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ON THE DEPENDENCE OF THE LOWER THERMOSPHERIC WIND REGIME ON THE SOLAR CYCLE

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The lower thermosphere (80-100 km) occupies the intermediate position between the overlying thermospheric layers, for which direct correlation of its parameters with solar activity variations is well established, and the underlying ones, where this correlation is mainly of an indirect character. Therefore, for understanding the mechanism of solar-terrestrial correlations it is important to investigate the dependence of different atmospheric parameters in the lower thermosphere, and of wind regime parameters in particular, on the solar activity.

The paper by SPRENGER and SCHMINDER (1969) was among the first investigations in this field. Similar results were obtained in other papers (PORTNYAGIN et al., 1977; KAJDALOV and PORTNYAGIN, 1976; DARTT et al., 1983; and TEPTIN, 1971), but the limited temporal coverage of the experimental data used for the analysis did not allow the authors to investigate the interannual variations of wind regime parameters with periods over 11 years.

Since then there has appeared a considerable amount of evidences of an obvious effect upon the Earth's atmosphere of the 22-year solar cycle (see, for example, MC CORMAN, 1982). In this connection it is reasonable to investigate the dependence of lower thermospheric wind regime parameters on the 22 year as well as the 11 year solar cycle.

With this aim in view, the authors have used several series of observations which include the results of meteor radar wind velocity measurements carried out in Obninsk (1964-1983) complemented by the data obtained using the same technique at Jodrell Bank from 1953 to 1958 (GREENHOW and NEUFELD, 1961) and in Kharkov from 1960 to 1963 (LYSENKO, 1963; KASHCHEEV et al., 1967).

Until 1973 measurements in Obninsk were carried out every month for 7 to 10 days and in the ensuing years practically continuously; at Jodrell Bank and Kharkov measurements were carried out in cycles, 3-4 days every month. Monthly mean values of prevailing wind velocities and semi-diurnal tidal amplitudes were estimated from these measurements.

Fig. 1 presents the interannual variations of values averaged over these periods for prevailing wind velocities and semidiurnal harmonic amplitudes and also results for some separate months. It is seen that interannual variations with periods close to one or both main solar cycles are typical of all wind regime parameters. To determine amplitudes and phases of these variations the data presented in Fig. 1 were subjected to harmonic analysis with decomposition periods of 22, 11, 7 and 5 years. The Wolf numbers for the corresponding period were similarly analyzed. The analysis showed that the sum the squares of the amplitudes of the 22- and

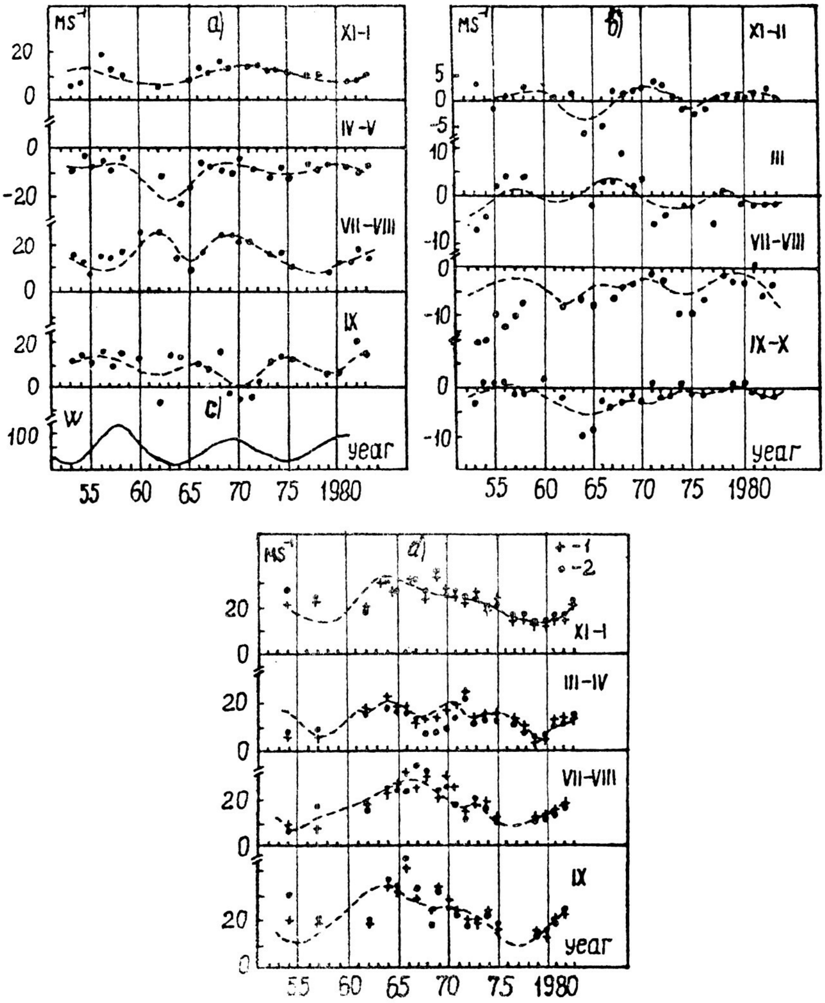

Fig. 1 Interannual variations of a) zonal and b) meridional prevailing wind velocities, c) mean annual values of the Wolf numbers, d) amplitudes of zonal (1) and meridional (2) components of the semidiurnal tide. Sums of the first five members of a Fourier series (semidiurnal tide only for the zonal component) are shown by broken lines.

11- year variations make up more than 70% of the total dispersion of the interannual wind regime parameter variations.

Results of the harmonic analysis are presented in Table 1. Here A_o is the parameter value averaged over the whole observation period, A_{22} and A_{11} are the 22- and 11- year harmonics amplitudes, ψ_{22} and ψ_{11} are their phases (the time of the maximum of westerly and southerly winds for the prevailing wind, the time of the maximum of amplitudes of the semidiurnal tide and the time of the maximum of the Wolf numbers values). The root-mean-square errors of wind parameter estimations are also presented.

The mean values of the analyzed parameters and the amplitudes of the 22- and 11- year oscillations in the majority of cases exceed the corresponding root-mean-square errors. The harmonic analysis method requires, a priori, prescribed periods in the Fourier series; therefore, it was necessary to make sure that the considered experimental data really possess periodicities corresponding to the main solar activity cycles. The standard spectral analysis method proves unacceptable for this case due to the proximity of periods of the investigated oscillations to the entire duration of the data series.

The problem was solved by constructing the dependences of correlation coefficient values on test periods (of 18 to 26 years) that are given in Fig. 2. The analysis of these dependences showed that for all seasons (or months) for which the calculated A_{22} and A_{11} exceed the errors of their determination the maximum correlation coefficient values (0.4 to 0.9) correspond to periods close to 22 years for the interval of 18-26 years and close to 11 years for the interval of 7-15 years.

The results obtained show that the oscillations with periods of 22 and 11 years revealed experimentally are physically real and thus the corresponding solar cycles could be their real cause. Relations between interannual variations of prevailing wind velocities and semidiurnal tidal amplitudes with long-term solar activity variations are confirmed by the fact that the phases of these variations are connected with those of the corresponding solar cycles and can serve as an additional proof of this. In part, the phases of the 11- year harmonics of the zonal and meridional components of the prevailing wind are such that the maxima of their velocities fall in the years of 11- year solar cycles maxima. The maximum values of both amplitude harmonics of the semidiurnal tide are observed during the years of the minimum of the solar activity cycles.

The data show that the 22- year period variations dominate variations of zonal prevailing wind velocities in the winter and meridional winds in the autumn months. Meridional prevailing winds vary in November-February mainly with the 11- year cycle. In the other months of the year the amplitudes of the 22- and 11-year velocity variations of the prevailing winds are similar. Oscillations with a 22- year period prevail for the amplitude of the semidiurnal tide. It should be noted that the solar activity dependences of the zonal and meridional component amplitudes of the semidiurnal tide are quite similar whereas the character of corresponding dependences of zonal and meridional prevailing wind is different.

Table 1

Harmonic analysis results of mean monthly Wolf numbers, prevailing wind and semidiurnal tidal amplitude.

	A_0	A_{22}	A_{11}	Y_{22}	Y_{11}
			W, Wolf numbers		
November-February	74±5	15±7,5	63±10	1958; 80±2,0	1959; 70; 81 ±0,5
March-April	73±4	14±7	65±7	1958; 80±2,0	1958; 69; 80 ±0,5
June-August	75±4	18±6	64±6	1957; 79±1,0	1959; 70; 81 ±0,5
September-October	79±7	17±9	70±10	1957; 79±2,0	1958; 69; 80 ±0,5
			a_0 EW, zonal prevailing wind		
November-January	12±1	4±1	1±1	1971; ±0,8	1959; 70; 81 ±2,0
April-May	-11±1	4±1	5±2	1979; ±0,9	1957; 68; 79 ±1,0
July-August	17±1	5±1	4±1	1967; ±0,9	1960; 71; 82 ±1,0
September	11±1	7±1	6±1	1961; ±0,7	1961; 72; 83 ±1,0
			a_0 NS, meridional prevailing wind		
November-February	0±0,5	1±1	3±1	1974; ±1,0	1958; 69; 80 ±0,5
March	1±1	4±2	2±2	1969; ±2,5	1958; 69; 80 ±3,0
July-August	-6±1	2±2	4±2	1968; ±2,0	1958; 69; 80 ±0,5
September-October	-3±1	3±1	1±1	1977; ±1,0	1959; 70; 81 ±1,0
			a_2 EW, zonal semidiurnal tide		
November-January	22±1	7±1	3±1	1967; ±1,5	1953; 64; 75 ±0,5
March-April	15±1	4±1	3±1	1968; ±1,5	1952; 63; 74 ±1,0
July-August	19±1	9±2	0±1	1967; ±1,0	-
September	23±1	10±2	5±2	1966; ±1,0	1951; 62; 74 ±1,0
			a_2 NS, meridional semidiurnal tide		
November-January	23±1	8±2	1±1	1968; ±1,0	1953; 64; 75 ±2,5
March-April	11±1	3±1	2±1	1968; ±2,0	1953; 64; 75 ±1,0
July-August	21±1	10±1	0±1	1967; ±0,5	-
September	24±1	9±2	4±1	1966; ±1,0	1953; 64; 75 ±1,0

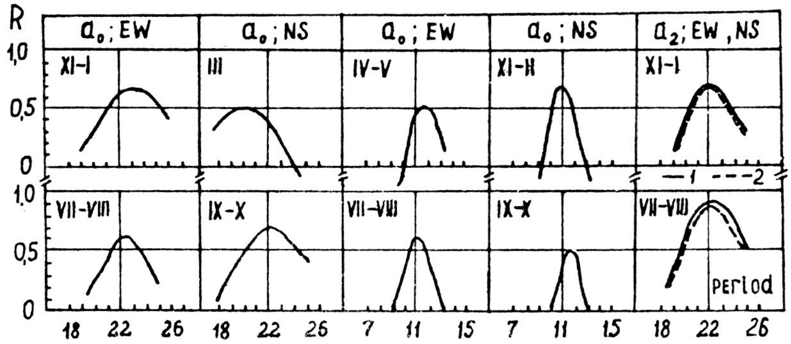

Fig. 2 Dependence of mutual correlation coefficients on period, 1) meridional component, 2) zonal component.

The results of this investigation show that when analyzing the dependence of the lower thermospheric wind regime parameters on solar activity it is necessary to take into account not only the 11- year, but also the 22- year cycle.

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