NISTIR 6089

NOAA/NIST/INSURANCE INDUSTRY WORKSHOP ON THE WIND PERIL CHANTILLY, VA - JUNE 4-5, 1996

Building and Fire Research Laboratory
Gaithersburg, Maryland 20899

NIST

United States Department of Commerce
...ology Administration
...al Institute of Standards and Technology

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January 1998
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

National Oceanic and Atmospheric
Administration
U.S. Department of Commerce

U.S. Department of Commerce
William M. Daley, *Secretary*
Technology Administration
Gary R. Bachula, *Under Secretary for Technology*
National Institute of Standards and Technology
Raymond G. Kammer, Director

ABSTRACT

This report presents findings and recommendations developed in the course of a two-day NOAA/NIST/Insurance Industry Wind Peril Workshop held at Chantilly, Virginia, on June 4-5, 1996. The workshop brought together administrators and researchers from NOAA and NIST laboratories involved with weather research and building technology and representatives of the casualty insurance industry, including officials from the Insurance Institute for Property Loss Reduction (IIPLR). Also attending were representative of the Federal Emergency Management Agency (FEMA) and the National Science Foundation (NSF). Ongoing research and development efforts that can impact the wind peril were described in detail, as were the needs and concerns of the casualty insurance industry with regard to wind losses, including losses due to wind-driven hail.

It was determined that there are numerous ongoing research projects within the Department of Commerce laboratories that could have a beneficial impact on the wind peril and that this impact could be greatly amplified with the establishment of a National Wind-Peril Mitigation Program modeled generally after the National Earthquake Hazard Reduction Program (NEHRP). To ensure the timely development of such a program, it is recommended that there be created a government/private sector steering committee of experts to provide the necessary guidance.

Keywords: atmospheric science; building technology; codes and standards; hail; hurricanes; insurance industry; tornadoes; weather research; wind damage; wind engineering; wind hazards; windstorms

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ACRONYMS

AOML	Atlantic Oceanographic and Meteorological Laboratory
ASCE	American Society of Civil Engineers
ASOS	Automated Surface Observing System
BFRL	Building and Fire Research Laboratory
ETL	Environmental Technology Laboratory
FEMA	Federal Emergency Management Agency
FSL	Forecast System Laboratory
HRD	Hurricane Research Division
IBHS	Institute for Business & Home Safety
IHC	International Hurricane Center
IIPLR	Insurance Institute for Property Loss Reduction
NCDC	National Climatic Data Center
NESDIS	National Environmental Satellite, Data and Information Service
NEXRAD	NEXt Generation Weather Radar
NHC	National Hurricane Center
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSF	National Science Foundation
NSSL	National Severe Storms Laboratory
NWS	National Weather Service
OAR	Oceanic and Atmospheric Research
OFCM	Office of the Federal Coordinator for Meteorology
SLOSH	Sea, Lake, and Overland Surges from Hurricanes
TDL	Techniques Development Laboratory
USWRP	U.S. Weather Research Program

1. EXECUTIVE SUMMARY

In September 1995, the late Secretary of Commerce Ron Brown convened a Roundtable Meeting with the Insurance Industry to discuss ways by which the Department of Commerce (DOC) and the Insurance Industry could work together to mitigate human suffering, as well as property and economic losses caused by natural hazards and, in particular, weather-related events.

The primary finding of the Roundtable Meeting was that DOC should serve as the driving force behind conducting a future Wind Peril Workshop. Furthermore, a need was identified for the creation of public/private partnerships to address issues that would reduce deaths, injuries and property damage. Thus, the NOAA/NIST/Insurance Industry Workshop was organized in the nine months following the Roundtable Meeting. The Workshop agenda was designed to allow for an exchange of research results, ideas and information among the participants. A focus was placed on the identification of the types of information--short-and long-range; near-surface wind data; details relating to the identity of areas subject to the risk of hail occurrences, damaging thunderstorms, tornadoes and severe windstorms--which could be provided to insurers. The Workshop discussed these and other critical issues, thereafter advancing seven key recommendations (see Section 2 and Section 8 - Where do we go from here?). The paramount recommendations were:

- That the veil of ignorance be lifted regarding wind, i.e., hurricanes, tornadoes, severe windstorms and hail in the United States, through enhanced education, communication and technology transfer.

- That the establishment of a National Wind-Peril Mitigation Program, modeled after the National Earthquake Hazard Reduction Program (NEHRP) be aggressively pursued.

- That there be created a government/private sector steering committee of experts to ensure follow-up on these and other recommendations, and to provide guidance for the establishment of a National Wind-Peril Mitigation Program.

The findings and recommendations in this report are intended to represent the consensus view of workshop participants. Individual participants may hold somewhat differing views with respect to any specific recommendation or finding.

2. KEY RECOMMENDATIONS

NOAA/NIST/INSURANCE INDUSTRY WORKSHOPS ON THE WIND PERIL

1. Establish a national wind-peril mitigation program, possibly modeled after the National Earthquake Hazard Reduction Program (NEHRP).

2. Lift the veil of ignorance regarding wind perils in the U.S. through enhanced education, communications and technology transfer.

3. The insurance industry and the public support continued studies and applied research leading toward enhanced life safety and property and economic loss reduction through improved design standards and retrofit procedures. The research effort should include cost-benefit analyses and financial incentives for the improvement and enforcement of building codes.

4. Data from the national NEXRAD network, the Wind Profiler Demonstration Network, and portable Doppler radars should be used to better define areas frequently at risk to:

    a) wind-driven hail occurrences
    b) damaging thunderstorm phenomena and tornadoes
    c) Severe windstorms of other origin, e.g. downslope winds and Chinooks.

    We need to ascertain the degree of risk and how a better understanding of that risk should be translated into structural design criteria. In addition, there is a need for "real-time" storm data that would allow for more effective and efficient disaster response planning.

5. Refine and enhance the NEXRAD, ASOS and wind profiler systems; specifically, government programs such as ASOS and NEXRAD should provide for the accumulation and archiving of standardized near-surface wind data. These data are required by atmospheric scientists to develop improved windfield models, by engineers to develop windload criteria, and by insurers to estimate losses, thus providing the opportunity to bridge the worlds of atmospheric scientists, engineers and insurance practitioners.

6. IIPLR[1] , NIST and NOAA researchers should work synergistically with the ASOS program to demonstrate the urgent need and cost-effective alternatives for fail-safe backup power in near-surface severe storm wind measurements and data archiving (including recorders) for use by engineers and atmospheric scientists.

7. Establish a government/private sector steering committee of experts to ensure follow-up on these recommendations and to provide guidance for the establishment of a National Wind-Peril Mitigation Program.

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[1] Effective August 1, 1997, IIPLR changed its name to Institute for Business and Home Safety (IBHS).

3. **PREAMBLE**

WIND PERIL WORKSHOP

In recent years, a series of natural disasters have acted as a wake-up call to the insurance industry and to the Federal sector. Consider the following...over the last six years, losses from domestic insured natural disasters have topped $55 billion. Eight of the top ten insured domestic losses were weather related--the other two were earthquakes. The Nation has experienced destructive California wildfires, extensive Mississippi River flooding, the Northridge earthquake and Hurricane Andrew.

With this magnitude of massive damage to businesses and communities, along with human suffering and loss of life as a backdrop, the Department of Commerce (DOC) convened a DOC/Insurance Industry Roundtable discussion. The meeting was held September 15, 1995, and was hosted by the American Meteorological Society at their headquarters in Boston, Massachusetts. Its purpose was to discuss ways in which DOC and the casualty insurance industry could work together to mitigate the losses and suffering from natural hazards. Additionally, the meeting provided an opportunity to develop an action plan to foster further cooperation between DOC and the casualty insurance industry.

A number of findings came out of the Roundtable (available in notes and discussion papers from NWS), with two of these findings being the driving force behind conducting a future Wind Peril Workshop. One was the need for public/private partnerships in reducing death, property, and economic damage from natural hazards; and two, among natural hazards, the wind peril accounts for over 80 percent of insurance industry natural hazard losses. With this as a foundation, a Wind Peril Workshop was held June 4-5, 1996, in Chantilly, Virginia.

The Workshop brought together key officials of the National Oceanic and Atmospheric Administration (NOAA) and Line Offices and Laboratories, the National Institute of Standards and Technology (NIST), the Insurance Institute for Property Loss Reduction (IIPLR), the Federal Emergency Management Agency (FEMA), the National Science Foundation (NSF), universities, and insurance companies. Major objectives were to understand each other's concerns, roles, language, and obstacles; and through public, private and academic partnerships, to reduce wind-related deaths, property loss and economic damage.

4. PURPOSE AND OBJECTIVE

As noted above, the Wind Peril Workshop grew out of the Roundtable discussions held in the Fall of 1995 by the late Secretary of Commerce, Ron Brown, with key insurance industry representatives. It was agreed that the Workshop would be organized by the two major Department of Commerce agencies involved in wind-hazard research, NOAA and NIST, for the purpose of exchanging technical information with the insurance industry on the state-of-the-science. To nurture and develop inter-agency and academic partnerships following the Workshop, representatives were invited from the National Science Foundation, the Federal Emergency Management Agency, and the Florida International University in Miami (collocated with the new Tropical Center, NWS). Dr. D. James Baker, the Administrator of NOAA, addressed the Workshop and noted that the health of the U.S. insurance industry was of great concern to the late Commerce Secretary Brown, and that Secretary Kantor intends to carry on with the same level of interest. Education of the insurance industry and the American public on NOAA/NIST research and operational products on wind phenomena should be one goal of this Workshop. Another goal should be to develop partnerships with the insurance industry.

Mr. Eugene L. Lecomte, President and CEO of the Insurance Institute for Property Loss Reduction[2] expressed his organization's appreciation for NOAA and NIST taking the lead in presenting the Workshop.

In his opening remarks, Mr. Lecomte stressed the importance of establishing a dialogue as well as on-going lines of communication with all of the stakeholders (Governments [federal, state, municipal]; academe; the engineering, scientific and research communities; developers; realtors; contractors; builders; bankers and insurers, etc). He focused briefly on the benefits and value of partnering to meet the challenges posed by natural hazards. Alluding to the emerging FEMA-IIPLR partnering, the IIPLR President indicated that this arrangement would serve effectively to confront natural hazard issues; it would establish meaningful mitigation programs while concurrently helping to avoid a duplication of effort and redundant cost burdens.

Turning to the rising values of residential and commercial structures in the first tier of counties along the Atlantic and Gulf Coasts, Mr. Lecomte stated that, in that narrow 50 mile span of real estate, more than $3 trillion dollars of structure value stand in harm's way. He indicated that this exposure would continue to rise as the coastal populations grow into the next century. Mr. Lecomte revealed that the factors of a constantly expanding population and escalating real property values pose a concern and threat to the property insurance industry, particularly if there might be more frequent severe weather events.

The IIPLR President stated that for these reasons, it is essential that there be a partnering between his organization and NOAA/NIST. He disclosed that the property insurance industry must clearly identify and articulate its needs in the areas served by NOAA/NIST expertise and services. Thus, he saw the Workshop as a "watershed" event, leading to a sharing of knowledge between the engaged parties, then to an exchange or transfer of technology, and ultimately to actions which would reduce deaths, injuries, and economic and property damage.

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[2] Since the Workshop, it has been announced that Mr. Harvey Ryland, formerly Deputy Director of FEMA, will be the new President and CEO of IIPLR effective October 1, 1996.

Dr. Richard N. Wright, Director of the Building and Fire Research Laboratory (BFRL) at NIST, noted that this laboratory is giving wind hazard reduction a high priority, and is engaged in wind loading research and the effects of wind on fires. Although BFRL participates in standards activities, this participation is not as a regulator but rather to provide research in support of standards. Dr. Wright expressed concern about the *lack of reliable near-surface wind speed measurements in extreme events* such as Hurricane Andrew (1992) and the importance of such data to the casualty insurance industry and to the building research community. He noted that wind engineering research has been severely underfunded and that we must look to the insurance industry to increase public awareness of wind losses and the need for action. We must define topics of priority to reduce wind losses, and we need to make clear to the Congress and to others what wind research will cost, what the benefits of that research will be, and what the cost will be if we do not pursue such research.

Franklin W. Nutter, president of the Reinsurance Association of America, commented that the insurance industry has an emerging recognition of the value of science in its strategic planning. The industry's natural antipathy toward regulation has, until recently, shielded it from positive contributions that government programs can make in serving insurance policy holders and insurer managements.

Mr. Nutter kindly remarked that the scientific programs conducted by NOAA and NIST offer the industry tremendous value in understanding the wind peril. The industry's new initiatives in hazard mitigation as well as a better understanding of the public's exposure to wind, as derived from science-based government programs, will prove to be invaluable.

5. AGENDA

NOAA/NIST/INSURANCE INDUSTRY WORKSHOP ON THE WIND PERIL
MARRIOTT-DULLES AIRPORT, CHANTILLY, VIRGINIA

TUESDAY, JUNE 4

MODERATOR: FRANK NUTTER, Reinsurance Association of America

10:00 Opening Remarks

D. James Baker, Under Secretary for Oceans and Atmosphere, U.S. Department of Commerce

Modesto A. Maidique, President, Florida International University

Richard N. Wright, Director, Building and Fire Research Laboratory, National Institute of Standards and Technology

Eugene L. Lecomte, President and CEO, Insurance Institute for Property Loss Reduction

Purpose and Problem at Hand

Discussion

MODERATOR: Joseph H. Golden, NOAA/OAR

11:15 New Wind Observing Systems

Operational Weather Forecasting and Doppler Radar: A Case Study-- Steve Zubrick, NOAA/NWS
*Doppler-On-Wheels--Erik Rasmussen, NOAA/OAR/NSSL
*Advanced Remote Sensing for Wind--Brooks Martner, NOAA/OAR/ETL
Wind Climatology-- Mike Changery, NOAA/NESDIS/NCDC
Reaction/comments/questions from participants

12:15 Working Lunch - New Wind Observing Systems (continued)

*Automated Surface Observing System Program -- Vickie L. Nadolski, NOAA/NWS

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*Indicates abstracts/viewgraphs are included in Section 9.

1:15 Modeling - NOAA

Overview:

The Evolution of the Weather Forecasting Process: Progress Made and Challenges Remaining--Louis Uccellini, NOAA/NWS

Operational:

Importance of Wind Observations for Forecasting Land-falling Weather Systems--Steve Lord, NOAA/NWS
A Simple Statistical Method for Predicting the Decay of Land-falling Hurricanes--Mark De Maria, NOAA/NWS

Research:

*Tornado/Severe Thunderstorms Wind Models--Erik Rasmuessen, NOAA/OAR/NSSL
Real-time Hurricane Surface Wind Analysis Models--Sam Houston, NOAA/OAR/AOML/HRD
*United States Weather Research Program--Joseph H. Golden, NOAA/OAR
Reaction/comments/questions from participants

2:45 Modeling - NIST

*Hurricane and Thunderstorm Modeling: Structural Reliability Issues--Emil Simiu, NIST
Reaction/comments/questions from participants

3:15 Break

MODERATOR: GENE LECOMTE, IIPLR

3:30 Modeling - Insurance Industry

*Underwriting the Wind Peril: Loss Estimation Models, Specific Risk and Portfolio Loss -- D. Bryan Freeman
Reaction/comments/questions from participants

4:00 Infrastructure and Lifelines

*Infrastructure and Lifelines: Insurance Industry Perspective- - Dean C. Flesner
Some Important Research Issues -- Emil Simiu, Richard Marshall, Riley Chung, NIST
Applied Research for Arizona Utilities -- Erik Rasmuessen, NOAA/OAR/NSSL
Reaction/comments/questions from participants

4:30 Open Discussion/New Dissemination Technologies

Open discussion of important issues raised during today's proceedings. As time permits, operational and research demonstration of new dissemination technologies will take place.
*The Dissemination Project: A Decision Support Tool For Emergency Managers--Rich Jesuroga, NOAA/ERL/FSL.

5:15 Adjourn

WEDNESDAY, JUNE 5

MODERATOR: DON WERNLY, NOAA/NWS

8:30 Response & Recovery

Response and Recovery: A FEMA Perspective -- Karen Marchs, FEMA
*Real-time Hurricane Damage Assessment --Mark Powell, OAR/AOML/HRD

Coordinated Post-event Data Collection - Don Wernly, NOAA/NWS
*Response and Recovery: The Insurance Industry Perspective - Dr. James W. Russell
Reaction/comments/questions from participants

9:30 Preparedness

Land Use Management -- NOAA/NOS
Partnership in Preparedness -- Rainer Dombrowsky, NOAA/NWS
*Coastal Zone Management: A Tool For Coastal/Mitigation — Dean. C. Flesner
Reaction/comments/questions from participants

10:15 Break

MODERATOR: RICHARD MARSHALL, NIST

10:30 Mitigation

Mitigation: Some Important Concepts--Cliff Oliver, FEMA
*A New Generation of Standards/Assessment Tools for Wind Effects--
Emil Simiu, NIST
*Wind Loads and Manufactured Homes: Implementing Existing Knowledge--
Richard Marshall, NIST
*Mitigation: The Insurance Industry Perspective--John J. Mulady
Reaction/comments/questions from participants
Where Do We Go From Here: A Multi-Disciplinary Approach--Tom Davis, IHC

MODERATOR: RICHARD N. WRIGHT, NIST

11:30	Where Do We Go From Here?
12:30	Adjourn
1:00 - 3:00	Optional Tour: National Weather Service Forecast Office at nearby Sterling, VA and National Weather Service Test and Evaluation Center Sterling, VA

6. DETAILED RECOMMENDATIONS AND DISCUSSIONS

It should be noted that most of the recommendations were developed in the final session of the Workshop after the participants had heard presentations of the latest findings in wind research and operations from NOAA/NIST representatives.

The first over-arching recommendation was for the establishment, at the Federal level, of a national wind peril mitigation program, and that the National Earthquake Hazard Reduction Program (NEHRP) would provide a good model to follow. This recommendation grew out of the fact that the total Federal funding for all wind-peril research is subcritical to meet just the stated needs of the insurance industry; indeed, Federal spending on all wind research is less than 5-10% of that for earthquake research in the U.S. It was emphasized to the Workshop that the template for such a wind research program, including budget estimates, is presented in the NAS/NRC 1993 report, "WIND AND THE BUILT ENVIRONMENT." The initial leadership in promulgating the activity should come from IIPLR, with NOAA and NIST weaving elements of the wind research program into their agency FY98 budget submissions, if possible.

A second corollary recommendation was to establish a government/private sector steering committee of experts to ensure follow-up on these recommendations and to provide guidance for the establishment of a National Wind-Peril Mitigation Program. It would also plan and advocate a private/public partnership arrangement with participants from Federal agencies, academia, industry and the Red Cross, for example. One suggestion was to work this through Congress via the National Fire Caucus.

The IIPLR representative urged that *collectively*, we lift the veil of ignorance regarding wind perils through enhanced education, communications and technology transfer. One example is the manufactured home industry. There was concern that unit costs would go up by as much as 30% with new Federal requirements for manufactured home construction and safety following Hurricane ANDREW. The actual increase was about one-third of that amount. Another example of the obstacles to wind-hazard mitigation is an IIPLR survey indicating that although people are willing to pay for wind-resistant construction, this does not appear to be happening in Dade County, Florida. Hurricane-resistant homes are not selling very well there and perhaps this is a public education problem. It was noted that experience gained with the earthquake hazard reduction program could be of some help in the area of wind hazard reduction.

There was much discussion about building codes and the need, as expressed by IIPLR, to bring about a national building code. Some concern was expressed about this concept because of *regional differences in both construction and windstorm climatology*. However, it was noted that the three major model building code groups are moving toward the establishment of a *single national building code*. The target date is around the year 2000. We have long had a single national wind loading standard with ASCE 7. One of the major private-sector building groups, the NAHB, has made it clear in public form that they do not want the Federal agencies issuing building regulations. An IIPLR public survey indicates that prospective home buyers want stricter codes and enforcement, and are willing to pay up to an extra $5,000 for a $100,000 home. Building code officials see a shift of interest away from personal injury to property loss reduction as well as life safety. They have introduced the new argument of cost/benefit in building codes. The problem is that there is not much reliable data on cost/loss in windstorms. The insurance industry indicated that it is making more progress with the code groups than with the builders. Preambles of building codes now emphasize life-safety and preservation of property, with improvement costs for wind-resistance running 3-5% of property value. However, the insurance industry so far has not considered *retrofit* for existing dwellings to improve windstorm resistance. It was noted by the insurance people that it would be worthwhile to get the applied research conducted by NOAA and NIST on the table as part of the democratic process for the model code groups.

Discussions led to a fourth recommendation that the insurance industry and the public support continued studies and applied research leading toward enhanced life safety and property/economic loss reduction through improved design criteria and retrofit procedures. The research effort should include cost-benefit analyses and financial incentives for the improvement and enforcement of building codes.

Following presentations on the NWS Modernization, including the new NEXRAD Doppler radar network nearing completion at 160 sites and ASOS at over 800 airports, the group felt that these new observational tools should be refined and enhanced to address the wind-hazard problem. The group was also made aware of the NOAA/ERL Wind Profiler Demonstration Network in place over the central US, useful for providing *continuous* profiles of winds from just above the surface to heights of 16 km or higher. In particular, preliminary results from the NOAA Project VORTEX, 1994-95, suggest that small, portable scanning Doppler radars could make significant contributions to improving the understanding and definition of low-level windfields in severe storms, especially in tornadoes and landfalling hurricanes. Therefore, a fifth recommendation was formulated that data from the NEXRAD network and portable Doppler radars should be used to identify areas frequently at risk to:

a) Wind-driven hail occurrences
b) Tornadoes and other damaging thunderstorm winds, e.g. downbursts
c) Severe windstorms of other origin, e.g.,downslope winds and Chinooks.

It was clear to the participants, from presentations of real-time data analysis and display systems by FSL (Rich Jesuroga) and HRD (Powell/Houston), that *there is also a need for "real-time" storm data that would permit more effective and efficient disaster response planning.* It was noted that some recent hurricanes have exhibited rapid intensity and/or structural changes in the few hours preceding landfall. Improved knowledge and monitoring of these changes could be of considerable importance in issuing warnings for inland areas, as well as aiding decisions on rapid deployment of disaster assessment and recovery teams.

Representatives of NIST, IIPLR and other elements of the casualty insurance industry expressed great concern and frustration over the paucity of surface wind observations in recent devastating hurricanes such as ANDREW (1992), and LUIS, MARILYN and OPAL (all 1995). The two major issues appear to be the lack of backup power and recorders for data archival on existing anemometer and the fact that most conventional anemometers and their mounting systems cannot withstand the high windspeeds and flying debris in severe storms. As most sites are on towered or non-towered airports, even the new ASOS system is hooked up to the airport's power supply and data is archived for only 12 hours and then overwritten, unless special prior arrangements are made. It was noted that data recorders for archiving the full-resolution base data (radial velocities, reflectivity and spectrum width) on NEXRAD are being installed at all sites, and that these data are available from the NOAA Climatic Data Center in Asheville.

It was apparent that NEXRAD and ASOS systems offer potentially a rich composite data source on boundary layer wind characteristics in severe storm phenomena if the problems noted above can be solved. Therefore, the group had two final recommendations:

1. Government programs should provide for the accumulation and archiving of standardized, near-surface wind data (esp. at 10 m standard heights). These data are required by atmospheric scientists to develop improved windfield models, by engineers to develop improved windload criteria, and by insurers to estimate losses, thus providing the opportunity to bridge the worlds of atmospheric scientists, engineers and insurance practitioners.

2. The agencies sponsoring ASOS (NWS/NOAA and FAA) should refine and enhance the ASOS system to provide fail-safe backup power for near-surface severe storm wind measurements and data archival (including directionality and peak gusts) for use by engineers and atmospheric scientists.

7. **WHERE DO WE GO FROM HERE?**

The Workshop achieved its first major objective - to improve understanding of the NOAA/NIST and casualty insurance industry concerns, roles, languages and obstacles to reducing the wind peril. The second objective, to reduce wind-related deaths and property and economic damage through public, private and academic partnerships, will be more difficult. Nevertheless, the summary of key recommendations presented in Section 2 of this report, coupled with a focus on the need for "**partnerships**" among the various stakeholders, provides an action plan for getting there, by making optimum use of existing expertise and by focusing future research on key aspects of the wind peril. Some of these research needs can be accommodated by redirecting existing programs, while other research needs require new program initiatives and new funding to support those initiatives. Overall success will depend critically on enhanced technology transfer efforts from NOAA/NIST and university partners to U.S. industry, and concerted education of the Congress and the public on the need for national attention to the wind peril (i.e., what we know, what we don't know, and research/funding priorities to get us from here to there).

There is the very real and significant problem of *implementation: improvement of building codes and standards, development of test methods, code enforcement, and the improvement of U. S. Building practices*. Each of these problems extends well beyond the roles envisioned for the Department of Commerce, the casualty insurance industry, or any partnerships that might develop. For this reason, it is important that a steering committee or "focus group of experts" be organized which will provide integration with other related efforts to reduce the wind peril. In addition, such a committee should provide for representation of the various parties having a role in wind hazard reduction, including building officials, the building materials industry, the construction industry, the casualty insurance industry, and other Federal agencies such as the Federal Emergency Management Agency and the National Science Foundation. One option for the formulation of such a steering committee appears to be through the auspices of the Building Seismic Safety Council and the National Institute of Building Sciences; indeed, there is a proposal involving these two groups to help define and establish a National Multi-hazard Mitigation Council.

Immediately following the organization of a steering committee, the committee should establish a set of objectives for reducing the wind peril and a list of milestones and responsible groups for attaining those objectives. Partnerships would be formed and new funding would be requested as needed to complete the various milestones. Details of the committee organization and operation could be patterned, as noted above, after the successful program activities carried out by the earthquake engineering community.

As a follow-on to the Workshop, NOAA and NIST have pursued, along with some of their companion elements of the Department of Commerce, a new FY99 budget initiative on Natural Disaster Reduction. The initiative has as one of its initial foci the development of technologies for reducing the impacts of windstorm disasters in the U.S. A central theme of the initiative is the early development of partnerships with industry and academe, as well as demonstration projects to test new ideas and concepts. We look forward to working closely with the Institute for Business and Home Safety (IBHS) and the insurance/reinsurance industry to move forward. Following the Workshop, a new MOU has been executed by NIST and IBHS to facilitate joint projects on the wind peril and other issues of mutual interest, and a similar MOU is under development with NOAA and Institute for Business & Safety (IBHS). This will be done with the establishment of the steering committee noted above, and a meeting of the new CEO of IBHS, Harvey Ryland, and representatives of NOAA and NIST is the next step.

Additionally, a second Workshop will be jointly organized as a logical follow-up to the first, and its chief goal will be to educate the insurance industry on the current knowledge and state-of-the-art in NOAA and NIST for hurricane hazards forecasting and mitigation.

8. LABORATORY SUMMARIES AND AFFILIATION

NAME	AFFILIATION
D. James Baker	National Oceanic and Atmospheric Administration
Auguste Bojssonnade	RMS, Inc.
Larry Campbell	Economics and Statistics Administration
Mike Changery	National Oceanic and Atmospheric Administration
Greagory Chiu	Insurance Institute for Property Loss Reduction
Riley Chung	National Institute of Standards and Technology
Paul Cogswell	Insurance Institute for Property Loss Reduction
Tom David	Florida International University, International Hurricane Center
Mark De Maria	National Oceanic and Atmospheric Administration
Paul Devlin	Insurance Institute for Property Loss Reduction
Rainer Dombrowsky	National Oceanic and Atmospheric Administration
Dean C. Flesner	State Farm Fire & Casualty Co.
D. Bryan Freeman	State Farm Fire & Casualty Co.
Joe Golden	National Oceanic and Atmospheric Administration
Sam Houston	National Oceanic and Atmospheric Administration
Rich Jesuroga	National Oceanic and Atmospheric Administration
Eugene Lecomte	Insurance Institute for Property Loss Reduction
Stephen Lord	National Oceanic and Atmospheric Administration
Modesto A. Maidique	Florida International University
Karen Marsh	Federal Emergency Management Agency
Richard Marshall	National Institute of Standards and Technology
Brooks Martner	National Oceanic and Atmospheric Administration
Bijan Mohraz	National Institute of Standards and Technology
John J. Mulady	USAA
Vickie L. Nadolski	National Oceanic and Atmospheric Administration
Franklin Nutter	Reinsurance Association of America
Raymond O'Keefe	National Oceanic and Atmospheric Administration
Cliff Oliver	Federal Emergency Management Agency
Mark Powell	National Oceanic and Atmospheric Administration
Erik Rausmussen	National Oceanic and Atmospheric Administration
Richard Roth	Consultant
James Russell	Insurance Institute for Property Loss Reduction
Nora Sabadell	National Science Foundation
Wil Shaffer	National Oceanic and Atmospheric Administration
Emil Simiu	National Institute of Standards and Technology
Jean Snider	National Oceanic and Atmospheric Administration
Rich Stone	National Oceanic and Atmospheric Administration
Paul Tertell	Federal Emergency Management Agency
Jim Travers	National Oceanic and Atmospheric Administration
Louis Uccellini	National Oceanic and Atmospheric Administration
Don Wernly	National Oceanic and Atmospheric Administration
Derek Winstanley	National Oceanic and Atmospheric Administration
Richard N. Wright	National Institute of Standards and Technology
Steve Zubrick	National Oceanic and Atmospheric Administration

9. **SELECTED ABSTRACTS AND VIEWGRAPHS**

DOPPLER-ON-WHEELS (DOW) RADARS

What they look like...
What they can do...

- Fully mobile
  Data collection while rolling
  Fixed deployment in < 1.5 minutes
- Winds and precipitation intensity
  Along-beam windspeeds; two radars yield 3D winds
  Resolves features as small as a few tens of meters at close range

Views quite near the ground

- Ideally suited for scales from 100 m to 10 km; can be used for larger phenomenon if needed

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DOPPLER-ON-WHEELS (DOW) RADARS

What they cannot do very well...

- Details of flow within tornadoes themselves (e.g. subvortices)
  Limited spectra can be recorded, so we can measure peak windspeeds, just not distribution in space
  Radar can't see through very heavy precipitation

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UNIV. MASSACHUSETTS MM-WAVE DOPPLER RADAR

Joint proposal to NSF with Dr. Howie Bluestein (OU)
and DOW radars (Rasmussen/Straka/Wurman)

- Fully mobile; must stop for deployment
- This radar can resolve features as small as ~ 10 m
- This radar will attenuate completely in rain; must be deployed in relatively rain-free conditions quite near tornadoes

Erik Rasmussen
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NOAA/ETL

ENVIRONMENTAL TECHNOLOGY LABORATORY

Mission: Develop new instruments and techniques for **remote sensing** of the atmosphere and ocean.

Apply these remote sensors in basic research of atmospheric and oceanic processes.

Light Waves --- Radio Waves --- Acoustic Waves

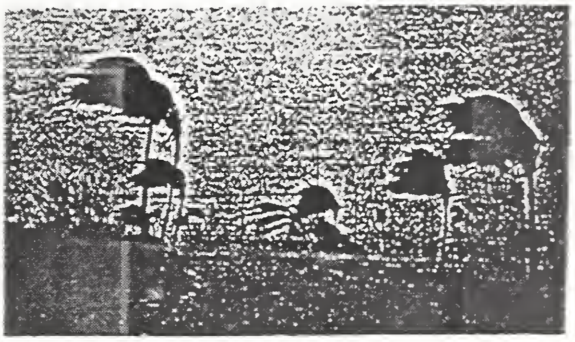
Lidars Radars Sodars

Radiometers

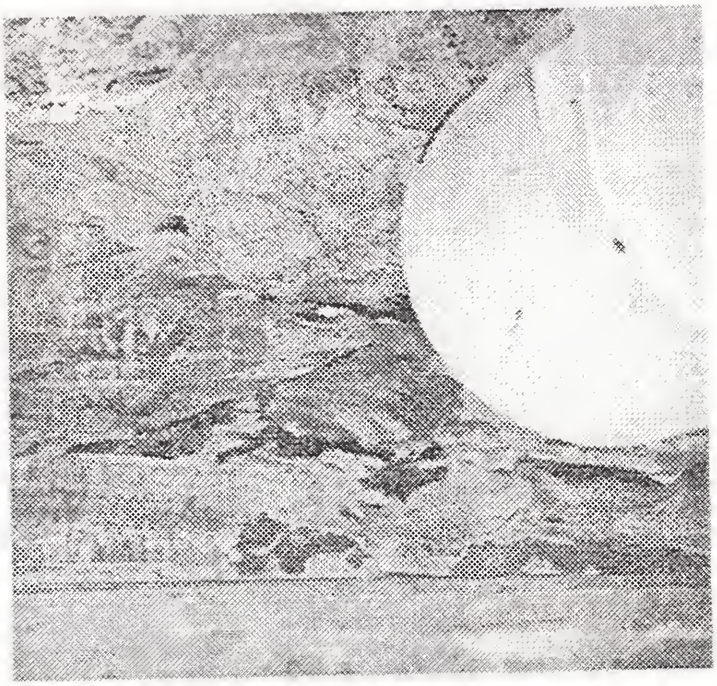
and more

WIND MEASUREMENT USING LIGHT WAVES DOPPLER LIDAR ("LASAR RADAR")

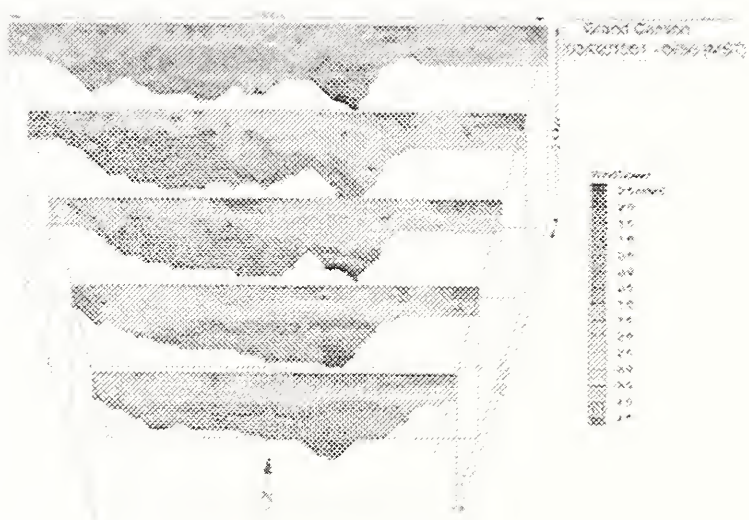
* Detects motion of dust particles in the air.
* Extremely narrow beam allows measurements very close to the ground.

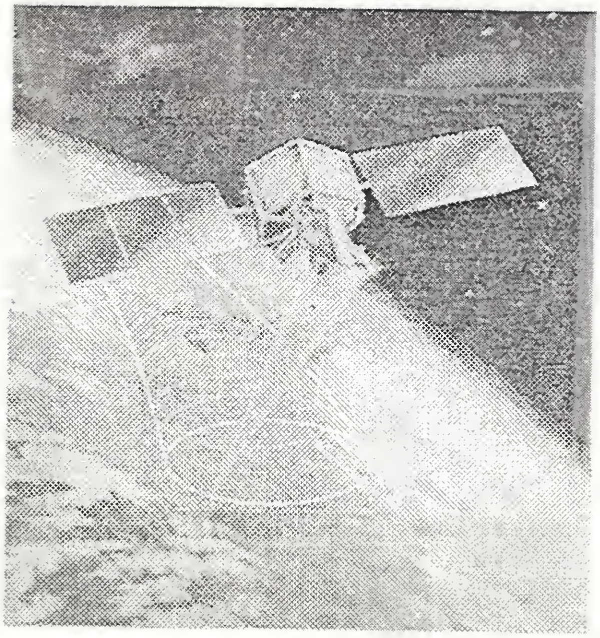


Measurements of:
- downslope mountain winds
- gust fronts
- smoke and toxic plumes
- canyon winds
- global winds aloft from satellite



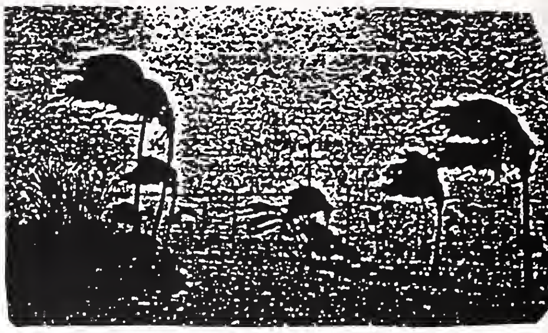
Doppler lidar measurements of
airflow patterns in the Grand Canyon





Satellite platform for the
Laser Atmospheric Wind Sounder
of the next decade

WIND MEASUREMENT USING RADIO WAVES (DOPPLER RADAR)



---- increasing wavelength ---->

Storm Surveillance Radar	Wind Profiler Radar	Over the Horizon Radar
tornadoes	winds aloft	hurricanes
gust fronts	fire weather winds	oceanic winds
microbursts	air pollution transport	
blizzards		

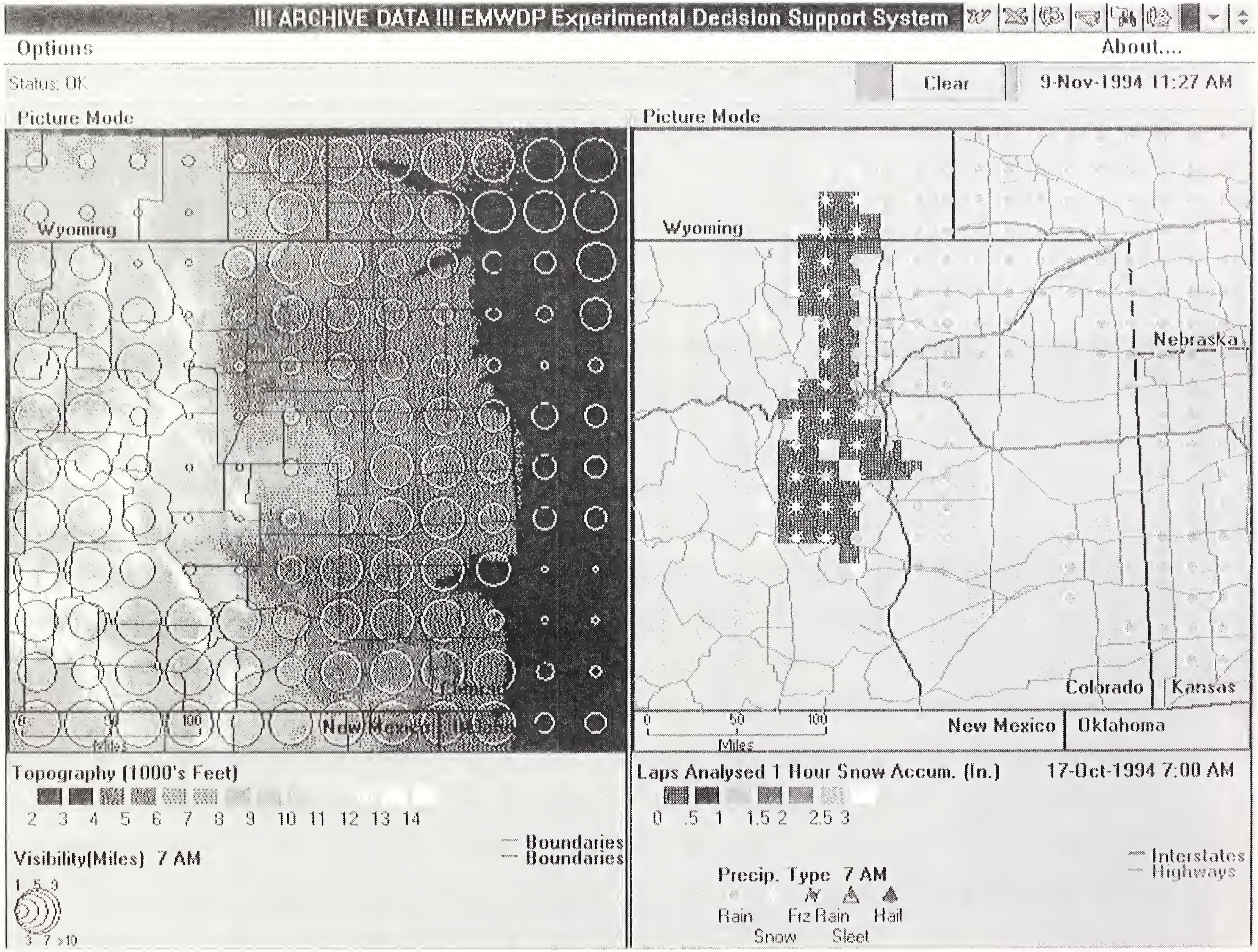
WIND MEASUREMENT USING SOUND WAVES

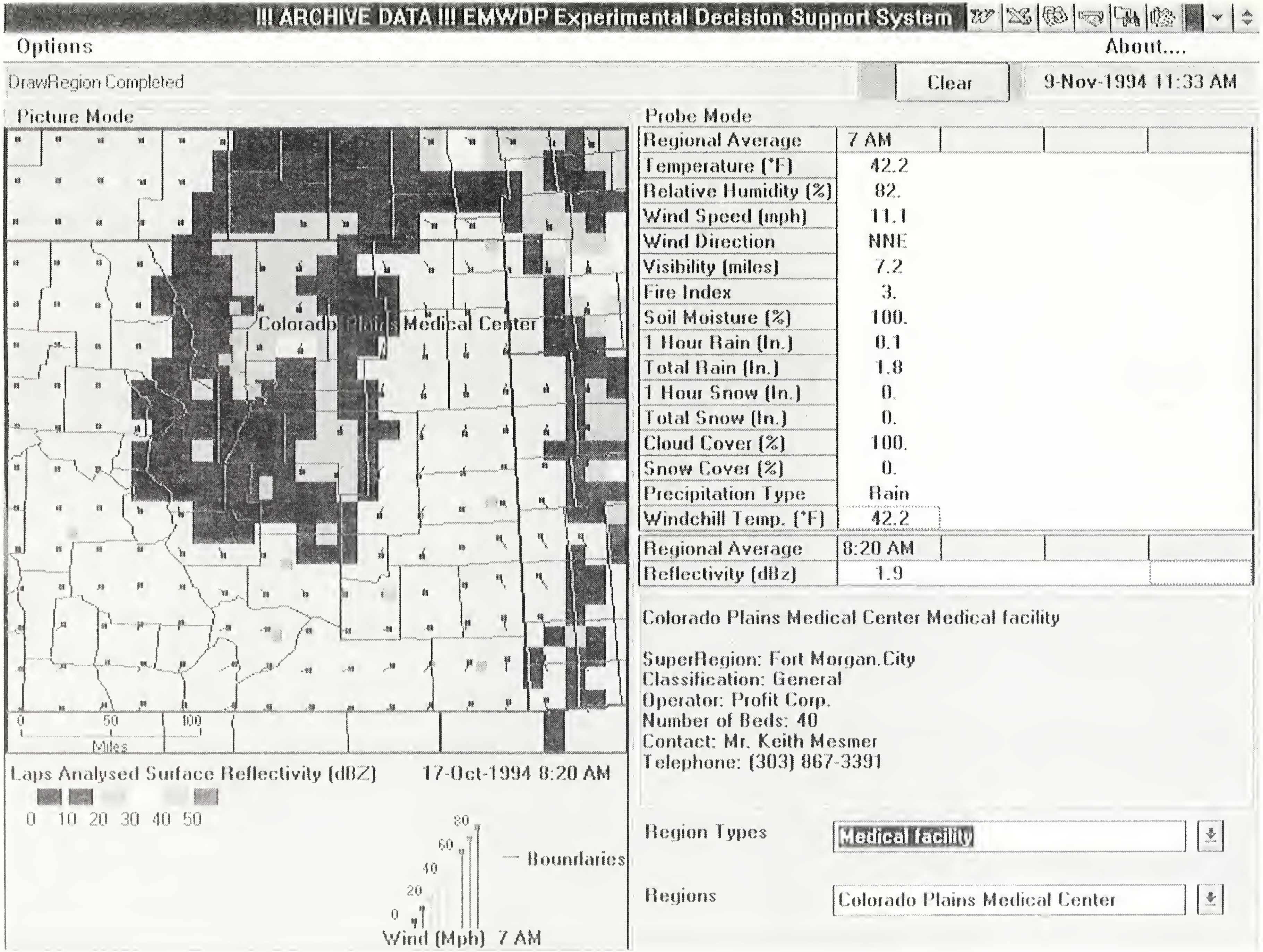
DOPPLER SODAR ("ACOUSTIC RADAR")

- airflow close to the ground
- urban canyon winds
- air pollution drift

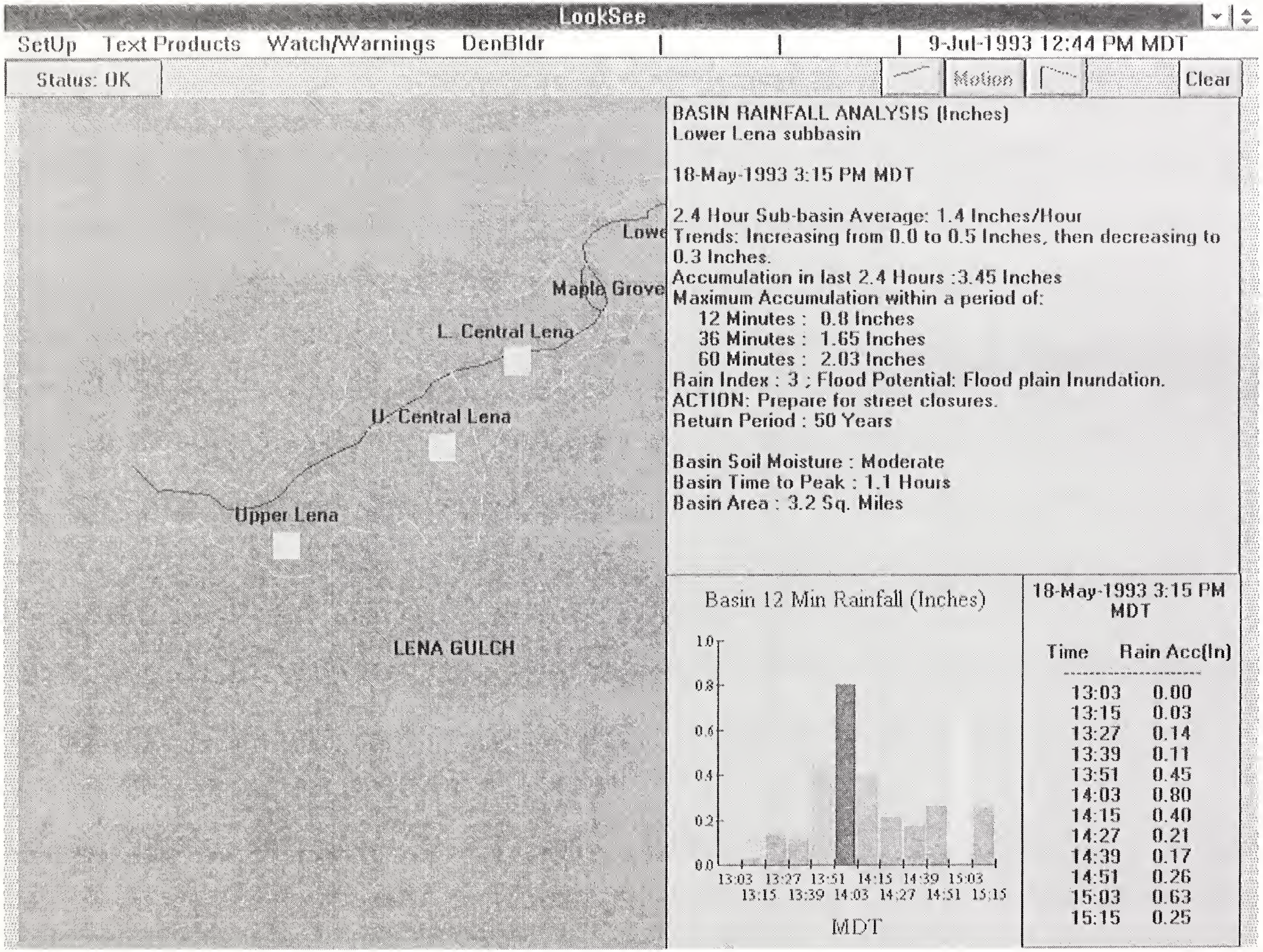
INFRASONIC SOURCE LOCATION

- thunderstorm rotating winds
- avalanches


III ARCHIVE DATA III EMWDP Experimental Decision Support System
Options
About....
Status: OK
Clear
9-Nov-1994 11:27 AM
Picture Mode
Wyoming
New Mexico
Miles
Topography (1000's Feet)
2 3 4 5 6 7 8 9 10 11 12 13 14
Boundaries
Boundaries
Visibility(Miles) 7 AM
1 .5 .3
3 7 >10
Picture Mode
Wyoming
Nebraska
Colorado
Kansas
0 50 100
Miles
New Mexico
Oklahoma
Laps Analysed 1 Hour Snow Accum. (In.)
17-Oct-1994 7:00 AM
0 .5 1 1.5 2 2.5 3
Interstates
Highways
Precip. Type 7 AM
Rain
Snow
Frz Rain
Sleet
Hail



!!! ARCHIVE DATA !!! EMWDP Experimental Decision Support System
Options
About....
DrawRegion Completed
Clear
9-Nov-1994 11:33 AM
Picture Mode
Colorado Plains Medical Center
0 50 100
Miles
Laps Analysed Surface Reflectivity (dBZ)
17-Oct-1994 8:20 AM
0 10 20 30 40 50
Boundaries
Wind (Mph) 7 AM
Probe Mode
Regional Average 7 AM
Temperature (°F) 42.2
Relative Humidity (%) 82.
Wind Speed (mph) 11.1
Wind Direction NNE
Visibility (miles) 7.2
Fire Index 3.
Soil Moisture (%) 100.
1 Hour Rain (In.) 0.1
Total Rain (In.) 1.8
1 Hour Snow (In.) 0.
Total Snow (In.) 0.
Cloud Cover (%) 100.
Snow Cover (%) 0.
Precipitation Type Rain
Windchill Temp. (°F) 42.2
Regional Average 8:20 AM
Reflectivity (dBz) 1.9
Colorado Plains Medical Center Medical facility
SuperRegion: Fort Morgan.City
Classification: General
Operator: Profit Corp.
Number of Beds: 40
Contact: Mr. Keith Mesmer
Telephone: (303) 867-3391
Region Types
Medical facility
Regions
Colorado Plains Medical Center


LookSee
SetUp
Text Products
Watch/Warnings
DenBldr
9-Jul-1993 12:44 PM MDT
Status: OK
Motion
Clear
BASIN RAINFALL ANALYSIS (Inches)
Lower Lena subbasin
18-May-1993 3:15 PM MDT
2.4 Hour Sub-basin Average: 1.4 Inches/Hour
Trends: Increasing from 0.0 to 0.5 Inches, then decreasing to 0.3 Inches.
Accumulation in last 2.4 Hours :3.45 Inches
Maximum Accumulation within a period of:
12 Minutes : 0.8 Inches
36 Minutes : 1.65 Inches
60 Minutes : 2.03 Inches
Rain Index : 3 ; Flood Potential: Flood plain Inundation.
ACTION: Prepare for street closures.
Return Period : 50 Years
Basin Soil Moisture : Moderate
Basin Time to Peak : 1.1 Hours
Basin Area : 3.2 Sq. Miles
Lowe
Maple Grove
L. Central Lena
U. Central Lena
Upper Lena
LENA GULCH
Basin 12 Min Rainfall (Inches)
1.0
0.8
0.6
0.4
0.2
0.0
13:03 13:27 13:51 14:15 14:39 15:03
13:15 13:39 14:03 14:27 14:51 15:15
MDT
18-May-1993 3:15 PM MDT
Time Rain Acc(In)
13:03 0.00
13:15 0.03
13:27 0.14
13:39 0.11
13:51 0.45
14:03 0.80
14:15 0.40
14:27 0.21
14:39 0.17
14:51 0.26
15:03 0.63
15:15 0.25

ASOS BRIEFING

NEW WIND OBSERVING SYSTEMS

WIND PERIL WORKSHOP

Presented by:
Vickie L. Nadolski, ASOS Program Manager
June 4, 1996

NWS MODERNIZATION

- ASOS
- NEXRAD (Next Generation Radar)
- AWIPS (Advanced Weather Information Processing System
- Integrated Satellite Products

DESIGNED TO PRIMARILY MEET AVIATION NEEDS

- Provides "Continuous Weather Watch" and Minute-by-Minute Updates

- Reports Basic Weather Elements:

  - Wind, Temperature, Dew Point, Pressure
  - Sky Condition (up to 12,000 feet)
  - Visibility (to 10 miles)
  - Present Weather (Precipitation Occurrence, Type, Intensity & Amount, and Freezing Rain)
  - Selected "Obstruction to Vision" - Fog vs Haze
  - Selected Remarks Related to Sky Condition, Visibility, Precipitation Begin/End Times, Temperature, Pressure, Wind

- Observes, Archives, & Transmits Observations Automatically

- Located at ~ 800 Airports Around the Country

- Supportive Communication for Aviation & Meteorological Users

ASOS DATA FROM COMMISSIONED SITES

- Primarily Supports Aviation Needs
- Also Used In Meteorological Models
- Ultimately Archived & Available From NCDC
- Built-In Remote Access Features
- Special Event Data Capture
- Local & National Quality Control

ASOS PRODUCTION CONTRACTS STATUS
AS OF 5/31/96

BASE PROGRAM	NWS	FAA	DOD	TOTAL
Purchased	270	537	98	905
Installed	247	413	59	719
Accepted	245	405	55	705

AS OF 5/31/96

ADDITIONAL ASOS	NWS	FAA	DOD	TOTAL
Purchased	25	0	12	37
Installed	2	0	9	11
Accepted	1	0	9	10

TOTALS: PURCHASED = 942 INSTALLED = 730 ACCEPTED = 715

ASOS WIND SENSOR SPECIFICATION

- SPEED
  Range: 0 to 125 Knots
  Accuracy: + /-2 Knots Or 5%, Whichever Is Greater
  Resolution: 1 Knot

- Direction
  Accuracy: + /-5 degree & wind speed OF 5 Knots & Above
  Resolution Nearest Degree (0 To 359 Degrees)

- OPERATING & Withstanding Requirements With Respect To Wind (Steady)
  Operational Test Limit: 30 Knots
  Withstanding Test Limit: 73 Knots

- OPERATING & Withstanding Requirements With Respect To Wind (Gust)
  Operational Test Limit: 46 Knots
  Withstanding Test Limit: 125 Knots

ASOS WIND DATA

Sensor: Manufactured By Belfort Instrument

Theory of Operation: Wind Sensor Consists Of Rotating Wind Speed Cups & A Wind Direction Vane. The Wind Speed Sensing Technique Uses A Rotating Disk With An Optical Sensor. The Wind Direction Sensing Technique Uses A Variable Resistor Attached To The Vane.

Performance:

- Still Have Some Freeze-Up Problems

Future Plans:

- Ice Free Wind Sensor (3 Vendor Types Under Test & Evaluation)

- Incorporate 3-Second Wind Once Approved Through Office Of The Federal Coordinator For Meteorology (OFCM)

THE ASOS WIND SENSOR

- Wind Speed
  - Sensor Provides 5s Avg
  - ASOS Reports 2-Min Avg
  - Updated Each Minute
  - Archived For 12 Hours

- Wind Direction
  - Sensor Provides 5s Avg
  - ASOS Reports 2-Min Scalar Avg
  - Updated Each Minute
    Archived For 12 Hours

- Wind Gust
  - Max 5s Wind During Past Minute
  - At Least 10 Knot Variation Between Peaks & Lulls
  - ASOS May Report For Up To 10 Minutes
  - Max 5s Wind Data Archived For 12 Hours

- Wind Shift
  - Compare Current Wind Direction With Direction 15 Min Prior
  - Shift Reported If Change In Direction $\geq 45^{\circ}$
  - With Wind Speeds Over 9 Knots
  - Archived In Observation Log For 31 Days

ASOS WIND DATA - CONTINUED

- Peak Wind
  - ASOS Generates Remark If Max 5s Wind Speed Since Last Hourly > 25 Knots
  - Daily Summary Records Max 5s Wind Speed Observed During Entire Day
  - Archived For 31 Days

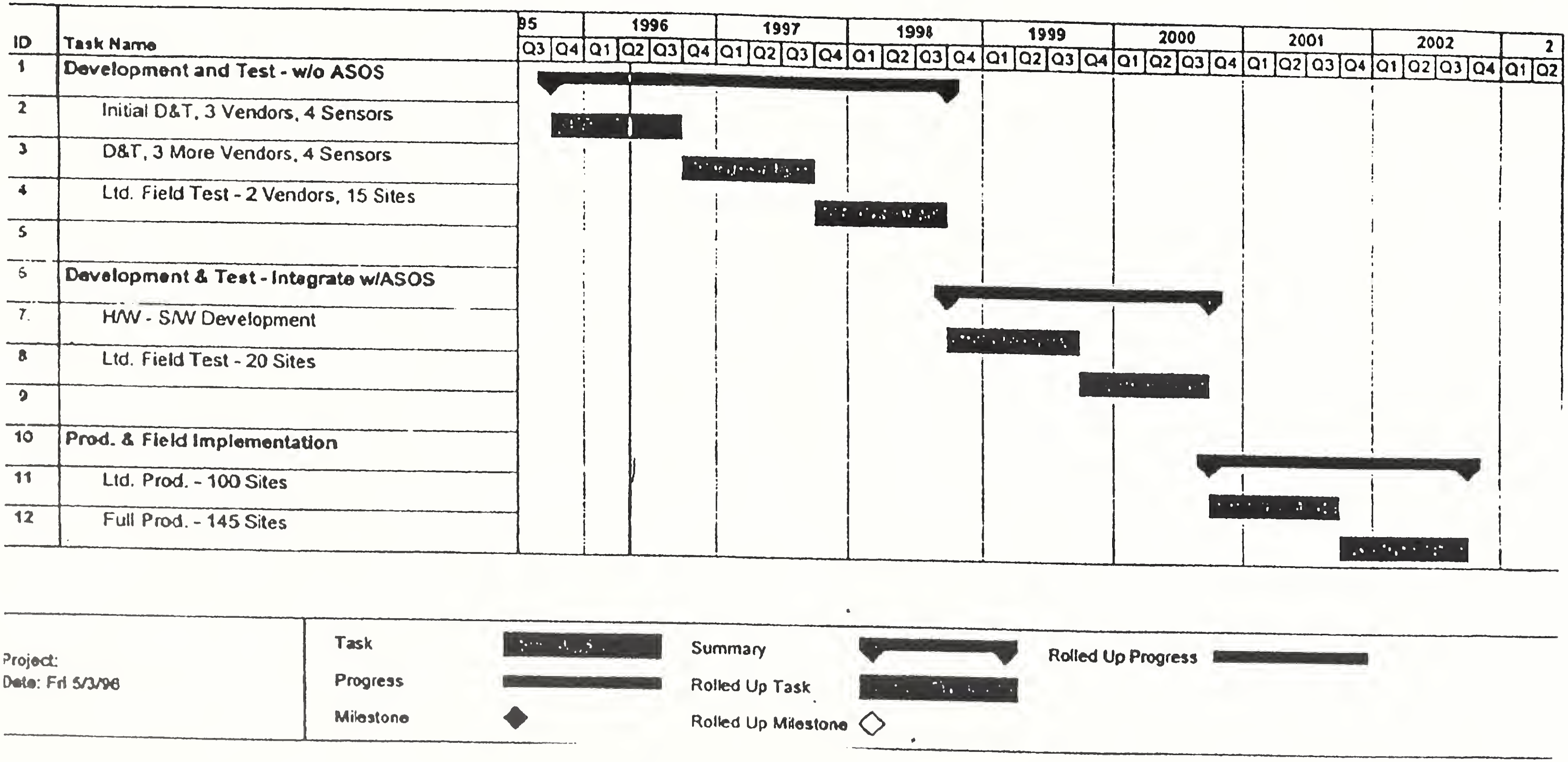
- Peak Squalls
  - Squall (SOA) = Increase In Wind Speed Of 15 Knots Or More, Sustained At 20 Knots For At Least 1 Minute
  - Squall (METAR) = Increase In Wind Speed Of 16 Knots Or More, Sustained At 22 Knots For At Least 1 Minute
  - Archived In Observation Log For 31 Days

PLANNED PRODUCT IMPROVEMENTS

Ice-Free Wind Sensor:

- Initial Development Testing Began December 1995
- Three Vendors, 2 ultrasonic & 1 Heated Cup/Vane
- 2nd Request for Proposal Issued in Commerce Business Daily
  April 1996
- Expect To Purchase Additional Sensors This Summer

ASOS Product Improvement
Ice Free Wind Sensor



INTRODUCTION

Wind-related work at NSSL and collaborators

- Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX)
  - How do tornadoes form?
  - What is the airflow in tornadoes
- Hurricanes, dust devils, and other critters
- Tornado climatology

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MOBILE/DEPLOYABLE MESONET

What They can do

- Fully mobile use
  - collect wind p, T, RH, GPS location every 2 seconds.
  - can/have withstood winds of >45 m/s (vehicle failure is limiting factor).
  - Used to document a variety of severe storm and larger-scale phenomena.
- Deployable
  - 5-m masts are being developed.
  - Will collect data as often as every 2 seconds for as much as 24 h.
  - Anemometer will withstand winds of 100 m/s; tower will be engineered to withstand strong winds and some limited debris impaction.
  - Deployment time < 30 minutes

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TURTLES

1 hour of 1-second observations
Pressure, Temperature, Humidity
Wind?

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SUMMARY, PLANS POSSIBILITIES

VORTEX analysis is ongoing

- Understanding, predicting tornadogenesis (5-years; 10 years)
- Predicting tornado intensity based on environment, parent storm characteristics could be possible (10-20 years)
- Improved warning capabilities (beginning next few years)

Hurricane Studies at Landfall Experiment (HUSTLE) proposed for next 5 hurricane sessions
Tornado climatology (where/when/how often/how intense?)

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SUMMARY, PLANS, POSSIBILITIES

VORTEX analysis is ongoing
Hurricane Studies at Landfall Experiment (HUSTLE)
proposed for next 5 hurricane sessions
Tornado climatology (where/when/how often/how intense?)

- NEXRAD shows storms capable of producing tornadoes.
- Improved reporting will tell us what fraction of these produce tornadoes.
- Geographical distribution gaps filled using radar indications.
-

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SUMMARY, PLANS, POSSIBILITIES

VORTEX analysis is ongoing
Hurricane Studies at Landfall Experiment (HUSTLE) proposed for
next 5 hurricane seasons

- 3-D mapping of wind (including near the ground), with one emphasis being the "critters" that cause damage locally more intense than the larger-scale hurricane winds.
- Will use dual-DOW radars.
- Will deploy MESONET instruments.
- Will collaborate with the Hurricane Research Division of AOML. (http://www.aoml.noaa.gov/hrd/)

Tornado climatology (where/when/how often/how intense?)

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U.S. WEATHER RESEARCH PROGRAM

- Needed - weather services for a qualitatively different world
- Agriculture/food
- Water resources
- Energy
- Transportation
- New Weather Services, Beyond 2000
- Must be seamless!

TASKS:

- Eliminate blind spots
- Predict high-impact weather
- Communicate impacts to users
- Accelerate user benefits from R&D

Progress to Date:

- Set scientific objectives and priorities
- Modest grant program with NOAA/NSF
- NOAA in-house grants program
- Reworking NOAA/NSF base Program ($30-40M)

HURRICANE AND THUNDERSTORM MODELING: STRUCTURAL RELIABILITY ISSUES

Emil Simiu
NIST Fellow
Building and Fire Research Laboratory
National Institute of Standards and Technology

To achieve risk-consistent and therefore safer and more economical designs, wind loads must be modeled realistically. In particular, margins of safety - which affect significantly structural reliability - must account for the fact that the variability of hurricane wind speeds is considerably larger than that of extra tropical wind speeds. This fact, which was documented recently in connection with the development of safety margins for wind loads, is not adequately reflected in the ASCE 7-95 Standard. Additional issues are the development of realistic distributional models for winds in areas in which extreme winds are associated with thunderstorms. Finally, wind directionality effects, which are explicitly accounted for in the latest British Code of Practice but not in the ASCE Standard 7-95, need to be addressed from both the climatological and design points of view.

UNDERWRITING THE WIND PERIL: LOSS ESTIMATION MODELS, SPECIFIC RISK AND PORTFOLIO LOSS

D. Bryan Freeman
Assistant Vice President
State Farm Fire and Casualty Company

Underwriting is the act of accepting or rejecting risk.

- **Specific Risk Factors (to evaluate wind exposure)**
  - √ Location of Building
  - √ Type of Construction
  - √ Quality of Construction
  - √ Protection of Openings
  - √ Shape and Size of Building
  - √ Intervening Structures
- **Portfolio Loss Factors**
  - √ Location
  - √ Market Penetration
  - √ Event History and Probability

Modeling is the use of historical data to simulate the activity of a future event.

- **Philosophical Challenges to the Use of Models**
  - √ Insurance rate makers and regulators have always used historical loss data to determine the future rate levels.
  - √ Modeling companies consider their data and methodology as proprietary which creates a "black box" mystery.

Data Needed for Good Hurricane Models

√ Real Time Field Information including:
- Radius of Maximum Winds Peak Gusts
- Maximum Sustained Wind speeds
- Forward Speed of Storm
- Path of Storm

MODELING

Bryan Freeman
State Farm Insurance

Modeling, or simulation, is basically the development of computer programs that describe or model a particular hazard (hurricane, earthquake, hail, etc.) All system variables and their inter-relationships are included. A computer then "simulates" the activity of the system and generates various outputs.

Models may be deterministic or stochastic (probabilistic). Monte Carlo simulation models are stochastic models so the variables which they include are random variables. Numbers are generated from the probability distributions of the random variables to assign values to the variables for each model simulation.

Computer simulation models can provide powerful tools for the analyses of a wide variety of problems, especially problems which involve solutions that are difficult to obtain analytically. Many complex, real-world systems cannot be accurately described by a mathematical model which can be evaluated analytically. Thus, a simulation is often the only type of investigation possible.

THE HURRICANE MODEL

A hurricane model will develop simulated claims and other data as a result of real or simulated hurricanes. The primary variables are meteorological or geophysical in nature. They may be classified as frequency or severity variables. The frequency variables determine the number of occurrences within a given time period. Severity variables account for a hazard's force, size, and duration. These variables are of course random variables with stable (time independent) probability distributions.

The model simulates the physical occurrence of hurricanes by generating numbers from these probability distributions. These probability distributions are estimated using historical data combined with the knowledge of authoritative meteorologists and geophysicists.

Variables that change with time, i.e., the geographic distribution of exposure units, the insured property values, and the building construction types, are inputs into the model. The probability distribution of losses from hurricanes given these inputs is the model output. Per occurrence as well as annual aggregate distributions are estimated.

The model simulates the physical occurrences of the hurricanes along with their effects on exposed properties thousands of times to estimate the distributions of losses.

Much of the storm data used in the development of various models were obtained from the U. S. Government. The data has been collected and analyzed by various researchers of the National Weather Service. Complete and accurate meteorological data are available for most hurricanes that have struck the U.S. in this century.

INFRASTRUCTURE AND LIFELINES: INSURANCE INDUSTRY PERSPECTIVE

Dean C. Flesner
Vice President
State Farm Fire and Casualty Company

- √ Most infrastructure property is uninsured--thus, the full loss falls on the shoulders of taxpayers.

- √ While infrastructure losses do not impact insurers to the same degree as other property losses, insurers have a strong interest in improved infrastructure mitigation efforts. Successful infrastructure mitigation will have a positive impact on private property loss mitigation.

- √ While it is typically assumed insurer interest in loss reduction relates to increased profits, the real desire is to hold down the cost of insurance products.

- √ Many of the mitigation efforts relating to private property would be applicable to infrastructure properties.

- √ Though not directly related to this subject, it was noted (and strongly supported by most participants) that our inability to have accurate surface level wind speed measurements during hurricane events is a major deterrent to improved mitigation efforts.

- √ Insurers clearly recognize that life safety issues must take precedence over property damage reduction. However, it is felt that often property damage mitigation is considered unnecessary since insurance will provide restoration funding. (That's what I buy insurance for).

- √ Given another 10-15 years of property development in coastal areas, evacuation will not be a practical option in many populous and semi-populous areas--witness the gridlock created by Hurricane Opal in a low population area. Thus, loss resistant lifelines become critically important.

THE DISSEMINATION PROJECT: A DECISION SUPPORT TOOL FOR EMERGENCY MANAGERS.

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Rich Jesuroga
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Boulder, CO 80303
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SUMMARY

The National Weather Service (NWS) is in the midst of a multi-billion dollar modernization program that will provide very timely, accurate mesoscale weather data in Weather Service Forecast Offices (WSFOs) nationwide. While local area high-resolution weather data can be extremely valuable for emergency preparedness, emergency management agencies typically lack the meteorological expertise and computing capabilities to process advanced weather information in real-time. Thus, in association with its modernization program, the NWS has implemented a project called the NOAA Emergency Management Weather Dissemination Project (EMWDP) within the Forecast Systems Laboratory (FSL). This project conducts experiments to determine the use of advanced meteorological information by local government operations. [Small, 1993, 1994] The project's premise is that local emergency preparedness agencies including sheriff, and police departments can greatly benefit from appropriate high resolution information about local weather hazards. EMWDP focuses on four weather hazards of particular importance to emergency preparedness: flash floods, fire danger, severe weather and disruptive winter storms through the Experimental Dissemination System (EDS). The system uses high resolution weather data sets produced by numerical weather models such as the Local Analysis and Prediction System (LAPS) [McGinley et. Al. 1991] and Mesoscale Analysis and Prediction Systems (MAPS) [Benjamin et. al., 1991][Bleck and Benjamin, 1993] and the Weather Surveillance Radar 1988-Doppler (WSR-88D) radar. [Rasmussen and Smith, 1989] LAPS and MAPS Surface analyses provide hourly updates at 10 and 60 kilometer resolution respectively. The WSR-88D provides 5 minute updates at 2 km resolution that gives the user mesoscale detail about rainfall distribution that is not available from raingauge networks. [Smith and Lipschutz, 1990][Kelsch, 1992] In addition to images of weather and geographic data, the system computes and displays assertions, weather characteristics related to spatial (regions) and temporal (periods) objects such as river basins and storm evolution. [Kerpedjiev, 1994]

I. INTRODUCTION

In July of 1991, Denver was the location of the costliest hail storm in the history of the United States. This storm was tracked moving roughly southeast through Boulder county, across the center of Denver and then exited the southeast corner of Denver. It was an intense hailstorm that was depicted very well by the new computer systems located at FSL and the Denver WSFO. Meteorologists at the WSFO in Denver were at their stations tracking the storm and sending out watches and warnings in a timely and accurate manner. The Denver WSFO assumed that the accurate predictions of the path of the storm and the timely broadcast of watches and warnings would have been used by the local EM offices to mitigate the danger effectively.

However, that night and the following day, the news and the newspapers had images of injured little children being led off a local amusement park's Ferris wheel where they had been stuck through the storm. During the investigation that followed, it was found that although the warnings were sent out in a timely manner and were received by the EM offices, an experienced dispatcher at a local office, placed little regard to the warning and did not take the necessary actions.

This lack of communication between the weather service and the emergency management community is the focus of the dissemination project. Its purpose is to try to build a bridge between the weak links in the above scenario. It is believed that the dispatcher would have given more weight to the warning if it had been more effectively conveyed than as a simple text message, albeit a very accurate one. The maxim of a picture is worth a thousand words is followed closely. Therefore, the dissemination system uses images, graphs, tables, text and even sounds to provide the emergency manager with good weather information in an effective manner. The system is designed to be simple to use. It provides a lot of information in an uncluttered manner where the important information is highlighted and brought to the attention of the EM.

We describe the system architecture next. Then a brief history and the assessment of the prototype systems. The current status of the system is then described followed by our future plans.

II. DESCRIPTION

The EDS consists of a server and a set of Emergency Management Decision Support (EMDS) workstations located at local Emergency Operations Centers (EOCs). The server has four primary purposes: 1) data interpreter 2) database 3) file server and 4) messaging center. The server, called the Community Server (CS), is a server for and run by the community. The CS is the sole link to the local WSFO and retrieves data from the local WSFO to be distributed to, and displayed by the EMDS workstations. In addition to the group of emergency preparedness users called general users, the system will serve a class of users called expert users. These users could be from organizations that have expertise in particular fields of weather hazard. For example, the Urban Drainage and Flood Control District (UDFCD) of Denver will be an expert user with expertise in flash flooding. The expert users will interpret the weather data that reside in the CS and add value to it using their expertise. The improved product is then sent to the general users via the CS. At present, FSL emulates the role of the local WSFO as the weather data source.

EMWDP follows a simple technique to achieve its objective; take weather information from the local WSFO, geographic information from local sources and action rules from the EM's warning plans, combine them to generate a set of displays that are condensed, coherent information to the EM in a user friendly graphical format. The development methodology adopted in the EMWDP is to develop and install experimental weather decision support systems at various evaluation sites, get feedback from real users, and repeat the cycle again.

III. HISTORY

The first prototype version of the general user system was designed, built and installed in the Boulder EOC in the autumn of 1992. Five months later an improved version replaced the first. The second version was decommissioned in April, 1994. The meteorological information and depiction methodology was studied and assessed for its potential use by university researchers and city and county users.

In general the system was received very well. The systems graphical user interface (GUI) was easy to use and learn. Since the system included the NWS AFOS forecasts and watches and warnings that the users had depended on, the transition from the old technology to the new was relatively smooth. One of the premises of the prototype systems was that images of the weather would be very useful. It was assessed that although images were useful, they were still limited. The users found multi-modal displays which combined an image, graph, text and table as shown in Figure 1 to be much more valuable. [Subramaniam and Kerpedjiev, 1994]

IV. CURRENT STATUS

A. System Architecture

At present, the first demonstration version is being installed at the Boulder EOC, Denver Urban Drainage and Flood Control District (UDFCD), Denver WSFO and Colorado Department of Transportation (CDoT) in Denver. The CS is a PC running Windows NT Advanced Server. Communication to the remote display PC's (running Windows NT) is through NT's Remote Access Service (RAS) software and modems on a business telephone line.

An application called Monitor performs the messaging center function of the CS. The messaging center has 3 sub-functions: 1) passing messages between the CS and remote systems, 2) passing messages between the remote systems, and 3) keeping track and statistics of the remote systems. Using the statistical information we hope to assess EMWDP's system and communication technology.

B. Functionality

Currently, there are 2 spatial scales the user can select from. The Local scale covers most of the state of Colorado and parts of Wyoming, Kansas, Oklahoma and New Mexico. It corresponds to the LAPS scale and LAPS is the primary data source for this scale. It is the primary scale that the user will use. The wider National scale uses MAPS Surface Analysis and corresponds to the MAPS scale which covers the continental United States.

The display workstation has 2 display modes referred to as Picture mode and Probe mode. The Picture mode is used to view the weather and geographic/map information in various combinations. For example, a user interested in winter road hazards may wish to view an image of the snow accumulations with overlays of visibility, wind and highways as in Figure 2. This will help the user locate roads where driving conditions are hazardous. Then, they can make the decision to close or reroute traffic from that particular road or road section.

The Probe mode, on the other hand, lists all weather conditions within the area of interest. The user selects a region of interest and the system calculates the weather characteristics for that region. The information is presented in a tabular format along with attribute information about the region such as affected population and contact person as shown in Figure 3. For example, when the EM office sees that a particular region such as a medical facility is in an area of hazardous weather, the user will now have information regarding the number of people to be evacuated, a contact person at the site, and even a telephone number.

V. FUTURE PLANS

The system will have two additional modes in the near future:

- a **surveillance** mode which constantly monitors weather hazards according to user specified criteria. Upon detection of a hazard, it warns the user and lists the actions to be taken.

- a **text** mode that will display all the National Weather Service AFOS text products.

A third scale called the Metro scale will be added. This scale will primarily use high resolution data from the WSR-88D radar and information from the users of the Experimental Dissemination System. Also, an application tool kit will be included to allow users to:

- customize their display system to suite their individual needs. For example, users will be able to add a new region or region type to the territory database using a Territory Tool. The territory database contains all the definitions of spatial objects (regions) used by Probe and Surveillance modes. Also, using a similar tool called the Event Tool users will be able to define events as any combination of weather parameters. These events will be stored in the event database.

- send information back to the CS. For example, this tool will be used by expert users to outline an area that s/he believes has a weather hazard and then add some additional descriptive text. Both the graphics and the text will then be sent to the general users via the CS.

Finally, we will be moving the CS into the community. Specifically, the Denver UDFCD office.

REFERENCES

Kerpedjiev, S., "MeteoAssert: Generation and Organization of Weather Assertions from Gridded Data." Proceedings, Tenth International Conference on Artificial Intelligence for Applications, San Antonio, TX, IEEE Press, 4275-4281, (1994)

C. Subramaniam, and S. Kerpedjiev, "BRMS: Monitoring Basin Rainfall and Potential Flooding." Proceedings, International Emergency Management and Engineering Conference, Hollywood Beach, FL. Eds. J. D. Sullivan and S. Tufecki, 353-358, (1994)

S. Benjamin et al., "An Isentropic Three-Hourly Data Assimilation System Using ACARS Aircraft Observations." Monthly Weather Review, 119,4:888-906, (1991).

R. Bleck, and S. Benjamin, "Regional Weather Prediction with a Model Combining Terrain-Following and Isentropic Coordinates. Part I: Model Description." Monthly Weather Review, 121, 6:1771-1785, (1993).

M. Kelsch, "Estimating Maximum Convective Rainfall Rates for Radar-Derived Accumulations." Proceedings Fourth Workshop on Operational Meteorology, September 15-18, 1992, Whistler, B.C., Canada, (1992).

J. A. McGinley, S. C. Albers, and P. A. Stamus, "Validation of a Composite Convective Index as Defined by a Real-Time Local Analysis System." Weather and Forecasting, 6, 337-356, (1991).

E. Rasmussen and J. Smith, "Real Time Precipitation Accumulation Estimation using the NCAR CP-2 Doppler Radar." Preprints, 24 Conf. On Radar Meteor, March 27-31, 1989, Tallahassee, Fl., American Meteor. So., Boston, Mass., 236-239, (1989).

D. Small, "The Dissemination Project." FSL in Review Fiscal Year 1992, 5-7, (1993).

D. Small, "The Dissemination Project." FSL in Review Fiscal Year 1993, 5-9, (1994).

J. K. Smith and R. C. Lipschutz, "Performance of the NEXRAD Precipitation Algorithms in Colorado during 1989." Conference on Hydrometeorology, Oct. 22-26, 1990, Amer. Meteorological Soc., Boston, Mass, (1990).

REAL-TIME HURRICANE DAMAGE ASSESSMENT

Dr. Mark Powell
NOAA Hurricane Research Division, AOML, Miami, FL

Timely evacuations and preparations before hurricane landfall help to save lives and property but losses are inevitable even with perfect forecasts. Mitigating a portion of such losses may be possible by effective use of monitoring information during and after the event. During landfall of a tropical cyclone, real-time analyses of measurements gathered from reconnaissance aircraft, land, marine and space observation platforms can help to identify communities experiencing the most severe winds and storm surge. Real-time information on the actual areas impacted by a hurricane's eyewall and strongest winds should help minimize confusion and assist search and rescue and recovery management at the earliest stages of a disaster. With support from Florida Power and Light Company (FP&L), research on damage produced by Hurricanes Andrew and Hugo identified meteorological predictors that correlate well with observed utility and insurance industry loss ratios. Development of damage assessment models (based on relationships between observed damage from past storms and predictors derived from analyses of meteorological quantities) could yield estimates of damage before there is opportunity to conduct visual surveys. These damage estimates could then be coupled with geographic information systems and infrastructure and demographics databases to estimate the impact of the disaster for emergency managers and decision makers.

According to FP&L, even a 10% improvement in estimation of losses after a Hurricane-Andrew-type storm can save on the order of $1 billion. A simple, one-predictor damage assessment model has been constructed for FP&L to use this season. However, it may be risky to develop a model based on only one or two cases; if additional damage databases and wind field reconstruction's from past storms were available, the resulting developmental data set could allow construction of more sophisticated damage assessment models that could be applied to any hurricane based on input from real time meteorological analysis products.

RESPONSE AND RECOVERY:
THE INSURANCE INDUSTRY PERSPECTIVE

Dr. James W. Russell
Insurance Institute for Property Loss Reduction

Comment was offered regarding the importance of insurer claim operations following a catastrophic wind event. Also reference was made to the following organizations and their functions:

- Property Claims Service
  700 New Brunswick Avenue
  Rahway, NJ 07068

- Property Loss Research Bureau
  1501 Woodfield Road
  Schaumburg, IL 60173

The following subjects were addressed:

√ The competitiveness among insurers including the role of function of an insurer's claims operation

√ The necessity to expeditiously investigate, adjust and pay losses

√ The potential impact of Post Event Regulatory directives

√ The need for insurer claims personnel to gain quick access to affected areas

√ The importance of coordinating insurer activities with the federal, state and municipal emergency management operations

√ The future participation of insurers in Emergency Operations Centers

√ The inclusion of insurers on post disaster investigation teams

In conclusion, the composition, "Charge" and work of the IIPLR Response and Recovery Committee was reviewed. The "Charge" is as follows:

> The Response & Recovery Committee is responsible for developing post-event loss reduction policies and procedures which identify what went wrong, e.g., deficiency in building codes, lax enforcement, material and structural design problems, etc. Further, the Committee will examine issues and procedures which would expedite the recovery process. The Committee will **not** engage in matters involving loss adjustment procedures, techniques or interpretation of coverage.

COASTAL ZONE MANAGEMENT: A TOOL FOR COASTAL MITIGATION

Dean C. Flesner
Vice President
State Farm Fire and Casualty Company

- √ Coastal zone management efforts have successfully elevated the focus on shoreline preservation over the past two plus decades.

- √ Recognizing that CZM efforts must remain within the parameters of enabling legislation, there is a need to broaden the CZM mission to take advantage of mitigation opportunities.

- √ Possible areas of expansion include:

  More emphasis on the quality of structures built in coastal areas
  Enlarge the geographic areas to which the CZM process applies

- √ Recent work by Dr. Orrin Pilkey at Duke University has greatly enhanced our knowledge of hazard characteristics on barrier islands. His published studies provide a means to evaluate the degree of hazard associated with individual building sites.

- √ The Lucas case, and others, have established that coastal property owners generally cannot be denied opportunity to develop their real property without compensation. However, much can be done with design and building code requirements--i.e., to build on defined coastal properties one must meet wind resistance and other building standards appropriate for the degree of hazard inherent in the location. This has worked effectively in areas exposed to urban wildfires.

- √ As insurers loss prediction models are refined, it is likely more area specific hazard data will be incorporated.

- √ Continuing studies of wind borne debris, and the influence of topographical features will help define geographic boundaries of coastal areas to which CZM efforts could/should be applied effectively.

A NEW GENERATION OF STANDARDS/ASSESSMENT TOOLS FOR WIND EFFECTS

Emil Simiu
NIST FELLOW
Structures Division
Building and Fire Research Laboratory
National Institute of Standards and Technology

Current data storage and computational capabilities allow the development of a new generation of standards whose provisions on wind loads can be structured as knowledge-based systems drawing the requisite information from large data bases. Examples were presented demonstrating that such provisions could be significantly more realistic and risk-consistent, and thus result in significantly safer and more economical designs, than their conventional counterparts which are of necessity based on reductive formulas, tables and plots. In addition to serving structural designers' needs, knowledge-based standard provisions could serve the insurance industry as certified hazard assessment tools that would be more realistic and dependable than similar tools developed without the benefit of careful public scrutiny and broad professional consensus.

WIND LOADS AND MANUFACTURED HOMES IMPLEMENTING EXISTING KNOWLEDGE

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Leader, Structural Evaluation Group
Structures Division
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, Maryland 20899

ABSTRACT

Using the wind load provision of the Manufactured Home Construction and Safety Standards (MHCSS) that were in effect at the time of Hurricane Andrew (1992), probabilities of failure in hurricane-prone areas such as Dade County, Florida, were found to be approximately 10 times the corresponding failure probabilities associated with ASCE Standard 7-93. Although much higher levels of structural reliability can be expected for manufactured homes designed in accordance with the revised MHCSS (1994), problems remain for homes designed for non-hurricane areas such as Omaha, Nebraska. However, it is the anchorage or tie-down requirements for manufactured homes that are in greatest need of improvement. Test data for various components of traditional anchoring systems show that the load capacity of these systems is substantially less than the load capacities implied by current standards covering the installation of manufactured homes. Permanent foundations offer the greatest promise for protection against both wind and seismic effects. If traditional anchoring systems that utilize shallow auger-type anchors are to be used, these systems should be designed on the basis of factored wind loads, and preloading of all anchors should be made an integral part of the installation process. A review of new products coming on the market suggests there are several cost-effective alternatives to the traditional shallow anchor system that can provide adequate windstorm protection.

MITIGATION: THE INSURANCE INDUSTRY PERSPECTIVE

John J. Mulady
Director, Industry Relations
United Services Automobile Association

Speaking as the Chairman of the IIPLR Building Code Committee, John J. Mulady reviewed and discussed the following topics:

- **Building Code Effectiveness Grading Schedule**

  - √ Developed by IIPLR - 1993-94. Turned over to ISO in 1994 for implementation.
  - √ Implemented in Florida, South Carolina, North Carolina in 1995.
  - √ Texas, Alabama, Georgia, Delaware, New Jersey, Maryland, New Hampshire, Massachusetts, Rhode Island, are to be graded in 1996.
  - √ Florida Statute 627-0269 requires BCEGS

IIPLR Building Code Initiatives

  - √ Developed and published An Introduction to Codes and Standards.
  - √ Prepared and published guideline for the practice of Code Enforcement Administration.
  - √ Developed Insurance Industry Wind & Seismic Training Programs.
  - √ Produced the Summary of the State Mandated Codes - 1996.
  - √ Prepared and presented Wind & Seismic Training for Building Code Officials.
  - √ Provided support for State Initiatives for Statewide Building Codes.
  - √ Worked with UL - producing Roofing Standards: A Hail Testing Protocol.
  - √ Conducted Surveys of Homeowners in Wind & Seismic locales.

10. LABORATORIES AND EXPERTISE

NATIONAL CLIMATIC DATA CENTER

Dr. Kenneth D. Hadeen, Director
Asheville, North Carolina

The National Climatic Data Center (NCDC) is the world's largest active archive of weather data. It is a component of the National Environmental Satellite, Data and Information Service (NESDIS), which is part of the National Oceanic and Atmospheric Administration (NOAA). NOAA, in turn, is a part of the U.S. Department of Commerce. All Federal guidelines have been followed to preserve the NCDC, known as the "National Resource for Climatic Information."

NCDC provides the historical perspective on climate. With the use of more than 100 years of weather observations, reference data bases are generated. With this knowledge, NCDC's clients can learn from the past to prepare for a better tomorrow. Wise use of our most valuable natural resource--**climate**--is the goal of climate researchers, state and regional climate centers, businesses, and commerce. NCDC's data and information are available to everyone, including the general public, industry, the legal profession, engineering, agriculture, and government.

From Ben Franklin and Thomas Jefferson's weather observations to today's data derived from the most modern weather satellite, the archives at NCDC contain a treasure trove of information. Through exacting standards and vigorous quality assurance practices, NCDC continues to build the world's most complete climatological reference data bases. Such data are essential for analyses of the earth's recent climatic history. A historical perspective of today's climate conditions helps decision-makers plan for tomorrow. An active dissemination function completes the data cycle of this modern climate center.

Evidence is mounting that global climate is changing; the extent to which humans are responsible is still being studied. Regardless of the causes, compiling a baseline of long-term climate data is essential; therefore, global data must be acquired, quality controlled, and archived. Working with international institutions such as the International Council of Scientific Unions, the World Data Centers, and the World Meteorological Organization, NCDC develops standards by which data can be exchanged and made accessible.

Brief History

In November 1951, the Weather Bureau, Air Force, and Navy Tabulation Units in New Orleans, Louisiana, were combined to form the National Weather Records Center in Asheville, North Carolina. Authority to establish it was granted under section 506 USC of the Federal Records Act of 1950 (Public Law 754, 81st Congress). The Center was eventually renamed the National Climatic Data Center (NCDC). The National Archives and Records Administration has designated NCDC as the Commerce Department's only Agency Records Center.

Over the years, NCDC gained new responsibilities. Data began to be received in ever-increasing amounts. These data became the roots from which U.S. climatology began to grow. Regional processing centers were combined in the 1960's to form the world's largest climatic center. Collocated with the NCDC are the Defense department's Air Force and Navy climatological centers. The resultant Federal

Climate Complex has facilitated the sharing of resources, computers, and expertise, ensuring that American taxpayers get the most for their tax dollars.
In the 1980's the push for a National Climate Services System began. The system's purpose is to draw together climatic activities at all levels of government. At the heart of this system is the **National Climatic Data Center**--for without data, no climate system can be successful.

Organization and Infrastructure

The NCDC is organized into three divisions:

- Operations and Support Division
- Global Climate Laboratory
- Climate Services Division

Contributions to NOAA's Mission

NCDC archives weather data obtained by the National Weather Service (NWS), military services, Federal Aviation Administration, and the Coast Guard, as well as that obtained from voluntary cooperative observers. NCDC has increased data acquisition capabilities to ingest new data streams such as NEXRAD and ASOS. Improving quality control, continuity, and timely availability of these new data sets have been paramount. As operator of the World Data Center-A for Meteorology, which provides for international data exchange, NCDC also collects data from around the world. It has more than 150 years of data on hand, with 55 gigabytes of new information added each day--equivalent to 18 million pages a day.

Data are received from a wide range of sources, including satellites, radar, remote sensing systems, NWS cooperative observers, aircraft, ships, radiosonde, wind profiler, rocketsonde, solar radiation networks, and NWS Forecast/Warnings/Analyses Products. NCDC supports many forms of data and information dissemination, including paper copies of original records, publications, atlases, computer printouts, microfiche, microfilm, movie loops, photographs, magnetic tapes, floppy disks, CD-ROM's, electronic mail, on-line dial-up, telephone, facsimiles, and personal visits.

NCDC archives 99 percent of all NOAA data, including over 320 million paper records; 1.2 million microfiche records; 510,360 tape cartridges/magnetic tapes; and satellite weather images dating back to 1960. NCDC annually publishes over 700,000 copies of climate publications that are sent to individual users and 33,000 subscribers. NCDC maintains 544 data sets to respond to more than 917,000 user contacts each year.

Producing numerous climate publications and responding to requests from all over the world, NCDC provides historical perspectives on climate that are vital to studies on global climate change, the greenhouse effect, and other environmental issues. NCDC stores information essential to industry, agriculture, science, hydrology, transportation, recreation, and engineering. This information can result in savings of tens of millions of dollars to concerned parties.

The NWS Cooperative Network, composed largely of 8,000 volunteer observers, has been making daily records since the 1880's. Ships at sea have also been observing the weather essentially the same way for more than 100 years.

However, new observing systems have been developed as technology has advanced. As aircraft began to fill the skies, information on the upper atmosphere was needed. Balloon-borne instruments radioed data; radars began to probe clouds; rockets reached the fringes of the atmosphere; and weather satellites, both geostationary and polar orbiting, now continuously watch the weather. These data are all archived by the NCDC.

Publications

Climatological publications have been produced and disseminated for more than 100 years.

Local Climatological Data (LCD), is produced monthly and annually for some 270 cities. LCD contains 3-hourly, daily, and monthly values. The annual issue contains the year in review, plus normals, means, and extremes.

Climatological Data (CD), also produced monthly and annually, contains daily temperature and precipitation data for more than 8,000 locations. CD is published by state or region (New England) with a total of 45 issues produced each month.

Hourly Precipitation Data (HPD) is produced monthly. It contains data on nearly 3,000 hourly precipitation stations and is published by state or region.

Storm Data (SD) documents significant U.S. storms and contains statistics on property damage, human injuries, and deaths.

Monthly Climatic Data for the World (MCDW) provides monthly statistics for some 1,500 surface stations and approximately 800 upper air stations.

In addition to these publications, NCDC also generates many non-periodicals, including normals, probabilities, long-term station and state summaries, and several atlases covering the land areas, coastal zones, and oceans of the world.

Economic Applications of NCDC Data/Services

Many sectors of the U.S. economy are highly dependent upon the climate data and services that NCDC provides. Some of these economic components include:

--Consulting Meteorologist Firms: Provide expert testimony in court to resolve cases involving the economic health of businesses and individuals.

--Attorneys: Settle legal disputes to ensure the continued operation and growth of business and industry.

--Insurance Industry: Settle weather-related disaster claims and provide casualty coverage for entertainment/sports events.

--Engineering, Marine, and Architectural Firms: Provide guidance in the design and construction of airports, port facilities, highway and dam projects, and electrical power plants.

--Public Utilities: Determine levels of electrical/gas demand, compute rate adjustments, research alternative energy sources, and conduct air pollution studies.

--Oil Companies: Determine timing of offshore oil drilling platform construction and plan the transport of personnel and materials to drilling locations.

--Manufacturers: Determine impact of weather/climate on product sales, develop optimum marketing strategies, and determine locations and climate conditions for product testing.

--Agribusinesses: Study effects of climate variations on crop yields, determine optimal geographic locations for crop types, and plan for applications of herbicides and pesticides.

--Transportation Companies: Determine favorable air; sea, and land routes for transport of goods and commodities; expedite transport of perishable goods.

--Housing/Real Estate Companies: Determine construction deadline penalties and extensions and assist in site selection for resort and retirement developments.

--Emergency Management Organizations: Use NEXRAD Doppler and other radar products to determine economic assistance for victims of natural disasters.

--Physicians/Medical Research Centers: Conduct research on the correlation between climate and diseases/physical disorders.

--Communications Industry: Assists with meteorological fact verification, plans for motion picture and television filming activities, and conducts microwave attenuation studies for tower planning.

--Research Institutes: Although climate research does not directly affect the Nation's economy, climate change studies ultimately impact the design of machinery, the use of alternative energy sources, and the amount of energy required by utility companies to service customers.

International Cooperation

Climate knows no political or geographical boundaries; it is a global phenomenon. To support the human quest to understand the entire climate system, data on a global scale must be archived, analyzed, and made available.

For NCDC, therefore, cooperation is an international as well as a national practice. Through numerous international agreements with individual nations and with groups like the World Meteorological Organization, NCDC continues to foster global exchange of data to enhance the global understanding of climate.

The global weather and climate community has established a communications network to flash observations around the world in a matter of seconds. These data are supplied to NCDC by the NWS National Centers for Environmental Prediction, the Air Force's Global Weather Central, and the Navy's Fleet Numerical Meteorology and Oceanography Command.

National Centers for Environmental Prediction, the Air Force's Global Weather Central, and the Navy's Fleet Numerical Meteorology and Oceanography Command.

NCDC also maintains World Data Center-A for Meteorology. The four World Centers (United States, Russia, Western Europe, and China) have created a free and open atmosphere in which data are exchanged and dialogue can take place.

The World Meteorological Organization, through its Resolution 35, has established the mechanisms for exchanging marine observations among participating countries. This exchange is perhaps the prime example of country-to-country cooperation over several decades.

However, to supplement all of the exchanges referred to above, NCDC also maintains cooperative agreements with individual countries. In exchange for U.S. data and information, those countries make their own data and information available.

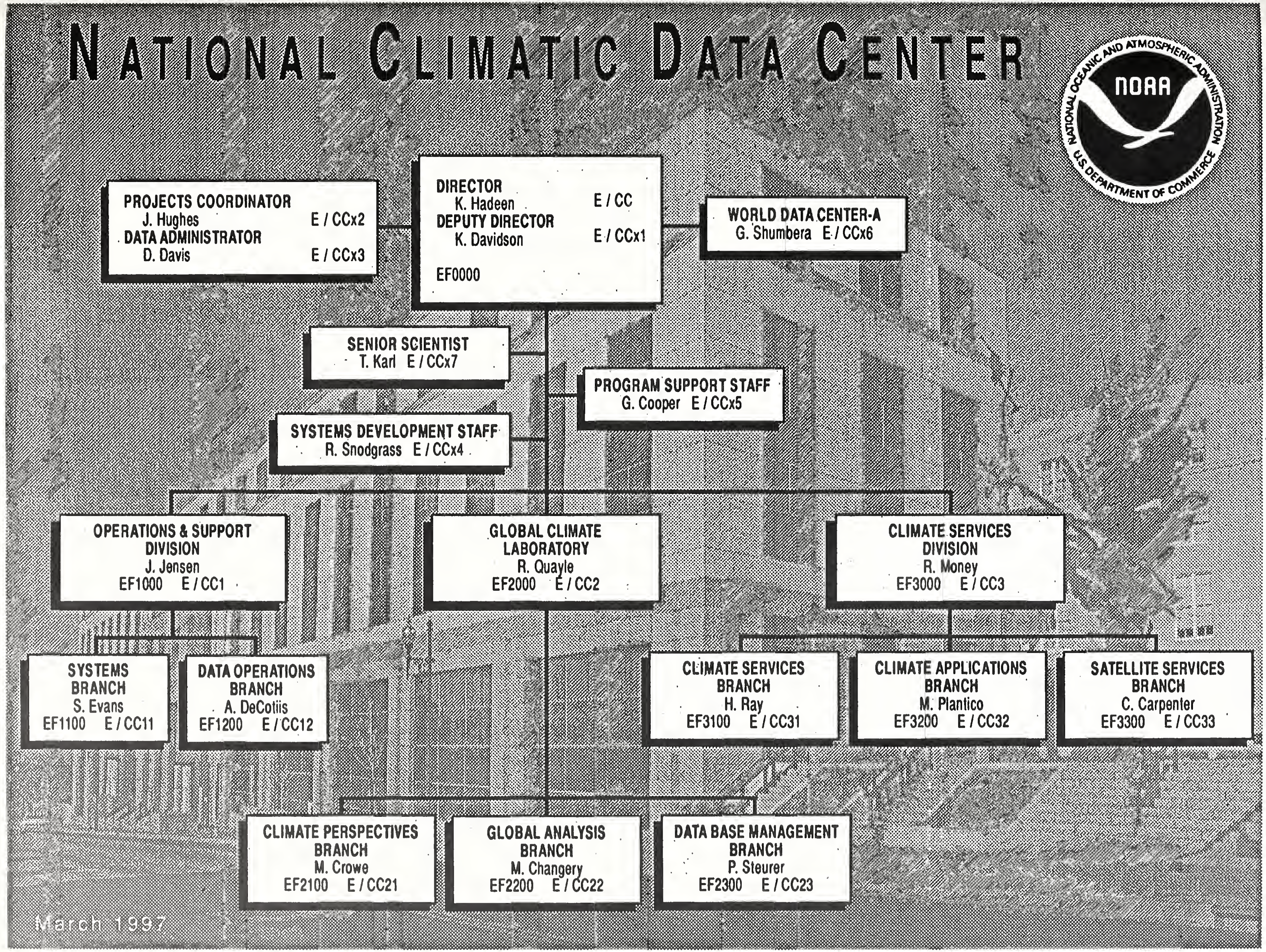
In today's high-speed, high-technology world, remaining in constant communication around the globe is crucial. The National Climatic Data Center is linked to the world's observing system, to the users of climate data, and to managers of climate organizations.

Servicing customers is a major source of pride for the staff of the National Climatic Data Center. NCDC's customers come not only from across America but from every corner of the globe.

Future Directions

Responding to national climatological needs has been a tradition at NCDC since its inception in the 1950's. We as a nation are learning that in the making of many policy decisions climate must be considered.

The future of climate data presents a challenge. Data-sensor technology and more rapid communications will overwhelm the climate system with huge volumes of data unless new solutions are found and implemented. High-resolution ASOS and NEXRAD present an immense challenges for NCDC. ASOS one-and five-minute data are ingested in near-real-time. Approximately 100 gigabytes per year of data will be received when all stations are commissioned. NEXRAD data is arriving at the incredible rate of 120 terabytes per year. However, the pay-off will be greater understanding of climatological processes from the global scale down to microscale and improved documentation of our climate.



NATIONAL CLIMATIC DATA CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE
NOAA
PROJECTS COORDINATOR J. Hughes E / CCx2
DATA ADMINISTRATOR D. Davis E / CCx3
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WORLD DATA CENTER-A G. Shumbera E / CCx6
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PROGRAM SUPPORT STAFF G. Cooper E / CCx5
SYSTEMS DEVELOPMENT STAFF R. Snodgrass E / CCx4
OPERATIONS & SUPPORT DIVISION J. Jensen EF1000 E / CC1
GLOBAL CLIMATE LABORATORY R. Quayle EF2000 E / CC2
CLIMATE SERVICES DIVISION R. Money EF3000 E / CC3
SYSTEMS BRANCH S. Evans EF1100 E / CC11
DATA OPERATIONS BRANCH A. DeCotiis EF1200 E / CC12
CLIMATE SERVICES BRANCH H. Ray EF3100 E / CC31
CLIMATE APPLICATIONS BRANCH M. Plantico EF3200 E / CC32
SATELLITE SERVICES BRANCH C. Carpenter EF3300 E / CC33
CLIMATE PERSPECTIVES BRANCH M. Crowe EF2100 E / CC21
GLOBAL ANALYSIS BRANCH M. Changery EF2200 E / CC22
DATA BASE MANAGEMENT BRANCH P. Steurer EF2300 E / CC23
March 1997

	HEADQUARTERS	LOCATION	PHONE NUMBER
ERL	Director	Silver Spring, MD	(301) 713-2458 x134
ERL	Deputy Director	Silver Spring, MD	(301) 713-2474 x114
AD	Associate Director	Boulder, CO	(303) 497-6000
AL	Aeronomy Laboratory	Boulder, CO	(303) 497-3134
AOML	Atlantic Oceanographic and Meteorological Laboratory	Miami, FL	(304) 361-4300
ARL	Air Resources Laboratory	Silver Spring, MD	(301) 713-0684 x100
CDC	Climate Diagnostics Center	Boulder, CO	(303) 497-6640
CMDL	Climate Monitoring and Diagnostics Laboratory	Boulder, CO	(303) 497-6074
ETL	Environmental Technology	Boulder, CO	(303) 497-6291
FSL	Forecast Systems Technology Laboratory	Boulder, CO	(303) 497-6818
GFDL	Geophysical Fluid Dynamics Laboratory	Princeton, NJ	(609) 452-6502
FLERL	Great Lakes Environmental Research Laboratory	Ann Arbor, MI	(313) 741-2244
NSSL	National Severe Storms Laboratory	Norman, OK	(405) 366-0427
PMEL	Pacific Marine Environmental Laboratory	Seattle, WA	(206) 526-6800
SEC	Space Environment Center	Boulder, CO	(303) 497-3311

ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

Miami, Florida
Kristina B. Katsaros, Director

The Atlantic Oceanographic and Meteorological Laboratory (AOML) conducts research in oceanography and tropical meteorology. Its oceanographic investigations center on fluxes of energy, momentum, and materials through the air-sea interface; the transport and composition (thermal and chemical) of ocean and coastal water masses; and the structure and dynamical processes on the sea floor. AOML's meteorological investigations are conducted to improve the description, understanding, and prediction of hurricanes and tropical meteorology. AOML maintains an eclectic mix of research initiatives, with efforts falling into two general types.

- Theoretical research, which seeks to answer a specific question, for example, What are the mechanisms and physical processes responsible for hurricane steering? The product of these efforts is scientific knowledge that is disseminated to hurricane forecasters and in publications, reports, and meetings.
- Observational research, which is performed to provide services, data products, and information for a wide variety of end-users in government, academia, and the private sector. Examples include upper-ocean thermal data acquisition, quality control, dissemination, and archival.

The initiatives at AOML have shifted toward observational science in recent years, with AOML products and accomplishments increasingly taking the form of large, multi-year sets of basic and derived environmental data.

Brief History

AOML traces its origins to the founding in June 1967 of the Environmental Sciences Service Administration (ESSA) Atlantic Oceanographic Laboratory; it operated in leased office space in Miami, Florida. Construction of a federally owned building specifically designed to house the laboratory was begun on Virginia Key, Florida, in 1969 and completed in 1972. In February 1973 the laboratory was dedicated as the Atlantic Oceanographic and Meteorological Laboratory, part of the then recently formed National Oceanic and Atmospheric Administration.

Organization and Infrastructure

Divisions: AOML is organized into four divisions:

- Physical Oceanography Division
- Hurricane Research Division
- Ocean Chemistry Division
- Ocean Acoustics Division

People: AOML employs 107 FTE Federal staff and approximately 40 contract, NOAA Corps, and temporary personnel (postdoctoral students, visiting scientists, and other students). In addition there are 12 personnel from the Cooperative Institute for Marine and Atmospheric Studies (CIMAS).

Facilities: AOML occupies a 7,000 m^2 building on approximately 5ha of federally owned land on Virginia Key, a small island separated from Miami proper by Biscayne Bay. Co-located on Virginia Key are the Rosenstiel School and CIMAS.

Budget: AOML's FY95 budget was $13.4 million, of which 90% was from NOAA sources and 10% from outside sources.

Partnerships

The Cooperative Institute for Marine and Atmospheric Studies (CIMAS) is a Cooperative Institute between NOAA/ERL/AOML, the Rosenstiel School of Marine and Atmospheric Science of the University of Miami, and the South East Fisheries Center (SEFC) of NOAA's National Marine Fisheries Service. CIMAS enhances NOAA-Rosenstiel School synergisms and thus promotes both the quality and the attractiveness of the laboratories as a working environment and center of excellence in areas important to the fulfillment of NOAA's missions. By arranging for short-term visiting specialists and engaging graduate students and postdoctoral fellows, CIMAS provides a mechanism for rapidly concentrating expertise and effort on topics complementary to the directed research programs of AOML, SEFC, and the Rosenstiel School.

Significant Accomplishments

- AOML demonstrated that observations with dropsondes deployed from aircraft can reduce errors in hurricane track forecasts by 16-30%, with concomitant savings in hurricane overwarning costs. This result led to NOAA's acquisition of a Gulfstream IV Jet to take these observations more efficiently.

- From 1962 through 1983 Project STORMFURY sought to diminish the destructive force of hurricane winds by artificially seeding hurricane clouds in order to induce formation of a second hurricane eyewall outside of the original eyewall. In theory this would have led to decreased maximum winds due to conservation of angular momentum. AOML research in the 1980's showed that preliminary positive results from Project STORMFURY were actually a misinterpretation of naturally occurring eyewall replacement phenomena, and that the project had little prospect for success because hurricane clouds do not contain enough supercooled water for effective cloud seeding.

Contributions to NOAA's Mission

AOML actively contributes to the accomplishment of NOAA's mission in the following elements of NOAA's Strategic Plan: Rebuild Sustainable Fisheries, Sustain Health Coasts, Advance Short-Term Warning and Forecast Services, Implement Seasonal to Interannual Climate Forecasts, and Predict and Assess Decadal to Centennial Changes. AOML's research supports NOAA's missions in climate, weather and ocean services, marine environmental assessment, and marine resources.

Recent Highlights

- AOML developed and used airborne, in situ, and Doppler observations to advance physical understanding of hurricane structure and intensity change.

- AOML performed real-time analysis of and displayed data observed by aircraft flying in hurricanes, notably surface winds and radar images. These data provide invaluable support for forecasters at the National Hurricane Center.

- AOML established and operates the Upper Ocean Thermal Center, which receives raw upper-ocean temperature profiles and performs quality control procedures on each individual profile before making the data available to researchers worldwide. Similarly, AOML operates the Global Drifter Center, which maintains the global distribution of drifting buoys. These buoys provide data on surface currents and meteorological parameters, which are relayed via satellite in near-real time. AOML provides drifter data that are paramount to the weather and climate forecasts prepared by NOAA's National Weather Service (NWS), the U. S. Navy, and private agencies.

- AOML pioneered the use of autonomous Lowered Acoustic Doppler Current Profilers (LADCP). These instruments generate three-dimensional profiles of water movement as they are deployed and recovered from research ships. AOML use of LADCP data has illustrated, among other things, that throughflow from the Southern Hemisphere, through the passages of the lesser Antilles, is about one-half of the conventionally accepted value. This information has profound implications for models of Northern Hemisphere climate.
- AOML researchers are major participants in the Ocean-Atmosphere Carbon Exchange Study (OACES), which seeks to document the change in the oceanic inventory of total dissolved inorganic carbon. Such measurements will provide both the first robust estimate of the amount of carbon dioxide taken up by the world's oceans and constraints for models of the effect on global climate of anthropogenic carbon dioxide.

- AOML has developed, using high-resolution video technology and optical particle counting techniques, automated instrumentation and sampling strategies that have successfully mapped the distribution of menhaden eggs off of the North Carolina coast. The technique is able to operate at high speeds, and can discriminate between eggs and larvae of different species of the fish. The technique has far-ranging applications to many fishery recruitment studies and represents a significant new tool in managing our Nation's fisheries.

- AOML researchers are leaders in the utilization of acoustic technologies to monitor the effects of human activities on our coastal ecosystems. Their studies of both sewage outfall plumes and the discharge of dredged materials have documented the transport, dilution characteristics, and eventual fate of these discharge plumes. This information is made available to Federal, state, and municipal governments, as well as utilities and disposal operators. It allows, for the first time, formulation of meaningful regulations concerning disposal at sea, based on rigorous, scientific observations.

Future Directions

As stated previously, in recent years the mix of initiatives at AOML has shifted toward observation-oriented science and will likely continue to do so in the near future. AOML will remain engrossed in all aspects of designing, producing, deploying, and operating large sensor arrays, and in processing, analyzing, disseminating, and archiving the resultant data to provide value-added, multi-year data products and services to a wide variety of end-users. This represents a paradigm shift from the days of curiosity-driven research, to research directed toward providing products and services to customers. The demands and needs of the customers drive the direction and focus of AOML's initiatives.

ENVIRONMENTAL TECHNOLOGY LABORATORY

Boulder, Colorado
Steven F. Clifford, Director

The Environmental Technology Laboratory (ETL) is dedicated to scientific research that enhances the safety and quality of life of our Nation's citizens by improving NOAA's weather prediction and ocean resource stewardship through the creation of new, remote, environmental-observing systems. To accomplish this mission, ETL pursues the following core disciplines: wave propagation science, technique development, atmospheric and oceanic science, and technology transfer.

Brief History

The Wave Propagation Laboratory (WPL) was formed in 1967, and became ETL in 1993. WPL spawned the Prototype Regional Observing and Forecasting System (PROFS) Program in the mid-1970's (later called the Program for Regional Observing and Forecasting Services) and the Wind Profiler Demonstration Network (WPDN) in the 1980's. These programs were merged in 1988 to form the nucleus of the ERL Forecast Systems Laboratory (FSL). ETL has consistently and purposefully modified its staffing balance, staffing sources, research orientation, and organizational structure to meet NOAA's changing research requirements.

Organization and Infrastructure

Divisions: ETL is organized into five divisions, each headed by a practicing scientist or engineer:

- Ocean Remote Sensing
- Atmospheric Lidar
- System Demonstration and Integration
- Radar Meteorology and Oceanography
- Meteorological Applications and Assessment

People: ETL employs 75 FTE Federal staff. The Federal staff collaborates with 30 scientists from two NOAA/ERL Cooperative Institutes, the Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, and the Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University, Fort Collins, and with 2 postdoctoral fellows. Technical support services are supplied by approximately 35 contractor employees. This represents a synergistic Federal, university, and contractor mix that is essential to achieve ETL's core mission of transfer of technology.

Facilities: The laboratory occupies 2,000 m^2 in three buildings on the University of Colorado's East Campus. This space is provided through a GSA lease with the university. Major capital investments include 3 radars, 16 wind profilers, 6 radiometers, 8 lidars, and a full complement of networked personal computers and workstations.

Budget: ETL's FY 94 budget was $12.3 million, 40% of which came from NOAA sources and 60% from reimbursables.

Partnerships

ETL's major external partnership is through NOAA's and the University of Colorado's Cooperative Institute for Research in Environmental Sciences (CIRES) in Boulder. ETL also maintains close relationships with other NOAA programs and line-organizations, State and Federal agencies, national laboratories, universities, and the international research community. Those groups and ETL's relationship with them are as follows:

NOAA

U.S. Weather Research Program	Helped formulate plans and priorities
North American Atmospheric Observing System	Provided programmatic and scientific input
Office of Global Programs	Developed new remote sensors and performed research on clouds and their radioactive properties
National Weather Service (NWS)	Provided real-time remote sensor data and advanced systems designs
FSL	Provides consultation on profiler issues and data from mobile profilers
PMEL	Collaborated on winter storm study with NOAA P-3 aircraft and an array of wind profilers on the Oregon Coast

Federal and State Agencies

Department of Energy (DOE)	Collaborated on the DOE Atmospheric and Radiation Measurement (ARM) Program, and performed research on the radioactive properties of clouds using active and passive remote sensors in the Midwest, on islands in the eastern Atlantic, and in the western tropical Pacific; participated in the Atmospheric Studies in Complex Terrain (ASCOT) program
Department of Defense (DOD)	Participates in various DOD projects: Office of Naval Research/Naval Research Laboratory, Coastal Meteorology and Marine Boundary Layer Studies, Advanced Sensor Applications Program, remote sensing of the ocean surface; Air Force developed a prototype 449-MHZ wind profiler, Army developed a mobile profiler system
National Center for Atmospheric Research (NCAR)	Participates in the Lidar Joint Research Program
National Aeronautics and Space Administration (NASA)	Evaluated derived cloud products from satellite data properties with ground-based sensors

NCAR/Federal Aviation Administration Program	Participated in the Winter and Icing Storms
National Science Foundation (NSF)	Contributed to the National Research Council state-of-the-science review of Coastal Meteorology and NSF workshop on stress-driven circulations of the coastal ocean; played a role in the scientific planning and instrument development for the Surface Heat and Energy Budget of the Arctic (SHEBA) program; provided the first Doppler sodar and the first radar wind profiler on the continent of Antarctica
North Carolina	Collaborates on development of profiler data analysis tools
California	Played the central role with the Air Resources Board to introduce wind profiler technology in California studies of mesoscale processes underlying transport of ozone and its precursors
Colorado	Collaborated with the Colorado Department of Public Health and the Environment on the application of remote sensing technology to the study of air quality in Colorado; provided the meteorological observations and analysis for studies of the Denver Brown Cloud

National Laboratories and Other Research Organizations

Pacific Northwest Laboratory	ARM and ASCOT research program collaborations
Canadian Institute for Ocean Sciences	Ocean remote sensing
Woods Hole Oceanographic Institute	Ocean remote sensing
Johns Hopkins Applied Physics Ocean Laboratory	remote sensing
University of Washington Applied Physics Laboratory	Ocean remote sensing

Universities

Colorado State University	Denver Brown Cloud Study
University of California, Davis	Observations and modeling of mesoscale weather systems over Antarctica
Georgia Institute of Technology	Nashville Ozone Study and the effect of boundary layer processes on dimethyl sulfide emissions from the ocean surrounding the Palmer Station (Antarctica) Long Term Ecological Research site

University of Arizona	Winter orographic storms
University of North Dakota	Convective storms
University of Washington	Ocean remote sensing
Naval Postgraduate School	Ocean remote sensing, coastal meteorology
South Dakota School of Mines	Convective storms
Pennsylvania State University	Cloud studies
State University of New York	Boundary layer studies
University of Wisconsin	Orographic clouds

International Research Community

Fronts and Atlantic Storm Tracks Experiment (FASTEX)	Represented NOAA in planning the FASTEX Scientific program
Geophysical Institute, Fairbanks/ Communications Research Laboratory, Japan	Collaborates on Arctic research

Significant Accomplishments

Throughout its history, ETL has consistently demonstrated an organizational agility to recognize future observing system needs and nurture new concepts and techniques that eventually meet these requirements. For example, ETL

- Developed as part of its transfer-of-technology mission 5 new companies and 18 new product lines for private industry, in various environmental monitoring technologies. These technologies, such as profiler radar, are new industries directly responsive both to NOAA's modernization and its core mission.

- Recognized the potential of Doppler radar and through seminal experiments demonstrated the power and effectiveness of such systems for monitoring severe weather. This paved the way for work at the ERL National Severe Storms Laboratory (NSSL) where refinements lead to the National Weather Service (NWS) Next-Generation Weather Radar (NEXRAD) system and a U.S. Doppler radar network.

- Conducted, with its sister ERL Aeronomy Laboratory (AL), early experiments to demonstrate that low-frequency radar-based systems could measure wind profiles, then created the Wind Profiler Demonstration Network. Later, acoustic signals were combined with the wind profiling radar to provide measurements of atmospheric temperature profiles.

- Pioneered the application of pulsed, high-energy Doppler lidar systems for atmospheric probing. This led to validation of the concept of measuring global winds from a satellite platform.

- Created the PROFS Program, which became the incubator for the next generation of NWS forecaster workstations, the Advanced Weather Interactive Processing System (AWIPS). The PROFS Program later evolved into FSL.

- Pioneered the use of combining radar-lidar-radiometric systems for studying cloud climate impacts and precipitation processes, an essential area of research to improve forecasts of climate change and quantitative precipitation.

Contributions to NOAA's Mission

Geophysical data and information underpin NOAA's stewardship, assessment, and prediction missions. Management of fisheries, weather prediction, and climate analysis all rely on data that describe the state of the environment. These same data become the historical record needed to develop models to forecast trends that affect national policy and decisions that affect the Nation's economy and the health and well-being of its citizens.

ETL is the only NOAA group fully dedicated to advancing the development of remote observing systems. Some universities address propagation theory. Other agencies such as NASA, DOD, and DOE address the development of instruments. Many groups explore the geophysical application of new sensors. By combining all three of these essential research and development activities in one laboratory, and by collaborating with our university and other-agency colleagues, ETL has created a unique ability to conceptualize and to create new observing methods focused on NOAA's mission. The interaction between propagation scientists, engineers, and geophysicists within a single laboratory environment has proved to be a highly cost-effective and efficient way to address NOAA's observing system issues.

Evidence of the importance of ETL's singular role is its recognition by other groups. For example, NCAR's Atmospheric Technology Division (ATD) provides instrument support to member universities of the University Corporation for Atmospheric Research. Because ATD does not have the equivalent theoretical and development expertise, it has joined with ETL to form a cooperative effort to advance the creation and use of lidar systems by the university and government research communities.

Some Recent Highlights

- ETL is addressing air-sea interaction processes and the development of new ocean remote sensing concepts. This work includes using a high-frequency radar to remotely monitor coastal ocean surface currents, and demonstrating the use of the Department of Defense early warning radars in an "over-the-horizon" (OTH) mode to measure currents, and surface winds over vast regions of the ocean. Daily OTH radar surface wind-direction maps were delivered to the National Hurricane Center and to the ERL Atlantic Oceanographic and Meteorological Laboratory (AOML) Hurricane Research Division during the 1994 hurricane season.

- ETL created, and delivered to the U.S. Army, a Mobile Profiling System (MPS). This system combines several ground and satellite-based, remote and onsite, sensors to produce real-time quality-controlled vertical profiles of wind, temperature, and moisture in the boundary layer and troposphere.

- ETL, in response to the acute need to improve the realism of cloud height and radiation code in climate models, developed several radar and lidar remote-sensing methods for monitoring cloud properties, such as their frequency of occurrence and height, as well as their ice and liquid water contents. These remotely sensed data sets are the first of their kind and are now being made available to climate modelers over Internet.

Future Directions

ETL will continue to advance the basic theory of wave propagation in the atmosphere and oceans. This theoretical work will result in the development of new remote sensor techniques that are essential to future weather forecasting, ocean monitoring, and climate prediction. The recent greater emphasis on ocean observing systems will be continued and accelerated as resources become available or are shifted from atmospheric work. In parallel, ETL will continue to explore the benefits of combining various remote sensors to achieve more effective total observing systems. Some specific areas of interest include the following:

- Quantitative precipitation forecasting and measurement. Recent developments in remote sensing hold promise for improved quantitative measurement of snowfall and rainfall using new multi-wavelength and polarization techniques. Improved measurement of water substance is becoming a critical issue in the age of rapid population growth in dry areas, particularly the Southwest. Such observations can also be helpful in mitigating the impact of flooding by more accurate monitoring of precipitation rate.

- Cloud remote sensing. ETL is completing the first of six unattended cloud radars to be used for monitoring cloud properties over long time periods. These radars will eventually be part of a network of cloud monitoring sites for quantitative cloud remote sensing directed at improved cloud parameterizations in general circulation models. The existing Ka-band scanning radars will be upgraded with new antenna and other features to keep them in the forefront of cloud research well into the next century. New emphasis will be placed on observations of Arctic clouds.

- Ocean remote sensing. ETL has enhanced two of its research radars, originally developed for atmospheric research, for use in ocean research. The two Doppler radars with dual-polarization capability have already been used to reveal new details of tidally forced internal waves near the coast. One has multifrequency capability that allows it to be operated in the delta-k mode used to measure ocean currents with a resolution nearly 100 times better than currently available systems. These radars continue to be enhanced and will be applied during future research in the coastal zone.

FORECAST SYSTEMS LABORATORY

Boulder, Colorado
Alexander E. MacDonald, Director

The mission of the Forecast Systems Laboratory (FSL) is to transfer scientific and technological developments in atmospheric and oceanic research to the Nation's operational services. It conducts programs to integrate, and apply developments to, information and forecast systems. These programs are important in helping NOAA meet its objectives to improve its ability to observe, understand, and model the environment and effectively disseminate its products and services to various users. The following are FSL's essential functions:

- Exploratory system development. Developing and validating information systems to satisfy NOAA's operation services.
- Research applications. Utilizing advances in understanding atmospheric and oceanic processes to develop improved data management systems, forecasting systems and analysis systems for geophysical data.
- System validation. Testing systems in realistic environments to assess their usefulness in improvement of NOAA's services.
- Technology transfer. Facilitating transfer of new techniques and systems to operational status, working directly with users.

Brief History

FSL was formed in 1988. It developed from three ERL program areas: The Program for Regional Observing and Forecasting Services (PROFS), the Profiler Technology Transfer Group (PTTG), and the Weather Research Program (WRP). These programs along with several other major activities make up the nucleus of FSL today.

Organization and Infrastructure

Organization: Activities within FSL are grouped into six divisions and one program:

Aviation Division
Demonstration Division
Facility Division
Forecast Research Division
Modernization Division
Systems Development Division
International Program

People: FSL employs 74 FTE Federal staff, as well as 27 scientists from the Cooperative Institute for Research in Environmental Sciences (CIRES), and the Cooperative Institute for Research in the Atmosphere (CIRA). In addition, staff from the National Weather Service (NWS), the National Center for Atmospheric Research, and guest scientists from other countries work in FSL. Two commercial service contractors provide 107 support personnel for computer operations, computer systems administration, computer hardware and software maintenance, systems analysis and design, system research and development, and meteoroligical research and development.

Facilities: FSL occupies about 4,000 m^2 in three buildings on the University of Colorado's East Campus. This space is provided by GSA lease and by contractor lease.

Budget: FSL's FY 95 budget was $25.9 million, of which 65% was from NOAA sources and 35% from outside sources.

Partnerships

FSL has very strong partnerships with NWS, the Federal Aviation Administration (FAA), and the Air Force, and with two NOAA/ERL Cooperative Institutes, the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado, Boulder, and the Cooperative Institute for Research in the Atmosphere (CIRA), at Colorado State University, Fort Collins. Partnerships with NWS include development of the Weather Forecast Office (WFO) Advanced workstation, which is a state-of-the-art workstation that is designed to be a prototype for the NWS Advanced Weather Interactive Processing System (AWIPS). The design and applications of this system are to be at least 2 to 3 years ahead of the currently planned AWIPS system so that the best features of the workstation can be incorporated into AWIPS upgrades. The second major partnership with NWS is in the area of high-performance computing and numerical model development. FSL is leading the way in developing high-performance massively parallel processing computer technology that will be required in the next decade for running numerical weather models having very high space and time resolution. In conjunction with this, FSL is developing high-resolution models that are currently, and will continue in the future to become, part of the operational suite of models running at the National Centers for Environmental Prediction (NCEP).

FSL is doing many of the same activities for the FAA and the Air Force. FSL is developing a complete workstation and numerical modeling demonstration system for the FAA that will become a component of its air traffic control system of the future. This includes developing high-resolution numerical weather models to depict aviation impact variables and developing display workstations. FSL is doing similar work for the Air Force with emphasis on military applications.

FSL's partnerships with CIRA and CIRES are more in the aspect of basic research to support FSL modeling and analysis activities. This includes applications ranging from assimilating new types of data into numerical models to displaying and utilizing the data.

Significant Accomplishments

- FSL has pioneered the development of improved ways of looking at multiple types of data and products and displaying these on state-of-the-art workstations for use in operational forecasting. This has led to the development of the two workstations that have been the basis for the development of the NWS AWIPS: the Denver AWIPS Risk Reduction and Requirements Evaluation (DARE) and the WFO Advanced workstations.

- FSL is the leading developer of new analysis and forecast models including the Mesoscale Analysis and Prediction System (MAPS) and the Local Analysis and Prediction System (LAPS). These models focus on small space and time scales and are leading the way for NOAA to substantially improve the forecasting of significant weather events.

- FSL designed, built, operates, and maintains the NOAA Profiler Network, a network of 32 wind profilers located mostly in the central United States. FSL has also been the leader in utilizing wind profiler data in weather forecasting as well as enhancing the profiler network with other technologies such as the Radio Acoustic Sounding System (RASS) for measuring temperature and the Global Positioning System (GPS) for measuring integrated water vapor. It is expected that this system will become a major component of the North American Atmospheric Observing System (NAOS), being developed within NOAA in conjunction with a number of other agencies and several other countries.

- FSL has supported additional technology development and technology transfer activities with other organizations involved with operational forecasting. FSL has assisted, and will continue to assist, technology transfer to the FAA, the Air Force Air Weather Service, and the government of Taiwan.

Contributions to NOAA's Mission

Research constitutes the fundamental underpinnings of NOAA's environment products and services. Research and the transfer of research into operations is the key to allowing NOAA to reach its strategic goals. Over its history, FSL has directly supported NOAA's mission by conducting research, developing new ways of displaying new products and data sets for operations, and working with end-users to transform data and products into a more user-friendly format. FSL has also pioneered the development of new analysis and forecast models, an activity that directly supports NOAA's mission to improve forecast and warning services.

Some Recent Highlights

- FSL has developed a software system, the Scalable Modeling System (SMS), to allow software to be easily ported from conventional computers to massively parallel computers, which is the computer technology that NOAA is expected to move into to meet its modeling requirements for the 21st century.

- FSL is working on new display/workstation technologies to handle data and display requirements for the Global Learning and Observations to Benefit the Environment (GLOBE) program.

- FSL is working with the FAA to develop a system that will make conventional meteorological data relevant to aviation operations, for safe and efficient operations in our Nation's airspace. Because weather accounts for nearly 85% of all natural hazards, FSL is working to develop a workstation to provide meteorological data in easily recognizable format to State and local government emergency managers.

- FSL will install the WFO Advanced workstation, which has been the basis for the development of the NWS AWIPS system, this spring and summer, and it will be tested in the operational environments of the forecast offices in Denver, Colorado, and Norman, Oklahoma.

- FSL developed a version of MAPS that became operational at the National Centers for Environmental Prediction (NCEP) during the summer of 1995.

- FSL continues work on the MAPS model to improve the space (30-kilometer) and forecast time (1-hour) resolutions. FSL is also developing a LAPS with higher space (1-kilometer) and time (15-minute) resolution, which was run in Atlanta in support of the Olympics.

Future Directions

From the discussions above it is clear that FSL's role is to be at the cutting edge of technology and to transfer this technology into operations. Workstation development will be continually tested and evaluated, and the best aspects of these workstations will be integrated into upgrades of the AWIPS system. Development will continue on new numerical models and on components that will be integrated into the operational suite of models running at NCEP.

In conjunction with this, FSL expects to get a state-of-the-art massively parallel computer system, in the 1998 time frame, that will allow it to lead the way within NOAA in utilizing this very cost effective computing technology. FSL will develop a high-level computer library for this new technology, and do the engineering to optimize its use. FSL will also begin running large numbers of modeling tests to assess NOAA's current weather observing network to determine the best mix of observing systems required to meet the observational requirements for the next century. This is a major activity of the NAOS Program.

FSL expects to continue work with the FAA and the Air Force, but with a transition from the development to the assessment phase of these programs.

NATIONAL SEVERE STORMS LABORATORY

Norman, Oklahoma
Robert A. Maddox, Director

The mission of the National Severe Storms Laboratory (NSSL) is to enhance the NOAA's capabilities to provide accurate and timely forecasts and warnings of hazardous weather events (for example, blizzards, ice storms, flash floods, tornadoes, lightning). The mission is accomplished in partnership with the National Weather Service (NWS) through a balanced program of research to advance the understanding of weather processes; research to improve forecasting and warning techniques; development of operational applications; and the transfer of understanding, techniques, and applications to users.

Brief History

NSSL was formed in 1964 as an outgrowth of the Weather Bureau's National Severe Storms Project (NSSP). NSSP was part of the Severe Local Storms Forecasting unit after the unit moved to Kansas City, Missouri, from Washington, D.C. A field site was soon established on the former North Base, U.S. Naval Air Station, Norman, Oklahoma. This site later became the NSSL headquarters. During its early life, NSSL was principally a radar development laboratory and field observational facility for the Weather Bureau, which became part of the Environmental Science Services Administration (ESSA) in 1965 and, finally, NOAA in 1970. NSSL is now co-located with the Norman NWS Forecast Office, the Storm Prediction Center of the NWS National Centers for Environmental Prediction (NCEP), and the NWS Doppler Weather Surveillance Radar (WSR-88D) Operational Support Facility.

Organizations and Infrastructure

Divisions: NSSL is organized into two divisions, each headed by a practicing scientist:

- Mesoscale Research and Applications Division
- Stormscale Research and Applications Division

People: NSSL employs 58 FTE Federal staff. The Federal staff collaborates with 41 scientists and technical support staff from the Cooperative Institute for Mesoscale and Meteorological Studies (CIMMS). NSSL has employees in various locations: Norman, Oklahoma; Boulder, Colorado; Phoenix, Arizona; Salt Lake City, Utah; Madison, Wisconsin; Seattle, Washington; and Atlanta, Georgia.

Facilities: NSSL facilities include a building (2,200 m^2) on the North Campus of the University of Oklahoma. In addition, a double-wide trailer (75 m^2) connected to the NSSL Norman Doppler radar houses several staff a temporary building (40 m^2) houses NSSL's storm electricity equipment; an old WSR-57 modular building (40 m^2) is used for storage; a warehouse (325 m^2) is also used for storage; and an additional warehouse (430 m^2) is used to house NSSL's mobile laboratory facility. A small staff occupies 140 m^2 at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado. Staff at other remote locations are housed by the co-located, collaborating organizations. In addition, an NSSL Doppler radar facility is situated 40 km northwest of the Norman location. The lease on the Norman facilities expired on 1993, and NSSL is currently finishing a second 2-year special extension awaiting a NOAA building consolidation. Major capital investments include a dual-polarization Doppler radar, 3 mobile laboratories, each with a Cross-chain Loran Atmospheric Sounding System (CLASS) and mobile mesonet capability; a transportable laboratory with an additional CLASS and mesonet capability, and a laboratory computer network that includes more than 100 PCS, nearly 30 Macintoshes, 30 SUN UNIX workstations, SGI and IBM workstations, and the legacy VAX computing network.

Budget: NSSL's FY 94 budget was $7.6 million, 83.5% of which was from NOAA sources and 16.5% from other agencies.

Partnerships

NSSL has a number of important collaborative projects under way with components of NWS. These include long-term work to "rehost" the Doppler Weather Surveillance Radar (WSR-88D) system to open, rather than proprietary, computing hardware; continuing work to both tune and refine current WSR-88D algorithms to account for regional differences in severe thunderstorm events and to develop new-generation algorithms for operational application; and collaboration with staff of the NCEP Storm Prediction Center (SPC.) to support the expanded severe-weather mission of the SPC.

NSSL works with the Federal Aviation Agency (FAA) to refine terminal Doppler products and to derive specific FAA-related products from WSR-88D data. The laboratory works with the Mesoscale and Microscale Meteorology Division of NCAR and has staff co-located at NCAR in Boulder, Colorado. The laboratory has a long-term working relationship with the University of Oklahoma through one of NOAA/ERL's Cooperative Institutes, the Cooperative Institute for Mesoscale Meteorological Studies (CIMMS). Many of the laboratory's applications projects and some field programs are accomplished in direct partnership with CIMMS.

Significant Accomplishments

Over its history, NSSL has consistently demonstrated an ability to improve our Nation's capability to forecast and warn of severe weather events by advancing the understanding of weather processes, improving forecast and warning techniques, developing new operational applications and transferring this knowledge to NWS and other public- and private-sector agencies. For example, NSSL

- Recognized the potential of Doppler radar to improve the detection and warning of severe weather. NSSL built the first real-time displays of Doppler velocity data, in which data were calculated using pulse-pair processing. This capability led to discoveries of tornado-related signatures, resulting in a field experiment called the Joint Doppler Operational Project. The successful demonstration that the Doppler radar could provide much improved severe thunderstorms and tornado warnings led to the Next-Generation Weather Radar (NEXRAD) program that has resulted in the WSR-88D operational network of Doppler radars. This important contribution to our Nation was recently recognized by the Department of Commerce's presentation of its Gold Medal to NSSL.

- Made the first observations of a tornadic storm with dual Doppler radars on 20 April 1974. This allowed for the mapping of the kinematic structure of a tornadic storm at several altitudes. Pioneering studies using dual Doppler analysis also led to the capability of producing dynamic and microphysical retrievals that provided reasonably accurate estimates of the temperature, pressure, and water quantities at one time over three-dimensional storm volumes.

- Continued to refine and build new conceptual models of severe storms, supercell structures, and mesoscale convective complexes and systems. These conceptual models have led to improved forecasting and warnings of tornadoes, flash floods, damaging winds, hail, etc. They have also led to understanding of environments conducive to the formation of thunderstorms, mesocyclones, and mesoscale convective complexes.

- Continued to refine the use of airborne Doppler for studies of mesoscale and stormscale phenomena. Since the installation of Doppler radar on the NOAA P-3 aircraft in 1983 by the National Hurricane Research Laboratory (now part of ERL's Atlantic Oceanographic and Meteorological Laboratory) and NCAR, NSSL has provided new insights into the structure of mesoscale systems. The laboratory obtained the first direct measurements of a tornado recorded with an airborne Doppler. New concepts of making dual Doppler measurements using the WSR-88D radar with the P-3 Doppler radar were first tested in 1989 and are now used routinely.

- Developed the first automated algorithm for detecting mesocyclones and provided the first automated wind profiles using the velocity azimuth display (VAD) technique. Both these algorithms were an important part of the first suite of algorithms used on the operational WSR-88D radars.

- Developed the first truly mobile capability for obtaining upper-air soundings of the atmosphere using the CLASS units mounted in 15-passenger vans modified to be mobile laboratories. NSSL pioneered techniques and invented a device for launching helium-filled balloons in very high winds. This capability allowed NSSL to take upper-air soundings in the vicinity of tornadoes, drylines, etc., obtaining critically needed observations in the near-storm environment of thunderstorms. In addition, this capability provided the first vertical profiles of electric fields inside a thunderstorm, leading to a new conceptual model of electrical structures within convective storms.

Contributions to NOAA's Mission

- NSSL's severe-weather research provides a foundation for fulfilling NOAA's mission of providing integrated and reliable observations in support of assessing forecasting, and warning for severe weather. These NOAA services enable the public to make informed decisions regarding safety, economic development, and environmental quality.

- NSSL is a leader in helping NOAA accomplish its vision of improved short-term forecast and warning products. All the accomplishments noted above have contributed to much-improved NOAA weather services. NSSL continues to provide the research (foundation) required to improve severe-storm warnings and forecasts. Although research is accomplished in universities and other government laboratories, NSSL both provides a conduit between operations and the academic research community and responds directly to NOAA short-term forecasting needs. NSSL maintains strong ties with both the operational and the academic communities and is continually striving to improve these ties through user groups and the recent co-location with the Storm Prediction Center.

- NSSL's important role in severe-storm research was demonstrated by its recent field program called the Verification of the Origin of Tornadoes Experiment (VORTEX). This project entrained the broader scientific community in the study of tornado formation, and involved NOAA operational forecasters who provide improved warnings that save lives and reduce property damage.

Some Recent Highlights

- NSSL has pioneered efforts in the area of using dual-polarization radar to improve precipitation measurements and hail identification. One of the many important findings is that differential phase measurements improve rainfall estimates when radar beams are significantly blocked. This is a serious issue for the 25 WSR-88D radars in the western United States where mountains can block the radar beams.

- NSSL led the large collaborative VORTEX field effort that collected a rich data set from a large number of non-tornadic super cell storms as well as several weak tornadoes, a strong tornado, and four violent tornadoes. This data set will allow scientists to determine the physical processes that generate and maintain tornadoes and then allow them to dissipate.

- NSSL has continued to improve automated-algorithm detection tools for the WSR-88D, which include the mesocyclone, tornadic vortex signature, storm series (identification and tracking), hail, and VAD. Several new versions of these algorithms have been delivered to the Operational Support Facility for implementation within the WSR-88D radars. NSSL is also leading an effort to change the WSR-88D from a proprietary computer platform to a UNIX-based open-systems platform, increasing the flexibility and maintainability of the system well into the next century.

- NSSL collaborated with the University of Oklahoma, National Science Foundation (NSF), and NCAR to build two new observational systems used in VORTEX. One called the "Doppler on Wheels" is an X-band mobile Doppler radar that captured data from its first tornado in 1995, providing a new picture of the flows around and within a tornado. In addition, more than a dozen mobile mesonets were built to obtain important environmental data in the vicinity of supercells and tornadoes. Both these observing tools have provided new data for unwrapping the mysteries of how tornadoes are formed and for eventually improving severe-storm warnings.

- NSSL has begun evaluating the abilities of improved mesoscale models to simulate convective events. Slight improvements in forecast skill have already been demonstrated. NSSL, in collaboration with the National Centers for Environmental Prediction, is coordinating a pilot study to investigate mesoscale ensemble techniques in 0- to 48-hour numerical weather prediction. Ensemble runs of the 80-kilometer ETA model and regional spectral model began on a weekly basis in May. Preliminary results show improvements over the single-model runs in the quantitative precipitation forecasts.

Future Directions

NSSL will focus on developing detection and short-term prediction algorithms for winter weather, flash floods, and mesoscale weather phenomena using the WSR-88D radars. Systems will be developed that ingest and utilize the full suite of meteorological observations to provide the forecaster with information needed in making critical warning and forecast decisions.

NSSL will develop and manage a research radar facility based on a NWS-provided WSR-88D. Early emphasis will be on implementing polarization diversity and evaluating the improvements that polarization allows in rain estimation. The laboratory will continue to collaborate broadly with the research community and be involved in field studies in support of the U.S. Weather Research Program (USWRP). The mobile Doppler radars developed in collaboration with NCAR/NSF, and the University of Oklahoma will be used extensively in these studies.

NSSL will continue to pursue longer-term process and phenomena studies of severe weather phenomena that affect the middle latitudes of the continental United States. These studies will place greater emphasis on numerical models and satellite data. Longer-term research will support both mission-specific NOAA goals and the broader research themes of the USWRP.

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY BUILDING AND FIRE RESEARCH LABORATORY

The Building and Fire Research Laboratory of the National Institute of Standards and Technology is dedicated to the life cycle quality of constructed facilities. BFRL's primary mission is to help U.S. industry and public safety by developing performance prediction method's, and measurement technologies and technical advances that improve the life cycle quality and economy of constructed facilities. Its products are used by those who own, design, construct, supply, and provide for the safety or environmental quality of constructed facilities.

Annually, about $900 billion is spent in the United States on the design, construction, maintenance, repair and renovation of constructed facilities, according to statistics from the U.S. Department of Commerce. New construction alone employs 6 million people. Safety is essential to quality and competitiveness. Fire losses and costs of fire safety are in excess of $100 billion annually. A single major earthquake of the magnitude of the Loma Prieta earthquake of 1989 close to any major urban center would cause estimated losses of $60 billion to $100 billion.

The Building and Fire Research Laboratory operates five Division as follows:

Structures Division
Building Materials Division
Building Environment Division
Fire Safety Engineering Division
Fire Science Division

Three of these Divisions are engaged in research activities that have a direct bearing on the subject of this Workshop.

STRUCTURES DIVISION

- provides technical bases for improved structural, earthquake, and wind design criteria;
- conducts laboratory, field, and analytical research in structural engineering, including investigations of important structural failures, characterization of building loads during construction and service, and structural response analyses;
- produces evaluation methods and criteria leading to safer and more economical construction practices; and
- determines engineering properties of soils and foundations and develops non-destructive evaluation methods and criteria for improving structural properties.

BUILDING MATERIALS DIVISION

The Building Materials Division performs research to advance construction materials science and technology. The Division;

- conducts analytical, laboratory, and field research, including the development of methods to measure and predict service life of construction materials; and
- develops technical bases for improving criteria and standards used to evaluate, select, use, and maintain construction materials and for improving tools to make decisions in selecting construction materials, including high-performance concrete and steels.

FIRE SAFETY ENGINEERING DIVISION

The Fire Safety Engineering Division develops methods to predict the behavior of the fire and smoke and to assess ways of mitigating their impact on people, property, and the environment. The Division:

- develops and demonstrates the application of analytical tools to building fire problems and quantitative prediction of threats to people and property from fires, as well as the means for assessing the accuracy of the models;

- develops techniques to predict, measure the behavior of, and mitigate the impact of large fires;

- maintains and advances the Fire Research Information Service (301)975-6860); and

- operates BFRL's large-scale fire test facility.