

PingThings

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**CENTRAL MAINE
POWER**

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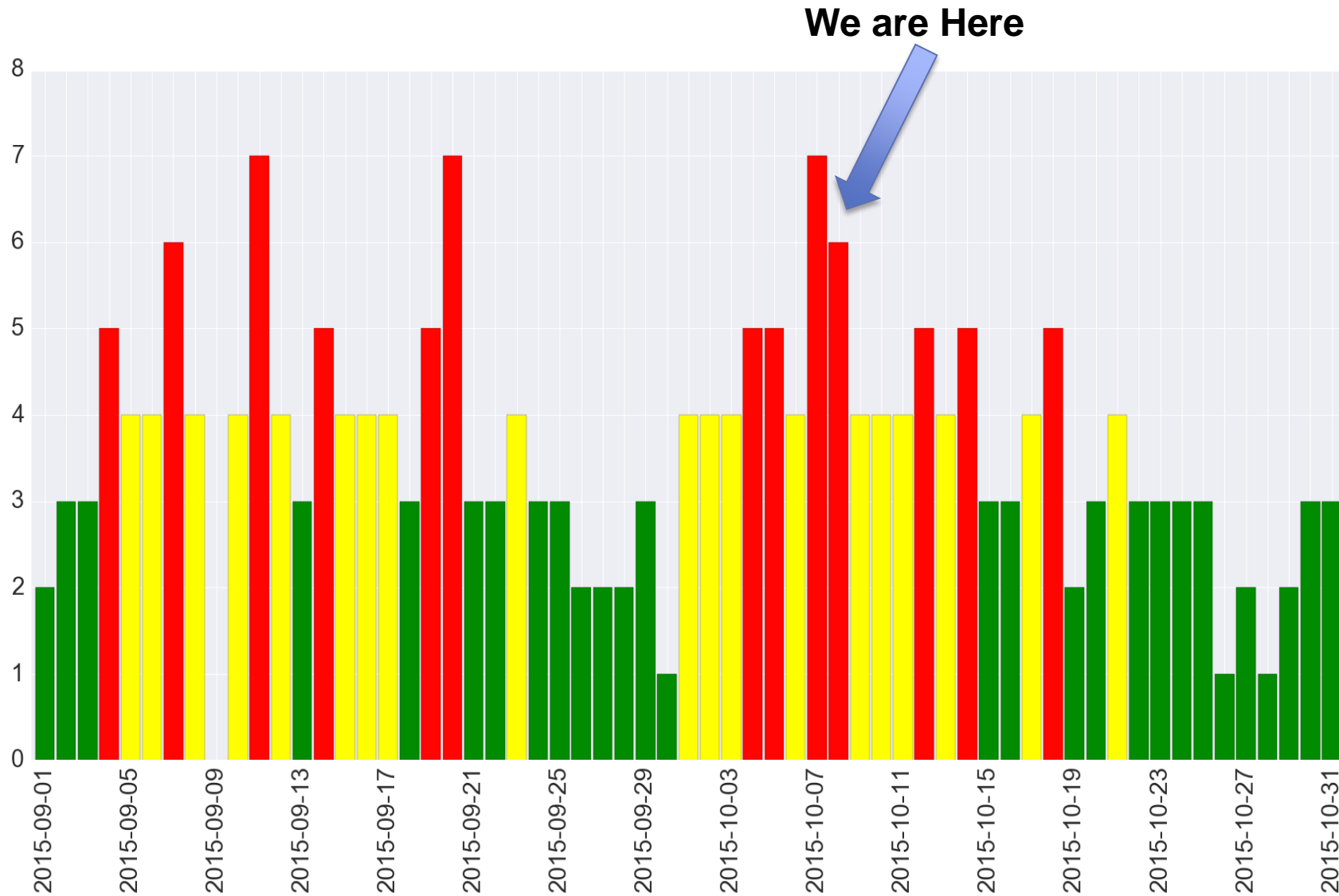


AVANGRID

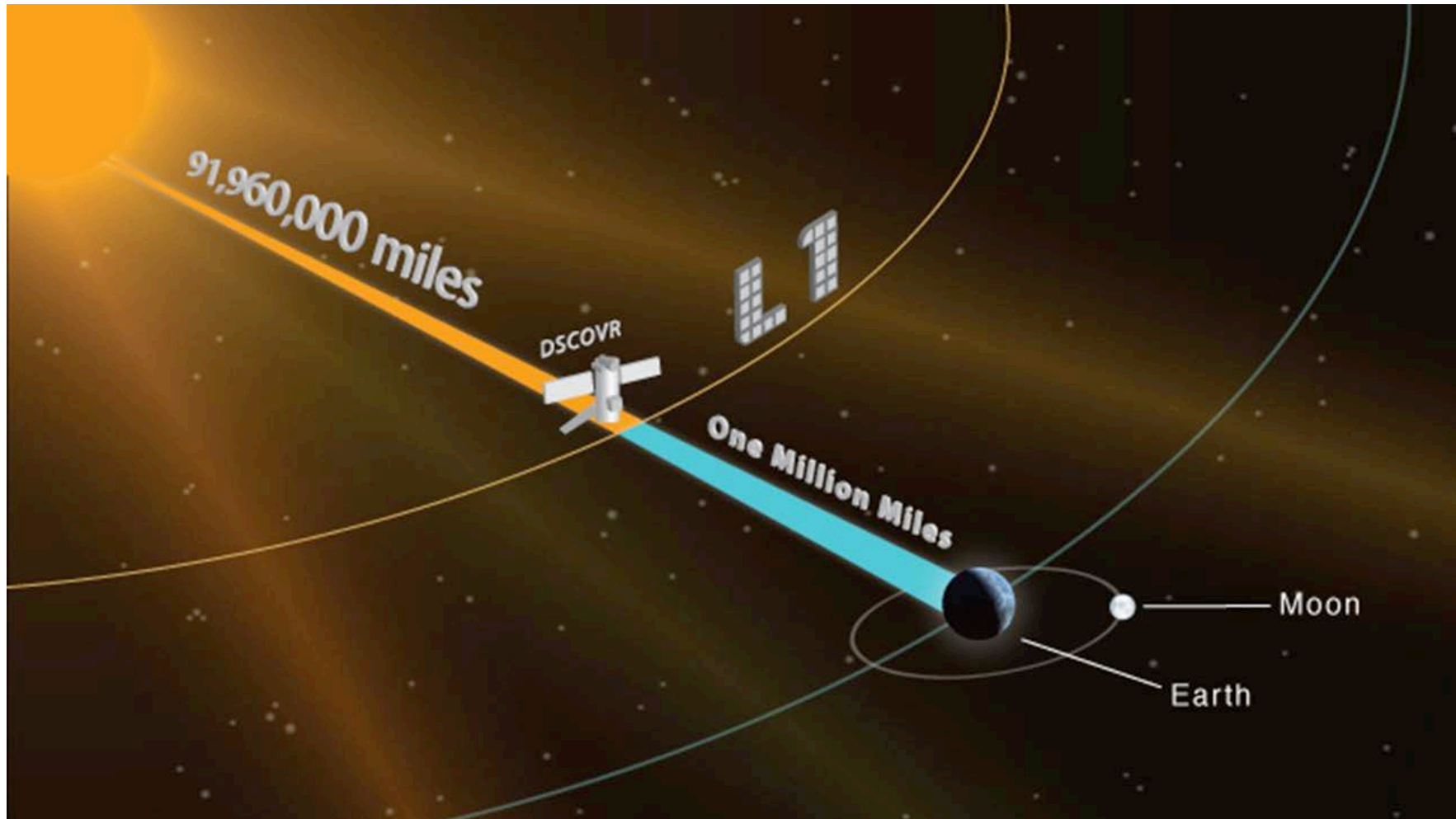
From the Sun to Maine: Investigating GMD's Impact on Operational Transmission Assets

NASPI Conference
Atlanta, GA
3-23-2016

Kp Index

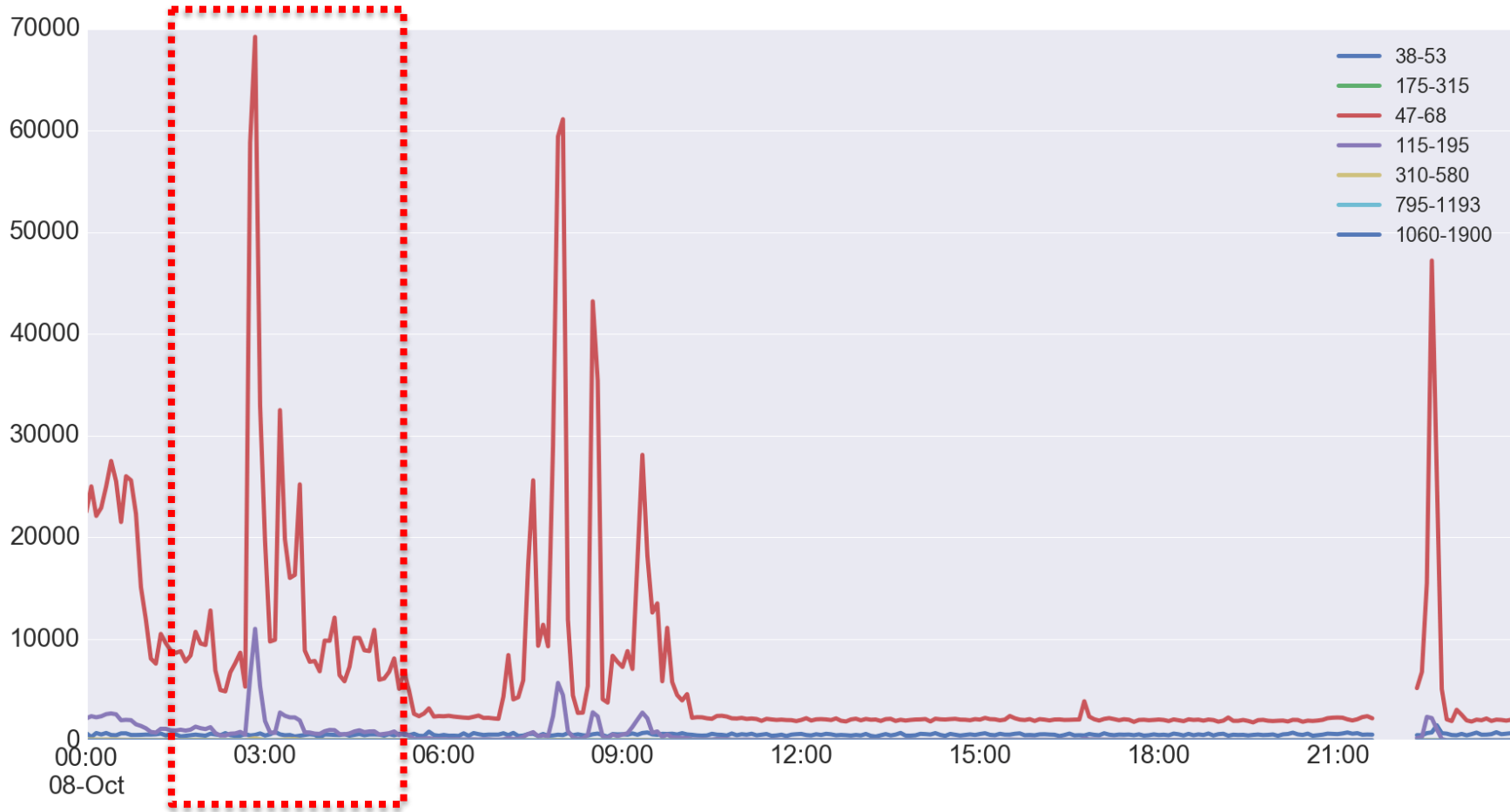


DSCOVR and ACE



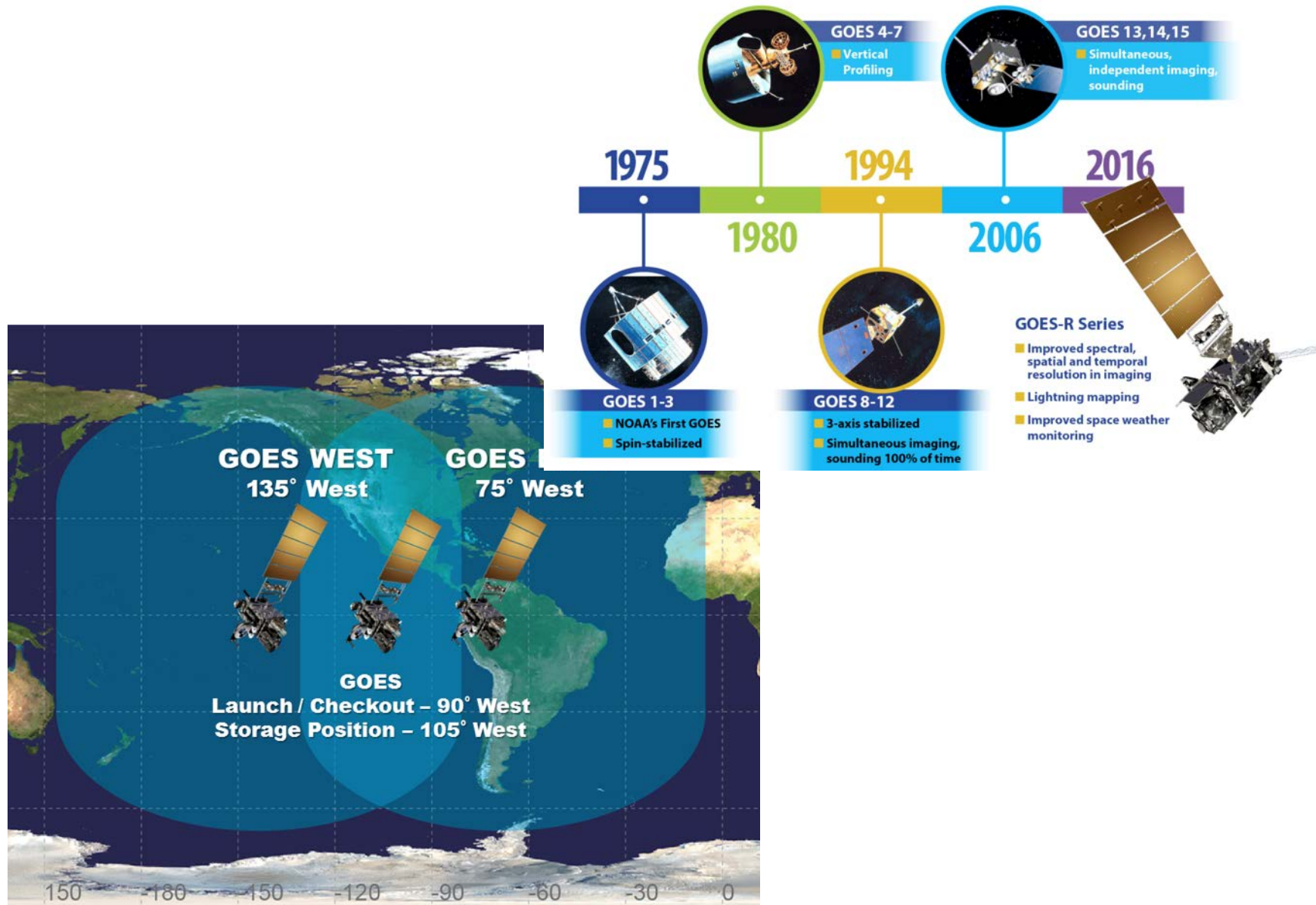
Source: NASA

Advanced Composition Explorer (ACE) – Solar Winds



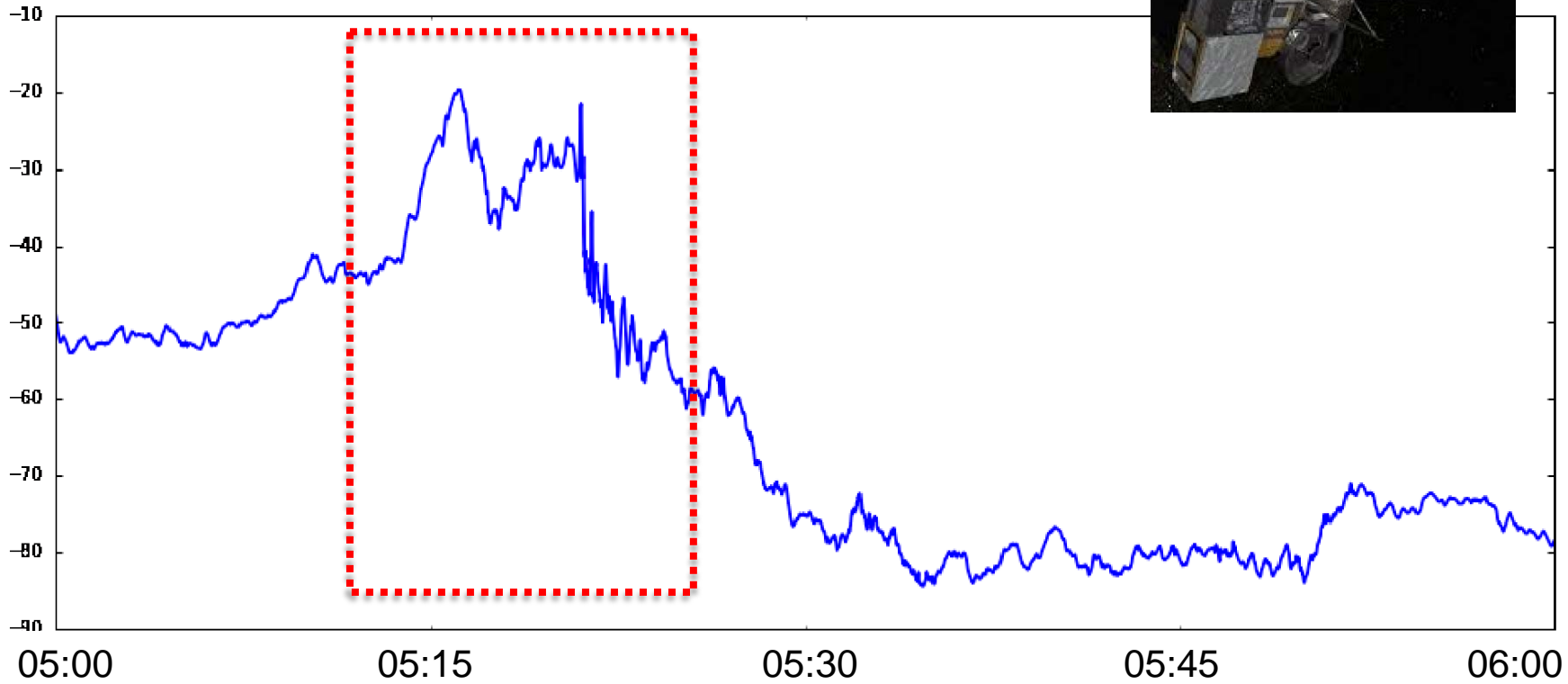
October 8, 2015, Time in UTC

Geostationary Operational Environmental Satellite 15 (GOES 15)



Geostationary Operational Environmental Satellite 15 (GOES 15)

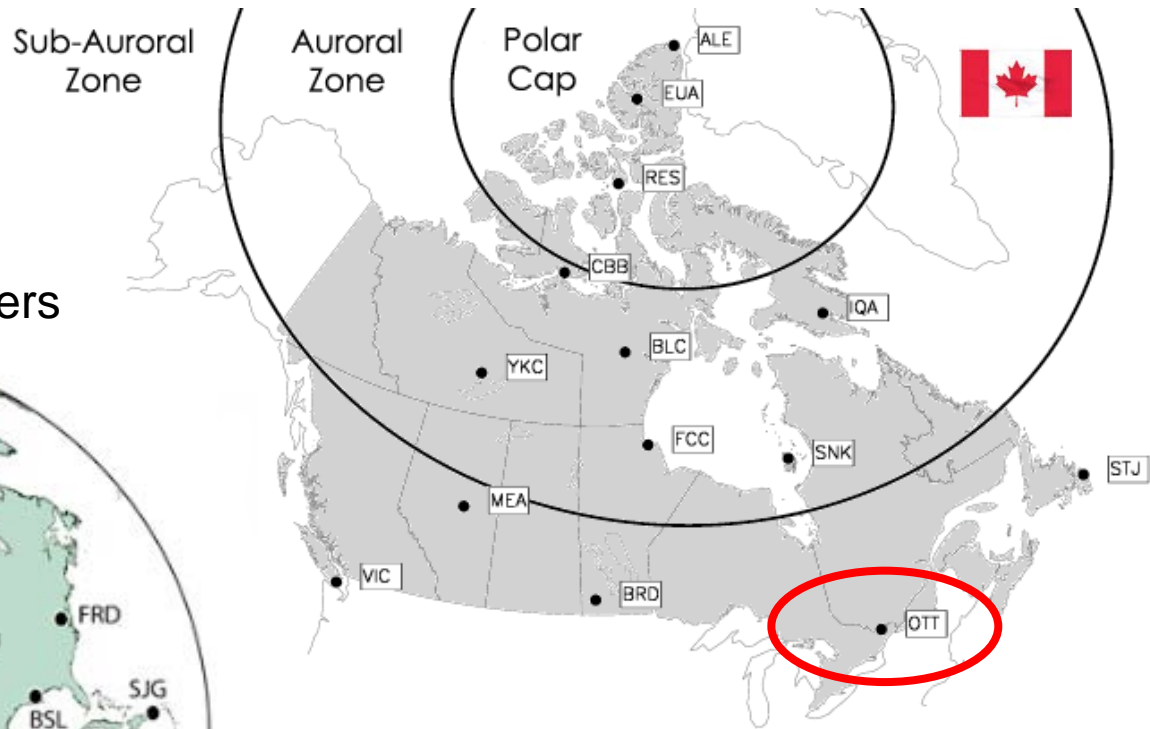
Magnetometer



October 8, 2015, Time in UTC

Earth-based Sensors

Canadian Magnetometers



Source: CANMOS

USGS Magnetometers

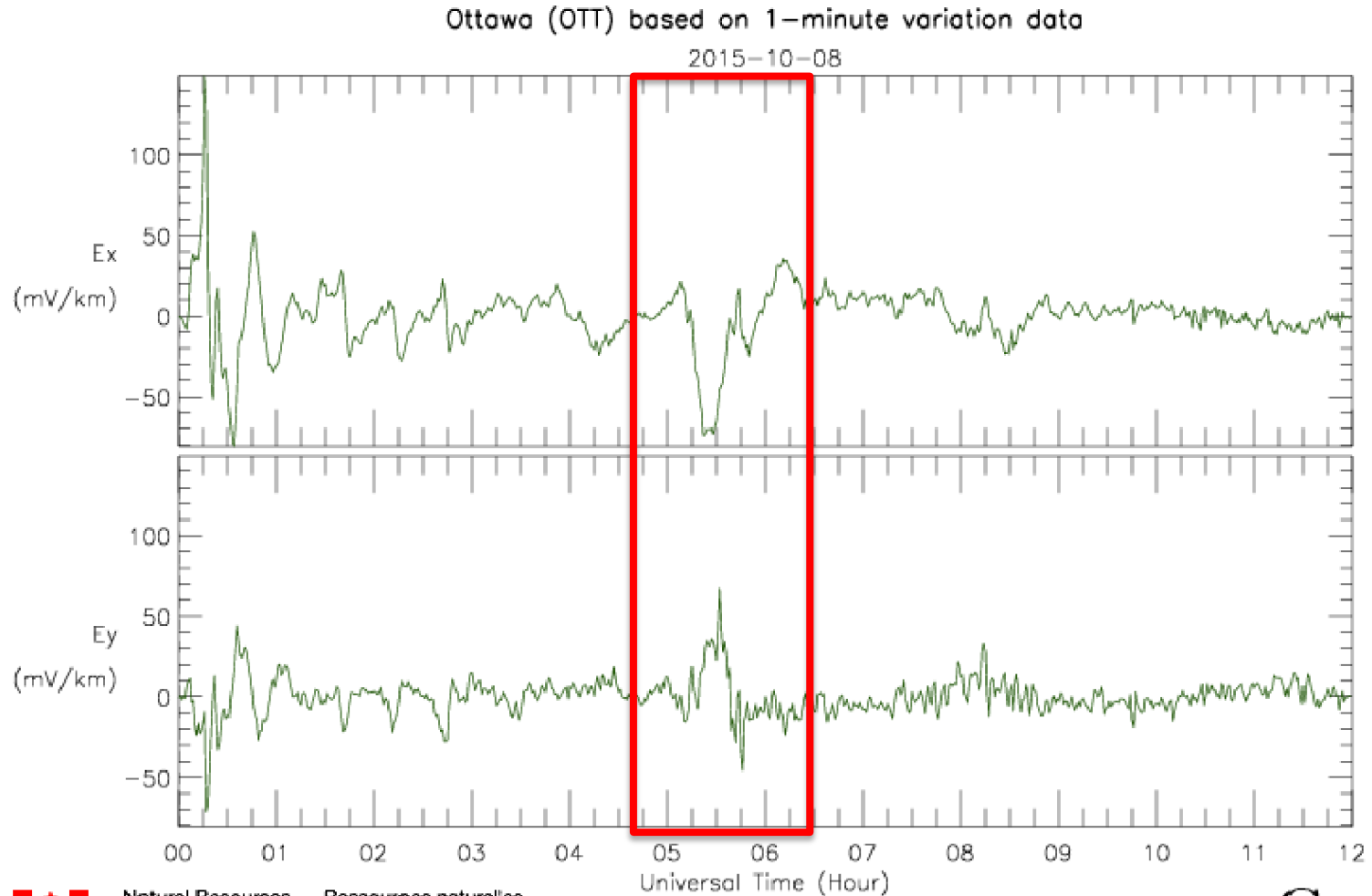


Source: USGS

Ottawa to Central Maine ~ 350 Miles



Geo-Electric Field, Ottawa, Canada

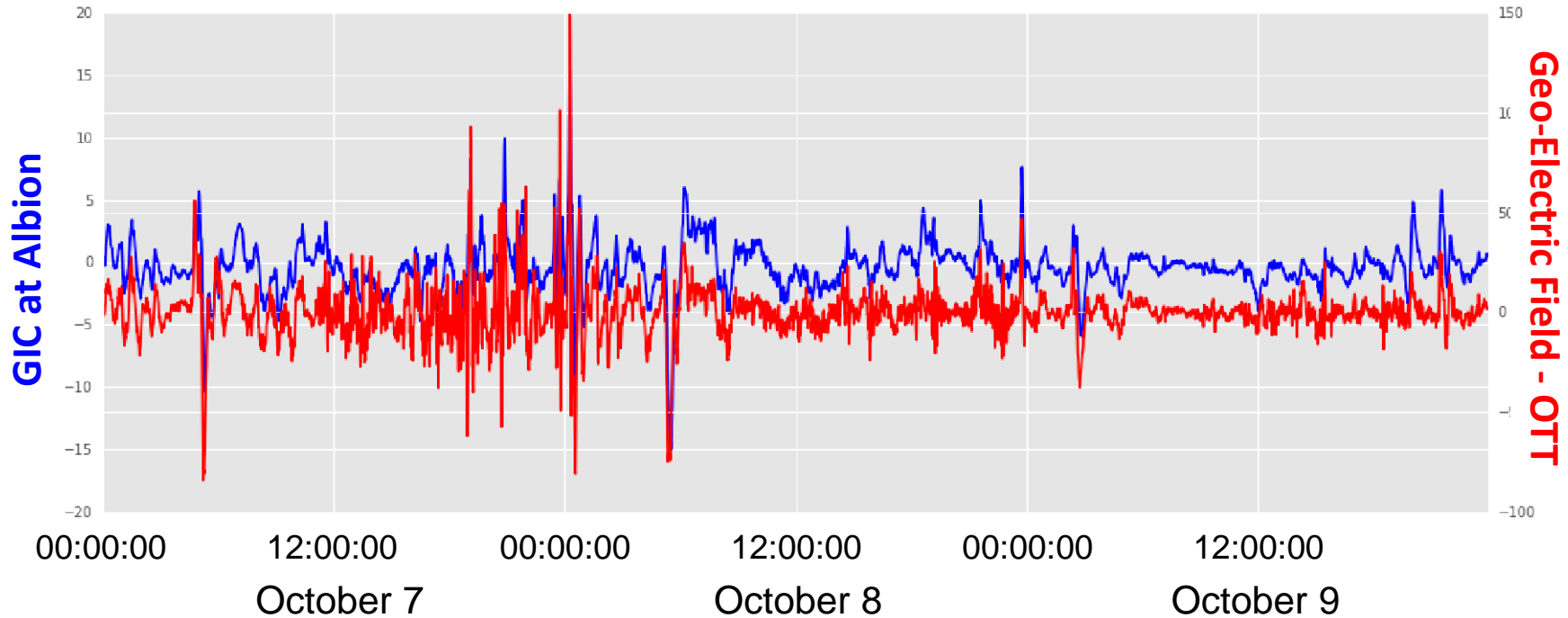


Natural Resources
Canada

Ressources naturelles
Canada

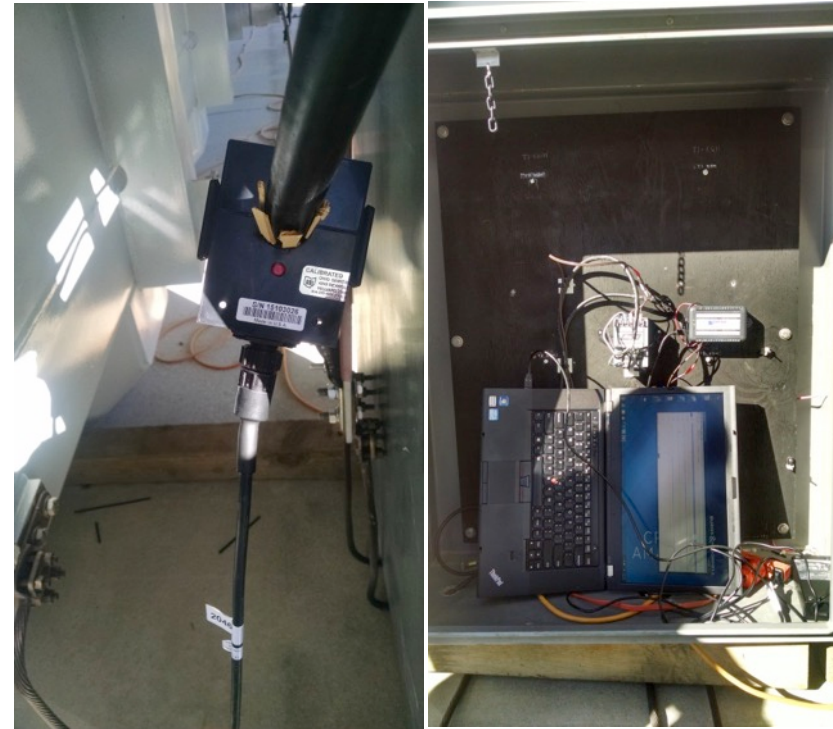
Canada

Correlation Between GIC at Albion and Geo-Electric Field at Ottawa

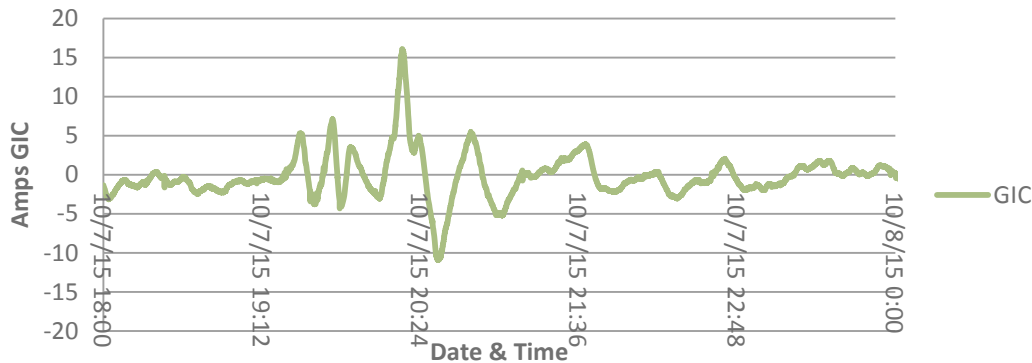


Monitoring Progress for GMD

Temporary GIC neutral installation on 345/115 kV autotransformer

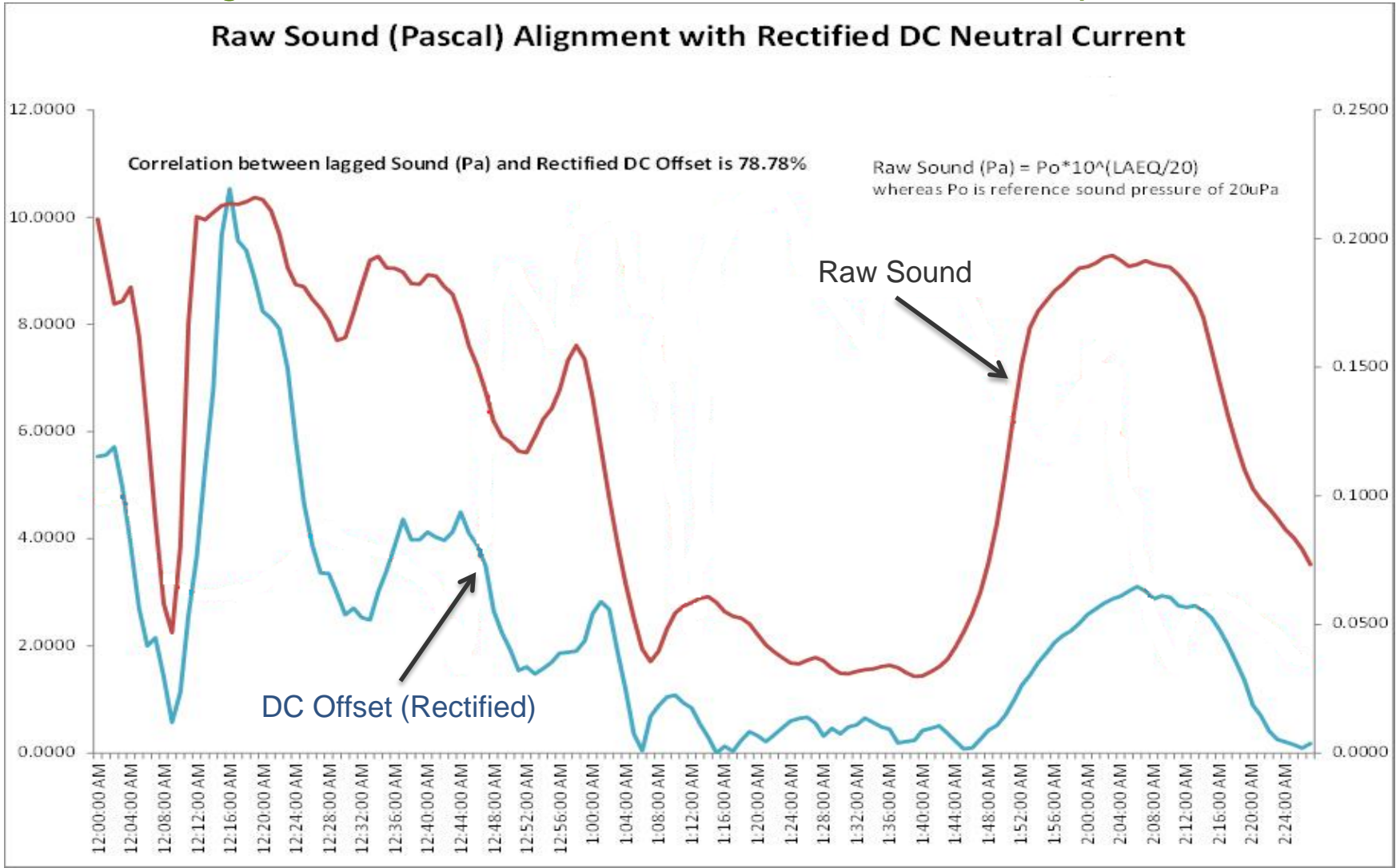


GIC on Transformer Neutral



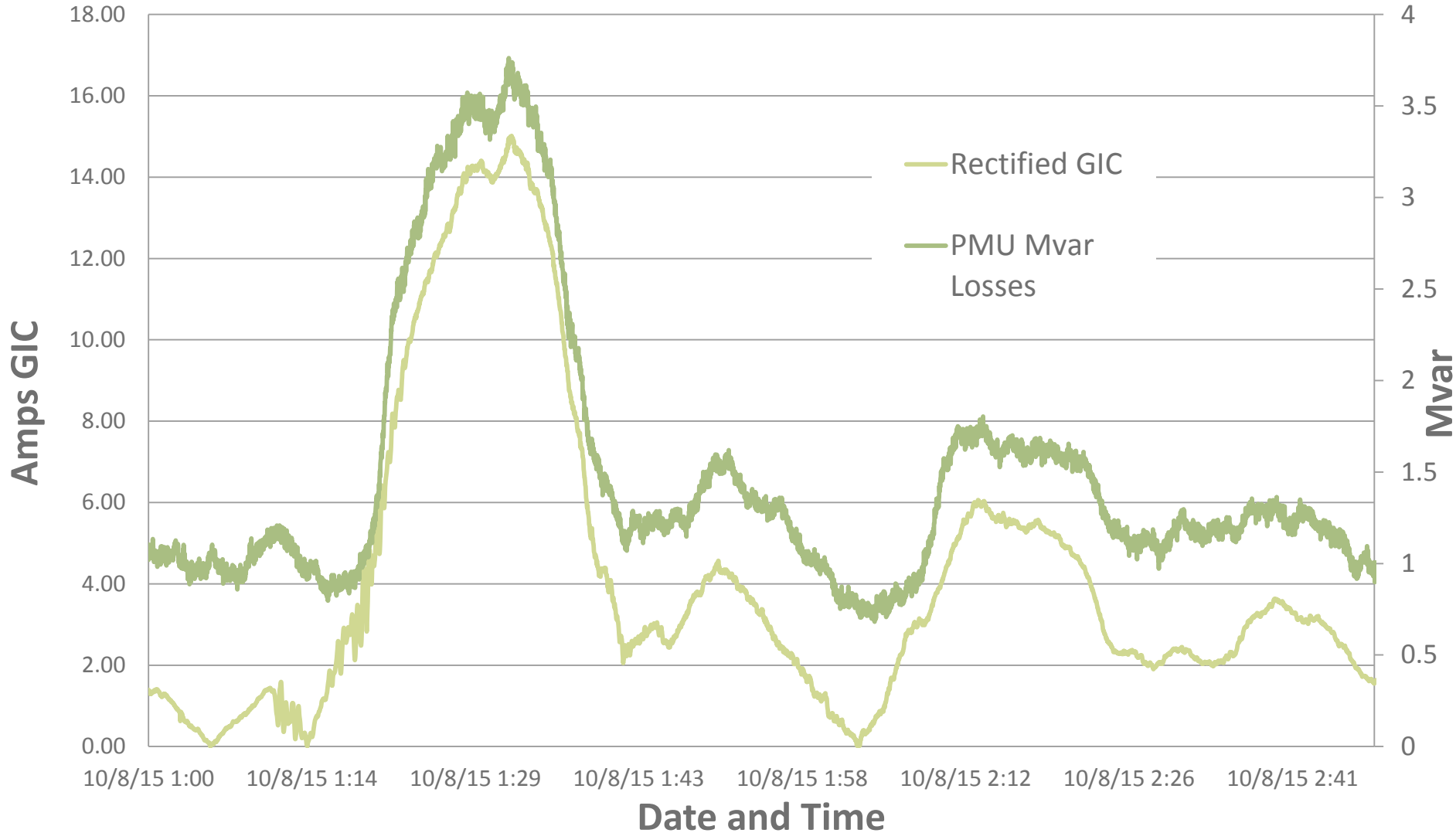
Monitoring Progress for GMD

Found a high correlation to transformer audio while GIC present



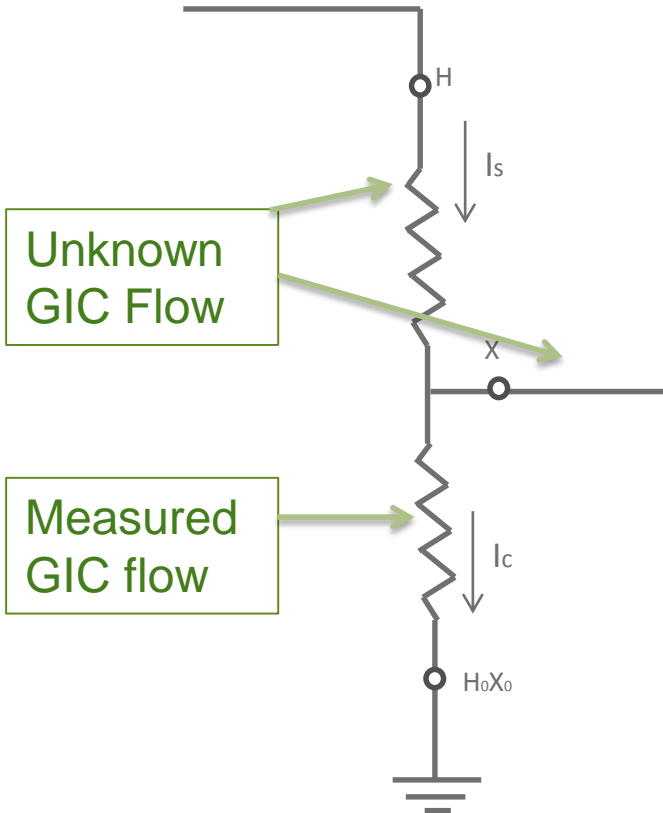
PMU Calculated Transformer Losses vs. GIC

GIC and Mvar Losses Vs. Time



Transmission Voltage Level DC Monitoring

Autotransformer DC model showing likely discrepancy

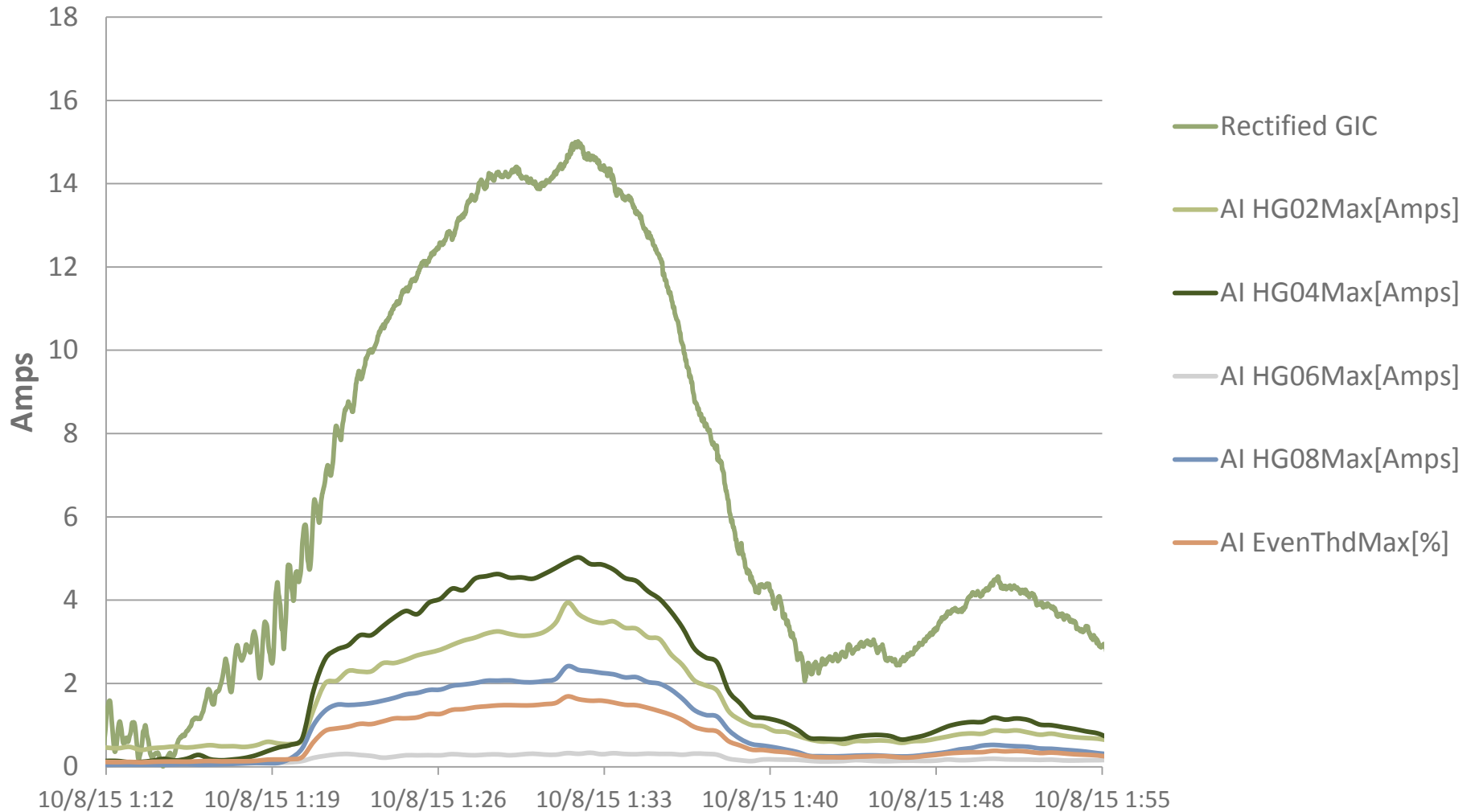


Proposing to measure DC flow on transmission

- As seen in effective current equation, current in one winding can have more impact than the other winding
- Looking into technologies to measure DC
 - Fiber optic
 - Hall Effect

Findings from previously collected data

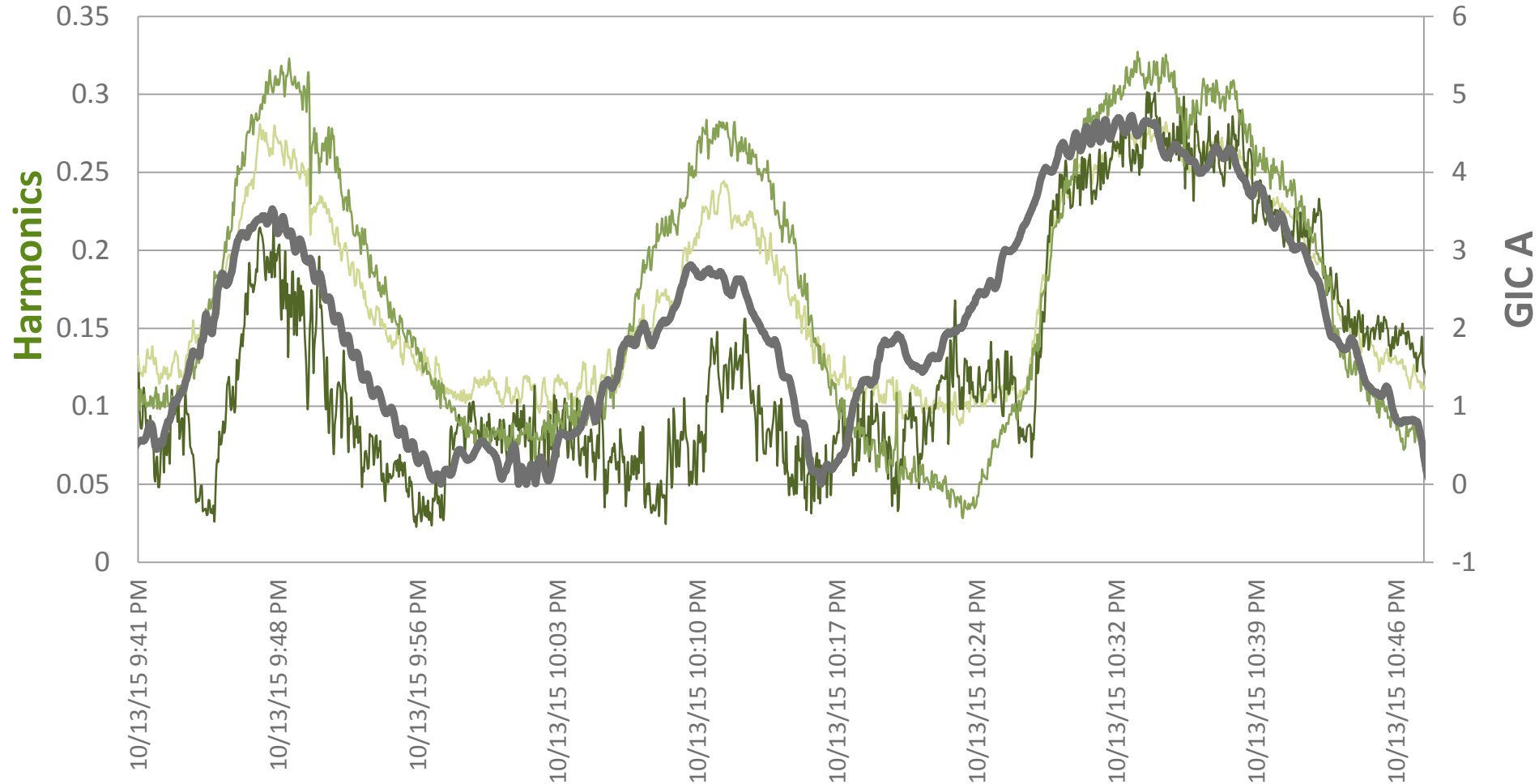
Rectified GIC and Harmoics



Findings from previously collected data

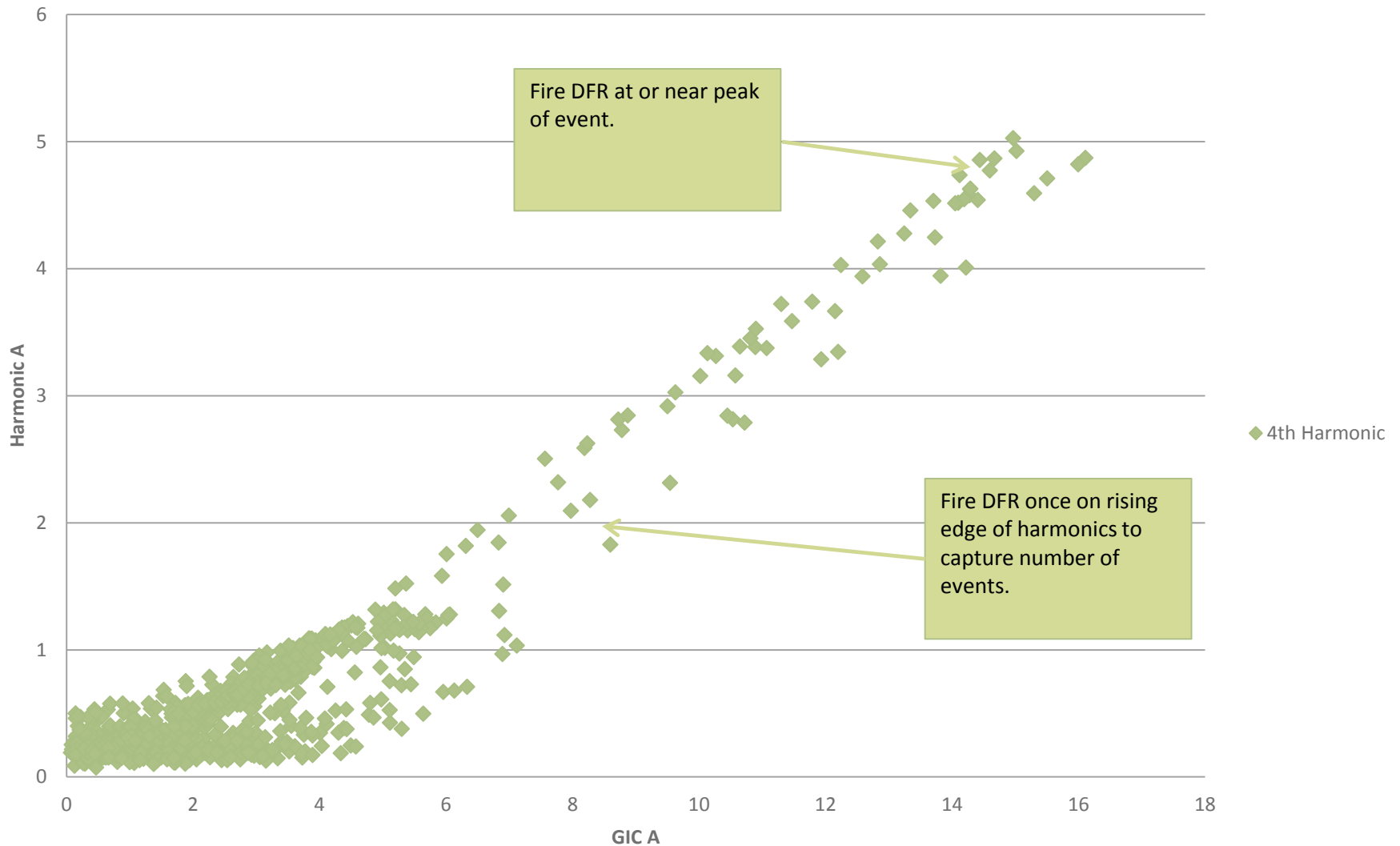
Low Level GIC Vs Harmonics

- AIEvenThdMax[%]
- AI HG04Avg[Amps]
- AI HG06Max[Amps]
- Rectified GIC



Findings from previously collected data (Potential DFR collection)

4th Harmonic Vs GIC



Tracking GMD through data analysis

- Enabled PMU data capture of high and low sides of transformers
- Applied GMD Power Flow studies to simulate the transmission system response
- Installed new GMD monitoring on transformer ground connections
- Monitored voltage and current harmonics at 345kV and 115kV
- Purchased fiber optic current sensors to gather high voltage GIC measurements

CMP will focus on deploying additional GIC monitoring and improving GMD models

- Deploy fiber optic current sensors to map GIC through auto transformers
- Configure Digital Fault Recorders to record during GMD events
- Expanding PMU network data being captured and stored
- Utilize additional information gathered to improve modeling
- Work with PingThings to develop a useable operator interface/display for reporting real time GIC impacts

Alstom/GE COSI F3 Fiber Optic Current Sensor



Alstom/GE COSI F3 Fiber Optic Current Sensor



Final Conclusions

- GIC is always present (at some level)
- More monitoring is needed with research into enhanced and standardized methods
- Data quality matters
- Currently deployed data architectures are not sufficient for real time analysis

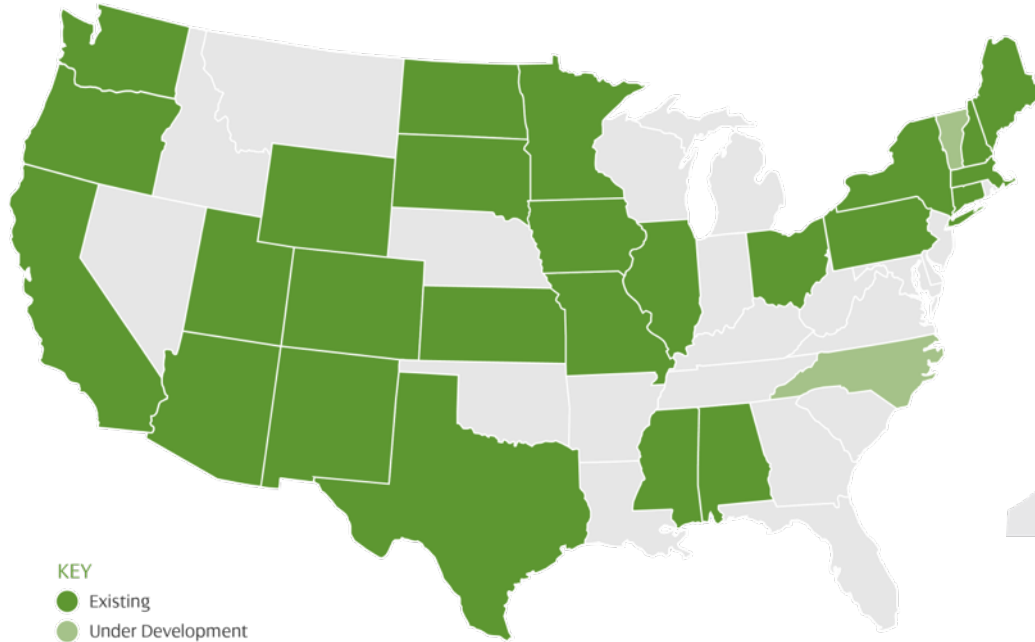
The End

The End

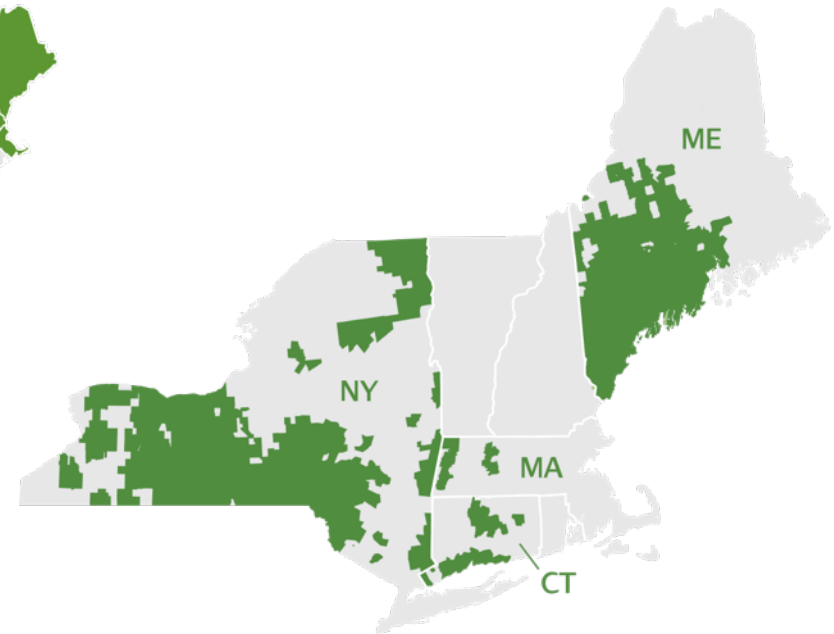
The End

AVANGRID Facilities and Operations

Geographic Presence



Regulated T&D



- **Avangrid Renewables** is the 2nd largest U.S. wind energy producer operating 5.7 GW of wind and solar in 18 states.
- **Avangrid Networks** provides electric and natural gas service to 3.1 million customers in New York and New England.

PingThings

- Founded 2014
- Agile, geographically disperse team
- Predictive analytics for real-time streaming big data
- Investors:
 - GE Ventures
 - Double M Partners
 - K Fund

Executive Team



Jerry Schuman
Cofounder/CTO



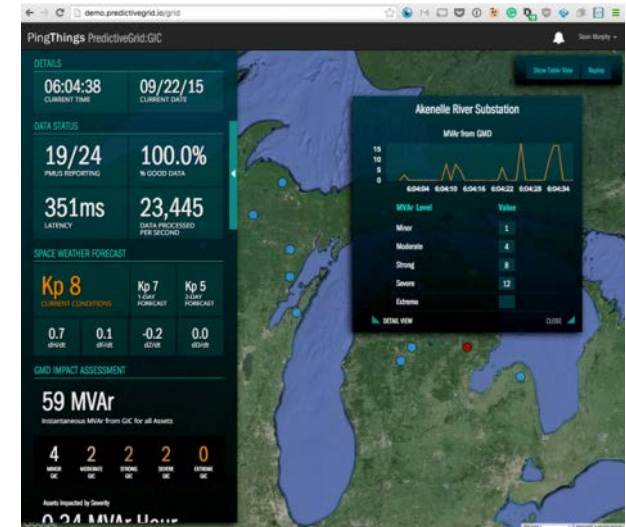
Rich Sootkoos
Cofounder/CEO



Sean Murphy
Chief Data Scientist



Mehrdod Mohseni
CCO



History and Recent Drivers

- Monitoring Geomagnetic Induced Current (GIC) activity at the Chester SVC since 1991
- CMP and ISO-NE regularly receive alerts on the timing and intensity in advance of solar events
- The Local Control Center monitors GIC measurements through SCADA and has operating procedures to respond if needed to alerts or measurements
- 2013 Maine Legislature passed a resolve requiring the Public Utilities Commission to develop a report on GMD impacts to the Maine Transmission system
- 2014 Transformer audible noise from two substations reported and later correlated to GIC

Overview

- 1) Who is Central Maine Power Co
- 2) History of GMD in Maine
- 3) Review of data collection
- 4) Findings from data
- 5) Future Efforts