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No. 3, March 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 551.524.3+551.513(215-17)

VARIABILITY OF TEMPERATURE AND CIRCULATION REGIMES IN NORTHERN HEMISPHERE ATMOSPHERE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 17 Jun 81) pp 8-20

[Article by G. V. Gruza, professor, L. K. Kleshchenko, candidate of geographical sciences, and T. P. Timofeyeva, All-Union Scientific Research Institute of Hydrometeorological Information-World Data Center]

[Abstract] A joint analysis of the long-term changes in a number of key characteristics of state of the atmosphere was made. The spatial and temporal changes in global and local parameters of the temperature and circulation regimes of the northern hemisphere were studied using data for the period 1949-1979 on the basis of the mean monthly fields of temperature and pressure at sea level and the geopotential field at the 500 gPa surface as interpolated at the points of intersection of a geographic grid with a 10° interval along the parallels and a 5° interval along the meridians. The investigation was limited to the latitude zone 30-80°N. In applying the empirical-statistical method it was not only the initial fields which were analyzed, but also the fields of their anomalies, the fields of zonal and meridional components of the horizontal gradient and the modulus of the vector gradient. This analysis indicated that there is a complete noncorrespondence between regional and global climatic changes, revealing an exceedingly complex pattern of climatic changes resulting from interaction of factors of global and local scales acting in unison over extensive regions of the earth only under exceptional conditions. This in-depth study clearly suggests that the long-term changes in the temperature and circulation regimes are characterized by a great diversity, have a complex and unstable character. During the 30-year period studied there are no linear trends in these changes. However, in the 1970's it is possible to see a transition from cooling to warming in mean hemisphere temperature and some increase in anomalousness of processes at the earth's surface manifested in an increase in the gradients of temperature and surface pressure anomalies. Figures 4, tables 3; references 22: 14 Russian, 8 Western.

UDC 551.509.313+551.524

INFLUENCE OF TEMPERATURE STRATIFICATION ON ADIABATIC FLUCTUATIONS IN POLYTROPIC ATMOSPHERE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 12 Jun 81) pp 21-29

[Article by O. K. Gorbunova and V. M. Kadyshnikov, candidate of physical and mathematical sciences, USSR Hydrometeorological Scientific Research Center]

[Abstract] This is essentially a continuation of earlier work by one of the authors (V. M. Kadyshnikov, "Small Oscillations of a Polytropic Atmosphere and Filtering Role of the Hydrostatic Approximation," METEOROLOGIYA I GIDROLOGIYA, No 11, 1979). Now, using the solution obtained in that article, a study is made of the dependence of the spectrum of oscillations in its different parts on γ, which is the principal characteristic of a polytropic atmosphere (γ is the temperature gradient of the main state). The dispersion expression determines two families of frequencies: S_+ gives acoustic waves and S_- gives gravitational waves. The dispersion expression contains two key variable parameters, α and β, and their behavior is examined in detail. In three cases, 1) $\beta \gg 1$, $\beta \gg b$, $\beta \gg \alpha$, $\alpha \neq 0$, 2) $\alpha \ll 1$, 3) $\alpha \gg 1$, $\alpha \gg b$, $\alpha \gg \beta$, using asymptotic formulas for confluent hypergeometric functions, a solution of the dispersion expression can be obtained in explicit form. Case 1, corresponding to long waves, gives a solution for both acoustic and gravitational cases; case 2, also corresponding to long waves, has a solution only for gravitational waves; case 3, corresponding to short waves, has a solution for both types of waves. With this taken into account, it was then possible to study the frequency spectrum of the equations of hydrothermodynamics linearized relative to a state of rest with a polytropic temperature distribution. After investigating the dependence of frequencies and group velocities on the vertical temperature gradient of this state and on the vertical variability of disturbances it was possible to demonstrate that with an increase in stability and a decrease in variability there is a decrease of acoustic frequencies and an increase in gravitational frequencies. It also becomes clear how the velocity of propagation of both types of atmospheric disturbances changes. Figures 2; references: 4 Russian.

UDC 551.509.314+551.524:551.577(47)(571.1)(574)

MAJOR TEMPERATURE AND PRECIPITATION ANOMALIES OVER EUROPEAN USSR, WESTERN SIBERIA AND KAZAKHSTAN

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 18 Jun 81) pp 30-38

[Article by O. V. Batyreva, candidate of physical and mathematical sciences, and L. Ye. Lukiyanova, candidate of geographical sciences, USSR Hydrometeorological Scientific Research Center]

[Text]

Abstract: The article gives a classification of growing seasons on the basis of the ratio between large positive and negative anomalies. The value 1.2 σ was adopted as the criterion for a major anomaly. It was possible to define four classes of growing seasons and an attempt is made to predict these classes by means of linear discriminant analysis. Evaluations of the probable success of the classification surpass the evaluations of a random classification. The mean probable success (guaranteed probability) is 0.70 (for a random classification 0.56), whereas the probability of a precise prediction of the class is 0.48 (for a random classification -- 0.25). The hypothesis of nondependence of the actual and prognostic classes is refuted using the χ^2 test with a 5% significance level.

The problem of long-range forecasting of major temperature and precipitation anomalies is one of the most important and difficult problems in modern meteorology. It has been dealt with in a great number of studies [1, 2, 13] in which the authors develop primarily synoptic methods for the long-range forecasting of large anomalies. As criteria for discriminating major anomalies use is made either of the excess of the σ value over a large part of the territory or the excess of some absolute value of the anomaly (for example, for temperature, etc.). In other studies for defining the types of anomalies use is made of the anomalousness coefficient K proposed by N. A. Bagrov; K^+ and K_- are considered separately for positive and negative anomalies. The anomalousness coefficient includes all the values of the anomalies in the considered territory, both large and small. However, in studying large anomalies it is possible that anomalies less than some critical value will not be taken into account at all. In a study by Aristova [3] the anomalousness criterion used was the fraction of the considered area for which the anomaly exceeds a stipulated level. Unfortunately, only whole values multiples of σ (σ, 2σ, 3σ, $-\sigma$, -2σ, -3σ etc.) are considered as such levels and intermediate levels are not considered in the corresponding intervals.

In this article as a criterion for defining a major anomaly we used the value 1.2σ. In the normal distribution of a meteorological element the probability that this value will be exceeded is 0.12 for an anomaly of each sign (a total of 0.24), that is, approximately about 1/4 of all the cases. Then for a characteristic of anomalousness of the territory it is possible to take the index v, that is, the relative number of stations for which the anomaly exceeds the level 1.2σ. In this way it is also possible to characterize the anomalousness of a stipulated period of time (number of months for which the anomaly $A > 1.2\sigma$). Like K_+ and K_- it is necessary to compute v_+ and v_- separately for positive and negative anomalies. The v value in part corresponds to the mean number of "surges" beyond a stipulated level. However, in the theory of surges a "surge" is an event in which the random value for the first time intersects a stipulated level and therefore the frequency and duration of the surge differ. The application of the theory of surges in meteorology is discussed, for example, in [8, 9] and elsewhere. The proposed v value includes all cases of exceeding of the level 1.2σ, regardless of the preceding and adjacent values of the meteorological element, that is, both the frequency of the surge and its duration are taken into account.

In the analysis of the anomalousness of precipitation and temperature anomalies we used mean monthly data from 1901 through 1978 -- for temperature for 20 stations located in the territory of the main agricultural regions of the USSR (European USSR, Western Siberia, Kazakhstan), for precipitation [10] -- the averaged values for 20 economic regions. The computed temperature and precipitation anomalies were normalized for the σ value and maps of major anomalies exceeding 1.2σ were constructed. The maps were analyzed from month to month in their natural sequence, which made it possible to prepare a catalogue of the most significant anomalies.

It should be noted that in most studies [13] an analysis was made of large anomalies for individual months with a discreteness interval of the data of one year.

An analysis of monthly maps of anomalies in their natural sequence made it possible to detect the characteristics of individual anomalies, common for both precipitation and temperature. As a rule, on each map somewhere there is an anomaly with $\geqslant 1.2\sigma$. Among the 936 maps of anomalies (78 years x 12 months) there were only 116 on which not at a single station did the temperature anomaly not exceed 1.2σ and only 51 such maps of precipitation anomalies where there was not an anomaly with $> 1.2\sigma$ and this was true of all economic regions. However, anomalies with $> 1.2\sigma$ rarely persist at one and the same point or in one and the same region for more than two months. The greatest duration was five months for precipitation and six for temperature. As a rule, the centers of the anomalies appearing initially at one point or in one region during the subsequent months move into adjacent regions, frequently increasing in area and withdrawing considerable distances from the initial center. The total duration of the large anomalies of the same sign, with movement taken into account, can attain 7-8 months and even a whole year. Usually the larger the anomaly is in area, the greater is the area occupied by centers of the same sign and the greater is the duration of this anomaly.

It is asserted in [1, 2] that a large value of the anomalousness index corresponds to a predominance of an anomaly of one sign and large K_+ and K_- values are rarely noted simultaneously. We feel that this is not entirely so. There were 50 such precipitation anomaly maps on which there were not less than three centers of different signs simultaneously. A typical example is the summer of 1972 when there were very large precipitation anomalies of different signs simultaneously in different parts of the considered territory: a strong drought in the northern and central regions of the European USSR and excess moistening in the western regions. During the warm months there is an inverse relationship between the temperature and precipitation anomalies, whereas in the cold months there is a direct relationship. The number of major positive precipitation anomalies in all months of the year is greater than the number of negative anomalies, which corresponds to data on the asymmetry of precipitation [4]. In summer positive temperature anomalies are encountered more frequently than negative anomalies, and in winter, vice versa, which also corresponds to the asymmetry values [5]. The mean frequency of recurrence of major temperature anomalies is 20-22%; for precipitation it is 18-20%. An increase in the total number of major anomalies has been clearly noted during the last decade (since 1970).

The maximum frequency of recurrence of major temperature anomalies, 25%, was observed from 1931 through 1940 and from 1971 through 1979. The maximum frequency of recurrence of major precipitation anomalies is 23% and falls in the 1960's and 1970's. This conclusion agrees well with the results in [6, 7, 14, 15], where the authors noted an appreciable increase in anomalousness in the 1970's both for the territory of the USSR and for the entire northern hemisphere. The spatial differences in the frequency of recurrence of major anomalies are not very great (from 18 to 24%); the anomalousness of the northern regions is somewhat greater than in the southern regions. There is a very small number of major negative precipitation anomalies for the 19th region -- Transcaucasia (11%). The frequency of recurrence of values $>1.2\sigma$ on the average is somewhat less than for an independent normal sample (24%), which is attributable to coherence in time and deviations from normality. The frequency of recurrence of major anomalies of different duration corresponds well to the evaluations of the probability of a surge beyond the level 1.2σ for a two-dimensional normal sequence, which, according to [8, 9], can be evaluated as 0.08-0.09. The differences in the character of the anomalousness between individual months of the year are also small (from 18 to 23%) and correspond well to the asymmetry and excess values. Since an analysis of individual anomalies is difficult due to the great differences in their duration and geographic position, first we analyzed the generalized characteristics of major anomalies as a whole for the entire territory and for a long period of time (year and growing season).

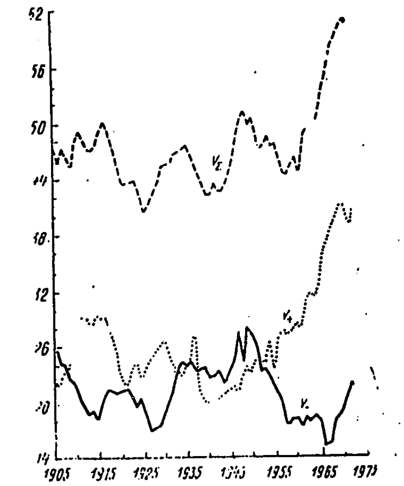

Fig. 1. Ten-year moving averages v_+, v_-, v_Σ of precipitation.

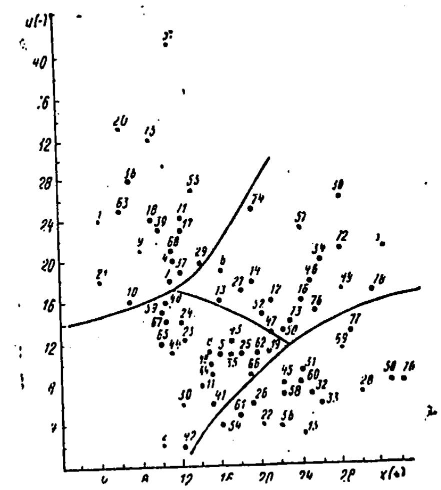

Fig. 2. Classification of growing seasons on basis of character of anomalousness of precipitation.

In order to define the climatic characteristics the values v_+, v_- and also their sums v_Σ for temperature and precipitation were summed both for the entire year and for the growing season (from April through September) and we constructed graphs of the temporal variation of these indices and also their five- and ten-year moving averages. Year-to-year variations are 15-20% of the annual sums v_+, v_- and v_Σ. There is a general increase in the total anomalousness of precipitation in the 1930's up to 1936, after which there is a decrease to a minimum in 1942. A general increase in the anomalousness of temperature and precipitation in the 1970's with sharp variations for individual years was characteristic. The moving averages graphs make it possible to define quasiperiodic variations with periods of 15-20 years. As a rule, the v_+, v_- curves vary in antiphase, although there are periods of a simultaneous increase in anomalousness of both signs. For example, all the moving five- and ten-year periods, including the 1970's, give an appreciable increase in the annual and semiannual sums v_+, v_- and v_Σ simultaneously (the total anomalousness of precipitation during recent years exceeds by approximately 20% the values encountered earlier). For temperature this characteristic is expressed to a lesser degree. Examples of the graphs are shown in Fig. 1.

Since major temperature and precipitation anomalies are most important for agriculture when they occur in the growing season, the breakdown of all the years into classes on the basis of the character of the anomalousness was carried out using the sums v_+, v_- and v_Σ for the entire growing season. A classification of all the growing seasons from 1901 through 1978 was carried out on the basis of the ratio of the total number of major positive and negative anomalies. The values of the sums v_+ and v_- for the growing season for all years from 1901 through 1978 were regarded as the coordinates of a point on a plane in a Cartesian coordinate system and were plotted on the graph.

The number of the year in the 20th century to which the corresponding values related was plotted near each point.

The distribution of points for precipitation is shown in Fig. 2. The separation of growing seasons on the basis of temperature was carried out in a similar way, with the single difference that the $\sum v_+$ and $\sum v_-$ axes changed places. Although no clear separation into groups could be detected in the figures, nevertheless it was possible to define some clusters of points in definite regions of the plane and draw the boundaries.

For example, it is possible to define four groups of points corresponding to four classes of growing seasons differing with respect to the ratio of the number of major anomalies of different signs. First, it was possible to define years for which the number of major anomalies of the same sign appreciably exceeds the corresponding number of anomalies of the other sign (on the average by more than the standard deviation "σ" of the corresponding value). Thus, we define two extreme classes -- first and fourth. The arid years for which $\sum v_- > \sum v_+$ entered into the first class for precipitation, whereas for temperature -- the anomalously hot years when $\sum v_+ \gg \sum v_-$. In the fourth class the moist periods with $\sum v_+ \gg \sum v_-$ enter for precipitation (and accordingly, for temperature, the cold years when $\sum v_- \gg \sum v_+$). The "middle" classes (second and third) are characterized by approximately equal values of the sums v_+ and v_-, whose difference, as a rule, does not exceed the standard deviation of the corresponding value. The second class includes years with small $\sum v_+$ and $\sum v_-$ values (less than the mean values), whereas the third class includes years with large values (greater than the means). In the first stage the separation into classes was carried out separately for temperature and precipitation. The lists of the corresponding classes are given in Table 1.

The cited lists show that the defined classes for precipitation and temperature partially correspond to one another, that is, about half the growing seasons fall in one and the same classes. The best correspondence is attained for the first class (dry and hot) and a worse correspondence for the fourth class.

In actuality, as is well known, hot and dry years are characterized by a predominance of anticyclonic weather, whereas major positive anomalies of precipitation in summer are associated with an intensification of cyclonic activity and the transport of moist air masses from the Atlantic; major negative temperature anomalies are associated with the intrusion of cold arctic air from the north.

If the moistening conditions during the growing season are considered, it is necessary to take into account temperature and moisture anomalies simultaneously. For example, D. A. Ped' [12] proposed an aridity index which represents the difference between the normalized temperature anomaly and precipitation. All the droughts known in history were accompanied by major anomalies of both precipitation and temperature (droughts of 1921, 1936, 1972, 1975, etc.). Thus, in order to characterize the moistening conditions during the course of the growing season it is possible to consider the values $w_- = v_-$ (precipitation) $+ v_+$ (temperature), w_+ (precipitation) $+ v_-$ (temperature). These values in turn can be divided into classes on the basis of the same principles as temperature and precipitation separately. The cited list of classes to a high degree corresponds to the classes of temperature and precipitation.

Table 1

List of Classes of Anomalousness of Temperature, Precipitation and the Generalized Index w (the Table Columns Give the Years of the 20th Century. For Example, 01 Should be Read 1901, 45 -- 1945, etc.)

Classes											
I	II	III	IV	I	II	III	IV	I	II	III	IV
Precipitation				Temperature				Generalized wind index			
01	02	03	15	01	03	06	02	01	05	03	02
04	05	06	22	20	05	09	04	06	07	13	04
07	08	12	26	21	10	15	07	08	10	23	09
09	11	13	28	24	22	17	08	20	18	29	11
10	19	14	31	31	25	23	11	21	22	31	12
17	23	16	32	32	27	29	12	24	25	34	14
18	24	27	34	36	30	34	13	36	27	46	15
20	25	34	45	37	33	39	14	37	30	49	16
21	30	38	53	38	35	49	16	38	32	50	17
29	35	46	54	40	43	50	18	39	35	52	19
36	40	47	56	46	44	52	19	40	43	68	26
37	41	49	58	48	59	54	26	48	44	73	28
39	42	50	60	51	61	62	28	51	53	77	33
51	43	52	61	53	64	65	41	55	54		41
55	44	57	69	55	68	73	42	57	59		42
63	48	72	70	57	70	76	45	66	61		45
68	59	73	77	63	71	77	47	67	62		47
71	60	74		66	74		56	71	64		56
75	62	76		67			58	72	65		58
	64	78		72			60	75			60
	65			75			69	74			69
	66						78	76			70
	67										

Table 2

Mean $\overline{d}_{ik}$ and Maximum $d_{jk(max)}$ Distances Between Classes

	Initial month					
	X	XI	XII	I	II	III
	Precipitation					
d_{jk}	0,77	0,62	0,84	0,85	1,04	1,03
$d_{jk(max)}$	1,65	1,13	1,24	1,60	1,73	1,35
	Temperature					
d_{jk}	1,23	0,92	1,28	0,62	0,87	0,83
$d_{jk(max)}$	1,59	1,32	1,56	0,82	1,39	1,36

Table 3

Probable Success of Classes of Anomalousness and Precise Falling Into Class

	Initial months										
	X	XI	XII	I	II	III	X-XI	XI-XII	I-II	X-XII	X-III
					Precipitation						
Probable success	0.69	0.68	0.67	0.64	0.68	0.68	0.69	0.72	0.71	0.73	0.83
Probability of precise falling into class	0.46	0.41	0.43	0.36	0.48	0.46	0.46	0.54	0.47	0.58	0.67
					Temperature						
Probable success	0.71	0.68	0.71	0.67	0.69	0.63	-	-	-	-	-
Probability of precise falling into class	0.51	0.46	0.56	0.42	0.45	0.36	-	-	-	-	-

It should be noted that the defined classes make it possible to describe only the general character of anomalousness during the entire growing season and for the region as a whole (region of the European USSR, southern part of Western Siberia, Kazakhstan). The classification does not take into account the location of the centers of positive and negative anomalies within the region and their change during the course of the growing season. Allowance for all these differences would lead to a far greater number of classes, which would make difficult their prediction. Nevertheless, the classification corresponds fairly well to the separation of years obtained by other methods. All the best known droughts fell in the first class. The only exception is the summer of 1972, which with respect to precipitation fell in the third class, not the first, since there were no major negative anomalies over the entire territory: a drought occurred primarily in the northern and central regions of the European USSR, whereas in the western regions at the same time there was a considerable positive precipitation anomaly. However, with respect to temperature and the w index 1972 fell in the first class.

It is of interest to give a prediction of the defined classes on the basis of an analysis of the preceding conditions in the atmosphere. The longest series are for the temperature field. It was selected as a set of criteria for making the classification. Since the years entering into each class were known in advance, we carried out the procedure of "learning with a teacher," that is, breakdown of criterion space into regions best corresponding to stipulated classes. The teaching sample represented the temperature field expanded in natural orthogonal components. The first eight normalized coefficients of the expansion were taken as criteria in the discriminant analysis. Linear discriminant analysis was used on the assumption of a normality of the distribution of criteria and the equality of the covariation matrices of the classes. Although these assumptions, strictly speaking, are not satisfied, nevertheless, as was demonstrated in [10], the advantage of use of quadratic discriminant analysis is not maintained with a changeover to independent material. In this case, since the breakdown was made into four classes, the samples for evaluating the covariation matrices of the four classes were too small. Accordingly, we used one covariation matrix for all classes. A linear parametric algorithm was used; the vectors of the mean criteria in space were found for each class and the corresponding linear discriminant functions were constructed.

As indicated in [11], the linear discriminant functions for normal objects with equal covariation matrices correspond to the classificator for the minimum distance from the class "standard" (the standards are the mean fields for each class). Since the expansion coefficients are statistically independent criteria, the distances d_{jk} are determined as the sum of the squares of the normalized expansion coefficients.

Table 2 gives the mean and maximum distances d_{jk} between the class standards. This value (the Mahalanobis distance) serves as an indirect evaluation of classification quality. Table 2 shows that the minimum distances were obtained for the prediction for January. The classes of temperature anomalousness are less different in the space of the selected criteria than the precipitation criteria. The distance between the first and fourth classes on the average exceeds the distance between the other classes (by approximately 0.4).

It is of interest to check the significance of the determined distances between classes. For this we will assume that the entire criterion space belongs to one and the same multidimensional normal set with a zero vector of the means and a unit covariation matrix. These conditions are well satisfied for the normal coefficients of expansion in natural components. We will find the critical distances between the means of the classes which would be obtained if the classes were formed randomly. The Mahalanobis distance between the j-th and k-th classes is

$$d_{jk} = (\mu_j - \mu_k)' S^{-1} (\mu_j - \mu_k) = \sum_{l=1}^{8} \left(\frac{\overline{A}_{jk}}{\lambda_l} - \frac{\overline{A}_{lk}}{\lambda_l} \right)^2, \quad (1)$$

where μ_j, μ_k are the vectors of the mean classes, S is the covariation matrix, $\overline{A}_{ji}$, $\overline{A}_{ki}$ are the mean values for the j-th, k-th classes of coefficients of the expansion, d_{jk} has the distribution

$$2\sigma^2 \left(\frac{\overline{A}}{\lambda} \right) \chi_8^2,$$

where χ_8^2 is the χ^2 distribution with 8 degrees of freedom. The parameters in the parentheses have the dispersion

$$\frac{2\sigma^2 \left(\frac{A}{\lambda} \right)}{n},$$

where n is the number of the class. Assuming the number of years in the class to be 20, we find that the dispersion of each term 2/20·1 is approximately equal to 0.1. Since the dispersion $D\chi_k^2 = 2k = 2.8$, then the dispersion d_{jk} =0.1·2·8 = 0.16, and the standard deviation $\sigma(d_{jk}) = 0.4$. The mean value d_{jk} is approximately equal to

$$2\sigma^2 \left(\frac{A}{\lambda} \right) \overline{\chi_k^2} \approx 0{,}1 \cdot 8 = 0{,}8. \quad (2)$$

Table 2 shows that the maximum distance between the classes in many cases exceeds 10% and even 5% of the critical distribution value $\chi_8^2(\alpha)$, equal to 1.33 and 1.55 respectively.

We evaluated the quality of the classification for all the teaching sample from 1901 through 1978. The evaluation was made in the following way: with precise falling into a class the evaluation of the forecast was equal to 1; when falling into the adjacent class -- 1/2, and in the opposite case -- 0. A purely random forecast of the equiprobable classes with such an evaluation matrix has a probable success (guaranteed probability) of 0.56, whereas the probability of precise falling into a class is 0.25 (each matrix "box" corresponds to a probability of entry equal to 1:16). The classes which we defined are nonequally probable and therefore the probable success of a random forecast is dependent both on the natural frequency of recurrence of classes and on the frequency of forecast of each class. We computed evaluations of random forecasts with the actual probabilities taken into account; they do not exceed 0.58-0.59, but the probability of precise entry into a class for a random forecast does not exceed 0.27-0.28.

Table 3 gives evaluations of the probable success of the discriminant analysis and also the frequency of precise falling into a class. Table 3 shows that the evaluations everywhere exceed the probable success of the random classification. The mean probable success p is equal to 0.70. The probable success of the classes for temperature for January is somewhat lower. Falling into a class in most cases exceeds by almost twice the corresponding number for a random classification and is about half of all the cases. The mean probability of a precise falling into a class is 0.78. With an increase in the advance time of the forecast the quality of the classification does not change significantly.

The next step was a classification on the basis of the minimum distance from the standard for the sum of the squares of the difference in the normalized expansion coefficients for two, three or more months. Although the expansion coefficients for the successive months have some coherence, it is not great and it can be neglected. The expansion coefficients for the different months can serve as new criteria for the classification. The combining of two, three or more months as prognostic criteria will make it possible to improve the evaluations of the classification up to 83%.

Table 4

Conjugation of Criteria

Fact	Forecast			
	I	II	III	IV
I	6	5	5	3
II	4	12	2	4
III	6	2	10	2
IV	3	2	4	8

The hypothesis of a nondependence of the actual and prognostic classes was checked using the χ^2 test. The matrix of conjugation of the criteria for the forecast for October is represented in Table 4. The computed values of the criterion were highly significant (24.96), whereas the 5% critical value was $\chi^2_9(0.05) = 16.56$. In this case the matrix of conjugation of criteria was constructed for predicting the classes of anomalousness of precipitation for October, having the evaluations $p = 0.69$ and $p_{ii} = 0.46$. As indicated by the conjugation matrix, the frequency of recurrence of prognostic classes approximately corresponds to the actual frequency of recurrence. The best probable success is for the "middle" classes (second and third) and the minimum success is for the first class. The falling of a forecast into a class opposite the actual class (first and fourth) is rather rare (6 cases in 78). The conjugation matrices for the other months have a similar character. The hypothesis of independence of the actual and prognostic classes in most cases is refuted. The probable success of a random classification was also checked using statistical modeling. The actual classes, defined on the basis of the character of anomalousness (Table 1), were compared with the classes formed randomly (from a table of random numbers) and selected simply in chronological order. The evaluations of the probable success of random classifications were in the range:

p = 0.55-0.59, p_{ii} = 0.21-0.24, which is close to the theoretical evaluations and is appreciably inferior to the quality of the classification for the temperature field.

Thus, the temperature field of the northern hemisphere can serve as a predictor for determining the general character of anomalousness over the course of the growing season.

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UDC 551.515.22+551.576+551.513.5

INTERACTION BETWEEN SUBCLOUD AND CLOUD LAYERS IN TROPICAL CYCLONES AND INTERTROPICAL CONVERGENCE ZONE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 18 Jun 81) pp 39-45

[Article by Ye. A. Agrenich and A. P. Khain, candidate of physical and mathematical sciences, USSR Hydrometeorological Scientific Research Center]

[Abstract] The method developed by J. Ogura and H. R. Cho (J. ATMOS. SCI., Vol 31, 1974) was used in a somewhat modified form in order to determine the height of the mixing layer, its structure and vertical mass flow in cumulus clouds at the level of their base. Under disturbed weather conditions the authors examine the layer under the clouds, whose thermodynamic structure is similar to the structure of the mixed layer under undisturbed conditions. In the formulated problem it is assumed that in the subcloud layer the dry static energy s_m and the mixing ratio q_m do not change with height. It is assumed further that the transitional layer has an infinitely small thickness (the level of the cloud base coincides with the upper boundary of the mixed layer). Ogura and Cho concluded that computations with k = 0.1 and 0.2 (k is an important proportionality factor used in a key formula derived by D. K. Lilly in QUART. J. ROY. METEOROL. SOC., Vol 94, No 2, 1968) but with $\alpha = 0.5$ (α is a variable parameter) (which assumes the presence of "warm roots" of clouds in the subcloud layer) the results are entirely realistic for weak tropical disturbances. The method was used in computing the mass flow in clouds and other characteristics for GATE phases I and III. The same method was applied in studying tropical cyclones Inez, Hilda and Daisy. It was found that the parameter k = 0.2 is not suitable for regions of a tropical cyclone close to the center. For tropical cyclones the results obtained with k = 0.7 are satisfactory. There is clear evidence that there are "warm roots" in clouds. Figures 1, tables 3; references 8: 3 Russian, 5 Western.

UDC 551.576.1+551.509.314(-062.5)

INVESTIGATION OF CLOUD COVER DYNAMICS IN TROPICAL ZONE USING TWO-DIMENSIONAL SPECTRAL ANALYSIS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 9 Jun 81) pp 46-49

[Article by A. V. Kislov, candidate of geographical sciences, Moscow State University]

[Abstract] Cloud cover can be used as an indicator of atmospheric thermodynamic processes and in the tropical zone is virtually the sole source of global meteorological information. By appropriately selecting the discreteness and resolution of space photographs it is possible to investigate meteorological phenomena at different scales. The investigated region virtually encircled the globe and was bounded on the north by 5°N and on the south by 20°S. The basis for the study was satellite cloud cover photographs, with visual interpretation of cloud coverage in each 5° square for each day from 1 November 1977 through 8 March 1978. The choice of this region and observation period was dictated by the need to study the dynamics of the cloud cover caused by waves in the easterly flow over a highly uniform underlying surface. The investigated region was divided into five latitude zones. In each such zone (containing M = 64 5° squares) the structure of the cloud cover was studied for a period (N = 128 days) and a matrix of initial data X(N, M) was stipulated. These data were subjected to two-dimensional spectral analysis (separately for each latitude zone) after carrying out filtering of the low-frequency components. As a result of this analysis it was found that in the equatorial and tropical zones there are synoptic disturbances of the easterly waves type with a period of 3 days and a length in a zonal direction of about 3,000 km. The materials presented here reveal the effectiveness of using two-dimensional spectral analysis for investigating stationary random fields. Figures 1; references: 6 Russian, 5 Western.

UDC 551.509.314+551.524

MODELS OF ONE-DIMENSIONAL AND JOINT DISTRIBUTIONS OF NON-NEGATIVE RANDOM VALUES

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 24 Jun 81) pp 50-56

[Article by A. S. Marchenko, professor, and A. G. Semochkin, Computation Center, Siberian Department, USSR Academy of Sciences]

[Abstract] A great number of different distributions dependent on one, two or a greater number of parameters are used in approximating the probability distributions of non-negative hydrometeorological elements with values in the range $(0, \infty)$. As an alternative, the authors here propose models of one-dimensional and joint distributions. The principle for constructing these was outlined by A. S. Marchenko, et al. in METEOROLOGIYA I GIDROLOGIYA, No 9, 1980. These are mixtures of distributions stipulated on the positive semiaxis. The best variants are mixtures of two two-parameter distributions, that is, distributions dependent on five parameters. Here the authors examine two gamma distributions with different densities

$$p_1(z)=\frac{z^{\nu_1-1}e^{-\frac{z}{\lambda_1}}}{\lambda_1^{\nu_1}\Gamma(\nu_1)},\quad p_2(z)=\frac{z^{\nu_2-1}e^{-\frac{z}{\lambda_2}}}{\lambda_2^{\nu_2}\Gamma(\nu_2)}, \tag{1}$$

and it is demonstrated that a family of distributions of the type

$$p(z)=\theta\, p_1(z)+\theta' p_2(z),\quad 0<\theta<1,\quad \theta'=1-\theta, \tag{2}$$

where $p_1(z)$ and $p_2(z)$ correspond to (1), contains distributions with any prestipulated mean value, dispersion and virtually any asymmetry. The described method for selecting the five parameters of the mixed distribution in principle is the same as in the article cited above but it takes into account new effects attributable to the fact that the $p_1(z)$ and $p_2(z)$ distributions are stipulated in the interval $(0, \infty)$. Models of time series with marginal distributions of this type are examined. As an illustration of application of the method the article gives approximating expressions for the correlation functions of the wind velocity modulus at several stations in January. The method was also successfully used in approximating the distributions of river discharges and the quantity of precipitation. Figures 3; references: 7 Russian.

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DISSIPATION OF KINETIC ENERGY IN CYCLONE OVER OCEAN

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 15 Jun 81) pp 57-64

[Article by K. A. Rogachev, Pacific Ocean Oceanological Institute]

[Abstract] A system of equations is derived constituting a closed system describing wind-wave interaction and relating the macroscale characteristics of the atmospheric boundary layer through the dissipation of kinetic energy to the characteristics of the near-water layer, dependent on the stage of development of wind waves. This system of equations in essence is a nonstationary model of the boundary layer of a weather system over the ocean. By stipulating the initial dynamic velocity v_{*0} and phase velocity of waves c_m it is possible to determine evolution of principal boundary layer characteristics. The described system is very sensitive to v_{*0} changes. With a dependence of the dissipation of kinetic energy on the regime of wave development the wave energy increases by an order of magnitude in a time less than a day in comparison to a variant when v_{*0} is constant. The kinetic energy of the wind in the near-water layer during this same time increases by a factor of 3. The complete analysis of this process reveals that the density of kinetic energy of the wind during a day can increase by several times only due to a change in dissipation related to the generation of wind waves. Due to the nonstationary character of the problem, because of the v_{*0} variability there is a different character of the change in dynamic velocity and phase velocity of wind waves with time. Whereas with constant v_{*0} the dynamic velocity in the near-water layer decreases rapidly with the development of waves, in the considered model v_* changes slowly during the entire time of growth of dynamic velocity v_{*0} in the external flow. Due to this and a decrease in the roughness parameter the wind velocity in the near-water layer increases. By examining the relationship between ocean-atmosphere energy exchange, energy transformations in the near-water air layer and the state of the ocean surface for the purpose of determining the dissipation of kinetic energy it can be seen that the wind-wave correlation is important in any change in wind kinetic energy. Figures 2; references 14: 5 Russian, 9 Western.

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PREDICTION OF WATER SALINITY IN GULF OF RIGA BOTTOM HORIZON

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 1 Jun 81) pp 65-73

[Article by Ye. N. Zakharchenko, Latvian Republic Administration of Hydrometeorology and Environmental Monitoring]

[Abstract] The author investigated the spatial and temporal variability of salinity in the bottom waters of the Gulf of Riga and developed a method for predicting salinity in the bottom horizon. Salinity is governed by the volumes of river water entering the gulf and water exchange with the Baltic Sea. Conditions vary with season. For example, during spring-summer there is a horizontal inhomogeneity. From the head of the gulf the salinity increases toward the central, deepest part and in the western sector, closest to Irbenskiy Strait, which communicates with the Baltic. The bottom horizon was regionalized on the basis of bottom hydrological characteristics, including salinity, into four parts: I) closest to Irbenskiy Strait, II) shallowest sector; III) deepest sector; IV) most distant from Irbenskiy Strait. The amplitudes of the month-to-month and year-to-year salinity variations are approximately identical and can attain 1.0-1.5^{o}/oo; these variations for the most part are attributable to variations in the intensity of water exchange with the Baltic. A series of equations (summarized in Table 1) was derived for predicting bottom-layer salinity for May and August. The article gives an example of such a forecast, 1979 and 1980 being used as test years. It was found that there is a definite correlation between wind over the sea, level in the Gulf of Riga and the latitudinal component of the current vector in the lower layer of Irbenskiy Strait. The restructuring of currents in the lower layer of the strait lags by 24 hours relative to wind restructuring over the sea. The clarification of the mechanism of water exchange through the strait made it possible to predict water salinity in the bottom layer in the gulf 1-1.6 months in advance. The derived formulas can be used in planning fishing operations and in evaluating biological resources. Figures 3, tables 2; references: 17 Russian.

UDC 551.461.2(268.4/.5)

STATUS AND PROSPECTS OF NUMERICAL HYDRODYNAMIC INVESTIGATIONS OF FLUCTUATIONS OF LEVELS IN ARCTIC SEAS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 25 May 81) pp 74-80

[Article by N. V. Mustafin and A. Yu. Proshutinskiy, candidates of geographical sciences, Arctic and Antarctic Scientific Research Institute]

[Text]

Abstract: This is a concise review of numerical hydrodynamic investigations of the formation of fluctuations of level in arctic seas. The authors deal with the tasks in improving models and combining numerical experiments with in situ observations. It is emphasized that the development of operational level forecasting methods must be based on the joint implementation of numerical hydrodynamic and physicostatistical investigations with practical experience taken into account. It is proposed that an integrated system be created for numerical hydrometeorological forecasts under the condition that arctic administrations of the State Committee on Hydrometeorology and Environmental Monitoring be supplied with modern electronic computers.

Introduction. A study of level fluctuations -- an integral indicator of the hydrological regime and an important element of oceanic dynamics -- is a component part of oceanological research. The practical aspects of study of level variability are extremely timely, such as for improving the service for level forecasts in the Arctic. Together with the ice and weather services it is the basis for the hydrometeorological support of navigation along the Northern Sea Route.

At the present time the study of level fluctuations on the basis of in situ data is combined with hydrodynamic modeling and numerical experiments. It is noteworthy that the latter became not simply a feasible, but also a necessary element of oceanological investigations. Such an approach not only broadens the possibilities of a scientific analysis, but also reduces the costs in carrying it out. Applicable to the problem of studying level fluctuations in the Kara, Laptev, East Siberian and Chukchi Seas by means of numerical hydrodynamic modeling, it is for the most part the following problems which are solved:

Investigation of the role of different factors forming level fluctuations under specific physiographic conditions in the arctic region as a whole and in each of the seas separately.

Development of methods for computing the level and its extremal characteristics for supporting hydrotechnical, industrial and communal planning and construction and also the planning of new types of transport ships and icebreakers.

Study of the regime of level fluctuations. The possibility of computing the characteristics of the phenomenon in regions inadequately or completely unsupplied with in situ data is acquiring particular importance.

A rough evaluation of the future regime and study of changes in the dynamics of level fluctuations of seas where the local geographic characteristics change as a result of implementation of major national economic measures (construction of dams, protective dikes, withdrawal of river runoff, etc.).

Developing methods for predicting level fluctuations for supporting navigation.

Review of investigations. The need for numerical hydrodynamic investigations of level fluctuations of arctic seas was indicated as early as 1966 in [4]. Some of the problems formulated there have now been solved. We will examine the status and results of numerical hydrodynamic investigations of level fluctuations in arctic seas, carried out at the Arctic and Antarctic Scientific Research Institute during recent years.

The extensive continental shelf (76-99% of the ocean area) and the relative shallowness of arctic seas favor the formation of considerable wind-induced level fluctuations. The tidal component of fluctuations was relatively small (numerical computations of tidal movements in arctic seas were earlier made by A. V. Kopteva (1959), B. A. Kagan (1968), K. D. Tiron (1975)). A still lesser contribution, as indicated in [2], is made by the steric component of level fluctuations. Accordingly, the first stage in the investigations included the aperiodic level fluctuations and dealt with the following problems:

Study of the applicability of existing hydrodynamic models for computing wind-induced level fluctuations in arctic seas.

Numerical realization of models and their calibration using in situ data for the investigated region.

Quantitative evaluation of the role of the wind, atmospheric pressure, bottom relief and shore configuration, the earth's rotation and river runoff in the formation of aperiodic level fluctuations in arctic seas on the basis of developed numerical methods for analysis of the phenomenon.

Table 1

Principal Numerical Experiments for Calibrating Models and Investigation of Characteristics of the Formation of Wind-Induced Level Fluctuations in Arctic Seas

Name of experiment	Purpose and character of experiment
"Kanal," "Basseyn" ("Channel," "Basin")	Investigation of forming of wind-induced phenomena in channels and model basins in two- and three-dimensional models. Evaluation of results by comparison with data from analytical solutions.
"Treniye na poverkhnosti"*	Determination of dependence for computing tangential wind friction. Calibration of dependences on the basis of in situ data.
"Veter" ("Wind")	Development of methods for computing wind fields in open sea. Selection of methods for interpolation of atmospheric pressure fields. Calibration using in situ data.
"Treniye u dna" ("Bottom friction")	Determination of dependence for computing bottom friction in two- and three-dimensional models. Calibration of dependences on the basis of in situ data.
"Zhidkiye granitsy"**	Selection and evaluation of boundary conditions on liquid contour of seas.
"Sopryazheniye" ("Coupling")	Determination of possibility of coupling of grid regions with different spatial resolution. Coupling of two-dimensional model of open sea with three-dimensional model of local regions.
"Obmen" ("Exchange")	Investigation of feasibility of computations of level fluctuations simultaneously in all seas in one model. Determination of role of water exchange between seas in forming structure of level fields in stormy periods.
"Rel'yef" ("Relief")	Evaluation of role of bottom relief and shore configuration in forming of wind-induced phenomena in arctic seas.
"Koriolis" ("Coriolis")	Determination of role of earth's rotation in development of wind-induced phenomena in region.
"Grad" ("Gradient")	Evaluation of role of atmospheric pressure (pressure gradients in model equations of motion "Grad") in forming level field spatial structure.
"Stok" ("Runoff")	Investigation of contribution of runoff of major rivers to development of considerable wind-induced phenomena along coast in computation of the regime characteristics of level fluctuations and detailed investigation of water dynamics in local regions.
"Dinamika" ("Dynamics")	Determination of dependence of magnitude and phase of level fluctuations on rate of movement and trajectory of pressure formations.
"Statistika" ("Statistics")	Series of model computations of level in real synoptic situations for obtaining mean statistical characteristics of modeling quality. Evaluation of accuracy of models and methods used in computing fields of atmospheric pressure and wind.

* "Surface friction"
** "Liquid

investigation of the regime characteristics of wind-induced level fluctuations in regions not supplied with observational data.

Two- and three-dimensional models of storm surges were used in solving these problems [11, 12]. The realization of models for arctic seas was described in [6-8]. Table 1 gives a list of the principal numerical experiments carried out as a result of investigation of the features of level fluctuations observed in arctic seas. In the first approximation a study was made of the most significant level fluctuations during the navigation season when the influence of the ice cover can be neglected. In order to satisfy the requirement of adequacy of the results of computations and data from in situ observations the modeling of wind-induced level fluctuations was accomplished simultaneously for the entire shelf zone of arctic seas. The criteria of agreement between computed and observed level values were the statistical evaluations used in numerical hydrodynamic weather forecasts: mean computation error, mean absolute error in computations, mean square error, computation quality parameter and correlation coefficient between the computed and actual level variation. A comparison of the results of modeling with observational data was carried out at 35 points located on the coast and on islands of the studied seas.

Table 2 gives the mean statistical quality characteristics obtained in the modeling of 10 synoptic situations causing the most significant level fluctuations. The presented evaluations are evidence of the accuracy which at the present time meets the requirements imposed on computations or prediction of wind-induced phenomena [9].

The developed methods for computing level fluctuations in arctic seas can be used for prognostic purposes when there is a reliable prediction of the surface field of atmospheric pressure or wind. Experience shows that for computing a situation with a duration of 36 hours it is necessary to expend 40 minutes with a "Minsk-32" electronic computer. The collection and processing of initial data require 40 minutes and the preparation of the collected information in a form convenient for analysis requires 20 minutes. It is desirable that the making of forecasts by hydrodynamic methods be carried out in combination with numerical forecasts of meteorological and other hydrological elements. This will make it possible to reduce the random errors in the transmission of data and reduce time consumption on preparatory work.

The advance time and accuracy in predicting wind-induced level fluctuations with use of the considered methods is dependent for the most part on the corresponding characteristics of prediction of the fields of atmospheric pressure and wind. In actuality, using as a point of departure an analysis of the equations of motion employed in computing wind-induced processes, it can be concluded that the level errors must be dependent not only on the errors in meteorological parameters, but also on the absolute velocity, direction and duration of the wind effect. An analysis made it possible to explain why in the computations of wind-induced phenomena for real situations the best results are obtained when modeling the most significant level fluctuations. First, considerable level fluctuations are caused by pressure formations with large horizontal gradients of atmospheric pressure, and in this case the errors in computing wind velocity and direction are usually minimum. Second, the wind in the case of great level fluctuations operates along the effective direction of wind-induced fluctuations and an error in wind direction in this case of even 30° causes an error in level of not more than 20 cm. Third, the duration of operation of strong winds usually does not exceed 6-12 hours, which also does not lead to significant level distortions.

In the modeling of insignificant level fluctuations caused by low-gradient pressure fields the relative errors in the computed levels sharply increase, for the most part due to an increase in the errors in determining the direction of the prevailing wind as a result of the nonrepresentativeness of blurred pressure fields resulting from the thin network of meteorological stations in the Arctic.

Thus, an evaluation of the accuracy of numerical hydrodynamic methods for computing wind-induced level fluctuations with the existing accuracy in determined and computed meteorological fields must be carried out using data on the maximum level fluctuations. Accordingly, the statistical evaluations of the quality of modeling were ranked using the magnitude of level fluctuations. It is desirable to formulate the requirements on the accuracy of meteorological forecasts in different regions, upon attaining which a numerical hydrodynamic prediction of wind-induced level fluctuations is applicable.

Within the framework of the developed methods an attempt was made to obtain regime characteristics of wind-induced phenomena of practical importance. One of these is the extreme level fluctuations which are possible once a year or once in 5, 10, 20 and 50 years. Maps with such characteristics were prepared for all the studied arctic seas and were included in a scientific-practical manual prepared for publication. A comparison of the computed extremal level values determined by hydrodynamic modeling and the results of computations of the extremal levels at shore stations, carried out using observational data and using the method described in [1], gave satisfactory results. For a number of points along the shore the data computed using the model were too low by 20-40 cm. This must be expected because in the developed method the computation of extremal levels did not take into account the movement of pressure systems. Within the framework of the created method it is evidently necessary to develop procedures for taking the movement of pressure formations into account in order to make allowance for possible resonance phenomena and also to take into account the interaction of wind-induced phenomena with tidal level fluctuations.

A definite step has been made in this direction. In particular, with the participation of Ye. N. Uranov there was a classification of atmospheric processes evidently causing considerable level fluctuations in the Kara Sea. This was done on the basis of a joint analysis of three interrelated synoptic fields (surface atmospheric pressure, air temperature at the earth's surface, field of altitudes of the 500-mb surface). Such an approach made possible an indirect allowance for cyclogenesis processes, variability of the trajectories of pressure formations and the influence of thermal factors on the formation of surface-level wind fields. As a result of the computations it was possible to define six types of level fluctuations, the modeling of standard processes was carried out, the sea area was regionalized on the basis of level reaction to the external atmospheric effect. Parallely, using a two-dimensional model, a series of computations were made of tidal movements in the Kara Sea. Thus, within the framework of a two-dimensional formulation of the problem the prerequisites were established for modeling the interaction of tidal level fluctuations and wind-induced phenomena. Similar studies are now being made for other arctic seas.

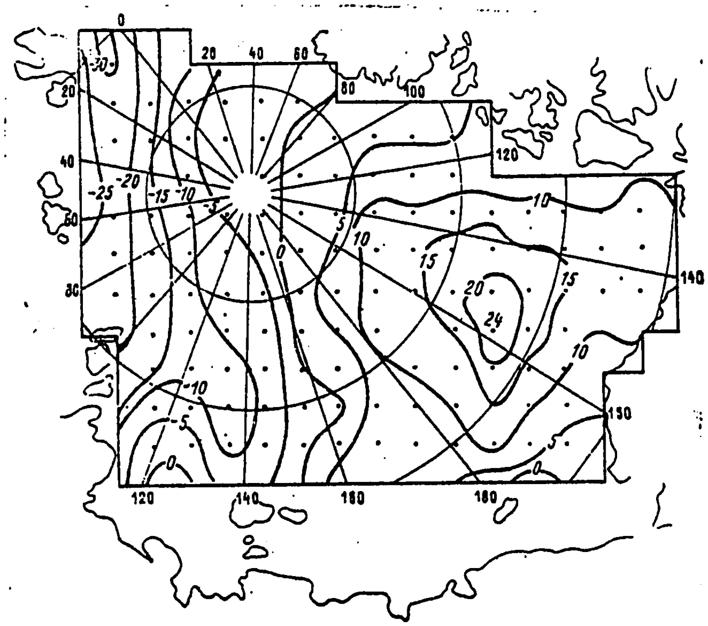

Fig. 1. Sketch map of relief of free surface (cm) of Arctic Basin caused by thermohaline circulation (computations using A. S. Sarkisyan model).

An attempt has been made at determining the water surface slopes of arctic seas and the Arctic Basin employing the A. S. Sarkisyan model [10]. The figure represents the topography of the free surface of the Arctic Basin caused only by thermohaline factors. The results as a whole correspond to current concepts concerning the circulation of waters in the considered region [5]. However, for determining the variability of level fluctuations caused by the redistribution of density it is desirable to solve the nonstationary problem.

Prospects for improvement in research. Further work on hydrodynamic investigations of level fluctuations in arctic seas provide for an improvement in the models and a combination of numerical and in situ experiments, including level observations in the open sea. Plans call for investigating, and in the models taking into account the interaction of wind-induced and tidal level fluctuations in the presence and in the absence of an ice cover with different characteristics of the latter.

The modeling of level fluctuations of arctic seas, communicating on the north with the ocean, must take into account the influence of so-called "external

Table 2

Mean Statistical Evaluations of Quality of Modeling of Wind-Induced Level Oscillations in Arctic Seas

$\bar{A}_{obs}$	$\bar{A}_{comp}$	$\bar{\Delta}$	$\lvert\bar{\Delta}\rvert$	σ	ε	R	Model
		For points with level oscillations from C to 50 cm					
47	43	0.0	7.3	9.4	0.52	0.65	Two-dimensional (2)
46	46	0.0	7.1	0.2	0.50	0.67	Three-dimensional (3)
		For points with level oscillations from 51 to 75 cm					
60	63	0.0	10.0	13.0	0.48	0.78	2
60	57	0.0	10.1	13.2	0.50	0.78	3
		For points with level oscillations from 76 to 100 cm					
81	83	0.0	12.1	15.0	0.32	0.85	2
80	76	-1.0	12.6	16.1	0.45	0.80	3
		For points with level oscillations more than 100 cm					
140	137	0.0	14.0	18.9	0.20	0.93	2
140	130	-4.0	16.2	21.5	0.40	0.87	3

Note. $\bar{A}_{obs}$ and $\bar{A}_{comp}$ are the mean observed and computed level oscillation values; $\bar{\Delta}$ is the mean computation error; Δ is the mean computation error; $\lvert\bar{\Delta}\rvert$ is the mean absolute computation error; σ is the mean square computation error; ε is a parameter of computation quality; R is the correlation coefficient between the computed and actual level variations.

surges" -- long waves generated by anemopressure conditions over the Arctic Basin. Propagating over the areas of the seas, they exert a substantial effect on the formation of wind-induced and tidal level fluctuations, especially in the shallow-water regions. There is definite experience in their investigation for the most part for the North Sea [13]. Particularly important is allowance for a wave surge in computations and predictions of wind-induced level fluctuations in those regions of arctic seas where there are extensive zones with shallow depths and with shoals along the coasts. In regions with a sharp stratification of waters, including at shallow depths, it is necessary that baroclinic effects be taken into account.

In order to achieve a high accuracy in hydrodynamic computation methods it is necessary to combine numerical and in situ experiments. However, a solution of this problem meets with considerable difficulties associated with the great cost of the latter, the inadequacy of transport and technical facilities. Nevertheless, there must be an optimum minimum of observations, carefully planned in accordance with specific models. They must include the registry of levels, currents, atmospheric pressure and wind in regions not covered by observations, including the open sea, and also aerial reconnaissance of ice. Such observations are also important over the area of the Arctic Basin. In order to calibrate local models with a high resolution (for example, for supporting drilling work on the shelf) there must be multisided observations in relatively small polygons.

Development of methods for predicting level and possibilities of their adoption in operational work. The problem of increasing accuracy and lengthening the advance time of level predictions both at the traditional times of arctic navigation and during winter has become extremely timely. With the improvement of existing and creation of new methods for predicting wind-induced level fluctuations it is necessary to be guided by what we regard as a highly important principle: close integration of numerical hydrodynamic and physicostatistical investigations. In this process it is necessary to take into account the many years of practical experience of forecasters.

The methodology, that is, the fundamental scientific basis of prognostic schemes, must evidently be unified. But the specific methods for predicting levels for individual seas and even different regions may differ as a result of allowance for specific physiographic features, as well as regional and local characteristics of the regime of level fluctuations. Precisely in this direction specialists are bringing about a further improvement in methods for predicting levels in arctic seas. The role of allowance for the regularities of the hydrometeorological regime in the development of corresponding forecasting methods within the framework of a definite conceptual model was indicated in [3].

It is desirable to create a unified, integrated system (with a data bank), including numerical hydrodynamic and physicostatistical models, for the purpose of computing and predicting level fluctuations, currents, waves, continuous, compressed and rarefied ice in any regions of the Arctic. An automated oceanological complex must be linked to a corresponding meteorological complex which would ensure the preparation of numerical forecasts of the distribution of atmospheric pressure and wind for arctic seas and the adjacent area of the ocean with an advance time of 5-10 days. The creation of such a system will accelerate the introduction of objective analysis and prediction of the entire complex of hydrometeorological conditions which are regarded as an organic part of the unified process.

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UDC 556.16:556.072

DESCRIPTION OF RIVER RUNOFF AT SEVERAL POINTS BY MULTIVARIATE CANONICAL EXPANSION METHOD

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 25 May 81) pp 81-87

[Article by I. V. Busalayev and S. K. Davletgaliyev, candidates of technical sciences, Kazakh Scientific Research Institute of Electric Power and Kazakh State University]

[Abstract] The canonical expansion method is proposed as a promising method for systemic modeling of river runoff. A model based on this method makes it possible to reproduce the entire correlation matrix (correlation functions of all orders are retained in the modeling) and it requires a lesser number of parameters than the corresponding autoregression model. An advantage of the method is that any month can be taken as the initial month. Such a model does not require the unwieldy three-step procedure of identification, computation and checking of correspondence, as required in two-term models. With relatively small values of the variation coefficient it is possible to reproduce a one-dimensional distribution function and γ-distributed random numbers can be used directly in the modeling. The linear operator of the canonical expansion can also be used effectively in predicting river discharge on the basis of extrapolation of a random process. It is shown that the method can also be employed in the modeling of correlated hydrological series simultaneously at several measurement points on the basis of multidimensional canonical expansion theory. The model was investigated in the example of monthly water inflows into the Bukhtarminskoye and Shul'binskoye Reservoirs. It was found that the cross-correlation and autocorrelation matrices of the mean monthly water discharges of the observed and modeled hydrological series are in satisfactory agreement. Tables 2; references 10: 9 Russian, 1 Western.

UDC 551.509.616

USE OF SURFACE GENERATORS OF ICE-FORMING AEROSOLS IN WORK FOR ARTIFICIALLY AUGMENTING PRECIPITATION IN MOUNTAINOUS REGIONS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 26 May 81) pp 88-93

[Article by A. G. Laktionov, candidate of physical and mathematical sciences, Institute of Applied Geophysics]

[Abstract] In mountainous regions the use of the aircraft method for the seeding of clouds is difficult or even impossible. In the USSR work has begun on the use of surface generators for the purpose of obtaining additional precipitation in the basin of Lake Sevan. One scheme provides for their placement on a water divide on the boundary of the target or surrounding highlands attaining the lower boundary of the supercooled zone of the cloud. Using such a scheme artificial nuclei can be directly introduced into the supercooled part of the cloud. The second variant is better and is discussed here in detail. The diffusion of an admixture in a cloudless atmosphere can be described by a simple Gauss semiempirical model. The entire diversity of meteorological conditions exerting an influence on the scattering of an admixture in a cloudless atmosphere is satisfactorily described by six types of weather (A, B, C, D, E, G) differing with respect to both the degree of atmospheric stability and turbulent fluctuations of wind direction in the horizontal plane. Formulas were derived and graphs constructed for obtaining the approximate concentrations of ice nuclei propagating in clouds due to diffusion. An estimate was made of the productivity of generators and then it was possible to compute the efficiency of cloud seeding in the horizontal and vertical planes. A specific example of the computations is given. For weather type D surface generators can effectively seed clouds with a thickness up to 500 m when the generator is at a distance of 6 km and the productivity is $Q \sim 0.1 Q_1 \sim 1 \cdot 10$ nuclei/sec. These findings are in disagreement with the results reported by W. R. Cotton, et al. (WEATHER MODIFICATION PROGRAMME PEP, Report No 9, 1978). Figures 2, tables 2; references 9: 5 Russian, 4 Western.

UDC 528.77+633(477.72)

EVALUATION OF STATE OF AGRICULTURAL CROPS FROM SATELLITE DATA

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 24 Aug 81) pp 94-101

[Article by G. I. Borisoglebskiy, candidate of geographical sciences, and V. V. Kozoderov, candidate of physical and mathematical sciences, State Scientific Research Center for Study of Natural Resources]

[Text]

Abstract: The possibility of an evaluation of the dynamics of development of agricultural crops on the basis of their images on space photographs is examined. The article gives some results of determination of the structure of agricultural fields and the state of winter crops over the territory of Khersonskaya Oblast on the basis of satellite images of average resolution.

The spatial inhomogeneity of the spectral brightness of agricultural fields during the growing season is governed for the most part by nonuniformity in the development and state of agricultural crops. This nonuniformity determines the field of reflected radiation registered from space vehicles.

The method for evaluating the state of agricultural crops on the basis of space images involves an allowance for differences in the reflected field of radiation from agricultural fields.

The state of agricultural crops is characterized by many parameters, including the quantity of vegetation mass (degree of coverage of the soil surface by a grass stand). Since the soil and vegetation cover have different spectral brightness coefficients, with a change in the quantity of the vegetation mass the brightness coefficient of the soil-vegetation system also changes. Accordingly, using the value of the brightness coefficient of the soil-vegetation system it is possible to judge the state of the vegetation cover [1, 4].

In this article, in the example of Khersonskaya Oblast, we will examine some relationships between the state of agricultural crops and their brightness characteristics, some results of processing of space photographs are given and these results are compared with data from expeditionary investigations of the state of sown crops.

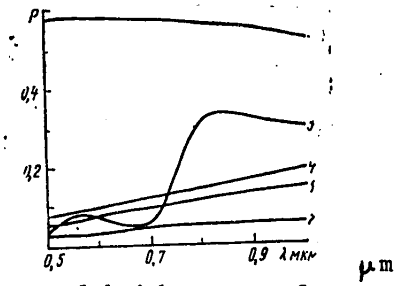

Fig. 1. Spectral brightness coefficients for snow (1), vegetation (5) covers and chernozem soils (2-4) in different states. 2) sticky soil; 3) soft plastic soil; 4) hard plastic soil.

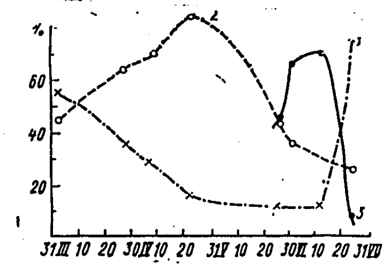

Fig. 2. Dynamics of percentage content of bare fallow (1), green vegetation (2) and yellow vegetation (3) for Khersonskaya Oblast in 1980 (according to data for Nizh. Serogoza station).

First we will examine the principal seasonal features of change in the reflective properties of the soil-vegetation system.

As indicated by observations, moistening of the surface soil layers changes most significantly in the early spring and late autumn. After disappearance of the snow cover the soil surface layer undergoes transition from a sticky (overmoistened) to a soft plastic state and then into a dry state. Depending on the geographic region and weather conditions the duration of dessication of the soil surface layer is usually 2-4 weeks. During this period there are substantial changes in the reflective properties of the soil surface layer, as is easily noted from the curves of spectral brightness coefficients (Fig. 1) of chernozem soil [2, 3] typical for Khersonskaya Oblast. During summer the soil surface layer is primarily in a dry and soft plastic state and its reflective properties do not change significantly (Fig. 1), although they can vary briefly, depending on the falling of precipitation.

During spring and autumn a considerable percentage of the lands in Khersonskaya Oblast (about 70%) is in a plowed state and therefore the changes in the reflective properties of the earth's surface during this period are dependent for the most part on the degree of moistening of the soil surface layer (transition from curve 2 to curves 3-4 in Fig. 1). From the time of dessication of the soil surface layer (to a soft plastic state) and renewal of the vegetation growing season, which by the calendar almost coincide with one another, the changes in the reflective properties of the underlying surface occur for the most part due to an increase in soil coverage by a grass stand (curves 4 and 5 in Fig. 1).

Table 1, in accordance with the curves in Fig. 1, gives the values of the brightness coefficients of snow, soil and vegetation covers, corresponding to the seasonal dynamics of their state. It follows from the data in Table 1 that the snow and vegetation covers differ substantially from the soil cover with respect to the values of the brightness coefficients. The variations of the brightness properties of chernozem soils are less great, depending on the state of the surface layer (from sticky to hard plastic). These features of the reflective properties are manifested in a corresponding way on space images as well, but for a quantitative interpretation of data from space measurements it is necessary to know the spectral response functions of the satellite apparatus. Nevertheless, in a first approximation the data in Table 1 make it possible to carry out a classification of the elements of space images on the basis of the phototone of individual photographs.

Table 1

Integral Values of Brightness Coefficients for Four Channels ($\Delta\lambda$) of Satellite Apparatus

No of curve in Fig. 1	$\Delta\lambda$ 0.5-0.6	0.6-0.7	0.7-0.8	0.8-1.0
1	0.57	0.56	0.55	0.52
2	0.028	0.037	0.044	0.058
3	0.054	0.078	0.11	0.13
4	0.090	0.11	0.14	0.17
5	0.066	0.057	0.19	0.32

Now we will examine changes in the percentage ratio of areas in Khersonskaya Oblast occupied by plowed soil, green and brown (mature) vegetation cover. The corresponding results, computed on the basis of the structure of sown areas and the phases in development of the principal agricultural crops, are given in Fig. 2. These data will be used henceforth in computing from the images on space photographs the areas with different states of agricultural crops. Figure 2 shows that during May it is possible to define at least two classes of objects differing substantially with respect to reflective properties: dark, corresponding to plowed soil, and light, corresponding to vegetation. The differences in phototone observed on space photographs are caused by the nonuniformity of the soil and vegetation covers: the difference in the projective coverage of soils by vegetation, different phenophases of agricultural crops, etc.

We will also examine the principal phenological characteristics of development of agricultural crops in the territory of Khersonskaya Oblast for the purpose of taking these characteristics into account in the analysis of space photographs.

Winter crops and perennial grasses end their cycle of development earlier than other agricultural crops. During the period of earing of winter wheat the stem growth process is still transpiring in early spring crops, whereas late spring crops are in the phase of appearance of sprouts - onset of stem growth. As a result of differences in the development phases these groups of crops during the period of formation of the grass stand differ appreciably in the quantity of vegetation mass. For example, on 28 May 1980, according to observational data for the meteorological stations of Khersonskaya Oblast, the height of winter wheat in the earing phase was 70-80 cm and the height of early spring grain crops in the phase of stem growth was 25-50 cm; the height of late spring crops (in the sprouting phase) was about 15 cm. During this period the color of the grass stand for all crops was green. As a result of the different height of the grass stand, that is, the different quantity of vegetation mass and the different degree of coverage of the soil with vegetation, the agricultural fields occupied by these crops differ in brightness, which makes it possible to distinguish them on space images on the basis of optical density.

The differences between crops, according to mean long-term data, at the times of onset of the development phases during their growing season, are given in Table 2.

Table 2

Difference (in Days) in Onset of Phases of Development of the Principal Agricultural Crops

Pairs of crops	Development phases				
	sprouts	stem extension	earing	milky ripeness	gold ripeness
Winter wheat - spring barley		19	6	5	4
Spring barley - corn	27	--	40	--	44
Sunflower - corn	15	--	--	--	13

It can be seen from the presented materials that winter wheat differs substantially from late spring crops with respect to the times of onset of one and the same development phases.

The differences between wheat and spring barley in the initial period of development are greater than during the maturing period. For example, the differences in the times of onset of the phase of stem extension (onset of stem growth) for these was 19 days, but for the phase of gold ripeness it was only 4 days. The differences in the height of the grass stand as these crops mature also decrease. Accordingly, on space images there are considerable difficulties in differentiating them during the maturity period.

Late-maturing crops (sunflower, corn) with respect to the state of the grass stand differ to a considerably greater degree from the group of early spring crops in the second half of the growing season. Sunflower and corn differ substantially from one another primarily with respect to the color of the grass stand and only during the maturing period.

Thus, using a phenological calendar it is possible to predetermine the periods most convenient for the recognition and evaluation of the state of agricultural crops on the basis of data from remote measurements.

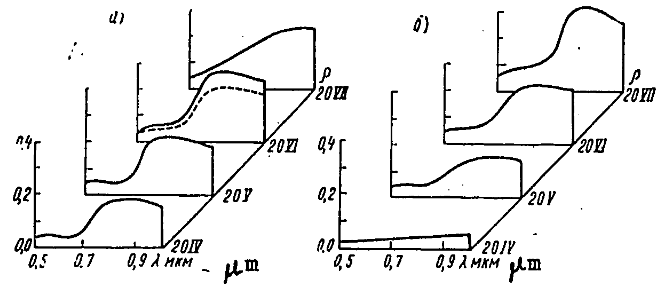

Fig. 3. Temporal variation of spectral brightness coefficients of soil-vegetation system. a) for winter crops, b) for spring crops.

Figure 3, in accordance with the data in Figures 1 and 2, gives the temporal dynamics of the spectral brightness coefficients of winter and spring crops. The results of the computations in Fig. 3 correspond to the description of the state of grain crops given in Table 3. In the computations we took into account the percentage contribution of vegetation and soils to the overall brightness of the soil-vegetation system. The corresponding weighting function was the projective coverage, equal to the ratio of the area occupied by vegetation to the total area occupied by the vegetation and soil.

A comparison of the curves in Fig. 3 makes it possible to conclude that the differences between the brightnesses of these objects in the visible spectral region ($\lambda = 0.5$–$0.7\mu m$) are small. The differences are appreciable only with transition from the vegetation to the soil cover. In particular, a poor state (low projective coverage) is virtually indistinguishible from a good state (almost continuous vegetation cover) in the visible region on the basis of brightness criteria. In the near IR region ($\lambda > 0.7\mu m$) these differences are more significant.

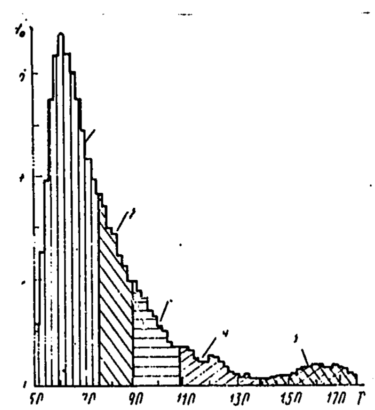

Fig. 4. Histogram of optical densities of space image for Khersonskaya Oblast (28 May 1980). 1) winter; 2) early spring; 3) late spring; 4) soil; 5) water bodies.

The described preliminary stages in establishing relationships between the state of agricultural fields and their brightnesses make it possible to proceed to a solution of the problem of evaluating the state of agricultural fields using data from space images.

A distinguishing characteristic of satellite images with an average resolution (about 250 m) is the small linear dimensions of agricultural fields, which makes difficult the tie-in of individual fields to data from field measurements. Accordingly, in the processing of satellite images with an average resolution it evidently is necessary to take into account not individual agricultural fields but a group of fields within the limits of individual districts, regions, etc.

The algorithm for the processing of a satellite image involved the following. The entire data bank of optical densities of space images was quantized into classes corresponding to different agricultural crops (feature recognition).* The next stage in the processing is the discrimination of optical density classes corresponding to a different state of the grass stand of a particular crop.

A determination of the boundaries (threshold levels) between optical density classes was carried out using characteristic breaks in the histogram (Fig. 4). The histogram represents the ratio of the number of elements with a particular optical density to the total number of optical density elements of the sector of the image being processed (in our case -- the territory of Khersonskaya Oblast).

The presence of well-expressed peaks (modes) or so-called breaks (change in histogram slope) indicates the presence of natural formations with different reflective properties. Intuitively it can be postulated that over the considered territory the natural features represented on this histogram (Fig. 4) include a water surface, plowed soil and fields with different projective coverage of the soil. On the date of the survey, 28 May 1980 (Fig. 5a), the following groups of agricultural crops differed considerably with respect to the height of the grass stand: winter, early spring and late spring. A knowledge of these facts and the differences in the spectral variation of agricultural crops considered above made it possible, using the breaks on the histogram in Fig. 4, to define 5 classes of objects differing significantly in brightness: winter, early and late spring crops, plowed soils and water bodies.

The threshold levels obtained on the basis of the histograms in Fig. 4 were used in quantizing the optical density of the analyzed image into individual classes (Fig. 5b), that is, the entire image, in accordance with the histogram, was represented in the form of 5 optical density classes.

A comparison of the actual data on the structure of sown areas in the Khersonskiy polygon, obtained by an expedition of the Geography Faculty at Moscow

* We will assume that there is a mutually unambiguous correspondence between the optical density of the processed photograph and the registered brightness. In the absence of such a correspondence it is necessary to make a brightness correction of the images. We will not examine this problem here.

Table 3

Description of State of Grain Crops Corresponding to Fig. 3

Date	Winter			Spring		
	development phase	color	projective coverage	development phase	color	projective coverage
20 April	Stem extension	Light green	0.1	Moist soil - seed germination	Dark	0.0
20 May	Earing	Green	0.5	Tillering	Light green	0.3
20 June	Flowering	Dark green	0.9(0.5)*	Earing	Green	0.6
20 July	Stubble	Yellow	0.4	Full maturity	Yellow	0.9

* The figure in parentheses indicates projective coverage in the case of a poor state (corresponds to the dashed curve in Fig. 3).

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State University and the results of quantization of image optical densities into classes indicates that there is a correspondence between them (Table 4).

Table 4

Structure of Agricultural Fields for Fragment of Khersonskaya Oblast on 28 May 1980

Land use areas	Area, %	
	results of quantization of optical densities	according to data of Moscow State University expedition
Water bodies	8	8
Plowed soil	12	15
Late spring crops	16	20
Early spring crops	20	11
Winter crops	44	46

Table 5

Evaluation (units)	Area, %	
	results of quantization of optical densities	according to data of Moscow State University expedition
Above average (4)	22	24
Average (3)	42	51
Below average (2)	36	25

The determination of areas with different fields from space images is dependent to a considerable degree on the correctness of discrimination of the threshold levels of optical densities from the histograms. These should be selected on the basis of a priori information, standard measurements, etc. As already stated above, for this purpose we used histograms of the distribution of optical density and a priori information on the phenophases of development of agricultural crops.

The sectors with groups of agricultural crops similar with respect to reflectivity, defined on the images, are also nonuniform with respect to optical density. In this case the optical density of the image is dependent on variations in state of the crop: the greater the degree to which the vegetation cover conceals the soil, the less is the optical density on the positive images. This fact can be used in discriminating areas having a different state of agricultural crops on the images. A further interpretation involves a determination of the quantitative relationships between the image optical density and the state of a particular crop (the quantity of vegetation mass or some other parameter).

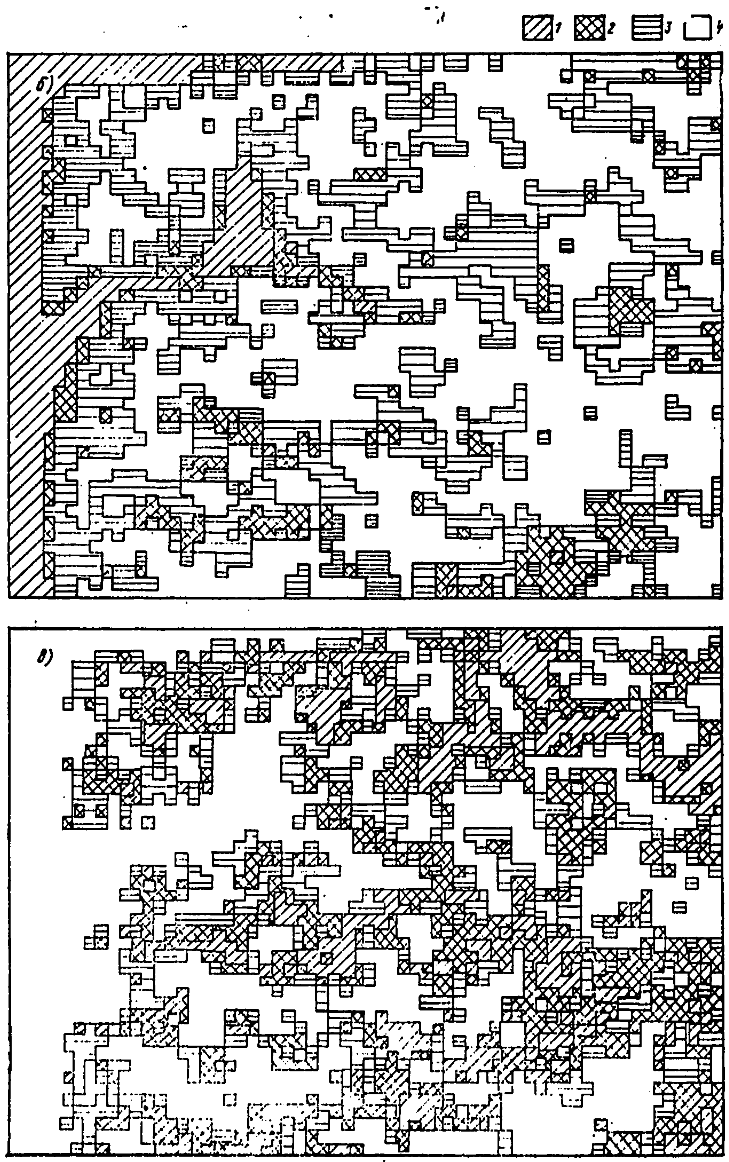

Fig. 5. Fragment of space image with average resolution on 28 May 1980 (a) and results of image processing. a) structure of agricultural fields (1 -- water bodies, 2) plowed soil, 3) spring crops, 4) winter crops); b) state of winter crops (1 -- above average, 2) average, 3) above average, 4) other land use areas.

Figure 5c gives an analysis of the state of winter wheat for the selected fragment of Khersonskaya Oblast. The image optical density of the selected sector, fed out to a color display, was uniformly divided into three parts corresponding to the mean state of winter wheat and states above and below the means, which approximately corresponds to a projective coverage of less than 60%, 80% and more than 80%. The selected image density gradations corresponded to those threshold levels which were mentioned above. Then by program all the analyzed fragment was represented in gradations of optical density in accordance with the threshold levels. Thus, on the basis of a specialized complex for the digital processing of images it was possible to compute areas with a different state of winter wheat. The results of an analysis of the space image are given in Table 5 together with the actual data obtained by an expedition of the Geography Faculty of Moscow State University on the state of winter wheat during this period. Table 5 shows that there is a definite correspondence between the results of an image and actual data, which indicates the possibility of using the described semiautomatic processing scheme for evaluating the state of agricultural crops over great areas.

To be sure, there is definite arbitrariness in the choice of threshold levels of optical density when using the described method for evaluating state. These levels, and also the interrelationships between density gradations and the quantitative indices of state must be found on the basis of simulated models of interaction between radiation and the soil-vegetation system with the use of a priori information. There are considerable difficulties in making a brightness correction of space images. However, the preliminary results of analysis of natural phenomena cited above and the results of processing of satellite images make it possible to conclude that there are real possibilities for evaluating the state of agricultural fields using space survey data with apparatus having an average resolution.

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UDC 551.508.953

EVALUATION OF SPECTRAL RESOLUTION OF OPTICAL APPARATUS FOR MEASURING MINOR GAS COMPONENTS IN ATMOSPHERE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 1 Jun 81) pp 102-106

[Article by A. V. Polyakov and Yu. M. Timofeyev, candidate of physical and mathematical sciences, Leningrad State University]

[Abstract] Great difficulties are encountered in studying the spatial-temporal variations in the content of minor gas components in the atmosphere. This dictates the creation of special optical instruments with a high or ultrahigh spectral resolution. In order to ascertain the required resolution of the needed instruments, as well as for evaluating already existing instruments, the authors examine a simplified model of transfer of solar radiation on oblique trajectories (measurements from satellite, aircraft or balloon) and have constructed nomograms (and expressions supplementing them) which make it possible to solve this problem in a broad spectral region (1-100μm) for a large number of minor gas components. The rules for using the nomograms are given. The procedures for determining $\Delta\nu_{det}$ and $\Delta\nu_{opt}$ are defined ($\Delta\nu_{det}$ is the spectral resolution necessary for detecting a spectral line with a known half-width and intensity for a stipulated altitude corresponding to a minor gas component with a known concentration; $\Delta\nu_{opt}$ is the optimum spectral resolution in line measurements at a stipulated altitude). By way of illustration, a table gives the $\Delta\nu_{det}$ and $\Delta\nu_{opt}$ values for different altitudes applicable to the conditions of a satellite experiment. Figures 2, tables 1; references 9: 7 Russian, 2 Western.

UDC 551.501.796+551.501.724

POSSIBILITY OF DETERMINING ATMOSPHERIC TEMPERATURE PROFILE BY ACOUSTIC SOUNDING

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 1 Jun 81) pp 106-110

[Article by A. Ya. Bogushevich and N. P. Krasnenko, candidate of technical sciences, Institute of Atmospheric Optics, Siberian Department, USSR Academy of Sciences]

[Abstract] At present it is possible to determine the temperature profile only by the combined radioacoustic method, based on the scattering of electromagnetic waves on periodic inhomogeneities of air pressure created by an acoustic packet. A new method for measuring the temperature profile is proposed here. Data on the temperature profile can be obtained by using a bistatic sounding geometry and by measuring the time of propagation of an acoustic pulse along its trajectory. In this method, assuming a stationarity and horizontal homogeneity of meteorological fields at the measurement scales (0.3-6 sec and 30-300 m), the entire boundary layer is broken down into n layers (altitudes H_1-H_n) and a piecewise-linear approximation of the temperature profile is used. It is shown that by successively measuring the sounding altitude H_1 it is possible to determine the temperature profile. The most significant factors exerting an influence on the accuracy in measuring temperature are: wind, acoustic noise, sound refraction, variation of the Q coefficient, finite character of the dimensions of the scattering volume and turbulent fluctuations of meteorological fields. The principal systematic and random errors associated with these influencing factors are individually analyzed. The influence of the wind, for example, can be taken into account by employing compensating geometries; wind refraction corrections can be made by the same procedure. A correction must be introduced for real humidity at the ground level. In general, it is easy to compensate for the systematic errors. Fluctuation errors are more important and the most important of the fluctuations is noise, resulting in fluctuations of signal arrival time. A formula is derived to take this into account. The article examines a model with an atmosphere with standard profiles of meteorological parameters and a Kolmogorov turbulence spectrum. There are optimum frequencies for acoustic sounding and optimum spacings between the antennas of the bistatic sounder with which the random error in determining temperature is minimum. In a particular example it is shown that in a suburban area the mean temperature profile could be measured by the bistatic acoustic sounder to altitudes 300-500 m with a good accuracy. Figures 2; references 7: 4 Russian, 3 Western.

UDC 551.577.53

INADVERTENT INFLUENCE OF MAJOR CITIES AND INDUSTRIAL CENTERS ON PRECIPITATION

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 (manuscript received 14 Jul 81) pp 111-119

[Article by I. V. Litvinov, candidate of physical and mathematical sciences, Institute of Experimental Meteorology]

[Abstract] Precipitation zones are known to develop more frequently over a city than in the suburbs. There is also an increase in the number of thunderstorms over cities and an increased frequency of recurrence of days with precipitation, as well as the frequency of extremal precipitation and the duration of precipitation. However, this pattern is not always observed: Leningrad, Moscow and Detroit, for example, do not entirely adhere to this generalization. The review of the literature presented in this article makes it clear that cities and industrial areas do exert an influence on precipitation sums both directly over built-up regions and nearby. It is the heat release of the cities and the structure of the built-up area which exert the greatest influence. It is not entirely clear how ice-forming nuclei of anthropogenic origin exert an influence on precipitation, but they do not alter precipitation sums by more than a few percent. However, urbanization does not exert an influence on the quantity of precipitation falling over extensive territories because city areas account for but a tiny percentage of the total area of a country, even in Europe. Over large cities and industrial areas this precipitation increase may be 30%, but the overall effect for the land is no more than a few tenths of a percent. During the last 100 years in Europe there has been only an insignificant increase in precipitation in the northwest and a decrease in the southeast. Nevertheless, there is an anthropogenic effect on precipitation and this must be taken into account in climatic studies and in investigating the results of artificial modification in the neighborhood of large cities and industrial centers. Figures 2; references 89: 38 Russian, 51 Western.

REVIEW OF MONOGRAPH 'GIDROLOGICHESKIYE PROTSESSY I IKH ROL' V FORMIROVANII KACHESTVA VODY' ('HYDROLOGICAL PROCESSES AND THEIR ROLE IN FORMING WATER QUALITY'), BY V. A. ZNAMENSKIY, LENINGRAD, GIDROMETEOIZDAT, 1981, 248 PAGES

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 pp 120-122

[Review by A. V. Karaushev, professor]

[Abstract] This new monograph is devoted to an investigation of the processes of transport of water masses and soluble substances in large water bodies situated in different zones. The author has developed a new multisided hydrological and hydrodynamic approach for evaluating the processes of formation of water quality. The book definitely has a practical character. Methods are proposed for the modeling and laboratory investigation of water exchange and the transport of substances in water bodies. The proposed methods can be used in planning systems for inventorying and monitoring water quality. Mathematical models have been proposed which can be used in solving ecological problems and in developing schemes for the multisided use and conservation of water resources. The book has an introduction, five chapters and summary. The introduction enumerates the principal problems examined by the author. Each chapter gives an evaluation of the present status of the considered matters. The first chapter is a detailed examination of water exchange processes in water bodies. The second chapter examines the hydrodynamic structure of flows in water bodies. The third chapter is devoted to the influence of water exchange and dynamic structures on the transport and distribution of dissolved substances. The fourth chapter gives the author's own methods for the hydraulic modeling of the processes of transport of water masses and dissolved substances, including the results of numerous experimental investigations. The fifth chapter gives proposals on use of such methods in solving problems in the rational use and conservation of waters, monitoring water quality and establishing norms for the admissible discharge of waste waters into water bodies, in the development of mathematical models of water quality and in planning the multisided use of water resources. The book will be highly useful in solving many problems in the national economy.

CONFERENCES, MEETINGS, SEMINARS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 pp 123-125

[Article by P. Yu. Pushistov, A. A. Zhelnin and V. F. Gridasov]

[Abstract] An international symposium "Current Problems in Weather Forecasting" was held in Vienna during the period 23-26 June 1981. It was organized by the Austrian and American Meteorological Societies. Representatives of 14 countries discussed theoretical and statistical aspects of short-range weather forecasting, intermediate- and long-range weather forecasting. This brief summary of the symposium gives the content of reports by American, British, Austrian, West German and other specialists, with a few lines or short paragraph being devoted to each report.

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A national conference on "Problems and Ways to Develop Methods for Observing Moisture Supplies for Crops" was held at Cherkassy during the period 8-12 September 1981. It was sponsored by the State Committee on Hydrometeorology and Environmental Monitoring and the Scientific and Technical Society of Agriculture. The conference revealed that during the last decade great advances have been made in determining soil moisture content and in ascertaining the parameters of moisture supply for agricultural crops, including the use of remote methods for measuring moisture, such as SHF radiometry and aerial gamma surveys. Portable multiparameter hygrometers are being readied for production (these are based on measurement of the electric parameters of the soil); some stations now have neutron hygrometers; more attention is being given to computation methods; the drying of soil samples in a thermostat is being replaced by high-frequency drying. There are still no adequate methods or instruments for replacing the thermostat-weight method for determining soil moisture content: neutron hygrometers, aerial gamma surveys, SHF radiometry and computational methods all have their shortcomings. Different organizations are striving to upgrade these methods or combine them for achieving better results. The reports and communications presented at this conference are to be published in the Transactions of the All-Union Scientific Research Institute of Agricultural Meteorology in 1982. The next such conference will be held in 1984.

NOTES FROM ABROAD

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 pp 125-127

[Article by B. I. Silkin]

[Abstract] In the journal NEW SCIENTIST, Vol 91, No 1267, 1981, it is reported that Doctor Stanley Shannon and his colleagues at the Illinois Hydrological Administration have completed a cycle of studies of the interrelationship between aircraft flights and weather conditions on the approaches to O'Hare Field. Since the 1960's these flights have caused a 10% increase in cloud cover over an extensive area along these routes. This has resulted in a definite cooling in Illinois and an increase in precipitation. On the other hand, at nighttime the temperatures remain higher and the winters have become warmer.

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NEW SCIENTIST, Vol 91, No 1274, 1981, reports that by making use of satellite data R. Orville and B. Vonnegut have compiled a map of the global distribution of lightning discharges. This phenomenon is virtually absent in the high latitudes and quite rare in the middle latitudes, being most common in the equatorial regions of the land. It still remains a mystery why lightning is so rare over the oceans.

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In another issue of NEW SCIENTIST (Vol 91, No 1267, 1981) it is reported that a specialist at the Atlantic Richfield Company, R. Currie, has proposed a method for superlong-range forecasting of meteorological conditions on the basis of cycles of the lunar tidal effect, making use of maximum entropy spectrum analysis. It appears that there is a correlation between the 18.5-year cycle of the maximum of the lunar-tidal effect and arid years in the Western United States (although in individual cases the drought coincides with the 22-year double cycle of the maximum in spot-forming solar activity).

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NEW SCIENTIST, Vol 91, No 1267, 1981, reports that World Data Center A on Solar-Terrestrial Physics at Boulder was threatened with complete shutdown as an economy measure, much to the dismay of the world scientific community. Now it has been decided that part of the work will be contracted out, which will result in higher user cost.

OBITUARY OF YEKATERINA NIKITICHNA BLINOVA (1906-1981)

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 pp 127-128

[Article by staff of the Board of the USSR State Committee on Hydrometeorology and Environmental Monitoring and personnel of the USSR Hydrometeorological Scientific Research Center]

[Abstract] Yekaterina Nikitichna Blinova, corresponding member, USSR Academy of Sciences, died on 15 December 1981. She was head of the Division of Planetary Atmospheric Dynamics and Hydrodynamic Long-Range Weather Forecasting at the USSR Hydrometeorological Scientific Research Center. First working (1934) at the Main Geophysical Observatory, she later (1943) moved to the Central Institute of Forecasts. Her entire career was devoted to the field of long-range weather forecasting. As early at 1943 she published the major monograph GIDRODINAMICHESKAYA TEORIYA VOLN DAVLENIYA, TEMPERATURNYKH VOLN I TSENTROV DEYSTVIYA ATMOSFERY (Hydrodynamic Theory of Pressure Waves, Temperature Waves and Atmospheric Centers of Action), which outlined the first theory of numerical long-range weather forecasting. In her doctoral dissertation of 1946 she described how theoretically it was possible to reproduce the really observed distribution of meteorological elements. She inspired others to follow her in advancing the development of the hydrodynamic theory of climate and long-range forecasting. The basis for these investigations was the spectral approach, applied widely thereafter in many linear models of climate, general circulation of the atmosphere and long-range forecasting. She supervised the first operational preparation of several variants of long-range forecasts. Ye. N. Blinova then proceeded from linear to nonlinear schemes and application of primitive equations of dynamic meteorology. During recent years she developed a method for long-range forecasting on the basis of discrimination of the "main oscillations" and published an algorithm for solving prognostic spectral equations. A model was proposed in which the changes in meteorological elements with time are computed simultaneously with the climatic background. All this represents but a fraction of her contributions to this field. She was active in the GARP program, being a member of the Soviet committee on this program and chairman of the subgroup on numerical experimentation. Figures: 1.

OBITUARY OF SERGEY IVANOVICH SIVKOV (1901-1981)

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 3, Mar 82 p 128

[Article by a group of comrades]

[Abstract] Sergey Ivanovich Sivkov, doctor of geographical sciences, an outstanding Soviet specialist in the field of actinometry, died at age 80 on 28 May 1981. He began his work at Kursk Observatory, advanced through the ranks and served as its head during the years 1928-1930. Thereafter he was director of the Tien Shan High-Mountain Observatory and from 1935 through 1950 was head of the Karadag Affiliate of the Actinometry Institute. On two occasions he wintered at polar stations in the Arctic. Subsequently he laid aside administrative assignments and dedicated himself exclusively to scientific research. His publications, 54 in all, dealt with such matters as methods for computing actinometric fluxes and investigating instrument performance. Much of his work is still of practical importance in the operation of Soviet and foreign actinometric services. During his work at the Main Geophysical Observatory he wrote (1968) a monograph entitled METODY RASCHETA KHARAKTERISTIK SOLNECHNOY RADIATSII (Methods for Computing Characteristics of Solar Radiation) and thereby earned the academic degree of doctor of sciences. His final area of research and publication was the investigation of cloud cover and radiation.

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