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ABOUT THE CHANGE OF ATMOSPHERICS INTENSITY IN ELF-RANGE DURING FORBUSH-DECREASES OF GALACTIC COSMIC RAYS

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Abstract. Some results of low latitudes atmospherics intensity measurements registered at PGI in Apatity are presented. The measurements were started in 2003 on frequencies 1-300 Hz. This range covers practically all spectrum of resonant frequencies of the globe. It is found, that in quiet conditions the atmospherics intensity has two maxima – the morning one at about 03-06UT and the evening one at about 17-21UT. Associated with the Apatity neutron monitor data for all past interval of observation - from July, 2003 till September, 2005 - 10 cases of significant Forbush-decreases (a decrease of counting speed by the neutron monitor - 4 % and more) were registered. The analysis has shown, that associated with observations in the Kola peninsula in all fixed events in the mentioned above range of frequencies the reduction of intensity and advent frequency - down to their complete disappearance is observed.

Introduction. As known, the cosmic rays are one of the basic sources of atmospheric ionization (see, for example, /1,2/). Especially it regards the high latitudes, where the intensity of other powerful ionizing factor - the thunderstorm activity - is much weaker in comparison with the low-latitudes areas. Besides that, in the last 15-20 years there have appeared certain indications there is a dependence of the atmosphere transparency and cloudiness on variations of the galactic cosmic rays /3-6/. Therefore, one can assume, that thunderstorm activity, at such a huge degree dependent on the processes of clouds formation, definitely can depend on changes of the intensity of cosmic rays.

Results of observation

Since the basic centers of thunderstorm activity are in low latitudes, the radiation of only a part of thunders discharges having a sufficient power for appreciable excess of the local fluctuation electromagnetic background reaches the high-latitudes areas. Essential energy of the similar pulses which have arrived in the observation place, appears concentrated in a range from units Hz up to tens kHz (see, for example, /7/). It is known thus /7 /, that at distances of over several thousands km the peak spectra of atmospheric electromagnetic pulses have two maxima, namely: in the area of 2-10 kHz (VLF) and in the interval from units up to 2-3 hundreds Hz (ELF). The strong dependence of the own frequencies on the height of spherical waveguide Earth-ionosphere is characteristic for the VLF-range. The own frequencies of the ELF-range are determined, mainly, by the size of the globe and practically do not depend on the height of the waveguide Earth-ionosphere. In this sense the ELF-range essentially differs from the VLF-range, and the ELF-signals can serve some characteristic of global parameters of the atmosphere describing its condition on the whole /8/. Hereby, it is necessary to note, that the additional ionization of the top layers of the high-latitudes atmosphere arising because of intrusions of corpuscular flows, results in the appreciable attenuation of the electromagnetic field in the VLF-range. In the ELF-range no such strong attenuation is present, and, consequently, one can assume, that if the changes of atmosferics intensity are observed, it is indicative of the changes in the processes responsible for the formation of the thunderstorm activity.

Taking into account this fact, at the Apatity atmospheric range of the Polar Geophysical Institute ($67^0$33'N, $33^0$20'E) since July, 2003 the carrying out of continuous observations of atmospheric electromagnetic pulses in the range of frequencies 1-300 Hz (on the level 0,5) has been done. As a sensor of the field the magnetic aerial such as toroid of the 3-d degree - is used with the purpose of suppression of industrial interferences, mostly having a linear polarization. The main plane of the toroid is on the plane of the "north/south" meridian. The filtration of the received signal is carried out by the 1-st degree filter in order to prevent additional interferences on account of "ringing" from especially powerful pulses. Thus, the amplification of the recorder has such a size, that the reception path does not enter into saturation at the reception of even most powerful atmospherics. Thus, the level of the local electromagnetic background is found to be close to zero.

As an example, in Fig.1 the daily record ELF-atmospherics in Apatity for quiet cosmic-physical conditions is given. It is seen, that in this case there are two maxima - in the morning in the area of 03-06UT and in the evening at about 17-21UT. Their location and magnitude can vary a little from day to day and from season to season, but in the quiet conditions usually both maxima are there.

However the situation varies sharply during Forbush-decreases of galactic cosmic rays. Let us remind, that the effect of Forbush-decreases of GCR is caused by the passage of shock waves from solar flares and the connected to them plasma flows, of the solar wind by the Earth, "frozen" magnetic fields of which as if "sweep away" the GCR from the Earth vicinity.

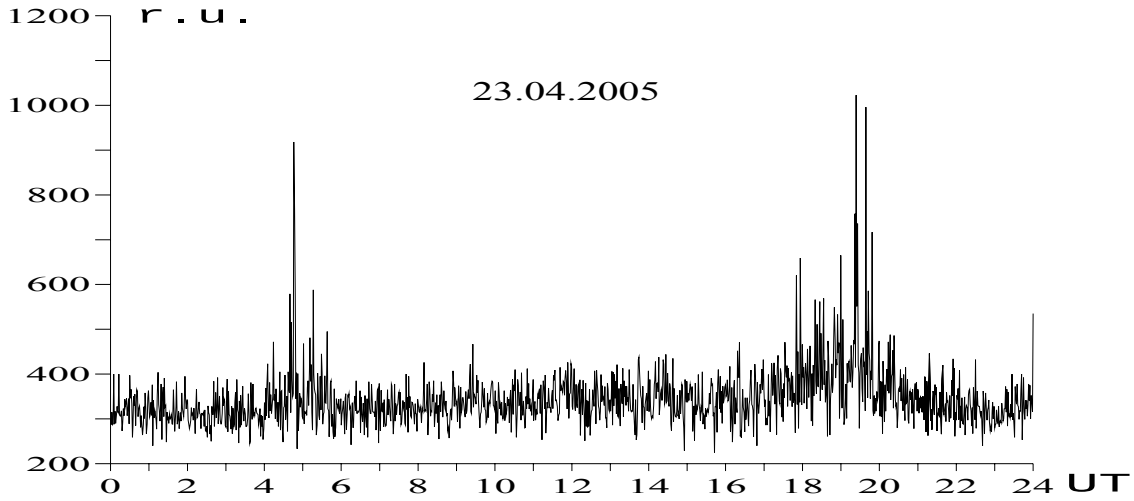

Fig.1. An example of the daily record of ELF-atmospherics in Apatity for quiet cosmic-physical conditions.

By the data of the neutron monitor in Apatity 10 events of significant Forbush-decreases (decrease of the counting speed by the neutron monitor - 4 % and more) were registered for the observation interval - from July, 2003 till September, 2005. The analysis has shown, that according to observations in the Kola peninsula in all the registered events in the above range of frequencies the reduction of intensity and frequency of atmospherics (down to their complete disappearance) is observed. As an example, in Fig.2 the diagrams for a case in January, 2005 are given; here: a - data of the monitor (the Forbush-effect began approximately at 12.00UT on the 17 of January), b - the behaviour of atmospherics in the ELF-range 1-300 Hz.

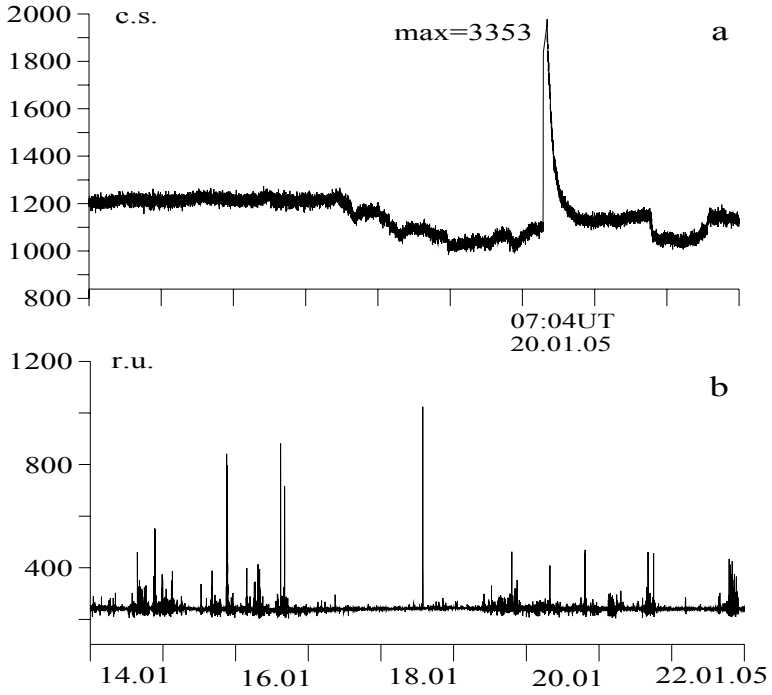

Fig.2. An example of ELF-atmospherics intensity variation during Forbush-decrease of GCR.

It is seen from the figure, that reduction of atmospherics intensity corresponds to the beginning of the Forbush-decrease of GCR on the 17 of January. The ending of the Forbush-effect can be considered the period of 24-25 January. As a whole, the recovery of thunderstorm activity of ELF-signals intensity falls on the same time also.

Discussion

As the characteristic of atmospherics intensity, as a measure of their power, as the first approximation their dispersion was chosen. In the table the ratio of ELF-signals dispersions for two days intervals before and after the beginning of the Forbush-decrease of GCR for each of the considered events are presented.

No	Date and time of Forbush-decrease beginning	Ratio of thunderstorm activity dispersions before/after of Forbush-decrease beginning
1	06.01.2004; 23 UT.	2,3
2	22.01.2004; 02 UT.	1,4
3	22.07.2004; 13 UT.	15,0
4	13.09.2004; 21 UT.	10,4
5	07.11.2004; 19 UT.	21,4
6	17.01.2005; 12 UT.	53,9
7	08.05.2005; 13 UT.	5,1
8	15.05.2005; 02 UT.	2,3
9	10.07.2005; 10 UT.	4,1
10	09.09.2005; 12 UT.	1,8

From the table it is seen, that in all events the intensity of ELF-atmospherics, registered in the Kola peninsula, decreases at the beginning of the Forbush-decrease of GCR.

In the discussion of the revealed phenomenon it is allowable, in our opinion, to assume, that thunder discharges such as " the thunder cloud - upper layers of atmosphere" - so-called sprites and jets (see, for example, /9/ and the brief review given there) play an essential role in the considered here ELF-atmospherics. The ionized area forming at such discharges, appears an effective enough antenna for the excitation of the terrestrial resonator, since it has a volume of hundreds and thousand km^3 (which exceeds many times similar volumes at the discharges "cloud - ground"). Besides the Forbush-decrease of GCR results in a decrease of atmosphere ionization at heights of 10-30 km and, as a consequence, in the increase of resistance of the air column and electric intensity above the thunder cloud (see, for example, /10 /). These factors should result in the reduction of intensity of sprites and jets formation, which, in turn, - results in the decrease of ELF-atmospherics intensity.

Nevertheless, the given explanation of the revealed phenomenon remains so far only a hypothesis requiring additional study, in which the analysis of the results of ELF-atmospherics intensity measurements at essentially different latitudes should be an essential part.

Conclusions

Based on the measurements in the Kola peninsula the decrease of atmospherics intensity (down to their complete disappearance) in the frequency range of 1-300 Hz in all 10 cases of significant Forbush-decreases GCR (decrease of counting speed by the neutron monitor in Apatity - 4 % and more), registered from July, 2003 till September, 2005 was observed.

A hypothesis is put forward, that the revealed phenomenon is caused by the reduction of intensity of the formation of discharges, such as " thunder cloud - upper atmosphere " (sprites and jets) because of the ionization decrease of the atmosphere at heights of 10-30 km during Forbush-decreases GCR.

Acknowledgments

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