NUTATIONAL MIGRATION OF THE ICELANDIC MINIMUM OF ATMOSPHERIC PRESSURE

GEOPHYSICS

1967

SovietRxiv

Abstract

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UDC 551.54

GEOPHYSICS

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NUTATIONAL MIGRATION OF THE ICELANDIC MINIMUM OF ATMOSPHERIC PRESSURE

(Presented by Academician V. G. Fesenkov, 29 XII 1966)

A number of works have been devoted to the study of the influence of free oscillations of the Earth' s axis of rotation on processes occurring in the ocean and atmosphere of the Earth ([1–7]). Here we set forth the results of a study of the dependence of the morphometric characteristics of the Icelandic minimum of atmospheric pressure on the free motions of the instantaneous pole of the Earth' s rotation.

The dimensions, depth, and position of the center of the Icelandic depression depend, as is known, on the distribution of water masses and the fronts separating them in the northern part of the Atlantic Ocean. In the ocean there is present a wave created by free oscillations of the Earth' s axis of rotation—the "polar tide." Producing rhythmic changes in the main currents in the ocean, the polar tide is capable, in our view, of influencing the main centers of action of the atmosphere and especially their position. To clarify this question we used the very valuable data on the mean depth of the Icelandic depression and on the coordinates of its center, calculated by R. V. Abramova ([8]) for each month of the period from 1900 to 1955. These data were analyzed with the aid of periodograms, obtained on the BESM-2 machine by the classical method of periodogram analysis according to A. Schuster. Each time, 14-year series of monthly mean values of the characteristics under study were introduced into the analysis. At the same time, the values of the component of the instantaneous pole of the Earth' s rotation along the 0–180° axis (X) were analyzed. The data obtained from the analysis of the characteristics considered are given in Tables 1–3 and in Figs. 1 and 2.

The results of the analysis provide grounds for the following conclusions:

1. The free motions of the instantaneous pole of the Earth' s rotation are directly connected with the corresponding 14-month motions of the center of the Icelandic depression. When the pole is displaced in the direction of the 0° meridian, the center of this depression moves along azimuth 258°, and conversely, when the pole is displaced in the direction of the 180°

meridian, the center of the depression moves along azimuth 78°. Thus, the Icelandic minimum of atmospheric pressure in its nutational motions seems to follow the pole. This gives grounds to speak of the existence of a nutational 14-month migration of the entire Icelandic depression.

2. The dimensions of the nutational migration of the Icelandic minimum are very large. The major axis of the nutational ellipse of the center of the Icelandic depression reaches, according to our data, 900 km (1942–1955). The 14-month nutational migration of the Icelandic minimum amounted on average to 45–48% of the annual 12-month migration of this center of action of the atmosphere. The real seasonal displacements of the Icelandic depression are always the result of the mutual superposition of these two main components in the motions of the Icelandic minimum. The principal consequence of the superposition of two phenomena different in their nature is a 7-year rhythm of seasonal changes in the position of the center of the depression. In the depth of the Icelandic pressure minimum, the nutational regularities appear very weakly and amount on average to 14% of the mean long-term annual changes.

depth of the depression. This means that the free motions of the Earth' s pole affect not so much the depth as the position of the Icelandic depression. This conclusion appears to be very important.

Table 1

Average values of the amplitude A and phase ψ of the 14-month variation of the mean depth P, latitude φ, and longitude λ of the center of the Icelandic minimum of atmospheric pressure, in comparison with the mean values of the amplitude and phase of the 14-month variations of the component of the Earth' s pole of rotation on the 0–180° axis (X)

Observation periods	P	P	φ	φ	λ	λ	X	X
	A, mb	ψ, deg.	A, deg.	ψ	A, deg.	ψ	$1{\cdot}10^{-2}$	ψ
1900 – 1913	1.18	69	1.3	285	5.3	79	15.8	25
1914 – 1927	1.05	230	1.7	17	4.1	42	10.8	312
1928 – 1941	0.31	101	0.4	85	3.1	95	6.8	45

Observation periods	P	P	φ	φ	λ	λ	X	X
1942–1955	0.77	273	1.5	165	7.4	175	20.6	5

Table 2

Average values of the phase difference "pole minus Icelandic minimum" * in the values of the mean depth, latitude, and longitude of the center of the Icelandic minimum of atmospheric pressure

Observation periods	$\psi(X)-\psi(P)$, deg.	$\psi(X)-\psi(\varphi)$, deg.	$\psi(X)-\psi(\lambda)$, deg.	λ_{cp}, deg.
1900–1913	−44	–	−54	30
1914–1927	82	−65	−90	26
1928–1941	−56	−40	−50	30
1942–1955	93	−160	−170	18

* The minus sign means that the corresponding reaction precedes the moment at which the Earth' s pole of rotation passes through the Greenwich meridian.

3. It is known that the magnitudes of the free oscillations of the Earth's axis of rotation change considerably with time, sometimes increasing for reasons that are still unclear, and sometimes decreasing. Accordingly, as it turns out, the magnitudes of the nutational migration of the Icelandic pressure minimum also change. Thus, for example, from 1928–1941 to 1942–1955, both the magnitudes of the free motions of the Earth' s pole and the magnitudes of the nutational displacements of the center of the Icelandic depression increased almost 2.5-fold. Along with this, the climate-forming role of the nutational migration of the depression also changes with time.

4. Various authors ([1,3,5,6]) have shown the existence in the Earth' s atmosphere of nutational, by origin, variations of monthly mean values of atmospheric pressure. However, the mechanism of this connection has not been clarified. If the question is considered statically, then it is obvious that the 14-month variations in the deformation force $[W_p]_{14}$ associated with the free oscillations of the Earth' s axis of rotation ([12]) are, in their magnitude, insufficient to explain the significant nutational changes in atmospheric pressure. However, static concepts do not

Table 3

Values of the ratio of the amplitude of the 14-month variation to the amplitudes of the annual (12-month) variation $A_{14} : A_{12}$ in the values of the mean depth P, latitude φ, and longitude λ of the center of the Icelandic minimum of atmospheric pressure

Observation period	P	φ, deg.	λ, deg.
1900–1913	0.19	0.54	0.36
1914–1927	0.16	0.61	0.40
1928–1941	0.05	0.12	0.48
1942–1955	0.16	0.52	0.68
Average	0.14	0.45	0.48

Fig. 1. Periodograms of multimonth changes in the depth P, latitude φ, and longitude λ of the location center of the Icelandic minimum of atmospheric pressure, and of X, a component of the pole of rotation of the Earth during the period from 1911 to 1924. On the ordinate axis of the periodograms are shown the oscillation amplitudes: for the X axis—in hundredths of an arc second; for the Icelandic minimum of atmospheric pressure: in the case of P—in mb of atmospheric pressure, in the case of φ—in degrees of latitude of the depression-center location, and in the case of λ—in degrees of longitude of the depression center.

Fig. 2. Ellipses of the free motions of the instantaneous pole of rotation of the Earth, in comparison with ellipses of 14-month displacements of the center of the Icelandic minimum of atmospheric pressure, on average for the periods from 1928 to 1941 and from 1942 to 1955.

cannot be used either to explain this phenomenon or to substantiate doubts as to its existence. Our study leads to a different explanation of the mechanism by which nutational pressure variations arise. From the data presented it is evident that the nutational changes in the mean depth of the Icelandic minimum are very small. But the changes in its position, namely in the mean latitude and longitude of the center of the depression, are very large. Consequently, the main role here is played by the nutational migration of the centers of action of the atmosphere. And the nutational variations of atmospheric pressure at individual points in the high latitudes of the planet arise only as a consequence of displacements of the centers of action of the atmosphere that are nutational in their origin. The cause of these displacements, as may be supposed, is the 14-month change—associated with the free oscillations of the Earth's axis of rotation —in the horizontal component of the deformation force W_p. It is precisely the action of the horizontal component of this force that explains, in particular, the already noted increase with latitude in the amplitudes of the nutational variations of atmospheric pressure.

Received
17 XI 1966

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