

SI-induced transient convective oscillation: comparison of SuperDARN observation and global MHD simulation

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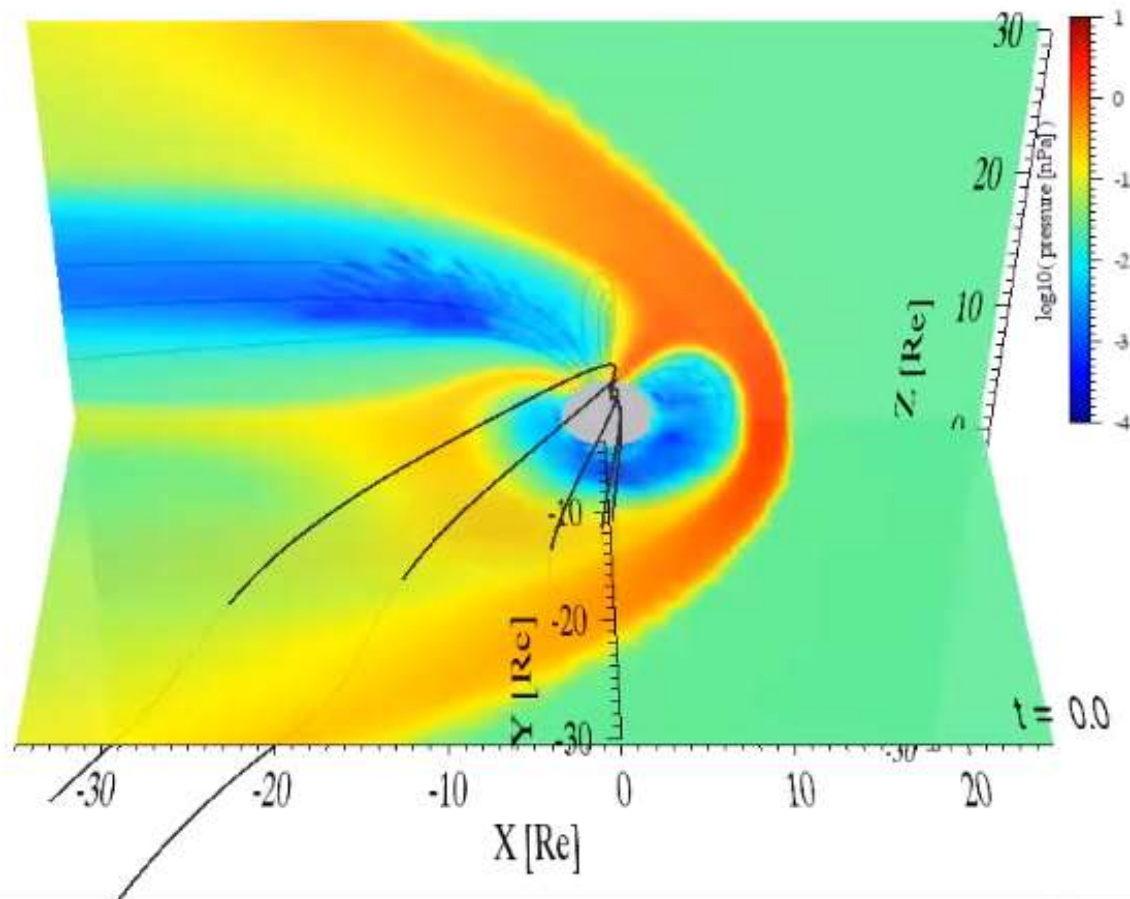
1. STEL, Nagoya Univ., 2. Meteorological College, 3. RISH, Kyoto Univ.

Today's talk

- ▶ 1. Introduction
- ▶ 2. Motivation & Objectives
- ▶ 3. Data & Method
- ▶ 4. Results
- ▶ 5. Discussion
- ▶ 6. Summary and Conclusion

1. Introduction

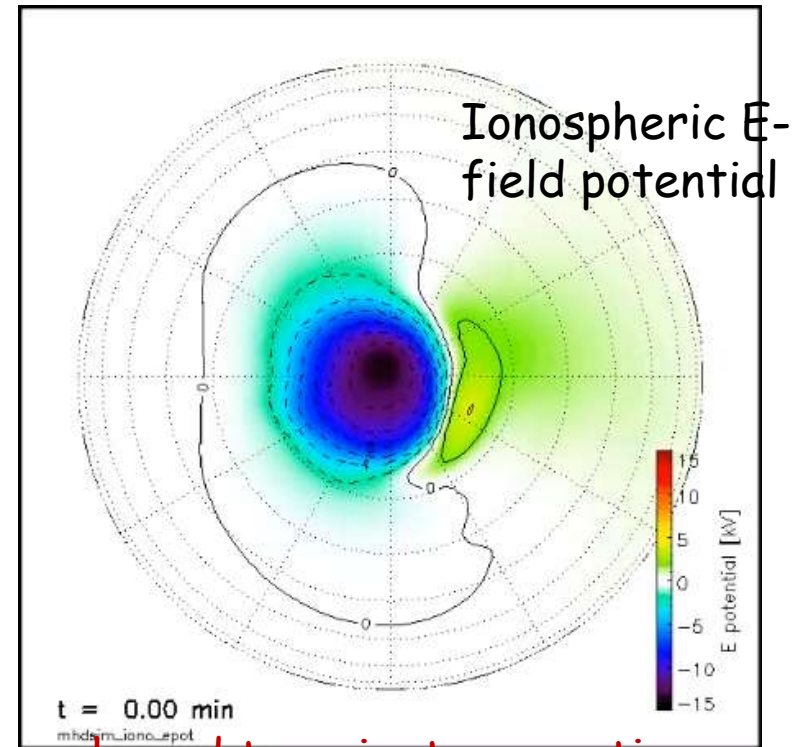
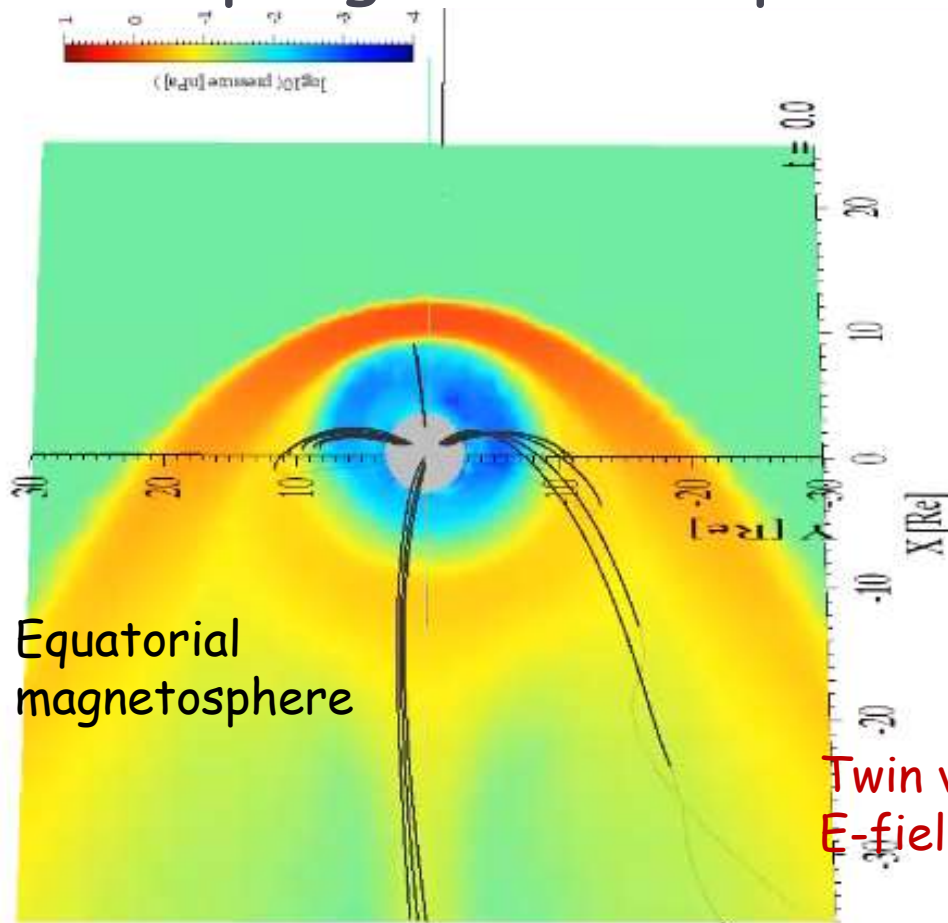
Sudden compression/expansion of magnetosphere



- ▶ Transient, but drastic changes in structure, E-M field are induced in the magnetosphere.

1. Introduction:

Coupling with dissipative, inductive ionosphere



Twin vortex-shaped transient convection
E-field oscillation in polar ionosphere

Transient field-aligned currents

[Fujita+2012]

- ▶ Structured compressional/rarefaction wave front → shear Alfvén wave

1. Introduction

SI-assoc. flow perturbation by SuperDARN

Ionospheric E-field potential

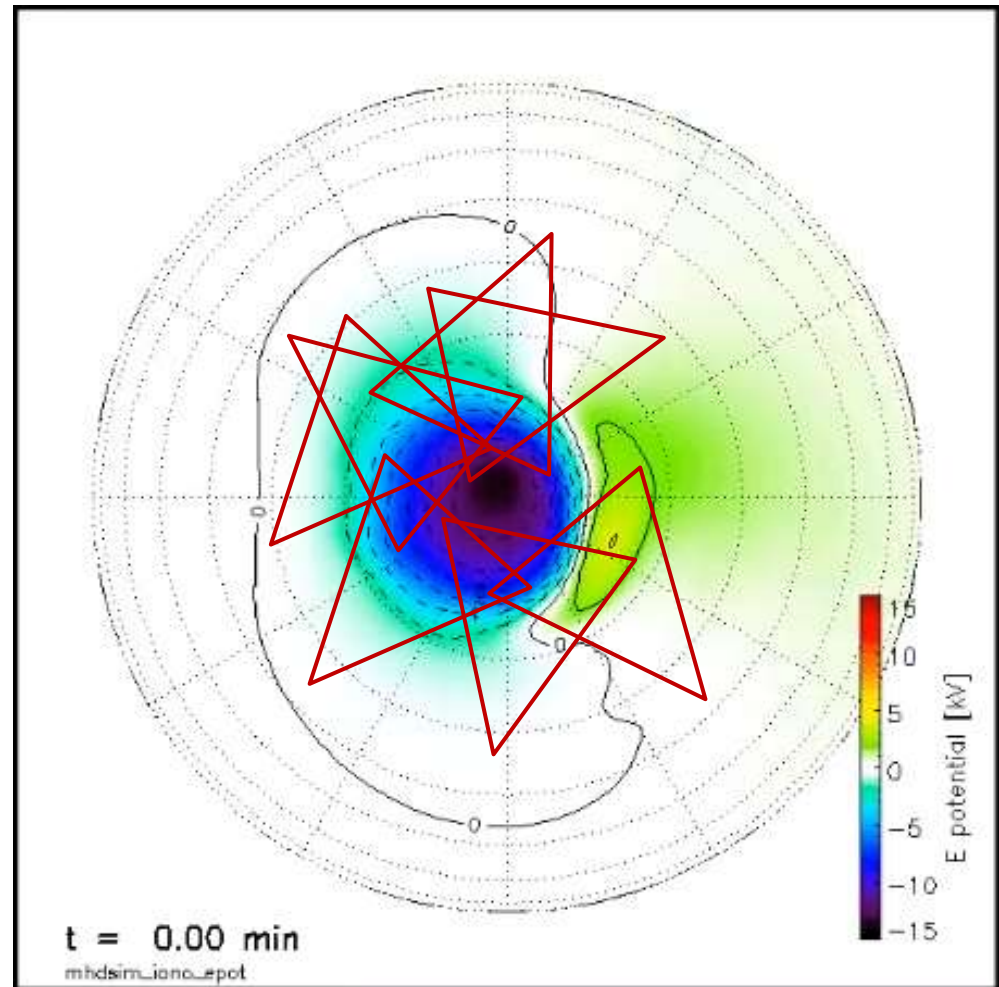


ExB drift of ionospheric electrons



SD can measure its line-of-sight velocity component as a Doppler shift

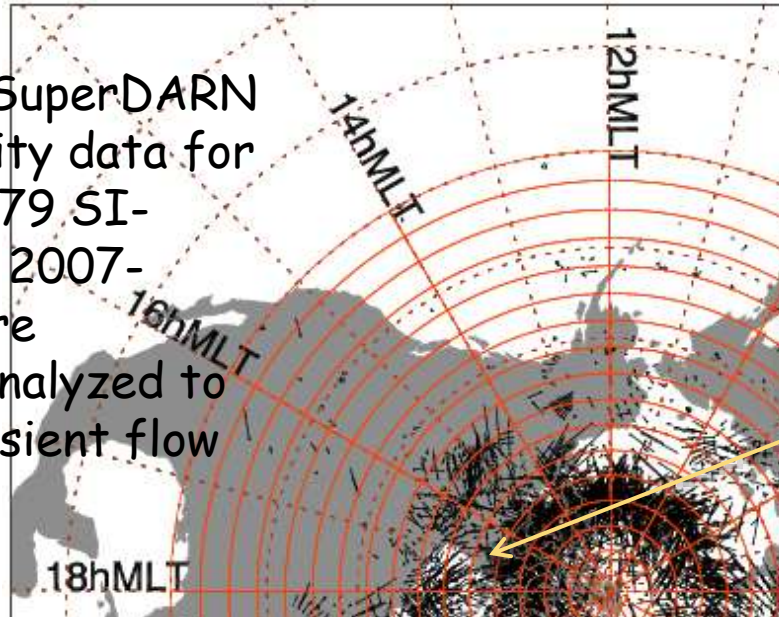
We examine **"E-field"** evolution associated with SI



1. Introduction

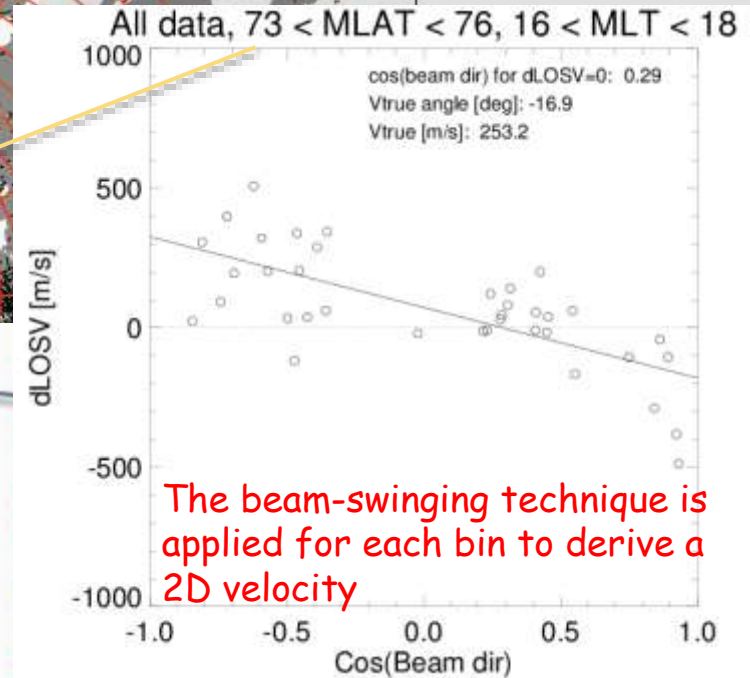
SuperDARN statistics for SI transient flow

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.

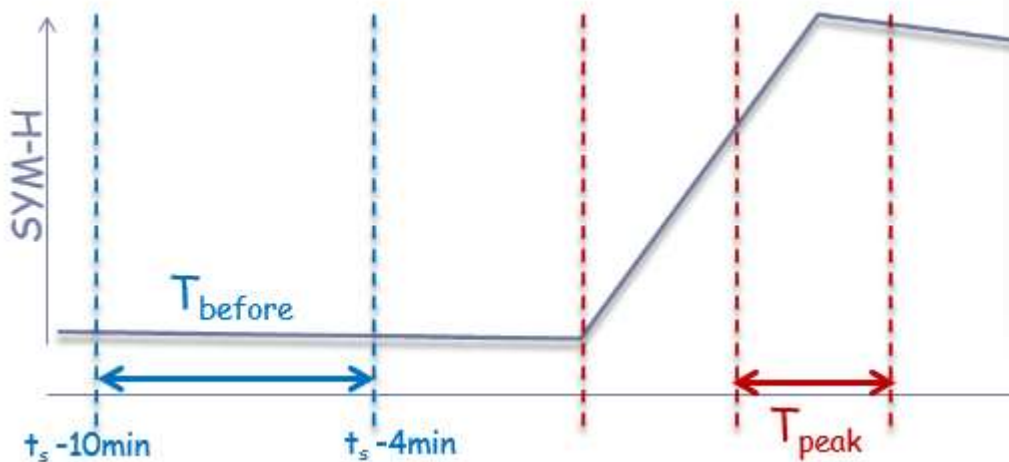


Nothing but a mess if just plotting all velocity data ...

[e.g., Makarevich+2007]



The beam-swinging technique is applied for each bin to derive a 2D velocity

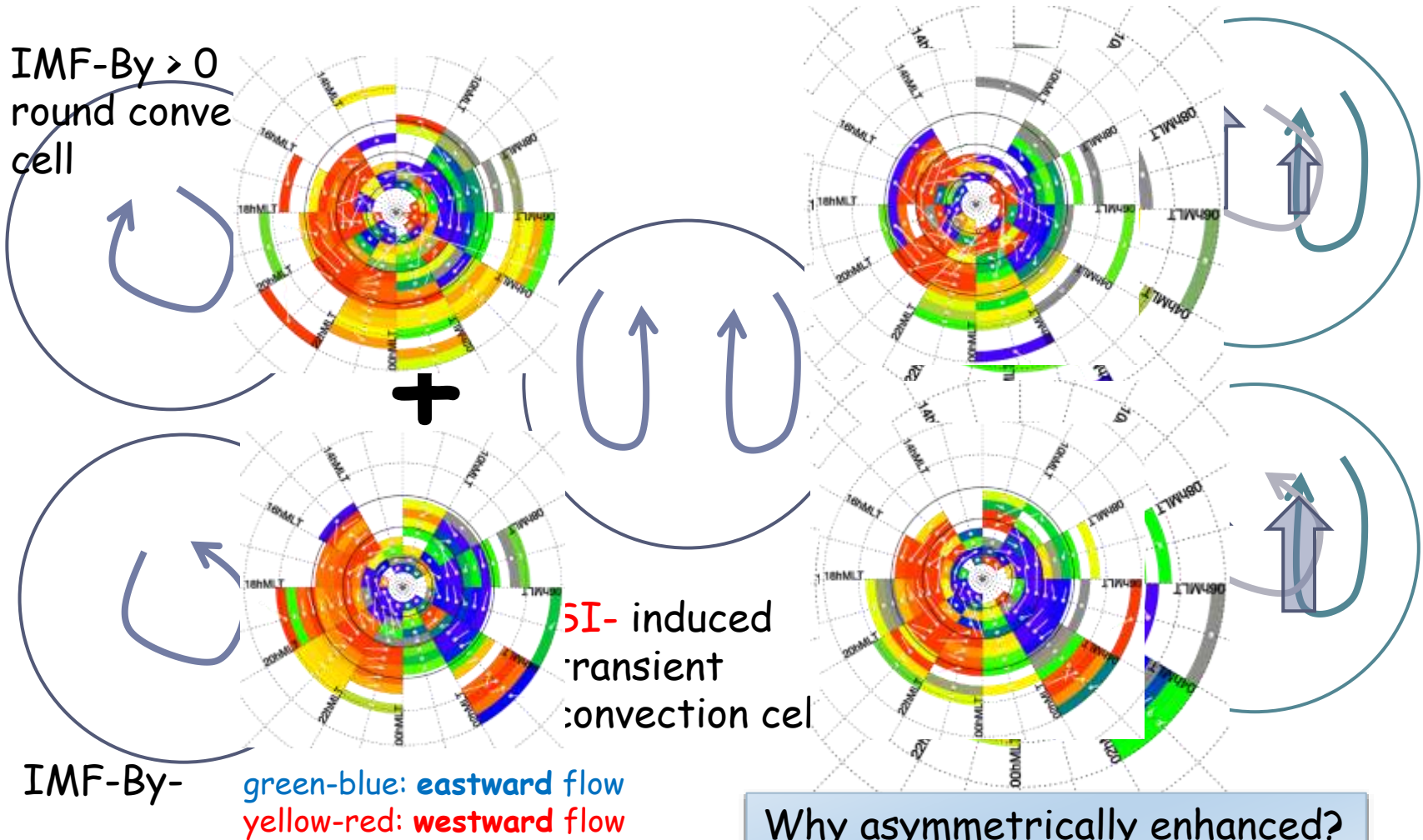


[Hori+, submitted to EPS, 2015]

9/14/2015

1. Introduction

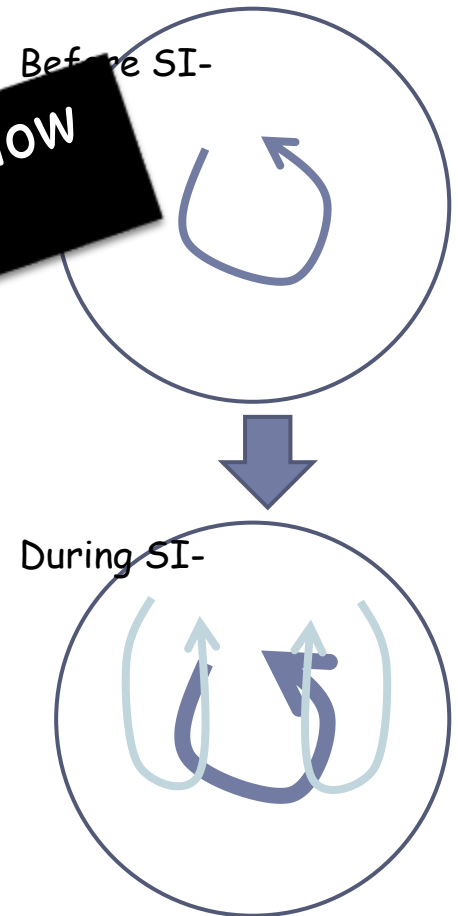
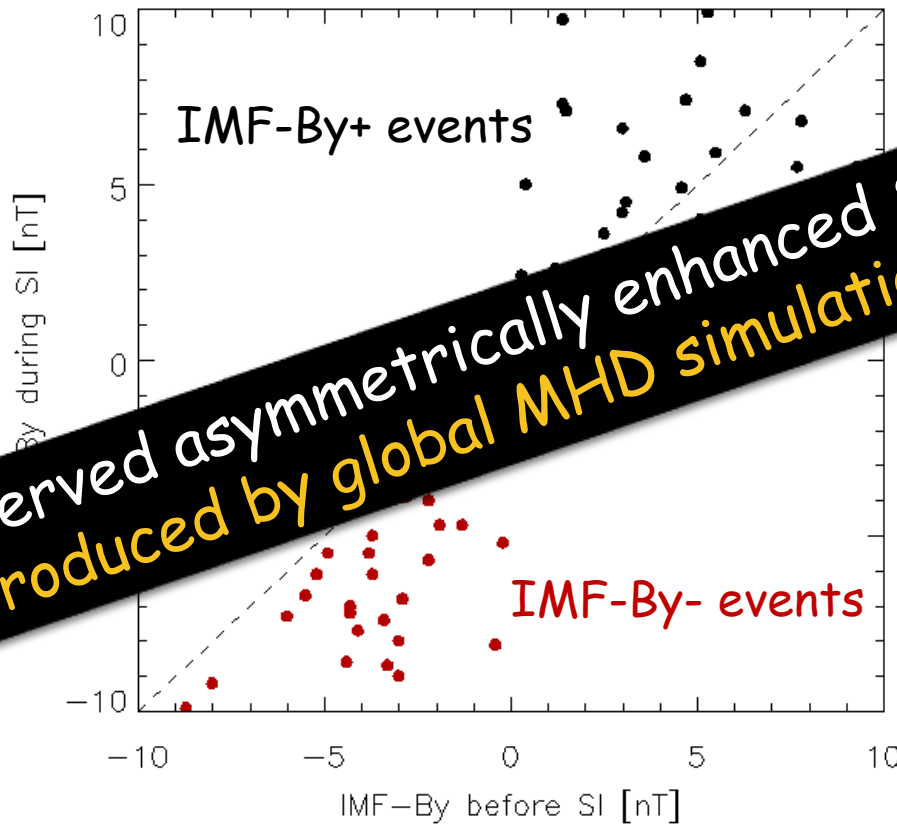
pre-existing round cell and **SI-** cells: SD obs.



[Hori+, submitted to EPS, 2015]

1. Introduction

IMF-By intensification and round cell evolution



$$\begin{aligned}
 V_{\text{pre-SI}} &= V_{\text{round cell}} \\
 V_{\text{SIpeak}} &= V_{\text{round cell}} + dV_{\text{round cell}} + V_{\text{SI cell}} \\
 \rightarrow V_{\text{SIpeak}} - V_{\text{pre-SI}} &= dV_{\text{round cell}} + V_{\text{SI cell}}
 \end{aligned}$$

[Hori+, submitted to EPS, 2015]

2. Motivation & Objectives

▶ Motivation

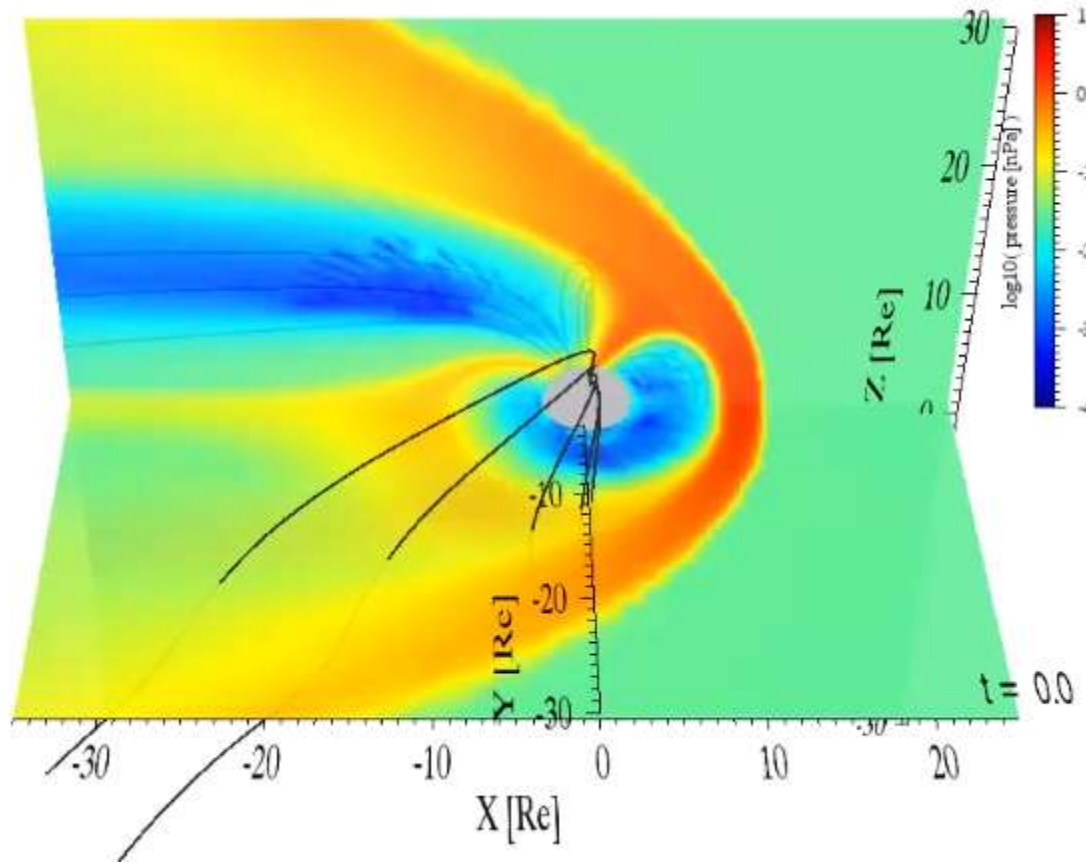
- ▶ Our hypothesis with the round cell evolution upon SI should be tested from a theoretical point of view.

▶ Objectives of the present (ongoing) work

- ▶ We perform a set of global MHD simulation runs to reproduce the responses of the M-I coupled system to sudden changes of solar wind dynamic pressure.
- ▶ The resultant profile of ionospheric potential/current and field-aligned current is compared with those observed by SD.

3. Data & Method

Global MHD simulation of M-I coupled system



Solar wind

V_{sw} : 350 km/s (fixed)

N_{sw} : 10 \rightarrow 40 \rightarrow 10 /cc (*)

IMF

IMF- B_x , B_z = 0 , +2.5 nT
(fixed)

IMF- B_y :

Run1: +4.3 nT (fixed)

Run2: +4.3 \rightarrow +2.9 \rightarrow +4.3 nT

Run3: +4.3 \rightarrow +6.5 \rightarrow +4.3 nT

Run4: +4.3 \rightarrow +8.6 \rightarrow +4.3 nT (*)

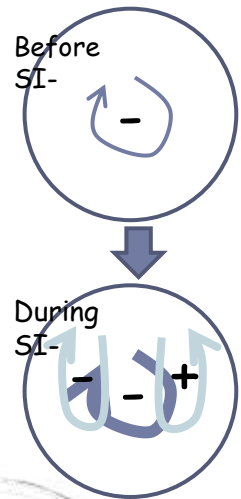
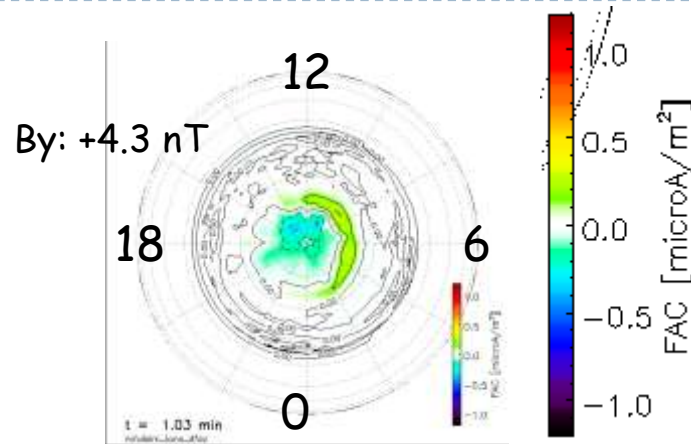
(*) Only Run4 with N_{sw} 10 \rightarrow 25 \rightarrow 10 /cc

- ▶ The same codes as those by Fujita+2012, Tanaka+2010.
- ▶ Employed a realistic inhomogeneous ionospheric conductance.

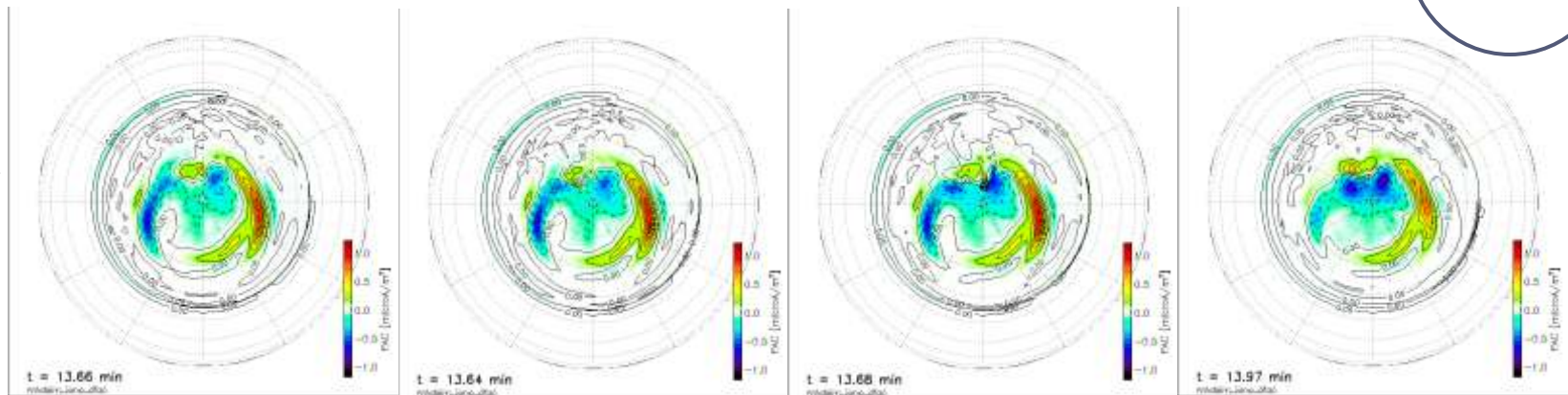
4. Results

FACs during **SI+** for different IMF-By jumps

Before
SI



At MI
peak



By: +4.3→+2.9 nT

By: +4.3 nT (fixed)

By: +4.3→+6.5 nT

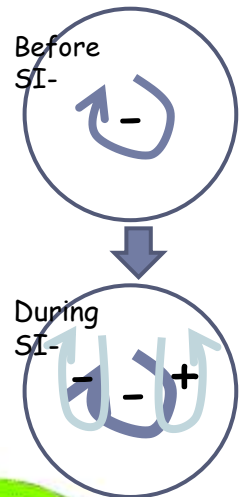
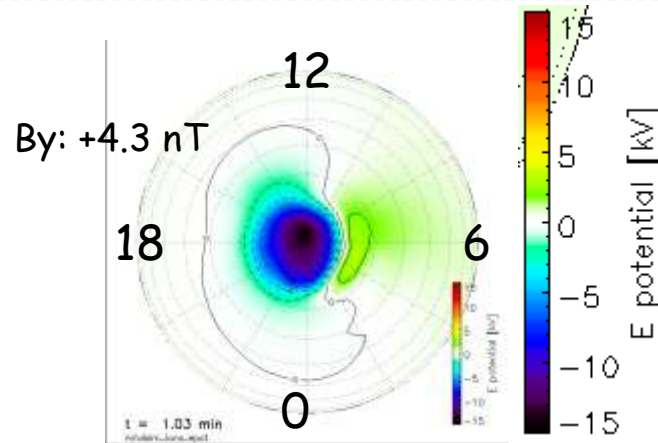
By: +4.3→+8.6 nT

- ▶ FAC for the round cell is enhanced more with larger post-SI IMF-By as expected.

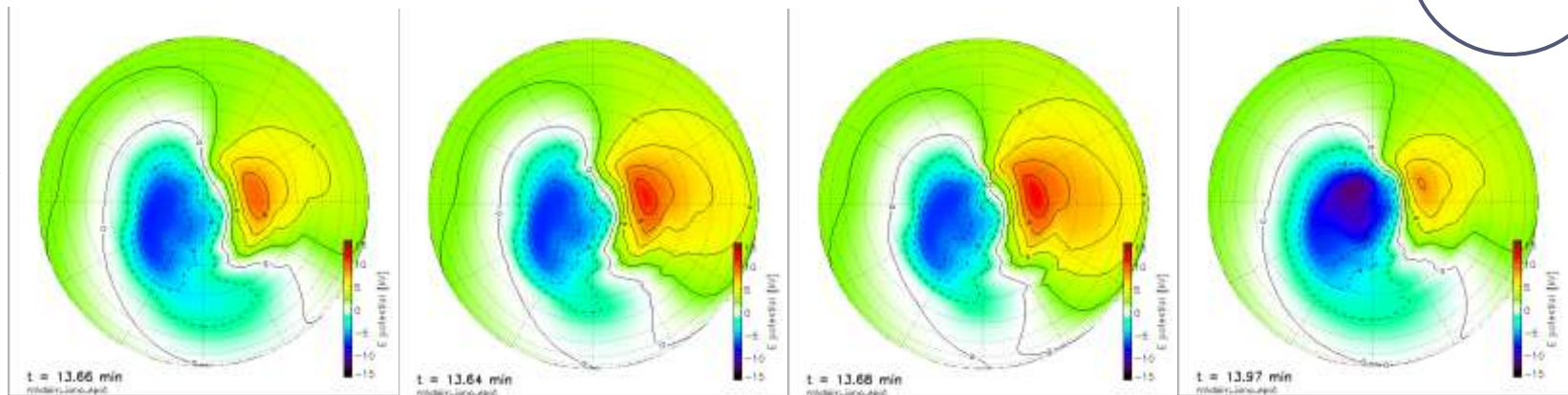
4. Results

E-potential during **SI+** for different IMF-By jumps

Before
SI



At MI
peak



By: +4.3 → +2.9 nT

By: +4.3 nT (fixed)

By: +4.3 → +6.5 nT

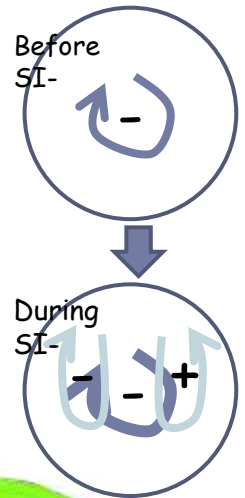
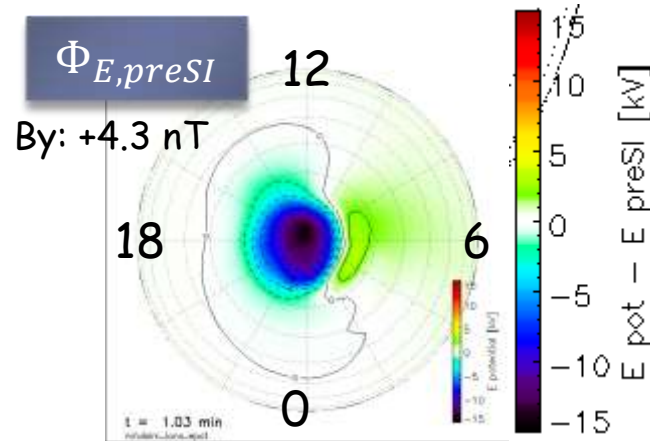
By: +4.3 → +8.6 nT

- ▶ The expected superposition of round cell and SI cells is seen for all cases.

4. Results

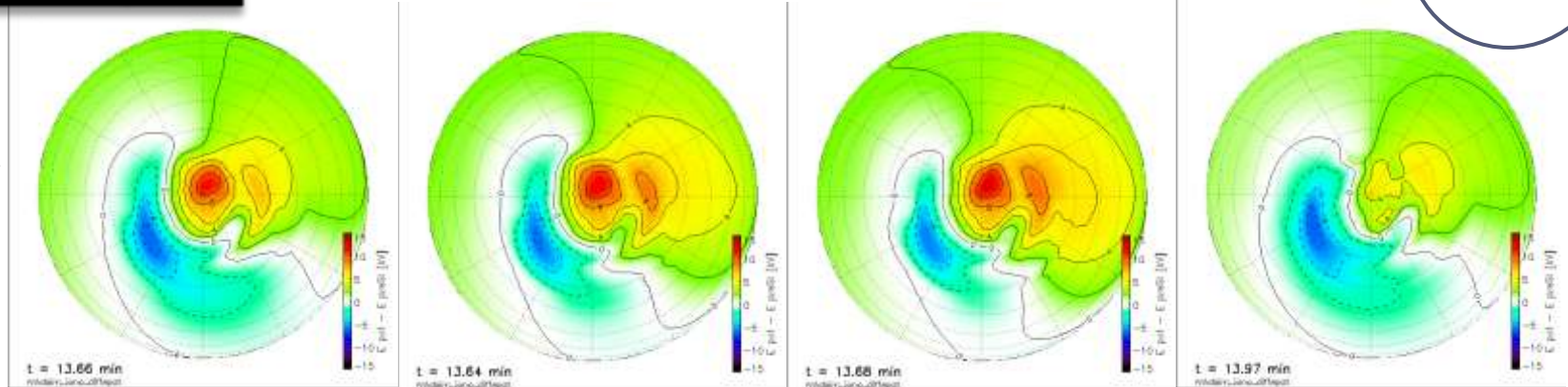
ΔE -potential during SI+ for different IMF-By jumps

Before
SI



$\Phi_{E,MI} - \Phi_{E,preSI}$

At MI
peak



By: +4.3 \rightarrow +2.9 nT

By: +4.3 nT (fixed)

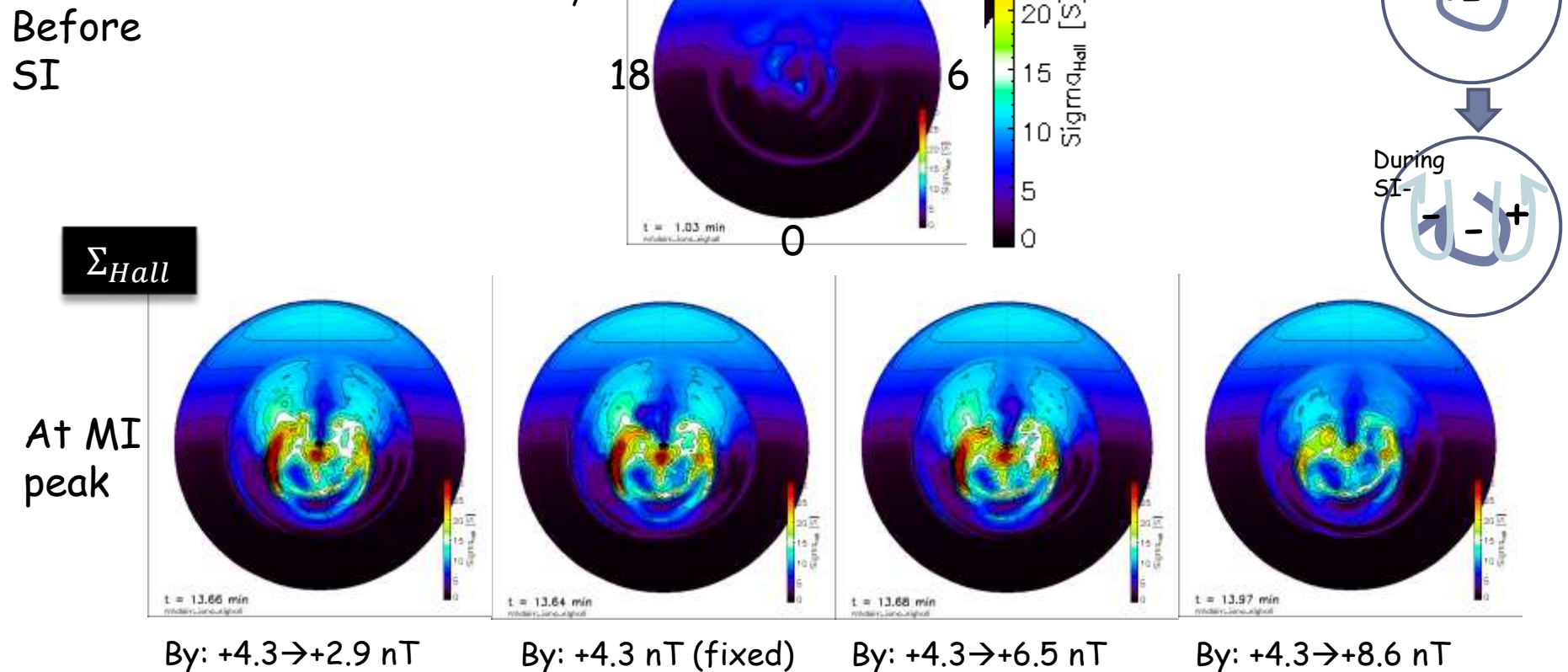
By: +4.3 \rightarrow +6.5 nT

By: +4.3 \rightarrow +8.6 nT

- ▶ The side of enhanced anti-sunward flow is opposite to the observation. Why?
- ▶ A residual positive round cell remains in polar cap \rightarrow pre-SI negative round cell diminishes?

5. Discussion

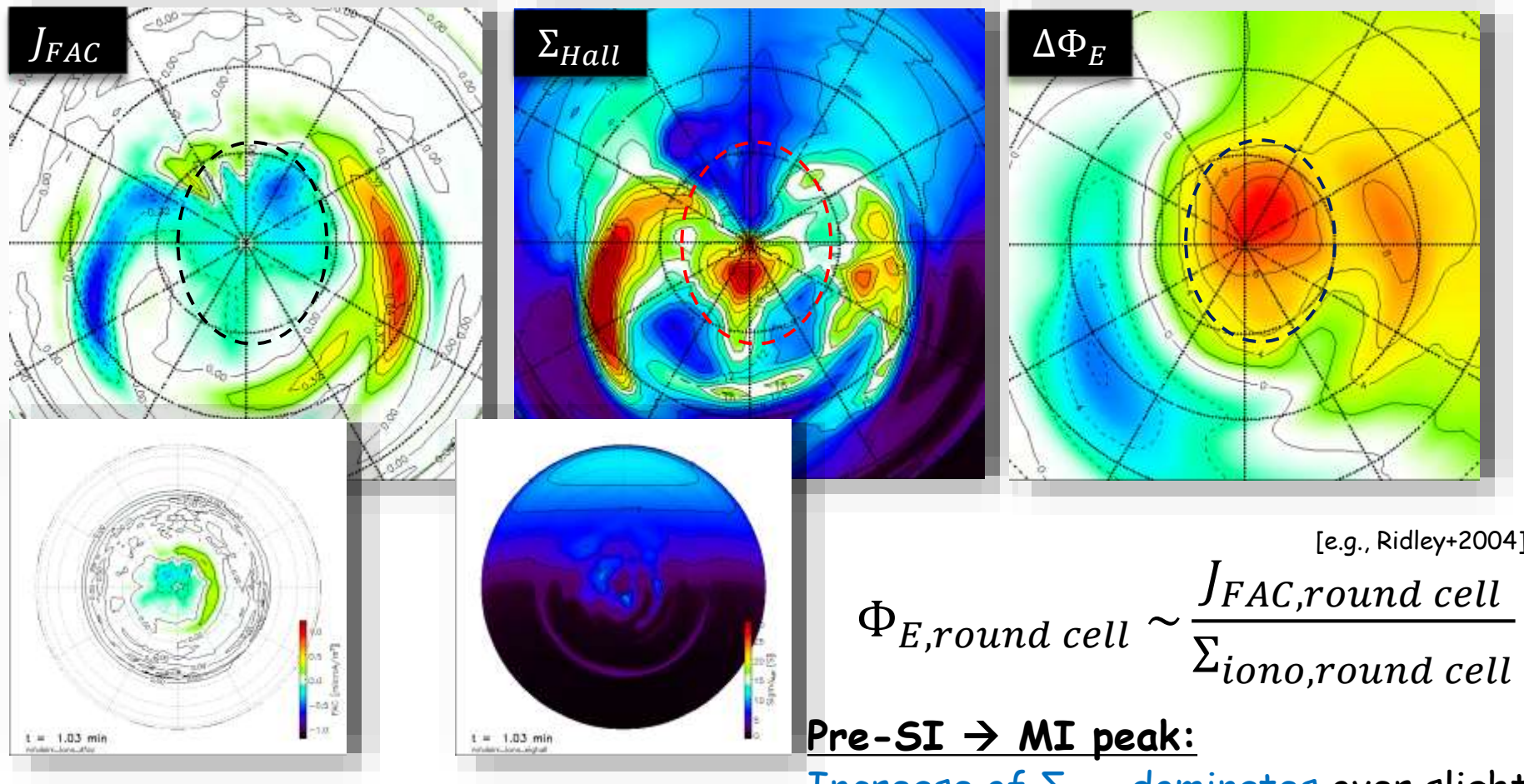
Ionospheric conductance during SI+ for different IMF-By jumps



- ▶ The expected superposition of round cell and SI cells is seen for all cases.

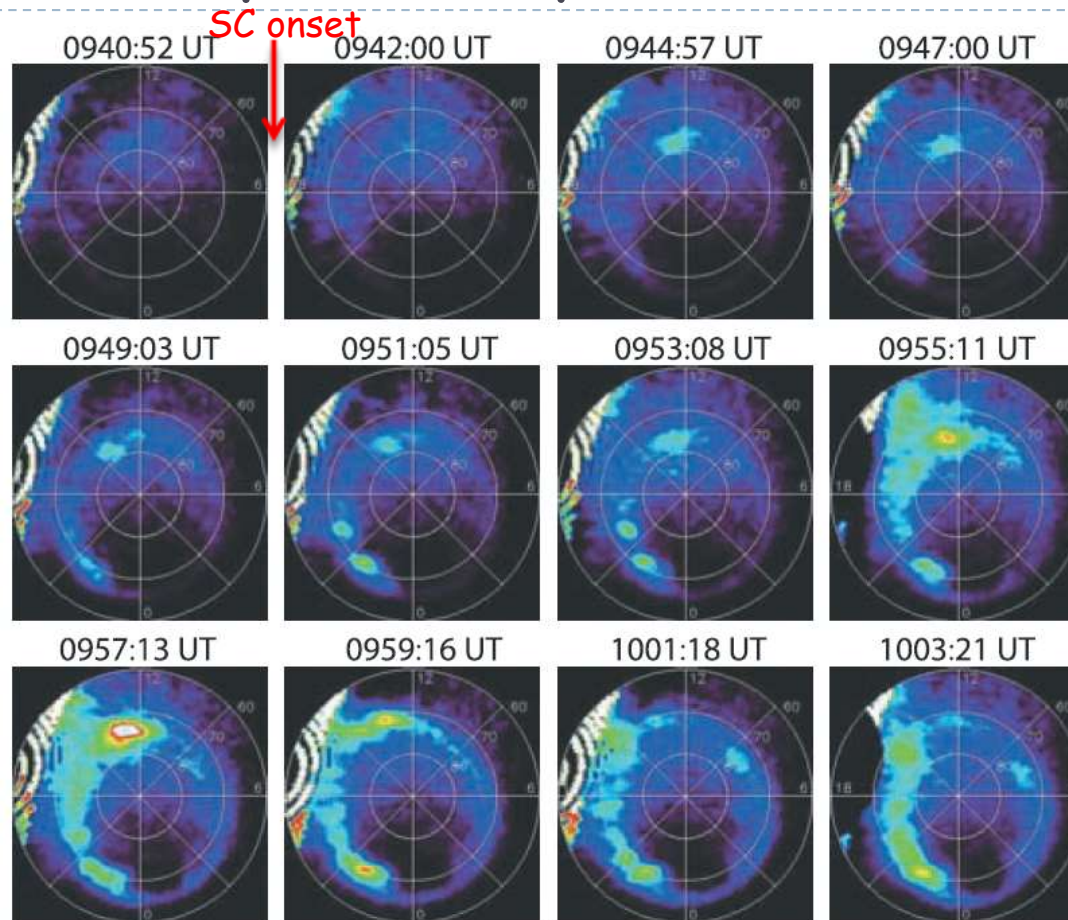
5. Discussion

Conductance, FAC, and E-potential relationship



5. Discussion

Shock aurora profile by IMAGE/FUV



[Zhou+2003]

In reality, auroral luminosity does not enhance in the polar cap in the course of SC, suggesting no significant Σ_{iono} enhancement.

6. Summary & Conclusion

- ▶ The dawn-dusk asymmetric enhancement of transient sunward flow associated with SI- can be attributed to the round cell intensification with increasing $|IMF-By|$ upon P_{sw} drops. We have examined if the above features are reproduced by a global MHD simulation.
- ▶ FACs for the round cell do intensify upon arrival of larger IMF-By, consistent with our hypothesis.
- ▶ The resultant E-field potential, however, gives flow enhancement of opposite sense. This may be due to unrealistic increase/decrease of ionospheric conductance assumed in the simulation.