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DISTRIBUTION OF LONG AURORAL DISTURBANCES OF DIFFERENT TYPES FROM SEASON TO SEASON AND DURING A SOLAR ACTIVITY CYCLE

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Abstract. Analysis of distribution of duration and number of Long Auroral Disturbances (LAD) events of 4 types from season to season and in a Solar Activity Cycle from 1978 up to 1993, has been carried out. It has been shown that in both distributions, curves of the 4-th LAD type (of periods of steady magnetospheric convection) are about same as mirror images of distribution curves for the first 3 types. Different spectral peaks of short-period variations of the solar activity are established within capacity spectra of various types LAD duration.

Introduction

It is well-known [1], that planetary geomagnetic activity is maximal in equinox periods and is minimal in the time of summer and winter solstice. In the distribution of A_p index from year to year, maximums were observed at the phase of decrease of the solar activity [2]. During the same years, the Earth's orbit had the largest number of high-velocity streams of interplanetary plasma. In order to be able to characterize periods of high magnetic activity in the auroral zone, the concept of long auroral disturbances (LAD) was introduced in the paper [3]. This concept was reconsidered in [4] and it was shown that the majority of LAD events could be divided into four types by temporal variations of auroral indices. An identification method of the relation between solar source classes and LAD types was suggested in [5]. It was established that corpuscular streams from coronal holes and helmet coronal streamers produce LAD of the first type, SDF streams - LAD of the second type, sf-streams - LAD of the third type. The solar source of streams, producing LAD of the fourth type, is still not identified. Although, planetary and auroral geomagnetic activities are interrelated, the studies of periodical variations of auroral activity, taking into consideration LAD classification by types and their comparison with variations of solar sources of geoeffective corpuscular streams, is of certain interest.

Initial data and their processing

For the analysis, we used data on auroral indices of years 1978-1988, 1990, 1993 [6]. LAD intervals were selected by graphs and numerical minute values of AU, AL, AE indices and LAD classification by types was carried out, according to [4]. For each LAD type, the number of n_j events and total duration Δt_j of the given type per each month during the above mentioned years were calculated. For more correct comparison, values Δt_j were recalculated for the 30 days interval $T_j = \Delta t_j \times 30/m$, where m stands for the number of days in a month. For further analysis after corrected values T_j, the monthly average duration of T_j' for each year and T_j'' for each month for 13 years were calculated. N_j' of j-type LAD per year and N_j'' in each month were calculated as well for 13 years. The total auroral disturbance, without being divided by LAD types was characterized by values N', N'', T', T'', obtained by summing of corresponding values of N_j, T_j, after j from 1 to 4. The spectral analysis of values T_j was carried out in order to reveal periodical variations in the characteristics of auroral disturbances of various types. A conventional month, equal to 365/12 = 30,4 days, was used as a time unit.

The analysis of results

It is seen from distribution of N' and T' by years (fig.1a), that the total auroral activity in the 21-st solar cycle corresponded to the planetary one: disturbances maximum was observed at the phase of the solar activity decrease in 1982-1984 and minimum at the phase of minimum in 1985-87. For 1-3 LAD types, maximums of distributions fell on years of the solar activity decrease as well. However, for the 3-d type, the maximum was large and it lasted in the epoch of minimum of spot-forming processes in the Sun. It might be related to a non-uniform distribution of the number of flares by phases of the solar cycle [7]: there are less subflares at the beginning of the cycle and there are more at the end. Maximums of distribution of N_4' and T_4' coincide with phases of the solar activity maximum and minimum coincide with phase of solar activity decrease. The curves 4 look like mirror images of the curves 5. It is natural to assume, the fourth type LAD were observed more often, when the orbit did not have more geoefficient corpuscular streams, producing LAD of 1-3 types. The anticorrelation between N_4' and $N = \sum_{j=1}^{3} N_j'$, and between T_4' and $T = \sum_{j=1}^{3} T_j'$ are confirmed this opinion. The coefficients of correlation r between them are, correspondingly, equal to -0,74 and -0,88.

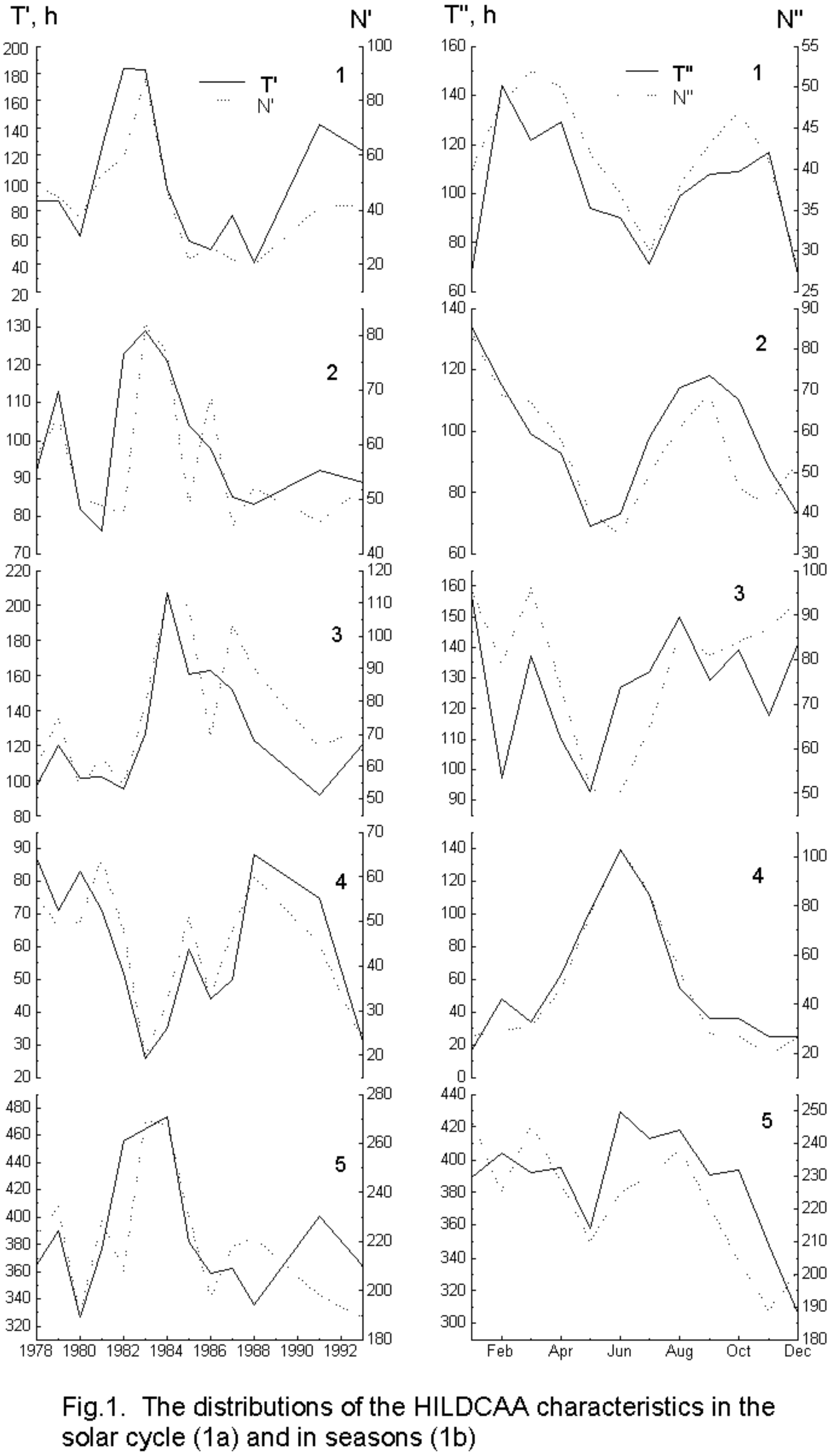

Fig.1. The distributions of the HILDCAA characteristics in the solar cycle (1a) and in seasons (1b)

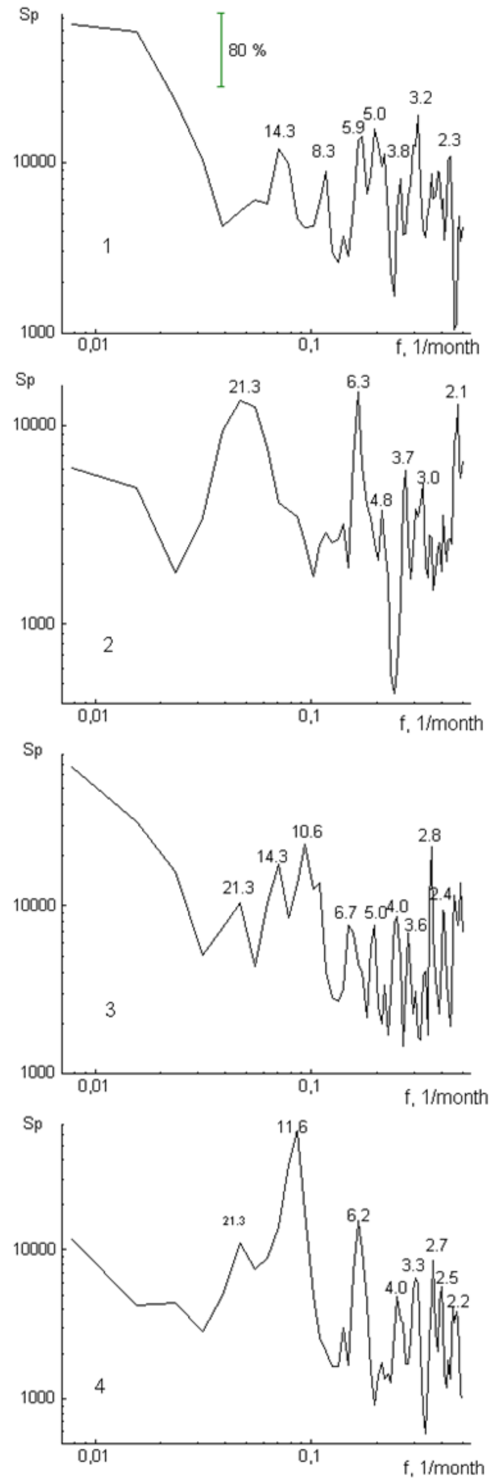

Fig.2. The spectra of Tj. Numbers near peaks indicate periods in conventional months.

Similar correlations were observed in the distribution of the fourth type of LAD and other types from season to season. Distribution of the fourth type LAD had a wide maximum in summer months, whereas for I, II, III types the minimum was observed. Correlation coefficients between N_4'' and $N = \sum_{j=1}^{3} N_j''$ and between T_4'' and $T = \sum_{j=1}^{3} T_j''$ were -0,82 and -0,77. These results allow for drawing a conclusion, that streams of interplanetary plasma, producing LAD of the 4 type (periods of steady magnetospheric convection) most likely have the lowest domination rating after their geoefficiency.

Distribution maxima N_2'' and T_2'', N_3'' and T_3'' in January, can not be explained by seasonal variations of solar sources (or variations of geodipole orientation and ionosphere conductivity). As shown in [8], the number of subflares during the spring-summer period was 25% more, than the one in the winter-autumn period. The maximum of ionospheric conductivity was observed, as we know, in summer and because of this, in summer months AU, AE indices and the duration of all types of LAD, determined by the criterion AE > 100 nT, increase. The latter explains the appearance of the summer maximum in T and its absence in seasonal change of N.

As noted in [7], during 11-year cycles, there are observed short-period variations of solar activity that can be considered as manifestation of the Sun's global unstable oscillations. These oscillations can be reflected in variations of characteristics of auroral disturbances at similar frequencies. Fig. 2 represents the power spectra of T_j for the interval from January 1978 up to June 1988. Numbers stand for periods in conventional months (1 month = 30,4 days) for statistically significant peaks in spectra. In the spectra for the 1and 3 types of LAD, a 152- day (5 months) and 1,2-year (14,3 months) periodicities are manifested, that were discovered earlier within the flare activity after the solar data [9]. The period of 1,78 of year (21,3 months) in spectra T_2 and T_4 is similar to the period of nonstationary oscillations of the solar activity of 1,6-1,9 year [7, 9]. Semi-annual variations, manifested in spectra T_2 and T_4 are most likely stipulated by seasonal changes in geodipole orientation, whereas the annual variation in T_4, seems to be a consequence of minimal rating of domination of geoefficiency of streams, causing periods of steady convection in the magnetosphere.

Conclusion

The distributions of characteristics of N_j and T_j for various types of LAD differ substantially through years, as well as through years. Only for the first type of LAD distributions of characteristics N_1 and T_1 follow the corresponding distributions of A_p index. The 4-th type LAD characteristics have maxima in distributions at the same periods, as totals of these characteristics after the first three types are minimal. For this reason, we have drawn a conclusion, that streams of interplanetary plasma, initiating periods of steady magnetospheric convection, have lowest rating of geoefficiency domination. The reasons, of the maximum occurrences in distributions N_j and T_j (j = 2, 3) in January, are not clear. This problem requires further additional studies.

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