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GLOBAL THUNDERSTORM ACTIVITY DURING 2001 AND 2007 ACCORDING TO OBSERVATIONS OF THE SCHUMANN RESONANCE INTENSITY IN THE ARCTIC

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Abstract. It is shown on the basis of the analysis of atmospheric noise electromagnetic field variations in 1-st Schumann resonance frequency (SR-1) measured during 2001 and 2007 in the central part of the Kola Peninsula, that energy relations between the Africa, Asia and America maxima of the SR-1 power considerably varied during different seasons. About 06UT the evidently expressed maximum of the SR-1 power is found out. The most probable reason of that can be presence of the thunderstorm center in the west side of central part of the Pacific ocean with an activity maximum in the interval 21-22LT. The power of this center some times is less than each of three basic world thunderstorm centers. It's shown that increase of the solar activity level (the reduction of galactic cosmic rays intensity) causes to increase of SR-1 power.

Introduction

Study of relationship between electric, aerosol, chemical and thermobaric components of atmosphere peculiar importance demands analysis of global electric circuit's (GEC) role in solar-terrestrial relationships system and climate fluctuation [*Roble*, 1985; *Adlerman and Williams*, 1996; *Tinsley*, 1996; *Ermakov et al.,*1997; *Svensmark and Friis-Christensen*, 1997; *Rycroft et al*., 2000]. The central place in GEC is taken by problem of the global atmospheric current generator. It could be considered as a global thunderstorm generator that is operated by lightning activity and atmospheric ionization [*Gish and Wait*, 1950; *Reiter*, 1992].

One of the basic ionization sources in troposphere and stratosphere is galactic cosmic rays (GCR) [*Reiter*, 1992; *Stozhkov*, 2003]. GCR intensity has maximum in years of the quiet Sun and minimum in years of the solar activity maximum [*Belov et al.,* 2001; *Carslaw et al.,* 2002; *Ahluwalia*, 2005]. Probably, GCR intensity variation should result in to changes of lightning formation processes. Atmospheric noise electromagnetic field (ANEMF) intensity in frequencies of Schumann Resonances (SR) can be an indicator of global thunderstorm activity in this case [*Schumann,* 1952; *Balser and Wagner,* 1960; *Bliokh et al.,* 1980; *Rossi et al.,* 2007]. Therefore it is possible to expect, that there is certain dependence SR intensity on the Sun activity state. However, this problem is studied till now insufficiently. Diurnal and seasonal variations of intensity ANEMF in the first SR frequency (about 8 Hz, SR-1), measured in Polar geophysical institute of Russian Sciences Academy "Lovozero" station (67,97^{0}N, 35,02^{0}E, Kola Peninsula), during 2001 and 2007 are viewed below. According to observation in Apatity (Kola Peninsula, http://pgia.ru/CosmicRay/Default.htm) neutron component of the GCR intensity at the ground level in 2007 (year of the quiet Sun) was about 15 % higher then in 2001(year of high solar activity).

Measuring method and data processing

ANEMF of recording was carried out by two-component induction magnetometer. Multiturns ferrite-cored solenoids (260,000 turns) oriented both along and transversely to the magnetic meridian are used as measuring elements. The signal calibration possibility is provided by quasi-monochromatic 5Hz signal for stability checking of power gain. The signal/noise ratio is approximately 30 dB at calibration level 0,5 pT.

Two features of these measurements are significant:

1) the "Lovozero" station is located in the Arctic region, i.e. far from the local thunder-storm centers of middle region during the spring/summer/autumn period. Therefore, signals are coming from world centers of thunderstorm activity (the South/Central America, the South/Central Africa and the South/East Asia), and free of local thunderstorm events, which take place in Arctic regions occasionaly even in the summer;

2) the geographical location of the Kola Peninsula is such, that direction to sector of the Africa centre is approximately perpendicular to directions to sectors of the America and Asia centers, and distance by order of values is approximately equal to distance of each centers (10+/-3 thousand in km).

These conditions give us a chance to obtain rather good spatial separation of the signals coming from previously mentioned directions (fig.1). The directional patterns orientation of magnetometer antennas in "Lovozero" station are presented relatively magnetic-poles and signal arrival sectors from different world thunderstorm activity centers are presented too. It is obvious, that signals from the American and Asian centers should be registered, mainly, in D-component, and from the African one- in H-component.

The initial data for every day were separated into 20 minutes intervals with overlap of 50 % for calculation of diurnal variations of amplitude SR-1. Power spectrums for each of them were made by modified Welch's periodograms method [*Welch,* 1967].

These spectrums in the vicinity of maximum SR-1 were approximated numerically by two terms of Taylor's series:
$P(f) = P - C(f - f_0)^2$,
where: f_0 - SR-1 frequency, $P(f)$ - spectral power of signal in frequency f, P - spectral power of signal in frequency f_0, C - parameter, which characterizes the SR-1width.
Then all counted 20 minute segments of value P (143 values for one day) were collected in files of corresponding days. Variations of values P averaged for days and months are subjects of the further discussion.

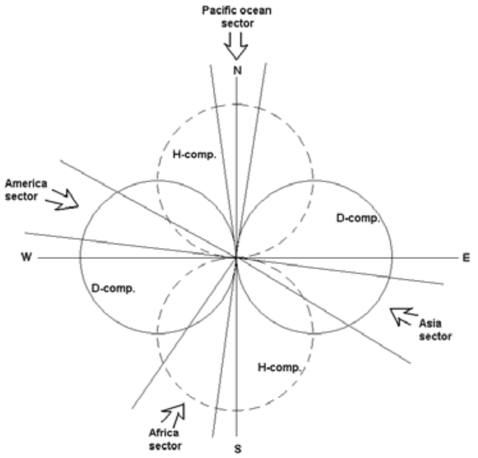

Fig. 1. Directional pattern orientation of magnetometer antennas in "Lovozero" station relatively magnetic-poles and sectors of signal SR-1 arrival from world centers of thunderstorm activity.

Results and discussion

Diurnal variations of intensity SR-1 averaged by the month for both components D and H are shown in fig. 2 and 3. The figures indicates, that ANEMF intensity variations measured in the SR-1 frequency on Kola Peninsula are representing overall picture of space-time variations basic regularities of global thunderstorm activity, namely: maximum of thunderstorm activity nearly 16÷18LT and increase of thunder-storms number during summer time in northern hemisphere [*Christian et al.,* 2003].

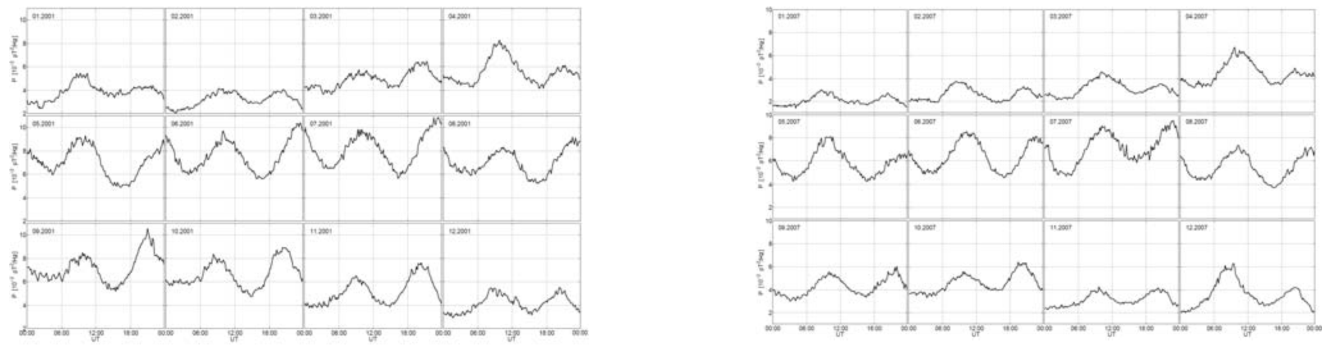

Fig. 2. The diurnal variations of intensity SR-1 averaged by month for D-component.

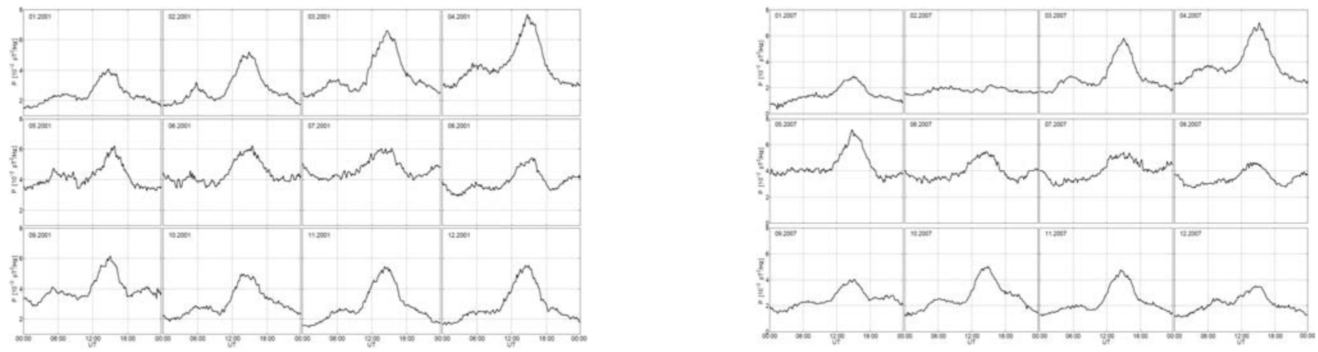

Fig. 3. The diurnal variations of intensity SR-1 averaged by month for H-component.

In fact, the first maximum (P_m1) in diurnal variations of D-component both in 2001 and in 2007 is registered about 9-10 UT and second one (P_m2) about 20-23 UT. P_m1 maximum can related to the Asia thunderstorm centre at LT = UT + (8-9). P_m2 maximum is caused by the America centre at LT = UT - (4-5). In diurnal variations of H-component the basic maximum (P_m3) is registered about 15UT, and it can related to the South Africa thunderstorm centre at LT = UT + (2-3). Above mentioned time shifts results approximately same Local Time, namely15-19 LT for all three maxima.

Seasonal intensity SR-1 variations in fig. 2 and 3 also well represent the thunderstorm activity relationship to season: magnitudes *P* for both components are incremented in 2-3 time by transition from winter requirements to summer in northern hemisphere.

According to the existent basic knowledge about behavior regularity of global thunderstorm activity, SR-1 power variations allow to reveal some specific space-time singularities of thunder-storms intensity variations too. In particular, in February 2007 an almost full disappearance of P_m3 maximum is fixed and this occurrence can be caused by anomalous weather environment in this period over the Central and South Africa. Furthermore, P_m2 maximum displacement is observed to late hours - to 23-24 UT interval in summer. The relation between all three power SR-1 maxima varies significantly during observation period. Herewith there are $P_m3 < P_m1$ and P_m2 during the great part of year. It's shown in the table 1, where mean *P* levels is given in 2001 and 2007 both for the whole year and for time spans 06-12 UT, 18-24 UT for D-component and 12-18 UT for H-component, which correspond to P_m1, P_m2 and P_m3 maxima (see fig.2 and 3).

Table 1. Average *P* values in 2001 and 2007 for different time intervals.

Parameters		Averaging interval				
		D-component			H-component	
		00-24UT	06-12UT	18-24UT	00-24UT	12-18UT
Average *P* values (+/- significant errors by 95% confidence coefficient), $10^{-2}pT^2/Hz$	2001	6,12 +/-0,02	6,87 +/-0,04	6,96 +/-0,05	3,70 +/-0,01	5,05 +/-0,03
	2007	4,56 +/-0,06	5,29 +/-0,05	4,95 +/-0,02	3,17 +/-0,03	4,30 +/-0,04
Difference 2001/2007, %		25%	23%	30%	14%	16%

The table 1 shows also, that average *P* values in 2007 are less than the same values in 2001 at all parameters. It is necessary to mark a specific circumstance. Usually, the thunderstorm activity is taken as the thunderstorms (lightings) amount registered per time and per square or in geographical area. Obviously, ANEMF intensity depends not only on frequency and density of thunder-storms, but on their power also. In this regard the ANEMF intensity in SR frequencies is more complicated and fuller characteristic of the thunderstorm activity and it must be under consideration in the analysis of experimental observation results. It appears to be that variations of GCR intensity level accompanied by both variations of amount and intensity of lightings because of ion formation condition changing and excitation of Schuman resonances by sprites and elves in Earth-ionosphere cavity [*Pasko et al.*, 1998; *Huang et al.*, 1999; *Rodger*, 1999]. However discussion of these problems pass the limits of our paper.

The presence of obviously expressed P_m4 maximum in the H-component approximately in 06 UT calls peculiar interest (fig. 2 and 3). It absent in 2001 only in July, and in 2007 - from May till August. In the D-component P_m4 maximum absent at all. Therefore, signals of thunderstorm source responsible for P_m4 maximum come from a sector located in minimum of D-component directional pattern, i.e. it lies on the magnetic meridian transiting through the "Lovozero" station (fig.1). This circumstance constrains to make the presupposition about existence of a stable thunder-storm source or in the morning (9-10 LT) over Africa, or in the evening (21-22 LT) in west side of central part of the Pacific Ocean. It is necessary to note, that thunderstorm clouds arise mainly in regions of developed convection where upward velocity of enough humid air has a maximum [*Matveev*, 1984]. To this reason the maximal number of thunder-storms over land is observed in afternoon period, when the land surface temperature and the thermal convection reach the greatest value during day. Moreover, the minimum of thunderstorm activity in daily variation is observed in the 8-10 LT [*Christian et al.,* 2003]. Taking into account this situation, existence of morning African thunderstorm source is scarcely probable. On the other hand, the conditions over sea for developed thermal convection increase more often at night, when the water surface becomes warmer than air layers fitting to it [*Matveev*, 1984]. Therefore, correspondence of P_m4 maximum to night thunderstorm activity source in west side of central part of Pacific Ocean is more probable. This source power is a small part of any of three basic world thunderstorm centers.

Conclusions

It is shown on the basis of the analysis of atmospheric noise electromagnetic field variations in 1-st Schumann resonance frequency (SR-1) measured during 2001 and 2007 in the central part of the Kola Peninsula that:

1) The SR-1 power changes represent the basic known spatial - temporal patterns of the global thunderstorm activity, namely: maximum of thunderstorm activity is in 16÷18LT interval in all three world thunderstorm centers and increase of thunderstorm activity is during summer time in northern hemisphere.

2) Energy relationship between the Africa, Asia and America maxima of the SR-1 power considerably varied during different seasons; herewith during the greater part of year the Africa maximum is small in comparison with Asia and America maxima.

3) In February 2007 an almost full disappearance of Africa maximum is fixed and this occurrence can be indicate about the anomalous weather conditions in this period over the Central and South Africa.
4) A shift of America maximum SR-1 power is observed to late hours - approximately 23-24UT in period from May till August.
5) The evidently expressed maximum of the SR-1 power is found out about 06UT. The most probable reason of that can be presence of the thunderstorm center in the west side of central part of Pacific Ocean with an activity maximum at 21-22LT. This source power is a small part of any of three basic world thunderstorm centers power.
6) The increase of solar activity level (decrease of galactic cosmic rays intensity) causes to increase of SR-1 power.

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