CIRA ANNUAL REPORT FY 01/02

COOPERATIVE INSTITUTE FOR RESEARCH IN THE ATMOSPHERE

Cover Photo (Marilyn Watson): CIRA Building, west view, CSU Foothills Campus

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Introduction

This report describes research funded in collaboration with NOAA's cooperative agreement and the CIRA Joint Institute concept for the period July 1, 2001 through June 30, 2002. In addition, we also included non-NOAA-funded research (for example, DoD-funded Geosciences, NASA-funded CloudSat and National Park Service Air Quality Research Division activities) to allow the reader a more complete understanding of CIRA's research context. These research activities are synergistic with the infrastructure and intellectual talent produced & used by both sides of the funded activities.

The research descriptions are designed to give the reader an overview of research topics with the details available in the Scientific Publication section. In the Scientific Publication section, we provide publication information from the beginning of the project which is often multi-year.

For further information on CIRA, please contact our web site:

http://www.cira.colostate.edu/

CIRA HIGHLIGHTS
July 1, 2001 – June 30, 2002

Atmospheric Model Evaluation

- In April of 2002, a 20km, 50-level version of the RUC was integrated into operation at NCEP. This new RUC version (RUC-20) incorporates a variety of new data sources, including GPS cloud-top pressure, precipitable water, boundary-layer profilers and RASS. The physics package used in the forecast engine was also significantly enhanced to improve convective parameterization and cloud microphysics. The existing soil model was enhanced to include a 2-layer snow model and high-resolution land-use/soil type and topography data.

- An optimized configuration of the LAPS hot-start forecast system, coupled with the non-hydrostatic MM5 forecast model, was developed and tested. The configuration utilizes a triple-nested domain, with the domains having a grid spacing of 10 km, 3.3 km, and 1.1 km. This configuration has been installed on a Linux cluster coupled to the local data assimilation and forecast system at the western space launch range located at Vandenberg AFB, CA. A similar configuration is being tested for the eastern range (Kennedy Space Center).

- The WRF Standard Initialization package was significantly enhanced to better process various datasets required for the initialization of the WRF land surface packages. New, modular horizontal interpolation routines were added as library functions to better interpolate these types of fields, which must be handled differently based on the model's representation of land or water surface types. Additionally, significant effort was put forth to accommodate the latest version of the WRF mass-based vertical coordinate using the Runge-Kutta dynamic core.

- Real-time runs of the WRF model using the LAPS diabatic initialization were set up on the FSL high-performance computing system for the IHOP campaign, and CIRA scientists will be analyzing these forecasts in follow-on research collaborations related to IHOP and WRF development.

- Development of an operational ensemble forecast system, including several diverse regional forecast models such as NCEP’s Eta and RSM, FSL’s RUC, and NSSL’s MM5, began this past year. The resultant ensemble forecast products are expected to improve the overall model prediction.

Cloud Physics

- Stratus cloud drizzle retrieval using the first three moments of the Doppler spectra to obtain drizzle properties from a 3-parameter log-normal model of the drizzle droplet distribution was initiated. Measurement data from the FIRE Artic Clouds Experiments, the North Slope of Alaska cloud radar, and a cloud radar on the NOAA research vessel Ron Brown will provide the Doppler spectra.

- Some earlier non-drizzle results have been published in refereed journals. One showed the results of comparisons between in-situ FSSP measurements and radar retirevals of stratus cloud effective radius. Another article was from retrievals of stratus cloud properties determined during SHEBA. A third article involving radar observations of clouds has been submitted to a refereed journal.

CloudSat

- CloudSat is a NASA ESSP mission scheduled for launch in April 2004. The mission includes two significant features: A cloud imaging 94GHz radar, and a formation flying aspect unlike other satellite missions.

- CIRA was selected as the Data Processing Center for CloudSat in 2000. As the DPC for CloudSat, CIRA will be responsible for creating all of the standard products as defined by NASA and the Principal Investigator, Professor Graeme Stephens. In addition, the DPC is responsible for the dissemination of CloudSat data to the PI, Science Teams, and the general science community. In effect, the DPC acts as a NASA DAAC for the duration of the mission (2 years) and, only after the mission is completed, will the data be transferred to the Langley DAAC for archive and subsequent dissemination.

- The last years activities include:

    1. Successfully passed the Critical Design Review
    2. Implementation of development software unique to CIRA and recognized by NASA as highly innovative
    3. Reintroduction of the Calipso data stream. This means CloudSat is the only satellite mission whose core products require another satellite.

Earthstation & Infrastructure

- The CIRA Infrastructure grew by 15% overall. Many systems were upgraded to Pentium 4 technology with additional memory and hard drive space. An additional local area network subnet was added to accommodate the growth. A new 1TB mass storage was brought online for general research. The modeling cluster was expanded to 24 Pentium-4 nodes. CIRA's local network was upgraded as necessary and a firewall was added for additional security. CIRA's storage archive continues to be a reliable source now using both DLT tapes and DVD disks.

- The CIRA satellite earthstation continued to provide global coverage ingesting and archiving over 60GB/day. CIRA also acted as the primary collection site for NOAA's GOES-11 science test.

Educational Outreach

- The GLOBE program initiated in 1995 achieved several major milestones in 2002. The Program has now expanded to over 12,000 schools in 98 partner countries, with 20,000 teachers having attended GLOBE workshops and GLOBE students having reported data from 8 million measurements worldwide. Science protocols have also expanded to now include Atmosphere/Climate, Hydrology, Soil, Land Cover/Biology, Phenology, as well as several special observations such as hummingbird behavior, budburst, and lilac phenology.

- Performance of the FX-Net system during the 2002 Winter Olympics in Salt Lake City was a resounding success. Application of this system in support of fire weather prediction is being explored.

Mesoscale Studies

- In a collaborative effort with RPN and UCLA to ascertain the appropriate large-scale forcing that should be included in the hyperbolic system, the relative contributions of the various physical parameterizations included in a typical operational weather prediction model to the large-scale forecast accuracy were determined. In agreement with the theory of the periodic updating of hyperbolic systems with multiple timescales, the periodic insertion of wind data alone provides mid-latitude initial conditions for the winds essentially identical to those of the operational assimilation system. Results from the collaborative manuscript (Gravel et al., 2002) were presented at the Canadian CMOS meeting in May.

- A well-posed, open boundary multiscale ocean model is being developed for ONR. A simple and computationally efficient model has been developed to demonstrate the accuracy and stability of the open boundary treatment. Preliminary results from this model have shown the feasibility of this approach. Theoretical work on a remaining issue in multiscale atmospheric dynamics will be conducted. The feasibility of accurate and stable open boundary conditions for a model based on the well-posed reduced system for oceanography will be completed during the coming year.

- Collaborative research on the improvement and testing of the QNH mesoscale model continued this past year. Comparative studies were conducted between the parallelized and serial versions of the QNH model. Additional sensitivity studies were conducted with the 10km version of the model, primarily involving QPF predictions. Effort began to produce daily runs of a 10km version of the mass-coordinate WRF model. The height-coordinate WRF model will be modified using a stretch coordinate.

- GPS tomography package to handle the GPS operational data set available at Japan Tsukuba dense GPS network was prepared. Compared with the software developed at the Japan MRI, the numerical results obtained from the FSL-developed tomography package were acceptable. Based upon the discussions at the Kyoto GPS workshop, FSL, MRI, and the University of Kyoto formed a collaboration to conduct future GPS tomography research on theoretical and operational experiments.

- Manuscript entitled "Impact of Formulation of Cost Function and Constraints on Three-Dimensional Variational Data Assimilation" (Xie et al., 2002) now in print for the Monthly Weather Review appears to contradict several operational 3DVAR implementations. Intent is to develop a new 3DVAR system based upon this theory. This system, which differs from the WRF 3DVAR in many respects, could be used as a research tool for comparing current 3DVAR analysis techniques.

Technology Transfer

- The WFO-Advanced forecast system was originally implemented on Hewlett Packard (HP) hardware, using the Hewlett Packard Unix (HPUX) operating system. The Linux operating system has been identified as an attractive replacement for HPUX; research and testing effort was initiated to determine the optimum transition from HPUX to Linux.

- Collaboration continued on the web dissemination component of LDAD known as the Internet-based Emergency Management Decision Support (EMDS) system. It is a web-based applet/application for use by a small number of state and local government users and/or a large number of public Internet users. The EMDS disseminates all types of weather data, including high-resolution weather analysis/forecast/model grids, radial radar grids, observations, quality control information and textual forecasts in a multi-modal GUI to a variety of users. It also allows the local and state government agencies to integrate weather information from the National Weather Service with their GIS data sets to create a personalized Decision Support System. The full deployment of EMDS at all WFOs was a major accomplishment for the year.

- The PACE effort comprised of two separate investigative projects—the FX-Connect and the TMU projects—is examining innovative software and data products to help minimize adverse weather disruptions to air traffic operations over the US. Aviation data sets and forecast products specifically tailored for the ARTCC air traffic weather forecasting environment are being prototyped, along with investigation into the utilization of collaborative weather forecasting techniques.

- Development continued on a directive-based model parallelization software suite called the Scalable Modeling System (SMS) that is used in the parallelization of weather and ocean models. The SMS parallel version of the Regional Ocean Modeling System at PMEL is being used to examine inter-annual to decadal variability in circulation and hydrography in the Coastal Gulf of Alaska region. One version of the SMS-parallelized Princeton Ocean Model is being used by NASA/Goddard to investigate century-scale variability in the North Atlantic and Arctic Oceans.

- Capabilities of different satellite sensors (DMSP, MODIS, AVHRR) in detecting fires were evaluated. A prototype application for a website posting daily maps of fire detections on a regional basis (S.E. Asia) by multiple sensors was developed. A particle dispersion model developed by NOAA (HYSPLIT) is incorporated into the website mapping, along with weather forecast data, to predict the trajectory and concentration of smoke from the fires. Analysis of aerial photography for calibration of DMSP nighttime lights data was also conducted, and images were produced for estimating percentage of development in the U.S. and the resulting effects on carbon cycling.

RESEARCH DESCRIPTIONS

DMSP Data Processing and Analysis

Principal Coordinator: John Dietz

In collaboration with the Solar-Terrestrial Physics Division at the National Geophysical Data Center (NGDC), several collaborative projects involving DMSP imagery, Geographical Information Systems (GIS) and other specialized remote sensing data manipulation and mapping techniques continued.

1. For an ongoing project of evaluating capabilities of different sensors (DMSP, MODIS, AVHRR) in detecting fires, Landsat 7 data was used as a calibration tool. By classifying and mapping burn scar using a short time series of Landsat data in Thailand, the relative accuracies of the different satellites are being compared.

2. A prototype application for a website posting daily maps of fire detections on a regional basis (S.E. Asia) by multiple sensors was developed. A particle dispersion model developed by NOAA (HYSPLIT) is incorporated into the website mapping, along with weather forecast data, to predict the trajectory and concentration of smoke from the fires. It is hoped that the website capabilities will be transferred and hosted at the weather service in Singapore. Figure 1 provides an example page from the website for fire monitoring and smoke prediction.

Figure 1. Sample of the website for fire monitoring and smoke prediction.

3. Collaboration on a project using analysis of aerial photography for calibration of DMSP nighttime lights data, resulting in images estimating percentage of development in the U.S., and the resulting effects on carbon cycling. See Figure 2.

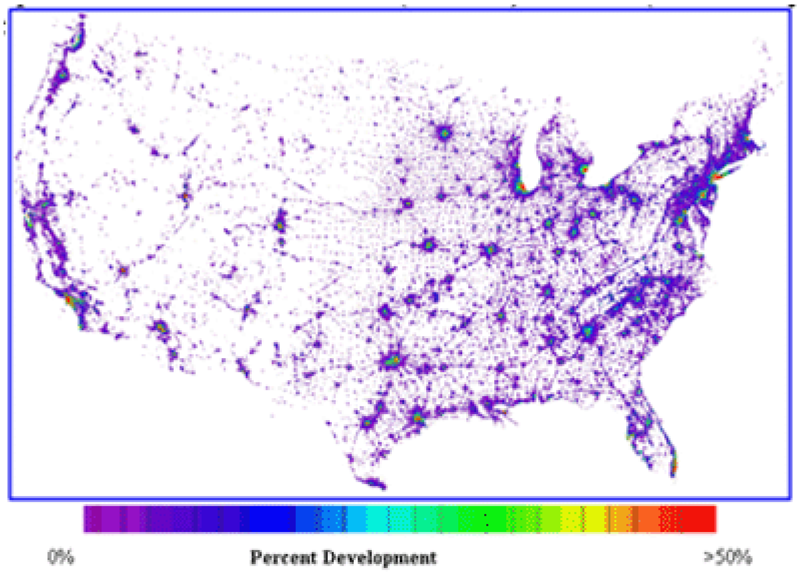

Figure 2. Estimate of percentage of development for the U.S. derived from DMSP radiance-calibrated night-time lights data and population-density data.

EAR—Developing a Mesoscale Observing Network over the North American Continent and Adjacent Ocean Areas to Support the Next Generation Numerical Weather Prediction Models

Principal Coordinator: John Cunning

Aircraft-Provided Weather Data - ACARS/MDCRS

Background: Many of today's modern commercial aircraft have the capability of providing weather (winds and temperature) data. The primary objective of this program is to expand this coverage over the United States, over North America, and over the globe. At the current time, six major airlines within the United States provide approximately 130,000 reports of winds and temperature every day, which is an increase of approximately 50% from last year. Over the globe, approximately 175,000 reports collected every day, which amounts to an increase of about 40% from last year.

Key Activities and Accomplishments:

- Working with the Canada AES, a MDCRS-type program called AMDAR was developed over Canada. First data from this program began early this July.

- Continued collaborations with the European community to develop the program over Europe. This program has expanded about 30% from last year.

- Working with several regional carriers to have them join the program. In particular, Atlantic Coast Airlines has been urged to participate in the New England Temperature and Air Quality Forecasting Experiment (see below).

The North American Atmospheric Observing System (NAOS) Program

Background: The North American Atmospheric Observing System Program has the key focus of developing the supporting materials to develop a mesoscale observing network over the North American continent and adjacent ocean areas to support the next generation numerical weather prediction models and forecaster requirements. This is accomplished primarily through numerical data sensitivity or data denial experiments, or through observing system simulation experiments.

Key Activities and Accomplishments:
This past year has been transition year for the NAOS Program. Efforts continue to redefine the goals and objectives of NAOS to fit within the US Weather Research Program. This has culminated in several planning and implementation documents. Decision is expected shortly on how best to proceed with the objectives of this Program.

The New England Temperature and Air Quality Forecasting Experiment

Background: The New England Temperature and Air Quality Forecasting Experiment is a new program started this year through special funding from Congress. The goals of this program are to:

- quantify the improvements in the forecasting of temperature and air quality in the New England region that result from new and augmented observations and modeling.

- assess the benefits of the resulting better predictive capabilities for the energy sector as a primary customer.

- provide a pathway to operational high resolution temperature and air quality forecasting.

Key Activities and Accomplishments:
As the Field Project Director in charge of the supplemental and special observations in support of the field phase of the program that began July 15, and will end on September 1, 2002:

- pursued obtaining supplemental aircraft observations from the airlines currently participating in the MDCRS Program.

- coordinating with Atlantic Coast Airlines to have them provide MDCRS observations for the field phase planned for FY 2004.

EAR—Multiscale Theory and Model Development

Principal Investigator: Gerald Browning

Traditionally, it has been assumed that the majority of the atmospheric energy is contained in balanced large-scale motions. Under the hypothesis that the period of time before the energy in small-scale storms has a significant impact on the total atmospheric energy is longer than the timescale for balanced large-scale atmospheric motions, the forced hyperbolic system that the latter flow should satisfy has been derived (Browning and Kreiss, 2002). In a collaborative effort with RPN and UCLA to ascertain the appropriate large-scale forcing that should be included in the hyperbolic system, the relative contributions of the various physical parameterizations included in a typical operational weather prediction model to the large-scale forecast accuracy have been determined. When a simple boundary layer drag is used as the sole physical parameterization, the short-term, large-scale forecast accuracy is comparable to that of an operational model. In order to determine the most efficient method to obtain initial conditions for the hyperbolic system from the current sparse observational network, the relative contributions of various observational data sources to the operational data assimilation process have also been determined. In agreement with the theory of the periodic updating of hyperbolic systems with multiple timescales, the periodic insertion of wind data alone provides mid-latitude initial conditions for the winds essentially identical to those of the operational assimilation system. Results from the collaborative manuscript (Gravel et al., 2002) were presented at the Canadian CMOS meeting in May.

EAR—GPS Water Vapor Analysis

Principal Researcher: Yuanfu Xie

This research effort over the past 2 years has increasingly been recognized by the scientific community as an early pioneering work in GPS tomography. Dr. Xie was invited by the Japanese Science Promotion Society (JSPS) to visit Japan for 3 weeks and to participate in a GPS workshop at the University of Kyoto through a research fellowship. During the visit, presentations were given not only on GPS tomography, but on some 3DVAR and 4DVAR analysis results to the Japan Meteorology Research Institute (MRI) in Tsukuba, Japan and the Numerical Prediction Division (NPD), Japan Meteorology Agency in Tokyo. Discussions on a wide range of numerical weather prediction topics were also held with meteorologists at these institutes. Before and during the visit, the GPS tomography package to handle the GPS operational data set available at Japan Tsukuba dense GPS network was prepared. Compared with the software developed at MRI, all of the participants were satisfied with the numerical results obtained from the CIRA/FSL tomography package. Based upon the discussions at the Kyoto GPS workshop, FSL/CIRA, MRI, and the University of Kyoto formed a collaboration to conduct future GPS tomography research on theoretical and operational experiments.

EAR—Three-Dimensional Variational Data Assimilation (3DVAR)

Principal Researcher: Yuanfu Xie

Theoretical analysis of 3DVAR solutions over the past several years has resulted in a series of discussions within FSL and with scientists from various external institutes. Our analysis appears to contradict several operational 3DVAR implementations. Following many rounds of discussions concerning the discrepancies with scientists and journal reviewers, the manuscript entitled "Impact of Formulation of Cost Function and Constraints on Three-Dimensional Variational Data Assimilation" by Xie, Y., C. Lu, and G. Browning is now in print for the Monthly Weather Review.

The intent is to develop a new 3DVAR system based upon our theory of 3DVAR at FSL. This system could be a research and forecast tool for comparing current 3DVAR analysis techniques at FSL. It differs from WRF 3DVAR in many respects. A few experiments with the NCAR 3DVAR (a preliminary version of WRF 3DVAR) that was installed at FSL have uncovered the following findings:

1. The control variables of NCAR 3DVAR could be reconfigured using the new system;

2. Uniform spacing weights of the NCAR 3DVAR could be modified, which could minimize a lot of necessary computing time to fix using the ensemble techniques;

3. The NCAR 3DVAR could be modified so that it becomes more efficient; there are many quantities that can be computed in the pre-processes phase;

4. There are some assumptions on boundary conditions made in the NCAR 3DVAR that are not physical and will be afforded new treatment in the new system.

Several basic packages have been developed thus far using Fortran 90.

EAR—A New Global Forecasting Model

Principal Researcher: Yuanfu Xie

Collaborations will begin on a new global numerical forecast model proposed for development by FSL. This innovative new model will be an extremely efficient forecast model based upon finite difference schemes over a so-called "Icosahedron grid". Since this will the first of its kind, participation in its development has begun with its basic design. Initially proposed as a simple second order scheme based upon a great circle on a sphere, with the WRF models approaching higher accuracy scheme, e.g., 5^{th} or 6^{th} order, consideration has been given to designing some higher order finite difference schemes over the icosahedron grid. For the higher order schemes, the partial derivatives of the model variables at grid points must be evaluated. I proposed a direct finite difference scheme which can use 15 neighbors of a given grid point to evaluate the model variables as long as its derivatives. This scheme avoids extra interpolation computations for computing the derivatives and it could be implemented on a massively parallel processing system extremely efficiently following Dr. MacDonald's incoherent memory access expectation. This new idea is under testing now.

EAR—Mesoscale Modeling Research

Principal Researcher: Chungu Lu

Major task this past year has been the focus on the Short-Range Ensemble Forecast project. The goal of this project is to develop an operational ensemble forecast system, which includes several diverse regional forecast models. The resultant ensemble forecast products are expected to improve the overall model prediction. The proposed models to join this ensemble forecast system are NCEP's Eta and RSM, FSL's RUC, and NSSL's MM5. Each model will provide five forecast members. Thus far, the setup of the RUC ensemble forecast system has been completed, including an interpolation package (Hybext), a pre-processing package (Hybpre), the RUC forecast model (Hybcst), and a post-processing package (Hybpost).

A second task involves activities on a Clear Air Turbulence project, including the analysis of a set of high-resolution-model output data to identify the characteristics of gravity waves and turbulence.

Most recently, a new task involves the integration of the WRFRUC forecast system for the TAQ project. The WRFRUC forecast system is comprised of a WRFRUC pre-processing package that is a modified version of the WRFSI, the WRF forecast model, and a WRFRUC post-processing package. Project has progressed well and the system is running operationally to support the TAQ project.

EAR—Quasi-Nonhydrostatic (QNH) and WRF Model Development

Principal Researchers: Mariusz Pagowski and Ming Ge

Collaborative research on the improvement and testing of the QNH mesoscale model continued this past year. Comparative studies were conducted between the parallelized and serial versions of the QNH model. Additional sensitivity studies were conducted with the 10km version of the model, primarily involving QPF predictions. Efforts are being directed to the improvement of initial moisture fields, the development of a high-resolution PBL coupling subroutine, and increased model resolutions-both in the horizontal and in the vertical. Work will continue on improving the cloud microphysical processes and investigations into higher resolution surface energy budgets. Efforts were begun on producing daily runs of a 10km version of the mass-coordinate WRF model. The height-coordinate WRF model will be modified using a stretch coordinate. WRF preprocessing function will be adapted to use Eta data. Other WRF functions will be adapted to make them similar to the processes used in the QNH model. The QNH post processing function will be modified and adapted for the WRF model. Comparative studies will then be conducted between the QNH and WRF models.

In the area of data assimilation, issues related to 3-D and 4-D variational data analysis will continue to be investigated. The use of GPS slant path water vapor analyses in a 3DVAR system will continue to be evaluated.

EAR—The PACE Project

Principal Researchers: Jim Frimel, Young Chun, and Lisa Gifford

<u>The Center Weather Service Unit (CWSU) Prototyping and Aviation Collaboration Effort (PACE)</u>

PACE is an operational test area located within the Fort Worth Air Route Traffic Control Center's CWSU for developing innovative science and software technology used to directly provide weather support for the ARTCC Traffic Management Unit (TMU). A major goal of PACE is to investigate aviation data sets and forecast products specifically tailored for the ARTCC air traffic weather forecasting environment among operational weather forecasting facilities, and to investigate the utilization of collaborative weather forecasting.

The PACE effort is currently comprised of two separate investigative projects—the FX-Connect Project and the TMU Project. The PACE effort examines innovative software and data products to help minimize adverse weather disruptions to air traffic operations within the National Airspace System (NAS). The FXC Project analyzes and applies software used in the PACE facility to demonstrate potential collaboration and prototyping of aviation specific data products. The TMU Project is the web-based application of products available directly to the air traffic controllers for their evaluation via the Internet. There are currently three separate facilities participating in this exercise—the Aviation Weather Center in Kansas City, the Fort Worth CWSU, and the Houston CWSU.

The FX-Connect software (FXC), developed at FSL, is a major component of the FXC Project. FXC is a software application tailored for use in the PACE facility. The major system used to acquire, distribute, create and provide the required data sets for the FXC and TMU Projects is the AWIPS Linux data ingest system. The Aviation Weather Center is where the AWIPS Linux component of the system is located in addition to the FXC Server/Client. The CWSUs are where the FXC Clients are located. The FXC system allows for the remote access and display of AWIPS data sets over the Internet, a collaboration capability among participants at physically different locations, and the ability to utilize tools to aid in discussing forecasts. The TMU Project is comprised of an AWIPS Linux data ingest system and Web Servers specifically developed for the creation of web-based products. The TMU Project web site and data ingest is housed at the Forecast Systems Lab.

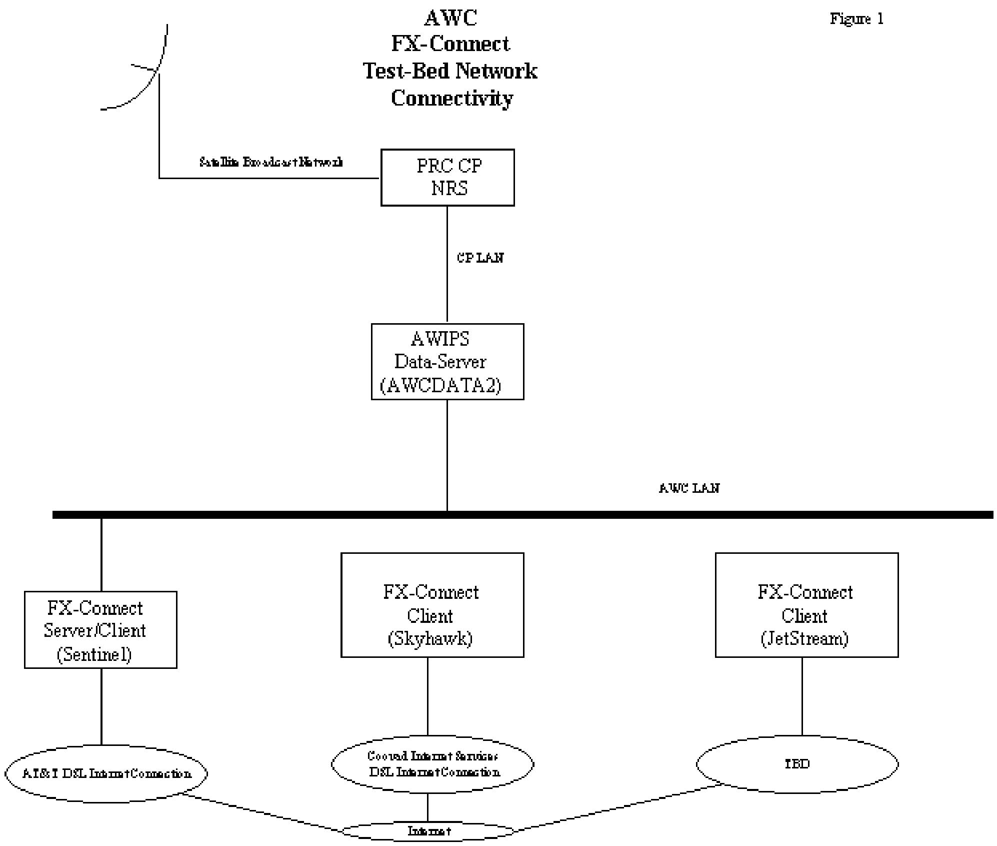

Figure 1 provides a functional systems overview of the FX Connect system.

CIRA researchers have focused on three major areas of research and development related to the PACE project. These areas encompass the software development infrastructure, advanced product displays and visualization, and the World Wide Web and Internet.

A full software development, integration, and testing environment for the FXC and TMU projects have been implemented. New Linux development systems were deployed to all research team members utilizing the localdev software development environment. Transition to this new development platform has allowed for more efficient and coordinated software development.

Efforts related to advanced product displays, visualization and the WWW have involved the development of prototype Convective Hazards product displays for the forecaster within the CWSU and the Air Route Traffic Controllers within the TMU. The Convective Hazards product display consists of data sets developed by the Convective Product Development Team and other aviation related data sets, as well as other relevant information. This can include data, map information, and scales as it relates to requirements and feedback learned by CIRA researchers from the FXC and TMU projects. Currently, the data products consist of the National Convective Weather Forecast (NCWF), National Convective Weather Detection (NCWD), and Convective SIGMETs. Additional experimental data sets included in development process are:

RSAS, RADAR, Convective Icing Product (CIP), and the Convective Collaborative Forecast Product (CCFP). Also, aviation-related maps and the new ARTCC and TRACON scales have been developed and are being researched for their utility.

CIRA researchers have created a framework to research advanced product displays and software for both the FXC and the TMU projects. The development of the TMU Content Generator and restricted website has also been accomplished. Figures 2 - 4 provide examples of products available on the TMU website. This consists of a highly responsive TMU content generator running a WFO-Advance software and dual fail-over web servers privately networked for maximum scalability and efficiency. The creation of this site provides a mechanism for access to the Convective Hazards products from TMU air traffic controllers. Additional development has included modifications to the image creation software for automatically generating prototype Convective Hazards products for the TMU restricted Web Site. These prototype product displays are available to the CWSU forecaster via the FXC software and the to the air traffic controllers via the TMU restricted web site.

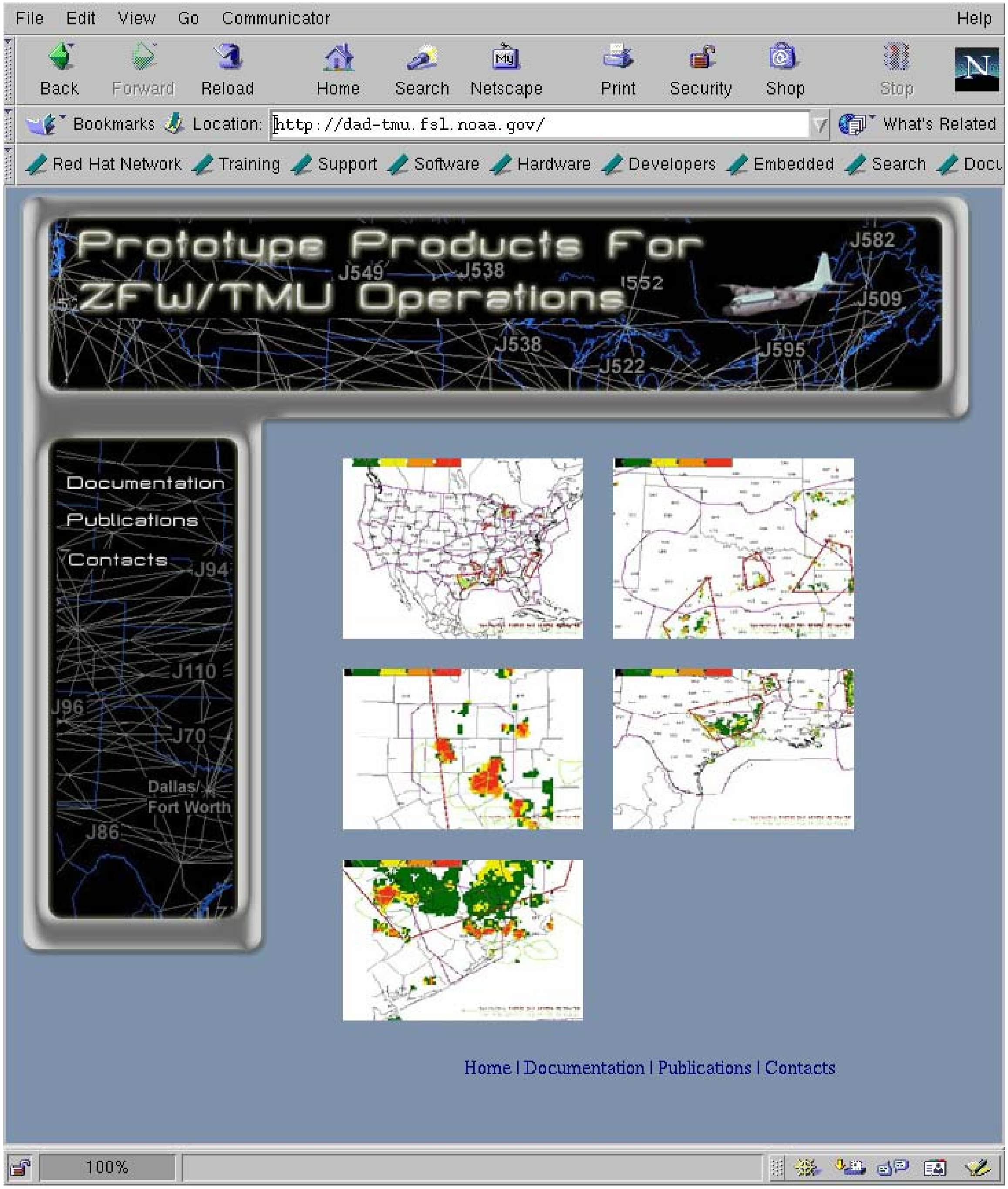

Figure 2. An example view of the TMU Home Page.

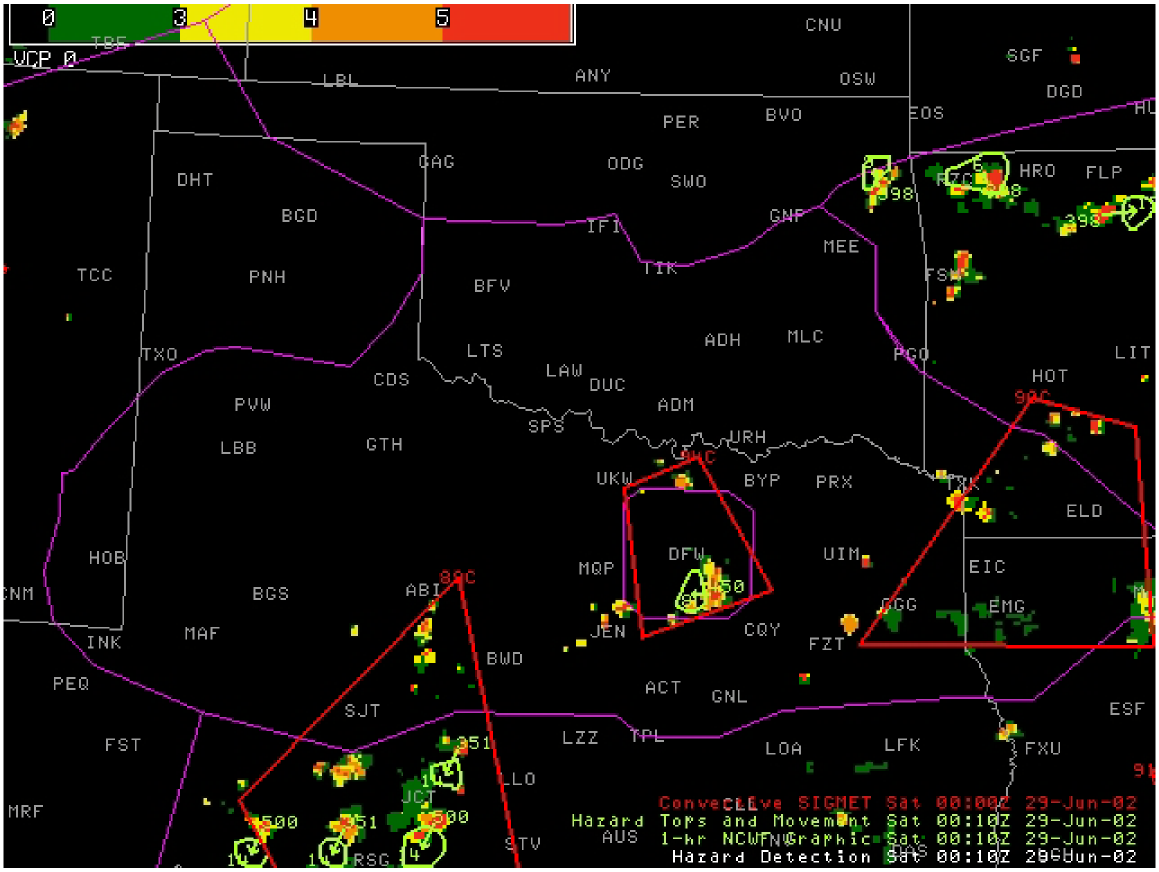

Figure 3. An example view of the TMU ZFW Tracon Scale with Convective Hazards.

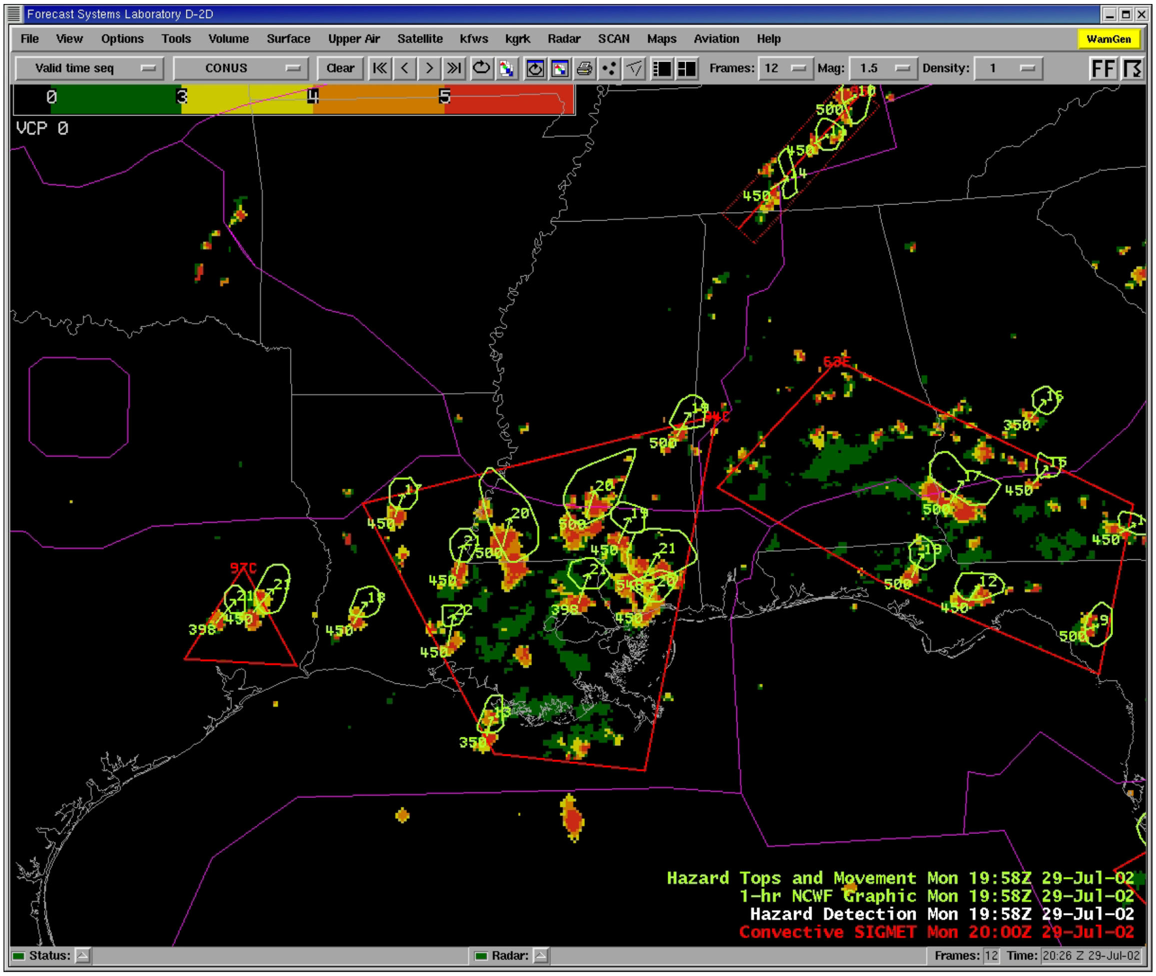

Figure 4. An example of a Convective Hazards product.

EAR—Development of a Directive-Based Parallelization Tool for Numerical Weather Prediction (NWP) Models

Principal Researchers: Dan Schaffer and Jacques Middlecoff

Development has continued on a directive-based model parallelization software suite called the Scalable Modeling System (SMS) that is used in the parallelization of weather and ocean models. The approach is to provide the modeler with a set of simple, general directives that can be added to the code. These directives (FORTRAN comments) are then translated by SMS to generate new or modified code, which allows the model to run correctly on an arbitrary number of processors. This code includes calls to SMS library routines that implement the communication necessary to run the model on parallel machines.

This year, SMS has been used to parallelize the following models:

1. The Regional Ocean Modeling System. This is a world-wide community model that is used, in particular, by Dr. Al Hermann at PMEL. The SMS parallel version of ROMS is being used to examine inter-annual to decadal variability in circulation and hydrography in the Coastal Gulf of Alaska region. SMS parallel ROMS is also now being used by half a dozen researchers around the world.

2. Two versions of the Princeton Ocean Model—one used by the Environmental Technology Laboratory in Boulder and the other used by Dr. Sirpa Hakkinen at NASA. She is investigating century-scale variability in the North Atlantic and Arctic Oceans.

3. Two assimilation systems in the Local Analysis and Prediction System (LAPS) at FSL—one assimilates wind observations; the other moisture observations.

4. An air chemistry model used by Dr. Stuart McKeen of the Aeronomy Laboratory in Boulder to study air quality and stratospheric ozone transport.

5. The Hybrid Coordinate Ocean Model (HYCOM) used by scientists at Los Alamos National Laboratory.

6. The Typhoon Forecast System used by scientists at the Central Weather Bureau of Taiwan.

A paper on SMS entitled "The Scalable Modeling System: Directive-based code parallelization for distributed and shared memory computers" has been submitted to *Parallel Computing* in July 2002. Effort on a follow-on paper dealing with performance aspects of SMS has begun.

Refer to the following Web site for additional information on SMS:
http://www-ad.fsl.noaa.gov/ac/ac.html

Development has continued on the I/O interface for the Weather Research and Forecast (WRF) project. WRF is a multi-institutional effort to develop an advanced mesoscale forecast and data assimilation system that is accurate, efficient, and scalable across a range of scales and over a host of computer platforms. The first release, WRF 1.0, was November 30, 2000, with operational deployment targeted for the 2004-05 time frame.

EAR-Outreach and Technology Transfer

Principal Coordinator: Sher Wagoner

This program seeks to develop research collaborations with scientists to solve operational weather problems and to create partnerships to assist in applying potential solutions. Additionally, industry partners are sought to join these collaborative efforts.

One example of research collaboration involves the development of a Standard Initialization scheme for the new community WRF (Weather Research and Forecast) model. Another effort is the design and development of meteorological algorithms and system architectures into operational systems at the space launch facilities at Vandenberg AFB and Cape Canaveral.

Data sets from the GPS-Met program are being made available to National Weather Service forecasters and Science Operations Officers. Two presentations and many individual meetings with the SOO's were conducted during the year to familiarize them with the data and their real-time and retrospective uses.

Presentations of the GPS-Met program were also given to representatives from the following organizations: National Data Buoy Center, NWS Eastern Region SOOs, Johnson Space Center, 45th Weather Squadron at Patrick AFB, GPS Control Center – Schriever AFB, SBIRS-Low Air Force program coordinators and NOAA's Space Environment Center.

As a member of FSL's Global Universal Profiling System (GUPS) research and development team, activities for the coming year will focus on educating the DOD and industry on the purpose and benefits of the proposed system in addressing the global climate change issue. Potential program development collaborations with these groups will be pursued.

Discussions on collaborative efforts in the investigation of expanded meteorological databases and data visualization in support of global meteorological delivery systems were also initiated. Potential activities to study the use of selected algorithms from the web-based Aviation Digital Data Service for operational DoD applications were also discussed.

An evaluation strategy for the web-based Real Time Verification System was developed. Testing includes web-design and usage as well as data display validation. This is an ongoing activity.

Technology transfer and program development activities will include an increased effort to develop new collaborations with the private sector and other government agencies utilizing mature technologies developed by FSL and CIRA. Included in this effort will be the seeking of additional venues for systems demonstrations and technical presentations.

EAR—Regional Analysis and Prediction (RAP)

Principal Researchers: Kevin Brundage and Tracy Smith

The primary focus of the RAP group is research and development of the Rapid Update Cycle (RUC), an hourly 4-dimensional data assimilation and numerical forecast model system. The RUC runs operationally at the National Center for Environmental Prediction (NCEP). CIRA researchers at FSL have been integral in this development.

In April of 2002, the RAP team integrated a 20km, 50-level version of the RUC. This new RUC version (RUC-20) incorporates a variety of new data sources, including GOES cloud-top pressure, precipitable water, boundary-layer profilers and RASS. The physics package used in the forecast engine was also significantly enhanced to improve convective parameterization and cloud microphysics. The existing soil model was enhanced to include a 2-layer snow model and high-resolution land-use/soil type and topography data.

CIRA scientists are currently principal investigators for the RAP team's participation in the New England Forecasting Pilot Program known as the Temperature and Air Quality (TAQ) Program, and a joint collaboration with the National Renewable Energy Laboratory (NREL) studying forecast methods to improve low-level wind prediction for wind energy production. The TAQ project incorporates a number of special observations, including boundary-layer profilers, GPS precipitable water, radar reflectivity and Mesonet observations into a nested (10-km nest) model running out to 48 hours 4 times per day. The NREL wind study uses model ensembles to estimate the probabilities and certainties associated with low-level wind forecasts to provide confidence levels in predicting wind-energy power generation.

The World Wide Web continues to be an important mechanism in MAPS/RUC development. The MAPS/RUC web pages now include a variety of plots derived from RUC20, RUC-2 backup and experimental 10km RUC-TAQ. These web products provide a convenient method for scientists at FSL, as well as forecasters in the field, to quickly compare the effect of various model changes.

For further information regarding MAPS and RUC-2, as well as a variety of real-time weather graphics and publications, see http://ruc.fsl.noaa.gov

EAR—Local Analysis and Prediction (LAP)

Range Standardization and Augmentation (RSA) Project

Participating CIRA Scientists: Brent Shaw and Steve Albers

An optimized configuration of the LAPS hot-start forecast system, coupled with the non-hydrostatic MM5 forecast model, was developed and tested. The configuration utilizes a triple-nested domain, with the domains having grid spacings of 10 km, 3.3 km, and 1.1 km. This configuration has been installed at the western space launch range located at Vandenberg AFB, CA by Lockheed-Martin Mission System and has been running on a Linux cluster in real-time since December 2001. The system produces hourly analyses on each of the three grids, as well as a 0-24 h forecast on the 10-km grid, 0-12 h forecast on the 3.3 km grid, and a 0-9 h forecast on the 1.1 km grid. The forecast model produces new forecasts every six hours, and all analyses and forecast grids are displayable on the local AWIPS system. This marks the first operational implementation of a Linux-based AWIPS system with a coupled local data assimilation and forecast system in a local forecast office environment. A similar configuration is being tested for the eastern range (Kennedy Space Center) by CIRA researchers and will be installed by Lockheed-Martin in mid-2002. The initial basic capability provides a system that ingests local narrowband WSR-88D reflectivity data, GOES imagery, surface observations, and national model grids via the NOAAPORT feed provided at the site.

Preparation for enhancements to the RSA modeling system was begun, including investigation of the sounding and profiler ingest programs to accept RSA datasets, such as RTAMPS balloons, 50/915 MHz profilers, and mini-sodars. Additionally, CIRA scientists provided recommendations for future research, including improvements to the cloud analysis and possible migration to the WRF forecast model. Example RSA analyses and forecasts are shown in Figures 1 and 2.

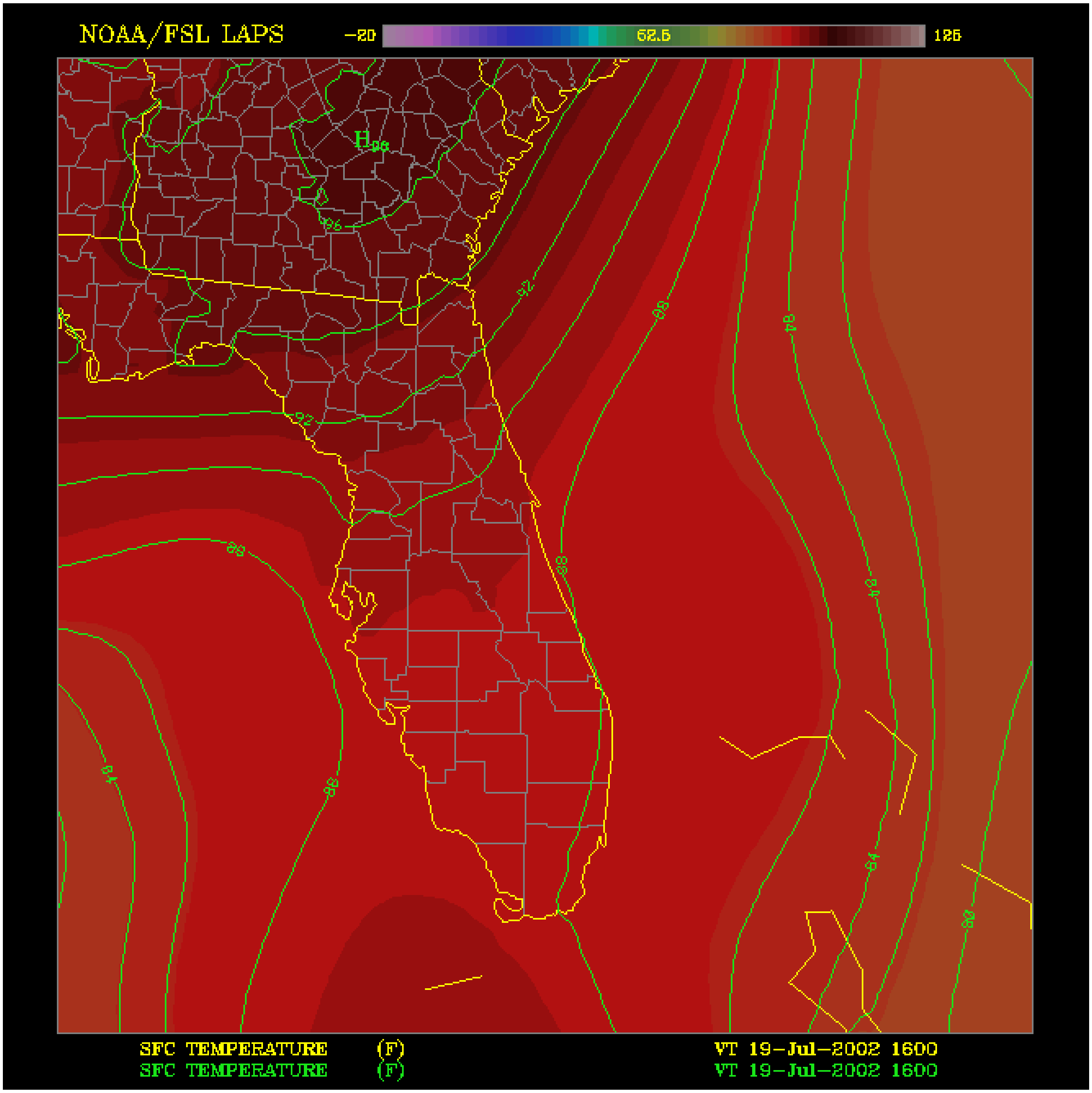

Figure 1a. Analyzed temperature field for RSA 10km domain centered at the Kennedy Space Center.

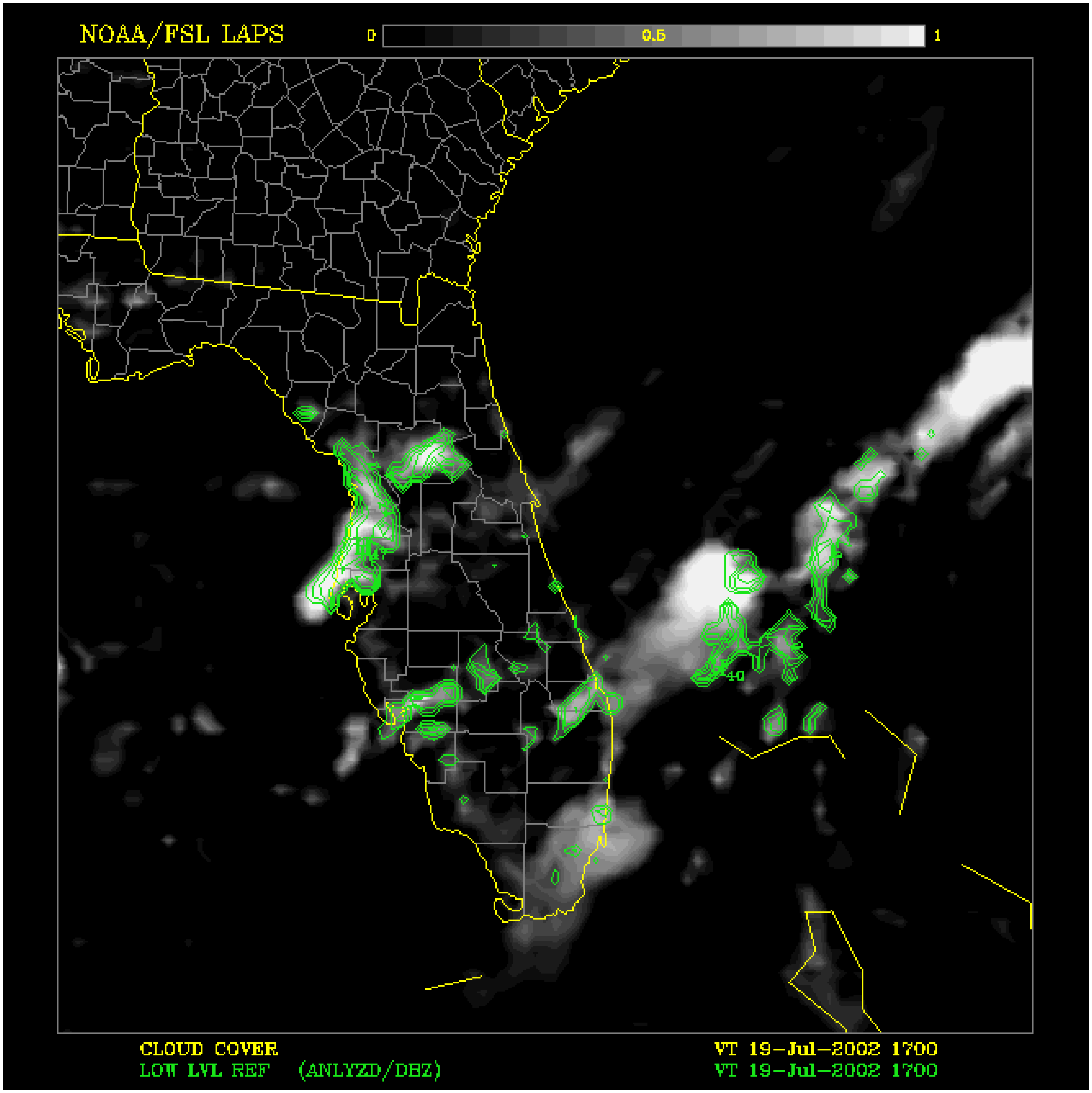

Figure 1b. Analyzed cloud and reflectivity fields for RSA 10km domain centered at the Kennedy Space Center.

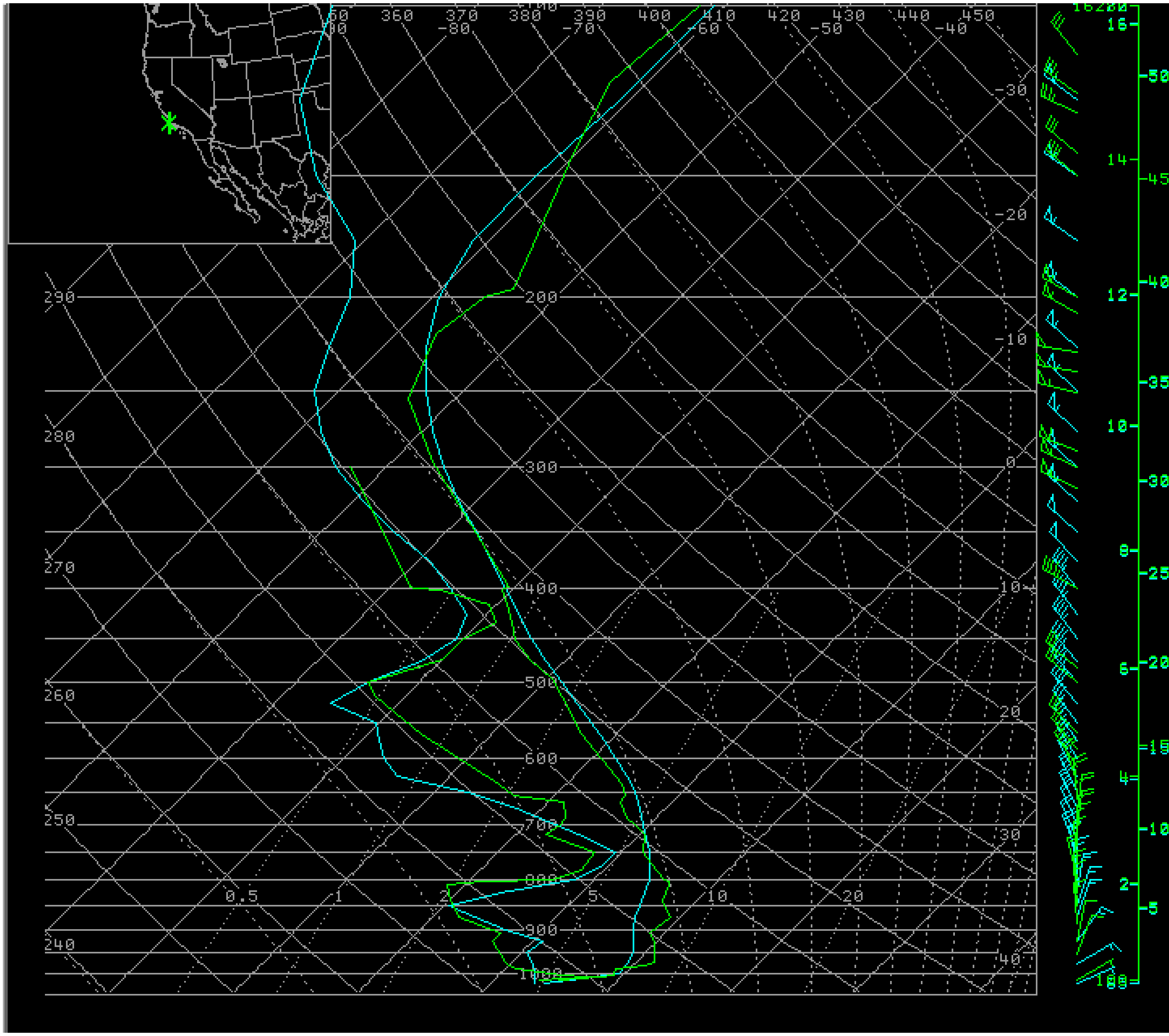

Figure 2. Observed Vandenberg Skew-T (green) and 4-h forecast from 1.1km MM5 forecast, valid 1000 UTC on 13 December 2001.

WFO Advanced

Participating CIRA Scientists: Ed Szoke, Steve Albers, and Brent Shaw

D3D Activities

This group continued to provide meteorological collaboration on the D3D development effort to incorporate its function into AWIPS. A new release of the D3D software was made in October of 2001. We continued to educate the meteorological community on the features and functionality of D3D through conference presentations. D3D was presented in a talk at the ECMWF 8th Workshop on Meteorological Operational Systems in Reading, England (November, 2001). A milestone of sorts was achieved when an entire session was devoted to D3D presentations (ours and several from WFOs) at the Interactive Symposium on AWIPS during the AMS Annual Meeting in January 2002 (Orlando, Florida).

EFF Activities

The Experimental Forecast Facility (EFF) fundamental idea is to foster the relationship between research and operational meteorology to the benefit of both sectors. Interaction within LAPS and the Boulder WFO includes research scientists working on operational shifts and presentations by members of the LAPS group at WFO workshops. Interaction on specific research efforts included assessment of the potential of D3D with a co-authored paper with WFO staff presented at the AWIPS Symposium. We have also used the collocation of the WFO with FSL at the David Skaggs Research Center to help with the operational evaluation of the utility of a local model (the MM5) at a WFO. Daily weather discussions at FSL that are coordinated by this group serves as a means of weather education, both for visiting groups and longer term student employees during the summer months, as well as another source of interaction with the Boulder WFO.

LAPS Improvements

Participating CIRA Scientists: Steve Albers and Brent Shaw

Many improvements were made in the LAPS analysis and forecast software.

LAPS Observational Data Sets

The RAOB ingest was improved to accept WFO filename format, and the handling of hourly METAR data for off-hour LAPS cycles was also made more efficient. Ingest of sea surface temperature observations from LDAD was added. Software to read these local LDAD observations was reorganized. Additional changes were made for reading multiple raw NIMBUS/WFO METAR files given various LAPS time windows/cycles. Temperature unit conversions were better standardized. The error checking (including climo QC) was improved when reading in surface observations.

Surface Analyses

A quality control check was added that compares surface temperature observations to the background. Standard deviation QC checks were tightened for temperature and dewpoint. The standard deviation QC thresholds can now be dynamically set by the user in the surface analysis namelist. The observation blacklist was updated to give better results over Colorado.

A check was added to limit the analysis increment (at each grid point) to the same increment threshold used for throwing out individual observations. This helps prevent occasional cases of too much overshooting of gradients into areas between the obs (e.g. in an NOS case study).

The analyses were modified so that the boundary is no longer initially being set by observations. Instead, the boundary is now being analyzed simultaneously with the rest of the interior domain. This measure will prevent cases when obs clustered near the center of the domain are the only information feeding (over a long distance) into the boundary obs. Several examples of this were noted in the Taiwan dew point analysis. The background field would be a better bet for the boundary in this situation. In the future, the use of obs external to the domain (if present) can be reinstated via use of data structures and calls to FSL's 4D background model interpolation routines. Some changes were started for this more flexible input of background model fields.

A new ground/water temperature analysis was added. Nominally, the ground temperature background is used, if available; otherwise, it uses the temp/dewpoint backgrounds to substitute over land/water, respectively. Also being utilized are the SST/SOIL temperature obs. Accordingly, the 'obs' data structure containing SST/SOIL obs is now being passed into 'laps_vanl'.

Using the previous surface analysis as a background can promote gradient overshoots so this procedure has been turned off for now. One future option would be a climatological field or to analyze only on larger scales with this type of cycling. The latter could be accomplished by setting an artificially high value to the RMS iteration thresholds. Limiting the increments is another option and diagnostic statistics were added in preparation for doing this.

More generic LAPS-wide routines to feed in the model background information are now used to help make the surface analysis more consistent with other analyses. Relative humidity observations can now be processed as part of the dewpoint analysis. A new namelist option to automatically set the reference level 'itheta' to 500hPa or 700hPa based on terrain was added. This helps with the WFO implementation of LAPS so that the surface temperature can be automatically adjusted to the proper theta level aloft. The snow cover analysis is now being read in for use in the fire weather field.

Software cleanup was done including removing unused code and renaming arrays. Some error handling was added to handle situations when few obs are in 'bkgwts'. Variable names were reorganized to help clarify units. Some data structures were added to enhance the capabilities and flexibility of the surface analyses. Refinements to the observation data structure handling include the addition of 'elev' & 'ldf' (land fraction) to obs data structures. This is part of the implementation of a new land fraction weighting term, segregating the influence of land and water observations, in turn improving the structure of the analyses along the coastlines. Statistics on the amount of U,V,P variational adjustment were added in the log file. The detailed reporting of verification statistics (e.g. with RMS calculations) was improved and made to be more in line with the assumed instrument error. The input data summary script, including the verification statistics summary and model background info, was improved.

Wind/Temperature Analyses

The wind analysis was made more generic so it can handle additional radars for Doppler velocity. More progress was made towards getting the wind analysis to run again in parallelized mode using SMS. This includes parallelizing the software section that handles Doppler radars in the analysis.

New data structures were added in the 'barnes_multivariate' subroutine to contain the observational data. This had been done previously with the use of sparse arrays. The benefit of this is to reduce the memory needed, and to allow the possibility of multiple obs per gridpoint as well as eventually using obs from outside the domain. Preliminary steps were taken towards the goal of reading surface temperature observations directly into the 3-D temperature analysis. Logging info about various items including sfc/3D temperature consistency was improved. Changes were made to prepare for the option of calculating analysis error fields.

A more accurate virtual temperature (from the first guess specific humidity) is now being used in the hydrostatic height integration. A new include file was set up to help standardize physical constants in LAPS. This is now being used in the hydrostatic height calculation. The hydrostatic height integration was moved prior to sfc analysis insertion to help smooth out the height field at lower levels. The temperature in the fictitious levels below the surface is now being set more closely to the background model values. The routines being used for temperature conversions were improved.

General Software Improvements/Portability

Scripts that produce web displays for the LAPS analyses and data reporting scripts used by the GUI were improved. Some of these scripts now write output to files useable by the balance package. Scripts that build, run, and purge LAPS, especially for parallelized SMS and WRF environments, were improved. The export version of the LAPS product monitor was improved. Filename conversion and other library routines were made more robust. Cleanup was done including timers as well as removal of unused code. Logging, error handling, memory use, quality control, software comments and documentation were improved. Software organization, efficiency, and portability, especially to LINUX platforms were also improved.

Efforts were made toward more generic map projection equations whose scale factor may depend on longitude in addition to latitude. This also relates to improved handling of projection rotation in wind plots. New subroutines were added to the library towards the goal of a generalized vertical coordinate.

WWW LAPS Interface

Numerous fields including upward radiation (simulated cloud) forecasts and surface U/V wind components, were added. Image capability for many fields as well as color tables and color bar improvements, was also added. Model background/forecast, wind, cloud omega, precipitation, radar, satellite, and balanced field plots such as 'rh' were added or improved. Other fields were improved such as heat-index, storm-total precipitation and precipitable water. Improvements in plot scaling, observation plots (e.g. ground temperature), zooming, user I/O, and labeling were made. Some work was done on cross-section contour and image plots (e.g. cloud and RH), as well as sounding plots. Geographic coastline database for the U.S. East Coast was improved.

Observing System Simulation Experiment (OSSE) Platform

Participating CIRA Scientist: Steve Albers

Several raw 'metadata' access routines were developed to improve the LIDAR OSSE capability. This includes RAOB, profiler, and ACARS data.

Water in All Phases (WIAP)

Participating CIRA Scientists: Steve Albers, Ed Szoke, and Brent Shaw

Radar Processing

The wideband radar remapping program was streamlined. This includes an improved horizontal fill operation as well as better lookup tables to support grid resolutions in the range of 1-5km. To date, this has been successfully tested at resolutions ranging from 4-12km. The strategy was also improved for processing radar scans from multiple times. The radar remapping software is being outfitted with a distance weighting capability and other improvements that apply to filling gaps in high-resolution grids (< 5km spacing). Remapping code is also more robust in its handling of missing radar data and "no echo" areas. Additional parameters defined at runtime are being used in the remapping software.

The radar mosaicing program was revamped to get it to work with real-time wideband as well as narrowband reflectivity data. This was tested and used with up to a dozen wideband radars. The software is robust enough to skip past missing tilts and continue looking for higher tilts. More graceful error checking was done for various missing parameters in the raw data.

The blending of NOWRAD low-level reflectivity data with other types of radar information was improved. This works by considering distances to all the wideband and NOWRAD radars. NCAR graphics program from the RUC group for plotting wideband radar data while it is still in NETCDF form was adapted. This is now in the repository. VAD radar processing was turned off until their reliability can be assessed.

Clouds/Precip Analyses

The use of the model first guess relative humidity was improved so that it gets used even when no other point observations are present. Quality control was improved for surface observations of cloud layer heights.

An input for the monthly terrain albedo database was added to the cloud analysis for use in visible satellite processing. This allows for more accurate assessment in visible light of cloud reflectance relative to the land surface. As a result, the original cloud clearing step and a newly developed cloud building step will both yield better cloud fraction values. The cloud-building step utilizes the assignment of 'sfc_albedo' (best estimate) and 'sfc_albedo_lwrb' (best lower bound). The lower bound values have defined values only over portions of water areas.

Visible satellite usage was improved by turning off the "cushion" threshold to give the cloud analysis a much smoother and realistic appearance. Visible satellite normalization and albedo calibration were adjusted, particularly for producing reliable results over large domains. Flexibility in using albedo data from low sun-angle data was improved.

Preparation for a 3.9 micron satellite cloud-clearing step was added. This would augment the 3.9u cloud-building currently performed.

A new option was added to read mosaiced 3-D (wideband) radar reflectivity into the cloud analysis. Handling of background fields in moist situations when deducing cloud-layer heights was improved.

The 'vis_radar_thresh_dbz' parameter was changed from 10 to 30 to give the visible satellite more weight when satellite says clear in the presence of echoes. This change allows the QC of some false wideband echoes appearing in the IHOP 4km runs in a clear sky area. Cloud-top processing was improved so that it would avoid aliasing effects as the LAPS grid spacing is varied below 10km.

Software to analyze the CO2 Slicing method derived cloud-top pressures from NESDIS was added. Options were coded for both image and point data, but this information wukk be treated as point data for now.

Fields within the cloud analysis output were added to specify the actual times and satellites that were used for image data in the cloud analysis. The cloud-sounding analysis step for cases of high grid resolution was also improved. Namelist flags were added that control which types of satellite data get used. Logging info for satellite and radar data used in the cloud analysis was improved.

Initial changes were made to allow the precipitation accumulation analysis to handle partial radar data coverage (including the discrimination of "missing data" from "no echo" areas). This dovetails with the new capability to combine NOWRAD (2-D) with 3-D volume reflectivity data in the same domain. Resetting criteria were improved for storm-total precipitation.

Prediction of Clear-Air Turbulence (FAA)

Participating CIRA Scientists: Adrian Marroquin and Ed Szoke

Objectives: This project is a continuation of the previous Aviation Impact Variables (AIV) effort, which involved the design and testing of diagnostic algorithms to forecast turbulence using numerical model output. The diagnostic turbulence algorithms have been used to produce daily turbulence product depicted on the FSL web page. See http://www-frd.fsl.noaa.gov/mab/tke This product has been well received by the private and commercial aviation communities. The DTF3 and DTF5 algorithms are also being used as part of the Integrated Turbulence Forecasting Algorithm (ITFA) suite undergoing real-time verification and evaluation at the Aviation Weather Center in Kansas City.

The emphasis of the present effort within LAPS is aimed at improving the forecasting capability of hydrostatic and nonhydrostatic models using the E-epsilon turbulence model. We are in the process of inserting a modified E-epsilon turbulence model within the new 20-km Rapid Update Cycle (RUC) model. Rationale for this effort is the belief that turbulence ultimately must be forecasted with nonhydrostatic, high-resolution models and with the proper physics in an attempt to decrease the uncertainties due to the approximations of the ITFA (that uses a fuzzy logic technique), diagnostic formulations, and poor horizontal and vertical resolutions of current numerical weather prediction models. Verification of turbulence has been difficult to perform with the traditional pilot reports (PIREPs).

A web page was developed to save some cases that compare the assessment of RUC-generated TKE and EDR for jet stream level turbulence examples, contrasting the different resolution RUC models (at 40 km, 20 km (current operational RUC) and 10 km) (http://laps.fsl.noaa.gov/szoke/turbulence/turbulence/TKE_cases_homepage.html).

Weather Research and Forecast Model (WRF)

Participating CIRA Scientists: Brent Shaw, Ed Szoke, and Steve Albers

The WRF Standard Initialization package was significantly enhanced to better process various datasets required for the initialization of the WRF land surface packages. New, modular horizontal interpolation routines were added as library functions to better interpolate these types of fields, which must be handled differently based on the model's representation of land or water surface types. Additionally, significant effort was put forth to accommodate the latest version of the WRF mass-based vertical coordinate using the Runge-Kutta dynamic core. CIRA scientists coordinated with WRF developers at NCEP, AFWA, and NCAR to ensure all requirements for the latest WRF release were being met by the Standard Initialization package.

Development and testing also began on a new round of enhancements for the WRF Standard Initialization, including support for the ingest of gridded fields on non-isobaric vertical levels (e.g., RUC native coordinate), improved user interfaces, and better scripting for real-time usage. We are participating in discussions to help design the LAPS/WRF Graphical User Interface.

Finally, real-time runs of the WRF model using the LAPS diabatic initialization were set up on the FSL high-performance computing system for the IHOP campaign, and CIRA scientists will be analyzing these forecasts in follow-on research collaborations related to IHOP and WRF development.

Diabatic Model Initialization (Hot Start)

Participating CIRA Scientists: Brent Shaw and Adrian Marroquin

Real-time runs of the LAPS diabatically-initialized MM5 model were continued. The model is run every 6 hours, with output provided to the Boulder and Pueblo NWS forecast offices. Some products are viewable on the web as well via the LAPS homepage (http://laps.fsl.noaa.gov). We continue to receive valuable qualitative feedback from the forecast offices on model performance. This feedback is used extensively by the CIRA team as we identify areas to focus our research efforts in this area. CIRA researchers were instrumental in designing and developing an optimized configuration of the LAPS-MM5 hot start system on a Linux cluster for implementation at both space launch ranges (see the RSA project information).

In support of the IHOP field experiment, assistance was provided to FSL in the selection and configuration of a new Linux cluster and the setup of the LAPS-MM5 modeling system localized for the Kansas/Oklahoma/Texas area of operation. Data from this system were provided to the IHOP forecast team in Norman via the FSL-developed FX-Net application, as well as via web products and GRIB data sets. The opportunity for close scrutiny of the forecast fields by operational forecasters once again allowed us to identify and correct deficiencies in the hot start technique. In particular, we improved how the analyzed cloud fields, relative humidity, and assumed cloud vertical velocity profiles interact with one another in the LAPS dynamic balance package.

In addition to the MM5 runs, testing also began on the LAPS hot start technique with both the RAMS and WRF models (Figures 3-4).

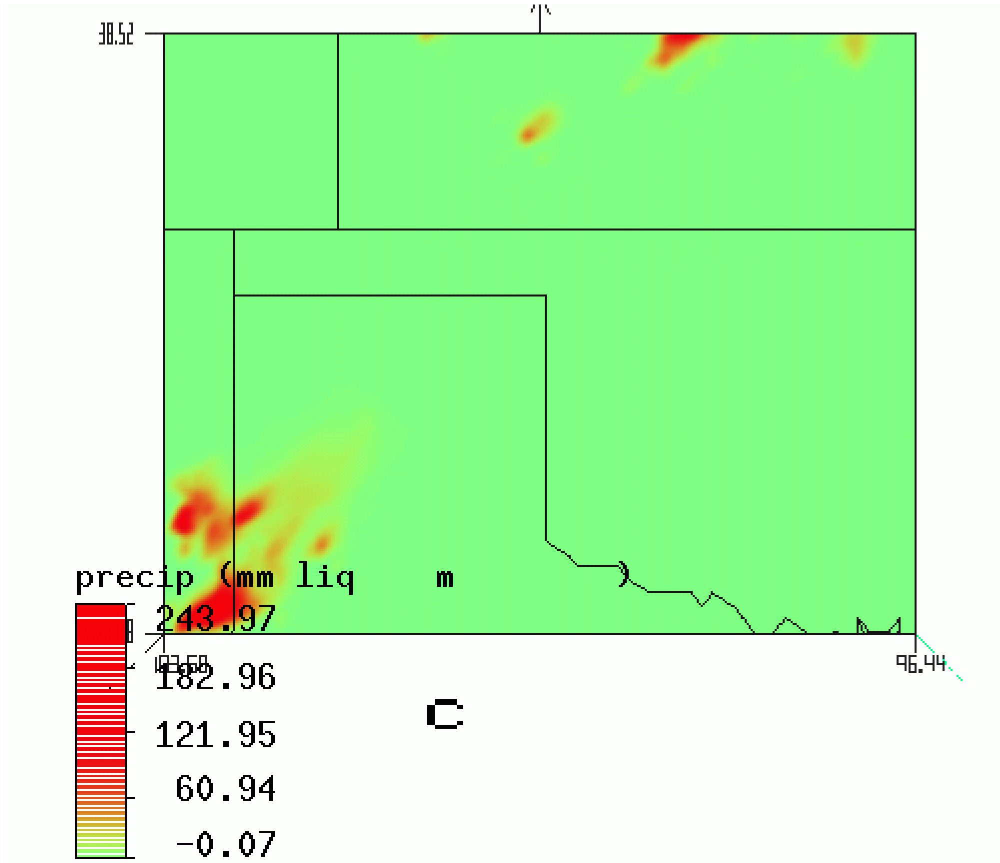

Figure 3 shows a 3-h forecast of precipitation (mm) from RAMS over the IHOP domain, valid 1800 UTC 3 June 2002. The model was run with the LAPS hot-start analysis and the lateral boundaries were taken from the ETA (32 km) model from NCEP. The grid spacing for the IHOP domain was 4 km nested within an outer grid of 12 km.

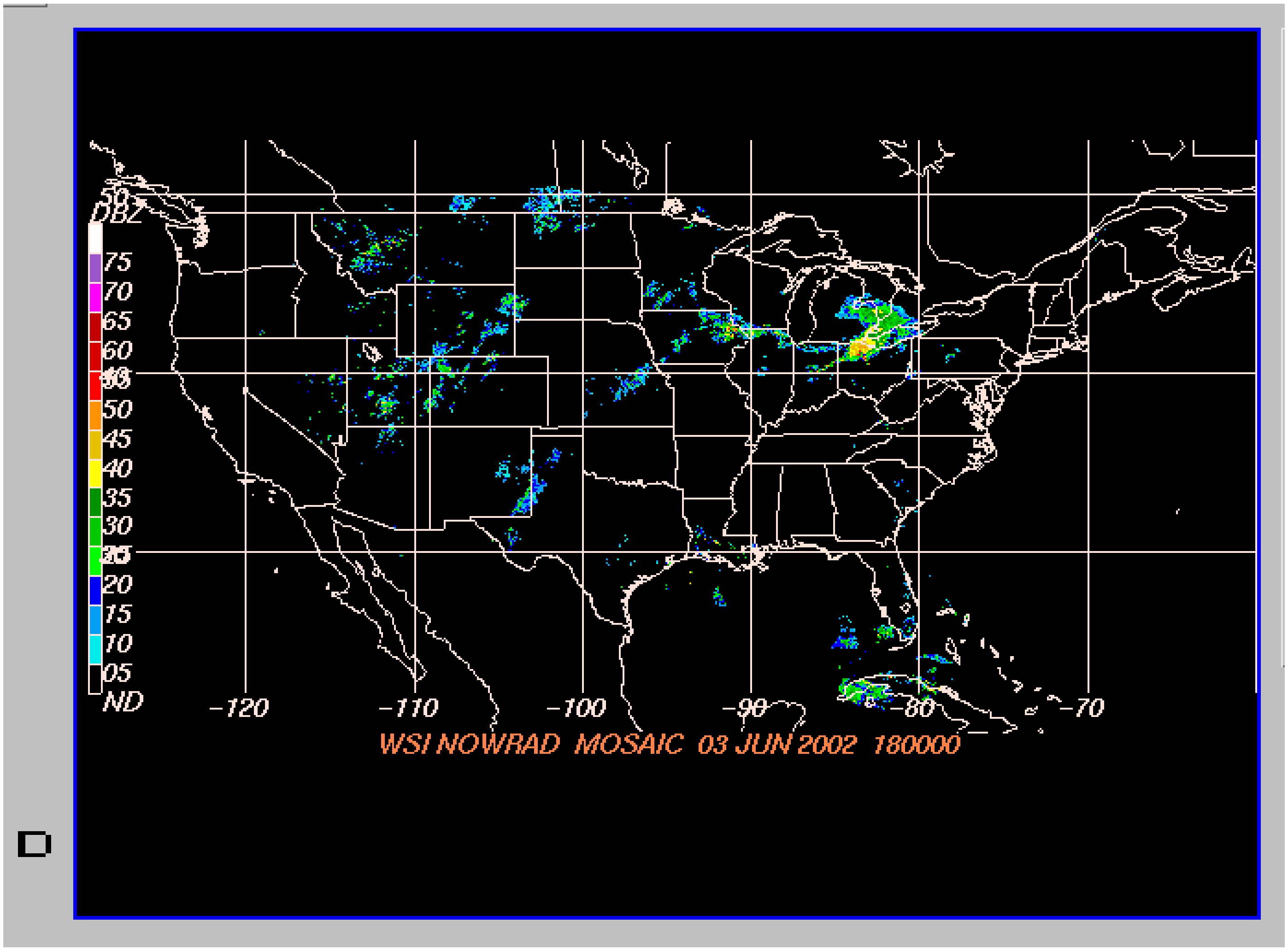

Figure 4 shows a NEXRAD composite valid 1800 UTC 3 June 2002. There is good correlation between the reflectivity that crosses the New Mexico - Texas border and the RAMS precipitation pattern (Figure 3).

<u>Other Research Projects</u>

Participating CIRA Scientists: Steve Albers, Adrian Marroquin, and Brent Shaw

IHOP

FSL had a major role in providing nowcast/short-range forecast support for IHOP operations, as well as real-time subjective evaluation of versions of the MM5 (12 and 4 km resolution) and RUC (20 and 10 km resolution) models run over the IHOP domain. Close interaction was conducted with the NOAA Storm Prediction Center (SPC), which provided meteorologists for the forecasting during IHOP, and FSL participated with them in model evaluation activities in association with their spring program for 2002. IHOP was held in Oklahoma (Operations Center at Norman, collocated with the SPC) during May and June of 2002. Real time runs of the WRF model were conducted and archived for post-analysis activities. Figures 5-7 below show an example 6-hour cloud forecast from the 12-km MM5 domain, the 12-km WRF domain, and the verifying satellite imagery.

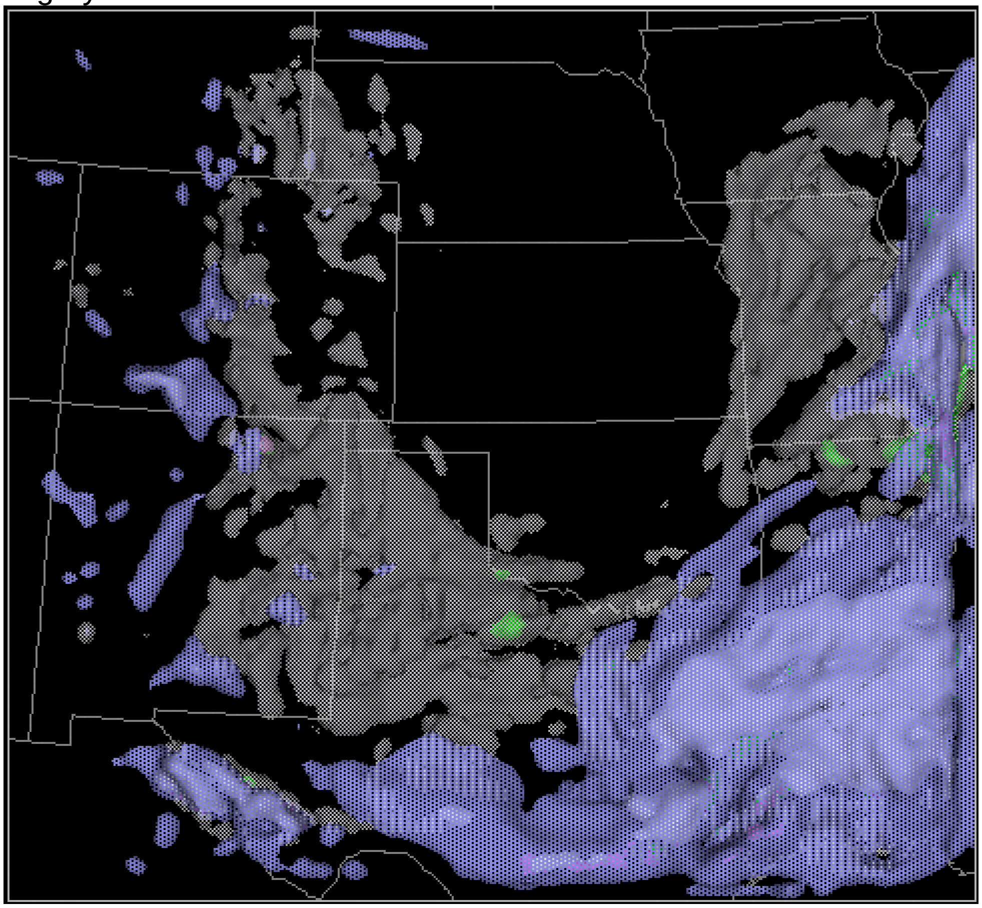

Figure 5. 6-hr hot-start MM5 12-km forecast, valid 2100UTC/17 May 2002.

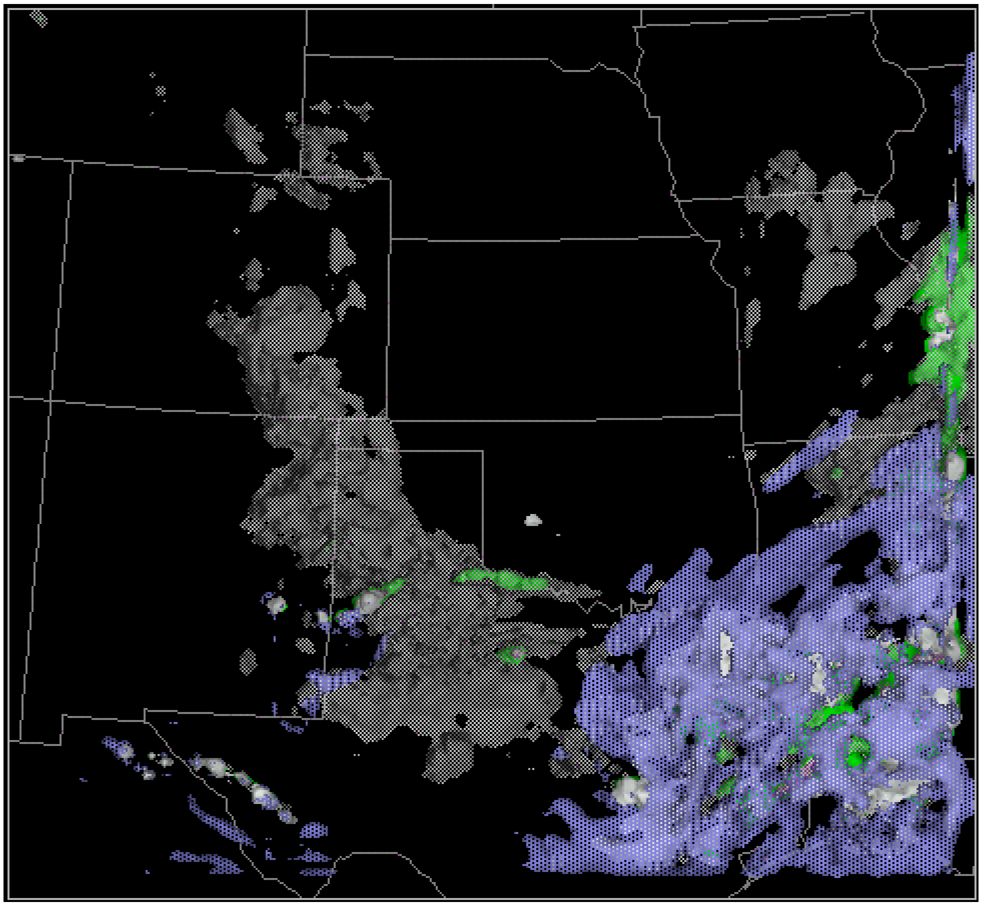

Figure 6. 6-hr hot-start WRF 12-km forecast, valid 2100UTC/17 May 2002.

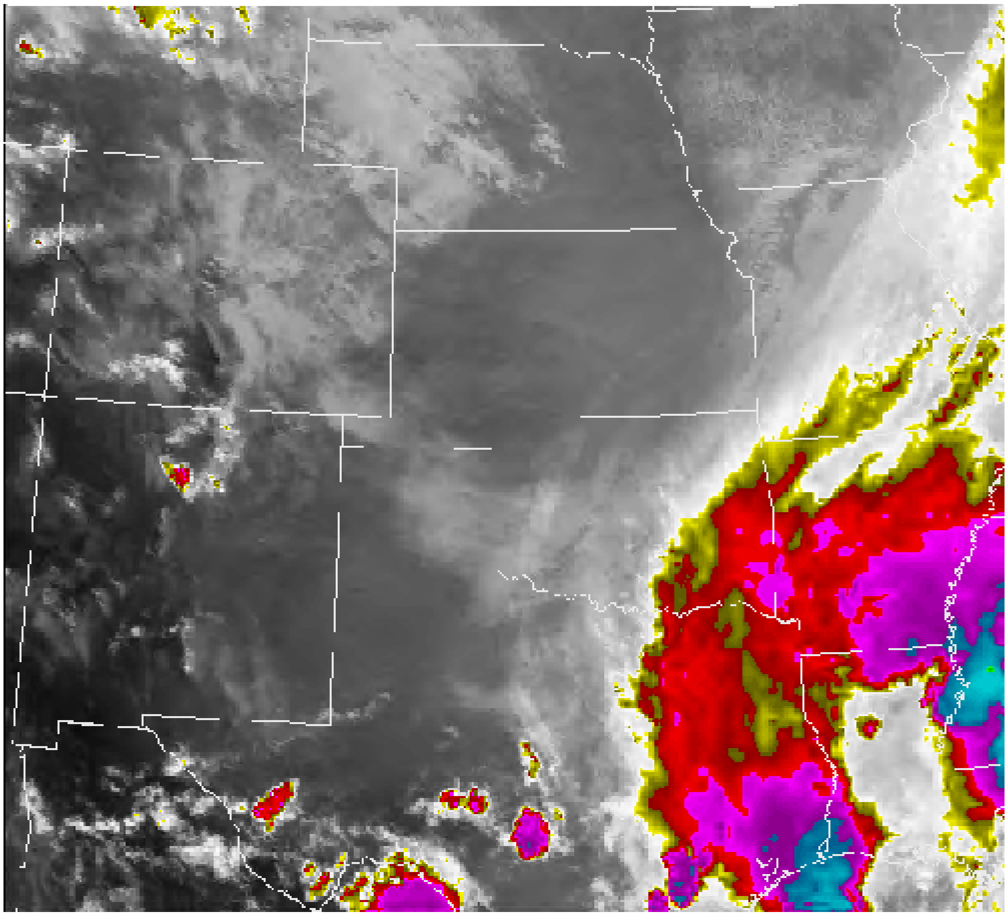

Figure 7. GOES IR satellite image valid 2100Z/17 May 2002.

Federal Highways (MDSS) and Fire Weather

The nonhydrostatic, numerical weather prediction model RAMS, version 4.3, and the NCAR/PSU MM5 version 3.4 were installed for real-time runs on the multi-processor computer Jet at FSL. The purpose of this collaborative effort is to provide forecast output for the ensemble forecast project sponsored by the Department of Transportation within the LAPS group (see Figures 8-9). The second objective is to eventually provide model forecasts to the Forest Service for fire prevention forecasting. RAMS is now running on Jet four times per day (48 h forecasts with output every 3 h) with initial and boundary conditions from the Eta and Aviation (AVN) model runs from NCEP. The grib output from these runs is now being provided to the NCAR team in charge of the ensemble forecast exercise. Scripts are now available to perform reruns of cases for which archived (on the mass store system at FSL) AVN and Eta output exists. This option will help in the completion of the full dataset required for the ensemble forecast exercise being conducted at NCAR with data provided by FSL from RAMS and MM5 models. Also, the model can be run with LAPS initial analysis for the hot start (to include convective activity at the initial time). Eventually, the RAMS hot start process will be included as a member in the ensemble forecast project.

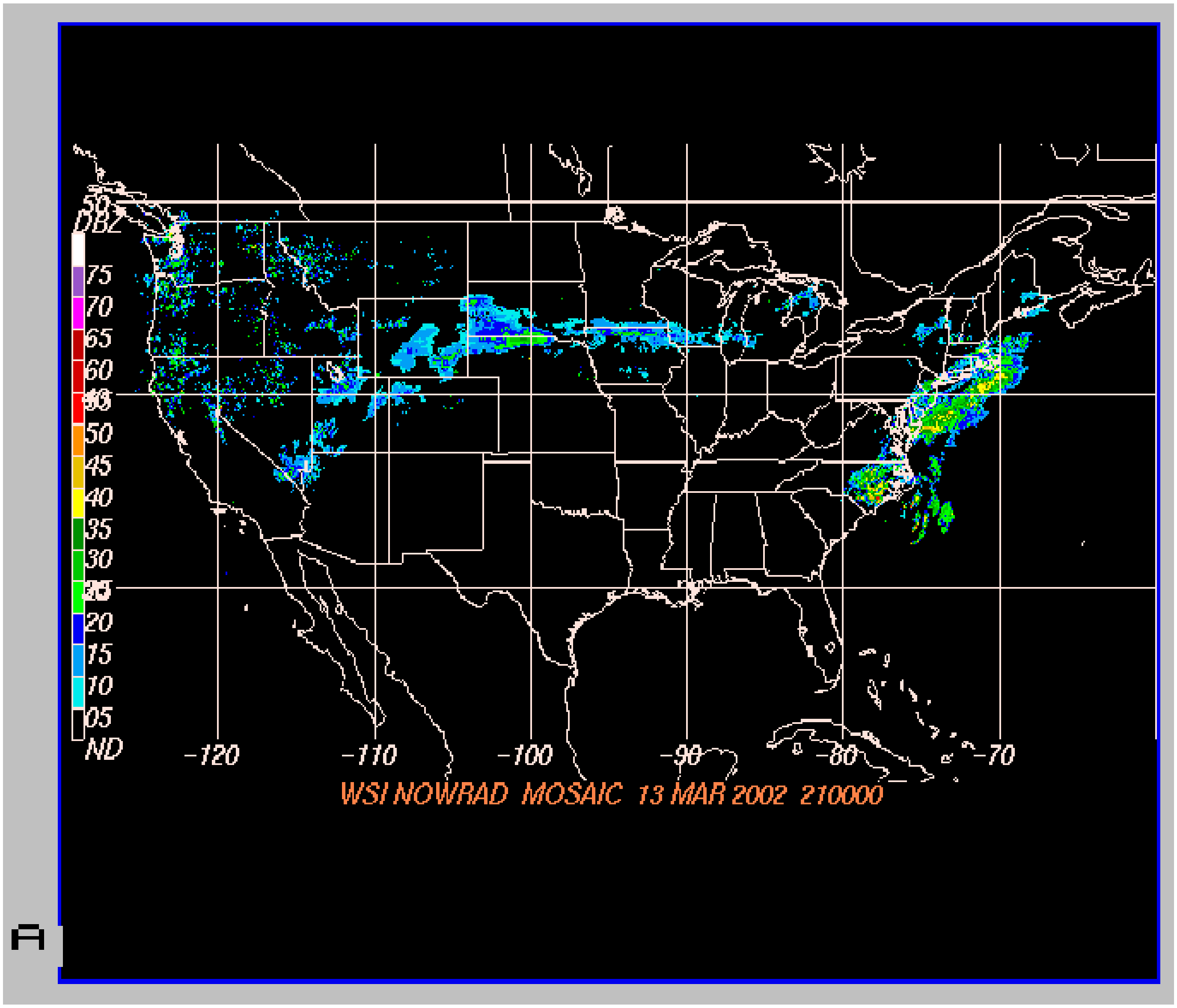

Figure 8. A NEXRAD composite valid 1800 UTC 13 March 2002.

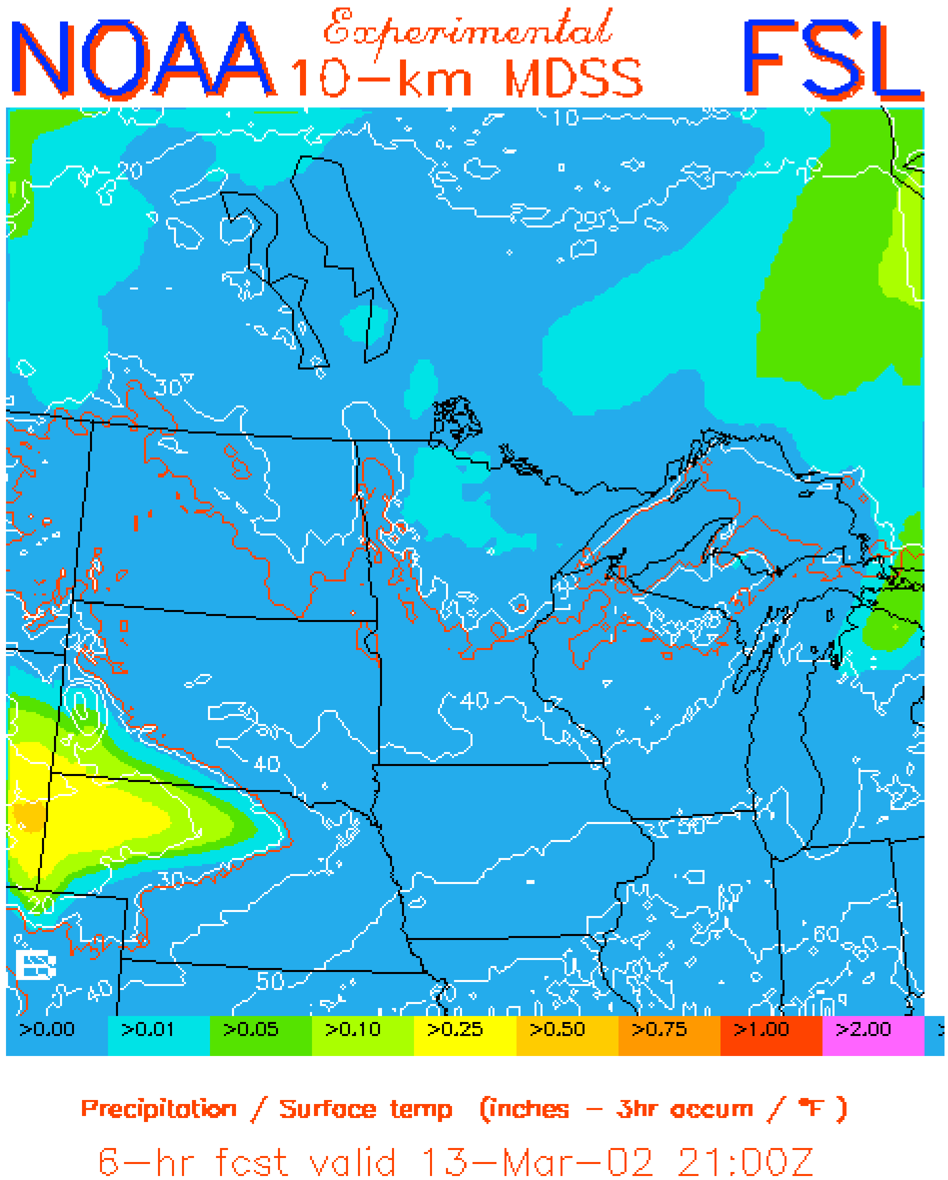

Figure 9. A 6-hr forecast using RAMS over the Minnesota domain (MDSS project). Excellent correlation is found between the radar reflectivity, located at the intersection of the -100 longitude line and the Nebraska-South Dakota border, and the corresponding precipitation pattern depicted in Figure 9.

An analysis window with 12km resolution and two nested windows at 4km were set up to assess the performance in analyzing and initializing forecast models for fire weather applications. Steve Albers visited the University of Washington Atmospheric Science Department in Seattle to exchange information about the analysis and forecasting of fire weather. We obtained software for fire weather indices from them that we are in the process of adapting and gleaning for use in LAPS. We also attended a Fire Weather Conference in Reno, Nevada during November. Our fire weather efforts are in conjunction with several research proposals that are in the works with the USFS/USDA and EROS Data Center.

LAPS External Development

Participating CIRA Scientists: Steve Albers and Ed Szoke

Research collaborations continued with CWB personnel. Efforts included the update of ingest software for satellite, RAOBs, surface observations (including expanded hourly mesonet), as well as model background fields. Within the surface observations, CWB's improved QC checks for cloud layers were added. Visible satellite data from Taiwan for use in the cloud analysis were calibrated. We continued to work with LAPS analysis runs for Taiwan both here at FSL and at the CWB to compare results, especially with the wide-band radar and IR satellite data. We collaborated with our new visiting scientist Dr. Guo-Ji Jian from Taiwan to use LAPS analyses for initializing the model forecast "hot-start" component of LAPS. Our baseline software now includes support for the use of the Taiwan CWB forecast model as a first-guess for the LAPS analysis and as lateral boundary conditions for MM5. We also worked with Dr. Jian to adapt model ingest software for use on LINUX platforms. Figure 10 shows a representative dew point analysis over our Taiwan domain.

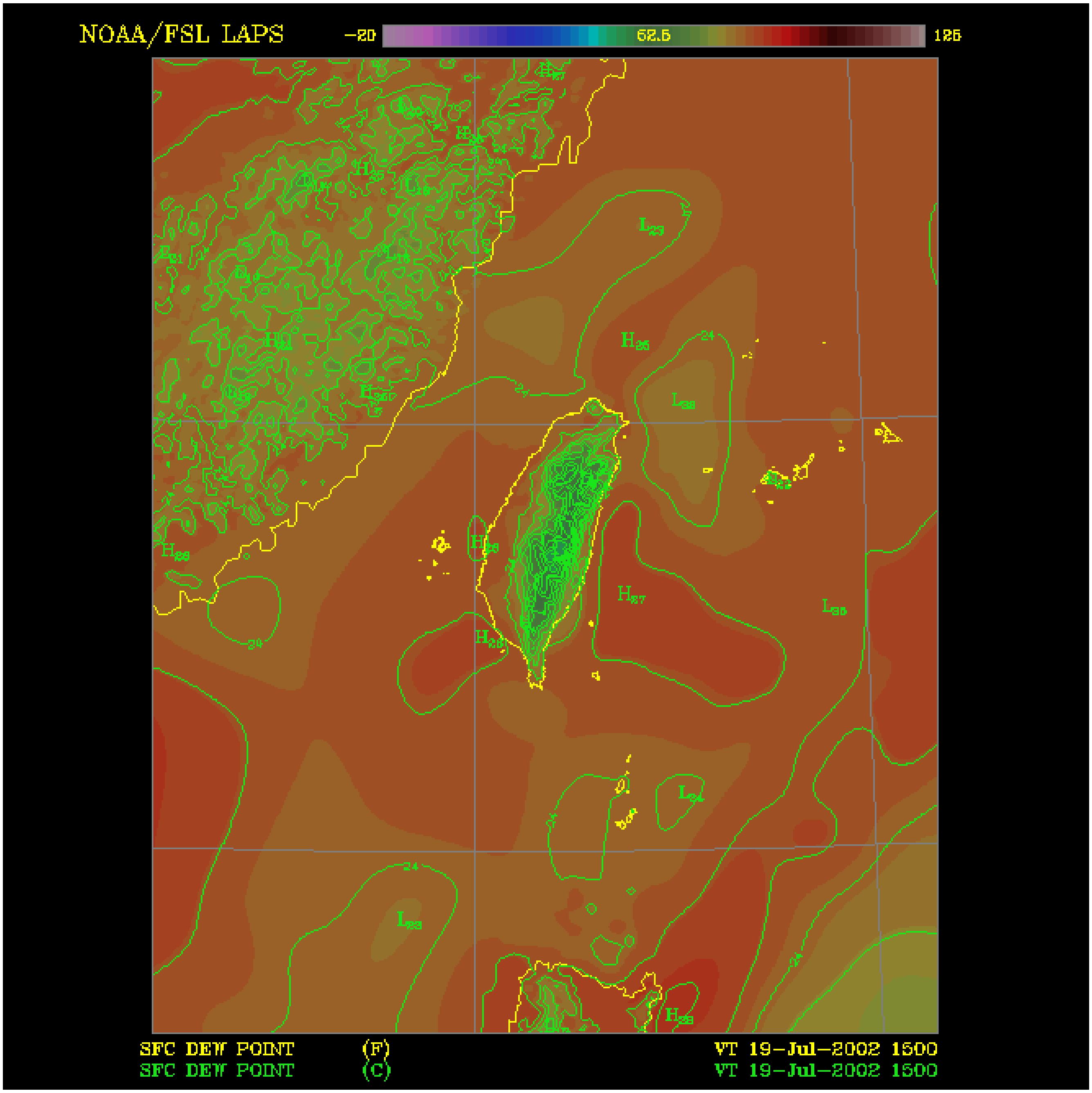

Figure 10. Surface dew point for the Taiwan area.

EAR—Meteorological Applications

Global Air-ocean IN-situ System (GAINS) Project

Principal Coordinators: Randy Collander and Brian Jamison

The GAINS project within the Meteorological Applications Branch of FSL's Forecast Research Division involves testing of a prototype weather balloon that differs from the "traditional" weather balloon in that it can ascend or descend on command. The "cannibal-loon" as it is sometimes called, consists of a helium-filled balloon within an air-filled balloon within a non-expanding fabric shell. Using radio control and on-board pumps, the amount of air within the balloon can be controlled, and since the fabric shell holds the volume constant, the density of the air can be increased substantially. This makes it possible for the balloon to have super pressure which can overcome the buoyant effects of the helium, and allow the balloon to descend.

GAINS is a major change in system concept from earlier efforts in developing a Shear-Directed Balloon System (SDBS). The SDBS program represented development toward a recoverable, reusable global sounding system to be operated in the troposphere. GAINS, in contrast, is a long-duration stratospheric platform, instrumented for environmental sensing through a combination of dropsondes, XBTs, and chemistry, particulate, in-situ, and remote sensors. Designed as a 120-ft diameter superpressure vehicle carrying a payload of 780 pounds for year-long flights up to 75,000 ft, GAINS is targeted to meet NOAA's observing and monitoring mission in the next century.

GAINS uses rechargeable batteries to power nearly all balloon functions, and has external solar panels for recharging. Communications to and from the balloon are currently done by high frequency radio, which will eventually be replaced by employing Low Earth Orbiting (LEO) satellite communications provided by Globalstar, ORBCOMM, and/or ARGOS. The balloon's position is provided by on-board Global Positioning System (GPS) instruments and ARGOS satellites.

Research efforts related to the GAINS project include: designing and developing various balloon components, preparing for and participating in field tests, and writing test plans and results. Software related to the GAINS project have been written and updated, including software to decode and quality control raw data transmissions from the balloon, display web pages and forecast trajectory. Additional software will be produced as needed.

Trajectory Prediction

--Added descent vector computation code to all trajectory prediction software versions to aid field teams in recovery of GAINS experimental flights. This gives the direction and distance that a balloon is predicted to travel from the termination point to landing. (See Figure 1 for an example of trajectory prediction).

--Worked with 22-km Eta model output in preparation for development of software to predict balloon trajectories based on this model output.

--Generated site-specific trajectories as needed for balloon flight planning.

--Wrote Perl-based software to generate predicted trajectories from 54-year climatological averages on a MS Windows-based system.

--Developed trajectory prediction software version which uses US Navy NOGAPS model analysis and forecast grids for balloon trajectory prediction.

--Discovered errors in FSL Central Facility routines which convert incoming GRIB format files to netCDF and requested that these be corrected.

--Developed software that permits users to generate balloon trajectories based on 1946-1999 climatological average rawinsonde data.

--Developed PC scripts which receive and process text output from interactive 1946-1999 climatological trajectory predictions and plot the trajectories onto the appropriate map background.

Figure 1. Trajectory predicted for a balloon launched at 1200 UTC 29 July 2002 from Tillamook, Oregon based upon global Aviation model winds. Float altitude is 58,000 ft; ascent and descent rates are 500 fpm and 600 fpm, respectively.

Rawindsonde Climatology

--Processed climatologically averaged rawinsonde data, generating objectively analyzed grids for use in predicting trajectories based upon these averaged winds fields.

--Developed and executed statistical analysis routines on the 1946-1999 rawinsonde data set. Daily, weekly and monthly means and standard deviations were calculated for approximately 1000 North American rawinsonde sites for the following parameters: temperature, dew point temperature, geopotential height, and wind speed and direction. All soundings were interpolated to 10mb incremental levels prior to analysis.

--Verified April statistics computed for Quillayute, Washington rawinsonde site using MSExcel.

--Created plots of wind data recorded at a balloon launch site in Windsor, Colorado, including: five-minute averaged wind speed, running means of the averages, and the wind speed medians, which provided information about preferable launch times when speeds were minimized.

Statistical Analysis

--Formulated course of action for statistical analysis of balloon trajectory forecasting for GAINS balloon flights, deciding to use series of 40-km Rapid Update Cycle (RUC) numerical model analyses as basis of comparison.

--Retrieved RUC analysis files from the FSL Mass Store System, and worked with other FSL personnel to convert these files from GRIB to netCDF format.

--Wrote FORTRAN code to compare trajectories predicted from the following sources: nearest rawinsonde site, objectively-analyzed rawinsonde observations and global Aviation (AVN) model, against the RUC analysis baseline trajectories for the period May 1 - 30, 2001. Comparison examined radial distance differences, as well as latitude and longitude variations to locate directional biases.

--Collaborated with FSL/ITS on setup and execution of software which converts global AVN model output files from GRIB to netCDF format.

Balloon Flight Prep

--Prepared new laptop computers for use in GAINS by loading all necessary software, setting up network and dial-in settings and testing all computer functions. Computers are used in field experiments for receiving and analyzing telemetry data transmitted by balloon instruments, post-flight processing of data and lab-based experiments and instrument package testing.

GAINS Flight Base Operations

--Designed standard form for logging information relayed by personnel in the field during balloon flights. Important items for post-flight debriefing include caller's name, personnel and balloon location and any relevant observations.

--Conducted "dry run" exercises which simulated operations at FSL Base during balloon flights. All real-time software was rigorously tested to assure proper function for balloon operations.

--Designed and developed computer processes which receive balloon position information via ARGOS satellites and incorporate these into the real-time balloon tracking web page, http://www-frd.fsl.noaa.gov/mab/sdb/ gains_rt.htm.

--Developed, tested and implemented web pages and cgi scripts for the purpose of entering field team and balloon positions during experimental flights. Added javascript code to web page for date entry error handling.

--Wrote Perl script to monitor automated operations and display status information, useful for spotting errors and anomalous behavior of software during balloon test flights.

--Provided pre-launch and mid-flight forecasting support from Boulder for the GAINS Prototype-III balloon flight launched from Tillamook, Oregon on June 21. Collaboration included evaluation of surface and upper-level winds, clouds and precippitation from numerical model output. Also performed trajectory predictions based on expected conditions and relayed results.

--Entered balloon position data into the FSL computers for display on the GAINS real-time flight web page, and monitored this page and the background processes to assure proper function and timely updates.

Field/Lab Experiments

--Participated in field testing of radio and balloon telemetry transmitters at the Department of Commerce Table Mountain site.

--Participated in an inflation test using the anchor balloon and the turbine pump at the NCAR Hangar at Jeffco Airport.

--Assisted with field test of balloon launch arm mechanism developed and constructed specifically for this project. Arm is designed to hold balloon and payload in place prior to launch until favorable wind conditions permit a nearly vertical ascent angle.

--Performed GAINS instrument testing in Climate Modeling and Diagnostic Laboratory (CMDL) environmental chamber. Use of the 27 cubic ft chamber allows for testing of instrumentation and balloon structural elements in an environment which simulates the pressure and temperature conditions expected during experimental flights.

--Analyzed parameters from ARGOS email transmissions during checkout of systems for the PIII balloon, to determine which are the most important in obtaining a position fix.

GAINS Web Page

--Developed Perl software which translates rawinsonde observations from FSL to FAA604 (GTS) format.

--Developed PC scripts for generation of upper-air charts for levels above 100 mb, including analyses of temperature, geopotential height and objectively-analyzed wind fields.

--Added links to GAINS Briefing web page, http://www-frd.fsl.noaa.gov/mab/sdb/tech_doc/briefing2.htm for access to upper-air and surface charts generated by GAINS computer.

--Modified trajectory map-generating PC scripts to accommodate new image manipulation software package.

--Added numerical model, surface, radar and web camera links to GAINS Briefing page.

--Linked 1946-1999 rawinsonde observation statistical analysis files to GAINS web site.

--Created web page for accessing trajectory predictions generated interactively by GAINS personnel, and wrote script to periodically purge old trajectories from the web page.

Publications/Presentations

--Presented preliminary results of May 2001 statistical analysis at Forecast Research Division seminar at FSL.

--Wrote paper "Evaluation of Balloon Trajectory Forecast Routines for GAINS" and presented results at the January 2002 AMS conference.

SCATCAT01 Project

Principal Coordinators: Brian Jamison and Randy Collander

Involvement in the SCATCAT (Severe Clear Air Turbulence Colliding with Air Traffic) project continued this past year. This project, headed by Dr. Mel Shapiro of NCAR and Dr. Cecilia Girz of FSL is a collaborative project to attempt to measure in-situ turbulence at jet stream levels near Hawaii. A GulfStream IV aircraft was flown to regions of predicted turbulence and dropped high- resolution dropsondes in short time intervals. The aircraft then flew back along the same route but at lower levels and in specific "stacking" or "porpoising" type patterns to try and capture in-situ turbulence. CIRA collaboration involved analyses of dropsonde data and generation of cross sections of specific variables from the dropsonde data.

--Plotted dropsonde deployment locations for research flights over the Pacific Ocean conducted during February and March 2001. Flights were in support of the Severe Clear-Air Turbulence Colliding with Air Traffic-2001 (SCATCAT-01) and Winter Storms Reconnaissance (WSR) program.

--Developed software to interpolate the high resolution dropsonde data to 100 meter levels and verified accuracy of interpolation.

--Developed technique to produce smoother cross sections, recreated the SCATCAT cross-sections using this technique, and updated the SCATCAT web page (http://www-frd.fsl.noaa.gov/mab/scatcat/) with cross-sections relating to each of the SCATCAT flights.

--Created a large number of data plots from the February 18 SCATCAT case, including Skew-T diagrams, temperature and relative humidity with height, wind direction and speed with height, and potential temperature with height.

NOAA Air Quality WEB Page

Principal Coordinator: Randy Collander

NOAA is launching a major new initiative related to chemical weather forecasting. This research program, leading ultimately to an operational national air quality forecasting system, will be a collaborative effort that is built on past work and will involve other federal agencies (most notably the EPA) and the private sector. At FSL, a multiscale air pollution prediction system based on the fifth generation Penn State / NCAR nonhydrostatic meterorological model (MM5V3), coupled with the RADM2 chemical mechanism, is used. In addition, biogenic emissions, deposition, tracer transport by convection and turbulence, photolysis, and transport by advection are all treated simulataneously with the meteorology ("online"). (See Grell et al. 2000). CIRA researchers collaborated on the following:

--Developed procedure for retrieval of model output images and generation of GIF animation of these images for 13 output products, analysis through 36 hour forecast.

--Linked static images and animations to the FSL web page,
http://www- frd.fsl.noaa.gov/aq.

--Designed and developed enhancements and improvements to the web page.

NCAR Driftsonde

Principal Coordinator: Randy Collander

The Inter-Continental Radiosonde Sounding System (ICARUSS), also called Driftsonde, is a proposed new atmospheric sounding system for use during the upcoming THORPEX experiment in 2003 or 2004.

The ICARUSS concept uses a thin polyethylene balloon (0.35 mil) with a volume of 268 cubic meters to lift a payload (< or =40 kilograms) of 24 dropsondes or modified radiosondes to an altitude of about 100 to 75 mb ((53,000 - 60,000 feet) and maintain that altitude for 5-6 days. The altitude of the balloon can be adjusted over a limited range to take advantage of the most favorable upper-level westerly wind flow.

Simulations using 1999 wind data over the Atlantic and Pacific oceans show that balloons launched from coastal radiosonde sites (eastern U.S. or Asian) will travel across the oceans in approximately 5-6 days. The dropsonde would telemeter the measured profile data back to the balloon where it would be received, processed, and stored. A compressed data set (e.g. WMO message or 10 second data) would be sent through a Low Earth Orbiting satellite (e.g. OBCOM) to a ground station and on to the THORPEX control center for further processing and/or input into the Global Telecommunications System (GTS).

The balloon gondola would house 24 dropsondes, a telemetry receiver card, PTH and GPS wind processing cards, a single board computer card for data processing and ballast control, a satellite transceiver card, a lithium battery power supply and a passive thermal control system to maintain the electronics above -10 deg C. During the nighttime transition period when the balloon volume decreases due to radiational cooling of the helium, ballast would be dropped to maintain altitude. An additional natural rubber balloon may be required during rain, wind and snow conditions to tow the ICARUSS balloon and payload through the severe weather. The rubber balloon would be jettisoned above the severe weather. CIRA collaboration on this project included:

--Created web page with links to trajectories predicted for NCAR Driftsonde experiment and upper-air charts (http://www-frd.fsl.noaa.gov/mab/sdb/ tech_doc/driftsonde.htm).
to compute trajectories for touch-and-go ascent to 60167 ft MSL (approximately 75mb).

--Modified web page generation script to automatically update and generate separate web page for use by NCAR project personnel and updated PC scripts to plot trajectories from special NCAR predictions onto map backgrounds.

Maintenance Decision Support System

Principal Coordinators: Randy Collander and Brian Jamison

The Maintenance Decision Support System (MDSS) is a project sponsored by the Federal Highways Administration. The goal of this project is to create a decision support software package to help winter road maintenance personnel decide how to best respond to weather problems on highways. MDSS takes automated weather observations and forecasts and runs pavement conditions models to suggest an optimum combination of plowing and chemical applications, and recommends the time to make these treatments.

FSL will provide web resources for display of output from the MM5 and RAMS numerical models (initialized by two different models--NCEP's AVN and Eta) for a total of four model runs, each run four times per day out to 36 or 48 hours. CIRA collaboration on this project included:

--Created MDSS web page, http://www-frd.fsl.noaa.gov/mdss/data.

--Modified perl cgi script for generation of case-specific tables of model output products.

--Generated GIF images of MM5 and RAMS numerical model-based output fields for several sample cases (March 2002) using IDL scripts developed by CIRA researchers.

Science Quality Datasets

Principal Coordinator: Brian Jamison

A science quality archive of radiosonde data for North America began as a collaborative effort between FSL and NCDC in 1992, and continues to be a widely used baseline data set for weather researchers and climatologists nationwide. The archive exists as a CD-ROM set available from NCDC, and is complemented by a web page updated regularly by MAB. Periodic updates to the CD-ROM set are also provided by MAB.

Tasks related to this project include: research and QC of the datasets to ensure highest level of accuracy, responding to users' questions and requests, and creating updates to the CD-ROM archive.

International H2O Project (IHOP)

Principal Coordinator: Brian Jamison

Although IHOP is a project comprised of a number of diverse missions, the focus of the MAB participation was to undertake two low-level jet observation missions. These missions employed four aircraft, two of which flew opposite each other on a paths defined by a rectangular "box" over northwestern Oklahoma, southwestern Kansas, southeastern Colorado and the eastern Texas panhandle regions. These aircraft dropped high-resolution dropsondes at pre-defined intervals for later analysis of moisture transport within the low-level jet.

Tasks related to this project include: design and development of web pages to graphically display products for analysis and forecasting; developing software to automate the process of data ingest and output for the web pages; developing software scripts to keep web page displays updated; participation in daily forecast discussions; participation onsite to outline and direct mission parameters; and post-processing and analysis of the collected data.

Specific Highlights

--Developed software to produce cross sections of mixing ratio in preparation for post-processing.

--Developed software to automatically run Interactive Data Language (IDL) scripts that create graphic images of planetary boundary layer winds, convective available potential energy (CAPE), moisture flux, 500 mb omega, and precipitable water from the Eta model over the IHOP domain, to update web pages used for forecasting purposes.

--Developed interactive web pages to display graphic loops of images for low-level jet forecasting (links at http://www-frd.fsl.noaa.gov/mab/IHOPLLJ/webforecasting.html).

--Participated in daily telephone conference meetings to discuss potential days for low-level jet missions and also participated on location in Norman, Oklahoma as a mission scientist to prepare a mission flown by four aircraft.

--Summarized low-level jet mission for submission to the IHOP main web page.

--Created a cross section of potential temperature from a portion of the collected dropsonde data.

TAMDAR Project

Principal Coordinator: Brian Jamison

The Tropospheric Airborne Meteorological DAta Reporting (TAMDAR) project was jointly developed by NASA and the FAA to investigate the potential contribution of meteorological observations from regional aircraft to improve aviation weather services. Several tasks are required for this project, one of which is to assess temporal and spatial data scarcity with the ACARS (Aircraft Communications Addressing and Reporting System) data.

Specific Highlights

--Wrote, submitted, and presented a paper entitled "An Analysis of the Temporal and Spatial Distribution of ACARS Data in Support of the TAMDAR Program" for the American Meteorological Society's 10th Conference on Aviation, Range, and Aerospace Meteorology.

Turbulence Project

Principal Coordinator: Brian Jamison

MAB, under support from the FAA Aviation Weather Research Program, conducts research to improve forecasts of clear air turbulence (CAT) by developing diagnostic algorithms and conducting field programs. Tasks related to this project include: design and development of web pages to graphically display diagnostic algorithms for analysis, developing software to automate the process of data ingest and model output, and developing software scripts to keep web page displays updated.

Specific Highlights

--Developed interactive web pages (http://www-frd.fsl.noaa.gov/mab/jamison/turb/) to display graphic loops of images for turbulence prediction and verification, including imbalance residual, omega-imbalance, quasi-geostrophic omega, and pilot reports.

--Created Perl and shell scripts that run Interactive Data Language (IDL) software to create gif images of turbulence indices derived from the Rapid Update Cycle (RUC) model output, and set up processes to automatically update these images to the web pages.

--Streamlined the scripts to avoid redundant operations and shorten processing time.

--Created software to display smaller gif image loops in a four-frame web page, then revised the software to display four-panel loops in one frame that operate with one set of controls.

--Developed a web page feature to allow users to select previous model runs up to 24 hours for viewing, allowing time-matching capabilities.

--Wrote a Perl script that fills all the web pages with the most recently available images, in the event that computer down time affects the model runs and image processing.

EAR—CIRA Research Projects in the International Division

Principal Researcher: Renate Brummer

GLOBE Program

The GLOBE Program is an international, environmental research program that links the efforts of students, teachers, and scientists. It was initiated in 1994 with the objective of increasing the awareness on a worldwide basis of the need to understand our environment. Since then, it has grown from 500 US schools in 1995 to more than 12,000 participating GLOBE schools located in 98 partner countries. Currently, there are more than 8 million GLOBE measurement records in the GLOBE database. CIRA staff members in the International Division are responsible for the design and development of the main GLOBE website as well as the real-time GLOBE data acquisition. The GLOBE website is located at http://www.globe.gov/

Figure 1. GLOBE students studying properties of the soil with a GLOBE scientist.

This past year, the CIRA GLOBE team made some major strides in the way of making the GLOBE website a highly available website. In collaboration with other GLOBE partners at NASA/GSFC, a mirror of the entire website at both FSL and NASA/GSFC was established. A user who requests www.globe.gov is sent to whichever mirror is 'closest' in terms of network topology. An additional and totally separate GLOBE training server was set up for use during GLOBE teacher training workshops and for students who wish to practice the data entry process without actually sending 'real' data to GLOBE.

Considerable development time was spent on the GLOBE website itself. The addition of a new GLOBE protocol called "Green-Up and Green-Down" required the design and development of new data entry pages. The protocol is part of the phenology group of protocols, which help track the season length and give clues to global warming. Green-up, as its name implies, refers to when trees and grasses start greening up in the spring. Green-down, on the other hand, refers to when trees and grasses start going into their dormancy state for the winter. A new interface was created that allows teachers to see how well GLOBE tasks align with their state education standards. The addition of new foreign language web pages (Russian, Arabic, and Dutch) supported the establishment of the GLOBE Program in new non-English speaking partner countries.

A substantial amount of research and development time was spent in realizing ideas, which make it easier for students to use and navigate the GLOBE website as well as in the creation of positive feedback to schools that have participated in GLOBE for long periods of time. A site search tool was added to the website to make it much easier to find specific information embedded within roughly 14,000 web pages. As a means to help encourage school data reporting retention, emails are now sent out to GLOBE schools the first time they report data. Subsequent emails are sent as they reach 'milestones' in terms of data reporting (250 measurements, 500, 1000, etc.) thanking them for their on-going contribution to the project. This helps to reinforce the idea that their data is important to the science and education communities.

There is a separate, non-public website which was developed early in the program which allows GLOBE HQ office staff in Washington, D.C. and GLOBE partner groups to track contact information for schools and teachers and GLOBE training workshop attendance. This site is primarily a data-entry- and report-based site, and is therefore nearly as complex as the public GLOBE website. New user interfaces were developed for HQ staff to manage information about when contacts are made with partners and for HQ to view school reporting patterns. An elaborate interface was set up for partners' to identify their goals and to specify which schools they wish to target within the U.S.

GLOBE scientists continue to help students and teachers improve the quality of their measurements, and as a result, more scientists in various disciplines are using GLOBE data in their research. First, in 2001, University of Oklahoma researchers announced that GLOBE data from a dozen countries are being used as the surface verification of remotely sensed global precipitation. GLOBE data is being incorporated into NOAA's Surface Reference Data Center (SRDC), and there is a neural network being created at EVAC (University of Oklahoma's Environmental Verification and Analysis Center) which combines surface precipitation measurements (includes GLOBE data) with water vapor estimates to create 3-month forecasts of precipitation. Also, GLOBE soil profile characterization, land cover, climate, and GPS data were used together to parameterize the GAPS model (General Purpose Simulation Model of the Atmosphere-Plant-Soil System), which simulates and validates biophysical (atmospheric, plant, and soil) processes. Finally, GLOBE budburst phenology data are used by University of Montana researchers to help select the optimal satellite composition length (a technique which reduces atmospheric, snow, and cloud contamination).

The FX-Net Project

The FX-Net project was established to develop a network-based meteorological workstation that provides access to the basic display capability of an AWIPS workstation via the Internet. FX-Net is intended to be an inexpensive PC workstation system for use in a variety of forecast, training, education, and research applications where the full capabilities of a WFO-Advanced type system are not required.

Although designed primarily for Internet use, FX-Net also accommodates local network, dial-up, and dedicated line use. The FX-Net system consists of a FX-Net HP Server and an FX-Net PC client. The FX-Net server is a modified AWIPS workstation. It is locally mounted next to an AWIPS data server via a high-speed link. The FX-Net client sends small-sized requests via the Internet to the FX-Net server that responds by sending products to the client. The FX-Net client user interface closely resembles the AWIPS workstation, but with reduced resolution and complexity to allow for rapid Internet response. Some of the FX-Net client functionality features are load, animation, overlay/toggle, zoom, and swap. The client Java application can be run on a number of standard PC platforms. The system performs best under Windows NT, Windows 2000, or under Windows XP Pro. The minimum client hardware configuration consists of a 400 MHz Processor with 256 MB memory. Internet bandwidth down to 56 kbps is considered sufficient for the FX-Net product transmission.

Most of the research and development for FX-Net focused on the “delivery method” for large file sizes to be transmitted over relatively low bandwidth. The knowledge and expertise of the FX-Net team in the area of compression techniques became the foundation for this project.

In early 2002, FX-Net successfully supported the weather forecasting functions at the Salt Lake City Winter Olympics. For this scenario, the FX-Net server was located at the NWS Western Region Headquarters in Salt Lake City. Forecasting offices at each of the five different Winter Olympics outdoor venues were equipped with FX-Net PC clients; performance and reliability of the FX-Net system were outstanding.

As in earlier years, FX-Net received enthusiastic comments by the established FX-Net clients in the university teaching and research environment. The workstation software is being used at Colorado State University, at University of Northern Iowa, and at Plymouth State College in New Hampshire to support undergraduate and graduate meteorological laboratories as well as to support research projects and field experiments.

During 2002, new development needs for FX-Net were established through contacts with fire weather forecasters and with the air quality forecast community. Both of these groups were in desperate need for a hi-tech meteorological forecast workstation which could be operated over low-bandwidth phone lines as well as higher bandwidth office lines. Yet, each group had different needs for special FX-Net data sets and functionalities. The system design of the FX-Net data server and the FX-Net server make it relatively easy to add complex additional data sets to the ingest part of the process. In order to serve the fire weather forecast community, development started with the focus on delivering high-resolution satellite imagery. There was also a need for additional densely located observational data, especially meteorological surface station data. Work started also on ingesting special air quality measurements, which were collected by a University of New Hampshire research team. The development team also began working on the data ingest of a nested air chemistry model and a number of meteorological forecast models to be displayed on FX-Net. In late summer of 2002, a large-scale air quality field experiment conducted in the New England region will use FX-Net as the real-time forecast workstation.

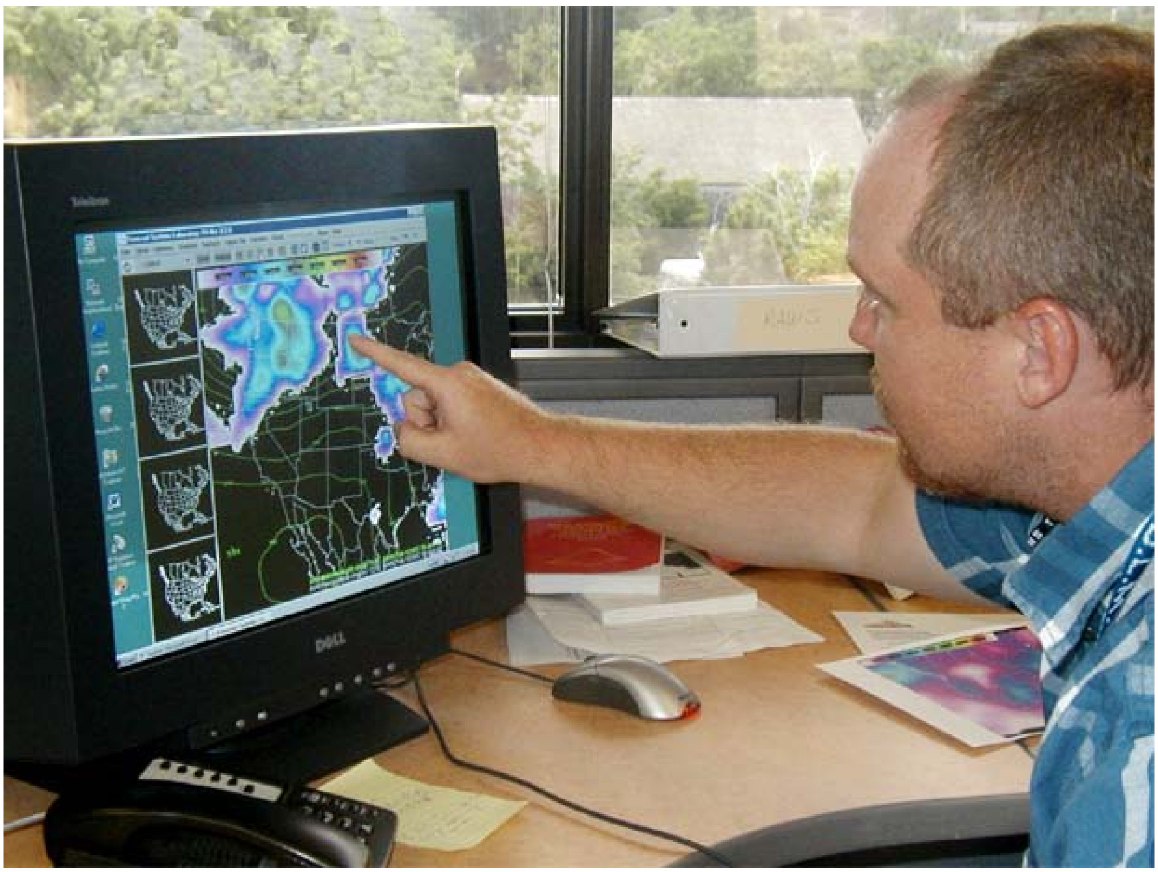

Figure 2. FX-Net used by a fire weather forecaster at the Lakewood GACC office

Wavelet Compression Application Research

After successfully applying the wavelet data compression technique to satellite imagery, the Wavelet Data Compression initiative was established to further investigate the possibility of using the technology for other meteorological datasets. Compared to imagery datasets, model data usually have higher numbers of dimensions, but each dimension is of much smaller size. Therefore, special treatments are needed to exploit the correlation among all dimensions. A multidimensional data arrangement and transform scheme has been developed to accommodate the special features of the model dataset. An experimental encoder and decoder package has been implemented to test various datasets with different standard waves and different post transform compression algorithms.

Efforts in applying wavelet compression to gridded model data were expanded this year. Several new models were investigated with focus on the difference in compression factors for stationary and non-stationary fields. Stationary fields are quite smooth (for example, upper-level temperature fields) in contrast to non-stationary fields (for example, vorticity or relative humidity). Accepting “reasonable loss” in information, stationary fields can be compressed two to ten times as much as non-stationary fields. The larger the entire four-dimensional model grid (three dimensions in space plus one dimension in time), the higher the compression factor that can be applied. Additional research was conducted on controlling the maximum or average error for each parameter. Work also began on the development of a “zero-tree” algorithm to further improve the data compression performances, including compression ratio, error distribution, and encoding time

The World-Wide Weather Workstation (W4)

Design of a new workstation system, called the World-Wide Weather Workstation (W4), began in summer 2000. The system is being designed to meet the forecast needs of developing nations and for forecast situations where forecast information is normally inaccessible. W4 is intended to be capable of operation in remote areas with a minimum of onsite computer expertise required. Flexibility in use and operation to support both national and local forecast needs, as well as emergency management and natural disaster situations, is required.

W4 development is based on the AWIPS general system concept and the look and feel of the AWIPS workstation. The foundation of this workstation concept is the wavelet compression technology, which was used very successfully in the FX-Net project. In contrast to FX-Net, the W4 workstation will be capable of delivering gridded model data rather than forecast products (in form of vector graphics files). The successful research conducted in the area of wavelet compression on gridded fields benefited this workstation development directly.

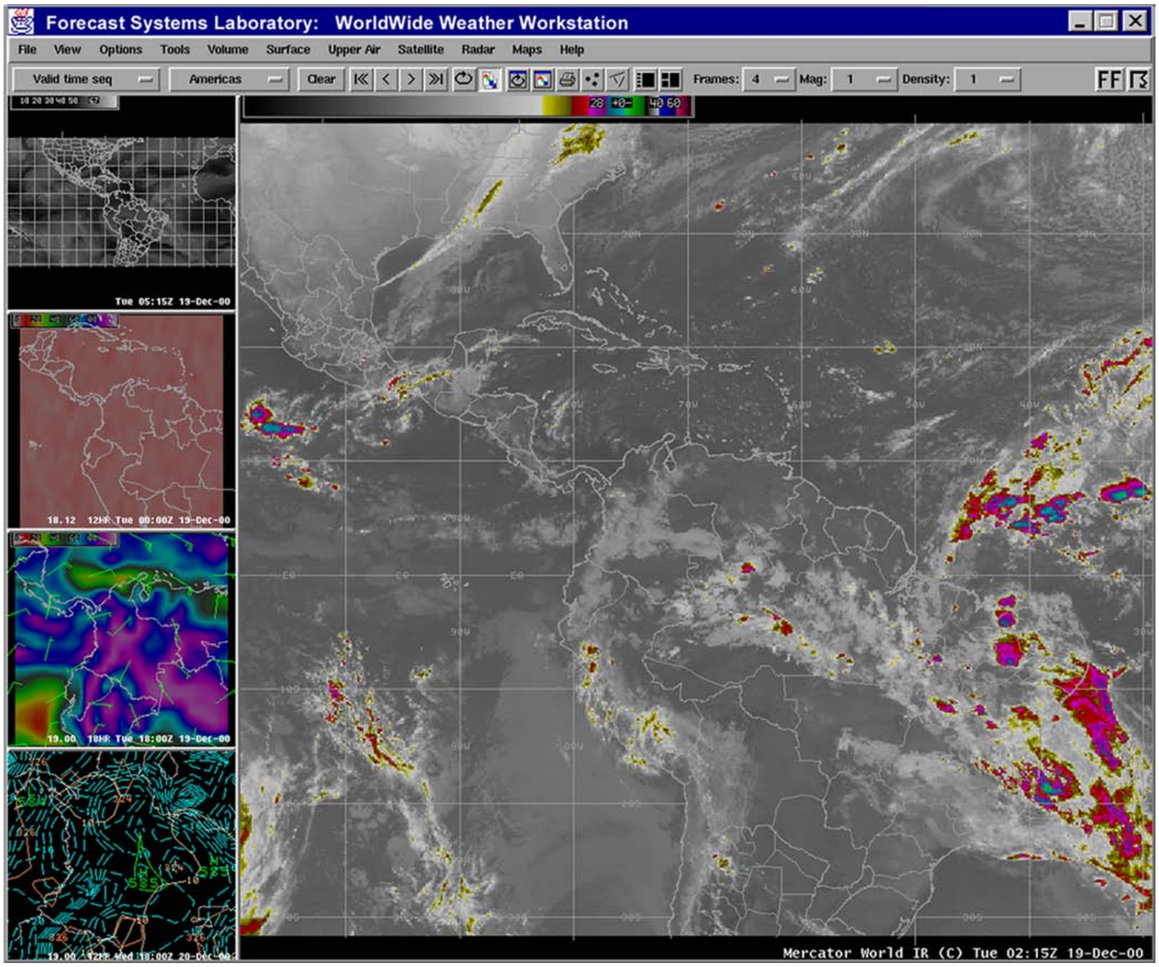

Figure 3. W4 client user interface

The first operational W4 workstation was demonstrated earlier this year. Datasets and model forecasts covering different scales from northern hemispheric scale down to a Caribbean Puerto Rico scale were displayed. The range of data included Geostationary Satellite imagery from GOES East, Global forecast models (MRF and AVN.), regional scale RUC model, and internationally available surface observations.

EAR—Data Acquisition, Editing and Display Functionalities of Advanced Forecaster Workstations

WFO-Advanced Data Acquisition System

Principal Researcher: MarySue Schultz

The WFO-Advanced project has the objective of developing a data acquisition and display system which enables weather forecasters to receive and display the large amounts of data needed to produce accurate forecasts, watches and warnings. Over the course of the project, CIRA researchers in the Modernization Division have made significant contributions to the data acquisition component of the WFO-Advanced forecast system.

During the past year, CIRA staff members were responsible for a number of improvements to the data acquisition software. CIRA personnel investigated different techniques for improving system performance and reliability. Although the WFO-Advanced forecast system already provided an impressive number of datasets for the forecasters to view, additional datasets became available last year, and they needed to be incorporated into the system as well. CIRA researchers were responsible for designing, writing and testing software that acquires the data and makes it available to the system's D-2D display. The new software enables forecasters to use the most current types of data when making their weather forecasts.

The WFO-Advanced data acquisition system includes a component that enables forecasters to acquire data directly from instruments that are located in the vicinity of their areas of responsibility, referred to as "local data". Local data is particularly important to weather forecasters, because it provides measurements of atmospheric conditions at a resolution not otherwise available. CIRA researchers redesigned a portion of the local data ingest software, allowing for a far more flexible schema for routing data from acquisition to disk storage. Local data comes in a wide variety of formats and sizes, and is delivered on a number of different schedules. Flexibility is a crucial characteristic of the local data acquisition software design, and improvements in this area will provide a benefit to the WFO-Advanced system by allowing new datasets to be added much more easily.

Linux Development Activities

The WFO-Advanced forecast system was originally implemented on Hewlett Packard (HP) hardware, using the Hewlett Packard Unix (HPUX) operating system. The Linux operating system has been identified as an attractive replacement for HPUX in the future, because Linux is both faster and cheaper. Last year, CIRA staff members participated in a research and testing effort aimed at obtaining performance measurements of the data acquisition software as it ran on both HPUX and Linux platforms. Different configurations of Linux and HP machines were also tested, in an effort to determine the best way to make the transition from HPUX to Linux.

WFO-Advanced Graphical Forecast Editor Suite (GFESuite)

Principal Researchers: David Howard and Deborah Miller

The GFESuite is a series of programs that provide an end-to-end interactive forecast preparation capability. The GFESuite components derive surface sensible weather elements from model data, manage the forecast data and metadata in a database, provide viewing and editing capability of the forecast data, and generate output products in a variety of formats.

The GFESuite has been designed for forecast situations where more than one forecaster will be simultaneously editing grids, which is usually the case at most forecast offices. The database server prevents simultaneous editing of the same forecast grids and lockout of grids while editing. It also provides notification of data changes, and when forecasters save their edited gridded forecast, all other GFEs connected to the same database server will see the changes immediately.

CIRA staff members at FSL responsible for the GFESuite, have aided in the research to carefully investigate and incorporate cutting-edge software design and development techniques. Those decisions include Object-Oriented design, Extreme Programming concepts and the use of Python, an interpreted programming language as an adjunct to C++. CIRA researchers have designed and developed core software, enhancements and procedures to test the entire GFESuite. The efforts of the CIRA staff have directly contributed to the quality of the product and overwhelming acceptance by its users.

Range Standardization and Automation (RSA) Project

Principal Researcher: MarySue Schultz

The RSA project is a collaborative project to provide space launch sites with weather forecasting technology based on the WFO-Advanced system to aid in their weather forecasting responsibilities.

Last year, CIRA researchers contributed to the development of data acquisition capabilities for the RSA system. One of the most important datasets will be radar volume scans and the associated products. A new method of disseminating data from the radars, called Open RPG, is about to come on line, and these launch sites will need to have an interface to the Open RPG software. During the last year, CIRA staff members tested and evaluated the Open RPG software to determine how best to design the interface software, given the network and hardware architecture at the launch sites. Radar acquisition software will be designed and implemented based on the results of this evaluation.

Software Configuration/Change

Principal Researcher: Robert Prentice

CIRA researchers have designed and implemented an automated regression test harness for the localdev package, which is the primary software management suite used by other software developers within the laboratory. Most of the command-level localdev tests have been converted to run within the automated test suite. A few more remain to be converted.

Automation of regression tests is highly desirable for all software development projects, but is just starting to get attention at FSL. This project serves as a demonstration of this capability, and the test harness can be easily reused by other projects. It will also be of direct benefit to the implementation of enhancements to the localdev set, and to implementation of the CM demonstration project described below. The test harness is implemented in Perl, and can be used to test any software that can be invoked via UNIX command-line. Executable test stubs can be created in any language to extend test harness support to the unit testing of components written in any language.

Test automation makes retesting of software after modification much faster and more reliable. The tests can also be more comprehensive because the results need not be validated manually. This leads to higher quality code as regression testing can be performed on a frequent, routine basis without heavy expenditure of resources. An indirect benefit of this capability is that the desired behavior of tested software is thoroughly documented by the code that performs test validation. Such details might otherwise be forgotten or overlooked.

CIRA members have been involved in research that will indicate what level of configuration/change management efficiency is possible for projects having requirements similar to the WFO-Advanced system. Primary requirements include development at multiple sites and on multiple platforms (including Linux), the ability to work simultaneously on multiple versions of software, and the ability to control and track the introduction of changes into multiple software releases. These requirements were assembled into a list of generic requirements defining a target project.

The complexity of such software and their configuration are such that it is only possible to accurately evaluate efficiency by performing a detailed, realistic demonstration of integrated software. Analysis by CIRA researchers has indicated a promising combination of software with which to perform such a demonstration: Perforce (a configuration management tool) and ExtraView (a change management tool). A change management process that would be suitable for the target project was defined, and the nature of the configuration and integration of the selected software have been identified. The software are currently being integrated onto a server in preparation for implementation of the demonstration.

EAR—WFO-Advanced Workstation

<u>Workstation Development Activities</u>

Principal Researcher: Mike Biere

CIRA researchers continued developing new capabilities for potential integration into future versions of the WFO-Advanced workstation. In particular, a number of new meteorological display capabilities were developed. The following are a few of the more notable examples:

ACARS/MDCRS profiles. ACARS (Aircraft Communication Addressing and Reporting System) provides automated weather reports from commercial aircraft. MDCRS (Meteorological Data Collection and Reporting System) is a similar system used by overseas airlines. A display of ACARS/MDCRS data was developed showing skew-T profiles from aircraft as they ascend after takeoff or descend prior to landing.

LSR (Local Storm Reports). The capability to display reports from local observers was added to the workstation display software.

Volume browser line-plot enhancements. Capability of differential zooming of line graph plots within the workstation volume browser was also developed. This allows zooming independently along either axis of the plot. A general capability of plotting meteorological variables vs. height was also implemented.

Multicast Data Distribution

A project to investigate multicasting to distribute data from a central server to individual workstations on a local area network was initiated. In a normal workstation site architecture, data is requested from a central NFS (Network File System) server by individual workstations on demand. The overhead of the NFS server, and the transmission delays are among the performance bottlenecks of existing architecture. Multicast is a push technology wherein the data is broadcast as available from a central server to many workstations simultaneously. The individual workstations then store the data locally as it is available, and the workstation displays then read it from the local disk on demand. The one-to-many nature of the multicast makes highly efficient use of network bandwidth, while storing data locally on the workstations results in considerably faster access to data than from an NFS server.

This new architectural approach to network data distribution requires considerable changes to the workstation data notifications scheme as well. For this research effort, the multicast software developed at the National Severe Storm Laboratory was used as the foundation and was modified to use the WFO-Advanced inter-process communications. A demonstration system is expected to be available early next fiscal year.

Enhancements for Range Standardization and Automation

This year, a large part of our effort was in developing WFO-Advanced workstation functionality for use by the Air Force launch ranges at Vandenberg, California and Cape Canaveral, Florida. Part of the WFO-Advanced adaptation involved the development of a specialized set of display scales tailored for the needs of each launch site. WFO-Advanced software includes a component known as localization to accommodate such localized specification. Most of the research required in adapting the workstation to the range requirements is in meeting the requirements for local data sets and specialized display capabilities unique to the mission of the ranges. See Figure 1 for an example of the Cape Canaveral map background with overlay of radar data.

The ranges have an extensive set of local weather instrumentation, not normally displayed by forecaster workstation. These include instrumented weather towers, lightning detectors, profilers, and field mills. Extensions to the WFO-Advanced LDAD (Local Data Acquisition and Dissemination) were developed to acquire these local data sets. The high temporal resolution of the tower data initially presented some problems in algorithms used to automatically update the display as new data is available. After some analysis of the problem, better algorithms were developed which have largely mitigated the problem.

Previous meteorological display research has emphasized plan-view data displays. The range users needs for plan-view displays are largely met by existing capabilities, with the addition of the local data sets. One newly developed plan-view display capability is the addition of a fast on-the-fly analysis of select point data fields. This will allow the range users to display contours of their local tower data, for example.

The range users have a more extensive set of requirements for x-y line plots than are met by existing workstations. These were implemented as extensions to the existing volume browser line plot capabilities. A flexible parameter vs. height display was designed and added. The most ambitious design extension was implementing a set of vertically stacked plots, providing a meteogram-like capability within the volume browser.

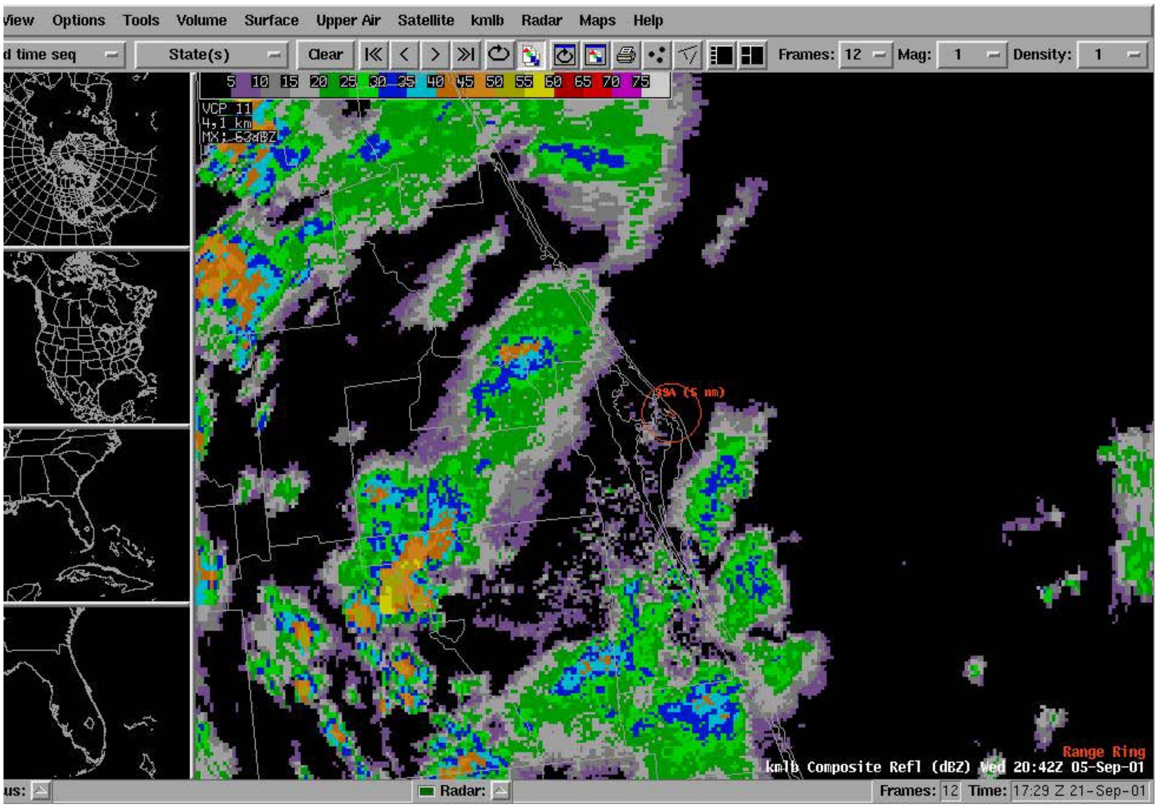

Figure 1. Cape Canaveral scale map background with overlay of radar data for range meteorological operations at Cape Canaveral, Florida (shown) and Vandenberg, California as part of the Range Standardization and Automation project.

Three-Dimensional Display Development

Principal Researcher: Phil McDonald

The Display-3D (D3D) workstation has the goal of providing an advanced meteorological workstation for operational forecasters with interactive three-dimensional visualization of atmospheric data. This year, many performance enhancements were implemented and several functional additions were designed. A new trajectory tool with a graphical user interface more consistent with the rest of D3D was also implemented.

Research on expanding D3D's capabilities to include the simultaneous display of data from more than one model was initiated. This concept of multiple data contexts has been available with Vis5D (the underlying 3D toolkit used from the University of Wisconsin), but has yet to be integrated in D3D. This capability is highly requested by D3D users and should be completed next year.

D3D now loads Vis5D's variable tables with only those variables a user requests. Previously, the variable tables were loaded with a predetermined set of variables that the user might want to use. This also limited the total number of variables from which the user could pick.

As part of the Range Standardization and Automation project, a prototype user interface and data visualization display for high-volume three-dimensional LDAR (Lightning Display and Ranging) data was developed. Figure 1 provides an example of a D3D window showing the Tcl/Tk GUI. The visualization layout contains a plan-view and orthogonal side views of lightning strikes in a presentation format similar to the LDAR display in use at Cape Canaveral. But, to aid volume visualization, a fourth panel contains a three-dimensional rendering of the data with a point of view that can be interactively manipulated by the user. See Figure 2 for an example of a 4-panel display. An associated user interface menu was developed and customized for the lightning data set. The intent of this prototype is to get early user interface requirements feedback from the users to ensure optimum functionality.

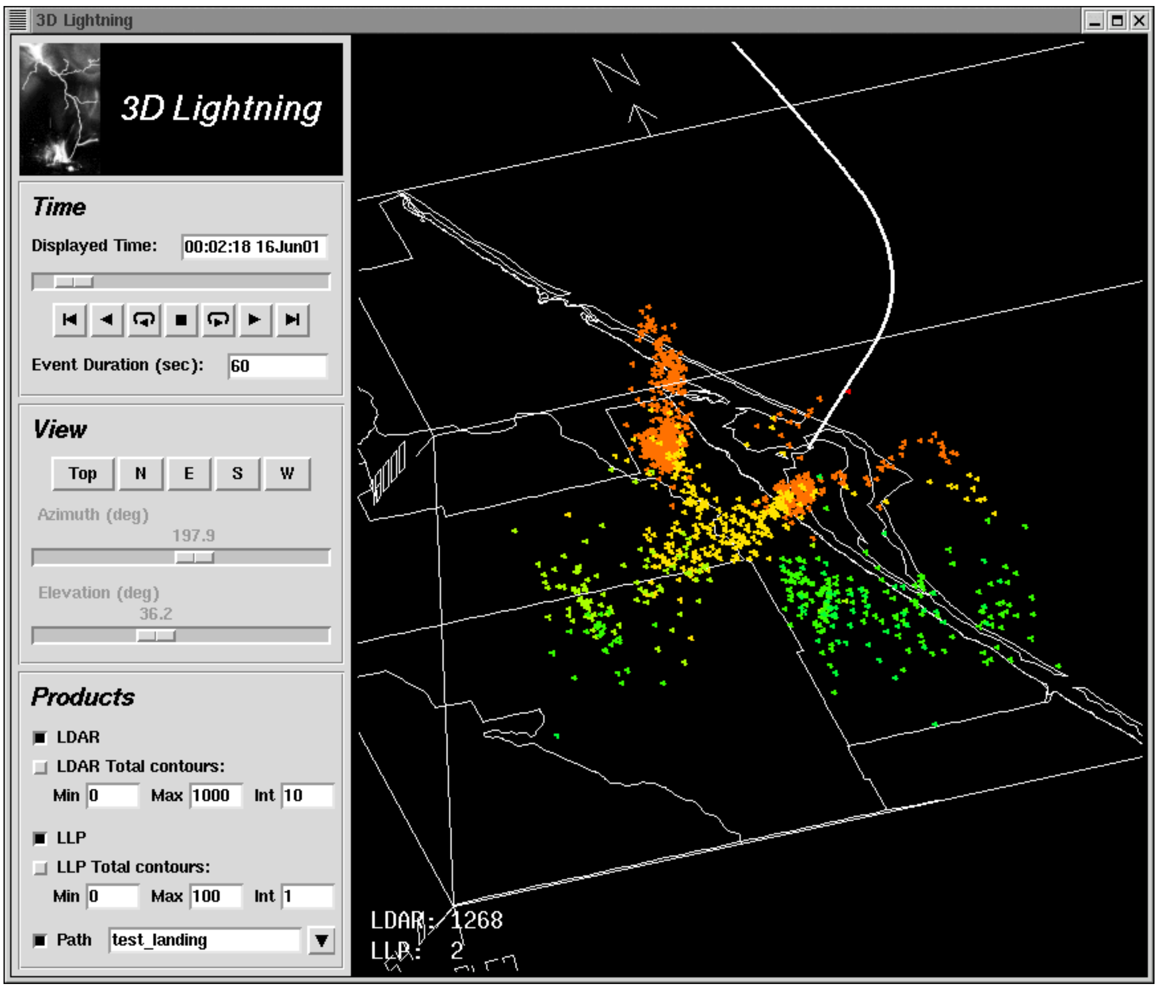

Figure 1. Actual 3D and 2D data from sensors at the Kennedy Space Center from 16 Jun 01. Small pluses ("+") are plotted at each of the lightning step leader nodes. The mostly vertical curving white line represents an actual space shuttle landing trajectory (but not from the same date). The color of each plus indicates the 3D distance of its corresponding step leader node from the trajectory. The colors are banded in 10 nautical mile increments: red 0-10nm; orange 10-20nm; yellow 20-30nm; yellow green 30-40nm; green 40-50nm.

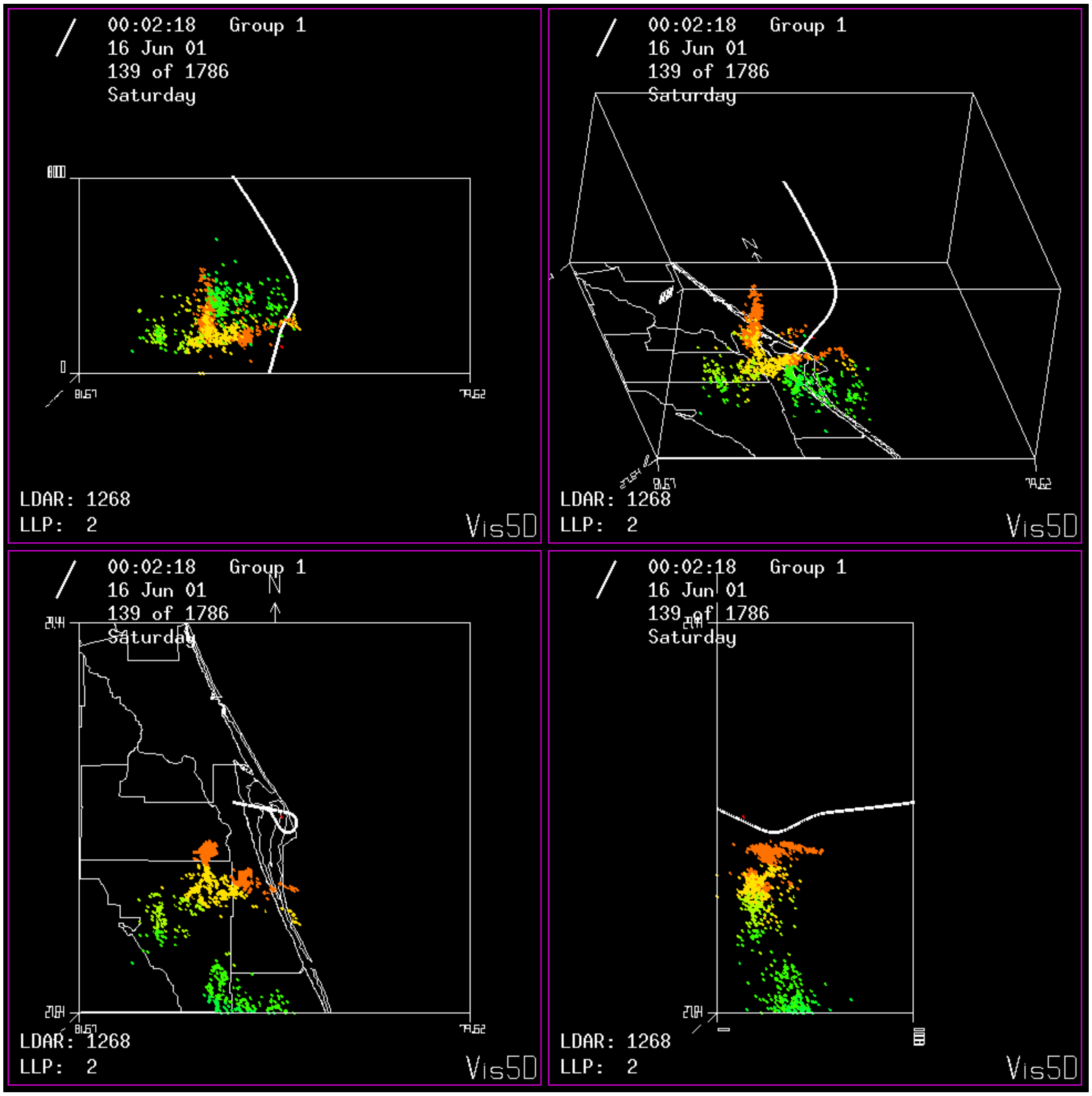

Figure 2. An example of a 4-panel display of 3D lightning data.

Local Data Acquisition and Dissemination (LDAD) Project

Principal Researcher: Christopher E. Steffen

FSL and CIRA research collaboration continued on the web dissemination component of LDAD known as the Internet-based Emergency Management Decision Support (EMDS) system. It is a web-based applet/application for use by a small number of state and local government users and/or a large number of public Internet users. The EMDS disseminates all types of weather data, including high-resolution weather analysis/forecast/model grids, radial radar grids, observations, quality control information and textual forecasts in a multi-modal GUI to a variety of users. It also allows the local and state government agencies to integrate weather information from the National Weather Service with their GIS data sets to create a personalized Decision Support System.

Through the cooperation and collaboration of the pioneering Rapid Prototyping Project (RPP) sites—Tulsa, Miami, Atlanta, Dallas-FortWorth, Iowa, and Eastern Region Headquarters—many software problems were identified/corrected and have permitted the full deployment phase of development. The EMDS should now be installed at all Weather Forecast Offices in the US. The full deployment of the EMDS is a major accomplishment for the year.

As planned, the Graphical Forecast Editor (GFE) grids are now disseminated via the EMDS. Likewise, better compression was implemented for grids. A large amount of documentation for the ingest and software components was also generated.

In addition to the effort on the EMDS, a project researching the feasibility of using rounding, differencing, and either bzip2 or gzip to compress model grids before transmission over the satellite broadcasting network was initiated. Investigation pointed to rounding, differencing, and bzip2 as the best approach. It compressed floats by about 10:1 which was about 3 times better than GRIB1 is currently doing. While more research could be done to improve the compression ratio, the wavelet compression method Ning Wang investigated appears to be the best approach. Compression of 50 to 1 was achieved, which is about 16 times better than GRIB1 is currently doing.

Next year's plans include completing the HPCC proposal to implement a surveillance capability within the EMDS and to demonstrate the use of the EMDS over a cell phone link.

EAR—Data Systems Group

Principal Researcher: Christopher MacDermaid

CIRA researchers in the Data Systems Group continue to design and develop the real-time meteorological data acquisition and processing systems in collaboration with FSL and CIRES scientists, researchers and developers. Multiple computers operate in a distributed, event-driven environment known as the Object Data System (ODS) to acquire, process, store, and distribute conventional and advanced meteorological data. These data are provided to scientists and developers who use it in various modeling, application, and meteorological analysis/forecast workstation research and development activities. The ODS data flow schematic is shown in Figure 1. Users access raw, translated, and processed data according to their needs.

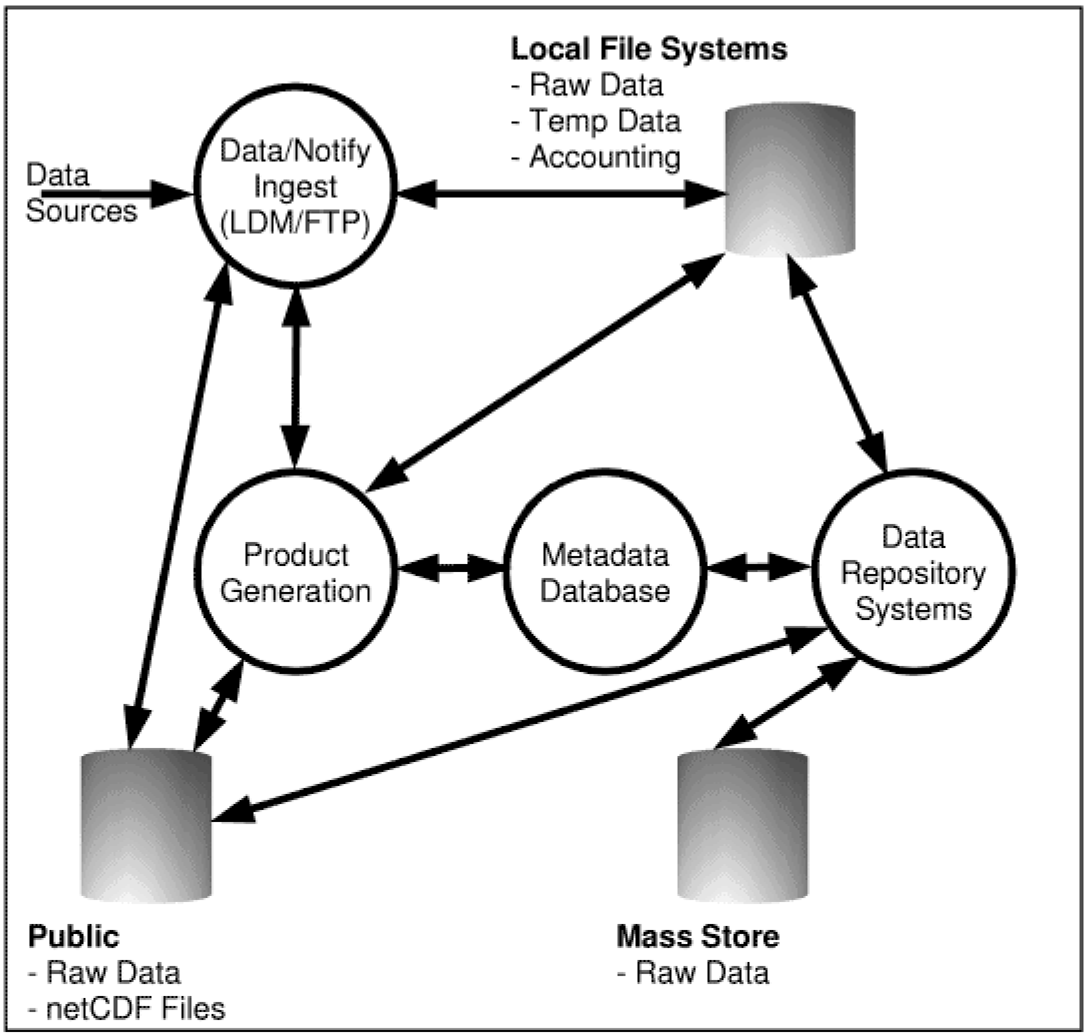

Figure 1. Object Data System

Data are received from operational and some experimental sources that include:
--The National Weather Service (NWS)
  -NOAAPORT
  -The National Centers for Environmental Prediction
  -WSR-88D Doppler radar
--Aeronautical Radio Inc. (ARINC)
--Weather Services International Corporation (WSI)
--The Forecast Systems Lab (FSL) Demonstration Division
--The Geostationary Operational Environmental Satellite (GOES)-8 and GOES-10
--The National Center for Atmospheric Research (NCAR)
--Meteorological Assimilation Data Ingest System (MADIS) data providers

Real-time data are also distributed to several external organizations using the Unidata Local Data Manager (LDM) protocol. Distributed data sets include:
--GOES imagery to the NOAA Environmental Technology Laboratory (ETL)
--Wind profiler data to University Corporation for Atmospheric Research (UCAR) Unidata program
--Quality controlled Aircraft Communications Addressing and Reporting System (ACARS) data to NCAR and a number of government agencies as well as universities

Data Acquisition

Meteorological Data

Design and development of subsystems for the ingest and processing of Doppler radar and geostationary satellite data continued. These data are used by various meteorological analysis and modeling applications, both internally and by external university and private organizations. Suite of satellite imager and sounder products are produced in network Common Data Form (netCDF) format. ACARS processing software was updated to handle several additional formats.

Data Processing

ODS Improvements/Upgrades

Software was designed and developed to streamline the acquisition and processing of point, radar, and satellite data. This new software was created using OO methods to reduce required maintenance and to allow for the generic handling of data types.

Facility Information and Control System (FICS)

FICS Monitor changes were implemented to account for the arrival of a variety of new data sets. Scripts were developed to monitor operation of the High Performance Computing System (HPCS) Mass Store System (MSS).

A new, more flexible method of monitoring LDM servers was developed.

R*eal-Time Advanced Weather Interactive Processing System (AWIPS) Data Processing*

Several new Linux data servers were implemented. Numerous Local Data Acquisition and Dissemination (LDAD) data providers were added as part of two collaborative research projects—the International H_2O Project (IHOP) and the NOAA New England High Resolution Temperature and Air Quality Forecasting Pilot Program (TAQ).

In collaboration with the FX-Net project, several data severs were customized for the display of data for the TAQ, IHOP, and Fire Weather projects. Associated FICS monitoring and troubleshooting procedures were developed to monitor these systems.

Data Storage and User Access

Data Repository System (DRS)

DRS included the continuing development of the centralized metadata database. This metadata database will improve metadata reliability and expedite user access to metadata.

Real-Time Data Saving (RTNDS)

RTNDS was improved and functionality was added to give users greater reliability and increased throughput.

Data Storage and Retrieval System Support (DSRS)

For efficiency purposes, and to work around problems when accessing the HPCS MSS via NFS, an alternate access method was developed and implemented.

A Look Ahead

Design and development for new and modified data sets will be an on-going activity. Use of ODS applications and methods will expand as legacy translators and product generation methods are replaced by new generic techniques. OO software development for point data will continue.

Research into replacing the aging NOAAPORT ingest system with a Linux based system will be completed. Candidate systems will be evaluated for optimum performance and reliability.

Design and development will continue on creating an automated “archive search” system for generating meteorological review cases to quickly permit researchers to obtain past weather events for examination.

Metadata handling techniques for use with Grid in Binary (GRIB) data sets is planned for implementation for real-time data processing. An automated system for acquiring and incorporating digital metadata is part of this plan. Further research will be conducted on the interactive interface that allows for easy query and management of the metadata content. Program interfaces will be added to allow for secure controlled data access. Retrospective data processing and metadata management are slated for incorporation.

Refer to http://www-fd.fsl.noaa.gov/dsg/ for additional information on DSG.

Investigation of Boundary Conditions and Numerical Methods for Littoral Flows

Principal Investigator: Gerald Browning

A well-posed, open boundary multiscale ocean model is being developed for ONR. A simple and computationally efficient model has been developed to demonstrate the accuracy and stability of the open boundary treatment. Preliminary results from this model have shown the feasibility of this approach. Theoretical work on a remaining issue in multiscale atmospheric dynamics will be conducted. The feasibility of accurate and stable open boundary conditions for a model based on the well-posed reduced system for oceanography will be completed during the coming year.

Link between Local Landscape Heterogeneities and Weather—RAMS Large Eddy Simulations

Principal Investigators: Roger A. Pielke Sr., Adrian Marroquin, and Giovanni Leoncini

RAMS Large Eddy Simulation (LES) Project

The main objective of this effort is to investigate the influences of the surface heterogeneities (terrain, soil moisture, soil type, vegetation, land use, etc.) on the boundary-layer circulations. In particular, we test the ability of RAMS to describe these interactions, and the possible use of RAMS as a forecasting tool in a large eddy simulation (LES) configuration for assessing the impact of dangerous pollution dispersion events on short notice. The model results are verified using lidar data provided by the Lake-Induced Convection Experiment (Lake-ICE) project (Web page http://lidar.ssec.wisc.edu/experiments/wisc98/jan).

The Lake-ICE 19 January 1998 case selected for this study was run with RAMS in an LES configuration. The RAMS-LES domain of the innermost grid (three-grid nested system), used in the simulation, covers an area 10 km x 10 km (50 m grid spacing). The initial and boundary conditions for this case were taken from the National Centers for Environmental Prediction (NCEP) reanalysis data. The surface conditions were defined using the United States Geological Survey data. The qualitative verification of the results (comparison of LES results with the Lake-ICE animations) showed that adjustment of the initial and boundary conditions were necessary to bring the LES results in close agreement with the observations. This experiment shows the need to initialize the model with observational data at spatial scales compatible with LES. Our general conclusion is that the RAMS model is capable of describing the planetary boundary-layer evolution despite the coarse initial and boundary conditions, and that, given the proper computer resources and local fine-scale observations, it is possible to use the LES model configuration as a forecasting tool.

A web document was prepared for the annual CG/AR review that was held at White Sands, New Mexico on 12 December 2001. This presentation can be viewed on the web at http://pielke.atmos.colostate.edu/report. Also, results were presented at a CG/AR seminar on 24 March 2002 at CSU.

A draft of the paper "A Large Eddy Simulation of a Lake-ICE Case Using RAMS" was prepared and submitted to the electronic journal "Earth Interactions". Animation graphics software (idl-based) was implemented to provide figures for the paper. These animations can be viewed on the website http://blue.atmos.colostate.edu/ by clicking on the Image Gallery.

Pressure Gradient Forces: Theory and Parameterization

The objective of this effort is to investigate issues concerning the parameterization of the pressure-gradient force term in hydrostatic and nonhydrostatic models, especially when diabatic sources are included.

Work commenced to implement the Dalu et al. technique (Dalu et al., 2002) to assess hydrostatic and nonhydrostatic effects, and linear and nonlinear effects associated with heterogeneous boundary-layer flows. RAMS will be run first on a flat terrain with a lake in it as a heat source. Then, the model will be applied to the Lake-ICE case described above.

Modifications to the RAMS code have been suggested aimed at expanding the model capabilities to include the option of modifying the initial and boundary fields to perform experiments related to error propagation and data assimilation.

In order to implement the technique presented by Dalu et al. (2002), two routines were developed and tested so that RAMS can now perform linear advection and the user can input surface fluxes with different time and spatial scale. Since RAMS equation set differs from the one used in Dalu et al., the same calculations of Dalu et al. are being carried out to compare RAMS contribution to pressure gradient force with the simplified set of equations utilized in the above mentioned paper.

Reference:

Dalu, G.A., M. Baldi, and R.A. Pielke, Sr., 2002: Mesoscale nonhydrostatic and hydrostatic pressure gradient forces: theory and parameterization. *J. Atmos. Sci. (submitted).*

Radar Remote Sensing of Marine and Continental Stratus Clouds

Principal Investigator: Shelby Frisch

Objectives

The quantities that are needed for instantaneous atmospheric radiative flux calculations with clouds present are the cloud boundaries, liquid water profiles and the effective radius of the cloud droplets. In addition, we are looking at the cloud variability and seeing how this variability may cause problems in models. The objectives of these studies were to supply radar derived estimates of these quantities from available data sets such as data taken at the CART site at the North Slope of Alaska, SHEBA, and the cloud radar on the NOAA research ship Ron Brown.

Approach

During the last year, most of the effort involved setting up the stratus cloud drizzle retrieval from cloud radar measurements. This retrieval uses the first three moments of the Doppler spectra and retrieves the drizzle properties from a 3-parameter log-normal model of the drizzle droplet distribution. Some data from the FIRE Artic Clouds Experiments, the North Slope of Alaska cloud radar, and a cloud radar on the NOAA research vessel Ron Brown are being processed. The analysis of the shipboard cloud radar is more complicated since the ship motion can add errors to the Doppler moments. There are motion sensors on the ship, and information from them will be used to determine the amount of error in the drizzle retrievals.

Results

Some earlier non-drizzle results have been published in refereed journals. One showed the results of comparisons between in-situ FSSP measurements and radar retirevals of stratus cloud effective radius. Another article was from retrievals of stratus cloud properties determined during SHEBA. A third article involving radar observations of clouds has been submitted to a refereed journal.

Publications

Shupe, M.D., T Uttal, S.Y. Matrosov, and A.S. Frisch, 2001: Cloud water contents and hydrometeor sizes during the FIRE Artic Clouds Experiment. *JGR* 106,15,015-15,028.

Frisch, A.S., M. Shupe, I. Djalalova, G. Feingold, and M. Poellot, 2002: The retrieval of stratus cloud droplet effective radius with cloud radars. *J. Atmos. and Oceanic Tech*. 19, 835-842.

Reinking, R., D. Korn, A.S. Frisch, B.W. Orr, L.R. Bissonnette, and G. Roy, 2002: Observations of effects of mountain blocking on traveling gravity-shear waves and associated clouds. *Weather and Forecasting (submitted).*

Studies of the Stable Boundary Layer during the Cooperative Atmosphere/Surface Exchange Study – 1999 (CG/AR)

Principal Investigator: Rob Newsom

The overall goal of this project is to increase our understanding of the nighttime stable boundary layer (SBL) through analysis of field data obtained during the CASES-99 experiment. The Center for Geosciences/Atmospheric Research (CG/AR) in cooperation with the NOAA Environmental Technology Laboratory (NOAA/ETL) deployed ETL's High Resolution Doppler Lidar (HRDL) to the CASES-99 field site near Wichita, Kansas. After participating in planning and preparation, a highly successful field project was completed in October 1999. HRDL recorded approximately 200 hours of data during 15 days of operation, including 12 intensive operation periods (IOPs). This extensive dataset contains measurements of radial velocity and aerosol backscatter showing excellent examples of nocturnal low-level jet (LLJ) behavior, gravity waves, shear instabilities, density currents, drainage flows and turbulent eddy formation. Our efforts are focused primarily on the analysis and interpretation of HRDL data. During the previous year, numerous case studies have been performed in close collaboration with other CASES-99 researchers. The research described here is being conducted in the context of broader efforts to develop improved turbulence parameterizations for the stable nocturnal boundary layer.

Combined analyses of in-situ and HRDL data indicate that turbulent mixing in the stable nocturnal boundary layer is controlled in large part by the vertical wind shear that initially develops during the evening transition period as the flow aloft decouples from the surface layer due to reduced stress. Decoupling allows the winds aloft to accelerate to super-geostrophic speeds, depending on the degree of ageostrophic departure prior to sunset. This results in the formation of the LLJ. The strength and height of the LLJ controls the vertical shear and thus the turbulence within the stable boundary layer. Thus, we have devoted considerable attention to understanding the dynamics of the LLJ.

HRDL proved to be particularly effective at documenting the structure and evolution of the LLJ. Last year, we conducted an initial study of LLJ characteristics (e.g. jet speed, height, direction, etc.) observed during the CASES-99 field program. Using HRDL data, the speed, height, and direction of the LLJ were determined and the frequency of occurrence, the spatial distribution, and the evolution through the night, of these LLJ characteristics were investigated. The jet of interest in this study was that which affects the shear and turbulence below the jet and near the surface, and thus was the lowest wind maximum. This wind maximum, which was most often between 7 and 10 m s^{-1}, was generally at or below 100 m AGL as measured by HRDL at the CASES central site.

The structure and evolution of the LLJ varied considerably from night to night, presumably due to the strong influence of mesoscale phenomena. One goal of this study is to understand how mesoscale events affect (or are affected by) turbulent transport within the SBL. Thus, we have recently begun to examine the larger scale factors affecting LLJ formation during the evening transition period. Specifically, we are comparing LLJ characteristics on six nights to ageostrophic winds and boundary layer depth just prior to sunset, and radiative cooling rates near sunset. We are also examining the effects of baroclinicity and changing geostrophic winds on the LLJ. This is a challenging problem because of the difficulty in computing accurate and reliable estimates of the geostrophic wind profiles. However, preliminary results indicate that baroclinicity is significant and that this may explain some apparent anomalous behavior in the LLJ observed on some nights.

Other studies performed under this project include a detailed examination of the evening transition period on 20-21 October 1999, a gravity wave event on the morning of 14 October 1999, a comparison of techniques for estimating gravity wave characteristics, and surface layer streaks under neutral and weakly stable conditions.

Investigation of Stress and TKE Profiles in the Convective Boundary Layer using Wind and Thermodynamic Retrievals from Single-Doppler Lidar Data (NSF)

Principal Investigator: Rob Newsom

The purpose of this study is to investigate the use of four-dimensional variational data assimilation (4DVAR) techniques for retrieval of wind and temperature fields from Doppler lidar data. Retrieved fields are analyzed in order to study profiles of TKE and stress under typical daytime convective conditions. To date, much of the emphasis in this study has been placed on the development and validation of the 4DVAR technique.

A Doppler lidar measures the component of air velocity parallel to the beam (radial velocity) as a function of distance along the beam. Spatially and temporally resolved measurements of radial velocity can be performed by repeatedly scanning the beam through a volume of the atmospheric boundary layer. A 4DVAR algorithm, implementing the adjoint of a large eddy simulation has been developed for the purpose of retrieving three-dimensional, time varying wind and temperature fields from Doppler lidar volume scan data. The algorithm consists of finding the optimal initialization of a set of prognostic equations (forward model), which minimizes a cost function. The cost function is a measure of the error between the observed radial velocity field and the radial velocity component of the forward model output. The initial conditions of the forward model are treated as control parameters, which are adjusted to minimize the cost function. Efficient minimization of the cost function is achieved using the so-called adjoint method.

During the early phase of this project, efforts focused on acquisition of appropriate Doppler lidar scan data and development of the 4DVAR code. Data for this project was obtained by taking advantage of field deployments funded under other projects (i.e. CASES-99). The 4DVAR code was modeled after Jenny Sun's (NCAR) original algorithm. That original algorithm was designed for radar data and several modifications were required in order to assimilate lidar data. During the past year, several new features have been added to the original algorithm. This includes a variable eddy viscosity and an improved data ingest scheme.

A new variable eddy viscosity scheme has been incorporated in order to more accurately model profiles of TKE, Reynolds stress, and heat flux. In the original 4DVAR algorithm, eddy diffusivities were assumed to be constant. The current implementation uses a simple, non-local scheme based on the work of Troen and Mahrt (1986). The momentum and heat diffusivities are modeled as height-dependent functions with several adjustable parameters. Thus, both the initial conditions and the free parameters in the eddy diffusivity profiles are adjusted to optimize the agreement between the model output and the lidar observations.

The use of a simple, height-dependent eddy diffusivity function has several advantages over more complex methods based on local values of the strain rate (Smagorinski) or non-local schemes based on the prognostic TKE equation (Deardorff). The major advantage is in the relative simplicity and lower computational cost of the adjoint equations.

An improved data ingest scheme has also been incorporated into the 4DVAR algorithm. This new scheme allows for more direct input of the lidar scan data and eliminates the need for interpolating the lidar data to the model grid prior to input. In the new data ingest scheme, the model output is spatially and temporally interpolated to the coordinates of the lidar measurements. This has advantages since the lidar measurements are often much more sparse (particularly in time) than the model output. Also, the new scheme more accurately represents the effects of spatial and temporal averaging inherent in the lidar returns.

Figure 1 shows an example of retrieved perturbation velocity fields using the 4DVAR method. For this example, data were acquired under convective conditions during the afternoon of 25 October 1999 at the main CASES-99 site, near Leon, Kansas. The NOAA High Resolution Doppler Lidar (HRDL) provided radial velocity data from repeated volume scans of the boundary layer. Volume data were acquired using a raster scan technique in which the laser beam scanned a 60^{o} sector in a sequence of elevation angles ranging from 0^{o} to 20^{o}. The retrieval algorithm converged to an optimal set of initial conditions after approximately 20 to 30 iterations (corresponding to 20 to 30 integrations of the adjoint equations).

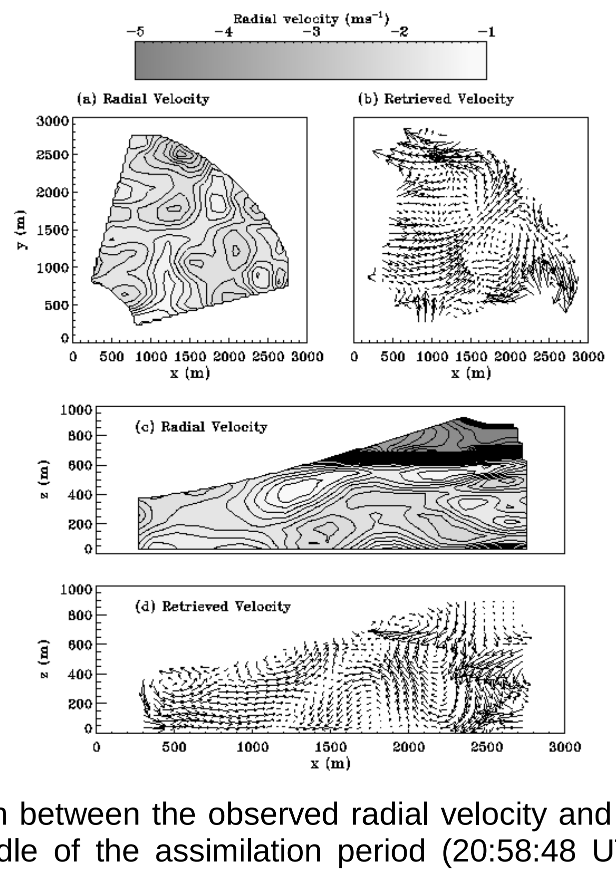

Figure 1. Comparison between the observed radial velocity and retrieved perturbation velocity from the middle of the assimilation period (20:58:48 UTC). (a) and (b) are horizontal cross sections at z=300m AGL. (c) and (d) are vertical cross sections at y=1000 m.

CIRA/FORT COLLINS

CIRA Infrastructure Group

Group Manager: Michael Hiatt

Members: Michael Hiatt – Group Manager/Engineer
Karll Renken – PC Technician
Dale Reinke (Part-time Software Support)

The Infrastructure Group provides all planning, deployment, support, and maintenance for both CIRA's infrastructure and CIRA's earthstation. The infrastructure continues to grow and now has more than 150 servers and workstations completely built and maintained by this group. The earthstation provided another year of excellent GOES, AVHRR, and Meteosat data with 98% reception quality. Beyond operations and maintenance, the Infrastructure group also developed new capabilities and innovations. Listed are key items pertaining to the group's activities:

Infrastructure

--Provided all central services including e-mail, WWW, FTP, accounts, accounting, DHCP, DNS, printing, dialup, central security, and property accounting
--Managed CIRA subnet, LAN/WAN, and associated switching hardware
--Managed 21 fund budget and expenditures
--Maintained/Upgraded 50 Servers and 115 Workstations
--Performed miscellaneous software upgrades–Windows 2000 SP2, security updates, etc.
--Provided technical support for the following groups/projects: RAMM, NPS, Bacimo, AMSU, Geosciences, CHANCES, CloudSat, Students
--Provided student support and visiting scientist support
--Provided technical expertise for CLOUDSAT and Geosciences programs
--Continued security monitoring and software patches
--Expanded CIRA subnet to accommodate growth
--Provided computer user support and training for 130 users
--Networked new ACRC building
--Developed camera security system and monitoring software "Motion Analysis" for CIRA security system. This system deploys 13 security cameras in ATS/CIRA and saves the appropriate images.
--Investigated DVD writers and in-house engineered data archive solutions
--Upgraded primary servers to Pentium 4 technology
--Maintained software licenses for Windows network
--Setup CIRA subnet .109.
--Deployed first CloudSat systems and provided technical expertise during contract phase
--Expanded Linux cluster to 24 node system and added mass storage unit
--Evaluated Windows and Office XP and created strategic plan for deployment

--Final Windows NT systems upgraded to Windows 2000
--All older AT type computers updated to ATX systems
--Deployed central antivirus package for email and system security
--Web: Infrastructure/Earthstation updates
--Web: Infrastructure/Earthstation user help
--Power outage report and response plan

Earthstation

--Continued satellite earthstation operations for GOES-8, GOES-10, NOAA-14, NOAA-15, Meteosat-5, Meteosat-7, and EMWIN. This data collection effort amounts to approximately 60GB/day and 25 servers. CIRA's collects and archives all data transmitted by each satellite. This represents a significant amount of resources and manpower. CIRA successfully collected 98% of all data transmitted and archived 97% of that amount.
--Only site to collect GOES-11 special experiment data.
--Provided technical lead on AMSU repair and rebuild
--Provided EMWIN support to CIRA and City of Fort Collins
--Provided technical assistance for ATS/CIRA Suminet system
--Moved entire earthstation to CIRA building and then into new ACRC for construction phase
--Developed fast image browser to allow quick quality assurance of Earthstation imagery. Excerpts of this code developed into complete JPEG image viewer called DigiVital.

Development of Advanced Applications Products using AMSU Data

Principal Investigators: S. Kidder/T. Vonder Haar

The Advanced Microwave Sounding Unit (AMSU), now flying on NOAA 15, 16, and 17 and on Aqua, is a major advance in microwave remote sensing. The purpose of this project is to develop advanced applications products from the AMSU data and to supply these products to forecasters for testing and evaluation.

Accomplishments This Year:

1. Did a VISIT training session on the use of POES data in forecasting.

2. Improved the TRaP technique and presented a paper.

3. With Darren McKague, began work on an AMSU-B moisture profile retrieval scheme.

Publications This Year:

Kidder, S. Q., S. J. Kusselson, J. A. Knaff, and R. J. Kuligowski, 2001: Improvements to the experimental tropical rainfall potential (TRaP) technique. *11th Conference on Satellite Meteorology and Oceanography*, American Meteorological Society, Boston, 375-378.

Vonder Haar, T. H., K. R. Dean, J. M. Forsythe, T. J. Greenwald, and S. Q. Kidder, 2001: Comparison of satellite and ground-based measurements of cloud liquid water in several climate zones. *International Geoscience and Remote Sensing Symposium* (IGARSS), Institute of Electrical and Electronics Engineers, Sydney, Australia, 9-13 July 2001, 3 pp.

McKague, D. S., R. J. Engelen, J. M. Forsythe, S. Q. Kidder, and T. H. Vonder Haar, 2001: An optimal-estimation algorithm for water vapor profiling using AMSU. *11th Conference on Satellite Meteorology and Oceanography*, American Meteorological Society, Boston, 633-636.

Technological Transfer and Validation of the CIRA Scheme for the Tropical Rainfall Potential (TRaP) Technique

Principal Investigators: S. Kidder/T. Vonder Haar

This is a follow on to the AMSU grant above. Its purpose is to compare the CIRA TRaP technique with the NESDIS technique and to transition aspects of the CIRA technique into NESDIS operations.

Accomplishments This Year:

1. Visited NESDIS colleagues at the NOAA science center, gave a seminar about the CIRA TRaP technique, and discussed ways to transition CIRA techniques into NESDIS operations

2. Revised the CIRA TRaP technique slightly to make it easier to compare NESDIS TRaPs with CIRA TRaPs.

3. Data continue to be collected for the 2002 hurricane season.

CENTER FOR GEOSCIENCES/ATMOSPHERIC RESEARCH
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A New Method of Noise-agile Data Assimilation for Over-sampled Data

In the last year Dr. Andrew Jones developed a computationally efficient discrete Backus-Gilbert (BG) method that is appropriate for resolution-matching applications using over-sampled data. The method builds upon existing BG methods and approximation techniques to create a modified set of BG coefficients. The method in its current form is restricted to a resolution-only minimization constraint but, in the future could be extended to use a simultaneous noise minimization constraint using a generalized singular value decomposition approach. A theoretical 1-D inter-comparison is performed using a hypothetical sensor configuration. A comparison of the discrete BG method with a non-discrete BG method shows that the new approach can be 250% more efficient while maintaining similar accuracies. In addition, a singular value decomposition approximation increases the computational efficiencies an additional 43% to 106%, depending upon the scene. Several quadrature methods were also tested. The results suggest that accuracy improvements are possible using customized quadrature in regions containing known physical data discontinuities (such as along coastlines in microwave imagery data). The ability to re-compute the modified BG coefficients dynamically at lower computational cost make this work applicable toward applications in which noise may vary, or where data observations are not available consistently (e.g., in RFI contaminated environments).

The last finishing touches have been made to the CHANCES global cloud climatology production software prior to their delivery to the USAF/AFWA. This 5 km resolution, global, hourly dataset will be used for mission planning and sensor studies and will provide the military with the highest resolution cloud cover database available today. Its basis is a composite of all geo and polar orbiting weather satellites – US and foreign.

Many cloud clearing and cloud detection algorithms use surface temperature (SST and land) to discriminate between cloud and background clutter. Don Reinke has developed a new algorithm that uses thermal rate-of-change instead of a static temperature threshold in the cloud detection process.

Don Reinke modified the CHANCES infrared cloud detection algorithm to compensate for the lack of USAF surface temperature database data for almost 4 of the 12 months of the 1999-2000 data period. The surface temperature data was either missing (over 3 months) or unusable (approximately 1 month).

The new algorithm produces an infrared (temperature) background from the IR data itself, using a technique that is similar to the time-tested visible background technique. The primary difference is that we produced a background over a 10-day period to minimize the impact of short-term cold or warm periods on a longer period (i.e. 1 month period that is used for visible data). The new algorithm was tested on a full month of data over several regions of the globe and, after some minor tuning, will be used on the remaining months that are devoid of USAF surface temperature data.

In addition to revising the IR cloud/no cloud detection routine, He is now able to build two additional products: a snow/ice product and a diurnal change Cloud/No Cloud (CNC) product.

The snow/ice product is built by examining the IR backgrounds over the full 24-hour diurnal cycle to identify the pixels that do not change temperature and are colder than a threshold temperature that would indicate a frozen surface. The assumption is that land will follow a diurnal warming/cooling pattern, and water will be much warmer than the cold threshold.

The diurnal change CNC product is built by examining the change in the IR background from one hour to the next and comparing that with the change in the actual imagery. The assumption here is that a ground or water pixel will change in concert with the derived background, while a cloudy pixel will remain at a nearly constant temperature. Conversely, if the background would suggest that a land or water pixel should remain relatively constant in temperature, and the pixel shows a marked increase or decrease, we can assume that a cloud has moved into or out of the field of view. This technique has done a very good job of identifying the formation and dissipation of cloud along the edges of cloud masses.

In order to develop and test this new technique, he designed and built a software system to build and test new applications that will be used to construct “Regional Cloud Products”. The system contains all of the applications that have been developed to produce the global CHANCES CNC products plus a formalized suite of applications to build products that have been produced, on a case-study basis, from the CHANCES database. The list of products include:

1. Cloud/No Cloud “QA” file output (I have modified to the original 1-byte QA output to a 2-byte output that now includes additional data flags for land/water, snow/ice, day/night, sun glint, the diurnal cloud test, and the new ir background test)
2. Frequency of Occurrence of cloud (% cloud cover for a month)
3. Persistence Probability (1-24 hour range, “if cloudy at hour A, what is the probability that cloudy conditions will persist through hour B)
4. Conditional Probability of Cloud (1-24 hour range, “if cloudy at hour A, what is the probability that it will be cloudy at hour B [not necessarily ‘persistent’])
5. PDF of cloud parameter (can produce Probability Density Function graph for any cloud parameter in the QA file … normally the frequency of occurrence of cloud)

CIRA started running Dr. Darren McKague’s profiling retrieval algorithm on AMSU data. It promises to be more accurate than other profile retrieval methods because it will allow other data to be used as ancillary data, thus constraining the results, thus improving its accuracy.

This Optimal Estimation profiling algorithm has been implemented near real-time with AMSU data. Co-located AMSU-A and AMSU-B microwave brightness temperatures are being used to simultaneously retrieve profiles of temperature and water vapor along with surface emissivity and liquid cloud water path over ocean. Based upon analysis of the near-real time retrievals, the number of retrieval levels and the form of the regression for the first guess profiles have been changed to achieve less random and systematic error in the retrieved profiles.

Development of the technique over land is near completion. Once fully tested, it will be incorporated into the over ocean, near real-time AMSU processing.

New Neural Network Research

Our neural network research has made a breakthrough. In the past, the neural network was trained with manually-analyzed cloud images for the standard cloud types (i.e., clear land, clear water, CU, ST, CI, etc.). Although this method gave very good results, it was limited by the training set. Those who have built training sets know it is a long and labor-intensive process. Training sets that cover the globe for all seasons, cloud types, time of day, and solar illumination conditions, etc. do not exist. As a result, we embarked on using the conventional surface data sets as the training sets. Taking that approach, we failed because of the different viewing angles between surface observer and the satellite sensor. But reframing the problem has yielded surprising results. Our new approach is to allow the neural network to type the clouds in an unsupervised process and then apply the surface data to define the types generated by the neural network. This method shows surprising skill at detecting cloud layers.

Continued work with the idea of using the surface observation as truth to train the neural network classifier and then using the trained system to determine the class label of different mixed cloud types and finally estimate the cloud-base only with satellite data. Various methods were tried to mitigate the discrepancy between surface observation and satellite imagery in the hope of purifying the training data set.

A conclusion has been reached in conjunction with the researchers at CIRA that the discrepancies between satellite imagery and surface observation results limited the use of surface observation as truth during the training. As a result, a new research direction was proposed, which will be the main research thrust for the next phases of the project. Specifically, the idea is to first segment the cloud images into a number of classes by using the textural features as well as correlations between neighboring blocks. As a consequence, each block in the image will be assigned a label. In the second step, the estimation of cloud base of each block will be given by looking at reports from its neighboring surface observation stations that have the same label.

A method based on Dempster-Shafer evidential theory was tried. Theoretically, the D-S evidential theory fits the problem very well, i.e., it can deal with the discrepancy between the satellite imagery and surface observation by building in some uncertainty measure into the classifiers. Although, the results so far have not been encouraging a more elaborate investigation is needed in the future.

Following the new research direction, a method that uses SOM (Self-Organized Map) neural network was tried. In this method, SOM is trained over all the blocks that have corresponding surface observations. After training, a segmentation process is performed on every image. Then a voting mechanism is adopted to give the cloud base estimation. Though this method is still in its initial stage and more investigation and improvement is needed, it did show some promise on the tested data. On images with less complexity of cloud distribution, the Correct Classification Ratio (CCR) varied from 65% to 83%. The average CCR for those complicated images was around 40%. Future work should concentrate on analysis of the centroids to account for the variation in CCRs. The other efforts will be devoted on developing a mechanism to deal with the case where none of the neighboring surface observation has the same label as that of the block under investigation.

Table 1. Overall Correct Classification Ratios on a Sequence of Images at 18:00 UTC - Days 182 to 212, 1998.

182	183	184	185	186	187	188	189
0.4098	0.2887	0.4966	0.4191	0.4857	0.8189	0.6475	0.5766

190	191	192	193	194	195	196	197
0.5435	0.6792	0.6074	0.4961	0.6133	0.5245	0.4621	0.5789

198	199	200	201	204	205	206	207
0.5520	0.7652	0.7447	0.6286	0.4958	0.5085	0.5968	0.4685

208	209	210	211	212
0.5319	0.4394	0.6439	0.7016	0.5287

Have been invited to present the paper entitled "A Pixel-based Temporally Adaptable Approach For Cloud Classification" by Jianqi Wang, Mahmood R. Azimi, Don Reinke and Thomas H. Vonder-Haar, at IGARSS 2002, June 24-28, Toronto, CA.

CLEX Field Experiment

After much planning and preparation, CLEX-9 was conducted from October 8 to November 4, 2001. The primary observational tool was the University of Wyoming King Air (WYKA) that was outfitted with microphysical probes, radiation probes and 95 GHz Doppler Cloud Radar (Wyoming Cloud Radar – WCR). There was also a ground site at North Platte, NE that included two dual-frequency radiometers, a micropulse LIDAR, radiation station, and a radiosonde/theodolite system.

Please see the following CIRA CG/AR Internet web page for a detailed summary of results. Click on individual days to see operational details.

http://www.cira.colostate.edu/GeoSci/CLEX/clex_main/CLEX9/clex9_main.htm

There were eight operational mission days, nine missions (both over the North Platte ground observation site and Lagrangian flights over NE/WY area), and 38 WYKA flight hours. One of the highlights of the operations was a dual-flight (SPEC Learjet and WYKA) mission over the North Platte area.

Preliminary results confirm the primary observations of CLEX-5 and -7. Nearly every cloud sampled had a liquid water peak at cloud top and an ice water peak lower in the cloud and often near cloud base. This has very important implications for aircraft and UAV icing, cloud radiation budget, lifecycle and microphysical parameterizations in cloud models.

A primary focus of CLEX-9 was to try and understand the sunrise dissipation of a large fraction of mid-level clouds that was seen in past experiments and in satellite climatology. Several successful missions began prior to sunrise in order to gather data on this effect (e.g., November 2, 2001).

All of the data comprising the CLEX-9 raw data set was received, inspected and archived. These data include: The University of Wyoming King Air Research Aircraft data (airborne cloud radar, atmospheric state measurements, microphysical data and radiation data); microwave radiation data collected at the CLEX-9 surface site at North Platte, NE by NOAA ETL; and data collected by CIRA – CSU Department of Atmospheric Science (Micro-Pulse Lidar, radiation budget, IR-interferometric data and radio theodolite soundings). Initial quality control and analysis have begun.

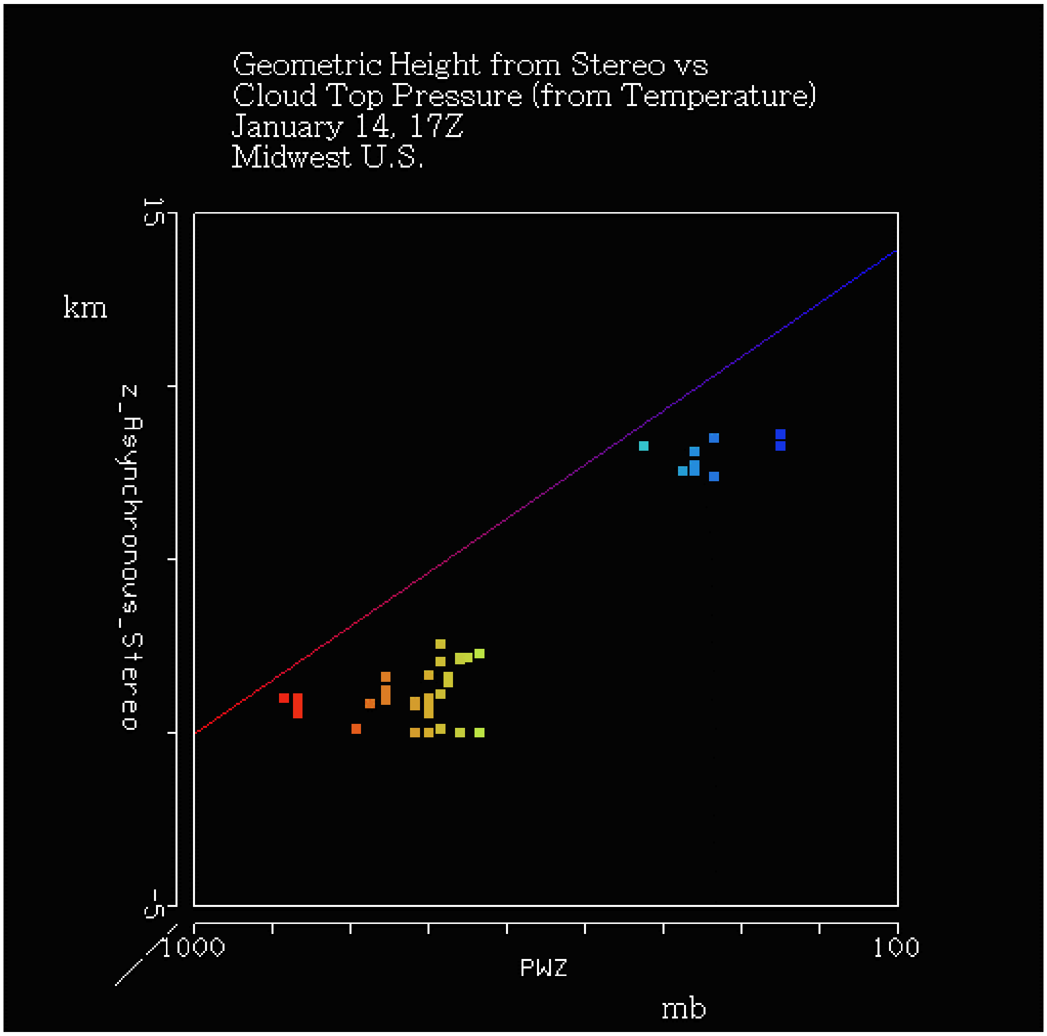
Cloud Drift Winds

This research effort was initiated as a joint NESDIS/DOD research area. Although we had developed a time adjusted stereoscopic method many years ago, we had never fully automated the process because of a problem with automatically selecting cloud features to run the geometric calculations on. That problem has now been overcome.

An automatic procedure has now been developed which grabs automatic wind vectors calculated at University of Wisconsin at Space Science and Engineering (SSEC). These vectors are used to initialize the cloud search procedure and then the stereo analysis is preformed. This is now an automatic procedure and can be used to validate the cloud top temperature based heights in the standard WINDCO analysis.

This new analysis procedure has been developed in JAVA with VisAD. In a test it has been ported from the development Windows platform to Unix with no trouble.

Figure 1 shows the results of one case, over the mid west on January 14. 2002.



4 Dimensional Data Assimilation Research

Our 4DDA team started Level 0 testing of RAMDAS (Regional Atmospheric Modeling and Data Assimilation System). This testing involved using full mesoscale model and associated adjoint in the 4D variational data assimilation algorithm but with model generated 'observations'. The tests that were performed so far were all successful. For example, 3D initial conditions of mesoscale weather case were recovered from the assimilation of cloud water mixing ratio fields. This approach is unique and represents the first step toward assimilation of satellite cloudy radiance data (collaboration between Vukicevic and Greenwald).

Revised manuscript with T. Greenwald on: An all-weather observational operator for radiance data assimilation with mesoscale forecast model. The manuscript was submitted to *Monthly Weather Review*.

The forward forecast model showed undesirable results for some cases when used in parallel mode. Performed many numerical tests to diagnose the problem. The problem was identified just recently. Currently working on an optimal solution.

Produced the first adjoint sensitivity results for clouds in the infrared. Results were submitted in a conference paper to the Symposium on Observations, Data Assimilation, and Probabilistic Prediction to be held at the AMS meeting in Orlando, FL in January 2002. They showed that negative response in the infrared temperatures to positive changes in cloud mixing ratio occurred for optically thin clouds.

CLOUDSAT DATA PROCESSING CENTER (DPC)
FORT COLLINS

CloudSat is a satellite experiment designed to measure the vertical structure of clouds from space and, for the first time, will simultaneously observe cloud and precipitation. The primary CloudSat instrument is a 94-GHz, nadir-pointing, Cloud Profiling Radar (CPR). The current launch date for CloudSat is April of 2004.

A unique aspect of this mission is the fact that CloudSat will be flying in formation with other Earth Sciences missions. CloudSat will be a part of a constellation of satellites that currently include NASA's EOS Aqua and Aura satellites as well as a NASA-CNES lidar satellite (CALIPSO), and a CNES satellite carrying a polarimeter (PARASOL. A unique feature that CloudSat brings to the constellation is the ability to fly a precise orbit enabling the fields of view of the CloudSat radar to be overlapped with the lidar footprint and the other measurements of the constellation. The precision of this overlap creates a unique multi-satellite observing system for studying the atmospheric processes of the hydrological cycle. Additional information about the CloudSat mission may be found at http://cloudsat.atmos.colostate.edu

CIRA will provide all of the science data processing support for the mission. All of the CloudSat standard data products will be produced at the CloudSat Data Processing Center in the new ATS-CIRA Research Center (completed in June, 2002, and located adjacent to CIRA and the Atmospheric Science Department). CloudSat data will be downlinked to the U.S. Air Force Satellite Control Network and transferred via the RTD&E Support Center (RSC), in Albuquerque NM, to the CIRA DPC (see figure 1). CIRA is responsible for the implementation of the hardware and software infrastructure that is necessary to produce the nine standard data products. Members of the CloudSat Science Team will develop the Science algorithms and software for each of these products (Table 1). Four universities and the NASA Jet Propulsion Lab (JPL) are participants on the CloudSat algorithm development team.

Standard Data Product	**Description**	**Algorithm Dev.**
1B-CPR	Level 1b CPR	JPL
2B-GEOPROF	CPR Geometrical Profile	U. Utah
2B-CLDCLASS	Cloud Classification	U. Maryland
2B-TAU	Cloud Optical Depth	CSU/Atmos
2B-LWC	Cloud Liquid Water Content	CSU/Atmos
2B-IWC	Cloud Ice Water Content	U. Utah
2B-FLXHR	Atmospheric Radiative Fluxes and Heating Rates	CSU/Atmos
2B-GEOPROF-LIDAR	CPR Geometrical Profile (CPR + Lidar)	U. Utah
2B-CLDCLASS-LIDAR	Cloud Classification (CPR + Lidar)	U. Alaska

Table 1. CloudSat Standard Data Products and responsible Algorithm Development Group

During the Operational (on-orbit) Phase, the DPC will be staffed by CIRA employees, Science and Technology Corporation personnel (under a sub-contract to CIRA), and part-time CSU students. More information about the DPC can be found at http://cloudsat.cira.colostate.edu

During the past year, CIRA's effort has been centered on two areas. The first is the development and implementation of the eight subsystems identified in Table 2. The other major effort has been devoted to the implementation of the CloudSat Standard Data Product software within these subsystems.

Subsystem Name / Function	**Description**
Algorithm Interface Management System (AIMS)	A database server that allows algorithm developers to specify both external and internal file and data specifications. It provides a single source for documentation and interface specifications for all Standard Data Products.
CloudSat Operational and Research Environment (CORE)	The system software shell that will manage input into, execution of, and output from each of the standard data product applications. The system will also be used to generate experimental products during the on-orbit phase.
Process Log and Data Status (PLaDS)	A comprehensive database that contains the status of all applications as well as serving as the central database for metadata from individual products.
Data Management System (DataMan)	Components include: Data Transfer (transfer of data between PC systems), Data Storage (tape / CD / DVD write and read), and Database (PLaDS) Query and Update.
Product Display and Quality Control (PDQC)	This system will provide a user interface for the operator to display and manually quality control CloudSat input and output data products.
Data Distribution and Query (DDaQ)	Manages the internet distribution of CloudSat data to CloudSat Science Team and other worldwide requestors of CloudSat Standard Data Products. The primary function of this subsystem is to control the flow of the large volume of CloudSat data products through an internet distribution network.
Operator Control System (OpCon)	Operator interface to the scripts that will control the execution of CORE and other applications, plus an interface into the PLaDS database to monitor the status of the individual applications.
Web Interface (WebI)	External interface to all subsystems

Table 2. CloudSat Data Processing Center Subsystems

To date, CIRA has received, implemented, and tested, approximately 1/3rd of the Algorithm Team software as shown in table 3.

Standard Data Product	Current Version Implemented at DPC
1B-CPR	V1
2B-GEOPROF	V2
2B-CLDCLASS	V2
2B-TAU	V1
2B-LWC	V0
2B-IWC	V0
2B-FLXHR	V0 due 8/25/02
2B-GEOPROF-LIDAR	V0 due 1/1/03
2B-CLDCLASS-LIDAR	V0 due 2/1/03

Table 3. Standard Data Product software implementation status

The following graphic shows the overall flow of data through the CloudSat system when the Data Processing Center system becomes operational in the early summer of 2004.

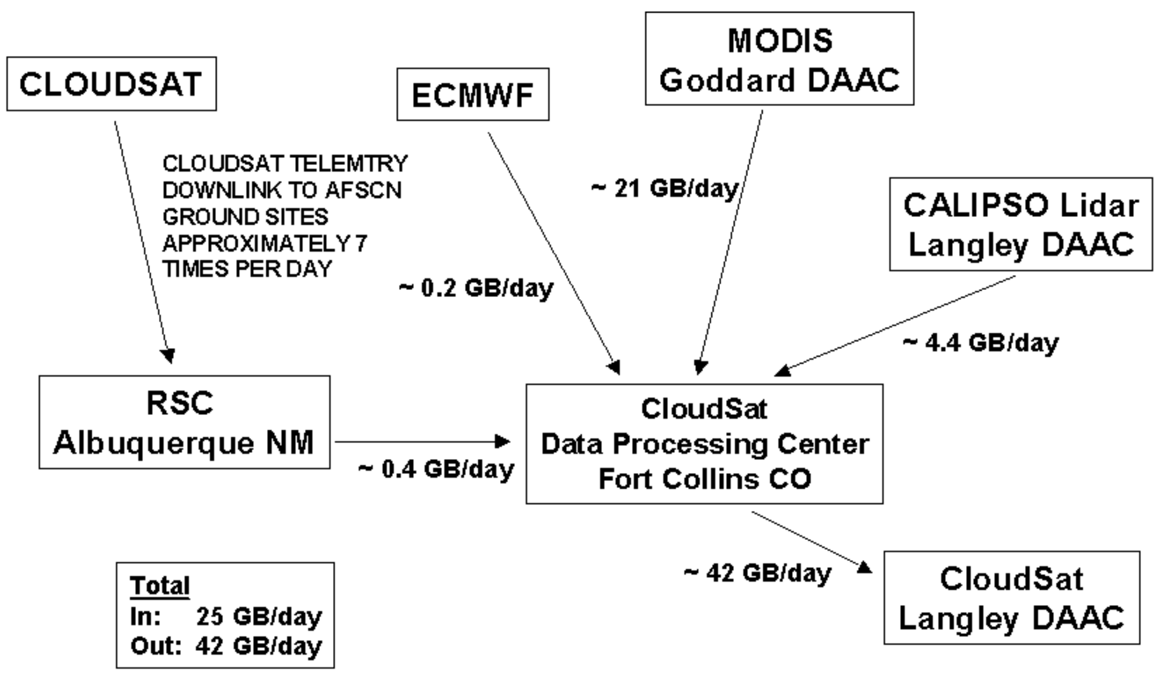


Figure 1. CloudSat System Data Flow and Data Rates

NATIONAL PARK SERVICE (AIR QUALITY DIVISION) FORT COLLINS

Principal Scientists: W. Malm/B. Schichtel

Introduction & Background

Since the early 1980s CIRA has supported the National Park Service visibility research program directed by Dr. Bill Malm. Through these years, this group has been responsible for formulating and implementing the Clean Air Act mandate to land managers to protect the visual resources of such special federal areas as National Parks and Wilderness, so called class 1 areas. The Clean Air Act, in 1977, set as "…a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Federal class 1 areas which impairment results from manmade air pollution."

Since the Act passed, the EPA has issued regulations to accomplish this goal, first, in 1980 addressing pollution that was "reasonably attributable" to a specific source, and most recently, in April 1999 addressing "regional haze." The regional haze regulations require States to plan to achieve "natural" visibility conditions within the next 60 years.

The NPS/CIRA research group under Malm's leadership has been instrumental in advancing the science and developing the methodologies that have enabled these regulations. Included in past accomplishments is development of the appropriate metrics to use for characterizing visibility, determination of the most appropriate instruments to measure visibility for this application and designing and implementing the national monitoring network for visibility. It is the national monitoring network, the IMPROVE network, that represents the group's most important contribution. IMPROVE is supported by the EPA, federal land managers and States, and implemented through contracts with the University of California, Davis and Air Resources Specialists, Inc. as well as others. This network has developed from its initial form as primarily a research tool to its current existence supporting the EPA and the States in developing and tracking accomplishments under the regional haze regulations. In addition to the IMPROVE network based aerosol research, the group conducts special studies associated with specific National Parks often, attempting to improve the understanding of relative contributions of individual pollution sources to visibility.

Current Results from the IMPROVE Network

IMPROVE is a network of 120 sites located to represent the class 1 areas, National Parks and Wilderness identified in the Clean Air Act. It has been expanded over the past year from about 70 sites which are used for the analysis reported in the latest IMPROVE report (Malm, 2000a). The basic measurements at each site are particles that are smaller than 2.5 micrometer in diameter. These particles are collected on Teflon, nylon and quartz filter substrates so that they can be subjected to a variety of chemical analyses that yield data allowing an approximation of the chemical nature of these particles to be determined. This chemical speciation has been essential in establishing the relationship between pollution sources and their final impact on visibility even after hundreds to thousands of kilometers of transport and both photochemical and aqueous phase transformations.

The EPA regional haze regulatory program requires a determination of what levels of visibility impairment are ‘natural.’ This is difficult to determine because there are a number of natural activities that contribute particles to the atmosphere (forest fires, volcanoes, dust.) However, it is helpful to look at the chemical species that contribute to visibility degradation in order to identify linkage between these concentrations and sources of pollution.

Special Studies Results

Periodically, the group participates in special intensive monitoring studies, such as the current Big Bend Regional Aerosol and Visibility Observational Study (BRAVO) study. Recent work to characterize the Grand Canyon visibility is also included here. These studies are designed to more fully characterize atmospheric aerosols and their optical properties, as well as to identify the major contributing sources to a particular class I area’s haze. In addition, special research activities are pursued which currently, include characterizing species dependent aerosol hygroscopicity; identifying the contribution of smoke to organic and sulfur aerosols; and characterization of coarse particle optical properties.

Future Directions for the Research

There are a number of sources of the organic carbon aerosol measured by IMPROVE. Transportation sources, other sources of volatile organic compounds, VOC’s, indeed all combustion of carbon containing fuels are included. Important to the National Parks and wilderness, however, are vegetation fires. Forest, grassland and agriculture burning, either as wildfire or within a management program, represents a source of carbon particulate that must be better understood.

Effects of Forest Fires on Visibility

We recently (Fox, et. al. 1999) suggested a list of research needs associated with smoke and visibility, largely repeated below:

--The attribution of smoke to PM2.5 and visibility degradation at points that are 100 km or more distant from a fire. While newly developed measurements of “markers” which allow attribution of elemental and organic carbon to wood smoke exist, they need to be tested in realistic field experiments.

--Instrumentation that has the capability to measure the mass of smoke emitted from various kinds of fire should be developed and tested in realistic field experiments.

--Assessing visibility impacts of smoke emission requires knowledge of the optical characteristics of smoke. The ability to accurately measure atmospheric absorption is essential for estimating the visibility effects of smoke. Smoke particle scattering albedos, extinction properties, particle size distributions, and microstructure (internal mixing characteristics) are all important for the accurate modeling of smoke optical properties. Instrumentation to estimate atmospheric absorption to an accuracy of 10% is needed.

--It is necessary to improve the capacity to simulate fire emissions and their effects on ambient aerosol concentrations. New measurement technologies combined with their use in field experiments will collect new data that can improve understanding of generation, transformation and removal processes for fine particulate. However, to determine historical levels of smoke and to evaluate the effectiveness of air quality management programs, these new data will need to be incorporated into the next generation of air quality models.

Web Site Development

The NPS research group at CIRA initiated development and presentation of research results including the monitoring data and information from the IMPROVE network in two newly developed, state of the science web sites. For more information about the IMPROVE Web site see: http://vista.cira.colostate.edu/improve/.

For the Western Regional Air Partnership, the group is developing a Web site capable of delivering all of the IMPROVE data as well as a presenting a catalogue of air quality and meteorological data in the western United States. For more information about the WRAP Web Site see: http://vista.cira.colostate.edu/wrap/.

NOAA/NESDIS/RAMM TEAM
FORT COLLINS

Team Leader: M. DeMaria

RAMM Team research is focused on applications of satellite observations to problems in regional-scale meteorology, including tropical cyclones, severe weather and mesoscale aspects of mid-latitude cyclones. Highlights of RAMM Team activities for the past year are divided into the following four areas.

Tropical Cyclone Research

To improve tropical cyclone diagnostic and forecast algorithms, an archive of storm-centered IR imagery for Atlantic and Eastern North Pacific storms from 1995-2001 is available on CD-ROMs. This data set, which contains more than 50,000 images, is currently being used to improve the Dvorak intensity estimation technique, to develop storm-relative averaging algorithms, to better understand the storm response to environmental vertical wind shear, and to improve intensity forecasting methods. This data set is also revealing new insights into semi-diurnal and shorter period oscillations in tropical cyclone convection. To compliment the IR data other tropical cyclone datasets are routinely archived including high-density winds, QuikSCAT winds, model analysis fields, aircraft reconnaissance data, and conventional (surface and upper air) observations.

Development has continued on algorithms to determine tropical cyclone wind fields from the Advanced Microwave Sounder Unit (AMSU) on the NOAA-15 and –16 polar orbiting satellites. Although the inner core of an intense tropical cyclone cannot be fully resolved, information on the vertical structure of the warm core can be obtained. Using hydrostatic and nonlinear balance constraints, the tropical cyclone wind field can be determined from the AMSU temperature soundings. Real-time analyses of the AMSU data for Atlantic and east Pacific tropical cyclones can be seen at www.cira.colostate.edu/ramm/tropic/amsustrm.asp. Statistical algorithms are also applied to the retrieved fields to estimate the maximum wind, minimum surface pressure and the radii of 34, 50 and 64 kt winds. These estimates are being sent in real-time to the National Hurricane Center in Miami, as part of project funded by the Joint Hurricane Testbed of the U.S. Weather Research Program (USWRP).

The operational Statistical Hurricane Intensity Prediction Scheme (SHIPS) for the Atlantic and east Pacific tropical cyclone basins is being improved through the incorporation of satellite data. The operational version of SHIPS includes predictors from climatology, persistence, the storm environment (vertical shear, etc) and sea surface temperature. An experimental version of SHIPS that also includes predictors from GOES infrared (Channel 4) imagery, and ocean heat content determined from TOPEX/Poseidon and ERS-2 satellite altimetry data is under development. Preliminary results with dependent data suggest that these new data sources can reduce the average forecast errors by up to 8%. The impact of these new data sources will be evaluated by comparison of the experimental and operational SHIPS intensity forecasts during the 2002 Atlantic hurricane season. This work is also a Joint Hurricane Testbed project. A similar intensity forecast model for the west Pacific basin has been developed at CIRA and implemented at the Joint Typhoon Warning Center in Honolulu.

Severe Weather Research

Methods are being developed to couple “forward” radiative transfer models with the Colorado State University (CSU) Regional Atmospheric Modeling System (RAMS) to develop data sets for current and future satellite product development. The visible, infrared and microwave frequencies are being considered. This system provides simulated satellite observations where all of the atmospheric properties are known from the model. A current application of this system is to develop improvements to the operational hydro-estimator algorithm for predicting convective rainfall rates from Channel 4 imagery. The model is being used to determine factors that affect the simulated rainfall rate and the corresponding imagery. Plans are underway to use this system to develop satellite algorithms for tropical cyclone and severe storm analysis.

Research was conducted to better understand the “storm-splitting” process. A case study was performed for 25 May 1999 where both the left- and right-moving storms in northern Texas were long-lived and produced severe weather. Normally, following the split of convective storm, the right-moving component tends to last longer and become more severe. Based upon an analysis of satellite, radar, and conventional observations, it was discovered that the dynamical factors that normally contribute to the decay of the left-moving storm in an environment with typical types of vertical wind shear can be counteracted by interaction with low-level outflow boundaries. This study provides useful guidance to operational forecasters, where the low-level outflows can be identified using satellite observations, and can help identify both left- and right-moving storms that have the potential to produce severe weather.

Work continued on the analysis of a unique GOES data set that was collected during the GOES-11 Science test. Super Rapid Scan Operations (SRSO) imager data (1-minute interval) was obtained in conjunction with 30-minute sounder data for a long-lived supercell that moved through South Dakota and Nebraska on July 24, 2000. The combined imager and sounder data provided insight into the storm evolution that was not possible to obtain using conventional observations. The storm moved along a north-south tongue of unstable air (as indicated by the lifted index derived from the sounder data). The line that the storm propagated along also had relatively low values of convective inhibition. This case illustrates the utility of the GOES sounder data in operational severe weather forecasting. The publication that resulted from this study generated some very interesting debate concerning the factors affecting storm motion, which appeared as a formal comment and reply in the meteorological literature.

Work continued on developing GOES cloud climatologies to gain insight into the effect of local geographic features on cloud frequency and evolution. Monthly climatologies of GOES-east and –west data have been created, and can be stratified by the low-level wind regime to better understand the influence of synoptic forcing. Collaborative research continues with the NWS forecast offices in Tallahassee, FL and Wakefield, VA and a new project with the Cheyenne, WY office is being initiated. Efforts are also underway to develop methods for incorporating the satellite climatologies into the Advanced Weather Interactive Processing Systems (AWIPS) used by the NWS.

GOES Product Development and Technology Transfer

RAMM Team completed the NESDIS portion of the Hurricane Mitch reconstruction effort in Central America. Arrangements were made to have a GOES satellite ingest system installed in Costa Rica by a private contractor. This data is being accessed by RAMSDIS workstations installed in Costa Rica and six additional countries in Central America. Two workshops were held in Costa Rica, which were attended by two representatives from each of the seven participating countries. A CIRA visiting scientist, in cooperation with NESDIS, adapted the GOES auto-estimator satellite rainfall algorithm to the region, which is now routinely running on the Costa Rica server. This project has improved the utilization of GOES satellite data and products at the National Weather Service offices in Central America.

RAMM Team scientists led a science test of the new GOES-12 satellite, which was successfully launched on 23 July 2001. The science test was conducted from September 23 to October 27, and special data sets were collected in tropical and mid-latitude environments. Special attention was given to assessing the capabilities of the new channel 6 (13.3 μm) which replaces channel 5 (12.0 μm) on the previous GOES satellites, and the increased spatial resolution of the water vapor channel (6.7 μm). Of particular concern was the ability to detect volcanic ash without channel 5. Preliminary results with the science test data suggest that volcanic ash can still be detected with the new GOES configuration, provided that optimal combinations of the imager channels are used.

Training

The Virtual Institute for Satellite Integration Training (VISIT) program is designed to accelerate the transfer of research results based on atmospheric remote sensing data into National Weather Service operations using distance education techniques. During the past year, RAMM Team contributed to the creation of ten new training sessions, which have been completed or are under development. Since 1999, more than 500 sessions have been offered to over 8000 participants.

PERSONNEL & FELLOWSHIPS

CIRA Research Initiative Award

This annual award recognizes outstanding research initiative or achievement by CIRA administrative professionals—individuals or groups. Nominations may be for single or multiple contributions/projects having taken place over the previous 3 years. Nominations may be submitted by any sponsoring agency manager or CSU/CIRA employee.

The selection criteria includes:

1. Demonstrates initiative, resourcefulness and/or creativity by the use of innovative techniques and/or technology in daily research activities.

2. Provides team leadership and/or mentoring in daily research activities.

3. Performs “cutting-edge research” which is reflected in publications, reports and deliverables.

4. Responsible for noteworthy accomplishment that results in substantial impact on CIRA, CSU, or sponsoring agency research mission.

5. Demonstrates successful proposal writing skills in attracting program funds.

6. Responsible for extraordinary achievement relative to the employee’s normal job responsibilities.

This year’s award winners appear on the following page.

Cooperative Institute for Research in the Atmosphere (CIRA)

CG/AR

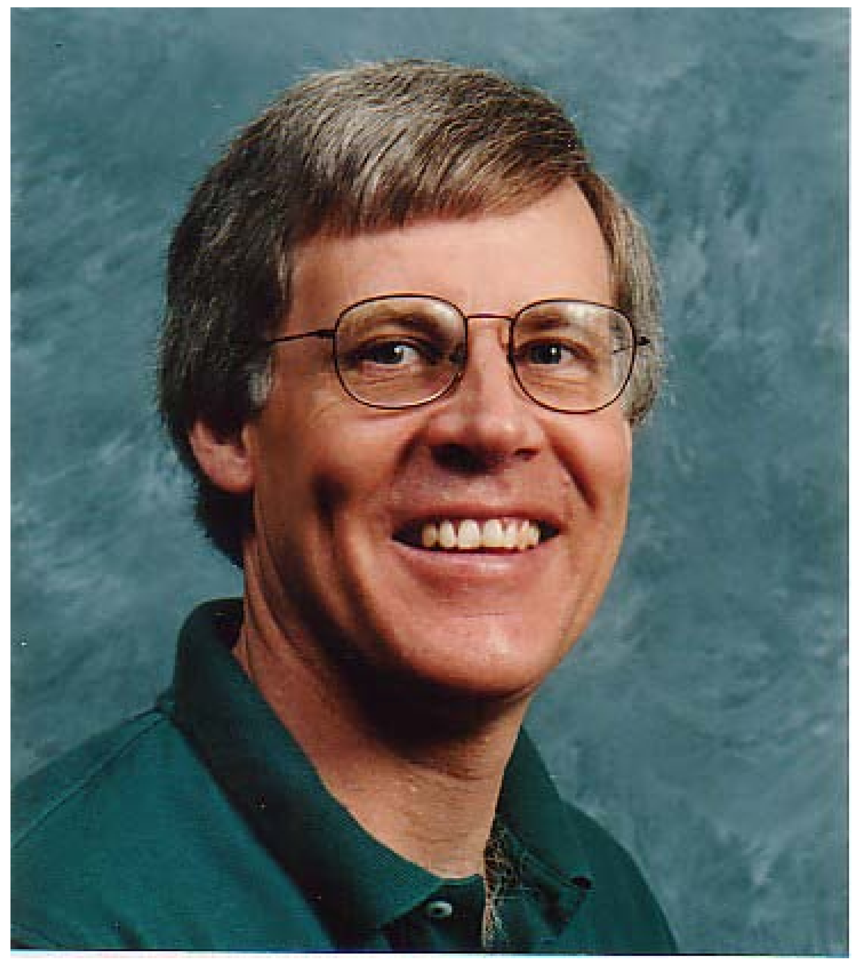
DOD Center for Geosciences / Atmospheric Research - Colorado State University

Colorado State University

2002 CIRA Research Initiative Award Winners

NOAA/NESDIS RAMM Team Members, Hurricane Mitch Reconstruction Project

Gerald Browning

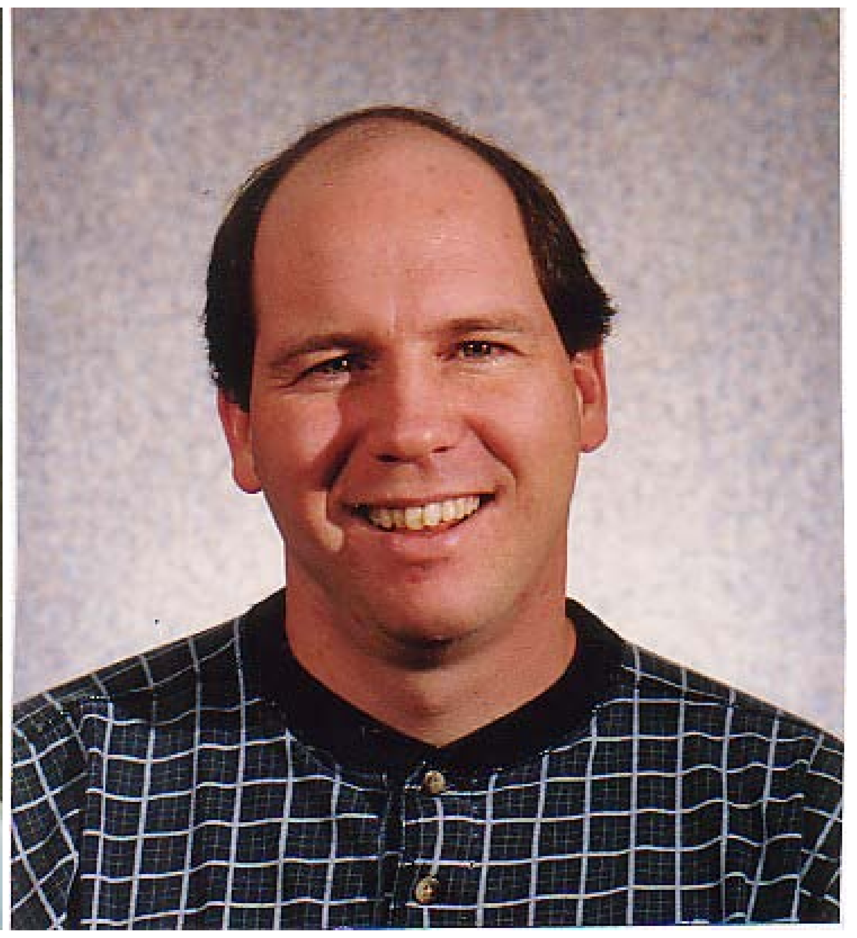


For inspiring mentorship, contributions to the NOAA Forecast Modeling Lab, advanced modeling efforts and pioneering work in numerical modeling

Bernie Connell

Hiro Gosden

Dave Watson



For essential support on the GOES rainfall auto estimator, coordination of training, and installation of a GOES satellite receiving station and network stations throughout Central America

Jim Frimel

For technical leadership, commitment, productivity and dedication vital to the recent success of the FAA TMU project

CIRA Personnel and Affiliates

Director
Vonder Haar, Thomas

Deputy Director
Eis, Kenneth

Associate Director – Boulder
Matsumoto, Cliff

Manager
Cismoski, Dave

Assistant Manager for Finances
Noble, Lance

Assistant Manager for Human Resources
Antich, Bonnie

Assistant Manager for Research Support
McInnis-Efaw, Mary

Fellows*
Cochrane, Hal, CSU/Economics
Cotton, William, CSU/Atmospheric Science
Cox, Stephen, CSU/Atmospheric Science
Holt, Frances, NOAA/NESDIS/Washington
Hooke, William, NOAA/Washington
Iyer, Hariharan, CSU/Statistics
Johnson, Richard, CSU/Atmospheric Science
Julien, Pierre, CSU/Civil Engineering
Kreidenweis, Sonia, CSU/Atmospheric Science
MacDonald, Sandy, NOAA/ORA/FSL
Mielke, Paul, CSU/Statistics
Pielke, Roger, CSU/Atmospheric Science
Rutledge, Stephen, CSU/Atmospheric Science
She, Chiao-Yao (Joe), CSU/Physics
Stephens, Graeme, CSU/Atmospheric Science

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DeMaria, Mark, NOAA/NESDIS/RAMM
Gebhart, Kristi, NPS
Hillger, Donald, NOAA/NESDIS/RAMM
Malm, William, NPS
Molenar, Debra, NOAA/NESDIS/RAMM
Weaver, John, NOAA/NESDIS/RAMM
Zehr, Ray, NOAA/NESDIS/RAMM

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Bennett, Helene, Admin Assistant III
DiVico, Joanne, Assistant to Director
Fryer, Kathy, Admin Assistant III
Watson, Marilyn, Admin Assistant II
Wilson, Loretta, Program Assistant II

Senior Research Scientists - Foothills
Fox, Doug
Kidder, Stan
Purdom, James

Senior Research Scientist - Boulder
Browning, Gerald, NOAA/ FSL

Research Scientists - Foothills
Adams, Chris
Vukicevic, Tomislava

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Frisch, Shelby, NOAA/FSL
Marroquin, Adrian, NOAA/FSL

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Knapp, Kenneth, NOAA/NESDIS/ORA , Camp Springs MD
Liu, Quanhua, NOAA/NESDIS/ORA, Camp Springs MD
Mundakkara Kovilakom, Rama,NOAA/ NESDIS/ORA, Camp Springs MD
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Zhao, Xuepeng, NOAA/NESDIS/ORA, Camp Springs MD

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Gibson, Harold

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Deo, Shripad (Kansas City,MO)
Dostalek, Jack, RAMM
Forsythe, John
Gosden, Hiro, RAMM
Grasso, Louie, RAMM

** these individuals are not CIRA employees*

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Lu, Chungu (Dan), NOAA/FSL
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Paschall, Robin, NOAA/FSL
Prentice, Robert, NOAA/FSL
Ramer, James, NOAA/FSL
Schaffer, Dan, NOAA/FSL
Shaw, Brent, NOAA/FSL
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Pankow, Glen, NOAA/FSL
Pichugina, Yelena, NOAA/ETL
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Pyle, John, NOAA/FSL
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Schultz, MarySue, NOAA/FSL
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Steffen, Christopher, NOAA/FSL
Tower, Frank, NOAA/FSL
Turpin, Michael, NOAA/FSL
Wagoner, Sher, NOAA/FSL
Wang, Ning, NOAA/FSL
Zimmerman, Alice, NOAA/FSL

Hourly Employees - Foothills
Cabell, Ryan
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Coleman, Daniel
Davey, Christopher
DeMaria, Robert
Fassler, Mark
James, Jonathan
Knipp, Matt
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Lyons, Tim
McClurg, Asha
McClurg, Matt
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Solheim, Inger
Walko, Ernest
Zajac, Bard

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Partain, Phil

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Demuth, Julie
Jones, James
Koyama, Tomoko
Moore, Richard
Ruston, Ben
Seaman, Curtis

** these individuals are not CIRA employees*

Members of the Advisory Board

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Professor, Colorado State Department of Atmospheric Science
Sandy MacDonald,
Director, Forecast Systems Laboratory
Thomas Vonder Haar (Chairperson)
Director of CIRA and University Distinguished Professor, Colorado State University Department of Atmospheric Science

FELLOWSHIP PROGRAM

CIRA accepts applications each year from June through October for its Fellowship Postdoctoral Program. This program is designed to support one, two or more scientists wishing to do research at the Institute. The program is designed to be attractive to both senior scientists on leave from their permanent positions and recent Ph.D. recipients. The Fellowship announcement is disseminated both nationally and internationally to over 600 hundred academic, government and private institutions and is also available on the Internet under the CIRA Web Page.

The following are the CIRA Senior and Postdoctoral Fellows with a short description of their research at CIRA:

Barbara Ervens
Barbara received her Ph.D. in Chemistry from University Leipzig, Germany. Her work involves the development and application of heterogeneous and multiphase chemistry models in support of NOAA's Intercontinental Transport and Chemical Transformation of Anthropogenic Pollution (ITCT) field experiment.

James Kossin
Jim received his Ph.D., in Atmospheric Science, from Colorado State University. His work centers on the use of satellite data for better understanding of the dynamics of storms. He also participates in CIRA's research on Variational Data Assimilation.

Milija Zupanski (Senior Fellow)
Milija received his Ph.D., in Meteorology, from the University of Oklahoma. As a member of CIRA's Data Assimilation Team, his work centers on 4DDA, probabilistic forecast methods, and data assimilation of satellite sensors into various meteorological models.

CIRA/ORA Collaborations

CIRA and the NOAA/NESDIS Office of Research and Applications (ORA) have established a Working Agreement setting forth the provision for as many as 10-15 research scientists to be appointed through CIRA as Postdoctoral Fellows, with those positions being located at ORA in Camp Springs, Maryland. The appointments are supported by NOAA/NESDIS via (a) ORA central funding or (b) ORA science projects.

The Postdoctoral appointments are generally for recent graduates, although some senior scientists may be appointed for a term. The appointments also carry the title of CIRA Associate Fellow as an honor of scientific distinction. Fellows are to be actively involved in CIRA/ORA related research. Initial appointments are for one calendar year, renewable by mutual agreement.

Professional interactions are fostered among the CIRA/ORA post docs and resident scientists in both groups by scientific collaborations, working visits, workshops and seminars, sharing of facilities, software and data sets, and by other means.

Our appointments under this collaborative agreement are as follows:

Jimmy O. Adegoke

Ph.D. 2000	The Pennsylvania State University, University Park
Specialty Area:	Remote Sensing of Land Surface Properties and Processes
ORA Mentor:	Dr. Kevin Gallo

Ivan A. Csiszar

Ph.D. 1996	Department of Meteorology, Eotvos Lorand University of Sciences, Budapest, Hungary
Specialty Area:	Remote Sensing of Land Surface Parameters
ORA Mentor:	Dr. Dan Tarpley

Aleksandr M. Ignatov

Ph.D. 1989	Marine Hydrophysics Institute, Sevastopol, USSR
Specialty Area:	Remote Sensing of Aerosol Parameters from Satellite (NOAA/AVHRR and TRMM/VIRS)
ORA Mentor:	Dr. Larry L. Stowe

Kinkade, Christopher

Ph.D. 2000	Columbia University, New York
Specialty Area:	Validating bio-optical products derived from visible region remote sensors and assessing the uncertainties with regard to the atmospheric correction procedures. Also performing analysis of pigment concentration variability with regard to atmospheric and tidal forcing.
ORA Mentor:	Dr. Dennis Clark

Kenneth R. Knapp

Ph.D. 2000	Atmospheric Science, Colorado State University, Fort Collins
Specialty Area:	Aerosol Remote Sensing Algorithms
ORA Mentor:	Dr. Larry L. Stowe

Liu, Quanhua

Ph.D. 1991	University of Kiel, Germany
Specialty Area:	Microwave Remote Sensing of Atmospheric and Surface Parameters and Their Applications in Numerical Weather Prediction Models
ORA Mentor:	Dr. Fuzhong Weng

Rama Varma Raja Mundakkara Kouilakom

Ph.D. 1999 Indian Institute of Tropical Meteorology, Pune, India
Specialty Area: Doppler Wind Lidar
ORA Mentor: Dr. James Yoe

Nicholas Nalli

Ph.D. 1999 University of Wisconsin, Madison
Specialty Area: Infrared Remote Sensing of Ocean Temperature
ORA Mentor: Dr. Larry L. Stowe

Peter Romanov

Ph.D. 1990 Central Aerological Observatory, Moscow, Russia
Specialty Area: Land Remote Sensing from Operational Environmental Satellites
ORA Mentor: Dr. Dan Tarpley

Skirving, William

Ph.D. James Cook University, Australia
Specialty Area: Development of tools and the use of those tools to study the various environmental stresses that cause corals to bleach. The main tools for this work are algorithms that are used to derive environmental variables from satellite data.
ORA Mentor: Dr. Alan Strong

Toscano, Marguerite

Ph.D. 1996 University of South Florida
Specialty Area: Development of improved long-term sea surface temperature records using satellite-observed, *in-situ*, and other oceanographic observations.
ORA Mentor: Dr. Alan Strong

Xuepeng Zhao

Ph.D. 1995 University of California, Los Angeles
Specialty Area: Radiation Transfer Calculations and Remote Sensing of Aerosol Particles Over Ocean and Land Surface
ORA Mentor: Dr. Larry L. Stowe

SEMINARS, MEETINGS, WORKSHOPS, COURSES, OUTREACH

SEMINARS, MEETINGS, WORKSHOPS, COURSES

DATE	PRESENTER(S)	TITLE
July 1, 2001 - June 30, 2002	B. Motta, D. Bikos, J. Weaver, B. Zajac, R. Zehr, D. Lindsey	Over 150 VISIT teletraining sessions were delivered to NWS offices
July 2, 2001	D. McKague	Development and Application of a Probability Distribution Retrieval Scheme to the Remote Sensing of Clouds and Precipitation
July 3, 2001	B. Motta, D. Hillger	COMET Executive Board teleconference briefing on RAMM Team's involvement in training activities at COMET and with the VISIT project
July 11, 27 & August 3, 2001	J. Weaver	Presentations on Spotter Training and Safety Aspects of Severe Weather
July 11-13, 2001	J. Weaver	Unusual Consequences of Natural Disasters and the Fort Collins Flood of July 28, 1997
July 12, 2001	B. Motta	Teleconference Presentation of Internet-Delivered Audio in Combination with Interactive RAMSDIS Online and VISIT View
July 13, 2001	L. Grasso	Observations of a Severe Left Moving Thunderstorm
July 16-20, 2001	J. Weaver, J. Knaff	Multiple Presentations Discussing Hurricanes and Severe Weather at the Colorado State University Kids in College Program
July 17, 2001	J. Adegoke (CIRA/South Dakota)	Modeling the Impact of Irrigation on Midsummer Surface Energy Budget and the CBL in the U.S. High Plains

DATE	PRESENTER(S)	TITLE
July 17, 2001	M. DeMaria	Status of the NESDIS Contribution to the Hurricane Mitch Reconstruction Project
July 21-25, 2001	H. Gosden	Training on RAMSDIS Workstations in Nicaragua, Guatemala, and Costa Rica
July 25, 2001	M. DeMaria	Current Status and Future Capabilities for Hurricane Rainfall Forecasting
July 25-27, 2001	J. Weaver, D. Hillger, D. Bikos, B. Motta, J. Dostalek	Presentations on Radiative Transfer Modeling and on Severe Thunderstorm Efforts at CIRA
July 29-August 2, 2001	B. Motta	Use of Satellite Imagery in Forecasting and Model
July 29-August 2, 2001	J. Dostalek	Left-Moving Thunderstorms in a High Plains, Weakly-Sheared Environment
August 1, 2001	M. DeMaria	Briefing on the NESDIS Contribution to the Hurricane Mitch Reconstruction Project
August 1, 2001	R. Edson (Anteon Corp./ Univ. of Guam/WERI	Recent Findings in the Operational Use of Microwave Data As Related to Tropical Cyclone Forecasting
August 13, 2001	M. DeMaria	Tropical Cyclone Applications of GOES and POES Data
August 15, 2001	M. DeMaria, L. Grasso	An Overview of the Progress on the Model Development
August 17, 2001	H. Borton (Caribbean Inst. Of Meteorology and Hydrology)	Overview of the Activities and Responsibilities of CIMH
September 13, 2001	R. Dargaville (NCAR)	Inter-annual Variability in Atmospheric Transport: Implications from Carbon Cycle Studies

DATE	PRESENTER(S)	TITLE
September 19, 2001	J. Weaver	The Problem of Trying to Pull Order from Chaos During and After a Natural Disaster
September 25, 2001	E. Kalnay (University of Maryland)	Low Dimensionality in Atmospheric Dynamics: Application to Data Assimilation
October 3, 2001	L. Grasso	Using a Radiative Transfer Model to Simulate GOES-8 CH4 of a Simulated Thunderstorm
October 3, 2001	J. Weaver	Using Satellite Data in the Warning Decision Making Process
October 4, 2001	B. Zajac	Lightning Meteorology 1: Electrification and Lightning Activity by Storm Scale
October 4, 2001	B. Mapes (NOAA/CIRES)	Lessons Learnt from Nested-Grid Simulations Over the Tropical America's
October 12, 2001	B. Connell	Satellite Meteorology
October 12, 2001	J. Weaver, B. Zajac	Thunderstorm Electrification
October 15-18, 2001	M. DeMaria	Validation of an Advanced Microwave Sounder Unit (AMSU) Tropical Cyclone Intensity and Size Estimation Algorithm
October 15-18, 2001	D. Hillger	Principal Component Image of MODIS for Volcanic Ash and Simulation of GOES-M 5-Band Imager Using MODIS Data
October 15-18, 2001	B. Motta	Recent Training and Results from the Virtual Institute for Satellite Integration Training (VISIT)

DATE	PRESENTER(S)	TITLE
October 15-18, 2001	R. Zehr	Tropical Cyclone Surface Wind Analysis Using Satellite Sensors
October 15-18, 2001	B. Connell	The Use of Mesoscale Climatologies for Monitoring and Forecasting Weather in Costa Rica
October 15-18, 2001	C. Combs	Wind Regime Cloud Cover Composites of Convective Development over the Wakefield, VA Region
October 15-18, 2001	D. Bikos	Observations of a Severe Supercell Thunderstorm on July 24, 2000 Using GOES-11 Sounder and Imagery
October 16-24, 2001	H. Gosden	RAMSDIS Training in Panama and Belize
October 17-19	V. Castro	RAMSDIS Training in Panama
October 18, 2001	C. Deser (NOAA/CIRES)	On the Persistence of Sea Surface Temperature Anomalies in Midlatitudes
October 25, 2001	W. Lyons (FMA Research, Inc.)	(Still More) Creatures in the Mesospheric Zoo
November 1, 2001	J. Curtis (Wyoming State Climatologist & WRDS Coordinator)	Climate Change and Metadata Resources Available in Wyoming
November 6, 2001	M. DeMaria, W. Gray	USWRP Congressional Briefings on Hurricanes at Landfall
November 6-8, 2001	B. Motta	Model Initialization Issues and Related Topics
November 8, 2001	J. Flemming (Colby College, Maine)	Carbon Dioxide and Climate: Ideas and Apprehensions on Decadal to Centennial Time Scales

DATE	PRESENTER(S)	TITLE
November 15, 2001	J. Hawkins (Naval Research Lab, CA)	Tropical Cyclone Structure Via Multiple Passive Microwave Satellite Sensors
November 15, 2001	P. Miller (NOAA FSL)	MADIS-Meteorological Assimilation Data Ingest System
November 15, 2001	D. Thompson	What is the Arctic Oscillation, and Why do we care?
November 16, 2001	M. DeMaria	The Current Status and Future Plans of the NOAA GOES and POES Satellites
November 19, 2001	J. Kossin	Daily Hurricane Variability Inferred from GOES Infrared Imagery
November 26-27, 2001	M. DeMaria	Development and Use of Statistical Models Based on Best Track Data
November 28, 2001	J. Kossin	Daily Hurricane Variability Inferred From GOES Infrared Imagery
December 4-7, 2001	B. Connell, R. Alfaro	Satellite Meteorology Workshop
December 5, 2001	J. Jimenez (CA Inst. Of Technology)	Bringing New Eyes Into the Problem: Developing and Applying Advanced Instrumentation For Atmospheric Chemistry Research
December 6, 2001	R. Carbone (NCAR)	Inferences of Predictability Associated with Warm Season Precipitation Episodes
December 12, 2001	J. Weaver	Using Satellite Date in the Warning Decision Making Process
December 12, 2001	C. Walcek (State Univ. of NY, Albany)	Improved Numerical Advection in Atmospheric Models
December 13, 2001	B. Zajac	Utilizing Lightning Data

DATE	PRESENTER(S)	TITLE
December 14, 2001	C. Anderson (CSU Dept. of Computer Sc)	An Introduction to Artificial Neural Networks
January 13-18, 2002	B. Motta	VISIT Integrated Sensor Training: Using AWIPS Satellite Products and Capabilities
January 13-18, 2002	B. Zajac	Lightning Meteorology 1: An Introductory Course on Forecasting with Lightning Data and an Overview of Lightning Training from NWS/VISIT
January 24, 2002	Y. Xie (NOAA/FSL/CIRA)	Impact of Formulation of Cost Function and Constraints on Three-Dimensional Variational Data Assimilation
January 31, 2001	A. Kasahara (NCAR)	The Role of the Horizontal Component of the Coriolis Vector in Nonhydrostatic Atmospheric Models
February 5, 2002	B. Lipscomb (Los Alamos National Lab)	Incremental Remapping: A New Transport Scheme for Climate Models
February 7, 2002	K. Wolter (CDC, NOAA)	Regionalization of Precipitation Patterns over Colorado and the Interior Southwest
February 14, 2002	T. Shepherd (University of Toronto, Canada)	What Have We Learned From the Canadian Middle Atmosphere Modeling Project?
February 18, 2002	S. Solomon (NOAA)	The Coldest March: Insight's into Scott's Fatal Antarctic Expedition
February 19, 2002	D. Barker (MMM Division, NCAR)	The Development of a 3DVAR Assimilation Capability for the WRF Model
February 26, 2002	Y. Wang (University of Hawaii)	Vortex Rossby Waves and Tropical Cyclone Structure and Intensity Changes in a Full Physics Model

DATE	PRESENTER(S)	TITLE
February 28, 2002	J. Gille (NCAR)	The MOPITT Experiment: Determining the Global Patterns of CO in the Troposphere
March 7, 2002	D. Collins (Texas A&M)	Recent Advances and Remaining Challenges in Aerosol Radiative Closure
March 11-15, 2002	J. Knaff	An Update on Joint Hurricane Testbed (JHT) Projects at CIRA and CIMMS and Mew Operational Tools to Produce Five-Day Tropical Cyclone Intensity Forecasts
March 13-14, 2002	J. Weaver	GOES RSO Imagery in the Warning Decision Making Process
March 19, 2002	M. DeMaria	Satellite Data Assimilation Experience and Interests at CIRA
March 21-26, 2002	D. Watson	Training for RAMSDIS/McIDAS-NT and VISIT View in Germany
March 21, 2002	K. Gurney	Towards Robust Regional Estimates of CO2 Sources and Sinks Using Atmospheric Transfer Models
March 26, 2002	M. Shapiro (NOAA/OAR)	The Hemisphere Observing System Research and Predictability Experiment (THORpex)
March 28, 2002	Z. Toth (NOAA/NCEP/EMC)	Ensemble Forecasting and Targeted Observations at NCEP
April 4, 2002	D. Edwards (NCAR)	The Terra/MOPITT Mission: Technique, Validation and Early Results
April 5, 2002	J. Corwin (Pacific Northwest National Lab)	Quantitative Single Particle Studies Applied to Field Aerosol Chemistry and Apportionment

DATE	PRESENTER(S)	TITLE
April 11, 2002	H. Wanner (NCCR, Switzerland)	North Atlantic-European Climate 1500-2000 AD: Reconstruction and Diagnosis of State Variables, Modes, and Extremes
April 12, 2002	M. DeMaria	Summary of RAMM Team Activities
April 18, 2002	J. Marwitz (Univ. of Wyoming, Laramie)	Melting Effects in Winter Storms
April 19, 2002	D. Hillger	Noise Reduction by Principal Component Truncation and Image Re-Transformation: An Important Aspect of PC Compression
April 29, 2002	D. Molenar, D. Hillger	Presentations on Satellite Image Products and Display Systems
April 29-May 3, 2002	M. DeMaria	The Use of GOES Imagery in Statistical Hurricane Intensity Prediction
April 29-May 3, 2002	J. Demuth	An Evaluation of CIMSS and CIRA AMSU Tropical Cyclone Intensity Estimation Algorithms
April 29-May 3, 2002	J. Knaff	What Are Annual Hurricanes? and Examining the Eight-Day Evolution of Upper Level Winds in Hurricane Floyd
April 29-May 3, 2002	R. Zehr	Vertical Wind Shear Characteristics With Atlantic Hurricanes During 2001
May 1, 2001	J. Weaver	Using Satellite Data in the Warning Decision Making Process
May 8, 2002	M. DeMaria	Summary of the NESDIS Contribution to the Hurricane Mitch Reconstruction Project
May 14, 2002	D. Zupanski	Model Error Optimization Using Advanced Data Assimilation Systems

DATE	PRESENTER(S)	TITLE
May 20-24, 2002	J. Knaff	Newly Developed Tropical Cyclone Intensity Forecast Algorithms and CIRA's AMSU-Derived Tropical Cyclone Intensity and Wind Radii Estimation Algorithms
May 28, 2002	M. DeMaria	Summary of Significant Weather from the GOES-West-Asia-Pacific Satellite Applications Training Course (APSAT)
May 31, 2002	M. DeMaria	Weather and Tropical Cyclones
June 3, 2002	M. DeMaria	Costal and Inland Effects of Tropical Cyclones
June 6, 2002	I. Solheim	An Introduction to IDL
June 24-28, 2002	J. Weaver, M. DeMaria, J. Dostalek	Hurricanes and Their Impacts - Emergency Response to Various Weather Related Disasters at Colorado State University's Kids in College Program
June 27, 2002	W.K. Tao	Mesoscale Convective Systems During SCSMEX: Simulations with a Regional Climate Model and a Cloud-Resolving Model

NOTE:
CIRA also conducted various tours for corporations and local public and private schools. Some seminars were jointly sponsored with the CSU Department of Atmospheric Science.

OUTREACH AND SPECIAL TOURS

April 12, 2002
Colorado Science Fair participants (two groups)

June 17 through 21, 20012
Kids In College (KIC) 3 hours per day for 1 week, teach set curriculum (Kelly Dean and Nan McClurg)

June 24 through 28, 2002
Kids In College (KIC) 3 hours per day for 1 week, teach set curriculum (Kelly Dean and Nan McClurg)

Note: Tours of the CIRA Facility were limited this year due to construction of a new building.

PAPERS AND REPORTS
FOR PROJECTS ACTIVE

JULY 1, 2001 - JUNE 30, 2002

(Typical overview of CIRA's Peer-Reviewed and Non Peer-Reviewed Publications is shown in the table on the following page)

	Calendar Year	
Publications	2001	2000
Peer-Reviewed		
NOAA Research Lead Authors	10	17
Other Lead Authors	65	35
Total	75	52
Non Peer-Reviewed		
NOAA Research Lead Authors	42	31
Other Lead Authors	41	42
Total	83	73
Total Publications 1997-2001	158	125

ADVANCED ENVIRONMENTAL SATELLITE RESEARCH

Principal Investigators: T. Vonder Haar/J. Purdom

Sponsor: NOAA

Abstract - As a link among CIRA, NOAA/NESDIS, and the general population of satellite data users, this position will work toward the goal of advancing more comprehensive use of satellite data by all users. The aim is to highlight the value of satellite data for environmental applications. Several areas of attention have been identified for the position as follows:

Liase with such international groups as the Committee on Earth Observation Satellites, Coordination Group for Meteorological Satellites, and World Meteorological Organization, to educate them on the relevance of satellites as part of an Integrated Global Observing System (IGOS).

Carry out studies to promote the role of satellites within an IGOS context and accordingly prepare papers and present scholarly lectures that pertain to this subject matter.

Spearhead efforts to expand the uses of environmental satellite data through training programs and lectures in national and international arenas.

Connell, B. H., M. DeMaria, J. Sessing, V. Leon, and J. F. W. Purdom. 2002. Reconstructioin efforts for meteorological offices in Central America in the wake of Hurricane Mitch. *AMS 29th International Symposium on Remote Sensing of Environment*, TS-28.1.

Connell, B. H., K. Gould, and J. F. W Purdom. 2001. High resolution GOES-8 visible and infrared cloud frequency composites over northern Florida during the summers 1996-1999. *Weather and Forecasting* 16, no. 6: 713-724.

Levizzani, V., P. Bauer, D. H. Hinsman, A. Khain, C. Kidd, F. S. Marzano, F. Meneguzzo, A. Mugnai, J. P. Poiares-Baptista, F. Prodi, J. F. W. Purdom, D. Rosenfeld, J. Schmetz, E. A. Smith, F. Tampieri, F. J. Turk, and G. A. Vicente. 2001. EURAINSAT: European satellite rainfall analysis and monitoring at the geostationary scale. *AMS 11th Conference on Satellite Meteorology and Oceanography*, 650-654.

Purdom, J. F. W. 2002. Environmental satellite remote sensing in the 21st century. *AMS 29th International Symposium on Remote Sensing of the Environment*, TS-13.5.

———. 2002. The virtual laboratory for satellite training and data utilization. *AMS 29th International Symposium on Remote Sensing of the Environment*, TS-1.2.

Purdom, J. F. W., and A. Mostek. 2001. Virtual laboratory for satellite training in meteorology. *AMS 11th Conference on Satellite Meteorology and Oceanography*, 324-327.

Uccellini, L., F. Einaudi, J. F. W. Purdom, D. Rogers, R. Gelaro, J. Dodge, R. Atlas, and S. Lord. 2001. Weather prediction improvement using advanced satellite technology. *AMS 11th Conference on Satellite Meteorology and Oceanography*, 216-219.

AIR-SEA INTERACTION REMOTE SENSING PROCESSES

Principal Investigators: T. Vonder Haar/S. Frisch

Sponsors: NOAA/ETL

Abstract - Development of cloud radar-radiometer techniques for the measurement of stratus cloud microphysical quantities continued. Analysis of data sets from field experiments has begun to compare simultaneous radar-radiometer measurements of stratus cloud properties with aircraft observations.

Albrecht, B. A., C. Bretherton, R. H. Johnson, W. H. Schubert, and A. S. Frisch. 1995. The Atlantic Stratocumulus Transition Experiment-ASTEX. *Bull. Amer. Meteor. Soc.* 76: 889-904.

Banta, R. M., B. Grund C. J. Orr, D. H. Levinson, A. S. Frisch, and S. D. Mayer. 1997. Estimation of TKE and momentum flux profiles from Doppler lidar scans during LIFT. *AMS 12th Symposium on Boundary Layer and Turbulence Symposium*.

Eberhard, W. L., S. Y. Matrosov, A. S. Frisch, and J. M. Intriere. 1997. Microphysical retrievals from simultaneous radar and optical or microwave measurements. *WMO Workshop on Measurements of Cloud Properties for Climate Studies*.

Feingold, G., A. S. Frisch, B. Stevens, and W. R. Cotton. 1999. On the relationship between cloud turbulence, droplet formation, and drizzle as viewed by Doppler radar. *J. Geophys. Res. (Accepted)*.

Feingold, G., A. S. Frisch, B. Stevens, and W. R. Cotton. 1997. Drizzling stratocumulus as viewed by radar, radiometer and lidar. *12th Symposium on Boundary Layers and Turbulence*.

Feingold, G., B. Stevens, W. R. Cotton, and A. S. Frisch. 1995. On the relationship between drop in-cloud resistance time and drizzle production in numerically simulated stratocumulus clouds. *Atmos. Sci. (Accepted)*.

Frisch, A. S., I. Djalalova, G. Feingold, and M. Poellott. 2001. On the retrieval of effective radius with cloud radars. *J. Geophys. Res. (in Prep.)*.

Frisch, A. S., C. W. Fairall, and J. B. Snider. 1995. Measurement of stratus cloud and drizzle parameters in ASTEX with a K-Band Doppler radar and a microwave radiometer. *J. Atmos. Sci.* 52: 2789-2799.

Frisch, A. S., C. W. Fairall, J. B. Snider, and D. H. Lenschow. 1995. Ground based cloud radar and radiometer methods for measuring stratus cloud parameters. *NOAA/CSU Cloud Process Modeling and Measurement Workshop*.

Frisch, A. S., G. Feingold, I. Djalalova, and M. Poellot. 2000. On the retrieval of the effective radius in continental stratus clouds with cloud radars. *10th ARM Science Team Meeting*.

Frisch, A. S., G. Feingold, C. W. Fairall, and B. Orr. 1995. Drizzle parameter measurements with a cloud sensing radar during ASTEX. *AMS 27th Conference on Radar Meteorology*.

Frisch, A. S., G. Feingold, C. W. Fairall, and J. B. Snider. 1998. On cloud radar and microwave radiometer measurements of stratus cloud liquid water. *8th ARM Science Team Meeting*.

———. 1998. On cloud radar and microwave radiometer measurements of stratus cloud liquid water profiles. *Tropospheric Profiling Symposium IV*.

Frisch, A. S., G. Feingold, C. W. Fairall, T. Uttal, and J. B. Snider. 1998. On cloud radar and microwave radiometer measurements of stratus cloud liquid water profiles. *J. Geophys. Res.* 103: 23195-23197.

Frisch, A. S., G. Feingold, T. Uttal, C. W. Fairall, and J. B. Snider. 1997. Stratus cloud properties with a cloud radar and microwave radiometer. *AMS 28th Conference on Radar Meteorology*.

Frisch, A. S., J. S. Gibson, and B. Orr. 1997. A rotating co-ordinate method of measuring planetary boundary-layer mean and turbulence quantities using a single Doppler radar in a cronical scan mode. *(in Prep.)*.

Frisch, A. S., D. H. Lenschow, C. W. Fairall, W. H. Schubert, and J. S. Gibson. 1995. Doppler radar measurements of turbulence in marine stratiform cloud during ASTEX. *J. Atmos. Sci.* 52: 2800-2808.

Frisch, A. S., D. H. Lenschow, B. Martner, B. Orr, and D. Fitzjarrald. 1997. Doppler radar measurements of vertical velocity statistics boreal forest. *Boundary Layer and Turbulence Symposium*.

Frisch, A. S., B. E. Martner, I. Djalalova, and M. R. Poellot. 1999. Comparison of radar/radiometer retrievals of stratus cloud liquid water content profiles with in-situ measurements by aircraft. *J. Geophys. Res. (Submitted)*.

———. Comparison of radar/radiometer retrievals of stratus cloud liquid water content profiles with in-situ measurements by aircraft. *9th ARM Science Team Meeting*.

Frisch, A. S., B. E. Martner, B. W. Orr, and D. H. Lenschow. 1999. The effect of cumulus cloud formation on boundary layer turbulence. *Ninth ARM Science Team Meeting*.

Frisch, A. S., I. Matrosov, G. Feingold, and M. Poellot. 2000. On the retrieval of the effective radius in continental stratus cloud radars. *JGR Letters (in Prep.)*.

Frisch, A. S., W. H. Schubert, and D. A. Randall. 1995. *NOAA/CSU Cloud Process Modeling and Measurement Workshop*.

Frisch, A. S., M. D. Schupe, I. Djalalova, G. Feingold, and M. Poellot. 2002. The retrieval of stratus cloud droplet effect radius with cloud radars. *J. Atmos. & Oceanic Tech.* 19: 835-842.

Frisch, A. S., T. Uttal, C. W. Fairall, and J. B. Snider. 1997. On the measurement of stratus cloud properties with a cloud radar and microwave radiometer. *IGARS*.

Gossard, E. E., B. B. Snider, E. E. Clothiaux, B. Martner, J. S. Gibson, R. A. Kropfli, and A. S. Frisch. 1997. The potential of 8 mm-radars for remotely sensing cloud drop size distribution. *J. Atmos. and Ocean. Tech.* 14: 76-87.

Kropfli, R., S. Matrosov, T.l Uttal, B. Orr, A. S. Frisch, C. Clark, B. Bartram, R. Renking, and J. B. Snider. 1995. Cloud physics studies with 8mm wavelength radar. *J. Atmos. Res.(in Press)*.

Lasarus, K., and A. S. Frisch. 2000. Evaluation of a cloud fraction parameterization using observations and model data. *10th ARM Science Team Meeting*.

Lazarus, S. M., S. K. Krueger, and A. S. Frisch. 1999. An evaluation of the Xu-Randall cloud fraction parameterization using ASTEX data. *ARM Science Team Meeting*.

Martner, B., A. S. Frisch, and R. Banta. 1995. Diurnal evolution of boundary layer turbulence over a boreal forest as observed by Doppler radar. *AMS Conference on Radar Meteorology*.

Matrosov, S. Y., A. S. Frisch, R. S. Kropfli, and T. Uttal. 2000. Retrievals of cloud content and particle characteristic size using NOAA ETL cloud radars. *1st International Workshop on Spaceborne Cloud Profiling Radar*.

Reinking, R., D. Korn, A. Frisch, B. Orr, L. Bissonnette, and G. Roy. 2002. Observations of effects of mountain blocking on traveling gravity-shear waves and associated clouds. *Weather and Forecasting* (Submitted).

Reinking, R. F., B. W. Orr, L. R. Bissonnette, G. Roy, A. S. Frisch, S. Y. Matrosov, and C. C. Ryerson. 2000. Remote sensing of cloud droplets during MWISP. *2000 International Geoscience and Remote Sensing Symposium*.

Schupe, M. D., T. Uttal, S. Matrosov, and A. S. Frisch. 2001. Cloud water contents and hydrometer sized during the FIRE-Arctic cloud experiment (Accepted). *J. Geophys. Res. Special Issue*.

Shupe, T. Uttal, S. Y. Matrosov, and A. S. Frisch. 2000. Cloud water contents and hydrometeor sizes during the FIRE-Arctic clouds experiment. *Journal of Geographic Resources (submitted)*, FIRE ACE Special Issue.

White, Allen, C. W. Fairall, A. S. Frisch, B. Orr, and J. B. Snider. 1996. Recent radar measurements of turbulence and microphysical parameters in marine boundary layer clouds. *J. Atmos. Res.* 40: 177-221.

AMS GRADUATE FELLOWSHIP FOR JULIE DEMUTH

Principal Investigator: T. Vonder Haar

Sponsor: AMS

Abstract - Support from the American Meteorological Society for graduate students.

DeMaria, M., J. Demuth, and J. A. Knaff. 2001. Validation of an advanced microwave

sounder unit (AMSU) tropical cyclone intensity and size estimation algorithm. *AMS 11th Conference on Satellite Meteorology and Oceanography*.

DeMaria, M., R. M. Zehr, C. S. Velden, J. A. Knaff, J. L. Demuth, and K. F. Brueske. 2002. An update on Joint Hurricane Testbed (JHT) projects at CIRA and CIMSS. *56th Interdepartmental Hurricane Conference*.

Demuth, J. L. 2002. "Objectively estimating tropical cyclone intensity and wind structure using the Advanced Microwave Sounding Unit." Colorado State University.

Demuth, J. L., K. Brueske, J. A. Knaff, C. Velden, and M. DeMaria. 2002. An evaluation of CIMSS and CIRA AMSU tropical cyclone intensity estimation algorithms. *AMS 25th Conference on Hurricanes and Tropical Meteorology*, 27-28.

Demuth, J. L., M. DeMaria, J. Knaff, and T. H. Vonder Haar. 2000. An objective method for estimating tropical cyclone intensity and structure from NOAA-15 Advanced Microwave Sounding Unit (AMSU) data. *AMS 24th Conference on Hurricanes and Tropical Meteorology*, 484-485.

Demuth, J. L., M. DeMaria, J. A. Knaff, and T. H. Vonder Haar. 2002. Validation of an Advanced Microwave Sounding Unit (AMSU) tropical cyclone intensity and size estimation algorithm. *J. Applied Met. (Submitted)*.

Knaff, J. A., M. DeMaria, and J. L. Demuth. 2000. Tropical cyclone forecast products derived from the Advance Microwave Sounding Unit. *Interdepartmental Hurricane Conference*.

ANALYSIS OF DATA FROM THE BRAVO STUDY

Principal Investigators: S. Kreidenweis/J. Collett, Jr.

Sponsors: NPS

Abstract - This proposal seeks funds to perform analyses of data from the 1999 Big Bend Regional Aerosol and Visibility Observational (BRAVO) Study. This group was supported in 1999 2000 to participate in BRAVO, to collect samples and make observations, and to perform chemical analyses and data reduction. The overall project goal was to examine the chemical composition, degree of internal mixing, and scattering and absorption properties of aerosols at Big Bend National Park during July October, 1999. The ultimate goals of our data analyses are:

1. characterize summer and fall aerosols at the surface at Big Bend, including chemical composition, size distribution, and optical properties;
2. develop an understanding of aerosol sources and transformations by combining the characterization with meteorological and source information;
3. determine whether known organic tracers can be used for aerosol source apportionment in BRAVO;
4. investigate the contributions of secondary organic species to aerosol mass and evaluate their potential use as tracers for source apportionment.

In this proposal, we are specifically requesting funds to support personnel to perform the analysis work needed to address our goals. We have already completed most of our initial data processing and submitted results to the BRAVO data base. We are now prepared to work on data interpretation, including collaborating with other BRAVO investigators to share data needed to address BRAVO study objectives. Our proposed work will also include additional laboratory studies of organic identification methods and applicability to the Big Bend site during these seasons. As part of this, we will analyze for organic compounds in numerous source samples obtained for us by DRI during their work on BRAVO source characterization.

Arnott, W. P., H. Moosmuller, P. J. Sheridan, J. A. Ogren, R. Raspet, W. V. Slaton, J. L. Hand, S. M. Kreidenweis, and J. L. Jr. Collett. 2002. Photoacoustic and filter-based ambient aerosol light absorption measurements: Instrument comparisons and the role of relative humidity. *J. Geophys. Res (Submitted)*.

Brown, S. 2001. "Characterization of carbonaceous aerosol during the Big Bend Regional Aerosol and Visibility Observational Study." Colorado State University.

Brown, S. G., P. Herckes, L. Ashbaugh, M. P. Hannigan, S. M. Kreidenweis, and J. L. Jr. Collett. 2002. Characterization of organic aerosol present in Big Bend National Park, Texas during the Big Bend Regional Aerosol and Visibility Observational (BRAVO) Study. *Atmos. Environ. (in Press)*.

Brown, S. G., P. Herckes, S. M. Kreidenweis, and J. L. Jr. Collett. 2001. "Characterization of carbonaceous aerosol during the Big Bend Regional Aerosol and Visibility Observational Study." *CIRA Report*, Colorado State University, Fort Collins, CO.

Brown, S. G., D. E. Sherman, J. L. Hand, T. Lee, S. M. Kreidenweis, and J. L. Collett. 2000. Aethalometer measurements of sub- and super-micron black carbon during the BRAVO study. *2000 Annual Meeting of the American Association for Aerosol Research*.

Collett, J. L., S. Brown, P. Herckes, T. Lee, M. Hannigan, and S. M. Kreidenweis. 2001. The molecular composition of BRAVO organic aerosol. *BRAVO Data Analysis Meeting*.

Collett, J. L. Jr., T. Lee, J. L. Hand, D. E. Sherman, J. E. Reilly, M. P. Hannigan, S. G. Brown, and S. M. Kreidenweis. 2000. Chemical and physical properties of aerosol sampled at Big Bend National Park during the 1999 Big Bend Regional Aerosol and Visibility Observational Study (BRAVO). *2000 Annual Meeting of the American Association for Aerosol Research* .

Collett, J. L. Jr., T. Lee, D. E. Sherman, J. E. Reilly, S. G. Brown, and S. M. Kreidenweis. 2001. The composition of aerosol sampled at Big Bend National Park during the 1999 Big Bend Regional Aerosol and Visibility Observational Study (BRAVO). *AWMA Conference*.

Hand, J. L. 2001. "A new technique for obtaining aerosol size distributions with applications to estimates of aerosol properties." Colorado State University.

Hand, J. L., and S. M. Kreidenweis. 2001. "A new technique for obtaining aerosol size distributions with applications to estimates of aerosol properties." *CIRA Technical Paper No. 0737-5352-49*, Colorado State University, Fort Collins, CO.

Hand, J. L., S. M. Kreidenweis, N. Kreisberg, S. Hering, M. Stolzenburg, W. Dick, and P. H. McMurry. 2002. Comparisons of aerosol properties measured by impactors and light scattering from individual particles: Refractive index, number and volume concentrations, and size distributions. *Atmospheric Environment* 36: 1853-1861.

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Hand, J. L., S. M. Kreidenweis, D. E. Sherman, J. L. Jr. Collett, S. V. Hering, D. E. Day, and W. C. Malm. 2002. Aerosol size distributions and visibility estimates during the Big Bend Regional Aerosol Visibility and Observational Study (BRAVO). *Atmospheric Environment (in Press)*.

Hand, J. L., S. M. Kreidenweis, D. E. Sherman, J. L. Jr. Collett, T. Lee, J. R. Slusser, G. Scott, and L. L. Ashbaugh. 2001. Investigations of aerosol optical properties using ground based remote sensing, aerosol size distributions and chemical measurements at Big Bend National Park, Texas. *IAMAS 8th Scientific Assembly.*

Hand, J. L., S. M. Kreidenweis, J. Slusser, W. Gao, and G. Scott. 2000. The relative contributions of accumulation and coarse mode particles to aerosol optical depth and their effect on the spectral variation of the Angstrom coefficient during BRAVO. *2000 Annual Meeting of the American Association for Aerosol Research*.

Hand, J. L., S. M. Kreidenweis, J. Slusser, and G. Scott. 2002. Comparisons of aerosol optical properties derived from sun photometry to estimates inferred from surface measurements in Big Bend National Park, Texas. *Geophysical Research Letters (Submitted)*.

Hand, J. L., D. E. Sherman, S. M. Kreidenweis, J. L. Collett, T. Lee, D. E. Day, and W. C. Malm. 2000. Characterization of aerosol physical and optical properties during the Big Bend Regional Aerosol and Visibility Observational Study (BRAVO). *2000 Annual Meeting of the American Association for Aerosol Research*.

Hand, J. L., D. E. Sherman, S. M. Kreidenweis, J. L. Jr. Collett, T. Lee, D. E. Day, and W. C. Malm. 2001. Aerosol physical and optical properties during the Big Bend Regional Aerosol Visibility Study (BRAVO). *AWMA Conference*.

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———. 2001. Molecular composition of organic aerosol sampled at Big Bend National Park, Texas during the 1999 Big Bend Regional Aerosol and Visibility Observational (BRAVO). *20th Annual Conference of the American Association for Aerosol Research*.

Herckes, P., M. P. Hannigan, D. E. Sherman, S. M. Kreidenweis, and J. L. Jr. Collett. 2000. Molecular composition of organic aerosol sampled at the Big Bend National Park (U.S.A.) during the 1999 Big Bend Regional Aerosol and Visibility Observational study (BRAVO). *7th International conference on Carbonaceous Particles in the Atmosphere*.

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Malm, W. C., D. E. Day, J. L. Hand, S. M. Kreidenweis, T. Lee, and J. L. Jr. Collett. 2001. Physical, chemical and optical properties of fine and coarse particles in west Texas (Big Bend National Park). *AWMA/AGU Regional Haze and Global Radiation Balance Conference*.

Sherman, D. E., J. L. Hand, S. M. Kreidenweis, J. L. Collett, T. Lee, D. E. Day, W. C. Malm, and K. A. Gebhart. 2000. The influence of meteorological conditions on ambient particle concentrations during BRAVO. *19th Annual American Association for Aerosol Research Conference*.

APPLIED RESEARCH IN SUPPORT OF IMPLEMENTATION OF NATIONAL WEATHER SERVICE'S ADVANCED HYDROLOGIC PREDICTION SERVICES IN CENTRAL REGION

Principal Investigator: C. Adams

Sponsor: NWS

Abstract - The Flash Flood Laboratory (FFL) at the Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University (CSU) proposes to collaborate with the Hydrologic Services Division (HSD) of the Central Region Headquarters (CRH) of the National Weather Service (NWS) to conduct applied social science research in support of the implementation of the Advanced Hydrologic Prediction Services (AHPS) program.

We are conducting applied research to document the AHPS demonstration project carried out at the NWS Weather Forecast Office (WFO) in Des Moines, IA. This research will provide an understanding of the processes of implementation, coordination, and communication used by the staff at WFO Des Moines. This research will be conducted in close coordination with the NWS HSD at CRH. The lessons learned from this assessment will serve to guide the implementation of AHPS at the WFOs in Chanhassen, MN; Grand Forks, ND; Davenport, IA; LaCrosse, WI; and Jackson, KY.

No publications to date associated with this project.

ASSISTANCE FOR VISIBILITY DATA ANALYSIS AND IMAGE DISPLAY TECHNIQUES

Principal Investigators: K. Eis/T. Vonder Haar

Sponsor: NPS

Abstract - The National Park Service has the responsibility of assessing the visual impact of pollutants on various scenic vistas. This assignment is accomplished through monitoring scenic vistas with various electro-optical devices. However, it is difficult for decision makers and other interested parties to visually interpret the meaning of changes in electro-optical variables used to quantify changes in scenic appearance under different atmospheric particulate loading conditions. The most effective way to present effects of pollutants on scenic vistas is through the use of photographic imaging techniques that accurately depict how the scene will appear under various illumination, meteorological and pollutant conditions. In order to meet the National Park Service's needs for computer imaging, the project staff will: 1) continue development and documentation of existing computer software codes and 2) develop new and refined techniques for "digitizing" color transparencies for purposes of accurately deriving quantifiable visibility indices from slides.

Ames, R. B., J. L. Hand, S. M. Kreidenweis, D. E. Day, and W. C. Malm. 2000. Optical measurements of aerosol size distributions in Great Smoky Mountains National Park: Dry aerosol characterization. *Journal of the Air and Waste Management Association* 50: 665-676.

Ames, R. B., and W. C. Malm. 1997. Estimating the contribution of the MOHAVE coal-fired power plant emissions to atmospheric extinction at Grand Canyon National Park. *Visual Air Quality Aerosols and Global Radiation Balance Conference*.

———. 2000. Comparison of sulfate and nitrate particle mass concentrations measured by IMPROVE and CDN: Averaging measurements from monitoring networks with disparate sampling frequencies. *A&WMA 93rd Annual Conference & Exhibition*.

———. 2000. Maps of the reconstructed light extinction coefficient using measured and point estimated particle mass concentrations from IMPROVE and the CDN. *19th Annual AAAR Conference*.

———. 2000. Trends in IMPROVE monitoring data frequency distribution parameters. *Atmos. Environ. (Submitted)*.

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———. 2001. Comparison of sulfate and nitrate particle mass concentrations measured by IMPROVE and the CDN. *Atmos. Environ.* 35: 905-916.

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Ames, R. B., W. C. Malm, B. A. Schichtel, and D. G. Fox. 2001. Apportionment of particle carbon to wildland fires, regional haze and global radiation balance - aerosol measurements and models: Closure, reconciliation, and evaluation. *AWMA Specialty Conference*.

Cahill, T. A., R. A. Eldred, K. Wilkinson, W. C. Malm, M. L. Pitchford, and R. Fisher. 1990. Spatial and temporal trends of fine particles on a continental scale: First results of the U.S. IMPROVE network. *Third International Aerosol Conference*, 1105-1108.

Cahill, T. A., R. A. Eldred, L. K. Wilkinson, B. P. Perley, and W. C. Malm. 1990. Spatial and temporal trends of fine particles at remote U.S. sites. *83rd Annual Meeting of the Air & Waste Management Association*.

Copeland, S. 1999. Visibility impairment in the San Bernardino Mountains: A detailed look at IMPROVE data. *Oxidant Air Pollution Impacts on the Montane Forests of Southern California*, 106-125. New York: Springer Verlag.

Dattore, R. E., K. A. Gebhart, W. C. Malm, and M. Flores. 1991. Use of an atmospheric trajectory model to explore the source regions affecting ozone concentrations at five eastern U.S. national parks. *84th Annual Meeting of the Air & Waste Management Association*.

Day, D. E., W. C. Malm, and S. M. Kreidenweis. 1994. Seasonal variations in aerosol acidity estimated from IMPROVE data. *International Specialty Conference*.

———. 1997. Aerosol light scattering measurements as a function of relative humidity. *Visual Air Quality Aerosols and Global Radiation Balance Conference*.

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ATMOSPHERIC ANALYSIS & DYNAMICAL MODELING OVER THE TOGA/COARE REGION

Principal Investigator: W. Schubert

Sponsor: OGP

Abstract - TOGA/COARE has provided atmospheric-oceanic data sets of unprecedented temporal and spatial resolution. The research is directed towards an area of study which involves the complementary use of the TOGA/COARE data sets with dynamical models to improve our understanding of the physical processes in the COARE region. The four areas of research are: 1) Dynamical adjustments of the trade wind inversion layer; 2) the extratropical and tropical tropopause as a dynamical interface; 3) dynamical adjustment of cumulonimbus anvils; and 4) water vapor transport in tropical regions.

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ATMOSPHERIC Co_2 INVERSION INTERCOMPARISON PROJECT (TransCom 3)

Principal Investigator: S. Denning

Sponsors: NOAA/OGP/NSF

Abstract - Atmospheric chemical tracer transport models (CTMs) can be used to calculate surface fluxes of trace species from spatial distributions of concentration, by a set of methods collectively known as "inversion." This technique has been applied to the study of sources and sinks of CO_2 , and the results have important implications for policy responses. Different CTM groups have produced conflicting results using the same observational data. We will conduct a three-year series of experiments in which leading chemical tracer transport models from around the world are used to calculate the global carbon budget of the atmosphere. The objectives of the proposed research are (1) to quantify the uncertainty in the O_2 budget that arises from differences in simulated transport; (2) to diagnose the mechanisms that produce these differences; and (3) to recommend and prioritize improvements to the models and observing network to reduce this source of uncertainty in the future.

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CENTER FOR GEOSCIENCES / ATMOSPHERIC RESEARCH

Principal Investigator: T. Vonder Haar

Sponsor: DoD

Abstract - The Cooperative Institute for Research in the Atmosphere at Colorado State University has conducted Army and DoD-relevant research in the area of meteorology and hydrology since 1986. This research, totaling over $17M, has a successful history of results. Research is performed by a multi-disciplinary group of faculty, staff, and students from CSU, with a few collaborators from other universities, NCAR, and federal labs. The first two phases of Center for Geosciences were funded through the Army Research Office; both basic and related, applied research was conducted. As a result of this earlier funding, many research topics have matured and have already been, or are ready for technical transition to operational users within the DoD. Phases III and IV of the Center for Geosciences/Atmospheric Research have been funded through the Army Research Laboratory with focus on further work and technology transfer in five research theme areas: Hydrometeorology; Cloud Structure, Dynamics and Climatology; N-Dimensional Data Assimilation and Fusion; (recently renamed) Boundary Layer Atmospheric Chemistry and Aerosols; and (recently renamed) Derivation of Battlespace Parameters. A new, cross-cutting theme area has recently been identified, Urban Environment.

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CHARACTERIZATION OF PARTICLE LIGHT EXTINCTION AT GRAND CANYON AND BIG BEND NATIONAL PARKS

Principal Investigators: S. Kreidenweis/J. Collett

Sponsor: NPS

Abstract - A research program is proposed to examine in detail, the chemical composition, degree of internal mixing, and scattering and absorption properties of aerosols. The project involves (1) analysis and interpretation of field data taken in a pilot study in summer 1998 in Grand Canyon National Park; (2) modification and application of the experimental methods developed in the pilot study and in SEAVS to a larger-scale study in Big Bend National Park (BRAVO) in 1999; (3) participation in the 4-month BRAVO field project in July-October 1999; and (4) analysis and interpretation of the measurements from BRAVO. The project also involves exploratory laboratory work, namely (5) examination of analytical methods for the characterization of organic and light-absorbing components in aerosols.

The aerosol was characterized during the Grand Canyon and BRAVO field studies both physically and chemically. Differential mobility analyzer, aerodynamic particle sizer, and optical particle counter measurements of the dry particle size distribution were obtained at ~15-minute intervals to span the particle size range from 0.02 to 20 µm diameter. Because of the desert environment at Big Bend, a particular focus was the characterization of the size distribution of the coarse mode of the aerosol and its role in particle light extinction. Chemical characterization was accomplished via filter and impactor sampling with subsequent chemical analysis for major ions and organic and elemental carbon. Analyses of major ions are aimed at examining whether an ion balance on mass concentrations can be achieved, or whether significant ionic mass is being missed. Further, we are determining the form(s) that aerosol sulfate is found in at Big Bend National Park (e.g., H_2SO_4, NH_4HSO_4, $(NH_4)_2SO_4$, NA_2SO_4, etc.) and we are examining the changes in sulfate content and speciation during transport of air from the coast to the park by analyzing filters from additional locations. At Big Bend, an aethalometer was used to obtain estimates of fine particle elemental carbon concentrations/absorption. We also collected samples for analysis of organic compounds and are performing exploratory examinations of analytical spectroscopic methods for the characterization of organic components in particles. Of particular interest, is the determination of dominant source types contributing to carbonaceous aerosol at Big Bend National Park and how these source types vary with transport conditions or season.

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CIRA ACTIVITIES IN THE U.S. WEATHER RESEARCH PROGRAM

Principal Investigators: T. Vonder Haar/M. DeMaria

Sponsor: NOAA/NESDIS

Abstract - Over the past several years, the CIRA Regional and Mesoscale Meteorology (RAMM) Team has performed research under funding from NOAA's Severe Weather Prediction Initiative (SWPI). Efforts have focused on the use of satellite data for mesoscale analysis of high-impact weather events, and on forecast product development. Beginning in 2000, the SWPI program was combined with the ongoing U.S. Weather Research Program (USWRP). For 2001-2002, contributions to the Joint Hurricane Testbed (JHT) effort have been emphasized by the USWRP. Two NESDIS/CIRA research projects were ranked as high priorities for the JHT. These include research related to improvements to the operational Statistical Hurricane Intensity Prediction Scheme (SHIPS) using satellite altimetry and GOES data, and the development of an Advanced Microwave Sounder unit (AMSU) algorithm for tropical cyclone intensity and size estimation. The second project is a joint effort with the Cooperative Institute for Meteorological Satellite Studies (CIMSS), located in Madison, Wisconsin. This continuation proposal describes the CIRA research contributions to the JHT for the second year of these two projects. The proposed research contributes directly to two of the eight primary themes of CIRA: 1. Local and Mesoscale Area Weather Forecasting and Evaluation, 2. Applications of Satellite Observations.

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CIRA ACTIVITIES AND PARTICIPATION IN DMSP SATELLITE DATA PROCESSING AND ANALYSIS

Principal Investigators: T. Vonder Haar/C. Matsumoto

Sponsor: NESDIS

Abstract - This program at CIRA is being undertaken to support NOAA's Defense Meteorological Satellite Program (DMSP) Program at National Geophysics Data Center (MGDC) in Boulder, CO. This effort emphasizes the use of current technology in the use and interpretation of meteorological satellite imagery, the development of new applications like the early detection of forest fires, the preparation of research quality data from DMSP satellites for the national archives, and the preparation and distribution of data and products to the user community.

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CIRA ACTIVITIES & PARTICIPATION IN THE GOES I-M PRODUCT ASSURANCE PLAN

Principal Investigators: T. Vonder Haar/M. DeMaria

Sponsor: NOAA/NESDIS

Abstract: In April 1994, NOAA introduced a new geostationary satellite series with the launch of GOES-8: the new series is called GOES-I/M. In May 1995, the second in the series, GOES-9, was launched and GOES-K is scheduled for launch in April, 1997. In response to the need to insure transition from GOES-7 to GOES-8 and GOES-9 day-1 products and beyond, CIRA has been involved in NESDIS' GOES-I/M Product Assurance Plan, GIMPAP. The GIMPAP provides the means to checkout the performance of GOES satellites immediately after launch, to assure the viability of GOES-I/M day-1 products, to improve operational products, to develop advanced products, and to ensure integration of the results into NESDIS operations. As a part of this effort, CIRA developed a system that allows for the display and analysis of digital satellite imagery at selected field sites. This system, known as RAMSDIS (RAMM Advanced Meteorological Satellite Demonstration and Interpretation System), is a prototype satellite imaging system which allows for menu-driven collection, display and manipulation of full-resolution digital satellite imagery. The system is allowing for interaction between RAMM/CIRA and NWS field offices (as well as selected OAR sites) in a virtual laboratory atmosphere. Techniques and algorithms developed at RAMM/CIRA are being tested and critiqued by both the research and operational community via this system, which is leading to technique and algorithm improvements.

Recently, most RAMSDIS systems at NWS offices have been retired now that the AWIPS deployment is completed. CIRA is continuing to develop GOES algorithms and products for severe weather, tropical cyclones and mesoscale aspects of mid-latitude cyclones, and fire and volcanic ash detection. These products are being tested and distributed using web-based applications, and eventually through the AWIPS system.

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A COMPARISON OF ROOFTOP AND STANDARD GROUND-BASED TEMPERATURE

Principal Investigators: T. McKee/N. Doesken

Sponsor: NOAA

Abstract - Accuracy and continuity of surface air temperature measurements are critical for many NOAA activities including short term weather forecasting and warning, climate monitoring and the prediction and assessment of decadal to centennial climate change. This project will study biases and uncertainties in temperature records caused by rooftop instrument locations. Both National Weather Service stations and non-NOAA sources will be investigated. Ground level to rooftop temperature differences will be studied to show what, if any, differences occur and whether these differences are significant, systematic, predictable and a function of current weather conditions or if differences are highly variable and inconsistent. Work will be performed at the National Climatic Data Center (NCDC) to better document where and when NWS weather stations have been situated on rooftops.

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CONVECTIVE AND BOUNDARY LAYER PROCESSES IN THE VICINITY OF THE SOUTH CHINA SEA DURING THE ONSET OF THE EAST ASIAN MONSOON

Principal Investigators: R. Johnson/D. Parsons

Sponsor: OGP

Abstract - This research is directed toward an improved understanding of air-sea coupling, convective processes, and large-scale dynamical processes over and surrounding the South China Sea during the onset of the East Asian Monsoon. It involves participation in the planning and execution of the South China Sea Monsoon Experiment (SCSMEX) in May and June 1998 and post-processing atmospheric sounding data collected during SCSMEX. Research topics include the role of 10-24 and 30-60 day oscillations in the monsoon onset, the large-scale evolution of diabatic heating over East Asia accompanying the onset, and the structure and properties of convection over the northern South China Sea during the monsoon onset.

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COPING WITH FLASH FLOODS

Principal Investigator: K.Eis

Sponsor: NATO

Abstract - The Flash Flood Laboratory has been funded by NATO to offer a NATO Advanced Studies Course to be held in Ravello, Italy November 8-17, 1999, entitled "Coping with Flash Floods". Our meeting will follow up on recommendations from a 1992 ASI "Coping with Floods". The 1992 session findings provide a solid understanding of how technology can and is being applied to reducing flood losses. Our 1999 ASI will focus on flash floods and will include participation from engineers, geographers, hydrologists, meteorologists, emergency managers, social scientists, and others addressing the challenges of reducing flash flood vulnerability. After presentations of the state of the art in the fields, the group will divide into groups. These groups will discuss within international and interdisciplinary contexts, a new research agenda and the best ways to learn from and apply current scientific and technological advancements to reducing vulnerability. Bold recommendations will be made.

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Gruntfest, E. 2001. Beyond flood detection: Alternative applications of real-time data. *Coping with Flash Floods.* Eds. E. Gruntfest, and J. Handmer, 167-81. Dordrecht, Netherlands: Kluwer Academic Publishers.

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Gruntfest, E., and J. Handmer, Eds. 2001. *Coping with flash floods*. Dordrecht, Netherlands: Kluwer Academic Publishers.

Gruntfest, E., and B. Montz. 2000. Flash flood research agenda: Following up on the NATO Advanced Study Institute findings. *European Geophysical Society Meeting*.

Gruntfest, E., and A. Ripps. 2001. Reducing loss susceptibility in flash floods. *Flood Hazards and Disasters .* ed. D. Parker, 377-390. London, England: Routledge.

Jennings, S., and E. Gruntfest. 2002. Flooding. *Handbook of Weather, Climate and Water*, 154-171. Columbus, Ohio: McGraw Hill.

Montz, B., and E. Gruntfest. 2002. Refining the research agenda: Reducing flash flood vulnerability through improved warning methodology (in Press). *Environmental Hazards.*

Weaver, J. F., G. Levy, and E. Gruntfest. 2000. Two floods in Fort Collins, Colorado: Learning from a natural disaster. *Bulletin of the American Meteorological Society* 81, no. 10: 2359-2366.

COUPLING BETWEEN MONSOON CONVECTIN AND SUBTROPICAL HIGHS IN THE PACS REGION ON SUBSEASONAL TO INTERANNUAL TIME SCALES

Principal Investigators: R. Johnson/W. Schubert

Sponsor: NOAA

Abstract - Recent analyses have shown a dynamical coupling between subtropical highs and monsoon convection. The hypothesis for this coupling over the PACS region has yet to be fully explored. In this proposal we outline a research plan to document the nature, extent and mechanisms for the coupling between the monsoon heat sources and adjacent subtropical anticyclones with their associated low-level jets using both modeling and observational approaches. The observational part of this research will supplement the sparse sounding network over adjacent oceans with profiler and NCEP reanalysis data. The modeling component will primarily use a well-tested general circulation model with realistic topography and a variety of specified heating profiles.

Since potential vorticity (PV) concepts have been shown to be useful in understanding the Asian monsoon circulation, we propose to apply PV concepts to the PACS region. In particular, we plan to investigate how PV is modified in the cross-equitorial flows that feed into the monsoon convection over Amazonia and into the eastern Pacific ITCZ and Central American convection.

Ito, T., E. P. Gerber, and W. H. Schubert. 2002. Formation and maintenance of black holes of water vapor in an idealized model of the tropical atmosphere. *J. Meteo. Soc. (in Prep)*.

DEVELOPING A MESOSCALE OBSERVING NETWORK OVER THE NORTH ATLANTIC CONTINENT AND ADJACENT OCEAN AREAS TO SUPPORT THE NEXT GENERATION NUMERICAL WEATHER PREDICTION MODELS

Principal Investigators: T. Vonder Haar/C. Matsumoto

Sponsors: NOAA/FSL

Abstract - This project entails work on developing a mesoscale observing network over the North American continent and adjacent ocean areas to support the next generation numerical weather prediction models. Specifically, activities will include coordination with US airlines to expand meteorological data coverage and efforts within the North America Atmospheric Observing System (NAOS) Program to design the next generation integrated upper air observing system over North America.

Cunning, J. 2000. Commercial aircraft-provided weather data. *Preprints, AMS 4th Symposium on Integrated Observing Systems*, 45-48.

DEVELOPING CAPABILITY TO IMPLEMENT, EVALUATE & USE MODELS-3/CMAQ FOR VISIBILITY, PM2.5 & ASSOCIATED WESTERN US AIR QUALITY ISSUES INCLUDING CONTRIBUTIONS FROM FOREST & AGRICULTURE BURNING

Principal Investigators: D. Fox/T. Vonder Haar/K. Eis

Sponsors: CIRA and NPS, supported additionally by United States EPA

Abstract - CIRA will conduct the following research work: Install and operational test the current release of Models3/CMAQ at CIRA; evaluate functionality and general performance capability of Models3/CMAQ; initiate research studies to link existing and next generation fire emissions models with the Models3 emissions processing capability, including the new Sparce Matrix Operator Kernel Emissions (SMOKE) processor; pursue development of the capabilities at CIRA for using and developing Models3 and associated scientific components to address contemporary air quality issues in the Western United States.

No publications to date associated with this project.

DEVELOPMENT AND IMPLEMENTATION OF A STATISTICAL TYPHOON INTENSITY PREDICTION SCHEME FOR THE WESTERN NORTH PACIFIC

Principal Investigators: T. Vonder Haar/J. Knaff/M. DeMaria

Sponsor: Office of Naval Research

Abstract - Forecasting tropical cyclone intensity changes is a challenging task. Changes in storm intensity are due to a complex interaction between the circulation on the scale of the eyewall, the mesoscale circulation of the storm envelope and the larger-scale synoptic environment. The exchanges of heat and momentum with the underlying ocean surface are also of fundamental importance. Because of these complexities, the development of a numerical tropical cyclone model that can skillfully predict intensity changes has been a slow process. In the Atlantic basin, the Statistical Hurricane Intensity Prediction Scheme (SHIPS) has shown some skill in forecasting intensity changes. In this proposal, a version of SHIPS will be developed for the Western North Pacific tropical cyclone basin. An updated version of a simpler model that only includes climatology and persistence as predictors will also be developed to help evaluate the skill of the West Pacific SHIPS model.

No publications to date associated with this project.

DEVELOPMENT AND IMPLEMENTATION OF GOES RAINFALL AND FIRE DETECTION PRODUCTS FOR GUATEMALA

Principal Investigators: B. Connell/M. DeMaria

Sponsors: SICA/AID Rio Lempa Project

Abstract - Under the Hurricane Mitch Reconstruction Efforts, a GOES ingest system will be installed in Costa Rica and satellite display systems will be installed in six additional countries in Central America (July-September 2001). When this occurs, GOES imager data will routinely be available in real time. One important application of this data in this region is the estimation of rainfall. A visiting scientist, Rosario Alfaro, is adapting the satellite rainfall estimation techniques to Central America under the Hurricane Mitch Reconstruction efforts. This project allows the implementation of the products on a web page before the operational systems are installed. This project also introduces monthly GOES infrared cloud frequency products to be used along with the rainfall estimates. Another important application of GOES imager data for Central America is the detection of fires. Although the spatial resolution of the GOES data is not as high as that of the polar-orbiting satellite data, the high time resolution of the data allows for more continuous monitoring of some of the larger fires. This project will adapt existing fire algorithms for the region and display the resulting imagery on the web page. The algorithms will be transferred to the operational systems after installation.

Connell, B. H., and V. Castro. 2001. The use of mesoscale climatologies for monitoring and forecasting weather in Costa Rica. *AMS 11th Conference on Satellite Meteorology and Oceanography*, 157-160.

Connell, B. H., Fryer, M. K., Watson, D., and Alfaro, R. 2001. "Real-time Satellite Rainfall and Fire Products for Central America ." Web page. Available at http://www.cira.colostate.edu/RAMM/sica/main.html.

DEVELOPMENT OF A FORWARD MODEL FOR HURRICANE INITIALIZATION

Principal Investigators: T. Vonder Haar/W. Schubert/M. DeMaria

Sponsors: NOAA/NWS

Abstract - To a first approximation, tropical cyclones are quasi-axisymmetric and the tangential wind rotates around a vertically oriented axis. Eliassen (1952) developed a set of equations that are appropriate for this type of flow. In the Eliassen vortex model, the flow is in hydrostatic balance in the vertical, and the tangential wind is in gradient balance with the mass field. The secondary circulation, i.e., the radial and vertical velocity, is diagnostic, given the tangential wind field and the radial and vertical distributions of friction and diabatic heating. The Eliassen balanced vortex model will be the basis of our forward model for hurricane initialization. Although the storm motion introduces a wavenumber one asymmetry even in very strong storms with well-developed eyes, it is assumed that the forward model will be used to provide increments relative to a background field obtained from an earlier model run. Since the primary contribution to the storm motion comes from the large-scale environmental flow, the asymmetry due to the storm motion will be included in the analysis when the symmetric flow from the forward model is added to the background field. This forward model will be tested in the NCEP Global Data Assimilation System (GDAS).

No publications to date associated with this project.

DEVELOPMENT OF A STATISTICAL TROPICAL CYCLONE RAINFALL ALGORITHM

Principal Investigators: T. Vonder Haar/ M. DeMaria

Sponsor: Insurance Friends of the National Hurricane Center, Inc.

Abstract - Over the past several decades considerable progress has been made in the ability to forecast the tracks of tropical cyclones. Some modest intensity forecast improvement has also been obtained. Since 1970, however, the largest loss of life in the U.S. from landfalling tropical cyclones has resulted from inland flooding. The primary tools for operational prediction of rainfall from landfalling tropical cyclones are dynamical models such as the operational version of the Geophysical Fluid Dynamics Laboratory (GFDL) hurricane model. Extrapolation of satellite-derived rainfall estimates are also sometimes used. However, the tropical cyclone rainfall forecasts from the GFDL model and other algorithms have not been systematically evaluated in the same way as the track and intensity forecasts have. One of the primary methods for evaluating the skill level of a particular forecast is by comparison with a forecast based upon climatology and persistence (CLIPER). CLIPER-type models are currently available for track and intensity forecasting, but no such model is available for rainfall prediction. In the proposed research, a rainfall CLIPER-type model for U.S. landfalling tropical cyclones will be developed. The model will use U.S. rain gauge data to determine the climatological rainfall rate associated with landfalling storms. This rainfall rate can be extrapolated along the forecast track of the storm to provide an estimate of storm-total rainfall amounts. This model will be useful for providing guidance for operational forecasting, and will provide a benchmark to evaluate the skill of other rainfall techniques. We plan to implement this model at the Tropical Prediction Center in Miami for an operational evaluation during the 2001 hurricane season.

DeMaria, M., and R. E. Tuleya. 2001. Evaluation of quantitative precipitation forecasts from the GFDL hurricane model. *81st Annual AMS Meeting*.

Kidder, S. Q., S. J. Kusselson, J. A. Knaff, and R. J. Kugligowski. 2001. Improvements to the experimental tropical rainfall potential (TraP) technique. *AMS 11th Conference on Satellite Meteorology and Oceanography*, 375-378.

Marks, F. Jr., G. Kappler, and M. DeMaria. 2002. Development of a tropical cyclone rainfall climatology and persistence (R-CLIPER) model. *AMS 25th Conference on Hurricanes and Tropical Meteorology*, 327-328.

DEVELOPMENT OF A VIRTUAL LABORATORY WEB SERVER FOR INTERNATIONAL SATELLITE METEOROLOGY TRAINING

Principal Investigators: B. Connell/D. Molenar/M. DeMaria

Sponsor: NOAA/NESDIS

Abstract - A meeting of an International Satellite Data Utilization and Training Focus Group was held at the European Meteorological Satellite (EUMETSAT) Agency in Darmstadt, Germany, 16-18 May, 2001. This meeting was organized by the World Meteorological Organization, and included representatives from NOAA/NESDIS and the international satellite community. A decision was made at this meeting to establish a Virtual Laboratory (VL) to foster the international exchange of satellite data and training material. For this purpose, web servers will be established at EUMETSAT, the Bureau of Meteorology (BOM) in Melbourne, Australia and at CIRA in Fort Collins, CO. This proposal is to purchase and configure the necessary hardware and software, coordinate the initial VL development with EUMETSAT and BOM, and to provide software support for the first year of the project. Relevant information regarding the CIRA contribution to the WMO Virtual Laboratory can be found in section 6 and Annex III and IV of the Final Report of the GGMS International Satellite Data Utilization and Training Focus Group.

No publications to date associated with this project.

DEVELOPMENT OF ADVANCED APPLICATIONS PRODUCTS USING AMSU DATA

Principal Investigators: S. Kidder/T. Vonder Haar

Sponsor: NOAA

Abstract - The Advanced Microwave Sounding Unit (AMSU) is the most significant advance on the NOAA-KLM satellites. The first of these satellites, NOAA 15, was launched on May 13, 1998. The second satellite carrying AMSU instruments, NOAA 16, was launched 21 September 2000. The exciting opportunity that the AMSU presents, is to develop advanced applications products from a new instrument and to supply these products to forecasters for testing and evaluation.

DeMaria, M., J. A. Knaff, S. Q. Kidder, and M. D. Goldberg. 2000. Tropical cyclone wind retrievals using AMSU-A data from NOAA-15. *AMS 10th Conference on Satellite Meteorology and Oceanography*, 149-152.

Demuth, J. L., M. DeMaria, J. Knaff, and T. Vonder Haar. 2000. An objective method for estimating tropical cyclone intensity and structure from NOAA-15 Advanced Microwave Sounding Unit (AMSU) data. *AMS 24th Conference on Hurricanes and Tropical Meteorology*, 484-485.

Johnsen, K. P., and S. Q. Kidder. 2002. Water vapor over Europe obtained from remote sensors and compared with a hydrostatic NWP model . *Physics and Chemistry of the Earth* 27: 371-375.

Kidder, S. Q., M. D. Goldberg, R. M. Zehr, M. DeMaria, J. F. W. Purdom, C. S. Velden, N. C. Grody, and S. J. Kusselson. 2000. Satellite analysis of tropical cyclones using the advanced microwave sounding unit (AMSU). *Bulletin of the American Meteorological Society* 81: 1241-1259.

Kidder, S. Q., M. D. Goldberg, R. M. Zehr, M. DeMaria, J. F. W. Purdom, C. S. Velden, N. C. Grody, and S. J. Kusselson. 2000. Tropical cyclone analysis using AMSU data . *AMS 10th Conference on Satellite Meteorology and Oceanography*, 185-188.

Kidder, S. Q., A. S. Jones, J. F. W. Purdom, and T. J. Greenwald. 1998. First local area products from the NOAA-15 advanced microwave sounding unit (AMSU). *Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) 1998 Conference*, 447-451.

Kidder, S. Q., J. A. Knaff, and S. J. Kusselson. 2001. Using AMSU data to forecast precipitation from landfalling hurricanes. *AMS 81st Annual Meeting*, 344-347.

Kidder, S. Q., S. J. Kusselson, J. A. Knaff, and R. J. Kugligowski. 2001. Improvements to the experimental tropical rainfall potential (TraP) technique. *AMS 11th Conference on Satellite Meteorology and Oceanography*, 375-378.

Knaff, J. A., M. DeMaria, and J. L. Demuth. 2000. Tropical cyclone forecast products derived from the Advance Microwave Sounding Unit. *Interdepartmental Hurricane Conference*.

Knaff, J. A., R. M. Zehr, M. D. Goldberg, and S. Q. Kidder. 2000. An example of temperature structure differences in two cyclone systems derived from the Advanced Microwave Sounder Unit. *Wea. Forecasting* 15, no. 4: 476-483.

McKague, D. S., R. J. Engelen, J. M. Forsythe, S. Q. Kidder, and T. H. Vonder Haar. 2001. An optimal-estimation algorithm for water vapor profiling using AMSU. *AMS 11th Conference on Satellite Meteorology and Oceanography*, 633-636.

Moore, R. W., M. DeMaria, J. L. Demuth, J. Dostalei, S. Q. Kidder, J. A. Knaff, and T. H. Vonder Haar. 2001. A three-dimensional temperature and wind analysis of a polar low utilizing the Advanced Microwave Sounding Unit. *Quarterly Journal of the Royal Meteorological Society (Submitted)*.

Vonder Haar, T. H., K. R. Dean, J. M. Forsythe, T. J. Greenwald, and S. Q. Kidder. 2001. Comparison of satellite and ground-based measurements of cloud liquid water in several climate zones. *International Geophysics and Remote Sensing Symposium (IGARSS) 2001*.

DEVELOPMENT OF EXTEND-RANGE TROPICAL CYCLONE INTENSITY FORECAST TECHNIQUES

Principal Investigators: T. Vonder Haar/ M. DeMaria

Sponsor: Insurance Friends of the National Hurricane Center, Inc.

Abstract - Since 1965, the National Hurricane Center (NHC) has had the responsibility for predicting the position and intensity of Atlantic tropical cyclones out to 72 h. However, some specialized interests such as the evacuation of naval fleets, space shuttle operations, and the evacuation of particularly vulnerable regions such as the Florida Keys and New Orleans require some actions to be take prior to three days in advance of a hurricane landfall. To address these needs, NHC is considering extending their track and intensity forecasts from three to five days. The primary tools for track forecasting are dynamical models, which can be modified to provide five-day predictions without major changes in their formulations. In fact, many of these models already provide five-day forecasts. Because the processes that affect tropical cyclone intensity change involve a wider range of scales of motion, dynamical model intensity forecasts are usually less skillful than their track forecasts. For this reason, the NHC forecasters also rely on statistical models for the prediction of intensity. A current limitation of the statistical intensity models is that they only provide three-day forecasts. Because these models use empirical relationships, the extension to five days is more difficult than for dynamical models, since new relationships must be developed for the day four and five predictions. In this proposal, the operational SHIFOR and SHIPS intensity forecasts will be generalized to provide forecasts out to five days for the Atlantic and Eastern Pacific tropical cyclone basins.

DeMaria, M. 2001. Extension of statistical tropical cyclone intensity forecasts to Day 4 and Day 5. *55th Interdepartmental Hurricane Conference*.

DEVELOPMENT OF TROPICAL CYCLONE WIND SPEED PROBABILITIES

Principal Investigators: J. Knaff/M. DeMaria

Sponsor: Insurance Friends of the National Hurricane Center, Inc.

Abstract - Every six hours the National Hurricane Center (NHC) provides forecasts of the track, maximum surface wind and radii of 34, 50 and 64 kt winds for all tropical cyclones in the Atlantic and east Pacific. If all of these parameters were perfectly forecast, it would be possible to determine in advance which regions along the storm path would experience hurricane force winds. However, forecast uncertainties result in the probability of a given point actually experiencing hurricane winds being less than one, even if that location is directly along the predicted storm track. Estimates of the probability of occurrence of wind speed thresholds at various lead times would be very useful for planning purposes. For example, decision-making tools that rely on quantitative probabilities of wind speed occurrences could be developed. Wind probabilities would also be useful for helping to determine the areas included in NHC coastal watches and warnings, and in high wind warnings issued by local National Weather Service (NWS) forecast offices for inland counties.   In this proposal a method will be developed to estimate these probabilities using the error characteristics from a long-term sample of the official NHC track, intensity and size forecasts.

No publications to date associated with this project.

EFFECTIVE COMMUNICATION AND UTILIZATION OF NATIONAL WEATHER SERVICE CRITICAL HYDROMETEOROLOGICAL INFORMATION

Principal Investigators: C. Adams/T. Vonder Haar

Sponsor: NWS

Abstract - The overall objectives of this project are to provide an understanding of how weather forecasts, warnings, and information are used for natural disaster reduction and the economic well being of the nation. This work continues a line of applied social science research projects addressing effective communication of National Weather Service warnings and forecasts. Earlier attention was paid to the weather warning process and effective use and coordination of critical information within the weather warning partnership. Research also focuses on the use and value of weather forecasts and services to the surface transportation industry. Economic analysis was conducted on the cost of hurricane evacuations.

Adams, C. R. 1997. Heat and cold: The next step in effective warning service. *22nd Annual Workshop on Hazards Research and Applications*.

———. 1997. Impacts of temperature extremes. *Workshop on the Societal and Economic Impacts of Weather*.

———. 1997. Lessons learned from the flood. *CSU Fort Collins Flood 1997 Conference*.

———. 1997. NWS/FEMA training project. *CSU Fort Collins Flood 1997 Conference*.

———. 1997. Virtual Institute for Applied Flash Flood Forecasting and Warning. *National Hydrologic Warning Council Meeting*.

———. 1997. Warning Coordination. *Pilot Course at FEMA National Training Center*.

———. 1997. Warning Coordination. *Pilot Course at FEMA Region VIII Headquarters*.

———. 1998. Warning Coordination: A Field Course for Emergency Managers on Warning Coordination for Hydrometeorological Hazards. Federal Emergency Management Agency.

———. 1999. Economic costs of hurricane evacuations. *USWRP Science Symposium, NCAR*.

———. 1999. Extreme Temperatures. *Natural Disaster Management: A Presentation to Commemorate the International Decade for Natural Disaster Reduction 1990-2000 .* ed. J. Ingleton Leicester, United Kingdom: Tudor Rose.

———. 1999. *The Social and Economic Impacts of Weather Information: A Case Study of the Surface Transportation Industry*, Cooperative Institute for Research in the Atmosphere, Colorado State University, Ft. Collins, CO.

———. 1999. Tornado warning and mitigation. *6th Conference of the Institute for Home and Business Safety*.

———. 2000. Hurricane preparedness, warnings, and response: Educating public officials. *National Hurricane Conference*.

———. 2000. Natural hazards: Bridging the gap between science and the public. *2000 Annual Meeting of the American Academy for the Advancement of Science*.

———. 2000. Social science: Bridging the gap between physical science and customers. *NWS Warning Coordination Meteorologists Conference*.

Adams, C. R., and D. Berri. 2000. The social and economic impact of weather information: A case study of the surface transportation industries. *Preprints, AMS Second Symposium on Environmental Applications*.

Adams, C. R., R. N. Dombrowsky, G. L. Austin, and A. C. Eustis. 1997. *National Weather Service Customer Impact Assessment Report*, National Oceanic and Atmospheric Administration, National Weather Service, Silver Springs, MD.

Adams, C. R., and et. al. 1999. *Community hurricane preparedness course*. EMI IS 324 ed. Emmitsburg, MD: Federal Emergency Management Agency and National Weather Service.

Adams, C. R., and E. Gruntfest. 1997. Warning coordination, communication and decision making. *Course at the National Hydrologic Warning Council Meeting*.

———. 1999. The flash flood laboratory. *23rd Annual Workshop on Hazards Research and Applications*.

Adams, C. R., E. Gruntfest, and D. Berri. 1999. Applied social and economic impacts research. *NOAA Science Advisory Board*.

Adams, C. R., E. Gruntfest, and K. E. Eis. 1998. Flash Flood Laboratory at Colorado State University. *ALERT Transmission* Winter: 2-6.

Adams, C. R., and W. Hooke. 2001. Improved flash flood predictions. *Coping with Flash Floods .* NATO ASI Series ed., ed. E. Gruntfest. Dordrecht, Netherlands: Kluwer Academic Publishing.

Berri, D. J., and C. R. Adams. 1999. On the utilization of weather information: A case study of the surface transportation industry. *Western Social Science Association Meetings*.

———. 2000. The social and economic impact of weather information: Acase study of the surface transportation industries. *Regional Business Review* 19: 13-31.

Dean, K., M. Hiatt, and C. Adams. 2000. Two inexpensive systems for receiving weather watches, warnings, and other pertinent weather information--NOAA Weather Radio and EMWIN. *American Geophysical Union 20th Hydrology Days*, 29-35.

Golden, J. H., and C. R. Adams. 2000. The tornado problem: Forecast, warning, and response. *National Hazards Review* 2: 107-118.

Weaver, J. F., G. Levy, and E. Gruntfest. 2000. Two floods in Fort Collins, Colorado: Learning from a natural disaster. *Bulletin of the American Meteorological Society* 81, no. 10: 2359-2366.

ENHANCED COMMUNICATIONS AT CIRA: UPGRADE OF THE CIRA COMPUTER LABORATORY

Principal Investigators: T. Vonder Haar/M. DeMaria/ D. Molenar

Sponsor: NOAA/NESDIS

Abstract - Over the past several years, CIRA has provided satellite data and experimental products to a wide variety of users. A low-cost PC-based workstation was developed (RAMSDIS) that allows outside users to obtain, display and manipulate digital satellite data. During the late 1990s, RAMSDIS systems were used at up to 50 National Weather Service (NWS) forecast offices throughout the U.S. In the past year, the RAMSDIS project within the NWS ended, due to the implementation of the Advanced Weather Interactive Processing System (AWIPS). More recently, RAMSDIS systems have been implemented at many international locations to enhance cooperative research and training efforts. These systems are also used at several research laboratories within the U.S., including CIRA. The Internet has continued to have an increasingly important role in the provision of satellite data and experimental products. For example, a web-based version of RAMDIS (RAMSDIS On-Line) provides animated loops of satellite imagery and products for a wide variety of applications.

The original RAMSDIS systems were developed in the context of an OS/2 operating system. The OS/2 operating system is rapidly becoming archaic, and is no longer supported by the McIDAS Users Group. If the CIRA laboratory is not upgraded, we will lose our ability to generate data and experimental products, and to continue our cooperative research and training efforts within the U.S. and internationally. We propose to upgrade the OS/2 systems in the CIRA computer laboratory to a more modern and supportable operating system (Windows 2000). This upgrade will allow us to continue to distribute data and experimental products to many outside agencies, and to continue our communications and collaborative research projects within and outside of CIRA. In addition, we plan to enhance the local AWIPS capabilities at CIRA, which will allow us to continue to collaborate with the NWS now that their modernization is completed. In particular, we plan to establish mass storage capabilities, which will be necessary to install the AWIPS Warning Event Simulator (WES) at CIRA. The WES adds case study capabilities to AWIPS, and will become an important component of the NWS training program.

No publications to date associated with this project.

ENHANCEMENT OF SATELLITE DATA PROCESSING AND ANALYSIS CAPABILITIES IN CENTRAL AMERICA

Principal Investigators: T. Vonder Haar/ M. DeMaria/D. Molenar

Sponsor: NOAA/NESDIS/IA

Abstract - On October 29, 1998, Hurricane Mitch came ashore near La Ceiba, Honduras with high winds and heavy rainfall. Mitch was a large and slow moving storm, and several locations in Central America received extreme amounts of rainfall (up to 36 inches) over a three-day period. This rainfall resulted in more than 9,000 fatalities, and had devastating effects on the infrastructure of several countries in Central America. In response to this disaster, an Interagency Agreement was signed between the U.S. Agency for International Development (USAID) and the U.S. Department of Commerce for Hurricane Mitch Reconstruction Activities in Central America. As part of the Mitch Reconstruction Activities, the National Environmental Satellite, Data and Information Service (NESDIS) has provided a work plan for the development of a satellite data receiving, processing and analysis capability in Central America. This plan was developed to address deficiencies in the ability to receive and use satellite data identified during site visits to several countries in Central America (Guatemala, Nicaragua, Honduras, and El Salvador) in October of 1999. The NESDIS activities will be implemented by the Office of International and Interagency Affairs in coordination with the NOAA cooperative institute at Colorado State University (CIRA). A GOES ingest system will be installed in Costa Rica by a private contractor, to supply the data necessary for this project. The contractor funding will be provided by NOAA. CIRA will provide RAMSDIS workstations in Costa Rica, Guatemala, Honduras and Nicaragua (two per country) to analyze and display the GOES data that is ingested in Costa Rica. Training sessions in Costa Rica for the participating countries will also be provided by CIRA as part of this project. A CIRA visiting scientist from the Central America region will be supported to improve satellite rainfall estimation techniques for the region.

Connell, B. H., and V. Castro. 2001. The use of mesoscale climatologies for monitoring and forecasting weather in Costa Rica. *AMS 11th Conference on Satellite Meteorology and Oceanography*, 157-160.

ENVIRONMENTAL APPLICATIONS RESEARCH

Principal Investigators: T. Vonder Haar/C. Matsumoto

Sponsors: NOAA/FSL

Abstract - This project involves scientific research collaborations performed at the Forecast Systems Laboratory (FSL). On-going collaborations fall under virtually all of CIRA's research themes and cross-cutting areas: Global and Regional Climate Studies; Local and Mesoscale Area Weather Forecasting and Evaluation; Cloud Physics; Applications of Satellite Observations; Air Quality and Visibility; Societal and Economic Impacts; Numerical Modeling; and Education, Training, and Outreach. Much of this research is also relevant to FSL's mission areas and benefits all phases of the Lab's essential functions--Exploratory System Development, Research Applications, System Validation, and Technology Transfer. In addition to NOAA and other government agencies, beneficiaries of many of the collaborative research and development efforts undertaken at FSL under this cooperative agreement include the universtiy community--in particular, Colorado State University--private industry, and the general public.

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Barjenbrunch, D. B., E. Thaler, and E. J. Szoke. 2002. Operational applications of three dimensional air parcel trajectories using AWIPS D3D. *AMS Interactive Symposium on AWIPS*, J136-J138.

Benjamin, S. G., J. M. Brown, K. J. Brundage, D. Devenyi, G. A. Grell, D. Kim, B. E. Schwartz, T. G. Smirnova, T. L. Smith, S. S. Weygandt, and G. S. Manikin. 2002. RUC20: The 20-km version of the Rapid Update Cycle. *NOAA Technical Memorandum* OAR FSL-28.

———. 2002. RUC20: The 20-km version of the Rapid Update Cycle. *NWS Technical Procedures Bulletin* 490.

Benjamin, S. G., J. M. Brown, K. J. Brundage, D. Devenyi, D. Kim, B. E. Schwartz, T. G. Smirnova, T. L. Smith, and A. Marroquin. 1997. Improvements in aviation forecasts from the 40 km RUC. *AMS 7th Conference on Aviation, Range and Aerospace Meteorology*.

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EXAMINATION OF LINKAGES BETWEEN THE NORTHWEST MEXICAN MONSOON AND GREAT PLAINS PRECIPITATION

Principal Investigator: W. Cotton

Sponsors: NOAA/OGP

Abstract - This project addresses two areas of the PACS North American Monsoon System (NAMS) initiative: (1) the apparent link between the summer monsoon in Northwest Mexico and precipitation in the U.S. Great Plains and its predictability based on antecedent ocean and land surface conditions; and (2) the influence of regional hydrometeorological land-surface processes on large scale precipitation over North America. Using a global coupled atmospheric-land surface model with two-way nested grids, we examine the following hypotheses for interactions between the northwest Mexican monsoon (NWMM) and precipitation over the Great Plains: 1. A burst phase of the NWMM provides a mid-level source of moisture conducive for heavy precipitation over the Great Plains; 2. the subsiding branch of the NWMM alters the low-level stability over the Great Plains; 3. NWMM bursts generate cloud plumes and excite upper tropospheric jet streaks favoring convection over the Great Plains; 4. NWMM convection influences the moisture carrying capability of the low-level jet over the Great Plains; 5. The onset and strength of the NWMM is modulated by antecedent precipitation, and by SST anomalies over the Pacific basin and in the Gulf of California.

The investigation of these hypotheses will be based on several selected monsoon seasons, wherein anamalously high or low seasonal precipitation, or unusually variable intraseasonal precipitation, over the NWMM region is associated with anamalously high, low, and/or variable precipitation over the Great Plains. Control simulations covering the onset and progression of the entire monsoon season will be run for each selected case, wherein SST and other boundary conditions are based on observed and modeled datasets. A high-resolution soil moisture estimation technique based on antecedent precipitation estimates is an important aspect of these boundary conditions. The control simulations are followed by various model sensitivity experiments with altered SSTs, soil moisture, and diabatic heating over the NWMM region. These will be used to examine the inter-related variability, both interannual and intraseasonal, of the NWMM and precipitation over the central U.S. The use of telescopically nested grids from regional scale to cloud resolving scale will be critical for identifying causal mechanisms for any subtle linkages and sensitivities on thunderstorm and MDS structure.

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FIELD INVESTIGATION OF SMOKE PLUMES: AEROSOL CHARACTERIZATION AND TESING

Principal Investigators: J. Collett/S.. Kreidenweis

Sponsor: NPS

Abstract - In order to understand the impacts wild and prescribed fires exert on regional visibility in National Parks and other scenic areas, it is necessary to have a fundamental understanding of the aerosol particles present in smoke plumes. It is also important to understand how these particles change as the plume ages and dilutes and as the environmental relative humidity varies. We propose here a field sudy to characterize the size distribution and hygroscopicity of smoke aerosol in the western U.S. Results from this first investigation will enable evaluation of IMPROVE program assumptions regarding the effect of carbonaceous aerosol on visibility and provide needed experience to plan larger smoke investigations in the future.

No publications to date associated with this project.

FIRE EFFECTS ON REGIONAL AIR QUALITY INCLUDING VISIBILITY

Principal Investigator: D. Fox

Sponsor: NPS

Abstract - While considerable research has been done on coarse particulate emissions (PM_{10}), there is less information on fine particulates and aerosols that contribute to regional haze. To meet new air quality regulations, there will be a need for improved information on fire emissions and their fate in the atmosphere and for consistent approaches to adequately identify and document the contribution of wildland fire to regional haze. This proposal works to quantify the impacts of smoke on regional air quality, especially regional haze, using tools that will be used by the regulatory community for its development of emissions restrictions on fire and other sources. We will develop a fire smoke emissions inventory for selected periods and regions in support of regional air quality modeling and update the existing NEI emissions inventory to include smoke from fire. We also propose to process the updated fire emissions inventory through SMOKE to generate the necessary input data for regional air quality models, and the third task proposes to add fire emissions to an ongoing regional air quality modeling activity. Finally, we will evaluate results of these simulations against regional measurements of visibility and aerosol species concentrations at IMPROVE monitoring locations throughout the western United States. Models or systems developed will be broadly applicable and acceptable to Federal, State, Tribal, and local wildland and air quality managers. They will also be compatible with the computing capabilities of users (e.g., Federal, State, Tribal, and local managers) through the WRAP website and with implementation in a query-able national data base structure.

No publications to date associated with this project.

FUNDS FOR THE COOPERATIVE INSTITUTE FOR RESEARCH PROGRAM

Principal Investigator: T. Vonder Haar

Sponsor: NOAA

Abstract - This project provides for the general operation of the Cooperative Institute for Research in the Atmosphere (CIRA). In realizing its goals, CIRA emphasizes research and graduate education. It has three major purposes: 1) To enhance the effectiveness of research and graduate-level teaching through the close collaboration of both CSU and NOAA; 2) to serve as a focal point for research in the atmosphere on specified programs by scientists from Colorado, the Nation, and the world; and 3) to train personnel for research in the atmospheric sciences and to accumulate experience with multifaceted research programs.

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GOES-I/M PRODUCT ASSURANCE AND ADVANCED PRODUCT DEVELOPMENT FOR A DEMONSTRATION PROJECT FOR SATELLITE METEOROLGY APPLICATIONS FOCUSED REGIONAL METEOROLOGICAL TRAINING CENTERS IN COSTA RICA AND BARBADOS

Principal Investigators: T. Vonder Haar/M. DeMaria

Sponsors: NOAA/NWS/IA

Abstract - The United States has historically been the leader in free and open exchange of meteorological data, especially data from meteorological satellites. In addition to providing data, NWS and NESDIS have been at the forefront in the training of users throughout the world in the use of these data. Many such efforts have been in conjunction with the World Meteorological Organization (WMO). The proliferation of satellites and evolution of multi-channel data sets from these satellites has resulted in a great demand for advanced training in the uses of satellite data for meteorological applications. In response to this increased demand for training and the limited number of experts available in the major satellite operating countries, the WMO developed a new training strategy known as "train the trainers". Through this RMTC effort, NESDIS and NWS are using CIRA to initiate a demonstration project for satellite focused RMTCs in Costa Rica and Barbados. The concept for the satellite focused RMTCs is that of a virtual laboratory which utilizes inexpensive personal computer technology and internet for data distribution; it is modeled on the highly successful RAMSDIS program. In response to this need, CIRA is providing training and digital satellite data analysis equipment to the WMO RMTCs in Costa Rica and Barbados.

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GOES-I/M PRODUCT ASSURANCE AND ADVANCED PRODUCT DEVELOPMENT FOR SUPPORT OF THE VIRTUAL INSTITUTE FOR SATELLITE INTEGRATION TRAINING (VISIT)

Principal Investigators: T. Vonder Haar/M. DeMaria/B. Motta

Sponsors: NOAA/NWS/OCWWS

Abstract - The purpose of the VISIT program is to provide remote education and training to NWS forecasters on the utilization and integration of modernized data sources. These efforts are aimed at meeting the objectives stated in the NWS Office of Meteorology Strategic Plan, which includes the incorporation of new advances in science an technology into the forecast process. CIRA's efforts under VISIT are also a component of the training and advanced prduct development effort as stated in the GIMPAP proposal.

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IMPACT ASSESSMENT OF MEASUREMENTS OF CO2 FROM SPACE, INCLUDING CRLS AND HIRS/(A)MSU

Principal Investigators: G. Stephens/R. Engelen

Sponsor: NOAA/NESDIS

Abstract - The goals of this proposal are assessing the extent to which existing satellite data, HIRS and MSU, and future satellite instruments, CrIS, contribute to our knowledge on CO_2 sources and sinks by flying simulated satellites over a simulated climate, analysis of the information content of the data so produced, and assessment of the impact of such data on our knowledge of the sources and sinks of CO_2.

Christi, J. J., and G. L. Stephens. 2002. Retrieving profiles of atmospheric CO2 in clear sky and in the presence of thin cloud using spectroscopy from the near and thermal infrared: A preliminary study. *J. Geophys. Res. (in Prep)*.

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IMPACT OF CLOUDS ON NITROGEN SPECIES AND OZONE IN THE NARE BOUNDARY LAYER

Principal Investigators: S. Kreidenweis/G. Feingold

Sponsors: NOAA/OGP

Abstract - Important roles for clouds in tropospheric chemistry have demonstrated (e.g., sulfate production; oxidant balance and distribution). Still, the uncertainties in our knowledge are high due to the many complexities in the interactions between gases, particles and clouds. The work proposed here is to use a Large Eddy Simulation (LES) model and a detailed microphysical/chemical parcel model in the context of case studies from the 1993 intensive of the North Atlantic Regional Experiment (NARE) to investigate heterogeneous and multiphase atmospheric chemistry, in particular, the role of marine boundary layer clouds in the processing of ozone and nitrogen oxides, including NO_2, HNO_3, and PAN. Previous modeling studies have usually employed either box- or parcel-models with detailed descriptions of cloud droplet formation and heterogeneous and multiphase chemistry, but highly simplified parcel dynamics, or larger-scale cloud dynamics models with parameterized aqueous chemistry and microphysics, that attempt to understand the broad impacts of chemistry and transport. Moreover, because they do not resolve cloud eddies, these latter models are unable to predict in-cloud residence times with good accuracy. The work proposed here will bridge the gap between these approaches by combining important features from both approaches. NARE cloud case studies will be simulated with the LES modes. Which explicitly simulates the drop size distributions and air motions within the cloud. During the course of the LES run, a large number (order 500) of trajectories will be traced and recorded; the trajectories include information on state variables, position, velocity components, and radiative fluxes. These trajectories are then used to drive an ensemble of parcel models, which contain detailed descriptions of gas/cloud droplet/particle interactions, including gas- and aqueous-phase chemical mechanisms. Parcel model output include not only the time histories of gas- and aqueous-phase constituents, but also those for aerosol and drop-size spectra. The output from the ensemble is mapped back to a fixed spatial grid that will be compared with the NARE measurements. The results from this study are expected to yield an enhanced understanding of the impact of cloud on the processing of ozone and of nitrogen species, and improved parameterizations for models of larger scale.

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IMPACT OF INTERACTIVE VEGETATION OF PREDICTIONS OF NORTH AMERICAN MONSOONS

Principal Investigator: S. Denning

Sponsor: NOAA

Abstract - Representing the strong seasonal and interannual variability of the North American Monsoon (NAM) system and variations in its complex spatial pattern in predictive models is a major challenge. One significant feature of the NAM is its sudden onset and the accompanied rapid greening of vegetation cover. Atmospheric processes can be highly dependent on surface heat and moisture fluxes, which are largely determined by live and dead vegetation, snow cover, and soil-moisture storage. Vegetation plays a major role in determining the surface energy partition and the removal of moisture from the soil by transpiration. We propose using a coupled RAMS and CENTURY modeling system in which both atmospheric variables and ecosystem variables are prognostic variables in the linked system to realistically represent vegetation's response to atmospheric and hydrologic influences, and therefore to achieve at least incremental and perhaps substantial improvement in numerical weather forecasting and climate predictions for North American Monsoon regions.

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IMPLEMENTATION OF OPERATIONAL ENSEMBLE INTENSITY FORECASTS

Principal Investigators: J. Knaff/M. DeMaria

Sponsor: Insurance Friends of the National Hurricane Center, Inc.

Abstract - The skill of operational intensity forecasts is considerably less than that of track forecasts (Lawrence and Gross 2001). In recent years, the Statistical Hurricane Intensity Prediction Scheme (SHIPS) has shown some intensity forecast skill (DeMaria and Kaplan 1999). Beginning in the 2001 season, the SHIPS model was generalized to include intensity forecasts out to five days. Preliminary results indicate that the track errors after 72 hours may be the primary limitation in the skill of the intensity forecasts. For example, the forecast track may take a storm over cool water, when the actual track remains over warm water. To provide forecasters with a range of possibilities, a method to provide an ensemble of intensity forecasts from the SHIPS model will be developed.

No publications to date associated with this project.

INFLUENCE OF THE TROPICAL WESTERN PACIFIC ON CLIMATE DYNAMICS

Principal Investigator: W. Schubert

Sponsor: OGP

Abstract - The field phase of TOGA COARE has provided atmospheric and oceanic data sets of unprecedented temporal and spatial resolution of the western Pacific warm pool region. The goal of the TOGA/COARE program is to advance our ability to predict seasonal to interannual climate variability over the tropical regions. In this proposal we outline a direction of study which involves the complementary use of existing data sets (atmospheric soundings, aircraft measurements, satellite and gridded analyses) with dynamical models to improve our understanding of the coupled ocean-atmosphere system over the tropical west Pacific and its impact on climate variability.

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Johnson, R. H., T. M. Rickenbach, S. A. Rutledge, P. E. Ciesielski, and W. H. Schubert. 1998. On the distribution of tropical clouds. *CLIVAR/GEWAX COARE 98 Conference*.

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Schubert, W. H. 2000. A retrospective view of Arakawa's ideas on cumulus parameterization. *General Circulation Model Development.* D. Randall, ed., 181-198. Academic Press.

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INFORMATION CONTENT OF VISIBLE AND INFRARED RADIANCE DATA: TOWARD DEFINITION OF NEW GENERATION GEOSTATIONARY IMAGERS

Principal Investigators: G. Stephens/R. Engelen./P. Gabriel

Sponsors: NOAA/NESDIS

Abstract - The next generation operational sounding instruments, planned for the NPOES era, will have many more channels than used in the past. Similarly the next generation imagers will also have more capabilities. For example, NPOES is planning an adaptation of the MODIS instrument and EUMETSAT is planning to include a 12-channel imager, SEVIRI, as part of the Meteosat next generation (MSG).

The purpose of this proposal is to consider how we might define the usefulness of new spectral data as we move forward in the planning phase for new advanced geostationary payloads. The focus of the research will be directed towards non-sounding products of the type typically provided by current imagers (cloud property information, aerosol information, and other information like upper tropospheric humidity and SST) and will attempt to use field campaign data whenever possible to test the results and procedures. Since the research is directed towards channel definition of a future advanced imager for geostationary application and towards characterizing the information contained in advanced sounders like AIRS, we intend to focus on visible and infrared radiance data and will not directly address microwave radiance measurements.

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Engelen, R. J., G. L. Stephens, and A. S. Denning. 2001. The effect of CO2 variability on the retrieval of atmospheric temperatures. *Geophys. Res. Lett.* 28: 3259-3262.

Miller, S. D., G. L. Stephens, and R. T. Austin. 2001. Evaluation of cloud optical property retrievals from GOES-10. *J. Geophys. Res.* 106: 17981-18055.

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INTERACTIONS OF THE MONSOONS AND ANTICYCLONES IN THE COUPLED ATMOSPHERE-OCEAN SYSTEM

Principal Investigators: D. Randall/T.Ringler

Sponsor: NOAA

Abstract - The summertime subtropical circulation can be loosely characterized as a sequence of thermal cyclonic flows located predominantly over land and anticyclones located predominantly over ocean. The cyclonic flows over land are often correlated with regions of heavy precipitation which can be labeled as monsoons. The subtropical anticyclones are characterized by relatively dry sinking air and are often accompanied by vast regions of marine stratocumulus clouds. As with the South American monsoon and eastern Pacific anticyclone, subtropical anticyclones are almost always found to the west of monsoon lows. Given the proximity of these two features, it is appropriate to study the monsoon and anticyclone as a single dynamical system. A great deal of attention has been given to the monsoon flows, with a smaller amount of attention given to the summertime subtropical anticyclones. Expect for the recent work of Hoskins et al., almost no attention has been given to how these neighboring large-scale circulations interact. We propose to study the South American monsoon and the subtropical eastern Pacific climate in the single framework of a monsoon-anticyclone pair.

We will study the mechanisms that control the strength of the monsoon-anticyclone system by using a full-physics coupled GCM. We intend to isolate specific feedback mechanisms to ascertain their influence on the amplitude, structure, and variability of the monsoon and the subtropical anticyclone. Specifically, we will focus on four feedback mechanisms. The first is the sensitivity of the monsoon-anticyclone system to enhanced longwave cooling in the region of the anticyclone. The dry sinking air radiates efficiently to space and promotes more sinking. The enhanced sinking leads to a stronger anticyclone and, possibly, a stronger monsoon flow. Closely related to the longwave feedback mechanism is the water vapor feedback mechanism. Even though a relatively small amount of water is present in the upper levels of the subtropical anticyclone, the thermal state of the anticyclone is sensitive to the amount of water present. The water enters the region of the anticyclone via convective outflows and some of these outflows are from monsoon convection. The third feedback mechanism involves the interaction between stratocumulus clouds, the ocean, and the monsoon-anticyclone pair. A variety of mechanisms can affect the extent of stratocumulus cloud cover. These mechanisms include enhanced SST cooling by stress-induced coastal upwelling, and other mechanisms which increase the atmospheric static stability. The final feedback mechanism we propose to study is the influence of available soil-moisture on the structure and amplitude of the monsoon-anticyclone system. To a large extent, the partitioning of the surface energy flux between sensible and latent heat is determined by the amount of moisture available for evaporation. As a result, the thermal structure of the monsoon and the properties of the low-level monsoon jet are also strongly related to available soil moisture.

Ringler, T. D., and D. A. Randall. 2002. Interactions of monsoons and subtropical anticyclones. *AMS 13th Symposium on Global Change and Climate Variations*.

INTERNATIONAL SATELLITE CLOUD CLIMATOLOGY PROJECT SECTOR PROCESSING CENTER FOR GOES

Principal Investigators: T. Vonder Haar/G. Campbell

Sponsors: NOAA/OGP

Abstract - Continuation of ISCCP data preparation and research associated with ISCCP. The Sector Processing Center work includes completion of the INSAT B2 data and histograms in support of the World Climate Research Programme rainfall estimation project. Continued analysis of ISCCP C1 or C2 products in the context of climate model simulations.

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Campbell, G. G., and G. Dengel. 2002. Verification of automatic winds and heights with asynchronous stereo analysis. *6th International Winds Workshop*.

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Davis, W. S., D. A. Lubich, and G. G. Campbell. 1986. Fractal techniques in satellite cloud imagery. *AAAS Conference*.

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INVESTIGATIONS OF BOUNDARY CONDITIONS AND NUMERICAL METHODS FOR LITTORAL FLOWS

Principal Investigator: G. Browning

Sponsor: ONR

Abstract - Littoral flows pose a number of challenges for numerical modeling. Because of the scale of these flows, they must be modeled using a fine mesh limited area model that allows open boundaries at the deep ocean interface and for any rivers entering the area of interest. The use of a well-posed differential system is essential in such a model to allow information to be transmitted properly between the deep ocean and rivers on the boundaries of the region of interest and the interior of that region. The proper treatment of other sloping bottom as it approaches the shore also needs to be understood.

Gravel, S., G. L. Browning, F. Caracena, and H. O. Kreiss. 2002. The relative contribution of forcing components and data sources to the large-scale forecast accuracy of an operational model (in prep.). *Tellus*.

INVESTIGATIONS OF STRESS AND TKE PROFILES IN THE CONVECTIVE BOUNDARY LAYER USING WIND AND THERMODYNAMIC RETRIEVALS FROM SINGLE-DOPPLER LIDAR DATA

Principal Investigator: R. Newsom

Sponsor: NSF

Abstract - Vertical profiles and budgets of turbulence kinetic energy (TKE), and to a lesser extent of the turbulent momentum flux or stress, have received considerable attention for the barotropic convective boundary layer (CBL) and for the neutral boundary layer under stationary, horizontally homogeneous conditions. This proposal is to apply to the study of the CBL new technology and new analysis procedures that have the potential to address a wider range of conditions. The plan is to first apply these techniques to the cases that have been studied, i.e., strongly convective and neutral, and then to begin building a database with which to broaden to other conditions. In addition to these profiles and budgets, the kinematics and dynamics of flow features (fronts, dust devils, terrain-forced updrafts or thermals, cloud updrafts or downdrafts, boundary-layer coherent structures, etc.) of opportunity that occur while taking data will also be studied.

The new technology is a scanning Doppler lidar, the High-Resolution Doppler Lidar (HRDL) designed by NOAA/ERL's Environmental Technology Laboratory (ETL) for boundary-layer work. The new analysis techniques are the four-dimensional data assimilation (4DDA) adjoint retrieval algorithms that have been developed for Doppler radar. These procedures produce a 'grid volume' of the 3 velocity components and the thermodynamic variables (p and T_v) from repeated volume scans of the radial wind component u_r. Both have been proven, and what remains is to blend the two and adapt the retrieval algorithms to use lidar data.

Once this is accomplished the technique will be applied to real lidar datasets, which are either existing or will be obtained at no additional cost to this project. The first goal of these studies is as a proof of concept, to verify the retrieved wind and temperature fields. Once established, these techniques offer a powerful tool for understanding the dynamics of the boundary layer as well as other small-mesoscale flows. The second goal is to use the retrieved data fields to study the turbulence properties of the CBL under the various conditions encountered and to study the dynamics of the features of opportunity.

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Newsom, R. K., and R. M. Banta. 2002. Sensitivity of wind and temperature retrievals from 4DVAR to prescribed eddy viscosity profiles. *AMS 15th Symposium on Boundary Layers and Turbulence*.

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MODELED AEROSOL OPTICAL PROPERTIES FROM MEASUREMENT-BASED MIXTURES OF CHEMICAL SPECIES: ASSESSING THE IMPACTS OF PARTICLE MORPHOLOGY AND ABSORPTION

Principal Investigator: S. Kreidenweis

Sponsor: NOAA

Abstract - This research proposed addresses the need for studies of radiative properties of mixed-composition aerosols, constrained by field observations, with a focus on the role of absorbing and nonspherical components. We have assembled a team of researchers with skills uniquely suited to the tasks at hand. Specifically, we will perform modeling studies that are guided by field measurements of size-resolved chemical speciation, hygroscopicity, dry aerosol size distributions, and aerosol scattering and absorption properties, from the summertime South Eastern Aerosol and Visibility Study (SEAVS), in which one of us (SMK) participated as a principal investigator. We will extend this work using aerosol data from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, with which we have worked in the past. A radiative model that can accurately represent the effects of externally and internally mixed soot and of light absorbing mineral components of the aerosol will be completed, and will be used to test the effects of the mixing assumptions for absorbing and nonabsorbing species. By comparison with field data, we hope to be able to recommend appropriate treatments of the radiative properties of such mixtures under various conditions. As a step toward constraining uncertainties in radiative forcing and sensitivities of satellite-based retrievals, we will use the optical models to explore changes in column forcing and clear-sky reflectance with measured changes in aerosol composition and ambient conditions.

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MONITORING AND MODELING ISOTROPIC EXCHANGE BETWEEN THE ATMOSPHERE AND THE TERRESTRIAL BIOSPHERE

Principal Investigator: S. Denning

Sponsors: NOAA/OGP

Abstract - The concentration and isotopic composition (13C, 18O) of atmospheric CO2 are key variables used in top-down analysis of the global carbon cycle. Isotopes in particular play a key role in distinguishing ocean from terrestrial sinks. Recent studies indicate that on a regional terrestrial basis it should be possible to further partition among landscape elements using isotope analyses. To better understand terrestrial carbon cycle dynamics, we have initiated a modeling and measurement program focused on carbon and oxygen isotope exchange by terrestrial ecosystems. We are conducting this research at the WLEF tower in northern Wisconsin, where long-term atmospheric measurements of CO2 are already underway by NOAA investigators, and in surrounding forest ecosystems.

No publications to date associated with this project.

A MULTISENSOR SATELLITE STUDY OF UPPER TROPOSPHERIC WATER VAPOR AND CLOUDS

Principal Investigators: G. Stephens/R. Engelen

Sponsors: NOAA/OGP

Abstract - The objective of this research is threefold: the development of simple moisture retrievals that can be applied principally to an existing and large body of satellite data, the development of new methods for analyzing new multisensor satellite data, and to bridge the gap between satellite and climate modeling studies by utilizing the analyses of data created here to contrast the results with simulations from present global climate models.

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NESDIS/CIRA POSTDOCTORAL PROGRAM

Principal Investigator: T. Vonder Haar

Sponsors: NOAA/NESDIS

Abstract - Program to support CIRA Postdoctoral Fellows working at NOAA/NESDIS

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PARAMETERIZING SUBGRID-SCALE SNOW-COVER HETEROGENEITIES FOR USE IN REGIONAL AND GLOBAL CLIMATE MODELS

Principal Investigators: G. Liston/R. Pielke

Sponsor: OGP

Abstract - To improve the depiction of winter land-atmosphere interactions and feedbacks within regional and global climate models, we are developing a snow-cover submodel that explicitly includes the influence of subgrid-scale snow-cover variability. A primary objective of this study is to improve our understanding and ability to describe and model the complex interactions among the atmosphere, snow and land during winter and spring seasons, within the context of climate models. To accomplish this we have implemented a climate version of the Regional Atmospheric Modeling System (RAMS), developed at Colorado State University, for a domain which includes the Rocky Mountains and Central States. The research takes advantage of recent improvements in the model's ability to perform full annual integrations, and makes additions which are designed to improve the model's representation of relevant snow-related processes, such as appropriate energy flux partitioning during the melt of patchy snow covers, and the relationships between melt and subgrid-scale snow distributions. The snow submodel also takes advantage of remotely-sense snow-cover distribution products produced by the NOAA National Operational Hydrologic Remote Sensing Center (NOHRSC). In addition, the submodel is formulated to assimilate future snow-distribution data sets generated as part of the SNOMAP algorithm being developed to map high-resolution (500m) daily global snow cover using the Earth Observing System (EOS) Moderate Resolution Imaging Spectroradiometer (MODIS). This research is expected to lead to Substantial improvements in gridscale and subgrid-scale representations of atmospheric and snow-related processes within regional and global climate models.

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PRECIPITATION AND SEDIMENT TRANSPORT IN THE RIO PUERCO BASIN

Principal Investigators: W. Cotton/T. McKee/J. Ramirez

Sponsor: USGS

Abstract - Colorado State University (CSU) is performing cooperative research with the U.S. Geological Survey (USGS) to improve quantitative estimates of flash flooding, erosion, and sedimentation transport in the Southwestern United States. In the short term, flash flood events are direct hazards to people and structures; in the longer term, their cumulative effects alter hydrological and ecological conditions, frequently harming local agriculture and incurring substantial civil works costs. The research is designed to improve the capability to assess short-term hazards and longer-term risks to hydrologic, ecological, and civil-works assets, particularly under condition of varying climate.

Flash-flood generation and associated erosion and sediment transport involve complex interactions among meteorology terrain, vegetation, and water transport. CSU has unique ability to assist USGS in developing quantitative descriptions of these components and their interactions; among CSU's unique assets are 1) interpretation of cloud heights and extent in terms of precipitation distribution, 2) models of the movement of water and sediment on the land surface, 3) models of the dependence of vegetation on grazing and on meteorological and soil conditions, and 4) the RAMS model to simulate large rainstorms.

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THE RESPONSE OF NORTH AMERICAN MONSOON TO BOUNDARY AND REGIONAL FORCING MECHANISMS AS SIMULATED BY CLIMRAMS

Principal Investigators: R. Pielke/T. McKee/G. Liston

Sponsors: NOAA/OGP

Abstract - The principal control on warm season precipitation in the western U.S. is the North American Monsoon (NAM). We have confirmed that a relationship exists between the NAM and the El Nino Southern Oscillation (ENSO) and the North Pacific Oscillation (NPO). Time-evolving daily Z-scores of moisture flux convergence and 500 mb height have been correlated with a new SST index that relates the combination of temporal variability of ENSO and NPO. New time-evolving regional precipitation indices for the Great Plains and southwest were also correlated with the index. These analyses show that the combination of ENSO-NPO favor the large-scale circulation response of the Pacific Transition pattern. Either a rough or ridge is centered in the vicinity of the northern Rockies and Great Plains. Whether a trough or ridge occurs determines the direction of moisture transport from the Gulf of California and Gulf of Mexico sources; either to the Great Plains (El Nino, high NPO) or to the southwest (La Nina, low NPO). There is a statistically significant response in moisture flux convergence and precipitation in these regions. These responses are most likely near NAM onset and diminish in the latter part of the summer. At this time the large-scale circulation may be affected by tropical systems or surface moisture feedback, or may undergo a transition to a winter ENSO regime. The proposed research will provide insight into the boundary and regional forcing on the NAM and how these factors vary in importance over the summer season. More important, it will also provide substantial socioeconomic benefits through improved understanding of the interrelationships between summer climate and environmental extremes such as droughts and floods.

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THE ROLE OF ATMOSPHERIC WATER CONTENT IN CLIMATE AND CLIMATE CHANGE (CLOUDSAT)

Principal Investigator: G. Stephens/T. Vonder Haar

Sponsor: NASA/Goddard Space Flight Center

Abstract - CloudSat is a pathfinder mission designed to provide the information needed by Numerical Weather Prediction (NWP) models and Global Circluation Models (GCMs) to validate and improve their predictions of clouds. This new information about the vertical distribution of cloud systems and their ice and water contents cannot be obtained from either existing or approved future spaceborne measurements. CloudSat will provide measurements of those properties of clouds that are directly predicted by NWPs and GCMs. In addition, CloudSat will provide the quantitative measurements of optical depth, layer thickness, base height and ice and liquid water contents of clouds, facilitating accurate determination of the radiative properties of clouds and their roles in the radiative heating of the atmosphere. The knowledge of this heating is critical to improving understanding of the cloud-climate feedback phenomenon.

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THE ROLE OF STRATOCUMULUS CLOUDS IN MODIFYING POLLUTION PLUMES TRANSPORTED TO THE NORTH AMERICAN CONTINENT

Principal Investigator: S. Kreidenweis

Sponsor: NOAA

Abstract: - *Analyze historical IMPROVE data for significant events of transport from Asia to the western U.S*. In particular, evidence of springtime Asian dust transport will be looked for in mineral species concentrations, and signatures from fires (local and long-range smoke transport) will be sought in organic carbon and potassium species.

Participate in DYCOMS data analysis activities. G. Feingold will participate in the Summer 2001 DYCOMS field experiment, and has initiated discussions with data PIs to collaborate on data analyses. The DYCOMS cloud and aerosol microphysics and chemistry data set is expected to be more complete and will include information on aerosol hygroscopicity and precipitation scavenging. We propose to conduct studies of how various types of data that are obtained can be used in the modeling framework, what model features need to be better developed to make full use of the data, and what new data need to be collected in future experiments to help elucidate aerosol processing mechanisms.

Modeling of aerosol processing pathways. Our prior work has focused on the role of clouds in aerosol processing. Heterogeneous chemistry also plays a role in creating mixed aerosols and in modifying the aerosol size distribution and particle lifetime. We will modify our existing codes that simulate aerosol processing to include some key effects from condensation onto aerosol particles and, where appropriate, surface reactions that modify the particles as well.

Involvement in ITCT field project(s), data interpretation and use of modeling. We expect to be fully-involved participants in all aspects of the ITCT experiment planning, conduct, and data analyses. Our specific contribution will be to assist in planning of observation and in data interpretation of aerosol processing as plumes are transported from Asia across the Pacific Ocean to the U.S.

Feingold, G., and S. M. Kreidenweis. 2002. Cloud processing of aerosol as simulated by a large eddy simulation with coupled microphysics and aqueous chemistry. *AMS 11th Conference on Cloud Physics*.

SATELLITE DATA RECEPTION AND ANALYSIS SUPPORT

Principal Investigators: T. Vonder Haar/L. Grasso

Sponsor: NOAA/NESDIS

Abstract - This grant covers Colorado State University (CSU) costs incurred in supporting the joint research activities between National Environmental Satellite, Data and Information Service (NESDIS) Regional and Mesoscale Meteorology (RAMM) Team and certain CSU scientists and graduate students. The support is in three main areas. They are 1) computer and ground station services to support RAMM Team and CIRA satellite research; 2) the augmentation of the CSU facility to improve the processing GOES data for new applications; and, 3) support for equipment to enhance and maintain current research tools.

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A SATELLITE-DERIVED CLOUD CLIMATOLOGY FOR THE MID-ATLANTIC STATES

Principal Investigators: T. Vonder Haar/M. DeMaria/C. Combs

Sponsor: NOAA/NWS

Abstract - Predicting the location and timing of the onset of convective precipitation remains a challenging forecasting task. For example, the 24 h Quantitative Precipitation Forecasts (QPFs) from the Hydrometeorological Prediction Center (HPC) in the summer typically have less than half the skill of the corresponding winter forecasts (HPC verification statistics available at www.hpc.ncep.noaa.gov). Numerical modeling studies suggest that surface characteristics (land-sea contrasts, land usage, topography, etc.) play an important role in the formation of convection. These studies also indicate that models can sometimes realistically simulate small-scale flow features even when initialized with very smooth initial conditions, provided that forecast information on convective initiation and development can be obtained from knowledge of the synoptic-scale flow and the surface characteristics.

In the proposed research, we plan to develop a climatology of cloud frequencies for the Mid-Atlantic States using GOES-8 satellite imagery. The cloud frequencies will be determined as a function of time of day, and stratified by synoptic flow regime. The domain will include all of the county warning area (CWA) of the Wakefield, VA forecast office (and some surrounding area), and will concentrate on the warm season (May-October). Once the climatology is developed, it could be used as a foredcast tool to help identify the timing and preferred regions for convective formation under various flow regimes. A similar study with the forecast office in Tallahasee, FL has shown applicability to forecasting sea breeze convection. Personnel from the Wakefield forecast office will participate in the determination of the domain for the study, flow regimes, and evaluations of the climatologies. All of the interaction between Wakefield and CIRA can be accomplished via e-mail and web-based satellite display capabilities at CIRA. The final product will be a PC application that can be run locally at the Wakefield office. In the future, it may also be possible to incorporate the satellite climatologies into AWIPS.

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SENSITIVITY OF CLOUD RESOLVING SIMULATIONS OF CONVECTIVE PRECIPITATION AND CLOUDINESS TO VARIOUS METHODS OF SOIL INITIALIZATION AND EVALUATION OF CONVECTIVE PARAMETERIZATIONS

Principal Investigator: W. Cotton

Sponsor: NOAA

Abstract - The proposed research is directed toward the program priority "GCIP (GEWEX Continental-Scale International Project)" of NOAA's Climate and Global Change Program (CGCP). The research focuses on three inter-related efforts: (1) improved soil moisture estimation and its initialization in coupled surface-atmospheric models; (2) mesoscale coupled surface-atmospheric simulations of case studies spanning the full spectrum of convection, in which the use of nested cloud-resolving model (CRM) grids allows explicit simulation of convective processes; and (3) refinement of cloud parameterizations for boundary layer (BL) cumulus, ordinary deep convection, and mesoscale convective systems (MCSs), and their implementation in regional and global coupled atmospheric-hydrologic models.

The simulations carried out in this research will provide high-resolution CRM data that will be used for refining convective parameterization schemes that we have developed for three classes of convection: BL cumulus, deep convection, and MCSs. The refined convective parameterizations will be evaluated by activating them in simulations using a range of coarser grid spacing, and without the CRM grids. The sensitivity of these parameterized simulations to initial soil moisture also will be evaluated. Parameterized simulations of independent cases documented in the different GCIP Large Scale Areas (LSAs) will be performed to establish the robustness of the schemes.

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SIMULATIONS OF THE INTERACTION BETWEEN DEEP CONVECTION AND THE OCEAN MIXED LAYER DURING TOGA COARE

Principal Investigators: W. Cotton/R. Pielke/R. Walko

Sponsor: OGP

Abstract - In this project we are applying a coupled atmosphere-ocean model system with a detailed representation of the ocean surface, cloud-scale dynamics, and cloud microphysical processes to the study of cloud-ocean interactions in the tropical western Pacific Ocean. We are focusing on the TOGA COARE cases selected by GCSS Working Group #4. Of central importance to this study is accurate model representation of the ocean skin temperature, which in calm water may differ by more than 1 K from the bulk water temperature within the top 1m of the surface. This temperature difference is induced by a combination of sensible, latent, and radiative heat flux divergences which occur at the ocean skin surface and by rainfall which introduces fresh water near the surface at a temperature generally lower than the bulk ocean temperature. The calm wind and stably stratified shallow halocline result in very little turbulent mixing in the ocean, which helps to preserve the shallow thermal gradient. The ocean skin temperature in turn determines sensible and latent heat fluxes with the atmosphere; and, therefore, directly influences the environment in which clouds form and develop. RAMS has been interfaced to the Princeton Ocean Model (POM) (Mellor, 1993) and modifications to the radiation and salinity equations are being done at this time.

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STATISTICAL ANALYSES RELATED TO AIR QUALITY AND ATMOSPHERIC VISIBILITY

Principal Investigator: H. Iyer

Sponsor: NPS

Abstract - This research involves 1) cluster analysis of back-trajectories and cluster relationships with aerosol concentrations at receptor sites; 2) formulation of finite population models for air quality data and associated analysis methods; and 3) data analyses for the Mojave Project.

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Malm, W. C., G. Persha, R. Tree, H. K. Iyer, and E. Law-Evans. 1988. The relative accuracy of transmissometer derived extinction coefficients. *Proceedings, 81st Annual Meeting of the Air Pollution Control Association.*

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STOCHASTIC MODELING AND SIMULATION OF THE GREAT LAKES NET BASIN SUPPLIES

Principal Investigator: J.D. Salas

Sponsor: NOAA

Abstract- The stochastic characteristics of the Great Lakes Net Basin Supplies (NBS) have been shown by many hydrologists to be quite complex. They include spatial and temporal variability with important high and low frequency components and possibly non-stationarity, in addition to the usual seasonality (periodicity) and variance-covariance properties. A number of approaches has been suggested in the past decades for stochastic modeling and simulation of the NBS of the Great Lakes system. Alternative models and modeling schemes for single-site and multi-site data; models for annual, monthly, and quarter-monthly time scales; and temporal and spatial disaggregation models have been used with various degrees of success. Also well known models such as autoregressive (AR), AR with moving average terms (ARMA), and their multisite versions thereof have been utilized. The main objective of the study proposed herein is to develop a multivariate shifting level model at the annual time scale so that it can be capable of simulating annual series of NBS at more than one site. The multivariate model will be contemporaneous in that only lag-zero cross-correlations will be explicitly preserved and it will include a direct persistence feature that is beyond the persistence that is normally induced by the shift. In addition, the model will have the flexibility of using shifting levels at a number of sites while other sites can be modeled based on ARMA models. Furthermore, the main approach for parameter estimation will be the method of moments.

No publications to date associated with this project.

STUDIES OF FLASH FLOODS AND SEDIMENT TRANSPORT IN THE SOUTHWEST

Principal Investigator: C. Adams

Sponsor: USGS

Abstract - The Flash Flood Laboratory is working collaboratively with the USGS Rocky Mountain Mapping Center to conduct research on flash flooding and sediment transport in the Southwestern United States. Dr. Raymond G. Watts, Co-located at the Cooperative Institute for Research in the Atmosphere (CIRA), is the principal research scientist on the project. The USGS research is designed to focus on three themes: Studies of floods and sediment transport in the Rio Puerco in New Mexico; the geography of intense precipitation and flash floods along the Colorado Front Range; and Application of flash flood information in natural disaster reduction

In support of these research themes, CIRA at Colorado State University has assembled a team of researchers to contribute significantly to this endeavor. These include both geophysical and social scientists with expertise in the field.

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Watts, R. 2000. Quantitative mapping of erosive incision. *American Geophysical Union 20th Hydrology Days*.

STUDY OF LARGE-SCALE MOTIONS, BOUNDARY-LAYER PROCESSES AND CONVECTIVE PARAMETERIZATIONS USING TOGA-COARE DATA

Principal Investigator: R. Johnson

Sponsor: OGP

Abstract - The proposed research is directed at improving our knowledge of clouds, convection and radiative processes that influence ocean-atmosphere coupling in the Pacific warm pool region. Specific research topics include merging ISS sounding and wind profiler data into a comprehensive COARE dataset, study of the diurnal variation of the atmospheric boundary layer over the warm pool, study of two-day waves in COARE, investigation of relative humidity errors n COARE soundings, study of tropical cloud populations, and determination of rainfall and radiative heating rates from atmospheric budgets.

Ciesielski, P. E., L. M Hartten, and R. H. Johnson. 1997. Impacts of merging profiler and rawinsonde winds on TOGA/COARE analysis. *J. Atmos. & Oceanic Tech* 14: 1264-1279.

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STUDY OF THE ROLE OF CLOUDS IN RELATIONSHIP BETWEEN LAND USE/LAND COVER AND THE CLIMATE AND AIR QUALITY OF THE ATLANTA AREA

Principal Investigator: S. Kidder

Sponsor: NASA

Abstract - This project is part of a larger project titled "A Remote Sensing-Based Study of Past and Future Land Use Change Impacts on Climate and Air Quality of the Atlanta, Georgia Metropolitan Region" funded by NASA Headquarters. The key goal of the larger project is to derive a better scientific understanding of how land cover changes associated with urbanization, principally in transforming forest lands to urban land covers through time, has, and will, affect local and regional climate, surface energy flux, and air quality characteristics. We propose three tasks aimed at improving our understanding the role of clouds in the land cover-climate connection: 1) Use GOES 8 data to understand the diurnal variability of albedo, soil moisture availability, thermal inertia, and surface roughness needed to initialize the mesoscale models, 2) Use GOES 8 visible data to construct an hourly, 1-km-resolution cloud climatology over Atlanta for the summer of 1996, and 3) Run the RAMS model with surface parameters deduced from the GOES 8 data to simulate the cloud field which is prevalent around Atlanta in the summer; compare the clouds produced in the model with the clouds observed GOES 8 data; determine what effects change in land use/land cover would have on the modeled cloud field. These tasks will illuminate the important role which clouds play in the relationship between land use/land cover and climate and air quality in the Atlanta region.

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SUPPORTING TASKS NASA PROPOSAL FOR SOUTHWEST REGIONAL EARTH SCIENCE APPLICATIONS CENTER

Principal Investigator: C. Adams

Sponsor: University of Arizona

Abstract - The objectives of this project are to recruit Federal, State, and local stakeholders as partners in this applied research project, to include a formal presentation at the Bi-Annual Conference of the Southwestern Association of ALERT Users, in which Maricopa County, Arizona and Federal agencies are very active; to develop collaborations with local and Federal agencies in Maricopa County Area including MCFCD, cities (Phoenix, Scottsdale and others), ADWR, SRP, BuRec, and Corps of Engineers; to identify possible atmospheric and hydrologic model output products to be developed by University of Arizona collaborators for use by stakeholders; to plan, organize, conduct, and document stakeholder meeting(s) in Phoenix, AZ; to conduct and write project report(s) on the formal survey of user requirements to identify specific user requirements to guide work of University of Arizona/Arizona State University collaborators in hydrology and atmospheric science; to develop strategy to communicate new information products to Federal, State, and local stakeholders; and to provide feedback on RESAC developed communication tools from user perspective with input from stakeholders.

No publications to date associated with this project.

TECHNICALLY ADVANCED SMOKE ESTIMATION TOOLS (TASET): NEEDS ASSESSMENT AND FEASIBILITY INVESTIGATION

Principal Investigators: D. Fox/K. Eis/T. Vonder Haar

Sponsor: NPS

Abstract - In this project we have identified tasks that land managers and air quality managers undertake in smoke management. Associated with each task, we have identified information needs and the tools and other information sources used to provide that information. Users, actual land and air quality managers are being polled regarding their use of these tools and their priority for improving them. We are now in the process of organizing these tools into a conceptual Structured Smoke Management System. Once completed, we will suggest priorities for further development of system components.

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TECHNOLOGICAL TRANSFER AND VALIDATION OF THE CIRA SCHEME FOR THE TROPICAL RAINFALL POTENTIAL (TRAP) TECHNIQUE

Principal Investigator: S. Kidder

Sponsors: NOAA/NESDIS/ORA

Abstract - As discussed by Kidder et al. (2001a), heavy rainfall from landfalling tropical cyclones is a major threat to life and property. Rappaport (2000) found that in the contiguous United States during the period 19701999, freshwater floods accounted for more than half of the 600 deaths directly associated with tropical cyclones.

Forecasting rainfall from landfalling tropical cyclones is a difficult task. While the storm is offshore, few rainfall observations are possible, and initializing NWP models with sufficient details of the storm so that accurate rainfall forecasts can be made is extremely difficult. Radar observations of storm rain rate and rain area are valuable, but only when the storm is within radar range of the coast.

Since 1992, the Satellite Services Division (SSD) of the National Environmental Satellite, Data and Information Service (NESDIS) has experimentally used the operational Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I) rain rate product (Ferraro 1997) to produce a rainfall potential for tropical disturbances expected to make landfall within 24 hours. The launch in 1998 of the first Advanced Microwave Sounding Unit (AMSU) on the NOAA-15 satellite provided an additional rainfall data source. The NESDIS/SSD technique (Kidder et al. 2000) was performed manually by an analyst and resulted in a single number called the tropical rainfall potential, defined as TRaP = $R_{av}DV^{-1}$, where R_{av} is the average rainfall rate of the storm, D is the diameter of the storm, and V is the speed of the storm. At CIRA, the technique was improved by automating it and by calculating the rainfall at every point in an image, so that the location as well as the amount of the precipitation could be estimated (Kidder et al. 2001a). NOAA 15 AMSU-A rain rate images were used. The TRaP technique was further improved in 2001 by (1) adding a second satellite (NOAA 16), (2) using higher-resolution AMSU-B rain rate images (Weng et al. 2002), and (3) acquiring more track forecasts to be able to use the technique over a larger fraction of the globe. Kidder et al. (2001b)

A similar but not identical TRaP method was developed by NESDIS/SSD and is now used semi-operationally by analysts to calculate TRaP images. This technique has been quite useful in the preparation of heavy rain forecasts associated with tropical cyclones. The purpose of this proposal is to transfer the CIRA technology into the NESDIS technique to produce an operational technique.

Kidder, S. Q., J. A. Knaff, and S. J. Kusselson. 2001. Using AMSU data to forecast precipitation from landfalling hurricanes. *AMS 81st Annual Meeting*, 344-347.

Kidder, S. Q., S. J. Kusselson, J. A. Knaff, and R. J. Kugligowski. 2001. Improvements to the experimental tropical rainfall potential (TraP) technique. *AMS 11th Conference on Satellite Meteorology and Oceanography*, 375-378.

TEMPERATURE, PRECIPITATION AND WIND CONTINUITY WITH ASOS

Principal Investigators: T. McKee/N. Doesken

Sponsor: NWS

Abstract - The recent nationwide deployment of ASOS (Automated Surface Observing System) by the National Weather Service (NWS) at major weather stations across the country introduced several fundamental changes in how weather observations are taken. As these changes were made, it was known that they could potentially affect long term climate records.

The Climate Data Continuity Project (CDCP) was initiated to identify and document discontinuities in our Nation's climate data resulting from changes in observing equipment, observing practices and station locations. Historically consistent climate data are necessary to accurately interpret and apply climatological information to many important elements of our Nation's infrastructure and commerce ranging from water resources to energy demands and costs.

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THEORETICAL AND OBSERVATIONAL ANALYSIS OF MESOSCALE VORTICITY AND WIND STRUCTURE IN HURRICANES

Principal Investigators: M. Montgomery/W. Schubert

Sponsor: NOAA

Abstract - Radar observations of mature hurricanes reveal intense "mesovortices" near the eyewall region that pose serious threats to life and property in populated areas as the storm makes landfall and to low-flying research aircraft operating over the open ocean. Other observations reveal strong gust factors, sub-kilometer horizontal-scale wind streaks in the boundary layer, and 10-km horizontal-scale spiral features which extend through the depth of the troposphere. Although wind gusts, wind streaks, and mesovortices might appear unrelated, we believe that such phenomena are intimately tied to the vorticity dynamics of the hurricane's eyewall region and that improved understanding of the attendant vortex dynamics will help wind engineers and emergency management personnel better prepare for hurricane-related disasters.

The proposed research takes a four-pronged approach toward understanding the mesoscale vorticity dynamics and wind structure of the hurricane eyewall region: theoretical, modeling, observational, and experimental. The theoretical and modeling efforts were built on recent research by the PIs who examined various two-dimensional aspects of polygonal eyewalls, mesovortices, and vorticity mixing in hurricane-like vortices. Using both two-dimensional and three-dimensional fluid dynamic models of the lower-tropospheric portion of the hurricane, we aim to further understand the vorticity mixing processes near the hurricane eyewall and to quantify the principle characteristics of hurricane meso-vortices, such as maximum wind speed and horizontal scale, during the time the hurricane is over the open ocean and also as it makes landfall. The observational effort is being coordinated with the Hurricane Research Division of NOAA/AOML with the objective of determining the nature of air motions within the eye, which can be used to assess the prevalence of mesovortices and vorticity mixing within the eye. Because there are no natural "scatterers" inside the eye suitable for the Doppler radar aboard the NOAA P-3 aircraft, chaffe will be deployed as scatterers. Finally, the experimental effort will obtain high spatial and temporal resolution velocity and vorticity data for the laboratory suction vortices described qualitatively in Vladimirov and Tarasov (1980). The observational and experimental data serves as a useful conceptual model and quantitative benchmark for the theoretical and modeling work.

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WESTERN REGIONAL AIR PARTNERSHIP WEB BASED AIR QUALITY DATA INTEGRATION, ANALYSIS AND DELIVERY SYSTEM

Principal Investigator: D. Fox

Sponsor: Western Governor's Association

Abstract - CIRA will design, develop, implement, and maintain an air quality and meteorological data integration, analysis, and delivery system (WRAP AQDS) for the United States, west of the 100th meridian. The data delivery system will be accessible for queries via the World Wide Web. The WRAP AQDS will be designed utilizing modern "data mart" principles and technologies. The data mart will utilize established and emerging software tools for PC hardware platforms networked under a Windows 2000 operating system.

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GLOSSARY

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4-DVAR	4-Dimensional Variational Analysis
AAAR	American Association for Aerosol Research
ACR	Airborne Cloud-Profiling Radar
ADDS	Aviation Digital Data Service
AFGWC	Air Force Global Weather Center
AFWA	Air Force Weather Agency
AGFS	Aviation Gridded Forecast System
AHOS-T	Automated Hydrologic Observing System
AIRMET	Airmen's Meteorological Information Bulletin
AIV	Aviation Impact Variables
AMOS/T	Automated Meteorological Observing System-Telephone
AMS	American Meteorological Society
AMSR	Advanced Microwave Scanning Radiometer
ANL	Argonne National Laboratory
ARTCC	Air Route Traffic Control Center
ASOS	Automated Surface Observing System
ASTEX	Atlantic Stratocumulus Transition Experiment
ATCSCC	Air Traffic Control Systems Command Center
AVARs	Aircraft Vertical Accelerometer Reports
AVHRR	Advanced Very High Resolution Radiometer
AWC	Aviation Weather Center
AWN	Automated Weather Network
AWIPS	Advanced Weather Interactive Processing System
BDI	Bounded Derivative Initialization

BRAVO	Big Bend Regional Aerosol and Visibility Observational Study
CASTNET	Clean Air Status and Trends NETwork
CDoT	Colorado Department of Transportation
CIDOS	Cloud Impact on DoD Operations and Systems
CIRA	Cooperative Institute for Research in the Atmosphere
CLEX	Cloud Layer Experiment
CLW	Cloud Liquid Water
CM	Configuration Management
CMI	Caribbean Meteorological Institute
CNN	Cloud Condensation Nucleus
COAMPS	Coupled Ocean/Atmosphere Mesoscale Prediction System
COARE	Coupled Ocean Atmosphere Response Experiment
COHMEX	Cooperative Huntsville Meteorological Experiment
COMET	Cooperative Program for Operational Meteorology, Education and Training
CONUS	Continental United States
CWB	Central Weather Bureau
D2D	Display 2 Dimensions
D3D	Display 3 Dimensions
DBSS	Direct Balloon Sounding System Project
DMSP	Defense Meteorological Satellite Program
DNS	Domain Name Server
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DRI	Desert Research Institute

ECMWF	European Centre for Medium-Range Weather Forecasts
EFF	Experimental Forecast Facility
EMDS	Emergency Management Decision Support
ERB	Earth Radiation Budget
ERBE	Earth Radiation Budget Experiment
ETL	Environmental Technology Laboratory
EUMETSAT	European Meteorological Satellite Agency
FAA	Federal Aviation Administration
FASTEX	Fronts and Atlantic Storm Track Experiment
FD	Facility Division
FEMA	Federal Emergency Management Agency
FIRSTT	Facility for Integrated Remote Sensing Technology Training
FSL	Forecast Systems Laboratory
GAC	Global Archive Center
GAINS	Global Air-ocean IN-situ System
GCIP	GEWEX Continental Scale International Project
GCM	Global Circulation Model
GEWEX	Global Energy and Water Cycle Experiment
GFS	Global Forecast System
GIMPAP	GOES I/M Product Assurance Plan
GINI	GOES-1 NOAAPORT Interface
GLOBE	Global Learning and Observations to Benefit the Environment
GMS	Geostationary Meteorological Satellite
GOES	Geostationary Operational Environmental Satellite
HIRS	High-Resolution Infrared Radiation Sounder

IPC	Inter-Process Communications
IIPS	Interactive Information and Processing Project
ISCCP	International Satellite Cloud Climatology Project
JGR	Journal of Geophysical Research
JPL	Jet Propulsion Laboratory
KDoT	Kansas Department of Transportation
LAN	Local Area Network
LAPB	Local Analysis and Prediction Branch
LAPS	Local Analysis and Prediction System
LARC	Limited Area Remote Collector
LDAD	Local Data Acquisition and Dissemination System
LES	Large Eddy Simulation
LWP	Liquid Water Path
MAPS	Mesoscale Analysis and Prediction System
McIDAS	Man-Computer Interactive Data Acquisition System
MSAS	MAPS Surface Analysis System
NAOS	North American Atmospheric Observing System
NAPAP	National Acid Precipitation Assessment Program
NASA	National Aeronautical & Space Administration
NASDA	National Space Development Agency of Japan
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NDDN	National Dry Deposition Network
NEXRAD	Next Generation Weather Radar (WSR-88D)
NESDIS	National Environmental Satellite, Data and Information Service

NFRAQS Northern Front Range Air Quality Study

NIMBUS Networked Information Management client-Based User Service

NNT Nearest Neighbor Tool

NOAA National Oceanic and Atmospheric Administration

NOGAPS Navy Operational Global Atmospheric Prediction System

NPS National Park Service

NPOESS National Polar Orbiting Environmental Satellite System

NREL National Renewable Energy Laboratory

NRC National Research Council

NSF National Science Foundation

NWS National Weather Service

OAR Oceanic and Atmospheric Research

OLR Outgoing Longwave Radiation

PIREP Pilot Report

PMS Particle Measurements Systems

POD-N Probability of Detection of No-Turbulence

PPP Parallelizing Pre-Processor

QPE Quantitative Precipitation Estimates

QPF Quantitative Precipitation Forecast

RAMMT Regional and Mesoscale Meteorology Team

RAMOS/T Remote Automated Meteorological Observing System-Telephone

RAMS Regional Atmospheric Modeling System

RAMSDIS RAMM Advanced Meteorological Satellite Demonstration and Interpretation System

RMTC Regional Meteorological Training Center

ROC	Regional Observation Cooperative
RTVS	Real Time Verification System
RUC	Rapid Update Cycle
SAB	Satellite Analysis Branch
SDD	Systems Development Division
SIGMET	Significant Meteorological Information Report
SMS	Scalable Modeling System
SOCC	Satellite Operations Control Center
SOO	Science Operations Officers
SRS	Scalable Runtime System
SSM/I	Special Sensor Microwave Imager
SST	Scalable Spectral Tool
SSM	Special Sensor Microwave (DMSP)
TIROS	TV and Infrared Radiation Observation Satellite
TKE	Turbulence Kinetic Energy
TPW	Total Precipitable Water
TRACON	Terminal Radar Approach Control
UCAR	University Corporation for Atmospheric Research
WDoT	Wyoming Department of Transportation
WFO	Weather Forecast Office
WV	Water Vapor