



# Recent advances and validation of GIC modelling in the UK

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# Modelling GIC

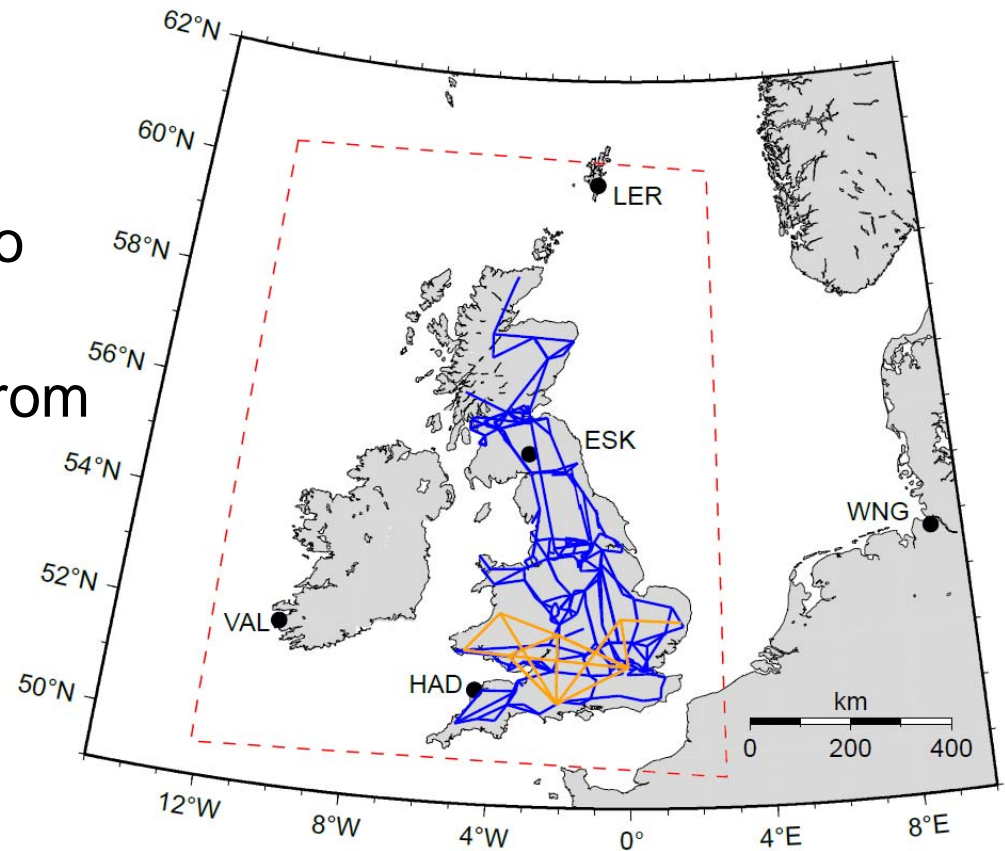
Models of geomagnetically induced currents (GIC) require:

- Input geomagnetic field
- Electric field calculation (including ground conductivity model)
- Estimation of GICs in the network

We have recently been upgrading our network and trying to validate each step in the process

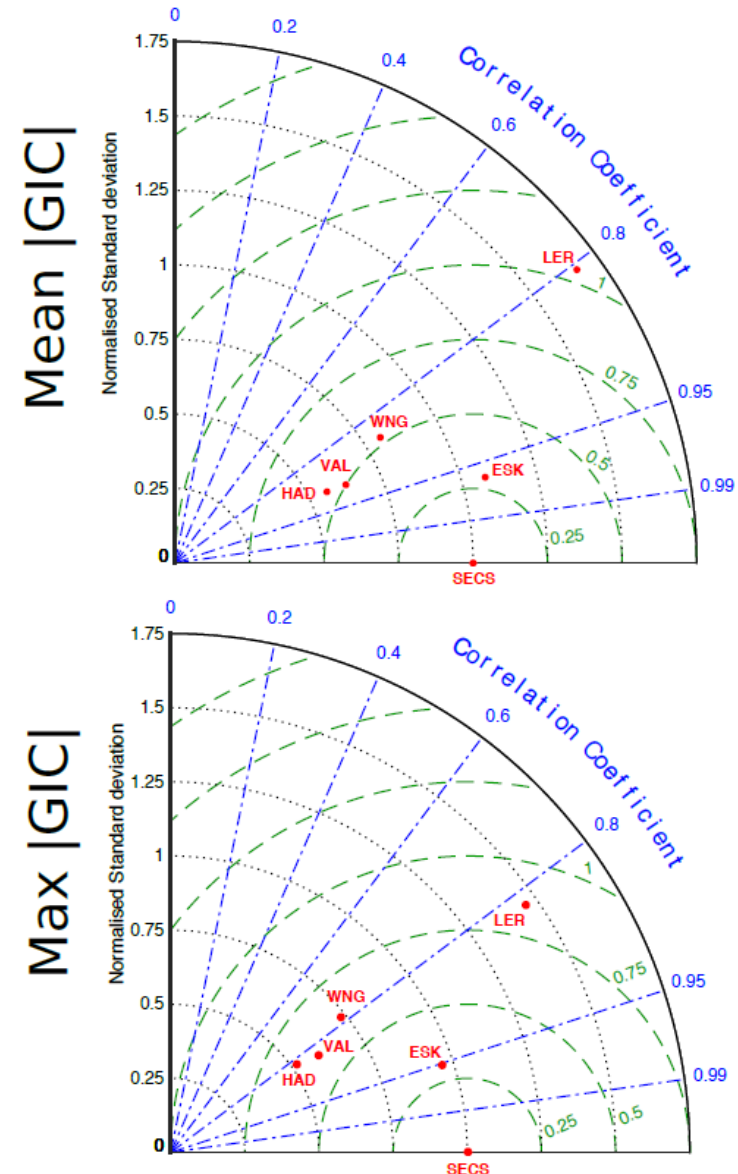
# Input geomagnetic field

- How does distance from observatory affects GIC estimates?
- Use Spherical Elementary Current Systems (SECS) to interpolate magnetic field
- Compare with using data from individual observatories across the whole grid



# Input geomagnetic field

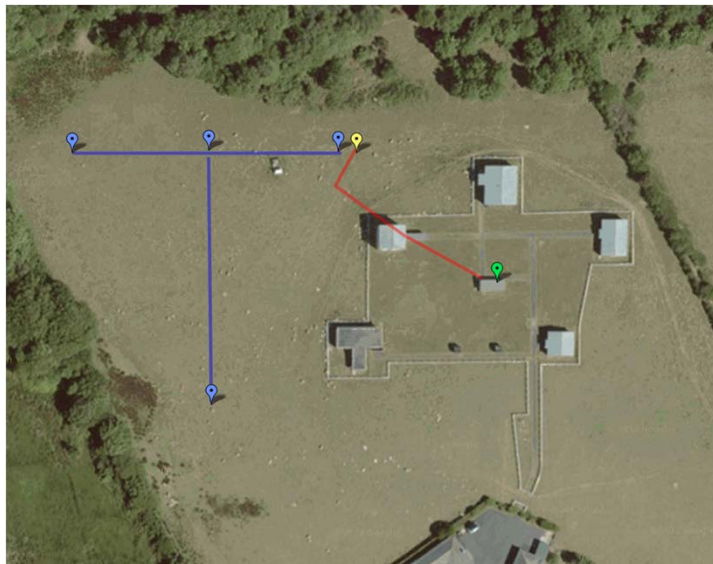
- Results shown for October 2003 storm
- Observatories within the network, or on the same geomagnetic latitude within 400km gave estimates within 25% on average with correlation  $>0.8$
- More distant observatories become less reliable, for example experiencing max GIC at different times



# Electric field calculation

## Measurements

- We have electric field measurements at the three UK observatories
  - 10Hz
  - Probes ~100m apart in NS and EW directions

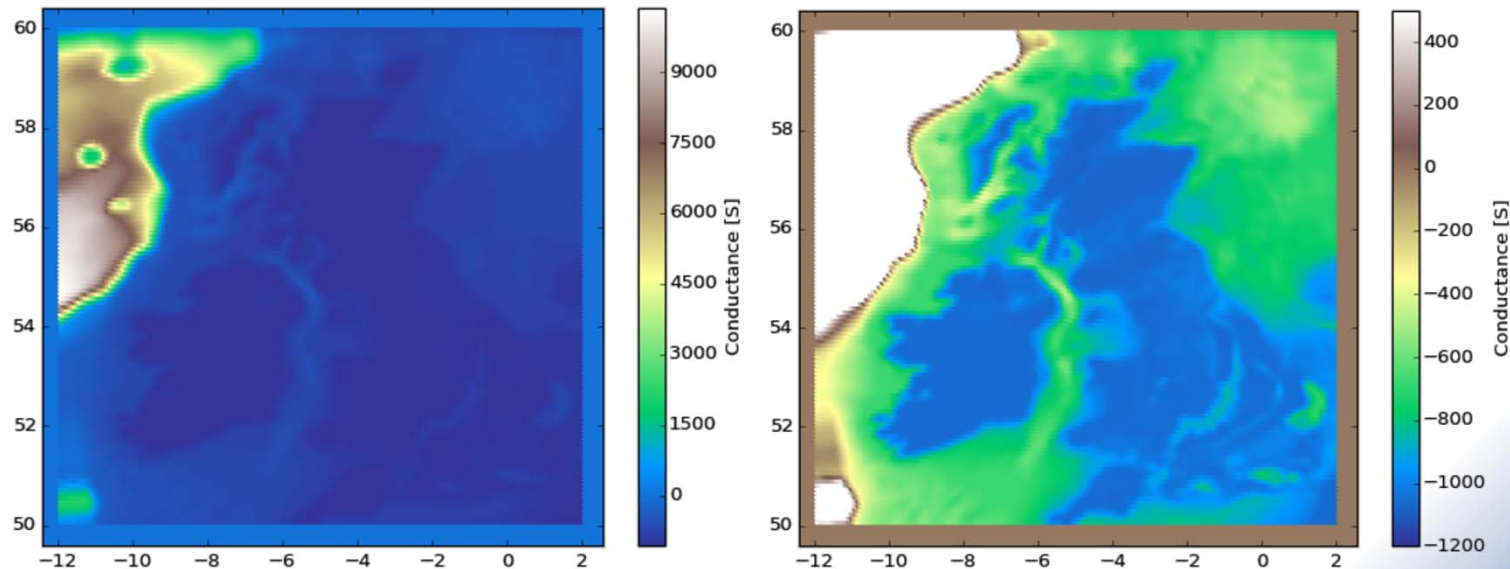
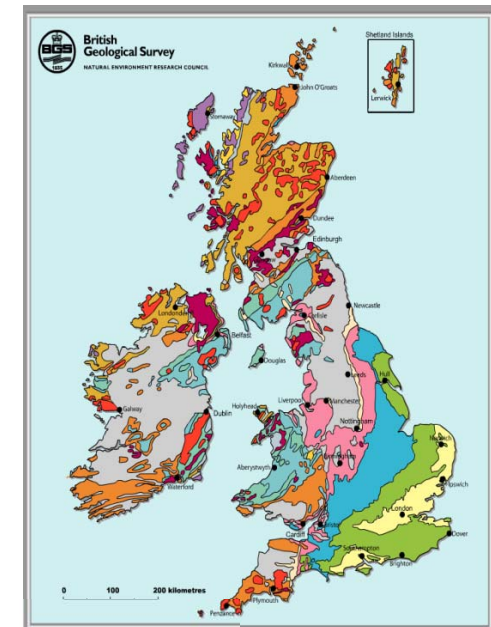




# Electric field calculation

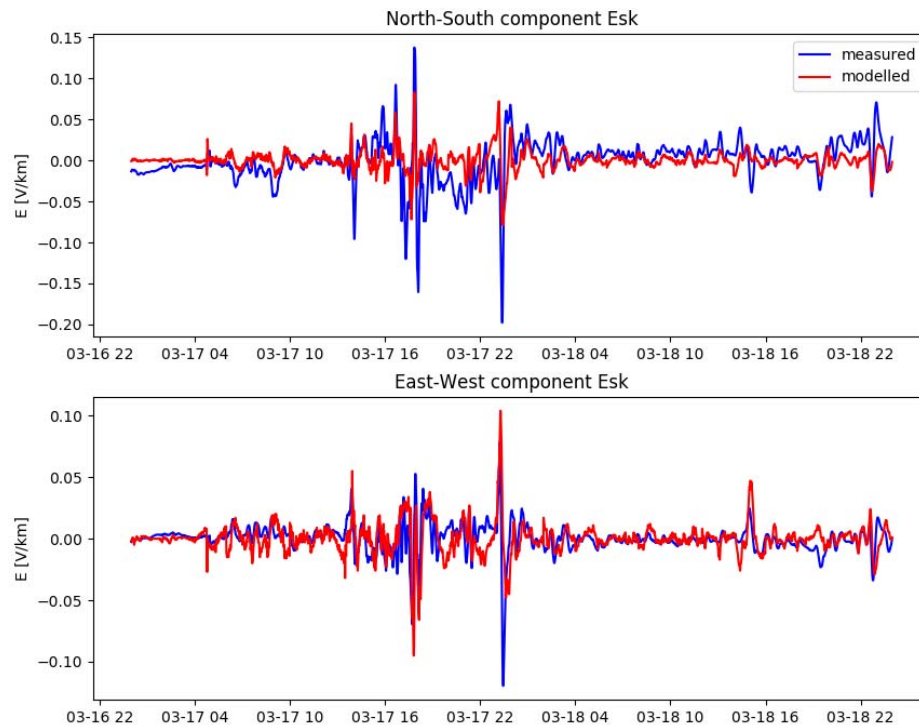
## Model

- Thin-sheet model
- The conductivity model of top 3km based on UK lithologies and bathymetry
- 10km grid



# Electric field

- Measured (blue) and modelled (red) E at 1 minute resolution



Correlation NS : 0.43  
EW : 0.43

Correlation NS : 0.04  
EW : 0.29

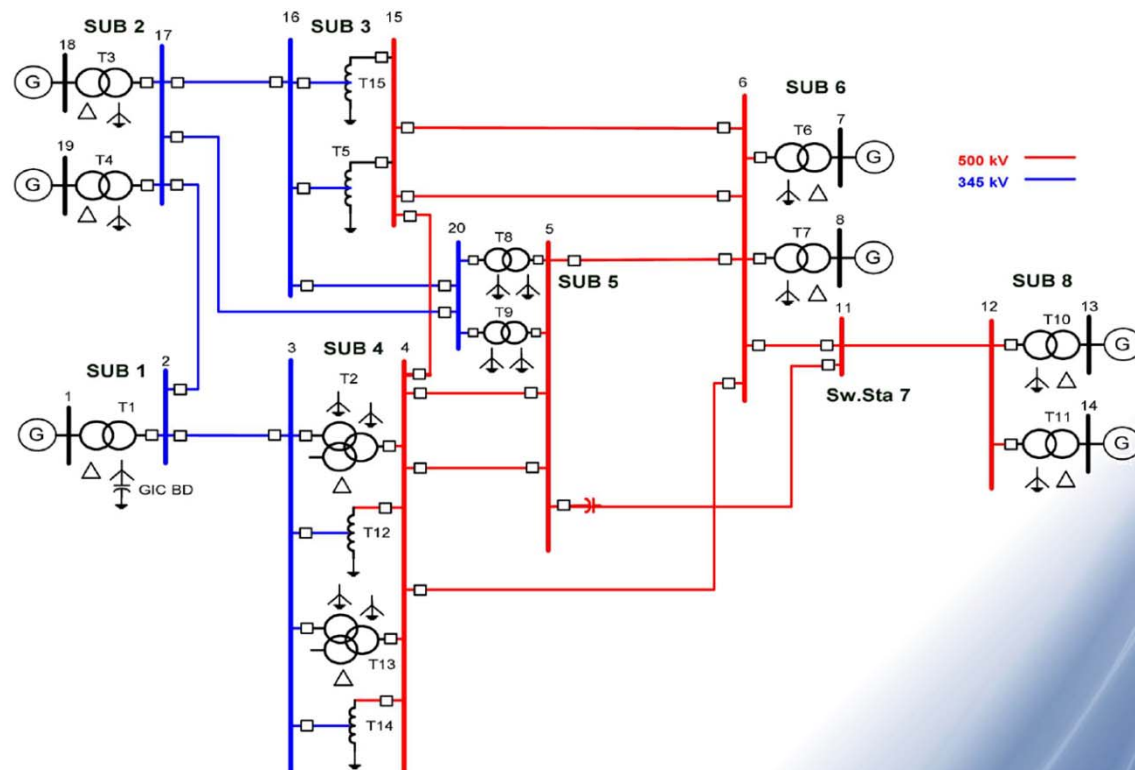
# Electric field

- We need to account for local effects better, e.g. galvanic distortion, tidal signals, local conductivity etc. (see poster 5 – Baillie et al.)
- More storms will help
- During the SWIGS project (see Poster 4 – Thomson et al.) we will measure E-fields at more sites in the UK so we can also test the model away from the observatories



# GIC calculation

- Horton et al 2012 (*IEEE Transactions on power delivery*, 27) provides a test grid and calculated GIC for a uniform electric field
- Mix of transformer types, single and parallel connections and blocking devices



# Comparison

- Despite some differences in the method we get results which are consistent with the Horton paper

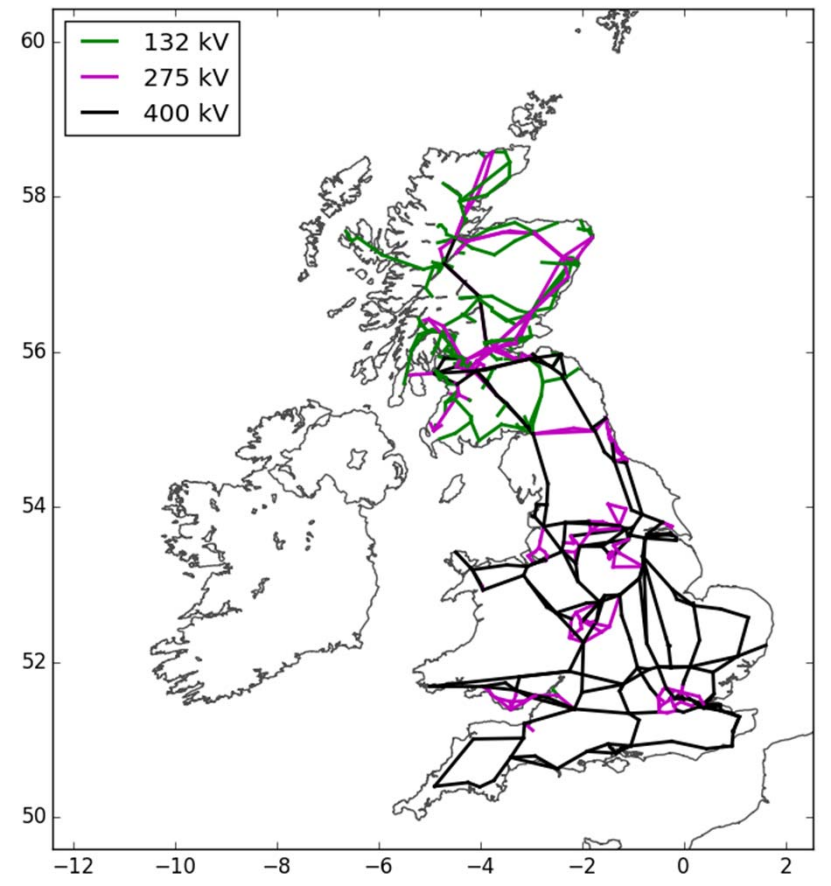
	Horton et al. (2012)		BGS	
	North	East	North	East
<b>Sub1</b>	0.00	0.00	0.00	0.00
<b>Sub2</b>	115.63	-189.29	114.25	-189.77
<b>Sub3</b>	139.85	-109.49	137.87	-109.79
<b>Sub4</b>	19.98	-124.58	19.22	-124.63
<b>Sub5</b>	-279.08	-65.46	-280.55	-63.94
<b>Sub6</b>	-57.29	354.52	-53.24	353.99
<b>Sub7</b>	0.00	0.00	0.00	0.00
<b>Sub8</b>	60.90	134.30	62.45	134.14

The root-mean-square differences is 2.3 A for the North direction and 0.7 A for the East direction

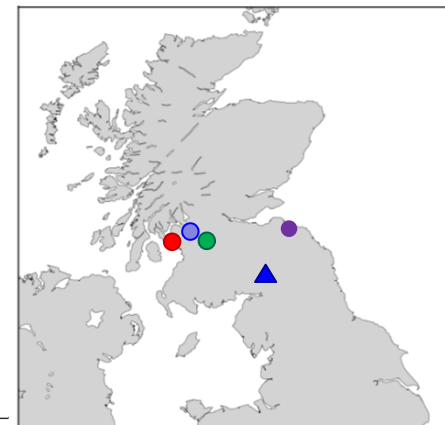
Per transformer we the difference was <1A per phase for all but 3 transformers and they were all <2A

# Power network upgrade

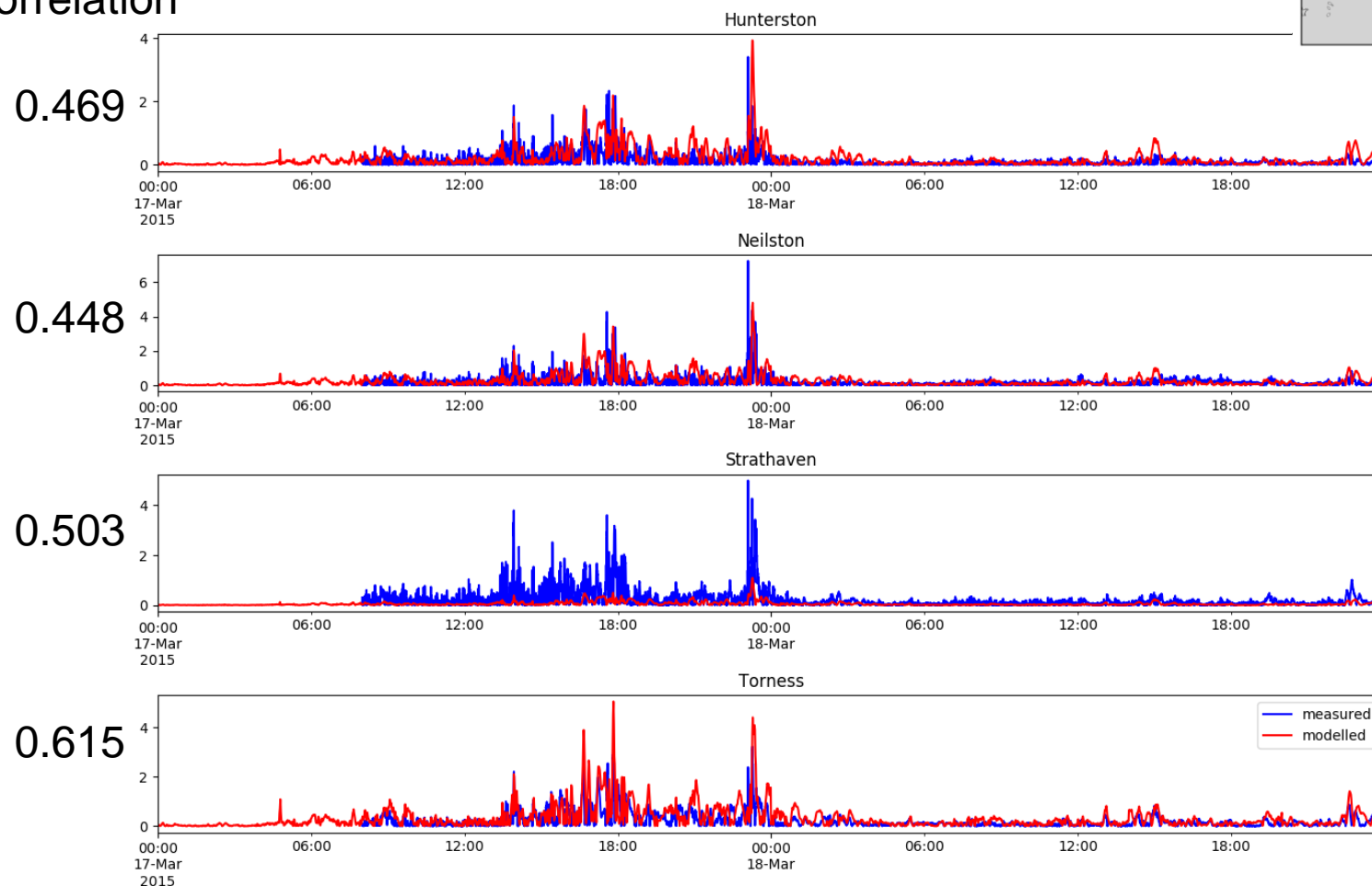
- Network upgrade using data from the 2016 Electricity Ten Year Statement
- Better representation of substation nodes
- Better inclusion of parallel lines



# Comparsion with GIC measurements



## Correlation



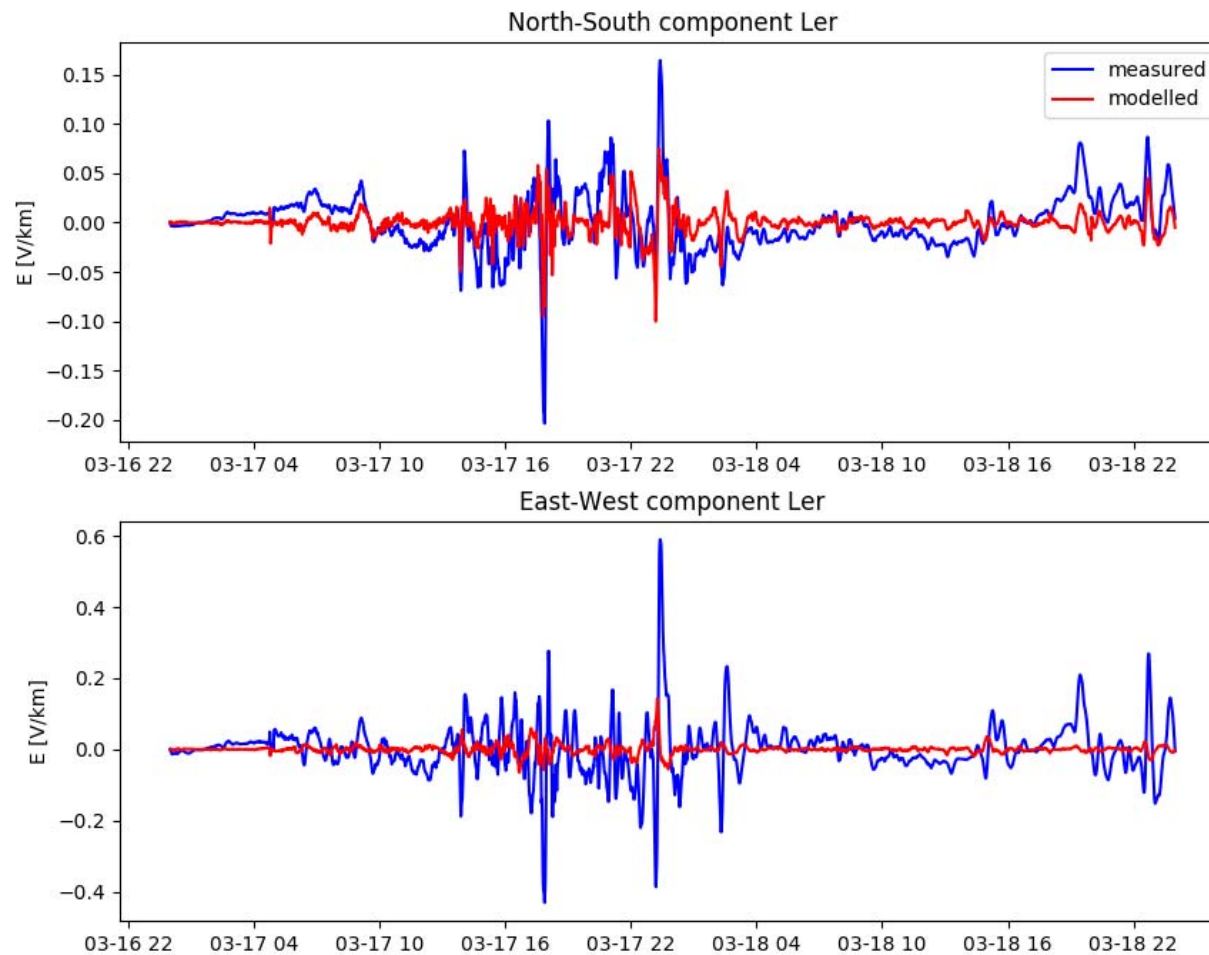
# Summary

- Electric field
  - on a broad scale we capture the storm
  - need to account for local effects better to truly compare the model and measured data
  - Future work will help with validation across the UK
- Validated GIC calculation
- Full GIC calculation
  - Getting the size and timing of GIC largely correct although these are relatively small GIC measurements
- SWIGS project will really help with validation – providing more measurements of both E and GIC

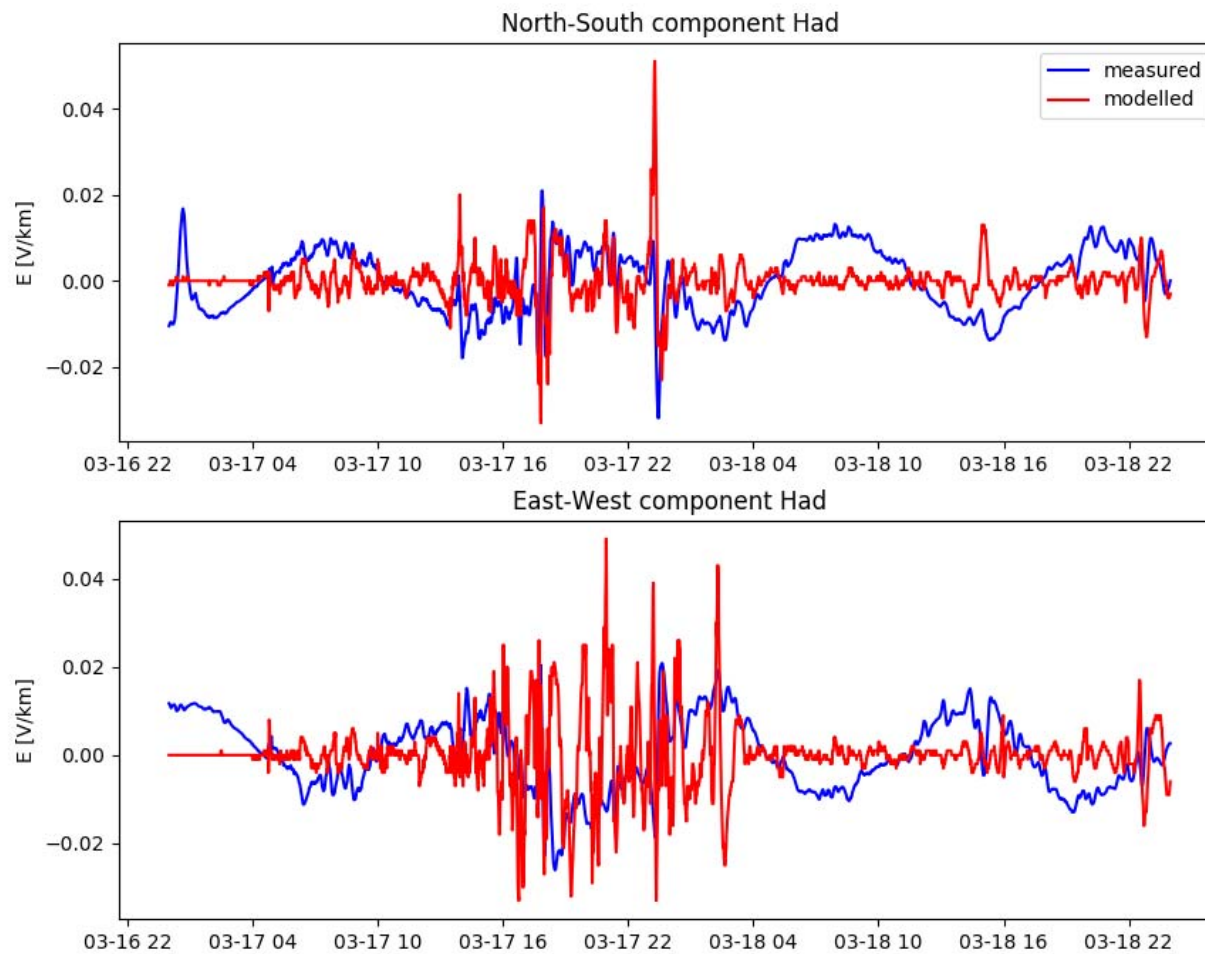




# Ler – Mar 2015



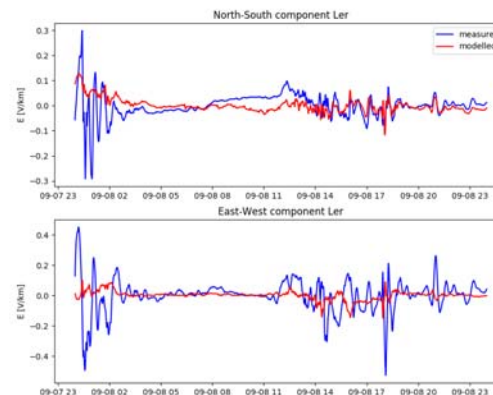
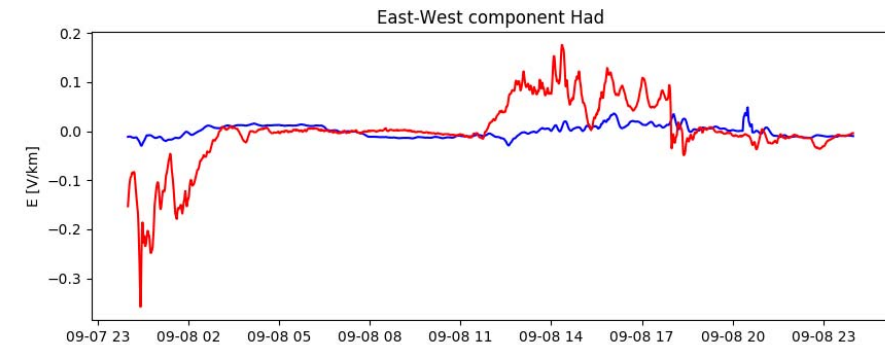
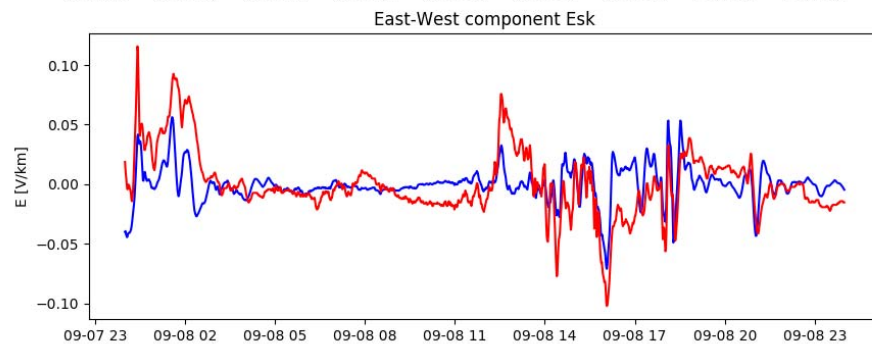
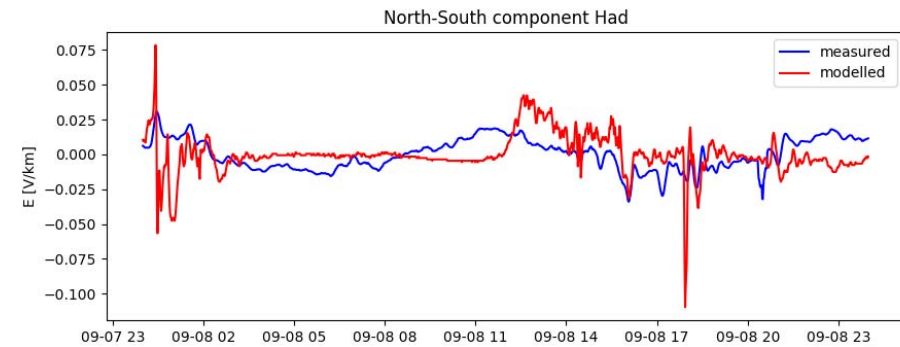
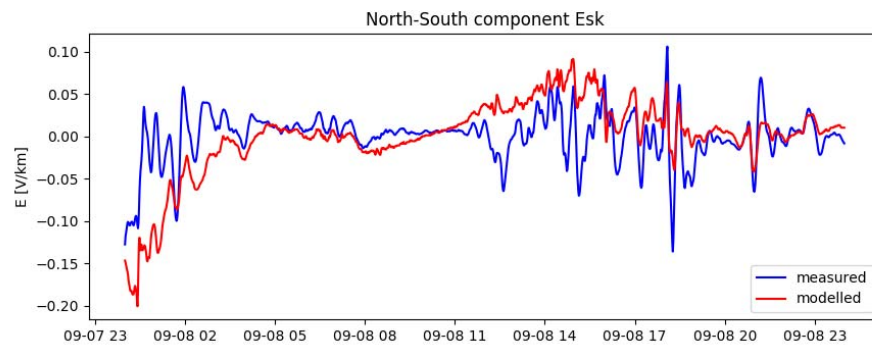
# Had - unfiltered



- 0.1406

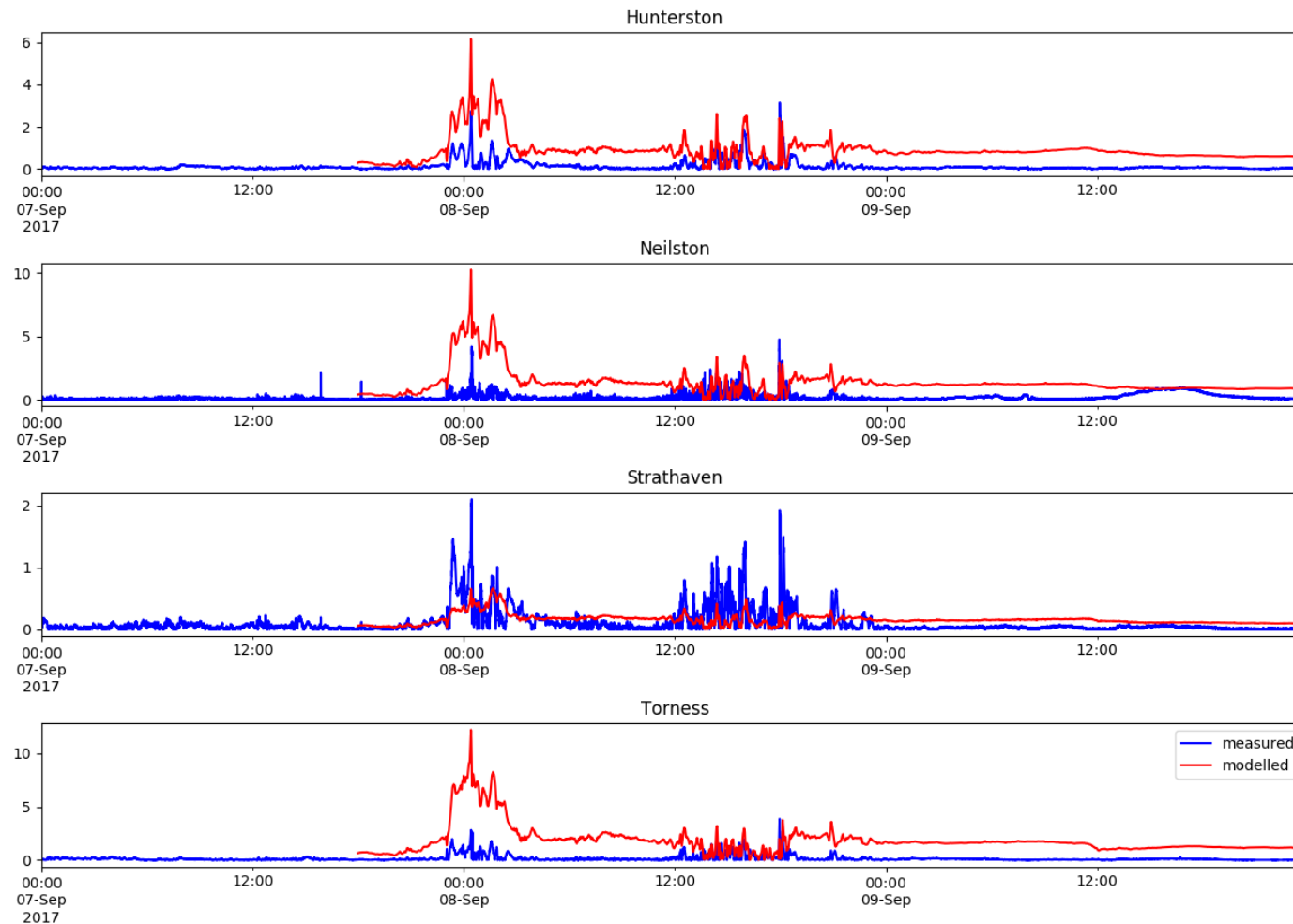
- 0.0314

# Sep 2017 – E-field



# Sep 2017 - GIC

correlation HUNT 0.5343286546782464  
correlation NEIL 0.1842394052155707  
correlation STRA 0.438831398654849  
correlation TORN 0.4891124941799598





# Mar2015 resampled to 1min means

