CIRA

CIRA on the Front Lines: Innovations and Insights on the 2002 Fire Season

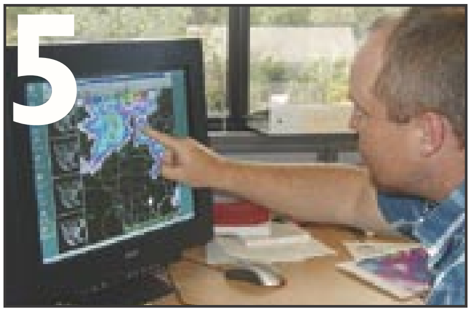
Colorado State University

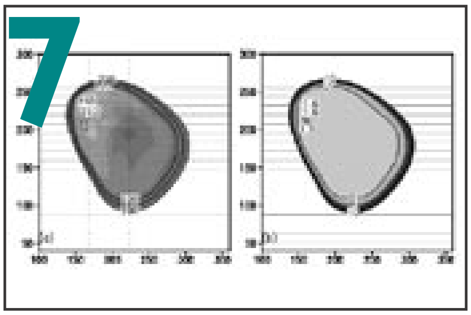
Knowledge to Go Places

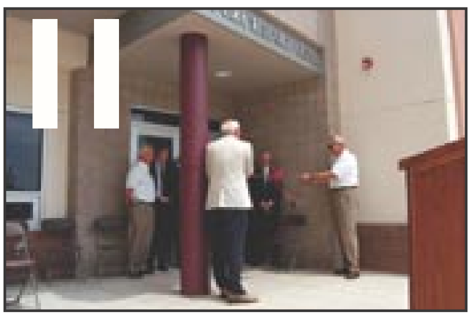
Volume 18

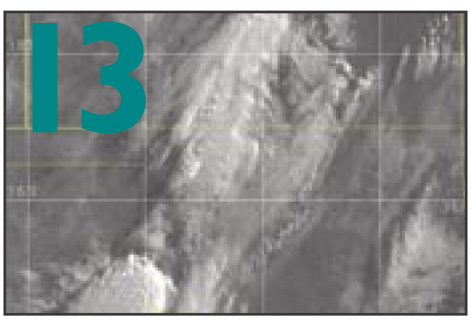
Fall 2002

Contents









Cover photo by John Weaver, NOAA/NESDIS/RAMM.

Editor

Mary McInnis-Efaw

Design

Publications and Printing, Colorado State University

Technical Committee

Bernadette Connell, Doug Fox,
Cliff Matsumoto, Darren McKague

Images of Smoke and Fires from MODIS and GOES

By Don Hillger

Data from both the MODerate-resolution Imaging Sepctroradiometer (MODIS) and the Geostationary Operational Environmental Satellite (GOES) were used to view the forest and range fires in the western U.S. during the summer of 2002. The diversity of bands on MODIS and GOES allows many types of atmospheric and surface features to be seen. Often these features are detected more readily by differencing the spectral band images to reveal the details of interest. Of interest in this article are examples of smoke and hot spots from a few of those summer fires.

MODIS data are available from NASA's Earth Observation Satellite (EOS) AM-1 Terra (launched in 1999) and EOS PM-1 Aqua (launched in 2002), both in low-earth polar orbit. Imagery is available at 1 km (infrared) ground resolution but 12 hour temporal resolution from each satellite. The MODIS instrument contains 36 spectral bands as listed on the Web site: http://modis.gsfc.nasa.gov/about/specs.html. Half of the bands are in the visible and near infrared portion of the spectrum, and the other half are in the shortwave and longwave infrared.

GOES Imager data are available from GOES-8 (east) and GOES-10 (west) in much higher geostationary orbit. Imagery is available in 5 spectral bands (much broader than MODIS bands) at 4 km (infrared) ground spatial resolution every 15 minutes from each satellite.

The Colorado Hayman Fire

One fire of special interest to Coloradoans was the Hayman Fire that burned 138,000 acres (560 km2) in the mountains southwest of Denver, CO. Figures 1 and 2 contain three-color (red-green-blue) composite images of visible and visible/shortwave-IR/longwave-IR bands respectively. Both images show the smoke plume extending from the fire toward the northeast onto the plains of eastern Colorado. The second image shows the hot spots around the edge of the burned area where the fire is most active.

Smoke from the Hayman Fire in Colorado this summer blocks out much of the sun. Photo credit: http://www.fs.fed.us/r2/psicc/fire/hayman/photos/index.htm

Arizona Fires Observed with MODIS Data

The Rodeo and Chediski fires near Show Low, AZ were also very active and merged into one fire consuming 469,000 acres (1900 km2) in eastern Arizona. Figure 3 shows

(continued on page 4)

Figure 1: True-color red-green-blue visible composite image of MODIS (bands 1, 4, and 3) at 2 km resolution for the Hayman Fire in Colorado on 10 June 2002 at 1830 UTC. Note that the smoke plume is composed of two parts that appear to track with the winds at different heights. Also, the forest-covered mountains are darker than the eastern plains of Colorado and the un-forested valleys. There are also a few (white) cumulus clouds over the highest mountain peaks.

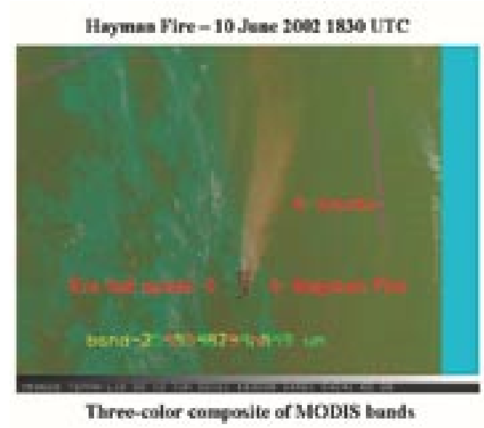


Figure 2: Same as Figure 1, but a false-color red-green-blue (shortwave IR, longwave IR, and visible) composite image of MODIS (bands 25, 31, and 1). The fire hot spots are dark-red to purple and the smoke is light-red to orange. Clouds are white.

Smoke and Fires *(continued from page 3)*

Principal Component Images (PCIs) generated from the MODIS spectral bands. Note that various combinations of the MODIS bands in the four panels yield different views of the smoke plume and the fire hot spots. The exact combinations of MODIS bands in these PCI image products are not explained here, but this type of analysis is useful for determining the bands that are most valuable for smoke and fire detection.

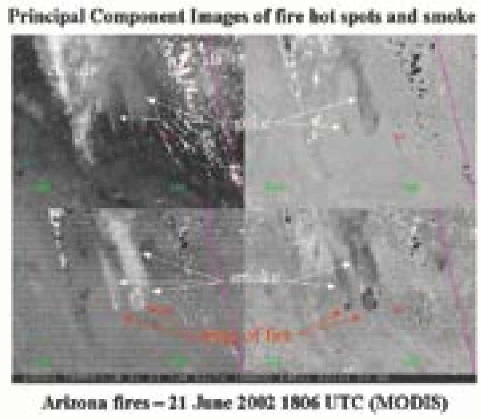


Figure 3: Four Principal Component Images (PCIs) at 4 km resolution of the Rodeo and Chediski fires near Show Low, AZ on 21 June 2002 at 1806 UTC. Note the differing views of the smoke and fires available from various combinations of MODIS bands in the PCIs (not explained here).

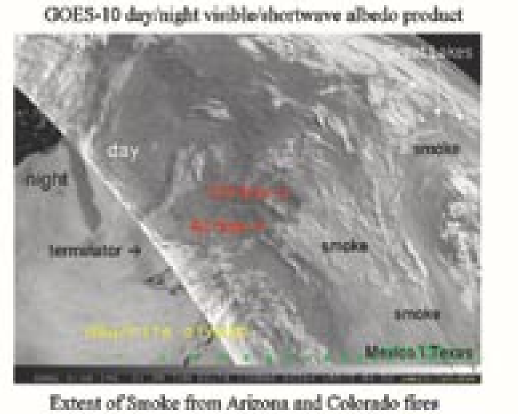


Figure 4: Smoke extent from several western fires on 25 June 2002 at 1300 UTC. This GOES-10 day/night visible/shortwave albedo image at 4 km resolution shows the smoke best through forward scattering of early-morning sunlight.

> *MODIS data offers an increased number of spectral bands to help reveal details.*

Smoke from Western Fires

The large number of fires created many days of extensive smoke and haze that not only affected the western U.S. but also extended far eastward. The GOES-10 visible image in Figure 4 shows smoke from the fires as a result of forward scattering of early-morning sunlight. The low light at this time of day was enhanced in this albedo product image by correcting all pixels for variations in solar zenith angle. Smoke can be seen covering much of the image area east of the fires.

Conclusions

While GOES data are available with high time frequency for viewing fires and smoke, MODIS data offers an increased number of spectral bands to help reveal details and variations in the smoke plumes and their associated fires. These multi-spectral data are continuing to be explored for smoke and fires and other atmospheric and surface features that are not as easily detected with fewer spectral bands.

Fellowships in Atmospheric Science and Related Research

The Cooperative Institute for Research in the Atmosphere at Colorado State University (CIRA) offers a limited number of one-year Associate Fellowships to research scientists including those on sabbatical leave or recent Ph.D. recipients. Those receiving the awards will pursue their own research programs, collaborate with existing programs, and participate in Institute seminars and functions. Selection is based on the likelihood of an active exchange of ideas between the Fellows, the National Oceanic and Atmospheric Administration, Colorado State University, and CIRA scientists. Salary is negotiable based on experience, qualifications, and funding support. The program is open to scientists of all countries. Submitted applications should include a curriculum vitae, publications list, brief outline of the intended research, a statement of estimated research support needs, and names and addresses of three professional references.

CIRA is jointly sponsored by Colorado State University and the National Oceanic and Atmospheric Administration. Colorado State University is an equal opportunity employer and complies with all Federal and Colorado State laws, regulations, and executive orders regarding affirmative action requirements. In order to assist Colorado State University in meeting its affirmative action responsibilities, ethnic minorities, women and other protected class members are encouraged to apply and to so identify themselves. The office of Equal Opportunity is in Room 101, Student Services Building. Senior scientists and qualified scientists from foreign countries are encouraged to apply and to combine the CIRA stipend with support they receive from other sources. Applications for positions which begin January 1 are accepted until the prior October 31 and should be sent via **electronic** means only to: Professor Thomas H. Vonder Haar, Director CIRA, Colorado State University, humanresources@cira.colostate.edu. Research Fellowships are available in the areas of: **Air Quality, Cloud Physics, Mesoscale Studies and Forecasting, Satellite Applications, Climate Studies, Model Evaluation, Economic and Societal Aspects of Weather and Climate.** For more information visit www.cira.colostate.edu.

FX-Net 2002: A Real-Time Fire Weather and Air Quality Forecast Workstation

By Renate Brummer

FX-Net is an Internet-based meteorological workstation that is being developed by a CIRA research team at NOAA's Forecast Systems Laboratory (FSL). By leveraging recent AWIPS workstation development, the FX-Net system is now able to deliver model forecast information for any location in the lower 48 states. The client, which emulates the AWIPS D2D interface, runs on readily available PC hardware over network bandwidth as low as that which is available with phone line-based modems. The list of products includes satellite imagery, model forecasts, and observational data. Among the significant improvements to the FX-Net system developed during 2002, is real-time access to air quality data. In parallel development, system functionalities and system operational environment were adapted to support the strict operational needs of fire weather forecasters as well.

System Overview

FX-Net is a request-based, client-server system intended to be an extension of the D2D capability – not just a PC version of the AWIPS workstation. The server is primarily responsible for data management (i.e., time matching of products) and for creation and delivery of these product files (see Figure 1). Written in C++, the server is a modified AWIPS workstation. Rather than support the local display of products, it uses the D2D software to produce and encode files in response to a product request by the client. As is the case for any real-time AWIPS workstation, the server must be collocated with an appropriately localized AWIPS data server. The client runs as a Java application on a PC. After retrieving products via the Internet, it allows a user to locally interact with the information. Connections to the server are only maintained during the request and retrieval of products.

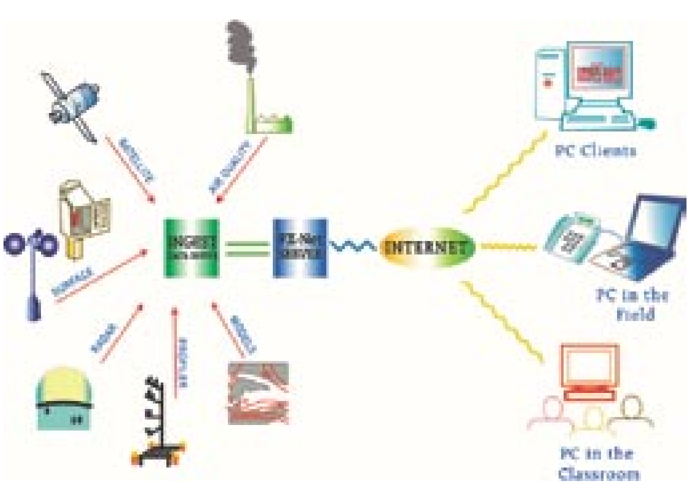


Figure 1: FX-Net System Overview

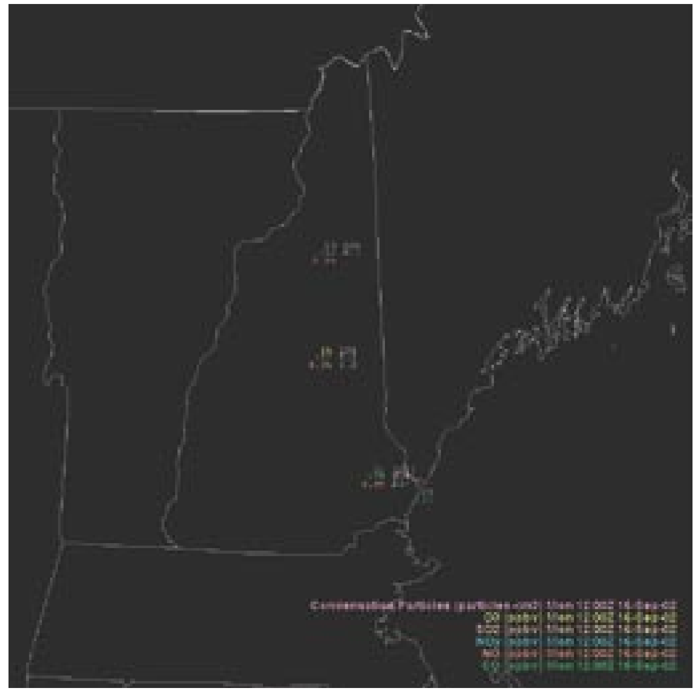


Figure 2: UNH Air Quality Measurements

FX-Net/AQ – The Real-Time Air Quality Workstation

For the last few years, FX-Net had been supporting the AIRMAP Program, a University of New Hampshire (UNH) based NOAA-funded program, which focuses on the long-term monitoring and forecasting of air quality parameters like nitrogen oxides, sulfur dioxide, carbon monoxide, and low-level ozone, which are hazardous to human health and other organisms when present in the lower atmosphere. Many of these chemicals are the result of burning fossil fuels, and are responsible for New Hampshire's high levels of acid rain. The primary mission of AIRMAP is to develop a detailed understanding of climate variability and the source of persistent air pollutants in New England. The availability of a real-time display station like FX-Net became very important to the program's success. The FX-Net team modified the existing real-time meteorological workstation by adding air-quality related data sets to the ingest and display system. A new FX-Net/AQ client was successfully released in July 2002, just in time to support the real-time forecasters who participated in a "High-Resolution Temperature and Air Quality" (TAQ) field experiment during this past summer. AIRMAP was part of this field project, and is described elsewhere in this newsletter. The new FX-Net/AQ data sets include six parameters (O3, CO, NO, NOy, SO2, Condensation Particles), which are continuously measured at three UNH sites (Mount Washington, Castle in the Clouds, and Thompson Farm) located in the state of New Hampshire (see Figure 2). The FX-Net/AQ user also has access to the data of 13 wind profilers recently installed across the

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New England states. In addition, hundreds of new meteorological surface observation data, fixed buoy records, and ship measurements are available on the latest FX-Net menu. On the continental U.S. scale (CONUS), FX-Net displays the hourly average of the national EPA low-level ozone data. The FX-Net team is still working on the ingest and display of the MM5 air quality model. Once this task is completed, FX-Net can truly be called a "real-time air quality workstation."

FX-Net – The Fire Weather Workstation

During the summer of 2001, the National Interagency Fire Center (NIFC) requested that FX-Net be modified to permit its use as the primary real-time meteorological workstation by fire weather forecasters at NIFC and the Geographic Area Coordination Centers (GACC). The plan called for the FX-Net to be used during the 2002 fire season on an experimental basis, with the FX-Net server located at FSL in Boulder. If the workstation was accepted by the fire weather forecast community at NIFC and the GACC Offices, the agreement called for the introduction of an operational solution for the 2003 fire season.

The FX-Net team added a variety of new functionalities to the FX-Net client with the goal of making additional products available to the fire weather community and adding new user-friendly tools to the client. One of the more outstanding new data sets is a complete text browser which allows for the display of a very large number of National Weather Service forecast and discussion products. Additional new tools allow for the export of products displayed in the primary window, preference client settings rather than former changes to the configuration file, and the change of contour intervals for displayed model products. FX-Net also added two special display scales, called Northern Rocky Mountains and Southern Rocky Mountains, for the viewing of high-resolution satellite imagery in areas with high potential for wildfires.

As is now well documented, the 2002 fire season turned out to be one of the worst fire seasons ever recorded for many states. The operational demand by NIFC and GACC forecasters for complete sets of meteorological products became paramount to support the issuance of the best possible daily forecasts. In response to the high operational tempo and requirements, the CIRA FX-Net team pursued every possibility to improve the reliability of all components of the system involved in the FX-Net data stream. Hardware was exchanged with newer systems, data streams rerouted, and multiple back-up systems were installed. By the second half of July, a significant improvement in the reliability of the FX-Net related systems was successfully achieved, with reliability exceeding 98 percent.

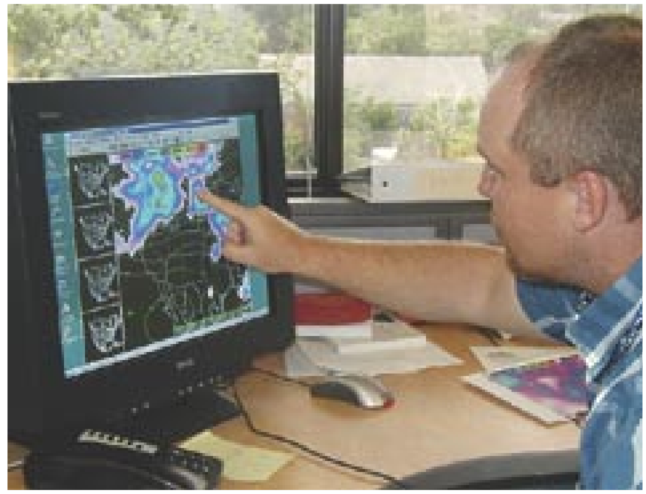

Figure 3: Fire weather forecaster using FX-Net at the Lakewood, Colorado GACC Office

The new list of fire weather products, the new functionalities added to the client, and the significant increase in reliability made FX-Net a truly operational fire weather forecaster workstation. It also resulted in very positive feedback from the NIFC management as well as from the GACC forecaster community.

Key Players

The enhancements and refinements necessary to develop the FX-Net air quality as well as the fire weather versions of the workstation were performed by the CIRA FX-Net team consisting of Sean Madine (Technical Lead), Dr. Ning Wang, Evan Polster, and John Pyle. Dr. Renate Brummer acted as the project manager. The CIRA Data Support Group members at FSL (Chris MacDermaid, Amenda Stanley, and Bob Lipschutz) provided excellent support for the data ingest component. The close collaboration between CIRA and FSL researchers was crucial for the success of the two projects.

Future Goals

In order to enhance the usability of FX-Net for the fire weather forecasters, follow-on tasks will be performed to produce additional high-resolution products. In the near future, FX-Net will serve a very high-resolution visible satellite image. The client will be able to choose an arbitrary view of visible satellite imagery by drawing a "view window" onto the existing CONUS or regional scale visible satellite image. In addition to the high-resolution satellite imagery, FX-Net will also provide arbitrary mosaics of radar products. These new high-resolution products will be complemented by additional high-resolution forecast model output from mesoscale models such as the MM5 and the MM5/Air Quality.

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Thunderstorm Brightness Temperatures

By Lewis Grasso and Thomas Greenwald

Introduction

Satellite data assimilation is a current research topic. Data assimilation involves an assimilation cycle; that is, a simulation followed by an adjoint. This cycle is repeated several times until an optimal initial state is determined. A first step in the development of a satellite data assimilation system is the testing of the simulation component of the assimilation cycle. Research presented here focuses on the simulation component; specifically simulating a thunderstorm and synthesizing 10.7 μm brightness temperatures (T_{bS}).

A general-purpose observational operator that calculates radiances from visible to infrared wavelengths of both clear sky and cloudy regions has been developed at CIRA. This operator was used to compute synthesized brightness temperatures of a simulated thunderstorm. In particular, characteristics of synthesized GOES imager 10.7 μm T_{bS} and their relationship to microphysical constituents are explored. Three new aspects of this research are as follows: first, hydrometeors were prognosed using two-moment microphysics. Second, hydrometeor optical properties were computed with physical models, as opposed to lookup tables or empirical methods. (Incidentally, the physical models took into account the different geometric shapes of each hydrometeor.) Third, a practical method was used to calculate infrared T_{bS} that included multiple scattering effects for optically thick clouds that contained different types of hydrometeors.

Numerical Procedures

The numerical cloud model used for this study was the Regional Atmospheric Modeling System (RAMS), version 4.29, which was developed at Colorado State University. Of particular importance, hydrometeors were predicted with a two-moment bulk microphysical scheme. Mass mixing ratio and number concentration were prognosed for six of the seven hydrometeor types while the mean diameter was diagnosed. The following hydrometeor species were included in the simulation: cloud droplets, rain droplets, aggregates, graupel, hail, snow, and pristine ice. Both graupel and hail are mixed phased; that is liquid water may exist on the surface of the two particles. However in computing optical properties, both graupel and hail were assumed to be homogeneous. Snow and pristine ice are each divided into five habit categories: columns, hexagonal, dendritic, needles, and rosetta.

The configuration of two grids and thunderstorm initialization was similar to methods used in previous simulations of thunderstorms. Horizontal grid spacings of 4 km (approximately equal to the footprint of GOES-9 10.7 μm imager) were used within a domain spanning 400 km x 400 km. A nested grid spanning 80 km in each direction was used to improve the resolution of the convective updraft and had horizontal grid spacings of 2 km. The domain of both grids extended to a height of approximately 23 km. Vertical grid spacings started at 100 m and were stretched by a factor of 1.1 to a value of 2000 m. A time step of 5 seconds was used and the simulation spanned 2 hours. In addition, a sounding used to initialize a horizontally homogeneous environment was retrieved from the GOES-11 sounder. Wind profilers, near the location of the sounding, were used to initialize the winds within the domain.

The observational operator used for computing brightness temperatures has several components. The three main components are as follows: radiative transfer models, hydrometeor optical (single-scatter) property models and a clear sky gas extinction model (OP-TRAN). As an overview, each of the components of the observational operator was linked together to produce synthesized 10.7 μm $T_{bS.}$ That is, the cloud optical model generated profiles of extinction, single-scatter albedo, and an asymmetry factor – for a distribution of hydrometeors – using anomalous diffraction theory. Gas extinction was computed using temperature, pressure, and water vapor from the simulation. In addition, OPTRAN used an ozone profile for the U.S. standard atmosphere. Next, the radiative transfer model applies a Delta-Eddington 2-stream to compute brightness temperatures. Because interest lies in obtaining radiances from the simulated thunderstorm, precise values of surface emissivity were less critical; therefore, a typical value was used: 0.98. In addition, surface temperatures were extracted from the simulation.

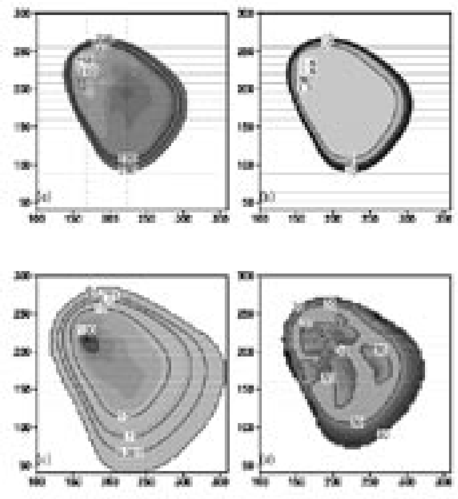

Figure 1. Shaded and contoured plots of (a) synthesized brightness temperatures (ºK), (b) monochromatic radiance (W m^{-2}sr^{-1}cm^{-1}), (c) column integrated pristine ice (kg m^{-2}) multiplied by 100, and (d) effective mean diamneter (µm) for pristine ice multiplied by 10^{6} at 2 hours into the simulation. In this and subsequent figures, darker shades represent greater values while coordinate values have units of kilometers.

Additional diagnostics were computed to aid in the analysis of not only synthesized $T_{bS,}$ but also the relationship between microphysical quantities and synthesized $T_{bS.}$ These diagnostics are column integrated mass mixing ratio (CIRx), 10. 7 μm weighting function (WFRx), and effective mean diameter (EFFDRx). In each quantity, CIRx, WFRx, and EFFDRx, the x will be replaced by either a (aggregates), c (cloud water), g (graupel), h (hail), p (pristine ice), r (rain), or s (snow).

Radiative Characteristics of the Simulated Thunderstorm

Brightness temperatures and a few other fields were plotted at two hours into the simulation (Figure 1). Brightness temperatures (Figure 1a) indicated the location of the thunderstorm anvil; that is, temperatures between 290 and 210 ºK were characteristic of the cloud top. Values of 210 ºK identify

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Summer Staff Retreats

By Mary McInnis-Efaw

The slower summer months provided an opportunity for CIRA managers to engage two groups of employees in retreat settings to discuss "big picture" issues that impact CIRA as an organization. The administrative staff met at the TAMA-SAG Retreat Center on August 9, and many researchers and Postdocs were invited to the Pingree Park Mountain Campus for a three-day retreat on August 14-16.

The administrative retreat was a welcome break from the routine and provided an opportunity for staff members to hear more about what CIRA's main research work has been and what is on the horizon in terms of major projects. Aside from some routine business regarding policy and upcoming administrative tasks, the group also discussed growth opportunities, office culture, and future directions.

The research retreat is an annual event which typically is a meeting for CIRA scientists and colleagues to discuss via talks and poster sessions what research they are engaged in. CIRA's core mission as an interdisciplinary organization is also a logical impetus for the retreat as the intent is to allow for discussion and insights into one another's work. This year, particular attention was paid to the future of CIRA and its goals.

The setting at 9,000 feet above sea-level also was an ideal change of pace for those invited, and time was set aside for attendees to go hiking in the area.

The setting of Pingree Park at 9,000 feet makes an ideal setting for an exchange of ideas.

The CIRA administrative staff had a productive meeting off-site to discuss a number of topics.

All photos courtesy of Ken Eis, CIRA Deputy Director.

CIRA's core mission as an interdisciplinary organization is also a logical impetus for the retreat as the intent is to allow for discussion and insights into one another's work.

Pingree retreat participants gather for a group photo.

CIRA Communiqué: Employee News

Trainer of the Year Award

Dr. Stan Kidder, a senior research scientist at CIRA, was recently awarded NOAA's Atmospheric Research and Applications Division Trainer of the Year Award for 2001. According to the notification letter, Dr. Kidder was selected in recognition of his many years of training and instruction. Kidder served as the lead academic instructor at the Satellite Meteorology courses held at COMET from 1996 to 2000. He was responsible for all aspects of the courses including actually teaching, preparing all classroom materials, conducting lab exercises, and administering evaluations. As an outcome to the experience, Kidder was lead author on an article entitled, "Two Simple GOES Imager Products for Improved Weather Analysis and Forecasting." (National Weather Digest, Volume 24, Number 4). More recently, in the fall of 2001 Kidder began teaching a monthly VISITview teletraining program, called "An Introduction to POES Data and Products." There have been 6 sessions with 84 students from 27 offices including the National Weather Service, Navy and the Meteorological Service of Canada.

Monfort Professor Award Goes to CIRA colleague

Dr. A. Scott Denning, an assistant professor of Atmospheric Science and frequent CIRA colleague, was awarded a Monfort Professor Award by Colorado State University in September 2002. Denning and another professor from Chemistry were the first of 10 to be selected for this honor in the next 5 years. According to the announcement, Denning has made a significant contribution to scholarship at CSU: "Since his appointment as assistant professor in 1998, Scott Denning has received more than $3.8 million in research funding and has opened up new research areas in biogeochemical cycles, seeking to understand the local and global impacts of important 'greenhouse' gases. He has served on panels developing a U.S. Carbon Cycle Science Plan, the North American Carbon Program and an international Carbon Observing System Plan being organized by the U.N. Food and Agriculture Organization. Dr. Denning plans to use his two-year Monfort professorship to create and teach a full-semester course in data assimilation for the study of the carbon cycle, one of the major areas of his research and an area of global concern."

RUC-2 Implementation

A joint effort between CIRA staff and our federal partners at the Forecast Systems Lab in Boulder has resulted in an update of the RUC system. The Rapid Update Cycle (RUC) is a system that provides high-frequency, hourly analyses of data sources over the 48 states, as well as short-range numerical forecasts. The RUC is in operational use at NOAA's National Centers for Environmental Prediction (NCEP) in Camp Springs, Maryland.

NCEP's mission is to provide weather forecasts, warnings and guidance to the public, and as such the RUC is a useful tool in this assignment. The RUC is one of a kind in its ability to produce updated, national-scale numerical analyses and forecasts more frequently than once every six hours. The system was developed in answer to the needs of the aviation community and others for high-frequency, mesoscale analyses and short-range forecasts covering the contiguous United States.

The new RUC-2 is a 20-km (as opposed to 40-km), 50-level version of the RUC. The four key aspects of the new version include: finer (20-kilometer) horizontal resolution (requiring about eight times the computations of the 40-kilometer version for the forecast model), an improved version of the RUC forecast model, assimilation of GOES-based cloud- top pressure to improve the initial RUC cloud fields for each forecast, and use of a three-dimensional variational analysis, replacing the current optimal interpolation analysis. Also, the existing soil model was enhanced to include a 2-layer snow model and high-resolution land-use/soil type and topography data.

CIRA passes on its congratulations to the CIRA researchers who contributed to the update:

RUC development group – Kevin Brundage, Tracy Lorraine Smith

Other Forecast Research Division collaborators – Ed Szoke, Adrian Marroquin

Information & Technology Services – Bob Lipschutz, Paul Hamer, Glen Pankow

Systems Development Division – Jim Ramer

Aviation Division – Dan Schaffer, Jacques Middlecoff

Welcome...

Julie Demuth - Hourly, Supervisor: John Knaff, Start date: August 19, 2002.

Jonathan James - Temporary Non Student Hourly, Supervisor: Marilyn Watson, Start date: April 11, 2002.

Shawn McClure - working with NPS Group, Research Associate II, Supervisor: Doug Fox, Start date: August 12, 2002.

Kevin Micke - Student Hourly, Supervisor: Hiro Gosden, Start date: May 20, 2002.

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CIRA Communiqué *(continued from page 9)*

David Richie - working with NPS Group, Supervisor: Doug Fox, Start date: July 15, 2002.

Phil Stephens - Hourly, Supervisor: Andy Jones, Start date: August 16, 2002, Work Location: UK.

Farewell...

Jimmy Adegoke - Post Doc, Supervisor: Tom Vonder Haar, End date: August 31, 2002, Work Location: South Dakota.

Monica Engle - Research Associate, Supervisor: Doug Fox, last day: June 30, 2002.

Renee Galvin - Student Hourly, Supervisor: Lance Noble, End date: August 9, 2002.

Wei Gao - Supervisor: Tom Vonder Haar, last day: July 31, 2002.

Tom Greenwald - Research Scientist, Supervisor: Ken Eis, End date: September 10, 2002.

Chris King - Boulder, Supervisor: Renate Brummer, last day: August 31, 2002.

Jim Kossin - Post Doc, Supervisor: Tom Vonder Haar, End date: May 31, 2002.

Tom McKee - CIRA Acting Director, last day: May 31, 2002.

Mark Sleeper - Boulder, Supervisor: Cliff Matsumoto, last day: June 30, 2002.

Margueritte Toscano - Maryland, Supervisor: Tom Vonder Haar, last day: July 31, 2002.

Katie Walters - Non Student Hourly, Supervisor: Don Reinke, last day: March 31, 2002.

Carol Youngren - Non-student Hourly, Supervisor: Loretta Wilson, End date: May 31, 2002.

Changes

Amy Colella, Supervisor: Bonnie Antich, Non-Student Hourly as of June 17, 2002.

John Davis, Supervisor: Tom Vonder Haar. John is back with CIRA as a Research Scientist III, Start date: August 1, 2002.

Daniel Lindsey - Ft. Collins, RAMM Team, was a Non Student Hourly, now a Research Associate as of July 8, 2002, Supervisor: Louie Grasso.

Mary McInnis is now Mary McInnis-Efaw, Supervisor: Ken Eis.

Milija Zupanski, was a Postdoc, now a Research Scientist as of June 1, 2002. Supervisor: Tom Vonder Haar.

September 2002 Employee of the Month at FSL

CIRA Research Associate Ali Zimmerman was recently honored as the Employee of the Month by the NOAA Forecast Systems Laboratory in Boulder. Ali works as a programmer on the GLOBE Project, an interactive Web site for elementary-aged children to learn about weather. As stated in the announcement: “Ali was chosen as an example of professionalism while enduring a disability (hearing impairment). Ali continues to provide significant support to the Web development activity of the GLOBE Project and has also supported the TAQ project during the field program segment when required. Through her work ethic and outside activities (acting) she provides a standard for all of us to emulate.”

Thunderstorm *(continued from page 7)*

the overshooting dome; also, the overshooting dome and region of precipitation were essentially collocated. Additional gray shades were added to the plot of T_{bS} to reveal the enhanced-V signature, a signature often associated with severe thunderstorms. Except for additional gray shades, similar remarks hold for the radiance field (Figure 1b).

Column integrated mass mixing ratio, effective mean diameter, and 10.7 μm weighting function were calculated for pristine ice. Maximum values of CIRp were near 1 kg m^{-2} within the over shooting dome (Figure 1c). Although CIRp values were relatively small, pristine ice existed over a greater region than that bounded by the 290 ºK isotherm in Figure 1a. Brightness temperatures greater than 290 ºK (Figure 1a) suggest the forward edge of the anvil was optically thin; radiation emitted from the surface passed through a layer containing small amounts of pristine ice. Even though the pattern of brightness temperatures, radiances and CIRp look similar, EFFDRp exhibited a pattern that differed from the previous three (Figure 1d). In other words, the location of the overshooting dome was less evident in the plot of EFFDRp compared to plots of brightness temperatures, radiances, and CIRp. In particular, the largest values of EFFDRp appeared along the anvil edge. Furthermore, a comparison of brightness temperatures and EFFDR p suggests a lack of a relationship between the two fields.

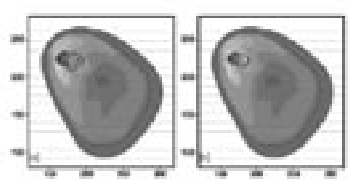

Figure 2. Shaded and contoured plots of synthesized brightness temperatures (ºK) along with (a) total simulated surface condensate (contoured from 0.2 to 2 g kg^{-1}) and (b) simulated precipitation rate (contoured from 20 to 80 mm hr^{-1}).

Exploring a possible relationship between T_{bS} and microphysical quantities is a topic of current research. Total surface simulated condensate was contoured within the shaded plot of synthesized T_{bS} (Figure 2a). As seen in the figure, the entire region of surface condensate was collocated with T_{bS} that varied just a few ºK. Further, surface simulated precipitation rate was also contoured within the shaded plot of T_{bS} (Figure 2b). Similar to Figure 2a, the precipitation field was also collocated with T_b that varied just a few ºK. These results suggest that a scatter plot of T_{bS} vs. precipitation rate would be nearly horizontal. That is, results suggest a lack of a relationship between T_{bS} and precipitation rate for this case.

Data Assimilation

Numerical methods discussed above may be used as

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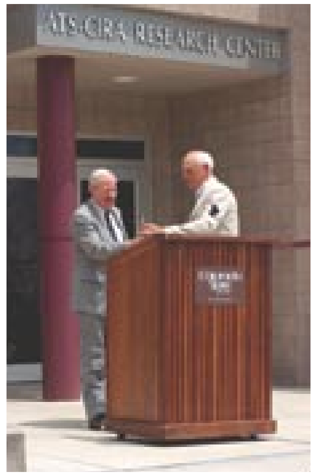
Ribbon-Cutting Ceremony Opens the Door to New Research Center



Above, left: The cutting of the ribbon makes it official: Dr. Vonder Haar (CIRA) and Dr. Rutledge (ATS) do the honors. Right: Dr. Vonder Haar introduces Dr. A.E. "Sandy" MacDonald, Director of the NOAA/OAR Forecast Systems Laboratory in Boulder.

An estimated crowd of more than 350 people gathered on a sunny July afternoon to witness the ribbon cutting for the newest facility on the Foothills Campus of Colorado State University: the Atmospheric Science/CIRA Research Center (ACRC).

July 10, 2002 marked the completion of a process that was set in motion more than 4 years ago. What began simply as a plan for an addition onto the CIRA building in early 1998 eventually grew into a multi-disciplinary, multi-use project between the Atmospheric Science Department (ATS) and CIRA. After some discussion, it was agreed that a larger facility could serve both entities and serve as a literal and figurative bridge between the frequently collaborating units. Thus CIRA and ATS agreed to jointly sponsor and construct an addition to the existing ATS building. With further support from the RBRF, the Vice President for Research and Information Technology, the Provost, and the College of Engineering, the over 14,000 sq. ft. facility now provides the space needed for the continually expanding research programs in both departments, and supports the academic function through training and research opportunities.

Invited speakers included a number of ATS and CIRA's research community partners and supporters.

The new facility provides research space for atmospheric scientists, postdocs, graduate students, support staff, and visiting scientists from all regions of the globe. It will also improve collaborative research activities with NOAA since it will contain visiting scientist rooms, classrooms with remote sensing ports, and our GOES Earthstation ingest equipment. Among the ongoing research projects being housed in ACRC is CloudSat, headed by mission Principal Investigator, Dr. Graeme Stephens (ATS), and the associated Cloud Sat Data Processing Laboratory headed by Dr. Thomas Vonder Haar (CIRA). The CIRA science data processing allows researchers to use new cloud radar data to verify cloud parameters determined from NOAA and GOES data with colleagues in the NESDIS RAMM team. Also, Dr. Serge Matsurov of NOAA/OAR Environmental Technology Lab is a member of the CloudSat Science Team along with Vonder Haar, Stephens and others.

Special capabilities within the new addition include an integrated classroom/lab with the capacity for lidar observations, a dedicated multi-circuit computer room for Cloud Sat data processing, a temperature and humidity controlled underground tape storage room, and high band width Internet computer connections throughout the facility. The new facility was officially opened to coincide with the 40th anniversary celebration for the Atmospheric Science Department.

Both Thomas Vonder Haar, University Distinguished Professor and Director of CIRA, and Steven Rutledge, Professor and Department Head of ATS addressed the crowd during the dedication ceremony.

CIRA and ATS employees, friends, and guests all were invited to part of the festivities.

Invited guests and speakers represented a wide variety of ATS and CIRA's research community partners and supporters. This prominent group included Dr. Sandy MacDonald, Director of the NOAA/OAR Forecast Systems Laboratory, and other university and federal agency representatives. The official ribbon cutting was followed by a barbeque and open house with scientific posters and displays.

CIRA Proudly Announces 2002 Research Initiative Award Winners

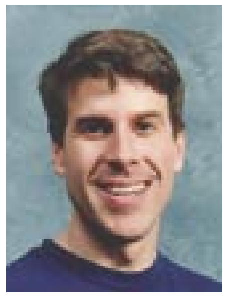
By Cliff Matsumoto and Mary McInnis-Efaw

The 2002 CIRA Research Initiative Awards were handed out in June of this year to two individual recipients and a team of three colleagues. CIRA is proud and honored to have them working with us, and congratulates each of them for their tremendous contributions to our mission.

Dr. Gerald Browning

Dr. Gerald Browning is a mathematician by training whose work with CIRA since coming on board in 1991 has furthered understanding in the atmospheric sciences. Dr. Browning was recognized with this award for two main reasons: beyond his work to advance the science, Dr. Browning is well known for his active role as a mentor to younger scientists at CIRA.

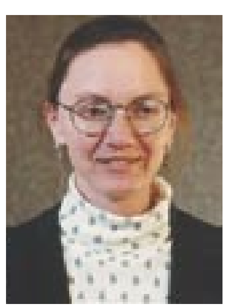
As Browning's nomination said: "In a series of papers, Browning and Professor Heinz Kreiss, a colleague and mentor, have extended Kreiss' Bounded Derivate Theory (BDT) to multiscale flows in the atmosphere and oceans. There are many ramifications of this new theory. The first is that the well posed system introduced by Browning & Kreiss as a replacement for the ill-posed primitive equations (used in all models for large-scale atmospheric flows) also accurately describes both the dominant and gravity wave portions of all remaining atmospheric flows, i.e., the new system is the only well-posed multiscale system that accurately describes all atmospheric motions. The second is that the reduced system clearly indicates what balances are appropriate for all diabatic cases, i.e., it is the only method that has provided a hot start initialization for cases where the heating is the controlling influence on the solution. The impact of this theory is being felt in many areas, and Browning's cutting-edge research and the potential for break-through applications in numerical modeling have drawn the support of the Office of Naval Research (ONR), the Air Force Office of Scientific Research (AFOSR), and NOAA."



Jim Frimel

Jim Frimel, a Research Associate in the Boulder division of CIRA since 1995, was described by his nominator as a leader and source of motivation for the team he leads in their work on the TMU Project. Frimel not only headed up the initial installation of the necessary infrastructure for the project, but has since worked tirelessly to enhance and upgrade the system. He has worked closely with everyone on the team, and has met or exceeded expectations on the usability of the system.

The Traffic Management Unit (TMU) Project "is a rapid prototyping effort designed to put the latest in meteorological data display tools in front of aviation weather forecasters." Frimel's nomination further states: "Jim's attention for detail and high standards for all areas of the system development cycle has made the staging and upgrading of systems for this high visibility project a success. Jim's technical and leadership capabilities continue to improve the organization and productivity of the ASDAD group. Without Jim's varied expertise and high motivation level this project would be failing. Jim is a vital asset to the team; he improves the process and quality of any software effort of which he has been a part."



Bernadette Connell

The Hurricane Mitch Reconstruction Project, sponsored by both USAID and NOAA, is aimed at providing all of Central America with better satellite systems for tracking hurricanes in the area. The devastation caused by Hurricane Mitch in October 1998 was the impetus for the project as perhaps more lives could have been saved had there been more warning to the population. Three individuals at CIRA Fort Collins won a group award for their efforts in this endeavor: **Bernadette Connell, Hiro Gosden,** and **Dave Watson.**

This comprehensive project involved three components: technology transfer, research, and training. As the nomination letter stated, "The technology transfer component to this project involved the installation of a GOES satellite receiving station in Central America, and a network of low-cost computer workstations for display and manipulation of the data in all seven Central American countries. Nominee Hiro Gosden, with assistance from the University of Costa Rica, performed the installation of the network of computer workstations in July-October 2001. The display capabilities of these workstations were provided by the existing RAMSDIS software technology, which was developed at CIRA and customized for Central American use by Mr. Gosden. This software interface, which runs in a MCIDAS environment, has been continually maintained and improved over the past several years by nominees Hiro Gosden and Dave Watson to support a number of different projects, including this one. The nominees resolved the many technical problems encountered throughout the project with great initiative and resourcefulness."

Hiro Gosden

"The research component of the project involved the hiring of a visiting scientist from

(continued on page 13)

Research Initiative *(continued from page 12)*

Dave Watson

Central America to work on improved methods for using GOES data to predict rainfall. Again, all of the nominees offered much of the needed technical support to implement this portion of the project."

"The training component of the project involved the organization and implementation of two regional workshops on applications of satellite data. Participants from all seven Central American countries participated in these weeklong training sessions, which were held at the University of Costa Rica. The contacts established during these workshops will have a long-term impact on collaborations between NOAA and scientists in Central America. Nominee Bernadette Connell coordinated much of the training. Dr. Connell also did much of the instruction as to the use of GOES imagery and derived products. The success of this project has led to other international interactions and training opportunities."

Thunderstorm

(continued from page 10)

part of a data assimilation system. During an assimilation cycle, a numerical model can be used to predict the state of an atmospheric event while the observational operator can simultaneously diagnoses T_{bS}. Results from this procedure can be compared to observations. An adjoint model may aid in the recovery of hydrometeor mass mixing ratio and number concentration of several hydrometeor types. In other words, an adjoint system can be used to aid in with the initialization of microphysical quantities that would otherwise be a difficult task.

CIRA Participation in IHOP

By Ed Szoke

The International H_2O Project (IHOP) was an extensive field project in the Southern Plains between 13 May and 25 June of 2002. The main focus of IHOP was to improve the characterization of the four-dimensional distribution of water vapor and its application to improving the understanding and prediction of convection. The four main components of the program were: quantitative precipitation forecast (QPF), convective initiation (CI), atmospheric boundary layer processes, and instrumentation. Scientists from around the world participated in this program, bringing an assortment of instrumentation designed to remotely measure the distribution of water vapor in the atmosphere. The hope of all involved was that someday some of these instruments, both ground-based and satellite-borne, might be able to provide much-improved measurements of moisture in the troposphere, and ultimately lead to better forecasts.

CIRA scientists at the NOAA Forecast Systems Laboratory in Boulder were involved in a number of aspects of IHOP, including design and participation in some of the experiments. They had a significant role in the planning and implementation of forecasting and nowcasting support for the field program, which included the opportunity to run and evaluate several high-resolution numerical models. This article will focus on the CIRA/FSL forecasting/nowcasting and modeling activities during IHOP.

Modeling Efforts during IHOP

With an impressive array of instrumentation, both ground-based (including fixed remote sensors as well as an armada of mobile instrument-equipped vehicles from the National Severe Storms Laboratory (NSSL)), and a variety of airborne sensors and satellite measurements, IHOP provided an opportunity to test the impact of all this special data on short-range forecasts from high-resolution numerical models. A number of groups planned to participate with special runs of their models, with varying horizontal grid resolutions. Model runs during the IHOP field phase only included some of the special project data, and provided a baseline for later sensitivity studies. The NOAA Forecast Systems Laboratory (FSL) has a long history of developing and running analyses and model systems with the Rapid Update Cycle model (RUC, Benjamin et al., 2002; homepage at http:// ruc.fsl.noaa.gov/) and the Local Analysis and Prediction System (LAPS, McGinley et al., 1991; homepage at http:// laps.fsl.noaa.gov). A number of CIRA scientists work with both the LAPS and RUC groups at FSL.

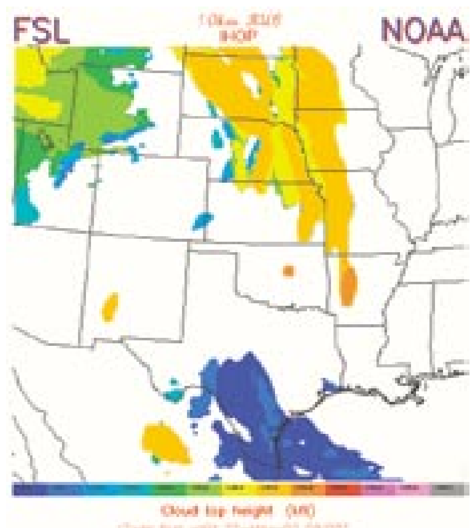


Figure 1. The 10-km RUC grid during IHOP. A forecast of cloud top height is shown in this example.

The RUC is a hybrid isentropic-sigma coordinate model that was developed in the 1980s to fill a void in shorter-term (out to 12 hour) prediction. The isentropic coordinate system made the RUC different from the other national scale operational models, but the RUC also provided a mechanism to

(continued on page 14)

Participation in IHOP *(continued from page 13)*

use observations from commercial aircraft (ACARS) as an important off-synoptic time data source for its frequent updating (initially every 3 hours, now every 1 hour). Today, the RUC ingests many types of data as well as the ACARS, and just before IHOP, was upgraded to a 20-km horizontal grid resolution for the operational runs at the National Center for Environmental Prediction (NCEP). RUC has run at 10-km horizontal grid resolution for special field programs like PacJET, and they used that configuration for IHOP as well, which involved moving the PacJET grid east to cover the IHOP domain (Figure 1).

LAPS development also began at FSL during the 1980s, and in contrast to the RUC, LAPS has always been viewed as an analysis system that would be run at a local forecast office (WFO) so that it could ingest data that may not be available to national scale models (basically whatever data that could be brought into a local office). LAPS can be run just as an analysis package, as is currently the case at all National Weather Service (NWS) WFOs in the continental United States as a part of the Advanced Weather Interactive Processing System (AWIPS, Wakefield, 1998). The "P" in LAPS represents the idea that high-quality local analysis would be an ideal input for starting a local-scale model to be run at a WFO. FSL has been testing various models with LAPS, including the CSU RAMS model, the MM5 model, and even more recently, the WRF model, which is being developed in a community-wide effort as a next-generation model. Brent Shaw of CIRA has been instrumental in this work, as well as Adrian Marroquin, while LAPS-expert and CIRA employee Steve Albers was involved in getting special radar data into LAPS for IHOP. Currently FSL runs LAPS with MM5 on a 10-km horizontal grid resolution and sends the output to the AWIPS system at

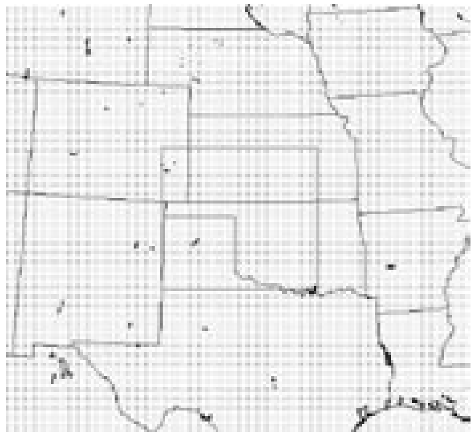


Figure 2. The 12- and inner 4-km IHOP grids for the LAPS MM5 and WRF runs.

the collocated Boulder WFO, which gives us a chance to get subjective model evaluation for a variety of weather events. We also frequently discuss the local model forecast as part of the FSL Daily Weather Briefing, held each workday from 11 to 11:30 a.m. The current version of MM5 uses a new scheme to better capture ongoing convection in the initial analysis and avoids spin-up problems that can result in under-forecasting precipitation in the first few hours of the forecast. This scheme is dubbed "hotstart," and uses the LAPS cloud analysis to input an assumed vertical velocity profile where echoes are present at initialization time (see Shaw et al., 2001 for more detailed discussion of the hotstart procedure). For output to the Boulder WFO, the MM5 hotstart is run 4 times a day out to 24 hours.

During IHOP, we ran a 12-km horizontal grid resolution version of the MM5 hotstart initialized with LAPS, with a nested 4-km version that covered the IHOP experimental domain, also initialized with a 4-km resolution LAPS for this smaller domain (domains are shown in Figure 2). LAPS was also used to initialize a similar 12 and 4-km setup for the WRF model. The models being run by FSL for IHOP are summarized in Table 1.

Model	x km	# vertical levels	Runs every x h	Out to x h
MM5hot	4	34	3	12
MM5hot	12	34	3	12
LAPSWRF	4	34	3	12
LAPSWRF	12	34	3	12
RUC	10	50	3	6-24

Table 1. FSL models in IHOP.

A considerable amount of work was necessary to get the models shown in Table 1 ready for IHOP. All the data for the model domains (aside from most of the special experimental measurements) had to be gathered into the FSL Central Facility to make it available to the LAPS and RUC analyses. The model output had to be somehow displayed in a timely manner while preserving the ability to manipulate the output and combine model output with actual data in an AWIPS-like setting. First, there was the need to configure an AWIPS data server to decode and make available for display output from the FSL special IHOP models. CIRA scientists Amenda Stanley, Paul Hamer, Bob Lipschutz, and Glen Pankow in the Data Systems Group headed by Chris MacDermaid worked on getting the IHOP data stream ready for both AWIPS and LAPS and RUC. Then there was the issue of how the output would be displayed. The solution was to use FX-Net, which emulates many of the capabilities of AWIPS but transfers data over low speed (56 K) lines on a PC platform using special data transfer techniques. One of the ideas for developing FX-Net was to provide a low-cost display tool that would look like AWIPS and be an ideal system to use in a university classroom setting. More recently, FX-Net has been used experimentally during this fire season at some locations by fire meteorologists for displaying weather information when onsite at a fire location. CIRA researchers Sean Madine and Renate Brummer, supported by Evan Polster and John Pyle, were key members of the FX-Net staff that worked to get the system ready for IHOP.

For IHOP we asked to have FX-Net available as a real-time meteorological workstation during the field phase at various sites supporting the operations. An FX-Net task list was composed to come up with the list of products that would be needed by the IHOP forecasters and nowcasters. The FX-Net client side was modified to include new functionalities, to display special IHOP-related domains, and to serve additional IHOP-relevant products like high-resolution surface

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observations (for example the Oklahoma Mesonet Plot and the IHOP forecast models).

The FSL IHOP models were run using a number of the processors on the FSL JET computer (for a description of JET see http://www- fd.fsl.noaa.gov/hpcs/), as well as another multi-processor machine. There was an ambitious schedule of running complete model cycles every 3 hours, out to 12 hours for MM5 and WRF, and varying from 12 hours to one run, out to 24 hours for the RUC. CIRA scientists involved included Brent Shaw and Steve Albers on the LAPS side, and Tracy Smith for the RUC. The FX-Net platform proved to be a very reliable and useful tool for displaying all the IHOP model output along with other conventional data typically found on AWIPS, and all in a timely manner.

We'll get back to how the models themselves were used and how they performed during IHOP, but first a discussion about the forecasting and nowcasting efforts.

Forecasting and Nowcasting Activities

The four components of IHOP (outlined earlier) meant that operations could occur under a wide range of conditions, encompassing both fair weather days and days with convective potential, so that very few "down" days were anticipated. CIRA personnel took part in many months of planning activities before IHOP began regarding the forecasting and nowcasting requirements for IHOP. At the general pre-IHOP meeting in November 2001 at NCAR, it was decided that forecasting activities would be undertaken by forecasters from NOAA's Storm Prediction Center (SPC). The SPC is responsible for issuing tornado and severe thunderstorm watches for the United States, among other products, and operates out of Norman, Oklahoma, in a setting collocated with NOAA's National Severe Storms Laboratory (NSSL). Detailed forecasts concentrating on the potential for convective initiation over the IHOP area, as well as where possible mesoscale convective systems might form and the position of the low-level jet, if present, were to be issued each day, with a preliminary forecast due at 9 a.m. and the main forecasts due by 1 p.m., at which time there would also be a general meeting of IHOP field personnel along with a detailed weather briefing.

Shorter-range forecasting and nowcasting efforts were to be done by FSL scientists, and in the planning the idea was that the forecasting for project support would generally pass to the nowcasters around 1 p.m. FSL (and CIRA) scientists worked very closely with SPC personnel to plan the forecasting and nowcasting for IHOP. In addition, both groups wanted to include an active real-time subjective assessment component to the activity, as this can provide valuable insight into model performance on a daily basis that cannot be obtained just by quantitative scores or by studying a few days out of the experiment. Indeed, the SPC for the last couple of years prior to IHOP had been running a "Spring Program" where they invited scientists to participate in a mock forecasting activity using conventional and experimental versions of models such as the Eta and the RUC. The activity took place in a room next to the SPC, called the Science Support Area (SSA), with forecasts made each morning, and then the previous day's forecasts evaluated during the afternoon. A comprehensive online form was developed to gather forecaster impressions of the model predictions, then to gather feedback from the evaluations. One of the key scientists who designed the forms that were used, is now with FSL as a member of the Real-Time Verification System team (RTVS, see their homepage at http://www-ad.fsl.noaa.gov/fvb/rtvs/). With his help we designed an online form that the nowcasters would use to evaluate the FSL models that were run (and available) in real-time during IHOP. The SPC had their own set of forms to evaluate the performance of the models that they were more interested in, such as the Eta, and the Eta with a Kain-Fritsch cumulus parameterization scheme, as well as the operational RUC (at 20-km resolution). However, there was close interaction between the two evaluation activities as we always tried to have one nowcaster present in the SSA to work alongside the SPC forecasters, and this was a very rewarding and interesting effort as the SPC forecasters were interested in seeing the other models as well. Many forecast and nowcast decisions arose from both groups working closely together.

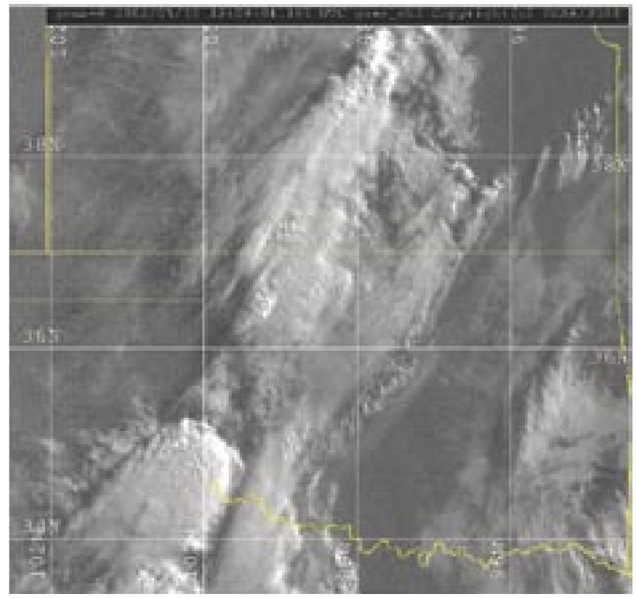

Figure 3. Visible satellite image over OK/KS showing early morning elevated convection.

It became clear as we designed the nowcasting and evaluation activities that it would take a multi-person effort to effectively accomplish everything. Scientists from FSL, NASA, and NSSL joined the effort to help, since the subjective evaluation alone could be a full-time job given that there were four different model runs available to look at (RUC-10 and 20 km, MM5hot 12- and 4- km) every 3 hours. CIRA scientists involved in the field phase included Ed Szoke, Brent Shaw, Tracy Smith, and Brian Jamison. Although at times we were simply not able to keep up with all the model output in terms of completing the evaluations, at least some of the models were examined carefully each day, and forecaster impressions noted, as well as recording initial impressions of forecast verification. Objective verification was also performed back at FSL, by the RTVS group, using both conventional scoring methods and attempting some experimental methods that try to account for displacement errors in the pattern of precipitation. The objective verification concentrated on the quantitative precipitation forecasts (QPF), and compared the FSL models with

(continued on page 16)

the operational Eta and AVN. Results are shown for IHOP on the RTVS homepage.

After all the planning was complete, we realized it would be an arduous task to accomplish all we hoped to during the field phase, and still provide nowcasting support for IHOP, which was done both from the SSA and from a special IHOP Operations Center located nearby in a temporary trailer. In actuality, when IHOP began it was even more complex than planned! With the variety of forecast/nowcast issues involved in planning for the experiments and dealing with up to seven aircraft, nowcasting/forecasting activities occurred as early as 3 a.m. and went as late as 8 p.m. A discussion of some of the forecast issues and how the FSL models handled them are covered in the next section.

Forecast Problems during IHOP; Forecaster and Model Performance

Although we archived all the FSL model data during IHOP, a very nice and easily accessible online archive of imagery, available in real-time during IHOP and frequently used, was assembled by UCAR's Joint Office for Science Support (JOSS, see http://www.joss.ucar.edu/). Their catalog from IHOP is available at http://www.joss.ucar.edu/ihop/catalog/, and includes conventional data as well as an archive from the special instruments used in IHOP and from the FSL numerical models. Some of the examples shown below are taken from this archive.

The nowcast and forecast issues were wide ranging. Boundary-layer flights required nearly clear skies so aircraft with downward-pointing lidars, which could not see through cloud cover, could operate effectively. These specialized forecasts ranged from planning outlooks the day before to very early morning nowcasts that determined whether the mission would be scrubbed, delayed, or carried out as planned. One of the more difficult aspects of this forecast was the very-tricky-to-predict elevated convection that is not much of a forecast problem in Colorado, but is one of the more aggravating problems for forecasters east of the Rockies, and one of the more difficult forecasts for numerical models to handle. Sometimes the elevated convection would be just an area of cloudiness (which would not be much of an issue for a forecast for the general public but a mission disaster for a boundary layer flight) but at other times it would take the form of an unexpected area of early morning thunderstorms. SPC forecasters were used to the difficulties of early morning elevated convection, though it was hard to get used to the idea of discussing when convective temperature might be reached in the late afternoon while thunderstorms (from elevated convection) were taking place at 7 a.m.! An example of such an elevated convection case is shown in the visible satellite image in Figure 3.

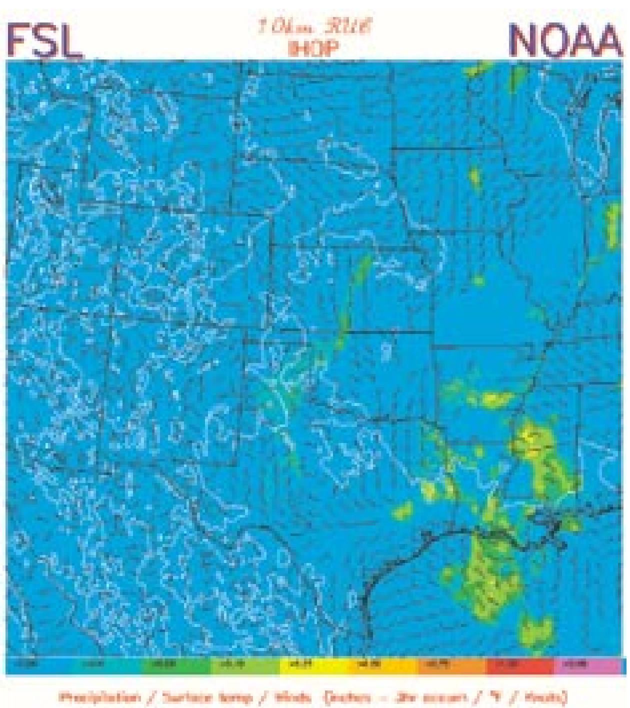

Figure 4. RUC-10 km surface forecast showing 3 h rain accumulation for a 12 h forecast ending at 1200 UTC on 30 May 2002, with a strip of rain near where the storms occurred (see Fig. 3).

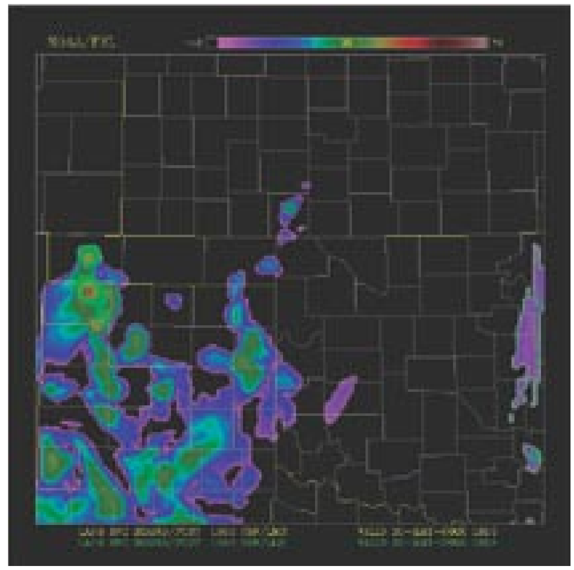

Figure 5. A 12-h forecast of reflectivity, valid at 1200 UTC on 30 May 2002, also showing indications of the early morning convection.

This convection was a surprise to the nowcaster arriving at 6 a.m. Based on the previous day's outlook, and with a Boundary Layer Mission planned to begin around 10 or 11 a.m. which included flight legs east to west across southern Kansas, a difficult nowcast problem was in place. After much deliberation/consulting among the forecasters and examination of the models and data on FX-Net and the other platforms available at the SSA, we decided not to scrub the mission, and the thunderstorm activity cleared by late morning, allowing the mission to go off nearly as planned. Interestingly, when looking back at the 12-hour forecasts from a couple of the special model runs, there was in fact an indication that early morning convection would be present from the previous evening's (0000 UTC) model runs, as shown in Figure 4, from the RUC-10 km run, and Figure 5, from the MM5- 4 km run.

Convective initiation was a major forecast issue, as many of the more complex missions involving mobile surface vehicles (the instrumented NSSL "armada") and multiple aircraft were aimed at studying the distribution and evolution of moisture in the vertical and horizontal near a persistent convergence zone (fine line) where convective initiation

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might occur. The idea was to position the ground armada and the aircraft on the fine line several hours before the convection actually initiated. In fact, once storms developed, the mission was basically over. This was often a very difficult forecast, complicated by the slow response time of the ground vehicles to positioning, so one had to predict hopefully several hours in advance where along a boundary layer a convergence zone convection would be most likely to occur, within the IHOP domain. Timing was also critical; if the forecast/nowcast was off by a couple of hours and convection initiated too quickly, the mission would be a failure.

When CI missions were being planned for IHOP, the well-known High Plains dryline was anticipated as the ideal target to study. Of course during the actual field program such idealized drylines were hard to come by! Dryline features were often quite obscure, evolved/moved during the day, and with some rather hot weather in place at times over the Oklahoma Panhandle (where most of the CI missions occurred), the dryline might be capped to the extent where CI was in doubt. As it turns out, the FSL models had some of their better successes with CI events. In several cases the models predicted convective development while the forecasters believed the atmosphere would remain capped, with development either not forecast to occur or forecast to happen later in the day. An example of one of the more well-coordinated

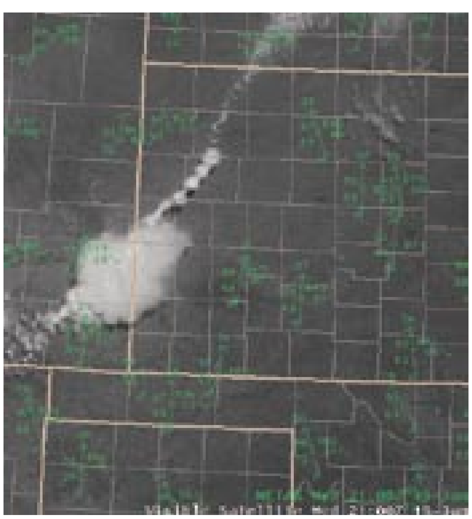

Figure 6. Image from FX-Net showing CI beginning along a stalled cold front over western Kansas at 2100 UTC on19 June.

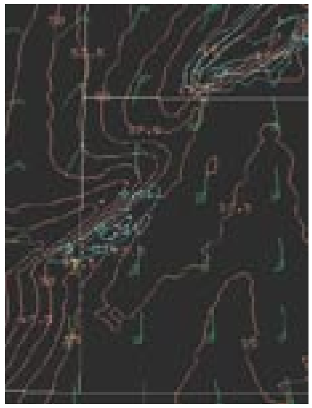

Figure 7. 3-h rain accumulation forecast from the RUC-10 1800 UTC run, ending at 0000 UTC on 20 June. The rainfall along the front was somewhat underforecast, but location and timing were good.

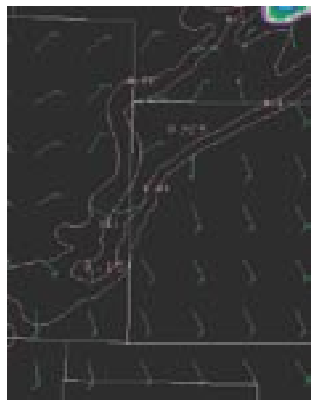

Figure 8. Accumulated rainfall for 1 h ending at 0000 UTC from the 1800 UTC run of the 12-km MM5hot. Also a good forecast, with more rainfall predicted then the other models.

and forecast dryline study days at the western edge of the domain is shown in Figures 6-8.

Other cases were presented in a talk at the Severe Local Storms and Numerical Weather Prediction Conference in August of 2002 held in San Antonio, Texas (Szoke et al., 2002; an online version of that presentation can be found at http:// laps.fsl.noaa.gov/szoke/IHOP/svrconf2002/slstalk.htm). For more complex cases there were successes as well as failures in the model forecasts. There is indication that the models have some skill in forecasting convective mode (evolution to a squall line, for example), although even at 4 km there is clearly not sufficient resolution to fully resolve convective scales, and this was often reflected in a displacement between model forecast convection and where it actually occurred, as well as poorer forecasts under conditions of less-organized convection. One of the goals of the hotstart procedure is to improve the short-term (0-3 hours especially) prediction of convection, when convection is ongoing. Although we demonstrated success with the procedure in eastern Colorado, in the more moist Oklahoma environment precipitation amounts were often excessive. Tweaking of the procedure resulted in better QPF verification, but less effective modeling of ongoing convection, indicating that further work will be necessary to tune the hotstart procedure properly. We hope to be able to examine more of the IHOP cases to further evaluate both model successes and failures, and perhaps return to Oklahoma with an improved version of the model and take part in the SPC's model evaluation exercise next spring.

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Yosemite Aerosol Characterization Study

Derek Day, William Malm, and Douglas Fox

The air quality group at CIRA studies visibility, especially in the cleanest areas of the United States, our National Parks and Wilderness areas. The group has been analyzing the data from a national network of visibility measurements, the IMPROVE network, for nearly 15 years. These measurements have led to an understanding about what constitutes clean air and how visibility is degraded by air pollution. Measurements include an assortment of direct optical measurements of visibility metrics including light scattering, light absorption, and simple photography. But the backbone of the program is aerosol sampling, using a set of filters and chemical analyses to yield speciated aerosol particles in the fine (< 2.5 micrometers) and coarse mode. As a result of these data and the contemporary understanding of atmospheric aerosols, relationships between aerosol concentration, relative humidity (a key variable in determining aerosol/visibility relationships), and scattering coefficient have been developed. Aerosol components that significantly affect visibility are Ammoniated Sulfate, Nitrates (either Sodium or Ammonium), Organic carbon, Elemental carbon (light absorbing carbon, black carbon, etc.), soil, and coarse mass. The sources of each of these components are a complex mixture of natural (sea salt, volcanic ash, etc.) and anthropogenic (fossil fuel combustion) origin. However, human sources input the vast majority of sulfate (over 90% in the western U.S. and over 99% in the eastern U.S.) and nitrate, but the carbon aerosol is a different story. Currently the breakdown between human caused and natural carbonaceous aerosol is not known.

Organic carbon is a special case; it is complicated in its makeup and results from a host of both natural and anthropogenic sources. Organic carbon aerosols are emitted directly from forest fires, or more generally, vegetation burning. However, organic aerosols are also formed through atmospheric chemical reactions of reactive hydrocarbon gases emitted from all of these sources as well as from living vegetation, especially trees. Present scientific understanding is weak about the precise reactions and chemical transformations involved; their relative abundance in different atmospheric conditions and the resulting mix of primary (directly emitted) and secondary (formed in the atmosphere) organic aerosols. Not only are these deficiencies of scientific significance, but they play a role in the implementation of the regional haze rule, a new U.S. EPA regulatory program. The regional haze rule calls for states to develop strategies to gradually improve visibility from its current impaired state to 'natural background.' Determining natural background and identifying controllable pollution sources to achieve it, are complex. Identifying the relative contributions from different sources to the ambient organic carbon aerosol is a primary complexity.

Although there are others, one area of great uncertainty relates to the contribution of carbonaceous materials from forest fires. Current monitoring protocol cannot adequately assess smoke's contribution to haze. In addition, the physical, chemical, and optical properties of smoke are not well characterized. Current estimates of light extinction using measured PM2.5 or concurrently measured species mass concentrations can sometimes be in error by more than a factor of two when compared to measured extinction and/or scattering under conditions of elevated smoke concentrations. Both the mass scattering efficiency and the influence of relative humidity are not known for smoke related aerosols.

Nevertheless, estimates suggest that 50% or more of the organic carbon in remote areas, especially in the western U.S., is due to forest fires. Of course, in a fire season such as the one this summer, the fire contribution can be expected to be considerably higher. Moreover, the recent sequence of severe fire seasons has highlighted the need for more use of prescribed fire as a fuel reduction strategy. Fire mangers are attempting to increase fuel management fires by over ten fold in the coming years. Thus, characterizing the fire contribution to regional haze is very important.

This summer, the National Park Service sponsored a study at Turtleback Dome in Yosemite National Park. Figure 1 shows some of the instrumentation used at the site. The objectives of the research were to: 1) characterize the physical, chemical, and optical properties of the aerosol associated with biomass smoke, and; 2) begin to develop unambiguous and routine methods to relate biomass smoke sources to ambient measured aerosol.

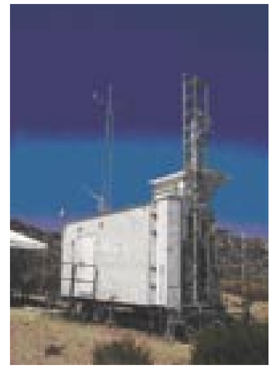

Figure 1: Instrumentation used during the study.

The study lasted for 8 weeks beginning in mid-July. CSU Atmospheric Science researchers in Atmospheric Chemistry were significant partners in this study. Various particle samplers, optical instruments, and meteorological sensors were used to measure bulk chemical composition, aerosol composition as a function of particle size, the light scattering coefficient, and the absorption of water by the aerosol particles in the ambient air. Key questions addressed are:

- What is the fine and coarse particle composition of the aerosol?
- How much do fine and coarse particles (>10.0 µm), and their associated species, contribute to extinction?
- How much of the carbonaceous material is associated with smoke?
- How much extinction is associated with each species in the fine and coarse mode of aerosols that are attributed to smoke?

1. What mass scattering efficiencies are associated with each species?
2. How does humidity affect each species associated with smoke?
3. What are the mass absorption efficiencies of each species?
4. How much sulfate and nitrate is associated with smoke?

Table 1 identifies the set of measurements used in Yosemite. The PM2.5 and PM10

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nephelometers measure fine (0.0-2.5 µm) and coarse (2.5-10.0 µm) mass scattering respectively, while the open-air nephelometer allows for a determination of scattering by particles greater than 10.0 µm. The aethalometer and integrating plate measurements give a direct measurement of absorption while the transmissometer measures the sum of both scattering and absorption. These measurements characterize the extinction (haze) properties of smoke as well as providing the key variables for closure calculations between theoretical estimated scattering and absorption derived from measured species mass and size distributions.

Table 1. This table identifies the instrumentation used at the Yosemite site. The first column identifies the instrument while the second column briefly identifies the purpose of the proposed measurement.

ARS – Air Resource Specialists, Inc.
DRI – Desert Research Institute
LBL – Lawrence Berkeley Laboratory
PNWL – Pacific Northwest National Laboratory
RTI – Research Triangle Institute
UCD – University of California, Davis

Size distribution measurements are necessary for estimating mass size scattering/absorption efficiencies, while the measurement of scattering and size as a function of relative humidity allows for an understanding the hygroscopic nature of smoke aerosols. The one unique feature of the aerosol drying system applied in this study is the use of Perma Pure Nafion drying tubes to extract water from the ambient aerosols, as opposed to heating the sample as most other researchers do (Day et al., 2000). Heating the aerosol as a way to reduce relative humidity before passing it into a sampling chamber is simple, but volatile organic compounds formed in a smoke plume most likely will be lost.

The measurements are designed so observables can be estimated or modeled in a number of different ways, which provides additional QA/QC on the measured data. For instance, fine mass is gravimetrically determined for both PM10 and PM2.5, which can be compared to reconstructed mass based on measured species. Dry and ambient 2.5 µm scattering is measured, which in turn can be compared to reconstructed scattering based on aerosol species measurements. Nephelometry is used to measure ambient scattering of fine and coarse particles, which in turn can be used with extinction measurements to develop estimates of absorption. Fine and coarse mass absorption is also derived from transmission measurements on filter substrates and, in addition, fine mass absorption is measured with an aethalometer. Scattering as a function of relative humidity is measured with a humidograph allowing estimates of aerosol growth. Modeling ambient scattering and the wet-to-dry scattering ratio facilitates both exploration of the validity of aerosol growth, mixing models, and associated assumptions and provides an estimate of the hygroscopicity of aerosol species other than sulfates and nitrates. A more detailed discussion of these measurements and their use in detailed optical properties of ambient aerosols can be found in Malm et al., (2000a), Malm et al., (2000b), Malm et al., (1994), and Day and Malm (2001). The inter-relationship between these variables is further highlighted in Figure 2.

CSU Atmospheric Sciences professors Dr. Jeffrey Collett and Dr. Sonia Kreidenweis and their research group are key partners in the design, implementation, and conduct of this field study. Scientists in their research groups will work with the CIRA air group staff and the other collaborators involved in this study over the coming years to analyze the data collected to help provide a more complete picture of the influence of smoke on regional haze and visibility in the United States.

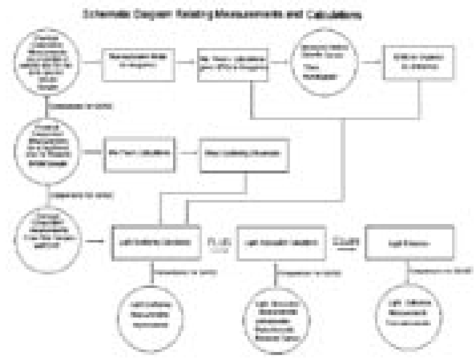

Figure 2: Schematic diagram relating measurements and calculations.

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CIRA Mission

The Cooperative Institute for Research in the Atmosphere (CIRA), originally established under the Graduate School, was formed in 1980 by a Memorandum of Understanding between Colorado State University (CSU) and the National Oceanic and Atmospheric Administration (NOAA). In February 1994, the Institute changed affiliation from the Graduate School to the College of Engineering as part of a CSU reorganizational plan.

The purpose or mission of the Institute is to increase the effectiveness of atmospheric research of mutual interest to NOAA, the University, the State and the Nation. Objectives of the Institute are to provide a center for cooperation in specified research programs by scientists from Colorado, the Nation and other countries, and to enhance the training of atmospheric scientists. Multidisciplinary research programs are given special emphasis, and all university and NOAA organizational elements are invited to participate in CIRA's atmospheric research programs. Participation by NOAA has been primarily through the Oceanic and Atmospheric Research (OAR) Laboratories and the National Environmental Satellite, Data, and Information Service (NESDIS). At the University, the Departments of Anthropology, Atmospheric Science, Biology, Civil Engineering, Computer Science, Earth Resources, Economics, Electrical Engineering, Environmental Health, Forest Sciences, Mathematics, Physics, Psychology, Range Science, Recreation Resources and Landscape Architecture, and Statistics are, or have been involved in, CIRA activities.

The Institute's research concentrates on global climate dynamics, local-area weather forecasting, cloud physics, the application of satellite observations to climate studies, regional and local numerical modeling of weather features, and the economic and social aspects of improved weather and climate knowledge and forecasting. CIRA and the National Park Service also have an ongoing cooperation in air quality and visibility research that involves scientists from numerous disciplines. CIRA is also playing a major role on the NOAA-coordinated U.S. participation in the International Satellite Cloud Climatology Program (part of the World Climate Research Programme).

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