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The discrimination between magnetospheric and ionospheric contributions in the ground manifestations of Sudden Impulses.

M. Piersanti, U. Villante

Department of Physics and Chemistry Science, University of L'Aquila, Italy

Consorzio Area di Ricerca in Astrogeofisica. Università dell'Aquila. (Italy)

mirko.piersanti@aquila.infn.it

Introduction.

The ground magnetic signature of Sudden Impulses (SI) usually exhibits a step-wise increase of the North-South component (H), although its amplitude and waveform show a complex global distribution depending upon local time (LT) and latitude. According to Araki (1994) developed model, the total disturbance field (D_{SC}) of the H component can be decomposed into different subfields:

$$D_{SC} = DL + DP_{PI} + DP_{MI}$$

The direct effect of the increased magnetopause current produces a step like increase of the H component (DL). A dusk-to-dawn electric field along the compressional wave front induces a twin ionospheric vortex system that produces a preliminary impulse of polar origin (DP_{PI}). If the increased pressure behind the Solar Wind (SW) discontinuity is kept up, the magnetospheric convection has to adjust itself to the compressed state of the magnetosphere: as a final result it produces a twin polar vortex system (DP_{MI}) which is opposite to the DP_{PI} field and corresponds to the MI. The DP_{PI} and the DP_{MI} are often unified in a global DP field (where P identifies the polar origin).

Description of the model.

The Tsyganenko model (TS04, Tsyganenko and Sitnov, 2005) is adopted to evaluate the effects of magnetospheric currents. Basically, the TS04 model is represented as the sum (B_{TOT}-field, hereafter) of: the Chapman-Ferraro current at the magnetopause (B_{CF}), the ring current (B_R), the tail current (B_T) and the field aligned currents (B_{FAC}).

In order to identify the effects of magnetospheric origin, the traces predicted by T04S model (starting from the B_{CF} field alone) at geosynchronous orbit are progressively added and compared with experimental observations.

After determining the TS04 profile that better represents the magnetospheric observations, its expected response at ground is subtracted from the observations.

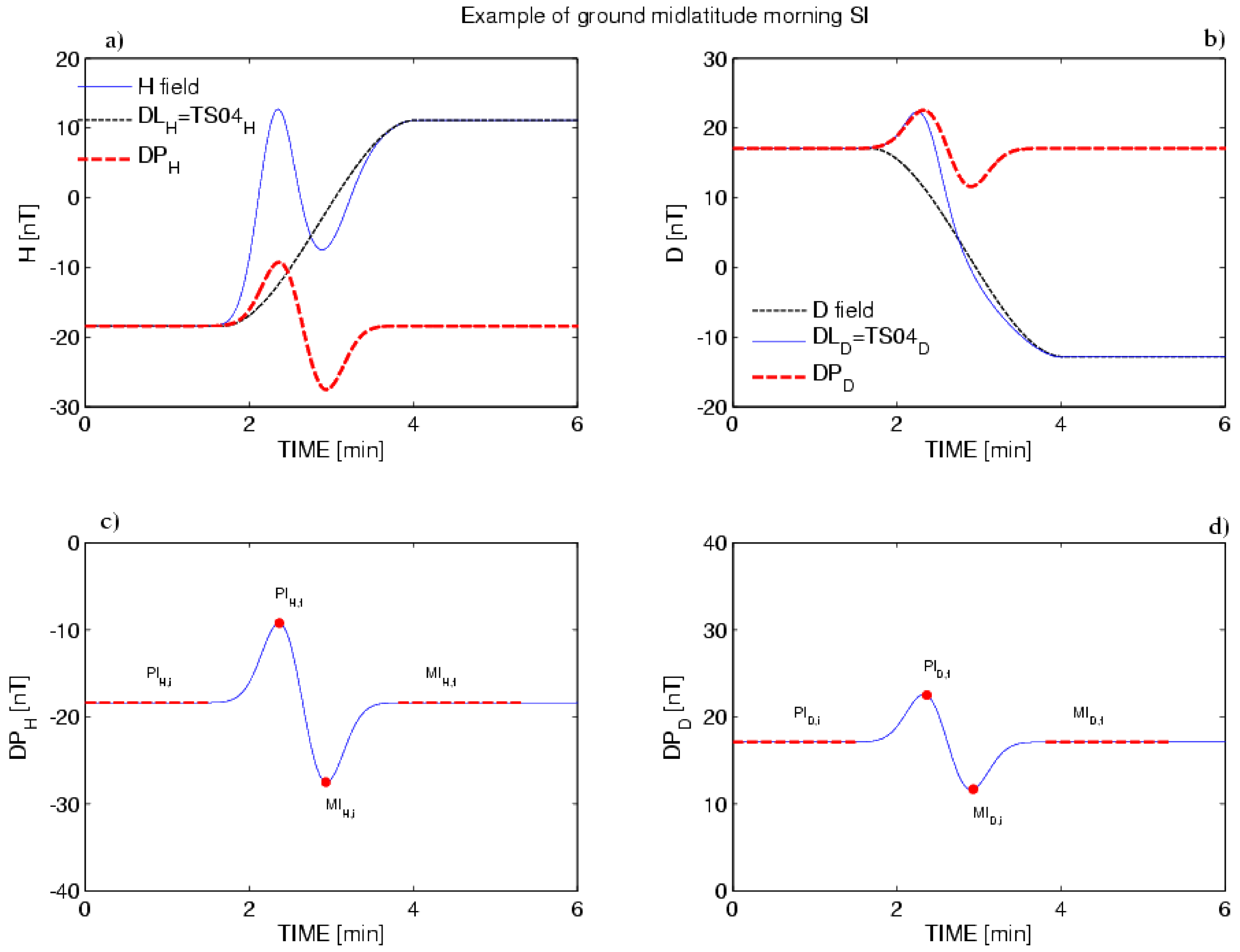

Figure 1: an example of the technique adopted for modelling a SI event. Top panels show the superposition of the TS04 model prevision (dashed lines) on the ground sudden impulse along H (panel a) and the D (panel b). Bottom panels show the residual disturbance fields $DP_H = H - H_{CF}$ (panel c) and $DP_D = D - D_{CF}$ (panel d): dotted lines represent the initial (hereafter as $PI_{H,i}$ and $PI_{D,i}$) and final steady states (hereafter as $MI_{H,f}$ and $MI_{D,f}$) of the DP fields. Black circles identify the estimate of the preliminary impulse ($PI_{H,f}$, $PI_{D,f}$) and main impulse ($MI_{H,i}$, $MI_{D,i}$) peak values. The $PI_{H,f}$, $PI_{D,f}$, $MI_{H,i}$ and $MI_{D,i}$ values are evaluated as the points where PI and MI reach peaks amplitudes.

Case event.

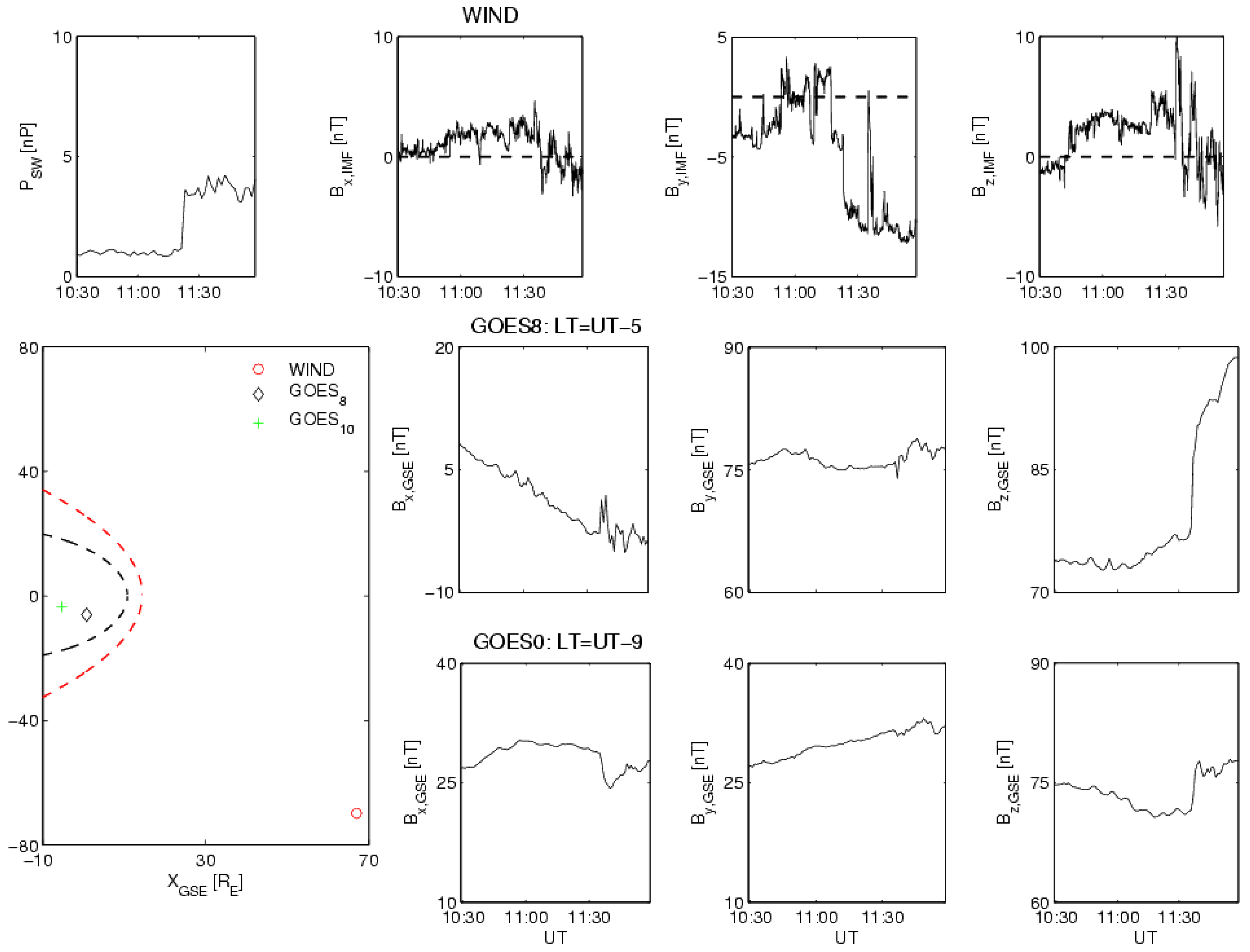

Figure 2: the interplanetary shock detected by WIND (top panels), and the SI observed by GOES8 (middle panels) and GOES10 (bottom panels) on March 23, 2002. At geostationary orbit a strong compression is observed in the Bz component in the dusk sector (ΔBz ≈20 nT at GOES8; ΔBz ≈6 nT at GOES10). The Bx and By components show smaller variations (ΔBx ≈7 nT and ΔBy ≈2 nT at GOES8; ΔBx ≈5 nT and ΔBy ≈1 nT at GOES10).

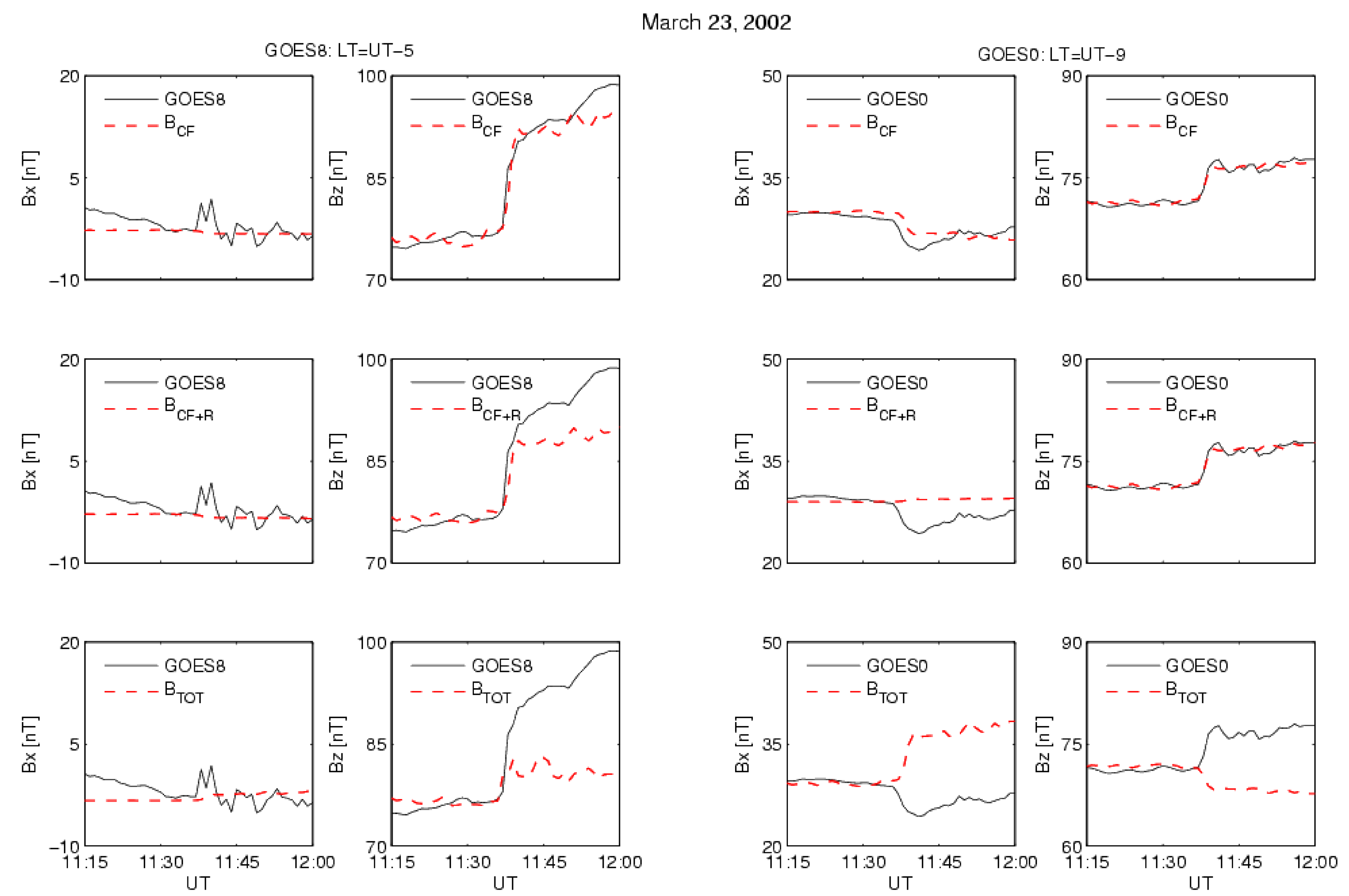

Figure 3: the superposition of the TS04 predictions. The B_{CF} field (top panels) provides the best prediction of the magnetospheric response. So, in this case event, the ground DL field can be modelled using the Chapman—Ferraro current alone.

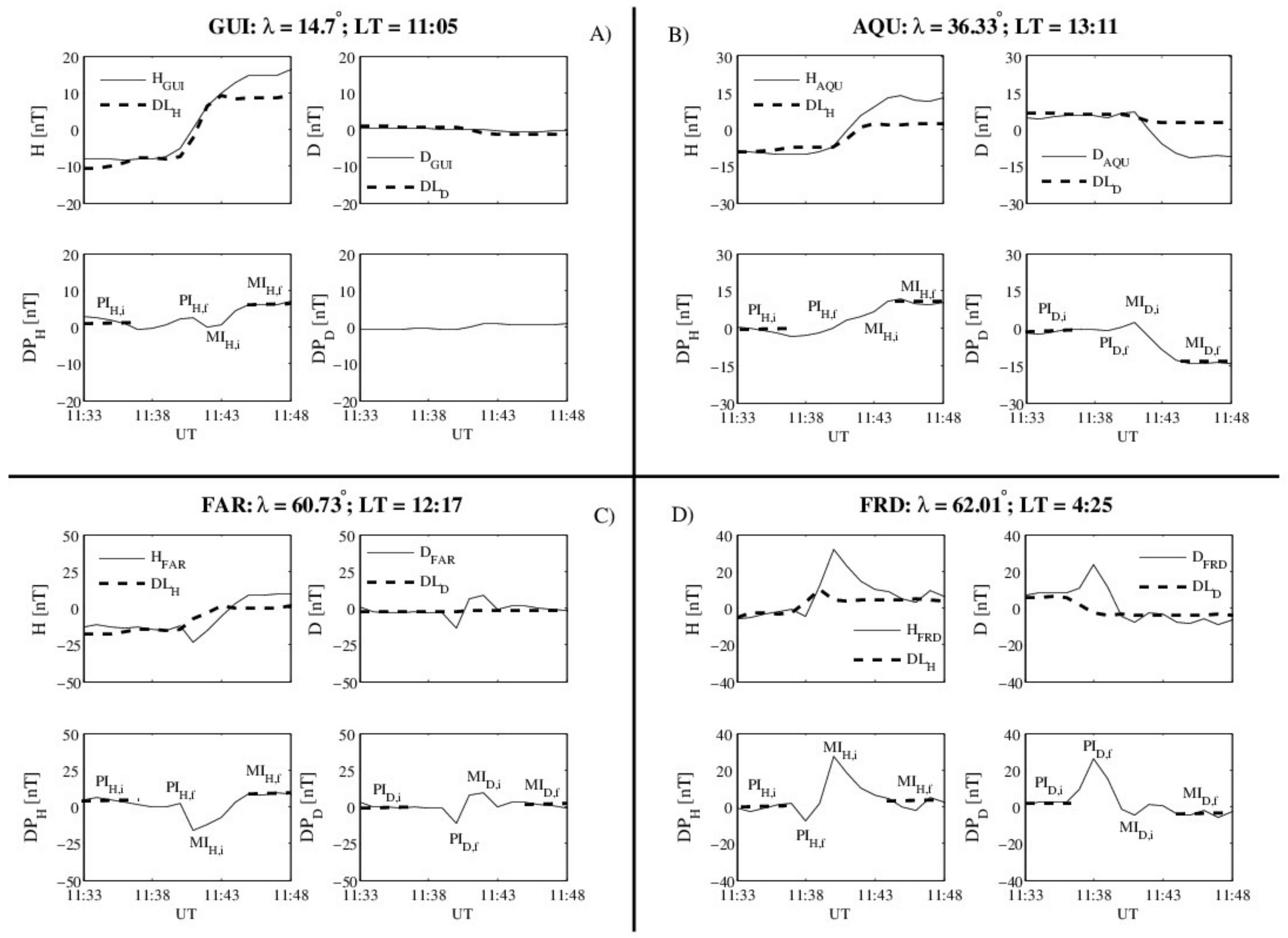

Figure 4: Box A) equatorial SI example; Box B): mid latitude noon SI example; Box C): high latitude noon SI example; Box D): high latitude early morning SI example. In each box: upper panels show the H (left) and the D (right) traces superimposed to the estimated *DL* fields (dashed line); lower panels present the residual DP fields; horizontal dashed lines represents our estimates of the initial/final PI/MI states.

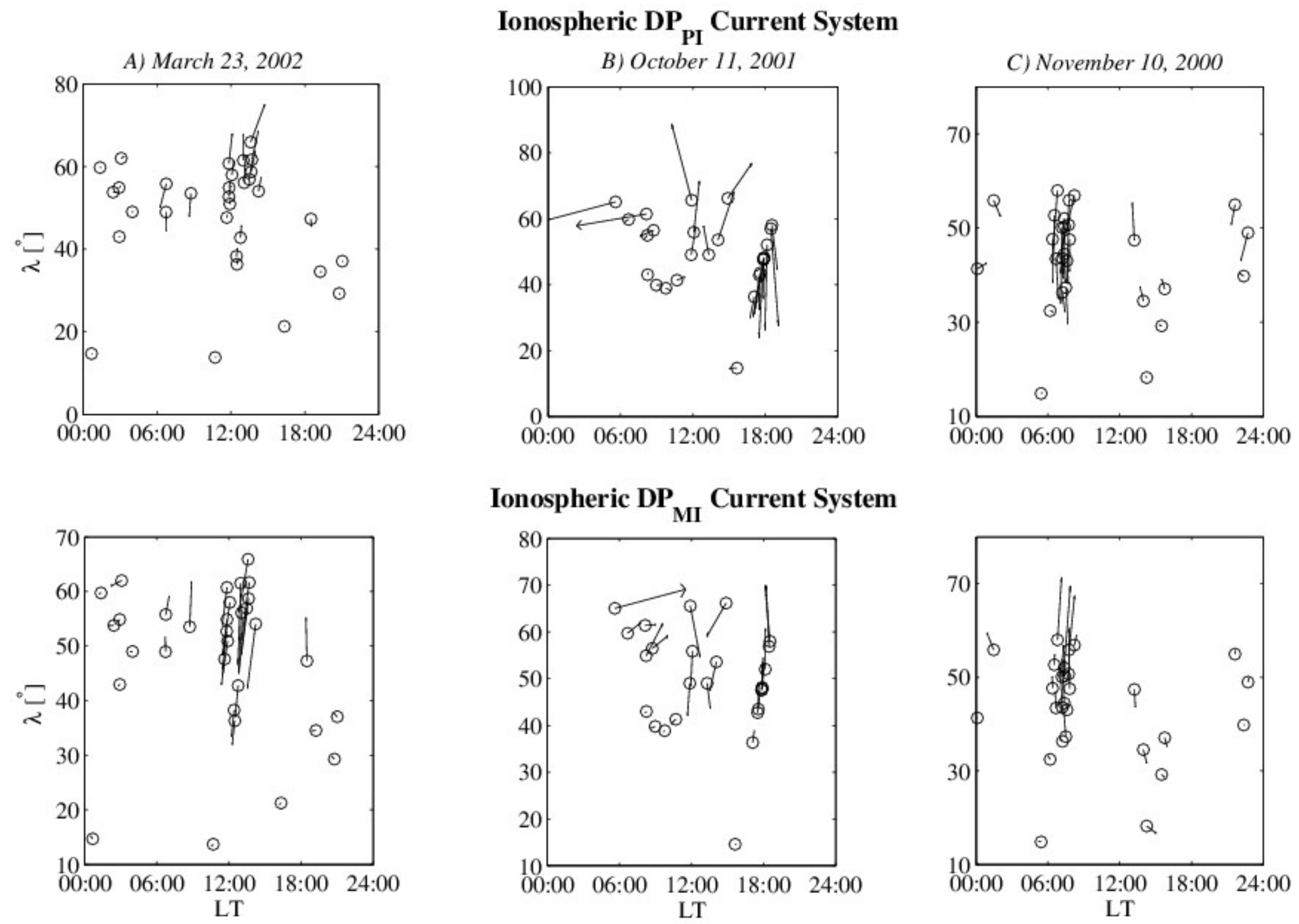

Figure 5. The direction of the ionospheric currents for three case events evaluated using our technique. Upper panels: the current direction for the PI; bottom panels: the current direction for the MI. The direction of the ionospheric currents have been determined by a 90° rotation of the disturbance magnetic field. The results for each event are consistent with a morning CCW and an afternoon CW vortex for the PI, with a morning CW vortex and an afternoon CCW for the MI (Araki, 1994);

Conclusions.

We developed a technique able to separate the magnetospheric and ionospheric contributions from a ground SI signature. This allows to separate and understand the magnetospheric and ionospheric dynamics on the ground, for the first time. The estimation of the DL field has a crucial rule in determining the characteristics of a Sudden Impulse on the ground. This research gives a method to well identify the DL field and its magnetospheric source using the TS04 Tsyganenko model. The PI and MI ionospheric current flow patterns results consistent with those proposed by Araki (1994): a morning CCW vortex and an afternoon CW vortex for the PI and a morning CW vortex and an afternoon CCW for the MI.

References.

Araki, T., 1994, A physical model of the geomagnetic sudden commencement, in Solar Wind Sources of Magnetospheric Ultra-Low-Frequency Waves, *Geophysical Monograph Series*, 81, 183 - 200.

Tsyganenko, N. A., and M. I. Sitnov, 2005, Modeling the dynamics of the inner magnetosphere during strong geomagnetic storms, *Journal of Geophysical Research*, 110, A03208.