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EMPIRICAL ORTHOGONAL FUNCTION ANALYSIS OF MEAN SEA LEVEL PRESSURE FOR THE NORTHERN HEMISPHERE AND THE EARTH

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SUMMARY

Northern hemispheric and global sea level pressure anomaly fields are prepared in this paper in order to study spatial patterns of the variability of circulation. It is examined how spatial patterns of the variability are modified by southern hemispheric processes. Predictability of this patterns has practical aspects.

KEY WORDS

Sea Level Pressure Anomaly Field - Spatial Pattern - Empirical Orthogonal Function Analysis - Eigenvector

Seasonal and monthly mean sea level pressure fields have been analysed to examine spatial patterns of variability of circulation for the Northern Hemisphere and the Earth. Furthermore it is studied that how spatial patterns of variability are modified over the Northern Hemisphere by those of the Southern Hemisphere.

The data basis stem from 247 meteorological stations which are approximately evenly distributed on the earth (Fig. 1). Empirical orthogonal function analysis of monthly and seasonal mean sea level pressure anomalies is used to determine the dominant modes which explain most of the variance for the period 1958-1980. Eigenvectors of January, April, July and October, moreover those of each season have been studied in this paper (Figs. 2-9).

At resolving each anomaly field into components it was enough to consider only the first 15 eigenvectors in order to explain at least 90 per cent of the total variance of each field. This means that if we are satisfied with restoring the original fields with 90 per cent accuracy, then the possible data reduction even in July is less as 30 per cent of the beginning data.

The monthly and seasonal first eigenvectors for the Northern Hemisphere (Figs. 2a-9a) and the Earth (Figs. 2b-9b), explaining greatest part of the variance of given fields, are generally characterised by zonality at high latitudes. The greatest anomaly centres of the eigenvectors are characteristically in regions of the centres of actions or near them. High and low latitudes have eigenvector anomalies of opposite sign. This anomaly pattern in the Northern Hemisphere is connected with the North Atlantic Oscillation (NAO) but spreads over greater territory - that is why it contains much more than the NAO, because the north-south fluctuations in mass take place not only in the Atlantic but - not so characteristically - in the Pacific, too. This pattern in the Southern Hemisphere is not so marked and stable as in the Northern Hemisphere.

Comparing the first three eigenvectors for the Northern Hemisphere and for the northern hemispheric components of the Earth respectively, it can be found that seasonally the first eigenvector pairs, moreover those of the middle months of each season show the greatest resemblance. Besides the first three eigenvector pairs of January are very similar. Of the eigenvectors of the middle months of each season and of those of each season the first eigenvector pairs generally correspond well for the Northern Hemisphere (Figs. 2a-6a, 3a-7a, 4a-8a, 5a-9a) and the Earth (Figs. 2b-6b, 3b-7b, 4b-8b, 5b-9b), respectively. The second and third eigenvector pairs differ more. Greatest difference can be found between the eigenvector pairs of northern hemispheric July and summer (Figs. 4a-8a).

The most interesting result of comparison of spatial eigenvector patterns, on the basis of correlation coefficients, is the difference of the eigenvector pairs of northern hemispheric July and summer for the Northern Hemisphere (Figs. 4a-8a) and the Earth (Figs. 4b-8b), respectively. (There are significant negative correlations between the first three eigenvector pairs of July and northern hemispheric summer for the Earth and there is no connection between them for the Northern Hemisphere.) The eigenvectors of July - especially those of the northern hemispheric summer - show weakest connection with the examined monthly and seasonal eigenvectors, respectively. Southern hemispheric components of the global empirical orthogonal functions hardly modify the first three seasonal and monthly northern hemispheric eigenvectors, respectively.

On the basis of correlation coefficients between the fields of standard deviation and the eigenvectors it has been found that there are positive significant connections between the first eigenvectors and the corresponding fields of standard deviation except summer and October. Areas with highest variance are at the same time regions of basical anomaly centres of the first few eigenvectors.

Seasonal and monthly eigenvectors with the same serial number correspond well with those of other studies. It has generally been stated that there is hardly any resemblance with corresponding eigenvectors of either July (Figs. 4a, 4b) or the northern hemispheric summer (Figs. 8a, 8b). The pattern is most marked in January (Figs. 2a, 2b) and in the northern hemispheric winter (Figs. 6a, 6b). Stability in position and intensity of anomalies of the first three (especially the first) eigenvectors are most characterised, not depending on whether from which period the data basis originates.

In most part of the seasons and months the dominant mode in the atmosphere is a high latitude zonal-type pattern, which corresponds to fluctuations in mass over the polar regions. Anomalies at high latitudes generally correspond to anomalies of opposite sign in low latitudes, both in the Northern and the Southern Hemispheres.

By harmonic analysis of the coefficient time series 2-3 yearly and 4-7 yearly significant periodicities are found. Further examinations are needed to reveal possible relations of these periodicities with the Quasi - Biennial Oscillation (QBO) and the Southern Oscillation (SO), respectively.

By bringing into connection coefficient time series and characteristic types of circulation it is concluded that zonal and meridional types of circulation are not determined unambigously by the sign of seasonal and monthly coefficients.

Significant correlations are found several times between monthly (seasonal) coefficient time series. If at the same time significant correlations are found between the corresponding eigenvectors as well, then a close relation is established between the given monthly (seasonal) anomaly fields. Close relation of considered anomaly fields in the Northern Hemisphere is not influenced by the southern hemispheric processes. Predictability of future monthly (seasonal) sea level pressure anomaly patterns on the basis of present anomaly patterns, by means of empirical orthogonal function analysis, can have practical advantage in long-range weather forecasts.

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Zones	No.	Zones	No.
90-80°N	2	0-10°S	17
80-70	14	10-20	13
70-60	17	20-30	19
60-50	24	30-40	14
50-40	27	40-50	7
40-30	24	50-60	7
30-20	18	60-70	5
20-10	22		
10- 0	17		
Northern Hemisphere	165	Southern Hemisphere	82
Earth: 247			

Table 1. Zonal distribution of stations

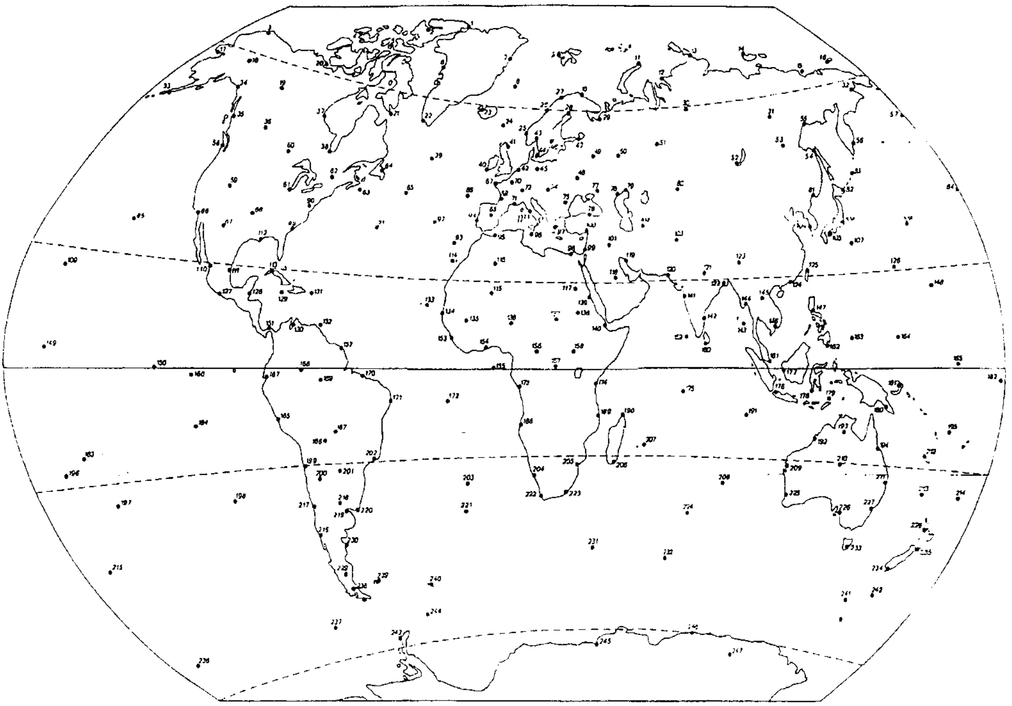

Fig. 1. Stations

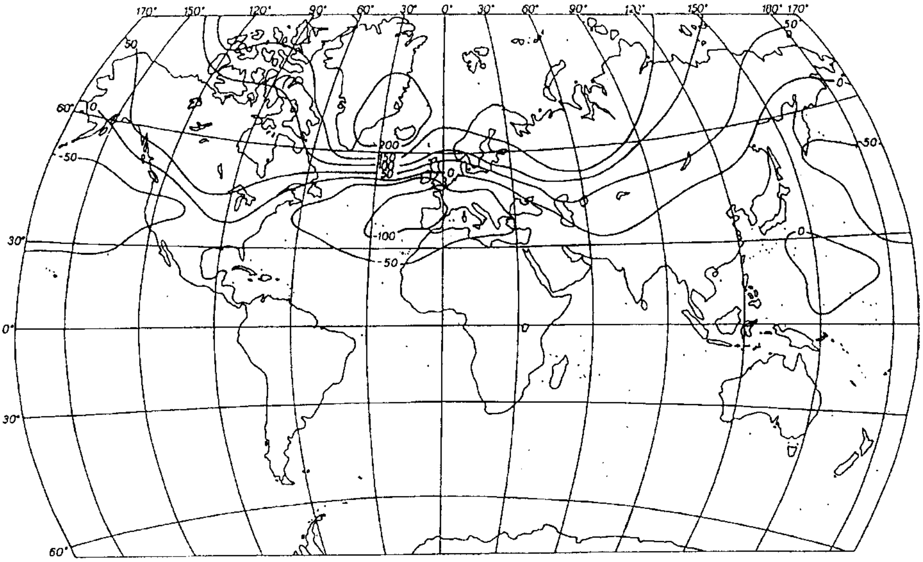

Fig. 2a. The first eigenvector for January, Northern Hemisphere

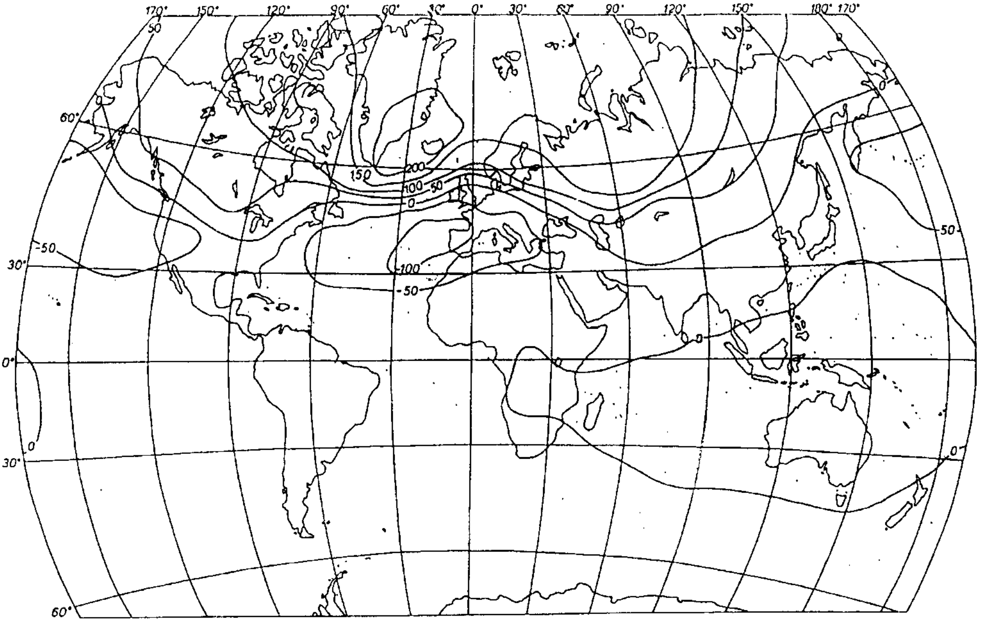

Fig. 2b. The first eigenvector for January, Earth

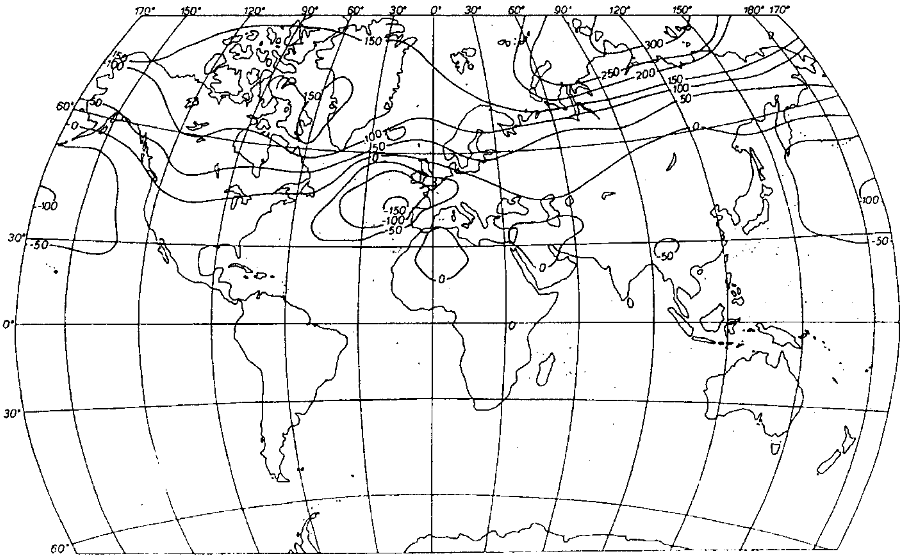

Fig. 3a. The first eigenvector for April, Northern Hemisphere

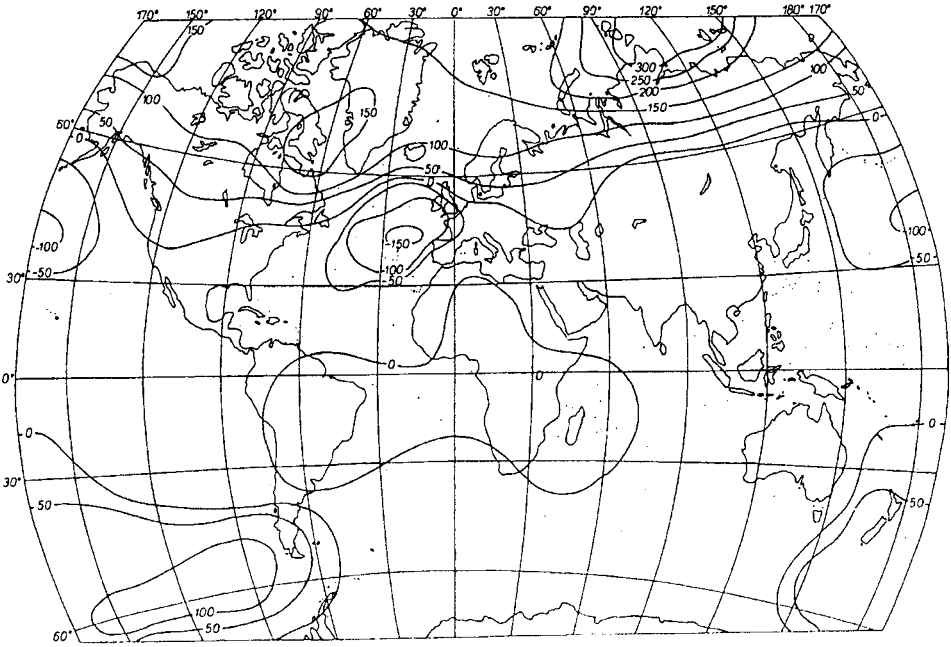

Fig. 3b. The first eigenvector for April, Earth

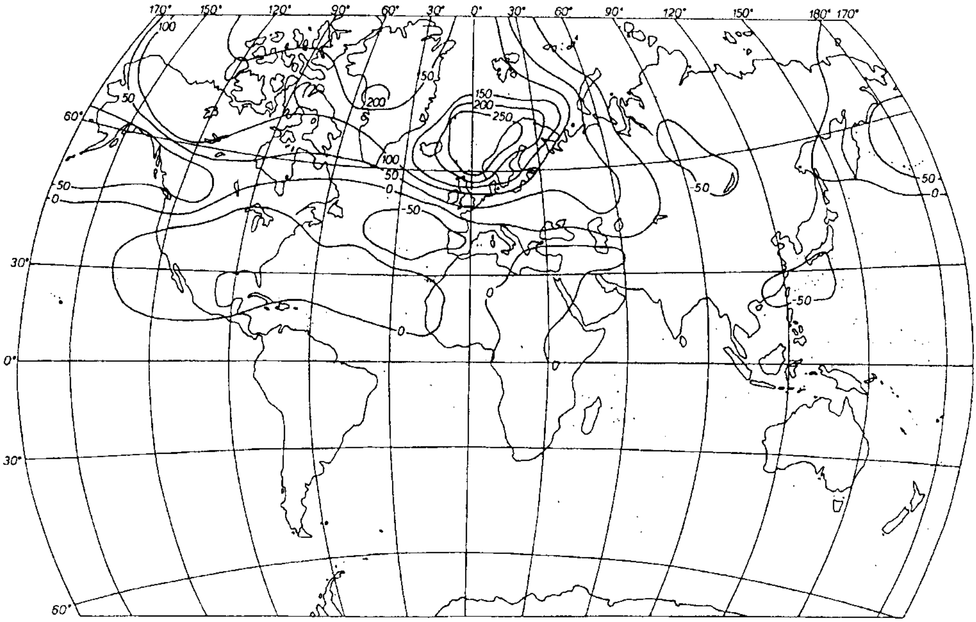

Fig. 4a. The first eigenvector for July, Northern Hemisphere

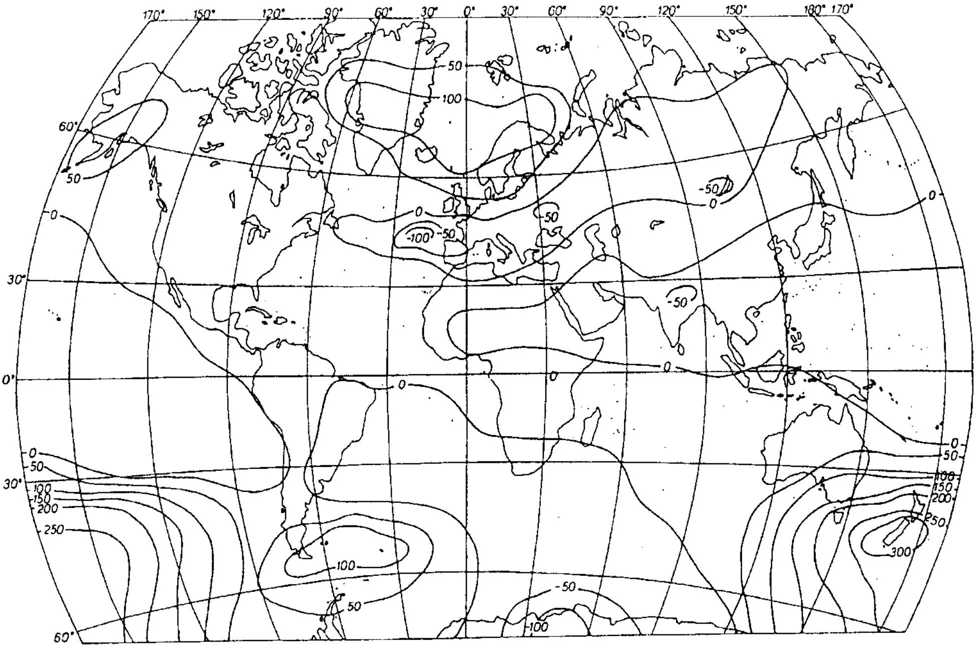

Fig. 4b. The first eigenvector for July, Earth

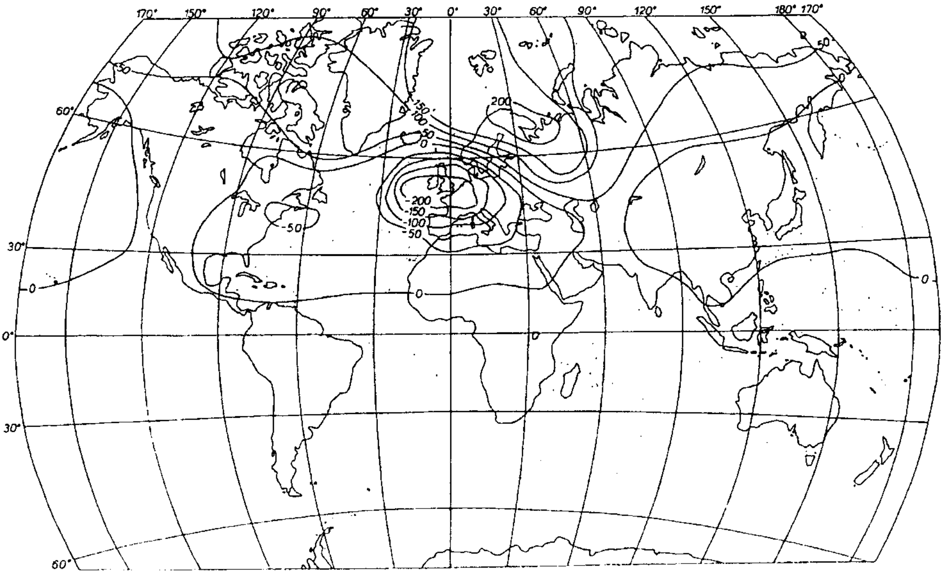

Fig. 5a. The first eigenvector for October, Northern Hemisphere

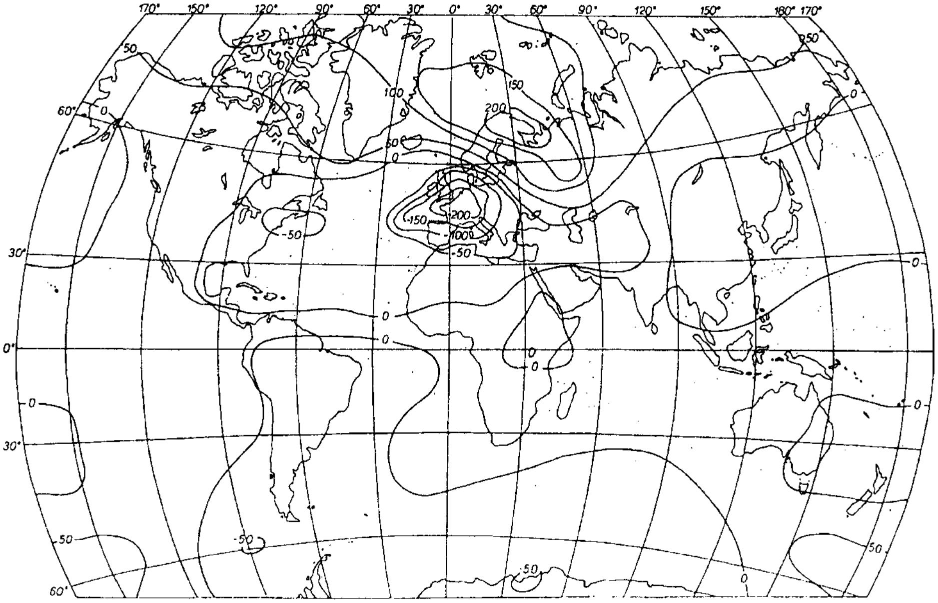

Fig. 5b. The first eigenvector for October, Earth

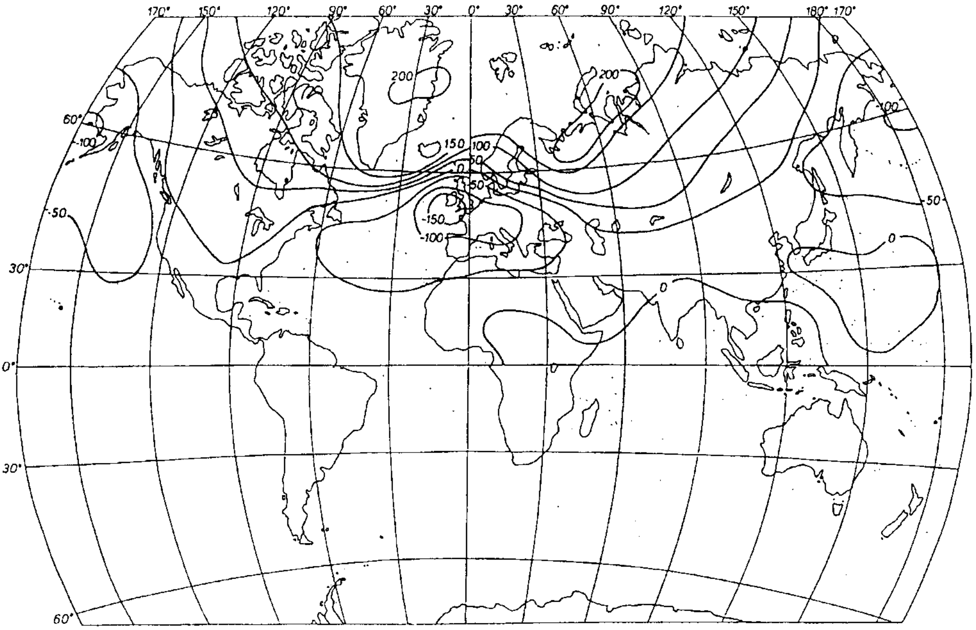

Fig. 6a. The first eigenvector for winter, Northern Hemisphere

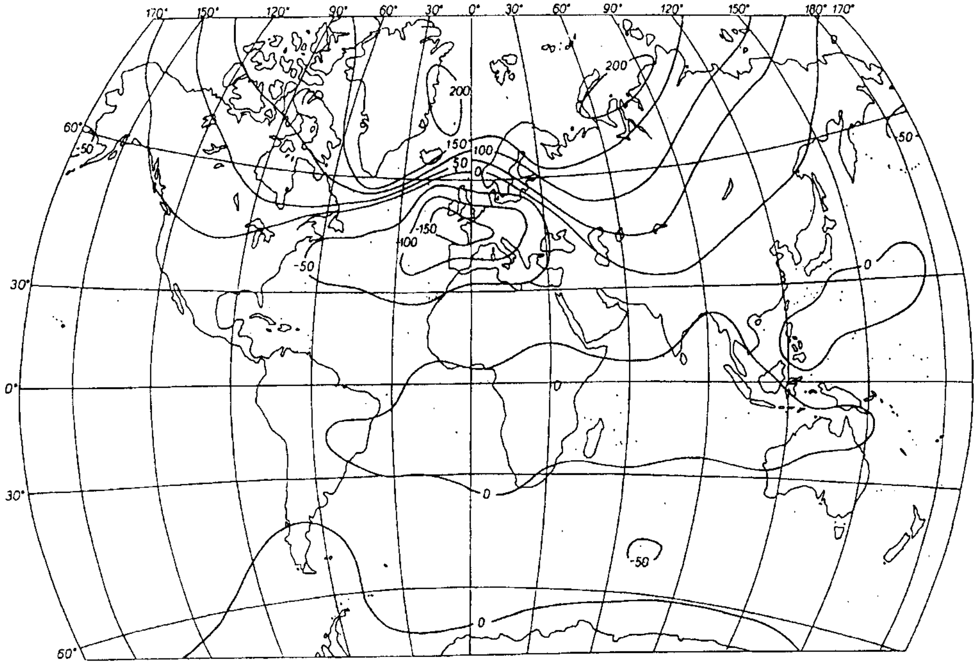

Fig. 6b. The first eigenvector for winter, Earth

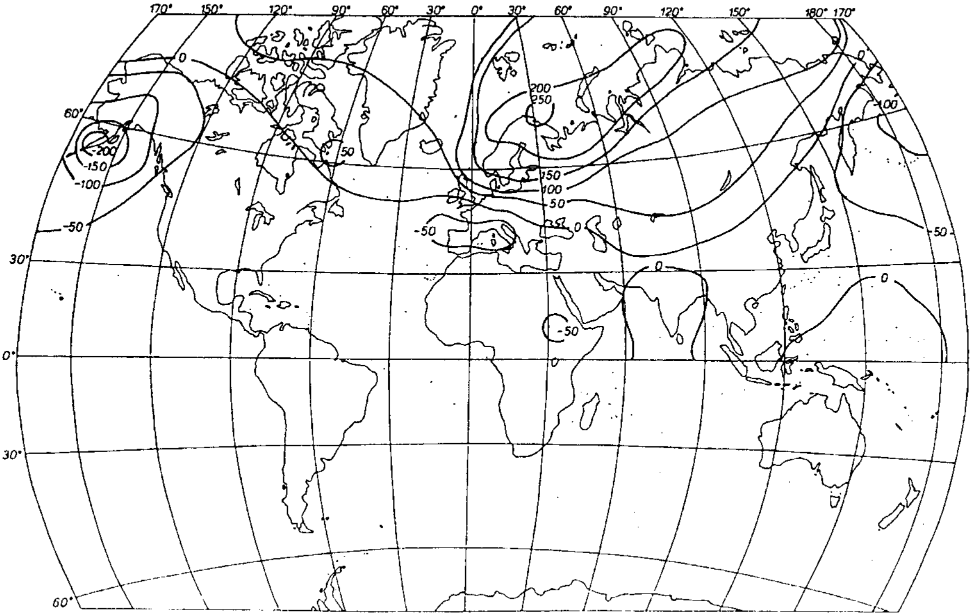

Fig. 7a. The first eigenvector for spring, Northern Hemisphere

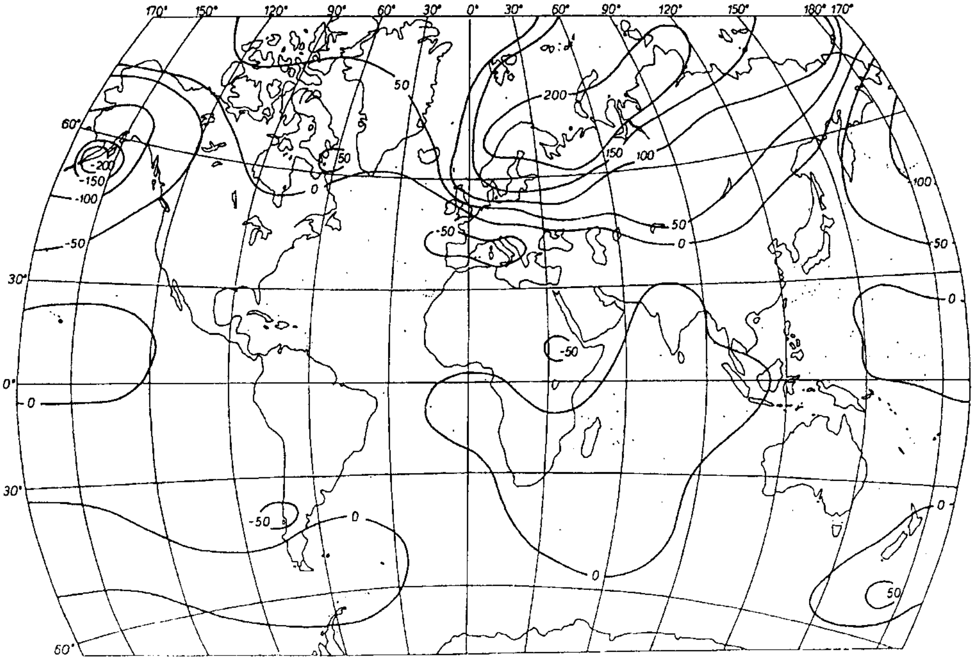

Fig. 7b. The first eigenvector for spring, Earth

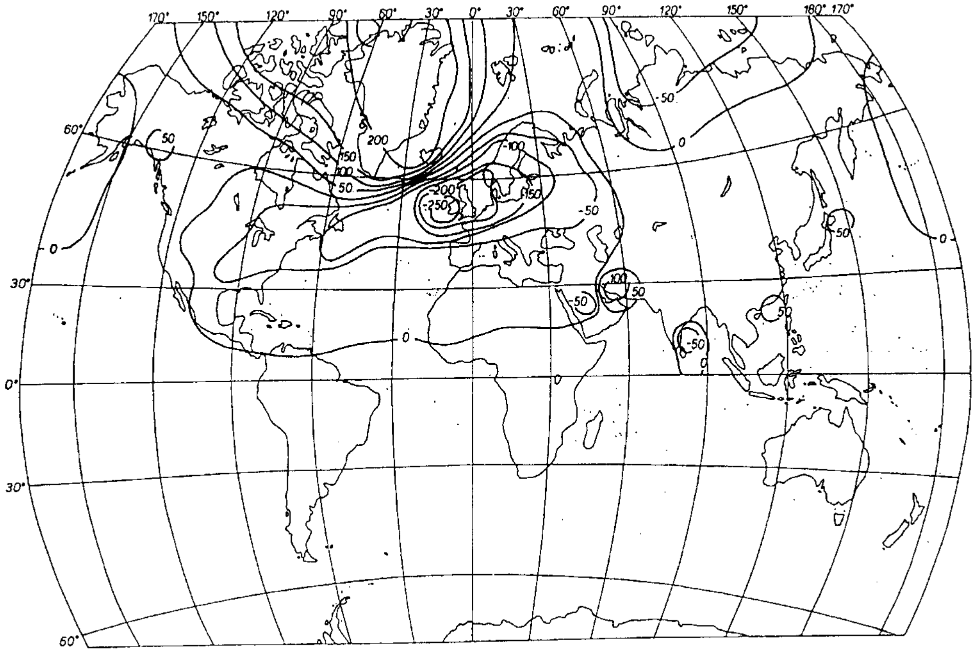

Fig. 8a. The first eigenvector for summer, Northern Hemisphere

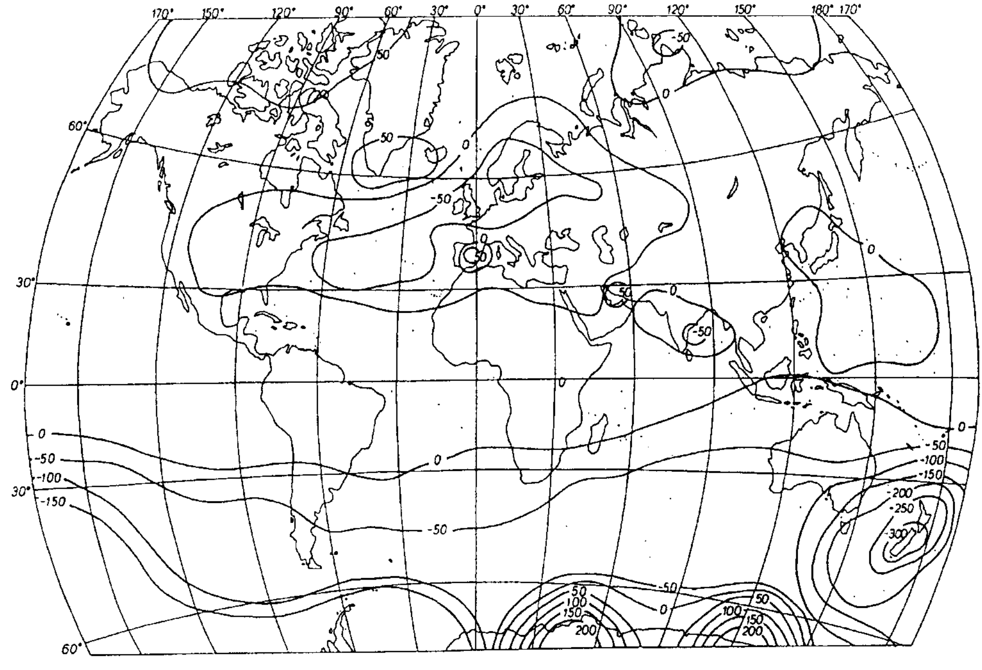

Fig. 8b. The first eigenvector for summer, Earth

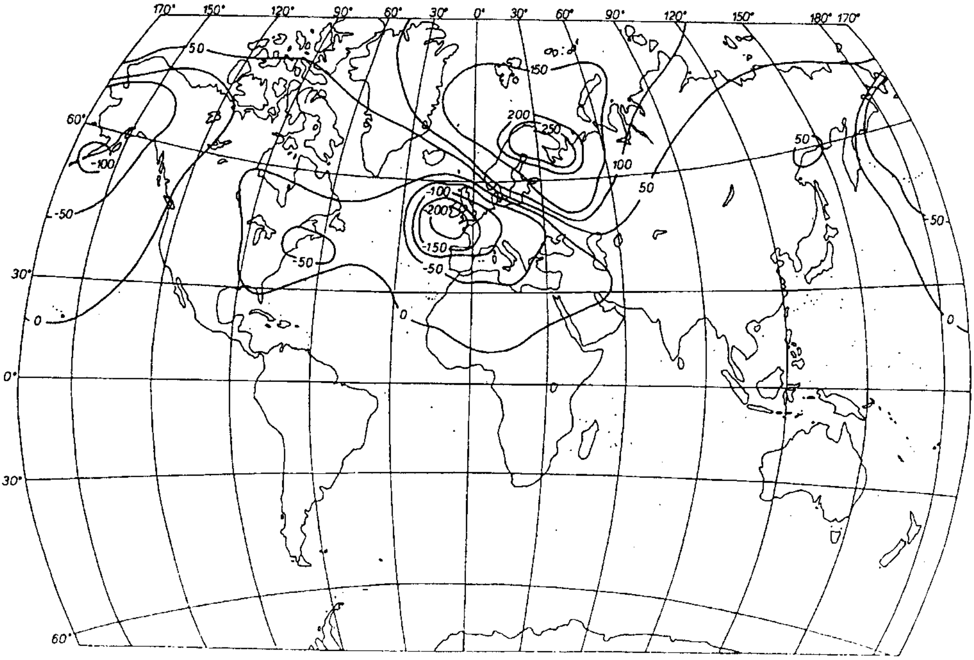

Fig. 9a. The first eigenvector for autumn, Northern Hemisphere

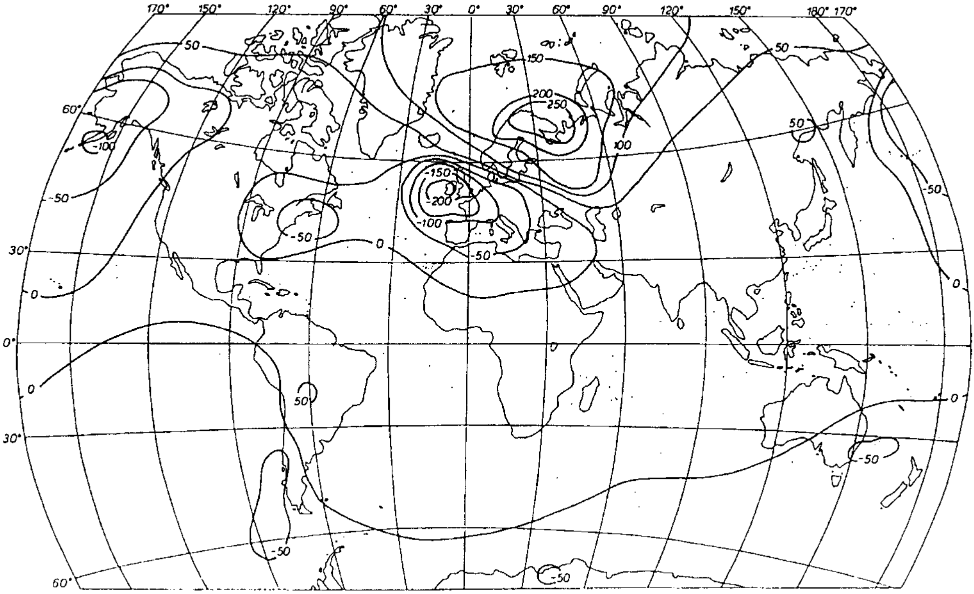

Fig. 9b. The first eigenvector for autumn, Earth