SEASONAL VARIATION OF LIGHTNING ACTIVITY PERIOD STRUCTURE IN THREE MAIN THUNDERSTORM CENTERS

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Abstract

In this paper we discuss the seasonal changes that occur among lightning activity in three main tropical thunderstorm centres located at Asia, Africa and America. Our study is based on a lightning activity index I_{RS} defined from ELF (extremely low frequency) observations carried out in years 2005-2007. .Base on the I_{RS} index dynamical power spectrum (DPS) maps are created. They allow to study the seasonal variability of a period structure in lightning activity indices for each of the global centre separately. The structures of periods observed in DPS maps indicate that different thunderstorm centre show different seasonal variability of the lighting activity.

Keywords: global lightning activity, seasonal variation, period structures, ELF waves

1. Introduction

For study of the lightning activity we propose and use a lightning activity index I_{RS} constructed from measurements of magnetic field of extremely low frequency (ELF) band where the physical resonance phenomena called Schumann Resonance (SR) is observed. This is the resonance of the electromagnetic field generated by lightning events inside the natural conducting cavity formed by the Earth's surface and its ionosphere. Inside this cavity are many thunderstorm cells permanently active around the Earth, which produce lightning events, mainly in the tropical centres (). The positions of the Schumann Resonance power spectrum peaks are defined for each resonance mode by the basic equation

$$f_n = \frac{c}{2 \cdot \pi \cdot R_E} \sqrt{n \cdot (n+1)} \, . \qquad (1)$$

Where: n=1, 2, 3, …; c-velocity of light in vacuum; R_E-radius of Earth . The variations of global lightning activity are main reason for the observed changes of SR amplitudes.
At the beginning of 2005 year the Astronomical Observatory of Jagiellonian University began measurements of SR phenomena using two magnetic antennas connected with a microprocessor acquisition system. The station is located in south-eastern Poland (Kulak et al. 2003a, 2003b). The antennas are directed horizontally north-south and east-west. The magnetic fields B_{NS} and B_{EW} are registered with resolution 3.8 nT per 16 bits and frequency sampling 178 Hz.

2. Index of daily lightning activity

Having the signal from the both antennas the lightning index is constructed. (Spain I czasopismo in press). Signals from both antennas (directions NS and EW) are analysing separately and the corresponding power spectra are computed. To the power spectrum obtained we are fitting a set of 7-th Breit-Wigner functions (Breit 1936, Kulak 2006), which described the SR modes receptively.

$$I_t = \sum_{n=1}^{6} p_n \qquad (2)$$

For each SR mode amplitude p_n, frequency f_n, width Γ_n, and asymmetry e_n are determined. Having amplitude values of the first six resonance modes we calculate I_t index according to the Eq. (2). It is used as a measure of lightning activity assigned for the moment t of recording to each of antenna separately. Because we have signals from two perpendicular antennas it is possible to construct daily indices for three centres: Asia, Africa and America (Nieckarz 2007a, Nieckarz 2007b). We do it using Eqs. (3), (4) and (5)

$$I^{Asia} = \frac{1}{12} \cdot \sum_{t=0}^{11} I_t^{NS}, \quad I^{Africa} = \frac{1}{12} \cdot \sum_{t=10}^{21} I_t^{EW}, \quad I^{America} = \frac{1}{12} \cdot \sum_{t=12}^{23} I_t^{NS} \quad (3), (4), (5)$$

where I_t^{NS} and I_t^{EW} are indices calculated for t hour average of the day. In the above formulas we applied intervals suggested by World Meteorological Organisation report (WMO, 1956) as those in which most lightning activity of the global centres is observed.

3. Dynamical Power Spectrum (DPS) maps

Our study is based on observations carried out in years 2005-2007. The calculated indices for three centres are presented on Fig. 1.

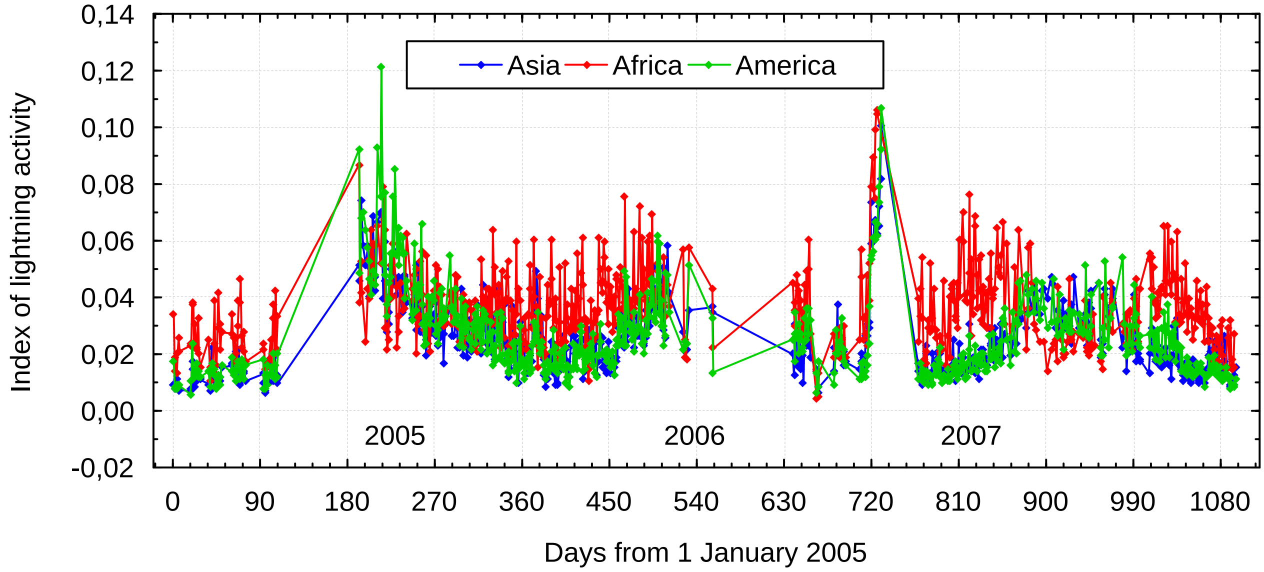

Figure 1. The daily runs of three indices (Asia, Africa, America) calculated for 2005-2007 years. All indices are presented in arbitral units the same for each centres.

In the first step, for each of the time series presented on Fig. 1 we calculated Scargle-Lomb periodogram (Lomb 1976, Scargle 1982) to find harmonics with periods longer then 70 days which were eliminated from the data. After that we produced DPS maps by calculating Scargle-Lomb periodograms for small subsets of the reduced data chosen by the sliding 90 days window. The position of the window was changing along time axis every one day. The DPS maps are shown on Fig. 2. Maximum amplitudes are presented as red colour and amplitudes equal zero as blue one. The two blue large segments (90-180 and 540-630 day) came from gaps in measurements.

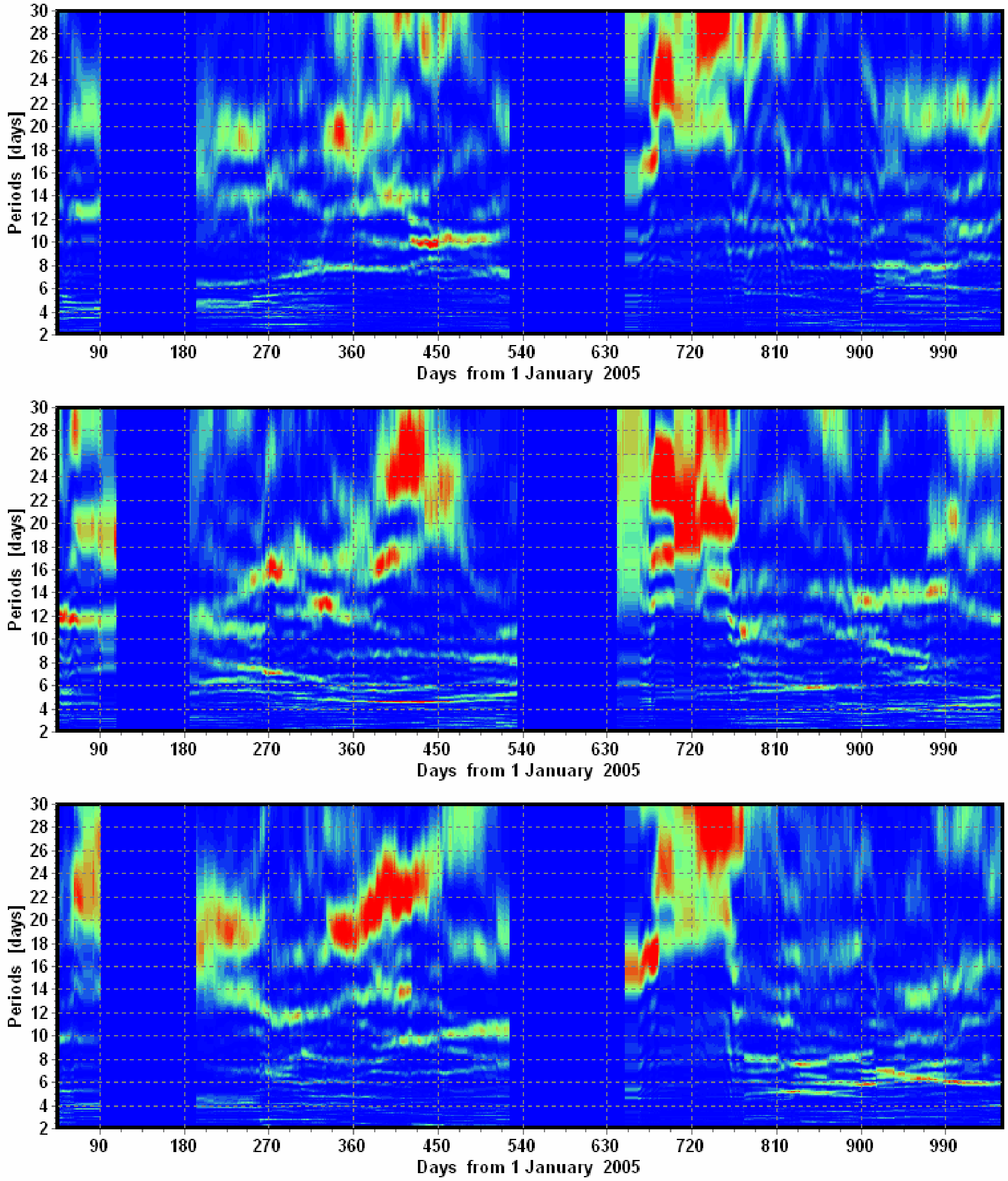

Figure 2. Dynamical Power Spectrum maps of daily I_{RS} index calculated for three centres: top Asia, middle Africa and bottom America. Periods between 2 and 30 days from 90 days window are presented. Maximum amplitudes are presented as red colour and amplitudes equal zero as blue one.

4. Conclusion

From Fig. 1 it is clear that the lightning activity of Africa centre ,measured by IRS index, dominates in north hemisphere winter. The very noticeable feature of DPS maps is the occurrence of changing structures. They are different for each centre and do not copy ideally year in, year out. However, some periods (for example about 22 days) can be found in all the centres. Short periods (period<10 days) structures are observed in all the centres but they patterns have different intensity also. For example in American centre this short periods in 2007 year are stronger intensity then in 2006 year. In the end of 2006 year strong intensity periods around 25-30 days are observed in all the centres. This analysis allows to follow changes of the period structure forming the lightning variability. In our opinion these periods are connected with various sources and we propose this kind of analyse as the new method for observation of those phenomena

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