UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL WEATHER SERVICE

NUMERICAL WEATHER PREDICTION ACTIVITIES REPORT

1979

CONTENTS

PART

I.	SUMMARY OF HIGHLIGHTS	1
II.	RESEARCH AND DEVELOPMENT IN NUMERICAL ANALYSIS AND PREDICTION SYSTEMS	3
III.	TECHNIQUES, DEVELOPMENT AND APPLICATION OF NEW PRODUCTS (Systems Development Office, Techniques Development Laboratory)	16
IV.	ANALYSIS-FORECAST SYSTEMS IN OPERATIONAL USE DURING 1979	24
V.	PLANS FOR FUTURE OPERATIONAL SYSTEMS	26
VI.	VERIFICATION PROGRAMS	27
VII.	PUBLICATIONS	33

UNITED STATES OF AMERICA

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL WEATHER SERVICE

PART I. SUMMARY OF HIGHLIGHTS

This report summarizes the numerical weather prediction activities of the National Meteorological Center and Techniques Development Laboratory for 1979. Highlights follow:

1.1 On 15 August 1979, a fourth-order coarse-mesh version of the 7L PE model became operational in the Large-Scale Run at 4+0. Normally it is used to extend the forecast at 0000 GMT from 60 to 144 (in place of 84) hours, but because of its faster computer running speed forecasters now replace the slower second-order finer-mesh version anytime problems or delays impede the delivery of the guidance.

1.2 A global spectral prediction model was introduced on 7 September 1979 on a limited operational basis for aviation purposes. It contains 11 layers and 24 horizontal modes rhomboidally truncated.

1.3 TIROS-N and NOAA-6 data were carefully introduced into various stages of the NMC numerical guidance system throughout the year as the retrieval systems were checked out and evaluated. Also implemented operationally were the European and Japanese cloud-tracked winds and data from the drifting buoys, ASDAR, constant level balloons, and the OMEGA dropsonde system.

1.4 The seven-layer version of the Limited-area Fine-mesh Model became operational on 1 March 1979. On 20 June 1979 a new subgrid scale convective precipitation scheme which contains improved moisture and heat budgets was introduced into the LFM.

1.5 On 26 August 1979, NMC's Ocean Services Development Group was transferred from Automation Division to Development Division.

1.6 The AFOS Aviation Monitoring and Updating technique was replaced by a Generalized Equivalent Markov (GEM) model. The GEM is currently capable of producing hourly probability forecasts of all surface-observed weather elements on the AFOS Eclipse minicomputer.

1.7 New thunderstorm and severe local storm forecast equations were developed for the spring, summer, and combined fall-winter seasons. Probabilities from the new equations are valid for the 12-24, 24-36, and 36-38 h intervals following 0000 and 1200 GMT.

1.8 The storm surge model, SLOSH (Sea, Lake, and Overland Surges from Hurricanes), was implemented in May 1979 for operational forecasting in the Tampa Bay, Florida area.

1.9 In the spring of 1979, Model Output Statistics agricultural weather guidance was produced for stations in South Carolina. Each day throughout the growing season, forecasts of air and soil temperature, precipitation amount, and daily insolation are generated from 7L PE model output.

ABBREVIATIONS AND ACRONYMS

AIDS	Aircraft Integrated Data Systems
AFGWC	Air Force Global Weather Central
AFOS	Automation of Field Operations and Services
ASDAR	Aircraft to Satellite Data Relay
BLM	Boundary Layer Model
CWF	Computer Worded Forecast
GARP	Global Atmospheric Research Program
GDAS	Global Data Assimilation System
GEM	Generalized Equivalent Markov
LFM	Limited Fine Mesh Model
MFM	Movable Fine Mesh Model
MOS	Model Output Statistics
MSL	Mean Sea Level
NMC	National Meteorological Center
NWS	National Weather Service
OI	Optimum Interpolation
PoP	Probability of Precipitation
RMSE	Root Mean Square Error
SPLASH	Special Program to List Amplitudes of Surges from Hurricanes
SLOSH	Sea, Lake, and Overland Surges from Hurricanes
SST	Sea Surface Temperature
TAP	Terminal Alerting Procedure
TDL	Techniques Development Laboratory
VTPR	Vertical Temperature Profile Radiometer
WMO	World Meteorological Organization
7L PE	Seven-Layer Primitive Equation Hemispheric Model
9L GLO	Nine-Layer Global Model
12L GLO	Twelve-Layer Global Model

PART II. RESEARCH AND DEVELOPMENT IN NUMERICAL ANALYSIS AND PREDICTION SYSTEMS

2.1 Regional Prediction Projects

2.1.1 Operational Changes in LFM II

Several aspects of the LFM II under study last year were implemented in the operational codes on 7 June 1979. Most important were improvements in the convective parameterization. The new version, in producing subgrid scale precipitation, conserves energy and moisture. A constraint additional to conditional instability was introduced for the onset of convection. A threshold value of moisture convergence now must be reached in the cloud base layer. Since implementation of these procedures mean monthly threat scores have exceeded previous maxima 5 out of 6 months. (Deaven)

A change was made at the same time which reduced the noise generated at the lateral boundaries, thereby reducing occurrences of spurious convective outbreaks. The new procedure reduces shocks by allowing the LFM solution to slowly converge toward the 7L PE solution.

An earlier change, 1 March 1979, was made to bring the LFM more in line with the structure of the 7L PE. Three stratospheric layers now exist in place of the former two plus the isentropic cap layer. While 100-mb forecasts were improved in some respects, some noise remained necessitating some additional smoothing of output fields at 100 and 150 mb. (Deaven, Newell)

New terrain heights were introduced on 24 September 1979. These were obtained by interpolation from a standard archive tape consisting of averaged values over 1° horizontal squares over the earth, except 1/4° resolution over the conterminous 48 states. Terrain fields were derived from the same archive for the 7L PE and placed in operation 10 July 1979. (Collins)

2.1.2 Development Work of LFM

An in-core version of the LFM that uses fourth-order differences has been tested. Similar to the operational LFM but with a computational domain of 53 x 45 grid points (Δx = 190.5 km at 60°N), flow patterns produced are almost identical to the operational model. Precipitation forecasts exhibit larger differences than pressure patterns, but on the basis of limited tests relative accuracy is undetermined. (Deaven)

LFM Development. A numerically new barotropic LFM was used to investigate questions of horizontal finite differences, boundary conditions, linearization of the semi-implicit equations, time differencing, and splitting of terms. Several test cases used 500-mb heights and winds as input. Forecasts out to 48 hours compared favorably with other barotropic models for the explicit version, but not for the semi-implicit version due to the uncentered time calculation of the nonlinear terms of the Helmholtz equation. The multilayer model development, therefore, has proceeded only with a split-explicit version. (Collins, Phillips)

Regional Analysis Project. A major milestone in the effort to improve the initial conditions for the LFM was passed during the year. Two analysis systems, one based on optimum interpolation and one on isentropic analysis, were developed as potential competitors for the present operational successive-approximations method. Six cases were selected in which both methods produced initial conditions for the LFM. Evaluation gave a slender advantage to the optimum interpolation method and it was selected for further refinement.

In terms of performance, the Regional Optimum Interpolation analysis performs competitively with the operational analysis; in terms of required computer time, it is competitive only when executed on a relatively coarse grid (381 km at 60N). Limited testing at higher resolution (191 km at 60N) suggests that the coarser grid loses little. Nevertheless, these tests were not exhaustive and some uneasiness about the coarse grid remains. NMC Office Note 203 describes the Regional Optimum Interpolation Analysis System. (Jones, Bergman, Gordon)

2.1.3 The Movable Fine-Mesh Model

Changes in Model Design. A modified Kuo parameterization of cumulus clouds permits a more realistic partitioning of evaporative and condensative processes during convection. Studies suggest that 70-80% of large moisture convergence converts to precipitation during convection (the MFM formerly allowed only about 35%). The model now develops vortices that are more realistic. (Hovermale)

Diagnostic Studies. The limitations that parameterization may place on storm structure and growth characteristics were studied. The model's 80% large-scale saturation criterion influences both features strongly by limiting minimum lapse rates in saturated columns which, in turn, limits the maximum temperature anomalies attainable in the storm core. Clearly, the study suggests that the large-scale saturation criterion, beyond precipitation rate and areal coverage considerations, should not only be increased, but that it must approach 100% before wall-cloud structures can be simulated. (Mathur)

Impact of Reconnaissance Data on Track Prediction. Storm-scale data from an aircraft-to-satellite data link were used to test the production of real-time analyses of storm structure. Seven forecasts, made with more detailed initial analyses of storm strength, produced better 48-hour forecasts than the operational system; on the average, the vector position error was reduced by about 10%. (Livezey, Rozwodoski)

2.2 Global-Hemispheric Prediction Projects

2.2.1 The Seven-Layer Primitive Equation Model

Operational Changes. 27 June 1979: An energetically consistent form of the hydrostatic equation was incorporated into the model to alleviate surges of kinetic energy in the early hours of the forecast; a nonlinear diffusion replaced the linear diffusion to maintain a constant mean kinetic energy throughout the forecast and was applied to all fields (θ, u, v, q) except pressure; the parameterization of long-wave cooling was adjusted to maintain a near constant mean potential energy. 15 August 1979: A fourth-order coarse-mesh (Δx = 381 km at 60°N) 7L PE became the operational model for the forecasts beyond 60 hours. 5 September 1979: Climatological sea-surface temperatures were replaced by NMC's recently developed sea-surface temperature analysis. 30 October 1979: Convective precipitation (patterned after a system originally developed for the LFM-II) was modified so that convection begins when a relative humidity of 75%, moisture convergence in the lower of two layers, and an unstable lifted parcel between layers obtain simultaneously; the modification produces rain at the ground, warms the upper layer, and dries the lower layer; during the first hour of the forecast period all rain and latent are disregarded; the model saturation criteria is set at 85% throughout the forecast. (Stackpole)

<u>Evaluation of "Tendency Method" Forecasts of Sea Level Pressure.</u> The model forecasts sea level pressure by adding computed pressure tendencies to the initial analysis. Over elevated terrain, this procedure retains the original pressure reduction techniques of the analysis throughout the forecast, rather than incorporating the modeled pressure reduction. Testing shows the tendency method to be of substantial value during summer. During fall, the method has no value. Winter and spring tests are planned. (Stackpole)

<u>Operational 4th Order 7L PE.</u> Fourth-order finite differencing has been applied to the horizontal advection terms in a coarse-mesh (Δx = 381 km at 60°N) version of the 7L PE. Fourth-order forecasts are competitive with the operational 7L PE (Δx = 190.5 km at 60°N), but require only 1/4 the computation time. (Campana)

<u>Fourth-Order Forecasts to Eleven Days.</u> The fourth-order coarse mesh 7L PE has run successfully to 11 days in four test cases. Model stability at this range required increased horizontal diffusion near the lateral boundaries after 6 days. (Campana)

<u>Initialization.</u> Experiments are being conducted to improve 7L PE initial data in tropical regions of the grid. Currently, model data south of 9°N bear no resemblance to the initial analyses, in that the region has been made meteorologically "bland" to promote model stability. In conjunction with a change in lateral boundary conditions (see following paragraph), the new initialization will use wind analyses over the entire grid, including the area south of 9°N, obtain a balanced height (on pressure surfaces) south of 20°N. (Brown, Campana, Mathur)

<u>New Lateral Boundary Conditions.</u> The lateral boundaries of the 7L PE were modified by removing the wall condition and including a "diffusive nudge" boundary similar to the LFM and MFM. Quantities near the lateral boundary (grid rows 2, 3, 4 and 5 inward from each lateral edge) are nudged towards their initial values by adding

$$K\nabla^2(\phi^{\tau-1} - \phi_i)$$

to $\phi^{\tau-1}$ each time step. Here, the value of the diffusion coefficient, K, is fixed at 0.04 and ϕ represents u, v, θ, and $\partial p/\partial\sigma$, while the subscript i indicates initial values of these quantities. The ∇^2 operator is the usual 5-point Laplacian without grid or map factor scaling. Initial values of all quantities are retained on the outermost grid rows throughout the period of integration. (Deaven)

Medium-Range Forecasting. The Medium-Range Forecast Group is developing two techniques to improve the 6-10 day outlooks. The first calculates simple linear regressions at each grid point of the mean 6-10 day 500-mb height forecasts. Thirty-five observed and forecast fields are used to calculate coefficients which are then applied to the forecast to produce a new height field.

The second is an analogue search based on 33 years of data. Using the 84-hr 500-mb forecast from the 7L PE, the computer searches for those dates which correlate most highly with the forecast over North America. The period is restricted to 15 days on either side of the forecast date in each of the 33 years searched. Historical map files are then referenced for the observed mean and daily weather patterns on these dates and the subsequent changes. (Andrews, Hughes)

2.2.2 The Three-Layer Global Model

A major effort was directed toward improving the precipitation forecasts. Several 11-day forecasts, using summer and winter initial data, were used to test a wind-stability-dependent form of the drag coefficient (C_D)*. The tests improved the conservation of specific humidity and provided a better correlation between forecasts of circulation and precipitation. The new C_D formulation was incorporated operationally in October 1979. (Bostelman)

2.2.3 Spectral Modeling

(Notation: Gnkm and Hnkm describe model type: G - global, H - hemispheric, n maximum zonal wave number, km - number of layers).

Short-Range (84-hr) Northern Hemisphere Forecasts. Selected cases were used to produce short-range forecasts that were then subjectively compared with the 7L PE. Both models performed similarly to 48 hours with slight differences, e.g. the 7L PE outperformed the spectral in precipitation forecasts and the spectral outperformed the 7L PE at 250 mb. At 84 hours the spectral forecasts appeared to gain in relative accuracy to the 7L PE.

Randomly selected cases were used to produce an additional 12 forecasts. All tests used an H30K12 version of the model. S1 verifications at 24 and 48 hours confirmed the similarity of the two models. Reruns of two cases using a G30K12 model produced almost identical spectral forecasts at 48 hours. (Sela, O'Connor, Rozwodoski)

---

*Gates, Lawrence W., 1973: "Analysis of the Mean Forcing Fields Simulated by the Two-Level Mintz Arakawa Atmospheric Model," Monthly Weather Review, Vol. 101, No. 5.

Arakawa, Akio, 1972: "Design of the UCLA General Circulation Model," Numerical Simulation of Weather and Climate, Technical Report No. 7, Dept. of Meteorology, UCLA.

Operational Configuration Changed. A G24K11 version replaced the G24K7 operational model during the first week of September. The increased vertical resolution is intended to provide backup to the Data Assimilation Cycle. Verification of 250-mb winds in the tropics shows skills over persistence. (Sela, Steinborn, Stackpole)

New Six-Day Forecast System Under Study. A forecast system to 48 hours and continuing to 144 hours using an H24K12 has been prepared for competition with the 7L PE operational system. Ten forecasts were produced and evaluation is in progress. (Sela, Rozwodoski)

Variations in Vertical Resolution Studied. Model vertical resolution variations were studied using the Hough analysis. A spectral model with equally spaced sigma layers was compared with a version having higher resolution in the upper layers. A statistical evaluation using station data revealed that both versions are very similar; the equally spaced configuration will continue to be used. (Sela, Rozwodoski)

Normal Modes Initialization. Machenhauer's initialization method was tested in a 6-hour data assimilation cycle out to a period of 72 hours. Fields were analyzed with the operational Hough programs. The comparison with an uninitialized cycle shows a positive impact when the first six normal modes of a G24K12 version are used. Time continuity in vertical velocity fields using consecutive 6-hour forecasts produced by a G30K12 model is under study. (Sela, Ballish)

2.2.4 A 12-Layer Version of the Nine-Layer Global Model

A 12-layer Global (12L GLO) version of the new 9L GLO has been constructed. The new model has nine layers in the troposphere, three layers in the stratosphere, and eight moisture-bearing layers. While the model dynamics are unchanged, minor changes to the model physics were required to accommodate the additional moisture-bearing layers. Both the precipitation and convection packages are involved. In forecasts to 48 hours, the model, as with the 9L GLO, loses mass near the poles. Model kinetic and potential energy remain nearly constant with time, however, and vertical velocities remain similar in magnitude to those generated by the 9L GLO. (Facey)

2.2.5 The Operational Global Data Assimilation System (GDAS) (10+0)

Developmental Changes. GDAS* developments progressed through three phases during 1979. First, the ingestion of data from the Global Weather Experiment's observing systems; this expansion of the data base resulted in a substantial increase in the computational time required to execute the GDAS. The second phase was therefore directed at making the GDAS more efficient. By reducing the maximum number of reports allowed to effect any update from 10 to 8, and adopting a modified Kurihara grid with a 3.75° resolution, the desired efficiency has been achieved. (Kistler, Gordon)

---

*The GDAS was documented by two papers published in the November 1979 Monthly Weather Review. Bergman presents the theoretical foundation of the optimum interpolation method. The other, jointly authored by the GDAS development team, describes the application of the theory and the design of the system.

Replacement of 9-Layer Global. Thirdly, attention was directed toward replacing the 9L GLO with a 12-Layer Spectral Model. At year's end, a version of optimum interpolation was adapted to interface with the spectral model, and preimplementation testing began. (Parrish, Kistler, Gordon)

Initialization. A major component of the spectral prediction model, with respect to its applications in the GDAS, is the nonlinear normal model initialization procedure. This method promises efficient enforcement of a general wind law, as embodied in the model equations, on analyzed mass and motion fields. Experimentation is underway to explore the possibility of restoring initialized fields toward analyzed fields to a degree proportional to the estimated analysis error. Thus where the estimated analysis error is low, indicating high confidence in the analysis, the restored fields would differ only slightly from the analysis. For high analysis errors, confidence is low, and the restored fields would closely resemble the initialized fields. (Parrish)

Monitoring and Diagnosis. The daily performance characteristics of the GDAS were monitored throughout the year. Mean and RMS deviations from radiosonde observations over two fixed networks: 110 North American stations and 102 Northern Hemisphere stations were calculated for analyses and short-range (6 hour) forecasts. The deviations were calculated twice daily, and summarized monthly.

The statistics for October 1978 to August 1979 (GDAS based on optimum interpolation) were compared with statistics for October 1977 to August 1978 (system based on Hough analysis). The comparison suggests that only minor differences in performance exists between the two systems over areas of dense radiosonde coverage. This statistical evaluation will be documented as an NMC Office Note. (Gerrity, Dey)

Diagnostic monitoring also revealed some characteristics of the mass-motion balance in the GDAS. After the introduction of TIROS-N temperature soundings into the GDAS data base, it became evident that although the soundings affected the mass field in a reasonable way, their effect on the motion field was generally less than might be expected. Since the prediction model's natural tendency is to adjust the mass field to the motion field for most scales of motion, the influence of the TIROS-N soundings in the analysis was quickly reduced in the subsequent short-range forecast. A review of the theory and application of multivariate optimum interpolation, with the aim of improving the GDAS' performance in this respect, was begun. (Gerrity, Phillips, Kistler, Ward, McPherson)

Wind Estimates from Satellite-Derived Temperature Soundings. Mass and wind fields, generated by the Global Data Assimilation System, indicate that in areas where no wind observations are available, especially in the Southern Hemisphere, the coupling between a mass field (updated with numerous satellite temperature soundings) and the updated wind field is weak. During the subsequent 6-hour 9L GLO forecast, the mass fields tend to adjust toward poorly defined wind fields and degrade the succeeding first guess fields. The assimilation system should have additional wind information and/or a better method of relating the mass and wind fields.

Two feasibility studies are in progress to provide pseudo wind information to the Data Assimilation System using different analysis methods:

(a) Nonlinear balance

The Hough analysis system produces global height analyses from satellite-derived geopotentials. Winds are then obtained from the nonlinear balance equation.

(b) Gradient Winds

A successive correction analysis system is used in both hemispheres to produce height analyses from satellite-derived geopotentials. Gradient winds are calculated poleward of 30 degrees, and winds between 20 and 30 degrees latitude are calculated by latitudinally weighting the gradient wind with a geostrophic wind such that the wind is geostrophic at 20 degrees. No winds are provided between 20°N and 20°S.

The Data Assimilation system is currently being tested, incorporating these pseudo winds with the normal data base. The accuracy and cost-effectiveness of each method of providing winds are being assessed.

(O'Lenic, DiMego, Desmarais)

2.2.6 Large-Scale Run Analysis Project

General. At year's end, initial conditions for the 7L PE hemispheric forecast in the Large-Scale Run were still provided by the Hough spectral objective analysis system. Alternative systems, based on optimum interpolation, were being developed as potential replacements.

The GDAS, executed with an earlier data cutoff, offers one attractive alternative, especially if NMC implements a spectral model in both the Large-Scale Run and the GDAS. In that event, initial conditions would be specifically tailored to the Large-Scale Run prediction model.

A second alternative lies with an analysis system intermediate between the Hough and the GDAS. The vertical structure and variables analyzed in the Hough system are shared in that the analysis is performed at 12 mandatory isobaric levels using geopotential heights rather than layer-mean temperatures; yet, the intermediate system remains similar to the GDAS in its horizontal grid and in the optimum interpolation procedure.

The isobaric optimum interpolation system is being tested. One analysis has been executed and a spectral forecast integrated from the initial conditons. Evaluation is underway.

A comparison of these two alternative approaches is envisioned for early in 1980. The more promising will be further refined for competition with the Hough system.

(Dey, Morone, Kistler, Gordon)

Hough Analysis TIROS-N Preimplementation Tests. Preimplementation tests were conducted with the Large-Scale (Hough) Analysis to use TIROS-N data in the Northern Hemisphere. Eight cases were seclected for parallel reruns, and each case was rerun in two different modes: 1) with TIROS-N and upper-air

(250 mb) height bogus; 2) with TIROS-N and no upper-air height bogus. Results indicate that the Hough system can handle TIROS-N data except at 250 mb when upper-air bogus is allowed in the same geographical area. Under such conditions, the Hough system forces the bogus to dominate the satellite soundings. Forecasters routinely monitor aircraft reports and bogus oceanic 250 mb height data to control the Large-Scale Analysis. Frequently, however, bogusing is generated without access to satellite soundings, Subsequently, therefore, the Large-Scale Analysis was modified to use TIROS-N soundings over water in the Northern Hemisphere, and to remove the influence of 250 mb height bogus in areas where TIROS-N data are available. (Desmarais, Parrish)

2.2.7 Data Systems Project

Impact Test of U.S. Cloud-Tracked Winds. Parallel 7-day runs were conducted on the GDAS to test the impact of U.S. cloud-tracked winds: one run (SAT mode) included NESS cloud-tracked winds; the other did not. Operationally these winds are available primarily at two levels, low (stratus) and high (cirrus), and over an area existing from 20W to the dateline and equatorward from about 50° latitude. Differences in mass amd motion-fields in the analyses between the SAT mode and the NOSAT mode were examined to determine impact.

The rest revealed: 1) 30-40 m sec^{-1} differences resulting from cloud-tracked winds in the upper troposphere and stratosphere in the tropics and Southern Hemisphere; 2) smaller, but significant differences at lower levels and in the Northern Hemipshere; 3) greater amplitude and intensity of weather systems in the SAT-mode analyses; 4) cloud-tracked winds generally improve the quality of the analyses. The test was described at the AMS Fourth Conference on Numerical Weather Prediction. (Tracton, McPherson)

Preimplementation Test of European Cloud-Tracked Winds. Cloud-tracked winds, produced by the European Space Agency, were investigated to determine whether they could be inserted into the operational data base safely; impact, per se, was not addressed. The data were introduced into an experimental version of the GDAS over 36 hours. Close examination suggested that the winds were generally reasonable. A few vectors were seriously mislocated in the vertical, and the GDAS was adjusted to defend against these.

(Morone, McPherson)

2.2.8 Temperature Observations from TIROS-N and NOAA-6

The following is a chronology of events for TIROS-type data at NMC, used over water only:

November 15, 1978. Began receiving TIROS-N test retrievals.

March 5, 1979. Temperature retrievals south of 10°S were used in optimum interpolation analysis program in Data Assimilation Cycle.

March 19, 1979. Same but for the spectral analysis program in Large-Scale Run. Data errors persisted.

April 30, 1979. Temperature retrievals from infrared channels only were used in Data Assimilation Cycle north of 10°S.

May 15, 1979. Retrievals from infrared plus microwave channels used in Data Assimilation Cycle.

July 15, 1979. Same for Large-Scale Run. Microwave retrievals later eliminated in NMC system from 20°N to 20°S.

October 19, 1979. Began using NOAA-6 temperature retrievals in Data Assimilation Cycle.

January 6, 1980. Because of NOAA-6 data processing and microwave channel problems, this data was the earliest that the NOAA-6 temperatures could be used in the Large-Scale Run.

A significant seasonal bias was found in the cloudy microwave retrievals over the extratropical Northern Hemisphere oceans. The problem is due to unrepresentativeness of the radiosonde-satellite comparisons in obtaining the least squares coefficients relating temperatures to microwave brightness temperatures. Being too heavily weighted by continental stations, the cloudy oceanic winter retrievals contain a cold bias of the order of 2 to 4 degrees in the 1000-850 mb layer and a warm bias above. The results are opposite in summer. This problem will be corrected in 1980.

Unfortunately, the engineering design criteria of TIROS-N resulted in an orbit in which the data in the eastern Pacific are not always available for the Large-Scale Run (4+0). Furthermore, precipitable water measurements reflect a serious underestimate of the atmospheric variability and have not been used in the NMC system. However, the TIROS-type temperature data appear to be a significant improvement over the previous operational satellite data. Stratospheric values seem quite good.

(Phillips, Desmarais, & Staff)

2.2.9 <u>Diagnostic Studies of Jet Stream Energetics</u>. The goal of this study is to enable a better understanding of the energy exchange processes of jet stream intensification, maintenance, and retardation. A series of diagnostic programs is being prepared, using presentations developed from available NMC forecast models. These include the presentation of the divergent part of the atmosperhic circulations, both on pressure surfaces and in vertical cross section form.

Displays of divergent circulations and kinetic energy generation from the operational (grid point) hemispheric forecast model showed several cases of strong oscillations in forecasts of these quantities, with a period of approximately 12 hours. The oscillations seemed to damp slowly with time into the forecast. The amplitude of the oscillation is stronger in some cases than in others, possibly depending on the first guess used for the particular day under examination. Comparable oscillations were found in a spectral model forecast which began from nondivergent initial conditions. Early tests of a spectral model with normal mode initialization showed no such oscillations.

The oscillations in the operational forecast model sometimes involves complete reversals of vertical circulations and kinetic energy production from 0 to 6 to 12 to 18 hours. They have to be destructive to the forecast, especially the forecast precipitation amounts.

Future plans are for application of diagnostic calculations to jet stream problems using forecasts prepared with normal mode initialization.
(Cressman)

2.3 Systems Evaluation Projects

2.3.1 Data Systems Evaluations

Colocation of Wind Observations. Winds from radiosondes, aircraft, ASDAR, GOES-A, GOES-B, and the Japanese and European satellites have been regularly monitored and compared by colocation. The maximum colocation window is 3 latitude degrees horizontally, approximately 600 m vertically for satellite-aircraft colocations, and 3 hours temporally. RAOB winds are interpolated to the altitude of the colocated observation. Results presented below are for 3°, 1 hour, and altitudes above 500 mbs.

Mean wind differences between aircraft and radiosondes were less than 2 m/sec with little month-to-month variation. Colocations between satellites and other sensors had larger mean wind differences and greater month-to-month variation. Generally, aircraft-satellite mean wind differences correspond rather well with radiosonde-satellite mean wind differences. (Vlcek)

Detailed Evaluation of European Satellite Winds. European satellite cloud-tracked winds were evaluated in some detail prior to operational utilization. The evaluations were based on radiosonde wind colocation statistics and subjective comparisons of the Data Assimilation Cycle, run with and without the winds for several analysis periods. The results indicated that most winds were synoptically reasonable and that the analyses were somewhat improved. Comparisons of the cloud-tracked wind against the level of best fit from the radiosonde wind profile indicated that the cloud-tracked winds were usually assigned to an elevation above the level of best fit.

These cloud-tracked winds were introduced in the OI Data Assimilation Analysis Cycle on May 17, and in the Large-Scale (Hough) Analysis on June 6.
(Desmarais, Morone, Hirano)

Aircraft Integrated Data Systems (AIDS) Data. In support of the NASA Commercial Aircraft Fuel Savings Program, NMC has agreed to rerun several analyses and forecasts with additional high resolution, high quality, non-real-time wind and temperature data collected from specially-equipped wide-bodied aircraft with storage systems to monitor aircraft performance. The AIDS data will be processed by the Special Aircraft Data Center in the Netherlands and forwarded to NMC for special periods during 1979.

Certain air carriers will compare new flight plans with actual enroute data for selected flights to access the potential for fuel savings that could be provided if the AIDS-type data were available to the meteorological community in near real-time. (Desmarais, O'Lenic)

Semi-Annual WMO Data Monitoring. In support of the WMO, summations were made of all processed aircraft reports in the NMC data base during the periods 1-15 June and 1-15 December 1979. Report counts were provided in 5 x 5 latitude/longitude boxes within 3 hours of the 0000, 0600, 1200 and 1800 GMT periods.
(Desmarais)

2.3.2 Analysis-Forecast Systems Evaluations

Spectral vs 7L PE. Test evaluations of the Spectral Model as a replacement for the operational 7L PE were initiated. The contending models were configured as follows:

Spectral:

- 12 equal sigma layers
- 30 modes, global, through 48 hours
- 24 modes, hemispheric, from 48 to 144 hours

7L PE:

- fine mesh, 2nd order differencing through 60 hours
- coarse mesh, 4th order differencing from 60 through 144 hours
- all operational changes through 1979 included plus modifications to the initialization and boundary conditions to improve the forecasts in tropical regions.

Ten cases were selected and objective and subjective verification and evaluation initiated with particular attention to those elements most critical to NMC's operations.
(Stackpole)

Systems Evaluation: Pre-GARP Basic Data Set. 7L PE forecasts from the pre-GARP Basic Data Set from 0000 GMT 4 November 1969 through 0000 GMT 8 November 1969 are being verified. Preliminary results show a reduction of RMS errors in 24-, 48-, and 72-hour height forecasts (1000 mb and 500 mb) relative to the errors of a set of 9L GLO model forecasts run from the same data several years ago.
(Vlcek)

2.3.3 World Weather Experiment Activities.

During 1979 NMC was operationally involved in real-time data processing of not only the conventional meteorological observations but also the special observational systems that were implemented for the Global Weather Experiment. Evaluation studies were conducted to determine the quality of the TIROS-N and NOAA-6 temperature soundings. Copies of the Level IIa, Level IIa', and Level IIIa data files were forwarded on a regular weekly basis to the World Data Center in Asheville. Dave Wright, on duty at NMC for the FGGE year from the Bureau of Meteorology, Australia, provided valuable monitoring of the drifting buoys and the TIROS-N temperature soundings, especially in the Southern Hemisphere.
(Desmarais)

The Global Weather Experiment Special Effort

Data Base: With the exception of the AIDS aircraft data, all components of the data base arrived for the first Special Observing Period (5 January - 5 March 1979). Data for the second SOP (May-June 1979) are nearly complete. The data base consists of conventional data and Level IIIa (Data Assimilation Cycle) analyses from NMC; constant level balloon, temperature dropsonde, drifting-buoys, ASDAR aircraft and TWOS-Navaid data; plus TIROS-N satellite soundings and European, Japanese, NESS and Wisconsin satellite cloud-tracked winds.

Hardware, Communications and System Support. All of the major components of the McIDAS (Man-Computer Interactive Data Access System) system have been installed and checked out. Since June, the McIDAS terminals have been run on a daily basis.

Applications Software. A large amount of software has been implemented on the McIDAS. This includes basic level and special purpose graphics routines, a variable resolution/projection geographical background package, Level II report and Level III grid unpackers, data plotting routines, data analysis routines, contour/streamline graphics routines and routines to set quality flags in the data base. (DiMego, McCalla, McCalla, Hess)

2.4 Ocean Services Development

2.4.1 Ocean Services Transferred.

Automation Division's Ocean Services Development Group was transferred to Development Division on 26 August 1979.

2.4.2 Sea Surface Temperature Analysis.

Global SST Project. An operational global sea-surface temperature analysis now provides information at the lower boundary of NMC's atmospheric numerical weather prediction models. A Carstensen-type conditional relaxation procedure is used to produce an analysis of sea surface temperature over a 129 x 129 polar stereographic grid. Reports from ships, fixed and drifting buoys, expendable bathythermographs, and satellites, composited over a two-day period, constitute the data base. Each hemisphere is updated once per day, on alternate days.

Following extended monitoring and adjustment, the global SST analysis began to influence the operational atmospheric prediction models on 5 September 1979. It continues to be monitored, however, as is noted below. An NMC Office Note is being prepared. (Larson, Gemmill)

Regional SST Project. The global SST analysis is too coarse for some applications and development of a higher resolution SST analysis for regional applications was initiated in 1978. During 1979, the regional SST analysis attained quasi-operational status: it is now executed twice weekly, on a non-scheduled basis, and is distributed by mail and once each week on DIFAX. Using a 5-day composite of ship and buoy data blended with satellite data, three regions are analyzed: the northeastern Pacific, Gulf of Mexico, and the western North Atlantic. The analyses are performed on a 20 km grid using the successive-correction interpolation method. (Gemmill)

2.4.3 Modeling

Gulf Stream Model. Early in 1979, work began on the construction of a model to predict the intermediate-scale meanderings of the Gulf Stream for periods up to 10 days. An equivalent barotropic prediction model is under development for this application. The model allows for an ocean with a variable but rigid bottom and a free surface. The determination of appropriate finite-differences forms and open-ocean boundary conditions were emphasized. Testing and evaluation is under way. (Gemmill)

Regional Wave Model. Several wave-prediction models are under evaluation for possible application to wave prediction in specific regions such as the Bering Sea and the Gulf of Alaska. Ultimately, the model will produce high-resolution wave-spectra forecasts operationally in support of civilian activities in coastal and offshore waters. Evaluation is continuing. (Larson)

2.4.4 Monitoring and Diagnosis

BATHY/TESAC. Data on ocean temperature structure (BATHY) and temperature-salinity structure (TESAC) are routinely monitored globally. Summaries, by originating GTS Center and reporting ship, are compiled monthly. Data from U.S. sources are monitored for quality control and then forwarded to users. The monitoring function is being facilitated by a program to provide monthly mean temperature-depth profiles at selected locations. (Gemmill, Kundrat)

Comparison of Satellite and Ship SST Data. Inhomogeneous data-sources pose one of the more difficult problems in SST analysis. The problem is most evident when comparing conventional, spot measurements from ships and buoys with satellite radiance measurements.

To study characteristics of the two sources, pairs of approximately colocated satellite and conventional SST measurements were collected using a window of 50 km.

Preliminary results, from a short period in August, reveal good agreement between surface SST reports and TIROS-N SST retrievals in the Southern Hemisphere. North of 40° in the Northern Hemisphere elsewhere, approximately 50% of retrievals were at least 1.5°C warmer than the colocated ship report: between 10°N and 20°N approximately 1/3 of retrievals in the 10-20 degree north latitude band were at least 1.5°C colder than the ship report. These results were presented at the Workshop on the Use of Satellite Data in Ocean Analysis and Prediction, Bay St. Louis, Miss. (Larson, Brown)

2.4.5 Sea-surface Temperature Fields

Analyzed sea surface temperatures were evaluated using mean monthly climatological sea surface temperatures as quality control. During a two-month period, the SST analyses appeared to be stable and accurate, evidencing virtually no disagreement with corresponding climatological values. Based on these results, the sea surface temperature analysis was implemented operationally.

PART III. TECHNIQUES, DEVELOPMENT, AND APPLICATION OF NEW PRODUCTS (Systems Development Office, Techniques Development Laboratory)

3.1 General Development Techniques

3.1.1 Goals

The goal of the research program of the Techniques Development Laboratory (TDL) is to develop improved objective methods of weather prediction. The components of the program are: public weather prediction, severe local storm prediction, marine environmental prediction, terminal weather prediction, agriculture weather prediction, and forecasts suitable for application within the anticipated system of Automation of Field Operations and Services (AFOS).

To accomplish this goal, TDL makes effective use of statistical procedures. Forecasts of the desired weather element are obtained from an appropriate combination of "predictors" derived from relevant observations, numerical forecasts, or both. In the technique known as "Model Output Statistics" (MOS), large samples of predictors are related to corresponding predictand samples by multiple screening regression, or other suitable means. When the need arises, TDL develops special purpose numerical models to supplement those in existence.

Implementation of AFOS will provide a new dimension to the use of automated techniques. For the first time, communication, computer, and display facilities will be collocated to a station and will allow rapid response to urgent queries by forecasters. Forecasts can be updated very quickly in the light of new data. Since AFOS features a national network of local minicomputers, some of TDL's techniques are being increasingly tailored for use on these minicomputer; these techniques are referred to as AFOS forecast applications. (Glahn)

3.1.2 Public Weather Prediction

General. Much emphasis is placed on developing new and improved automated predictions of weather elements contained in public weather forecasts. Efforts are focused on four key meteorological elements: precipitation, temperature, clouds, and wind. (Miller)

Precipitation Forecasting. Since 1972, TDL has been producing MOS forecasts of the probability of precipitation (PoP) through the Regression Estimation of Event Probability (REEP) model. A recent experiment with the logit model, using predictors selected by REEP, showed consistent though modest, improvements in the forecasts. Little difference was found when the predictors were selected by a screening logit model. (Gilhousen)

Frozen Precipitation Forecasting. Forecasts of the conditional probability of precipitation type (PoPT) were produced by the logit model with predictors from the Limited-area-Fine Mesh (LFM) model. Data from different stations were combined by transforming the predictor variables into deviations from each station's 50% values. An improved transformation method was devised which accounts for the difference in the slope of the logit curve between stations, in addition to the difference in 50% values. (Bocchieri)

Quantitative Precipitation Forecasting. TDL continued to expand the MOS quantitative precipitation forecast (QPF) guidance package. Forecasts of the probability of precipitation amount (PoPA) and categorical forecasts of precipitation amount are now available for 6-h intervals from 6 to 24 hours after 0000 GMT and from 6 to 36 hours after 1200 GMT. Forecasts are also available for 12-h intervals from 12-48 hours after both 0000 GMT and 1200 GMT, and also for 24-h intervals from 12 to 60 hours after 0000 GMT and 24 to 48 hours after 1200 GMT. The PoPA guidance package is based entirely on LFM model output and is available for about 230 cities throughout the conterminous U.S. In developing this new PoPA guidance package, a new objective technique was used to convert probability forecasts to categorical forecasts. Previously, asubjective technique was used to derive these threshold probabilities which maximize the threat score. (Zurndorfer)

Surface Temperature Forecasting. TDL continued to monitor and improve the objective temperature guidance supplied daily to NWS offices and other users. MOS forecasts of the calender day maximum/minimum (max/min) temperature are generated from LFM ("early" guidance) or PE ("final" guidance) model output. These are available during both the 0000 and 1200 GMT cycles and are valid out to approximately 60 hours in advance.

As part of the early guidance, LFM-based MOS forecasts of the surface temperature at 3h intervals from 6 to 51 hours after 0000 or 1200 GMT are also available. Subsets of 3h temperature forecast equations were derived simultaneously with the appropriate max or min forecast equation to enhance consistency among all the objective temperature forecasts.

New 3-month MOS max/min forecast equations were developed for 14 stations in Alaska. These equations are valid for the spring (March-May), summer (June-August), fall (September-November), and winter (December-February) seasons. The forecast projections are the same as those of the early and final guidance mentioned above. (Dallavalle)

Cloud Forecasting. The previously reported early guidance four-category MOS forecasts of cloud amount, based on LFM II model output, continue to provide operational guidance for conterminous United States locations. The use of the final guidance equations (based on LFM II and 7L PE model output) has been discontinued.

Forecasts of cloud amount for 26 NWS and Department of Defense locations in Alaska are now available operationally twice-a-day. The predictions are valid every 6 hours from 12 to 48 hours after 0000 and 1200 GMT. (Hebenstreit, Vercelli)

Surface Wind Forecasting. Early guidance (LFM-based) MOS forecasts of wind direction and speed, valid every 6 hours from 6 to 48 hours after 0000 GMT and 1200 GMT, are currently available via the request/reply teletypewriter circuit for approximately 230 stations in the conterminous United States. This year, TDL improved the guidance for the cool season (October-March) by using an updated version of the screening regression program which prevents the selection of very highly correlated predictors. In the past, the combination of highly correlated predictors and a short developmental data sample resulted in equations which occassionally produced unrealistic forecasts. The new equations have been used in daily operations since October 1979.

Forecasts of thunderstorm induced surface wind gusts of 25 kt or more were improved and expanded. Convective gust potential forecast equations were developed for seven additional NWS stations in the western United States. The equations for the original ten stations were rederived to include two more seasons (May-September of 1977 and 1978) of developmental data. Also, for the first time, guidance was provided for both the 0000 and 1200 GMT forecast cycles. (Janowiak, Carter)

3.1.3 Severe Local Storm Prediction

General. A major research effort is devoted to the development of automated techniques for forecasting severe local convective weather, notably thunderstorms and their manifestations like hail, strong wind gusts, and tornadoes. The forecasts cover three time ranges: 12-48 hours (medium range), 2-6 hour (short range), and 0-2 hour (very short range). These are dealt with in three distinct tasks. In addition, a predictive numerical model of the planetary boundary layer has been developed in support of both the short- and medium-range tasks. (Alaka)

Medium Range Forecasting. The MOS technique has been used to develop new regression equations for forecasting the probability of thunderstorms and severe local storms for projections of 12-24, 12-36, 24-36. and 36-48 hours following initial data time. Forecast probability values are computed at a grid of points 80 km apart, covering the United States east of the Rocky Mountains. Different severe local storms forecast equations were developed for spring, summer, and combined fall-winter seasons. For thunderstorms, equations were developed for the spring-summer and fall-winter seasons. The forecast probabilities are transmitted by facsimile, teletypewriter, and video displays to NWS field offices. (Reap, Foster)

Short Range Forecasting. A combination of classical statistics and MOS techniques is being used to produce 2-6 hour probability forecasts of thunderstorms and severe local storms. Predictors are derived from objectively analyzed hourly surface observations, output from NMC's LFM model, manually digitized radar data, and the climatic frequency of the predictand. Forecasts for the periods 1700-2100, 2000-0000, 2300-0300, 0200-0600 GMT are transmitted daily during the convective season by teletype bulletins and in map form to NWS field offices. During the 1979 season, new equations featuring greater geographical reagionalization, longer historical samples, and refined interactive predictors were developed. (Charba)

Very Short Range Forecasting. Efforts in this range (0-2 hours) rely on the capability of weather radar to indentify and trace the development of severe local storms. Basic data consists of digitized radar reflectivities collected at different elevation angles. Screening regression techniques are used to relate severe weather occurrences to parameters derived from base level reflectivities and estimates of the vertically integrated liquid water content. Five years of stormy season data have been used to develop computer programs which automatically isolate and compute estimates of the probability of severe weather associated with different cells. (Elvander-Saffle)

Boundary Layer Model (BLM). A three-dimensional numerical planetary boundary layer model is run twice daily to forecast wind, temperature, and humidity in the lowest 2 km of the atmosphere. The forecasts are for periods of up to 24 hours and extend over most of the United States east of the Rocky Mountains. The model's horizontal mesh spacing is about 82 km. Ten levels, with separation increasing with elevation, are used in the vertical. The 50-m thick surface layer supplies turbulent fluxes of heat, momentum, and humidity to the transition layer above. Other model features include the solution of an engery balance for surface temperature and humidity, the modification of temperature by radiation, and the solution of the transition layer equations by linear finite elements.

Forecasts are being saved for later use in developing MOS regressions for severe storm forecasts. Several products appear particularly useful: 1) the best lifted index (a measure of atmospheric instability), 2) precipitable water within the boundary layer, 3) vertical motion at 2 km, and 4) horizontal moisture convergence. Case studies suggest that these four parameters, taken together, correlate well with severe storms. (Long, Shaffer, Kemper)

3.1.4 Marine Environmental Prediction

General. The Techniques Development Laboratory has continued to develop new techniques and improve existing techniques of forecasting for the marine environment. The work continues under three separate tasks: oceanic forecasting, coastal forecasting, and Great Lakes forecasting. (Pore)

Oceanic Forecasting. Automated wave forecasts have continued to be produced for the North Atlantic, North Pacific and Gulf of Mexico. The Atlantic and Pacific forecasts are based on wind forecasts of NMC's 7L PE model; the Gulf forecasts are based on boundary layer wind forecasts of LFM II model. (Pore)

Development work has continued on oil spill trajectory forecasting. The object is to develop an operational model to forecast the movement and fate of petroleum in the open ocean. Six university contracts on various aspects of the research have been completed. Integration of these studies and operational implementation of the model is in progress.

An oil spill advection model based on NMC's LFM II model forecasts is available for operational use. Implementation of a more advanced oil spill model is in progress. (Barrientos, Hess)

Coastal Forecasting. SPLASH (Special Program to List Amplitudes of Surges from Hurricanes) was continued in operational use during the year. The program applies a stretched-sheared coordinate system to 34 basins along the U.S. east and Gulf of Mexico coasts. The sheared system considers the effects of curved coastlines on surge generation. The stretched system continuously adjusts the computational grid to suit the surge dynamics; it provides a finer grid in shallow water where surge dynamics are stronger.

Development has continued on the dynamic surge model for inland flooding. The SLOSH, (Sea, Lake, and Overland Surges from Hurricanes) model considers two-dimensional inland flooding, overtopping of levees and other barriers, as well as surges along broken coastlines. A polar coordinate system has been developed for the SLOSH model, which provides fine-scale resolution over inland water bodies and terrain, and coarser resolution over deeper ocean areas. During 1979, Tampa Bay became the third area for which SLOSH is operational; the other two are the New Orleans area and Lake Okeechobee, Florida. (Jelesnianski, Chen)

The statistical method or extratropical storm surge forecasting for the east coast of the United States was continued in operational use at 12 locations. These forecasts, are based on sea-level pressure forecasts of NMC's LFM II model. (Richardson)

The statistical beach erosion forecast method for the United States east coast from Maine to South Carolina was modified in December 19. The purpose of the modification was to eliminate overforecasting beach erosion intensities along the Maine and Massachusetts coasts during unusually high spring tide conditions. The qualitative forecasts of beach erosion intensities (none, minor, moderate, major, or severe) are based on times and heights of astronomical high tides and extratropical storm surge forecasts. (Richardson)

The coastal wind forecast model continued to be run operationally for the east and west coasts. The model was expanded to include four new forecast locations off southern California and six locations in Chesapeake Bay. (Burroughs)

Great Lakes Forecasting. Operational wind and wave forecasts for the Great Lakes were continued through 1979. The wind forecasts, developed by the MOS method, are produced twice daily for 12 forecast areas of the Great Lakes. In May, the wind speed forecasts were "inflated" to expand the scatter about the mean so that extremes are forecast more often. Automated wave forecasts which are based on the uninflated wind speeds continue to be made for 64 points on the lakes pending further study. (Burroughs, Pore)

The Great Lakes storm surge forecast program for Lake Erie was changed during 1979 to use a forecast method developed by the Great Lakes Environmental Research Laboratory (GLERL) of NOAA. The GLERL method, which is based on a dynamical model, transforms TDL Lake Erie wind forecasts into storm surge forecasts for Buffalo, New York and Toledo, Ohio. Lake Huron storm surge forecasts for Essexville and Lakeport, Michigan continue to be made with a statistical method. These forecasts are based on sea-level pressure forecasts of the LFM II model. (Richardson)

3.1.5 Terminal Weather Prediction

General. MOS forecasts of ceiling and visibility, designed to benefit aviation activities at or near airports, are now available for projections of up to 48 hours in an early guidance package. (Miller)

Ceiling and Visibility. Early guidance six-category ceiling and visibility MOS equations are in operation to provide guidance for conterminous United States locations. The forecasts are valid every 6 hours from 12 to 48 hours after observational cycle times. In 1979, six-category ceiling and visibility guidance forecasts were introduced for 26 locations in Alaska. The use of final guidance was discontinued.
(Vercelli, Hebenstreit)

Computer-Formatted Terminal Forecasts. Three sets of cloud amount, ceiling, and visibility equations were developed to support this project. All use the output from the LFM II model, but have different observation predictors. The two sets for the 0000 GMT cycle use the 0600 GMT and 1200 GMT observations, respectively. The 1200 GMT cycle set uses the 1800 GMT surface observations. Forecasts are made at three-hourly intervals from 9 to 36 hours (15 to 42 in the case of the second set on the 0000 GMT cycle). These forecasts, along with those for other elements in the MOS data base, are used to generate a guidance terminal forecast (GFT) in exactly the same format as the current FT.
(Hebenstreit)

Special Department of Defense Aviation Support. The Air Force Global Weather Central (AFGWC) liaison office at TDL has developed prediction equations which either augment existing TDL MOS guidance or provide guidance for new weather elements. Surface wind forecasts using a generalized operator approach are produced twice daily for CONUS locations not covered by single station equations. The wind forecasts are valid for consecutive 6-hour projections from 6 to 60 hours after cycle time. The generalized operator approach was also applied to forecast ceiling, visibility, and cloud amount beyond the usual 48-h projection. Now, 54- and 60-h guidance forecasts are available for these elements twice daily for all civilian and military locations in the CONUS. Regionalized MOS guidance forecasts were developed for obstructions to visibility (haze, smoke, fog, etc.).

These consist of eight 6-h consecutive projections from 6 to 48 hours after cycle times and are available twice daily for over 400 locations in the CONUS. The entire MOS guidance data base is routinely transmitted twice daily to AFGWC in support of Department of Defense operations within the CONUS.
(Best, Garrison, French)

3.1.6 Agricultural Weather Prediction

General. TDL continued to develop specialized agricultural weather forecast packages for individual states. In 1979, this service was extended to South Carolina. In addition, MOS equations to predict dew point temperature are being developed for stations throughout the contiguous United States.
(Jensenius)

Specialized Agricultural Weather Guidance. During 1979, TDL developed and implemented an agricultural MOS forecast guidance package for South Carolina, based on the 0000 GMT cycle run of the 7LPE model. Automated forecasts of maximum and minimum air temperatures, maximum and minimum soil temperatures at the 4-in level, precipitation amount, and daily insolation are provided for 21 locations throughout the state. The air and soil temperature forecasts are made for projections of up to 108 hours, while precipitation amount and daily insolation are forecast up to 84 hours.
(Jensenius)

General Agricultural Weather Guidance. Using the MOS approach, TDL began a new effort to predict the dew point temperature for about 230 stations throughout the contiguous United States. When the work is completed, forecasts will be available every 3 hours from 6 to 51 hours following 0000 GMT and 1200 GMT. The dew point guidance can be combined with temperature predictions for the same projections to obtain forecasts of the relative humidity. (Jensenius)

3.1.7 AFOS Forecast Applications

General. During 1979, more field locations saw AFOS equipment being installed. In anticipation of the time when the system becomes fully operational, software dealing with local applications that can be run on AFOS minicomputers is being developed and tested. (Lowry)

Aviation Monitoring and Updating. The current version of this program allows the AFOS minicomputer to compare each observation at a terminal with its forecast, and alerts the forecaster of significant discrepancies with a terminal alerting procedure (TAP) message which also provides a guidance forecast. The current method of producing the guidance forecasts is being replaced by a Generalized Equivalent Markov (GEM) technique which will produce on-station, short-period (1-12 h) forecasts of all observable weather elements. (Vercelli, Miller)

Computer-Worded Forecasts. Computer worded forecasts (CWF) are now available for 217 stations in the conterminous U.S. In addition, CWF's for zones have been made available for use by five Weather Service Forecast Offices. The matrix upon which the CWF's are based has been expanded to include a fourth period and contains forecasts for the probability of freezing rain and categorical forecasts of heavy snow and precipitation type (rain, freezing rain, and snow). (Bermowitz, Heffernan)

Local Updating System. TDL has been working on a system that will use the most recent local observations and regional analyses of meteorological variables to update MOS guidance at any time between scheduled computer runs. A data base consisting of hourly observations of sea level pressure, wind, temperature, dew point, cloud cover, ceiling, and visibility has been established and error checking and analysis procedures have been "fine-tuned" for these data. (Gilhousen)

Flash Flood Alerting. In an attempt to relate hourly precipitation amounts to D/RADEX observations, a scheme was designed for linearizing the highly nonlinear relationship between these variables. The scheme was used to develop regression equations at several radar sites, and over various range intervals at each of these sites. Reductions of variance of between 20 and 60 percent were obtained, showing that the regressions provide useful approximations. However, the results suffer from the limited number of heavy precipitation events in the available data sample. With future regular collection of D/RADEX observations and the corresponding increase of the data sample, the regressions can perhaps be sharpened further. (Alaka, Lewis)

Interactive Forecasting. During 1979, TDL continued an AFOS-related effort under contract with Pennsylvania State University. The objective is to develop a synergistic relationship between the NWS forecaster and the AFOS system, resulting in a forecasting capability more effective than that of either operating alone. The approach to this task is to choose and develop a number of AFOS forecast applications that are forecaster controlled rather than completely automated.

The contractor, had previously developed four applications: (1) problem of the day examination, (2) a convective cloud model, (3) a fog model, and (4) a cloud-band decision tree model. These applications have been fine-tuned so that they are now ready for testing and evaluation. (Lowry, Cahir, Norman)

AFOS-Era Verification. An AFOS-era forecast verification system is being developed for the National Weather Service. Both a nationally and regionally administered program will be implemented. The first will emphasize seasonal summaries for the whole United States and for individual Regions; the latter will emphasize rapid feedback to forecasters and local management at individual stations.

For the regional program, software has been developed to collect and quality control MOS forecasts, local forecasts, and verifying observations. The forecasts are then archived for inclusion in the national verification program. The national program is designed to collect and centrally archive the collated forecasts received from each station. Regional and national verification summaries will be produced in due course. (Heffernan)

PART IV. ANALYSIS-FORECAST SYSTEMS IN OPERATIONAL USE DURING 1979

4.1 Four basic analysis-forecast cycles continue to be run operationally from 0000 and 1200 GMT data times:

1. Barotropic. This quick-look hemispheric system remains unchanged, meeting some operational needs and providing a standard relative to historical performance in the past few decades.

2. Regional. This run continues to employ a successive approximation analysis and the LFM II forecast model. Several improvements have been introduced in the model within the past year including an improved cumulus parameterization and an additional layer in the stratosphere.

A trajectory (TRAJ) model computes three-dimensional parcel trajectories from smoothed wind forecasts generated by the LFM II. The initial temperature and moisture are analyzed at the trajectory origin by means of an objective analysis technique which uses all available surface and upper-air data as well as initialized gridpoint data from the LFM II. Forecasts for 24 hours are subsequently prepared by following variations of temperature and moisture along the parcel trajectories.

Objective guidance, based on an application of the Model Output Statistics (MOS) approach, is obtained by using output from a regional model. Forecasts of maximum/minimum temperature, surface temperature at 3-h intervals, surface wind, precipitation, thunderstorms, severe weather, precipitation type, cloud amount, ceiling, and surface visibility are produced for several hundred stations in the conterminous United States. Forecasts of the maximum/minimum temperature are also made by the "perfect prog" approach for several U.S. and Canadian stations. In addition, marine forecasts of surface wave and sea conditions are generated for the Gulf of Mexico, Great Lakes, and the Atlantic Ocean along the eastern U.S. Storm surge forecasts are also provided for the Great Lakes and the east coast of the U.S.

3. Large-Scale. This run continues to employ the Hough spectral analysis and the hemispheric 7L PE model. Improvements on cumulus parameterization were introduced in a manner identical to the LFM II. A fourth-order finite difference version of the model has been used to extend integrations to six days. This has been accomplished by running the high order version on coarse (381 km) grid mesh after 60 hours, thus reducing computer time that would be required on a 381/2 km mesh.

Model output statistics are obtained by using the forecasts from the Regional and Global Cycles. Forecasts of maximum and minimum temperatures, probabilities of precipitation and frozen precipitation, precipitation amounts, cloud amounts, ceilings, surface visibilities, surface winds and probabilities of thunderstorms for several hundred stations in the United States and a few stations in Canada are included. In addition, marine forecasts of surface wave and sea conditions for the North Atlantic and Pacific, plus storm surge on the Great Lakes are provided.

A three-dimensional trajectory model similar to the one described above, but based on smoothed wind forecasts from the 7L PE model is also available.

MOS forecasts of surface weather elements are also obtained from the Global model output. Forecasts of maximum/minimum temperature, surface wind, precipitation frozen precipitation, cloud amount, ceiling, and visibility are produced for stations in the conterminous United States, and Alaska. In addition, guidance for soil temperatures, solar radiation, minimum relative humidity, and ground condensation is generated for a number of agricultural locations in the United States. Maximum/minimum temperature predictions are also made by the "perfect prog" approach for several U.S. and Canadian stations. Finally, forecasts of surface wave and sea conditions for the North Atlantic and the North Pacific are provided.

4. Data Assimilation. This 6-hr cycle employs the optimum interpolation system for analysis and 9-layer global model for extrapolation through time. The system continues to be improved with the experience gained over the first year or so of operations.

PART V. PLANS FOR FUTURE OPERATIONAL SYSTEMS

5.1 The spectral model looks promising for use in the Large-Scale Run (4+0). Therefore it will be tested and evaluated against the 7L PE to determine its operational feasibility. It will also be considered as a possible replacement for the 9L GLO model in the Data Assimilation Cycle (10+0) and for the 3-layer model in the 6- to 10-day program.

5.2 The nonlinear normal mode initialization method which is designed for use with the spectral model will be further developed and tested for application in both the Large-Scale Run and the Data Assimilation Cycle.

5.3 The optimum interpolation analysis technique will be further developed for possible use in the Large-Scale Run in place of the spectral (Hough) program and in the Regional Run (2+20) in place of the successive correction program.

5.4 Prediction model improvements will be sought through concentrated development efforts in precipitation physics and boundary layer modeling. These will proceed in parallel with efforts to improve the initial state specification and to evaluate the new data types, with particular emphasis on the use of the data base of the Global Weather Experiment.

5.5 MOS forecasts will be improved by using longer developmental data samples, more effective stratification of the data, and new statistical techniques. Forecast equations for additional weather elements will be developed. Boundary layer model forecasts will be used to derive new MOS equations for surface temperature and wind, precipitation type, and thunderstorm probabilities.

5.6 Efforts will continue to combine MOS forecasts of different weather elements in computerized formats similar to present public weather forecasts and terminal weather forecasts for aviation.

5.7 Increased efforts will be devoted to developing and testing meteorological products suitable for implementation on AFOS.

5.8 The storm surge model, SLOSH (Sea, Lake, and Overland Surges from Hurricanes), will be applied to the Galveston Bay, Texas and the Charlotte Harbor, Florida areas. A wind-wave forecast model, similar to that is used for the Great Lakes, will be developed for the Chesapeake Bay.

5.9 Development and implementation on MOS forecasts of soil temperature and moisture, designed for agricultural guidance, will be expanded and extended to more localities.

PART VI. VERIFICATION PROGRAMS

6.1 Routine Verification Programs

6.1.1 Precipitation Verification

NMC's operational model precipitation forecasts are evaluated using a network of stations. Characteristics of model forecasts are described in terms of precipitation threat score (Tsp) and bias (B) calculated for typical cool and warm season months for the LFM II.

In 1978, over the eastern portion of the network, warm months exhibited very wet biases at 12 hours that decreased to reasonable values by 48 hours. Cool months, however had dry biases (very dry at 12 hours) throughout the 48 hours of forecast. Over the western portion, biases increase with time and excessively so during the cool months.

In late June 1979, the precipitation parameterization method in the LFM II was modified. The net effect over the east has been to generally remove the dry biases during the cool months and produce a slightly less wet bias at 36 and 48 hours during the warm months. Over the west, there appears to be an increase in wet biases at 12 and 24 hours during the cool months.

In general, the 7L PE exhibit characteristics that are similar to the LFM II. Changes made to the LFM II in late June were incorporated into the 7L PE in October.

(Horodeck, Hirano, Hovey)

6.1.2 Routine Verifications with Respect to Analyses and Model Performance

The S1 scores for the past year, and the averages for the last four years are shown on the graph on the next page. The 1979 S1 scores tend to vary only slightly from the 1978 S1 scores reflecting little change in the models. This constancy is somewhat surprising, considering the replacement of the VTPR data by TIROS-N data in the spring. The progress made during 1978 by reducing the mesh length of the models is maintained. The S1 scores for the 7L PE and LFM models seem to be very similar, with the boundary problems degrading the LFM in the fast moving winter regime and higher resolution improving the LFM scores in the summer.

The following table gives yearly averages for S1 scores over the eastern and western U.S. areas. An additional point of interest is the barotropic S1 scores. For both barotropic forecasts made from analyses in the Data Assimilation Cycle (FNL) and from the spectral Hough analyses at 1+10 (RDT), the 1979 scores were somewhat worse than the 1978 scores. Since there have been no changes to the models, this is most likely due to natural variations, that is, 1979 was harder to forecast than 1978. Another possibility, of course, is changes in the data base, which would affect these models.

(Marks)

6.1.3 Monthly Mean Analysis and Forecast Charts

Monthly mean and forecast error charts (12 hours through 48 hours), for the 7L PE and LFM, have been archived since March 1976. Maps are for MSL, 500 mb and 300 mb. Charts of RMSE, bias and standard deviation-of-error are also available. Reproductions of the analysis and 48 hr forecast error charts follow. (Marks)

6.2 MOS Products

A National verification program, designed to compare the performance of MOS guidance forecasts with official local forecasts, has been in operation for several years. Forecasts included in the comparison are: probability of precipitation, maximum/minimum temperatures, surface wind, cloud amount, ceiling, visibility, and precipitation type. While there is considerable variation in the relative accuracy of guidance and official forecasts of different elements, it has become clear over the years that the MOS guidance forecasts are quite useful.

A quantitative illustration of the comparative performance of the two sets of forecasts is given in Figs. 1 and 2 which show the percent improvement over climatology of local and guidance forecasts of the probability of precipitation during the cool and warm seasons. The comparison is made in terms of a score P, defined for a sample of size N as follows:

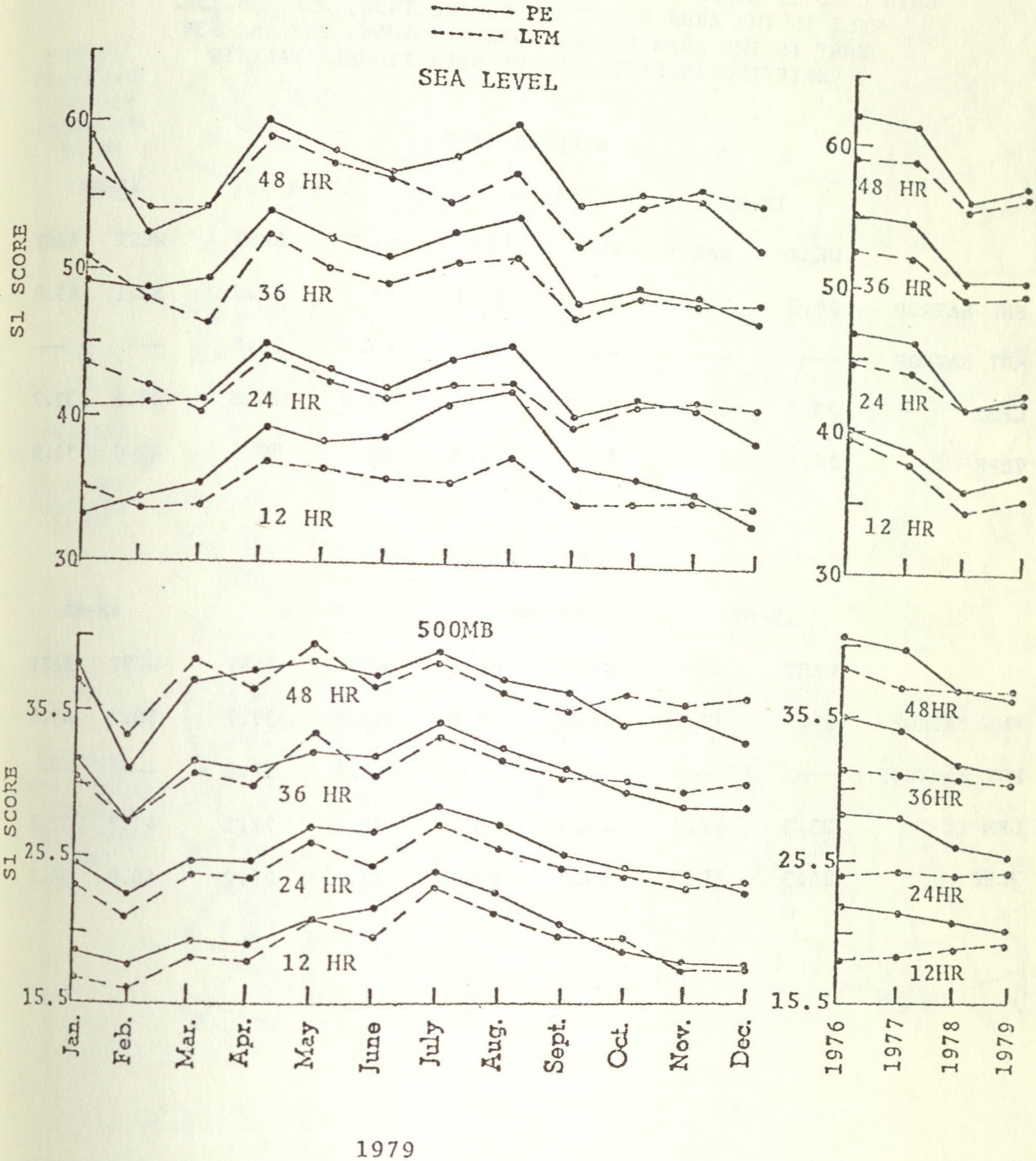
$$P = \frac{1}{N} \sum_{i=1}^{N} (f_i - E_i)^2$$

where f_i is the forecast probability that precipitation will occur and E_i takes on the value 1 or 0, respectively, according to whether precipitation did or did not occur.

Figs. 1 and 2 show that for the first forecast period (12-24 h), the official local forecasts perform significantly better than the guidance, although during the 1978 warm season and 1978-79 cool season (the last seasons for which scores are available), the difference in improvement over climatology is only 2 or 3 percent. For the second period (24-36 h), the local forecasts are in general slightly better than the guidance. For the third period (36-48 h), there is little difference between the two sets of forecasts. We note, however, that LFM-based early guidance forecasts, which became available in 1977, equalled or surpassed the local forecasts during the most recent cold and warm seasons.

Another example is provided by Figs. 3 and 4 which compare the mean absolute errors associated with guidance and local forecasts of cool season maximum and minimum temperatures. Here, 24-h max temperature forecasts are distinctly better than the guidance, although the LFM-based early guidance is within 0.1°F mean absolute error of the local forecasts for the last season for which scores are available. Also, there seems to be little difference between the local and LFM-based forecasts for the 36-h min, 48-h max, or 60-h min during the most recent season.

S1 COMPARISONS OF THE 7L PE AND LFM FOR THE CONTIGUOUS UNITED STATES. GRID USED: 49-POINT LAT/LON GRID. THIS IS A SUBSET OF A 63-POINT GRID WHICH COVERS THE AREA BETWEEN 65 WEST AND 145 WEST LONGITUDE, AND BETWEEN 25 NORTH AND 55 NORTH LATITUDE.
GRIDPOINT SPACING IS 5 DEGREES LATITUDE BY 10 DEGREES LONGITUDE.



S1 SCORE COMPARISONS OF THE BAROTROPIC, LFM2 AND 7LPE 500 MB FORECASTS
OVER THE WESTERN AND EASTERN UNITED STATES.
GRID USED IS 33-POINT 5 DEGR LATITUDE/10 DEGR LONGITUDE GRID
WEST IS THE AREA BETWEEN 105W AND 145W, 25N AND 55N.
EAST IS THE AREA BETWEEN 65W AND 105W, 25N and 55N
VERIFYING ANALYSIS IS THE OPERATIONAL ANALYSIS

AVERAGE 1978

	12-HR		24-HR		36-HR		48-HR	
	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST
FNL BATROP	26.3	21.4	36.4	30.1	44.1	37.7	50.1	43.0
RDT BATROP	---	---	---	---	43.5	36.8	---	---
LFM2	23.6	17.3	30.0	21.6	36.3	26.8	42.6	32.7
7LPE	24.8	20.5	31.4	24.3	36.6	30.5	42.0	34.9

AVERAGE 1979

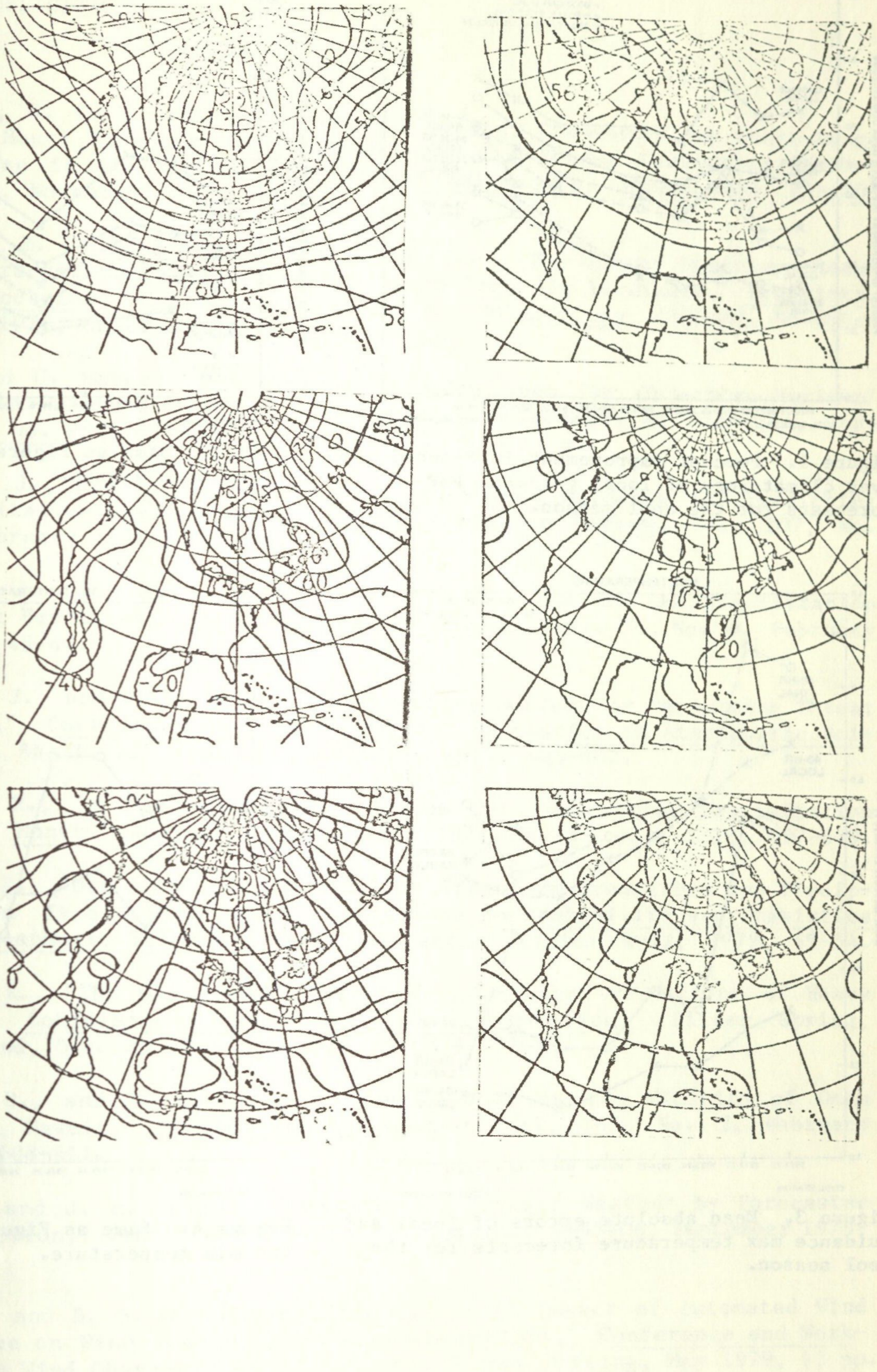
	12-HR		24-HR		36-HR		48-HR	
	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST
FNL BATROP	28.2	23.1	36.2	32.0	43.4	39.7	50.2	45.9
RDT BARTROP	---	---	---	---	44.3	37.9	---	---
LFM II	23.5	17.3	29.5	20.9	35.8	27.1	41.7	32.7
7LPE	24.3	19.3	30.0	23.8	35.2	29.2	40.0	34.2

Jan 79 | Jul 79

500 mb Observed (Contour Interval 60 m)

LFM 48HR Error (BIAS) (Contour Interval 20m)

PE 48HR Error (BIAS) (Contour Interval 20m)



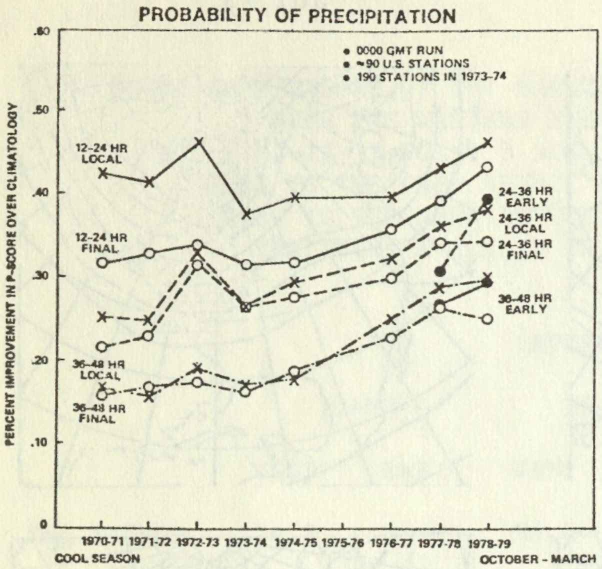


Figure 1. Percent improvement in P-score over climatology of local guidance PoP forecasts for the cool season.

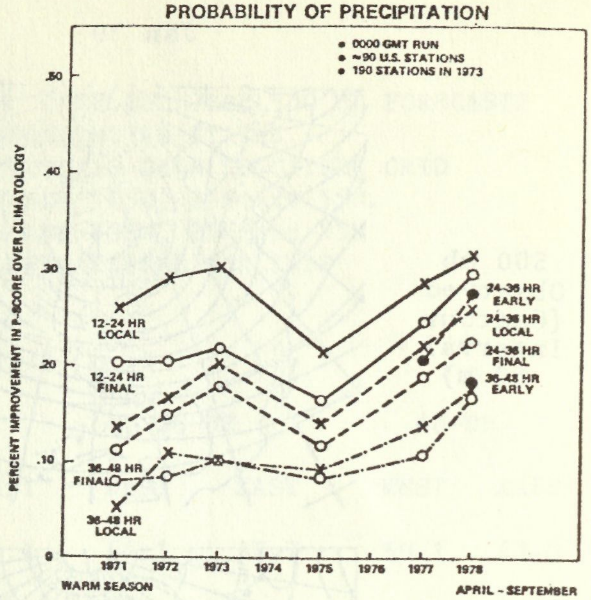


Figure 2. Same as Figure 1 except for the warm season.

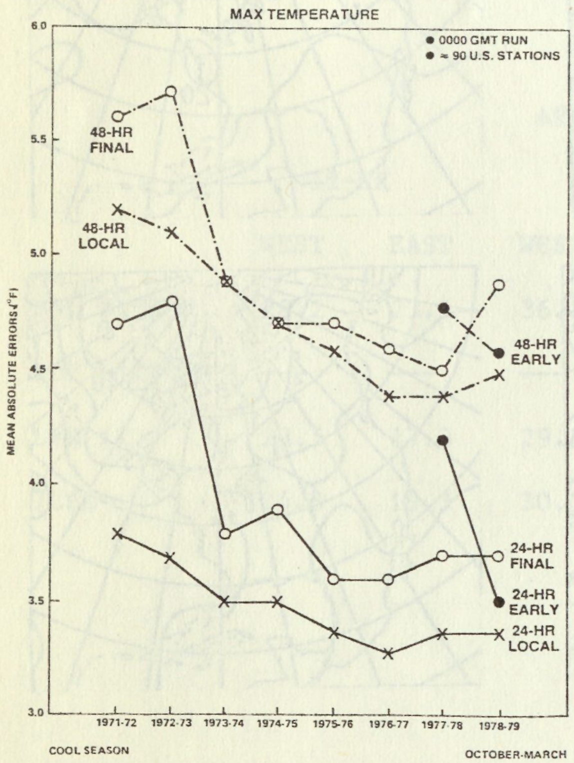


Figure 3. Mean absolute errors of local and guidance max temperature forecasts for the cool season.

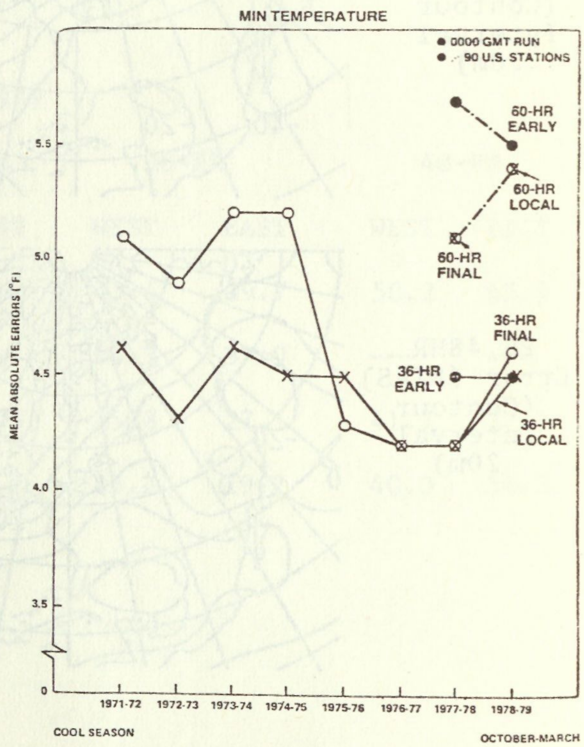


Figure 4. Same as Figure 3 except for min temperature.

PART VII PUBLICATIONS

TDL

Alaka, M. A., R. C. Elvander, and R. E. Saffle, "Nowcasts and Short-Range (0-2 Hour) Forecasts of Thunderstorms and Severe Convective Weather for Use in Air Traffic Control," Final Report, Contract No. FAA-RD-79-98, November, 1979, 31 pp.

Alaka, M. A., R. C. Elvander. and R. E. Saffle, "The Use of Digitized Radar to Forecast Convective Weather at or Near Air Terminals," Preprints, WMO Technical Conference on Aviation Meteorology (TECOM), November 5-9, 1979, Geneva, Switzerland, 21 pp.

Baker, G., and G. Weber, "Development of Techniques for Objective Maximum/ Minimum Guidance for Zone Forecasts," University of Michigan, Contract No. 0501-7199-3536, February 1979, 127 pp.

Bermowitz, R. J., and E. A. Zurndorfer, "Automated Guidance for Predicting Quantitative Precipitation," Monthly Weather Review, Vol. 107, No. 2, February 1979, 122-128.

Bermowitz, R. J., and E. A. Zurndorfer, "On the Use of LFM Precipitation Amount Equations," National Weather Digest, Vol. 3, No. 4, February 1979, 45-47.

Bermowitz, R. J., and D. L. Best, "An Objective Method for Maximizing Threat Score," Conference on Probability and Statistics in Atmospheric Sciences, Banff, Alberta, October 9-12, 1979, 103-107.

Bocchieri, J. R., "A New Operational System for Forecasting Precipitation Type," Monthly Weather Review, Vol. 107, No. 6, June 1979, 637-649.

Bocchieri, J. R., "Use of the Logit Model to Transform Predictors for Precipitation Type Forecasting," Conference on Probability and Statistics in Atmospheric Sciences, Banff, Alberta, October 9-12, 1979, 49-54.

Bocchieri, J. R., "The Use of LFM Output for Automated Prediction of Heavy Snow," Conference on Numerical Weather Prediction, Silver Spring, Maryland, October 29 - November 1, 1979, 77-81.

Burroughs, L. D., and R. N. Larson, "Wave Clouds in the Vicinity of Oahu Island, Hawaii," Monthly Weather Review, Vol. 107, No. 2, February 1979, 608-611.

Cahir, J. J., and J. M. Norman, "Analysis of Frontal Weather by Forecaster Interaction," Penn State University, Contract T-35406, September 1979, 55 pp.

Carter, G. M., and D. B. Gilhousen, "The Potential Impact of Automated Wind Guidance on Wind Energy Conversion Operations," Conference and Workshop on Wind Characteristics and Wind Energy Sitting, May 1979, 13 pp.

Carter, G. M., J. P. Dallavalle, A. L. Forst, and W. H. Klein, "Improved Automated Surface Temperature Guidance," Monthly Weather Review, Vol. 107, No. 10, October 1979, 1263-1274.

Charba, J. P., "Two to Six Hour Severe Local Storm Probabilities: An Operational Forecasting System," Monthly Weather Review, Vol. 107, No. 3, March 1979, 268-282.

Charba, J. P., "Recent Performance of Operational Two-Six Hour Objective Forecasts of Severe Local Storms on Outbreak Days," Preprints, 11th Conference on Severe Local Storms, AMS, October 2-5, 1979, Kansas City, Missouri, 600-607.

Gabriel, K., and F. C. Pun, "Binary Prediction of Weather Events with Several Predictors," The University of Rochester, Rochester, New York, 14627, September 1978, 99 pp.

Gilhousen, D. B., "Automated Prediction of Boundary Layer Winds and Turbulence for the Savannah River Laboratory," Final Report, Dept. of Energy under Agreement No. EY-77-A-09-1007, June 1979, 23 pp.

Gilhousen, D. B., "Testing the Logit Model for Probability of Precipitation Forecasts," Conference on Probability and Statistics in Atmospheric Sciences, Banff, Alberta, October 9-12, 1979, 46-48.

Glahn, H. R., "Computer Worded Forecasts," Bulletin of the American Meteorological Society, Vol. 60, January 1979, 4-11.

Glahn, H. R., "Statistical Weather Forecasting in the National Weather Service," Conference on Probability and Statistics in Atmospheric Sciences, Banff, Alberta, October 9-12, 139-147.

Hess, K. W., "The National Weather Service Oil Spill Motion Forecasting Program," Workshop on the Physical Behavior of Oil in the Marine Environment, Princeton University, Princeton, New Jersey, May 8-9, 1979, 311-322.

Hess, K. W., and C. L. Kerr, "A Model to Forecast the Motion of Oil on the Sea," 1979 Oil Spill Conference (Prevention Behavior, Control, Clean up), Los Angeles, California, American Petroleum Institute, 653-663.

Jensenius, J. S., Jr., and G. M. Carter, "Automated Forecasts of Agricultural Weather Elements," 14th Conference on Agriculture and Forest Meteorology, Minneapolis, Minnesota, April 2-4, 1979, 42-44.

Kemper, J. E., P. E. Long, and W. A. Shaffer, "Forecast Guidance Products from the Techniques Development Laboratory's Boundary Layer Model," Preprints, Fourth Conference on Numerical Weather Prediction, AMS, October 29 - November 1, 1979, Silver Spring, Maryland 270-277.

Long, P. E., J. E. Kemper, and W. A. Shaffer, "Physics, Numerics, and Forecasts of the National Weather Service's Atmospheric Boundary Layer Model," Proceedings, Third IMACS, June 20-23, 1979, Bethlehem, Pennsylvania, 427-433.

Miller, R. G., "Estimating Event Probabilities by Discrete Likelihood Function," Conference on Probability and Statistics in Atmospheric Sciences, Banff, Alberta, October 9-12, 1979, 93-97.

Miller, R. G., and D. L. Best, "A Model for Converting Probability Forecasts to Categorical Forecasts," Conference on Probability and Statistics in Atmospheric Sciences, Banff, Alberta, October 9-12, 1979, 98-102.

Miller, R. G., and R. C. Whiton, "A Weather Simulation Model Based on REEP," Conference on Probability and Statistics in Atmospheric Sciences, Banff, Alberta, October 9-12, 1979, 167-172.

Miller, R. G., "Conditional Climatology given the Local Observation," National Weather Digest, November 1979, (in press).

Reap, R. M., and D. S. Foster, "On Producing Categorical Forecasts from Operational Probability Forecasts of Thunderstorms and Severe Local Storms," Preprints, 11th Conference on Severe Local Storms, AMS, October 2-5, 1979, Kansas City, Missouri, 619-624.

Reap, R. M., and D. S. Foster, "Automated 12-36 Hour Probability Forecasts of Thunderstorms and Severe Local Storms," Journal of Applied Meteorology, Vol. 18, No. 10, October 1979, 1304-1315.

Richardson, W. S., "A Frequent Visitor to Lake Erie," Marine Weather Log, Vol. 6, No. 23, November 1979, 375-378.

Pore, N. A., "Automated Wave Forecasting for the Great Lakes," Monthly Weather Review, Vol. 107, No. 10, October 1979, 1275-1286.

Saffle, R. E., "Objective Forecasts of Convective Weather Using Digitial Radar Data," Preprints, 11th Conference on Severe Local Storms, AMS, October 2-5, 1979, Kansas City, Missouri, 191-201.

Shaffer, W. A., J. E. Kemper, and P. E. Long, "Potential Thunderstorm Forecast Guidance Products from the Techniques Development Laboratory's Boundary Layer Model," Preprints, 11th Conference on Severe Local Storms, AMS, October 2-5, 1979, Kansas City, Missouri, 151-157.

Zurndorfer, E. A., J. R. Bocchieri, G. M. Carter, J. P. Dallavalle, D. B. Gilhousen, K. F. Hebenstreit, and D. J. Vercelli, "Trends in Comparative Verification Scores for Guidance and Local Aviation/Public Weather Forecasts," Monthly Weather Review, Vol. 107, No. 6, July 1979, 799-811.

NMC

Bergman, K. H., "Multivariate Analysis of Temperatures and Winds Using Optimum Interpolation," Monthly Weather Review, Vol. 107, No. 11, November 1979, 1423-1444.

Brown, J. A., and J. B. Hovermale, "Research Activity at the National Meteorological Center," Proceedings of the (Thirteenth) Stanstead Seminar held at Bishop's University, Lennoxville, Quebec, Canada, July 9-13, 1979, 30-41.

Campana, K. A., "Higher Order Finite-Differencing Experiments with a Semi-Implicit Model at the National Meteorological Center," Monthly Weather Review, Vol. 107, No. 4, April 1979, 363-376.

Collins, W. G., "Parameterization of the Vertical Momentum Flux Due to Flow Over Orography in Numerical Prediction Models," Preprint Volume of the Fourth Conference on Numerical Weather Prediction, held at Silver Spring, Maryland, October 29-November 1, 1979.

Dey, C. H., "An Integration Technique Especially Efficient in Dynamic Initialization," Monthly Weather Review, Vol. 107, No. 10, October 1979, 1287-1298.

Dey, C. H., "A Dynamic Initialization Experiment with the NMC Global Data Assimilation System, " Preprint Volume of the Fourth Conference on Numerical Weather Prediction, held at Silver Spring, Maryland, October 29-November 1, 1979.

Gemmill, W. H., and S. E. Larson, "Real-time Ocean Thermal Structure Analysis," Joint IOC/WMO Seminar on Oceanographic Products and IGOSS Data Processing and Service System. Moscow, USSR, 2-6 April 1979, 115-142.

McPherson, R. D., K. H. Bergman, R. E. Kistler, G. E. Rasch, and D. S. Gordon, "The NMC Operational Global Data Assimilation System," Monthly Weather Review, Vol. 107, No. 11, November 1979, 1445-1461.

Ward, J. H., 1979: "A Diagnostic Evaluation of the NMC Global Data Assimilation System and the Hough Spectral Data Analysis Procedure", Preprint Volume of the Fourth Conference on Numerical Weather Prediction, Silver Spring, Maryland, AMS, Boston, pp. 72-76.

Yu, T., 1979: Comments on "A Method for Determining Flux Parameters in the Absence of a Temperature Profiles," Boundary Layer Meteorology, 16, pp. 515-516.

Yu, T., and R. D. McPherson, "Surface Pressure Analysis Using Scatterometer Derived Wind Data from the SEASAT-A Satellite," Paper presented at the Fourth Conference on Numerical Weather Prediction, Silver Spring, Maryland, pp. 351-355.

TECHNICAL MEMORANDA

NWS-TDL-69	"Comparison and Verificatin of Dynamical and Statistical Lake Erie Storm Surge Forecasts"	Richardson, Schwab
NWS-TDL-69	"A Simple Heat Flux Calculation for Numerical Models"	Shaffer

NWS-NMC-63 "Day-Night Difference in Radiosonde Observations of the Stratosphere and Troposphere" McInturff, Finger, Johnson, Laver

TECHNICAL REPORT

NWS-22 "The Nested Grid Model" Phillips

TDL OFFICE NOTES

79-1 "Comparative Verification of Operational Two To Six Hour Objective Forecasts and Official NWS Watches of Severe Local Storm: An Update" Charba, Burnham

79-2 "Comparative Verification of Guidance and Local Aviation/Public Weather Forecasts--No. 5 (October 1977-March 1978) Gilhousen, Bocchieri, Carter, Dallavalle, Hebenstreit, Hollenbaugh, Janowiak, Vercelli

79-3 "Development of LFM Max/Min and 3-Hourly Temperature Equations for the Cool Season" Dallavalle, Carter, Forst

79-4 "An Objective Scheme for Including Observed Snow Cover in the MOS Temperature Guidance" Dallavalle, Carter

79-5 "Extratropical Storm Surge Forecast Guidance for Ocean City, MD" Richardson

79-6 "Users Guide for TDL's Computer Worded Forecast Program" Hefferman, Glahn

79-7 "An Improved Use of the Logit Model to Transform Predictors for Precipitation Type Forecasting" Bocchieri

79-8 "Improved Prediction of Liquid Precipitation Type" Gilhousen

79-9 "Verification of Great Lakes MOS Wind Forecast" Burroughs

79-10 "Experimental Forecasts of Convective Gust Potential--Phase II" Carter

79-11 "Comparative Verification of Guidance and Local Aviation/Public Weather Forecasts--No.6 (April 1978-September 1978)" Dallavalle, Carter, Gilhousen, Hebenstreit, Hollenbaugh, Janowiack, Vercelli

79-12 "Studies in the Specification of Precipitation Type from Observed Upper-Air Soundings," Bocchieri

79-13 "Techniques Development Laboratory Software Standards" Glahn

79-14 "Experiments in the Use of Local Surface and Upper-Air Observations to Update MOS Precipitation Type Guidance" Bocchieri

79-15 "Specialized Agricultural Weather Guidance for South Carolina"
Jensenius, Carter

79-16 "Development of Objective Maximum/Minimum Temperature Forecast Equations for Alaska"
Dallavalle

79-17 "Comparative Verification of Guidance and Local Aviation/Public Weather Forecasts--No. 7 (October 1978-March 1979)"
Hebenstreit, Bocchieri, Carter, Dallavalle, Gilhousen, Hollenbaugh, Janowiak, Vercelli

79-18 "Verification of Automated East Coast Extratropical Storm Surge Forecasts:
Richardson, Andrews, Rosenstein

79-19 "A Comparison of Conditional and Unconditional Forecasts of the Probability of the Precipitation Amount"
Zurndorfer

NMC OFFICE NOTES

197 "Objective Verifications of the NMC Data Assimilation Cycle"
Dey, Caporaso

198 "Weather Prediction"
Shuman

199 "Application of an Iterative Variational Method with Balanced Constraint to Hemispheric Analysis and Prediction"
Chu, Gerrity

200 "Multivariate Analysis of Temperatures and Winds Using Optimum Interpolation"
Bergman

201 "A Recurving Tropical Storm and Perfect Boundary Conditions Regarding the Movable-Area Fine-Mesh Model in the Western Pacific"
Kerlin

202 "Optimum Interpolation Analysis of Surface Pressure Using SEASAT-A Scatterometer Wind Data"
Yu, McPherson

203 "Regional Multivariate Optimum Interpolation Analysis"
Bergman, Gordon

204 " Characteristics of FGGE Level IIIa Data Sets from the NMC Global Data Assimilation System"
Staff, AAB

205 "A Delivery Monitoring Program for Satellite Temperature Data"
Phillips

206 "Axi-Symmetric Analysis of the Hurricane Vortex with the Aid of Two-Dimensional Model Statistics
Livezey

207 "A Special Satellite-Radiosonde Colocation Program"
Phillips

208 "Extraction of the Axi-Symmetric Part of a Hurricane Vortex from High-Frequency Aircraft Observations"
Livezey