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EFFECT OF THE IMF *By* ON DAYSIDE POLAR GEOMAGNETIC DISTURBANCES: CASE STUDY

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Abstract. We present a study of magnetic bay-like disturbances occurred in the dayside sector of the polar geomagnetic latitudes on Jun 23, 2015 and on May 24, 2000 under similar IMF and the solar wind conditions. These dayside bays developed during untypical long-duration interval of the strong negative IMF *Bz* under invariable the solar wind velocity and low the solar wind dynamic pressure. On June 23, 2015 the long-duration dayside negative magnetic bay (~ -350 nT) was recorded at the high-latitude IMAGE stations while the IMF *Bz* was more intensive than the IMF *By* (the ratio of the $|Bz|/|By| \approx 3$). On May 24, 2000 the sequence of positive and negative bays occurred in the dayside sector of the polar latitudes ($\Phi > 70°$) under the positive or negative IMF *By* respectly, and the ratio of the $|Bz|/|By|$ varied from 0.3 to 0.9. It is shown that examined dayside polar geomagnetic disturbances should be prodeced by different high latitude current systems controlled by IMF *By*. We suppose the IMF *By* effect on dayside polar geomagnetic disturbances substantially depends on the IMF $|Bz|/|By|$ ratio.

Introduction

It is well known, under a positive *Bz* component of the Interplanetary Magnetic field (IMF) there is no new energy input into the magnetosphere. But dayside polar bay-like magnetic disturbances could be occur associating with the high-latitude ionospheric electric currents [e.g., *Iwasak*i, 1971; *Friis-Christensen and Wilhjem*, 1975; *Feldstein et al*., 2006]. The role of the ratio of IMF *Bz* and *By* components controlling the development of the high latitude geomagnetic disturbances has been described previously but mainly under a dominant IMF *By* component [e.g. *Friis-Christensen et al*, 1985; *Vennerstrom et* al., 2002].

The aim of our study is to show the role of the ratio of IMF *Bz* and *B*y components in the dayside magnetic bay-like disturbances occurrence. Here we studied two events of magnetic bay-like disturbances occurred in the dayside sector of the polar geomagnetic latitudes on Jun 23, 2015 and on May 24, 2000 under similar IMF and the solar wind conditions.

Data

Our study is based on the OMNI data [*http://omniweb.gsfc.nasa.gov*], on the ground-based Scandinavian magnetometer data (IMAGE profile) [*http://space.fmi.fi/MIRACLE*], observations by the DMSP [*http://sd-www.jhuapl.edu/Aurora/spectrogram*] and IMAGE [*https://cdaweb.sci.gsfc.nasa.gov/cgi-bin/eval1*] low orbiting satellites, the OVATION model of the auroral oval location [*http://sd-www.jhuapl.edu/Aurora/ovation*], and the AMPERE data, based on the magnetic measurements on 66 low-altitude globally distributed Iridium communication satellites [*http://ampere.jhuapl.edu/products/plots*].

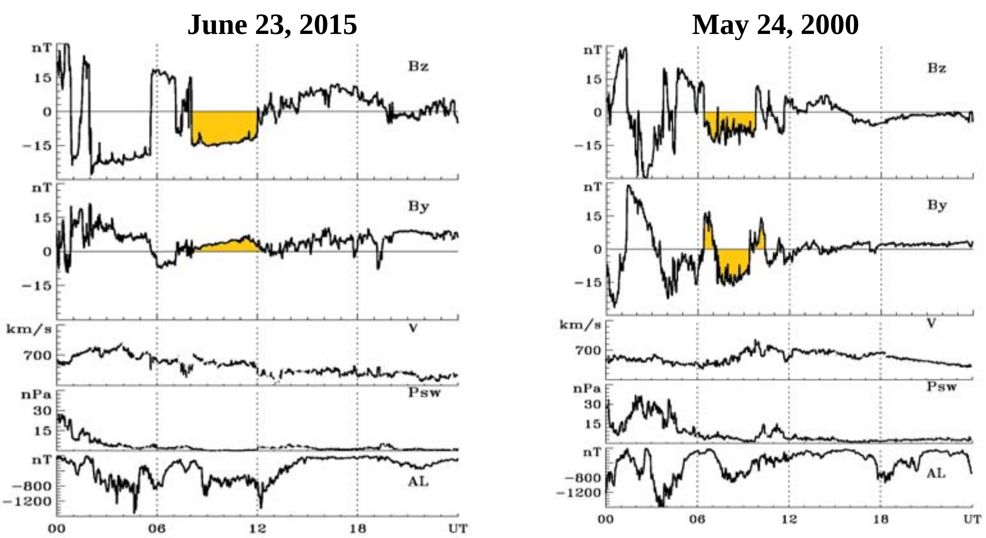


Figure 1. The IMF *Bz* and *By*, solar wind velocity *V* and dynamic pressure *Psw*, and the *AL*-index.

Observations

The space weather conditions during these two events are presented in Fig. 1.

The dayside bays on June 23, 2015 and May 24, 2000 developed during long-duration untypical for recovery phase intervals of the strong negative (-15 nT) IMF *Bz* under non-variable solar wind velocity (~600-700 km/s) and low dynamic pressure. The IMF *By* was weakly positive during whole examined interval of June 23, 2015 (Fig.1, left), but on May 24, 2000, the IMF *By* sharply changed from positive to strong negative (-18 nT), remained negative during two hours and then returned to positive again (Fig. 1, right).

In the both examined events, the high latitude geomagnetic disturbances in the nightside sector of the auroral zone was similar, *AL*-index changed weakly near -1000 nT.

Fig. 2 demonstrates the IMF *Bz* and *By* components and IMAGE difference magnetograms of *X* component of the geomagnetic field for June 23, 2015 (left). and May, 23, 2000 (right). They represent the geomagnetic variations compared to the most magneto-quiet 2009 level [*Levitin et al*., 2014]. The considered dayside magnetic bays marked by yellow. The auroral oval position according to the OVATION model for the first event and the electron image from the IMAGE satellite for the second one are shown in Fig. 2 as well.

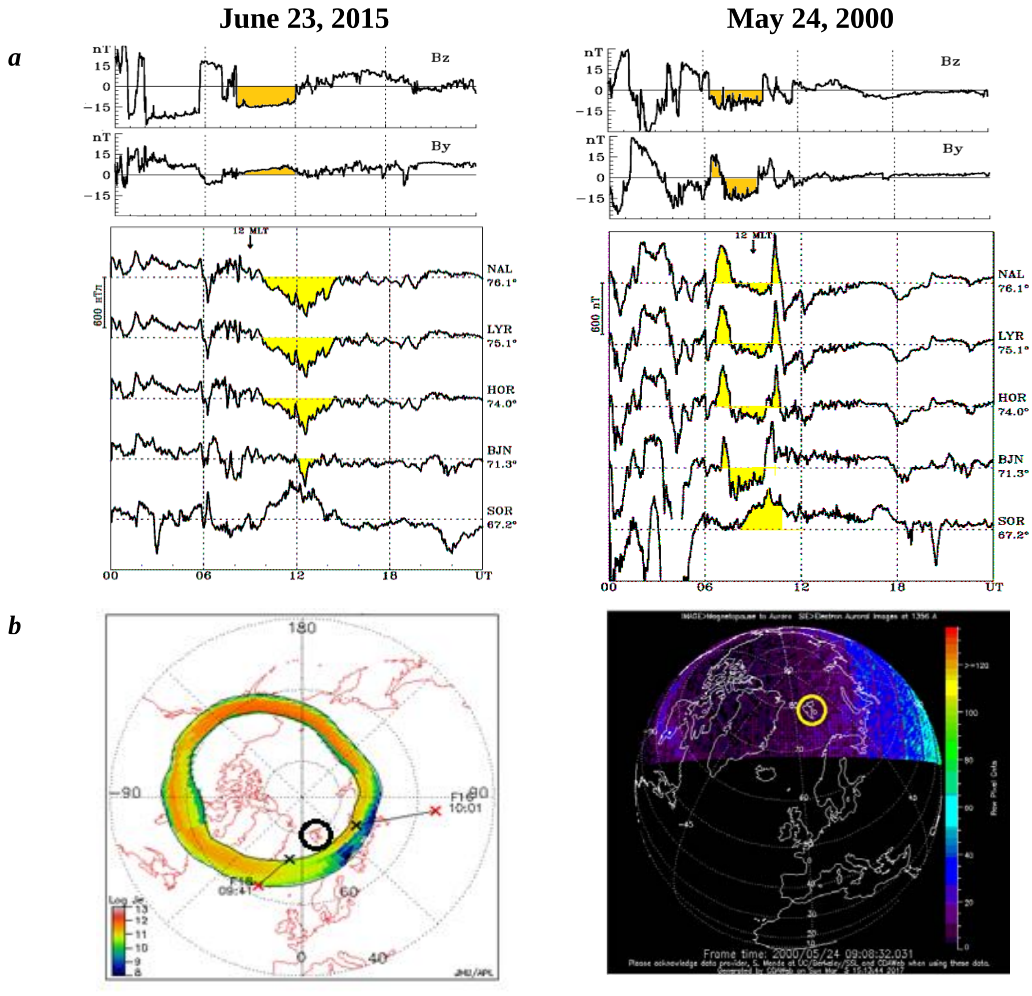


Figure 2. **a)** IMF *Bz* and *By* components and IMAGE difference magnetograms for June 23, 2015(*left*) and May 24, 2000 (*right*). Examined dayside magnetic bays are marked by yellow; **b)** *Left*: the auroral oval position according to the OVATION model. *Right*: the electron image from the IMAGE satellite. Yellow/black circle marks the location of the high latitude IMAGE stations.

On June 23, 2015 (Fig. 2, leftt), the long-duration dayside negative magnetic bay (-350 nT) was recorded at the high-latitude IMAGE stations (NAL – SOR) while the IMF *Bz* was more intensive than the IMF *By*. The ratio of the $|Bz|/|By| \approx 3$. On May 24, 2000 (Fig. 2, right), the sequence of positive and negative bays occurred in the dayside sector of the polar latitudes ($\Phi > 70°$) under the positive or negative IMF *By* respectively. The ratio of the $|Bz|/|By|$ varied from 0.3 to 0.9.

Discussion

Fig. 3 demonstrates IMF *Bz* and By components, the horizontal vectors of the geomagnetic field and the AMPERE data for the event of June 23, 2015. The horizontal vectors of the geomagnetic field presented in Fig. 3 (and below in Fig. 4) were constructed on the base of difference magnetograms (see Fig. 2). The AMPERE data shows reduced magnetic field residual data showing the horizontal plane vector data of magnetic perturbation and the radial current density.

The ground magnetic vectors demonstrate the counter-clockwise magnetic vortex above high-latitude IMAGE stations (Fig. 3a). This vortex could be regarded as a proxy of an intensification of upward field-aligned currents. The AMPERE model demonstrates very intensive upward *FACs* (Fig. 3b) expanded poleward. We suppose due to the southern IMF *Bz* was more intensive than IMF *By*, the intensification of the *FACs* of region 1 in the polar latitudes produced by the ionospheric current system controlled by *Bz* see Fig. 2a). These currents (named *DP2* current system) increase under IMF *By* > 0 in the postnoon sector of the Northern hemisphere [*Troshichev et al.*, 1982]. Thus the intensification of *FACs* of the Region 1 *[Iijima and Potemra*, 1976] could be a source of a high-latitude bay-like magnetic disturbances, such as the examined dayside negative magnetic bay shown in Fig. 1a.

June 23, 2015

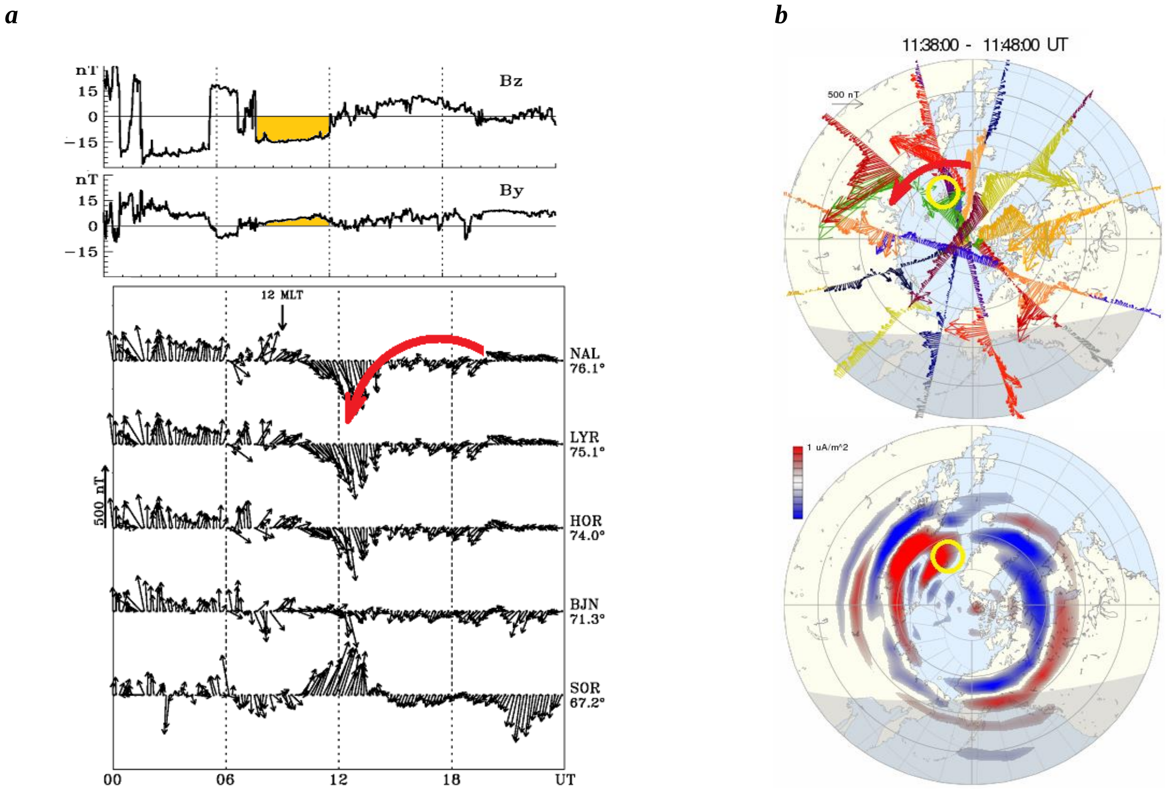


Figure 3. **a)** IMF *Bz* and *By* components and the horizontal vectors of the geomagnetic field; **b)** The AMPERE data: reduced magnetic field residual data showing the horizontal plane vector data of magnetic perturbation (*upper*); the radial current density (*bottom*). Upward currents are shown in red and downward currents in blue, yellow circle shows the position of the high latitude IMAGE stations.

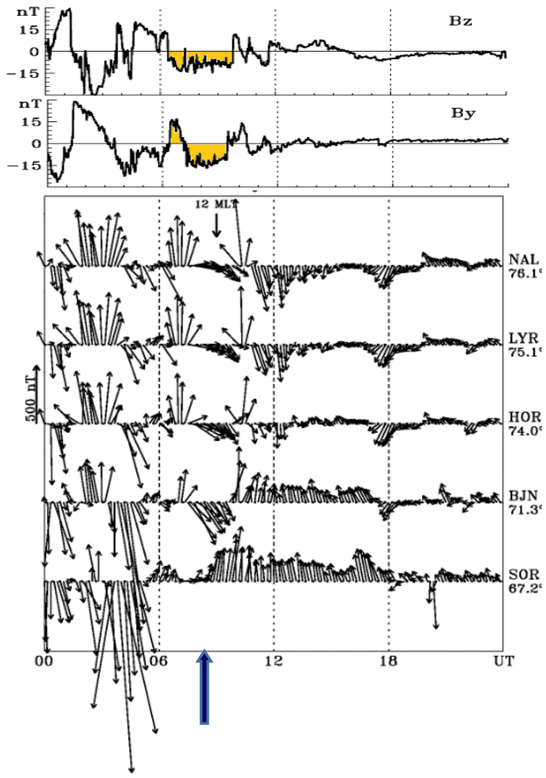
Fig. 4 presents the ground magnetic vectors and DMSP F13 precipitating particle data for the events of May 24, 2000. The ground magnetic vectors don’t demonstrate any pronounced magnetic vortex above high-latitude IMAGE stations (Fig. 4a). It is apparent from the DMSP F13 spectrograms of the precipitating particles that there was no particle (ions and electrons) enhancement in the same area as the examined dayside polar magnetic bays were observed (Fig. 4b). We suppose that FACs are weak and do not provide increasing of the geomagnetic activity in the high-latitudes. When the IMF *By* predominates over the IMF *Bz,* the high-latitude *DPY* current system controlled by the IMF *By* sign intensified, penetrating deep into the polar cap [*Vennerstrom et al.*, 2002] and produced sequence of dayside polar magnetic bays. On May 24, 2000 (Fig. 2b) the sequence of positive and negative bays occurred under the positive or negative IMF *By* be probably caused by the eastward or westward polar electrojets respectively [*Feldstein et al.*, 2006]. We suppose that due to the IMF *By* was more intensive than IMF *Bz, DPY* current system controlled by the IMF *By* sign (eastward and westward electrojets) produced such sequence of dayside polar magnetic bays.

Summary

If the IMF *Bz* is more intensive than the IMF *By*, *DP2* current system predominates over other dayside current systems and produces magnetic dayside magnetic bays.

May 24, 2000

a



b

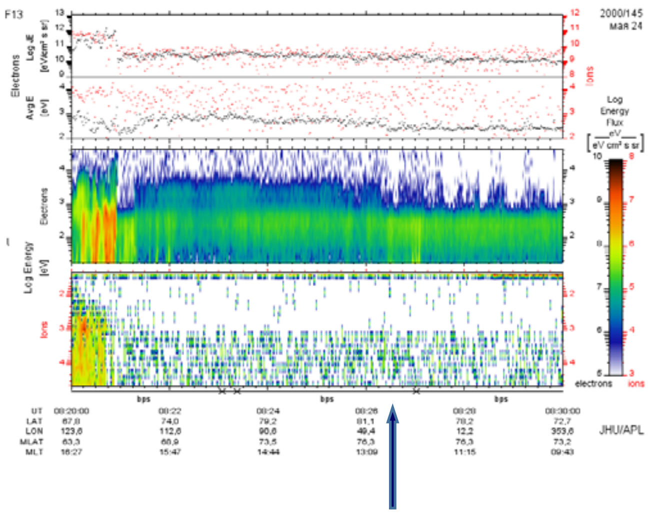


Figure 4. **a)** IMF *Bz* and *By* components and the horizontal vectors of the geomagnetic field; **b)** DMSP F13 precipitating particle data. Blue arrow marks moment when DMSP F13 located above high latitude IMAGE stations.

When the IMF *By* predominates over the IMF *Bz*, the high latitude *DPY* current system controlled by the IMF *By* sign intensified, penetrating deep into the polar cap [*Vennerstrom et al.*, 2002] and produced sequence of dayside polar magnetic bays.

We suppose that the IMF *By* effect on dayside polar geomagnetic disturbances substantially depends on the IMF |*Bz*|/|*By*| ratio.

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