Leeds, England
- University of Manchester Institute of Science and Technology, England
- CETIIS, Paris, France
- Institute of Atmospheric Physics, Germany
- Munich Institute of Meteorology, Germany
- University of Munich, Germany
- Eotvos Lorand University, Hungary
- Seoul National University, Korea
- Korea Advanced Institute of Science
- Utrecht University, Netherlands
- Swiss Federal Institute, Switzerland

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COMMUNITY SERVICE

Models Maintained - Workshops and Tutorials

The division's research models, particularly the NCAR/Pennsylvania State University Mesoscale Model (MM5) and the Clark-Hall Model, are used extensively not only for research purposes, but also for direct applications. As an aid to users of these models, the division has established a series of tutorial sessions to introduce new users to our modeling systems and to instruct them on how to run and modify the models to meet their research needs. Experienced users are informed of new features that have recently been added to the models, and the division, in turn, receives valuable input on enhancements these researchers either have made or desire to have made to the models.

The NCAR/PSU Mesoscale Modeling System (MM5)

Model Development

We continued to improve (and to add options of) physical parameterization schemes into the standard version of MM5, which is available to the broad university community. These include the implementation and testing of a multi-layer soil heat transfer model by Jimy Dudhia, the Biosphere-Atmosphere Transfer Scheme (BATS) by Anyu Wang (visitor from Zhong-Shan University, Canton, China) and Mercedes Lakhtakia (PSU), the Emanuel cumulus parameterization by Rosella Ferretti (visitor from University of L'Aquila, Italy), the Troen-Mahrt PBL scheme by Dudhia and S.-Y. Hong (National Centers for Environmental Prediction, NCEP), and the Gayno-Seaman Planetary Boundary Layer (PBL) scheme by Kevin Manning. The Gayno-Seaman scheme was designed to predict turbulent kinetic energy (TKE) in the boundary layer and fog, using a fog module that allows for patchy fog (non-zero cloud water in a grid box that is, on average, subsaturated). Manning performed one-dimensional simulations for cases of fog over the central United States to test the scheme.

MM5 Version 2 Release

Version 2 of the MM5 model was released to the user community in the summer of 1996. Dudhia, Wei Wang, Daniel Hansen, and Sue Chen were the main contributors to the development of MM5 version 2. Several new options for physical parameterization were added to the MM5 model including the Betts-Miller, Kain-Fritsch, Fritsch-Chappell cumulus parameterization schemes, the Burk-Thompson second order, the level 3 PBL scheme, and the Goddard 3-ice cloud microphysics scheme. The new code uses Unix and C utilities to allow selective compilation of physics options, is portable to most workstation platforms, and is now maintained under a standard version control system (CVS). It now includes more supported options for cumulus parameterization, the boundary layer, radiation, and microphysics.

MM5 User Service

The MM5 Web pages have been on-line since August 1995 (the URL is http://www.mmm.ucar.edu/mm5/mm5-home.html). The Release Notes for MM5 version 2, and the newly updated Tutorial Notes for Modeling-System Users, are also available on the Web. Two MM5 tutorial classes were offered to new users in 1996. Twenty-two people from 16 institutions (including three from foreign countries) attended the January 1996 tutorial class; 28 people from 23 institutions attended the July 1996 tutorial class (including eight from foreign countries). The four-day classes, comprised of lectures on each component of the modeling system and hands-on practice sessions, were given by Wang, Dudhia, David Gill, Manning, Yong-Run Guo, and Hansen. The tutorial class participants learned how, through exercises based on prepared lectures, to run the MM5 modeling system on the NCAR Cray YMP as well as on workstations.

The Sixth Annual Users' Workshop was hosted by the Mesoscale Prediction Group (MPG) in July 1996. A total of 60 users

from 28 institutions participated in this three-day event. The 44 presentations given by the users covered topics of model development, regional climate, data assimilation, PBL and surface processes, coastal and lake meteorology, topographic effects, tropical systems, mid-latitude systems, air quality and chemical transport modeling, and real-time modeling. The MPG also hosted a two-day workshop on real-time mesoscale forecasting, organized by Clifford Mass (University of Washington); 59 participants from the university community and forecast centers attended.

Coupled Atmosphere-Ocean Version of MM5

Jordan Powers (ASP postdoctoral fellow) continued the development of a coupled environmental modeling system comprised of the MM5, the Princeton Ocean Model, and the GLERL-Donelan Wave Model. The coupled model is being tested to investigate the effects of (i) using high-resolution atmospheric data from a mesoscale model (the MM5) to drive marine wave and circulation models, and (ii) incorporating detailed sea state and heat flux data from the marine models into the MM5's atmospheric forecast. System developments have included the preparation of a more portable, non-distributed version of the coupled model. Test results from simulations using the coupled modeling system have indicated the potential for profound impacts from atmosphere-ocean coupling. In a case involving cold frontal passage across Lake Erie, the results show that coupling yields significantly enhanced surface roughness and increased sensible and latent heat fluxes in the MM5 simulation. The coupled MM5 shows promise as a tool for future investigations of processes and phenomena involving strong air-sea interaction, such as marine cyclogenesis and Central American cold surges.

Visualization Software Development

Hansen continued the development of MM5 visualization software, originally created for the Advanced Research Projects Agency (ARPA)/COOP-3D project. The "MM5 Explorer Viewer" uses the Explorer graphics package to plot raw MM5 output, and represents a new, interactive visualization tool for the MM5 modeling system. The software is being developed to fill the gap in the MM5 modeling system's interactive analysis capabilities, and will become available to the broad user community.

Clark-Hall Model Development

A new generation of the Clark-Hall model was created that includes the most recent developments of parallel processing and large-scale data initialization. Considerable success was achieved applying the new model to the Arizona Program winter storms, the Colorado windstorm, and tropical convection case studies. The code has used up to 16 processors efficiently, and is currently running on Cray and SGI shared-memory systems. Current plans are to streamline the message-passing algorithm so that the model can easily be converted to distributed memory systems and still retain a high efficiency similar to the shared memory code.

Clark-Hall Model User Service

Members of the Cloud Scale Modeling Group (CSMG) continued their interaction with, and service to, the atmospheric science community by making the Clark-Hall model available for community use. An annual workshop was conducted in June 1996 in which 10 participants learned a wide range of model applications including flow over complex terrain, weather modification, convective storms, atmospheric chemistry, frontal systems, boundary layer studies, and the linking of hydrologic and mesoscale atmospheric models.

U.S. Weather Research Program

Richard Carbone served as Lead Scientist of the U.S. Weather Research Program (USWRP) during FY96. In this capacity he organized and conducted seven meetings involving more than 100 scientists to define the scientific program and publish reports which chart the emerging research issues and opportunities related to weather prediction. It was decided that the initial scientific foci of the USWRP would be: studies related to the importance and mix of observations in numerical weather prediction; studies related to quantitative precipitation forecasting; and studies related to the landfall of hurricanes.

Carbone worked with U.S. agencies, the World Meteorological Organization (WMO), the International Council of Scientific

Unions (ICSU), the International Association of Meteorology and Atmospheric Physics (IAMAP), and representatives of more than 10 countries to establish the USWRP as a funded program and to establish the World Weather Research Program internationally. Under the USWRP a joint university grants program, an NCAR research proposal competition, and a NOAA laboratory proposal competition were instituted in FY96 involving roughly $4M in total research funds. Late in FY96, both the U.S. Navy and NASA agreed in principle to join in cosponsorship of the USWRP. In FY97, it is expected that all four participating agencies (NSF, NOAA, U.S. Navy, and NASA) will fund the Office of the Lead Scientist.

Data Analysis Software Support

William Anderson and L. Jay Miller continued support of software, installed at NCAR and at several universities and government research agencies, used for analysis and display of radar, mesonetwork, and aircraft data. Anderson developed prototype Graphical User Interfaces (GUIs) for both radar and aircraft software to improve their interactive use. Anderson and Miller improved the connection between the radar software and those packages developed elsewhere, as well as those available commercially, by adding the network Common Data Format (netCDF). The radar software normally uses its own self-describing, highly efficient, portable but specialized format for gridded data.

MMM Visitor Program

Throughout FY96 the MMM Division hosted 252 visitors, of which 35 were long-term (6 months or longer) and 217 were short-term (less than 6 months). The Visitor Program continues as an ever-growing and vital part of the division's mission and operation. Three Affiliate Scientists have appointments with MMM, one of which is joint with ATD. Decisions on visitor appointments are coordinated through the division's Visitor Advisory Committee and the seven science group heads. Forty-one (41) universities within the U.S. and eighteen (18) foreign countries were represented by visitors during the year. For a complete listing of the division's visitors, please refer to the Visitors and Collaborators list.

Workshops and Colloquia

During FY96 the division hosted or facilitated a number of workshops, meetings, and colloquia including

- Geophysical and Astrophysical Convection Workshop, 10-13 October
- International Workshop on Mesoscale Meteorology and Heavy Rainfall in East Asia, 7-10 November
- Fourth GCSS Science Panel Meeting, 11-15 December
- MM5 New Users' Tutorial, 9-12 January
- CASES Strategy Meeting, 22-23 February
- NASA CloudSat Workshop, 25-28 February
- USWRP First Prospectus Development, 1 March
- ARM Tropical Western Pacific Advisory Panel, 7-8 March
- USWRP Stakeholders Workshop, 1 April
- Predicting Hurricane Landfall, 30 April-2 May
- Societal Aspects of Weather, 1 May
- Clark-Hall Model Workshop, 3-14 June
- STERAO B, 17-19 June
- Small Cumulus Microphysics Study Meeting, 26-29 June
- Predictability and Importance and Mix of Observations in Data-Sparce Regions, 1 July
- MM5 New Users' Tutorial, 16-19 July
- PSU/NCAR Mesoscale Model Workshop, 22-24 July
- Special Workshop on Real-Time Mesoscale Modeling in the University Community, 25-26 July
- Third International Cloud Modeling Workshop, 17-24 August
- Quantitative Precipitation Forecasting and Convection, 28-29 September

The MMM Division also hosts a weekly seminar series. During FY96 there were a total of 38 seminars presented, of which 12 were given by MMM scientists and 7 were given by long-term visitors. In FY96 the series was coordinated by Andrew Crook, who will also coordinate the series in FY97. Upcoming presentations can be viewed on MMM's Home Page (the URL is http://www.mmm.ucar.edu/sem/seminars.html).

To view other community service activities (editorships, committees/advisory boards, honors, and awards) provided by MMM and NCAR staff, click here.

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MMM STAFF, FY 96

Staff or long-term visitors with MMM appointments as of 30 September 1996

Division Director's Office

Amy Allen
Toni Biter
William Bonner (senior research associate)
Robert Gall (director)
Teresa Harris (also supports SMG)
Sudie Kelly
Kathleen Morgan

U.S. Weather Research Program (USWRP)

Richard Carbone (lead scientist)
Linda Morris

System Management Group (SMG)

William Boyd
Jody Williams
Patricia Waukau (group head)

Boundary Layer and Turbulence Group (BLTG)

Martine Bunting (also supports PMG)
Jackson Herring
Peter Hildebrand (long-term visitor; ATD)
James Howell (long-term visitor; ASP)
Donald Lenschow (group head; joint appointment with ATD)
Chin-Hoh Moeng
Ilga Paluch
Harvey Segur (long-term visitor)
Peter Sullivan
Jielun Sun (long-term visitor)
Jeffrey Weil (long-term visitor)

Cloud Scale Modeling Group (CSMG)

Olivia Bortfeld (also supports CSG and MAG)
Roelof Bruintjes (joint appointment with RAP)
Terry Clark (group head)
Janice Coen
N. Andrew Crook (joint appointment with RAP)

William Hall
Robert Kerr
Juanzhen Sun

Cloud Systems Group (CSG)

William Anderson (also supports PMG and MAG)
N. Andrew Crook (joint appointment with RAP)
Wojciech Grabowski
Changhai Liu (long-term visitor)
Mitchell Moncrieff (group head)
Piotr Smolarkiewicz
Xiaoqing Wu (long-term visitor)

Mesoscale Analysis Group (MAG)

Richard Carbone
James Fankhauser (long-term visitor)
Robert Grossman (long-term visitor)
Joachim Kuettner (senior research associate; joint appointment with UCAR Office of Programs)
Margaret LeMone (group head)
L. Jay Miller
John Pflaum (long-term visitor)
Melvyn Shapiro (long-term visitor)
Stanley Trier
John Tuttle (joint appointment with RAP)

NOAA/NSSL, Mesoscale Research and Applications Division--Boulder

Diana Bartels
David Blanchard
John Daugherty
Robert Hueftle
David Jorgensen (chief)
Sharon Lewis
Thomas Matejka
Eric Rasmussen

Mesoscale Dynamics Group (MDG)

Nolan Atkins (long-term visitor; ASP)
Scott Braun (long-term visitor; ASP)
Joseph Klemp (group head)
Ingrid Moore (also supports MPG)
Richard Rotunno
William Skamarock
Christopher Snyder
Morris Weisman

Mesoscale Prediction Group (MPG)

James Bresch (long-term visitor)

Christopher Davis (joint appointment with RAP)
Jimy Dudhia
David Gill
Yong-Run Guo
Daniel Hansen
Wei Huang
Ying-Hwa (Bill) Kuo (group head)
Alexis Lau (long-term visitor; joint appointment with RAP)
Simon Low-Nam
Kevin Manning
Jordan Powers (long-term visitor; ASP)
Francois Van den Berghe (long-term visitor)
Anyu Wang (long-term visitor)
Wei Wang
Qingnong Xiao (long-term visitor)
Dexin Zhang (long-term visitor)
Xiaolei Zou

Physical Meteorology Group (PMG)

Steven Aulenbach
Mary Barth (joint appointment with ACD and CGD)
Daniel Breed (joint appointment with RAP)
William Cooper (joint appointment with ASP)
James Dye (group head; joint appointment with ATD)
Janine Goldstein
Rick Graves
Andrew Heymsfield
David Johnson
Charles Knight
Nancy Knight
John Latham (long-term visitor)
Gregory McFarquhar
Larry Miloshevich
Roy Rasmussen (joint appointment with RAP)
Jan Rosinski (long-term visitor)

Affiliate Scientists

Jean-Louis Brenguier (Centre National de Recherches Meteorologiques, France; joint appointment with ATD)
Larry Mahrt (Oregon State University)
Richard Reed (University of Washington)

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MMM VISITORS AND COLLABORATORS, FY 96

Dates refer to visitor's stay at NCAR during FY 96. No dates are given for collaborators who did not visit NCAR.

STEVE ACKERMAN: University of Wisconsin, CIMMS, 25-28 February 1996, Cloud Systems Group

THOMAS ACKERMANN: Pennsylvania State University, 25-28 February 1996, Cloud Systems Group

MARK ALBRIGHT: University of Washington, 22-26 July 1996, Mesoscale Prediction Group

JAMES ALBRITTON: Lawrence Livermore National Laboratory, CA, 25-26 July 1996, Mesoscale Prediction Group

JOAN ALEXANDER: University of Washington, 23-24 January and 26 August - 15 September 1996, Physical Meteorology Group

JORGE AMADOR: University of Costa Rica, San Jose, 15-20 July 1996, Mesoscale Prediction Group

DARCY ANDERSON: University of Arizona, 5-6 August 1996, Physical Meteorology Group

STEVEN ANDERSON: Woods Hole Oceanographic Institute, MA, Mesoscale Analysis Group

NOLAN ATKINS: University of California, Los Angeles, 30 October 1995 - 29 October 1997, joint appointment with Advanced Study Program and Mesoscale Dynamics Group

JEFF BAILEY: NASA Marshall Space Flight Center, 14-29 August 1996, Physical Meteorology Group

ROBERT BALLENTINE: State University of New York, Oswego, 22-26 July 1996, Mesoscale Prediction Group

ALBERT BARCILON: Florida State University, 7 June - 19 August 1996, Mesoscale Prediction Group

CORNELIS BEETS: Utrecht University, Netherlands, 28 April - 27 May 1996, Boundary Layer and Turbulence Group

RICHARD BLAKESLEE: NASA Marshall Space Flight Center, 25 August - 9 September 1996, Physical Meteorology Group

WARREN BLIER: University of California, Los Angeles, 22-24 July 1996, Mesoscale Prediction Group

HOWARD BLUESTEIN: University of Oklahoma, 4 January - 21 August 1996, Mesoscale Prediction Group

WILLIAM BLUMEN: University of Colorado, Boundary Layer and Turbulence Group

LANCE BOSART: State University of New York, Albany, 30 June - 13 July 1996, Mesoscale Prediction Group

DONALD BOUCHER: Aerospace Corp., Los Angeles, 22-24 July 1996, Mesoscale Prediction Group

BRENT BOWER: National Weather Service, MD, 25-26 July 1996, Mesoscale Prediction Group

ALEX BRANDENBURG: Nordita University, Denmark, Boundary Layer and Turbulence Group

PETER BREITENBACH: Texas Natural Resource Conservation Commission, Austin, 16-19 July 1996, Mesoscale Prediction Group

JEAN LOUIS BRENGUIER: Centre National de Recherches Meteorologiques, Meteo-France, 5 February - 4 March 1996, Physical Meteorology Group, and Boundary Layer and Turbulence Group (joint affiliate scientist appointment with Atmospheric Technology Division)

JAMES BRESCH: University of Washington, 1 May 1994 - 1 October 1996, Mesoscale Prediction Group

KEITH BREWSTER: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

CHARLES BROCK: University of Denver, 11 January 1996, Cloud Systems Group

JOHN BROWN: NOAA Environment Research Laboratory, Boulder, 25-26 July 1996, Mesoscale Prediction Group

DANIEL BUNZLI: Swiss Federal Institute, Zurich, Switzerland, 1 August 1995 - 26 July 1996, Mesoscale Prediction Group

ZHOHAO CAO: University of Toronto, 15-20 July 1996, Mesoscale Prediction Group

WILLIAM CAPEHART: Pennsylvania State University, 16-19 July 1996, Mesoscale Prediction Group

RICHARD CARPENTER: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

FREDERICK CARR: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

CHI HUNG CHAN: Hong Kong University of Science and Technology, 15-20 July 1996, Mesoscale Prediction Group

KWING LAM CHAN: Hong Kong University of Science and Technology, 16-19 July 1996, Mesoscale Prediction Group

DONG-EON CHANG: Seoul National University, 22 July - 21 August 1996, Mesoscale Prediction Group

JEFFREY CHASNOV: University of Hong Kong, Boundary Layer and Turbulence Group

DANIEL CHAU: University of California, Davis, 3-14 June 1996, Cloud Scale Modeling Group

CHAING CHEN: NASA Goddard Space Flight Center, 22-26 July 1996, Mesoscale Prediction Group

SUE CHEN: Naval Research Laboratory, Monterey, CA, 25-26 July 1996, Mesoscale Prediction Group

SHOU-JUN CHEN: Peking University, China, 25 March - 25 November 1996, Mesoscale Prediction Group

XIN-AN CHEN: University of Hawaii, 25 October 1995 - 24 October 1996, Mesoscale Prediction Group

FANG-CHING CHIEN: University of Washington, 22-24 July 1996, Mesoscale Prediction Group

JASON CHING: NOAA National Environment Research Laboratory, NC, 22-26 July 1996, Mesoscale Prediction Group

YOUNG-DAE CHO: Korea Water Resources Corporation, Taejon, 3-14 June 1996, Cloud Scale Modeling Group

BOON CHOY: Royal Observatory of Hong Kong, 8-12 January 1996, Mesoscale Prediction Group

HUGH CHRISTIAN: NASA Marshall Space Flight Center, 23-24 January 1996, Physical Meteorology Group

PAUL CIESIELSKI: Colorado State University, Mesoscale Analysis Group

SAM CONTORNO: National Weather Service, MD, 25-26 July 1996, Mesoscale Prediction Group

BO CUI: Chinese National Meteorological Center, Beijing, 13 January - 13 April 1996, Mesoscale Prediction Group

KENNETH DAVIS: University of Colorado, CIRES, 15 May 1989 - 29 July 1996, and University of Minnesota, 21-24 August 1996, Boundary Layer and Turbulence Group

DANIEL DeBENEDICTIS: Hanscom Air Force Base, MA, 8-12 January 1996, Mesoscale Prediction Group

FRANK DeLUCCIA: Aerospace Corporation, Los Angeles, 8-12 January 1996, Mesoscale Prediction Group

PAUL DeMOTT: Colorado State University, Physical Meteorology Group

DAVID DEMPSEY: San Francisco State University, 22-26 July 1996, Mesoscale Prediction Group

JOHN DERBER: National Centers for Environmental Prediction, Washington, D.C., Mesoscale Prediction Group

GEOFF DiMEGO: National Weather Service, MD, 25-26 July 1996, Mesoscale Prediction Group

PETER DITLEVSEN: University of Copenhagen, 27 October 1995 - 3 May 1996, Boundary Layer and Turbulence Group, and NCAR Geophysical Turbulence Program

BRIGHT DORNBLASER: Texas Natural Resource Conservation Commission, Austin, 15-20 July 1996, Mesoscale Prediction Group

DAVID DOWELL: University of Oklahoma 15 July - 15 August 1996, Mesoscale Dynamics Group

KELVIN DROEGEMEIER: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

SYTSKE DRURY: Pennsylvania State University, 22-24 July 1996, Mesoscale Prediction Group

YANG DU: Ohio State University, 8-12 January 1996, Mesoscale Prediction Group

CLAUDE DUCHON: University of Oklahoma, 22-23 February 1996, Mesoscale Analysis Group

DALE DURRAN: University of Washington, Mesoscale Dynamics Group

GERHARD EHRET: German Aerospace Research Institute (DLR), Boundary Layer and Turbulence Group

KERRY EMANUEL: Massachusetts Institute of Technology, Mesoscale Dynamics Group

FRANKLIN EVANS: University of Colorado, 25-28 February 1996, Cloud Systems Group

CHIEN-HUI FANG: National Taiwan University, Taipei, 22-24 July 1996, Mesoscale Prediction Group

JAMES FANKHAUSER: NCAR, 11 June 1995 - 11 June 1997, Mesoscale Analysis Group

ROSSELLA FERRETTI: University of L'Aquila, Italy, 27 June - 18 September 1996, Mesoscale Prediction Group

JOE FOWLER: Argonne National Laboratories, IL, 3 April 1996 - 2 April 1997, Mesoscale Analysis Group

ALAN GADIAN: University of Manchester Institute of Science and Technology, England, 2-14 June 1996, Cloud Scale Modeling Group

BART GEERTS: University of Alabama, Huntsville, Mesoscale Analysis Group

ANDREAS GIEZ: German Aerospace Research Institute (DLR), Boundary Layer and Turbulence Group

RONALD GOODSON: Environment Canada, Edmonton, 16-26 July 1996, Mesoscale Prediction Group

MIKHAIL GORBUNOV: Institute of Atmospheric Physics, Moscow, Russia, Mesoscale Prediction Group

MICHAEL GREENSLADE: University of Leeds, England, 13 June - 26 July 1996, Cloud Systems Group and Mesoscale Dynamics Group

GEORG GRELL: Fraunhofer-Institute for Atmospheric Environmental Research, Germany, 22-24 July 1996, Mesoscale Prediction Group

ROBERT GROSSMAN: University of Colorado, 16 July 1993 - 1 January 1997, Mesoscale Analysis Group

JOSHUA HACKER: University of British Columbia, 25-26 July 1996, Mesoscale Prediction Group

BRYAN HAHN: Regional Weather Information Center, Grand Forks, ND, 8-12 January 1996, Mesoscale Prediction Group

JOHN HALLETT: University of Nevada, Reno, 23-24 January 1996, Physical Meteorology Group

SCOTT HAUSMAN: Offutt Air Force Base, NE, 22-26 July 1996, Mesoscale Prediction Group

MATTHEW HECHT: Los Alamos National Laboratory, Cloud Systems Group

JAMES HEGARTY: Atmospheric and Environmental Research, Inc., Cambridge, MA, 22-24 July 1996, Mesoscale Prediction Group

CHRISTOPHER HERBSTER: National Weather Service, Tallahassee, FL, 22-26 July 1996, Mesoscale Prediction Group

WOLF DIETRICH HEROLD: Paul Scherrer Institute, Switzerland, 17 April 1995 - 2 February 1996, Physical Meteorology Group

EDGAR HERRERA: Ciudad Universitaria, Mexico 15-20 July 1996, Mesoscale Prediction Group

BRUCE HICKS: NOAA Environment Research Laboratory, Silver Spring, MD, 22-23 February 1996, Mesoscale Analysis Group

PETER HILDEBRAND: Atmospheric Technology Division, 1 April 1996 - 1 January 1997, Boundary Layer and Turbulence Group

PAUL HIRSCHBERG: Naval Postgraduate School, Monterey, CA, 25-26 July 1996, Mesoscale Prediction Group

GREGORY HOLLAND: Bureau of Meteorology Research Centre, Australia, 5-23 February 1996, Cloud Systems Group

SONG-YOU HONG: National Centers for Environmental Prediction, Washington, D.C., 25-26 July 1996, Mesoscale Prediction Group

HSIAO-MING HSU: Woods Hole Oceanographic Institute, MA, 19 January 1994 - 30 September 1996, Cloud Scale Modeling Group

HANS XIANG-YU HUANG: Danish Meteorological Institute, Copenhagen, 15-18 August 1996, Mesoscale Prediction Group

WEI HUANG: Peking University, China, 1 August 1994 - 31 July 1996, Mesoscale Prediction Group

JAMES HUDSON: Desert Research Institute, Reno, 28-29 June 1996, Physical Meteorology Group

JOHN HUDSON: South Dakota School of Mines and Technology, 23-24 January 1996, Physical Meteorology Group

WENJE HWU: University of Arizona, 16-19 July 1996, Mesoscale Prediction Group

RICHARD IGAU: Texas A & M University, 3 June - 16 August 1996, Mesoscale Analysis Group and Physical Meteorology Group

ANTHONY ILLINGWORTH: University of Reading, England, 25-28 February 1996, Cloud Systems Group

BISHER IMAM: University of Arizona, 16-19 July 1996, Mesoscale Prediction Group

VLAD ISAKOV: Desert Research Institute, Reno, 8-12 January 1996, Mesoscale Prediction Group

DAVID JAHN: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

HERMANN JAKOBS: University of Cologne, Germany, 22-24 July 1996, Mesoscale Prediction Group

MARY ANN JENKINS: York University, Ontario, Canada, 27-30 November 1995, Cloud Scale Modeling Group

BRIAN F. JEWETT: University of Illinois, Urbana, 25-26 July 1996, Mesoscale Prediction Group

YI JIN: North Carolina State University, Raleigh, 8-12 January 1996, Mesoscale Prediction Group

RICHARD JOHNSON: Colorado State University, Mesoscale Analysis Group

WESLEY JONES: Silicon Graphics, Mountain View, CA, 8-12 January 1996, Mesoscale Prediction Group

MININ KARMINI: Jakarta, Indonesia, 3-14 June 1996, Cloud Scale Modeling Group

THOMAS KEENAN: Bureau of Meteorology Research Center, Australia, Mesoscale Analysis Group

DANIEL KEYSER: State University of New York, Albany, Mesoscale Dynamics Group

CHRISTOPH KIELME: German Aerospace Research Instutute (DLR), Boundary Layer and Turbulence Group

YOUNG KIM: Korea Advanced Institute of Science and Technology, Taejon, 3-14 June 1996, Cloud Scale Modeling Group

YOSHI KIMURA: University of Nagoya, Japan, 21 November - 5 December 1995, 4-28 March 1996, and 9 July - 18 August 1996, Boundary Layer and Turbulence Group

DAVID KINGSMILL: University of Washington, 12 March 1996, Mesoscale Analysis Group

ARLENE KISHI: Aerospace Corp., Los Angeles, 22-24 July 1996, Mesoscale Prediction Group

RICHARD KNABB: Florida State University, 16-19 July 1996, Mesoscale Prediction Group

KEVIN KNUPP: University of Alabama, Huntsville, Mesoscale Analysis Group

STEVEN KRUEGER: University of Utah, 15 September - 27 October 1996, Cloud Systems Group

PAUL KRUMMEL: Commonwealth Scientific Research Organization, (CSIRO), Australia, Boundary Layer and Turbulence Group

ROBERT KUHN: Kuck and Associates, Champaign, IL, 25-26 July 1996, Mesoscale Prediction Group

MICHAEL KUIPER: Swinburne University, Melbourne, Australia, 13-22 September 1996, Physical Meteorology Group

CHING-CHI LAM: Royal Observatory of Hong Kong, 8-12 January 1996, Mesoscale Prediction Group

PIERRE LAROCHE: Office National d'Etudes et de Recherches (ONERA), Meudon, France, 29 February - 1 March 1996, Physical Meteorology Group

ROAR LARSEN: Colorado School of Mines, 9-20 November 1995, and 20-22 February 1996, Physical Meteorology Group

SONIA LASHER-TRAPP: University of Oklahoma, 1-3 November 1995, and 24-28 June 1996, Physical Meteorology Group

JOHN LATHAM: University of Manchester, England, 1 March 1993 - 1 October 1998, Physical Meteorology Group

ALEXIS LAU: Hong Kong University of Science and Technology, 9 May 1994 - 31 December 1996, Mesoscale Prediction Group

SHARON LAU: Royal Observatory of Hong Kong, 8-12 January 1996, Mesoscale Prediction Group

DONG-KYOU LEE: Seoul National University, 17 July - 15 August 1996, Mesoscale Prediction Group

MI-SEON LEE: Korean Meteorological Administration, 22-24 July 1996, Mesoscale Prediction Group

ROBERT L. LEE: Lawrence Livermore National Laboratory, CA, 25-26 July 1996, Mesoscale Prediction Group

ALAN LEPTON: Air Force Phillips Laboratory, MA, Mesoscale Prediction Group

DENNIS LETTENMAIER: University of Washington, 22-23 February 1996, Mesoscale Analysis Group

MARTIN LEUTBECHER: German Aerospace Research Institute (DLR), 16-24 July 1996, Mesoscale Prediction Group

RANDALL LeVEQUE: University of Washington, 9-13 November 1995, Cloud Systems Group

FUK LI: California Institute of Technology, 25-28 February 1996, Cloud Systems Group

LONG LI: Lawrence Livermore National Laboratory, CA, 16-19 July 1996, Mesoscale Prediction Group

SHANG-WU LI: Central Weather Bureau, Taiwan, 14-27 July 1996, Mesoscale Prediction Group

CHING-LONG LIN: Stanford University, 1 March 1994 - 30 June 1996, Boundary Layer and Turbulence Group

TIAN LIN: University of Chicago, 26-29 June 1996, Physical Meteorology Group

XIN LIN: Colorado State University, 6 June 1996, Cloud Systems Group

CHANGHAI LIU: Texas A & M University, 1 May 1994 - 31 December 1996, Cloud Systems Group

SHUAIREN LIU: University of Utah, 7 June 1996, Cloud Systems Group

ZHONG LIU: Byrd Polar Research Center, Columbus, OH, 16-19 July 1996, Mesoscale Prediction Group

CHRIS LUCAS: Texas A & M University, Mesoscale Analysis Group

LARRY MAHRT: Oregon State University, Affiliate Scientist appointment, 25 March - 4 August 1996, and 8-18 September 1996, Boundary Layer and Turbulence Group

ANDREW MAJDA: New York University, Courant Institute, 11-18 May 1996, Cloud Systems Group

TARAS MAKOGON: Colorado School of Mines, 2-8 August 1996, Physical Meteorology Group

JAKOB MANN: Risoe National Laboratory, Denmark, Boundary Layer and Turbulence Group

LEN MARGOLIN: Los Alamos National Laboratory, 27 November - 1 December 1995, and 25-29 March 1996, Cloud Systems Group

LINSEY MARR: Harvard University, 10 June - 2 August 1996, Boundary Layer and Turbulence Group

CLIFFORD MASS: University of Washington, 22-26 July 1996, Mesoscale Prediction Group

GRAEME MATHER: South African Weather Bureau, Nelspruit, South Africa, 27 June - 13 July 1996, Cloud Scale Modeling Group

SHANE MAYOR: University of Wisconsin, Boundary Layer and Turbulence Group

EUGENE McCAUL: NASA Marshall Space Flight Center, Mesoscale Dynamics Group

PATRICK McCORMICK: NASA Langley Research Center, 25-28 February 1996, Cloud Systems Group

JOHN McHENRY: North Carolina Supercomputing Center, Research Triangle Park, 22-26 July 1996, Mesoscale Prediction Group

JAMES McWILLIAMS: University of California, Los Angeles, Boundary Layer and Turbulence Group

PHILIP MERILEES: Atmospheric Environment Service, Canada, 17 June - 13 July 1996, MMM Director's Office

OLIVIER METAIS: Institute de Mecanique de Grenoble, France, 8 July - 1 August 1996, Boundary Layer and Turbulence Group

JOHN MICHALAKES: Argonne National Laboratory, IL, 22-24 July 1996, Mesoscale Prediction Group

DIANE MINFA: Monash University, Australia, 10-25 June 1996, Mesoscale Dynamics Group

DAVID MITCHELL: Desert Research Institute, Reno, 5-12 January 1996, Physical Meteorology Group

GEORGE MODICA: Air Force Phillips Laboratory, MA, Mesoscale Prediction Group

GRIFFITH MORGAN: Thunderstorm and Hail Prevention Research Center, Gorizia, Italy, 10-28 January 1996, Cloud Scale Modeling Group

MICHAEL MORGAN: University of Wisconsin, Madison, 17-20 January 1996, and 8 July - 5 August 1996, Mesoscale Prediction Group

REBECCA MORSS: Massachusetts Institute of Technology, 6 January - 3 February 1996, and 23 July - 27 August 1996, Mesoscale Dynamics Group

STEVEN MULLEN: University of Arizona, 24-26 July 1996, MMM Director's Office

DAVID MURAKI: New York University, Courant Institute, 27 June - 21 August 1996, Mesoscale Dynamics Group

BALU NADIGA: Los Alamos National Laboratory, Cloud Systems Group

JON NELSON: University of Colorado and Oak Ridge National Laboratory, 11 May 1994 - 11 August 1996, Physical Meteorology Group

JOHN NIELSEN-GAMMON: Texas A & M University, 16-19 July 1996, Mesoscale Prediction Group

DONALD NORQUIST: Hanscom Air Force Base, MA, 8-12 January 1996, Mesoscale Prediction Group

WENDELL NUSS: Naval Postgraduate School, Monterey, CA, 25-26 July 1996, Mesoscale Prediction Group

DENNIS O'BRIEN: Commonwealth Scientific Research Organization, Australia, 25-28 February 1996, Cloud Systems Group

HARRY OCHS: Illinois State Water Survey, 26-29 June 1996, Physical Meteorology Group

DENNIS OJIMA: Colorado State University, 22-23 February 1996, Mesoscale Analysis Group

DARYL ONTON: University of Utah, 22-24 July 1996, Mesoscale Prediction Group

LEON OSBORNE: Regional Weather Information Center, Grand Forks, ND, 8-12 January 1996, Mesoscale Prediction Group

MARTIN OTTE: Pennsylvania State University, 16-19 July 1996, Mesoscale Prediction Group

DAVID PACKHAM: Monash University, Australia, 3-30 November 1995, Cloud Scale Modeling Group

DZONG-MING PAN: Colorado State University, 6 June 1996, Cloud Systems Group

SEON KI PARK: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

JUDY PECHMANN: University of Utah, 22-24 July 1996, Mesoscale Prediction Group

STEVEN PECKHAM: Texas A&M University, 8-12 January 1996, Mesoscale Prediction Group

MARIA PERISTERI: Meteorologisches Institut Muenchen, Germany, 24 February - 4 April 1996, Mesoscale Dynamics Group

ANDREAS PFEIFFER: University of Munich, Germany, 22-24 July 1996, Mesoscale Prediction Group

JOHN PFLAUM: NOAA and Argonne Laboratory, IL, 3 September 1991 - 1 October 1998, Mesoscale Analysis Group

KEN PICKERING: University of Maryland, 23-24 January 1996, and 19 June - 17 July 1996, Physical Meteorology Group

ROGER PIELKE: Colorado State University, 22-23 February 1996, Mesoscale Analysis Group

JONATHAN PLEIM: US Environmental Protection Agency, Research Triangle Park, NC, 22-24 July 1996, Mesoscale Prediction Group

MANUEL PONDECA: Florida State University, 17 June - 15 August 1996, Mesoscale Prediction Group

JORDAN POWERS: University of Washington, 1 October 1993 - 31 July 1997, Mesoscale Prediction Group

JOSEPH PRUSA: Iowa State University, 30 June - 31 July 1996, Cloud Systems Group (joint appointment with Atmospheric Chemistry Division)

DAVID RANDALL: Colorado State University, 25-28 February 1996, Cloud Systems Group

ANIL RAO: Florida State University, 22-24 July 1996, Mesoscale Prediction Group

GANDIKOTA V. RAO: St. Louis University, 22-23 February 1996, Mesoscale Analysis Group

ROBERT RAUBER: University of Illinois, Urbana, 26-29 June 1996, Physical Meteorology Group

JOHN RAYNER: Ohio State University, 16-19 July 1996, Mesoscale Prediction Group

JEAN LUC REDELSPERGER: Centre National de Recherches Meteorologiques, Meteo-France, Toulouse, France, Cloud Systems Group

RICHARD REED: University of Washington, Affiliate Scientist appointment, 31 January 1996 - 7 February 1996, and 2-9 June 1996, Mesoscale Prediction Group

MICHAEL REEDER: Monash University, Australia, 23 January - 12 July 1996, Mesoscale Dynamics Group

IAN RENFREW: University of Toronto, 8-12 January 1996, Mesoscale Prediction Group

FINDY RENGGONO: Jakarta, Indonesia, 3-14 June 1996, Cloud Scale Modeling Group

ANDREAS REULER: Institute of Atmospheric Physics (GKSS), Geesthacht, Germany, 29 November 1995, Physical Meteorology Group

STEVEN REYNOLDS: Envair, San Rafael, CA, 16-24 July 1996, Mesoscale Prediction Group

HARALD RICHTER: Monash University, Australia, 7 June 1996, Mesoscale Dynamics Group

DAVID ROGERS: Colorado State University, Physical Meteorology Group

STEVE RUTLEDGE: Colorado State University, 23-24 January 1996, Physical Meteorology Group

DAVID SAILOR: Tulane University, New Orleans, 16-19 July 1996, Mesoscale Prediction Group

MURRY SALBY: University of Colorado, 25-28 February 1996, Cloud Systems Group

KENNETH SASSEN: University of Utah, 25-28 February 1996, Cloud Systems Group

JOHN SCALA: State University of New York, Brockport, 19 June - 17 July 1996, Physical Meteorology Group

DONALD SCHLEEDE: State University of New York, Brockport, 25-26 July 1996, Mesoscale Prediction Group

OTMAR SCHMID: University of Missouri, Rolla, 3 June - 3 August 1996, Physical Meteorology Group (joint appointment with Atmospheric Technology Division)

HANS-GEORG SCHREIBER: German Aerospace Research Institute (DLR), Boundary Layer and Turbulence Group

RONALD SCHWIESOW: Ball Brothers, Boulder, Boundary Layer and Turbulence Group

NELSON SEAMAN: Pennsylvania State University, 22-24 July 1996, Mesoscale Prediction Group

HARVEY SEGUR: University of Colorado, 5 August 1996 - 1 June 1997, Boundary Layer and Turbulence Group, and Mesoscale Dynamics Group

JOSEPH SELA: National Centers for Environment Prediction, Washington, D.C., Mesoscale Prediction Group

ROBERT SHARMAN: Logicon, Inc. and University of California, Los Angeles, 22 January - 22 September 1996, Cloud Systems Group, and Boundary Layer and Turbulence Group

LEI SHI: SeaSpace Corporation, San Diego, 22-26 July 1996, Mesoscale Prediction Group

STEVE SIEMS: Monash University, Australia, 17-23 January 1996, Boundary Layer and Turbulence Group

E. SLOAN, JR.: Colorado School of Mines, Physical Meteorology Group

LESLIE SMITH: Yale University, Boundary Layer and Turbulence Group

ROGER SMITH: University of Munich, Germany, 5-11 March 1996, Mesoscale Dynamics Group

SONYA SMITH: Howard University, Washington, D.C., 4-6 September 1996, Boundary Layer and Turbulence Group

BRADLEY SMULL: NOAA/NSSL and University of Washington, 19-28 July 1996, Mesoscale Analysis Group

SERGEY SOKOLOVSKIY: Institute of Atmospheric Physics, Moscow, Mesoscale Prediction Group

RICHARD SOMMERFELD: U. S. Forest Service, Ft. Collins, CO, Physical Meteorology Group

ZBIGNIEW SORBJAN: University of Oklahoma, 22 January - 15 April 1996, Boundary Layer and Turbulence Group, and Cloud Systems Group

RAMASH SRIVASTAVA: University of Chicago, 26-29 June 1996, Physical Meteorology Group

PAUL STACKHOUSE: Colorado State University, 26 October 1995, Physical Meteorology Group

EDWARD STANFORD: Jackson State University, MS, 8-12 January 1996, Mesoscale Prediction Group

DAVID STAUFFER: Pennsylvania State University, 22-26 July 1996, Mesoscale Prediction Group

JAMES STEENBURGH: University of Utah, 22-26 July 1996, Mesoscale Prediction Group

GRAEME STEPHENS: Colorado State University, Cloud Systems Group

J. STEPPELER: Institute of Atmospheric Physics, Germany, 25-26 July 1996, Mesoscale Prediction Group

DAVID STEVENS: New York University, Courant Institute, 21 July - 3 August 1996, Cloud Systems Group

JEFFREY STITH: University of North Dakota, 23-24 January 1996, Physical Meteorology Group

ROLAND STULL: University of British Columbia, 25-26 July 1996, Mesoscale Prediction Group

KWANG SOO SUH: Korea Advanced Institute of Science and Technology, Taejon, 2-14 June 1996, Cloud Scale Modeling Group

JIELUN SUN: University of Colorado, 11 July 1995 - 10 July 1997, Boundary Layer and Turbulence Group

ROBERT SWANSON: University of Utah, 8-12 January 1996, and 22-24 July 1996, Mesoscale Prediction Group

MARCIN SZUMOWSKI: University of Illinois, Urbana-Champaign, 20 August - 20 December 1995, Cloud Systems Group

ISTVAN SZUNYOGH: Eotvos Lorand University, Budapest, Hungary, 21 September 1996 - 20 January 1997, Mesoscale Dynamics Group

OLIVIER TALAGRAND: Centre National de la Recherche Scientifique, France, 31 October - 30 November 1995, Mesoscale Prediction Group

ZUYU TAO: Peking University, China, 29 January - 29 May 1996, Mesoscale Prediction Group

DEON TERBLANCHE: South African Weather Bureau, Bethlehem, South Africa, 5-6 October 1995, Cloud Systems Group

RAFAEL TERRA: University of California, Los Angeles, 16-19 July 1996, Mesoscale Prediction Group

LARRY TIESZEN: Augustana College, Sioux Falls, SD, 22-23 February 1996, Mesoscale Analysis Group

ZOLTAN TOTH: National Centers for Environmental Prediction, Washington, D.C., 19-27 May 1996, and 7-11 September 1996, Mesoscale Dynamics Group

TADASHI TSUYUKI: Florida State University, 7-10 February 1996, Mesoscale Prediction Group

ADRIAN TUCK: NOAA Aeronomy Laboratory, Boulder, Physical Meteorology Group

DOUGLAS TUNNEY: Florida State University, 8-12 January 1996, Mesoscale Prediction Group

PAUL VAILLANCOURT: McGill University, Quebec, Canada, 11-29 February 1996, Cloud Systems Group

FRANCOIS VAN den BERGHE: Cabinet d'Etude Technique Industrielle et d'Innovation Scientifique, France, 1 April 1996 - 31 March 1997, Mesoscale Prediction Group

HANS VERLINDE: Pennsylvania State University, 28-31 May 1996, Cloud Scale Modeling Group

HOLGER VOEMEL: University of Colorado, 5 October 1995, Physical Meteorology Group

FABIAN WALEFFE: Massachusetts Institute of Technology, Boundary Layer and Turbulence Group

STEVEN WALTER: California Institute of Technology, 25-28 February 1996, Cloud Systems Group

ANYU WANG: Zhongshan University, China, 14 September 1994 - 10 October 1996, Mesoscale Prediction Group

QING WANG: Naval Postgraduate School, Monterey, CA, 28-31 May 1996, Boundary Layer and Turbulence Group

DINGYING WEI: New Mexico State University, Mesoscale Analysis Group

JEFFREY WEIL: University of Colorado, CIRES, 16 May 1990 - 1 October 1997, Boundary Layer and Turbulence Group

ROBERT WELLER: Woods Hole Oceanographic Institute, MA, Mesoscale Analysis Group

MARTIN WELLS: University of Manchester Institute of Science and Technology, England, 3-14 June 1996, Cloud Scale Modeling Group

JOSEPH WERNE: University of Colorado, 1 October 1995 - 1 July 1996, Cloud Systems Group

MARV WESELY: Argonne National Laboratory, IL, 22-23 February 1996, Mesoscale Analysis Group

KENNETH WESTRICK: University of Washington, 22-24 July 1996, Mesoscale Prediction Group

SETH WHITE: University of Colorado, 6 October 1993 - 20 August 1996, Boundary Layer and Turbulence Group

LOUIS WICKER: Texas A & M University, 22 July - 5 August 1996, Mesoscale Dynamics Group

BRUCE WIELICKI: NASA Langley Research Center, 25-28 February 1996, Cloud Systems Group

ANDRE WIERZBICHI: University of South Alabama, 1-2 July 1996, Physical Meteorology Group

ROBERT WILHELMSON: National Center for Supercomputing Applications, University of Illinois, Urbana, Mesoscale Dynamics Group

WINFRIED WILCKE: HAL Computer Systems, Denver, 9 January 1996, Cloud Scale Modeling Group

WOLFRAM WOBROCK: Universite Blaise-Pascal, France, 2-14 June 1996, Cloud Scale Modeling Group

BING WU: Pennsylvania State University, 28 May - 8 June 1996, Cloud Scale Modeling Group

CHUN-CHIEH WU: National Taiwan University, Taipei, 16-19 July 1996, Mesoscale Prediction Group

XIAOQING WU: University of California, Los Angeles, 1 October 1993 - 31 December 1996, Cloud Systems Group

QINGNONG XIAO: Nanjing University, China, 18 July 1996 - 17 July 1997, Mesoscale Prediction Group

AIJUN XIU: North Carolina Supercomputing Center, Research Triangle Park, 22-24 July 1996, Mesoscale Prediction Group

XUANYONG XU: University of Wyoming, 16 October 1995 - 15 October 1997, Cloud Scale Modeling Group

MING XUE: University of Oklahoma, 25-26 July 1996, Mesoscale Prediction Group

JUN-ICHI YANO: Monash University, Australia, 6 July - 7 October 1995, and 13 May - 1 September 1996, Cloud Systems Group

JOSEPH ZEHNDER: University of Arizona, 28-31 May 1996, MMM Director's Office

DEXIN ZHANG: National Meteorological Center, Beijing, China, 10 June 1996 - 11 March 1997, Mesoscale Prediction Group

SHUXIA ZHANG: University of Minnesota, 16-26 July 1996, Mesoscale Prediction Group

MING-YU ZHOU: National Research Center for Marine Environmental Forecasts, Beijing, China, 13 August - 16 November 1996, Mesoscale Analysis Group, and Boundary Layer and Turbulence Group

EDWARD ZIPSER: Texas A & M University, 28 June 1996 - 28 August 1996, Physical Meteorology Group

MILIJA ZUPANSKI: National Centers for Environmental Prediction, Washington, D.C., 16 November - 18 November 1995, Mesoscale Prediction Group

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ESIG Director's Message

What follows are some of the highlights of the research and outreach activities of members and visitors of ESIG during FY96. It was quite an active year, during which group members prepared research papers and books for publication, and organized three major international multidisciplinary workshops. We would welcome any comments readers may have concerning the information provided in these Web Pages about our activities during the past fiscal year. We would also welcome partners in collaboration from the university, government, non-governmental, and industry communities.

Michael H. Glantz

Table of Contents

FY 1996 Publications

FY 1996 Science Highlights

Community Service

Educational Activities

Staff, Visitors and Collaborators

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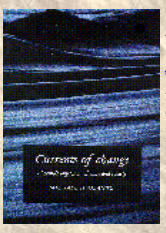
ESIG's FY96 Science Highlights

- **Perhaps ESIG's most important accomplishment of FY96 has been its emphasis on "Usable Science" and the application of that notion to El Niño-Southern Oscillation (ENSO)-related research. The societal and environmental aspects of ENSO have been a constant research interest of ESIG since the mid-1970s. The convening of an October 1995 Usable Science workshop in Ho Chi Minh City, Vietnam brought together researchers, resource managers, and educators for the purpose of bridging the communications gap between the research community and those decisionmakers who are expected to use that research output. This Usable Science workshop was sponsored by the UN Environment Programme (UNEP) and was organized and chaired by Glantz.**
  (Photo taken by M.H. Glantz, Northern Vietnam)

- **On behalf of UNEP's Atmosphere Unit, Glantz organized a second Usable Science workshop for FY96 (and the fourth in the series). It was directly sponsored by UNEP's Regional Office for Latin America and the Caribbean, held in Havana, Cuba in January 1996, and was hosted by the Institute of Meteorology in Havana.**



As a part of the focus on Usable Science, Glantz finished work on *Currents of Change:El Niño's Impact on Climate and Society*. This book presents an all-encompassing view of the El Niño phenomenon, its causes and impacts. Published by Cambridge University Press in September 1996, it includes testimonial comments by 35 researchers on their involvement in ENSO research over the decades.
Click on image to view entire cover (183k)

- **Richard Katz completed an edited book (with Allan Murphy, Prediction and Evaluation Systems) on *The Economic Value of Weather and Climate Forecasts* for Cambridge University Press. The project was multidisciplinary in nature, including authors from meteorology, statistics, psychology, and economics. The book's publication date is 1997.**

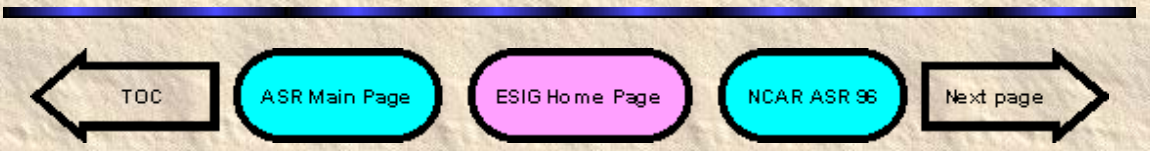
- **A paper prepared under the Rates and Processes Initiative by Mary Downton, "Measuring Tropical Deforestation: Development of the Methods," *Environmental Conservation*, 22(3):229-240, was recently awarded a Best Paper Prize by the Foundation for Environmental Conservation, to be announced in *Environmental Conservation*, 23(3).**

- **Kathleen Miller and research assistant Robert Parkin (University of Colorado-Boulder) finalized their report of the Institute on the Economics of the Climate Resource. The report contains the full transcripts of 18 lectures delivered at the June 1995 Institute. A broad range of topics is covered, with attention given to questions relating to global climate change as well as to present-day climate and weather.**

- **Roger Pielke, Jr. co-chaired, along with Jeff Kimpel (University of Oklahoma), the US Weather Research Program Prospectus Development Team #6 on the societal aspects of weather. It is generally accepted that weather problems are comprised of both social and physical phenomena. Despite the centrality of this research**

area, it has in the past received too little attention and too few resources. The report of the meeting is scheduled to be published in March 1997 in Bulletin of the American Meteorological Society.

- **Glantz and Igor Zonn (UNEP National Committee for Russia) received funding from the North Atlantic Treaty Organization (NATO) to support an Advanced Research Workshop on the Scientific, Environmental, and Political Issues in the Circum-Caspian Region. Glantz and Zonn organized and chaired the workshop, which was held in Moscow in May 1996.**



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ESIG's FY96 Educational Activities

- Formal Teaching Arrangements
- Workshops and Colloquia
- Scientific or Technical Seminars
- Non-Technical, Popular Presentations

Formal Teaching Arrangements

Teaching

- John Firor has held an an appointment as a Senior Wirth Fellow in the Graduate School for Public Affairs at the University of Colorado at Denver since 1 September 1996. He will be supervising independent studies graduate students in areas related to policy issues flowing from global change research, organizing national and state conferences on environmental policy issues, and giving seminars.

- Michael Glantz co-taught the Spring 1996 graduate course at the University of Colorado on "Policy Responses of Global Environmental Change" through the Environmental Policy Certification Program.

- Michael Glantz held an electronic dialogue on the Internet through the Iowa State University Global Change Course team on "Societal Responses to Regional Climate Change" on 29 April 1996.

- Roger Pielke, Jr., designed and taught "Methods of Policy Analysis," at Denver University (INTS 4967), a graduate-level survey course on quantitative methods for public policy analysis. Topics covered included basic probability and statistics, cost/benefit analysis, forecasting, budgeting, and policy problem structuring.

- Roger Pielke, Jr. designed and taught "Science, Climate, and the Policy Process," University of Colorado (ASRC 1510), a seminar focused on environmental science and its use in various processes of decision. Students completed units on the policy implications of hurricanes, El Niño, and global climate change.

Dissertation Committees

- Richard Katz, External Examiner, Ph.D. thesis, John Sansom, Institute of Statistics and Operations Research, University of Wellington, New Zealand.

Workshops and Colloquia

- Michael Glantz organized and chaired a workshop on *ENSO and Extreme Events in Southeast Asia*, 23-26 October 1995 in Ho Chi Minh City, Vietnam. The workshop was co-sponsored by ESIG and UNEP. It was the third of four workshops on "Usable Science."

- Michael Glantz organized and chaired a workshop on *ENSO and Extreme Events in the Greater Caribbean Region*, held 9-12 January 1996 in Havana, Cuba. The workshop was co-sponsored by ESIG and UNEP. It was the fourth of

four workshops on "Usable Science."

- Michael Glantz organized and co-chaired (with Igor Zonn) a NATO Advanced Research Workshop on *The Scientific, Environmental and Political Issues in the Circum-Caspian Region*, held 13-16 May 1996 in Moscow, Russia.
- Kathleen Miller organized a Symposium on Climate-Related Variability, Economics, and Management, 27 August 1996, at the American Fisheries Society 126th Annual Meeting, Dearborn, Michigan.
- Pielke, Jr., R.A. (co-chair with James Kimpel), 1996. U.S. Weather Research Program Prospectus Development Team on Social and Economic Aspects of Weather, 13-15 May, National Science Foundation, Arlington, Virginia.

Scientific or Technical Seminars

- Mary Downton gave an invited talk on "Time Series Models of Relationships Between Alaskan Salmon Catch and Large-Scale Climate Phenomena," American Fisheries Society Annual Meeting, 26-29 August 1996, Dearborn, Michigan.
- John Firor gave two presentations to mid-level government managers at the Office of Personnel Management, Denver, 10 October 1995 and 25 July 1996. The subject each time was evidence for substantial global change and impacts.
- John Firor was the Keynote speaker at the Conference on Uncertainty in Science and the Implications for Society at the University of Colorado-Boulder, 4 November 1995. The subject was the current state of climate science.
- John Firor spoke on policy issues surrounding climate change and ozone depletion to a class on Global Issues at the University of Colorado-Boulder, 15 November 1995.
- John Firor gave a presentation to a public forum of the Boulder County Healthy Communities Initiative on the nature and definition of sustainable development, 30 November 1995.
- John Firor spoke at a session of the Wednesday Seminar series at Resources for the Future, Washington, DC, where he was a visiting scholar for the period 5 March to 31 May 1996. The subject was rapid change in climate science.
- John Firor visited Hamden-Sydney College in Farmville, Virginia on 2 April 1996, and spoke to an honors class on human impact on the environment.
- Michael Glantz gave a presentation at the Global Change Science and Policy Forum for the Southeast Asia Regional Committee for START (SARCS) at Chulalongkorn University in Bangkok, Thailand on 27-28 March 1996. He also chaired three sessions at the forum.
- Michael Glantz gave a presentation at a workshop on *Earth Science Research and the Challenges of Environmental Security* at George Washington University on 9 July 1996.
- Michael Glantz gave a presentation and chaired a session on *Environmental Change and Food Security* at the 28th International Geographical Congress, 5-10 August 1996, in The Hague, The Netherlands.
- Richard Katz, "Statistical methods for generating scenarios of future climate change." Invited talk at Annual Meeting of Society for Risk Analysis, Honolulu, Hawaii, 3-6 December 1995.
- Richard Katz, "Overdispersion phenomenon in stochastic modeling of daily precipitation." Talk at American Meteorological Society Thirteenth Conference on Probability and Statistics in Atmospheric Sciences, San Francisco, California, 21-23 February 1996.
- Richard Katz, "Quality/value relationships for weather and climate forecasts." Invited talk at Workshop on the Evaluation of Space Weather Forecasts, NOAA, Boulder, Colorado, 19-21 June 1996.
- Richard Katz, invited discussant for session on "Advances in statistical climate modeling and analysis." Joint

Statistical Meetings, Chicago, Illinois, 4-8 August 1996.

- Kathleen Miller gave a seminar on "Stock Variability and the Political Economy of the Pacific Salmon Treaty" at the Environment and Behavior Program, Institute of Behavioral Science, University of Colorado, Boulder, Colorado, 6 November 1995.

- Kathleen Miller gave a presentation on the "Economics of the Climate Resource" at the American Meteorological Society Symposium on Environmental Applications, Atlanta, Georgia, 29 January 1996.

- Kathleen Miller gave a presentation on "An Economic Perspective" at the meeting of the U.S. Weather Research Program Prospectus Development Team #6 on Social and Economic Aspects of Weather, National Science Foundation, Arlington, Virginia, 13 May 1996.

- Kathleen Miller presented a paper on "Property and Water: A Historical Analysis" at the 7th Annual Conference of the European Association of Environmental and Resource Economists, Lisbon, Portugal, 29 June 1996.

- Kathleen Miller presented a paper on "Stock Variability and the Political Economy of the Pacific Salmon Treaty," to the Symposium on Climate-Related Variability, Economics, and Management, at the American Fisheries Society 126th Annual Meeting, Dearborn, Michigan, 27 August 1996.

- Roger Pielke, Jr., was Keynote speaker on "The Changing Ecology of United States Science," Survival in the 21st Century: Priorities for Agricultural Research, Agricultural Research Institute 45th Annual Meeting, 23-24 September 1996, Bethesda, Maryland.

- Roger Pielke Jr. was Principal speaker on "The Changing Environment of U.S. Science Policy," A New Paradigm for Science: Public Private Partnership, American Association of Cereal Chemists, 17 September 1996, Baltimore, Maryland.

- Roger Pielke Jr. presented a discussion paper on "Improving Policies for Extreme Weather in the United States: A Need for Problem Definition and Preparedness Assessment," for the Aspen Global Change Institute Summer Science Session on "Global Change and Natural Hazards," 10-20 July, 1996, Aspen, Colorado.

- Roger Pielke Jr. was Session Convener and presented a paper on "Societal Vulnerability to Tropical Cyclones," Climate Variability and Tropical Cyclone Prediction, Risk Prediction Initiative, Bermuda Biological Station for Research, Inc. 12-15 June 1996, St. George, Bermuda.

- Roger Pielke Jr. spoke on "The U.S. Weather Problem: A Review of Indicators," at the U.S. Weather Research Program Prospectus Development Team on Social and Economic Aspects of Weather, 13-15 May 1996, National Science Foundation, Arlington, Virginia.

- Roger Pielke, Jr. spoke on "Societal Impacts of Weather," at the U.S. Weather Research Program Prospectus Development Team on Orographic Weather Effects, 18 March 1996, National Center for Atmospheric Research, Boulder, Colorado.

- Roger Pielke Jr. presented a paper on "Meteorological Research and Societal Needs: Asking the Right Questions," at The *76th Annual Meeting of the American Meteorological Society*, Symposium on Environmental Applications, January 28 - February 2 1996, Atlanta, Georgia.

- Roger Pielke Jr. presented a paper on "Wholesaling and Retailing ENSO Information," at *Usable Science IV: ENSO and Extreme Events in the Wider Caribbean Region*, sponsored by the United Nations Environment Programme, 9-12 January 1996, Havana, Cuba.

- Roger Pielke Jr. acted as Rapporteur and presented a paper on "Usable Forecasts: ENSO Information and Societal Vulnerability to Extreme Weather Events," at *Usable Science III: ENSO and Extreme Events in Southeast Asia*, sponsored by the United Nations Environment Programme, October 22-26 1995, Ho Chi Minh City, Vietnam.

Non-Technical, Popular Presentations

- John Firor gave an after-dinner talk to meeting of the American Wind Energy Association in Denver, Colorado on 26 June 1996, about the role of wind energy and environment.
- John Firor gave three similar presentations to teachers or to technicians involved with recycling: (1) Boulder Valley school teachers involved with recycling and other environmental activities (8 November 1995); (2) Saint Vrain teachers (10 November 1995); and (3) of Ecocycle in Boulder (14 November 1995). The topic was global change.
- Michael Glantz and Roger Pielke, Jr. spent a day at work with Kyle Thielen, Southern Hills Junior High, Boulder, Colorado; 6 May 1996.
- Roger Pielke, Jr., presented a talk on "Teaching for Critical Thinking," University of Colorado 12th Annual Fall Intensive, Graduate Teacher Program, Graduate School, 21 August 1996, Boulder, Colorado.
- Roger Pielke, Jr., gave a talk on "Weather Disasters" at Burlington Elementary School, Longmont, Colorado, 30 May 1996.
- Roger Pielke, Jr., gave a talk on "Hurricane Impacts in the United States," at National Center for Atmospheric Research, Boulder, Colorado, 20 December 1995.
- Roger Pielke, Jr., spoke on "Can the U.S. Global Change Program Deliver on Its Promises?" at National Center for Atmospheric Research, Boulder, Colorado, 3 November and 8 December 1995.

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FY 1996 NCAR ANNUAL SCIENTIFIC REPORT
RESEARCH APPLICATIONS PROGRAM

RAP Director's Message

Brant Foote

The Research Applications Program began at NCAR in 1982 with an emphasis on severe convective downdrafts, known as microbursts, that were implicated in a number of airline accidents. The directed research and engineering development undertaken at RAP was pivotal in deriving an operational solution to that important safety problem in terms of timely detection and warning of the event, and pilot training. The combination of research, development, and interaction with end-users (in this case the Federal Aviation Administration and the airlines) has served as a model for RAP's ongoing activities in the technology transfer arena.

With the microburst work essentially wrapped up, the Program's activities have broadened to encompass a more general goal: the attainment of an improved capability for detecting, warning, and forecasting relevant mesoscale weather phenomena, and the transfer of this capability to the operational sector. Using automated nowcasting techniques, remote sensing methods, and mesoscale and cloud-scale models, RAP is concentrating on three main areas: aviation weather, numerical weather prediction (for a variety of non-aviation purposes), and water resource applications. The aviation efforts emphasize aeronautical hazards and efficiency concerns involving thunderstorms, icing and snowfall, and a variety of turbulence phenomena. Most of this work has been on-going for several years and receives the most attention in this year's report. In the area of numerical weather prediction, new work has been started on developing an operational fine-scale forecast model, including local terrain effects, for the Army's Test and Evaluation Command. Other aspects of this effort involving the development of an integrated weather display system. In the water resources arena, new programs to develop more accurate techniques for remote measurement of precipitation, and to evaluate the effectiveness of a relatively new hygroscopic seeding technique to enhance rainfall have also been initiated.

Historically, most of the funding for RAP's activities has come from the FAA. With the diversification of the program, the FAA work amounts to about half of the total effort, with other significant support coming from foreign governments, DoD, and private companies.

RAP conducts its work in collaboration with universities, government laboratories, and other Divisions of NCAR, particularly the Mesoscale and Microscale Meteorology Division and the Atmospheric Technology Division. In many of its activities, particularly those involving foreign governments, RAP works closely with Weather Information Technologies, Inc.

In pursuing its mission of directed research, innovative development and technology transfer, RAP maintains a staff that is split approximately equally between engineers and scientists. It is the work of the latter that is most emphasized in this

Annual Scientific Report, though the contributions of the former are of equal importance to the overall program.

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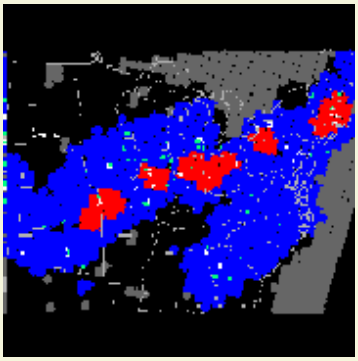
Science Highlights

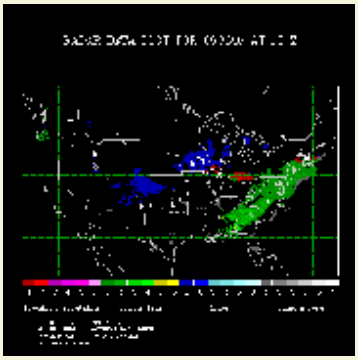
Scientific highlights at RAP during 1996 include:

- **development of two new in-flight icing algorithms based on**

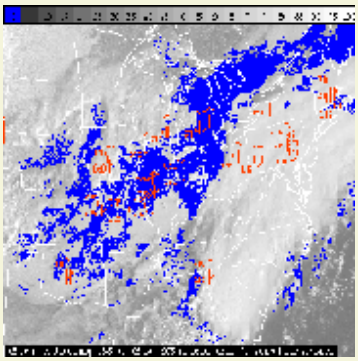
  surface weather data, model output (click here for animated version),



  radar data (click here for animated version),



  and satellite data (click here for animated version) .



RAP has had success with development of an in-flight icing algorithm based on temperature and relative humidity outputs from operational numerical weather forecast models. However, there were still plenty of opportunities for improvement. New regulations for turboprop aircraft flying in freezing drizzle made an accurate forecast of that phenomenon highly desirable. To respond to this need, RAP staff examined results of a study they had recently completed relating icing, and specific types of icing likely related to encounters with freezing drizzle, to weather features. Using this information they formed an algorithm which combined numerical model outputs, surface observations of precipitation, and national-mosaic

NEXRAD radar data to diagnose or forecast where freezing drizzle was likely. The algorithm was transferred to the National Weather Service's Aviation Weather Center where is is used in daily operations.

Other newly-developed technology provided a different source for inflight icing diagnoses. The new Geostationary Orbital Earth Satellites (GOES-8/9) detect more wavelengths of radiation than did previous weather satellites. Scientists are just learning to use these data for specific applications -- one of these being the detection of supercooled liquid cloud tops which may represent in-flight icing hazards. By knowing typical water droplet and ice crystal sizes and concentrations expected in clouds, and combining this knowledge with their radiative transfer properties, RAP scientific staff developed an algorithm that uses combinations of visible and infrared radiation information from GOES 8/9. A new icing diagnosis can be provided every 15 minutes, allowing a forecaster to loop through previous images to determine the movement of icing hazard areas.

These two developments represent effective application of new technology and knowledge to meet user needs in aviation meteorology.

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RAP Educational Activities

Workshops and Colloquia

Marcia Politovich made a presentation at the American Institute of Aeronautics and Astronautics Annual Meeting in Reno, gave a seminar to the Aerospace Department at the University of North Dakota, Grand Forks, made a presentation at Alaska Mesoscale Meteorology Workshop, in Fairbanks, made presentations at Plenary Session and Forecast/Avoidance Working Group Sessions for the FAA International In-Flight Icing Conference in Springfield, Virginia. She also gave an NCAR seminar in the early part of the year titled "The Relationship between in-flight aircraft icing and synoptic-scale weather patterns"

Seminars and Presentations - Non-Technical Audience

Rachel Ames gave two presentations of a talk called: "A Mathematical Model for the Cubic Growth of AIDS in the US". I gave these presentations to calculus classes at CU. The talk explains the dynamics of the US population and AIDS and then shows how the cubic growth of AIDS in the US fits the model.

Jeffrey Cole gave a Mobile CLASS demonstration for Middle School Students, and a Marshall Instrument Site Tour for University of Colorado, Boulder Hydrology Class Students.

Sandra Henry made presentations to students at George Washington High School, Manual High School and Cole Middle School.

Teddie Keller gave a seminar to the Denver Area Physics Teachers Association in April entitled "The Beauty of the Atmosphere: Waves, Wakes, and Windstorms."

Marcia Politovich gave a public talk on in-flight icing forecasting to the University of North Dakota, Grand Forks, and a talk on improvements in in-flight icing Forecasting to a Western Kansas chapter of the American Meteorological Society. She also gave an informal talk at Niwot High School.

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Publications

Refereed Publications

Brandes, E.A., J. Vivekanandan, J.D. Tuttle, and C.J. Kessinger, 1996: A study of microphysics with multiparameter radar and aircraft observations. *Mon. Wea. Rev.,* **123,** No. 11, 3129-3143.

Crook, N.A., 1996: Sensitivity of moist convection forced by boundary layer processes to low-level thermodynamic fields. *Mon. Wea. Rev.* , **124** , 1767-1785.

Davis, C. A., E. D. Grell, and M. A. Shapiro, 1996: The balanced dynamical nature of a rapidly intensifying oceanic cyclone. *Mon. Wea. Rev.*, **124,** 3-26.

Persson, P.O.G., and T.T. Warner, 1996: The nonlinear evolution of idealized, unforced, conditional symmetric instability: A numerical study. *J. Atmos. Sci.*, **52,** 3449-3474.

Politovich, M.K., 1996: Response of a research aircraft to icing and evaluation of severity indices. *J. Aircraft*, **33** (2), Amer. Inst. of Aero. and Astro., Washington D.C., 291-297.

Reinking, R.F., S.Y. Matrosov, and R.T. Bruintjes, 1996: Hydrometeor identification with elliptical polarization radar: Applications for glaciogenic cloud seeding. *Journal of Weather Modification,* **28,** 6-18.

Sun, J., and N.A. Crook, 1996: Comparison of thermodynamic retrieval by the adjoint method with traditional retrieval methods. *Mon. Wea. Rev.*, **124,** 308-324.

Warner, T.T., 1996: Environmental applications of mesoscale atmospheric models. In *Numerical Simulations in the Environmental and Earth Sciences,* Cambridge University Press, Cambridge, MA.

Unrefereed Publications

Bernstein, B.C., 1996: The stovepipe algorithm: Identifying locations where supercooled large droplets are likely to exist. *Proc. FAA International Conf. on Aircraft Inflight Icing,* Vol. **2,** 353-364.

Bernstein, B.C., 1996: A new technique for identifying locations where supercooled large droplets are likely to exist: The stovepipe algorithm. Preprints, *15th Conf. on Wea. Analysis and Forecasting,* Norfolk, VA, 19-23 August. Amer. Meteor. Soc., Boston, 5-8.

Bernstein, B.C., and M.K. Politovich, 1996: Formation of freezing

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drizzle via shear-enhanced collision-coalescence near cloud base. Preprints, *12th Int'l Conf. on Clouds and Precipitation*. Zurich, 19-23 August. Amer. Meteor. Soc., Boston, 109-112.

Bernstein, B.C., M.K. Politovich, T.A. Omeron, and F. McDonough, 1996: Surface weather features associated with freezing precipitation and in-flight aircraft icing. Preprints, >i> 7th Int'l Workshop on Atmospheric Icing of Structures, Chicoutimi, Quebec, 3-7 June.

Brandes, E.A., 1996: A review of research and development activity related to WSR-88D algorithms. Report prepared for System Technology Associates, Inc., 122pp.

Brown, B.G., 1996: Verification of in-flight icing forecasts: Methods and issues. *Proc. FAA International Conference on Aircraft Inflight Icing,* Vol. II. U.S. Department of Transportation.Federal Aviation Administration, Report No. DOT/FAA/AR-96/81,II, 319-330.

Brown, B.G., 1996: Impacts of incomplete observations on verification methods and results. *Proc. Workshop on the Evaluation of Space Weather Forecasts,* , Boulder, CO, 19-21 June. National Oceanic and Atmospheric Administration, Space Environment Center (Boulder CO).

Brown, B.G., and A.H. Murphy, 1996: Verification of aircraft icing forecasts: The use of standard measures and meteorological covariates. Preprints, *13th Conf. on Probability and Statistics in the Atmospheric Sciences,* San Francisco, 21-23 February. Amer. Meteor. Soc., Boston, 251-252.

Bruintjes, R.T., 1996: Arizona winter storm case 5-6 March 1995. Preprints, *Fourth International Cloud Modeling Workshop,* Clermont-Ferrand, France, 12-16 August.

Bruintjes, R.T., and G. Thompson, 1996: Comparisons between observations and numerical model simulations of the formation of supercooled drizzle drops in stratiform clouds. Preprints, *12th International Conference on Clouds and Precipitation,* Zurich, 12-16 August. Amer. Meteor. Soc., Boston, 85-88.

Cornman, L.B., and K. Goodrich, 1996: Turbulence detection from Doppler radars. Paper AIAA-96-0269, 34th Aerospace Sciences Meeting and Exhibit, Reno, 15-18 January. Amer. Inst. of Aero. and Astro.

Cornman, L.B., 1996: An automated, sensor-based warning system for terrain induced aviation hazards. Paper AIAA-96-0508, 34th Aerospace Sciences Meeting and Exhibit, Reno, 15-18 January. Amer. Inst. of Aero. and Astro.

Cornman, L.B., and R.K. Goodrich, 1996: The detection of atmospheric turbulence using Doppler radars. Preprints, *Workshop on Wind Shear and Wind Shear Alert Systems.* Oklahoma City, 13-15 November. Amer. Meteor. Soc., Boston.

Cornman, L.B., P.A. Robinson and G. Cunning, 1996: Energy-state

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analysis of aircraft flight in atmospheric disturbances. Paper AIAA-96-0505, 34th Aerospace Sciences Meeting and Exhibit, Reno, 15-18 January. Amer. Inst. of Aero. and Astro.

Cornman, L.B., R.K. Goodrich and C.S. Morse, 1996: The detection of wind shear and turbulence using wind profilers. Preprints, *Workshop on Wind Shear Alert Systems*, Oklahoma City, 13-15 November. Amer. Meteor. Soc., Boston.

Cornman, L.B., J. Vivekanandan, and R. Wagoner, 1996: Application of GPS data in automated, hazardous weather detection and forecast systems. National Research Council Workshop on GPS applications. Boulder, CO,

Crook, N.A., 1996: Comparison of convection initiation in an eddy-resolving model and in an eddy-parameterized model. Preprints, *7th Conf. on Mesoscale Processes*, Reading, UK, 9-13 September. 547-549.

Crook, N.A. 1996: Sensitivity of moist convection to low-level thermodynamic fields. Preprints, *18th Conf. on Severe Local Storms }*, San Francisco, 21-23 February. Amer. Meteor. Soc., Boston, 733-736.

Crook, N.A., J.B. Klemp and R. Rotunno, 1996: Depth of lifting at a convergence line. Preprints, *15th Conf. on Wea. Analysis and Forecasting.* Norfolk, VA, 19-23 August. Amer. Meteor. Soc., Boston, 276-279.

Crook, N.A., and Juanzhen Sun, 1996: Single-Doppler velocity retrieval with the GalChen-Liou method and comparison with retrieval by the adjoint method. Preprints, *7th Conf. on Mesoscale Processes,* Reading, UK, 9-13 September. 604-606.

Davis, C.A., K.W. Manning, and X. Zou, 1996: Short-range numerical prediction of mesoscale snow bands using adjoint techniques. Preprints, *7th Conf. on Mesoscale Processes*, Reading, UK, 9-13 September.

Droegemeier, K.K., M. Xue, A. Sathye, K. Brewster, G. Bassett, J. Zhang, Y. Liu, M. Zou, N.A. Crook, V. Wong, R. Carpenter, and C. Mattocks, 1996: Real-time numerical prediction of storm-scale weather during VORTEX95 Goal and Methodology. Preprints, *18th Conf. on Severe Local Storms*, San Francisco, 21-23 February. Amer. Meteor. Meteor. Soc., Boston, 6-10.

Henry, S.G., C. Mueller, and J.W. Wilson, 1996: Base-line statistical evaluation of the automated thunderstorm nowcaster. Preprints, *15th Conf. on Wea. Analysis and Forecasting,* Norfolk, VA, 19-23 August. Amer. Meteor. Soc., Boston, 344-345.

Keenan, T., R. Carbone, S. Rutledge, J. Wilson, G. Holland, and P. May, 1996: The maritime continent thunderstorm experiment (MCTEX): overview and initial results, Preprints, *7th Conf. on Mesoscale Processes,* Reading UK, Amer. Meteor. Soc.

Mueller, C.K., and F. McDonough, 1996: Extrapolation of thunderstorm growth and decay based on storm characteristics and boundary layer

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convergence lines. Preprints, *15th Conf. on Wea. Analysis and Forecasting*, Norfolk, VA, 19-23 August. Amer. Meteor. Soc., Boston.

Neilley, P.P., 1996: Using anemometers to detect and forecast turbulence at Hong Kong's new airport. Preprints, *Workshop on Wind Shear and Wind Shear Alert Systems*, Oklahoma City, 13-15 November. Amer. Meteor. Soc., Boston.

Politovich, M.K., 1996: Forecasting large droplet icing: A weather briefing. *Proc. FAA Int'l Conf. on In-Flight Icing, Volume I: Plenary Sessions}*. Springfield, VA, 6-8 May. 109-114.

Politovich, M.K., B.G. Brown, G. Thompson, R. Bruintjes, and B.C. Brown, 1996: Toward improved aviation forecast for icing. 34th Aerospace Science Meeting and Exhibit, Reno, NV, 15-18 January. American Institute of Aeronautics and Astronautics, Washington, D.C.

Politovich, M.K., and G. Thompson, 1996: A meteorologically-based icing severity index. *Proc. FAA Int'l Conf. on In-Flight Icing, Volume II: Working Group Papers.* Springfield, VA, 6-8 May. 375-385.

Roberts, R.D., 1996: Integration of WSR-88D and GOES-8 data for detecting and forecasting storm initiation. Preprints, *15th Conf. on Wea. Analysis and Forecasting*, Norfolk, VA, 19-23 August. Amer. Meteor. Soc., Boston, 287-290.

Sun, J., and N.A. Crook, 1996: Retrieval of the dynamical and microphysical variables in observed Florida convective storms using a cloud model and its adjoint. Preprints, *18th Conf. on Severe Local Storms*, San Francisco, 21-23 February. Amer. Meteor. Soc., Boston, 555-558.

Thompson, G., R. Bruintjes, and J.F. Bresch, 1996: Comparison of numerical model simulations and satellite observations of an upslope cloud system. Preprints, *12th Int't Conf. on Clouds and Precip.*, Zurich, 19-23 August. Amer. Meteor. Soc., Boston, 892-894.

Wilson, J.W., and D.L. Megenhardt, 1996: Thunderstorm initiation, organization and lifetime associated with convergence lines. Preprints, *15th Conf. on Wea. Analysis and Forecasting*, Norfolk, VA, 19-23 August. Amer. Meteor. Soc., Boston, 451-454.

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Community Service

Editorships of Peer Reviewed Journals

Teddie Keller, Associate Editor for the *Journal of Atmospheric Sciences,* 1996.

Marcia Politovich, Associate Editor, *J. Applied Meteorology*, 1996.

Committees/Advisory Boards

Tenny Lindholm, organized and led a turbulence workshop in February which included about 110 participants from all corners of the aviation industry, national and international.

Martha Limber, was a member of a panel for a career workshop for the CU-Boulder Mathematics Department.

Awards

Barbara Brown, the American Statistical Association Chapter Service Recognition Award.

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Staff, Visitors and Collaborators

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Dave Atlas; NASA/Goddard Space Flight Center; Applied Science Group

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