SI-associated transient ionospheric flow observed by SuperDARN

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Introduction:
Sudden impulse (SI+, SI-)

Ground B. observation of SI+

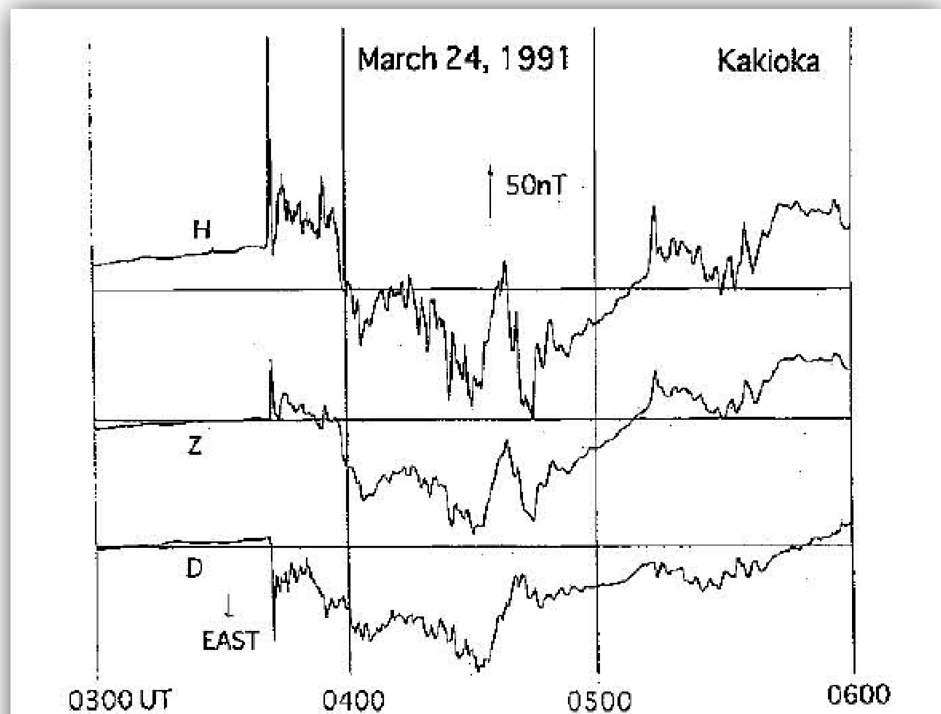
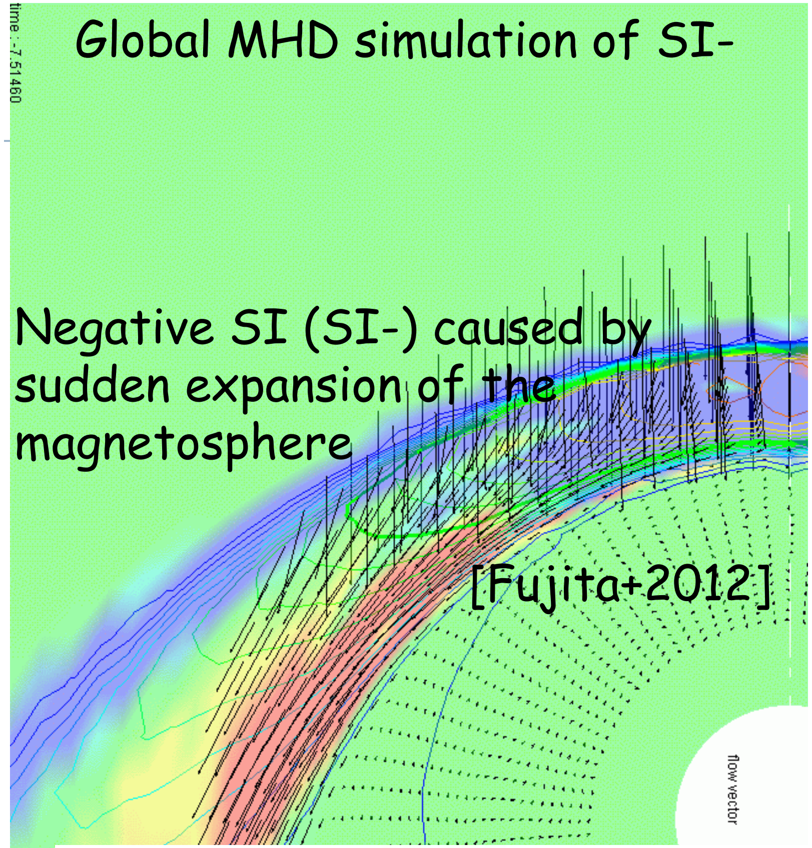


Figure 2a. Sudden commencement (SC) observed at Kakioka (geomagnetic latitude = 26.6°N), Japan on March 24, 1991.

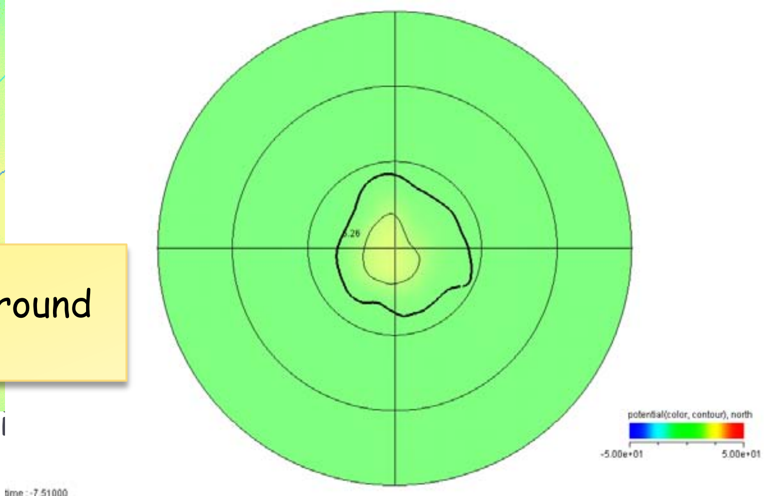
[Araki+1997]

Global MHD simulation of SI-



Negative SI (SI-) caused by sudden expansion of the magnetosphere

[Fujita+2012]



- Rapid compression/expansion of the magnetosphere
  → sudden rise/drop of the horizontal geomagnetic field on ground

Introduction: Ionospheric current vortices from geomagnetic field observation

$$dB_{ground} = D_L + D_P + D_{MS}$$

[Araki1994, modified]

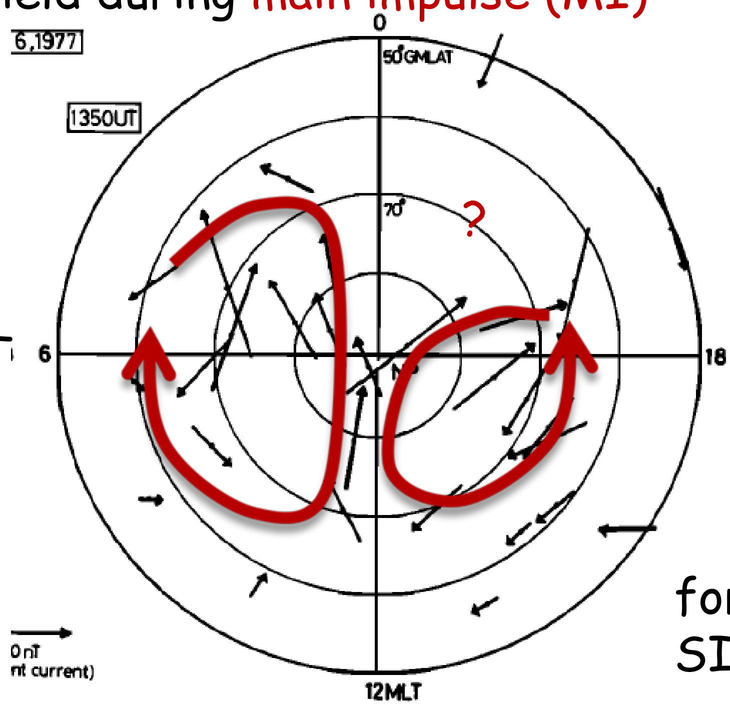
DL: due to magnetopause current,

<u>D_P: due to ionospheric current</u>

D_{MS}: due to magnetospheric currents

$$D_p \propto \Sigma_H (B \times E)$$

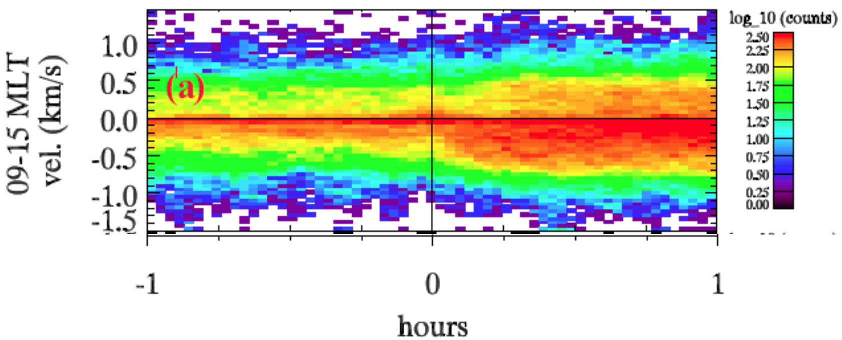
DP field during main impulse (MI)



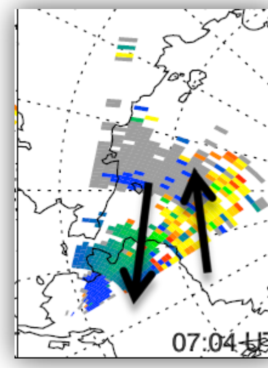
[Araki and Nagano, 1989]

for a negative SI event

Introduction:
SI-induced vortex seen by SuperDARN



Flow enhancement after positive SIs
[Gilles+2012]



Dusk sector flow during MI of a negative SI
[Hori+2012]

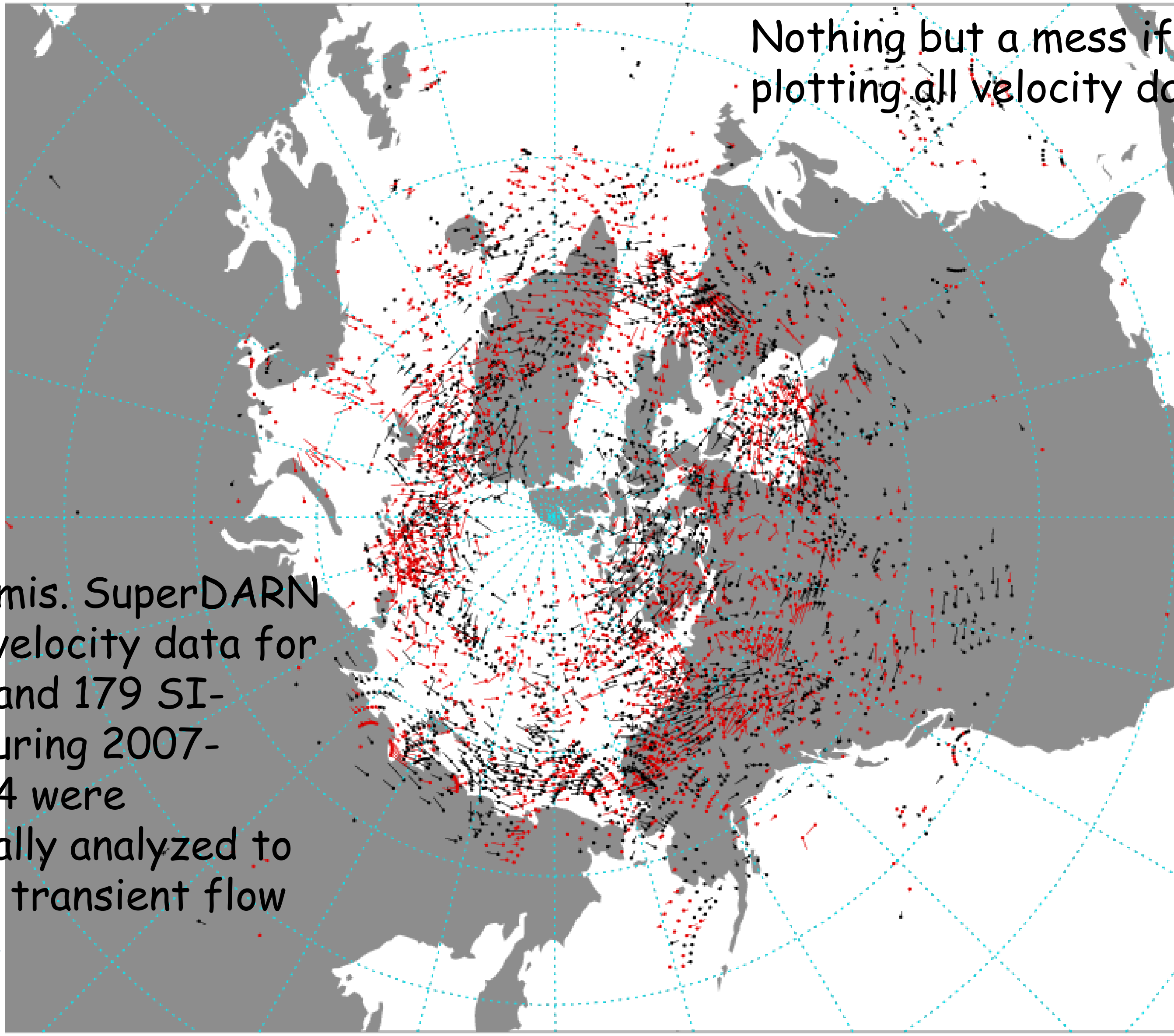
[e.g., Lyatsky+1999; Thorolfsson+2001; Vontrat-Rbeberac+2002; Coco+2008; Huang+2008; Kane+2010; Liu+2011; Gillies+2012; Hori+2012; Liu+2013]

<u>Previous works by SD</u>

- Covered only limited portions of vortices on dayside or dusk.
- Examined the vortex polarity on the basis of event study.
- Gross average of flows around SIs.

- <u>No study so far on the global structure of transient flow associated with SI wave forms.</u>

All LOS-V data during positive SIs

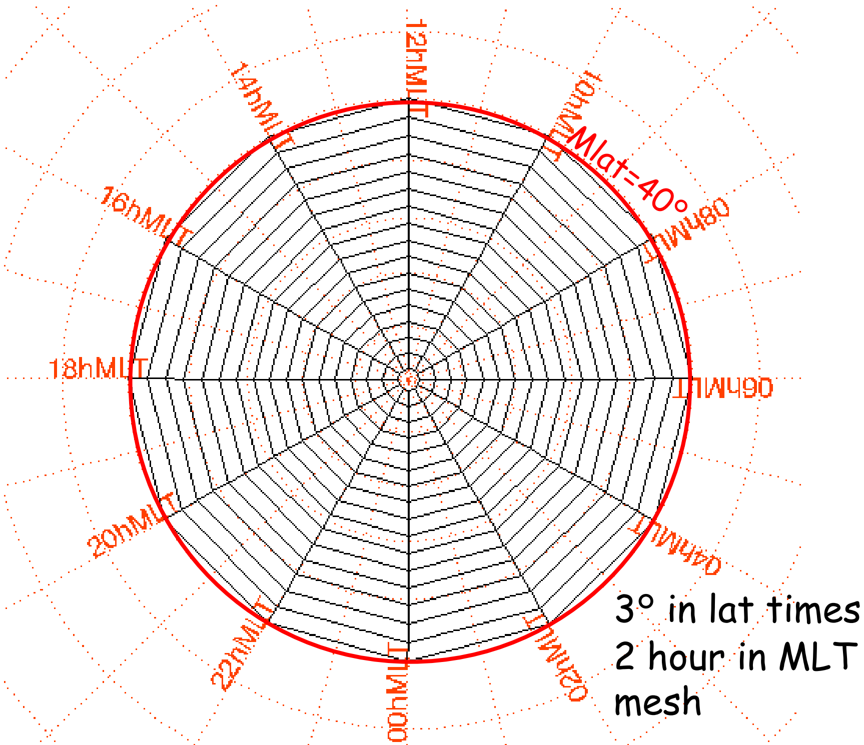


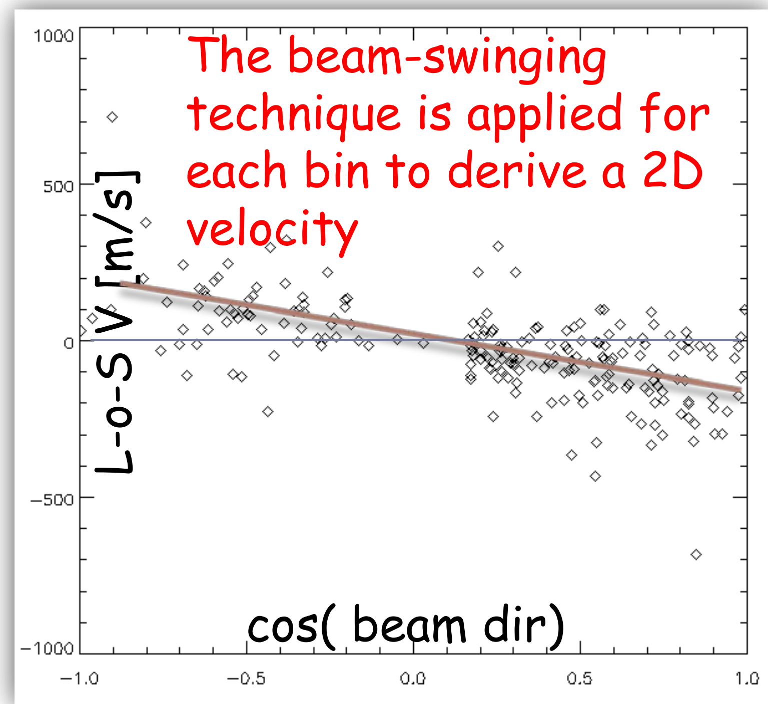
Nothing but a mess if just plotting all velocity data …

All N. hemis. SuperDARN Doppler velocity data for 192 SI+ and 179 SI- events during 2007-early2014 were statistically analyzed to deduce a transient flow pattern.

2-D velocity statistically derived by the beam-swinging technique

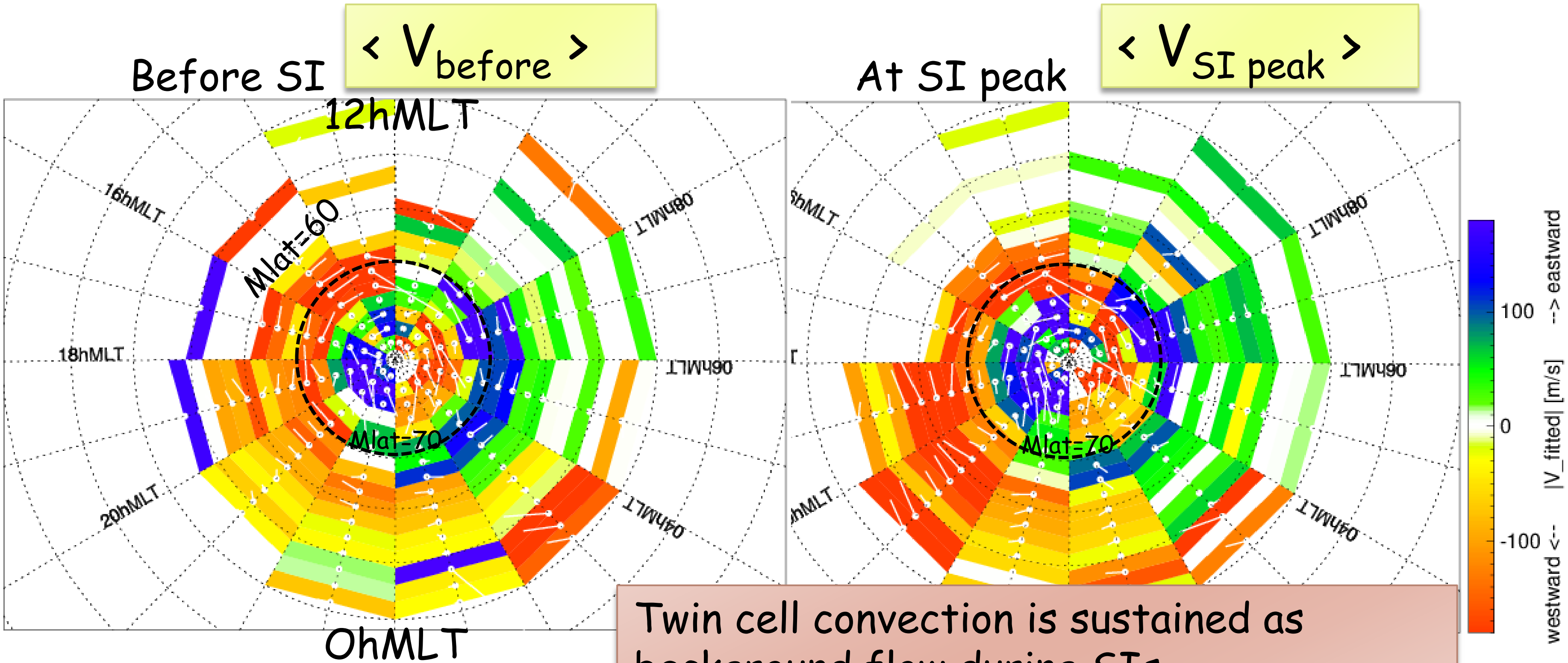
[e.g., Makarevich+2007]





- Line-of-sight Doppler velocities obtained in each lat-lon pixel are fitted to give a 2-D velocity vector.

fitted flow map for all SI+ events

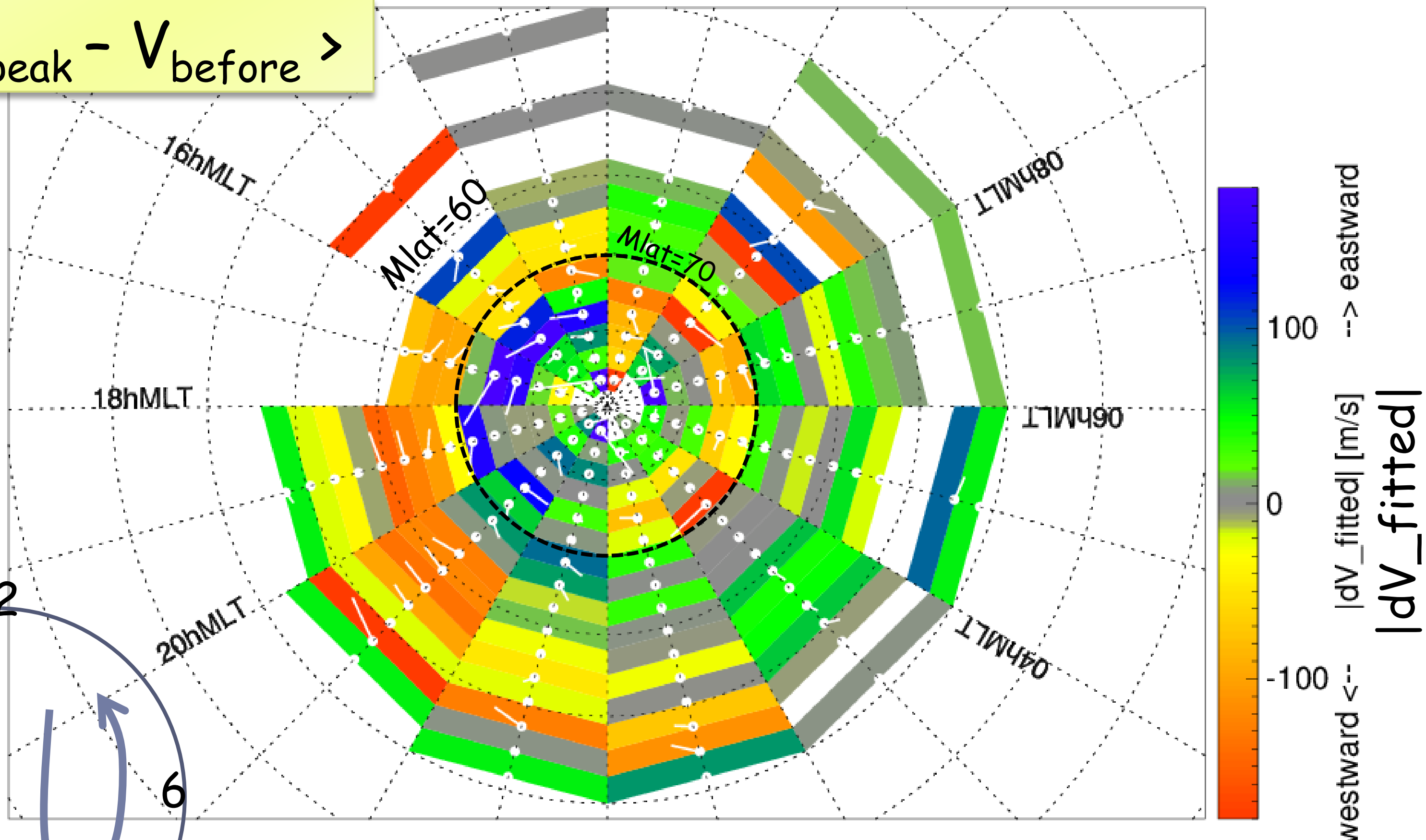


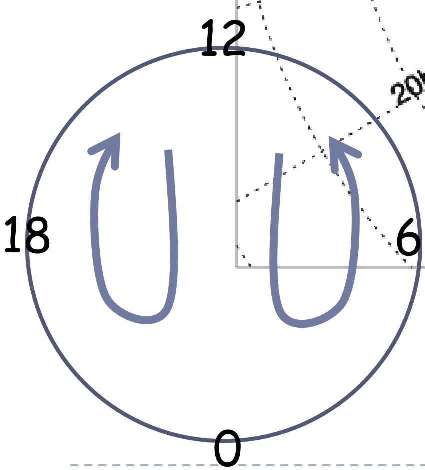
Twin cell convection is sustained as background flow during SIs.

White pins show each fitted 2D velocity vectors for each pixel. Pixel colors denote flow speeds with polarity of local time flow component.

Difference of flow vector between "before" and "at SI peak" (all SI+ events)

$< V_{SI\ peak} - V_{before} >$





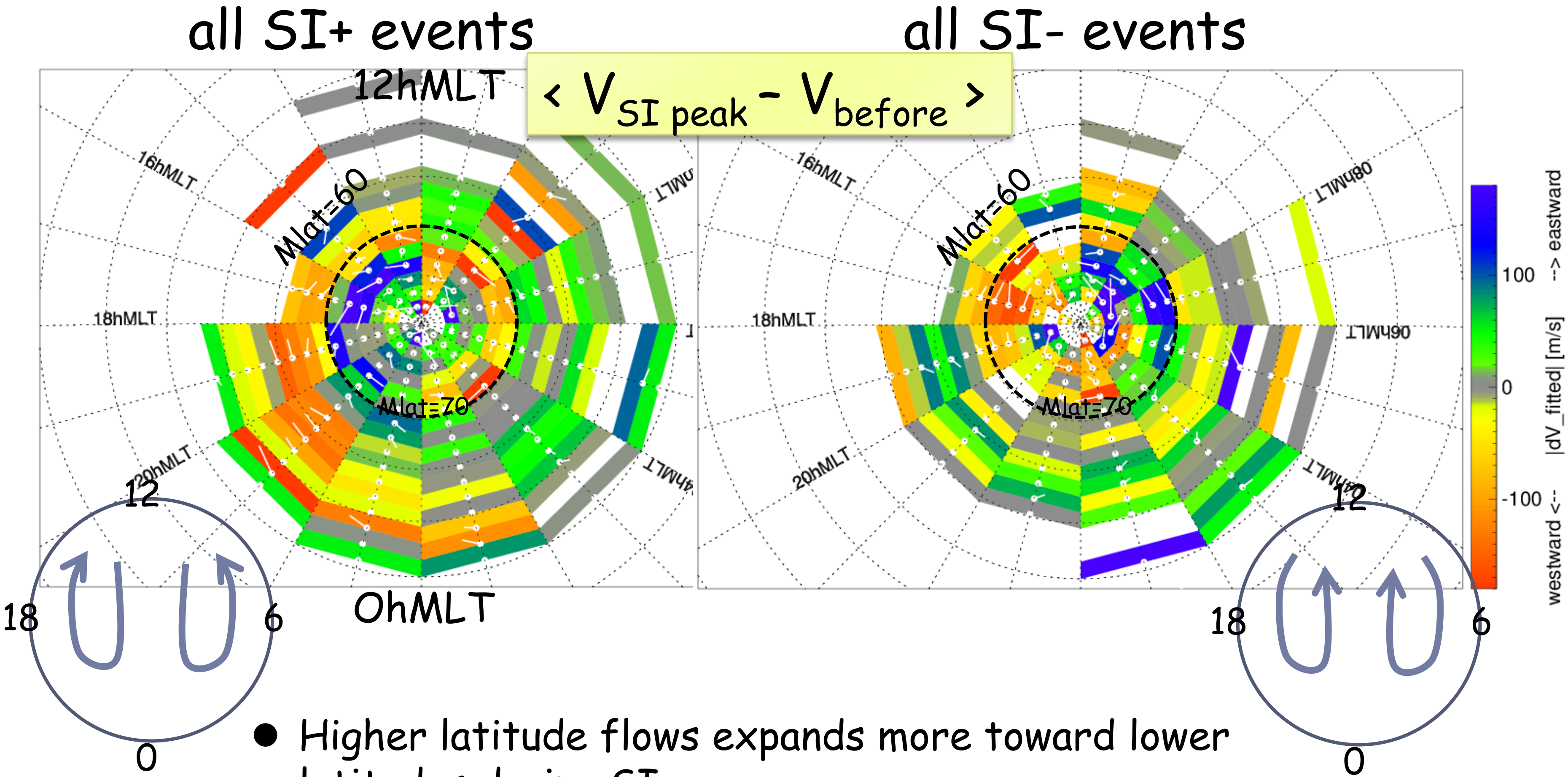
White pixel: no or too few data

Findings so far based on SI statistics

- Polarity of flow vortices is basically consistent with the MI model [Araki1994, Araki&Nagano1988].

- Slower evolution of flow vortices for SI- than SI+.
- MI vortices emerge always at lower latitudes than PI ones.
- The higher latitude flows of vortices expand toward lower latitudes for SI- than SI+.
- IMF-By-induced flow asymmetry between SI+ and SI- [SGEPSS2014].
- Dependence of flow vortex magnitude on $\Delta P_{solarwind}$
-

dV_{fitted} map for SI+ and SI- peak

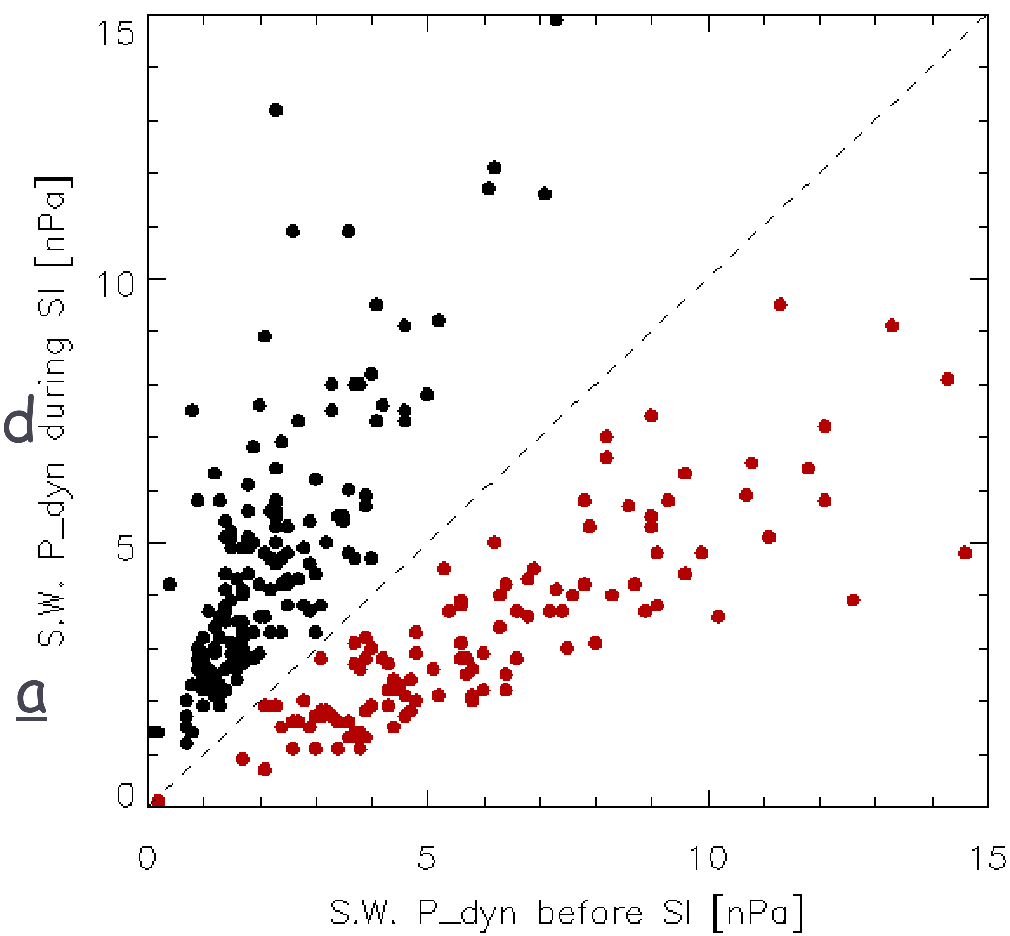


- Higher latitude flows expands more toward lower latitudes during SI-.

Dawn-dusk asymmetry and SI+—SI- asymmetry

- Transient flows expands more toward lower latitudes during SI-.

- Answer so far:
  - The magnetosphere is always more compressed than usual (supported by the solar wind data)
  - "Compressed magnetosphere" stores <u>a free energy to expand outward</u>.

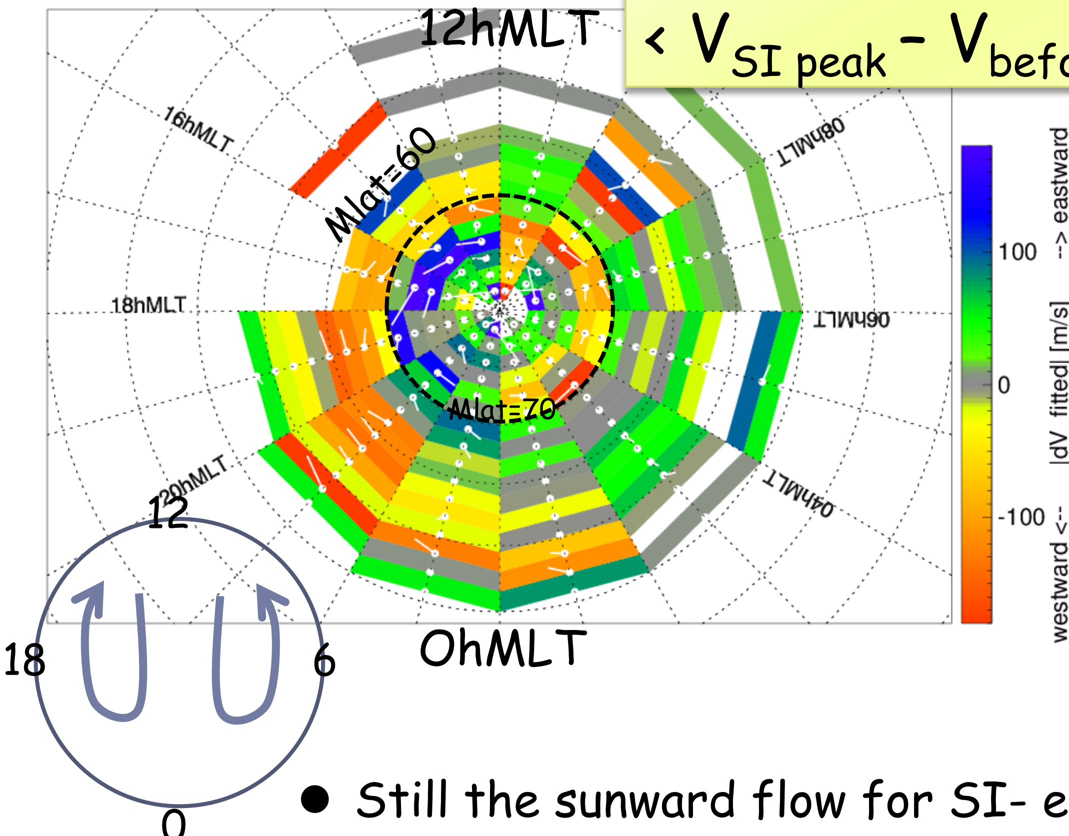


dV_{fitted} map for SI+ and SI- peak

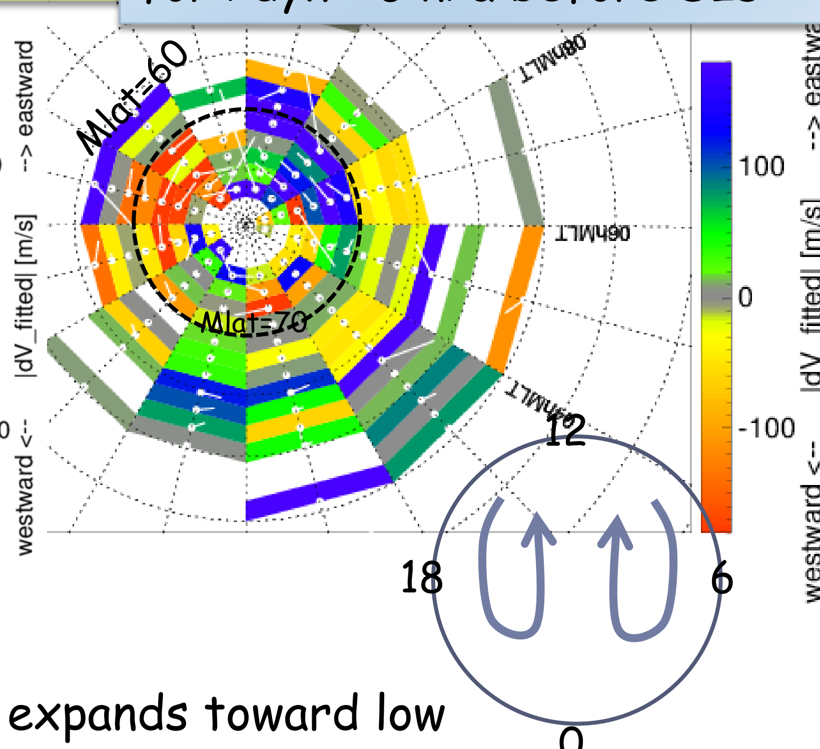
$< V_{SI\ peak} - V_{before} >$

Data samples are limited only for Pdyn < 6 nPa before SIs

all SI+ events



all SI- events



- Still the sunward flow for SI- expands toward low latitudes … There should be other reason(s) for this asymmetry between SI+ and SI-.

Summary and conclusion

SI-induced transient ionospheric flows observed by SuperDARN were statistically analyzed.

- The polarity of flow vortices is basically consistent with that inferred from geomagnetic observations [Araki, 1994].
- However, SI+ and SI- is not a mirror image of each other somehow in terms of convection/convection E.