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INFLUENCE OF INTERPLANETARY MAGNETIC FIELD ON AURORAL ACTIVITY

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Abstract

Variations of a polar flux in northern and southern ovals are analyzed in connection with changes of the geliospheric magnetic field near the Earth. It covered the period from 1978 to 2001. The increase of the auroral activity is confirmed at southern IMF orientation Bz <0. There is shown an asymmetric distribution of average values Bz components in the GSM XY plane. It is established, that average activity of polar lights for both hemispheres is higher, when Bx> 0 under northward IMF. The increasing of the auroral activity of different hemispheres is observed under different signs of By-components. The seasonal variation of the auroral activity is observed also – auroral power flux is maximal during equinoxes. The dependence of the auroral activity on azimuthal components of IMF decreases during winter and increases during summer.

Introduction

The configuration of the magnetosphere changes with the interplanetary magnetic field (IMF). Aurora is a typical phenomenon of the magnetosphere. Therefore morphology of aurora has been extensively studied as a function of IMF orientation [4, 8]. Some studies found that the auroral activity, position and motion of aurora depended upon the component of IMF [4, 6]. Auroral activity also depends on the season. The different parts of the auroral oval depend on IMF orientation in various ways [1, 10].

Some scientists found the dependence of the aurora on azimuthal By component of the interplanetary field [3, 5, 10]. The increase of auroral forms velocity is observed with increasing of |By| [13]. It may be explained by partial penetration of IMF from the solar wind in magnetosphere [12] that leads to the results of reconstruction magnetospheric current systems. Some scientists found the dependence of the auroral arcs [7] and auroral oval [9, 11] on radial Bx component of the interplanetary field.

Bx and By components of IMF are anticorrelated in classical model of a spiral field. But the direction of IMF vector is essentially chaotic. Therefore we investigate the behavior of auroral activity with azimutal and radial components of IMF.

Auroral activity strongly depends on conductivity of the ionosphere. The ionospheric conductivity has a seasonal effect. Therefore, we investigate the influence of IMF on aurora for different seasons.

Data

As a characteristic of the auroral activity, the power flux (PF), obtained from NOAA POES (http://sec.noaa.gov/ftpdir/lists/hpi/) was used. Instruments on board the polar satellites continually monitor the power flux carried by the protons and electrons that produce aurora in the atmosphere. Power flux is measured in gigawatt. The data for northern and southern ovals is available and gives us a unique opportunity for comparing the processes in different hemispheres. It covers the period since 1978 to 2001.

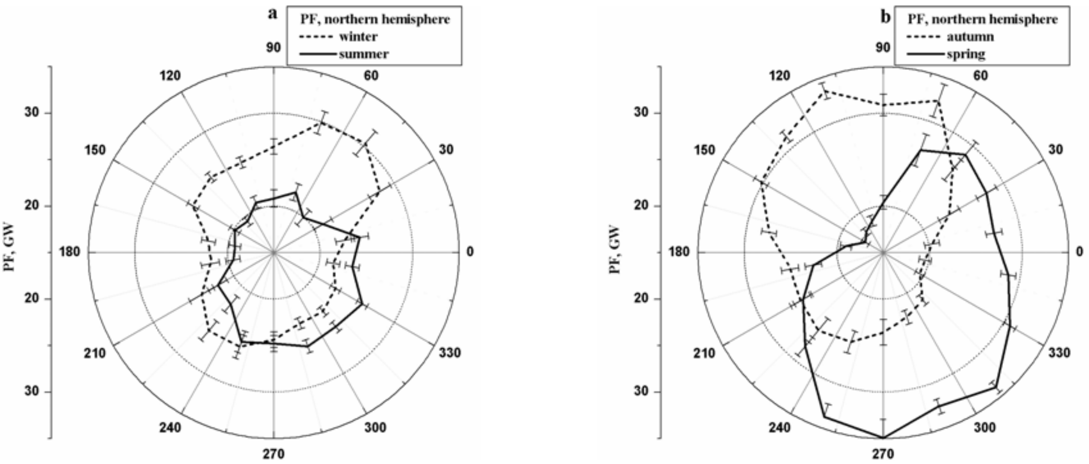

Fig. 1 Power flux in northern oval for winter and summer solstices (a) and for vernal and autumnal equinoxes (b) as a function of IMF orientation in GSM XY coordinates

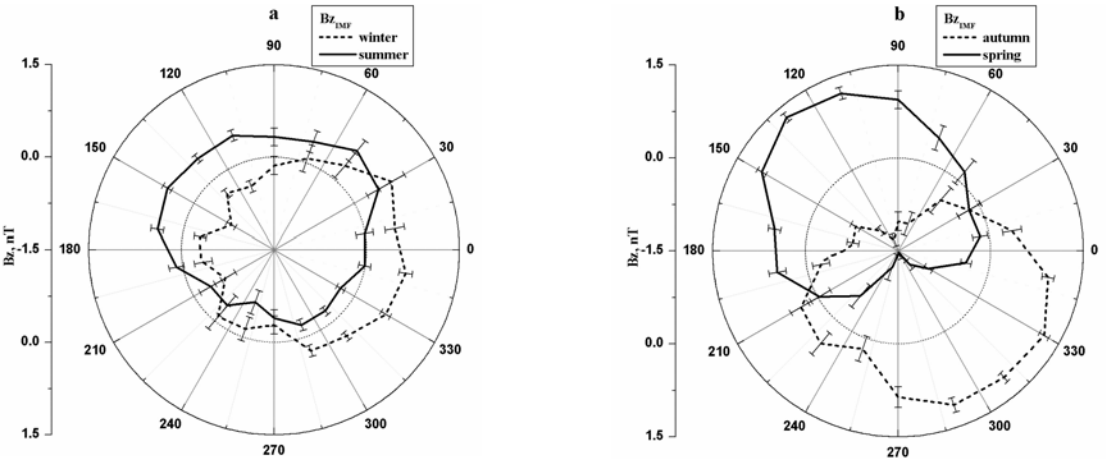

Fig. 2 IMF Bz component during winter and summer solstices (a), vernal and autumnal equinoxes (b) as a function of IMF orientation in GSM XY coordinates

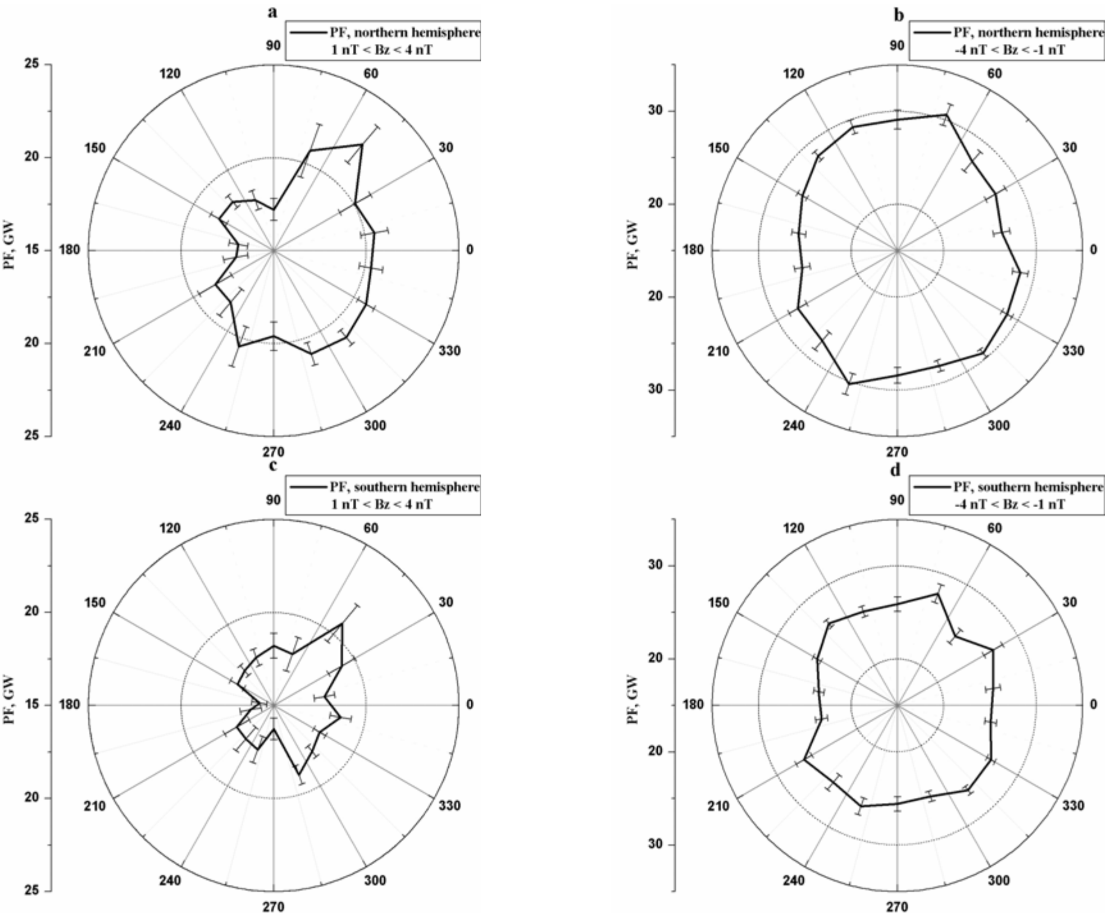

Fig. 3 Power flux in northern (the top line) and southern (the bottom line) ovals for northward IMF (the left column) and southward IMF (the right column) as a function of IMF orientation in GSM XY coordinates

We used information about IMF orientation from the OMNI database (http://dbserv.npi.msu.su/data/release2/omnionline.html). Most of the IMF data were obtained from IMP8 and ISEE3 observations during 1978-2001. We used hourly averaged IMP8 data in our study. Input data is presented in GSM system. The axis X is directed along Sun-Earth line. The axis Y is perpendicular to the Earth's dipole axis.

The physical parameter *p* discussed in this article is presented as a function of an azimuthal IMF angle φ=arctg(By/Bx) at the moment of the parameter observation. The corner φ is counted from the direction on the Sun (φ = 0°) counter-clockwise in XY plane of GSM system. For the sake of clarity the full circle range of φ was subdivided into twenty-degree sectors. The results are presented in the polar diagrams as function *p*(φ) and a scale for the diagram is specified on the left. The total number of auroral events collocated with IMF data is about 65 thousand in each hemisphere. A full list of the calculated data was then classified by the direction and IMF magnitude and the year seasons.

Results and discussion

PF(φ) dependences for various seasons are presented in fig.1. Strong asymmetry can be explained by the influence of azimuthal component of IMF and other characteristics of solar wind also. Fig.2 shows an IMF Bz dependence on an azimuthal IMF angle φ during 1978-2001. Bz distribution is not isotropic. Southward IMF is the most geoeffective one. Southward IMF corresponds to negative values of our study. The minimum of average Bz values should correspond to the maximum of auroral activity. Asymmetries of Bz distribution (fig. 2b) and PF (φ) (fig. 1b) are opposite during spring and autumn equinoxes. A similar dependence (but not so big) is presented to winter and summer solstices (fig. 1a, 2a).

PF(φ) dependence is controlled by IMF Bz. We set an upper limit of Bz = 4 nT and lower limit of Bz = 1 nT for northward IMF. We have also set a lower limit of Bz=-4nT and upper limit of Bz = -1nT for southward IMF.

PF distribution in GSM XY coordinates for northward and southward IMF is presented in fig. 3. Dependence PF(φ) for northward IMF is asymmetric. Power flux is higher when the vector of the interplanetary magnetic field lies in the fourth quadrant (Bx> 0 and By <0) under northward IMF (fig.3a, c). For the southward IMF the average power flux distribution is almost symmetric (fig. 3b, d). But power flux is higher when the IMF vector lies in the first quadrant (By> 0 and Bx> 0). Influence of IMF By is opposite in northern and southern ovals. This effect was predicted in theoretical papers [2].

The dependences ontained above are synthetic. They accumulate all seasons. We received PF(φ) and IMF Bz dependences for summer (fig. 4a, d) and winter (fig. 4c, d). Power flux is higher when the vector of IMF lies in the fourth quadrant of GSM XY coordinates during the summer. But PF-index increases when the vector of IMF lies in the first quadrant during the winter.

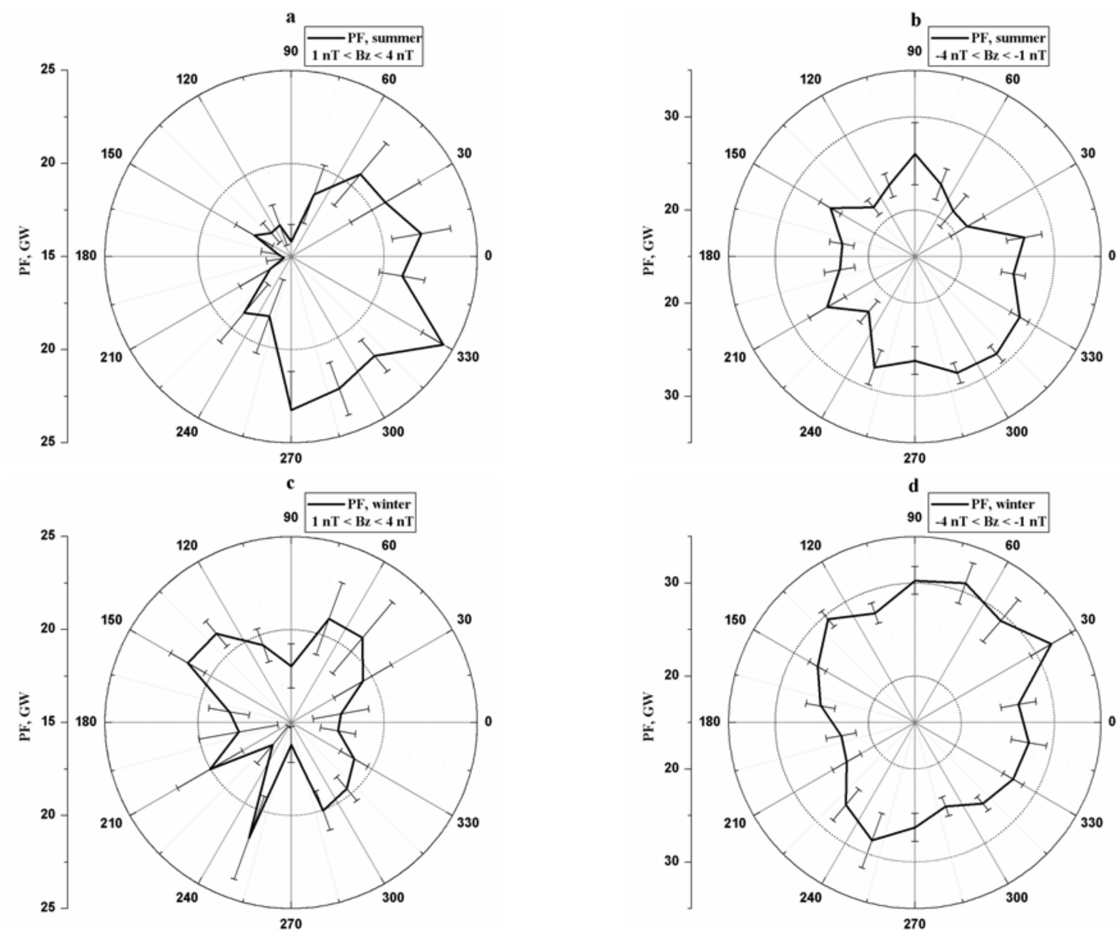

Fig. 4 Power flux in northern oval for northward IMF (the left column) and southward IMF (the right column) during a summer (the top line) and winter (the bottom line) solstice as a function of IMF orientation in GSM XY coordinates

The asymmetry of PF distribution is minimal during the winter. Season effects may be explained with season changes of the ionospheric conductance. It is known that auroral currents depend on the product of ionospheric conductance and electric field produced IMF By [2].

Conclusions

1. We have studied variations of the power flux as a function of IMF orientation. Auroral activity distribution as a function of IMF has been performed using NOAA POES observations. There was covered the period since 1978 to 2001. IMF Bz distribution has also been obtained during the different seasons.
2. A statistical study of effects of IMF clock angle on global auroral activity has been performed with northward and southward IMF orientation. It has been established that average power flux for both hemispheres is greater when Bx >0. The increase of the auroral activity for northern and southern hemispheres is shown in accordance with various sign of IMF By.
3. The auroral activity distribution depends on the season. Power flux is minimum during the solstices and maximum during the equinoxes. The auroral precipitation during summer is higher when the vector of the interplanetary magnetic field lies in the fourth quadrant (Bx>0 and By<0). The auroral activity during winter is higher when IMF vector lies in the first quadrant (Bx> 0 and By> 0). IMF orientation effect on auroral power flux is less during the winter than the one during summer. The asymmetry of seasonal effects on auroral activity may be explained with seasonal reconstruction of magnetospheric current systems.

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