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Evolution of the magnetopause X line during variable IMF orientation

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Abstract. At 22:05 UT on January 02, 2003, in the solar wind $B_z > 0$ and $B_x < 0$. At the same time the northern SuperDARN convection map displays two high latitude reverse cells. We use the Cooling and Tsyganenko models to project the reconnection X line onto the polar ionosphere and we compare such projection with the SuperDARN map. We suggest that in the cusp region the considered models do not correctly reconstruct the ionospheric projection of the X-line, due to their inability to cope with the cusp indentation.

Key words. magnetopause reconnection – ionospheric convection – X line

1. Introduction

Magnetic reconnection is the main mechanism by which solar wind energy and momentum are transferred to the magnetosphere (Dungey, 1961). According to reconnection models, the location of the X-line, where reconnection occurs at the magnetopause, is controlled by the relative orientation of IMF and terrestrial magnetic fields. However its exact location is still an open problem.

In this paper we address the issue of projecting the X-line from the magnetopause onto the polar ionosphere. For that purpose, we present a case study of lobe reconnection at 22:05 UT on January 02, 2003, based on SuperDARN data (Chisham et al. 2007) and on the Cooling et al. (2001) model, which has been extensively used in the past to calculate the motion of reconnected flux tubes at the magnetopause (e.g see Wild et al. 2007).

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2. The 02 January 2003 event

The Cooling model makes use of the Kobel and Flückiger (1994) model of the magnetopause and propagates the IMF and solar wind plasma data through the magnetosheath by using the Spreiter et al. (2008) gas-dynamic model. On this basis it allows to: evaluate the probability of component merging; reconstruct an X-line at the magnetopause starting from a user defined central point; follow the motion of reconnected magnetic flux tubes from the X-line over the magnetopause surface.

For the event under study, the ACE spacecraft (located at the L1) observed a northward IMF with dominant B_y. Starting from the ACE data, we calculated various Cooling X-lines at the magnetopause, projected them onto the Tsyganenko 96 (T96) magnetopause and then computed the T96 X-line projections onto the polar ionosphere by using the T96 model (Tsyganenko 1995). Finally, we compared such projections with the ionospheric

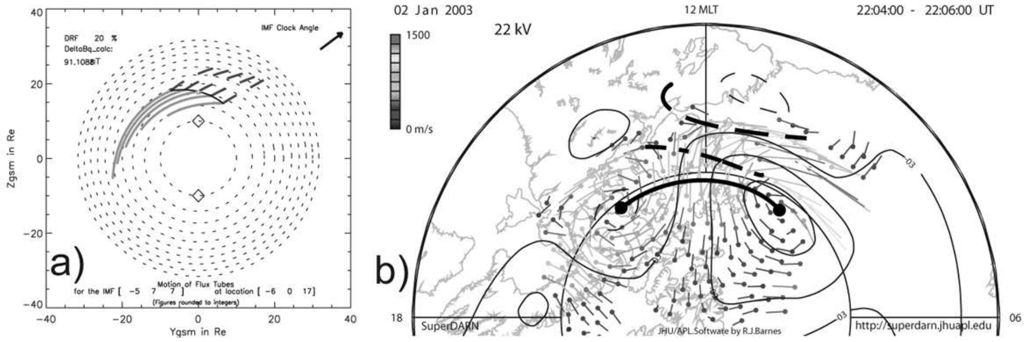

Fig. 1. a) Cooling X-line (black line) for IMF **B** = (-5, 7.5, 7.5) nT. Solid and dashed lines highlight the motion of flux tubes from the X-line. diamonds indicate the cusps. **b**) SuperDARN convection map with the projection of the ”most probable” X-line (dashed black line) and of the X-line which best fits the SuperDARN map (dot-dashed black line). The black line shows the probable site of the lobe merging line.

convection map obtained from SuperDARN data by using the ”Map Potential” software (Ruohoniemi & Greenwald 1996).

Fig. 1a shows the projections onto the YZ GSM plane of intersections of the magnetopause model (dotted circles) with planes parallel to the YZ plane at intervals of 2 R_E. The black solid line indicates the X-line calculated from the Cooling model which best fits the SuperDARN convection map (Fig. 1b), with (-6, 0, 17)R_E as a central point.

Fig. 1b displays the SuperDARN northern convection map at 22:04-22:06 UT. Here we observe two clear reverse lobe cells, accompanied by a westward flow at lower latitude. The projections of two X-lines are overlaid on the SuperDARN map: the ’most probable’ X-line (dashed black line), having (4, 1, 10) R_E as a central point; the X-line which best fits the SuperDARN global convection maps (dot-dashed black line), which corresponds to the X-line shown in Fig. 1a. Moreover, the black line highlights the probable location of the lobe merging line connecting the foci of the dawn to dusk cells. In this case the ”best” Cooling X-line and the ”most probable” X-line project equatorward of the SuperDARN X-line by 3° and 5° respectively. We notice that for the ”best” X-line a reasonable agreement with the SuperDARN X-line is achieved by choosing an ”ad hoc” central point at the magnetopause at X=-6 R_E, where lobe reconnection should become unstable due to the local increase of the MSH flow velocity to super-magnetosonic values.

3. Conclusions

We have discussed a case in which the projection of the Cooling X-line onto the ionosphere and the probable location of the X-line projection as inferred from SuperDARN maps cannot be easily reconciled. As the studied event implies lobe reconnection close to the cusp region, this may suggest that the observed differences be due to the inability of the considered model to cope with the cusp indentation.

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