Conference Proceedings for the Advanced Multimodal Transportation Weather Services Partnership Initiatives

Held on September 28, 1998

Volpe National Transportation Systems Center

55 Broadway

Cambridge, MA 02142

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Preface

The Symposium on Advanced Multimodal Transportation Weather Services was a noteworthy and productive event, and the contributions of many people helped to make it successful. I would like to thank the following individuals at the Volpe Center who helped in preparations for the symposium and in the creation of these proceedings: Tom Seliga, Basav Sen, Carol Ann Courtney, Robert Wiseman, and Judy Yahoodik. I would also like to thank Bernie Blood and Fenton Carey for sponsoring this effort. Special thanks go to Richard R. John for his unflagging enthusiasm for the subject matter. Our nine speakers all made excellent presentations that outlined critical aspects of the Symposium topic. These talks and lively discussions resulted in many ideas and concepts that will provide an ample basis for the future development of better ways and means of dealing with weather's effects on the nation's entire transportation system. The efforts and thoughtful analyses of our speakers and other participants deserve much of the credit for the success of the symposium.

Michael A. Rossetti
DOT Volpe Center

Abstract

A symposium was held at the Volpe National Transportation Systems Center on September 28, 1998 to continue an active dialogue on issues related to the use of weather information to support transportation decision making, safety, and efficiency. Approximately 50 individuals attended, including highly knowledgeable experts in transportation and meteorology from government, academia, and private sector organizations. Nine speakers provided a stimulating mix of perspectives on how to identify and solve existing and emerging weather problems that affect the transportation sector.

In a futuristic resource paper prepared for advance reading by participants in the symposium, Louis J. Boezi helped to crystallize the discussion on weather technology and modernization as they pertain to major users that make up the increasingly multimodal transportation sector. A major message was that technological advancements of weather observing and forecasting systems in themselves are insufficient to serve the needs of the transportation sector. This sector must participate actively in decisions that define the requirements of a new weather infrastructure both before and while it is being introduced. Ultimately, investments that are made without critical user input will produce sub-optimum results for society.

> "The Department of Transportation needs to facilitate the development and test of a transportation system interstate network, either real or virtual, that can be used to collect and forward information on highway and surface weather and road conditions and to serve as the conduit for highway and weather information to the traveling public."

Boezi also stressed the importance of developing better dissemination systems for transportation weather information. We need to move beyond proven but limited methods such as NOAA Weather radio and official forecast products distributed over the mass media. Communication of weather information should be characterized by customized, high-resolution products, widely accessible via radio, and by packaging weather information with other data and voice products of situational value to the vehicle operator or traffic manager.

It may also be time to reinvent the vocabulary that the National Weather Service (NWS) traditionally uses to convey weather to information to the public. The information needs to be more relevant to circumstances. Again, there is an attendant need for strong user participation within the processes required for bringing about such change.

Weather affects the vulnerability of transportation modes over a continuum of time, ranging from minutes to hours, days, week, and even months. The longer periods involve planning decisions based on increased probabilities of events such as more floods or severe storms in a particular region. The shortest time scales are primarily for short-term decision making under hazardous conditions, where immediate threats to life or property can often be avoided through evasive or preventative actions.

Boezi concludes with a call to action that combines risk-reduction activities in combination with demonstration projects. Reduction of risks from weather events includes better lead times and dissemination of weather critical information, and better

coordination with those in responsible positions of emergency management and traffic management. Transportation projects, particularly multimodal transportation projects, aimed at demonstrating the benefits of new weather technology or other innovations must test clearly articulated measures and outcomes that are well defined in advance.

In his keynote address, Rich Wagoner of the National Center for Atmospheric Research (NCAR) set the tone of the symposium:

> "Weather is a major influence on many aspects of the multimodal transportation system. We are looking at weather not just from the viewpoint of one mode but across all modes, and we're particularly concerned about the impact of weather on safety, and also on mobility, accessibility, and efficiency."

This address, the presentations that followed, and the continuing interchange and discussion ranged across many issues associated with the use of weather information to support transportation. Primary among them, were the following:

- **Integration of weather information systems across air, rail, marine, and highway modes**
- **Development and application of small-scale numerical weather prediction for transportation applications**
- **Fog forecasting for transportation systems**
- **Weather information for surface transportation**
- **Perspectives of the commercial meteorological sector**

Specific talks at the session included:

- *Integrating Weather Information Systems Across Air, Rail, Marine and Roadway Modes* – Richard A. Wagoner, National Center for Atmospheric Research
- *Development and Application of Small-scale Numerical Weather Prediction to Commercial Aviation and other Sectors of Transportation* – Kelvin K. Droegemeier, University of Oklahoma
- *Weather Data Applications Within the Aviation Community* – Ken Leonard, Federal Aviation Administration
- *Fog Forecasting for Transportation Systems* – Wesley Wilson, Massachusetts Institute of Technology/Lincoln Labs
- *FORETELL/Weather Information for Surface Transportation* – Paul Pisano, Federal Highway Administration
- *Evolving Opportunities in Weather Depiction and Prediction* – Rit Carbone, National Center for Atmospheric Research
- *Risks and Rewards of Using Weather Products for Transportation Applications* – Michael R. Smith, WeatherData, Incorporated
- *Public/Private Partnerships for the Next Millennium* – Maria A. Pirone, Litton/Weather Services International
- *Roundtable Discussion: Future Directions*: Lou Boezi & Associates (Discussion Leader)

Follow-through Actions, Future Plans, and Recommendations

On October 20, the Volpe Center organized a meeting of transportation interests in the New York City area to discuss the possibility of performing a demonstration project using the FAA Integrated Terminal Weather System (ITWS) that was developed by MIT Lincoln Laboratories for terminal air traffic control applications. The Port Authority of New York and New Jersey (PANYNJ) provided meeting space for the discussions. The meeting continued efforts to establish partnerships under the National Science and Technology Council (NSTC) umbrella, specifically its initiative on "enhanced transportation weather services." The objective was to generate interest in a demonstration project/case study in the New York metropolitan area, which would allow the Volpe Center to conduct an assessment of using ITWS as a general-purpose, weather "nowcasting" aid for transportation advisories, flow, and safety.

The meeting was well-attended by an assortment of transportation interests in the New York area, including representatives from the MTA Bridges and Tunnels, Transcom, PANYNJ's Aviation Department, MARAD, Coast Guard, New York DOT, and FHWA. Jim Evans and Duane Grant from MIT/Lincoln Labs presented a slide show on the ITWS, and how it may be used for surface and marine transportation. Tom Seliga of Volpe NTSC contributed a number of ideas related to surface transportation uses of ITWS-type weather information products. Some initial interest in the project has been uncovered, and we will work to pursue this further in the months ahead.

The ITWS was developed by MIT/Lincoln Labs for the FAA, and is a "nowcasting" weather system that displays integrated, real-time information about convective weather, radar and surface observations, lightning, and other meteorological data within a 50 mile radius of the airport. Because of its high resolution in both time and space, the ITWS (or similar systems) holds significant potential for use by modes other than aviation, and could be employed as a base from which to add other components such as fog prediction modules and forecast information for both surface and marine interests.

Weather information proceeds from data to information to utilization within different transportation modes. Data access and utilization are also key ingredients to time-sensitive and geographically-specific forecast products. For weather information to achieve its full potential, we must find ways to link data from remote sensors such as meteorological radars and satellites with direct sensors along roadways, at airports and from aircraft, along railroads, in major waterways, and from other local and national observational systems. These should be integrated with technologies such as the Global Positioning System (GPS) and with intelligent alarm systems that warn operators of impending hazards and impacts of weather along with other information such as construction delays, accidents, and other incidents that affect transportation. Through these same technologies, we can also dramatically increase the amount and quality of environmental data required for improving numerical weather forecasting models.

One of the more effective ways to jump-start the process of better utilization of weather information within transportation is through selective demonstration projects. These projects have a secondary advantage in that they provide an opportunity of testing and validation of emerging technologies and new concepts. Furthermore, they are practical means for technological transfer and can readily lead to development of an effective national system for distribution of customized weather products to the traveling public, traffic managers, and transportation planners. Such projects are also valuable for providing user input to the plans and programs of the National Weather Service as well as the commercial meteorological industry. We must attempt to build upon our existing meteorological, transportation, and communications infrastructure and expand its applications for the public good. There are several institutional issues worth addressing as we move ahead. Cooperation among public and private sectors is essential in order to ensure the public good while benefiting from competition and expertise of the private sector. The diversity of state and local governmental roles may make the introduction of regional systems more complicated than first appears, especially in large metropolitan areas that cut across state boundaries. Finally, we must work to educate consumers and users about weather-transportation relationships and the value of benefits that would result from investments in systems and practices that mitigate against weather's influence on transportation.

The Volpe Center will also aims to continue to work closely with participants in the symposium, and especially with the US Weather Research Program's (USWRP) User Impact Committee and Prospectus Development Teams. Transportation should be included as a key applications element within the USWRP. Additional recommendations are as follows:

- conduct further assessments of weather effects/relationships to transportation;
- conduct other major national and international symposia focusing on weather and transportation relationships; and
- pursue the development of a National Transportation Weather Information System (NTWIS) as outlined by Rich Wagoner in his keynote address to the symposium.

SYMPOSIUM ON ADVANCED MULTIMODAL TRANSPORTATION WEATHER SERVICES

September 28, 1998
Volpe National Transportation Systems Center
Cambridge, Massachusetts

INTRODUCTION

The National Science and Technology Council's (NSTC) "Transportation Science and Technology Strategy" (Sept. '97) outlined an ambitious public-private partnership to develop weather services for multimodal transportation applications, including highways, aviation, railroads, and maritime transportation. The Council anticipated that, if today's weather data sources and forecasting tools could be integrated and tailored to meet transportation data requirements, improved weather information would be available to air, ground, and marine users, and owners and operators of infrastructure and equipment.

An example involves the Department of Transportation (DOT) working more effectively with the National Oceanic and Atmospheric Administration (NOAA), other agencies, and the private sector. This initiative would expand on an existing Federal Highway Administration (FHWA) program to deploy a road weather information system (RWIS) across five states in the Mississippi Valley region and Western Ontario. The program will employ a wide suite of Intelligent Transportation Systems (ITS) and meteorological services. It aims to benefit from modernization technologies such as NEXRAD, the Automated Surface Observing System (ASOS), satellite imagery, and the Advanced Weather Interactive Processing System (AWIPS). Weather forecasts and nowcasts will be disseminated by ITS service centers as data packages that are tailored to the requirements of specific markets.

The FHWA program and the expanded use of local, aviation weather information are examples of systems that could benefit other transportation users. Through these types of systems, we can hope to achieve more comprehensive data fusion from all available weather data sources, including NEXRAD, weather satellites, wind profilers, numerical models, and airborne, surface and vehicle sensors.

Weather is a major influence on many aspects of the multimodal transportation system, particularly for safety, which is now the number one goal of the Secretary of Transportation. Safety risks occur through decreased visibility, loss of traction, instability of moving vehicles, and degradation of transportation equipment and infrastructure. Recent data show weather being a factor in 44 percent of all fatal air taxi crashes, 42 percent of fatal commuter air crashes, and 12 percent of recreational boating accidents. Weather events also influence mobility, accessibility, and economic efficiency. It contributes to delays, which translate into economic costs.

A symposium was held at the Volpe National Transportation Systems Center on September 28, 1998 to continue an active dialogue on issues related to the use of weather information to support transportation decision making, safety, and efficiency. The objectives of this symposium were:

1. To identify the kinds of weather information that needs to be presented to and that can be easily understood by different types of air, ground, and marine users.

2. To identify new multimodal weather system products and programs that address the needs of major groups of users in partnership with the private sector.

3. To plan the implementation of advanced multimodal weather services through cooperative partnership programs that involve federal, state, and local governments working with industry and academic institutions.

This symposium involved the presentation of weather service topics and products and possible future advances in weather sensing, weather systems, and forecasting models that lend themselves to integrated multimodal applications. The symposium included time for participants to discuss their own weather service issues and proposed methods to promote multimodal applications and partnerships.

Summary of Presentations

KEYNOTE ADDRESS

Richard A. Wagoner, National Center for Atmospheric Research (NCAR)
Integrating Weather Information Systems Across Air, Rail, Marine, and Roadway Modes

Mr. Wagoner set the tone of the symposium beginning with the comment that weather must be viewed "not just from the viewpoint of one mode but across all modes." He stressed the concern about the impact of weather on safety, mobility, accessibility, and economic efficiency. Since weather is a cause or factor in 44 percent of fatal air taxi crashes, 42 percent of fatal commuter air crashes, and 12 percent of recreational boating accidents, weather obviously has an impact on safety. Weather contributes significantly to delays in all modes of transportation; and, these delays translate into increased costs in terms of both loss of time for passengers and of delays in freight delivery. Approximately half of all flight delays are attributable to weather.

With the combination of advanced weather sensing, fine grid numerical models, and advanced transportation information technologies, the opportunity now presents itself to provide weather information to transportation users and decision-makers in a comprehensible and useable form. Mr. Wagoner stressed the importance of the NSTC's advanced transportation weather services initiative and its advantage of coordinating research and development efforts and minimizing duplication of efforts in an age of ever decreasing resources. He then provided an overview of the goals of the symposium and of the topics to be discussed. He concluded with his hope that "this symposium will generate concrete plans, and, most important, action plans for the future, not merely covering the symposium, but the follow-up to it, including the implementation of ideas..."

In his presentation, Mr. Wagoner provided an historical perspective explaining why there is so little integration of weather information today. He cited the fact that aviation weather is at least ten to fifteen years ahead of rail, road, and marine transportation. Through its application of advanced weather systems, aviation weather is this far ahead because of its well-organized user community and especially the fact that although fewer people die annually in aviation accidents, they die in a much more visible way. In addition, for many operations within the aviation community, weather is part of a regulation – not so for the other modes where, for example, a filed "road" plan is not a requirement for operation of an automobile or truck.

The use of a number of advanced weather technologies are notable within the aviation community. Beginning in the seventies, wind shear was targeted and dealt with through research and development efforts that led to operational systems for dealing with this threat. Consequently, only one fatal accident has occurred due to wind shear since 1985. Mr. Wagoner emphasized that this type of advanced technology application could not have been achieved without focused Federal funding. He then talked about the potential for creating information systems in a completely integrated way across all modes of transportation, and he discussed several examples. The first of these was highlighting GPS, not as a navigational tool, but as a meteorological tool. He mentioned automatic surface sensing systems such as LIDAR, advances in thermomapping and horizon data as sources of intelligence. He stressed the need for more effective ways of combining data from multiple sources to derive intelligence for transportation applications.

Mr. Wagoner then remarked that although scientific advances are significant, unless they are economically viable, they will not be implemented. Achieving economies of scale across modes must be pursued vigorously. He emphasized that there is much fine-tuning that can be done at the second tier to effect models for transportation for a number of modes, therefore eliminating reinventing the wheel for each mode. Resource sharing and standardization also offer great return, but must be accomplished through cooperation among government organizations and the private sector. Mr. Wagoner's belief is that things happen when you do two things: 1) grow things from the ground level up with major involvement of the user community; and 2) have a focus to capture people's imagination.

He concluded by showing his thought-provoking concept of a National Transportation Weather Information System (NTWIS) including raw data simulation, running models, merging real-time with the data models, and incorporating them all into a Transportation Impact Variables (TIVs) product generator. This general database would identify the kinds of information that can be drawn on by decision-makers for their individual decision systems. The essence of the NTWIS would be the creation of a database that includes multiple sources filtered by layers of intelligence. The update frequency would be no more than one hour and five miles in spatial resolution. He identified a variety of potential users of the NTWIS concept.

Mr. Wagoner concluded by saying that many sources for this data already exist. Many organizations sponsoring related programs are within the Federal government and states, but many other specific data sources are resident in the private sector. It is here that innovative solutions to questions of proprietary systems and data acquisition must be resolved, perhaps for reasonable access fees. If these systems and data can be coordinated in a national system, they have applicability to many modes not just one – that for which they may have been developed.

Kelvin K. Droegemeier, University of Oklahoma
Development and Application of Small-Scale Numerical Weather Prediction to Commercial Aviation and Other Sectors of Transportation

Mr. Droegemeier provided the participants with an overview of research and operational testing with respect to commercial aviation through a partnership between a university and a major airline proving the viability of this technology for commercial aviation. He provided a brief historical perspective of precipitation prediction models and explained how the skill level had improved dramatically by showing that a 1990 72-hour forecast is as accurate as a 36-hour forecast in 1975. Continual improvement will allow the prediction of very small-scale, high-impact weather that is important for transportation. The ability to predict such events, using numerical models one to two hours in advance will greatly improve transportation. The NEXRAD network is but one example of technology that is allowing this to happen. At the University of Oklahoma, the Center for the Analysis and Prediction of Storms is able to take information from a single Doppler weather radar to initialize data to predict time-critical, very high-impact small-scale weather events. The resolution being achieved is at the very high end, 2-kilometer grid level. However, with this resolution comes a great deal of variability. Part of the mission of the Center is to understand scientifically if it is possible to concentrate on more regional events like lake-effect snowstorms.

The University partnered with American Airlines to take this technology from the laboratory to the operational environment. The Advanced Regional Prediction System (ARPS) is the result of this partnership. The system is a numerical forecast tool, an end-to-end system that is fully automated and operational. This system brings in data from NEXRAD, wind profilers, and satellites, and commercial aircraft reports, then analyzes the data in real time. The data then go into an actual numerical forecast model and then into a decision support system. Operational real time testing for this system has been ongoing for five to six years. This system is a real time weather analysis product that gives a snapshot of what is happening today, every hour. American Airlines receives 450 analysis products every hour, 24 hours a day to use in their own operations. The resolution achieved with this system continues to improve. Mr. Droegemeier provided several examples such as a five-hour forecast for the Texas Panhandle area. With more complete integration of radar data, the potential for even more accurate forecasts is far greater.

Mr. Droegemeier concluded his overview by stating that this system has great potential for surface transportation. Weather prediction models are a small part of an overall goal to have a fully integrated system linked to other decision support tools.

Ken Leonard, Federal Aviation Administration
FAA Aviation Weather Research Program

Mr. Leonard provided an overview of aviation weather research at the FAA. He discussed numerous systems such as OASIS, AWOS, ASOS, ITWS, NEXRAD, ASR, and TDWR. He then went on to discuss issues of concern within the FAA. The FAA is looking for operational solutions and is focusing on what can be done through applied research, taking fundamental scientific principles and applying them through applications that can improve aviation operations. The agency's primary concern is safety. The FAA attempts to avoid anything that might improve efficiency of flight at the expense of safety. The optimum is to look at specific ways to realize both safety and efficiency. By creating better products, the FAA hopes to do both. FAA's weather research concentrates on 1) taking new information, or information that exists but wasn't being used effectively, and developing a new product; and, 2) getting information out through a variety of dissemination mechanisms.

The FAA is creating a number of meteorological development teams made up of government, universities and laboratories across the country to "connect" the myriad of data and systems available and in development. The FAA has its weather program on a seven-year plan that fits both the agency's budget process and is a reasonable timeframe for an applied research program. Five Product Development Teams (PDTs) fit into the weather areas. The FAA has the benefit of receiving input of people with real operational experience in its development activities. The FAA has developed models that have gone from a 12-hour forecast timeframe to 4-5 hours, recognizing the need for even finer tuning – down to about 30 minutes. Twelve hours for aviation is just unacceptable. A traffic controller who is trying to handle a traffic push when three of his gates are shut down, and runways are about to be closed due to convective weather, needs up-to-the-moment information and guidance for the next 20-minutes. The FAA has also had great success in the development of its icing diagnostic model. This work was done in conjunction with NCAR. A new tornado detection algorithm will be in Build 10 of the NEXRAD radars. In flight turbulence is another area the FAA and NASA are researching by using onboard sensors. The development of a convective weather growth and decay product that forecasts up to one hour also has some application for surface transportation.

Mr. Leonard concluded by discussing a number of innovative partnering arrangements the FAA is using – vehicles under which no money changes hands, but the FAA provides the weather data (or, vice versa). The development of products using this data results in a positive interchange between government and industry. In addition, existing cooperative research agreements are used.

Mr. Leonard responded to a number of questions, which concerned the use of in situ turbulence information via Internet link products using the ACAR System.

Wesley Wilson, MIT/Lincoln Laboratories
Fog Forecasting for Transportation Systems

In his opening statement, Mr. Wilson referred to a Monet painting showing a bridge with some traffic, but not being able to discern the traffic. This is fog – you can't see. He spoke about COBEL, a radiation fog forecasting model designed to predict boundary layer processes. The model has produced improvements by dealing with what meteorologists call microphysics or micro scale – exactly where fog lives or dies. French researchers initiated COBEL, and MIT/Lincoln Labs is employing it in the mid-1990s through a cooperative arrangement with the University of Montreal. The model is now robust enough to run 24 hours and is being used to improve predict fog in the vicinity of the San Francisco airport which is often affected by fog during certain periods of the day throughout a large fraction of the year. This effort can also lead to surface transportation applications . A possible practical goal would be: by the 11:00 p.m. news be able to tell people whether or not they need to get up early the next morning for the rush hour commute in order compensate for anticipated fog delays. The current model still requires refinement before it can be used operationally for aviation or surface transportation.

Mr. Wilson concluded with questions concerning the marine environment and some specifics on the definition of fog.

Paul Pisano, Federal Highway Administration, Turner Fairbanks Highway Research Center (TFHRC)
Foretell/Weather Information for Surface Transportation

Mr. Pisano spoke about the nature and extent of adverse weather on the highway environment and what the FHWA is doing both in terms of general solutions as well as the Foretell project. He began by discussing the economic impact of adverse weather on surface transportation, with $2 billion being spent annually in the US and in Canada on snow and ice control alone; and, of the annual 40,000 roadway fatalities, 20% are most likely the result of adverse weather. Environmentally, the salt, sand, and chemicals used to combat ice and snow are a major problem. These problems are intensified more in rural areas as compared to urban areas. Because of this anomaly, the Foretell project began within the rural Intelligent Transportation System (ITS) program of the FHWA.

Foretell is the name of the particular consortium working to accomplish many of the goals described below.

The FHWA is focusing on the convergence of three key efforts: the Intelligent Transportation System (ITS) program, Road Weather Information Systems (RWIS), and the NWS modernization. RWIS projects place weather sensors along roadways and embed them into road pavement. They gather information concerning when pavements are expected to freeze so that highway departments can more accurately determine when to dispatch maintenance apparatus. With the further infusion of ITS developments, this work can expand to address the needs of commercial vehicle operators, general travelers, and traffic managers as well. A June 1997 workshop discussed these possibilities and led to the ideas behind Foretell. The modernization focus is building up to that ITS framework with the development of a National ITS Architecture. FHWA realizes the need to develop support tools that are directed at the transportation community, not just meteorologists.

The objective of the Foretell project is to develop a system that provides localized weather and road condition information for maintenance operations and traveler information. It not only looks at the weather side, but also looks at road condition prediction. The design concept was completed in March 1998. First tier, though not full-scale operation, is expected this upcoming winter season. Full-scale operation is expected in the following winter (1999-2000). A series of evaluations will be conducted before and during full-scale operations. The total budget for Foretell is $4.45 million with $1.3 million directly from FHWA. Matching funds are from the state DOTs and from private partners.

Mr. Pisano concluded with several questions from the audience.

Rit Carbone, National Center for Atmospheric Research (NCAR)
Evolving Opportunities in Weather Depiction and Prediction

Mr. Carbone discussed how the US Weather Research Program (USWRP) involves assembling together 300 scientists, practitioners of weather prediction, and users of weather information from various sectors to look at today's issues and the opportunities they present. The overall objective of the USWRP is influenced by the need for specificity and reliability in weather prediction. The activities of the program are fundamental research to improve understanding and some parameterizations of physical processes, developing techniques associated with measurements, observations, data simulations, numerical models, and then actual research mode demonstrations of improved prediction capabilities. The NSF is the lead organization, with additional sponsorship from NOAA, the Navy, and NASA.

He outlined advances made in hurricane prediction as well as the strengths and weaknesses of this capability. He pointed out some primary weaknesses in precipitation forecasts, knowledge of conditions over the Pacific, and the difficulties in forecasting near steep terrain. He also highlighted the use of very reliable satellite data in overcoming some of these problem areas. Mr. Carbone pointed out that there is great promise in event-based information in urban zones and he envisioned this resulting in a very strong collaboration between the private sector and government at many levels. He ended his presentation by emphasizing the need for coordination of information on the weather infrastructure now in place.

Michael Smith, WeatherData
Risks and Rewards of Using Weather Products for Transportation Applications

Mr. Smith began his presentation by emphasizing that private sector weather companies, because they work very closely with their transportation clientele, have addressed and are addressing a number of the issues mentioned by speakers at the symposium. He made note of the fact that the culture of private sector meteorology is very different than the public sector. Within the public sector, no one is going to pay for information in the long term unless there is significant value added and specific requirements are addressed.

Generally, the private sector does not do basic research, but takes basic research and other information to apply it to real world problems. Generally, the private sector provides forecasts with excellent accuracy and specificity to the transportation community. He provided two examples: the Northwest Airlines turbulence forecasts and the recent forecasting of Hurricane George. The private sector should create specific business-to-business products and services.

Mr. Smith then concentrated on work the private sector does for railroads. Raw weather data comes from the NWS, from states, NOAA's satellites, and from the National Lightning Detection Network, and is put into a proprietary weather analysis system called "Smart Warn, " a sophisticated weather workstation for short-term weather forecasting. The system provides railroad clients the information needed to issue storm warnings. The information gets to a client within 45 seconds, including composition time. Next, it goes to a coordination desk that oversees the entire railroad system, and finally to a particular dispatcher affected by the particular weather event. In this system, users define the decision criteria they need to know if it becomes necessary to issue orders to stop a train. WeatherData provides the meteorology, and if certain parameters are exceeded, the train stops. The system has been adopted for rail, aviation, trucking, and can be adapted for the individual consumer.

Mr. Smith noted that the system could be further improved, but that a major obstacle presently is the conflict between "proprietary" systems in the private sector and the public sector's desires to use such systems. Consistency in accurate forecasting must continue to improve in order to maintain the trust of the consumer. Improved training for meteorologists must also occur on a continuing basis.

Mr. Smith fielded a number of questions concerning the inability of some states to read RWIS data, and issues regarding the NWS modernization. He concluded by emphasizing the opportunity and the necessity for the public sector and the private sector to partner to resolve many issues.

Maria A. Pirone, Weather Services International (WSI)
Public/Private Partnerships for the Next Millennium

Maria Pirone discussed the necessity for Public/Private Partnerships as a way of resolving the ever-increasing problem of decreasing public funding. Private sector capabilities may help reach the next level of achievement if public sector issues are understood. With multimodal systems increasing, involving many more partners – is inevitable. The public sector is not viewed as embracing "bleeding edge" technology as fast as the private sector. A partnership with the private sector can help achieve this. The private sector can also help a great deal in reducing the time involved in the actual implementation and deployment of advanced weather systems. Historically, the public sector has been very slow to deploy new and emerging technologies. She concluded her remarks by stressing the need to include manufacturers, the user community, national laboratories as well as governments and corporate America.

As an example of some new products, Ms. Pirone provided an overview of the Federal Express forecasting/scheduling system and of the FAA's Weather Research Program, the Convective Weather PDT as examples of successful partnerships.

Louis J. Boezi, Louis J. Boezi & Associates, Inc. (Discussion Leader)
Roundtable Discussion

With Mr. Lou Boezi as discussion leader, the symposium concluded with a Roundtable Discussion on issues posed during the day. These concentrated on the improvement of forecasting models, the coordination of weather data and information, the problems of proprietary information and systems in the private sector as opposed to the public sectors, and the nature and necessity for more public/private partnerships to reach the goals of the weather and transportation communities.

Advanced Multimodal Transportation Weather Services

09/28/98
9:30 AM to 5:30 PM
DOT – Volpe Center
Management Information Center
12th Floor
55 Broadway
Cambridge, MA 02142

Agenda

Coffee and pastries available 9:00-9:30 AM

1. Welcome to the Volpe Center	Richard John, Director	9:30-9:45 AM
2. Introduction and Goals	Michael Rossetti (Volpe Center)	9:45-10:00 AM
3. ***Keynote speech***: Integrating weather information systems across air, rail, marine, and roadway modes	Rich Wagoner (NCAR)	10:00-10:30 AM
4. Development and application of small-scale numerical weather prediction to commercial aviation and other sectors of transportation	Kelvin Droegemeier (U.Oklahoma)	10:30-11:00 AM
5. Break		11:00-11:15 AM
6. Weather data applications within the aviation community	Ken Leonard (FAA)	11:15 –11:45 AM
7. Fog forecasting for transportation systems	Wesley Wilson (MIT/Lincoln Labs)	11:45-12:45 PM
8. Lunch (on your own)		12:15-1:15 PM
9. Foretell /Weather information for surface transportation	Paul Pisano (FHWA)	1:15-1:45 PM
10. Evolving opportunities in weather depiction and prediction	Rit Carbone (NCAR)	1:45-2:15 PM
11. Break		2:15-2:30 PM
12. Risks and rewards of using weather products for transportation applications	Michael Smith (WeatherData)	2:30-3:00 PM
13. Public/Private partnerships for the next millenium	Maria Pirone (WSI)	3:00 3:30 PM
14. Roundtable discussion: Future Directions	Lou Boezi (Lou Boezi & Assoc.) Discussion Leader	3:30 – 5:30 PM

ADJOURN

List of Participants, Affiliations, and Contact Information

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Submitted Papers and Presentations

Considerations
for the
Integration of Modernized Weather Information
in
Future MultiModal Transportation Systems

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Resource Paper

Prepared for
The Symposium on Advanced Multimodal Transportation
Weather Services, September 28, 1998

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Considerations for the Integration of Modernized Weather Information in Future Multi-Modal Transportation Systems

By
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A Look Ahead....

It's 2018 and the nation has just endured its seventh consecutive season of La Nina influenced weather patterns. International debate continues over the influence of human activities on climate and global weather. Natural resource depletion and mismanagement grew to a point in the early 2000's that prompted a panic response by governments to employ more scientifically based management methods. Efforts were started to begin the conservation of the minimal quantities of resources remaining while looking for substitutes in order to continue the social processes on the planet. Research continues toward the improved understanding of the nature and extent of the various forcing functions and dynamic processes of global climate change and resultant weather systems.

Throughout the last 20 years progress has been marked in predicting the stronger El Nino and La Nina events as well as in making some improvement in forecasting micro scale severe weather events. While the public debate over global warming began in earnest in 1997 the rhetoric has ebbed and flowed as each year's featured weather events played havoc with the global economy and exasperated the lives of populations on the earth. Since the Department of Transportation began addressing the integration of weather information with the evolving multi modal transportation system of the nation, the electronic industry continued to sprint far ahead of other economic sectors, driven by extraordinary new technological innovations. The use of personal information systems carried in wrist modules slightly larger that a large sports watch and, personal communication devices the sizes of 1998 vintage miniature cell phones incorporating voice, video, GPS and digital data has progressed to the point that in the U.S. school children are issued these devices upon entry into the first grade. Newly developed data collection technologies, particularly remote sensing systems, to support transportation management are beginning to be deployed. Roadside kiosks for gathering and forwarding remotely sensed data and disseminating voice and digital information useful to the intelligent vehicle and the new age driver educated in crises management are used in a number of states.

Technological changes continue to pervade our very being, and create enormous global competitions to keep abreast of rampant societal changes. The transportation field meanwhile continued on its pragmatic pace moving from one year to the next trying to find ways of replicating past practices with new technologies; it continued distributed efforts among states to provide and utilize information pertinent to the safe and efficient management and operation of the nation's highways; it also continued to replicate consumer/public communication practices of the 1980's.

The National Weather Service (NWS) has yet to overhaul its dissemination systems, implement the North American Observing System (NAOS) and to organize the increase in the nations' surface observing networks. Thus opportunities for improvement in aviation, marine and surface transportation weather and water forecasting as well as to public forecasting are very much lagging. Much needed advancements in predicting fine scale weather events have been slowed pending the acquisition of the higher resolution data. Overall the NWS is facing yet another major overhaul instead of the desired natural evolutionary changes concurrent with the evolution of other agencies and the economic sector. Lacking the demand pull from federal agencies and assistance from the private economic sector, the NWS lost major opportunities to further develop and integrate weather information into various transportation programs.

Detroit, continuing its customary practice of secrecy and independence, has developed two and one half generations of platforms in this period which resulted in major inconsistencies between efficient and safe automobile operation and the rest of the intelligent transportation system. State, county and municipal governments failed to establish common standards for environmental data quality, collection and dissemination to the driving public. Jurisdictional disputes continue over transportation management procedures resulting in even further congestion, road rage, and economic loss. The major result of the chaos is a confused and wary driver community. While automobiles possess information on their precise latitude and longitude position information, by virtue of inexpensive GPS technology, drivers remain relatively uninformed as to their current location vis-a-vis traffic disruptions, threatening weather events or weather related road hazards. Highway speeds continued to creep upward, driven by extreme public pressure on elected officials. Congestion continues to grow, despite efforts to use automatic traffic management techniques to optimize flow; differences continue in traffic management procedures between geopolitical boundaries. Driver education has only recently begun to introduce crises' management of the intelligent automobile. States are still trying to use periodically spaced highway signage, now of even more dubious value, to explain subtle and newly detected weather hazards and roadway conditions with a vocabulary dating back to the 1980's.

Europe continued over the last two decades to implement advanced concepts of intelligent transportation systems with limited integrated weather information. The restricted availability and high cost of weather information on the Continent does not encourage the frequent and open use of weather information in advanced technologies. European highway systems continue to lag behind the US in new construction, innovative instrumentation and highway management, creating increased confusion among the international travelers. A growing trend of more international cooperation and joint ventures is beginning to form, however after missing grand opportunities over the past decades, resentment prevails in the world community, particularly between the USA and Europe.

In the U.S. the century long policy of free and open exchange of environmental data and information was overturned by the overwhelming pressure from intellectual rights activists. The scientific community's pleas for balanced policies protecting the public interest and the needs of researchers at Universities and laboratories lost out in the decade long struggle of the 1990s. Free and unrestricted access to these data and information which is essential to promoting the further understanding of the natural variability of the earth's climate and satisfying the public's need of better forecasts and warnings lost out to the stronger, more vocal and organized financial interests. The flame of excitement to incorporate real time weather information further into our daily lives, kindled during the late 1990s after the promise of the NWS Modernization became understood, began to fade resulting in fewer ventures to integrate weather information in advancing technologies. Although some ventures did proceed and were highly successful, the setback took a long time to overcome; in a strange turn of events, public resentment for these failed opportunities was directed to the weather and climate communities and government agencies, who represent key economic segments in the nation, for failing to better influence public policy.

THE PRESENT - Weather Services in the 1990's

The National Weather Service began its weather modernization in the 1970s with the interagency research and development of advanced observing technologies, particularly doppler-based weather radar and automated surface observation systems. In the early 1980s the multi-agency procurements began for the Next Generation Doppler Radar System (NEXRAD) and Automated Surface Observation System (ASOS). Also in the 1980s the NWS began test and development activities for the Advanced Weather Interactive Processing System (AWIPS) that would serve as the information and telecommunication systems linking future Weather Offices in the country and serve as the local gateway to external networks. At the end of the century all three technologies will have been deployed and became operational. The development of a new generation of Geostationary Satellites and the modest upgrading and continual replenishment of Polar orbiting satellites continued during the 1990s.

It was not possible to define the needed improvements to the Upper Air observing system in a timely fashion and as a result they were not included in this phase of modernization effort. During the 1990s, development and test of new technologies to replace the old Radiosonde network with a multidimensional, internationally planned North American Observing System (NAOS) has been successful. However, NAOS deployment as yet remains unscheduled. This redesigned network is as vital to improvements in centralized numerical predictions and aviation forecasting as it is to local public forecasting. Figure 1. depicts the observational domain for given forecast periods.

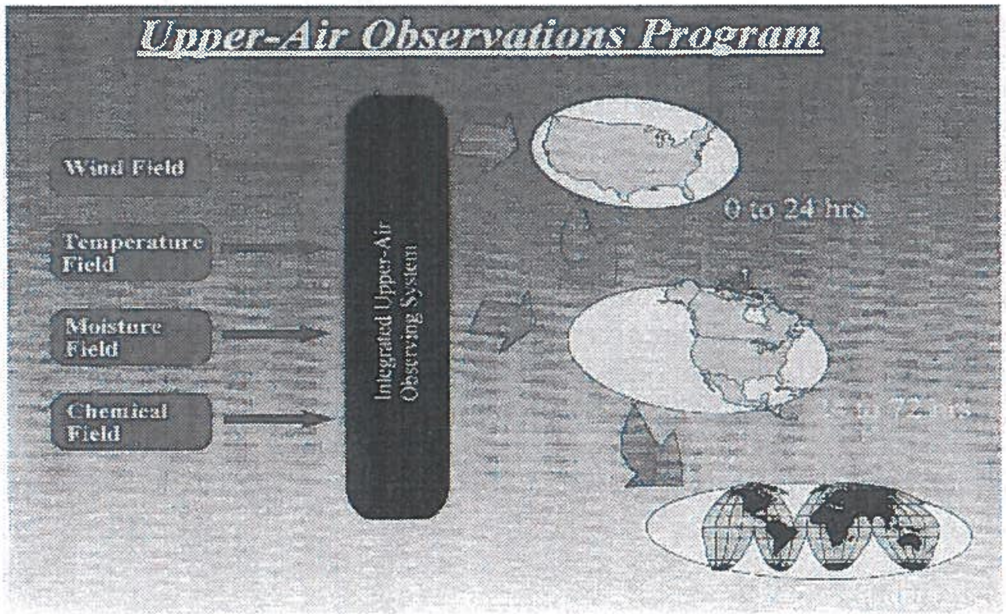


Figure 1 Observational domains vs forecast periods

In March of 1989, the NWS issued The Strategic Plan for the Modernization and Associated Restructuring of the National Weather Service. This plan, which detailed the specific steps the NWS would pursue, would prove to serve the Agency, without change, through the completion of the program in 1999. This plan was based on sound research, fully developed technologies and reasonable expectations of what improvements could be attained in public services. The **Modernization** entailed the implementation of advanced observational systems and information and telecommunication technologies developed in previous decades; the **Associated Restructuring** involved the redesign of the field weather office structure that had served the country through the 20th century and would entail closure of more than one third of the existing weather offices and the establishment of nearly 120 new super weather offices and facilities. In addition, the Associated Restructuring involved the complete transformation of the work force to a smaller, fully professionalized structure with a comprehensive new training and educational program to support modernized operations.

The major focus of this Modernization and Associated Restructuring effort was on improving forecast and warning operations of the NWS for meso scale events - those short lived, life threatening weather events such as flash floods, severe thunderstorms and tornados. For decades the NWS maintained performance statistics for its forecast and warning services. As a result of the Modernization, the public is vaguely familiar with the concepts of Probability of Detection (POD), False Alarm Rates(FAR) and Lead time in association with the life threatening weather phenomena such as severe weather, tornados and flash floods. Throughout the recent decades, continued measurable improvement in synoptic scale forecasting has been maintained in the National Centers for Environmental Predictions (NCEP) through the periodic addition of improved supercomputers and advanced numerical models. These synoptic or large scale weather systems themselves can also be devastating in economic terms and are life threatening as well. They tend to be slower moving and more easily observable using the synoptic scale observational technologies that have been available, principally the Radiosonde based Upper Air Network and modern satellites.

Throughout the recent decades it has been the policy of the NWS to make improvements in numerical modeling and centralized prediction operations which would be pursued as improved supercomputing capabilities became available. Supercomputing capabilities have historically been the limiting dimensions in improving numerical weather predictions over the development of improved models. New generations of models fed by increased amounts of surface and upper air data, which possess the requisite quality and increased resolution in space and time, would result in improved predictions not only for synoptic scale systems, but for the smaller mesoscale weather events. NCEP expects to run 4 Km models for the whole country by the end of this decade *if the necessary data and computational capabilities are available.*

THE RESULTS OF THE NWS MODERNIZATION AND ASSOCIATED RESTRUCTURING

The NWS' $4.5 B investment has yielded the expected improvements in warning services. The National Institute of Standards and Technology's cost benefit study of this Modernization projected a $ 2 B yearly return on this investment to the nation's economy. The Departments of Transportation's current weather related activities are aimed at achieving some of those expected returns. The following figures depict the service improvement attained over a ten-year period.

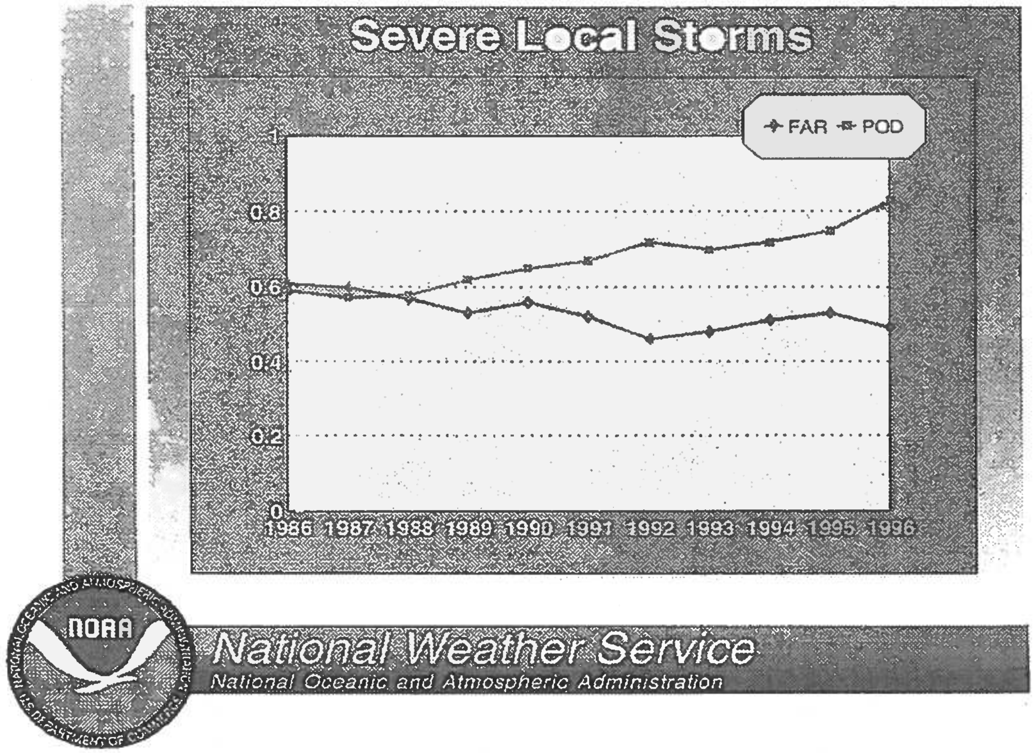


Figure 2-Probability of Detection

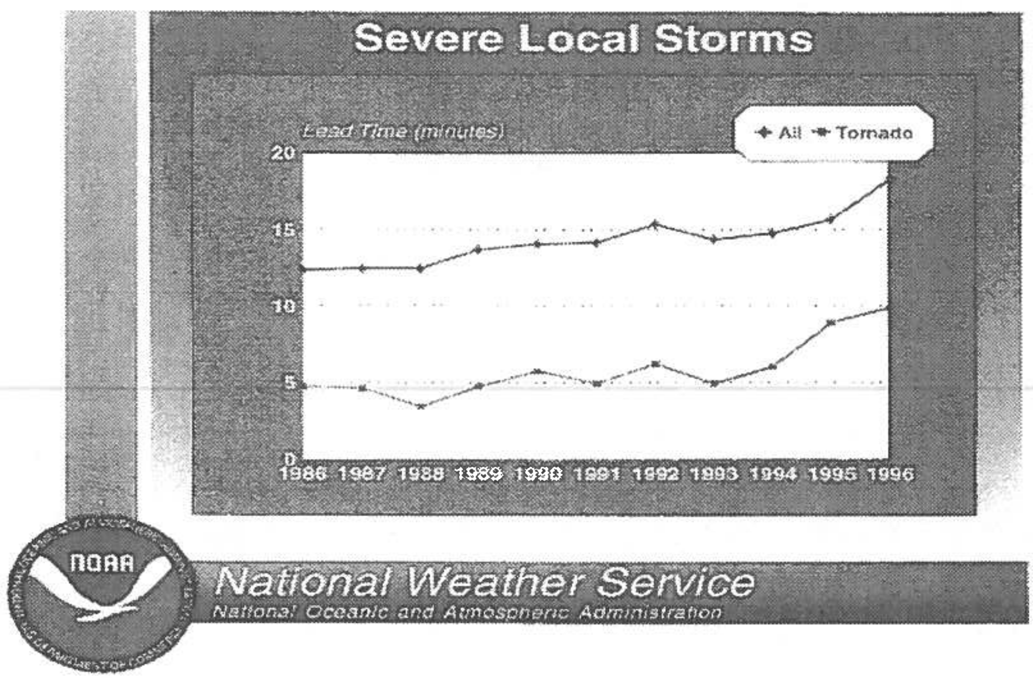


Figure 3-Lead Time

While Lead Time and the Probability of Detection (POD) have reached expected levels, the False Alarm Rate (FAR) needs improvement, some of which will occur with the maturation of operations based on the new technologies and additional improvement will occur with increased understanding of the finer scale dynamical processes.

No satisfactory infrastructure currently exists to routinely make modernized weather information that is currently resident in weather offices available to the transportation consumer. AWIPS provides for digital connectivity between Weather Forecast Offices and other networks, e.g., the Internet, state intranets. The Department of Transportation needs to facilitate the development and test of a transportation system interstate network, either real or virtual, that can be used to collect and foreward information on highway and surface weather and road conditions and to serve as the conduit for highway and weather information to the traveling public.

THE NEED FOR FURTHER IMPROVEMENTS IN THE WEATHER INFRASTRUCTURE.

The improvements in the basic weather infrastructure of the country, resulting from the current Modernization of the NWS, present an excellent opportunity to initiate activities to enhance productivity in various economic sectors of the nation, particularly elements of the national transportation enterprise. However as each economic sector begins to incorporate weather information into its business decisions and operations, the need for further improvements in weather and flood services will become apparent. A considerable length of time is required to improve our understandings of the climate and weather processes, develop the technological innovations that need national implementation and to integrate the resulting information with the continuing evolutionary business processes in the country. Appropriate national level investments made in a timely manner and consistent with the natural evolution of societal and economic processes are warranted because of the large return available for a relatively small investment. This next period of improvements in weather and flood forecasting services must be guided by strong involvement of the user community to strategically plan the order and timing of the possible range of improvements. The user community must be capable of gauging the rate that improvements can be made. It must be capable of determining what steps towards integrating new weather information can be accomplished that are consistent with the overall orderly evolution of their respective business activities.

Further improvements in surface observational networks are needed. This data will be equally important to improving national and local modeling, centralized predictions and public and private forecast operations. The national deployment of the land-based ASOS network marked an historic period of cooperation between federal agencies to provide important information to support aviation safety and improved operations. However aviation operations themselves were changing during this same period, driven by technological changes and legal and economic requirements that evolved over time. The Government and the aviation community unfortunately did not have a commonly shared vision and a process to ensure awareness and coordination of respective improvement programs. The aviation industry's involvement in specifying further staged improvements in surface observational networks and aviation forecasting is essential, but in itself not sufficient. These improvement can also be of great benefit to the general public and other economic interests as well. Representatives from all segments of the transportation enterprise, the agricultural community and service and manufacturing industries need to participate in defining future changes.

The broader transportation interests (marine, surface and aviation) can serve a useful role in defining the evolution of the country's surface and marine observational networks by participating in specifying national standards for data quality, equipment installation, operations and maintenance. Currently a number of states are deploying observational networks along the national highways in efforts to understand ways to enhance the management and operations of the highway systems. These Capitol investments are costly and represent considerable liability against future State and national operating budgets. The roadside installation of these technologies is a harsh environment; it is not conducive to reliable and accurate operations of sensitive instrumentation. Calibration and maintenance costs will be high and might ultimately become a limiting factor on the eventual extent of the overall instrumentation of our nation's highway system.

Remote sensing technologies currently exist that are applicable to collecting this type of highway data. Appropriately developed "black boxes," placed on mobile platforms, e.g., public vehicles, busses, interstate carriers, etc., could remotely feed data to roadside kiosks which would forward this data to central processing centers such as state and municipal highway management centers and nearby NWS offices. The kiosks would also provide processed information to transportation managers to support highway operations, to intelligent vehicles to assist in their automatic operations, and provide verbal information to advise vehicle operators of impending conditions. The remote sensing black boxes would periodically be returned to maintenance depots for calibration and repair resulting in an economy of scale and overall efficiency that could reduce maintenance costs. An analogy can be drawn to the aviation industry's joint venture with the FAA and the NWS to share in the use of environmental data collected on most large aircraft for overall aviation forecasting purposes. These data are forwarded to NCEP, at marginal costs, and are used for improving aviation and public forecasts.

Maritime commerce is well served by improving insitu ocean measurements that are used to provide marine forecasts and warnings. The current network of coastal buoys is under a continual threat of extinctions owing in large part to public ignorance of the use and inherent value of these data to mariners and the misconceptions that satellites alone can provide sufficient information for forecasting purposes. Satellite derived information, while valuable, is not sufficient to support marine forecast and warning operations. Additional buoy systems are needed and existing networks must be maintained. The marine transportation community can have a large impact on the public's perception of these important data sources.

DISSEMINATION OF HIGHWAY AND WEATHER INFORMATION

The existing NWS direct public information dissemination system, NOAA Weather Radio (NWR), is used primarily for making severe weather warnings and public forecast information available in the fastest manner. NWR operates on a frequency (VHF Band) that is unavailable to a large percentage of traveling public. These transmissions are also available to the nation's Emergency Broadcast Network, a set of commercial radio stations whose programming and operating policies are commercially driven and which vary widely from station to station. The genesis of NWR in the 1960s was the direct support to the near shore marine community.

A Roadway Information Service (RIS) carrying voice as well as digital information is needed that is compatible from state to state and that operates on a more readily available set of radio frequencies, e.g., A.M. radio band. Weather Service programming needs to include better defined traveler products that when combined with State provided highway information, ensures the driver has a complete set of information to safely manage their travels. Experiments in a number of states are currently underway to evaluate certain aspects this communication approach.

The existing "weather vocabulary" a result of mid 20th century weather forecasting and national communication capabilities is in need of substantial change as the intelligent transportation system evolves over the next several decades. If future vehicle operations include some form of crises management under certain hazardous circumstances, the current weather lexicon will not be effective. Surface transportation can look to the experiences of the aviation sector for examples of communication techniques specifically tailored for predictable response to changing threat conditions. A stylized transportation and weather vocabulary tailored to each stage of evolution of the intelligent transportation system will take time to develop, test and deploy. Research is warranted to carefully characterize this new vocabulary, define necessary trigger words and phrases and the expected human response. Driver education requirements would also be determined during this research.

VULNERABILITIES OF TRANSPORTATION MODES TO VARYING TIME SCALES OF WEATHER EVENTS.

LAND

Surface land transportation of goods and commodities in this nation are preplanned operations organized up to several weeks or longer in advance. Trucking companies can arrange the pickup and delivery of loads during a week to ten day period and over large geographical distances while factoring in driver home visits, the coordination of load transfers at hubs, vehicle transit times, federal operating rules, safety, vehicle maintenance, etc. Long range weather information presented in a useful manner can have significant benefit to the operating decisions in dispatch centers. Intra modal connectivity, e.g., between rail and trucking, barge and rail or aviation and trucking, can be affected by weather events and can similarly benefit from weather information supporting long range planning.

In contrast, a truck driver has time constraints for safe, efficient and timely vehicle operations that warrant the use of weather information in a different format at much shorter time scales. Driver responsibilities include operating decisions ranging in time from the immediate to up to perhaps the next 12 hours that can greatly affect service performance, contractual arrangements, safety and efficiency of operations. The operational efficiency of tractor trailer rigs is greatly affected by highway conditions, traffic delays, etc. Appropriately scheduled and presented traffic/roadway conditions and accompanying weather information can be of significant importance to drivers whose real time decision making involves balancing such factors as fuel consumption, safety considerations, delivery deadlines and mandatory rest periods. The growing national trend of "just on time" and "single source" contracts places an even greater performance demand on trucking companies and individual drivers. Failure to performance satisfactorily can have large financial penalties.

The timely provision of time - stratified and creatively structured weather information presented in an effective manner will enhance operational decision making and can greatly improve the efficiency and effectiveness of trucking operations.

The time domains, content and predicable interpretations (resulting from user education and response training) of weather information for other surface modes must also be determined and planned for implementation in a manner coincident with the evolution of each particular transportation mode. Automobile platforms have a life cycle of about eight to ten years. The evolution of complex innovations can take even longer to fully deploy based on a variety of factors such a number of model years required to introduce reliable vehicle performance, decisions of whether whole fleets will undergo similar changes and the time required to gain consumer acceptance. The introduction and education of drivers to new technological innovations can evolve on yet different time scales based on other factors including desirableness of the innovation, cost, complexity of the change, effectiveness of the platform's human engineering interface to the driver. The intelligent automobile of the future will operate in several distinct safety modes based on highway, weather and traffic conditions; it will be outfitted with sophisticated sensor systems to maintain safe speeds, direction and distance between vehicles; these cars will also sense surface friction and lateral stresses and be capable of applying torque and/or braking in order to maintain directional control under hazardous conditions. These vehicles should also be capable of utilizing continually updated roadside weather and traffic condition information to anticipate the next required change in safety modes and also inform the driver of impending conditions and possible courses of actions the driver must be involved in. None of this infrastructure currently exists nor is it properly defined or standardized for consistent national implementation.

AIR

The current trend in the aviation industry toward free flight route operations, based on the use of GPS technology, sophisticated on board collision avoidance systems and upgraded ground support systems is critically dependant upon the use of highly processed weather information. The advanced weather information will be derived from rapidly updating high resolution aviation models dependant on NAOS upper air data, and advanced image presentation technologies providing a continuous flow of timely and operationally effective information.

The general aviation segment of the flying community suffers a large number of aviation fatalities yearly due to hazardous weather. As compared to commercial operations, this segment does not enjoy the wide spread use of advanced technologies for weather detection or display. The general aviation community is the least prepared to handle an abundance of complex real time weather information while attending to flight safety and en route aircraft operations.

Current and evolving technologies for the communication and presentation of advanced weather information are encouraging and could have significant impact on flight safety and air traffic management and operations in the 21st century. These advanced information handling technologies, when coupled to the increasing capacity of the US weather industry to generate improved high resolution predictions of hazards to airmen, form a cornerstone of the 21st century general aviation enterprise. The highest imperative is of transforming the interpretation and use of complex technologies and weather information into the most efficient and effective flow of information that is fully consistent with the real time mental model of the general aviation pilot. Aircraft operations during periods of high volumes of traffic, severe weather and poor visibility are one of the most difficult and complex circumstances into which the infusion of constantly changing real time information can be effected. Determining what weather information is needed and when and how it should be presented to the pilot under these worst case scenarios should be the focus of organized risk reduction programs at a number of locations in the country. These activities can also provide the needed understanding and guidance for the preparation of future weather information to ensure compatibility and usefulness in advancing aviation operations of the next century.

MARINE

Coastal ocean waters, ports and transoceanic maritime operations are highly susceptible to severe weather events. The effectiveness and efficiency of coastal commerce and inter-modal transfers of goods (ship to land transfers) are affected by major events such as hurricanes and other synoptic scale events as well as by localized events such as fog and high wind conditions. Near shore weather warnings are being enhanced by the deployment of coastal NEXRAD radars and the increasingly sophisticated analysis of satellite imagery and soundings. However, in situ measurements in the coastal marine environment and coastal forecasts for winds and waves are areas for potentially significant improvements that can have great impact on coastal transportation, fishing operations and recreational boating. Advanced coastal forecast technologies are under development in NOAA, in the Great Lakes environment, that show significant value in improved weather and water forecasts. The maritime community and marine electronics industry need to be involved in these demonstration projects and in the subsequent national deployments throughout the coastal US. Demonstration projects are needed to quantify the economic benefits of these improved services to coastal marine commerce and to help specify the most effective implementation programs over the next decades.

INLAND WATERWAY

The amount of water available in the world for human use is a small fraction of the global water reserve. The increased demand for the use of fresh water in industrialized countries and the serious health and economic conditions existing among the less advantaged nations is growing as a world wide issue. In this country, major waterways serve as important conduits for the delivery of services and the transportation of goods and products. Conditions of flooding and drought greatly affect the management of these resources at the federal, state and local level. Management practices over the years have been hampered by the ability to forecast future water conditions with sufficient lead time to employ management techniques that might mitigate damages. Recent advances in the NWS in climate forecasting coupled with improved hydrological modeling and the modernization of the NWS present the opportunity to forecast water conditions out to several months in advance. This capability has been demonstrated by the NWS in several countries and most recently on a limited scale in the Des Moines, Ia area. This long range prediction capability, when expanded to all the major inland waterways of the country will virtually change the fresh water management paradigms in use.

History reveals numerous flooding and drought events in this country that have had significant economic impact on the regions involved and the nation as a whole. Barge traffic was seriously impacted on the Mississippi during the drought conditions of 1988. During low water conditions barge loads are carefully planned in the Gulf region to anticipate the navigability of the upper reaches of the waterway a week or two hence. An error of only one inch in free draft on a loaded barge can have significant financial consequences to the operators. Insufficient amount of water a thousand mile up river can have costly consequences to traffic flow.

Similarly, extensive flood conditions bring equally disruptive, but different effects on transportation, commerce and public safety. Figure 3. depicts the basic issues confronting municipalities under these conditions.

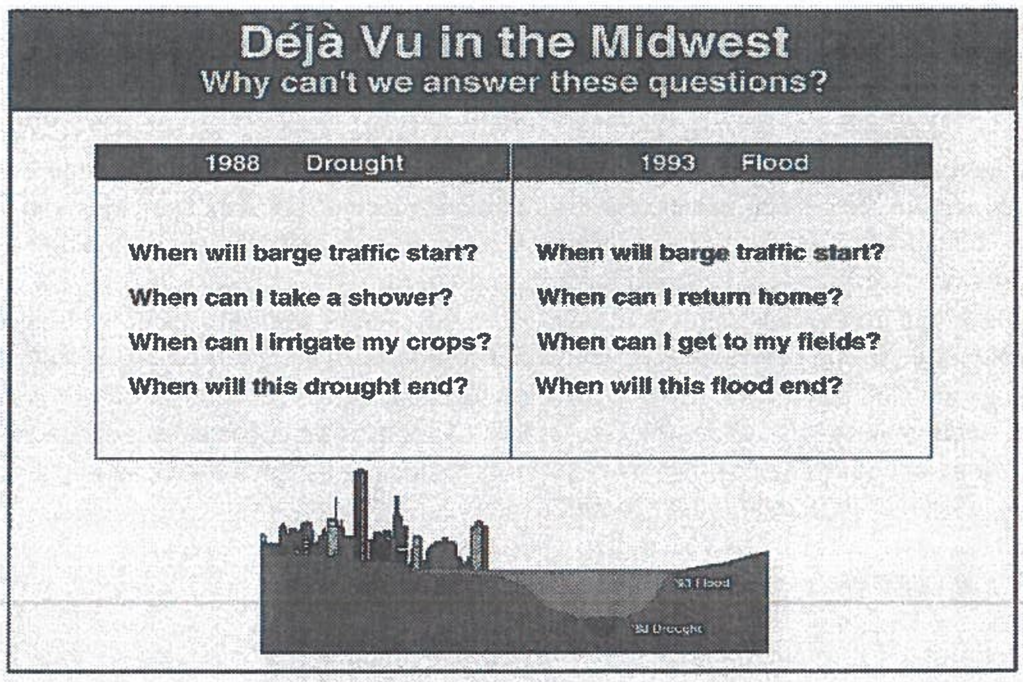


Figure 4- What to do?

TRANSPORTATION MANAGEMENT

The productivity of the national transportation enterprises is greatly impacted by daily weather occurrences. The efficient flow of transportation on the nation's interstate highways and between municipalities can be greatly enhanced if timely, properly structured and presented weather information is available. The time stratification of weather information must be carefully considered. State highway departments must consider highway maintenance, vehicular operation, public safety, logistical placement of maintenance and safety crews, etc. days in advance of a significant weather event. During the event as conditions fluctuate, management decisions for redeployment of crews, application of abrasives, shutting down segment of highways and rescue of stranded travelers are also impacted by real time weather information. Winter storms, major flooding and hurricanes are the most familiar synoptic scale events with serious impact. On the other hand, heavy precipitation, freezing conditions, high wind, smoke, fog and severe thunder storms and even the occasional tornados can be more localized in affect, but with equally demanding operational decisions by state, county and municipal transportation managers. Figure 4. is an example of decision support information.

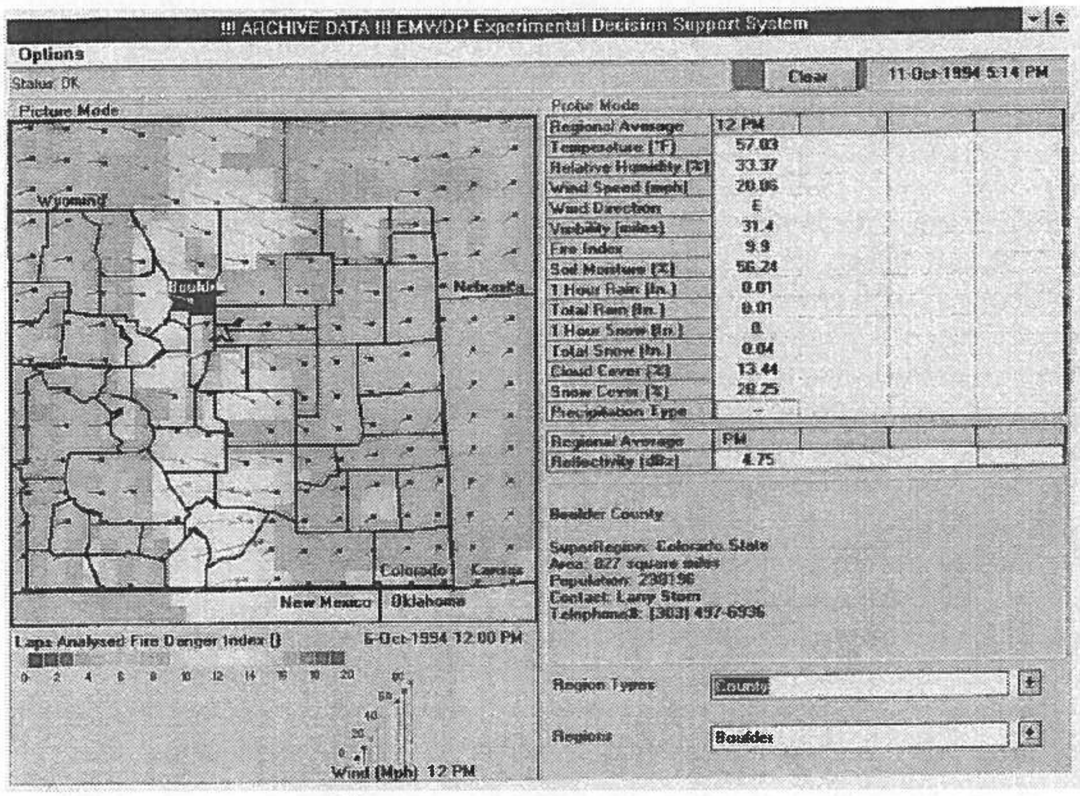


Figure 5 Decision support image

INTERGOVERNMENTAL COORDINATION ON TRAFFIC MANAGEMENT

The long history of the country is rife with inter and intra state jurisdictional disputes over most matters of governance. Traffic flow between municipalities is a good example to highlight- and to correct. Local traffic is often congested, delayed and confused during typical weather events as well as severe weather conditions. In most large cities the mere presence of light precipitation is cause for ruined rush hour commutes. Properly structured and coordinated weather statements and advisories along with preplanned management responses, much akin to severe weather emergency management operations, is an approach that might be taken to minimize jurisdictional differences and response to traffic congestion. A variety of structured and geographically dispersed demonstration projects targeted at developing the appropriate trigger conditions, related weather statements and associated management response actions would go a long way towards defining the inter-municipality traffic management model of the future.

NEXT STEPS

This paper attempts to present scenarios to promote the integration of advanced weather information in the nation's multi - modal transportation systems being developed for the next century. It identifies risk reduction projects designed to gain the fundamental understanding of subtle aspects of information presentation, display and the most likely response to a new activity or process . Risk reduction activities are designed to gain a basic understanding of the unknown, be it a process, questions of implementation never before experienced or the identifications of basic requirement underpinning a particular new technology or operation. They are necessary before large investments are to be made to minimize the chance for error and contain costs.

Demonstration projects have a different characteristics as called for in this paper. These projects are intended to expose issues of choice or preference under real world conditions. They give ultimate users insight into what is to come and provide the opportunity to make adjustments or corrections before large scale projects are initiated.. Demonstration projects emulate real conditions, to the greatest extent possible, and encourage the fullest participation by government and non - government participants who ultimately have vested interest in the results. Demonstration projects also permit customers to experience the new dimensions of the particular activity and estimate the economic benefit to their own commercial activities. The economic benefit information of particular new programs is essential in persuading policy makers to support large investments and national programs of consequence. They also, by virtue of the design of the projects generate advocates outside government to the new ventures.

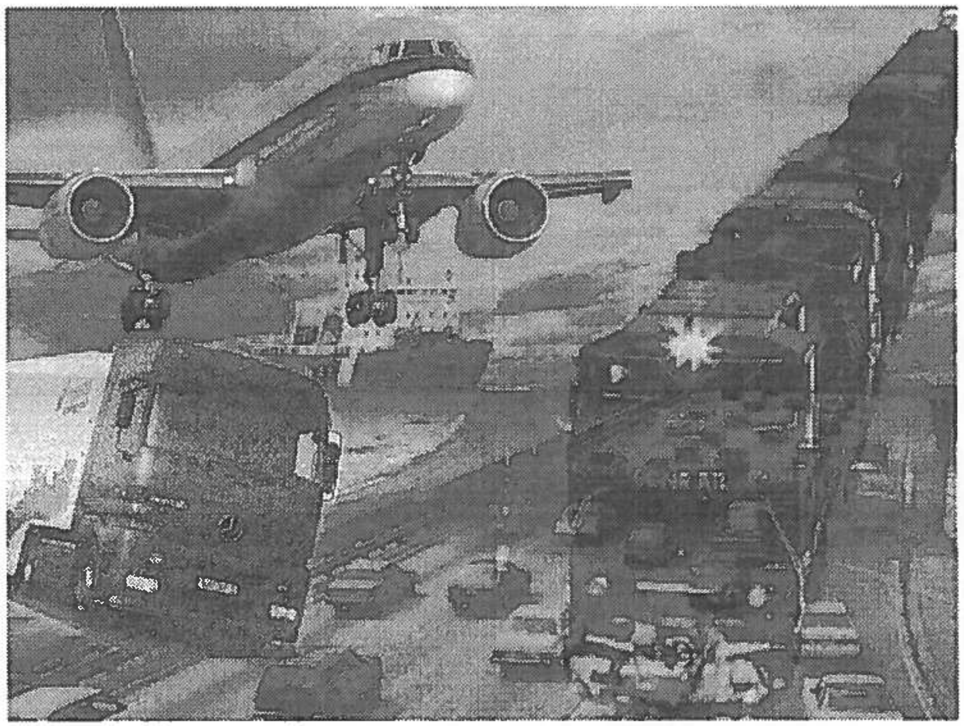
The old adage"if you don't know where you are going, then any way will get you there" applies to the problem of the integration of advanced weather information into the evolving multi - modal transportation systems. That would pretty much guarantee many disasters along the way. The converse is a systematically laid out set of plans and activities targeted to future states of evolution, peppered with sufficient risk reduction and demonstration activities to maintain a steady focus and measure progress. National participation must be organized and managed and cannot be assumed. Systematic schedules should be generated to give sufficient insight into the progress of any program and also serve as a vehicle to communicate the nature and flow of complex projects into complex national programs.

Programs of the nature being contemplated by the DOT must be clearly defined and the end results clearly identified at the onset. When proposing activities whose results defy clear identification at the outset, significant milestone establishing points in time when fundamental answers are to be known should be also identified and the antecedent activities to those milestones need to be carefully managed.

This paper points out improvements needed in the nations Weather Service. These are activities essential to the proposed future state or conditions of the various transportation modes. The DOT and the transportation enterprise as a whole need to support the NWS activities to gain appropriate authorization for these improvements. The DOT must carefully monitor those activities of other agencies essential to support their own objectives to ensure the timely and coordinated attainment of the desired results.

The sheer dimensions and scope of the evolution of the nations' multi - modal systems warrant the greatest support from the entire transportation enterprise at the outset. Without this success might never be attained and the nation could suffer the loss in productivity in the long run.

Integrating Weather Information Systems Across Air, Rail, Marine and Roadway Modes



Presented by

Richard A. Wagoner

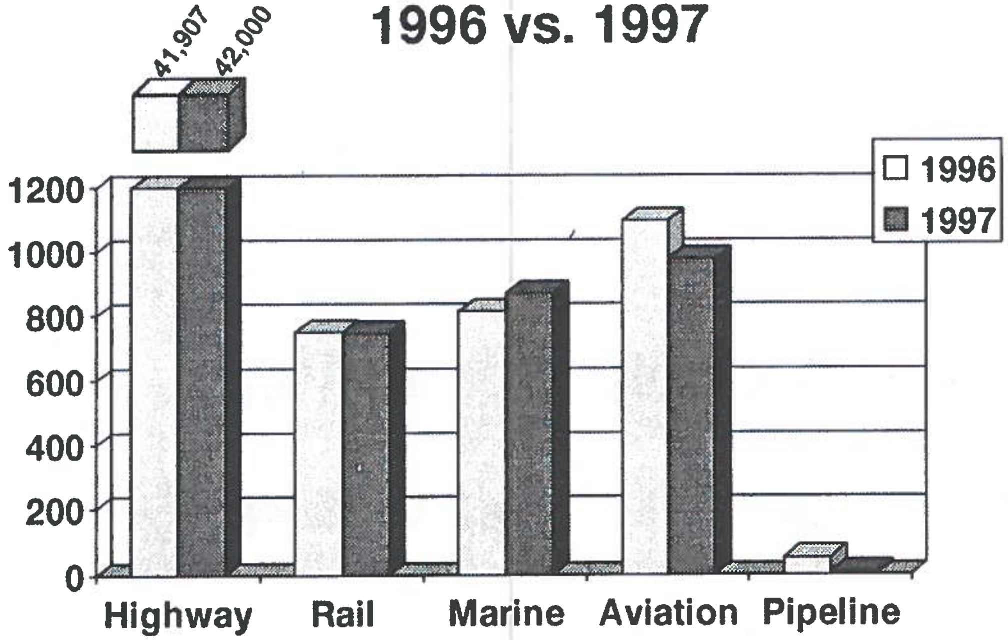
Research Applications Program

National Center for Atmospheric Research

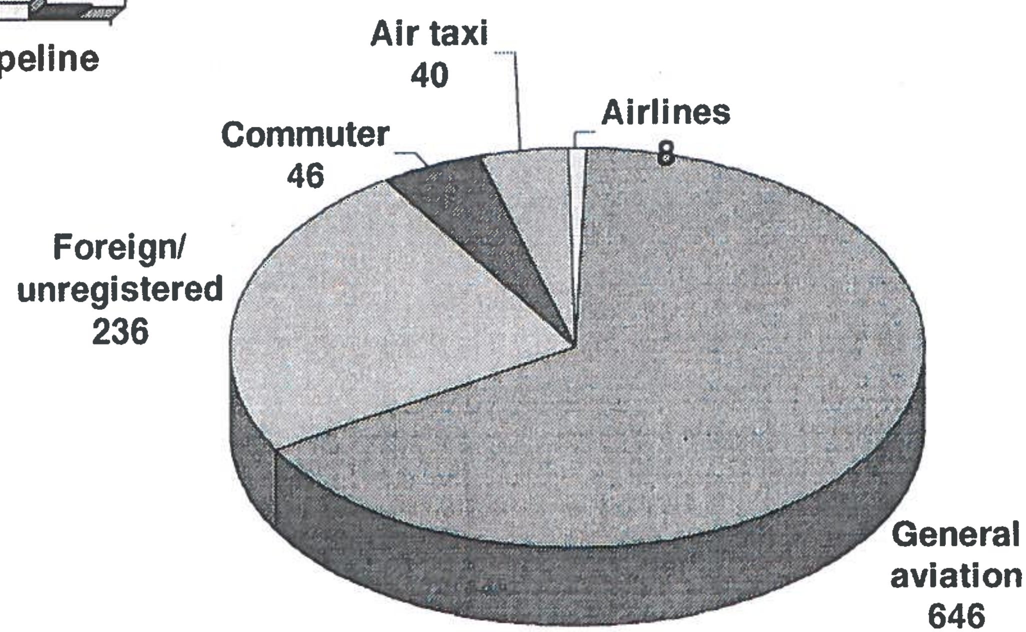
Historical Perspective

- **Very little integration in past and current systems**
- **Aviation weather systems at least a decade ahead**
- **Rank order (aviation, marine, roadway/rail)**
- **Why are aviation weather systems so far ahead?**
  - Very organized user community
  - Fatal accidents ***very*** visible

U.S. Transportation Fatalities 1996 vs. 1997



Aviation Fatalities - 1997



Source: NTSB

Project Hub-CAPS

A Research and Development Partnership Between

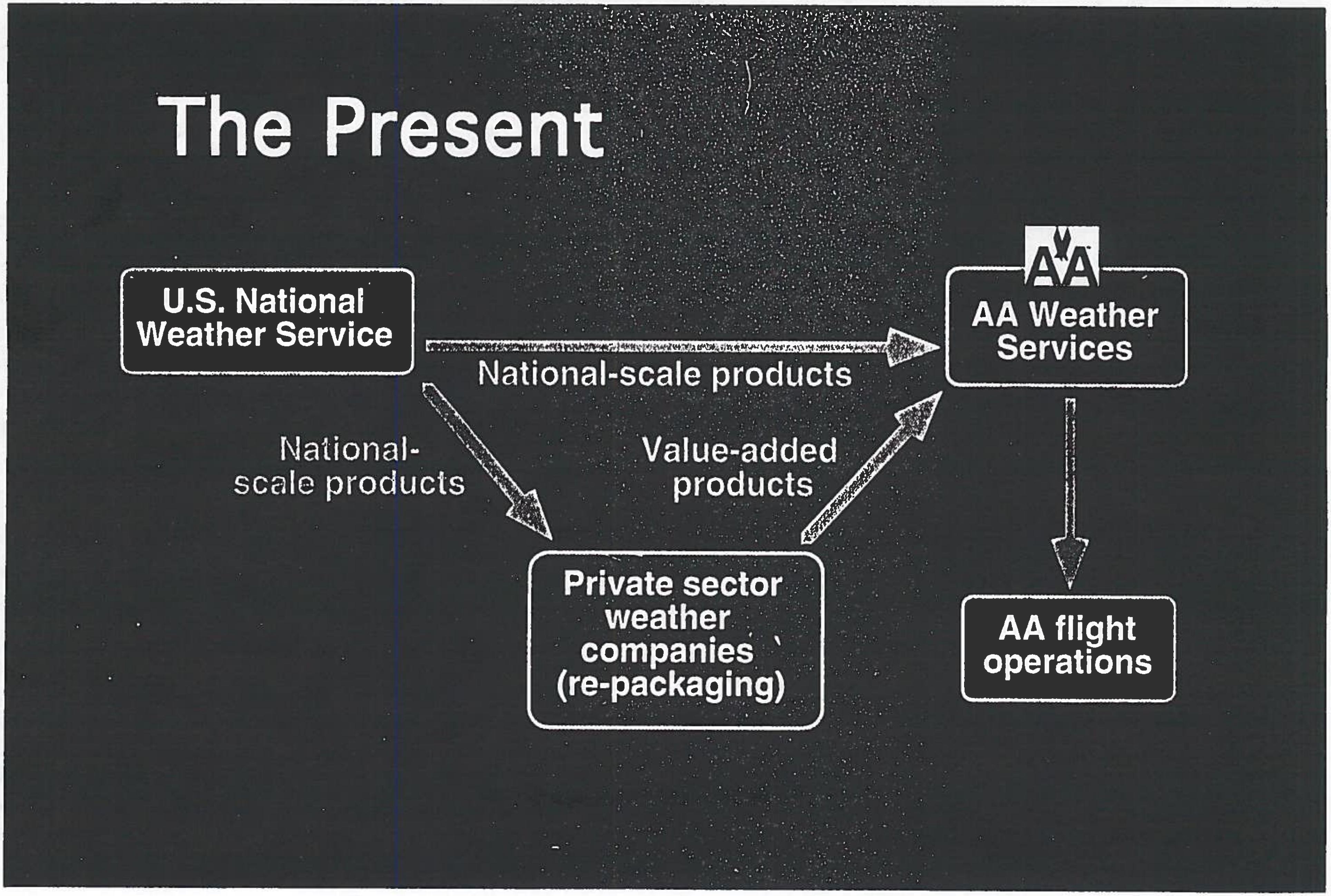
The University of Oklahoma
Center for Analysis and Prediction of Storms

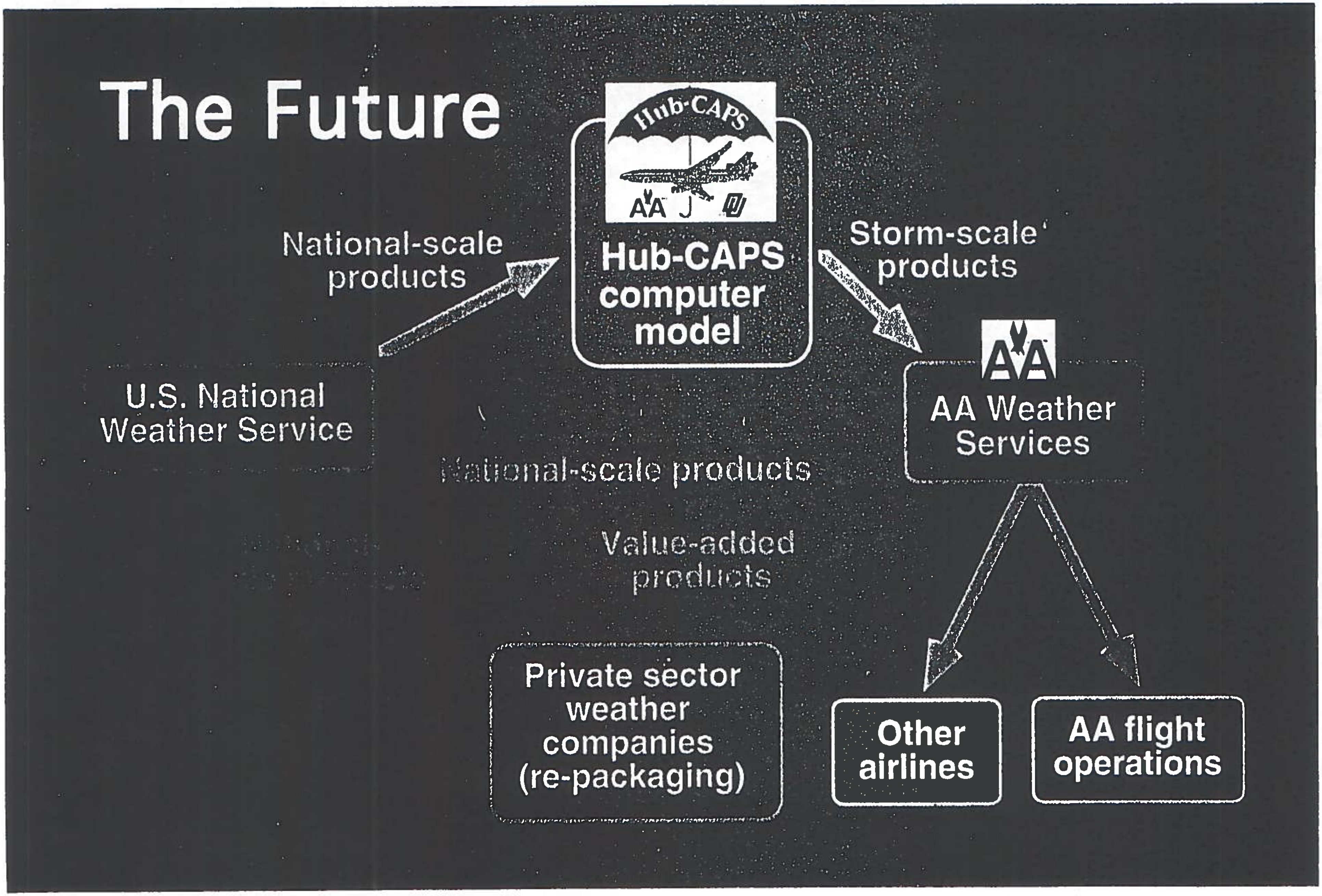
and

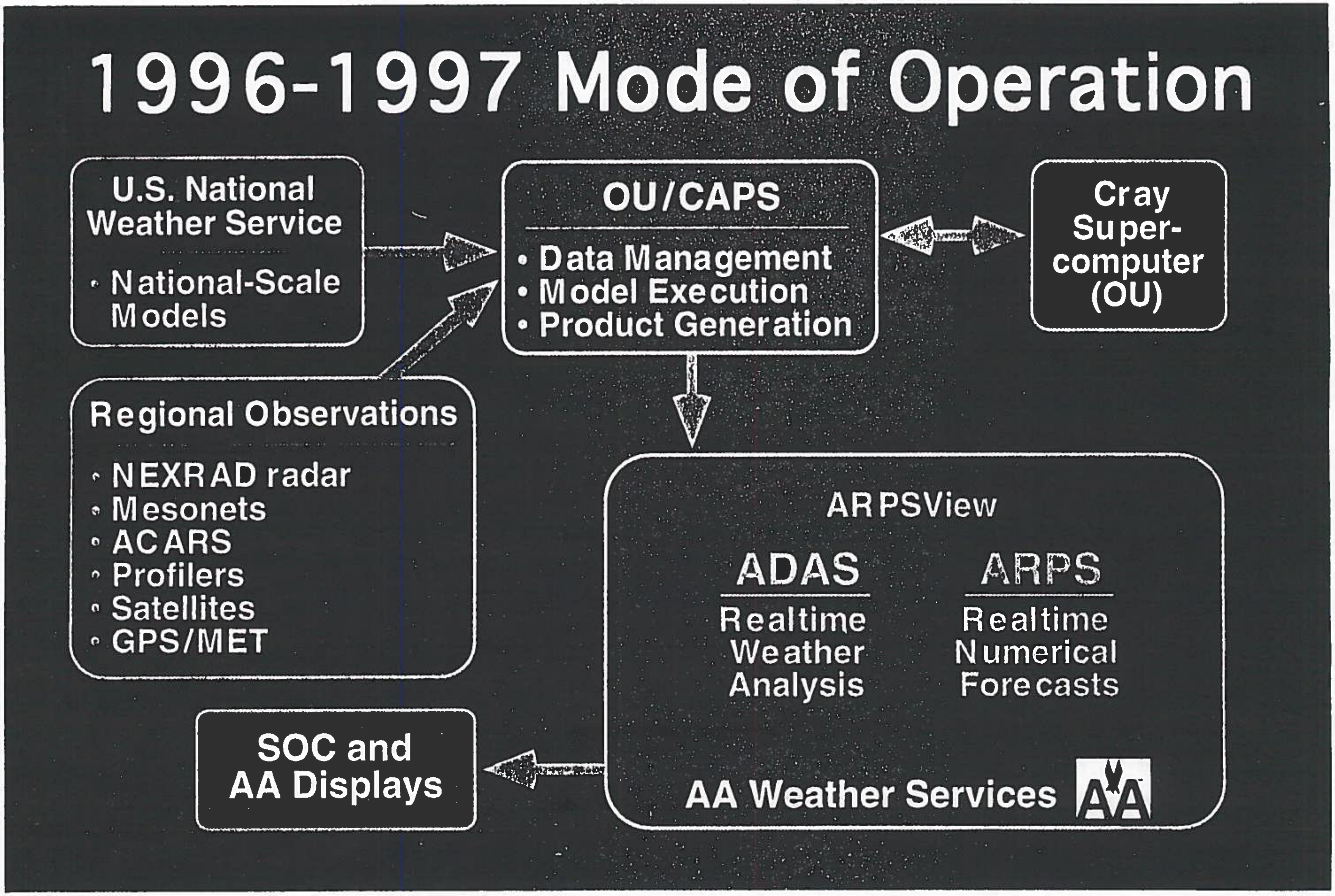
AMR Corporation/American Airlines

Project Hub-CAPS

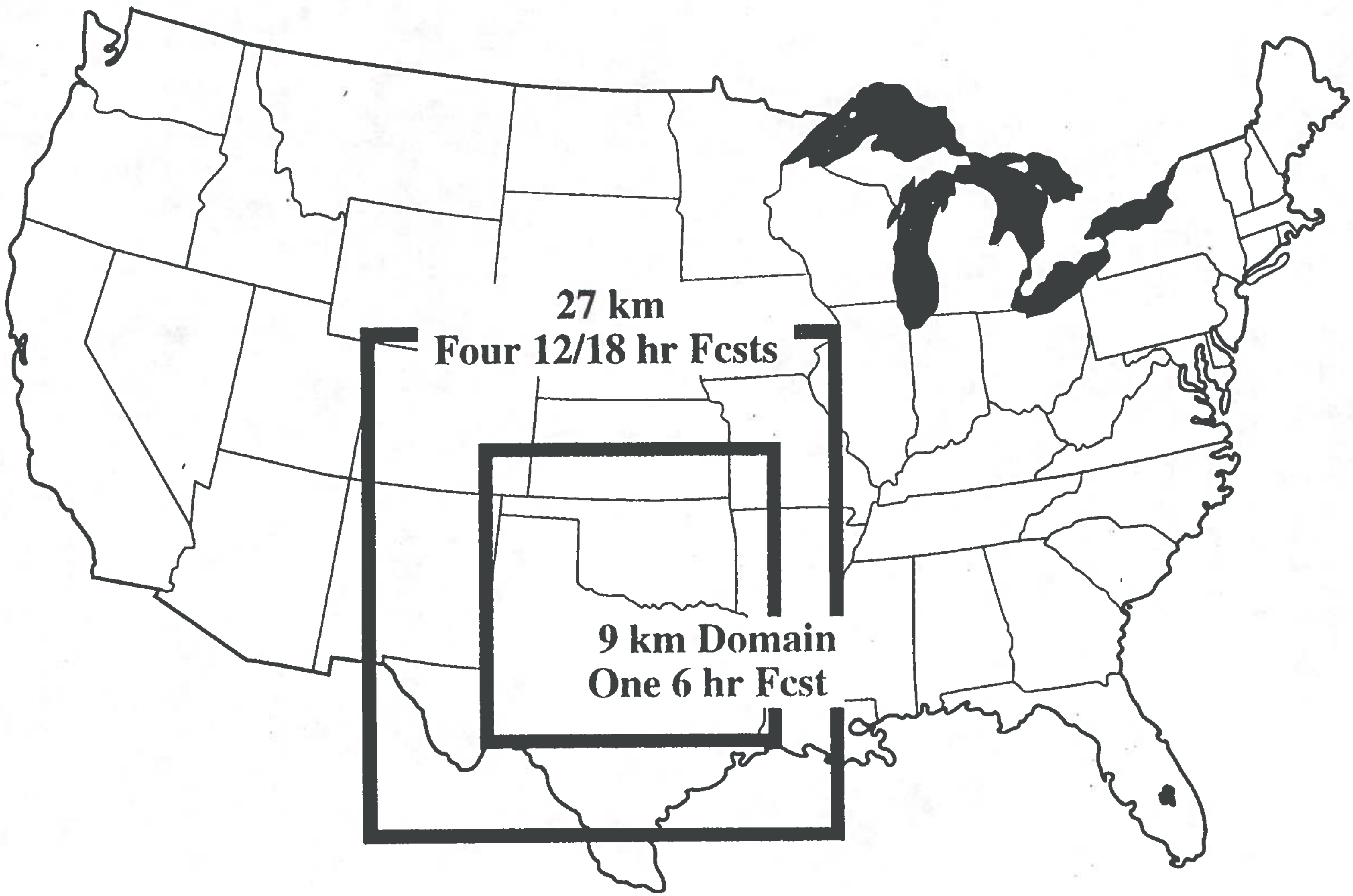
- 3-year R&D project to test the viability of storm-scale numerical prediction for AA based on CAPS' technology
- Field an operable system at end of 3 years
- Developed in collaboration with AA (compare WSI)
- Ensure broad applicability
- Full training and integration


The Present
U.S. National Weather Service
National-scale products
AA Weather Services
National-scale products
Value-added products
Private sector weather companies (re-packaging)
AA flight operations


The Future
National-scale products
Hub-CAPS computer model
Storm-scale products
U.S. National Weather Service
AA Weather Services
National-scale products
Value-added products
Private sector weather companies (re-packaging)
Other airlines
AA flight operations


1996-1997 Mode of Operation
U.S. National Weather Service
• National-Scale Models
OU/CAPS
• Data Management
• Model Execution
• Product Generation
Cray Super-computer (OU)
Regional Observations
• NEXRAD radar
• Mesonets
• ACARS
• Profilers
• Satellites
• GPS/MET
ARPSView
ADAS
Realtime Weather Analysis
ARPS
Realtime Numerical Forecasts
AA Weather Services
SOC and AA Displays

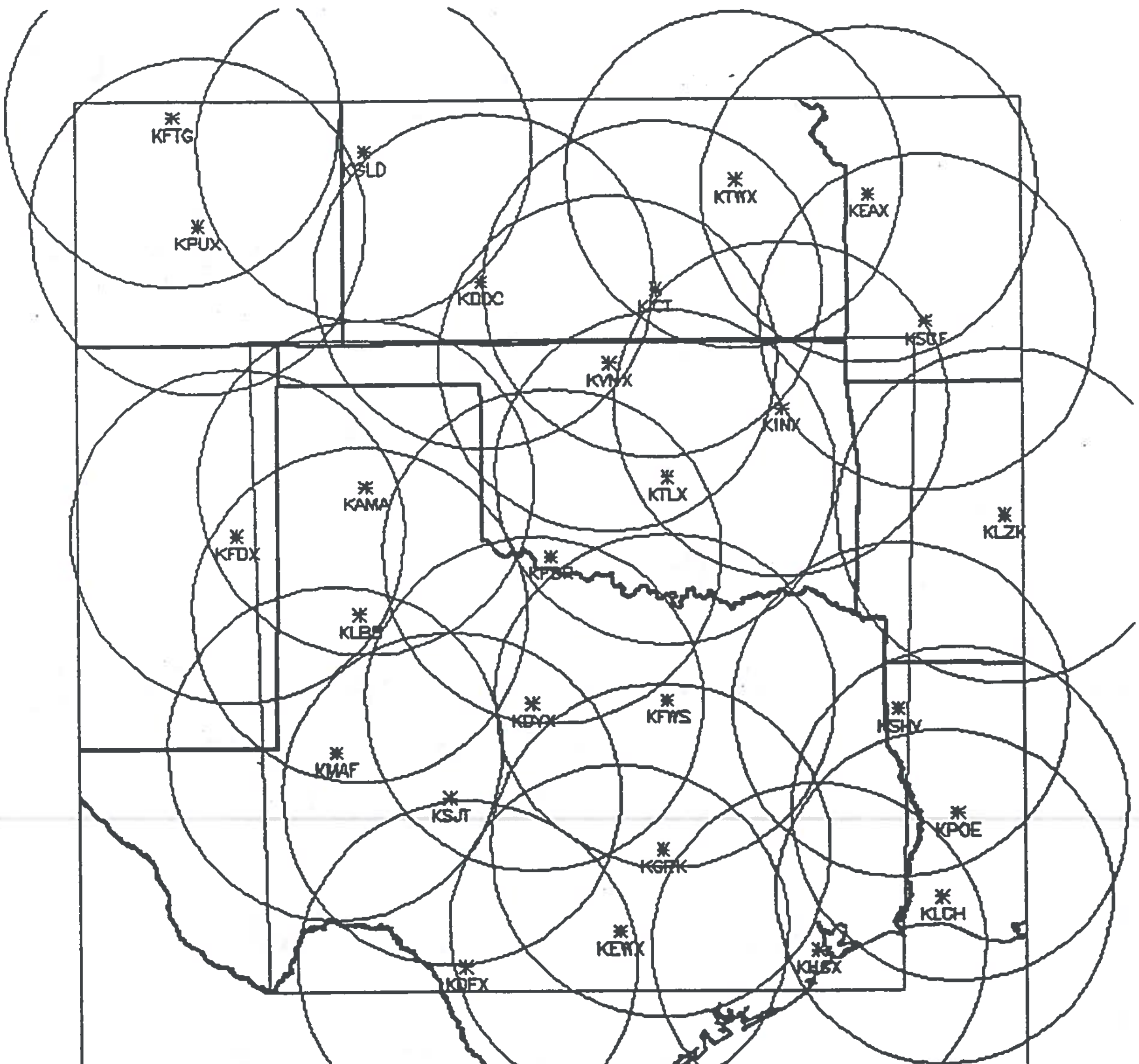
1997-1998 CAPS Forecast Domains



Current Realtime Configuration

- Fully automated and functionally complete forecast system.
- Four 12/18 hour, 27 km resolution forecasts per day over the central US per day plus hourly analyses over 4 regions
- Two 6 hour, 9 km resolution forecasts each day on a relocatable grid
- Over 450 fields and products produced every hour for both analyses and forecasts (http://hubcaps.ou.edu)
- Principal high resolution data: WSR-88D NIDS data from 20 Doppler radars: OK Mesonet; SAO; GOES Satellite
- Using full model physics including ice
- Realtime verification statistics being produced (http://comet-tik.ou.edu)

NIDS Data Sites



Lat/lon range: 28.000 40.000 -106.000 -92.000

DFW Region Analysis
20Z Mon 08 June 1998

ARPSView

(atlas : ar1998060820)

The current analysis page reloads automatically every 15 min.

News:

Archive	DFW Region 08 Jun 1998								Current Analysis		Latest Forecast	
									Prev Day		Next Day	
Analyses	00Z	01Z	02Z	03Z	04Z	05Z	06Z	07Z	08Z	15Z	16Z	17Z
	18Z	20Z										
Forecast (08.06ZA)	06Z	07Z	08Z	09Z	10Z	11Z	12Z	13Z	14Z	15Z	16Z	17Z
	18Z	19Z	20Z	21Z	22Z	23Z	d2/00Z					
Other	Verification		Current Analysis (Cen/E U.S.)		Current Analysis (NE U.S.)		Current Analysis (ORD)		Latest Forecast (ORD)			

4-panel Montages

Surface parameters 1	Surface parameters 2	Upper air	Cross-sections

Analysis Products on Horizontal Levels

Surface	Composite Reflectivity, Sea-Level Pres, Wind Barbs	20Z	Dew Point, Wind Barbs	20Z	Temperature, Wind Barbs	20Z
	Wind Speed/Barbs, Streamlines	20Z	Composite Clouds	20Z	Precip Type	20Z
	CAPE, Helicity, CIN, Wind Barbs	20Z	LI, Cap Strength, Wind Barbs	20Z	Moist Conv, Theta-E, Wind Barbs	20Z
	Div, BL Conv, Wind Barbs	20Z	BRN, BRN Shear	20Z	Est Storm Motion	20Z
	Reflectivity & Wind 2 km MSL (FL 066)	20Z	Reflectivity & Wind 3 km MSL (FL 098)	20Z	Reflectivity & Wind 4 km MSL (FL 131)	20Z
	Precip Amount	20Z	Soil Moist, Soil Temp	20Z	Deep Soil Moist, Soil Temp	20Z

	Product	850 mb	700 mb	500 mb FL 180	300 mb FL 300	250 mb FL 340	200 mb FL 390
Upper Air	Abs Vort, Geopotl Hgt, Wind Barbs	20Z	20Z	20Z	20Z	20Z	20Z
	RH, Temp, Wind Barbs	20Z	20Z	20Z	20Z	20Z	20Z
	Vert Velocity, Horiz Wind Speed/Barbs	20Z	20Z	20Z	20Z	20Z	20Z
	Vert Shear, Richardson Nmbr	20Z	20Z	20Z	20Z	20Z	20Z

Analysis Products on Vertical Cross-Sections

Map showing cross-section locations, sounding locations (blue circles), and other markers (grey)

Product	S-N (west)	S-N (center)	S-N (east)	W-E (south)	W-E (center)	W-E (north)	NW-SE	SW-NE
Horiz Wind, Vert Vel	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
RH, Temp	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Reflectivity & Clouds	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Precip Type	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Vert Shear, Richardson Nmbr	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z

Soundings The unaltered RUC or Eta sounding may also appear on each plot.											
DFW	OKC	AMA	ABI	ABQ	AEX	CNK	CRP	CVS	DDC	DEN	DLF
ELP	END	FSM	GAG	GCK	GLD	GRK	IAH	ICT	LBB	LIT	LTS
MAF	MCI	MRF	PUB	SAT	SGF	SHV	SPS	SJT	TUL		

Animations (Requires Netscape 4.0 or higher)							
Comp Reflect, SL Pres	Reflect 3 km MSL	Sfc Td	Sfc T	CAPE, Helicity	LL Cap Strength	Sfc Moist Conv, Theta-E	Precip Amount
Sfc Wind, Streamlines	700 mb Vert/Horiz Speed	500 mb Heights, Abs Vort	300 mb Vert/Horiz Speed	DFW sounding	OKC sounding	AMA sounding	ABI sounding

Aviation Impact Variables

Provided by Project COMET-Tinker. See Help at that site for information on each parameter.

Aviation Impact Variables at Surface							
Visibility	Cloud Type (LAPS)	Echo Tops	Precip Type (Condnl; LAPS)	Precip Type (Condnl; Eta)	Hail Potnl	Icing Potnl (RAOB)	Icing Potnl (RAP)
Icing Index (LAPS)	Icing Index (Stovepipe)	Supr-coold liqd (ARPS)	Supr-coold liqd (Tremblay)	Low Level Wind Shr	Downburst Potnl	Heat Stress Index	Wind Chill Index

Aviation Impact Variables on Constant Height Surfaces										
Product	FL030	FL050	FL080	FL100	FL120	FL150	FL180	FL200	FL250	FL320
Cloud Type (LAPS)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Precip Type (Condnl; LAPS)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Icing Potnl (RAOB)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Icing Potnl (RAP)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Icing Index (LAPS)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Icing Index (Stovepipe)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Supr-coold liqd (ARPS)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Supr-coold liqd (Tremblay)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z

Product	FL030 - FL050	FL080 - FL100	FL120 - FL150	FL180 - FL200	FL250 - FL320
CAT (AFGWC)	20Z	20Z	20Z	20Z	20Z

Aviation Impact Variables on Isentropic Surfaces										
Product	296K	298K	300K	302K	304K	310K	315K	320K	325K	330K
Height	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Montgomery Strm Fnctn	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
RH, Pres	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z

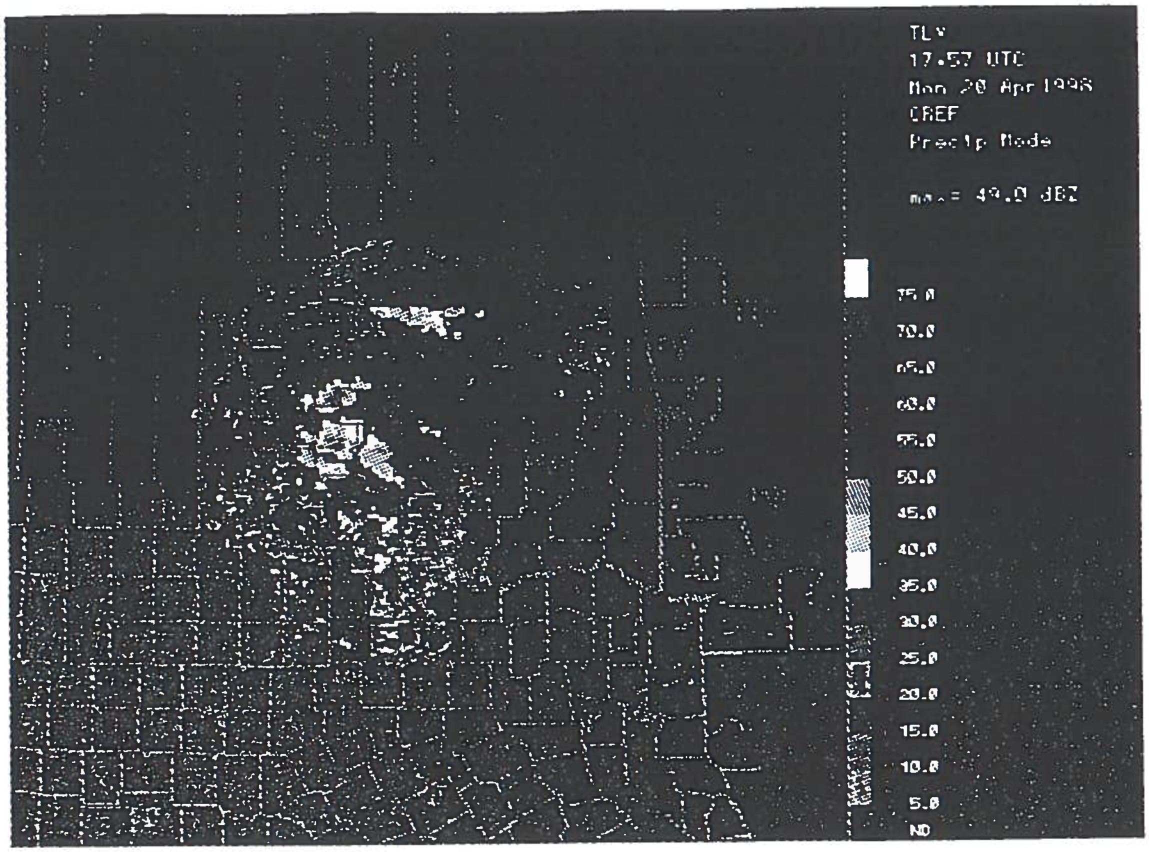
Aviation Impact Variables on Vertical Cross Sections								
Product	S-N (west)	S-N (center)	S-N (east)	W-E (south)	W-E (center)	W-E (north)	NW-SE	SW-NE
Cloud Type (LAPS)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Precip Type (Condnl; LAPS)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Icing Potnl (RAOB)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Icing Potnl (RAP)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Icing Index (LAPS)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Icing Index (Stovepipe)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Supr-coold liqd (ARPS)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z
Supr-coold liqd (Tremblay)	20Z	20Z	20Z	20Z	20Z	20Z	20Z	20Z

Soundings and Meteograms BOLD = Sounding; A = Additional products; M = Meteogram							
DFW [A M]	OKC [A M]	AMA [A M]	ABI [A M]	ABQ [A M]	AEX [A M]	CNK [A M]	CRP [A M]
CVS [A M]	DEN [A M]	DLF [A M]	ELP [A M]	END [A M]	FSM [A M]	GAG [A M]	GCK [A M]
GLD [A M]	GRK [A M]	IAH [A M]	ICT [A M]	LBB [A M]	LIT [A M]	LTS [A M]	MAF [A M]
MCI [A M]	MRF [A M]	PUB [A M]	SAT [A M]	SGF [A M]	SHV [A M]	SPS [A M]	SJT [A M]
TUL [A M]							

Status of this analysis (adas_ar1998060820)

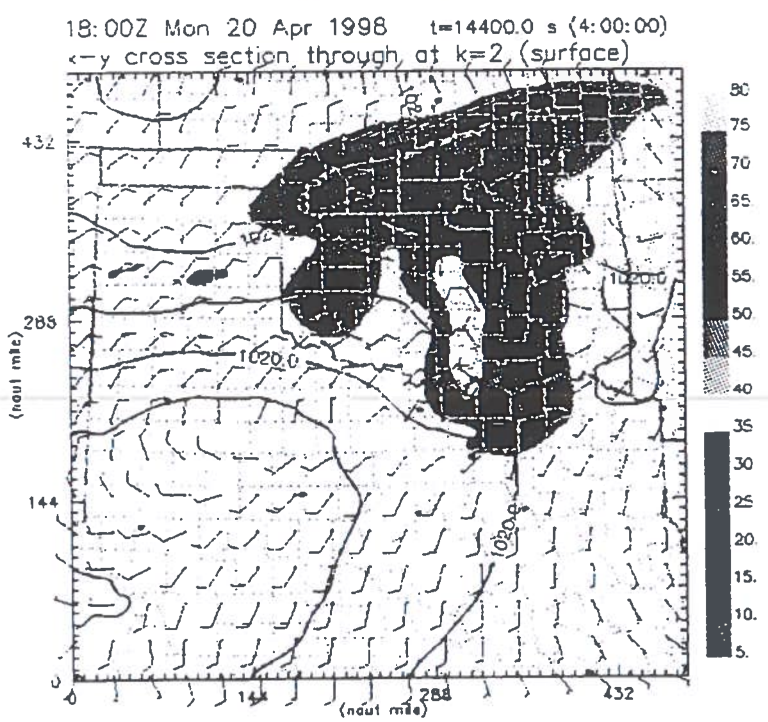
The ARPSView Guide and Parameter Table discuss the use of each product. Products involving condensed water (green font) are currently meaningful for DFW forecasts and analyses only

Products on this server are experimental. Please read the disclaimer.



DFW Region

4 h Forecast valid 18Z Mon 20 Apr 1998



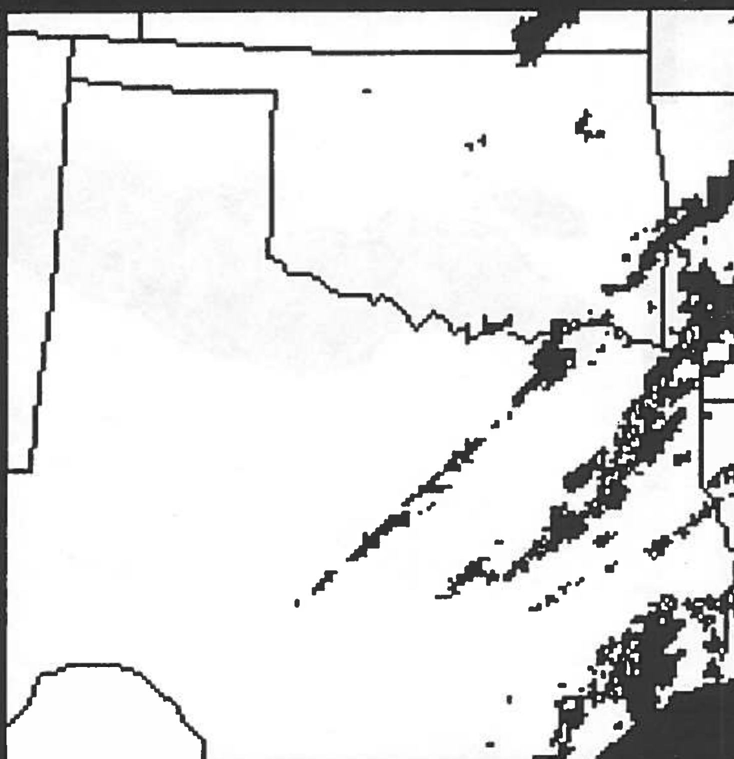
Composite Ref (dBZ, shaded) Min=0. Max=39.9

Sea Level Pressure (mb, contour) Min=0.102E+04 Max=0.103E+04 Inc=2.00

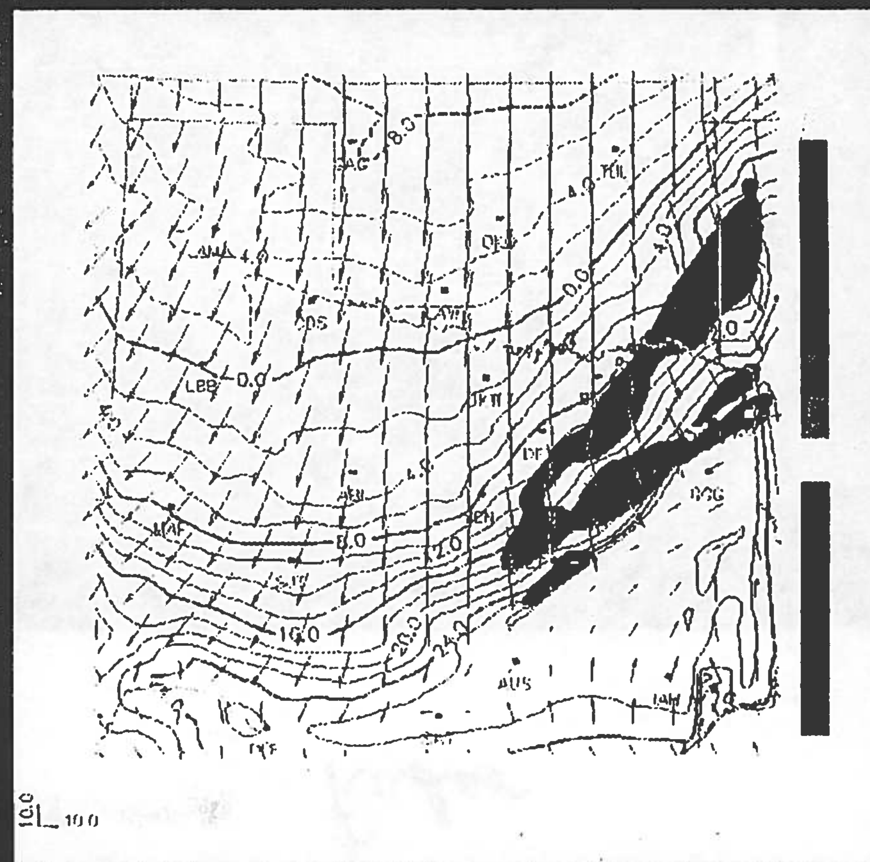
u-v (kts, barb) Umin=-11.22 Umax=15.06 Vmin=-12.33 Vmax=13.00

Project Hub-CAPS

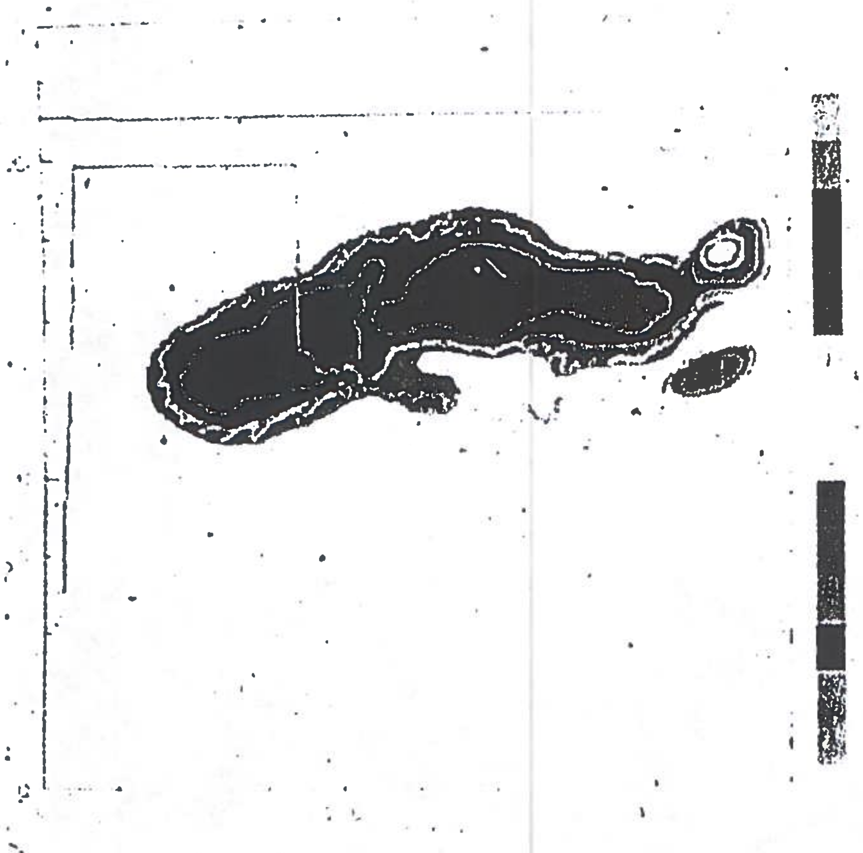
22Z Radar Mosaic

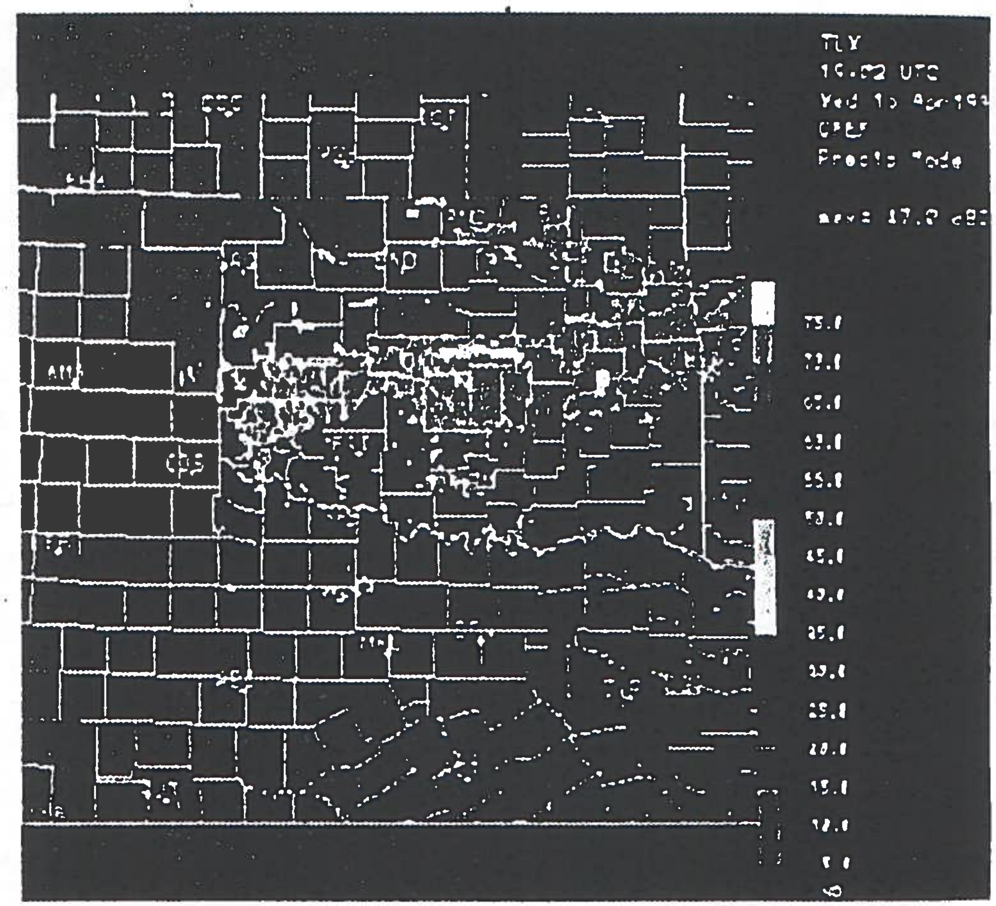


5 hr ARPS forecast valid 27 January 1997, 22Z

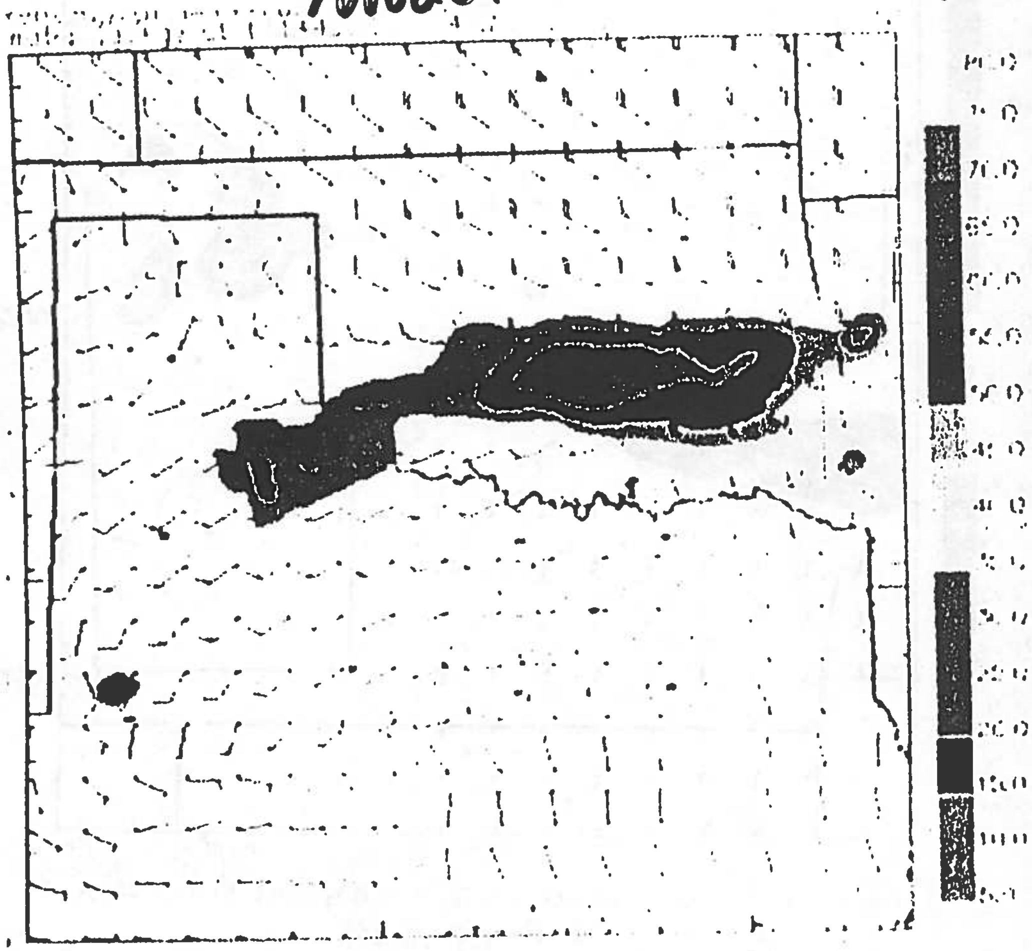


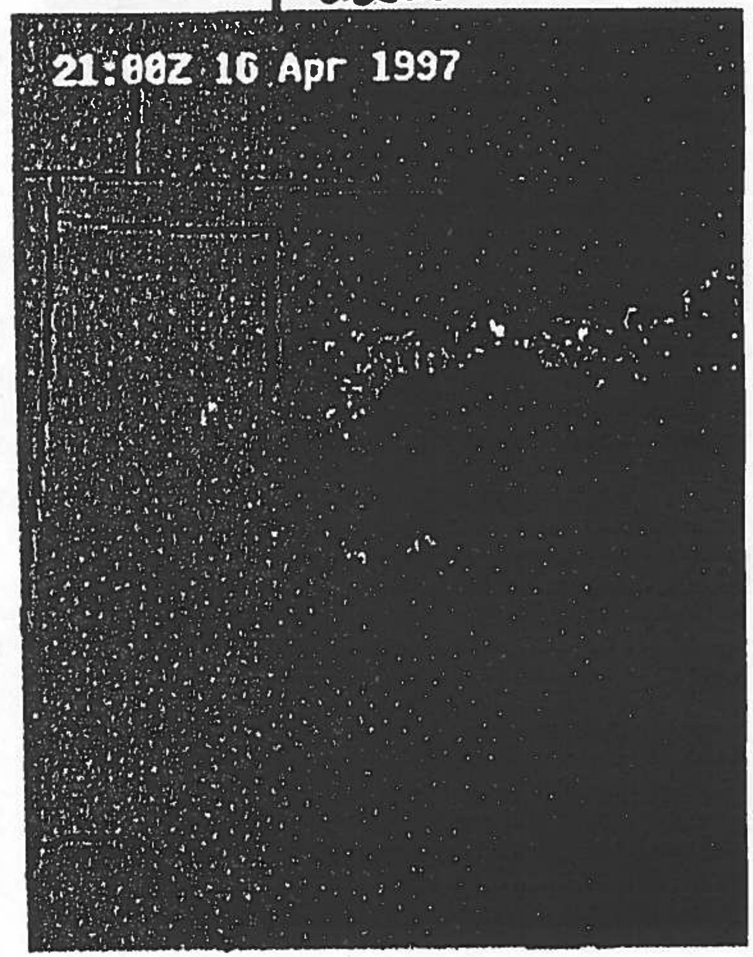
Model t=3hr Radar



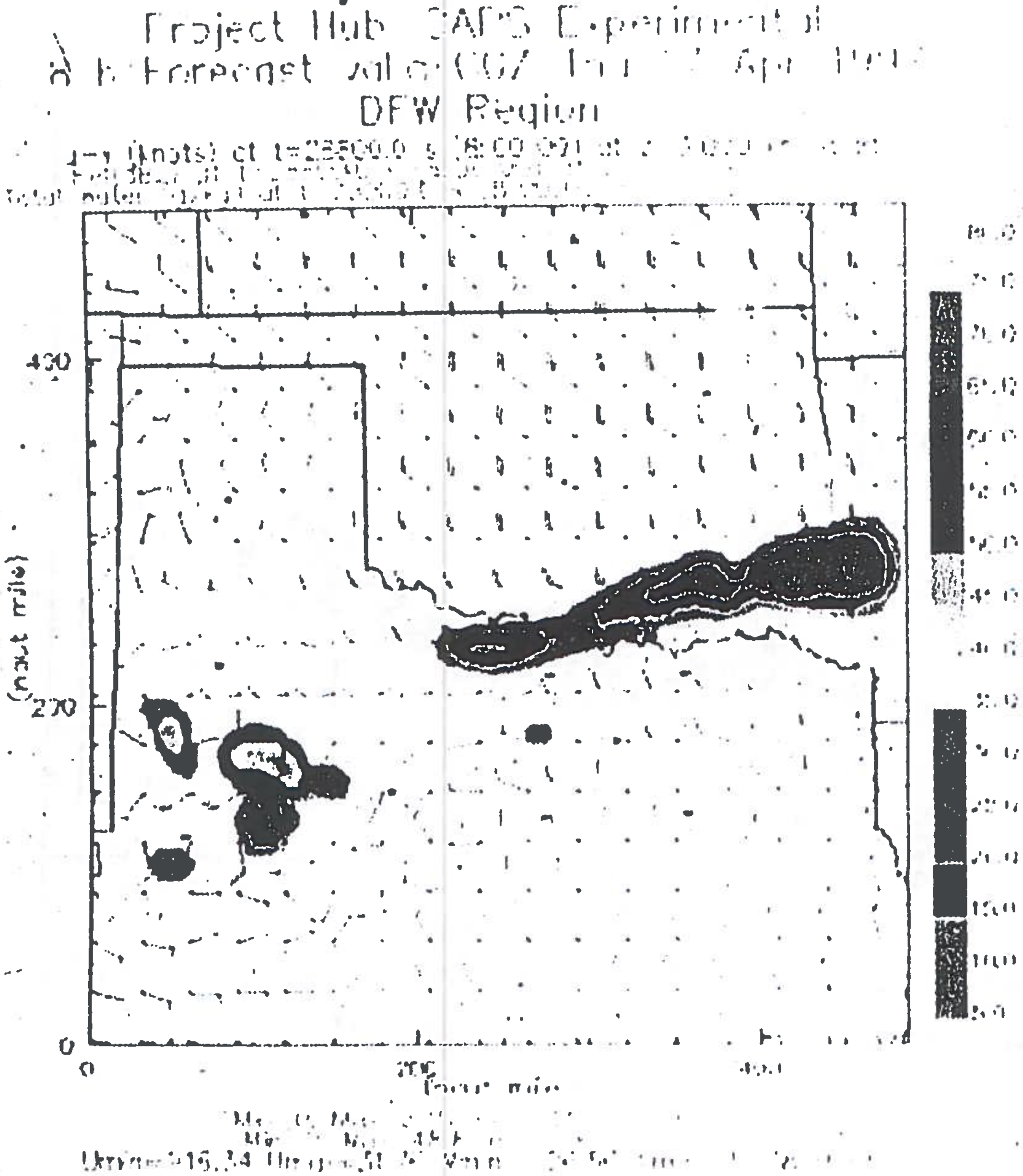


Model t=4 hr Radar

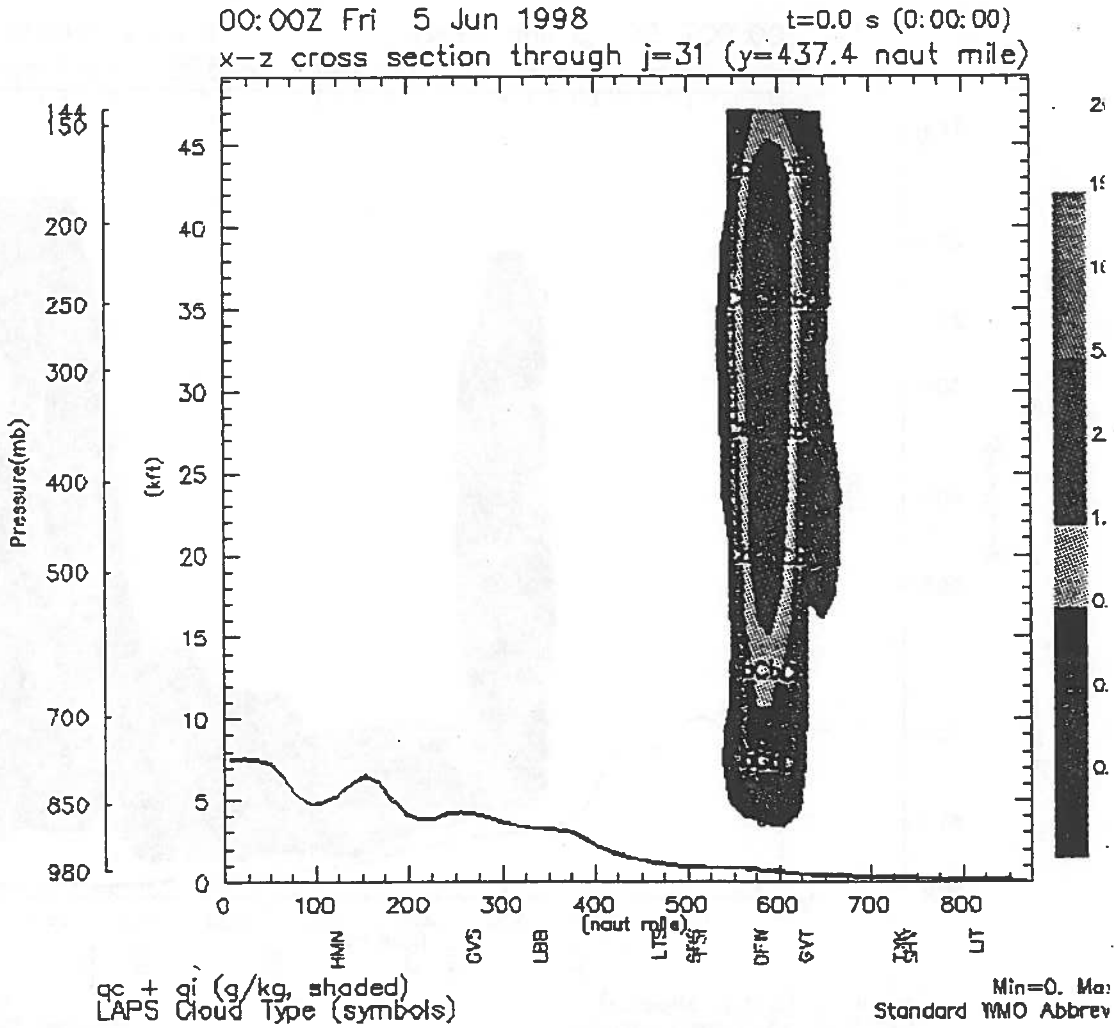




Model t=8hr Radar



Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region



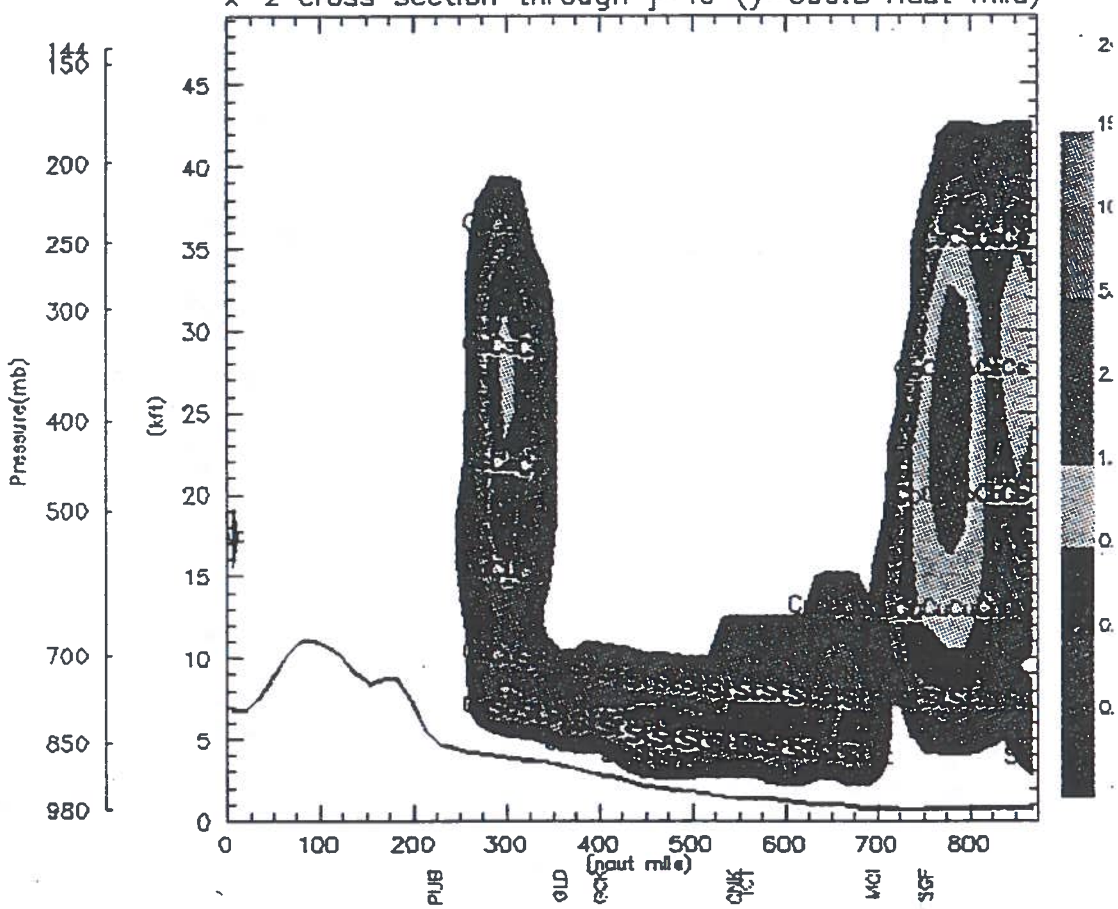
Experimental Product

Project COMET-Tinker

Plot: 1998

Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region

00:00Z Fri 5 Jun 1998 t=0.0 s (0:00:00)
x–z cross section through j=49 (y=699.8 naut mile)



qc + qi (g/kg, shaded)
LAPS Cloud Type (symbols)

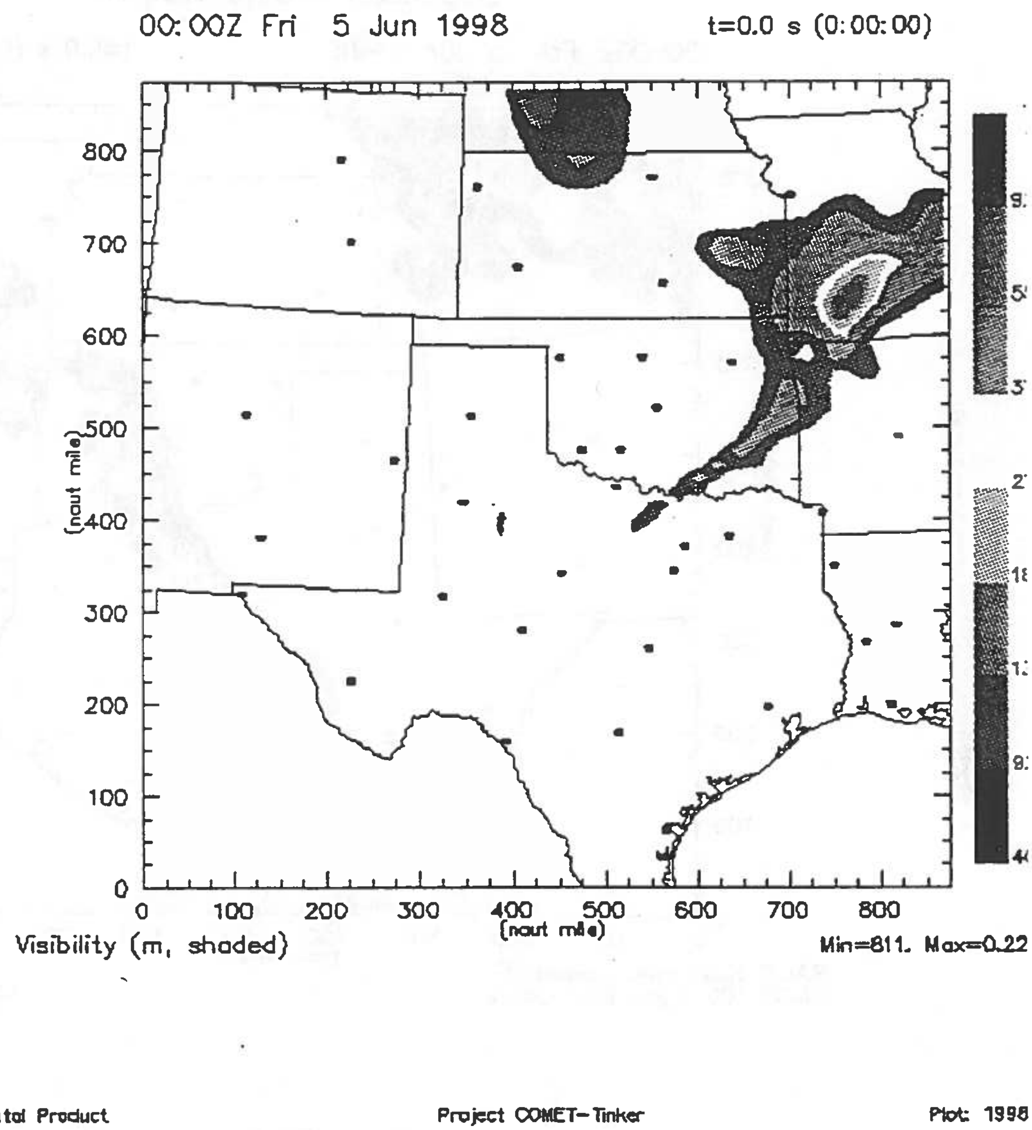
Min=0. Ma
Standard WMO Abbrev

Experimental Product

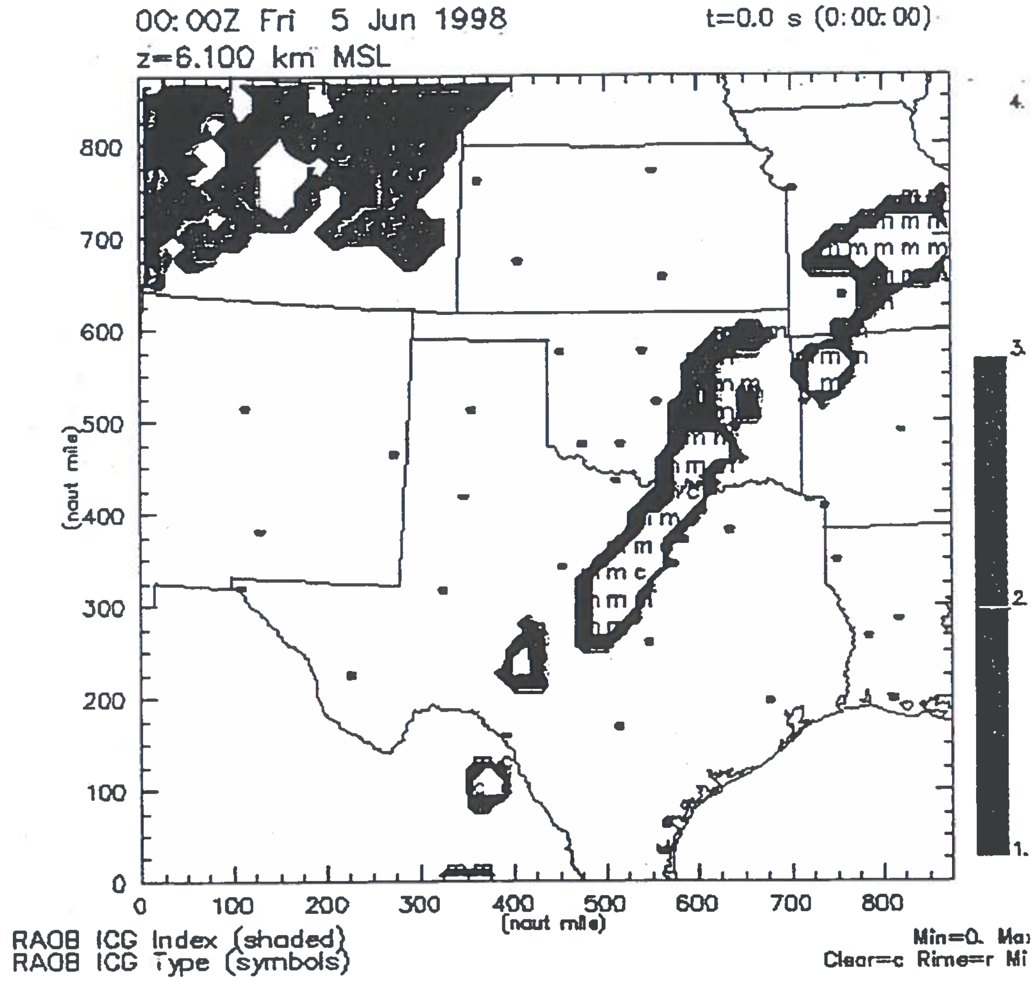
Project COMET–Tinker

Plot: 1998

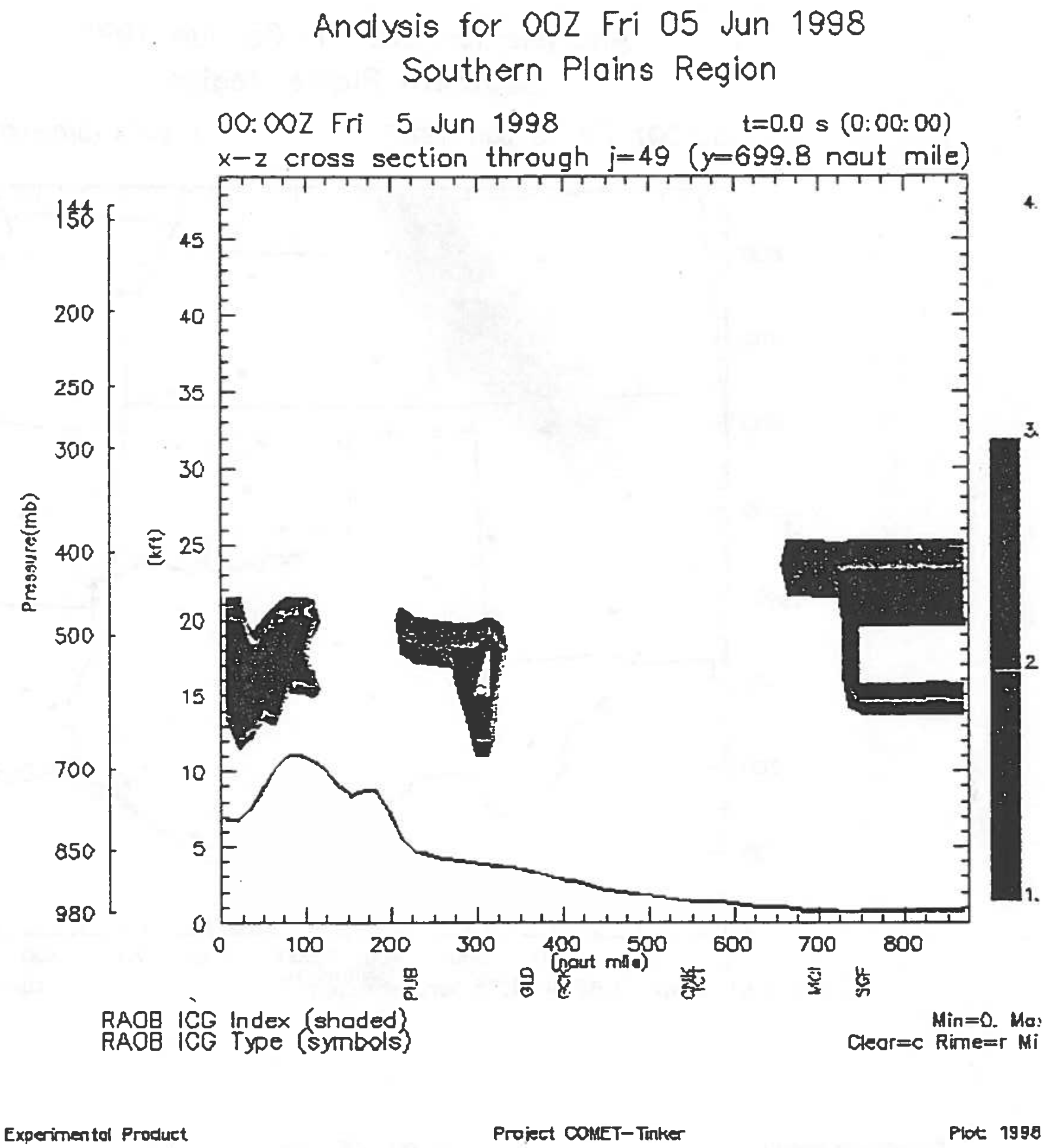
Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region



Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region

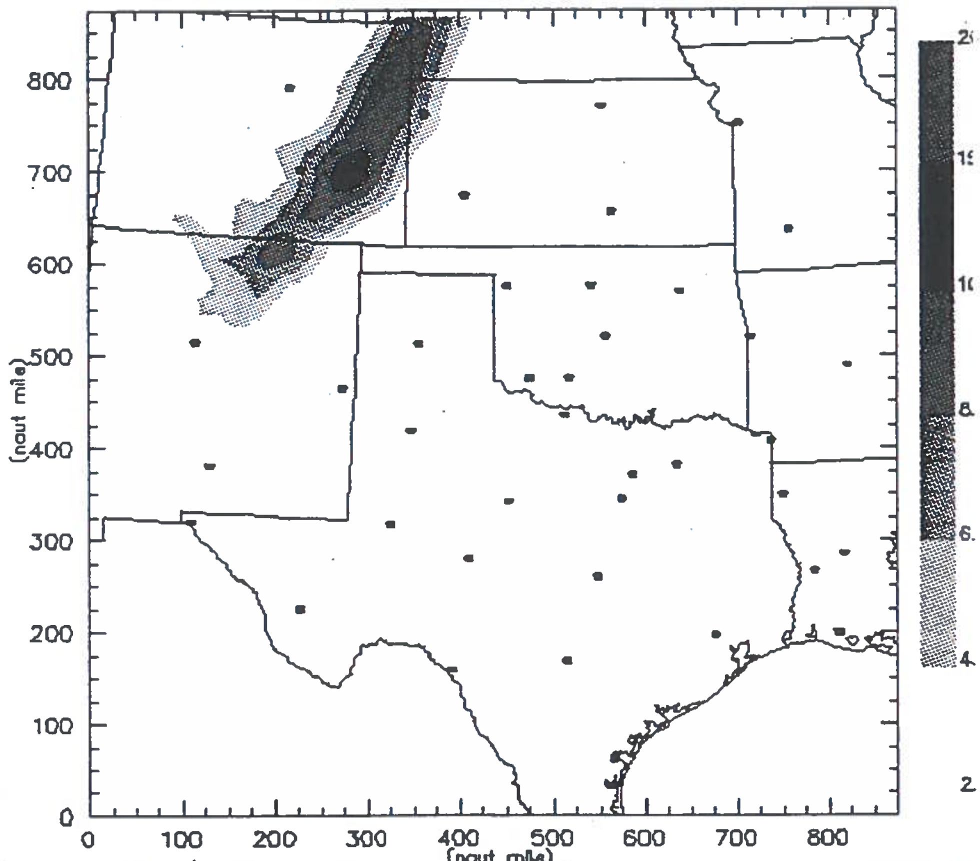


Experimental Product Project COMET-Tinker Plot: 1998


Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region
00:00Z Fri 5 Jun 1998
t=0.0 s (0:00:00)
x-z cross section through j=49 (y=699.8 naut mile)
Pressure(mb)
(kft)
(naut mile)
PUB
GLD
RCK
ICT
MCI
SGF
RAOB ICG Index (shaded)
RAOB ICG Type (symbols)
Min=0. Ma
Clear=c Rime=r Mi
Experimental Product
Project COMET-Tinker
Plot: 1998

Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region

00:00Z Fri 5 Jun 1998 t=0.0 s (0:00:00)



USAF CAT Index (7.62 – 9.75 km, shaded) Min=-2.12 Ma

Experimental Product Project COMET-Tinker Plot: 1998

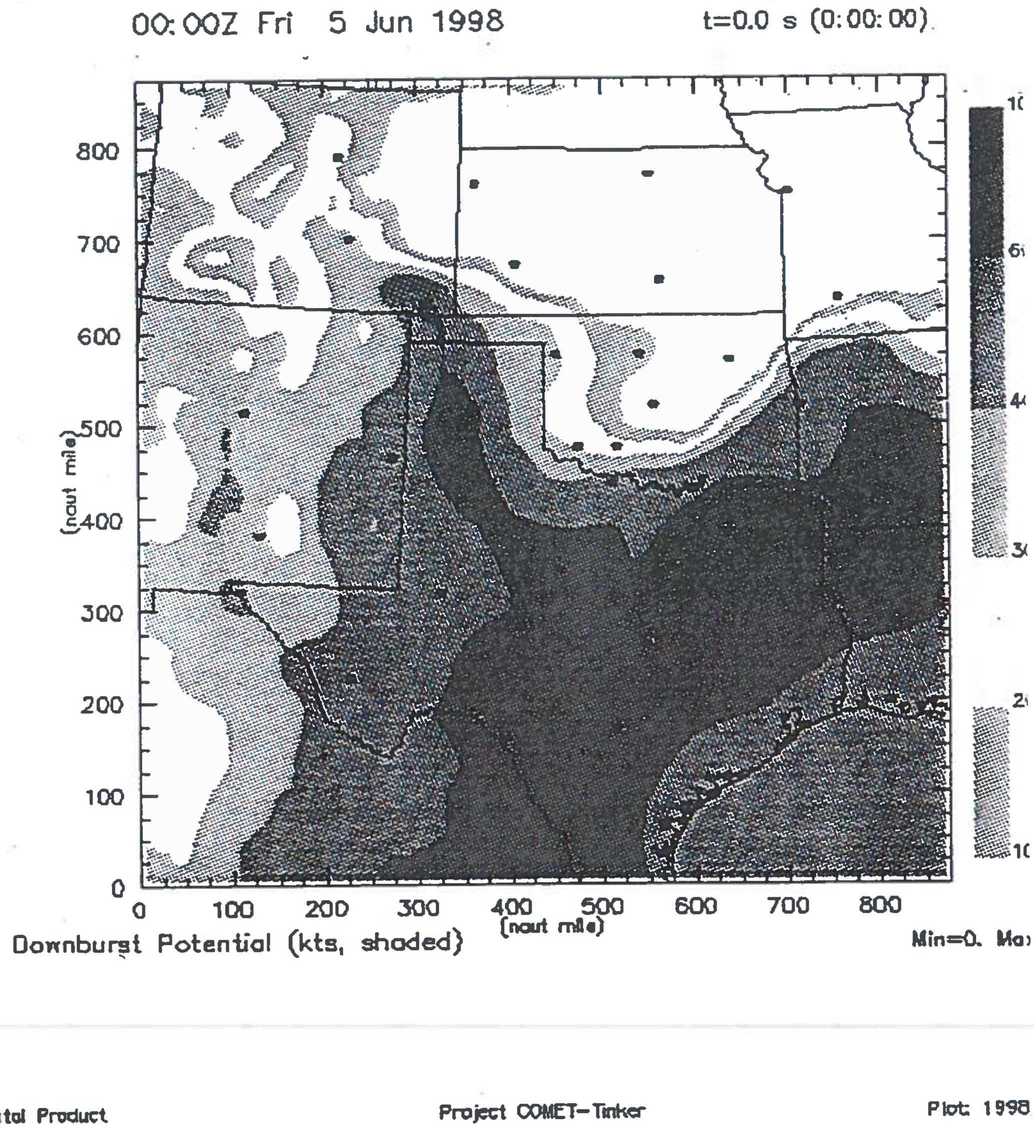
Web Addresses

SAMEX
http://origin.caps.ou.edu/~samex

CAPS
http://www.caps.ou.edu

CAPS Realtime Forecasts
http://hubcaps.ou.edu

Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region



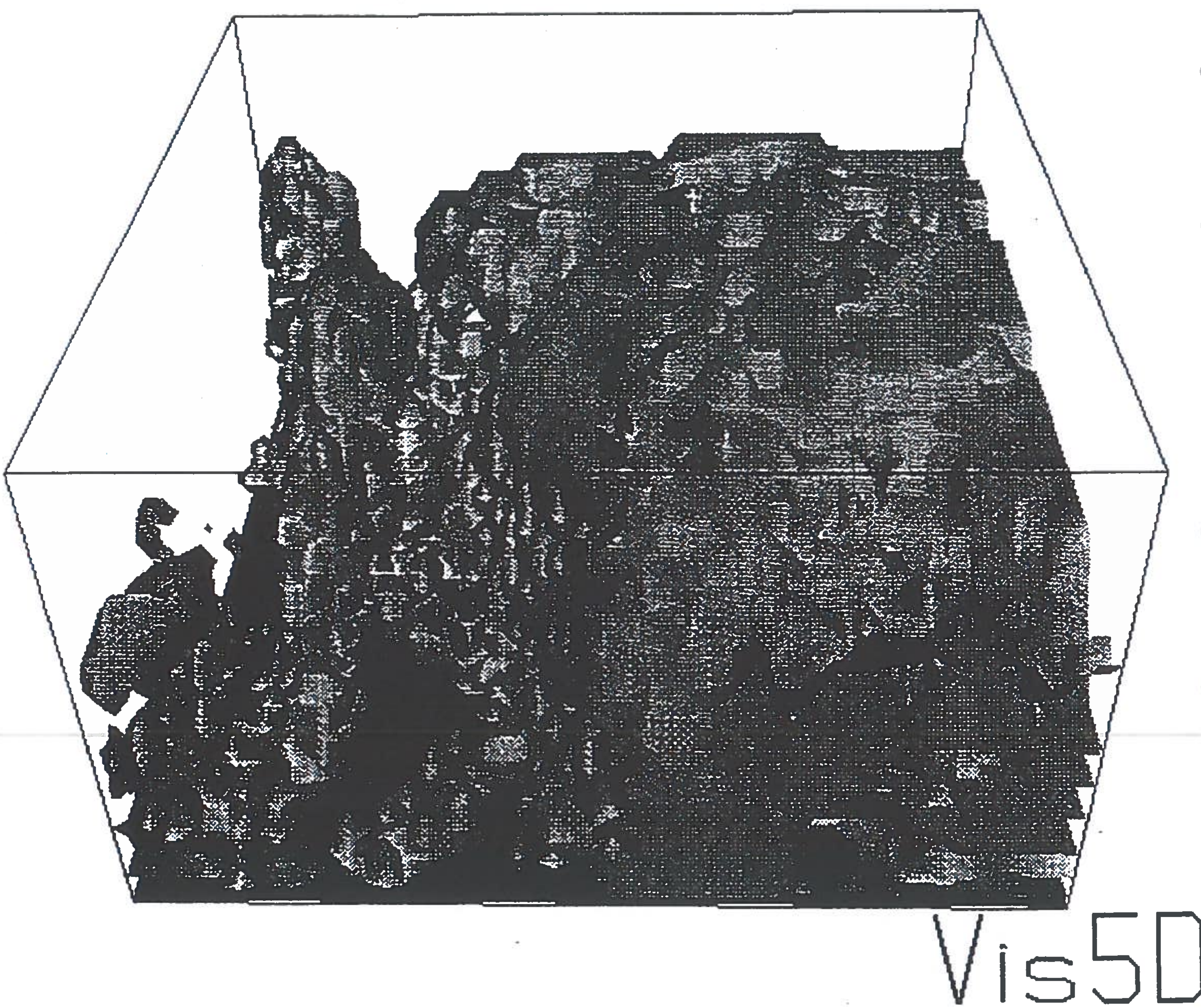
SOUNDING EVALUATED CLOUD AMOUNT FORECAST
(COMET-Tinker Experimental)

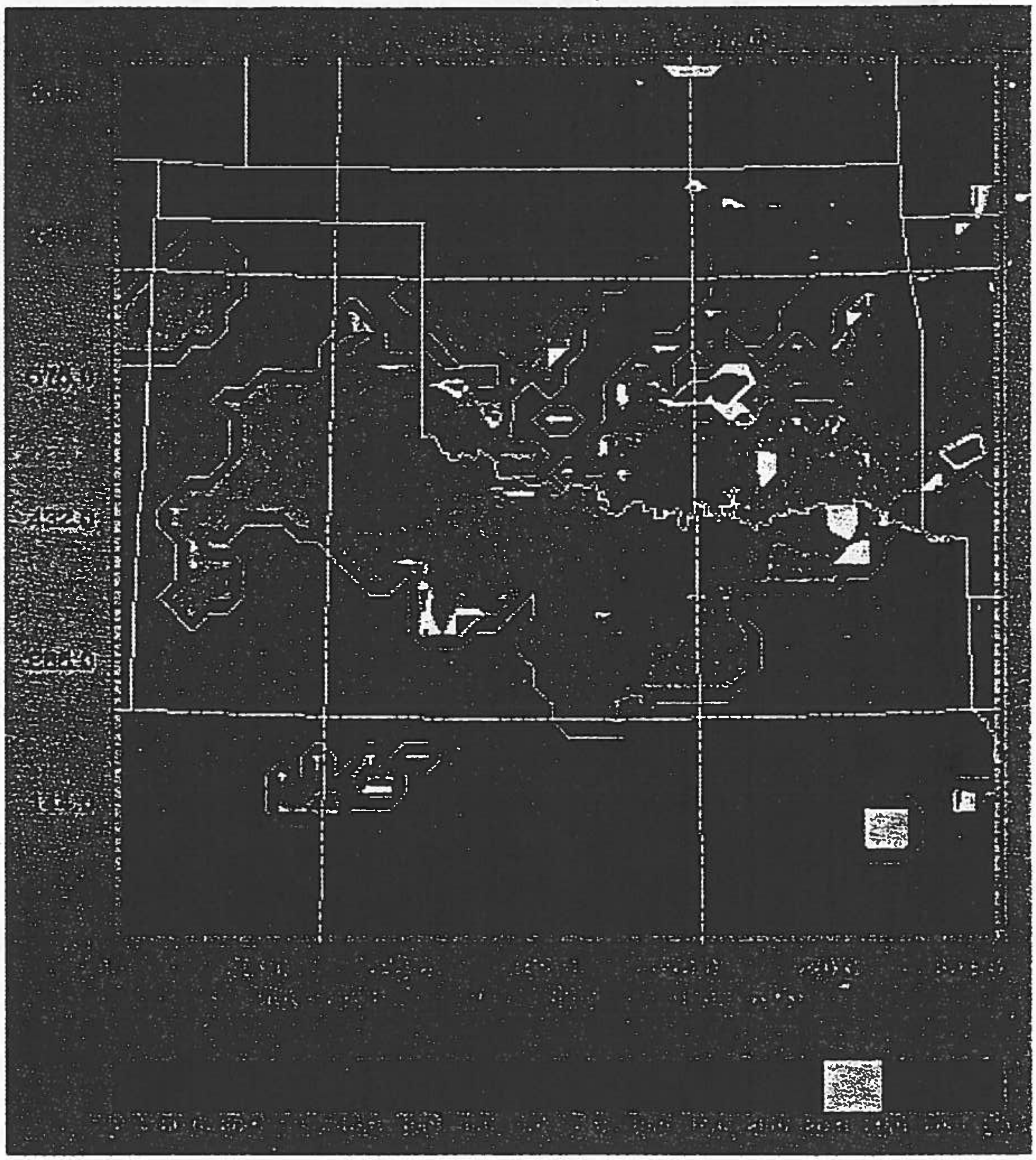
Forecast valid for ICT on 06/05/98 at 00Z

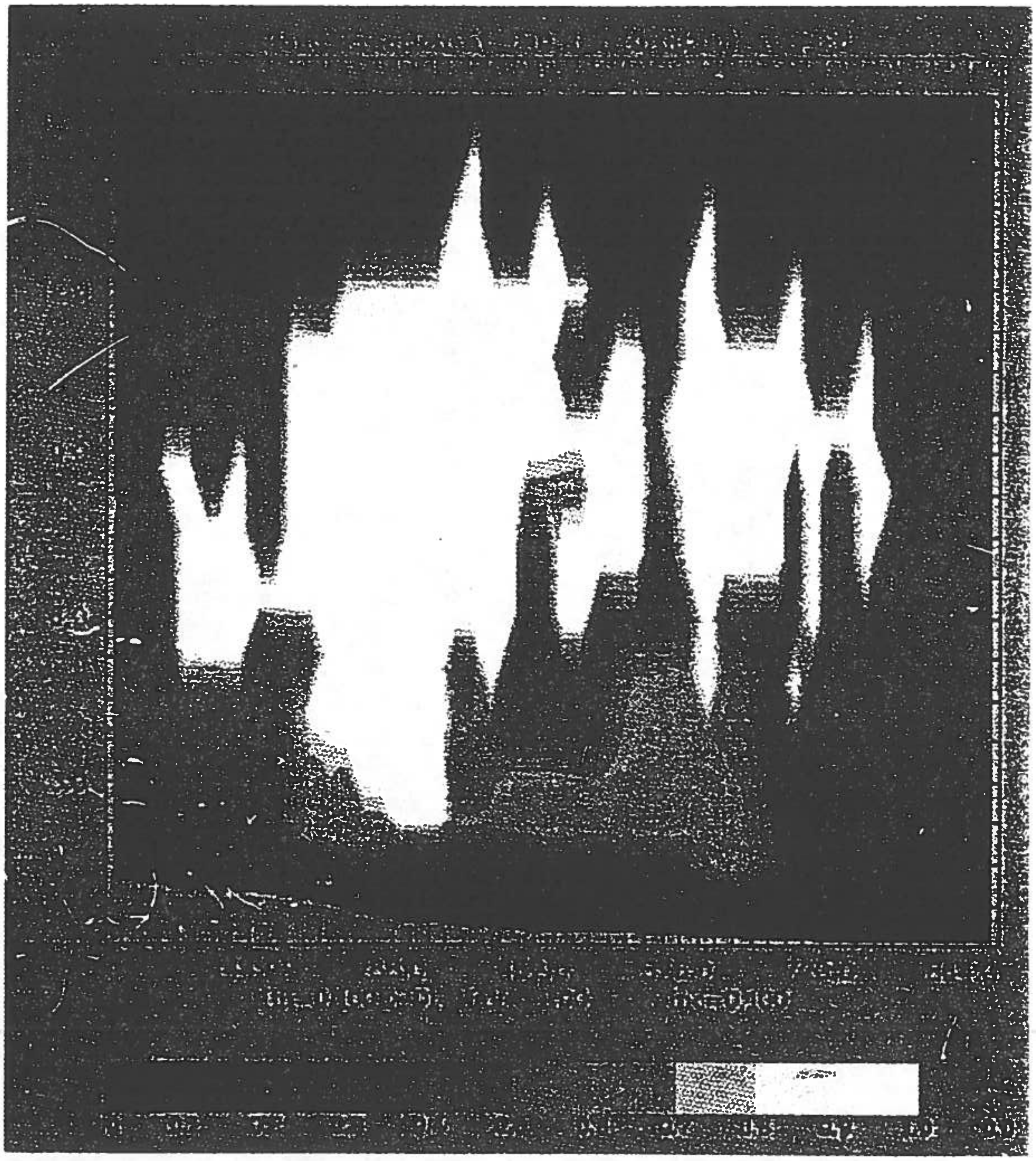
NOTE: Based solely on DEWPOINT DEPRESSION

Height(ft) (msl)	T-Td Cloud Amt Fcst
1315	SCT-FEW
1347	SCT-FEW
1435	SCT-FEW
1589	SCT
1850	SCT-BKN
2278	OVC
2958	OVC
3992	OVC
5480	OVC
7482	SCT-BKN
9999	CLR
12969	CLR
16294	CLR
19870	CLR
23615	CLR
27465	CLR
31381	CLR
35334	CLR
39300	CLR
43266	CLR
47232	CLR

18:00:00
07 May 95
1 of 1
Sunday







ZCZC MKCSWOMCD ALL;407,1048 386,0974 366,0974 387,1048;
ACUS3 KMKC 241718
MKC MCD 241718
COZ000-KSZ000-242100-

SPC MESOSCALE DISCUSSION #0487 FOR ...ERN CO INTO WRN AND CNTRL KS... CONCERNING...SEVERE THUNDERSTORM POTENTIAL...CONVECTIVE TRENDS...

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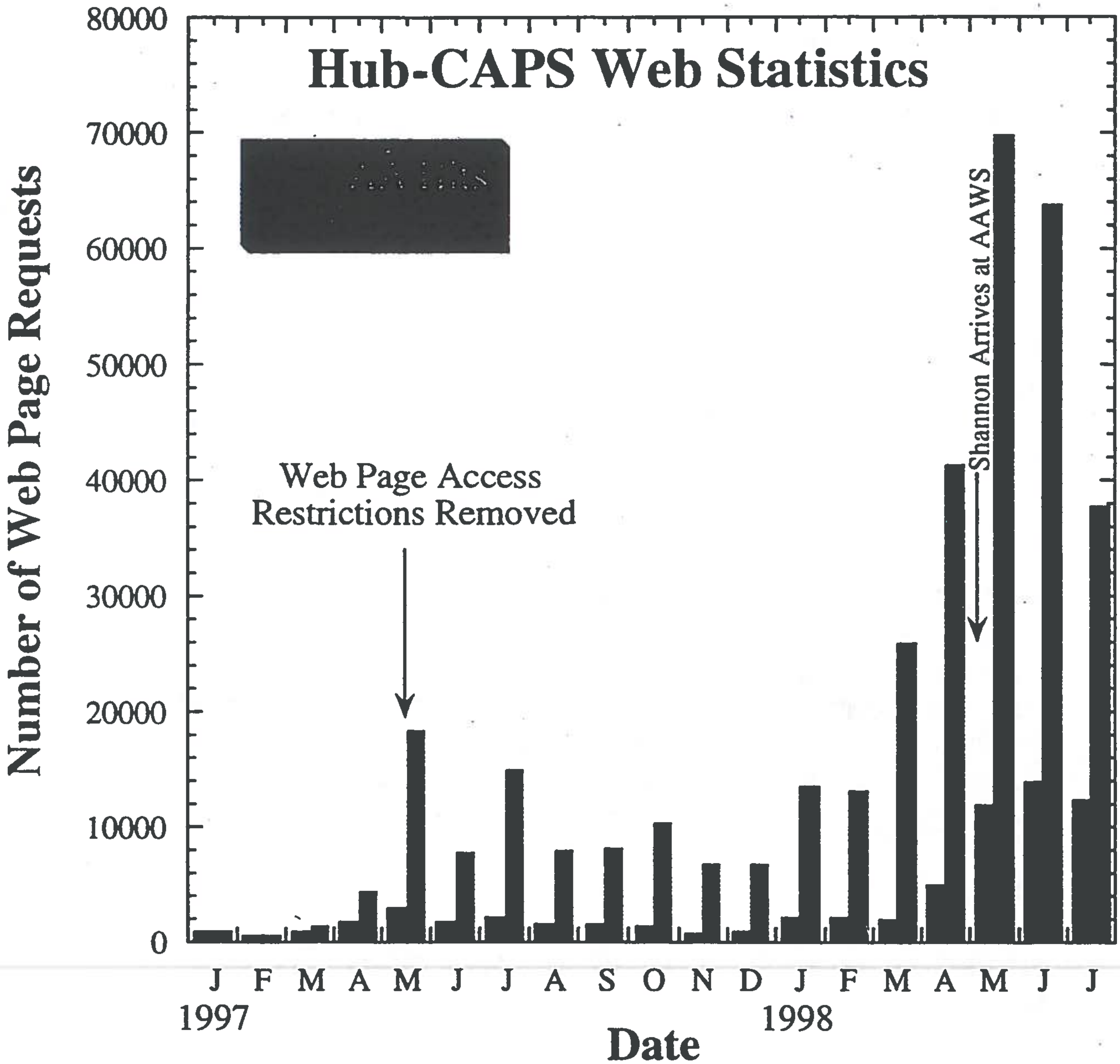
..MCCARTHY.. 05/24/98

...PLEASE SEE WWW.NSSL.NOAA.GOV/~SPC FOR GRAPHIC PRODUCT...
NNNN


Hub-CAPS Web Statistics
[redacted]
Number of Web Page Requests
80000
70000
60000
50000
40000
30000
20000
10000
0
Web Page Access
Restrictions Removed
Shannon Arrives at AAWS
J F M A M J J A S O N D J F M A M J J
1997
1998
Date

Quantifying Forecast Skill

- Some traditional measures (e.g., RMS errors, anomaly correlations) are not appropriate for storm-scale phenomena
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Hub-CAPS

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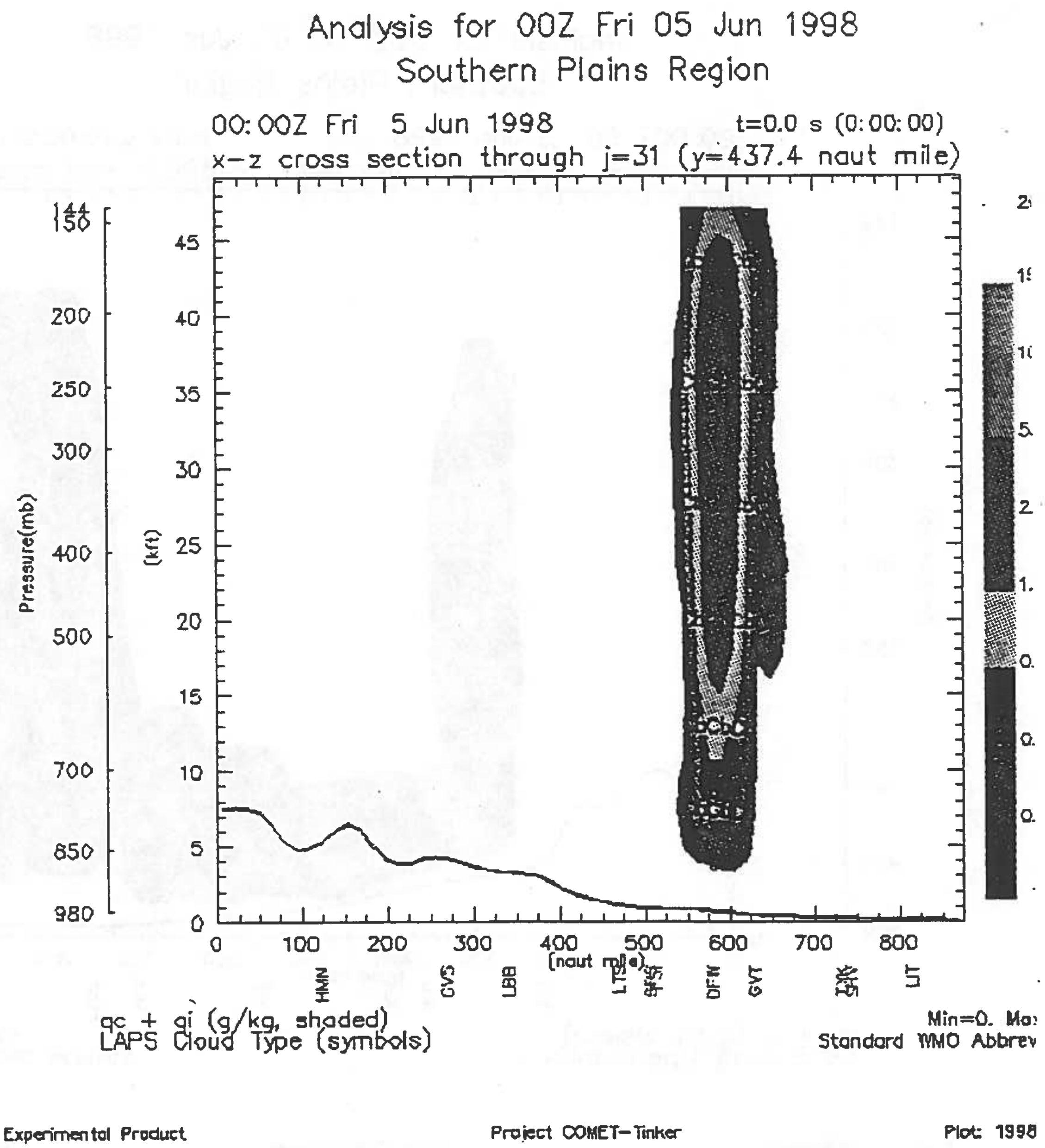
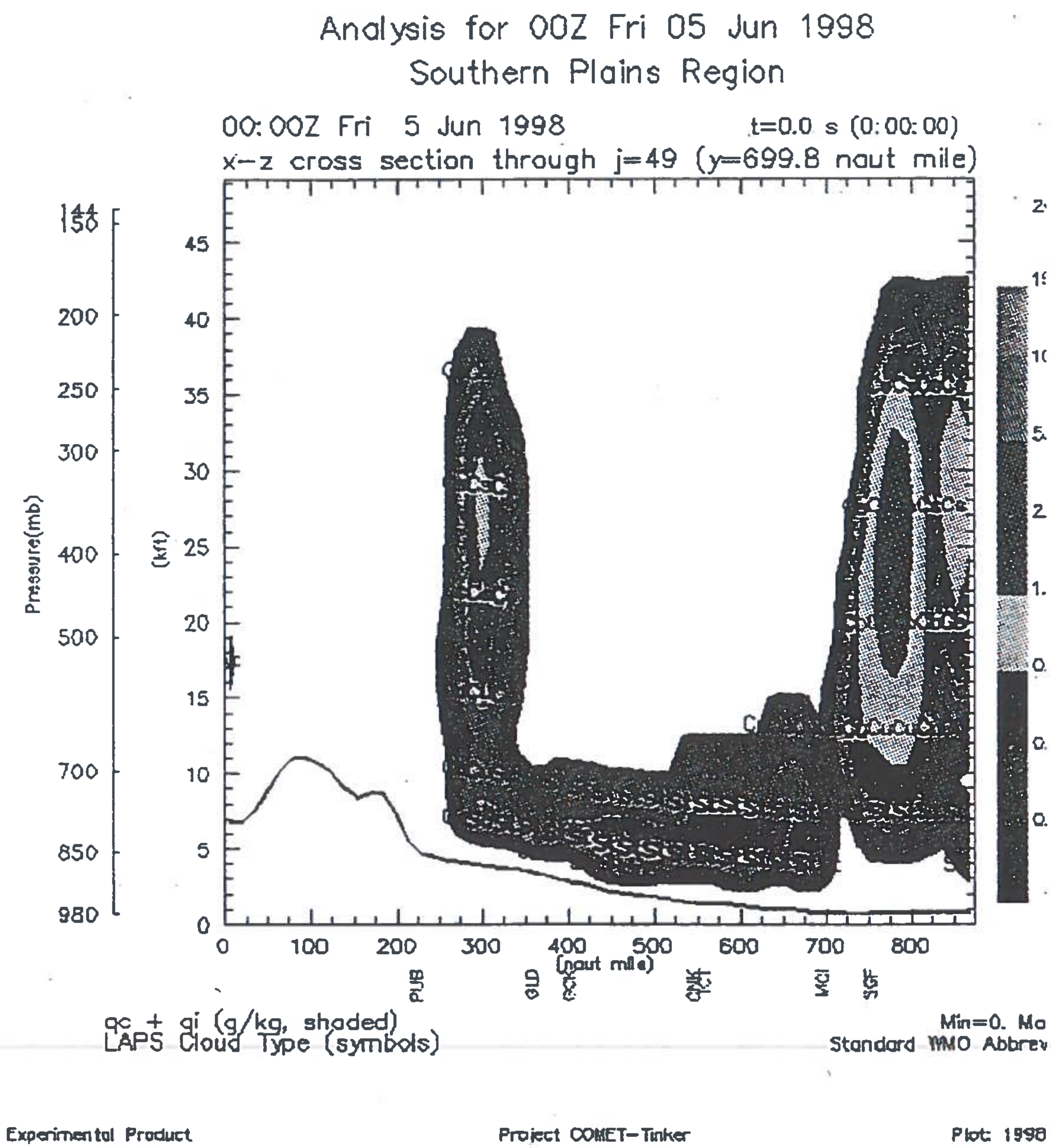
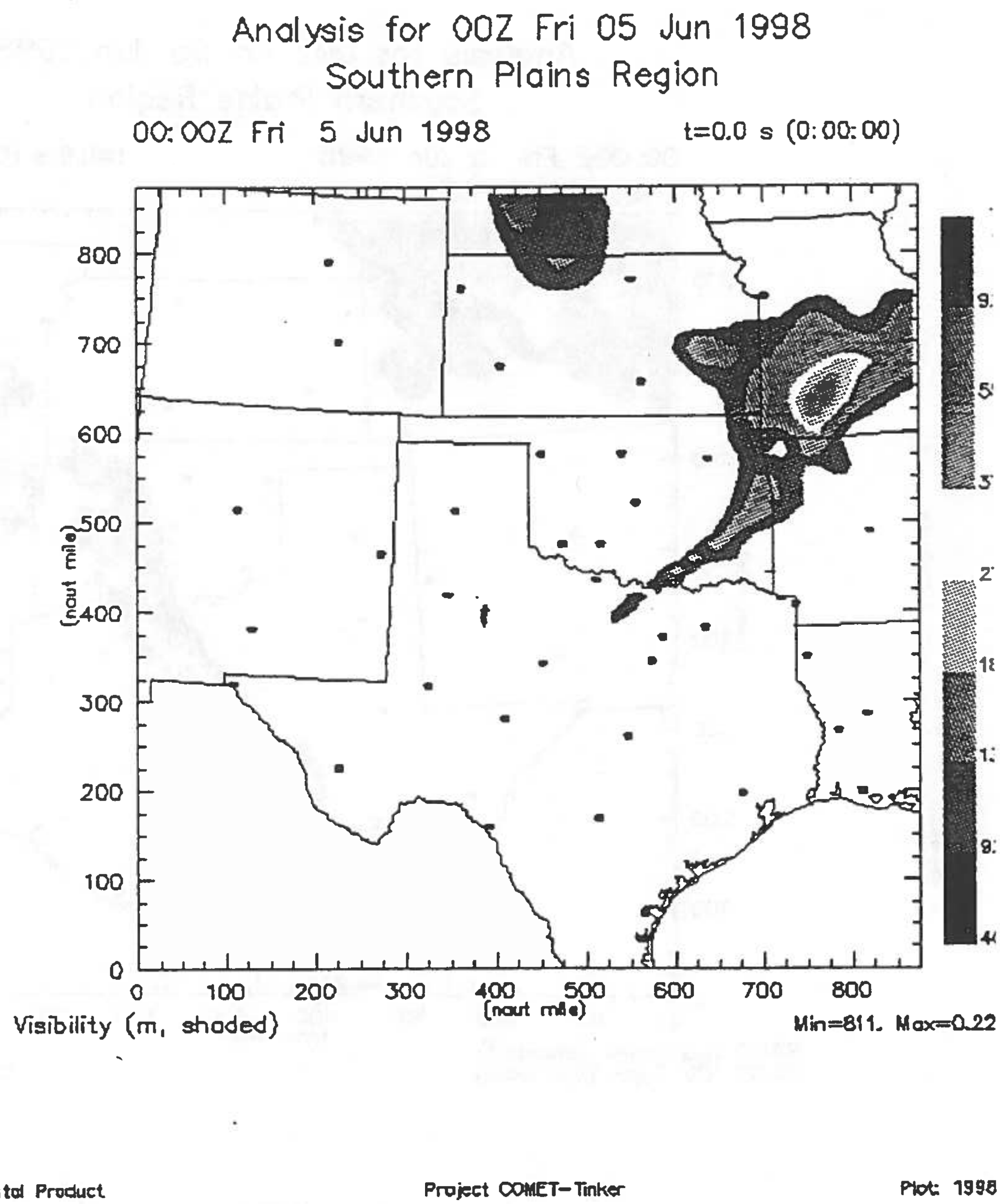
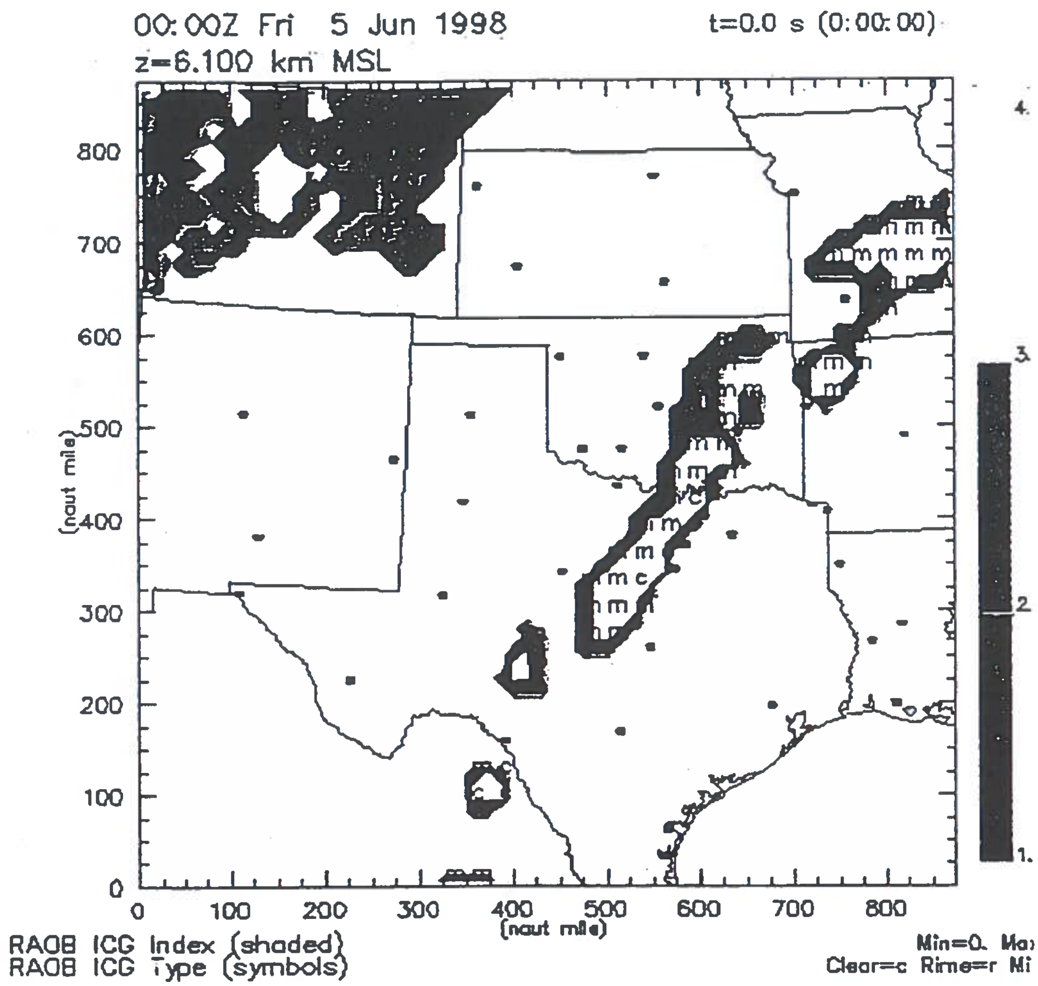

Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region
00:00Z Fri 5 Jun 1998
t=0.0 s (0:00:00)
x-z cross section through j=31 (y=437.4 naut mile)
Pressure(mb)
(kft)
(naut mile)
HMN
CVS
LBB
DFW
GVT
qc + qi (g/kg, shaded)
LAPS Cloud Type (symbols)
Standard WMO Abbrev
Experimental Product
Project COMET-Tinker

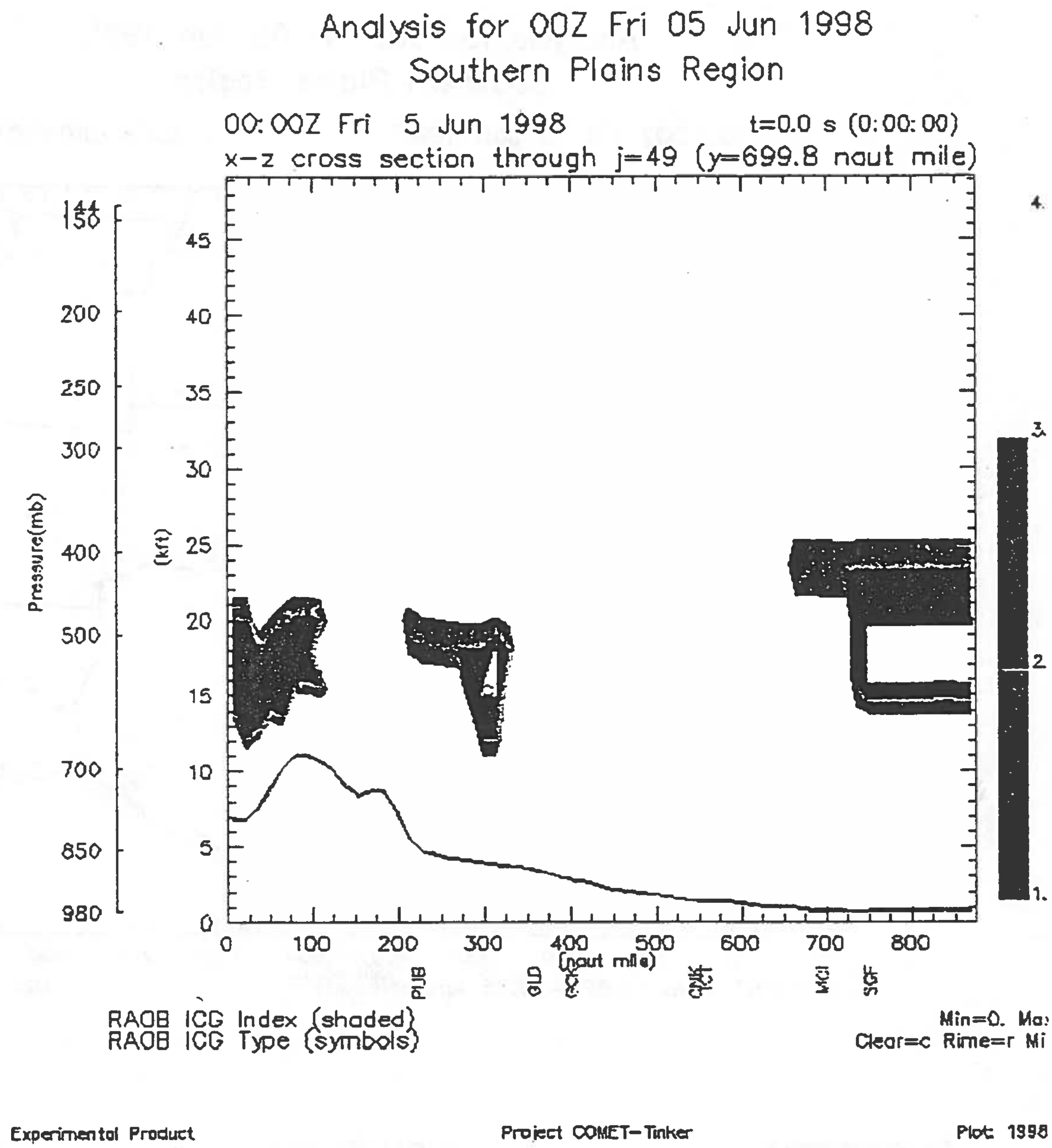

Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region
00:00Z Fri 5 Jun 1998
t=0.0 s (0:00:00)
x-z cross section through j=49 (y=699.8 naut mile)
Pressure(mb)
(kft)
(naut mile)
PUB
GLD
CNK
MCI
SGF
qc + qi (g/kg, shaded)
LAPS Cloud Type (symbols)
Min=0. Ma
Standard WMO Abbrev
Experimental Product
Project COMET-Tinker
Plot: 1998

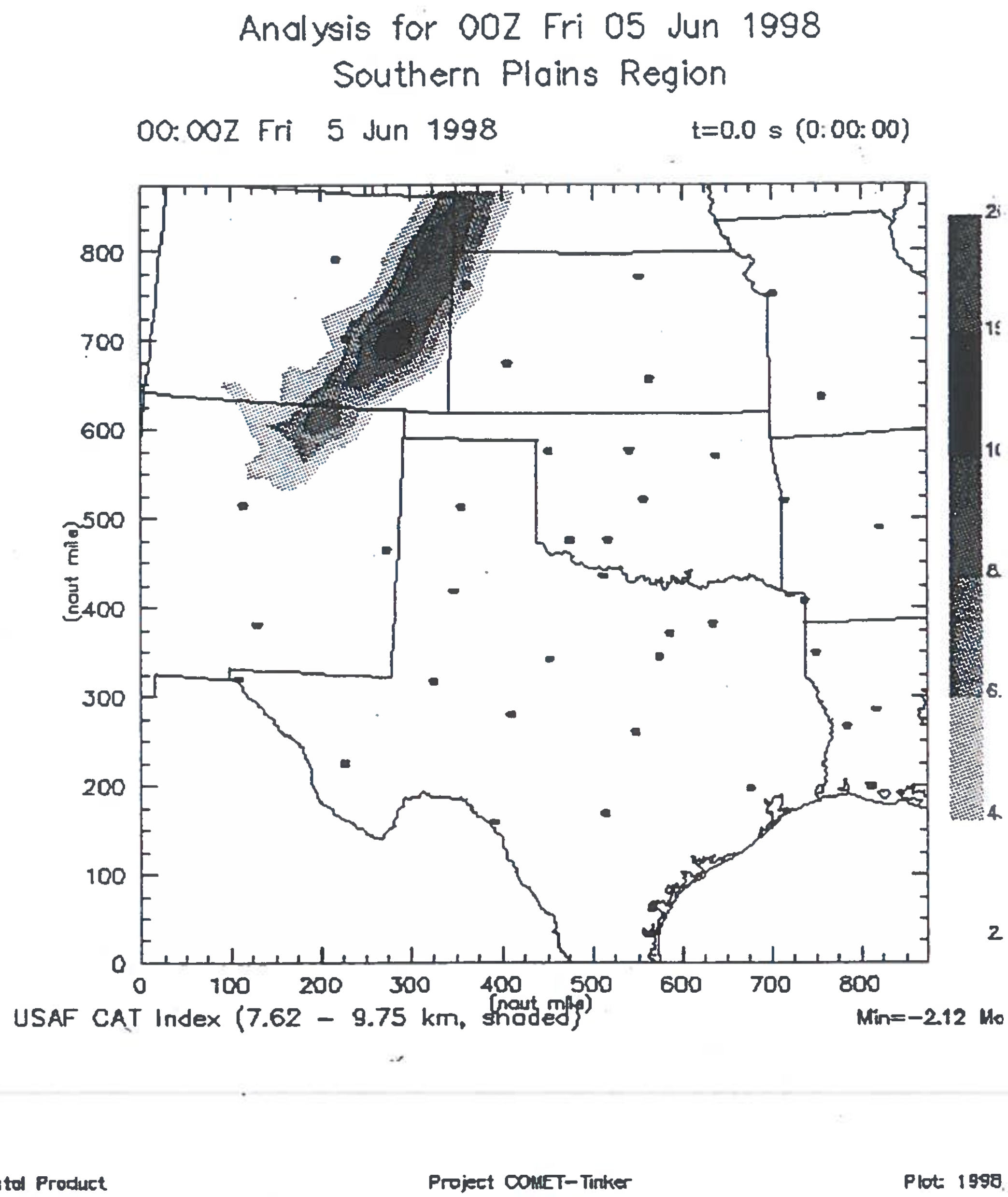

Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region
00:00Z Fri 5 Jun 1998
t=0.0 s (0:00:00)
(naut mile)
Visibility (m, shaded)
Min=811. Max=0.22
Experimental Product
Project COMET-Tinker
Plot: 1998

Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region



Experimental Product Project COMET-Tinker Plot: 1998


Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region
00:00Z Fri 5 Jun 1998
t=0.0 s (0:00:00)
x-z cross section through j=49 (y=699.8 naut mile)
Pressure(mb)
144
150
200
250
300
400
500
700
850
980
(kft)
45
40
35
30
25
20
15
10
5
0
0
100
200
300
400
500
600
700
800
(naut mile)
PUB
GLD
MCI
SGF
4.
3.
2.
1.
RAOB ICG Index (shaded)
RAOB ICG Type (symbols)
Min=0.
Clear=c Rime=r
Experimental Product
Project COMET-Tinker
Plot: 1998


Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region
00:00Z Fri 5 Jun 1998
t=0.0 s (0:00:00)
(naut mile)
(naut mile)
USAF CAT Index (7.62 - 9.75 km, shaded)
Min=-2.12
Experimental Product
Project COMET-Tinker
Plot: 1998

Web Addresses

SAMEX

http://origin.caps.ou.edu/~samex

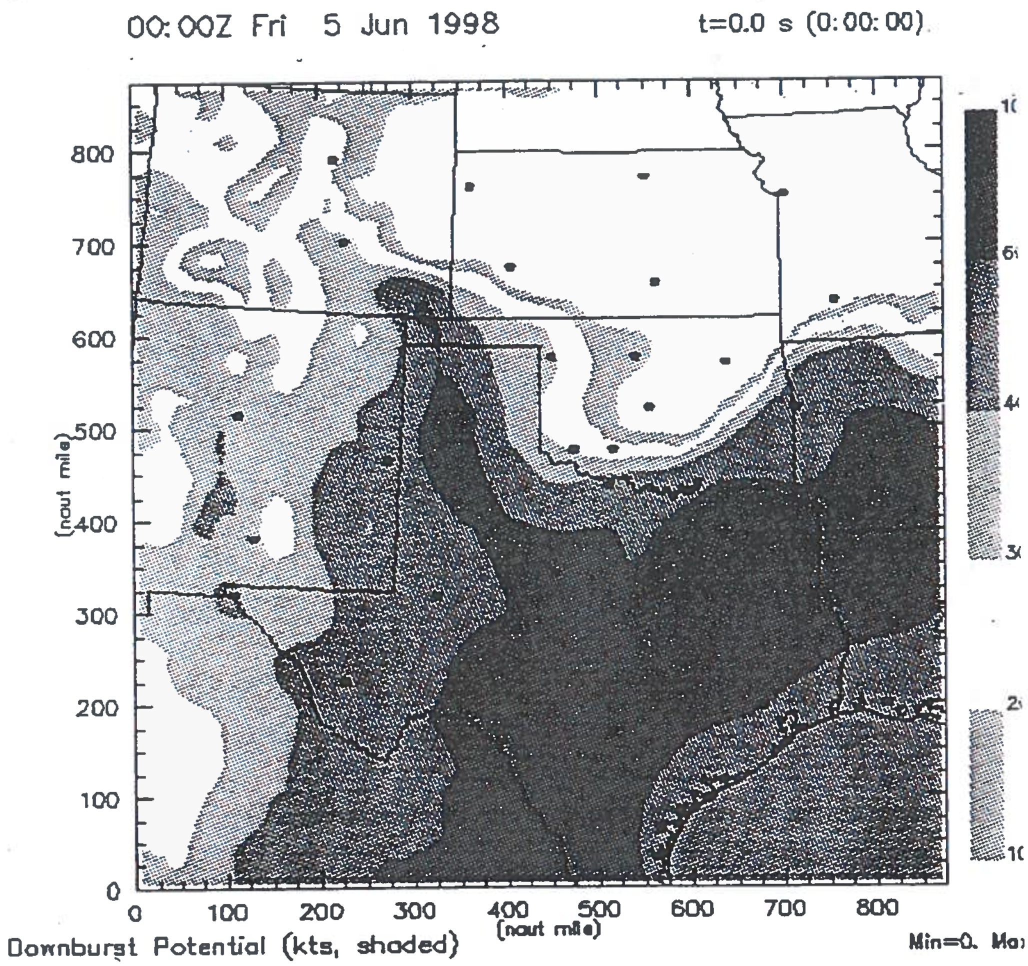
CAPS

http://www.caps.ou.edu

CAPS Realtime Forecasts

http://hubcaps.ou.edu

Analysis for 00Z Fri 05 Jun 1998
Southern Plains Region



Experimental Product

Project COMET-Tinker

Plot: 1998

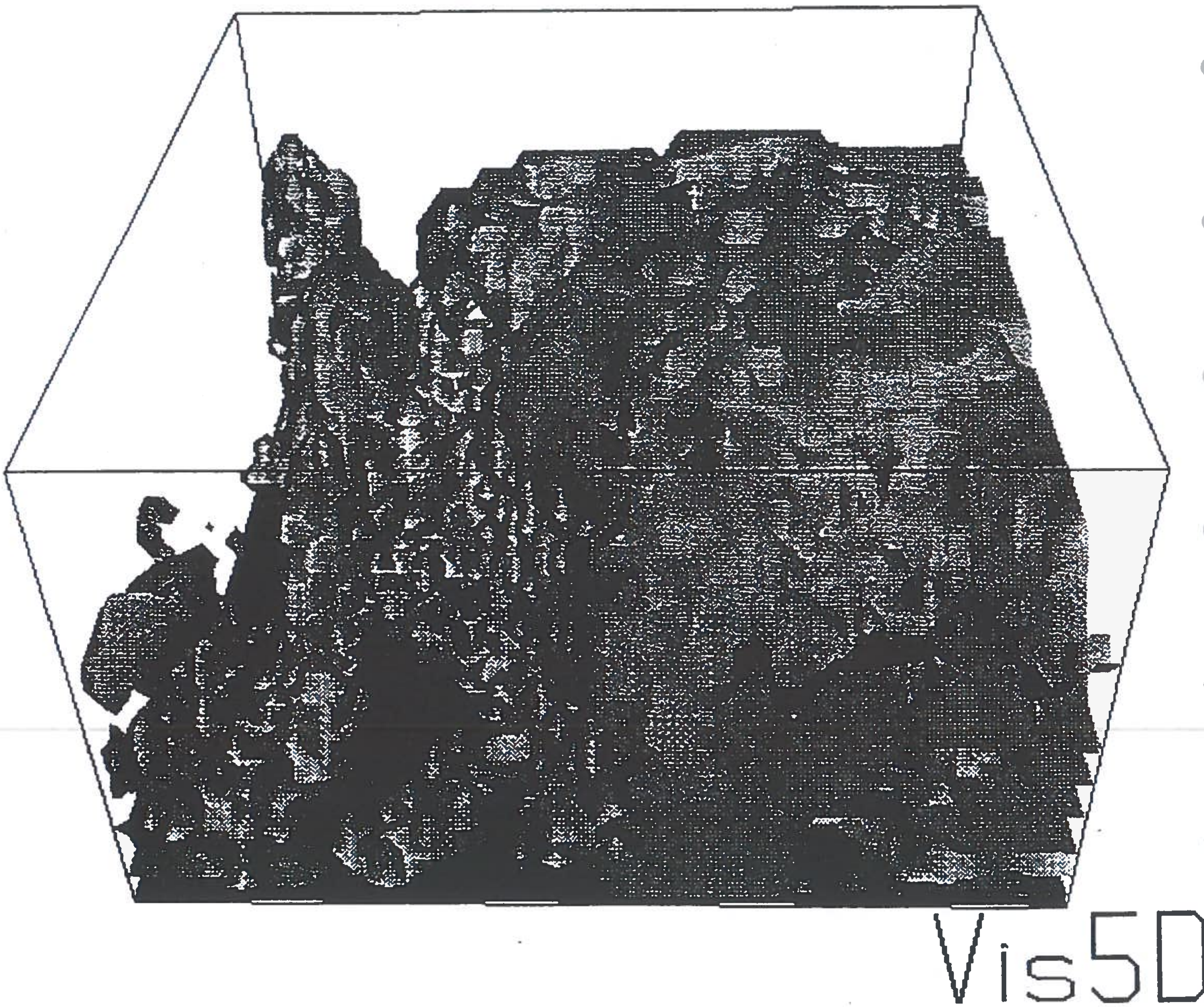
SOUNDING EVALUATED CLOUD AMOUNT FORECAST
(COMET-Tinker Experimental)

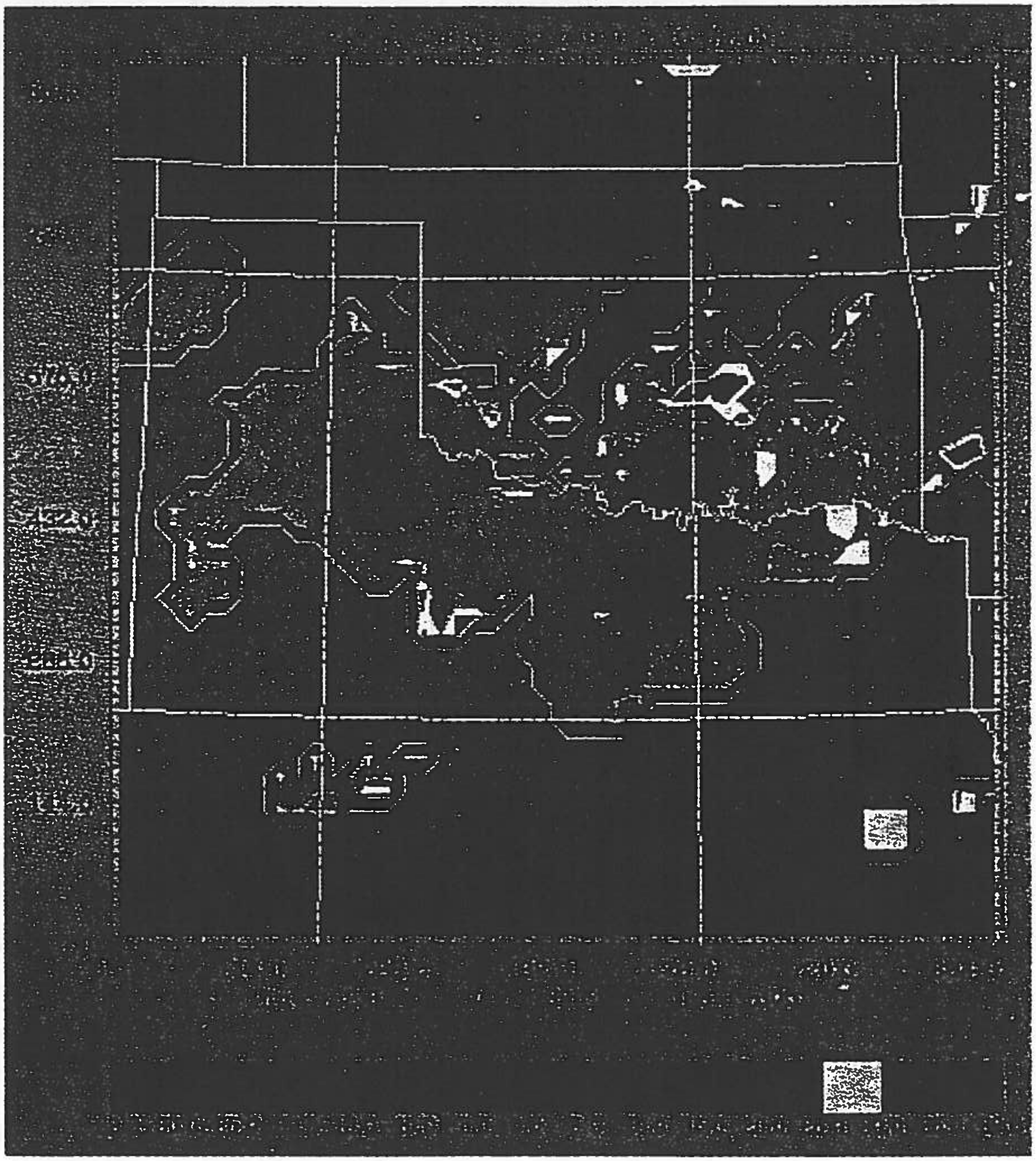
Forecast valid for ICT on 06/05/98 at 00Z

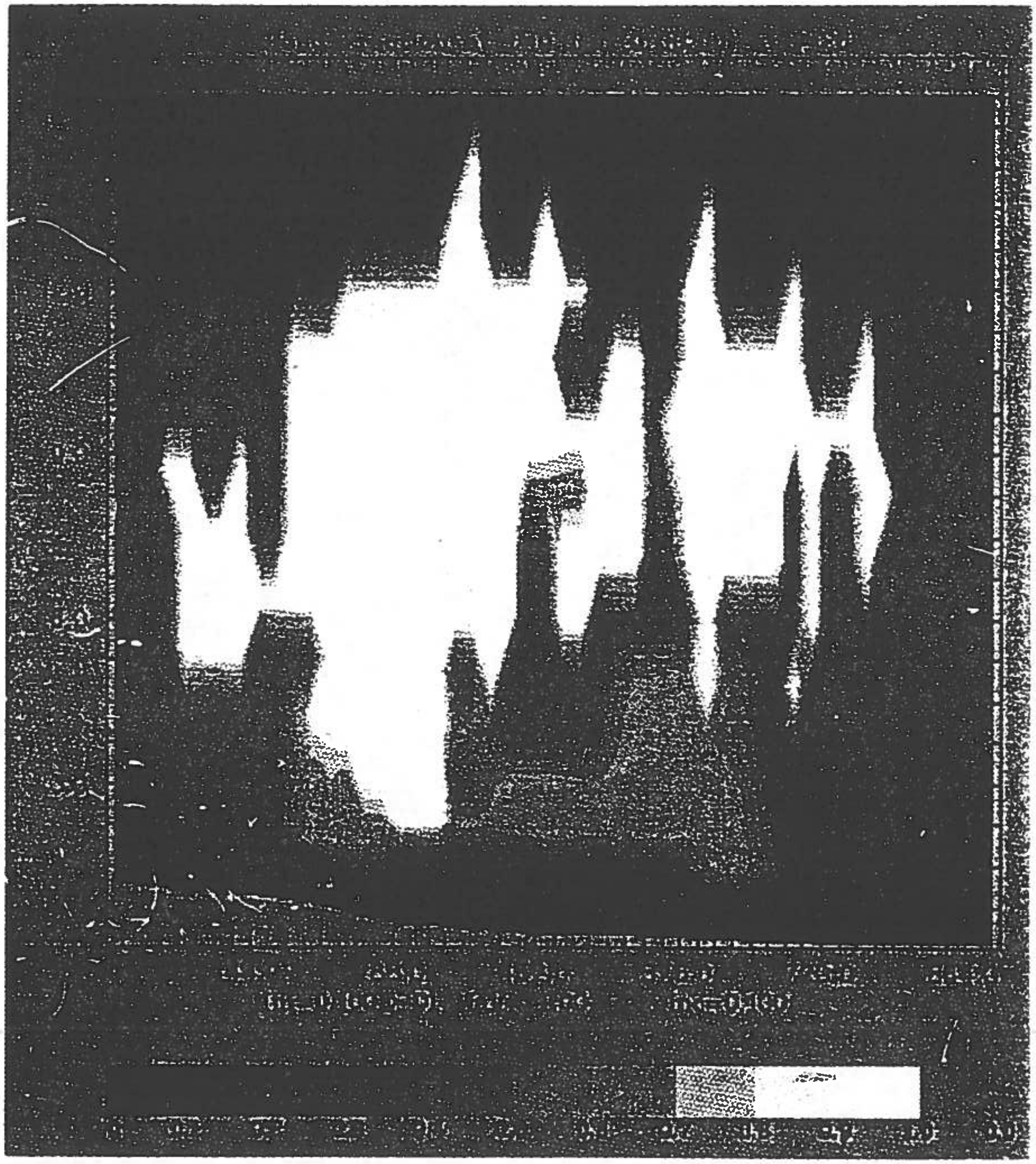
NOTE: Based solely on DEWPOINT DEPRESSION

Height(ft) (msl)	T-Td Cloud Amt Fcst
1315	SCT-FEW
1347	SCT-FEW
1435	SCT-FEW
1589	SCT
1850	SCT-BKN
2278	OVC
2958	OVC
3992	OVC
5480	OVC
7482	SCT-BKN
9999	CLR
12969	CLR
16294	CLR
19870	CLR
23615	CLR
27465	CLR
31381	CLR
35334	CLR
39300	CLR
43266	CLR
47232	CLR

18:00:00
07 May 95
1 of 1
Sunday







ZCZC MKCSWOMCD ALL;407,1048 386,0974 366,0974 387,1048;
ACUS3 KMKC 241718
MKC MCD 241718
COZ000-KSZ000-242100-

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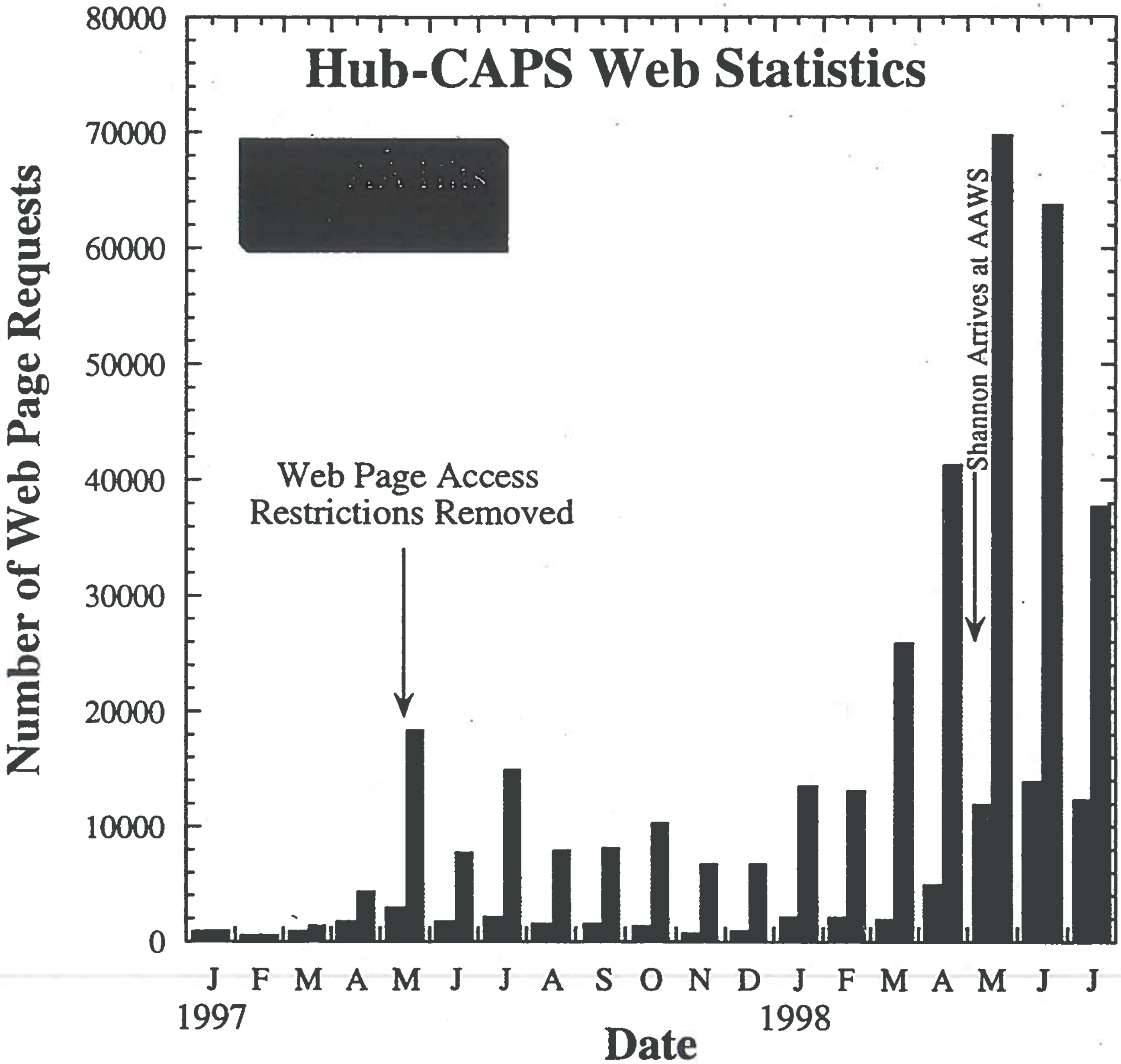
Hub-CAPS Web Statistics
Number of Web Page Requests
80000
70000
60000
50000
40000
30000
20000
10000
0
Web Page Access
Restrictions Removed
Shannon Arrives at AAWS
J F M A M J J A S O N D J F M A M J J
1997
1998
Date

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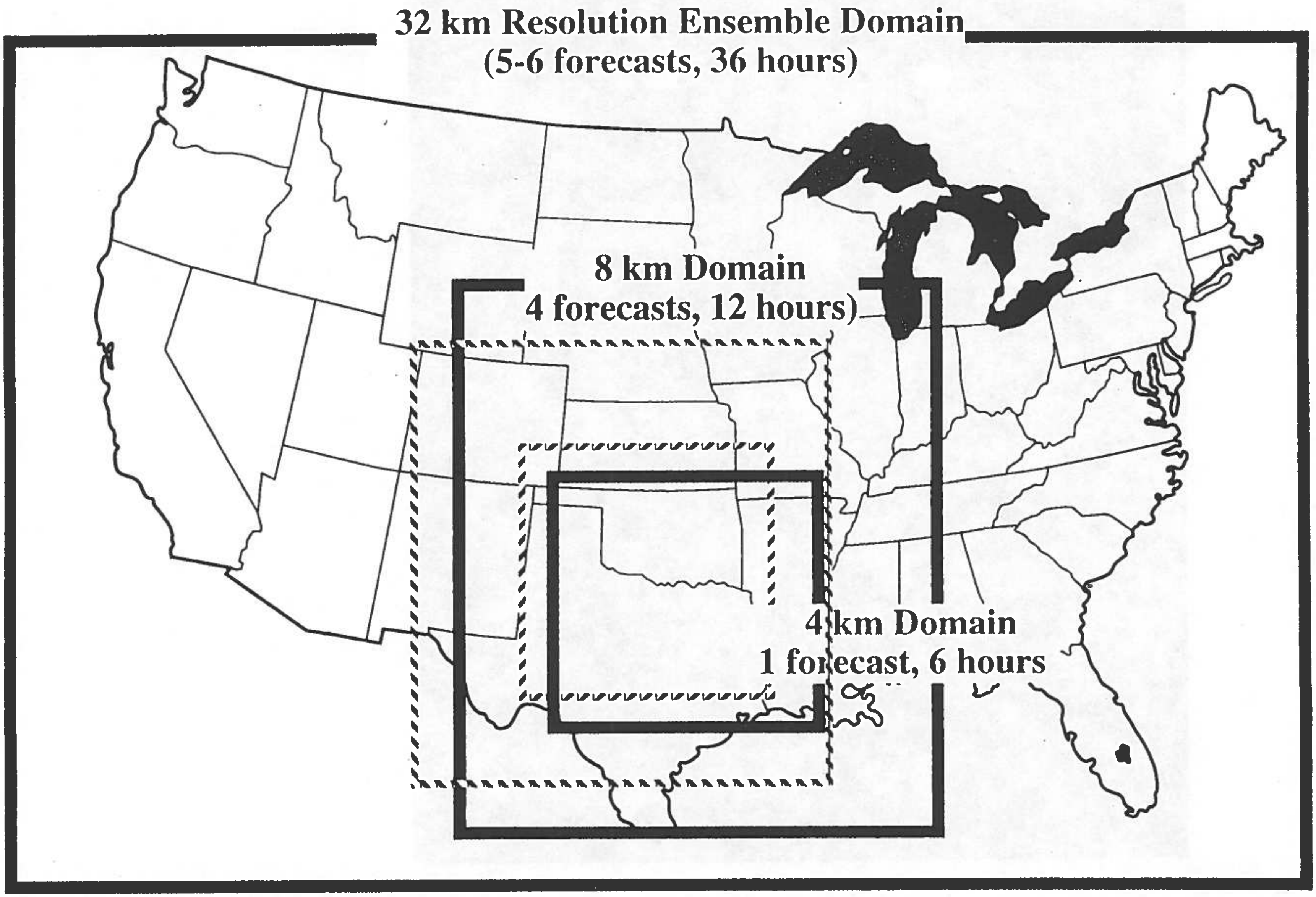
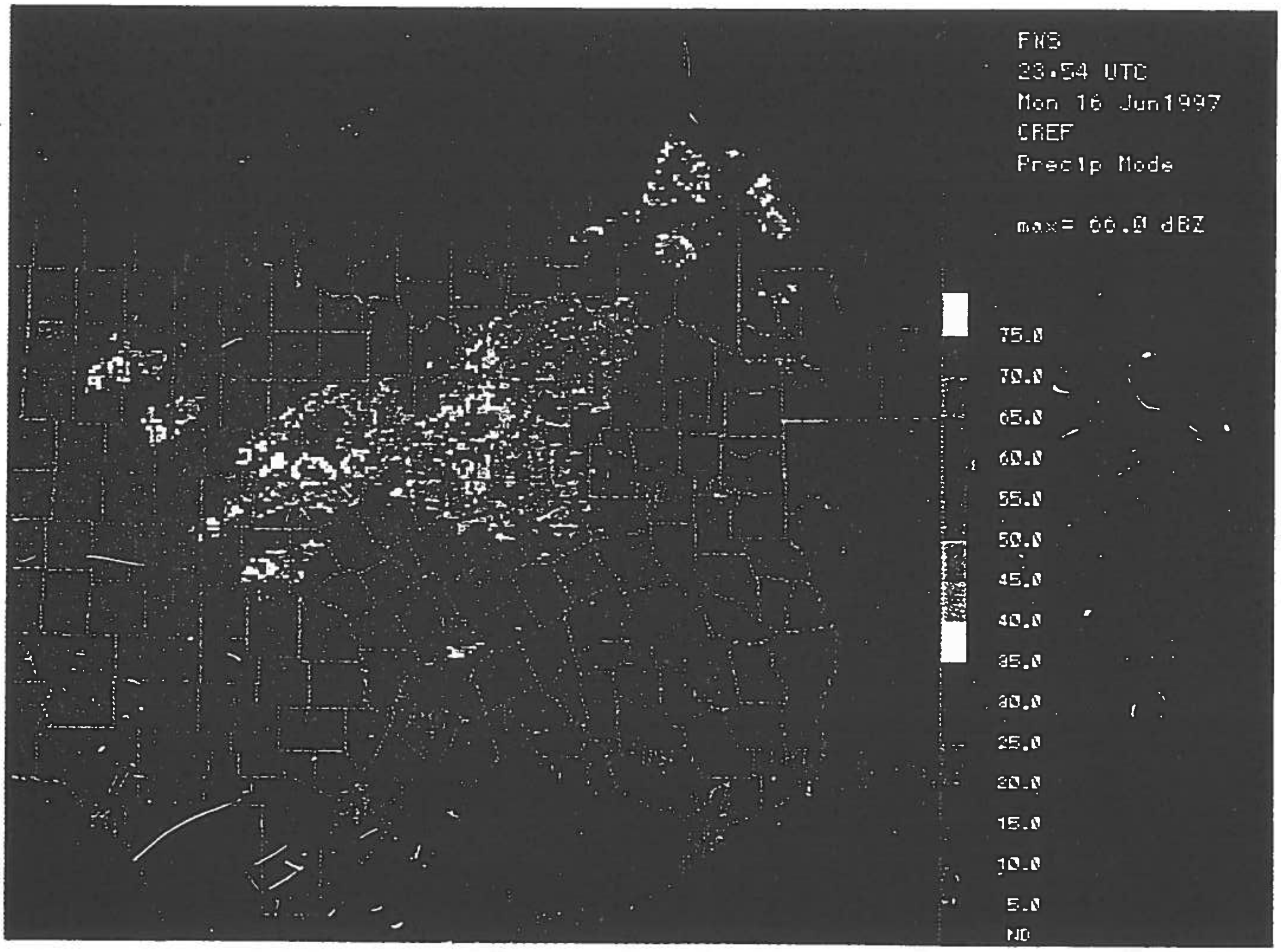
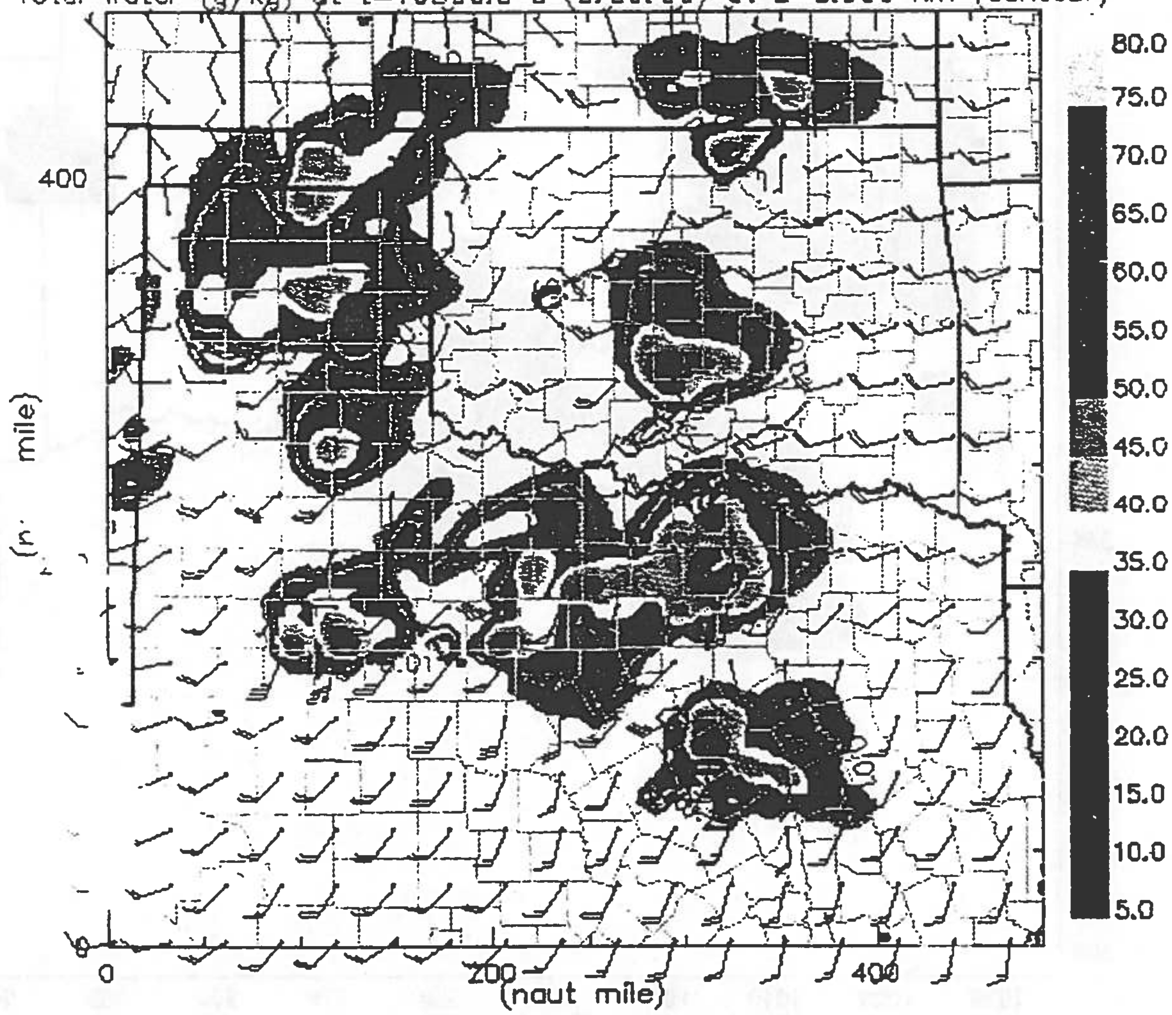
Year-3 Hub-CAPS Forecast Domains




FWS
23:54 UTC
Mon 16 Jun1997
CREF
Precip Mode
max= 66.0 dBZ
75.0
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
ND

Project Hub-CAPS Experimental
3 h Forecast valid 00Z Tue 17 June 1997
DFW Region

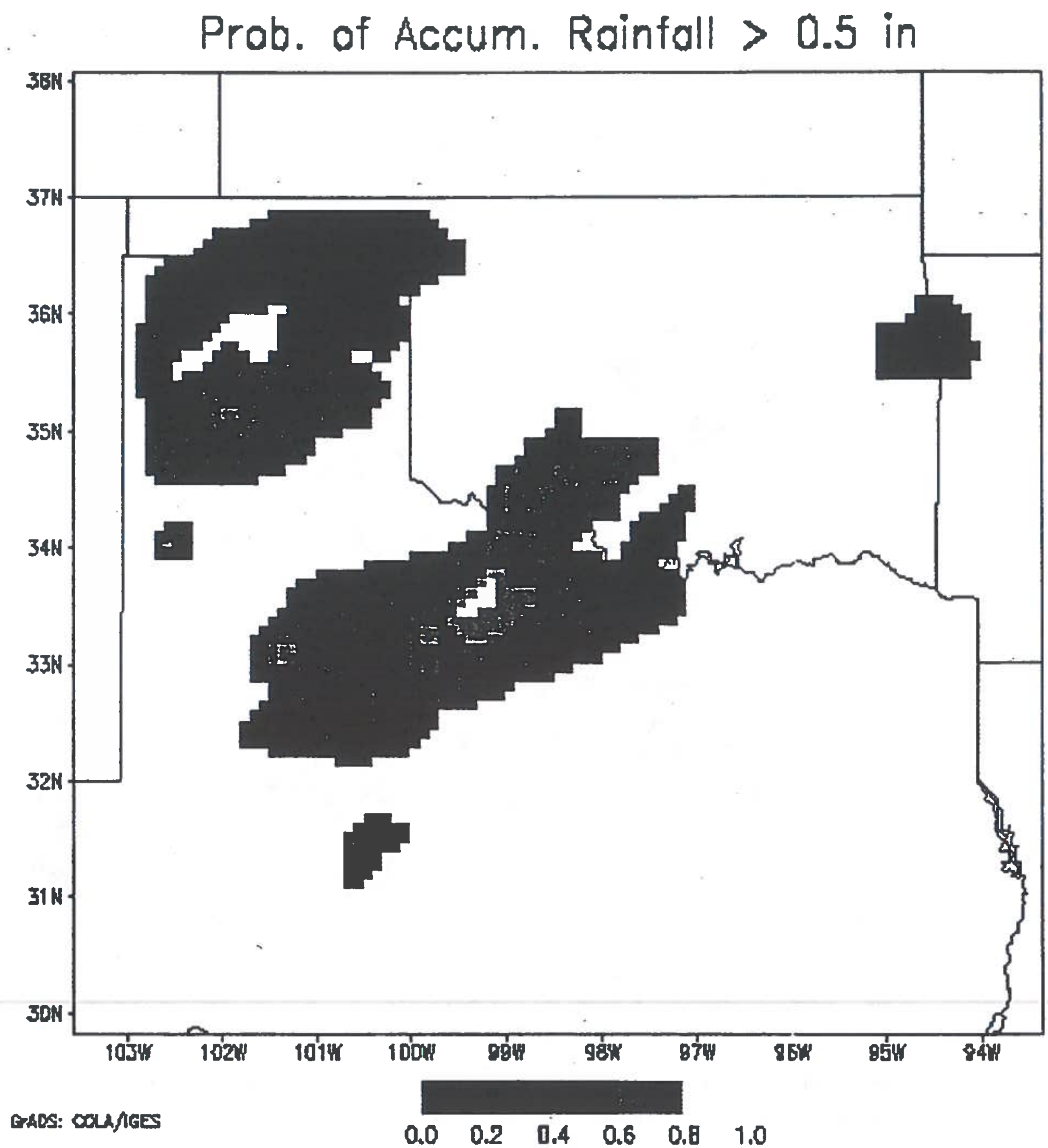
u-v (knots) at t=10800.0 s (3:00:00) at z=3.000 km (barb)
Ref(dBZ) at t=10800.0 s (3:00:00) at z=3.000 km (shaded)
Total water (g/kg) at t=10800.0 s (3:00:00) at z=3.000 km (contour)



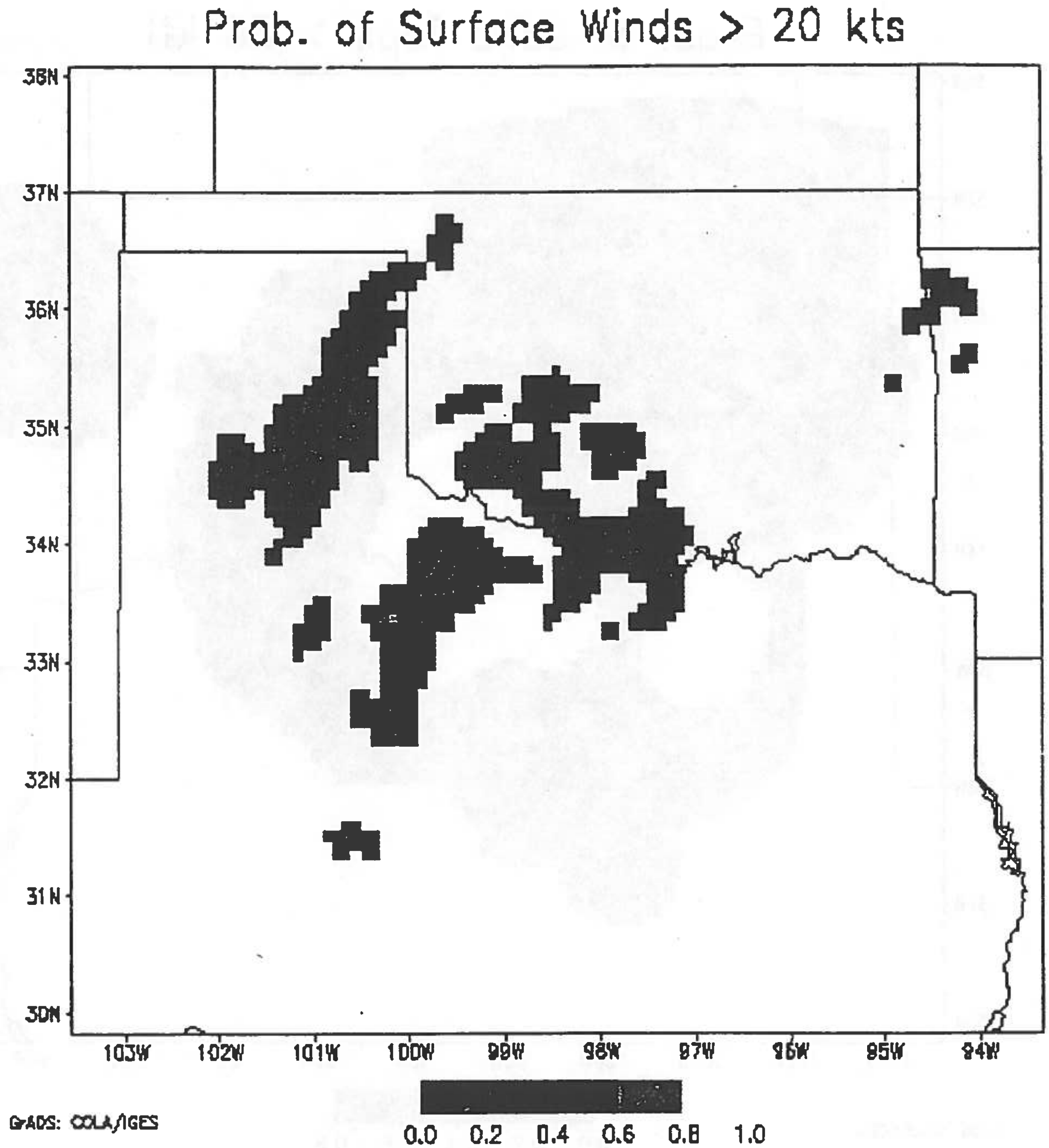
Min=-.864E-14 Max=14.2 contours: 0.01 0.10 0.20 0.50 1.00 2.00 5.00 10.00 15.00 20.00 (contour)
Min=0. Max=61.1 Inc=5.00 (shaded)
Umin=-26.27 Umax=48.51 Vmin=-30.01 Vmax=50.38 (barb)

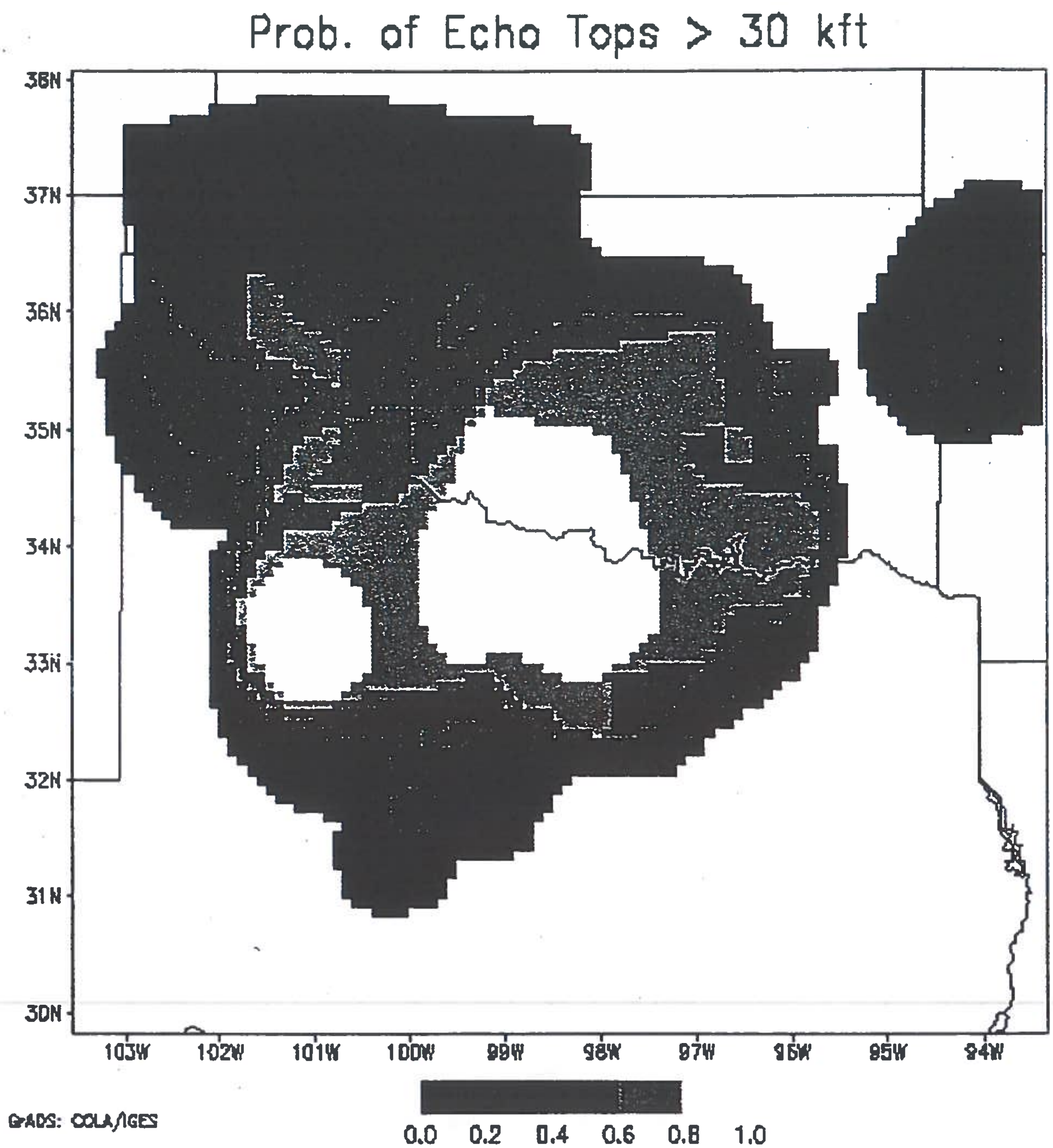
ar97061621_dd_21Z
Project Hub-CAPS Experimental Plot: 1997/09/02 15:55 LT

NEW FORECAST <u>WITH</u>
CLOUD ANALYSIS



Prob. of Accum. Rainfall > 0.5 in
38N
37N
36N
35N
34N
33N
32N
31N
30N
103W
102W
101W
100W
99W
98W
97W
96W
95W
94W
0.0
0.2
0.4
0.6
0.8
1.0
GrADS: COLA/IGES


Prob. of Surface Winds > 20 kts
38N
37N
36N
35N
34N
33N
32N
31N
30N
103W
102W
101W
100W
99W
98W
97W
96W
95W
94W
0.0
0.2
0.4
0.6
0.8
1.0
GrADS: COLA/IGES



Prob. of Echo Tops > 30 kft
38N
37N
36N
35N
34N
33N
32N
31N
30N
103W
102W
101W
100W
99W
98W
97W
96W
95W
94W
GrADS: COLA/IGES
0.0
0.2
0.4
0.6
0.8
1.0

Does Small-Scale NWP Have a Future?

- " [our own results] support your ideas and long-held belief that operational cloud-scale resolution forecasting is eminently doable!" (J. Michael Fritsch, Penn State University)

- "Most importantly, these real-data experiments have provided indications that, as was hypothesized in the original CAPS proposal... cloud-scale prediction may be possible." (NSF Site Visit Report, November, 1997; J.M. Fritsch, K. Emanuel, R. McPherson, T. Schlatter)

- "We at the Center Weather Service Unit (CWSU) in Fort Worth have been using your Hub-CAPS web site for some time now, and find it to be one of the best forecast tools for the D/FW area". (T. Hicks, Meteorologist in Charge, Fort Worth CWSU)

FAA Aviation Weather Research Program

Symposium on Advanced Multimodal Transportation Weather

September 28, 1998

Ken Leonard, AWR Team Lead
FAA AUA-460
(202) 493-0139
http://www.faa.gov/aua/awr

AWR Product Description

- Conduct of Applied Research
  - Leading to operational solutions
  - Leading to cost-effective implementations
- Limited Basic Research
  - Increase scientific understanding of atmospheric processes which impact aviation

AWR Goals

- Outcomes
  - Reduce weather-related accidents and incidents
  - Relieve weather impact on system capacity and efficiency
- Outputs
  - Provide the capability to generate weather observations, warnings & forecasts with higher resolution & accuracy
  - Improve accessibility & delivery of weather information
- Involves
  - Developing new data sources
  - Extracting new information from old data sources
  - Exploiting and fusing data in new ways

Focused Research Teams

Meteorological Teams

- In-flight Icing
- Aviation Gridded Forecast System (AGFS)
- NEXRAD Enhancements
- Winter Weather Research
- Turbulence
- Convective Weather
- Ceiling & Visibility
- Model Development & Enhancement

Core Members

- NCAR
- NWS (NCEP: AWC, EMC)
- NOAA (FSL, ETL, and NSSL)
- MIT/LL
- WJHTC
- Universities

Extended Members

- NASA Lewis/Langley/Ames * DoD * Airlines * Port Authorities * Cities
- Weather Service Industry
- Aviation Trade Associations

FY 98 Related Accomplishments

- RUC II Operational Implementation at NWS
  - Produces hourly products, surface and aloft, including microphysics
- Installed Integrated Icing Diagnostic Algorithm at AWC
  - Icing aloft fused from radar, satellite, RUC, and surface obs
- Completed NEXRAD Tornado Detection Algorithm
  - For NEXRAD Build 10. Hail was Build 9.
- Commenced WSDDM Tech Transfer to Wx Service Vendor
  - Aimed at aircraft deicing; used for runway and roads plowing
- Commenced In-flight Turbulence Algorithm Evaluation
  - By 3D-VAR, will better initialize RUC & Eta for all parameters
- Growth and Decay Algorithm at Dallas, and National
  - Better movement of thuderstorms

Near-Term Plans

- Implement In-Situ Turbulence Algorithm on multiple airframes
- Ceiling and Visibility Algorithm Development based on SFO data collection
  - Fog affects surface traffic too
- Complete WSDDM Tech Transfer to Wx Service Vendor for Operational Implementation Winter FY 99
  - Available for purchase by highway departments and municipalities
- Convective Weather growth & decay algorithm commercial tech. transition

Path to Operations

NCEP

- Aviation Weather Center
- Environmental Modeling Center
- NCEP Central Operations

FAA NAS Platforms

- ITWS
- WARP
- Others

Industry via CRDAs

- Accu-Weather
- GTE
- Harris
- Kavouras
- WSI
- *SMI
- *Jeppesen
- *ARINC
- *Radian

*in-process

Model Development & Enhancements PDT

- FSL, NCAR, NCEP (AWC, EMC), CU
  - Exploit observations, some largely ignored (assimilation)
  - Define detailed wind & cloud features to forecast turbulence, icing, ceiling (resolution & modeling)
  - Improve internal representation of clouds, thunderstorms (physics)
- Implemented Rapid Update Cycle (RUC) II at NCEP with 40km resolution, 40 vertical levels, larger domain, and full physics
- Meso Eta: 32 km, 45 vertical levels, 4 times per day
- Future:
  - Exploit cloud/precip observations for model initial conditions
  - Enhance cloud analysis using satellite images and radiometry
  - Community weather research and forecast (WRF) model

NEXRAD Enhancements PDT

- NSSL, MIT/LL, NCAR
  - Maximize the utility of the NEXRAD network for the aviation community
  - Develop applications to detect/predict hazardous weather and facilitate implementation on the network
- Implemented NEXRAD algorithm upgrades for storm cell identification and tracking; hail detection (Build 9)
- Tornado Detection Algorithm (Build 10)
- Mesocyclone Detection; Damaging Downburst; 1-minute Update; MIGFA; Growth & Decay (Open Build 2)
- Dual Polarization; higher FAA vertical resolution

Convective Weather PDT

- MIT/LL, NCAR, NSSL
  - Thunderstorms account for half of US air traffic delays
  - American Airlines: 55% of turbulence incidents are from convection
  - Seek reliable 0-6 hour forecast
- Breakthrough 1-hour terminal product in test at DFW
  - Scale separation technique
  - More than just extrapolated position; includes growth and decay
- National Scale Convective Weather field test to airlines
- Satellite cloud and convergence detection
- Radar characteristic analysis of longevity
- Boundary layer wind retrieval

Turbulence PDT

- FSL, NCAR, NCEP (AWC, EMC)
  - Produce timelier and more accurate analyses and forecasts
  - Develop user-friendly turbulence products
- Commenced in-situ turbulence algorithm evaluation
  - Objective, aircraft-type independent, downlinked in real time
  - Software addition to Aircraft Condition Monitoring System
  - Flying on five United AL B737s and B757s; going to 200+
  - On 17 Quantas B747s for ICAO evaluation vs. Australian algorithm
- Remote sensing via NEXRAD upgrade; possible for TDWR
- Integrated Turbulence Forecast Algorithm
  - Diagnostic Turbulence Forecast: model jets, mountains, convective
  - Artificial Intelligence fusion of DTF, in-situ, remote sensing

Ceiling and Visibility PDT

- MIT/LL, SJSU, NWS, PSU, DRI, UOk, NPS, NCAR, UQAM
  - Decision aid for traffic management and arrival/departure rates
- San Francisco capacity: $2.5M delay, tankering, diversions
  - Ceiling and visibility algorithm development based on SFO data
  - Forecast aid to provide 1-2 hour forecast of burn-off time
  - Synergy with extensive Navy funding on coastal meteorology
  - Ran data collection with use by CWSU—radiometers, sodar, etc.
  - Algorithm to automate guidance complete FY99, demo FY00
- Northeast Corridor, FY00 start
  - Association with major wx systems, initially extratropical storms
  - Synergy with New York ITWS and NASA AWIN
- True national C&V program not funded

Water Vapor Sensing System

- NOAA partnership
  - Critical to cloud processes, stability (thunderstorms), precipitation, ceiling/visibility, storm winds, icing, etc.
- Real-time downlink in ARINC MDCRS data stream
- UPS: 3 aircraft equipped with WVSS flying, increasing to 36.
- Northwest Airlines: system installation drawings sent Feb 98
- American Airlines: Potential upgrade of 102 B-757 starting in Nov 98
- United, Delta, Continental: possible; no formal agreements
- Foreign
  - France: Interested for A-320 and A-319; some technical issues
  - WMO Aircraft Met Data Relay (AMDAR) panel underway

In-Flight Icing PDT

- NCAR, AWC, FSL, ETL
  - Accurate hourly gridded, hi-resolution, forecast of icing conditions
- Integrated Icing Diagnosis Algorithm (IIDA), Forecast (IIFA)
  - Fuzzy logic combines up to 56 interest fields
  - Field Test IIDA at AWC FY98 with GOES, RUC, sfc obs, NEXRAD
  - IIFA added FY99
- SLD flying research leveraged with NASA, Canada
- Radar with ETL; dual polarization results aimed at NEXRAD
- Model microphysical parameterization to be passed to RUC, Eta
- Real time in-situ data to be obtained via MDCRS for IIDA/IIFA and for AWC forecaster feedback

Winter Weather Research PDT

- NCAR
  - Real time short term forecasts for ground deicing and terminal management during winter storm conditions
  - Response to deicing accidents with visibility-driven decisions
- Weather Support to Deicing Decision Making (WSDDM)
  - 30-minute nowcasts of snowbands and snowfall liquid equivalent
  - Manage deicing fluid, holdover times, departure management
  - Prototypes used by Delta, USAirways and UAL at DEN, ORD, LGA
  - WSDDM technology transferring to Cooperative Research and Development Agreement partner: ARINC
- Future work: improved detection; 4-12 hour forecasts, TDWR inclusion

Internet Links

- AWR Home Page
  - http://www.faa.gov/aua/awr
- AWC ADDS
  - http:// www.nws.noaa.gov/adds
- AWC Home Page
  - http://www.awc-kc.noaa.gov/
- AWC EFF Neural Icing
  - http://www.awc-kc.noaa.gov/awc/Aviation_Weather_Center.html
- ADDS Pirep Viewer
  - http://www-ad.fsl.noaa.gov/asdd/java_appl.html
- Icing Sample
  - http://www.rap.ucar.edu/largedrop/integrated/
- Turbulence Sample
  - http://www-frd.fsl.noaa.gov/mab/tke/tke.cgi
- Convective Weather
  - http://www.wx.ll.mit.edu/itws/cwx/dfw/
- RUC/MAPS
  - http://maps.fsl.noaa.gov/

Operational Fog Forecasting for Transportation Systems

Wes Wilson
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MIT Lincoln Laboratory
Peter Zwack & Robert Tardiff
University of Quebec, Montreal

$$ Chase

- Headlines
  - Accidents & Damage
  - Storms
    - Winds
    - Floods
    - Hail
- Cost - Daily Drain
  - Temperature / Icing / Freezing Line
  - Fog
- Transportation Synergy
  - Data Systems
  - State the Case or No Focused $$

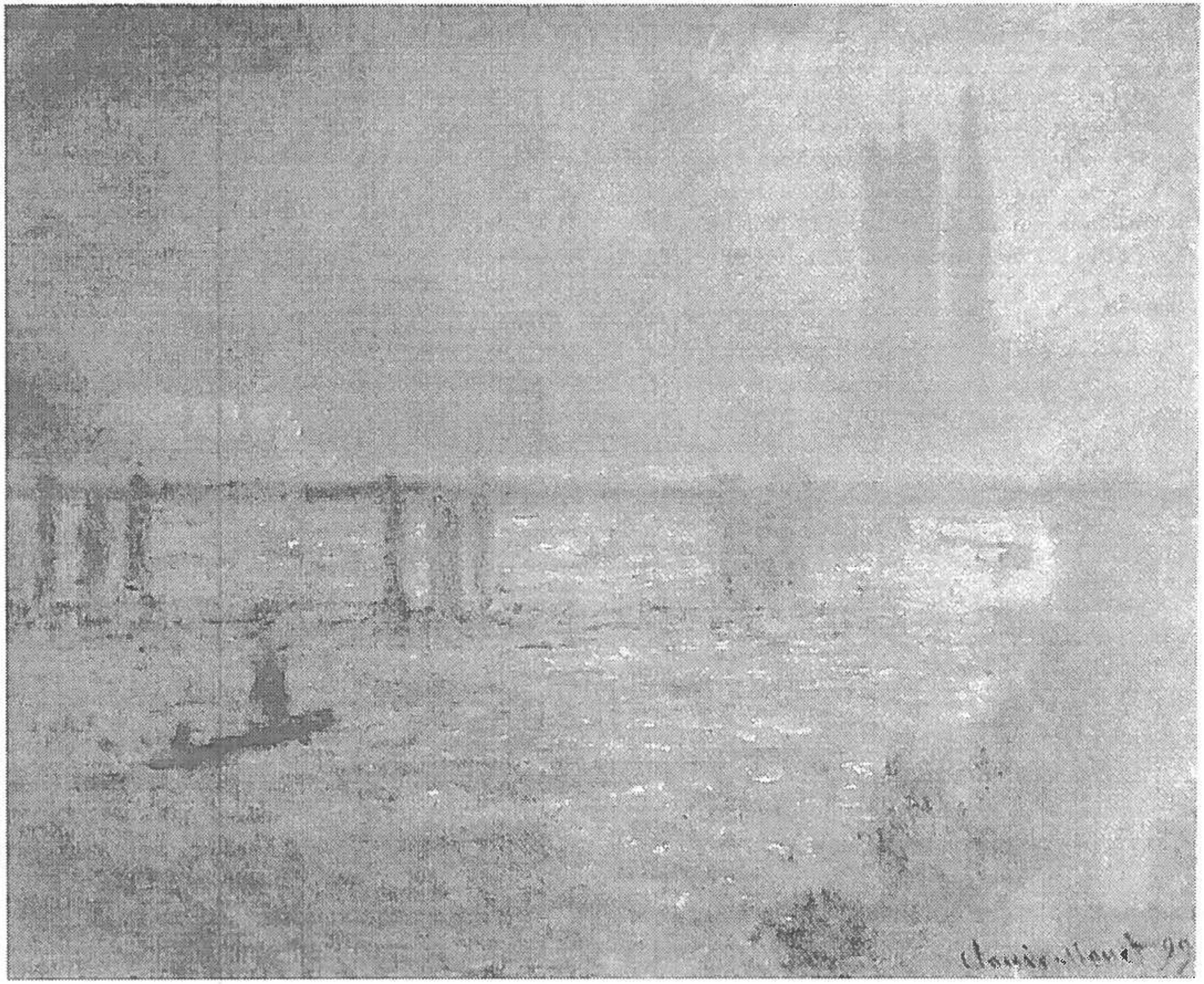
Overview

- The Fog Forecasting Problem
- Introduction to COBEL
- Lille Fog Forecasting Experiment 1988-92
- COBEL Forecasting Skill

Fog Forecasting

- Radiation Fog formation: Forced by surface cooling
- Crucial Question: Does the liquid water remain suspended as fog or does it deposit as dew / frost?
  - Calm winds make deposition very likely
- Fog Formation:
  - IR cooling of the surface
  - IR cooling of the fog-top
  - Drainage of cool air into a basin
- Fog Dissipation:
  - SW (solar) radiation heats the surface
  - IR (downward) radiation from mid-level clouds
  - Strong surface winds mix the surface layer
- "The onset time of fog, and the transitions... , are sensitive to the balance between all processes" -- Turton and Brown
- These mechanisms are subtle and their observation requires accurate and precise sensing systems with frequent updates

Fog and Transportation



Hurricanes at Landfall

Milestones

- **Track**
  - Collect enhanced observations as part of NOAA Hurricane Field Program (HFP) (00-04).
  - Develop data assimilation techniques to incorporate enhanced observations into operational models (00-04).
  - Accelerate research in ensemble forecasting using enhanced observations (00-04).
- **Intensity**
  - Focused field experiments to isolate influence of convection and ocean response (00-03).
  - Develop coupled atmosphere/ocean models (00-04).
  - Improve model physics (Atmospheric Boundary Layer and convective parameterization) (00-04).

Hurricanes at Landfall

Milestones (cont.)

- QPF & Wind Forecasts at and after Landfall
  - Use mobile landbased observing system to map Atmospheric Boundary Layer and precipitation structure (00-04).
  - Augment NOAA Hurricane Field Program to focus on QPF issues (03) in association with a NASA field program (00-03).
- Develop real-time analyses and displays to assist local officials focus recovery efforts (00-04).

Optimal Mix of Observations
(Quantitative Precipitation Forecasts)

Forecast Goals and Benefits

- Extend range of weather forecasts to day-7.
- Increase skill by two full days for current day-5 and day-6 & -7 forecasts.

  Numerous positive impacts (e.g., agriculture, power industry, water resources).

Optimal Mix of Observations
(Quantitative Precipitation Forecasts)

Forecast Goals and Benefits (cont.)

- Increase skill of day-1 QPF by 50%.
- Increase skill of day-2 & -3 QPF by 1 day.
- Introduce Probabilistic QPF (PQPF) through day-3 for use in Advanced Hydrologic Prediction System (AHPS).
- Improve lead time of AHPS-based flash flood warnings by 50% (from 39 min to 60 min). Savings in lives and over $36M/year.

Optimal Mix of Observations
(Quantitative Precipitation Forecasts)

Research Directed Toward:

- Observations/Applications
  - Better utilization of existing observations (especially satellite).
  - Determining what new observations are necessary.
  - Integrating in situ and remotely-sensed observations.
- Data assimilation/Applications
- Model Development/Applications
  - Ensemble prediction.
  - More relevant forecast verification.

Optimal Mix of Observations
(Quantitative Precipitation Forecasts)

Research Directed Toward (cont.):

- QPF/Applications
  - Better representation of convection in forecast models.
  - Orographics effects.
  - Developing coupled atmosphere/hydrologic models.
  - Short-range ensemble models.
  - Improved observation of winds, temperature, and moisture.

Optimal Mix of Observations
(Quantitative Precipitation Forecasts)

Milestones

- Conduct studies related to improved use of existing observations (00-04).
- Conduct a definitive regional/seasonal N. Pacific Experiment (NORPEX-01).
- Forecast demonstration projects (02-03).
- Conduct warm-season field studies over central U.S. to evaluate new water vapor measurements (02-03).
- Conduct observing system simulations - linked to NAOS decisions (00-04).

Optimal Mix of Observations

A Key to Many Forecast Problems

- Practically all of USWRP Science Teams came back to "Optimal Mix" of Observations issue as a key to their progress.
- Increasing attention to North Pacific is also recommended.

Satellite Issues in the USWRP

- Increasing need for high temporal and spatial resolution
  - points to the need for more complete utilization of existing Geostationary satellite observations (Imager and Sounder)
- Satellite needs to be operated in a targeted mode
  - has implications for the independent operation of Imagers and Sounders
- Need for observations in cloudy areas
  - points to a potential requirement for microwave instruments on future Geostationary satellites

USWRP Budget Projection

- All budget numbers provided by workshops and reviewed by USWRP project office.

Total incremental costs of Hurricane Landfall (HL), Mix of Observations (MO), Quantitative Precipitation Forecasts (QPF), and Impacts research in $M

FY	00	01	02	03	04	Total
DA Research	5	8	10	9	8	40
PAC field	7.1	6.3	0.3	0.2	0.1	14
Cont. field	0.1	2.1	4.3	4.3	0.2	11
Total DA	12.2	16.4	14.6	13.5	8.3	65
HL Research	4	5	6.5	6	5.5	27
HL field	4	4	0.5	4	0.5	13
Total HL	8	9	7	10	6	40
QPF Mtn. (field)	0.6	0.7	0.8 (1.3)	0.8	.8	5
QPF Repres. conv.	0.5	0.6	0.7	0.6	.6	3
QPF Hydro (field)	0.5	0.7 (1.2)	1.0 (2.2)	0.6 (0.1)	0.6 (0.1)	7
Total QPF	1.6	3.2	6.0	2.1	2.1	15
Total Impacts	2	2	2	2	2	10
Total	23.8	30.6	29.6	27.6	18.4	$130M

Synthesis

- USWRP addresses the principle theme of NDRI, with societal benefits built in.
- USWRP follows a process that involves community outreach for setting priorities and service science linkage for developing plans.
- Community has identified two priorities.
  - Hurricanes at Landfall
  - Optimal Mix of Observations (QPF)
- Societal benefits built in.
  - Lives and order of $1 Billion in potential savings/year
- Advanced Geostationary satellite observations will be critical to the success of USWRP.

Summary

- Service-Science linkage is being successfully applied to formulating interagency USWRP focused projects.
- HAL/OM/QPF multi-agency total:
  - $130M over 5 years with $23.8M required in FY 2000.
- Tremendous opportunity to leverage multi-agency funds to address critical service and research issues.

Risks and Rewards of Using Weather Products for Transportation Applications

Michael R. Smith
Certified Consulting Meteorologist
President
WeatherData, Incorporated

WeatherData INCORPORATED

Warning!

Parts of this presentation may be
"~~Politically~~ Incorrect"

MeTeorologically

WeatherData
INCORPORATED

The NWS' mission is:

- Data gathering and processing
- Storm warnings for the general public
- Forecasts for the general public

As defined in the "Public-Private Partnership" Statement.

WeatherData INCORPORATED

My compliments to Lou Boezi for a thought-provoking paper.

However...

WeatherData
INCORPORATED

The statements:

"Opportunities for improvement in aviation, marine, and surface transportation weather...forecasting...are very much lagging."

– and –

"No satisfactory infrastructure currently exists to routinely make modernized weather information that is currently resident in weather offices available to the transportation consumer."

Would be factually incorrect if applied to commercial meteorology.

WeatherData INCORPORATED

Private-sector weather companies, because they work closely with their transportation clientele, have addressed and are addressing these issues.

WeatherData INCORPORATED

Private-Sector Innovations:

- 1950 – Tornado warnings
- 1970 – Time lapse weather radar
- 1976 – Color radar
- 1976 – Electronic overlay maps for color radar
- 1978 – Color remoting of NWS radars
- 1979 – Video time lapse cloud photography
- 1981 – Video time lapse weather satellite imagery
- 1982 – Operational, real-time Doppler radar
- 1982 – The Weather Channel®
- 1986 – Automatic warning displays for television
- 1986 – Track-specific railroad forecasts
- 1987 – Computerized newspaper weather packages
- 1987 – In-home agricultural weather displays (color in 1992)
- 1995 – Radar-based precipitation type displays

WeatherData
INCORPORATED

The private-sector weather industry in the United States provides forecasts of outstanding accuracy and specificity to the transportation industry.

Examples include:

- Northwest Airlines' turbulence forecasts
- WeatherData, Incorporated's surface transportation system

WeatherData INCORPORATED

We believe the private sector in meteorology should:

- Create specific business to business products and services
- Work to adapt new science to the needs of business
- Provide the "person to person" contact so important in critical weather situations

WeatherData
INCORPORATED

If the transportation sector of the United States is going to receive "optimal" weather information (the most useful for lowest cost), it is essential that DOT and NWS policymakers familiarize themselves with private-sector weather companies.

Otherwise, time and money will be wasted "reinventing the wheel."

WeatherData
INCORPORATED

Recommendations for the Future

First steps...

- Require RWIS data be disseminated. Data becomes more valuable with increased distribution.
- All meteorologists should learn radar and satellite interpretation plus mesoscale forecasting techniques.
- State transportation officials should provide frequent, realistic travel condition reports.
- The NWS should improve the reporting of snowfall.

WeatherData INCORPORATED

Recommendations for the Future

Future Steps...

- Cease using the verification of models as a proxy for public forecasting skill.
- Employ verification techniques which evaluate models, forecasts and warnings in the same way non-meteorologists view them.
- Research techniques to improve forecast <u>consistency</u>.

WeatherData INCORPORATED

In order for weather forecasting and storm warnings to reach their full potential, "human factors" in meteorology will have to be researched.

How do we best use human intelligence in the weather forecasting process?

WeatherData INCORPORATED

"Human Factors" have been extensively studied in aviation and computer science.

With the exception of Dr. Tom Stewart's work, there has been little or no human factors research in meteorology.

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The NWS, private sector weather companies, the research community and transportation-related users of weather information can work together to create transportation oriented weather solutions!

Thank You!!

WeatherData INCORPORATED

Litton
WSI

Public-Private Partnerships for the Next Millenium

Maria A. Pirone
Weather Services International

28 September 1998

Litton WSI

Position Statement

- There needs to be a coordinated effort to partner public programs and initiatives with private sector capabilities in order to advance the weather industry to the next level.
- Multi-modal transportation systems *depend* on this fusion of capabilities to reach their pinnacle early in the next century.

Litton WSI

Background forces at work

- As technology advances at lightning speed, the need to be an "early adopter" is more important than ever before.
- As government downsizes, efficient use of limited funds will impact every weather dollar spent.
- Weather needs, to support multi-modal systems, will increase.

Three competing forces at work.

Forces within the Public Sector

- Traditionally, Public Sector initiatives don't embrace "bleeding edge technology" -
  - Requirement gathering is cumbersome
  - Procurement process is prolonged
  - Rollout schedules expand over time

Litton WSI

Forces within the Public Sector

- In addition, the modernization of existing programs take years to complete--
  - NWS WSR*88*d Doppler Radars
  - FAA ***Interim*** Graphical Weather Display System
  - AWIPS-***90***

Litton WSI

Forces within the Private Sector

- Competition drives the adoption of new technology forward.
- End-users are vocal about needs -- they typically don't settle for less.
- Corporations are driven by shareholders "best interests"--there is definitely accountability for their actions.

Forces within the Private Sector

- Size lends itself to agility in most cases.
- Corporations have been forced to not only embrace but also seek out partnering in the 90's.

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WSI

U.S. WEATHER INDUSTRY MODEL
The Flow of Weather Information

Data Collection → ***Service Providers*** → ***End Users***

SENSOR NETWORK Implementation, Maint. & Support

GOVERNMENT
- Obs. stations
- Radiosondes
- Global Satellites
- Radar

PRIVATE SECTOR
- Lightning
- Aircraft
- Ground

GOVERNMENT
- Global Computer Models
- Public Forecasts
- Official Warnings
- Hurricane Tracking
- Aviation Wx Forecasts & Advisories
- Long term Databasing
- Internet sites
- NOAA WxWire
- NOAA Wx Radio
- WAFS

PRIVATE INFO PROVIDERS
- Value-added Products
- Databasing
- Data Dissemination
- Software and Systems
- Internet Services

END USERS
- Aviation
  - Airlines
  - Corp. Flt Dept.
  - FBOs
  - Pilots
  - Air Route Traffic Control Centers
- Media
- Transportation
- Government
  - Local, State & Federal
- Utilities
- Emergency
- Agriculture
- Commodities
- Oil/Mineral
- Education
- Research Labs
- Consumers

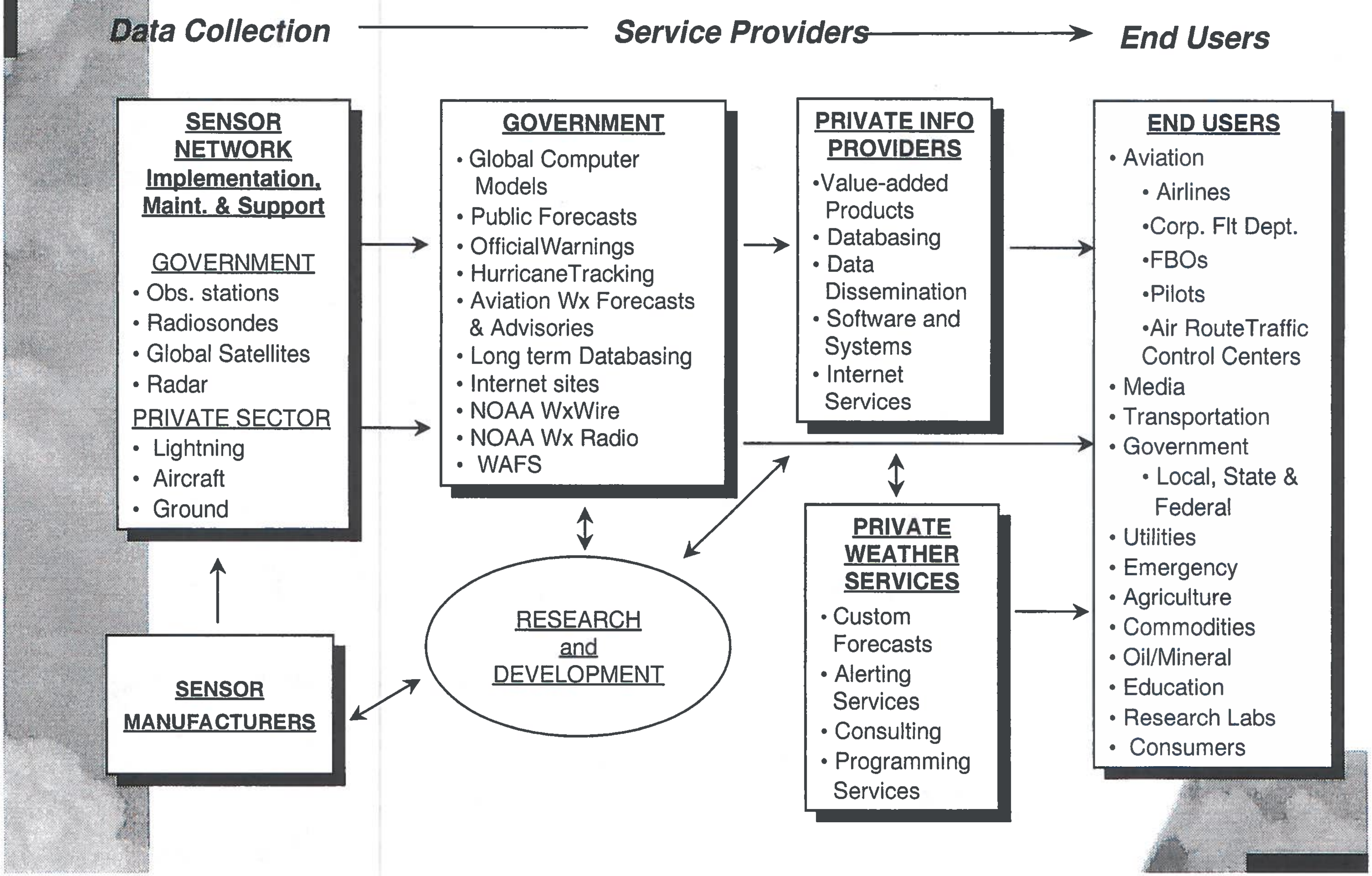
SENSOR MANUFACTURERS

RESEARCH and DEVELOPMENT

PRIVATE WEATHER SERVICES
- Custom Forecasts
- Alerting Services
- Consulting
- Programming Services

Litton WSI

U.S. WEATHER INDUSTRY MODEL
The Flow of Weather Information



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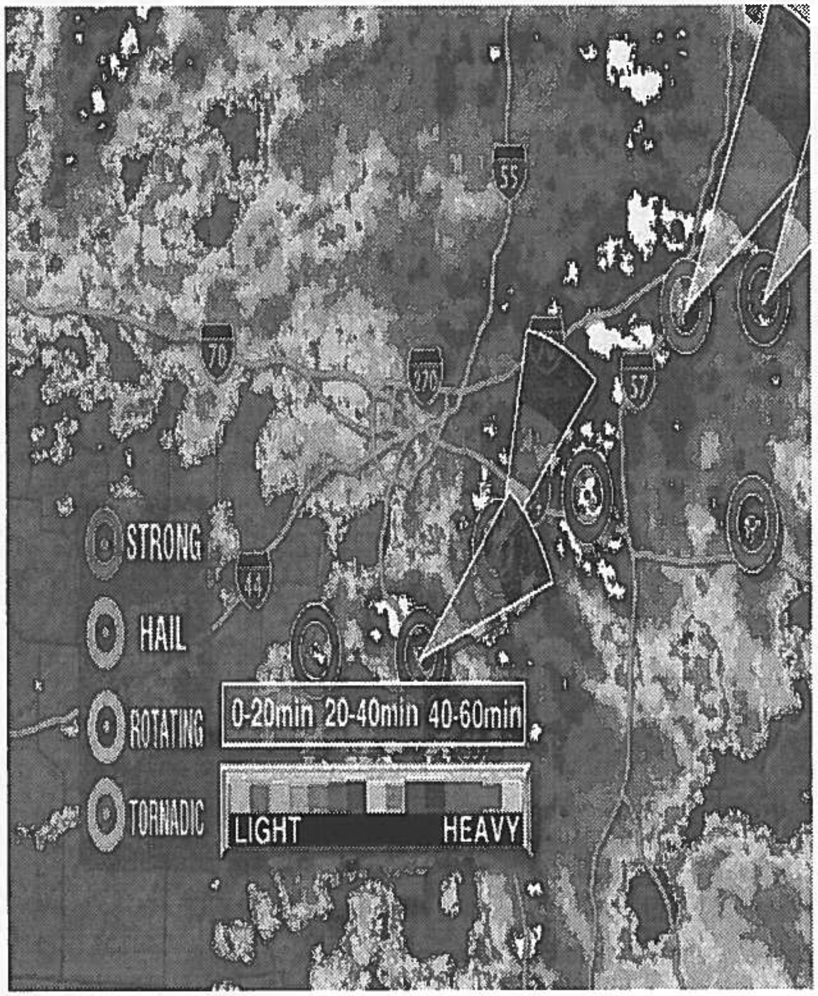
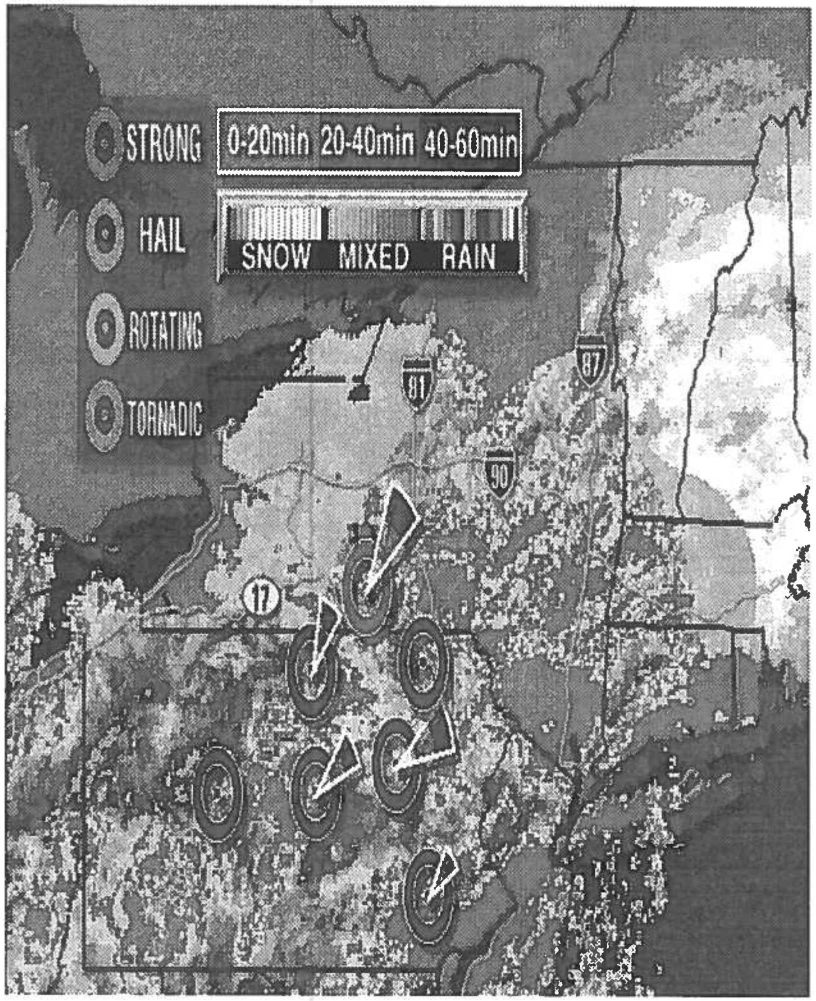
Forecast Products based on Real-time Sensors



- Assimilating data sets to generate useful information
- Ground transportation as well as air transport use this in their operations
- Friendly graphics that are familiar to the user

Litton WSI

Layering Information



- Forecasting storm position in 30 minutes
- Monitoring the freezing line
- Identifying the impact on roadways & airports

Partnering in Aviation Initiatives

- FAA's Weather Research Program
  - Convective Weather PDT
  - Icing PDT
  - Turbulence PDT
- NASA AWIN Program
  - Weather in the Cockpit Initiative

Litton WSI

Next Steps

- What are the next steps to take advantage of the Public-Private partnerships that exist?
- What areas overlap with the FHWA?
- Where do we go from here?

Considerations for the Integration of Modernized Weather Information in Future Multi-Modal Transportation Systems

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President
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So You Want More "Weather" in the Future Modes of Transportation?

What are Some Obstacles to Mitigate?

- Decay of basic weather infrastructure of the country
  - Additional improvements are warranted
- Coordination of Transportation Enterprise
  - Federal,State and Local Governments
  - Commercial players
    - Aviation-National and Regional carriers, General Aviation
    - Surface - Land (automobile, trucking, rail)
    - Marine -coastal & inland
    - Insurance Industry
    - ...?

Why Bother?

- ✔Improved Efficiency and Economy
  Maintenance, Logistics, Time, Fuel
- ✔Economic Competitiveness
  Reliability, Timeliness, Costs
- ✔Safety of Lives & Property
  Reduce lives lost
  Property damages
  Insurance claims

What Can Be Done?

Identify Specific projects, activities & players

- Define the larger context for the activity
- Define the clear purpose and objective of the project/activity
- Define the players, schedules, resources required and sources
- Define the measurables, reporting methods and accomplishments
- Get on With It!

Examples of useful Demonstration Projects to integrate Weather into the Transportation Enterprise

- Inland Water Transportation- Long Range Water forecasting
- Coordination of Weather Based Urban Traffic Management
- Development of a Distributed Highway Transportation Information System

Inland Water Transportation- Long Range Water forecasting

- Implement Advanced Hydrologic Prediction System
- Organize Water Management, Transportation Interests and Principle Water User Community (Energy, Timber, Agriculture, Transportation, Fishing...)
- Strategically Plan to Revise Water Resources Management and Decision Making Paradigms

Coordination of weather based urban traffic mgt

- Select urban areas
- Define weather "triggers" and expected traffic management responses
- Establish management information system and protocols

Distributed Highway Transportation Information System

- Define:
  - data and information sources and providers
  - data quality and standards,
  - information users (i.e. destinations)
  - Information content- Wx & traffic /road conditions
- Establish:
  - Initial Communication methods
  - Data & information collection sytem
  - Information dissemination
- Define participants :
  - Governments
  - Industry: Trucking, Electronics, Platform Manufcturers,....
  - Insurers
  - Safety & Education, Media