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USSR Report

METEOROLOGY AND HYDROLOGY

No. 2, February 1982

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Translation of the Russian-language monthly journal METEOROLOGIYA I GIDROLOGIYA published in Moscow by Gidrometeoizdat.

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UDC 551.588.7

THEORY OF ANTHROPOGENIC EFFECTS ON LOCAL METEOROLOGICAL PROCESSES IN CITY

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 15 Aug 81) pp 5-16

[Article by M. Ye. Berlyand, professor, and M. N. Zashikhin, Main Geophysical Observatory]

[Abstract] A study was made of an urban heat island, with emphasis on formulation of a theory of change in air temperature and humidity, as well as wind velocity and the radiation regime in a city, and also the diurnal variation and interrelationship of these parameters. Allowance is made for the advective influence of air flow onto an urban territory from its neighborhood. The mathematical formulation of the problem of modeling urban microclimate is based on solution of a system of equations for the influx of heat and moisture in the atmosphere, thermal conductivity of the soil, continuity equation and equation of motion. The initial parameters for solving the problem are velocity of the geostrophic wind, mean daily temperatures of the underlying surface and the gradient of vertical temperature decrease in the air and soil, the degree of moistening of the underlying surface, as well as the thermal conductivity and heat capacity coefficients, both in the city and outside it. In solving the radiation part of the problem it is necessary to stipulate the optical thickness and certain radiation characteristics of urban air basin contamination. A series of 6 examples with different parameters was investigated. The computed values of the intensity of the heat island, the nature of its change in the course of the day in its annual variation, and also the dependence on wind velocity, altitude, etc., agree well with the known results of numerous observations. Among the factors taken into account in the model are air contamination, the degree to which the city is built up, changes in the characteristics of heat and moisture exchange and release of heat due to economic activity. Such computations and their analysis made it possible to examine differences in the diurnal fluctuations of air temperature, wind velocity and exchange coefficient, as well as the development of radiation fogs in the city and outside it. Figures 3; references 19: 10 Russian, 9 Western.

UDC 551.509.314+551.547.3(215-17)

INVESTIGATION OF STABILITY OF REGRESSION SCHEME FOR PREDICTING H_{500} FIELD FOR NORTHERN HEMISPHERE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 3 Jul 81) pp 17-25

[Article by V. A. Steblyanko, candidate of physical and mathematical sciences, and A. A. Burtsev, USSR Hydrometeorological Scientific Research Center]

[Abstract] In most statistical weather forecasting schemes there is an increase in the prediction error with transition from a dependent to an independent sample because the evaluations of the correlations between the predicted parameter and the set of predictors obtained empirically using a dependent sample do not have adequate stability. The authors have attempted to solve the problem of formulating a forecasting scheme which insofar as possible takes into account the limited nature of the sample and nonstationarity. The scheme has an adaptive character (its parameters can be adjusted in dependence on newly arriving information). The problem is solved by a combination of the "moving control" and "screening" methods. The example considered here is a variant of prediction of the mean monthly H_{500} field, as the predictors taking some parameters characterizing the preceding months. As possible predictors use was made of the expansion coefficients for the OT_{1000}^{500} field in the latitude zone 40-75°N on the basis of mixed polynomials (Chebyshev polynomials along the meridian and trigonometric functions along the circles of latitude) and the coefficients of expansion of the H_{500} field in the polar region in natural orthogonal functions. An algorithm is proposed for investigating the asymptotic behavior of the parameters of the vector of regression coefficients. This algorithm is based on the Robbins-Munro stochastic approximation procedure. Evaluations of the quality of forecasts with choice of the predictors only by the "screening" method and also by the "screening" method in combination with "moving control" are given. Tables 1; references: 7 Russian.

UDC 551.509.313

STATISTICS OF ERRORS IN PREDICTING GEOPOTENTIAL

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 25 May 81) pp 26-32

[Article by A. M. Babaliyev and V. V. Kostyukov, candidate of physical and mathematical sciences, Karaganda State University and West Siberian Regional Scientific Research Institute]

[Abstract] An attempt is made to study the errors in two specific prognostic models presently being used in the USSR on the basis of a series of statistical characteristics. The first model is a hemispherical model based on primitive equations, making it possible to obtain forecasts for a hemisphere (Ye. Ye. Kalenkovich, et al., CHISLENNYYE METODY RESHENIYA ZADACH PROGNOZA POGODY I OBSHCHEY TSIRKULYATSII ATMOSFERY, Novosibirsk, VTs SO AN SSSR, 1970). The following statistical parameters were used: relative error, correlation coefficient between two random values, evaluation of similarity of evolution of fields of predicted and actual trends, mean square error, mean arithetical error, "signal noise," equal to the ratio of the dispersions of the field of errors and the actual field, mean values M_{at}, M_{pt} and the standard deviations σ_{at} and σ_{pt} of the actual and predicted trends. These evaluations were computed separately for different physiographic regions. Six regions were defined. Table 1 gives the mean values of the evaluations for two- and three-day predictions of geopotential at the 500-mb level. The success differed considerably for different regions. The relative errors of two-day forecasts were minimum for Europe, and for three-day forecasts -- for North America, whereas the greatest errors were for the Pacific Ocean area. Also considered, on the same principles and employing the same statistical criteria, was a model for a limited territory (regional model) (G. R. Kontarev, IZV. AN SSSR: FIZIKA ATMOSFERY I OKEANA, Vol 11, No 3, 1975). This model is also based on primitive equations and was developed for the Novosibirsk region. A table gives evaluations of daily forecasts with the regional model for the 500-mb surface. In both cases there is a discussion of the problems involved in taking the errors into account in order to increase the quality of forecasts. Figures 4, tables 4; references: 7 Russian.

UDC 551.509.314+551.55

PARAMETERS OF STATISTICAL MONITORING OF VERTICAL WIND PROFILE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 26 May 81) pp 33-37

[Article by S. I. Gubanova and S. M. Olevskaya, candidates of physical and mathematical sciences, USSR Hydrometeorological Scientific Research Center]

[Abstract] It is more difficult to monitor the wind than geopotential or temperature. However, due to the recent availability of new data on the statistical structure of wind components the authors undertook computations of the appropriate parameters for monitoring wind components at nine isobaric levels from 1000 to 100 mb. In seeking the parameters for vertical statistical monitoring by the optimum interpolation method used was made of the detailed data on vertical statistical structure of wind components in V. D. Kaznacheyeva, et al., "Generalized Characteristics of Vertical Wind Correlations Over the USSR," PRIMENENIYE STATISTICHESKIKH METODOV V METEOROLOGII, Moscow, Gidrometeoizdat, 1978. Since there is a dependence of the interlevel correlations of wind components on season and latitude (the zones 45-60°N, north of 60°N and south of 45°N are defined), computations were made separately for these latitude zones for winter and summer. A table gives the computed monitoring parameters for both components for January and July. This table reveals that the influence of season on the values of the weighting factors a_i, b_i in the key formula is insignificant, especially for the zonal component and can be neglected for all zones and both components. However, there is a dependence of a_i, b_i on latitude. If the zone $\varphi < 45°$ is excluded, for the two remaining zones it is possible to use the same interpolation weights. It is shown that the a_i, b_i values can be employed in experimental computations in a vertical statistical monitoring scheme. In a sample test with use of actual data from 173 stations in the Soviet Union it was found that the standard deviations of the zonal and meridional wind components were from 4 to 20 m/sec. Vertically these parameters change approximately identically; they increase with altitude to some level near 200-300 mb and decrease aloft. Tables 2; references 8: 7 Russian, 1 Western.

UDC 551.571(571.1)(574)

SPATIAL STRUCTURE OF HORIZONTAL FLOW OF ATMOSPHERIC MOISTURE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 25 May 81) pp 38-44

[Article by L. P. Kuznetsova and N. P. Chernova, candidates of geographical sciences, Institute of Water Problems]

[Abstract] The authors have endeavored to apply the aerological method in computing the water balance elements of river basins of different areas and evaluating the feasibility of the objective interpolation method in studying the spatial structure of the horizontal flow of atmospheric moisture in the basins of the Ob' and Irtysh Rivers. In this article emphasis is on determination of the space correlation functions for the flow of atmospheric moisture. Much of the article is devoted to determination of the values of the correlation coefficients for the latitudinal and longitudinal space correlation function in different distance gradations for the four seasons of the year. It was found that the fields of components of the flow of atmospheric moisture have a clearly expressed anisotropy caused by the seasonal characteristics of circulation of air masses. It is further shown that the space correlation functions, computed independently of direction, provide no adequate information on the structure of the spatial correlations in the moisture transfer field. They are suitable only for very approximate computations and for short distances. In the considered region this distance is 800-1000 km, approximately corresponding to the width of the zone of intensified westerly transfer. Correct computations of the horizontal moisture flow require the use of a system of space correlation functions computed for individual components of the moisture flow and for different directions. Figures 1, tables 3; references 9: 8 Russian, 1 Western.

UDC 551.510.534

PARAMETERIZATION OF FLUCTUATIONS OF STRATOSPHERIC OZONE CONTENT

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 4 May 81) pp 45-50

[Article by O. M. Pokrovskiy, candidate of physical and mathematical sciences, and A. Ye. Kaygorodtsev, Main Geophysical Observatory]

[Abstract] In this study of the parameterization of fluctuations of stratospheric ozone concentration the initial data used were the mean monthly fields of total ozone content during a 10-year observation period 1957-1967 in the northern hemisphere in a regular grid. Then using the Bozhkov latitudinal-seasonal regression method it was possible to reconstruct the mean ozone concentration (to be more precise, its partial pressure) in nine atmospheric layers situated between altitudes 5 and 45 km. Computations were made for a 10-year sample for the northern hemisphere for two seasons -- winter and summer. In summer the maximum concentration falls in the low latitudes in the middle stratosphere where processes of photochemical reproduction of ozone are most intensive. In winter there are two anomalous regions of maximum concentrations. The first is the high-latitude region where a large quantity of ozone is accumulated, transported by meridional circulation. The second is the tropical zone where the processes of photochemical reproduction of ozone and its transport from the southern hemisphere are important. Maximum turbulent transport is in the high-latitude region, whereas transport by stationary waves predominates in the temperate latitudes. Ozone is transported from the summer hemisphere into the winter hemisphere by mean meridional circulation and toward the poles by turbulent dynamics. Both the stationary and turbulent components of ozone concentration fluctuations are approximated quite well by empirical orthogonal functions. The first three empirical orthogonal functions satisfactorily describe the spectrum of natural variations in the meridional section. Figures 3, tables 1; references 9: 1 Russian, 8 Western.

UDC 551.465.7:551.513(261)(215-17)

EFFECT OF WATER TEMPERATURE ANOMALY IN NORTH ATLANTIC ON CIRCULATION, THERMAL REGIME AND MOISTURE CYCLE IN NORTHERN HEMISPHERE ATMOSPHERE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 27 May 81) pp 51-62

[Article by V. P. Meleshko, candidate of physical and mathematical sciences, and A. P. Sokolov, Main Geophysical Observatory]

[Text]

Abstract: A model of general circulation of the atmosphere was used in investigating the influence of the water temperature anomaly in the North Atlantic on general circulation, thermal regime and moisture cycle in the atmosphere. A positive anomaly is stipulated in the zone of active thermal interaction between the atmosphere and the underlying surface, situated in the northeastern part of the Atlantic Ocean. The state of the atmosphere in the northern hemisphere in January was computed by means of integration of a system of equations for a period of two months, with and without allowance for the water temperature anomaly. The article gives a detailed comparative analysis of atmospheric characteristics for the northern hemisphere and individual regions on the European continent.

Introduction. Recently a number of interesting investigations directed to study of large-scale interaction between the atmosphere and ocean and evaluation of the influence of water temperature anomalies in the upper layer of the ocean on general circulation and thermal regime of the atmosphere have been carried out.

Bjerknes [19, 20] established that the formation of a positive thermal anomaly in the equatorial zone of the Pacific Ocean is accompanied by an intensification of the zonal current in the middle-latitude atmosphere in winter. In his opinion, this correlation is governed by an increase in ascending movements and water vapor condensation over the region of the anomaly, causing an intensification in meridional circulation in the Hadley cell and an increase in the transport of the moment of momentum from the low latitudes into the middle and high latitudes. In the example of anomalous weather conditions over the northern part of the Pacific Ocean and North America Namias [25-27] demonstrated that there is a correlation between atmospheric processes over these regions and water temperature in the northern and central regions of the Pacific Ocean. He also established that in a number of cases water temperature anomalies of a considerable extent can persist for a period of several months and therefore data on them are of definite prognostic value.

The problem of the influence of the North Atlantic on the formation of average weather conditions over Europe and the territory of the USSR has been examined in numerous Soviet and foreign studies. In most of these studies attempts have been made to establish synchronous and asynchronous statistical correlations between the thermal regime of the North Atlantic and atmospheric circulation, on the one hand, and weather conditions over Europe and the European USSR, on the other. For example, V. G. Semenov [15] established that during the winter months when there is a negative temperature anomaly in the northern part of the Atlantic Ocean (to the west and southwest of Iceland) a zonal circulation is observed over Europe, whereas when there is a positive anomaly there is an intensive meridional transport of air masses. He noted the existence of a feedback between water temperature anomalies in the northern regions of the ocean and air temperatures over the European USSR in winter and their relatively weak direct correlation during the summer months. It was noted in a study by S. T. Pagava, et al. [13] that in order to detect the correlation between the thermal state of the North Atlantic and air temperature in Europe it is extremely important to take into account not only heat exchange between the ocean and the atmosphere, but also information on the type of synoptic processes. In another study [14], S. T. Pagava formulated the conditions under which there are direct and inverse relationships between air temperature in Europe and water temperature in the North Atlantic.

On the basis of observational data Ratcliffe and Murray [28] established that the development of blocking anticyclones over Western Europe and Scandinavia is associated with the appearance of negative anomalies over an extensive area of the ocean to the south of Newfoundland and passage of active cyclones was associated with the formation of a positive anomaly. Among the other studies in this direction here we should mention as well the investigations made by A. N. Kryndin [8], A. L. Kats, et al. [6], N. A. Bagrov and N. I. Mertsalova [2], A. L. Duytseva and D. A. Ped' [5], A. I. Ugryumov and A. P. Krupyanskaya [16], L. V. Klimenko and L. A. Strokina [7].

Although the important role of the ocean in the formation of weather on the continents, especially over Europe, has been confirmed by numerous investigations and a great number of different prognostic procedures have been proposed, the basis for which has been the correlations between individual characteristics of the ocean and atmosphere, the quality of long-range forecasts still remains unsatisfactory. The reason for such a situation is evidently the extreme diversity of the processes of thermodynamic interaction both in the atmosphere itself and in the ocean-atmosphere system caused by the operation of mechanisms with feedbacks.

A number of hypotheses have been proposed in which the long-observed development of anomalous weather conditions over individual regions of the earth can be attributed to such factors as the development of stable anomalies in the upper layer of the ocean, the anomalous extent of sea ice and snow cover on the continents, etc. Among the investigations in which a study was made of the influence of water temperature anomalies in the Pacific Ocean on atmospheric circulation and certain hypotheses explaining the formation of anomalous states of the atmosphere over the North American continent and other regions of the earth were checked we should mention the studies of Spar [30, 31], Chervin, et al. [21], Kutzbach [22], Rowntree [29], Shukla and Bangaru [32]. The studies of G. I. Marchuk, et al. [9, 10] proposed a mathematical approach based on integration of the conjugate equations of hydrothermodynamics of the atmosphere and ocean which makes it possible to describe some asynchronous relationships between the atmosphere and ocean and to determine thermally active regions in the world ocean, exerting a considerable influence on the formation of macroscale air temperature anomalies over individual regions of the earth.

The Soviet program "Razrezy" will be an important contribution to study of the processes of interaction between the ocean and the atmosphere for the purpose of establishing a correlation between thermal and dynamic anomalies in the ocean and formation of anomalous thermal and circulation regimes in the atmosphere. Implementation of this program has already begun. Our investigation was carried out in accordance with the plan for work under the mentioned program.

Model of Atmosphere and Formulation of Experiment

The objective of our investigation was an evaluation of the influence of the water temperature anomaly in one of the regions of active thermal interaction between the atmosphere and ocean, situated in the North Atlantic, on general circulation, thermal regime and moisture cycle in the atmosphere.

Fig. 1. Distribution of total heat flow (turbulent flow and heat losses in evaporation) computed using atmospheric model for January (W/m^2). Regions in which heat flow is over 180 W/m^2 are shaded.

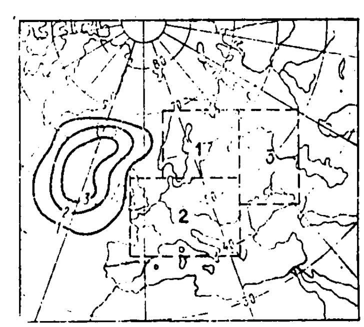


Fig. 2. Position of region with water temperature anomaly (°C). The dashed line defines three regions on the European continent.

Some information on regions of an active thermal effect can be obtained from the HEAT BALANCE ATLAS [1], which gives the distributions of turbulent heat flows and heat expenditures on evaporation, computed for different months of the year. According to the maps cited in the atlas, during the cold season of the year the greatest total heat flow values, including the turbulent heat flow and expenditures of heat on evaporation, are situated along the eastern shores of the Asiatic and American continents, and also in the tropical zone.

Figure 1 shows the distribution of the mean total heat flow, computed by means of a model of general circulation of the atmosphere for January conditions. Figure 1 shows the distribution of heat flows to the atmosphere as a whole to be in agreement with [1], although the region of great heat flows in the North Atlantic in the model was displaced in the direction of the European continent. Accordingly, for stipulating of ocean surface temperature anomalies we selected a region situated in the northeastern part of the Atlantic Ocean in which the computed total heat flows entering the atmosphere from the underlying surface were the greatest (see Fig. 2).

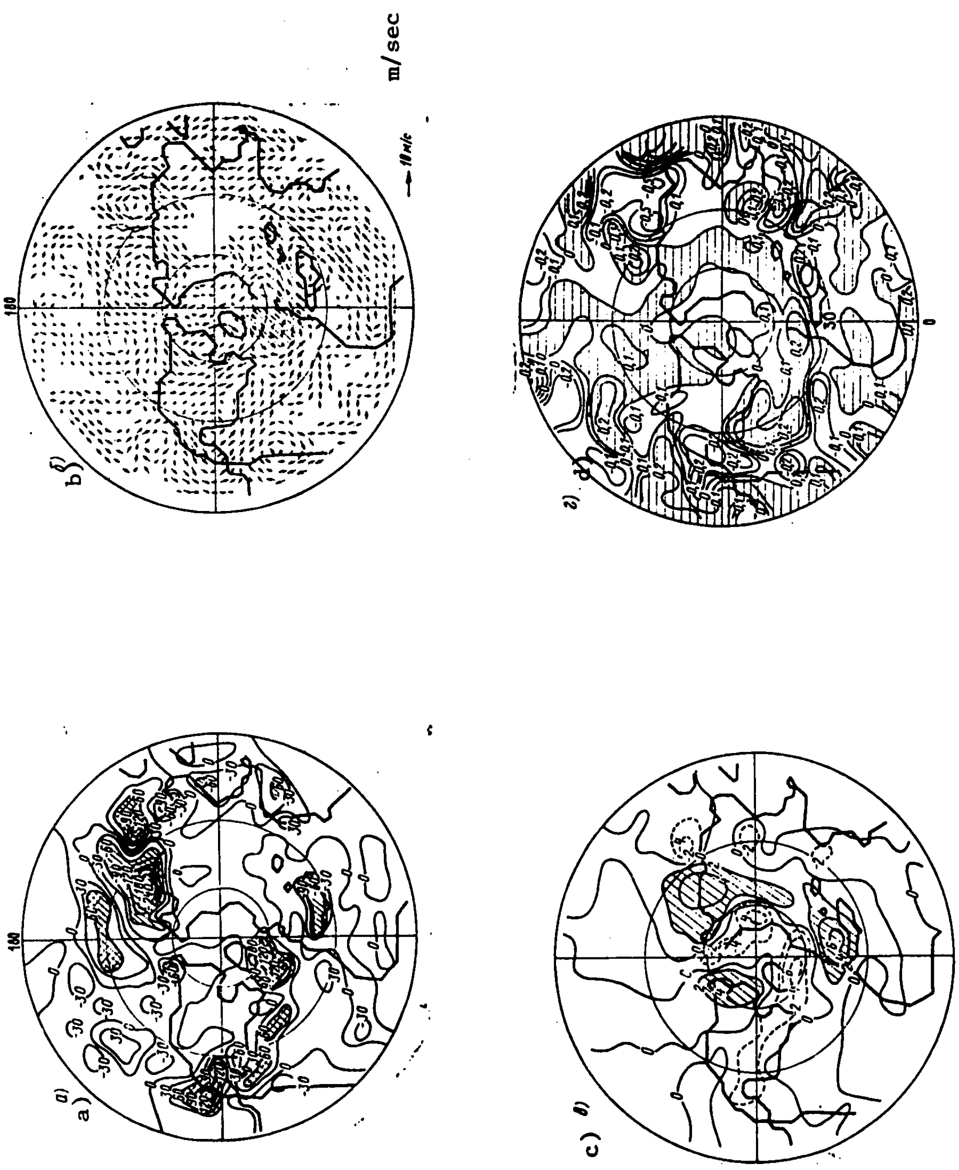
The investigation was made using a model of general circulation of the atmosphere developed at the Main Geophysical Observatory imeni A. I. Voyeykov. Detailed information on the model is given in [11] and therefore it will only be described briefly.

The model has three layers of equal mass; the integration region is a hemisphere. The geographical distribution of the continents and their relief is taken into account. The mean horizontal grid interval is 425 km.

The model makes use of a full system of equations in hydrothermodynamics in an σ-coordinate system. The principal physical processes operative in the atmosphere are taken into account: transport of solar and long-wave radiation, turbulent exchange in the boundary layer, macroscale condensation and convection, hydrological regime of the active soil layer and mesoscale diffusion. The flux of solar radiation reaching the upper boundary of the atmosphere is computed taking into account the temporal change in mean daily solar altitude. The quantity of two-level clouds is determined using empirical expressions on the basis of the relative humidity values in the corresponding layers of the atmosphere computed in the model.

An evaluation of atmospheric response to water temperature anomalies at the ocean surface was made in two numerical experiments. In the first of these the water temperature was assumed equal to its climatic value (with seasonal changes taken into account). Henceforth for convenience in exposition we will call this experiment the control (CE). In the second experiment the values of the anomalies were added to the climatic water temperature values in the region shown in Fig. 2. Both the value of the anomaly itself and the horizontal extent of the region of its stipulation were considered constant during the entire integration time. We will call these computations an experiment with an anomaly (AE).

In each experiment the system of equations was integrated for 60 days with the use of real initial data, which corresponded to 1 December. The computations were analyzed for the period from 31 to 60 days of the forecast, corresponding to January.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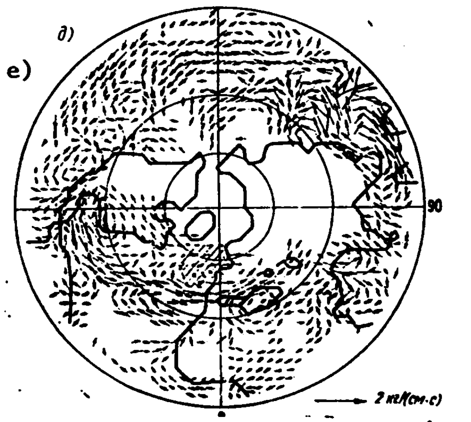


Fig. 3. Differences between values computed using data from AE and CE experiment for 31st-60th days of forecast. a) total heat flows H + LE (W/m^2) at underlying surface. (The regions in which the differences in heat flows are greater than 60 W/m^2 are denoted by dense shading and the regions in which the differences are less than 60 W/m^2 are denoted by light shading); b) wind velocity vector (m/sec) at level σ = 0.5. (Region with anomaly is cross-hatched); c) temperature at level σ = 0.833 (°C); d) intensity of precipitation (cm/day). (Regions with positive values of the difference are cross-hatched); e) velocity vector of horizontal moisture transport (g/(m/sec)) in atmospheric layer 660-1000 gPa. (Region with water temperature anomaly is cross-hatched).

In discussing the results it must be remembered that the differences between the variables represented in the figures were obtained by subtracting the values computed for the CE experiment from the corresponding values obtained in the AE experiment.

Change in Circulation, Thermal Regime and Moisture Cycle in Northern Hemisphere Atmosphere

In the formation of a positive water temperature anomaly the lower layers of the troposphere began to receive additional heat over the region with an anomaly due to an increase in the vertical transport of turbulent heat and the latent heat of condensation. The quantity of the additional heat influx is dependent on changes in the vertical drop in temperature and specific humidity, and also on stratification of the lower layer of the troposphere.

Table 1

Quantity of Turbulent Heat Flow H and Heat Losses in Evaporation LE, Computed in AE and KE Experiments for 31-60 Days of Forecast Over Region With Water Temperature Anomaly

Heat flow, W/m^2	CE	AE
H	81	206
LE	139	195

Table 1 shows that as a result of the effect of these anomalies the total heat flow increased by a factor of 1.8. This change occurred for the most part due to an increase in the turbulent heat flow.

It is interesting to note that with an increase in water temperature by 1°C the computed changes in the heat flows considerably exceed the corresponding changes in the flows obtained in [22] for the northern part of the Pacific Ocean. This is evidently attributable to the fact that the thermal interaction between the atmosphere and ocean in the northeastern part of the Atlantic Ocean is more intensive than in the northern and northeastern regions of the Pacific Ocean (see Fig. 1).

The computed changes in some characteristics of the moisture cycle, and also the thermal and circulation regime of the northern hemisphere as a result of the effect of ocean temperature anomalies, are shown in Fig. 3.

Although the general picture was quite complex, from a comparative analysis of the cited fields it is possible to establish a number of interesting peculiarities.

Considerable changes in the total heat flow were obtained not only in the water temperature anomalies, but also in other regions of the northern hemisphere. The greatest changes in the heat flows are concentrated in regions of active thermal interaction between the atmosphere and the underlying surface situated in the Atlantic and Pacific Oceans (Fig. 3a).

A macroscale cyclonic eddy in the field of differences in the horizontal velocity vector, whose axis is somewhat tilted to the east with an increase in altitude, is formed over the region with the anomaly (Fig. 3b). Macroscale eddies with cyclonic or anticyclonic rotation in the field of differences in the horizontal velocity vector are observed in other regions of the northern hemisphere. The most intense eddies are formed near the eastern shores of the continents, that is, over regions of active thermal interaction between the atmosphere and the ocean surface.

It can be noted from a comparison of Figures 3a and 3b that the formation of cyclonic eddies in zones of active thermal interaction is closely associated with the sign of the difference in total heat flows: positive flow differences correspond to cyclonic eddies and negative flow differences correspond to anticyclonic eddies.

The air temperature in the lower troposphere increases to the southeast of the region with the anomaly and decreases to the north of it (Fig. 3c). Air temperature changes which are large in absolute value and different in sign are observed at considerable distances from the North Atlantic. It should be noted that the regions of increase (decrease) in temperature agree well with the corresponding regions of decrease (increase) in pressure, reduced to sea level. Large pressure differences are observed primarily over the continents in the middle and high latitudes. The Icelandic and Aleutian Lows were somewhat transformed: the first extended in the direction of Western Europe, the extent of the second decreased. An example of the important role which is played by circulation factors in formation of the thermal regime of the atmosphere is the temperature distribution directly over the region of the ocean surface temperature anomaly. In the northern part of this region, at altitudes of about 1.5 km, there is a rather considerable decrease in air temperature which is associated, as indicated by Fig. 3b, with the formation of the mentioned cyclonic cell, and as a result, with the transport of cold air masses into the Atlantic Ocean area from the northern part of the European continent.

The problem of why in the AE experiment there was a change in the circulation and thermal regime of the atmosphere in regions situated at a considerable distance from the North Atlantic is quite complex. One of the possible explanations of this phenomenon is as follows.

The heating of the lower layer of the troposphere over the region with the water temperature anomaly favored a decrease in air density in a column of the atmosphere and a redistribution of mass in the northern hemisphere. This was the reason for some change in circulation. Since the water temperature did not change over other parts of the oceans in the AE experiment, the turbulent flows of heat and the expenditures of heat on evaporation could change only as a result of a change in wind velocity, air temperature and humidity in the lower troposphere. These changes to a great extent are dependent on stratification of the planetary boundary layer. The greatest heat flow changes can be expected in zones of active thermal interaction, where the stratification of the lower layer is unstable in comparison with other regions. As a result, the initially arising changes in circulation and the thermal regime in the lower troposphere can increase over the zones of active thermal interaction as a result of the influence of mechanisms with positive feedbacks.

The fact that substantial changes in pressure and temperature are observed not only near the region with the water temperature anomaly, but also at a considerable distance from it, serves as a confirmation of the well-known hypothesis of the existence of a conjugate character of atmospheric processes in individual regions of the earth. For example, Spar [31] noted that in the modeling of global circulation with a water temperature anomaly in the northern part of the Pacific Ocean considerable pressure changes were discovered in the middle latitudes of the southern hemisphere.

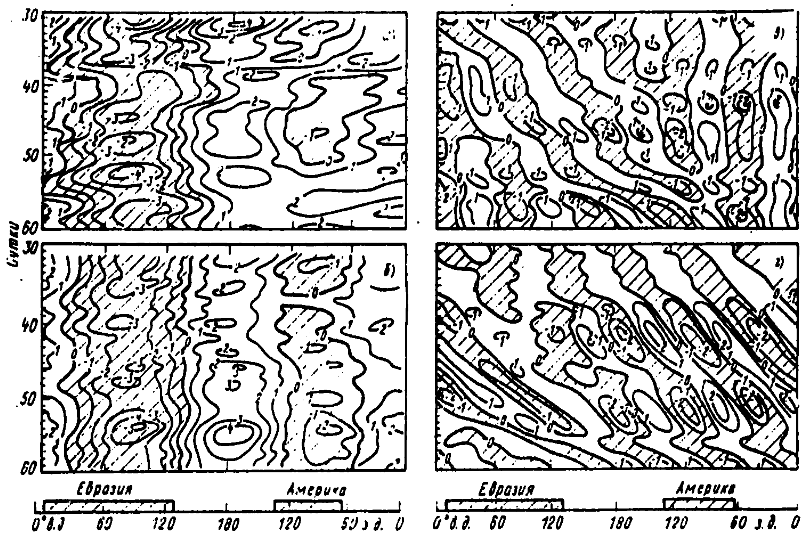
An analysis of the results of computations also reveals that in regions with the greatest air temperature differences, which are situated primarily over the continents, the greatest temperature dispersion values also occur. These features are in qualitative agreement with the empirical investigations carried out earlier. For example, on the basis of an analysis of the natural orthogonal functions for the temperature and pressure fields in the northern hemisphere M. I. Yudin [18], A. V. Meshcherskaya, et al. [12] studied oscillatory processes on a planetary scale. In the temperature and pressure fields there was found to be a number of nodes of different sign which resemble standing waves in the atmosphere of the thermopressure seiche type described by V. V. Shuleykin [17]. A study by E. I. Girskaya [4] also revealed macroscale temperature variations in individual regions of the northern hemisphere for different months.

Figures 3d and 3e give the differences in the intensity of precipitation and the vectors of horizontal transport of moisture in the atmospheric layer 600-1000 gPa. Figure 3d shows that the zone of a considerable increase in precipitation in the AE experiment is situated along the southern regions of the European continent and over the greater part of the North Atlantic. It is noteworthy that an increase in precipitation occurred not only to the east of the anomaly, but also in a westerly direction as far as the North American continent, that is, opposite the main west-east transport of air masses.

Figures 3b and 3e show that in addition to the formation of a cyclonic eddy an eddy of similar intensity was formed over the second region of active thermal interaction between the atmosphere and ocean situated in the region of the Gulf of Mexico (see Fig. 1). As a result, these two eddies formed an intercontinental circulation cell whose northern branch carries cold air onto the North American continent from the eastern regions of Europe and the polar basin, whereas the southern branch transports warm and moist air from the region of the Gulf of Mexico onto the European continent and then to the Caspian Sea. As a result of intensification of the zonal wind component along the southern branch of the circulation cell evaporation from the ocean surface also increased in this zone.

Extensive regions with considerable differences in precipitation are observed in other regions of active thermal interaction between the atmosphere and ocean and the continents adjacent to it. The sign of change in precipitation agrees quite well with the nature of change in the horizontal transport of moisture in the lower troposphere. In particular, on the continents precipitation increases in those places where the horizontal transport of moisture in the field of differences is directed from the ocean and decreases in those regions of the ocean where the corresponding transport occurs from the continent.

days



Eurasia America Eurasia America

Fig. 4. Longitude-time distributions of deviations of altitude of 500 gPa surface (dam) from zonal values. a) wave numbers 1 and 2, CE experiment; b) wave numbers 1 and 2, AE experiment; c) wave numbers 5 and 6, CE experiment; d) wave numbers 5 and 6, AE experiment.

Table 2

Dependence of Square of Amplitude of Altitude of 500 gPa Isobaric Surface on Wave Number for Latitude Zone 50-60°N According to AE and CE Experiments

	Wave Number									
	1	2	3	4	5	6	7	8	9	10
CE	37.5	50.6	21.0	18.6	14.7	11.0	9.0	4.5	2.4	5.3
AE	19.8	88.9	11.3	18.0	25.7	20.4	9.7	5.0	3.7	6.4

Changes in Amplitude and Velocity of Movement of Wave Disturbances

Now we will examine the influence of the water temperature anomaly on the velocity of propagation of wave disturbances in the atmosphere in the latitude zone passing through the region with the anomaly.

Table 2 shows that considerable changes were exhibited by the amplitudes of planetary waves with the numbers 1, 2 and 3 which are determined by the value of the thermal contrast between the continents and oceans. The formation of an anomaly in the North Atlantic favored an intensification of an ultralong wave with the number 2 to a considerable degree at the expense of waves 1 and 3. The energy of baroclinic waves with the numbers 5 and 6 also increased appreciably.

The evaluations show that in the considered latitude zone the energy of all the waves increased by 18% in the middle troposphere. The energy of planetary waves with the numbers 1, 2, 3 increased by 10% (with an increase in the energy of the wave with the number 2 by 80%), the energy of the baroclinic waves with the numbers 5, 6 -- by 76%, and the energy of all the shorter waves -- by 8%.

Figure 4 gives the longitude-time diagrams (distributions of troughs and ridges) for two groups of waves whose diameters were subjected to an appreciable change: planetary waves with the numbers 1 and 2 and baroclinic waves with the numbers 5 and 6. These diagrams were constructed on the basis of data on the change in the altitude of the isobaric surface 500 gPa from 31 through 60 days for the latitude zone 50-60°N.

It follows from Figures 4a,b that an increase in the amplitude of the planetary wave with the number 2 and attenuation of a wave with the number 1 in the AE experiment caused an intensification of the ridge over the Pacific Ocean and a trough over the North American continent. With respect to the trough over Eurasia its intensity almost did not change, but it became less mobile in the AE experiment.

The intensity of the troughs and ridges, which correspond to baroclinic waves with the numbers 5 and 6 (Fig. 4c,d), increased over the Pacific and Atlantic Oceans and North America in the AE experiment. Moreover, whereas in the CE experiment the ridges and troughs over North America and the Pacific Ocean were motionless or moved little, in the AE experiment they became deeper and more mobile. The mean velocity of their movement to the east was about 130/km day at all longitudes.

A similar spectral analysis of altitude of the 500 gPa surface was made for the latitude zone 40-50°N, that is, to the south of the anomaly, which also indicated that the amplitudes of the baroclinic waves with the numbers 5 and 6 somewhat increased, whereas the troughs and ridges became more mobile. If it is assumed that the mentioned baroclinic waves correspond to large pressure formations in the atmospheric model, it can evidently be assumed that in the formation of a positive water temperature anomaly there is an intensification of cyclonic (anticyclonic) activity and a meridional type of circulation in the middle latitudes of the northern hemisphere.

Regional Changes in Precipitation and Thermal Regime Over European Continent

For a more detailed clarification of the mechanism of the influence of the water temperature anomaly in the North Atlantic on the thermal regime of the atmosphere over the European continent this continent was broken down into three major regions (see Fig. 2): northwestern regions of the USSR and Scandinavia (region 1), Western Europe (region 2), central and southern regions of the European USSR (region 3). These regions include 9, 12 and 12 points of grid intersection.

Table 3 shows that temperature changes in different regions of Europe are not identical. In Western Europe (region 2) and in the European USSR (region 3) the temperature of the troposphere increased, especially significantly in the first of the mentioned regions. On the other hand, over the northwestern regions of the USSR and Scandinavia it decreased at all levels in the atmosphere.

As indicated by Figures 3b and 3e, the main reason for the temperature increase in the troposphere over regions 2 and 3 was an increase in the horizontal transport of heat and humidity from the Atlantic Ocean onto the continent by the southern branch of the intercontinental circulation cell, whereas the decrease in temperature over region 1 was caused by an intensification of the horizontal transport of cold air masses from the internal regions of the continent. With respect to the insignificant decrease in temperature at the level 150 gPa over all the regions, it was caused by a general attenuation of west-east transport over Europe.

Table 3

Mean Differences Between Air Temperatures (°C) at Four Atmospheric Levels. Computed Using Data From AE and CE Experiments for Three Regions in Europe for 31-60 Days of Forecast

Changes in air temperature	Region 1	Region 2	Region 3
δT_{150}	-0.4	0.2	-0.1
δT_{500}	-2.4	1.2	0.4
δT_{850}	-2.0	4.9	1.4
δT_{1000}	-2.9	5.2	1.6

Table 4

Mean Intensities of Precipitation (in cm/day) Obtained in AE and CE Experiments for Three Regions for 31-60 Days of Forecast

Experiment	Region 1	Region 2	Region 3
CE	0.27	0.27	0.19
AE	0.19	0.40	0.22

Table 4 gives the mean intensities of precipitation obtained in the AE and CE experiments. In regions 2 and 3 precipitation increased by 48 and 16% respectively, whereas in region 1 it increased by 30%. With respect to surface pressure, it decreased in all three regions: in the first -- by 6.0 gPa, in the second -- by 11.5 gPa, and in the third -- by 4.1 gPa. Thus, in the AE experiment over a large part of the European continent there was a warming in the troposphere and an increase in the quantity of precipitation and only over Scandinavia and the northwestern regions of the USSR did the temperature drop and did the quantity of precipitation decrease.

Statistical Significance of Changes in Temperature and Precipitation

The question of the extent to which these changes in the thermal regime in the troposphere and precipitation are statistically significant is of definite interest. As a significance test we will examine the ratio [24]

$$r_0 = \frac{\Delta}{\sigma_T}.$$

Here $\Delta = B_A - B_K$ is the difference in two sample means in which B_A and B_K are the mean monthly values of the variable B in experiments with allowance for the stipulated water temperature anomaly and without allowance for it, σ_T is the mean square error in evaluating the mean.

The volume of the sample which is used in evaluating significance is very limited and therefore the evaluations obtained here must be regarded as extremely approximate. The evaluation of significance was made on the basis of 30 instantaneous states of the atmosphere with a time interval of one day. The mean square error σ_T was computed taking into account that the variables entering into the time series are not random. First, on the basis of the results of numerical experiments we determined the time autocorrelation function for temperature at the level $\sigma = 0.833$ and precipitation separately over the continents and oceans in the middle and low latitudes. A comparison of the four normalized functions for each variable indicated that the differences between them are insignificant. Accordingly, in the r_0 evaluations we used one (but different for temperature and precipitation) normalized autocorrelation function, which was approximated by an analytical formula ensuring its positive determinancy. The evaluations indicated that the changes in temperature in the lower troposphere were significant ($|r_0| > 1$) over great regions of the northern hemisphere, including Western Europe and the European USSR.

Similar evaluations were made for precipitation and indicated that for the northern part of the Atlantic Ocean, Europe, Far East and Southeast Asia the computed changes are also statistically significant.

Summary

The results of the numerical experiment and the model of general circulation of the atmosphere indicated that the influence of the positive water temperature anomaly in the ocean on general circulation, thermal regime and moisture cycle in the atmosphere is manifested very complexly. In the formation of an anomaly in the northeastern part of the Atlantic Ocean there is an appreciable increase in temperature of the troposphere and an increase in precipitation over Western Europe and a considerable part of the European USSR. On the other hand, a decrease in air temperature and decrease in precipitation occur in the northern regions of Europe.

Changes in the thermal regime of the atmosphere are also observed in other regions of the northern hemisphere: air temperature increases in the Far East and in Alaska and decreases over the polar basin and over the greater part of the North American continent. Substantial changes in precipitation are discovered in the low latitudes. Macroscale pressure formations became more intensive and mobile in the middle latitudes in the AE experiment.

The additional heat flow entering the atmosphere over the region with the water temperature anomaly causes a redistribution of atmospheric mass and a change in circulation. This is evidently the principal factor favoring appreciable changes in heat transfer to the atmosphere over other regions of active thermal interaction. The value and the sign of these changes are determined by the complex of physical processes with feedbacks, so that it is extremely difficult to establish a cause-and-effect sequence for these processes.

In this connection it is worth noting further investigations directed to the determination of the conditions under which the intensity of heat transfer from the underlying surface to the atmosphere can change substantially in the regions of active thermal interaction quite remote from the regions of formation of water temperature anomalies in the ocean.

We note in conclusion that the results obtained in this investigation to a certain degree are dependent on the properties of the atmospheric model, in particular, on the presence of a boundary at the equator, methods for the parameterization of physical processes, etc. For this reason it is desirable to carry out similar investigations with other atmospheric models.

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NUMERICAL EXPERIMENTS WITH MODEL OF ACTIVE LAYER OF OCEAN

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[Article by V. A. Ryabchenko, candidate of physical and mathematical sciences, Institute of Oceanology, USSR Academy of Sciences]

[Text]

Abstract: An integral model of the active layer of the ocean [4] for taking into account the feedback between the heat flow at the water-air boundary and temperature of the ocean surface is given. Results of computations of the annual variation of temperature in the upper quasihomogeneous layer in the region of weather station N agree well with observational data. The results of numerical experiments are given. These illustrate the sensitivity of the solution to variations in parameters of the model. It is shown that the reaction of the solution is substantially greater with the variation of the external (atmospheric) parameters and weaker with the variation of the internal parameters.

The authors of [4] proposed an integral model of the active layer of the ocean based on the assumption of a proportionality between integral dissipation and the production of turbulent energy of mechanical and convective origin. At the same time it was assumed that mechanical turbulent energy dissipates completely within the limits of the Ekman boundary layer. The model was used for computing the seasonal evolution of characteristics of the active layer in the region of weather station N in the Pacific Ocean. The results of computations of the annual variation of temperature and thickness of the upper quasihomogeneous layer (UQL), although they do not contradict the observational data, nevertheless differed appreciably from them. Suffice it to mention that the computed values of temperature of the UQL during the period of the maximum of summer heating were 2-2.5°C higher than the observed values. One of the possible explanations for the noted discrepancy is the absence of allowance for a feedback between the heat flow at the water-air discontinuity and the temperature of the ocean surface (we recall that in [4] the heat flow values at the ocean surface were considered stipulated). In this article we will attempt to eliminate this limitation and we will cite the results of numerical experiments illustrating the sensitivity of the solution to variations of different kinds of parameters of the model.

The seasonal evolution of the active layer of the ocean in the case of weak horizontal advection and diffusion can be described using the following system of equations for temperature T_s in the UQL, temperature T_h at the upper boundary of the seasonal thermocline, thickness h of the UQL and turbulent heat flow q_h at the lower boundary of the UQL (see [4]):

$$h\frac{dT_s}{dt} = q_0 - q_h, \qquad (1)$$

$$\frac{dT_h}{dt} = \gamma\left(\frac{dh}{dt} - w_h\right) \quad \text{with} \quad \left(\frac{dh}{dt} - w_h\right) > 0,$$

$$T_h = T_{s0} + \frac{2}{h - h_0}\int_{t_0}^{t}\left(\frac{dh}{dt} - w_h\right)(T_s - T_{s0})\,dt \quad \text{with} \quad \left(\frac{dh}{dt} - w_h\right) \leq 0, \qquad (2)$$

$$\frac{dh}{dt} - w_h = -\frac{C_1 q_0}{T_s - T_h}\left[1 - \frac{C_2}{C_1}\mathrm{Rf}^{-1}F\left(\frac{h}{h_e}\right)\right] \quad \text{with} \quad \mathrm{Rf} \leq \frac{C_2}{C_1}F,$$

$$\frac{h}{h_e} = 1 - \frac{C_1}{C_3}\mathrm{Rf} \quad \text{with} \quad \mathrm{Rf} \geq 0, \quad \left(\frac{dh}{dt} - w_h\right) < 0, \qquad (3)$$

$$q_h = \begin{cases} (T_s - T_h)\left(\frac{dh}{dt} - w_h\right) & \text{with} \quad \left(\frac{dh}{dt} - w_h\right) > 0, \\ 0 & \text{with} \quad \left(\frac{dh}{dt} - w_h\right) \leq 0. \end{cases} \qquad (4)$$

Here q_0 is the specific (normalized to the volume heat capacity of sea water) turbulent heat flow at the ocean surface, w_h and γ are vertical velocity and the temperature gradients at the upper boundary of the seasonal thermocline,

$$F\left(\frac{h}{h_e}\right) = \begin{cases} (1 - h/h_e) & \text{with} \quad h < h_e, \\ 0 & \text{with} \quad h \geq h_e; \end{cases}$$

$h_e = u_*/(C_3|f|)$ is the thickness of the Ekman boundary layer, u_* is dynamic wind velocity, f is the Coriolis parameter, $\mathrm{Rf} = -\frac{g\alpha_T q_0 h}{u_*^3}$

is the Richardson flow number, α_T is the coefficient of thermal expansion of sea water, g is the acceleration of free falling, C_1, C_2 and C_3 are numerical constants, t is time, the subscript "0" denotes the values of the characteristics of the active layer at the time $t = t_0$ of change in the sign on q_0 falling at the beginning of the heating period. The temperature gradient γ in the seasonal thermocline is determined at the time $t = t_1$ of cessation of the rising of the lower boundary of the UQL $\left(\frac{dh}{dt} - w_h < 0\right)$

using the formula

$$\gamma = \frac{T_{h1} - T_{s0}}{h_1 - h_0} = \frac{2}{(h_1 - h_0)^2} \int_{t_0}^{t_1} \left(\frac{dh}{dt} - w_h\right)(T_s - T_{s0})\, dt$$

and then is considered invariable during the entire period of deepening of the lower boundary of the UQL $\left(\frac{dh}{dt} - w_h > 0\right)$ up to a new annual cycle.

The system of equations (1)-(4) is closed and can be solved by stipulating the heat flow q_0 at the ocean surface, dynamic wind velocity u_* and also vertical velocity w_h. In [4] the q_0 values were stipulated on the basis of observational data in the form of a periodic function of time. There, as already noted, no allowance was made for the feedback between q_0 and the temperature of the ocean surface (by definition the latter is equal to T_s). In order to take this correlation into account we will turn to the heat balance equation for the ocean surface, in accordance with which

$$q_0 = Q_s - (Q_b + Q_h + Q_e), \tag{5}$$

where Q_s is the flow of direct and scattered short-wave solar radiation, Q is the effective radiation, Q_h and Q_e are the flows of apparent and latent heat. All the flow values were normalized to the volume heat capacity of sea water.

We will examine each term entering into (5) in greater detail. The expression for the total flow of solar radiation absorbed by the ocean can be written in the form

$$Q_s = Q_{s0}(1 - \varphi(n))(1 - \alpha_0), \tag{6}$$

where Q_{s0} is the total flow of solar radiation incident on the ocean surface in the absence of a cloud cover, α_0 is the albedo of the ocean surface; α_0, like Q_{s0}, are known tabulated functions of latitude and season of the year (for example, see [3]), φ (n) is an empirical function characterizing the dependence of Q_s on the mean tenths of cloud cover n (specific form of φ(n) can be found in [1, 2]).

Adhering to [7], we will represent the dependence of the effective radiation of the sea surface on its temperature in the form of a Taylor series in powers $T_s - T_A$) (here T_A is air temperature in the near-water layer of the atmosphere). Limiting ourselves to the first two terms of the series, we obtain

$$Q_b = [Q^* \sigma T_A^4 + 4 Q^* \sigma T_A^3 (T_s - T_A)]/\rho_0 c_0, \tag{7}$$

where $Q^* = 0.985\ (0.39 - 0.05\ e_A^{1/2})(1 - 0.6\ n^2)$ is a dimensionless empirical coefficient taking into account the influence on effective radiation by cloud cover and air humidity, e_A is water vapor elasticity (in millibars) at the standard altitude of meteorological measurements, σ is the Stefan-Boltzmann constant, $\rho_0 c_0$ is the volume heat capacity of sea water.

The T_A and T_s temperature values are given in (7) in K.

The sum of turbulent flows of apparent and latent heat, as usual, are parameterized in the form

$$Q_h + Q_e = \frac{\rho_A c_p}{\rho_0 c_0} C_D^{1/2} u_* \left[(T_s - T_A) + \frac{L}{c_p}(q_s - q_A)\right], \qquad (8)$$

where q_A is specific air humidity at the height of standard measurements, q_s is saturating specific humidity at the temperature T_s, $\rho_A c_p$ is the volume heat capacity of air, C_D is sea surface drag, L is the latent heat of evaporation.

If it is now assumed that $q \approx a \frac{e}{p_A}$ and the Clausius-Clayperon equation is used, as a result we obtain

$$q = a \frac{e_0}{p_A} \exp\left\{-\frac{L}{R_w}\left(\frac{1}{T} - \frac{1}{T_0}\right)\right\}, \qquad (9)$$

where p_A is atmospheric pressure at sea level, R_w is the specific gas constant of water vapor, e_0 = 6.11 mb is water vapor elasticity at a temperature T_0 = 273 K, $a \approx 0.622$ is a numerical constant.

Thus, if the dynamic wind velocity u_*, air temperature T_A, dew point temperature T_r and the cloud cover tenths n are functions of time, equations (1)-(4) together with expressions (5)-(9) and the initial conditions unambiguously determine the temporal evolution of the thickness and temperature of the UQL, temperature at the upper boundary of the seasonal thermocline, and also the heat flows at the ocean surface and at the lower boundary of the UQL.

Below we give the results of computations of the seasonal evolution of the active layer for the conditions at weather station N in the Pacific Ocean (φ= 30°N, λ = 140°W). All the necessary initial information was taken from [6]. In that study it was shown that for the selected point in the ocean it can be assumed that $w_h = 0$, n = 0.75, $Q_s = \overline{Q}_s + \hat{Q}_s \sin(\omega t - \pi/2)$,

$$u_* = \overline{u}_* + \hat{u}_* \sin\left(\omega t + \frac{\pi}{2}\right), \quad T_A = \overline{T}_A + \hat{T}_A \sin(\omega t - \pi),$$

$$T_r = \overline{T}_r + \hat{T}_r \sin(\omega t - \pi), \text{ где (where) } \overline{Q}_s = 34{,}1 \cdot 10^{-6} м \cdot °C/c \text{ (sec)}$$

$$\hat{Q}_s = 13{,}4 \cdot 10^{-6} м \cdot °C/c, \ \overline{u}_* = 0{,}232 \ м/c, \ \hat{u}_* = 0{,}052 \ м/c \text{ (m/sec)}$$

$$\overline{T}_A = 18{,}5°C, \ \overline{T}_r = 14{,}5°C, \ \hat{T}_A = \hat{T}_r = 3°C,$$

the line at top corresponds to the mean annual values; the sign "$\wedge$" corresponds to the amplitudes of oscillations of the considered characteristic.

The values of the numerical constants C_1, C_2 and C_3, figuring in expressions (4), are stipulated in accordance with [4] equal to:

$$C_D = 1{,}1 \cdot 10^{-3}, \quad C_1 = \begin{cases} 1 & \text{with } q_0 \geqslant 0, \\ 0{,}2 & \text{with } q_0 < 0, \end{cases}$$

$$C_2 = \begin{cases} 0{,}24 \cdot 10^{-3} & \text{with } u_* \leqslant 0.25 \text{ m/sec}, \\ 0{,}38 \cdot 10^{-3} & \text{with } u_* > 0.25 \text{ m/sec}, \end{cases} \quad C_3 = 60.$$

As the initial values of the thickness of the UQL and temperature we assume h = 120 m and $T_s = T_h = 18°C$.

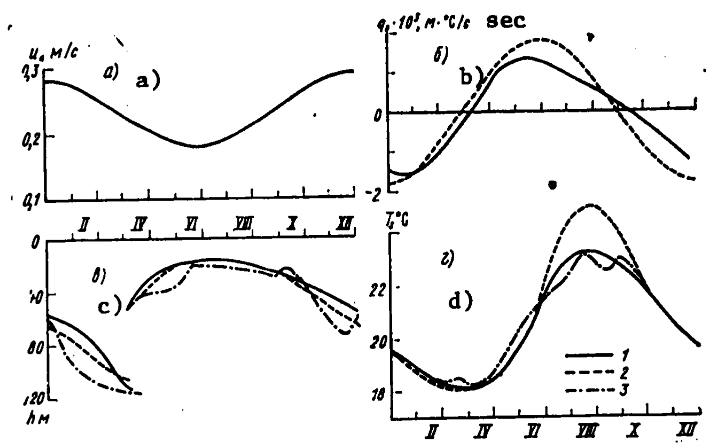

Fig. 1. Annual variation of dynamic wind velocity (a), heat flow at the surface (b), thickness (c) and temperature (d) of upper quasihomogeneous layer at weather station N in Pacific Ocean. 1 and 2) results of computations with determination and stipulation q_0; 3) observational data [6].

The results of computations of the annual variation of the principal characteristics of the UQL are represented in Fig. 1. As a comparison, here we have given the results of computations with a stipulated heat flow q_0. It can be seen that agreement with the observational data in the first case is appreciably better than in the second. With stipulation of the surface heat flow the discrepancies between the computed and observed temperature values at individual times in the annual cycle can attain 2-2.5°C, whereas when determining the surface heat flow in the process of solution of the problem they do not exceed 0.6°C. The second maximum in the seasonal variation of surface temperature, observed at the beginning of October, is absent in both computations. This in all probability is associated with the exclusion of the salinity effect and the approximation of the external parameters by only two terms of a Fourier series in time. With respect to the thickness of the UQL, the model ensures only a qualitative similarity of the computed and observed h changes. The reason for this is both the limitations of the model itself and known difficulties in determining h on the basis of experimental data. In actuality, on the one hand, the jump layer, whose thickness under real conditions is not less than 10-30 m, is replaced in the model by a layer of zero thickness; on the other hand, the accuracy in determining the lower boundary of the quasihomogeneous layer on the basis of experimental data does not exceed 5-10 m (see, for example, [5]).

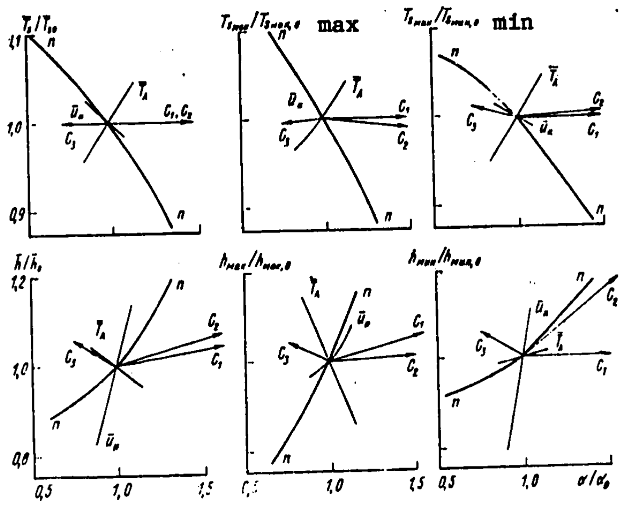

Fig. 2. Relative changes in mean annual and extremal values of temperature and thickness of UQL as function of variations of external parameters of model. The values of the normalization factors, noted by the subscript "O", correspond to the conditions of the main experiment (Fig. 1). α is any of the model parameters cited in the figure.

For the purpose of investigating the sensitivity of the solution to the accuracy in stipulating the internal parameters of the model (numerical constants C_1, C_2, C_3) and atmospheric characteristics ($\overline{T}_A$, $\overline{u}_*$ and n) we carried out a number of numerical experiments. It was found that the variations of the indicated parameters did not lead to any substantial changes in the phase relationships between the sought-for variables. Accordingly, here we will limit ourselves only to a discussion of their mean and extremal values.

Figure 2 shows that variation of the constants C_1 and C_2, corresponding, all other conditions being equal, to the change in the contribution of thermal convection* and mechanical mixing to the heat flow at the lower boundary of the UQL (see first of the equations (3)), leads to insignificant changes in the temperature and thickness of the UQL. A decrease in the constant C_3, equivalent, all other conditions being equal, to an increase in the thickness of the Ekman layer h_e, has little influence on the T_s value and at the same time causes an appreciable increase in the mean value and amplitude of h variations. However, even in this case the relative changes in h are less than with a change in the

* Here reference is to the C_1 value with $q_0 < 0$.

dynamic velocity of the wind $\overline{u}_*$, air temperature $\overline{T}_A$ and the tenths of cloud cover n. The same can be said with respect to changes in temperature of the UQL. With an intensification of the wind and an increase in cloud cover tenths as might be expected, there is a decrease, whereas with a temperature increase there is an increase in the mean annual value and amplitude of the T_s variations.

Thus, the reaction of the solution to changes in the external and internal parameters of the model is not the same: it is substantially stronger with a variation in the external and weaker with a variation of the internal parameters. This circumstance is evidence of the reliability of the model and the possibility of its use in mass computations of the seasonal evolution of temperature and thickness of the UQL.

The author expresses appreciation to S. P. Smyshlyayev for assistance in carrying out the computations.

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UDC 532.517.4

CRITERIA CHARACTERIZING FLOW OF FLUIDS WITH STABLE STRATIFICATION

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 25 May 81) pp 69-76

[Article by A. N. Shabrin, candidate of technical sciences, Hydromechanics Institute, Ukrainian Academy of Sciences]

[Abstract] A study was made of a model of a current in which a flow of fluid with a free surface and the density ρ_1 flows into a water body filled with a fluid with the density ρ_2 (with $\rho_2 > \rho_1$). An example of such a situation would be when fresh water flows into the sea or some water body filled with saline water. The author seeks an answer to these two questions: 1) what are the conditions for the penetration of saline water into the fresh water flow? 2) what is the nature of the interaction of fresh and saline water when fresh water flows into the sea? In solving these problems no effort is made to take wind-induced and tidal phenomena into account. Solutions are sought for the case of stable stratification. Different approaches used in the past in arriving at stability criteria are reviewed and a new method is proposed for analyzing stability conditions for the interface of fluids of different density. Experimental and theoretical investigations made by the author both reveal that there is a clearly expressed and unambiguous interrelationship between interface stability and the ratio of flow frequency and buoyancy. Knowing this, it is possible to employ parameters which are quite easy to obtain experimentally for an analysis of interface stability conditions not only when there is a uniform density gradient in the entire thickness of the layer, but also when the interface layer is divided into parts. Figures 3, tables 2; references 10: 8 Russian, 2 Western.

UDC 556.535.6

DEPENDENCE OF ACCURACY IN COMPUTATIONS OF PARAMETERS OF SEA WIND WAVES ON PRINCIPAL WAVE-FORMING FACTORS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 20 Apr 81) pp 77-81

[Article by R. A. Dalin, candidate of naval sciences, Leningrad Hydrometeorological Institute]

[Text]

Abstract: On the basis of use of the method of linearization of the random arguments function a study was made of the change in accuracy in computing the mean heights and periods of wind waves in deep water as a function of the errors in initial values of the principal wave-forming factors: wind velocity, its fetch and the duration of the effect. The article gives the accuracy characteristics of the principal wave-forming factors, which make it possible to compute the parameters of wind waves with an accuracy satisfying practical requirements. It is shown that the main influence on the accuracy in computations is from errors in wind velocity. There is a considerably lesser influence on the results of computations even of considerable errors in determining the fetch and duration of exposure to the wind.

Methods for computing the parameters of wind waves which are recommended for application in official documents [3, 5] are now used in the practice of hydrometeorological support of the transport and fishing fleets, in hydraulic construction and in other work at sea. The basis for the mentioned methods is the expressions derived by a group of Soviet researchers [2]. According to [3], for deep-water conditions these expressions have the form

$$\frac{g\bar{h}}{V^2} = 0{,}0042\left(\frac{gx}{V^2}\right)^{1/3}, \quad (1)$$

$$\frac{g\bar{h}}{V^2} = 0{,}0013\left(\frac{gt}{V}\right)^{5/12}, \quad (2)$$

$$\frac{g\bar{\tau}}{V} = 18{,}7\left(\frac{g\bar{h}}{V^2}\right)^{3/5}. \quad (3)$$

Here $\bar{h}$ and x are expressed in meters and $\bar{\tau}$ and t are expressed in seconds.

If the dependence of the mean height $\bar{h}$ and the mean period $\bar{\tau}$ of wind waves is expressed in explicit form on the principal wave-forming factors -- wind velocity V, fetch x and duration t of exposure to the wind and x and t are converted into kilometers and hours respectively, expressions (1)-(3) assume the form

$$\bar{h} = 9{,}1 \cdot 10^{-3} \sqrt[3]{x V^4}, \qquad (4)$$

$$\bar{h} = 1{,}04 \cdot 10^{-2} \sqrt[12]{t^6 V^{19}}, \qquad (5)$$

$$\bar{\tau} = 7{,}5 \sqrt[5]{\frac{\bar{h}^3}{V}}. \qquad (6)$$

The last expression, with (4) and (5) taken into account, can be represented by the formulas

$$\bar{\tau} = 0{,}45 \sqrt[5]{x V^3}, \qquad (7)$$

$$\bar{\tau} = 0{,}48 \sqrt[4]{t V^3}. \qquad (8)$$

We note that the finding of the parameters $\bar{h}$ and $\bar{\tau}$ by the use of formulas (4), (5), (7) and (8) when modern microcalculators are available requires only a few seconds and is considerably less fatiguing and more precise than when using the nomograms cited in [3, 5]. At the same time, these formulas make it possible to establish the dependence of the errors in determining the parameters of wind waves on the errors in the initial values of the wave-forming factors.

In actuality, if the method of linearization of [1] is applied to expressions (4), (5), (7) and (8), it is possible to obtain the following relationships:

using expression (4)

$$\sigma_{h(V)} = 1{,}21 \cdot 10^{-2} \sqrt[3]{x V}\, \sigma_V, \qquad (9)$$

$$\sigma_{h(x)} = 3{,}03 \cdot 10^{-3} \sqrt[3]{\frac{V^4}{x^2}}\, \sigma_x; \qquad (10)$$

using expression (5)

$$\sigma_{h(V)} = 1{,}65 \cdot 10^{-2} \sqrt[12]{t^6 V^7}\, \sigma_V, \qquad (11)$$

$$\sigma_{h(t)} = 0{,}43 \cdot 10^{-2} \sqrt[12]{\frac{V^{10}}{t^7}}\, \sigma_t; \qquad (12)$$

from expression (7)

$$\sigma_{\tau(V)} = 0{,}27 \sqrt[5]{\frac{x}{V^2}}\, \sigma_V, \quad (13)$$

$$\sigma_{\tau(x)} = 0{,}09 \sqrt[5]{\frac{V^3}{x^4}}\, \sigma_x; \quad (14)$$

from expression (8)

$$\sigma_{\tau(V)} = 0{,}36 \sqrt[4]{\frac{t}{V}}\, \sigma_V, \quad (15)$$

$$\sigma_{\tau(t)} = 0{,}12 \sqrt[4]{\frac{V^3}{t^3}}\, \sigma_t. \quad (16)$$

In formulas (9)-(16) $\sigma_{h(V)}$ and $\sigma_{\tau(V)}$ are the mean square errors in computing $\bar{h}$ and $\bar{\tau}$ respectively in dependence on the mean square error in wind velocity σ_V; $\sigma_{h(x)}$ and $\sigma_{\tau(x)}$ are the mean square errors in computing $\bar{h}$ and $\bar{\tau}$ respectively in dependence on the mean square error in the fetch σ_x; $\sigma_{h(t)}$, $\sigma_{\tau(t)}$ are the mean square errors in computing $\bar{h}$ and $\bar{\tau}$ respectively in dependence on the mean square error in the duration of exposure to the wind σ_t.

In the considered case the legitimacy of applying the linearization method is justified by the fact that as a result of the smallness of the errors in the V, x and t values in comparison with their absolute values the functions describing the dependence of h and $\bar{\tau}$ on these values, not being linear in the entire range of change in their arguments, are almost linear in a narrow range of their random changes.

Using expressions (9)-(16) for conditions close to those which are usually encountered in practical computations, that is, for wind velocities 5, 10 and 15 m/sec, a fetch of 200 and 300 km, duration of exposure to the wind of 6 and 12 hours, we computed the evaluations of the possible errors in determining the mean height and mean period of waves as a function of the errors σ_V, σ_x and σ_t.

The computed data are given in Table 1. An analysis of the table shows that the errors in computing the wave parameters can attain considerable values. These errors are particularly sensitive to the errors in initial wind velocity values. Thus, even an insignificant error in wind velocity -- 1 m/sec -- results in an error in computing the mean height of waves attaining more than 20 cm. It must be noted that a mean square error in determining wind velocity of 1 m/sec is entirely possible since the methods for determining wind velocity by use of weather maps ensure a higher accuracy.

The errors in initial durations of wind action, especially wave fetch, exert a lesser influence. However, in these cases as well, they can attain values which to some degree are capable of distorting the final result of the computations.

However, it should be mentioned that the value of the σ_h and σ_τ parameters is not adequately indicative. In actuality, one and the same error σ_h, for example, with great wave heights, can legitimately be considered insignificant, but in the case of low heights -- inadmissible. In order to take this circumstance into account it is desirable to proceed to a relative characterization of the error -- the variation coefficient [4], that is, in our case

$$k_h = \frac{\sigma_h}{\bar{h}} \cdot 100\% \tag{17}$$

and

$$k_\tau = \frac{\sigma_\tau}{\bar{\tau}} \cdot 100\%. \tag{18}$$

Then, taking expressions (4) and (9) into account, it can be written that

$$k_{h(V)} = \frac{4}{3} \frac{\sigma_V}{V} \cdot 100\%; \tag{19}$$

It follows from expressions (4) and (10) that

$$k_{h(x)} = \frac{1}{3} \frac{\sigma_x}{x} \cdot 100\%; \tag{20}$$

from expressions (5) and (11) --

$$k_{h(V)} = 1{,}58 \frac{\sigma_V}{V} \cdot 100\%; \tag{21}$$

from expressions (5) and (12) --

$$k_{h(t)} = 0{,}42 \frac{\sigma_t}{t} \cdot 100\%; \tag{22}$$

from expressions (7) and (13) --

$$k_{\tau(V)} = 0{,}6 \frac{\sigma_V}{V} \cdot 100\%; \tag{23}$$

from expressions (7) and (14) --

$$k_{\tau(x)} = 0{,}2 \frac{\sigma_x}{x} \cdot 100\%; \tag{24}$$

from expressions (8) and (15) --

$$k_{\tau(V)} = 0{,}75 \frac{\sigma_V}{V} \cdot 100\%; \tag{25}$$

and finally, from expressions (8) and (16) --

$$k_{\tau(t)} = 0{,}25 \frac{\sigma_t}{t} \cdot 100\%. \tag{26}$$

It should be noted that using expressions (19) and (21), derived from different initial formulas, it is possible to compute one and the same variation coefficient $k_{h(V)}$, which characterizes the dependence of the relative error in computing the mean height of waves on the error in wind velocity. It is easy to see that the $k_{h(V)}$ values, obtained using different formulas, are rather close to one another. A similar comment must be made with respect to expressions (23) and (25), which make it possible to compute the variation coefficient $k_{\tau(V)}$.

Using formulas (19)-(26) for the same conditions which were adopted earlier in computing the σ_h and σ_τ parameters, computations were made of the variation coefficients as a function of the errors in initial data σ_V, σ_x and σ_t. The results of the computations are given in Tables 2-4. The data in these tables make it possible to draw conclusions which will be of interest for practical applications.

Table 1

Errors in Determining Mean Height of Waves σ_h m (At Left) and Mean Period of Waves σ_τ sec (At Right)

		V = 5 м/с (m/sec)		10 м/с		15 м/с		V = 5 м/с		10 м/с		15 м/с	
		x км											
		200	300	200	300	200	300	200	300	200	300	200	300
σ_V м/с	1	0,12	0,14	0,15	0,17	0,17	0,20	0,41	0,44	0,31	0,34	0,26	0,29
	2	0,24	0,28	0,30	0,35	0,35	0,40	0,82	0,89	0,62	0,67	0,53	0,57
σ_x км	10	0,01	0,01	0,02	0,01	0,03	0,03	0,03	0,02	0,05	0,04	0,07	0,05
	20	0,02	0,01	0,04	0,03	0,06	0,05	0,07	0,05	0,10	0,07	0,13	0,10
		t ч (hours)											
		6	12	6	12	6	12	6	12	6	12	6	12
σ_V м/с (m/sec)	1	0,09	0,12	0,13	0,18	0,17	0,23	0,38	0,45	0,32	0,38	0,29	0,34
	2	0,18	0,24	0,27	0,36	0,34	0,45	0,75	0,90	0,63	0,75	0,57	0,68
σ_t ч (hours)	1	0,02	0,01	0,06	0,04	0,11	0,07	0,10	0,06	0,18	0,10	0,24	0,14
	2	0,04	0,03	0,12	0,08	0,22	0,15	0,21	0,12	0,35	0,21	0,48	0,28

First we should note the very "strong" dependence of the accuracy of computations on the errors in wind velocity. In the case of weak winds even an insignificant mean square error of 1-1.5 m/sec leads to an increase in the variation coefficient for wave heights to 30-40%, and with respect to periods -- up to 20%, which is an extremely high value. However, we should note the exceptionally weak influence of the error in the initial wind fetch on the final results of the computations. Even with a mean square error in fetch attaining half its absolute value, the variation coefficient in computing the mean height and period of waves is insignificant (less than 20%). The latter makes it possible to assert that in computations of the parameters of wind waves no effort need be made to make a detailed determination of fetch since even an extremely rough calculation of its value will make it possible to obtain a result which is entirely satisfactory.

It is also necessary to mention a similar insignificant, although to a somewhat lesser degree, influence of the errors in determining the duration of the wind effect on the results of the computations.

Table 2

Values of Variation Coefficients $k_{h(V)}$ and $k_{\tau(V)}$ as Function of Errors in Determining Wind Velocity σ_V

σ_V м/с	V м/с m/sec					
	5	10	15	5	10	15
	$k_{h(V)}$ %			$k_{\tau(V)}$ %		
0,5	13	7	4	6	3	2
1,0	27	13	9	12	6	4
1,5	40	20	13	18	9	6
2,0	53	27	18	24	12	8

Table 3

Values of Variation Coefficients $k_{h(x)}$ and $k_{\tau(x)}$ as Function of Errors in Determining Wind Fetch σ_x

σ_x км	x км			
	200	300	200	300
	$k_{h(x)}$ %		$k_{\tau(x)}$ %	
20	4	2	2	1
50	8	6	5	3
100	17	11	10	7

Table 4

Values of Variation Coefficients $k_{h(t)}$ and $k_{\tau(t)}$ as Function of Errors in Determining Duration of Wind Effect σ_t

σ_t ч	t ч hours			
	6	12	6	12
	$k_{h(t)}$ %		$k_{\tau(t)}$ %	
1	7	4	4	2
2	14	7	8	4
3	21	10	12	6
4	28	14	17	8

It must be noted, however, that Tables 2-4 and accordingly formulas (19)-(26) make it possible to solve not only the direct problem -- evaluation of the final accuracy in computations, but also the inverse problem -- determination, by stipulating the necessary accuracy in computations, that mean square error which can be allowed in determining the initial data V, x and t without an appreciable decrease in the accuracy of the computed parameters $\bar{h}$ and $\bar{\tau}$. For example, if the admissible value used for the level of the variation coefficient is 10-20%, as is usually assumed when carrying out the computations, it is necessary that in the presence of weak winds, for example, σ_V is not greater than 0.5 m/sec, in the case of moderate winds, not more than 1 m/sec, in the case of strong winds -- not more than 1.5-2 m/sec.

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DISPERSION OF SUSPENDED MATTER IN HOMOGENEOUS WATER FLOW

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 15 May 81) pp 82-90

[Article by O. I. Samsonov, candidate of geographical sciences, Moscow Institute of Water Transportation Engineers]

[Abstract] An attempt is made to develop a new approach to study of the dispersion of suspended matter in a homogeneous water flow. The approach is based on the introduction of additional terms into the equation for conservation of solid matter for taking into account the change in the concentration as a result of accumulation and erosion. A solution of the problem is complicated by the inadequate study of the problem of computation of the distribution of suspended matter with allowance for the exchange of sediments between the flow and the bottom of a water body; this matter therefore is discussed in detail. Particular attention is given to derivation of the two-dimensional turbulent dispersion equation and the one-dimensional equation of longitudinal dispersion. Then attention is given to the practical problem of the distribution of the concentration of suspended matter resulting from the carrying out of dredging work. References 20: 12 Russian, 8 Western.

UDC 556.124.3:556.134(571.56)

SPRING SNOW THAWING AND EVAPORATION IN CENTRAL YAKUTIA

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 19 May 81) pp 91-96

[Article by A. L. Are, candidate of geographical sciences, and M. S. Petropavlovskaya, candidate of technical sciences, Permafrost Institute, Siberian Department, USSR Academy of Sciences, and State Hydrological Institute]

[Abstract] Central Yakutia has inadequate precipitation and snow plays a particularly important role. The snow cover accumulates over the course of 6-7 months and by the onset of thawing the water reserve sometimes attains 100 mm. In some years up to 50% of the melt water becomes ground water. A monitoring of moisture receipts requires determination of such parameters as the maximum and mean intensity of snow melting, its duration, mean dates of beginning and end of melting and moisture losses in snow evaporation. Daily observations were made in the spring of 1978, 1979 and 1980 at the heat balance station of the Permafrost Institute Siberian Department USSR Academy of Sciences. The water balance method was used; measurements were made at about 1700-1800 hours (when daytime thawing had ceased); evaporation was measured simultaneously. Measurement data were used in determining snow density, snow depth and moisture reserve. Spring snow melting usually lasts 10-15 days. During thawing periods snow evaporation varies from 0 to 1.7 mm/day. Two types of thawing occur: solar and solar-advective; separate formulas are derived for expressing the relationship between these two types and air temperature. Figures 2, tables 1; references: 5 Russian.

UDC 630:551.521

COMPUTING OPTIMUM DENSITY OF PLANTED FIELDS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 22 Jul 81) pp 97-103

[Article by Kh. G. Tooming, doctor of biological sciences, Estonian Agrometeorological Laboratory, All-Union Scientific Research Institute of Agricultural Meteorology]

[Abstract] The optimum density of placement of plants in sown fields was investigated in the example of potatoes. The most important period for yield formation is the period of maximum growth. During that period every possible measure must be taken to ensure the proper density of plants. During a single 10-day period about 30% of the entire yield of tubers is formed. Experiments were carried out with plantings of different density. The increase in dry biomass and the relative area of leaves in plantings of different density was determined. The photosynthetically active radiation absorbed by plantings was measured or computed. Different productivity indices were determined. Then the optimum density of plants was ascertained using the criterion of maximum efficiency of plantings during the maximum growth period. The procedures are illustrated in the example of experiments with Sulev potatoes. The experiments were carried out with densities of 3, 6, 10 and 15 plants per 1 m^2. Once or twice each ten days the growth of total dry biomass of the plants, dry biomass of tubers, leaves and other plant organs were determined. The dynamics of the leaf surface was ascertained. The total radiation incident on the plants was continuously registered. Total radiation was transformed to photosynthetically active radiation. According to the maximum efficiency method the optimum density for the planting of these potatoes is 6 plants per 1 m^2. Figures 3; references 16: 14 Russian, 2 Western.

UDC 551.509.001.57

COMPUTING OPTIMUM GRIDS FOR REGIONAL SHORT-RANGE WEATHER FORECASTING MODELS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 17 Jun 81) pp 104-105

[Article by G. R. Kontarev, candidate of physical and mathematical sciences, Computation Center, Siberian Department, USSR Academy of Sciences]

[Abstract] In an earlier article ("Solution of Hydrodynamic Equations on a Sphere," METEOROLOGIYA I GIDROLOGIYA, No 7, 1978) the author proposed use of a grid region for a polar stereographic projection with intervals nonuniform in this projection; the maximum accuracy in that case was in the polar region, but with equatorward movement to 30-40° the error does not exceed $0.01\Delta x$. Proceeding along these lines, the author now proposes a method for computing the coordinates of the points of intersection of an optimum grid for a stipulated region (in this variant the grid pole can be selected within the limits of this region). For 80% of the area of the region the error allowed does not exceed $0.03\Delta x$ and is not greater than $0.1\Delta x$ at the margins. An integration region is selected for a regional model with a center having the geographic coordinates: latitude S and longitude D. This center is considered to be the pole of a new spherical coordinate system. The zero meridian is the direction to the south relative to the initial coordinate system. The optimum grid is constructed relative to the new pole. The initial parameters, in addition to latitude and longitude of the new pole, are the dimensions of the grid at points of intersection, the coordinates of the new pole at the points of grid intersection and the grid interval in degrees along the meridian. The method for computing the geographical coordinates of the points of intersection of the optimum grid is described. Using the formulas of spherical trigonometry it is possible to compute the distances between the points of intersection along the x- and y-axes. An algorithm is proposed in the form of programs in FORTRAN. An example is given of computations of an optimum grid for which a numerical forecast is made for Novosibirsk. References: 2 Russian.

UDC 551.509.32

APPLYING SEPARATING FUNCTION FOR ALTERNATIVE DIAGNOSIS OR PREDICTION USING DEPENDENT PREDICTORS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 11 May 81) pp 105-109

[Article by I. I. Marmershteyn and G. A. Medvedev, candidates of physical and mathematical sciences, Odessa Hydrometeorological Institute and Central Aerological Observatory]

[Abstract] The use of mathematical statistics in meteorology for forecasting purposes usually requires the nondependence of series of random values in the teaching sample, but under real conditions the predictors selected for a forecast are always dependent on one another, possibly differing in degree and character. When there is a linear dependence between predictors it is shown in this article that it is possible to arrive at a separating function in such a way that the region of ambiguity of an alternative forecast will be minimum. The application of this principle is illustrated in this article in the writing of a linear combination separating cumulonimbus clouds into "hail" and "shower" types. The random values used in this study were from radar sounding of clouds and temperature sounding of the atmosphere obtained in Moldavia during 1974-1978. With the pertinent parameters it was found that the probability of a "hail cloud" was 27%. Similar alternative identifications can be made for other phenomena, such as a thunderstorm and fog. This method for arriving at a separating function is also suitable for an alternative forecast. In this case the initial sample must reflect the state of the object with such a time in advance prior to onset of the phenomenon with which the forecast is to be made. It is possible in this way to predict not only weather phenomena, but also the possibility of transition of the value of some meteorological element through some critical value, such as passage of air temperature through 0°C. The alternative diagnosis or prediction method can also be used in solving many hydrometeorological problems. Figures 1; references: 7 Russian.

UDC 551.465.5(265.07)

MEANDERS OF CROMWELL CURRENT

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 11 Feb 81) pp 109-111

[Article by V. A. Bubnov, candidate of geographical sciences, and V. D. Yegorikhin, Atlantic Division, Institute of Oceanology]

[Abstract] During February-March 1980, during the 24th voyage of the "Dmitriy Mendeleyev," in a study of synoptic fluctuations of currents in the central part of the equatorial Pacific, a series of self-contained buoy stations was set out in a polygon involving two meridional sections across the equator, along 167°W and 163°15'W, near 1°30'N, 0°45'N, 0°, 0°45'S and 1°30'S. Current recorders at 10 buoy stations gave time series of observations of a duration up to 39 days. The duration of synchronous observations along these sections was 25-27 days. The vertical structure of the velocity field in the layer 0-600 m is formed by three zonal flows: South Trades Current, Equatorial Subsurface Countercurrent (Cromwell Current) and Western Equatorial Intermediate Current. The Cromwell Current has an easterly direction which takes in a layer with a thickness of about 200 m. Polygon observations indicated that the velocity field is subject to a considerable temporal variability with periods from a half-day to two weeks. The most energetic fluctuations of the Cromwell Current are associated with its meandering relative to the equatorial plane. At the depth of its axis the latitudinal amplitude of the meanders is about 30-40', in some cases attaining 1'. However, it is difficult to determine the precise parameters of this meandering, especially when estimating the phase difference of the oscillations between sections. This is due to distortions of the meander wave by oscillations of other periods. For this reason it is better to examine latitudinally averaged data. A special analysis revealed that within the polygon the Cromwell Current meanders with a period of 10 days. These oscillations are closely correlated on both sections. It was possible to compute the parameters of meanders (period in days, phase velocity, wave length). Figures 2, tables 1; references 6: 4 Russian, 2 Western.

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PROBLEMS IN METEOROLOGICAL IMAGE RECOGNITION

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 (manuscript received 16 Dec 80) pp 112-119

[Article by V. P. Pashchenko, doctor of physical and mathematical sciences, Scientific Research Institute of Instrument Making]

[Abstract] Many meteorological parameters can be described by one or two numbers obtained by contact of a sensor with the medium, but meteorological phenomena such as clouds, fogs, sunshine and range of visibility can be described only by a set of many numbers. In this article the author uses the term "mathematical image" or simply "image" for the specially formulated set of numbers. An "image" can be a single number, line from a set of numbers, column from a set of numbers, matrix, matrix row, etc. If the structure of the mathematical image is found for a series of meteorological phenomena, and the operations on the images are determined, the problem of the measurability of this phenomenon will thereby be solved. A "meteorological image" is defined as a representation of the totality of the parameters and criteria determining all meteorological situations in some subset. The main body of this article traces all the stages in the forming of meteorological images (in different stages in the exposition, for the sake of clarity, the representation process is illustrated by the case of optical sounding) and possible approaches to the identification of meteorological images are set forth. The method as a whole is applied to an evaluation of the possibility of using an M-105 instrument (for measuring the altitude of the lower boundary of clouds and estimating vertical visibility) for identifying meteorological phenomena. Figures 2, tables 1; references: 11 Russian.

EIGHTIETH BIRTHDAY OF YELIZAVETA LUARSABOVNA ANDRONIKOVA

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 p 120

[Article by A. S. Korovchenko, Ye. S. Selezneva and V. D. Stepanenko]

[Abstract] Yelizaveta Luarsabovna Andronikova, an outstanding librarian in the fields of meteorology and climatology, working in the Hydrometeorological Service for more than a half-century, completed her 80th year on 21 November 1981. Following her college studies at Moscow State University in the Physics-Mathematics Faculty, she became affiliated with the Main Geophysical Observatory, where she still works. It can be said that she made a significant contribution during the Great Fatherland War by the preparation of climatic descriptions and collecting needed materials from world publications such as were available in the archives of the Main Geophysical Observatory, the largest library of this type in the USSR. In 1944 she was called upon to bring the library resources into proper order after the reevacuation of the Main Geophysical Observatory. In this task she exhibited outstanding qualities as a librarian and as a specialist in the field of meteorology and climatology. In 1946 Ye. L. Andronikov was designated head of the scientific-technical library and continued in that post until 1979. This was all during a period of intensive growth of the library. (This library, dating back 130 years, includes almost 400,000 books). On the 100th anniversary of the Main Geophysical Observatory she compiled the BIBLIOGRAFICHESKIY UKAZATEL' RABOT GGO (1849-1948) (Bibliographic Index of Studies of the Main Geophysical Observatory (1849-1948)) and on the 50th anniversary of the October Revolution she was a coauthor of the BIBLIOGRAFICHESKIY UKAZATEL' RABOT GGO ZA PERIOD 1818-1967 (Bibliographic Index of Studies at the Main Geophysical Observatory During the Period 1818-1967). In addition, she prepared bibliographies of the works of Academician M. A. Rykachev and Professor P. A. Molchanov.

AWARDS AT USSR ALL-UNION EXHIBITION OF ACHIEVEMENTS IN NATIONAL ECONOMY

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 pp 121-123

[Article by M. M. Kuznetsova]

[Abstract] A series of awards has been presented to participants (organizations and individuals) in a special exhibit "Study of the Arctic, Antarctica and the World Ocean..." and the display "Hydrometeorology..." in the "Hydrometeorological Service" Pavilion. First-degree diplomas were awarded to: the Arctic and Antarctic Scientific Research Institute -- for geographical investigations of natural conditions in Antarctica, as well as developments in the support of navigation, fishing and aircraft flights. Central Design Bureau for Hydrometeorological Instrument Making -- for developing, fabricating and introducing the "Gidrozond" complex for measuring and registering the principal parameters of sea water. Main Geophysical Observatory -- for equipment on an aircraft-laboratory, developing methods and programs for flight tests, and creation of a unique complex of on-board measurement apparatus, this being of great value for subsatellite experiments. Institute of Experimental Meteorology -- for developing a spectroradiometer for investigating the spectral composition of plasma formations. Second-degree diplomas were awarded to: State Hydrological Institute -- for evaluating the water resources in the zone of the Baykal-Amur Railroad and developing methods for computing hydrological characteristics. Omsk Territorial Administration of Hydrometeorology and Environmental Monitoring (TAHMEM) -- for hydrometeorological support of construction of the Komsomol'sk-Surgut-Chelyabinsk gas pipeline. Leningrad Weather Bureau of the Northwestern TAHMEM -- for hydrometeorological support of ships in the Baltic, furnishing them with recommended navigation routes in the North Atlantic. Hydrometeorological Observatory of the Komi ASSR of the Northern TAHMEM -- for excellent hydrometeorological support of the national economy of the Komi ASSR. Moscow Division of the All-Union Scientific Research Institute of Hydrometeorological Information-World Data Center -- creation of an Atlas of Climatic Characteristics of cloud cover on the basis of artificial earth satellite data. Krasnodarsk Zonal Hydrometeorological Observatory of the Northern Caucasus TAHMEM -- for hydrometeorological support of rice cultivation in Krasnodarskiy Kray. Rostov-na-Donu Aviation Center of the Northern Caucasus TAHMEM -- for developing and introduction of new forecasting methods. Ukrainian Aviation Meteorological Center -- for high-quality servicing of two KRAMS-M stations. Ukrainian Scientific Research Institute -- development of technical specifications for reoutfitting a Yak-40 aircraft into a meteorological laboratory. Other organizations were awarded third-degree diplomas. A total of 639 individuals were given lesser awards.

AT USSR STATE COMMITTEE ON HYDROMETEOROLOGY AND ENVIRONMENTAL MONITORING

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 pp 123-125

[Article by V. Zakharov and G. K. Veselova]

[Abstract] During the period 2-3 November 1981 the Presidium of the Scientific and Technical Council of the State Committee on Hydrometeorology and Environmental Monitoring discussed the plan for scientific research and experimental design work for 1982. Emphasis will be on methods for predicting meteorological, hydrological and heliogeophysical phenomena and the development of methods and equipment for the collection, processing, transmission and dissemination of environmental data. Other important work is planned on study of the effects of contamination, means and methods for artificial modification of meteorological processes, methods for evaluating climatic changes and the effect of such changes on the national economy and evaluating climatic, agroclimatic and water resources. On 6 October the Central Methodological Commission on Hydrometeorological Forecasts examined the results of testing of a number of long-range forecasting methods and methods for hydrological forecasts. For example, it approved a hydrodynamic-synoptic-statistical method for forecasting the mean five-day maximum and minimum air temperatures for the European USSR and Western Siberia (see details in METEOROLOGIYA I GIDROLOGIYA, No 6, 1973, No 4, 1977. A yearlong testing of this forecasting scheme has given satisfactory results. The Commission also approved a method for predicting air temperature with two-month averaging for the most important agricultural regions of the USSR based on a linear regression scheme and using as predictors the coefficients of expansion of temperature fields in the northern hemisphere in natural orthogonal components. The first forecast is prepared 10 months in advance and is later updated, taking into account the development of hemispherical macroprocesses (see details in TRUDY GIDROMETTSENTRA SSSR, No 195, 1977, No 211, 1978). Also examined were methods for preparing territorial long-range forecasts of the volume and maximum of spring high water in rivers of the Volga and Severnaya Dvina basins. (A detailed description of these methods is given in TRUDY GIDROMETTSENTRA SSSR, No 186, 1977, No 223, 1980 and No 236, 1981). The Commission approved the special handbook "Use of Satellite Information in Synoptic Practice," based on the results set forth in the "Manual on Use of Satellite Information in Weather Analysis and Forecasting." Only two of the proposed three chapters were approved for publication at this time. The first describes use of cloud cover photographs from satellites in the analysis of fronts, cyclones and anticyclones. The second gives recommendations on the use of cloud cover photographs for predicting the synoptic situation.

NOTES FROM ABROAD

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 pp 125-126

[Article by B. I. Silkin]

[Abstract] It has been reported in SCIENCE NEWS, Vol 119, No 21, 1981, that a national center for climatological forecasts has been established at the Scripps Oceanographic Institute, La Jolla, California with its task being defined as improvement in the long-range prediction of temperature and precipitation for the coming seasons of the year. Three different forecasting methods will be employed and these will be evaluated for comparative effectiveness.

The journals WORLD ARCHAEOLOGY, Vol 13, 1981, and NEW SCIENTIST, Vol 91, No 1263, 1981, report that the archaeologist E. Marshall, after comparing data on the structure and siting of man's dwellings in the Neolithic in Europe and so-called longhouses now constructed by Melanesian tribes in New Guinea, noted that the Melanesian dwellings always have their narrow side in the direction of the prevailing wind. During the Neolithic European dwellings had their narrow facade toward the northwest. It was therefore concluded that in the fourth century B.C. the prevailing winds, especially in winter, were northerly and northwesterly. This corresponds to the opinion among paleoclimatologists that between the sixth and third millenia (B.C.) in Europe there was a so-called Atlantic climate during which the temperature was higher and the precipitation was more abundant than at the present time, that is, the climate was similar to the present-day climate of the highlands in New Guinea.

It is reported in the JOURNAL OF GEOPHYSICAL RESEARCH, Vol 86, 1981, and NEW SCIENTIST, Vol 91, No 1261, 1981, that Canadian hydrologists have made a study of the problem of the relationship between sea level fluctuations and the calving of glacier masses, leading to the formation of icebergs and floating ice islands. Particular attention was given to glacier "tongues" floating on the sea surface; these evidently successively pass through different phases of growth and breakup into large icebergs. It is postulated that an important role in this process is played by the resonance phenomenon: the detachment of an iceberg is stimulated by a coincidence of the frequency of oscillations of sea waves and the characteristic frequency of vibration of the glacier. The critical moment arrives when the frequency of the characteristic oscillations of the tongue coincides with the frequency of the constant sea surf in the region where the tongue is afloat. The resonance effect comes into play and the amplitude of the glacier oscillations increases. Stresses accumulate and the strength of the glacier is exceeded and part is detached in the form of an iceberg.

OBITUARY OF YEVGENIY KONSTANTINOVICH FEDOROV (1910-1981)

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 82 pp 127-128

[Article by board members of the USSR State Committee on Hydrometeorology and Environmental Monitoring]

[Abstract] Yevgeniy Konstantinovich Fedorov, an academician of the USSR Academy of Sciences, director of the Institute of Applied Geophysics, perhaps the leading figure in Soviet hydrometeorology, died on 30 December 1981 in his 72d year. He made major contributions to the development of Soviet geophysical science, investigation of the Arctic and Antarctica, development of space research and safeguarding of the environment. At the same time he was an effective champion of world peace. His entire life was dedicated to hydrometeorology, beginning with work at polar stations in the Arctic, on Franz Josef Land and Cape Chelyuskin. He was a participant in the legendary drift on the "Severnyy Polyus-1" station and was designated a Hero of the Soviet Union for his contributions there. In the 1930's he became director of the Arctic Institute and in 1939 was designated head of the USSR Hydrometeorological Service; he headed this service for almost 20 years (1939-1947, 1963-1974). He was largely responsible for raising the service to its present-day outstanding level. In 1956 he organized the Institute of Applied Geophysics and served as its director until 1968, and then from 1974 to the end of his life. Under his leadership the institute made outstanding contributions in the field of environmental monitoring and study of heliophysical processes in space. His fields of interest included: weather and climate, water resources, investigation of the seas and oceans, the ionosphere, earth's magnetic and radiation fields, artificial modification of hydrometeorological processes, environmental contamination. During 1959-1962 he was main scientific secretary of the Presidium USSR Academy of Sciences; he became a full academician in 1960. His list of accomplishments is long and impressive: overall technical reoutfitting of the service using the latest technical apparatus: meteorological satellites, meteorological rockets and radars, automatic hydrometeorological stations and automatic facilities for the collection, processing and dissemination of hydrometeorological information. He was largely responsible for establishing a system for the monitoring of radioactive contaminants, radiation conditions and environmental contamination, as well as such organizations as the Institute of Experimental Meteorology, All-Union Scientific Research Institute of Hydrometeorological Information, State Scientific Research Center for the Study of Natural Resources, Central Asian and West Siberian Scientific Research Hydrometeorological Institutes. Figures 1.

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