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DAYSIDE POLAR MAGNETIC DISTURBANCES DURING A MAGNETIC STORM: EVENT ON 4-5 JUNE 2011

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Abstract. The complicated event of dayside polar bay-like magnetic disturbances at geomagnetic latitudes above 70°N has been analyzed. The event was observed during the small (SymH ~-50 nT) magnetic storm on 4-5 June 2011, when the IMF *By* was positive. The MIRACLE model of the ionospheric equivalent currents classified this event as the eastward electrojet. We assume that the sign of this daytime polar disturbance was controlled by the sign of the IMF *By*. The considered magnetic storm was caused by the impacts of the sequence of the different types in the solar wind: SHEATH and following it a magnetic cloud (MC), again SHEATH and following it EJECTA. The catalog of the large-scale solar wind phenomena (*ftp://ftp.iki.rssi.ru/omni/)* and OMNI data base have been used for determination of the solar wind types. We found that the most favorite conditions for the daytime polar perturbation excitation were created by the SHEATH passages, when the solar wind dynamic pressure significantly increased. It was shown that both SHEATHs were accompanied by occurrence of daytime polar disturbances. A possible interpretation is discussed basing on the multi-instrument observations including the geomagnetic field data from the IMAGE magnetometer chain and INTERMAGNET data set, the Field Aligned Current (FAC) distributions from the AMPERE set of 66 low-altitude commercial satellites measurements, the particle precipitations from DMSP-17 satellite. We suppose that the considered dayside polar magnetic disturbances, recorded in the vicinity of the poleward boundary of the auroral oval, are caused by the sudden enhancement of the solar wind dynamic pressure and generated by the same mechanism as the dayside shock auroras observed by ultraviolet images of many satellites.

Introduction

The properties of dayside polar magnetic disturbances observed at the geomagnetic latitudes above 70º, i.e., in the vicinity of the polar boundary of the auroral oval, are poorly investigated. In the early papers, these magnetic variations have been defined as "DPY- disturbances" [*Friis-Christensen and Wilhjelm*, 1975]. Later in some papers, e.g., [*Kleimenova et al.,* 2015; *Levitin et al.,* 2015; *Gromova et al*., 2016], the dayside polar magnetic bays appearing during strong magnetic storms under positive IMF *Bz* were called "daytime polar substorms". In the most of the cases, the sign of these bays was controlled by the IMF *By* [*Gromova et al*., 2017]. We suppose that the daytime polar magnetic disturbances could occur during moderate storms and small magnetic ones as well. So, one of these complicated dayside magnetic events was observed at the Scandinavian IMAGE magnetometer chain on 5 June 2011 during the small magnetic storm.

The aim of this paper is the analysis of this event as a responce on large-scale solar wind irregularities. The study was based on the multi-instrument observations: (i) the magnetic field data from the IMAGE magnetometer chain (*http://www.space.fmi.fi/IMAGE*), (ii) the solar wind and Interplanetary Magnetic Field (IMF) data provided by OMNIWeb (*http://omniweb.gsfc.nasa.gov/*), (iii) the Field Aligned Current (FAC) distributions from the AMPERE project available at (*http://ampere.jhuapl.edu*), (iiii) the particle precipitations by DMSP-17 measurements (*http://sd-www.jhuapl.edu/Aurora/spectrogram/*).

Observation and discussion

Fig. 1a shows the considered here dayside high-latitude alternating magnetic disturbances, recorded on 5 June 2011 at ~08-14 UT by the IMAGE magnetometer chain. The event was observed during the small (SymH ~-50 nT) magnetic storm caused by the consecutive arriving of the large-scale solar wind structures: SHEATH + magnetic cloud (MC) and SHEATH + EJECTA (*ftp://ftp.iki.rssi.ru/omni/*) as it is shown in Fig. 1b. We found that the most favorite conditions for the excitation of the daytime polar perturbation were created by the SHEATH passages, when the solar wind dynamic pressure significantly increased. Both SHEATHs were accompanied by the dayside high-latitude magnetic bay-like variations. During the first SHEATH, these disturbances were recorded at CBB (77.4º MLAT) and BRW (69.7º MLAT) stations located at the dayside (not shown here).

The second SHEATH (on 5 June) was characterized by the relatively stable IMF with the positive *By* and *Bz* components, and the burst of the strong enhanced solar wind dynamic pressure *Psw* (up to ~40 nPa) lasting of about one hour. The impact of this *Psw* pulse caused the high-latitude magnetic disturbances at the dayside of the Earth starting at ~09 UT as the decreasing of the X-component of the geomagnetic field. The MIRACLE model of the ionospheric equivalent currents (Fig. 2a) classified this event as the eastward electrojet, which very quickly shifted to the lower latitudes after 13 UT.

It is seen (Fig. 1a and 2a) that around 09 UT, the occurrence of the magnetic bay at polar latitudes (NAL station) suddenly suppressed the generation of the Pc5 pulsations at all station where they were observed (from TAR to NOR). The similar effect has been seen during the September 2017 strong magnetic storm [*Kleimenova et al*., 2018].

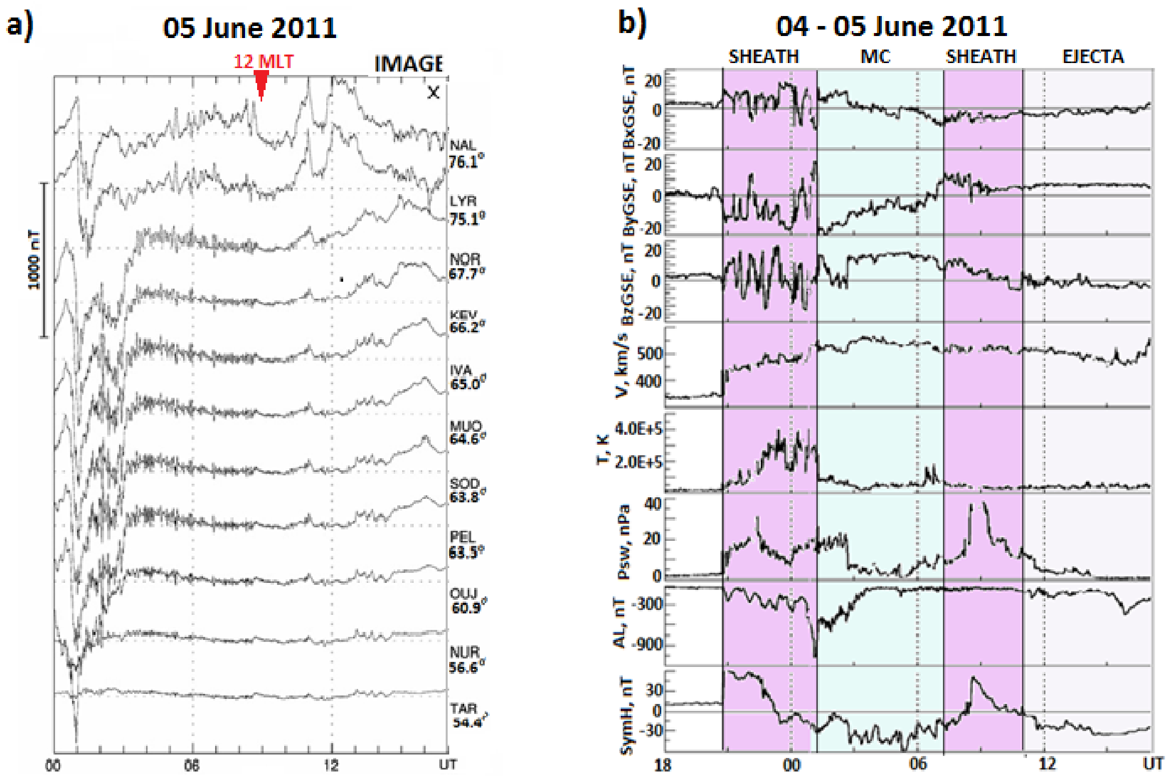

Figure 1. (***a***) - Magnetograms from the selected Scandinavian IMAGE chain stations; (***b***) - OMNI data of the IMF (*Bx*, *By*, *Bz*) and solar wind (*Vsw*, *T*, *Psw)* parameters as well as the *AL*- and *SymH* indexes during the considered time.

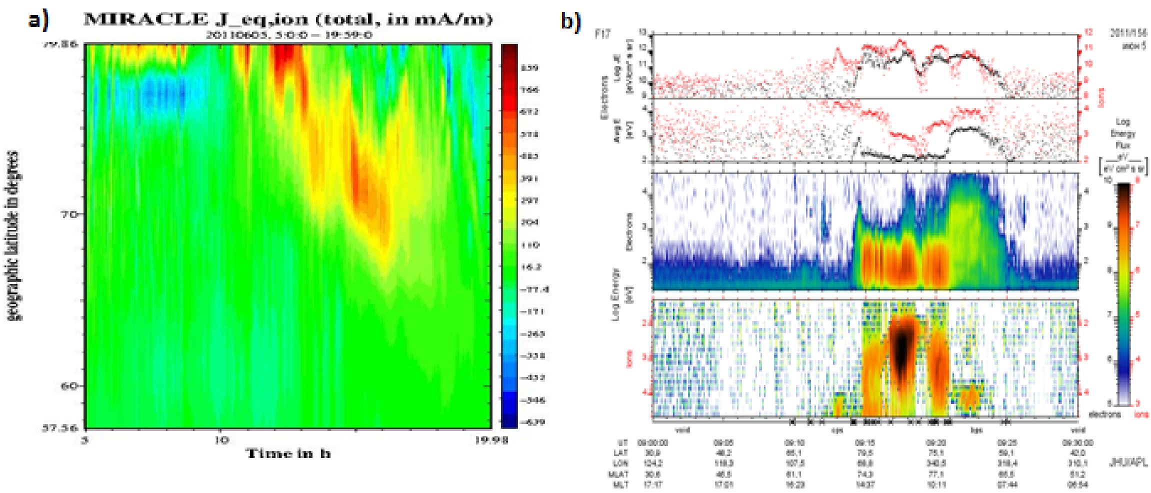

Figure 2. (***a***) - The MIRACLE model of the ionospheric equivalent currents showed the eastward electrojet; (***b***) -the electron precipitation data by DMSP-17.

Near 01 UT, near the end of the first SHEATH, the negative pulse of the IMF *Bz* occurred, the *AL*-index reached 1000 nT and the strong magnetic substorms were recorded by IMAGE magnetometers (Fig. 1a). Strong magnetic disturbances were observed in the global scale as it is seen in the globally increasing of the FACs (Fig. 3a).

However, later on during the second SHEATH under the positive IMF *Bz*, the enhanced FACs were observed only in the dayside of the Earth as it is shown in Fig. 3b. In this time, in the dayside sector of the Earth, the precipitation of the soft particles, both electrons and ions, was recorded by the low-altitude satellite DMSP-17 at ~74-77º MLAT.

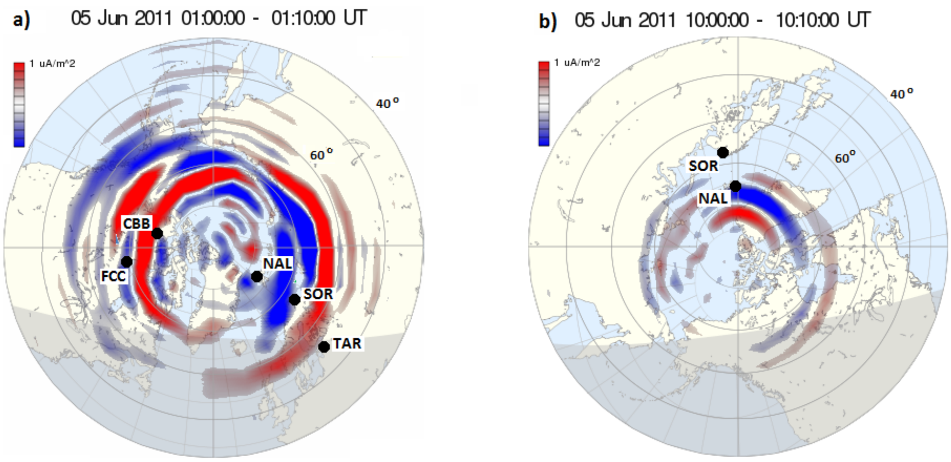

Figure 3. The AMPERE global maps of the FAC distribution (the upward FAC is marked by red and downward – by blue) calculated on the base of the magnetic measurements by the 66 low-altitude commercial satellites. It is shown that the currents were globally observed at ~ 01 UT (***a***) and were concentrated in the dayside sector at ~10 UT (***b***).

The similar feature was observed during the first SHEATH under the increased solar wind dynamic pressure and strong variations of the IMF *Bz* as it is shown in Fig. 4. The enhanced FACs were recorded only at the very high geomagnetic latitudes in the dayside of the Earth (Fig. 4a). At that time, the ground-based negative magnetic disturbances were recorded at CBB and BRW stations (not shown here), located in the vicinity of the intensified upward FACs. The IMF *By* was negative (Fig. 4b) confirming that the sign of the ground-based daytime high-latitude magnetic bays is controlled by the sign of the IMF *By*.

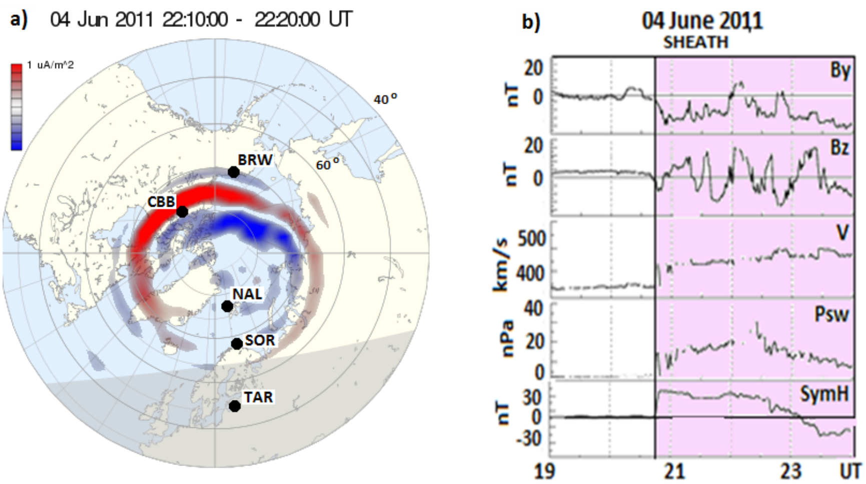

Figure 4. The global maps of the FAC (***a***) and OMNI data (***b***) on 4 June during the first SHEATH.

We suppose that the considered dayside polar magnetic disturbances are caused by the shock or the sudden enhancement of the solar wind dynamic pressure by the same mechanism as the dayside shock auroras which have been identified in ultraviolet images by Dynamic Explorer 1 (DE1), Polar UVI, IMAGE FUV satellites [e.g., *Craven et al.*, 1986; *Vo and Murphree*, 1995; *Spann et al.*, 1998; *Zhou and Tsurutani*, 1999; *Vorobjev et al.*, 2001; *Zhou et al.*, 2003]. An impact of a sudden pressure enhancement compresses the magnetosphere and cause various physical processes on the magnetopause boundary layer including magnetic reconnection, magnetic shearing, plasma and waves transport. Magnetopause perturbation may lead to the polar-latitude precipitation of the low-energy electrons, the field-aligned current generation and the dayside auroral intensification in the poleward region of the auroral oval [*Lui et al*., 1989; *Southwood and Kivelson*, 1990; *Sibeck*, 1990; *Fasel et al.,* 1992; *Leontyev et al.,* 1992; *Zhou et al*., 2003]. The schematic model of these processes is discussed in [*Zhou and Tsurutani*, 1999; *Zhou et al*., 2003].

Summary

We found that the most favorite conditions for the dayside polar magnetic disturbances are created by the SHEATH passages, when the solar wind dynamic pressure significantly increased. The sign of the dayside polar magnetic bays is controlled by the sign of the IMF *By*.

We suppose that the considered dayside polar magnetic disturbances are caused by sudden enhancement of the solar wind dynamic pressure and are exited in the vicinity of the polar boundary of the auroral oval by the same mechanism as the dayside shock auroras observed by ultraviolet images of many satellites.

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