Symmetry and asymmetry of interhemispheric dayside ionospheric convection seen by the SuperDARN Kerguelen and Hankasalmi radars

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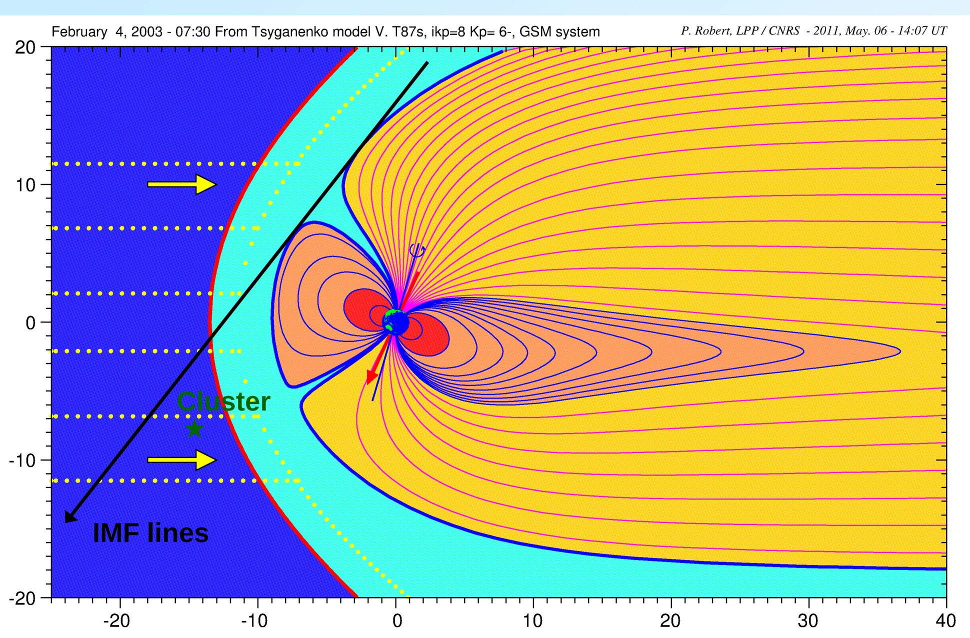
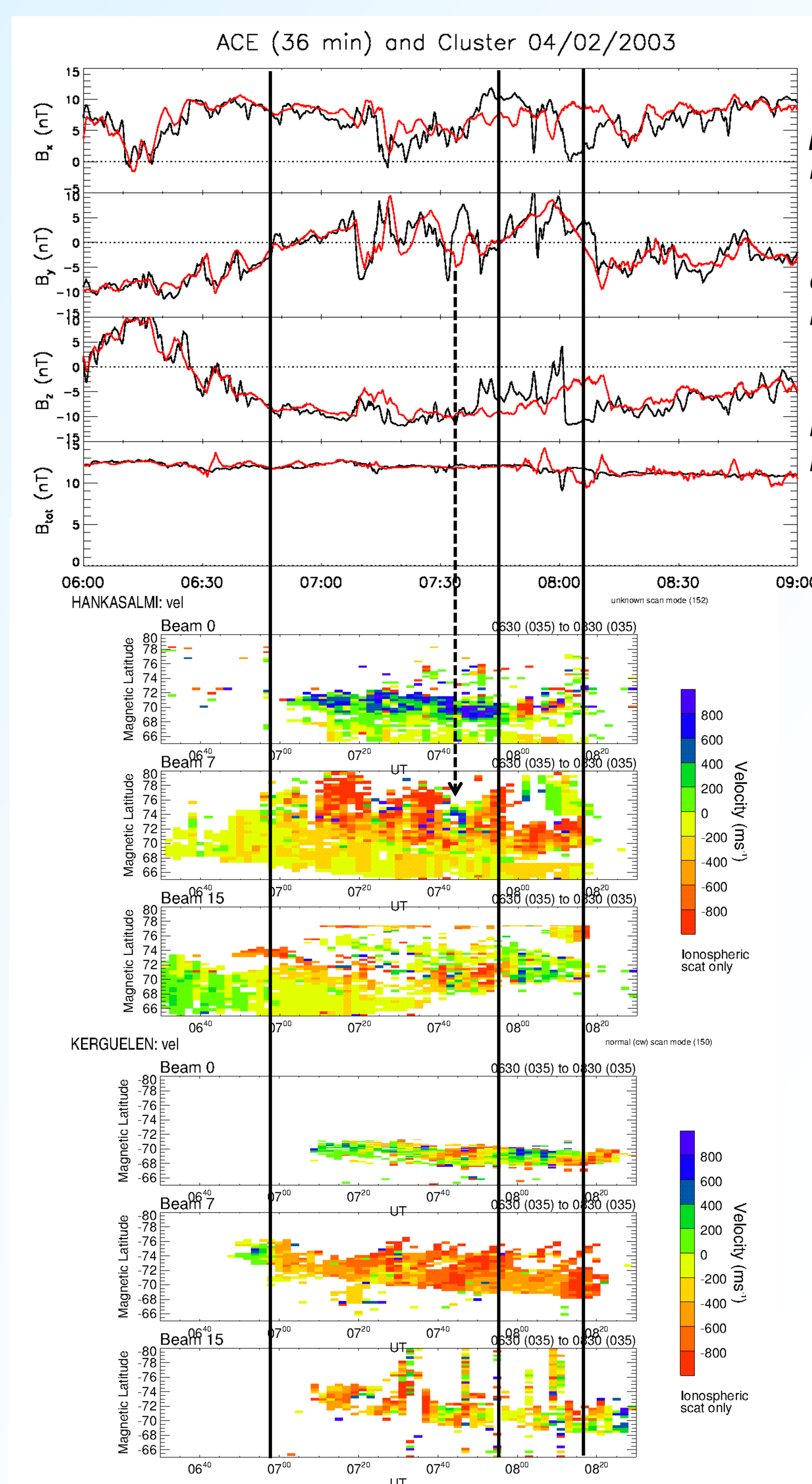
***Abstract** – We have identified excellent conjugated observations in the cusp regions by Hankasalmi (Northern Hemisphere) and Kerguelen (Southern Hemisphere) SuperDARN radars. First, we have studied the location of the boundary between low and high spectral width in both hemispheres and have compared the location of the northern spectral width boundary with the open-closed magnetic field boundary obtained from particles precipitation measured by low-altitude spacecraft. Second, we have identified conjugated pulsed ionospheric flows characteristics of sporadic magnetopause reconnection events. These observations are perfectly conjugated. However, the number, the velocity, and the shape of these ionospheric structures are very different in both hemispheres. We investigate the causes for these different properties, with respect to season and interplanetary conditions.*

Magnetospheric configuration and solar wind conditions





Variable, but positive
B_x ~ 0 to 10 nT

Variable, but centered on 0
B_y ~ -5 to 10 nT

Variable , but negative
B_z ~ -4 to -10 nT

Magnetospheric configuration

- between winter solstice and equinox in the Northern hemisphere

-> dipole tilt angle: ~ -24°

Solar wind conditions

- dominant IMF-B_x and IMF-B_z

-> elevation angle: ~ -39°

- stable Solar Wind Pressure: 3 < P_{SW} < 4

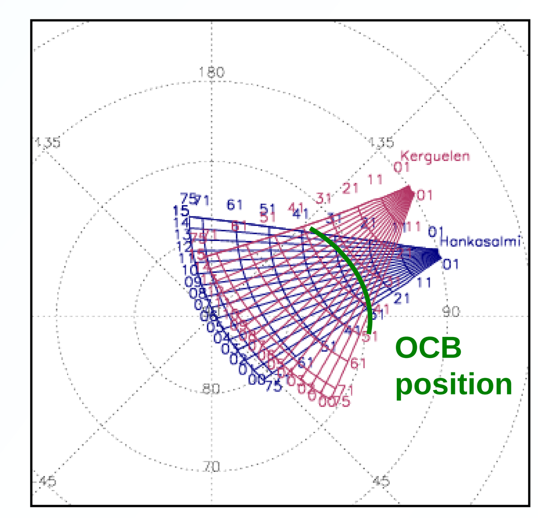
- intermediate Alfvén Mach Number: ~6

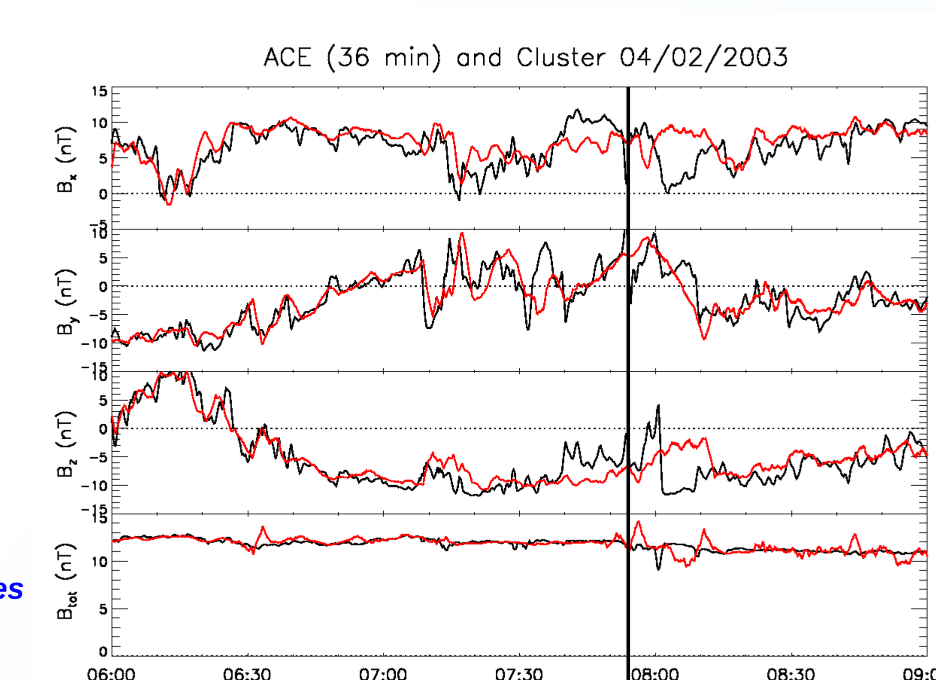
Precise estimation of the SW propagation delay, from IMF-B_y variations and ionospheric convection responses

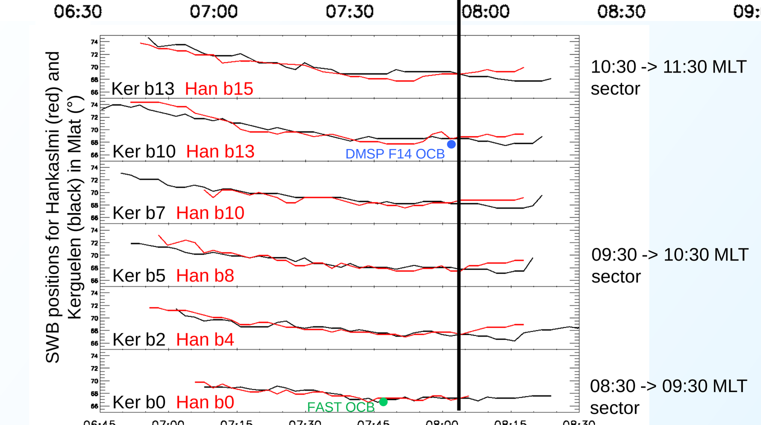
-> ACE-ionosphere: ~47 min

-> Cluster-ionosphere: ~11 min

North and South Spectral Width Boundaries location







Spectral width boundaries (SWBs) location in both hemispheres in the dawn sector

• IMF-B_z component effect

- SWBs follow roughly IMF-B_z variations (dominant component)

- SWBs at same magnetic latitudes (within 100 km) in both hemispheres for all radar beams (02:00 MLT coverage)

-> from Coleman et al. (2000) during solstice season, anti-parallel reconnection sites should mapped to different MLAT in both hemispheres for dominant IMF-B_z. Is the negative tilt angle compensated by the positive IMF-B_x (EA~-39°)?

• IMF-B_y component effect

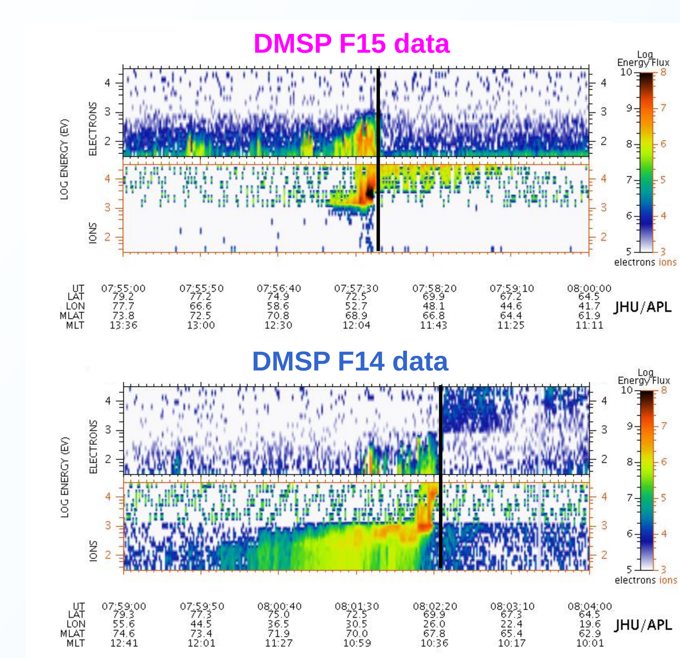
- SWBs start to deviate after 08:05 UT when IMF-B_y remains positive for ~20 min. SWBs deviation begins ~10 min after IMF-B_y turns positive

- all the other IMF-B_y inversions (07:30-08:05 UT) are too short to be accompanied by clear SWBs deviations even if convection is changing

- SWBs deviation starts almost simultaneously on all beams -> no clear MLT propagation of this deviation

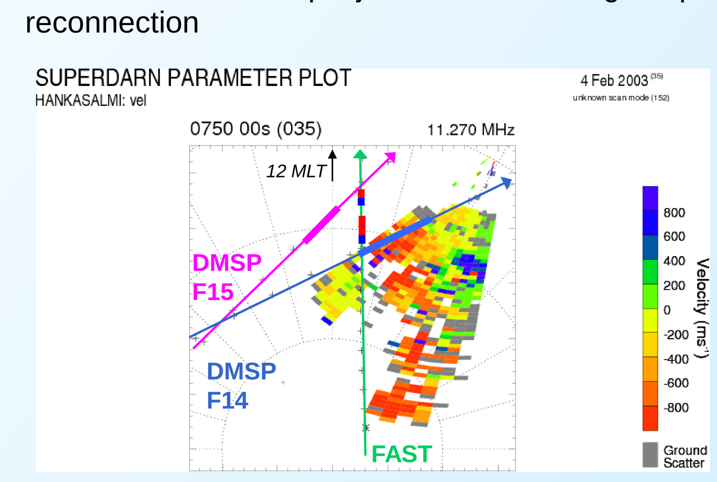
- OCB locations observed by FAST and DMSPF14 at slightly lower latitudes than SWBs (within 1°)

Low-altitude spacecraft observations



Simultaneous low-altitude spacecraft observations in Northern Hemisphere

- DMSP F14 (08:02 UT), DMSP F15 (07:57 UT) and FAST (07:47 UT) observe ion velocity dispersion characteristics of cusp injections due to magnetopause reconnection



FAST observations

2 main cusp injections characterized by:

- a pair of FAC: downward at low latitude and upward at high latitude

- downward FAC associated with upward electrons, E=[0,1 keV]

- current intensity of each FAC: $J_{//}$ ~ 4 µA/m²

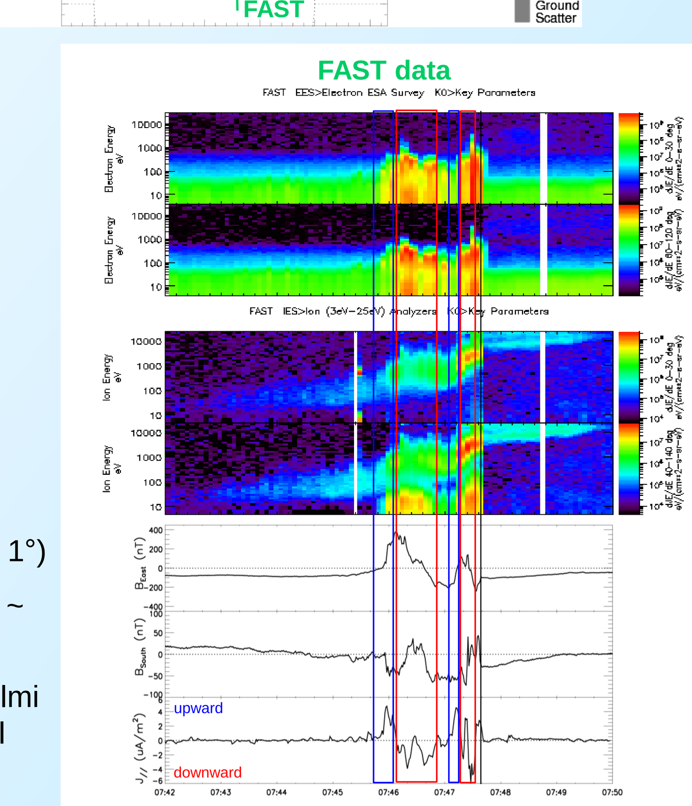
Small-scale structure of the injections

- substructures of parallel current perfectly associated with substructures in e- precipitation

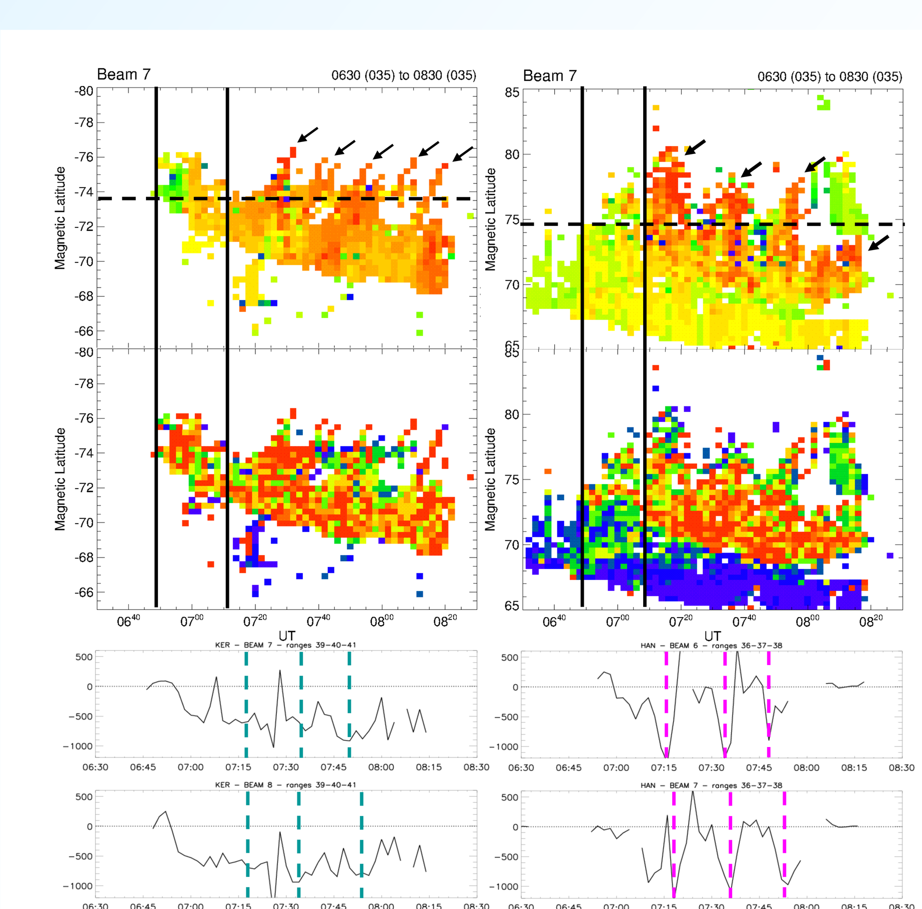
-> 1st injection, close to OCB: small latitudinal extension (Mlat ~ 1°)

-2nd injection, at higher latitude: larger latitudinal extension (Mlat ~ 2.2°), with a larger extension for the downward current

-> 4 patches of high antisunward velocities observed by Hankaslmi up to 90° Mlat - > 4 successive injections (the higher being fossil signatures, no more $J_{//}$)?



Reconnection properties from ionospheric observations



Radial velocities averaged over 3 ranges

Ionospheric reconnection signatures

- continuous antisunward convection starts ~ 06:49 UT at Hankasalmi and at Kerguelen (1st vertical lines)

- Pulsating Ionospheric Flows (PIFs) start ~ 07:08 UT at Hankasalmi and ~ 07:12 UT at Kerguelen (concomitant with the first sharp IMF-B_y inversion) (2nd vertical lines)

-> similar appearance time of cusp echoes at Hankasalmi and Kerguelen for continuous reconnection

-> ~ 4 min delay for Pulsed Ionospheric Flows onset between Hankasalmi and Kerguelen (Alfvén propagation time along field lines with different lengths?)

-> ~ 20 min delay between continuous and sporadic reconnection onsets (caused by IMF variations?)

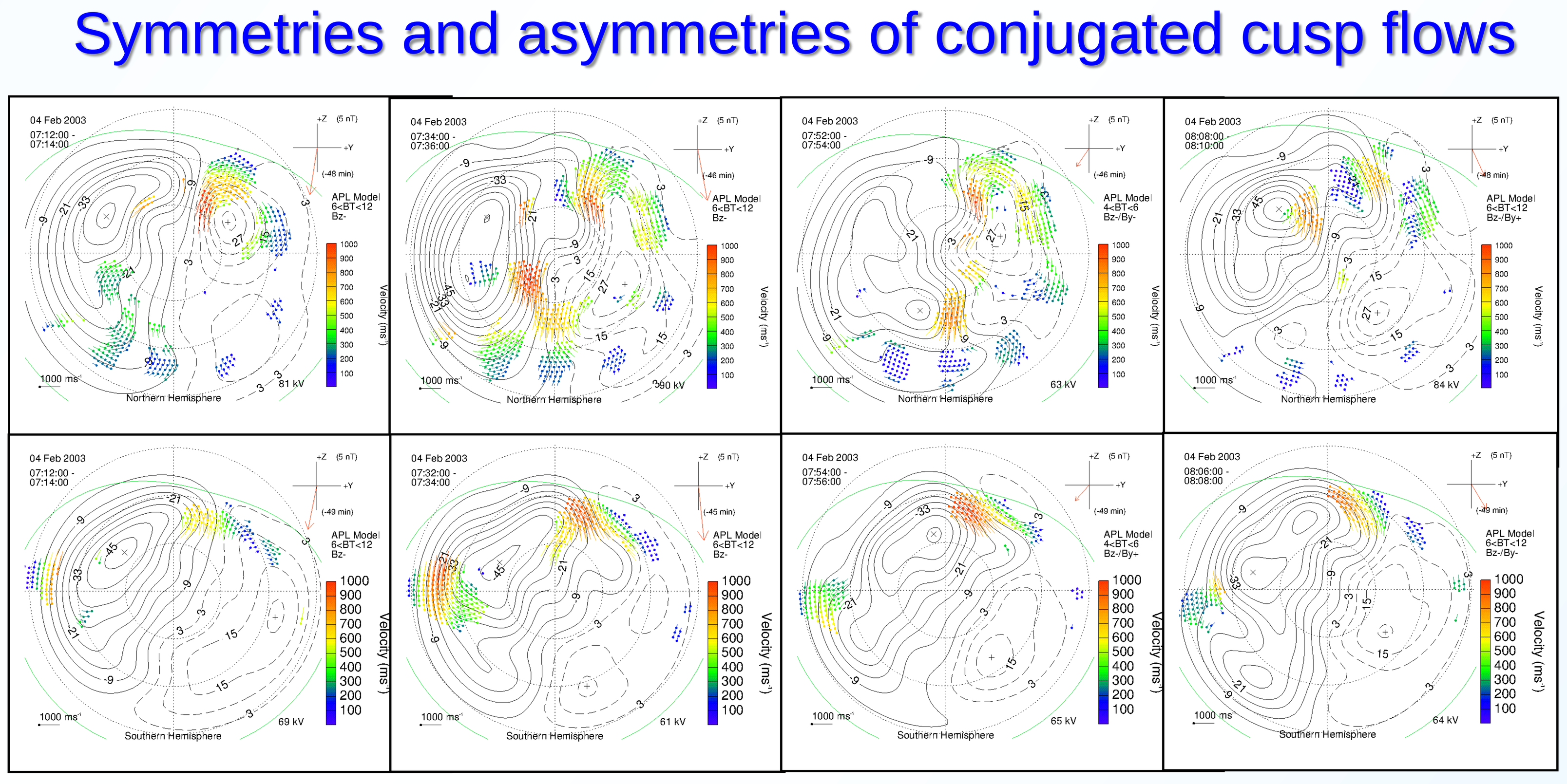
Comparison of Pulsed Ionospheric Flows (PIFs) between hemispheres

- higher velocities at Hankasalmi than at Kerguelen

- PIFs at Kerguelen displaying clear time-range (latitude) dispersion vs more patchy velocity enhancements at Hankasalmi

- 3 PIFs around 07:15, 07:35 and 07:50 UT are observed quasi-simultaneously in both hemispheres

Symmetries and asymmetries of conjugated cusp flows



Ionospheric cusp flow signatures

- 1st row of maps at 07:12 UT: very similar cusp convection direction in both hemispheres, mainly antisunward (due to the dominant negative IMF-B_z)

- 2nd row of maps at 07:34 UT (time of 2nd PIF event): different cusp convection direction, mainly antisunward at Hankasalmi despite a non-zero IMF-B_y, but showing also simultaneously dawnward and duskward bifurcations at Kerguelen

- 3rd row of maps at 07:52-54 UT (time of 3rd PIF event): different cusp convection direction, mainly antisunward at Hankasalmi despite a non-zero IMF-B_y, but dawnward and antisunward at Kerguelen

- 4th row of maps at 08:06 UT: similar cusp convection direction, mainly dawnward and antisunward in both hemispheres despite a positive IMF-B_y, which should favor a duskward flow at Kerguelen

-> Cusp convection does not follow usual pattern (as given by the IMF-B_y component), especially during PIFs in the Northern hemisphere

-> Are these unusual cusp convection flows due to the particular magnetosphere-solar wind configuration (negative dipole tilt and negative elevation angle) or caused by badly constrained maps due to sparse data?

Scientific perspectives

- Cause of cusp convection flows asymmetries between hemispheres and cause of PIFs differences (shape, velocity amplitude):

** difference in ionospheric conductivities caused by different solar illumination between hemispheres (quasi-solstice season)*

** deviation of the reconnection line from subsolar point due to dipole tilt and/or IMF-B_x component and/ or IMF-B_y component*

- Precise electrodynamics study of cusp injections with FAST data (SuperDARN and FAST convection comparison)

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