



Energy Flux and Conductance from Meso-Scale Auroral Features

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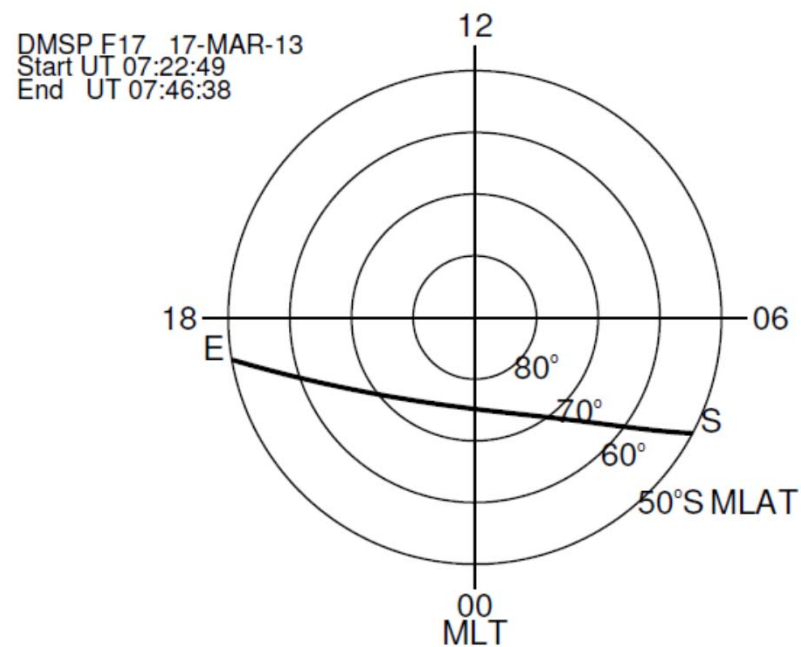
December 13, 2019

Motivation



Global ionosphere models capture large-scale features well but...

(c) Ion density: GITM vs. DMSP



Data: DMSP
Model: GITM at 550km

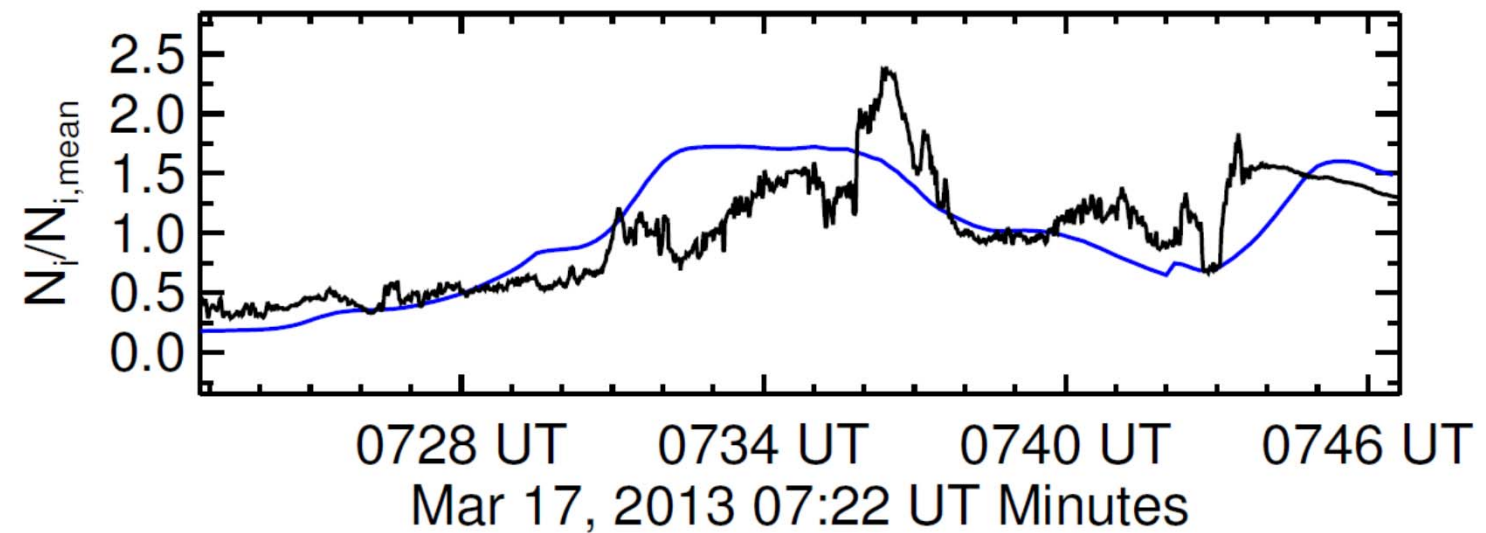
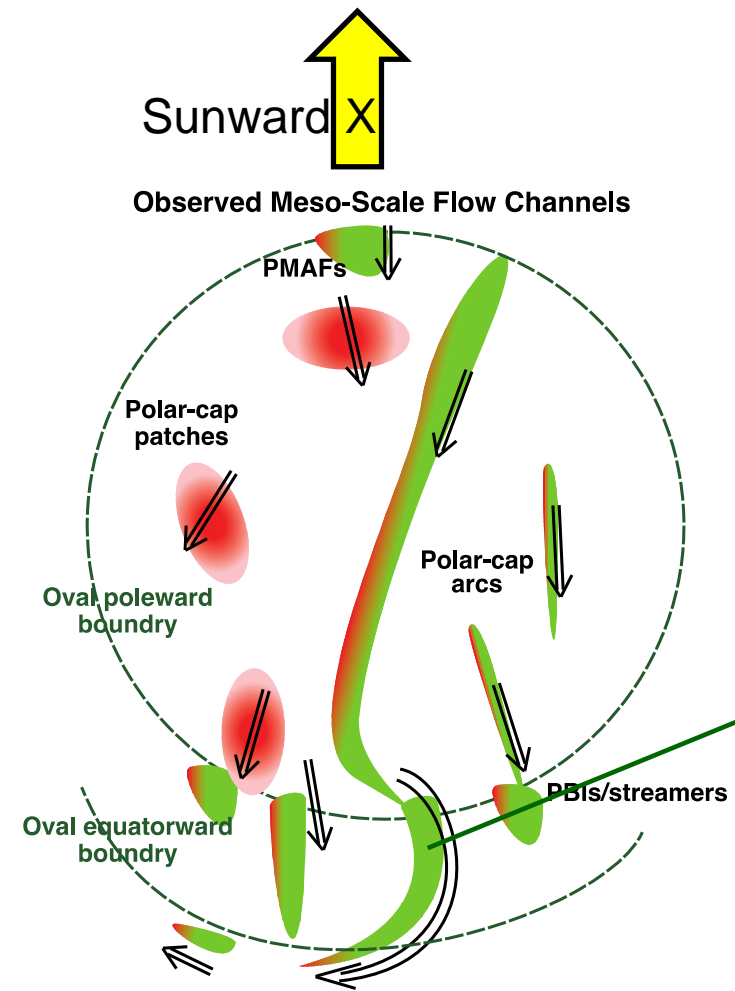


Figure courtesy of Yue Deng

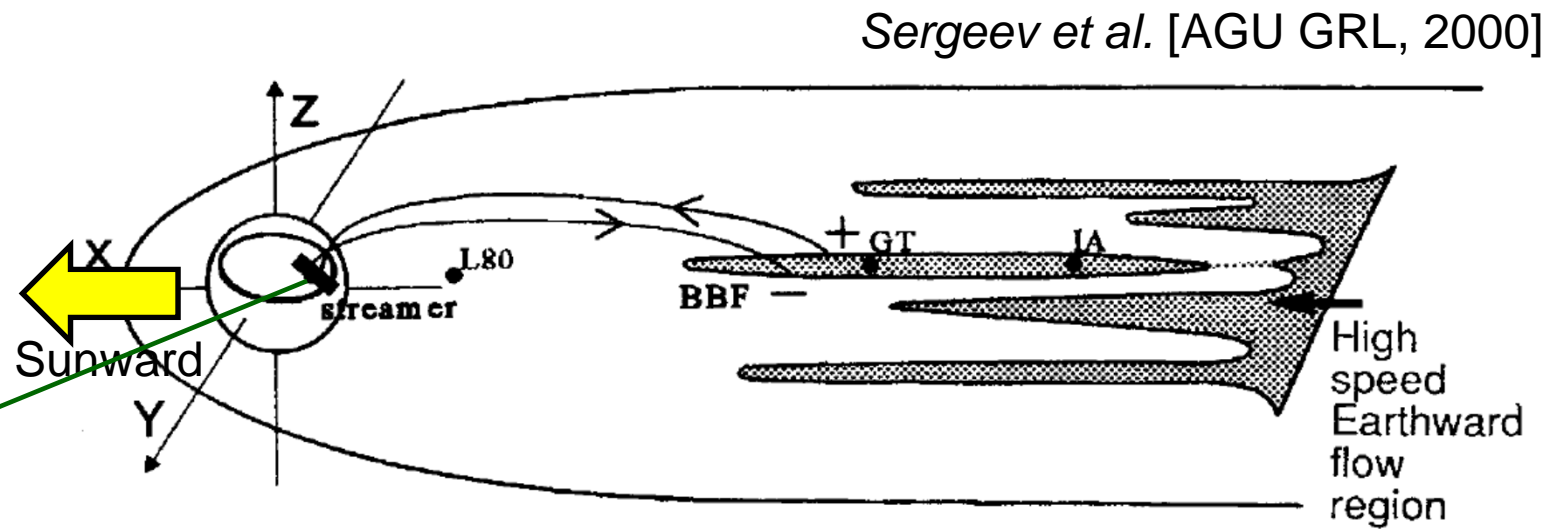
Missing meso-scales: ~50-500 km

Motivation



Modified from Lyons *et al.* [AGU JGR 2016]

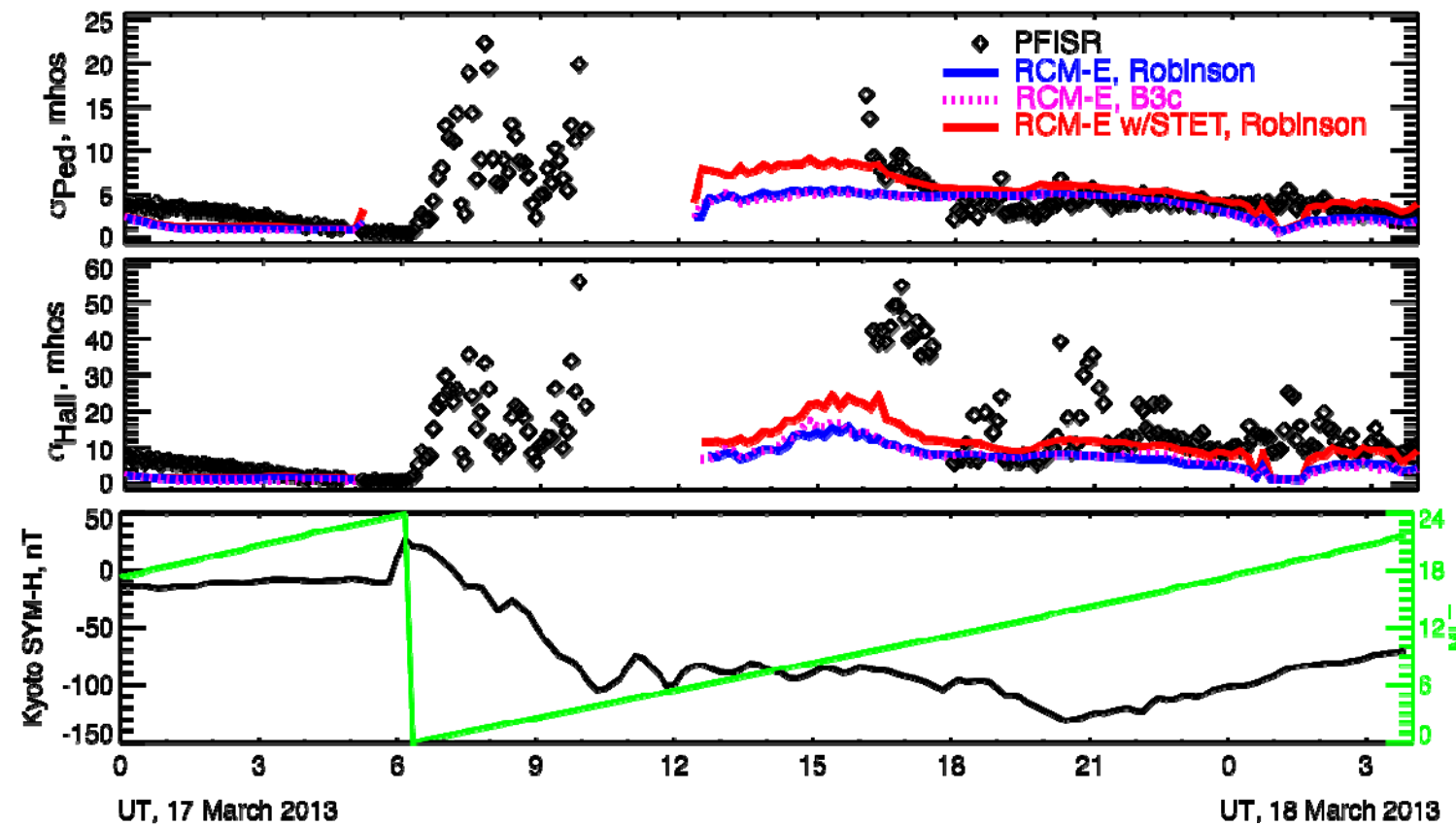
Magnetosphere-ionosphere coupling occurs on meso-scales.



Sergeev *et al.* [AGU GRL, 2000]

- Which spatial scales within the meso-scale range are most important in the energy deposition budget?
- To what extent may these various spatial scale characteristics, locations, and energy fluxes drive localized conductance variations?

Motivation: Conductance



[Strickland et al., AGU JGR 1993; Chen et al., AGU JGR 2015; 2019]

Improved conductance models are needed.



During the storm main phase, the simulations could not account for the enhanced observed conductance associated with discrete aurora that is not modeled by the RCM-E.

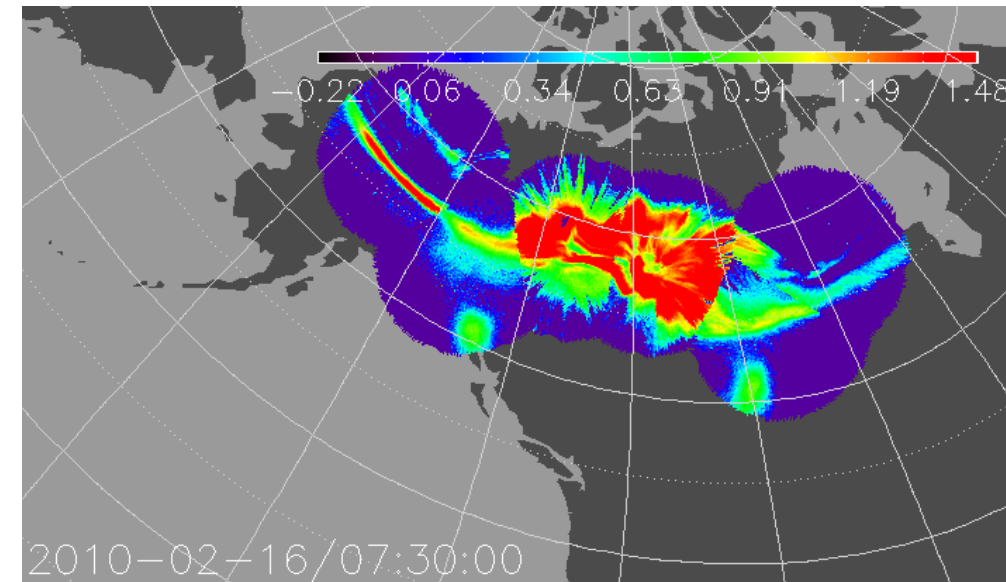
Methodology

THEMIS All-Sky-Imager White Light Decomposition

- **Current difficulties in answering these questions:**

- Satellite overpasses (e.g., DMSP) are temporally and spatially restrictive. The aurora evolution cannot be monitored, and small scales are washed out.
- Meridian Scanning Photometers (MSPs) do not provide adequate spatial coverage. They only monitor along a single longitude.
- ISRs allow us to calculate accurate conductance, but only at a single point in space.

ASIs provide detailed info at 3 sec cadence for hours over the same, large area.



[Nishimura et al., AGU Books on Ionosphere, 2020]

- **White Light ASI Limitations**

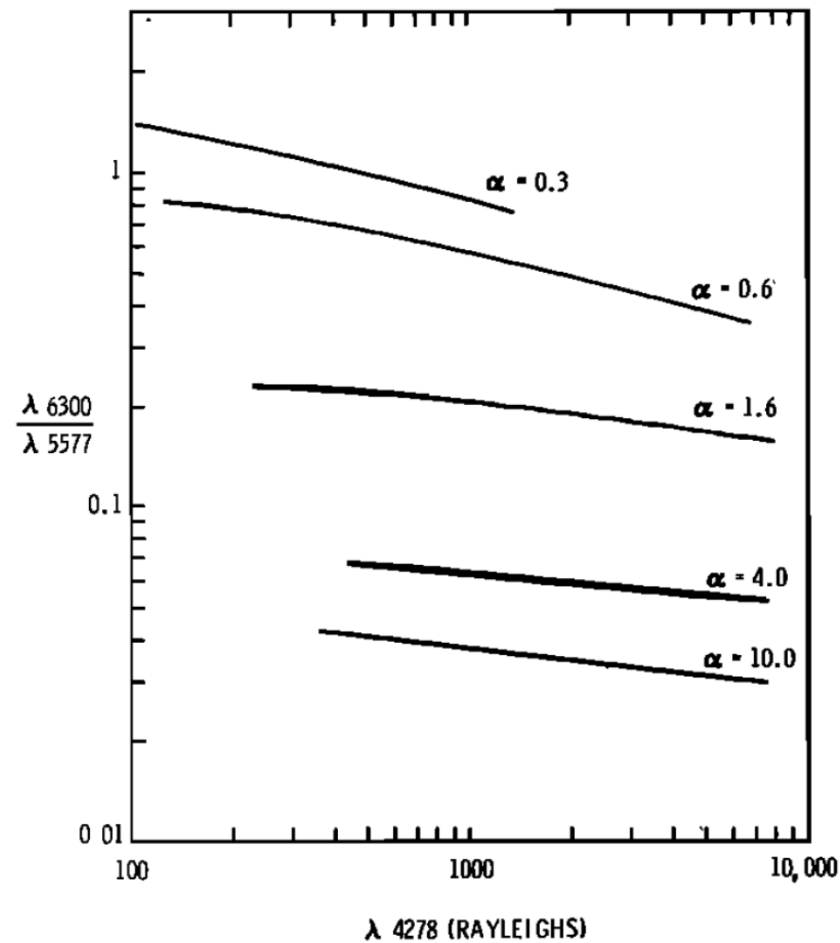
- Each ASI is usable ~50% of the time, multiple cameras usable simultaneously ~20% of the time due to cloud coverage.
- At low elevation angles, LOS cuts through more flux tubes.
- White light does not detect the lowest fluxes (but redline does).
- White light deconstruction assumes relationship between white light intensity and color intensity. This translates to a relationship between energy and eflux. Not true for diffuse aurora, but shown to be true for discrete aurora.

Methodology

Because precipitating particles of increasing energy penetrate deeper into the atmosphere, the aurora's color—which changes with altitude—is indicative of the particle energy and energy flux.

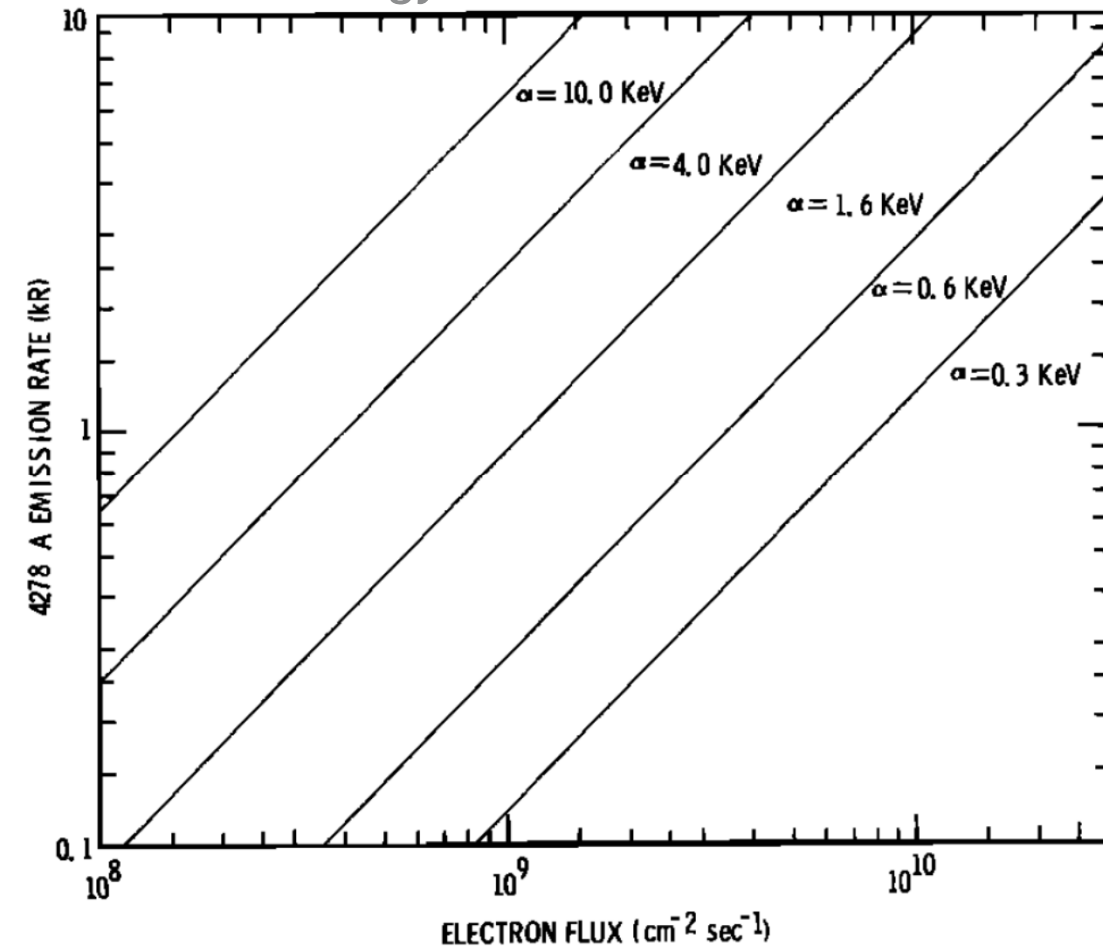


Energy Determination



- Knowing the red to green intensity ratio and the blue light emission, the energy can be found. (Left)
- Knowing the blue light emission and the energy, electron flux can be calculated. (Right)

Energy Flux Determination

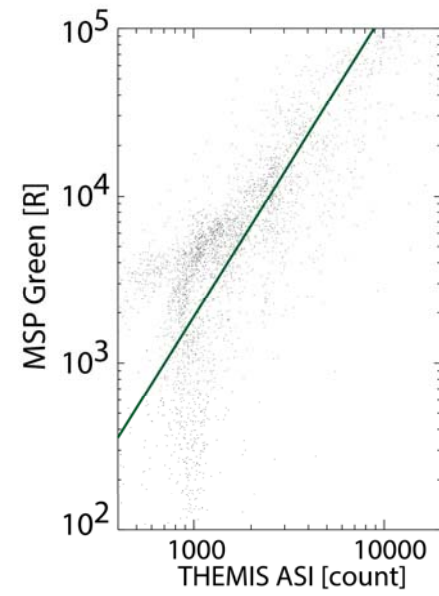


Rees and Luckey, AGU JGR 1974

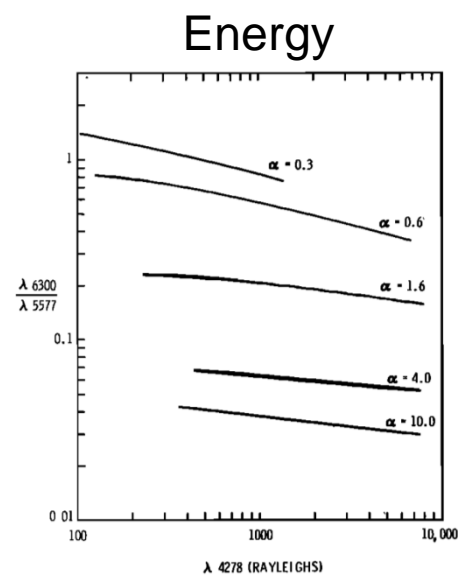
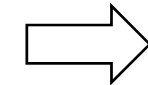
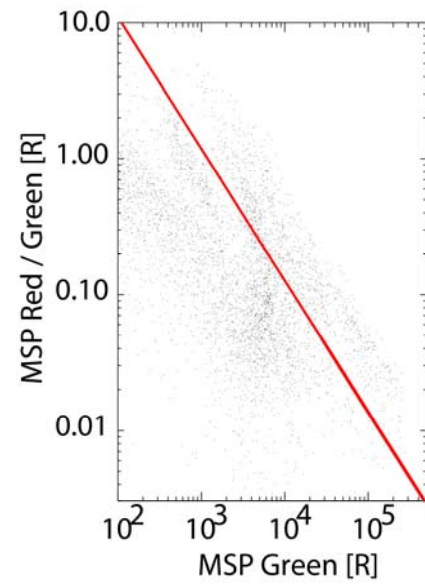


Methodology

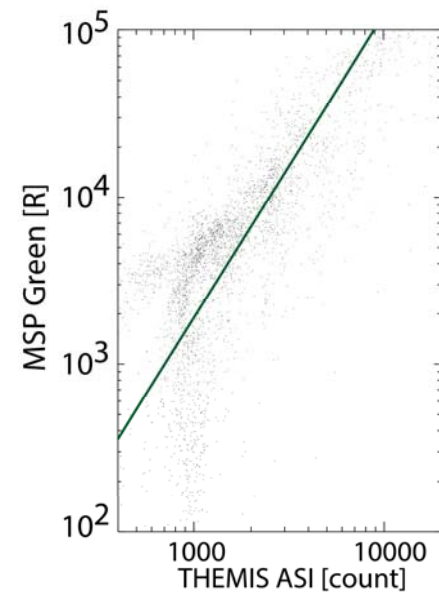
THEMIS All-Sky-Imager White Light Decomposition



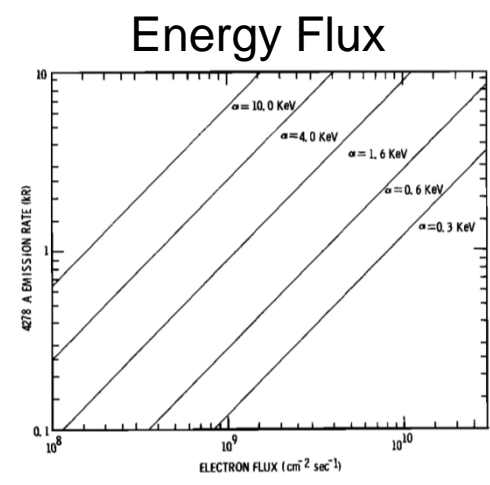
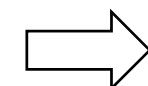
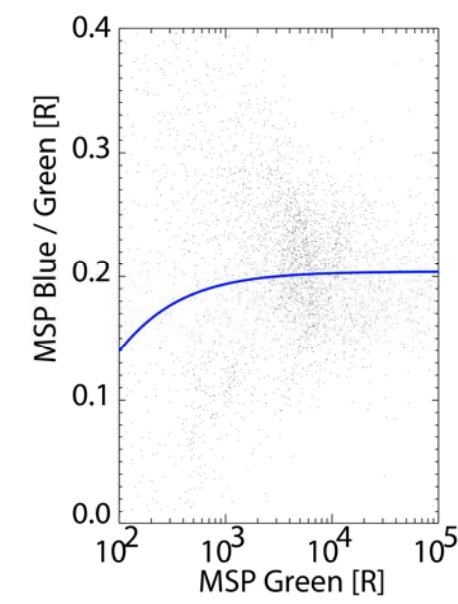
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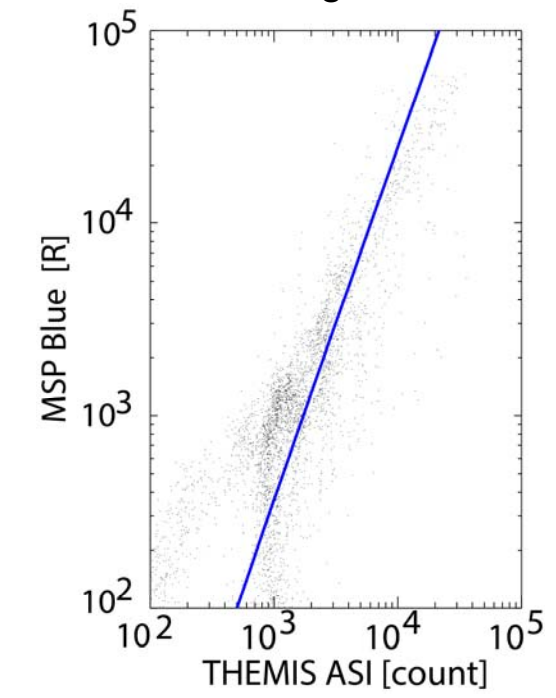
Develop empirical relationship between white light imager and MSP data.



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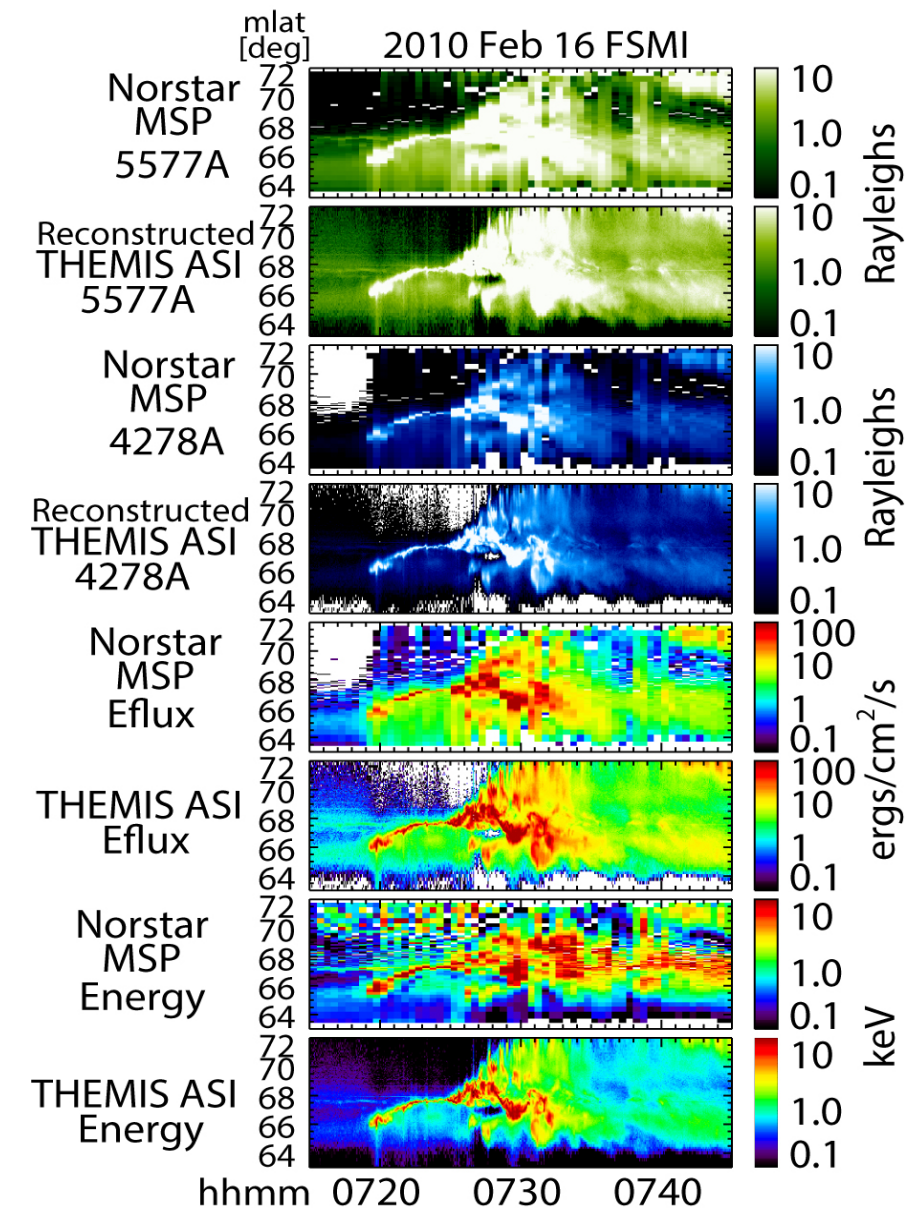
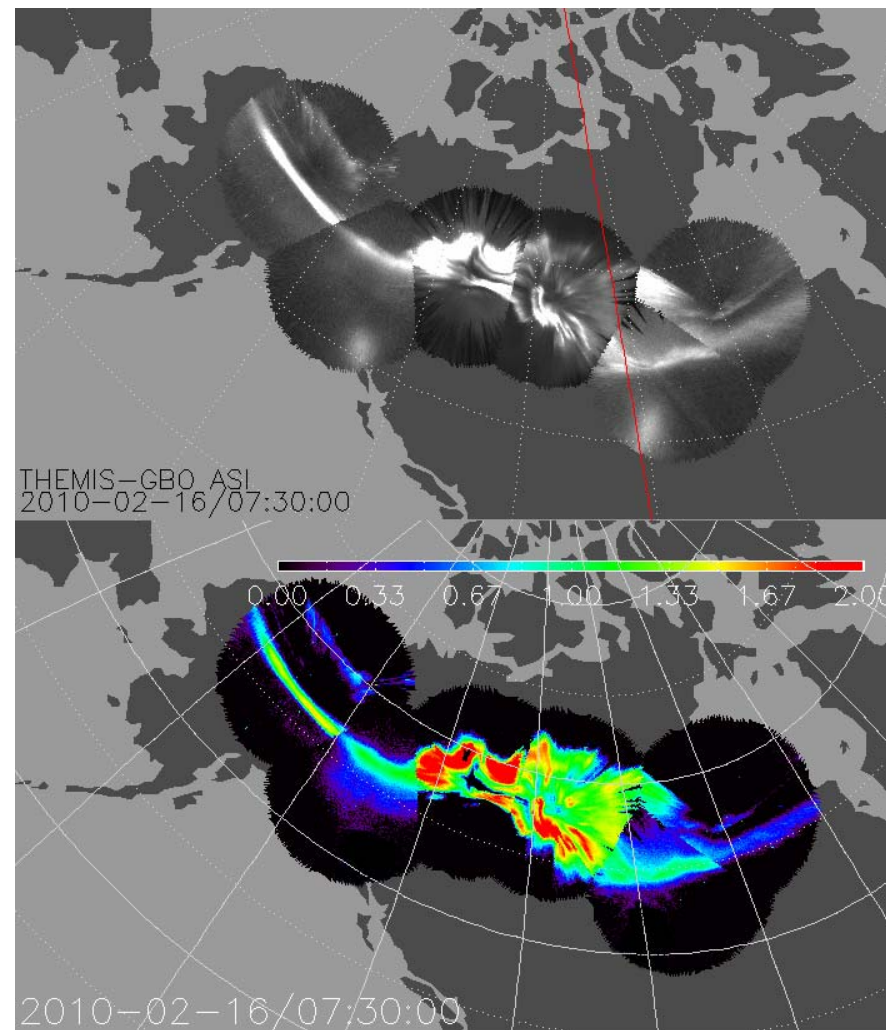


Test: Line predicts Blue intensity from White Light



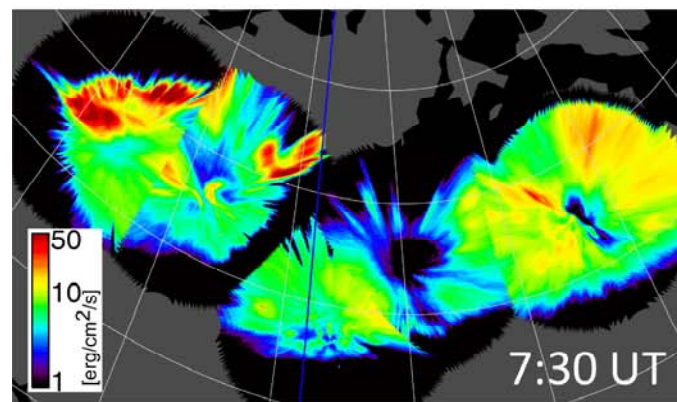
Methodology

THEMIS All-Sky-Imager White Light Decomposition

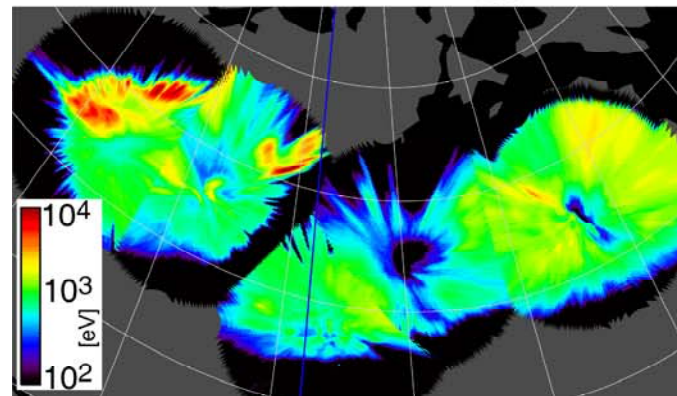


Validation with DMSP

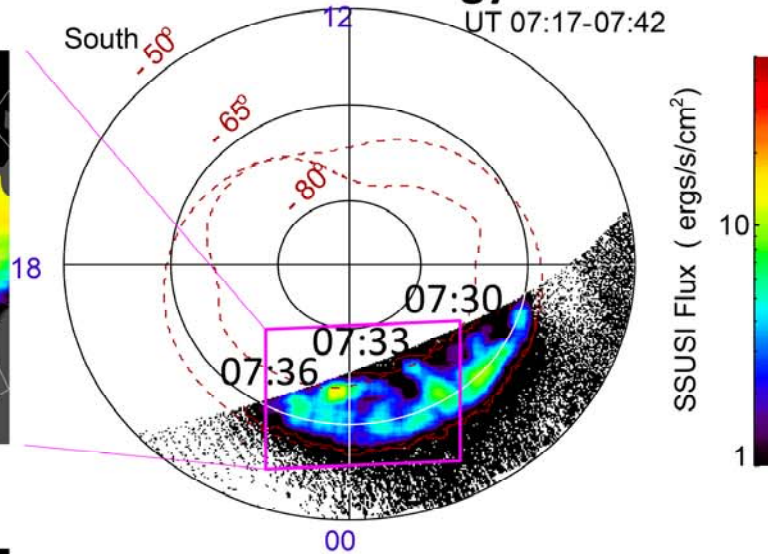
THEMIS ASI energy flux



THEMIS ASI energy



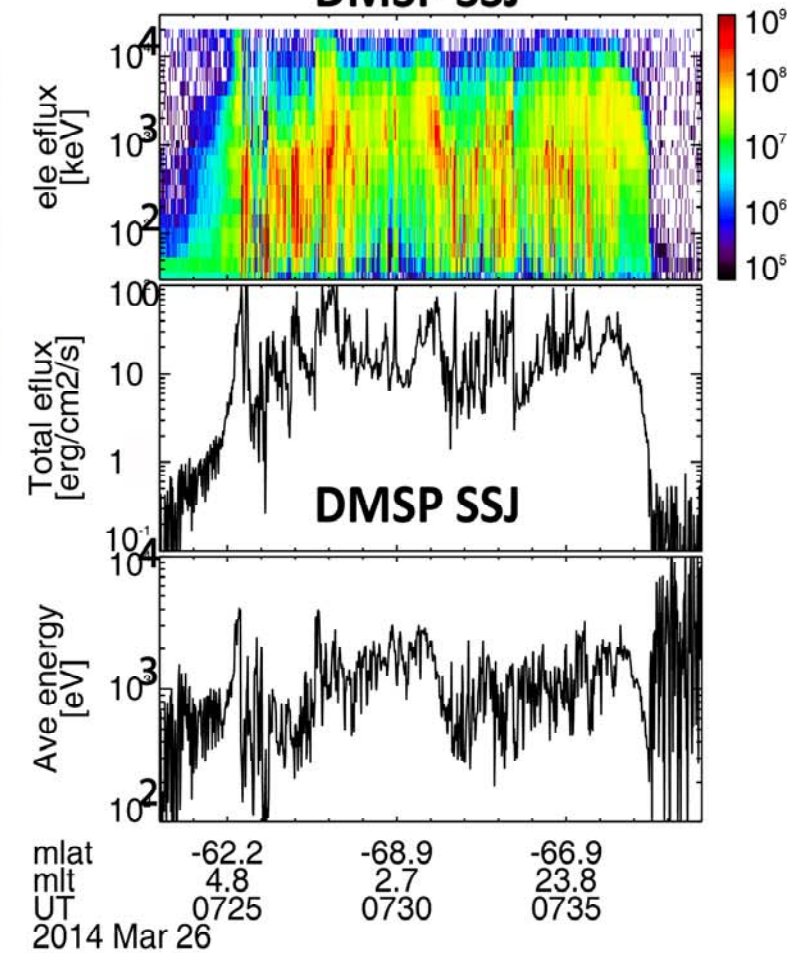
DMSP SSUSI energy flux



Eflux magnitude and distribution are consistent with SSUSI data within a factor of 2.

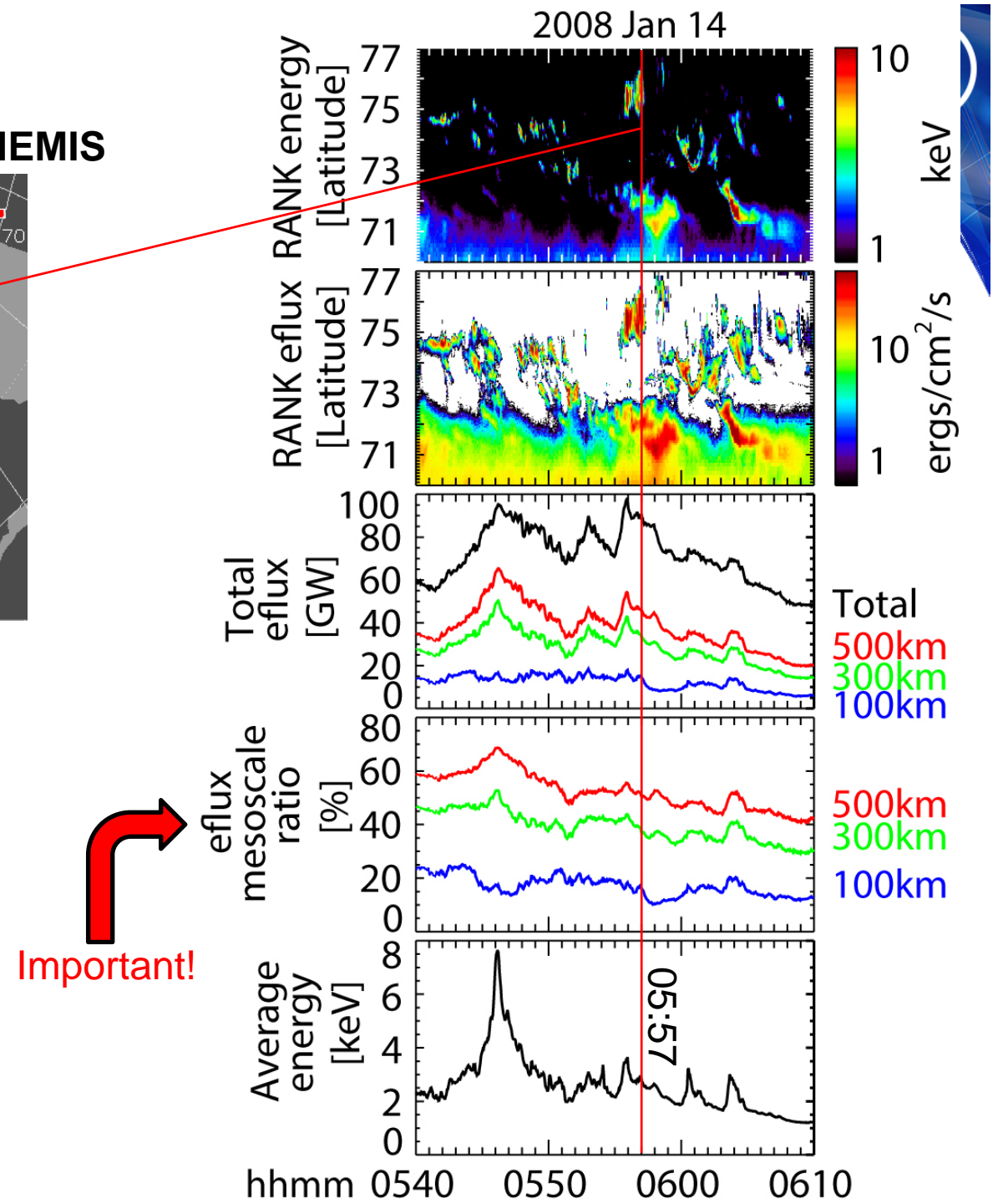
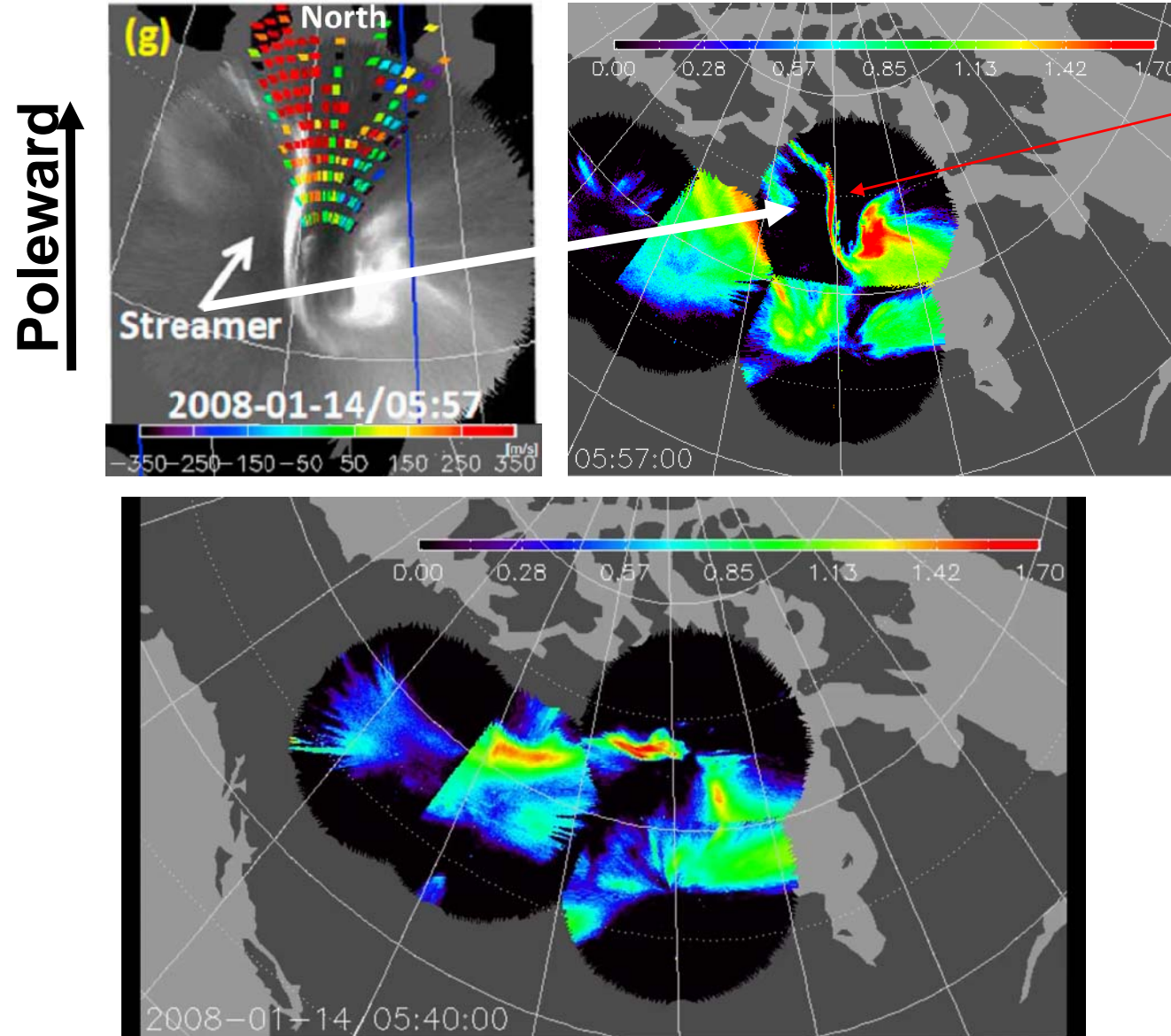
ASI data is consistent with precipitating electron measurements (SSJ): ~10 erg/cm²/s with localized bursts: 1-2 keV energy.

DMSP SSJ

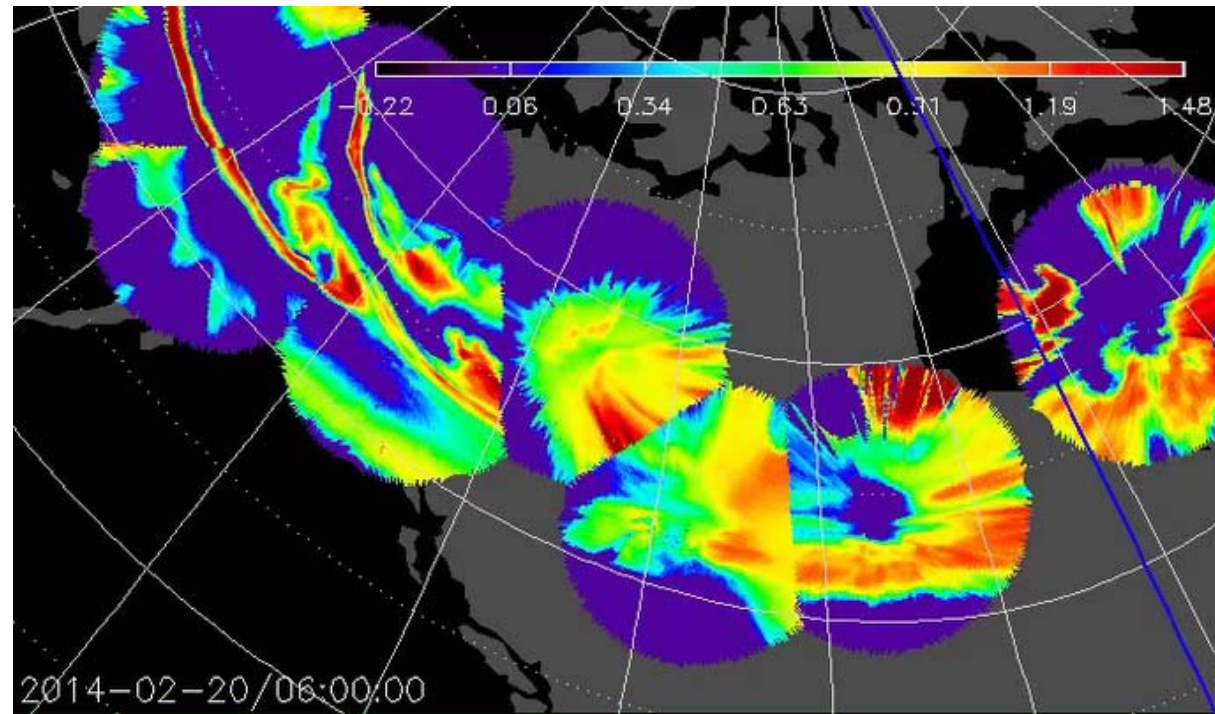


Scale Sizes: 2008 Jan 14 Substorm

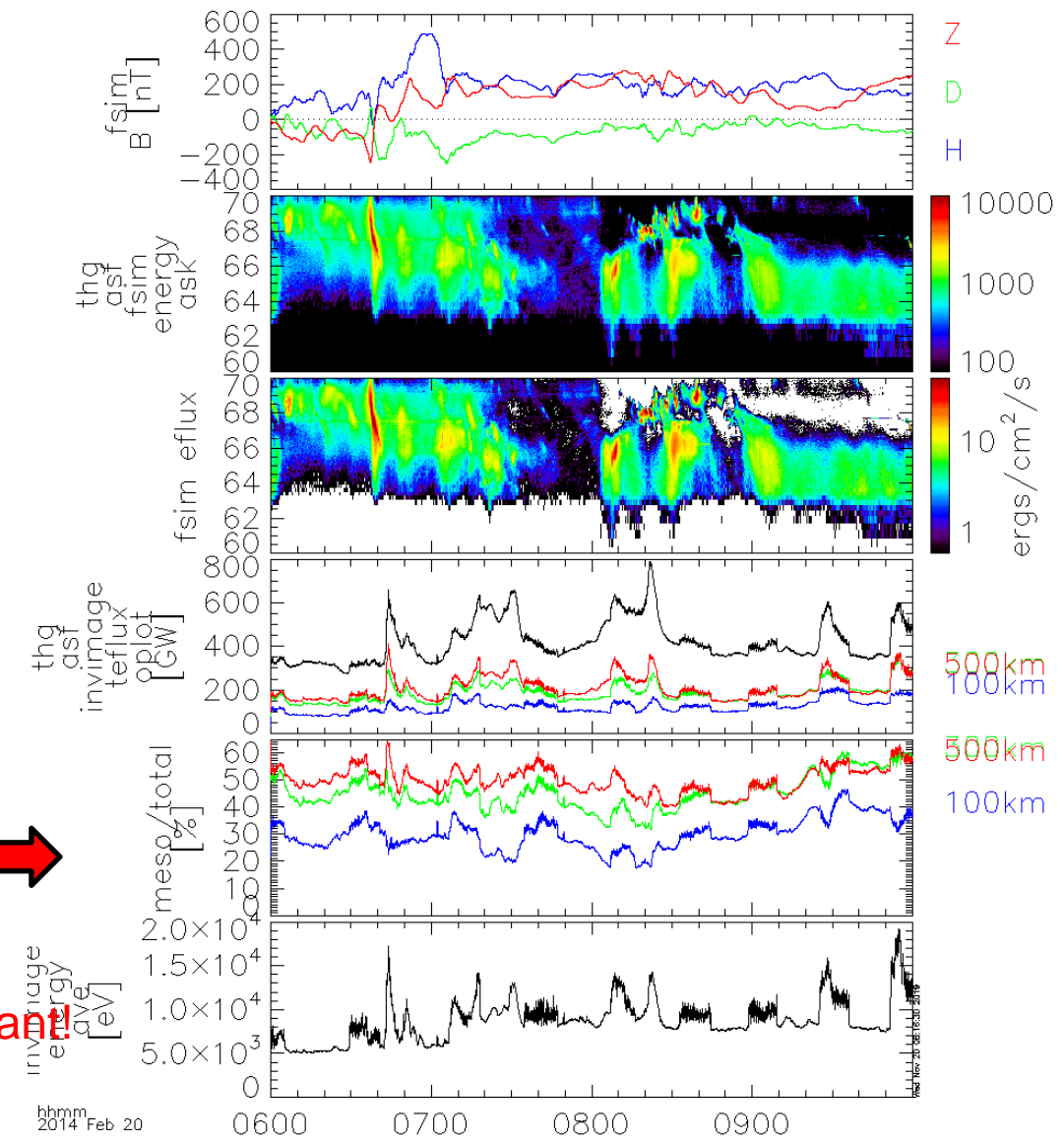
SuperDARN THEMIS ASI Energy flux mosaic from THEMIS



Scale Sizes: 2014 Feb 20 Storm



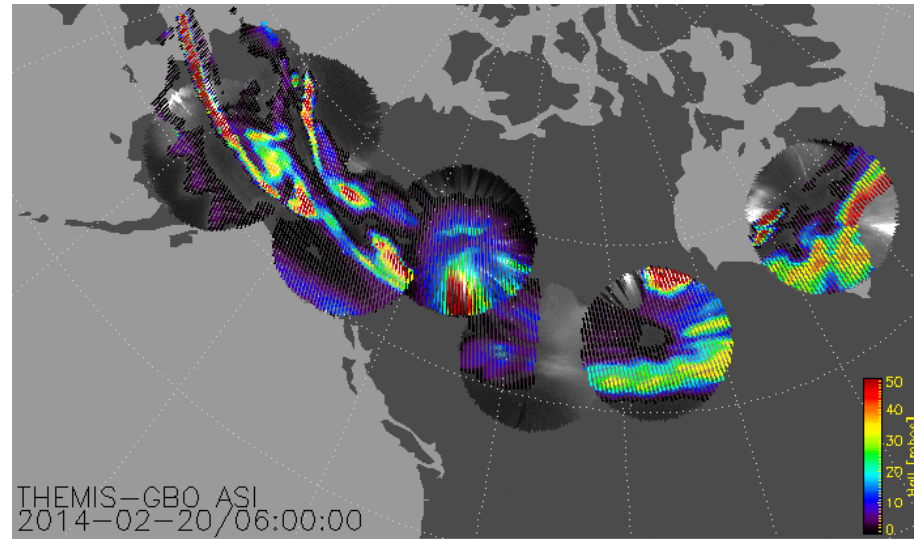
Important!



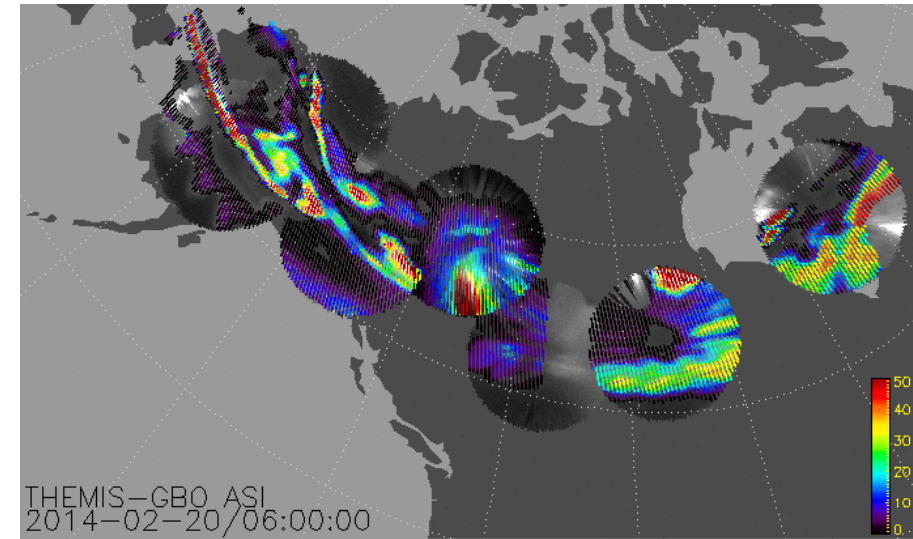
Conductance: 2014 Feb 20 Storm



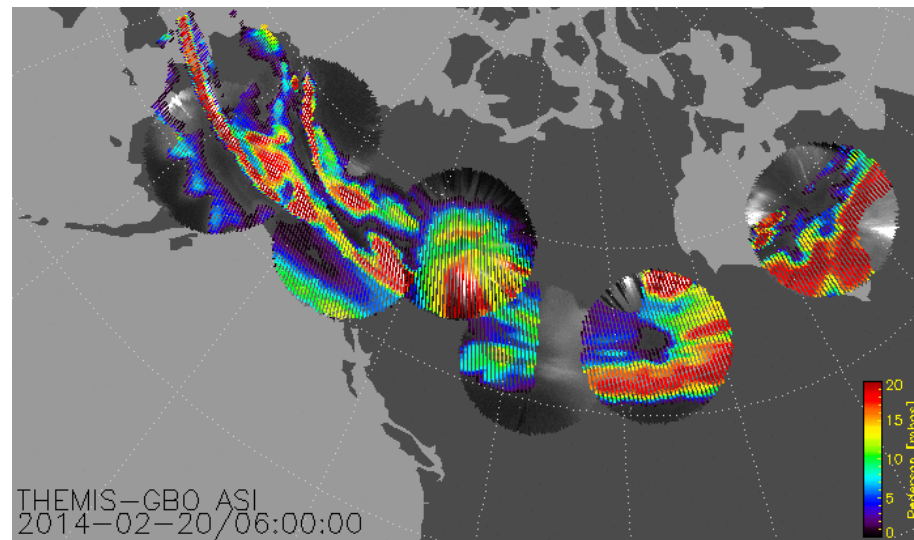
Hall Conductance from Robinson Formula



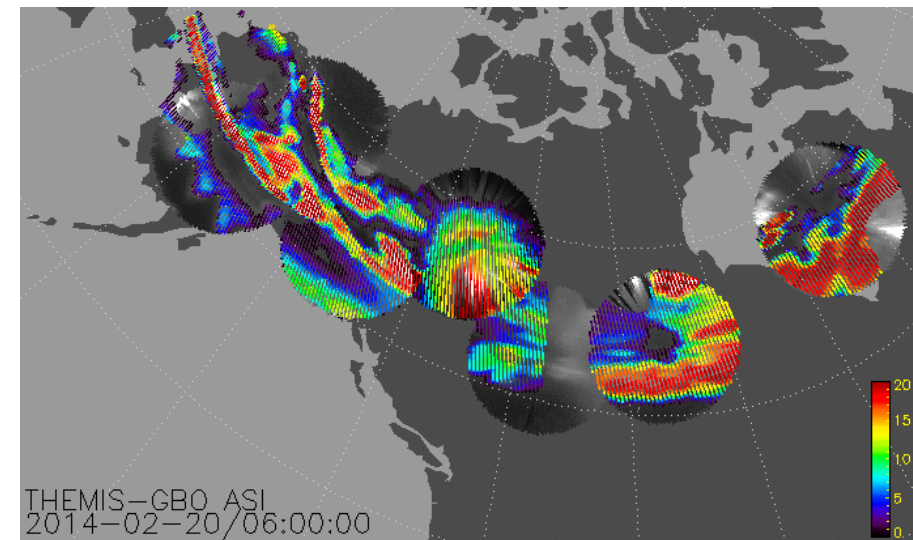
Hall Conductance from Bc3



Pederson Conductance from Robinson Formula

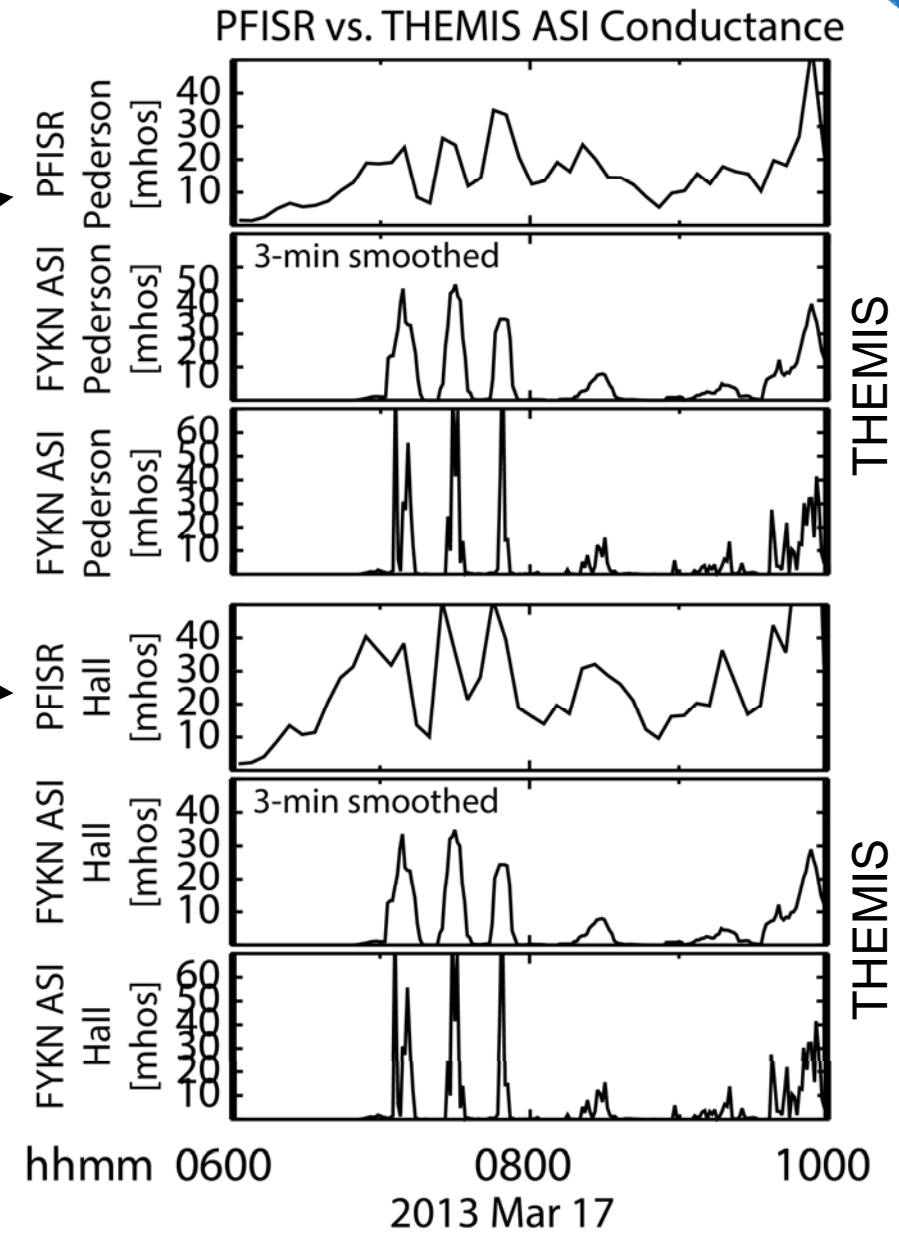
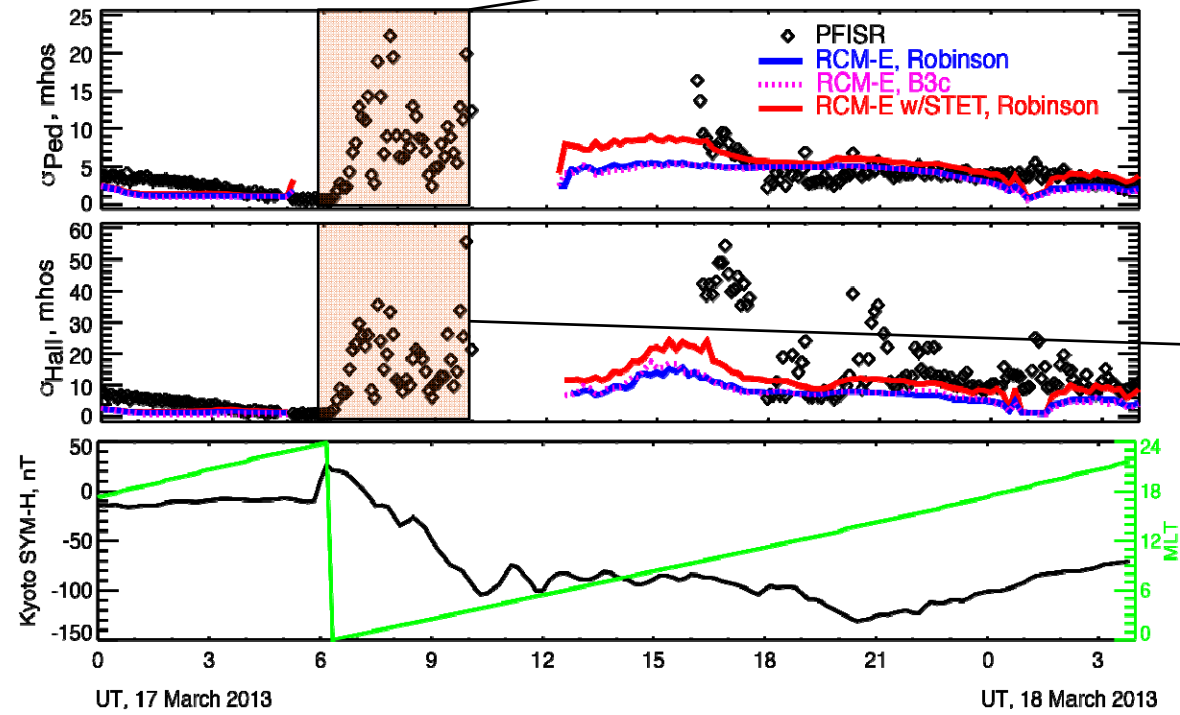


Pederson Conductance from Bc3



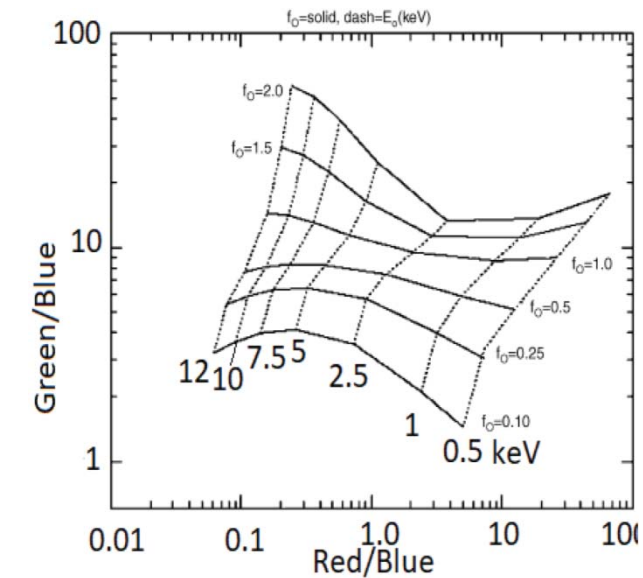
Conductance: 2013 March 17 Storm

THEMIS ASI captures conductance missing from RCM-E. Good match to PFISR conductance.



Future Work

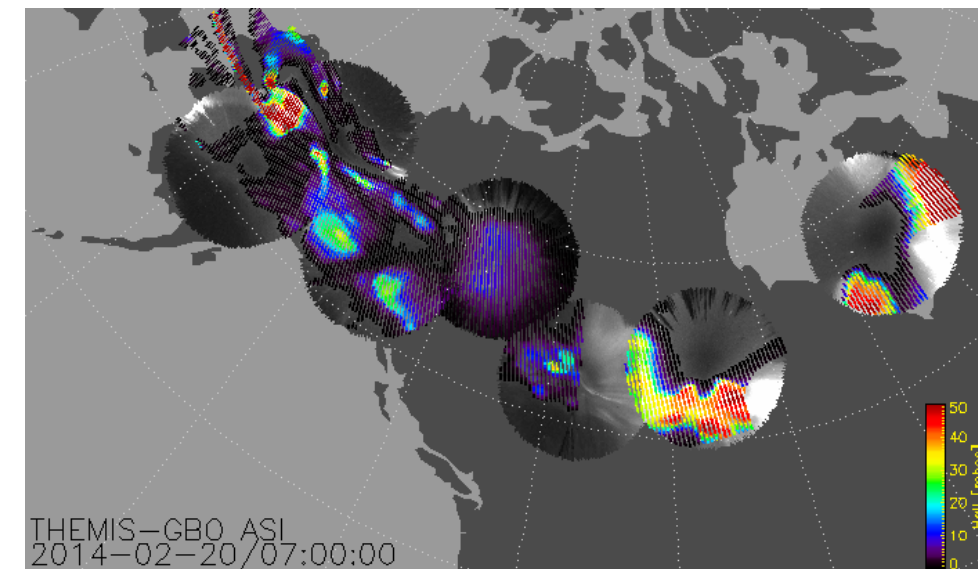
- Improve white light decomposition with updated relationships (e.g., *Hecht et al., 2006*).
- Determine characteristic scale sizes important for energy deposition for different magnetospheric modes of response (substorm, storm type, etc.)
- Separate diffuse from discrete aurora.
- Improve conductance calculations.
- Envelop TReX color ASIs as they become available.



Hecht et al., AGU JGR 2006

Summary

- Meso-scales are important contributors to the total energy budget for both substorms and storms.
- THEMIS ASIs can provide data to improve conductance models in 2D.





Thank you!

Extra



MCGR also had some unreal spikes.

