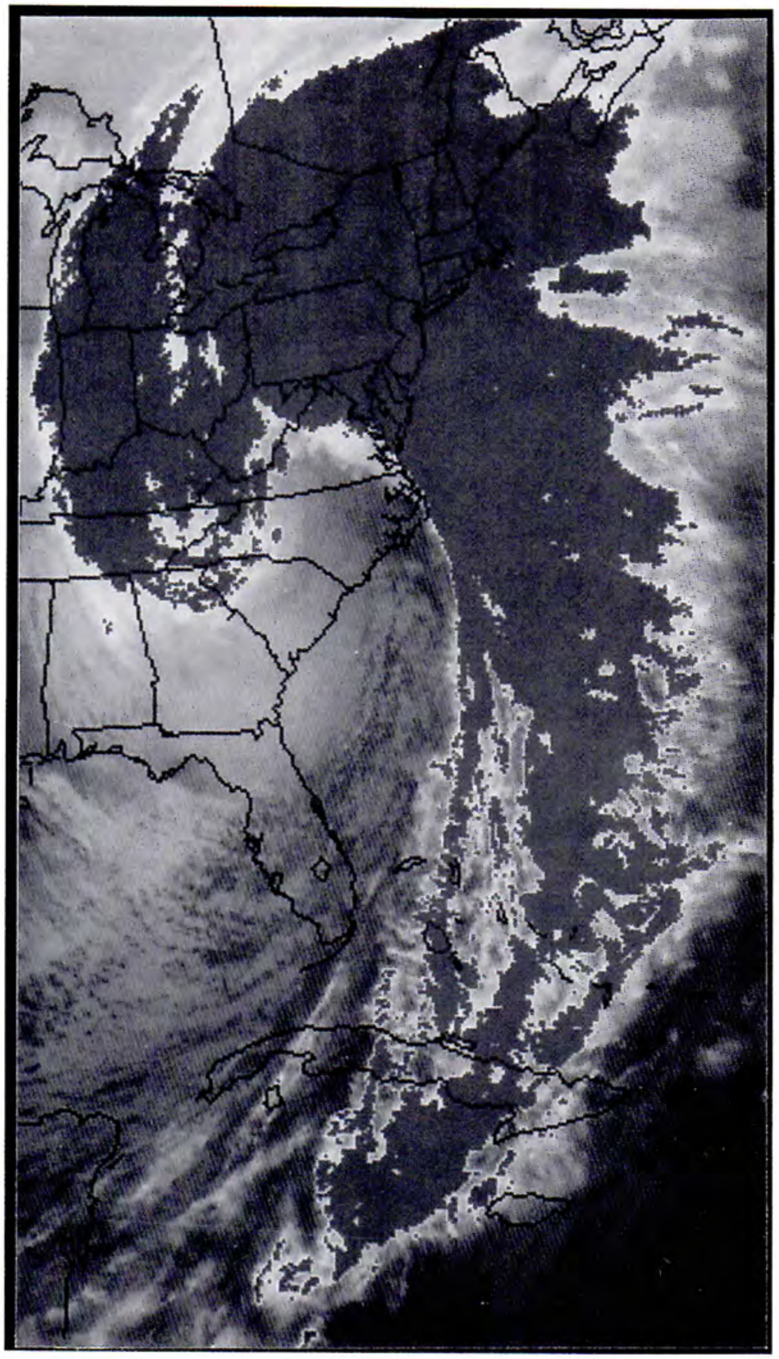
Natural Disaster Survey Report



Superstorm of March 1993

March 12-14, 1993

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Silver Spring, Maryland

Front Cover: GOES Satellite Image of Superstorm Saturday morning, March 13, 1993
Photograph courtesy of NESDIS

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May 1994

U.S. Department of Commerce
Ronald H. Brown, Secretary

National Oceanic and Atmospheric Administration
Dr. D. James Baker, Administrator

National Weather Service
Dr. Elbert W. Friday, Jr., Assistant Administrator

Preface

Although unusual for this late in the season, and unprecedented in the areal extent for such a severe winter storm, the **Superstorm of March 1993** was not a surprise to most of the residents of the eastern states. This was due in large part to the exceptional long range prognostic precision of National Oceanic and Atmospheric Administration's (NOAA) dynamic atmospheric computer model guidance, the early and accurate watches and warnings developed by National Weather Service forecasters, the energetic and consistent communication to the media, emergency management officials (EMO) and the public, and the cooperation of print and broadcast media and EMOs in getting the message to the public.

The combined warning system is not perfect however. Regretfully, the intensity of the low and the resulting storm surge experienced by the residents of the upper west coast of the Florida Peninsula was not fully captured by the warning system as the **Superstorm** strengthened on the night of March 12-13 and rapidly crossed the northern Gulf of Mexico.

Yet in spite of this ill-fated event, the overall efforts of NOAA were extraordinary. I congratulate all concerned on their expertise and professionalism in foreseeing this developing storm system and providing the appropriate response. You have served the American public well.

Elbert W. Friday, Jr.

May 1994

Foreword

The report on the **Superstorm of March 1993** was prepared by the NOAA Natural Disaster Survey Team (DST) following on-scene assessments and interviews conducted mostly between March 17-24, 1993. Such surveys are conducted at the direction of the Assistant Administrator for Weather Services whenever significant weather events occur.

The purpose of such reports is to assess the performance of NOAA in alerting the public to these events and to make recommendations as to how the National Weather Service (NWS) and the rest of NOAA can better perform its mission. An equally important secondary objective is to assess how the partnership of the NWS, the media, and government response organizations could be even more effective in alerting the public and thus mitigating the deaths, injuries, and damage that occur in such events.

Due to the widespread geographical area affected, the Team was divided into four groups. In their assigned areas, each group contacted and interviewed NWS employees; federal, state, and local EMOs; other public officials; media representatives; and members of the general public. Those interviewed were questioned regarding their perception of the timeliness and accuracy of the forecasts received (whether from NWS or commercial sources) and their actions in response to those forecasts.

The entire Team is grateful to the many people who helped before, during, and after these visits by gathering information, and who took the time from other activities to spend time with us.

Natural Disaster Survey Team

The Superstorm of March 1993
Natural Disaster Survey Team

The members of the Natural Disaster Survey Team for the **Superstorm** are listed below. To better investigate the storm, the Team was divided into four groups. Northern Group One consisted of Wright, Gruntfest, Ronco, and Leivers, and covered the northeastern seaboard from Washington, D.C., to Boston, Massachusetts. Northern Group Two consisted of Schmeling, Weiger, Konop, and Kluepfel, and covered the inland area from Charleston, West Virginia, to Albany, New York. Southern Group One included McCarthy, O'Brien, Goldsmith, and Mason, and reported on the Atlantic coastal area from Melbourne, Florida, to Charleston, South Carolina and the Outerbanks of North Carolina. Finally, Southern Group Two consisted of Sabones, Koziara, Tebeau and Golden, and visited Gulf of Mexico sites from Tampa to Tallahassee, Florida, and inland sites from Birmingham, Alabama, to Raleigh, North Carolina. Brian Smith joined Dr. Golden in conducting aerial surveys of tornado damage in Florida using aircraft of NOAA's Aircraft Operations Center. Paul Kocin assisted in the analysis of the hydrometeorological events of the storm. Our Editor was Joan Weinberg, who pulled the many parts of the Report together.

Team Members

Team Leader: **Julian Wright**, Federal Coordinator for Meteorology
Team Technical Leader: **Kevin McCarthy**, Operations Officer, Office of Meteorology
Team Chief Scientist: **Dr. Joseph Golden**, Meteorologist, Office of Atmospheric and Oceanic Research
Field Representative: **Gary Schmeling**, Regional Operations Services Meteorologist, Central Region Headquarters
Field Representative: **Michael Sabones**, Deputy Meteorologist in Charge, WSFO Indianapolis, Indiana
Non-Governmental Expert: **Dr. Paul O'Brien**, Associate Professor of Sociology, California State University-Stanislaus
Non-Governmental Expert: **Dr. Eve Gruntfest**, Associate Professor of Geography, University of Colorado
Field Representative: **Fred Ronco**, Deputy Meteorologist in Charge, WSFO Portland, Maine
Subject Matter Specialist: **Benjamin Weiger**, Office of Hydrology
Lead Public Affairs Specialist: **Dane Konop**, Public Affairs Officer, OAR
Field Representative: **Nicholas Leivers**, WSFO Los Angeles
Subject Matter Specialist: **Curt Mason**, Coastal Ocean Program Office
Field Representative: **Mike Koziara**, WSFO New Orleans
Public Affairs Specialist: **Jay Tebeau**, NOAA Public Affairs
Subject Matter Specialist: **Barry Goldsmith**, Office of Meteorology
Subject Matter Specialist: **Charles Kluepfel**, Office of Meteorology
Subject Matter Specialist: **Brian Smith**, National Severe Storms Forecast Center
Subject Matter Specialist: **Paul Kocin**, National Meteorological Center
Editor: **Joan Weinberg**, Office of Meteorology
Technical Assistant: **Kenneth Barnett**, Office of the Federal Coordinator for Meteorology

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Acronyms and Abbreviations

ABT	Auxiliary Backup Terminal
AFB	Air Force Base
AFOS	Automation of Field Operations and Services
AVN	Global Spectral Model for Aviation
C-MAN	Coastal Marine Automated Network
CFW	Coastal Flood Warning
CLEAN	Commonwealth Law Enforcement Automated Network
COE	Army Corps of Engineers
CPoS	Conditional Probability of Snow
CWA	County Warning Area
DST	Natural Disaster Survey Team
DoD	Department of Defense
DVIP	Digital Video Integrated Processor
EBS	Emergency Broadcast System
ECMWF	European Center for Medium-range Weather Forecast model
EMO	Emergency Management Office/Official
EPD	Extended Forecast Discussion
ESF	Flood Potential Outlook
FEMA	Federal Emergency Management Agency
GOES	Geostationary Operational Environmental Satellite
HAMS	Amateur Radio Operators
HHL	Hurricane Hot Line
HWW	High Wind Warning
kt	Knots
LFM	NMC Limited-area Fine Mesh Model
mb	Millibar
MEOW	Maximum Envelope of Water
MIC	Meteorologist in Charge
MOS	Model Output Statistics
MRF	NMC Medium Range Forecast Model
NAWAS	National Warning System
NDBC	National Data Buoy Center
NESDIS	National Environmental Satellite, Data, and Information Service
NGVD	National Geological Vertical Data
NGWLMS	Next Generation Water Level Measurement System
nm	Nautical Miles
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSSFC	National Severe Storm Forecast Center
NWLON	National Water Level Observation Network
NWP	Numerical Weather Prediction
NWR	NOAA Weather Radio

NWS	National Weather Service
NWSH	National Weather Service Headquarters
NWSO	NEXRAD Weather Service Office
NWWS	NOAA Weather Wire Services
NYSPIN	New York Statewide Police Information Network
PEMA	Pennsylvania Emergency Management Agency
PNS	Public Information Statement
PoP	Probability of Precipitation
QPF	Quantitative Precipitation Forecast
RAFS	NMC Regional Area Forecast System
SDM	Station Duty Manual
SFD	State Forecast Discussion
SFP	State Forecast Product
SLOSH	Sea-Lake Overland Surge from Hurricanes
SOP	Standard Operating Procedure
SVS	Severe Weather Statement
SWIS	Satellite Weather Information System
TVS	Tornado Vortex Signature Algorithm
UKMO	United Kingdom Meteorological Office model
UPS	Uninterruptible Power Supply
UTC	Coordinated Universal Time
WCM	Warning Coordination Meteorologist
WSFO	National Weather Service Forecast Office
WSO	National Weather Service Office
WSOM	Weather Service Operations Manual
WSR-57	Weather Surveillance Radar - 1957
WSR-88D	Weather Surveillance Radar - 1988 (Doppler)

Executive Summary

The long range precision of the National Meteorological Center's (NMC) prognostic guidance, the early and accurate warnings developed by NWS field forecasters, and the energetic dissemination activities of the media and government response organizations were unprecedented in preparing the public for this winter storm of incredible proportions.

Despite the strongly worded early warnings, the storm was responsible for some 200 deaths. The primary direct causes for these fatalities were tornadoes and coastal flooding in Florida. **In fact, Superstorm surge killed more people from drowning than Hurricane Hugo and Hurricane Andrew combined.** The primary indirect cause of fatalities was heart attacks brought on by overexertion while shoveling snow.

Due to the widespread geographic area affected, a DST was organized into several groups, two dispatched to assess warning and forecast effectiveness in the northern states, and two groups sent to survey damage and warning and forecast effectiveness in the south part of the affected area. The DST traveled from Florida to New England on the coast and to selected inland sites from Alabama to West Virginia to New York. Overall, the DST found that NWS did an extraordinary job in getting its message of warning across to the populace of nearly 40 percent of the Nation that felt the effects of the **Superstorm of March 1993**.

The Southern Survey Team

The southern survey team found that for the most part the information disseminated to the public, the media, and EMOs was timely and accurate. There were a number of separate hazards created by the storm for those in the southern states affected by the **Superstorm**. As the storm gathered strength over the Gulf, the first threat was from severe thunderstorms and tornadoes. As it neared landfall, high winds and coastal flooding became the primary hazard and finally, as the system moved up the Atlantic coast, very cold temperatures became the peril.

The perception and response to these various threats were uneven, however. The lack of personal experience with severe non-tropical storms resulted in a large number of people, and some EMOs, failing to fully appreciate the seriousness of the threat. For example, in recent history, severe coastal flooding has not occurred in Florida in storms other than hurricanes. It must be noted that a winter storm of this ferocity was simply beyond the scope of experience of anything the southeastern part of the country had faced in recent memory. The subsequent lack of response led to difficulties for the populace in preparing properly for the approaching storm throughout the southeast U.S., particularly in Florida. Many people and some EMOs were simply unprepared for the event.

The Northern Survey Team

In the northern states, the threat was mainly from the heavy snow and high winds causing blizzard conditions. There was also the threat of coastal flooding. The possibility of a blizzard got the public's attention, was understood, and resulted in appropriate reaction by the population.

Emergency preparedness officials, the media, and the public were highly complimentary of the accuracy and long lead time of the forecasts prior to the storm. Warnings and statements were perceived as timely and well-worded. The public and other users seemed to understand the potential magnitude and destructiveness of this severe winter storm.

For the northern states impacted by this event, it was not quite the "Storm of the Century." Although the storm set new snowfall and low pressure records in a number of locations, the surface winds attained, for the most part, only the lower ranges that were forecasted. Also, the times of maximum on-shore winds did not coincide with the time of high tide, thus only minimal coastal flooding occurred along the northeast Atlantic coast.

General Problem Areas Identified

There are several areas that the DST identified, that if corrected, would enable NOAA to perform its mission more effectively. These shortcomings are summed up in the Major Findings and Recommendations section and are discussed in more detail in the individual chapters of this report. In general there are three areas of concern that require attention to allow NOAA and NWS to more effectively safeguard the lives and property of the American public. They are the availability of observation data, improved communication with state and local EMOs, and improved public response to NWS warnings and forecasts.

1. Availability of Observation Data. All along the Atlantic and Gulf coasts, the quality of marine forecasts and warnings suffers from insufficient ground truth data for NWS forecasters to use in formulation and verification of their products. This ranges from weather observation buoys offshore and near the coast, to observations from automated sites on the coast. It is impossible to adequately monitor coastal flooding along the majority of the U.S. coast due to the lack of real time data from the relatively few tide gages located along the coast. There are even fewer sites that monitor water levels on the sounds and bays so that flooding in those regions is even more poorly observed. The need for additional marine data has been highlighted in previous DST reports but, due to continuing budget constraints, the situation has not improved. Fewer sites are available now than there were several years ago.

2. Communication with Emergency Management Officials. Communication with EMOs is generally one way, i.e., from NWS to the EMOs via printed messages or in some cases via NOAA Weather Radio (NWR). While many offices attempt to provide full explanations of the coming or ongoing weather event, there are inevitable gaps. Also, there is generally no way for the EMOs to feed back information or ask questions other than through the telephone. There are just too many EMOs for NWS to speak to them individually. The use of the National Warning System (NAWAS) provides a good model for contacting a number of EMOs

at once, but this system does not reach all areas at the present time. During the **Superstorm** there were a number of instances in Florida where messages from NWS did not reach threatened people. A better system must be developed to surmount this shortcoming.

3. Improved Public Response to NWS Forecasts and Warnings. While not a problem in the northern areas where the warnings were limited to one problem (i.e., blizzard conditions), in the south there were several hazards associated with the storm. The public and some EMOs in the South did not fully understand the multiple threats and, therefore, provided an uneven response to those threats.

While NWS did a good job alerting the public in Florida and the Carolinas of the coming threat, the communication was sometimes ineffective since the public did not perceive the urgency of the situation. Florida residents are accustomed to hearing the terms "storm," "thunderstorms," and even "tornadoes" on a frequent basis. When the same expressions are used for a storm system recognized by NWS to be of much greater consequence, the urgency of the message is not conveyed to the public forcefully. As it was, many people were more concerned about the possibility of freezing pipes and crop losses later in the weekend than they were to the more immediate threat of severe weather and coastal floods.

In some cases this was even true of EMOs who got an individual phone call alerting them to the imminent conditions. This points out the continuing need for NWS to provide education to the EMOs and the public at large regarding what NWS can do and what it cannot do.

Other than underforecasting the unprecedented coastal flooding conditions experienced on the west coast of Florida, overall NWS performance was remarkable for the accuracy of its long lead time predictions of the conditions experienced by the public in the eastern states during the **Superstorm of March 1993**.

Major Findings and Recommendations

A major function of any DST is to identify areas where NOAA and NWS can make improvements in the services provided to the public. To better focus attention on the most important issues, only the most significant Findings and Recommendations are listed here. Less important findings or recommendations are not included in this section but instead have been highlighted within the text of the Report through the use of bold printing.

Chapter 1 - The Event and Its Impact

Finding 1.1 - NWS could have made improvements to the Coastal Flood Watches and Warnings for the Florida Gulf Coast. A significant contributing factor to this problem was the insufficient number of Gulf of Mexico marine and coastal observations, water level measurements, and a lack of storm surge guidance products to assist in forecasting these events. NWS has never had sufficient marine observations nor enough real-time water level information. The need for these data were also noted as deficiencies in the DST Report on the Halloween Nor'easter of 1991. Chapter 4 and Finding and Recommendation 4.1 further address these problems.

Finding 1.1a - NWS does not have an operational dynamic numerical forecast model for predicting coastal surge and flooding associated with extratropical systems. Current guidance products are statistically derived and extend only from Cape Hatteras north. The lack of surge forecast capability is also evident for sound and bay flooding events as occurred in the Albemarle and Pamlico Sounds of North Carolina during the **Superstorm**.

Recommendation 1.1 - NOAA should accelerate development of a dynamic numerical prediction model capable of predicting coastal surge and flooding from extratropical storm systems. Also, models should be developed for major bays and sounds. Concurrent development of a coupled ocean-atmosphere prediction model is necessary to optimize initial conditions for the dynamic coastal surge model.

Finding 1.2 - The Storm Data Reports prepared at each WSFO are inadequate for the preparation of disaster survey reports because they generally do not include sufficient details, particularly on indirect deaths, or on clean up costs to local and state governments.

Recommendation 1.2 - Field offices must provide the DST comprehensive reports of direct and indirect deaths and injuries in a timely fashion (i.e., within 60-90 days) after the event(s). These reports should also contain estimates of damage including the clean up costs incurred by local and state governments. The efforts to obtain complete data should include solicitation of articles from newspapers in the affected areas as well as information gathered from affected EMOs.

Chapter 2 - Hydrometeorological Analysis

Finding 2.1 - As a result of automation of field office equipment, NWS has discouraged data archiving of model output and satellite imagery. Case analysis, model consistency studies, and research efforts have suffered as a result. Learning from past experience can be extremely valuable in predicting future weather events.

Recommendation 2.1 - **NWS field offices should be able to readily retrieve or reconstruct guidance materials and satellite data for event analysis, long term archiving, and case studies.**

Chapter 3 - Warning Services

Finding 3.1 - WSO Tampa did not use the correct product identifier/routing header in issuing the Coastal Flood Warning because it is not normally authorized to issue those messages. However, in an emergency such as existed with the Miami office incapacitated by the loss of electric power, a WSO can issue Coastal Flood Warnings. Although we have no evidence, the use of the Coastal Flood Statement header instead of the Coastal Flood Warning category may have hampered warning dissemination.

Recommendation 3.1 - **WSFO Miami, and all WSFOs with coastal flood responsibility, should clearly outline procedures to allow WSOs to issue coastal flood warnings when necessary. Normally, the WSO(s) would use the CFW category authorized for the parent WSFO (e.g., MIACFWMIA) to enable the widest dissemination possible. This problem will be alleviated in the modernized NWS as the coastal flood watches and warnings are decentralized.**

Finding 3.2 - WSFO Miami was severely hampered by the loss of electric power and communications other than the telephone during the height of the coastal flooding events associated with the **Superstorm**. It appeared the WSFO staff tried to "tough it out" rather than being proactive and turning over warning and forecast responsibilities to appropriate backup offices.

Recommendation 3.2 - **All NWS field offices should periodically review their procedures for initiating backup warning and forecast services.**

Finding 3.3a - The WSR-88D Mesocyclone Identification Algorithm depicts an excessive number of mesocyclones. At times it indicated several circulations even though matched storm-relative velocity images indicated only moderate gate-to-gate shear. The NWSO staff had to differentiate between true mesocyclones and false signatures while also deciding whether to issue a Tornado Warning or a Severe Thunderstorm Warning.

Finding 3.3b - Short-lived, weak to moderate (F0-F3) tornadoes, such as occurred at Chiefland and elsewhere over north central Florida, can still cause significant destruction and death. However, the WSR-88D does not always detect or permit prediction of such events using the existing algorithms.

Finding 3.3c - Range-folding obscured the velocity information in some tornadic storm echoes.

Recommendation 3.3 - Additional research is required to continue to improve the performance of the WSR-88D. In addition to the Mesocyclone Identification Algorithm problem, the problems associated with range-folding and the detection of weak tornadoes also require urgent attention by NOAA.

Chapter 4 - Data Acquisition, Communications, and Facilities

Finding 4.1 - High availability of buoy and coastal station observation data are vital to support the NWS marine forecast and warning program. The scarcity of marine weather observations greatly impacted the quality of NWS marine forecast and warning services during the **Superstorm**. A similar finding was noted in previous DST Reports.

Recommendation 4.1 - NOAA should pursue additional marine observation sources including collaborative efforts with state and private organizations.

Finding 4.2 - Real-time water level data is essential to NWS coastal flood warning and forecast program. The lack of timely access to water level gages greatly diminished NWS's ability to issue accurate and timely coastal flood warnings. The majority of the measurements from the NWLON of 189 coastal and Great Lakes reporting stations are not available automatically nor in real time. These reports would have provided critical observations and verification of coastal flood watches and warnings and would have been of significant value as the **Superstorm** crossed the northern Gulf of Mexico. Software problems that occurred at WSFO Boston further reduced tide gage data availability at NWS offices.

Recommendation 4.2 - NOS with NWS should develop and support an Implementation Plan to complete the installation of the NGWLMS. This plan should include real-time reporting capabilities and a method of transmitting water level measurements to NMC. NMC should transmit a collective of these observations to field offices. In addition, local NWS offices should have direct access to NOS gages in their CWA.

Finding 4.3 - The NGWLMS can support up to 11 ancillary measurements such as air temperature, atmospheric pressure, and wind speed and direction. Optimization of this additional capability could partially compensate for the scarcity of marine observations.

Recommendation 4.3 - NWS should take action to include the addition of environmental sensors at NGWLMS stations to measure additional parameters for relay in real-time to NMC for processing and dissemination on AFOS.

Finding 4.4 - Data from the WSR-88D at Eglin AFB was not available at WSO Tallahassee due to communication linkage drop outs during the **Superstorm**. The result was that during the height of the storm little radar data was available at Tallahassee.

<u>Recommendation 4.4</u> - Communications problems between the Eglin AFB WSR-88D and the WSO Tallahassee PUP should be corrected by NWS and the communications link upgraded if needed.

<u>**Finding 4.5**</u> - The volume of reports during widespread events such as major winter storms or significant severe weather outbreaks makes it difficult for NWS to use SKYWARN data quickly. Several NWS offices obtained spotter information via packet radio that provided a hardcopy form of the HAM spotter reports. This method was less disruptive and labor intensive than receiving HAM radio reports via phone.

<u>Recommendation 4.5</u> - NWS should explore either purchasing packet radio receiving equipment or acquiring this equipment via cooperative agreements with such organizations as FEMA, state/local EMOs, and amateur radio clubs, to automate collection of spotter reports. *An Operations Manual Letter* will be issued shortly by NWS Headquarters that allows obtaining this type of equipment.

<u>**Finding 4.6**</u> - The only significant problem with NWS facilities was with emergency power systems. A number of NWS sites had commercial and back-up power problems (emergency generators, UPS and battery failures) during the **Superstorm**.

<u>Recommendation 4.6</u> - NWS offices should exercise their backup power contingency plans regularly. This should include operating the emergency generators routinely under full load conditions for a set period.

Chapter 5 - Coordination and Dissemination

<u>**Finding 5.1**</u> - Use of the HHL by NWS Eastern Region forecasters was very effective in producing a well-coordinated watch and warning effort, providing continuity across forecast boundaries. However, in at least two instances during the **Superstorm**, the HHL malfunctioned at one of the offices involved in the coordination calls. Also, NWS Southern Region should encourage its coastal WSFOs with access to the HHL to participate in the calls. Inland offices are not connected to the HHL.

<u>Recommendation 5.1</u> - Coastal WSFOs in NWS Southern Region that are connected to the HHL should be included in the coordination calls when appropriate. The HHL should be tested at least weekly at each office on the system to detect outages. Finally, NWS should establish a system that allows all NWS offices to coordinate actions during major storms such as a NAWAS-type system connecting all NWS offices.

<u>**Finding 5.2**</u> - State and local EMOs acquire NWS warnings and forecasts using differing transmission systems ranging from telephone to dedicated computer systems. These variations can cause delays and unequal delivery of NWS products to EMOs.

Recommendation 5.2 - NWS, in coordination with FEMA, should actively develop reliable links to relay NWS watches, warnings, etc., to state and local EMOs. Automated retransmission systems are preferable because they are faster than manual systems. The time saved can save lives. These systems should also provide two-way communications to enable EMOs to query NWS and relay storm reports.

Finding 5.3 - NAWAS is used by NWS to alert many EMOs to watches, warnings, and advisories of impending hazardous weather. However, the system is not in place at a uniform level of government from state to state, or within all states. This hinders NWS's ability to provide urgent information to EMOs.

Recommendation 5.3 - NWSH should assist FEMA in developing a policy that establishes NAWAS uniformly, preferably at the county level.

Finding 5.4 - In many EMOs, NWWS is not monitored continuously due to other work being performed. There were instances during the **Superstorm** that EMOs reported that so much information being transmitted that they did not notice warnings immediately. This caused delays in their responses to those warnings.

Recommendation 5.4 - A means of distinguishing warning information from routine messages must be found for NWWS. For example, on the Weather Channel warnings are displayed on a red background to indicate they are urgent. A possibility is to program NWWS so that if a short-fuse warning is issued (e.g., tornado, severe thunderstorm, flash flood) NWWS would print "WARNING" or "TORNADO WARNING" as appropriate in large letters on a page prior to the actual warning message. This would indicate that an urgent transmission rather than a routine message was to be transmitted next.

Finding 5.5 - Some offices, most notably WSO Jacksonville, were not fully informed about upstream severe weather due to a lack of coordination with adjacent offices.

Recommendation 5.5a - Active coordination with adjacent/nearby offices should be a high priority during severe weather conditions. WSR-88D-equipped offices should contact nearby NWS offices if the WSR-88D is indicating potentially severe weather in a county for which another office is responsible and the severe storm in question is within 124 nm of the Doppler radar.

Recommendation 5.5b - NWS offices must remain in contact with each other to ensure coordination of efforts and to be aware of approaching weather. This should include reviewing warnings and statements, including local storm reports from surrounding offices, and routine review of observed data.

Finding 5.6 - Some Florida EMOs were unprepared for a storm as strong as the **Superstorm**. In particular, they were not ready for the extreme coastal flooding that occurred. The EMOs felt there should have been more urgency from NWS and comparisons made to hurricanes since that is the primary threat they prepare for each year.

Recommendation 5.6 - NWS must be clear, concise, and specific in its messages. This should include SPECIFIC warning advice. To say "strong wind" means different things to different people.

Chapter 6 - Preparedness Activities

Finding 6.1 - The most often heard complaint during the Survey, particularly in the northern areas where the event lasted for over 24 hours, concerned the volume of data and length of the products sent to the media and other users. In many cases they were simply overwhelmed with information.

Recommendation 6.1 - NWS offices should keep their statements as short as possible. For example, they should not reuse call-to-action statements repeatedly. Shorter, more frequent, statements are preferred to ones that are all inclusive. The broadcast media in particular will not use lengthy messages.

Chapter 7 - Media and Public Response

None.

Overall Finding - NWS's performance during the **Superstorm of March 1993** was remarkable. Early recognition of the storm's threat and aggressive communications with EMOs, media, and the public of the extreme danger led to timely issuance of watches, warnings and statements.

Overall Recommendation - NWS should be appropriately recognized for the excellent service provided to the Nation before and during the Superstorm that resulted in saving hundreds of lives and millions of dollars.

Chapter 1

The Event and Its Impact

Overview

The **Superstorm of March 12-14, 1993**, was among the greatest nontropical weather events to affect the Nation in modern times. Blizzard conditions were prevalent to the north and west of the storm center, while high winds, coastal flooding, and severe convective weather occurred to the south and east. Record cold temperatures followed the storm in all regions. Newspaper accounts suggested as many as 270 deaths attributed to the storm although the number actually documented as directly related to the storm was considerably less. The **Superstorm** adversely impacted over 100 million citizens during its lifetime and severely crippled economic activities in the eastern one-third of the U.S. Repercussions were felt nationwide in personal loss, travel, trade, and other commercial activity during the storm and for several days thereafter. For example, about 25 percent of scheduled airline flights were canceled nationwide on Saturday and Sunday with associated monetary losses to the airline industry estimated in the tens of millions.

The Superstorm produced over $2 billion in property damage across portions of 22 states in the eastern part of the Nation. However, timely and accurate warnings and forecasts limited the direct storm-related death toll to under 100 persons. The majority of the deaths associated with the Superstorm occurred during post-storm cleanup activities.

The State of Florida, still recovering from Hurricane Andrew and the October 1992 Tampa Bay tornadoes, was dealt yet another blow. Property damage costs were estimated at $1.6 billion, and approximately one-third of all direct storm-related deaths occurred there. The remainder of the southeast U.S. sustained over $400 million in property damage, and more than 30 lives were lost. In the mid-Atlantic and northeast U.S., storm-related losses were significantly lower. However, economic misfortune due to slowed business activity was extensive.

Regional Summaries

Florida

Hazardous weather associated with the **Superstorm** raked the entire state during an 18-hour period from late evening on Friday, March 12, through the afternoon on March 13. The storm produced virtually every type of hazardous weather — coastal floods along Florida's Gulf shores, severe thunderstorms and tornadoes across the peninsula, extremely high winds everywhere, and up to 5 inches of snow in the northern panhandle.

In Florida there were 28 direct fatalities, injuries to 150 or more, and damage to over $1.6 billion in property. Eleven others drowned in the open waters of the Gulf of Mexico when strong winds and high seas capsized several boats and sank a ship. Eleven more died in post-storm rescue and cleanup efforts bringing the total number of deaths in Florida to 51. Thirteen of the direct storm-related deaths were attributed to coastal flooding in the predawn hours on Saturday; seven were killed by tornadoes and downburst winds late Friday night; five more died when vessels were flooded or capsized by high winds near the Gulf coast; and three others died in sustained high winds during the day on Saturday.

An unprecedented extratropical storm surge of 9-12 feet struck the Gulf Coast from Taylor County south to Hernando County. A surge of lesser magnitude affected Hernando County to the Tampa Bay region. Minor flooding and significant beach erosion were common along the coast south of Tampa Bay. The coastal flooding damaged or destroyed thousands of residences and businesses in the predawn hours of March 13. The height of the surge and speed that it moved ashore resembled that of a Category 1 hurricane for that area, but extended over a much larger area of the coast. The large area affected was due to the extraordinary size of the **Superstorm** relative to the size of a hurricane.

The most severe flooding occurred in Taylor County, southeast of Tallahassee, where 10 people perished and 57 residences in Dekle Beach and Keaton Beach were destroyed. Property damage was estimated near $50 million. Another death occurred in Pasco County when a 5-8 foot surge inundated coastal communities, drowning an elderly woman in her home. From Aripeka to Hernando Beach, 61 residences were destroyed and over 3,300 were damaged; numerous homes and businesses were flooded throughout coastal Pasco County.

Finding 1.1 - NWS could have made improvements to the Coastal Flood Watches and Warnings for the Florida Gulf Coast. A significant contributing factor to this problem was the insufficient number of Gulf of Mexico marine and coastal observations, water level measurements, and a lack of storm surge guidance products to assist in forecasting these events. NWS has never had sufficient marine observations nor enough real time water level information. The need for these data were also noted as deficiencies in the DST Report on the Halloween Nor'easter of 1991. Chapter 4 and Finding and Recommendation 4.1 further address these problems.

Finding 1.1a - NWS does not have an operational dynamic numerical forecast model for predicting coastal surge and flooding associated with extratropical systems. Current guidance products are statistically derived and extend only from Cape Hatteras north. The lack of surge forecast capability is also evident for sound and bay flooding events as occurred in the Albemarle and Pamlico Sounds of North Carolina during the **Superstorm**.

Recommendation 1.1 - NOAA should accelerate development of a dynamic numerical forecast model capable of predicting coastal surge and flooding from extratropical storm systems. Also, models should be developed for major bays and sounds. Concurrent development of a coupled ocean-atmosphere prediction model is necessary to optimize initial conditions for the dynamic coastal surge model.

The high seas generated by gale and storm force winds accompanying the **Superstorm** wreaked havoc with numerous vessels immediately off the coast on the night of March 12-13. Five persons were killed as a result. Two persons died near Clearwater (Pinellas County) when their sailboat capsized after striking bridge supports. Further north, near Homossasa (Citrus County), two fishermen drowned after they were apparently thrown off their boat. A 38-foot fishing boat was swamped by seas in excess of 20 feet off Honeymoon Island (Pinellas County), killing one crewman.

Other deaths and property damage resulted from moderate-to-strong tornadoes and extremely fast-moving severe thunderstorms. The majority of these events occurred north of a line from St. Petersburg to Vero Beach. A total of 11 tornadoes raked the north half of the Florida peninsula between 11:00 p.m., March 12, and 1:30 a.m., March 13, killing five persons, injuring 88 others, and causing over $66 million in damage.

Five significant tornado paths were observed. The strongest tornado (F-3 on the Fujita Tornado Intensity Scale, Appendix A) touched down near Chiefland in Levy County. Tracking only 2.5 miles, the twister killed 3 persons, injured 10 others, and caused $5 million in damage, including the destruction of several homes in Chiefland (Figure 1-1, Aerial photo of destroyed homes). Two females were suffocated in one home when a wall fell on them. The third death occurred as the tornado destroyed a nearby mobile home, killing a 73-year old man.

Figure 1–1. Aerial photo of destroyed homes. (Photo courtesy of Brian Smith.)

The longest tornado (F-2) began in central Lake County, near Howey-in-the-Hills, and proceeded northeastward through the town of Mt. Dora and continued into Volusia County before ending near De Land. The total path length was 31 miles. The tornado left one dead, injured 60 others, and caused $5 million in property damage. The death occurred 10 miles northeast of Mt. Dora when a mobile home was destroyed, killing a 5-month old boy inside the mobile home. Twelve other residences were destroyed, and 346 sustained damage.

Two strong tornadoes (F-2) skirted through the central sections of Marion County, bisecting the city of Ocala. Although there were no injuries, over $1.5 million in property was damaged along the two paths, which covered a total of 22 miles (Figure 1-2, Aerial Survey Track Map). One tornado track was observed for 10 miles across the west and north parts of Ocala that caused the majority of the damage. The second tornado tracked for 12 miles south of Ocala producing primarily agricultural damage. At the Ocala Municipal Airport, several hangars sustained major damage or were destroyed, and a dozen small aircraft suffered damage. A DC-3 also flipped over (Figure 1-3, Aerial Photo of Ocala Airport including the DC-3). After striking the airport, the twister moved northeast, uprooting and snapping several trees before producing widespread damage at an industrial park. Several light-metal constructed warehouse buildings were ruined, while substantial damage was seen inside an adjacent concrete-walled depot, where garages had blown out and walls partially failed. (Figure 1-4, Damaged Industrial Park from the Ground).

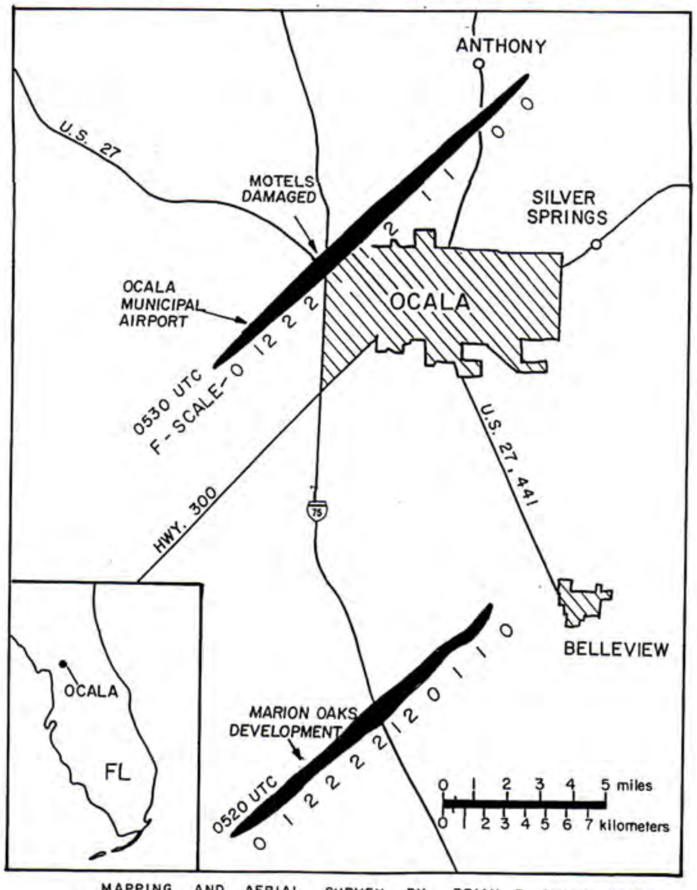


Figure 1–2. Aerial Survey Track Map.

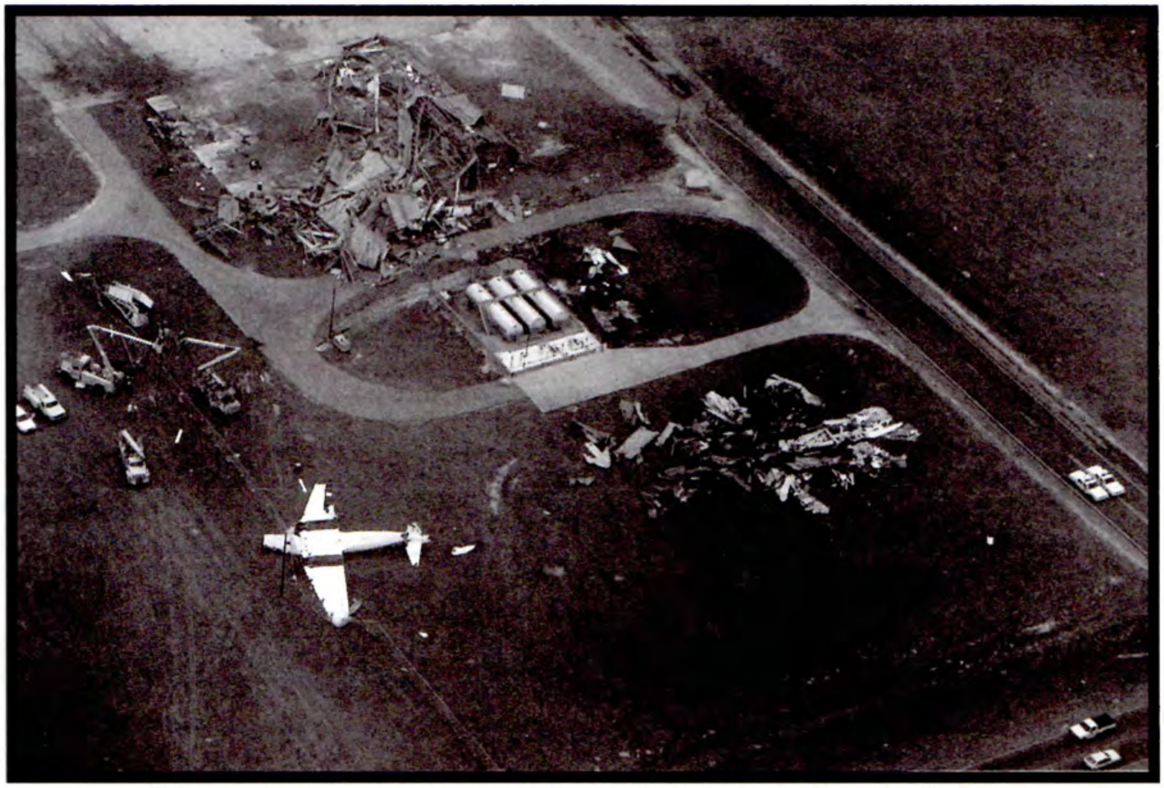


Figure 1–3. Aerial Photo of Ocala Airport including the DC-3.
(Photo courtesy of Brian Smith.)

Figure 1–4. Damaged Industrial Park from the Ground.
(Photo courtesy of Kevin McCarthy.)

Finally, an F-1 tornado touched down briefly (less than 1 mile) near LaCrosse in northern Alachua County, killing one person, injuring four, and producing over $1 million in damage. The death of a 5-year-old girl and all four injuries occurred when a mobile home was destroyed. Additional homes were destroyed by the tornado and a resulting propane explosion at one residence.

Two deaths were attributed to downburst winds. In Manatee County near Terra Ceia Bay, a 43-year-old male drowned while trying to evacuate his boat as the squall line moved through. Shortly before 5:00 a.m., the south part of the squall line passed the Miami area (Dade County). A 36-year-old woman was killed when her trailer flipped over.

Three more people perished in Florida after sunrise Saturday when high winds, often gusting over 60 mph, occurred. In Broward County, one person was killed in Davie when a tree struck a 60-year-old male; and another was killed in Pompano Beach, when a building wall collapsed onto a motorcyclist standing nearby. A male motorist was killed in Brevard County when his high-profile truck was blown over as he drove across a bridge. Lastly, a waterspout (generated by the high winds) killed a boater on Lake Charles in Highland County on Sunday. Figure 1-5 depicts the location of the confirmed tornadoes as well as contours indicating the areas of the highest wind gusts. These were derived from aerial surveys conducted immediately after the storm as well as the Storm Data Reports prepared by WSFO Miami.

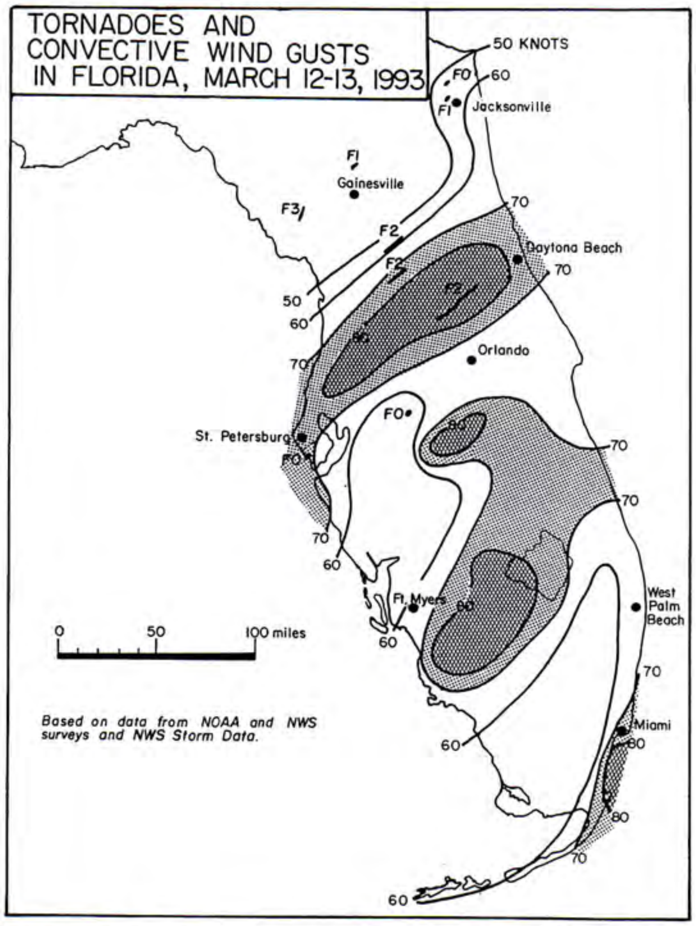


Figure 1–5. Tornadoes and Convective Wind Gusts in Florida, March 12-13, 1993.

The Southeast (eastern Georgia, coastal South Carolina, eastern North Carolina)

Extremely high winds with occasional heavy rains and thunderstorms dominated the weather across the Southeast during daylight hours on March 13. Sustained winds over 50 mph, with frequent gusts in excess of 80 mph, produced widespread property and agricultural damage along the coast from St. Simons Island, Georgia, to Cape Hatteras, North Carolina. Much of the damage occurred to beach front property, water craft, and marinas. Four persons were killed as a result of these winds. In general, ocean coast flooding was mitigated since wind flow paralleled the coastline or was directed offshore.

In southeast Georgia, the main casualties were crops and forests. Incomplete estimates indicated between $25 and $50 million in crops were damaged from the high winds and the post-storm hard freeze, including up to 75 percent of the peach yield and nearly 30 percent of the tobacco crop. Thousands of trees were uprooted or snapped by the high winds, and many fell on electrical lines, leaving nearly one-half million residents without power. Manmade structures also sustained major damage of $15-20 million. Hit hard were Savannah where $1 million in property was damaged and the Brunswick/St. Simons Island area where severe damage, in excess of $4 million, occurred to marinas and boats. There were about 20 injuries due to flying debris and at least one death directly related to the storm in this area.

As with coastal Georgia, extremely high winds dominated the weather across coastal South Carolina during the late morning and afternoon Saturday. Sustained winds over 50 mph, with much higher gusts, produced widespread damage totalling nearly $14 million, especially to boats and marinas. For example, several marinas along the west sides of the barrier islands (e.g., Beaufort, Charleston) were severely damaged by waves and high water. Other, mostly roof, damage occurred at ocean resort homes and there was minor oceanfront beach erosion. Streets were flooded in downtown Charleston when a 20 foot concrete pier broke loose from the Carolina Yacht Club. The high winds cut power to nearly 100,000 residents in the region and many remained without electricity for nearly a week.

As the **Superstorm** raced through central North Carolina, winds quickly shifted southwest and increased. In eastern North Carolina, the high winds caused two deaths, 10 injuries, and damages estimated at $16 million. Brunswick County was hard hit with $6.6 million in damages and the erosion of about 50 feet of shoreline at Long Beach that rendered about 200 homes uninhabitable. In Carteret County, a 9-year-old boy was killed after a large tree fell on his family's mobile home near Newport. Further south, in Duplin County, an elderly woman was killed by a falling tree. Extremely high wind gusts were recorded in eastern North Carolina, including 83 mph at Cherry Point Marine Corps Air Station and 71 mph at Jacksonville.

The southwest winds caused considerable soundside flooding along the Outer Banks. Maximum surge levels reached about 9 feet at Rodanthe, north of Cape Hatteras, and over 7 feet at Salvo. The DST inspection identified a debris line along the west side of the ocean dune field, the only barrier preventing the island from being totally over washed by storm surge from the sound side. Several mobile homes were destroyed, and the Rodanthe Post Office burned "to the water line" because fire equipment could not reach the scene.

Farther north at Nags Head, from late afternoon through the night, fire and police responded to calls from residents threatened by the rising waters. Numerous rescues were made, primarily in the south Nags Head area, where water was reported to be 4.5-5.5 feet above normal. Three Sheriff's vehicles and a fire engine were ruined by flooding during the rescue efforts. Thirty private vehicles were also lost. Several homes were flooded in the Stumpy Point area of Hyde County. At the Oregon Inlet Fishing Center, sound waters rose over the bulkheads, causing severe damage to boats and loss of more vehicles.

At Duck, two construction barges broke loose from their moorings at the U.S. 158 bridge and washed up on the east shore of Currituck Sound. (Figure 1-6, Barges on Beach.) Several more were stranded in mid-sound. In addition, the town of Collington was flooded with sound water. By 4:55 p.m., Rodanthe had 3.5 feet of water. Figure 1-7 shows some locations of sound side flooding in feet above ground from Frisco to Sanderling. Damages to the Outer Banks reached $4.7 million.

Figure 1–6. Barges on the Beach. (Photo courtesy of Curt Mason.)

Figure 1-8 shows readings from the Army Corps of Engineers (COE) equipment at Duck, North Carolina. The data show a rather dramatic increase in the sound water level between 4:00 p.m. and 6:00 p.m., March 13, which coincides with the winds shifting to the southwest. These data indicated that strong westerly flow maintained high water in Currituck Sound for the remainder of March 13 and into March 14. The sounds have an average depth of 15-18 feet and, as a result, they respond rapidly to strong winds as shown in the Figure. **As was the case in many sites along the coast, the data from the Duck COE site was not available to any NWS office in real time.**

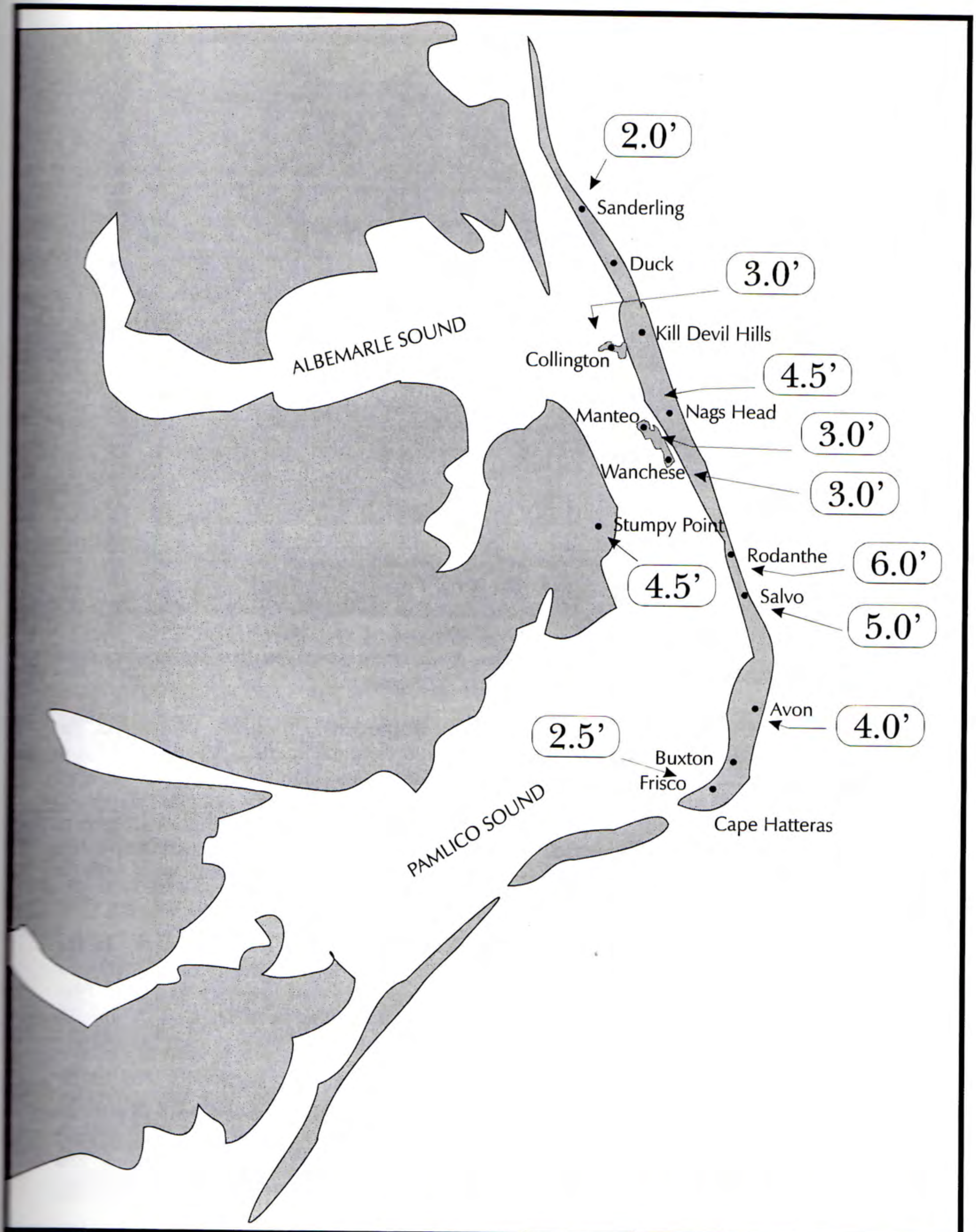


Figure 1–7. Locations of Sound Side Flooding from Frisco to Sanderling.

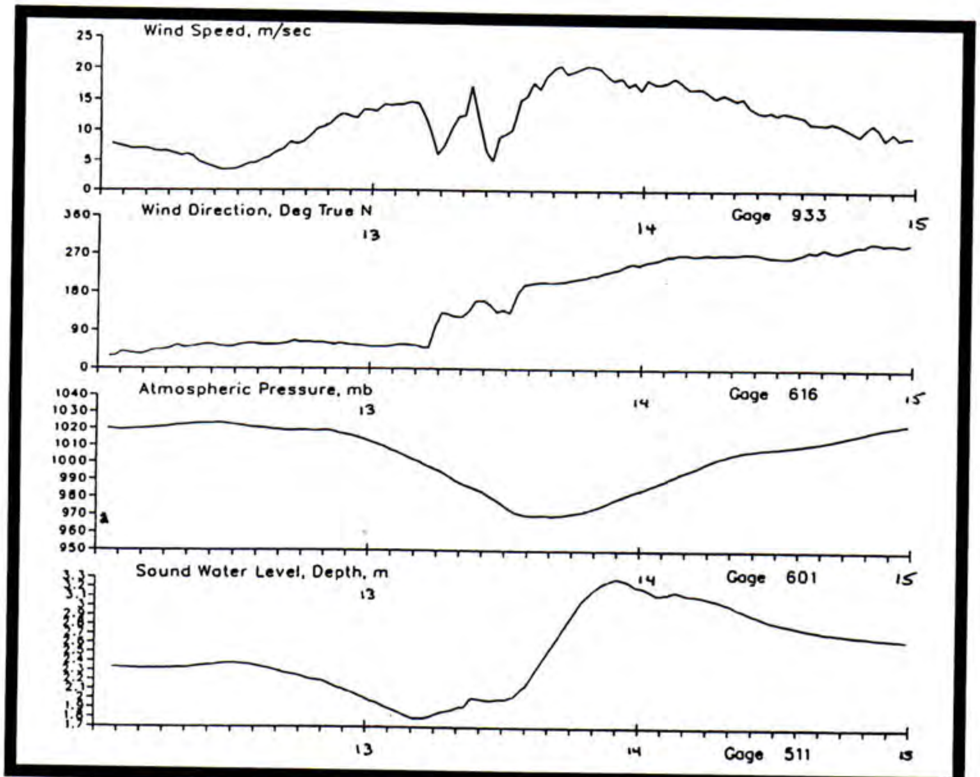


Figure 1–8. Readings from the Army Corps of Engineers (COE) equipment at Duck, NC.

The Southern Appalachians (northern Georgia, northwestern South Carolina, western North Carolina, northeastern Alabama, eastern Tennessee)

The true blizzard conditions associated with the **Superstorm** occurred throughout the southern Appalachian region during the predawn and daylight hours of March 13. Heavy snow combined with rapidly falling temperatures and very high winds caused at least 27 fatalities, over 500 injuries, and more than $500 million in property damage. Second to Florida, this region suffered the most. Although well forecast, the unprecedented southward penetration of blizzard conditions combined with extreme cold following the storm paralyzed the area for nearly a week. At the height of the storm, over one million homes were without power, and sections of all major interstate highways were closed.

Heavy snowfall was widespread, with accumulations greater than 1 foot common. In the higher mountains of north Georgia, southeast Tennessee, and western North Carolina, accumulations were generally above 18 inches with some localized areas up to 3 feet. (See Figure 1-9.) The strong northerly winds accompanying the heavy snow dropped wind chills to dangerous levels as low as -20°F. The majority of the fatalities resulted from exposure to the frigid conditions.

Blizzard conditions struck the northern third of Alabama equally hard. At least 14 persons died, all due to exposure, and damage estimates exceeded $100 million. Six persons died after abandoning their vehicles; seven more died outside, and one person died at home. The weight of the snow combined with wind gusts in excess of 50 mph knocked out power,

Figure 1–9. Heavy snow in western North Carolina.
(Photo courtesy of Jesse Ferrell, National Climatic Data Center.)

collapsed numerous roofs, and downed thousands of trees. At the height of the storm, over 400,000 residences were without electricity. In some locations, roads remained impassable for nearly a week, hampering emergency and relief efforts. Snow amounts ranged from 2 inches along the Gulf Coast to nearly 20 inches in the northeastern mountains. Generally, 6-12 inches fell across north Alabama, with a 40-mile-wide swath of 12-20 inches from Birmingham (13 inches) northeast to the Georgia/Tennessee borders. Following the storm, record cold invaded the state. The deep snow cover combined with clear skies and light winds dropped temperatures to near zero on March 14. A record March low temperature of 2°F occurred in Birmingham.

The hardest hit area of the southern Appalachians was the north third of Georgia, where 14 persons perished. Another 402 persons sustained injuries. Eight of the deaths were directly attributable to the storm from either fallen trees or exposure to the elements while the remaining six deaths were indirectly caused by the storm. The property damage of more than $325 million was concentrated primarily in Gordon, Whitfield, and Murray Counties where over 120 carpet mills suffered heavy losses when warehouse roofs collapsed from the weight of the snow. Thousands of trees and power lines were downed by the high winds. Severe agricultural losses were prevalent, including the destruction of 90 chicken houses where one million chickens were housed. Snowfall totals ranged from 4-8 inches in the lowest elevations from Columbus through Macon to Athens to over 2 feet in the higher terrain north of Atlanta. Totals of 6-12 inches were common in the Atlanta metropolitan area. Snow drifts greater than 3 feet occurred at the low elevations with drifts up to 10 feet in the mountains.

In extreme northwest South Carolina, high winds combined with heavy snow, sleet, and rain to produce widespread agricultural damage and scattered property damage. There was one death from exposure to the elements during the storm, and another occurred 2 days later from the extreme cold. Over 28,000 forested acres were damaged, and the storm trapped hundreds of people in the mountains, requiring several rescue missions. Over 100 teenagers were evacuated by helicopter from Camp Greenville. Snowfall totaled 2-5 inches in the piedmont and up to 18 inches in the mountains.

Residents of western North Carolina were not spared either. Seven elderly persons were killed directly from exposure to the elements or loss of home heating. Seven more died from indirect causes, including heart attacks from shoveling snow. Hikers, campers, and motorists were stranded requiring dangerous rescue missions. This included another group of over 100 high school students from Michigan who were on an outing to test the survival skills they learned. Damage estimates in western North Carolina stand at $8.75 million. Included in this figure are the destruction of 55 homes and damage to 3,300 others. The blizzard downed trees and power lines, leaving over 300,000 residents without electricity. Snowfall totals ranged from 2-13 inches in the western piedmont, 15-19 inches in the foothills, 18-24 inches in the valleys, and upwards of 2 feet in the mountains. One of the **Superstorm's** highest snow total was recorded atop Mount Mitchell where 50 inches fell. Drifts at higher elevations ranged as high as 21 feet.

The blizzard also struck eastern Tennessee where two died from exposure. Thirteen others died from indirect causes, at least $275,000 in damage occurred, and parts of all interstate highways in the area were closed. Hundreds of people were stranded in the Great Smoky Mountains, but all were rescued with noticeably few injuries reported. Most damage occurred to roofs that failed to withstand the weight of the snow. Snowfall totals ranged from 6 inches to 2 feet in the Smoky Mountains. However, Mt. LeConte recorded the greatest snowfall from the **Superstorm** with 60 inches. Chattanooga received 20 inches of snow. This is the all time record for that city.

Central Appalachians (eastern Kentucky, West Virginia)

Heavy snow and strong winds continued north into the central Appalachians during Saturday afternoon. Blizzard conditions were not as widespread here as in the southern Appalachians since wind speeds were somewhat lower. Although storm-related casualties and damage were relatively light, much of the region was snowbound for 24-72 hours following the event, and this is an area where heavy snowfalls occur yearly.

Across eastern Kentucky, snow depths ranged from 6 to 30 inches and winds gusted to 50 mph. Drifts as high as 20 feet were produced. Some of the greatest snow accumulations were 30 inches in Leslie County, 26 inches in Hazard, and 24 inches in Pikeville. There was one death directly attributable to the storm. A man was found frozen in the snow in Whitley County. There were two indirect deaths. A male heart attack victim while shoveling snow and a motor vehicle accident. Thousands of travelers were stranded in the region due to closed roads and airports. This included many spectators who were attending the Southeastern Conference Basketball Tournament in Lexington.

In West Virginia, the storm produced the most widespread snow depth from one event since World War II. Three persons perished directly due to exposure, and at least six others were indirectly killed from over exertion while shoveling snow. Reported property damage did not exceed $500,000. Damage was mainly confined to collapsed flat roofs of several businesses in the southern part of West Virginia. A State of Emergency was declared late on March 13, closing all highways to non-emergency vehicles. The travel ban was lifted the next day, but the State of Emergency continued until March 16. The West Virginia National Guard and Army reserve units assisted in the massive snow removal effort. Although most state residents stayed home, many others were stranded on interstate highways. Over 2,000 persons ended up in hotels and various shelters.

Snowfall totals generally ranged from 16-24 inches statewide, with over 30 inches common in the higher elevations from Beckley northeast to Pickens. Several records were set for the greatest 24-hour snowfall, including Beckley (28.2 inches), Huntington (21.8 inches), and Charleston (17.2 inches). Cold temperature records were set in the wake of the storm.

Blizzard conditions continued northward through eastern Ohio and caused eight injuries and $2.75 million in property damage. Six persons died from heart attacks while shoveling snow. A State of Emergency was declared in 25 counties in eastern Ohio for 2 days prohibiting all travel. Hundreds of motorists were stranded; local residents and shelters provided refuge for them. The National Guard and Army reserve units were called in to assist in storm relief efforts. Snowfall totals ranged from 5 inches in Columbus to 22 inches in Ironton. The snow, driven by wind gusts over 35 mph, drifted up to 12 feet near Steubenville.

The Middle Atlantic (New York, New Jersey, Pennsylvania, Maryland, Delaware, the District of Columbia)

A mixed bag of heavy precipitation occurred with the **Superstorm** in the mid-Atlantic region. Blizzard conditions were common from the western suburbs of the major metropolitan centers to the mountains. Snow changed to a sleet and rain mix in the metropolitan areas during the day on March 13 before changing back to snow towards evening. Along the coastal plain, the majority of precipitation fell as rain while the strong winds caused some beach erosion and minor coastal flooding. The main casualty in this region was the economy, where business came to a halt on Saturday and made a slow recovery thereafter. Clean up was very difficult because the snow accumulated to about a foot in the metropolitan areas and then was soaked with sleet and rain before a hard freeze turned it to "concrete." Schools were closed for 3-4 days in many areas due to icy, impassable roadways.

In the Virginia, Maryland, Delaware, and D.C. region, only one death was directly related to the storm. A woman died from exposure in Baltimore, Maryland. In addition, two people sustained injuries in Washington, D.C. Two men reportedly died of heart attacks shoveling snow in Newark, Delaware, after the storm. Property damage for the region was estimated near $39 million, with most occurring across Virginia ($16 million). In Virginia, 4,000 travelers required temporary housing during the peak of the storm. The entire western third of Virginia was particularly hard hit, closing interstate highways and causing roof collapses along the entire spine of the Shenandoah mountains. To the east, minor coastal flooding and some wind damage occurred in the Norfolk area. Snowfall totals ranged from 1 inch near Norfolk, to near 1 foot in the central Piedmont regions, to near 3 feet in the highest elevations in extreme western Virginia.

In Maryland, D.C., and Delaware, damage was much less, including collapsed roofs in Frederick County and Baltimore County. Clean up costs were estimated at $23 million. Power outages in the Baltimore-Washington metropolitan area affected nearly 250,000 homes and businesses. Along the Delaware and Maryland shore, minor coastal flooding occurred at high tide on Saturday, which caused significant beach erosion between Rehoboth and Bethany Beaches in Delaware. Snowfall of 1-3 inches occurred before changing to rain on the eastern shore. In the central sections, 3-15 inches of snow fell, topped by as much as 3 inches of sleet. In western Maryland, snowfall of 27-36 inches was observed, with drifts as high as houses in Garrett County.

In Pennsylvania there were 4 deaths directly attributable to the storm. Each of these deaths was due to exposure. As many as 48 others died in the post-storm clean up, primarily from heart attacks while shoveling snow. Some snowfall reports were 36 inches at Latrobe, 27 inches at State College, and 24 inches at Dubois. All airports and highways were closed for a time, and the Governor declared a State of Emergency Saturday afternoon that remained in effect through the following week. Property damage in the state was relatively light considering the magnitude of the **Superstorm**. Most of the damage was due to the weight of the snow on roofs, although there was some minimal wind damage as well. The highest recorded wind gust was 66 mph at Philadelphia International Airport.

As much as 26 inches of snow fell in interior sections of northern New Jersey while 12-15 inches were more common elsewhere in the state. Coastal flooding of 6-9 feet was experienced causing some beach erosion. There were four fatalities from the storm, all indirectly caused during the clean up phase. Most of the damage estimates were for snow removal costs.

Southeastern New York and Long Island were also hit hard with up to 20 inches falling on interior areas of the region. Lesser, but still significant, amounts fell on the coast. The snow changed to rain or mixed with sleet and rain near the coast in the afternoon. Over 100,000 homes were without power due to the high winds and there were major disruptions to travel. Thirty beach front homes on eastern Long Island at West Hampton were washed into the sea. Two deaths related to the storm include a woman struck by an out of control car in Islip, and a man buried by an avalanche while working to free his car from the deep snow.

Blizzard conditions were common across the interior sections of New York with very low visibilities Saturday afternoon. Snowfall amounts ranged as high as 40 inches in the Adirondack Mountains. Some other significant snowfall amounts were: 36 inches at Prattsville, 35 inches at Binghamton, and 34 inches at Cortland. There were five deaths directly related to the event in interior New York. Four of these were due to exposure while the last was caused by snow falling off a woodpile and burying a man in his yard. Damages in the region were primarily due to the weight of the snow on buildings. These included the collapse of an unused theater and a sports bubble at the State University at New Paltz. There were also reports of wind damages. For example, an elementary school in Endicott had two floors damaged and a supermarket in Ticonderoga lost a portion of its roof. Tens of thousands of people were without electricity due to downed power lines. Damage estimates for New York totaled over $25 million.

New England (Connecticut, Rhode Island, Massachusetts, Maine, Vermont, New Hampshire)

For southern New England, this storm produced stronger winds than the December 1992 storm; produced the largest 24-hour snowfall event in a decade for Providence, Boston, and Hartford; and was accompanied by blizzard conditions for several hours Saturday afternoon. Wind gusts of 71, 81, and 83 mph were measured at Salem, Boston's Logan International Airport and Blue Hill Observatory, respectively. Major coastal flooding was averted because the winds, while strong, were of shorter duration than the December storm, and relaxed during the early Sunday morning high tide cycle thereby releasing the storm surge. Precipitation totals were far less in this storm than the December 1992 storm, primarily because it moved north faster than the December storm. As elsewhere, airports were closed due to the storm, and commerce was generally at a standstill for the next few days until roads were cleared. There were few other serious impacts from the **Superstorm**.

Higher elevations inland received as much as 3 feet of snow where the snow never mixed with rain or sleet. Cape Cod, on the other hand, had only 2-4 inches of snow before the precipitation changed to heavy rain Saturday afternoon. Nearly 100,000 customers were without electric power for a time due mainly to the high winds. Most outages were only 6-12 hours duration. The only recorded deaths directly related to the storm were a couple who were killed when their car skidded off a snow covered road in Maine. Damage estimates were primarily for road cleanup costs.

Storm Data Reports

Appendix B summarizes the deaths, injuries and damage estimates associated with the **Superstorm** and the ensuing clean up efforts. In reviewing Appendix B you will notice it is incomplete in a number of areas. Determination of death, injury, and damage statistics related to the **Superstorm** was the most difficult part of compiling this Report. Much of the information for Appendix B was taken from the Storm Data Reports, but these are inadequate for anything other than the severe weather and flash flood events that they were originally intended to document. For example, the media reports during and immediately after the **Superstorm** indicated as many as 270 deaths from the event. The Storm Data Reports, however, document only about 150 deaths. The deaths and injuries directly related to this storm appear to be well covered by the Storm Data Reports. It is the indirect deaths and damage/clean up costs that can not be determined accurately using the existing procedures. Timeliness of the reports and accuracy of some of the information, particularly regarding injuries and damage cost estimates, were frequently a problem.

Storm Data rely heavily on newspaper accounts of weather events. This works well in documenting relatively easily defined events such as thunderstorm winds or hail damage, but frequently will not provide the information needed on post-storm clean up costs or on deaths that are a result of the clean up. For the **Superstorm**, the prime example of this is the great number of heart attack deaths that occurred in areas hit with heavy snow. Many of these would not be detailed in routine newspaper accounts and would, therefore, not be included in the Storm Data Reports. Similarly, clean up costs to local and state governments, which are legitimate costs to be included in a disaster survey report, are generally not included as part of the Storm Data because the data are not available to NWS.

Even significant tornadoes can be missed by Storm Data if the WSFO does not have direct knowledge of a them before the Storm Data Report is prepared. This was true of the **Superstorm** in Florida. The aerial survey documented more than one tornado that was not in the Storm Data Report from WSFO Miami even though the WSFO made a concerted effort to prepare the report. The information was simply not available to them using the current procedures.

Finding 1.2 - The Storm Data Reports prepared at each WSFO are inadequate for the preparation of disaster survey reports because they generally do not include sufficient details, particularly on indirect deaths, or on clean up costs to local and state governments.

Recommendation 1.2 - **Field offices must provide the DST comprehensive reports of direct and indirect deaths and injuries in a timely fashion (i.e., within 60-90 days) after the event(s). These reports should also contain estimates of damage including the clean up costs incurred by local and state governments. The efforts to obtain complete data should include solicitation of articles from newspapers in the affected areas as well as information gathered from affected EMOs.**

Chapter 2

Hydrometeorological Analysis

Chronology of the Event

The large-scale meteorological analyses presented are taken from the operational NMC product suite available to all NWS offices during the actual event. Additional mesoscale analyses have been made by NMC using additional data not available operationally.

Prior to the explosive **Superstorm** development, an amplifying long-wave trough existed over the intermountain areas of the U.S. There was a 300 millibar (mb) isotach maximum ranging from 100-150 knots (kt) to the rear of the trough, plunging south southeast over the Great Basin. In addition, there was pronounced cold-air advection in the mid and lower troposphere over the central and southern Rockies during early Friday, March 12, which shifted into Texas by evening. This process aided in strengthening the baroclinic zone and initiating explosive cyclogenesis over the Gulf of Mexico.

The earliest indication of a surface frontal-wave appeared near sunset on Thursday, March 11, over central Mexico (Figure 2-1). By the predawn hours on March 12, a well-defined frontal wave (1000 mb) emerged off the Texas Gulf Coast near Brownsville, and began to intensify as it moved over the Gulf. The March 12, 1800 UTC infrared Geostationary Operational Environmental Satellite (GOES) image (Figure 2-2) shows extensive deep convective clouds to the northwest through southeast quadrants (clockwise) of the low center.

During Friday, March 12, the frontal cyclone deepened rapidly at 1-2 mb/hour as it tracked east northeast toward the Florida Panhandle. By 7:00 p.m., Friday (Figure 2-3), the post-storm mesoscale analysis clearly indicated a rapidly intensifying cyclone with a central pressure of 984 mb, south of Morgan City, Louisiana. That afternoon, there had been ship and oil platform reports from off the Louisiana coast that showed sustained north winds up to 70 kt. There was also an extensive rain shield to the north of the low, with embedded heavy thunderstorms that may have produced wind gusts in excess of hurricane force over the northern Gulf of Mexico. **In hindsight, these winds were not just associated with the large squall line that later moved across the Florida Peninsula but were indicative of the increasing strength of the storm.**

By Friday evening (13/0000 UTC), 300 mb winds of over 100 kt extended into the base of the upper-level trough over the southern Gulf, with a primary northerly speed maximum of 150 kt over the Texas Panhandle. Simultaneously, the GOES infrared satellite images indicated a strong vorticity maximum over the southern Gulf of Mexico. All the ingredients for explosive cyclogenesis were now present; a negatively-tilting trough aloft, increasing warm advection at low levels over the southeast U.S., and continued cold air advection into the northwest Gulf. As a result, the Friday evening (13/0000 UTC) surface mesoscale analysis showed continued deepening of the cyclone as it approached Florida.

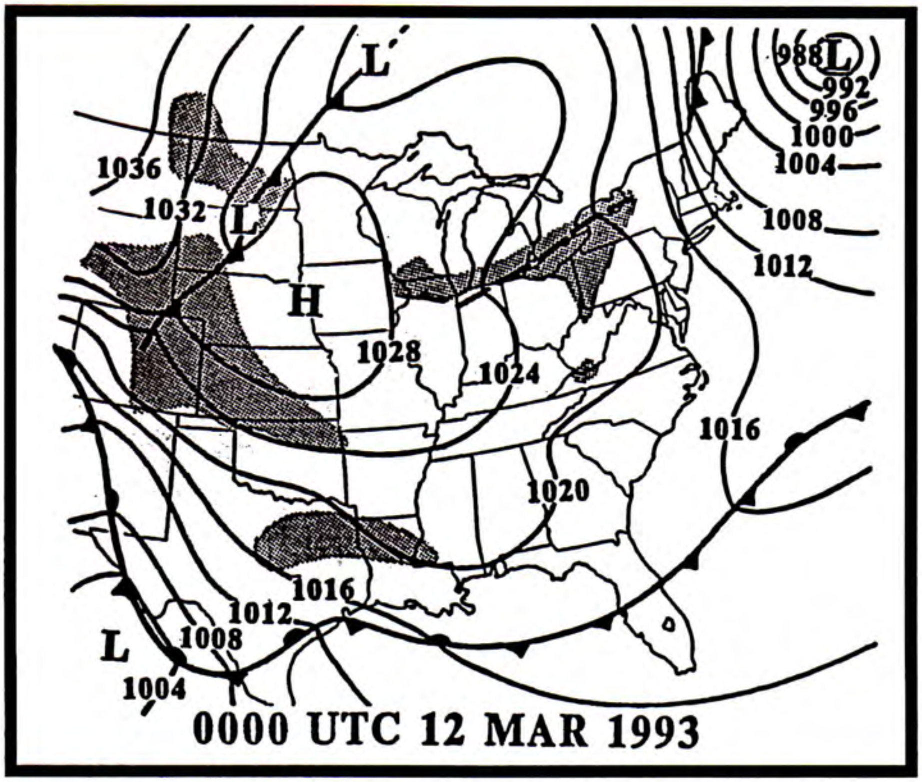


Figure 2–1. NMC Post-Storm Mesoscale Analysis at 7 p.m., March 12, 1993.

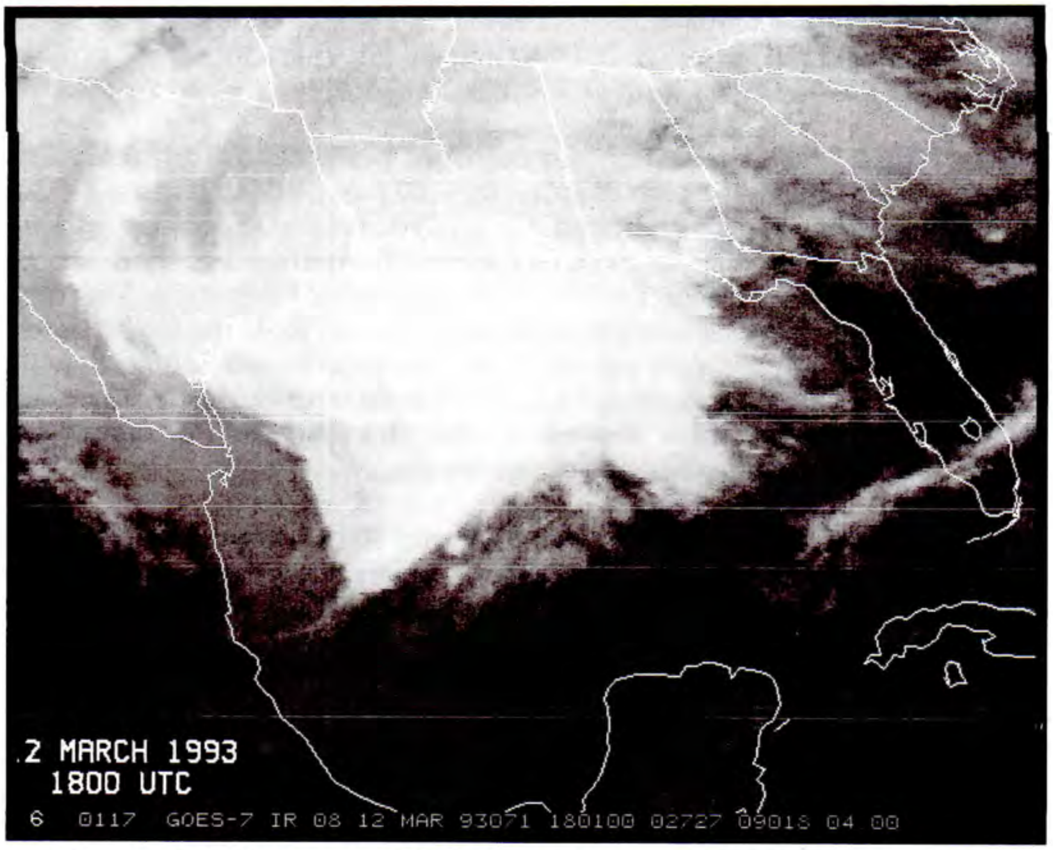


Figure 2–2. Infrared GOES Image From March 12, 1800 UTC.

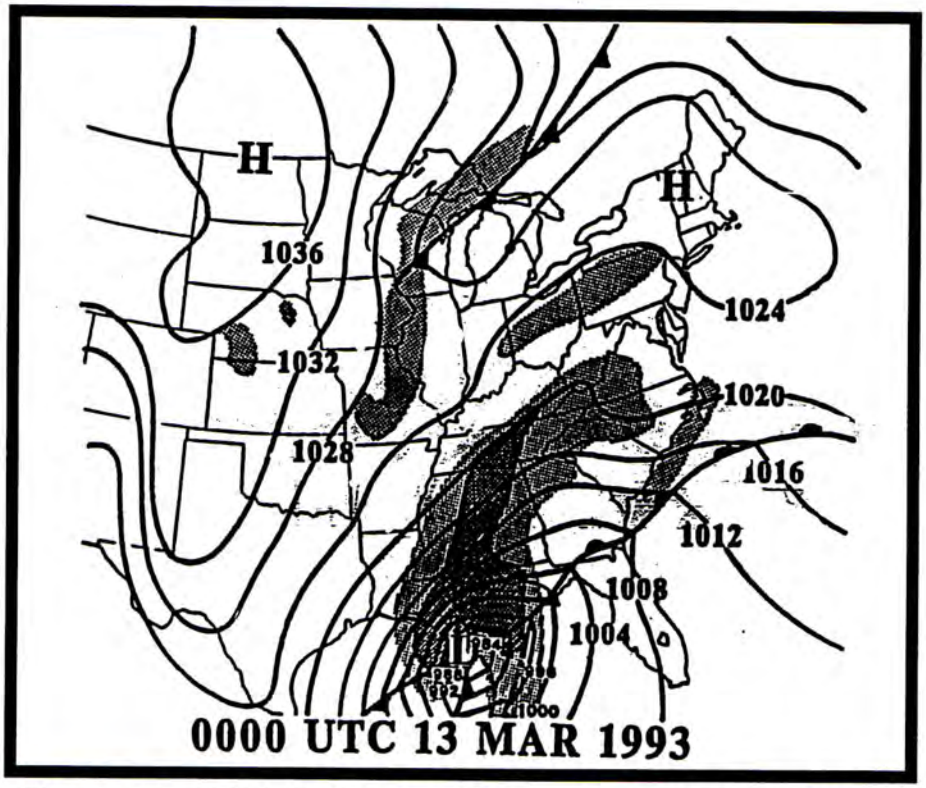


Figure 2–3. NMC Post-Storm Mesoscale Analysis at 7 p.m., March 13, 1993.

As evening progressed, the precipitation shield expanded to cover all of the southeastern U.S. (Figure 2-4 GOES Infrared Image, 1 a.m., March 13, 1993). Also, a squall line developed in the eastern Gulf and propagated rapidly toward Florida. Figure 2-5 is a radar composite showing the squall line crossing the Tampa metropolitan area at midnight March 13. The squall line produced numerous severe weather events over northern Florida. Moving at nearly 70 mph, the north part of the line produced 11 confirmed tornadoes and numerous downbursts before exiting the Atlantic coast by 1:30 a.m., Saturday, March 13. **One unusual aspect of this case was that all tornadoes were spawned in association with either bow-echoes or localized circulations (i.e., mesocyclones) along the solid, intense squall line.** The south part of the line produced damaging winds over southern Florida, including the Keys, prior to passing off the southeast Florida coast.

By early Saturday morning, the upper trough had a strong negative tilt combined with a wind speed maximum of 150 kt or greater at 300 mb. Meanwhile, an area of very strong upper level diffluence continued to develop ahead of the trough. These features clearly indicated that the **Superstorm** would continue to deepen, reaching record low pressure readings. At 7:00 a.m., Saturday, the center of low pressure (971 mb) was near Waycross, Georgia. Precipitation had already spread into New England. Heavy precipitation was common across the southeast U.S., and unseasonably cold air continued to pour into the northwest side of the storm changing the rain to snow. Increasing winds and falling temperatures produced blizzard conditions across northern Alabama and Georgia. By midday on Saturday, the storm center was near Raleigh, North Carolina. By that time snow had spread into New England, while behind the storm center it continued to snow in parts of Mississippi. The storm system was still deepening and enlarging, with a circulation that encompassed over 3-million square miles. It had truly become a **Superstorm!**

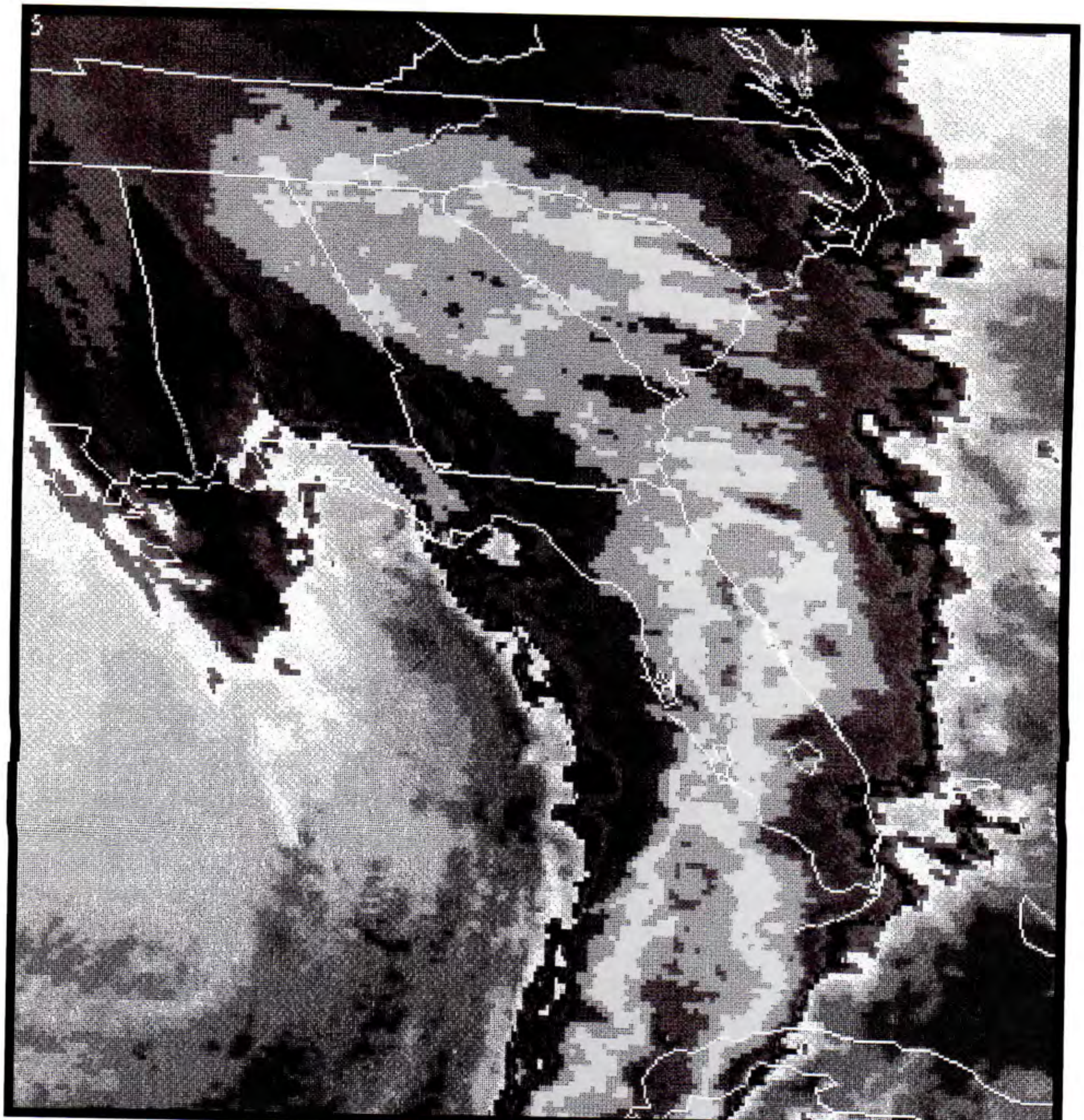


Figure 2–4. GOES Infrared Image, 1 a.m., March 13, 1993.

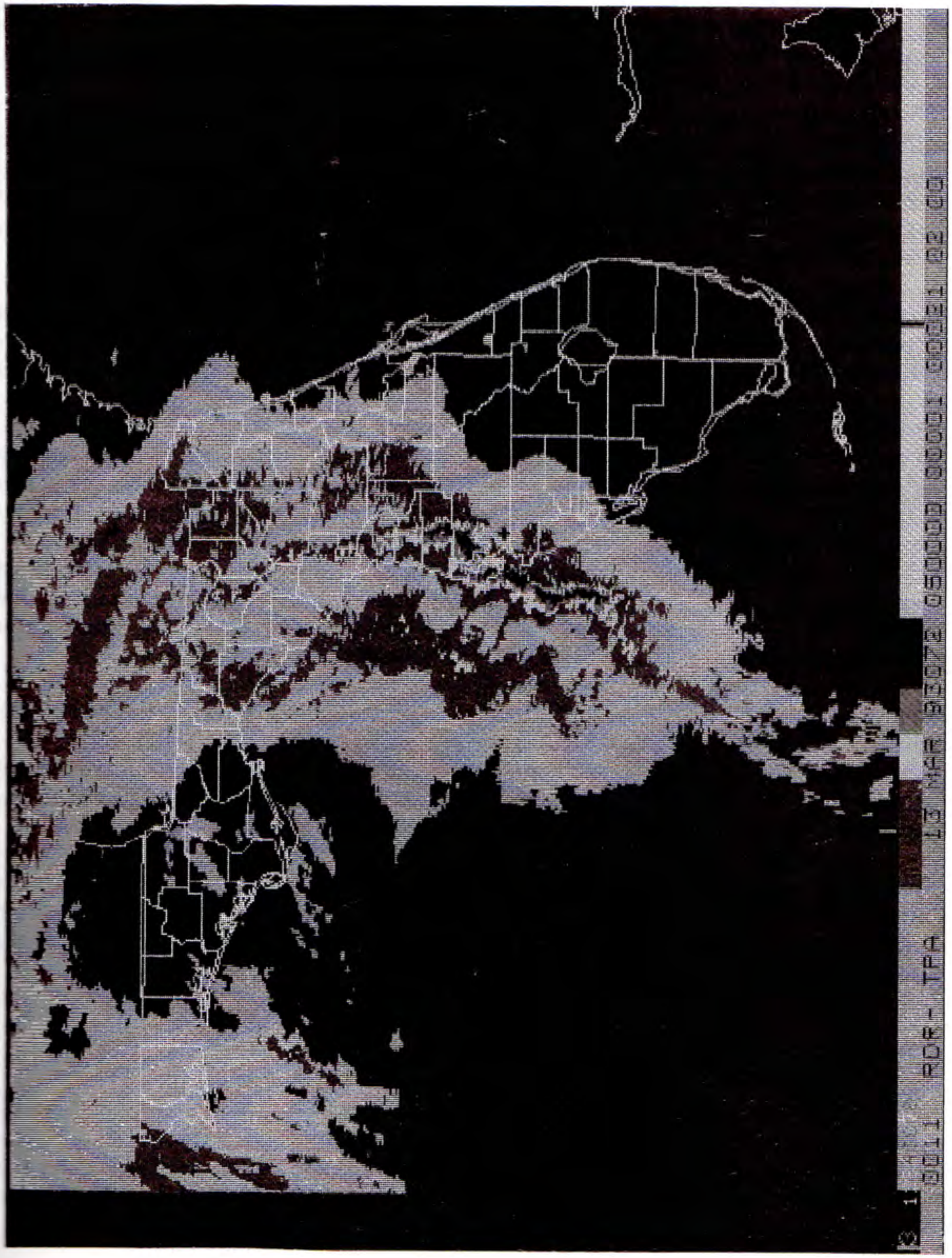


Figure 2–5. Radar Composite of Squall Line at midnight, March 13, 1993.

At the peak of the **Superstorm**, winds gusted to 50 mph or higher over a large part of the East. The storm system transported copious amounts of Gulf and Atlantic moisture throughout the eastern third of the Nation, producing heavy snow as much as 600 miles from the storm center. To the south of the storm center, sustained strong winds buffeted the coastal regions of Georgia and the Carolinas.

Coastal flooding of ocean beaches was minimal. However, significant soundside flooding occurred in North Carolina as waters from the Albemarle and Pamlico Sounds were pushed northeast by the strong winds onto the barrier beaches and nearby islands from Beaufort, South Carolina, to Kitty Hawk, North Carolina. Sound waters rose rapidly, increasing about 4 feet at Duck, North Carolina, by 10:00 p.m. and remaining high throughout Sunday.

Intensification of the system slowed by Saturday evening, as the upper level trough became fully negative, centered near the central Appalachians. At this point, the 300 mb jet speed maximum, estimated at over 170 kt, was located east of North Carolina. Surface pressures had deepened to 960 mb over the Chesapeake Bay — a record for the region.

The atmospheric environment around the **Superstorm** resulted in several precipitation types throughout the day. Heavy snow and blizzard conditions were prevalent in the southern Appalachians, expanding east to the North Carolina, Virginia, and Maryland Piedmont, and continuing north to interior sections of the Middle Atlantic and New England regions. The snow turned to sleet in the megalopolis of cities from Washington, D.C., to Boston, Massachusetts, while rain dominated the coastal plains from South Carolina to New Jersey and the immediate coastlines of New York and New England. Embedded thunderstorms were common everywhere, producing locally heavy amounts of precipitation.

By Sunday morning, March 14, a full-latitude trough stretched from near the North Pole to the southeast U.S. Weakening winds aloft precluded further surface development, and the central pressure increased somewhat to 966 mb over Maine by 7:00 a.m. Cold air, however, had spread over the east half of the Nation, setting record low temperatures in many locations.

The upper-level trough began lifting northeastward during Sunday, taking the **Superstorm of March 1993** with it. In its place, cold and dry high pressure remained, bringing lighter winds and clearing skies. As clear, calm conditions settled in over the east Sunday night, additional low temperature records were set.

Description of Coastal Flooding in Florida

The single most deadly phenomenon associated with the **Superstorm** was the coastal flooding that occurred near sunrise Saturday in the Dekle Beach and Keaton Beach areas of Taylor County, Florida. Figure 2-6 shows a resident of Dekle Beach pointing to the height of the storm surge on his home. Due to the devastating impact of this event, it deserves special attention in this part of the DST Report.

Figure 2–6. Dekle Beach Storm Surge.
(Photo courtesy of Mike Koziara.)

As the storm system gathered strength Friday afternoon in the central Gulf of Mexico, the winds across the eastern Gulf were from the south and were slowly increasing to gale force. The sustained southerly winds pushed water from the open Gulf into Apalachee Bay, located south of Tallahassee. As evidence, the tide gage trace from the National Ocean Service (NOS) Next Generation Water Level Measurement System (NGWLMS) station at Apalachicola is shown in Figure 2-7. Note that the normal fluctuation of the tide was lost on March 12 and the readings continued to rise after the astronomical high tide was reached that morning. The peak water level height was attained about 6:30 a.m. on March 13 and was about a meter above normal. While this does not appear very high, it is significant when it is realized that this reading was indicative of the height of the water across the entire bay and of the great volume of water that this in turn represented.

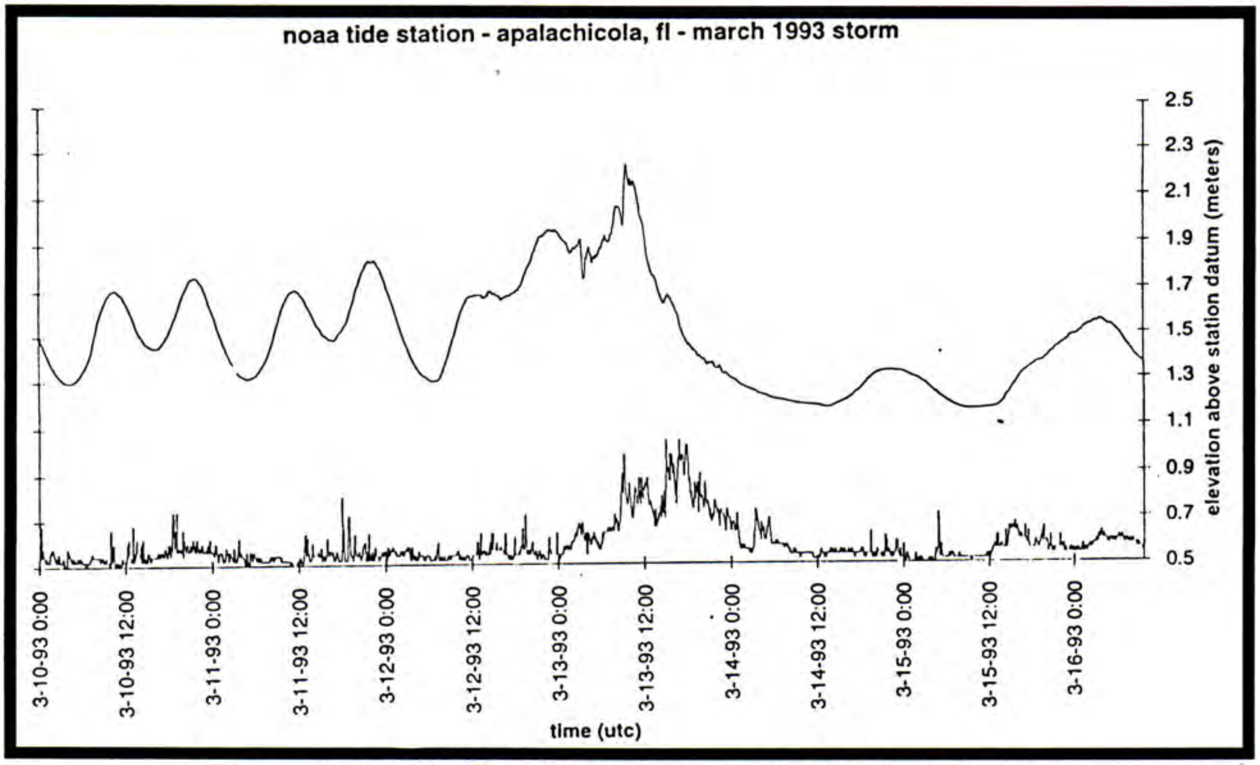


Figure 2–7. Tide Gage Data from Apalachicola, Florida.

The GOES enhanced infrared imagery sequence suggested the rapid development of a mesoscale circulation in the low- to mid-level clouds south of the main low, that crossed the coast southwest of Tallahassee about 3:00 a.m., Saturday. This feature was not detectable from any of the other data over the Gulf or adjacent coasts. Special high-resolution NMC model analyses and a few surface reports suggested that a large area of westerly surface winds in excess of 50 kt developed in the southwest quadrant of the synoptic low by Friday night (see Figure 2-8, ETA Model Mesoscale Surface Analysis). As the cold front from the low center passed across Apalachee Bay and slammed the Florida Gulf Coast about 3:30 a.m., the winds shifted to the southwest, increasing to 50 mph or more with much higher gusts. These winds served to shove the mass of water that had been "piled up" in Apalachee Bay east onto the shores of Taylor County and the other counties bordering the Gulf of Mexico north of St. Petersburg.

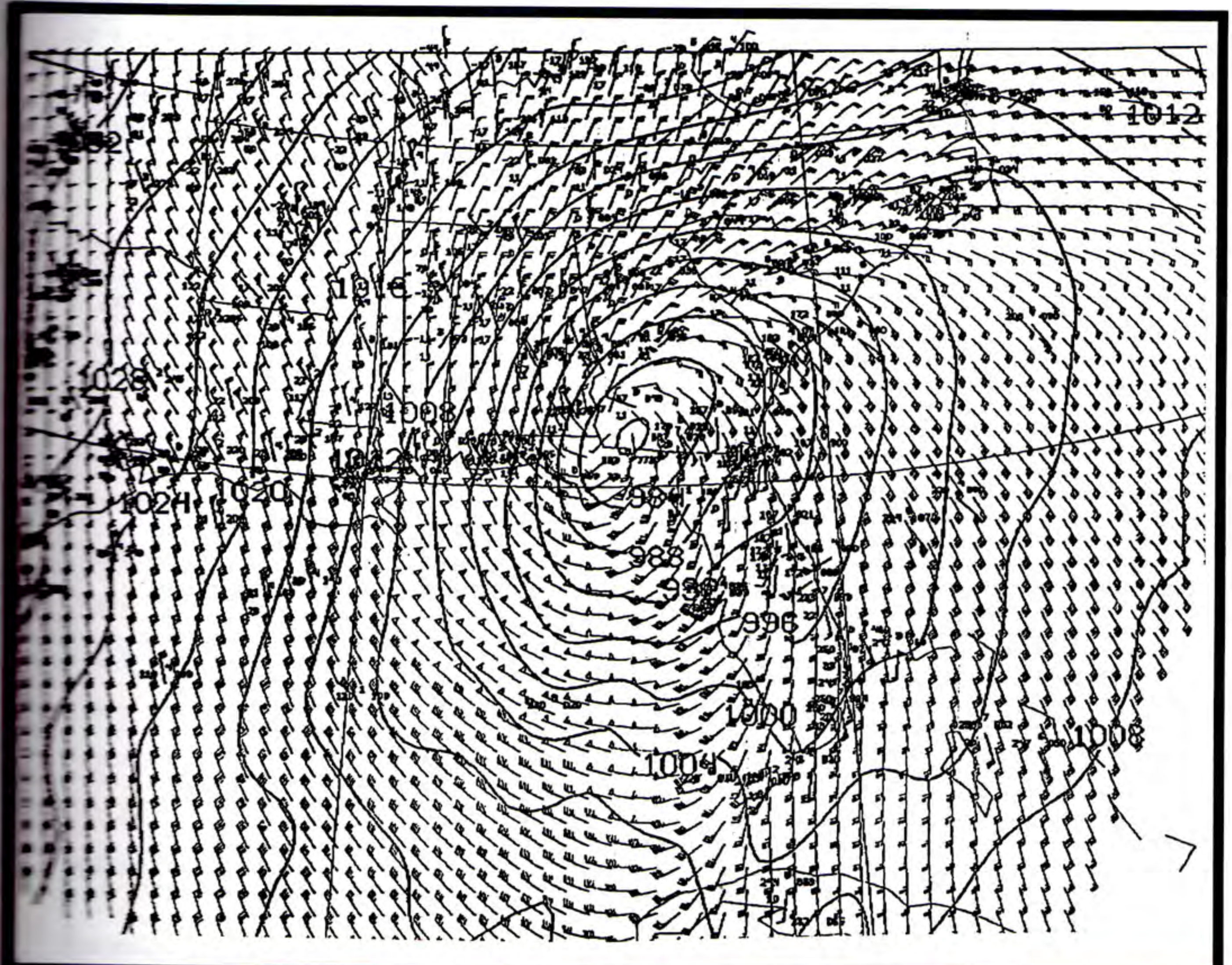


Figure 2–8. ETA Model Mesoscale Surface Analysis for 4 a.m., March 13, 1993.

There were several factors that tended to amplify the storm surge along the Florida Gulf Coast for this event. They include the shallow offshore depth in the area, the shape of the coast line, and the onset of the surge near the time of astronomical high tide. This region has been recognized by NWS as particularly susceptible to a significant storm surge. Computer models had shown that this region could experience up to 30 feet of storm surge.

Unlike a hurricane, which would begin to dissipate after landfall, the **Superstorm** deepened 26 mb after the low made landfall and raced northeast to the Carolinas by Saturday afternoon. Another characteristic that distinguished this storm from a hurricane was the large radius of maximum winds that extended about 200 miles from the center. This meant that a larger area of the coast would be impacted by the storm surge than what would have occurred with a hurricane. Finally, the maximum storm surge occurred well after the storm made landfall and was located about 60 miles southeast of the center. With a hurricane, the maximum surge would be prior to or at landfall and would occur very close to the eye.

The NOS tide gage at Cedar Key, Florida, even more dramatically supports the scenario of water pushing ashore from Apalachee Bay. The tide trace is presented in Figure 2-9. It too shows the normal tide cycle prior to the storm is disrupted, and the water slowly rises ahead of the front. It then peaks rapidly over the course of several hours after the front moves onto the Florida Peninsula. The reading of 8.9 feet is a record for the station that has been in place since 1938. Readings from this gage were not available in real time.

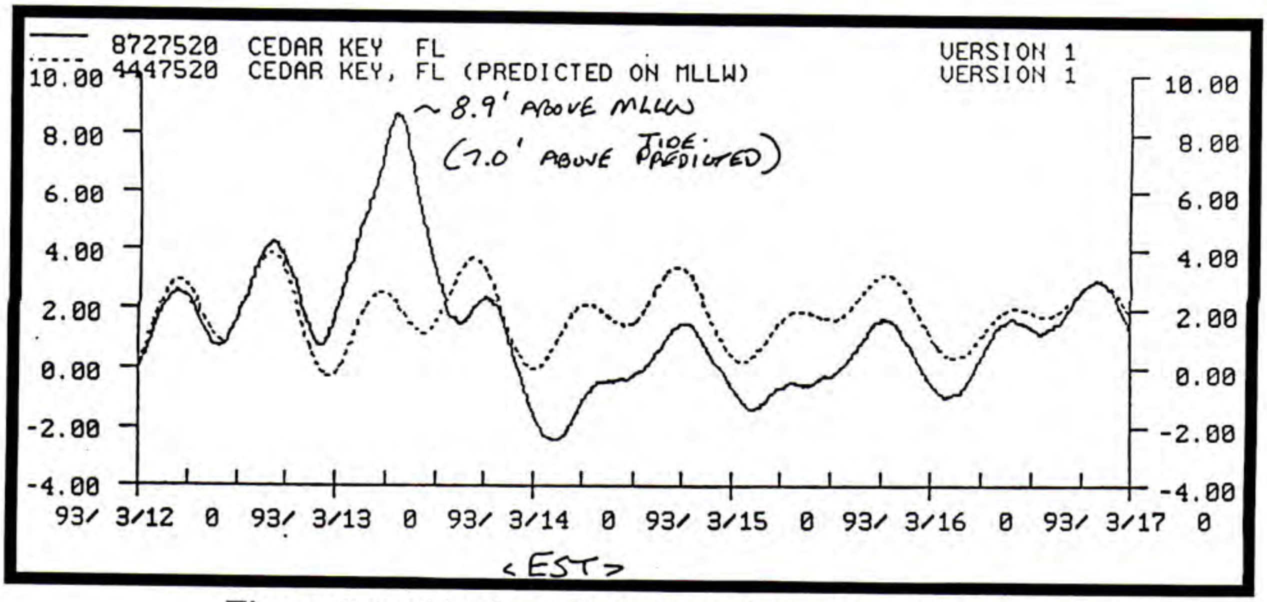


Figure 2–9. Tide Gage Data from Cedar Key, Florida.

This gage reading, which is within the hardest hit area, compares well to the findings of the U.S. Geological Survey representative who visited the region after the storm and provided the data for Figure 2-10. A storm surge of 9-12 feet inundated the Taylor County coast south to Hernando County. A 5-7 foot surge was measured in Pinellas and Hillsborough counties in the Tampa Bay metropolitan area. Eleven people were drowned by the surge between 4:20 a.m. and 6:30 a.m., March 13, with ten of these fatalities in Taylor County.

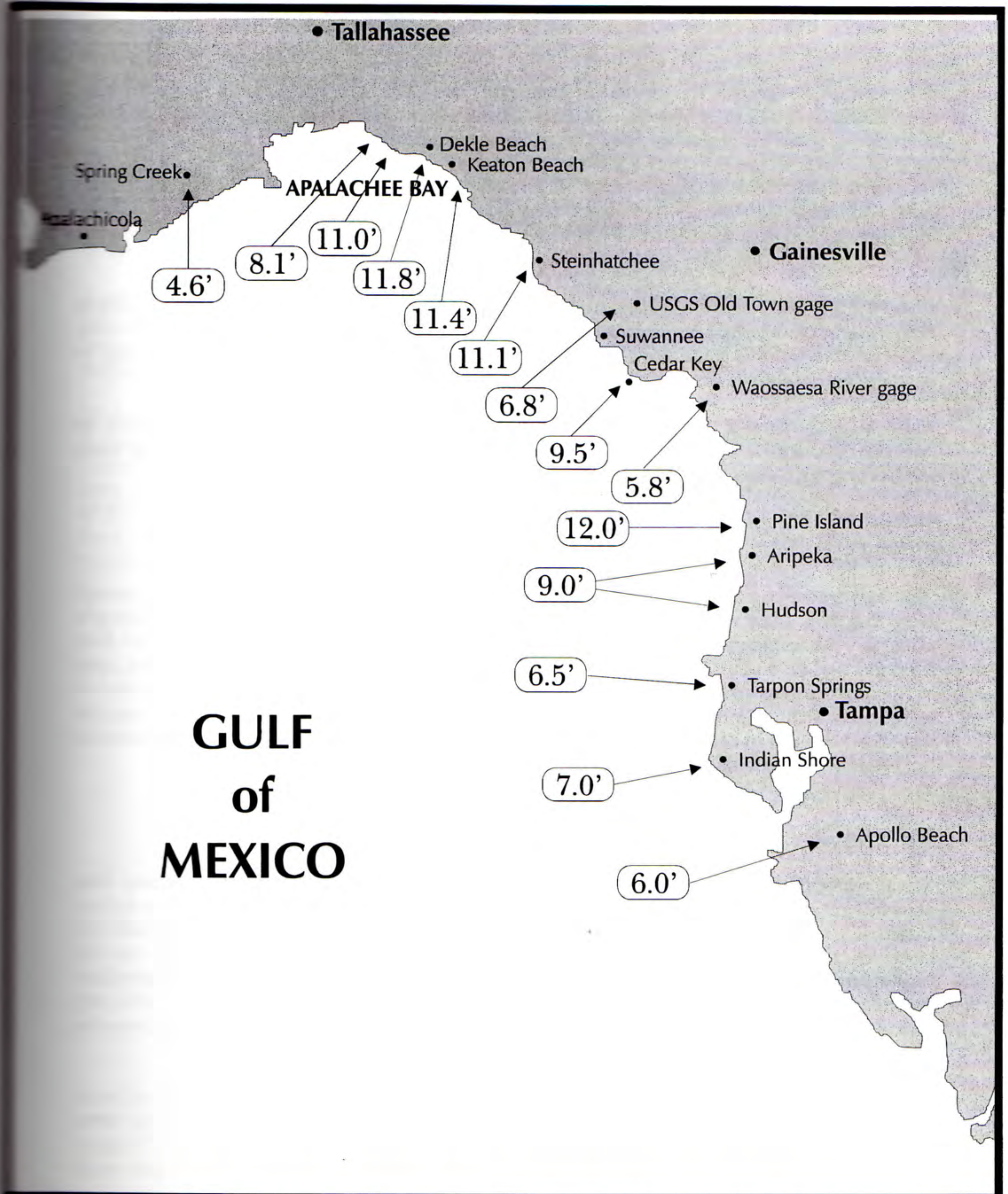


Figure 2–10. Storm Surge Heights on Florida's Gulf Coast.

To our knowledge, no winter storm has ever produced a deadly storm surge of such magnitude in the Gulf of Mexico. **In fact, Superstorm surge killed more people from drowning than Hurricanes Hugo and Andrew combined.**

During the DST field visits it was very difficult at most NWS offices to easily obtain graphic data comparing the various forecast models, satellite pictures, etc. These are valuable tools for training and documentation of office actions during significant weather events.

Finding 2.1 - As a result of automation of field office equipment, NWS has discouraged data archiving of model output and satellite imagery. Case analysis, model consistency studies, and research efforts have suffered as a result. Learning from past experience can be extremely valuable in predicting future weather events.

Recommendation 2.1 - NWS field offices should be able to readily retrieve or reconstruct guidance materials and satellite data for event analysis, long term archiving, and case studies.

Flood Potential

The **Superstorm** dumped massive amounts of precipitation from the Gulf Coast through New England. The river flood potential increased significantly as a result. For example, after the **Superstorm**, areas in the upper Ohio Valley through New York and into New England had as much as a foot of water equivalent locked in the snowpack. In short, most of the eastern part of the Nation was at an elevated risk for flooding. For this potential to be realized, either significant rain would have to fall. In some areas, extended warm weather would be enough to cause flooding. The following describes the spring river flood potential for the mid-Atlantic and Northeast after this severe winter storm.

Mid-Atlantic

Many stations in Virginia, West Virginia, and Pennsylvania set 24-hour or storm total snowfall records. Among the most remarkable totals: High Knob, Virginia — 40 inches; Pickens, West Virginia — 34 inches; and Latrobe, Pennsylvania — 36 inches. The snow was heaviest in the mountains and diminished toward the coast, with the 1-foot line running roughly from Washington, D.C., through Philadelphia to New York City. Only the immediate coast escaped the heavy snow. As a result of this broad area of snow cover, much of it very unusual for mid-March, there was an above average potential for spring flooding across the entire region.

An additional factor that increased the flood potential in this area was the saturated state of soils. Heavy rains (up to 4 inches) that caused some flooding in early March on the lower Potomac and James Rivers, had greatly increased soil moisture levels throughout Virginia, Maryland, Delaware, and New Jersey. The wet soils reduced the infiltration rate and would lead to increased runoff during any rapid snowmelt or heavy rain event.

Northeast

The **Superstorm** increased the potential for spring flooding in the Northeast substantially, putting the entire region into an above average category. The area of greatest concern was in southern New England where snow on the ground ranged from 15-48 inches, with a water equivalent of 2-8 inches. Rain on top of the snow coupled with warm temperatures could result in a rapid meltdown of the snowpack. Another area for higher concern was western New York, where the potential for flooding was also much above normal. This was due to the increased snowpack that ranged from 26-60 inches, the wet ground, and the susceptibility of the area to ice jam flooding.

A second, less conventional threat for New York existed along the shorelines of both Lake Erie and Lake Ontario where a wet 1992 caused lake levels to rise 1-2 feet above their historical averages. The flood threat here was similar to coastal flooding driven by strong winds rather than from the usual inland/river flooding due to runoff and snowmelt.

While the blizzard was not unprecedented in terms of snow totals for northern New England, it added to an already substantial snowpack. Snowpacks in the Green Mountains of Vermont and White Mountains of New Hampshire ranged from 30-80 inches deep, and held from 6-15 inches of water. New York's Adirondack and Catskill Mountains had snowpacks of 20-75 inches, with 4-15 inches of water. All of Maine received from 1-2 feet of fresh snow from the storm, and depths exceeded 5 feet in the interior. The potential was above normal for flooding.

Chapter 3

Warning Services

Introduction

For large scale events such as the **Superstorm**, the warnings issued by NWS are the culmination of the analysis of observations of the atmosphere, and centrally generated (i.e., NMC) guidance forecast products and numerical computer model outputs. The final products are issued to EMOs, the media, and the public for their use and action. This section reviews the performance of the forecast and warnings that resulted.

NMC Guidance Products

Overview

Objective numerical and graphical forecast guidance as early as March 8 indicated the potential for a well-organized cyclone to develop late in the week. The corresponding subjective (human) surface pressure forecast, based on objective guidance from the previous evening, showed a deepening cyclone over western Georgia by 7:00 a.m., March 13 (Figure 3-1). Temperature and precipitation forecasts from the same model runs indicated unseasonably cold air from the Atlantic Coast to the Great Lakes. More interestingly, they showed exceptionally high probabilities of precipitation (up to 85 percent), when compared to climatological normals, at most sites in the east.

Overall, the subjective and objective (computer-based) forecast products were of exceptional quality. This is all the more remarkable considering the many record-breaking aspects of this event. Moreover, the very early indications of the storm's great magnitude and ferocity given by most numerical weather prediction models (NWP), as well as the overall consistency of those models, was critical to the success of the warning and forecast process for this extreme event. **However, the human interpretations and analytical judgment provided vital additional refinement to the exemplary final forecast, watch, and warning issuances.**

The final track of the **Superstorm** from its earliest detection over Mexico (Thursday, 7:00 p.m.) to its fully occluded state over the Canadian Maritimes late Sunday is shown in Figure 3-2. This storm track was derived from analysis of NMC synoptic charts, coupled with subsequent mesoscale analyses, using late data. This track was useful in assessing the performance of the NWP and products. The first 12 hours of the cyclone history depicted in Figure 3-2 should be viewed with some caution (due to data sparseness in Mexico), as the system appeared to explosively develop as it moved into the Gulf of Mexico. Nevertheless, the storm did deepen rapidly as it crossed the Gulf to the Florida Panhandle Friday and Friday night.

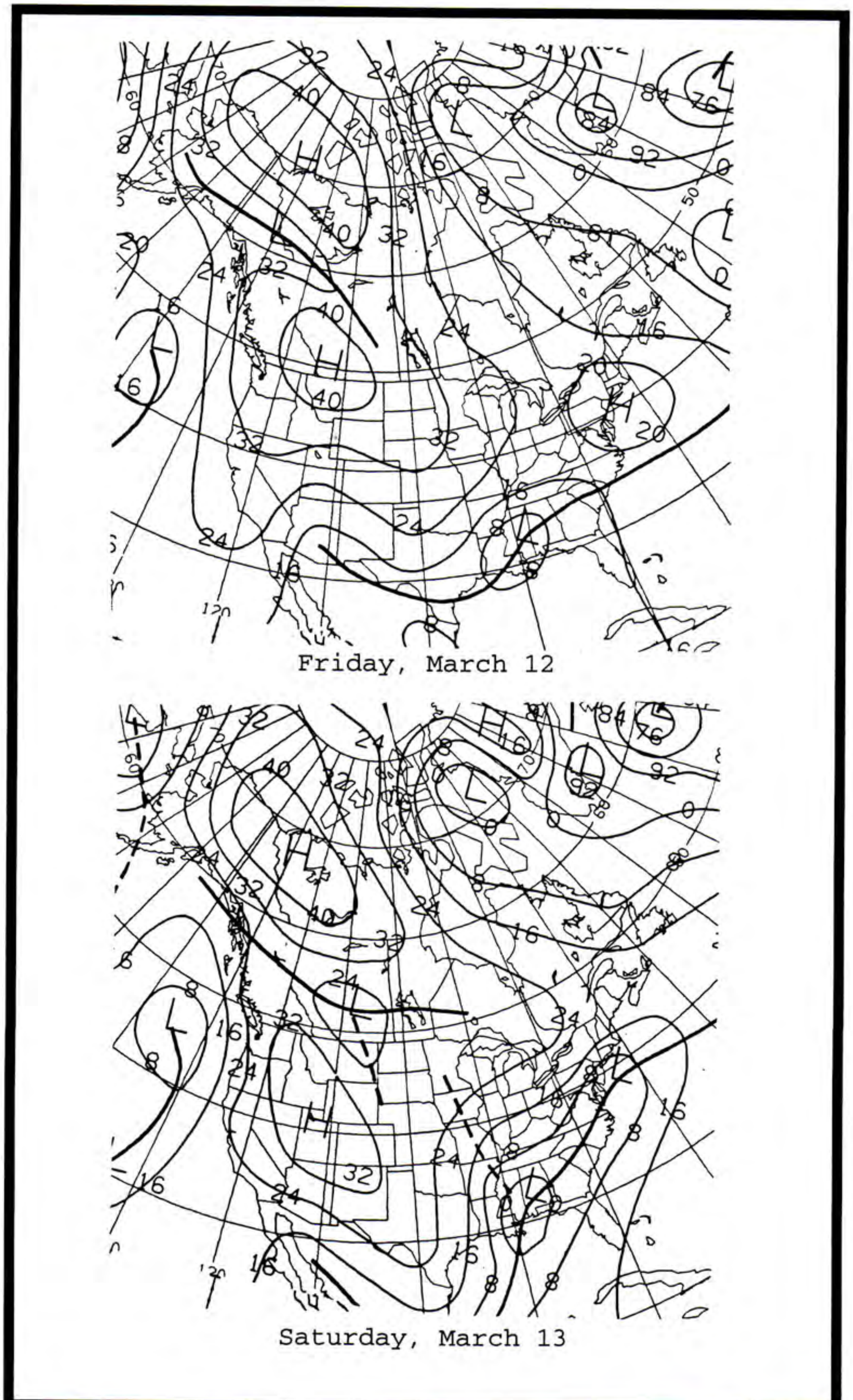
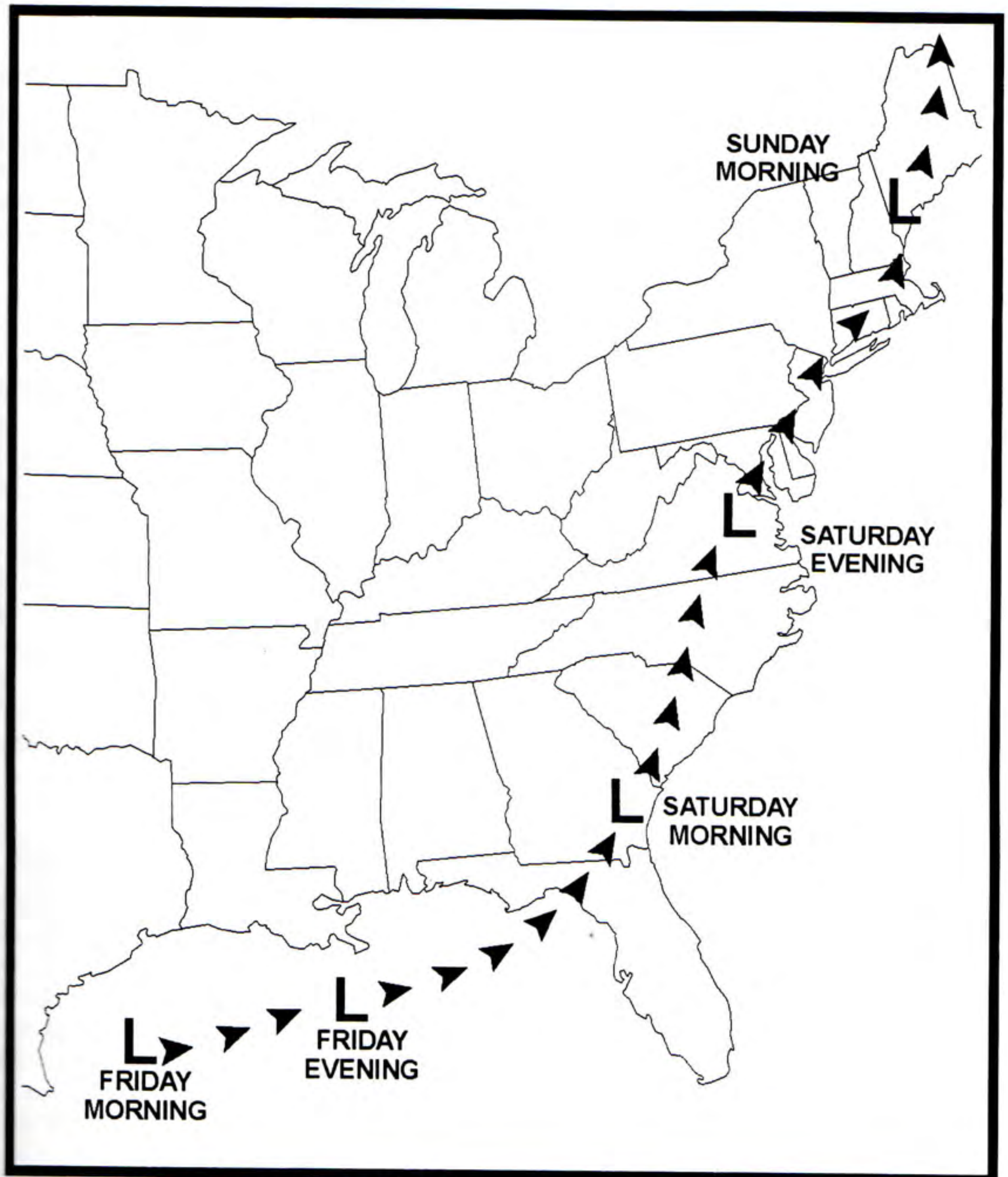


Figure 3–1. NMC Subjective Surface Forecasts for Day 4 and 5. Prepared Monday, March 8, 1993.



PREPARED BY: PAUL KOCIN (NMC)

Figure 3–2. Final Track of the Superstorm.

Medium Range (3-5 Day) Forecasts and Guidance

As early as Monday afternoon, both the NMC medium-range forecasters and much of the NWP output were indicating the potential for a significant late-winter storm over the eastern U.S. by the weekend. For example, at 2:30 p.m., Monday, the NMC Extended Forecast Discussion (EPD) contained the following passage, "...(the low), posing the threat of late winter heavy snowfall from the southern Appalachians/eastern Tennessee Valley northeastward through the major metro areas from D.C. to Boston."

The three models available to NMC meteorologists were the NMC Medium-Range Forecast model (MRF), the United Kingdom Meteorological Office model (UKMO), and the European Center Medium-range Weather Forecast model (ECMWF). Forecasters had access to the most recent 0000 UTC (7:00 p.m.) model runs from the MRF and UKMO, and the previous day's 1200 UTC (7:00 a.m.) run from the ECMWF, prior to issuing their guidance forecasts. All three models predicted a deepening 500 mb trough over the eastern U.S. by Saturday. However, the axis was positive or neutral, and the center was located northeast of its later observed position. As a result, the surface low was also forecast to be well northeast of its observed position and significantly weaker.

On Tuesday, March 9, the 0000 UTC, UKMO and MRF diverged substantially from the 1200 UTC, March 8, ECMWF. The ECMWF had continued the forward progress of the 500 mb trough, resulting in a slight negative axis over the central Appalachians by 1200 UTC, Saturday. This was reflected at the surface by a strong, fully developed low off the Virginia Capes. Meanwhile, the MRF and UKMO forecast open, positively-tilted troughs over the southern Mississippi Valley, with increasing northerly winds behind them. The forecast surface lows, therefore, were less developed and further south and west. Figures 3-3, 3-4, and 3-5, show 500 mb and surface charts from all three models (0000 UTC, March 9, for UKMO and MRF; 1200 UTC, March 8, for ECMWF respectively). Forecasters accepted the UKMO/MRF solution, as evidenced in Figure 3-6 (NMC Surface Forecasts for Day 4 and 5, Prepared Tuesday, March 9). Note the deep cyclone forecast over southwest Georgia on Saturday morning. This is an excellent forecast of the storm's position when compared to the final storm track.

On Wednesday, forecasters were nearly certain of a major East Coast storm. However, conflicting NWP output cast some doubt as to when and where the most rapid intensification would occur. The ECMWF from 1200 UTC, March 9, retreated from its bold prediction of March 8, leaving a significantly weaker, positively-tilted 500 mb trough over the middle Mississippi Valley. The well-developed surface cyclone became a weak inverted trough extending northwest from Cuba through the central Appalachians. The UKMO latched onto the strong northerly flow behind the trough, creating a negatively-tilted trough centered in northeast Arkansas. At the surface, an occluded cyclone was forecast over extreme southwestern North Carolina. The MRF maintained consistency, keeping an open, positively-tilted 500 mb trough over the lower Mississippi Valley. The surface low had the same configuration and intensity as on Tuesday, but was positioned over central Georgia. NMC meteorologists discounted the ECMWF solution and were skeptical of the UKMO prognosis; thus, they concluded that the MRF was the best guidance available. The EPD issued at 2:30 p.m., Wednesday, stated, "...there is little doubt that there will be very heavy snowfall all along the Appalachians from Georgia through New England."

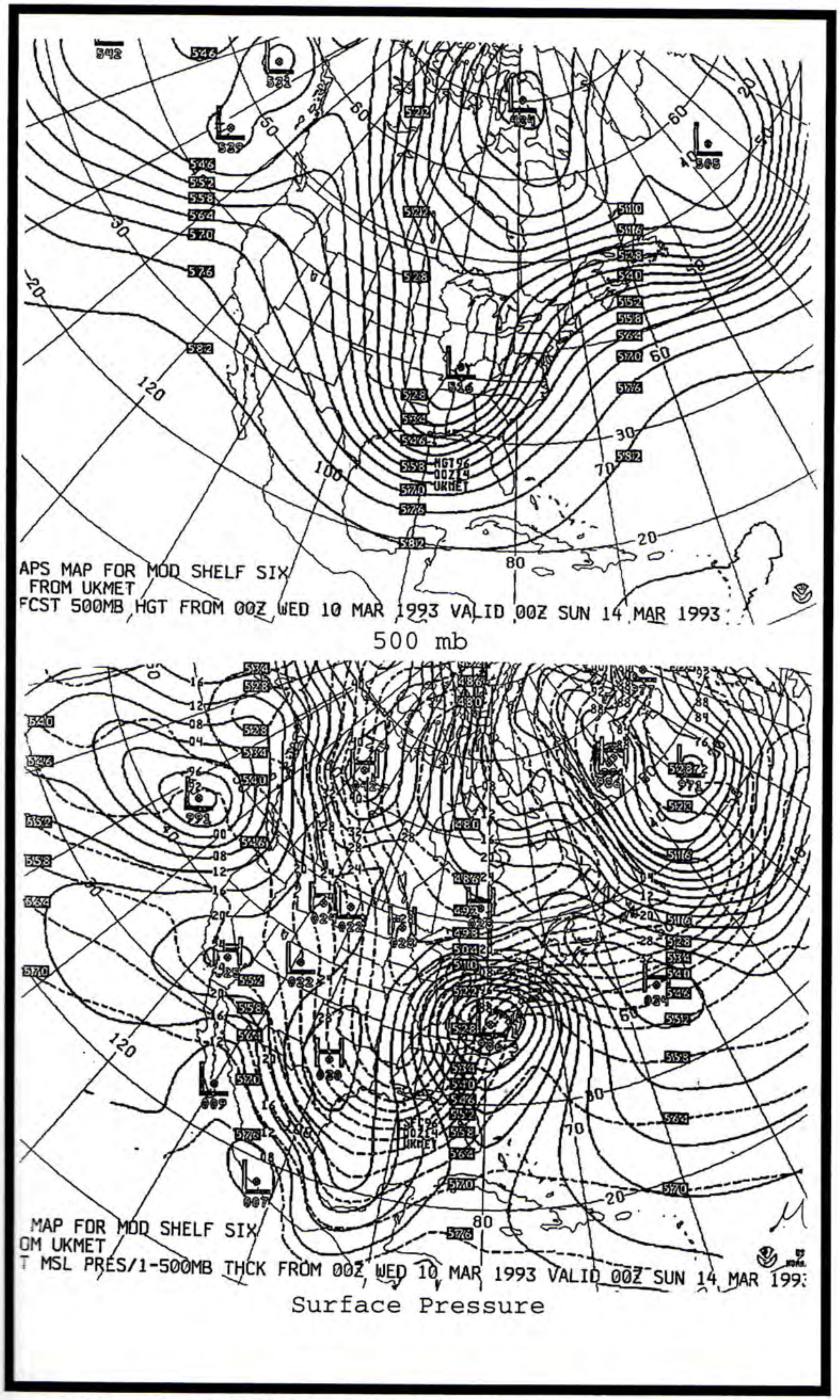
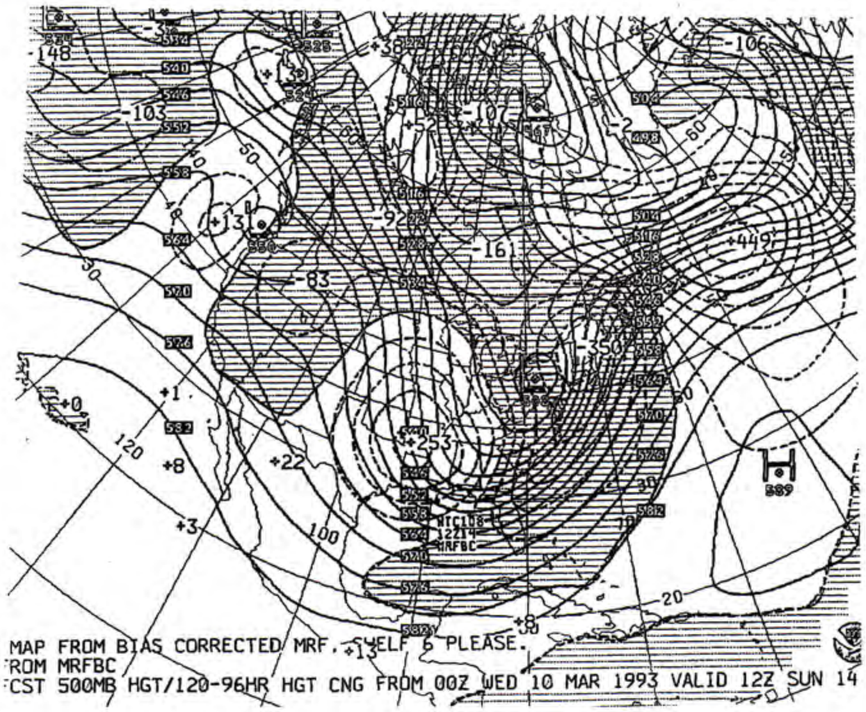
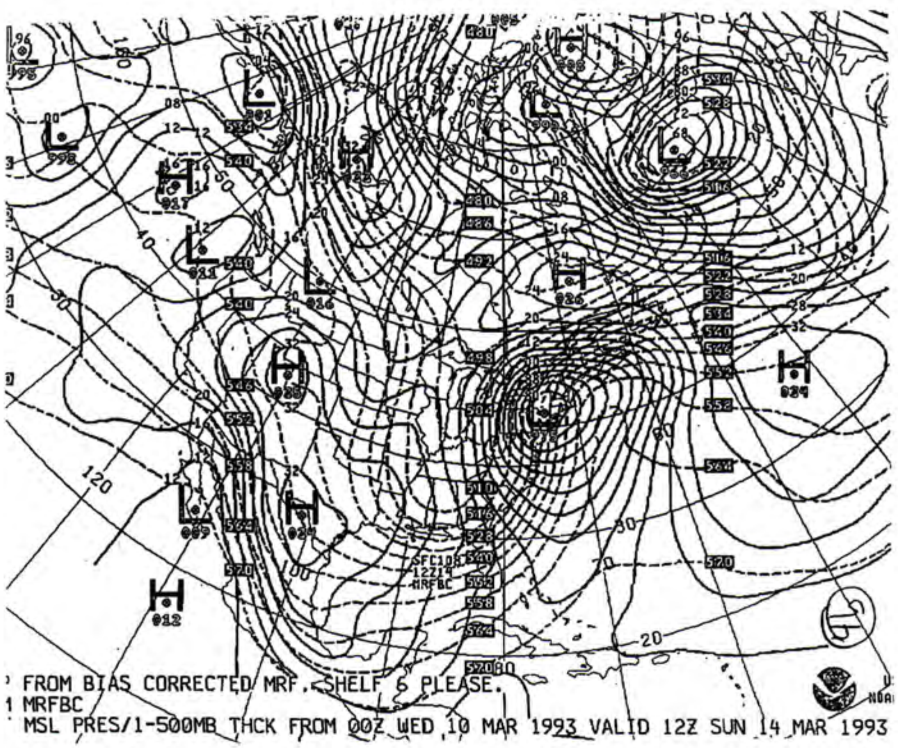


Figure 3–3. UKMO Forecasts Valid Sunday, March 14, 1993.



500 mb



Surface Pressure

Figure 3–4. MRF Forecasts Valid Sunday, March 14, 1993.

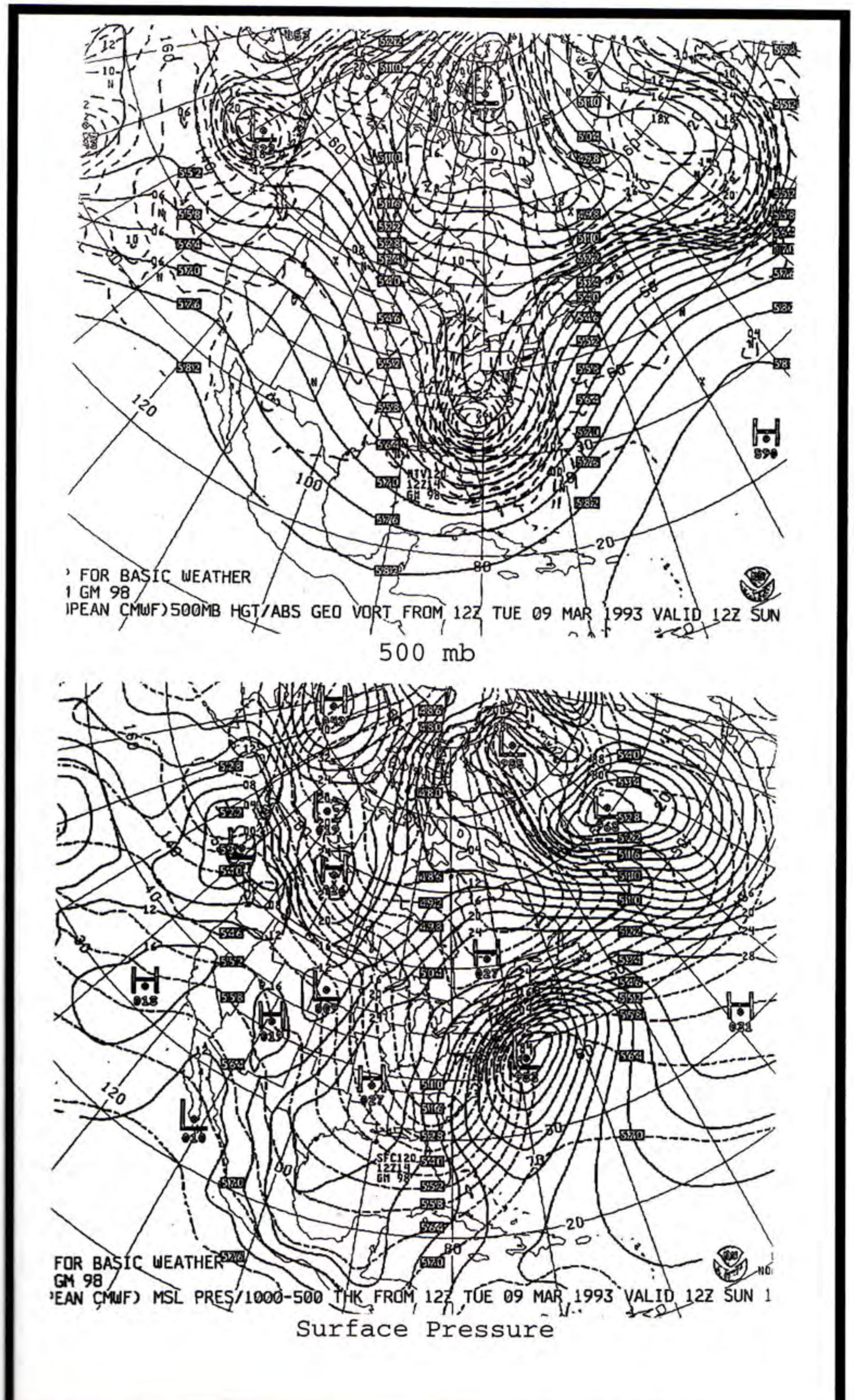
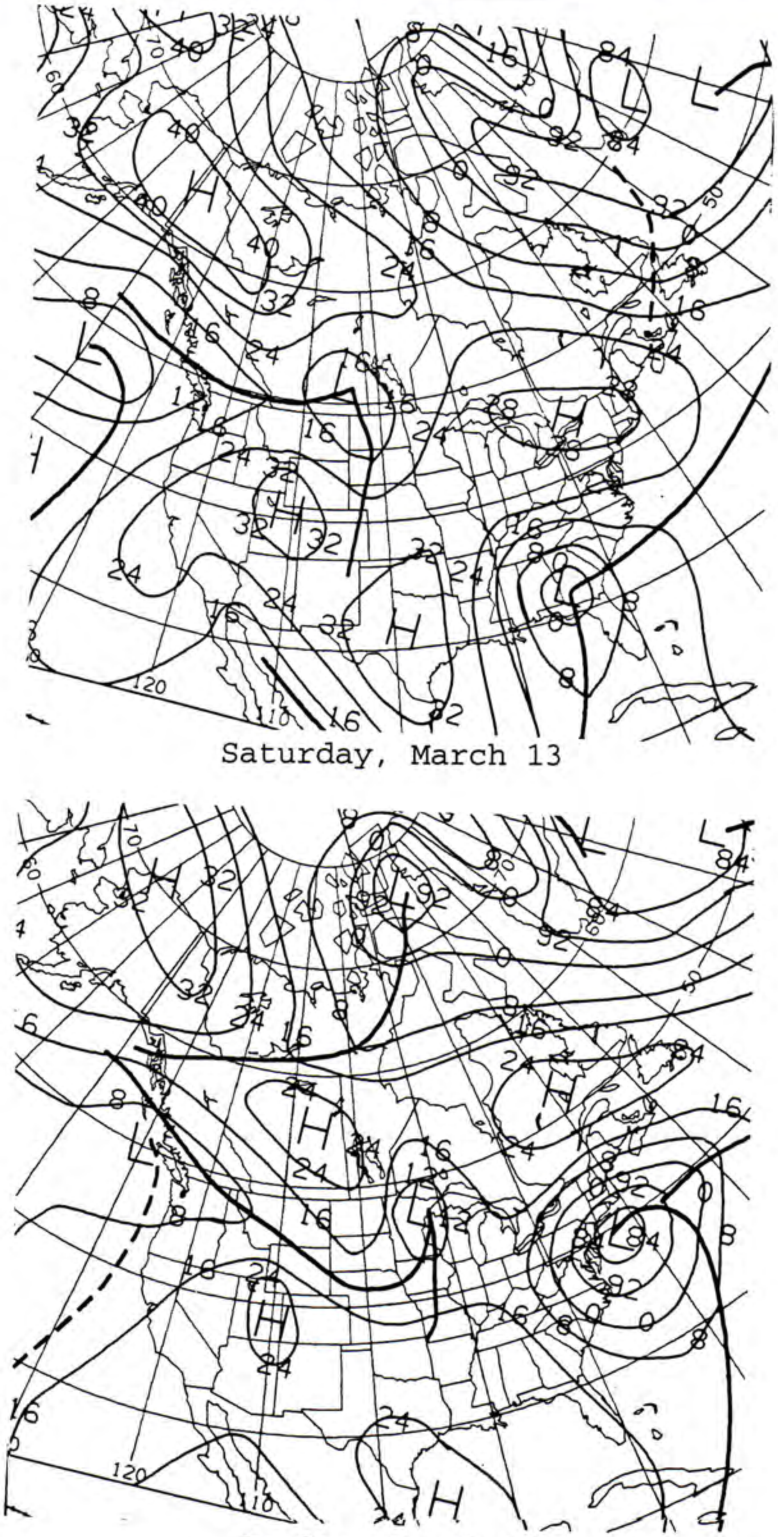


Figure 3–5. ECMWF Forecasts Valid Sunday, March 14, 1993.



Saturday, March 13

Sunday, March 14

Figure 3–6. NMC Subjective Surface Forecasts for Day 4 and 5. Prepared Tuesday, March 9, 1993.

In addition to the medium-range NWP graphic output fields, forecasters had access to objective forecasts based on a Model Output Statistics (MOS) approach applied to the MRF model. MRF MOS forecast elements include temperature, Probability of Precipitation (PoP), cloud amount, and Conditional Probability of Snow (CPoS). Remarkably, this last piece of guidance, which trends towards climatological means at later projections, forecast ≥ 50 percent CPoS as far south as north central Georgia and Alabama, overlaid with PoP values ≥ 40 percent, at the 96-hour and 120-hour projections. Forecasters used these anomalous predictions to justify the likelihood of significant March snowfall in parts of the Deep South.

Short Range (0-2 Day) Forecasts and Guidance

In general, the short-range model guidance correctly forecast the record-breaking low pressure of the fully-developed cyclone over the eastern seaboard. However, some important observed mesoscale features were not accurately depicted, and in others not resolvable at all by the NWP models. None of the operational models correctly forecast the magnitude of the cyclone's deepening Friday night; explosive deepening was instead predicted for Saturday. In particular, the early part of the cyclone's life-cycle over the northern Gulf of Mexico was not well-forecast in the short range, either objectively or subjectively.

Short-range NMC forecasters used three NWP models in developing their guidance: the Limited-Area Fine Mesh (LFM) model, the Regional Analysis and Forecast System (RAFS) model, and the Global Spectral Model for Aviation (AVN). The first hint at explosive cyclogenesis in the northeast Gulf was given by the LFM. The 48-hour forecast from the 1200 UTC, March 11, LFM run indicated an intense (980 mb) surface low centered over the South Carolina/Georgia border. Meanwhile, the RAFS and AVN had significantly weaker systems. The LFM also had the more impressive trough at 500 mb. Forecasters, however, disregarded the LFM, since they believed the intense cyclone it depicted was the result of exaggerated convective feedback within the model. Figure 3-7 shows the resulting 48-hour NMC Subjective Surface Forecast valid Saturday morning.

This trend continued into the next model run (0000 UTC, March 12), where only the 36-hour forecast from the LFM had a deep cyclone (984 mb). (See Figure 3-8.) The RAFS and AVN, however, were intensifying the storm at 36-hours and converging on a position. (Figure 3-9 and 3-10, respectively.) Once again, the forecasters discounted the LFM for "...suffering from convective feedback." However, they did allow for more deepening than shown by the RAFS or AVN, given the strengthening of the 500 mb trough (Figure 3-11, 36-hour NMC Subjective Surface Forecast valid Saturday morning). The 48-hour NWP forecasts (valid 0000 UTC, March 14) showed the fully-developed low over different parts of Virginia. At this point, forecasting became quite difficult. Slight (i.e., less than 100 miles) differences in the low position played havoc in determining the rain/snow line. The LFM's storm center (971 mb) was just east of the Virginia Capes; the RAFS' (982 mb) and AVN's (966 mb) over the southern Chesapeake Bay. Forecasters felt the AVN handled the development most reasonably, using it as their primary guidance at 48-hours. Figure 3-12 shows the 48-hour NMC Subjective Surface Forecast. The forecast position and intensity were nearly perfect.

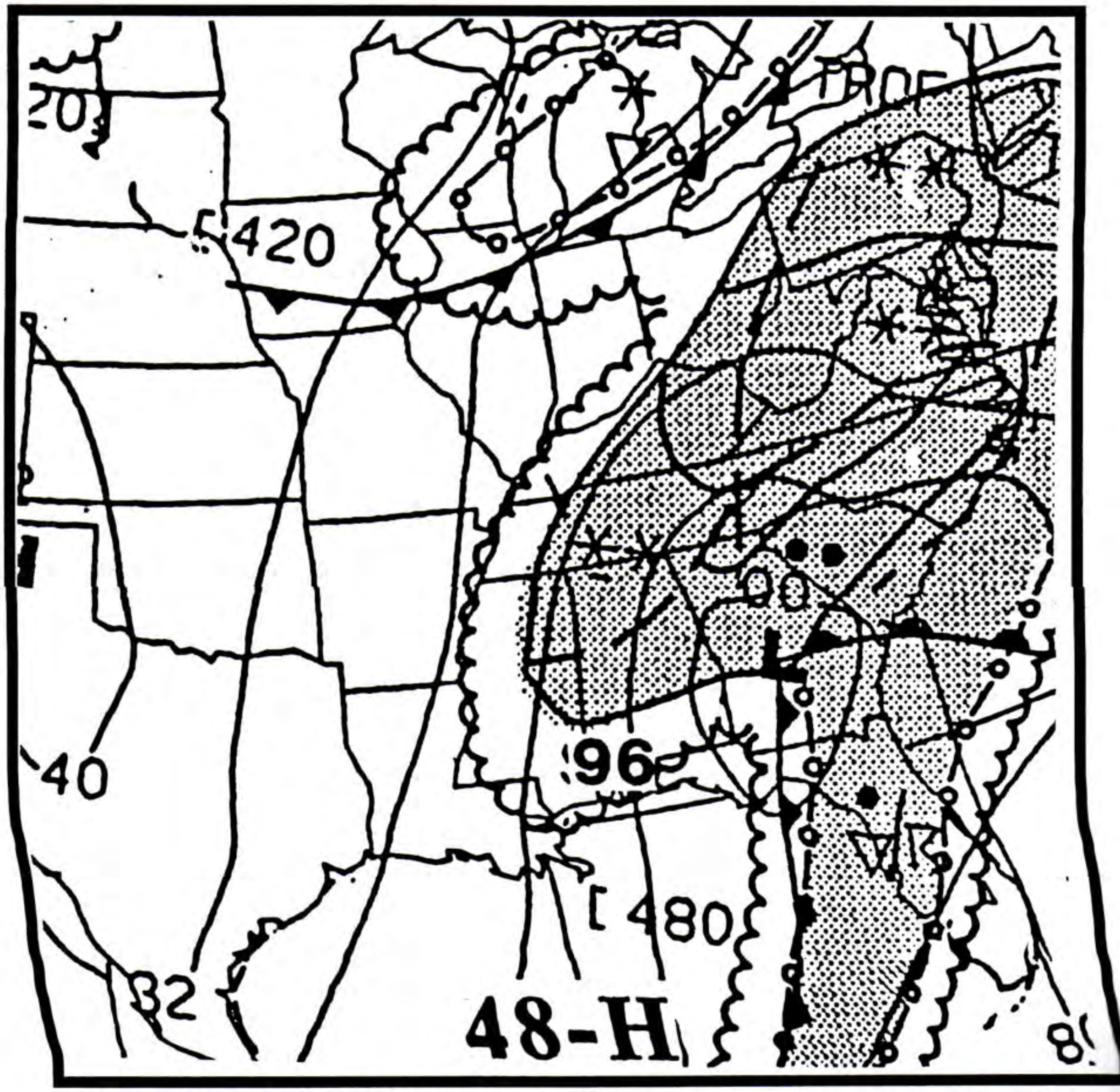


Figure 3–7. 48-Hour NMC Subjective Surface Forecast Valid 7 a.m., Saturday, March 13.

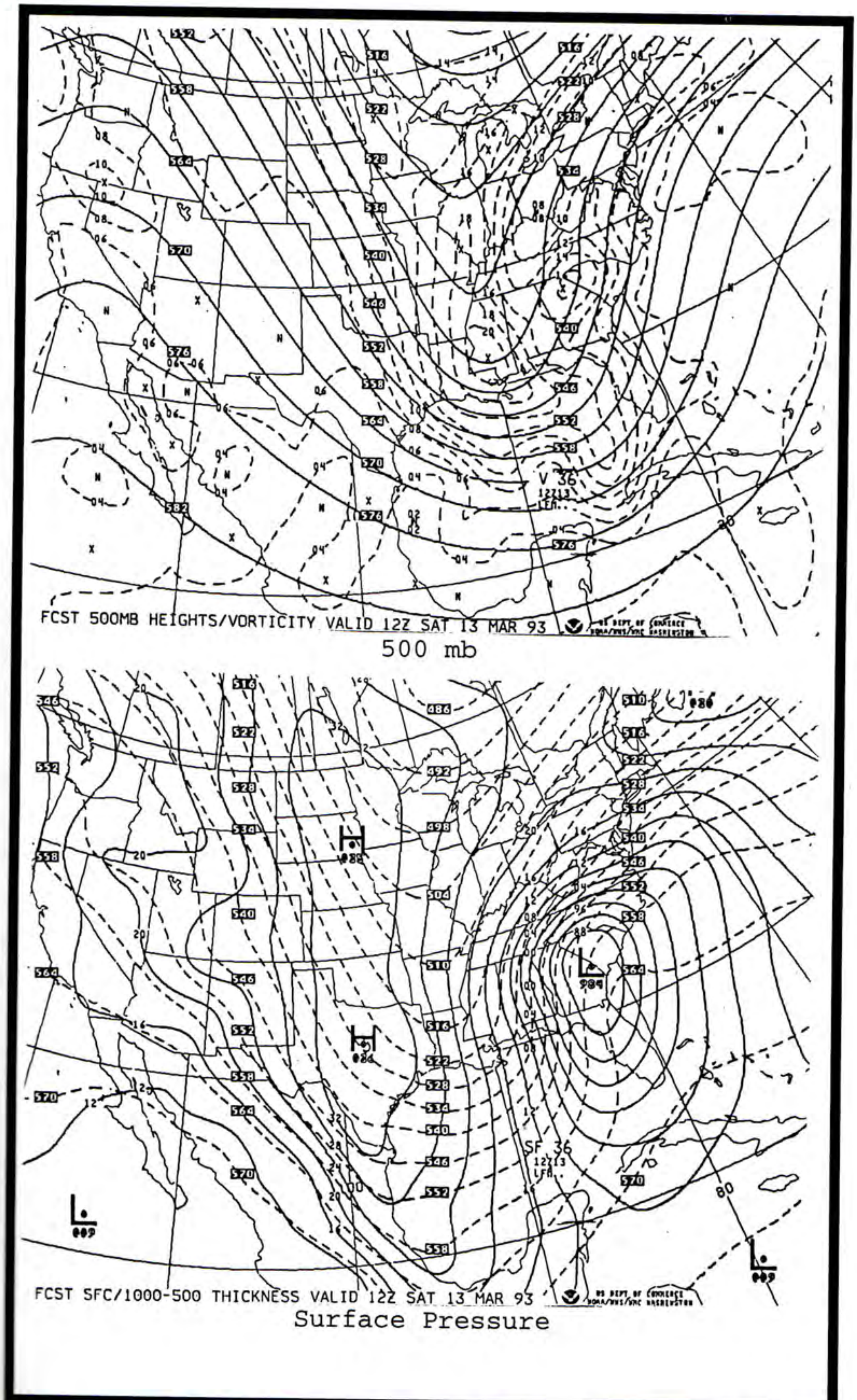


Figure 3–8. LFM 36-hour Forecasts Valid 7 a.m., Saturday, March 13.

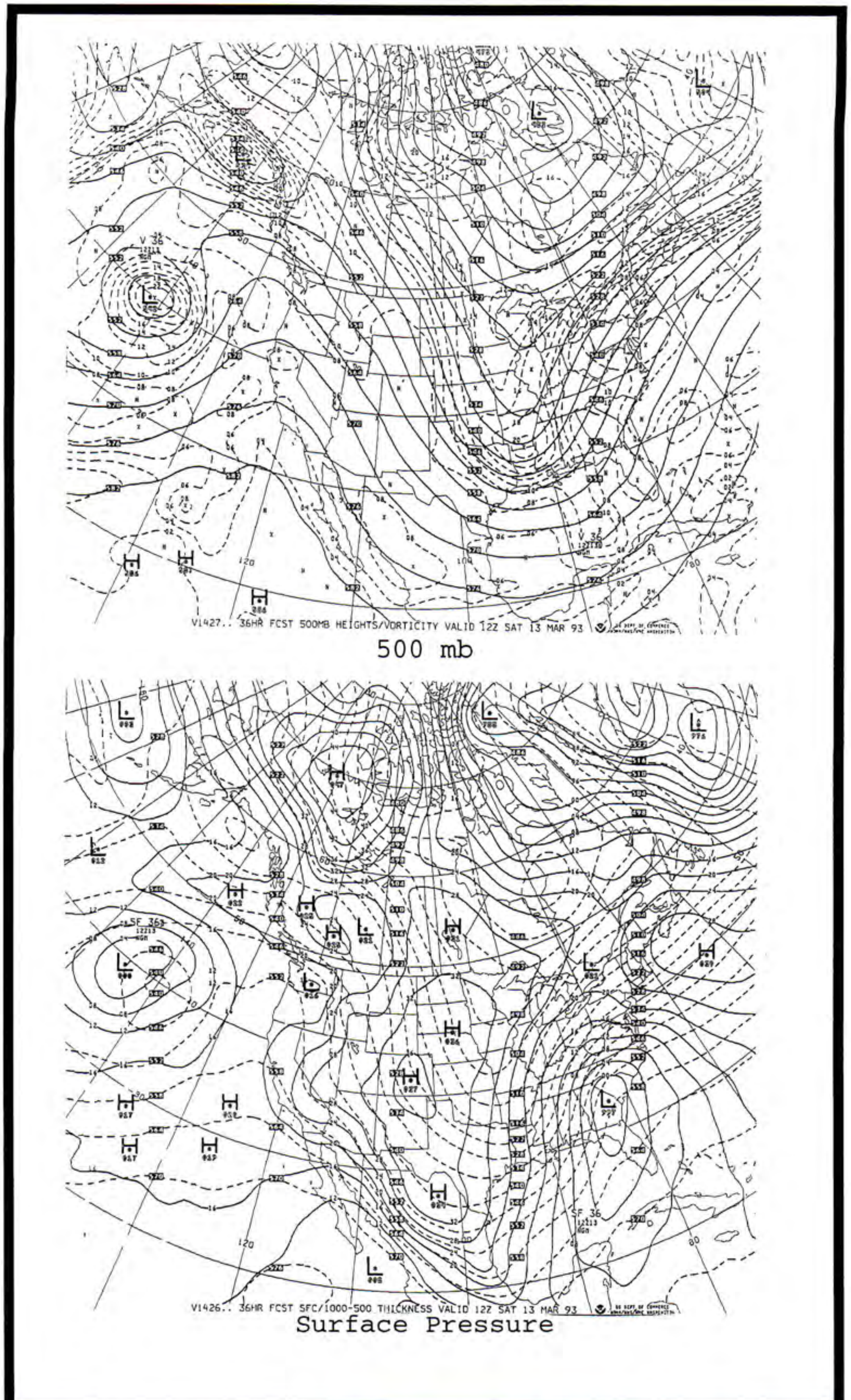


Figure 3–9. RAFS 36-hour Forecasts Valid 7 a.m., Saturday, March 13.

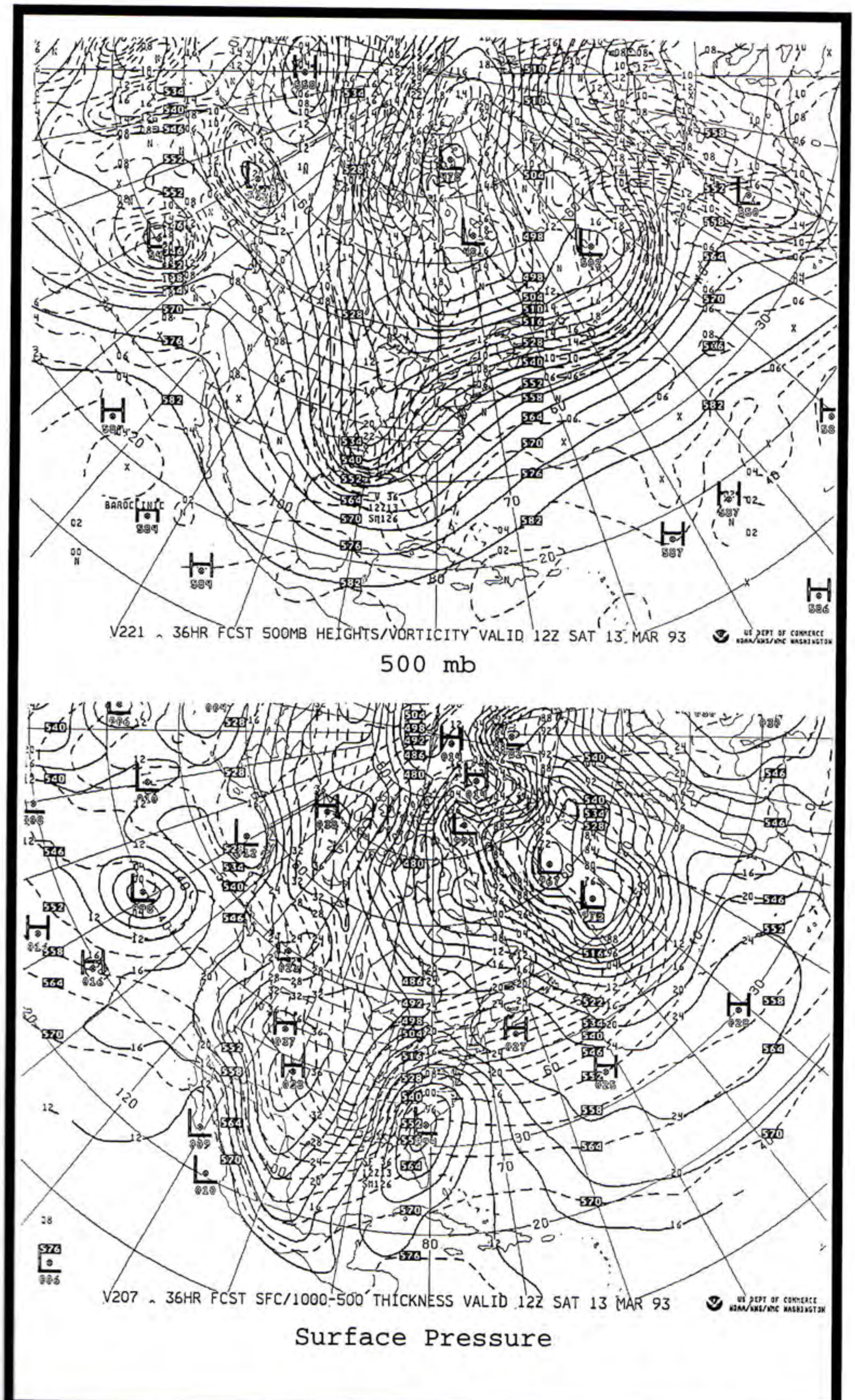


Figure 3–10. AVN 36-hour Forecasts Valid 7 a.m., Saturday, March 13.

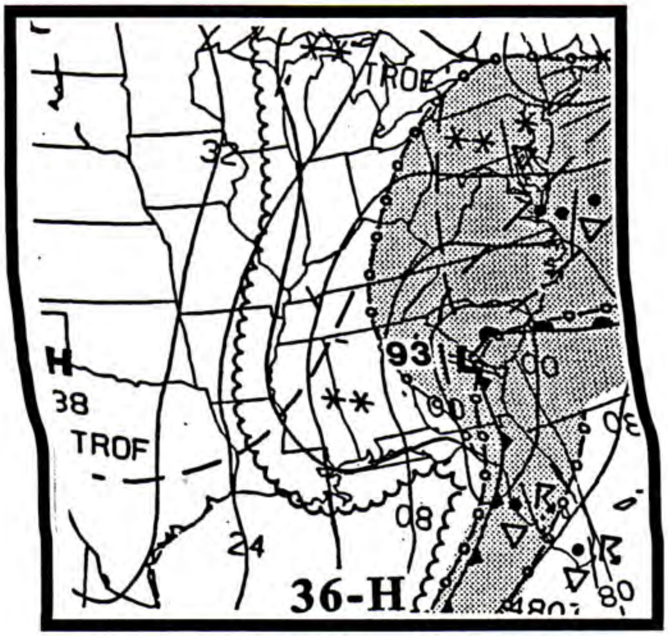


Figure 3–11. *36-Hour NMC Subjective Surface Forecast valid Saturday morning.*

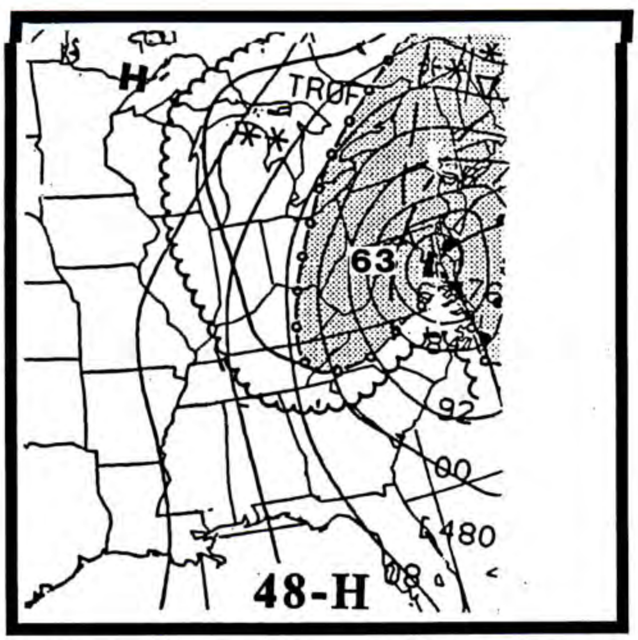


Figure 3–12. 48-Hour NMC Subjective Surface Forecast valid Saturday evening.

By Friday morning (1200 UTC, March 12), all of the short-range models were converging - depicting similar storm center locations and intensities, especially after 24 hours. This was of primary importance since this model run led directly to the majority of the warning issuances.

Where the LFM once stood alone in predicting the intense cyclone over southern Georgia by 1200 UTC, March 13, the RAFS now had a similar storm (982 mb). The AVN continued its slow development, positioning the center (991 mb) too far northeast. The 36-hour forecasts (valid 0000 UTC, March 14) showed a similar intensity, but with a different position. The RAFS continued its westward trend, centering the low (962 mb) over western Virginia, while the LFM's position (968 mb) was just west of Norfolk. The AVN maintained continuity from the previous run, showing the storm center over the Chesapeake Bay. Forecasters now agreed that rapid deepening would begin over the northern Gulf overnight and continue as the storm moved towards the Chesapeake Bay, Saturday (Figures 3-13 and 3-14, 24- and 36-hour NMC Subjective Surface Forecasts, respectively).

The models from Friday evening (0000 UTC, March 13) all forecast explosive deepening over the Gulf of Mexico during the following 12 hours, but still not as much as was observed. The 24-hour model forecasts continued to converge on a solution, with the AVN remaining most consistent. NMC meteorologists now headlined, "...mid-Atlantic Region under gun for serious winter storm...", and by using the AVN as guidance, produced another near perfect short-range forecast, including the location of the liquid/frozen precipitation line (Figure 3-15, 24-hour NMC Subjective Surface Forecast valid Saturday evening).

The most significant error, however, in objective and subjective guidance occurred in the 12- to 24-hour period. All guidance had a 30-hour period of explosive deepening. In general, about 20 mb of deepening was predicted by the models between 1:00 p.m., March 12 and 7:00 a.m., March 13, and again between 7:00 a.m. and 7:00 p.m., March 13. However, observations indicated that the deepening rate between 1:00 p.m., March 12 and 7:00 a.m., March 13 (26 mb) was twice that of the observed rate between 7:00 a.m. and 7:00 p.m., March 13 (13 mb). Therefore, what occurred was a nearly unprecedented extratropical "Gulf of Mexico Bomb" instead of the more common "East Coast Bomb." This difference was vitally important to those areas along the Gulf of Mexico which were affected by the **Superstorm**.

Quantitative Precipitation Forecasts

The NMC Meteorological Operations Division's Weather Forecast Branch issues 24- and 48-hour quantitative precipitation forecasts (QPF) which represent area averages and are valid at 1200 UTC, twice daily at 0600 and 1200 UTC, with an update for the 24-hour QPF issued at 1800 UTC.

Observed precipitation amounts ending at 1200 UTC, Saturday, March 13, ranged from 1 to 3 inches of water equivalent amounts (i.e., liquid amounts). These amounts extended from the south Texas Gulf coast to southwest Virginia and encompassing the Appalachians. A second precipitation maxima area encompassed the entire state of Florida where two inch amounts were common. Most of the precipitation north of the Gulf Coast was in association

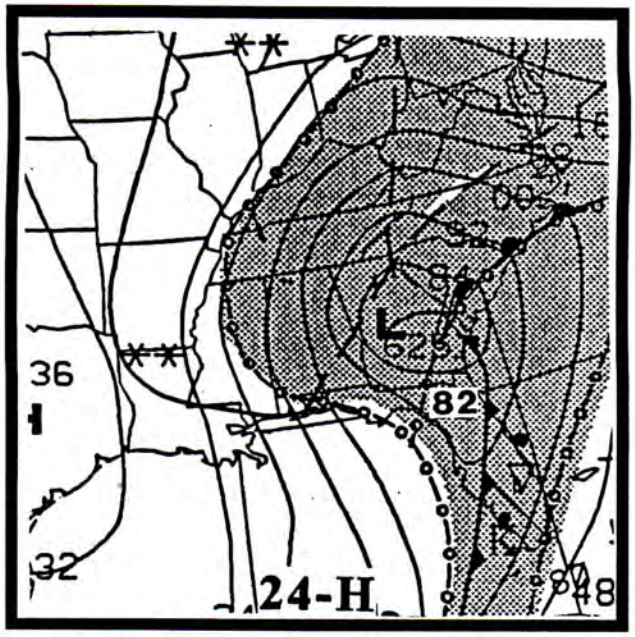


Figure 3–13. 24-hour NMC Subjective Surface Forecast valid Saturday morning.

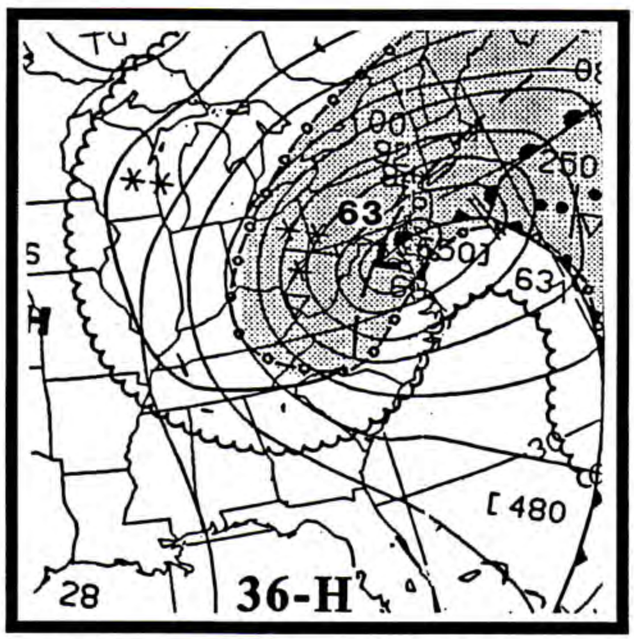


Figure 3–14. 36-hour NMC Subjective Surface Forecast valid Saturday evening.

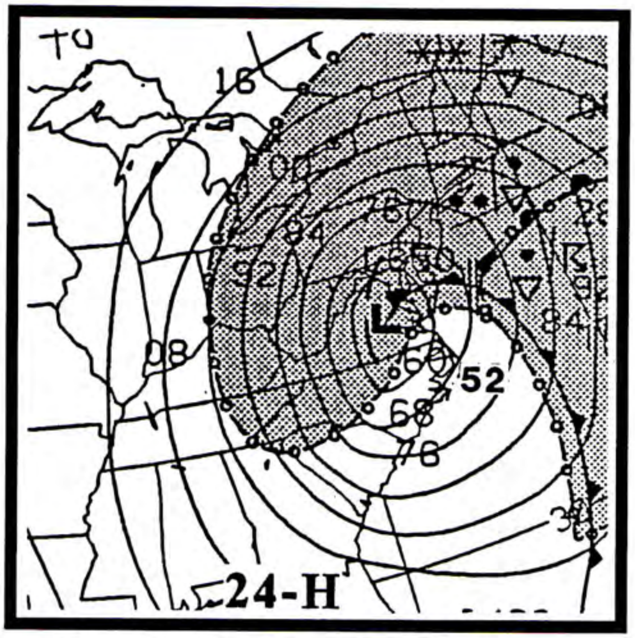


Figure 3–15. 24-hour NMC Subjective Surface Forecast valid Saturday evening.

with strong overrunning in advance of the **Superstorm's** warm front and a strong easterly flow of moist air circulating around a high pressure system extending from western New York to the Delmarva Peninsula. The precipitation in the state of Florida was associated with a squall line and an arctic cold front.

The skill of the QPFs valid Saturday improved with each issuance and update, except for the precipitation that fell across Florida. The 48-hour QPF underestimated the rainfall amounts in Florida. It also did not include the precipitation that fell along the Texas Gulf Coast. The 48-hour QPF 2-inch isohyet covered a small area encompassing extreme western North Carolina into extreme southwest Virginia. This feature verified based on precipitation observations, however, there were several other areas extending southwest from this region that received two inch amounts. The 24-hour QPF did a better job of identifying the spatial extent and average precipitation amounts along the southern Texas Gulf Coast, but did not pick up the precipitation maxima for that area. It also recognized the separate precipitation regime in southern and central Florida. The 1-inch isohyet was shifted east from the previous QPF, but actually should have been shifted westward. The 24-hour updated QPF made significant improvements in the spatial expanse and alignment of the 1-inch isohyet. It deteriorated somewhat with respect to the spatial coverage and quantitative amounts in central and south Florida. The improvement in subsequent issuances was likely a result of the numerical models beginning to converge on the storm track and intensity. The under forecasting of precipitation during this 24 hour period is likely due to the short range models inability to forecast the explosive deepening of the surface low over the Gulf of Mexico. Overall, each QPF issuance valid at 1200 UTC, March 13, did an excellent job of delineating the spatial coverage of the precipitation.

Observed precipitation amounts for the period ending at 1200 UTC, March 14, showed 1-2 inch amounts common throughout the Northeast and the mid-Atlantic states with 1/2-1 inch amounts common in the south Atlantic and southern Appalachian states. Most of the precipitation was associated with the intense occluded storm.

The skill of the QPFs valid for 1200 UTC, Sunday, was excellent. Both the 24- hour QPF and the updated 24-hour QPF had a 3-inch isohyet extending from eastern Maryland north to Long Island. The observed analysis showed a solid area of 2 inch amounts in this area, but only scattered 3 inch amounts. Figure 3-16 shows the total water equivalent precipitation amounts for the **Superstorm**. Figure 3-17 depicts the total snowfall amounts for the **Superstorm**.

NSSFC Guidance

The National Severe Storm Forecast Center (NSSFC) displayed its expertise by issuing an array of timely, well-worded, outlooks and watches in association with the **Superstorm of March 1993**. The risk of severe weather for central and north Florida was highlighted as early as 2:00 a.m. (CST), March 11. By 7:00 a.m., March 12, nearly all of Florida was under a moderate risk of severe weather for the overnight period. Wording indicated the "...potential for supercells and tornadoes over central/northern Florida peninsula."

As the thunderstorm activity intensified in the central Gulf of Mexico, Tornado Watch #49 was issued at 8:21 p.m. for much of the Florida Panhandle, the northern peninsula, and extreme southern Georgia. At 9:20 p.m., Tornado Watch #50 was issued for the remainder of the Florida Peninsula. This second tornado watch included the wording "...this is a particularly dangerous situation with the possibility of very damaging tornadoes..."

Verification of the watches showed that all 11 tornado events occurred within the above Watches, as did nearly 100 percent of all severe weather events. Tornado and severe thunderstorm event lead times on Watches ranged from 2 hours 10 minutes to 7 hours 40 minutes, with an average of 4 hours 10 minutes.

Field Office Actions

Florida - WSFO Miami

WSFO Miami was aware of the potential of the **Superstorm** and provided excellent services prior to its onset. Well-worded statements indicating the dangerous aspects of the brewing storm were issued as early as 3:00 p.m., March 11. This initial statement headlined strong winds and thunderstorms, as well as low wind-chills following the storm. An updated statement at 9:30 p.m., Thursday, mentioned the possibility of tornadoes and the threat of gale force winds. Boaters were discouraged from leaving port. Finally, a comprehensive statement was sent Friday at 2:00 p.m., March 12, including all potential hazards (severe convective weather, coastal floods, gale winds, dangerous wind chills, and frost/freeze potential). The statement was headlined, "A powerful storm system will begin affecting Florida later tonight" and was read on NAWAS. Those EMOs on the system were briefed including answering follow up questions. The Florida State EMO faxed the statement to those county EMOs not on NAWAS.

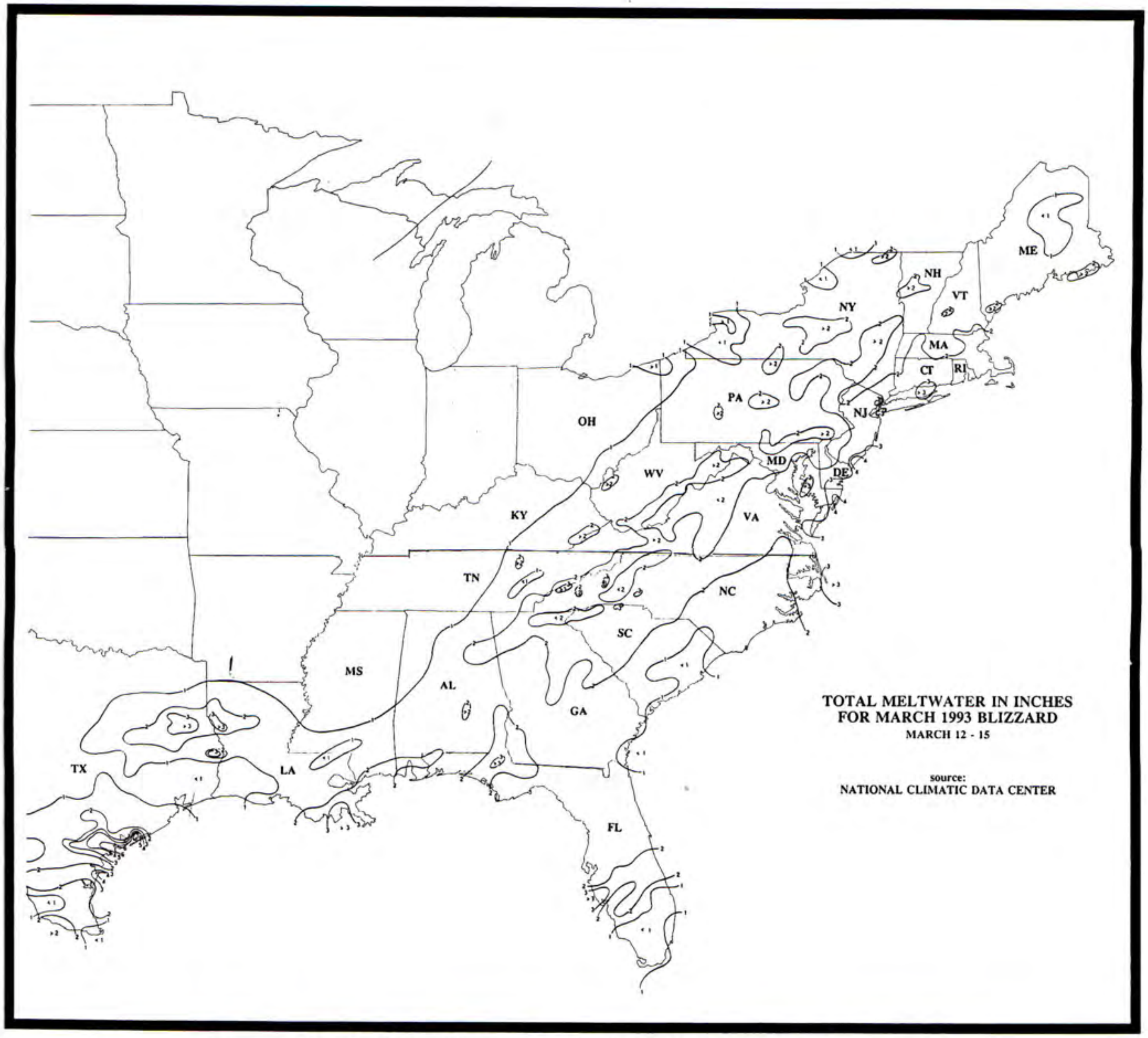


Figure 3–16. Total Water Equivalent Precipitation Amounts.

Figure 3–17. Total Snowfall Amounts.

A Coastal Flood Watch was issued for the entire Florida Gulf Coast at 3:45 p.m., Friday, mentioning tides of 2-4 feet above normal overnight and during Saturday, March 13. A Gale Warning was issued at 4:30 p.m. for the coastal waters. Redefining statements on Tornado Watch #49 and 50 were issued in a timely fashion. Finally, the state EMO was briefed again by phone at 10:45 p.m., just prior to the squall line moving ashore.

The first severe storm report for the WSFO Miami County Warning Area (CWA) was relayed from Weather Service Office (WSO) Tampa, indicating a possible tornado near Naples (Collier County), at 3:05 a.m. An additional report of a waterspout just offshore prompted the WSFO to issue a Tornado Warning for Collier County.

WSO Tampa called again at 4:40 a.m., alerting WSFO Miami to minor coastal flooding on the central Florida Gulf Coast. The WSFO had just lost all electrical power and the backup generator failed. It should be noted that the WSR-57 radar at WSFO Miami had been destroyed by Hurricane Andrew and that the radar data available to the WSFO, therefore, was less than optimum even before the power outage. Because of the power outage, WSFO Miami gave WSO Tampa permission to issue a Coastal Flood Warning (CFW) for the central Florida Gulf Coast. The WSO updated its Local Forecast to include the Coastal Flood Warning at 5:06 a.m. The WSO issued a statement at 5:47 a.m. for 10 counties that highlighted the Coastal Flood Warning. Due to the power and communications problems, and because of the lack of reports of additional coastal flooding, WSFO Miami, which had statewide coastal flood warning responsibility, did not upgrade the Coastal Flood Watch.

Finding 3.1 - WSO Tampa did not use the correct product identifier/routing header in issuing the Coastal Flood Warning because it is not normally authorized to issue those messages. However, in an emergency such as existed with the Miami office incapacitated by the loss of electric power, a WSO can issue Coastal Flood Warnings. Although we have no evidence, the use of the Coastal Flood Statement header instead of the Coastal Flood Warning category may have hampered warning dissemination.

Recommendation 3.1 - WSFO Miami, and all WSFOs with coastal flood responsibility, should clearly outline procedures to allow WSOs to issue coastal flood warnings when necessary. Normally, the WSO(s) would use the CFW category authorized for the parent WSFO (e.g., MIACFWMIA) to enable the widest dissemination possible. This problem will be alleviated in the modernized NWS as the coastal flood watches and warnings are decentralized.

The squall line knocked out electrical power at WSFO Miami during the critical time period of 4:30 a.m. to 6:30 a.m. There were seven wind damage incidents produced by the squall line as it moved across the WSFO CWA between 3:15 a.m. and 5:30 a.m., Saturday. No warnings were issued prior to these occurrences.

Finding 3.2 - WSFO Miami was severely hampered by the loss of electric power and communications other than the telephone during the height of the coastal flooding events associated with the **Superstorm**. It appeared the WSFO staff tried to "tough it out" rather than being proactive and turning over warning and forecast responsibilities to appropriate backup offices.

<u>Recommendation 3.2</u> - All NWS field offices should periodically review their procedures for initiating backup warning and forecast services.

Once power was restored, the WSFO issued a Coastal Flood Warning for most of Florida's Gulf Coast at 6:45 a.m., Saturday. A High Wind Warning (HWW) was issued for the northern half of Florida at 6:15 a.m. Later (9:00 a.m.), the entire state east of the Apalachicola River was put under a HWW, with forecast winds of 35 to 45 mph and higher gusts.

WSO Tampa Bay

The staff of WSO Tampa performed exceptionally well prior to and during the **Superstorm**. The initial threat of severe weather was recognized by the WSO staff shortly after 9:30 p.m., Friday, as an extremely fast-moving line of strong thunderstorms was approaching Florida's Gulf Coast. Their WSR-57 radar indicated several very strong (Digital Video Integrated Processor (DVIP) 5) cells with maximum echo tops to 42,000 ft, embedded within the squall line located 125 miles offshore. Individual cells were racing north northeast at 45 mph. By 10:30 p.m., a solid line of very strong echoes was racing east at nearly 70 mph, only 75 miles off the coast. Based on the intensity and speed of the cells, the office blanketed most of their coastal counties with a Severe Thunderstorm Warning, issued at 10:50 p.m. The first report of severe weather was received 48 minutes later.

As the line crossed the coast, numerous severe weather reports began flooding the office. In all, 45 events were reported in WSO Tampa's CWA during the 5-hour period of severe weather. The majority of events, as is common with fast moving squall lines, were convective wind gusts and thunderstorm wind damage. Winds gusting 60-86 mph were observed by storm spotters from 11:30 p.m., Friday, March 12, to midnight, March 13 in the Tampa Bay/Clearwater metropolitan area. These gusty winds then continued unabated across Florida for the remainder of the night. Six tornadoes were reported in the WSO Tampa CWA.

Review of the verification statistics shows clearly that excellent warning services were provided by WSO Tampa. Of the 26 severe weather warnings issued, 22 verified. **Of the 45 reported events, 43, or 95 percent, occurred with either a Severe Thunderstorm or Tornado Warning in effect prior to the event. These results are exceptional for any NWS office.**

These statistics alone do not tell the entire success of the Tampa office. Unlike the new Doppler radars, the WSR-57 cannot differentiate between tornadoes and severe thunderstorms in squall lines. Of the 26 warnings issued, only 4 were Tornado Warnings, so they did not over warn by blanketing the area with tornado warnings. In fact, three of the WSO Tampa Tornado Warnings were issued based (at least partially) on coordination with NEXRAD Weather Service Office (NWSO) Melbourne that used its WSR-88D. The Chiefland F-3 tornado, which was located far outside Melbourne's WSR-88D effective Doppler range, occurred during the Severe Thunderstorm Warning for the county and had a lead time of 48 minutes when it struck at 11:38 p.m.

Following the severe weather, the central Florida Gulf Coast suffered again with extensive coastal flooding and more high winds. At approximately 3:00 a.m., the cold front swept through. The low center was still undergoing explosive deepening while moving rapidly northeast across the Florida Panhandle. Behind the front, winds became southwest and increased in speed. Gulf waters began surging inland, rising to levels exceeding 5 feet in some places in Hernando, Pasco, and Levy Counties.

Coastal flooding was widespread throughout the WSO Tampa CWA. In New Port Richey, 25 miles north of Tampa in Pasco County, extensive property damage was noted up to 1 mile inland. Although no warnings were in effect at the onset of flooding, as noted earlier, WSO Tampa issued a Coastal Flood Warning at 5:47 a.m. In preparing the Coastal Flood Warning, the WSO looked at SLOSH (Sea Lake Overland Surge from Hurricanes) MEOWs (Maximum Envelope of Water) for the Tampa Bay basin for tropical storms and Category 1 hurricanes to get some objective guidance for the storm surge potential (Figure 3-18). Coupled with the few reports of flooding, they determined a maximum height of 6-7 feet would be reached. This was a good forecast of what actually occurred across most of their CWA.

WSO Tallahassee

WSO Tallahassee issued one unverified tornado warning based on radar information for Calhoun County on March 12. There were no severe thunderstorm or tornado episodes in its CWA.

As mentioned previously ten people were drowned by storm surge in Taylor County between [illegible] a.m. and 6:30 a.m., Saturday. WSO Tallahassee was experiencing commercial power problems because of high gradient winds during this time period and the WSO was forced to rely on a backup means (a personal computer with a modem) for communications. These factors degraded its warning posture and contributed to the delay in issuing the Coastal Flood Warning (issued at 6:29 a.m.) for its coastal counties after consulting with WSFO Miami.

Mr. Michael McKinney, a resident of Keaton Beach, has provided the most detailed account of what happened in the hardest hit areas. In a post-storm interview by the DST, he said that, at 4:00 a.m., the southwest winds were 55-65 mph and water levels were near normal high tide. The astronomical high tide was at 5:35 a.m. By 4:30 a.m. the winds had increased to [illegible]-85 mph and the storm surge was 3 feet over the land by his house. He stated that between 5:00 a.m. and 5:30 a.m. that winds were about 80 mph on his anemometer and that severe coastal flooding was occurring. He called WSO Tallahassee to notify them of the winds and flooding soon after 5:00 a.m. The office responded with a strongly worded Special Weather Statement at 5:30 a.m. that mentioned the "winds as high as 85 mph and severe flooding..." By 6:30 a.m. the surge had peaked at around 10 feet above ground. A U.S. Geological Survey inspection of the Taylor County area found high water marks of 11.4 feet NGVD (National Geological Vertical Data) at Keaton Beach, and 11.8 feet NGVD at nearby Dekle Beach. Mr. McKinney said his anemometer height was about 30 feet above the ground and had excellent exposure.

NWSO Melbourne

The staff at NWSO Melbourne also performed very well during the **Superstorm**. The first short-fused statement was issued at 9:40 p.m., Friday, highlighting a line of severe thunderstorms over the Gulf. Another statement was issued at 10:50 p.m., noting the storms were just offshore, but moving at "over 50 mph." The Meteorologist in Charge (MIC) phoned the Lake County EMO (furthest west in Melbourne's CWA) at about 10:30 p.m. alerting them that severe weather was likely as early as midnight, with the potential for "a significant severe weather outbreak" and that a Tornado Watch was in effect.

Severe weather began in Melbourne's CWA shortly after midnight on March 13 in Lake County, and ended around 3:30 a.m., exiting the coast near Vero Beach. Numerous events were reported, yet only six were confirmed for verification purposes. Although most were severe thunderstorm events, one was a confirmed tornado. A strong (F-2) tornado killed one person, injured at least 60 more, and caused extensive property damage in Lake and Volusia Counties beginning about 12:30 a.m. near Mt. Dora.

The storms provided an opportunity for the NWSO forecasters to use the WSR-88D in providing excellent warning services. Preliminary analysis showed that of eight warnings issued between 12:08 a.m. and 4:05 a.m., March 13, six were verified by events. The devastating tornado that struck Mt. Dora (Lake County) was preceded by a Tornado Warning with a 22 minute lead time. All areas that were warned had between 13 and 33 minutes prior notice before the severe weather occurred.

In addition to communicating severe weather information to WSO Tampa, the Melbourne office alerted WSO Daytona Beach to a mesocyclone moving towards Ocala (Marion County) at 12:28 a.m., Saturday. In addition, phone calls and NAWAS messages were sent throughout the event to various EMOs within their CWA.

While the NWSO Melbourne WSR-88D performed well during the **Superstorm**, there are a number of areas of research related to the Doppler that would improve the operation of the system and capabilities of NWS. These items relate to all WSR-88D systems and not just to the one at Melbourne.

Finding 3.3a - The WSR-88D Mesocyclone Identification Algorithm depicts an excessive number of mesocyclones. At times it indicated several circulations even though matched storm-relative velocity images indicated only moderate gate-to-gate shear. The NWSO staff had to differentiate between true mesocyclones and false signatures while also deciding whether to issue a Tornado Warning or a Severe Thunderstorm Warning.

Finding 3.3b - Short-lived, weak to moderate (F0-F3) tornadoes, such as occurred at Chiefland and elsewhere over north central Florida, can still cause significant destruction and death. However, the WSR-88D does not always detect or permit prediction of such events using the existing algorithms.

Finding 3.3c - Range-folding obscured the velocity information in some tornadic storm echoes.

Recommendation 3.3 - Additional research is required to continue to improve the performance of the WSR-88D. In addition to the Mesocyclone Identification Algorithm problem, the problems associated with range-folding and the detection of weak tornadoes also require urgent attention by NOAA.

WSO Daytona Beach

Though responsible for only three counties, WSO Daytona Beach issued seven severe weather warnings between 12:05 a.m. and 1:15 a.m., March 13. Verification data show that all reported events were covered by severe weather warnings. Five of the seven warnings verified; more importantly, two of three tornado warnings issued were verified by confirmed tornadoes.

The most damaging tornado (F-2) near Ocala (Marion County) was initially covered by a Severe Thunderstorm Warning, issued at 12:05 a.m. A 15 minute lead time occurred with this warning, which was upgraded to a Tornado Warning at 12:35 a.m. However, wording in the original Severe Thunderstorm Warning for Marion County had noted "...a number of tornado touchdowns have been reported...(to the west) during the past hour." The upgraded warning was based on coordination with NWSO Melbourne, whose WSR-88D indicated a mesocyclone south of the Ocala airport. This radar signature was later confirmed to be associated with the tornado that did extensive damage to the Ocala airport and a nearby industrial park along an 12 mile path.

WSO Jacksonville

WSO Jacksonville had noticeable difficulties with the storm. The combination of the fast-moving squall line, AFOS problems due to several power outages, and lack of coordination with nearby offices and the parent WSFO precluded WSO Jacksonville from issuing timely warnings. All warnings were based on spotter, sheriff, and EMO reports, in some cases well after the events had moved into the Atlantic Ocean. None of the five warnings issued were verified. WSO Jacksonville's CWA had six tornadoes (out of seven events), including one killer near LaCrosse (Alachua County).

A detailed description of the tornado tracks is contained in Appendix C. This was prepared by Brian Smith who, along with Dr. Joe Golden, conducted the aerial survey of some of the damaged areas. Appendix D, "**Superstorm** Severe Weather Event Data, March 12-13, 1993," shows the verification information for each warning and severe weather event during the **Superstorm** in Florida.

Alabama and Interior Georgia

WSFO Birmingham

Alabama was one of the first states affected by the snow from the **Superstorm**. The state experienced record snowfalls, high winds, a damaging freeze, and dangerous cold which set a number of low temperature records.

The WSFO followed a policy of gradual escalation during the early stages of the storm. It issued its first Special Weather Statement on the potential storm Wednesday morning. At the same time phone contacts were made with law enforcement and emergency management officials advising them to consider additional preparations and staffing in advance of the storm.

A Winter Storm Watch was distributed Thursday afternoon for Friday night; and the first Winter Storm Warning was sent at 5:00 a.m., Friday morning for the north part of Alabama. Frequent statements were issued throughout the storm to keep the public, EMOs, and media updated on the impacts of the storm and expected snowfall amounts. Several Public

Information Statements with preparedness information were issued to further alert and prepare the public.

The services provided by WSFO Birmingham were excellent during this storm and were typical of the services provided by all NWS offices in the states that experienced the heavy snows and blizzard conditions associated with the **Superstorm of March 1993**. The threat was recognized early by each of the offices, and they coordinated among themselves and with the user community very effectively. Winter Storm Watches were issued well before the first snow fall, some with as much as 43 hours of lead time. The users, ranging from the media to emergency managers to law enforcement officials and road crews, were all alerted well in advance and used that time to make themselves ready for an extraordinary storm.

Because the services and long lead times were similar throughout the affected areas, the exact time of issuance of watches and warnings from each office will not be listed in each state. Rather only the more unusual reports or accounts and pertinent facts will be included in order to keep this report from becoming overly redundant.

WSFO Atlanta

WSFO Atlanta also was initially conservative in handling the storm. The first Winter Storm Watch was issued for extreme northern Georgia Thursday afternoon. The area covered by the Watch was enlarged southward to include the north and western suburbs of Atlanta early Friday and the watch period was extended from Friday night into Saturday. The WSFO did an excellent job of delineating the areas that would receive the greatest snowfall and the time period during which it would fall. For example, 12-16 inches of snow were forecast in the mountains, 4-6 inches north of Atlanta to Athens, and 1-3 inches over the remainder of north Georgia. This definition of the threat enabled those responding to the emergency to properly respond even though some of the amounts that were recorded were even higher in the extreme north part of the state.

A Heavy Snow Warning for northwest and extreme northeast Georgia was issued Friday evening and was upgraded to a Blizzard Warning at 5:00 a.m., Saturday. The Blizzard Warning was expanded southward later that morning to include Atlanta, Athens, Columbus, and Macon.

<u>Coastal Georgia</u>

WSO Savannah

Southeast Georgia was hit by severe weather, followed by high winds, and even accumulating snow showers, during the 18 hour period from approximately 1:00 a.m., March 13, through 7:00 a.m., March 14. Severe weather events were infrequent; however, gradient winds after frontal passage were similar to those in coastal South Carolina.

WSO Savannah produced effective warnings and statements throughout. However, as was the case in much of the southeast U. S., gradient wind speeds were under forecast until the event was in progress. High Wind Warnings were included in the local forecast by 5:30 a.m. with a peak gust of 64 mph was observed at Savannah's Travis Field at 11:12 a.m., March 13.

Severe weather occurred in the region between 1:30 a.m. and 3:30 a.m., as the squall line moved through. Numerous trees were blown down, but there were no deaths or injuries. Thunderstorm wind damage was noted in Glynn, Bryan, Long, Chatham, and Effingham Counties. No warnings were issued for Bryan and Long Counties; however, Severe Thunderstorm Warnings were in effect for the other counties. Warning lead times ranged from 16 to 38 minutes.

The Carolinas

WSO Charleston

The low country of South Carolina received no severe convective weather. However, sustained winds after the frontal passage were excessive, estimated to be over 65 mph along the entire coastline, with gusts perhaps as high as 90 mph.

Public perception of the event was that most knew a powerful storm was coming, but no one was aware it would contain winds in excess of 65 mph. Although WSO Charleston issued an excellent statement on the impending storm at 2:00 p.m., Friday, indicating the potential for greater than 50 mph wind gusts, the local forecasts that evening only mentioned a "wind advisory" and a gale warning for marine interests, with winds forecast to decrease after frontal passage. In fact, the strongest winds occurred after frontal passage.

Local forecasts and marine forecasts were updated at 5:00 a.m. on March 13 to include High Wind Warnings, with gusts in excess of 45 mph (public), and Storm Warnings for the coastal waters with gusts in excess of 60 kt.

WSFO Raleigh

North Carolina experienced the widest variety of weather extremes of any state affected by the **Superstorm**. High winds, heavy rains, and coastal flooding buffeted eastern North Carolina; mixed precipitation occurred in the central part of the state; and blizzard conditions struck the west, especially along the Appalachians. Amazingly, very few storm-related fatalities (eight) were reported. Damage costs were estimated at $13.5 million, the vast majority due to coastal flooding and high winds near the coast.

WSFO Raleigh did a good job throughout the storm, issuing numerous well-worded statements, watches, and warnings, up to 72 hours in advance of the onset of dangerous conditions. A Winter Storm Watch issued at 10:30 p.m., March 11, (over 24 hours in advance) mentioned the "...potential to be a very dangerous late winter storm," for the entire state. The watch was upgraded to a Winter Storm Warning at 5:50 a.m., March 12, for the mountains and a Winter Weather Advisory was issued for the piedmont and foothill areas. By late afternoon, a Blizzard Warning was in place across the northern mountains.

Further east, WSFO Raleigh was monitoring the potential for high winds, heavy rains, and coastal flooding. A Coastal Flood Watch was issued at 4:00 a.m., March 12, for the coast for

Friday night and Saturday for tides of 2 to 4 feet above normal. By 4:20 p.m., Gale Warnings were upgraded to Storm Warnings, a Flash Flood Watch was initiated for much of eastern North Carolina, and the potential for High Wind Warnings on Saturday was highlighted for the areas not under a Blizzard Warning.

A Coastal Flood Warning was issued at 7:45 a.m., Saturday, for the ocean beaches south of Cape Hatteras and the Coastal Flood Watch was continued from Cape Hatteras north to Virginia. The warning stated that "strong winds associated with this storm will drive ocean waters ashore along the entire north coast today..." At 7:00 a.m. winds were gusting 71 mph at Holden Beach and 52 mph at Wrightsville Beach. The warning also cautioned that there was a "threat of some flooding along the west side of the Outer Banks from sound waters." However, at 5:00 p.m., the Coastal Flood Watches and Warnings were discontinued. The justification for this decision was that the winds had become more westerly and tides were receding. The statement also stated that flooding was occurring on the sound side of the Outer Banks and that Highway 12 was closed due to high waters from Salvo north. It said the sound side flooding would abate later that night. Unfortunately, WSO Hatteras was just beginning to receive many reports of sound side flooding. For a time Saturday evening all communications were cut off at WSO Hatteras due to the flooding. Services from the WSO continued though because the observations (surface, radar, and upper air) were relayed via HAM radio to WSFO Raleigh where the information was entered on AFOS.

The Middle Atlantic and New England

WSFO Washington, D.C. (Sterling)

WSFO Washington initiated the first HHL conference call on the **Superstorm** on Thursday, March 11, at 2:00 p.m. All offices were in agreement that this was going to be a major storm for the eastern seaboard. The office continued to lead the HHL discussions until the storm had moved north of the mid-Atlantic region. A Winter Storm Watch and Coastal Flood Watch were issued Thursday afternoon at 4:00 p.m. The Winter Storm Watch was replaced with a Winter Storm Warning early Friday morning and upgraded further to a Blizzard Warning for western portions of the forecast area at 3:00 p.m. A Coastal Flood Warning was also issued while Storm Warnings were posted for all of the coast and the lower Chesapeake Bay. Numerous media interviews and briefings for EMOs were conducted beginning Wednesday. Heavy snow fell across nearly all of the region but mixed with sleet and rain across the Delmarva Peninsula Saturday morning. This reduced the total accumulations of snow where the changeover occurred. The demarcation line for the heaviest snow generally ran through the District of Columbia and Baltimore. The mountain areas of western Virginia and Maryland had as much as 3 feet of snow and drifts reported as high as 12 feet were created by the high winds.

Warning services for the mid-Atlantic and farther north and inland were exemplary, aided by a combination of good NWP, excellent subjective guidance, extraordinary coordination among offices, and most noteworthy, the efforts of NWS personnel.

As early as Monday afternoon, March 8, some northeastern WSFOs were including mention of a potential weekend storm in their State Forecast Discussions (SFDs) and the State Forecast Products (SFPs). Coordinated outlook statements were released on March 11 by

Chapter 4

Data Acquisition, Communications, and Facilities

Marine Data Sources and Availability

The surface and marine weather observations routinely available to NWS forecasters come from several sources: 1) data buoys deployed in nearshore and offshore locations, 2) Coastal Marine Automated Network (C-MAN) platforms, 3) ship observations, 4) drifting buoys, and 5) NOS operated water-level gages. The buoys and C-MAN units are operated and maintained by the NOAA Data Buoy Center (NDBC). (Figures 4-1 and 4-2, buoy and C-MAN locations, respectively)

NDBC Systems

Moored buoys and C-MAN stations telemeter hourly observations from the observing platforms through the GOES system to the National Environmental Satellite, Data, and Information Service (NESDIS) Wallops Island, Virginia, ground facility for relay to NMC and NWS field offices.

Although most of the network was operational, recent storms and collisions by ships, as well as the reduction in the number of navigation buoys equipped with meteorological sensors, had greatly depleted available systems along the Atlantic and Gulf coasts. The Gulf of Maine buoy, designated number 44005, was not reporting wind and temperature conditions. The Georges Bank, Nantucket Shoals, and east of Hatteras buoys, 44011, 44008, and 41001 respectively, had failed and had not been repaired. The Edisto buoy off South Carolina, 41004, was not reporting sea conditions. The Molasses Reef buoy off southern Florida, 42025, had no sea level pressure or wind speed and direction sensors, and the wave height data was only being disseminated 85 percent of the time.

In addition, the Delaware Bay and Five Fathoms, New Jersey buoys, 44009 and 44012, had been replaced by the Coast Guard in the fall of 1992 with smaller navigation buoys unable to support NWS observational equipment. The result has been a shrinking data base of surface marine data for NWS forecasts.

With respect to C-MAN units, the Diamond Shoals, North Carolina, (DLSN7) was inoperative during the storm, having ceased observations on February 18, 1993. The Lake Worth, Florida, (LKWF1) C-MAN had been destroyed on October 31, 1991, and had not been replaced. The Fowey Rocks, Florida, (FWYF1) C-MAN stopped reporting wind data on August 24, 1992, during the passage of Hurricane Andrew. The rest of its data was lost on March 8, 1993. The Buzzards Bay, Massachusetts, (BUZM3) wave data had been unavailable since February 25, 1992. Several C-MAN units (MISM1, FPSN7, FBIS2, and SANF1) had short outages during the storm. All other C-MAN sites were providing observations during the period of the **Superstorm**.

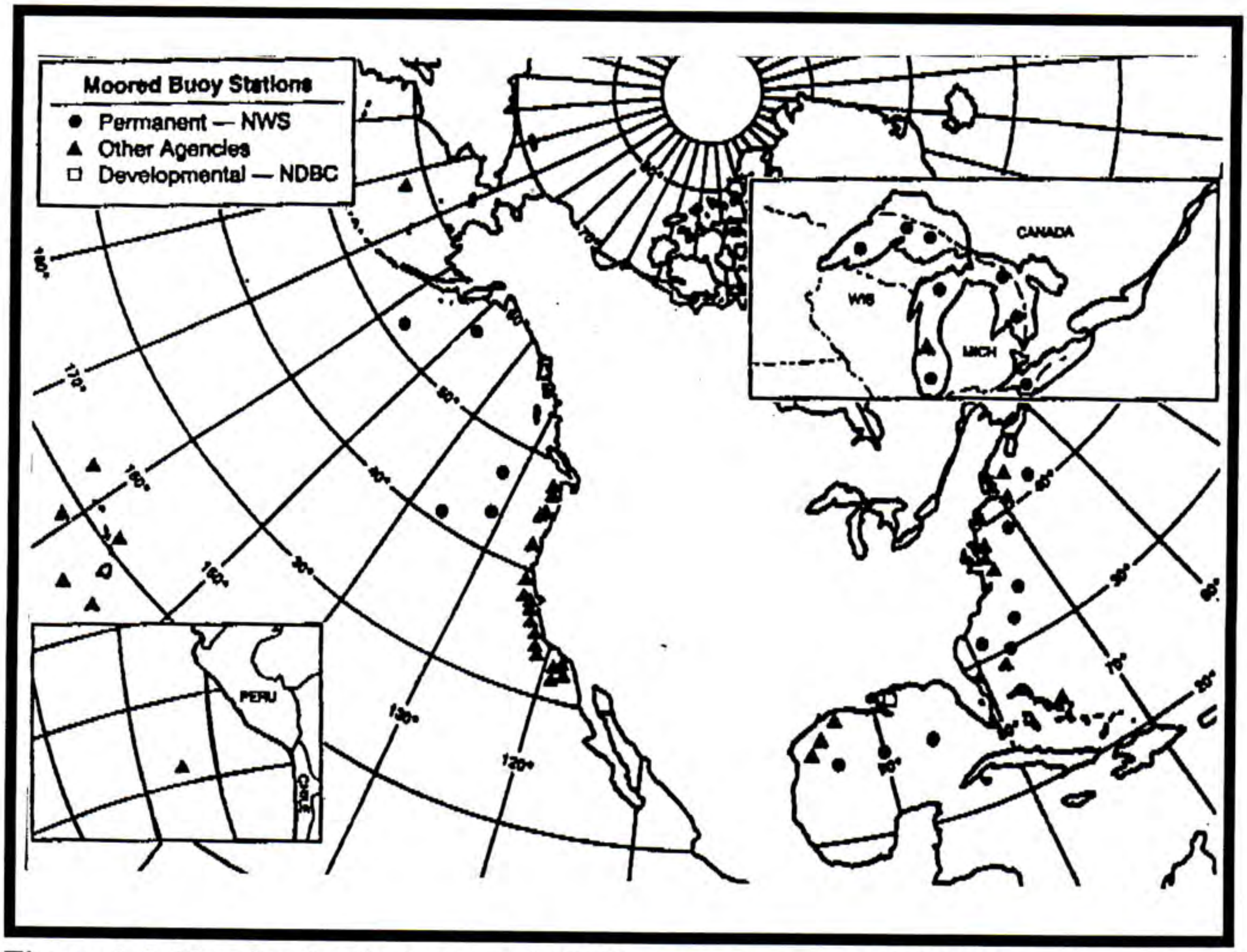


Figure 4–1. Map showing the location of NDBC moored buoys and USCG Navigational Buoys. Most stations denoted by ▲ are temporary buoys supported by other agencies for specific projects and time periods.

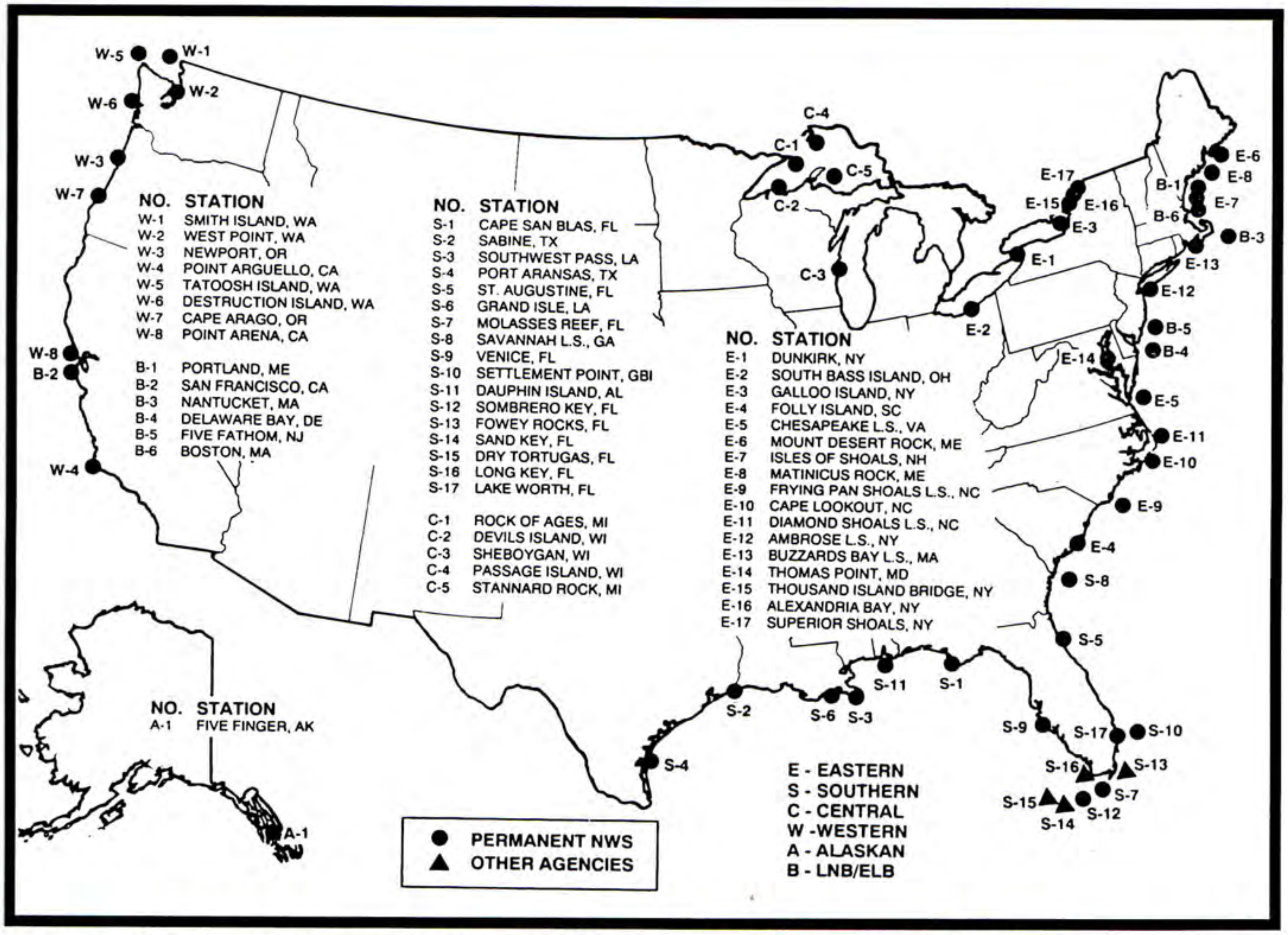


Figure 4–2. Map showing the location of NDBC fixed C-MAN stations in North America, including USCG Navigational Buoys.

Finding 4.1 - High availability of buoy and coastal station observation data are vital to support the NWS marine forecast and warning program. The scarcity of marine weather observations greatly impacted the quality of NWS marine forecast and warning services during the **Superstorm**. A similar finding was noted in previous DST Reports.

Recommendation 4.1 - NOAA should pursue additional marine observation sources including collaborative efforts with state and private organizations.

NOS Water Level Information

Water level information is provided to forecasters primarily from the NOS National Water Level Observation Network (NWLON). This network of gages is maintained primarily to record long- and short-term variations in water levels. For these tasks, real-time data are not an NOS requirement. NWS, because it does have a requirement for real-time information during potential coastal flooding and tsunami events, in cooperation with NOS, has modified selected gages to allow real-time access.

Two methods of providing this access are: 1) Handar equipment, developed for NWS from technology used on river gages, and 2) TIDES_ABC, a NOS-developed software package that plots water-level readings from the past 24 hours against predicted astronomical tide heights.

Handar technology, maintained by NWS, incorporates a programmable unit that monitors and transmits the water-level gage data via commercial telephone line to a NWS office. Either the field office can initiate the call for a reading or the Handar unit can initiate a call based on a specific time interval or whenever the gage height reaches a critical level. Multiple readings each hour can be obtained through this system. The unit can also store a record of data up to several weeks long.

In the TIDES_ABC system, a tide gage and a NWS office computer are also connected via telephone. The TIDES_ABC software at the NWS office initiates a call to one of several gages available to a particular office. Water-level observations for up to 24 hours are displayed graphically on the computer along with the corresponding predicted water levels for the same period. Departures from tidal predictions can be seen at a glance, and trends are readily apparent.

A disadvantage of TIDES_ABC is that it is more cumbersome and time-consuming to use than the Handar-equipped systems. NWS forecasters prefer accessing the Handar equipment at locations where both methods of access are available. As with Handar units, only selected gages are equipped for access via TIDES_ABC.

Overall, tide gages performed well throughout the storm. However, some problems were encountered in obtaining water level readings at several locations: 1) The TIDES_ABC software at WSFO Boston did not work. Boston accessed a Handar unit to get water level data from the Boston Harbor tide gage. WSFO New York could access the Boston Harbor gage using TIDES_ABC software, but WSFO Boston could not. 2) The tide gage at Portland, Maine, which was Handar equipped, was frozen in ice during the **Superstorm** due to prolonged cold weather. WSFO Portland made arrangements with NOS for temporary access to the Next Generation Water Level Measurement System (NGWLMS) tide gage data at the same location prior to the storm.

__Finding 4.2__ - Real-time water level data is essential to NWS coastal flood warning and forecast program. The lack of timely access to water level gages greatly diminished NWS's ability to issue accurate and timely coastal flood warnings. The majority of the measurements from the NWLON of 189 coastal and Great Lakes reporting stations are not available automatically nor in real time. These reports would have provided critical observations and verification of coastal flood watches and warnings and would have been of significant value as the **Superstorm** crossed the northern Gulf of Mexico. Software problems that occurred at WSFO Boston further reduced tide gage data availability at NWS offices.

__Recommendation 4.2__ - NOS with NWS should develop and support an Implementation Plan to complete the installation of the NGWLMS. This plan should include real-time reporting capabilities and a method of transmitting water level measurements to NMC. NMC should transmit a collective of these observations to field offices. In addition, local NWS offices should have direct access to NOS gages in their CWA.

__Finding 4.3__ - The NGWLMS can support up to 11 ancillary measurements such as air temperature, atmospheric pressure, and wind speed and direction. Optimization of this additional capability could partially compensate for the scarcity of marine observations.

__Recommendation 4.3__ - NWS should take action to include the addition of environmental sensors at NGWLMS stations to measure additional parameters for relay in real-time to NMC for processing and dissemination on AFOS.

__Weather Radar Data and Availability__

Several Weather Surveillance Radar (WSR) systems failed during the **Superstorm**. The WSR-57 at Wilmington, North Carolina, was inoperative for about 48 hours when commercial power was lost, and the backup generator was unable to provide sufficient power to operate the radar. The network radars at Knoxville, Tennessee, and Chatham, Massachusetts, also failed due to hardware problems.

The most serious problem with a WSR-88D occurred at WSO Tallahassee. Its Principal User Position (PUP) is connected to the Department of Defense (DoD) WSR-88D at Eglin AFB.

__Finding 4.4__ - Data from the WSR-88D at Eglin AFB was not available at WSO Tallahassee due to communication linkage drop outs during the **Superstorm**. The result was that during the height of the storm little radar data was available at Tallahassee.

__Recommendation 4.4__ - **Communications problems between the Eglin AFB WSR-88D and the WSO Tallahassee PUP should be corrected by NWS and the communications link upgraded if needed.**

The WSR-88D system at Sterling, Virginia, had some difficulties as well. **The WSR-88D became unstable (the Remote Product Generator crashed twice) due to communications problems. It is believed that too many dial-ins to the system caused this problem. This has serious implications for the way the WSR-88D systems are operated during stormy weather.**

Other Data

Upper Air

At Sterling, the 1200 UTC run on Saturday, March 13, had to have a second release because relative humidity data were lost before 400 mb was reached, which is the minimum level needed for a successful flight. The second release was successful. A supplementary sounding was run successfully at 1800 UTC that day to provide additional information on the storm system. All other runs were normal that day.

The only other upper air problem was on Saturday night when severe icing at WSFO Albany, New York, forced the radiosonde down before it reached 400 mb. A second release for the 0000 UTC sounding was successful.

Lightning Detection Systems

The lightning detection systems at WSFO Sterling detected the thunder-snowstorms. ARSI's display seemed to do a better job at detecting the cloud to ground strikes as verified through SKYWARN reports. The lightning detection system interface at WSFO Albany was very reliable and also helped detect thundersnows during the blizzard conditions.

PCGRIDS

The Science and Operations Officer at WSFO Sterling led the forecast teams through the RAFS and ETA models using PCGRIDS. PCGRIDS is a personal computer based program for the display of NWP model fields. The forecasters found this extremely useful because it allowed them to evaluate model fields that are not available on the Automated Field Operations and Services (AFOS).

Other than those items noted above, forecasters had good access to the data from all data collection and analysis systems used to handle the event.

Communications

The AFOS communications system is the primary means of disseminating information within NWS and to users of NWS products. There were no AFOS failures at WSFOs that required implementing service backup plans at NWS field offices, although there were some electrical stability problems when using backup power generators that impacted individual AFOS systems. There was an AFOS hardware failure at WSO Huntington, West Virginia, that resulted in the office having their backup personal computer as their only means of communication throughout the event.

The NOAA Weather Wire System (NWWS) is used to communicate NWS watches, warnings, and advisories along with routine observations and forecast products to EMOs, the media, and other users. There were a few communications problems that occurred during this storm. In a few locations it appeared that NWWS had failed. In fact, snow had accumulated on the satellite dish and blocked the satellite signal. A forecaster cleaned snow off the satellite transmission disk at the forecast office in Pittsburgh, Pennsylvania, for example, and normal communications resumed. However, several EMOs reported a similar problem with snow on their satellite dish but were unable to correct the problem because they did not have access to the satellite reception dish. **Both transmitting offices and those receiving NWWS products should to be made aware of this problem so that they can take appropriate action should it recur.**

NWR is a prime means of disseminating forecast and warning information to the emergency management community as well as to the public at large. There were several failures of NWR stations during the **Superstorm**. The NWR station at WSO Harrisburg, Pennsylvania, was knocked off the air due to a lightning strike at the transmitter site around 1:30 a.m. on Saturday, March 13, and was not restored to operation until 4:45 p.m., March 16. The NWR transmitter at Anniston, Alabama, was off the air for an extended period also when the Uninterruptible Power Supply (UPS) was drained after the commercial power was lost to the site. **A requirement for backup transmitters and emergency generators at NWR sites should be considered.**

WSFOs rely heavily on weather spotter networks, including amateur radio operators (HAMS), during intense storms. The spotters provide valuable information that allows NWS to provide a better warning and forecast service. The means of receiving spotter information varies (telephone calls, HAM radio operators in NWS offices, packet radio, and telephone facsimile). Telephone calls are very labor intensive, and not all offices have toll-free telephone numbers for spotters to call. HAM radio operators are not always able to get to the NWS office. Facsimile transmissions can be slow especially if only one facsimile machine is available.

Some examples of the number of spotter reports generated during the **Superstorm** are: WSFO Sterling received over 1000 spotter reports during the event using HAMS, telephones, and packet radio. WSFO Charleston, West Virginia, used packet radio technology and received over 100 reports. In addition, they relied heavily on cooperative observer reports and weather reports from the West Virginia Department of Transportation.

Finding 4.5 - The volume of reports during widespread events such as major winter storms or significant severe weather outbreaks makes it difficult for NWS to use SKYWARN data quickly. *Several NWS offices obtained spotter information via packet radio that provided a* hardcopy form of the HAM spotter reports. This method was less disruptive and labor intensive than receiving HAM radio reports via phone.

Recommendation 4.5 - NWS should explore either purchasing packet radio receiving equipment or acquiring this equipment via cooperative agreements with such organizations as FEMA, state/local EMOs, and amateur radio clubs, to automate collection of spotter reports. An Operations Manual Letter will be issued shortly by NWS Headquarters that allows obtaining this type of equipment.

Facilities

A number of offices (Boston, Massachusetts; Albany and Syracuse, New York; Williamsport and Pittsburgh, Pennsylvania; Norfolk, Virginia; Wilmington, North Carolina; Charleston, South Carolina; Miami, Jacksonville and Tallahassee, Florida) experienced battery, generator or UPS problems.

Finding 4.6 - The only significant problem with NWS facilities was with emergency power systems. A number of NWS sites had commercial and back-up power problems (emergency generators, UPS and battery failures) during the **Superstorm**.

Recommendation 4.6 - NWS offices should exercise their backup power contingency plans regularly. This should include operating the emergency generators routinely under full load conditions for a set period.

Chapter 5

Coordination and Dissemination

There are two elements critical to the issuance of timely and accurate watches and warnings during major weather events such as the **Superstorm of March 1993**. These elements are good internal coordination among field offices, and effective dissemination to EMOs and to the public through the media. It became apparent there were two issues regarding internal NWS coordination during the **Superstorm.** The first issue related to how well NWS coordinated internally regarding the large scale storm development and its effects. The second issue was how well NWS coordinated internally as the severe weather struck Florida Friday evening and crossed the state overnight.

Internal Coordination of the Large Scale Storm Event

As described previously, NMC began indicating the potential for a significant winter storm to affect the eastern U.S. as early as Monday, March 8. Through the NMC messages and their own analyses, NWS field offices were aware of the possibility of a significant winter storm well before the event. As early as Wednesday, some offices began contingency planning for staffing and facilities requirements should a major storm develop. They communicated with each other through their routine messages, the State Forecast Discussions (SFD) that accompany each major forecast issuance and describe the forecaster's reasoning for the upcoming forecast package, and in some cases by telephone.

On Wednesday, March 10, coastal WSFOs within NWS Eastern Region began to use the Hurricane Hot Line (HHL) for direct discussion and coordination of the upcoming forecast. Also included in the discussions were NWS Eastern Region Headquarters and NMC. As the name implies, the HHL system was originally installed for coordination concerning hurricanes, but it has been used for winter storm coordination by NWS Eastern Region for several years.

Adjacent offices were able to discuss the watches and warnings in detail along with the reasoning behind them. Winter Storm Watches and later Winter Storm Warnings and Blizzard Warnings were placed in effect smoothly and uniformly up and down the Atlantic coast as a direct result of the efficient use of the HHL. This method of communication also saved considerable time since in the past many phone calls would have had to have been made to accomplish the same level of coordination.

Finding 5.1 - Use of the HHL by NWS Eastern Region forecasters was very effective in producing a well-coordinated watch and warning effort, providing continuity across forecast boundaries. However, in at least two instances during the **Superstorm**, the HHL malfunctioned at one of the offices involved in the coordination calls. Also, NWS Southern

Region should encourage its coastal WSFOs with access to the HHL to participate in the calls. Inland offices are not connected to the HHL.

Recommendation 5.1 - Coastal WSFOs in NWS Southern Region that are connected to the HHL should be included in the coordination calls when appropriate. The HHL should be tested at least weekly at each office on the system to detect outages. Finally, NWS should establish a system that allows all NWS offices to coordinate actions during major storms such as a NAWAS-type system connecting all NWS offices.

Even in the states in the southeast that experienced the full brunt of the **Superstorm**, and that did not have the benefit of the HHL coordination calls, the coordination of the large scale events and features of the coming storm were generally well understood, and appropriate actions and forecast decisions were made. This is likely due to the long lead time on the storm through the early prediction by the NWP models, the outlooks and messages discussing the potential of the storm from NMC and NSSFC, and because with only a relatively few offices within NWS Southern Region affected, they were able to coordinate effectively via telephone.

Dissemination of the Large Scale Storm Information

As a direct result of the excellent internal coordination prior to and during the **Superstorm**, there were few major problems related to the dissemination of messages to EMOs and the media. Warnings, watches, advisories, and statements were well worded, timely, and accurate.

Dissemination to EMOs was accomplished through the usual means (i.e., NWR, NWWS, and NAWAS), but in many cases also included individual phone calls. These added emphasis and urgency to the message from NWS that this was much more than an ordinary winter storm. This emphasis carried over in the actions taken by EMOs. For example, after consultation with WSFO Albany, the New York EMO activated the Emergency Broadcast System statewide on Friday at 12:30 p.m. This action was unprecedented and assisted NWS greatly in providing widespread dissemination of information concerning the upcoming winter storm. A number of offices also used telephone facsimile systems to relay NWS messages that had been sent to the media. This helped fill the gap for EMOs that could not afford the cost of subscribing to and operating NWWS and who are not on NAWAS to receive NWS messages verbally.

Finding 5.2 - State and local EMOs acquire NWS warnings and forecasts using differing transmission systems ranging from telephone to dedicated computer systems. These variations can cause delays and unequal delivery of NWS products to EMOs.

Recommendation 5.2 - NWS, in coordination with FEMA, should actively develop reliable links to relay NWS watches, warnings, etc., to state and local EMOs. Automated retransmission systems are preferable because they are faster than

manual systems. The time saved can save lives. These systems should also provide two-way communications to enable EMOs to query NWS and relay storm reports.

<u>Finding 5.3</u> - NAWAS is used by NWS to alert many EMOs to watches, warnings, and advisories of impending hazardous weather. However, the system is not in place at a uniform level of government from state to state, or within all states. This hinders NWS's ability to provide urgent information to EMOs.

<u>Recommendation 5.3</u> - NWSH should assist FEMA in developing a policy that establishes NAWAS uniformly, preferably at the county level.

<u>Finding 5.4</u> - In many EMOs, NWWS is not monitored continuously due to other work being performed. There were instances during the **Superstorm** that EMOs reported that so much information being transmitted that they did not notice warnings immediately. This caused delays in their responses to those warnings.

<u>Recommendation 5.4</u> - A means of distinguishing warning information from routine messages must be found for NWWS. For example, on the Weather Channel, warnings are displayed on a red background to indicate they are urgent. A possibility is to program NWWS so that if a short-fuse warning is issued (e.g., tornado, severe thunderstorm, flash flood) NWWS would print "WARNING" or "TORNADO WARNING" as appropriate in large letters on a page prior to the actual warning message. This would indicate that an urgent transmission rather than a routine message was to be transmitted next.

There were a number of specific, but minor, dissemination problems that occurred during the **Superstorm**. In several locations, some NWWS messages were not relayed successfully to the user community. For example, Severe Weather Statements (SVS) were sent from WSFO Sterling but did not get to the users. The Philadelphia office had a similar problem in that their SVS messages were not relayed on the Commonwealth Law Enforcement Automated Network (CLEAN) due to coding errors by the CLEAN operators who were retyping the messages for retransmission on CLEAN. **Each WSFO should periodically send test messages on NWWS to ensure that users receive the information they need.**

Internally, some NWS offices experienced confusion in issuing products under the correct AFOS identifier because of the proliferation of possible products. This can become especially confusing with the multiple events brought on by a winter storm of this magnitude. For example, WSFO Philadelphia was issuing blizzard warnings, winter storm warnings, and coastal flood watches for different areas at the same time. **To assist field offices in preparing statements, etc., and in selecting the proper AFOS header, NWS should develop a menu-driven computer program for use in the message preparation. This could be similar to the system already in use for issuing severe weather warnings.**

The proposed system would also serve to alleviate another problem that occurred after the **Superstorm**. Many offices received inquiries concerning the potential for flooding related to the increased snowpack. In response they issued statements or outlooks describing the flood potential. However, a variety of products were used. **Flood Potential Outlooks**

(AFOS identifier ESF) should be issued after major winter storms, especially if the flood potential risk category increases as a result of the snowfall. This should be reflected in WSOM Chapter E-42, "Types of Hydrologic Products."

A number of offices visited by the DST reported some difficulties in making contact with some of the media, EMOs, highway departments, etc., during this event. These were needed to confirm reports or disseminate the latest information quickly. **Each office should have a consolidated phone listing of important contacts (EMOs, media, spotter groups, etc.) readily available to those on shift.** Normally this would be in the Station Duty Manual.

The DST noted that there were few dissemination problems in the north. This was likely due to the extensive coordination among offices and with the user community even before the event began. **Offices in the northeast were especially adept at relating the magnitude of this storm by wording products in such a way that the targeted audience understood exactly what was being forecast. This should not be underestimated as a causal factor for the low mortality rates in areas severely impacted by the Superstorm.** In fact, Pennsylvania Emergency Management Agency (PEMA) reported 52 total deaths associated with the event. Of these, 48 were post-storm deaths due to shoveling the heavy snow accumulations. This trend of higher post-event deaths was evident in other northeastern states as well, although most states did not report these deaths as definitively as Pennsylvania.

Internal Coordination of Severe Storm Events in Florida

As the **Superstorm** moved across the northern Gulf of Mexico on Friday, it deepened explosively and became much stronger than the NMC models had forecasted. This was not evident to all of the field offices dealing with the storm system. When the squall line associated with the storm approached the west coast of Florida Friday night it was moving at 40-50 mph when first detected by the radar at WSO Tampa. As the squall line neared the coast line, it accelerated to nearly 70 mph.

This extremely rapid movement made it very difficult for the offices in Florida to coordinate their actions prior to issuing warnings. There were notable exceptions, however. For example, discussions between Tampa and Melbourne regarding the Doppler radar data played a role in the issuance of several tornado warnings by Tampa.

The Jacksonville WSO was not so fortunate. DST discussions there revealed that due to intermittent power problems and a lack of coordination with surrounding offices (Daytona Beach, Melbourne, and Tallahassee) regarding imminent severe weather, Jacksonville had short lead-times on warnings or no warnings at all. Their warnings were issued solely on spotter and police reports. The WSO later determined that some of the storms had moved into the Atlantic Ocean by the time Jacksonville was notified and began the warning process.

Finding 5.5 - Some offices, most notably WSO Jacksonville, were not fully informed about upstream severe weather due to a lack of coordination with adjacent offices.

Recommendation 5.5a - Active coordination with adjacent/nearby offices should be a high priority during severe weather conditions. WSR-88D-equipped offices should contact nearby NWS offices if the WSR-88D is indicating potentially severe weather in a county for which another office is responsible and the severe storm in question is within 124 nm of the Doppler radar.

Recommendation 5.5b - NWS offices must remain in contact with each other to ensure coordination of efforts and to be aware of approaching weather. This should include reviewing warnings and statements, including local storm reports from surrounding offices and routine review of observed data.

Dissemination of the Severe Storm Events in Florida

Prior to the severe weather events in Florida, NWS offices did an excellent job of informing the media and EMOs. As described earlier, Miami issued a very comprehensive statement and provided an excellent briefing Friday afternoon for the state and local EMOs. Similarly, the severe weather watches from NSSFC were timely and strongly worded.

Discussions with a number of EMOs in Florida revealed that overall NWS warnings were adequate for the severe weather they experienced. The exception was for the coastal flooding that occurred on the Florida Gulf Coast where the EMOs felt the warnings were insufficient. Several EMOs in the Tampa and Melbourne CWAs were quite pleased with the advanced notifications and timely and accurate warnings that occurred as the squall line struck the region.

The single major complaint from Florida EMOs was that they were not prepared for a storm of the ferocity of the **Superstorm**. Several of them said they believed that only expected a "normal" winter storm was forecasted and indicated they would have reacted differently if comparisons to a hurricane had been made in the statements, forecasts, and warnings.

Finding 5.6 - Some Florida EMOs were unprepared for a storm as strong as the **Superstorm**. In particular, they were not ready for the extreme coastal flooding that occurred. The EMOs felt there should have been more urgency from NWS and comparisons made to hurricanes since that is the primary threat they prepare for each year.

Recommendation 5.6 - NWS must be clear, concise, and specific in its messages. This should include SPECIFIC warning advice. To say "strong wind" means different things to different people.

Chapter 6

Preparedness Activities

Overview

Preparedness efforts up and down the eastern seaboard were quite comprehensive. **Nearly 100 NWS offices were involved to varying degrees in preparing EMOs and the public for the Superstorm.** Preparedness activities have been divided into long term and short term categories for this Report. Those actions taken specifically in response to the **Superstorm** threat are described under the short term activities. Those preparedness activities undertaken as part of normal NWS operations are described under the long term category.

Long Term Preparedness

Intergovernmental Drills - As a matter of routine, all NWS offices participate in drills with state and local EMOs. Frequently, the media are also included. In many states the Governor will issue a proclamation designating a week as "Tornado Awareness Week" or "Winter Weather Awareness Week" in order to raise the visibility of the activities and to add emphasis for media coverage and participation. This in turn leads to greater public understanding and education.

These kinds of activities were conducted in all of the states affected by the **Superstorm** although some in the South, where the threat from winter weather is less likely, did not hold winter weather-specific drills. At least 13 of the 22 states that bore the brunt of this storm had held winter weather drills. Appendix E, "Getting Ready for WINTER!," is a brochure prepared by WSFO Birmingham for the Winter Weather Preparedness Week that was held in Alabama in December 1992 (four months before the **Superstorm**).

Contacts With EMOs, Other Local Officials, and Major Media Outlets - Regular contact with the people directly involved in taking action during emergency situations firmly establishes the communication links that are essential during weather events that threaten life and property. These contacts enable the development of a dialogue pertaining to NWS procedures and address the needs of the users and those of NWS. **State and local emergency management agencies and the media highly praised the NWS efforts related to the Superstorm event. Only in Florida were there officials who felt they were not adequately served by NWS.**

NWS Internal Drills - The purpose of NWS internal Station Drills is to ensure proficiency among the staff in handling weather events. Drills concentrate on watch and warning operations, including coordination and dissemination, and NWS policy. Winter weather-specific drills were conducted at over three-quarters of the WSFOs and WSOs visited by the

DST. This number is disproportionately small because the nine offices in Florida do not conduct winter weather drills due to the rarity of significant winter storms there. However, they do conduct hurricane drills and appropriate severe weather drills. Bearing this in mind, 100 percent of the NWS offices surveyed had conducted internal drills within the previous year. Appendix F contains a sample Winter Weather Drill administered at WSFO Boston. **The only area of weakness in the NWS internal preparedness program was in the coastal flood program. Offices with coastal responsibilities generally did not have adequate coastal flood forecast training. This is a reflection of the overall low level of knowledge of coastal surge flooding throughout NWS.**

Station Duty Manuals - The DST reviewed the SDM at many of the NWS offices visited. As mentioned in Chapter 3, NWS had issued a new WSOM Chapter C-42, "Winter Weather Warnings," in September 1992. There were significant changes to NWS procedures in this new WSOM. These necessitated the revision of the SDM at all offices. **The manuals that were inspected were in many cases completely rewritten and, in all cases surveyed, current.**

Spotter Training - This is one of the fastest growing, yet still underutilized, sources of weather information in emergency circumstances. Typically, it involves training the public or members of public service organizations in the identification of hazardous weather phenomena and in the relay of that information to NWS or other appropriate officials who will relay the reports to NWS. NWS offices have been quite resourceful in identifying organizations with the potential for providing numerous spotter reports and in using innovative methods of training them. In addition to the amateur radio organizations that have long provided invaluable service to the public, NWS has also recently trained police academy cadets (WSFOs Pittsburgh and Albany), and highway road crews (WSFO Philadelphia). WSFO Charleston keeps in touch with the amateur radio spotters that have been trained through a periodic ham radio "show" whereby WSFO staff provide spotter tips, announcements, and hold question and answer sessions that are relayed by a control amateur radio operator to others within broadcast range.

The use of spotters in obtaining ground truth information proved to be invaluable to all NWS offices during the **Superstorm**. A rough estimate of the number of reports sent to NWS offices during and after this event is 3000-5000. **All offices should provide training in winter weather procedures to the storm spotters. These should be added to make the best use of the spotters year round.**

Mailings and Brochures - These are used by a number of offices to keep in touch with spotters, EMOs, etc., during the year and to supplement training sessions. Some offices use newsletters to describe winter weather procedures, for example, which were not covered in the spotter training classes. Appendix G, "North Carolina SKYWARN News, November 1992," is an excellent illustration of one of these mailings. This one was sent out by WSFO Raleigh. Similarly, WSFO Sterling developed a Guide To Developing A Severe Weather Emergency Plan For Schools.

Short Term Preparedness

As noted earlier, the possibility of a significant winter storm was known by NWS early in the week. This allowed NWS offices to make extraordinary preparations for the potential storm. **This long lead time was a major factor in the success of the resulting forecasts, warnings, and statements.**

Pre-Event Planning Sessions - As NWS offices recognized the potential severity of the coming storm, they took steps to prepare themselves as well as notify the users (i.e., EMOs and the media). They scheduled additional staff coverage, arranged sleeping and eating accommodations, and ensured their equipment was operating properly. In most cases, this included testing their emergency generators. It is unusual for NWS offices to have the luxury of preparing not only the public, but themselves as well. Some offices, however, still needed to work extraordinary hours during the storm due to unforeseen travel problems or other emergencies. For example, several of the staff at WSO Williamsport, Pennsylvania, worked over 24 hours straight when their relief was unable to reach the office. It should be noted that this is not an unusual occurrence in major winter storms.

Internal Coordination - As discussed earlier, Eastern Region WSFOs participated in 6-hourly internal coordination conference calls using the HHL. This was begun Wednesday afternoon and was initiated by WSFO Sterling. There were also innumerable telephone calls between WSFOs and WSOs throughout the affected area as part of the internal coordination efforts. The resulting forecast products were well thought out, and the ensuing watches and warnings were phased in and progressed logically and consistently from one state to another.

Pre-Event Briefings - NWS field offices were very aggressive in their actions to inform the public, media, and EMOs of the extraordinary potential of the expected winter storm system. Many offices began individual briefings as early as Wednesday morning. By Friday, from Georgia north, all offices (WSFOs and WSOs) had called each county in their CWA.

Newspapers and the broadcast media were also kept well informed. Based on office logs and estimates, approximately 500 pre-storm briefings and interviews were provided to media outlets worldwide. Note that this number does not include any interviews or briefings done during the event. The **Superstorm was THE news** story for the latter part of the week even before the system had formed. The media worked exceptionally well with NWS in conveying the message of the remarkable potential of the brewing storm. NWS and the media worked together to give specific information to the public for their preparation and protection. The result was that East Coast was well prepared for the storm. As a reporter from the Philadelphia Inquirer said, "You had to be living under a rock to not know this storm was coming."

Finding 6.1 - The most often heard complaint during the Survey, particularly in the northern areas where the event lasted for over 24 hours, concerned the volume of data and length of the products sent to the media and other users. In many cases they were simply overwhelmed with information.

Recommendation 6.1 - NWS offices should keep their statements as short as possible. For example, they should not reuse call-to-action statements repeatedly. Shorter, more frequent, statements are preferred to ones that are all inclusive. The broadcast media in particular will not use lengthy messages.

Chapter 7

Media and Public Response

This chapter is probably the most important part of any DST Report since it describes from the users perspective how well NOAA met its mandate to protect the public. The DST has chosen to do this by minimizing interpretations; quoting newspaper articles and editorials directly, incorporating DST interviews with the EMOs, media, and public, and by including a few letters concerning the **Superstorm**.

Media Overview of the Superstorm

Blizzard was problem '600 miles across'

Bill Nichols, *USA Today*, Monday, March 16

Many bone-shaking blizzards have been pretenders to the title of "Storm of the Century," only to be forgotten when their icy fury melted into memories.

But the Blizzard of 1993 won that title spectacularly--dumping a monstrous mixture of snow, ice, sleet and hurricane-force winds on an eastern USA ready to swap long johns and ski caps for Bermuda shorts and baseball.

But instead of signs of spring, this mid-March weekend was marked by a killer storm that left more than 100 people dead, cut electricity to millions and left most of the East dazed with cabin fever.

The blizzard of March 12, 1888, which killed more than 400 people...is the benchmark against which all winter storms used to be measured. Not any more.

"I'm 37, but I feel like 100 today," says meteorologist Mark Rosenthal of Boston's WCVB-TV, one of many weather forecasters who became local heroes by being on the money in predicting the severity of the storm.

"Nothing like this in recent history has struck the state of New York, or the Northeast for that matter," says Jim Ryan, spokesman for the New York state emergency office. "You're talking about a problem that's 600 miles across."

Meteorologists say this storm qualifies as the storm of the century for two reasons--the huge area covered and the record-breaking low atmospheric pressure, which created its strong wind ...

"From our standpoint, the low pressure makes it academically the storm of the century," says Wes Junker, a senior forecaster at the National Weather Service. Air pressure differences between the low pressure center and higher pressure around the storm determine how fast winds blow.

Forecasters proudly pointed out that the severity of this storm was being predicted as much as a week beforehand, giving most residents a chance to batten down the hatches with food, drink, batteries and maybe a favorite video or two. Or half a dozen.

"It's the Super Bowl of weather for us," says Robert Kovachick, the meteorologist at WNYT-TV in Albany, N.Y.

"It's weather you might only see once in a lifetime," says Mike Wyllie, in charge of the National Weather Service's 25-member forecast office in New York City.

And the storm's consequences were a deadly serious business throughout the affected region, which was still struggling Sunday to get ready for a difficult back to work day today:
*In Georgia's Gordon County, county industry was devastated when roofs on 24 carpet mill buildings collapsed.
*A 200-foot Honduran freighter sank in the Gulf of Mexico off Florida, killing three of its 10-member crew.
*On Caesar's Head, S.C., National Guard helicopters ferried 100 teenagers and counselors to safety. In the Great Smokey Mountains National Park and adjacent Cherokee National Forest, "We are plucking people from all over the mountains," says Army National Guard Col. Larry Shelton in Tennessee.
*Eight people were stranded for 24 hours in a mountaintop cabin in Woodrow, W.Va., but were rescued by road crews who used front-end loaders to carve a path through 15-foot drifts.

*At least 100 cars spent Saturday night inside tunnels on Interstate 77 at the Virginia-West Virginia line, trapped by snow drifts at both ends, says West Virginia Gov. Gaston Caperton's office.

...For many, however, this storm's effects were not quite so severe. Instead, it was a weekend of inconvenience, the details of which will soon become the stuff of local and family legend:
*In Pittsburgh, marchers bedecked in green slogged through ankle-deep snow in the annual St. Patrick's Day parade. "There's nothing that keeps the Irish down," says Trish Cloonan, Miss Smiling Eyes.
*Birmingham, Ala., got 13 inches of snow within 24 hours--more than the city had ever gotten in an entire winter.

Asked where they were in the Blizzard of '93, many will answer that because of the advance warning, they were home, watching videos and listening to the unearthly sound of thunder crashing as snow covered the windows and the wind howled.

In Washington, where its southern heritage is never so apparent as when the threat of snow brings near-pandemonium, pedestrians walked through deserted city streets Sunday morning.

For others in the Northeast, however, digging out is an almost everyday winter occurrence, and taking snowstorms as a matter of course is a matter of civic pride.

But even in Syracuse, one of the nation's snowiest cities, the Blizzard of '93 won't soon be forgotten, not after 3 feet of snow. Says Public Works commissioner Vito Sciscioli: "Normal, this time, is going to take a few days to achieve, I'm afraid."

Florida is hardest hit

Dozens were left dead and more than 2 million left without power as the storm blew through Florida with high winds, tornadoes. Rescues: Coast Guard rescues at least 139 people from sinking boats or rising water. Agriculture: Cold worries citrus farmers, other fruit producers. South Dade: More wind, cold hit area damaged by Hurricane Andrew.

Weather Service Agreement To Enhance Emergency Preparedness

Bellport (N.Y.) *Pennysaver News*, Jan. 21

A landmark agreement to provide vital weather information and communication networks to protect New York residents from severe storms, flooding, and other disasters was signed recently by officials with the National Weather Service and the State Emergency Management Office (SEMO).

"New York State and the federal government will now be sharing the latest in weather technology and communications systems to better protect New York residents from the ravages of mother nature and other disasters," SEMO Director Donald A. DeVito explained.

"New York's emergency system will have almost instant access to the latest weather data and will be able to utilize federal communications systems for disasters such as explosions, toxic spills, and forest fires," the Emergency Preparedness Director said at a recent signing ceremony at the National Weather Service (NWS) Eastern Regional Headquarters in Bohemia.

According to Susan F. Zevin, Eastern Region Director for the NWS, New York will benefit through the latest in weather warning and forecast technology under the Weather Service's Modernization and Restructuring Program. "We are constructing new Forecast Offices with state-of-the-art Doppler weather radars and advanced computer systems in Albany, Buffalo, Binghamton, Long Island, and in surrounding states as part of a network of 116 facilities nationwide," Zevin said...

"Through our close working relationship with the federal government, and by taking advantage of the latest in emergency management technology, New York will be better prepared for natural disasters and other emergency situations," DeVito concluded.

Students to study the cause and effect of severe weather

Bladen Daily Journal, Elizabethtown, N.C., Monday, Feb. 22

Local schools and businesses will turn their attention to severe weather next week. Students will be learning about the impact tornadoes, hurricanes and lightning can have.

Businesses will be looking over their plans for protecting employees and property, should inclement weather pose a threat.

February 21-28 has been proclaimed Severe Weather Week by Governor Hunt. The observance is a cooperative effort among the N.C. Division of Emergency Management, the N.C. Department of Public Instruction and the National Weather Service...

New radar may boost forecasting

Albany, N.Y., *Times-Union*, Tuesday, March 2

Think of the difference between conventional radar and what Next Generation Doppler radar (NEXRAD) can do as analogous to X-ray versus CAT scan.

"Doppler won't make us perfect, but it will greatly improve our forecasts," says Roland Guy Loffredo, Albany area manager for the National Weather Service...

The National Weather Service freely admits its accuracy in predicting small, localized severe weather patterns such as flash floods, spotty thunderstorms and erratic tornadoes has been poor.

"Doppler is going to improve every aspect of weather forecasting," Loffredo says. "It would be a crime not to take advantage of this new technology and to continue making forecasts the way we've done it since the 1950s."

This Year's Weather: It Really Was Strange

William K. Stevens, *The New York Times*, Tuesday, March 9

For the last year, it seems the Northeastern United States has lurched from one abnormal weather event to another...

A resurgent El Nino would probably reinforce a strong subtropical jet stream that has been traversing the Southern United States this winter, bringing more cool, wet weather to much of the Southern tier, said Jim Wagner, an analyst at the National Weather Service's Climate Analysis Center at Camp Springs, MD...

A new pattern took hold in the first week of February, when the big high pressure system repositioned itself over western Canada, according to Paul G. Knight, a meteorologist at the Pennsylvania State University. This time it directed arctic air down through the central plains. There it encountered moist air from the Gulf of Mexico and from a strong southern branch of the jet stream that owed its strength partly to El Nino. This produced snow storms that moved across the country and eventually hit the Northeast.

This pattern ended on Feb. 28, Mr. Knight said, and it is unclear what will replace it. Last week's rains, snows and high winds in the Northeast developed in what Mr. Knight described as a transition period between two stable weather patterns. Such transition periods, he said, can be quite volatile...

THE **SUPERSTORM** IN THE SOUTH

Media Interviews: Television weather reports

WJKS-TV17, Tampa, Fla., March 17. Based on Weather Service and private forecast services, *WJKS* station manager, Jay Solomon said the station's forecaster had seen the storm developing as early as Tuesday, March 9. They were prepared for the storm and had extra crews standing by in advance of the storm's arrival.

Salomon reported a potential serious problem with the delivery of weather service information by Tampa-area radio stations. He said some local radio stations owned by large out-of-state companies are not attuned to local conditions because they are virtually unmanned satellites that do no news gathering themselves. Instead they merely broadcast remote feeds.

WBRC-TV6, *WBMC-TV4,* Birmingham, Ala., Friday, Saturday, March 12-13. *WBRC-TV6* noontime meteorologist Dan Satterfield broadcast National Weather Service watches and warnings with crawls and interruptions of regular programming. He called the watches and warnings "excellent and on time." Although he thought the change in terminology in describing the approaching storm from a "winter storm watch" to a "heavy snow warning" for the Birmingham metro area was somewhat confusing, he said that the warnings for northern Alabama were fine. He felt the wording of the weather advisories highlighted the seriousness of the storm and gave the forecast an overall A+.

WBMC-TV42 meteorologist Fred Barnhill used crawls to get National Weather Service watches and warnings to the public. He reported the Weather Service forecasts were timely and provided plenty of information.

Media Interviews: Radio Weather Reports
WODL / WIKX, *WERC*, *WRBC*, *WZZK*, Birmingham, Ala. Friday-Monday, March 12-15. *WODL / WIKX* radio general manager Jim Dent reported that Weather Service forecasts were good, but the snowfall was underestimated when 4 to 6 inches of snow was predicted instead of the actual 13 inches that fell. The station issued winter weather watches during news breaks; warnings were issued immediately.

WERC radio's Alan Collins reported the station contracts with *WRBC's* James Span and the Associated Press weather wire. He said overall the forecasts were fine. The station simulcast with *WMJJ* radio from Saturday, March 13, to Monday morning, March 15, allowing residents to call in for weather information and emergency assistance.

WZZK news director Melanie Berry called Weather Service forecasts timely, helpful, and understandable. She said, however, that forecasts changed rapidly and called for 5 to 8 inches, when 13 actually fell. The station aired watches and warnings with some Weather Service statements read verbatim. The station also provided its own special reports on the storm. The heavy snow warnings were issued well in advance and worded well, saying, "Don't be fooled. Bad weather is just around the corner."

The Atlanta Journal & Constitution
Commemorative Edition, Saturday, March 20
The Blizzard of '93

They told us it was coming, and they said it would be big.

Yet when the Blizzard of '93 howled into Georgia a week ago today, its intensity was so startling that we might as well have been caught totally by surprise.

At the end of a tame Georgia winter, the combined power of snow, wind and cold took us aback...

A storm's fury

It took only minutes for a chilly rain to turn into an angry blizzard. It would be days before the full extent of the storm's wrath would be evident...

In Georgia as well as most of the eastern quarter of North America, the toll from the Blizzard of '93 was about as grim as it gets when the forces of nature do battle.

Statewide there were 15 deaths, hundreds of thousands of people without power for days, thousands stranded on ice-choked roads, lost crops and devastated commercial centers of northwest Georgia...

What made winter's frozen-earth policy so lethal in Georgia was the nearly universal belief that things simply couldn't get as bad as they ultimately did. Despite weather forecasters' warnings in the afternoon of Friday, March 12, that the "Storm of the Century" was on its way, most people just pressed on with their plans for the weekend--and many others treated the coming storm as a last chance to get out and play in the snow.

Vacationing families and college students on spring break wanted to leave Florida and head north to get back home before Monday. Truckers knew that the interstates were their best chance to get their loads through; the boldest slush-jockeys were the ones who'd make it, they thought. Hundreds of hikers and campers weren't about to let a little foul weather intrude on their plans to hit the trails of the great Appalachian outdoors. Thousands of pilgrims had come from around the South to a Conyers farm where the Virgin Mary supposedly appears. And if faith can move mountains, it surely could forestall snow, couldn't it?

Well, the hand of God was made icily manifest with dawn's light Saturday, though not in a way that even the secular meteorologists had envisioned. And while it's easy with hindsight to call those caught outside foolhardy, almost nobody could have known just how vicious a late-winter sucker punch the storm would deliver.

It all turned so vicious so fast...

In Union County, where three people died, Sheriff Stanley Richardson said the storm would serve as a warning to the increasing number of people building retirement homes in the splendid isolation of the mountains: The splendor can turn to terror in storms such as this one...

Northbound and westbound, the blizzard created massive ice clogs in the asphalt arteries of interstate routes out of Georgia. For three days, hardly anything moved over the freeways from Georgia into Tennessee or Alabama.

For thousands stranded Friday night on Interstate 75 between Calhoun and the Tennessee line, it was like camping out on a hockey rink. Police found many drivers asleep in their cars in the middle of the expressway. Most motels in the area were filled far beyond normal capacity, and some converted their lobbies into sleeping space for the stranded...

War Stories

Tuesday, March 9, Late Afternoon Forecasters first predict a chance of snow for the weekend. "It looks like we're going to get some sort of precipitation either late Friday or Saturday," National Weather Service meteorologist Terry Murphy says Tuesday night. "There's at least a chance that there will be some [snow] in North Georgia, from the Atlanta area up to the mountains."

Wednesday, March 10, 5 A.M. The weather service continues to forecast a chance of snow for Saturday. **AFTERNOON** Atlanta's high is 75.

Thursday, March 11, 5 A.M. The weather service says a mixture of rain and snow is "likely" Saturday across all of North Georgia, including metro Atlanta. **10 P. M.** The weather service issues a winter storm watch for Friday night for an area north of a line from Cedartown to Jasper to Clarksville, saying the mountains could get 2 to 4 inches of snow and flurries are possible as far south as Atlanta.

Friday, March 12, 6 A.M. The weather service revises its forecast and predicts a "major winter storm." The forecast calls for 12 to 16 inches of snow in the mountains and 2 to 4 inches in metro Atlanta, along with "blizzard-like conditions" and bitterly cold wind chills. **10 A.M.** Scattered patches of light rain mixed with snow begin moving into northwest Georgia. **FRIDAY AFTERNOON** Grocery stores and video rental stores across North Georgia are swamped as residents stock up for the impending storm. Road crews prepare snow removal and sand spreading equipment. **FRIDAY NIGHT** The rain begins changing to all snow in extreme northwest Georgia. **11 P.M.** Tennessee closes Interstate 75 from Chattanooga to Knoxville. Northbound traffic backs up from Ringgold to Calhoun, Ga. **MIDNIGHT** Several inches of snow have accumulated in northwest Georgia's Dade County... The weather service issues a heavy snow warning for extreme North Georgia and a snow advisory for the rest of the northern third of the state, calling for up to 6 inches in metro Atlanta...

Saturday, March 13, 5 A.M. The rain changes to all snow and begins accumulating at Hartsfield [International Airport, Atlanta]. The weather service issues a blizzard warning for North Georgia, including metro Atlanta. **7:14 A.M.** Wayne White, a homeless man with artificial legs, is found frozen to death in Atlanta. **7:30 A.M.** Hartsfield International Airport closes because of dangerous cross winds blowing at 45 to 50 mph... **2 P.M.** One lane of I-75 north of Atlanta reopens in each direction, but Georgia transportation officials warn motorists to exit before Calhoun. **7:05 P.M.** Tennessee officials claim Georgia closed southbound I-75, stranding motorists in Tennessee. Georgia officials say they erected a barricade near Cartersville on northbound I-75. **7:34 P.M.** The low of 18 degrees at the National Weather Service office at Hartsfield ties the record for the date. In Marietta, the low dips to 15 degrees. **1 P.M.** ...Rescue workers reach the body of Travis Asher, who died in Walker County after the two Jeeps he and seven friends were traveling in became stuck on Taylor's Mountain Friday night as the storm began.

Monday, March 15, Early Morning Low temperature records are set in Atlanta (20 degrees), Columbus (20), Macon (20), Augusta (19) and Athens (19). Virtually all school systems from Atlanta and Athens northward cancel classes for the day. **10 A.M.** At least one lane of I-75 is opened north- and southbound...

Tuesday, March 16, 6 A.M. Power remains off to nearly 100,000 customers...across the state. About 1,370 metro Atlanta homes are still in the dark...Most Georgia school systems, including some in metro Atlanta, cancel classes for the second day...An estimated 2,000 Fannin County residents are still stranded in remote areas...

Wednesday, March 17 Power officials report 17,500 customers...still without service.

Supercomputers gave first glimpse of coming blizzard

Birmingham News, Tuesday, March 16

When computers produced the first glimpse of the Blizzard of '93, weather forecasters thought the storm was too big to be true.

It wasn't. Meteorologists double-checked their work and predicted the huge storm days in advance. It was a proud moment for a profession that is the butt of jokes when the weather throws them a curve.

"The forecast process worked as well as could be hoped for...We were giving an outlook on the storm days in advance," said Louis Uccellini of the National Meteorological Center in Camp Springs, Md.

The giant extra-tropical cyclone was a unanimous prediction of global weather models run by super-computers at the Camp Springs center, the European Center for Medium-Range Forecasting and the Royal Meteorological Service in England.

"We thought we had a mistake or something because it was showing a storm of relatively unprecedented proportions," said Elbert Friday, director of the National Weather Service.

Uccellini said the three models disagreed about which direction the storm would take, but forecasters went with the American version, which proved correct.

The storm began to develop in the Gulf of Mexico on Thursday and by late that day the lightning detection system showed strikes covering the entire Gulf.

"We've never seen that kind of intensity before," Friday said.

Accu-Weather Inc., a private forecasting company based in Pennsylvania, began sensing Wednesday afternoon that a major storm could be in the offing, said senior forecaster Paul Walker. "By Thursday afternoon, it became very obvious that a major storm was coming on," Walker said. "This was a once-in-century type of storm; its magnitude wasn't obvious" right away, Walker said.

Officials: Review storm forecasts

Tallahassee Democrat (from *AP*) Thursday, March 18

Florida officials and the National Weather Service are reviewing the government's ability to warn beach communities about incoming storms, Florida's top emergency officials said Wednesday.

"The governor was very distressed in some of the coastal areas that the evacuation warnings--actually that the weather warnings--may not have been sufficient," said Linda Shelley, secretary of the state Department of Community Affairs...

From Tampa Bay north to Taylor County, Gulf Coast residents expressed surprise at the winds and tides that came ashore.

Hardest hit was Taylor, which had more than twice as many deaths as any other county. The storm surge left 10 people dead when beachside homes collapsed.

Bob Pifer, a lead forecaster with the National Weather Service in Miami, said the record-breaking winter storm over the weekend was beyond the experience of most people.

"Word was out enough that everybody knew something big was coming, but they put it in their own historical perspective," he said Wednesday.

He said the National Oceanic and Atmospheric Administration, the parent agency of the National Weather Service, would do a detailed review of the forecasting for the storm, standard in the wake of any major weather system.

Shelley said Gov. Lawton Chiles would "call upon the National Weather Service to work with us to upgrade their technologies so that these early warnings are available to our local emergency-management directors."

She said that she wasn't accusing anyone of dropping the ball but that local officials, who have the first responsibility for ordering evacuations, have told Chiles that they didn't think they were adequately warned about the storm.

"We are asking the National Weather Service to review with us their procedures for the warning status, the alert status, the watch status, so that the most timely notification to the local officials can occur," Shelley said.

State Sen. Charles Williams, D-Tallahassee, said he didn't intend to be critical of the National Weather Service.

"It was of such magnitude and happened so suddenly that nobody--nobody--could predict that we would have the wind damage and the high waters," he said.

But Rep. Allen Boyd, a Monticello Democrat whose district had 14 deaths, said he thought there should have been better emergency and evacuation procedures.

"We were unprepared, it came without warning," Boyd said.

"We have two communities that are washed off the face of the earth," he said, referring [to] Deckle Beach and Keaton Beach in Taylor County. "I don't know if we could have stopped that, but we certainly could have stopped the deaths."

"It all happened so suddenly," Pasco County Commissioner Ed Collins told Chiles late Monday, when the governor toured Hernando Beach and other coastal towns. "Nobody expected the tides to come in as high as they did early Saturday morning. It caught everybody by surprise."

Obviously something went wrong with storm warnings, but what?

Tallahassee Democrat, Friday, March 19

Governor Chiles is looking for an answer to that question, and right now the federal weather-information network looks bad.

Chiles released a lengthy transcript of telephone and radio contacts between the State Department of Community Affairs, county emergency offices and National Weather Service outposts in Miami and Tampa.

Conversations were filled with seemingly routine comments about high waves and winds, falling temperatures and possible tornado lookouts.

But there was no hint of the towering walls of water that smashed homes in coastal communities or the winds of more than 70 mph that ravaged 23 counties early Saturday morning. At least 39 lives were lost as the storm blasted across the state.

"So we're looking at close to seven-foot elevation flooding," the transcript quoted a voice from the Tampa weather-service command post. "Have you opened any shelters in the counties? Are you going to open shelters?"

"What we were thinking was that we were going to be able to squeak by this high tide this morning. The afternoon would be the problem. Obviously, we underestimated the tidal rise, based on the storm itself--and it ain't over yet. That's the bad news."

The transcript quoted Skip Dugger, an operations officer in the state's Division of Emergency management, telling the Miami weather center at 9:32 p.m. Friday that cable television's *Weather Channel* and several local TV stations along the coast were reporting hurricane force winds. The Miami bureau replied that "right now, we got a couple of tornado watches over the state" and that winds offshore were 45 to 50 mph.

Subhead: [**Forecasters defend work for storm**]

Doug Reardon, *Tampa Tribune*

(based also on *Associated Press*) Friday, March 19

CLEARWATER--Under a hail of criticism, National Weather Service meteorologists around Florida are defending their performance during last week's deadly storm.

Fishermen, coastal homeowners, emergency officials and others are questioning the timeliness and accuracy of the weather services [sic] warnings about the storm, which led to at least 44 deaths.

"We rely on the National Weather Service. In this case, however, I am concerned that warnings were not posted early enough to keep people out of harm's way," Governor Lawton Chiles said in a letter requesting an investigation of the weather service's actions.

Weather service meteorologists in Tallahassee and Tampa acknowledge their forecasts did not accurately predict the magnitude and timing of coastal floods. But, they say, the weather service told coastal communities to watch for floods and warned of the storm's danger.

"Nobody would have forecast a 12-foot storm surge on Deckle Beach," said Paul Duval, meteorologist in the Tallahassee office.

Yet early Saturday morning a surge of that magnitude swept ashore on the beaches of Taylor County, where 10 people were killed.

No historical precedent existed for the NWS to anticipate the surge in the area, Duval said.

Moreover, he added, the service lacked the equipment in the northeastern part of the Gulf of Mexico to sufficiently monitor the storm.

Weather buoys, at $20,000 each, are scheduled to be installed in the next few years.

Chiles' office released transcripts of the service's communications with county emergency managers to show that the service failed to warn of the killer tides.

But the transcripts also show the service went to considerable lengths to show that the approaching storm was extremely dangerous.

* 2 p.m. Friday - The weather service held a conference call with county emergency managers around the state, warning "we are expecting some pretty wild weather."

*3:44 p.m. - The weather service issued a flood watch for all the coastal counties from Apalachicola to Cape Sable.

On Friday afternoon, the service was forecasting gale force winds up to 45 mph and tides two to four feet higher than normal. No evacuation orders were issued.

Then as night fell, the service began to focus on the dangers of severe thunderstorms and tornadoes, according to the transcripts. The storm was approaching the coast "like gang busters ... with winds in excess of 90 mph" a communique states.

*10:56 p.m. - Bob Balfour, chief meteorologist of the service's office in Ruskin, issued a severe thunderstorm warning and special marine warning for West Central Florida.

"That's about the highest call to action we can give," said Balfour.

Balfour's communique stated, "If you are in any of the warned counties move to a reinforced building immediately."

*3 a.m. - The storm front had passed through the Tampa Bay area.

However, most of the deadly flooding followed the storm front.

Although the coastal flood watch was still in effect after the storms passed, no specific call went out to warn about the storm surge, Balfour and Duval said.

*4:30 a.m. - Balfour issued a flood warning.

Chiles and others say the warning came too late for many people to flee.

But, Balfour said, in weather service terminology a warning designates the event is occurring or imminent.

"I don't want to get into who-shot-who," Chiles said Thursday. "What we're interested in is why there was no advance warnings of the storm surge and flooding. Could we do a better job?"

The Forecast for Weather Forecasts: Signs of Clearing

The [Baltimore] *Sun*, Sunday, March 21

The Blizzard of '93 slathered the Atlantic coast in 10 to 50 inches of snow, scattered record lows from Florida to upstate New York, fanned winds up to 110 mph, poured a quick-freezing mix of snow and hail on Baltimore, blocked interstate highways, sank ships and caused at least 193 deaths.

It was a monster, a killer, a once-in-a-lifetime snowstorm. But it did a lot less damage than it might have because people had plenty of time to get out of its way.

What made that early warning possible, said Robert Derouin, deputy chief of meteorological operations at the National Weather Service's National Meteorological Center, is bigger computers, more raw data and a better understanding of how to put the two together to accurately mimic the daily clash of forces in the atmosphere.

Forecasters at the center, located in a run-down office building in Camp Springs, first spotted the brewing atmospheric imbroglio on Monday, March 8--four days in advance.

Day-by-day, the scientists watched the storm develop, just as their computers predicted. Meanwhile, they fed their increasingly gloomy weather maps and data to 274 local weather service offices scattered around the country, as well as private forecasters, television and radio stations.

By Tuesday, local forecasters began spreading the news that snow was expected over the weekend as far south as Georgia. By Wednesday, "we had the first indication that it was going to be a superfantastic East Coast storm," said Paul J. Kocin, a research meteorologist with the meteorological center.

Road crews and the National Guard were alerted. Motorists canceled weekend travel plans. Most folks had ample time to strip supermarket and video store shelves, then hunker down in their dens and club rooms for the long winter's weekend.

Fewer people were killed, chilled, stranded and stressed than if the storm had sneaked up unnoticed. The credit, colleagues say, belongs mostly to the meteorologists and computer jockeys at Camp Springs.

Eugene M. Rasmusson, a senior meteorologist at the University of Maryland at College Park, called it "a stunningly good forecast" that took some courage to make.

"I told my wife Friday evening, this storm's either going to be one tremendous hit or one tremendous bust," he said. "The weather service didn't hedge on it. They went all out. And it worked out beautifully."

...Predicting that the Blizzard of '93 would develop four days in advance was not an astounding feat in itself, meteorologists said.

The storm was a classic example of what is called a Northeaster--where cold polar air sweeps south along the Mississippi Valley into the gulf of Mexico, picks up prodigious, moisture and then takes a U-turn up the East Coast, spreading snow in winter and rain in summer.

"This is just sort of a hybrid of a fairly typical weather system, just very extreme," said Mr. Kocin, an expert on Atlantic storms.

What was remarkable was that forecasters saw early on that the storm would do something very unusual--quickly approach peak intensity over the Gulf and the southern United States. Typically a Northeaster doesn't turn vicious until it reaches New England.

Meteorologists were able to predict the storm's size, its production of rain and snow, its timing and its track with great precision," Dr. Rasmusson said.

"I started forecasting weather in 1952 when we drew our own maps with a pencil, so I've seen the changes," he said. "Even as recently as three weeks ago, I don't think this kind of accuracy would have been possible."

But the [National Meteorological] center had a chance to shine with the Blizzard of '93, which dumped more water over the East Coast than flows out of the Mississippi River in 40 days...

MacDill air base gets reprieve

Fay Leisner, *Miami Herald* (from *AP*,) Sunday, June 20

TAMPA - As bases around the country face closure, MacDill Air Force Base got a boost Friday when Commerce Secretary Ron Brown announced the runway will stay open under federal control.

... "It's a tremendously important step," Brown said. "It is also an example of the seriousness of the Clinton administration to take the lead to convert some military facilities for different kinds of uses."

... Brown dedicated the NOAA hangar and discussed the stepped-up delivery of sophisticated weather service equipment for the Tampa Bay area. State-of-the-art Doppler will replace a 35-year-old system in the National Weather Service's Ruskin office south of Tampa in January--a year ahead of schedule.

Brown acknowledged a spate of destructive weather blamed for the loss of nearly 100 lives and billions in property damage were factors in the decision.

A wide swath of Dade County was devastated by Hurricane Andrew last August, tornadoes struck the Tampa Bay area in October, and the mid-March "storm of the century" slammed the peninsula.

He took issue with criticism by Gov. Lawton Chiles that weather warnings for the mid-March killer storm were too little, to late.

"It seems to me that most who analyzed it said unequivocally that it was probably the finest prediction job ever done on a storm of that magnitude, Brown said.

"Those who have been following these things for years and years have praised the weather service for the job they did. The situation would have been much worse but not for the early warnings."

"I would argue that we did about the best job we could possibly do in early warning and preparation," Brown said. "The preparation part is not something the weather service can do anything about except notify state and local jurisdictions, which we did. Then those steps are taken by them."

Brown said his agency is planning a $4 billion modernization of the weather service nationwide to upgrade equipment to better predict hurricanes, storms, tides and winds, and Florida is the top priority.

A weather data buoy will be located in the northeast Gulf to help warn of severe weather and coastal flooding.

THE SUPERSTORM IN THE NORTH

"Stormageddon" feared
District gets first blizzard warning since late '70s

Butler (Pa.) Eagle, Friday, March 12

If there's not at least a foot of snow on the ground sometime this weekend, a lot of important people are going to look like Chicken Little.

Everyone yesterday said the sky, full of snow, was going to fall.

For example:

*Weather forecasters pulled out all the dire descriptions they could think of to warn of the onrushing storm, which began near Louisiana and is expected to roar up through the Carolinas.

At 3 p.m., the National Weather Service placed the Pittsburgh region under a blizzard warning--the first time that's happened since the late 1970's, said meteorologist Ray Visneski.

Each day the National Meteorological Center in Washington, D.C., does computer analyses of barometric pressures nationwide. Visneski said an analysis yesterday showed the storm could bring with it the lowest barometric pressure "that has ever been registered in the history of barometers, which have been around since the 1600s."

Visneski may have been a little too caught up in the excitement.

Actually, said Dr. Richard Pasch at the National Hurricane Center in Miami, some individual weather station in the northeastern United States could record historical low barometric pressures.

He said the barometer could drop to 28 inches of mercury, "which is very low for a wintertime storm," Pasch said...

*The county coroner issued what one person in (that) office called an unusual warning to people with a history of heart or lung disease or anyone over 55: Don't shovel snow.

...A winter storm watch is in effect for Saturday through Sunday. The National Weather Service said there is a potential for 6 to 12 inches falling in the Pittsburgh area Saturday night, with 1 to 2 feet falling in the mountains to the east.

Blizzard blasts state
Storm of decade packing big punch

Charleston (W.Va.) *Daily Mail*, Saturday, March 13

...Weather officials, calling it the storm of the decade, predicted Charleston could get as much as two feet of snow in the storm blasting through the East Coast...

Lee Czepyha, a meteorologist with the weather service in Charleston, predicted the storm would set several records for 24-hour snowfall totals.

Snowfall totals were predicted between 16 and 20 inches by Sunday morning in low-lying areas and up to three feet in the mountains, meteorologists said...

"This is a very impressive storm. It's even more powerful right now than it was forecasted to be," Czepyha said.

The storm could not have come at a worse time for students at the state's colleges and universities who began their spring break Friday afternoon.

Seated before two computer monitors, meteorologist Jerry Orchanian carefully scanned through screen after screen of incomprehensible numbers, charts and graphs...

After digesting all the data the National Weather Service can muster, the forecasters working from their center near Charleston's Yeager Airport said Friday they had no doubt of what the weekend would hold for residents.

"We know that this is going to be a major snowstorm," Orchanian said. "It's probably the storm of the decade. It's the worst I've seen since I got here in 1978."

...The weather service as early as noon Friday began to consider issuing a blizzard advisory. The entire state remained under the 24-hour advisory today.

Employees at the weather service began preparing for the snow Friday. They dug snow shovels out of storage and began looking for equipment which could be used to measure what's expected to be the largest snowfall in years.

Meteorologist Phil Zinn said the forecast was something to be excited about.

"It's unusual to have a storm of this intensity any time of the season," he said. "We want to get out and stress how serious it is."

The weather service issued a winter storm watch for the weekend as early as Thursday for the Charleston area, but upgraded it to a warning Friday morning after digesting updated weather reports...

On Thursday, meteorologists predicted between 4 to 8 inches of snow by tonight. But a forecaster working the midnight shift cut the estimate in half.

"We came back (Friday) and looked at his material and thought ours was better," Orchanian said Friday...

There was no disagreement in the Charleston office that this weekend holds an unusual storm, forecasters said. And the magnitude of the predicted storm brings a little pressure to get the forecast right.

"That's part of the job," Orchanian said. "We get credit when credit is due, and we hear about it when it isn't."

Huge storm was born in Gulf of Mexico

Michael Mokrzycki, *Associated Press*, Saturday, March 13

An enormous storm developed yesterday in the Gulf of Mexico and took aim for much of eastern North America. It threatened to cause blizzard conditions from Georgia to the Canadian Maritimes, batter vulnerable coastline with hurricane-force winds and flooding, and freeze crops in the South.

"This could be the worst storm of the century," the National Weather Service in Philadelphia said in one of a series of blizzard warnings posted from North Carolina to Maine, including Washington, D.C., Baltimore, New York and Boston.

"We're not crying wolf this time. It's really coming," said Brenda Page, a weather service meteorologist in Huntsville, Ala.

...Forecasters said snow accumulations in the hardest-hit areas could be measured in feet, not inches.

...The weather service said hurricane-force winds, waves to 25 feet and tides as much as 6 feet above normal would cause major flooding and severe beach erosion along the Atlantic Coast from the Carolinas north; gales and seas to 18 feet were forecast down to northern Florida and along the Gulf coast.

...The weather service office in New York put the storm's size in perspective. By the time the snow was expected to start in the city around dawn today, the storm's center would still be over Georgia, some 700 miles away.

...The Federal Emergency Management Agency, the American Red Cross and many state and local agencies activated emergency plans, including the Emergency Broadcast System. Officials were considering evacuations of coastal areas.

Snow

Emily Tipping, *Butler (Pa.) Eagle*, Saturday, March 13

BUTLER - Here's how to survive this weekend's snow storm: stay home...

The National Weather Service office in Pittsburgh said the winter storm that is blanketing the southeastern part of the country has stayed on track, packing up to 18 inches of snow fall for the Pittsburgh area by tomorrow night.

Blizzard conditions are expected, as well, with snow drifts, winds up to 50 mph and below-zero temperatures.

...Jim Orloff, State Police Trooper at the New Castle barracks, said most advice for winter driving is common sense--don't go out if you don't have to...

Windy winter storm leaves six-foot drifts in Alabama

Associated Press, Sunday, March 14

..."it's turning into a record snowstorm for the East Coast," said National Weather Service meteorologist Mike Wyllie in New York City...

"This is a hurricane with snow," said Devin Dean, a forecaster at the Atmospheric Research Center of the State University of New York in Albany.

Battered by blizzard

Dennis B. Roddy, *Pittsburgh Post-Gazette*, Sunday, March 14

A massive blizzard--which threatened to be the worst in a century--blasted Pennsylvania yesterday, snarling traffic, stranding travelers, emptying store shelves, and canceling many events.

..."It's clear it's going to get a lot worse before it gets better," said Lt. Gov. Mark Singel, head of the state's Emergency Management Council. Singel said it was likely that Gov. Casey would declare a statewide emergency.

"Using the terminology of some people, it may be a history making type of storm. That's the magnitude we're talking about here," said Russell Demaris, a hydrometeorologist at the weather service's Pittsburgh office...

Pittsburgh International Airport closed at 1 p.m., stranding 5,000 travelers in its cavernous terminal.

Massive Snowstorm Batters Region

Stephen C. Fehr, *Washington Post*, Sunday, March 14

A weekend storm that had everything--snow, sleet, rain, high winds, even lightning and thunder--pounded the Washington area yesterday, dumping more that a foot of snow, knocking out electrical power, disrupting travel and shelving weekend plans for thousands of residents.

The storm, carrying hurricane-force winds and this area's largest snowfall in a decade, forced Washington to hold up a collective "Closed" sign yesterday.

After two days of hearing forecasters' warnings about the intense storm approaching from the Gulf of Mexico, most people stayed home. Airports, shopping malls, restaurants and other places usually busy on weekends were shut down, and few motorists braved slushy roads throughout the region. Mail wasn't delivered in many areas, and the few gasoline stations that were open sold fuel to snowplows.

As a result, the area avoided many of the maladies that have plagued it during past storms--such as in 1983, when a powerful weekend snowstorm stranded hundreds of people on highways and in airports and bus stations. Roads were virtually empty yesterday, with few serious accidents and no fatalities.

Don't overexert yourself shoveling snow

The Times/Beaver (County, Pa.) Newspapers, Sunday, March 14

BRIGHTON TWP. - If it's your job to clear the snow from your sidewalks and driveway, be careful. Overexertion can cause a heart attack.

Tales of heroism, humor, hardship

Pittsburgh Post-Gazette, Sunday, March 14

...Most hospitals said their emergency rooms were unusually quiet during the blizzard, but their staffs were pulling double duty because most relief shift workers were unable to come in.

At Allegheny General Hospital, Valerie Say began preparing for a crisis at 4:30 p.m., Friday, when she heard the blizzard warning from the National Weather Service.

It's worst storm in 43 years

Beaver County (Pa.) Times, Sunday, March 14

You are witnessing the worst snowfall in 43 years.

Meteorologist Victor Nouhan of the Nation Weather Service in Moon Township expected 16 to 20 inches of snow to fall by Sunday morning. Lesser amounts were to continue falling throughout the day...

Gov. Robert P. Casey declared a state of emergency throughout Pennsylvania Saturday. All interstate highways closed...

"A lot of people may be shut in," he (Nouhan) said. "They should also worry about heavy drifting."

The (weather) service is warning residents that conditions are life threatening.

"Don't venture outside. And if you have to, don't venture outside unless you have a four-wheel-drive vehicle," Nouhan said.

His warning was too late for hundreds of motorists who got stranded along area highways and at Pittsburgh International Airport on Saturday. The airport closed early Saturday afternoon and wasn't scheduled to reopen before 8 a.m. today. Airports in Harrisburg and Philadelphia also closed.

Storm of '93 takes place in history

Charleston (W.Va.) Daily Mail, Monday, March 15

The great snow of 1993 was one that today's children might very well tell their grandchildren about.

The 17.2 inches of snow that fell in Charleston between Friday and Saturday is the greatest snowfall ever recorded for the city in a 24-hour period, said John Lewis, a National Weather Service meteorologist.

Drivers causing problems
Officials repeat: Stay off roads

Roger Gaboury, Schenectady, N.Y., *Daily Gazette*, Monday, March 15

FONDA - Montgomery County officials were perturbed and baffled by motorists who broke the driving ban to venture into the sun-covered and snow-covered roads Sunday.

Under the state of emergency imposed with the advent of Saturday's storm, all county roads were closed to non-emergency traffic...

"Believe it or not, only one couple we found was going out to get something to eat. Everybody else was going to the video store," said Rick Sager, the county's deputy emergency management director...

"People just aren't listening to the warnings," Furman said.

How about that Weather Channel? (editorial)

Charleston (W.Va.) *Daily Mail*, Monday, March 15

Nothing like a little snow to give people a little perspective...And how about that Weather Channel? ...watching the weathermen was riveting.

The Weather Channel may be as dull as dishwater most of the time, but it was darned interesting this weekend. The National Weather Service and the personnel of the Weather Channel probably saved countless lives with the urgency of their warnings.

Death Toll in State: 19 Dead

Associated Press, Monday, March 15

The Blizzard of '93 was followed by biting winds and temperatures that froze the state (Pennsylvania), causing at least 19 deaths and leaving some roads too dangerous for travel a full day after the snow ended...

Most of the 19 deaths were blamed on exertion after the storm...

Blizzard brought flurry of TV news activity

Barbara Vanchen, *Pittsburgh Post-Gazette*, Monday, March 15

..."We knew it was coming. We predicted it. We were ready for it," Al Blinke, WPXI's news director, said yesterday afternoon, as his own snowy driveway awaited his attention...

WPXI...called in extra staffers to flesh out its normally spartan (sic) weekend crew...weatherman Kevin Brenson..and anchors Lori Savitch and Margaret Shortridge camped out...Some had brought their sleeping bags...The story was much the same in newsrooms at WTAE and KDKA, where hardships became part of the routine...

Region Turns Arctic
11 deaths reported in region

Anthony R. Wood, *Philadelphia Inquirer*, Monday, March 15

The epic winter storm that shattered snowfall records and is being blamed for killing at least 11 people in the area has left the region encased in a rock-hard mass of snow and ice.

Philadelphia, ordinarily quiet on any Sunday, yesterday was locked in what the National Weather Service called an "arctic landscape" as the storm generated extraordinarily cold weather, with temperatures expected to drop into the single digits overnight...

Officially a foot of snow fell in Philadelphia, most of it Saturday morning, sometimes at the rate of 2 inches an hour...

Thanks to the steady warnings of weather forecasters, the Streets Department was able to have trucks ready to roll about 3 a.m. Saturday...

The weather apparently did not deter many casino gamblers. The Trump Taj Mahal in Atlantic City was booked up for the weekend--although the storm did drive occupancy down to 90 percent--and the casino floor at Bally's Grand yesterday was crowded...And the only public transit that rolled through the blizzard were casino busses.

A Blizzard is Tamed

Editorial: Albany, N.Y., *Times Union*, Monday, March 15

... Ready to meet nature's monster was a network of road crews, emergency planners, state and local officials, shelter volunteers, utility repair workers and the National Weather Service, whose early alerts gave everyone time to prepare for the worst.

Everyone affected by storm

Yvette H. Blackman, *Associated Press*, Monday, March 15

ALBANY - ...The storm that barreled up the East Coast Saturday on the anniversary of the Blizzard of 1888 paralyzed Syracuse under almost 38 inches of snow. No other major city received as much snow as Syracuse...

Over exertion appears to be the cause of at least four of six storm-related deaths reported across the state. The four victims, all men, apparently suffered heart attacks while shoveling snow.

Broadcasters brave the blizzard to report on Storm of the Century

Steve Bornfield, Albany (N.Y.) *Times Union*, Tuesday, March 16

...Yes, the Blizzard of '93 seriously challenged local broadcasters. Bottom line: They performed wonderfully under snow-bound pressure, keeping us well-informed on the worst Storm of the Century...

All shelled out emergency declarations and phone numbers, road condition info, shelter availabilities, interviews with police and clean-up crews, and on-the-spot reports from shivering, blizzard-blown reporters...

They gamely maintained their professionalism while battered by the elements, imploring people to do what they couldn't--stay inside.

It can't get any worse that this

Butler County (Pa.) Times, Tuesday, March 16

...And giving credit where credit is due, local forecasters and the National Weather Service were right on the mark with their predictions. The storm came and went almost exactly as they said it would. Local radio and television stations were very good at keeping their listeners apprised of the storm's path.

WEATHER: Storm holds true to computer model

Craig Brandon, Albany *Times Union*, Tuesday, March 16

...Early Tuesday, March 9, before a single flake of snow had fallen, the computers were predicting the possibility of a major storm as three storm systems appeared to be converging over the Gulf of Mexico.

By Thursday forecasters were predicting a major storm and by Friday afternoon emergency broadcast systems went into operation warning people to stock up on food and flashlight batteries...

The fact that the storm also occurred on a weekend was a factor in allowing people to stay home.

"I think the weekend was a factor, and the accuracy of the forecasts were a factor," said John Quinlan, a meteorologist for the National Weather Service in Albany. "The warning were issued far in advance and people believed them, even though it seemed unlikely to anyone who was outside Friday."

Cooperation helped area weather storm

Mathew Roy, Schenectady, N.Y., *Daily Gazette*, Tuesday, March 16

...Michael Landin, a meteorologist at State University of New York at Albany, said more might have died had it not been for accurate predictions of a major storm that the public began hearing as soon as Monday of last week. The predictions accurately tracked the storm through Saturday and Sunday.

Storm coverage was a credit to local TV, radio broadcasters

Schenectady, N.Y., *Daily Gazette*, Tuesday, March 16

It's a tribute to local coverage of the weekend blizzard that by Saturday night I was very tired of it.

The blizzard was a story that was made for local television and radio. With a situation that was changing hourly, with the very real risk to people and property, broadcasters were in a position to let people know what was going on minute to minute, and so to give viewers and listeners a chance to prepare...

We knew the storm was coming. We knew that lines might be long at the grocery or the video store. We could see what the storm was doing in other parts of the country. We had been warned what to wear, where to call, and most of all what not to do--the short version being to forget about any travel for awhile. And we knew that the storm was moving quickly, so we might see sunshine by Sunday--and some of us did.

So, having been warned and warned again, we sat Saturday night, the storm roaring outside, flashlights at the ready, pantry stocked, emergency phone numbers near the phone, and watched the heaps of snow pile outside.

Storm toll 219; last 24 campers safe

Associated Press, Wednesday, March 17

The last of 24 Michigan campers jumped and waved at a search helicopter and were rescued from the snowy Appalachian wilderness yesterday, four days after being stranded by a megastorm that killed 219 people from Cuba to Canada.

The campers, mostly teenagers who all had undergone wilderness survival training, were among a group of 117 who set out more that a week ago and had been scheduled to emerge from the woods yesterday.

Most had been found Monday, leaving 21 students and three teachers missing.

They were located yesterday afternoon...

Media Interviews: Charleston, W.Va., March 18

Daily Mail - When he needs a good quote, he calls the Charleston Weather Service Forecast Office, said city editor Frank Hutchins. "Every time I've called, they've been more than helpful. Access to the staff is "excellent." Hutchins reports the WSFO even made themselves available for a Saturday photo op. "We've all been pleased with the weather service. They've always been cooperative."

The Gazette - Gazette reporters spent much time interviewing weather service forecasters during the storm. They routinely provide quotes and are always "very cooperative," according to assistant city editor Andy Wessels.

WSAZ-TV3 (NBC affiliate) - "If they (the public) didn't get the word, it's their own fault," said weathercaster Tony Cavalier. He did two interviews with "my colleagues" at the WSFO Saturday during the storm and got plenty of "quality info" that was understandable for non-meteorologists. "I try not to bother the forecast office when I know they're going to be busy. But when I do call they're always very helpful."

WCHS-TV83 - Reporter Melanie Walters says she "just loves the National Weather Service." The station was "highly impressed" with the NWS weather wire; station newscasters wanted to put the NWS winter storm advisory on a crawler Thursday night, but management decided not to. "Kudos for John Lewis" and my other "colleagues" at the Charleston weather service office.

Media Interview: Roanoke, Va.

WDBJ-TV7 (CBS affiliate) - Weathercaster Patrick Evans was "pleased with coverage of events leading up to the storm" and was "impressed with the model runs." The Charleston forecast office, he said, does a "super job; they always do a very good job keeping open lines of communication." Ken Batty was called about "our side of the mountains. He is always ready to go." Evans stayed in touch with the weather service (in Sterling, Va., and Charleston) prior to, during, and after the storm. The Weather Service gives "solid forecasts," he said, but he would like snowfall depths on a more regular basis. Otherwise, "we had all the tools we needed to keep the public informed. (The weather service) was terrific. By

Tuesday night, we had a bead on the storm from the local (Charleston) office and Washington."

Asked how the weather service's Charleston office could have done better for broadcast meteorologists, weathercaster Robin Reed said "I can't think of anything we were lacking." He did say that the snowfall forecasts could have been better: 10-inch guess Wednesday. 12-inch guess by Thursday. Blizzard warnings by Friday noon.

The Charleston office is always helpful; "John Lewis' weather book is 'Weather 101.' It's helped us out quite a bit."

Media Interviews: Indiana, Pa., March 18

Indiana Gazette - Editor Karl Kalogi says the *Gazette's* new Sunday edition (begun in response to the *Pittsburgh Press* strike) ran on its front page in 72-point type: **Leapin' Lizard It's a Blizzard**. Reporter Randy Wells, who did most of the storm stories, said the weather service Pittsburgh office is always very helpful. "They are not real technical, (but are) easily understood...with not a lot of technical jargon.

Media Interviews: Albany, N.Y., March 19

Times Union - City editor Carl Korn says he "tends to use Accu-Weather for daily weather information. When a storm comes, I use 40% Accu-Weather, 40% National Weather Service, 20% SUNY at Albany." He called the Albany WSFO's responsiveness "truly excellent." In response to inquiries, he said the WSFO staff is "patient, very forthcoming. They looked things up, (gave) hour-by-hour descriptions. (They gave) comparisons with earlier storms (and) records from the National Weather Service."

Gazette - City editor Tim Fonda uses the Albany WSFO for "breaking news," but has no NOAA weather radio. The paper subscribes to the Associated Press weather wire and weather information from the Weather Center at Western Connecticut State.

WRGB-TV6 - Weathercaster Steve LaPointe said that the office is otherwise always "very helpful." Their forecasts are always "clear, very organized, and timely."

WNYT-TV13 - Weathercaster Arnie Rosen said during the storm he called the WSFO "many times, regularly." Their statements were "pretty thorough." Forecasters were "very cooperative." He thinks the weather service does "a really good job. Others might like to take cracks. But I think they're (NWS forecasters) greatly underrated. I wish they could get more credit. The weather service takes a lot of hits, (but they) deserve a bigger pat on the back. I always try to credit the weather service; I did an internship with the weather service in Garden City in the '70s."

WGY Radio - Reporter Monica Mahaffey said the Weather Service was "right on top of it (the storm). They were huge! The hourly snowfalls were good, and very timely...and I'm not an easy person to please." As far as doing interviews, the weather service forecasters are "dolls. They do tape. They're not jerks about it. When you're really busy, you tend to be edgy; but not them."

Public Interview: Albany

Grizzled old cab driver from Albany airport to hotel: "The (Weather Service) forecast of the storm was right on the money, but so was the Farmer's Almanac."

Letters:
Tampa Tribune, Wednesday, March 17 - As one whose job it is to monitor, forecast, explain, and communicate expected weather and appropriate warnings, a few comments are in order. In the wake of the massive storm that has just passed across Florida, we are all counting our blessings. With a storm of this magnitude, it is not unusual for there to be a certain amount of confusion and uncertainty on the part of the public and out-cries of "we weren't told."

My comments are directed more to public officials who claim they weren't told. WTVT Channel 13 began a discussion of the unusual nature of this storm five days in advance of its arrival--three days before it was even on the weather map. With each passing day, it was stressed more specifically what could be expected.

As the storm approached Friday, we began periodic special updates detailing and defining its impact. Before the storm arrived, terms such as "dangerous," "unprecedented," "life-threatening" and "can't emphasize enough" were continuously used.

The multiple facets of this storm were detailed. During this period and during the storm's duration we interrupted regular programming, frequently stressing warnings on gales before and after the tornado threat; the tornadoes and damaging winds; flooding potential, and cold wave frost/freeze expectations.

It is beyond my comprehension how any public official couldn't understand and be prepared for any eventuality of the storm event.

The National Weather Service numerical predictive unit at the National Meteorological Center in Washington did an outstanding job on projecting this unusual storm. Somewhere there continues to be a breakdown between prediction, warnings, and civil action. I am not convinced more money will fix it.

The public also needs to realize, even in the absence of someone taking them by the hand and putting them under a table when the wind blows, or telling them not to go to bed when gale warnings and a flood watch are under way, that individual vigilance is needed to protect one's life and those you love.

There are storms that are still unpredictable--this was not one.

--Roy Leep
Tampa

The writer is executive director of WTVT Television Weather Services.

The following excerpts were taken from a letter, dated May 18, 1993, by Ms. Clarice Carter of Lake Placid, Florida. She wrote Dr. Friday in support of NWS after reading a newspaper article critical of NWS performance.

"The National Weather Service and its very competent meteorologists are 'on the carpet' needlessly. At the first mention of the word 'storm,' days before the March storm hit us, I was almost glued to the TV set (and everyone else should have been!) because I must see to the safety of my elderly mother, her house and pets, and my own house ...

As the storm moved nearer Florida's west coast the meteorologists gave excellent reports of its progress, the impending danger...

There are too many people who will not pay attention to the weather news. ...those same people are the first to scream, or whine, 'Why didn't someone tell me?' ...But the weather bureau and meteorologists most definitely are not to be blamed! You did your job and did it well. Thank you. You are appreciated."

These excerpts are from a letter by Mrs. Eva Snow to the Alpine Lake, West Virginia, Newsletter. The Snows, a retired couple, live near Tampa, Florida, during the winter and at Alpine Lake during the summer. The letter recounts their experience with the Superstorm.

"...The 'No Name Storm of the Century'...was approaching Florida's West Coast. Marine advisories were posted, storm warnings were out... About dusk, dirty little clouds began flying across the sky. The Weather Service advised us to stay up...from 12 a.m. to 2 a.m. when the worst of the storm was to hit the Tampa Bay area. Morning came...with gale force winds and the water was rising. Lots of roofs were still being blown off. (We) went out to check the water level of the Bay. We found we were already cut off from the main road. ...the sheriff ordered the whole park evacuated. The worst period of flooding was expected around 4 p.m. when high tide combined with the storm surge. The Weather Service said we might possibly have four or five more feet of water and that would wipe out our park. Eight of us piled into a pickup. The Hillsborough County Sheriff's Department took care of all our needs at the shelter.

The high tide and surge did not occur in our area, and we were spared. A lot of people criticized the Weather Service for failing to give sufficient warnings... I feel they did the best job they could."

March Snowstorm Given Credit for a Bumper Crop of Babies

Leef Smith, Washington, D.C., *Washington Post*, Saturday, December 4

Nine months after one of the century's worst winter storms in the Washington area, hospitals from Reston to Cheverly are reporting a boomlet of "blizzard babies."

Reston Hospital Center is delivering as many as 10 babies a day, twice the usual number for this time of year.

"There's just something about snow and a fire in the fireplace," said Amy Gallagher, 30, of Montclair. She and (her) husband...had their third child...on Nov. 26.

(She) was due today, the date that doctors calculate a baby conceived during the March 13 blizzard would be born.

Selected Emergency Management Responses

FEMA Northeast Division - FEMA acquires NWS information from NWR, The Weather Channel, and phone calls to NWS field offices. They were very impressed with the timeliness and accuracy of the NWS forecast and warning products. They prepositioned staff people in Pennsylvania, West Virginia, Delaware, Maryland, and Virginia to support state emergency management organizations. In the aftermath of the storm, they were very concerned about the flood potential in the Mid-Atlantic and Northeast. FEMA Headquarters acquires weather information through the regional FEMA offices.

WSFO Washington, D.C. - The EMOs in the WSFO Washington service area were very pleased with the support provided by NWS. They were particularly impressed with the pre-storm phone call briefings alerting them to the major winter storm several days in advance. Many of the local EMOs were also very pleased with the pre-storm briefings provided over NAWAS. Some of the state EMOs also use the Weather Channel to acquire weather information.

WSFO Charleston - State and local emergency management organizations in the WSFO Charleston service area were very satisfied with the service they were provided. The WSFO staff provided initial advance warning of the event to WV officials by phone. The WV Office of Emergency Services acquires NWS products via NWWS and redistributes the information via a teletype link called WEAPONS to the state police and through them to the EMOs. They also acquire weather information from The Weather Channel. One county in West Virginia first heard of this potential winter storm from the national media several days in advance. Some counties in West Virginia do not have NAWAS drops and were interested in acquiring a drop for their county EMO.

WSFO Pittsburgh - EMOs in the WSFO Pittsburgh service area were similarly pleased with the information they received regarding the **Superstorm**. The long lead time assisted many county EMOs in staff preparation, opening shelters, and coordination with law enforcement and health organizations. The Pennsylvania Emergency Management Agency (PEMA) has a very sophisticated dissemination system for the county EMOs. They acquire NWS products via NWWS and use an automated computer/satellite communications system to disseminate these products to local EMOs. PEMA also acquires weather information from a private vendor. They were very pleased with the accuracy and lead time of the NWS forecasts. The majority of the local EOCs provided similar responses. Some of the counties in western Pennsylvania also activated the county cable TV EBS system, however, not all counties have this capability.

WSFO Albany - WSFO Albany and the NY State Emergency Management Office (SEMO) had recently signed an agreement that clarified the responsibilities of each regarding dissemination and exchange of information concerning weather-related hazards. NYSPIN is the primary means of disseminating NWS information to NY EMOs. NYSPIN also provides NWS with spotter type information to support the NWS mission. This system is one of few in the U.S. that provides for a 2-way exchange between the NWS and the emergency management community. As described in Chapter 3, at 12:30 p.m., Friday, March 12, a single message activated the New York State EBS to warn the public of the storm. This message was coordinated between WSFO Albany and SEMO. In addition, at about 1:00 p.m., Friday, the Vermont Emergency Management Office, in concert with the NWS, issued a press release to EBS broadcasters and the Vermont media that included safety tips to better prepare the public for the impending storm. SEMO recommended that NWS products include information on the onset and termination of significant snow and high winds to assist the DOT with snow removal operations.

Fujita Tornado Intensity Scale

Category	Definition--Effects
(F0)	Gale tornado (40-72 mph): Light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage sign boards.
(F1)	Moderate tornado (73-112 mph): Moderate damage. The lower limit is the beginning of hurricane wind speed; peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads.
(F2)	Significant tornado (113-157 mph): Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
(F3)	Severe tornado (158-206 mph): Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown.
(F4)	Devastating tornado (207-260 mph): Devastating damage. Well-constructed houses leveled; structure with weak foundation blown off some distance; cars thrown and large missiles generated.
(F5)	Incredible tornado (261-318 mph): Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile sized missiles fly through the air in excess of 100 yards; trees debarked; incredible phenomena will occur.

Listing of Superstorm Deaths, Injuries, and Damages by State

State	Deaths Direct	Deaths Indirect	Injuries	Damage Estimates Millions
Alabama	14			$100.0
Georgia	15		420	355.0
Florida	28	22	150	1,600.0
South Carolina	2	2	4	22.2
North Carolina	2	7	13	13.5
Tennessee	2	13		0.5
Virginia		11		16.0
West Virginia	3	6		0.5
Maryland	1			22.0
Delaware		2		0.5
District of Columbia		1	2	0.5
Pennsylvania	4	48		10.0
Ohio			8	5.0
New Jersey				
New York	8		4	25.0
Connecticut				
Rhode Island				
Massachusetts				
Vermont				
New Hampshire				
Maine		2		
Totals	**79**	**118**	**601**	**$2,170.7**

Report on the Aerial Survey of the Tornadoes and Damaging Winds in Florida

1. Introduction

On Tuesday, March 17, the DST requested that an aerial survey of the wind and tornado damage in Florida be conducted. NOAA's Aircraft Operation Center (AOC) at MacDill Air Force Base, Tampa, Florida, supplied the aircraft and the pilots for the survey. Dr. Joe Golden, OAR, and Chief Scientist of the DST, and Brian Smith, NSSFC Meteorologist, conducted the survey.

The aerial survey team was hampered by low ceilings, convective showers and poor visibility for much of the time. Surveys were conducted Wednesday through Friday, March 17-19, 1993. A total of four tornado tracks were surveyed.

It was decided to terminate surveying further damage because: 1) The weather forecast for the next couple of days indicated not much improvement in clouds and ceiling conditions, and 2) One week had passed since the storm events occurred. Cleanup, especially in urban areas, would have made it difficult to ascertain near-ground wind flow and strength. Only rural regions with fallen trees or crop damage that had been left untouched, would be useful in assimilating the wind and storm type.

The following is a summary of each tornado surveyed.

Ocala North Tornado
Maximum F-Scale: F2
Path Length: 11.9 miles
Path Width: 1500 feet

This tornado began approximately 1 mile southwest of Ocala Municipal Airport in a wooded area where minor tree limb damage occurred. The tornado then tracked northeast across the central and north part of the north-south runway. The tornado demolished several hangars east of the runway. The most severely damaged one was the one furthest north. A DC-3 aircraft flipped over east of this hangar. It is not clear whether the large plane was actually in the hangar or tied down outside. The storm damage was rated a strong F-2.

The tornado strengthened again as it entered a campground southwest of the intersection of Interstate 75 and U.S. Highway 27. Several motels on the west side of this intersection sustained roof damage and minor structural damage to walls. The tornado was rated F1 at this location.

Continuing northeast, the tornado crossed northwest of the intersection of NW 27 Avenue and NW 35th Street. This was where a mobile home was demolished by the storm. The storm proceeded northeast between a set of four tall radio towers. Because these towers were near our flight level, we were not able to fly above the damage. Continuing to track northeast, the tornado crossed U.S. Highway 301-441, toppling trees. The tornado damaged a few outbuildings and uprooted a few trees just southwest of a private airfield (located 1.5 miles south-southwest of Anthony). The tornado weakened and produced only scattered tree damage from that point on. It crossed highway 200 south of Anthony and dissipated about 0.75 miles southeast of Anthony.

Ocala South Tornado
Maximum F-Scale: F2
Path Length: 10 miles
Path Width: 2000 feet

The track of this tornado paralleled the Ocala North Tornado discussed above. This tornado began approximately 12 miles south of Ocala, southwest of the Marion Oaks development along the Marion/Sumpter County line. The tornado began rather weak and moved across a northwest/southeast orientated high tension power lines. The tornado quickly gained strength and widened after moving into the southern portion of the Marion Oaks Development. Literally thousands of trees were uprooted or snapped off in this development. The tornado also became a half-mile wide at this point. Many of the trees fell in the same direction as the storm path. This is typical of fast-moving tornadoes.

The storm continued northeast and crossed Interstate 75 about 0.75 mile south of Highway 484. After crossing the interstate, the tornado produced F1 damage to trees and homes. The tornado blew the roof off a horse stall near Highway 484. The roof appeared to have lifted off the barn, become airborne, and crash landed on the north side of Highway 484. The tornado began to weaken after crossing the highway downing only a few trees and producing minor roof damage to homes.

After crossing Highway 485 1 mile north of Monroe's Corner, the tornado again strengthened. Numerous trees were uprooted at a horse farm. The tornado maintained F1 strength until 2.5 miles west of Belleview where the storm quickly dissipated.

Chiefland Tornado
Maximum F-Scale: F3
Path Length: 2.5 miles
Path Width: 800 feet

The Chiefland tornado was a relatively short-lived storm that reached its maximum strength at the end of its path. The tornado began 2.5 miles south-southwest of Chiefland and moved north-northeast towards Chiefland. Much of the damage that occurred south of the town was to trees. Trees were either uprooted or snapped. The tornado gathered strength as it entered the southwest portion of town just north of highway 345. This was where the tornado reached between F2 to F3 strength. Mobile homes were demolished, and frame or block homes suffered severe damage leaving only interior walls. Two people died in this area when a wall of their home fell on them while they were sleeping. A third person was killed in a mobile home that was demolished. The tornado ended abruptly and dissipated after producing this extensive damage. Investigation of conventional radar data indicated a small scale bow echo that moved through Chiefland. This bow structure, located on the north end of the squall line, lasted a very short time, 5-10 minutes. There was also evidence of microburst damage to the east of the tornado track. Isolated toppled trees and roof damage were identified one block west of the intersection of Alternate U.S. 27 and U.S. Highway 19.

MOUNT DORA TORNADO
Maximum F-Scale: F2
Path Length: 31 miles
Path Width: 1500 feet

The Mount Dora tornado was the longest of all of the tornadoes surveyed. It began east of Howey-in-the-Hills along the shore of Little Lake Norris. The tornado began with strengths between F0 to F1 strength with scattered damage to corrugated metal barns. It continued northeast across Little Lake Harris and produced scattered tree damage between Little Lake Harris and Lake Dora. The tornado then proceeded across Lake Dora and moved into Mt. Dora. Damage was generally light, with primary damage to fallen trees and shingles. The tornado was still between F0 to F1 strength at this time. Continuing northeast, the tornado crossed U.S. 441--Florida highway 500. The tornado produced damage to a golf course. The tornado's strength began to increase from this shore of Lake Seneca. During its trek from Lake Seneca, across highways 44 and 44A, mobile homes were demolished, greenhouses smashed, and trees toppled. The tornado reached its maximum strength, F2, here. It was also in this area where a death occurred.

The tornado continued northeast, south of Lake Norris and weakened, producing spotty damage until just crossing into Volusia County west of De Land.

This tornado was associated with a fast-moving bow-echo that accelerated as it tracked east-northeastward across the peninsula. The storms transnational motion was 60 kts near the head of the bow echo. WSR-88D data from Melbourne showed a mesocyclone in the velocity data along the path of the tornado path.

CONCLUSIONS AND ACKNOWLEDGEMENTS

Damaging downburst winds also occurred with the line of fast-moving thunderstorms that moved across the Florida peninsula. Wind gusts of 80 kts or higher occurred over several areas in Florida. A swath of greater than 80 kts was associated with the bow-echo that spawned the Mt. Dora tornado. Another swath of greater than 80 kt winds occurred south of Fort Myers to Lake Okeechobee. Little information on winds was received over the Everglades.

The DST would like to thank Captain George Player and Lieutenant Commanders Steve Nokutis and Mike White of the AOC for their assistance.

Severe Weather Verification Statistics for Florida

The following tables show severe weather event and warning verification data for the **Superstorm** as it affected Florida. Tables 1 and 2 show tornado and severe thunderstorm events, respectively; Table 3 shows all issued severe weather warnings. Events were obtained from a combination of preliminary *Storm Data* logs and aerial reconnaissance, and warnings were obtained from AFOS archive data. All times are in Central Standard Time (CST) using a 24-hour clock with leading 0's deleted. (Example, 11:30 p.m. = 2330; 12:30 a.m. = 30.) All lead times are listed in total minutes.

Description of Selected Table Columns

The follow column titles are described since they may be ambiguous or are abbreviated.

Table 1: **SEQUENCE** - first value is the tornado number, according to time of occurrence; second number denotes county number. for example, a hypothetical tornado tracking through three counties would have the sequence 1-1, 1-2, and 1-3.

Tables 1/2: **DD** - Number of deaths incurred in county.
INJ - Number of injuries incurred in county.
$$ - Damage Category

The damage category values are as follows:

1 - <$50
2 - $50 to $500
3 - $500 to $5,000
4 - $5,000 to $50,000
5 - $50,000 to $500,000
6 - $500,000 to $5,000,000
7 - $5,000,000 to $50,000.000
8 - $50,000,000 to $500,000,000
9 - $500,000,000 to $5,000,000,000

Table 3: **WBTIME** - Warning starting time
WETIME - Warning expiration time

Summary of Verification Statistics By Office

Office	**# Events**	**#Vrf Evnts**	**# Wrngs**	**# Vrf Wrngs**
Tampa, FL	45	43	26	22
Melbourne, FL	6	6	8	6
Miami, FL	7	0	1	0
Daytona Beach, FL	8	5	7	4
Key West, FL	4	3	5	2
West Palm Bch, FL	3	2	1	1
Jacksonville, FL	4	0	5	0
Tallahassee, FL	0	0	1	0
Totals	**77**	**59**	**54**	**35**

Tornado Events for Superstorm of March 12-14, 1993

DATE	STATE	COUNTY	WSO	F SCALE	SEQUENCE	EVENT TIME (CST)	WARN TYPE	WARN TIME	LEAD TIME	WATCH TIME	LEAD TIME	DD	INJ	$$
MAR12	FLORIDA	LEVY	TBW	F3	1-1	2238	TSTM	2150	48	1921	217	3	10	7
MAR12	FLORIDA	CITRUS	TBW	F1	2-1	2238	TSTM	2150	38	2020	138	0	3	6
MAR12	FLORIDA	PINELLAS	TBW	F0	3-1	2300	TORN	2238	22	2020	160	0	0	4
MAR12	FLORIDA	PASCO	TBW	F0	4-1	2304	TORN	2238	26	2020	164	0	11	6
MAR12	FLORIDA	MARION	DAB	F2	5-1	2320 - 2328*	TORN**	2335	0	2020	180*	0	0	6
MAR12	FLORIDA	MARION	DAB	F2	6-1	2320 - 2326	TORN**	2335	0	2020	180	0	—	6
MAR12	FLORIDA	ALACHUA	JAX	F1	7-1	2320	TORN**	2329	0	1921	239	1	4	6
MAR12	FLORIDA	LAKE	MLB	F2	8-1	2330 - 0000	TORN	2308	22	2020	130	1	60	6
MAR13	FLORIDA	VOLUSIA	DAB	F2	8-2	0000 - 0008	TSTM	2305	3	2020	228	0	0	—
MAR12	FLORIDA	HILLSBOROUGH	TBW	F0	9-1	2330	TORN	2308	22	2020	190	0	0	5
MAR13	FLORIDA	DUVAL	JAX	F1	10-1	0	NONE			2020	230	0	0	6
MAR13	FLORIDA	DUVAL	JAX	F0	11-1	10	NONE			2020	240	0	0	5
MAR14	FLORIDA	HIGHLANDS	TBW	F0	12-1	900	NONE					1	0	0

* Time estimated; earlier TSTM warning in effect

** Event occurrence ≤ 10 min prior to warning issuance

Severe Thunderstorm Events for Superstorm of March 12-14, 1993

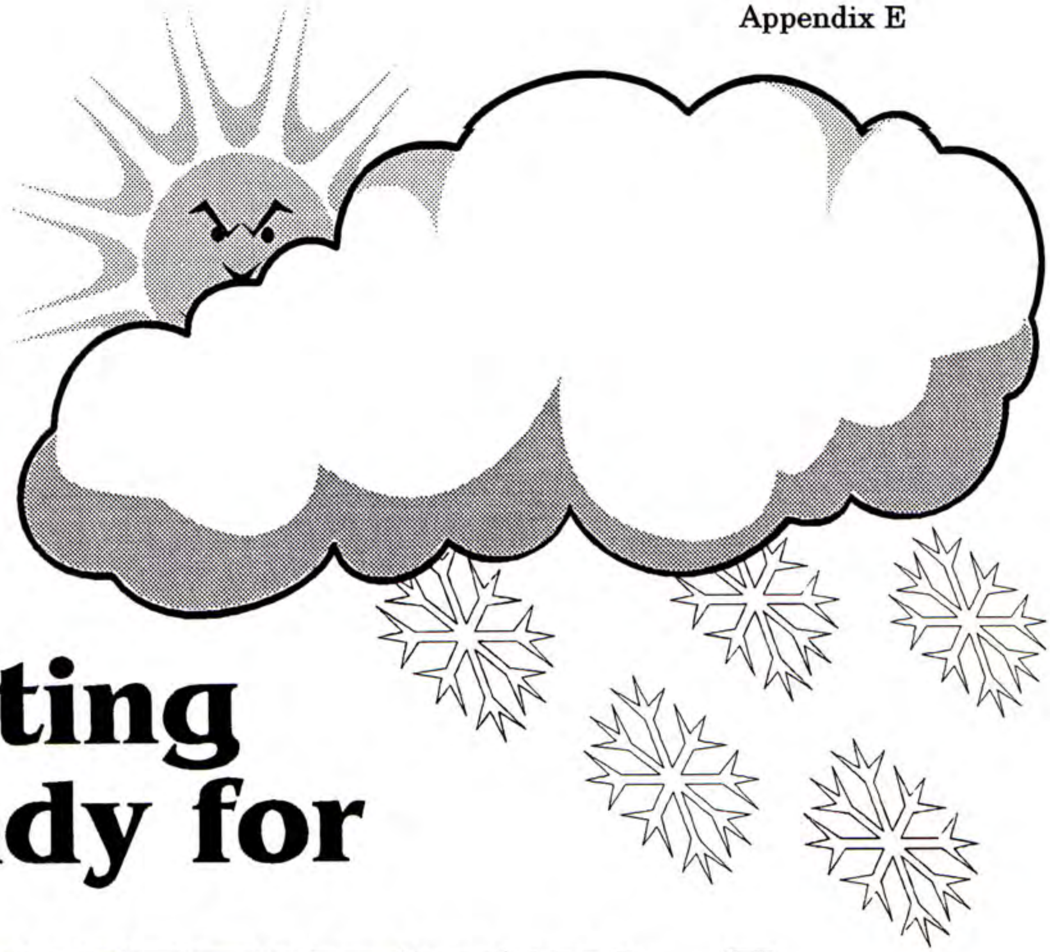
DATE	STATE	COUNTY	WSO	EVENT TYPE	EVENT TIME (CST)	WARN TYPE	WARN TIME	LEAD TIME	WATCH TIME	LEAD TIME	DD	INJ	$$
MAR12	FLORIDA	MANATEE	TBW	TSTMW	23XX	TSTM	2150		2020		1	0	5
MAR12	FLORIDA	PINELLAS	TBW	TSTM (G74)	2230	TSTM	2150	40	2020	130	0	0	0
MAR12	FLORIDA	CITRUS	TBW	TSTM (G56)	2240	TSTM	2150	50	2020	140	0	0	3
MAR12	FLORIDA	MANATEE	TBW	TSTMW	2245	TSTM	2150	55	2020	145	0	0	3
MAR12	FLORIDA	PINELLAS	TBW	TSTM (G65)	2257	TSTM	2150	67	2020	157	0	0	5
MAR12	FLORIDA	HERNANDO	TBW	TSTM (G52)	2259	TSTM	2150	69	2020	159	0	0	3
MAR12	FLORIDA	VOLUSIA*	DAB	TSTM (G64)	2300	NONE			2020	160	0	0	0
MAR12	FLORIDA	SARASOTA	TBW	TSTM (G57)	2300	TSTM	2222	38	2020	160	0	0	0
MAR12	FLORIDA	PINELLAS	TBW	A75	2306	TSTM	2150	76	2020	166	0	0	0
MAR12	FLORIDA	MANATEE	TBW	TSTMW	2307	TSTM	2150	77	2020	167	0	0	4
MAR12	FLORIDA	HILLSBOROUGH	TBW	TSTM (G83)	2309	TSTM	2150	79	2020	169	0	0	6
MAR12	FLORIDA	PASCO	TBW	TSTMW	2315	TSTM	2150	85	2020	175	0	0	5
MAR12	FLORIDA	SARASOTA	TBW	TSTM (G51)	2320	TSTM	2222	58	2020	180	0	0	0
MAR12	FLORIDA	HERNANDO	TBW	TSTMW	2325	TSTM	2150	95	2020	185	0	0	5
MAR12	**FLORIDA**	**HAMILTON***	**JAX**	**TSTMW**	**2330**	**NONE**			**1921**	**249**	**0**	**0**	
MAR12	FLORIDA	HILLSBOROUGH	TBW	TSTM (G65)	2334	TSTM	2150	86	2020	176	0	0	6
MAR12	FLORIDA	SUMTER	TBW	TSTMW	2335	TSTM	2254	31	2020	185	0	0	5
MAR12	FLORIDA	PASCO	TBW	TSTMW	2335	TSTM	2150	95	2020	185	0	0	4
MAR12	FLORIDA	MANATEE	TBW	TSTMW	2335	TSTM	2150	105	2020	195	0	0	5
MAR12	FLORIDA	LEE	TBW	TSTMW	2336	TSTM	2150	106	2020	196	0	0	5
MAR12	FLORIDA	PINELLAS	TBW	TSTMW	2338	TSTM	2150	108	2020	198	0	0	3
MAR12	FLORIDA	MANATEE*	TBW	TSTMW	2340	TSTM	2150	110	2020	200	0	0	
MAR12	FLORIDA	POLK	TBW	TSTMW	2345	TSTM	2254	51	2020	205	0	0	5
MAR12	FLORIDA	SARASOTA	TBW	TSTMW	2347	TSTM	2222	75	2020	207	0	0	3
MAR13	FLORIDA	POLK	TBW	A100	0	TSTM	2254	66	2020	220	0	0	0
MAR13	FLORIDA	HILLSBOROUGH	TBW	TSTMW	0	TORN	2308	52	2020	220	0	0	
MAR13	**FLORIDA**	**MANATEE***	**TBW**	**TSTMW**	**8**	**TORN**	**2343**	**25**	**2020**	**228**	**0**	**0**	
MAR13	FLORIDA	HARDEE	TBW	TSTMW	10	TSTM	2323	47	2020	230	0	0	3
MAR13	FLORIDA	ORANGE	MLB	TSTM (G62)	10	TORN	2337	33	2020	230	0	0	2
MAR13	FLORIDA	FLAGLER	DAB	TSTMW	15	TSTM	5	10	2020	235	0	0	5
MAR13	FLORIDA	SEMINOLE	MLB	TSTMW	20	TORN	2348	32	2020	240	0	1	2
MAR13	FLORIDA	VOLUSIA	DAB	TSTM (G55)	22	TSTM	5	17	2020	242	0	0	0
MAR13	FLORIDA	POLK	TBW	TSTMW	25	TSTM	2254	91	2020	245	0	0	2
MAR13	FLORIDA	FLAGLER*	DAB	TSTM (G75)	30	TSTM	5	25	2020	250	0	0	
MAR13	FLORIDA	POLK	TBW	TSTMW	40	TSTM	2254	106	2020	260	0	0	3
MAR13	FLORIDA	ORANGE	MLB	TSTMW	55	TSTM	42	13	2020	275	0	0	2
MAR13	FLORIDA	VOLUSIA	DAB	TSTM (G55)	55	TSTM	5	50	2020	275	0	0	3
MAR13	FLORIDA	POLK	TBW	TSTMW	100	TSTM	2254	66	2020	280	0	0	5
MAR13	GEORGIA	GLYNN	SAV	TSTMW	100	TSTM	41	19	1921	339	0	0	5
MAR13	FLORIDA	VOLUSIA	DAB	TSTMW	110	NONE			2020	290	0	0	3
MAR13	FLORIDA	MONROE	EYW	TSTM [illegible]	110	NONE			[illegible]	[illegible]	0	0	[illegible]

Severe Thunderstorm Events for Superstorm of March 12-14, 1993

DATE	STATE	COUNTY	WSO	EVENT TYPE	EVENT TIME (CST)	WARN TYPE	WARN TIME	LEAD TIME	WATCH TIME	LEAD TIME	DD	INJ	$$
MAR13	FLORIDA	SARASOTA	TBW	TSTM (G71)	110	TSTM	37	43	2020	290	0	0	0
MAR13	FLORIDA	BREVARD	MLB	TSTMW	113	TSTM	58	15	2020	293	0	0	2
MAR13	FLORIDA	CHARLOTTE	TBW	TSTM (G53)	115	TSTM	2323	112	2020	295	0	0	0
MAR13	GEORGIA	LONG	SAV	TSTMW	115	NONE			1921	354	0	0	0
MAR13	FLORIDA	LEE	TBW	TSTM (G64)	120	TSTM	2323	117	2020	300	0	0	3
MAR13	GEORGIA	BRYAN	SAV	TSTMW	130	NONE			1921	369	0	0	0
MAR13	FLORIDA	DE SOTO	TBW	TSTMW	130	TSTM	2323	127	2020	310	0	0	4
MAR13	FLORIDA	LEE	TBW	TSTMW	145	TSTM	131	14	2020	325	0	0	6
MAR13	GEORGIA	CHATHAM	SAV	TSTMW	158	TSTM	142	16	1921	397	0	0	0
MAR13	FLORIDA	LEE	TBW	TSTM (G60)	202	TSTM	131	31	2020	342	0	0	6
MAR13	FLORIDA	LEE	TBW	TSTMW	211	TSTM	131	40	2020	351	0	0	5
MAR13	FLORIDA	COLLIER	MIA	TSTMW	215	TORN**	225	0	2020	355	0	0	2
MAR13	GEORGIA	EFFINGHAM	SAV	TSTMW	220	TSTM	142	38	1921	419	0	0	0
MAR13	FLORIDA	COLLIER	MIA	TSTMW	222	TORN**	225	0	2020	362	0	0	0
MAR13	FLORIDA	MONROE	EYW	TSTM (G65)	222	TSTM	205	17	2020	362	0	0	0
MAR13	FLORIDA	LEE	TBW	TSTMW	235	TSTM	131	64	2020	375	0	0	3
MAR13	**FLORIDA**	**MONROE***	**EYW**	**TSTMW**	**243**	**TSTM**	**230**	**13**	**2020**	**383**	**0**	**0**	
MAR13	FLORIDA	MONROE	EYW	TSTM (G58)	258	TSTM	232	26	2020	398	0	0	0
MAR13	**FLORIDA**	**SARASOTA***	**TBW**	**TSTM (G59)**	**300**	**TSTM**	**256**	**4**	**2020**	**400**	**0**	**0**	
MAR13	FLORIDA	MARTIN	PBI	TSTMW	315	NONE			2020	415	0	0	3
MAR13	FLORIDA	INDIAN RIVER	MLB	TSTM (G72)	327	TSTM	305	22	2020	427	0	1	5
MAR13	FLORIDA	GLADES	MIA	TSTMW	330	NONE			2020	430	0	0	5
MAR13	**FLORIDA**	**PALM BEACH***	**PBI**	**TSTMW**	**339**	**TSTM**	**331**	**8**	**2020**	**460**	**0**	**0**	
MAR13	FLORIDA	DADE	MIA	TSTM (G72)	345	NONE			2020	445	0	0	0
MAR13	FLORIDA	DADE	MIA	TSTMW	352	NONE			2020	452	1	2	5
MAR13	FLORIDA	BROWARD	MIA	TSTMW	400	NONE			2020	460	0	0	3
MAR13	FLORIDA	PALM BEACH	PBI	TSTM (G64)	400	TSTM	331	29	2020	460	0	0	3
MAR13	FLORIDA	DADE	MIA	TSTMW	400	NONE			2020	460	0	0	3

* In preliminary log but not in F-8

** Event occurred ≤ 10 min prior to warning issuance



Getting Ready for WINTER !

Winter Weather Preparedness Week in Alabama December 7-11, 1992

A Public Awareness Campaign
sponsored jointly by the
National Weather Service and the
Alabama Emergency Management Agency

WINTER STORM PREPAREDNESS WEEK in Alabama
December 7-11, 1992

Governor Guy Hunt has proclaimed December 7-11, 1992, as Winter Weather Preparedness Week in Alabama. The National Weather Service and the Alabama Emergency Management Agency ask your help in spreading information to the public about winter weather preparedness.

One may not think of Alabama as a state that is directly impacted by severe winter weather. However, in many years winter weather has been the primary cause of weather related deaths and injuries in Alabama.

What's Inside

THE COLD FACTS

Alabama is no stranger to winter's deadly grip. One of the most tragic outbreaks of cold weather in Alabama occurred January 10-18, 1982, when 20 people died and 300 were injured. Sixteen thousand people were forced into emergency shelters and storm damage totaled some $78 million. The arctic outbreak of December 19-21, 1981, took the lives of at least two people in unheated homes and at least 17 people suffered injuries caused by slipping and falling on ice.

At least 5 people perished in the extreme cold of January 19-22, 1985, that rewrote the record low temperatures over much of Alabama. Ice accumulations up to one foot were reported in Lauderdale County. Bridges were coated with ice well into Central Alabama and four people were killed in traffic accidents on icy roads.

The most recent outbreak of severe cold weather occurred during the period December 22-25, 1989, when an arctic outbreak of unprecedented proportions spread over Alabama. Actual low temperatures for two consecutive nights dropped to the 0 to -5 degree range over the northern third of Alabama and into the single digits all the way to the Gulf Coast. Daytime temperatures reached only into the teens for two consecutive days. Brisk northerly winds created wind chills as low as -15 to -35 degrees below zero over North Alabama and zero to -15 in South Alabama. Many lakes, ponds, and creeks froze over. There was widespread damage to water pipes that burst during the lengthy freeze. Five people died due to exposure from the extreme cold.

Alabama Snow Facts

City	*Most Snow in 24-hrs*	*Date*
Huntsville	*11 in.*	*12/31/63-1/1/64*
Birmingham	*11 in.*	*1/29/36*
Montgomery	*11 in.*	*12/5-6/1886*
Mobile	*6 in.*	*2/14-15/1895*

January 18-19, 1992, the problem wasn't the extreme cold, it was snow! During that 2-day period, snow was reported from Huntsville to Montgomery. The heaviest snow of about 5 to 7 inches fell east to west across the state in a 25 mile wide band from Pickens County through Southern Jefferson and Northern Shelby Counties, east through Randolph County. At least 3 inches fell as far north as Jasper and Gadsden, and as far south as Clanton and Alexander City. Officially, with 4.5 inches at the Birmingham Airport, this snow storm went into the record books as the city's eleventh heaviest snowfall. Unofficially, though, the 7 inches found in Southern Jefferson County ties the record for Birmingham's 4th largest snow storm!

Cold Weather Facts

City	*Coldest Temperature*	*Date*
Huntsville	*-11*	*1/30/66 & 1/21/85*
Birmingham	*-10*	*2/13/1899*
Montgomery	*-5*	*2/13/1899*
Mobile	*-1*	*2/13/1899*

BE WINTER SMART

Injuries and deaths due to winter weather can be prevented through proper winter safety measures. This holiday season provides an opportunity to educate family and friends about winter weather safety rules. There is no better gift that we can give than an awareness of safety measures that could save a life. Everyone is urged to make this a safe and happy holiday and winter season by using proper winter safety precautions.

The National Weather Service, a component of the United States Commerce Department's National Oceanic and Atmospheric Administration (NOAA), issues timely warnings against the hazards of winter weather. Twenty-four hours a day, National Weather Service meteorologists work to detect the disturbances which may become winter storms and issue watches and warnings as the storms approach.

The term Winter Storm Watch means severe winter conditions may affect the area. This includes heavy snow (more than two inches), accumulations of freezing rain or freezing drizzle, heavy sleet, or a combination of these events. The watch is usually issued first and gives a longer notice of the potential for winter weather. A Winter Storm Warning is used to alert the public that a winter storm has formed and is approaching the area. People in the alerted area should listen for the latest information over radio and television or the National Weather Service's own continuous VHF broadcasts on NOAA Weather Radio, and begin to prepare for the winter weather. The Winter Storm Warning means that a winter storm is imminent and immediate action should be taken to protect life and property.

When winter weather approaches, many people may feel some apprehension about severe winter weather and how it may affect them, their home, or their family. Information in this booklet will help you to better prepare for winter and will help you handle many winter emergencies. For more information on winter safety, please contact your State/County Emergency Management Agency or the National Weather Service. Brochures containing winter safety tips are available from the National Weather Service.

WINTER'S EFFECT ON THE BODY

Winter weather can be hazardous to your health! Each year, many people are injured, suffer illness, and even death due to frostbite, and hypothermia.

During extreme cold or snowstorms, stay indoors unless it is absolutely necessary to go out. If you decide to go outside, avoid overexertion. The cold air puts an added strain on the heart. If you add unaccustomed exercise such as shoveling snow, pushing a car, or even walking too fast or too far, you risk a heart attack or stroke.

Wear proper clothing. Whether outdoors, or inside with little or no heat, wear several layers of loose-fitting, light-weight, warm clothing instead of one thick heavy garment. The trapped air warmed by the body will circulate between the layers to keep you warmer. The layers can be removed as necessary to avoid overheating.

Keep your clothes dry. Wet clothing looses all insulating value and should be changed as quickly as possible.

Mittens and a wool hat are also a necessity. The body looses about 50 percent of its heat through the head, so whether you are outdoors or inside an unheated home, day or night, a hat will go a long way in helping you to stay warm. Mittens, unlike gloves, allow the fingers to touch, keeping your hands warmer.

Watch for symptoms of frostbite and hypothermia. Frostbite causes numbness and white or blue tinted skin and occurs most commonly in the fingers, toes, ears, and nose. Hypothermia, an abnormally low body core temperature, is another condition caused by prolonged exposure to cold. Hypothermia can occur inside the house as well as outside, causing body functions to slow to a dangerously low level. Symptoms include slurred speech, incoherence, drowsiness, poor coordination, a slow heart beat, uncontrollable shivering, or no shivering at all.

At greatest risk are the elderly. According to the Center for Environmental Physiology, tens of thousands of older Americans literally 'freeze to death' in their own homes each year. These deaths are a result of cool temperatures indoors and may develop over the course of a few days, and not from prolonged exposure to the outdoors as one might think.

If you suspect hypothermia, take the person's temperature. If their temperature is below 95 degrees Fahrenheit, take them to a hospital immediately. Also, to prevent further heat loss wrap the person in a warm blanket, making sure you cover the head and neck.

Handle the person very gently. DO NOT rub or massage the extremities, DO NOT give the person alcohol or drugs, DO NOT raise the legs or place a hot water bottle on the feet, and DO NOT give hot food or hot drinks. The victim must be WARMED SLOWLY with the use of blankets and/or quilts.

WINTERIZE YOUR HOME

Your home should be just as prepared for winter as you are. Winter storms can quickly become severe, knocking down power and telephone lines. Roads can quickly become treacherous making it difficult or impossible to get out of the house. Here are some tips to help ease the hardships you and your family could suffer while riding out the snow and cold at home.

Before winter's furry hits, make sure your home is well insulated. Caulk and weather strip doors and windows to help keep the heat in and the cold out. Install storm windows or cover windows with plastic.

Have some type of emergency heating equipment available so you can keep at least one room warm enough to be livable if your furnace is not operating. Know how to use this emergency heating equipment safely to prevent fire or dangerous fumes.

Stock an emergency supply of food, now! Even if you live close to a grocery store, their supplies will dwindle fast if roads are closed to supply trucks. Include foods that require no cooking or refrigeration or have emergency cooking facilities in case of power failure. Natural foods like raisins and other dried fruit are great quick-energy producers.

Also, don't forget to stock a flashlight, a fire extinguisher, a battery powered radio, and extra batteries.

Should your furnace fail, keep water pipes from freezing. Wrap the pipes in insulation made especially for water pipes, or tie layers of old newspaper around the pipes. Cover the newspaper with plastic to keep out moisture. Let faucets drip a little. Although this wastes water, it may prevent freeze damage. Know how to shut off the water coming into the house. As a last resort you may have to shut off this main valve and drain all the pipes to keep them from freezing and bursting.

If your home furnace fails and is gas-fired, check the pilot light. Follow the manufacturer's instructions and use caution in relighting the unit. If the unit will not light, check other gas appliances to make sure your main gas supply has not been cut off. If that doesn't solve the problem, call your local utility or servicing agent for help.

Don't hesitate to ask for help if the situation at home starts to get out of control. Call a neighbor or a local social or emergency service agency. Write those phone numbers down in advance and keep them handy.

WINTER SURVIVAL ON THE ROAD

No one should drive during bad winter weather, however, business obligations or holiday plans often make winter traveling necessary. Regardless if winter weather comes to Alabama or you drive to meet it, here are some points to consider when traveling to help you have a safer trip.

First, be sure your car is in good condition and properly serviced. Snow tires and chains are a must! Keep your car's gas tank as nearly full as possible, especially if you are unfamiliar with your route, or are entering open country. This also prevents moisture from condensing on the sides of your gas tank.

Plan your trip carefully. Listen to weather forecasts and advisories and keep an alternate route in mind. Let friends or family know where you are going and when you plan to arrive. Travel by daylight and use major highways if possible since snow and ice removal will begin there first. Also try not to travel alone.

Even if you restrict your winter driving to short local trips, certain supplies can help you in an emergency. You should always keep basic items such as a windshield scraper, a set of battery jumper cables, a tow chain or rope, a bag of sand or gravel, a flashlight (with extra batteries), and road flares in your car. For longer trips, you may want to add a transistor radio (with extra batteries), a first aid kit, road maps, matches and candles, blanks, and a small non-perishable food supply such as nuts, dried fruit, and candy. A means of communication such as a 2-way radio or portable phone will prove invaluable should you need to call for help.

If you should get caught on the road during a winter storm, keep calm. Give some indication you are in trouble - turn on your flashing lights, set your flares, raise the hood, or tie a cloth from an antenna or door handle. It is usually best to remain in the car unless you can see shelter within a reasonable distance.

For heat, turn on the car engine and heater for brief periods. To avoid deadly carbon monoxide poisoning, always leave a downwind window open slightly. Also, make sure the exhaust pipe is clear of snow when the engine is running.

Exercise from time to time by clapping your hands and moving your arms and legs. Avoid staying in one position too long, but do not overexert yourself by shoveling or trying to push the car.

Above all, drive carefully and defensively. Don't try to save time by traveling faster than the road and weather conditions permit. If a storm begins to test your ability and endurance, don't hesitate to seek shelter.

WINTER STORM SAFETY RULES

Keep ahead of a winter storm by listening to the latest weather warnings and bulletins on NOAA Weather Radio, local radio and TV stations, or cable TV such as The Weather Channel for updates. Be alert to changing weather conditions and avoid unnecessary travel.

- Check battery powered equipment before the storm arrives.You may have to depend on a portable radio or TV for weather information. Also check emergency cooking facilities and flashlights.
- Check your supply of heating fuel.
- Check your food and stock an extra supply. Your supplies should include food that requires no cooking or refrigeration in case of power failure.
- Prevent fire hazards due to overheated coal or oil burning stoves, fireplaces, heaters, or furnaces.
- Stay indoors during storms and cold snaps unless you are in peak physical condition. Avoid overexertion, especially when shoveling snow.
- Make necessary trips for supplies before the storm develops or don't go at all. Arrange for emergency heat in case of power failure.
- Dress to fit the season. Wear layered, loose-fitting clothing. Wear a hat, scarf, and mittens.
- Get your car winterized before the storm season begins. Maintain a checklist of the preparation required. Keep water out of your fuel by keeping your gas tank full.
- Carry a winter storm car kit, especially if you plan cross country travel or if you anticipate travel in the northern states.
- If the storm exceeds or even tests your limitations, seek available shelter immediately. Plan your travel and select primary and alternate routes.
- Check the latest weather information before departing and drive carefully and defensively.

... *WIND CHILL INDEX* ...

A very strong wind combined with a temperature slightly below freezing can have the same chilling effect as a temperature nearly 50 degrees Fahrenheit lower in a calm atmosphere. Arctic explorers and military experts have developed what is called the wind-chill factor, which shows the combined effects of wind and temperature as equivalent calm-air temperatures.

Calm air as used in wind-chill determinations actually refers to the conditions created by a person walking briskly (at 4 miles an hour) under calm wind conditions. In effect, the index describes the cooling power of the air on exposed flesh. The wind-chill table provided here shows this cooling power for various combinations of wind and temperature and will help you gauge how much protection you really need.

To determine the wind-chill on the chart below, find the outside air temperature on the top line, then read down the column to the measured wind speed. For example, when the outside air temperature is zero degrees, and the wind speed is 20 miles per hour, the rate of heat loss is equivalent to minus 39 degrees under calm conditions.

EQUIVALENT TEMPERATURE (DEGREES F)

	Calm.	35	30	25	20	15	10	5	0	-5	-10	-15	-20
		COLD											
W	5.	32	27	22	16	11	6	0	-5	-10	-15	-21	-26
I			VERY COLD										
N	10.	22	16	10	3	-3	-9	-15	-22	-27	-34	-40	-46
D					BITTER COLD								
	15.	16	9	2	-5	-11	-18	-25	-31	-38	-45	-51	-58
S	20.	12	4	-3	-10	-17	-24	-31	-39	-46	-53	-60	-67
P.													
E	25.	8	1	-7	-15	-22	-29	-36	-44	-51	-59	-66	-74
E									EXTREME COLD				
D	30.	6	-2	-10	-18	-25	-33	-41	-49	-56	-64	-71	-79
	35.	4	-4	-12	-20	-27	-35	-43	-52	-58	-67	-74	-82
M	.												
P	40.	3	-5	-13	-21	-29	-37	-45	-53	-60	-69	-76	-84
H	.												
	45.	2	-6	-14	-22	-30	-38	-46	-54	-62	-70	-78	-85

U. S. Department of Commerce, NOAA
National Weather Service Forecast Office
11 West Oxmoor Road, Suite 417
Birmingham, AL 35209-6451

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Winter Weather Preparedness Week in Alabama
December 7 - 11, 1992

11/24/92

TO: WSFO BOS Staff
Through: Bob Thompson, AM Southern New England
FM: Walt Drag

Subject: Winter Storm Drill

This drill is designed primarily to have each of us become aware of changes in winter storm procedures from last winter as well as become familiar with the revamped WS SDM. References are included.

Please complete this drill by December 14 and place it in my mailbox.

Thank you.

Questions 1-5 are found on page 2 of the Winter Storm SDM.

1. What day is a Winter Storm Outlook issued for?________________

2. How many adjacent offices must agree before it can be issued?__

3. What afos product is used to announce the winter storm outlook? ____ __

4. Should WSO's reissue this product?

5. Should the outlook be highlighted in the extended portion of the SFP?

Questions 6 through 10 are from pages 3 and 4 in the WS SDM.

6. A Winter Storm Watch is issued primarily for what periods?

7. What afos product is used by WSFO BOS to issue a Winter Storm Watch?

8. If a WSO re-issues this announcement, what afos product do they use?

9. How often are follow-up SPS's issued on a watch?

10. Is a cancellation statement necessary for a Watch?

Questions 11 through 14 are from pages 6 and 7 in the WS SDM.

11. What are the two main criteria for issuing an event specific HEAVY SNOW warning in southern New England?

12. What afos product is used by WSFO BOS to announce a warning issuance?

13. Should WSO's re-issue the warning issuance as SPSxxx or as another afos product?

14. IS UGC zone or county coding used for winter products (relatively long fused as compared to SVR/TOR/FFW/SLSMA)?

15. From the winter storm/watch checklist, do we relay WATCHES to MEMA between 4pm and 7am?

16. Massport snow briefings/packages usually are requested whenever____" or more of snow is forecast? (WS SDM p10)

17. There has been no change to HOTLINE coordination. What pages of the WS SDM is this information found on?

18. To add areal extent, change the timing, or upgrade/downgrade the condition within the winter WATCH/ADVY/WARNING ladder...do you issue an SPS or a new **WSW/NPW**? (Ref:statement sections of the WS SDM and also memo 11/19/92)

Questions 19 through 24 pertain to snow amount as found on pages 14 through 19 of the WS SDM.

19. Snowfall estimates are generally confined to what periods?

20. Are POPs necessary in a forecast period when a Watch/Advisory or Warning is in effect?

21. Are POPs used in forecast periods when snow amounts are mentioned?

22. Snow advisories are issued for a minimum amount of ___ in 12 hours?

23. What page in the SDM details options on Winter Storm Warning snow amounts?

24. During a winter season, what is the average number of greater than 6" snows at BOS and ORH? greater than 1" snows at BOS and ORH?

25. How many blizzards have occurred along a portion of coastal Massachusetts since the "Blizzard of 78"? (WS SDM p25)

26. The criteria for issuing a wind chill advisory is minus __deg or lower for at least __ hours using only sustained wind. (WS SDM p30)

27. A fog advisory is issued under what afos product? (WS SDM p30)

28. Should a Fog Advisory be issued if the 1/4 mile or less visibility is not expected to be widespread in the forecast zone? (WS SDM p30).

29. What are two ways to handle a borderline dense fog advisory without issuing the advisory?

30. Is it the responsibility of each office in southern New England to issue an SPS for icy roads caused by other than freezing rain or freezing drizzle? (WS SDM p34)

31. For what period(s) is the High Wind Watch issued? (WS SDM p35)

32. Does WSFO BOS issue Wind Advisories? (WS SDM p37)

33. For coastal flooding, occasionally SHPAT1 data may be useful. (Ref: Ship Code Card)

    What does the 2 group after the water temperature offer?
    What does the 4 group after this 2 group offer?

34. Please attach an example of the TIDES 1 program output with a 3 foot surge.

35. Please dial the Boston tide gage and check to see if the data is close to the forecast for that hour. Please write the tide level and note any problems in the space below. (Ref: Coastal flood SDM/also the marine desk)

36. Is there a problem with issuing a statement that has a UGC expiration time that is prior to the AFOS stamped issuance time?

37. On what page of the WS SDM would you find a coordination map that would assist coordination from the SFD storm coordination segment (SCC) message or also be of value to the HOTLINE coordinator?

38. What SDM contains airport/state police and observer #s that would be helpful in on-going or post-storm weather support? (it's blue)

North Carolina SKYWARN News

November, 1992
Vol 1 Issue 3

A cooperative effort between the National Weather Service at Raleigh-Durham Airport and the Amateurs of North Carolina

SKYWARN

Winter Storms

by Rod Gonski

Although North Carolina has been spared severe winter weather in the most recent couple of years, snow, ice, and extreme cold have frequented the state in the past. Given the outbreaks of abnormally cold air across North America the latter part of 1992, it appears likely we'll have to deal with freezing rain, sleet, heavy snow, dangerous wind chill, or any combination thereof at some point this winter season.

Many of us think about the excitement and beauty of a fresh blanket of snow, the novelty of winter sports and unexpected break from our daily routine. But... winter weather can cause major disruptions in daily services, increases the chance of injury from accidents, and winter weather can be life threatening, especially to the elderly.

In early March of 1980, a severe winter storm blanketed the state with heavy snow. Eastern parts of the state had over a foot of snow with amounts up to 25 inches reported at Elizabeth City. Thirteen people died, most suffering from exposure and overexertion while shoveling snow.

In January of 1985, a blast of arctic air hit North Carolina pushing temperatures below zero degrees (Fahrenheit) over the entire state. New all-time record lows occurred at almost every weather reporting station. Fourteen people died of hypothermia.

February 1987, a major winter storm dumped 2 to 6 inches of sleet over central North Carolina. Fortunately, no deaths were directly attributed to the ice and cold. But extensive property damage occurred. Some building roofs collapsed under the weight of the ice, farm animals were lost, and many residential streets in Raleigh and elsewhere remained impassable for a week, putting people and property at risk.

And on December 22nd and 23rd 1989, a fierce winter storm along the coast of the Carolinas produced 60 m.p.h. winds and 34 foot waves over the near-shore waters, and blizzard conditions over portions of eastern North Carolina. More than a foot of snow fell over the coastal counties and four to twelve inches accumulated over the Coastal Plain and Sandhills. Two people died of hypothermia.

The key to surviving a winter storm or extreme cold is knowing ahead of time the types of danger that it poses to ourselves, our families, and our homes, and being prepared to cope with those dangers. To prepare adequately for the hazards of winter weather, we need to know what to expect from a winter storm.

The following articles have been written to better inform you about winter storms and the hazards they present. Information also includes ways that amateur radio operators might be able to assist the National Weather Service in providing timely and more accurate news to the public about winter weather.

What is a Winter Storm?

by Rod Gonski

A winter storm for North Carolina usually evolves from a low pressure area over the northeast Gult Mexico that tracks across the Florida panhandle and southern Georgia and northeastward along the Carolina coast. Another typical pattern features a developing low pressure area over coastal North Carolina that intensifies rapidly and moves northeastward to become a classic Nor'easter for the Mid-Atlantic and New England states. Each situation is preceded by or coincides with a surge of arctic air associated with high pressure over the Great Lakes or New England region.

"Winter Storm" conditions are defined as one or a combination of the following in North Carolina:

Heavy Snow....... equal to or exceeding 4 inches accumulation
Heavy Sleet........ equal to or exceeding 1/2 inch accumulation
Ice....................... equal to or exceeding 1/4 inch accumulation from freezing rain or freezing drizzle.

A Winter Storm in North Carolina is classified a "Blizzard" if visibility is reduced to less than 1/4 mile in snow and/or blowing snow and wind speed exceeds 35 m.p.h. and these conditions last for more than 3 hours.

The National Weather Service in North Carolina alerts the public to the threat of Winter Storms in three stages as follows:

Outlook...............issued 36 to 48 hours in advance for a significant threat of winter storm conditions.
Watch..................issued 12 to 36 hours in advance for a significant threat of winter storm conditions.
Warning..............issued when winter storm conditions are imminent or expected within 12 hours.

A warning may be further specified whenever a single type of precipitation is expected to predominate over an area. For instance, Heavy Snow Warning, Heavy Sleet Warning, or Ice Storm Warning, may be used in place of the more generic Winter Storm Warning.

The National Weather Service will issue a Blizzard Warning when it is expected that very strong winds heavy snow or blowing snow will combine to produce very poor visibility for periods of time exceeding three hours. Usually, temperatures are in the 20's or colder, and the wind makes it feel like the temperature is below zero. Blizzards are one of nature's most life-threatening storms.

Other Advisories for Winter Weather

by Rod Gonski

In addition to the Outlooks, Watches, and Warnings for Winter Storms, the National Weather Service will issue advisories for other winter weather hazards in North Carolina.

A Winter Weather Advisory is issued when winter weather conditions may cause significant inconvenience, but if people are careful, should not be life-threatening. Often, the greatest hazard is to motorists. In terms of precipitation, winter weather conditions are defined as one or a combination of the following:

Snow........1 to 3 inches accumulation
Sleet.........less than 1/2 inch accumulation
Ice............less than 1/4 inch accumulation from freezing rain or freezing drizzle

A Winter Weather Advisory is issued when winter weather conditions are imminent or expected to occur within 12 hours over an area. As with Winter Storm Warnings, an advisory may be further specified whenever a single type of precipitation is expected to predominate. For instance, Snow Advisory, Sleet Advisory, or a Freezing Rain or Freezing Drizzle Advisory may be used in place of the more generic Winter Weather Advisory.

Wind Chill is a measure of the effects of wind and cold on the rate of heat loss from exposed skin. In other words, if the temperature outside is 20°F and the wind is blowing at 20 miles an hour, it feels like 10 degrees below zero with no wind. Below is a table for computing wind chill using temperature and wind speed.

The National Weather Service in North Carolina issues an Advisory for Dangerous Wind Chill whenever wind chill values of -20°F or lower are expected for more than two hours within the next 24 hours.

Observing and Reporting the Elements

by Rod Gonski

For SKYWARN spotters, the question is "What information about the weather elements are important to ..e National Weather Service during the cold season?"

First, let's define what those elements are.

Snow............................The term "snow" with no modifiers means a steady fall of snow for a few hours or more.

Snow flurries.............. "Flurries" means intermittent flakes of light snow with no measurable accumulation.

Snow showers.............A term more often used in the mountains means a heavier fall of snow than "flurries," but the intensity varies and may stop and start several times. Accumulation is possible but is often "spotty" (i.e. snowfall on one side of the mountain, but not the other).

Blowing snow.............This term is used to mean that wind is picking snow off the ground and driving it through the air to reduce visibility and cause significant drifting.

Sleet.............................The term "sleet" with no modifiers means a steady fall of ice pellets or granules (droplets) of frozen rain. Sleet usually bounces when hitting a surface. (Sleet should not be confused with hail. Hail is composed of balls of ice that falls from thunderstorms.)

Freezing rain/drizzle.. This is rain or drizzle that falls and freezes upon contact with a surface. Metal or glass surfaces are usually most susceptible to accumulations of ice from freezing rain or freezing drizzle.

Often times in central North Carolina, there are transition zones between the various types of winter precipitation. And the locations of these transition zones are subject to change making it very difficult, at times, for the ...ational Weather Service to keep the public informed and up-to-date about the potential hazards.

The most important information about winter weather that can be used by the National Weather Service from SKYWARN spotters has to do with the transition zones. As rough guidelines, should any of the following conditions occur, consider reporting them through the SKYWARN network to the National Weather Service:

1. For those with a <u>reliable</u> thermometer, rain or drizzle is falling and the temperature suddenly drops to 32°F or below.

2. Precipitation, snow, sleet, freezing rain, rain, suddenly changes from one type to another.

3. On the road, wet roads suddenly become icy, especially on bridges and overpasses.

4. Winter weather conditions unexpectedly become worse (pose a greater hazard to the public) than predicted in the National Weather Service forecast. For instance, suppose a Winter Weather Advisory is in effect (see previous article on advisories). And tree limbs or power lines begin to fall under the weight of ice, posing a threat to life and property. This should be reported.

5. People are injured or killed or significant property damage occurs as a direct result of winter weather. For instance, a well-constructed building collapses under the weight of snow, or ice-laden tree limbs fall and injure people. The occurrence of numerous traffic accidents can be important to know, but these reports are often received from law enforcement agencies.

The kinds of information that are not as critical to the National Weather Service typically involve confirmation of existing forecasts or contain items of little or no risk to life or property. For instance, reports of snow flurries or a few snow flakes mixed in with rain with temperatures above freezing are of little conse-...ence. But should the snow suddenly intensify and accumulate, or the temperature drops below freezing with ...e rain, and these conditions are not forecast, the information becomes critical. Simply put, please use discretion when reporting winter weather conditions on the SKYWARN net.

Winter Weather Safety

by Rod Gonski

As with any threat of hazardous weather throughout the year, keep updated with a reliable source weather forecasts and information. The National Weather Service broadcasts weather information continuously on NOAA Weather Radio. The radio frequency from the Durham transmitter is 162.55 MHz. From the Fort Bragg transmitter, it's 162.475 MHz. Broadcasts from Tarboro are also at 162.475 MHz. And from Winston-Salem, tune to 162.400 MHz.

In winter storms, people at greatest risk are on the highways. It's best to avoid travel during the storm. But if you become trapped in a vehicle, it is usually best to stay inside and await rescue. Disorientation can occur quickly in wind-driven snow and cold. Run the motor sparingly, perhaps ten minutes each hour. Make sure the window is open just a crack and that the exhaust pipe is not blocked. Otherwise, carbon monoxide poisoning can occur.

Several layers of loose-fitting, lightweight, warm clothing are better than one or two layers of heavy cover. The air trapped between several layers helps insulate the body. Also, layers can be shed to avoid perspiration and subsequent chill. Wool is one of the few materials that can still insulate you when damp. But it is best to stay dry in cold weather. Considering that half of body heat loss is from the head, wearing a hat can significantly reduce the risk of hypothermia.

An extra supply of batteries is always a good idea when preparing for winter storms. Flash lights, battery-powered lanterns, and a battery-powered Weather Radio, AM/FM radio, or TV come in handy if commercial power is suddenly lost.

Other safety/preparedness reminders include:

- Keeping an extra supply of non-perishable food, especially high energy snacks, and a 3 day supply of drinking water;
- Having adequate medical and first-aid supplies;
- Having an emergency heating source at home or work and checking fuel supplies;
- Keeping the car gas tank near full to avoid a buildup of ice from moisture caught in the tank or fuel lines;
- Providing adequate shelter to pets and livestock;
- Checking on others, especially any elderly or disabled neighbors who might require assistance during prolonged periods of power loss, or who might be trapped in their home because of the snow and ice.

Spotter Training Status Update

by Jerry Stuckle, AI0K

Although we have been in the "slow" season as far as severe thunderstorms go (even though there were a couple of major tornadoes in November), Rod has been busy with Spotter Training courses. I have just added the 100th ham to our database. We are growing! Some of the hams have taken Spotter Training at ham club meetings, others have attended sessions sponsored by County Emergency Management. We have had excellent turnout at the ham club meetings, with this being one of the most popular programs.

We are still in the winter weather season, but springtime is not far off. We'd like to have a big push to get more hams trained before the 1993 season starts up. Now is the time to start planning for a spotter training (or other NWS) program. Contact Rod Gonski at the NWS office (919-840-0450, M-F 8:00-4:30) to schedule a session. If your club is not large enough to sponsor it's own program, check with other clubs in your area to see if they would be interested in a joint meeting (another good way to meet other hams!).

Wind Chill Chart

Wind Speed

		5	10	15	20	25	30	35	40	45
A	35	32	22	15	11	7	5	3	2	1
i	30	26	15	8	4	0	-2	-3	-5	-6
r	25	21	9	2	-3	-6	-9	-11	-13	-14
	20	16	3	-4	-10	-14	-17	-19	-21	-22
T	15	11	-2	-11	-17	-21	-24	-27	-28	-29
e	10	5	-8	-17	-24	-29	-32	-35	-36	-37
m	5	0	-14	-24	-31	-36	-40	-42	-44	-45
p	0	-4	-20	-31	-38	-43	-47	-50	-52	-53
e	-5	-9	-27	-37	-45	-51	-55	-58	-60	-61
r	-10	-15	-33	-44	-52	-58	-62	-66	-68	-69
a	-15	-20	-39	-51	-59	-66	-70	-73	-76	-77
t	-20	-25	-45	-58	-66	-73	-78	-81	-84	-85
u	-25	-30	-51	-64	-74	-80	-85	-89	-91	-93
r	-30	-36	-57	-71	-81	-88	-93	-97	-99	-101
e	-35	-41	-63	-78	-88	-95	-100	-104	-107	-109
	-40	-46	-70	-84	-95	-103	-108	-112	-115	-117
	-45	-51	-76	-91	-102	-110	-116	-120	-123	-125

Figure 1. Wind Chill Computation

In the late 1940's, Antarctic explorers Siple and Passel experimented with measuring the time it took to freeze 250 grams of water in different temperature and wind conditions. They developed empirical formulas relating these data to the rate of heat loss from exposed human skin. They developed the following formula which was used to determine the wind chill index. At wind speeds of 4 m.p.h. or less, the wind chill temperature is the same as the actual air temperature.

$$T_{wc} = 0.0817(3.71\,V^{0.5} + 0.581 - 0.25V)\,(T - 91.4) + 91.4$$

V = wind speed in m.p.h.

T = Temperature in °F

T_{wc} = Wind Chill Temperature

No specific rules exist for determining when wind chill becomes dangerous. Soviet experiments in the late 1960's shows that for still air, the air temperature has to drop to -39.8°F before the exposed skin temperature reaches freezing. However, frostbite resulted after a short period of exposure to a 12 m.p.h. wind at an air temperature of only -5.8°F (wind chill of -21.8°F).

What to Report

by Jerry Stuckle, AI0K

Information on current weather conditions is used by the National Weather Service for hourly updates and to issue bulletins and warnings. Schools and businesses depend on this information, to determine if they should close or keep running. Closing when there is no need is expensive; alternatively staying open and keeping students and employees there when conditions are rapidly worsening is dangerous. Therefore, we need to provide current, accurate information to the NWS.

In his "Observing and Reporting the Elements" article above, Rod indicated what kind of information the NWS needs. To assist hams who wish road and weather information, our liaison stations in tracking weather conditions, and others who monitor the frequency, we would like some additional information. Note that not all reports may be passed on to the NWS. The information we would like is:

1. Current conditions at your location, if hazardous or potentially so. This includes any freezing rain, sleet, snow (other than snow flurries), or rain if the temperature is near freezing.
2. Any change in precipitation (rain to freezing rain, sleet to snow, etc.).
3. Amount of snow on the ground (if any).
4. Dangerous (or potentially so) road conditions. This includes slick bridges, snow on the road (other than just blowing across it), and anything else which makes driving dangerous.
5. Any accumulation of ice on trees, power lines, cars, etc.
6. Any damage which has been done by the storm - i.e. limbs or power lines down due to ice. (Downed power lines should also be reported to your power company - the SKYWARN liaison station and NWS will not report individual power lines down).
7. Any other conditions which may pose a threat to life and/or property.

In general, we are not interested in reports of rain when the temperature is above freezing, snow flurries, or the like. However, at the NWS request, we may ask for any information in certain areas, as they may need it to track the leading edge of the storm. Please do not report nonthreatening conditions unless you are in an area where the request is made.

All reports to the SKYWARN liaison station should contain the following information:

1. What time the observation was made. This is especially important for tracking the transition of one form of precipitation to another.
2. The location of the observation. Please use directions which can be easily identifiable - i.e. mile marker 287 on I-40, 5 miles west of Apex on Hwy 64, etc.
3. What is being reported.
4. The call sign of the station making the report (if you are relaying it).
5. The repeater being monitored by the reporting station (if any).
6. Your call, if you are relaying for another station.

The information does not need to be in any order; the most important thing is to report [illegible] to SKYWARN liaison station. The most important things are accuracy and timeliness. A report 5 hours old is[illegible] as useful as a current one, but may still be helpful, so please make it. A report of rain and 40°F is generally not helpful, so please don't make it unless information is requested from your area.

SKYWARN Net Operations during Winter Weather

by Jerry Stuckle, AI0K

Winter weather is upon us, and has been mentioned above, the possibility of dangerous storms. Since winter weather does not develop as quickly as severe thunderstorms and tornados, the urgency of our reports is not as important. However, this does not mean the reports themselves aren't important - quite the opposite!

As a result, our SKYWARN operations are quite different. There will generally not be a net operating - just a liaison station monitoring. Any repeaters we are monitoring will be open for normal operations, and you are encouraged to use them as you wish. As the most common topic at this time will be the weather, we will be able to get quite a bit of information from just monitoring. At times, the SKYWARN liaison station may break into your QSO to request more detailed information about something you have mentioned. Please don't let this discourage you; there are a lot of people monitoring our wide area repeaters (many of them non-hams), and they may have the same questions!

Every hour on the half hour, the SKYWARN liaison station will collect reports from around the affected area. We encourage you to monitor at this time if you are interested in the weather, and if you have anything worth reporting, to do so. This may mean breaking into a QSO for a short time; we appreciate your patience and will clear the frequency as quickly as possible.

These reports must be compiled quickly, as the SKYWARN liaison station must collect and collate the reports into a meaningful sequence and call them into the National Weather Service by 15-20 minutes before the hour. The reports are then used by the NWS to produce their hourly statement, due out on the hour. So, as you can see, the SKYWARN liaison station and NWS are pretty busy about that time! In addition, any unexpected information may be called into the NWS between the hourly reports. So, if you call for the SKYWARN liaison station and don't get an answer, please try again in a few minutes.

The SKYWARN liaison station will also be available to give hams weather and road reports, as available. However, since we try to schedule them for only a couple of hours at a time, they may not have been monitoring for very long, and may not have much information. You are free to call for the SKYWARN liaison station and ask for information on a certain area; if they don't have it, there are usually other stations which have been monitoring for longer; they may be able to help you. Note that if you just put out a general request for information on a certain area, and the SKYWARN liaison station doesn't have anything, he/she will probably not answer you. This doesn't mean they aren't there - just they don't want to tie up the repeater telling you they don't' have anything!

As with severe thunderstorms, the 146.28/88 Mhz repeater in Raleigh will be our main repeater, with 147.75/15 Mhz (also Raleigh) as backup. Reports can always be made on this repeater; however, depending the location of the weather and availability of SKYWARN liaison stations, we may also be asking for reports on 147.825/225 (Hillsboro) and 147.705/105 (Broadway) - both wide are coverage repeaters. Generally we will not be monitoring these repeaters, unless sufficient SKYWARN liaison stations are available.

We also have a need for SKYWARN nets on other repeaters which the liaison stations in the Raleigh area cannot reach. We are in need of volunteers to act as liaison between these repeaters and the 146.28.88 repeater in Raleigh. If we are short of liaison stations, we may even need volunteers to act as liaison for some of the other repeaters. This operation do not require any special training - just the willingness to monitor the frequency and collect reports. Reports need to be called into the main SKYWARN liaison station on the half hour (they may also be called directly into the NWS recorder at 1-800-662-SWAT (1-800-662-7928). If you are interested in helping out in this way, please check in with the SKYWARN liaison station on 146.28/88 during winter weather conditions. We appreciate your assistance.

Articles Needed

by Jerry Stuckle, AI0K

We are always in need of articles for the North Carolina SKYWARN News. Articles can be on any topic related to ham radio and the weather. Perhaps you had an experience with antennas being struck by lightening or blown down in a heavy thunderstorm. Maybe you spotted something during a SKYWARN net operation which you would like to share with others. Or you might have worked with SKYWARN in other areas of the state or country and would like to tell about your experiences (and net operations) there.

These and others are all good topics for the North Carolina SKYWARN News. Please submit articles to:

North Carolina SKYWARN News
P.O. Box 17283
Raleigh, NC, 27619-7283

Deadline for the February newsletter (which will be on Severe Thunderstorms and Tornadoes) is February 1st.

Notes from the Editor

by Jerry Stuckle, AI0K

I must apologize for this newsletter being late. It should have been out a couple of months ago. However, between Rod's work (and the tornadoes in November) and my traveling (this was a busy autumn for me!), we're just now getting it out. We hope to have future issues published in a more timely manner.

So far this year, we have only had one near miss. There was freezing rain and sleet in the western part of the state on December 27th, and SKYWARN was monitoring for a time here in Raleigh. However, we got lucky and missed the worst of it. (Actually, I wasn't here to suffer with many of you - I was basking in the 70's and 80's in southern Florida! And the fishing was just great...).

With January and February ahead of us though, we'd be very optimistic to believe this is the only storm we would have this winter. Although we haven't had much snow in the past three years, anyone who has lived here for any length of time can tell you that is <u>very</u> atypical.

This newsletter was designed with you in mind - to provide you with information on winter weather, how to survive it, and how to help others. We hope you have enjoyed it and thank you for your interest and help in the SKYWARN program.

North Carolina SKYWARN News

by Jerry Stuckle, AI0K

The North Carolina SKYWARN News is a joint effort between the National Weather Service in Raleigh-Durham, and the Amateur Radio Operators in the area. It is published three times a year, approximately February, June and November, and is available to spotters and SKYWARN Net Control Stations in the area.

Each issue will provide information on what will be occurring over the next few months. The February issue is about severe thunderstorms and tornadoes, June discusses hurricanes, and November focuses on winter weather. They provide information on the causes and effects of storms, safety tips to remember if you are caught in a storm, and other valuable information.

Issues are free to registered spotters who have completed SKYWARN training in the last year; we request a donation of fifty cents from others, to help defray the cost of printing. To register, you must complete a SKYWARN Spotter Training Session. At that time, you will receive a registration form.

We welcome your input as to what you think about this newsletter, and what you would like to see in it. Please send your comments to me at the above address. This newsletter is for you, and we would like your input to make it better. Thanks!