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DEPENDENCE OF SUBSTORM EXPANSION OF AURORAS AND AURORAL ELECTROJET ON INTERPLANETARY PARAMETERS

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Introduction

Influence of the solar wind (SW) conditions on dimensions and shape of the auroral bulge at substorm expansion is an important point, since it clarifies specific features of the solar wind energy transfer into the Earth's magnetosphere and ionosphere. The area occupied by the auroral bulge at the stage of its maximum development, enables to estimate the magnitude of the magnetic flux reconnected at the magnetospheric tail during substorm. Myiashita et.al. [1] have found a considerable correlation between a decrease of the total pressure in the tail and polar expansion of the auroral bulge (the breakup). The decrease of the total pressure in the magnetospheric tail is a measure of the energy dissipated in the process of reconnection during a substorm. The amount of the released energy, in its turn, depends on the energy accumulated in the tail lobes in the course of its transfer from the solar wind.

The influence of SW and IMF conditions on the position of the equatorial and poleward boundaries of the auroral bulge has been investigated in a number of papers. Zverev et al. [2] by using Explorer-33,34,35 spacecraft data as well as askaplots from Dixon, Chelyuskin and Mirny stations studied the effect of the Bz IMF component in dynamics of auroras during substorms. It was shown that southward Bz IMF increasing is accompanied by a sharp decrease in the initial latitude of the auroras along with a simultaneous increase of the maximum latitude they reach during the expansion. Vorobyov and Zverev [3], based on the DMSP satellite data, analysed the influence of the SW velocity on the position of the auroral oval boundaries. It was shown that under the growth of the southward Bz IMF, an increase in the SW velocity causes the shift of the auroral poleward boundary to higher latitudes, yet the equatorial boundary is shifted to lower ones. Under the northward (or positive) Bz IMF, with SW velocity increasing, the luminosity band is getting wider and displaced to lower latitudes. Unfortunately, the data used in [3] do not permit monitoring substorm development, since the satellite observations of boundary positions fall on different phases of the substorm. Gussenhoven [4] studied the conditions, under which the auroras reach extremely high geomagnetic latitudes (over 80^0) as depending on the SW parameters and IMF. In particular, it turned out that the auroras expanding to such latitudes are observed under high SW velocities.

The influence of the SW conditions on propagation of the substorm-associated westward electrojet to high latitudes was studied by Sergeev et al. [5] and Dmitrieva and Sergeev [6]. Using the data of the ground-based magnetic stations, the authors explored the disturbances initiating in the auroral zone and propagating to extremely high latitudes. The geomagnetic latitude reached by the westward electrojet appeared to be higher for higher solar wind velocity.

Data and results

In this paper we present a comparative analysis of the influence of the SW velocity, IMF southward and azimuth components and interplanetary electric field, the latter representing the joint effect of the SW velocity and IMF, on auroral bulge development. By using observations of the Polar satellite, the one with a high apogee, we can control the phase of the substorm examined. Along with the auroral boundary positions, we also considered the area of the auroral bulge under different interplanetary conditions as well as the latitudinal position of the westward electrojet. This gave us a possibility to compare the influence of SW and IMF conditions on the latitudinal movement of both the auroras and westward electrojet in the course of substorm development. The SW and IMF parameters were taken as observed by the WIND satellite (we used the SWE and MFI data with 1 minute resolution). The analysis of auroral activity was performed based on the Polar satellite UVI data. The polar aurora shots of one minute resolution within the short wave (LBHS, 1400-1600 A) and long wave (LBHL, 1600-1800 A) emission bands were used. To study the latitudinal displacement of the westward electrojet we used the data from the ground-based magnetometer meridional chain of IMAGE stations.

We selected all substorms in December 1996 and January 1997, for which the Polar satellite data were available (92 events in sum). The following characteristics of the auroral bulge were identified: the equatorial latitude of the auroras L_0 at the substorm onset, latitude of the auroral polar edge L_m at substorm maximum and the total area of the auroral bulge S along with its longitudinal (L_{lon}) and latitudinal (L_{lat}) dimensions at substorm maximum. These quantities versus solar wind velocity V, IMF southward component B_s and azimuth component of the interplanetary electric field E are presented below.

One can see from Fig.1, that with increasing each of the above parameters, the difference between L_m and L_0 increases too. At the same time, B_s affects both the initial latitude of the substorm L_0 (by shifting it to lower latitudes) and maximum latitude L_m (by removing it towards the pole). On the other hand, the solar wind velocity mostly affects L_m without changing L_0. As follows from Fig.2, the total area of the auroral bulge S increases considerably as both B_s and E_y grow. The growth of S with V increasing is not so pronounced. We found that B_s and E_y influence both the longitudinal L_{lon} and latitudinal L_{lat} dimensions of the bulge. The velocity, in its turn, affects $L_{lat,}$ without producing any noticeable effect in L_{lon}. These results are presented in Fig.3.

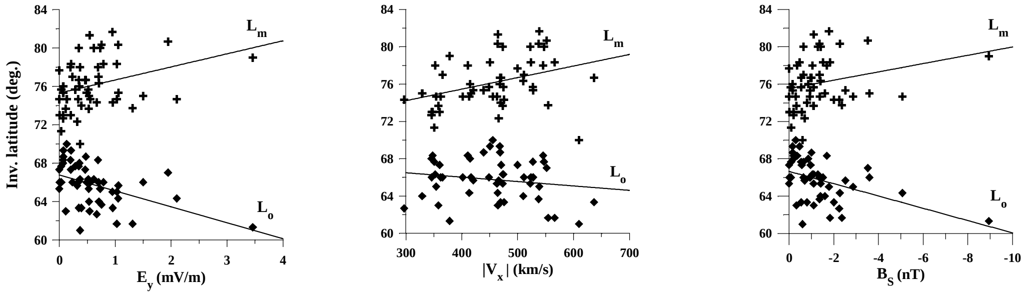

Fig.1

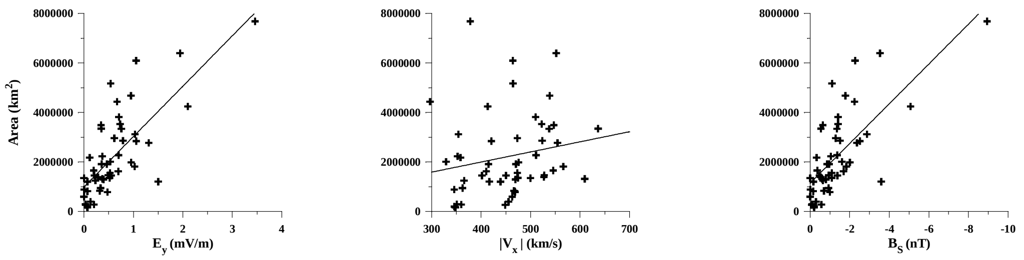

Fig.2

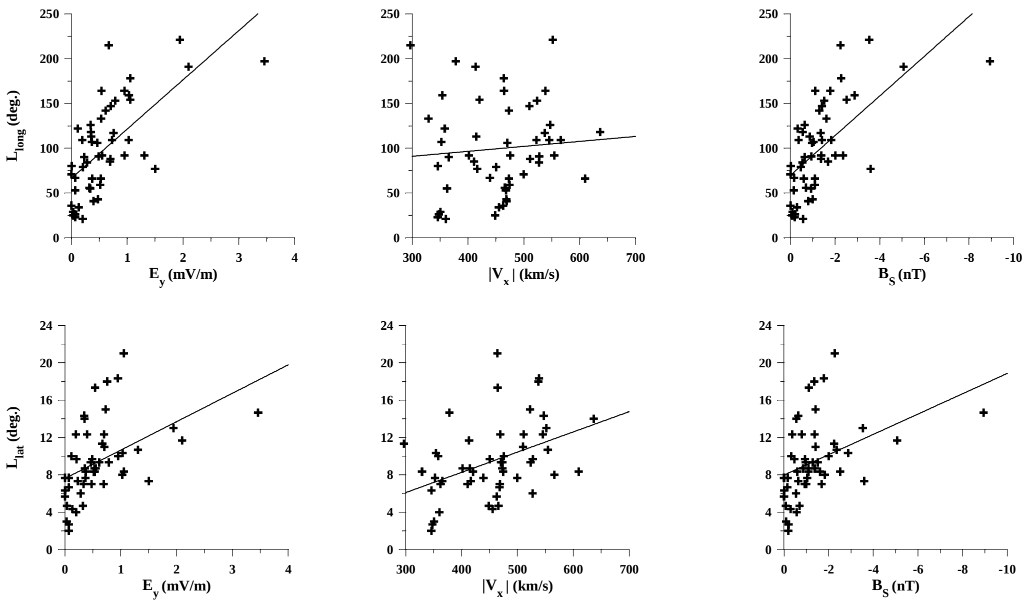

Fig.3

The above results can be interpreted within the framework of magnetic reconnection. In fact, the magnitude of the azimuth component of the interplanetary electric field determined by the product of B_s and V controls the reconnection rate at the magnetopause and, consequently, the magnitude of the magnetic flux accumulated in the tail lobes. On the other hand, the dimension of the auroral bulge is proportional to the magnetic flux reconnected around the near-Earth-neutral line in the course of substorm.

Now let us turn to the westward electrojet behaviour. The electrojet latitude has been determined by standard analysis from variations of the geomagnetic field H and Z-components. As one can see from Fig.4, both the initial (L_s) and maximum (L_f) latitudes of the electrojet decrease with either southward B_s IMF or azimuth electric field E_y increasing. However, the latitudinal extent of the substorm site L_f -L_s actually does not increase much. The velocity V causes a considerable increase in L_f but does not influence L_s. Thus, we can see that interplanetary parameters affect differently the latitudinal propagation of the westward electrojet and auroras. On the average, the maximum latitude of the westward electrojet does not increase but rather decreases as B_s grows, which is essentially different from auroras' behaviour. This might be connected with the fact, that with B_s increasing, more intense particle precipitation from the inner magnetosphere forms a channel of enhanced ionospheric conductivity in the near-equatorial part of the auroral bulge.

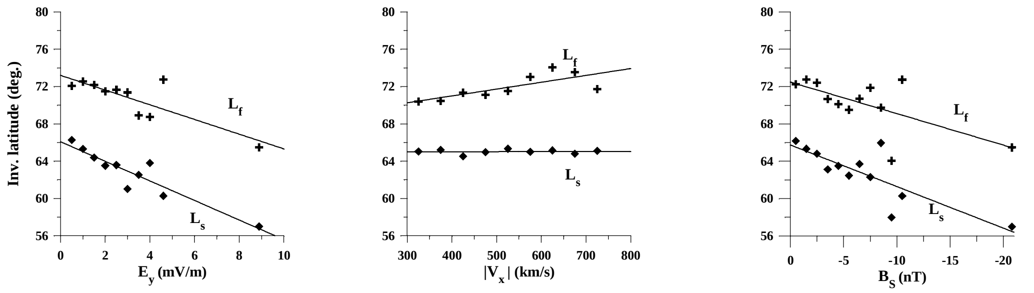

Fig.4

Conclusions

In conclusion we formulate the principle results:

1. The latitudinal extent of the substorm auroral bulge is proportional to the southward IMF component and solar wind velocity, with B_s affecting both L_0 (the larger is B_s, the lower is L_0) and L_m (the larger is B_s, the higher is L_m), and V affecting only L_m (the larger is V, the higher is L_m). As a result, the latitudinal extent of the auroral bulge increases with increasing the azimuth component of the solar wind electric field.

2. The total area of the auroral bulge S increases with B_s and E_y increasing. The southward IMF component and azimuth component of the electric field affect both longitudinal L_{lon} and latitudinal L_{lat} dimensions of the bulge, whereas the solar wind velocity does affect only the latitudinal one.

3. The maximum latitude of the substorm associated westward electrojet does not increase and even goes down with the growth of B_s, which differs essentially from the aurora behaviour.

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