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Bagrov, N. A. and A. P. Kukhto

Determining the Laplacian Field from the H_{500} Geopotential. Meteor. i. gidrol., No. 4, 1961, pp. 23-27.

The authors present a method for computing the Laplacian of the height of a pressure surface which is convenient for programming for the computer "Pogoda", used at the Central Forecasting Institute.

The method had been programmed for a grid bounded by 75°N and 35°N and 30°W to 90°E. Spherical coordinates are used and grid points are spaced every 5° of latitude and every 10° of longitude.

Basically the scheme is one in which the heights at the grid points are resolved into Tschebycheff polynomials. Coefficients for the normalized polynomials are obtained by the computer program for $n = 9$ and $n = 13$.

The scheme was tested on a known field of sine and cosine functions and it was found that the method was sufficiently reliable at the internal points. However, this was not the case for the values in the boundary region.

Bagrov, N. A. and N. I. Zverev

Means of Forecasting the Fields of the H_{500} Geopotential in Mean Flows.
Trudy Tsentral'nogo Instituta Prognozov, No. 108, 1961, pp. 3-22

The authors report on a method of forecasting 7-day 500 mb height anomalies. Daily charts of the anomalies for five years were divided into 7-day periods. For each period the total sum of the 500 mb height fields was represented analytically by Tschebycheff polynomials - 24 components. Correlation links between the coefficients which were found for adjacent 7-day periods were sought. The computer "Pogoda" was used to obtain the coefficients, and the system of normalized equations linking the coefficients was solved on a "Ural" computer. Twenty 7-day forecasts were made whereby each day was verified. In a verification scheme which scored from -1 (no skill) to +1 (perfect forecast) the mean verification of the sign of the anomalies was +0.28.

Belousov, S. L. and V. G. Boldyrev

On the Forecasting of Geopotential in the Upper Portion of the Atmosphere.
Trudy Tsentral'nogo Inst. Prognozov, Vol. 111, 1961, pp. 3-12

This is an interesting report of a short-range numerical forecasting method of predicting the geopotential field at the middle or upper troposphere or lower stratosphere. The model which is formulated is essentially a geostrophic one in which thickness forecasts are made. These forecasts are dependent upon the time variations of the topography at some lower level which is governed by the barotropic approximation.

The model is formulated as follows: By neglecting friction and mountain effects and vertical momentum transport in the vorticity equation and non-adiabatic effects in the thermodynamic equation (differentiated with respect to pressure) an expression for the local geopotential tendency is obtained. This equation is applied at two levels and then differenced. Using a constant static stability the three-dimensional Green's functions are constructed to invert the elliptic operator to obtain $\frac{\partial}{\partial t}(\phi_1 - \phi_2)$. In a similar scheme the solution to the barotropic equation, applied at a lower level, is obtained.

The authors state that due to a rapid decrease of the Green's functions with distance, the computational method was stable. (However, during the 24-hour integrations a smoothing operator was applied four times at all levels.) Forecasts were performed on a 20 x 27 grid array whereby the grid interval was 250 km. A time step of 1.5 hours was used throughout. Forecasts were made on a computer whereby the lower level was 700 mb. The higher levels chosen were 500 and 300 mb. The Beta term and the undifferentiated Coriolis parameter were treated as constants. The results of four 24-hour forecasts gave mean absolute height errors of 37.0, 45.5 and 83.0 meters at 700, 500 and 300 mb, respectively. Forecast fields for one case were presented.

Belov, P. N. Numerical Prediction of the Baric Field by a Three-Level Atmospheric Model.
Trudy Tsentral'nogo Inst. Prognozov, Vol. 111, 1961, pp. 29-38.

This is a discussion of a three-level geostrophic model which is designed to account for a variable static stability and surface friction effects. The geostrophic form of the vorticity equation neglecting the vertical transport, friction and twisting terms are combined with the adiabatic form of the thermodynamic equation differentiated with respect to pressure, and a resulting prediction equation for geopotential is obtained which does not contain pressure vertical velocity terms explicitly. The entire formulation is in the Cartesian coordinate system. Due to small correlations, according to the author, of the geopotential of isobaric surfaces which are separated by pressure increments of 300 mbs, it was decided to use a 3-level scheme which utilized the 200, 500, and 850 mb surfaces. It was assumed that the pressure vertical velocity is zero at $p = 0$, and at the earth's surface the vertical velocity is proportional to the geostrophic relative vorticity at this lower boundary.

The prediction equation is applied at the 3-levels with certain lateral and vertical boundary constraints. The importance of the application of a 9-point smoothing operator to the initial height fields is stressed. In addition, the author utilizes a linear combination of the usual finite difference Jacobian and one which is off-centered towards the direction from which blows the geostrophic wind. The forecasting equation is of the Helmholtz type and is solved through the Liebman relaxation scheme. The grid interval was 300 km. The drag coefficients which were used were those presented in Kibel's book ("Introduction to Hydrodynamic Methods of Short Term Weather Forecast," 1957). It appears that in the actual tests made on a computer the stability was a function of pressure only.

The grid size was not described in further detail nor were example forecasts presented.

Belov, P. N. Use of Empirical Influence Functions for a Weather Forecast at a Single Station.
Trudy Tsentral'nogo Inst. Prognozov, Vol. 111, 1961, pp. 44-49

This is a description of a short-range statistical forecasting method for a single station and an evaluation of its accuracy. Empirical influence functions are obtained for predictors which are based on a careful selection of the independent variables. This selection is based on the form of the prognostic equations obtained from the hydrodynamic equations governing the physical behavior of the atmosphere. Special emphasis is made for incorporating past data as well as current data. The statistical model is essentially a 2-level one in which the 1000-mb and 500-mb geopotential fields are considered at various locations surrounding the point of interest. Influence functions are obtained which relate linear functions of these parameters to the elements to be forecast - 1000- and 500-mb geopotential 12 to 24 hours in advance, maximum and minimum surface temperatures one to two days in advance, amount of precipitation occurring during each of two successive days, the amount of lower clouds on the succeeding night and day, and the surface wind for the succeeding night. The smoothed values of 500- and 1000-mb heights for 15 regularly arrayed locations (centered mostly to the west of Moscow) are used. The optimum grid interval chosen was 750 km. The coefficients are obtained through means of an electronic computer (presumably "Pogoda") from a system of normal equations consisting of 60 unknowns.

The sample size is not specified. Correlation coefficients and root-mean-square errors are presented (presumably for the dependent data). Average correlation coefficients of 0.91 and 0.90 are given for 24- and 72-hour surface pressure forecasts, respectively -- 0.90 and 0.89 for similar forecasts of 500-mb heights. The average root-mean-square error in precipitation amounts and lower cloud cover were 1.1 mm and 2.3 tenths, respectively.

Bel'skaia, N. N., P. K. Dushkin, and E. G. Lomonosov

Numerical Method of Forecasting for a High Level Pressure Field.
Materials of the Conference of the Coordinating Commission on Numerical Forecast Methods, 1961, pp. 25-35

This is a description of a 3-level geostrophic model for short-range forecasting which was the first model used as an operational product of the Central Institute of Forecasting. According to the authors this numerical model has been in use since April 6, 1960. Forecasts of the 850- 500- and 300-mb levels are made on a 22 x 26 grid region from an adiabatic, frictionless scheme which was presented in 1959 (P. K. Dushkin, E. G. Lomonosov, and M. S. Tatarskaia: "Forecast of Cyclo- and Anti-cyclogenesis by Means of Computing Machines," Meteorologiia i Gidrologiia, No. 6, pp. 11-16). The integration method involves the use of three-dimensional Green's functions as obtained by Boleyev and Marchuk in 1958 to relate the geopotential fields at the various levels. The maximum horizontal radius of influence of the functions is about 1080 km.

It is reported that the best results are obtained for a time-step of one hour. The finite difference forms of the non-linear advective terms are given. The grid interval was 300 km, and a combination of centered and non-centered vertical differences were used. Twenty-four hour forecasts were obtained through use of a forward difference in time, and several tests were applied to the results. It was necessary to apply a smoothing function to the fields each time-step in order to maintain computational stability. It was found that the contribution of the temperature advection term to the height tendency was considerably smaller than the vorticity advection term, but it's importance was evident by a significant error reduction. According to the authors, verification tests indicated a slight superiority of the 500- and 300-mb numerical forecasts compared to subjective ones. (850-mb forecasts were not compared.) For April and May, 1960, the correlation coefficients obtained from the 24-hour numerical prognoses for 55 stations was 0.59, 0.77 and 0.78 for 850, 500, and 300 mb respectively. Two forecasting examples are presented.

The authors further report that the computer time required (presumably on the STRELA) for a 24-hour forecast is about 15 minutes.

Blinova, Ye. N. A Hydrodynamic Forecast of the Mean Monthly Temperature Anomalies for the Northern Hemisphere Obtained by Using International Geophysical Year Data. Doklady Akademii Nauk SSSR, (Translation from Doklady of the Academy of Sciences of the USSR, Earth Sciences Sections, Vol. 131, No. 2, American Geological Institute), 1960, pp. 293-296

The author presents the theory and two results (one winter month and one summer month) for a monthly surface temperature forecast for the Northern Hemisphere. From 1952 to the end of 1957 similar forecasts were made "under operational conditions" but over only a portion of the Northern Hemisphere. Since May 1958 forecasts of mean monthly temperature anomalies were made at the Institute of Applied Geophysics, Academy of Sciences, USSR.

The basic scheme was introduced by Blinova in 1950 and discussed by Baum and Thompson ("Long-range Weather Forecasting in the Soviet Union," Bulletin AMS, Vol. 40, No. 8, pp. 394-409, 1959) in considerable detail. The method introduced in the present paper is briefly as follows:

Mathematically the stream function is denoted as

$$\psi = \bar{\psi} + \psi' + \psi''$$

where $\bar{\psi}$ is the latitudinal value, ψ' is the climatic non-zonal value, and ψ'' is the meridional part. The vorticity equation in spherical coordinates is linearized into the form

$$\frac{\partial}{\partial t} \nabla^2 \psi'' + \alpha \frac{\partial \nabla^2 \psi''}{\partial \lambda} + 2(\alpha + \omega) \frac{\partial \psi''}{\partial \lambda} = 0 ,$$

where ∇^2 is the Laplacian operator and α and ω express the absolute rate of rotation of the zonal winds where ω is that part due to the earth's rotation. Also, the balance equation is linearized into the form

$$\cos\theta \nabla^2 \psi'' - \sin\theta \frac{\partial \psi''}{\partial \theta} = \frac{g}{2(\alpha + \omega)} \nabla^2 H'',$$

where θ is the co-latitude, g is the gravitational acceleration and H is the height of the 600 mb pressure surface.

The solutions of ψ'' and H'' are each expressed in the form of a series of coefficients in spherical harmonics. Recurrence equations relating both sets are obtained. After the coefficients, A_n^m and A'^m_n, are obtained such that

$$H'' = \sum_{n=1}^{\infty} \sum_{m=1}^{n} (A_n^m \cos m\lambda + A'^m_n \sin m\lambda) P_n^m(\cos\theta)$$

the corresponding coefficients for ψ'' are obtained from the recurrence formula, $n \leq 36$ and $m \leq 18$. Thus the meridional nonstationary wind, v''_θ, can be calculated. This is used in the basic temperature forecast equation

$$\frac{\partial \tau}{\partial t} + \alpha \frac{\partial \tau}{\partial \lambda} + 2M \frac{\sin\theta}{a_\circ} v''_\theta = \frac{k''}{a_\circ^2} \nabla^2 \tau + \frac{\partial}{\partial Z}\left(k' \frac{\partial \tau}{\partial Z}\right)$$

Here $\tau = \frac{T''}{\sin\theta}$, M is proportional to $\frac{d\bar{T}}{d\theta}$, and k' and k'' are the coefficients of eddy conductivity and horizontal diffusion respectively (both treated as constants). The above equation together with certain boundary conditions approximating non-adiabatic heating effects are utilized.

The annual variations of α and M were taken into account.

τ was obtained using a scheme similar to that for H'' and ψ''.

The two monthly forecasts of the meridional temperature anomalies which Blinova presented are surprisingly accurate considering the drastic linearization involved. No overall comparisons with subjective techniques are given.

Chekirda, A. Z. Consideration of Dependence of Rate of Zonal Flow Upon Latitude in Calculation of Stream Function Field at Mean Atmospheric Level,
Izv. Akad. Nauk SSSR, Ser. geograf. i geol, No. 11, 1961, pp. 1103-1110 (English ed.)

In this paper the author points to the importance of the changes with time of the zonal wind profile and the effects produced on the pressure formations. As is the usual practice in Soviet work in long range prediction the non-divergent form of the vorticity equation is linearized and the resulting equation expresses changes in the stream function perturbations, ψ', against the background of a given zonal flow. Using the assumption that $\bar{\psi} = \frac{\bar{\Phi}}{f}$ the author relates the zonal part of the stream function, $\bar{\psi}$, to the zonal part of geopotential, $\bar{\Phi}$, through use of a series of normalized Legendre polynomials. The solution of ψ' is expressed in the form of a series of spherical functions with time-dependent coefficients. He then obtains a set of equations for the coefficients of expansion of the function ψ' into the series of spherical functions which he solved on a "universal electronic computer." The author concludes from the analysis that the zonal wind profile distorts short waves with axes greatly extended along the meridians very little and they move with speeds close to the wave propagation speed. Further, waves of any length which have axes parallel to the latitude circles are very sensitive to changes in the zonal wind profile. The author observes that waves of the latter type are observed infrequently in the mid-troposphere. The analysis also indicated that the short waves of the two types should interact only slightly.

Two 600-mb forecasts were made on an electronic computer -- one in which the zonal wind profile changed little and the other where large changes were observed from 60° to 90°N Latitude. The large errors obtained in the latter case were largely attributed to these profile changes which were assumed to be invariant by the prediction model. Three hour time steps were made and the forecasts presented were valid three days after the initial time.

De-Chan, Din An Experiment in Quantitative Prediction of Precipitation
Meteorologiya i Gidrologiya, No. 12, 1961, pp. 23-25

This is a short report in which the author describes a simple method for calculating precipitation amounts. The scheme is essentially one in which the vertical velocity at a particular pressure level in the atmosphere is estimated from the mountain influence and the mean horizontal wind divergence. This is used in the abbreviated moisture equation

$$M = \frac{\Delta t}{g} \int_{p_0}^{0} \left(u \frac{\partial q}{\partial x} + v \frac{\partial q}{\partial y} + \omega \frac{\partial q}{\partial p} \right) dp .$$

Here M is the precipitation amount, Δt is the time interval, p_0 is the lower boundary pressure, u and v are the horizontal wind components, q is the specific humidity, and ω is the pressure vertical velocity. Twenty-four hour precipitation amounts were estimated for a very small region in China using the observed wind and moisture measurements for the period. The above relationship was used to obtain the estimates in the 1000-850, 850-700, and 700-500 mb layers. The calculated results were verified against the observed amounts, and a good agreement was found for the case chosen.

Dobryshman, E. M. Examples of Precise Solutions of Nonlinear Forecasting Equations.
Izv. Akad. Nauk SSSR, Ser. geograf. i. geol., No. 2, 1961, pp. 189-195 (English Ed.)

The author discusses the general and certain particular solutions of the nondivergent barotropic forecasting equation in both the Cartesian and spherical coordinate systems. Examples are presented of precise solutions for simple flow patterns. In addition examples of solutions are given for the case when turbulent viscosity is also taken into account. It is shown that due to this dissipation the waves of smaller wavelength will dampen out more rapidly than the larger ones.

Several examples of precise solutions of the geostrophic forecast equation [as originally introduced by Charney in 1948 ("On the Scale of Atmospheric Motions," Geophysiske Publ., Vol. 17, No. 2)] are given. This equation was derived through a consistent formulation of the vorticity and thermodynamic equations in which friction and non-adiabatic effects were neglected. In the equation used by the present author the static stability was treated as an invariant. Descriptions of the solutions in terms of the flow and temperature patterns are given.

An interesting argument is presented by the author in which he compares his exact solution of the non-divergent barotropic forecasting equation to that obtained through solving the equation in the Poisson form. He states that the solution of the elliptic equation contains errors such that the wave amplitudes increase uniformly with time while those in his solution are periodic functions of time. Thus, he concludes that the method presented permits a larger time-step than does the solution from the elliptic equations.

Dubov, A. S. Forecasting the Geopotential Field in the Lower Stratosphere. Materials of the Conference of the Coordinating Commission of Numerical Forecast Methods, 1961, pp. 55-62.

An argument based on a statistical analysis of certain data leads the author to a simplified two-dimensional forecasting equation for the 200 mb level. The thermodynamic equation is reduced to an expression which approximates the pressure analog of the vertical velocity as a function of the temperature advection alone. This is substituted into the divergent term of the vorticity equation (where the vertical transport, twisting and the frictional terms are neglected). Through further, convenient simplifications the resulting equation is transformed into a form suitable for graphical integration. However, in the eight cases tested the results were obtained on a "Ural-1" computer.

The forecasts were performed on an 84-point grid where the grid spacing was 330 km. The mean correlation coefficient between actual and forecast changes was 0.56.

Dubuque, A. F. and Hsui-Hsuao-Chin

Determination of Wind Above Mountains According to Pressure Field at Variable Coefficient of Friction in Limited and Unlimited Turbulent Atmosphere.
Bulletin(Izvestiya) Academy of Sciences, USSR, Geophysics series, No. 7, 1961, pp. 710-713.

The authors present a theoretical development of the wind velocity in the boundary layer over mountains. From the equations of motion for a viscous fluid the combined effects of both orography and friction upon the wind are expressed in equations for the u and v wind components. These equations are extremely complex and require accurate representations of the terrain irregularities and vertical and lateral coefficients of virtual friction.

Evseev, P. K. The Application of Calculating Procedures in Meteorology. Meteorologiya i Gidrologiya, No. 12, 1961, pp. 6-14.

The author discusses the need for a complete change in the Soviet Hydrometeorological Service in observational recording techniques and processing and analysis of data. The need for a more extensive investigation in the field of numerical weather prediction is stressed. The lack of attention by a large portion of the local scientific community to the capability of modern electronic computer application to meteorological problems is pointed out as a serious shortcoming. The author states that the Novosibirsk branch of the Scientific Research Institute of Aeroclimatology, established in 1960, is performing valuable data tabulation work. Mention is made of the fact that the speed and size of the computers in the Central Institute of Forecasting and the Main Geophysical Observatory have been inadequate for operational numerical forecasting. The more complicated problems have had to be solved on computers leased in non-meteorological organizations, but "As a rule the computer time is not available at the time when it is necessary to the meteorologists, but when the computers are free from their basic load."

To remedy some of the basic difficulties the author points to several programs which are in the planning or implementing stages. Equipment is being developed to rapidly automatically photograph punched card data to minimize storage and handling requirements and facilitate machine calculations for climatic formulations. To minimize the time required in taking and recording observations a system is being developed in which equipment at the observation locations will automatically record the data and transmit it to central locations for automatic processing. The Combined Meteorological Computing Center, also presently in the development stage, is to perform research based on dynamical formulations of atmospheric processes, produce operational short- and long-range numerical forecasts, study statistical methods of forecasting and work on the objective analysis problems.

Galin, M. B. Separation of Long Waves in the Hydrodynamic Forecasting of Pressure Fields in the Medium and Upper Troposphere on the Northern Hemisphere of the Earth.
Akademii nauk SSSR Doklady, Vol. 138, No. 5, 1961, pp. 1073-1075

This work is an extension of a previous study performed by the author ("On the Stability of Planetary-Scale Atmospheric Motion," Izv. Akad. Nauk SSSR, Sov. geograf. i geol., No. 4, pp. 393-400, 1959. English ed.) Forecasts based on a two-level geostrophic model, as described in the 1959 paper, were made on a "Ural" computer. The author applies the vorticity equation at the 700-mb and 300-mb levels. Here he neglects friction and the vertical momentum transport. The non-divergent level is assumed to exist at about 500-mbs. The adiabatic form of the thermodynamic equation is used, and mountain effects are ignored. These two equations are combined and the vertical velocity is eliminated. Through perturbation analysis approximations the resulting equations are linearized, and the final equations contain quantities which are proportional to the average zonal index for each level and a quantity proportional to the average static stability. The forecasts are obtained through spherical harmonic analysis of the initial fields at 700-mb and 300-mbs and each wave component is moved with the correct frequency. The author credits a substantial decrease in forecasting skill after 24-hrs to unsatisfactory handling of the planetary waves (waves 1, 2, and 3). The results of a 72-hr 700-mb forecast in which these long waves were treated as invariant quantities were presented. Thus far in all forecasts made by this method the stream function, ψ, has been approximated by $\psi = \Phi/f$, where Φ is the geopotential and f is the Coriolis parameter.

Gandin, L. S. On the Objective Analysis of Meteorological Fields. Materials of the Conference of the Coordinating Commission of Numerical Forecast Methods, 1961, pp. 94-105.

This is a report of the results of studies conducted in the department of dynamic meteorology of the A. I. Voeikov Main Geophysical Observatory on "optimum interpolation" for objective analyses of meteorological fields. The method which is presented is intended to minimize the mean square error of interpolation through use of weighting coefficients. An attempt is made to incorporate the average observational error in order that erroneous data may be rejected and compromises obtained. In order to conveniently test the interpolation scheme it was assumed that the observational network did not vary. This assumption appears to have been dictated by the capabilities of the "Ural-1" computer which was available for this study. Thus, all weights were computed in advance.

The method was applied at 500 mb and an observational error of approximately 17 meters was assumed. The interpolation required eight observations which were close to the grid point and surrounded it. Thus, certain data were invented from a subjective hand analysis of the field under consideration. The optimum interpolation involves station distances as well as station to grid point distances. However, it appears that in the tests made only the latter ones were used in obtaining the weighting coefficients. Furthermore, the importance of wind observations was stressed, but due to what appears as inadequate computer capabilities only heights were utilized.

Analyses of 10 January cases were made and compared with the subjective analyses. The comparatively smooth form of the objective analyses suggested inadequacies due to the neglect of the wind observations by the objective scheme. A 65 by 67 latitude-longitude grid array was utilized. Due primarily to low speed data input the computation time for one analysis was 1.5 hours.

Gubin, G. I. Computing the Height of Isobaric Layers for a Two-level Model of the Atmosphere on the 'URAL' Electronic Computer. Materials of the Conference of the Coordinating Commission on Numerical Forecast Methods, 1961, pp. 53-54.

This is a brief report of a 2-level geostrophic formulation and results obtained on the "URAL" computer. The model is a relatively simple one in which the simplified geostrophic form of the vorticity equation and the adiabatic equation are transformed into the well-known "omega equation." In a straightforward manner the vorticity equation is applied at the 700- and 300-mb levels, and the omega equation is applied to this layer. The vertical velocity is set equal to zero at $p = 0$ and $p = 1000$ mb.

In the first test the vorticity equation consisted of the local tendency term, the advective term, and the divergence term. In the second test an additional term, the twisting term, was included. Calculations were performed on a 17 x 20 grid with a grid interval of 250 km. Time steps of 1.0 hour and 1.5 hours were tested using centered space differences and uncentered time differences.

Forecasts for 24 hours were made for five days in November 1954. According to the author the relative accuracy of the two schemes varied for different stations. The amount of computer time for a calculation of one time step was 45 minutes and 1 hour for the first and second methods respectively. The computer was equipped with magnetic-tape storage.

Iudin, M. I. A Complete System of Equations for Determining a Non-geostrophic Wind and Vertical Motions. Materials of the Conference of the Coordinating Commission on Numerical Forecast Methods, 1961, pp. 63-70.

A system of equations is obtained from the general hydrodynamical set which is intended for determining the geostrophic wind departure (u' and v') and the vertical velocity. The horizontal winds are considered as sums of the geostrophic and non-geostrophic parts. Furthermore, the temperature and geopotential are considered as sums of standard values which are functions of pressure only and deviations from the standard values. By differentiating the horizontal equations of motion with respect to pressure and the thermodynamic equation with respect to y and x and neglecting certain small terms, two equations result which express the geostrophic departures in terms of derivatives of the total and geostrophic wind. These together with the "divergence equation" and continuity equation are transformed into a set of four equations relating the fields of the three components of the stream function and the fields of the velocity potential to the wind fields.

The author suggests that solutions may be obtained which would greatly improve methods of height and wind analysis which are presently used. The geostrophic wind departures and the vertical velocities obtained together with the hydrodynamical equations in their primitive form may be used to obtain wind and temperature forecasts.

A systematic error is introduced into the scheme when $\frac{du'}{dt}$ and $\frac{dv'}{dt}$ are set equal to zero initially. This would result in a spurious increase of kinetic energy with time. Ways of circumventing this difficulty are being considered.

Iudin, M. I. Relationships Between the Elements of Large-scale Atmospheric Motions and Certain Prognostic Consequences. Materials of the Conference of the Coordinating Commission on Numerical Forecast Methods, 1961, pp. 5-24.

The author develops a scale theory like Charney's (Geofys. Publ., V. 17, #2, 1948) and applies it to the ultra-long ("planetary") waves, as well as to the so-called long waves and shorter. He refers to the pertinent works of both Charney and Burger (Tellus, V. 10, No. 2, 1958), the latter having applied Charney's scale theory to the planetary wave. He verifies Burger's conclusion that waves in the westerlies longer than 5000 km (of scale larger than 800 km by his special measuring stick) are so nearly geostrophic that the divergence is geostrophic and the local tendency term in the vorticity equation is a small difference between large terms.

Iudin, M. I., and A. A. Kobiakova

On the results of a forecast of the geopotential field at the 500 and 850 mb levels for 24 and 48 hr by means of a two-level model.
Materials of the Conference of the Coordinating Commission on Numerical Forecast Methods, 1961, pp. 36-43

A two-level model is discussed, and verification statistics are presented for 35 cases which are scattered throughout the seasons. The model is closely akin to Thompson's integrated thermotropic model. The principal interest of the work lies in the numerical procedures used.

The investigators have adopted a triangular mesh in which to phrase the finite-difference equations, and have used non-isotropic smoothing operators to control truncation error in the small scale. They have also dealt with truncation error control in the larger scales, using procedures analogous to Gates' (Monthly Weather Review, Vol. 89, pp. 115-124). The triangular mesh, the non-isotropic smoothing, and large-scale truncation error control in a triangular mesh, are all rather straight-forward developments founded on well-known theoretical bases. They have been, however, seldom if ever used in meteorological work, even though they possess certain advantages.

The verification statistics which are presented fall within the general range of such statistics compiled elsewhere (e.g., National Meteorological Center, Suitland, Maryland) in operational NWP practice. The statistics presented, however, indicate skill lower than should be attainable with the present state of the art. One reason for this, as the authors indicate, is undoubtedly the small size of their forecast area, roughly 6000 km on a side. Another reason, of which the authors seem to be unaware, is their explicit use of the geostrophic wind in the vorticity equation. Spurious sources and sinks of vorticity are thereby introduced (Shuman, Monthly Weather Review, Vol. 85, pp. 229-234).

Kats, A. L. Features of the Empirical Influence Functions in the Northern Hemisphere for a Forecast of the Pressure Field for 3-5 Days by a Single-Type Initial Large-Scale Process. Meteorologiya i Gidrologiya, No. 12, 1961, pp. 15-22.

This is a discussion which deals with the subject of statistical forecasting for periods out to five days. The method is a modification of the scheme presented earlier by Velov ("Short-range Forecast of the Pressure Fields by Means of the Electronic Computer 'Weather'," Trudy Tsentral'nogo Inst. Prognozov, No. 86, 1959) in which predictions of the 1000, 700, and 300 mb surfaces were made. The present author used a two-level model for finding the empirical influence functions which were used to predict variations in the sea level pressure and the 500 mb geopotential. Eleven locations over the North Atlantic, Europe, and western Asia were used. The predictors which were used were: deviation from the mean of the sea level pressure, deviation from the mean of the 500-mb height, a measure of the zonal index and a measure of the meridional index. The method of least squares was used to obtain the coefficients. All calculations were performed on the electronic computer "Pogoda." It was found that the first two predictors, sea level pressure and 500-mb height at the point where the forecast applied, produced maximum values for the weighting coefficients. The empirical influence functions were obtained for two different types of synoptic classifications for 2, 3, and 5 day forecasts.

The author discusses certain characteristics of the functions obtained and their synoptic relationships. For 120 forecasts of both the sea level pressure and the 500-mb geopotential, correlation coefficients of around 0.76 were obtained for both elements for 48, 72, and 120 hour forecasts.

Mashkovich, S. A. On the theory of pressure waves in a baroclinic atmosphere.
Trudy Tsentral' nogo Instituta Prognozov, No. 111, 1962, pp. 13-27

The author has performed a linear analysis of the "filtered" equations (the meteorological equations from which both sound and gravity oscillations have been removed). His analysis treats multi-level models with a very high degree of vertical resolution -- four parameter in one case, and ten-parameter in another. He is thus able to study not only questions of stability of motion, but also the manner in which disturbances propagate vertically. He has performed analyses with a variety of initial conditions.

The work has little immediate bearing on the practice of NWP, but is aimed, rather, at understanding baroclinic mechanisms.

Mashkovich, S. A. and Ia. M. Kheifets

On Certain Characteristics of the Zonal Circulation of the Atmosphere Over the Northern Hemisphere during the International Geophysical Year.
Trudy Tsentral'nogo Inst. Prognozov, Vol. III, 1961, pp. 50-51.

Because of the wide use of the zonal circulation index in hydrodynamical methods of forecasting, particularly in the field of long-range forecasting, the authors present a tabulation of these values for various atmospheric levels for 1957, 1958, and 1959. This is in the form of a supplement to the above publication.

Musayelyan, Sh. A. Long-term Forecasts of Anomalies in the Vertical Air Speed Above the Northern Hemisphere of the Earth.
Doklady akademii nauk SSSR, Vol. 137, No. 1, 1961, pp. 72-75.

The techniques used in this investigation are for the most part those used by Blinova in the past. The vertical velocity computations are based on the scheme which utilizes the simplified vorticity equation; i.e., the form in which friction, vertical transport and the twisting terms have been neglected. A linearized form of this equation is obtained through usual perturbation approximations. Following the method used by Blinova in 1960 ("A Hydrodynamic Forecast of the Mean Monthly Temperature Anomalies for the Northern Hemisphere Obtained by Using International Geophysical Year Data," Doklady Akademii nauk SSSR, Vol. 131, No. 2, pp. 293-296) to obtain expressions for temperature and the mean (600 mb) stream function, the author proceeds to eliminate the tendency term and obtains a diagnostic equation expressing the departure from normal of the meridional part of the 600 mb vertical velocity in terms of the surface temperature and the 600 mb stream function.

Time averages of the anomalies were obtained over forecast periods of from 40 to 70 days. Two examples for March and June 1959 are presented together with observed precipitation amounts.

The computations were made at the Laboratory of Planetary Dynamics of the Atmosphere and Hydrodynamic Long-Range Weather Forecasting of the Institute of Applied Geophysics. The author further states that the forecasts for the entire Northern Hemisphere are made on an operational basis.

Nemchinov, S. V. The Forecasting of Pressure and Wind Fields in the Atmosphere.
Bulletin (Izvestiya) Academy of Sciences, USSR Geophysics Series, No. 7, 1961, pp. 704-709 (English ed.)

This is a very interesting article in which the author presents a method of forecasting the quantity pgz (p is pressure, z is isobaric height, and g the acceleration of gravity). The set of equations which is solved was also used by Kibel in a 1958 article titled "A Method of Short-Term Forecasting of Meteorological Elements." These equations consist essentially of the first two equations of motion in frictionless form, the continuity equation, and the adiabatic form of the thermodynamic equation in hydrostatic balance. In contrast to Kibel's article the wind is not separated into the divergent and nondivergent parts. Instead, the function $\hat{H} = \frac{p}{p_o gz}$ is introduced, where $\hat{H} = 0$ for $p = 0$ for an air column of infinite height. Expressions for u and v are obtained from the equations of motion. From the continuity equation

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial \bar{\tau}}{\partial \zeta} = 0 ,$$

where

$$\bar{\tau} = \frac{\zeta}{RT} \left[\frac{\partial}{\partial t} (\Phi) - gw + \mathbf{V} \quad \nabla\Phi \right]$$

and

$$\zeta = \frac{p}{p_o} ,$$

the function $\frac{\partial \bar{\tau}}{\partial \zeta}$ is obtained. The variable $\bar{\tau}$ is then eliminated from the thermodynamic equation and a single equation is obtained for z. Finally, an equation for the function $h = \hat{H}/C$, where C^3 is proportional to the stability is obtained. With boundary conditions for h, solutions are presented for cases where c = constant and $\frac{df}{dy} = 0$ and also for c = constant and $\frac{df}{dy} \neq 0$.

One difficulty with the method is that it requires calculating the initial divergence from the winds. The author states that machine analyses will achieve this. This is questionable. What advantage this method would have over the straightforward integration of the "primitive" equations is not known. Although the integration appears considerably complex, the author suggests a time step of 1 to 2 hrs.

Petrichenko, I. A. and M. V. Kartashova

On the Calculation of Observational Data at Certain Atmospheric Levels in an Objective Analysis of the Pressure Contour Map. Trudy Tsentral'nogo Inst. Prognozov, Vol. 111, 1961, pp. 39-43.

The results of an investigation of the accuracy of a geopotential objective analysis scheme is presented. Basically the method which is tested is one in which the geopotential is approximated by a second degree polynomial in x, y, and p (pressure). The coefficients were determined by the method of least squares. 850, 700, and 500 mb heights from six observing stations over a relatively small region in Russia were used for the tests. The interpolations obtained for the three levels were compared with those obtained from a simpler scheme in which the geopotentials were approximated by a second degree polynomial in x and y independently for each level. From 457 cases tested it was found that a better "fit" was obtained from the three-dimensional scheme for 500 mb. However, the simpler two-dimensional approximation was superior at 850 mb. Ths mean absolute height difference between analyzed and observed values from all cases from the spatial method was 7.3, 7.7, and 10.2 meters for the 850, 700, and 500 mb levels, respectively. Similarly those from the two-dimensional scheme were 5.9, 7.4, and 12.1 meters.

The computations were performed by the computer "Weather." An assumption in the scheme presented here was that all stations considered reported heights of all three levels for each case. Thus, the computations of the coefficients does not vary. Wind observations were not considered.

Romov, A. I. Numerical Wind Forecast in the Free Atmosphere by Means of Electronic Digital Computers. Materials of the Conference of the Coordinating Commission of Numerical Forecast Methods, 1961, pp. 71-87

An interesting formulation of the general filtered equations is presented together with a description and results of a wind prediction model. The frictionless form of the horizontal equations of motion (in which the vertical transport terms are neglected) and the continuity equation are used to obtain a form of the vorticity and divergence equations. These equations contain first order horizontal derivatives of the quantities $\frac{du}{dt}$ and $\frac{dv}{dt}$. Here

$$\frac{d}{dt} = \frac{\partial}{\partial t} + u \frac{\partial}{\partial x} + v \frac{\partial}{\partial y}$$

and u and v are the horizontal wind components. Through further differentiation expressions are obtained for the horizontal Laplacian of these quantities. Through a scale theory argument the equations are simplified by neglecting the smaller terms. The thermodynamic equation is used to eliminate the pressure vertical velocity from these equations. The geopotential does not appear explicitly.

Thus it is argued that these two equations can be used to obtain the quantities $\frac{du}{dt}$ and $\frac{dv}{dt}$ given the u and v wind fields, and $\frac{\partial u}{\partial t}$ and $\frac{\partial v}{\partial t}$ can be obtained from the equations of motion.

Boundary conditions for the frictionless adiabatic case are presented. The author further presents a method of consecutive approximations for determining suitable initial wind fields. However, this procedure has not been tested.

Tests of the model were made for the case of a barotropic atmosphere. The Poisson equations (for $\frac{du}{dt}$ and $\frac{dv}{dt}$) were solved through use of a Green's function method. The geostrophic winds were used for the initial wind fields, the grid interval was 300 km, and a 24-hr forecast was obtained for 700 mbs over Europe and Western Asia. A forward time step of 1 hour was used. Calculations were performed on a "KIEV" computer. One forecast example was presented.

Shekhtman, Ye. D. On the Problem of Forecasting the Pressure Field at High Altitudes.
Trudy Kazakhstanskogo Nauchno - isslyedovatyel'skogo Gidrometeorologicheskogo Instituta, Vol. 15, 1960

The author's reference to "high altitude" is the height of the 300 mb pressure surface. From a simplified form of the geostrophic approximation of the vorticity equation,

$$\nabla^2 \frac{\partial z}{\partial t} + J\left(z, \frac{g}{f} \nabla^2 z + f\right) = \frac{f^2}{g} \frac{\partial \omega}{\partial p},$$

the author points to the importance of the "vertical velocity" profile, $\frac{\partial \omega}{\partial p}$. Here $\omega = \frac{dp}{dt}$, z is the height of the isobaric surface, g is the gravitational acceleration, p is pressure, and f is the Coriolis parameter. Since vertical velocity measurements were not available, they were estimated from a scheme based on the hypothesis that the increase of the humidity - saturation level with height indicates ascending motion while a decrease indicates descending motion. (The validity of this hypothesis is questionable.) To by-pass relaxation or other more complicated methods of solution of the above equation, an extreme simplification is made. The resulting forecasting equation is one in which the 300 mb tendency is dependent upon the geostrophic advection of absolute vorticity, the vertical velocity profile, and the 300-700 mb thickness tendency. The sign of the 300 mb 24-hr tendency coincided with the sign of the 300-700 mb 24-hr thickness tendency in 80% of the 368 cases tested for February 1959. However, no mention is made of a method to estimate the thickness tendency.

Tseng Ching-Ts'un Application of a Complete System of Thermo-hydrodynamic Equations for Short-term Weather Forecasts by Means of a Two-level Model.
Doklady Akademii nauk SSSR, Vol. 137, No. 1, 1961 pp. 76-78

In 1960 Kibel proposed a short-range weather forecasting scheme ("A Finite-Difference Scheme for the Solution of the Complete System of Equations of Short-range Weather Forecasting and the Quasi-geostrophic Relation," Doklady Akademii nauk SSSR, Vol. 132, No. 2, pp. 319-322). The present paper is a report of an application of this scheme to a two-level model -- 250 and 750 mbs. Effects of friction, mountains and non-adiabatic heating are neglected. The equations of motion are applied at the two levels, and the thermodynamic equation differentiated with respect to pressure is applied near 500 mbs. Introducing the vertical finite differences and denoting with subscripts 1, 2, and 3 for the 250-, 500-, and 750-mb levels, respectively, prognostic equations are obtained for $U = (u_1 + u_3)/2$, $V = (v_1 + v_3)/2$, $u = (u_1 - u_3)/2$, $v = (v_1 + v_3)/2$ and $h = (\Phi_1 - \Phi_3)/2$. Diagnostic equations for $H = (\Phi_1 + \Phi_3)/2$ and ω_2 are utilized. Here u and v are the horizontal wind components, Φ is the geopotential, and ω is the p-vertical velocity. The scheme was programmed for the BESM-2 computer and several 24-hr forecasts were made. The time increment used was 30 minutes and the grid interval was 300 km. No forecast results were presented. In contrast to the 30-minute time increment used here, the value generally used in non-Soviet Bloc research in non-geostrophic formulations is about 10 minutes. This has been required to prevent computational instability.

Tszen Tsin-Tsun' and Chju Yun-Tee

The Non-linear Problem of Atmospheric Motion on a Planetary Scale.
Izv. Akad. Nauk SSSR, Ser. geograf. i geol., No. 1, 1961, pp. 98-99 (English ed.)

Modeling techniques made by Blinova ("A Method of Solving the Non-linear Problem of Atmospheric Motion on a Planetary Scale," Proc. [Doklady] Acad. Sci. USSR, Vol. 110, No. 6, 1956) are considered in a (θ, λ, ζ) - system of coordinates. Here θ is the colatitude, λ is the longitude and $\zeta = p(\theta, \lambda, z, t)/P$, z is height, t is the time, and P is the standard sea level pressure. The vertical velocity was eliminated from the vorticity and thermodynamic equations as used by Blinova. An expression for $\frac{\partial \psi}{\partial t}$ (ψ is the stream function) was obtained. An adiabatic form of the thermodynamic equation, in which the vertical velocity was assumed to be proportional to the stream function tendency and the static stability was invariant, was applied at the lower boundary. The introduction of the lower boundary static stability yielded an insignificant correction to the value and character of the Green's function.

Uspenskiy, B. D. Forecasting the Evolution of Low-Level Cyclones and Anticyclones.
Meteorologiya i Gidrologiya, No. 1, 1961, pp. 11-15.

Through careful analysis of winds, heights, and pressures at 12 synoptic times in 1958, the author has attempted forecasting 22 cases of surface cyclogenesis and anticyclogenesis (presumably over Europe and Asia). By obtaining estimates of the horizontally and vertically averaged divergence, vorticity, and stability directly in the vicinity of the expected development, the author reports that the techniques involved produced correct predictions of the sign (pressure rise or fall) 86.4% of the time for 24-hr forecasts.

The techniques described require extremely accurate analyses of the fields at 1000, 850, and 700 mbs. In addition, the approximate mean radius of the formation is required initially.

V. V. Vykov and G. P. Kurbotkin

The Objective Analysis of Aerological Data.
Izv. Akad. Nauk SSSR, Ser geograf. i geol., No. 2, 1961, 196-203, 1961, (English ed.)

An objective (machine) analysis of aerological data for the numerical forecast of meteorological elements is discussed. A computation scheme of the analysis is described, and peculiarities of the programming for the electronic computer "Strela" are pointed out. A computation example is given. Results of the objective analysis of aerological charts are used for numerical forecasting.

The scheme described by the authors is one in which the geopotential height of the constant pressure surfaces are represented in the vicinity of each grid point by a polynomial of the third degree in x and y. The method of least squares is used to obtain the coefficients. The winds are assumed to be geostrophic. The calculations were performed on a rectangular grid (20 rows of 24 points) which covered a portion of the North Atlantic, Europe, and Western Asia. The grid interval was 250 km.

The objective analysis was first made for the grid point immediately surrounded by the maximum number of upper air observations and thence from grid point to grid point in the order of decreasing amounts of surrounding data. The analysis of one point requires about 10 seconds of machine time. Analyses compare favorably with those made by conventional methods, but in the vicinity of centers of highs and lows the amplitudes are suppressed by the objective analyses.

Analyses of geopotential heights were made for the 850-mb, 700-mb, and 500-mb levels and 500-1000 mb thickness. Temperatures, dew-points, and winds were also analyzed. The results of a winter and spring case were used as initial data for machine forecasts on the BESM-2 computer. The forecast results were not presented. However, the authors mentioned that the results did not differ substantially from those made using subjective analyses.