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Ionospheric convection observed by SuperDARN during ongoing lobe reconnection revealed by Cluster

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Abstract. Since Dungey's work in the early sixties, who suggested that the interplanetary magnetic field and the geomagnetic field could reconnect, a lot of debate has been going on regarding how the reconnection process exactly occurs at the Earth's magnetopause. In fact, many fundamental questions remain unanswered, in particular regarding the shape and the extension of the reconnection sites for variable IMF orientation. The polar ionospheric convection strongly depends on the orientation of the IMF; such dependence can be explained in the framework of the reconnection between interplanetary and geomagnetic fields. Here we use SuperDARN observations of the ionospheric convection in coordination with space observations provided by the Cluster spacecraft to infer large scale configuration and evolution of the reconnection at the magnetopause during an extended period of Northward IMF.

Key words. Sun: solar-terrestrial relations – Magnetic fields

1. Introduction

Solar wind energy transfer is the cause of the highly dynamical state of the magnetosphere-ionosphere system. It is thought that the greater part of this energy is transmitted through the magnetic reconnection between the interplanetary magnetic field (IMF) and the geomagnetic field lines. Momentum transfer from the solar wind results in large scale plasma convection in the polar ionosphere of both hemispheres. The ionospheric convection pattern strongly depends on the orientation of the IMF. This fact can be explained in terms of reconnection (see Figure 1). For Southward IMF (Bz<0), the anti-parallel IMF and geomagnetic fields become connected at the dayside magnetopause (MP), are convected tailward and reconnect in the geomagnetic tail. Therefore, dayside magnetic closed flux is converted in tail open magnetic flux, which afterwards is transformed in 'new' closed flux by the reconnection in the equatorial tail, with release of plasma kinetic energy and plasma acceleration towards the Earth. Correspondingly two convection cells develop in the ionosphere, with anti-sunward

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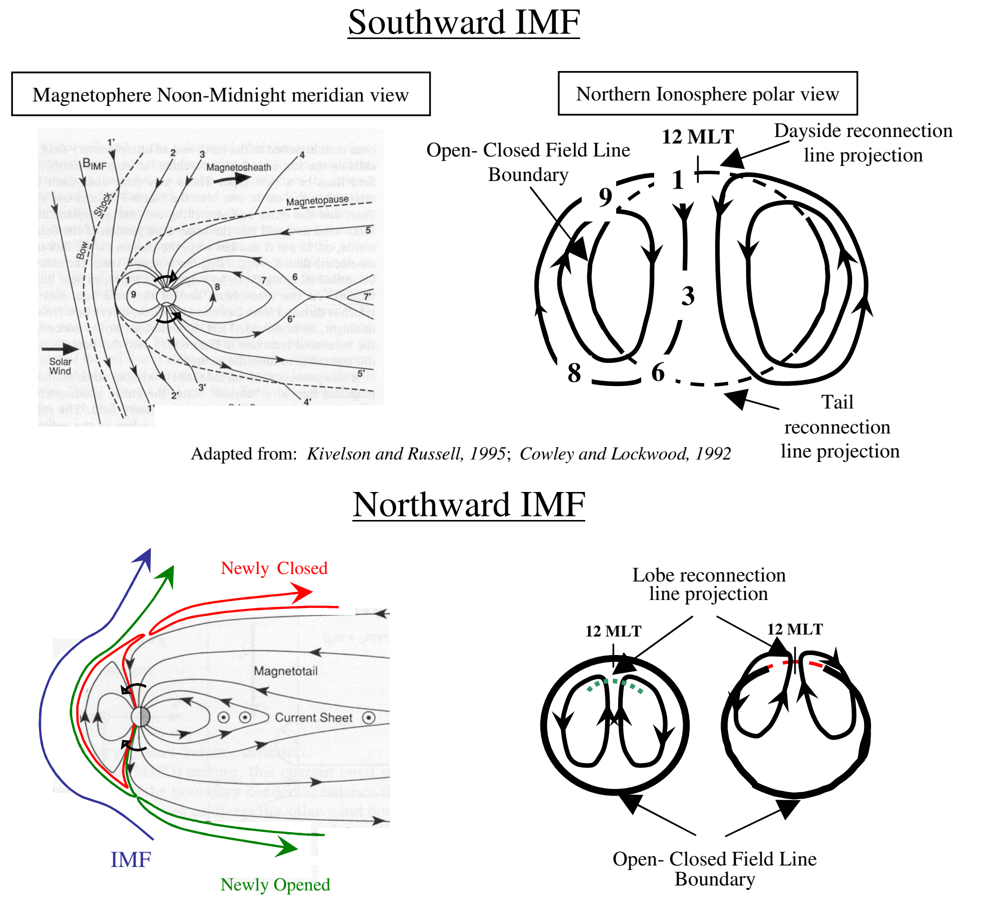

Fig. 1. Large scale configuration of the reconnection at the magnetopause for Southward and Northward IMF together with the corresponding high latitude ionospheric convection.

flow over the polar cap and return sunward flows at lower latitudes. The reconnected field lines cross the open-closed field line boundary both at the dayside and at the nightside. Dayside magnetopause and tail reconnection rate can be different, so that the polar cap can shrink or expand (Cowley & Lockwood, 1992). During Northward IMF (Bz>0), the IMF reconnects with the lobe field lines at high latitudes, tailward of the magnetospheric cusps. Reconnected lines are first convected sunward due to magnetic tension and then move anti-sunward along with the solar wind flow. Two reversed convection cells develop in the polar ionosphere, with sunward flow at the pole and anti-sunward flows at lower latitudes (Reiff & Burch, 1985). If reconnection occurs at one hemisphere only (green line) reconnected lines are stirred inside the polar cap. If reconnection occurs simultaneously at both hemisphere, reconnected lines cross the dayside open-closed field line boundary, and tail magnetic flux become new dayside closed flux. At the same time, reconnection can proceed or not in the geomagnetic tail; in Figure 1, lower panel, only the dayside portion of convection is drawn.

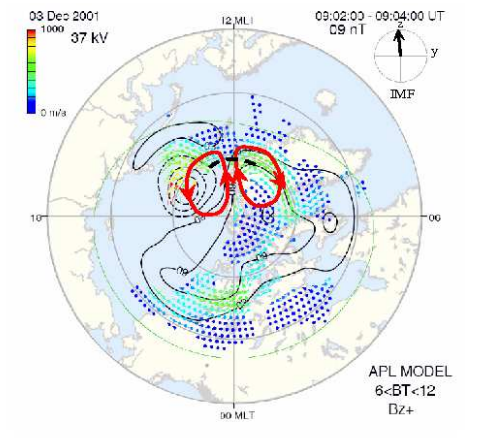

Fig. 2. Ionospheric convection map of the Northern Hemisphere for a two minute scan during the period of the observations.

2. Cluster and SuperDARN observations

During December 3, 2001, in the time period 07:00 - 12:00, the IMF pointed steadily Northward, apart for two very short southward turning, until it rotated dawnward in the last part of the interval. This time period has been extensively studied using Cluster data by Retinò et al. (2005). The Cluster spacecraft were skimming the southern high-latitude duskside magnetopause in a way that at least one satellite was present at the MP during most of that period. Therefore it was possible to observe in situ evidence of reconnection, based both on tangential stress balance between the magnetosheath and the MP and on kinetic features of transmitted magnetosheath ions inside the MP and reflected magnetosheath ions just outside the MP, throughout the event. The observations are consistent with magnetic reconnection occurring tailward of the Southern cusp and going on continuously. For the same time interval, SuperDARN radars (Greenwald et al. 1995) provided measurements of the ionospheric convection in the Northern Hemisphere with an extremely good data coverage. The ionospheric convection map for 09:02 - 09:04 UT, when the IMF was purely Northward, is shown in Figure 2. Two reversed convection cells can be identified with sunward flow in the polar cap and antisunward flows at lower latitude. The black dashed line can be considered as a proxy of the projection of the lobe magnetopause reconnection line. Such type of convection is observed all throughout the period, with the duskward (dawnward) cell enhanced when the IMF By component is negative (positive) and dominating. Therefore SuperDARN observations are consistent with reconnection occurring at high latitudes, tailward of the Northern cusp during the period of observations.

3. Conclusions

Cluster observations evidence that reconnection is continuously occurring between lobe field lines and the external magnetic field in the Southern Hemisphere (Retinò et al. 2005). SuperDARN observations of the Northern Hemisphere polar convection are consistent with lobe reconnection occurring also at the Northern Hemisphere. Therefore our observations show that from 07:00 to 12:00 most probably lobe reconnection is occurring simultaneously at both hemisphere so that at least part of the lobe flux is eroded and transformed in dayside closed flux (Onsager et al. 2001).

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References

Cowley, S.W.H, & Lockwood, M. 1992, Ann. Geophys., 10, 103.
Greenwald, R. A., et al. 1995, Space Sci. Rev., 71, 761.
Onsager, T. G., et al. 2001, J. Geophys. Res., 106, 25467.
Rème, H., et al. 2001, Ann. Geophys., 19, 1303.
Reiff, P. H. & Burch, J. L. 1985, J. Geophys. Res., 90, 1595.
Retinò, A., et al. 2005, Ann. Geophys., 23, 461.