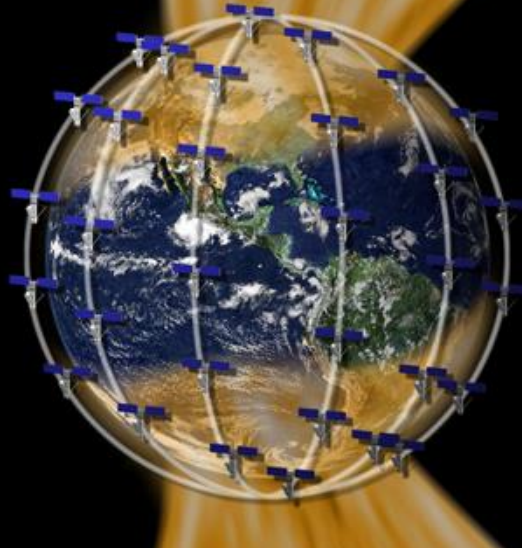


Recent Science Results from

AMPERE



Active
Magnetosphere and
Planetary
Electrodynamics
Response
Experiment

**Applications to Advancing our
Understanding of Magnetosphere-
Ionosphere-Thermosphere Coupling**

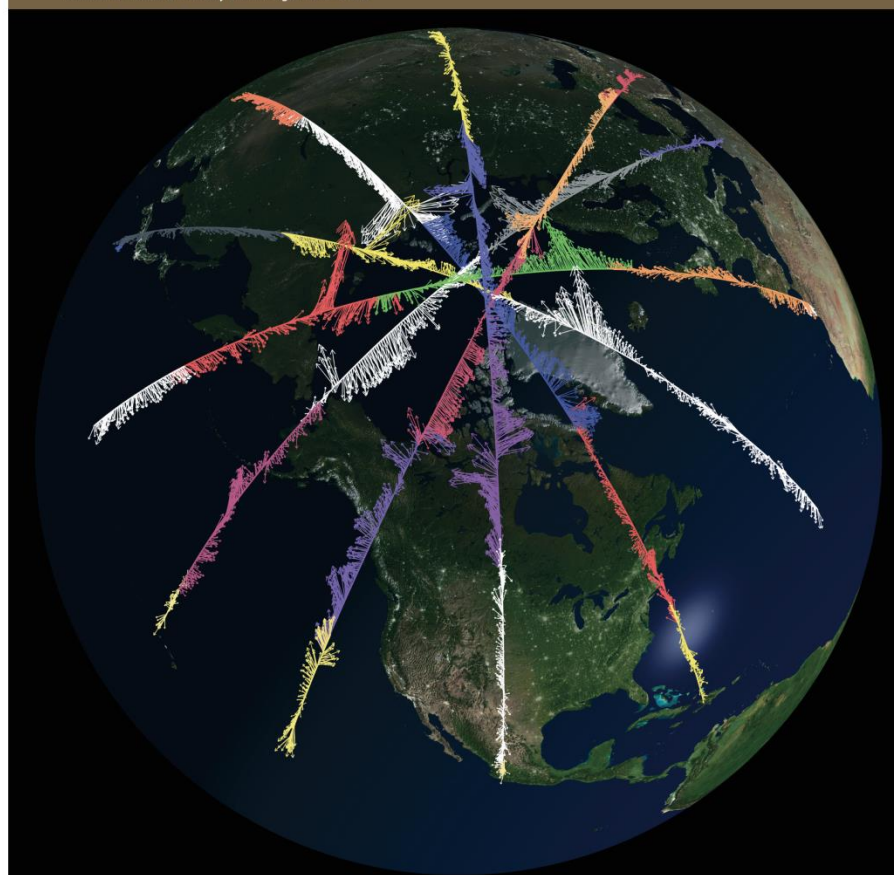
Brian J. Anderson, Haje Korth, Colin L. Waters,
Viacheslav G. Merkin, and Robin J. Barnes

- **Magnetometer on every satellite**
 - Part of avionics
 - **30 nT resolution: S/N ~ 10**
- Satellite communication network continuous true real-time data transmission to ground
- **>70 satellites, 6 orbit planes, ~11 satellites/plane**
- Six orbit planes provide 12 cuts in local time.
- 9 minute spacing: re-sampling cadence
- **780 km altitude, circular, polar orbits**
- Polar orbits ensure coverage for all levels of geomagnetic activity

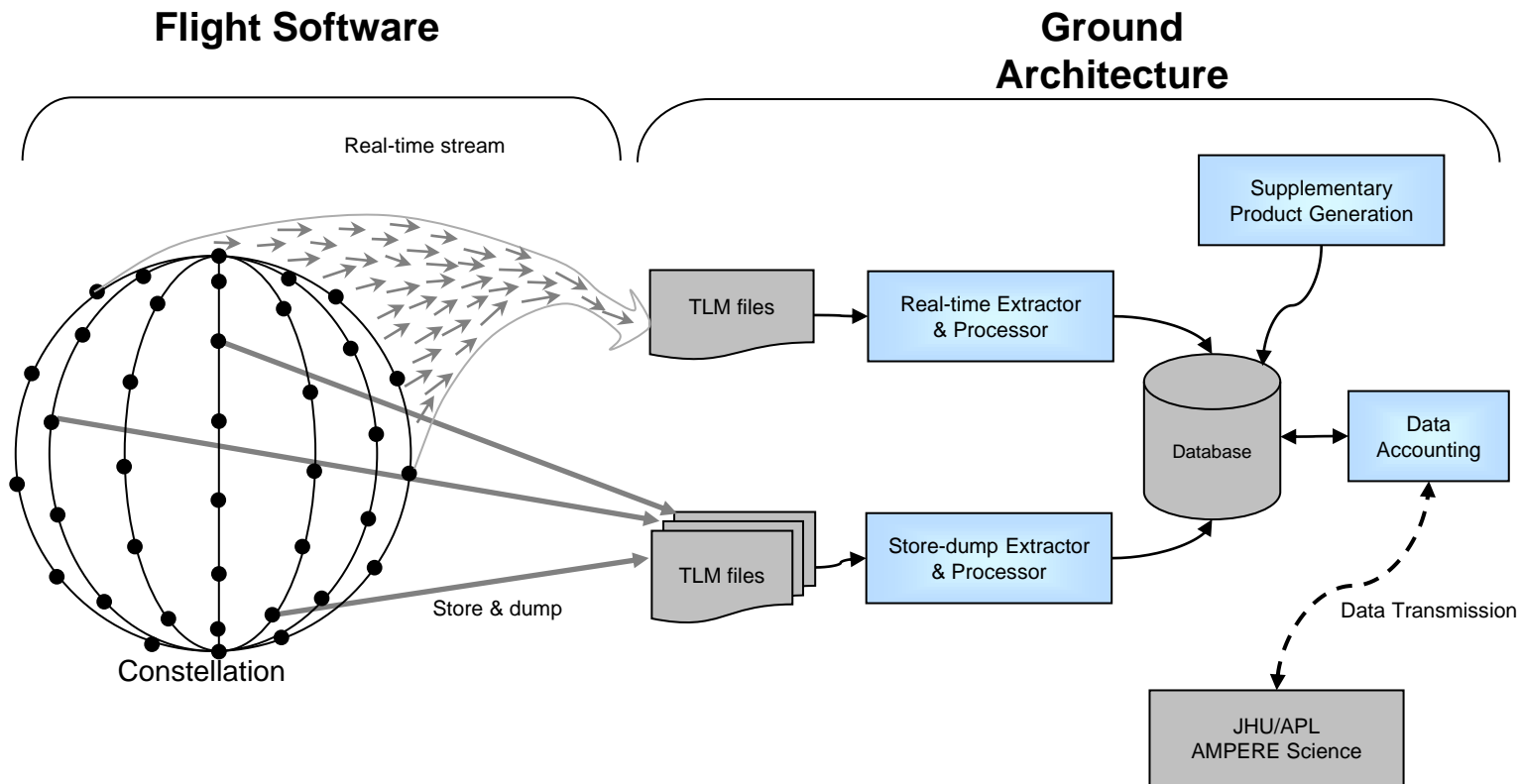
Geophysical Research Letters

AN AGU JOURNAL

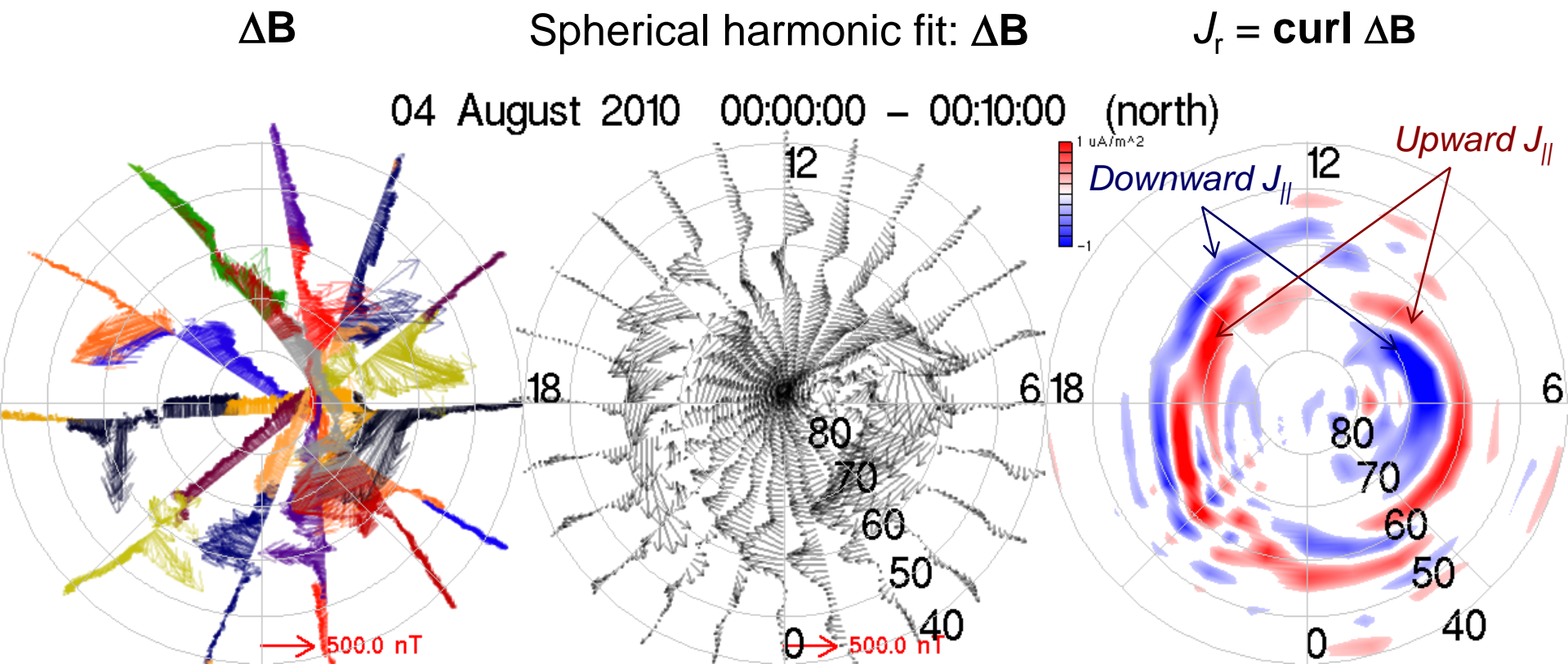
Volume 41 • Issue 9 • 16 May 2014 • Pages 3017–3322



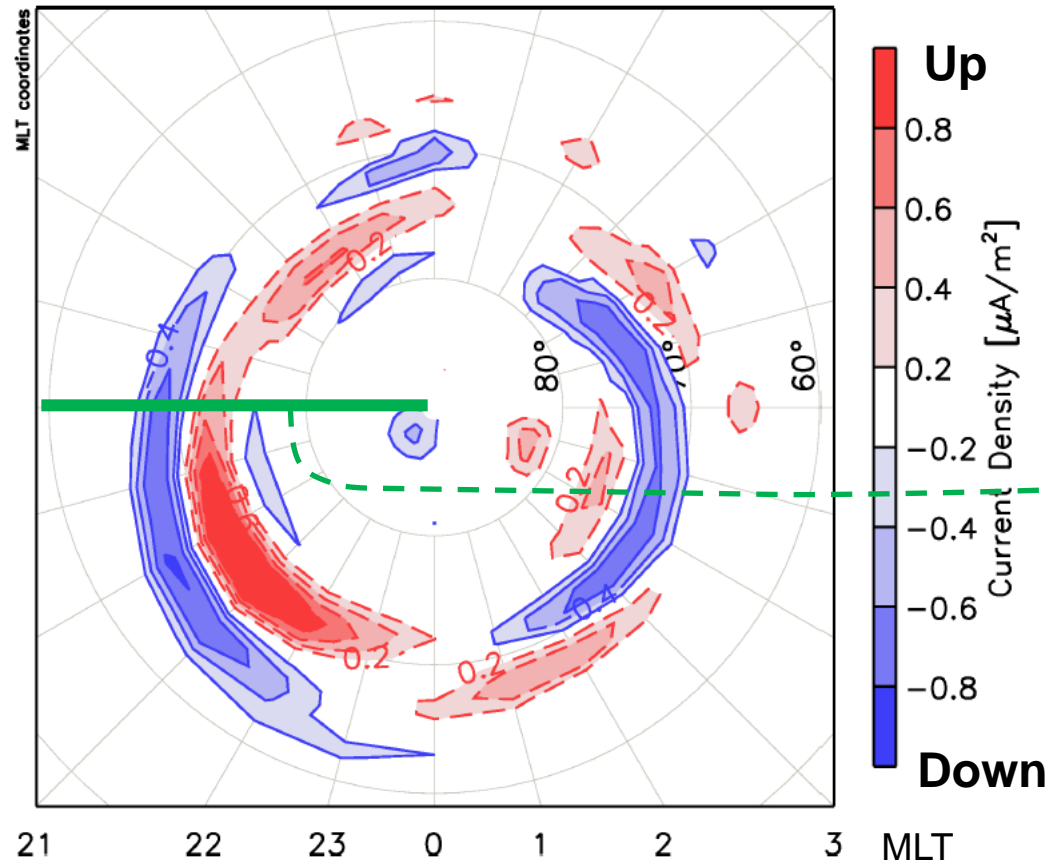
- Flight software acquires magnetometer samples at 20s or 2s intervals on every satellite 24/7
- Transmits to ground in real-time over satellite network
- Store & dump data used fill any gaps; definitive orbit/attitude



- Vector $\Delta\mathbf{B}$, data, continuous $\Delta\mathbf{B}$ map via SH fit
- J_r from Ampere's law applied to horizontal $\Delta\mathbf{B}$
- Time cadence: 9 min set by inter-spacecraft separation
- Lat res: 1.15° for 19.44s sampling, 0.13° for 2.16s sampling

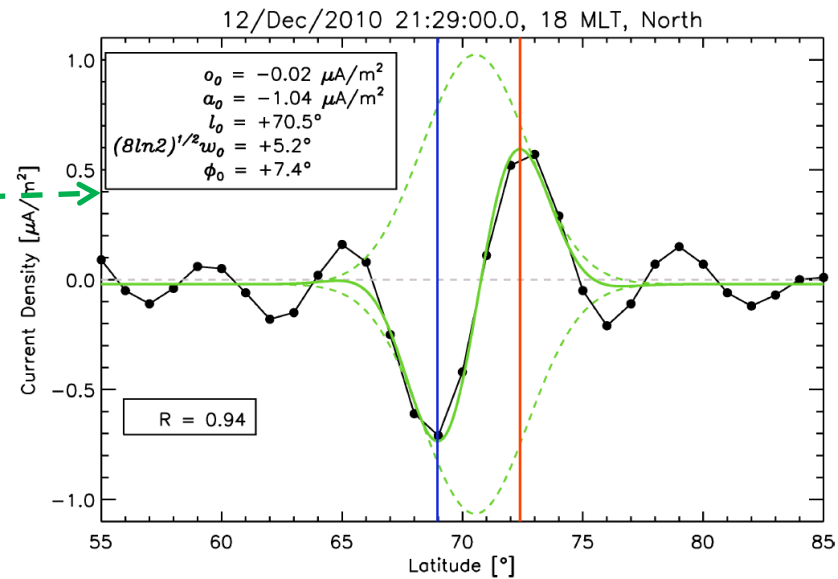


AMPERE Currents: 12 December 2010 21:29-21:39 UT



Fit to J_r : gaussian x sin

$$j_{\text{fit}}(l) = o_0 + a_0 \exp\left(-\frac{(l-l_0)^2}{2w_0^2}\right) \sin\left(2\pi\frac{l-l_0}{2\sqrt{8\ln 2}w_0} + \phi_0\right)$$



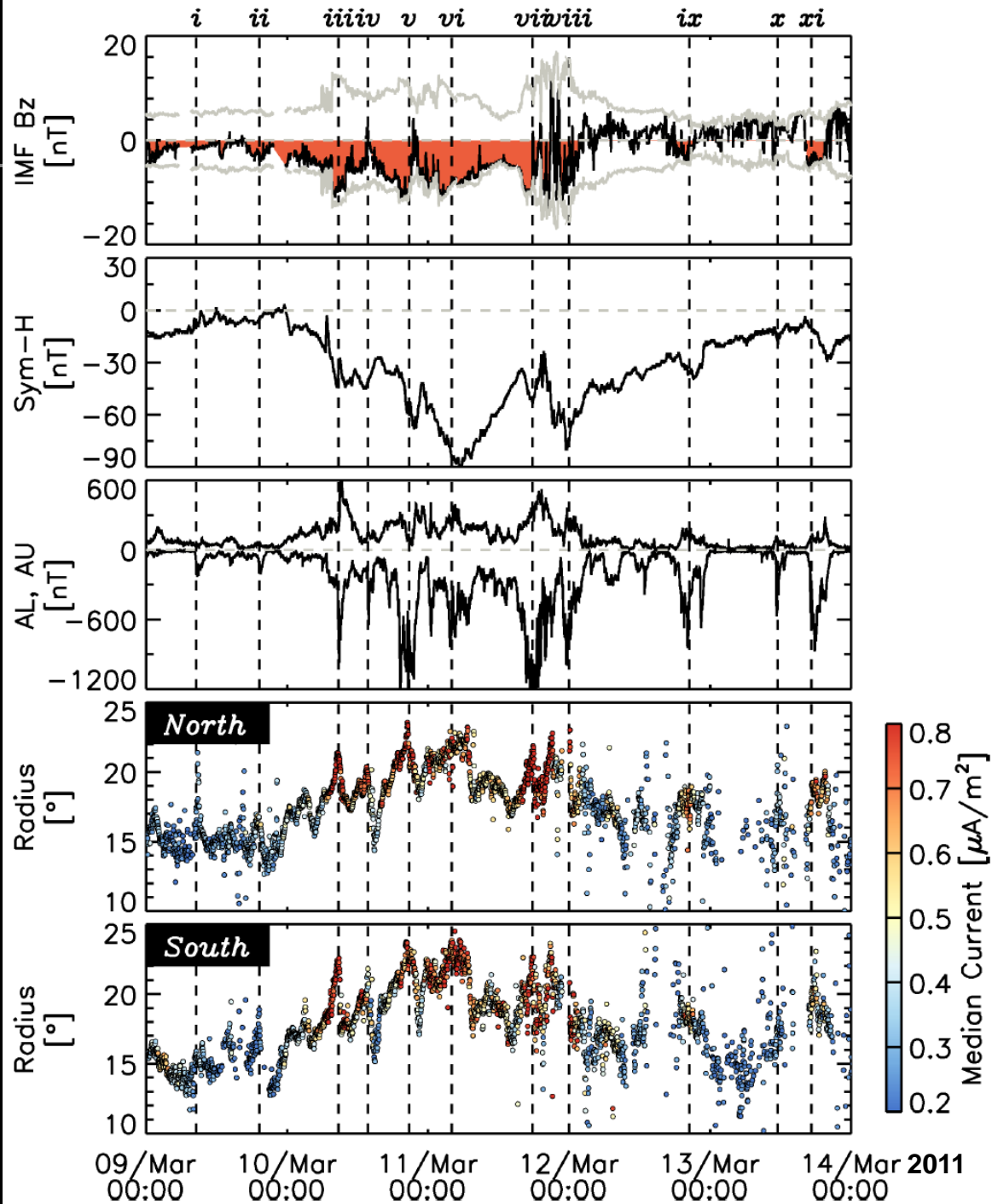
R1 oval co-latitude vs time.

Substorm onsets: *i*, *ii*, ... *xi*

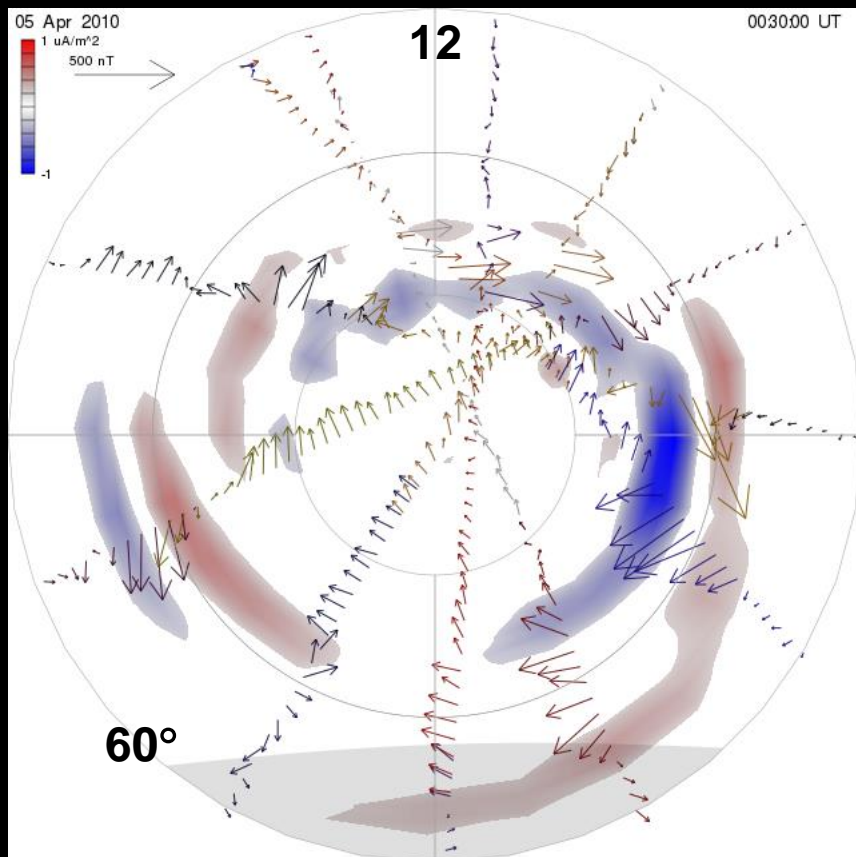
N/S are in close agreement.

R1 oval expansions & contractions are consistent with growth-onset-recovery substorm cycle

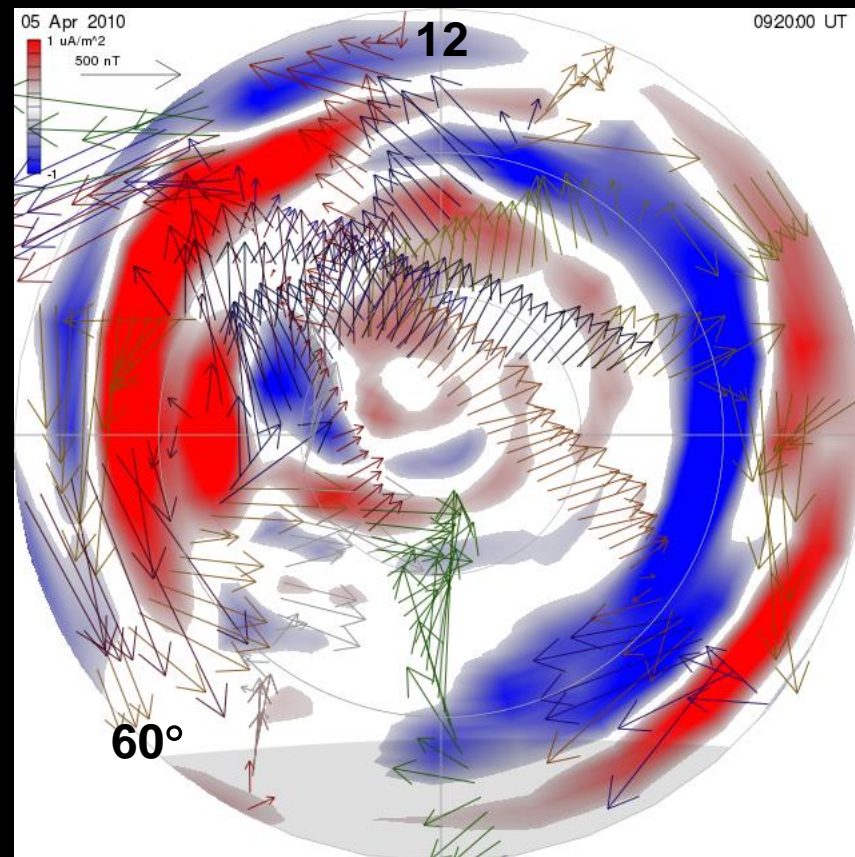
Clausen et al., 2012



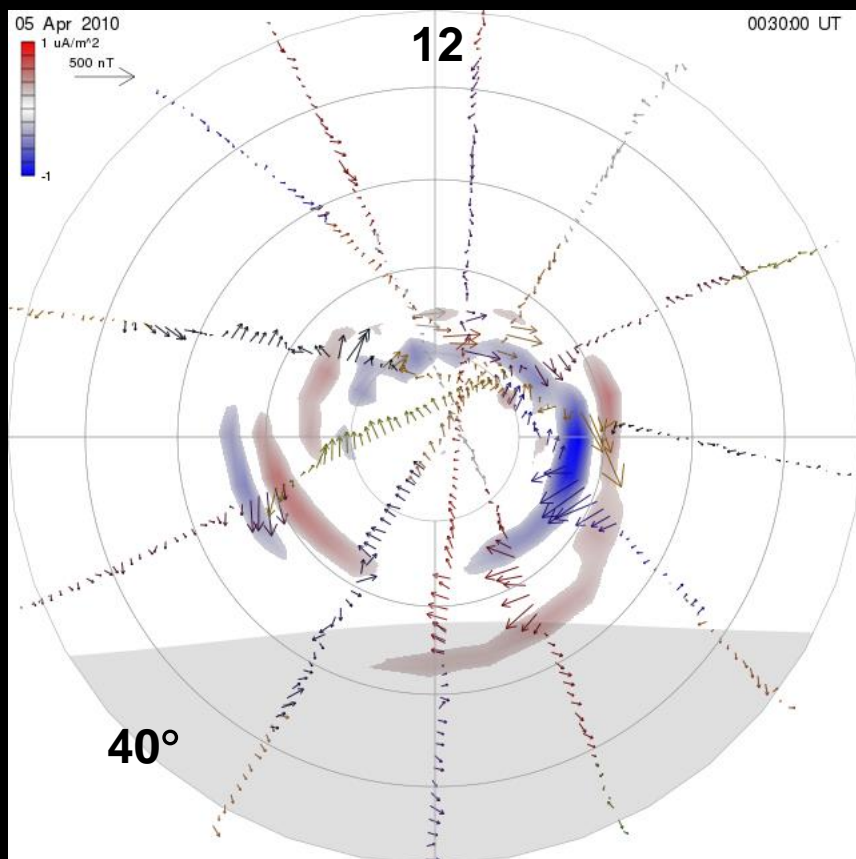
2010 Apr 5: 0030 – 0040 UT



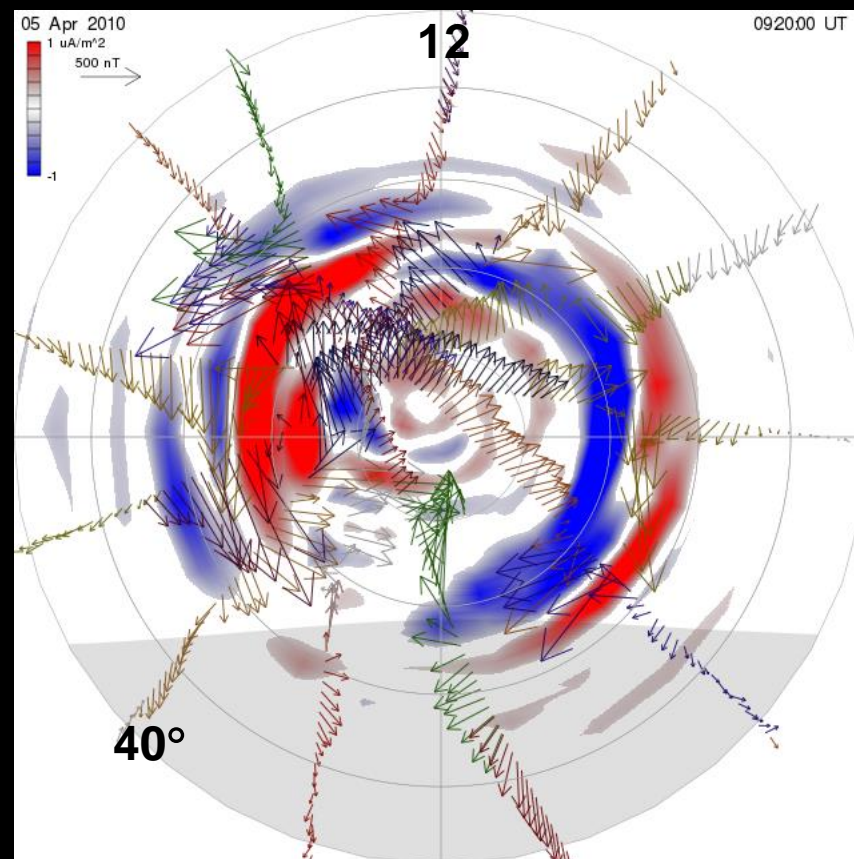
2010 Apr 5: 0920 – 0930 UT



2010 Apr 5: 0030 – 0040 UT

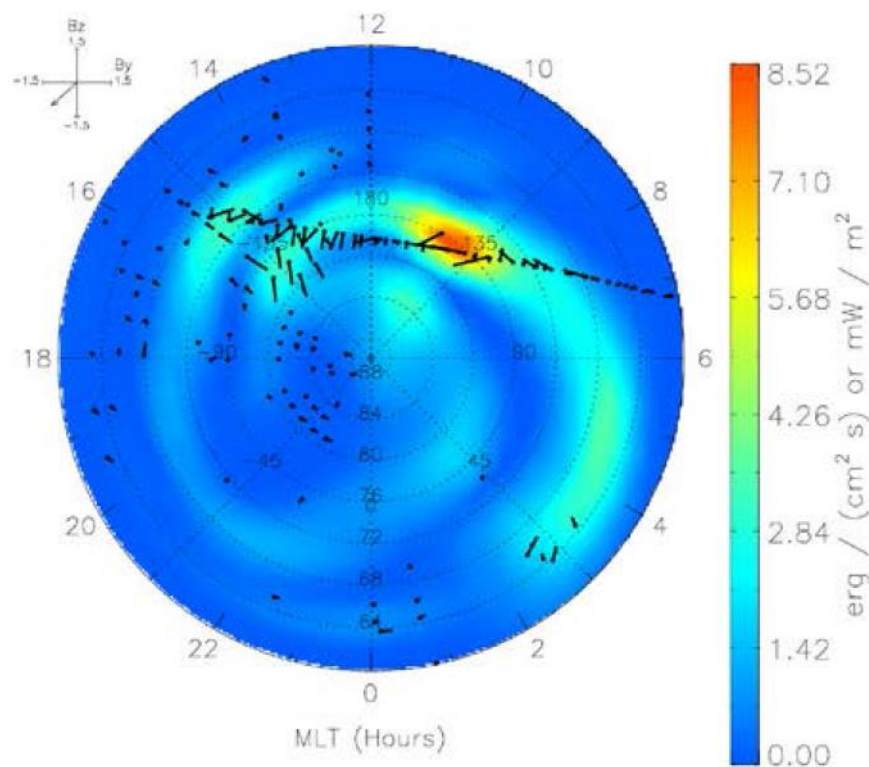


2010 Apr 5: 0920 – 0930 UT

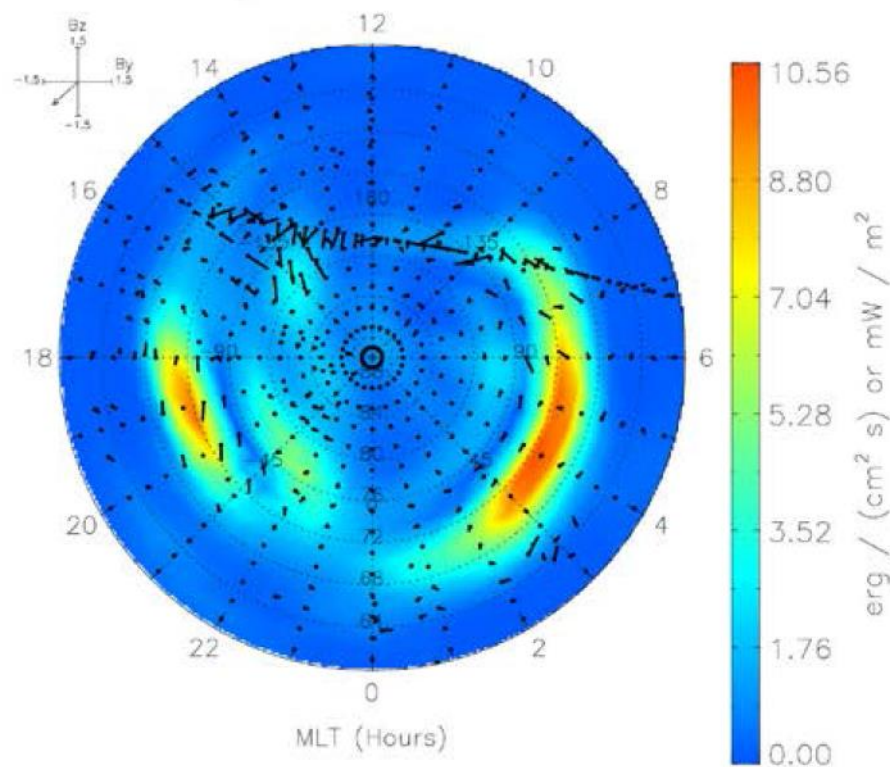


Ionospheric Integrated Joule Heating from NCAR-AMIE 00:30-00:40 UT 5 April 2010

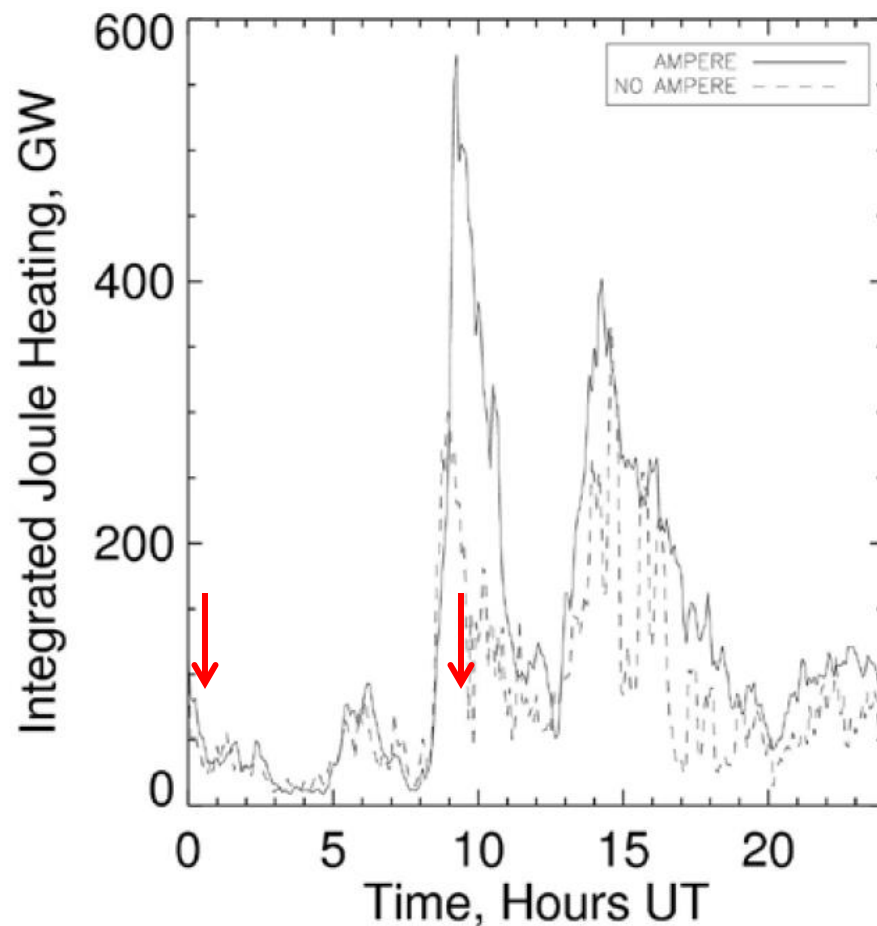
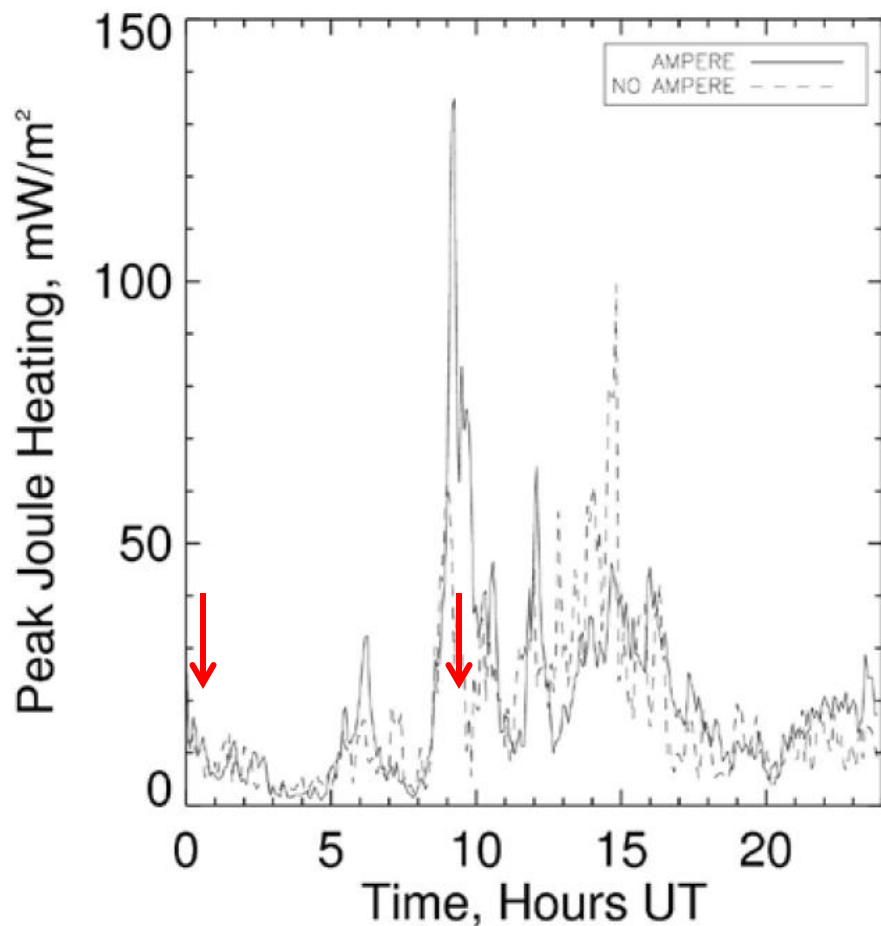
Ground magnetometers,
DMSP E-field, SuperDARN



AMPERE Included

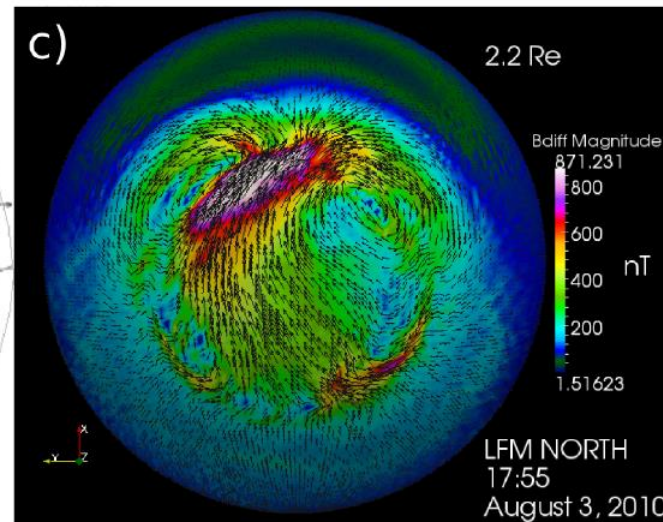
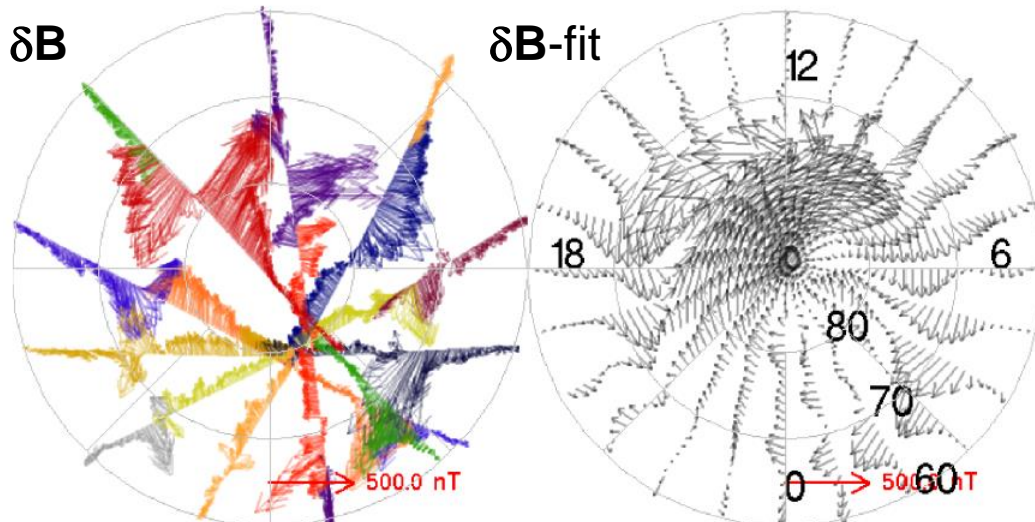


Ionospheric Integrated Joule Heating from NCAR-AMIE 5 April 2010

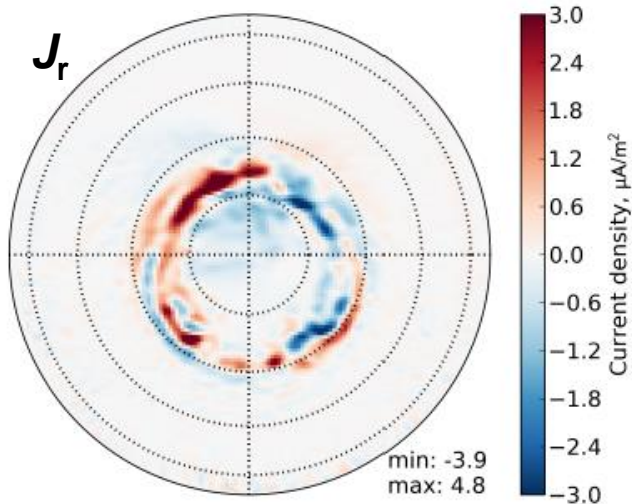


03 August 2010 17:50-18:00 (north)

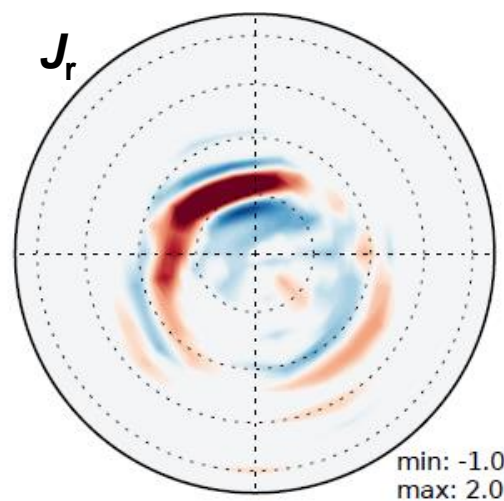
Merkin et al., 2013



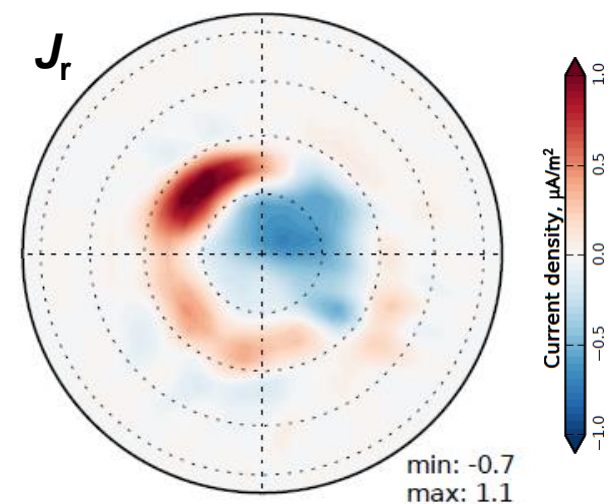
LFM High res.: 17:55:38



AMPERE: 17:50-18:00

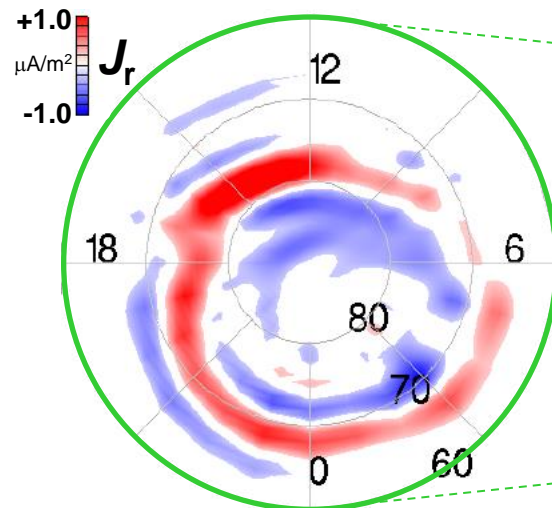
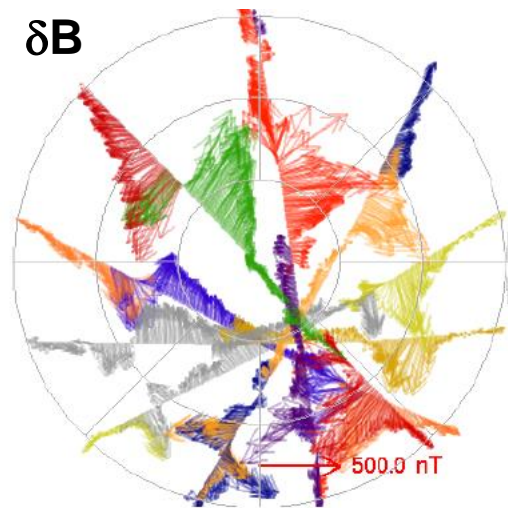


LFM Low res.: 17:55

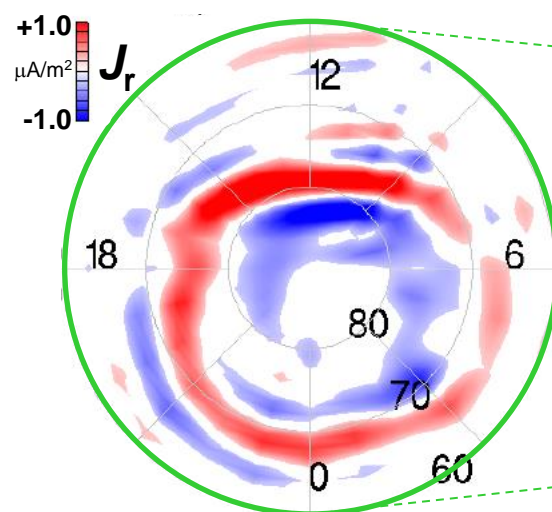
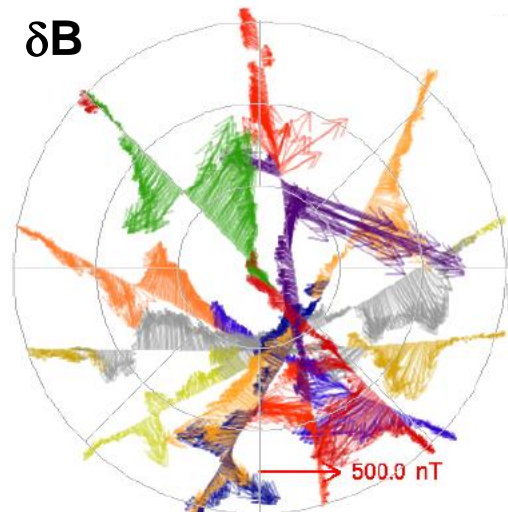
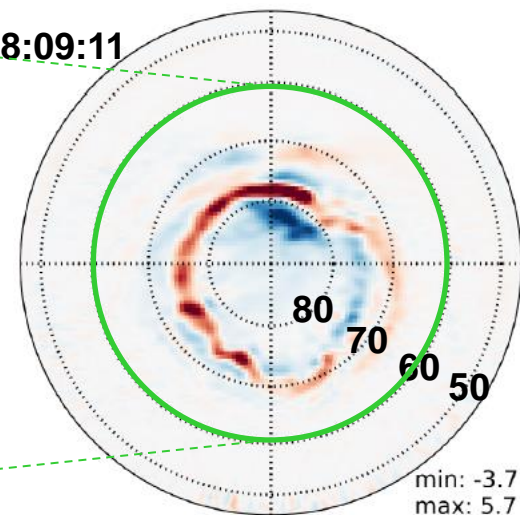


AMPERE 3 August 2010 17:58-18:08 UT (north)

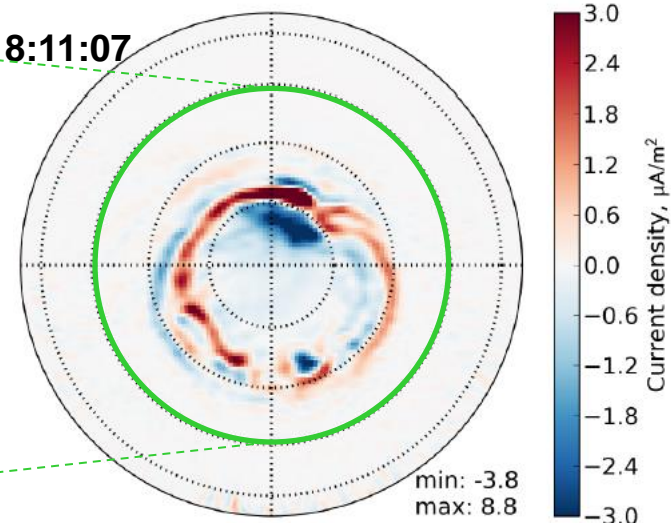
LFM High Resolution J_r



18:09:11

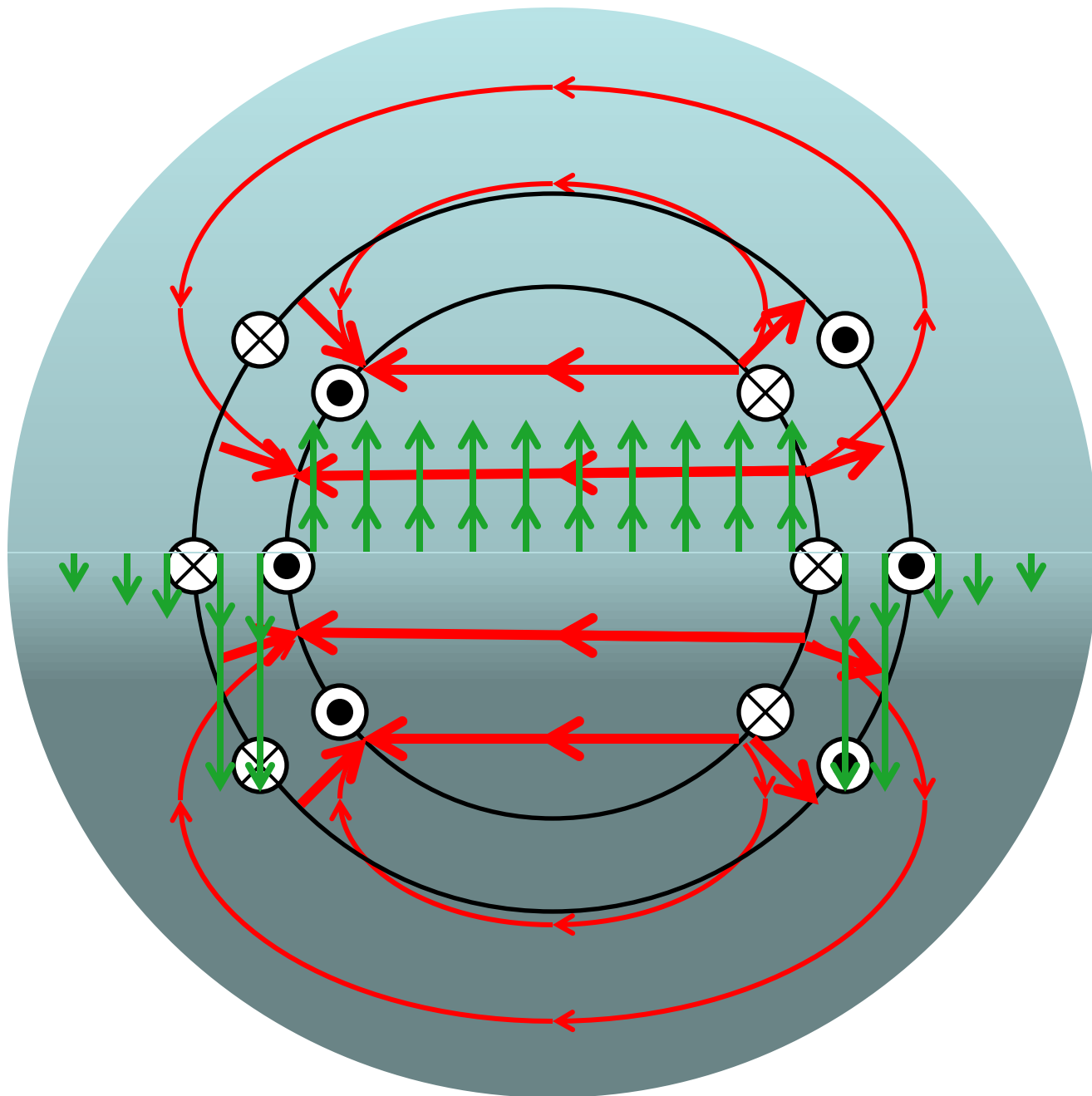


18:11:07



Sun
↑

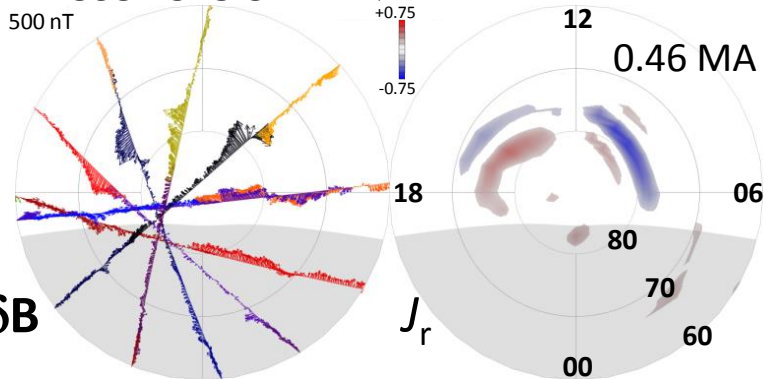
\otimes
B



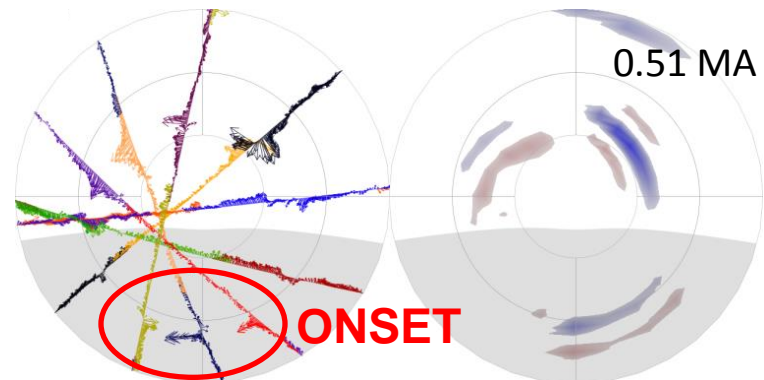
24 February 2010

AMPERE

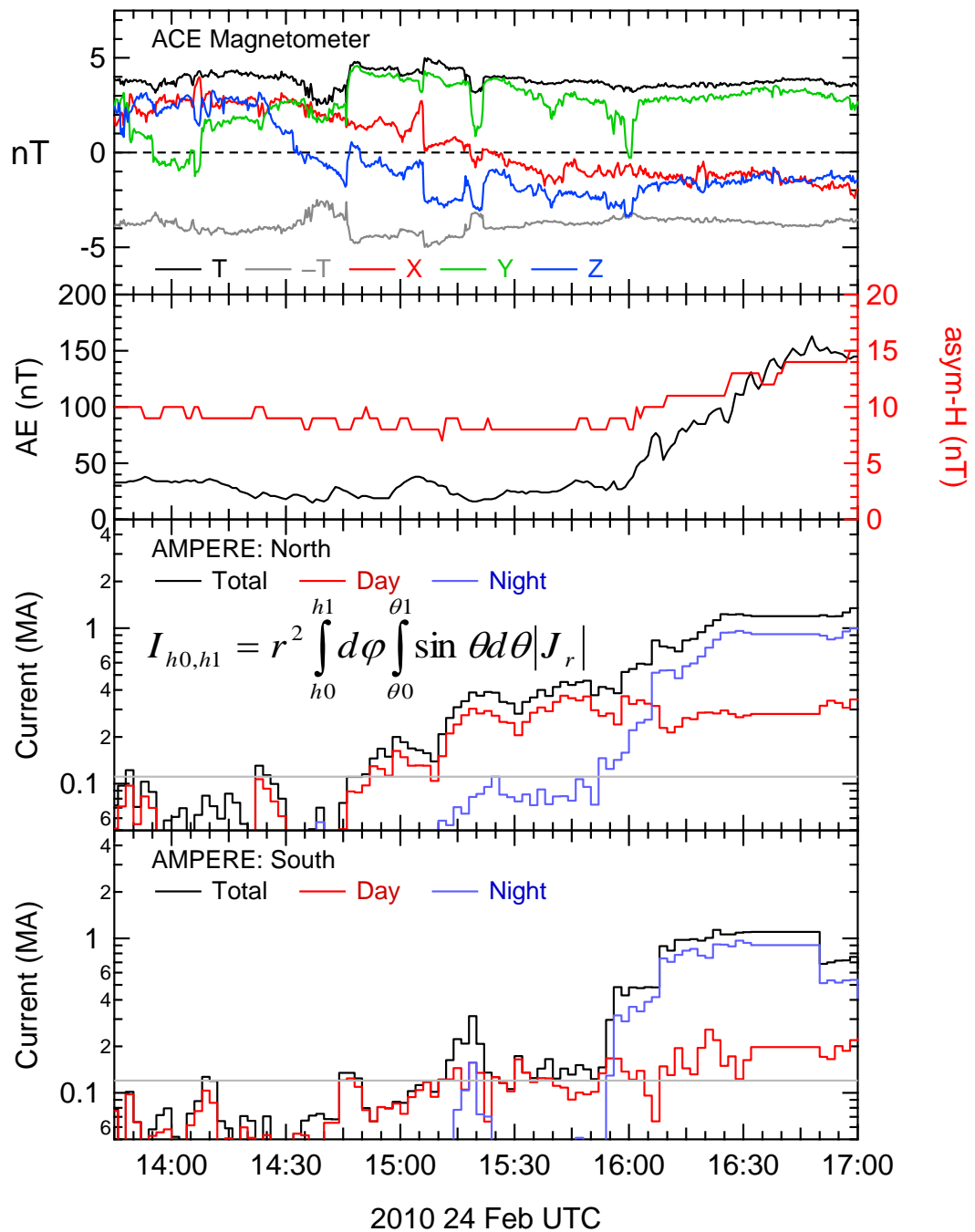
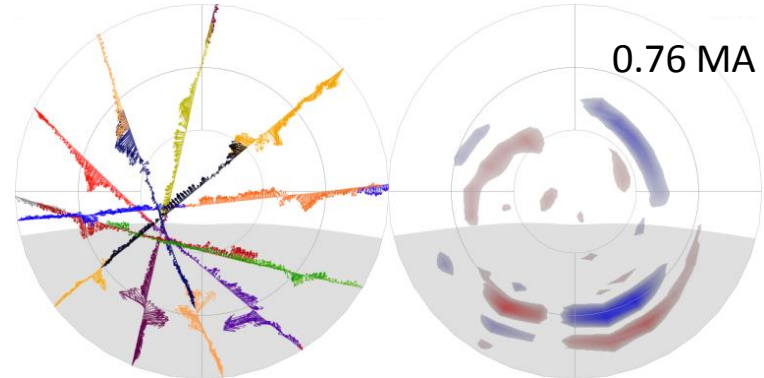
1538-1548 UT



1548-1558 UT



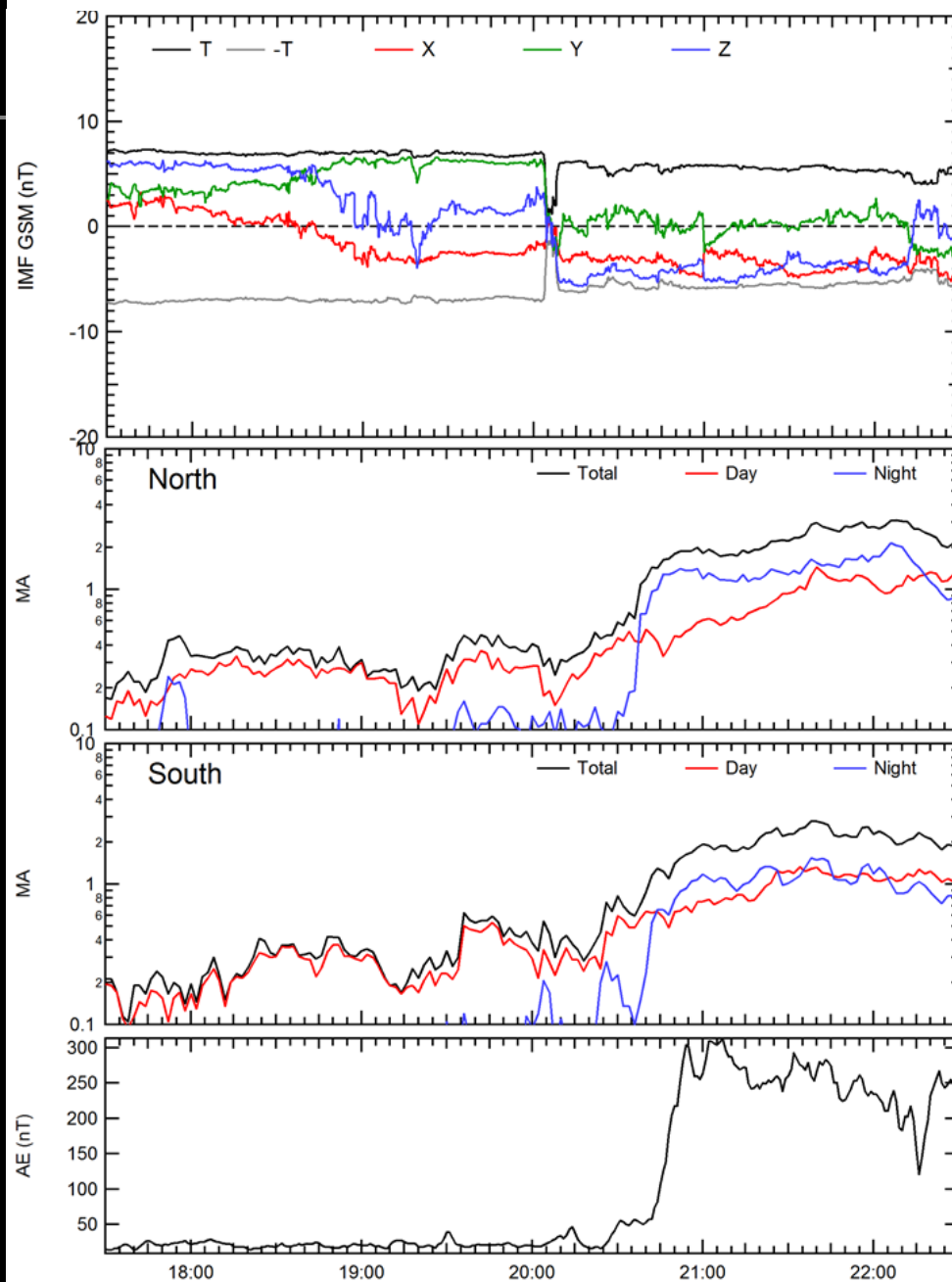
1558-1608 UT

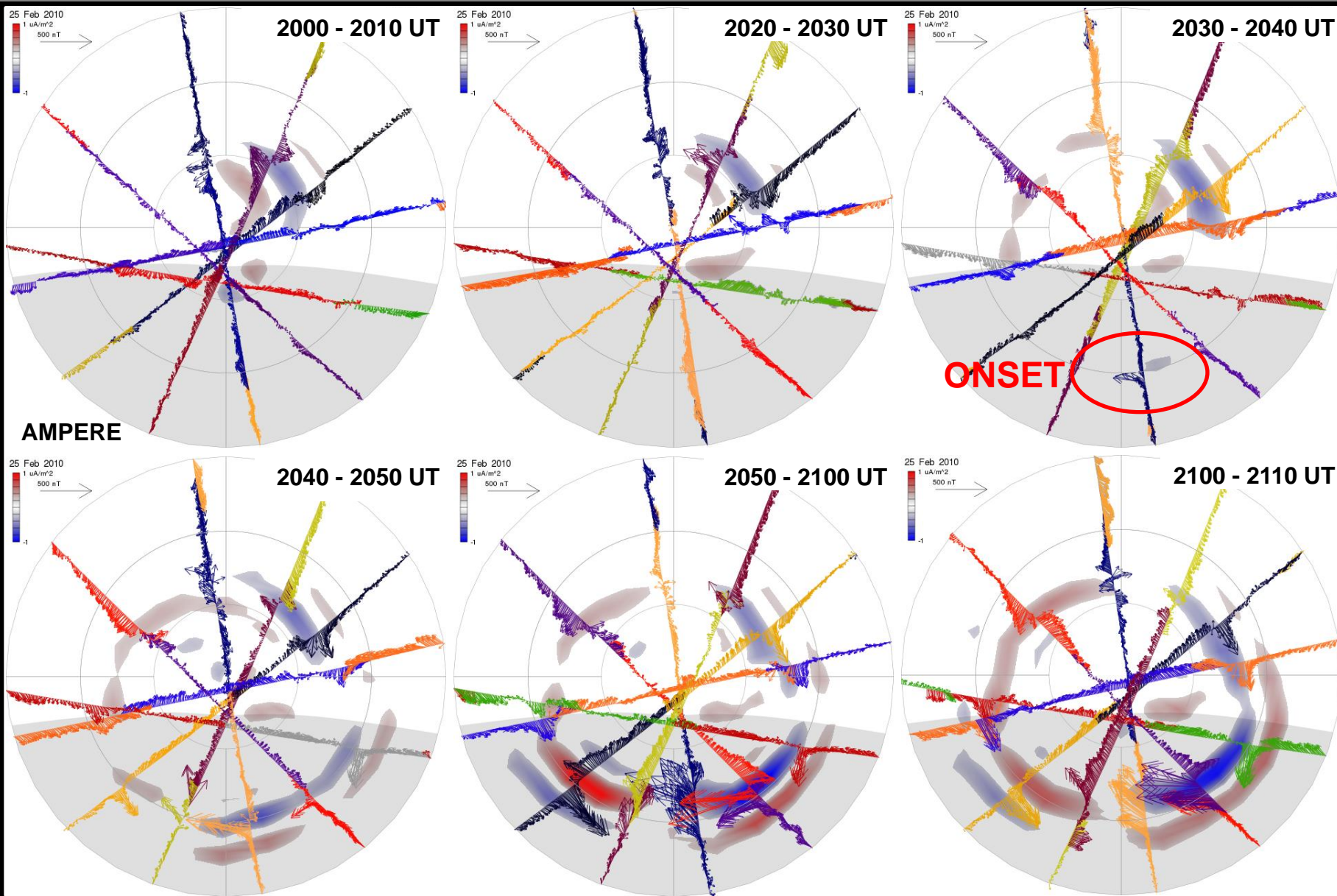


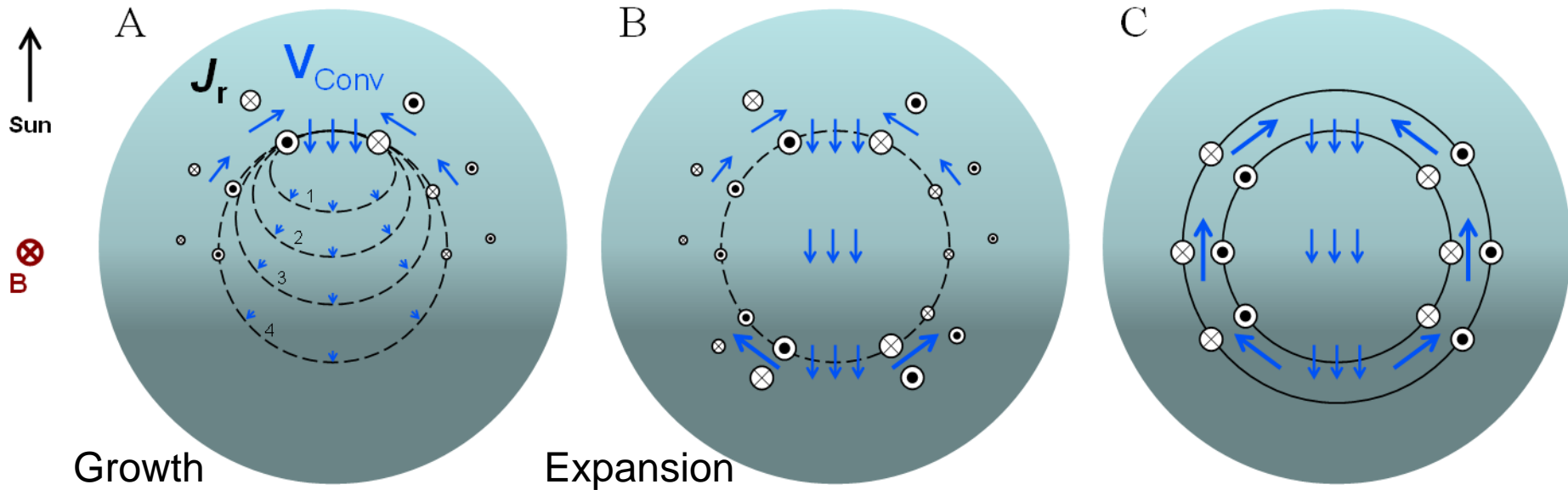
Anderson et al., 2014

- January – June 2010
- Scan for sudden increases in I_{Tot}
- 24 clear cases: all show same basic pattern:
 - Southward IMF turning
 - Dayside R1 (&R2)
 - Night-side onset of R1&R2 ~40 min later
 - Expansion of full R1/R2.

2010 Feb 25







- Fringing E-fields during growth and early expansion phase may contribute substantially to penetration E-field effects.
- Modeling inner magnetosphere and ionosphere response to imposed R1 currents does not reflect actual system dynamics.

- AMPERE-II concept:
 - AMPERE-Continuation: on Iridium (Block-1)
 - AMPERE-NEXT: on Iridium NEXT (Block-2)
 - Replacement launches begin in 2015.
- AMPERE-NEXT:
 - Iridium-NEXT satellites do have magnetometers.
 - AMPERE on NEXT will be different but superior.
 - Same orbital configuration: 6 orbit planes with 11 SVs equally spaced in each plane.
 - Time sampling will be fixed but return more than twice as much data as the present AMPERE standard rate: $<0.5^\circ$ latitude resolution 24/7.
 - Attitude knowledge: $\sim 10x$ greater accuracy. Higher quality $\delta\mathbf{B}$ data, more stable baselines (cf. Knipp et al., 2014).

- Add community products: e.g. Claussen R1/2 fit, etc.
- Improve data processing:
 - Revise attitude estimation and baselines (cf. Knipp et al., 2014).
 - Reduce 'noise': ~2x reduction in δJ_r to ~0.07 mA/m².
- Higher latitude resolution inversions:
 - Data support down to 1.2° resolution
 - Need faster inversion algorithm
- Ingest other magnetometer data: DMSP, SWARM?
- Regional inversions
 - Orbit crossing region is often in cusp or substorm onset region
 - Apply finite-element or other inversion algorithms
- Multi-data type inversions
- Community
 - Users group, steering committee, user working meetings virtual (webinars) and real (SWW, GEM/CEDAR)

- AMPERE-II budgets under revision. (Data from 1 June 2013 forward are not yet purchased.)
- Funding is constrained.
- Science priority: make sure the data and products we have are as reliable and useful as possible.

Thus

AMPERE-II will include only low rate AMPERE Continuation data (**no high rate data or any Iridium NEXT data**) and work on improving the data processing products, and involving the community. The AMPERE data will begin to degrade starting in 2015 as Iridium NEXT launches occur.