



The Influence of Inner Magnetosphere Data on a Regional Geomagnetically Induced Current Forecasting Model

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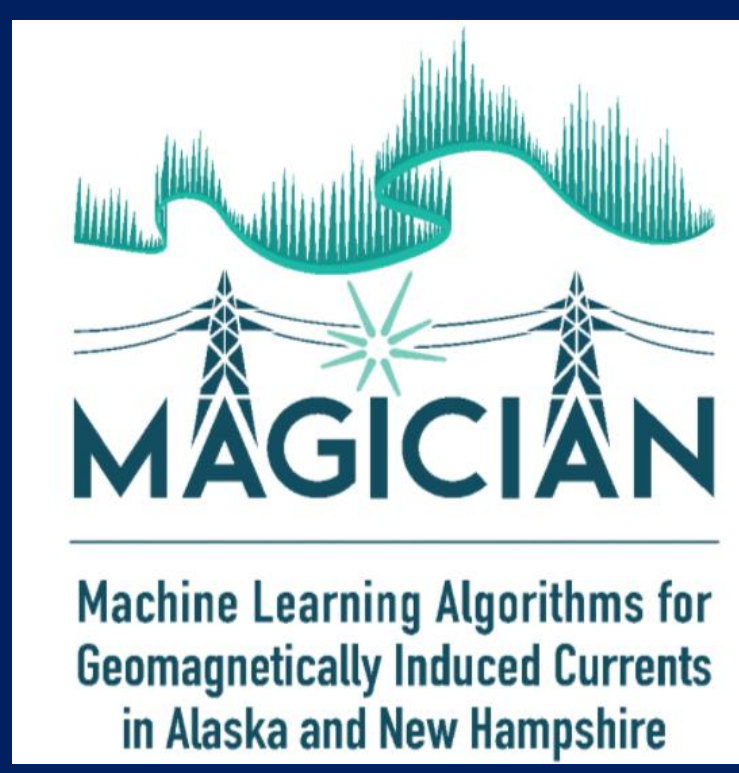
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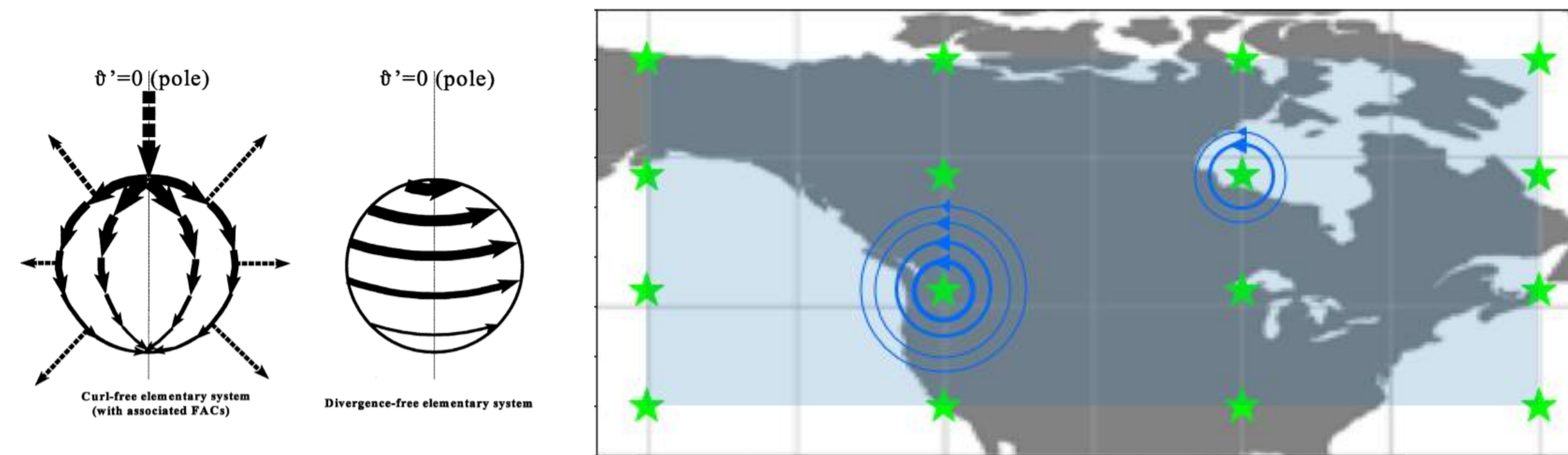
Introduction

- The solar wind's interaction with the Earth's magnetic field can cause Geomagnetically Induced Currents (GICs) at ground level, which are hazardous to power and communications infrastructure.
- Perturbations in the horizontal component of the ground magnetic field ($\delta B_H/dt$) are commonly used as a proxy for GIC measurements and forecasting.
- Perturbations are often highly localized during geomagnetic storms. It is important to understand what factors contribute to this localization.
- Here we study how including data from a DMSP spacecraft during training can affect our forecasting models.
- We examine the overall performance of the new model as well as the differences the new data creates in regional perturbation heatmaps.

Spatial Interpolation with Spherical Elementary Current Systems

How can we estimate $\delta B_H/dt$ far away from magnetometer stations?

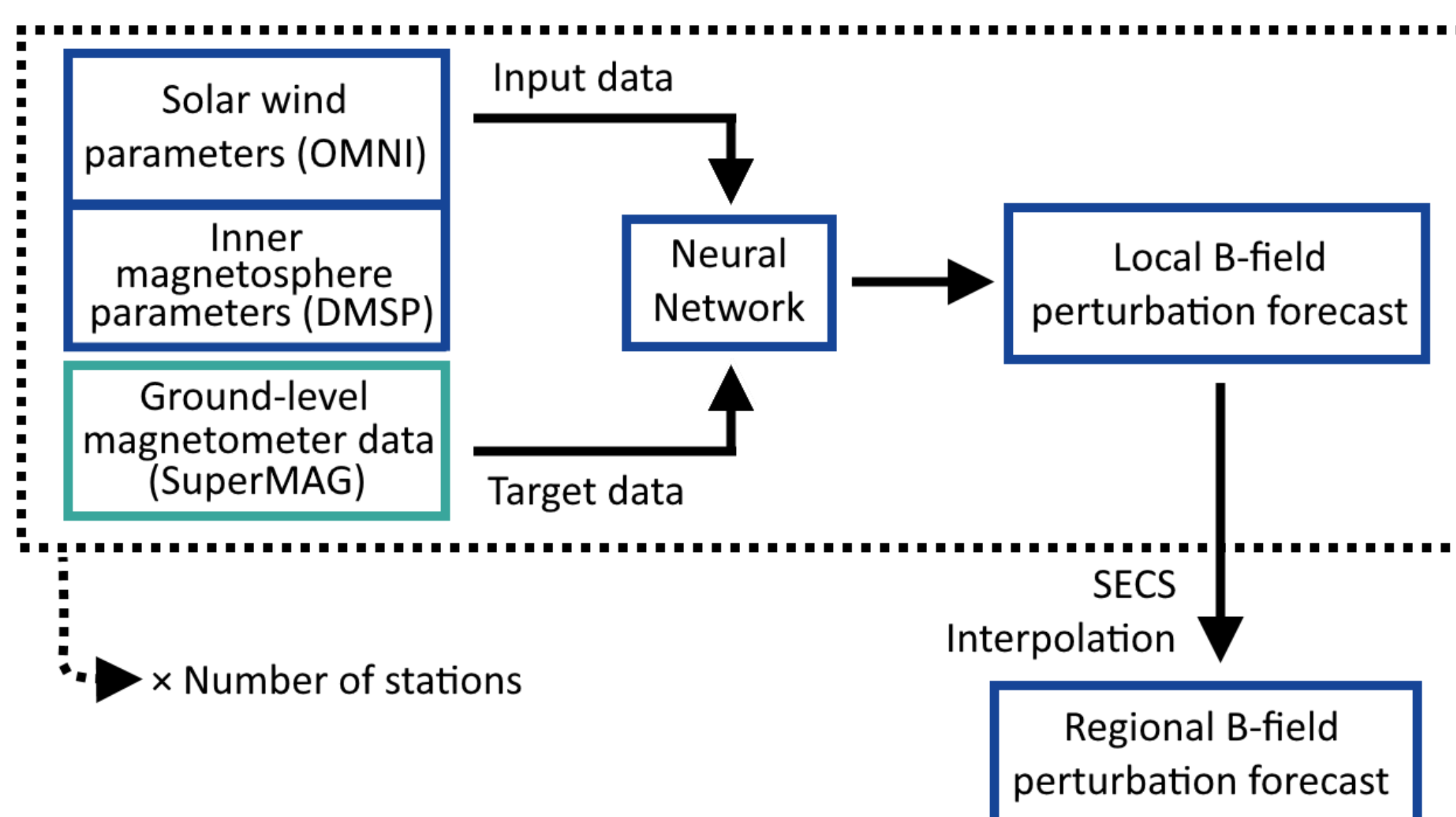
Spherical Elementary Current System (SECS) Interpolation. A hypothetical current sheet is constructed at ~ 100 km altitude. The vector field describing the current is expressed as a superposition of divergence-free basis vector fields, each centered at a different point on a latitude-longitude grid. In the superposition, each elementary basis field has a strength coefficient. We tune the values of each coefficient so that the overall current sheet reproduces the true B_N and B_E values at all magnetometers. The total current sheet is then related to the magnetic field via the Biot-Savart law.



Left figure: The current basis vector fields at a single example Current System. The curl-free component vanishes below the ionosphere and is not used in our analysis. Taken from (Amm & Viljanen 1999).

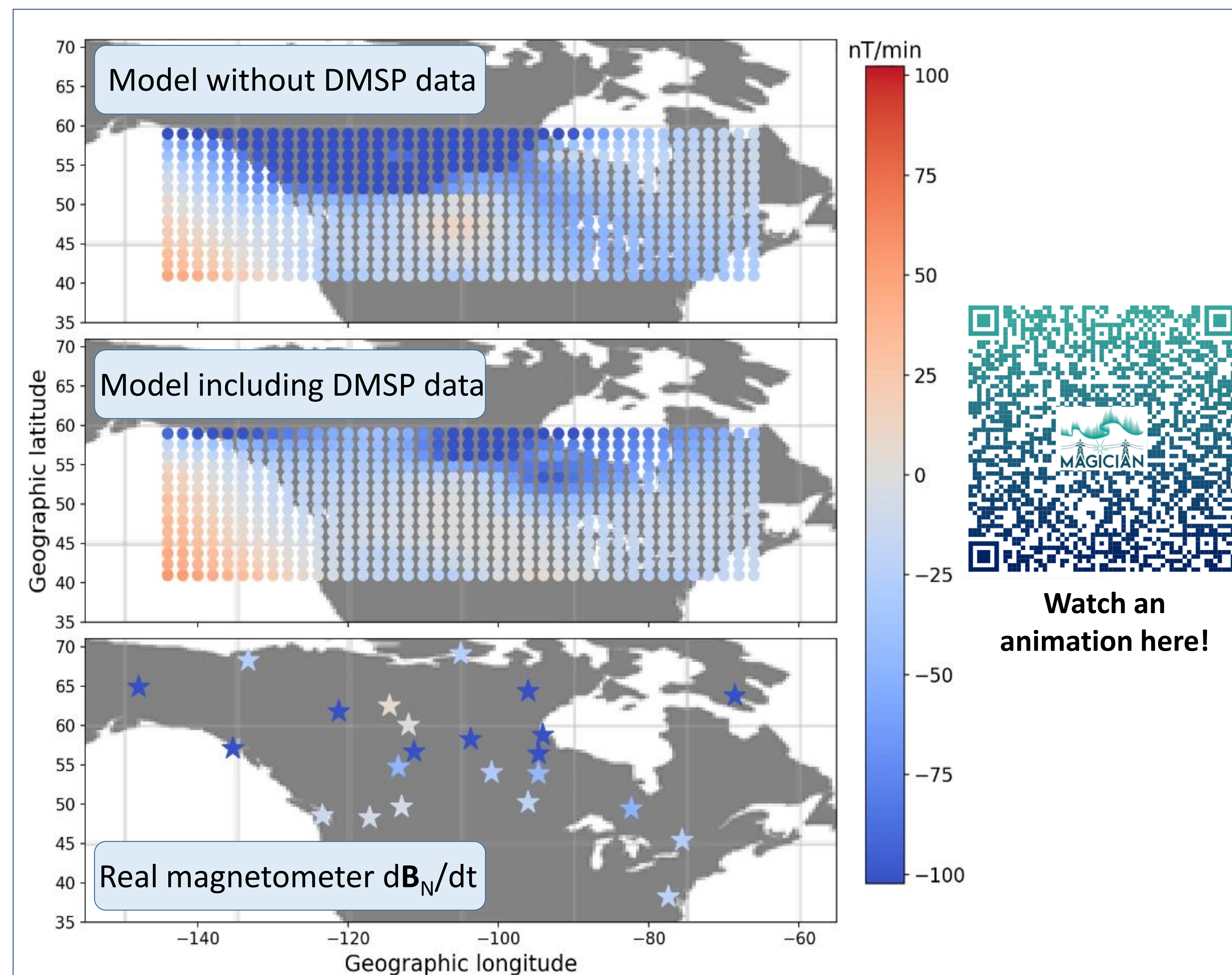
Right figure: The green stars are hypothetical locations of Current Systems; the blue circulating fields around them show their contribution to the model current sheet. Each system contributes different amounts of current. The total model current sheet is the sum of each of these vector fields. The model current sheet is fit to magnetometer measurements inside the light blue rectangle.

Model Details



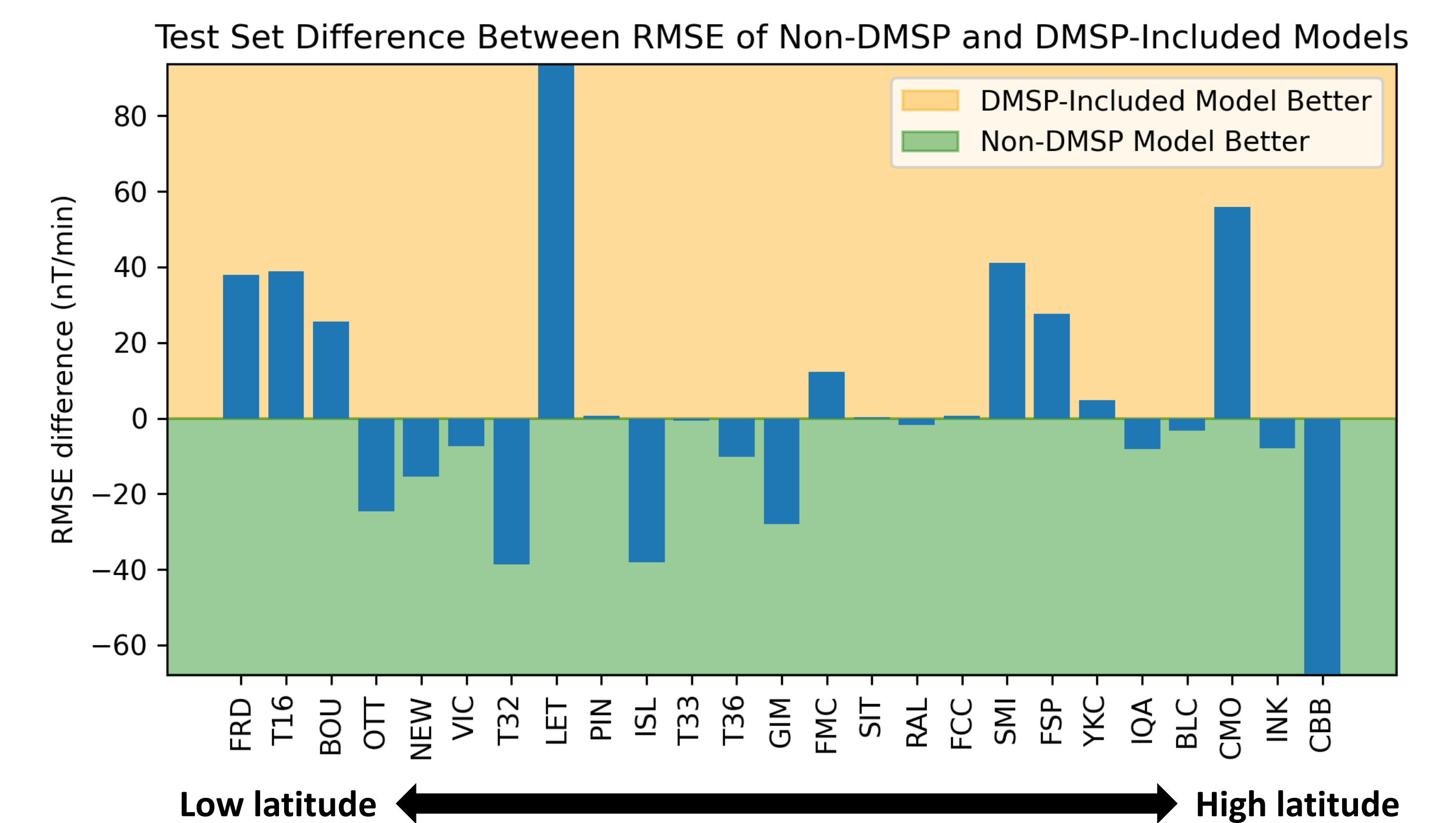
- A local $\delta B/dt$ forecast is generated at each magnetometer station by a simple feed-forward neural network using a 4-hidden-layer architecture with 300-150-75-37 neurons each.
- Each neural network was trained on 1-minute cadence OMNI and DMSP-F16 SSIES data with 60 minutes of time history. The target data is 1-minute cadence SuperMAG data from North American magnetometers with >50% yearly data availability. All data is from storm time.
- Our spatial interpolation model is fit to forecasts from all 25 stations. The model is composed of a grid of 10×28 Current Systems.
- The model is validated at each magnetometer via a leave-one-out scheme.

Differences in $\delta B_N/dt$ Heatmaps



- Qualitatively, the DMSP-included model more often shows smaller-scale structure. Future work will develop "roughness" metrics to make this more quantitative.
- The "hot" area in the southwest corners is probably an edge effect because that area is not well-surrounded by magnetometers. The central "warm" area may be a real feature, but that cannot be made certain without magnetometers in that area.

Differences in Model Performance



- The models are validated at each magnetometer. The plot above shows the difference in their RMSEs over the Oct. 11, 2008 geomagnetic test storm.
- There is no clear dependence on the magnetic latitude of the test station.

Acknowledgements

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- OMNIWeb data from omniweb.gsfc.nasa.gov
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