Simultaneous tracking of reconnected flux tubes: Cluster and conjugate SuperDARN observations on 1 April 2004

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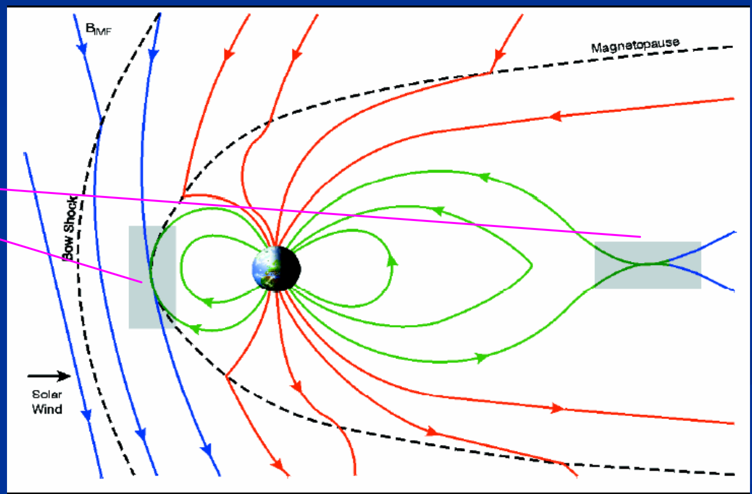
Outline

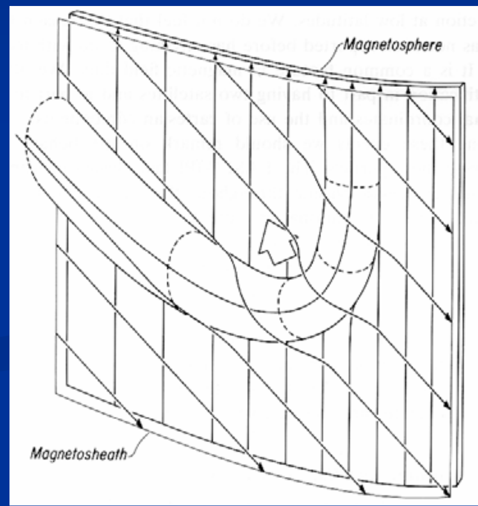
- Background
- Observations of the reconnection signatures
- FTEs motions and dayside ionospheric convections
- Summary

Background

- Magnetic reconnection is a commonly accepted process, resulting in energy and momentum transfer from solar wind to the magnetosphere.

Magnetic reconnection





(Xiao, et al., 2007)

(Russell and Elphic, 1978)

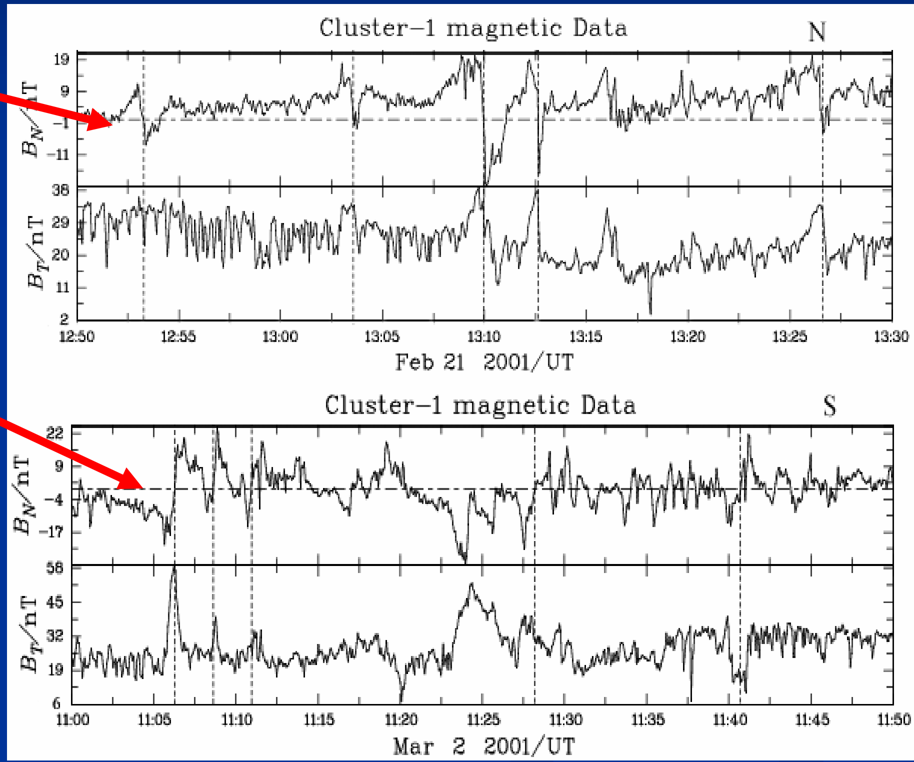
- Reconnection process signatures is often of an **independently intermittent and spatially limited nature** on the dayside magnetopause (MP) were first obtained by Haerendel et al.(1978) and Russell and Elphic(1978).
- Termed "flux erosion events" by Haerendel et al. and **"flux transfer events" (FTEs)** by Russell and Elphic.

Background

- **Characters of FTEs:**

  a) bipolar signatures in the field component (Bn) normal to the MP (+/- in N and -/+ in S) and increase in total |B| (sometimes decrease in magnetosphere).

  b) With intricate mixing signatures of magnetosheath and magnetospheric plasma populations



(Liu, et al., 2006)

- **Location: vicinity of the MP**
- **Size: ~R_E**
- **Periods：~8 min**

Cluster/Double Star (TC-1、2)

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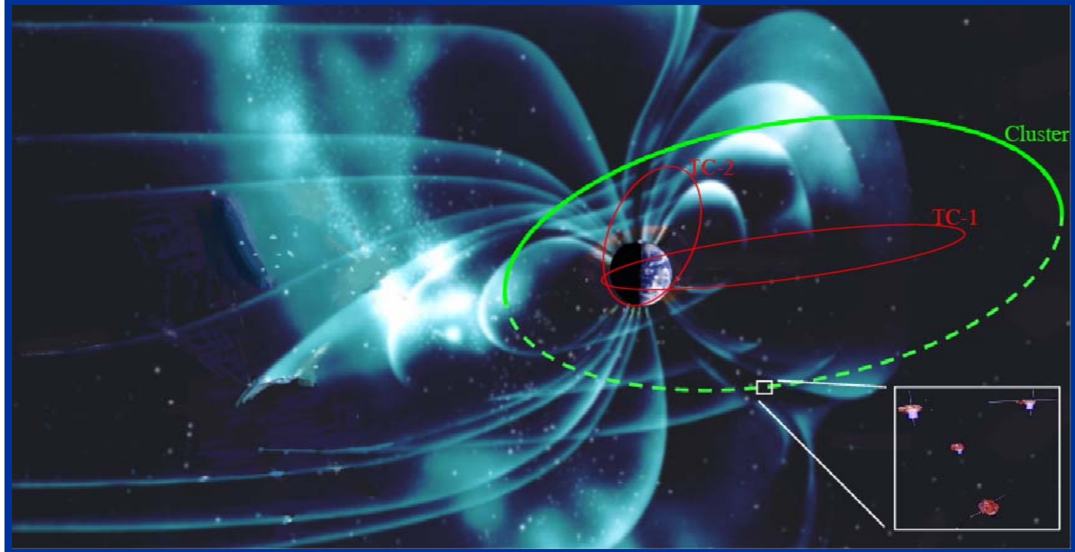
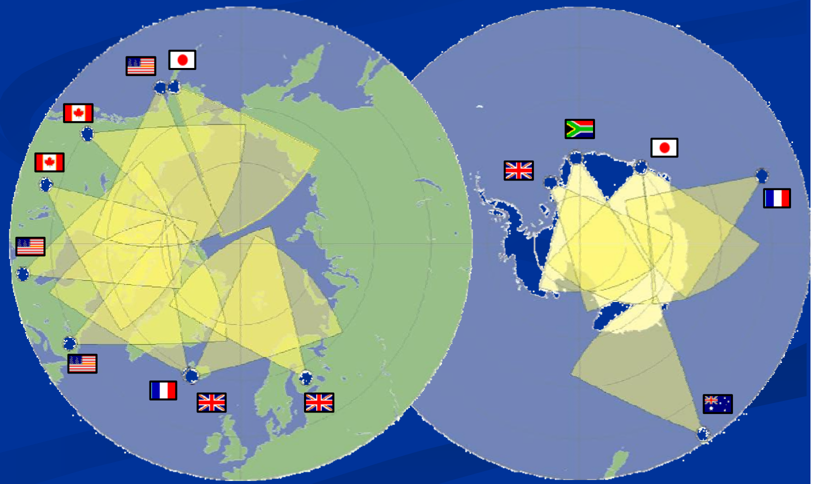
First time to realize simultaneous obsevations of the earth magnetosphere from five or six points in space.

SuperDARN

- **Cluster/Double star often simultaneously observed high- and low-latitude MP**



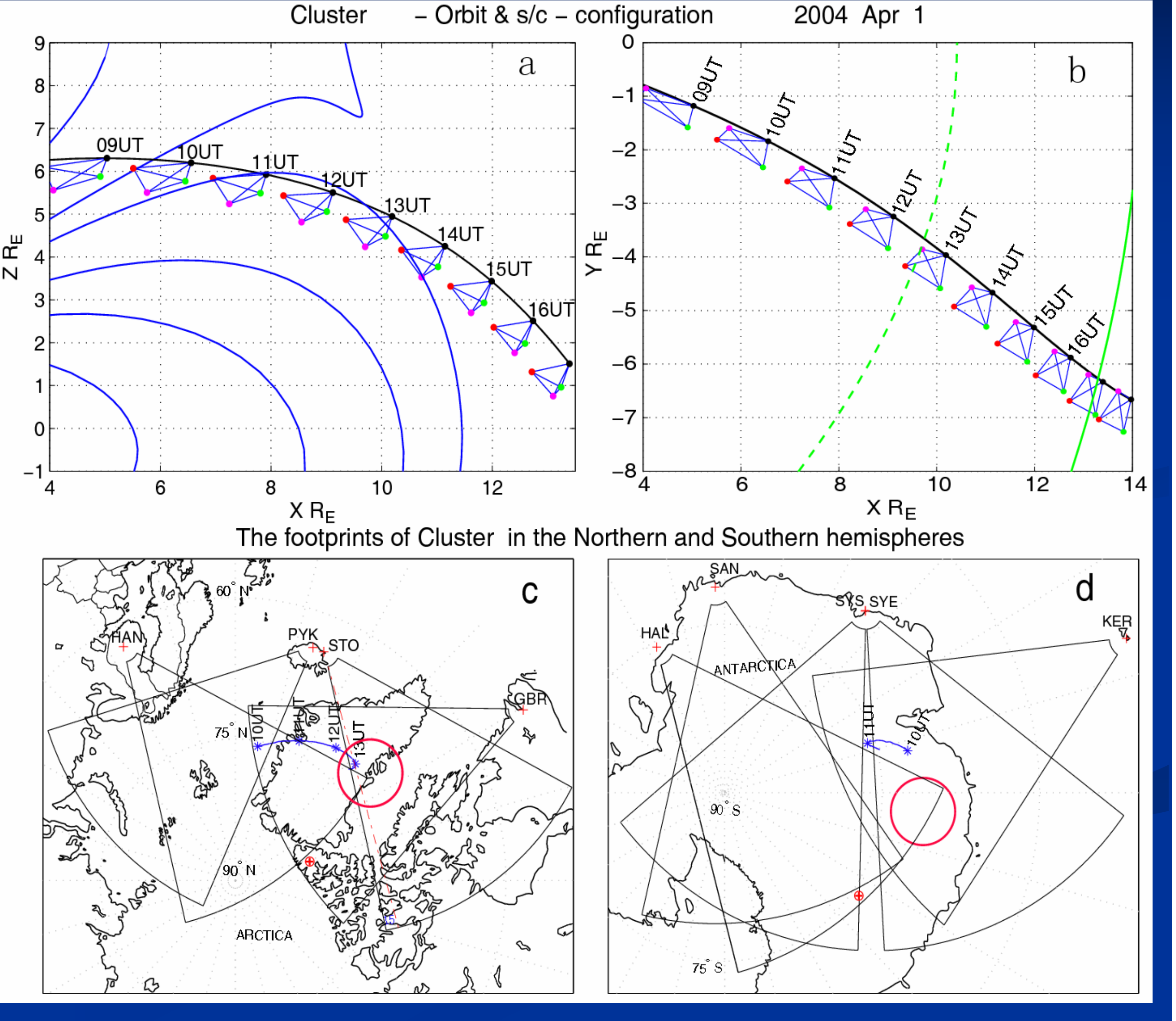


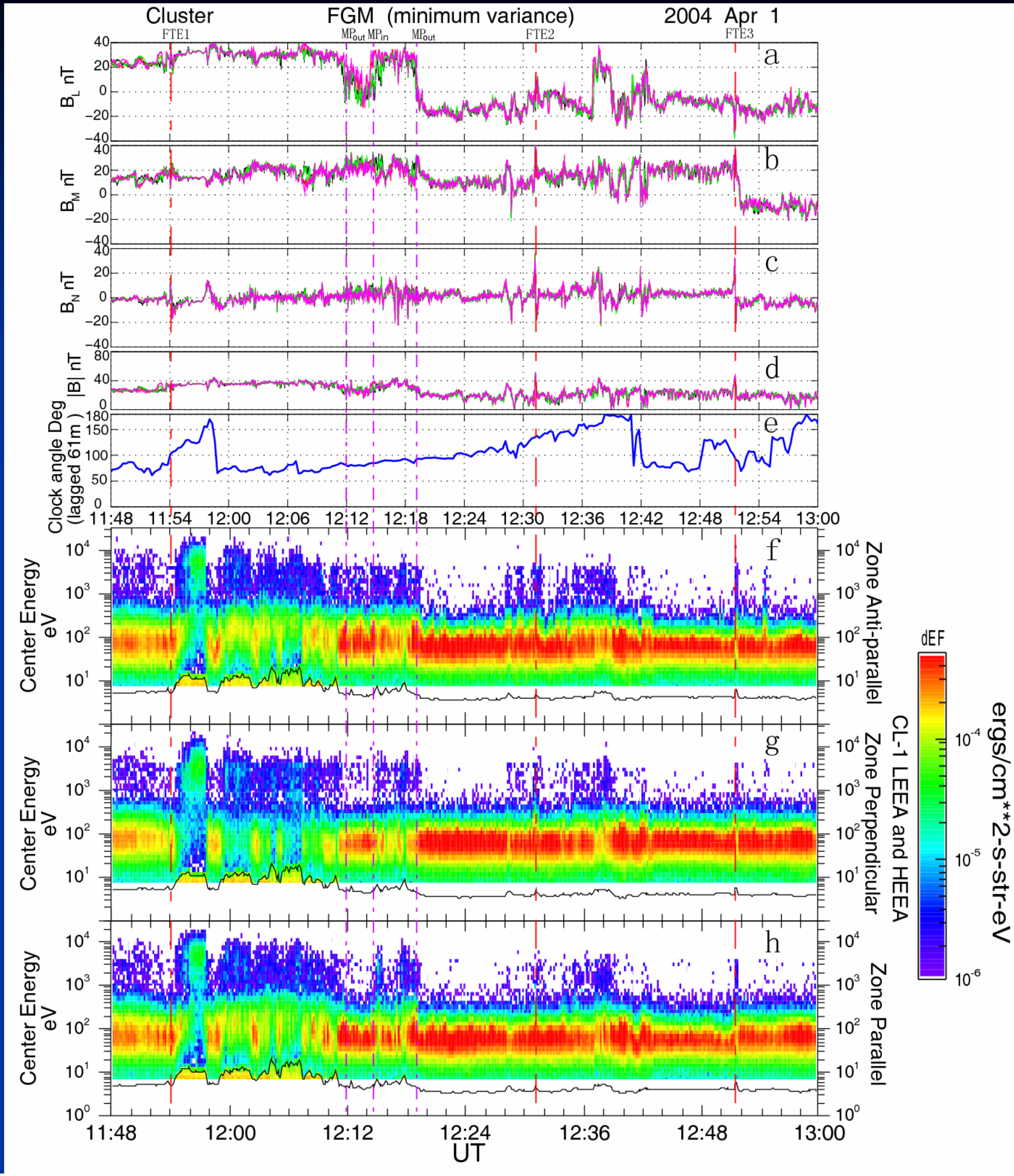
Coordinated Cluster/Double star and SuperDARN observations can reveal the evolution of the FTEs

Events studies: FTEs on 1 April 2004 (Zhang et al., Ann. Geo. In press, 2008)

Cluster cross through the cusp into the high-latitude, dayside plasma sheet, eventually crossing the magnetopause.

Supported by the conjugate SuperDARN observations





Cluster observations

In magnetic field data:

A series of bipolar signatures in B_N with increasing |B|

In PEACE electron data:

Mixing of magnetosheath and magnetospheric plasma populations with each FTEs

Three Typical FTEs:

11:54UT, 12:31UT, 12:51UT

Motion analysis

FTEs	UT	V_{FTE} (km/s)	N	Last time (s)	Size (R_E)
1	11:54:10	102	-0.64, -0.63, 0.43	38	0.61
2	12:31:16	179	-0.50, -0.21, 0.83	33	0.92
3	12:51:41	218	-0.20, -0.05, 0.98	26	0.88

With simultaneous observations of four-point magnetic field in space by Cluster, and applying four-spacecraft techniques.

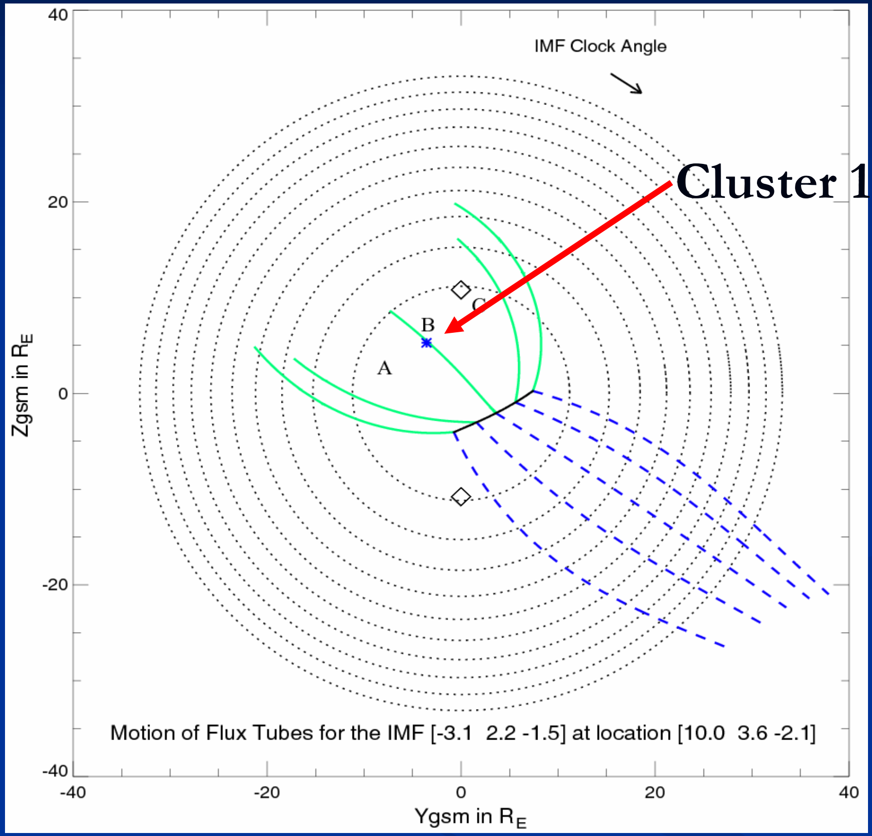
Motion analysis

Cooling Model comparison :

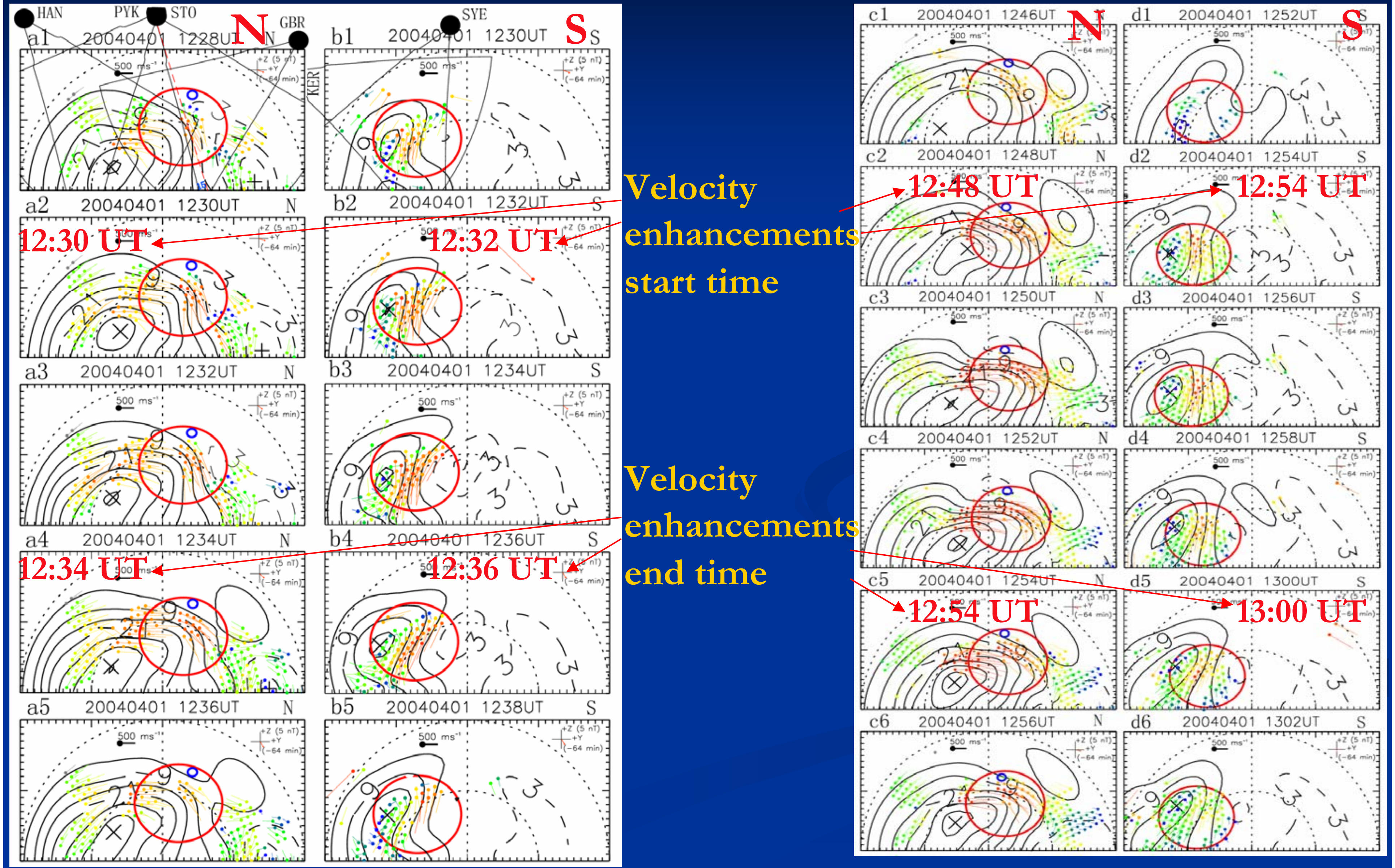
a) At region A FTE tube mainly moves dawnward; at B it moves north-westward, and at C, it mainly moves northward.

b) The expected motion at the locations A, B, or C are consistent with the flux tubes observed at 11:54, 12:31, and 12:51 UT respectively.

c) the expected motions of the southern branches are all south-eastward in the model.

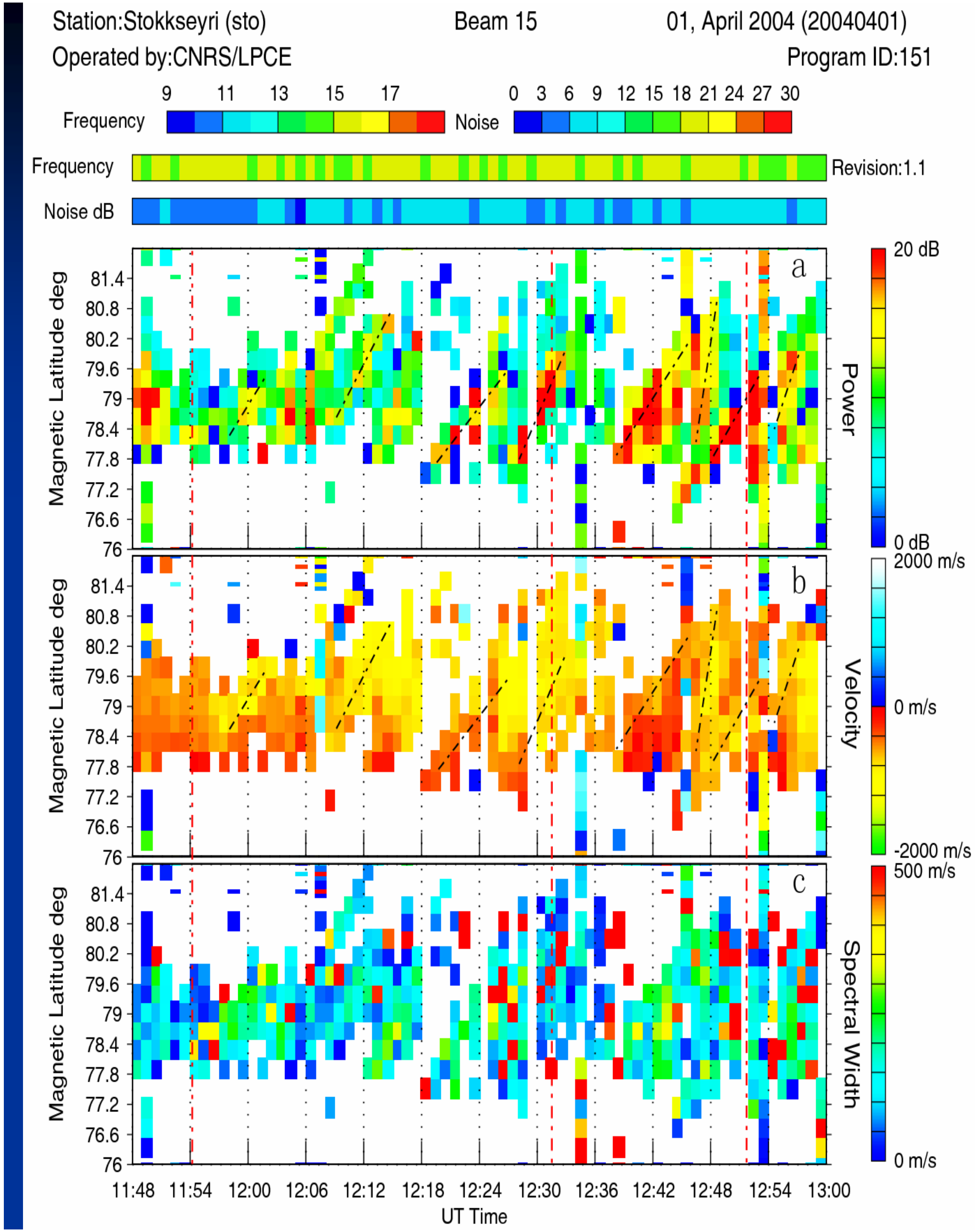


Conjugate SuperDARN observations



Comparison of the SuperDARN observations in both hemispheres and the Cooling expected motion

- The directions of flows enhancements in convection maps from SuperDARN observations are consistent with the motions of the FTEs observed by Cluster and the Cooling expected motions.
- The time durations of the velocity enhancements in the northern hemisphere infer that the evolution time of FTEs is about 4 - 6 minutes from its origin on magnetopause to its addition to the polar cap.
- However, the ionospheric response time in the southern hemisphere might be 2 minutes longer than the response time in the northern hemisphere, for the 12:31 UT FTE, and 6 minutes longer, for the 12:51 UT FTE.



a). backscatter power ： "poleward-moving radar auroral forms" (PMRAFs)

b). l-o-s Doppler velocity ：the ionospheric flows are almost all in anti-sunward with clear "pulsed ionospheric flows " (PIFs)

c). Large spectral width

Summary

- Two large, typical FTEs are simultaneous observed by Cluster at the high-latitude magnetopause and by SuperDARN.
- FTE motions observed by Cluster are consistent with the expected motion of reconnected magnetic flux tubes over the surface of the magnetopause, arising from a predominantly low-latitude reconnection during the prevailing IMF and solar wind conditions.
- Flux tube motions are consistent with the velocity enhancements and flow directions in the ionospheric convections in the northern hemisphere.
- Sub-solar reconnection also results in south-east directed ionospheric flows in the southern hemisphere.
- However, the ionospheric response time in the southern hemisphere is 2 minutes longer than the response time in the northern hemisphere, for the 12:31 UT FTE, and 6 minutes longer, for the 12:51 UT FTE. This suggests the reconnection site is located northward of the subsolar region.


Thanks for your attention！
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