Response of the ionosphere to high-speed solar wind streams during 20-31August 2010

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ABSTRACT

This study is the first attempt to analyze the latitudinal response to geomagnetic activity driven by high-speed solar wind stream (HSS) which emanates from a transition coronal hole. After the HSS hits the earth's magnetic field on 24 August 2010, it was observed during four days. We study the magnetic disturbance related to the ionospheric disturbed electric current, in different magnetically conjugated observatories in various longitude sectors. The asymmetry between northern and southern hemispheres magnetic disturbances in all latitudes is examined. The magnetic disturbances reveal that different large electrodynamics perturbations produced by the HSS last during four days in the different latitude sectors.

Key words: Ionospheric disturbance dynamo, solar wind, asymmetry.

1. DATA SET AND DATA PROCESSING

To study the ionospheric-magnetic signature of this HSS, we used the following parameters: -Solar wind speed V_x and B_z component of the Interplanetary Magnetic Field (IMF) recorded on board the satellite ACE to characterize the solar wind. – The magnetic indices Dst, AU, AL and Am are extracted from Data Analysis International Union of Geodesy and Geophysics (IUGG), to approach magnetospheric and auroral electric currents - Ground data recorded in magnetically conjugated observatories of INTERMAGNET network

We focus on the horizontal component H of the geomagnetic field, as this is mainly affected by the magnetospheric dynamics. Variations of the external geomagnetic field component ΔH has some effects stemmed out from the magnetosphere- ionosphere coupling: (i) The regular electric current related to global winds driven by solar heating, (ii) The ionospheric disturbance Diono associated both to the ionospheric disturbance dynamo Ddyn related to the disturbance winds driven by high latitude heating and ion drag [1] and the prompt penetration of magnetospheric electric field DP2, throw all latitudes [2]; [3] (iii) The symmetric part of the ring current effect D_R which is derived from the Dst index: $D_R = SYMH \cos(ª)$, where λ is the colatitude of the observatory and *SYMH* is the one minute high-resolution version of *D*st derived. The mean regular variation Sr is computed by the mean arithmetical value of the H component using the quiet- day daily variations Sq of the month with the daily Am < 20.

The ionospheric electric disturbance Diono is defined by the both expressions:

$$\text{Diono} = \Delta H - D_R - Sr \qquad (1a)$$

$$Diono = DP_2 + DP_1 \quad (1b)$$

From top to bottom, figure 1 illustrates the time variation of solar wind speed Vx (Km/s) with time resolution of 1 min, the Bz component of the IMF with time variation of 1min Bz (nT), the geomagnetic indices Dst (nT) with time variations of 1 hour and auroral electrojets AU, AL (nT) with time resolution of 1 min. On 24 August 2010, Vx increases from 450 to 700 km/s at the time of HSS struck the magnetosphere. It reaches a maximum value of 728 km/s on 24 August 2010 at 08:34 UT. From 24 to 28 of August 2010, Vx is higher than 600 km/s and sometimes more than 700 km/s. On 28 August 2010, Vx gradually decreases until the 31 August 2010 where the value of Vx becomes less than 350 km/s. On 24 August 2010, the IMP Bz turns southward at around 3:55 UT with the value of -5.73 nT, and reaches the maximum value of -9.86 nT at 6:56 UT the same day. It oscillates during whole perturbed period from 24 to 28 with southward and northward excursions. The Dst index remains relatively low with a minimum value of -40 nT around 8:00 UT on 24 August 2010. AU and AL indices show large and persistent variations during the HSS event. AL reaches the minimum value of -953 nT on 25 August 2010 at 3:46 UT and AU a maximum value of 435 nT at 06:01UT on 24 August 2010.

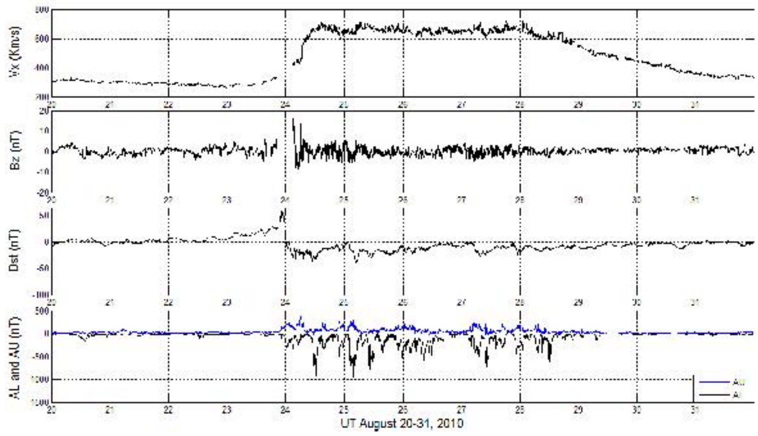

Figure 1. Variations in solar wind parameters and geomagnetic indices from 20 to 31 August 2010. From top to bottom: component Vx of the solar wind speed, the Bz component of the interplanetary magnetic field, the Dst index and the AU and AL indices.

RESULTS AND DISCUSSION

Figure 2 shows that the amplitude of the perturbations varies with the latitude of the observatory. There is a gradual decay in magnetic disturbance towards lower latitudes (AAE, HUA). The strongest variations of the magnetic disturbance associated to the ionospheric electric current disturbance are observed at auroral (BRW-MCQ) latitudes. This behavior is consistent with the increase conductivities in the auroral zone due to the precipitation. At mid-latitude pair of magnetically conjugated observatories (AQA-KMH), we observe that the magnetic signature of the ionospheric disturbances shows globally similar amplitude of the maximum enhancements of the ionospheric equivalent current (Diono). On the contrary, in the magnetically conjugated observatories from sub auroral (SHU-EYR) to polar cap (RES-SBA), the data reveal a significant asymmetry between northern and southern hemispheres. More precisely, the decrease of the Diono current shows intense and rapid oscillations related to the DP2 equivalent current, which are stronger in the northern than the southern hemisphere. This fact was previously pointed out by [4]. All these results confirm that although wind high-speed streams do not produce strong magnetospheric ring current (Dst ~ -40 nT), they do drive important geomagnetic activity [5]. A CWA of Diono is used to separate the ionospheric disturbance dynamo (Ddyn) from the prompt penetration of magnetospheric electric field (DP2). We confirm the existence of two different regimes in the Diono current during the HSS event. From lower to higher latitude, the dominant period of the Ddyn is approximately between 19 and 24 hours and DP2 exhibits a period between 2.4 hours and 36 minutes.

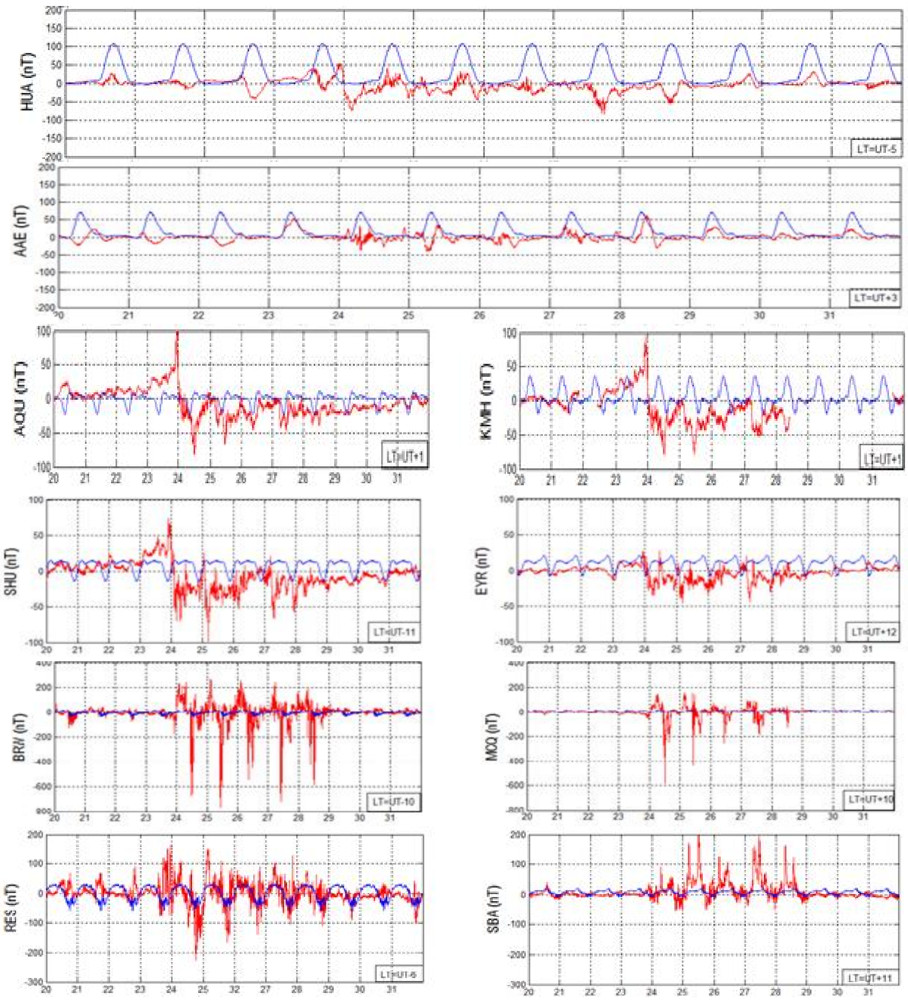

Figure. 2 Latitudinal variation of magnetic disturbance Diono (red curves), associated to the electric ionospheric current disturbance, for the pairs of observatories selected, from August 20 to 31, 2010. The mean regular variation of the horizontal component of the earth's magnetic field S_R(H (blue curves) is superimposed to Diono. Observatories from the north hemisphere are in the left side and its conjugated from the south hemisphere are in the right side.

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