GICs in the Irish Power Grid during Kp8 and Kp9 Storms

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An Chomhairle um Thaighde in Éirinn

BGS 1835
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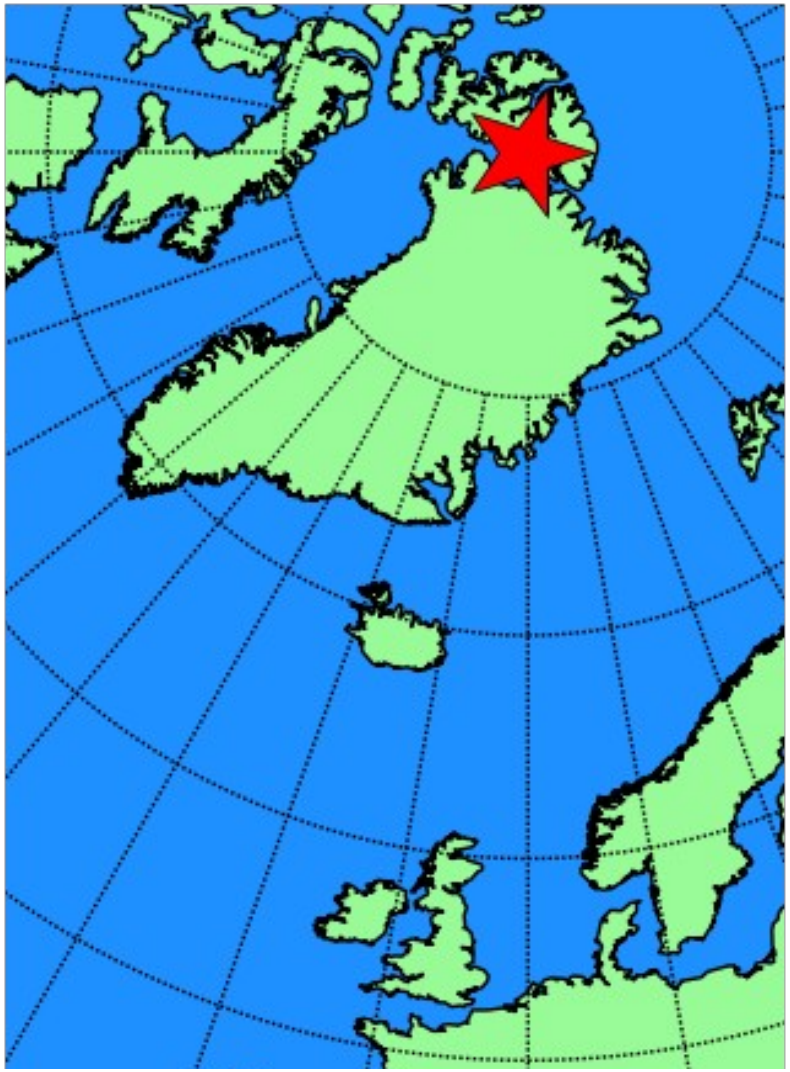
Space Weather in Ireland



Geographic Latitude: 53.34
Geomagnetic Latitude: 56.03

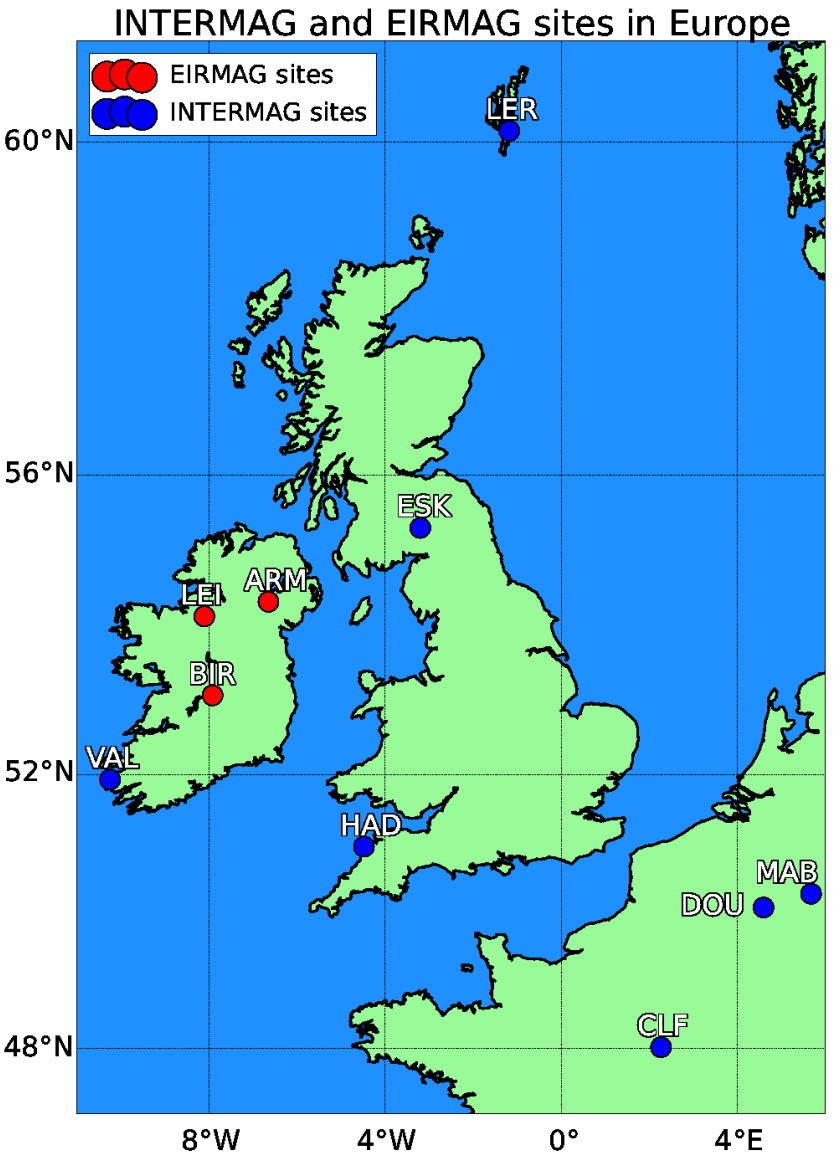
Source: 500px.com/danielmcglashin

GICs in Ireland: The Problem

- No historic power grid failures attributed to GICs
- No direct measurement of GICs
- Sparse electric field data from magnetotelluric surveys

GICs in Ireland: Monitoring

- **Eirmag**:
  - Long-term magnetic fields



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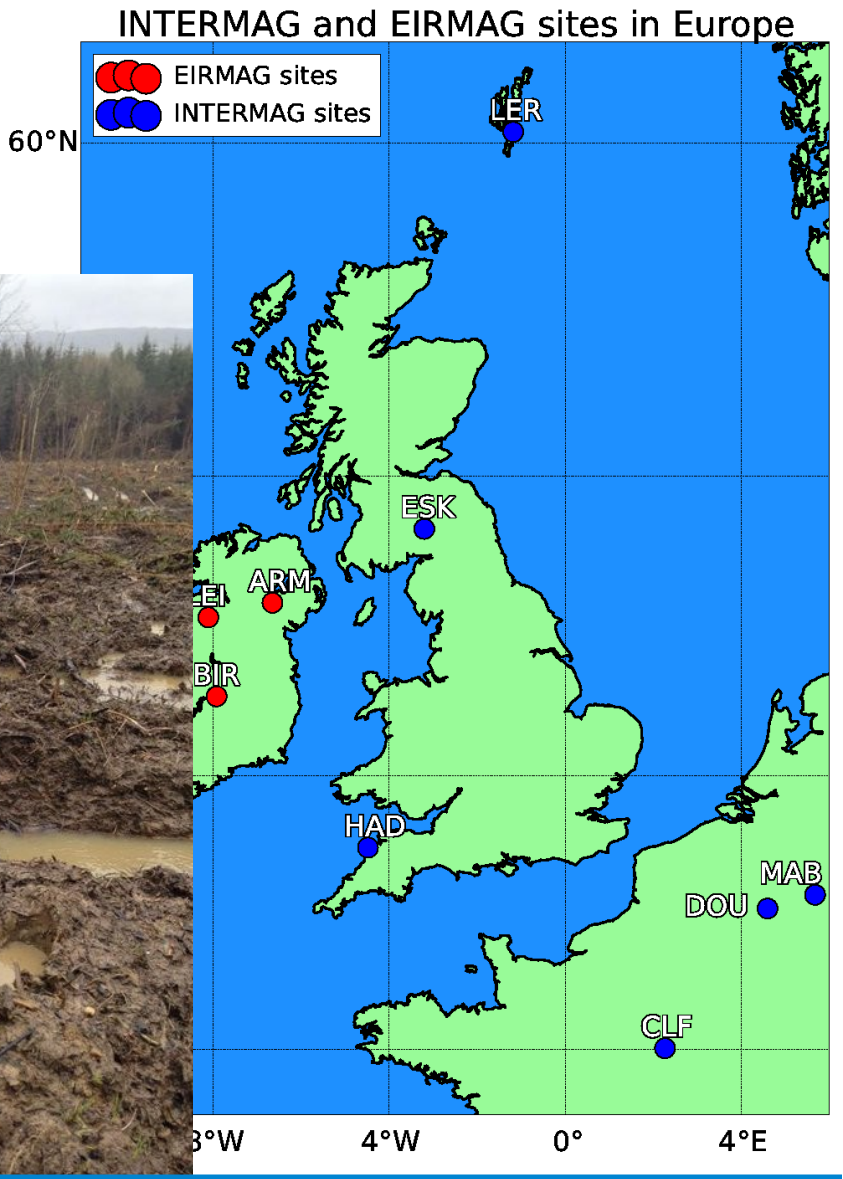
  - Long-term electric fields



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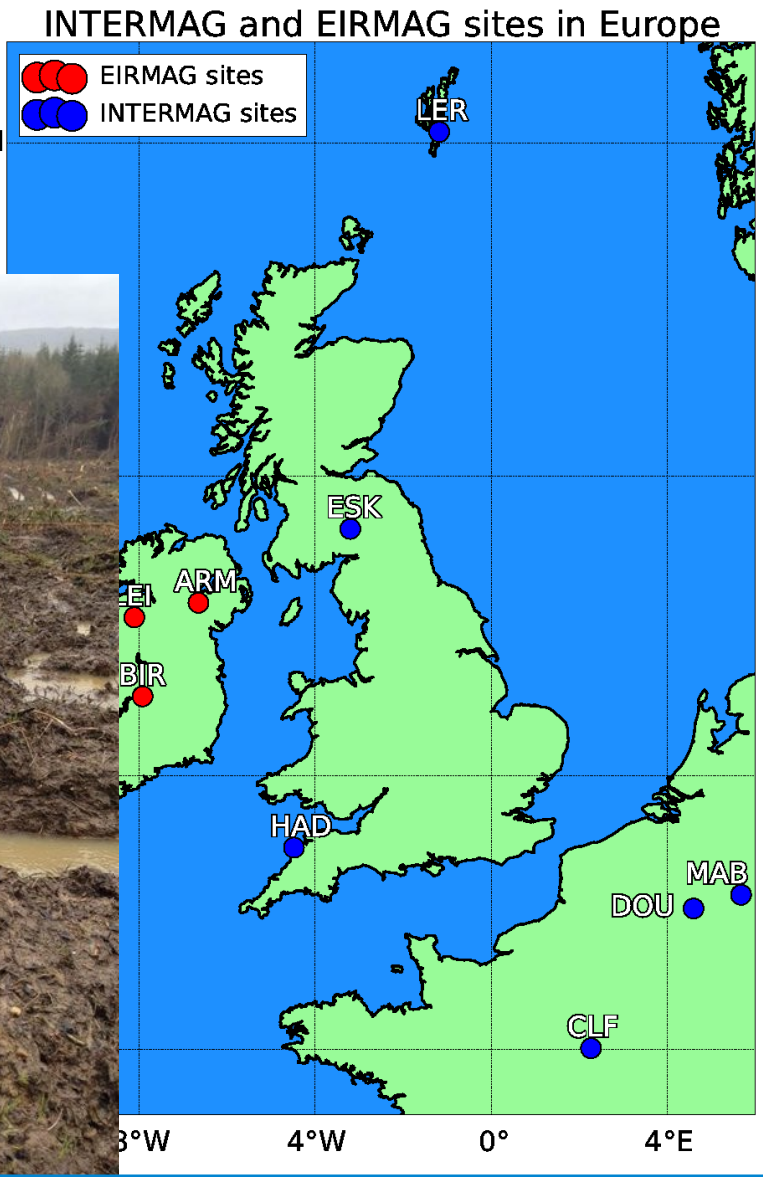
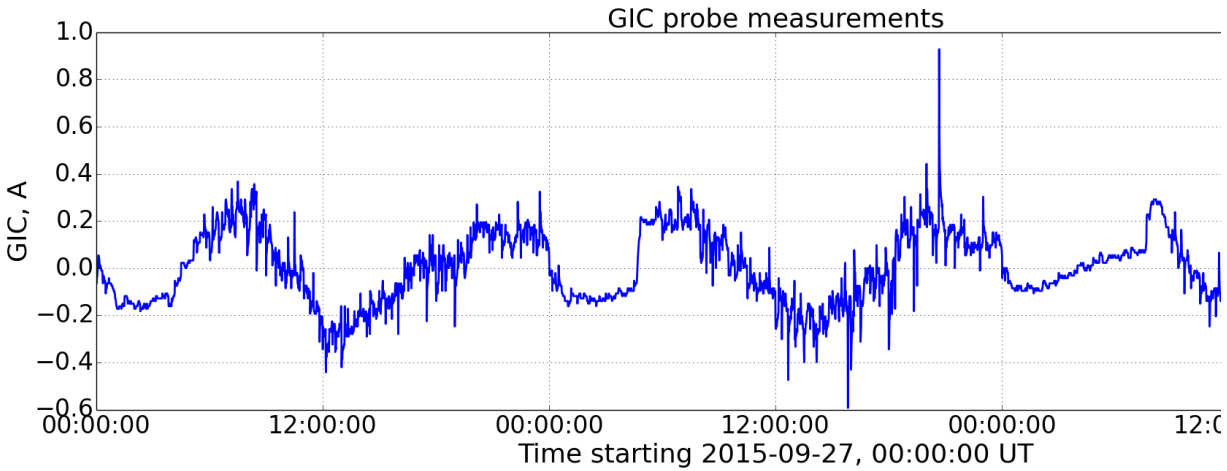
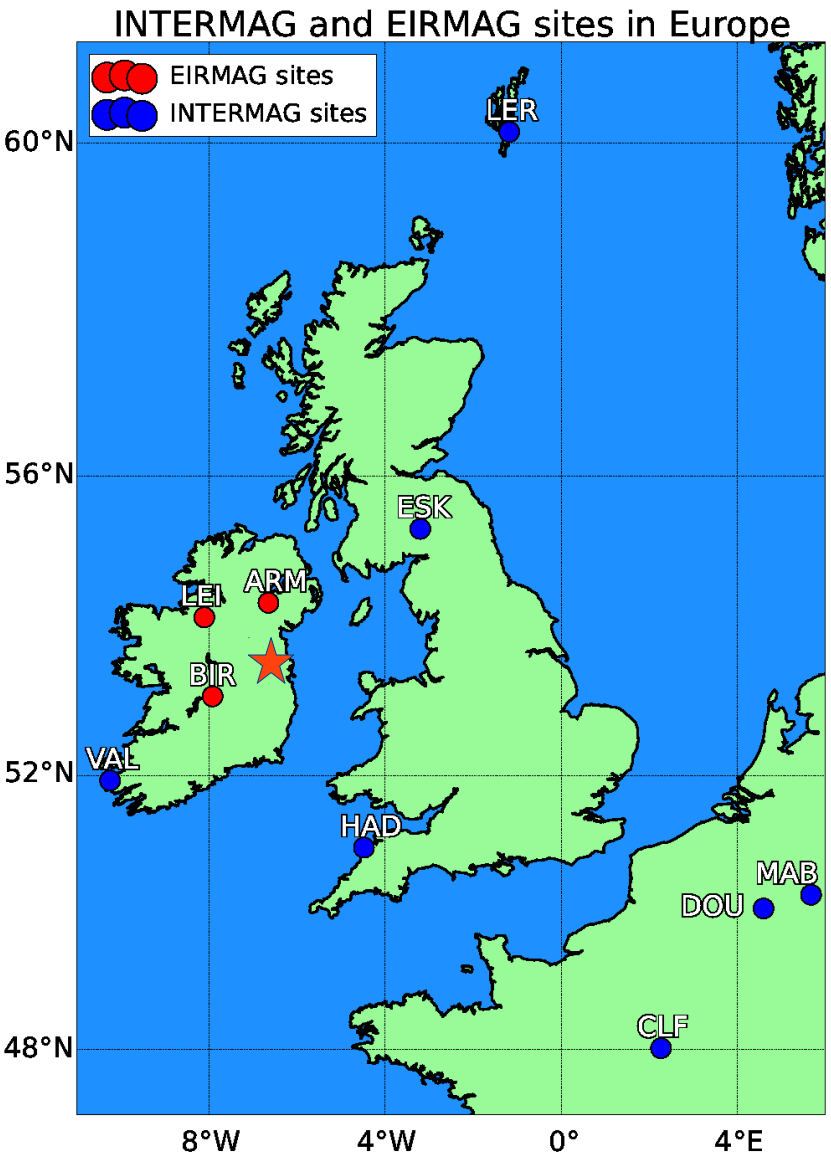


GICs in Ireland: Monitoring

- **Eirmag**:
  - Long-term magnetic fields
  - Long-term electric fields

- **GIC probe**
  - since August 2015





The Events

	March 1989	Halloween 2003	St. Patrick's 2015	June 22 2015
Kp	9.0	9.0	8-	8+
Dst (nT)	-589	-383	-223	-195

Simulation

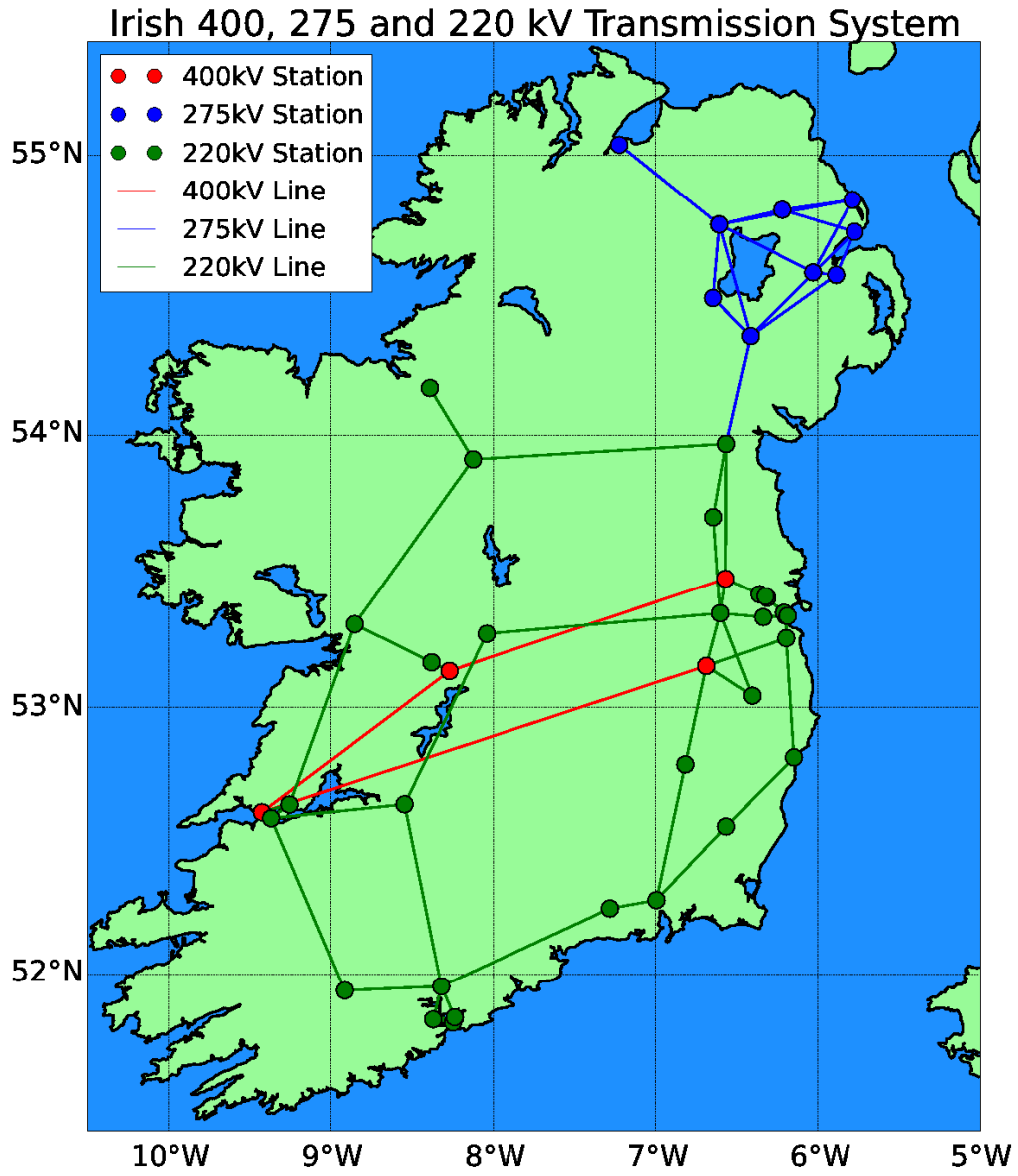
1) Interpolate Magnetic Field using Spherical Elementary Current System method.

2) Calculate E-field using plane wave approximation.

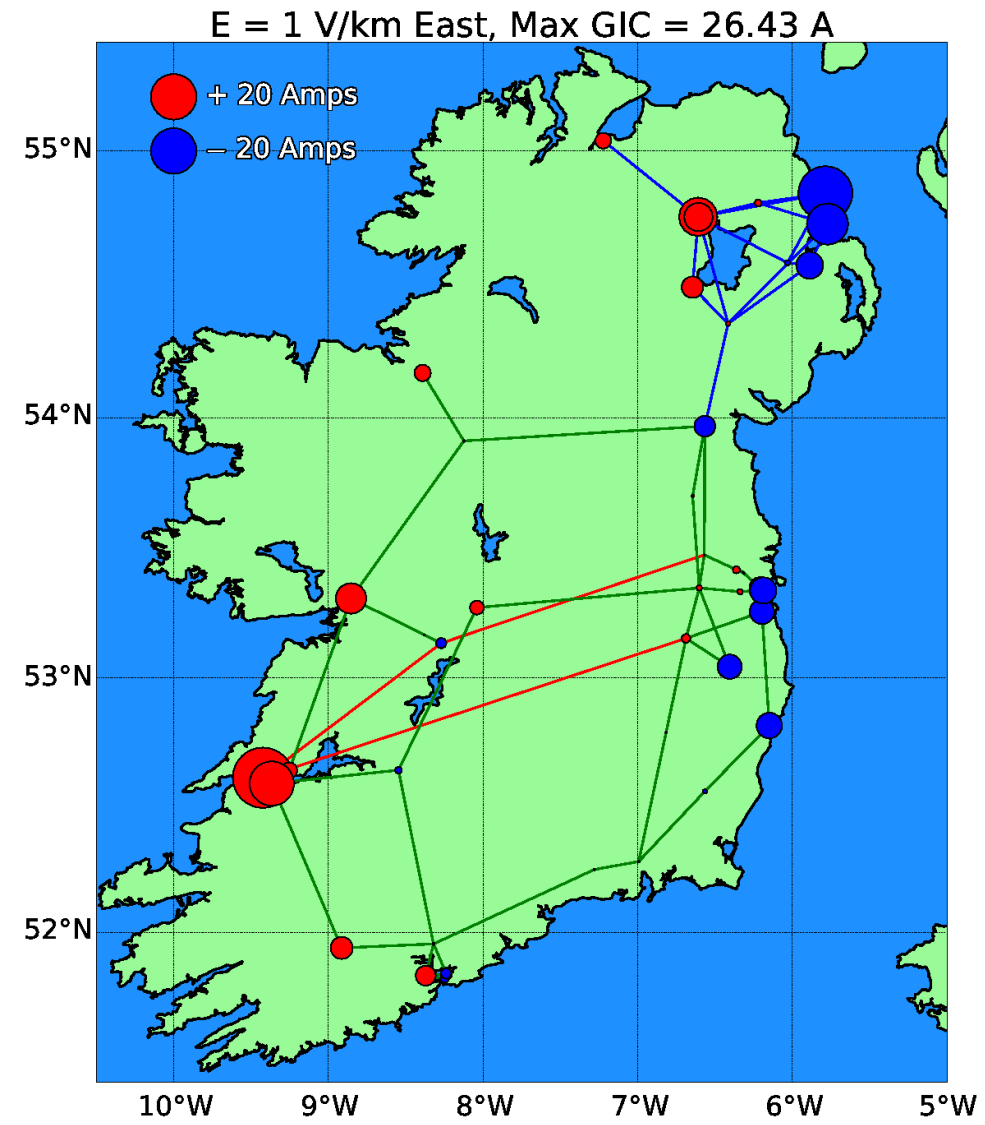
3) Calculate GICs in grid.

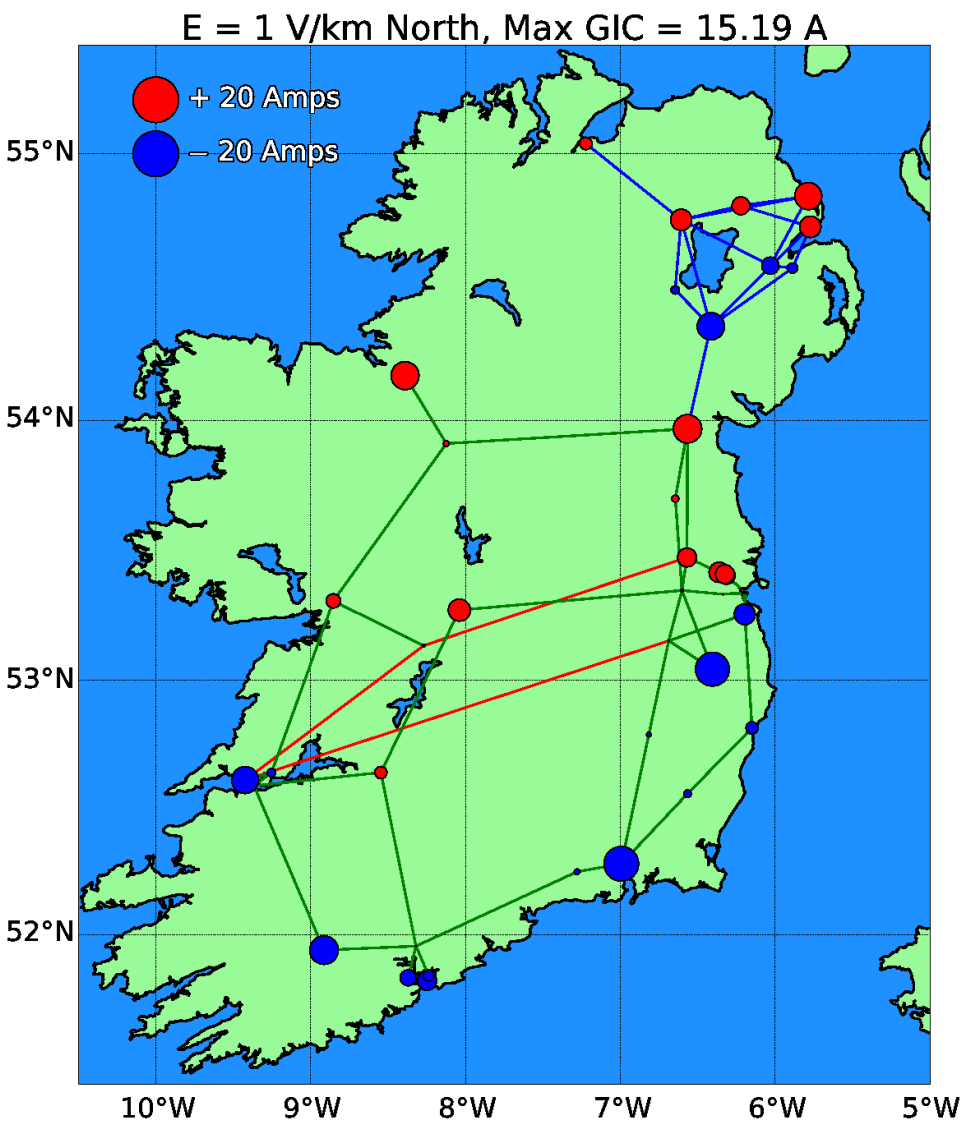
Irish Power Grid Model

- Straight-line lengths
- Excluded lower voltage lines
- Assumed transformer ground resistance of 0.5 Ohms



Irish Power Grid Response

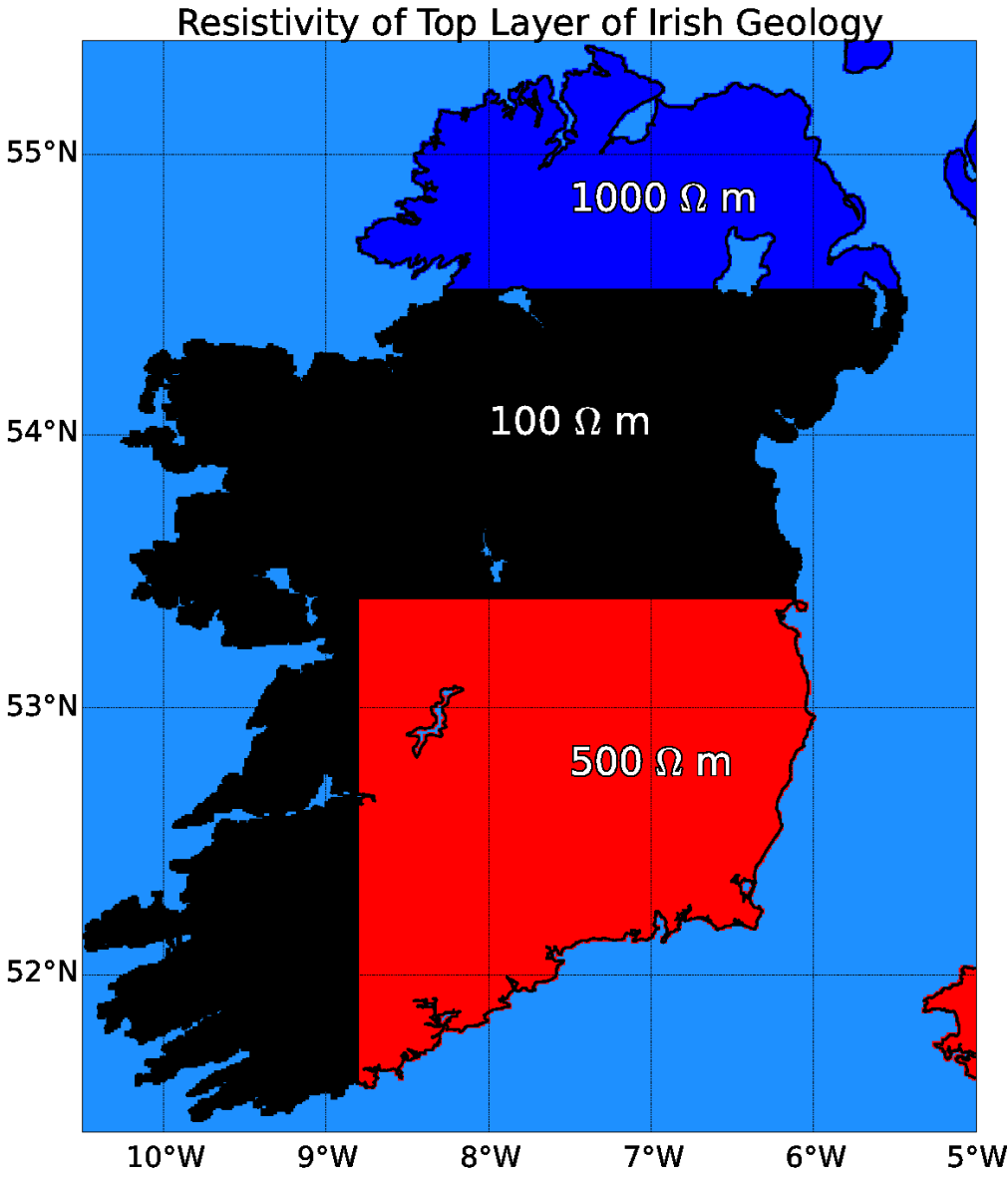




Electric Field

$$E(t) = -\frac{1}{\sqrt{\pi \mu_0 \sigma}} \int_0^\infty \frac{1}{\sqrt{\tau}} \frac{dB(t-\tau)}{dt} . d\tau$$

σ From *Ádám et al. 2013*



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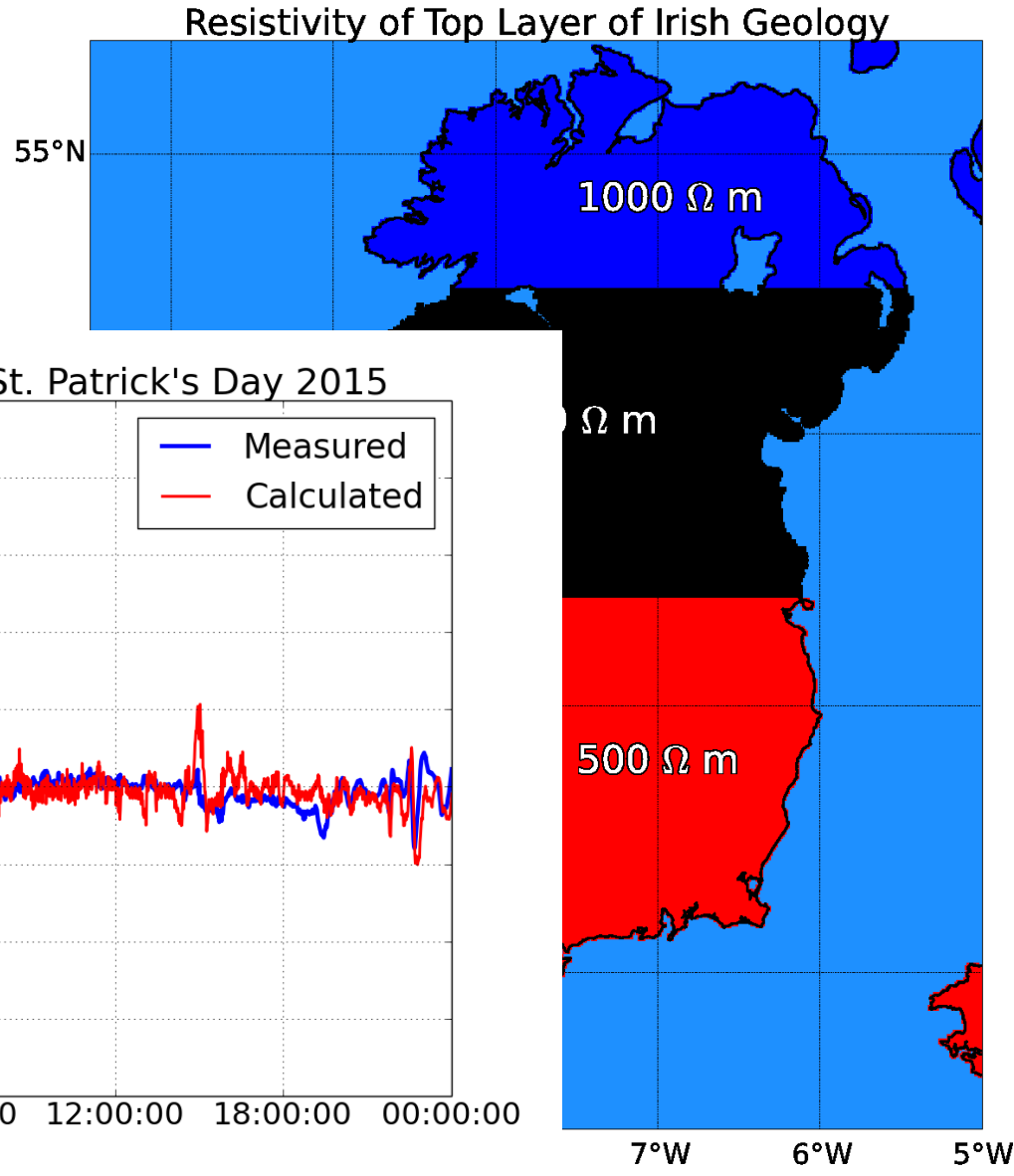
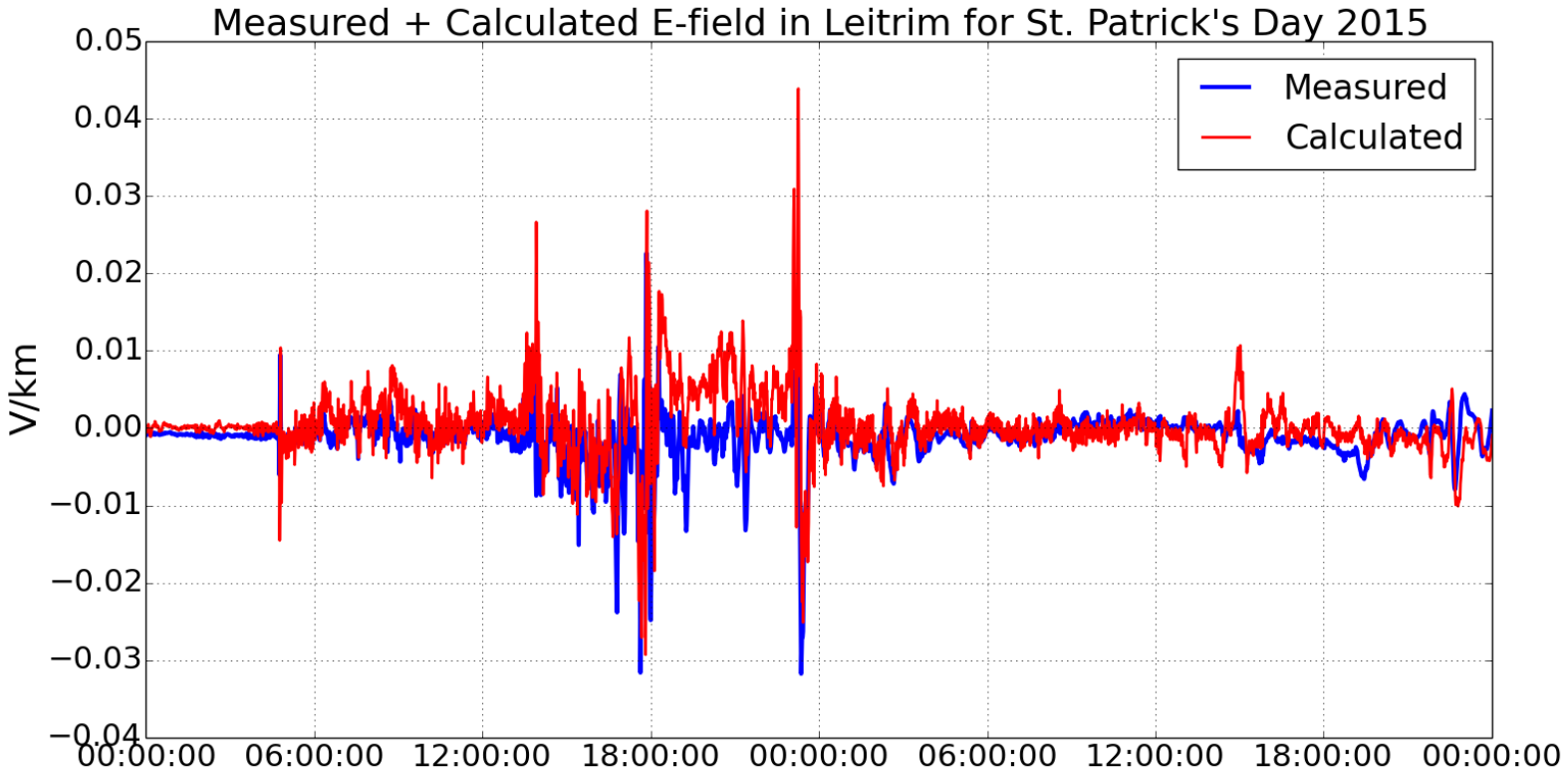




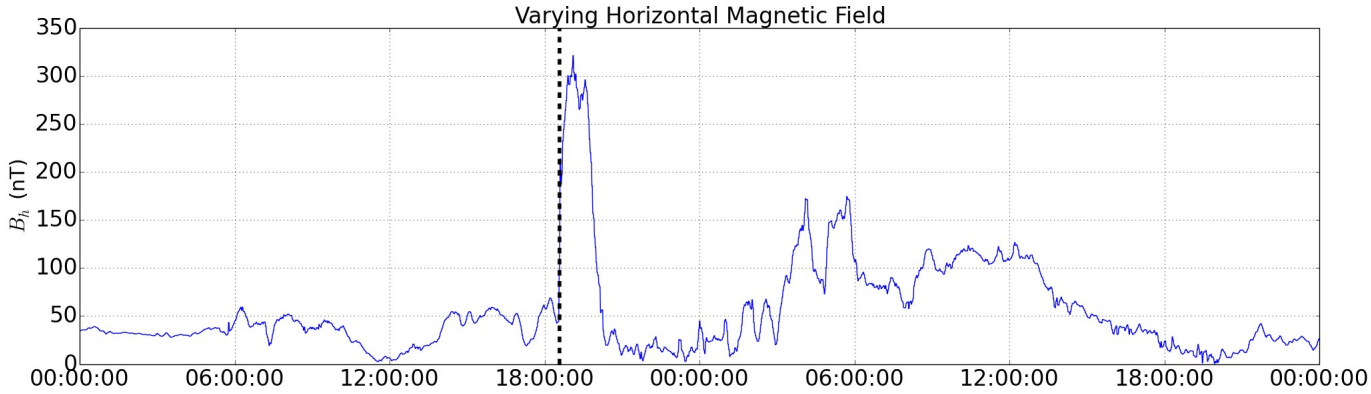
Results: 22-23 June 2015

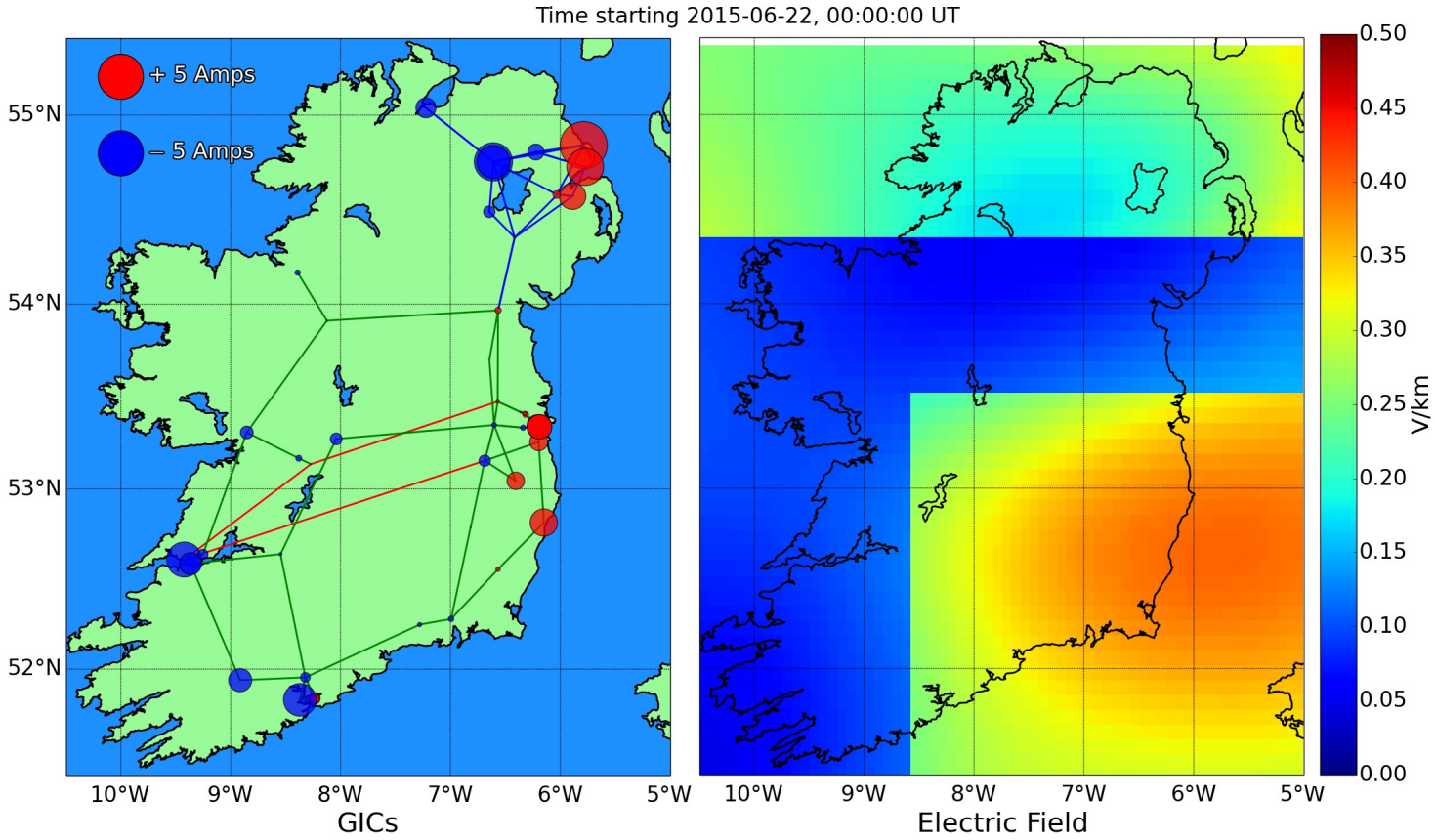
Peak Values:

dB/dt: 16.39 nT/min

Eh: 0.439 V/km

GIC: 5.2 A





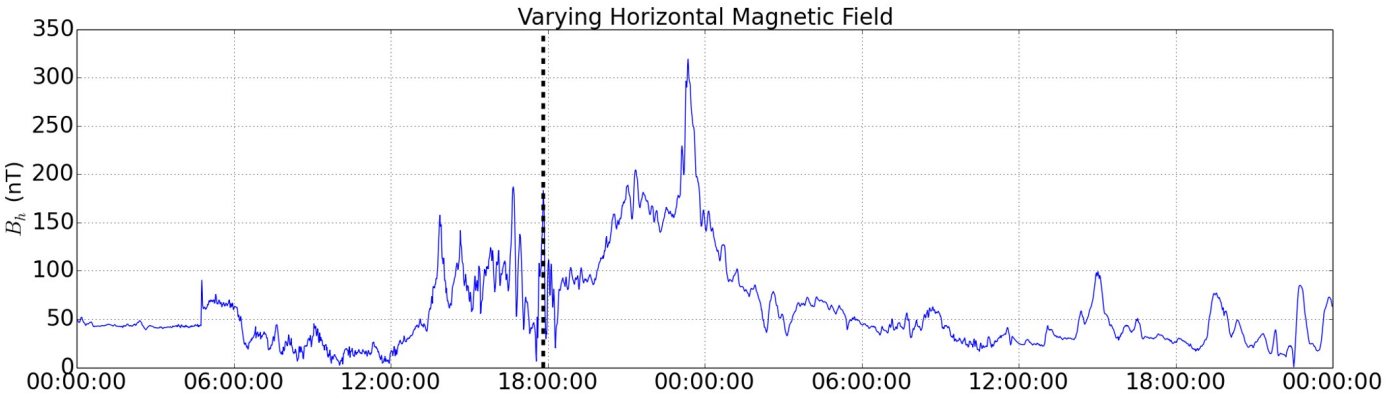
Results: 17-18 March 2015

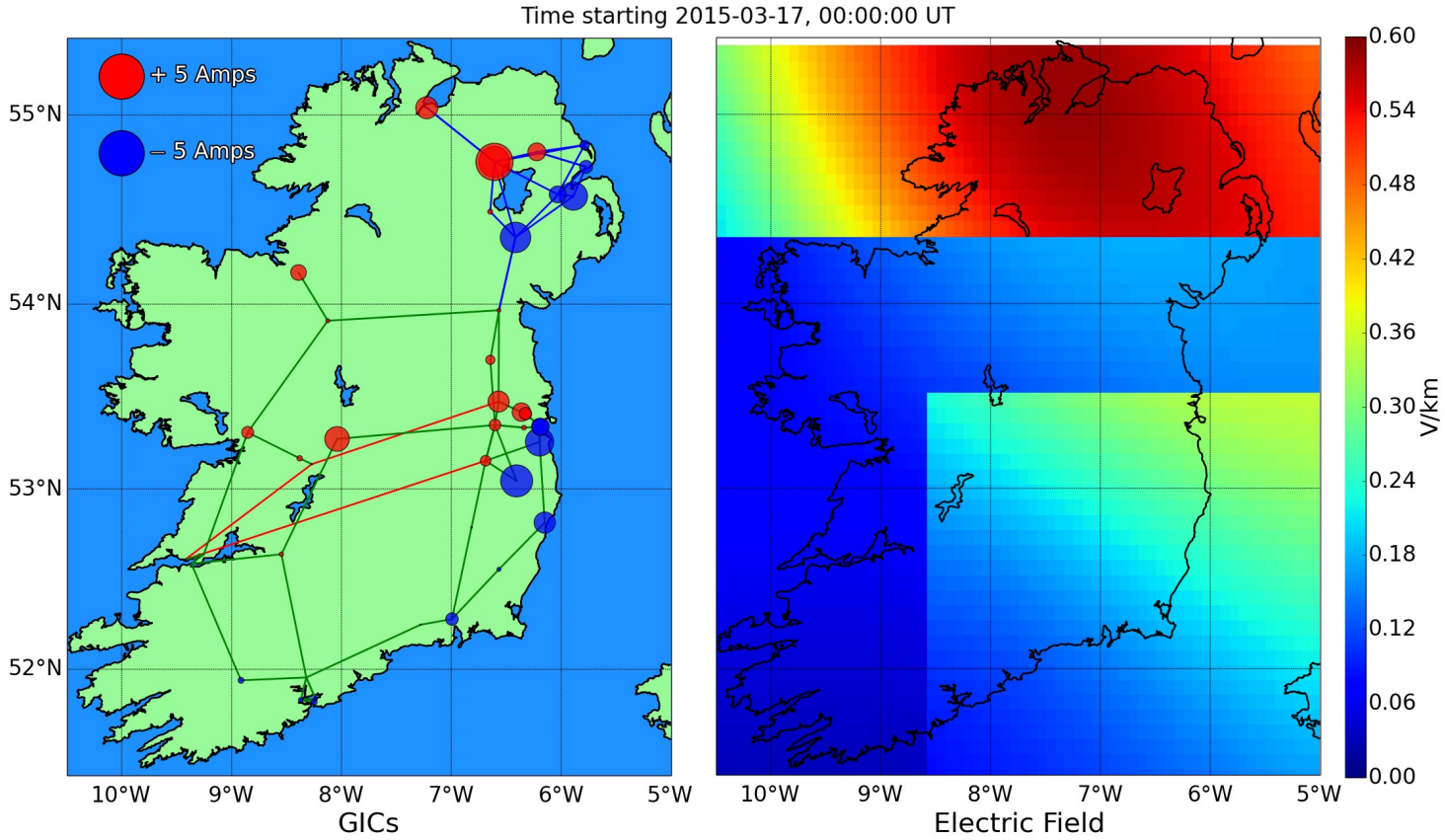
Peak Values:

dB/dt: 2.14 nT/min

Eh: 0.58 V/km

GIC: 11.06 A





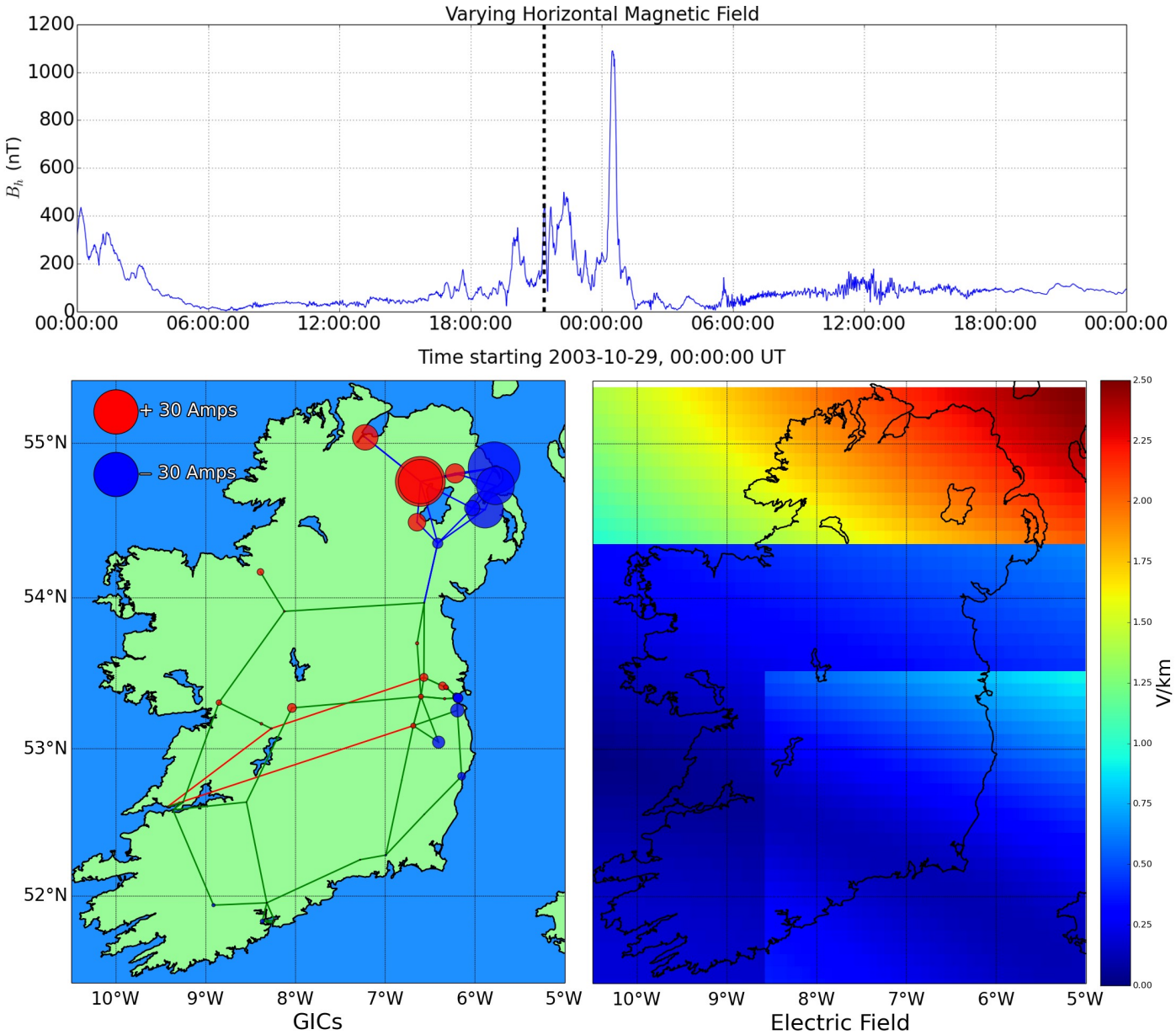
Results: 30-31 October 2003

Peak Values:

dB/dt: 7.748 nT/min

Eh: 2.42 V/km

GIC: 47 A



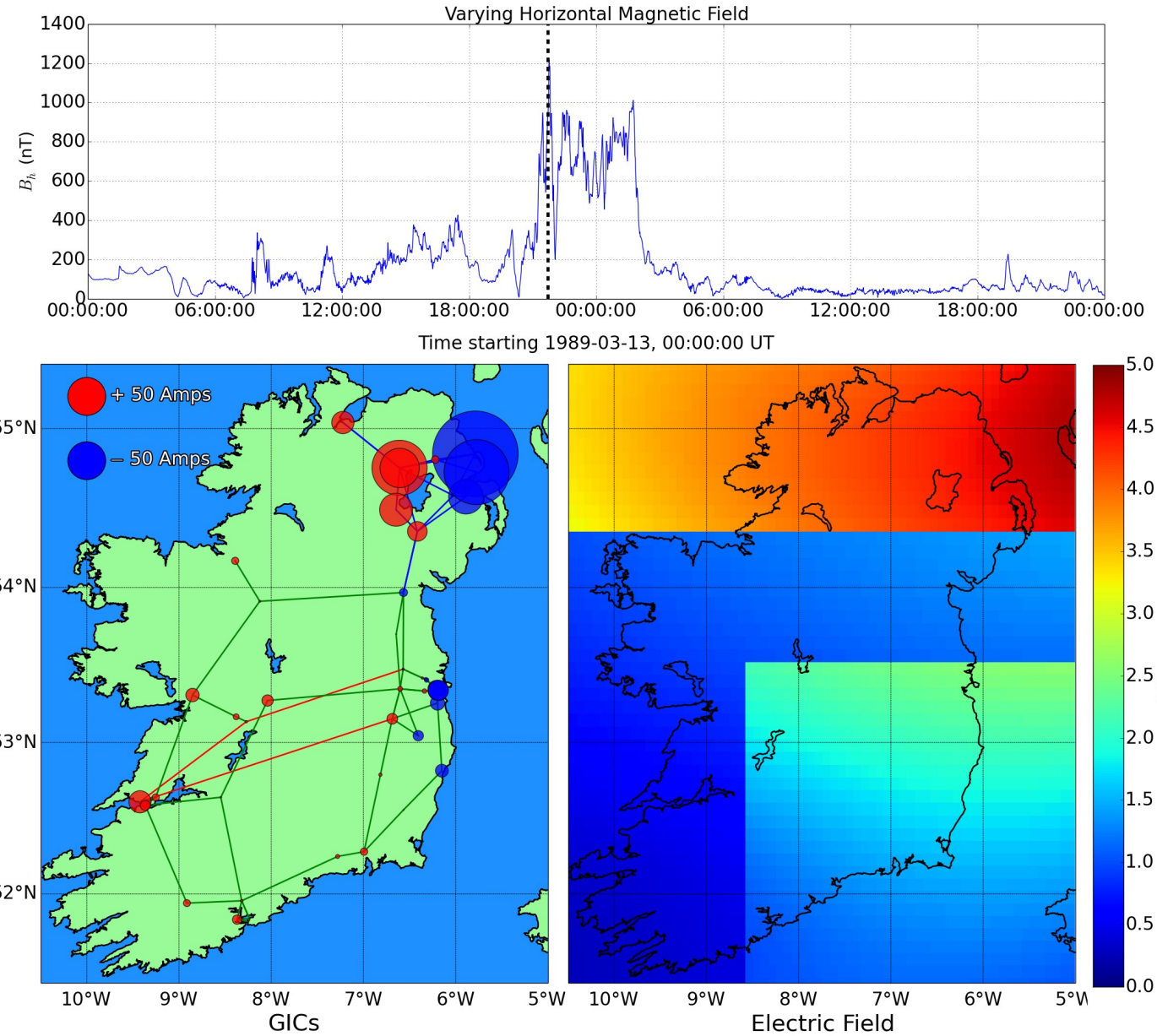
Results: 13-14 March 1989

Peak Values:

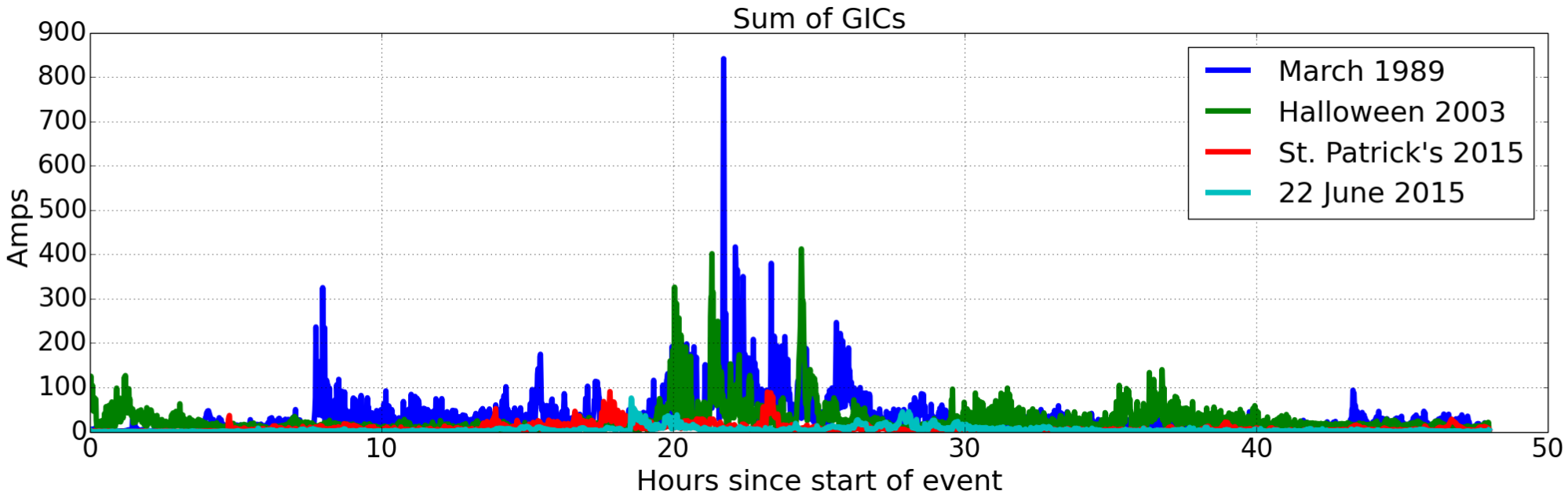
dB/dt: 16.39 nT/min

Eh: 4.5 V/km

GIC: 112 A



GICs


Sum of GICs
Amps
Hours since start of event
March 1989
Halloween 2003
St. Patrick's 2015
22 June 2015
0
100
200
300
400
500
600
700
800
900
0
10
20
30
40
50

Conclusions and Future Work

1) New **Eirmag** network:
   - Long-term magnetic and electric field monitoring.
   - Eirgrid operated GIC probe to directly measure GICs.
   - Data will be available online next year.

2) Plane-wave model has given estimates of GICs comparable to other mid-latitude countries
   - Use thin-sheet model in the future.
   - Improve conductivity map in the future.