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Numerical Weather Prediction Activities

National Meteorological Center
Second Half 1970

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UNITED STATES DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

NUMERICAL WEATHER PREDICTION ACTIVITIES

NATIONAL METEOROLOGICAL CENTER

SECOND HALF OF 1970

CONTENTS

I. REVISIONS IN OPERATIONAL PROGRAM

A. Revised Method of 1000 MB Height Computation in the PE Model

In the PE model, sea level pressure (or 1000 mb height) is not forecast directly since the terrain height of the model (the lowest level for which parameters are forecast) is above sea level over nearly all of North America. No attempt is made in the model to forecast fictitious underground "atmospheric" conditions. The problem then is to take our terrain level forecast quantities and compute corresponding sea level or 1000 mb quantities. This is the basic reduction to sea level problem.

What the PE model does is to take the forecast temperature in the lowest tropospheric layer and the boundary layer, and extrapolate the temperature down through the mountains to obtain a fictitious mean temperature for the underground layer. This method presents two problems: one to do with initialization, the other with the forecast. The initialization problem is that even if we had a perfect model representation of the atmosphere, the 1000 mb height patterns (in elevated regions) would differ from the analysis/observations simply because of different pressure reduction methods used in the field. And if we generated a perfect forecast, this problem would still be there and give an apparent error in the 1000 mb or sea level pressure forecast.

For some time, NMC has had available 1000 mb height and sea level pressure charts from a program of J. E. Newell (DAD). These are forecasts taken from the PE model, but using an alternative pressure reduction. The basic difference is that the temperature extrapolation is formed by going from the layer above the boundary layer, down with a constant temperature lapse rate to either sea level or 1000 mb. Thus, the boundary layer temperature is avoided. Further refinements on Newell's method were made by Dr. Shuman, based upon considerations relating to the Bigelow/National Weather Service methods of reducing station pressures to sea level. We refer to the new procedure as the 'Shuell Method'. The revised method was implemented on December 23,1970 and is expected to significantly improve the sea level pressure forecasts over elevated terrain. (See Item II.C.)

B. Other significant changes to the operational model are listed in Item II.A.

II. DEVELOPMENT DIVISION

A. Primitive Equation Prognostic (PEP) Model - Operational Changes

1. 12Z July 6 Mean linear variation of potential temperature with the function of pressure (Exner function) in sigma-layers is defined as geometric mean for output purposes. This was done to reduce bias in sigma to pressure interpolations at high levels.

2. 00Z July 31 Surface observation contributions to tropospheric mean humidity were altered. (See IV.A.1.c.)

3. 12Z Sept. 8 Computation of saturation precipitable water was modified to effect an increase forecast of precipitation. (See II.B.)

4. 12Z Dec. 23 Technique for reduction of forecast surface pressures to sea level was substantially improved. (See II.C.)

B. Quantitative Precipitation Modification to PE Model

At 12Z September 8, 1970, computation of saturation precipitable water was slightly modified to effect an increase forecast of precipitation. In the former version of the model, precipitable water (W) was forecast every time step (10 minutes) and compared with the saturation precipitable water (W_s) which is computed every other time step (20 minute intervals). Precipitation began at saturation - 100% relative humidity.

In the modified version of the model, precipitation will effectively begin at 90% relative humidity, i.e., saturation is constrained to occur whenever W exceeds 90% W_s in any of the three moist layers. This simulation has been accounted for in the same way as was done in the one-layer-moisture version prior to October 1969. However, in the present laminated version, 90% is used rather than 80% in winter and 70% in summer. It is expected that little difference will be noted in all forecast parameters except that the relative humidity values will be inflated by 10% and the quantitative precipitation forecast will be increased to remove the previously noted dry bias in the laminated version of the model. [Stackpole]

C. PEP Model Sea Level Pressure Reduction - The Shuell Method

In general, Laplace's equation as applied to the atmosphere states that the pressure at sea level p_o is an exponential function of the surface pressure p^*, the terrain elevation above sea level z^*, the acceleration of gravity g, the gas constant R, and the mythical mean temperature of the "air" underground T_m - thus:

$$p_o = p^* \exp(gz^*/RT_m).$$

The basic reduction to sea level problem is then centered in the specification of T_m, the temperature of the underground air column.

Prior to December 23, the PE model determined T_m essentially by extrapolating the forecast temperatures of the two lowest σ layers. This was poor for two reasons: (a) the temperature structure thus assumed and the resultant p_o values are quite dependent upon the boundary layer temperature and the forecast of the latter is one of the PEP model's weakest points, particularly at high elevations, and (b) this method does not correspond to what is actually done at the local National Weather Service (NWS) stations. The latter would cause an apparent error in the surface pressure forecast, even if all other parameters were forecast perfectly.

After a considerable study of just *how* the NWS *does* perform the pressure reduction, it seems that one can approximate:

$$T_m = \tfrac{1}{2}(T_o + T^*)$$

where T^* is the surface temperature °K, and

$$T_o = 290.66 - 0.005\ (T^* - 290.66)^2$$

For the PE model, T^* is obtained by extrapolating the temperature of the lowest troposphere layer (*not* the boundary layer) to the ground at a fixed lapse rate of 6.5°/km.

This method is used for warm periods when $T^* > 290.66$. For cold periods ($T_o < 290.66$), T_o is given directly by the extrapolation from the lower troposphere layer all the way to sea level at 6.5°km. For the intermediate case, $T_o = 290.66$. [Stackpole]

D. New Operational Model - HEMPEP

The preparation of what is proposed to be the next NMC operational model - the HEMispheric Primitive Equation Prognostic model (HEMPEP) continued in the dreary checkout stages. Some of the previously undecided items were firmed up: e.g., a 2.5° latitude-longitude grid was selected, the moisture in the form of specific humidity will be predicted in the lowest five layers of the model, and the radiation package, alluded to in the First Half Report (Item III.G.), proved to be efficient enough to incorporate if the radiation fluxes are recomputed but once per hour.

Some preliminary tests with real data from the Hough-Flattery-Johnson analysis (see Item II.F.) showed early computational instability - this was removed by increasing the longitudinal extent of the tendency averaging terms.

Subsequent instabilities became catastrophic at about 30 hours. A simple time smoother was applied to the past-present-future timestep as a means of circumventing the difficulty. The results thus far are inconclusive. Considerable attention is also being given to decreasing the running time of the programs since it is somewhat excessive at present. A full description of the physics and numerics of the model will appear in due course. [Stackpole]

E. Local Forecast Model (LFM)

The LFM parallels the NMC operational primitive equation forecasting model, insofar as its design and physics are concerned. In particular, the LFM now forecasts moisture parameters in the same manner as the operational model. A map of the terrain with appropriate finer resolution has been constructed for use by the LFM, covering North America with a 53 by 57 rectangular array of points centered along 105° west longitude and having half the mesh length of the NMC operational grid.

All analyses needed by the LFM are now done on the finer mesh grid. Height and temperature data are analyzed on the standard constant pressure surfaces using first guesses that are interpolated from the operational hemispheric run. Moisture is analyzed directly in the boundary and lower two tropospheric layers of the sigma-coordinate system. In an attempt to enhance the detail in these analyses, surface reports are used to augment radiosonde data by inferring relative humidities aloft from surface reports of relative humidity, layered cloudiness and present weather.

A completely satisfactory treatment of the lateral boundaries has not been achieved as yet in this model. Presently, space varying initial values for the boundaries are taken from the hemispheric operational run. These values are kept constant throughout the forecast and some of the calculated tendency for the various forecast parameters is suppressed at points near the boundaries. These actions permit the LFM to run with no serious deterioration of the forecast over the contiguous United States for time periods to 36 hours.

The LFM is being evaluated both subjectively and objectively by NMC operational forecasters. Beginning on October 26, 1970, the model has been operated once per week to make 36-hour forecasts. In four cases, the LFM has failed to reach its planned exit. Stratospheric exhaustion occurred at 26, 27 and twice at 31 hours. These failures can be attributed to boundary problems, which are being investigated. Results to data appear to show that the LFM is at least competitive with the operational model in all cases, and frequently shows more desirable detail in meteorological systems than is observed in the corresponding operational run. Pending the outcome of the present test series, accelerated and expanded testing of the LFM is being planned for next Spring. [Howcroft, Desmarais]

F. Spectral Analysis and Forecasting

A 15-level (1000-10 mb surfaces) hemispheric analysis system is being used to produce height, wind and temperature analyses for Stackpole's 8-layer hemispheric model (see Item II.D.) and Vanderman's 7-layer global model (using reflection at the equator in lieu of Souther Hemisphere analysis). (See Item II.H.) For Stackpole's model, a gridpoint surface temperature is provided by interpolation or extrapolation from the sounding at that gridpoint to the elevation of that gridpoint used in the forecast model. Some experimentation is under way in the calculation of a tropopause pressure at each grid point. At present, the calculated tropopause is constrained to be between 200 mb and 50 mb, and may be either at the level of maximum wind, or the level of minimum temperature or some mean of the two. The major problem is that stratospheric temperature analyses lack sufficient horizontal gradient.

Spectral analyses of the mean 1000-500 mb relative humidity closely resemble conventional analyses in areas of plentiful data, but generally provide values too great in data-sparse areas, especially in the tropical regions. Running time of the spectral analysis has been decreased from over one hour to 30 minutes by the use of CDC 6600 Extended Core Storage. At present, the program is being recoded to use data from permanent disk files rather than from tapes. A one-level global analysis has been prepared also to provide input for Vanderman's global barotropic forecast model.

Hough analyses were used to initiate a 500 mb spectral equation forecast for the Northern Hemisphere. Time-steps of 1.5 hours were carried out to 36 hours. The model was run operationally once daily (00Z) for several weeks during August and September. Initial analyses compared reasonably well with the grid-point analyses. The forecasts appeared to reproduce the major features of the verification chart with reasonable fidelity, although some waves appeared to progress more slowly in the spectral model than in the barotropic or PE models. [Johnson]

G. Mountain Flow

The study of flow over mountains was continued. Emphasis was placed upon two characteristics of the flow: (1) the transfer of energy by lee waves, and (2) the formation of rotors. Only a partially successful linear model was used for (1), while three different primitive equation models were used to investigate rotors. In all cases, the models were two-dimensional and Coriolis accelerations were neglected. The models and their uses are:

1. Multi-layered, hydrostatic, incompressible model

This model has been used by others to investigate hydraulic jumps which are believed to be the manifestation of rotors in such models. Two- and four-layer versions were used to investigate this hypothesis and certain difficulties of interpretation were encountered when the idea was applied to a model with progressively more layers.

2. Hydrostatic, compressible model with continuous density stratification

This model exhibits pressure jumps under certain circumstances which have a large dependence upon the horizontal scale of the mountain. The addition of vertical diffusion makes the model solution agree more closely with atmospheric observations.

3. Non-hydrostatic, compressible model with continuous density stratification

The difficulties with this model were resolved during this period. It appears abnormally hard for this model to form a pressure jump. Work in this area will continue. This model shows the non-steady characteristics of mountain flow and the adjustment towards a steady state for some cases. [Collins]

H. Three-Layer Global Primitive Equation Forecast Model

The global three-layer version of NMC's six-layer operational forecast model was run successfully for the first time in September 1970. (See Item III.S., First Half 1970 NWP Activities Report). This model has a surface boundary layer 100-mbs deep, two equal layers in the troposphere, with respect to pressure, and a tropopause coincident with the top of the upper layer at the 100-mb level. Mountains are included and data are carried on a 3.75 latitude-longitude grid. U and v components of the wind and potential temperature are carried at the middle of each layer; pressure p, heights Z, and sigma dot (vertical motion) are carried at the interfaces between layers, at the ground and 100 mbs. At the ground and the 100 mb level, sigma dot is set equal to zero. Pressure depth of the troposphere is also one of the forecast dependent variables. Initial data for the forecast model are calculated and interpolated from seven (1000, 850, 700, 500, 300, 200, and 100 mbs) pressure level analyses of u, v, and z. Potential temperature is calculated from the mean temperatures that are generated from height and pressure values.

Initial data for this model is provided by the Hough function analyses (see Item II.F.). To date, only one set of analyses for 1200Z February 18, 1970, for the Northern Hemisphere is available. These analyses and the Northern Hemisphere mountains have been reflected to the Southern Hemisphere. A zero north-south wind was necessarily imposed at the equator. By computing six hours of forward-backward (in time across the initial time) calculations using the Euler-backward differencing method, and allowing wind and height to mutually adjust, forecasts were calculated to 48 hours by the following techniques: (1) using Euler-backward, (2) centered in time, (3) centered in time with a time tendency smoother, and (4) centered in time with a time tendency smoother and surface friction applied to the boundary layer. Cases (1), (3), and (4) produced reasonable forecasts for 48 hours; Case (2) agreed well with the others at 24 hours but showed considerable noise in the forecast fields at 48 hours. The height gradients were weakened greatly, especially in the lower levels of the atmosphere, by 48 hours in Case (4). Case (1) required twice as much computer time as that for (2), (3), and (4). The time tendency smoother employed in Cases (3) and (4) was of the form:

$$u^*_\tau = \alpha\, u_\tau + \tfrac{1}{2}(1-\alpha)(u^*_{\tau-1} + u_{\tau+1})$$

with $\alpha = .50$. Tau values of the dependent forecast variables were replaced each time step with tau-star values.

Global Hough function analyses of wind and height for at least seven pressure levels should become available soon. At that time, systematic testing of the forecast model will begin. In addition to friction, heating effects due to solar radiation and warm water will be incorporated. Subsequently, moisture and its various effects will also be included. [Vanderman, Hirano]

I. Implicit Integration Methods

1. A paper entitled, "On an Efficient Scheme for the Numerical Integration of a Primitive Equation Barotropic Model" has been submitted to the *Journal of Applied Meteorology*.

2. Work is continuing on explicit and implicit versions of a two-layer model using Phillips' σ-coordinate. Although preliminary results are encouraging, there is an apparent growth of noise in both versions by 72 hours.

3. Work is continuing on a slab symmetric, multi-level implicit model using a modified version of Shuman's σ-coordinate. Problems are still being encountered in the design of an appropriate scheme for the relaxation of the Helmholtz equations under the periodic boundary conditions.

4. The free-gravitational modes have been calculated for one-, two-, and four-layer isothermal models using Phillips' and Shuman's σ-coordinates. An Office Note will be prepared to document these analyses.

5. An analysis of the linear computational stability of a two-layer primitive equation model utilizing a Phillips' σ-coordinate has been completed. A paper is being prepared on this analysis and will be submitted for critical review. [Gerrity, McPherson, Polger, Gordon]

J. Finite Difference Formulation

1. NOAA Tech. Memo WBTM NMC #49, "A Study of Non-Linear Computational Instability for a Two-Dimensional Model," was prepared by P. Polger.

2. A paper summarizing recent work in this and related projects was presented in November 1970 at the Israel International Conference on Meteorology by R. McPherson.

3. An analysis of the linear stability of a scheme for filtering the local time tendency was carried out. The results will be documented in an Office Note. [Gerrity, McPherson, Polger]

K. Air Pollution Potential (APP) Forecast Program

1. During the second half of 1970, a 4-panel air pollution stagnation package was begun on the Forecast Office Facsimile (FOFAX) network which depicts: (a) stagnation areas out to 36 hours in 12-hour increments from initial observed data, (b) composite stagnation areas for the period from 12Z through 00Z on the second day after, and (c) mixing height and transport wind speed information.

2. Plans are now being finalized to transmit the air pollution stagnation package two times/day via FOFAX. It will utilize forecast information from the 00Z and 12Z PE runs. More details about these packages will be included in January 1971 Technical Procedures Bulletin.

3. With the aim of improving the stagnation model, a probability of precipitation forecast is being tested for inclusion in the model. Input parameters are derived from the PE model, as interpolated bilinearly from grid points to selected stations. We are utilizing relative humidity, lifted index, 500 mb absolute vorticity and their respective 12-hour trends, and the 700 mb vertical velocity. An empirical value has been assigned to these parameters, with special tests for specific areas of the United States.

4. A new display program to plot and analyze soundings automatically on the CDC 6600 is also operational. The soundings consist of temperatures, dew points, and winds plotted on a Stüve diagram at 86.7% of the original size. The lowest 10,000 feet of the soundings are scanned for inversions, isothermal layers and regions where the lapse rate becomes more stable than moist adiabates. Average winds are calculated within the stable layers along with the intensity of the stability. It is our aim to eventually utilize this information in our operational APP program. This program presently runs at 00Z but will be implemented at 12Z very shortly. It is capable of plotting every sounding in the United States in 22 seconds, central processor time, and can also plot selective soundings from history tapes.

5. A complete climatology and verification program for mixing heights and stagnation areas is also operational. [Gross]

L. Initialization Experimentation with the Operational PE Model

A new method of initialization for the six-layer primitive equation model has been successfully tested on two cases. In the forecasts made to 48 hours, the synoptic scale features were similar and in some instances superior to the corresponding operational forecasts. The new method was designed to circumvent the problems associated with the use of the balance equation. It utilizes the rotational part of the objectively analyzed wind fields and the previous 12-hour forecast divergent wind component, valid at the initial time. No additional damping or dispersing mechanisms were incorporated into the forecast model.

Statistical verification for seventy stations was made for one of the cases. While the temperature forecast differed little, the wind forecast using the new method was significantly superior to the operational result, particularly in the vicinity of the tropopause. Furthermore, the new technique requires substantially fewer calculations than the balance equation technique.

A satisfactory technique of obtaining a gradient wind for replacing the geostrophic wind, presently used as a first guess for the objective wind analysis, has not yet been found.

The results of a simpler two-layer PE model are being used for guidance in perfecting the new method of initialization.
[Campana, Brown]

M. Upper Air Branch (UAB)

The Upper Air Branch is engaged in a broad program of basic and applied research, whose fundamental goals consist in defining the structure and circulation of the upper atmosphere and the coupling of this region with the troposphere. It is anticipated that the results of these investigations will be utilized in extended forecast models and possible forecast techniques with application to various aerospace vehicle operations. The principal activities within this effort are:

1. Analysis of Stratospheric Data

a. Determination of Temperatures and Heights from Radiances

SIRS-B was implemented as the operational infrared sounding system on June 29, 1970. Temperature and height profiles are being retrieved from radiance measurements by means of a combined iterative-direct model development by Smith and Fleming of NESS and Woolf of NMC. Despite the loss of the 692 and 899 cm^{-1} channels on the SIRS instrument, derived soundings appear to be satisfactory in quality.
[Woolf]

b. Application of SIRS Radiance Data

Radiances measured in the 669 and 680 cm^{-1} channels of SIRS are mapped on both polar stereographic and Mercator projections on a daily operational basis to aid in the detection of stratospheric warmings. Longitude-time sections of these radiances at selected latitudes are being constructed on a monthly basis to provide additional information on stratospheric thermal structure. [Woolf]

SIRS radiances have been used to depict stratospheric temperature changes in both Northern and Southern Hemispheres during autumn transition periods. A paper is being prepared with Fritz of NESS. [McInturff]

c. Change in Data-Merge

Work is in progress (with the aid of personnel in DAD) to perform two sets of IQSY analyses daily, the map for 00Z making use of current 00Z data and the preceding 12Z data, that for 12Z making use of current 12Z data and the preceding 00Z data. (Under the old program, only one analysis was done daily, with nominal map time of 12Z, making use of 00Z data that were 12 hours earlier than map time as well as 00Z data that were 12 hours later than map time.) [Finger]

d. Evaluation of SIRS Data

Several evaluation efforts are in progress, with a view to determine the comparability of radiosonde data with SIRS retrievals. The stratospheric energy budget as determined from SIRS data will be checked against that determined from radiosonde data.
[Finger, Woolf, Johnson, McInturff, Miller, Gelman]

e. Conversion of Stratospheric Synoptic Analysis Program to CDC 6600 Computer

The multi-level analysis program for mandatory levels above 100 mb has been written in FORTRAN Extended (level 3.0) for the CDC 6600 Computer. Checking of regression equations continues and utilization of disk data files remains to be programmed. [Johnson]

2. Research on Stratospheric Circulation

a. Energetics

Preparation of summaries of various terms in the energy momentum budgets has continued. Seasonal and interannual varieties of the "pressure-work term" ($\omega'\phi'$), kinetic energy and the horizontal transports of heat and momentum have been evaluated for the period of January 1963-December 1968. The results indicate a general year-to-year modulation of the atmospheric energy cycle that may prove to be important in seasonal forecasts. [Miller, Johnson]

b. Stratospheric Warming

An extensive study of the mid-winter warming of December 1969, which is concerned with all aspects of the circulation changes of the stratosphere and troposphere, is in progress. [Miller, Brown, Campana, Johnson]

c. Accuracy of High-Level Temperatures

Data obtained at Wallops Island using radiosondes, rocketsondes and satellites are being analyzed. [Miller, Finger]

d. Planning for Meteorological Support of SST Operations

Forecasting requirements for the stratosphere are being investigated. [Finger, McInturff]

e. SIRS Radiance Data Interpretation

A nomogram has been developed for specifying amplitude and altitude of warming and has been tested for the stratospheric warming of December 1969, with highly satisfactory results. A comprehensive report, including a detailed synoptic history of the radiance changes during December 1969-January 1970, has been completed. Use of the warming profiles as first-guess profiles for improving temperature retrievals during warmings is being investigated by NESS. [Quiroz]

3. Quality Control

a. Quality Control Working Group (QCWG)

A QCWG has been established with NMC and OMO. The group will act as an inter- and intra-agency intermediary for investigating and remedying operational data problems [Thomas]

b. Acquisition of Marine Upper Air Data

Daily monitoring of the quality and quantity of marine upper air data being received at NMC is being accomplished. Status reports are being sent to the Atlantic and Pacific Weather Project Managers and other interested offices. Suggestions for improving the program are being routinely provided. [Thomas]

c. Notification of Operational Data Deficiencies

Since Sept. 1, 1970, notification of deficiencies in rawinsonde data from the Western Hemisphere have been sent to Weather Service Offices having jurisdiction over the regions where data are generally deficient. Feedback from the field is being evaluated to determine the cause of the problem. [Thomas]

d. An automated program has been developed which computes monthly summaries of the frequency which RAOB and pibal data are being processed within the 3+25 operational deadlines. Complementary programs are also being developed to provide similar information for the 1+30, and 2+50 and 10+00 operational runs. Performance standards are also being studied and samples of the output have been distributed to field units for their review. Statistical analyses that are derived from these programs will be used to expand the quality control of operational data. [Thomas]

III. EXTENDED FORECAST DIVISION

A. Thermodynamic Model for Long-Range Numerical Weather and Ocean Temperature Predictions

The model continues to be run twice a month on a real-time basis for possible use in preparation of the official forecast, and a discussion of its performance is included in the postmortem of the 30-day outlook. Reports of previous work have been published in *Tellus*, Vol. 22, No. 4, 1970 and in *Monthly Weather Review*, Vol. 98, No. 10, Oct. 1970.

The highlights of the research activities for the period of this report are given below:

1. A series solution for the conservation of thermal energy equation applied to the upper layer of the oceans was obtained, and used to determine truncation errors when approximating the time derivative of the temperature anomaly by a finite-difference Euler approximation and using a forward time step. The permissible time step depends on the scale or size of the initial anomalies, surface wind speed, ocean current speed and horizontal mixing.

For the case when the terms due to advection of heat by mean ocean currents and horizontal mixing are neglected, the solution is independent of the size of the anomalies; and a time step of 30 days appears to be justified. However, when these horizontal transport terms are included, a shorter time step must be used which depends on the above-mentioned parameters. The results provide a theoretical basis for the choice of the time steps. [Adem]

2. Considerable efforts were put into numerical experiments in which forward integrations are used, instead of an implicit method, both for the atmosphere and the ocean. The results look promising in the ocean, where much longer time steps can be used, according to the previously mentioned theoretical study. [Adem, Bostelman]

3. Evaluation of the normal heating components of the atmosphere-ocean-continent system for January and July, and for the Northern Hemisphere, were completed. [Adem, Bostelman]

4. Numerical experiments were undertaken with the most complete model, for the Northern Hemisphere, for studying possible climatic and seasonal changes in temperature and in the heat sources and sinks in the atmosphere-ocean-continent system due to fluctuations of the following parameters: the solar constant, surface albedo, cloudiness, absorption of short wave radiation by the atmosphere and clouds, atmospheric window, storage of heat in the ocean, austausch coefficient,

boundary conditions, initial conditions, evaporation from the surface layer, heat given off to the atmosphere from the surface and the condensation of water vapor in the clouds. The numerical experiments for January and July are almost complete. [Adem, Bostelman]

5. A systematic comparison was started of the observed ocean temperature from Monterey data with that from EFD - conventional data, and will be continued on a permanent basis. [Adem, Bostelman]

B. Evaluation and Adaptation of Extended-Range Numerical Predictions

1. Individual regression equations for specifying daily precipitation probability from prognostic 700-mb heights and their 24-hr. changes are being selected and coded for 108 stations for each half-monthly period. Twenty-one of the twenty-four sets have been completed. [Gilman, Gelhard]

2. Percentile limits (5% and 95%) of daily anomalies of maximum and minimum temperatures are being determined for each month at 130 stations. Eight months have been completed, thus far. [Gilman, Durdall]

3. Verification of 12 two-week forecasts of daily precipitation over the United States generated by the GFDL model has been completed. Results include control comparisons with persistence and climatology. A journal note will be written jointly with Dr. Miyakoda of GFDL. [Gilman, Taubensee]

4. A CDC 6600 code is being written to plot and analyze fields of temperature and precipitation data, observed or objectively forecast, over the United States with the VARIAN device. [Gilman, Durdall]

C. Vertically-Integrated Primitive Equation Model

A vertically-integrated PE model is being designed for application to the extended range. The integration, with respect to the vertical, introduces eddy and boundary terms. The necessary parameterization of the vertical eddies is investigated using normal and daily values of the meteorological variables. The use of normals allows the determination of one parameter, while a time series of daily data permits more degrees of freedom. The best parameterization must be determined experimentally.

The coding of the model is currently underway. The numerical scheme employs a semi-implicit method as well as provisions for treating the non-linear terms in a manner analogous to the time-averaged advection recently developed at NMC. [Sela]

D. Objective Prediction of Sea-Surface Temperature

A numerical method was developed for predicting mean-sea surface temperatures a month in advance, using screening regression on oceanic and atmospheric data for the North Pacific. Some background work is discussed in *Journal of Geophysical Research*, Oct. 20, 1970. Material is being assembled for a report on the next phase of the study, and plans are underway for further work.

E. Programming Support for Operations and Research

1. Extended Forecast System. Computations are being made of the following items:

a. Fifteen-day mean errors of 500-mb and sea-level progs for 72, 96 and 120 hours. [Gelhard, Andrews]

b. Series of daily 12Z 700-mb and sea-level means, 1947 to date, for use as a climatological norm in the daily forecast program. [Gelhard]

c. Conversion of portions of extended forecast system to disk mode in order to eliminate tape failures. [Hiland]

d. Revision of extended forecast system to provide guidance for a D+3 mean forecast instead of D+5. [Hiland]

e. Initial outlines have been completed for conversion of the entire daily forecast system to the CDC 6600. [Hiland, Gelhard]

f. Revision of daily max-min temperature verification code, and enlarging to 108 stations. [Hiland]

g. Change tape read-write subroutine in WMO-66 (5-day mean international transmission) to conform to CDC 6600 system tape handling changes. [Jones]

h. Percent frequency of precipitation for each calendar day for 108 stations for the 19-years 1947-1966. [Jones]

2. Monthly and Seasonal Forecast Support. The following programs are being written, completed or tested:

a. Updating of local archives (700-mb height and temperature, sea-level pressure) for computation of regression equations to forecast monthly mean height and pressure. [Gelhard]

b. Revision of the monthly forecast diagnostic program for correlating monthly mean to daily components, so as to use the disk bank instead of cards. [Gelhard]

c. Utilization of disk data bank instead of cards as the data source for 30-day forecast programs. Status: Program complete, being tested. [Hiland]

d. Conversion of 30-day program computations to CDC 6600 for including VARIAN graphic output. Status: Program complete, being tested. [Jones]

e. Program to consolidate and utilize monthly air-sea data from the National Marine Fisheries Service. Status: Operational. [Gelhard]

IV. DATA AUTOMATION DIVISION

A. Statistical Techniques and Analysis Branch

1. Objective Analysis

a. Starting September 17, 1970, analysis of the 70, 50, 30, and 10 mb levels was increased from once to twice per day. These analyses are now based on current data available for the FINAL (10+00) run and 12-hour-old data from the previous cycle. They are performed as part of the 10+00 runs.

b. Starting December 2, 1970, the decoding of surface data was switched from the IBM 7094 computer to the IBM 360 computer. The reports still appear in B3 format for users. The new dictionary contains many more entries and the amount of decoded reports has been increased from about 1,900 to 3,500 for the RAOB (2+50) cut-off time.

For the objective analyses of sea level pressure and surface temperature on the 1977-point octagonal grid, the surface reports are "thinned" by the following procedure. The hemisphere is partitioned into areas of approximately 40,000 km^2 (200 km each side) and only one report is accepted per area. The reports selected to be used in the analysis are flagged; however, all reports are retained in the files. Bogus reports are added after the thinning process and are not flagged, although they are used in analysis. The priority for accepting the report for an area is as follows: (1) when all possibilities have an elevation equal to or greater than 610 meters, then the station with the lowest elevation is flagged; (2) if among the possibilities, two or more have an elevation less than 610 meters, then the one nearest the center of the square is flagged; (3) if only one falls in a square, it is flagged regardless of its elevation or location. The total number of reports utilized by the new procedures is essentially the same as before. The uniformity of the distribution of reports for analysis is much improved and a series of test analyses indicate that the quality was not adversely affected.

c. A procedure which utilizes radiosonde and surface reports of humidity for objective analysis of the mean mixing ratio in the 100-mb layer next to the earth's surface (ref. R. L. Inman, Technical Circular No. 11, NSSL, March 1970) was extended to determine if surface dewpoints could be used to define the mean mixing ratio in the tropospheric sigma layers of the PE model. Results from several test cases using North American radiosonde reports showed that the variability of the ratio of (1) the mean mixing ratio in a layer to (2) the surface mixing ratio increases with height in the atmosphere. The radiosonde data used in the test were not stratified by air-mass type or in any other way. Perhaps the variability could be reduced if this were done. In any case, since the PE model is currently designed to use mean relative humidities in the sigma layers, a similar test was made using the ratio of (1) the mean relative humidity in a sigma layer to (2) the surface relative humidity. The results of this test showed an even greater variability of the ratios, compared to those for the mixing ratio, especially in the upper layers. Except for the boundary layer and possibly the lowest tropospheric layer, the variability when dealing with mixing ratio or relative humidity appears to be so large that it may be difficult to use surface reports to yield accurate estimates of moisture.

d. The upper-air analysis program has been modified for the CDC 6600 computer. The major differences between this program and the operational analysis code are (1) the 300-mb level replaces the 500-mb level as the first level analyzed; and (2) a modified weighting function has been incorporated. The first of these differences accomplishes better utilization of available data, as there are considerably more aircraft reports and few more SIRS reports at 300 mb than at 500 mb. The amount of conventional data is about the same at both levels in most parts of the grid. The second difference eliminates the latitudinal bias from the weighting function. The new program was also modified to perform analyses on a 53 by 53 coarse mesh octagonal grid (for experimental purposes) and for the 53 by 57 fine-mesh rectangular grid to provide analyses for the local forecast model (LFM). (See Item II.E.)

e. An experiment was conducted to obtain a 300 mb height field for the tropical regions by using analyzed u and v wind components in the solution of the balance equation for the tropical grid. The solution required that the mean height at 30°N be the same as the mean height of the 12-hour 300 mb height forecast at the same latitude. No other form of height information was used. The resulting height field was compared with a subjectively drawn height field (using observed heights) and in some regions there is good agreement, but in others the agreement was poor. Also, there appears to be too much cross-equatorial flow.

2. PE Forecast Model Output

a. The collection and verification of wind and temperature forecasts at 70 Northern Hemisphere radiosonde stations have been extended to include the output at 60, 72 and 84 hours from the 1200 GMT forecasts. A persistence forecast, made directly from the observations, is verified at 12-hour intervals from 12 to 84 hours in direct competition with the operational forecasts. The persistence forecast serves as a useful control against which to judge the performance of the numerical forecasts.

b. Investigation of alternative methods of computing sea-level pressure from the model resulted in adopting an improved method which became operational on December 23, 1970. For details about the procedures, see Item II.C. of this activities report.

c. Effort has also been directed toward determining a method of obtaining surface temperature forecasts from the model. The principal forecast quantity used for this purpose is the temperature in the first layer above the boundary layer. This temperature is then reduced to the station elevation in a manner which depends on whether the forecast time is 0000 GMT or 1200 GMT. No systematic verification of these temperature forecasts has been performed as yet.

3. Satellite Infrared Radiation Spectrometer (SIRS) Data

a. The advective method of correcting asynoptic SIRS reports (see Semi-Annual Report for Second Half 1969, Item II.A.1.b.) was implemented for the OPNL (3+25) analyses beginning November 3, 1970. In conjunction with this change, SIRS reports are accepted up to 6 hours off-time rather than the previous amount of only 3 hours.

b. Data for 11 cases have been collected, to be used at a later time, for investigating a method of updating asynoptic height reports with forecast height changes. These same cases are being used also to investigate the method mentioned in (a) above, in order to determine if 12-hour updates should be used in the objective analyses if no on-time reports are available nearby. To simulate this condition, radiosonde reports for a data-rich region over the United States are relocated by using a 500 mb space mean flow obtained from initial and 12-hour forecast stream function fields. At each relocation, the height and temperature are verified for nine isobaric levels from 850 to 100 mb by interpolating with the appropriate operational analyses to obtain the "truth." At these same relocations, the first-guess heights and temperatures, obtained by running the operational analysis code without any data, are verified. In addition to this and at the same relocation, the heights and temperatures from the analysis preceding verification time by 12 hours are also verified. These following procedures are possible ways of obtaining "data" for an analysis if no current reports are available: (1) update 12-hour old reports by advective method; (2) use the current operational method; or (3) use persistence from the previous analysis. A verification of these three procedures is expected to indicate if there is a better method than is currently employed. A somewhat different technique for method (1), developed by Dr. Hayden of NESS, is also being verified for these cases. Results should be available early in the next reporting period.

4. Pre-GARP Basic Data Sets

No back-log of processing developed during the June 1970 collection and all maps, listings, and magnetic tapes were delivered in a timely fashion. Summaries of machine-processed data for surface and upper-air reports were prepared for the June collection and a copy of each summary was forwarded to the project coordinator in Geneva. These summaries contain the following information:

a. Percentage receipt by station of upper-air reports for those stations received at least once during June (N.H. and S.H.).

b. Percentage receipt, by station, of all surface reports in the dictionary (N.H. and S.H.).

c. Percentage receipt for each 300 km square for surface reports (N.H. only).

d. List of missing surface reports for each 300 km square. If no reports in a square were received, a pre-selected station in the square was listed as missing.

e. List of missing upper-air reports for each station in dictionary (except OSV reports).

5. Machine-processed Observations

a. In addition to the switch-over to using decoded surface reports from the IBM 360 computer (see 1.b.), a program was written to provide all aircraft reports from the 360 decoder. These will continue to appear in B3 format in the data files. This change will be implemented later this year.

b. A program was also written to summarize the receipt of second transmissions for RAOB stations available for the FINAL (10+00) run when the upper levels (above 100 mb) are analyzed.

c. A data receipt survey was made to determine the average number of reports available for the OPNL (3+25) run. This survey consisted of 226 cases during the period from August through November 1970.

The numbers which follow show the average receipts of non-redundant reports:

Land stations (RAOB and PIBAL) - - -	665
Aircraft (± 6 hours) - - - - - - - - -	510
Ships - - - - - - - - - - - - - - - - - --	19
Reconnaissance aircraft - - - - - - -	16
ATS (satellite movie loop winds) - -	65
SIRS (satellite soundings) - - - - --	21*

d. A program to log the receipt of surface reports for each month is being written for the IBM 360 computer system.

e. By utilizing the programming effort directed towards the pre-GARP data sets, the following information is routinely prepared for use in quality control:

(1) For each run, RADAT (1+30), RAOB (2+50), OPNL (3+25), and FINAL (10+00), a complete list of stations in the upper-air dictionary is prepared showing receipt or non-receipt of height, temperature, and wind for each of the 15 mandatory levels from 1000 mb to 10 mb.

(2) The percentage receipt for the month for each upper-air station (for those received at least once) based on the OPNL (3+25) runs.

(3) A list for each upper-air station in the dictionary showing the date and time for which reports were not received in time to be used in the OPNL (3+25) run.

6. Support Programs

a. To obtain wind flow lines for aviation facsimile charts, a program was written which interpolates and merges the tropical and octagonal grid wind fields in the same manner as is done for the flight planning wind messages. After these wind fields are merged, stream function fields are computed for a 3-degree longitude Mercator grid extending around the globe from 48°S to 61°N. The tropopause and temperature fields are also merged in order to obtain values for this same grid.

b. Several changes to the operational tropical analysis program were implemented in order to improve the procedures to follow when the National Hurricane Center wishes to run the Sanders' objective

*This number has since been increased due to the change indicated in Sect.3.a.

analysis and the NMC layer mean wind hurricane analysis. Also, a modification was made to the Sanders' barotropic hurricane forecast model which improves the method of tracking the hurricane position in the flow field.

c. A program was written which calculates the inflow/outflow of mass along the boundaries of the local forecast model (LFM) grid, and modifies the u and v wind components in each sigma layer such that the net mass change in the grid is zero. Tests of the usefulness of this procedure are in progress. (See Item II.E.)

B. Programming Branch

1. Program Conversion

a. Programs which are operational on the CDC 6600 are being converted to use data in the formats described in Office Notes 28 and 29. Output from these programs which must be processed on the IBM 7094 will use a subroutine, W3FI03, to convert field data to the old B3 format.

b. Considerable programming effort went into changing some of NMC's 6600 programs to respond to a change in a FORTRAN compiler. Computer Division made the change on December 30, 1970. NMC experienced one difficulty during its operations when the change was made. FOUS 1 and FOUS 2 were transmitted about 2 hours late on the 12Z run for December 30.

2. Computer Graphics System

a. The automatic tropical forecast charts which were initiated on the Miami FAX circuit during the first half of 1970 continued. In September, transmission was begun of Pacific sections of the Mercator chart to San Francisco and Honolulu on an experimental basis for evaluation.

b. Additional map backgrounds have been developed. The contouring program has been generalized to handle various map scales, and a wind plotting procedure has been programmed.

c. Programming assistance was provided TDL for preparation of a max-min temperature forecast FAX chart.

3. Map Correlation Types

The programming required to compute Map Correlation types for the Western Regions was completed. The procedure is described in Technical Procedures Bulletin No. 51: 500-MB Map Type Correlations. Twice daily transmission of these data on Service C began in August 1970.

4. Clear Air Turbulence

Work continued on the NOAA-FAA sponsored Clear Air Turbulence (CAT) project. (See Semi-Annual Report Second Half 1969, Item II.B.3.b.)

5. Programming assistance to the Development Division continued. Work included:

a. Programming for McPherson's two-level sigma surface model using a staggered grid. (See Item II.I.5)

b. Programming changes in Økland's two-level model.

C. <u>Information Processing Branch</u>

1. Operational changes on the IBM 360 System #1 communication computer:

a. A major effort by the entire Branch ended when a new CCAP assembly became operational on August 21, 1970. Included in this assembly are the following:

(1) Reallocation of core storage assignments to take full advantage of the IBM 360-40's increased core capability.

(2) Enlargement of our lines pool to accommodate 88 lines, the maximum anticipated line load for the next 2 years.

(3) Restoration of the batch core size from 14K to 16K.

(4) Space in core set aside for the expected bi-synchronous interfaces with Tokyo, Bracknell and Kansas City.

(5) Important changes in the I/O software to permit us to use full word address constants to handle core addresses beyond 65K.

(6) Enlargement of the checkpoint area by adding extra line transmit buffers to cut down on disk accesses on the output disk.

b. Checkout on the new Tokyo-Washington 2400 BPS bi-synchronous communication link commenced in August, 1970. After extensive checkout, this link became operational on November 24, 1970.

c. The following events took place in the Aviation Digital Forecasts:

(1) In September 1970, TWA joined the list of ATA users.

(2) By mid-October 1970, all 11 ATA users were utilizing the automatic retrieval feature negating the necessity for long distance calls and manual operator intervention.

(3) Early in December 1970, the ATA run was divided into three parts instead of five for transmission.

d. Gander began receiving their data in packed decimal format on July 9, 1970, reducing their telephone aviation digital forecast transmission from four to two minutes.

e. SIRS data (TUXX) began flowing to Carswell at the end of June 1970.

f. The departure of Det. 44, 7th Weather Wing (AWS) on August 1, 1970, allowed us to free one 1050 wpm line and two 100 wpm AUTODIN lines. Elimination of all TOUT dumps of incoming data also became effective.

g. The DSCR code was operational on October 1, 1970. This code enables us to post statistics for any output line on our Line 1 teleprinter every 15 minutes. These statistics include the bulletin name, time of receipt into our system, the bulletin output number, and the time it left our system on a particular line. It is currently being used for the San Francisco and Offenbach output lines.

h. The FD1 and FD2 terminal forecasts from Canada were re-encoded into the FDCN 1-8 bulletins and transmitted four times daily into Service A. This was effective November 3, 1970.

j. The program to print upper-air data for the Automated Analysis Branch (AAB) on System #1 local printer became operational on November 5, 1970. At the same time, a general overhaul of operator procedures that control local and remote printers and the Sanders (CRT) box was implemented.

k. The program to update and change overlays without the necessity of shutting down the communications computer for this purpose, became operational November 9, 1970.

l. Improved software procedures to quickly determine when a line has gone down or when a machine check or other mishap has dropped the multiplexor from operation became operational December 10, 1970. At the same time, improved software was incorporated to check the validity of a checkpoint read at restart time.

m. Changes were made in the retrieval procedure for output bulletins (RETX) to avoid internal software conflicts.

n. A considerable improvement resulted in our on-line debugging capability via the code PEEK. This enabled us to easily and effectively print out the contents of the input and output queues.

o. Numerous changes were made in our directory and accompanying batch codes, to accommodate changing line responsibilities (Tokyo, etc.).

2. Operational changes on IBM 360 System (#2):

a. Conversion of the directory generation from card base to tape to allow more efficient handling.

b. Rewrite of the Caribbean transmission code.

c. Program to process on tape decoded aircraft reports, in a special format for subsequent sorting and listing by other programs. (10 times daily).

d. Program to format a dictionary of desired surface weather reporting stations to disk from a tape generated on the CDC 6600.

e. Programs to process aircraft reports and store them, in a standard format, on disk for use by AAB and to generate new transmission bulletins. At the same time, all aircraft reports with uncoded remarks are stored on disk for use by the Aviation Weather Forecast Branch. Lists of all aircraft reports are also prepared for both Branches.

f. New surface decoder program became operational October 1, 1970. This program processes and stores surface reports from a selected set of surface reporting stations. It includes the WMO recommended set for global analysis, augmented by domestic requirements. This data is then used to encode surface report bulletins for transmissions, for gathering max-min data for charts, for archiving data for the National Climatic Center at Asheville, and for data input for the IBM 7094 and CDC 6600 forecast programs.

3. Activities in Graphics

a. Completed program to read new Alden-scanner-digitizer and output scanned maps in a form suitable for display via the Varian display programs.

b. Changed Varian display programs to allow for use of packed input tapes using current DAD compression techniques.

c. Amended facsimile map pack and transmit programs so that a variable number and size subset may be extracted from original fax maps. These can then be transmitted in original or double scale without packing each subset on disk separately. The transmission program can extract three unique subsets from one map packed on disk and send them to three destinations simultaneously.

4. Activities in Progress

a. Nearing completion of an IBM 360 upper-air data processor.

b. Nearing completion of a new CRT control program designed to handle three CRT's.

c. Program to encode upper-air transmission bulletins (US, UX, UK) from the data decoded by the 360 upper-air processor is in checkout stage.

d. Program to process aircraft reports received from ARINC being developed.

e. Research to develop a new packer to increase compression ratio and decrease transmission time and storage space of computer generated facsimile maps.

f. Developing a surface synoptic report plot and display program.

D. Operations Branch

1. Incorporated a fast indexing scheme, accessing input from permanent files for a 3-level Balance Equation on CDC 6600 computer.

2. Preserved all card decks and recent versions of operating systems on magnetic tape for emergencies.

3. Systems Activities on the System 360 Computers:

a. Disk Operating System (DOS) release 22/23 became operational. This new release contains normal IBM maintenance and improvements. Foreground One (F1) has been allocated 28k bytes, and Foreground Two (F2) has been allocated 20k of storage. F1 is used by POWER II (Spooling) and F2 is used by Sanders CRT equipment.

b. POWER II, Version 2 (Spooling) was implemented under DOS using F1 area. POWER II (Priority Output Writers, Execution Processors and Input Readers) system is an automatic spooling processor and priority scheduler for normal batch processing under DOS. Under this system, a disk pack is used for intermediate storage. The input card images for the background are written in input queues on disk, and the output images are written in output queues on disk for printing and punching, when the job that created the images is completed. This system allows the operator to queue up job input according to priorities and also provides the capability to put a job in hold status for later running. The operator has a number of other available console commands for communication with the system. Some advantages of the POWER System are:

(1) Execution time of any job is decreased.

(2) Increases system throughput.

(3) If the printer becomes unavailable, job stream execution can continue with data collected in the print queue. When the printer becomes available, the operator can start the printing for all jobs in the print queue with no loss of output or CPU time.

(4) Increases device utilization.

(5) Maximizes the amount of channel overlap.

(6) Command chaining to reduce I/O interruptions.

c. Gave assistance to NOS to allow a special DOS to be used at NMC for production and check out work.

d. Several IBM 1401 programs have been rewritten for the IBM 360/40:

(1) Pack Print and Punch (Print Single and Double Space and Punch Binary).

(2) SOS and IBSYS Card to tape.

(3) Copy B3 data tapes.

(4) List B3 data tapes.

(5) Load row binary cards.

e. A number of program changes were made for the Universal Character Set Print Chain (UCS) on the System IBM 360/40.

f. With the changing of the IBM 2540 Card Reader/Punch and the 1403 Printer from the multiplexor to channel two, a number of program changes had to be made.

E. <u>Electronic Equipment Branch</u>

1. The Digital Facsimile Interface (DFI) #2 was delivered to NMC in October 1970. EEB modified and installed several circuits within the unit to improve it operationally, and make it compatible with DFI #1. Three new circuits were incorporated in the DFI #1 and DFI #2, permitting a 20 to 1 ratio instead of a 100% modulation on the facsimile output. Thus correcting a perennial problem of signal echo at the receiving end of the transmission. In order to provide system back-up for computer facsimile transmission, a switch was designed, built and installed by EEB. This switch permits the transmitting of facsimile products from System 360 #2 or System 360 #3.

2. Arriving with the DFI #2 was a Scanner-Digitizer, which scans hard-copy weather maps, or geographical grids and converts the analog signal to digital data. The digitizer, being a prototype, required considerable reworking by the EEB staff in order to meet our operational requirements.

3. We also acquired a surplus EAI Data Plotter system. After modifying the logic unit and the plotting board of the system, it was placed into service, replacing one of our four operational systems.

4. The Varian Company installed a new type head in our Varian digital recorder, thus improving the contrast of the product. We are still experimenting with varieties of paper to further enhance the product.

5. During the check-out stage of the Tokyo circuit, there was a need for a device to interface the low-speed back channel from the modem to the IBM 2703 unit. EEB designed a power supply and relay arrangement to interface the two devices.

6. Six facsimile scanner transmitters were modified by Alden at their factory at the request of Communications Division. This change was to allow the operator to transmit various frequencies and signals on the facsimile circuits. When the first two scanners were received, EEB checked them out and found them completely unsatisfactory for what they were intended. EEB redesigned and modified the scanner transmitters and forwarded the changes to the Alden Company, so that they could be incorporated in the remaining units. The remaining scanners are being delivered in satisfactory condition.

7. A proposed project for the EEB is to interface the hi-speed and low-speed back channels of the communication circuits into the Interdata-Varian terminal for monitoring.

F. Uninterruptible Power System

The Uninterruptible Power System (UPS) installation contract got underway in September 1970. A 200 KW diesel generator has been procured. It can provide auxiliary power through the UPS, and thence will be used to back up the primary facsimile operations, as well as to support the air conditioning required for the IBM 360 computer room. In addition, technical power from the UPS will be provided to protect the CDC 6600 disk units which are vulnerable to power fluctuations. The loss of these disk units would have an adverse impact on NMC's operational workloads.

The brown-out scare in September necessitated the emergency activation of the electric generator. The generator was temporarily lashed together and was ready to go on-line if the utility power had failed.

Phase II, or the final installation of the Generator/UPS, is scheduled to get underway in January 1971 when the UPS hardware shipment is completed.

V. FORECAST VERIFICATIONS - Monthly Means for 1970

A. NMC Grid Area (1977 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 mbs																		
July	.69	149	15.0	195	19.3	.72	184	16.8	251	23.1				.72	210	18.9	280	25.4
Sept.	.77	150	14.8	232	22.0	.76	195	17.4	294	26.0				.75	225	19.4	327	28.0
Nov.	.80	174	16.2	283	24.5	.81	216	18.5	358	29.1				.78	261	21.2	401	31.2
300 mbs																		
July	.74	131	13.4	189	19.3	.76	161	15.2	242	23.1				.76	185	17.4	274	25.6
Sept.	.81	135	13.7	228	22.5	.81	173	16.2	289	26.7				.79	201	18.3	323	28.8
Nov.	.85	155	15.1	298	27.1	.85	196	17.9	373	31.8				.83	242	21.0	417	34.1
500 mbs																		
July	.73	89	8.8	124	12.3	.75	114	10.3	162	15.0	.68	121	10.9	.75	130	11.4	184	16.6
Sept.	.80	94	9.3	153	14.8	.80	121	10.9	197	17.7	.69	143	12.5	.79	140	12.4	223	19.3
Nov.	.86	108	10.7	210	19.2	.86	138	12.6	264	22.3	.71	186	15.1	.82	173	15.0	296	24.0
850 mbs																		
July	.64	79	7.8	85	8.1	.65	100	8.5	111	9.8				.67	111	9.3	125	10.6
Sept.	.76	78	7.6	109	10.1	.76	99	8.9	140	12.1				.77	111	9.7	158	13.0
Nov.	.82	90	8.8	146	12.8	.82	110	10.0	181	14.5				.79	133	11.6	201	15.3
1000 mbs																		
July	.62	85	9.6	92	9.8	.61	114	10.7	120	11.8				.58	129	12.2	131	12.3
Sept.	.74	88	9.9	120	12.2	.74	113	11.5	151	14.3				.71	128	12.8	169	15.0
Nov.	.81	102	11.0	166	15.5	.82	125	12.6	202	17.5				.78	151	14.8	222	18.2

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 mbs																		
July	.82	112	12.0	198	20.2	.82	146	14.2	260	24.7				.81	162	16.3	293	27.6
Sept.	.87	131	13.3	264	25.2	.86	174	16.4	340	30.2				.85	210	19.3	384	33.1
Nov.	.88	146	14.6	316	27.4	.84	205	18.3	400	32.8				.79	271	22.1	450	35.5
300 mbs																		
July	.84	101	11.4	194	20.5	.83	137	13.8	253	24.8				.81	159	16.2	285	27.6
Sept.	.89	125	13.9	273	27.8	.88	167	16.9	344	32.6				.86	201	20.0	386	35.2
Nov.	.92	143	15.3	366	33.9	.89	202	19.5	459	39.7				.84	267	23.7	514	42.5
500 mbs																		
July	.84	68	7.6	126	13.0	.83	89	9.1	167	16.0	.79	97	9.5	.80	106	10.3	187	17.5
Sept.	.87	84	9.2	174	17.2	.87	110	11.0	221	20.5	.81	130	12.5	.84	135	12.9	248	22.1
Nov.	.91	103	10.6	257	23.7	.89	144	13.4	323	27.5	.78	195	17.3	.84	192	16.5	362	29.3
850 mbs																		
July	.80	59	6.5	90	8.9	.80	74	7.2	117	11.1				.79	88	8.4	131	11.9
Sept.	.85	69	6.9	120	11.5	.83	90	8.3	148	13.4				.81	109	9.9	163	14.1
Nov.	.88	82	8.0	169	14.9	.88	105	10.0	210	17.2				.84	130	11.7	226	17.2
1000 mbs																		
July	.71	78	9.2	96	9.9	.75	96	9.9	125	12.2				.73	117	11.6	138	12.9
Sept.	.82	87	9.5	134	13.2	.82	112	11.4	167	15.7				.79	137	13.4	181	16.3
Nov.	.87	99	10.6	195	17.8	.87	126	13.0	240	20.3				.84	152	15.2	257	20.5

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 mbs																		
July	.78	162	15.6	257	24.8	.76	219	19.2	332	30.4				.77	255	22.2	379	33.7
Sept.	.85	146	14.4	286	26.2	.83	197	18.3	360	31.4				.83	226	20.4	411	33.8
Nov.	.89	154	14.2	333	28.3	.87	211	18.7	425	33.9				.84	260	22.1	482	36.4
300 mbs																		
July	.82	167	17.1	300	29.6	.82	215	20.5	381	36.1				.80	258	24.1	439	40.1
Sept.	.86	152	15.8	312	29.8	.84	207	19.9	391	35.5				.84	235	22.4	446	38.3
Nov.	.90	160	15.8	372	33.7	.88	220	20.6	458	39.2				.85	278	24.5	518	41.6
500 mbs																		
July	.82	110	10.3	195	18.3	.81	150	12.8	257	23.1	.77	158	14.3	.81	177	14.7	300	26.0
Sept.	.85	104	10.1	205	19.1	.83	145	13.0	266	23.3	.77	172	15.1	.83	168	14.8	308	25.5
Nov.	.87	114	10.9	252	22.5	.87	158	14.2	316	26.4	.75	202	16.6	.83	201	17.1	355	28.3
850 mbs																		
July	.78	74	6.9	116	10.1	.79	93	8.1	156	12.8				.79	111	9.4	180	14.3
Sept.	.84	79	7.9	139	12.1	.83	104	9.0	184	14.9				.83	118	10.2	212	16.3
Nov.	.86	92	8.4	185	16.0	.84	125	10.7	226	18.3				.80	152	12.6	249	19.2
1000 mbs																		
July	.78	72	7.4	120	10.9	.76	99	8.9	157	13.4				.75	117	10.5	177	14.6
Sept.	.85	78	7.8	148	13.3	.84	103	9.7	187	15.5				.82	124	11.4	216	17.1
Nov.	.86	100	9.5	205	18.4	.84	132	11.6	243	20.3				.79	164	14.3	263	21.1

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 mbs																		
July	.66	148	14.8	188	18.6	.72	175	16.8	238	22.1				.71	205	19.4	270	24.4
Sept.	.76	150	14.6	228	21.6	.77	183	17.7	286	25.5				.73	229	20.2	321	28.2
Nov.	.79	164	15.4	277	23.3	.81	195	18.1	343	27.5				.81	217	19.5	385	29.7
300 mbs																		
July	.66	129	12.6	160	16.6	.72	148	13.8	202	19.4				.73	168	16.0	230	21.4
Sept.	.79	131	13.4	217	21.7	.80	161	16.0	271	25.7				.78	193	17.8	306	28.3
Nov.	.86	149	14.6	311	27.0	.87	180	17.2	391	31.7				.86	200	19.0	433	34.3
500 mbs																		
July	.66	85	8.3	99	10.4	.69	102	9.6	128	12.4	.54	114	10.1	.69	118	10.6	144	13.4
Sept.	.79	88	8.9	138	14.1	.80	110	10.2	175	16.6	.61	141	11.8	.77	132	11.8	196	18.3
Nov.	.87	101	9.8	218	19.3	.88	119	11.4	273	22.3	.63	212	14.9	.88	137	13.0	305	24.3
850 mbs																		
July	.46	99	9.1	73	7.5	.43	120	10.1	94	8.9				.52	120	10.5	102	9.4
Sept.	.68	87	9.0	103	10.1	.69	113	10.7	129	11.9				.70	118	11.1	142	12.8
Nov.	.80	97	10.1	139	11.5	.82	110	10.9	169	13.0				.78	128	12.3	187	13.9
1000 mbs																		
July	.45	107	12.1	83	9.0	.45	142	14.2	114	11.9				.47	155	16.7	115	11.4
Sept.	.62	116	13.8	119	12.4	.62	150	16.1	148	15.0				.61	164	17.7	160	15.3
Nov.	.78	124	14.6	171	15.2	.81	139	15.7	210	17.4				.75	172	19.0	228	17.7

R Correlation coefficient of forecast versus 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 6-layer primitive equation baroclinic forecast model
PERS Persistence forecast
BAROTROPIC Operational barotropic forecast model

See grid map page 43.

VI. MACHINE PERFORMANCE AND UTILIZATION

A. IBM 7094/II

1. 7094/II Profile - No changes
2. Utilization - 2,581 hrs.

B. IBM 1401

1. 1401 Profile - No changes
2. Utilization - 1,488 hrs.

C. IBM 360/30

1. 360/30 Profile - No changes
2. Utilization - 3,146 hrs.

D. IBM 360/40

1. 360/40 #1 Profile

   a. Leased equipment

      1 - MAI 2301-1 'Disk Storage Drive' 11-70
      1 - IBM 2701 'Data Adapter Unit' 09-70
      1 - IBM 2701 'Data Adapter Unit' 10-70

2. Utilization - 4,228 hrs.

E. IBM 360/40

1. 360/40 #2 Profile

   a. Purchased equipment

      1 - IBM 2040-G 'Central Processing Unit' 07-70

   b. Leased equipment

      1 - IBM 1052-7 'Printer Keyboard' (Spare) 07-70
      1 - IBM 1416-1 'Train Carriage' (QNC) 11-70

   c. Released equipment

      1 - IBM 1416-1 'Train Carriage' (HN) 11-70

2. Utilization - 1,280 hrs.

F. CDC 6600, Computer Division, NOAA

1. CDC 6600 Profile

   a. 1 - 6601 Central Processing Unit (CPU)
   b. 1 - 6613 " " "
   c. 1 - 6602 Console
   d. 1 - 6612 "
   e. 22 - 607 Tapes
   f. 5 - 512 Printers
   g. 5 - 3555 Printer Controllers
   h. 3 - 3423 Mag. Tape Converters
   i. 4 - 405 Card Readers
   j. 4 - 3447 Card Reader Converters
   k. 2 - 415 Card Punches
   l. 2 - 3446 Card Punch Converters
   m. 10 - 6681 Data Chan. Converters
   n. 1 - 3228 Mag. Tape Converters
   o. 3 - 604 Mag. Tapes
   p. 2 - 3291 Entry Display Units
   q. 4 - 6638 Disk Systems
   r. 4 - 10037A/RW Options
   s. 2 - 6671 Data Set Multiplexes

2. Utilization for NMC work - CPU 665 hrs.
   PPU 1,981 hrs.

VII. PERSONNEL CHANGES

A. Data Automation Division (DAD)

1. Robert Hollern, Mathematician (Sen. Programmer), Programming Branch, resigned September 11, 1970.

2. Carla Anne Steinborn, Mathematician, joined Programming Branch, December 28, 1970.

3. William Hagarty, Supervisory Digital Computer Systems Operator, Operations Branch, transferred to District Government, December 12, 1970.

B. Development Division (DD)

1. James G. Howcroft, Meteorologist, joined the staff of Development Division, September 1, 1970.

C. Analysis & Forecast Division (A&FD)

1. Robert A. Case, Meteorologist, was reassigned to Basic Weather Forecast Branch from Juneau, Alaska, September 20, 1970.

2. Gerald Grossman, Meteorologist, Aviation Weather Forecast Branch, resigned September 4, 1970.

3. Earl W. Estelle, Executive Assistant, Meteorological Operations, was reassigned to NMC as Deputy Chief of A&FD, November 1, 1970.

VIII. DISTRIBUTION OF PRODUCTS

As of December 31, 1970, NMC was originating approximately 420 separate teletype bulletins per day for transmission over Weather Service, Navy, Air Force, and Air Transport Association teletype circuits. The Automated Analysis Branch (AAB) was responsible for the following daily facsimile transmissions:

National Facsimile Network	46
Navy Facsimile Network	2
Air Force Facsimile Network	18
International Facsimile (European) Network	32
Russian Facsimile Network	21
Forecast Center Facsimile Network	64
High Altitude	36
Honolulu-Southwest Pacific	64

IX. PUBLICATIONS BY NMC PERSONNEL

1. Adem, J., "On the Prediction of Mean Monthly Ocean Temperature." Presented at AMS-AGU Washington meeting. Abstract in *EOS*, Vol. 51, No. 4, April 1970, p. 311.

2. _________ "Incorporation of Advection of Heat by Mean Winds and by Ocean Currents in a Thermodynamic Model for Long-Range Forecasting." *Monthly Weather Review*, Vol. 98, No. 10, Oct. 1970, pp. 776-786.

3. _________ "On the Prediction of Mean Monthly Ocean Temperatures." *Tellus*, Vol. 22, No. 4, 1970, pp. 410-430.

4. Andrews, J. F., "The Circulation and Weather of 1969." *Weatherwise*, Vol. 23, No. 1, Feb. 1970, pp. 5-11, 30-31.

5. _____________ "Evaluation of 500-Millibar Daily and 5-Day Mean Numerical Predictions." *Monthly Weather Review*, Vol. 98, No. 5, May 1970, pp. 385-398.

6. Clapp, P. F., "Parameterization of Macroscale Transient Heat Transport of Use in a Mean-Motion Model of the General Circulation." *Journal of Applied Meteorology*, Vol. 9, No. 4, Aug. 1970, pp. 554-563.

7. Dickson, R. R., "On the Relationship of Variance Spectra of Temperature on the Large Scale Atmospheric Circulation." Tech. Note BN-35, University of Maryland, Jan. 1970, 58 pp.

8. Finger, F. G., and R. M. McInturff, "Meteorology and the Supersonic Transport, *Science*, January 1970.

9. Gerrity, J. P., A. Robert, F. G. Shuman, "On Partial Difference Equations in Mathematical Physics." *Monthly Weather Review*, 98, 1.

10. Henry, Robert M., and R. S. Quiroz, "Preliminary Results from a Meteorological Rocket Experiment." *Nature*, June 1970.

11. Johnson, K. W., and R. M. McInturff, "On the Use of SIRS Data in Stratospheric Synoptic Analysis." *Monthly Weather Review*, Sept. 1970.

12. McPherson, R. D., "Recent Research in Numerical Methods at the National Meteorological Center, U.S.A." Paper presented at International Conference on Meteorology, Tel Aviv, Israel, November 1970.

13. Miller, A. J., "A Note on Vertical Motion Analyses for the Upper Stratosphere, *Monthly Weather Review*, March 1970.

14. Miller, A. J., "The Transfer of Kinetic Energy from the Troposphere to the Stratosphere." *Journal of Atmospheric Sciences*. May 1970.

15. ____________, F. G. Finger and M. E. Gelman, "30-Mb Synoptic Analyses for the 1969 Southern Hemisphere Winter Derived with the Aid of Nimbus III (SIRS) Data, NASA TM X-2109, December 1970.

16. ____________, and K. W. Johnson, "On the Interaction Between the Stratosphere and Troposphere During the Warming of Dec. 67 - Jan. 68, *Quarterly Journal of the Royal Meteorological Society*, Jan. 1970.

17. Namias, J., "Climatic Anomaly Over the United States During the 1960's." *Science*, Vol. 170, No. 3959, Nov. 13, 1970.

18. __________ "Empirical Evidence for the Causes of Irregular Variations in the General Circulation." Presented at the Conference on the Motion and Dynamics of the Atmosphere, Houston, March 23-25, 1970. Abstract in *Bulletin, American Meteorological Society*, Vol. 51, No. 1, Jan. 1970, p. 75.

19. __________ "Macroscale Variations in Sea Surface Temperatures in the North Pacific." *Journal of Geophysical Research*, Vo. 75, No. 3, Jan. 20, 1970, pp. 565-582.

20. Scherhag, R., K. Labitzke, F. G. Finger, "Developments in Stratospheric and Mesospheric Analyses which Dictate the Need for Additional Upper Air Data." *Meteorological Monographs*, Oct. 1970.

21. Sela, J., and A. Wiin-Nielsen, "Energetics of a Two-Layer Quasi-Geostrophic Model." Presented at AMS-AGU Washington meeting. Abstract in *EOS*, Vol. 51, No. 4, April 1970, p. 295.

Technical Memoranda

#46 "Noise Analysis of a Limited-Area Fine-Mesh Prediction Model" - J. P. Gerrity and R. D. McPherson

47 "The National Air Pollution Potential Forecast Program" - E. Gross

48 "Recent Studies of Computational Stability" - J. P. Gerrity and R. D. McPherson

49 "A Study of Non-Linear Computational Instability for a Two-Dimensional Model" - P. Polger

Office Notes

#35 "An Accelerated Method for Calculating the Exner Function" - H. A. Bedient

36 "PEP Computation of Dew Point Temperature at Mandatory Levels" - H. A. Bedient and J. D. Stackpole

37 "Adjustment to a Moist Adiabatic Lapse in the PEP Model" - J. D. Stackpole

38 "Linear Analysis of a Semi-Implicit Differencing Method" - J. A. Brown

39 "Energy Equations for the NMC Operational Primitive Equation Model" - J. A. Brown

40 "Summary of Verification of 30-Day Temperature Predictions with the Thermodynamic Model over Contiguous U.S. for 1969" - Julian Adem, William Bostelman and Paul Polger

41 "Type of Radiation Model Needed in the Thermodynamic Approach to Long-Range Prediction" - Julian Adem

42 "The Relationship of the Froude Number to Numerical Stability of the Gravity Wave Equations" - R. D. McPherson

43 "Structure of Tropical Data Tape" - Lena Loman, Joseph Irwin and Richard Schnurr

44 "NMC Permanent Files" - Arthur R. Kneer

45 "An Analysis of the Computational Stability Criteria for Explicit and Implicit Integration Schemes Using a Two-Layer Model in Phillips σ Coordinate" - Joseph P. Gerrity and Ronald D. McPherson

46 "Estimating Monthly Precipitation from Satellite Data" - P. F. Clapp

47 "An Analysis of the Free Modes of One, Two and Four Layer Models Based on Sigma Coordinates" - J. P. Gerrity, R. D. McPherson and P. D. Polger

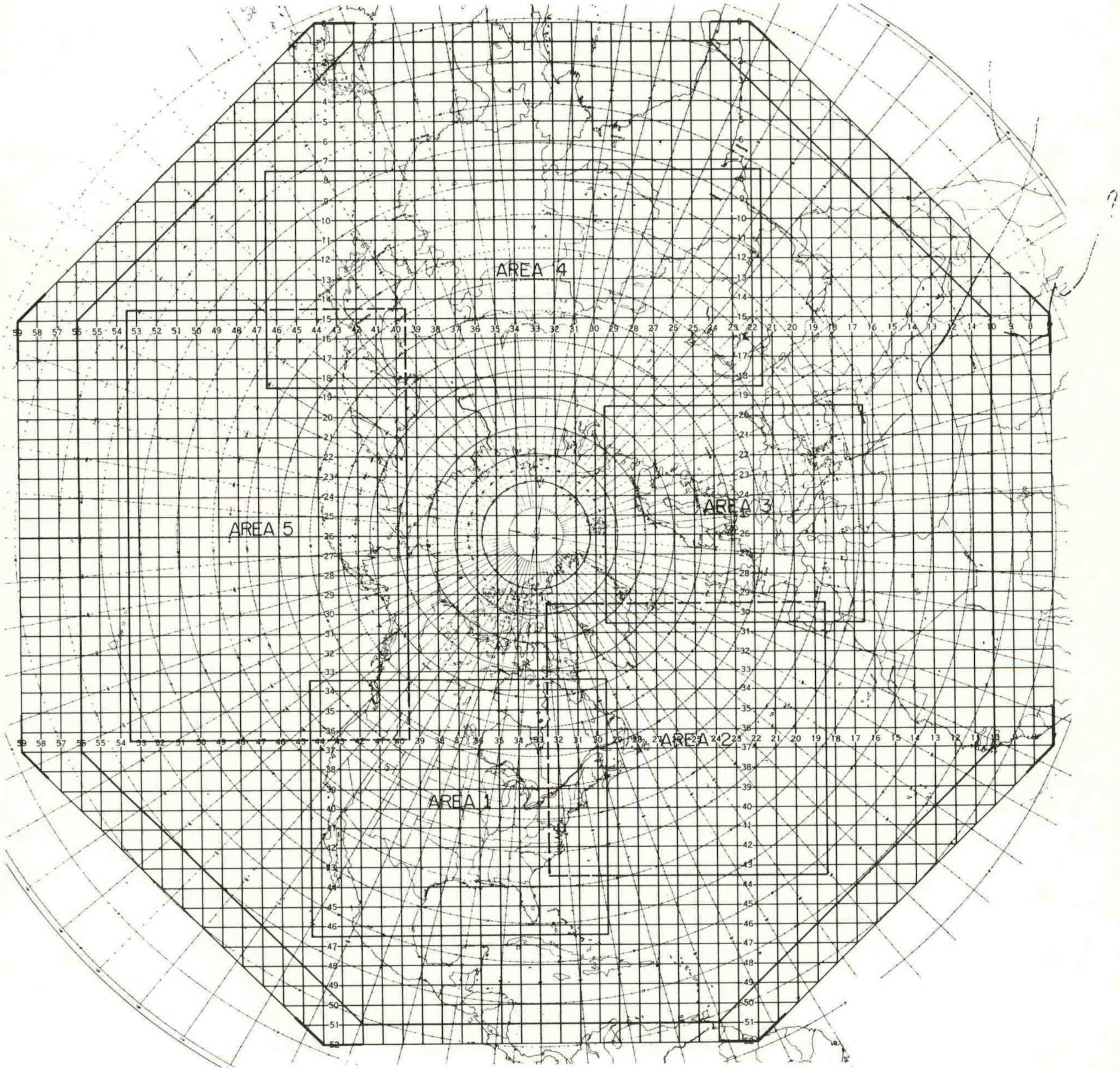
48 "Relation Between Monthly Mean Cloudiness and Precipitation" - P. F. Clapp

49 "An Analysis of Linear Computational Stability of Explicit and Implicit Integration Schemes for a Two-Layer Model Using Shuman's σ-Coordinate" - Joseph P. Gerrity and Ronald D. McPherson

50 "Local Forecast Model: Present Status and Preliminary Verification" - James G. Howcroft

51 "Comparative Analysis of a New Integration Method With Certain Standard Methods" - J. P. Gerrity and P. Polger

52 "Linear Computational Stability Analysis for a Modified Semi-Implicit Integration Technique for Gravity Oscillations in a Two Layer Model in Phillips σ Coordinate" - J. P. Gerrity, R. D. McPherson, P. Polger



Verification Areas