GEOPHYSICS

1957

SovietRxiv

Abstract

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GEOPHYSICS

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FORECASTING PRECIPITATION ON THE VIRGIN LANDS OF WESTERN SIBERIA AND KAZAKHSTAN

(Presented by Academician V. V. Shuleikin, 10 IV 1957)

One of the characteristic features of the continental climate of the region of development of the virgin lands of Western Siberia and Kazakhstan is the great variability of the amount of precipitation during the growing season from one year to another. Without any visible statistical regularity, well-moistened and droughty years alternate here. A vivid illustration of such contrasts is provided by the last three years: the years 1954 and 1956, very favorable for agricultural production, and between them 1955, with an exceptionally severe drought. In a long-term series one can note the so-called paired years, when an excess of precipitation (in comparison with the norm) or drought is observed for two, and sometimes three, years in succession. For example, the years 1949 and 1950 had good moisture supply, while the three following years in succession were droughty.

Considering that precipitation anomalies prolonged in time and covering a large territory are a consequence of established features in the macro-circulation processes of the atmosphere, and assuming that a good reflection of the latter is the field, conditioned by them, of meridional and monsoon heat transport in the atmosphere, let us examine the direct connection between the amount of precipitation and the fields of indices of cold transport, as one of the components of heat transport in general, in the pre-winter preceding a given summer. As was shown in work (^{1}), such an index may be the mean of the three minimum values (for October, November, and December) of the anomaly of the relative topography of the 500 mb surface above the 1000 mb surface (RT 500/1000), calculated from mean charts for the natural synoptic period relative to its long-term norm (1947–1953) for the central day in any system of points.

In Fig. 1, as an example, fields (indices) of cold transport are shown in the pre-winters before the droughty summer of 1955 and the well-moistened summer of 1956 on the virgin lands. Thin lines denote even anomalies of isohypses in dynamic decameters, while thick lines with arrows at the ends, drawn through the centers of the minimum regions and along the axes of troughs, denote the axes of the prevailing cold transport. From a comparison of these fields, the

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opposite character of the systems of cold transport with respect to the region under study in the compared pre-winters is clearly revealed. Indeed, in the pre-winter of 1954 the axes of cold advection passed around the region of the virgin lands clockwise, while in the pre-winter of 1955 they passed counterclockwise. It should be noted that these pre-winters were opposite also in the localization of the axes of transport of heat proper directed from the south, and this opposition extended far beyond the limits of the territory under study and, apparently, to the entire Northern Hemisphere.

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In accordance with the direction and position of the axes of advection of cold and of heat proper relative to the territory under study, we shall call the heat-transfer system in the prewinter of 1954 anticyclonic, and in the prewinter of 1955 cyclonic.

After the prewinters considered in the example, with heat-transfer systems of opposite sign, there followed, on the virgin lands of Western Siberia and Kazakhstan, a spring and summer with extremely opposite anomalies of precipitation, and with them of the entire complex of meteorological conditions that are of primary importance for crop formation.

Not having sufficient data for a physical explanation of the noted relationship, we shall prove its existence statistically. For this purpose, as a measure of the cyclonicity or anticyclonicity of the system of meridional (and monsoon) heat transfer in the atmosphere over the territory under study, we shall take the algebraic value of the projection onto the SW—NE direction of the gradient in the field of cold-advection indices between neighboring axes of ridges and troughs in triangle ABC (Fig. 1), whose vertices are located at the points $\varphi = 45^\circ$, $\lambda = 60^\circ$; $\varphi = 45^\circ$, $\lambda = 90^\circ$; and $\varphi = 60^\circ$, $\lambda = 90^\circ$.

It is most convenient to measure this gradient by the three-point method known from field theory (^{2}). In the case of a homogeneous field they are taken at the vertices of triangle ABC, and the calculations are very simple; in the case where ridges or troughs are present within triangle ABC, they are somewhat more complicated, since the space between the latter must first be divided into triangles, but nevertheless they are always feasible and their results are unambiguous. Let us denote the modulus of the gradient in dynamic meters per degree of meridian by a, and the azimuth of its direction (from larger to smaller) by α; then the adopted measure is the value $D = a\cos(\alpha + 45^\circ)$. The value D for the prewinter was compared with the precipitation total R, in millimeters, averaged over

Fig. 2. Changes by year in the argument D for the preceding pre-winter period (dashed line) and the precipitation total R from April through June of the given year (solid line)

Figure 2: Fig. 2. Changes by year in the argument D for the preceding pre-winter period (dashed line) and the precipitation total R from April through June of the given year (solid line)

39 stations located between the parallels 47 and 56° and the meridians 62 and 87°, for the following period from April through June inclusive. The entire series of years was studied, beginning with the prewinter of 1938, when upper-air meteorological charts first began to be compiled.

The results of calculating the index D for each preceding prewinter and the mean depth of the precipitation layer R from April through July of the given year were as follows:

Year	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948
D	−0.9	3.4	7.9	7.1	−0.9	−0.2	−5.9	9.0	14.2	0.0
R	89	81	99	101	92	92	95	124	122	94

Year	1949	1950	1951	1952	1953	1954	1955	1956	1957
D	6.8	2.0	−4.0	−3.2	−1.8	7.1	−8.8	4.1	−2.0
R	108	113	97	82	87	113	42	108	77

A graphical comparison of the values D and R by years (Fig. 2) clearly shows that, over nineteen years, the curve D from year to year, with small deviations, leads the curve R, and thereby makes it possible, in advance, several months ahead, to form an idea of the coming summer as either droughty or well supplied with moisture.

The correlation coefficient between D and R (excluding 1957) was found to be 0.780, and the regression equation is as follows:

$$R = 92.1 + 2.38\,D. \tag{1}$$

The triangle ABC was selected in such a way that the value D calculated within it proved to be most closely correlated with the precipitation value R over the territory under study.

The correlation coefficient between D and R exceeds its minimum significant value for 18 correlated pairs (0.708) at the very

Fig. 2. Changes by year in the argument D for the preceding pre-winter period (dashed line) and the precipitation total R from April through June of the given year (solid line)

high level of significance accepted in mathematical statistics, $P = 0.001$. It follows from this that there is a physical relationship between D and R, which can be used for the purposes of a long-range background forecast of precipitation for spring and the first half of summer. According to equation (1), it can be calculated in the first days of January.

After the article had been submitted for publication, it became possible to supplement Table 1 and Fig. 2 with the precipitation value R for 1957 and thereby to verify the forecast for that year. The forecast error proved to be only +10 mm, or 8% of the amplitude of R in the series of years studied.

Received
10 IV 1957

REFERENCES

1. D. A. Drogaitsev, *Izv. AN SSSR, Ser. Geogr.*, No. 3 (1957).
2. D. A. Drogaïtsev, *Probl. Arktiki*, No. 2 (1944).

Note: Figure translations are in progress. See original paper for figures.

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