

Summary of the Second National Winter Weather Workshop

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1. Introduction

The Second National Winter Weather Workshop was held in Raleigh, North Carolina on 26–30 September 1988. The workshop was hosted by the National Weather Service Eastern Region with support from National Weather Service Headquarters. Forty-eight presentations were made. There were five laboratory sessions. Approximately 150 people attended the workshop, most of whom were National Weather Service meteorologists from all NWS regions except the Pacific. Smaller numbers of private sector meteorologists, U.S. Air Force meteorologists, and students and faculty from North Carolina State University were present. Fourteen Canadian meteorologists represented the Atmospheric Environment Service, the Canadian Forces, and Transport Canada.

A postprint volume containing many of the papers presented at the workshop will be available from the National Weather Service Eastern Region for a nominal fee to cover printing and handling. Inquiries regarding the availability of the volume can be made to the National Weather Service.¹

2. Workshop program

The opening presentation of the workshop was made by Elbert W. Friday, Jr., Assistant Administrator for Weather Services, National Oceanic and Atmospheric Administration. He summarized the implementation schedule of NEXRAD and described the related restructuring of the National Weather Service warning and forecast programs. Meteorologist, meteorological

technician, and hydrologist staffing requirements of the new Warning and Forecast Offices (WFO) were discussed.

a. Session 1: East Coast storms (Review by Laurence G. Lee)

The presentations in this session focused on one of the major problems confronting forecasters in the eastern United States: the forecasting of snow events along the East Coast. The first two speakers discussed various aspects of significant East Coast cyclogenesis. The final presentation viewed the forecast problem from a different perspective, that of dealing with a light to moderate snowfall.

Paul Kocin began the session with a presentation entitled "Synoptic Studies of Major Snowstorms Along the East Coast." He summarized the horizontal and vertical structure and temporal evolution of 20 of the most crippling snowstorms affecting the heavily populated Northeast from 1955 through 1985. Conventional weather charts were used to 1) identify patterns in surface and lower- and upper-tropospheric fields that precede and accompany the development of heavy snowfall, and 2) document case-to-case variability that frustrates attempts to provide a general set of necessary conditions that apply to all storms. The talk was concluded with a summary of patterns of geopotential height, wind, temperature, and other fields that are suggestive of the dynamical and physical processes contributing to development. The following features were common to development: 1) a well-defined, upper-level trough and cyclonic vorticity advection, 2) an increase in amplitude and decrease of wavelength of the upper-level pattern, 3) diffluence downwind of an increasingly negatively tilted trough, 4) upper-level jet streaks, and 5) anticyclones in a position favorable for cold air damming east of the Appalachians and the enhancement of thermal gradients.

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The next talk, "Model Diagnostics of East Coast Storms," was by Louis Uccellini. He emphasized that the development of winter storms along the East Coast involved the interaction of physical and dynamical processes within regional-scale domains acting over relatively short periods of time. Because upper-air and numerical model data are available only at 12-h intervals, serious problems exist in understanding and forecasting heavy snow events that develop in much shorter time periods. Model-generated fields and diagnostic computations were presented to demonstrate how model simulations can be used to supplement the radiosonde data, increase understanding of physical processes contributing to storm development, and ultimately improve forecasts. Examples derived from model simulations of the 19 February 1979 East Coast snowstorm were emphasized. A video of the model simulation of the rapid developing phase of the storm was also shown.

Jeff Homan discussed "Winter Forecast Problems Associated With Light to Moderate Snow Events in the Mid-Atlantic States." Two cases of light and moderate snow were shown because different snowfall patterns were produced even though both systems had similar features at the surface and aloft. Isobaric and isentropic analyses were employed to focus on the structure and evolution of the thermal fields and temperature advection patterns in the lower troposphere. Three-hourly soundings from the Genesis of Atlantic Lows Experiment (GALE) were shown for one of the cases to demonstrate the effects of evaporative cooling. The frequent soundings illustrated the importance of enhanced datasets when applied to the forecasting of weather events that undergo rapid changes in time periods less than 12 hours.

b. Session 2: Application of satellite imagery to winter weather forecast problems
(Review by Rodney F. Gonski)

The session focused on the use of satellite imagery to forecast heavy cold-season precipitation. In various degrees, ranging from simple pattern recognition to more elaborate decision-tree methods, each of the papers described ways of discerning from operational GOES imagery, areas of potentially heavy precipitation associated with extratropical cyclones.

Rod Scofield began the session with a well-illustrated presentation entitled "Instability Bursts and Heavy Precipitation From Extratropical Cyclone Systems." The paper describes how satellite imagery had been used to detect convective-banded structures resulting from maximum advection of warm, moist, unstable air in lower levels phasing with upper-level dynamics. This process, termed "instability bursts," can lead to heavy precipitation and has been found to occur across a full range of meteorological scales.

Sam Beckman followed with "Satellite View of

Convective Type Clouds and Heavy Snow." The presentation further emphasized the relationship between convective-type cloud structures and heavy precipitation, particularly snowbursts, within larger scale systems. Two cases illustrated how techniques for detecting and projecting these features forward in satellite imagery can be used for near-term predictions of rapid snowfall accumulation.

Detecting and projecting areas of heavy snow potential in extratropical cyclone systems was also the central theme of the paper entitled "A Method to Determine the Width of Snow Bands Associated With Winter Storms by Using Infrared Satellite Data" by Allan Morrison. Case examples showed that the heaviest snow is often concentrated in a band between the head of the comma-shaped cloudmass and the area of dry air intrusion in a well-developed extratropical cyclone.

The session ended with a paper by Sheldon Kusselson entitled "Which Satellite Precipitation Estimation Technique to Use? A Look at the Christmas Eve 1987 Heavy Rain Event in the Mississippi Valley." The central theme presented in this paper demonstrated that no single technique based on satellite imagery can be used exclusively without considering the state of the atmosphere or the important dynamical processes involved.

c. Session 3: Examining winter storms with new technology
(Review by Eugene P. Auciello)

The common theme of the three papers presented in session 3 was the use of new technology and resultant datasets to improve winter forecasting techniques. The technology presented included the Denver AWIPS-90 risk reduction requirements evaluation (DAR³E), the East Coast lightning detection network, and the Colorado profiler network.

The session began with a videotape presentation by Lawrence Dunn entitled, "Mesoscale Winter Forecasting Using DAR³E." The presentation demonstrated how Doppler radar, profilers, surface mesonet, and the new capabilities of the AWIPS-90 workstation were used in real time by the meteorologists at the National Weather Service Forecast Office at Denver during the winter storm of 26–27 December 1987. The new, higher-resolution datasets were able to identify features of storm structure not evident in analyses based on current radars and the standard surface and upper-air observing networks.

Carl C. Ewald presented a study entitled "Winter East Coast Lightning Data and Survey of Lightning Strikes in Storms." Lightning data from the East Coast lightning detection network were examined for three East Coast storms during the 1986–88 winter seasons. The data revealed the location, development, and movement of the storms over data-sparse ocean areas.

The lightning strike patterns could also be related to the track of the surface lows and to intensity changes. The data were most effective as thunderstorms formed over the warm Gulf Stream water.

The last paper in the session, presented by Stan Barnes, was entitled "Quasi-Geostrophic Diagnostics for the Christmas Weekend Storm of 1987." Data from the Colorado profiler network were used to reveal certain aspects of the dynamical structure of the storm system. Upper-level jet streaks were found to be associated with an increase in snowfall intensity.

d. Laboratory I

Rod Scofield conducted the first laboratory session of the workshop, "3-12 Hour Heavy Precipitation Forecast Index for Extratropical Cyclone Systems (ECSs)." Using satellite imagery and conventional weather charts, he led the group in several exercises designed to help forecasters sharpen their skills in forecasts of significant precipitation events. The exercise encouraged forecasters to identify the type of cloud system, determine if signatures or mechanisms of heavy precipitation are present or expected, examine current observations for evidence of precipitation, and then evaluate the mesoscale and synoptic scale environments for clues to the movement of the system and the likelihood of strengthening or weakening.

Frederick Sanders delivered the opening presentation Wednesday morning. His talk was entitled "Explosive Cyclogenesis Over the North Atlantic—Recent NMC Skill and How to Tell the Big Blasts From the Little Pops." He stated that performance of the nested grid model (NGM) and medium-range forecasting (MRF) model in predicting explosive cyclogenesis over the western North Atlantic during the 1987/88 cool season appears to represent a distinct increase in skill over prior seasons. Determining exactly when and where explosive cyclogenesis occurs, however, is still a major problem. A study of western North Atlantic explosive cyclogenesis from 1962 to 1977 indicated that strong cases—not marginal ones—occurred in a planetary-scale environment of colder-than-normal 1000–500 mb thicknesses which were evident up to 5 days in advance. Reduced static stability over a broad region appears to be the main factor in the violent cyclogenesis.

e. Sessions 4a and 5a: Precipitation type forecasting (Reviewed by James R. Poirier)

Forecasting the occurrence and amount of precipitation is often a complex task, but determining the type of precipitation is frequently even more difficult. The papers presented in sessions 4a and 5a addressed this significant forecast problem.

The sessions were initiated with a presentation by Kenneth D. LaPenta entitled "The Role of Melting in Determining Precipitation Type in Eastern New York During the Storm of October 4th, 1987." The presen-

tation demonstrated how cooling due to melting was a critical factor in changing rain to snow, accounting for the bulk of the observed temperature change in the lower troposphere in this event. Since the latent heat of fusion is nearly an order of magnitude less than the latent heat of condensation, it is often overlooked in precipitation-type forecasting.

Joseph A. Ronco offered a presentation entitled "A Procedure for Forecasting Precipitation Type Using NGM Low-Level Temperatures and limited-area fine-mesh (LFM) MOS Frozen Precipitation Forecasts." This procedure makes use of the low-level temperatures forecast by the NGM, combined with the model output statistics (MOS) probability of frozen precipitation values from the LFM, to improve upon the precipitation-type forecast solely by MOS.

Kermit Keeter continued the theme of these sessions in his presentation "WSFO RDU's Local Guidance for Predicting Precipitation Type." This routinely generated guidance product is based upon regression equations which predict the conditional probability of measurable frozen precipitation at ten locations representing the climatological regions of North Carolina. The equations are supplemented by nomograms used to predict freezing rain and to provide a climatological reference for the recognition of relatively rare phenomena such as heavy sleet. This guidance acts as a local supplement to MOS by providing a short-fused, site-specific forecast of precipitation type from radiosonde data. The precipitation-type forecast is extended by using the perfect-prog approach.

"Winter Precipitation Type" was the title of Richard P. McNulty's presentation. The physical processes involved in rain versus snow versus freezing precipitation were examined and factors affecting local temperature change in the lower troposphere were discussed. A method to make better use of raob data was presented, thus improving understanding of the low-level thermal structure that affects precipitation type.

Finally, Michael L. Schichtel presented a study entitled "The Specification of Precipitation Type in Winter Storms." Several methods were used to determine the relationship between precipitation type and various predictors derived from upper-air soundings. The most successful predictors were (a) coldest temperature in a saturated layer, (b) surface wet-bulb temperature, (c) 1000–700 mb thickness, (d) 1000–850 mb thickness, (e) "area" of the warm layer of the sounding whose wet-bulb temperature was greater than 0°C, and (f) "area" of the surface based cold layer of the sounding whose wet-bulb temperature was less than 0°C. A decision tree to specify precipitation type was formulated.

f. Session 4b: Mesoscale structure of winter storms (Reviewed by Robert A. Marine)

This session provided an in-depth look into the structure of winter cyclones. The session was broken into three parts so examination of these structures could

be reviewed by different characteristics. Data were compiled by using the Colorado profiler network, Doppler radar, and rawinsonde data. In part 2, the speaker noted that certain mesoscale structures could be defined by using conventional and everyday products.

Stan Barnes started the three-part presentation with his paper entitled "An Analysis of the Christmas Weekend Storm of 1987." The analysis combined rawinsonde data and the Colorado profiler network to reveal certain aspects of the dynamical structure of the storm system. In this event, a combination of large-scale forcing with several mesoscale processes led to the heavy snow amounts and large spatial variation in total accumulations. It was determined that several upper-level jet streaks accompanied an increase in snowfall intensity.

Part 2, "The Diagnosis and Prognosis of Mesoscale Structure in Synoptic-Scale Cyclones," was presented by Brad Colman who illustrated the evolution of a mesoscale structure. By using conventional and routinely available data, he showed how to detect those characteristics of the environment likely to support a mesoscale structure. Also emphasized were real-time guidelines to recognize the important mesoscale structures in a storm and how to determine the amount and distribution of precipitation produced by those features.

Edward Tollerud presented the third study entitled "Composite Structure of Colorado Front Range Snowstorms." The talk demonstrated how a system-relative radiosonde compositing scheme in which the salient features of 51 such storms were assimilated into three dimensional "snapshots" of different stages of the system life cycle. This analysis provided the basis for computations to assess the likelihood of slantwise moist convection in Front Range winter storms along the Rockies.

g. Session 5b: Winter storms along the east slopes of the Colorado Rockies
(Reviewed by Robert A. Marine)

Jim Wiesmueller discussed "Synoptic Patterns Associated With Heavy Snow Along the Front Range of Colorado." All snowfall events that required the issuance of a winter storm warning at Denver and adjacent Front Range cities from 1948 to 1986 were studied. The study indicated that three general large-scale patterns and evolutions bring heavy snow to the region: the eastern development trough, the arctic trough, and the California cutoff. Analysis for each event consisted of data from all constant pressure levels, surface analysis, hourly surface observations, and satellite imagery 48 hours before the onset of snow. Characteristics and frequency of occurrence of each pattern were examined.

The presentation by Jennifer Luppens was entitled "Climatology of Winter Precipitation at Denver and

Colorado Springs." By using hourly observations from September 1948 to December 1987, a detailed climatology of winter precipitation events was developed. A variety of graphs was used to depict individual occurrences of snowfall according to start-time, duration, and accumulation. Differences in climatology between the two closely spaced stations were also examined. The differences apparently result from variations in topography and dissimilarities of synoptic regimes.

h. Session 6: Winter weather forecasting from differing perspectives
(Review by Steven Businger)

The two papers presented in this session dealt with forecast errors in numerical weather prediction (NWP) models.

The session began with a paper by Denis Bachand (Quebec Weather Centre) entitled, "Snow Forecasting Using Physical Parameters and Pattern Recognition" that discussed ways of coping with errors in NWP forecasts. Mr. Bachand presented results of a technique that correlates measured snow accumulations with the predicted fields of moisture and vorticity advection by the thermal wind associated with a storm. The importance of synoptic pattern recognition to complete the assessment of a storm system was also briefly discussed.

The second presentation by Frank Brody of the National Meteorological Center in Washington, D.C. was entitled "The Operational Dilemma of Huge Numerical Model Differences." Mr. Brody presented examples of large forecast differences emphasizing the circulation pattern associated with forecast cyclogenesis and the implications for the resultant weather. Large forecast differences create a problem for NMC's planned automation of the public zone forecasts during the AWIPS-90 era. A concerted effort will be made at NMC to smooth the transition to the new era of data processing and communications.

i. Laboratory II

Frederick Sanders conducted a laboratory exercise entitled "Eyeballing Q -Vectors Can Be Easy and Fun." Using a set of basic charts, including surface and 1000–500 mb thickness analyses, he demonstrated how to manually infer the direction of the low-level ageostrophic wind and, therefore, the Q -vector field. Several idealized cases were examined to confirm that convergence and divergence of Q were related to areas of ascent and descent estimated from older methods of quasi-geostrophic diagnosis.

j. Laboratory III

The "Use of Satellite Imagery to Determine Heavy Snow Areas" was the topic of the laboratory session led by Samuel K. Beckman. His analysis method included using recent observations, reviewing the latest

NMC guidance, and interpreting satellite imagery. Forecasters were told to note unusually heavy convective clouds near or south of snow areas under the southern portion of the enhanced cloudiness in a developing system. Guidelines were suggested for establishing heavy snow trends from a combination of observed data, numerical guidance, and satellite images.

k. Group discussion

Ralph A. Petersen conducted an evening group discussion which was preceded by a presentation entitled "NMC Models and Regional Winter Weather Prediction." During the time that NMC's Regional Analysis and Forecasting System (RAFS) has been operational, a number of systematic errors have been identified and corrected. Petersen focused on two of these topics: 1) the impact of small scale effects (such as snow cover specification) that are unknown to the field forecaster and 2) the ability to monitor and evaluate model forecast differences now and in the era of AWIPS.

The Thursday morning opening presentation was "A Review of Cyclogenesis in Cold Air" by Steven Businger. He summarized recent advances in the understanding of cyclogenesis in polar air masses. The review consisted of three parts: 1) observed features of polar-lows, 2) theoretical ideas concerning their origins, and 3) results of numerical modeling experiments aimed at simulating their development. Case studies showed that environments conducive to the development of strong polar lows included a deep outflow of arctic air over open water and a cold-core, closed low aloft. Also, forcing from a small-scale vortex aloft is associated with the development of polar-lows. Under synoptic conditions favorable for the formation of polar-lows, a number of them often develop in close proximity to each other. Once favorable conditions develop, they often persist for several days and can result in several polar-low outbreaks.

l. Sessions 7a and 8a: Winter forecast problems in the South

(Review by Rodney F. Gonski)

In the South, winter weather, perceived as almost benign by people from other parts of the country, can cause major disruption because the events tend to be rare. Events with significant accumulations of snow and ice accompanied by arctic cold do occur even in states with the balmiest of climates.

Ed Mortimer presented a climatological analysis and described pattern recognition techniques for cold weather events in a paper entitled "Major Arctic Outbreaks Affecting Louisiana." The study was co-authored by Henry Lau.

The next three papers focused on case studies of storms causing havoc in the South during the previous winter. Frank Makosky described the influence of local

factors and their effects across Alabama in "The Winter Storm of January 15, 1988." John Hoffner was co-author. Robert Kelly and Mary Jo Parker presented "Winter Storm Event of January 15, 1988 Over Coastal South Carolina." They discussed the performance of numerical models and the atmospheric developments prior to the event. James Noffsinger described how local forecast techniques had been used to adjust model guidance in a paper, co-authored by John Laing, entitled "Georgia Winter Storm—January 7, 1988."

In closing, Milt Brown introduced a different factor related to snow and ice accumulation potential from winter storms. His presentation "Relationship of Snow Accumulation to Soil Temperature in South Carolina," provided a statistical technique for adjusting snow and ice accumulation based on antecedent temperatures of the ground.

m. Sessions 7b and 8b: Winter forecast problems along the East Coast

(Review by Kenneth D. LaPenta)

The presentations in session 7b examined a potpourri of winter weather topics under the general theme of winter forecast problems along the East Coast of the United States. Gene Auciello explained his checklist for predicting "bombs" in the western Atlantic off the East Coast. The checklist incorporates meteorological parameters such as vorticity characteristics, jetstream characteristics, and NGM output. Forecasters at the Boston National Weather Service Forecast Office (WSFO Boston) routinely uses the checklist and the results have been good. Verification for the 1987/88 cold season resulted in a probability of detection of 0.80, a false alarm ration of 0.33, and a CSI of 0.57.

Wayne Weeks gave a detailed account of operations at a center weather service unit (CWSU). CWSUs are comprised of four National Weather Service meteorologists stationed at the Federal Aviation Administration's (FAA) Air Route Traffic Control Centers (ARTCC) across the country. The CWSU meteorologists act as consultants to the staffs of the ARTCCs, providing critical weather information for dealing with hazardous weather, smooth and efficient air traffic flow, and air traffic controller staffing. A major point of emphasis was that small variations in the weather can have a significant impact on air traffic control operations.

Mike Sabones then presented a paper (co-authored by Kermit Keeter) on late season snowfall in the North Carolina mountains associated with cutoff lows. Three cases from April 1987 and April 1988 were examined. Orographic effects associated with upslope flow, as well as the thermal structure of cutoff lows, helped sustain the cold air needed to produce the snow event while most meteorological factors favored rain at the lower elevations. Understanding the lower tropospheric

thermal structure and being able to visualize the three-dimensional dynamic state of the atmosphere were essential to forecasting snow with these systems.

Session 8b dealt exclusively with forecasting lake effect snow near the Great Lakes. Lake effect snows are common downwind of the Great Lakes in the late fall and winter when cold air moves over the relatively warm, unfrozen waters of the lakes. They are mesoscale phenomena that can produce sharp variations of snowfall over a small distance.

Frank Kieiltyka discussed three methods of forecasting lake effect snows in northeast Ohio. The Rothenberg trajectory envelopes show probabilities of lake effect snow containing at least 0.04 in. of water equivalent in a 6-h period at Cleveland, Ohio and Erie, Pennsylvania. The Collier index, modified for use at Cleveland from a technique developed for Buffalo provides a 12-h maximum snowfall forecast. The index consists of the difference between the lake temperature and the 850-mb temperature and the difference between the lake temperature and the 700-mb temperature. The Dockus lake effect scheme considers three types of lake snows depending upon the sign of the 500-mb vorticity advection, the fetch, and the 850-mb temperature. The scheme provides 6-h snowfall totals through 48 hours.

Tom Niziol presented a talk on the synoptic and mesoscale interactions in a lake effect snowstorm. The case of 4–5 January 1988 was examined in detail. This storm produced up to 70 in. of snow in a narrow band east of Lake Ontario and was accompanied by lightning. Lake effect snows depend on several factors including the temperature difference between the lake surface and 850 mb, the wind direction from the boundary layer through 700 mb, directional wind shear in this layer, and the presence and height of a low-level inversion. These parameters determine the structure (single band vs multiple band) of the snow systems, the intensity of the snowfall, and the location of the snow.

n. Session 9: Snow forecasting
(Review by Robert W. Kelly)

The topic of this session was forecasting both location and amount of snow. Most forecasters have their favorite schemes; some approaches were presented here.

Ned Johnston presented two of the favorite techniques for determining the track of the heaviest snow in a storm. He demonstrated, using the track of the vorticity maximum, that the heaviest snow was generally 1° lat north of the track. He then presented a technique that required tracking the upper low and the dry slot wrapping around the upper low. The maximum snow depth was 2.5° north of the circulation center.

Ron Reap presented a direct technique, which is easy to use on AFOS, for determining the intensity of

snow to be expected. His forecast scheme works well for forecasting snow intensity in the 12- to 24-h forecast period. Using the trajectory model, which is based on the LFM, the forecaster can overlay the net vertical displacement with the 850 mb temperature. For temperatures colder than -2°C , the snow intensity can be forecast based on the displacement, stratified into three levels; light, moderate, and heavy.

o. Laboratory IV

Frank Brody, from the NMC Meteorological Operations Division, conducted a laboratory exercise entitled "Forecasting a Major Snowstorm." Prior to the exercise, several basic snow forecasting techniques used at NMC were described. Lab participants were then given a set of charts containing observed data and numerical model guidance from which forecasts of snow distribution and snowfall amounts were made. The forecasts were verified by comparing them with the actual precipitation occurrence.

p. Laboratory V

Mike Mogil, (NOAA/NESDIS Satellite Applications Laboratory) led the group through a laboratory exercise "Numerical Model Initial Analyses—On Target or Off?" Before numerical guidance can be used to assist in formulating a forecast, the forecaster must know whether or not the initial numerical analyses correctly depict the state of the atmosphere at observation time. The central theme of the laboratory examined techniques using satellite imagery and other datasets to determine if the NMC numerical models were properly initialized.

The opening presentation Friday, by Lance Bosart, was "The Physical Basis for East Coast Cyclogenesis: Some Operational Lessons From Case Studies." He stated that the timing, location, and intensity of East Coast cyclogenesis is dependent upon the degree of baroclinity, the amount of moisture in the air, overall static stability, and, most importantly, a favorable synoptic-scale environment in the form of a mobile short-wave trough/jet streak system in the westerlies. The proximity of the Gulfstream to the shore guarantees there will be background baroclinity along the coast in winter when the land is much colder than the ocean. Cyclogenesis is favored when the background baroclinity is locally enhanced by Appalachian cold air damming, the presence of a snow cover to enhance the cold dome caused by damming, oceanic sensible and latent heat fluxes, and coastal frontogenesis. The synoptic trigger for development is provided by a favorable trough–ridge system with embedded jet streaks aloft.

q. Session 10: Projects GALE and ERICA
(Review by Thomas A. Niziol)

The three papers presented in this session dealt with projects ERICA (Experiment on Rapidly Intensifying

Cyclones over the Atlantic) and GALE (Genesis of Atlantic Lows Experiment). It was noted that the ERICA field study is unique in that no major field project has studied rapidly deepening cyclones.

Ron Hadlock opened the session outlining the ERICA field study planned for December 1988–February 1989. The Experiment on Rapidly Intensifying Cyclones over the Atlantic is specifically designed to achieve scientific understanding of the explosive intensification of some winter maritime storms. A number of new instrument systems that are to be deployed during the experiment were discussed, especially drifting buoys and new sondes to be deployed by specially equipped research aircraft.

Greg Forbes discussed the forecasting and nowcasting effort planned for implementation during ERICA. He illustrated how Hovmoller diagrams might be used to gain some lead time in storm prediction in relatively long range (72–96 h) forecasts of rapid cyclogenesis. Also discussed were the scheduling and logistics involved with the ERICA forecast office in the World Weather Building and the use of electronic mail (OMNET) for the coordination of activities among the World Weather Building team, remote forecasters, and the aircraft operations center in Brunswick, Maine.

The last paper, "NMC Involvement in GALE and ERICA," was presented by Ralph Petersen. He discussed a project by the NMC Development Division to reanalyze operational platform data from GALE. The project will form the basis for such efforts as profiler simulation studies, continuous data assimilation studies, and other experiments with the RAFS and the "eta-coordinate model," which is undergoing testing and development at NMC. Petersen also pointed out the advantages of having the operations center for the ERICA project at NMC where it would allow access to operational forecast products and possible reruns of forecasts using higher resolutions of the NGM model.

r. Session 11: New forecast techniques and planning for the future

(Review by Laurence G. Lee)

Wayne E. McGovern opened the session with a talk "High Resolution Remote Sensing Data: Future Applications to Winter Weather Forecasting." He stated that the key to improved mesoscale forecasting is an enhanced data base on a scale commensurate with the particular phenomenon. The best way to obtain such information is through the use of high-resolution re-

mote sensors such as NEXRAD, lightning detectors, profilers, and satellite imagers and sounders. Much of the research with these systems, however, has been with respect to warm-season events. McGovern discussed the possible applications of these sensors in nowcasting and forecasting events such as rain/snow lines (radar), heavy snow (radar, profiler), and snow showers (lightning detection).

Alan Nierow's presentation was entitled "NEXRAD in Winter Weather." His talk began with an overview of the National Weather Service's NEXRAD program. Basic Doppler theory was summarized with particular emphasis on radial velocity. Several NEXRAD products that pertain to winter weather were discussed. Doppler displays from winter storms in the western United States were shown as examples of the enhanced datasets that NEXRAD will provide in support of nowcasting and forecasting winter events.

The "NWS Winter Weather Program of the Future" was presented by Steve Harned. The talk focused on the new technology (NEXRAD, profilers, AWIPS, etc.) planned for implementation by the National Weather Service during the next decade. Along with the new technology will come revised operational procedures to enhance the NWS winter weather program.

The final talk of the workshop was "Training Development at a WSFO—Easy As A, B, C" by H. Michael Mogil. Even though forecasters at a WSFO do not have much time to create professional training aids, they do have a considerable amount of operationally oriented subject matter expertise. Mogil described the availability of resources within NOAA that forecasters can tap to help turn a local study into a polished product that can be used for on-station training or for training elsewhere.

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