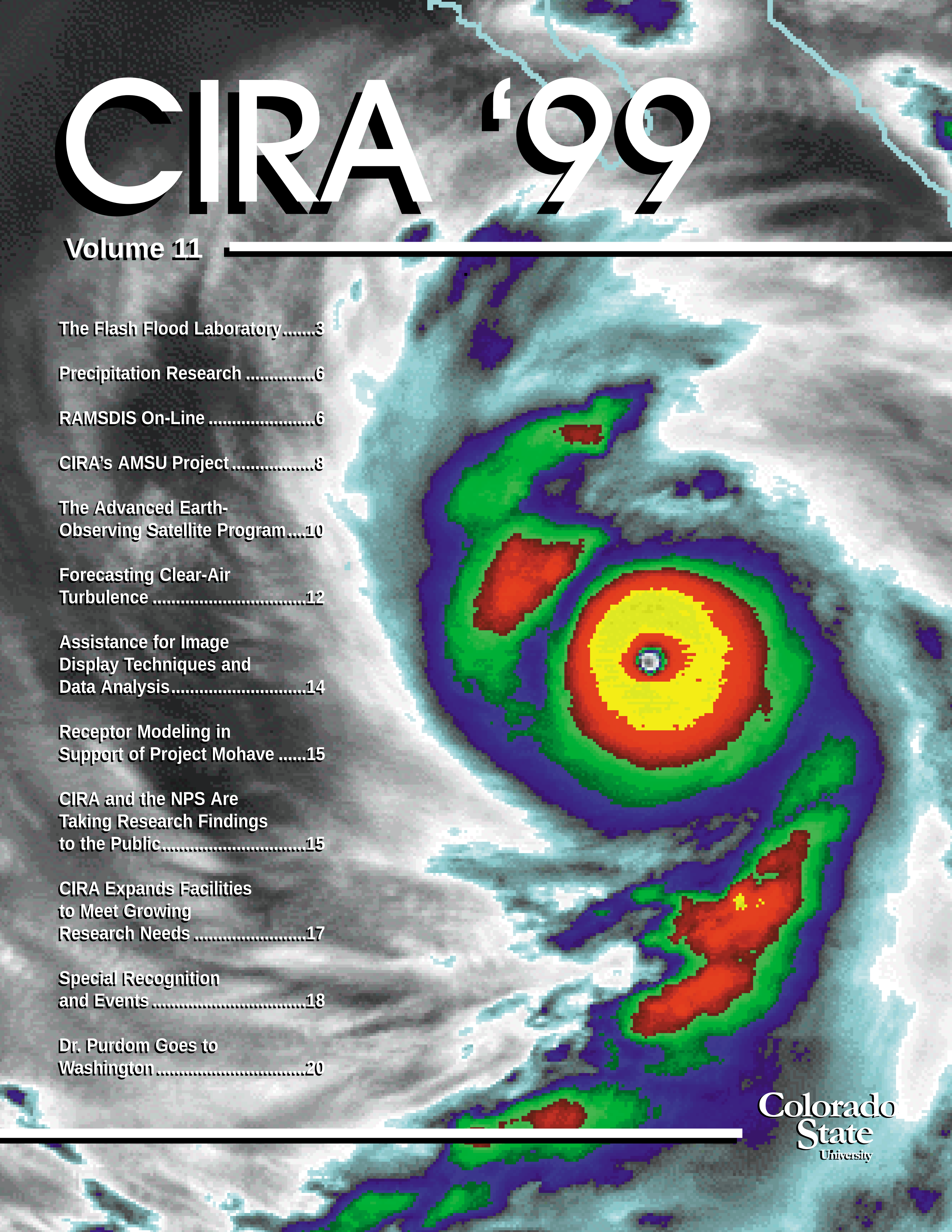

CIRA '99

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CIRA

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. Awards may be made to senior 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 afirmative 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 21, Spruce Hall. 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 to: Prof. Thomas H. Vonder Haar, Director CIRA, Colorado State University, Fort Collins, CO 80523, USA.

Research Fellowships are available in the areas of:

Air Quality, Cloud Physics, Mesoscale Studies and Forecasting, Satellite Applications, Climate Studies, Agricultural Meteorology, Model Evaluation, Economic and Societal Aspects of Weather and Climate

For more information, contact www.cira.colostate.edu.

Editor's Note

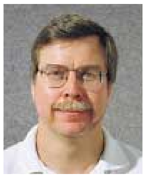
Some changes have been added to this edition of the newsletter, such as a full-cover-image, new employee photos, drop caps, and some shaded text and table boxes.

If you have any further changes you'd like to see made, or articles to submit for future issues (which will probably be yearly, around July), please let me know. I'm located in Room 002, at 1-2209. Send e-mail to lemke@cira.colostate.edu.

Jeff Lemke

Cover Image: Color-enhanced GOES infrared image of Hurricane Linda. This image was created as an average of 5 consecutive images over a 2-hour period with the motion vector used to relocate images before averaging so that it is a center relative average. This will smooth out some of the more variable features and highlight the persistent features. Objective IR satellite based hurricane intensity estimates with this image indicated near record intensity with a well-defined warm eye and a symmetric cold ring associated with the eyewall convection. The yellow shading indicates cloud top temperature colder than -80 degrees Celsius. The maximum sustained surface winds were estimated near 155 knots (178 mph) at the time of this image, 0000-0200 UTC 12 September 1997. The hurricane was located in the eastern Pacific Ocean off the coast of Mexico and was moving slowly to the west-northwest.

The Flash Flood Laboratory



Christopher R. Adams

Eve C. Gruntfest

Kenneth E. Eis

As we saw in the last issue of ALERT Transmission, El Nino may well influence heavy precipitation patterns in parts of the country. Recent heavy rain and flash flooding in Laguna Beach in Orange County, California may be a harbinger of things to come.

To address the physical and social problem of flash flooding, Colorado State University (CSU) has created the FLASH FLOOD LABORATORY. It is designed to focus the attention of faculty, researchers, and students on many aspects of flash flooding. The issues of concern to physical and social scientists reflect a complex set of social, scientific, and economic problems. This interdisciplinary laboratory provides the opportunity for a wide range of academic disciplines including atmospheric science, hydrology, geology, geography, sociology, public administration, economics, and natural resources to collectively address flash flooding in an end-to-end process. Projects will concern atmospheric modeling of heavy rain storms; hydrologic run off modeling; application of geographic information systems in analysis, warnings, and recovery; hazard mitigation, emergency planning, and warning decision-making and response to develop useful tools for local, state, and federal officials. Interaction between the numerous social and physical processes will be explored.

The Cooperative Institute for Research in the Atmosphere (CIRA) has brought in geographer Eve Gruntfest as a senior fellow for six months to help sociologist Chris Adams and atmospheric scientist Ken Eis establish The Flash Flood Laboratory. Eve was a member of the disaster analysis teams for both the Big Thompson and Fort Collins floods and brings more than 20 years of work in flash flood mitigation.

CSU has internationally renowned research and teaching programs in atmospheric science and hydrology that offer a chance for significant synergism. The university offers a unique combination of capabilities. These include development and refinement of the operational RAMMS mesoscale atmospheric model, ongoing work on several hydrologic flow models, applied research with NOAA's Forecast Systems Laboratory and the National Weather Service, and a focus on application of scientific advances to help local officials deal with weather and flood hazards. The social aspects of the weather group at CIRA routinely work closely with local, state, and federal officials to improve their understanding and response to hazardous weather. Through this new laboratory, we propose to develop prototype solutions for dealing with the problems associated with flash floods.

Flash Flood Laboratory Goals

Our interdisciplinary focus allows us a broad range of applied research goals. We have the following aims:

- To enhance our scientific understanding of the dynamic interrelated atmospheric, hydrologic, geographic, and social conditions that produce disastrous flash floods
- To improve integrated scientific models to predict and describe the causes and dynamics of flash floods
- To combine physical and social science research to produce useful decision support tools for local, state, and federal officials
- To increase understanding of effective flash flood education, warning, and response behavior and to take best advantage of technological innovations
- To develop flash flood hazard analysis models for local communities based on storm climatology, topography, flood experience, and factors of the built environment.

Cooperating Partners

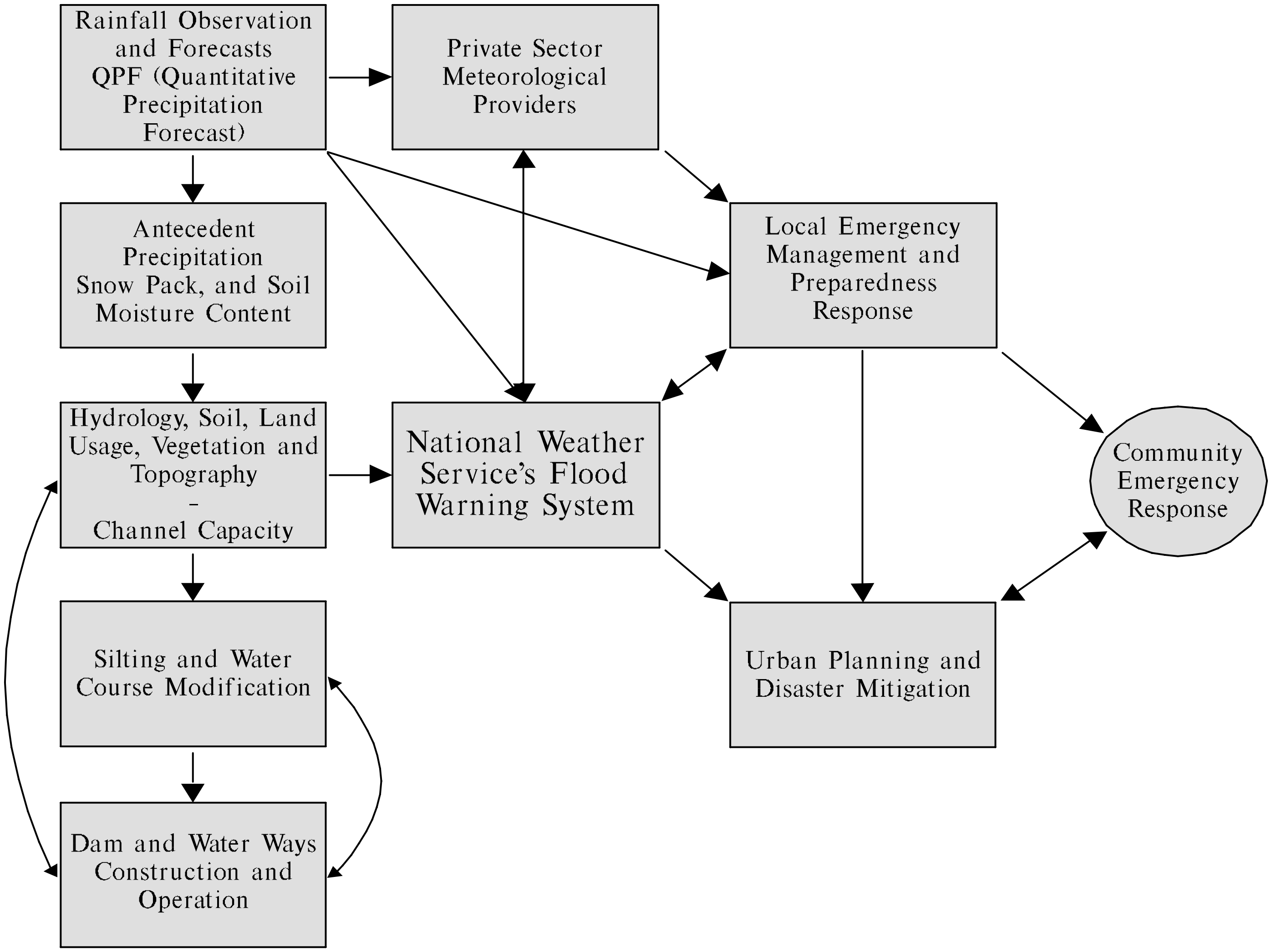
To accomplish these goals, the Flash Flood Laboratory will work closely with The Water Center, CIRA, the Colorado Water Resources Research Institute, and academic departments. A variety of jurisdictions and organizations have already expressed interest in the lab. These include the cities of Fort Collins and Boulder, the Urban Drainage and Flood Control District in Colorado, the National Oceanic and Atmospheric Administration, the National Weather Service, the Federal Emergency Management Agency, the United States Geological Survey, the Bureau of Reclamation. We will also work closely with the ALERT Users Groups, the Southwestern Association of ALERT Systems, and the National Hydrologic Warning Council.

The laboratory is exploring new ways to collaborate with the private sector. We are exploring partnerships to encourage the transfer of research findings into tools for a variety of organizations and jurisdictions.

Developing the Laboratory

We began by looking at the physical end-to-end process of flash flooding. This process addresses both the meteorological/flash flood disaster cycle and the geological and reservoir cycle. This process integrates pre-existing conditions, precipitation, runoff, flooding and impacts. It also integrates catchment and reservoir capacity, silting, erosion and water-course changes with other flood factors.

Next we identified the complex end-to-end functional process. This process focuses on how organizations predict and



warn for flash floods. We address how communities can better identify and understand their local vulnerabilities. We want to help develop tools that allow local communities to identify the precursors of flash flooding. This will allow officials the opportunity to proactively respond to local flash flood threats. This allows for mitigation and planning efforts tailored to community risks. In addition we focus on developing more effective community preparedness and warning response activities to maximize community emergency response.

The Flash Flood Problem

When federal agencies consider flood hazard, their primary concern is slow-rise flooding. Legislation since the 1920s has focused on riverine hazards and the threat of main stem river floods. The laws were written following major flooding in the east and central parts of the country. However, not all floods are created equally. While slow-rise floods cause billions of dollars in damages each year in the U.S., flash floods take many lives.

Flash floods present their own set of constraints and opportunities. A better understanding of the characteristics of flash floods would improve standardization of data collection and provide the basis for effective warnings and response.

There are five main types of flash floods.

i. Inadequate urban drainage systems transform small intense rainstorms into killer catastrophes such as the flash floods in Dallas, Texas in May 1995 and in Fort Collins, Colorado in July 1997.
ii. Severe stalled thunderstorms over steep mountain watersheds have calamitous results as in the Big Thompson Canyon in Colorado in July 1976 when 145 people were killed.
iii. In the eastern United States, flash floods often result from hurricane landfalls.
iv. Areas flooded by ice jams often are not in the designated flood plains but are rather upstream of bridges or other obstacles that allow the ice to accumulate and,
v. Many aging dams in the United States have officials focusing attention on the threat of flash floods resulting from dam breaks.

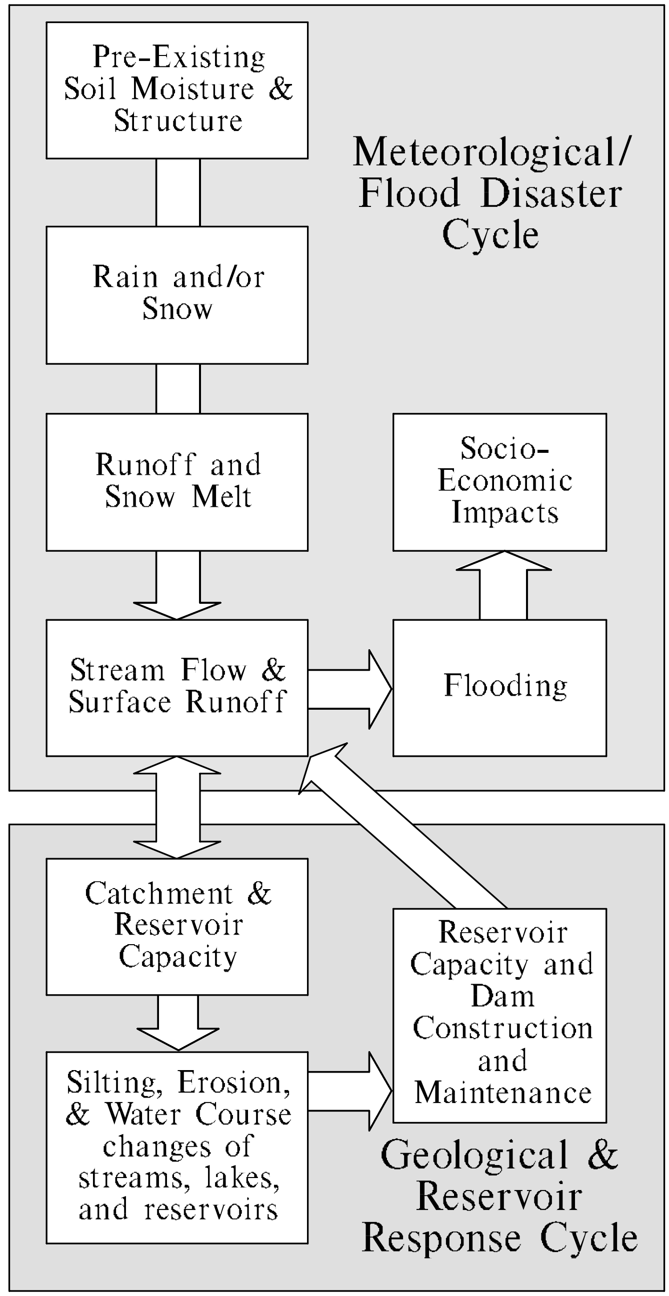
In the Eastern U.S. the flash floods associated with hurricane landfalls can offer up to 12 hours of lead-time. In the West, flash floods can offer less than one-hour advance warning. In arid and semiarid environments, steep topography, little vegetation and infrequent precipitation in the form of intense thunderstorms typify the flash flood hazard areas of the Western United States.

Changes in land use patterns worsen disastrous flash flood impacts as more people move into the arid southwest. People are rapidly moving into scenic flood plains and into harm's way. Flash floods on alluvial fans in the West are attracting greater attention as the population living in hazardous areas continues to rise. Throughout the United States, urban environments, where vegetation has been removed, where bridges and culverts constrict flow, and where buildings and paving have greatly expanded impermeable surfaces, there is an increasingly serious flash flood problem. The patterns, amount and timing of heavy rain runoff is altered, all too often with disastrous consequences.

The flash flood laboratory allows the rare and essential interaction between meteorologists, hydrologists and social scientists to address flash flood challenges. Technological advancements in remote rain gage and stream gage monitoring, hydrologic and meteorological applications of geographic information systems, new findings on the importance of seasons and elevation, and discoveries in paleo-hydrology, and innovations in modeling, are among the exciting research topics for the laboratory.

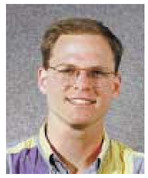
The number of deaths and injuries from flash flooding will continue to rise as more people move to and visit places vulnerable to flash flooding. Researchers and practitioners have worried about flooding, however flash floods have only been a subset of their efforts. The Flash Flood Laboratory will explore opportunities in mitigation, preparedness, and response by learning from earlier work on flooding but recognizing that flash floods pose a different set of problems and challenges. The emphasis on reducing the loss of life and other issues created by the rapid onset of these events will benefit from the Laboratory's vast talent pool in the physical and social sciences. In our research on flash flooding, we will explore new ways to look at the problem that will advance our understanding of and reduce our vulnerability to flash flooding. We will explore and test new frameworks for flash flood research that incorporate researchers and practitioners from multiple disciplines.

This exciting and ambitious undertaking focuses attention on reducing the losses from flash floods through applied interdisciplinary research. For further information please contact Chris Adams at 970-491-3899, Ken Eis at 970-491-8397, or Eve Gruntfest at 970-491-8448; or mail us at CIRA, Foothills Research Campus, Colorado State University, Fort Collins, CO 80523-1375.



Fort Collins, July 28th, 1997. Photo by John Weaver, NESDIS.

Precipitation Research



Eric R. Hilgendorf

Flooding is one of the most deadly weather related hazards, accounting for roughly 100 deaths per year in the United States. In an attempt to reduce the number of flood related fatalities, the National Weather Service has named quantitative precipitation forecasting (QPF) and estimation as top priorities. In response to this priority, CIRA is investigating new approaches to precipitation diagnosis.

The main difficulty in developing an algorithm to diagnose precipitation rates is verification. It may seem that determining rainfall would be a simple matter of measuring the depth of water that accumulated in a rain gauge. Unfortunately, rain gauges are plagued with problems. Even if the gauges themselves were perfectly accurate they would still be inadequate due to the poor spatial density of gauge sites. Storms often pass between gauges resulting in little if any sampling of the precipitation region.

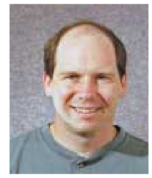
Radar, too, has its problems. Radar estimates can have errors on the order of 200% and greater, and radar coverage of the continental U.S. is incomplete. Satellite measurements are not perfect either, introducing viewing angle problems and being limited to observing only storm tops.

Although any one method of estimating precipitation is faulty, the combined information gained from these tools may provide an accurate diagnosis of rainfall. CIRA is currently researching methods of combining satellite imagery, radar, station observations, and soundings to improve current QPF algorithms. In addition to the observations, CIRA is implementing the Regional Atmospheric Modeling System (RAMS), developed at Colorado State University.

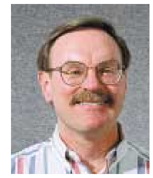
One of our recent projects is the study of factors that affect the efficiency with which a storm converts water vapor entering the cloud base to liquid precipitation reaching the ground. Another of our projects is the inclusion of satellite observed clouds in RAMS. We are also working with the precipitation group at NOAA/NESDIS to aid them in the refinement of their precipitation diagnosis algorithm that uses primarily geostationary satellite observations.

CSU, Fort Collins, July 29th, 1997. Photo by John Weaver, NESDIS.

RAMSDIS On-Line: A Web-based Tool For the Satellite Data User



Dave Watson



Don Hillger

What Is RAMSDIS On-Line?

A popular attraction developed by the Regional and Mesoscale Meteorology (RAMM) Team at CIRA in 1998 has been RAMSDIS On-Line (ROL). An average of 400 users per day of varying levels of interest access ROL for the opportunity to view animated real time GOES data via the World Wide Web (WWW). It was constructed with the idea of putting a RAMSDIS and some of its capabilities on the web. RAMSDIS was developed by the RAMM Team to provide a low cost solution of getting real time digital satellite data into National Weather Service Forecast offices. Currently there are over 60 of these systems deployed and in use nationwide. ROL allows for a much larger audience to view the GOES products ingested and generated by RAMSDIS.

Several image sectors from two different satellites can be chosen: western U.S. (currently GOES-10), or eastern U.S. (currently GOES-8). The user can select among the various satellite products, and options allow the user to view a loop or just the latest image. While viewing the animations users can start the loop, stop the loop, step through the images, adjust loop speed, and omit partial or noisy/corrupted images from the loop.

How does ROL work?

ROL is constructed with the novice user in mind. The only limitations are that users must have a newer browser (Netscape 3.0+ or Internet Explorer 4.0+) and they must have the patience to load the images depending on their Internet connection speed. ROL is developed with Javascript code, which only the newer browsers support.

Images of certain sectors and resolutions are ingested on a RAMSDIS unit. Once ingested images are displayed with the proper graphics and color enhancements, GIF files are made of the display. The GIF files are then transferred to a server to allow access from ROL.

What can the ROL user see?

During the past year ROL has expanded from the popular U.S. coverage to other image sectors and features of interest. Special ROL sections include coverage of fires, hurricanes/tropical storms, and past case studies of interesting weather events.

The eastern and western U.S. image sectors allow users to see real-time satellite coverage over their area of interest. ROL provides users with 4 GOES channels: visible, thermal infrared, water vapor, and shortwave infrared, each of varying resolutions and enhancements. Also available are generated products including: nighttime fog, daytime reflectivity, Sounder precipitable water, and Sounder lifted index.

One of the useful features of the daytime reflectivity product is in detecting fires. ROL has added coverage of the wild fires affecting Florida, Mexico, and Brazil during the past year. ROL's fire coverage has also greatly helped the Incident Meteorologists in the field in locating and combating these fires. The Florida fire images were requested by Kennedy Space Center personnel and were set up within 48 hours of the request. Some of ROL's images were featured on ABC TV's morning news during the height of the Florida fires this summer.

For the hurricane season several tropical image sectors have been added to ROL. These show users the development and progression of the latest tropical storms.

Also added to ROL is an 'archives and case studies' page, showing past cases of severe weather: tornadoes, hail, and wind damage, and other interesting cases such as the 1998 total solar eclipse of the sun.

Where is ROL?

ROL can be found on the Web at:
http:\\www.cira.colostate.edu\ramm\rmsdsol\main.html.

The future of ROL

As new GOES products are being developed and tested, ROL will continue to evolve to include some of those products, making them available to a wider audience of users. Feedback is welcome. An e-mail address is available at the bottom of the ROL page.

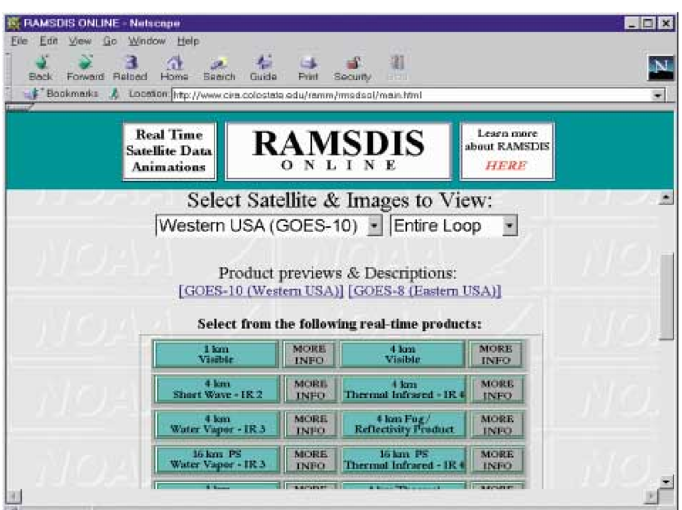


Figure 1: RAMSDIS On-Line (ROL) home page window showing buttons for selection of GOES images or image products.

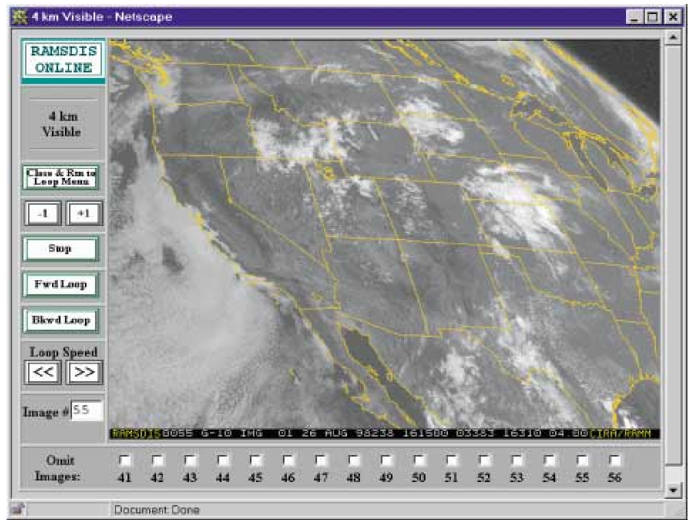


Figure 2: ROL image loop window showing a typical 4-km visible image from GOES-10.

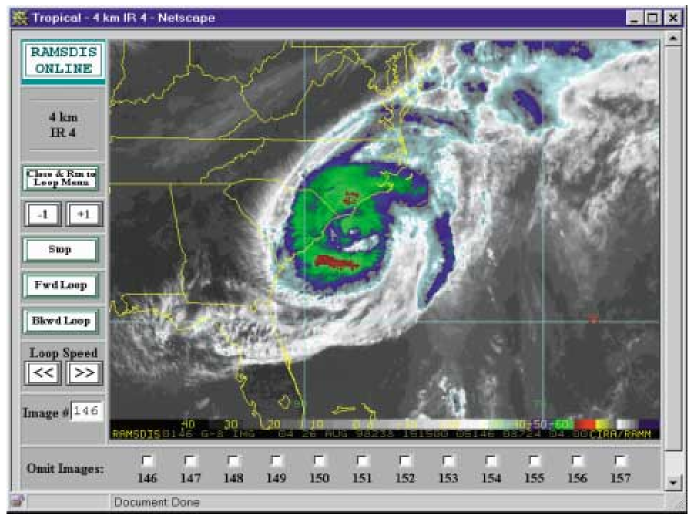


Figure 3: GOES channel-4 (10.7 μm) infrared image at 4 km spatial resolution showing Hurricane Bonnie.

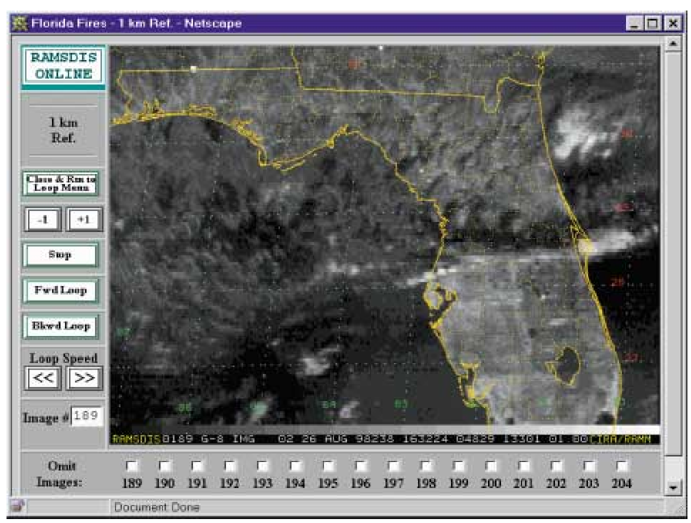


Figure 4: GOES Experimental Fire Product image taken long past the maximum fire situation in Florida. Note the fires (white spots) on the Florida-Alabama border, at the very top of the image in Georgia, and in central Florida north of Lake Okeechobee.

CIRA's AMSU Project

Stanley Q. Kidder

The *NOAA 15* weather satellite was successfully launched May 13, 1998, into a near polar orbit, carrying the first Advanced Microwave Sounding Unit (AMSU) sensors. The AMSU has 20 channels and is the first microwave instrument in space to combine geophysical channels (such as on the DMSP SSM/I instrument) with temperature sounding channels (such as on the NOAA MSU instrument) and moisture sounding channels (such as on the DMSP SSM/T2 instrument). Further, the AMSU offers higher resolution than most previous microwave instruments. Tables 1 and 2 compare these instruments. Since microwaves penetrate clouds, the AMSU is nearly an all-weather meteorological instrument.

CIRA has a NOAA grant to develop products from the AMSU data. In real time we acquire the 20 ASMU brightness temperatures and five products generated by NESDIS's Microwave Sensing Group (see Table 3) in Hierarchical Data Format (HDF-EOS). Three types of products are currently produced at CIRA:

1. Single-orbit McIDAS areas of each channel and product. Figure 1 is an example of this type of data. At 89 GHz, ocean appears cold (black), and land appears warm (white). Glaciers, as on Iceland (near the center of the image) and

Table 1. *Microwave Instrument Comparison*[a]

Parameter	*SSM/T*	*MSU*	*SSM/I*	*AMSU-A*	*AMSU-B*	*SSM/T-2*
Satellites	DMSP	NOAA	DMSP	NOAA K, L, M	NOAA K, L, M	DMSP
No. of Channels	7	4	7	15	5	5
Frequency Range (GHz)	50.5–59.4	50.3–57.95	19.35–85.5	23.8–89.0	89.0–183.3	91.6–183.3
NEΔ*T* (K)	0.4–0.6	0.3	0.4–1.7	0.25–1.20	0.8	0.5
Beam width	14°	7.5°	0.3°–1.2°	3.3°	1.1°	3.3°–6.0°
Best Ground Resolution (km)	204	110	12.5–50	48	16	48–84
Scan steps	7	11	64–128	30	90	28
Swath width (km)	2053	2347	1394	2179	2179	2053

[a]After Kidder and Vonder Haar (1995)

Table 2. *Microwave Frequencies*[a] *(GHz) and Polarizations*[b,c]

Channel	*SSM/T*	*MSU*	*AMSU-A*	*AMSU-B*	*SSM/I*	*SSM/T-2*
1	50.5H	50.30R	23.8R	89.0R	19.35H	183.3±3R
2	53.2H	53.74R	31.4R	150.0R	19.35V	183.3±1R
3	54.35H	54.96R	50.3R	183.3±1R	22.235V	183.3±7R
4	54.9H	57.95R	52.8R	183.3±3R	37.0H	91.7R
5	58.4V		53.6R	183.3±7R	37.0V	150R
6	58.825V		54.4R		85.5H	
7	59.4V		54.9R		85.5V	
8			55.5R			
9			57.2R			
10			57.29±.217R			
11			57.29±.322±.048R			
12			57.29±.322±.022R			
13			57.29±.322±.010R			
14			57.29±.322±.0045R			
15			89.0R			

[a]*Notation*: $x \pm y \pm z$; x is the center frequency. If y appears, the center frequency is not sensed, but two bands, one on either side of the center frequency, are sensed; y is the distance from the center frequency to the center of the two pass bands. If z appears, it is the width of the two pass bands. This pattern is easily implemented with radio frequency receivers, and it effectively doubles the signal (two pass bands instead of one).

[b]V = vertical, H = horizontal, R = rotates with scan angle.

[c]After Kidder and Vonder Haar (1995)

Table 3. AMSU products produced by NESDIS's Microwave Sensing Group

Product	*Range/Units*
Total Precipitable Water (TPW)	0–75 mm
Instantaneous Rain Rate (RR)	0–35 mm/hr
Cloud Liquid Water (CLW)	0–6 mm
Snow Cover (SNO)	0–100%
Sea Ice Cover (ICE)	0–100%

Greenland (on the left edge), appear cold. Clouds and water vapor over the ocean appear milky.

2. Mapped products in McIDAS format. The above single-orbit areas are composited in roughly 12-hour maps, in eight Mercator or Polar Stereograpic projecions. Figure 2 is an example of such an image. It is a 150 GHz image of Hurricane Georges, and it shows scattering from ice at the top of rain bands. Note that the microwaves penetrate the central dense overcast to reveal the rain structure below. this is is one of AMSU's greatest advantages. These maps are available in real time to the Satellite Analysis Branch of NESDIS and to the Western Region of the National Weather Service.

3. Interactive browse images. We have developed a Java-based interactive McIDAS image browser. Figure 3 is an example of the browse images. It is a nearly global Total Precipitable Water image.

For more information, and to view the real-time images, please visit our AMSU Web site (***http://amsu.cira.colostate.edu***) and give us feedback.

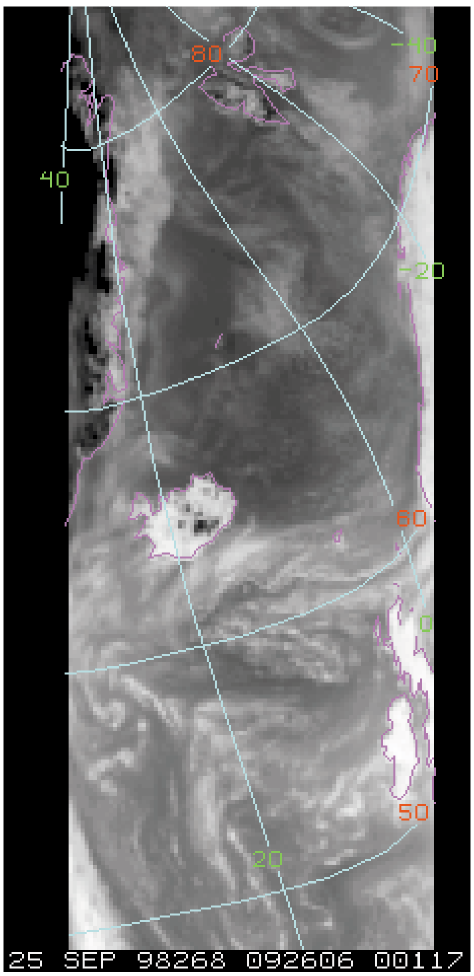


Figure 1. *A portion of a single orbit of AMSU-B 89 GHz data.*

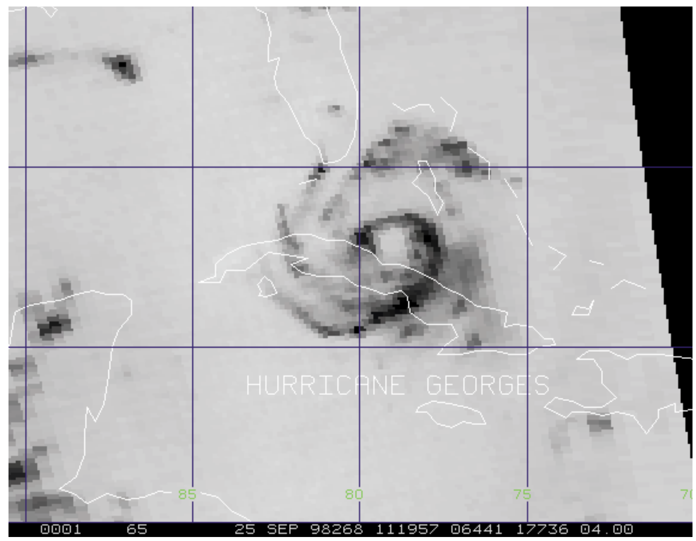


Figure 2. *150 GHz AMSU-B image of Hurricane Georges showing rain bands beneath the central dense overcast.*

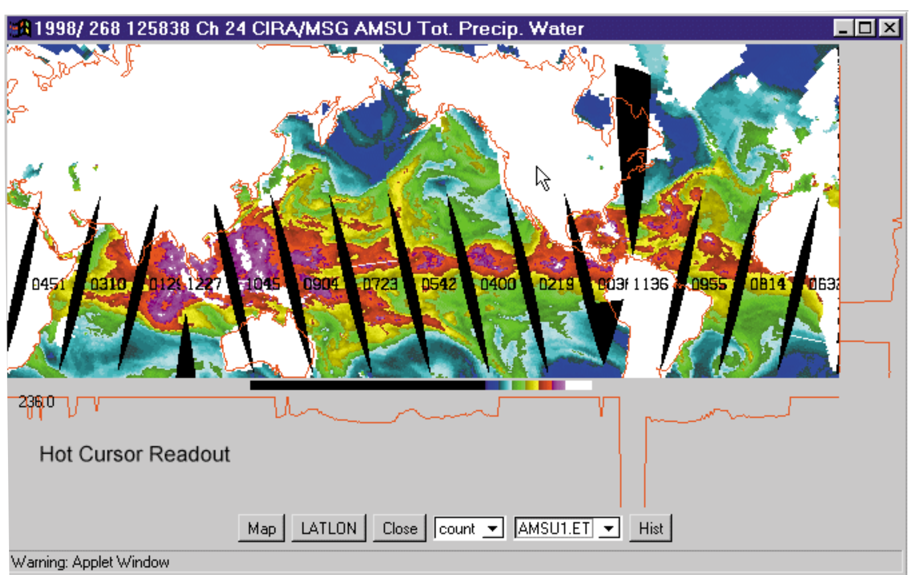


Figure 3. *Java-based display of AMSU data suitable for browser use.*

The Advanced Earth-Observing Satellite (ADEOS) Program

Tom Greenwald

On August 17, 1996 the National Space Development Agency of Japan (NASDA) launched the first in a series of satellites, the Advanced Earth Observing Satellite (ADEOS), to support international efforts to observe the earth-atmosphere system for better understanding of the global environment. The ADEOS program will complement the NASA sponsored program, Mission to Planet Earth, whose purpose is also in understanding the total earth system with an emphasis on both natural and human-caused environmental change. NASDA is planning to launch two more satellites in the future, ADEOS II and ADEOS III, to provide continuous observations until 2010. These three satellites contain a host of diverse instruments for measuring many aspects of the earth's atmosphere, surface, and biomass (see Table). These instruments are built by various Japanese organizations and a number of agencies from different countries making it a truly international cooperative effort.

Unfortunately, the first ADEOS mission ended prematurely and abruptly when the solar panel failed on June 30, 1997, severing power to the satellite. While this cut short its intended 3-year mission, the measurements obtained from TOMS (built by NASA) provided valuable information about the lowest levels of ozone ever recorded during late-March and early-April over the Arctic. The assimilation of wind observations from NSCAT (also built by NASA) into weather forecast models also demonstrated improvements in forecasting ability particularly in the Southern Hemisphere. Due to the unfortunate failure of the ADEOS, the launch of its successor (ADEOS-II) was postponed until early 2000.

CIRA's role in the ADEOS program has been its participation in pre-launch scientific research activities for the future ADEOS-II. Two research proposals were selected for funding by NASDA beginning in January 1997 and over a two-year period. The first involves work with the Global Imager (GLI), a 36-channel optical sensor used for studying the biomass over land and ocean, and the properties of clouds, aerosols, water vapor and land surfaces. The investigators on this project are Prof. Tom Vonder Haar, Ken Knapp, and Ken Eis. The focus of this research is to conduct sensitivity studies to determine the ability of the GLI to sense aerosols under various conditions and the development of a method to estimate aerosol amount and size for simulated GLI data over land. This work is important for understanding the net effect of aerosols on global climate, which at this time is poorly known. This research also has ties to the Fog and Haze Observations portion of the prior DOD Center for Geosciences Phase II work and possible future Phase III activities. The GLI should provide improved measurements over the current Geostationary Operational Environmental Satellite (GOES) sensors and Advanced Very High Resolution Radiometer (AVHRR) for observing aerosol characteristics, thus providing a natural extension of the Phase II research.

The second proposal deals with the Advanced Microwave Scanning Radiometer (AMSR), a 14-channel passive microwave sensor used for gathering information about cloud liquid water, water vapor, rainfall and surface properties to better understand the global water cycle. Investigators on this project include Prof. Tom Vonder Haar, Dr. Tom Greenwald, and Dr. Dave Randel. The aim is to develop physically based methods for estimating the amount of liquid water in clouds and the amount of water vapor over the ocean and to characterize the retrieval errors. Through the DOD Center for Geosciences, CIRA has developed expertise in the remote sensing of cloud liquid water using passive microwave satellite measurements including the development of new retrieval techniques, particularly over land regions (Jones and Vonder Haar 1990; Greenwald et al. 1997; Combs et al. 1998). We are currently in competition with several other research groups to develop retrieval methods for two of the standard AMSR products. NASDA has tentatively selected our method as the standard algorithm for deriving cloud liquid water over the ocean. The final selection of the retrieval methods will be made by NASDA 6 months following the launch of ADEOS-II.

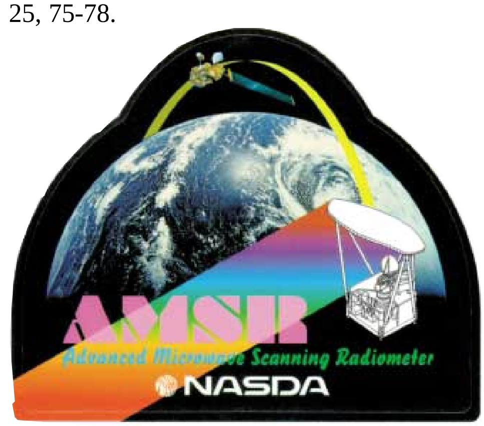
The ADEOS program is anticipated to provide a wealth of information for understanding our changing world. Hopefully, CIRA will continue to be a valuable part of this program.

References

Jones, A. S., and T. H. Vonder Haar, 1990: Passive microwave remote sensing of cloud liquid water over land regions. J. Geophys. Res., 95(D10), 16673-16683.

Greenwald, T. J., C. L. Combs, A. S. Jones, D. L. Randel, T. H. Vonder Haar, 1997: Further developments in estimating cloud liquid water over land using microwave and infrared satellite measurements. J. Appl. Meteor., 36, 389-405.

Combs, C. L., T. J. Greenwald, A. S. Jones, D. L. Randel, and T. H. Vonder Haar, 1998: Satellite detection of cloud liquid water over land using polarization differences at 85.5 GHz. Geophys. Res. Lett., 25, 75-78.



Instrument Name	Instrument Type	Measured Quantities	ADEOS	ADEOS-II	ADEOS-III
OCTS	Optical radiometer	Ocean color and surface temperature	X		
TOMS	Optical spectrometer	Total ozone	X		
ODUS	UV spectrometer	Ozone			X
ATRAS	Spectrometer	Vertical profiles of greenhouse gases			X
GLI	Visible/infrared imager	Cloud, aerosol, land, ocean, and water vapor characteristics		X	
SGLI					X
AMSR	Microwave radiometer (Imager)	Water vapor, cloud, rainfall, land/ice surface properties		X	
AMSR II	Microwave radiometer (Imager / Sounder)	Water vapor, cloud, rainfall, land/ice surface properties plus vertical profiles of water vapor and temperature			X
ILAS	Limb Spectrometer	Vertical profiles of ozone, water vapor, temperature and other trace gases	X		
ILAS II				X	
ILAS III					X
POLDER	Optical imaging radio-meter/polarimeter	Polarization/directional reflectance characteristics of aerosols, clouds, land, and ocean	X	X	
NSCAT	Scatterometer	Wind speed/direction over ocean	X		
Seawinds				X	
Seawinds II					X
AVNIR	Visible/near-infrared radiometer	Surface reflectance	X		
RIS	Infrared pulsed laser	Ozone and other trace gases	X		
IMG	Spectrometer	Water vapor and other greenhouse gas concentrations	X		

Forecasting Clear-Air Turbulence

Adrian Marroquin

1. Introduction

Under the sponsorship of the Federal Aviation Administration (FAA), several diagnostic turbulence forecasting algorithms (DTF3, DTF4, DTF5) have been designed and tested at the Forecast Systems Laboratory (FSL). The algorithms have been designed using the best and most recent turbulence theories. The aim is to use the best physics to link the physical processes conducive to atmospheric turbulence and the response of the diverse types of aircraft to this turbulence. This approach is also geared toward keeping pace with the new effort to provide automated in-situ eddy dissipation rate (EDR) from aircraft. An Algorithm Development and Verification System (ADVS) has been designed to provide a tool to easily calibrate, compare, and verify several turbulence forecasting algorithms for the same time period, the same model output, and the same turbulence observations.

The main purpose of the ADVS is to serve as a research tool capable of offering the user the flexibility to manipulate algorithm parameters, external parameters, and the addition of new algorithms. This should be the first stage in the algorithm development before it is sent out to forecasters. In the field, the Real Time Verification System (RTVS) could be used to keep track of the algorithm performance and feedback from forecasters could be provided to the ADVS user for further algorithm recalibration and testing.

The purpose of this note is to present preliminary results from the calibration, comparison, and verification of the following algorithms: Ri (gradient Richardson number), Elrod index (no convection), DTF3, DTF4, and DTF5 (Marroquin, 1995, 1998). These algorithms were verified with pilot reports (PIREPs) using forecast output from the MAPS model (or RUC2 version operational at NCEP).

2. Algorithm Verification

Once the calibration of each one of the algorithms (procedure not described here) had been done, the verification process was initiated by computing the probability of detection (POD) of yes- and no- turbulence for each algorithm with several thresholds and external parameters. The verification period was from 1 December 1997 to 10 January 1998, with a total of about 895 hours (model output available every hour). The turbulence variable at the PIREP location is the volume average of the variable computed (using the model's native coordinate basic variables) at each grid point of a horizontal box 4x4x3 with the PIREP located in the innermost grid box. The box (thickness 1000 ft) is vertically centered at the elevation of the PIREP. PIREPs within a time interval of 30 minutes around each forecast time are included in the verification.

The external parameters are the aircraft flight level, weight, and PIREP turbulence intensity. The main aircraft categories are: heavy aircraft (HA) and general aviation (GA). The HA category includes aircraft with weights equal or greater than 120,000 lbs and flight levels equal or higher than 20,000 ft while the GA category is composed of all aircraft types and all flight levels. The total number of PIREPs for the verification period is 17,504 with 7,716 No-turbulence reports (44%), and 9,788 Yes-turbulence reports (56% of light or greater turbulence intensity reports)

3) Results

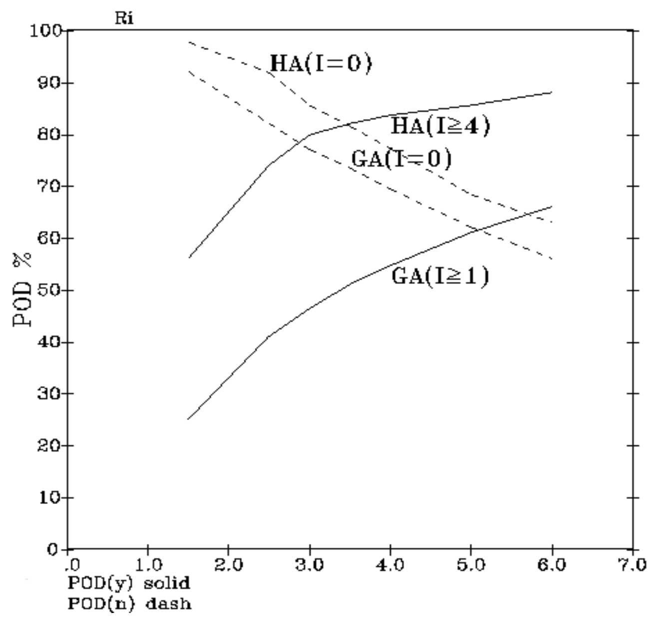


Fig. 1: *Verification of the Richardson number (Ri) with PIREPs and RUC2 output for the period 1 December 1997 to 10 January 1998. See text for description of figure.*

Figures 1-2 show the POD-no and POD-yes for the algorithms Ri and DTF5. Figure 1 shows the verification of the gradient Richardson number, Ri. The horizontal axis shows the range of Ri thresholds (nondimensional) for which POD's of No- and Yes-turbulence were computed (vertical axis). The turbulence intensity range is indicated in parenthesis near each curve label (I=1, light; I=2, light-to-moderate; I=3, moderate; I=4, moderate-to-severe; I=5, severe; I=6, severe-to-extreme; I=7, extreme). Curve B corresponds to POD-yes for GA and for turbulence intensities of light or greater, while curve C corresponds to the POD-yes for HA and for turbulence intensities moderate-to-severe or greater. Curve A shows the POD-no for GA. The crossing point between curves A and B is where the POD-no = POD-yes = 62%. This means that Ri = 5.0 represents an optimum balance between the POD's for GA because any other choice of threshold would give an unreasonable POD-no and POD-yes. The A-C crossing shows POD-no = POD-yes = 78% for an optimum Ri = 2.8 applicable to HA. Here, curve A is taken as the lower bound for the POD-no for HA (explicit POD-no curves for HA are not available at this point). This comment is also applicable to the next figure below.

Figure 2 shows the verification of DTF5. The horizontal axis indicates the range of thresholds that was used. The curve labeled A is for POD-no applicable to GA, while curves B and C are for POD-yes for GA. Curves D and E show the POD-yes applicable to HA. For GA, the A-B curve crossing shows POD-no = POD-yes = 59% while the A-C curve crossing shows POD-no = POD-yes = 70%. For HA, the A-D crossing shows POD-no = POD-yes = 64% and the A-E crossing shows POD-no = POD-yes = 80%.

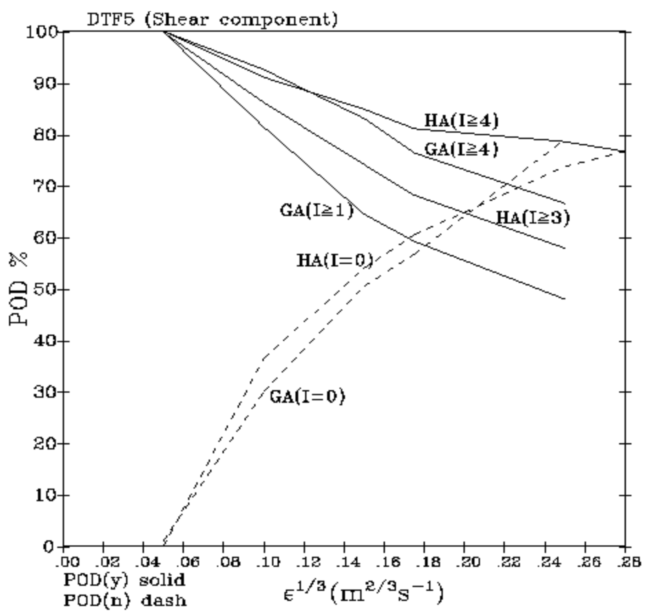


Fig. 2: *As for Fig. 1, except for algorithm DTF5.*

Due to lack of space, figures for the other algorithms are not shown. However, a summary and comparison of results is presented in Table 1.

4) Conclusions

The results presented show that all algorithms perform about equally. However, DTF5 is based on better physics and provides the same metric as the in-situ EDR. DTF5 should be the algorithm of choice to forecast clear-air turbulence from shear instabilities (upper jet/front systems). Unlike the other algorithms, DTF5 can be calibrated and compared with turbulence observations from field experiments and explicit TKE from numerical models like COAMPS or ARPS.

Table 1: *Verification summary of algorithms Ri, Ellrod index, DTF3, DTF4, and DTF5.*

	POD-no = POD-yes	POD-yes
	GA	HA
Ri	62%	78%
Ellrod	62%	79%
DTF3	63%	82.5%
DTF4	60%	79%
DTF5	59%	80%

The reasons for disagreement between POD-yes for GA and HA are attributable to:

- ambiguity in the PIREPs,
- simplifications in algorithm formulations,
- coarse model resolution, and
- model limitations in providing realistic Ri values.

The above results show that it is difficult to make progress in turbulence forecasting because of uncertainties in the PIREPs data (different turbulent kinetic energy is associated with different aircraft reporting the same intensity) and coarse model resolution.

Acknowledgements

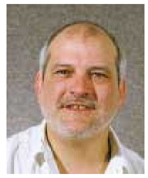
This research is in response to requirements and funding by the Federal Aviation Administration. The views expressed are those of the author and do not necessarily represent the official policy or position of the U.S. Government.

References

Marroquin, A., 1995: An integrated algorithm to forecast CAT from gravity wave breaking, upper fronts and other atmospheric deformation regions. 6th Conference on Aviation Weather Systems, Dallas, TX, *Amer. Meteor. Soc.*, 509-514.

————, 1998b: An advanced algorithm to diagnose atmospheric turbulence using numerical model output. 16th Conference on Weather Analysis and Forecasting, Phoenix, Arizona, *Amer. Meteor. Soc.*, 11-16 January, Phoenix, Arizona.

Assistance For Image Display Techniques and Data Analysis



James Sisler

CIRA, in collaboration with the National Park Service, plays a significant role in protecting national air quality as mandated by the 1977 Clean Air Act (CAA). Section 169(a) of the 1990 amendments to the CAA states the national goal of, "..the prevention of any future and the remedying of any existing, impairment of visibility in a mandatory Class 1 Federal areas which impairment results from manmade air pollution." Congress has given the National Park Service and other Federal land managers the "affirmative responsibility to protect the Air Quality Related Values of the Class I areas" that are managed from "adverse air pollution effects."

In response to the national visibility goal the National Park Service and CIRA have joined forces to provide a scientific understanding of visibility, how air pollution affects visibility, and the sources of air pollution. The bottom line is to portray the affect of air pollution through advanced image processing techniques. Doing so requires extensive optical and aerosol monitoring of Class 1 areas and developing models that accurately describe the physical/chemical properties of ambient aerosols.

Activities carried out during the following year include:

* IMPROVE aerosol monitoring – assess visibility conditions and trends in Class I visibility areas. The IMPROVE (Interagency Monitoring of PROtected Visual Environments) monitoring network, by virtue of the fact that we now have 10+ years of data, has become a mature database that can describe trends in aerosol composition and visibility on a continental scale. This database will enable verification of the latest cuts in emissions as well continued progress toward the National Visibility goal.

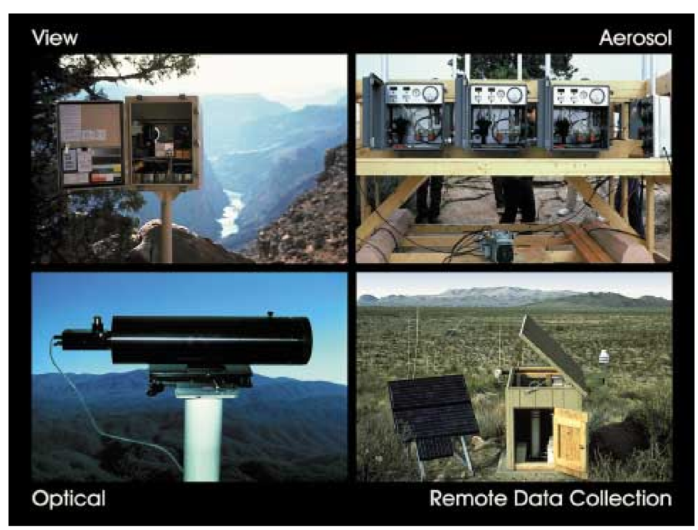
* SEAVS (South East Aerosol and Visibility Study) – hygroscopicity of acid and organic aerosols and their effects on visibility at Great Smoky Mountains NP. Emission controls on sulfate released are being phased in. Because the east has an ammonia limited atmosphere the dynamics of the photo-chemistry is such that unanticipated results on visibility may occur.

* Grand Canyon NP absorption study. Absorption is a key element reported by the IMPROVE monitoring network and has the subject of much debate. The Park Service has funded much theoretical work at CIRA on absorption, the field study will put to test the theoretical findings.

* Project BRAVO Scoping study – Trans-boundary pollution issues, an international study with Mexico mandated by the NAPAP treaty. Two Class I visibility areas in Texas (Big Bend NP and Guadaulpe Mountains NP) are impacted by trans-boundary pollution from Mexico. The scoping study to design the much larger field study know as BRAVO was carried out last summer. The data is currently being reduced by scientists at CIRA, the Park Service and from Mexico and preliminary findings will be published

* SAMI – Southern Appalachian Mountains Initiative. A compact of Federal Land Managers and State governments to assess the visibility conditions in Class I visibility areas for the purpose of policy recommendations for State Implementation Plans.

Communicating the finding of these activities is the central issue addressed at CIRA and is done through publications in peer reviewed journals and periodic reports. But more importantly a variety of graphical, audio and visual products has been developed, in the case of visibility the saying "a picture is worth a thousand words" is an understatement. To accurately portray the effect of visibility has led to the development of advanced image processing tools that allow the user to model scenic vistas and the affect of various pollutants on visibility. By coupling these tools with our knowledge of ambient aerosols and the affect of aerosols on visibility we can communicate to the public, policy makers, and elected representatives the benefits associated with protecting Class 1 scenic vistas.



Types of data gathered.

Receptor Modeling In Support Of Project Mohave

James Sisler

Project MOHAVE is a major monitoring, modeling, and data analysis study of visibility in the southwestern United States, with the particular goal of estimating the impact on visibility of the MOHAVE generating station located in southern Nevada. Project MOHAVE is a collaborative effort of many government agencies, universities, and the private sector. The co-sponsors are the U.S. Environmental Protection Agency and Southern California Edison Company. The Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University has been involved with Project MOHAVE since its inception. This involvement has included planning and many modeling and data analysis activities.

The field portion of Project MOHAVE, including data reporting and validation has been completed. A major component of Project MOHAVE was the release of perfluorocarbon tracers from the stack of the Mohave Power Plant and other locations during a 50 day summer study and 30 day winter study. In July 1996, a report was distributed to study participants comparing the results of the different attribution analyses. The attribution analyses generally did not agree. The tracer data showed that none of the models worked well. After the release of the tracer data and its use in evaluating the source attribution models, the final phase of Project MOHAVE was planned.

To reconcile disparate results, assessment efforts in three main areas have been carried out: 1) Attribution of extinction using non tracer techniques; 2) Use of tracer data to characterize transport and dispersion; and, 3) Reconciliation of attribution analyses. These activities are further described below.

More recently, the scope of the work was expanded to include a study of absorption measuring techniques at the Grand Canyon. The field study was conducted during the summer of 1998. Absorption is a key element reported by the IMPROVE monitoring network and has been the subject of much debate. The Park Service has funded much theoretical work at CIRA on absorption; the results of the field study will put to test the theoretical findings.

Many aspects of the research activities are complimentary to each other; where this is the case much can be done to improve the models that are utilized as well as understanding their limitations. For example, use of tracer data to understand transport and dispersion can have a direct influence on trajectory models where dispersion is a model parameter. In this fashion the tracer data becomes a tool for refinement and understanding. The remaining analysis will be used to place bounds, both upper and lower, on attribution results.

CIRA and the National Park Service Are Taking Research Findings to the Public

Julie Winchester

Interpreting critical resource issues in National Parks requires the blending of science, resource management, and interpretation. The resolution of issues requires public support and sometimes behavorial change. In a cooperative effort with CIRA, the National Park Service Visibility Research group is using interactive technology to tell visitors how human activities impact natural systems within the park.

An interactive air quality kiosk will soon attract visitors to Oconnaluftee Visitor Center in Great Smoky Mountains National Park, Tennessee. A colorful touchscreen display will entice visitors to learn more about how air pollution affects the air, water, soil, plants, and animals in the park. In “Shrinking Views” visitors learn where the haze comes from and how it affects their views. In “Ozone Pollution” they see how ozone is affecting over 30 species of plants in the park. And in “Acid Overload” we see how acid rain impacts fish and soils.

Program information is based on 20 years of air quality research efforts based here at CIRA and in Great Smoky Mountains National Park. Pictures, colorful graphics, and animated sequences tell the stories in an entertaining yet informative way. Over 1 million people visit the Great Smoky Mountains each year. Many of them will leave better understanding how resources are damaged and a clear view of what each can do to help solve the problems. If this prototype program is successful similar ones will be introduced in parks throughout the country.

Opening screen of the CD-ROM interactive program.

Sample frames from the program.

Through information, education, and interpretation comes an understanding of the problems. Communication facilitates public participation in resource stewardship, helping people to understand their relationship and impact on the resources. Each visitor must then make the leap of caring, concern and action.

CIRA Expands Facilities to Meet Growing Research Needs

Julie Winchester

The Cooperative Institute for Research in the Atmosphere added a new wing to its facility this year. In January 1998 ground was broken for a 3600 square foot addition that includes eight offices, a large conference room, multi-use office area, and staff break room.

The new conference room accommodates 35 people and is equipped for presentations utilizing many current research technologies, including a computer projection system that displays video and high resolution graphic images. The mini-kitchen facility and a balcony with a view of the Front Range make this a perfect place for meetings.

The east conference room has been converted to a teleconferencing facility enabling CSU researchers to communicate with other scientists at off site locations. The new teleconferencing capability will help implement the various virtual laboratory concepts like the VISIT program and the Flash Flood Laboratory.

CIRA took occupancy of the new wing in mid June 1998. The new space significantly relieves overcrowded work areas and provides space to accommodate personnel for new research programs begun in the last year. CIRA can now provide office space for visiting scientists and collaborators.

CIRA continues planning for future growth and designs are in the works to remodel the central services area including a new entry and enhanced reception area. CIRA appreciates all the efforts of employees in contributing their time and patience to this effort.

Special Recognition and Events

James F. W. Purdom (former Leader of the NOAA/NESDIS/RAMM Team at CIRA), **Debra A. Molenar** (RAMM/CIRA), and **Benjamin Watkins** (NESDIS, Washington DC) received the **Department of Commerce Bronze Medal Award** for Superior Federal Service in November 1996. The award, the highest honorary award given by NOAA, recognized their achievements in developing and supporting the RAMM Advanced Meteorological Satellite Demonstration and Interpretation System (RAMSDIS), which brought high quality digital satellite data and training to over 60 National Weather Service Forecast Offices throughout the U.S.

Don Hillger received recognition as a **Fellow of the U.S. Metric Association (USMA)** in 1997 for his volunteer work in developing and maintaining the Web site for the national non-profit organization. The Fellow rating is awarded to those performing prolonged, outstanding services toward metrication. The Web site that Hillger developed for the USMA is supported by Colorado State University through it educational outreach efforts and has been hit over 100 thousand times in its first 2 years of service. See: http://lamar.colostate.edu/~hillger/

John Weaver has been nominated in 1998 for a **National Public Service Award** because of his efforts surrounding the devastating Fort Collins flood of 28 July 1997, a Presidentially declared national disaster, which resulted in 5 deaths and $200 million in property damage. Mr. Weaver provided a wealth of weather expertise and volunteered numerous hours to the City of Fort Collins before, during, and after the flood. He continues to help Fort Collins, which is one of 50 cities in the U.S. designated as a FEMA Project Impact "Disaster Resistant Community". His efforts also provide a model for a good working relationship between federal and local government agencies, part of the mission of NOAA.

Civil engineering graduate student **Darcy Noss (now Molnar)** was the recipient of the **H.W. Shen Award** (Fall 1996) while she was supported by the Center for Geosciences. The award is a distinction for outstanding graduate students in water resources. Darcy has since completed her Ph.D.

Arlene Laing received an **Outstanding Student Paper Award** for her presentation at the 1996 AGU Fall meeting (December 1996, San Francisco) entitled, "The Global Distribution of Mesoscale Convective Complexes". She also received the **Max A. Eaton Award** for her presentation at the 22nd AMS conference on Hurricanes and Tropical Meteorology (May 1997, Fort Collins) entitled, "The Large-Scale Environment of Mesoscale Convective Complexes: Comparisons With Other Deep Convective Systems".

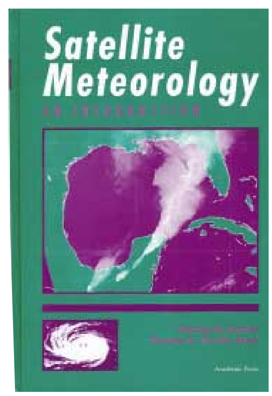
Nan McClurg was awarded the **Joan Kuder Scholarship** in January 1997. The award encourages life-long learning, and the important role it plays in employees' job satisfaction. The scholarship is given to applicants and nominees who have an active record of academic achievement and advancement, are working toward an identified educational goal, and have contributed to his/her particular unit and/or to the University community by serving in additional capacities.

Thomas H. Vonder Haar was the faculty speaker featured at the dedication and ribbon cutting ceremony of the major addition to the William Morgan Library. The ceremony took place on Friday, September 25th, 1998 at 11 AM. The welcome was given by Camila Alire, Dean of Libraries. Other remarks were offered by State Senator Peggy Reeves, CSU President Albert Yates, and Director of Communications Heather Hope.

Dr. Gerald Browning receives plaque from Dr. Sandy MacDonald, Director of the Forecast Systems Laboratory, and Dr. Clifford Matsumoto, CIRA Associate Director. The manuscript he coauthored with **Dr. Heinz Kreiss** entitled "The Role of Gravity Waves in Slowly Varying in Time Mesoscale Motions" was selected the **ERL Outstanding Scientific Paper for 1998**.

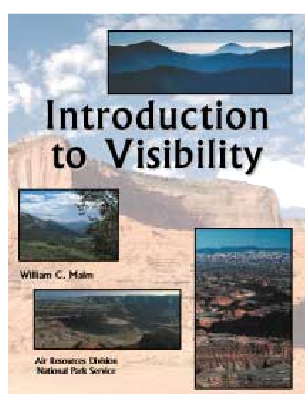
In their paper, they discuss the three types of motion with different frequencies in the atmosphere. Typically, the magnitude of the frequency of Rossby, gravity, and sound waves increases in the order listed. For large-scale atmospheric motions, it is well known that there is very little energy in the latter two types of waves, but their presence in a numerical weather model can have an adverse effect on the forecast. Thus, the initial data for large-scale weather prediction models is always prepared using a process called initialization in order to remove gravity waves from the forecast. However, in mesoscale storms driven by heating and cooling processes, there has been considerable controversy about the importance of gravity waves. This paper proves that the gravity waves that are generated by such storms have very little energy and essentially do not interact with the meteorologically significant part of a mesoscale storm. It also shows that when both parts of the storm are present over an observational site, they cannot be distinguished by only considering time series of the surface pressure at the site. Because this technique has been the most commonly used method to observe gravity waves, the new theory explains why there has been considerable confusion about these waves. The theory also proves that the amplitude of the pressure perturbations and time scale of the gravity waves is the same as the meteorologically significant part of the storm, but their wave length is much longer than that of the heating source.

The textbook ***Satellite Meteorology: An Introduction***, co-authored by **Dr. Stan Kidder** of CIRA and **Professor Tom Vonder Haar** of CIRA/Atmospheric Science, has been very well-received by the research, academic, and industrial communities. Several colleges and universities have adopted the book for their Atmospheric Science courses. The publisher, Academic Press, reports that *Choice* selected it as an "Outstanding Academic Book" in 1996. It has been adopted by the American Meteorological Society Committee on Satellite Meteorology as the textbook for their 1998 Short Course on Satellite Meteorology. Several aerospace companies distribute copies to their engineers and other technical staff as background for their work on new meteorological satellites, instruments, and data processing.



The book is based upon graduate class material taught at CSU by Prof. Vonder Haar and at the University of Illinois and University of Alabama by Dr. Kidder. Since it took 8 years of part-time work by the authors, plus a full sabbatical period for Dr. Kidder to develop the first edition, the authors speak cautiously about a second edition. However, they appreciate the many comments already received and encourage submission of other comments to: http://www.cira.colostate.edu/satmet.

William Malm has recently completed a new edition of "***Introduction to Visibility***". It is an updated and greatly expanded version of the book which was originally published in 1983.



This publication is intended as a primer on the causes, nature, and effects of haze on natural landscape features. It will be widely used by federal, state, and local air resource managers as a reference document.

Dr. James Purdom "GOES" to Washington

Brian Motta

The summer of 1997 marked the end of a 17-year era at CIRA's Regional and Mesoscale Meteorology Team. Founder, Dr. Jim Purdom, accepted a position as the new Director of the National Environmental Satellite, Data, and Information Service's Office of Research and Applications.

For the past 20 years, Dr. Purdom has championed the use of satellite imagery for meteorological applications in a number of forums. He led and constructed an excellent team of research meteorologists to focus on the study of the development and evolution of deep convection with special emphasis on the study of mesoscale processes using satellite data. Special research emphasis has been in the uses of satellite data for severe and tornadic storm identification. Over 100 scientific articles on the subject matter have been contributed in this research area.

The Regional and Mesoscale Meteorology Team grew and prospered under Purdom's leadership and has been recognized both nationally and internationally by leading laboratories and agencies.

Dr. Purdom was promoted to an office directorship in fall of 1998, positioning him in the forefront of one of five NESDIS line offices. He now oversees three divisions: Atmospheric Research and Applications, Climate Research and Applications, and Oceanic Research and Applications.

He is now responsible for conducting an integrated program of research and technology development in the uses of satellite data to support the operational requirements of NOAA. That role involves coordinating NESDIS Earth science and satellite experiments, assessing and integrating the requirements of the remote sensing community, providing expert services to other NESDIS offices and agencies, as well as interacting with the academic community on research and science issues.

We wish Jim the best of luck in his new and important leadership activities in NESDIS. His efforts are already leading to more targeted and effective contributions with the NESDIS/Office of Research and Applications, across other NESDIS offices and across various disciplines.

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. Initial participation by NOAA has been primarily through the Environmental Research Laboratories (ERL) 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.

During the past fiscal year, the Institute's research has concentrated 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. The Institute and the National Park Service also have an ongoing cooperation in air quality and visibility research which involves scientists from numerous disciplines. CIRA is playing a major role in the NOAA-coordinated U.S. participation in the International Satellite Cloud Climatology Program (part of the World Climate Research Programme).

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