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INFLUENCE OF IMF BY ON THE LOCATION OF WESTERN ELECTROJETS DURING THE MAGNETIC STORM ON NOV. 9-10, 2004

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Abstract. The spatial-temporal distribution of westward electrojets in the northern hemisphere has been investigated using geomagnetic ground observation data for November 9-10, 2004 geomagnetic storm. It is shown that the location of the maximum westward electrojet depends on the IMF orientation. It is in the evening or morning sector when $B_Y < 0$ or $B_Y > 0$. With the increase of positive IMF B_Y, the region of intensity maximum shifts to morning hours. Thus, the azimuthal IMF component not only controls the pattern of magnetospheric convection, but also affects the longitudinal location of the westward electroject pattern during the magnetic storm.

Introduction

It is known that under quasistationary conditions in the magnetosphere the high-latitude ionospheric convection pattern in the northern hemisphere is controlled by IMF azimuthal component (B_Y) [Svalgaard, 1968; Heppner, 1972]. Heppner and Maynard [1987] indicated that for the positive IMF B_Y the convection vortex in the evening sector expands and the drift velocity of ionospheric plasma decreases during the post-noon and evening hours. At the same time the width of the morning convection vortex becomes drastically narrower, where the intensity of the convective electric field increases. For $B_Y < 0$ an opposite pattern is observed: the morning vortex expands and the convection velocity increases in the post-noon and evening regions. The influence of IMF B_Y is manifested not only in the pattern of ionospheric convection but also in the location of the substorm disturbance center [Gelberg and Boroyev, 2000; Velichko, et. al., 2002]. Ground and satellite observations show that substorms occur more often in the morning or evening sector when $B_Y < 0$ or $B_Y > 0$. These results are in a good agreement with aurora shift observations [Liou et. al., 2001], suggesting an effective penetration of IMF B_Y into the magnetosphere. However, it is not clear whether the IMF B_Y affects the development of global geomagnetic disturbances such as magnetic storms. The present paper investigates the dynamics of auroral electrojets depending on the IMF B_Y orientation in the ecliptic plane during the November 9-10, 2004 magnetic storm.

Data and analysis

In this paper we use the magnetic data obtained from the global magnetometer chains of CPMN, IMAGE, CANOPUS, MACCS, Greenland Coast array and a number of low-latitude and equatorial stations with the 1-20 s resolution. Using Popov method [Popov et. al., 2001], we obtained the temporal-spatial distributions of the intensity and dynamic characters of auroral electrojets in the high latitude regions. The variations of the solar wind (SW) and IMF parameters have been studied using data from the ACE spacecraft, which is outside the magnetosphere ($X_{GSM} \sim 242\ R_E$) on the subsolar side. Fig.1 illustrates the variations of Dst and SYM-H indices, in addition IMF B_Y, B_Z-components obtained from the ACE spacecraft are also shown, where the IMF parameters are shifted by 32 min. according to the delay of ACE observations (solar wind speed $V_{SW} \sim 800$ km/s). In order to study the control of By to the westward electrojet, we choose three interval events of 1900-2100 UT on Nov. 9, 0130-0330 UT and 0630-1000 UT on Nov. 10 with IMF southward B_Z (as shown by dashed lines in Fig.1). For the first interval the IMF B_Y is positive (~ 8.4 nT) from 1853 UT to 2030 UT with sharp deviations to the negative value range. Since the response of ionospheric convection vortex configuration depending on solar wind parameters occurs with a time delay [Ridley et. al., 1998], then one can suppose that the magnetosphere is under the influence of IMF positive B_Y during 19-21 UT. In the second interval 0130-0330 UT on Nov. 10, B_Y is negative (~-29 nT). In the third time interval positive B_Y is observed.

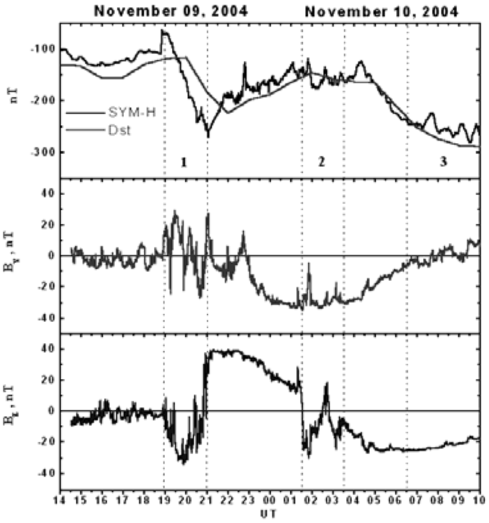

Fig.1. Variations of the SYM-H and Dst indices, IMF By and Bz components from the ACE satellite during the November 9-10, 2004 geomagnetic storm.

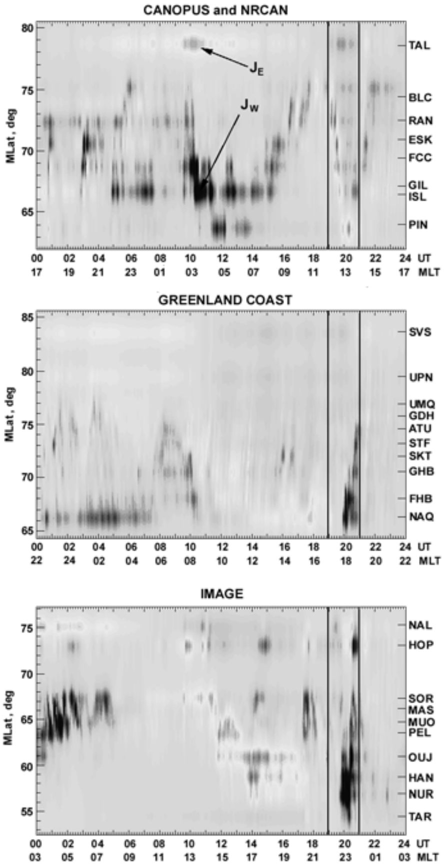

Fig.2. Spatial-temporal dynamics of westward (J_W) and eastward (J_E) electrojets at three meridian chains on November 9, 2004.

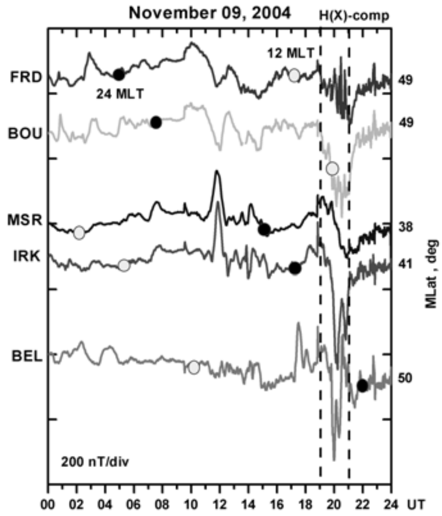

Fig.4. Variations of H(X)-component in different local time sectors at latitudes $\Phi' \approx$ 38-50^0 during magnetic storm.

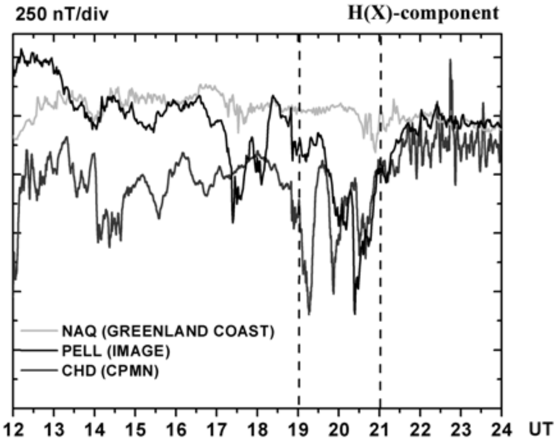

Fig.3. Longitudinal variations of H(X)-component of geomagnetic field at auroral zone latitudes on November 9, 2004.

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Fig. 2 shows the spatial-temporal distribution of the intensity of the eastward (J_E) and westard (J_W) electrojets in CANOPUS, GREENLAND and IMAGE chains constructed using the Popov methods [Popov et. al., 2001] for the magnetic storm of Nov. 9. For the first time interval (1900-2100 UT) the stations of CANOPUS, GREENLAND and IMAGE chains are located in the post-noon sector, evening sector, and midnight sector, respectively. It is seen from Fig. 2 that the enhancement of western electrojet begins at 2000 UT in the evening and midnight sectors and is accompanied by the extension of its region near the midnight meridian towards both high and low latitudes. The maximum of intensity of western electrojet is observed near midnight in the middle panel of Fig. 2 for IMAGE chain. Fig. 3 presents the variations of X(H) components for NAQ(66.31ºN, 43.91ºE), PELL(63.55ºN, 104.92ºE) and CHD(64.67ºN, 212.12ºE) stations in Greenland Coast, IMAGE and CPMN chains. However, compared to Fig 2, Fig.3 shows that the original enhancement of westward electrojet onsets (starts) earlier and reaches the maximum at 1915 UT at the CHD station in the morning sector. The second sharp enhancement of westward electrojet took place at 1930 UT and persisted for 15 min in the midnight (PELL) and morning (CHD) sectors. The highest intensity of westward electrojet is observed in the morning sector (CHD). At a later time (2020 UT) the onset of a magnetic negative bay is observed simultaneously in a wide sector of longitudes, its maximum amplitude is near midnight. To identify the peculiarities of westward electrojet dynamics, the longitudinal variations of H(X)-component at latitudes $\Phi \sim 38^o$-50^o are analyzed as shown in Fig. 4. It is clearly seen from the longitudinal chain of low-latitude stations that the maximum disturbance of amplitudes is observed in the morning sector (IRK) near the geomagnetic meridian of the CHD station. Apparently, the southward shift of the western electrojet in the morning sector resulted in that the amplitude of H component in CHD is less than that of PELL in IMAGE chain at 2020 UT. Thus, for By>0 the maximum increase of intensity of westward electrojet is observed in the morning sector.

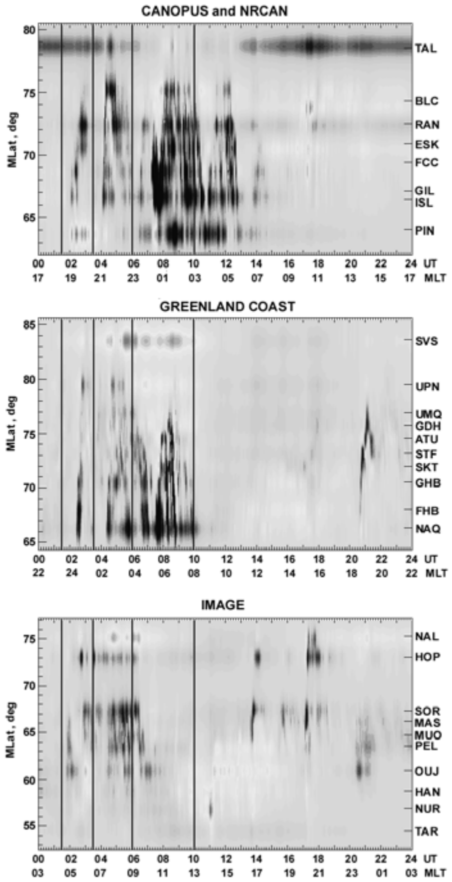

Fig.5. Spatial-temporal dynamics of westward (J_W) and eastward (J_E) electrojets at three meridian chains on November 10, 2004.

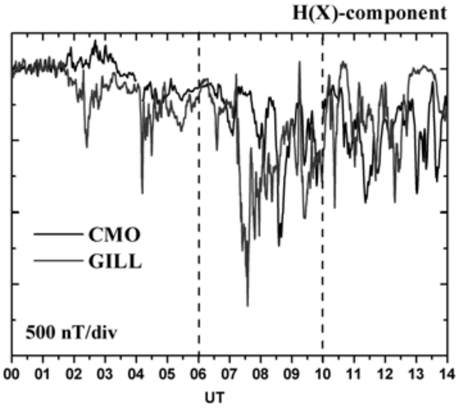

Fig.7. Longitudinal variations of H(X)-component at auroral zone latitudes in the evening-midnight sector on November 10, 2004.

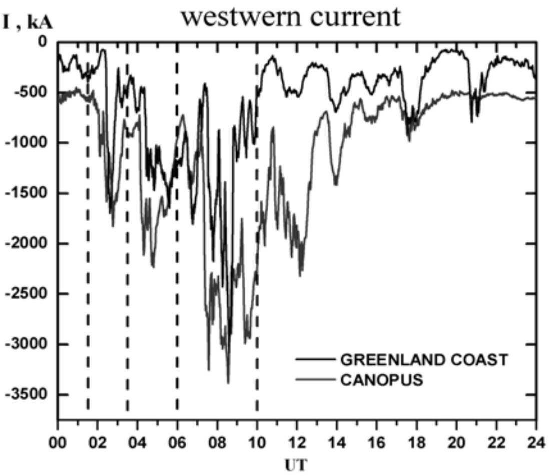

Fig.6. Variations of the westward electrojet intensity integrated by measurement data at two meridian chains during the November 10, 2004 magnetic storm.

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Fig. 5 presents the spatial-temporal distribution of westward electrojet for Nov. 10, 2004. For the interval of 0130-0300 UT the CANOPUS, Greenland Coast and IMAGE arrays is in the evening sector, t midnight sector and the morning sector, respectively. The region of enhancement of the western electrojet spread over the evening-midnight sector. There is a weak geomagnetic activity in morning sector where IMAGE chain is located. The intensity of westward electrojets in the midnight sector (GREENLAND Coast chain) is stronger than that in evening sector (CANOPUS). Figure 6 indicates the variation of the westward electrojet intensity in CANOPUS and GREENLAND chains on Nov. 10. The maximum amplitude of westward electrojet are formed in the CANOPUS meridian chain. Thus, for $B_Y < 0$ the intensity maximum of westward electrojet is observed in the evening sector.

In the third interval of 0600~1000 UT on Nov. 10, 2004, IMF B_Y is positive, and the region of the maximum intensity enhancement of westward electrojet shifts toward the morning sector. To identify the geomagnetic activity during evening hours the magnetograms from the high-latitude stations are shown in Fig.7. For the interval of 0600-1000 UT the CMO station is in the evening-midnight sector, GILL station is in midnight-morning sector. It is seen from Fig.7 that the region of maximum intensity enhancement of western electrojet occurs in the morning sector. To make more precise the peculiarities of westward electrojet dynamics the longitudinal H-component variations at latitudes Φ~38-50° are analyzed (Fig.8). It is seen from Fig.8 that the maximum amplitude of disturbance is observed in FRD station located in the morning sector.

Discussion and Summary

The above results show that during a geomagnetic storm the azimuthal IMF component has an effect on the longitudinal location of the intensity maximum of westward electrojet, i.e. the change of the structure of convection vortices leads to the shift of intensity maximum location of westward electrojet relative to the midnight meridian.

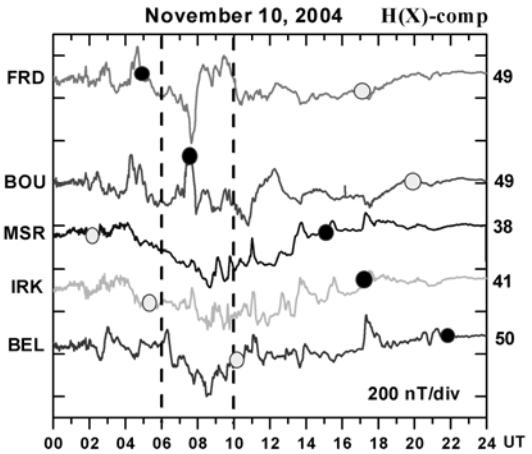

Fig.8. Variations of H(X)-component in different local time sectors at latitudes $\Phi' \approx$ 38-50^0 for the November 10, 2004 magnetic storm.

According to a convectional point of view, magnetospheric substorms are an important component of geomagnetic storm [Kamide, 1992]. It is seen from Fig.3 that during the time interval from 1900-2100 UT three powerful substorm disturbances were observed at the CHD station. For other time intervals the same substorm activity is registered. It is natural to suppose that the character of the westward current in the considered time intervals of a geomagnetic storm is determined by the rate of appearance of substorm disturbances and their intensity. The location of a substorm center in the magnetosphere is determined by the IMF B_Y [Gelberg and Boroyev, 2000; Velichko, et. al., 2002]. The westward electrojet location is also connected with the sign of azimuthal IMF component and is the response to the large-scale magnetospheric convection. On the other hand, the ionospheric location of the westward electrojet may be caused by a turn of the magnetotail relative to the X axis.

1. During magnetic disturbances the maximum westward electrojet intensity is localized in the evening or morning sector for $B_Y < 0$ or $B_Y > 0$.
2. With the increase of positive IMF B_Y, the maximum intensity range of westward electrojet shifts to the morning hours.

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