Numerical Weather Prediction Activities

National Meteorological Center

First Half 1973

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CONTENTS

ABBREVIATIONS AND ACRONYMS

AD	Automation Division
ADP	Automated Data Processing
AERINC	Aeronautics Incorporated
AMFAX	Aviation Meteorological Facsimile Service
ATA	Air Transport Association
ATOLL	Analysis of Tropical Oceanic Lower Layer
BPS	Bits per Second
CBS	Carrier Ballon System
CDC	Control Data Corporation
COMMS	Communications Division (NWS)
CRT	Cathode Ray Tube
DATAC	Data Acquisition Division (NWS)
DFI	Digital Facsimile Interface
DOS	Disk Operating System
DST	Data Systems Test
EEB	Electronic Equipment Branch
FAX	Facsimile Transmission
FAXX	Facsimile Transmission Program
FD	Forecast Division
FT	Terminal Forecast
GISS	Goddard Institute for Space Studies
IBM	International Business Machines
I/O	Input/Output
ITPR	Infrared Temperature Profile Radiometer
LFM	Limited-Area Fine-Mesh Model
NAFAX	National Facsimile Network
NEMS	Nimbus E Microwave Spectrometer
NESS	National Environmental Satellite Service
NHC	National Hurricane Center
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
NWS	National Weather Service

OOPS	Overseas Operations Division (NWS)
PBL	Planetary Boundary Layer
PE	Primitive Equation
PIREP	Pilot Report
PMO	Post Meteorological Officer
RGS	Remote Graphics System
SCR	Selective Chopper Radiometer
SIRS	Satellite Infrared Spectrometer
TROPAN	Tropical Analysis Network
TWERLE	Tropical Wind, Energy Conversion and Reference Level Experiment
VTPR	Vertical Temperature Profile Radiometer
WMO	World Meteorological Organization
3L GLOBAL	Three-Layer Global Model
8L GLOBAL	Eight-Layer Global Model
8L HEM	Eight-Layer Hemispheric Model
6L PE	Six-Layer Primitive Equation Model

I. INTRODUCTION

This report summarizes the numerical weather prediction (NWP) activities of the National Meteorological Center (NMC) for the first half of 1973. There were no changes made in the operational six-layer primitive equation (6L PE) model during this period. Operational changes were made in the area of integration and the lateral boundary conditions of the limited-area fine-mesh model (LFM). (See Sections II. A. and III. B. 1. of this report.) Progress was made in the automation of plotting of surface reports. (See Section IV. A. 5.) Reference to an error in the NMC forecast geostrophic wind statistics was made in the _NWP Activities Report for the First Half of 1972_. Approximate correction factors to be used on published statistics prior to July 1972 are given in Section II. B. These are based on 1 year of calculations made with and without the error.

The reorganization of the Development Division, the research arm of the NMC, was completed. This is reflected in Chapter III of this report in the method of summarizing the work in this group under four headings: Global Modeling Branch, Regional Modeling Branch, Data Assimilation Branch, and Upper Air Branch. Of particular interest is an effort in hurricane modeling for operational purposes, which is just now evolving. This effort will reside in the Regional Modeling Branch.

II. REVISIONS IN OPERATIONAL PROGRAMS

A. New Procedures Introduced into the LFM

The operational code for the LFM was changed on February 7, 1973, to reduce its domain of integration. The topmost 12 grid rows, those over the polar regions, were dropped--thereby reducing the grid from 53 by 57 (3021) to 53 by 45 (2385) points. The purpose of the change was to reduce the running time of the LFM and avoid conflicts with the higher priority hemispheric 6L PE operational model. The 21-percent reduction in the number of grid points has resulted in an equivalent reduction in the running time of the forecast portion of the code. The instances in which the LFM has been prematurely terminated due to conflicts have been sharply reduced since February and, from that standpoint, the change has been successful.

On this same February date, a time-varying lateral boundary condition was incorporated. As before, the initial values for the boundaries are established by the analysis procedures. During the course of the forecast, these values are forced to change by imposing parameter tendencies at each time step of the LFM forecast. The tendencies are taken from the 12- to 36-hour 6L PE forecasts made during the preceding NMC operational cycle by interpolating linearly between 6-hourly values. These changes are discussed more fully in _NWS Technical Procedures Bulletin No. 82_.

After operational implementation of the reduced area grid with time-dependent boundaries, it became apparent that the "pillow" problem had been aggravated by doing so. The pillow, the spurious inflation or deflation of surface pressure over wide areas of the forecast basin, has been a continuing problem--but reached unacceptable proportions with this change. A technique was developed to reduce this effect by recovering constant pressure heights from the wind field rather than the mass field. This "desloshing" is done only for output purposes and was made operational on June 5, 1973. The technique is described in NWS Technical Procedures Bulletin No. 90 and in Section III. B. 1. of this report. (Howcroft)

B. Forecast Verification Statistics

Approximate multiplication correction factors to be applied to NMC's geostrophic wind statistics published prior to July 1972 were provided earlier (see NWP Activities, First Half 1972, Chapter I, Section C). As possible refinements to these correction factors, beginning with July 1972 and extending through June 1973, calculations with the inverted map factor were made for comparison with the published (correct) statistics. No particular seasonal bias was evident in the comparisons. The following table contains average multiplication correction factors (July 1972 through June 1973) by verification areas, pressure levels, and the four different geostrophic wind values. The number appearing beside the area designation is the factor for the area provided earlier. In order to obtain an approximate correction to an NMC geostrophic wind statistic published prior to July 1972, multiply the published value by the corresponding correction factor shown in the table.

CORRECTION FACTORS FOR VERIFICATION STATISTICS

	FWE	FW	PWE	PW
Grid--1.40				
1000 mb	1.44	1.36	1.37	1.38
850 mb	1.43	1.34	1.34	1.34
500 mb	1.38	1.32	1.32	1.32
300 mb	1.41	1.34	1.33	1.34
200 mb	1.44	1.38	1.37	1.38
Area 1--1.33				
1000 mb	1.35	1.30	1.30	1.32
850 mb	1.34	1.28	1.29	1.30
500 mb	1.31	1.30	1.29	1.30
300 mb	1.32	1.31	1.29	1.30
200 mb	1.36	1.32	1.32	1.32
Area 2--1.23				
1000 mb	1.22	1.20	1.21	1.21
850 mb	1.22	1.20	1.20	1.21
500 mb	1.21	1.21	1.20	1.20
300 mb	1.22	1.21	1.20	1.21
200 mb	1.24	1.23	1.22	1.23

	FWE	FW	PWE	PW
Area 3--1.09				
1000 mb	1.09	1.08	1.07	1.07
850 mb	1.10	1.08	1.07	1.07
500 mb	1.09	1.09	1.08	1.08
300 mb	1.10	1.10	1.08	1.09
200 mb	1.12	1.11	1.10	1.10
Area 4--1.31				
1000 mb	1.34	1.32	1.30	1.32
850 mb	1.35	1.30	1.30	1.29
500 mb	1.30	1.30	1.28	1.30
300 mb	1.31	1.30	1.28	1.30
200 mb	1.33	1.32	1.30	1.32
Area 5--1.32				
1000 mb	1.31	1.28	1.29	1.29
850 mb	1.31	1.28	1.27	1.28
500 mb	1.30	1.29	1.27	1.28
300 mb	1.30	1.29	1.28	1.28
200 mb	1.30	1.30	1.30	1.30

FWE - Forecast wind error
FW - Forecast wind
PWE - Persistence wind error
PW - Persistence wind

III. DEVELOPMENT DIVISION

A. Global Modeling Branch

1. Eight-layer Longitude/Latitude Forecast Model

a. Evaluation of the 2.5^{o} Northern Hemisphere forecasts proceeded with inconclusive results. The evaluation to date has centered upon S_1 scores of the sea-level pressure forecasts, and these have not shown any consistent improvement over the forecasts from the operational six-layer Cartesian coordinate model (6L PE). An error was discovered in the new model in mid-April which was of random nature and could have affected the pressure forecasts prior to that time. Unfortunately, there is no way of determining whether the error did occur in any particular forecast. Subjective reviewing of the forecasts with the error in mind proved fruitless as well.

Some preliminary tests indicated that passing a smoother over the output fields has an appreciable effect upon the S_1 score--improving it. (See also Section V. 4. of this report.) The 6L PE forecasts are routinely smoothed for display purposes. Further experimentation, including the design of a smoother appropriate for a latitude/longitude grid, is necessary to obtain a similar filtering of the eight-layer forecasts. (Stackpole)

b. Changing the vertical structure

Experiments were undertaken wherein the vertical structure was changed from the original of two boundary layers, three tropospheric and three stratospheric layers to one with no boundary layers, six tropospheric and two stratospheric layers, i.e., the tropospheric resolution was substantially improved. Again, limited testing suggests that this may result in an improvement of the forecast of sea-level pressure. (Stackpole)

c. Divergence damping

Appropriate coding was introduced into the model to effectively damp the divergent part of the wind by methods outlined by Shuman and Sadourney. This was in an effort to control what appears to be excessive internal gravity waves induced by initial imbalances between heights and winds. A series of tests was run to find an optimum degree of divergence damping, if such exists, and the results have been documented in NMC Office Note 83. The results indicate the damping contributes to the internal wave/noise suppression, but that some form of data initialization may be necessary in addition. See also Section C. 3. b.

(McPherson and Stackpole)

2. Global Three-Layer (3L GLOBAL) PE Forecast Model

Study of energy changes in the sigma vertical coordinate model using the 3L GLOBAL model has continued. Several different finite difference formulations for the calculation of the pressure force terms, $c_p\theta\nabla\pi + \nabla\phi$, in the u- and v-tendency equations have been tested. Some forms of vertical mass weightings of temperature greatly impede and reduce the magnitude of the increase in kinetic energy mentioned in NWP Activities Second Half of 1972, Section III. C. 2. But the problem (or problems) has not yet been solved. Further study and numerical experiments will be made. (Vanderman)

3. Spectral Analysis

A series of 48-hour forecasts is being made with the 6L PE using the Hough analysis technique. This series now incorporates the spectral moisture analyses. The forecasts are being evaluated relative to those of the operational 6L PE system, which incorporates the Cressman objective analysis technique. Preliminary tests obtained thus far are discussed in Section V. 3. of this report.

Until the eight-layer longitude/latitude forecast model has been fully tested for operational implementation, the 6L PE model will continue as the operational model. However, present plans are to incorporate the spectral analysis technique with the 6L PE when the first IBM 360/195 computer is delivered in the latter part of 1973. (Flattery)

4. PE Model Initialization

The initialization method which has been tested involves a PE forecast model from which gravity waves have been removed (termed the filtered PE model), see NWP Activities, First Half 1972, Chapter III, Section I. It was found necessary to revise the original formulation of this model in order to achieve proper filtering. However, in order to integrate the revised model, it was necessary to solve a diagnostic hyperbolic equation (see NWP Activities, Second Half 1972, Chapter III, Section G).

The solution to such an equation is not unique in the differential case. It is unique in the finite difference case, but it is unstable in the sense that a very small change in the boundary values causes a very large change in the solution over the interior of the grid. This was verified by a simple experiment. Due to this fact, it was not possible to integrate the filtered PE model successfully.

Alternative approaches, using the general concept of blending the primitive equations with quasi-geostrophic theory, are under consideration. (Dey)

5. Vertically Integrated Model

A paper discussing a number of experiments has been submitted to Monthly Weather Review. Further experiments including heating and moisture are being conducted. Seasonal observed values of eddy and mean momentum and heat transports are computed from previously collected data. (Sela and Bostelman)

6. Spectral Methods

A Hough function generator based on Flattery's eigenfrequencies has been programmed to be used in conjunction with Flattery's analysis for the purpose of preparing initial data for spectral models.

A generalized guassian quadrature code (suitable for an arbitrary number of guassian latitudes) has been prepared for use with full transform techniques. (Sela and Bostelman)

7. Mountain Flow

A two-dimensional nonlinear anelastic model has been used to investigate the flow over small-scale mountains. Particular attention was given to the formation of overturning to the mountain's lee. This work will be included in the paper "On the Contributions of Nonlinearity and Nonhydrostatic Accelerations to Low-Level Critical Flow Over Mountains," to be published.

Work has begun on a study to determine possible methods and the utility of including more accurate mountain effects in local areas within large-scale numerical prediction models. A first test views the small and medium scale effects as an additional contribution due to the more accurate lower boundary specification. (Collins)

8. Cumulus Convection

The 1972-73 academic year was spent at the University of Maryland. In addition to the regular course work in meteorology, computer methods and mathematics, particular emphasis during the spring semester was on readings in current literature in the area of cumulus convection. This was done with the intent of incorporating the effects of cumulus convection into large scale models. (Hirano)

B. Regional Modeling Branch

1. Desloshing the LFM Output

A long-recognized problem in the LFM has been the "pillow." At times, large portions of the displayed 500-mb height and mean sea level pressure charts have had inflated or deflated values that are not completely reasonable. Our recent studies have tentatively identified this phenomena as being the result of large-scale gravity waves generated at the lateral boundaries of the model. The gravity wave responsible for the pillow problem is largely external in its characteristics, and a more descriptive term for it might be the "slosh." Its wave length is of the order of the total grid width or large fractions of it. The amplitude is quite variable from run to run, but has been as much as 200 meters at the 500-mb level. It has been noted that even when the slosh is large, the circulation features of the LFM forecasts can be quite good--or at least within the usual uncertainty limits. Also, despite the slosh, the thicknesses between pressure levels have been reasonable.

To recover data from the sigma-coordinate system to the constant pressure surfaces used in the facsimile display package, the LFM data are interpolated to those surfaces. A post-processing program uses the pressure differentials between the sigma levels and the temperatures in the sigma-layers as a basis for finding the heights of those surfaces by building with thicknesses from pressure at the model terrain. The gravity wave is an integral feature of this mass field buildup. However, there is an alternate way of finding the height of constant pressure surfaces available to us and we have indeed used this method in our investigations to identify these gravity waves.

The technique that has evolved to deslosh the height field is a reverse balance to obtain the 500-mb heights from the wind components. The heights are also found by the older buildup method and the difference between these two sets of heights is formed. By definition, this difference is the slosh. The desloshing technique uses the balance equation described by Shuman (1957) in Monthly Weather Review, Vol. 85, No. 10, "Numerical Methods in Weather Prediction: I. The Balance Equation," in a reverse sense; that is, given a stream function, reverse balance to find the height of the pressure surface. The stream function is found by inverting the equation $\nabla^2\psi = \zeta$, where ζ is the relative vorticity of the wind field. The wind components for the particular pressure level are gotten by the interpolation process in the LFM post-processor. This reverse balancing technique seems to work rather well for the 500-mb surface, but does not return satisfactory heights for the lower levels.

The 500-mb heights found by the new method is the set displayed in the facsimile charts. To find the heights of other constant pressure surfaces, the slosh--or a factor times the slosh--is taken out of the height fields found by the usual older method. In doing so, one assumes that the new slosh is indeed an external gravity wave and that the thicknesses between the pressure levels are acceptable as forecast. This technique was introduced into the LFM operational model on June 5, 1973. (Howcroft)

2. Planetary Boundary Layer Model (PBL)

The PBL continues to operate on an experimental basis, providing 24-hour forecasts based on 0000 GMT data. Beginning April 11, 1973, the number of time cross-sections being transmitted daily by facsimile was reduced from five to four, and the facsimile transmission of two severe weather indices produced from the PBL commenced for evaluation. A description of these indices is given in NWS Technical Procedures Bulletin No. 85.

An error in the PBL analysis program was detected which resulted in a loss of detail in the vertical structure. Modifications were carried out, and the corrected version was implemented February 1, 1973. Due to changes in the LFM, boundary conditions at the top of the PBL are presently derived from LFM winds at constant pressure levels, rather than constant height levels.

The forecast section of the PBL remained unchanged except for the relative humidity criteria for cloud formation, which was changed from 95 to 80 percent to reflect a more realistic temperature regime.

A slab-symmetric version of the PBL model has been developed to facilitate the testing of certain features of the model. A study is also being made of the technique used to specify the cloudiness parameterization.

The task of evaluating the PBL performance continues to play a major role in the overall program.

Data have been received from those forecast offices verifying the time cross-sections and from the Forecast Division of NMC, which has been verifying several of the PBL products. An evaluation will be forthcoming. Presently, the National Severe Storms Forecast Center is conducting a verification program of the severe weather indices obtained from the PBL. (Polger and Jones)

3. New Numerical Forecast System (Semi-Implicit)

The semi-implicit version of the NMC operational 6L PE model has been run successfully to 4 1/2 days. This new model uses an hour time step and has a grid staggered in space--with pressure, temperature, and vertical motion on one set of grid points and **u,v** velocity components on the other. It covers the hemisphere with a grid spacing twice that of the 6L PE model, uses absolute temperature as the thermodynamic variable, and has neither orography nor diabatic effects. Though computational noise (which rapidly developed in early tests) has been reduced, it was necessary to employ Shuman's "smoother-desmoother" on each forecast variable at 36- or 48-hour intervals in order to run to 4 1/2 days.

Several problem areas that were a source of much of the computational noise in the semi-implicit model have been identified and partially solved. These were:

a. Initial data are extracted from every other grid point of the 6L PE model and smoothed. The operational initialization procedure is modified to accommodate the new temperature variable.

b. Boundary values of all variables, which previously had been held constant during the forecast, are now allowed to change while satisfying the operational "wall" condition.

c. Rapid increases of kinetic energy and "noise" in the computational cap are detrimental to the forecast--but by constraining the velocity components there to change slowly, the problem has been alleviated.

Comparisons between the unsmoothed semi-implicit 48-hour forecast and that of the 6L PE model (without orography or diabatic effects) are quite similar. Since possible future uses of this new integration scheme involve fine mesh and hurricane modeling, further work will be done to incorporate orography and diabatic effects, to reduce the grid size, and to solve the above-noted problem areas. (Campana and Gerrity)

C. Data Assimilation Branch

1. Data Impact Tests

a. First Vertical Temperature Profile Radiometer (VTPR) test

In order to determine the impact of VTPR data on the NMC operational analysis/prediction system (denoted the A-mode cycle), a parallel cycle (B-mode) was established. The two systems were as nearly identical as possible with the exception that VTPR data, which were available to the A-mode, were withheld from the B-mode. The parallel cycle was run in real time for two periods of approximately 2 weeks: 1200 GMT March 8 to 0000 GMT March 21, and 1200 GMT March 27 to 0000 GMT April 13. Data sets and analyses from both A- and B-modes were archived. Subsequently, 48-hour forecasts were run from the B-mode archives on nine separate cases for comparison with the corresponding operational (A-mode) forecasts. The forecast part of each cycle as well as the 48-hour forecasts were performed on the Goddard Institute for Space Studies (GISS) IBM 360/95 computer in New York.

Evaluation of results is not yet complete; however, preliminary examination reveals the following:

(1) Differences between A- and B-mode analyses are, in general, small.

(2) Largest differences occur over the oceans, as expected, where VTPR data are available to the A-mode and where manual bogusing is performed.

(3) There is no tendency for differences between A- and B-mode analyses to increase with time during the experiment. When large differences occur, they diminish during the following one or two cycles.

(4) Differences between A-mode and B-mode analyses lead to different 48-hour forecasts, but the operational (A-mode) forecasts are not always superior to the B-mode forecasts.

b. Infrared Temperature Profile Radiometer (ITPR) test

There have been problems with the scan apparatus on Nimbus 5; however, it did operate in full-scan mode in the Northern Hemisphere between March 30 and April 6. The ITPR, Selective Chopper Radiometer (SCR), Nimbus E Microwave Spectrometer (NEMS) data collected during this period were made available for an impact test. The experiment was conducted in a non-real-time mode during June, but results have not yet been evaluated.

c. Second VTPR test

Plans have been made to conduct a second real-time impact test of the VTPR data in November-December 1973. This experiment will be very similar to the earlier VTPR test, except that the analysis system and the prediction model used to provide first-guess fields will be different. The present operational analysis system will be supplanted by Flattery's spectral global analysis, and the operational prediction model at final time will be the 8L GLOBAL model. Conversion of the necessary codes to operate on the GISS computer is nearly complete.

2. Data Archiving

Preliminary plans have been made for archiving data during the period of the Data Systems Test (DST) in 1974. Level II data (meteorological parameters at the place and time of observation) will be archived with a late cutoff time of approximately 24 hours. Tapes containing these data will be made available to the National Climatic Center in Asheville, N.C., about 2 days after the data are received. In addition to the operational data base received at NMC, archive tapes will include--as they become available--retrieved soundings from Nimbus satellites, cloud-tracked winds, and Carrier Balloon System (CBS) and Tropical Wind, Energy Conversion and Reference Level Experiment (TWERLE) data.

During selected months of the DST, we will archive analyzed Level III data sets (Initial State Parameters) based upon the special data collection described above. The analysis system will be spectral, using first-guess fields provided by the 8L GLOBAL forecast model (see Section 3). Off-time data will be assimilated through a 6-hour analysis/forecast cycle. The analysis/forecast cycle will be carried out by remote operation of the GISS computer. We are in the process of converting global forecast and analysis codes for this purpose.

3. Data Assimilation Studies

a. Next operational assimilation system

Plans have been made for an intermittent data assimilation system based on the Flattery global analysis and the 8L GLOBAL model operating in a basic 6-hour cycle. This system will have two advantages over the presently-used updating method:

(1) The asynoptic data will be treated as synoptic within ±3 hours of nominal reanalysis time, thus avoiding the necessity of correcting the observations by means of the forecast tendencies.

(2) Off-time analyses will use conventional synoptic data at 0600 GMT and 1800 GMT, which currently do not enter the NMC data base.

Plans for this system are documented in _NMC Office Note 80_.

b. Noise analysis

A major problem area associated with this assimilation system is the presence of large-amplitude, gravitational noise in the 8L GLOBAL model. Because the 6-hour forecasts are to serve as first-guesses for the global analysis system, it is highly desirable that these forecasts be as accurate as possible.

Accordingly, a noise analysis of the 8L GLOBAL model was performed. It showed prominent oscillations with periods of 2 to 3 hours, 5 to 6 hours, and 10 to 12 hours. A special visconsity term, which damps only the divergence (Shuman, _NMC Office Note 32_), was formulated for the global model's finite difference system, and several integrations were performed with values of the viscosity coefficient ranging from $10^7 m^2 sec^{-1}$ to $10^8 m^2 sec^{-1}$. The results indicated an optimum value of approximately $2x10^7 m^2 sec^{-1}$. With this value, the shorter-period oscillations were damped adequately without noticeable side effects. For larger values, undesirable distortion of the flow near mountainous terrain occurs--probably as a result of the slope of the σ-coordinate system in such areas.

These experiments are documented in NMC Office Note 83. Efforts to suppress the longer-period oscillations through initialization procedures are continuing.

c. Simulation experiments

The goal of the data assimilation studies is an operational, continuous, four-dimensional assimilation system. In connection with this long-range goal, we have begun conducting assimilation experiments with a primitive equation barotropic model in order to investigate the feasibility of using the economical implicit-backward integration method vis-à-vis an explicit damping scheme, the Euler-backward. The damping properties of the implicit-backward method are discussed in NMC Office Note 81. The results indicate that the implicit method is more economical than the explicit method. Documentation may be found in NMC Office Note 86.

D. Upper Air Branch

1. Analysis of Stratospheric Data

a. Stratospheric synoptic analysis

A control card option for forcing relatively high temperatures to be held in the analysis during stratospheric warming episodes has been introduced. (Johnson and Laver)

b. Comparison of satellite data with radiosonde data

A comprehensive effort is continuing to determine compatibility of satellite-derived temperature and height data with radiosonde data at stratospheric levels. Results of evaluating SIRS-B compatibility appear in the March 1973 issue of the Monthly Weather Review, Vol. 101, No. 3, "Compatibility of Radiosonde and Nimbus 4 SIRS Derived Data at Stratospheric Constant Pressure Surfaces." Data from the recently launched VTPR on NOAA-2 as well as from the ITPR, the SCR and the NEMS on Nimbus 5 are being studied. Results of comparisons between VTPR and radiosonde observations have been reported to National Environmental Satellite Service (NESS) experimenters and other interested persons.
(Johnson, Finger, Gelman, McInturff, and Laver)

c. Southern Hemisphere temperature analysis

The 14-level temperature analysis program for the Southern Hemisphere supplied to NESS for providing profile-guess information for operational retrievals of the VTPR has been modified to use the Global Analysis (Hough-function Analysis) as a first guess from 1000 to 100 mb. (Johnson)

d. Thickness specification

Radiance fields from the various remote sounding instruments are being monitored on a regular basis. The relationship between radiance (as measured by SIRS and SCR) and the thickness of stratospheric layers with lower boundaries at 100 to 10 mb has been investigated (Monthly Weather Review, Nov. 1972). Results are being extended for use with VTPR, ITPR, and SCR data. A technique which has been recently developed uses measured radiances to specify hemispheric thickness fields which, by addition to the lower boundary height field, give synoptic maps at heights above the 10-mb level. (Quiroz and Gelman)

e. Rocketsonde data exchange and analysis

The United States and the Soviet Union continue to exchange meteorological rocket data for special inter-hemispheric stratospheric and mesospheric studies. On a reimbursable basis, NMC performs research for the United States. Weekly synoptic analyses at the 5-, 2-, and 0.4-mb levels are being performed using all available rocketsonde, radiosonde, and satellite data. Meridional cross-sections for the Western Rocket Network are being done weekly, with minimal time lag, on the basis of preliminary reports. Final meridional cross-sections for both Eastern and Western Hemispheres are also being drawn; these are based on published data. (Finger, Gelman, McInturff, and Nagatani)

2. Research on Stratospheric Circulation

a. Baroclinic instability forced from below

A two-level model has been developed that allows us to examine the effect of vertical flux of eddy kinetic energy by the pressure-work term at the boundaries on the baroclinic instability of the layer. Preliminary results indicate a marked increase in baroclinic instability, even with zero convergence of eddy kinetic energy. A paper coauthored with David Rodenhuis of the University of Maryland and A. J. Miller of the Environmental Research Laboratories, NOAA, has been submitted to the Monthly Weather Review. (Johnson)

b. Empirical study of critical-layer theory

A pilot study of quasi-geostrophic potential vorticity transport, before and during stratospheric warming episodes, indicates that significant generation of potential vorticity occurs in the initial stages of stratospheric warmings. This generation of potential vorticity is related to a critical layer or layers. Further numerical studies are underway. A paper was presented at the American Meteorological Society Meeting in January 1973. (Johnson)

c. Investigations of long-term tropical oscillations

Power-spectrum and cross-spectrum analyses have been performed on winds and temperatures at Ascension Island ($8^{o}S$), at 20, 24, 30, 40, and 50 km (as reported by radiosondes and rocketsondes) for the years 1971-72, with the purpose of discovering connections between the annual, semiannual, and quasi-biennial oscillations. The quadrature spectrum in particular is being studied for clues it may provide to the vertical transport of zonal momentum. Data from other stations are also being examined, in order to explore further any possible links between the fairly regular tropical oscillations and extratropical disturbances. (McInturff)

d. Comparative study of recent stratospheric warmings

SIRS and VTPR radiance data provide a virtually homogeneous data source for studying stratospheric behavior since 1969. A comparative study of the major warmings of December 1969, December 1970 and January-February 1973, and of the minor warming of February 1972, is in progress. (Quiroz)

e. Stratospheric warming

A major stratospheric warming that occurred in January 1973 is being studied. All available rocketsonde, rawinsonde, and satellite data are being used for a description of the warming. Special emphasis is being given to investigating the causes and effects of the warming with regard to tropospheric behavior. (Finger, Quiroz, Johnson, Gelman)

3. Quality Control

a. Compilation of information on upper air programs in World Meteorological Organization (WMO) countries

A considerable amount of detailed information concerning the upper air programs at individual stations in several WMO member countries has been received from the President of the Commission for Instruments and Methods of Observation of the WMO. This information will be synthesized and, if possible, published as a reference work. The work will continue into late 1973. (Thomas)

b. Tape-slide presentation of quality control of data

In collaboration with the Data Acquisition Division (DATAC) in the Office of Meteorological Operations of the NWS, a tape-slide presentation is being prepared on the subject of quality control. It illustrates the flow of data from the source through the final processing system of a user.

Specific examples of the effects that data deficiencies have on automated data processing can thus be shown. Plans call for distribution of this package to each NWS Regional Headquarters for further presentation at the field stations and possibly in selected technical training courses. The package should be ready for field distribution by September 1973. (Thomas)

c. Statistical summaries

The monthly summaries, showing the percentage of rawinsonde data processed by NMC from each station in the world, have been discontinued. In their place, a weekly and monthly summary of the number of reports processed from North American stations is being distributed. The new information will be available to field officers much sooner than the old type summaries were. (Thomas)

d. Study of day-night humidity differences

Preliminary research to determine the effects of radiation on upper air humidity measurements has been completed. Mean monthly day-night differences of mixing ratios were computed for each upper air station on a global scale. These were plotted against solar elevation angles and according to hygristor classes. The results of this study for United States instruments should be distributed by September 1973.
(Finger, Johnson, McInturff, and Thomas)

e. Quality control of surface observations from ships

A pilot study has been undertaken to try to improve the availability and quality of surface data from ships. In collaboration with Automation Division (AD), Forecast Division (FD), Regional Officers, and Port Meteorological Officers (PMOs), NMC is providing quasi-real time feed-back to docking ships on the number of reports received during their inbound passage. PMOs notify FD in real time of an incoming vessel that will be visited. FD obtains daily listings of reports received and processed from the vessel, and telephones this information to the PMO the same day. The PMO then compares the reports received or processed by NMC; vital information, such as transmission time, shore radio receiver and so on, is logged. The information on data losses will be summarized in order to isolate and correct chronic problem areas. (Thomas)

f. Quality control study of Caribbean data

In cooperation with DATAC, Overseas Operations Division (OOPS), and Communications Division (COMMS), a 2-week investigation (June 1-15) of the quality and availability of Caribbean data has been undertaken. The Upper Air Branch coordinated acquisition of data and computer products at

NMC. OOPS is obtaining original copies of data from the Caribbean countries for comparison. COMMS is obtaining corresponding data from the Kansas City Switch for June 6, 9, and 12. DATAC will assist in the data analysis. The aim is to isolate the causes of discrepant, late, and missing data and to get them corrected. (Thomas)

IV. AUTOMATION DIVISION (AD)

A. Meteorological Techniques Branch

1. Objective Analysis

a. An elliptical and an off-level, off-time weighting function has been developed and incorporated into the LFM wind analysis program. This procedure was implemented March 20, 1973. The first (elliptical) weighting is an attempt to better define jet stream features by assigning greater weight upstream and downstream than lateral to the wind flow. The off-level, off-time weighting allows greater weight to aircraft reports which are nearest the constant pressure level being analyzed and nearest in time to the analysis map time. This weighting is a quasi-three-dimensional approach using a scan type analysis scheme. Tests with these weighting procedures for the coarse-mesh analyses have not given encouraging results when considered against the additional machine time consumed.
(Zbar and Burek)

b. Both the fine-mesh and coarse-mesh operational upper air analysis programs were modified so that only SIRS (VTPR) constant pressure height thicknesses are utilized. Because of the difficulties encountered when the reference level (NMC 850-mb 12-hour height forecast) used in the retrieval procedures is in error for one reason or another, this reference level is discarded in favor of the latest available 1000-mb height. By doing this, a new set of constant pressure heights can be assigned and used by the analysis program. This procedure additionally allows the use of SIRS heights south of 20° latitude, where the retrieval reference level is sea level and the 1000-mb height is assumed to be zero. The implementation of this new procedure was 1200 GMT February 21, 1973, for the coarse-mesh analyses and 1200 GMT April 18, 1973, for the fine-mesh analyses.
(Burek)

c. The smoothing procedures for the u- and v-wind component analyses were modified for both the coarse-mesh and fine-mesh analyses. The smoothing technique for the coarse-mesh was restored to the method used by the IBM 7094 program (Shuman's nine-point complex "operational" smoother) beginning 1200 GMT April 17, 1973. This change results in a better fit to the observations, apparently because of less damping of short wave length features. The wind analysis smoother was also changed in the fine-mesh program to lessen the damping of short waves. This latter change was implemented 1200 GMT June 18, 1973, resulting in an improvement in fitting the wind observations. (Zbar and Burek)

d. A procedure to retain observations which are located just off the analysis grid was implemented 1200 GMT April 3, 1973. Any report within 2° latitude of the grid boundary is utilized by assigning it a fictitious latitude. This is merely an internal programming convenience, having no effect on other programs using the report. (The non-use of these near boundary reports was actually an oversight when converting from the IBM 7094 to the CDC 6600 system.) (Burek)

e. The PBL analysis code was modified to accept the new format from the LFM program. Since this new output no longer contains wind information at constant height levels, the analysis code was changed to substitute isobaric level winds. (Newell)

2. Machine-processed Observations

a. A procedure for logging certain types of errors in NWS upper air data reports was implemented during the period. If a report requires manual assistance to get it through the processors, the reason is logged. Several times each day, a station discrepancy message is prepared and transmitted to selected stations for quality control purposes. (Webber)

b. The upper air processing program was augmented to allow data to be stored for a 24-hour period before the disk area is reused. At the same time, improved methods for updating the station lists for the master dictionary and other operational dictionaries were implemented. (Webber)

3. Programming for IBM 360/195

a. Data array packers, unpackers, and check-sum checkers have been written (in FORTRAN H+) for the data formats which will be used on the IBM 360/195 computer. Reprogramming has been started the pre-analysis processor for the global spectral analysis. (Chase)

b. The global spectral analysis program is being converted for running on the IBM 360/195 computer. Despite the fact that the program was originally written in FORTRAN, extensive revisions are necessary because of the difference in the CDC 6600 and IBM 360/195 computers. (Newell)

c. The report processors which currently run on the IBM 360/40 computer are being designed so that they can be run on the 360/195. (Costello, Byle, Webber, and Fleming)

d. The moisture pre-analysis processor and moisture analysis programs are being programmed for the 360/195. (Costello and Webber)

4. NMC-NHC Activities

The new tropical analysis (ATOLL) has become fully operational, replacing a hand-drawn chart prepared twice daily. The analysis is prepared at two levels approximately analogous to the 850- and 200-mb levels.

Experiments with time-dependent boundaries for the SANBAR barotropic hurricane forecast model are continuing with an attempt to compare the performance of the model with live boundaries as juxtaposed to the usual fixed boundary condition.

New regression equations were derived by seasons for the eddy objective analysis, which currently produces initial conditions for the SANBAR forecast model.

A backup procedure to support NHC operations during hurricane crisis periods has been worked out, making use of the Cathode Ray Tube (CRT) in Miami and the NMC communications computers. This may be needed in the event the user 200 terminal in Miami is inoperative, breaking NHC's link to the CDC 6600 computer system. (Zbar)

5. Miscellaneous Programs

a. Automatic plotting of surface reports

Operational surface plotting began March 22, 1973, with the preparation of 0000 and 1200 GMT tropical maps. These charts extend completely around the earth from 30°N to 50°S and have synoptic reports plotted from the FINAL (10+00) surface data files. The plotted charts are produced on the Varian display device at 1:20 million scale. These charts are then analyzed by hand in the Forecast Division, duplicated, and the resulting map sections are transmitted via facsimile to Puerto Rico, San Francisco, and Australia. Other internal uses also are made of the charts. Additional work is continuing to complete the current weather (ww) symbols and the ship plotting model.

An experimental 1:10 million-scale chart covering part of North America is being produced routinely. This chart displays the machine analysis of sea level pressure and surface temperature which serve as input to the 1200 GMT LFM run. (Irwin and Shimomura)

b. Aviation digital forecasts

In order to save time on the IBM 360/30, the preparation of the transmission messages (for computer to computer) has been programmed to be done on the CDC 6600 computer. This, plus blocking the records into larger groups, has resulted in a significant time saving and allowed higher priority tasks to be completed without further delaying the availability of these messages. (Irwin)

c. Automatic data receipt summaries

The summary programs, which are produced for quality control of upper air data receipt for NWS stations, have been modified to date check and execute four times monthly, doing a 7-day summary each time. (Costello)

d. To improve the monitoring procedures for SIRS (VTPR) reports, a program was written and implemented which reassigns the reference level from the 850-mb 12-hour height forecast to the latest NMC 1000-mb analysis before these data are plotted (NWP Activities Second Half 1973, Chapter IV. Section A. 6). This step gives the monitors a better estimate of what the analysis program will be using for SIRS height values (see Section 1. b). (Carlton and McDonell)

B. Services and Applications Branch

The major programming effort for this period has been (1) preparation for an increase in the production of digital facsimile products via the CDC 6600 computer, (2) "last stand" projects for the IBM 7094 computer, (3) training of personnel for conversion to IBM 360/195, and (4) program upgrading and maintenance for the CDC 6600 operational programs.

1. Programming Support Section

The Programming Support Section has been primarily concerned with maintenance and upgrading of NMC operational programs (exclusive of graphics); the conversion of the remainder of 7094 programs to the 6600, and a "last" project for 7094.

a. The 6L PE initialization is undergoing modifications to reduce its memory requirements. (Helmick)

b. The 8L HEM post-processor (6600 version) has been written. Its products are being compared with those from the 6L PE post-processor. This program is to be modified to run on the IBM 360/195. (Helmick)

c. The 6L PE post-processor has been modified to drop the 3-hourly output. In addition, improvements were made in the half unpacker logic (NAIØ5F) and buffer I/O was inserted. (Carlton)

d. The packing subroutine changes mentioned in NWP Activities Second Half 1972, Chapter IV, Section B. 1. d. were implemented on April 24, 1973. (Carlton)

e. The barotropic data processor has been combined with the D1000 program (0000 GMT cycle only); also, the barotropic stream function fields are being saved in the permanent file. In addition, the processor has been modified to produce u- and v-wind components at the 60- and 72-hour forecast periods. This latest modification will be operational in July. (McClees)

f. The NMC operational programs which send transmissions to the NMC 360 site via long-line tapes are being modified to use the 6600-360 interface, thus eliminating the long-line tapes. (Townshend and Raymond)

g. The ADP Dictionary Compile and the IJ conversion programs were translated from the IBM 7094 SOS language to a 6600 FORTRAN program (one more link removed in the phase-out of the IBM 7094). (Townshend)

h. The IBM 7094 program, which produced the Western Region Transmission, has been converted and is now operational. (Finnican)

i. NESS is currently producing a set of SIRS bulletins composed of soundings by geographical areas as the SIRS data are processed. A program has been written which sorts these bulletins and regroups the soundings so that all data for the same geographical area are in one bulletin. (Steinborn)

j. NMC received a request to produce a "Tropical Wind Atlas." For this atlas, past years of tropical analyses are to be summarized to accumulate mean monthly statistics. Approximately 5 years of analyses spanning 1968-1972 have been archived by NMC. This archive contains the wind components at five pressure levels: 700, 500, 300, 250, and 200 mb. The grid used for the analysis consists of 1679 points (73 by 23) with a spacing of 5^{o}. The initial phase of the project was programmed on the 7094 (hopefully the last new project for this machine) and produced 12 mean monthly data tapes. The format of the tabulated values is described in NMC Office Note 28 and consists of five data files on each tape, one file for each level. Each file is comprised of seven records containing the following information: mean u-component, v-component, and speed; the standard deviation of u, v, and speed; and the steadiness factor. The second phase of the project is being programmed for the 6600 computer. The plan is to draw streamlines of the mean monthly u- and v-components and contour the mean resultant wind speed. (Allard)

2. Graphic Support Section

<u>NMC Computer Graphics on the CDC 6600</u>. A great portion of the Graphics Support Section programming effort has been in preparation for a considerable increase in the number of digital facsimile charts scheduled for mid-1973. Changes made in the IBM 360 program to handle the planned increase necessitated changes in the CDC 6600 programs which generate the digitized map information that is input to the IBM 360 facsimile transmission system. Some of the operational map-generating programs were written several years ago, and these have been updated to work with the latest versions of the graphics subroutines, so that those changes needed to meet the IBM 360 program's new requirements could be incorporated. The graphics subroutines were also modified to speed up the handling of character-type display.
(Bedient, Schnurr, Dent, and Shimomura)

a. New display packages put into NMC operations include: Varian display of the Global Analysis and Global Forecast Models on polar-stereographic projections for both hemispheres; facsimile chart of the Probability of Cloudiness (by category of sky cover) for the Spaceflight Meteorology Group in Houston (effective May 9, 1973).

b. Program to automate facsimile schedules

The increasing number of charts also provided the impetus for automating some of the record-keeping procedures associated with the scheduling of automated charts for facsimile transmission. In addition to keeping the usual facsimile schedule information such as time-of-transmission, title, number and area of chart, the automatic scheduler assigns the control numbers which are incorporated into the digitized map file for use by the IBM 360 computer to compose the facsimile chart from portions of the given basic digitized map. An additional function of the scheduler is to keep track of the operational charts output on the Varian plotter for local use.
(Bedient, Schnurr, and Millman)

c. Facsimile schedule changes

A new Bracknell circuit schedule was installed, replacing the Offenbach schedule. Other routine schedule changes were made as required.
(Schnurr and Hopkins)

d. Digital-facsimile system

Extensive changes were made to the Digital Facsimile System, especially in the IBM 360 facsimile-transmission program (FAXX) in anticipation of the increase in the number of automated charts to be processed. The FAXX program was modified to handle an additional disk for increased storage capacity for maps awaiting transmission, and the disk storage was partitioned to provide temporary storage for local Varian display charts. For increased efficiency, the input buffer of the FAXX program was enlarged and the line-interrupt routines were improved.

An additional Digital Facsimile Interface (DFI) unit with its four ports has been added to the system, so that automated facsimile transmissions can go out on twelve circuits simultaneously. (Hopkins)

e. Remote graphics system (RGS)

The program modules necessary to the IBM 360 portion of the RGS have been incorporated into the 360 FAXX program, and improvements were made to the program assemblers for the system.

Making the RGS operational depends upon the acquisition of a Graphics Terminal Controller, which would be a minicomputer with more speed and capacity than the present Model 4 Interdata minicomputer that is driving the local Varian electrostatic plotter. (Hopkins)

C. Information Processing Branch

1. We continued the process of automating our communication system with a decrease in the use of magnetic tapes in favor of disk. In the middle of January, we began creating on the Disk Operating System (DOS) alpha-numeric transmission bulletins on the swinging disks (previously prepared on tape) to be picked up and switched out automatically on the IBM 360 communication computer. We began with the international transmissions (North American upper air bulletins). Since that time, we have gradually converted over other--but not all--such bulletins.

2. We overcame a vexing problem encountered in the input-output (I/O) software of our communication system in regard to swinging disks. The original I/O software had not been designed to properly handle disks used in this manner. The increasing use of these disks to pass information between the two 360 computer systems caused several I/O problems to surface leading to loss of data. A redesign of the I/O software became mandatory and was finally accomplished in February.

3. With the advent (in mid-March) of an extra 65K of core for the operational 360/40's (bringing each up to 196K), we inaugurated a new second batch (background) processing capability. This allowed us to relieve the strain on the first batch area, minimize interruptions to the basic data cycle codes which run the first batch area, and accommodate those codes requiring more core than is available in the first batch area (43K vs 16K). At the current time, codes using the second batch area include several on-line debugging and monitoring codes, codes to process radar reports, and Aeronautics Incorporated (AERINC) Pilot Reports (PIREP), codes to decode incoming hourly PIREP and Terminal Forecast (FT) data and

encode outgoing bulletins, as well as a lengthly magnetic tape code to process the Air Transport Association (ATA) transmissions. Peak data-handling hours, such as 1800 GMT, no longer experience long data backups.

4. In early April, we successfully substituted two Inktronic printers (operating at 1050 words per minute) for an IBM 1443 printer to be used by the charting unit of the Forecast Division. Considerable software changes were involved. Reliability, higher computer channel integrity, and ability to remote the Inktronics when NMC relocates were all important factors in this change.

5. The old NMC-Offenbach 1050 bits per second (BPS) asynchronous data/facsimile system was phased out in stages between January and April in favor of a synchronous 2400 BPS data channel--75 BPS backward channel, data/ facsimile system. This is one leg of the WMO main trunk circuit.

Currently, 60 charts and approximately one million characters of data are sent to Bracknell daily. The same amount of data, but only about 16 charts, are received from Bracknell.

Among the many codes newly written or revised was a code to create the Bracknell FAX schedule on disk and display it on demand. The code is also used to reschedule FAX bulletins and exercise limited dynamic control over the FAX flow.

6. Data Base Changes

a. The hourly data base formed on the communication system has been augmented with Alaskan, Mexican, military, and Pacific Island reports.

b. Codes have been written on the DOS side to dump these hourlies on tape, and thus provide the data base for the CDC 6600 and a DOS hourly decoder.

c. By urgent request, the PIREPS data base was redesigned to hold about 10 PIREPS for each station per hour. It was also expanded to include military PIREPS.

d. The FT data base was made operational on the swinging disks, and about 80 FT's added in support of "SKYLAB."

7. On the CRT effort, codes were written to display parts A, B, C, and D of the radiosonde and rawinsonde observations and to display undecoded surface reports.

8. Markers have been put in for incomplete or incorrect data, and the changes for the new upper air record format have been completed.

9. We make almost daily changes in our bulletin directory. Since the first of the year, over 4,000 changes, insertions, and deletions have been made--including major overhauls to handle the NMC-Bracknell data link (inclusion of WMO catalogue numbering scheme) and the handling of three letter station calls, coordinated with Toronto and Kansas City.

10. Miscellaneous

a. New 150-baud strip circuit to San Francisco brought up in January.

b. An Air Transport Association (ATA) error statistic message and the low level bulletins for the Eastern Equatorial Pacific were added to the ATA transmissions.

c. Another WMO survey was done for May 3-5.

d. Our system was changed to put all tapes and the chronolog clock on Channel 2.

e. Numerous and frequent code updates to handle disk transmissions, second batch area queues, new line device addresses, updated polling lists, formatting of the 2314 disks from cards, etc.

D. Operations Branch

1. Continued modifications and improvement of our archival data base by:

a. changing the archive tapes from unlabeled to labeled magnetic tapes;

b. adding Radat data to Verification files;

c. establishing a historical file of LFM analysis and forecast data.

2. Improved techniques for transferring files when switching machines or restarting on same, by establishing a series of jobs in a dependency string with appropriate instructions to enable file transfer more reliably and timely.

3. DOS operating systems modifications extended by the addition of a series of routines to the DOS Attention Routines. The cancellation problem in DOS power spool was solved.

4. Maintained a high proficiency level in operator and systems response by routine communications lines and various meetings to review training.

E. Electronics Equipment Branch (EEB)

1. The Dacom/Alden System

This system needed additional testing after the Dacom Unit was returned from the factory for modification. COMMS and AD agreed on test input weather chart data from our 360 computers to be transmitted over a 4800-baud line to the Gramax Building in Silver Spring.

We modified circuit #1 in DFI #3 to appear as a digital output device, interfacing the computer to the transmitting Dacom unit. Start of line, Buffer full, data, start/stop and clock signals had to be furnished. The new speed of the system is 720 rpm (21.6 kHz bits per second). These signals had to be designed and implemented in the DFI. The clock frequency was difficult, since it had to be generated from existing clocks in the DFI.

The test was a success and was demonstrated at the Alden Electronics booth at the Armed Forces Communications and Electronics Association show in Washington, D.C.

2. New Data/FAX Switch

EEB designed and installed a data/FAX switch for the Suitland-Bracknell circuit. Under computer control, when there are data to be transmitted, the switch stays in the data mode and facsimile is blocked out. When there is a weather map scheduled to be sent, the computer will disable the data circuit and will switch to the facsimile mode. When the switch senses the start signal preceding a map, data are blocked out until the stop signal is sensed at the conclusion of the map. Data can then be transmitted. The switch is on both the transmit and receive sides of the circuit. There is a manual data override button that can be depressed to put the complete operation in the data mode if problems develop. Also on the Bracknell data/FAX circuit, a need for automatic starts and stops for charts coming from the DFI was requested. This feature was designed and installed. There was also a request to have an automatic start and stop for weather charts being transmitted from a flatbed Alden scanner on the Bracknell circuit. A scanner was redesigned and circuits implemented to perform this function.

3. DFI

EEB is continuing to add refinements to the DFI's. For some of the facsimile circuits, a method was needed to switch the recorders from 96 to 48 lines per inch. This feature is accomplished by selecting either a 300-Hz start tone for 96 lines per inch, or 675-Hz start tone for 48 lines per inch. The electronic circuit was designed and added to the DFI's to accomplish this task.

Another requirement was to develop a tone in the DFI's (852 Hz) to be computer selectable, which would switch the recorders from 120 rpm to 240 rpm on the facsimile circuits. In combining software and hardware techniques, the following combinations of facsimile charts can be transmitted from the computer via DFI's: 120 rpm - 96 lines per inch; 120 rpm - 48 lines per inch; 240 rpm - 96 lines per inch; 240 rpm - 48 lines per inch, plus the moss codes for customer selection of the charts they want to receive.

V. FORECAST DIVISION (FD)

A. Basic Weather Forecast Branch

1. The sea-level pressure prognoses from LFM and 6L PE models at the latitude/longitude points of the S_1 score verification grid are provided by a numerical program of biquadratic interpolation (T. Flattery) as of 0000 GMT November 1, 1972. The result is that S_1 scores are lower than with the former subjective interpolation. The lowering is estimated to be 0.4 points for the 36-hour prognosis--which is the score of longest record.

2. The area of the S_1 grid for verification of 24-hour prognoses was reduced as of 0000 GMT February 1, 1973, so that only the area of the LFM displayed on National Facsimile Network (NAFAX) is now verified. The reduction resulted in S_1 scores for the sea-level LFM prognoses, which were somewhat lower (better) than for the 6L PE--at least until the LFM was modified 1200 GMT February 7, 1973.

3. Twelve cases of the 6L PE sea-level prognoses run from the Hough function analysis, but without initialization, were verified by S_1 score and mean absolute pressure error. Comparison with the operational 6L PE showed the Hough function version to be a little poorer at 24 hours but slightly better thereafter, with the advantage increasing as the forecast period increased to 48 hours.

4. Subjective comparison of 19 cases of the 8L HEM with the 6L PE showed the 8L to be very slightly better. However, S_1 verification showed the 8L to be inferior at all forecast periods--although the difference decreased as the period increased. The S_1 verification results are questionable because of an error in output of the 8L and because the 8L was not smoothed. Verification of one smoothed 8L after correction of the output error supports the subjective evaluation.

VI. FORECAST VERIFICATIONS--MONTHLY MEANS FOR 1973

A. NMC Grid Area (1,977 Grid Points)

	24 hours					36 hours								48 hours				
	PE MODEL			PERS		PE MODEL			PERS		BAROTROPIC			PE MODEL			PERS	
	R	H	W	H	W	R	H	W	H	W	R	H	W	R	H	W	H	W
200 mb																		
Jan.	.82	188	23.4	318	34.3	.82	243	27.4	406	40.9				.80	289	30.9	456	43.7
Mar.	.79	173	22.4	270	32.0	.79	220	26.3	337	37.0				.76	262	29.7	365	38.5
May	.82	134	19.3	230	28.4	.82	175	22.8	301	33.8				.82	194	25.5	335	36.2
300 mb																		
Jan.	.86	174	21.9	343	37.7	.84	231	26.1	427	44.0				.82	280	30.0	476	46.7
Mar.	.86	161	21.1	308	36.1	.84	210	25.4	374	41.2				.80	256	29.3	405	42.8
May	.85	134	18.2	251	29.9	.85	173	21.5	324	35.6				.85	196	24.5	365	38.5
500 mb																		
Jan.	.85	128	15.5	244	27.1	.83	175	18.8	306	31.5	.69	225	22.3	.80	214	21.6	341	33.4
Mar.	.85	119	15.2	219	25.7	.83	156	18.1	269	29.4				.78	198	20.9	294	30.5
May	.82	101	12.7	176	20.6	.82	130	15.1	227	24.4	.72	156	17.1	.83	148	17.0	258	26.4
850 mb																		
Jan.	.82	104	13.2	170	18.0	.78	142	15.7	208	20.5				.74	170	17.8	226	21.0
Mar.	.82	95	12.4	150	16.9	.77	133	14.8	184	19.2				.73	164	16.9	202	19.7
May	.79	82	10.3	122	13.5	.78	104	12.5	157	16.0				.79	117	13.5	177	17.0
1000 mb																		
Jan.	.83	111	14.8	185	21.0	.79	151	17.9	223	23.5				.75	182	20.5	240	23.9
Mar.	.83	100	13.7	164	19.8	.78	142	16.5	198	22.2				.74	173	19.0	214	22.7
May	.80	82	11.3	127	15.5	.78	108	13.6	163	18.0				.79	122	14.9	181	18.9

B. North America--Area 1 (195 Grid Points)

	24 hours					36 hours								48 hours				
	PE MODEL			PERS		PE MODEL			PERS		BAROTROPIC			PE MODEL			PERS	
	R	H	W	H	W	R	H	W	H	W	R	H	W	R	H	W	H	W
200 mb																		
Jan.	.84	169	19.8	337	37.7	.84	222	25.7	426	44.7				.81	281	30.6	480	48.7
Mar.	.87	126	18.0	274	34.6	.86	170	23.4	346	40.8				.81	219	27.6	368	41.7
May	.86	112	15.2	223	28.0	.85	149	18.5	287	34.1				.84	179	22.2	333	37.8
300 mb																		
Jan.	.90	173	21.2	424	49.2	.88	236	28.3	523	56.7				.85	293	33.6	579	60.2
Mar.	.92	137	19.6	357	46.3	.90	184	25.6	436	52.9				.85	240	30.9	462	53.2
May	.88	122	16.1	262	33.2	.86	166	20.3	336	40.0				.84	198	24.5	381	43.1
500 mb																		
Jan.	.90	123	14.7	298	34.1	.88	169	19.4	367	39.5	.79	212	23.7	.85	211	23.4	409	42.0
Mar.	.92	98	13.8	257	32.2	.90	133	18.1	317	37.1				.86	172	21.3	340	37.6
May	.86	85	10.8	176	21.6	.85	118	13.9	232	26.6	.80	134	16.0	.84	137	16.3	264	28.6
850 mb																		
Jan.	.88	90	10.9	184	20.0	.86	117	14.0	223	23.1				.81	145	16.4	243	24.0
Mar.	.90	74	10.0	169	19.4	.88	101	12.9	210	23.2				.83	130	15.3	229	23.9
May	.80	72	8.3	117	13.4	.82	88	10.1	157	16.8				.81	100	11.9	175	17.7
1000 mb																		
Jan.	.88	97	13.5	196	22.4	.86	125	16.6	239	25.8				.81	159	19.9	259	26.8
Mar.	.89	86	12.8	180	21.4	.88	111	15.4	225	25.5				.85	141	17.9	241	26.0
May	.80	78	10.3	120	15.1	.82	92	12.2	159	18.5				.81	108	14.3	175	19.4

C. Europe--Area 3 (143 Grid Points)

	24 hours					36 hours								48 hours				
	PE MODEL			PERS		PE MODEL			PERS		BAROTROPIC			PE MODEL			PERS	
	R	H	W	H	W	R	H	W	H	W	R	H	W	R	H	W	H	W
200 mb																		
Jan.	.85	181	18.1	358	33.3	.85	237	22.1	462	40.3				.82	308	26.9	524	43.1
Mar.	.87	130	14.7	263	25.6	.87	161	17.0	340	31.1				.84	197	19.7	373	33.3
May	.86	108	12.9	215	22.7	.85	146	16.0	281	27.7				.84	175	18.7	323	30.3
300 mb																		
Jan.	.88	181	18.2	387	38.2	.86	243	23.7	486	44.9				.82	317	29.3	546	47.7
Mar.	.90	146	16.2	341	34.1	.90	190	19.7	430	40.8				.86	238	23.6	470	43.5
May	.87	126	14.5	272	29.4	.87	172	18.8	356	36.2				.86	208	22.1	408	39.4
500 mb																		
Jan.	.86	139	13.5	276	26.7	.84	183	17.4	347	31.7	.73	232	20.8	.80	239	21.1	389	33.4
Mar.	.89	108	12.0	241	24.3	.88	144	14.4	306	29.1				.85	183	17.5	335	31.0
May	.86	95	10.4	195	20.1	.85	133	13.2	257	24.9	.77	159	15.3	.84	160	15.8	296	27.1
850 mb																		
Jan.	.84	105	9.9	200	18.1	.82	132	12.5	233	20.8				.78	166	14.7	253	21.2
Mar.	.85	86	8.5	164	15.3	.83	113	10.7	203	18.0				.82	133	12.4	226	19.0
May	.85	68	7.1	133	12.3	.85	91	9.0	174	15.2				.84	110	11.0	201	16.6
1000 mb																		
Jan.	.84	111	10.2	207	18.9	.82	137	13.1	237	21.3				.76	178	15.6	250	21.2
Mar.	.84	93	9.2	169	16.2	.83	121	11.9	208	18.8				.81	144	13.9	230	19.6
May	.86	68	7.5	136	12.8	.86	89	9.4	176	15.7				.84	112	11.6	201	17.1

D. Asia--Area 4 (275 Grid Points)

	24 hours					36 hours								48 hours				
	PE MODEL			PERS		PE MODEL			PERS		BAROTROPIC			PE MODEL			PERS	
	R	H	W	H	W	R	H	W	H	W	R	H	W	R	H	W	H	W
200 mb																		
Jan.	.78	173	21.5	271	30.3	.77	231	25.8	342	35.8				.77	265	28.9	387	38.5
Mar.	.74	171	21.2	247	29.0	.68	243	25.7	304	33.1				.70	268	29.6	338	36.0
May	.83	137	18.0	249	30.3	.83	182	22.0	322	36.2				.83	212	25.2	366	39.7
300 mb																		
Jan.	.86	154	19.6	301	34.4	.84	210	23.5	370	39.6				.82	246	26.6	411	42.1
Mar.	.82	154	19.1	276	32.8	.75	229	24.2	341	37.6				.76	259	27.8	377	40.4
May	.87	128	17.0	265	32.1	.87	171	21.1	340	38.2				.87	196	23.9	390	42.5
500 mb																		
Jan.	.84	109	13.6	202	23.5	.81	151	16.4	249	27.0	.60	225	20.8	.78	182	18.9	277	28.5
Mar.	.85	98	12.7	186	22.2	.79	145	15.6	233	25.5				.78	168	17.8	253	27.0
May	.86	89	11.6	173	20.7	.86	113	14.1	220	24.8	.74	146	16.1	.85	137	15.9	253	27.3
850 mb																		
Jan.	.75	103	14.5	135	14.7	.69	138	16.3	162	16.7				.67	163	18.1	178	17.2
Mar.	.78	93	13.3	127	14.8	.73	126	15.6	156	16.9				.70	148	17.0	165	17.3
May	.79	82	12.8	121	14.6	.77	110	15.6	152	17.2				.76	126	16.3	172	18.8
1000 mb																		
Jan.	.79	106	14.5	156	17.9	.73	149	17.7	185	20.3				.69	184	20.6	202	20.7
Mar.	.81	93	13.1	147	18.0	.79	125	15.8	178	20.4				.73	154	18.4	192	21.2
May	.81	82	11.3	131	16.5	.75	122	15.1	169	19.7				.78	127	16.3	185	20.8

R Correlation coefficient of forecast and actual height change
H Root-mean-square deviation of height in feet
W Root-mean-square vector geostrophic wind error in knots
PE MODEL Operational six-layer primitive equation baroclinic forecast model
PERS Persistence forecast
BAROTROPIC Operational barotropic forecast model

VII. MACHINE PERFORMANCE AND UTILIZATION

A. IBM 7094/II

1. Profile

   a. Released equipment

2 - IBM 729-4 Magnetic Tape Units	2-73

2. Use - 789 hours.

B. IBM 360/30 GF

1. Profile - No changes

2. Use - 1,859 hours.

C. IBM 360/40 GF - #1

1. Profile

   a. Released equipment

2 - IBM 2944 Channel Repeaters	3-73
1 - IBM 2911 Switching Unit	3-73

   b. Leased equipment

1 - Ampex Memory Unit	3-73
1 - IBM 2914 Switch Unit	4-73

2. Use - 4,307 hours.

D. IBM 360/40 GF - #2

1. Profile

   a. Released equipment

1 - IBM 1443 Printer	3-73

   b. Leased equipment

1 - Ampex Memory Unit	3-73

2. Use - 4,219 hours.

E. <u>IBM 360/40 G - #3</u>

1. Profile (acquired 5-73)

a. Leased equipment

1 - Ampex Memory Unit 6-73

2. Use - 1,278 hours.

F. <u>CDC 6600, NOAA</u>

1. CDC 6600 Profile

3 - 6612 Central Processing Units (CPU)
3 - 6613 Consoles
26 - 607 Tape Drives
6 - 512 Printers
6 - 3555 Printer Controllers
4 - 3423 Magnetic Tape Converters
4 - 405 Card Readers
4 - 3447 Card Reader Converters
2 - 415 Card Punches
2 - 3446 Card Punch Converters
20 - 6681 Data Channel Converters
5 - 3291 Entry Display Units
4 - 6638 Disk Systems
1 - 6639 Controller
6 - 10037 A/RW Options
3 - 6671 Data Set Multiplexes
6 - 595 Train Cartridges for 512 Printers
9 - 217 Terminal Cathode Ray Tubes (CRT)
9 - 224 Terminal Readers
9 - 222 Terminal Printers
1 - 6635 Extended Core Storage
6 - 10010 Long-Line Driver Modifications
2 - 659 Magnetic Tape Transports (9-track)
4 - 3518 Magnetic Tape Controller
3 - 6846 Modified to 6671
2 - GK122 Channel Switches
1 - GK128 Channel Switch
2 - GK130 Channel Switches
2 - 3446 415 Controller
1 - CC534 Display Station
1 - CE123 Card Reader
1 - CL896 Printer
11 - 841-8 Diskpack Unit
4 - 3553 841 Controller

2. Use for NMC work - CPU 2,627 hours.

VIII. PERSONNEL CHANGES

A. Development Division

1. Kenneth H. Bergman, Research Meteorologist, joined the staff of the Data Assimilation Branch, April 1.

2. Ronald M. Nagatani, Research Meteorologist, joined the staff of the Upper Air Branch, April 15.

3. Roderick A. Scofield, Research Meteorologist, joined the staff of the Regional Modeling Branch, June 10.

4. David Goddard, Mathematician, transferred June 15.

5. Dale A. Chiusano, Meteorologist, joined the staff of the Data Assimilation Branch, June 18.

6. John B. Hovermale, Research Meteorologist, joined the staff of the Regional Modeling Branch, June 24.

7. Donald G. Marks, Mathematician, joined the staff of the Regional Modeling Branch, June 24.

8. Thomas Flattery, Research Meteorologist, transferred June 29.

B. Forecast Division

1. David L. Sherrieb, Meteorologist, joined the staff of Automated Analysis Branch, January 7.

2. Raymond A. Green, Meteorologist, retired from the Extended Weather Forecast Branch, January 7.

3. William D. Schallert, Meteorologist, joined the staff of the Surface Analysis Branch, April 29.

4. Holbrook Landers, Meteorologist, joined the staff of Basic Weather Forecast Branch, May 13.

5. Stephen D. Kauffman, Meteorologist, joined the staff of the Surface Analysis Branch, June 18.

6. Margaret V. Supplee, Meteorologist, retired from the Surface Analysis Branch, June 30.

7. Walter D. Erwin, Meteorologist, retired from the Automated Analysis Branch, June 30.

8. Russell J. Younkin, Supervisory Meteorologist, Chief of Quantitative Precipitation Branch, retired June 30.

9. DeWitt Morgan, Meteorologist, retired from the staff of the Surface Analysis Branch, June 29.

C. Automation Division

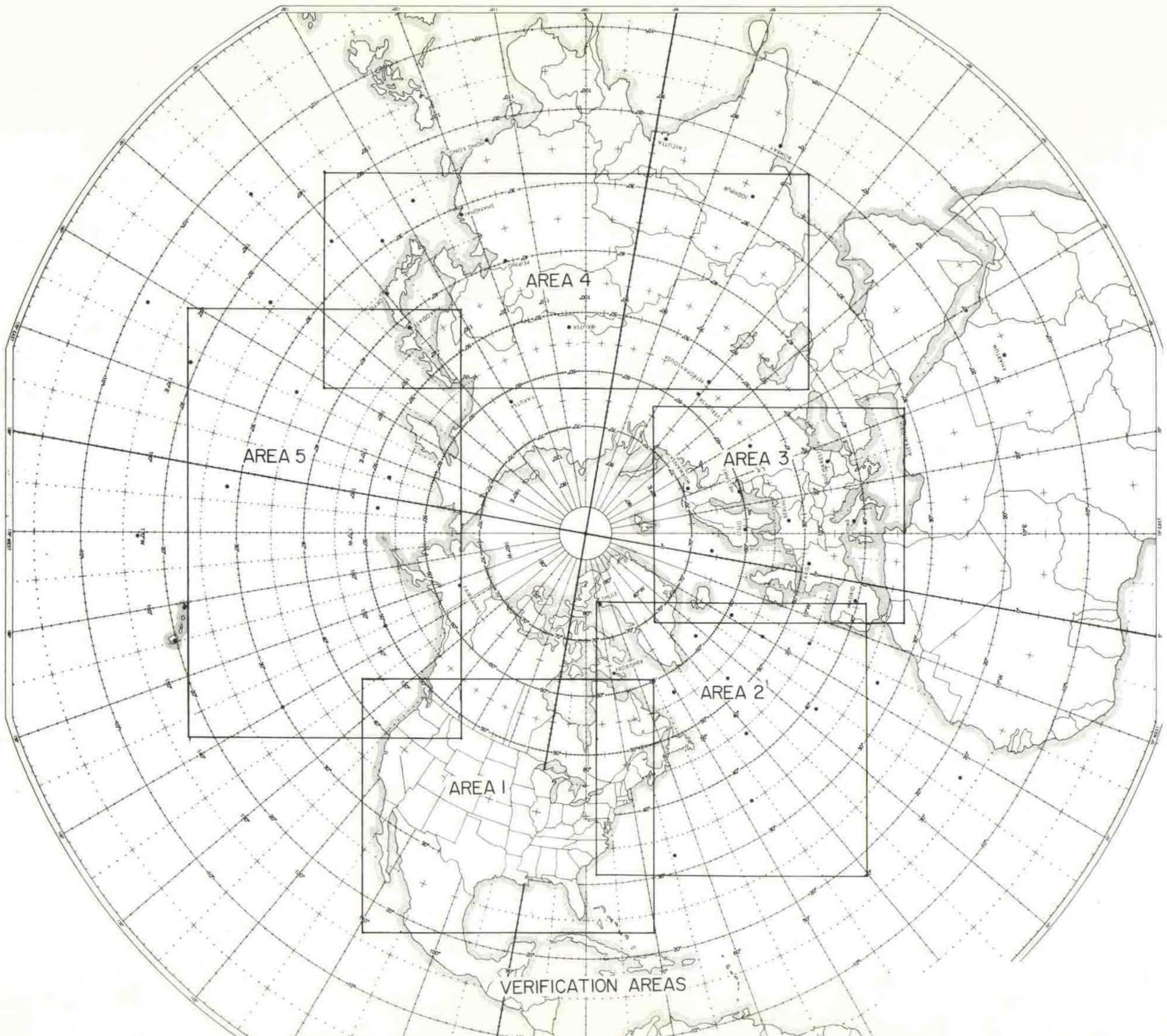
1. Peter P. Chase, Mathematician, joined the staff of the Meteorological Techniques Branch, March 4.

2. Peggy T. Wingert, Mathematician, resigned from the Services and Applications Branch, June 1.

IX. DISTRIBUTION OF PRODUCTS

As of June 22, NMC was originating about 810 separate teletypewriter bulletins each day for transmission over NWS, U.S. Navy, U.S. Air Force, and Air Transport Association teletypewriter service. The following table shows the additional NMC daily facsimile transmissions:

Recipient	Number of Transmissions
National Facsimile Network (NAFAX)	52
Aviation Meteorological Facsimile Service (AMFAX)	43
Navy Facsimile Network:	
70S537	29
GS18204	67
Air Force Facsimile Network:	
GF20309	50
GF10814	58
RAFAX	14
International Facsimile Network (Offenbach, Germany)	31
Russian Facsimile Network	21
Forecast Office Facsimile Network (FOFAX):	
Circuit #10206	59
Circuit #1020	59
Circuit #10208	59
Caribbean Radio	19
Tropical Analysis Network (TROPAN)	39
Suitland-Honolulu Circuit	54


AREA 4
AREA 5
AREA 3
AREA 2
AREA 1
VERIFICATION AREAS