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RELATIONSHIP BETWEEN CERTAIN PARAMETERS OF THE TROPOSPHERE AND IONOSPHERE AND THE VARIATIONS OF SOLAR WIND VELOCITIES

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SUMMARY

This study is based upon the correlation between data on solar wind velocities (s.w.v.) and on near-Earth atmospheric pressure on the one part, and also between the former and the critical frequencies variations in the F2-layer of the ionosphere. Comparative diagrams are presented, involving American data of IMP-2, Mariner-2 and Pioneer-6, and Russian data on Δf_0F_2.

The existence is assumed of an enhancing mechanism in the solar wind action upon the Earth's magnetosphere, in which the variations of s.w.v. constitute a modulating agent. The polarity of the interplanetary magnetic field may possibly play the role of external control voltage in the trigger mechanism whose action determines the direction of a series of geophysical processes.

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In accordance with [1] new relationships have been established between the variations of solar wind velocities (s.w.v.) and the fluctuations of meteorological parameters on various isobaric surfaces in certain regions. The disturbed state of the F2-layer of the ionosphere can also be satisfactorily correlated with the changing character of solar plasma behind the outer boundary of the leading shock wave. Part of the corresponding data are presented below.

Figure I shows the s.w.v. fluctuations measured by a satellite of the VELA-2 [2] series over the course of four solar revolutions Nos. 1793-1796. Each revolution is divided into four sectors with predominant polarity of the interplanetary magnetic field. In determining the assumed boundaries of these sectors data were taken into account concerning the stability of the active region on the Sun in its magneto-optical or magnetic phase, the distribution of s.w.v. within a sector and the geomagnetic activity associated with it, and the presence of recurrent sc and si. For correlation purposes, measurements of the polarity of the interplanetary field were used, which were performed with the IMP-I satellite and the MARINER-4 station [3] in the early and latter parts of 1964. The assumed boundaries of the sectors and the polarity of the interplanetary field indicated in [1], were confirmed by making use of the data obtained from the IMP-2 satellite [4].

Curve 3 in Fig.I, which characterizes the fluctuations of the near-earth atmospheric pressure at 1200 hours UT, was obtained by averaging the data from 7 Kurilo-Kamchatka regions. According to [5] the center of one of the zones of cyclogenesis caused by the Sun is located in this area. As may be seen in Fig.I, pressure variations in the regions examined are stochastically connected with the fluctuations of solar wind velocities, similarly to the temperature field of the troposphere along the Black Sea coast [1], As in [1], this connection has an inversional character, i.e. the variations of the connection sign take place with change in the interplanetary field polarity. The passage of the sector boundary does not induce a change of the connection sign in this region every time (11 August, 24 October); if , however, inversion does take place, it is observed after the passage of boundaries (3 and 31 August, 6 and 27 September, 3 and 17 October). The correlation factors, r, characterizing the crowded state of the negative and positive connections and obtained by combination of the factors, are respectively equal to - 0.51 and 0.56. We compute the values of z, σ_z and of the probability P of a random correlation factor deviation for the above values of r by utilizing the Fisher transformation: the negative connection $z = 0.563$, $\sigma_z = 0{,}127$, $P < 0{,}0001$, the positive connection $z = 0{,}633$, $\sigma_z = 0{,}183$, $P = 0{,}0006$. The values of P thus obtained are evidence of the high significance of the correlation factors. Fig.I shows quite clearly not only the 27-day recurrence of pressure peaks corresponding to high-velocity plasma fluxes or to quiet solar wind periods, but also the 27-day recurrence of inversions of the connection sign; at the same time, some sector boundaries were found to be more effective in this respect for the given regions (boundary of sectors I-II and II-III), while others did not induce such an inversion (boundary of sectors III-IV).

Fig.I also gives the curve 2 showing in percent the deviations of the critical frequencies f_0 of the ionosphere's F2-layer from the monthly median (Moscow). The deviations were averaged for the period from 1000 to 1400 hours LT. Comparison of curves 1 and 2 shows that the disturbed state of the F2-layer can be correlated with changes of s.w.v. The connection is characterized by a negative sign with the exception of sector II of the revolution No. 1796, where inversion of the connection sign is observed after the passage of the sector boundary on 24 October. The correlation factor, calculated by means of "variable differences" (so as to exclude long-

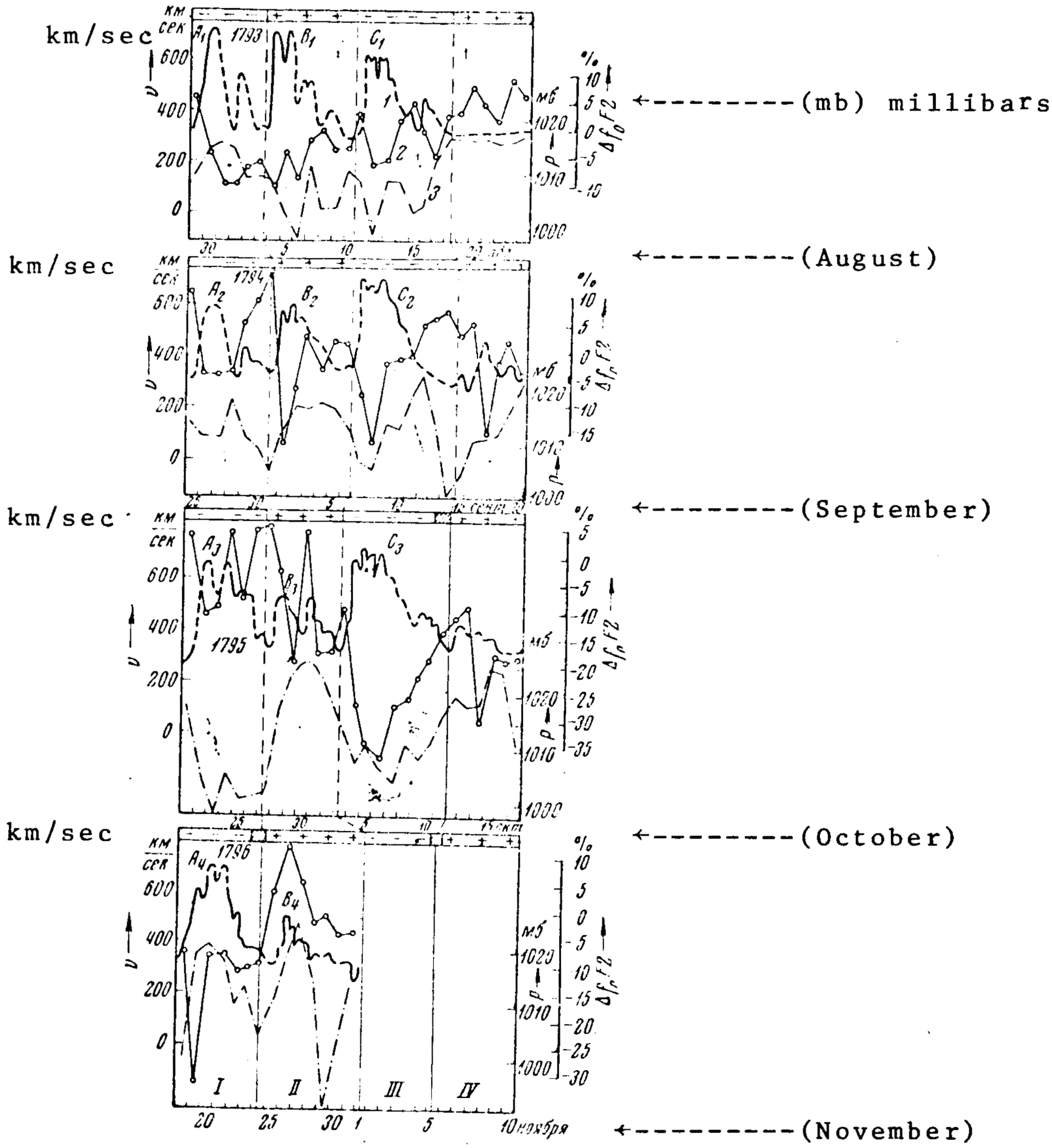

Fig.I.

1) Curve of solar wind velocity. The dotted line corresponds to the position of the satellite in the boundary layer inside the Earth's magnetosphere; 2) curve of critical frequency deviations from the monthly median in % ($\Delta f_0 F2$), at the Moscow station, averaged for the period 1000 to 1400 LT; 3) curve of the near-Earth atmospheric pressure at 1200 UT, averaged for 7 Kurilo-Kamchatka meteorological stations.

Vertical solid lines are sector boundaries of interplanetary field according to data from the IMP-2 satellite [4]; dotted lines are the assumed sector boundaries. For each solar revolution, the polarity of the interplanetary field is shown on top. The assumed interplanetary field polarity corresponds to the dotted-line sector boundaries. Shaded areas designate the absence of measurements on the IMP-2 Satellite. I-IV are arbitrary sector numbers.

period variations), is equal to - 0.57; $z = 0,648$, $\sigma_z = 0,115$, $P < 0,0001$. For a given region and period the drop of f_0F2 coincides in time with the rapid plasma flow past the Earth's magnetosphere, while the increase of f_0F2 is associated with quiet solar wind periods and the passage of sector boundaries. Although some of the Δf_0F2 do not exceed 5-10% and therefore cannot be classified into the category of ionospheric disturbances, it is important to note that even small day to day fluctuations of electron density are closely associated with the variations in the parameters of the unperturbed solar plasma. The disturbance of the nighttime ionosphere is also well correlated with s.w.v.; this, however, for a shift of the corresponding curve by several hours with respect to curve 2.

Data on s,w,v, from MARINER-2 and PIONEER-6 were also compared with Δf_0F2 (Moscow). Characteristic for the working period of MARINER-2 [6] are the more frequent inversions of the connection sign with predominance in the duration of the positive connection A sharply expressed positive connection is observed during the period of s.w.v. measurement with PIONEER-6 [7]. On the basis of an analysis of these data we may conclude that the nature of the connection between ionospheric and magnetic disturbances in a given region depends upon the connection sign of s.w.v. and the ionospheric disturbance criterion. In the case of negative connection (see Fig.I) increases of f_0F2 during quiet solar wind periods take place in the background of an undisturbed geomagnetic field. The predominance of this type of connection (negative disturbances) during periods of maximum and decreasing solar activity at high and medium latitudes provided a basis for concluding [8] that there is no connection between positive disturbances and the geomagnetic activity. On the other hand, in the case of positive connection the increase of K_p during periods of passage of high-velocity fluxes will correspond to an increase of f_0F2; however, when Δf_0F2 exceed + 20% , it will correspond to positive disturbances. If the connection sign of s.w.v. and Δf_0F2 is mainly determined by the sectorial structure and polarity of the interplanetary field, the basic importance of studying this aspect of interplanetary field interaction with the Earth's magnetosphere, becomes obvious.

As may be seen from Fig.I, an increase of f_0F2 takes place before the Earth's magnetosphere hits the fast plasma jet; this is followed by a sharp drop of f_0F2 and the development of negative disturbances. When the corresponding Δf_0F2 are high (scale 2-3) their combination may constitute a two-phase disturbance. Disturbances 3-7 August, 3 September, and 19-20 October (with respect to perturbation of the nighttime ionosphere may be referred to such a type. More often, however, positive deviations prior to negative disturbances do not exceed 5-10%. From the detailed matching of curves 1 and 2 it follows also that the intensity and character of the D_{st}-variation of f_0F2 are to a significant extent determined by the distribution of s.w.v. within the given sector.

Examination of the temporal course of mean drift velocities of ionospheric inhomogeneities in the F2-and E-layers (Katsiveli station, Crimea) indicates a trend toward a sharp increase in drift velocities during those periods when the Earth is located in high-velocity plasma fluxes. The change in the sign of the ionospheric perturbation and of the K_p dependence that is of drift velocity to an inverse function, during transition from moderate to equatorial latitudes [9,10], is also evidence of the existence of a common cause responsible for an increase in perturbation and drift velocities in the ionosphere.

The very existence of a link between s.w.v. and Δf_0F2 could have been expected, starting from the presence of an intimate correlation between s.w.v. and the K_p-index and between K_p and Δf_0F2. In view of the clearly expressed "response" of the ionosphere even to small variation in s.w.v., we may assume the presence of a deep causative phenomenon connection. The maximum fluctuations of f_0F2 and h'F2 are observed in the aurora zone tied up to coastal sea regions [11]. From this zone acoustic gravitational waves [12] propagate into low latitudes, these being generated during the passage of the Earth through the shock wave front.

In the example considered here the effect of sectorial structure of the interplanetary field is less pronounced in the ionosphere than in the troposphere. A greater "response" of the ionosphere is characteristic for the period during which MARINER-2 was operating.

Measurements of s.w.v. and of the locations (positions) of the magnetopause and of the leading shock wave, performed with satellites of the VELA-2 series, have shown that the shifts of the magnetopause and the shock wave, taking place at high speeds, are connected with the change in pressure of solar plasma and are correlated with the K_p-index and, consequently, with s.w.v. [13]. When the shape and size of the magnetosphere change, hydromagnetic and acoustic gravitational waves are excited, and the action of these waves results in a more intense circulation in the upper atmosphere. Dissipation effects of magnetohydrodynamic waves in the ionosphere manifest themselves in a disruption of the temperature regime and in corresponding changes of the effective recombination coefficient and of the photochemical reactions rate [14]. Spatial displacements of the shock wave and of the magnetopause are likely to contribute to the excitation of internal gravitational waves, which manifest themselves in the propagation of ionospheric disturbances in vertical and horizontal directions. The rapid transmission of disturbances from the upper atmosphere into the stratosphere and troposphere results in an activation of Sun-induced action centers of the atmosphere and of subsequent variations in the macrosynoptic process. Energetic considerations compel us to assume the existence of an enhancing mechanism in the action of the solar wind upon the Earth's magnetosphere, in which variations of s.w.v. constitute a modulating agent [15]. To this we must add that the polarity of the interplanetary field possibly plays the role of an external control voltage in a trigger mechanism whose action determine the direction of a series of geophysical processes.

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