Deployment of sensors for GIC hazard mitigation

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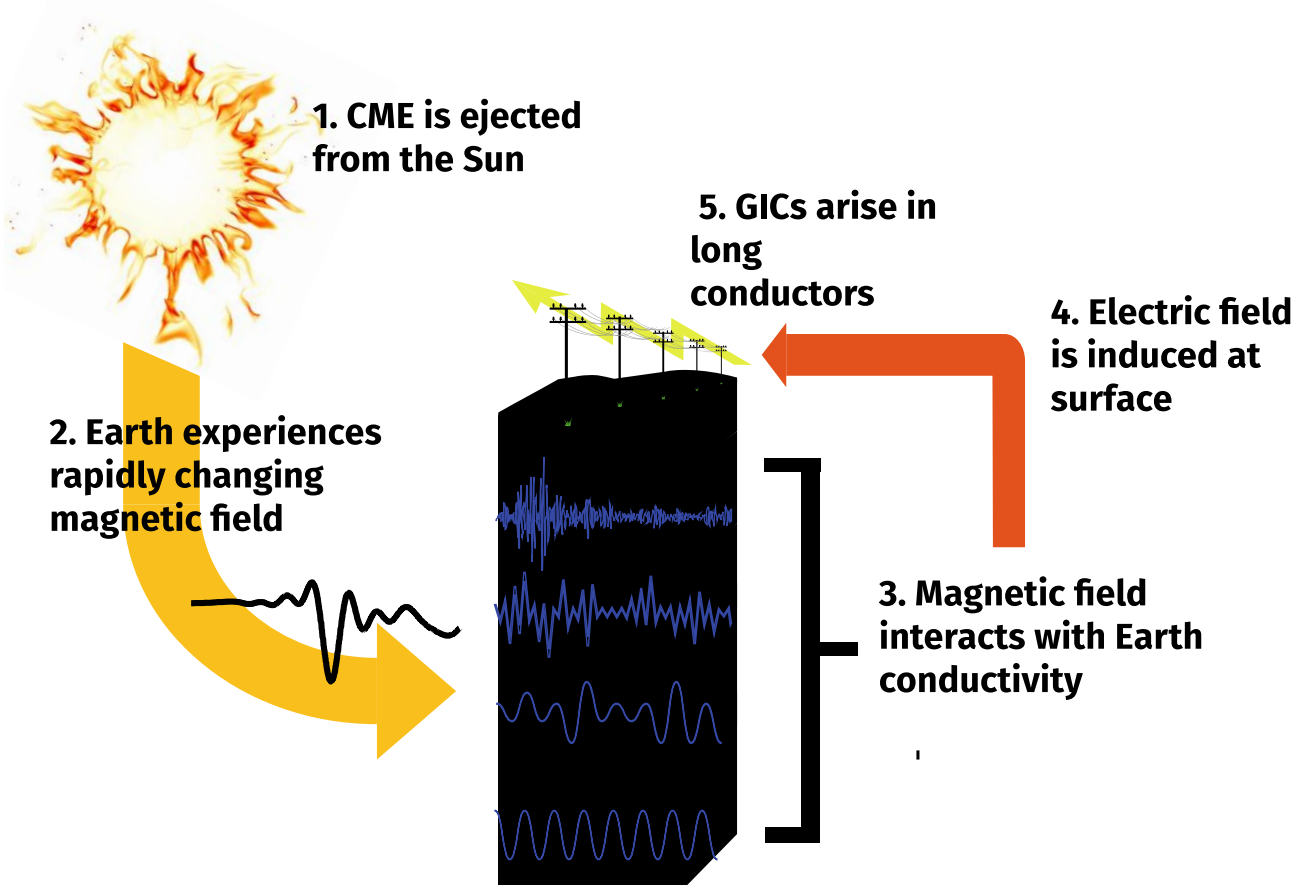
Overview

1. Specific needs for industry-grade magnetometers

2. Installation and operational difficulties unique to industry-grade magnetometers

3. Examples of how magnetic field data can be used in power utility planning and operations

Changing magnetic fields drive the GIC hazard.



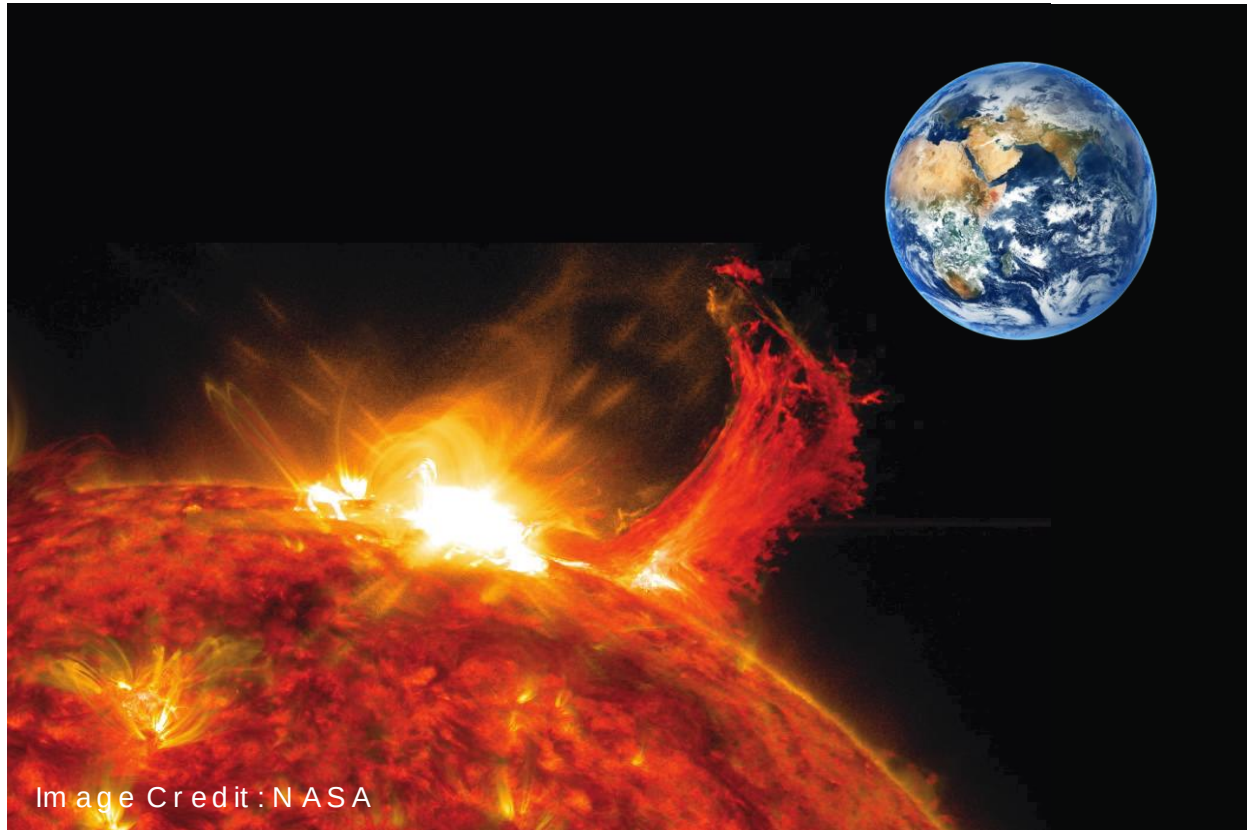
Changing magnetic fields interact with deep earth conductivity to produce electric fields at the surface of the Earth.

Local hazard conditions can vary greatly between locations.

Magnetic field data can be used for GIC hazard mitigation.

- Source data for real-time GIC simulators
- Validation of GIC calculations/models and earth modelling assumptions
- Requirements of

  NERC-TPL-007-2



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CPI : Space Hazard Monitors (SHMs)

Supported by NSF project EAR-1520864, in partnership with Hennepin County Emergency Management, GIC Magnetics, UIUC, TAMU, and our utility partners.

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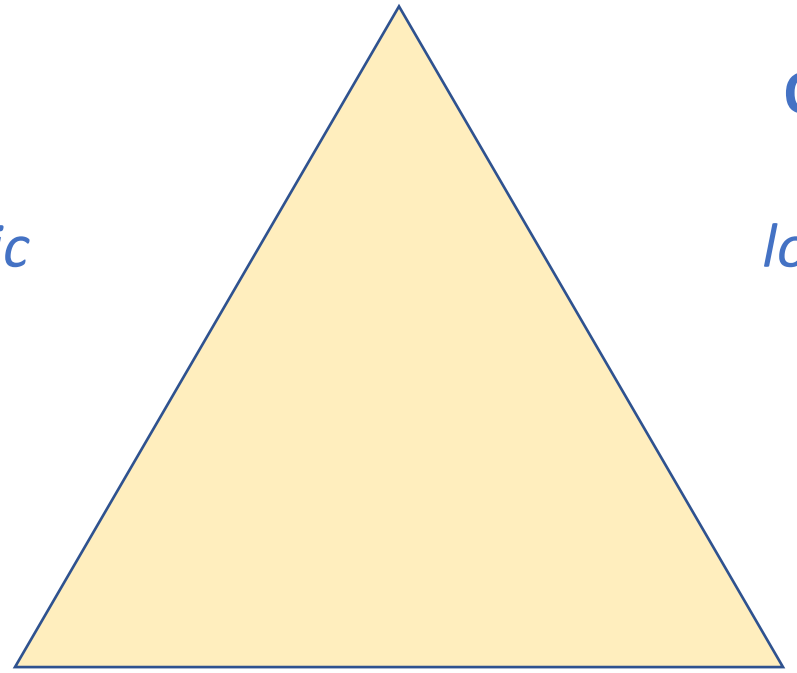
There are unique challenges to each class of magnetometer

Academic Installations: *Specific scientific questions*



Observatories: *High quality, long-term, many different applications*

Industry Grade ?

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Industry-grade magnetometers require **accuracy, reliability, and security**

A few key considerations:

1. What matters is dB/dt, not absolute accuracy.

2. Finding a good installation site can be challenging.

3. There are additional security concerns.

4. Good data management must be maintained.

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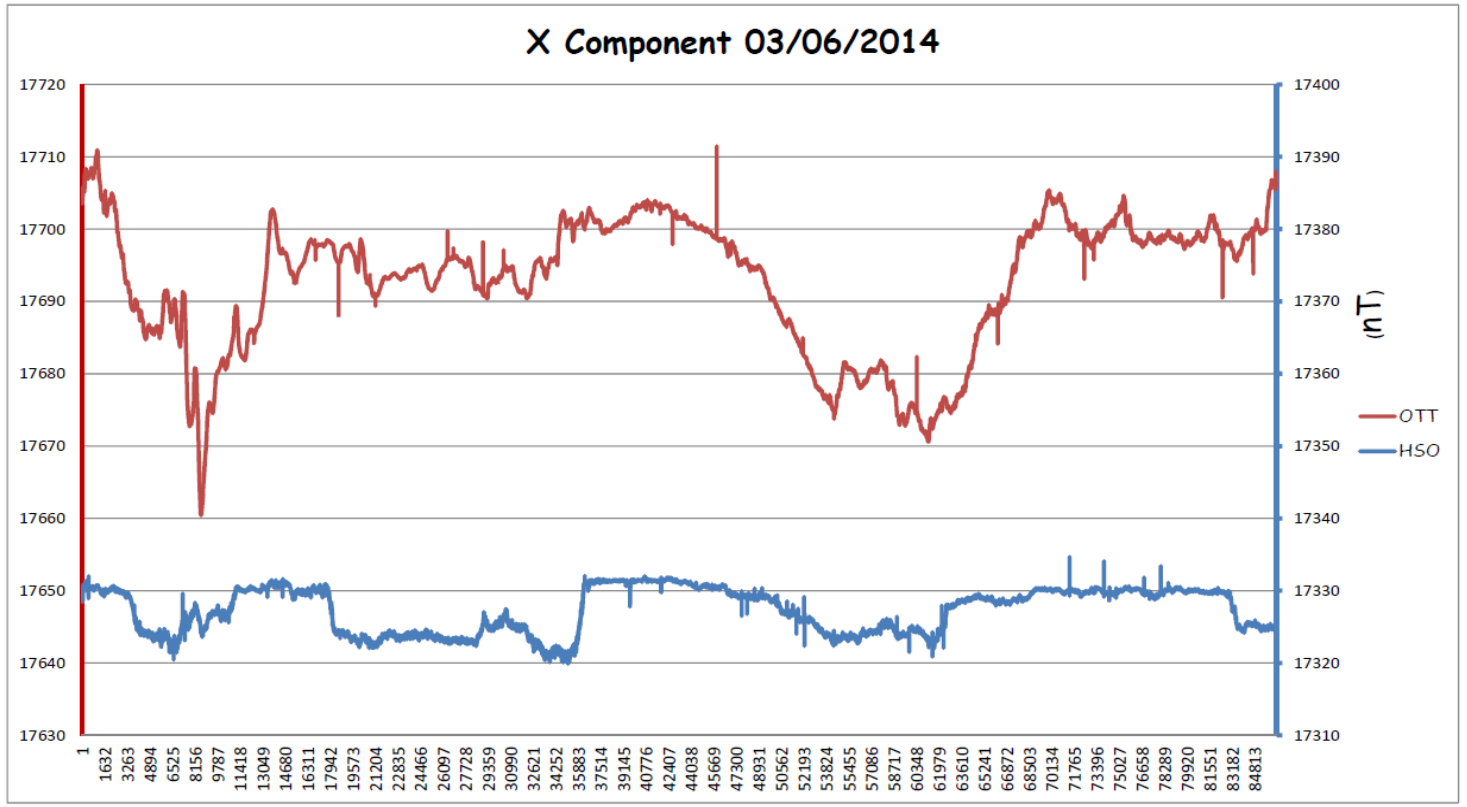
Finding a good installation site can be challenging.

- Available property
- Quiet conditions (not near power lines!)
- Impact of ferromagnetic material nearby
- Secure location
- Consider proximity to a substation (will come back to this)

… with **security concerns** taken into account!

The magnetic field inside a substation is significantly different than the natural magnetic field.



Recordings at the Ottawa magnetic observatory (red) and just inside the fence at a nearby substation (blue)

Courtesy of: David Boteler (NRCAN), Luis Marti

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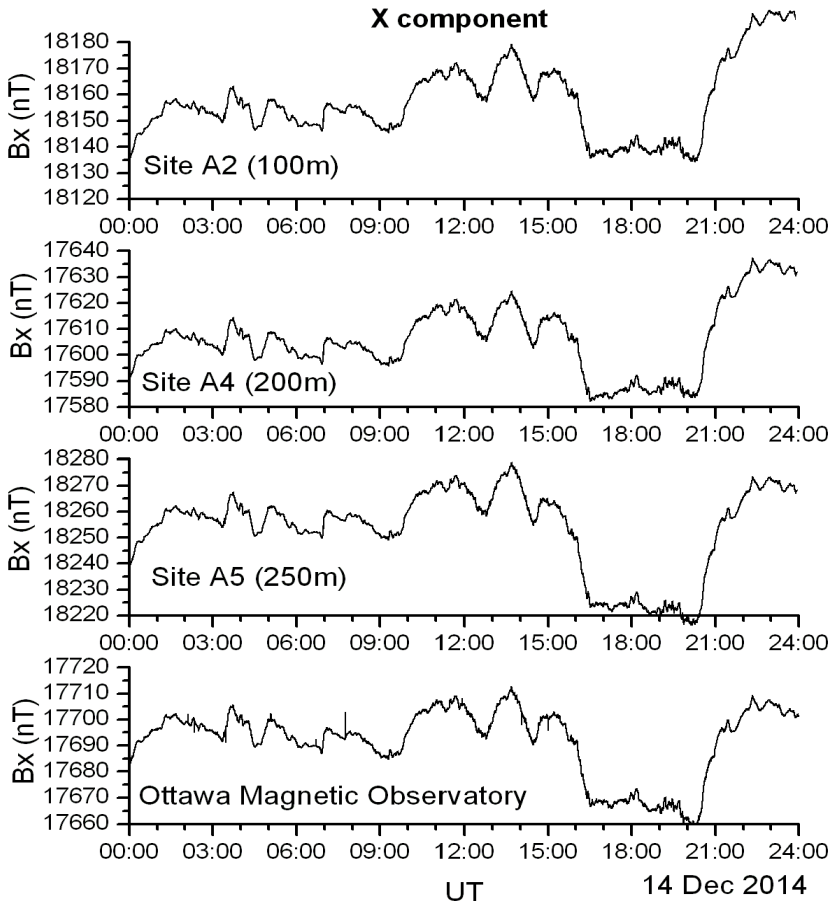
Place magnetometers far enough away from noise sources to get usable data…

The magnetic field recorded inside a substation is not just the natural magnetic field variation with some added spikes or noise.

Magnetic recordings **100 metres or more** away from the substation were unaffected by the substation.

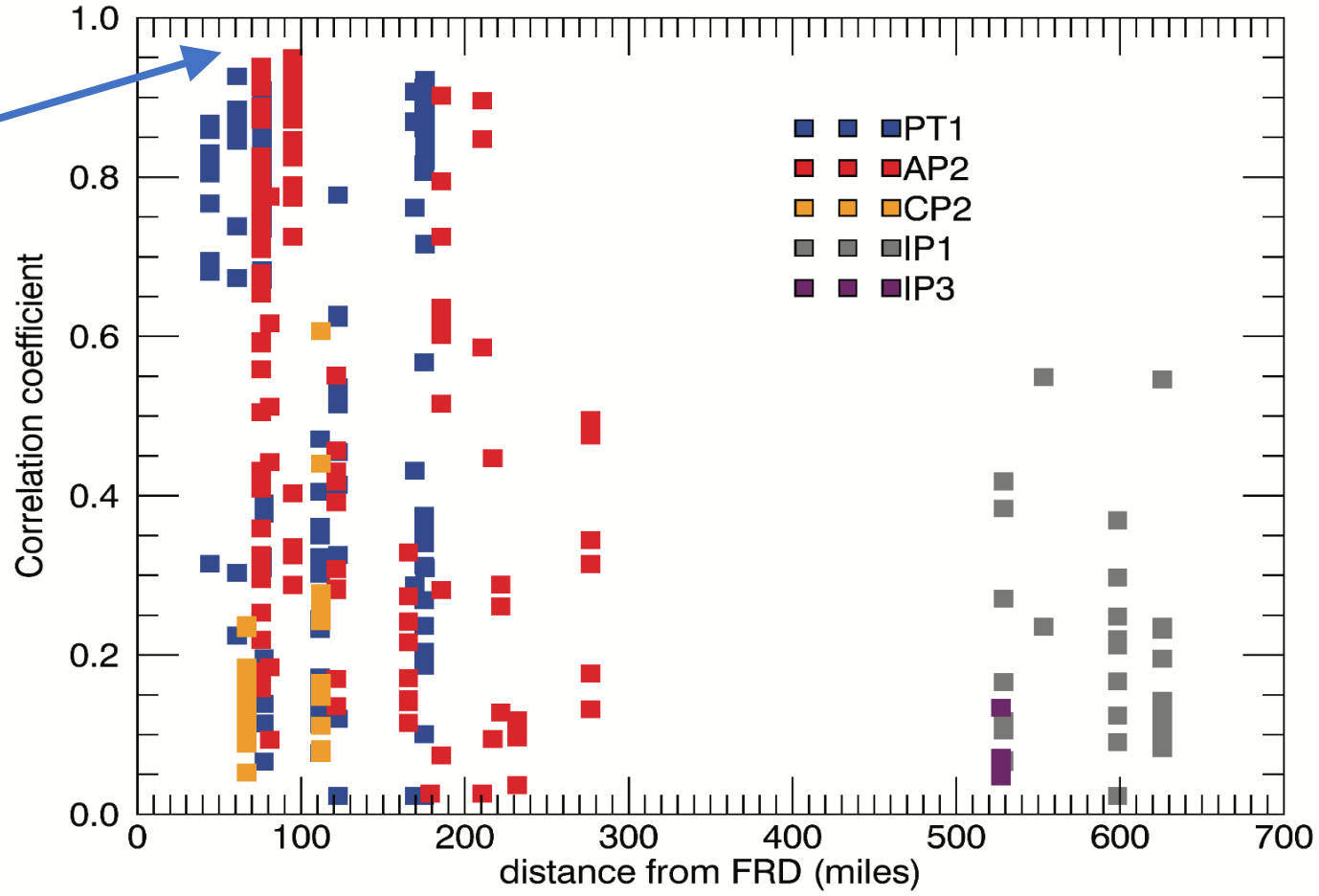
Courtesy of: David Boteler (NRCAN), Luis Marti



… but close enough to be relevant and actionable.

Good correlation of GIC with electric field **~200 miles** from magnetometer.

Data courtesy of PJM and Emanuel Bernabeu



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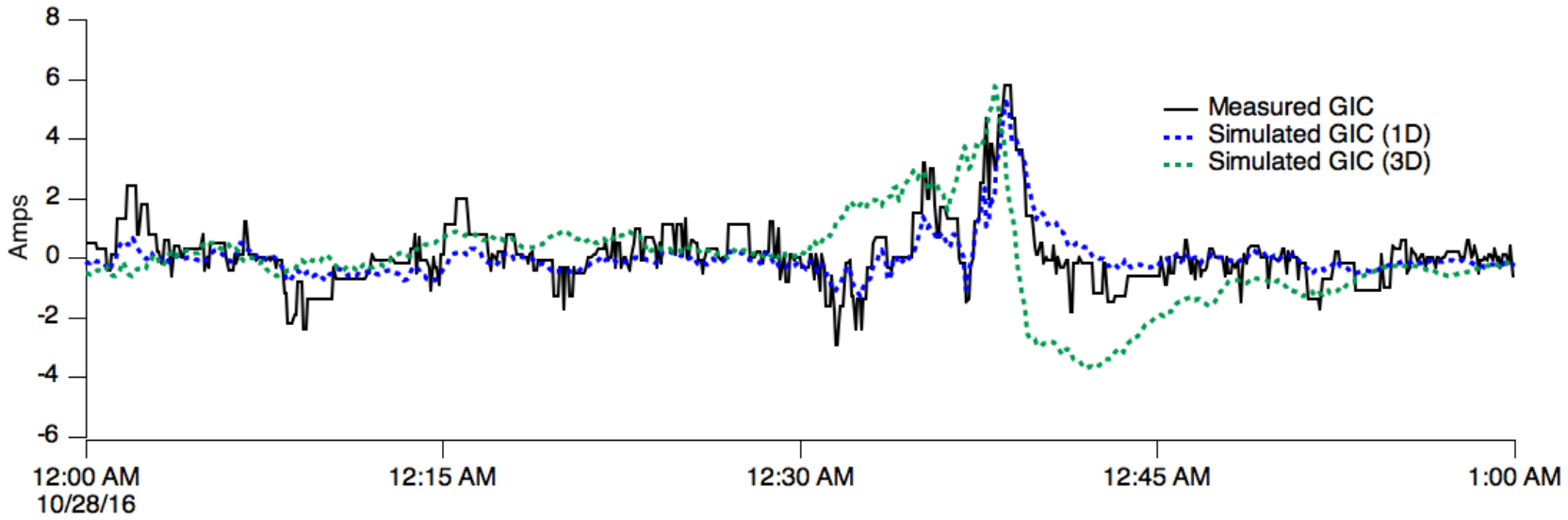
Good data management must be maintained.

- Archiving data
- Time stamping/integration to operational systems
- Filtering/data cleaning – onsite or archival
  - Temperature effects
  - Local disturbances (bad data)
  - Sensor orientation

What can be done with mag data for GIC hazard planning?

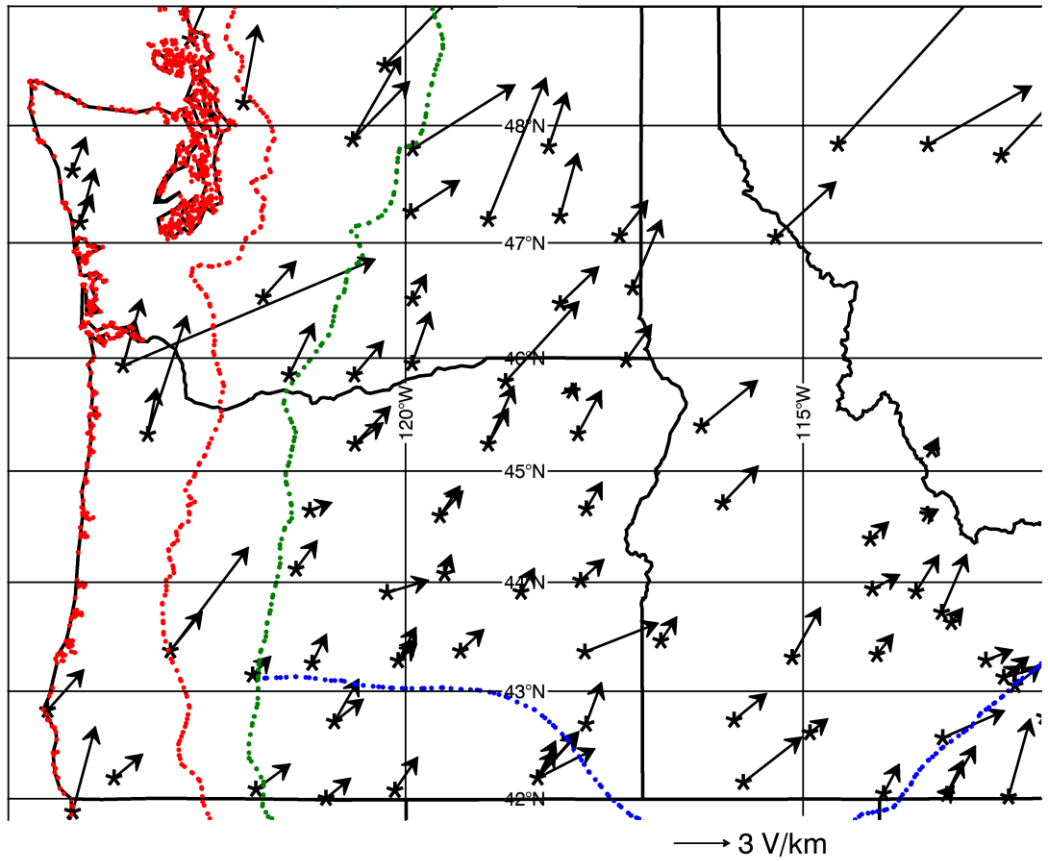
Quite a bit!

- Use to validate **system models**
- Use to validate **conductivity models**
- Understand local **hazard and risk**



(from Shetye et al., under review)

Magnetic field data is used to estimate GIC using system models.



- GIC estimates in Amps/phase for 13 example nodes in this system
- Using 10-second magnetic field data
- Differences due to field direction and local effects

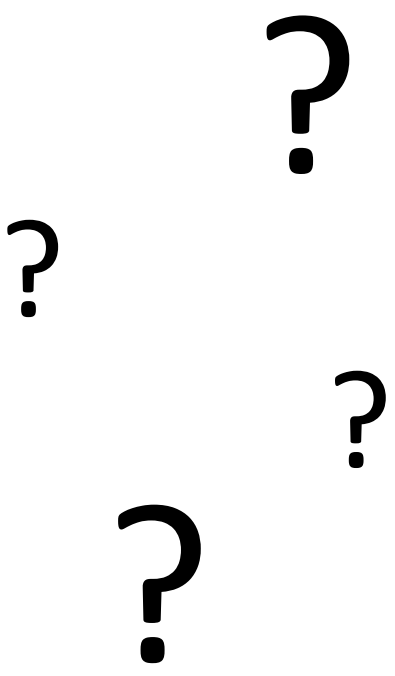
node	1D	3D
L1	29.9	9.0
L2	6.3	2.1
L3	3.2	1.6
L4	20.7	9.0
L5	13.5	14.3
L6	3.3	0.9
L7	3.3	0.4
L8	3.0	1.9
L9	26.8	5.7
L10	3.0	3.0
L11	6.8	4.5
L12	7.7	3.2
L13	9.7	6.9

(from Gannon et al., 2017)

What can be done with mag data for ops?

Still lots of work to do….

- How do utilities want to handle **data management**?
- How to integrate this data into **operational systems**?
- How do we make this information **actionable?**



Summary

Magnetometers are being deployed for GIC hazard mitigation purposes.

There are special requirements and considerations for industry-specific mag installations.

Magnetometer data can be used effectively in GIC hazard planning, and eventually, in operations.