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DEPENDENCE OF APPEARANCE FREQUENCY OF AURORAL ABSORPTION ON ITS INTENSITY

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Introduction

The frequency of appearance of auroral absorption (AA) changes during 24 hours and from season to season. It also changes with the 11-year solar cycle [Kuzmin, 2000]. There is little information on the dependence of AA appearance frequency on the absorption intensity. In [Basler, 1963] the distribution of AA appearance frequency in dependence on the absorption value in each 15-min interval during an extremely disturbed month (February, 1958) by observations in a College (Alaska) was given. It is stressed that approximately 63% of observed absorptions have the intensity less than 2 dB. Driatsky [1974] presents the appearance frequency of auroral absorption up to 6 dB with a step of 0.5 dB for the day, evening and night groups by observations in Tixie Bay. The number of events in the day group is 402, in the evening one is 164 and in the night group is 514. It is stressed that at night more intense absorptions than in the afternoon and evening are observed and the character of change of the number of AA appearance events depending on the intensity is similar in all groups. About 80% and 92% of absorption have the intensity less than 2 dB and 3 dB, correspondingly.

The purpose of the present paper is to study the dependence of AA appearance frequency on the intensity and its change during 24 hours, the 11-year Solar cycle and from season to season as well.

Experimental data

Riometer measurements have been carried out in Tixie from 1986 to 1997 at the frequency of 32 MHz with the antenna of wave channel type directed to the North star. The events of polar cap absorption (PCA) caused by proton events from the Sun and sudden absorption of space radio noise caused by solar X-ray bursts have been excluded from the observed absorptions with the intensity of 0,3 dB and more and with the duration of not less than 10 min per/hour. The procedure of identification and exclusion of such events is described in [Kuzmin, 2000]. Such a treatment method allows us to consider the residual part of data, which were caused by the precipitation of energetic electrons. There have been determined integral frequencies of absorption appearance depending on a threshold intensity of absorption 0.3, 1.0, 2.0 and 3.0 dB, presented in Table 1.

Table 1
Annual integral appearance frequency of auroral absorption depending on threshold absorption

Threshold intensity, dB	1986	1987	1988	1989	1990	1992	1993	1994	1995	1997
0,3	2475	2254	2693	2650	2865	3639	3683	3814	3217	2049
1,0	1004	764	948	1112	988	913	1348	1469	994	499
2,0	423	235	295	432	386	334	574	737	379	158
3,0	173	68	123	183	150	110	253	346	161	73

The analysis of dependence of the AA appearance frequency on the threshold intensity has shown that it is satisfactorily approximated by $lgN(>A)=a-k\bullet A$. The parameters a and k have been determined by the method of least squares and are given in Table 2. The experimental data for 1991 and 1996 have not been used due to gaps in observations. Fig.1a presents the annual average distribution of AA appearance frequency depending on the intensity for all 10 years of observations and the approximating graph.

The a and k parameters have been calculated separately for winter (XI, XII, I, II) and summer (V, VI, VII, VIII) months. For all 10 years the k value is permanently larger in summer than in winter. An average for the 10 years distributions $N(>A)$ in summer and in winter and approximating graphs are given in Fig.1b. It is seen that the difference between data for winter and summer is obvious. Also the distribution $N(>A)$ during the evening (1600-

2100 LT) and night (2300-0400 LT) hours has been found for every year. According to [Befersdorff, 1966] during these hours of day the most difference in the precipitating electron spectrum rigidity is observed. The *k* value at evening hours is permanently larger than at night .

The 10 years average distribution of AA appearance frequency at evening and night hours and approximating graphs are given in Fig.1c

Table 2.
Annual average *a* and *k* parameters of approximating dependence

Parameter	1986	1987	1988	1989	1990	1992	1993	1994	1995	1997
$a \pm \Delta a$	3,428±1,0%	3,476±0,2%	3,518±2,0%	3,497±1,0%	3,531±1,8%	3,606±2,7%	3,623±1,9%	3,648±1,7%	3,636±2,3%	3,326±4,0%
$k \pm \Delta k$	0,409±4,7%	0,552±6,8%	0,494±7,6%	0,419±4,5%	0,463±7,5%	0,535±9,7%	0,419±8,8%	0,369±9,0%	0,475±12,2%	0,518±13,8%

Δa and Δk are given in % from the values of parameters *a* and *k* .

Discussion

The distributions of AA appearance frequency depending on its threshold intensity, presented in Fig.1, allows to make conclusions about the change of a portion of intense absorption from season to season, during a day and the 22-nd solar activity cycle on the whole. As it is noted above, the experimental data can be approximated by the form $lgN(>A)=a-k\bullet A$. The parameter *k* in the 11-year cycle varies in a wide range, from 0,369 to 0,552. No dependence of k on the solar activity phase is observed.

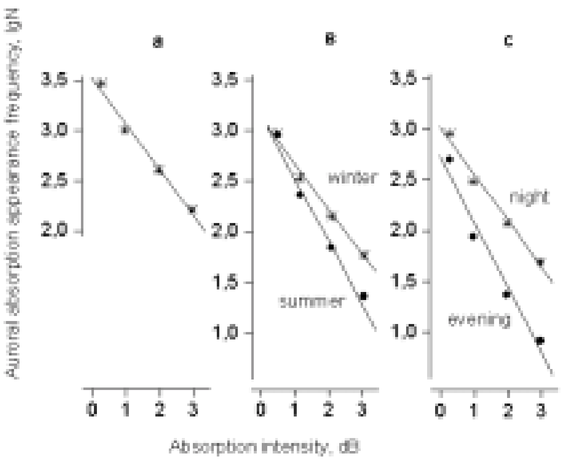

Fig.1 Annual average distribution of AA appearance frequency depending on the absorption intensity for 1986-1997:

a) all events;
b) events in winter and in summer;
c) evening (1600-2100LT) and night (2300-0400LT) events.

Circles and stars are experimental values, the right lines are approximating them graphs.

Fig.2 presents the change of solar activity in the 22-nd cycle and the corresponding changes of *N(>A)*. One can see that the change of AA appearance frequency with the i>0,3 dB ntensity does not correspond to the solar activity change. It is noted in [Kuzmin, 2000]. The change of AA appearance frequency in most degree depends on the intensity of high-speed solar wind streams. The character of the change with time of AA appearance frequency with the intensity more (1, 2 and 3 dB) differs essentially from the corresponding change of N(A>0,3 dB).

In order to see this difference clearer, the curve 2 corresponding to the AA appearance frequency with the intensity from 0,3 to 1,0 dB has been constructed. It is seen, that the change of N(0,3<A>1,0) differs essentially from the corresponding change of N(A>1, 2, 3) (the curves 3, 4 and 5). The last three curves clearly show that there is an increase of portion of intense absorption in 1993-1995 when the high-speed solar wind streams are observed most often. Analysing the temporal change of the variation of N(0,3<A>1,0) we conclude that from 1987 to 1993 many absorption of little intensity occur. On the basis of totality of experimental data one can suppose that the reason of small intensity AA is magnetosphere disturbances caused by solar spot activity at the end of maximum phase and at the beginning of the phase of solar activity decay. The appearance of AA with the intensity more than 1 dB is the consequence of effect of the high-speed solar wind streams on the magnetosphere. In this fact, perhaps, both the flux and the spectrum type of precipitation electron is changed.

As it is noted above, in winter the value of *k* is systematically less than in summer. The average value *k*=0,603 in summer and 0,448 in winter, i.e. the portion of intense absorption in winter is more than in summer. In the work [Osepyan, 1999] it has been shown that the rigidity of the precipitation electron spectrum does not depend on a season. If it is so, it should be assumed that the observed difference in the portion of intense absorptions is caused by the difference in the value of precipitation electron fluxes in winter and in summer. During wintertime the value of the precipitation electron flux, on the average, is more than in summer.

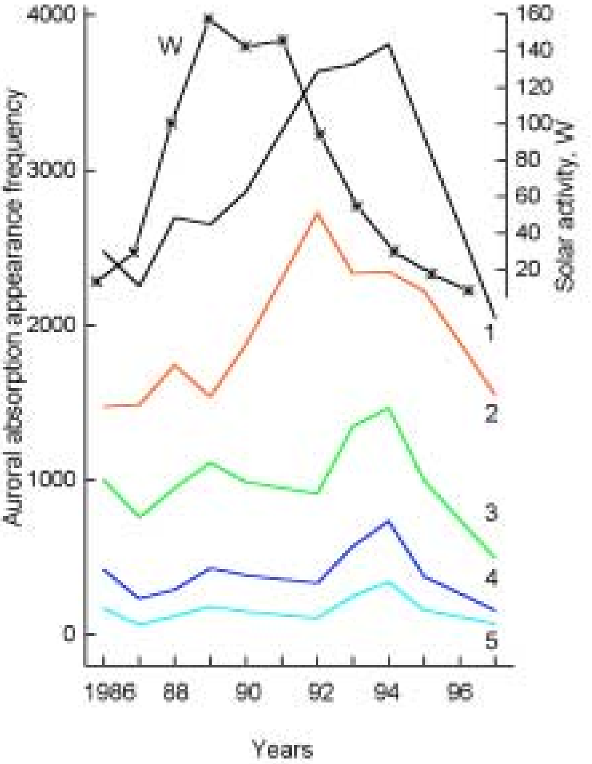

Fig.2 Change of AA appearance frequency for 1986-1997:
1 – in all events;
2 – with absorption value A>0.3 dB;
3 - A>1.0 dB;
4 - A>2.0 dB;
5 - A>3.0 dB.
The line with stars is a solar activity index (W) for the same period.

In Fig.1c the dependence of the AA appearance frequency on its intensity at evening and night hours is shown. The difference of N(>A) at evening and night hours is obvious. On the average for 10 years, the parameter *k*=0,458 at night and 0,643 in the evening, i.e. during night hours the portion of intense absorption is more than at evening hours. According to [Osepyan, 1999] the electron precipitations with a steep spectrum at the evening-night hours (2000-0300 LT) and with rigid spectrum at the morning-day hours (0300-1200LT) are typical. In that paper , it is shown that in order to provide the identical absorption intensity, the electron flux at night should be greater by the factor of 10^2 than in the morning. Thus, in the night sector the precipitation electron spectrum is steeper, but their flux is greater. Comparing the data obtained by us on the portion of intense absorption in the evening and at night, we are prone to think that the observed difference in distribution of N(>A) is caused, to a greater degree, by the difference of precipitation electron fluxes in these sectors of days.

Conclusions

1. The analysis of AA appearance frequency distribution by the intensity has shown that during the 11-year solar activity cycle the portion of intense absorption changes in a wide range. The AA appearance frequency with the intense absorption (>1, 2 and 3 dB) essentially depends on high-speed solar wind streams increasing by the factor of 2, 3 and 5, correspondingly during the years of their maximum appearance. The AA appearance frequency of small intensity (A<1 dB) is connected with magnetosphere disturbances caused by solar spot activity.
2. The portion of intense absorptions depends on season and time of day. In winter and at night hours the portion of intense absorption is large than in summer and in the evening. The change of the type of precipitation energetic electron spectrum, perhaps, plays a small role in the changes of intense absorption portion. The determining factor in the change of intense absorption portion is the value of precipitation electron flux.

References

1. Driatsky V. M. The nature of anomalous absorption of the space radio emission in the lower ionosphere of high latitudes (in Russian). //Gidrometeoizdat, L.: 1974. 224 p.
2. V. A. Kuzmin V.A., Sokolov V. D., Bezrodnykh I.P. Variations of energetic pacticle precipitation frequency in the 22 solar activity cycle (in Russia). //Geomagnetism and Aeronomy. 2000. V.40. №6. p.104-106.
3. Basler Ray P. Radio Wave Absorption in the Auroral Ionosphere // J. Geophys. Res. 1963. V.68. №16. p.4665-4681.
4. Bewersdorff A., Dion J., Kremser G., et al. Diurnal Energy Variation of Auroral X-rays // Ann. Geophys. 1966. V.22. №1. p.23-30.
5. Osepyan A.P., Smirnova N.N., Kirckwood S. Daily and seasonal variations of the precipitation electron energy spectrum by data of electron concentration measurements using the method of incoherent radiowave scattering (in Russia)// Geomagnetism and Aeronomy. 1999. V.37. Issue 4, p.348-355.