A Predictive Model for the High-latitude Ionospheric Convection

Dogacan S. Ozturk[1], Bharat Kunduri[2], Evan G. Thomas[3], Hyunju K. Connor[4], Kathryn A. McWilliams[5], Amy M. Keesee[6]

1: Geophysical Institute, University of Alaska Fairbanks, 2: Virginia Tech, 3: Dartmouth College, 4: NASA/GSFC, 5: University of Saskatchewan, 6: University of New Hampshire

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Machine Learning Algorithms for Geomagnetically Induced Currents in Alaska and New Hampshire

Why is there a need for a multi-scale model of ionospheric convection?

- The multi-scale definition is necessary to accurately quantify the electromagnetic energy input and momentum transfer to the I-T system.
- This input is responsible for the generation of various disturbances in the I-T system.

Leveraging the SuperDARN Network

- Super Dual Auroral Radar Network is a global network of continuously operating scientific HF radars.
- The radars span mid to polar latitudes, monitoring plasma convection.
- SuperDARN is one of the most valuable assets for studying Space Weather.

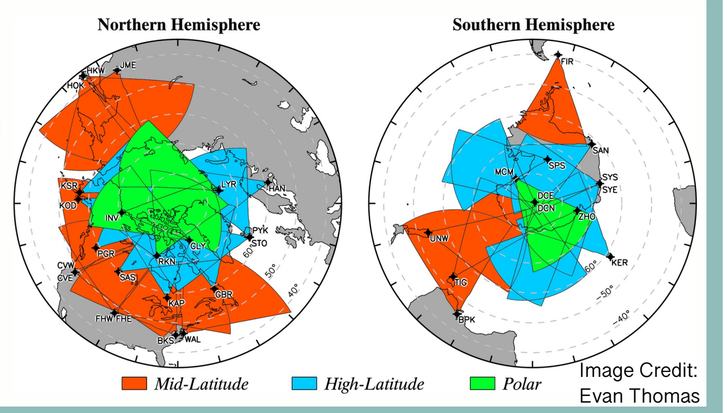


Image Credit: Evan Thomas

Specifics of the Data Set and Model

Dataset:

- PGR radar, 2010-2016, converted to VLAT and VLON + mlat, mlon, mlt, doy, ut
- IMF BX, BY, BZ with 20 min. time history
- Solar wind VX, VY, VZ, NP with 20 min. time history
- sym-H, asym-H, AL, AU
- 2 min. resolution

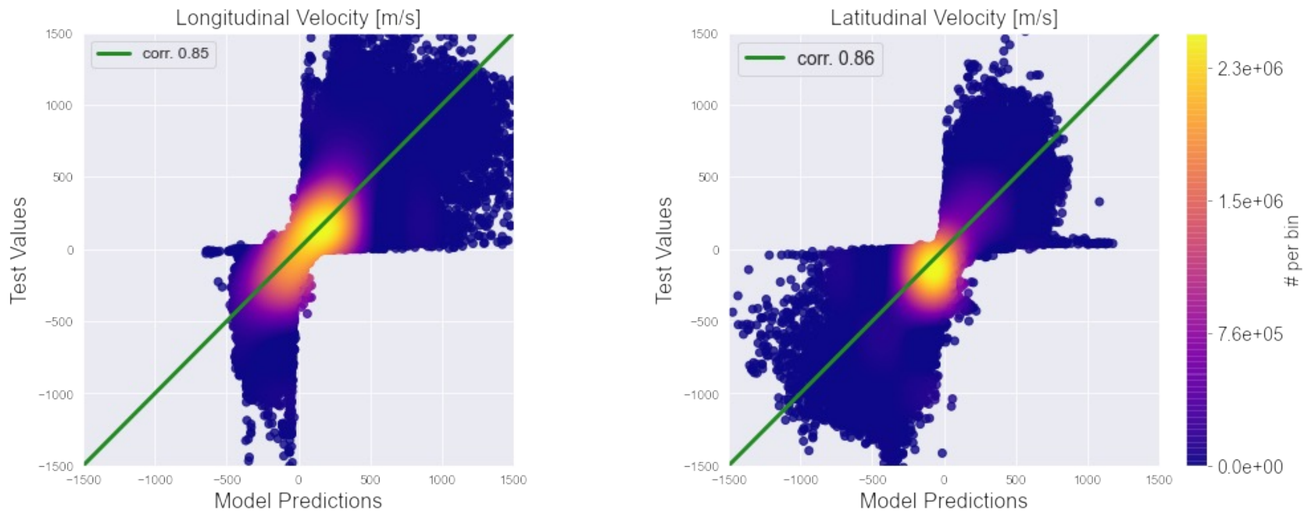
Model

- Multi-layer perceptron model
- ~18 Million data points
- 117 variables (20 minute time history from solar wind and IMF, sym-H, asym-H, AU, AL)
- Training set: %60, validation set: %30, test set: %10

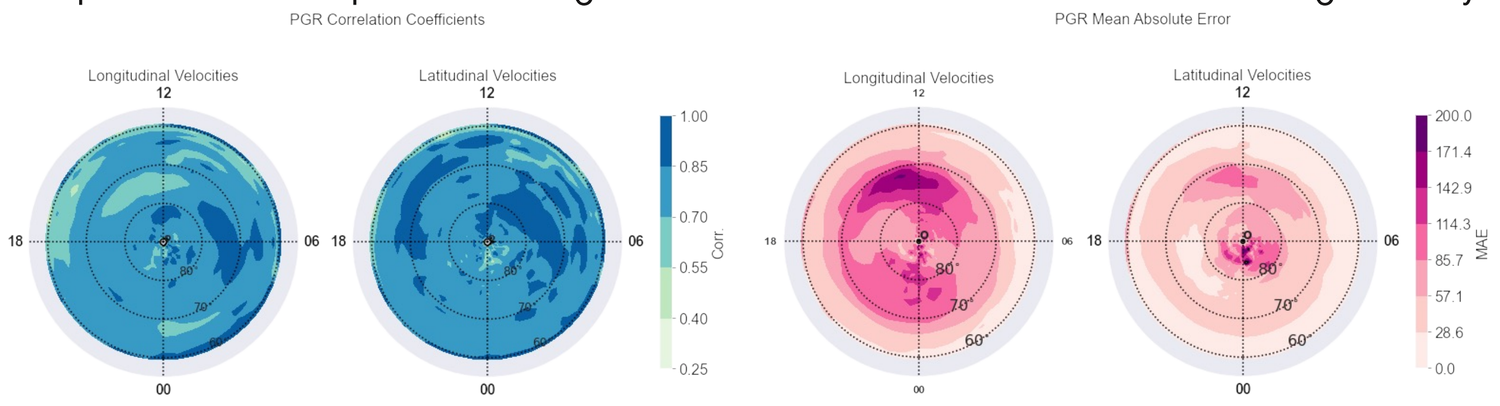
The MLP model fine-tuned using KerasTuner for the following properties: number of hidden parameters, number of neurons per layer, dropout rate, activation function, optimizer, learning rate, and batch size.

Performance of the MLP model on the test data set

The Pearson correlation coefficient is 0.85 for VLON and 0.86 for VLAT.



The performance depends on magnetic latitude and MLT due to radar beam geometry.

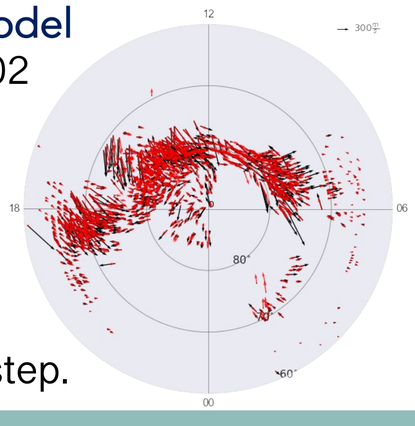


Findings of the study

- SuperDARN has 2 minute resolution. --> Capturing temporal variations below 10 min.
- No need to bin drivers (IMF+SW) --> More input parameters, better specification
- The MLP model performance depends on magnetic latitude.
- The model predictions at data gaps help construct a more complete picture of the ionospheric convection.

Next steps for the convection model

- Model vs data during 2016-03-02 show good agreement.
- MLP models are trained for SAS and KSR radars.
- A performance-based congregated method using high-latitude radars is the next step.



Long-term/deliverable goal: An operational multi-scale ionospheric convection model to specify upper boundary conditions for GCMs.

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