High-latitude convection maps derived from AMPERE field-aligned currents and comparisons with SuperDARN line-of-sight velocities

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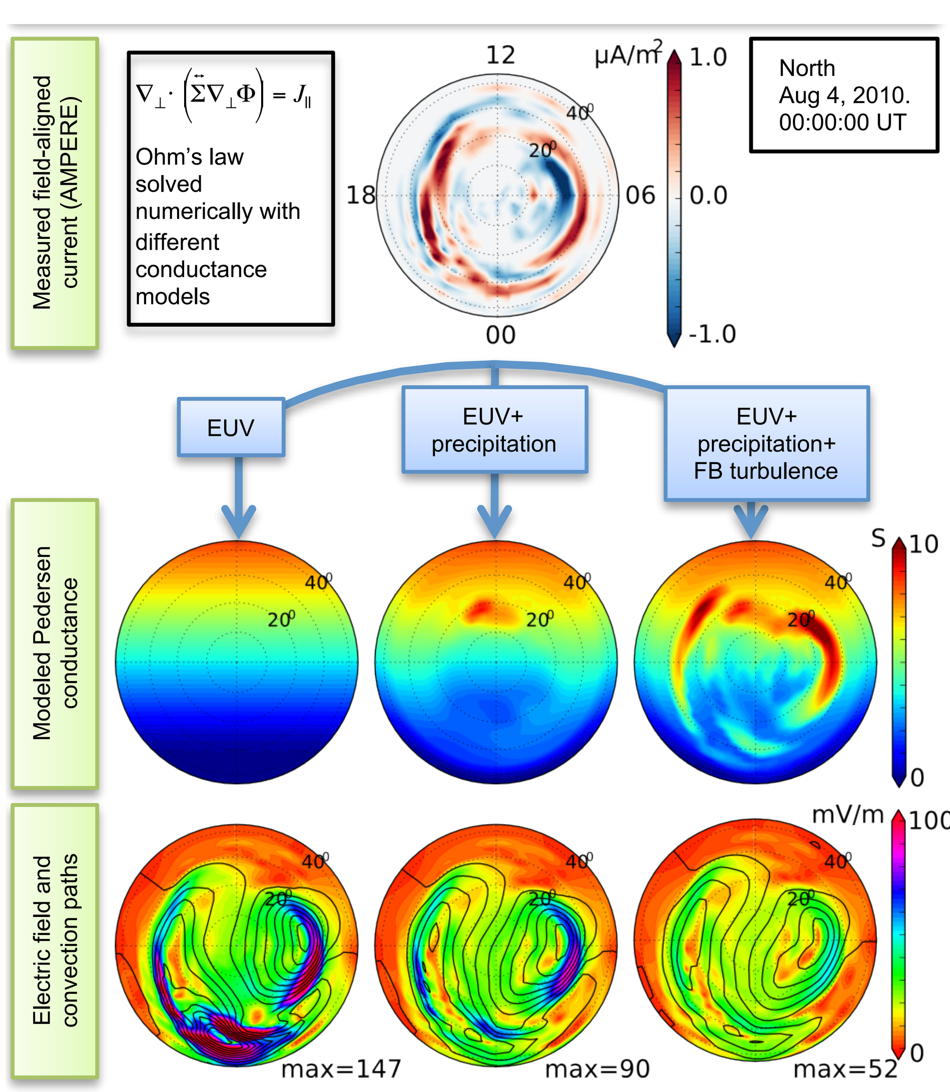
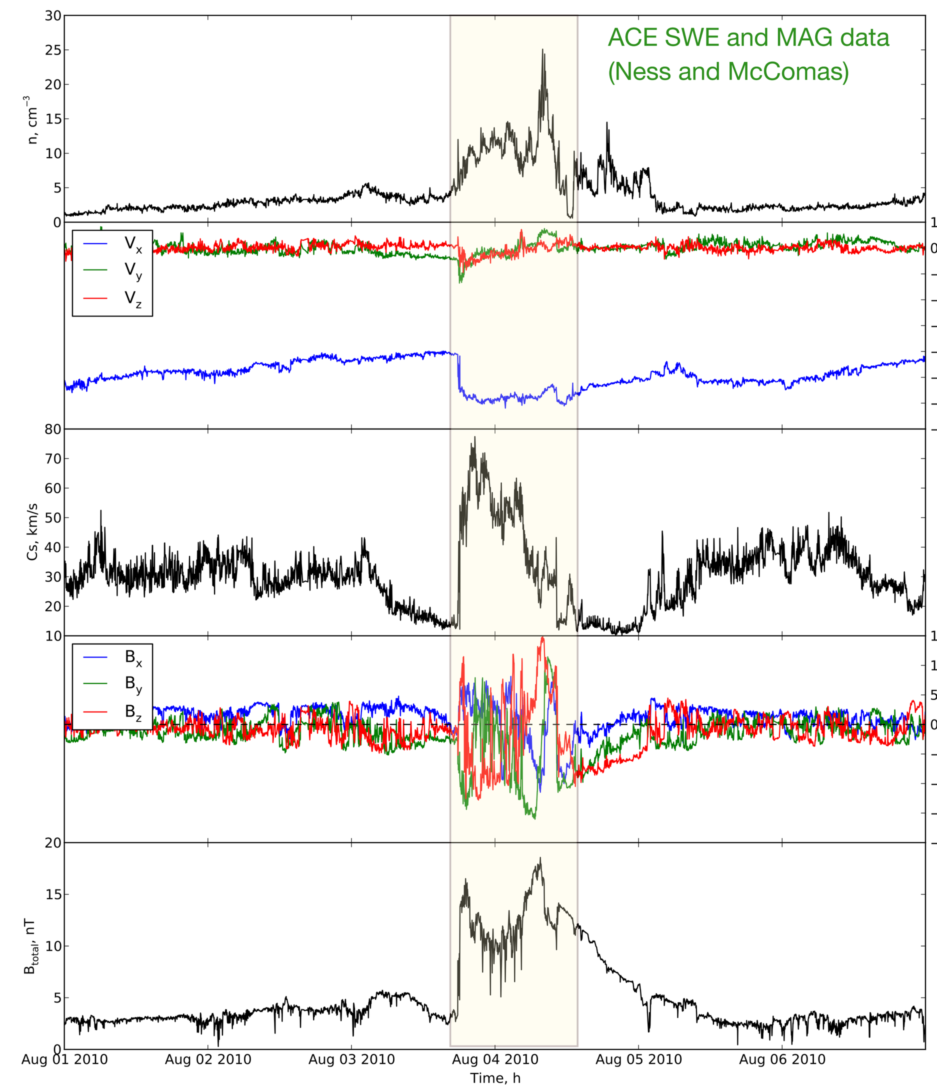
Introduction

- We use the MIX code [*Merkin and Lyon*, 2010], which solves the ionospheric Ohm's law, to derive high-latitude convection patterns from the field-aligned Birkeland currents provided by the Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE).
- AMPERE calculates the Birkeland currents from magnetic field measurements by Iridium spacecraft.
- We use three models of the ionospheric conductance:
  1. An empirical model of Extreme Ultraviolet (EUV) ionization.
  2. Model 1 with particle precipitation added.
  3. Model 2 with a parametric specification of Farley-Buneman turbulence which results in anomalous electron heating in the E-layer and leads to enhanced conductances.
- Given a distribution of field-aligned currents and conductances (Hall and Pedersen) we solve for the ionospheric electrostatic potential.
- The derived convection patterns are compared with SuperDARN line-of-sight velocities as an independent test.
- The process is schematically outlined below:



An example event: CME on Aug 3-4, 2011

- The solar wind data is shown below:



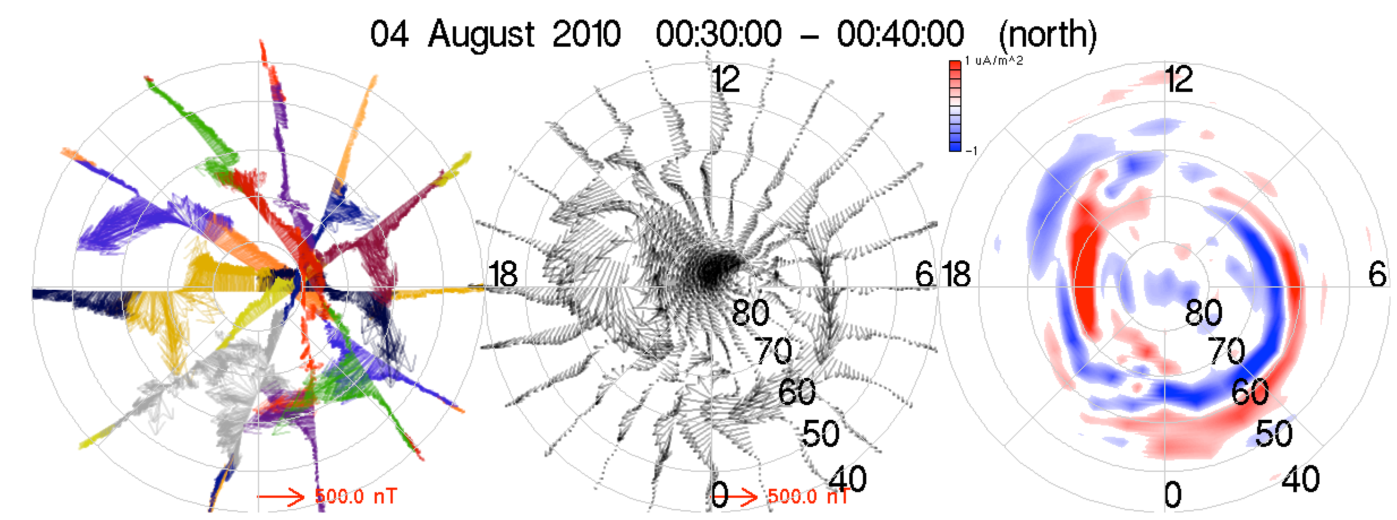
- We simulate the shadowed period above using the Lyon-Fedder-Mobarry (LFM) global magnetosphere magnetohydrodynamic (MHD) model. The results of the simulation are used for a broader study comparing LFM with various ionospheric datasets, but here we limit the use of LFM results to the specification of the plasma sheet density and temperature needed to estimate the diffuse aurora contribution to ionospheric conductivity.

How is conductance calculated.

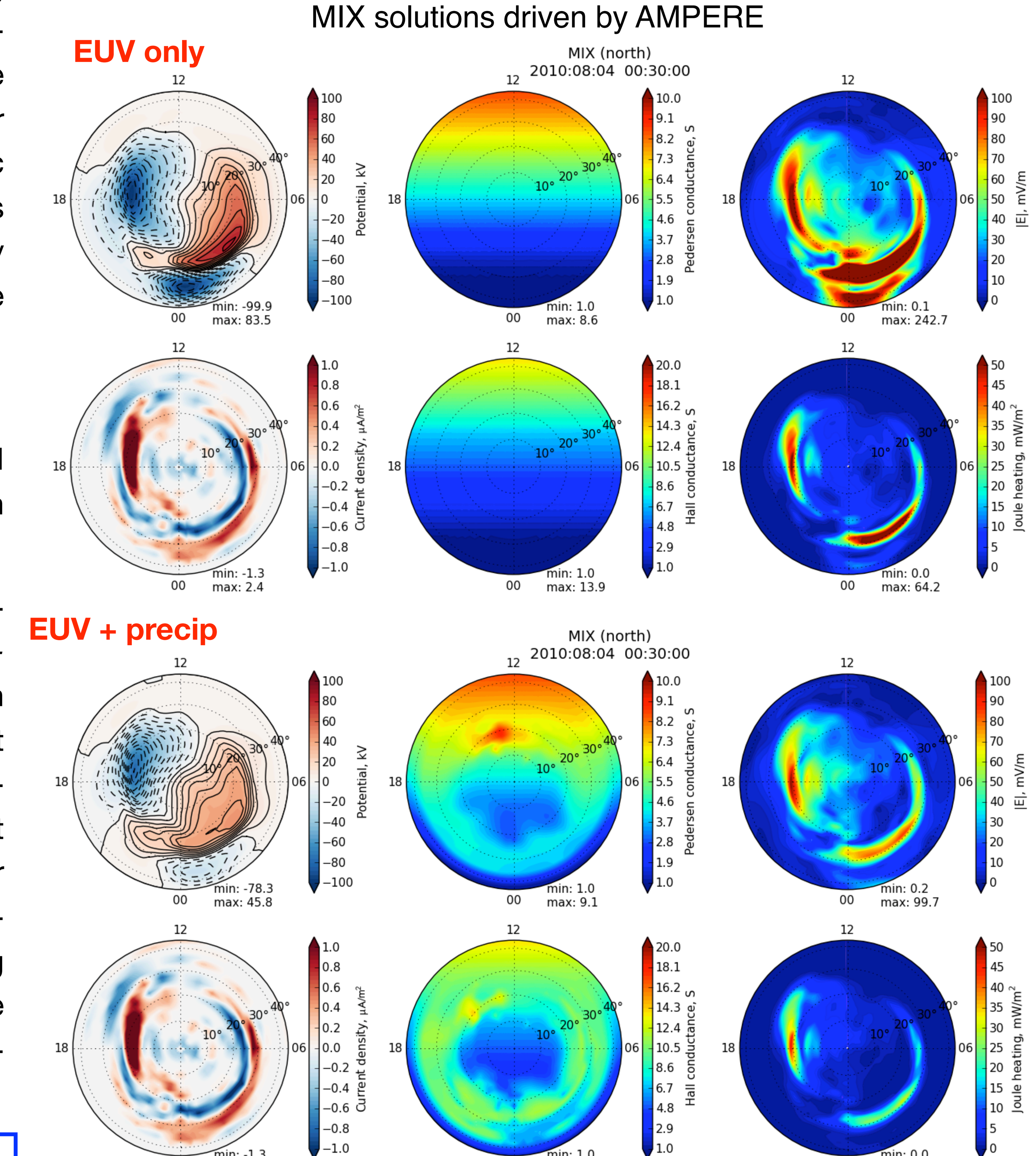
1. **EUV** contribution is the same as in the LFM model (taken from AMIE). An example is shown on the left.
2. **Precipitation** calculation is built upon the precipitation module within the LFM code [e.g. *Wiltberger et al.*, 2009]: diffuse electron precipitation is parameterized by the simulated plasma sheet density and temperature; discrete electron precipitation is related to the field-aligned current through the Knight relation [*Knight*, 1973]. In our procedure, we essentially replace the LFM currents with the AMPERE currents. The resulting precipitation energy and flux are used in the "Robinson" formula [*Robinson et al.*, 1987] to obtain the Hall and Pedersen conductance.
3. **Farley-Buneman turbulence** affects the ionospheric conductance via anomalous electron heating and non-linear turbulent current [*Dimant and Oppenheim*, 2010a,b]. Through this mechanism, conductance becomes non-linearly dependent on the laminar convective electric field. Following our previous work [*Merkin et al.*, 2005] we use a simple parameterization of the conductance-electric field dependence: $\Sigma \sim E^{0.5}$. This simple function roughly approximates the complex dependence, which can only be fully estimated from 3D Particle-in-Cell simulations, and depends on a handful of ionospheric and driving parameters, but it provides a realistic parameterization, suitable for qualitative studies.

Results

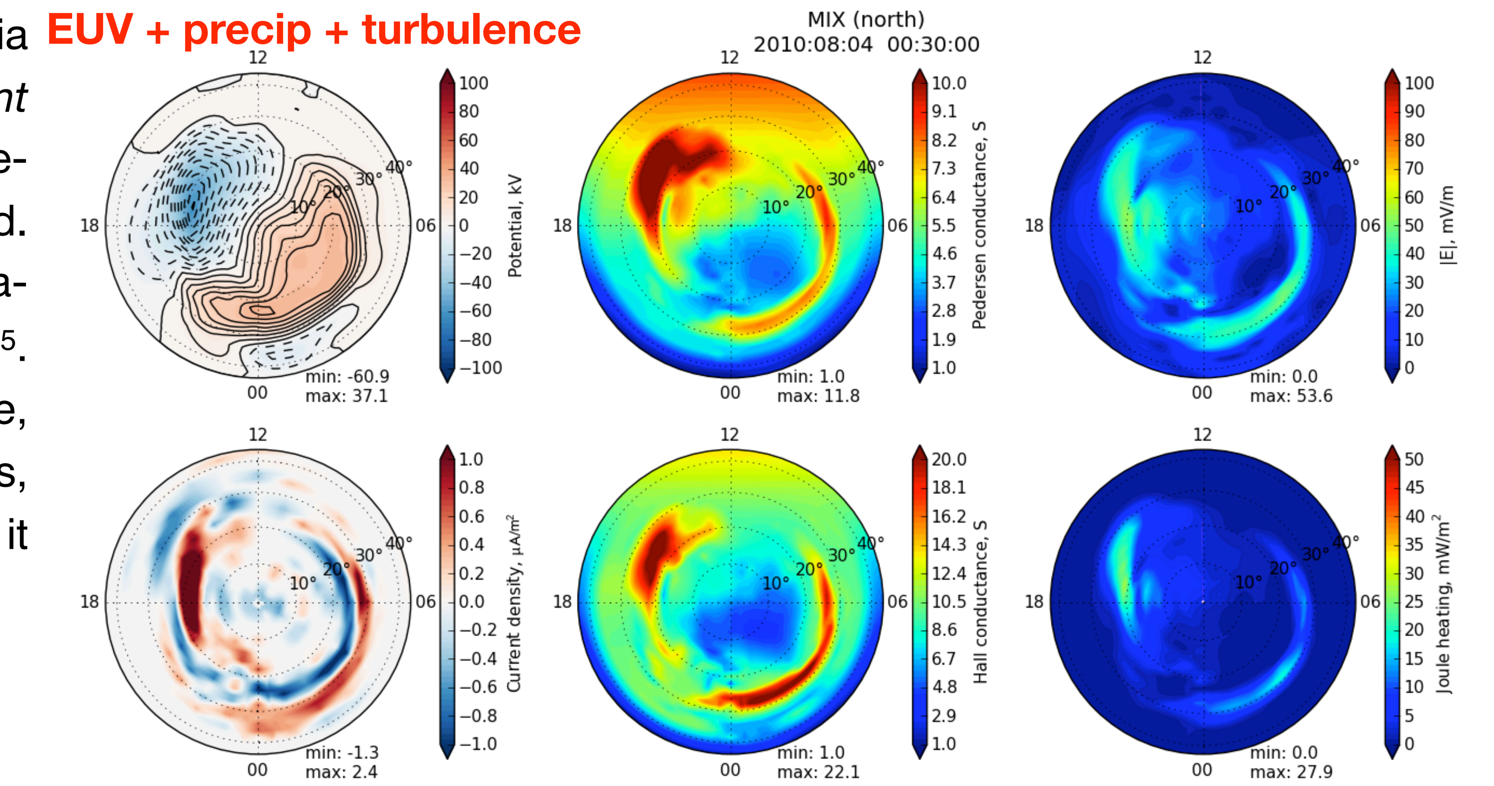
Interval 1: IMF By=0, Bz<0: 00:30-00:40 UT, Aug 4



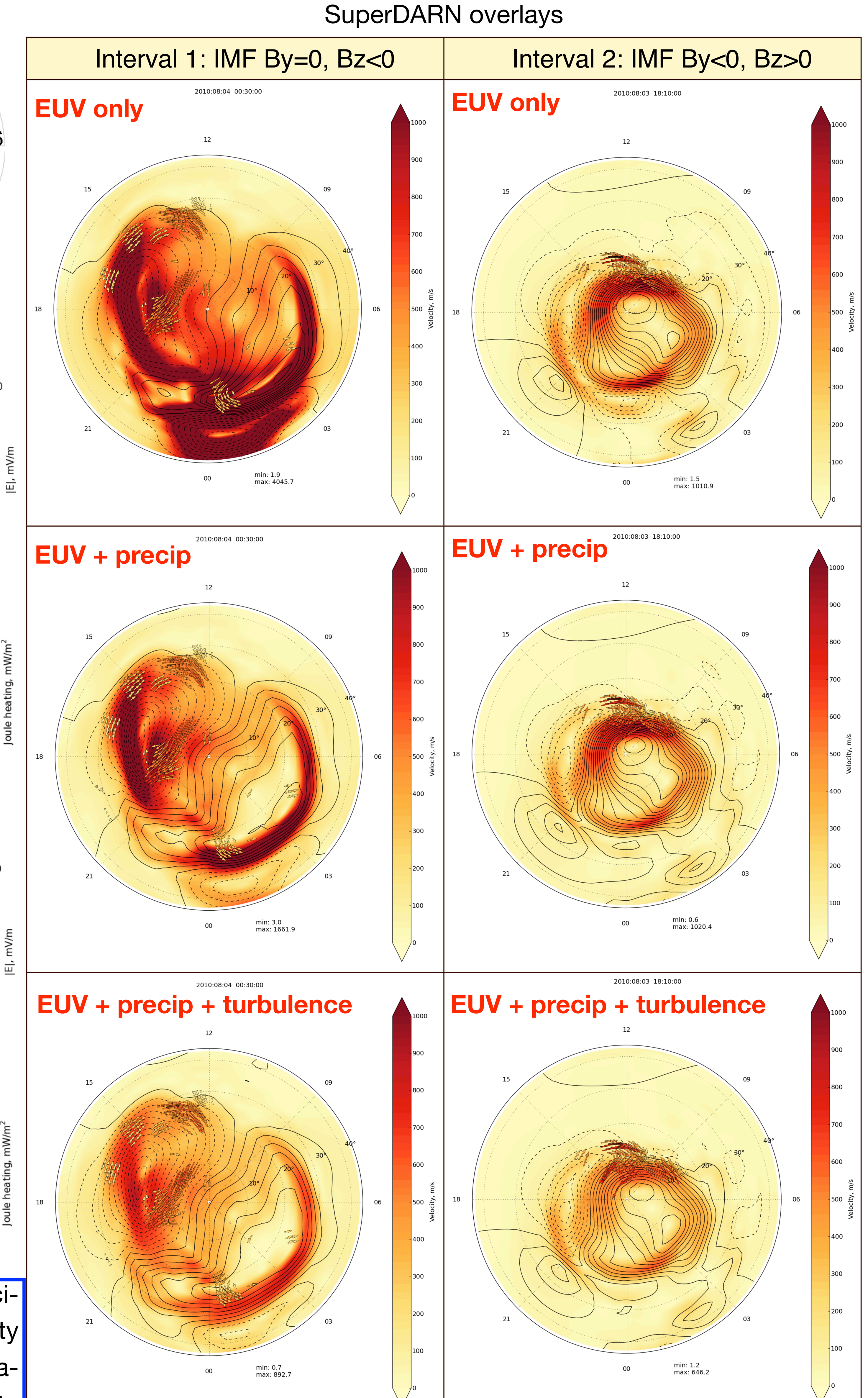
MIX solutions driven by AMPERE



EUV + precip + turbulence



SuperDARN overlays



The arrows are colored by the velocity magnitude on the same color scale as the background, computed from AMPERE.

Discussion: We show a promising technique for reconstruction of ionospheric convection patterns from AMPERE field-aligned currents. Three different models of ionospheric conductance are used and show that i) The current distribution places a surprisingly tight constraint on the convection pattern; ii) As expected, ionospheric conductance affects significantly the strength and geometry (both locally and globally) of the convection pattern but does not substantially alter the regions of maximum electric fields; iii) SuperDARN overlays show a very good agreement with AMPERE-inferred velocities and immediately yield a direct evaluation of the conductance model used. For instance, in the "Bz<0" case shown, precipitation does not provide enough conductance to bring AMPERE velocities in agreement with SuperDARN measurements; iv) Local conductivity gradients are clearly necessary in many places to match the flow orientation. These results underscore the utility of combined ionospheric data sets for constraining ionospheric conductance.