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Abstract

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OSCILLATIONS OF THE BARIC FIELD OF THE NORTHERN HEMISPHERE IN THE 11-YEAR CYCLE OF SOLAR ACTIVITY

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The present stage in the development of research in the field of Sun–Earth relations is characterized by the fact that, from establishing individual connections between elements of the hydrometeorological regime and solar activity, a transition has been made to consideration of planetary regularities in solar-conditioned changes in the circulation of the atmosphere and ocean. In this connection it seems important to consider the question of the influence of the 11-year cycle of solar activity on the baric field of the Earth' s Northern Hemisphere.

For this purpose, maps of mean monthly sea-level pressure compiled by the U.S. Weather Bureau from 1899 to 1939 were used.* On the basis of data taken from these maps, annual mean values of sea-level atmospheric pressure were calculated at the nodes of a coordinate grid spaced every 5° in latitude and 20° in longitude. From the material thus obtained, the 40-year mean amplitudes and phases of the 11-year solar-conditioned variation of atmospheric pressure in the Northern Hemisphere were determined at 271 points. All calculations were carried out on the BESM-2 electronic computer.

Figures 1–3 present the results of the analysis: maps of amplitudes and phases of the 11-year variation of atmospheric pressure, as well as a graph of the change with latitude of the amplitudes of the variation under consideration, averaged over the hemisphere.

The maps and graph presented make it possible to draw the following conclusions concerning solar-conditioned multiyear oscillations of atmospheric pressure in the Earth' s Northern Hemisphere.

1. Analysis of the distribution of amplitudes (Figs. 1 and 3) of the 11-year pressure variation over the hemisphere shows that its maximum values are confined to the latitudinal belt 65–75° N. The result obtained is very noteworthy, since this latitudinal belt is characterized by the maximum

Figure 1. Distribution of the amplitudes of the 11-year solar-conditioned variation in the baric field of the Northern Hemisphere of the Earth (the cross marks the geomagnetic pole of the Earth; the thick solid line is the principal zone of auroras)

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density of solar corpuscular radiation, the maximum development of auroras, powerful high-altitude anticyclogenesis ([1]), and also, as recent studies by B. I. Sazonov show, by the maximum disturbance of zonal circulation.

The greatest values of the amplitude of the 11-year variation of atmospheric pressure are reached in the northwestern part of North America, in the region of Alaska, and amount to 2 mb. This means that over 11 years the mean annual change of atmospheric pressure in this region is about 4 mb. In the regions of the centers of action of the atmosphere, the change of pressure in the 11-year cycle amounts to 1.0–2.0 mb.

The minimum values of the amplitude of the 11-year pressure variation are observed in the latitudinal zone 20–25° N. Toward the equator, the amplitudes of this variation increase somewhat.

2. From the results of the analysis of the distribution over the hemisphere of the phases of the 11-year solar-conditioned variation of atmospheric pressure, it is necessary to note the opposite course of pressure in the zones of the high-latitude minima and the equatorial depression and in the zone of the subtropical belt of high pressure. When the pressure in the region of baric minima decreases, the pressure in the region of maxima increases. In this case, comparison of the phases of the 11-year pressure variation in the regions marked on the map

* Available at the International Meteorological Centre in Moscow.

Fig. 1. Distribution of the amplitudes of the 11-year solar-conditioned variation in the baric field of the Northern Hemisphere of the Earth (the cross marks the geomagnetic pole of the Earth; the thick solid line is the principal zone of auroras)

Fig. 2. Distribution of the phase of the 11-year solar-conditioned variation in the baric field of the Northern Hemisphere of the Earth (the lightly hatched region (**1**) is the region in which oscillations of atmospheric pressure are in phase with oscillations of solar activity; the densely hatched region (**2**) is that in which oscillations of atmospheric pressure are in phase opposite to the phase of oscillations of solar activity), $\varphi_{\odot} = 173^{\circ}$

zones with the phase of the course of solar activity over the same period shows

Figure 2. Distribution of the phase of the 11-year solar-conditioned variation in the baric field of the Northern Hemisphere of the Earth (the lightly hatched region (1) is the region in which oscillations of atmospheric pressure are in phase with oscillations of solar activity; the densely hatched region (2) is that in which oscillations of atmospheric pressure are in phase opposite to the phase of oscillations of solar activity), $\phi = 173°$

Figure 2: Figure 2. Distribution of the phase of the 11-year solar-conditioned variation in the baric field of the Northern Hemisphere of the Earth (the lightly hatched region (1) is the region in which oscillations of atmospheric pressure are in phase with oscillations of solar activity; the densely hatched region (2) is that in which oscillations of atmospheric pressure are in phase opposite to the phase of oscillations of solar activity), $\phi = 173°$

Fig. 3

Figure 3: Fig. 3

that, with an increase in solar activity, pressure rises in the region of baric depressions and pressure falls in the region of the location of stationary anticyclones. As is seen from Fig. 2, the pattern obtained extends to the regions of the Icelandic and Aleutian lows, on the one hand, and to the regions of the Azores, North Pacific, and Siberian anticyclones, on the other, i.e., it represents a global pattern. This result contradicts the law of accentuation of the baric field of E. E. Fedorov–V. Yu. Vize ([2]). However, this is not unexpected. Long ago, in studies of oscillations of the general circulation of the atmosphere, conclusions were obtained that contradicted this law. Thus, many researchers ([3,4]) established that when the level of solar activity rises, the zonality is disturbed and meridional processes in the atmosphere intensify, whereas, if the law of accentuation were observed, the zonal circulation should have developed considerably.

Fig. 3. Latitudinal variation of the amplitude of the 11-year solar-induced variation of atmospheric pressure, averaged over the entire Northern Hemisphere

In reality, however, when solar activity intensifies, the Icelandic and Aleutian depressions are filled in and pressure decreases in the subtropical maxima. The meridional pressure gradients decrease, the zonality of circulation inherent in the atmosphere is disturbed, and conditions are created for the development of meridional processes.

In conclusion, it should be noted that the results obtained, in the part concerning the global character of the distribution of the amplitudes of the 11-year variation in the mean value of surface atmospheric pressure, in general confirm the conclusions obtained by I. V. Maksimov and B. A. Sleptsov ([5]). However, they do not confirm these authors' conclusion about the existence in the Earth' s atmosphere of a solar-induced planetary baric standing wave, whose crests are located at the poles and the equator, and whose nodal lines are on the 35°

parallel. The 11-year solar-induced baric wave is a considerably more complex phenomenon. Its main feature consists in a simultaneous increase of pressure in polar and equatorial geomagnetic latitudes and a decrease of pressure in middle geomagnetic latitudes, and conversely. When solar activity increases, this leads to a weakening of baric formations, a decrease in meridional pressure gradients, a disturbance of zonal circulation, and an intensification of meridional circulation.

The result of the existence of an 11-year solar-induced cycle in the Earth' s baric field should be a similar cyclicity in a number of hydrometeorological phenomena; moreover, the sign of the connection between changes in the hydrometeorological regime and solar activity will be determined by the location of the region under consideration relative to the principal centers of action of the atmosphere. The degree of influence of solar activity on various indicators of the hydrometeorological regime will also not be the same in different regions of the Earth. It may be assumed that the maximum influence of solar activity on processes in the atmosphere should be observed at high latitudes and, above all, in the region of the northern part of the Pacific Ocean and Canada and in the north of Eastern Siberia.

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