

COMPARISON OF MODELLED AND MEASURED GEOMAGNETICALLY INDUCED CURRENTS DURING A MODERATE GEOMAGNETIC STORM IN ALBERTA, CANADA



October 12, 2021 Aurora, Edmonton, AB, Canada
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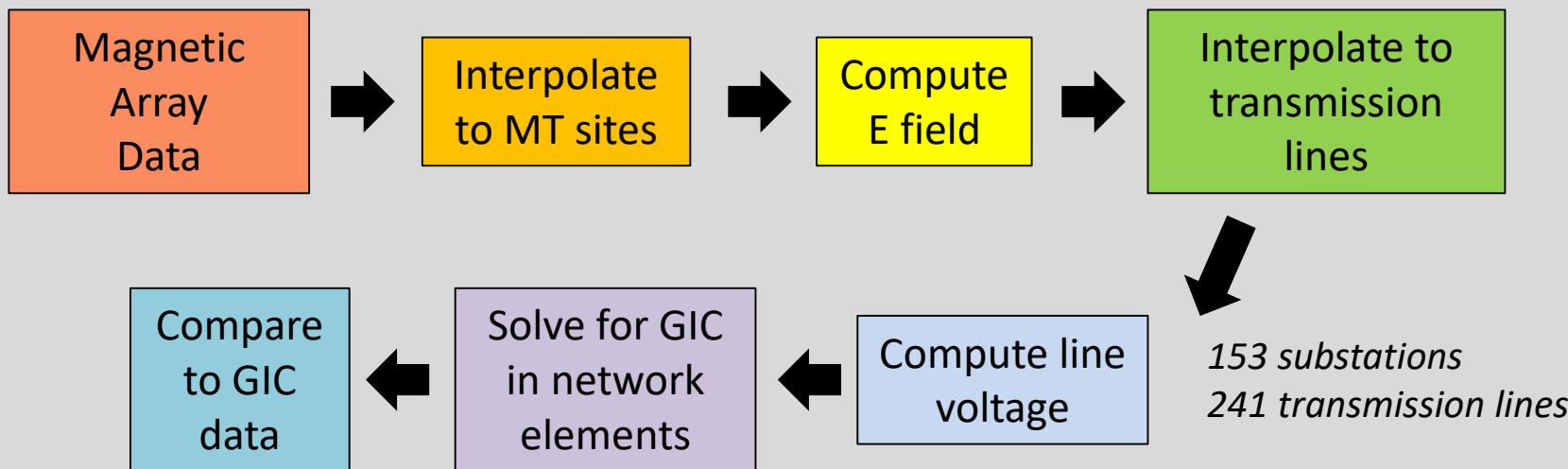
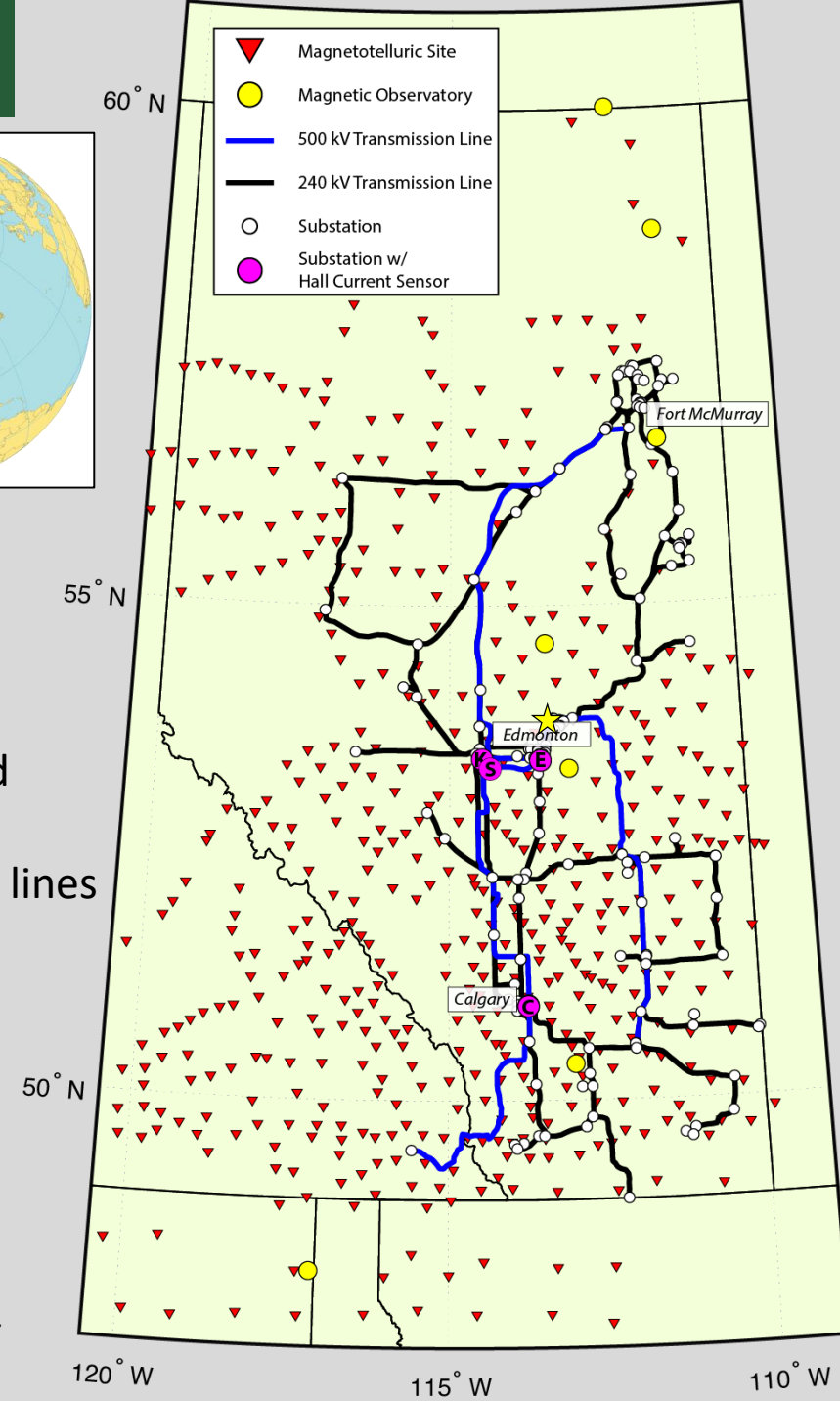
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Ryan Cui² Eva Kelemen², Colin Clark^{2,3}

February 20, 2024 | DASP Workshop

¹University of Alberta, ²AltaLink L.P., ³Pattern Energy Group

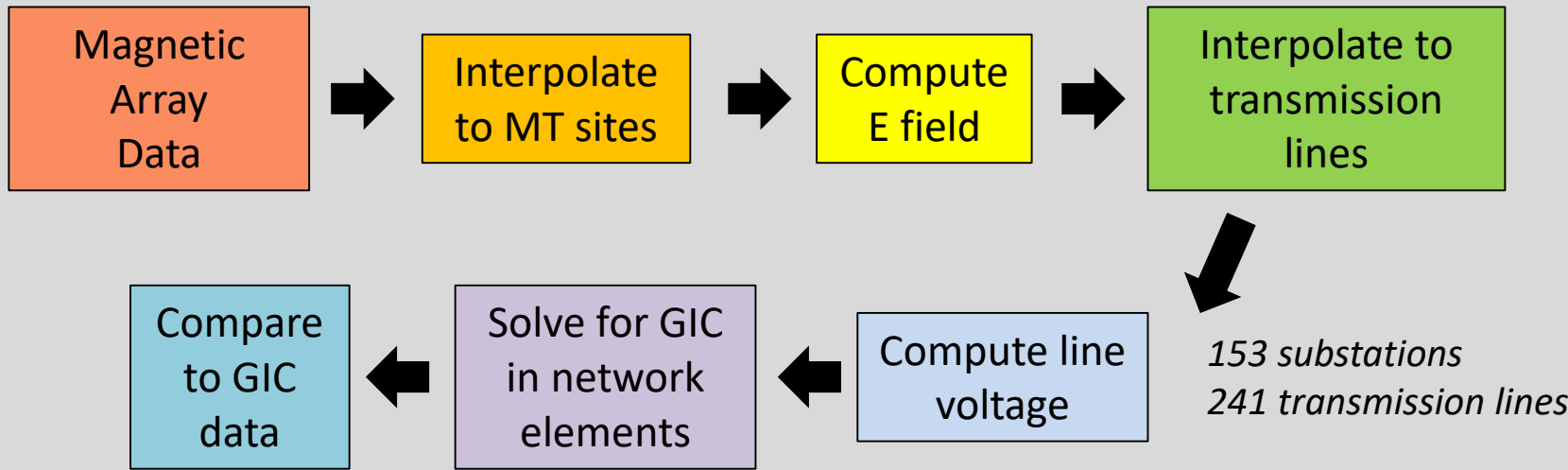
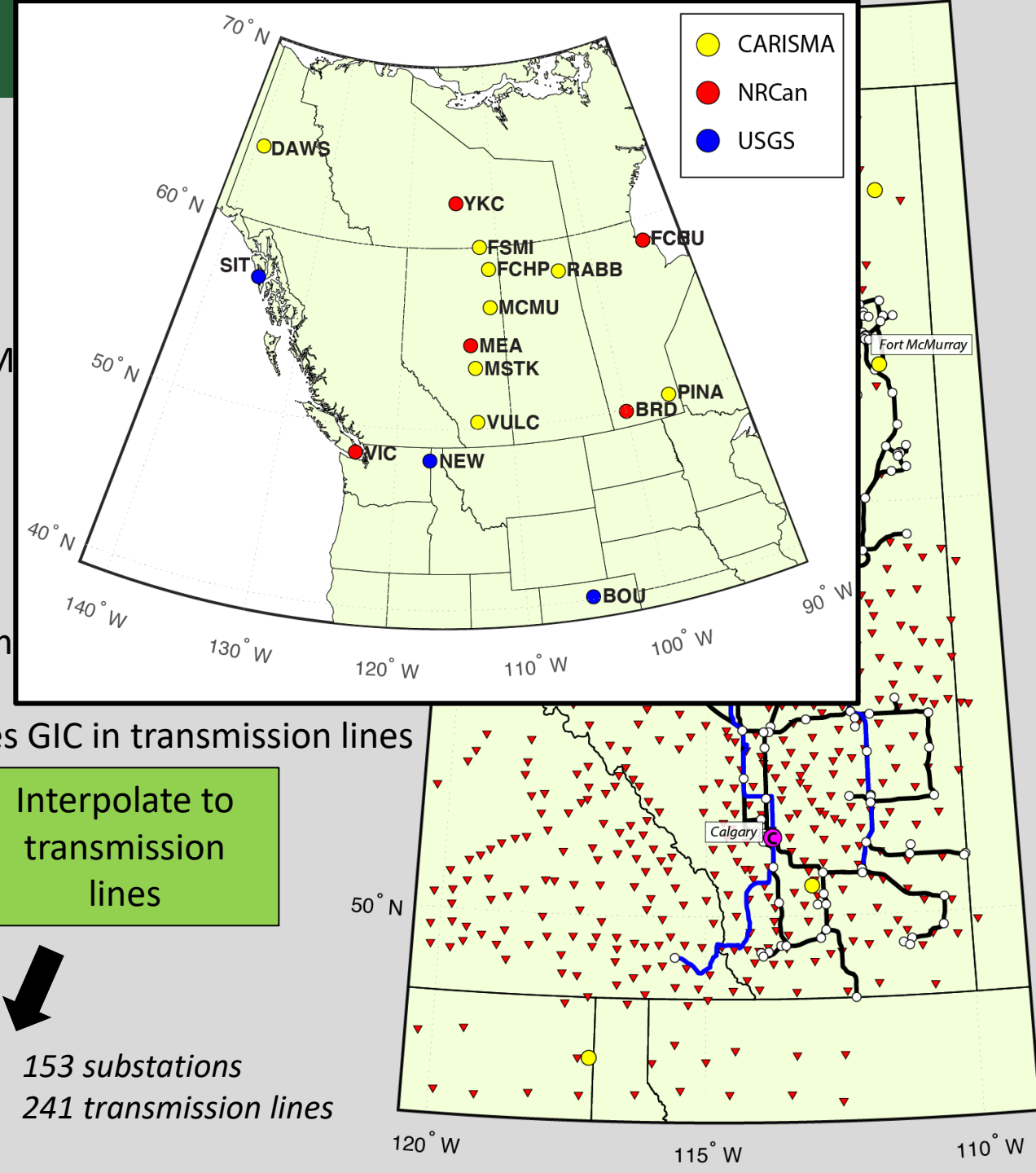
Background and Methodology

- GICs caused by space weather can damage electrical infrastructure and lead to blackouts
- Why Alberta?
 - Located at high geomagnetic latitude and prone to larger GMD
 - >500 magnetotelluric surface impedance measurements
 - Relatively dense CARISMA magnetometer array
 - 6 GIC monitors installed by AltaLink at 5 substation transformer neutral-to-ground
 - 1 Differential Magnetometer Measurement (DMM) measures GIC in transmission lines

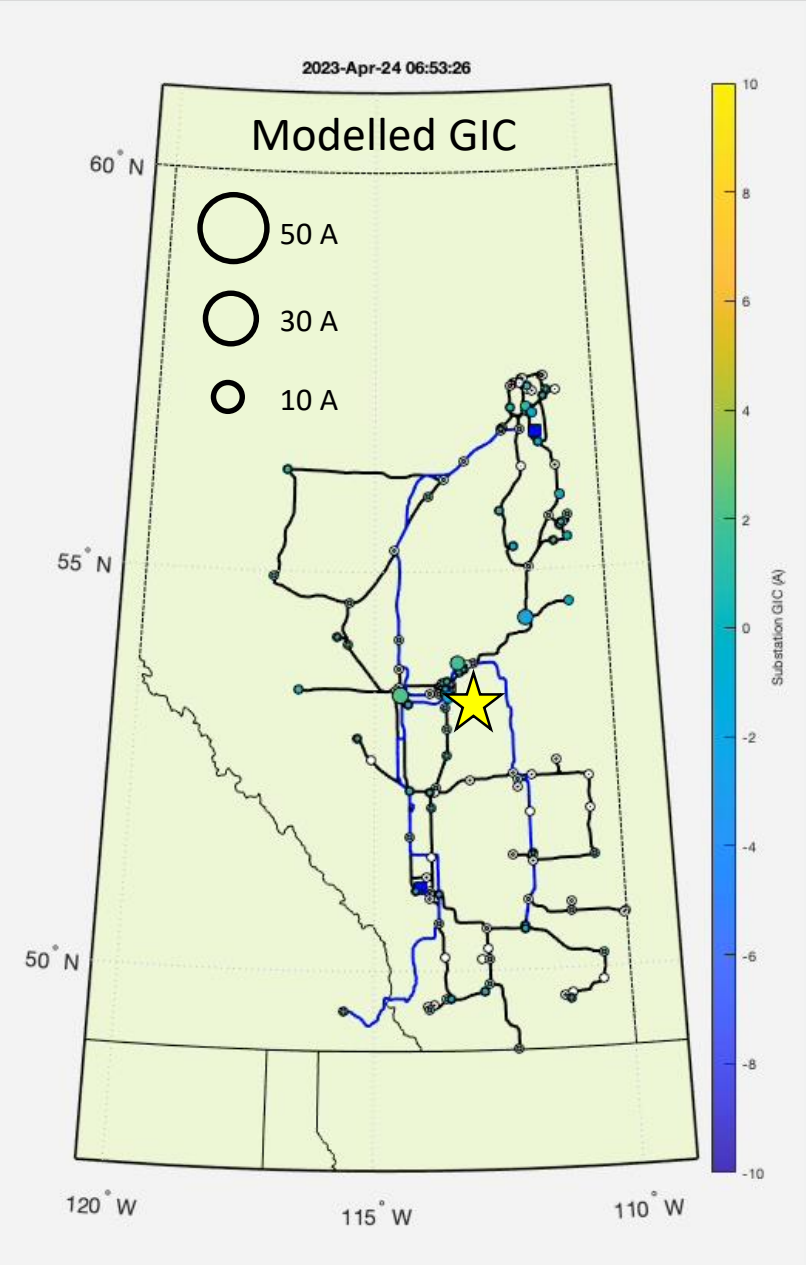
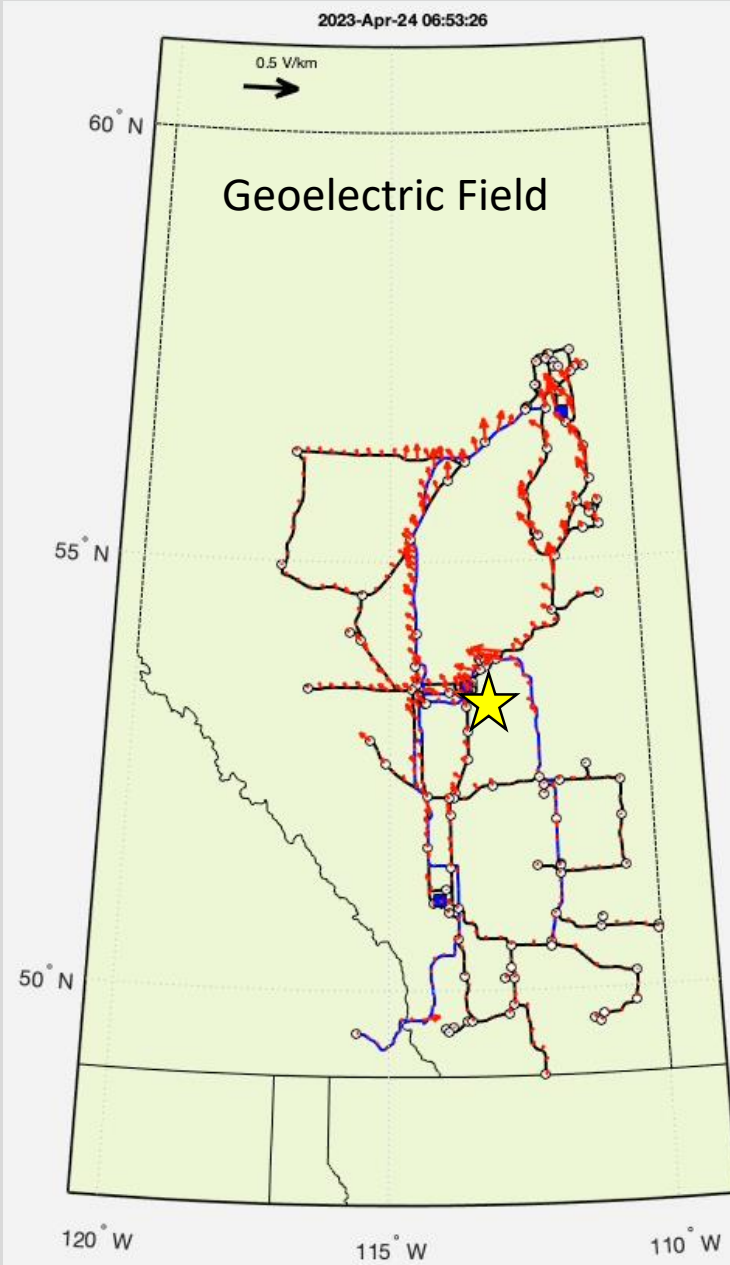
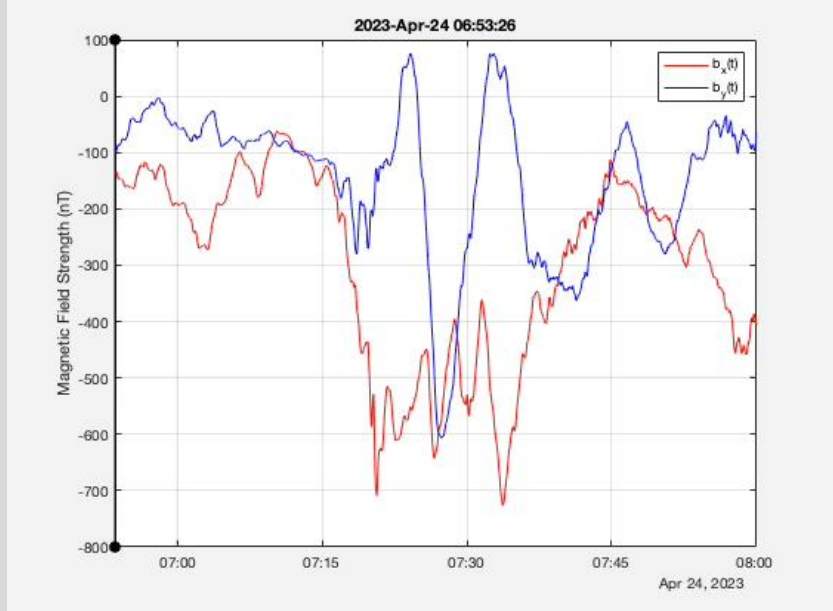
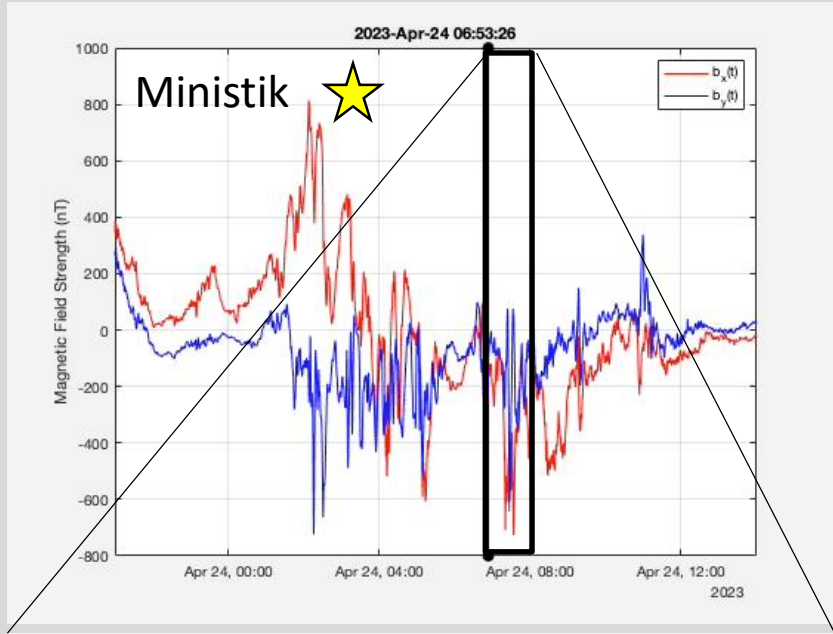


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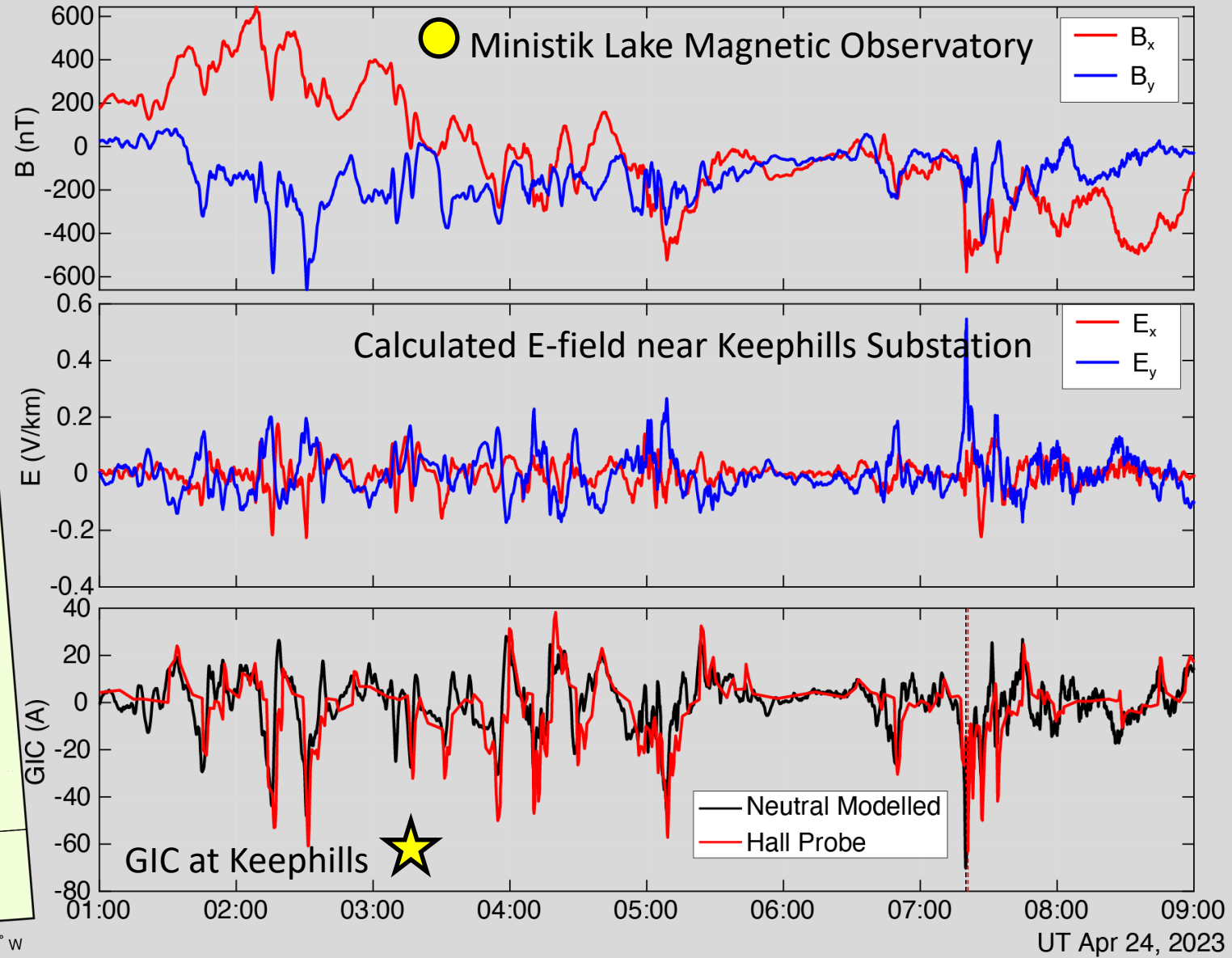
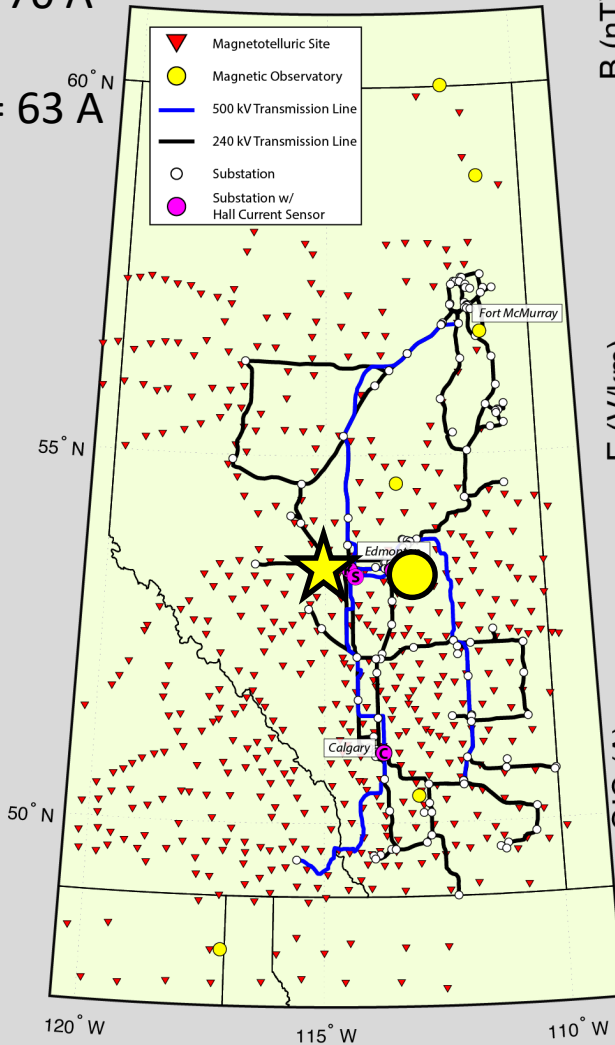


Modelling GICs in Alberta Network: April 23-24, 2023



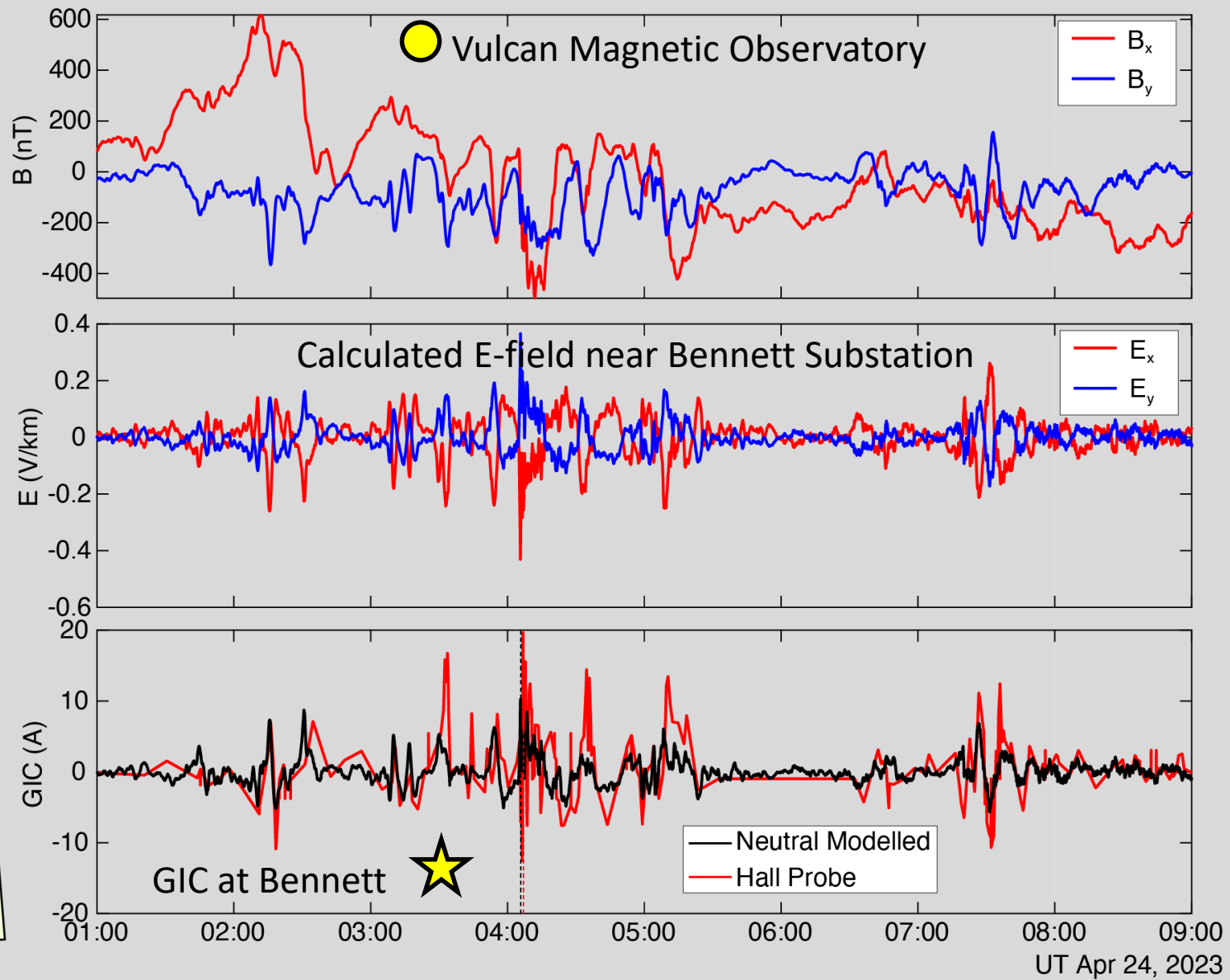
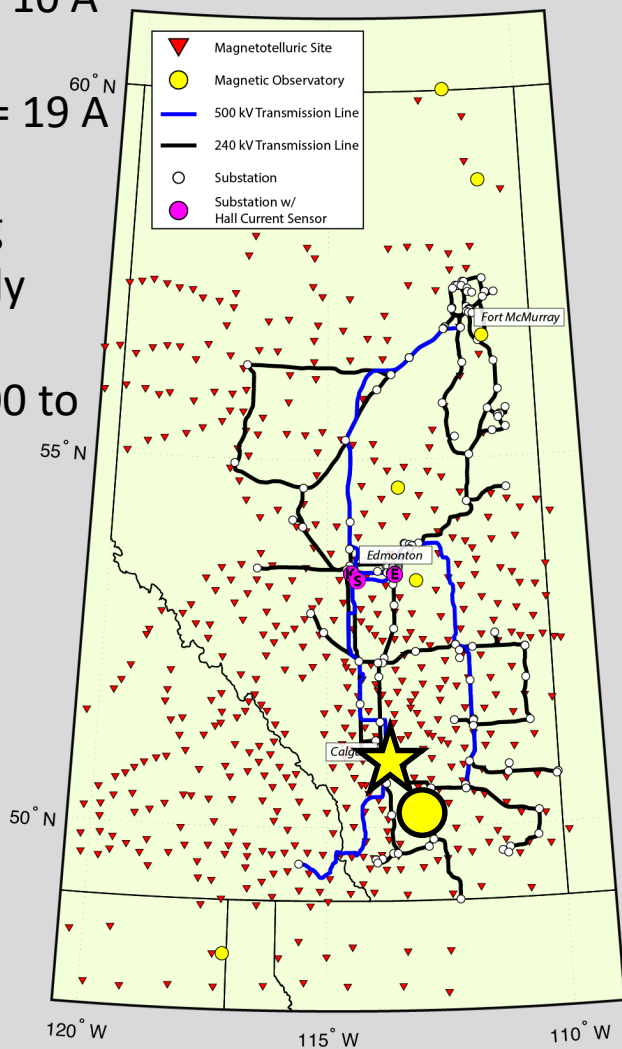
Model Performance: The Good

- Excellent correlation (0.79) at Keephills
- Peak modelled = 70 A
- Peak measured = 63 A
- Model appears to be behaving well!



Model Performance: The Okay

- Okay correlation (0.56) at Bennett
- Peak modelled = 10 A
- Peak measured = 19 A
- Underestimating largest peaks only primarily during interval from 4:00 to 5:00 UT



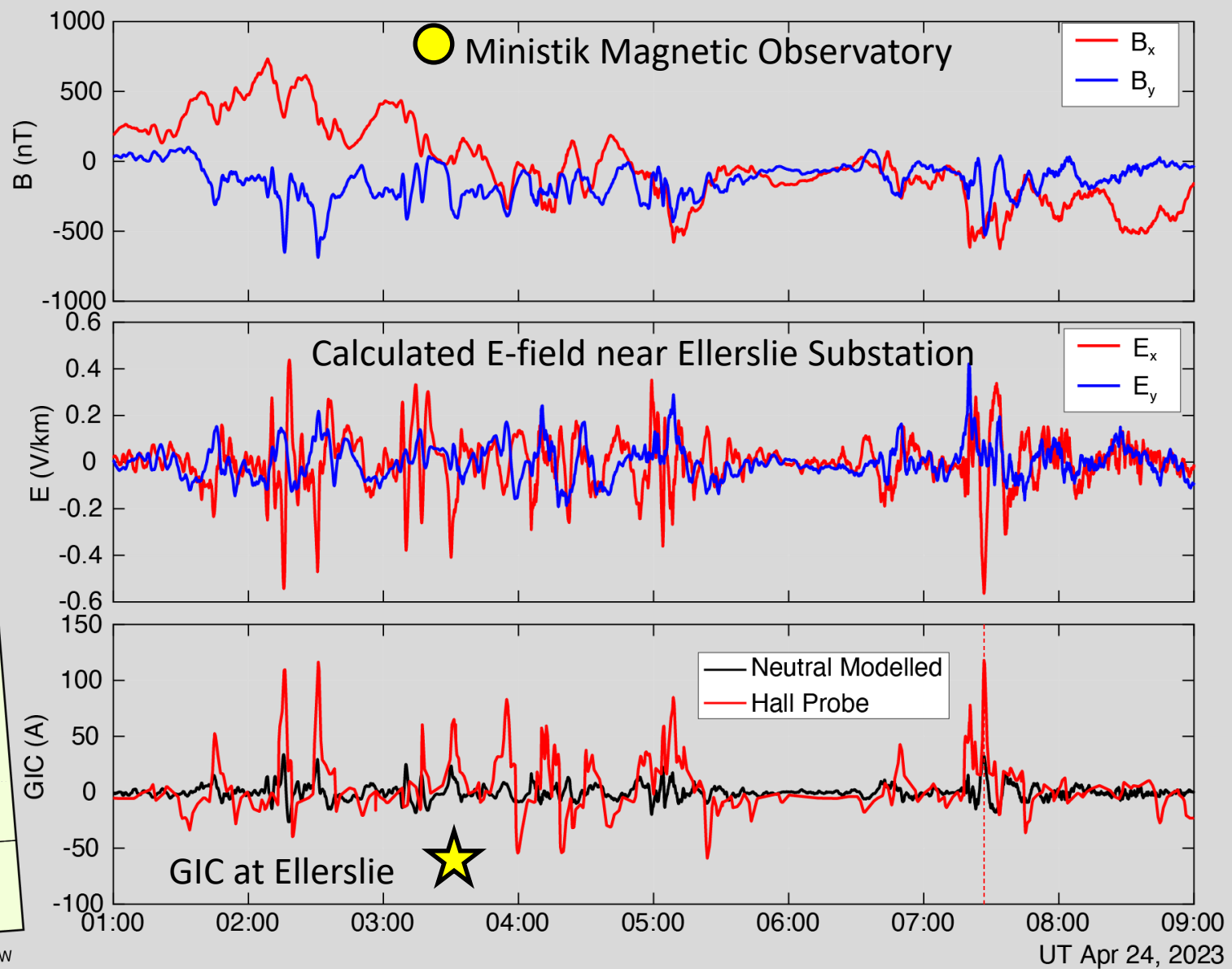
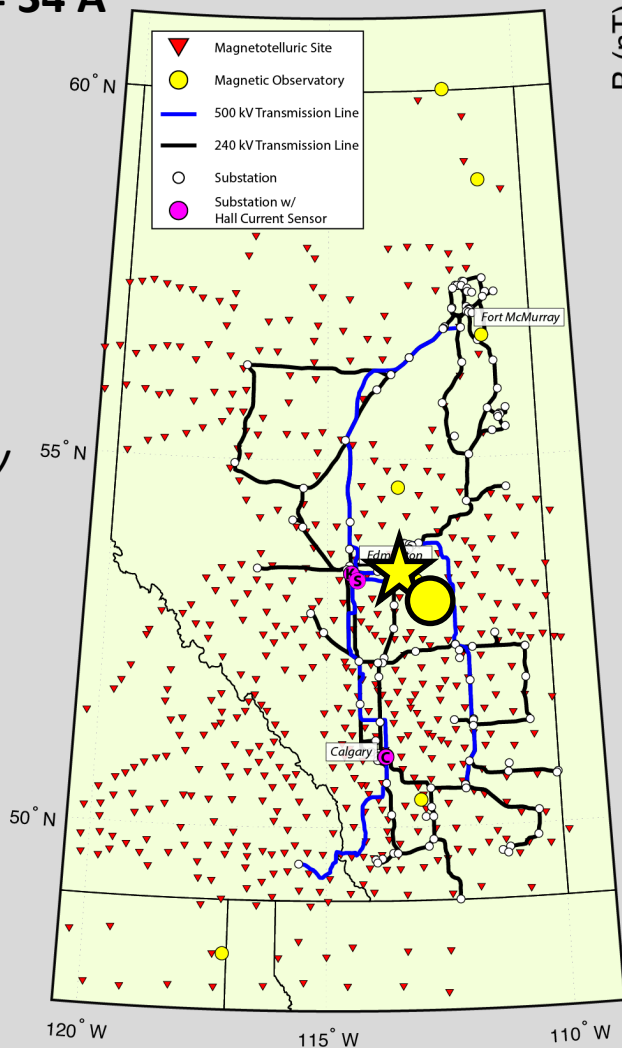
Model Performance: The Not-so Okay

- Poor correlation (0.45) at Ellerslie

- **Peak modelled = 34 A**

- **Peak measured = 118 A**

- *Significant degradation in peak GIC over whole interval by factor of >3*

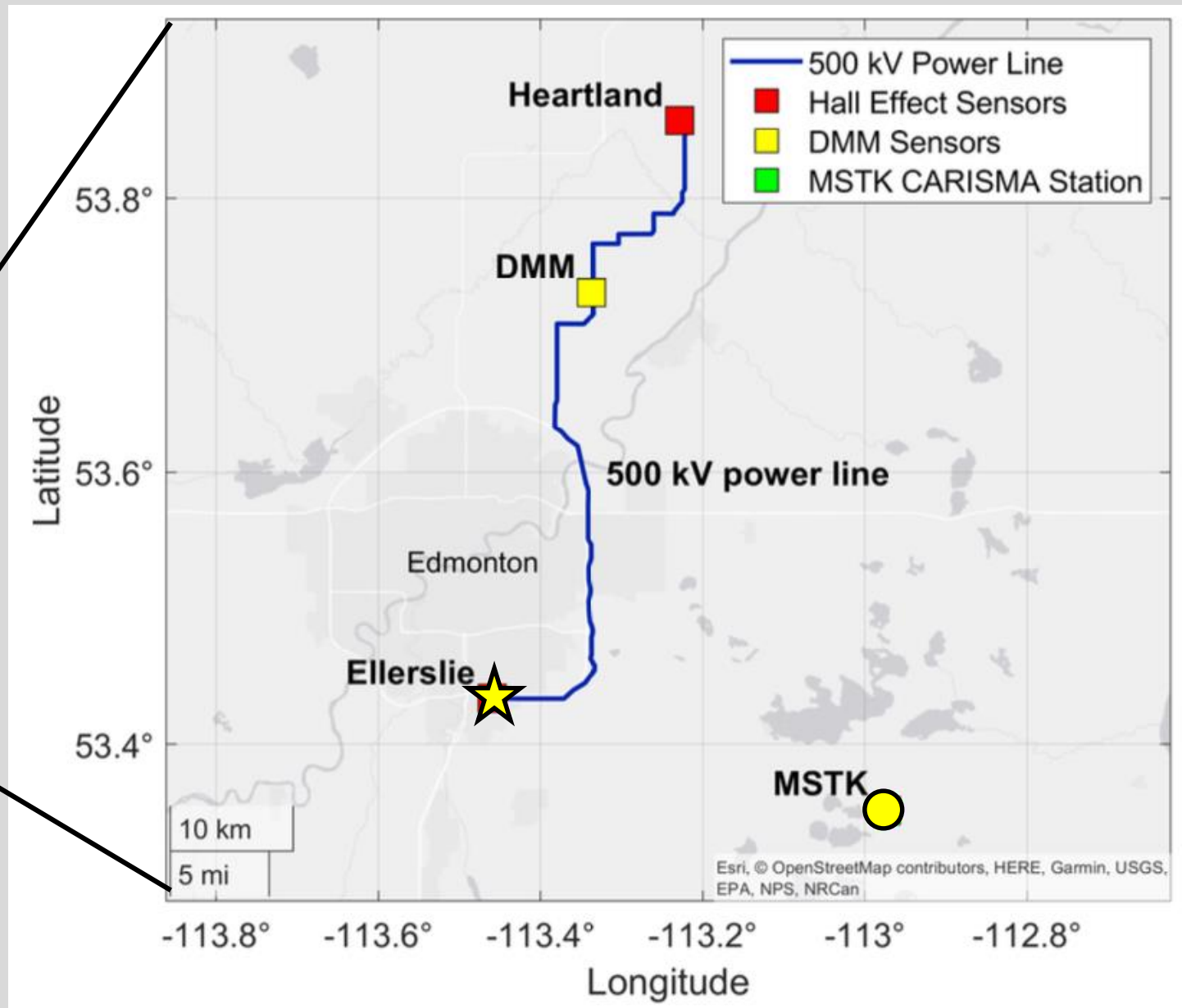
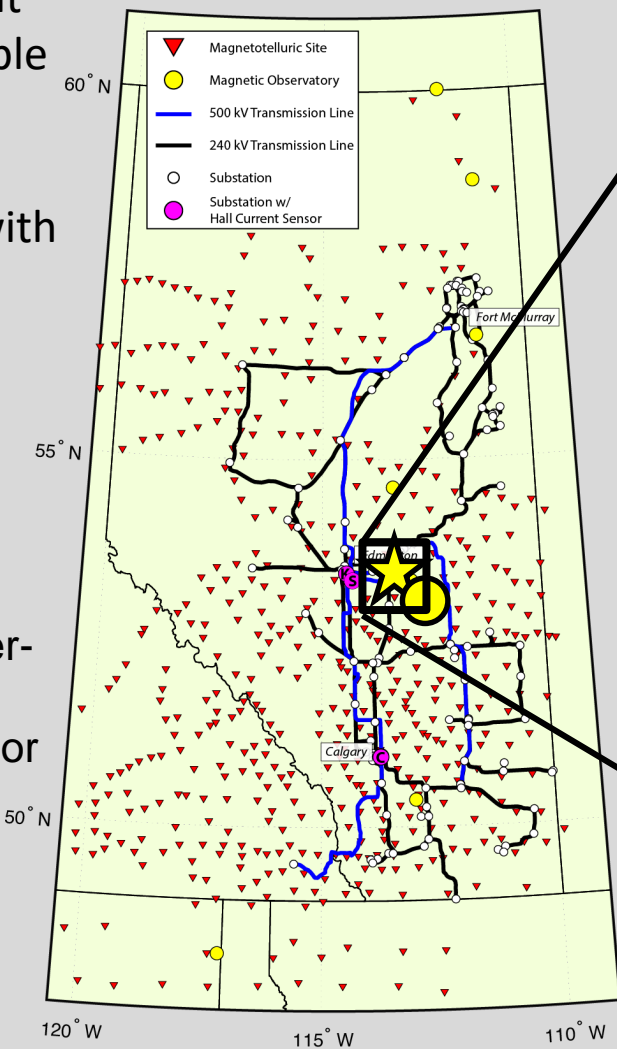
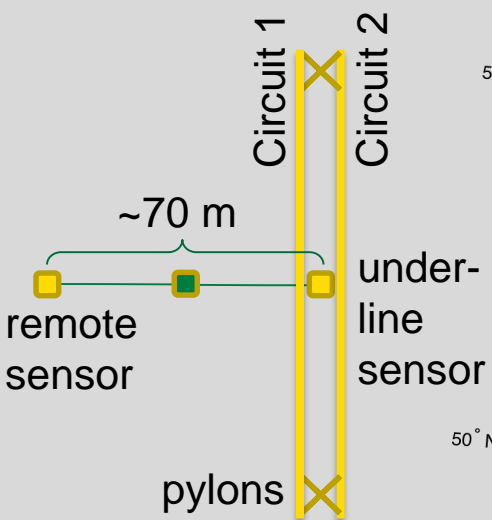


DMM Data: Independent Verification

- Poor correlation (0.45) at Ellerslie

- DMM measurement location along double circuit 1202/1206L

- Transmission line with DMM connects to Ellerslie



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DMM Data: Independent Verification

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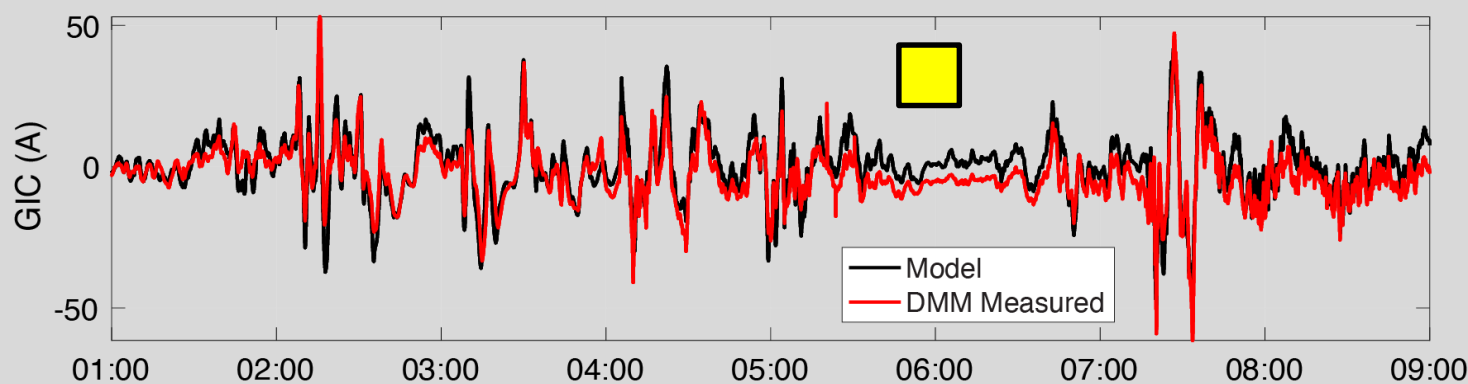
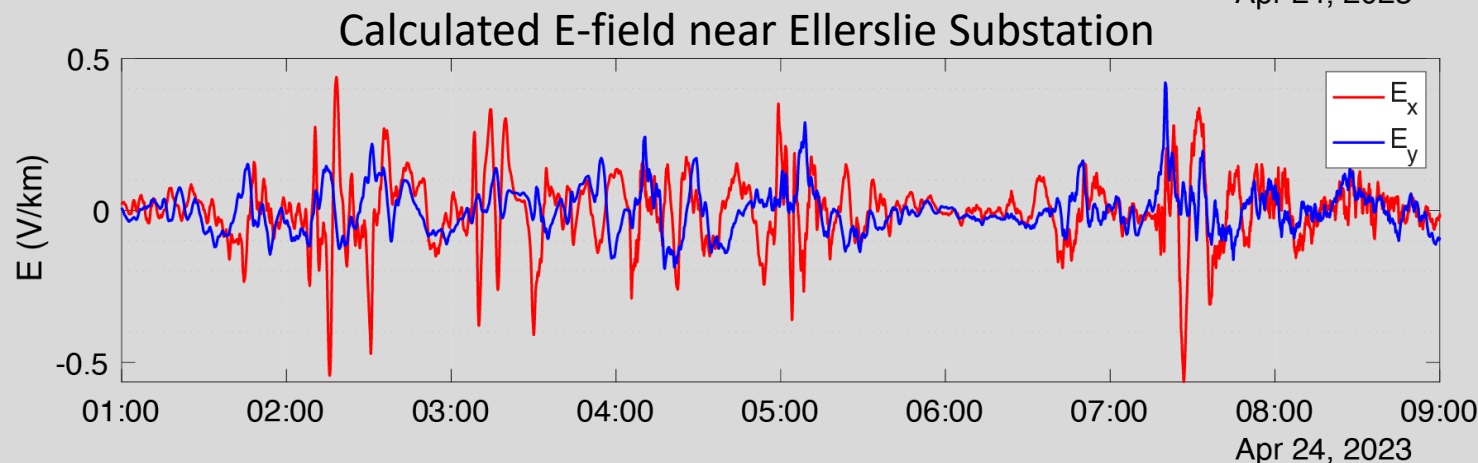
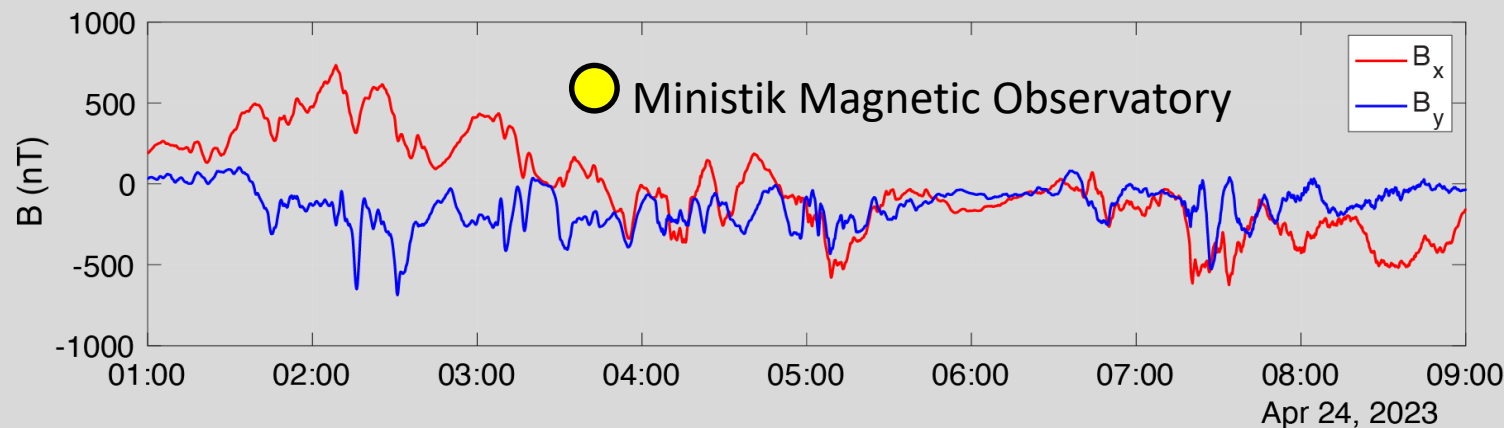
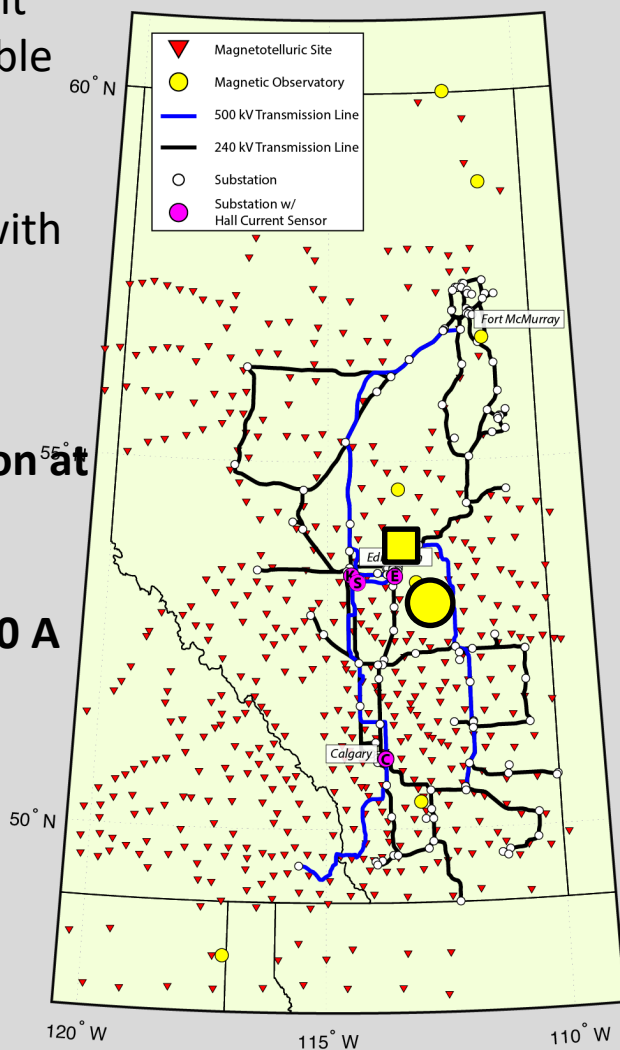
○ DMM measurement location along double circuit 1202/1206L

○ Transmission line with DMM connects to Ellerslie

○ **Excellent correlation at DMM (0.88)**

○ **Peak modelled = 50 A**

○ **Peak measured = 61 A**



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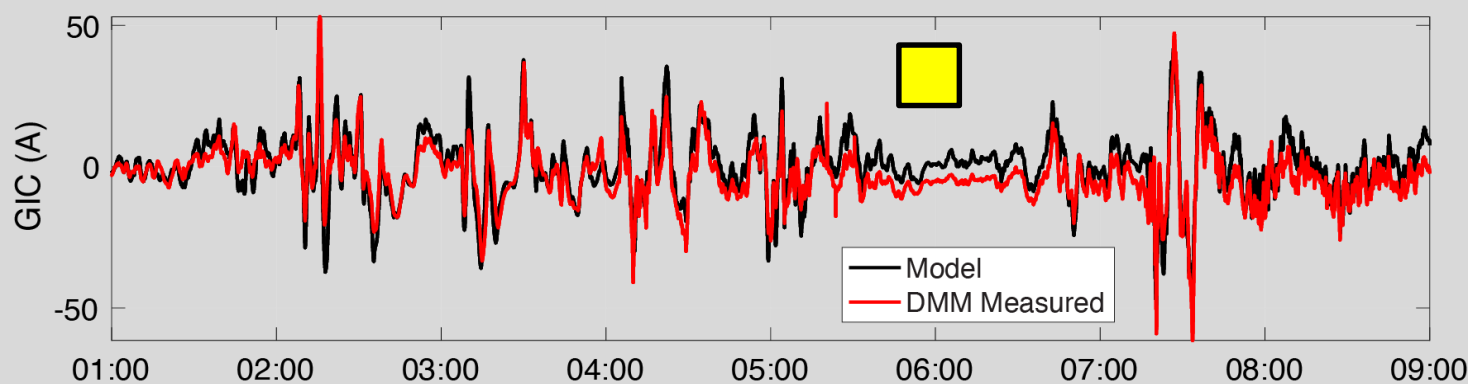
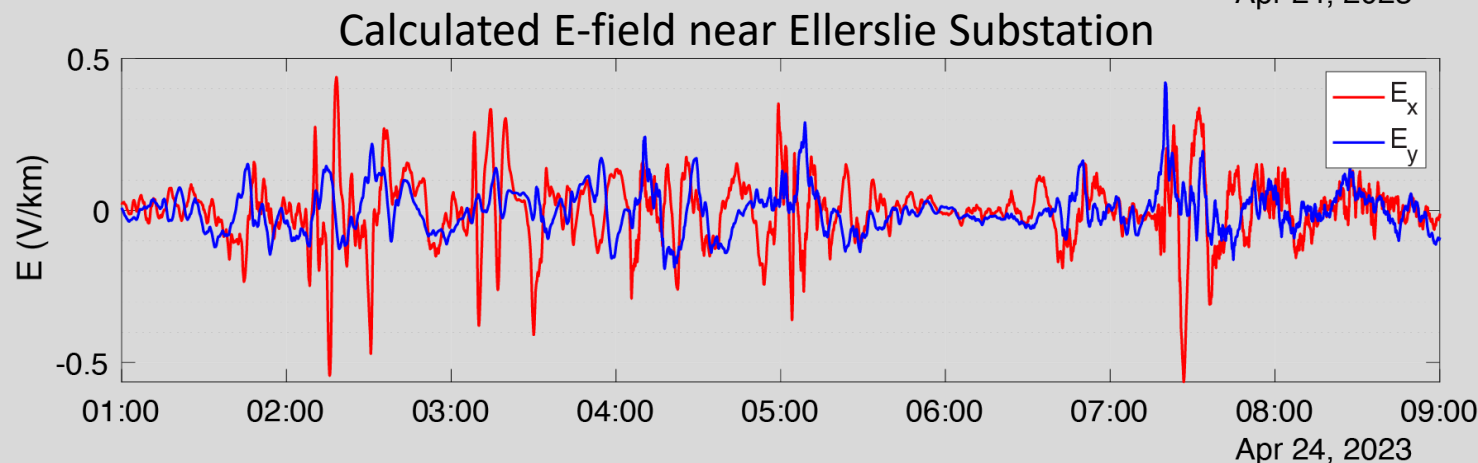
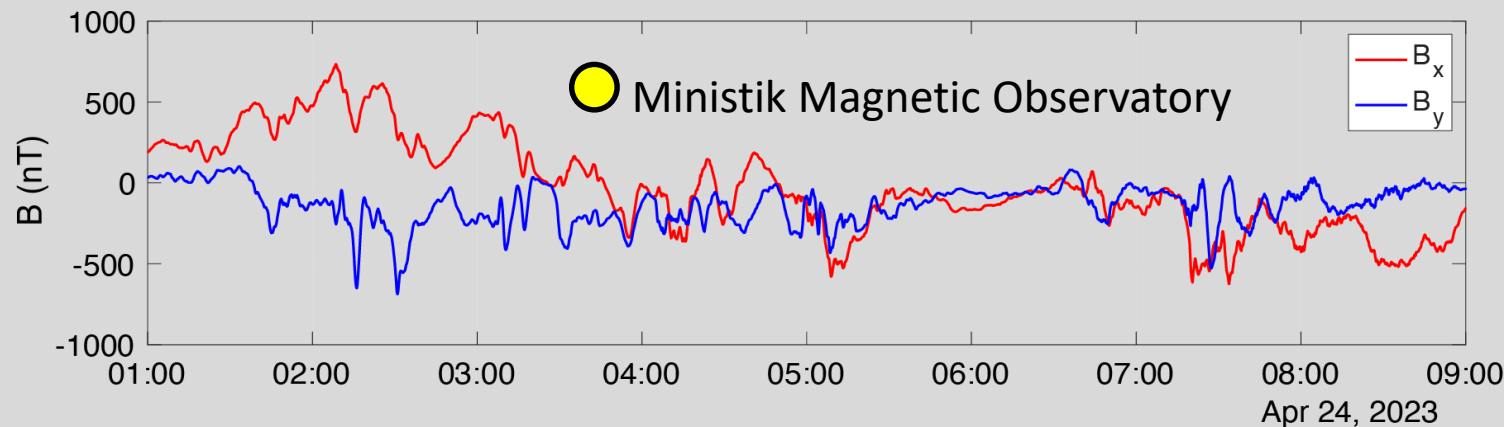
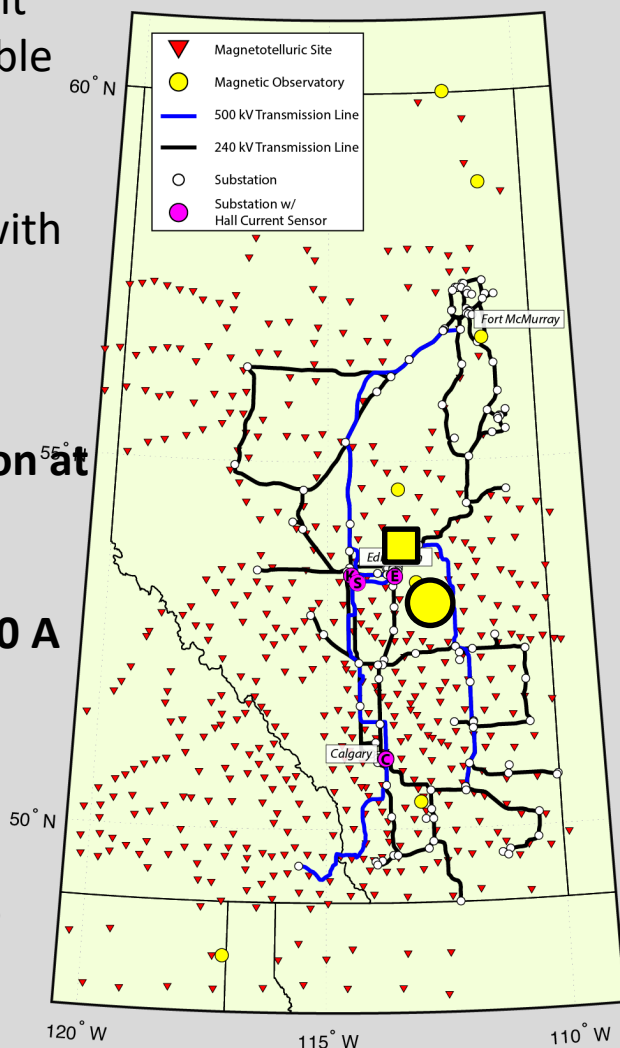
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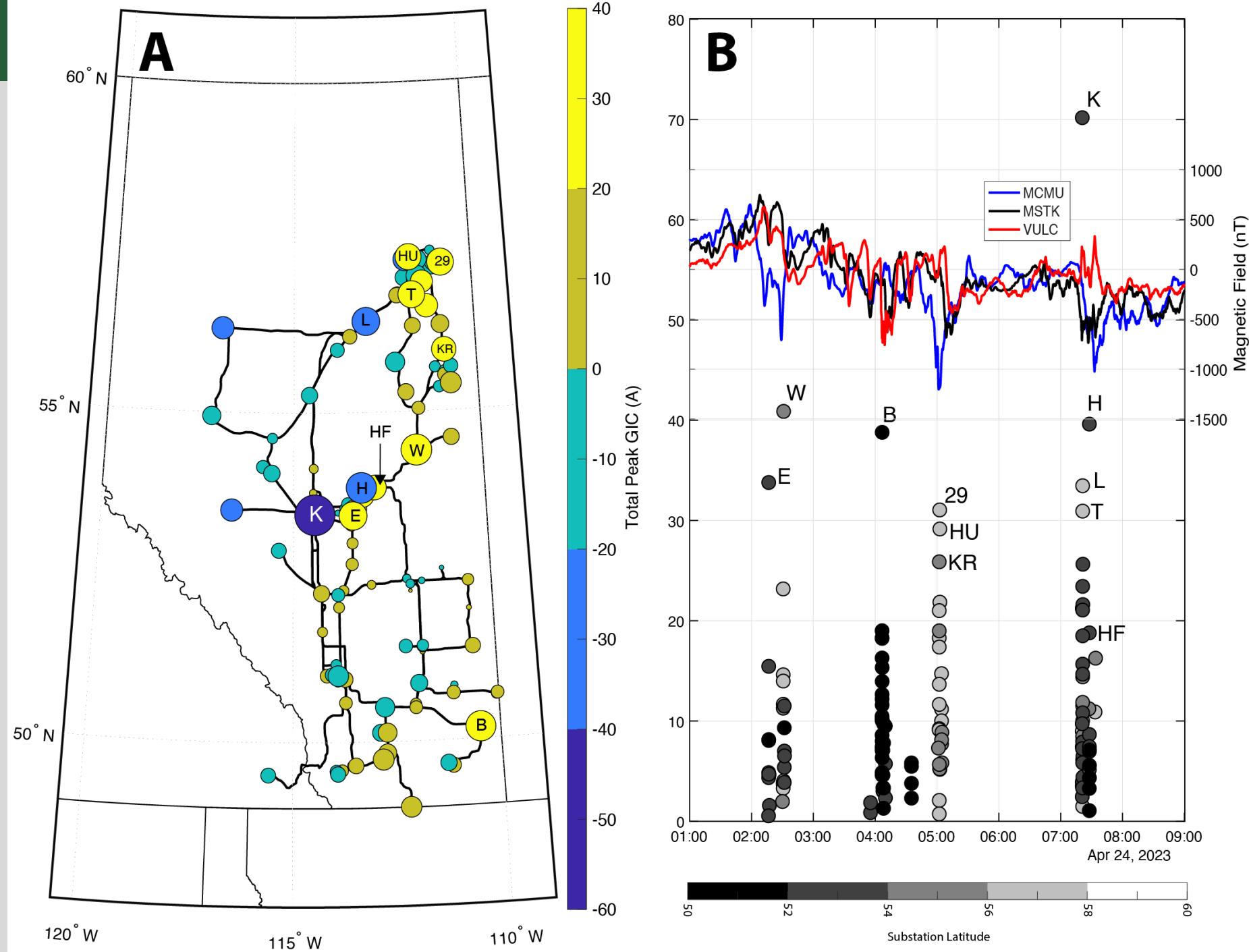
○ **Peak measured = 61 A**

Problems with sensor data at Ellerslie?



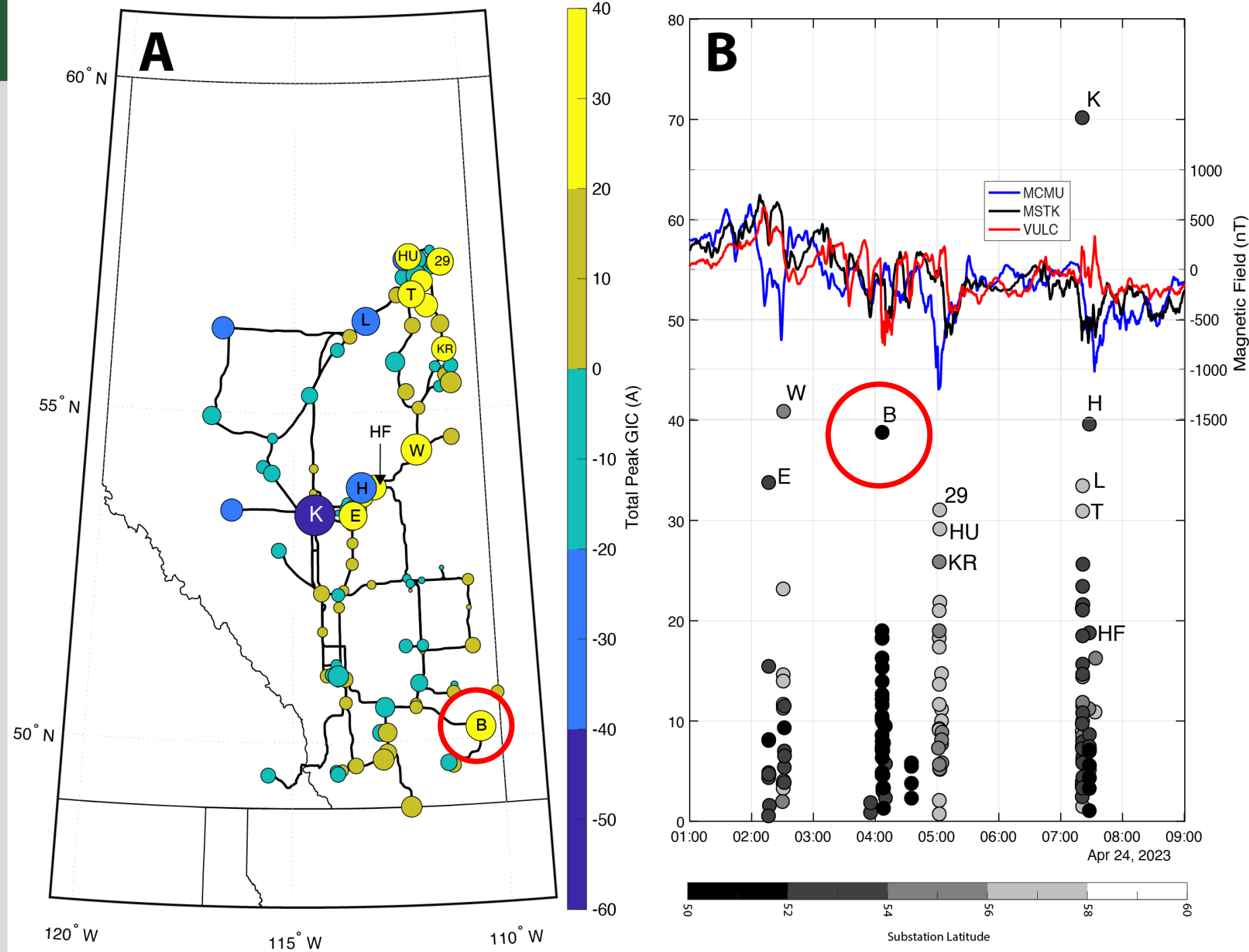
Peak GICs in the Network

- Largest peaks in northeastern Alberta (~5:00 UT) and Edmonton region (~7:30 UT)
- Edmonton region has peaks on 500 kV network
- Northeastern AB has peaks mostly on 240 kV network
- Southern Alberta has smaller peaks, mostly ~4:00 UT



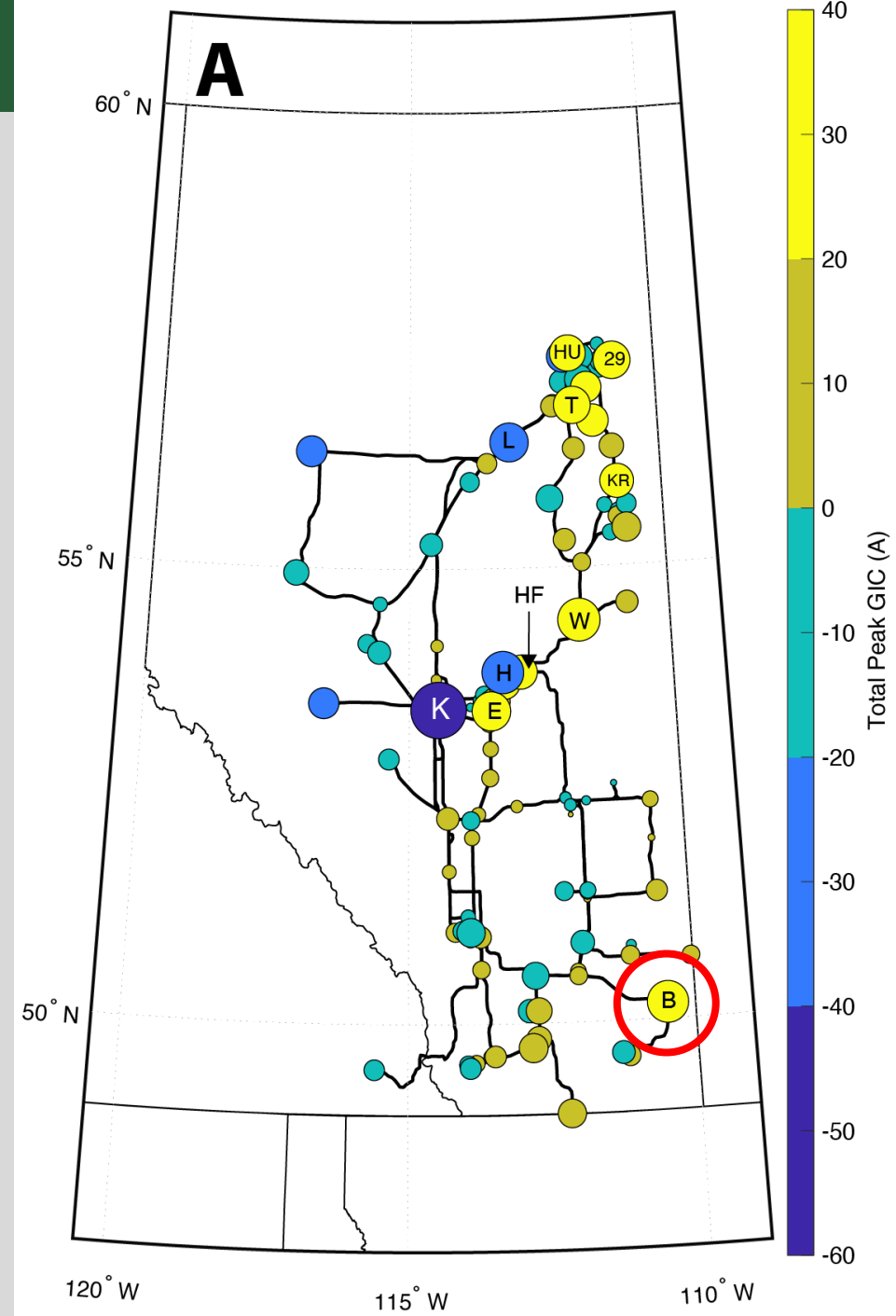
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- Bowmanton Outlier?



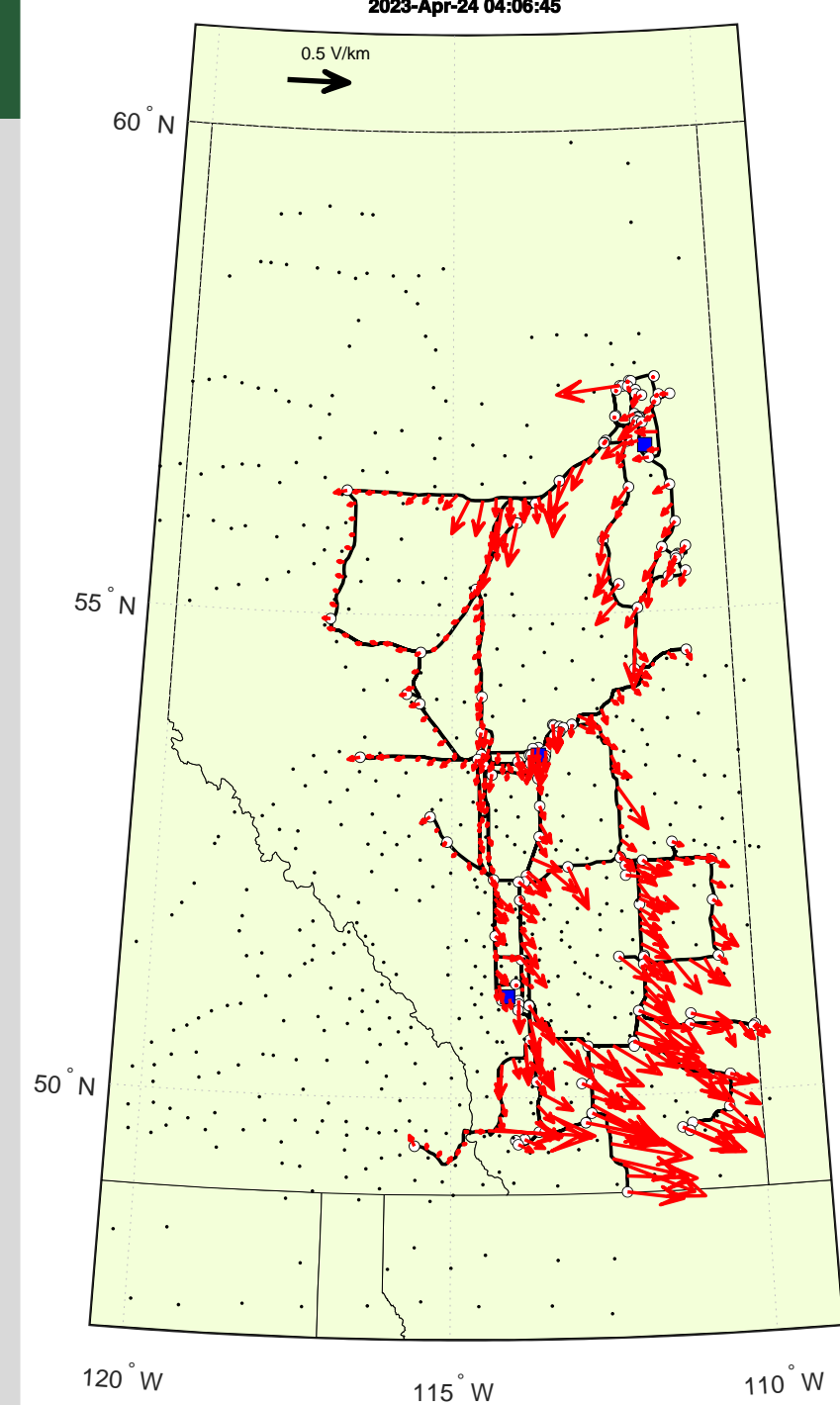
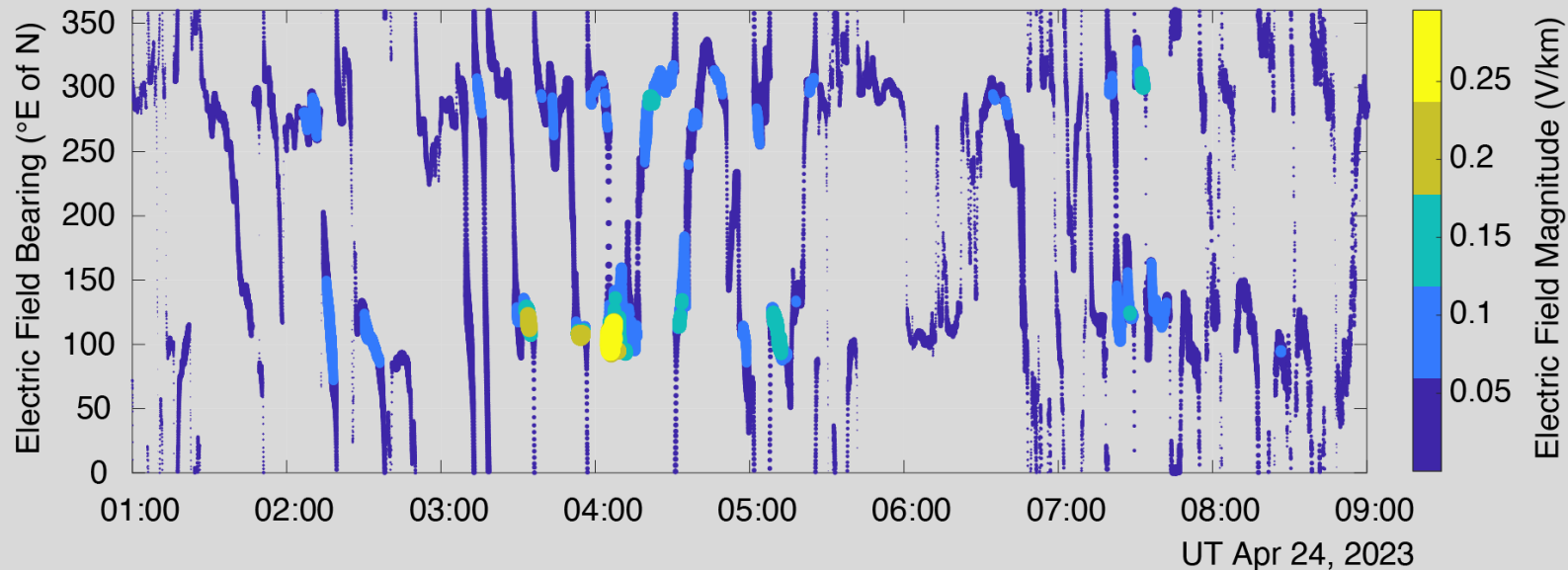
Why is Bowmanton GIC so big?

- Bowmanton located at southeast corner of network with transmission lines entering/exiting from northwest
- If largest magnitude geoelectric field *happens* to be oriented southeast, then current has nowhere to go



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- If largest magnitude geoelectric field *happens* to be oriented southeast, then current has nowhere to go
- Peak geoelectric field (0.3 V/km) around Bowmanton is oriented 110°E of N
- Combination of network topology and geoelectric field direction contributes to large GIC during this particular geomagnetic storm

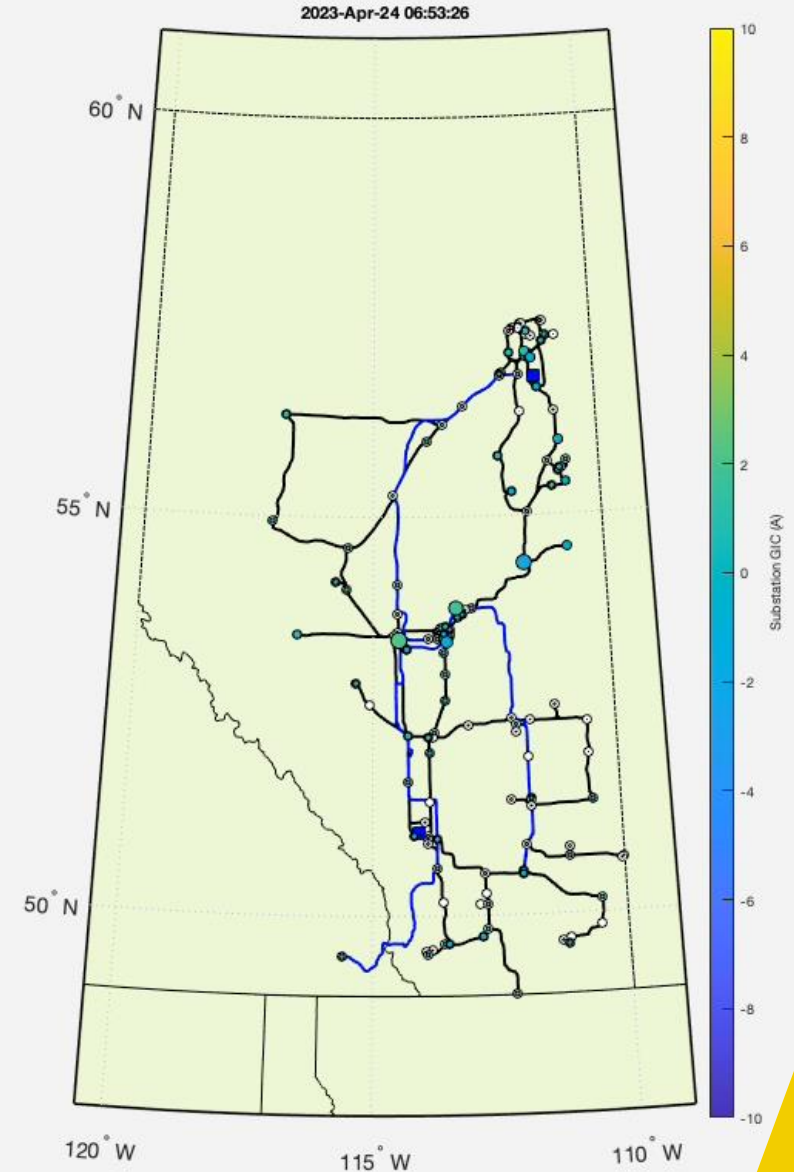
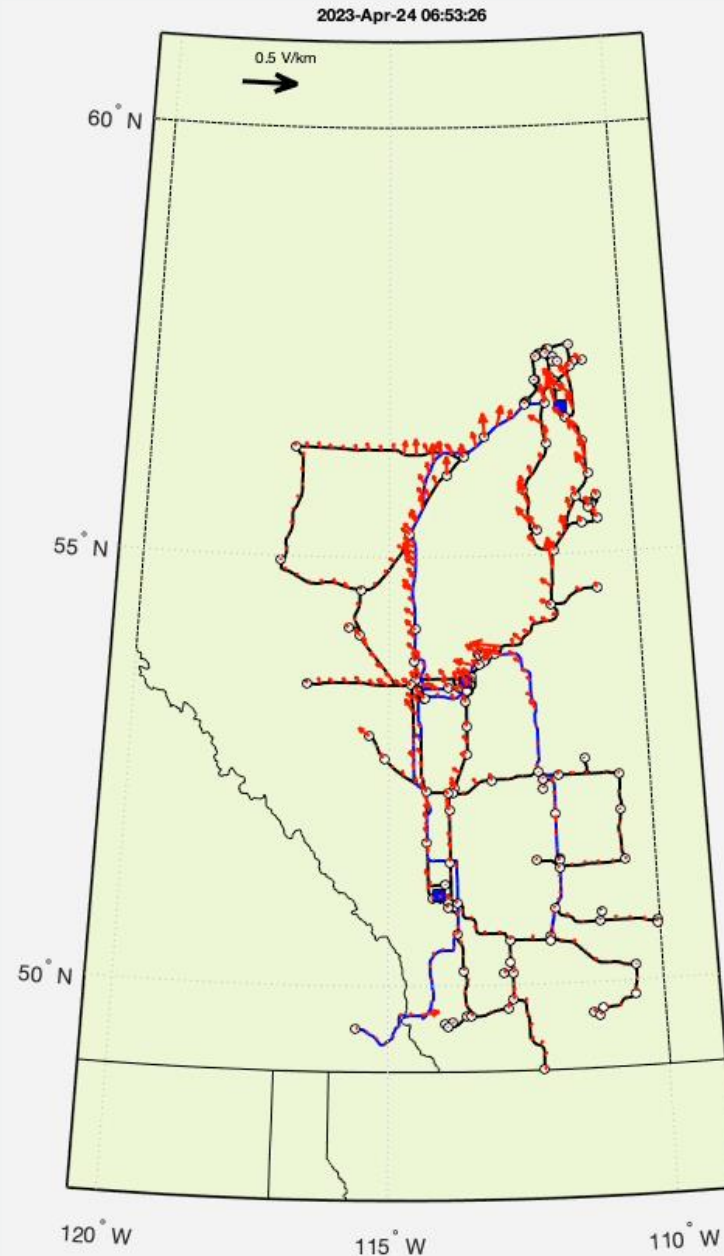


Key Takeaways

Large GIC (>70 A) observed in Alberta network

GIC model agrees with observations at some substations and at DMM

Largest modelled GIC occur in northeastern Alberta and Edmonton region



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Darcy Cordell



**Solar Phenomena
(e.g. CME)**

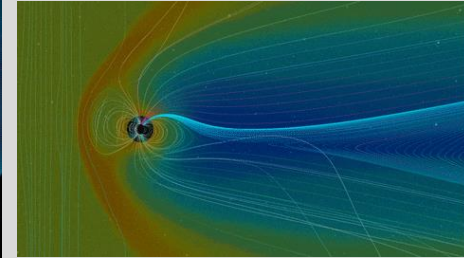
Background and Methodology



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**Geomagnetic
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Background and Methodology



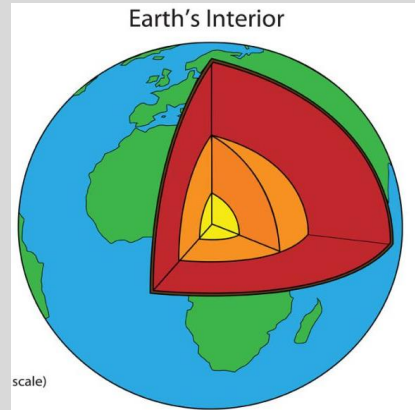
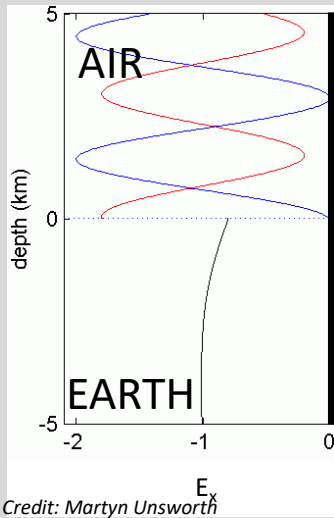
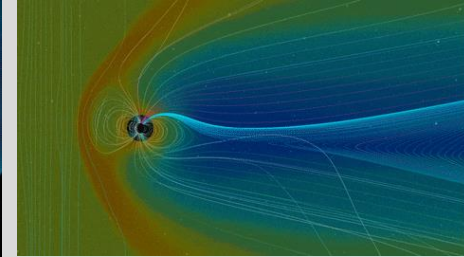
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**Induced Geoelectric
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Background and Methodology



**Solar Phenomena
(e.g. CME)**



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**Geomagnetically
Induced Current (GIC)**

