SOLAR WIND AND THE TEMPERATURE FIELD OF THE TROPOSPHERE

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Figure 1

Figure 1: Figure 1

Abstract

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SOLAR WIND AND THE TEMPERATURE FIELD OF THE TROPOSPHERE

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Direct measurements of solar-plasma fluxes with the aid of space stations and satellites open up new possibilities for tracing solar-terrestrial relationships. In Figs. 1-3 the data are compared for solar-wind velocities (s.w.) (1–3) with the air temperature of the near-surface layer, averaged over seven regions of the Soviet coast of the Black Sea. The comparison shows that during the operation of the interplanetary station Mariner 2* a connection is continuously observed between changes in s.w. and the temperature of the lower layer of the troposphere, with inversions of the sign of the relationship. As can be seen from Fig. 1, for solar rotations Nos. 1767-1768 the dates of the inversions, 11 IX, 26 IX, and 8 X 1962, coincide with the Earth' s passage through the boundaries of sectors of the interplanetary field (^{4}); moreover, for the given regions there is a tendency toward a positive relationship under predominantly— sector of negative polarity, and vice versa. This tendency is retained for rotation No. 1770,* where, after the sector boundary that we assume passed on 30 XI (according to the geomagnetic sequence, the change in the solar-wind velocity

Fig. 1. Comparison of curves of solar-wind velocities *(1)*, nocturnal temperature *(2)*, and tropopause height *(3)*. For each rotation, three-hour K_p indices are plotted at the bottom. The blackened triangles are sudden commencements of magnetic storms (*sc*). In the upper parts the boundaries of sectors of the interplanetary field and its polarity are shown.

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* In using the Mariner 2 data, allowance was made for the change in the delay time in the arrival of solar-wind fluxes at the station relative to the Earth' s magnetosphere.

Fig. 2. Comparison of curves of solar-wind velocity (1), night (2), mean daily (3), and daytime temperature (4). The dashed line in the upper parts denotes the assumed sector boundary and their polarity.

Figure 2: Fig. 2. Comparison of curves of solar-wind velocity (1), night (2), mean daily (3), and daytime temperature (4). The dashed line in the upper parts denotes the assumed sector boundary and their polarity.

Figure 3: Comparison of curves of mean daily solar-wind speeds (1) and daytime temperature (2). The dashed line (1) denotes absence of data. December 1965.

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and recurrent *si*), a change is observed in the negative sign of the relationship to a positive one. The correlation coefficients by sectors for rotation No. 1767 are, respectively, −0.768 and 0.681; for rotation No. 1768, respectively, −0.553 and 0.867. Verification of the reality of the relationship by means of the *t*-distribution shows that the coefficients obtained correspond to significance levels above 0.05 for the second and third coefficients and above 0.001 for the first and fourth. The 27-day recurrence of temperature extrema is connected, as follows from Fig. 1, with the recurrence of the distribution of the solar-wind velocity within sectors and of sector boundaries. Thus, a temperature minimum, corresponding to the increase in s.w.s. and observed on 3 IX, is traced successively on 29 IX, 27 X, 23 XI, and is especially clearly expressed on 21 XII. After the passage of the sector boundary on 11 IX, 8 X, and, presumably, 4 XI, 30 XI, and 27 XII, in all cases there was a development of a temperature minimum associated in this sector with a decrease in s.w.s. On the other hand, changes in s.w.s. depending on the phase of development of the active region, and possible shifts of sector boundaries, will contribute, along with the troposphere’ s own processes, to distortion of the 27-day recurrence in the temperature field. The time of transmission of the disturbance into the troposphere from the front boundary of the shock wave must be small, which is confirmed by changes in s.w.s. and temperature values that are close in time (within several hours).

Fig. 3. Comparison of the curves of mean daily solar-wind speeds *(1)* and

* For rotation No. 1769 the velocity data are incomplete because of an interruption in the operation of the station.

daytime temperature *(2)*. The dashed portion *(1)* denotes absence of data. December 1965.

In Fig. 2, for rotations Nos. 1793–1794, a comparison is given of s.w.s. [2] with temperature changes for the same regions. The dashed portion of the s.w.s. curve corresponds to the satellite being outside interplanetary space. Fig. 2 shows that a noticeable connection is observed between the phenomena under consideration. Thus, from 1 VIII to 10 VIII 1964 this connection has a clearly expressed negative sign. Thereafter the connection changes sign to the opposite one and again becomes negative with the beginning of a new s.w.s. maximum on 25 VIII. A tendency toward a positive connection may be noted after 5 IX up to the end of rotation No. 1794. It is characteristic that the dates of the sign inversions of the connection—11 VIII, 25 VIII, 6 IX, and also 21 IX and 3 X—tend, on the one hand, toward periods after which s.w.s. increases, and, on the other, correspond to the beginnings of geomagnetic sequences. The periods of sign change are not associated with the beginning of every geomagnetic sequence and the corresponding increase in s.w.s., although a substantial change in the latter is reflected in the temperature field of the troposphere. The noted dates of sign inversions have a 27-day recurrence; recurrent *sc* and *si* also tend toward them. All this forces one to suppose that the sign inversions of the connection, as in Fig. 1, relate to the passage of sector boundaries. For the beginning and end of 1964, data are available (IMP-1, Mariner-4) on the sector structure and polarity of the field [4]. Tracing the possible positions of the sectors for the interval under consideration, we arrive at the conclusion that the periods of positive connection between fluctuations of s.w.s. and of the temperature field probably belong to sectors with negative polarity. From a comparison in Fig. 2 of three temperature curves—nighttime, mean daily, and daytime—it follows that the process of the action of the solar agent manifests itself first on the illuminated, and then on the nighttime hemisphere. The more significant phase shift of the temperature minimum on 4 IX relative to the s.w.s. maximum, denoted A_2, compared with the preceding rotation, can evidently be explained not by the fall of the absolute s.w.s. values in A_2 relative to A_1, but by the influence of the troposphere' s own thermobaric oscillations.

In Fig. 3 a comparison is given in which preliminary data on s.w.s., measured by Pioneer 6 [3,5], are used. Here, too, an interrelation of the phenomena under consideration is observed, the details of which may subsequently be clarified with the involvement of additional materials. A similar agreement is found in the changes of temperature values and fluxes of solar plasma measured by Soviet space stations and satellites. The authors [6–9] demonstrated a correlation between

magnitudes of the solar-plasma fluxes and the K_p-indices. According to Mariner-1 data (8,9), on 30 November 1962 plasma fluxes of $\sim 10^9$ cm^{-2}sec^{-1} were observed. This date is associated with the presumed passage of a sector boundary and the subsequent development of a temperature minimum, when over 2 days the temperature fell by 12°. On 5 December 1964, the Zond-2 station (9) measured small ion fluxes $(3\div7)\cdot10^7$ cm^{-2}sec^{-1}, with comparatively small solar-wind velocity components of 300–415 km $\cdot$ sec^{-1}. This day, like 4 December, is characterized by one of the highest temperature maxima in November–December 1964 for the regions under consideration. The transmission of a solar-caused disturbance from the exosphere into the troposphere should manifest itself at all structural "levels" of the atmosphere ([10–12]). Figure 1 gives a curve of the variation in the height of the tropopause (Crimea), which, like the temperature curve, "responds" to the change in solar-wind velocity and the passage of the sector boundary.

On the map constructed by the authors ([13]) for the Northern Hemisphere, the centers of zones of solar-caused cyclogenesis and anticyclogenesis are shown. The former include the region of Davis Strait and the southern extremity of the Kamchatka Peninsula; the latter include the region of the Baltic Sea between southern Sweden and northern Germany and the northwestern extremity of Alaska. Preliminary comparisons of changes in meteorological parameters on various isobaric surfaces in these and some other regions with solar-wind velocity reveal, in a number of cases, analogous relationships; moreover, fluctuations of temperature values and surface heights occur in phase for some regions and in antiphase for others. Periodic inversions in the sign of the relationship may apparently encompass some regions while being little reflected in others. This increases the complexity of the interaction between them.

It is possible that tropospheric processes are influenced not so much by the absolute magnitude of the solar-wind velocity as by its time derivative. In this sense, special attention should be paid to studying the influence on the synoptic process of recurrent and sporadic magnetic storms with *sc*, associated with the passage of the Earth through the front of a collisionless shock wave ([14]).

It is characteristic that the centers of action on the map ([13]) are located either in coastal zones of continents (Alaska, Kamchatka) or tend toward narrow places of the sea and straits. Such an arrangement is possibly connected not only with the properties of the underlying surface and the electromagnetic activity of coastal zones, but also with the existence here of a quasi-stable circulation in the lower ionosphere due to the difference in effective-radiation fluxes over land and sea ([15]).

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REFERENCES

1. M. Neugebauer, C. W. Snyder, *J. Geophys. Res.*, **71**, No. 19, 4469 (1966).

2. R. Lüst, *The Properties of the Interplanetary Medium*, paper presented at the International Symposium on Solar–Terrestrial Relationships, Belgrad, Yugoslavia, 29 VIII–2 IX 1966.

3. A. J. Lazarus, H. S. Bridge, J. Davis, *J. Geophys. Res.*, **71**, No. 15, 3787 (1966).

4. P. J. Coleman, L. Davis et al., *J. Geophys. Res.*, **71**, No. 11, 2831 (1966).

5. N. F. Ness, *J. Geophys. Res.*, **71**, No. 13, 3319 (1966).

6. K. I. Gringauz, *Space Res.*, **2**, Proc., Amsterdam, 1961, p. 539.

7. K. I. Gringauz, V. V. Bezrukikh et al., *Space Res.*, **3**, Proc., Amsterdam, 1962, p. 602.

8. K. I. Gringauz, V. V. Bezrukikh et al., *Space Res.*, **4**, Proc., Amsterdam, 1964, p. 621.

9. V. V. Bezrukikh, K. I. Gringauz et al., DAN, **163**, No. 4, 873 (1965).

10. C. E. Palmer, *J. Geophys. Res.*, **64**, No. 7, 749 (1959).

11. R. A. Craig, M. A. Lateef, *J. Geophys. Res.*, **67**, No. 5, 1839 (1962).

12. M. Kenneth, *J. Geomagnetism and Geoelectricity*, **18**, No. 2, 141 (1966).

13. T. Asakura, A. Katayama, *Papers on Meteorol., Geophys.*, **9**, No. 1 (1958).

14. S. B. Pikelner, *Fundamentals of Cosmic Electrodynamics*, Moscow, 1966.

15. V. V. Shuleikin, *A Short Course in the Physics of the Sea*, Leningrad, 1959.

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