Heliocyclical Factors in Interdecadal Variability of Climate and Natural Processes on the Example of Yakutia

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Abstract. The natural systems of Yakutia (Eurasian north-east) serve as example in examining the problem of interdecadal variability of climate and natural processes. The work explores the response of heat and moisture supply of the climate and of tree trunk growth for the pines of afeis valleys of Central Yakutia over the modulation of odd and even 11-year solar cycles. The climatic forecasting for slowing down of winter warming and enhancing the role of summer drought seasons within the next decade is substantiated. In the afeis valleys we can expect the recovery of afeis formation, forest fires and slowing down of forest stand trunk growth. The most consequential natural process abnormalities (extremal cooling and warming, droughts, flood waves, forest fires, etc.) are to develop in the segments of rise and fall of the 11-year cycles, in proximity to the periods of solar activity extremums (the maximums and the minimums). Today we have one of such extremums (the minimum of 11-year cycle №25).

1. Introduction

Sun-troposphere correlations have long called for attention of geophysicists and climatologists. However, it was not until the middle of the 20\(^{th}\) century that, owing to recent scientific discoveries in solar-terrestrial physics, this line of research made a fresh start. As one of such discoveries we should recognize the discovery of the effect of the 22-year Hale cycle (defining the interplanetary magnetic field alignment) on the long-term changes in large-scale atmospheric circulation. Of equal significance is the effect of Schwabe-Wolf 11-year cycle. Investigating these effects, in the opinion of B. A. Sleptsov-Shevelovich, may contribute to substantiation and development of theoretical foundations of long-term climate forecasts [7]. In recent decades climate conditions in Yakutia, as well as globally, have been considerably instable, which quite often leads to the development, at the local level, of hazardous anomalies of atmospheric precipitation, extreme cold against the background of warmer winters, increased momentum of flood waves, droughts, forest fires, intensification of hazardous cryogenic geological processes, earthquakes, etc. [2 to 6]. The question whether these phenomena are accidental or logical and regular is of great importance, because depending on the answer decisions are to be made on taking prevention measures of engineering protection regarding the infrastructure of industrial and social facilities located in cryolithozone and ensuring sustainable development of the Northern regions.
2. **Aim of the study**
The overriding aim of our investigation is the search of consistent patterns in the response of heat and moisture supply of the climate and of tree trunk growth for the forest stand in Yakutia over the modulation of odd and even 11-year solar cycles in order to elaborate on the trends of variability in natural and climatic conditions for the coming decades.

3. **Methodological substantiation**
The methodological framework of the study is provided by the developments in the area of sun-troposphere correlations made by prominent heliogeophysicists, astronomers and climatologists such as A. L. Chizhevsky, A. I. Voyeykov, L. S. Berg, N. Shaw, D. Brent, A. V. Dyakov, W. Blass-Wiese, B. Duill and H. Duill, M. S. Eygenson, B. M. Rubashev, I. V. Maksimov, L. A. Vitels, T. V. Pokrovskaya, O. A. Drozdov, A. V. Shnitnikov, B. A. Sleptsov-Shevlevich, and others. A. L. Chizhevsky [8] was one of the first to show the key role of solar activity in the dynamics of the whole spectrum of natural processes occurring in the global biosphere, developing the matrix of the 11-year cycles that allowed direct matching of the dynamics of processes under study and the space factor in the form of Wolf numbers (relative sunspot numbers) and other solar activity (SA) indices. In his fundamental synthetic work “Sun, weather and climate” M. S. Eygenson gives convincing evidence of the solar origin of any climatic fluctuations, including the paleoclimatic ones [9]. B. A. Sleptsov-Shevlevich [7], who, using in his analysis the data of long-term patterns of instrumental observations of geomagnetic activity, thermobaric fields, North Pole migration and ice coverage of the Arctic seas, presented convincing evidence that all these phenomena are related to the 22-year SA pattern. In addition, in the allied (even to odd) 11-year patterns that form the joint 22-year SA patterns, the phenomena in consideration tend to manifest themselves in phase opposition. A corresponding phenomenon was earlier discovered by A. V. Dyakov in investigation of the periodicity of abnormally cold winters in West Siberia and European part of Russia (EPR). To specify, A. V. Dyakov not only discovered the correlation of winter cold anomalies with reference phases of the 11-year cycle but also singled out the regional peculiarity of the problem consisting in the phase opposition of the course of phenomena under study not in relation to odd and even 11-year cycles as well as to observation points located in EPR and in the adjacent territories of West Siberia [1].

4. **Materials and discussion**
In this research we turn to analysis of hydrometeorological data: the monthly and annual averages of ground air temperature and precipitation (a number of weather stations in Yakutsk, continuous observations of 1893 to 2008) as well as to annual growth ring monitoring of the trunks of Scotch Pines in Ulakhan-Taryn location (the Middle Lena River valley). The latter characterize the integral indicators of changeability of bioclimatic conditions in Central Yakutia [4]. The space reference mark was presented by a curve of Wolf numbers, the key SA index. The investigation embraces the 11-year cycles №13 to №25, which includes 5 even and 6 odd ones in the period of 1893 to 2008 (a total of 115 years).

As research tool we used the A. L. Chizhevsky epoch folding method, successfully tested in case studies in North Atlantic and the Arctic by I. V. Maksimov and B. A. Sleptsov-Shevlevich [2].

The obtained results are presented as graphs in Figure 1.
(a) Average monthly temperature in January in the course of even and odd 11-year cycles

(b) Average monthly temperature in July

(c) Atmospheric moisturizing over a dendrochronology year (September to August)
Figure 1. Meteorological element fluctuation (precipitation and average annual temperature, Yakutsk hydrometeorological stations) and trunk growth of pines in Ulakan-Taryn (Middle Lena) in the course of even and odd 11-year solar cycles (folding epochs).
Figure 1 shows that all trend lines of the presented curves demonstrate the increasing dynamics of the represented processes in the course of all even 11-year SA cycles and the decrease in the course of the odd ones. The same can be observed in the course of the 22-year cycle, judging by the trunk growth of the Ulakhan-Taryn pines (see D-1). This leads to the conclusion that in Yakutia, as well as in EPR and West Siberia, we see the response of natural and climatic conditions to the modulations of the 22-year Hale magnetic cycle and of its components, the even and odd 11-year SA cycles (see 1E). The mechanisms of the identified fluctuations is based on large-scale atmospheric circulation dynamics determined by the sum spot pattern. In its turn, it is the atmospheric circulation that determines the pattern of the largest pressure field in North Asia – Siberian anticyclone. This conclusion is confirmed, in particular, by studies of A. V. Dyakov conducted on the materials obtained in EPR and West Siberia [1]. As he writes, “the most protuberant anomalies, the deviations of average normal course of the atmospheric circulation, showed in the years close both to minimum and to maximum solar activity. Moreover, it should be mentioned that the anomalies manifested themselves in the reversely mutually conjugated areas of Eurasia – the European part of Russia and West Siberia. This connection can be traced hundreds of years back not only in respect of winters but also in respect of summer droughts [1, p.3].

5. Conclusion
Considering the fact that the current even solar cycle №24 is drawing to a close, with the advent of the next odd one №25 in Yakutia, and quite likely in the adjacent territories of Siberia we can expect some decrease in the rate of winter warming as well as enhancing the role of the summer drought seasons. In aufeis valleys like Ulakhan-Taryn we can expect the recovery of aufeis formation and slowing down of forest stand trunk growth. With this, the most consequential natural process abnormalities (cooling, droughts, forest fires, floods, etc), as the materials obtained during studies of Yakutia show, are to develop in the segments of rise and fall of the 11-year SA cycles, in proximity to the periods of solar activity extremums (the maximums and the minimums) [2]. Today we are close to one of such extremums.

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