FAC validation in global MHD

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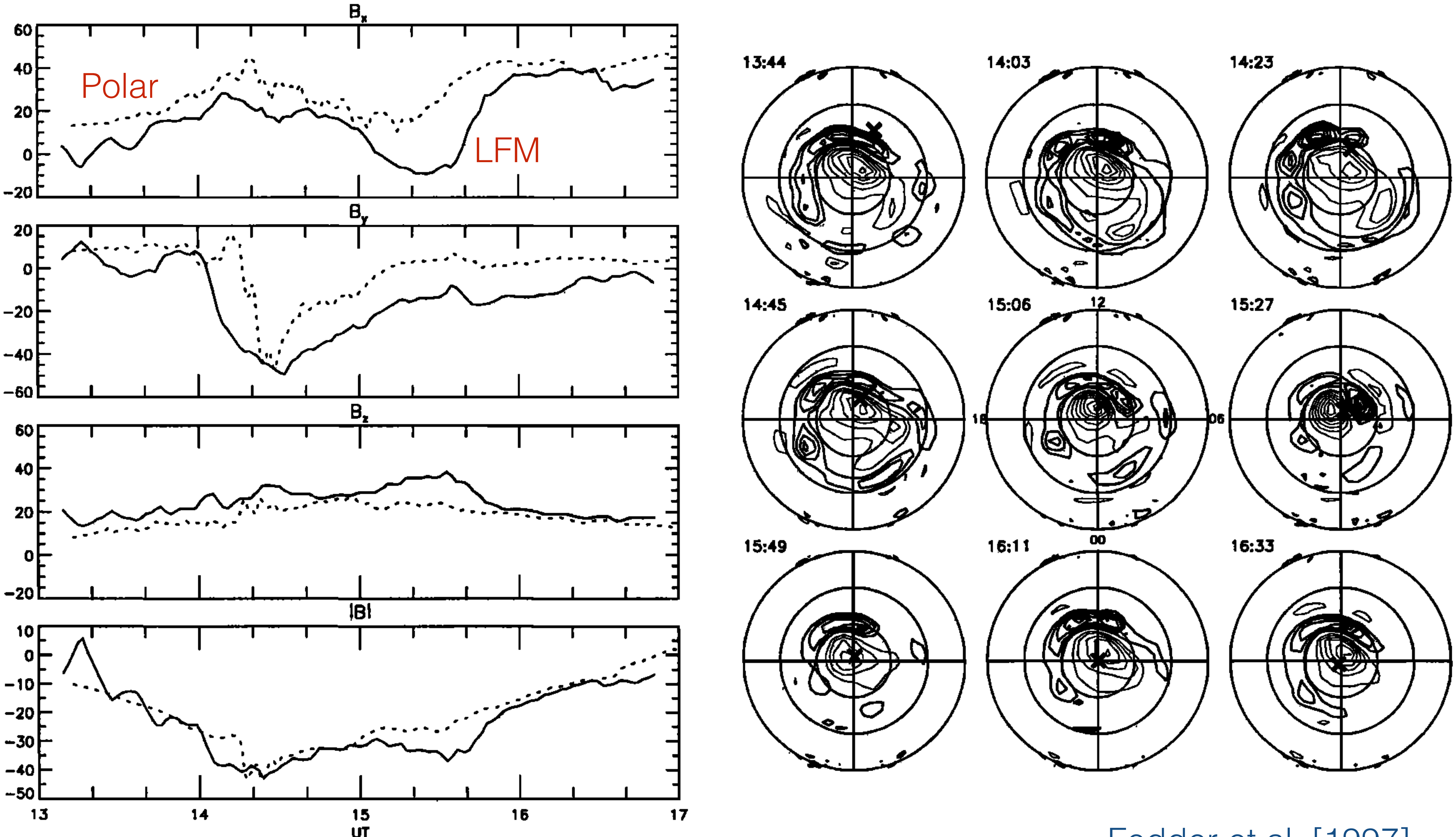
This is an old exercise



Fedder et al. [1997]

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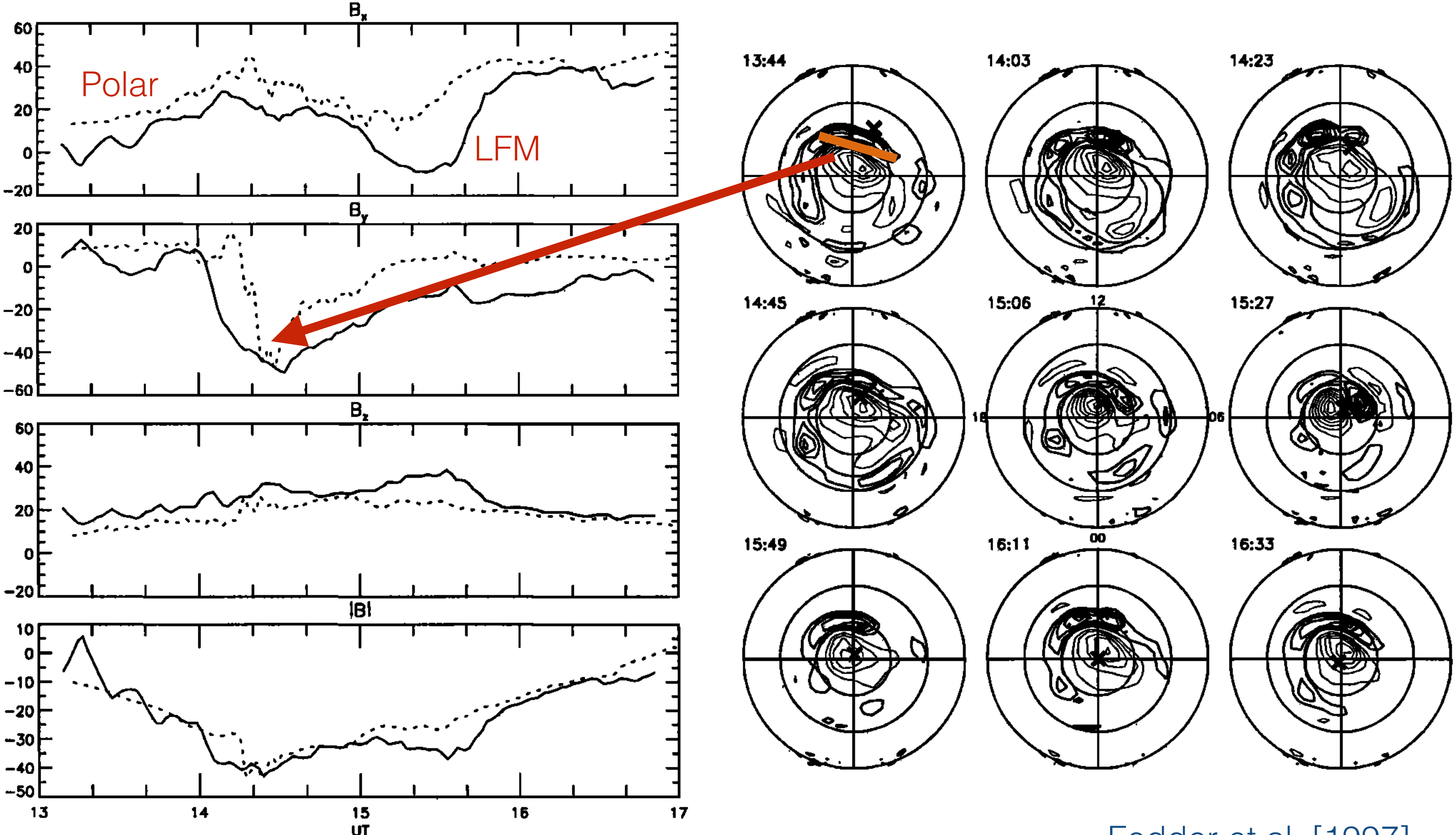

Fedder et al. [1997]

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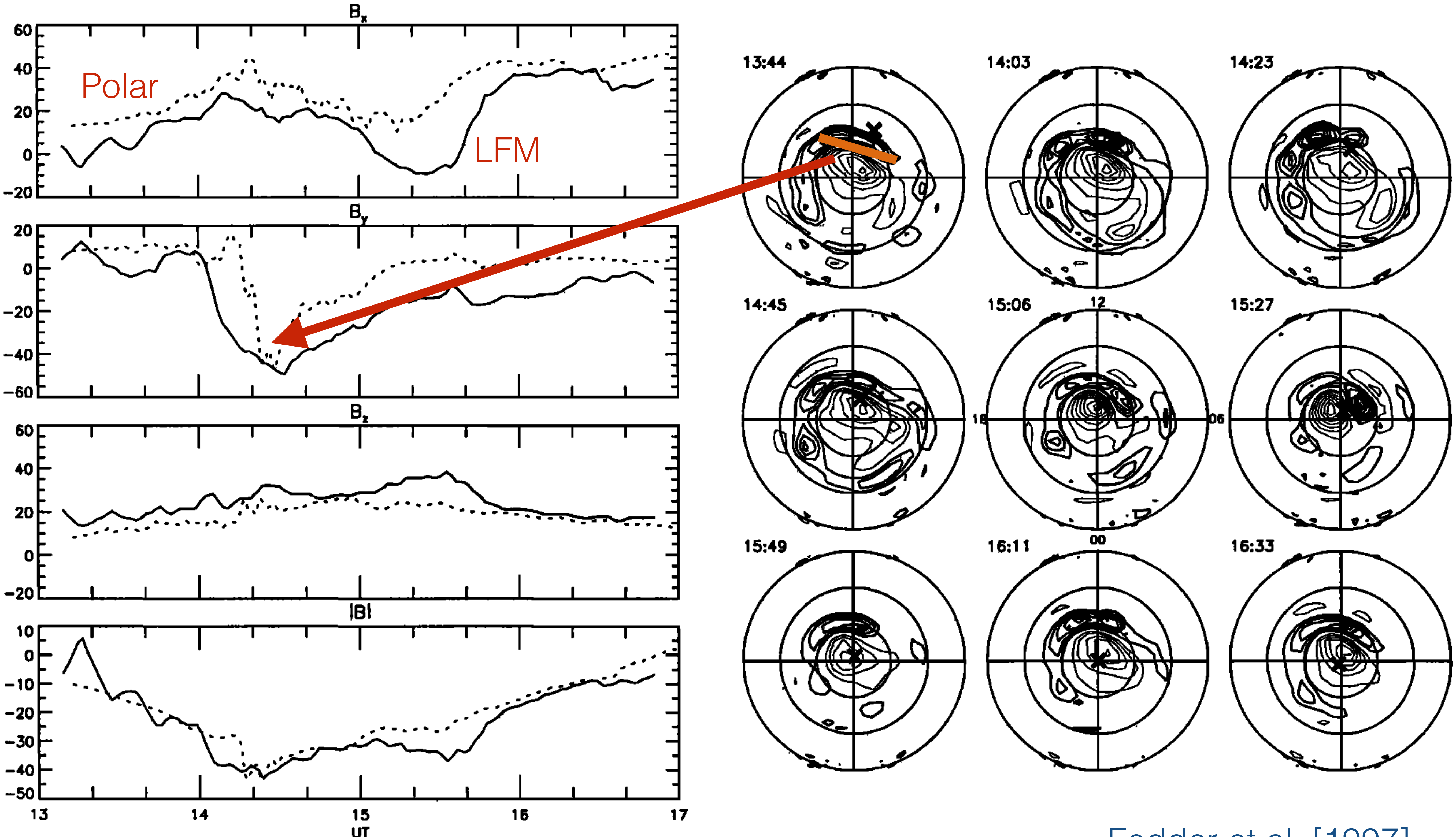

Fedder et al. [1997]

“The agreement between the curves is remarkable”

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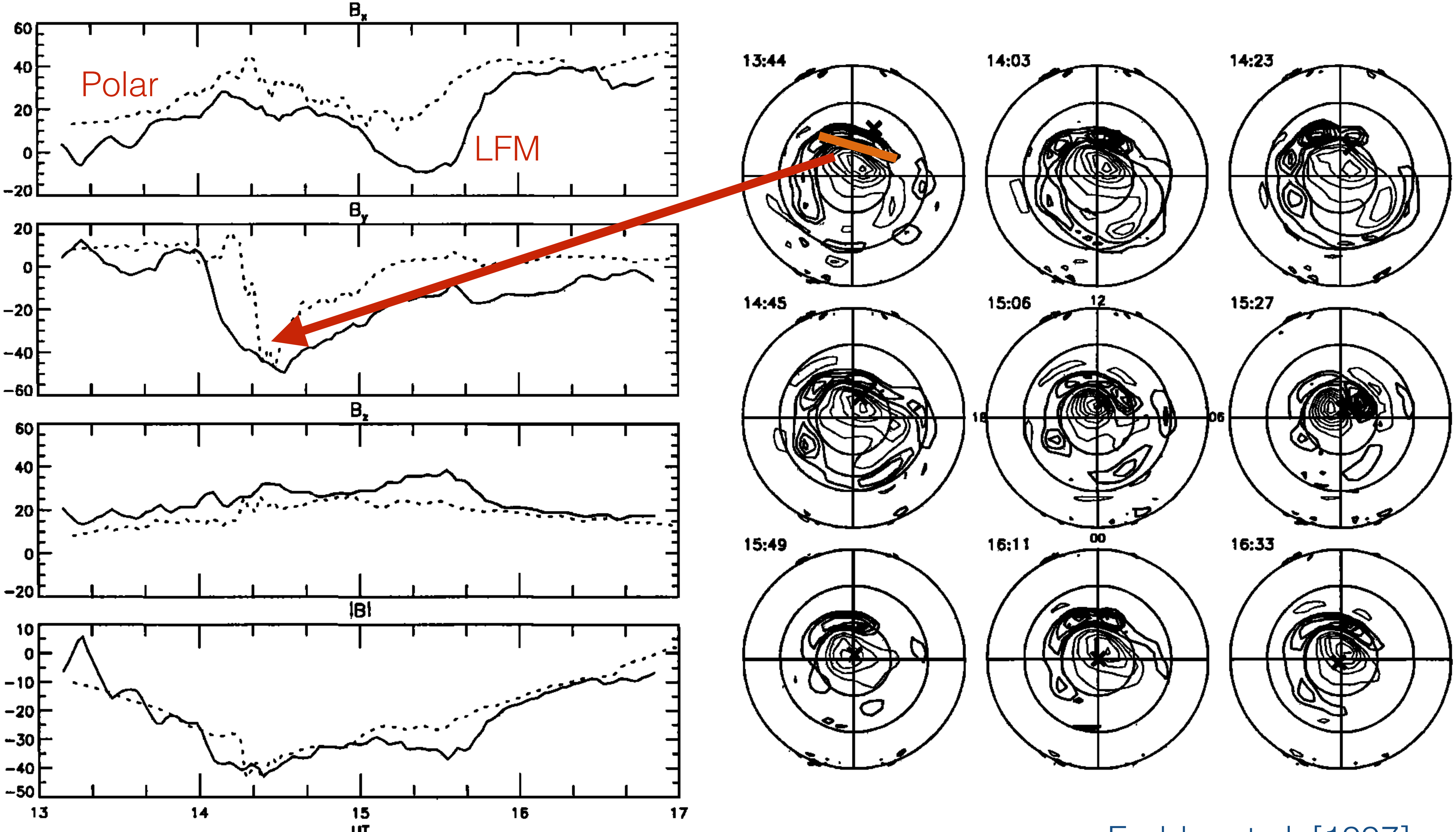


Fedder et al. [1997]

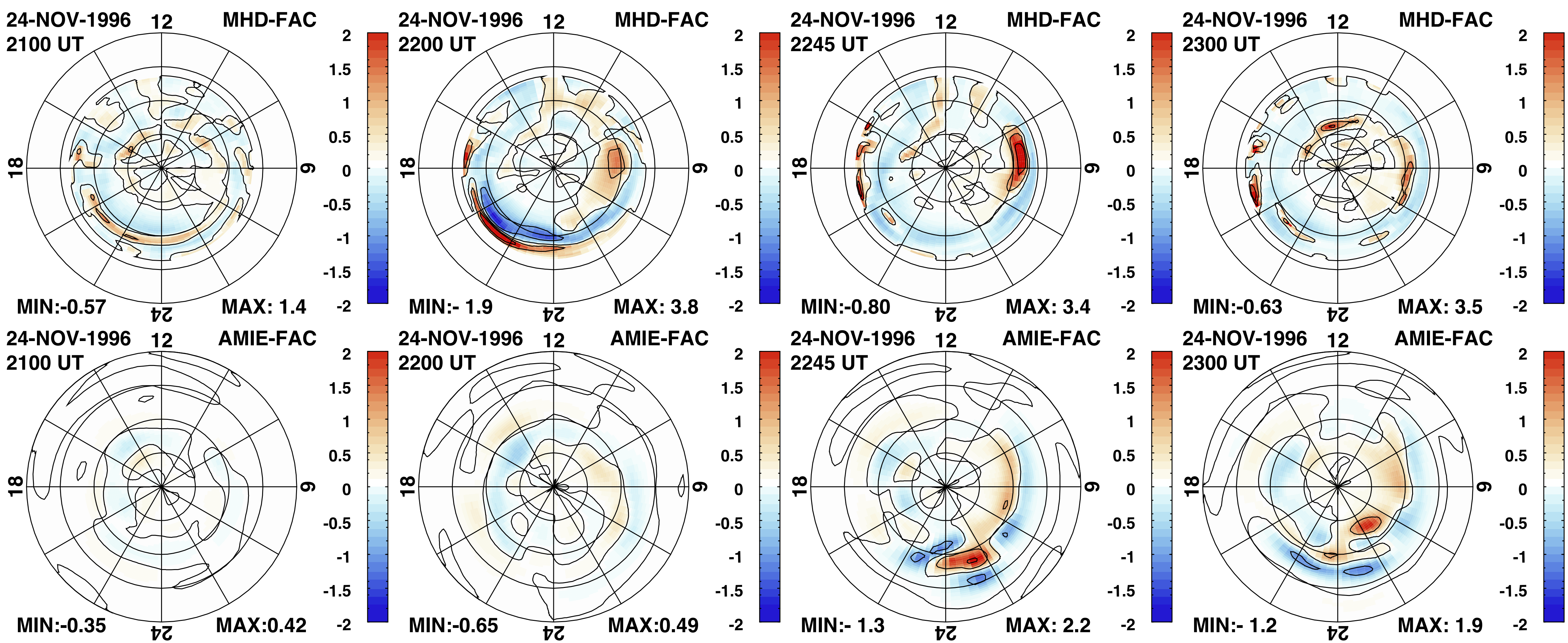
“The agreement between the curves is remarkable”

“It is satisfying that the simple method chosen worked so well”

Limited FAC data sources

FAC patterns compared with AMIE

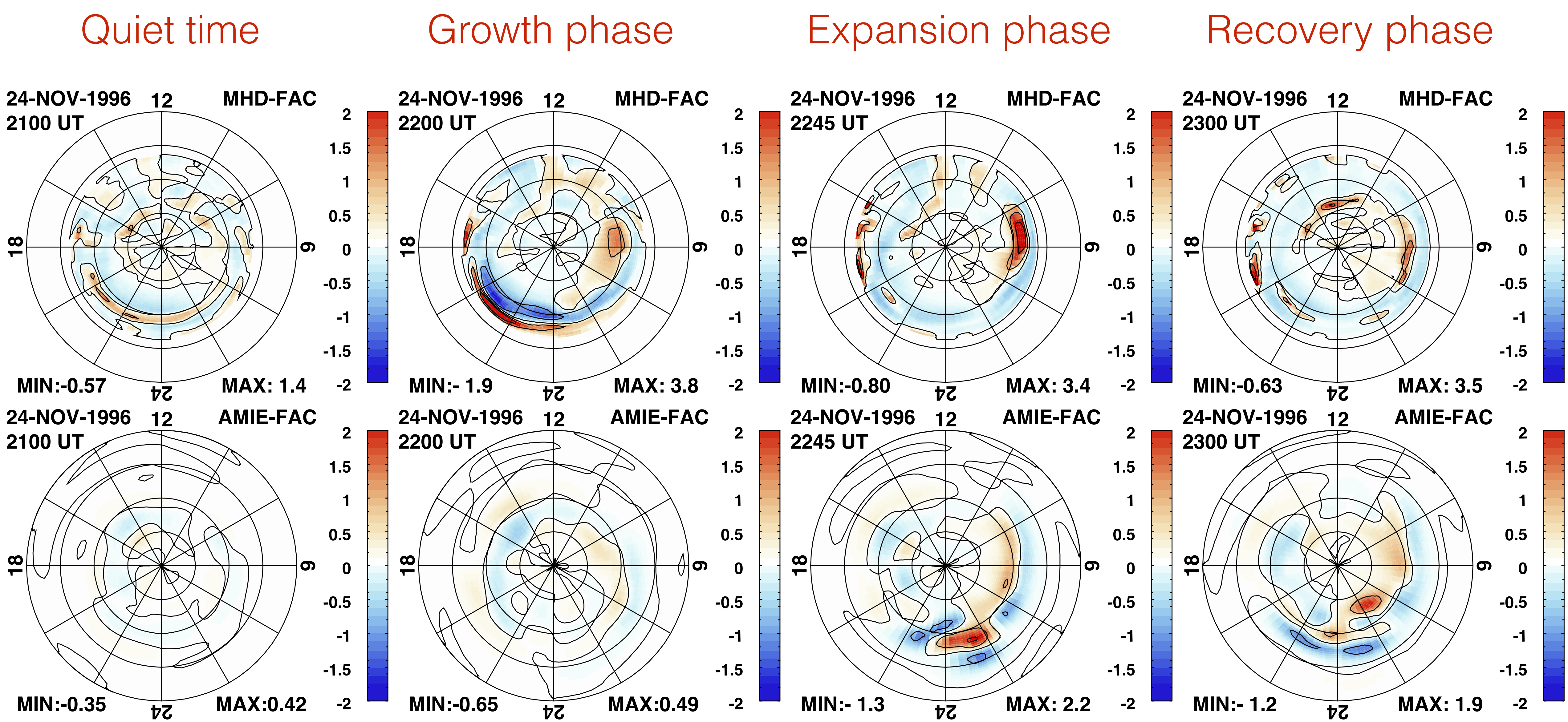
Quiet time | Growth phase | Expansion phase | Recovery phase



Raeder et al. [2001]

Limited FAC data sources

FAC patterns compared with AMIE



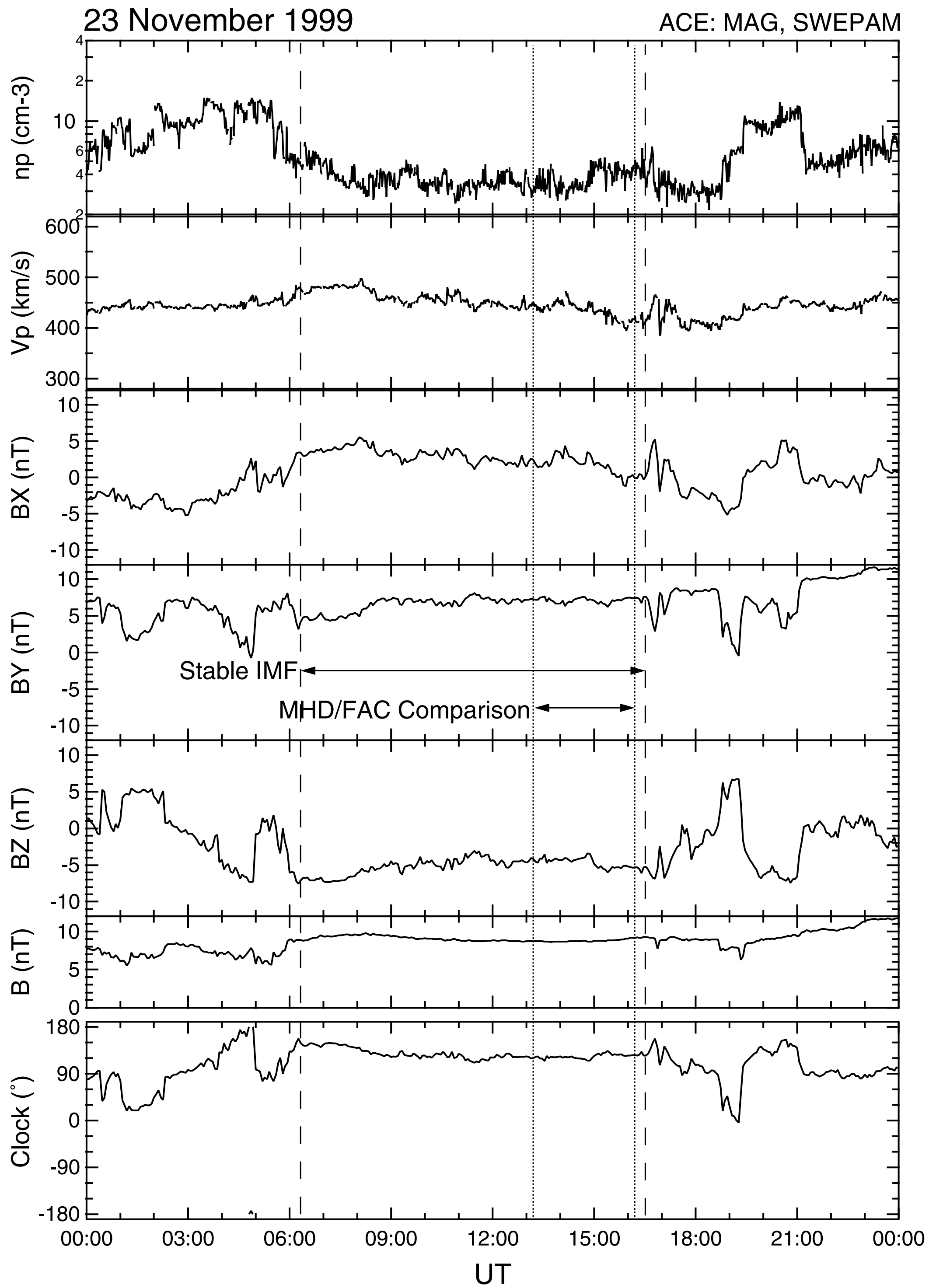
Raeder et al. [2001]

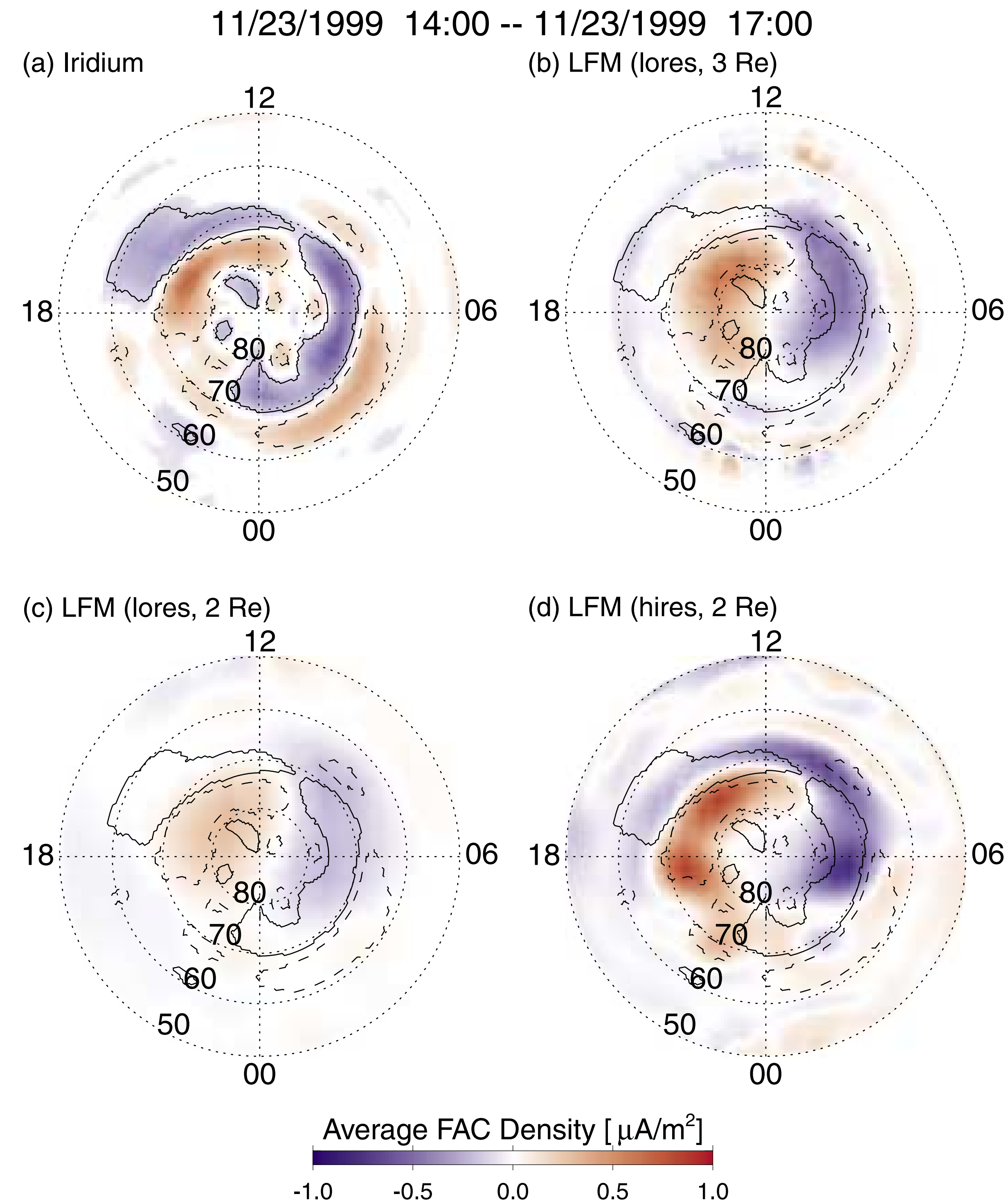
+ ground mags and DMSP magnetometers, e.g., [Ridley et al. 2001]

Iridium patterns

Korth et al. [2004]

Steady southward IMF conditions

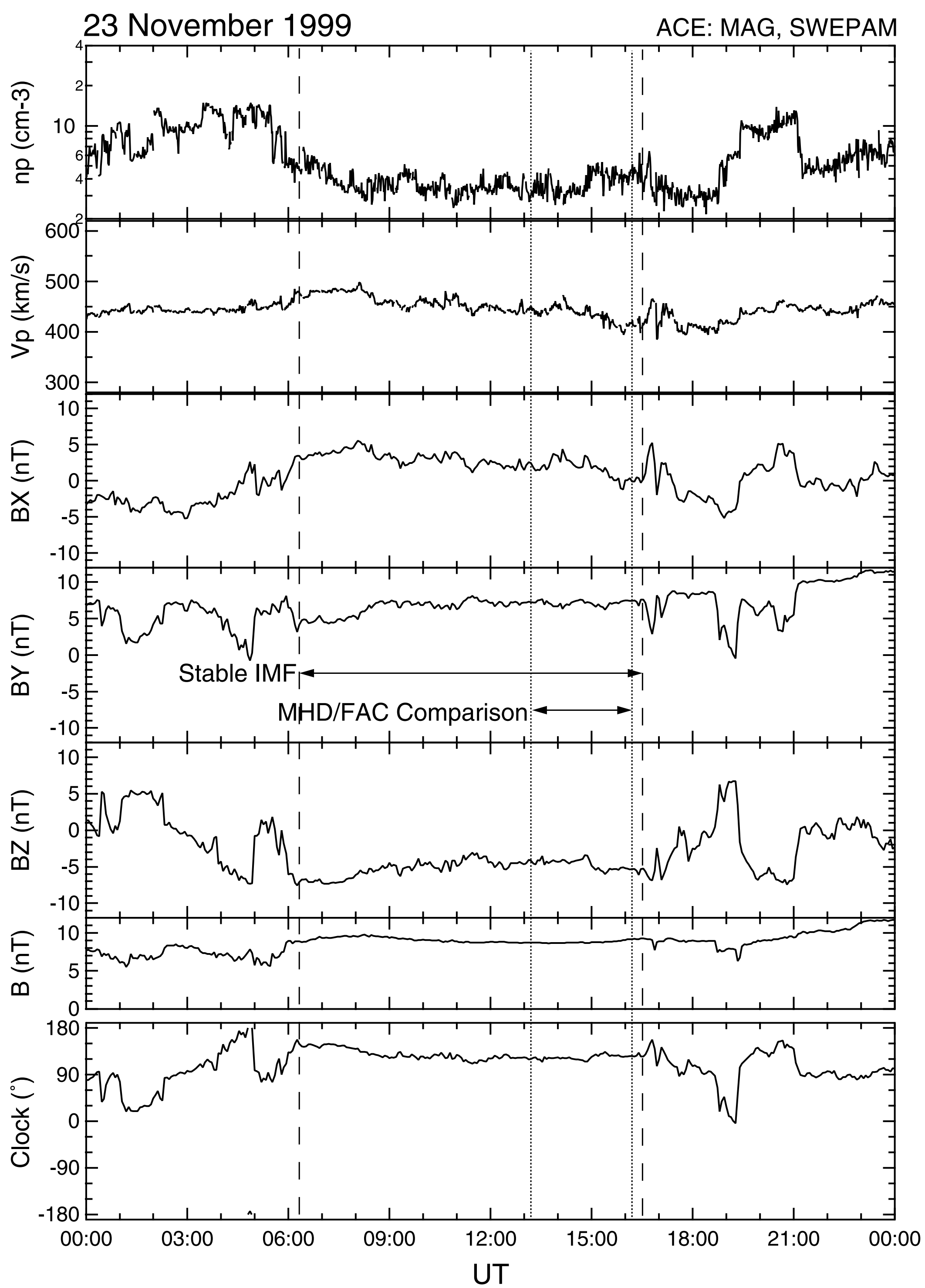


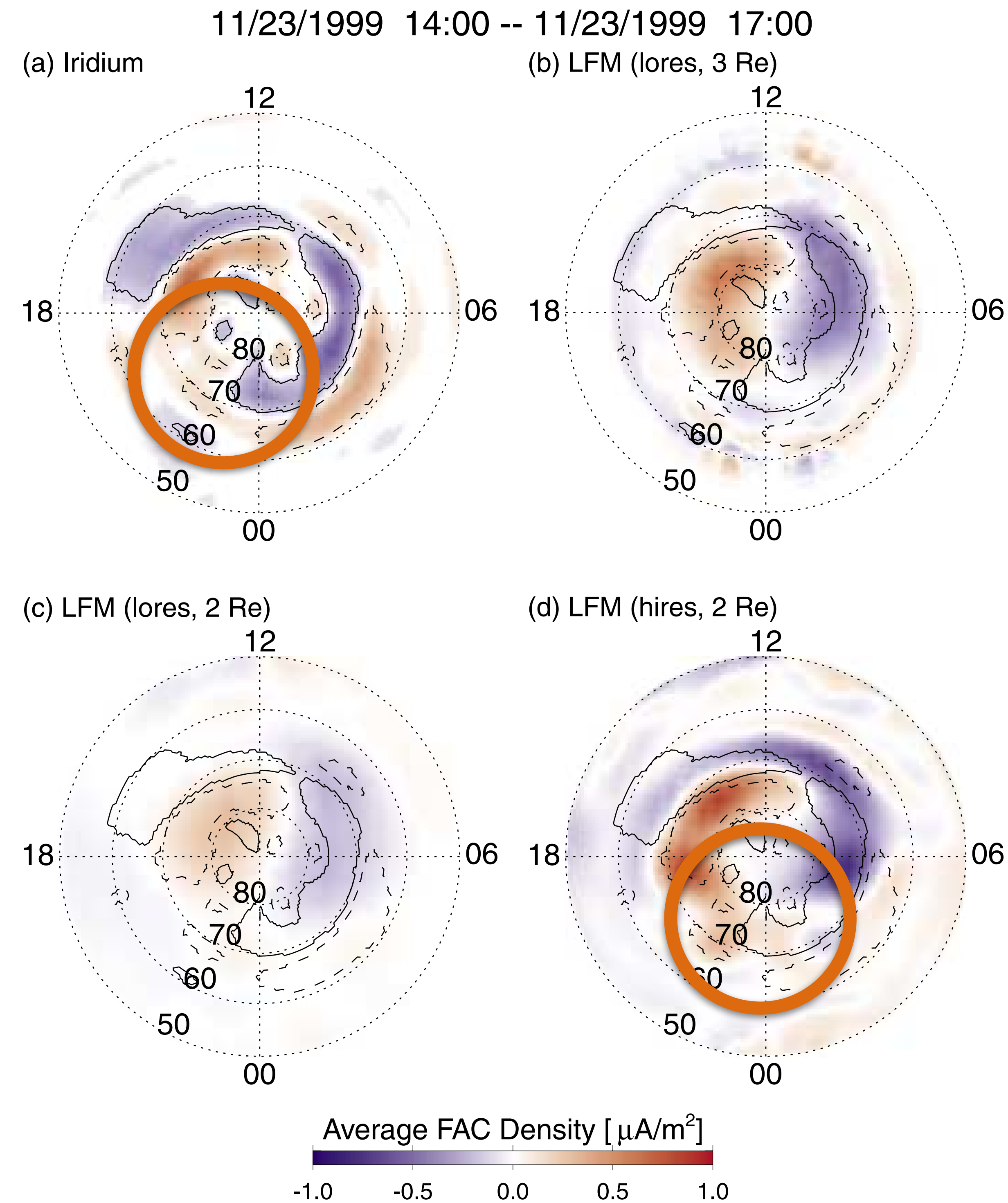


Iridium patterns

Korth et al. [2004]

Steady southward IMF conditions

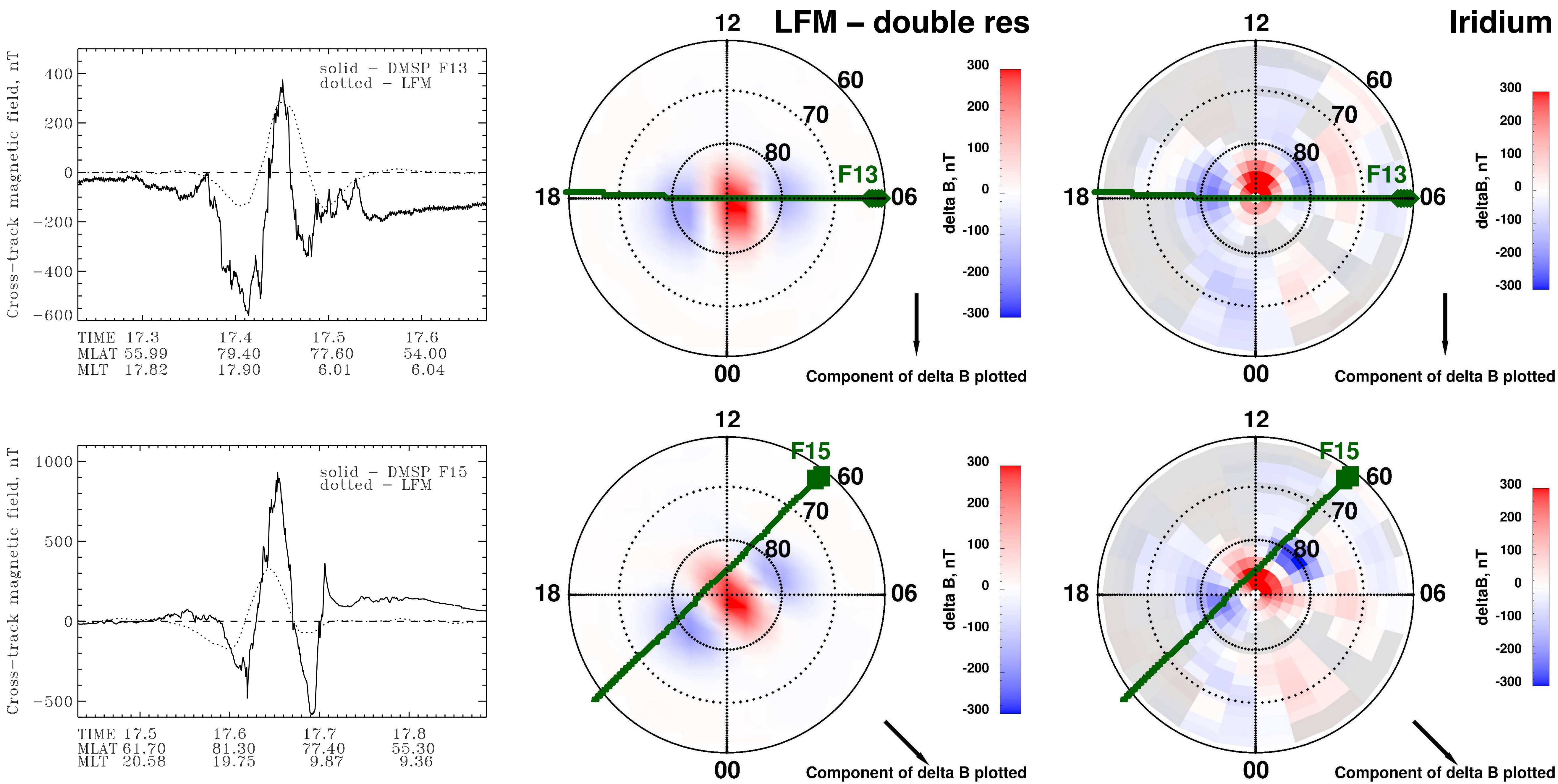




Discrepancy due to strong nightside Hall current in the simulation

Iridium patterns and DMSP cross-validation

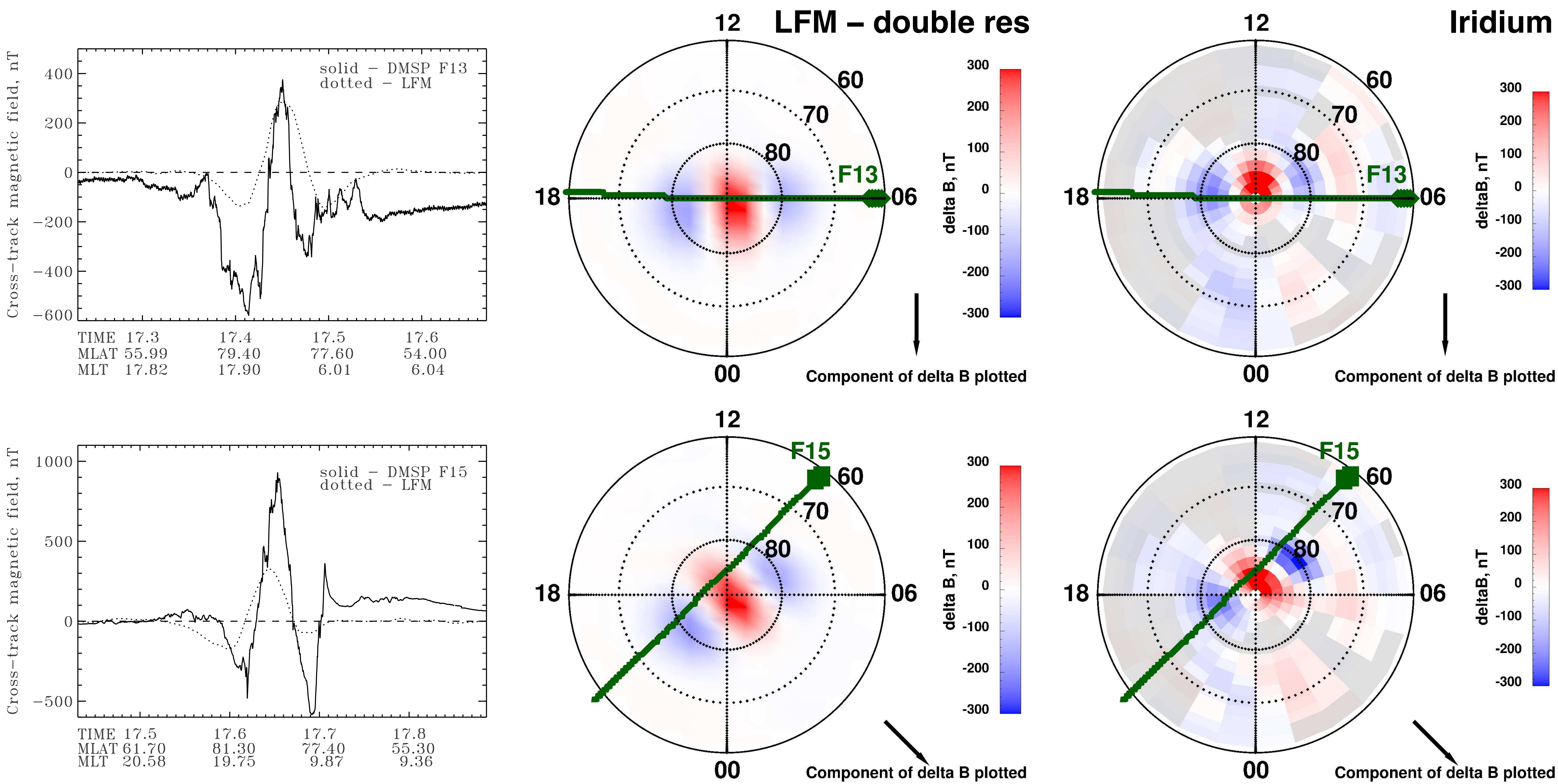
Steady northward IMF conditions



Merkin et al. [2007]

Iridium patterns and DMSP cross-validation

Steady northward IMF conditions

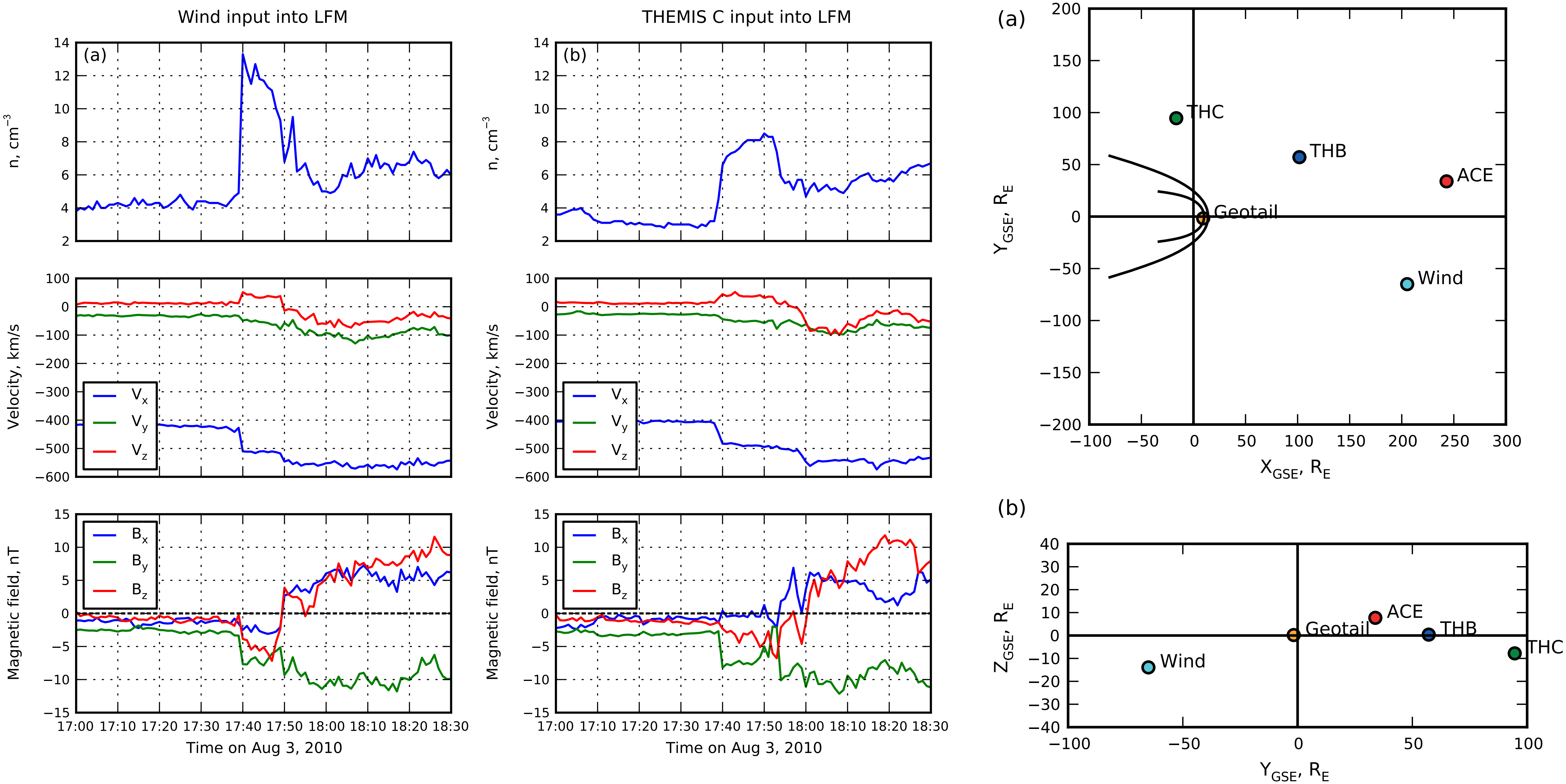


- Iridium allowed global comparisons.
- Revealed close agreement with simulation.
- In-situ validation still important. Model under-resolved.

Merkin et al. [2007]

AMPERE: Global and nearly simultaneous coverage

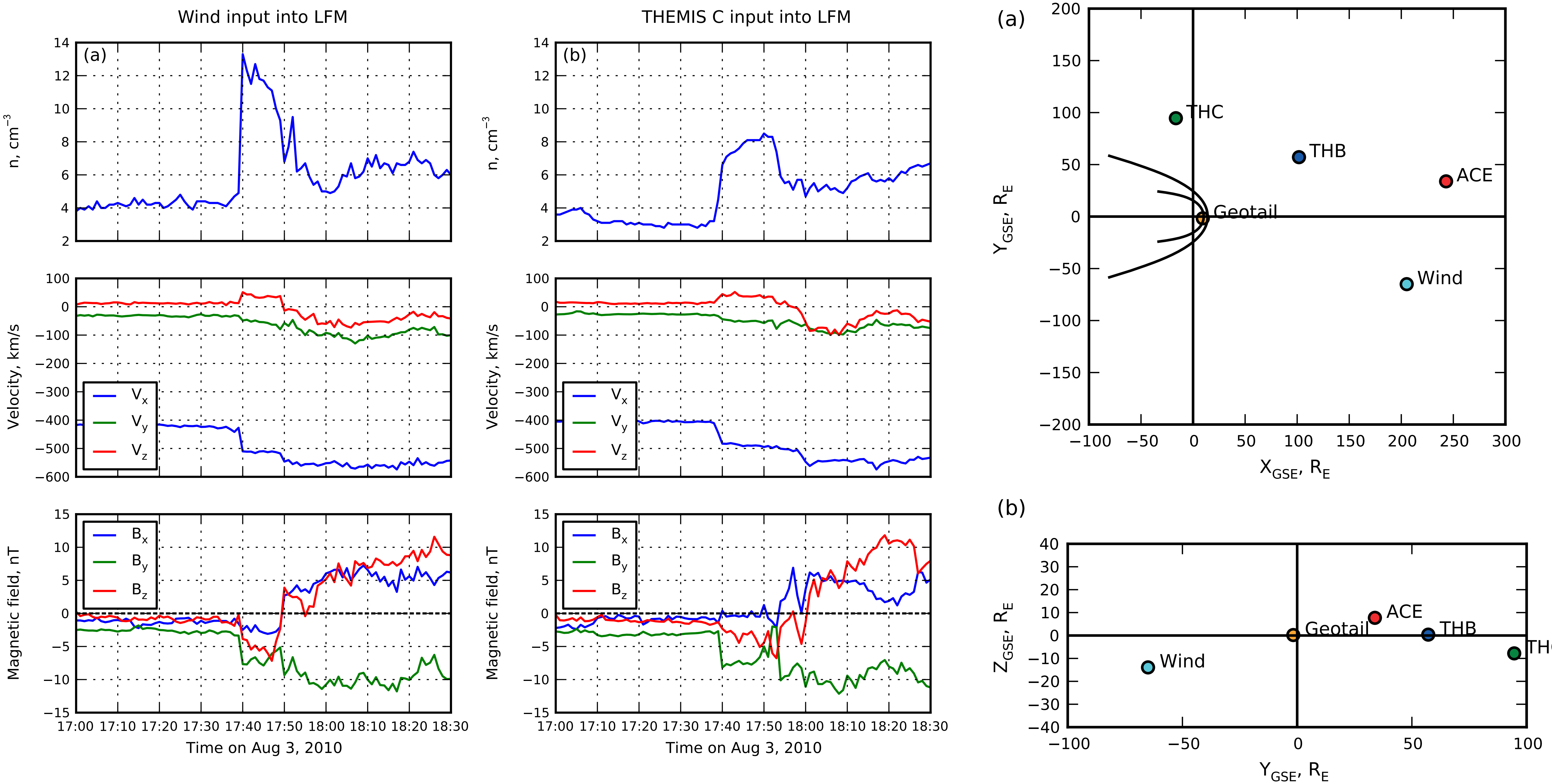
10-min global FAC patterns vs high-res LFM



Merkin et al. [2013]

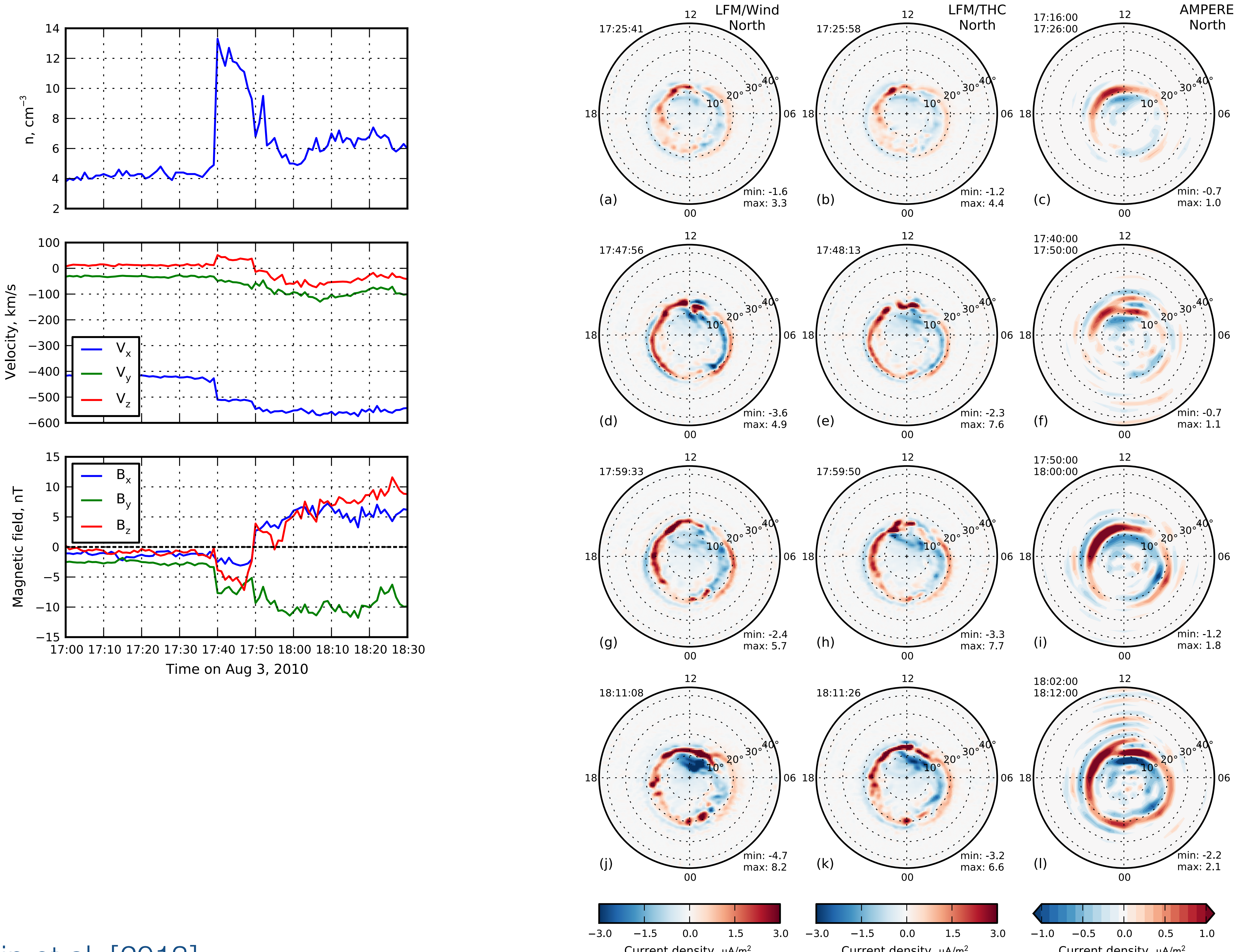
AMPERE: Global and nearly simultaneous coverage

10-min global FAC patterns vs high-res LFM

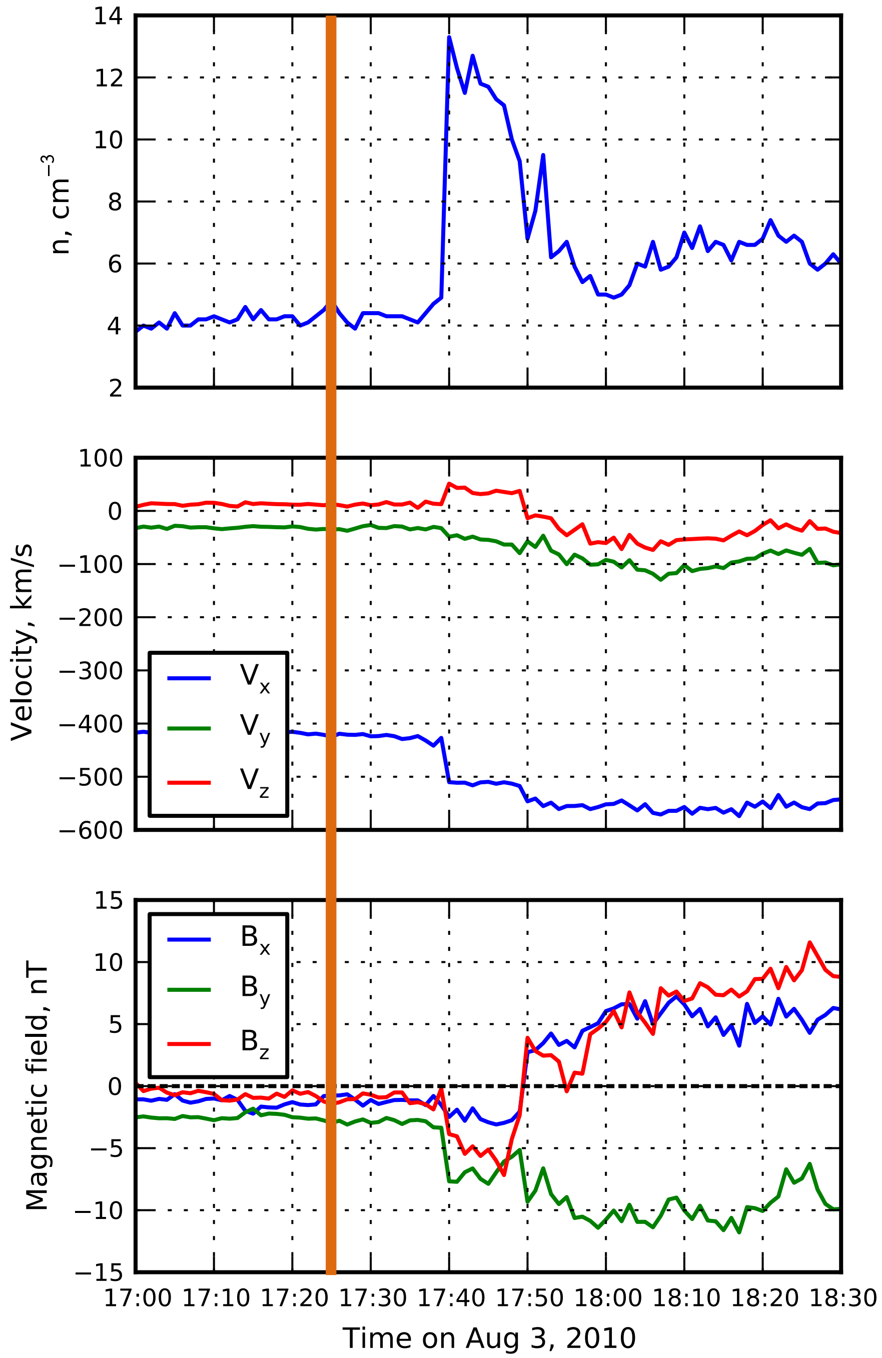


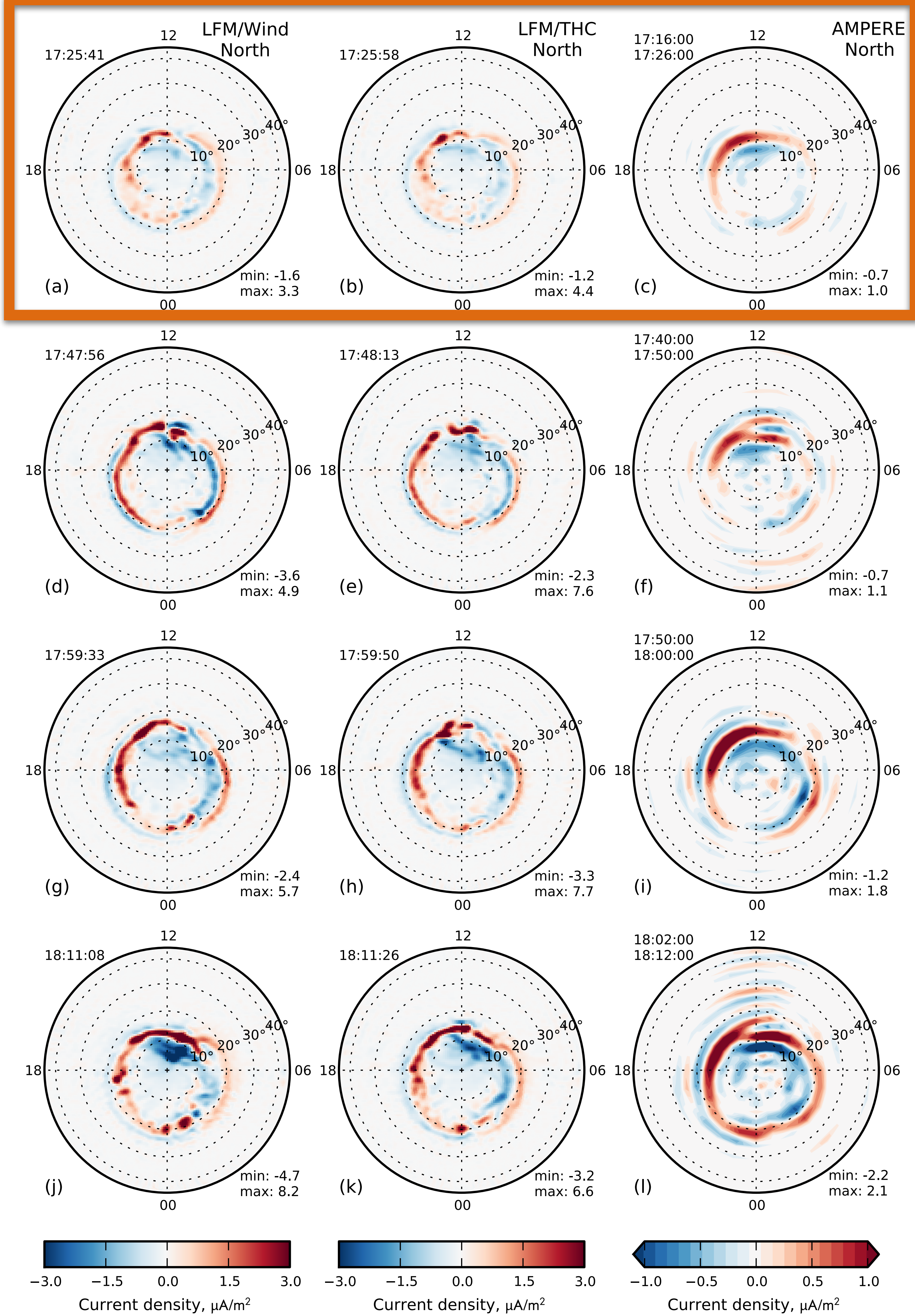
Merkin et al. [2013]

- What is the actual solar wind driver?



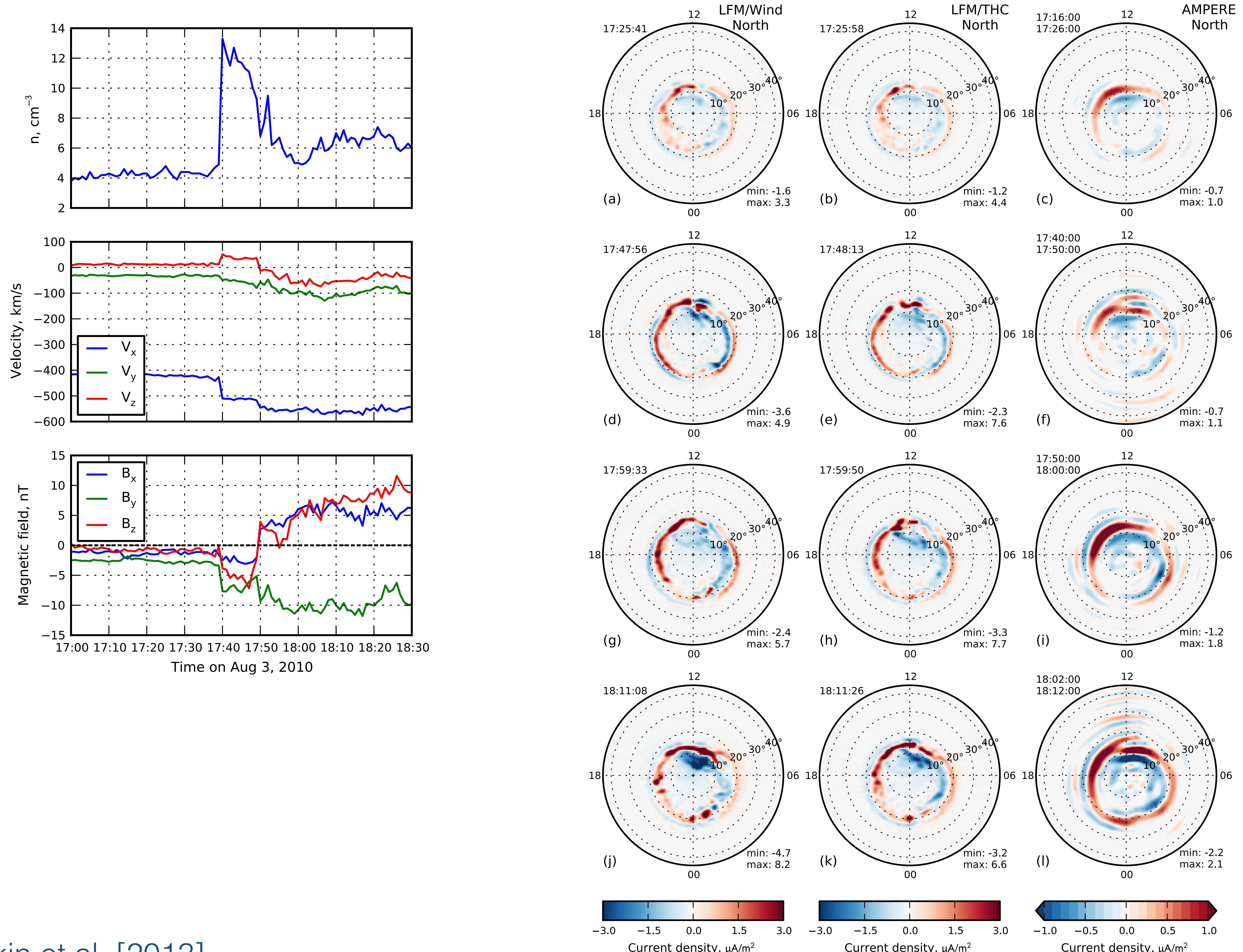
Merkin et al. [2013]



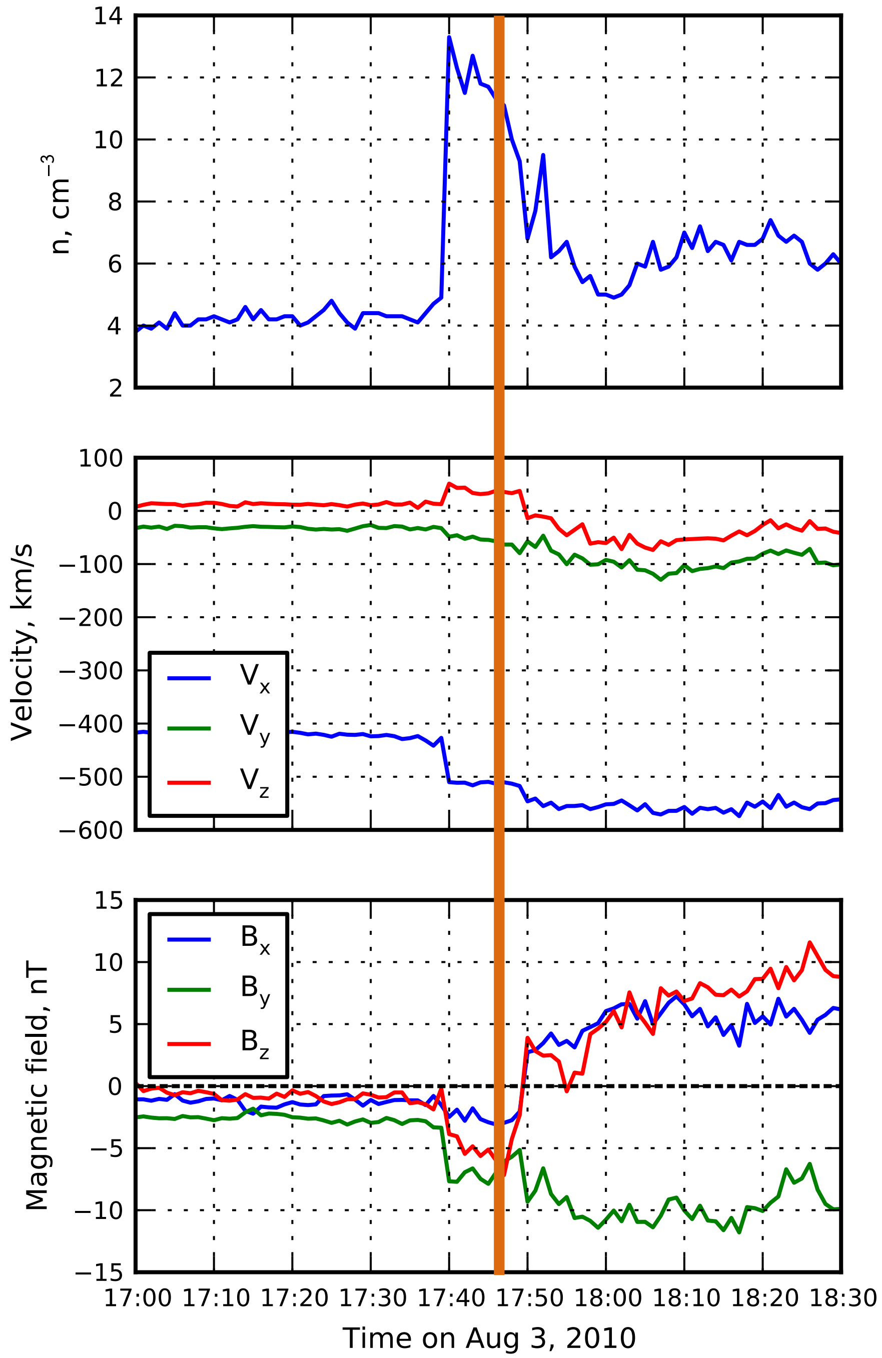


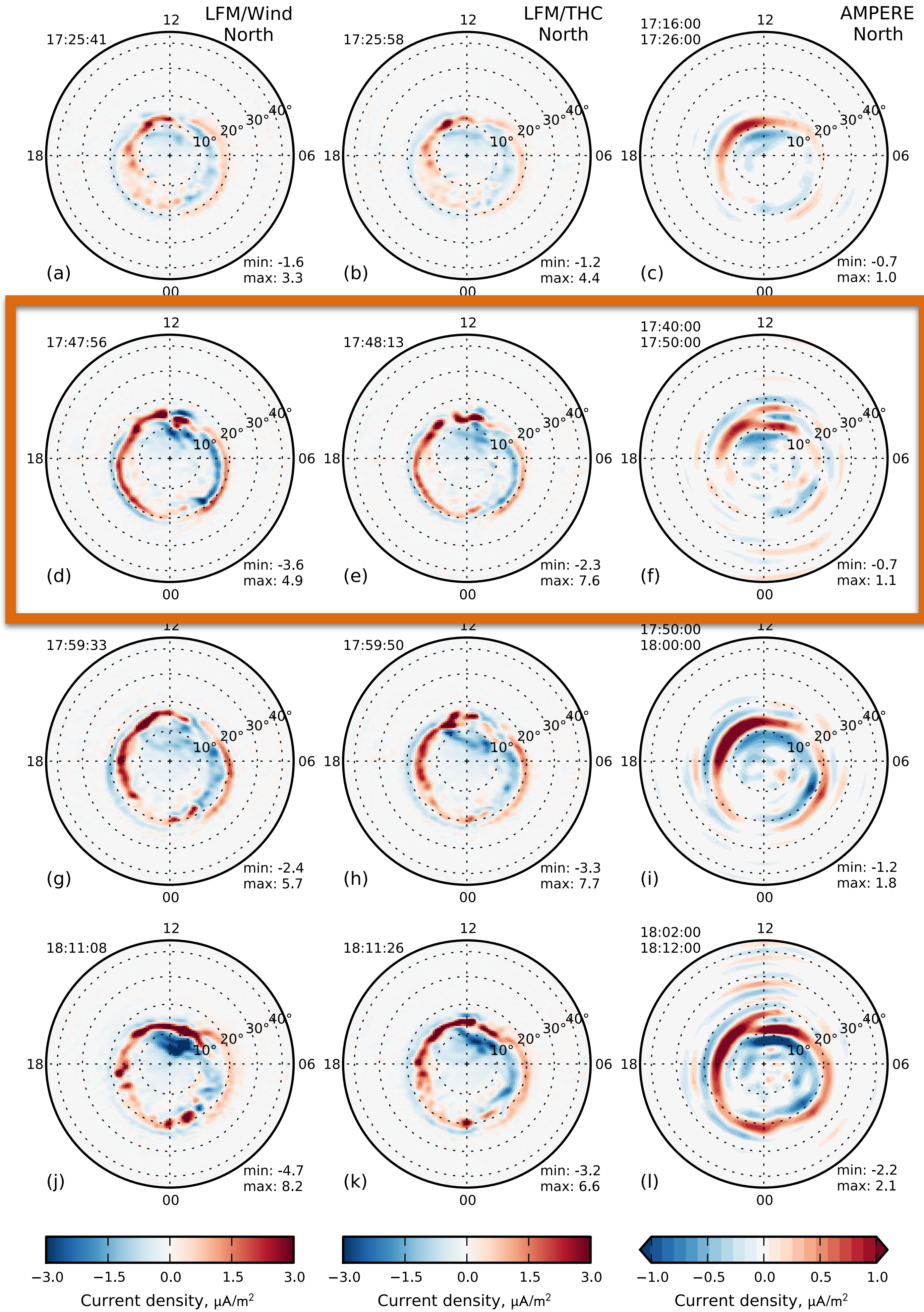
- Steady state prior to shock arrival
- Good agreement of FAC morphology

Merkin et al. [2013]



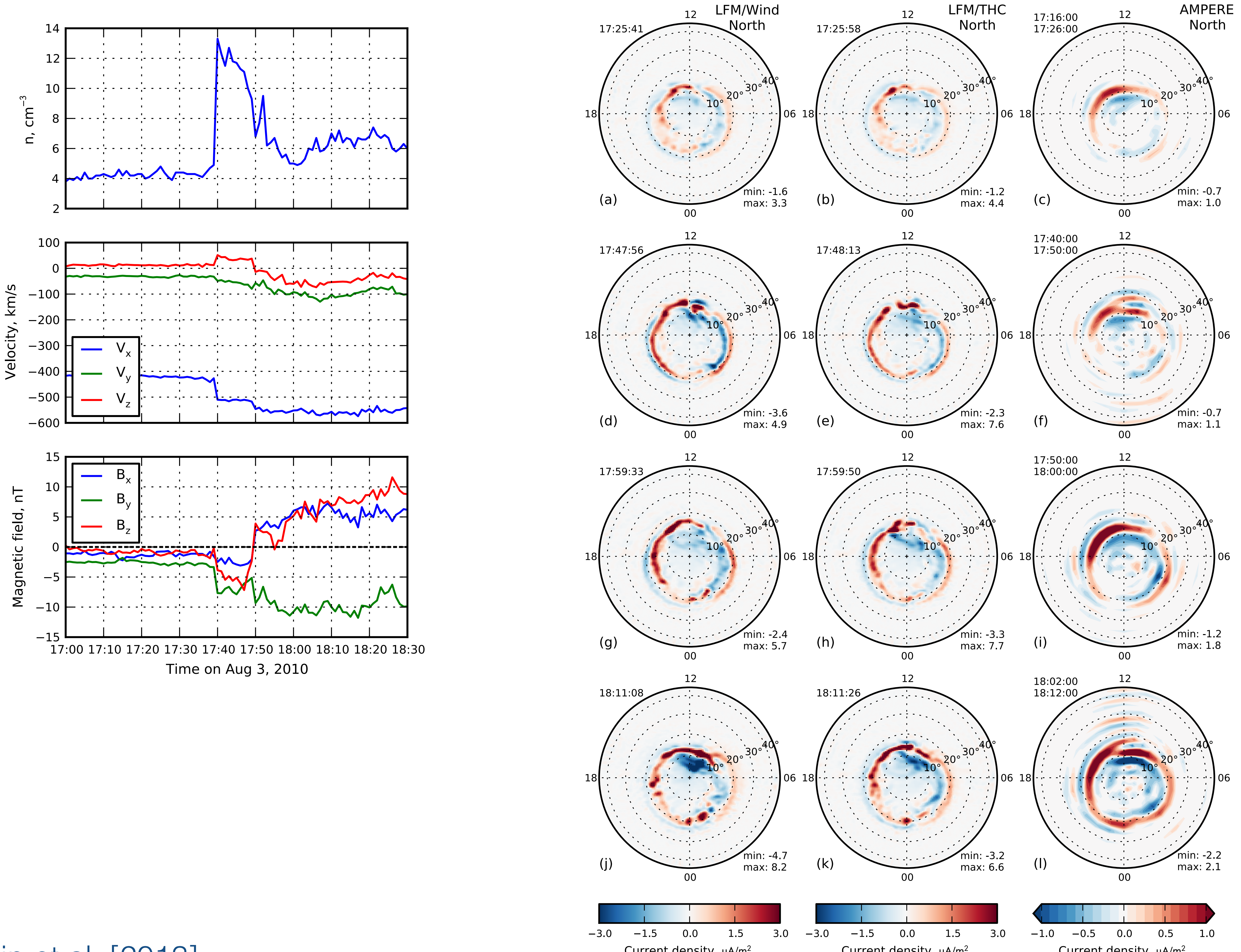
Merkin et al. [2013]



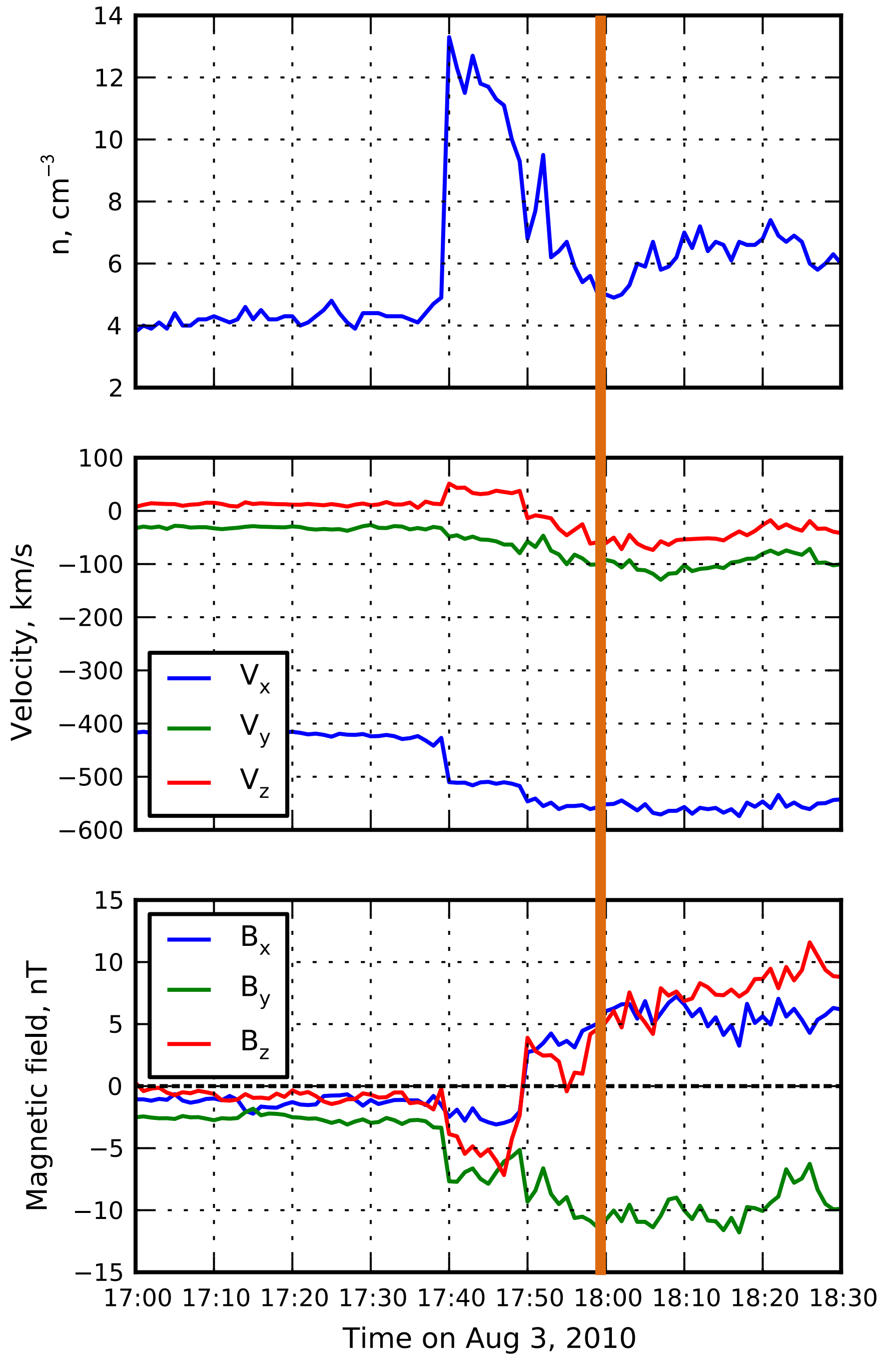


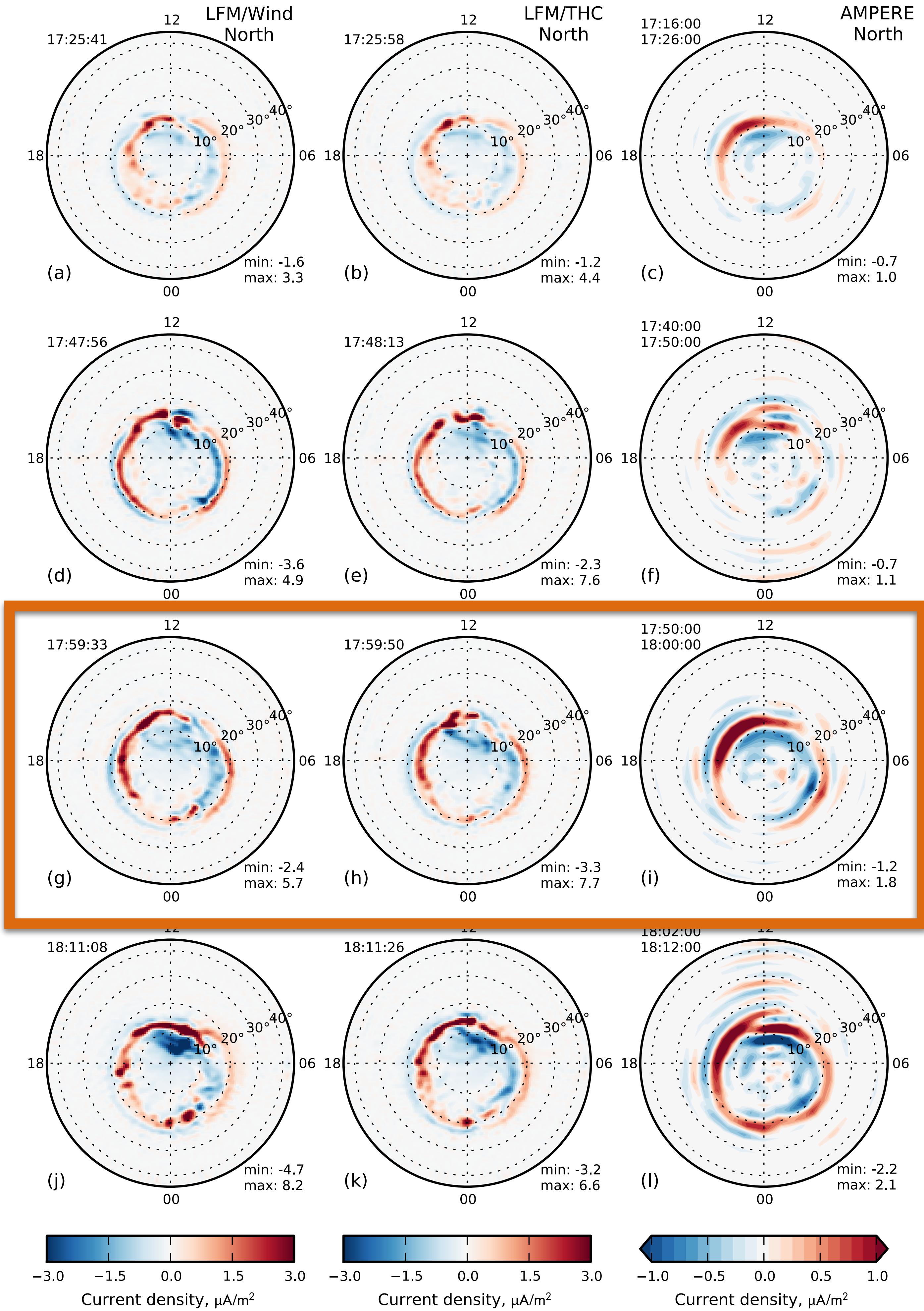
- After shock arrival
- Only dayside currents updated in AMPERE
- Nightside: stale data

Merkin et al. [2013]



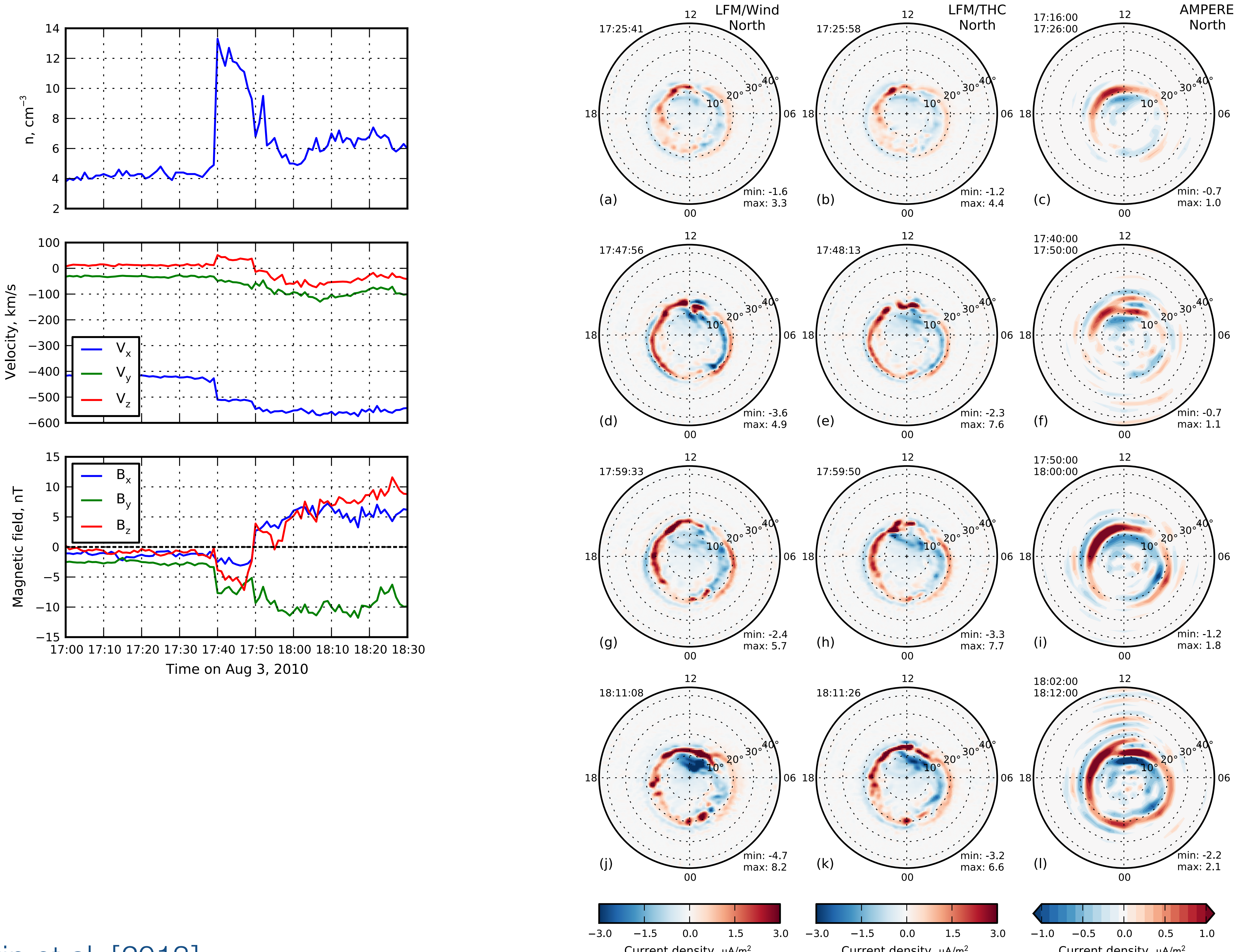
Merkin et al. [2013]



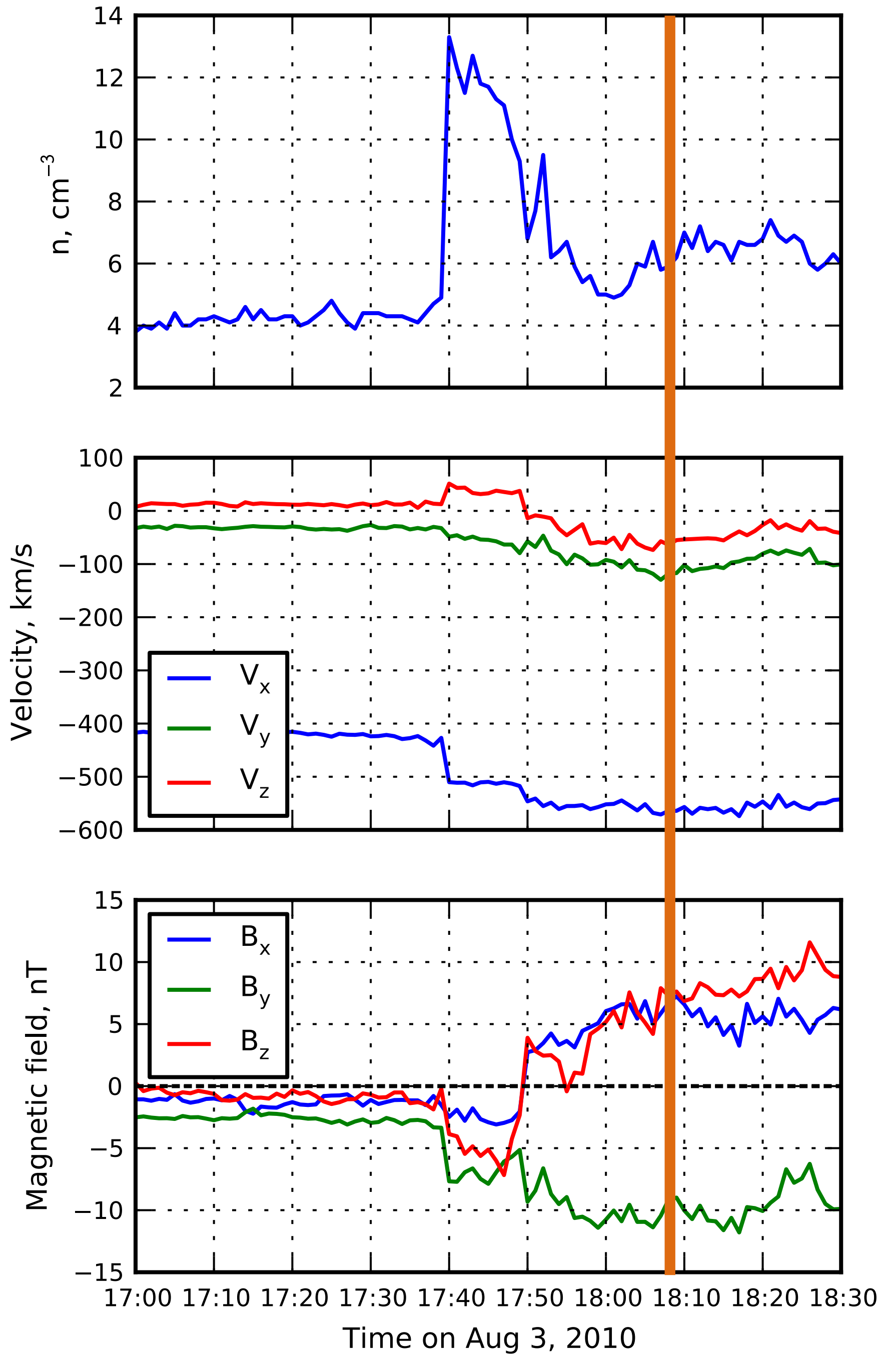


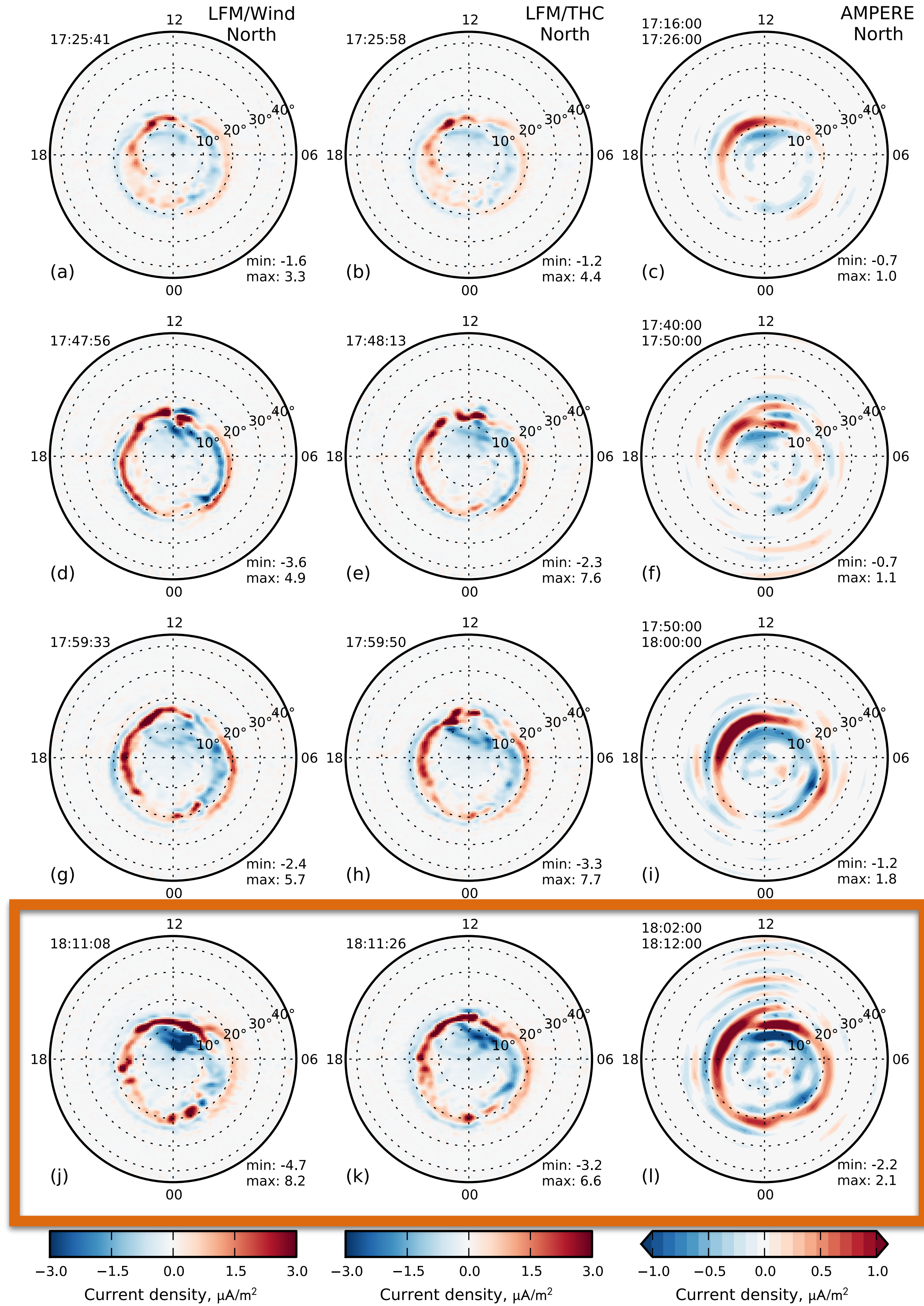
- After shock passage
- All currents updated in AMPERE
- Good agreement of morphology, including R2

Merkin et al. [2013]



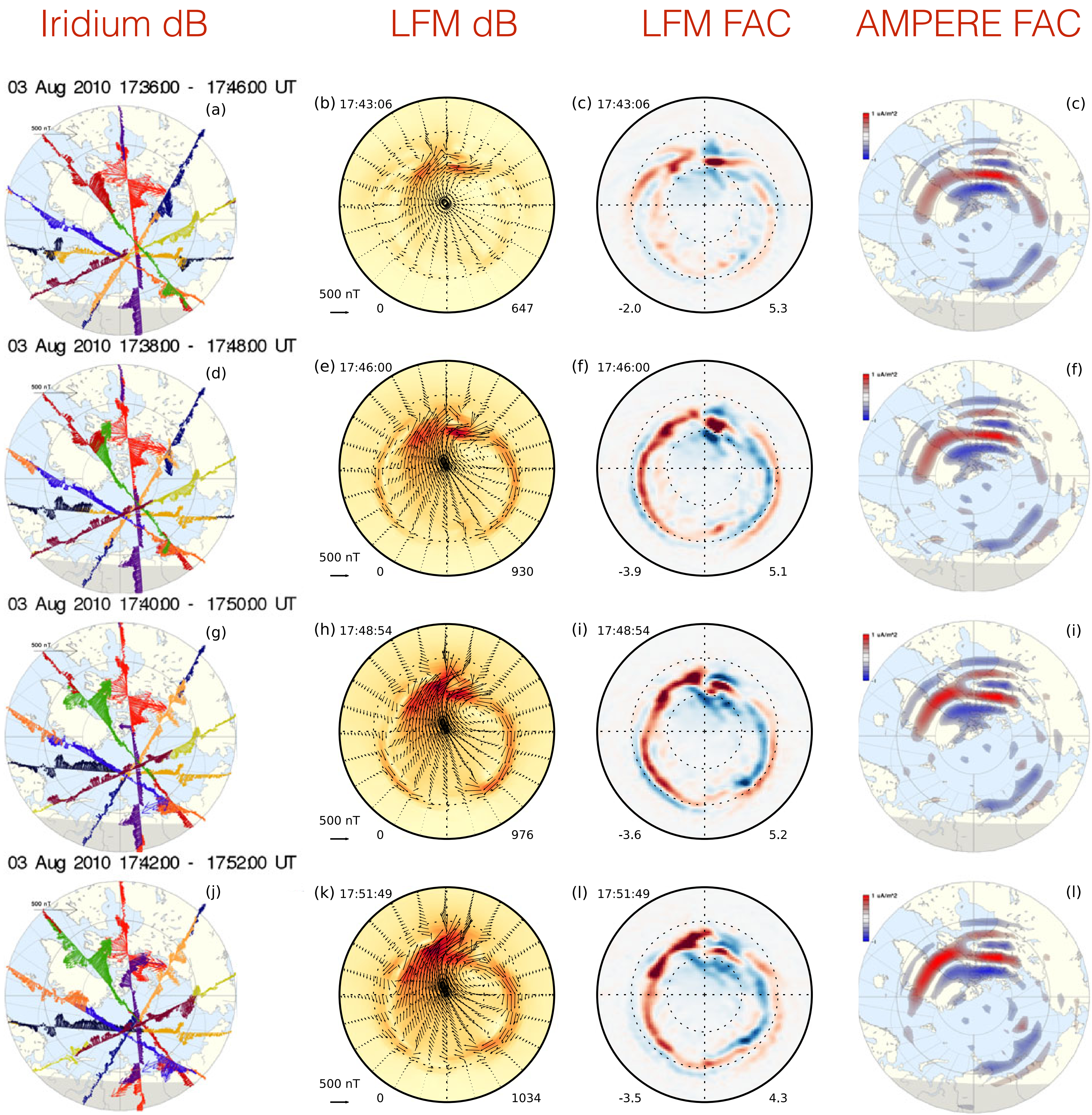
Merkin et al. [2013]





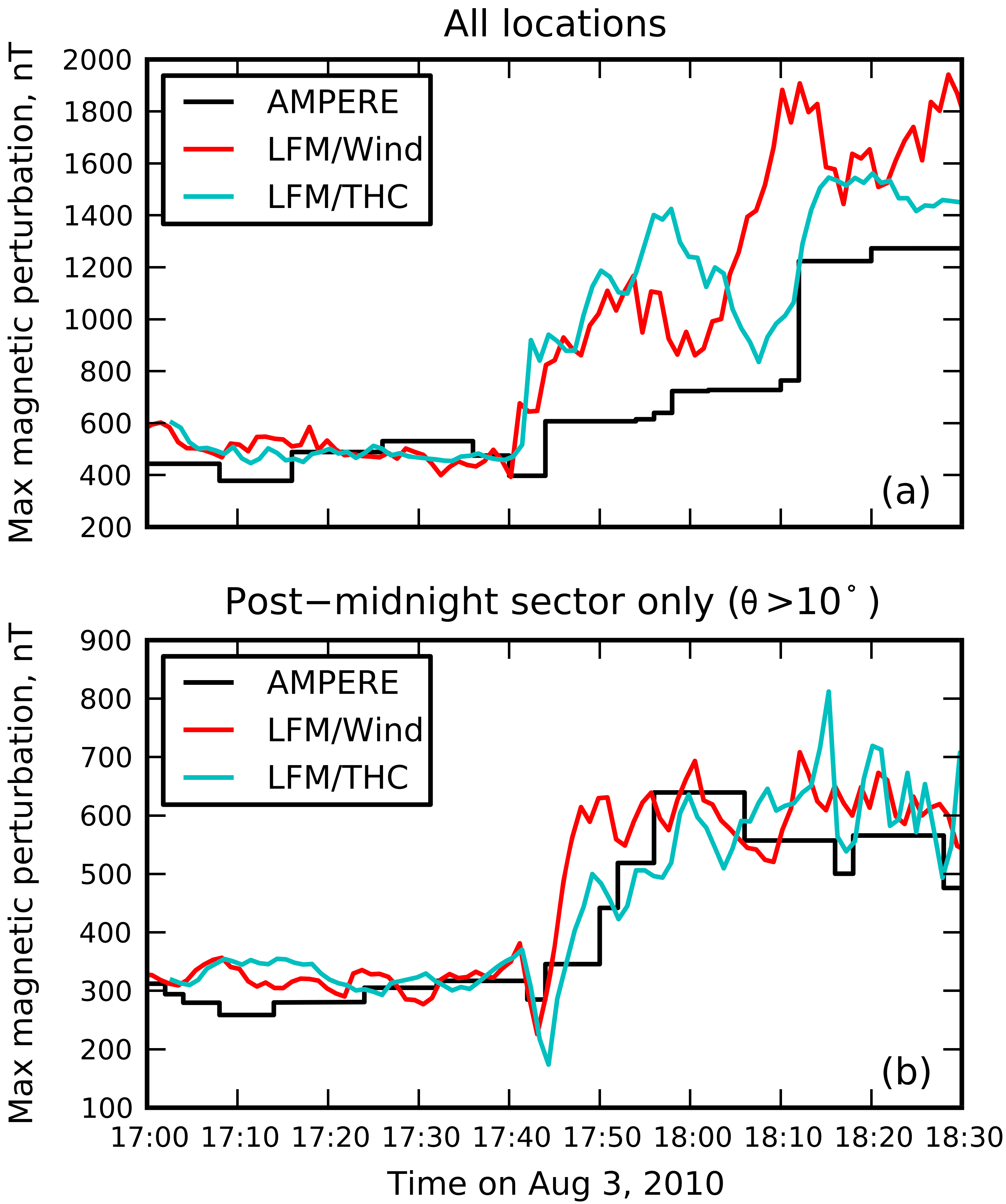
- After northward IMF rotation
- Good agreement of morphology, including R2
- Convection throat orientation not fully captured in AMPERE because it falls between Iridium tracks

Merkin et al. [2013]



- Model FAC change rapidly in response to shock. AMPERE pattern does not resolve the time evolution.
- Time-dependence is a major challenge.
- But if you are careful and patient, significant information can be extracted from individual spacecraft tracks.

Merkin et al. [2013]

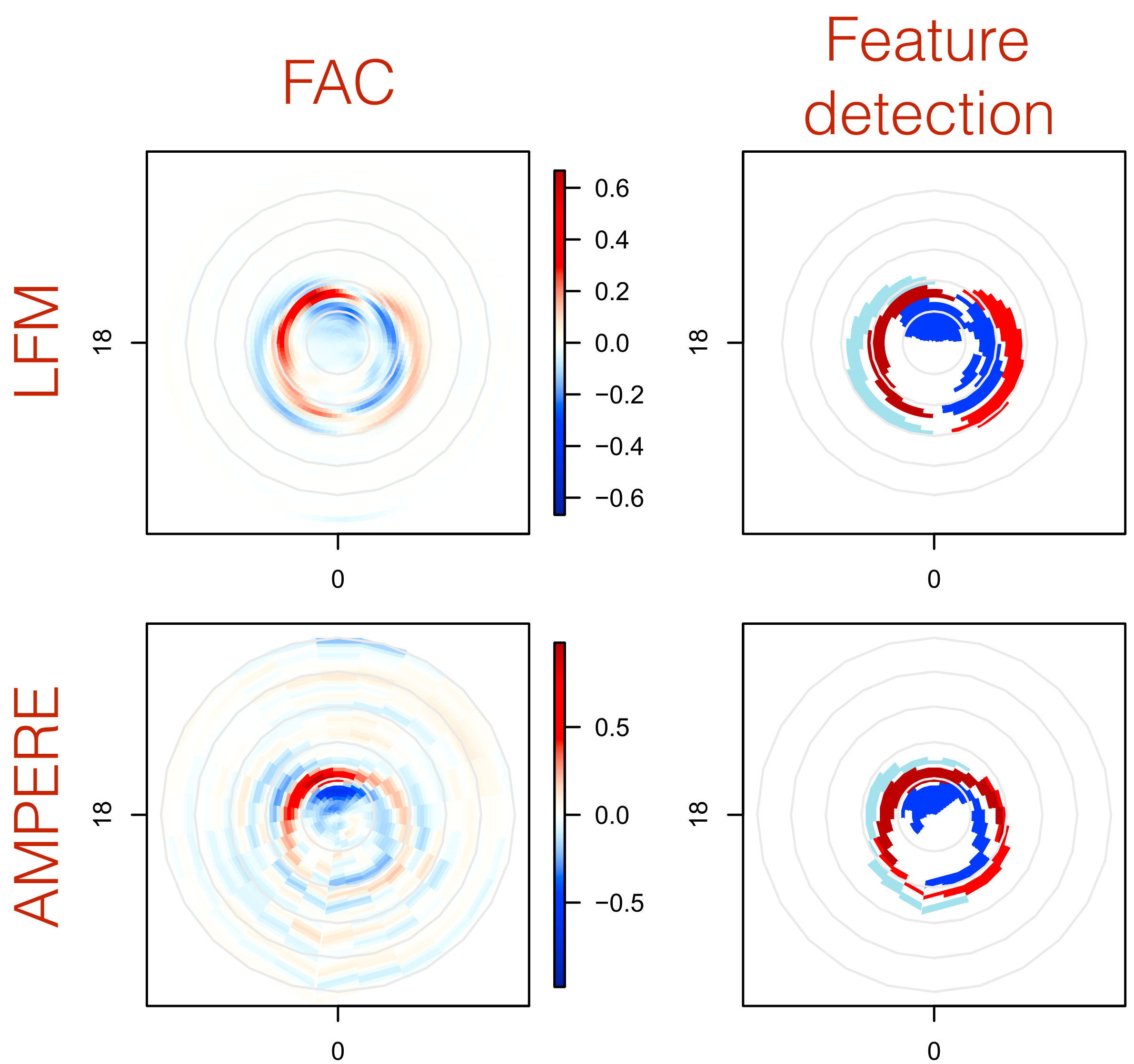


- AMPERE FAC density lower than LFM.
- Is it true for dB magnitude?
- dB magnitudes agree very well in regions where sheet currents are a good approximation.

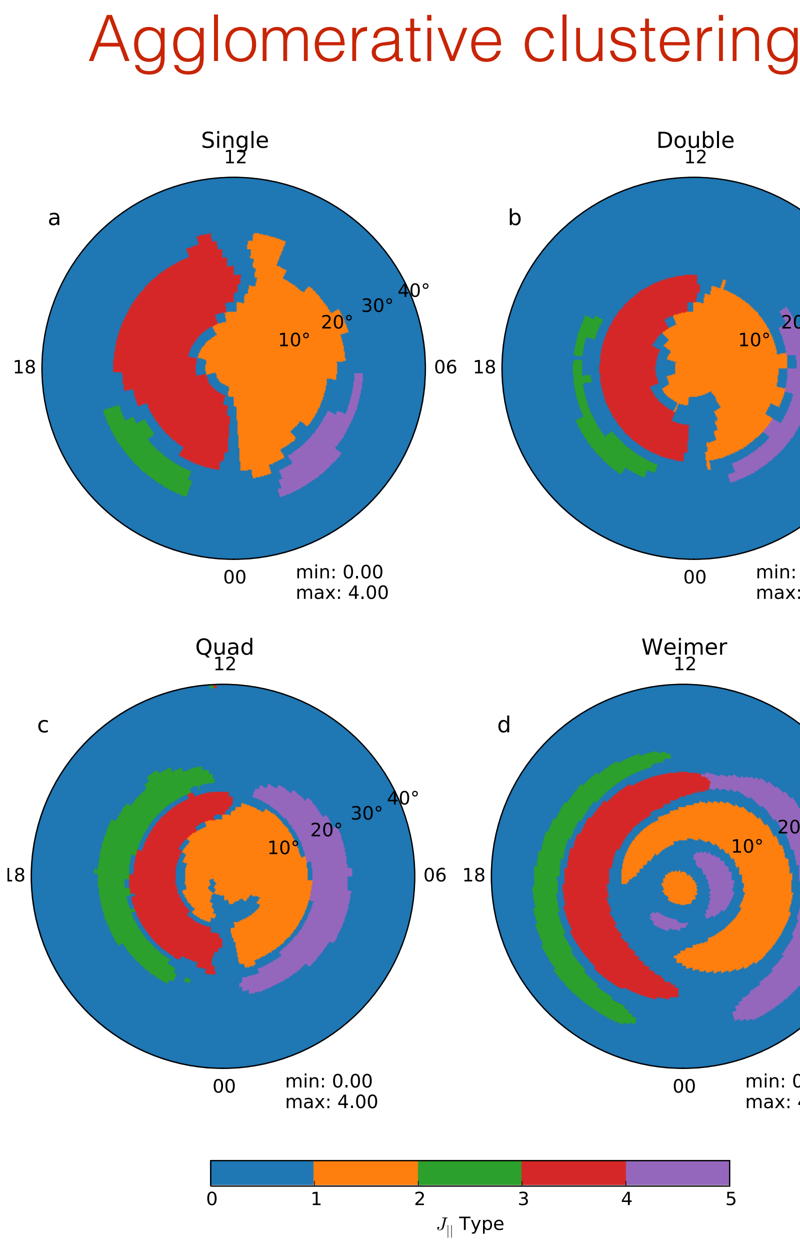
Merkin et al. [2013]

Feature-based model validation

Same event as Merkin et al. [2013]



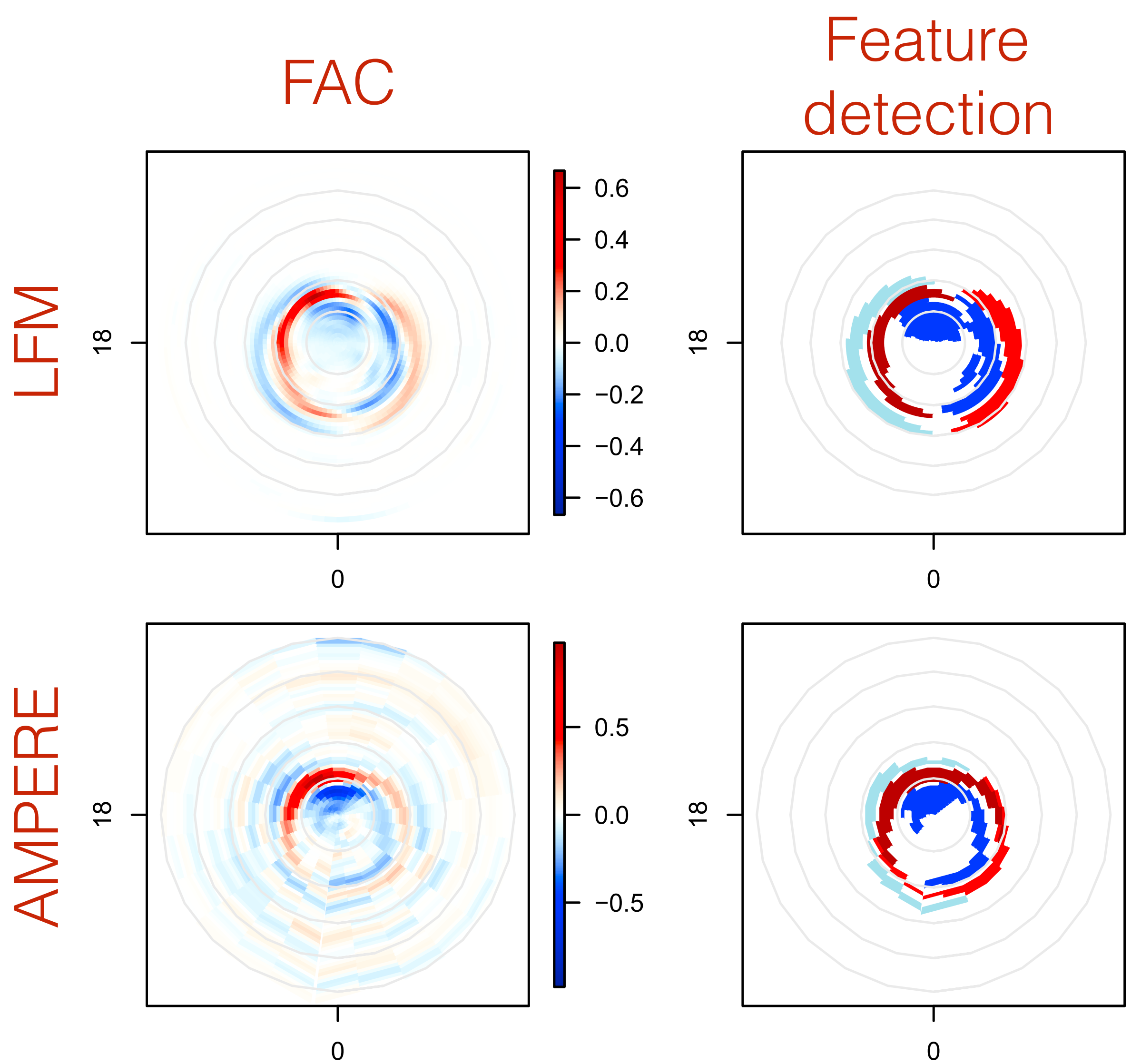
Kleiber et al. [2015]



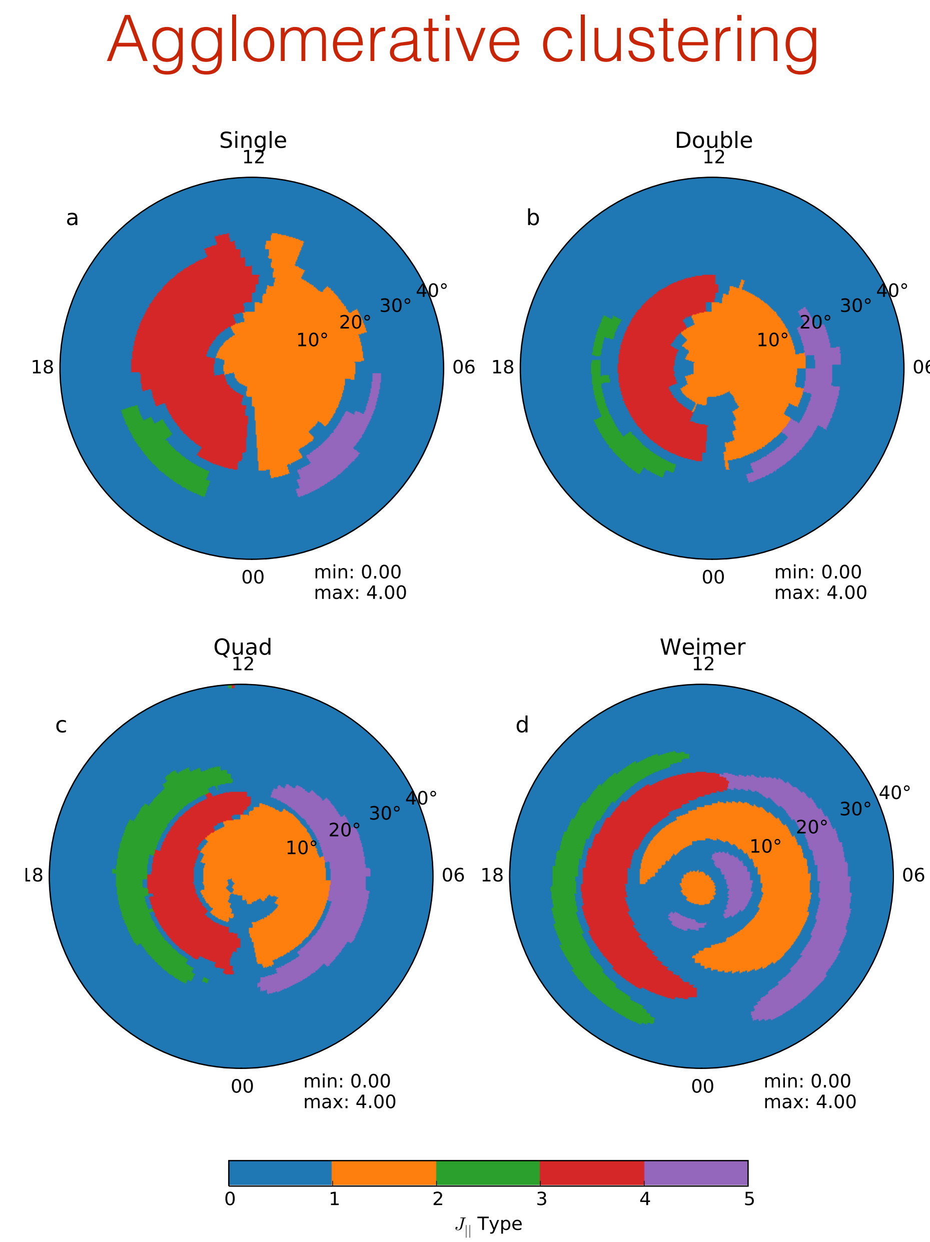
Wiltberger et al. [2016]

Feature-based model validation

Same event as Merkin et al. [2013]



Kleiber et al. [2015]

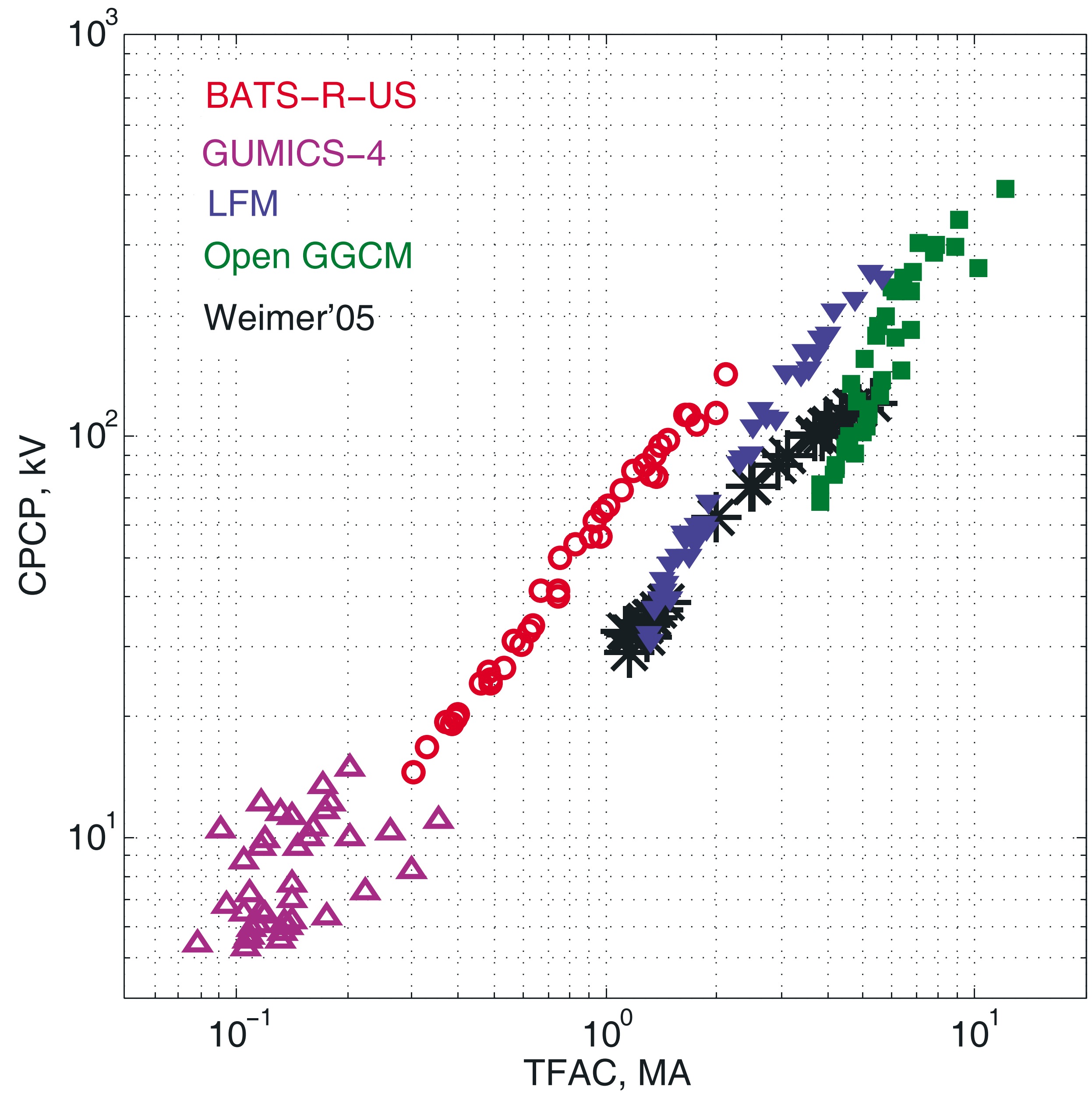


Wiltberger et al. [2016]

- New types of validation enabled by global data sets

Global ionosphere datasets: Going beyond a single parameter

- AMPERE, SuperMAG and SuperDARN (together with SUSSI, etc.) can now be used to provide global simultaneous maps of key ionospheric electrodynamic parameters.
- Proof of principle: current-voltage relationship compared with Weimer model.



Gordeev et al. [2015]

Summary

- Global observational FAC patterns became available only recently.
- Together with other global ionospheric data sets they provide a new type of a validation tool for global codes.
- Validation exercise gets more complicated: “global” usually means temporal and spatial dimensions are intermingled. Time-dependent comparisons are a challenge on fast scales, but possible if care is taken.
- New types of comparison algorithms need to be developed, e.g., pattern recognition. Efforts are already underway.
- Combined analysis of available ionospheric datasets with models provides insight into the physics of the system previously impossible to glean.