

Analysis of Multi-Spacecraft Observations with SWMF/BATS-R-US+RCM

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CCMC contribution: L. Rastaetter, M. Mendoza

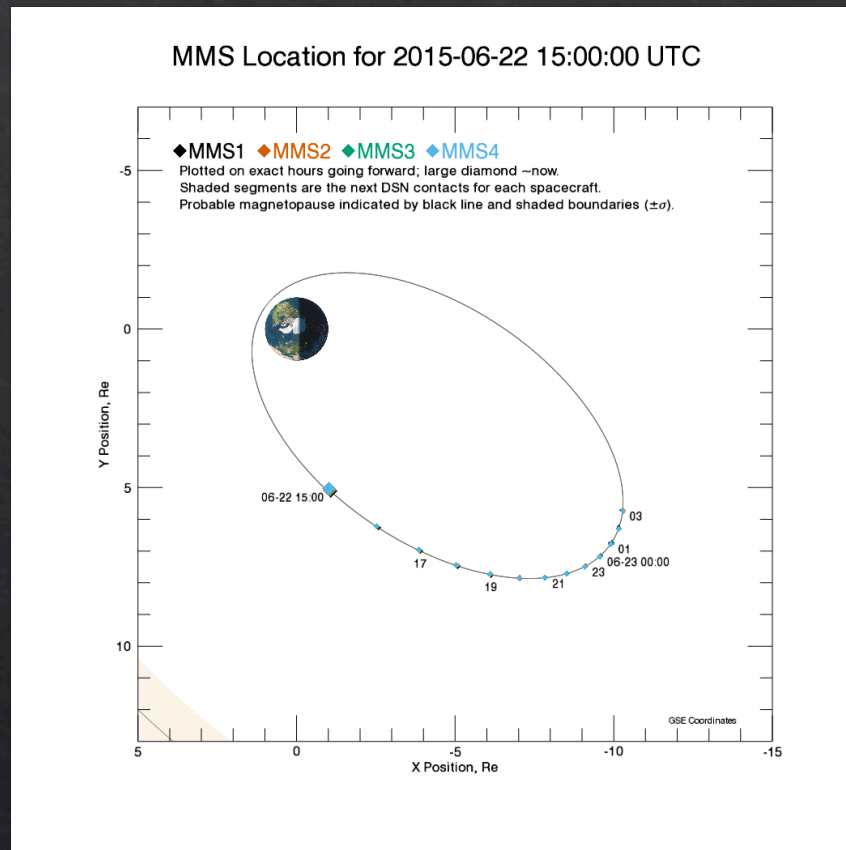
BATS-R-US+RCM at CCMC

- ◇ BATS-R-US+RCM is a version of Space Weather Modeling Framework (SWMF) that is configured as a global MHD code coupled to an inner magnetosphere.
- ◇ The code was developed to:
 - ◇ include particle drift physics in the inner magnetosphere to reproduce injection of keV particles (“ring current”) and the corresponding inflation of the magnetic field;
 - ◇ improve spatial resolution in the inner magnetosphere.
- ◇ Model has been available at CCMC for ~ 10 years (versions have changed). Runs on Request database shows a few hundred runs.
- ◇ This was the first time our group used it for analysis of multi-spacecraft observations.

Observations during June 22-23, 2015

- ◇ The biggest storm of the current solar cycle.
- ◇ This event occurred during the commissioning of the Magnetospheric Multiscale Mission (MMS). Although not all of the instruments fully operational, all of the magnetometers and many of the particle detectors were making measurements and saw the dynamic response of the magnetosphere.
- ◇ Other datasets:
 - ◇ Van Allen Probes
 - ◇ DMSP ionospheric flows
 - ◇ AMPERE field-aligned currents
- ◇ Data available in the inner magnetosphere on the nightside.

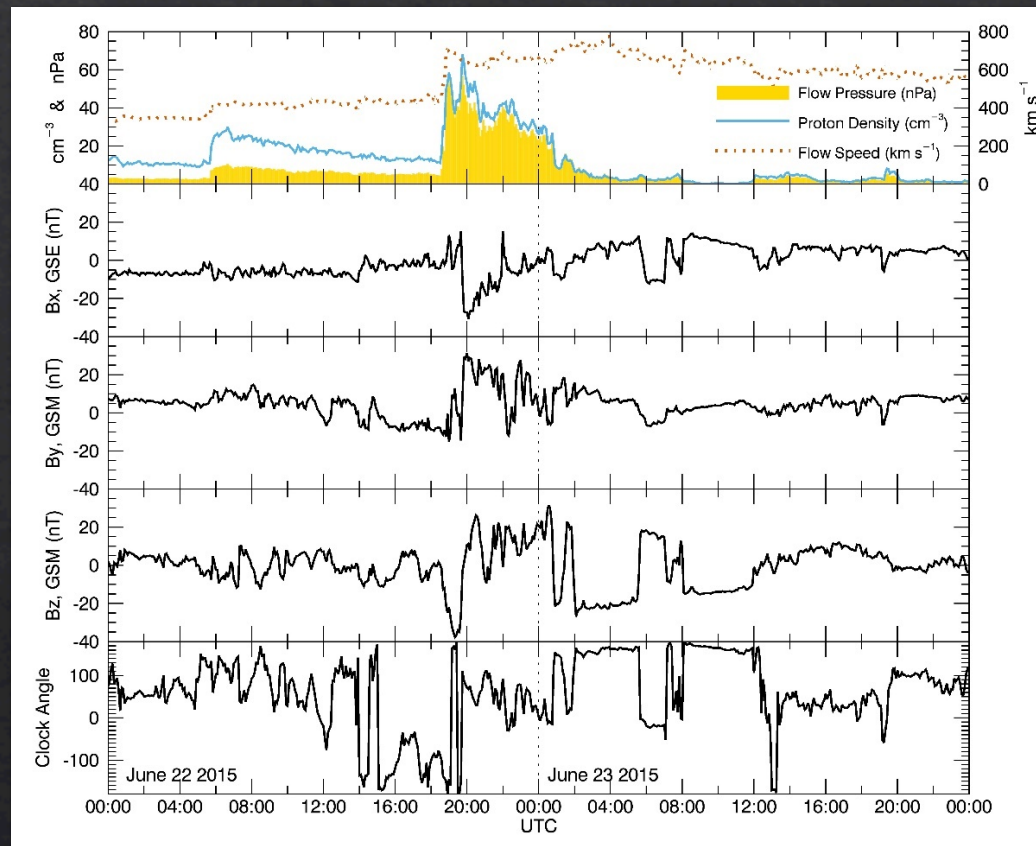
MMS Orbit in June 2015



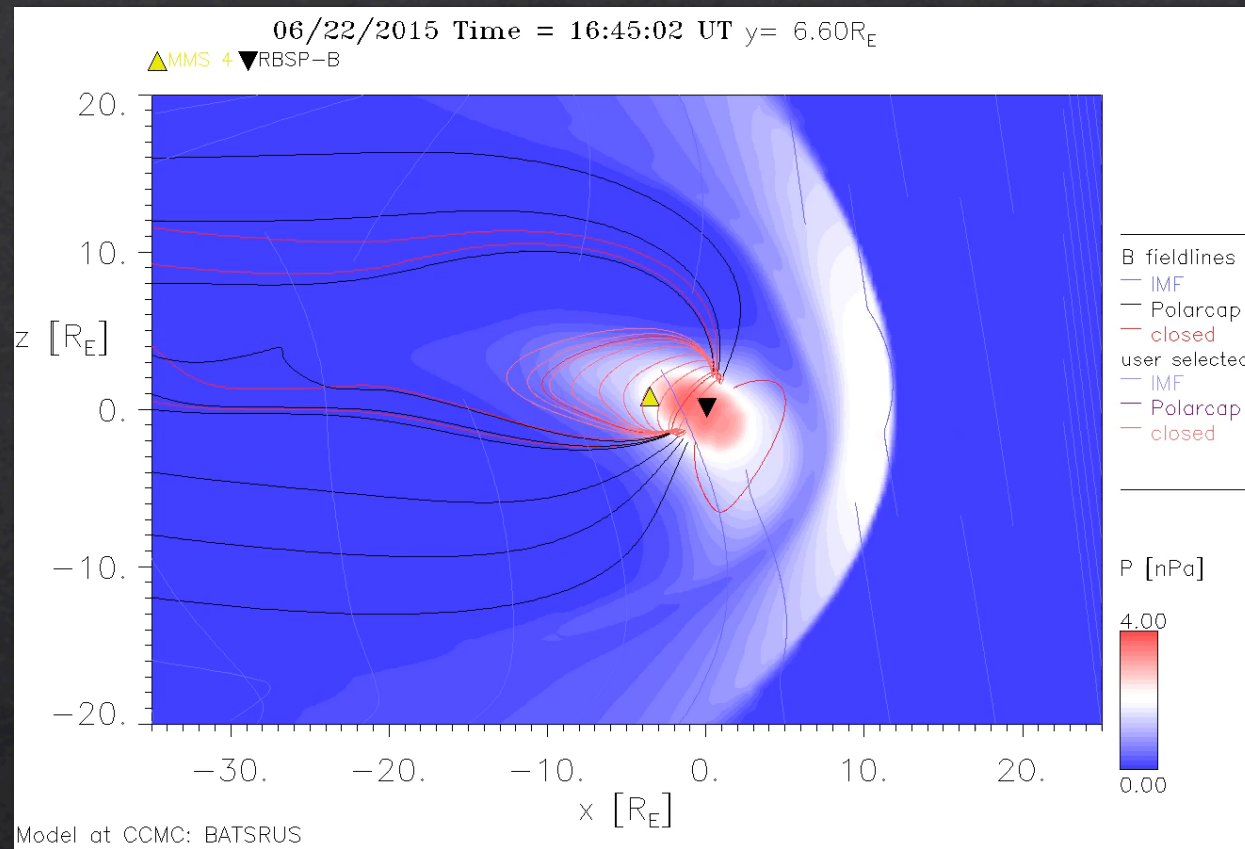
BATS-R-US+RCM simulations

- ◇ We used the code at CCMC and runs-on-request for this event (including special requests).
- ◇ Simulations were driven by time-shifted ACE solar wind and IMF data.
- ◇ Total of 3 runs (2 with 1 million cells, one with 2 million cells).
- ◇ Most of the analysis was done using CCMC web-based visualization tools.

June 22-24, 2015 Magnetic Storm

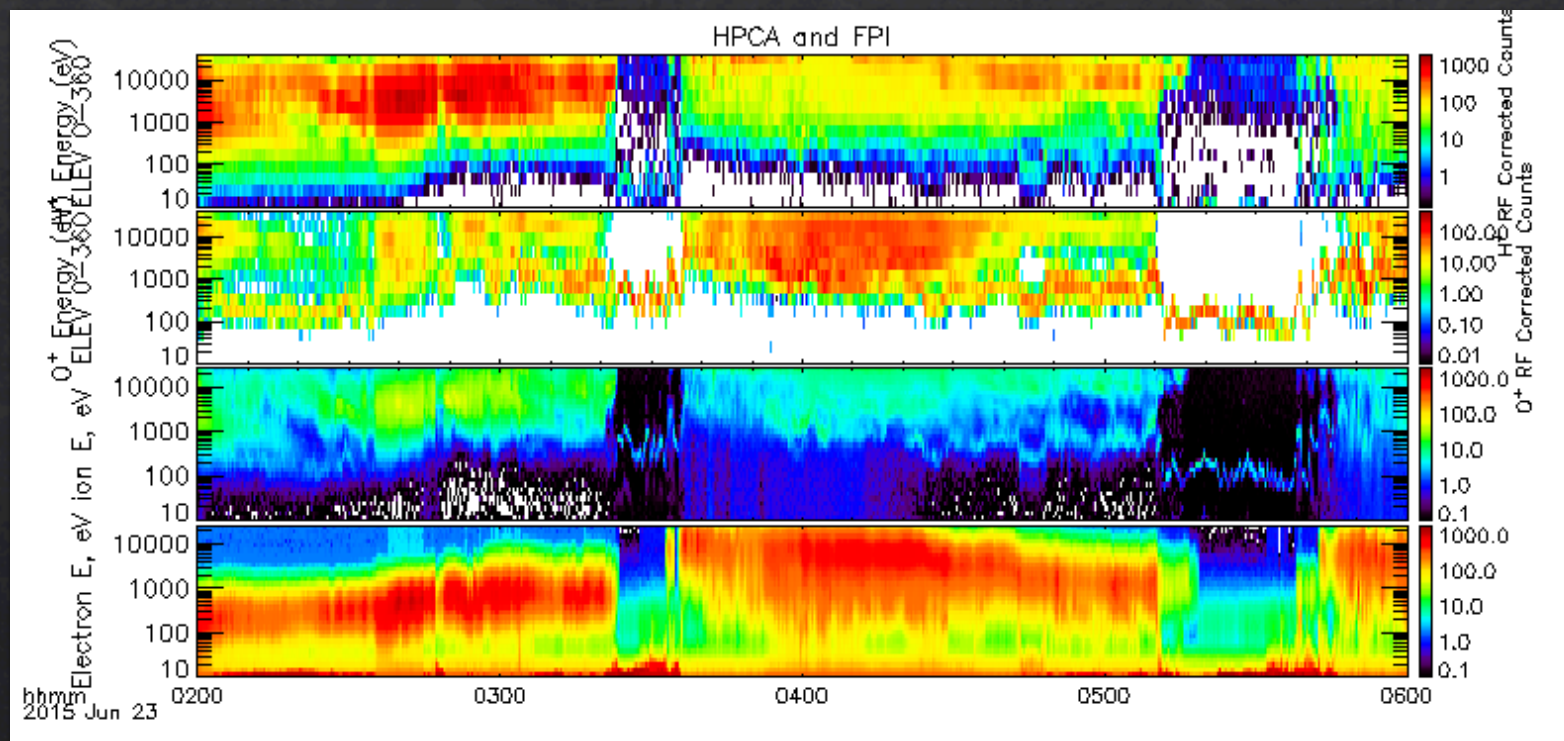


Tail Dynamics in Simulations

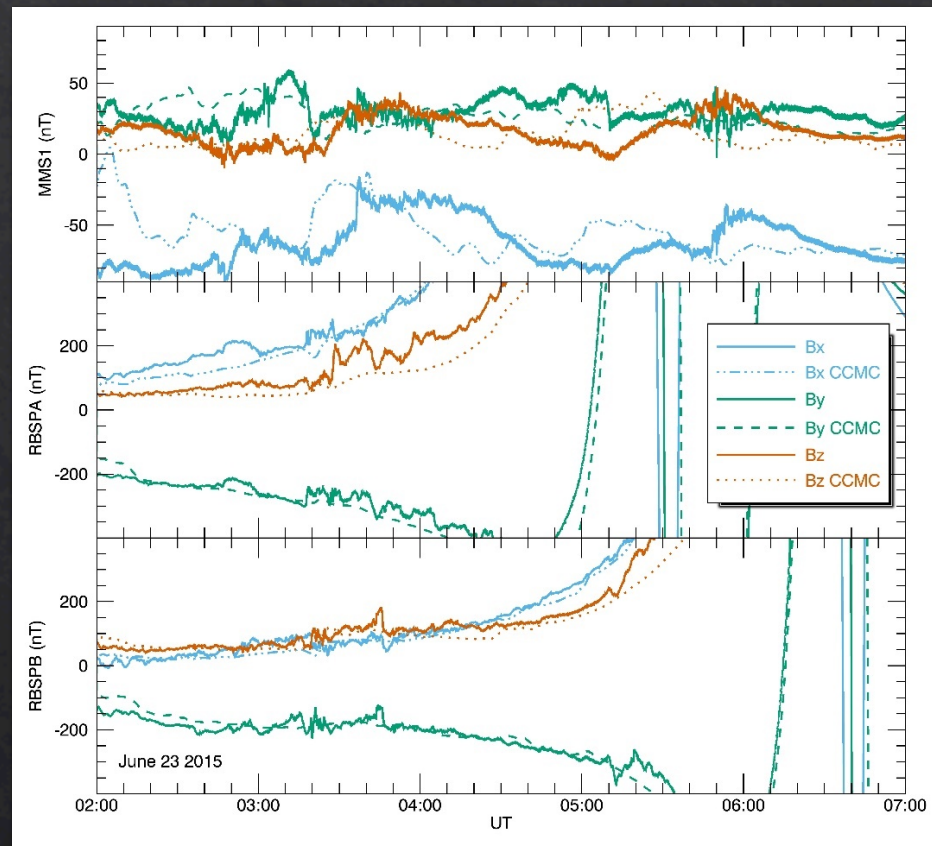


Y-plane cuts follow MMS dynamically.

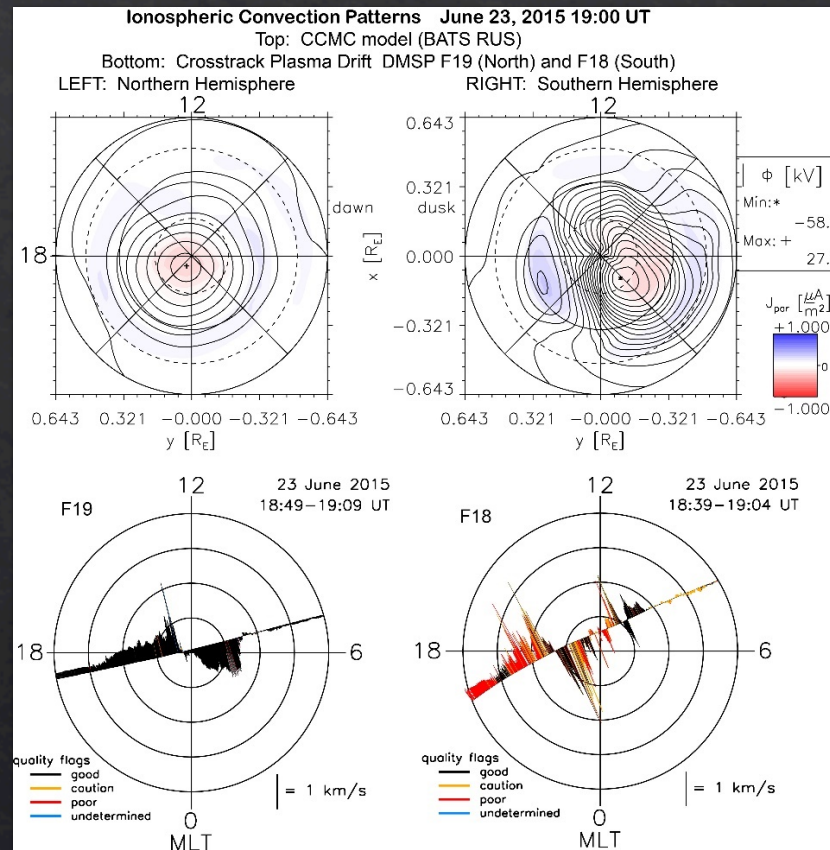
MMS Particle Observations



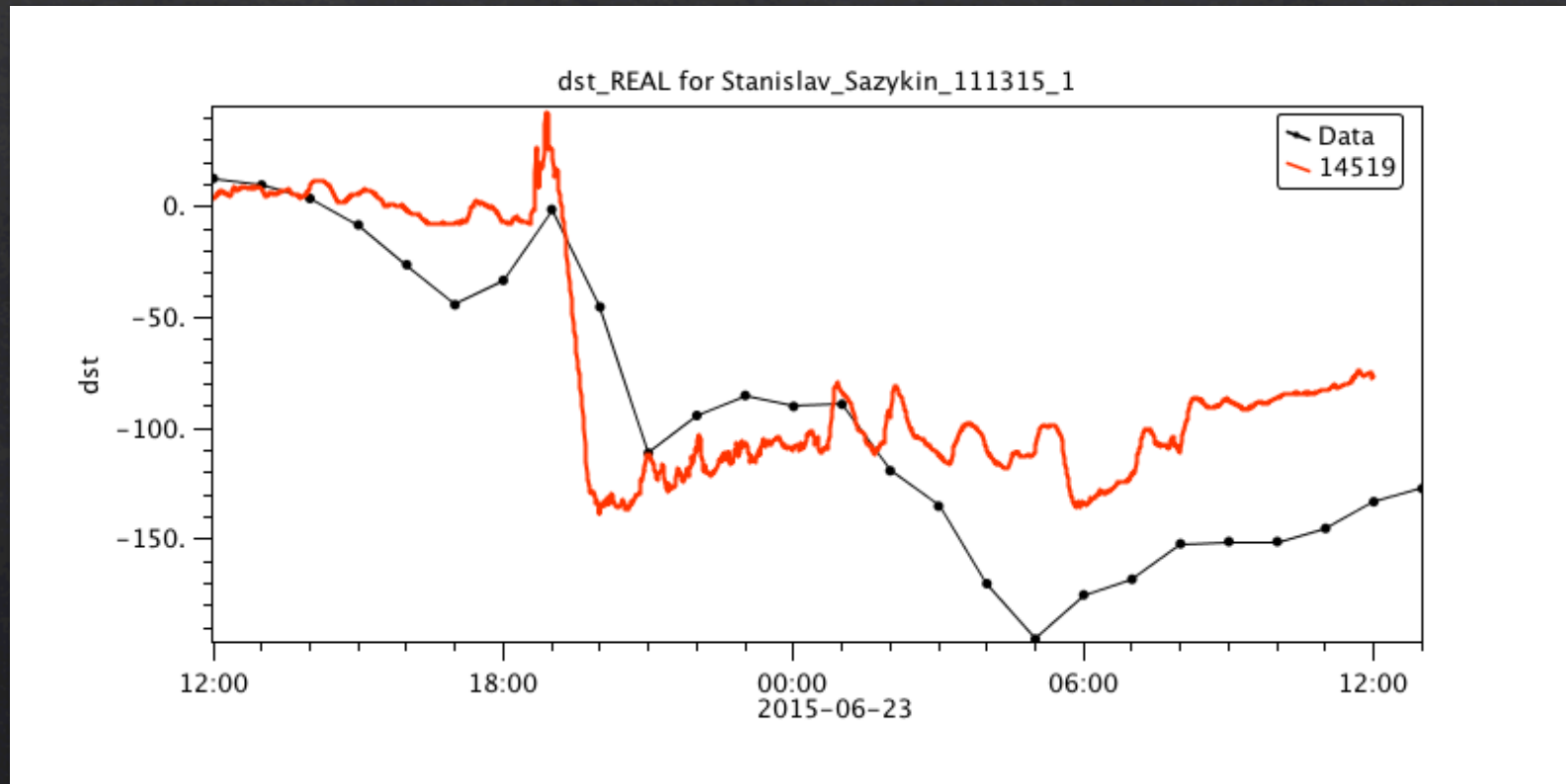
Tail B-field Stretching and Collapses



Single-Cell Convection Pattern

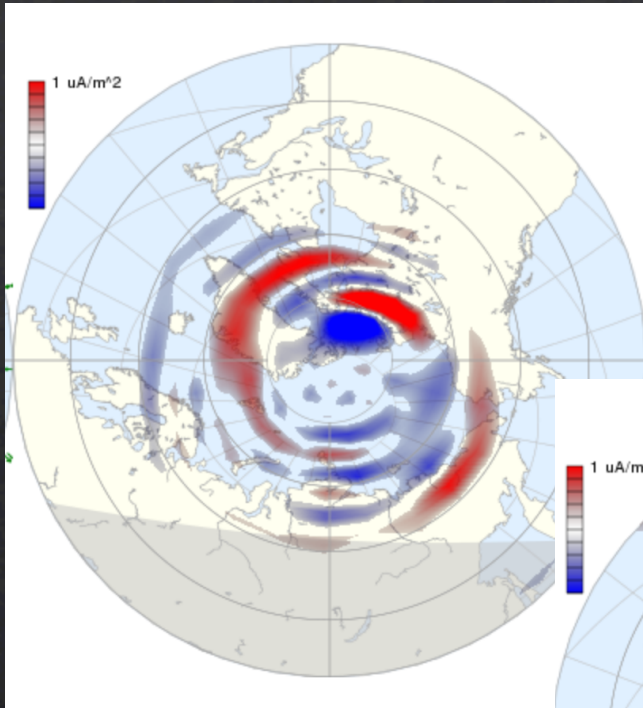


Dst Prediction

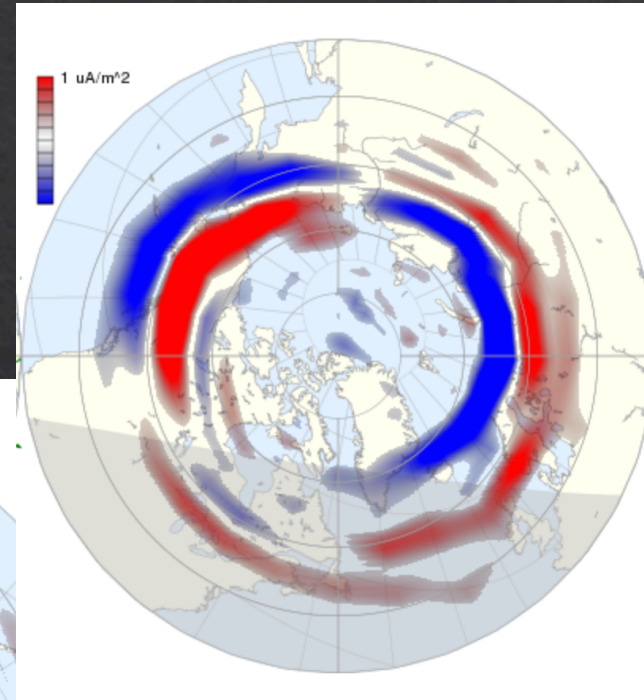


Michigan Virtual Model Observatory (<http://vmr.engine.umich.edu>)

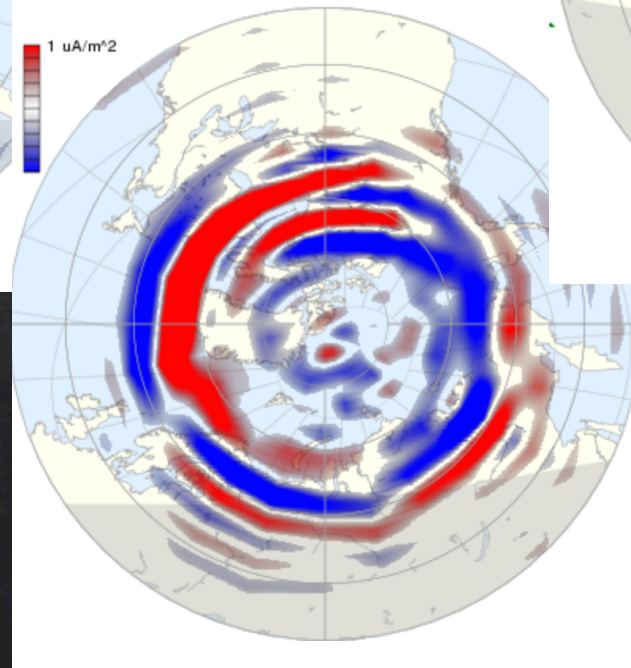
AMPERE (measured) Birkeland Currents



6/22 16:00 UT

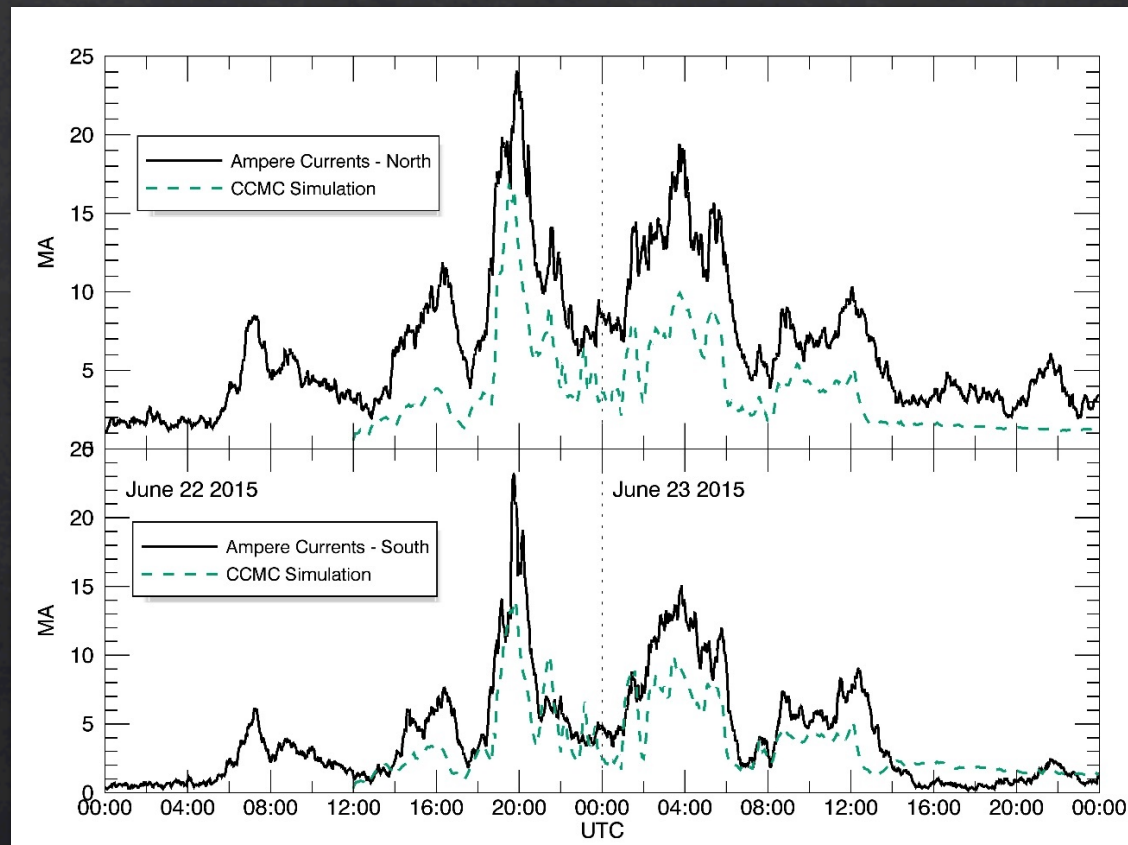


6/23 03 UT



6/22 19:00 UT

Total Field-Aligned Currents



Summary

- ◇ BATS-R-US+RCM at CCMC was used for interpretation of multi-spacecraft observations during an extremely large and unusual geomagnetic storm.
- ◇ The model did an admirable job of reproducing the amount of field change during the dipolarizations, estimating the polar cap convection and currents, and the approximate location of MMS near the separatrix during a very dynamic magnetotail sequence.
- ◇ CCMC provided the full range of capabilities for analysis.
- ◇ Lacking capabilities:
 - ◇ Ionospheric module
 - ◇ Ion outflows