

Geomagnetic Conditions in Ireland During the St. Patrick's Day 2015 Storm

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Summary

- Two coronal mass ejections were launched in quick succession from the Sun on March 15, 2015. They impacted the Earth's magnetosphere two days later on St. Patrick's Day (March 17), resulting in a geomagnetic storm with a planetary K-Index of 8.
- Magnetic variations were measured across a recently deployed magnetometer network in Ireland and geoelectric fields were measured at a site in Co. Leitrim (magnetic latitude 57.08°). A local K-index maximum of 7 was calculated at Birr, Co. Offaly (magnetic latitude 55.97), while the aurora borealis accompanying the geomagnetic storm was visible as far south as Co. Waterford (magnetic latitude 55.13°).
- The British Geological Survey thin-sheet surface electric field model was used together with our magnetometer measurements to calculate electric fields and geomagnetically induced currents (GICs) in the Irish power grid.
- Although it was one of the most magnetically disturbed days in a decade, with dB/dt reaching ~50 nT/min, the peak GIC level estimated in the Irish power grid was ~10 Amps. Note, no adverse effects were reported in the Irish power grid demonstrating its resilience to geomagnetic storms of this magnitude.

1. Geomagnetic Monitoring

- We have established a new network of magnetometers in Ireland, which include stations at Met Éireann's Valentia Observatory (VAL), the Rosse Solar-Terrestrial Observatory in Birr (BIR), Armagh Observatory (ARM) and Leitrim (LEI). These are being developed to provide near-realtime measurements and alerts of geomagnetic activity in Ireland.
- The Leitrim site also includes instrumentation to measure geoelectric fields associated with geomagnetic disturbances. Since installation in February of this year, the site has measured two planetary K8 events - the St. Patrick's Day storm on March 17 and the June 22 event. The measured electric and magnetic fields are shown in Figure 1, while the corresponding local K-index for Birr is shown in Figure 3.

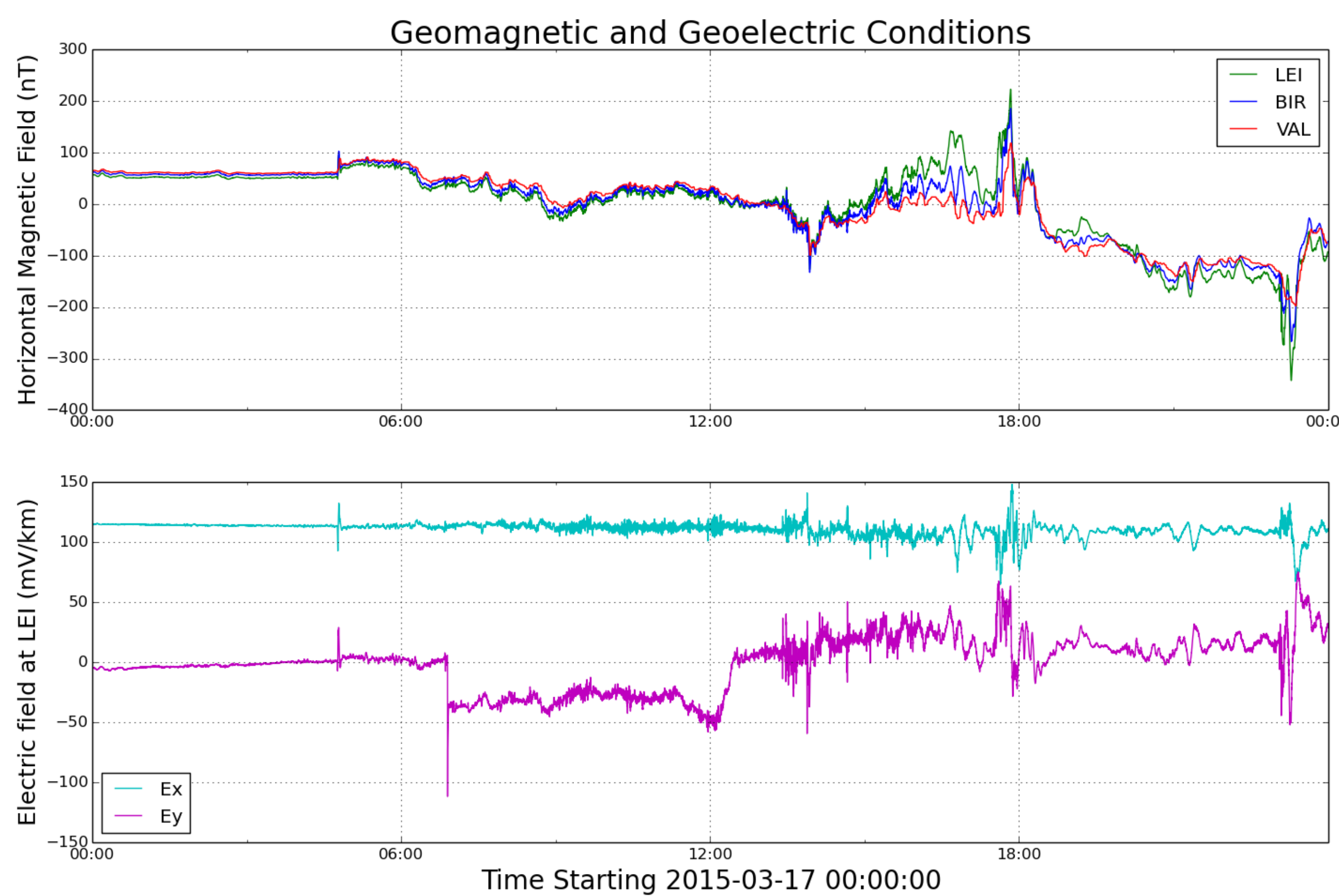


Figure 1 (Top) Magnetic field variations measured at three of our magnetometer sites. The trough at 23:20 UT corresponds with the largest GICs calculated. (Bottom) Ex and Ey values measured at our Leitrim site.

- On March 17, the horizontal magnetic field changed by ~560 nT in under 6 hours in Co. Leitrim. For the same site, a change in horizontal electric field was measured at 90 mV/km.

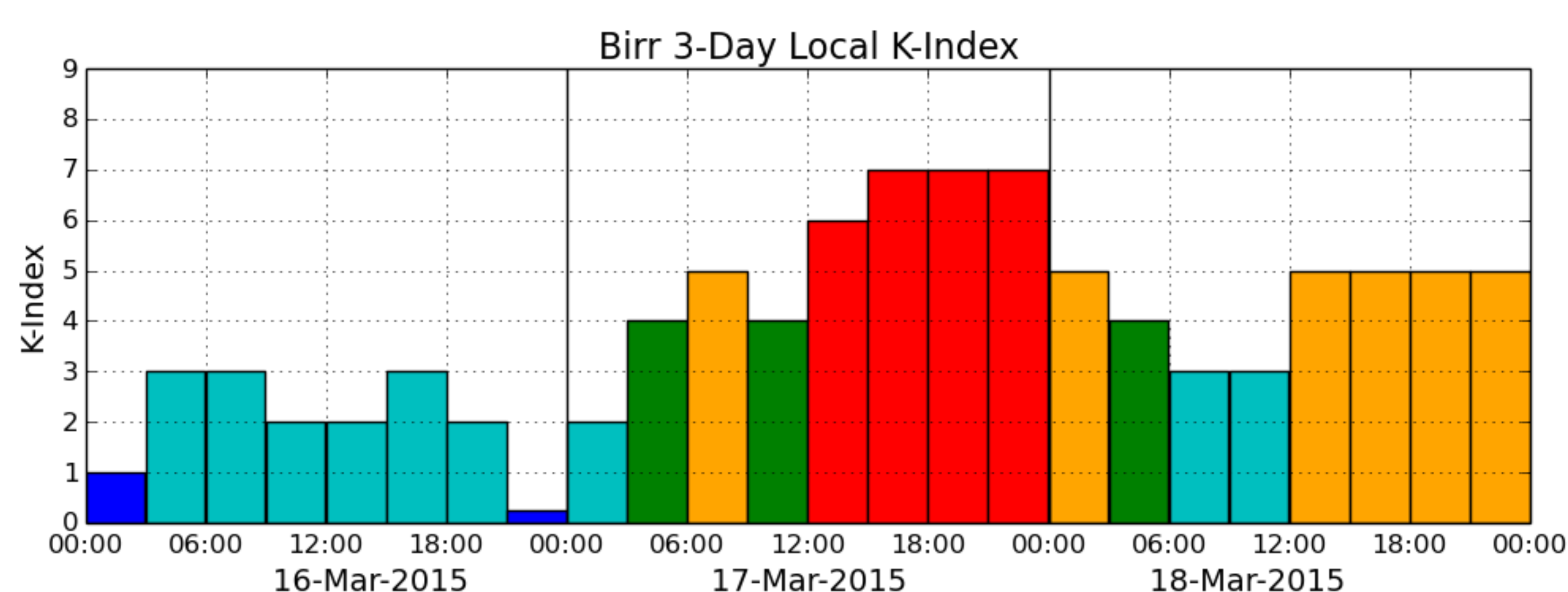


Figure 2 Local K-Index for March 16 to March 18, at Birr (BIR) in the Irish midlands. A planetary K-Index of 8 was measured for the storm.

2. GIC Simulations

- Irish magnetometer network and Intermagnet measurements from Britain and mainland Europe were used to calculate magnetic field variations across Ireland using spherical elementary current systems [1].
- Electric field values were then calculated for the island using a thin-sheet surface electric field model [2]. This model has previously been used to calculate electric fields for Britain. Maximum surface electric fields estimated for Ireland during this time period were ~800 mV/km.
- Finally, a model of the Irish power grid, with 400, 275 and 220 kV transformers and transmission lines were overlaid on the electric field, and GICs were calculated. These GICs peaked at approximately 10 Amps at 23:20 UT in the higher voltage transformers.

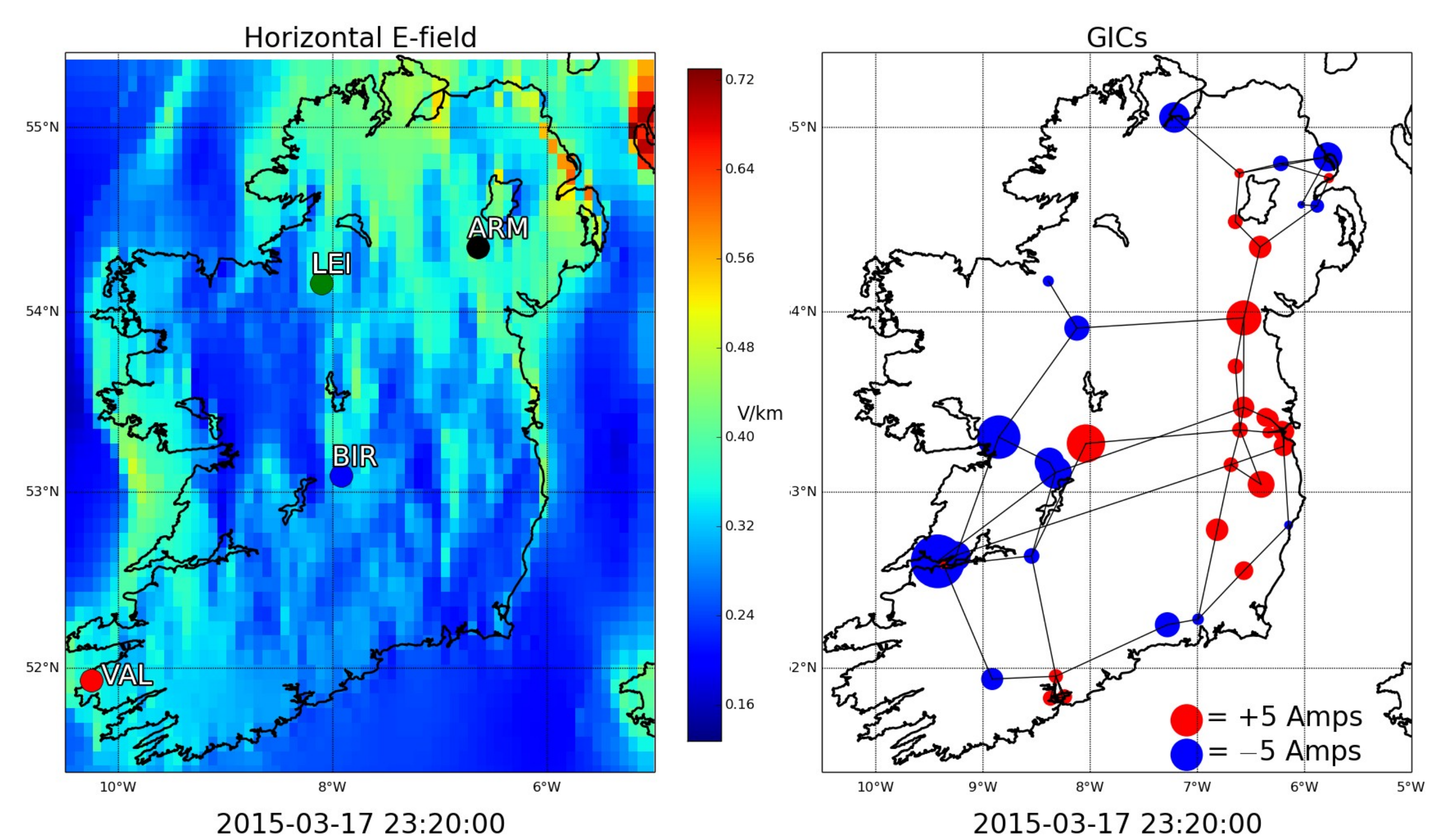


Figure 3 The calculated geoelectric field and GICs in Ireland at 23:20 UT on March 17. The location of the magnetometer sites are shown at left. Transmission lines connecting 400, 275 and 220 kV transformers are showing in black at right. The size and colour of each circle at right indicates the magnitude and direction of the GICs calculated.

3. Conclusions

- A new network of magnetometers has been installed in Ireland and is being developed to provide monitoring and warnings of geomagnetic storms in near-realtime.
- A large geomagnetic storm (planetary K8) was detected on March 17, 2015. The geomagnetic field varied by ~560 nT and the geoelectric field varied by ~90 mV/km over 6 hours.
- GICs were calculated to reach a maximum of ~10 Amps in a 400 kV transformer on the west coast of Ireland on the Shannon estuary. No significant adverse effects were reported in the Irish power grid demonstrating its resilience to geomagnetic storms of this magnitude.

References

- [1] McLay, S. A. & Beggan, C. D. *Annales Geophysicae*, 28(9), 2010
 [2] Vasseur, G. & Weidelt, P.. *Geophysical Journal International*, 51(3), 1977