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physical-statistical relationships not taking into account the dynamics of infiltration and using some integral indices of soil water absorptivity. At the same time, the use of models of heat and moisture transfer in the soil can considerably broaden the possibilities of computing these indices and deepening their physical content.

The most important information on the water-absorption properties of the soil in the formulation of the physical-statistical relationships for predicting the volume of the spring high water is contained in data on the reserves and distribution of soil moisture content, but due to the great variability of soil moisture content over the area and the inadequate volume of observations, in place of the measured moisture reserves it is customary to use their indirect characteristics, which are found using the water balance equation on the basis of measurements of precipitation and evaporation data. For example, as an indirect characteristic of the moisture reserve prior to the onset of winter it is most common to take the sums of precipitation during the preceding three months with evaporation subtracted [4]. Such indices do not take into account the processes of moisture migration in the soil which can play a significant role in the change in moisture content of the upper soil layers, especially during the period of freezing of the soil and with the ground water at a shallow depth.

As an indirect characteristic of the thermophysical processes transpiring during the winter, in long-range predictions of spring runoff it is most common to use the measured depth of soil freezing [4]. The principal shortcoming of this index is that it does not always reflect the temperature regime by the time of snow melting. In addition, it must be taken into account that the depths of freezing differ considerably in area and the accuracy of measurements of these parameters at individual points is low.

The equations of heat and moisture transfer make it possible, using such readily available hydrometeorological data as those which are observed in determining the usually employed indirect characteristics, to compute the development of the principal processes of heat and moisture exchange in the soil and to find those indices which to a considerable degree are free of the shortcomings of these characteristics.

Below we will examine the method for obtaining such indices and we will demonstrate the possibilities of their application for long-range forecasting of the volume of spring high water (in the example of the Kostroma River basin as far as Buy station).

Computation of Moisture Reserves and its Distribution in Depth

The dynamics of soil moisture content can be described using the moisture diffusion equation

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z}\left[D(\theta)\frac{\partial \theta}{\partial z}\right] - \frac{\partial K(\theta)}{\partial z}, \tag{1}$$

where θ is the volumetric moisture content of the soil, z is the vertical coordinate, directed downward, t is time, D(θ) is the coefficient of moisture diffusion, K(θ) is hydraulic conductivity.

Due to the fact that in this case we are interested in the mean moisture contents for the drainage basin, as the initial conditions for solving equation (1), due to the great spatial variability of the moisture content it is usually impossible to use the measured moisture content profiles (even in a case when such measurements are available for a large number of points). Therefore, computations made using equation (1) should begin from the moment of disappearance of the snow, when the soil in the entire basin is still close to total saturation. Taking into account that for determining the prewinter or winter moistening of the soil the computations in this case must be carried out for a long period of time and the main influence on the moisture content of the active soil layer will be exerted by the hydrometeorological conditions at the soil surface, the influence of gravitational forces on moisture content and the variability of soil hydrophysical characteristics can be neglected. Then from (1) we obtain the equation

$$\frac{\partial \theta}{\partial t} = D\frac{\partial^2 \theta}{\partial z^2}, \tag{2}$$

where D is a constant value which can be selected using observational data on soil moisture content.

The lower boundary can be stipulated at the depth where the moisture content during the summer-autumn period changes little and it can be considered constant.

At the upper boundary of the considered soil layer we stipulated the condition

$$\begin{aligned} R - E &= D\frac{\partial \theta}{\partial z}\Big|_{z=0} \quad \text{when} \quad \theta(t, 0) < \theta_m, \\ \theta(t, 0) &= \theta_m \quad \text{when} \quad \theta(t, 0) \geq \theta_m, \end{aligned} \tag{3}$$

where θ_m is the maximum moisture content of the upper soil layer, R is the intensity of precipitation, E is the intensity of evaporation from the soil surface.

For computing evaporation we used the formula

$$E(t) = k_1 d_n(t)\, e^{-\frac{d_n(t)}{\theta_m \Delta z}}$$

or the simpler formula

$$E(t) = k_2 d_n(t)\Theta(0, t-1).$$

[В = air, П = soil] where $d_{soil}(t)$ is the deficit of soil moisture content in the upper layer Δz, $d_{air}(t)$ is the air moisture content deficit, k_1 and k_2 are empirical constants.

The dsoil(t) value can be determined from the water balance equation for the layer Δz:

$$d_П(t) = \Delta z\,[\theta_m - \theta(0, \Delta z)] - \sum_{j=0}^{t} P(j) + \sum_{j=0}^{t} E(j) + \\ + \sum_{j=0}^{t} q(t) + \sum_{j=0}^{t} I(j), \tag{4}$$

[П = soil] where q(t) is the runoff modulus,

$$I = -D\left.\frac{\partial \theta}{\partial z}\right|_{z=\Delta z}. \tag{5}$$

Thus, the entire model of dynamics of soil moisture content includes three parameters: D, k and θ_m. The last of these parameters was stipulated using observational data on soil moisture content (as the maximum value of the observed moisture contents).

A numerical integration of equation (2) was carried out using an implicit four-point difference scheme with use of the "elimination" method [5].

The depth interval Δz was assumed equal to 10 cm; the time interval was assumed equal to 1 day.

On the basis of available observations of moisture content at individual points an optimization of the coefficients D and k was carried out and control computations were made; the latter revealed that in general the used moisture transfer model satisfactorily describes the dynamics of moisture content of the soil during summer and autumn. Then the optimum values of the coefficients D and k were used in computing the moisture distribution with depth on the basis of the hydrometeorological data averaged for the area of the basin, beginning from the time of disappearance of the snow to a stable transition of air temperature through 0°C in autumn. The moisture distribution on the latter date was used both for determining the index of autumn moisture reserves and as the initial conditions for computing the thermal regime of the soil in winter and prior to snow melting.

Computation of Characteristics of Soil Temperature Regime

For describing the soil freezing process we use the following basic assumptions:

1) moisture transfer in the snow and soil, except for migration of moisture from the thawed zone to the freezing front, exerts a weak influence on heat transfer;
2) with migration of moisture toward the freezing front it is possible to neglect gravitational forces;
3) phase transformations in the snow are absent;
4) snow density and depth of the snow cover change slowly.

The introduction of these assumptions makes it possible to reduce computations of the temperature and moisture content regimes of the soil during freezing to solution of the following problem:

$$
\begin{aligned}
&\frac{\partial T_c}{\partial t} = K_c \frac{\partial^2 T_c}{\partial z^2} && \text{for} \quad 0 < z < -h(t), \\
&\frac{\partial T_M}{\partial t} = K_M \frac{\partial^2 T_M}{\partial z^2} && \text{for} \quad 0 < z < \eta, \\
&\frac{\partial T_T}{\partial t} = K_T \frac{\partial^2 T_T}{\partial z^2} && \text{for} \quad \eta < z < L,
\end{aligned}
\qquad (6)
$$

$$T_c(-h, t) = T(t), \quad T_T(L, t) = T_n(t),$$

$$T_M(\eta, t) = T_T(\eta, t) = 0, \quad T_c|_{z=0} = T_M|_{z=0},$$

$$\lambda_M \frac{\partial T_M}{\partial z}\bigg|_{z=\eta(t)} - \lambda_T \frac{\partial T_T}{\partial z}\bigg|_{z=\eta(t)} = L_M \rho\, [\theta - \theta_n(0)] \frac{d\eta}{dt},$$

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z}\left(D \frac{\partial \theta}{\partial z}\right), \quad \eta(t) < z < L,$$

$$\theta(\eta, t) = \theta_n(0), \quad \theta(l, t) = \theta_c,$$

[c = snow; M = frozen soil; T = thawed soil] where z is the vertical coordinate, directed downward and reckoned from the soil surface, T_s, T_{fs} and T_t, K_s, K_{fs}, and K_t are the thermal conductivity coefficients, λ_{fs} and λ_t are the effective heat conductivity coefficients of frozen and thawed soil, $L\theta$ is the latent heat of fusion of ice, $\eta(t)$ is the depth of freezing, T(t) is the air temperature near the snow surface, $T_s(t)$ is the stipulated soil temperature at the depth L, where the temperature variations are traced poorly, ρ is water density, θ is the volume soil moisture content, D is the coefficient of moisture diffusion, θ_s is constant soil moisture content, stipulated at the depth L, $\theta_n(0)$ is the quantity of water not freezing at 0°C.

The phase transitions of water, not freezing at 0°C, are indirectly taken into account in the effective thermal conductivity coefficients and the thermal diffusivity coefficients. $\theta(\eta, t)$ is considered close to $\theta_n(0)$).

For numerical integration of system (6) we used the "through calculation" method with an implicit difference scheme recommended for solution of the Stefan problem in [5].

Computations were made for the soil layer 1.5 m with intervals $\Delta z = 1.0$ cm and $\Delta t = 1$ day.

The coefficients K_{fs}, K_t, λ_{fs} and λ_t, and also the quantity of water not freezing at 0°C were found by the optimization method using observational data on the depth of freezing. The K_s value was determined from snow density using the Yanson formula

$$K_c = 86{,}4\ (12\ \rho_c^{1} + 0{,}1\ \rho_c^{-1} + 3{,}8),$$

[c = snow] where ρ_s is snow density, g/cm^3.

Derivation of Prognostic Expressions

As the indices of autumn moistening of the basin, on the basis of the computed moisture content values we determined the value

$$W_{0-100} = \sum_{z_i = 0}^{z_i = 100\ \text{см}} \theta\ (z_i,\ t_0),$$

where t_0 is the date of stable transition of air temperature through 0°C and as the indices of moistening of the basin prior to melting of the snow we use the characteristic of soil ice content, which was found as

$$Л = \sum_{\eta_i = 0}^{\eta_i = \eta_m} [\Theta\ (\eta_i,\ t_0) - \Theta_н\ (0)]\ \varphi\ (\eta_i), \tag{7}$$

where η_m is the maximum depth of freezing, $\varphi(\eta_i)$ is a weighting function, selected in such a way that the greatest value was assigned to the upper soil layers.

As the index of cold reserves in the soil prior to snow melting we used the value

$$H = \sum_{z_i = 0}^{z_i = L} \{[\sigma_п C_п + \rho_в C_в \Theta_н\ (0)]\ T\ (z_i) + \rho_л L\, \Theta_л\ (z_i)\}\ \varphi\ (z_i), \tag{8}$$

[П = soil] where σ_{soil} is the volumetric weight of the soil, ρ_w and ρ_i are the densities of water and ice respectively [B = water = w, Л = ice = i], C_s and C_w are the heat capacities of the soil and water (the value $C_s = \lambda_{fs}/\sigma_s K_{fs}$), $\theta_i(z_i)$ is volumetric ice content.

Taking into account that the heat content of the soil skeleton and the non-freezing water is usually appreciably less than the quantity of heat necessary for the thawing of the ice contained in the soil, the H value is also an index of the ice content.

The values W_{0-100}, I [Л] and N [Н] were computed for all years for which runoff observations were available (1942-1973) on the basis of area-averaged data for hydrometeorological observations in the basin of the Kostroma River to Buy station (the area of the basin was 8,870 km^2).

In order to derive the dependences between the runoff volumes at high water and the principal factors determining it, we used data from hydrometeorological observations during the period from 1942 through 1963. Observational data for the period from 1964 through 1973 were used in making trial forecasts of meltwater runoff.

The water reserves in the snow by the onset of snow melting were computed using data from snow-measuring surveys.

For determining the maximum water reserves in the snow at the end of winter we used observational data in field sectors of the basin, since regular snow-measuring surveys in the forests in the considered area began only in 1967. The snow reserves in the forest were determined during the entire observation period by multiplying the snow reserves in the field sectors by the factor 1.1. The mean maximum water reserves in the basin snow were computed using the formula

$$S_{\text{б}} = S_{\text{п}}(1-\alpha) + S_{\text{л}}\alpha, \tag{9}$$

[Б = b(asin); П = f(ield); Л = for(est)] where S_f, S_{for} are the mean water reserves in the snow, for field and forest sectors of the basin respectively; α is the forest cover of the basin in fractions of the area, assumed to be equal to 0.75.

The dates of onset of the maximum snow reserves were averaged for the basin.

To the value of the water reserve in the snow cover we added the precipitation during the period of thawing of the snow and the water reserves in the ice crust at the soil surface.

From the volume of spring runoff of the Kostroma River at Buy station we excluded the ground water and rain components of spring runoff. The ground water runoff was determined by means of horizontal cutting, rain water runoff was determined by cutting of the high water on the high-water hydrograph using a typical dropoff curve.

The dependences $y_t = f_1(S, W_{0-100})$, $y_t = f_2(S, I)$ and $y_t = f_3(S, N)$, where y_t is the volume of the spring high water, S is the total water reserve in the basin, are given in Fig. 1.

The mean square error in the dependence $y_t = f_1(S, W_{0-100})$ for the years which were used in its construction was found to be equal to 13 mm with a ratio of the mean square error s to the standard deviation of runoff from the norm $s/\sigma = 0.26$ for the dependence $y_t = f(S, I)$ -- 10 mm when $s/\sigma =$

0.20, for the dependence $y_t = f(S, H)$ -- 11 mm when $s/\sigma = 0.22$.

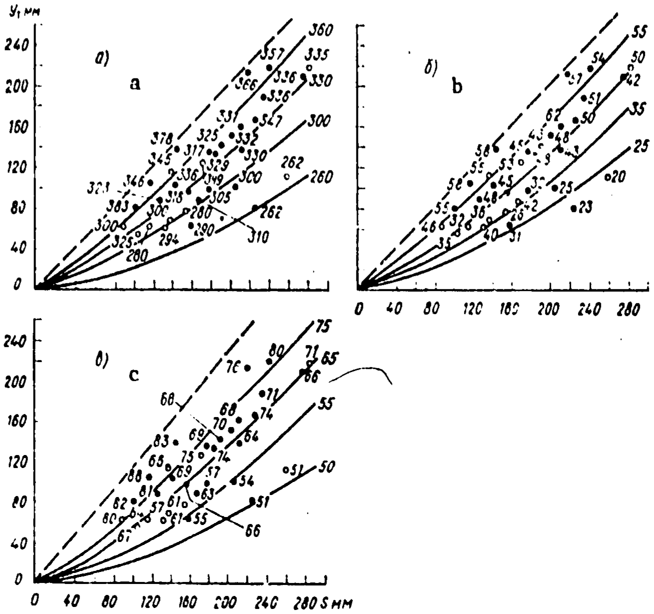

Fig. 1. Dependence of runoff volume of Kostroma River during high water period on snow reserves and indices of soil moistening by onset of winter W_{0-100} (a), ice content of upper soil layers before snow melting I (b) and cold reserve in upper soil layers before snow melting $H \cdot 10^{-1}$ (c).

For the years which were not used in constructing the dependences, the error for the dependence $y = f(S, W)$ is equal to 14 mm when $s/\sigma = 0.28$, for the dependence $y_t = f(S, I)$ -- 13 mm when $s/\sigma = 0.26$, for the dependence $y_t = f(S, H)$ -- 13 mm when $s/\sigma = 0.26$.

According to the Instructions for the Forecasting Service [3], such prognostic dependences can be classified as good, which indicates an adequate information content of the used runoff loss indices.

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UDC 556.06(470.43)

PREDICTION OF HYDROGRAPH OF SPRING INFLOW OF WATER INTO KAMA RESERVOIR FOR UP TO TWO MONTHS IN ADVANCE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 80-87

[Article by Doctor of Geographical Sciences V. I. Sapozhnikov, USSR Hydrometeorological Scientific Research Center, submitted for publication 16 June 1978]

Abstract: The article describes methods for the long-range forecasting of the hydrograph for water inflow into the Kama Reservoir based on the 10-day period distribution of the volume of spring runoff (predicted on the basis of snow reserves) from five parts of the basin using standard high-water hydrographs. The latter were obtained taking into account the water levels on rivers at the time of the forecast, the anticipated 10-day air temperature during snow melting and the 10-day runoff predicted on the basis of hydrometric and meteorological data. The hydrograph predictions are given at the end of each 10 days of the initial stage of high water.

[Text] The Kama Reservoir was formed as a result of blocking of the Kama River in 1954 by the dam of a hydroelectric power station above Perm'. It collects water from an area of 168,000 km^2 of wooded plain and the western slopes of the Ural Mountains. The entry of melt and rain water in this basin is characterized by a considerable nonuniformity in space and time.

Daily information on the actual inflow of water into the reservoir Q_{in} for providing data to the hydroelectric power station are determined by the method developed at the Kama Hydrometeorological Observatory, taking into account the sum of water flows of the rivers entering the reservoir:

[π = in(flow)

$$Q_{\text{п},t} = Q_{1,t} + Q_{2,t} + Q_{3,t} + Q_{4,t} + Q_{6,t}, \tag{1}$$

where $Q_1, Q_2, \ldots, Q_5$ are the water discharges in the rivers: 1) Kama at Bondyug village (46,300 km^2), 2) Vishera at Ryabinino village (30,900 km^2), 3) Chusovaya at Lyamino station (21,500 km^2), 4) Sylva at Podkamennyy village (19,700 km^2) and 5) from a lateral area, equal to 49,600 km^2.

The inflow from the lateral area Q_5 is computed approximately using the equation

$$Q_5 = 0{,}13(Q_3+Q_4)+1{,}51\,Q_6+3{,}52\,Q_7+2{,}08\,Q_8+1{,}28\,Q_9+1{,}45\,Q_{10}, \qquad (2)$$

where the subscripts for the water discharges designate the stations: 6) Ust'-Igum village on the Yayve River (573 km^2), 7) Oshchepkovo village on the Kondasa River (896 km^2), 8) Sludka village on the In've River (5,210 km^2), 9) Rozhdestvenskoye village on the Obve River (5,540 km^2), 10) Ostanino village on the Kos've River (6,220 km^2).

This inflow into the reservoir computed on the basis of formulas (1) and (2) during the spring high waters of past years is used for developing a method for the long-range forecasting of its hydrograph. Such work was done separately for each of the five partial basins (1). As a result, it was possible to take into account the spatial and temporal variability of runoff in the basin of the Upper Kama, exerting a substantial influence on the form of the high water hydrograph. The spring runoff volumes necessary in this case for parts of the basin are predicted using its dependences on the water reserves in the snow cover [1]. During the development of high water its volume is refined on the basis of the runoff of small rivers, taking into account the remaining snow reserves using the method proposed by Yu. V. Gorbunov and V. A. Zykova [2].

The anticipated volume of spring inflow from each part of the basin is distributed during the time of the high water using standard hydrographs obtained using the characteristics of the actual and anticipated (on the basis of a weather forecast) state of hydrometeorological conditions with subsequent summing of the high-water hydrographs for high water from all parts of the basin (1).

The initial data for developing the method for predicting the inflow hydrograph were the mean 10-day water discharges during the high-water period for 1936-1971 for four rivers flowing into the reservoir. The hydrographs from the lateral area for the past years were computed using equation (2).

The method proposed below for the long-range forecasting of the distribution of spring water inflow into the Kama Reservoir by 10-day periods provides for the preparation of forecasts at different times in the initial high-water stage. Usually the high water on the rivers in the basin of the Upper Kama begins during the first 10 days in April. Therefore, for predicting the hydrograph of inflow into the reservoir we used constant dates: 31 March, 10, 20 and 30 April. These data were used in a classification of the high-water hydrographs for the five parts of the Kama River basin above the line of the Kama Hydroelectric Power Station, including the four rivers flowing into the reservoir and the lateral area. The anticipated volumes of spring discharge at these times are distributed for the high-water period by mean ten-day water discharges to the end of July.

As indices of the actual state of the water regime in the classification we used the water levels on the rivers at the time of the forecast. The anticipated conditions for subsequent melting of the snow, exerting an influence on the intensity of development of high water, are characterized by the predicted 10-day air temperature [3, 4].

At the adopted forecast times n using the mean long-term water levels $\bar{H}_n$ on rivers flowing into the reservoir (1), and for the lateral area (2), whose runoff was assumed to characterize approximately the levels of the Kos'va River at Ostanino, all the spring high waters were divided into two groups which had water levels at the time of the forecast Hn greater than and less than the mean level $\bar{H}_n$. The group with the values $Hn > \bar{H}_n$ was related to the early high waters, since by the time of the forecast the levels had already definitely developed and had attained values higher than the usual at these times. The spring high waters whose water levels at the time of the forecast were less than the mean values on these dates $H_n < \bar{H}_n$ were classified as "late."

Since the mean of the positive air temperature values for the 10-day period after preparation of the forecast $\bar{\theta}_{n+10}$ was used as a "harmony" index for the development of high water, all the spring high waters for which $\bar{\theta}_{n+10}$ was above the mean for the long-term period $\bar{\bar{\theta}}_{n+10}$, are assumed to be harmonious $\bar{\theta}_{n+10} > \bar{\bar{\theta}}_{n+10}$. When after the date of the forecast the 10-day air temperature was lower than the mean value $\bar{\theta}_{n+10} < \bar{\bar{\theta}}_{n+10}$, then such spring high waters are classified as "nonharmonious."

Thus, on the basis of two criteria -- the water levels on the rivers at the time of the forecast H_n and the anticipated 10-day air temperature $\bar{\theta}_{n+10}$ -- all the spring high waters in each special basin i were distributed in four groups j, whose hydrographs are arbitrarily called:

-- early harmonious $H_n > H_n,\ \bar{\theta}_{n+10} > \theta_{n+10};$

-- early nonharmonious $H_n > H_n,\ \bar{\theta}_{n+10} < \bar{\bar{\theta}}_{n+10};$

-- late harmonious $H_n < H_n,\ \bar{\theta}_{n+10} > \bar{\bar{\theta}}_{n+10};$

-- late nonharmonious $H_n < \bar{H}_n,\ \bar{\theta}_{n+10} < \bar{\theta}_{n+10}.$

For these groups we obtained the mean hydrographs of the 10-day high-water discharges

$$\bar{Q}_{i,j,t} = \frac{1}{N}\sum_{l=1}^{N} Q_{i,j,t},$$

where N is the number of spring high waters in each j-th group of the i-th special basin.

The hydrographs obtained in this case are reduced to the mean long-term high-water runoff in the i-th part of the basin using the expression

$$\overline{\overline{Q}}_{i,j,t} = \frac{\sum_{1}^{T} \overline{\overline{Q}}_{i,t}}{\sum_{1}^{T} \overline{Q}_{i,j,t}} \overline{Q}_{i,j,t}, \tag{3}$$

which includes the sums of the water discharges during the period of high water T of a normal hydrograph $\overline{\overline{Q}}_{i,t}$ and the mean hydrograph for each j-th group of spring high waters during this same time $\overline{Q}_{i,j,t}$. The water discharges of typical spring high waters are plotted in tables, which are usually used in the preparation of forecasts.

We note that in developing the method for predicting the hydrographs for inflow into the reservoir and in their classification use is made of the observed air temperature in the basins, and in the prediction -- the predicted air temperature in the basins [3, 4], which makes it possible to take into account the anticipated (on the basis of the weather forecast) meteorological conditions. At the time of the forecast, for each special basin it is necessary to know two classification criteria -- the water levels on the rivers and the air temperature predicted for the subsequent 10-day period. Using these criteria it is possible to establish the type of anticipated hydrograph for the high water season $\overline{Q}_{i,j,t}$ from each part of the basin and the predicted water discharges are computed using the expression

$$Q_{i,j,t} = \frac{y_i}{\overline{\overline{y}}_i} \overline{\overline{Q}}_{i,j,t}, \tag{4}$$

in which y_i is the predicted spring runoff, $\overline{\overline{y}}$ is its norm, $\overline{\overline{Q}}_{i,j,t}$ are the water discharges from an i-th part of the basin (j-th standard high-water hydrograph), reduced using formula (3) to a long-term series.

The substitution of the computed values (4) into (1) gives an expression for the long-range forecasting of the water inflow hydrograph during the time of high water for the waters flowing into the Kama Reservoir

[π = in(flow)]

$$Q_{\pi,t} = \sum_{i=1}^{6} \frac{y_i}{\overline{\overline{y}}_i} \overline{\overline{Q}}_{i,j,t}. \tag{5}$$

In the example of 1974, without going into detail, we will illustrate the sequence for preparation of a long-range prediction of the distribution of the spring inflow into the Kama Reservoir by 10-day periods. The prediction is given using the predicted volume of high water using standard distributions of spring runoff from 10 April through the end of July. The initial data necessary for such a forecast -- the anticipated layer of spring runoff y, its norm $\overline{y}$ and the modular coefficient $k = y/\overline{y}$, the water levels on

10 April $H_{10\ IV}$, their norm $\overline{H}_{10\ IV}$ and the mean 10-day air temperature $\overline{\theta}_{11-20\ IV}$ (expected from the forecast) are given in Table 1 for five parts of the basin.

The volumes of spring runoff y for special basins -- the Kama River to Bondyug, the Vishera River to Ryabinino and the Chusovaya River to Lyamino -- are predicted using the dependences (derived at the State Hydrological Institute [1]) on the maximum water reserves in the snow $y = f(s)$ and on the snow reserves, taking into account the precipitation norms $y = f(s+\overline{x})$. For special basins -- the Sylva River to Podkamennyy and the lateral area (49,600 km^2) -- the anticipated later of spring runoff is adopted using the same dependences derived for the entire basin of the Kama Reservoir.

Using the characteristics $H_{10\ IV}$ and $\overline{\theta}_{11+20\ IV}$ cited in Table 1 it was possible to establish corresponding standard hydrographs for each part of the basin. Their water discharges are taken from the above-mentioned summary tables. Then the discharges are multiplied by the modular coefficients of the anticipated spring runoff and for each 10-day period to the end of July are summed from the five parts of the basin (5).

For predicting the hydrograph of water inflow into the Kama Reservoir at the above-mentioned times we also developed a second method, which makes it possible, using the volume of spring runoff together with the use of water levels on rivers at the time of the forecast H_n, to take into account the mean water discharges $\overline{Q}_{n+10}$ for the subsequent 10-day period as a characteristic of the harmony of the high water period. As a result of separation of the high-water hydrographs for past years on the basis of these criteria into four groups, their averaging and reduction to the norm (3), the four following types of spring high water were defined:

-- early harmonious $H_n > \overline{H}_n,\ \overline{Q}_{n+10} > \overline{\overline{Q}}_{n+10},$

-- early nonharmonious $H_n > \overline{H}_n,\ \overline{Q}_{n+10} < \overline{\overline{Q}}_{n+10},$

-- late harmonious $H_n < \overline{H}_n,\ \overline{Q}_{n+10} > \overline{\overline{Q}}_{n+10}$ и

-- late nonharmonious $H_n < \overline{H}_n,\ \overline{Q}_{n+10} < \overline{Q}_{n+10},$

where $\overline{Q}_{n+10}$ are the mean long-term 10-day water discharges.

In each special basin, on the basin of hydrometric data and the course of snow melting and rains, we obtained dependences for prediction of 10-day runoff. For the first 10-day period after the date of preparation of the hydrograph forecast we use the predicted runoff using the dependences on channel water volumes at the time of the forecast and the predicted inflow of melt and rain water, whereas for the subsequent 10-day periods the runoff is determined on the basis of its standard distributions using the formula (5).

Table 1

Long-Range Prediction of Hydrograph of Spring Water Inflow into Kama Reservoir Prepared on 10 April 1974 on the Basis of Water Levels in Rivers at the Time of the Forecast $H_{10\ IV}$, Anticipated 10-Day Air Temperatures $\overline{\theta}$ 11-20 IV and Spring Runoff Volumes y in Five Parts of Basin

y мм	$\overline{\overline{y}}$ мм	$k = \frac{y}{\overline{\overline{y}}}$	$H_{10\ IV}$ см	$\overline{H}_{10\ IV}$ см	$\overline{\Theta}_{11-20\ IV}$	Тип 1	2 Ожидаемые декадные расходы воды $\overline{Q}_{i,\ пр} = k_i\ \overline{\overline{Q}}_{i,\ j,\ t}$ м³/сек										
							апрель 3		май 4			июнь 5			июль 6		
							II	III	I	II	III	I	II	III	I	II	III
7 р. Кама — с. Бондюг																	
298	180	1,66	136	89	−1,0	рпд	174	578	2268	3380	3491	2563	953	699	651	564	465
8 р. Вишера — пос. Рябинино																	
446	303	1,47	102	98	−1,5	рпд	260	438	1514	5052	3972	2964	1341	945	667	610	563
9 р. Чусовая — пст. Лямино																	
253	233	1,09	174	284	2,9	пид	254	607	1613	1453	880	443	459	185	145	138	83
10 р. Сылва — с. Подкименное																	
168	154	1,10	391	177	4,5	рд	959	752	558	223	240	163	133	138	152	165	146
11 Боковая площадь 49 600 км² (уровни: р. Косьва — д. Останино)																	
82	109	1,0	243	171	1,42	пид	1396	1517	1579	1681	1866	1941	1257	804	595	190	283
12 Общий приток в Камское водохранилище																	
13 $\overline{Q}_{пр}$:							3043	3892	7532	9789	10449	8065	4143	2771	2810	1667	1540
14 $\overline{Q}_{ф}$:							1993	5316	7709	11618	8901	7881	4512	1936	2198	1486	885
$\Delta\overline{Q} = \frac{\overline{Q}_ф - \overline{Q}_{пр}}{\overline{Q}_ф}$ 100%							−52,6	26,7	2,2	15,7	13,7	−2,3	8,1	−43,1	−0,5	−12,1	−74.0

KEY TO TABLE 1:

1. Type
2. Anticipated 10-day water discharges $\bar{Q}_{i,\,pre} = k_i \bar{\bar{Q}}_{i,j,t}$ m^3/sec
3. April
4. May
5. June
6. July
7. Kama River - Bondyug village
8. Vishera River -- Ryabinino village
9. Chusovaya River -- Lyamino station
10. Sylva River -- Podkamennyy village
11. Lateral area 49,600 km^2 (levels: Kos'va River - Ostanino village)
12. Total inflow into Kama Reservoir
13. predicted
14. actual

The dependences for predicting the 10-day runoff $\bar{Q}_{n+10}$ for each special basin include three components of the anticipated runoff

$$\bar{Q}_{n+10} = \bar{Q}_1 + \bar{Q}_2 + \bar{Q}_3, \qquad (6)$$

caused, respectively, by the channel water volumes at the time of the forecast, the water inflow into the river network at this same moment and the anticipated entry of melt and rain water.

The channel reserves W_n and the inflow into the river network q_n at the time of the forecast are computed in each special basin at 3-4 hydrometric stations using the formulas

$$W = \sum_{i=1}^{N} a_i' Q_i, \qquad (7)$$

$$q = Q_i + \Delta W, \qquad (8)$$

where a' are constant coefficients, determined taking into account the water travel time in river reaches, Q_i are the water discharges at N stations, ΔW is the change in water channel volumes during a computation time unit equal to two days.

The components in equation (6) for each part of the basin are determined in the following way. First using observational data for past years we construct curves of the dependences of 10-day runoff $\bar{Q}_{n+10}$ on the channel water volumes at the time of the forecast W_n(7). For the declining part of the runoff, from the envelope from the direction of the volumes axes we determine the component $\bar{Q}_1 = aW_n$, where a is a constant value. From the difference $\bar{Q}_{n+10} - aW_n$ and the water inflow into the river network at the time of the forecast q_n (8), for the period of decline we obtain the dependence of the component $Q_2 = bq_n$, where b is a constant coefficient. The actual values of the component $\overline{Q}_3$ caused by meltwater-rainwater runoff, are determined from the differences $\overline{Q}_{n+10} - aW_n - bq_n$, for which their dependences on the anticipated receipt of melt h_t and rain h_r water are determined.

The method for computing the receipt of melt water at the basin surface has been developed quite fully by V. D. Komarov [5]. The method uses the maximum water reserves in the snow, their probability curves for field and forest, and the constant coefficients for melting in open and forested areas. After approximately 20% of the snow reserves are melted the water release from the snow cover begins [6]. Therefore, the computations of receipt of melt water at the surface of open and wooded parts of the basin usually begin after accumulation of the sum of degrees of positive air temperature

$$\Sigma\theta_+ = \frac{0{,}2\ h_{\text{макс}}}{k_{\text{с}}}, \tag{9}$$

[MAKC = max; c = thaw(ing)] where h_{max} are the maximum water reserves in the snow cover. The thawing coefficient k_{thaw} is assumed for the field and forest to be 5 and 2 mm respectively per degree of positive mean daily air temperature. For the initial sum of degrees of positive temperature in accordance with expression (9) we adopted the values for an open area

$$\Sigma\theta_+ = 0{,}04\ h_{\text{макс}}$$

and for a wooded area

$$\Sigma\theta_+ = 0{,}01\ h_{\text{макс}}.$$

[MAKC = max]

The probability curves for snow reserves, necessary for computing snow thawing, for the conditions in the Kama River basin, were taken as determined by the V. V. Rakhmanov method [7]. They were computed from the curves for the micro-and macrodistribution of the snow cover and in essence more fully characterize the conditions under which the snow lies in the five considered parts of the basin.

The precomputation of the melt-rain component $\overline{Q}_3$ on the basis of the course of snow melting and precipitation is accomplished for each special basin using the formula

$$\overline{Q}_{3,\,n+10} = \frac{\overline{Q}_{n-10} - aW_{n-10} - bq_{n-10}}{\sum\limits_{i=n-10}^{n} k_i\,(h_{\text{т}} + h_{\text{д}})\,\overline{p}\,(\tau,\,10)} \sum_{i=n}^{n+10} k_i\,(h_{\text{т}} + h_{\text{д}})\,\overline{p}\,(\tau,\,10), \tag{10}$$

[T = t(haw), Д = rain] where $\overline{Q}_{n-10}$ are the mean water discharges for the past (n-10) 10-day period, W_{n-10} and q_{n-10} are the channel volumes and inflow into the river network at the beginning of the past 10-day period (n-10), k_i is the conversion factor from the runoff layer in millimeters to the water discharges in m^3/sec, h_t and h_{rain} is the layer of melt and rain water entering into the basin (determined 10 days before the time of the forecast and 10 days thereafter respectively). The transformation of the layer of melt and rain runoff in each special basin is accomplished using the travel time curves $p(\tau)$, which are determined from individual high waters formed from the precipitation falling during the computation time interval. By means of averaging for 10-day time segments of these curves we obtain the distributions $p(\tau, 10)$ for computing the 10-day runoff [8].

On the right-hand side of expression (10) the ratio of the component $\overline{Q}_{3,n-10}$ during the past 10-day period, computed on the basis of hydrometric data, on the one hand, and on the basis of the layer of melt and rain water up to the forecast time, on the other hand, is a relatively stable value. Computations for a number of spring high waters indicate that this ratio changes, for the most part, from high water to high water in the range 0.02-0.05 and is somewhat less variable during a period of high water. Accordingly, in a prediction of the component $\overline{Q}_{3,n+10}$ the persistence of this ratio is admissible only within the mentioned limits. The value of the component $\overline{Q}_{3,n+10}$ for the next 10-day period is computed from the receipt of melt water at the basin surface, predicted taking into account the anticipated air temperature. The 10-day runoff precomputed in this way is used in predicting the total inflow into the Kama Reservoir during the 10-day period after preparation of the forecast and in determining the standard hydrograph for the subsequent 10-day periods on the basis of the H_n and Q_{n+10} criteria.

A prediction of the 10-day inflow of water into the Kama Reservoir at the time of high water is made using the sum of the predicted values of this inflow from five parts of the basin

[π = ln]

$$\overline{Q}_{n,\,n+10}=\sum_{i=1}^{5}(a_i W_{i,n}+b_i q_{i,n}+\overline{Q}_{3,i,n+10}). \qquad (11)$$

In this expression the anticipated values of the component of the 10-day runoff from snow melting after the prediction date are computed using formula (10). During the first period of high water the relative role of this component is great; in the second case, after snow melting, it decreases substantially.

An evaluation of the probable success of long-range forecasts of the hydrograph of water inflow into the Kama Reservoir for a 35-year period was made for the entire high-water period on the basis of calendar 10-day water discharges. First for each 10-day period for a long-term period we determined the standard deviations σ of water discharges and the mean square errors in predictions of the 10-day water discharges s. Using the ratio s/σ we determined the effectiveness of the method for predicting the 10-day water discharges during the time of high water.

The computations made by Z. I. Rubtsova and V. T. Kurbatova demonstrated that for most of the 10-day discharges of water inflow into the Kama Reservoir, predicted for a period of up to two months, s/σ is 0.52-0.84.

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UDC 556.132

APPLICATION OF SIMILARITY THEORY TO COMPUTATION OF EVAPORATION FROM A WATER SURFACE

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 88-95

[Article by Candidate of Geographical Sciences R. I. Geta, Limnological Institute Siberian Department USSR Academy of Sciences, submitted for publication 30 May 1978]

Abstract: On the basis of processing of observational data on evaporation from a water surface by the methods of similarity theory it was possible to define two evaporation regimes. Equations were derived for the dependence of the dimensionless evaporation rate on the determining factors. For the case of forced convection in the region $8 \cdot 10^4 \leqslant \mathrm{Re} \leqslant 20 \cdot 10^5$, corresponding to a wind velocity from 1.7 to 6.0 m/sec, the dimensionless evaporation rate is an unambiguous function of the Reynolds number. It is shown that the evaporation rate is directly proportional to the wind velocity in the power n (less than unity) and is inversely proportional to the extent of the evaporating surface in the power 1-n. A dependence is derived for computing the conversion factor (reduction coefficient) from the readings of one evaporation apparatus to another.

[Text] Despite the extensive literature on the problem of evaporation from a water surface the problem of its reliable determination is far from solved. Among the existing methodological approaches to the estimation of evaporation from water bodies the one of the greatest interest from the practical point of view is the hydrometeorological method. This makes it possible to compute the evaporation value on the basis of empirical expressions and using standard hydrometeorological observations. Many such expressions have now been accumulated. However, the complexity of the evaporation process, determined by many factors of the evaporating medium and the atmosphere situated above it and the absence of a clear idea concerning some details of its physical structure have not yet made it possible to obtain a dependence satisfying the most different conditions.

Most of the existing empirical dependences are represented in the form

$$E = A\,(e_0 - e_{200})(1 + BW_{200}^n), \tag{1}$$

the values of the constant factors A and B and the exponents n differ rather broadly in the writings of different authors, corresponding to the hydrodynamic conditions of water vapor transport from the surface of a specific evaporator into the atmosphere during some period. Accordingly, the empirical dependences have a local character. The extension of the region of their application to other evaporators and to other natural conditions usually results in a decrease in their accuracy.

Strictly speaking, the empirical dependences are applicable only in those conditions and in those evaporators for which they were obtained. In this respect turbulent diffusion methods are more flexible; they take into account hydrodynamic evaporation conditions not averaged over the water area and with time, but in dependence on the state of the evaporating surface and the near-water air layer at a definite point at a specific moment in time. To be sure, a number of assumptions, the low reliability in determining the parameters of the turbulent diffusion formulas, the need for a poorly supported interpolation, and in particular, their extrapolation over the area of water bodies (frequently having a complex morphological structure, and hence nonuniform hydrodynamic and thermal conditions of the water surface), and finally, the inevitability of their averaging over the computation time intervals, virtually wipe out the advantages which are given by these formulas due to a more rigorous allowance for the physical side of the process. As a result, the turbulent diffusion formulas are reduced to the level of local empirical dependences.

The existence of a large number of computation dependences is a normal consequence of inadequacy of the methodological approach and the mathematical expression of the physical essence of the evaporation process to the process itself. Thus, the manifestation of a dialectic contradiction in learning about any natural phenomenon is clear. Naturally, for eliminating the contradiction which arises there must be a qualitative jump both in the experimental study of the process and also in the approach to formulating its mathematical model.

In this paper, for interpreting the results of standard observations of evaporation from a water surface, we have used similarity theory methods making it possible to take into account the conditions and degree of similarity of the studied phenomenon.

The soundness of applications of similarity theory is contained in a whole series of studies by Soviet and foreign authors [2, 6, 7, 8, 11, 14-17 and others]. It can be summarized as follows. A set of dimensional parameters, characterizing a definite process, is equivalent to a set of dimensionless complexes (similarity criteria) formed from them, and therefore, the integral of the differential equation, describing the process, can be represented as a function of the mentioned dimensionless complexes. At the same time, similarity theory applies to the dissemination of the experimental results only to similar phenomena, establishing, on the basis of an analysis of similarity criteria, the limits of the latter.

Similarity theory has found its broadest application in technical applications, especially in the solution of heat exchange problems, for which it has been adequately well developed. Since the processes of heat and mass exchange are described, in principle, by one and the same differential equations, the criterial or generalized methods for solving applied heat exchange problems, developed on the basis of similarity theory, are also applicable to mass exchange processes.

The Fick equation

$$\frac{dq}{d\tau} = D\left(\frac{\partial^2 q}{\partial x^2} + \frac{\partial^2 q}{\partial y^2} + \frac{\partial^2 q}{\partial z^2}\right), \qquad (2)$$

relating the rate of mass transfer $dq/d\tau$ to the field of concentrations q in the solution of the stationary problem for the case of forced convection, makes it possible to generalize data on evaporation in the form of a criterial dependence [6, 9, 10]

$$\mathrm{Nu}_D = K\,\mathrm{Re}^n\,\mathrm{Pr}_D^m, \qquad (3)$$

where $\mathrm{Nu}_D = \beta L/D$ is the dimensionless coefficient of mass transfer (Nusselt diffusion number; in the foreign literature known as the Sherwood number, Sh); $\mathrm{Re} = WL/\nu$ is the Reynolds number; $\mathrm{Pr}_D = \nu/D$ is the Prandtl diffusion criterion, sometimes called the Schmidt number, Sc; W is the velocity of movement of a fluid or gas; β is the mass transfer coefficient; L is the characteristic dimension; ν is the coefficient of kinematic viscosity; D is the molecular diffusion coefficient.

Among the attempts at application of similarity theory to study and computations of evaporation from a water surface, carried out on the basis of laboratory experiments, we will mention the equations derived by L. S. Leybenzon [9], A. G. Kolesnikov [5], A. V. Lykov [9] and A. V. Nesterenko [12].

According to Lykov, the equation for the evaporation rate in dimensionless coordinates has the form

$$A = K\,\mathrm{Re}^n, \qquad (4)$$

where K and n vary in dependence on the Re number. The Lykov dependence itself was approximated graphically using a curve convex to the Re axis. Later I. P. Budarov [1] found its analytical expression

$$A = 6{,}3 + 0{,}162\,\mathrm{Re}^{0{,}7}. \qquad (5)$$

The first attempt to use similarity theory for study and description of evaporation from evaporators and evaporation basins, insofar as known to the author from the Russian literature, was made by Z. Sakipov [13]. Taking the Lykov scheme as his basis, Sakipov obtained a dependence which in the first approximation is described by him using two equations:

$$A=0{,}072\,\mathrm{Re}^{0,78} \quad \text{for the region} \quad 2\times10^4\leqslant \mathrm{Re}\leqslant 3\times10^5 \qquad (6)$$

$$A=0{,}002\,\mathrm{Re}^{0,97} \quad \text{for the region} \quad \mathrm{Re}\geqslant 3\times10^5. \qquad (7)$$

Equation (4) is derived easily by proceeding from the following reasoning. According to Dalton's law, the evaporation rate ΔE can be represented by the expression

$$\Delta E=\beta S(q_0-q_{200}), \qquad (8)$$

hence

$$\beta=\frac{\Delta E}{S(q_0-q_{200})}. \qquad (9)$$

Here β is the already known mass transfer coefficient (evaporation coefficient); q_0 and q_{200} is air specific humidity at the water surface level and at a height of 200 cm; S is the area of the evaporating surface, equal to the product of L x L; L is a side of an equivalent square, used as the characteristic dimension. (For evaporation apparatus with an area of 100, 20, 3 and 0.3 m^2 L was assumed equal to 10.0 m; 4.5 m; 1.7 m and 0.54 m respectively).

Substituting (9) into the formula for Nu_D and converting from specific humidity to water vapor elasticity, we obtain the expression

$$\frac{\Delta E R^* T}{\mu_n D L\,(e_0-e_{200})}=K\,\mathrm{Re}^n\,\mathrm{Pr}_D^m, \qquad (10)$$

where R^* is the universal gas constant, kg·m/(mol·degree); $T = 273 + \bar{t}$ ($\bar{t} = (t_0 + t_{200})/2$, t_0 and t_{200} is the temperature of the water surface and air at a height of 200 cm; u_{vap} [π = vap] is the molecular weight of water vapor, kg/mol; D is the diffusion coefficient for water vapor in the air, adopted from [10], equal to $0.0792 + 0.00044\,\bar{t}$, m^2/hour.

The kinematic viscosity coefficient ν in determining the Re number was computed from the dependence [11]

$$\nu=(13{,}28+0{,}09\,\bar{t})\times10^{-6}, \quad m^2/\text{sec}. \qquad (11)$$

The value of the Prandtl diffusion number for water is close to unity (about 0.75) and the value of the exponent m varies from 0.30 to 0.44, averaging 0.33 [9].

Dividing the equation (10) term-by-term by Pr_D^m and denoting its left-hand side by A, we obtain the sought-for expression $A=K\mathrm{Re}^n$,

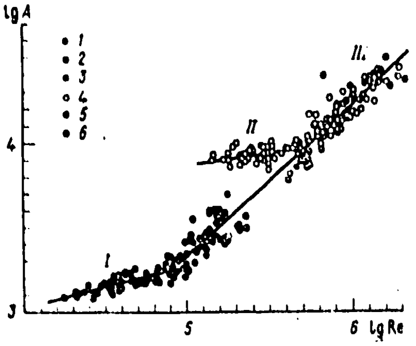

Fig. 1. Dependence of dimensionless evaporation rate A on Reynolds number Re. 1) GGI-3000 evaporator in ground; 2) GGI-3000 evaporator in water body (Kengirskoye Reservoir); 3) evaporation basin with area of 3 m^2 in ground; 4) evaporation basin with area of 20 m^2 in ground; 5) evaporation basin with area 20 m^2 in water body (Kengirskoye Reservoir); 6) evaporation basin with area 100 m^2.

With known A the evaporation rate Δ E is determined using the equation

$$\Delta E = A \frac{\mu DL}{R \cdot T} (e_0 - e_{200}). \tag{12}$$

For determining the numerical form of the dependence (4) we used observational data from the water evaporation network of the USSR using GGI-3000 evaporators, evaporation basins with an area of 3, 20 and 100 m^2, located in different natural zones and taking in the time period from 1953 through 1969 inclusive. As a result of the computations made for monthly time intervals (totalling 314 month-points) we obtained the dependence of the evaporation rate on the determining factors in dimensionless coordinates (Fig. 1). The dependence has a complex character and is described by the equations

$$\text{I. } A = 112\ \mathrm{Re}^{0,341} \tag{13}$$

for the region $\mathrm{Re} \leqslant 8 \times 10^4$ (GGI-3000 evaporator)

and

for the region $8 \times 10^4 \leqslant \mathrm{Re} \leqslant 20 \times 10^5$

$$\text{III. } A = 0,083\ \mathrm{Re}^{0.881} \tag{14}$$

(apparatus of all types);

$$\text{II. } A = 1514\,\mathrm{Re}^{0.136} \tag{15}$$

for the region $\mathrm{Re} \leqslant 5 \times 10^5$ (basin 20 m^2).

It can be seen from the cited equations (13)-(15) that in a forced convection regime (dependence (14)), corresponding for the evaporation basins to wind velocities of 1.6 m/sec or more, the dimensionless evaporation rate for all the enumerated types of evaporation apparatus is an unambiguous function of the Re number.

With a decrease in wind velocity the influence of the Re number on the intensity of evaporation is lessened, which on the graph (Fig. 1) is manifested in a decrease in the slope of the correlation line to the Re axis. The latter hypothetically indicates that with definite dimensions of the evaporating surface and small wind velocities the evaporation rate becomes self-similar relative to Re. A tendency to this can be traced easily, in particular, from equations (13) and (15), describing the dependence of the dimensionless evaporation rate on the Re number for the GGI-3000 evaporator and an evaporation basin with an area of 20 m^2 for small wind velocities. Unfortunately, the shortage of factual data at our disposal did not make it possible to derive such dependences for basins with an area of 3 and 100 m^2. The latter in the range of low velocities is characterized by only one point.

In the case of low wind velocities, below 1.6 m/sec, when the influence of the dynamic factor on the intensity of evaporation lessens, in addition to the Prandtl number, the Grashof number also becomes determining, the latter characterizing the influence exerted on the evaporation rate by buoyancy forces

$$\mathrm{Gr} = \frac{gL^3}{\nu^2}\left(\frac{\mu_{\text{в}} T_{\text{п}}}{\mu_{\text{п}} T_{\text{в}}} - 1\right), \tag{16}$$

[B = air; П = vapor] where g is the acceleration of free falling; μ_a and μ_v are the molecular weights of air and water vapor.

It is not impossible that the condition of self-similarity of the dimensionless rate of evaporation relative to the Reynolds number at low wind velocities is already satisfied for a basin with an area of 100 m^2. Thus, one can almost conclude that for estimating the evaporation from water bodies of sufficient extent the wind term in equation (1) becomes superfluous and can even be a source of additional errors. The influence of the dynamic factor in this case is taken into account by the air humidity profile, which to a certain degree is itself a function of wind velocity.

The introduction of a correction for wind velocity into the computation formulas therefore follows not from the physical evaporation law

$$\Delta E = C(q_0 - q_z),$$

but from the conditions of its observation [3,4]. The necessity for the addition of a wind term in the evaporation formulas is caused by the influence of local factors essentially different even for two stations situated close together. However, if the factors exerting an influence on evaporation are quite uniform, as is characteristic for large water bodies, the proportionality factor with $q_0 - q_z$ will be relatively constant, not requiring corrections for wind conditions.

Dependence (12) can be transformed to the form

$$E = C' \frac{D}{T\nu^n} W_{200}^n (e_0 - e_{200}), \quad \text{mm/day}, \tag{17}$$

where C' is a constant factor equal to

$$\frac{24 K \mu \mathrm{Pr}_D^n}{R^* L^{1-n}}.$$

Taking into account that $D/T\nu^n$ is a function of temperature $(\bar{t})$, equation (17) can finally be written in the following form convenient for computations:

$$E = (0{,}254 + 0{,}00024\,\bar{t})\, W_{200}^{1{,}36} \ (e_0 - e_{200}), \quad \text{mm/day} \tag{18}$$

for a wind velocity up to 1.7 m/sec inclusive and

$$E = (0{,}183 - 0{,}00072\,\bar{t})\, W_{200}^{0{,}881} \ (e_0 - e_{200}), \quad \text{mm/day} \tag{19}$$

for higher wind velocities.

On the basis of the dependences (18) and (19) for the stations Kamen'-na-Ob', Bratsk, Angarsk, Bol'shoy Ushkaniy Ostrov, we carried out a selective checking of the correspondence between the observed and computed evaporation values (Table 1). The table shows that computations made using these dependences gave evaporation values more or less close to those observed, whereas the errors in computations made using the B. D. Zaykov formula (State Hydrological Institute), recommended for determining evaporation from water bodies, in almost all the considered cases were appreciably greater.

One of the merits of representing the results of evaporation observations in the form of criterial dependences is the possibility of its modeling, taking into account the equality of the similarity criteria.

In the case of forced convection, such a criterion, as we have seen, is the Reynolds number.

An analysis of the equations for the dimensionless rate of evaporation shows that all other conditions being equal, the intensity of evaporation is directly proportional to wind velocity in the power n and is inversely proportional to the extent of the evaporating surface in the power 1-n.

With wind velocities greater than 1.6 m/sec (averaging 1.7 m/sec) the exponent n is an identical value for all types of evaporation apparatus. In the case of lower wind velocities it is dependent on the extent of the evaporating surface. The greater the extent of the water surface in the direction of the air flow, the lesser, all other conditions being equal, is the influence exerted on the intensity of evaporation by the horizontal wind velocity component.

Table 1

Comparison of Observed and Computed Evaporation Values for Season from the Surface of a 20-m Evaporation Basin

Год 1	$E_{набл}$, мм 2	3 $E_{рассч}$, мм		4 Ошибка, %	
		по формуле Зайкова, ГГИ 5	по уравнениям (18) и (19) 6	по формуле Зайкова, ГГИ 5	по уравнениям (18) и (19) 6
7 *Камень-на-Оби*					
1972	499	618	606	23,8	21,4
8 *Братск*					
1969	218	184	202	—15,6	—7,3
1972	292	271	290	—7,2	—0,7
9 *Ангарск*					
1954	433	461	432	6,5	—0,2
1968	444	471	443	6,1	—0,2
1971	421	430	427	2,1	1,4
1972	434	459	431	5,8	—0,7
1974	352	383	362	8,8	2,8
10 *Большой Ушканий остров*					
1968	311	334	334	7,4	7,4
1969	298	313	303	5,0	1,7
1972	263	301	291	14,4	10,6

KEY:

1. Year
2. E_{obs}, mm
3. E_{comp}, mm
4. Error
5. using Zaykov formula, State Hydrological Institute
6. using equations (18) and (19)
7. Kamen'-na-Ob'
8. Bratsk
9. Angarsk
10. Bol'shoy Ushkaniy Ostrov

Evidently, a decrease in this influence occurs in conformity to a hyperbolic law, with definite dimensions of the water surface attaining some stable value governed by the thermal and hygrometric properties of the evaporating surface and the atmosphere.

Strictly speaking, the derived dependences can be used only in the limits bounded by the observed values of the Re number. In other words, they are applicable for computations of evaporation from GGI-3000 evaporators and evaporation basins with an area up to 100 m^2 with wind velocities from 0.5 to 6.0 m/sec.

The extension of the region of their applicability to large water bodies nevertheless requires a corresponding experimental validation with the subsequent processing of observational data by similarity theory methods.

We should also mention the possibility of using the generalized dependences for obtaining factors for conversion from the readings of one evaporation apparatus to another more soundly and reliably than when using known reduction factors.

The expression for the conversion factor (reduction coefficient) r_{1-2} in this case is written in the form

$$r_{1-2} = \frac{K_1}{K_2} \frac{L_2^{1-n_2}}{L_1^{1-n_1}} \frac{D_1}{D_2} \frac{T_2}{T_1} \frac{\nu_2^{n_2}}{\nu_1^{n_1}} \frac{W_{200,1}^{n_1}}{W_{200,2}^{n_2}} \frac{(e_0 - e_{200})_1}{(e_0 - e_{200})_2}. \tag{20}$$

With evaporation in a forced convection regime (equation (14)) the coefficient $r_{20-0.3}$ for conversion from the readings of the GGI-3000 evaporator to an evaporation basin with an area of 20 m^2 in the case of an equality of wind velocities is determined using the equation

$$r_{20-0,3} = 0,78 \frac{D_{20}}{D_{0,3}} \frac{T_{0,3}}{T_{20}} \left(\frac{\nu_{0,3}}{\nu_{20}}\right)^{0,881} \frac{(e_0 - e_{200})_{20}}{(e_0 - e_{200})_{0,3}}. \tag{21}$$

In the range of low wind velocities (on the average less than 1.7 m/sec) the expression for $r_{20-0.3}$ assumes the form

$$r_{20-0,3} = 2,33 \frac{D_{20}}{D_{0,3}} \frac{T_{0,3}}{T_{20}} \frac{\nu_{0,3}^{0,244}}{\nu_{20}^{0,136}} \frac{W_{200,20}^{0,136}}{W_{200,0,3}^{0,244}} \frac{(e_0 - e_{200})_{20}}{(e_0 - e_{200})_{0,3}}. \tag{22}$$

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UDC 551.50:633.1

METHOD FOR PREDICTING THE STATE OF WINTER CROPS UP TO CESSATION OF THEIR GROWING SEASON

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 96-102

[Article by Candidate of Geographical Sciences T. A. Maksimenkova, USSR Hydrometeorological Scientific Research Institute, submitted for publication 11 July 1978]

Abstract: This is a brief analysis of agrometeorological conditions during the period of the autumn growing season for winter crops in the European USSR. For the first time a method is proposed for predicting their state up to the time of cessation of their growing season for the territory of an oblast, kray and republic for different times in advance.

[Text] The leading place in the grain balance of the country is occupied by winter crops, which yield more than a third of the gross grain harvest. The autumn period is very important in the life of winter grain crops. During this period the winter crops undergo processes of organogenesis in the apical cone and accumulation of reserves of energy-bearing substances which play a great protective role during the wintering period. Under favorable agrometeorological conditions during the autumn period there is an intensive development of leaves, vegetative shoots and the root system [2, 4, 9]. Under unfavorable agrometeorological conditions during this period the winter crops end the autumn growing season with little thickening out, with an inadequately developed root system, with reduced resistance to winter conditions, and with a small accumulation of nutritional and protective substances. This leads to the death of the plants during the wintering period, to a decrease in the number of ear-bearing stems, and accordingly, a decrease in yield [10].

The principal reason for the poor state of winter crops in part of the area of sown crops in the Nonchernozem zone is the unfavorable agrometeorological conditions during the presowing period, which leads to late maturing of the crops occupying fallow and a shortening of the growing season, and in the Nonchernozem zone -- to the dessication of the soil in connection with the deficit of precipitation. The sowing of winter crops in such cases is delayed to later times, the plantings are frequently under unfavorable conditions of heat and moisture supply, leading to an increase in the area with a poor state, especially with respect to nonfallow predecessors [7, 9].

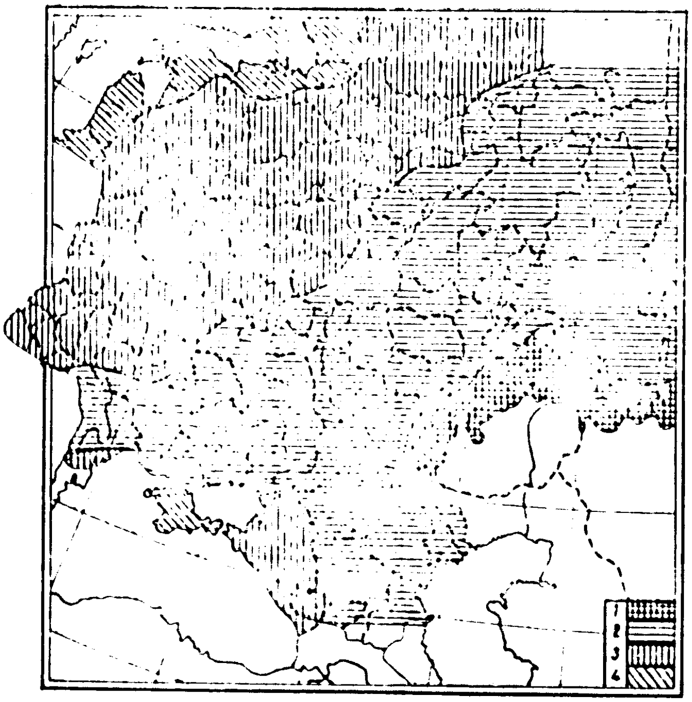

Fig. 1. Mean long-term duration of autumn period. 1) less than 40 days, 2) 40-50 days, 3) 51-60 days, 4) more than 60 days

The area with poor sowings in spring in most cases is determined by the extent of the area with poor plantings in autumn and the area in which the winter crops perished completely or were greatly thinned out in winter.

The extent of the area with a poor state of winter crops in autumn has a great spatial and temporal variability. The maximum area is in the southwestern European USSR, and the minimum is in the Nonchernozem zone.

During the last 12 years the average area of plantings of winter crops with a poor state in autumn as a whole for the USSR was 8%, and for individual regions it was considerably greater (20-25% of the entire sown area). In some years the area of the poor plantings in autumn for individual oblasts in the steppe zone attains more than half of the sown area.

Therefore, an evaluation of the state of winter crops and a determination of the extent of their areas in different states during the autumn period is of great interest and is of very great importance to the national economy.

In the European USSR during the period of the autumn growing season of winter crops the agrometeorological conditions are very diverse. The duration of the growing season for winter crops in autumn in the northwest is almost 1 1/2 times greater than in the southeast (55-60 days instead of 40) (Fig. 1). The sum of temperatures (effective temperatures -- above 5°C and positive temperatures -- above 0°C) during the period of the autumn growing season for winter crops, according to mean long-term data, agrees very well with the duration of the period of the autumn growing season and also decreases from northwest to southeast.

The quantity of precipitation falling during the period of the autumn growing season for winter crops in the European USSR also has a great spatial variability. In the Baltic area, in the western oblasts of the RSFSR and in Belorussia, the sum during this period is 100-150 mm, and in the southern Ukraine, in Rostovskaya and Volgogradskaya Oblasts, in the eastern part of Saratovskaya Oblast and in Orenburgskaya Oblast -- only 45 mm, that is, two or three times less. In the remaining regions of the European USSR the precipitation total during the period of the active growing season for winter crops is predominantly 60-100 mm.

The distribution of moistening of the upper (0-20 cm) soil layer used for winter crops during the autumn period agrees quite well with the territorial sum of precipitation, decreasing to the southeast of the European USSR almost by a factor of two.

A. A. Shigolev [11], S. A. Verigo [1], Ye. S. Ulanova [10], A. Ya. Grudeva [2], V. A. Moiseychik [9] and others have established that the principal factors in the life of winter crops in autumn are air temperature and soil moisture content, but the dependences of the duration of the interphase periods were obtained by them on individual factors with optimum values of the others.

We investigated the complex influence of these main agrometeorological factors on the development of winter wheat of the Mironovskaya-808, Bezostaya-1 and Kavkaz varieties.

Complex dependences of the duration of the interphase periods (n) of winter crops for these varieties on the mean air temperature during the period and the reserves of productive moisture of the cultivated soil layer were established for the first time. They are effective with both an adequate and with an inadequate heat and moisture supply of plantings of winter crops sown with nonfallow predecessors.

The analytical expression of the dependences of the duration of the interphase periods on temperature and soil moistening is the following:

sowing-sprouting

$$n=60{,}5-5{,}21\,\bar{t}+0{,}15\,\bar{t}^2-0{,}73\,\bar{w}+0{,}01\,\bar{w}^2;\quad \eta=0{,}73;\qquad n=64;\quad E_y=\pm 3 \text{ days};$$

sprouting-third leaf

$$n=51{,}71-6{,}36\,\bar{t}+0{,}21\,\bar{t}^2+0{,}48\,\bar{w}-0{,}01\,\bar{w}^2;\quad \eta=0{,}71;\qquad n=66;\quad E_y\approx 4 \text{ days};$$

third leaf-onset of tillering

$$n=29{,}88-0{,}14\,\bar{t}+3\cdot 10^{-4}\,\bar{t}^2-0{,}44\,\bar{w}+9\cdot 10^{-2}\,\bar{w}^2;\quad \eta=0{,}60;\qquad n=70;\quad E_y\approx 5 \text{ days}.$$

In the enumerated dependences $\bar{t}$ is the mean air temperature, $\bar{w}$ are the mean reserves of productive moisture (mm) during the corresponding periods.

An analysis of the presented dependences indicated that the main influence on the duration of the sowing-sprouting period is exerted by the reserves of moisture and air temperature to an almost equal degree; during the subsequent development of plantings of winter crops more and more influence on the duration of the periods is exerted by air temperature, especially in the case of late sowing times.

As indicated by our investigations [8], the reserves of productive moisture exert a significant influence on the density of the sowings. With reserves of productive moisture during the 10-day sowing period of 30-40 mm the number of plants by the time of cessation of the growing season per 1 m^2 is about 500 and the condition of the sowings is excellent; with moisture reserves of 25-30 and 40-45 mm the condition of the sowings of winter crops can be evaluated as good (the number of plants is about 400). With a further decrease and increase in the moisture reserves in the cultivated soil layer the density of the sprouts of winter crops worsens. In fields with reserves of productive moisture in the cultivated soil layer of less than 15 mm it is undesirable that winter crops be sown until there is considerable precipitation, since with such reserves the winter crops by the time of cessation of the growing season are thin (less than 200 plants per 1 m^2).

As indicated by our investigations, soil moisture content and air temperature also exert a significant influence on the length of the apical cone of the plant's main growth shoot. It was found that the longer and more favorable is the period from the onset of tillering to the cessation of the growing season and the greater is the temperature sum during this period, the greater is the development of the growth cone. Analytically this dependence is expressed by the regression equation:

$$l=0{,}235+6\cdot 10^{-3}\,t-7\cdot 10^{-7}\,t^2.$$

where L is the length of the growth cone of the main growth shoot (determined by the laboratory of the biology of plant development Moscow State University); t is the sum of positive air temperatures during the period onset of tillering -- cessation of growing season:

$$\eta=0,82; \quad n=106; \quad E_y=\pm 0,06 \text{ мм.}$$

The length of the growth cone of the main growth shoot correlates well with the bushiness of the winter crops by the time of cessation of the growing season (η = 0.80-0.90). Therefore, the indices for evaluation of the condition of winter crops in autumn on the basis of the degree of bushiness, adopted earlier in agrometeorology, characterize not only the morphological condition of the plants, but also the size of the growth cones for autumn shoots.

These dependences make possible a more precise determination of the role of the autumn period in the life of plants and also to determine the influence of the conditions of the autumn growing season on the productivity and winter resistance of winter crops. The good development of the growth cone in plants in autumn is an index of their high productivity. However, plants with overgrown growth cones will have a reduced winter resistance. F. M. Kuperman and V. A. Moiseyechik [6, 9] established a close inverse proportional dependence between winter resistance and the length of the growth cone in winter wheat plants.

Thus, having data on the moisture reserves in the soil and air temperature, using the dependences which we have derived it is possible to evaluate the agrometeorological situation of the autumn growing season and determine the state of winter crops in specific fields.

However, at the USSR Hydrometeorological Center specialists annually give a quantitative evaluation of the condition of winter crops not only in specific fields, but also for greater areas. The actual areas with different conditions of winter crops are determined on the basis of aerial and ground reconnaissance. But these observations are carried out sporadically and not for every oblast, kray and republic. Therefore, our task was to develop a method for calculating the areas with different conditions of winter crops in autumn on the basis of territorially averaged indices, both with respect to individual factors and their totality.

Our investigations indicated that the greatest influence on the extent of the area with a poor and a good state is exerted by the reserves of productive moisture in the cultivated soil layer, the precipitation sum and air temperature observed here. But the importance of these factors in different regions of the European USSR is not the same.

In the Ukraine, in Moldavia and in the Northern Caucasus the main influence on the condition of winter grain crops is exerted by the reserves of productive moisture in the sowing period and the precipitation totals during the autumn growing season (η= 0.67-0.75). In the territory of the Central

Chernozem oblasts and in the rayons along the Volga the influence of the moisture reserves in the cultivated soil layer and precipitation on the state of winter crops is almost the same ($\eta = 0.60$); the role of air temperature here is somewhat increased ($\eta = 0.48$). In the Nonchernozem zone of the European USSR precipitation exerts a lesser influence on the extent of the area with a poor condition of winter crops ($\eta = 0.54$). In this zone it is air temperature which is the principal limiting factor ($\eta = 0.66$).

The closest correlation of the extent of the area of winter crops with a good and poor condition of the sown areas has been established with the number of plants per 1 m^2 in autumn, both in specific fields and as a whole for an oblast, kray and republic.

As already mentioned, the number of plants per 1 m^2 by the time of cessation of the growing season for winter crops is dependent on the reserves of productive moisture in the cultivated soil layer and characterizes well the overall state of the sown areas in specific fields. This index proved to be a reliable characteristic for sown fields over great areas (oblast, kray, republic).

The correlation between the mentioned factors was computed for different zones in the European USSR and was analytically expressed for

Ukraine, Moldavia and Northern Caucasus

$$\bar{u} = 178,68 + 21,735\,\bar{w} - 0,459\,\bar{w}^2;$$

$$\eta = 0,70 \pm 0,02; \qquad E_u = \pm 34,7; \qquad n = 176,$$

Central Chernozem Oblasts and Volga Region

$$\bar{u} = 109,20 + 22,015\,\bar{w} - 0,352\,\bar{w}^2;$$

$$\eta = 0,70 \pm 0,03; \qquad E_u = \pm 45,6; \qquad n = 74.$$

Nonchernozem Zone

$$\bar{u} = 117,35 + 22,29\,\bar{w} - 0,361\,\bar{w}^2,$$

$$\eta = 0,70 \pm 0,02; \qquad E_u = \pm 33,5; \qquad n = 61.$$

where $\bar{u}$ is the mean number of winter crop plants per 1 m^2 (averaged for an oblast); $\bar{w}$ are the mean reserves of productive moisture (averaged for an oblast) (when 20% of the oblast is sown in winter crops).

It was found that with mean reserves of productive moisture in the cultivated soil layer of 25-35 mm (averaged for an oblast) the condition of the sown fields is optimum (400-500 plants per 1 m^2). Thus, already in the 10-day period of large-scale sowing (when 20% of the area of winter crops for the oblast is sown) it is possible to compute the density of the sown areas and determine their condition by the time of cessation of the growing season over the territory of an oblast, kray or republic, since the number of plants per 1 m^2 is closely related to the extent of the area with a different condition of winter crops.

Table 1

Dependence of State of Winter Crops on Number of Plants per Square Meter

Территория 1	Уравнение 2	r	n	E_y
3 Нечерноземная зона	$S_0 = -0{,}061\,\bar{u} + 32{,}208$	−0,70	61	±3,9
	$S_{\text{хор}} = 0{,}148\,\bar{u} - 7{,}553$ 8	0,67	61	±9,3
4 Центрально-Черноземная зона и Поволжье	$S_0 = -0{,}07\,\bar{u} + 34{,}64$	−0,80	74	±4,38
	$S_{\text{хор}} = 0{,}233\,\bar{u} - 33{,}424$	0,76	74	±13,9
5 Молдавия и южные районы Украины	$S_0 = -0{,}218\,\bar{u} + 102{,}377$	−0,82	42	±9,4
6 Остальные районы Украины и Северный Кавказ	$S_0 = -0{,}103\,\bar{u} + 51{,}166$	−0,60	134	±7,98
7 Украина, Молдавия и Северный Кавказ	$S_{\text{хор}} = 0{,}163\,\bar{u} - 14{,}439$	0,74	176	±7,3

KEY:

1. Territory
2. Equation
3. Nonchernozem zone
4. Central Chernozem zone and Volga Region
5. Moldavia and southern rayons in Ukraine
6. Remaining regions of Ukraine and Northern Caucasus
7. Ukraine, Moldavia and Northern Caucasus

Note: S_0 is the extent of the area of winter crops (in %) with a poor state by the time of cessation of the growing season; S_{good} is the extent of the area of winter crops (in %) with a good condition by the time of cessation of the growing season; $\bar{u}$ is the number of plants per 1 m^2 by the time of cessation of the growing season.

8. good

The dependence of the extent of the area (in % of the sown area) with good and poor conditions of winter crops in autumn on the mean oblast number of plants per 1 m^2 for different zones is given in Table 1.

Knowing the reserves of productive moisture in the cultivated soil layer during the 10-day sowing period, using the derived expressions it is possible to predict the condition of winter crops by the time of cessation of the growing season two months in advance. The forecast gives the extent of the area in percent of the sown area with good, satisfactory and poor conditions of sown areas for oblasts, krays and republics.

But at this time winter crops have already been partially sown and it is late for solving the problem of the structure of their sown areas.

Therefore, the need arose for determining the agrometeorological factors in the period preceding sowing on which the moisture supply of winter crops during the 10-day sowing period are dependent.

L. A. Razumova, Ye. S. Ulanova and N. B. Meshchaninova and others established a quite close correlation between the reserves of productive moisture in different soil layers. This enabled us to postulate the existence of a correlation between the reserves of productive moisture in the meter soil layer during the month prior to the sowing of winter crops and in the cultivated layer during the 10-day sowing period. The regression analysis of the results of determination (in a large network of agrometeorological stations during the last 12 years) of the reserves of productive moisture in the 100-m soil layer in the case of nonfallow predecessors in the fields a month prior to the sowing of winter crops and the reserves in the 20-cm soil layer in the 10-day period of sowing of winter crops, which we carried out, indicated the presence of a close correlation between these values. An exception was the years when abundant rains fell before the onset of the latest possible times for the sowing of winter crops.

Our investigations indicated that if a month prior to the sowing of winter crops in the case of nonfallow predecessors in the soil layer 0-100 cm in the southern half of the European USSR there were less than 50 mm of productive moisture, in the cultivated soil layer during the 10-day sowing period with the optimum times of sowing the reserves of productive moisture will be less than 15 mm, which is inadequate for the growth and development of winter crops. In these cases the sowing of winter crops must be done at later times, whereas in the case of absence of an adequate quantity of precipitation 40-50 days prior to cessation of the growing season it is absolutely inadmissible to sow winter crops in the case of nonfallow predecessors. An exception are the southern regions of the Ukraine, Moldavia and the Northern Caucasus, where the growing season for winter crops is a possibility during individual periods even in winter.

The correlation between the reserves of productive moisture (mm) in the 0-20-cm soil layer during the 10-day period of the sowing of winter crops and in the meter soil layer a month before their sowing has a linear character.

For the territory of the Ukraine, Moldavia and the Northern Caucasus region it is expressed by the regression equation

$$y = 0.22x + 0.3,$$

where x are the reserves of productive moisture (mm) in the soil layer 0-100 cm a month before the sowing of winter grain crops; y are the reserves of productive moisture (mm) in the soil layer 0-20 cm during the 10-day period of the sowing of winter crops. The correlation coefficient $r = 0.93 \pm 0.01$; the number of cases is $n = 184$; $E_y = \pm 3.69$ mm.

Thus, using the derived dependences, it is possible to determine the anticipated condition of winter grain crops even prior to their sowing and on this basis determine more precisely the sown areas for the territory of oblasts. During the 10-day period of mass sowing of winter crops the prediction of the condition of the sown areas is refined.

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UDC 551.(558.1+577)(470.23)

CONVECTION UNDER THE CONDITIONS OF A LARGE CITY

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 103-105

[Article by Candidate of Geographical Sciences N. I. Novozhilov, Main Geophysical Observatory, submitted for publication 25 June 1978]

Abstract: It is demonstrated that temperature mesoadvection, determined from the interdiurnal variability of temperature, is observed more frequently in a city than outside a city. It exerts an unfavorable effect on convection and therefore the most active formation of showers, judging from the mean daily quantity of precipitation, is not observed in the city, but outside it.

[Text] During recent decades observations have shown that appreciably more precipitation falls in large cities, sometimes by 10-30%, than outside the city. This is observed due to the more frequent recurrence of relatively light rains in the city. Although in some cities (London, Washington) there have been cases of intensification of local convection, as a result of which heavy rains fall, nevertheless, this process is not typical for large cities. The distribution of precipitation in Leningrad and at Voyeykovo, situated 24 km to the east of the urban meteorological station, was also in conformity with the noted pattern.

During the three summer months in Leningrad there were 43 days with shower precipitation and at Voyeykovo there were 37 such days. The quantity of falling precipitation was 241.5 mm and 219.4 mm respectively, that is, the mean daily quantity of precipitation at Leningrad was 5.6 mm and at Voyeykovo it was 5.9 mm. This means that the intensity of the shower-forming process outside the city was somewhat greater than in the city.

The influence of enormous modern cities is extended to phenomena of a mesoscale nature, and therefore for explaining the peculiarities of precipitation it is desirable to use the mesoscale characteristics of the lower troposphere. But first of all we will briefly examine the results obtained during recent years from study of the structure of air flows over a city without citing the extensive literature well known to specialists.

Increased friction over the city "squeezes" the air currents into the higher layers of the atmosphere, where, accordingly, there is an increase in relative humidity and the streamlines fall closer together. But the city is also a heat focus: in built-up areas in comparison with the suburban sectors the temperature is usually 2-3°C higher. However, this heat focus is not uniform and is conspicuous at altitudes not greater than 500 m. Even in such large cities as Moscow and Tokio the influence of urban heat does not extend beyond the limits of the boundary layer.

The air is propagated over the city from the heat focus in the form of non-uniform tongues, since the focus has a spotty nature.

Over the city these tongues create an alternation of relatively warm and cold layers. As a result, the boundary layer stratification over the city is more stable than over suburban areas. An increased aerosol content in urban air favors activation of radiation heat fluxes, and at the same time, maintenance of temperature contrasts between the air flow layers.

The vertical convergence of the flow arising over the city, although it leads to the formation of a weak mesojet at a height of 100-200 m above the roofs of buildings, nevertheless is unrelated to the horizontal convergence of flow, and therefore here there is an absence of those typical conditions for an intensification of convection under which the latter could undergo transition into a mesoscale process [2]. It is possible that the low urban mesojet impedes the formation of a mesojet under the clouds, having a decisive importance for the development of mesoconvection.

Thus, a city does not favor activation of either Cu convection or mesoconvection. An increased quantity of precipitation and an increased number of days with precipitation in the city must be considered the result of an increased concentration of condensation nuclei.

The activation of convective activity is usually reflected to a considerably greater extent on the leeward outskirts of the city, where in specific cases there is an increase in shower precipitation and thunderstorms. But this does not lead to the formation of suburbs with anomalous phenomena, since with a change in wind velocity and direction there is also a change in the position of the leeward part of the outlying area.

Now we will examine a method for the mesoanalysis of shower-forming activity during the summer period, based on allowance for the day-to-day variability of temperature.

As is well known, at the end of the process of transformation of an air mass the day-to-day temperature variability of this mass is insignificant, about ±1-2°C. In this case the temperature field is uniform within the limits of mesoscale distances -- several hundreds of kilometers. In our method the mesoscale temperature field was assumed to be uniform in those cases when the day-to-day variability did not exceed 2°C over a period of at least two days. With an impairment of this condition the mesoscale temperature field was considered nonuniform. We used the values of the day-to-day variability of temperature at the ground level at 0700 hours at Leningrad and at Voyeykovo, and also at the 700-mb level using data from the release of a radiosonde at Voyeykovo at 0300 hours. Mesoadvection was determined at the beginning of the day during which precipitation was observed. The nature of the precipitation under conditions of different temperature fields at the ground surface is given in Table 1.

Table 1

Nature of Shower Precipitation Under Conditions of Different Temperature Fields in June-August 1966

Характеристика 1	Однородное температурное поле 2		Неоднородное температурное поле 3	
	Ленинград 4	Воейково 5	Ленинград 4	Воейково 5
6 Число дней с данной структурой температурного поля (процент от общего числа дней)	43 (47)	52 (57)	49 (53)	40 (43)
7 Число дней с ливневыми осадками в условиях данного температурного поля (процент от общего числа дней с ливневыми осадками)	27 (63)	20 (54)	16 (37)	17 (46)
8 Количество ливневых осадков, мм (процент от общего количества ливневых осадков)	173,5 (72)	172,7 (80)	68,0 (28)	46,7 (20)
9 Среднесуточное количество осадков, мм	6,4	7,0	4,2	4,2

KEY:

1. Characteristics
2. Uniform temperature field
3. Nonuniform temperature field
4. Leningrad
5. Voyeykovo
6. Number of days with particular structure of temperature field (percentage of total number of days)
7. Number of days with shower precipitation under conditions of a particular temperature field (percentage of total number of days with shower precipitation)
8. Quantity of shower precipitation, mm (percentage of total quantity of shower precipitation)
9. Mean daily quantity of precipitation, mm

At Leningrad, as indicated in Table 1, there were approximately 20% fewer days with a uniform temperature field than at Voyeykovo, whereas the number of days at Leningrad with a nonuniform field was greater than at Voyeykovo.

In this evaluation what constitutes uniform and nonuniform temperature fields?

We have already seen that over a city a disordered mesoadvection of heat is frequently noted. In this process vertical currents can be manifested only in warm and cold layers of relatively small thickness. Therefore, favorable conditions for a considerable convective rising of air in a city are observed more rarely than outside the city. Since urban heat is realized to a considerable degree by means of the mesoadvection of temperature, we assume that a uniform temperature field is observed in the absence of mesoadvection, whereas nonuniform fields, on the other hand, are observed in its presence. This criterion makes it possible to explain some peculiarities of the urban precipitation regime.

In actuality, in the city, as indicated in Table 1, the number of days with a nonuniform field, that is, with mesoadvection, constituted somewhat more than half of all the days, whereas the number of days with shower precipitation under these conditions was only a little more than one-third of all the days with showers. With respect to the quantity of precipitation, during these days in the city there was only about one-quarter of the total quantity of shower precipitation during the summer. On days with a uniform temperature field, when convection was impaired less by mesoadvection and therefore mesoadvection occurred more frequently, in the city it was relatively more common to observe showers, but the falling quantity of precipitation constituted about three-quarters of its total quantity. The low shower-forming activity in the city under the conditions of a nonuniform field and the more considerable activity under the conditions of a uniform field is also confirmed by the mean daily precipitation quantities.

Table 1 shows, in addition, that a nonuniform temperature field is rather frequently observed also outside the city and its influence on precipitation is as significant as in the city.

Now we will investigate the activity of the process on those days when a uniform temperature field was observed not only at the ground level, but also at an altitude of 700 mb, where the nature of the field was assumed to be identical for both points and where the field most frequently was uniform. The results are given in Table 2.

Table 2 shows that although the number of days with shower precipitation under the conditions of a uniform temperature field at two levels in the lower troposphere is only half the total number of days with shower precipitation at a particular point, the fraction of falling precipitation on these days is rather considerable, as is also confirmed by the more significant mean daily precipitation values, particularly outside the city. These data make it possible, thus, to detect the conditions for the most active shower-forming process. However, this process under uniformity conditions at the upper level is not more active in the city, but outside the city.

Table 2

Characteristics of Shower Precipitation in Presence of Uniform Temperature Field Simultaneously at Earth and at 700-mb Level in June-August 1976

Characteristics	Leningrad	Voyeykovo
Number of days with shower precipitation	22	19
(% of total number of days with showers)	(51)	(51)
Quantity of shower precipitation, mm	163.6	165.8
(% of total quantity of shower precipitation)	(68)	(75)
Mean daily quantity of precipitation, mm	7.4	8.7
(% of mean daily values for days with nonuniform temperature field)	(176)	(207)

The cited data evidently reveal quite convincingly the retarding role of temperature mesoadvection on convection under the conditions prevailing in a large city. It can be foreseen that in the further evolution of the climate of a city the most characteristic peculiarities of its weather will more and more often be low cloud cover and fine-droplet rain.

The intensity of the mentioned "leeward" phenomena will increase, as is already being noted in some cities of the United States. The weather contrasts between a city and its outskirts are inevitably intensifying, that is, the processes here are assuming a clearer mesostructure. This will be the contribution of the city to that general process of change in atmospheric circulation which, according to the data in [1], can transpire under the influence of anthropogenic contamination of the atmosphere.

We also note, as indicated in Table 2, that the quantity of precipitation, depending on the presence or absence of temperature mesoadvection, differs in the city by a factor of more than 1 1/2, and outside the city -- by a factor of more than 2. Allowance for mesoadvection could substantially improve the prediction of convective phenomena.

In conclusion the author expresses appreciation to Professor A. Kh. Khrgian for editing of the article, making it possible to focus the reader's attention on the most important problems.

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UDC 551.465.71

PARAMETERIZATION OF ATMOSPHERIC EFFECTS IN PROBLEMS OF NUMERICAL MODELING OF SEA DYNAMICS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 105-108

[Article by Ye. A. Tsvetova, Computation Center Siberian Department USSR Academy of Sciences, submitted for publication 28 March 1978]

Abstract: The article describes a method for modeling the wind regime for stipulating the boundary conditions at the surface of a water body, based on the method of statistical modeling and using climatic information on the pressure or wind fields and their regime characteristics. The method is discussed in the example of Lake Baykal.

[Text] The formation of currents occurs during the continuous interaction between a water mass and the atmosphere. In this connection the problem arises of selection of parameterization of atmospheric effects properly reflecting the principal characteristics of the hydrometeorological regime over a water body.

In problems of the modeling of water dynamics as the boundary condition at the surface it is customary to stipulate the wind shearing stress, which is computed using the known formulas through atmospheric pressure or wind velocity. Depending on the purposes of the computations, the boundary conditions are stipulated either as constant or variable with time.

The method described below for modeling the wind regime is used in a model of the dynamics of Lake Baykal [5]. A classification of the wind and pressure fields prepared by N. V. Savinova [3] was adopted for the parameterization of atmospheric effects. It was possible to define six principal types of wind fields, divided into subtypes and differing by having seven wind velocity gradations. The regime characteristics, such as the frequency of recurrence of standard fields, the succession of types, continuous duration of their effect, etc. [1] were also computed.

In the proposed method the standard situations are examined as a basis for approximate representation of real meteorological fields, and the order of alternation of meteorological situations is determined by the Monte Carlo method in accordance with the tables of regime characteristics. In the modeling we used archives of standard situations, examined as a totality of random values. Each element in the archives is represented by three two-dimensional fields describing atmospheric pressure at the lake surface, the direction and modulus of the wind velocity vector and a three-digit code number in which the first digit defines the type of wind, the second -- the subtype, and the third -- the velocity gradation. The identification and recognition of archives elements is accomplished on the basis of the code number. At the present time the archives for Baykal winds includes about 70 standard situations. The characteristics necessary for modeling the changes in the wind regime with time are contained in tables of the frequency of recurrence, succession and mean and maximum continuous duration of the effect of wind types by months. The method for preparing these tables and their numerical data are given in [3].

Using the Monte Carlo method, we successively carry out the two principal stages: determination of the number of the type of wind and determination of the time of effect of the selected type. For determining the number of the type we will form additionally a one-dimensional mass of numbers of types and subtypes represented by the first and second digits of the code number. To each element in this mass we will assign numbers from 1 to N, where N is the total number of types and subtypes, and in contrast to the code number, we will call it the sequence number of the type. We will represent the table of frequency of recurrence by a two-dimensional data mass in which the number of the row is determined by the sequence number of the month and the number of the column is determined by the sequence number of the type. There is a mutually unambiguous relationship between the table columns and the mass of sequence numbers of types. The table of the frequency of recurrence is prepared in such a way that the sum of elements in each row is equal to unity. This makes it possible to regard the elements in the rows as the probabilities of appearance of the corresponding wind situations in each month.

We will denote the row elements by p_i, where $i = 1,\ldots, N$ is the sequence number of a standard situation. Examining p_i as the probabilities of appearance of a situation with the number i in a particular month, we will assume that the sequence number of the wind situation is a discrete random value ξ, distributed with the probability $\{ p_i(i = 1,\ldots,N).\}$

Thus, determination of the situation number was reduced to finding the discrete random value α, assuming the value i with the probability p_i. For solving this problem we will use the algorithm described in [2]. The essence of this algorithm is as follows.

Assume that there is a random value α, uniformly distributed in the interval [0, 1], as well as a discrete random value ξ, assuming the values n_i with the probability p_i. Then the inequalities

$$\sum_{k=1}^{j-1} p_k < \alpha \leq \sum_{k=1}^{j} p_k \quad \text{or} \quad 0 < \alpha - \sum_{k=1}^{j-1} p_k < p_j \tag{1}$$

determine the number j for which $\xi = n_j$. In the case which we considered $n_j = j$; therefore $\xi = j$. The inequalities cited above always make sense since

$$\sum_{k=1}^{j} p_k < 1 \quad \text{when} \quad j < N, \quad \sum_{k=1}^{N} p_k = 1. \tag{2}$$

Thus, for determining the number of the wind type it is necessary, using a procedure generating random numbers uniformly distributed in the segment [0,1], to obtain the number α, then, using the inequalities (1), to compute the sequence number of the type, from which we then determine the code of the type and the archive element corresponding to it. After the wind situation has been selected, it is necessary to determine the duration of its effect. A duration table, for each standard situation, includes two characteristics: mean duration a and maximum duration b. We will assume that the duration of the effect of the meteorological situation is also a random value and we will consider the procedure for its modeling. Using the two parameters a and b, we will stipulate the distribution law in the form of a piecewise-linear function

$$y = \begin{cases} \frac{2x}{ab}, & \text{when} \quad 0 < x < a \\ \frac{2(x-b)}{b(a-b)}, & \text{when} \quad a < x < b. \end{cases} \tag{3}$$

We have the following relationship:

$$\int_0^x y\,dx = \begin{cases} \frac{x^2}{ab}, & \text{when} \quad 0 < x < a \\ 1 - \frac{x-b}{b(b-a)}, & \text{when} \quad a < x < b. \end{cases} \tag{4}$$

Using the relationship expressed by the N. V. Smirnov transformation [2], between the value α uniformly distributed in the segment [0, 1] and the random value with the stipulated distribution law

$$\int_0^x y\,dx = \alpha, \tag{5}$$

for x we obtain the expression

$$x = \begin{cases} \sqrt{\alpha ab}, & \text{when} \quad \alpha \leq \frac{a}{b} \\ b - \sqrt{(1-\alpha)(b-a)b}, & \text{when} \quad \alpha > \frac{a}{b}. \end{cases} \tag{6}$$

The x value computed in this way is the continuous duration of effect of the wind type in hours.

Further modeling is carried out using succession tables, whose elements are regarded as the conditional probabilities of transition of one type into another. Each of the rows in the table has a normalization similar to (2) and can be regarded as a table of the probabilities of occurrence of a new wind situation. Therefore, the algorithm for computing the number of the new situation uses the procedure described above.

In accordance with the succession table there can be a repetition of the number of the already effective type. In this case in computing the continuous duration we take into account the entire time interval during which there is no change in the number of the type. The effect of the wind situation ceases upon elapsing of the interval of the maximum continuous duration and the next number of the situation is not computed from the succession table, but from the table of frequency of recurrence. That is, consultation of the table of frequency of recurrence occurs either at the beginning of the computations or in connection with exceeding of the interval of maximum duration of the effect.

The "calendar" of types prepared in this way serves as the input information in models of dynamics. In accordance with this, at definite moments in time we select from the archives different meteorological situations. With the multiple use of this procedure in the numerical modeling we use the statistical structure of the fields entered in the tables of regime characteristics.

Information on the wind and pressure fields and their regime characteristics in the form of atlases and tables is available for many internal water bodies and oceanic regions (for example, see [4]). Therefore, we feel that the described parameterization method will be useful in many modeling problems and especially in those where reference is to the prediction of the future state of the water body in connection with man's economic activity. The use of the methods of statistical modeling of random values with distribution laws obtained as a result of processing of actual information will make it possible to take into account the principal characteristics of the climatic regime and the most characteristic meteorological situations over the investigated object.

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UDC 551.482.212

REASONS FOR THE FORMATION OF RIDGED RELIEF ON THE SURFACE OF FLOODPLAINS OF MEANDERING RIVERS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 108-109

[Article by Yu. I. Kamenskov, State Hydrological Institute, submitted for publication 2 March 1978]

Abstract: The author clarifies the mechanism of formation of one of the principal morphological peculiarities of the floodplains of meandering rivers -- ridges or channel banks forming along the convex bank of each meander.

[Text] A distinguishing characteristic of the floodplains of meandering rivers, repeatedly mentioned in the literature, is the formation of ridged surface relief. This peculiarity has a single explanation, whose earliest formulation can be found in [5]: "The displacement of the channel seemingly occurs in jumps from high water to high water; its magnitude is dependent on the intensity of the overflow, varying from year to year, and on the dynamics of the flow specifically at the particular moment in time, not being the same due to the continuously transpiring channel deformation. These same variables govern the quantity of entrained alluvium carried from the shoals along the channel. As a result, first, the zone of their accumulation shifts in a jump, and associated with this is the formation of a series of parallel isolated ridges which on the floodplain surface mark the successive stages in channel displacement, and second, this governs the nonuniform height of the ridges."

Such an explanation, on the one hand, contradicts the fact that the channel banks (ridges) are formed in the stage of dropoff of high water [4] or at the time of low high waters [1], that is, when there is an appreciable curvature of the water flow [4], and on the other hand, it is understood that the channel banks are formed very rapidly -- in one, or in an extreme case, in two years.

By measuring the distances between the ridges and the rate of horizontal channel displacement it is easy to confirm that the period of formation of one ridge in many cases is 10-20 years. In this case the variations in the height of high water from year to year and the jumplike nature of the horizontal channel deformations cannot explain the separation of the ridges by troughs. In addition, in clarifying the reasons for formation of the ridges it is necessary to take into account the following circumstances: 1) on the surface of a sandy beach there is only one forming ridge or its base in the form of a raised strip -- the longitudinal crest of the sandy beach; 2) the beach is clearly bounded in the direction of the floodplain by the first ridge from the channel, which, in essence, is the brow of the convex bank of the flow in the meander during the high-water period and virtually does not differ in height and structure from the more ancient ridges; 3) the broadest sectors of the main channel at the time of high water are situated over the banks.

From everything which has been stated above, we obtain the following picture of the process of ridge formation. The erosion of the concave bank causes an increase in the shoal along the banks, the formation of an excessive channel width and differences in the configurations of the convex and concave banks. Therefore, during the period of high water along the convex bank of the meander or along the river slope of the first ridge from the channel there is formation of a zone of cutoff of streamline flow or a relatively stagnant zone. Within its limits the transport and accumulation of bottom sediments will be expressed to a lesser degree than at the contact between this zone and the main water flow in the channel. Accordingly, the zone of greatest accumulation is situated at some distance from the brow of the alluvial bank or the river slope of the first near-channel segment from the channel. This zone (ridge base) can be formed not in the course of a single year, but in the course of a number of high waters and low-water periods, increasing gradually downstream and increasing its height. Taking into account the annual increment in the horizontal channel displacement, the downstream part of the longitudinal crest of the sandy beach, augmenting itself in a downstream direction, can more and more deviate from the brow of the alluvial bank (or the river slope of the first ridge from the channel) and can also approach to it. The possibility of the first or second case is determined, on the one hand, by the relationship of the horizontal deformations of the meander in its middle and downstream sectors, and on the other hand, by the rate of ridge formation. In the first case a so-called backwater is formed in the downstream part of the beach. As a result, the ridge will grow in a downstream direction (against the background of horizontal deformations of the meander); its upstream sector will have the greatest width and the gentlest slopes.

The fact that small ridges, transporting alluvium from the underwater part of the shoal onto the beach, are situated near the low-water line, whereas in the above-water part of the entire shoal there is a predominance of longitudinal ("running" with the current) and larger ridges, suggests that the beach to a high degree consists of particles transported from the above-lying meander. The upstream part of the ridge, developing on the surface of the sandy beach, is the first sector on the path of the alluvium-saturated currents of the flow passing along the erodable bank of the above-lying meander. Therefore, it will increase in height more rapidly than the downstream part and earlier will move out from the zone of frequent and prolonged inundations.

After the height of the upstream part of the forming ridge approaches the maximum water level with a 50% probability, the channel flow in a large part of the periods of high water will bend around the ridge. But during the time of growth of the ridge in height and length, as a result of horizontal deformations of the meander there will again be a noncorrespondence in the outlines of the brows of the concave and convex banks of the channel in the meander, that is, the channel becomes excessively broad. Therefore, in front of the formed ridge there is formation of a zone of cutoff of streamline flow and the formation of a new ridge begins and this will also be situated at some distance from the preceding one.

Thus, each ridge passes through the principal stages in its development into the phase of its positioning along the channel, that is, is situated on the surface of the sandy beach.

The first ridge from the channel has virtually the same longitudinal slope as the other, older ridges. Accordingly, the slope of the surface of the segment and a decrease in the coarseness of the alluvium in a downstream direction are a result of the similar peculiarities of the sandy beach surface, the upper (upstream) part of which is the first segment on the path of the currents moving along the concave bank of the above-lying meander and saturated with the products of its erosion. The water currents, straightening the segment at the time of high water, in actuality lose the greater part of their energy and alluvium over its upstream part [1-3], but this process does not create, but only somewhat increases the already created longitudinal slope of the segment surface and also leads to some softening of the ridged relief, since between the ridges the layer of deposits is greater in this case than at the tops of the ridges.

Most frequently sufficiently large meandering rivers form floodplains with a ridged surface relief. But there are floodplains of meandering rivers with a level surface of the segments along the channel. Such a case can evidently be attributed to a combination of small rates of horizontal deformations of the channel and great river turbidity, which causes a considerable accumulation of suspended alluvium within the limits of the narrow zone of cutoff of streamline flow.

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UDC 551.593.576

MULTIPLE SCATTERING IN TURBID MEDIA CONSISTING OF SPHERICAL PARTICLES

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 110-113

[Article by R. I. Bogdanov, Candidate of Physical and Mathematical Sciences A. Ye. Tyabotov, Doctor of Physical and Mathematical Sciences V. I. Shlyakhov and A. B. Shupyatskiy, Central Aerological Observatory, submitted for publication 14 April 1978]

Abstract: The article describes a method for determining the limits of onset of multiple scattering and its values in the case of laser pulsed sounding of turbid media consisting of spherical particles. As a result of backscattering of plane-polarized radiation in such media the degree of polarization of the registered signal differs from the polarization of the irradiated wave. Such a change in polarization occurs as a result of multiple scattering, whose onset and value are dependent on the optical density of the scattering medium. The authors give the results of experimental measurements of the dependence of the degree of polarization of the scattered radiation and the distance from which multiple scattering appears on the coefficient of attenuation of radiation in a cloud.

[Text] A determination of the limit of onset of multiple scattering and its value is one of the important problems in the optics of turbulent media. Until now, in solving a number of practical problems in this field, such as in determining visibility in clouds and fogs or when ascertaining their microphysical characteristics, etc., these parameters were determined within the limits of single scattering, taking into account a correction for multiple scattering which was found by means of complex solutions of integro-differential transfer equations or by the Monte Carlo method. A bibliography of studies which discuss the methods for such solutions is given in [4]. The difficulties involved in determining the optical thickness of the medium, from which multiple scattering begins, and also its values, with respect to experimentation, are yet to be overcome. However, the investigations which have been made of changes in the degree of polarization of scattered radiation of a lidar in dependence on the optical density of the medium have indicated the possibility of an instrumental determination of the limits of onset of multiple scattering and its values [1, 3, 6].

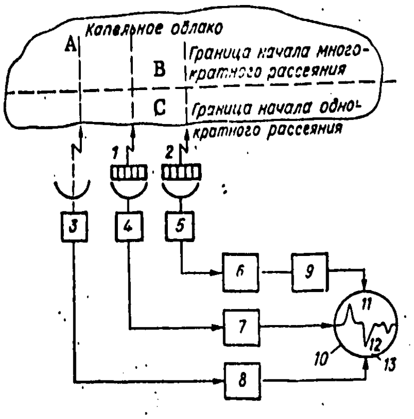
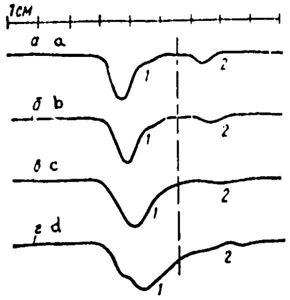


Fig. 1. Block diagram of lidar.

KEY:

A. Droplet cloud
B. Limit of onset of multiple scattering
C. Limit of onset of single scattering



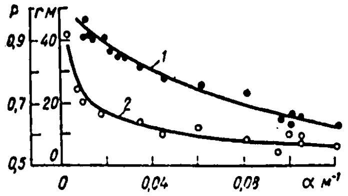


Fig. 2. Oscillograms of signals reflected from droplet clouds. Scanning of 1 cm in 0.1 sec.

Fig. 3. Dependence of degree of polarization P (1) and distance (2) on α.

In this study we present the results of experimental investigations of these parameters in droplet clouds and also the results of investigation of the possibility of using the polarization method for determining the coefficient of attenuation in turbid media consisting of spherical particles. For this purpose we used a method based on the determination of the degree of polarization and the time shift of two mutually orthogonal components of lidar backscattered radiation [1]. The realization of this method was accomplished using an instrument whose block diagram is shown as Fig. 1. The light source used is a ruby lidar 3, emitting plane polarized pulsed signals with a power $P_1 = 2$ MW. The duration of the emitted pulse at the level 0.5 of the maximum amplitude is $= 30$ nsec; the divergence of the emitted beam is $\varphi_1 = 10$ min; the angle of the field of view of the detectors is $\varphi_2 = 1°$.

As is well known, with the passage of polarized light through a turbid medium, consisting of a great number of spherical particles, such as through droplet clouds or fogs, the reflected signal will be partially depolarized [5]. In such media depolarization arises as a result of multiple scattering. The scattered signal is received in a backscattered direction using two detectors 4 and 5, each of which consists of a telescope, photomultiplier and polaroids 1 and 2, situated at the input of these detectors. The polaroid at the input to the detector 4 transmits light whose polarization plane coincides with the polarization plane of the emitted wave, whereas the polaroid installed at the input of the detector 5 transmits light with a polarization perpendicular to the polarization plane of the emitted wave. With such a receiving system the first detector will receive all the radiation scattered in a back direction, as well as multiply scattered radiation for which the plane of oscillation of the electric vector coincides with the plane of polaroid transmission 1. The second detector will receive the orthogonal component of scattered radiation, that is, the signal caused by multiple scattering, the plane of oscillation of whose electric vector coincides with the transmission plane of the polaroid 2.

Signals are fed from the photomultiplier to the indicator 10 through the amplifiers 6 and 7. On the record of this indicator the leading edge of the depolarized signal 13 will be displaced relative to the leading edge of the main signal by the distance from which multiple scattering begins. The beginning of the leading edge of the appearing depolarized signal shows the limit from which the multiple scattering begins. The doubled integral value of the entire depolarized signal, taking into account the angle of beam divergence and the angle of the field of view of the detector, shows the multiple scattering value. Here it is assumed that the contribution of multiple scattering to the signals received by the two detectors will be identical. Such an assumption can be made, allowing a mean arithmetical error of not more than 3%, since, as shown by computations, made by the method described in [5], the components of intensity of doubly scattered lidar radiation on the average differ from one another by such a value, although in individual cases, in dependence on the microstructure of the cloud medium, the difference in these components can attain up to 10%. It was established from an analysis of the results of these computations that the main contribution to multiple scattering is introduced for the most part by the doubly scattered lidar radiation, since the intensity of multiple reflections above the second accordingly then will be about 2-3 orders of magnitude less. Hence, subtracting from the signal received by the first detector the signal received by the second detector, we obtain the value of the singly scattered signal.

It should be pointed out that the angles of the field of view of both detectors in this case should be identical.

Thus, on the basis of the time shift of the signals received by two detectors discriminating the orthogonal components it is possible to determine the limit of multiple scattering and its value in turbid media consisting of spherical particles.

Figure 2, as an example, shows oscillograms of the signals scattered in a back direction by droplet clouds with different density. The oscillogram (a) shows the signal 1 received by the detector 4 and the signal 2 received by the detector 5. These signals were received during the scattering of laser radiation by clouds with an attenuation coefficient $\alpha = 0.106$ m^{-1}. This dense cloud is caused by the high depolarization of the signal, as a result of which the degree of polarization $P = 0.65$. On the oscillograms (b), (c) and (d) we see signals received from clouds with the corresponding attenuation coefficients $\alpha = 0.081$, 0.036 and 0.012 m^{-1} and $P = 0.73$, 0.82 and 0.91.

In order that during registry with a single-channel oscillograph the received signals not be superposed on one another, the depolarized signal is shifted in time by means of the delay unit 9 by the time $t = 0.25$ μsec relative to the main signal 12. In Fig. 2 these signals are denoted by the figures 2 and 1 respectively. With reflection from a plane surface the depolarized signal 2 must begin $t = 0.25\mu$sec after the main signal 1, that is, from the dashed line indicated in Fig. 2. However, with scattering by clouds of different density the signal 2 appears from a different depth r and its value, and accordingly, its polarization, are essentially dependent on cloud density.

On the oscillograms in Fig. 2 the r value is determined from the time shift $\Delta\tau$. The conversion from the time characteristics to the range characteristic is determined from the expression

$$r = \frac{c\Delta\tau}{2}, \qquad (1)$$

where $\Delta\tau$ is the time interval between the arrival of two mutually orthogonal components of the backscattered lidar radiation at the detectors and c is the speed of light.

Figure 3, in the form of the curves 1 and 2 respectively, shows the dependence of the degree of polarization P and the depth r from which multiple scattering begins on the attenuation coefficient α. The numerical values of these parameters are also presented in Table 1. In this case the P value was determined on the basis of the maximum values of the amplitudes of the main and orthogonal components of the received signal. These results were obtained using a lidar installed on an IL-18 aircraft of the Central Aerological Observatory. At the same time, by the lidar sounding of clouds we carried out measurements of the attenuation coefficient α by the method in [2].

Table 1

Value of the Attenuation Coefficients α, Degree of Polarization P and the Distance r Between the Orthogonal Components of a Reflected Signal of Lidar Apparatus

α м$^{-1}$	P	r м	α м$^{-1}$	P	r м
0,062	0,76	10	0,018	0,89	19
0,048	0,78	11	0,032	0,81	12
0,081	0,73	9	0,024	0,84	14
0,103	0,62	5	0,035	0,76	10
0,022	0,86	16	0,073	0,71	8
0,016	0,90	19	0,056	0,78	11
0,025	0,84	14	0,063	0,74	10
0,063	0,75	10	0,049	0,79	8
0,126	0,62	5	0,106	0,65	6
0,093	0,64	3	0,036	0,82	12
0,009	0,95	25	0,012	0,91	21

Joint measurements by means of a lidar and apparatus for measuring cloud transparency [2] were carried out in such a way that first there was laser sounding of the cloud during a pass of the aircraft at the distance R = 400-500 m from it and then the aircraft entered the cloud and at a depth of 20-40 m from the cloud edge it flew in the opposite direction along this same route. In this case there was continuous registry of the attenuation coefficient in the cloud at a distance equal to the length of the wing, since the reflecting prism was mounted on its end. The tie-in of the results of the measurements to the results obtained using the transparency measuring apparatus was accomplished taking into account the length of the aircraft flight path and its velocity over the cloud and in the cloud. The length of the path was selected at not more than 10 km. During the time of the pass along such a path no significant changes occurred in the cloud structure. The passage of the aircraft in the cloud at the mentioned depths was desirable because the maximum of the reflected signals during laser sounding from an aircraft at distances R = 400-500 m from the cloud corresponded to these depths.

It follows from an analysis of the oscillograms cited in Fig. 2, and also the results of measurements of α, P and r, presented in Table 1 and Fig. 3, that during the scattering of laser radiation by denser clouds the depolarized signal appears from a lesser depth. Its amplitude is sufficiently great, but the degree of polarization P is less than during scattering in less dense clouds. For example, with $\alpha = 0.103$ m^{-1} P = 0.62, r = 5 m, with $\alpha = 0.106$ m^{-1} P = 0.65, r = 6 m. With lesser α values the P and r values are larger. If $\alpha = 0.016$ m^{-1}, then P = 0.9, r = 19 m, with $\alpha = 0.012$ m^{-1} P = 0.91, r = 21 m.

It can be seen that the data collected on the correlation between P and r and α agree qualitatively with the results of computations carried out in [3]. A close coincidence is not observed due to the fact that the computations in [3] were made for a lidar with other instrumental parameters.

It should be mentioned that the P and r values are significantly dependent on the geometrical parameters of the lidar. For example, with a decrease in the angle of the field of detector view the strength of the signal shaped as a result of multiple scattering will also decrease and the value of the degree of polarization P will also increase. The distance r from which multiple scattering begins will in this case also increase.

With an increase in the angle of the detector field of view the strength of the signal shaped as a result of multiple scattering will increase and the P and r values will decrease. In a general case the geometrical parameters of the lidar will enter into the formula for polarization P [5] of a backscattered signal in the following form:

$$P = \frac{P_{\text{дв}} I_{\text{дв}} k + P_{\text{одн}} I_{\text{одн}}}{I_{\text{дв}} k + I_{\text{одн}}}, \tag{2}$$

where

$$I_{\text{дв}} = I_{\text{дв}_1} + I_{\text{дв}_2}; \quad P_{\text{дв}} = \frac{I_{\text{дв}_1} - I_{\text{дв}_2}}{I_{\text{дв}_1} + I_{\text{дв}_2}};$$

$$k = \frac{L_{\text{дв}} \operatorname{tg}^2 \frac{\varphi_2}{2} \left[(R+r)^2 + (R+r)(R+r+L_{\text{дв}}) + (R+r+L_{\text{дв}})^2\right]}{L_{\text{одн}} \operatorname{tg}^2 \frac{\varphi_1}{2} \left[R^2 + R(R+L_{\text{одн}}) + (R+L_{\text{одн}})^2\right]}.$$

[ДВ = d(oubly), ОДН = s(ingly)] Here P_d is the degree of polarization of doubly scattered radiation, I_{d1} and I_{d2} are the intensities of doubly scattered radiation registered for the longitudinal and transverse components of the electric vector respectively, φ_1 is the angle of divergence of the transmitter ray, φ_2 is the angle of the detector field of view, r is the depth of the medium from which the double scattering begins, R is the distance to the cloud, L_s and L_d are the thicknesses of the layers with single and double scattering respectively.

With $I_{d1} = I_{d2}$ formula (2) assumes the simpler form:

$$P = \frac{P_{\text{одн}} I_{\text{одн}}}{I_{\text{дв}} k + I_{\text{одн}}}. \tag{3}$$

Here the values I_s, I_d and k are determined experimentally, $P_s = 1$, since the medium is irradiated by a plane polarized ray. Thus, from an analysis of the results of our measurements it follows that a method based on the measurement of the degree of polarization of scattered lidar radiation makes it possible to determine the limit of the onset of multiple scattering and its value in turbid media consisting of spherical particles and also the value of the attenuation coefficient in these media.

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UDC 551.509.58:639.206

EXPERIENCE IN SUPPLYING THE FISHING FLEET WITH DATA ON THE REGIME OF DANGEROUS AND PARTICULARLY DANGEROUS HYDROMETEOROLOGICAL PHENOMENA

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 114-117

[Article by Candidate of Geographical Sciences O. G. Kornyushin and A. P. Tyurin, All-Union Scientific Research Institute of Hydrometeorological Information - World Data Center and the Main State Fishing Fleet Inspectorate USSR Fisheries Ministry, submitted for publication 10 March 1978]

Abstract: The article describes experience in investigating the regime of dangerous and especially dangerous hydrometeorological phenomena affecting navigation and fishing in the world ocean: storm winds and waves, restrictions on visibility, icing of ships, tropical cyclones, ice and icebergs. The author describes the method for preparing specialized atlases of dangerous hydrometeorological phenomena. The content of these atlases is briefly discussed. The prospects of development of work in this direction are outlined.

[Text] The system for routine hydrometeorological support for ships in the fishing fleet and for fish farms has now been organized quite well. Fishing expeditions as a rule receive all the routine hydrometeorological information necessary for ensuring the safety of navigation and increasing the efficiency of fishing from the operational agencies of the USSR Hydrometeorological Service: weather bureaus, hydrometeorological bureaus and synoptic groups situated on ships of the fishing industry directly in fishing regions. These operational agencies prepare short-range weather forecasts, storm warnings, warnings on the threat of icing, ice information, predictions of sea waves and other routine summaries for ships. All this information is broadcast for ships by on-shore radio centers or the radio stations on ships carrying synoptic groups. In individual cases the ships of the fishing industry fleet receive weather bulletins for ships transmitted by the radio centers of WMO participating countries.

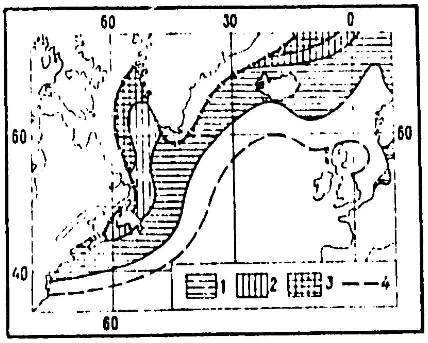

Fig. 1. Zones of icing of ships in January. 1) slow icing, 2) rapid icing, 3) very rapid icing, 4) limit of possible insignificant icing during particularly severe winters.

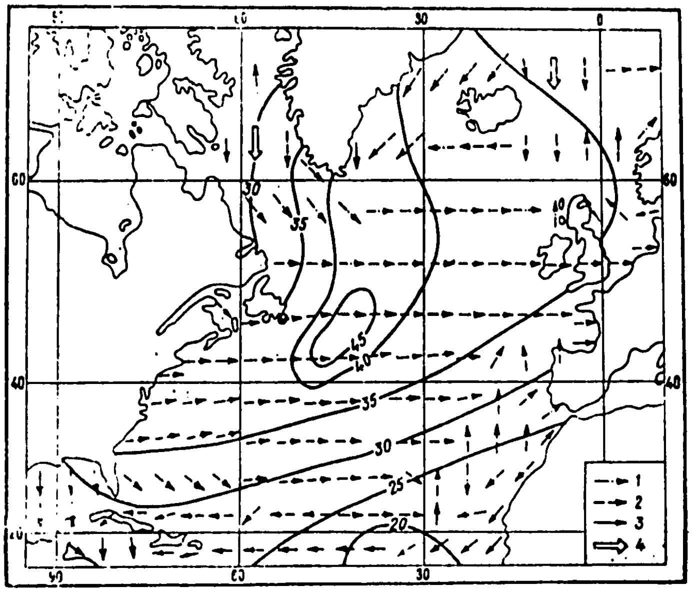

Fig. 2. Characteristics of distribution of strong winds in January. The isolines represent the maximum observed wind velocities, m/sec; the arrows represent the prevailing direction and frequency of recurrence of winds with velocities of 17 m/sec or more. 1) frequency of recurrence 0-20%, 2) frequency of recurrence 21-40%, 3) frequency of recurrence 41-60%, 4) frequency of recurrence 61-80%.

During their passage through the oceans from port to the fishing areas and back the ships of the fishing fleet and fish farms make extensive use of the recommendations of the operational agencies of the USSR Hydrometeorological Service on the choice of the optimum navigation routes in dependence on the current and anticipated weather conditions and the hydrological regime along the navigation routes. During 1977 such recommendations were used by 874 ships of the fishing industry. The time gain from this type of servicing as an average per ship was 9 hours for the Pacific Ocean and 6 hours for the Atlantic Ocean.

In addition to routine hydrometeorological data, the ships of the fishing industry and the fishing organizations were interested in obtaining regime hydrometeorological data for the navigation and fishing regions. This information is necessary for planning the periods of fishing, the times for beginning and ending work, distribution of the fleet, planning fishing operations for different types of ships and ensuring the safety of navigation. The most important information for these purposes is data on the frequency of recurrence and the intensity of dangerous and particularly dangerous hydrometeorological phenomena arising in the fishing regions of the world ocean, including storms, hurricanes, heavy waves, occurrence of ice, icing of ships, reduced visibility, etc. Studies on creating aids characterizing hydrometeorological conditions which are dangerous and especially dangerous for navigation and fishing have been carried out for a number of years at the All-Union Scientific Research Institute of Hydrometeorological Information in collaboration with the Main State Inspectorate of Navigation Safety and Port Supervision of the Fishing Industry Fleet of the USSR Fisheries Ministry.

One of the most dangerous phenomena for the fishing fleet is the icing of ships. The USSR Fisheries Ministry, with participation of specialists of the USSR Hydrometeorological Service, has carried out expeditionary investigations of the hydrometeorological conditions for the icing of fishing vessels and the conditions for ice deposition on ships during the period of the most real development of this phenomenon. Field experiments made it possible to develop a method for predicting icing and made it possible for the All-Union Scientific Research Institute of Hydrometeorological Information-World Data Center and the Main State Fishing Fleet Inspectorate to compile and publish in 1968-1972 atlases of the icing of ships for the principal fishing regions of the northern hemisphere. These atlases are regarded as obligatory aids for fishing ships and are used by them.

The basis of the icing atlases is monthly maps which show zones of slow, rapid and very rapid icing (Fig. 1). These criteria were selected on the basis of investigations of conditions for the icing of ships which were carried out in the Far Eastern, Northern and Western basins. As the "standard" vessel in the development of these criteria we used the most massive type of fishing vessel -- the SRT intermediate fishing trawler with a length of 39 m, a displacement of 450-462 tons, with a crew of 24-26 men.

As the principal indices for determining the criteria of the rate of ship icing we used: 1) the time required for the ship to reach critical instability if the crew does not take measures for contending with icing; 2) the capability of the crew to ensure safety of the vessel when there are manual means available for contending with icing.

In the case of slow icing the rate of ice deposition on the ship must not exceed 1.5 ton/hour. In this case the ship attains critical instability after more than 24 hours. With such an intensity of icing the ship's crew can independently contend with the chipping away of the ice and ensure the ship's safety.

In the case of rapid icing the rate of ice deposition on the ship is 1.5-4.0 ton/hour. Critical instability of the ship is attained after 12-24 hours. The ship's crew can contend with the chipping away of the ice on their own provided there is continuous work by the entire crew other than the captain, the on-duty engineer and the radioman.

Very rapid icing is characterized by a rate of ice deposition on the ship of more than 4.0 ton/hour. Critical instability of the ship begins in less than 12 hours if measures are not taken for contending with the icing. The crew through its own efforts can lessen the icing and prolong the time of onset of critical instability, but measures must be taken to remove the ship from the danger zone and in case of necessity call larger vessels or a rescue tug to its assistance.

The icing of vessels arising in the zones indicated on the maps occurs under the following hydrometeorological conditions.

Slow icing:

a) air temperature from -1 to -3°C, any wind velocity, presence of spraying of vessel or at least one of the phenomena -- precipitation, fog, sea steaming;
b) air temperature -4°C or below, wind velocity up to 9 m/sec, presence of ship spraying or at least one of the phenomena -- precipitation, fog, sea steaming.

Rapid icing:

air temperature from -4 to -8°C and wind velocity from 10 to 15 m/sec.

Very rapid icing:

a) air temperature -4°C or below, wind velocity 16 m/sec or more;
b) air temperature -9°C or below, wind velocity 10-15 m/sec.

A continuation of the work on supplying the fishing industry with regime data on dangerous and particularly dangerous hydrometeorological phenomena was the development and publication of the SPRAVOCHNIK PO OSOBO OPASNYM

I OPASNYM GIDROMETEOROLOGICHESKIM YAVLENIYAM SEVERNOY CHASTI ATLANTICHESKOGO OKEANA (Handbook on Dangerous and Especially Dangerous Phenomena in the Northern Part of the Atlantic Ocean) (Moscow, Gidrometeoizdat, 1974). This handbook gives information on the frequency of recurrence of directions, the mean and maximum number of days with wind having a velocity of 20 m/sec or more, on the frequency of recurrence of wave heights of 8 m or more with a wind velocity of 20 m/sec or more and on the principal characteristics of tropical cyclones and the ice regime.

A further investigation of the influence of dangerous and particularly dangerous hydrometeorological phenomena on the work of the fishing fleet and an analysis of the shipboard use of earlier published regime hydrometeorological materials on dangerous phenomena made it possible to proceed to the preparation of more perfect and more complete aids on hydrometeorological phenomena dangerous and particularly dangerous for navigation and fishing. For example, in 1975, at the All-Union Scientific Research Institute of Hydrometeorological Information-World Data Center, in collaboration with the Main Fishing Fleet Inspectorate, work began on preparation of a series of atlases of dangerous and especially dangerous hydrometeorological phenomena threatening navigation and fishing arising in the world ocean. Also participating in the preparation of these atlases was the USSR Hydrometeorological Center and the Murmansk Division of the Arctic and Antarctic Scientific Research Institute. They constitute the first specialized aids for navigation and fishing, most fully revealing the structure of dangerous and especially dangerous hydrometeorological phenomena, taking into account the peculiarities of operation of the fishing industry and fish farm fleets and the types of fishing vessels.

The atlases in preparation will consist of seven parts, in each of which histograms and isolines will show the distribution of dangerous hydrometeorological phenomena.

The first section will give the characteristics of the distribution of strong winds (Fig. 2). Three series of maps will reflect the distribution of the frequency of recurrence and continuous duration of winds with velocities of 15, 17, 25, 33 m/sec or more and also the maximum registered wind velocity, wind direction and stability of the storm wind.

The second part will give information on the frequency of recurrence and duration of waves with a height of 4, 6, 8 m or more, and also wave heights with a 1% guaranteed probability.

The third section characterizes the spatial-temporal structure of decreases in visibility (2, 1, 0.5 miles, 1 and 0.5 cable lengths or less).

The fourth section will present information on the average and extremal positions of the limits of drifting ice and the distribution of icebergs.

The fifth section gives the latest information on the intensity of ship icing. Here, supplementing earlier published atlases of ship icing, for the first time we will propose the characteristics of the probability of ship icing with different intensity.

In the sixth and seventh sections an evaluation is given of the circulation peculiarities of development of severe storms most dangerous for navigation and fishing. The sections will give the generalized characteristics of tropical cyclones. Data will be given on the extent of storm regions and the duration of storm winds in dependence on distance to the center of the hurricane. Here the regions of formation of severe storms in the extratropical latitudes will be given for definite standard synoptic situations.

The atlases which will be prepared are intended for the most part for the navigators of ships of the fishing industry and fish farms, specialists in the fishing industry planning fishing operations, directors of fishing expeditions and also workers of the Main State Fishing Fleet Inspectorate and its agencies in the field concerned with the matters of ensuring the safety of navigation and supervision of fishing. Like the ship icing atlases, the atlases of dangerous and especially dangerous hydrometeorological phenomena will enter into the list of mandatory aids for ships in the fleets operated by the fishing industry and fish farms. In addition, they can be used by navigators of ships of the Merchant Marine Ministry and other ministries and departments and also by academic, scientific and prognostic subdivisions.

The need for further improvement in the servicing of ships in the fleets operated by the fishing industry and fishing organizations with regime hydrometeorological materials for different regions of the world ocean places before the USSR Hydrometeorological Service the problem of creating new, more extensive archives of marine hydrometeorological information. At the All-Union Scientific Research Institute of Hydrometeorological Information-World Data Center work has already developed on the forming of more extensive archives of such information on microfilms and magnetic tapes with the use of the most modern technical means.

REVIEW OF MONOGRAPH 'WATER RESOURCES OF RIVERS IN THE ZONE OF THE BAYKAL-AMUR RAILROAD LINE' (VODNYYE RESURSY REK ZONY BAM), EDITED BY A. I. CHEBOTAREV AND V. M. DOBROUMOV, LENINGRAD, GIDROMETEOIZDAT, 1977, 271 PAGES

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 p 118

[Article by Doctor of Geological and Mineralogical Sciences O. N. Tolstikhin]

[Text] The Hydrometeorological Publishing House (Gidrometeoizdat) has pleased specialists with a necessary and good book written at the State Hydrological Institute and devoted to the water resources of rivers in the zone of the Baykal-Amur Railroad Line. The team of authors has succeeded in creating a monograph which is uniform in structure, level of processing and analysis of the extensive factual material. The monograph reflects the complex and diverse aspects of the hydrology of an enormous area constituting a considerable part of Eastern Siberia. In this study, with exposition of all the principal characteristics of the water resources and characteristics of the hydrological regime of rivers in the zone of the Baykal-Amur Railroad Line, one is well impressed with the logical and laconic presentation, clarity of references and conclusions and the successful interrelationship of the volumes of descriptive material and tabular and graphic factual material.

Work engineers and planners, management directors and construction men will find here the information which they require on the annual runoff of rivers and its distribution by seasons of the year, data on the maximum and minimum runoff indices, peculiarities of formation of sediments and mudflows, ice regime, channel and ice encrustation processes. The mean annual runoff values have been characterized on the basis of reduction of data for different periods to long-term values, which will considerably increase the reliability of the characteristics and the reliability of their use for all possible computations and predictions. Recommendations on computation of the intraannual distribution of runoff of unstudied rivers can be of great practical importance.

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I would especially like to note the high level of design and printing of the book, although these qualities are characteristic for this publishing house. The colorful dust jacket of the book, the fly-leaf which carries a map of the Baykal-Amur Railroad zone with the river network and the route of the future railroad, the clarity of the headings and the purposefulness of the type-settings used ensure a correspondence between the content and the form of the book. I want to take it in my hands to examine it and after examining it -- read it.

Thinking about the book gives rise to a number of questions which have not been adequately dealt with in it. This relates, in particular, to an investigation of the theoretical and regional patterns of formation of water resources, the influence exerted on the hydrological characteristics of rivers by a complex set of natural factors, including permafrost and hydrogeological. Taking into account the intensive exploitation of the Baykal-Amur Railroad zone, such an analysis can have the most direct practical interest; it will assist in a more precise prediction of the reaction of water resources to a change in the regional conditions for their formation, caused by man's economic activity.

In this connection it is worth giving attention to the specifics of formation of the hydrochemical regime of rivers caused by the prolonged period of setting in of the ice, low mean annual air temperatures and water temperatures, ice encrustation and permafrost regulation, as well as the close interaction between surface and ground water. Their discussion would make possible a more thorough approach to the problems of rational use and preservation of water resources, a considerable expansion of the extremely general concepts in this field presented in section 2.1 of the book, a presentation of useful and timely recommendations on how to take care of the water resources of the Baykal-Amur Railroad zone and organize their most desirable exploitation. The published book is a good basis for such work.

MONOGRAPH BY L. P. AFINOGENOV, S. I. GRUSHIN AND YE. V. ROMANOV ENTITLED "APPARATUS FOR INVESTIGATING THE SURFACE LAYER OF THE ATMOSPHERE" (APPARATURA DLYA ISSLEDOVANIYA PRIZEMNOGO SLOYA ATMOSFERY), LENINGRAD, GIDROMETEOIZDAT, 1977, 319 PAGES

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 118-120

[Book Review by A. A. Gurevich]

[Text] One of the significant difficulties which arises in the broad introduction of automated systems for the processing of data in all branches of the national economy is the overcoming of the human psychological barrier, since man does not fully comprehend the methods and possibilities of the new technique. It is clear that one of the ways for overcoming this contradiction should be continuous self-education, giving rise to a need for special literature addressed to a specific reader. We feel that this literature should meet the following requirements:

-- it should define important aspects of the measurement method and the method for processing the results to the detriment of technical details;
-- it should draw attention to the new possibilities which are afforded by the new measuring apparatus and the new data processing methods;
-- it should devote great attention to aspects earlier inadequately discussed in the special literature;
-- it should combine clarity and simplicity of exposition with a sufficiently high theoretical level.

The reviewed book to a considerable degree corresponds to the formulated requirements and is addressed, in particular, to the operating personnel in the network concerned with self-education in the field of measurements and instruments. It can also be useful to engineers concerned with the formulation of hydrometeorological experiments and students of meteorology.

The book consists of two parts and contains 12 chapters.

The first part (seven chapters) is devoted to a description of the primary measuring converters of meteorological elements. The first chapter gives a formulation of the problems involved in measurements in the surface layer of the atmosphere and covers the requirements on different classes of meteorological information.

On the basis of the measurement problems it was possible to formulate the general requirements on the corresponding apparatus. The authors of the monograph have introduced the concepts of the dynamic properties of measurement converters, their statistical characteristics, static and dynamic measurement errors and some ways to compensate static errors. Here it is of particular interest to analyze the calibration principle.

On the basis of the requirements formulated in the first chapter, the chapters which follow (Chapters 2-7) examine the measurement methods and the principles for constructing the measurement converters for the principal meteorological elements characterizing the state of the surface layer of the atmosphere.

The authors successively examine the measurement of temperature, humidity, wind, atmospheric pressure, radiation and the characteristics of atmospheric electricity.

The material cited in these chapters for the most part covers modern electrical methods for measuring the elements, making it possible to organize automated measurements, and also methods based on new principles and the component base. These sections also contain material earlier inadequately covered in the academic literature. The second chapter, for example, describes temperature converters on the basis of semiconductor instruments and quartz plates. The fourth chapter devotes particular attention to acoustic methods for measuring wind parameters, etc. Such a principle is also characteristic for the remaining sections in this part of the monograph.

The second part of the book contains five chapters (Chapters 8-12) and is devoted to an examination of the components of secondary measurement converters, and also to an analysis of measurement systems.

Two chapters are devoted to gradient and pulsation measurements. The materials in these chapters, especially on pulsation measurements, in our opinion are of special interest because these sections up to now have been inadequately represented in the literature on meteorological measurements and instruments. Here also, with justified completeness, there is a discussion of both methodological problems and the principles for schematic realization.

In conclusion, there is an examination of measurement data systems. The monograph discusses the trends in their development, the principles of organization and standard structures. Also discussed are the principles of organization of an automated experiment with the use of computers. As examples, the authors examine the structures of automated stations used in the Hydrometeorological Service.

Without having the possibilities for a detailed analysis of each chapter as a whole, it can be noted that the authors of the book to a considerable degree have succeeded in meeting the requirements formulated at the beginning of the review.

As a rule, the attention of the reader is centered on the fundamental methodological problems of formulating this type of measurements. Particular attention has been devoted to an analysis of the measurement errors and ways to contend with them, as is particularly important, taking into account the needs of the information user -- the meteorological engineer.

In addition to the already adopted means and methods, sufficient attention has been devoted to promising methods and technical means. Along these lines, we feel that the 11th and 12th chapters are particularly informative; they successfully generalize the materials set forth in periodicals and related literature.

The authors for the most part have succeeded in adhering to a style of exposition combining a high level with comprehensibility. The book does not contain detailed descriptions of apparatus and schematic details, which is more fitting for handbooks and instructions and which overburden some academic aids.

A consideration of the general principles for the measurements and processing of information in the book is combined with successfully selected examples illustrating the use of the presented principles in the practice of hydrometeorological instrument making. The bibliography has been successfully selected; this facilitates the use of the book for deepening the study of the sections of interest to the reader. The book is well illustrated and is tastefully designed.

Together with the list of merits, presented above and by no means complete, it is not free from a number of shortcomings. For example, it is hard to understand why the authors have not included sections relating to measurements of the meteorological range of visibility, widely applied at the present time in aviation meteorology and in other fields.

We feel that the sequence of exposition of material is not entirely justified. For example, the section on "Components of Secondary Measurement Converters," containing, in essence, information not only on components, but also on some principles on the measurement and processing of data, is not given at the beginning of the book, but in its second part. As a result, the examination of a number of measurement methods in the chapters in the first part is without the necessary basis. An example is the description of acoustic anemometers in which use is made of diagrams of time measurement and other diagrammatic representations unclear for the uninformed reader.

In general, this section does not contain some basic information used in the other sections, for example, the concepts of logical elements. Neither this nor the other sections of the book cover with methodological clarity or completeness the compensation principle of measurement used repeatedly in different applications (Chapters 5, 6). Here the authors deviate from the principle of discussion of the principles of the method, replacing it by an illustration.

In the first chapter the author introduces the concept of dynamic error, which, unfortunately, is not always used in the subsequent analysis of methods and instruments. It appears that the modern mathematical preparation of meteorologists would enable the authors to give a more detailed examination of the problem of the transpiring of the random process in the dynamic channel and also to provide a sound basis for rational time and level quantization. The necessary additional mathematical approach could be given in an appendix.

It goes without saying that all these wishes would require a substantial increase in the volume of the book, but, it appears that this increase would be justified. Any new book cannot be without some shortcomings. We feel that in this case the shortcomings are in no way commensurable with the merits of the considered book.

Meteorologists have received a good and timely book. We believe that it will be of great service to all who work in the field of technical re-equipping of the hydrometeorological service engaged in scientific and practical work involved in hydrometeorological measurements.

HIGH AWARDS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 p 121

[Unsigned article]

[Text] By a decree of the Presidium of the Supreme Soviet USSR, dated 27 October 1978, entitled "Awarding of Orders and Medals of the USSR to the Workers Most Distinguishing Themselves in the Successful Implementation of Winter Arctic Voyages for the Delivery of Freight to Regions of the Far North," the following workers of organizations of the State Committee on Hydrometeorology were presented awards:

Order of the Red Banner of Labor

Aleksandr Aleksandrovich Girs -- director of a division at the Arctic and Antarctic Scientific Research Institute.

Aleksandr Serafimovich Glazunov -- chief of a division at the Dikson Administration of the Hydrometeorological Service;

Order "Emblem of Honor"

Alina Petrovna Golovina -- senior engineer of the Hydrometeorological Observatory of the Tiksi Administration of the Hydrometeorological Observatory.

Aleksey Vasil'yevich Krutikhin -- senior engineer of the assembly team of the Amderma Administration of the Hydrometeorological Service.

Vladimir Pavlovich Popov -- senior engineer of the Northern Administration of the Hydrometeorological Service;

Medal "For Outstanding Work"

Valeriy Il'ich Andryushenko -- junior scientific associate Arctic and Antarctic Scientific Research Institute.

Nadezhda Prokop'yevna Gudkova -- radio operator of the territorial communications unit at the Tiksi Administration of the Hydrometeorological Service.

Boris Dmitriyevich Popov -- division chief at the Murmansk Administration of the Hydrometeorological Service;

Medal "For Distinction in Work"

Yuriy Nikolayevich Yemelin -- division chief at the Dikson Administration of the Hydrometeorological Service.

Alla Andreyevna Kotlyarova -- weather bureau chief at the Amderma Administration of the Hydrometeorological Service.

Aleksandr Nikolayevich Nekrasov -- division chief at the Pevek Administration of the Hydrometeorological Service.

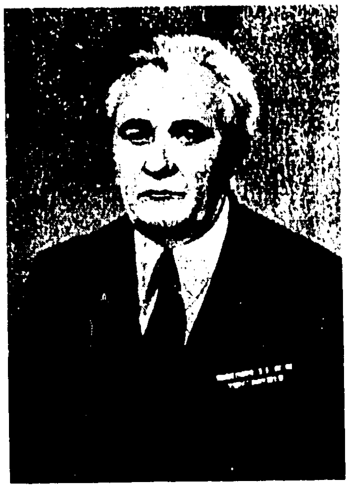
Tamara Alekseyevna Pavlova -- senior technician at the hydrometeorological observatory at Cape Shmidt of the Pevek Administration of the Hydrometeorological Service.

SIXTIETH BIRTHDAY OF VASILIY GRIGOR'YEVICH PAVLENKO

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 121-122

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

[Text] The day 23 February 1979 marked the 60th birthday of Vasiliy Grigor'yevich Pavlenko, chief of the Sakhalin Administration of the Hydrometeorological Service. Vasiliy Grigor'yevich began his work activity in the Hydrometeorological Service in May 1941 after graduating from the Feodosiya Hydrometeorological Technical School. During the years of the Great Fatherland war he was in the active army. He was given awards for participating in combat on the Karelian front, where in 1944 he entered the ranks of the CPSU.



During the period 1945-1956 V. G. Pavlenko worked in Azerbaydzhan as chief of the marine hydrometeorological stations Artem Island and Neftyanyye Kamni, whose materials were used in the planning and operation of sea petroleum facilities along the shores of the Apsheron Peninsula. During this period he combined his successful productive activity with correspondence study at Azerbaydzhan State University, from which he graduated in 1960.

Vasiliy Grigor'yevich proved himself to be a highly qualified specialist and an able organizer and in 1958 was promoted to the post of deputy chief of the Administration of the Hydrometeorological Service of the Azerbaydzhan SSR, and since 1969 has been working as chief of the Sakhalin Administration of the Hydrometeorological Service.

During recent years, under the direction of and with the direct participation of V. G. Pavlenko the Sakhalin Administration of the Hydrometeorological Service has achieved considerable successes in the development and improvement of hydrometeorological servicing of the multisided and complex national economy of Sakhalinskaya Oblast, especially aviation, the fishing industry and the merchant marine, agriculture, coal, petroleum and gas industries, and also other branches of the national economy and population. The tsunami warning service has received further development. V. G. Pavlenko devotes much attention to the development of work for study of the climatic and water resources of Sakhalin and the Kuriles, the hydrometeorological regime of seas, monitoring of the contamination of the natural environment, introduction of new methods and technical equipment into the practical activity of operational-productive and research activity of the Sakhalin Administration of the Hydrometeorological Service. We should especially note the great work of Vasiliy Grigor'yevich on the introduction of automatic stations.

The personnel of the Sakhalin Administration have repeatedly emerged the victor in socialist competition among the administrations of the Hydrometeorological Service; it was awarded the Challenge Red Banner of the Hydrometeorological Service and the Central Committee of the Trade Union of Aviation Workers.

Vasiliy Grigor'yevich combines high requirements on himself and his subordinate workers with constant concern for improving the material and living conditions of workers of the Sakhalin Administration Service and network, which has favored a decrease in the turnover of personnel and the arrival of new specialists in the Administration of the Hydrometeorological Service, whose education and training receives much attention from V. G. Pavlenko.

Vasiliy Grigor'yevich Pavlenko, in addition to great routine-productive and organizational activity, actively participates in public life. The professional and personal qualities of V. G. Pavlenko, his demanding but sensitive attitude toward workers, have won him meritea authority in the organizations of the State Committee on Hydrometeorology and other departments. For his work successes he was awarded the order "Emblem of Honor" and medals.

Vasiliy Grigor'yevich Pavlenko meets his 60th birthday full of creative forces. In congratulating Vasiliy Grigor'yevich on this birthday, we wish him good health and further work successes.

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

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 122-124

[Article by M. M. Kuznetsova]

[Text] The USSR Main Committee of the Exhibition of Achievements in the National Economy (AEANE) has presented awards to participants in the AEANE USSR 1978 for the "Hydrometeorological Service" Pavilion.

First-Degree Diplomas:

Order of Lenin Arctic and Antarctic Scientific Research Institute -- for creating a method for long-range meteorological weather forecasts for a long period in advance; for formulating the fundamental principles for determining the influence of the ice cover on navigation; for developing methods for infrared aerial thermal surveys of arctic seas and introducing them into routine practice.

Order of the Red Banner of Labor Institute of Applied Geophysics -- for organizing an operational constantly operating service for the monitoring and prediction of radiation conditions in circumterrestrial space and ensuring the availability of regular data for the "Salyut" and "Soyuz" manned space stations.

Second-Degree Diplomas:

Hail Prevention Service Azerbaydzhan SSR -- for operational support for protection of valuable agricultural crops against hail in a territory greater than 700,000 hectares; the economic effect from work for protection against hail falls was 15 million rubles in 1977.

Hail Prevention Service Tadzhik SSR -- for operational support in the protection of valuable agricultural crops against hail in the territory of the Tadzhik SSR over an area of 520,000 hectares. The economic effect from work for protection against hail falls was 8.8 million rubles in 1977.

Departmental Subdivision on Hail Protection Ukrainian SSR -- for the operational support for protection of valuable agricultural crops against hail in the territory of the Ukrainian SSR over an area of 275,000 hectares.

The economic effect from protection of agricultural crops was more than 7 million rubles in 1977.

Central High-Elevation Hydrometeorological Observatory -- for the introduction of the first part of a system of automated observations and monitoring of the environment (ANKOS-V) in the Moscow River basin.

Ashkhabad Weather Control Bureau Turkmen SSR -- for highly effective hydrometeorological support of the migratory livestock industry.

Magadan Weather Bureau of the Kolyma Administration -- for organizing and regular implementation of helicopter inspection of reindeer pastures and highly effective hydrometeorological support of reindeer grazing.

State Oceanographic Institute -- for investigating the world ocean for the purpose of improving weather forecasting for the national economy and participation in constructing hydrometeorological charts of the world ocean.

Ufa Hydrometeorological Observatory of the Ural Administration -- for carrying out operational and methodological work on refining forecasts of the yield of sugar beets, potatoes, spring wheat, computing moisture reserves in reconnaissance investigations, studies of heat supplies in the growing season. As a result of the measures which were carried out on an experimental basis at a number of farms the mean increment in yield was: grain crops -- 2 centners/hectare, potatoes -- 20 centners/hectare, sugar beets -- 30 centners/hectare, green mass of corn -- 30 centners/hectare.

Third-Degree Diplomas:

Voronezh Aviation Meteorological Station of the Central Chernozem Oblasts -- for ensuring accident-free, highly effective meteorological servicing of civil aviation and the introduction of new forms of meteorological support of aircraft flights.

Gor'kiy Hydrometeorological Observatory of the Upper Volga Administration -- for developing and introducing a method for preparing latex envelopes making it possible to raise the ceiling of radiosondes and radio pilot balloons and to have annually a stable altitude for the ascent of radiosondes to 30,460 m and radio pilot balloons to 31,160 m.

Hydrometeorological Bureau of the Gorno-Altay Region of the West Siberian Administration -- for carrying out special expeditionary investigations and developing a method for zoometeorological evaluation and allowance for the influence of weather conditions on the carrying out of winter grazing of sheep and goats in mountainous regions. The economic effect from hydrometeorological support of migratory animal husbandry during the winter of 1976-1977 in the Gornyy Altay was 5.5 million rubles.

Frunze Weather Bureau of the Kirgiz SSR Administration -- for support of investigations of seasonal pastures, the results of which were used in the distribution of herds of cattle and in the distribution of emergency fodder.

The economic effect during the period of cattle transmigrations was about 3 million rubles.

Leningrad Weather Bureau of the Northwestern Administration -- for developing a program for transmitting and introduction of a method for sending hourly hydrometeorological information through the autoinformer of the Leningrad telephone station via the Lengorspravka system.

Southern Sakhalin Weather Bureau of the Sakhalin Administration -- for developing and introducing the sending of warnings to national economic organizations, making it possible to reduce the time required for the sending of warnings to users by a factor of 10-15 and for around-the-clock supplying of the population and national economic organizations through the "Sakhalin-meteo" radio station with forecasts and warnings on dangerous hydrometeorological phenomena.

Arkhangel'sk Weather Bureau of the Northern Administration -- for ensuring transmissions by radio and television for the population of Arkhangel'skaya Oblast with weather forecasts and other information. The economic effect from the use of agrometeorological information alone in the agriculture of Arkhangel'skaya Oblast in 1977 was about 10,000 rubles.

A number of workers of the State Committee on Hydrometeorology were awarded medals of the All-Union Exhibition of Achievements in the National Economy USSR.

Gold Medal:

Yu. S. Sedunov, S. I. Avdyushin, A. A. Girs, P. A. Gordiyenko and Ye. A. Sobchenko.

Silver Medal:

A. G. Akopov, V. V. Bogorodskiy, I. I. Burtsev, Z. I. Volosyuk, F. F. Grishakov, Z. M. Gudkovich, E. A. Kozhushiyan, L. N. Korennoy, N. I. Kuznetsov, I. S. Lukicheva, M. A. Masterskikh, G. M. Mikhaylova, V. L. Nezhevenko, N. K. Pereyaslova, T. A. Pobetova, I. V. Privalova, V. S. Ragozina, A. A. Rybnikov, P. M. Svidskiy, G. N. Sergeyev, G. P. Sokol, V. A. Spitsyn, V. M. Fedorov, Yu. S. Tsaturov.

Bronze Medal:

A. Azamatov, M. M. Aleksandrov, V. D. Andreyev, I. L. Appel', A. I. Arikaynen, K. A. Astakhova, I. V. Balashova, P. D. Bantikov, F. Z. Battalov, M. Sh. Bolotinskaya, V. P. Bolotskikh, N. N. Bondarenko, V. V. Borets, V. A. Varfolomeyev, V. P. Vasil'yeva, V. P. Vashchenko, Z. M. Velichko, N. D. Vinogradov, V. P. Gavrilo, A. S. Genesina, B. M. Ginzburg, Ye. Ya. Gol'nik, G. G. Gromova, A. Ya. Grudeva, A. V. Gusev, F. L. Dlikman, I. P. Dolgushin, V. M. Dubrovskiy, V. P. Yefimova, V. G. Zaytsev, V. G. Zakharov,

V. A. Zakhozhiy, T. G. Ivanidze, A. P. Ivanov, I. G. Ivanov, O. P. Kaddo, G. V. Kazmirchuk, I. D. Karelin, L. A. Katasev, N. S. Kim, O. I. Klimenko, V. I. Kozenko, A. A. Kolotilkina, S. A. Krestnikov, G. I. Krest'yaninova, A. M. Krechetova, Yu. M. Kulagin, T. F. Kulakova, S. A. Kurbanov, I. I. Lytkina, I. N. Makiyenko, T. A. Maksimenkova, A. B. Malyshev, G. B. Mashkova, I. P. Minchenko, A. V. Mironovich, T. K. Monseyeva, Yu. A. Morina, S. N. Moshonkin, L. N. Nesterova, E. N. Novikova, M. V. Nikiforov, G. A. Nikul'shina, L. R. Orlenko, L. P. Panova, N. N. Pegoyev, B. M. Petrov, Yu. I. Portnyagin, G. Yu. Postanogova, B. Reyimkulyyev, G. D. Reshetov, L. A. Romanov, I. A. Serebriyskiy, A. I. Snitkovskiy, A. F. Skokova, A. L. Sokolov, R. P. Sosnovskaya, V. F. Sukhovey, A. V. Tambovtseva, F. M. Tikhomirova, I. P. Traktin, G. V. Trepov, G. P. Khokhlov, M. V. Tsvetikova, L. A. Tsymbalyuk, Ye. A. Chistyakova, S. F. Chuprin, K. A. Shatalov, V. N. Shiryayev, R. I. Shul'ginskaya and M. A. Yudin.

The total number of participants was 434. In addition to the workers of the State Committee on Hydrometeorology, the Main Committee of the USSR Exhibition of Achievements in the National Economy for the Pavilion "Hydrometeorological Service" awarded prizes to specialists of unaffiliated organizations directly participating in the development of a number of themes.

CONFERENCES, MEETINGS AND SEMINARS

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 124-125

[Article by V. G. Simov, Yu. G. Slatinskiy, V. S. Vuglinskiy and V. I. Babkin]

[Text] A conference-seminar on investigations in the mouth regions of rivers in the Sea of Azov-Black Sea basin was held on 10 April 1978 at the Sevastopol' Division of the State Oceanographic Institute. Twenty-three reports were presented on a wide range of problems related to the development of predictions of the influence of water management measures on the hydrological and hydrochemical regimes of the mouth regions of rivers.

In the reports and addresses of the conference participants it was noted that the continuously increasing volume of water consumption in the southern regions of the country, the execution of major water management measures (the creation of reservoirs, construction of major canals for irrigation and water supply and the redistribution of runoff among individual basins, etc.) require a many-sided economic evaluation, the development of variants of the most effective use of water resources and maintenance of the developing environmental conditions. However, the lack of scientifically sound forecasts of economic and social consequences of the redistribution of river runoff can have extremely significant negative consequences. In particular, it was noted that during the last two decades the runoff into the Sea of Azov has been reduced by almost one-third. The removal of water, increasing with each passing year, together with periods of natural low water, served as a reason for a stable increase in salinity of the open part of the Sea of Azov by 1.5-2°/oo and Taganrog Gulf by 4-5°/oo. As a result, there was a marked change in level and the nature of the biological processes, which led to a considerable reduction of the ranges of the most valuable migratory and semimigratory fish, to a deterioration of the conditions for the feeding of fish and a decrease in the fish productivity of the entire water body as a whole.

The appearance of some typical Black Sea organisms, never encountered there previously, has been noted in the mouth regions of rivers.

A complex situation is developing in the mouth region of the Dnepr and the Yuzhnyy Bug. The systematic increase in the nonreturn removal of water from the reservoirs of the Dnepr cascade is leading to a stable increase in the salinity of waters in the Dnepr-Bug estuary and the adjacent part of the northwestern region of the Black Sea.

In order not to allow an irreversible change in the entire ecological situation in the basin, and especially in the mouth regions of the river, specialists have proposed different variants of regulation of water resources. In addition to the shifting of the runoff of northern rivers, specialists are considering the problem of redistribution of local water supplies.

In particular, plans call for blocking off the Dnepr-Bug estuary at Ochakov and a large canal for shifting a part of the Danube runoff into the Dnepr basin. The canal, with a length of about 300 km, would have its origin in the lower reaches of the Kiliyskiy distributary of the Danube delta, would pass through the channels of the Sasyk-Shabolatskaya group, would intersect the Dnestrovskiy channel near the Tsaregradskiy strait, bend around Odessa and reach the Dnepr-Bug estuary in the neighborhood of Ochakov. The plan calls for the construction of about 10 pumping stations on the channel. Provision is made for reinforcing the barrier beaches separating the coastal lagoons from the sea and transforming them into large reservoirs. At the present time the construction of the first stage of the canal is underway -- the channel connecting the Sasyk estuary with the Black Sea has been blocked off. the building of a dike along the barrier beach is being completed, and in the coming years this will make it possible to accumulate in this water body not less than 0.7-0.8 km^3 of fresh water for irrigating the regions in the southern part of Odesskaya Oblast.

In order to prepare a technical and economic justification for the channel it is necessary to carry out a rather significant volume of investigations, in particular, to study the problem of the fate of small rivers along the path of the channel and to evaluate the possible changes in the regime of runoff currents at the mouth of the Danube, in Tsaregradskiy strait and in Kinburnskiy strait. Similar investigations for the prevention of unfavorable consequences in connection with the planned construction of the Kerch hydroelectric power complex must also be carried out in the deltas of the Don and Kuban'. In this connection each year there is an increase in the volume of observations carried out by mouth stations and hydrometeorological observatories under the scientific-methodological direction of the river mouth laboratory of the Sevastopol' Division of the State Oceanographic Institute. During 1977 alone about 2,000 individual stations were occupied, 79 multiday stations were occupied (about 900 series of observations) and 13 automatic buoy stations with automatic current recorders were placed. The total volume of collected information is about 9,000 observation horizons. A particularly great volume of work was carried out in the Kuban' River delta. It has involved an extensive sector from the lowest-lying station at Tikhovskiy village to the sea margin of the delta. There were more than 50 synchronous measurements of discharges in delta distributaries, multiday measurements of water discharges in the straits of coastal inlets (Solov'yevskoye, Kulikovskoye, Peresypskoye straits), salinity surveys in the delta distributaries, measurements on 10 control profiles at the points of channel branching and other studies.

During 1978-1979 plans call for carrying out major complex expeditions in the mouth region of the Don in the reach between the Dolgaya and Belosarayskaya spits, in the Dnepr-Bug and Dnestr estuaries. On the basis of the collected data specialists will develop a method for computing water exchange in mouth water bodies (gulfs, estuaries) with the open sea, which will make it possible to investigate the problem of the direction of changes in the hydrological and hydrochemical regimes of these water bodies in accordance with the volumes of extraction of river runoff planned for the coming 10-15 years.

A resolution adopted by the conference participants formulated proposals for collating the research plans of different departments in the mouth regions of rivers in the Black Sea and Sea of Azov basins. Recommendations were adopted for all Administrations of the Hydrometeorological Service in the basin for the further development of the operating network of stations and posts at the mouths of rivers, their strengthening by additional trained personnel, outfitting with instruments, equipment and ships. In particular, it was decided to ask the Administration of the Hydrometeorological Service Ukrainian SSR to establish at Belgorod-Dnestrovskiy a mouth station on the basis of the existing local hydrological station and to ask the Sevastopol' Division of the State Oceanographic Institute and the Northern Caucasus Administration of the Hydrometeorological Service to examine the problem of broadening research in the lower pool of Krasnodarskoye Reservoir. Plans also call for refining the research program in the mouth region of the Danube.

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During the period from 20 to 22 June 1978 at the Valday Scientific Research Hydrological Laboratory imeni V. A. Uryvayev there was a conference-seminar on the subject: "Computation of Channel Water Balances With Allowance for the Use of Water."

The participants examined the status of introduction of a unified system for the state inventory of waters for the USSR (Edinaya Sistema Gosudarstvennogo Ucheta Vod -- YeSGUV) with respect to quantitative and qualitative indices and they generalized the experience in computing channel water balances and the balances of chemical substances in individual river reaches and in river basins as a whole.

In the reports of I. A. Shiklomanov (State Hydrological Institute) and L. V. Brazhnikova (State Chemical Institute) the authors examined the prospects for use of the YeSGUV for evaluating the influence of economic activity on the quantitative and qualitative indices of river water.

The results of generalization of the experience in determining channel water balances for the Volga, Kuban', Dnepr, Amudar'ya, Ural, Irtysh, Tom and Lena, taking into account data on the use of water for 1976 were presented in a report of specialists of the State Hydrological Institute K. P. Voskresenskiy, V. I. Babkin, G. A. Plitkin, I. B. Ivanova and T. Ye. Grigorkina.

The methodological problems involved in evaluating accuracy and hydrological monitoring of data from the state water inventory and its use, the determination of the balances of chemical substances and channel water balances were discussed in the reports of B. S. Ustyuzhanin, I. B. Vol'ftsun, V. P. Novikova, Yu. V. Russ (State Hydrological Institute), T. Kh. Kolesnikova and V. M. Ivanik (State Chemical Institute).

The representatives of the Northern Caucasus Administration of the Hydrometeorological Service, the Administration of the Hydrometeorological Service of the Kazakh, Uzbek, Kirgiz, Turkmen, Georgian, Armenian, and Azerbaydzhan SSRs familiarized the seminar participants with the results of determination of channel water balances during monthly and annual time intervals in river reaches with intensive economic use. A general analysis of the status of work on the preparation of channel water balances at the Administrations of the Hydrometeorological Service and an evaluation of their accuracy was given in communications by A. V. Savel'yeva and V. P. Smirnova (State Hydrological Institute).

The conference-seminar declared that the State Hydrological Institute, the State Chemical Institute and the Administrations of the Hydrometeorological Service have carried out considerable work on the organization of the state water inventory and water use in the unified system for the USSR within the framework of the surface waters section. In particular, methodological recommendations have been prepared on evaluation of the accuracy and hydrological monitoring of data from the state water inventory and water use. (1977); jointly with agencies of the USSR Water Management Ministry specialists have prepared lists of enterprises, organizations and institutes extracting water directly from surface water bodies or dumping waste water into them; there was a generalization of results of computations of channel water balances during 1976 for the river basins of the USSR and their individual reaches.

A resolution of the conference-seminar noted the principal problems in the further introduction of the YeSGUV in the system of the State Committee on Hydrometeorology. In particular, it was deemed necessary to match the computation reaches of the rivers for which the agencies of the State Committee on Hydrometeorology prepare the channel balances and the balances of chemical substances with the reaches for which water management balances are being prepared in the Water Management Ministry USSR. It was decided that this ministry would be asked to improve the primary inventory of water use.

It was decided to activate the work of the Administrations of the Hydrometeorological Service in selecting the computation reaches for determining channel and inventory water balances and balances of chemical substances.

It was deemed advisable at the Administrations of the Hydrometeorological Service of the Estonian, Ukrainian, Belorussian, Armenian, Georgian, Azerbaydzhan SSR's and the Upper Volga and Ural Central Hydrometeorological Observatories to carry out work on the preparation, in 1979-1980, of the inventory balances of chemical substances in one or two experimental river reaches under a program coordinated with the State Chemical Institute. The State Hydrological Institute and the State Chemical Institute were called upon, in 1978, to carry out computations of channel water balances and the balances of chemical substances, taking into account data on water use in 1977.

It was also deemed necessary to increase the accuracy of hydrometric work and computations of runoff, especially at the sites of hydroelectric power stations.

NOTES FROM ABROAD

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 p 126

[Article by B. I. Silkin]

[Text] As reported in INTERAVIA AIR LETTER, No 8973, 1978, in accordance with the participation of the United States in the GARP program, beginning in December 1978 a system of artificial earth satellites, designated GOES-A, GOES-B and GOES-C, will be put into operation. The three satellites GOES "D," "E," and "F" are a further development of this system of meteorological satellites.

The first of these satellites will be put into a stationary orbit at a point situated over 75°W. The mass of this artificial satellite, like the other two satellites identical to it, is approximately 320 kg. An infrared radiometer with circular scanning is mounted in its cylindrical body with a length of about 4.5 m and a diameter of about 2.2 m. This instrument gives two-dimensional images of cloud cover, collects information on the velocity and direction of cloud movement, and data on the temperature and humidity at altitudes of up to 15 km above the underlying surface.

In addition to the radiometer, each satellite carries instrumentation collecting data transmitted by the telemetric systems of surface and shipboard meteorological stations, seismic stations and meteorological buoys situated in different regions of the western hemisphere and also instruments for registering the level of solar activity.

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As reported in SCIENCE NEWS, Vol 113, No 4, 1978, one of the commonly used methods for determining climate prevailing in remote eras is a study of the thickness of the annual rings on tree trunks. However, this frequently leads to contradictory results.

A new method, involving the use of direct radioisotopic wood analysis, was developed by the geochemists S. U. Epstein and C. Yapp (California Institute of Technology). The method is based on measurement of the ratio of deuterium to hydrogen in the cellulose of the plant mass, which is directly related to the ratio of these elements in the water participating in the formation of molecules in this cellulose. The latter, in turn, is dependent on the temperature observed at the time when this water fell from the atmosphere in the form of precipitation. It is known that for the heavier water molecules containing deuterium to be condensed the air masses must have a higher temperature than is necessary for the condensation of molecules of "ordinary" water. Therefore, for regions with a cold climate there is characteristically precipitation with a lesser specific weight of water containing deuterium.

After carrying out an analysis of the wood in 40 trees growing in different regions of North America in the zone of the last glaciation, researchers were able to determine the air temperature in the period between 9,500 and 22,000 years ago. The age of the trees themselves was established using the radio carbon (C 14) method.

It was found that the cellulose of trees growing 14,000-22,000 years ago contains more deuterium than is typical for present-day trees. It is evident that the climate during this period on the average was milder than now; the winter, evidently, was warmer and the summer was cooler.

Under such conditions, as a result of the abundance of air saturated with moisture, moving from the oceans and carrying snow, the continental glaciers were subjected to lesser melting in summer and received a greater increment in winter than occurs now when the cold dry (with little snow) winters are customary for the largest regions of glaciation -- Greenland and Antarctica.

An analysis of wood with an age from 10,000 to 12,000 years also confirmed that the transition from the conditions of glaciation to our modern climate was very sharp and occupied a total of approximately 2,000 years.

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As reported in SEA TECHNOLOGY, Vol 18, No 12, 1977, the oceanologists of the University of Texas, working in collaboration with specialists of the St. Louis Research Laboratory of the US Navy, established that in the deep part of the northern regions of the Gulf of Mexico along the meridian 91°20'W there is a basin of waters with an anomalously high salinity which they assigned the name Orca.

In a deep layer with a thickness of 200 m the salinity in this basin attains 258°/oo. Such concentrations of "brine" were earlier discovered at the bottom of the Caribbean Sea, but their area is two or three times less than the area of the Orca basin. The upper boundary of the concentration is at a depth of about 2,400 m. The water temperature in it is only 1.5°C greater than the temperature of the surrounding layers. This also distinguishes the Orca basin from the corresponding regions of the Red Sea, in which the saline waters are characterized by a considerably greater heating. In the sea floor layers underlying the Orca basin there are large salt deposits. The dissolving of this salt probably accounts for the formation of this phenomenon.

IN MEMORY OF VALER'YAN ANDREYEVICH URYVAYEV (1908-1968)

Moscow METEOROLOGIYA I GIDROLOGIYA in Russian No 2, Feb 79 pp 127-128

[Article by V. Korzun, A. A. Sokolov and I. V. Popov]

[Text] The day 23 December 1978 marked the 70th birthday of the outstanding scientist and hydrological engineer Valer'yan Andreyevich Uryvayev. His name is inseparably related to the development of hydrology in the USSR, and he is rightfully regarded as one of the founders of Soviet hydrology.

V. A. Uryvayev was designated director of the State Hydrological Institute in 1942 during the severe days of the Great Fatherland War, requiring a radical restructuring of hydrological research in the interests of supporting combat operations of the Red Army.

It was necessary to possess remarkable capabilities as a scientist and talented organizer in order to be able, over a period of 34 years, to head a great body of skilled professional hydrologists, to assume and enjoy undisputed authority and respect.

In examining the scientific activity of V. A. Uryvayev, it is impossible not to note the broad range of his interests, deep penetration into the essence of the phenomena and processes which he investigated, the ability to generalize different facts, to formulate and solve many complex scientific and practical problems in the field of hydrology in the interests of development of the national economy.

Already in 1941 V. A. Uryvayev compiled a new isoline map of the least annual mean diurnal water discharges having great importance in water management planning work and proposed a method for taking into account the influence of lakes on minimum runoff.

V. A. Uryvayev contributed much work to completion of compilation of the VODNYY KADASTR SOVETSKOGO SOYUZA (Water Inventory of the Soviet Union).

During the period of the Great Fatherland War, under the direction and on the initiative of V. A. Uryvayev, multisided investigations and studies for meeting the needs of different branches of the Red Army were made.

He systematically prepared consultations on hydrological conditions at the fronts, worked out important aids for troops, carried out special hydrological computations and forecasts. V. A. Uryvayev organized and carried out complex field experimental studies for investigating the passability of terrain by different kinds of military equipment, the results of which were included as an important part in special standard-setting aids, monographs and courses of lectures.

The present-day hydrological network, which V. A. Uryvayev considered to be the basis of hydrology, owed much to him, especially with respect to the formulation of the scientific principles for the distribution of observation stations, the writing and use of methodological manuals on the carrying out, processing and generalization of hydrological observations, and also with respect to the training and improvement of knowledge of professional hydrologists.

Not only stationary hydrological observations, but also expeditionary hydrographic work on rivers carried out on an extensive scale during 1945-1948, were under the constant supervision of V. A. Uryvayev.

However perfect might be the control hydrological network, for revealing the essence of many phenomena and processes it is necessary to formulate special experiments, as a result of which it is possible not only to collect new facts, but also to penetrate into the essence of hydrological phenomena. This was obvious to V. A. Uryvayev, who was constantly concerned with the leading role of Soviet hydrology.

The term "experiment" was understood by V. A. Uryvayev in a broad sense. This combination of continuous and detailed stationary observations and expeditionary studies in basins, and at the same time, an active field experiment, in which the different natural conditions were changed and a study was made of the effect of different kinds of human activity on hydrological phenomena and processes, was characteristic. On the initiative of V. A. Uryvayev, already in 1945 work began on construction of the large experimental laboratory base of the State Hydrological Institute near Leningrad, at Il'ichevo village. Now this is a whole scientific city with beautifully equipped laboratories, which is widely known in the USSR and abroad.

During the post-war period V. A. Uryvayev carried out an enormous amount of work on transforming the Valday Runoff Station, which was virtually completely destroyed during the war, into the world-renown Valday Scientific Research Hydrological Laboratory of the State Hydrological Institute (VNIGL), now bearing his name. This laboratory is carrying out an extensive complex of water balance and hydrophysical investigations and is outfitted with unique instruments and apparatus. Such a laboratory has been established for the first time in the world.

Giving great importance to experimentation in hydrology, V. A. Uryvayev endeavored to organize the work in such a way that the key specialists at the institute took a direct part in the work of the VNIGL.

V. A. Uryvayev always had good will toward, but at the same time put high demands on young people. He carried out active and productive teaching activity at the Leningrad Hydrometeorological Institute and in different courses used extensively by the VNIGL as a basis for the practical work of students at many schools of higher learning. V. A. Uryvayev made extensive use of his experience at the VNIGL for establishing a number of runoff (water balance) stations in zones throughout the country having different natural and hydrological conditions.

The development of experimental hydrology required the creation of fundamentally new instruments and apparatuses and more complex equipment. V. A. Uryvayev had unexcelled capabilities as an inventor. He developed a design for a unique soil evaporator (BGI), an original flume for calibrating hydrometric current meters, and a series of instruments for studying the physical properties of the snow cover.

V. A. Uryvayev made a considerable contribution to study of precipitation. He constructed gradient towers for making observations in forests and organized the study of precipitation by means of radar with the simultaneous creation of a dense network of posts for measuring showers.

V. A. Uryvayev was the initiator of use of aerial methods for making hydrometric measurements in rivers and very rightly he can be considered the creator of a new branch of hydrometry -- aerial hydrometry.

The history of hydrology is rich in major expeditions, not rarely affecting great areas and entire basins. However, it is precisely to V. A. Uryvayev that we owe the creation of a new type of expeditionary investigations characterized by a broad complexity and a combination of expeditionary surveys with the creation of a temporary hydrological network. The expeditions organized under the direction of V. A. Uryvayev made a detailed study of the water resources of the virgin lands -- Kustanayskaya, Kokchetavskaya, Pavlodarskaya and Zapadno-Kazakhstanskaya Oblasts, Altayskiy Kray and Turkmenia.

Monographs published on the results of expeditions, under the editorship of V. A. Uryvayev, have found very extensive application at planning and design organizations and represent a significant contribution to the exploitation of the virgin lands.

The achievements of hydrology, especially during the post-war years, enabled V. A. Uryvayev to proceed with initiative in creating a series of norm-setting manuals on hydrological computations, so necessary for the needs of planning on rivers. The creation of these manuals required the organization of additional investigations specially carried out by large teams of scientists at the State Hydrological Institute. Some of these manuals have been adopted by Gosstroy as an All-Union State Standard; some of them have an interdepartmental character.

V. A. Uryvayev engaged in enormous and productive international activity. He was an active member of the USSR Interdepartmental Committee on the International Hydrological Decade and he enjoyed broad recognition and respect in international organizations and among foreign scientists due to his contribution to the development of international cooperation in the field of hydrology.

Valer'yan Andreyevich dealt with great seriousness relative to his foreign activity and endeavored to strengthen and maintain the high international authority of Soviet hydrology.

The activity of V. A. Uryvayev was recognized by many governmental awards, including the Order of Lenin. He also received an award from the All-Union Exhibition of Achievements in the National Economy.

The day 11 October 1978 marked the 10th anniversary of the premature death of V. A. Uryvayev, but the memory of him as an outstanding scientist, engineer, friend and comrade is not lessening. His name is associated with an entire epoch in the development of Soviet hydrology. The ideas and thoughts of V. A. Uryvayev are receiving further development in our day in the solution of new and complex hydrological and water management problems directed to the rational use and conservation of the water resources of the Soviet Union.

In memory of the services of Valer'yan Andreyevich a prize was established in 1971 in his name and in the name of another outstanding Soviet hydrologist, V. G. Glushkov; this is awarded once each three years for the best work in the field of hydrology of the land and experimental hydrological investigations.

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