



Behaviour of the UK geo-electric field during the March (& June) 2015 geomagnetic storms

Gemma Kelly, Ciarán Beggan,
Tony Swan, Alan Thomson

www.geomag.bgs.ac.uk/data_service/space_weather/geoelectric.html

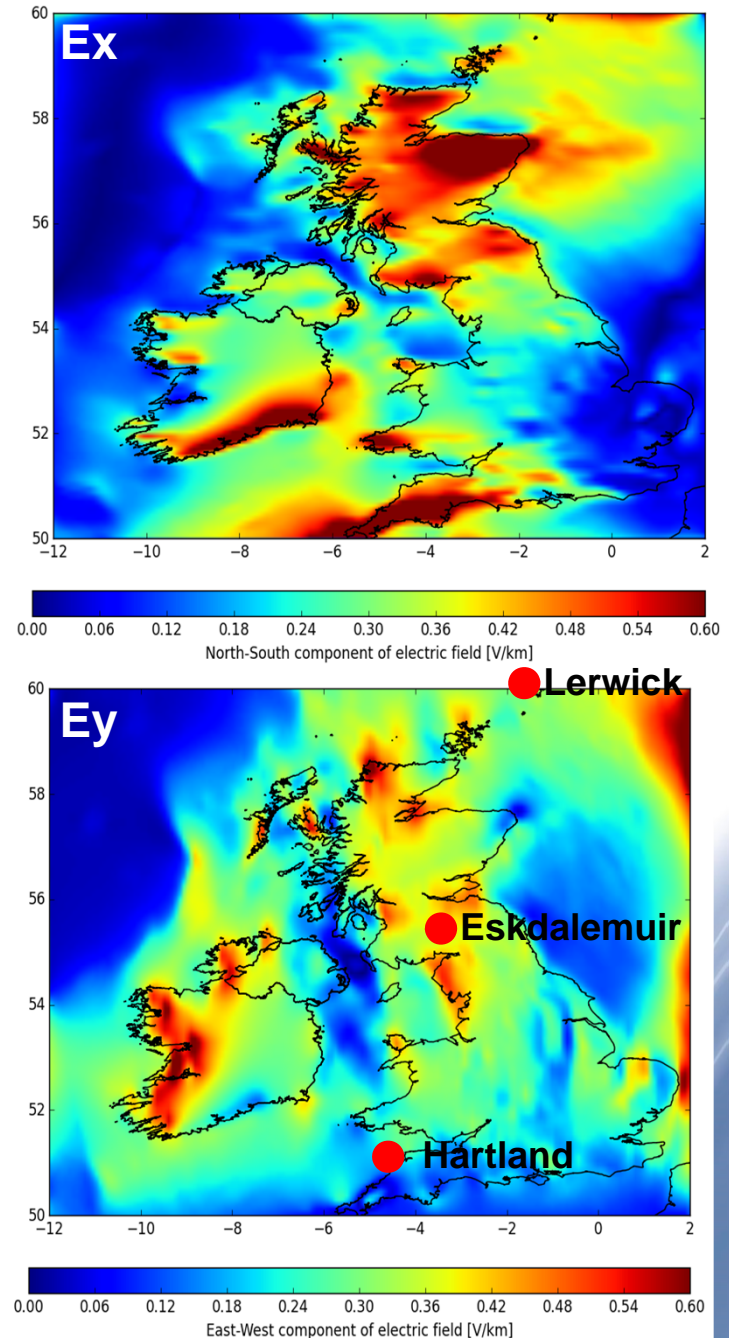
<http://ow.ly/OSaZ3>



Geoelectric Monitoring

- Validating models of surface electric fields that cause geomagnetically induced currents (GIC) in power grids
- Providing additional monitoring of space weather impact at ground level
- Long term monitoring to study space weather and space climate variability
- Measurements started at Eskdalemuir in November 2012
- Lerwick was installed in March 2013
- Hartland was completed in May 2013

17th March 2015



Slide 2

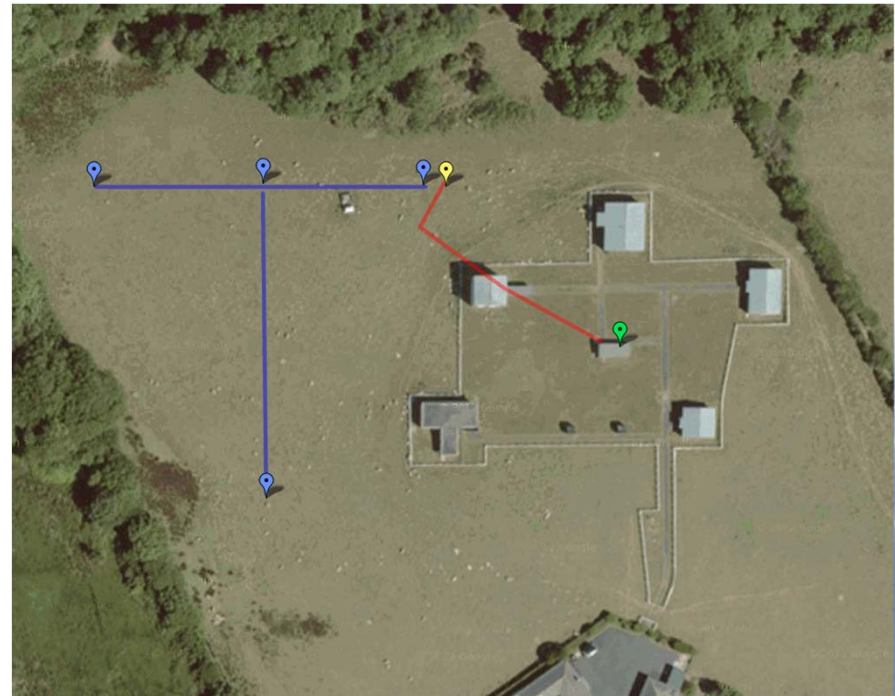
awpt5

I have inserted slides as if this version of the talk is for the IUGG meeting. Obviously we can cut things out for the NAM version, if this is shorter in duration.

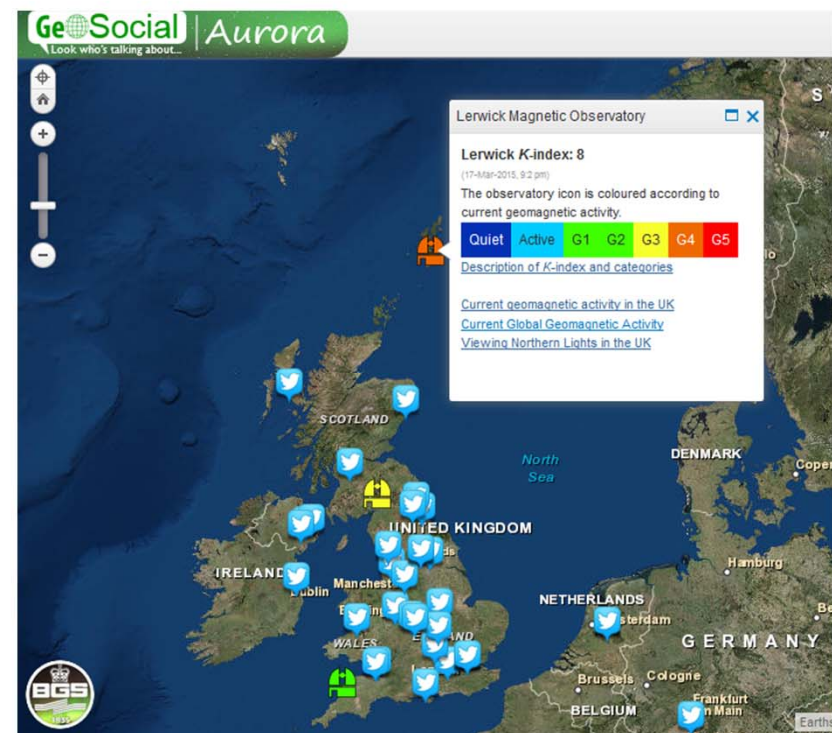
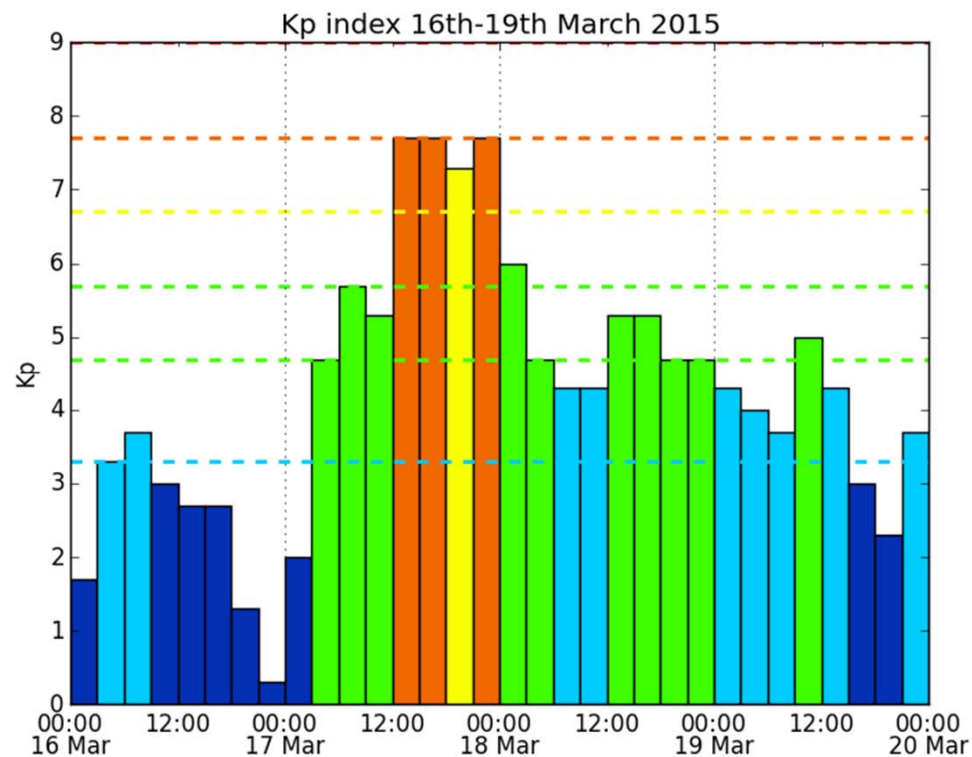
Alan Thomson, 29/04/2015

Field Setup

- Measurements of the electric field are made by recording the voltage difference between two points in the ground, separated by a known distance in a given orientation.
- At each site two electrode pairs are used, spaced approximately 100m apart, in a North-South and East-West configuration

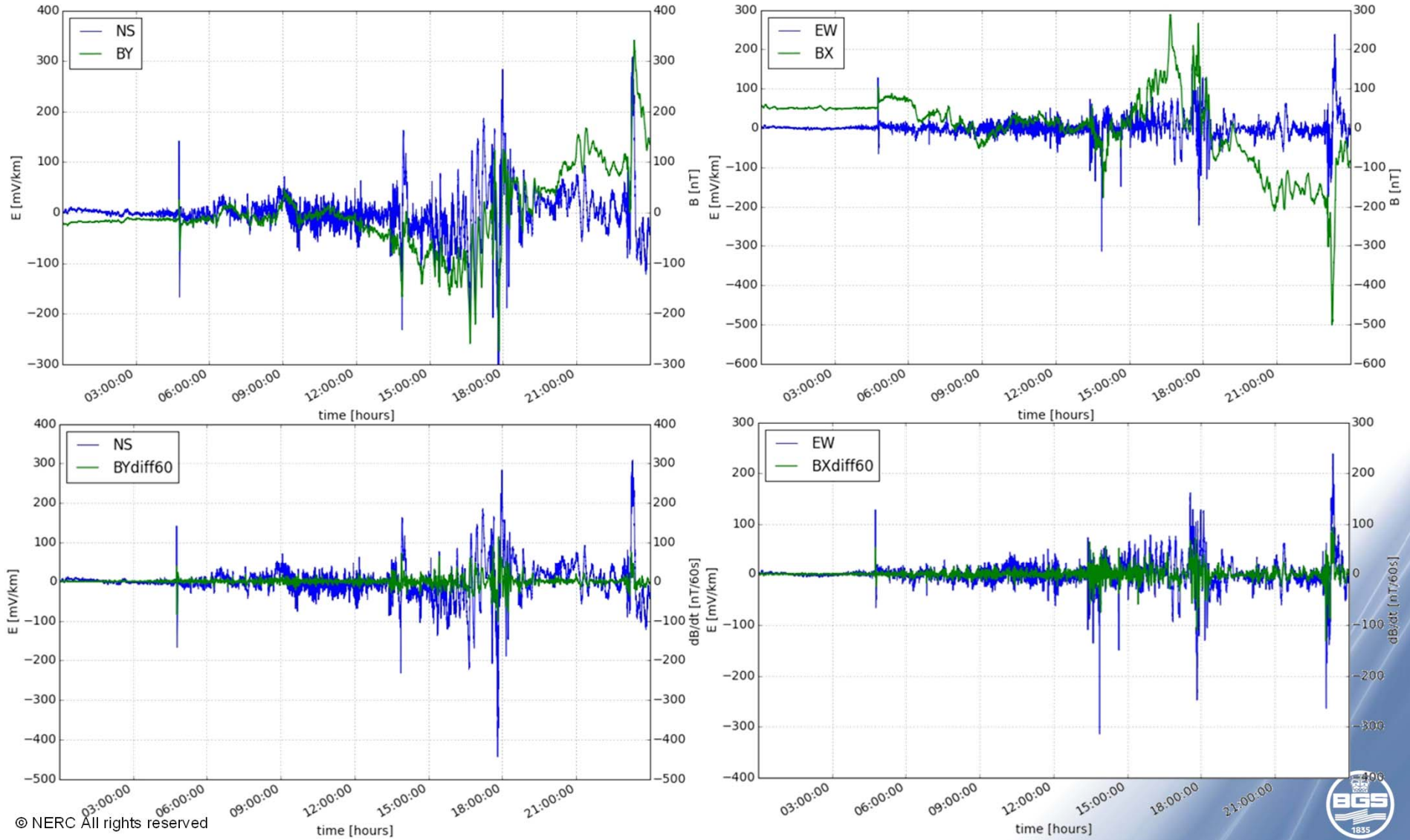


17th March 2015: Eskdalemuir



<http://www.bgs.ac.uk/citizenScience/geosocial/home.html>

17th March 2015: Eskdalemuir



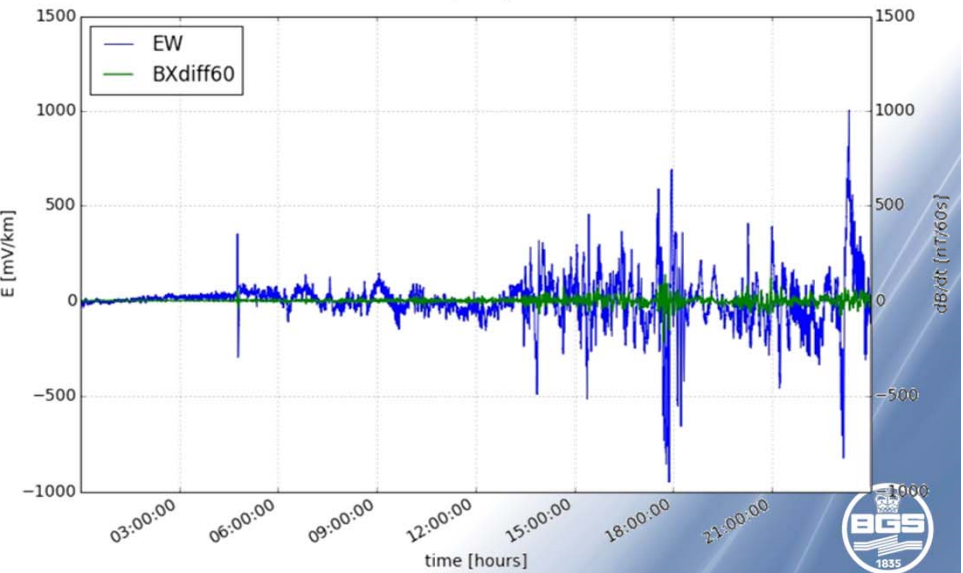
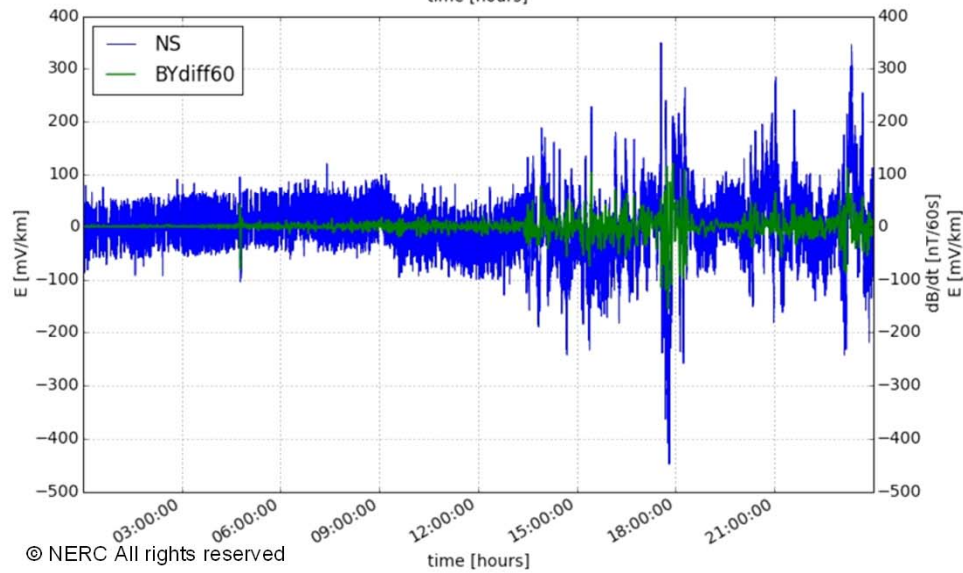
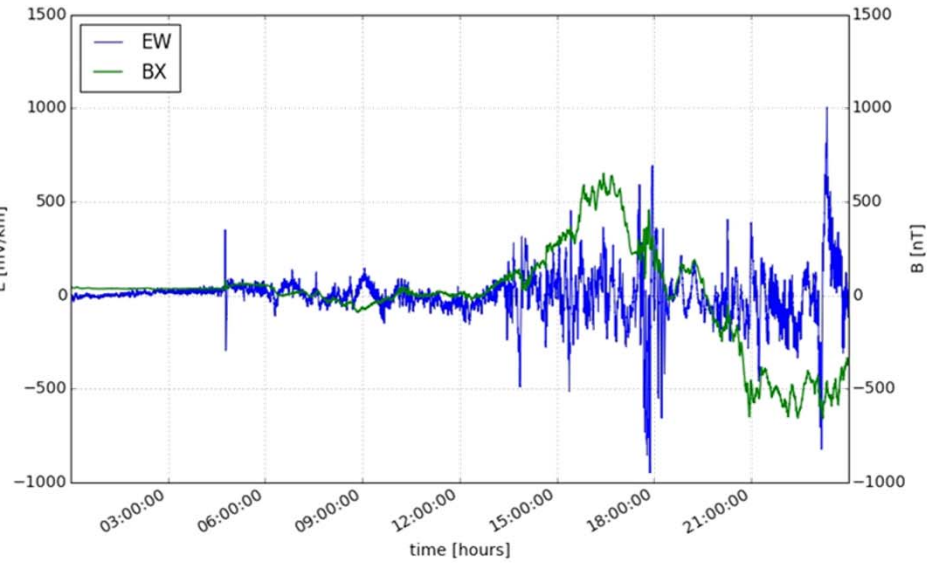
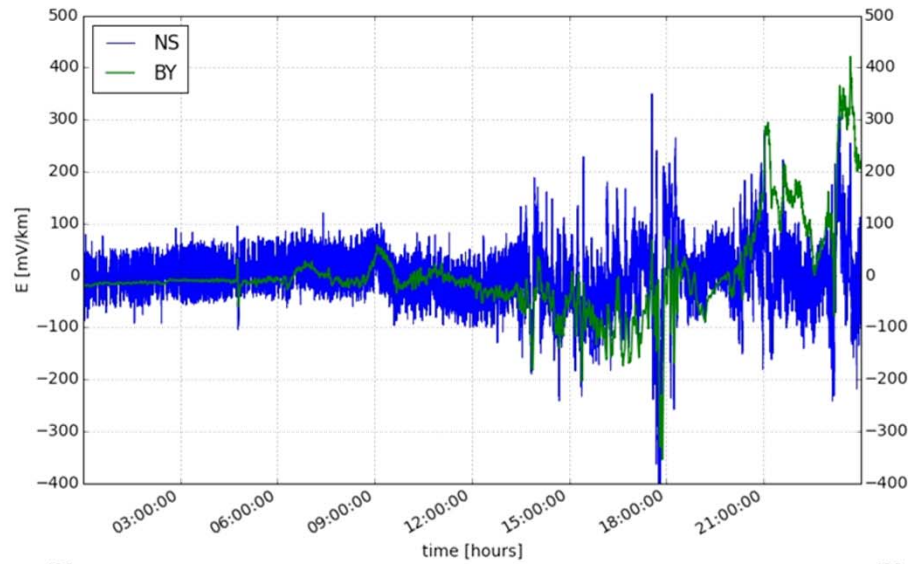
Slide 5

awpt3

Also would be useful to have a plot of E-field over the long term, e.g. a month, to show issues like jumps, spikes, drift etc. Would be of interest for the observatory community as these guys are engineers.

Alan Thomson, 29/04/2015

17th March 2015: Lerwick



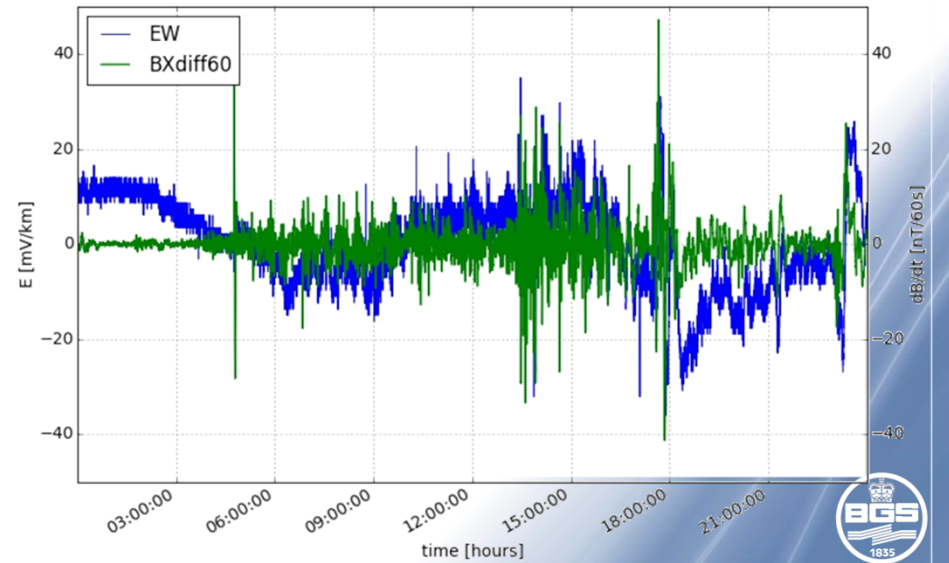
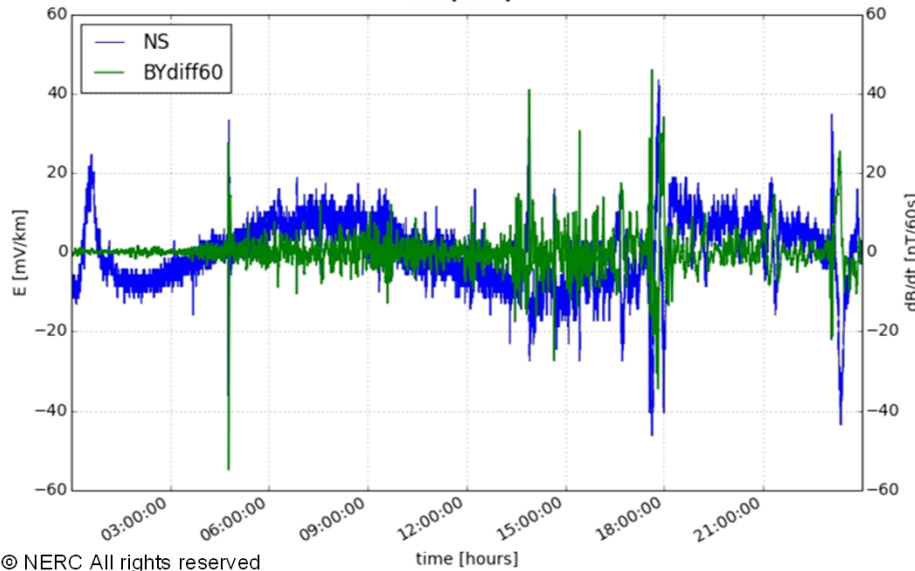
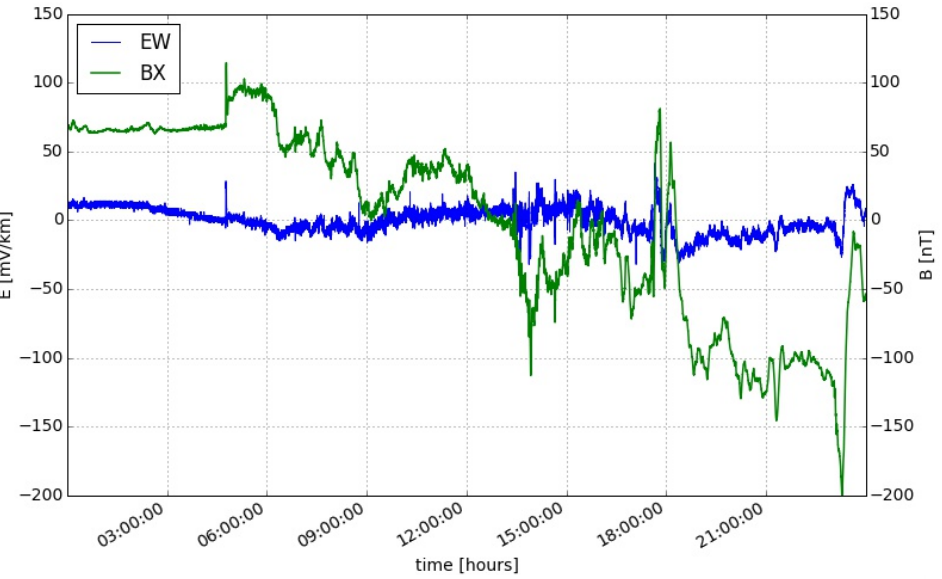
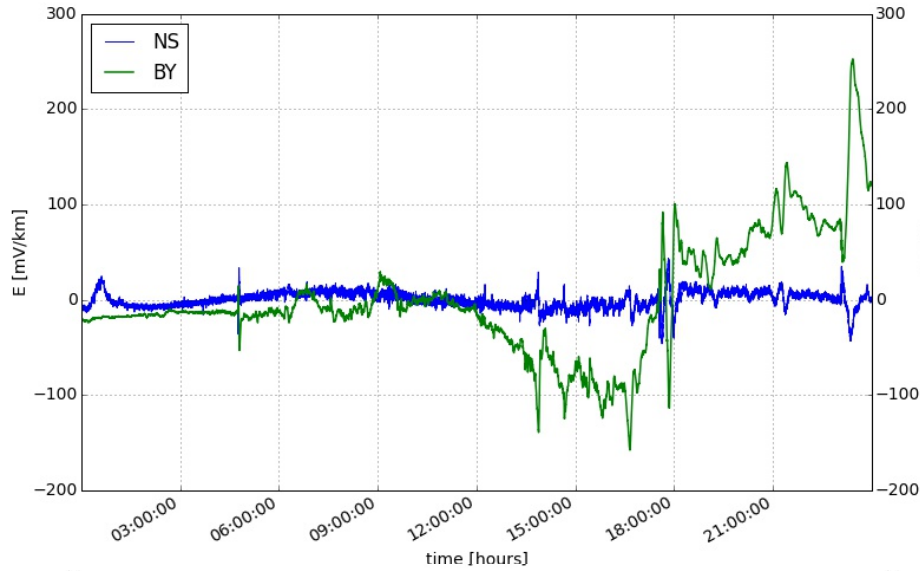
Slide 6

awpt3

Also would be useful to have a plot of E-field over the long term, e.g. a month, to show issues like jumps, spikes, drift etc. Would be of interest for the observatory community as these guys are engineers.

Alan Thomson, 29/04/2015

17th March 2015: Hartland



Slide 7

awpt3

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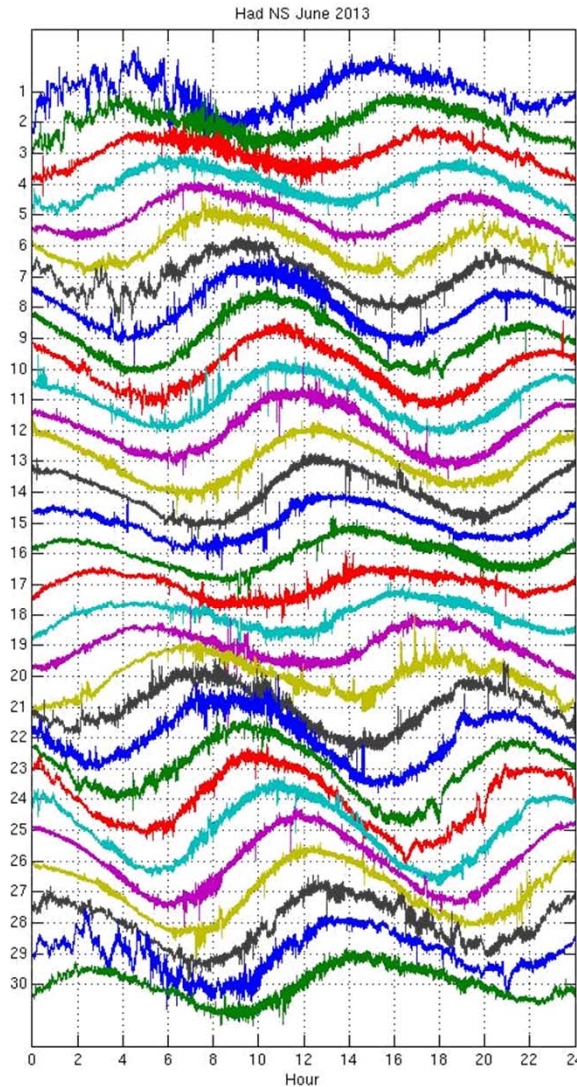
Alan Thomson, 29/04/2015

Tides

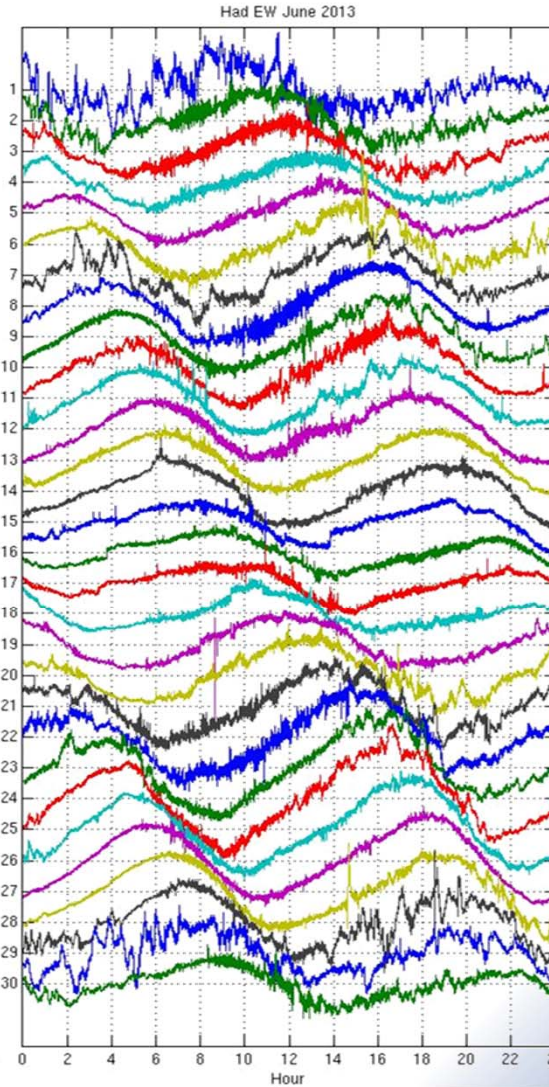
- Particular problem at Hartland – but some tidal signal in all 3 locations



Ex

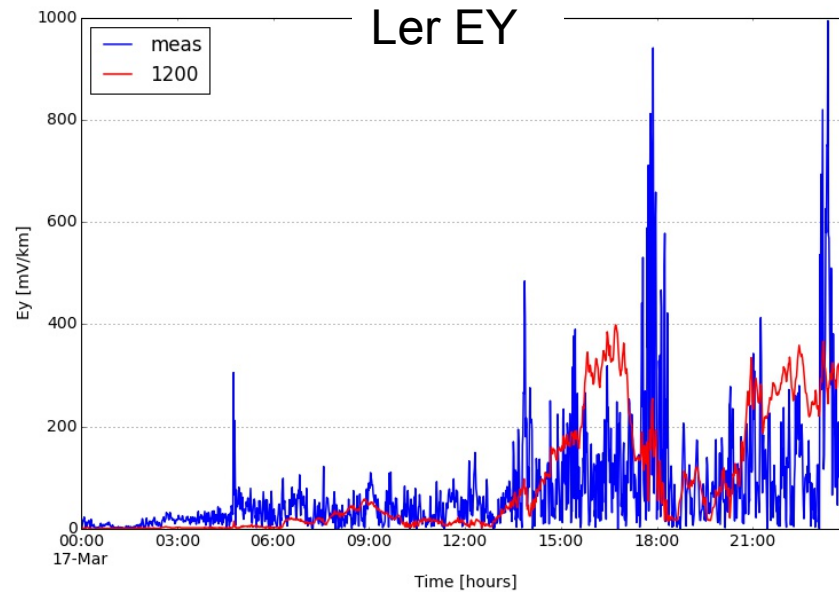
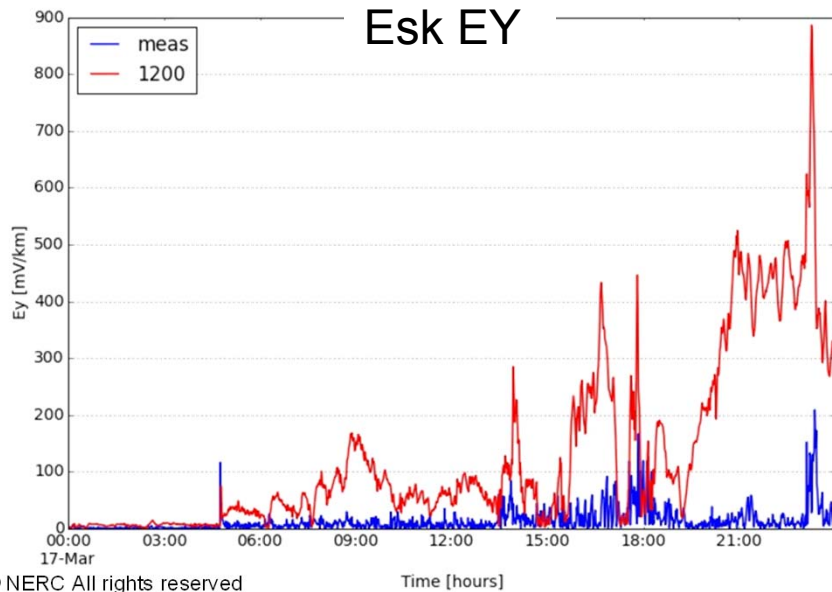
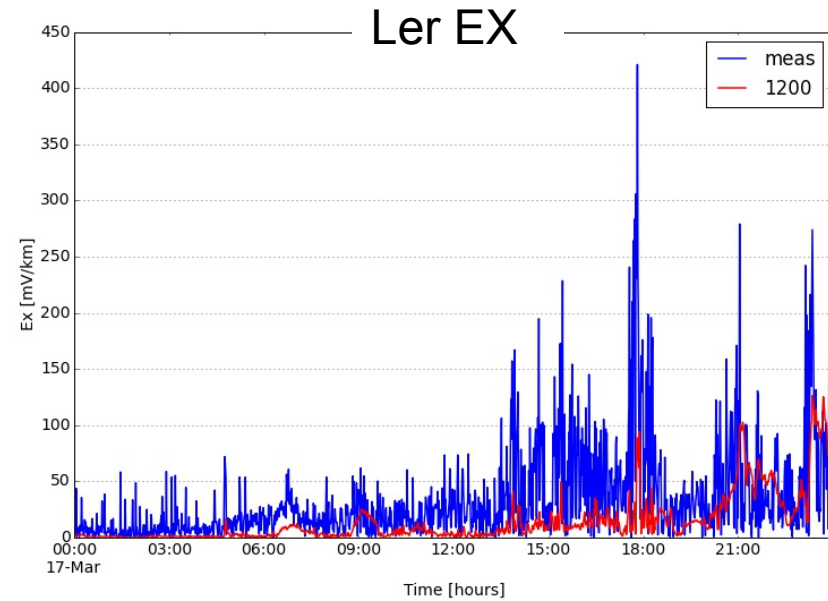
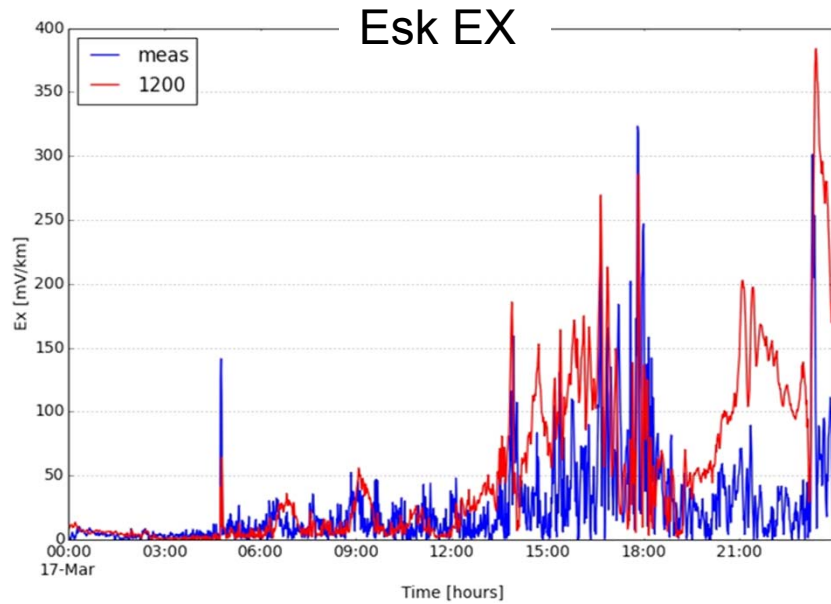


Ey

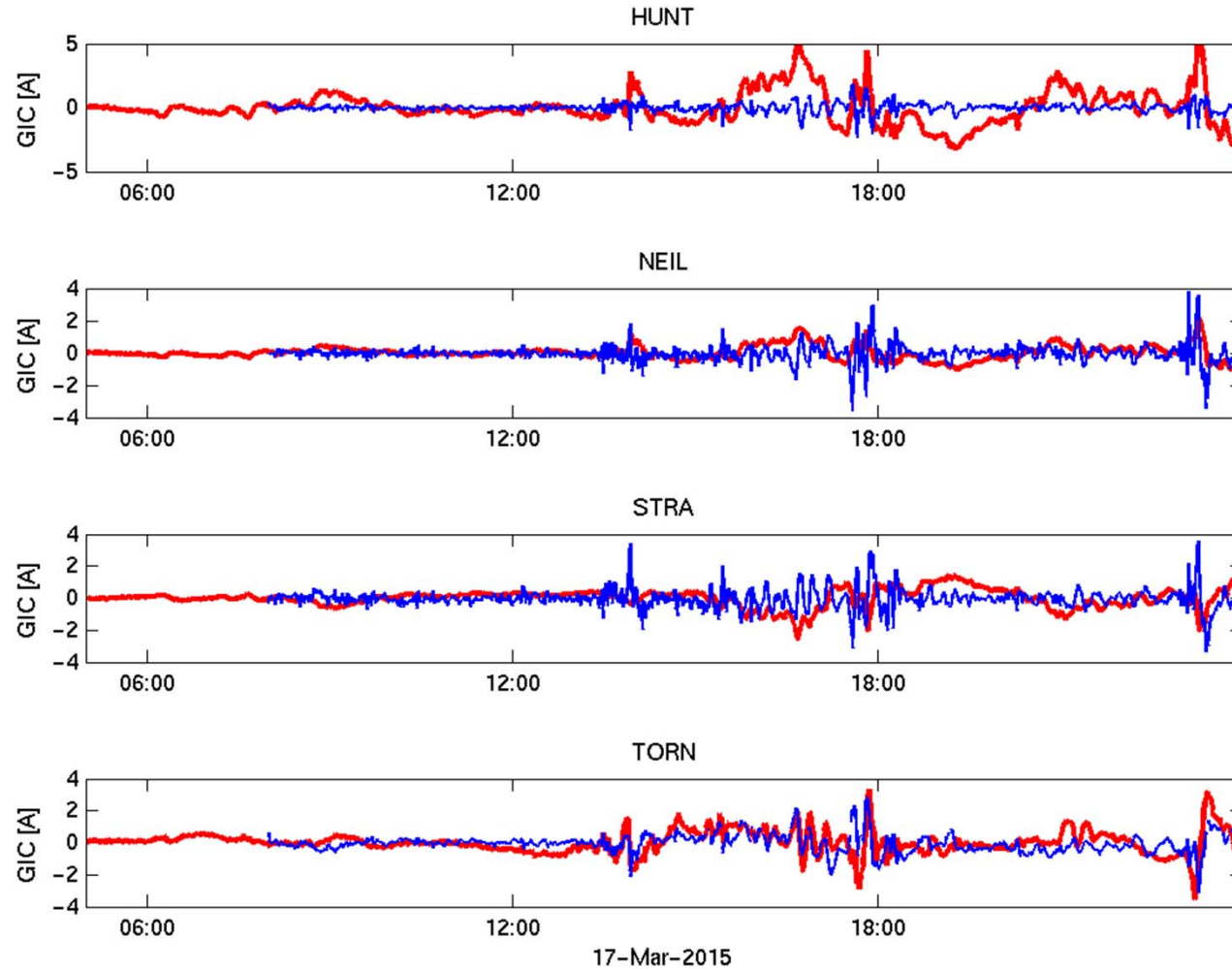


Comparison with model: 17th March 2015

SECS Source field, assumed period of 20 minutes



GIC model



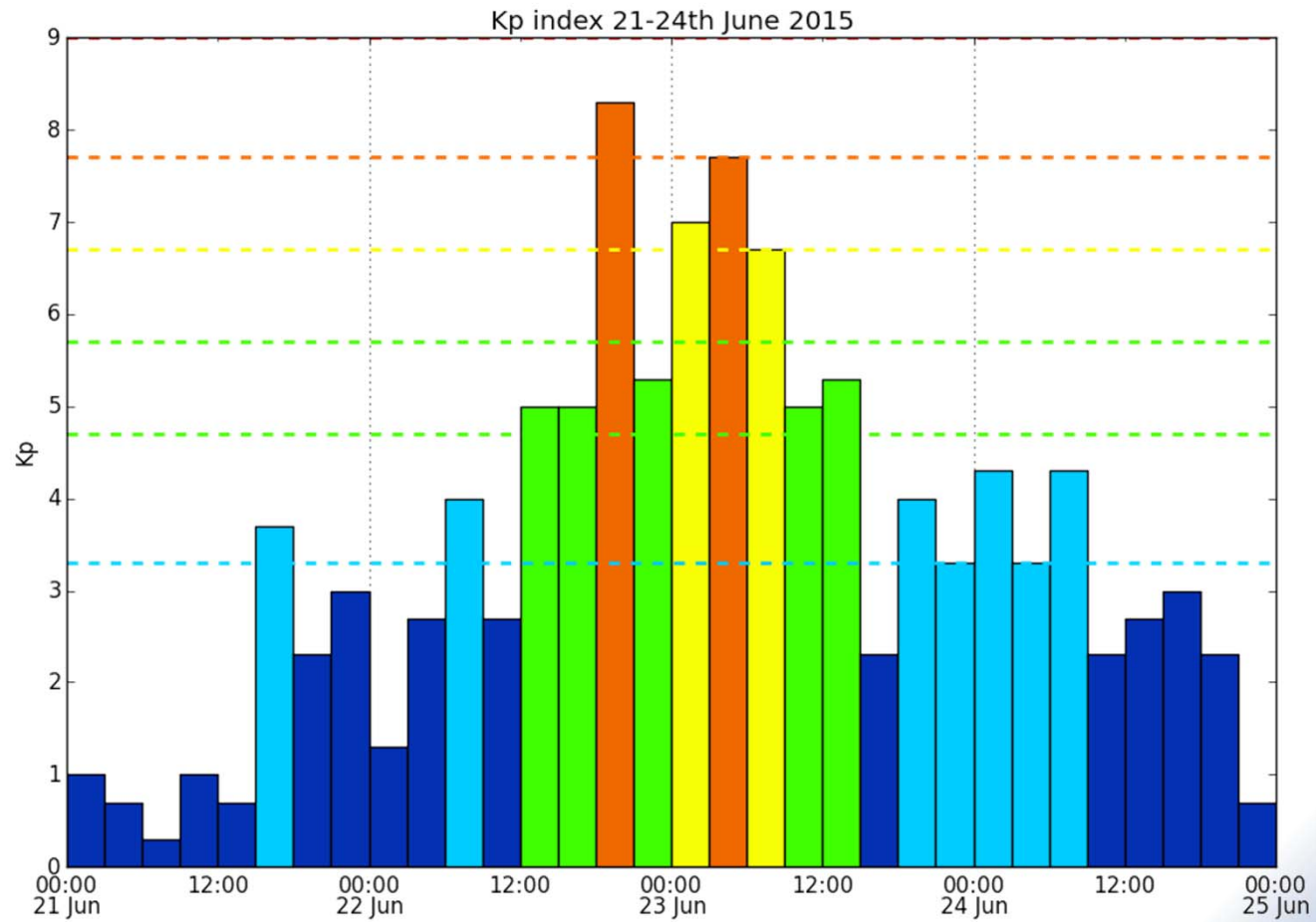
Slide 10

awpt6

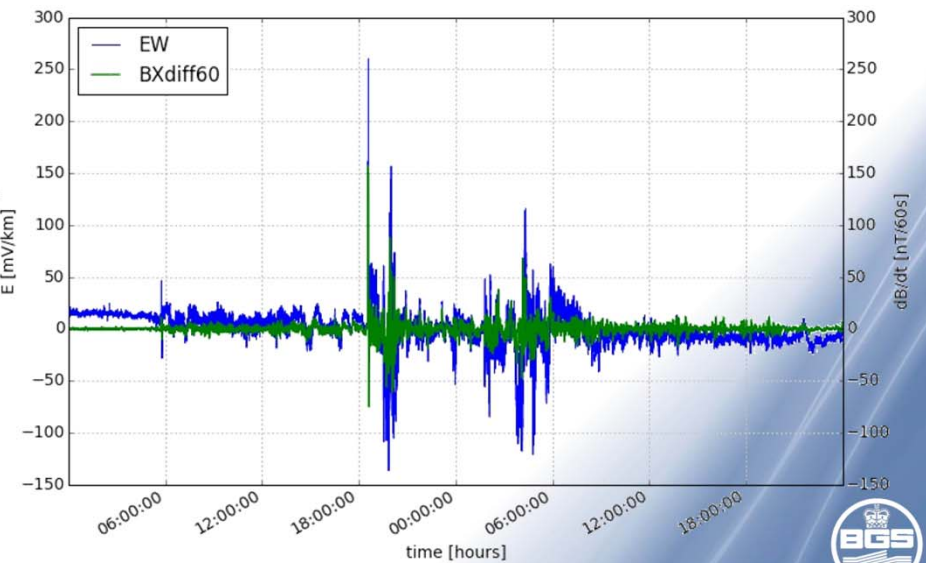
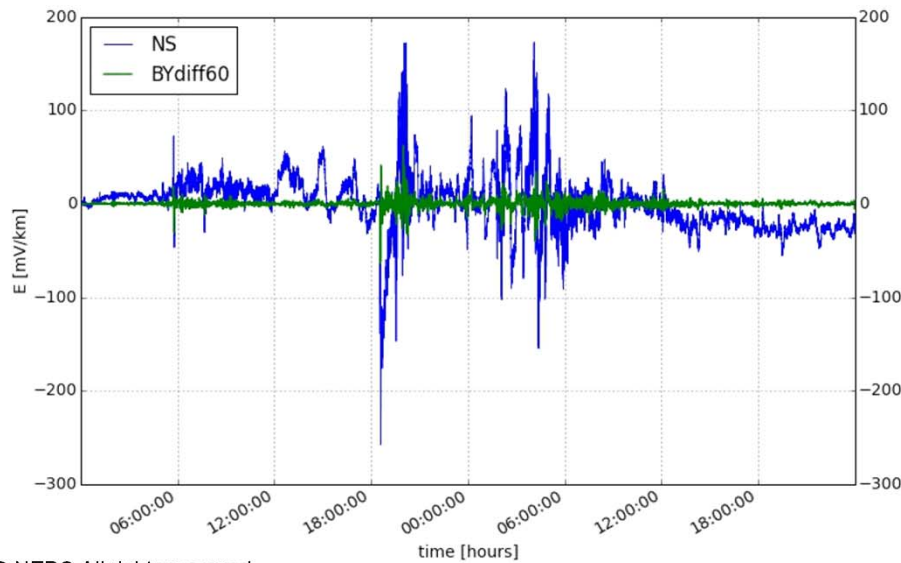
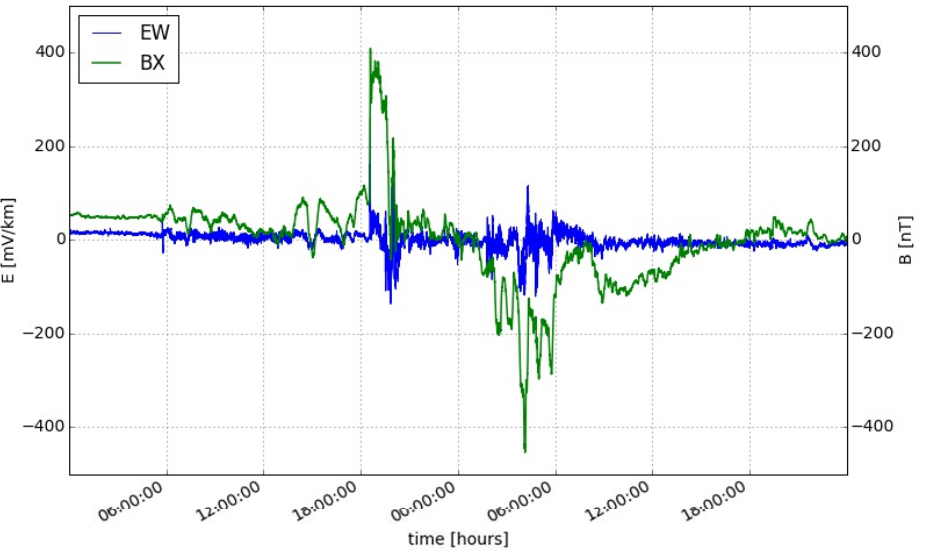
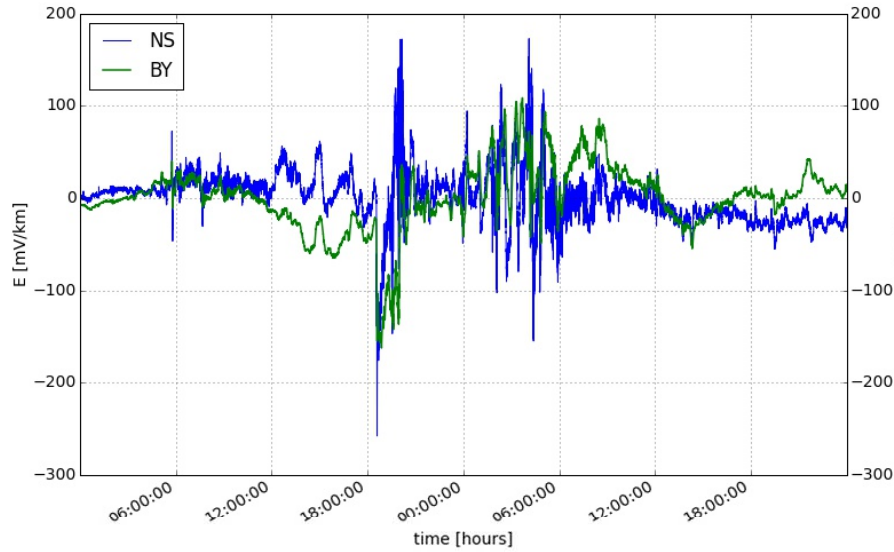
Get Ciaran's thoughts on this before he goes off on paternity leave, e.g. based on his modelling results

Alan Thomson, 29/04/2015

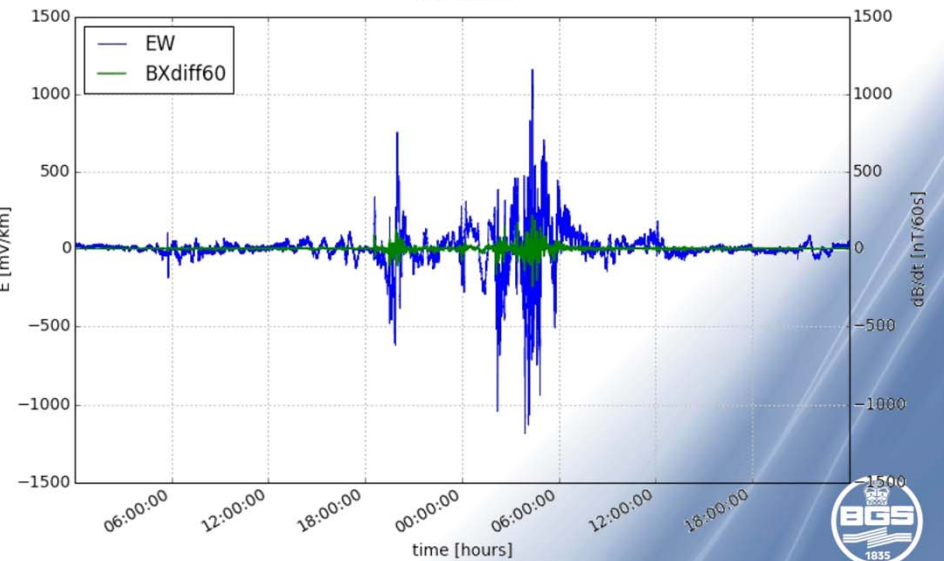
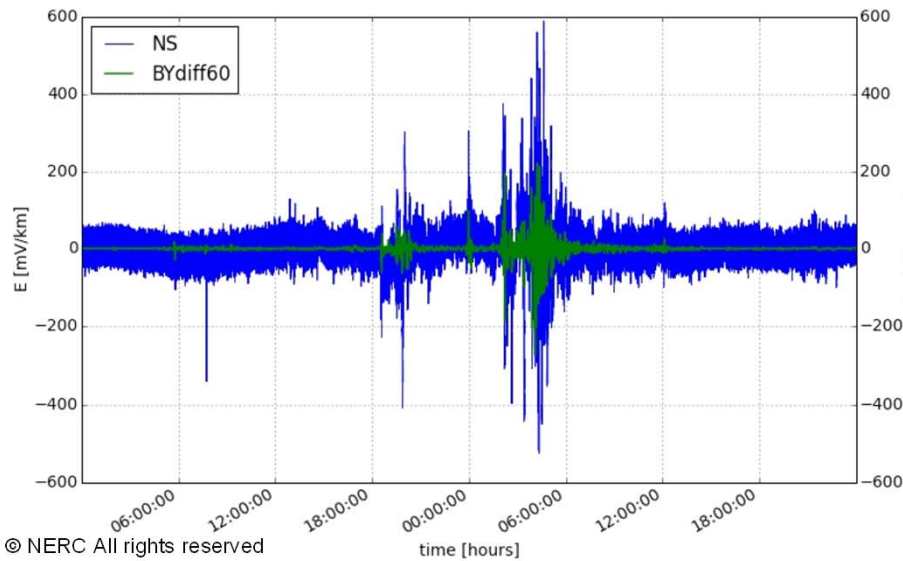
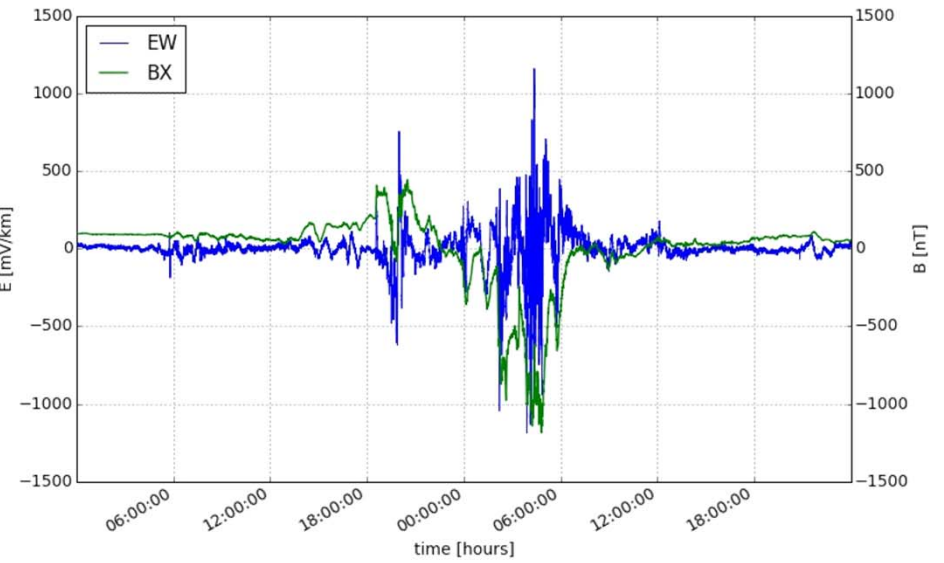
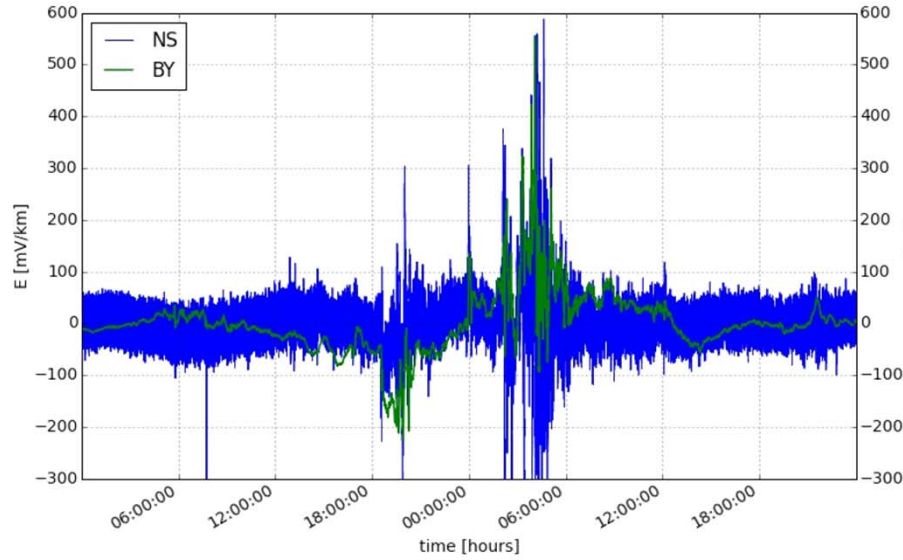
22nd-23rd June 2015



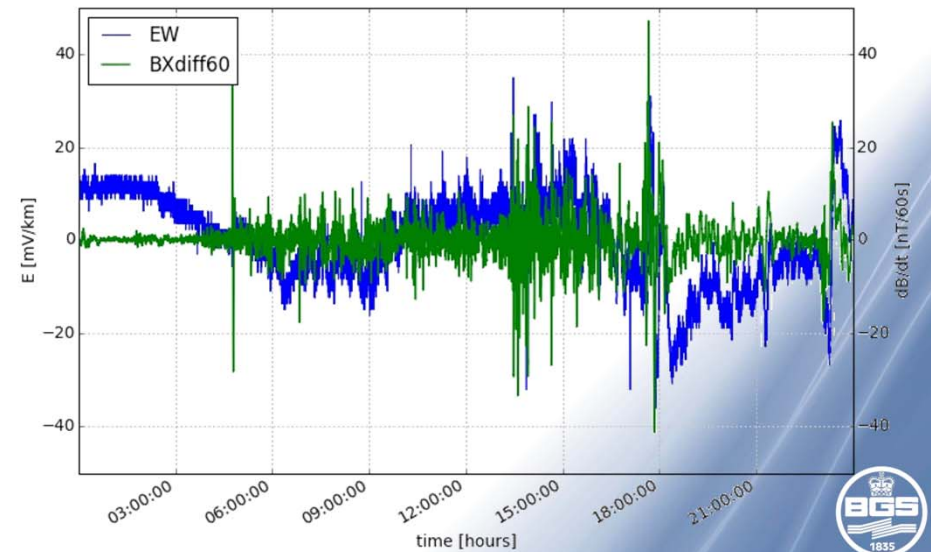
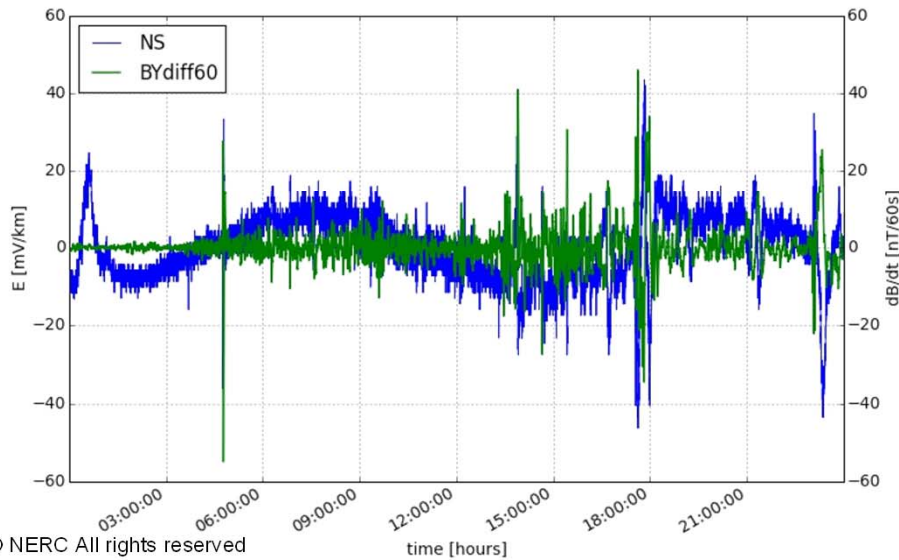
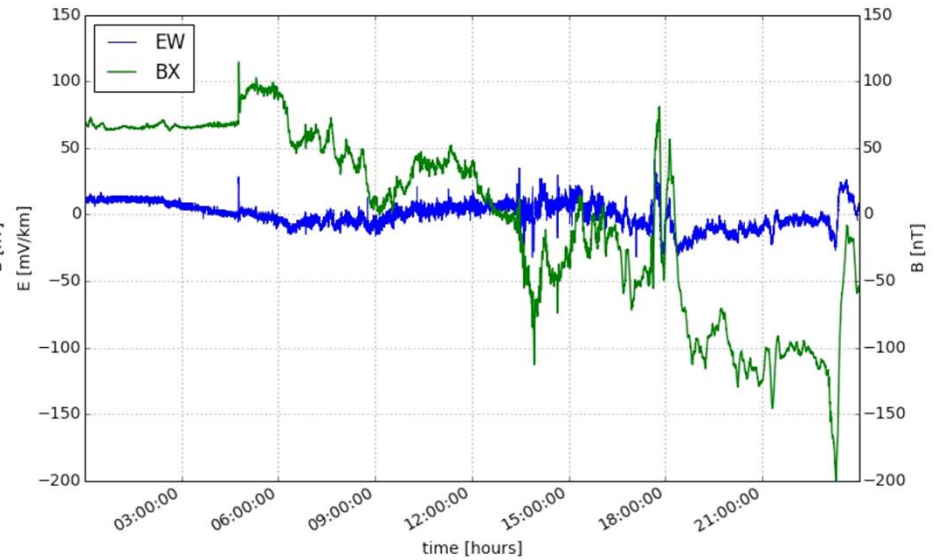
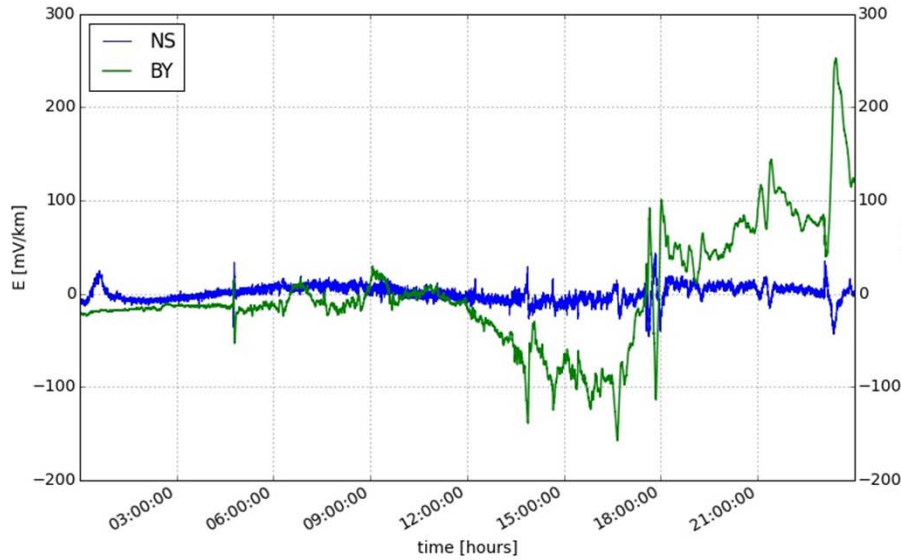
22nd-23rd June 2015: Eskdalemuir



22nd-23rd June 2015: Lerwick

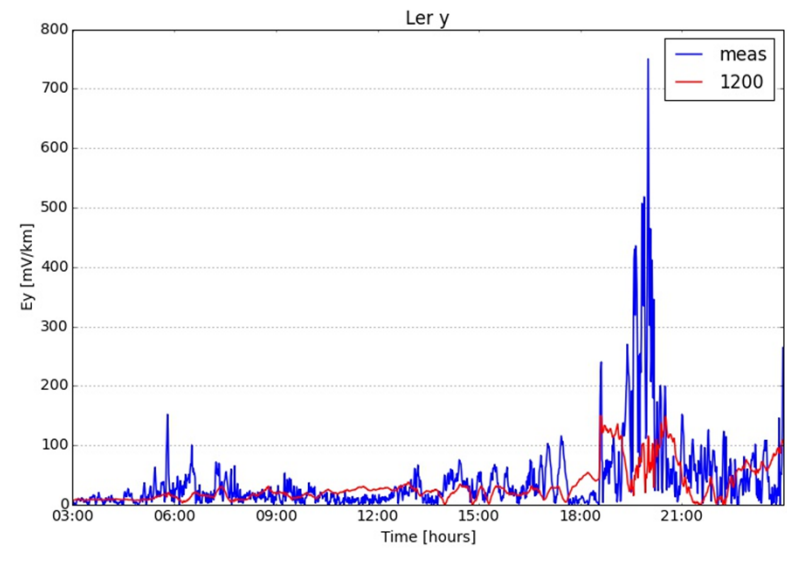
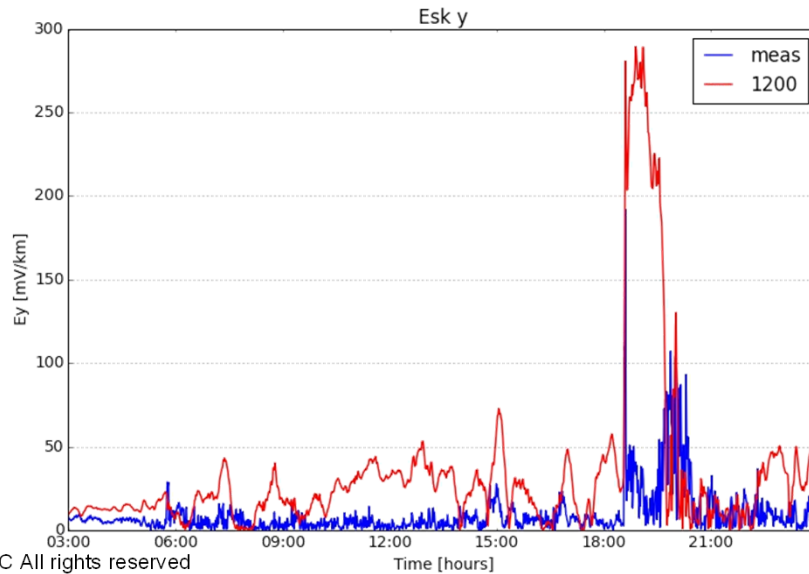
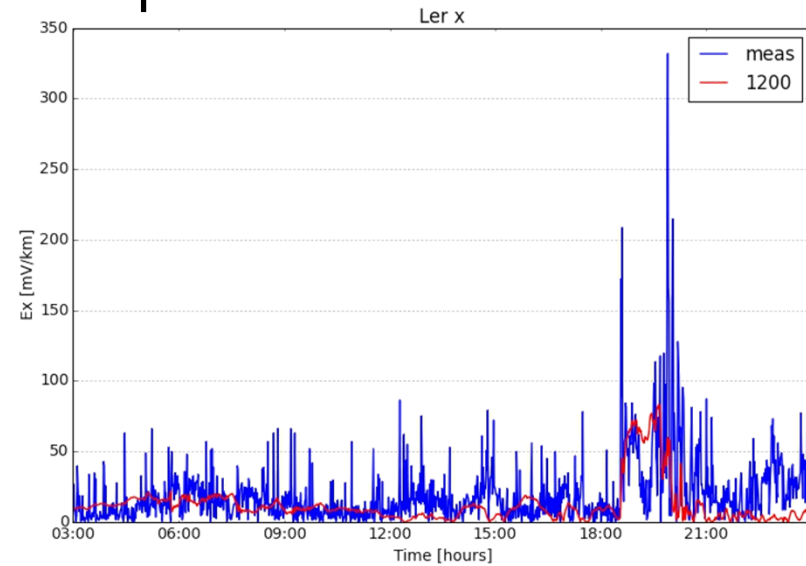
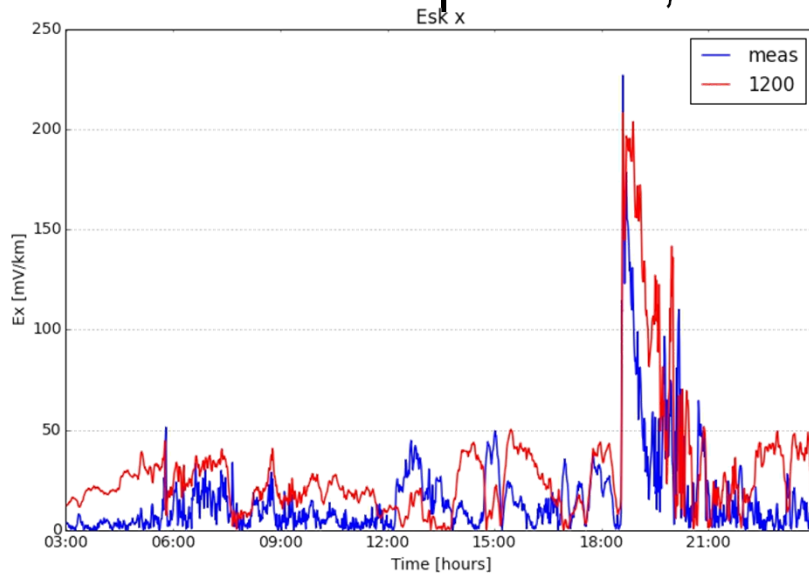


22nd-23rd June 2015: Hartland



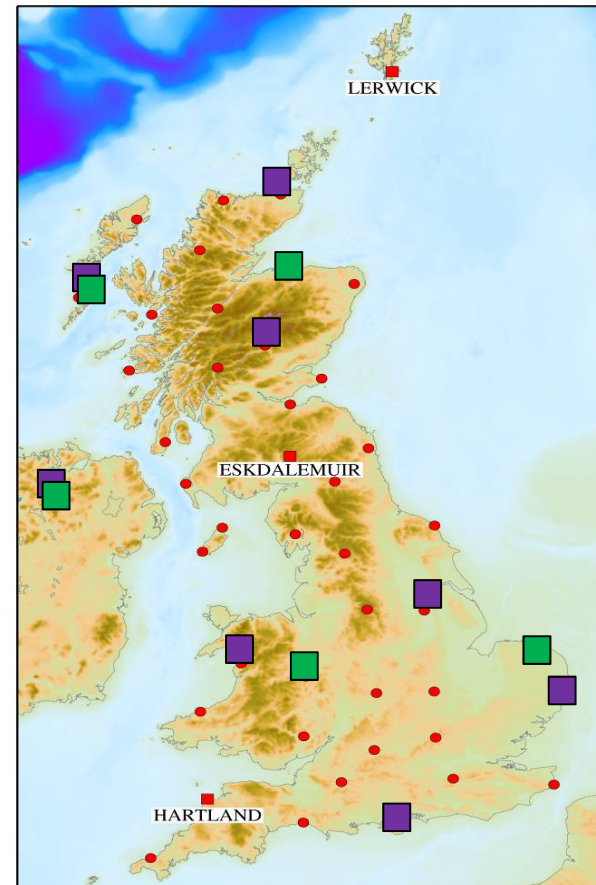
Comparison with model: 22nd June 2015

Plane wave interpolation, assumed period of 20 minutes



Future developments

- A few more storms would be nice....
- Distortion tensor
- Improvements in filtering and field set up to follow
- Better QC and data processing also needed – but data available on request
- More sites across the UK?
(See Sean Blake's poster for more on sites in Ireland)



Summary

- Tides, rainfall, lightning and probably temperature variations in the data
- Other problems and noise evident in the data, this is very much a learning experience
- E-field data follows both B and dB/dt suggesting complex geology
- Comparison with the model:
 - Clear local differences w.r.t measurements (the 'classic MT problem')
 - Not fully dealt with un-modelled periodic sources: tides and S_q
 - But some agreement with regional scale models gives support to modelling methodology

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Geo-electric measurements

Rapid variations of the geomagnetic field, caused by space weather, produce an electric field in the Earth's surface. This electric field is the source of electrical currents that can, for example, cause damage to transformers in the power grid and cause corrosion to pipelines.

The plots below show measurements made at BGS observatories to allow us to monitor this geo-electric field.

Latest measurements:

Eskdalemuir

Yesterday (Click to enlarge) Today (Click to enlarge) Last 8 hours (Click to enlarge) Last 30 days (Click to enlarge)

Lerwick

Yesterday (Click to enlarge) Today (Click to enlarge) Last 8 hours (Click to enlarge) Last 30 days (Click to enlarge)

Hartland

Yesterday (Click to enlarge) Today (Click to enlarge) Last 8 hours (Click to enlarge) Last 30 days (Click to enlarge)

Notes

- Data are updated every 10 minutes.
- At the moment there is no additional processing - we are just plotting the measurements as they are.
- dB/G is calculated as the difference between the measurement now and the measurement 10 seconds ago divided by 10 seconds.

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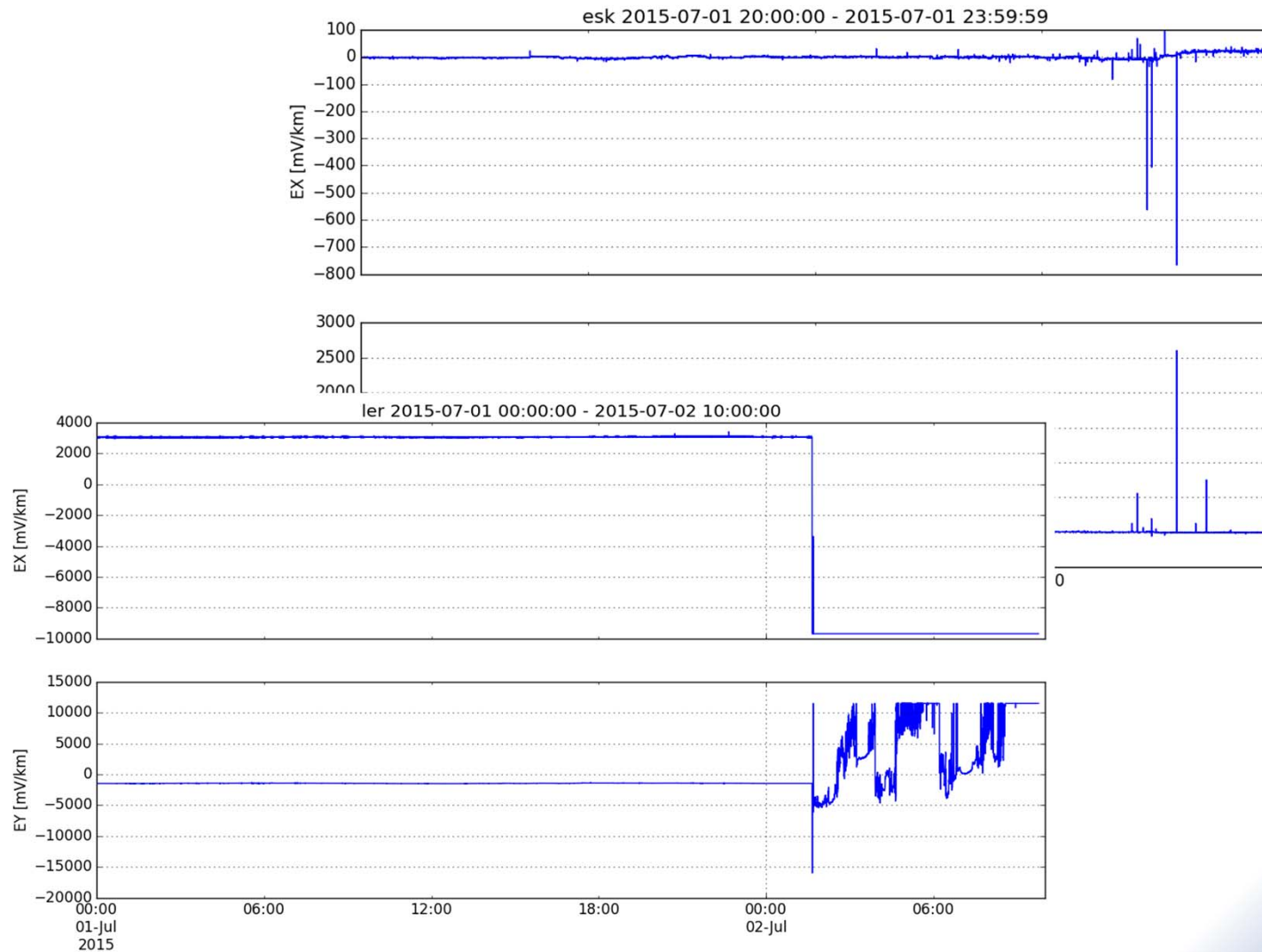
<http://ow.ly/OSaZ3>

http://www.geomag.bgs.ac.uk/data_service/space_weather/geoelectric.html





Lightning

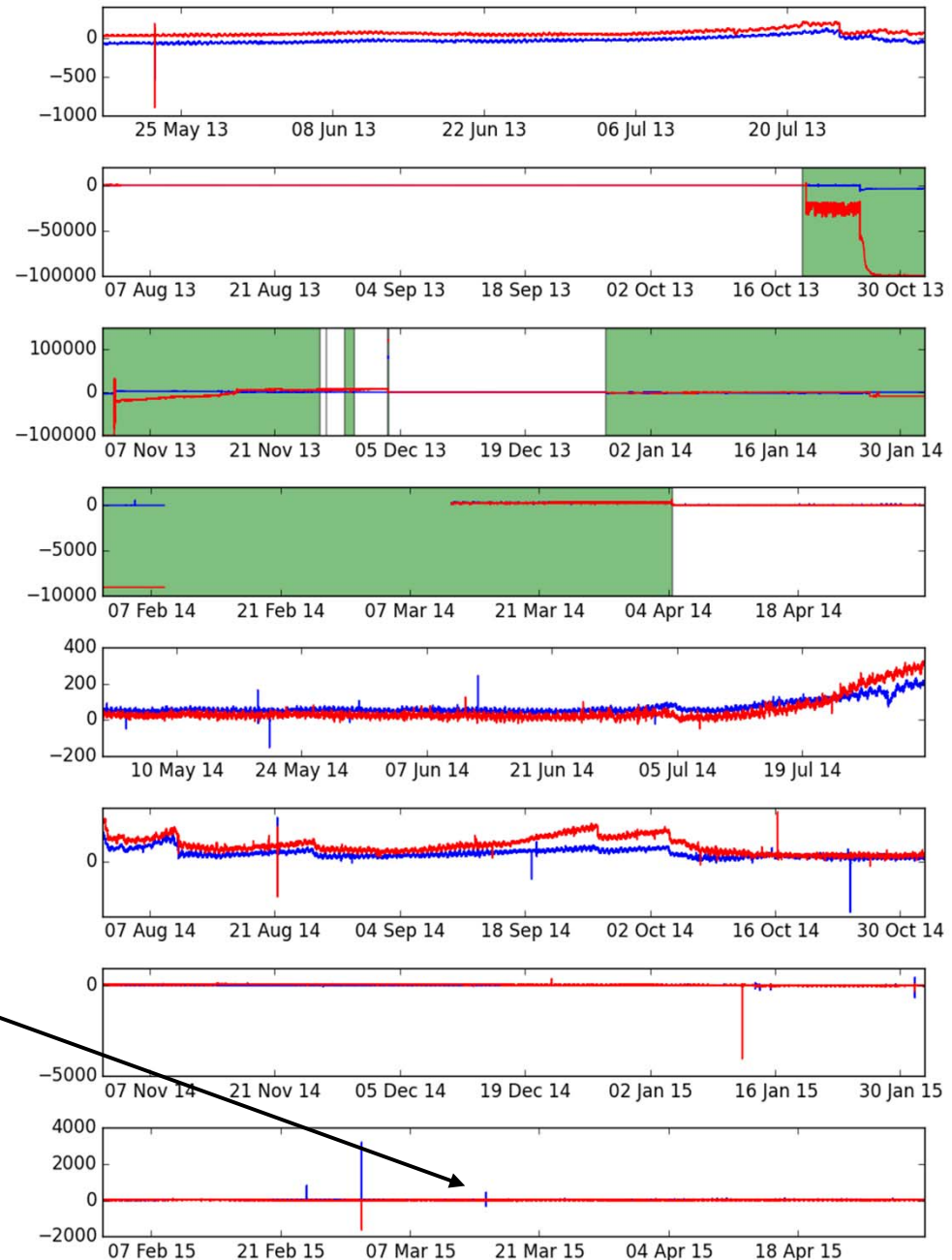


Data quality

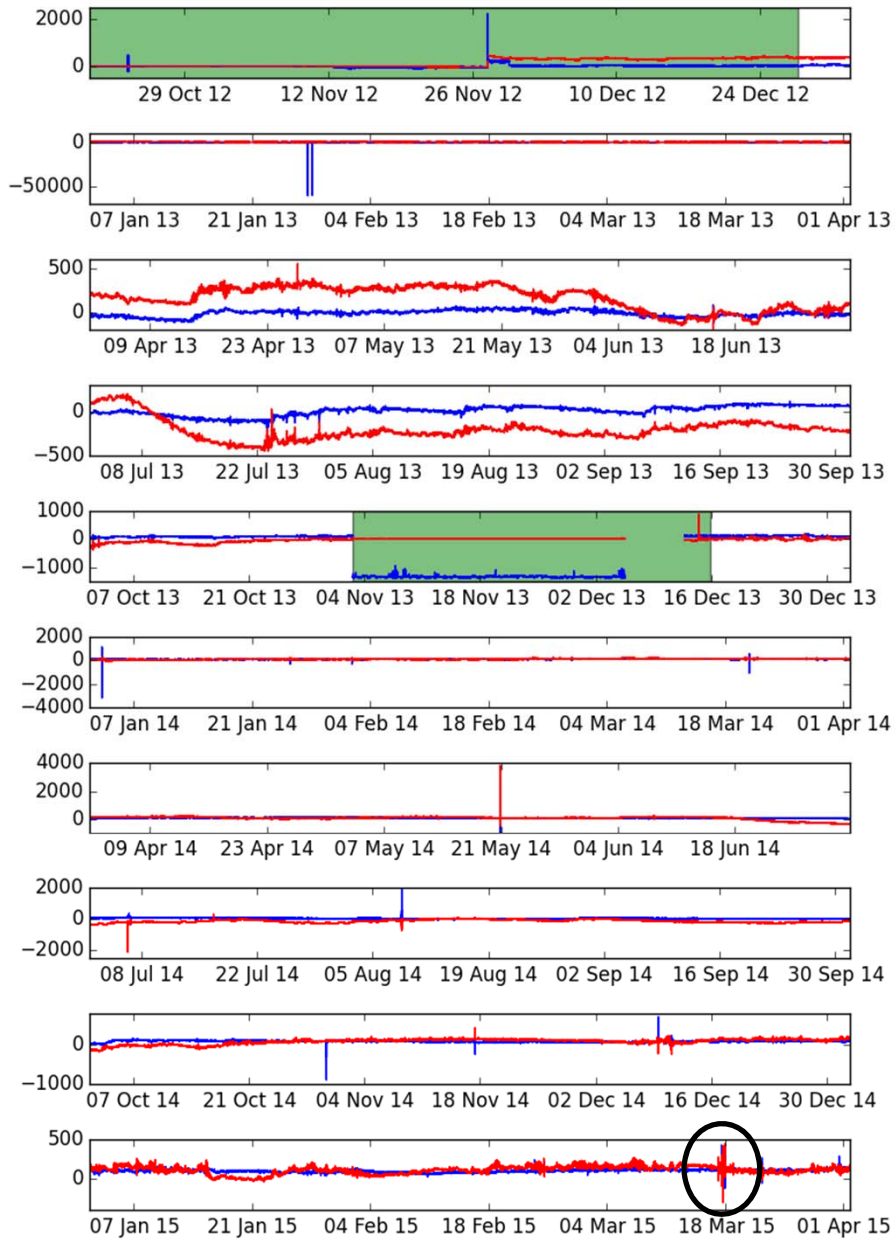
- Example of the raw data over nearly 2 years
 - Green shading shows where there are clear problems
 - Steps and spikes common
 - Note auto-scaling is used

St Patrick's day magnetic storm

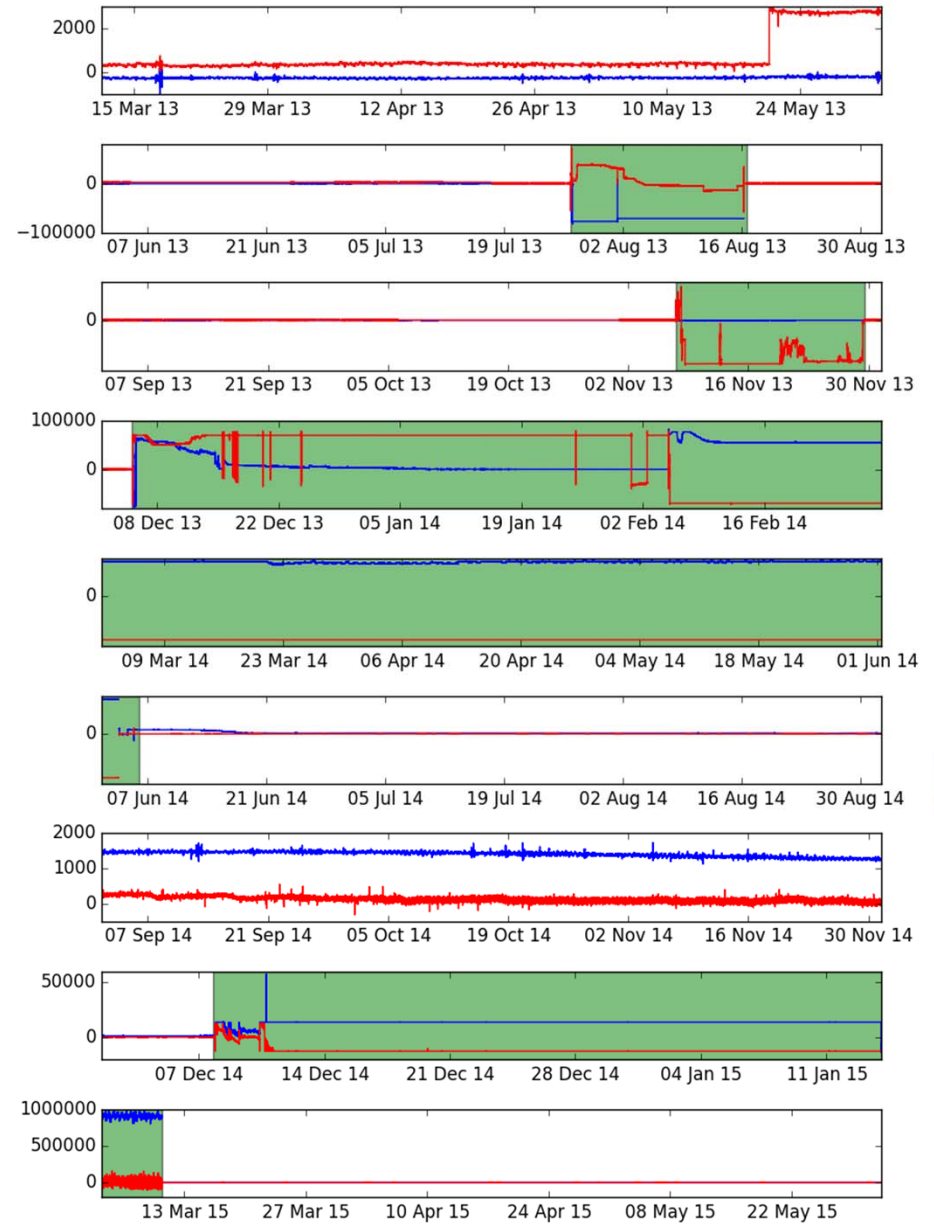
Hartland



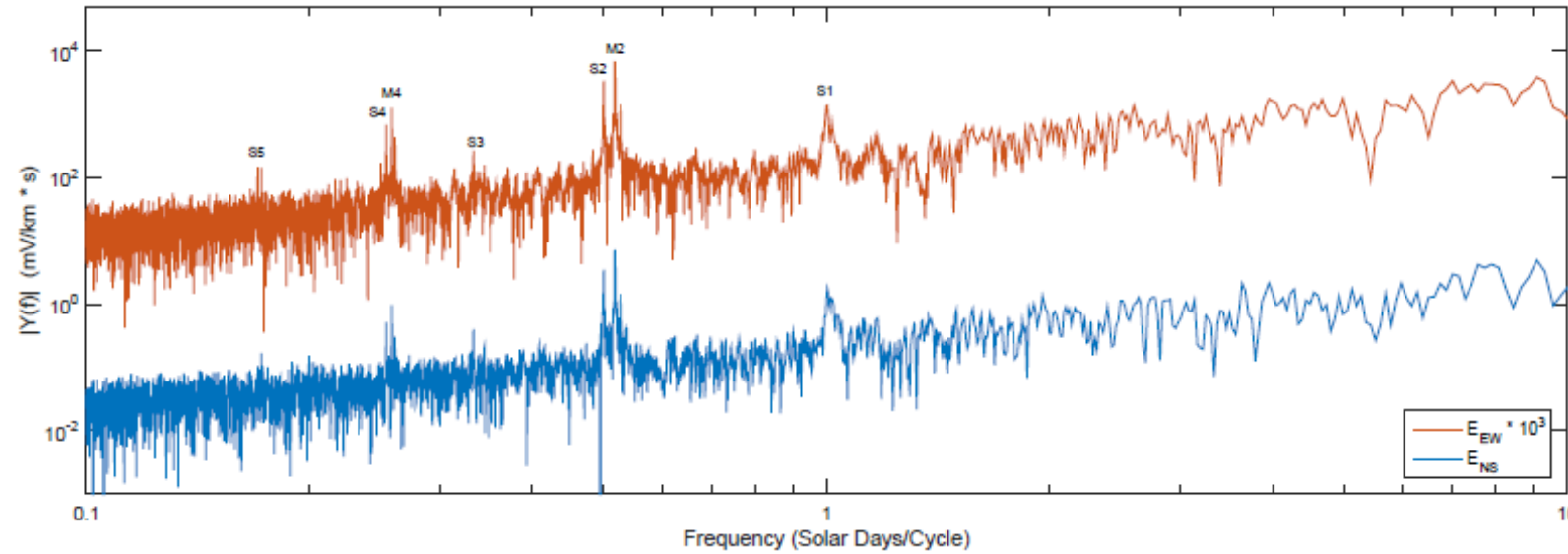
Eskdalemuir



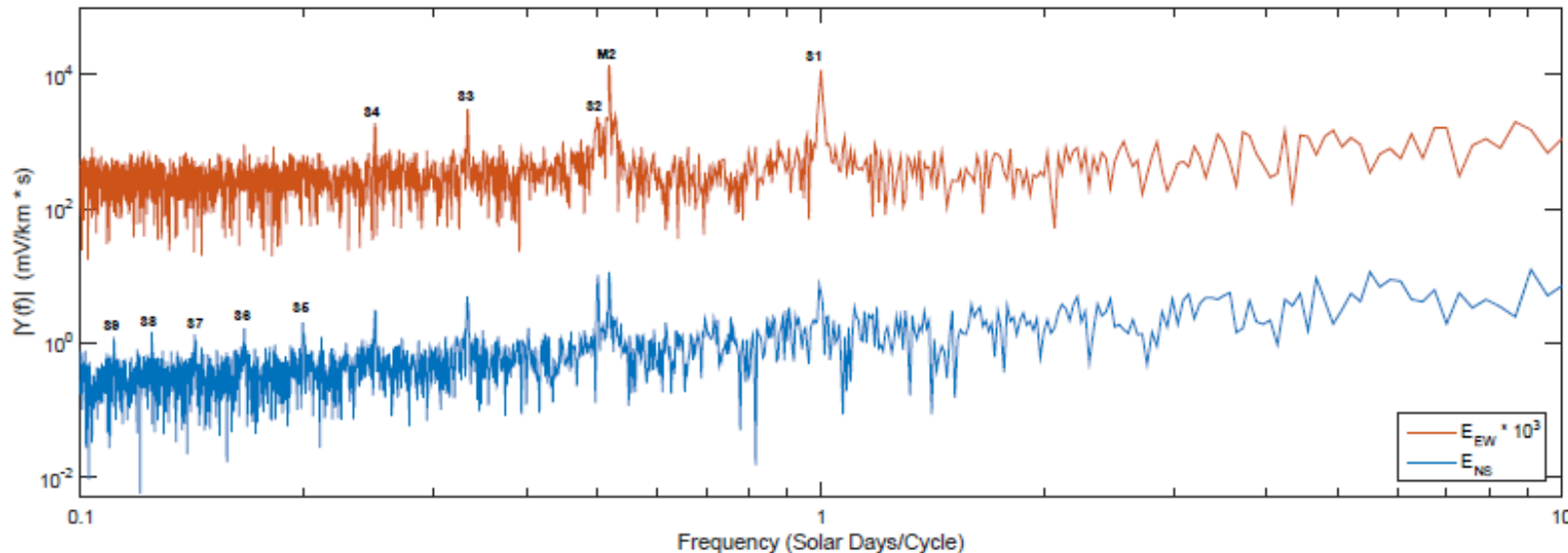
Lerwick



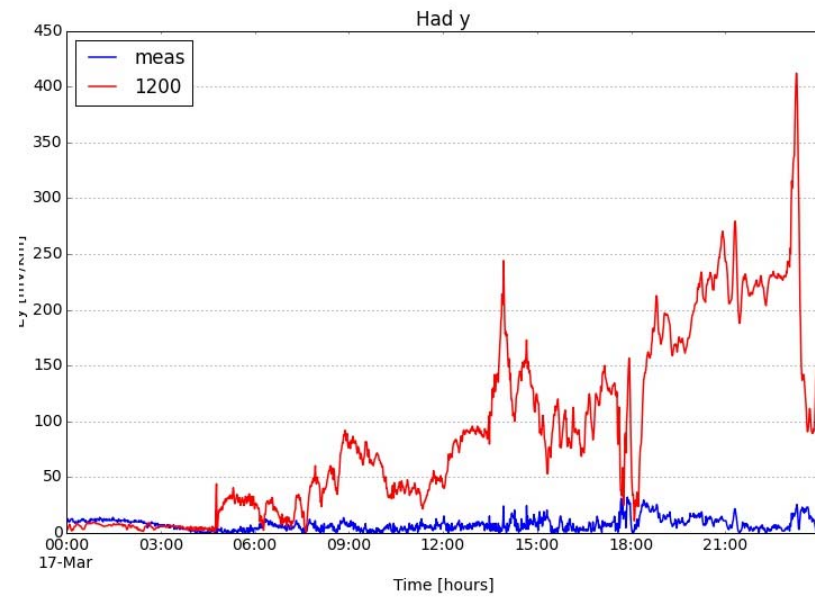
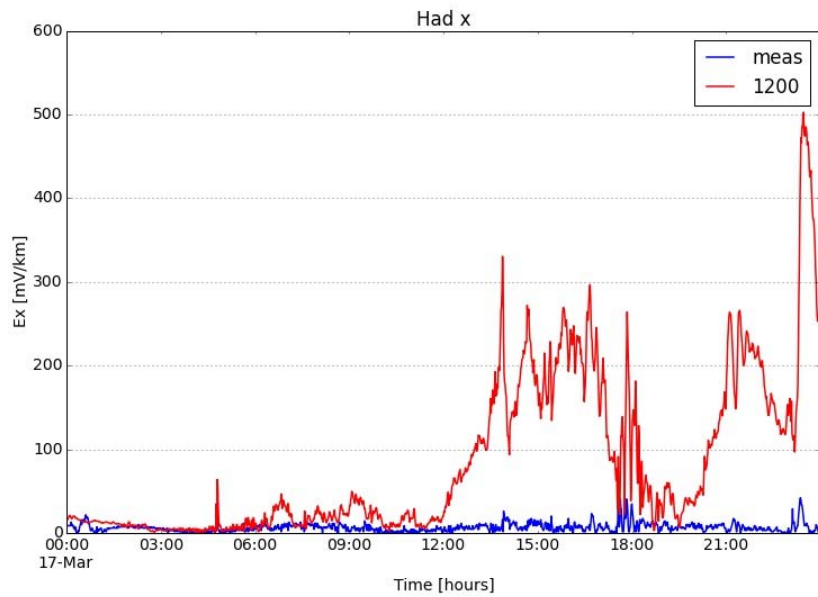
Tidal Signature at Hartland & Lerwick



The uni
plots ar
wrong

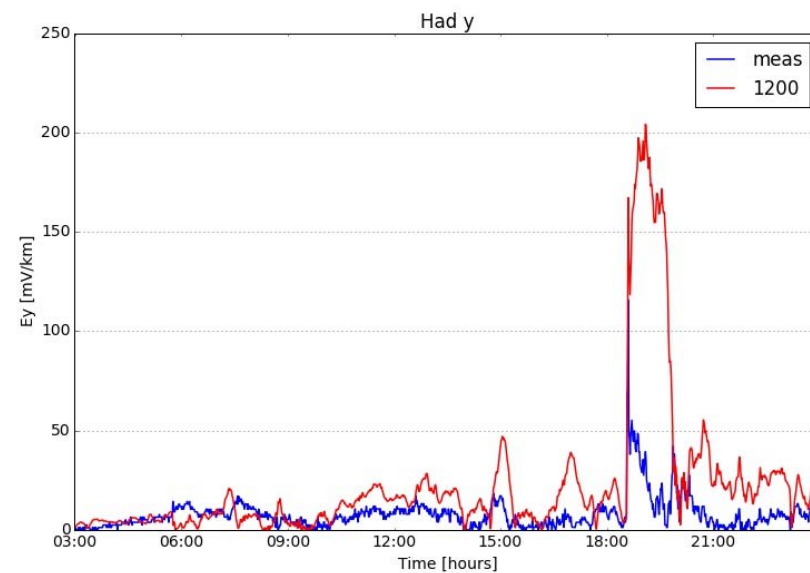
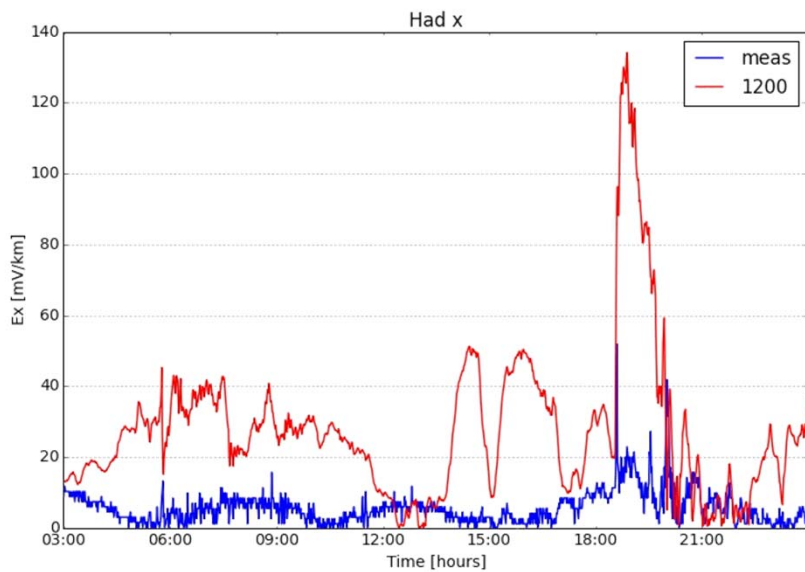


March 17th 2015: Hartland

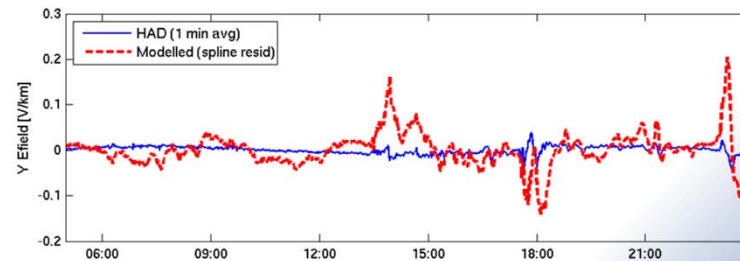
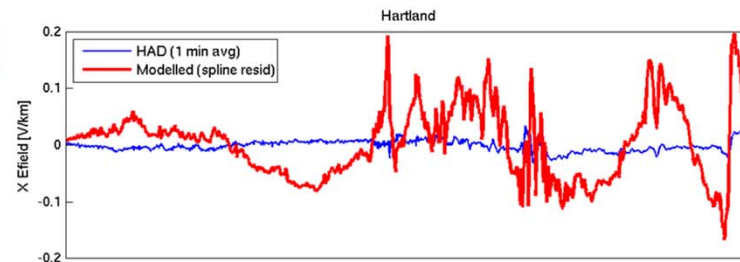
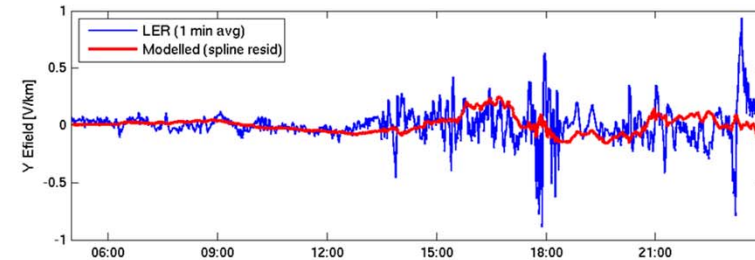
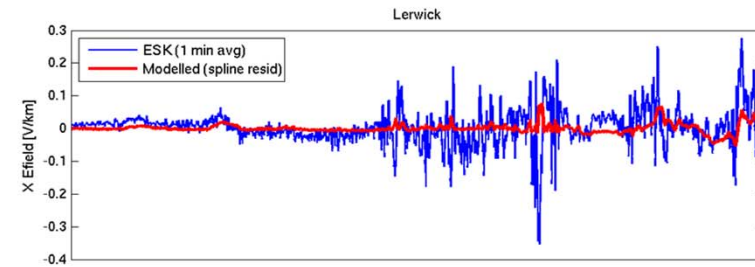
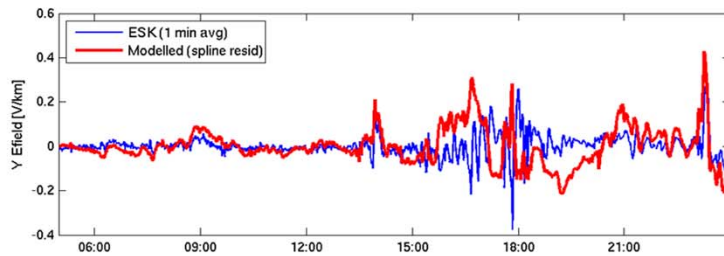
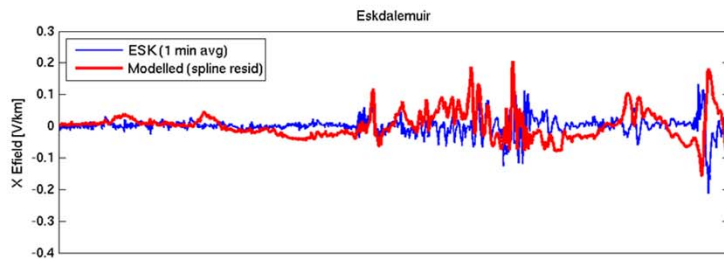


Comparison with model: 22nd June 2015

Plane wave interpolation, assumed period of 20 minutes

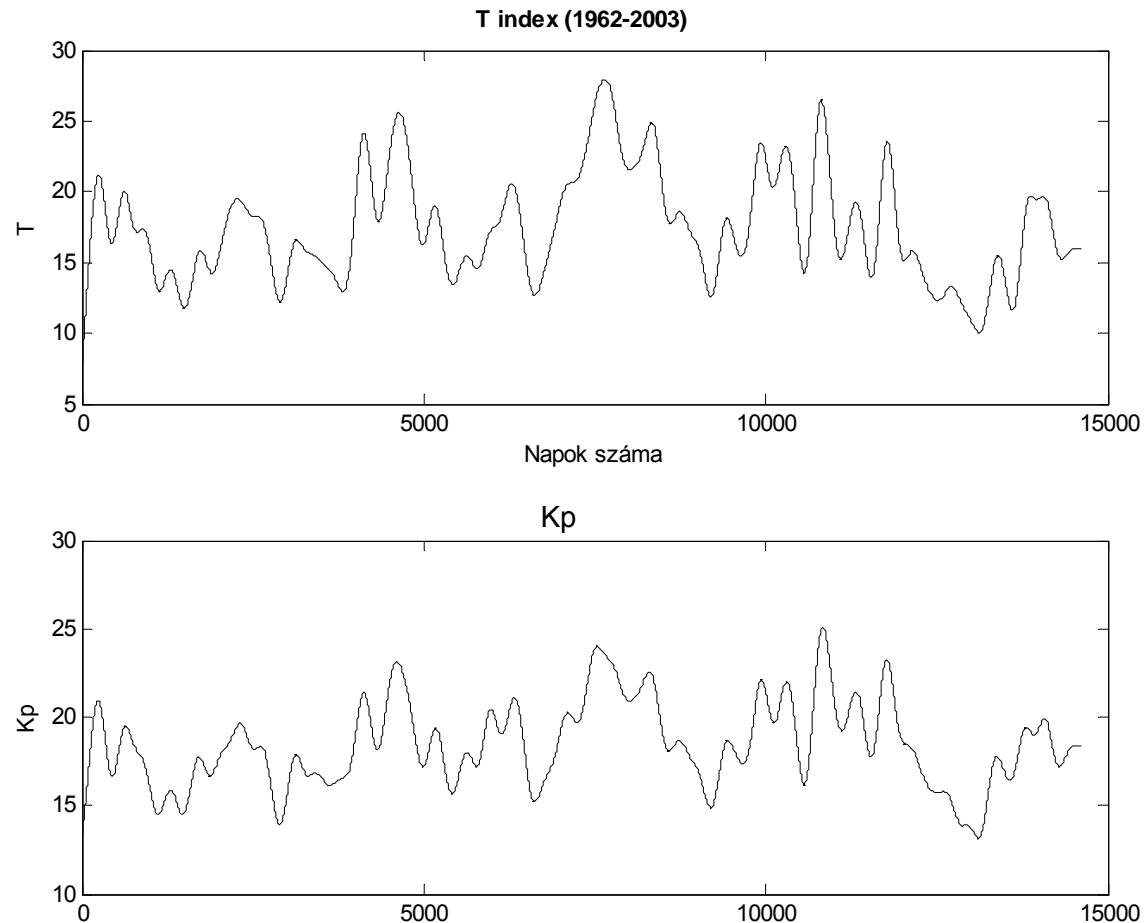


Spline fit to model to remove trend



Geoelectric Indices – NCK T-Index

- The T-Index is a 3-hour range index computed for Nagycenk Observatory, Hungary
- Values are given as 0-9, in steps of 1.8 mV/km for the largest of E_x or E_y
- Daily sum of T is shown
- Perhaps other shorter duration indices would be better?



Days since 01-01-1962: 12 month smoothing filter

Slide 27

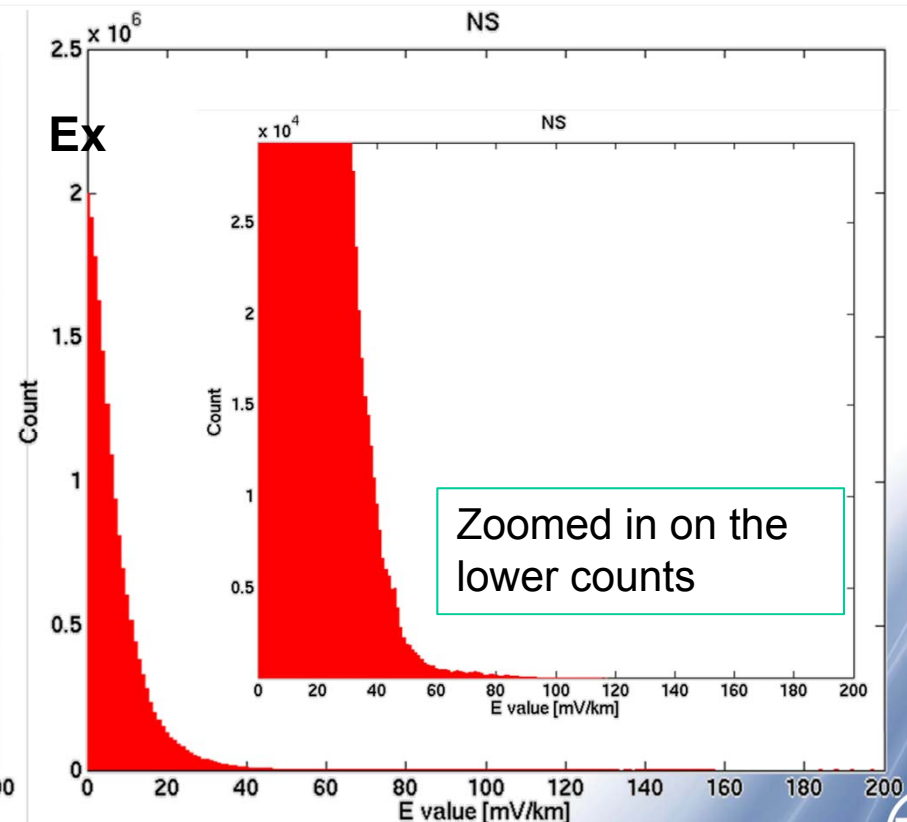
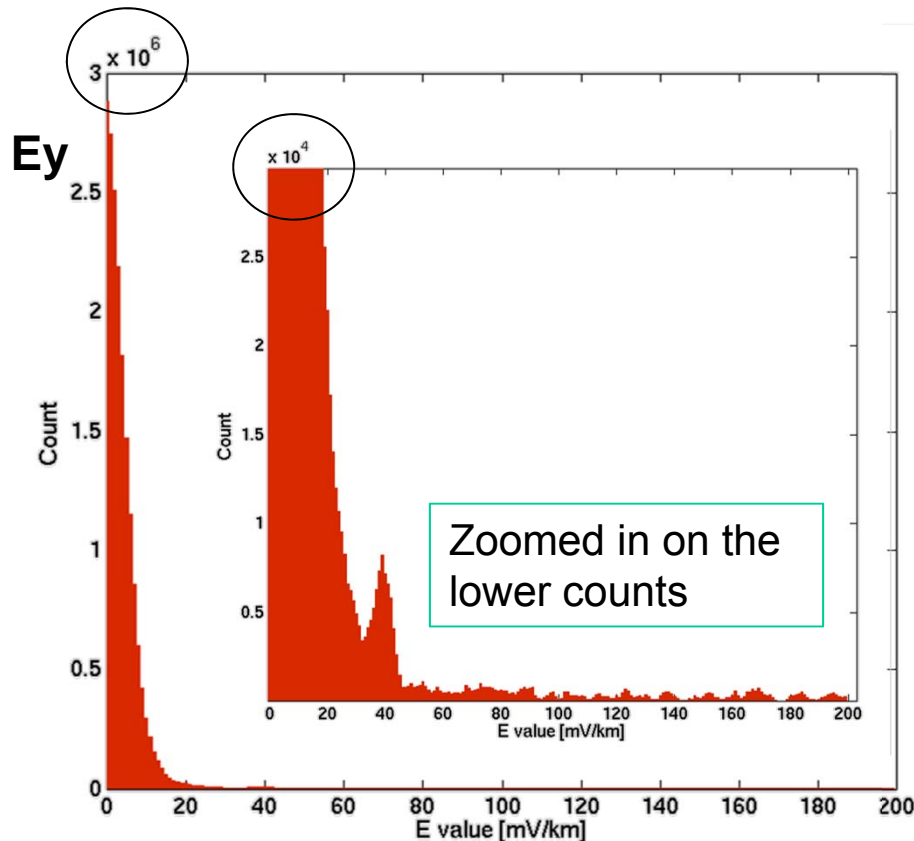
awpt2

Could you plot a distribution function of the E-field for Esk, say, over many months of data and we can see where we might put bounds to construct our own version of the T index? I wonder what the characteristics of this distribution would be, e.g. in relation to a distribution function for e.g. dB/dt over the same time span.

Alan Thomson, 29/04/2015

Building a Local T Index: Distribution of E-fields

- 1 second data from 1/1/2013 to 05/08/2013 at ESK
- De-trending each individual day and removing data > 1000 mV/m as spikes

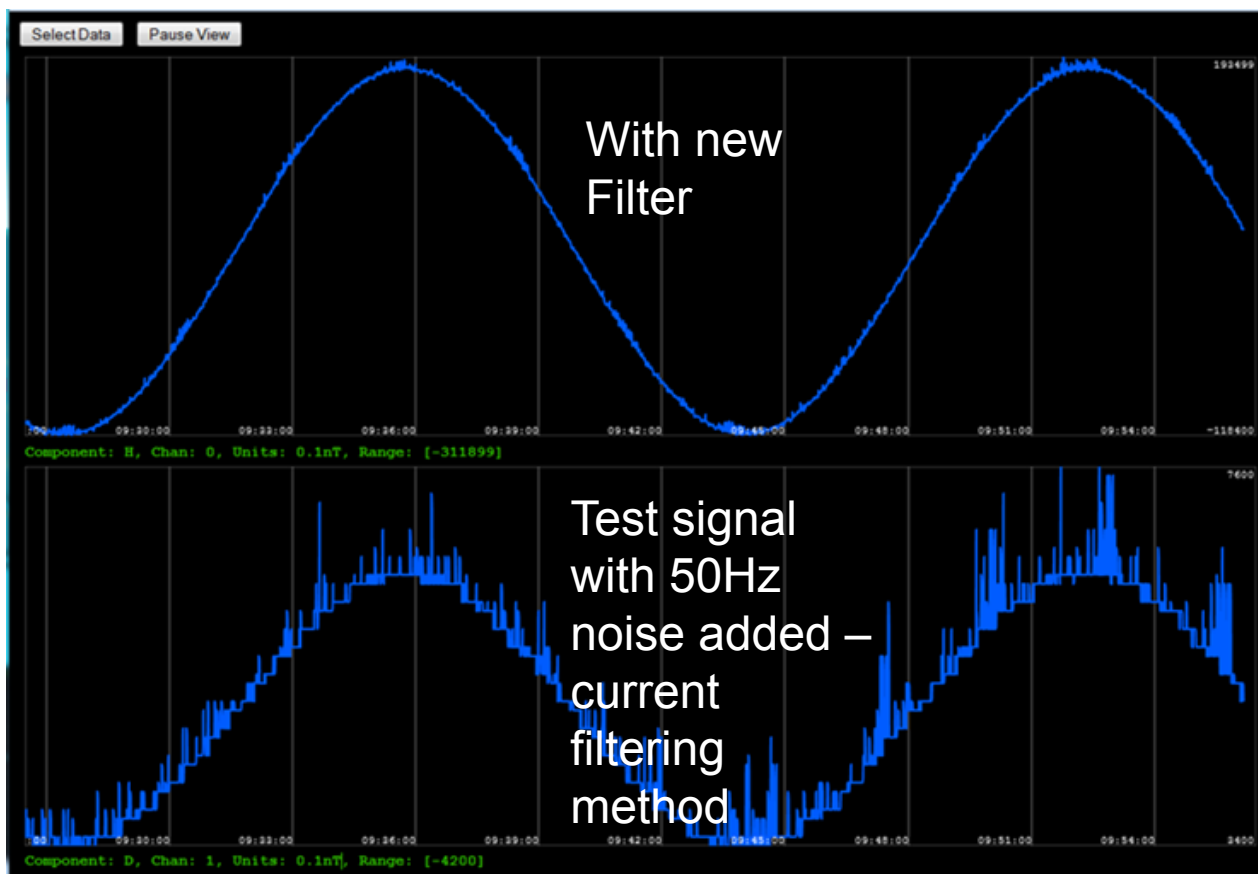


Geo-electric Field Monitoring - Details

- Electrodes maintained in a 'neutral' Cu-CuSO₄ clay mixture to prevent polarisation/self potential effects
- Transient resistance between electrodes checked before & after installation ($< 5 \text{ K}\Omega$)
- Buried in pits ~ 0.6m deep (helps minimise temperature variation)
- Electrode pairs separated by about 80-100 m
- Shielded cable to minimise pick-up of noise on signal line



Improving Filtering in 2015



- 50Hz noise in signal
- New design of pre-amp/filter
 - x100 gain
 - 3-pole Butterworth low-pass filter ($f_c = 20\text{Hz}$)
- Will be installed at all UK electric field sites