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Night–side effects on the polar ionospheric convection due to a solar wind pressure impulse

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Abstract. The Sudden Impulse (SI) of solar wind dynamic pressure of 20 february 2000, 21:03 UT, is investigated by making use of data from WIND, GEOTAIL, POLAR and GOES; ground magnetometer chains (Greenland, IMAGE, CANOPUS); SuperDARN HF radars in both Northern and Southern hemispheres. The main effect of the SI described herein is an enhancement of the ionospheric convection around midnight MLT. We suggest that such an enhancement be due to an increase of the dawn–dusk electric field caused by the SI compression of the magnetospheric tail.

Key words. Sun: solar-terrestrial relations – Sun: solar wind – Convection – Plasmas

1. Introduction

Sudden Impulses of solar wind dynamic pressure (SI) have long been known to trigger a global response of the magnetosphere–ionosphere system. SI's are sudden variations of the solar wind dynamic pressure associated with corotating and travelling solar wind shocks and tangential discontinuities, whose effects on the magnetosphere extend from hours to days (Sibeck 1990,and ref. therein).

The day–side effects of SI's on the magnetosphere–ionosphere system are well studied: a pressure perturbation generates a compressional MHD wave which propagates in the magnetospheric cavity; coupling to the auroral ionosphere requires the generation of a Field–Aligned Current (FAC) system that is carried by a field–guided Alfvén mode, thus leading to the formation of characteristic vortex–like structures, whose signatures are well identified in ground magnetometers (e.g. Southwood and Kivelson, 1990; Araki, 1994).

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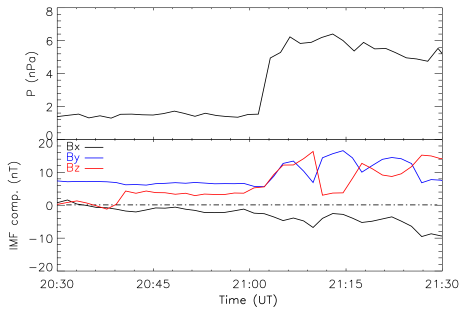

Fig. 1. Solar wind and IMF data as measured by WIND the 20 february 2000 between 20:30 and 21:30 UT.

We present here preliminary observations of an SI, occurred the 20 february 2000; the Interplanetary Magnetic Field (IMF) B_y and B_z components were steady and positive for a long period before the event, and keep a positive value during and after the event: being in a typical situation of minimum energy transfer between the solar wind and the magnetosphere, the effect of the SI itself can be evidenced.

2. Event Overview

Figure 1 shows the dynamic pressure and the IMF measured by the WIND spacecraft between 20:30 and 21:30 UT on 20 february 2000. The WIND position was $X = 162\,R_E$, $Y = 22\,R_E$, $Z = 11\,R_E$ in GSM coordinates. The upper panel shows the solar wind dynamic pressure: prior to the SI, the solar wind pressure was close to 2 nPa exhibiting only small fluctuations; at 21:03 UT, the pressure jumped to more than 6 nPa. The lower panel displays the three components of the IMF: the black curve represents B_x, the blue curve is for B_y and the red curve is for B_z. B_x is negative and decreases continuously during the whole period. B_y and B_z are both positive and almost costant after 20:40 UT; both have a strong increase at the SI time ($\sim$ 21:03 UT), followed by large fluctuations.

Data from other satellites near the Earth's orbit (POLAR and GOES8–10, not shown here), and from ground based magnetometers all around the world, evidenced the SI passage around 21:38 TU. Figure 2 shows the B_x component of the geomagnetic field as measured by the GEOTAIL spacecraft, which was located in the geomagnetic tail at $X = -26\,R_E$, $Y = 9.2\,R_E$, $Z = 3.4\,R_E$ in GSM coordinates. Around 21:42 UT, a strong increase of B_x is observed (dashed red line), leading the field value up to 35 nT in 5 minutes. This is the effect of the SI compression along the geomagnetic field lines in the tail.

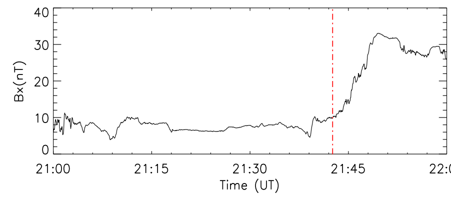

Fig. 2. B_x component of the geomagnetic field as measured by the GEOTAIL spacecraft the 20 february 2000 between 21:00 and 22:00 UT.

3. SuperDARN Data

The principle of operation of the SuperDARN HF radars is fully described in Greenwald et al. (1995). At present, 9 radars work in the Northern hemisphere and 6 in the Southern hemisphere. From the complex autocorrelation function of the backscattered signals, it is possible to derive the horizontal ambient plasma velocity along the line of sight (e.g. Hanuise et al., 1985; Villain et al., 1987), and through a spherical harmonic expansion technique (Ruohoniemi and Baker 1998), the equipotential curves in the ionosphere are reconstructed.

Figure 3 shows the Northern hemisphere plasma convection patterns for two subsequent SuperDARN two-minutes scans for the present event. In the left panel, the 21:40 → 21:42 UT scan is represented: being both IMF B_y and B_z positive, the polar convection is almost entirely confined above 70° of magnetic latitude; the strong positive B_y makes the "afternoon" cell wider than the "morning" cell. In the right panel, the 21:42 → 21:44 UT scan is shown: the morning cell expanded, pushing the afternoon cell across midnight. At the same time, an enhancement of the antisolar convection is

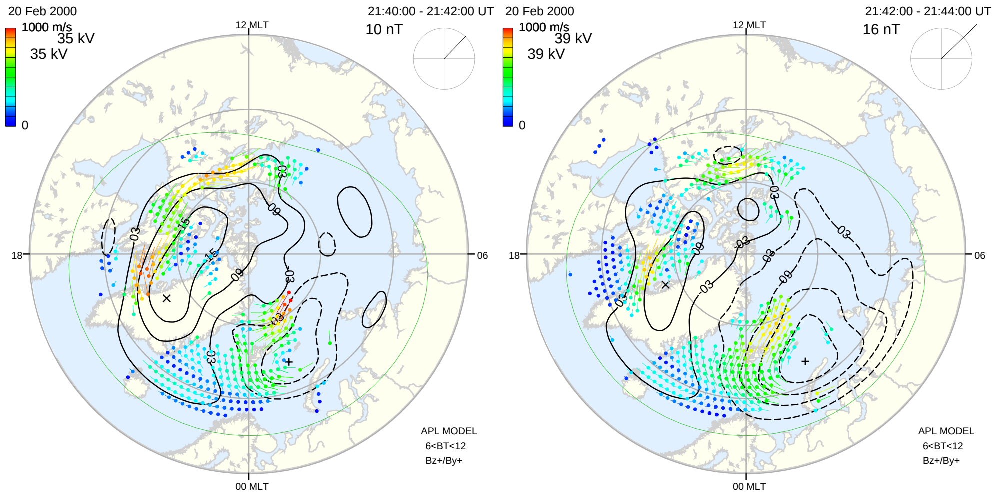

Fig. 3. SuperDARN potential maps during two radar scans in the Northern polar ionosphere for the 20 february 2000 event. In the left panel the 21:40 → 21:42 UT scan is shown, in the right panel the 21:42 → 21:44 UT scan is displayed. The polar plots show the equipotential contours in geomagnetic latitude and Magnetic Local Time (MLT). The plotted vectors are the convection velocities measured by the radars, whose color scale is represented on the left for each panel.

seen near 24:00 MLT in the southern hemisphere (not shown).

4. Conclusions

The SI event we have discussed yields a reconfiguration of the ionospheric convection. The main feature of this reconfiguration is an increase of the antisolar convection speed around midnight, in both hemispheres: the passage of the SI along the magnetotail causes the stretching of the field lines which mainly affects the B_x component, as seen by GEOTAIL at 21:42 TU (see Fig. 2). This could induce an increase in the dawn–to–dusk electric field and the projection of such electric field upon the night side ionosphere along the magnetic field lines leads to an increase of the ionospheric $\mathbf{E}\times\mathbf{B}$ convection velocity in the antisunward direction. To our knowlegde, it is the first time that such an effect is reported.

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