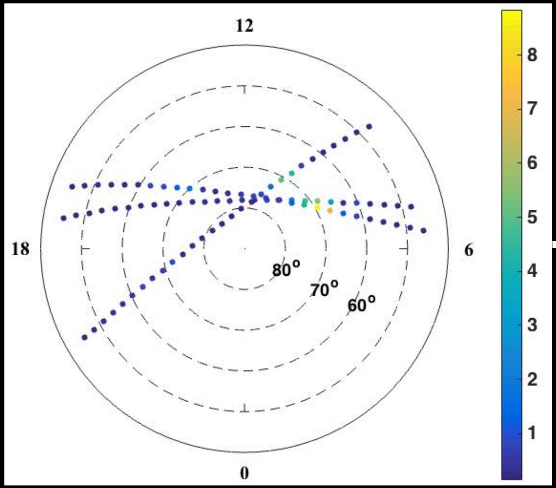
Colorado Center for Astrodynamics Research
University of Colorado
Boulder, Colorado

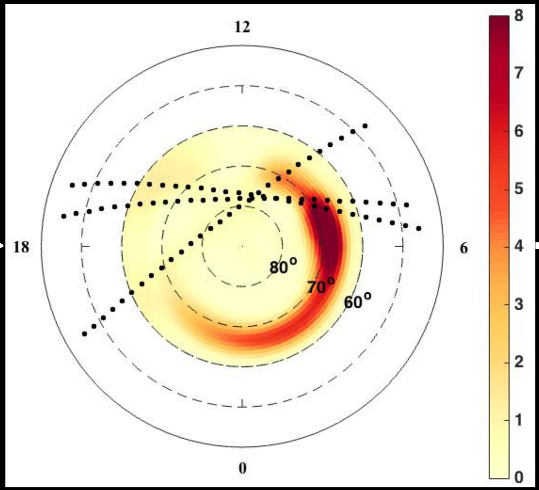
Enabling system science: Ionospheric conductivity

Ryan McGranaghan
Thayer School of Engineering
Dartmouth College
Delores Knipp, Tomoko Matsuo
CU Boulder, NCAR HAO

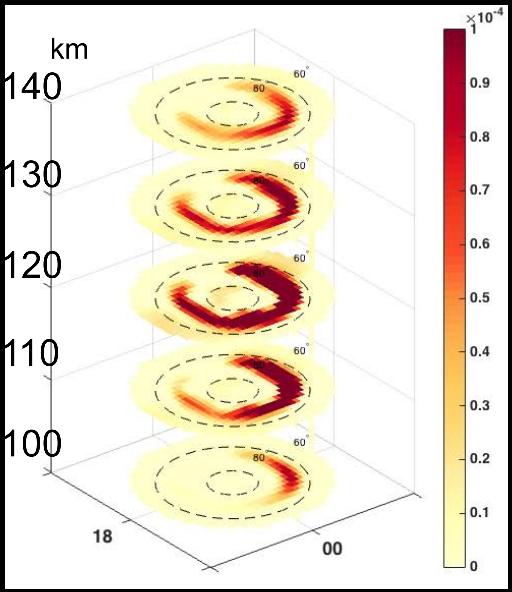
Assimilative approach
- Bring diverse data together
- Estimate of uncertainty
- Particularly effective in addressing modeling shortcomings



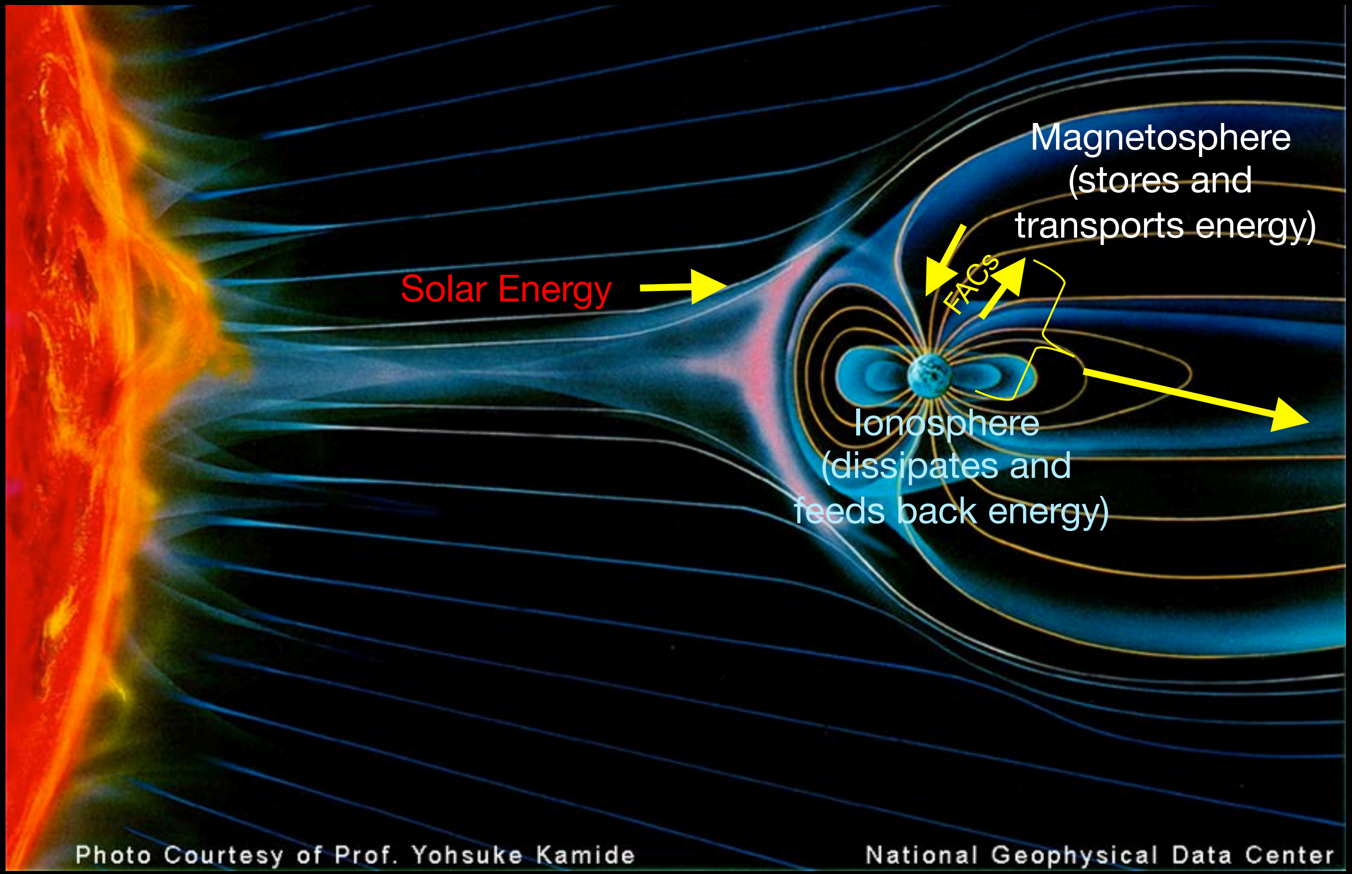
2D



3D



Conductivity critical to high-latitude geospace system



Electromagnetics governed by conductivity

$$\mathbf{J} = \tilde{\sigma} \cdot \mathbf{E}$$

Where is conductivity modeling currently?

Colorado Center for Astrodynamics Research
University of Colorado
Boulder, Colorado

1. Difficulty specifying auroral component

Maxwellian energy particle precipitation assumption

and

Robinson formulas (*Robinson et al.*, [1987])

$$\Sigma_P = \frac{40E}{16 + E^2}\Phi_E^{1/2}$$

$$\frac{\Sigma_H}{\Sigma_P} = 0.45(E)^{0.85}$$

Where is conductivity modeling currently?

1. Difficulty specifying auroral component

Maxwellian energy particle precipitation assumption

and

Robinson formulas (*Robinson et al.*, [1987])

$$\Sigma_P = \frac{40E}{16 + E^2} \Phi_E^{1/2}$$

$$\frac{\Sigma_H}{\Sigma_P} = 0.45(E)^{0.85}$$

2. Height-integrated

$$\mathbf{J} = \tilde{\sigma} \cdot \mathbf{E}$$

$$\int_h \sigma \, \mathrm{d}h = \Sigma$$

Application of modeling improvement:

1 Studying local features in global analyses;

2 Facilitating closer agreement between diverse observations; and

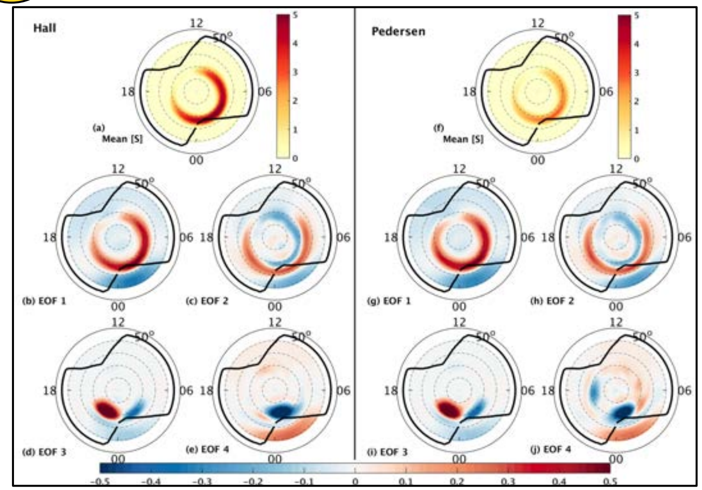
3 Connecting these results to the broader picture: Significance to NEROC community

Optimal Interpolation (OI) technique: 3 Steps

Colorado Center for Astrodynamics Research

University of Colorado
Boulder, Colorado

1 Characterize the variability

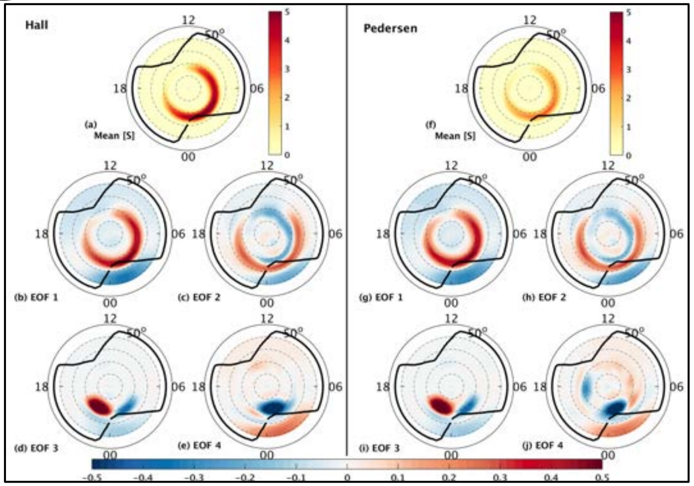


McGranaghan, R. et al. (2015), Modes of high-latitude conductance variability derived from DMSP energetic electron precipitation observations: Empirical Orthogonal Function (EOF) analysis. J. Geophys. Res. Space Physics, 120, 11,013–11,031, doi: 10.1002/2015JA021828.

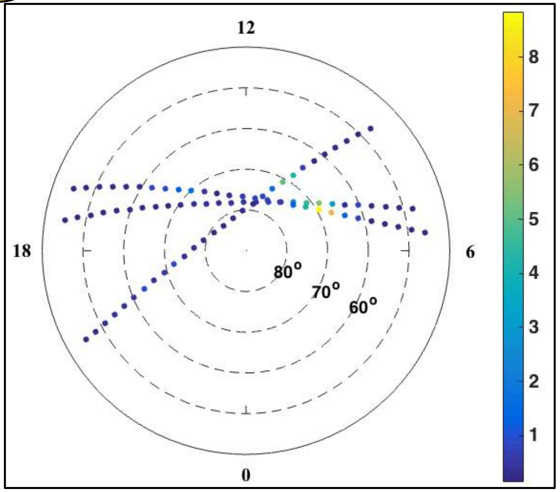
Optimal Interpolation (OI) technique: 3 Steps

Colorado Center for Astrodynamics Research
University of Colorado
Boulder, Colorado

1 Characterize the variability



2 Accumulate observations



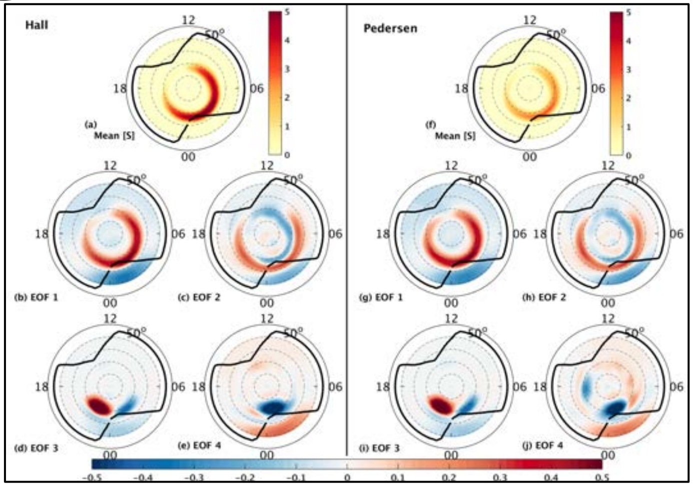
McGranaghan, R., D. J. Knipp, T. Matsuo, and E. Cousins (2016), Optimal interpolation analysis of high-latitude ionospheric Hall and Pedersen conductivities: Application to assimilative ionospheric electrodynamics reconstruction, J. Geophys. Res. Space Physics, 121, 4898–4923, doi:10.1002/2016JA022486.

Optimal Interpolation (OI) technique: 3 Steps

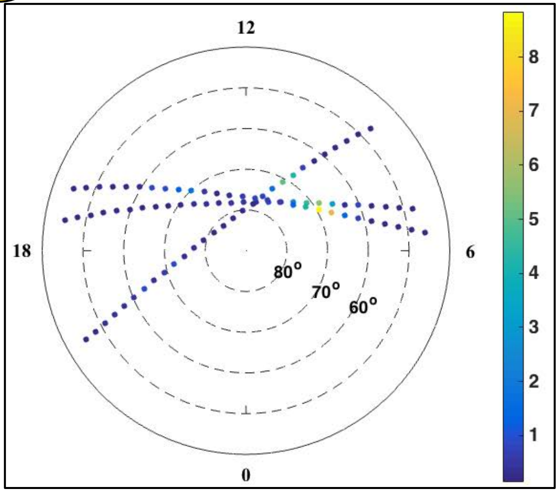
Colorado Center for Astrodynamics Research

University of Colorado
Boulder, Colorado

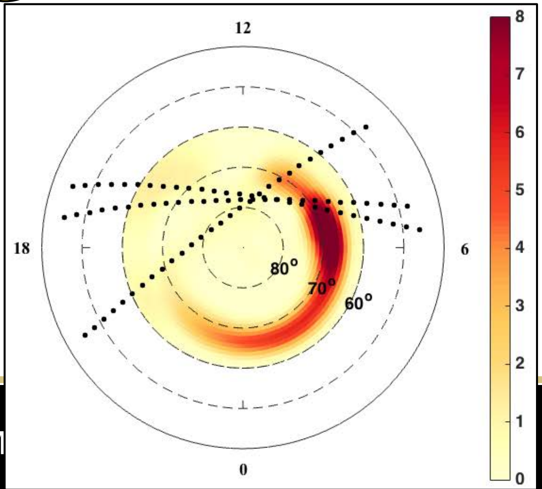
1 Characterize the variability



2 Accumulate observations



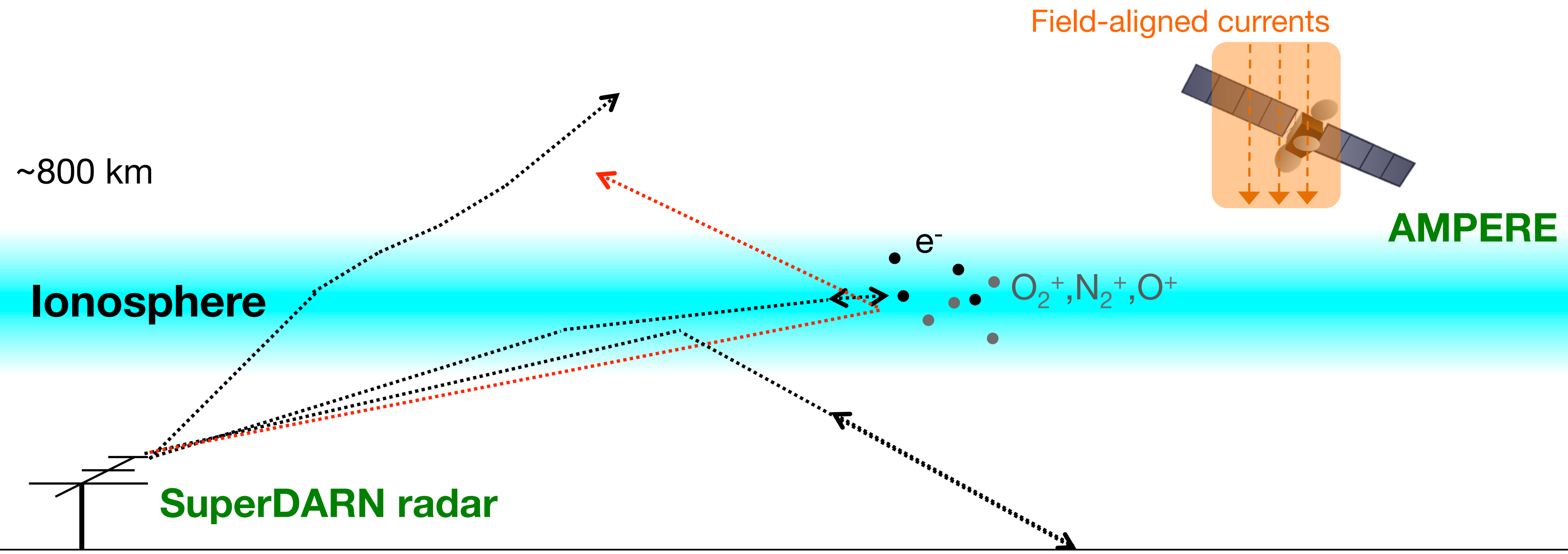
3 Optimal interpolation

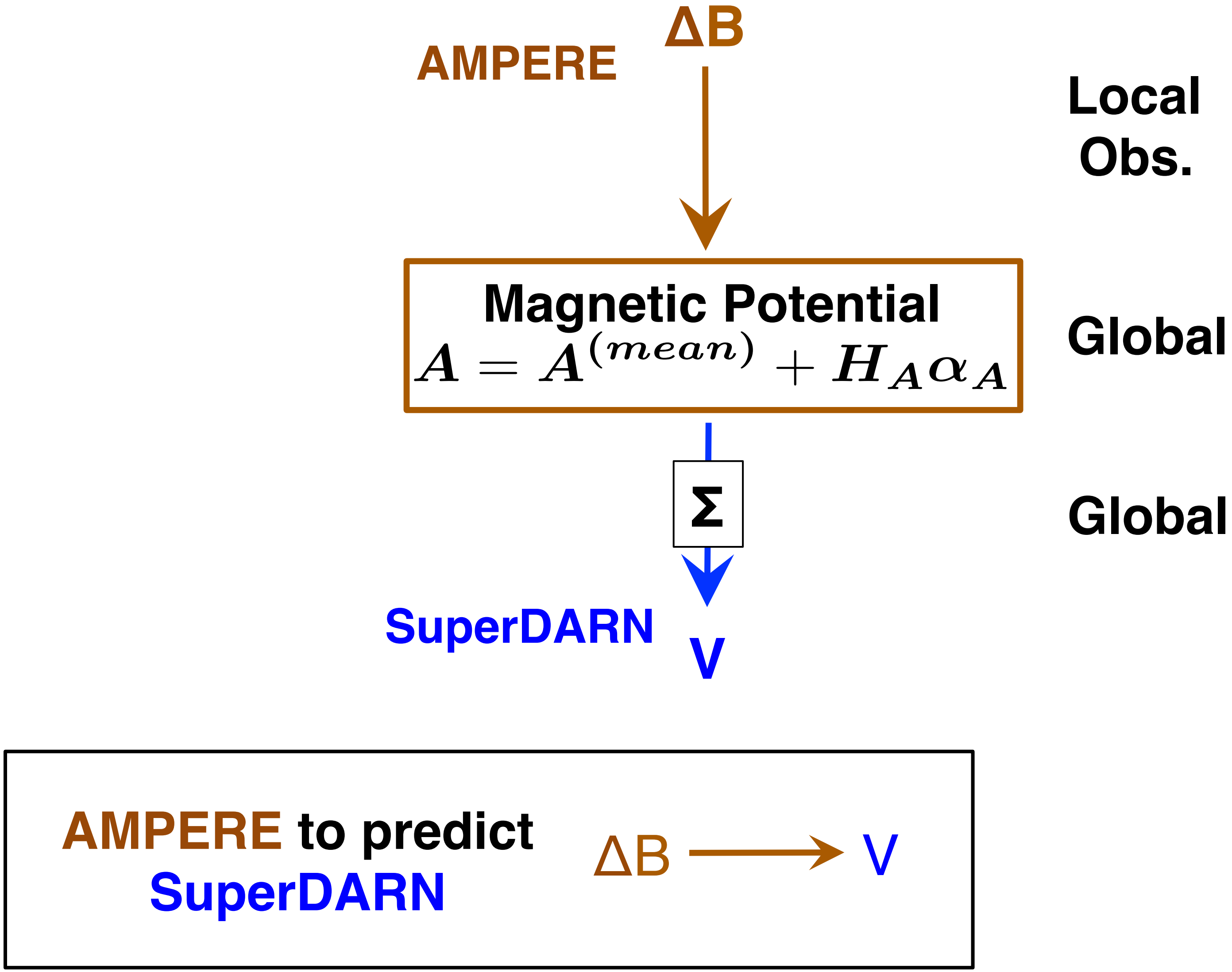


McGranaghan, R., D. J. Knipp, T. Matsuo, and E. Cousins (2016), Optimal interpolation analysis of high-latitude ionospheric Hall and Pedersen conductivities: Application to assimilative ionospheric electrodynamics reconstruction, J. Geophys. Res. Space Physics, 121, 4898–4923, doi:10.1002/2016JA022486.

How can we quantitatively test the conductance models?

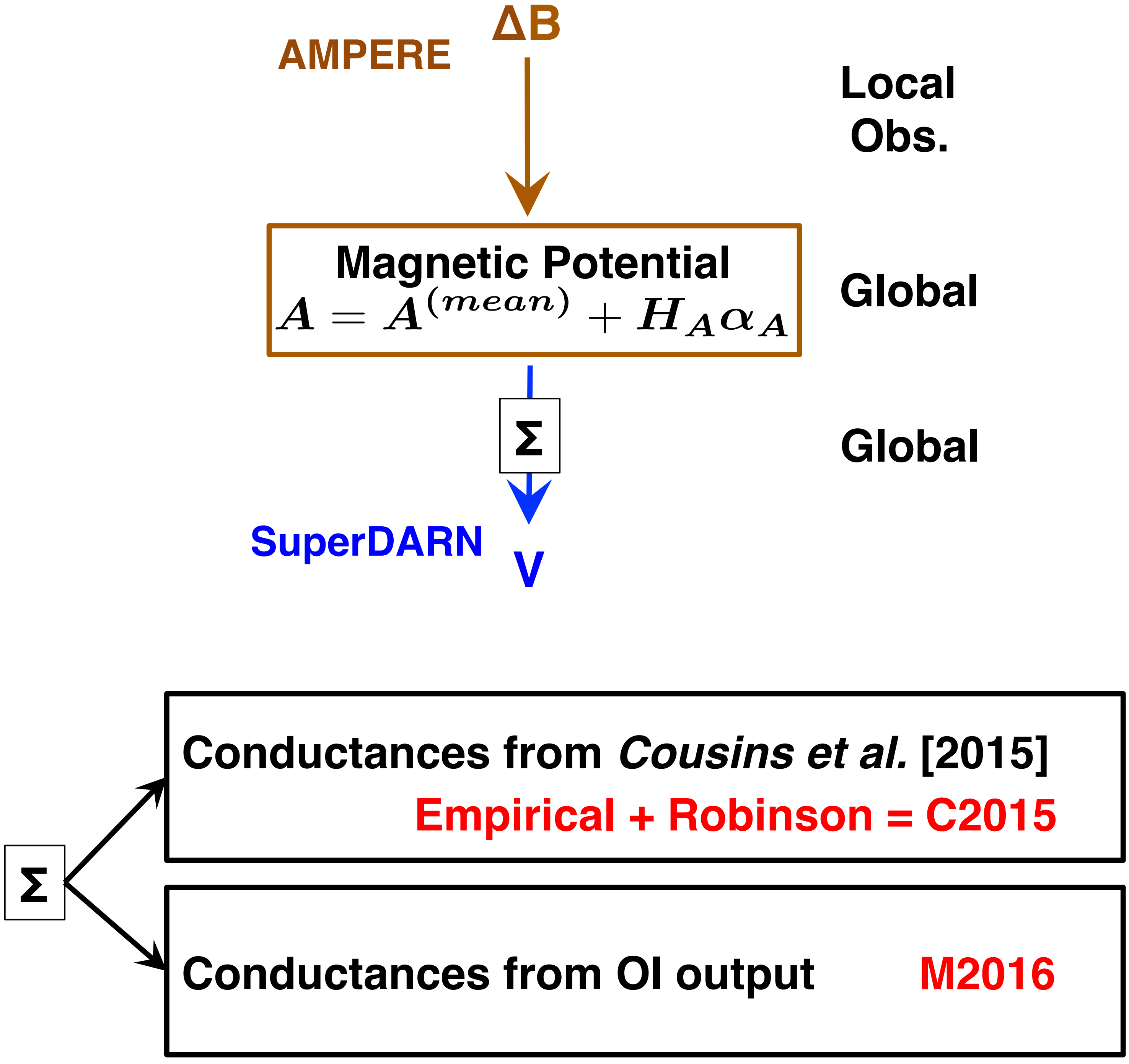
How can we quantitatively test the conductance models?





McGranaghan, R., D. J. Knipp, T. Matsuo, and E. Cousins (2016), Optimal interpolation analysis of high-latitude ionospheric Hall and Pedersen conductivities: Application to assimilative ionospheric electrodynamics reconstruction, J. Geophys. Res. Space Physics, 121, 4898–4923, doi:10.1002/2016JA022486.

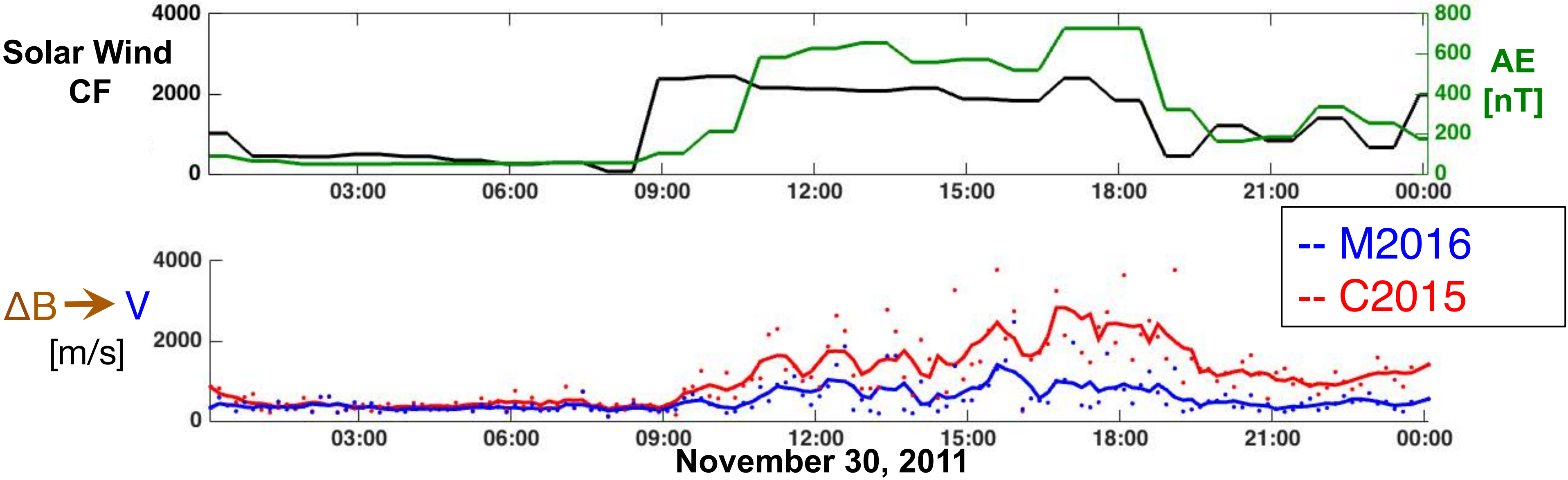
Cousins, E. D. P., T. Matsuo, and A. D. Richmond (2015), Mapping high-latitude ionospheric electrodynamics with SuperDARN and AMPERE, J. Geophys. Res. Space Physics, 120, doi:10.1002/2014JA020463.



ΔB
AMPERE
Local
Obs.
Magnetic Potential
$A = A^{(mean)} + H_A \alpha_A$
Global
Σ
Global
SuperDARN
V
Conductances from *Cousins et al.* [2015]
Empirical + Robinson = C2015
Σ
Conductances from OI output
M2016

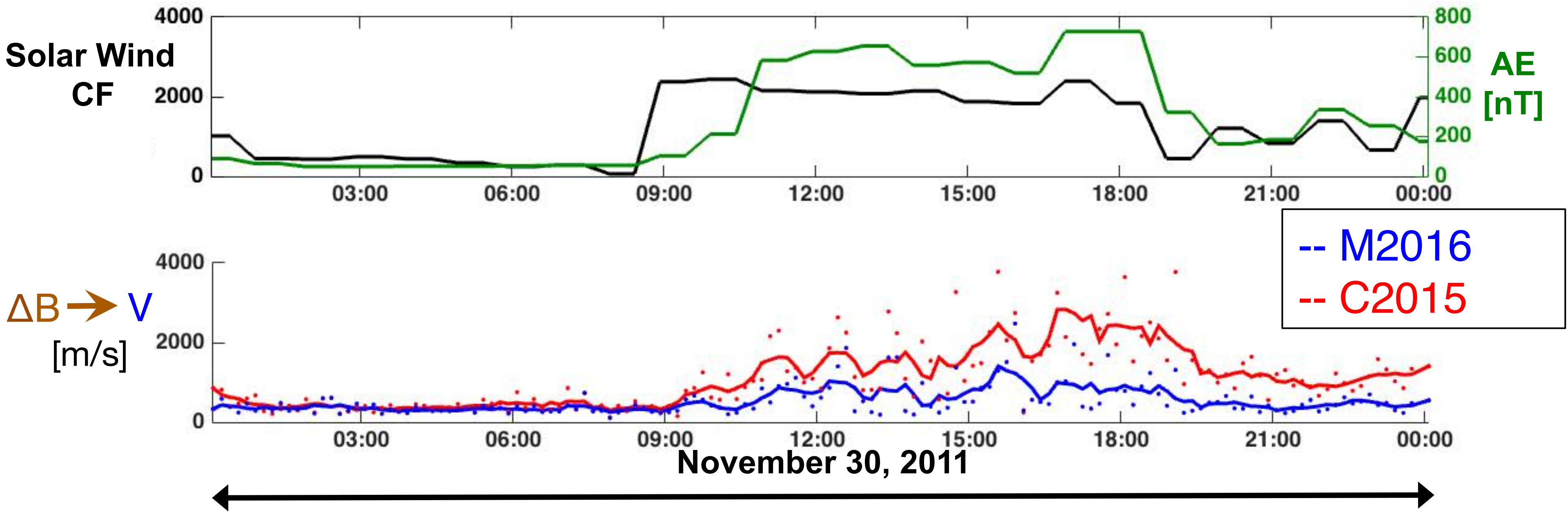
ΔB → V

Median Absolute Deviations (MADs)



ΔB → V

Median Absolute Deviations (MADs)

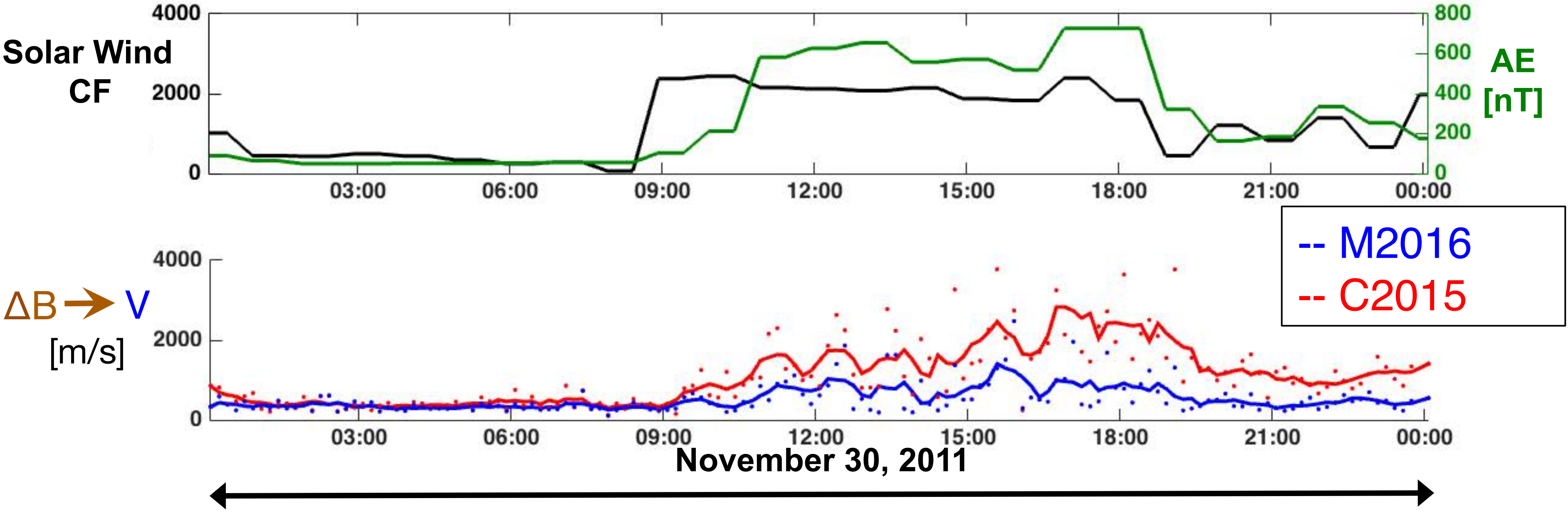


Total ΔB → V MADs [m/s]

C2015:	**684.2**
M2016:	**382.7**

ΔB → V

Median Absolute Deviations (MADs)

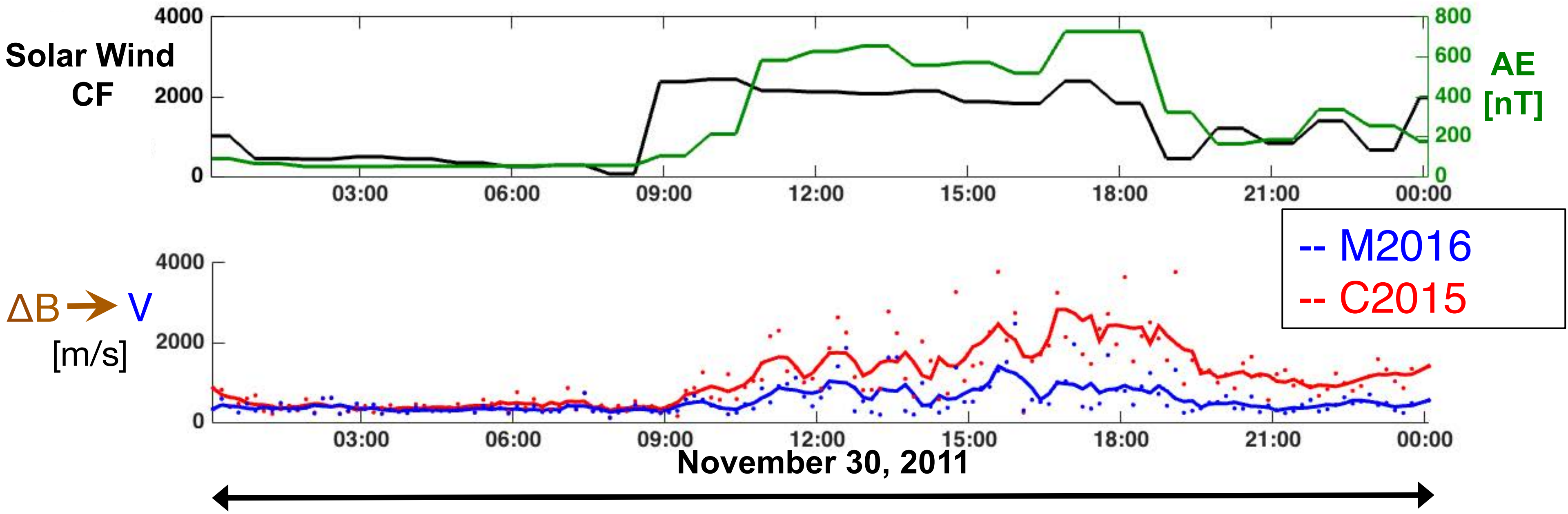


Total ΔB → V MADs [m/s]

C2015:	**684.2**
M2016:	**382.7**
M2016+SSUSI:	**359.1**

ΔB → V

Median Absolute Deviations (MADs)



Total ΔB → V MADs [m/s]

C2015:	**684.2**
M2016:	**382.7**
M2016+SSUSI:	**359.1**

Reconciling observations

Application of modeling improvement:

1. Studying local features in global analyses;
2. Facilitating closer agreement between diverse observations; and
3. Significance to NEROC community

Application of modeling improvement:

1. Studying local features in global analyses;
2. Facilitating closer agreement between diverse observations; and
3. **Significance to NEROC community**

Data assimilation at intersection of data and modeling (current understanding)

This community uniquely positioned to take advantage

Email: Ryan.M.McGranaghan@Dartmouth.edu

Application of modeling improvement:

1. Studying local features in global analyses;
2. Facilitating closer agreement between diverse observations; and
3. **Significance to NEROC community**

Data assimilation:

- Utilize diverse observational system
- Perform system science
- Conduct multi-scale analyses

Email: Ryan.M.McGranaghan@Dartmouth.edu