PRACE GEOGRAFICZNE, zeszyt 107

Instytut Geografii UJ
Kraków 2000

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QUASI-MONTHLY AIR TEMPERATURE CYCLICITY IN THE LOWER STRATOSPHERE

Abstract: By means of Blackman-Tukey spectral method geographical regions of distinct quasi-monthly temperature cycle were delimited in the stratosphere. No significant relation between 28-day thermal cycle and similar periodicity of Coronal Index was detected. However marked increase in amplitude of synodical cycle of coronal activity is observed 10-12 days before key event, i.e. the rise in corresponding periodicity of temperature in the stratosphere.

Key words: coronal activity, superposed epoch, lower stratosphere, 28-day thermal cycle.

1. Introduction

The research concerning 27-day recurrence of phenomena occurring in the Earth's magnetosphere have been carrying out for at least hundred years. After Skylab mission in 1973 it was revealed that solar wind originating from the coronal holes is the main reason for recurrent magnetic storms (Neupert, Pizzo 1974).

The possible mechanisms of the transformation of geomagnetic impulse into weather signal is presented by Bucha (1983). He advances hypothesis, according to which, higher than normal geomagnetic activity leads to marked increase of zonal flow.

According to Haurwitz (1946) the ozonosphere enables the Sun to influence the troposphere. Solar flares cause rapid rise of total energy emitted by the Sun. The ozone absorbs part of surplus of short-wave radiation which affects temperature in the stratosphere. Due to meridionally diversified absorption of UV meridional gradient is generated inducing the air to move northwards, which in turn may alter circulation conditions in the stratosphere.

The majority of papers refer to the 27-day oscillations of the air temperature. The recurrence of thermal waves in Łódź as well as amplitude of the 27-day cycle of the Sun's spottedness were probed by Degirmendžić (1995). Valnićek (1965) analysed the short-term variation of temperature in the region of former Czechoslovakia. Dates of solar flares in 1947 were selected as key times used for overlapping temperature records. Marked peaks repeating after 0, 27 and 54 day were observed.

Many authors (Bucha 1983; Haurwitz 1946; Visser 1958; Vitels 1959) point out that geomagnetically disturbed days precede sudden transformation of circulation patterns which affects temperature. Circulation conditions also initiate 27-day cycle of precipitation in Southern California (Rosenberg, Coleman 1974).

2. Data and Methods

The primary aim of this paper is to characterize basic spatial features of quasi-monthly periodicity of the temperature at 100 hPa level. In order to complete this task grid point data (12 UTC) of temperature and geopotential height were used. Lat-lon grid format is comprised of 540 equally sited points in a 36 by 15 array. Data cover the Northern Hemisphere from 20°N and span the period from 1962 to 1994. Gaps were filled in with linear interpolation. All grided data were derived from CDROM version III produced by NCAR.

Author also attempts to give some clues concerning the origin of 27-day periodicity, taking into consideration similar cycle of coronal activity. Daily values of Coronal Index (CI) for the period 1962-1994 were used – data were obtained from National Geophysical Data Center, Boulder. CI measures total energy emitted by the Sun's corona at a wavelength of 530.3 nano-meters (with-in the Fe XIV spectral line). Some additional data used in this analysis - Kp and Ap indices - were derived from GGO catalogue, Obninsk.

The Blackman-Tukey method was used for detecting 27-day rhythm in the thermal and solar data. Moving spectrum for consecutive 90-day intervals was computed. An attempt was made to establish the possible reason for 27-day temperature cycle. To do that one used superposed epoch method (Wilcox et al. 1974). This method arranges data in «a row-column array in which the „response" index values filling any row are data pertaining to a single key event. The columns line up the index values in fixed time in relation to the key times; column averages comprise „superposed epoch analysis". By this averaging method, any fluctuations in the response index that are locked in time relative to the key time column are preserved in the average» (Brier, Haurwitz 1981). That procedure answers the question whether the preceding occurrence of key impulse is sufficient for atmospheric disturbance to occur.

Unless one can be certain that every key event modifies meteorological parameter, because other factors for instance quasi-biennial cycle in the stratosphere (Labitzke, van Loon 1990) could interfere with solar-terrestrial energy transfer, one should reverse the procedure used in superposed epoch analysis. Thermal phenomena should be treated as key times events while CI as a response index. Such procedure answers the question whether the indispensable condition for temperature disturbance occurrence is the coronal impulse. In this paper two samples of key times are selected. First sample (S1) is comprised of values of moving spectrum for quasi-monthly temperature cycle which are at least double as high as the upper quartile and the second sample (S2) of values which are lower than the lower quartile. As the response index differences between corresponding spectrum of CI and its critical values were applied. Statistical significance of superposed curves was checked with Student's t test.

3. Quasi-Monthly Thermal Cycle at 100 hPa Isobaric Level over the Northern Hemisphere

27-day cycle was ascribed to the period of Sun's rotation which is equal to 27.3 days. The change in solar rotation rates with heliographic latitude. This differential rotation may produce main (27.3-day) peak and nearby ones. Power spectrum of CI for the period 1962-1994 shows two distinct peaks falling on 27.1- and 13. 5-day period. Spectral analysis of Ap and Kp indices gives several peaks nearby „27-day" period at: 25.0, 26.5, 28.7, 29.5, 31.0-day. Similar conclusion can be drawn from the spectral analysis of temperature. Maximum variance refers to 28.15-day cycle, other nearby peaks are situated at 27.1, 29.8-day period. With reference to such power spectrum, analysis carried out in this paper was focused on 28.15-day period (0.036 cycles d^{-1}).

In order to determine the spatial distribution of intensity of quasi-monthly (28.15-day) temperature oscillations, spectral estimates and 5% critical values of red noise were calculated for each of 540 grid points covering the Northern Hemisphere (1962-1994). The maps display values of spectrum substracted from 5% significant level. In that way the regions of statistically significant oscillations were delimited. The area

Fig. 1. Spectral estimates of the 28.15-day thermal cycle substracted from 5% critical values at 100 hPa isobaric level. Thick line delimit the regions of significant variation.

Fig. 2. Power spectra of the air temperature records at 100 hPa level in 200°E-70°N (upper) and 240°E-70°N (lower) grid point for the period of 1962-94. Dashed line indicates 1% significance level.

with the most distinctively revealed quasi-monthly cycle is situated mainly over Northern Canada. The second region of significant 28.15-day variability spreads over the Scandinavian Penisula (Fig. 1). Power spectra for two grid points: 200°E-70°N and 240°E-70°N are enclosed (Fig. 2).

4. The Possible Origin of the Short Periodical Temperature Variation in the Stratosphere

The following analysis concerns only Canadian Centre of 28-day oscillations. Figure 3 displays superposed spectra of 0.036 cycles d^{-1} frequency of CI substracted from critical values (response index) pertaining to both samples of key events: S1 and

Fig. 3. Superposed curves calculated with respect to samle S1 (key times - high values of spectrum of 28-day thermal cycle in 240°E-70°N grid point) - (bar chart) and to sample S2 (key times - low values of the same moving spectrum record) - (solid line).

S2. Student's t test was applied in order to verify the significance of the rise in CI spectrum. Increase of periodicity of coronal activity preceding thermal oscillations in the stratosphere appears to be insignificant.

Nevertheless, it is worth noticing that the peak of CI spectrum occurs about 10-12 days before the key day while the second curve of CI spectrum does not „respond" to low intensity of temperature cycle.

Quasi-monthly variation of 100 hPa geopotential were also analysed in order to check whether the periodical changes of circulation at 16 km height could modify the temperature cycle. According to Bucha (1983) altitude of 100 hPa height decreases during the period of high geomagnetic activity being as a part of deepening cyclone. In the light of this theory periodic changes of circulation in the layer from 500 to 100 hPa generated by recurrential magnetic storms may be treated as a factor amplifying short-term thermal variation. The spatial distribution of spectrum of 100 hPa geopotential height is presented in Figure 4. The power spectrum of geopotential height calculated for 220°E-60°N grid point depicts marked 28.15-day peak, rather isolated from the other high frequences (Fig. 5)

The analysis concerning quasi-monthly oscillations of temperature in the stratosphere delimits the geographical regions of a distinctly marked periodicity. In the light of the results presented here and in the other papers one can stated

Fig. 4. Spectral estimates of the 28-day cycle of geopotential height (100 hPa) substracted from 5% critical values of the red noise. Thick line delimts the regions of significant variation.

Fig. 5. Power spectrum of 100 hPa geopotential height in 220°E-60°N grid point for the period of 1962-94. Dashed line indicates 1% significance level.

undoubtedly that such cyclicity constitutes the significant feature of thermal regime in the lower stratosphere. However, in order to find sufficient explanation for the observed short-term variability one should create comprehensive theory discussing the additive impact of the ozonosphere and magnetosphere as well as the influence of the Moon on the atmospheric conditions.

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