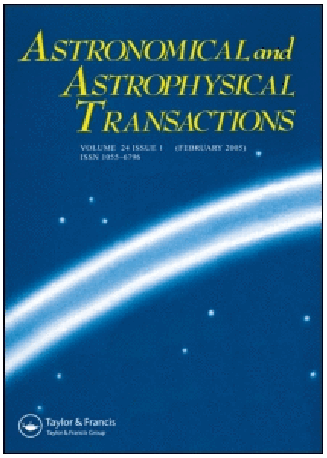

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SOME ASPECTS OF HELIOMETEOROLOGIC COUPLING

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Solar activity events that influence the lower atmosphere of the Earth have been considered as a function of various geographical factors. Certain regions have been isolated, where meteorologic characteristics are closely related to solar activity. The summer duration in one of these regions is shown to correlate well with solar activity characteristics, such as the Wolf number and the geomagnetic *aa*-index. A hypothesis is suggested that there are certain zones through which solar activity controls the entire Earth's atmosphere. The ways to locate such zones are discussed.

1 INTRODUCTION

A lot of attempts have been made to discover relations between the solar activity and the Earth's weather and climate. The results obtained are very contradictory, but some aspects of the problem are listed below:

a) The main geoeffective agents are the broad-range electromagnetic radiation and corpuscular radiation. The effect of the electromagnetic factor does not obviously depend on geomagnetic variations, whereas the corpuscular effect is determined by the geomagnetic field and must strongly depend on the geomagnetic latitude.

b) Atmospheric effects of solar activity depend critically on the initial conditions, such as the observation site coordinates, characteristic local meteorologic instabilities, the phase of the 22-year solar cycle, the phase of the 2-year solar cycle, and quasi-biennial oscillations in the stratospheric circulation. Therefore, one may expect the existence of some regions where the relation of local meteorologic factors to solar and geophysical activity is especially pronounced (Marchuk, 1987).

c) The energy necessary to trigger a cyclone is generally provided by energetic particles precipitated from the Earth's radiation belts (that contain enormous and practically constant energy) to a region of magnetic anomaly. It was shown that magnetic storms were accompanied by slow precipitation of energetic particles and a total energy flux of electrons was about 5×10^{29} erg at Northern latitudes (O'Brien, Laflin, and Van Allen, 1963). For comparison, the energy of a cyclone is 10^{25} erg and the kinetic energy of the atmospheric circulation is 10^{27} erg. So, the difference is not as large as usually believed, though the heliomagnetic activity should be regarded as a small signal that stimulates energy release in the atmosphere.

2 THE CONCEPT OF THE HELIOMETEOROLOGIC WEATHER CONTROL ZONES (HMWCZ)

The effect of solar activity on the Earth's atmosphere depends on a number of physical factors that determine energy variations and generation of vortices. This effect increases with the geomagnetic latitude. The largest changes in the zonal circulation intensity and the earliest reconstruction of atmospheric processes are observed at the geomagnetic poles, where the conditions for penetration of corpuscular solar fluxes are most favorable (Vorobyeva, 1973). The influence of the Sun is best pronounced in the vortex generation regions, where the atmospheric parameters display a large dispersion. One may suggest the existence of specific zones in the atmosphere where the effect of solar activity is the largest.

At the onset of geomagnetic disturbances (Usmanov, 1960), the winter global-scale regions of increased density occur over Europe, over West Siberia and at the West of the North–American continent, whereas the regions of low density occupy the North Atlantic, the East of the North–American continent, the North Pacific, East Siberia and Far East of Russia. Inside these global regions of high or low pressure, there are regional or local features that suggest inhomogeneous response of the atmosphere in certain physical and geographic zones, probably associated with local or regional gravitational and magnetic anomalies. This is also corroborated by close correlation between the mean distribution of air pressure for many years and the Earth's crust inhomogeneity. As shown by Mustel (1987), a considerable drop of pressure following geomagnetic disturbances is recorded at the Iceland and the Aleutian minima, which may be regarded as enhancement of the baric feature due to solar activity.

It should be noted that the influence of solar and geomagnetic factors on the atmospheric circulation strongly depends on the original baric field, its anomalies, and the season. Every solar and geomagnetic disturbance transforms the baric field taking into account its initial state and the physical and geographic properties of the region.

Proceeding from previous text, we can state that:

- specific regions are expected to exist in the atmosphere, in which the effect of solar and geomagnetic activity on the local meteorologic conditions is especially pronounced. These regions are obviously located in the precipitation zones of energetic particles in the vicinity of large magnetic anomalies. The presence of baric anomalies is also important. Since a significant local effect in these regions may result in global-scale (though less pronounced) consequences, we shall call them the Heliometeorologic Weather Control Zones (HMWCZ);

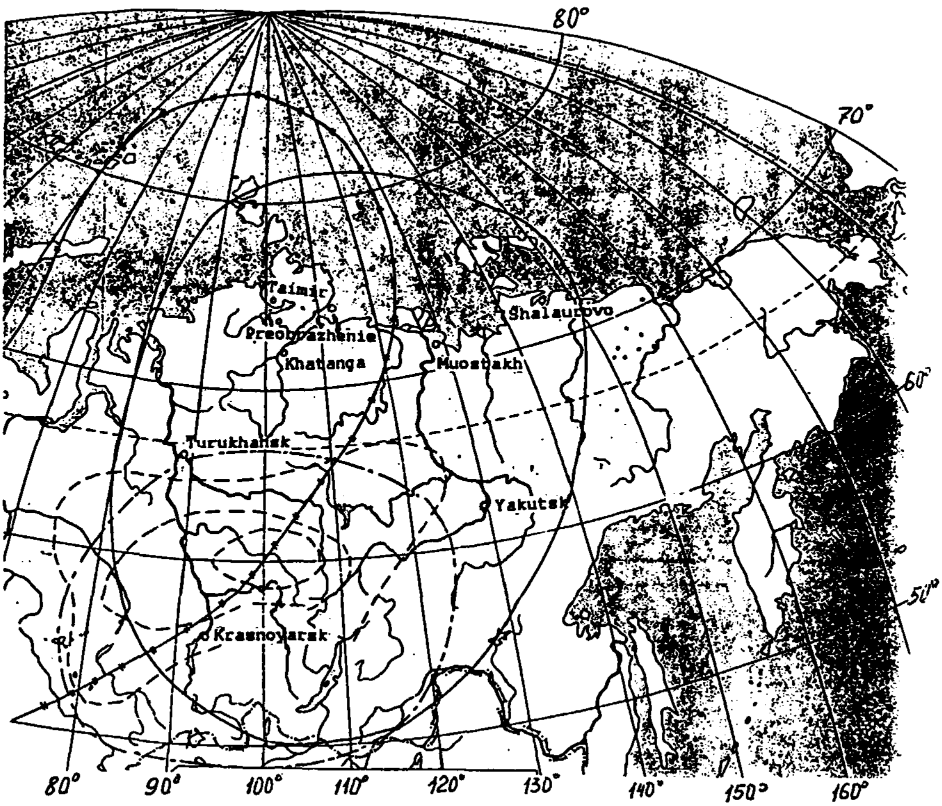

Figure 1 The map of locations of meteorologic stations, the vast geomagnetic anomaly, and the particle precipitation zone. —"—, the circulation anomaly zone; —·—,the zone of low pressure after magnetic storms; ——, the magnetic anomaly zone; - - - -, the particle precipitation zone.

- since the principal coupling mechanism is, obviously, of corpuscular/geomagnetic character, the effect may depend on whether we have an even or an odd solar cycle;
- one can also expect a dependence on quasi-biennial oscillations, i.e. variation of the correlation coefficients with a characteristic time of the order of 1–3 years.

3 THE HELIOMETEOROLOGIC WEATHER CONTROL ZONES IN EAST SIBERIA

We have used the smoothed monthly mean Wolf numbers, R, and the geomagnetic aa-index for our analysis. As a meteorologic parameter, we have used the summer duration in several regions of Siberia, i.e. the number of days from melting to settling of the snow cover (snowless period). Correlation with the summer duration

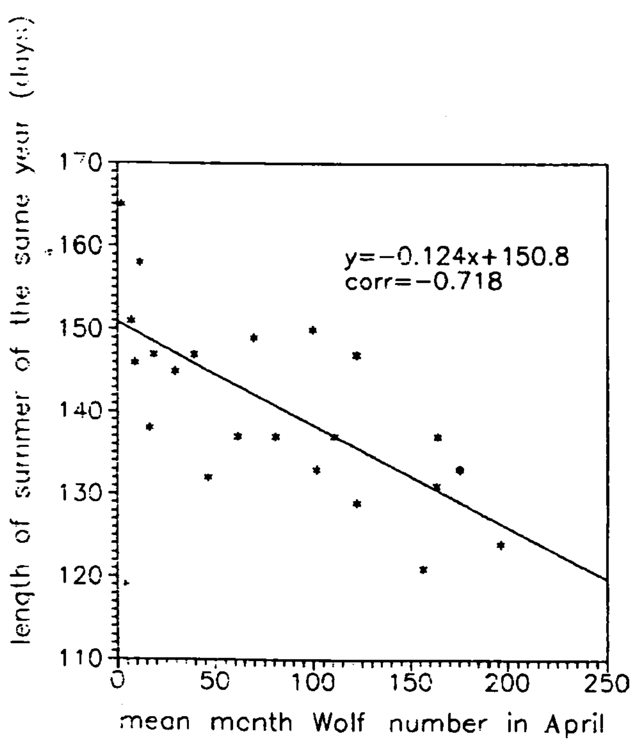

Figure 2 Correlation between the Wolf numbers in April and the summer duration in teh same year for odd solar cycles.

has been analyzed for the time interval of 1939 through 1991 for several points in East Siberia. Their location is shown on the map in Figure 1. This area has been deliberately chosen because it contains a vast geomagnetic anomaly and a particle precipitation zone, and therefore it is very likely that a heliomagnetic weather control zone may exist there.

Columns 2 and 3 in Table 1 show the correlation coefficients for the annual mean Wolf numbers and *aa*-indices, and the summer duration at the station listed. One can readily see that correlation is practically absent, though the correlation coefficients differ essentially from station to station.

The situation changes significantly if we discriminate between odd and even cycles. Results of our calculations are represented in Table 1 – column 4 for the Wolf numbers in odd cycles (R_0), and column 5 for the *aa*-index in the even/odd pair of cycles (aa_{eo}). The exceptional position of Turukhansk is obviously beyond doubt, and the correlation coefficient of 0.669 is high enough for this kind of studies.

The correlation between the summer duration and the monthly mean heliogeophysical indices is still better in spring and in summer. Figure 2 illustrates the linear regression equation and the correlation between the Wolf numbers in April

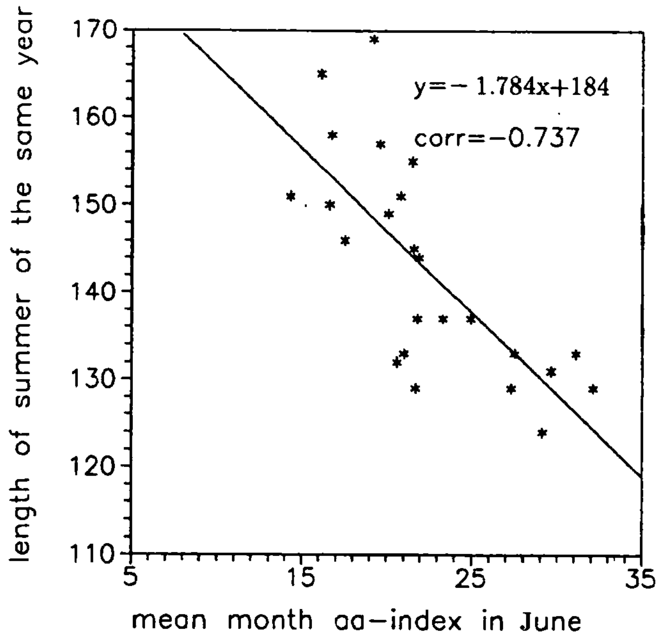

Figure 3 Correlation between the *aa*-index in June and the summer duration in the same year for even-odd pairs of cycles.

and the summer duration in the same year for odd cycles. The correlation coefficient is −0.718. Figure 3 shows the linear regression equation and the correlation between the *aa*-index in June and the summer duration in the same year for the even/odd pairs of cycles. The correlation coefficient is −0.737.

Thus, it can be stated that Turukhansk is a heliometeorologic weather control zone. This is due to its location relative to the magnetic anomaly, to the cyclone and anti-cyclone formation zones, and to the precipitation regions of the Earth radiation belt particles. The location of Turukhansk near the long-lived atmospheric circulation anomalies may affect the atmospheric circulation as a whole (Lau, 1988).

Table 1.

Station	*R*	*aa*	R_0	aa_{eo}
Khatanga	−0.040	0.130	−0.095	0.062
Yakutsk	−0.112	−0.027	−0.099	0.062
Krasnoyarsk	0.170	0.001	−0.141	−0.018
Muostakh	−0.109	−0.139	−0.232	0.021
Preobrazhenie	−0.163	0.011	−0.076	0.218
Shalaurovo	0.038	−0.099	−0.216	−0.053
Taimir	0.110	0.002	−0.137	0.019
Turukhansk	−0.201	−0.384	−0.604	−0.699

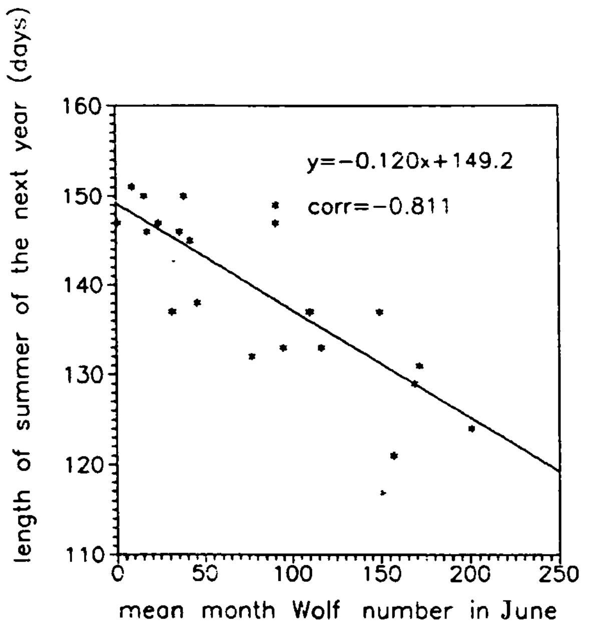

Figure 4 Correlation between the Wolf number in June and the summer duration in the same year for odd cycles.

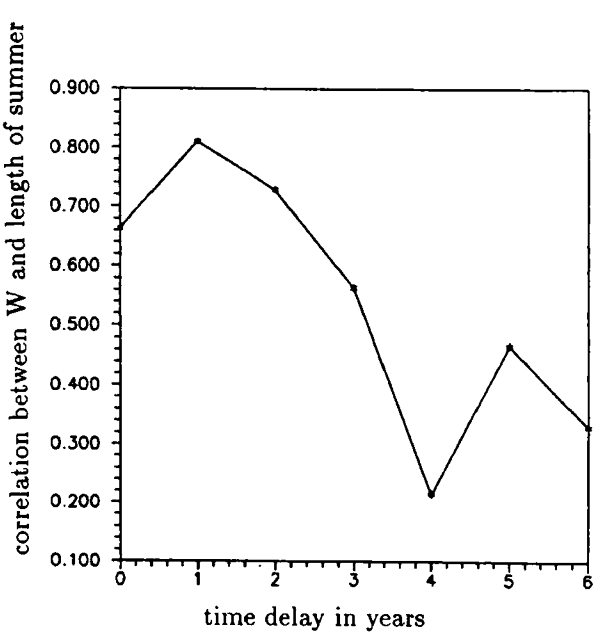

Figure 5 The cross-correlation function between the summer duration and the monthly mean Wolf numbers for odd cycles.

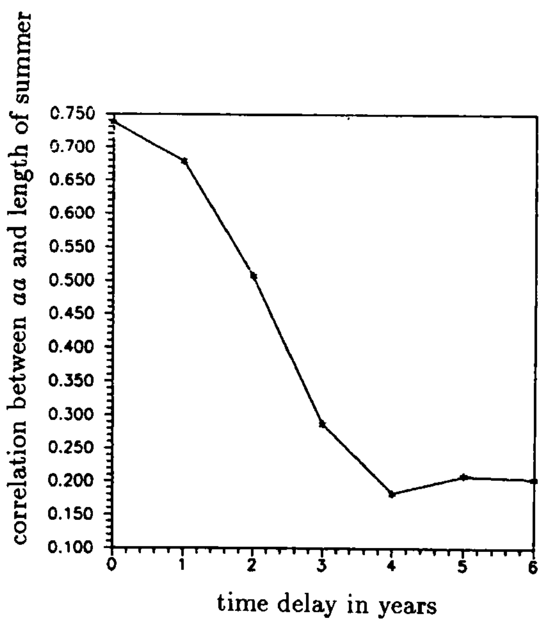

Figure 6 The cross-correlation function between the summer duration and the monthly mean *aa*-indices for even-odd pairs of cycles.

Further investigation has shown that in odd cycles, the Wolf numbers are even more closely related to summer duration of the following year than on that of the same year (the correlation coefficient is −0.811) (see Figure 4). Figure 5 represents the cross-correlation between the summer duration and the monthly mean Wolf numbers in odd cycles. It is readily seen that a year's shift provides the highest correlation.

The annual mean Wolf numbers in odd cycles also display a good correlation with the summer duration for the following year (the correlation coefficient is −0.743; cf. −0.604 in Table 1). This may be regarded as manifestation of quasi-biennial oscillations observed both in the Sun and in many atmospheric parameters on the Earth. If corroborated, this effect may be successfully used in weather forecasts.

Figure 6 illustrates cross-correlation between the summer duration and the monthly mean *aa*-index in the even/odd pairs of cycles. The maximum correlation is observed when the shift is zero.

4 CONCLUSIONS

Thus, as shown above, the search for solar/meteorologic coupling will not provide reliable results, unless we take into account specific relations between the "corpuscular" mechanism and the geographical factor. The Turukhansk region combines 6 factors discovered independently by different authors (see Figure 1). These are:

(1) a powerful magnetic anomaly (Mustel, 1987);

(2) increase flux of charged particles (Ginzburg, Kurnosova, Logachev, 1961);

(3) maximum fall of atmospheric pressure after 25 strong magnetic storms (Mustel, 1987);

(4) maximum variability of the 500 mb altitude from 1962 to 1980 (solar cycles 20-21); frequent long-lasting anti-cyclones (Rex 1950, Knox 1981, Wallace and Blackmon 1983);

(5) long-lived meteorologic anomalies in the atmospheric general circulation (Lau, 1981);

(6) a high correlation between solar, geomagnetic, and meteorologic indices.

Thus, a heliometeorologic weather control zone (80–120 E, 60 N) exists in the Turukhansk region. Other similar zones may be expected to have geographic coordinates 10–20 W, 60 N and 160 W, 45 N, where anomalies 1–5 listed above are observed. For example, a high correlation between the vegetation period and the Wolf numbers has been revealed at Exdalemoore (3 W, 55 N) situated in such a heliometeorologic weather control zone (King, 1973).

Acknowledgments

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