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

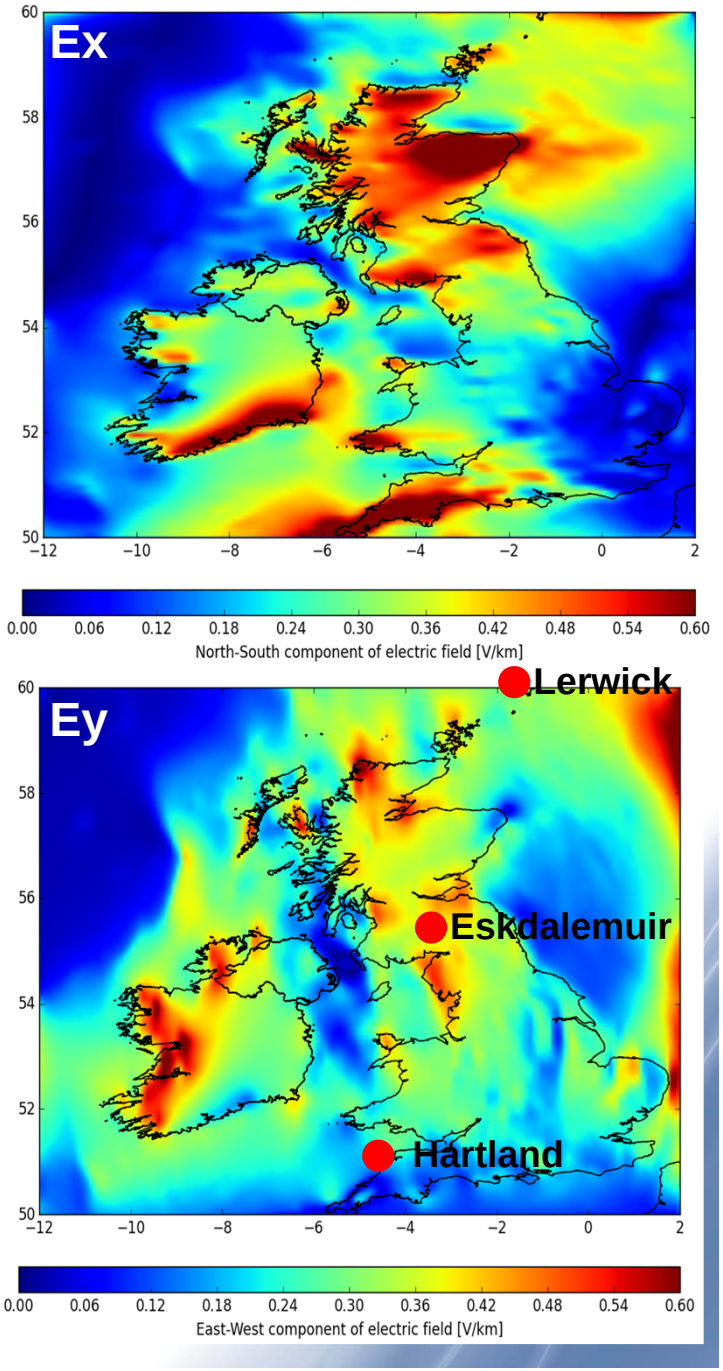
NAM 2015, Llandudno

awpt5

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

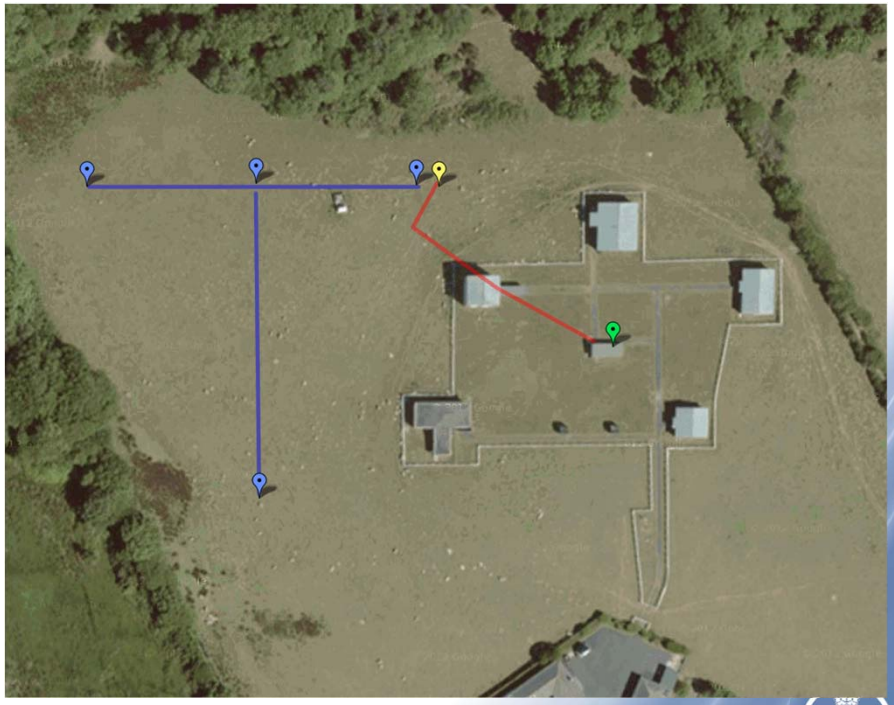
awpt5 I have inserted slides as if this verson of the talk is for the IUGG meeting. Obviously we can cut things out for the NAM version, if this is shorter in duration.

Alan Thomson, 29/04/2015

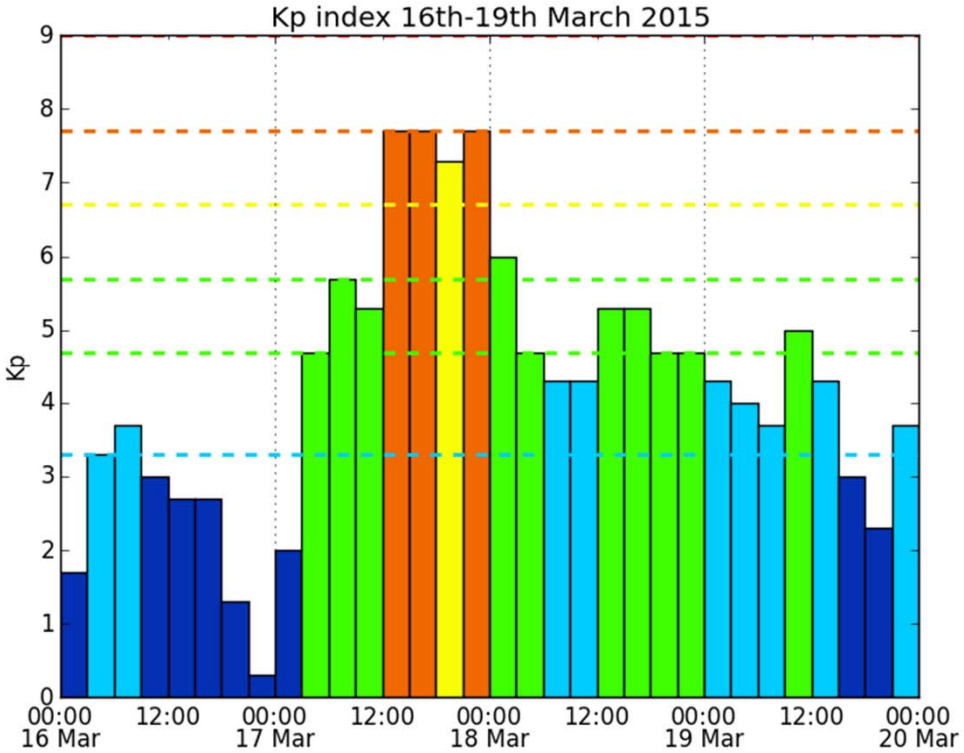
Field Setup

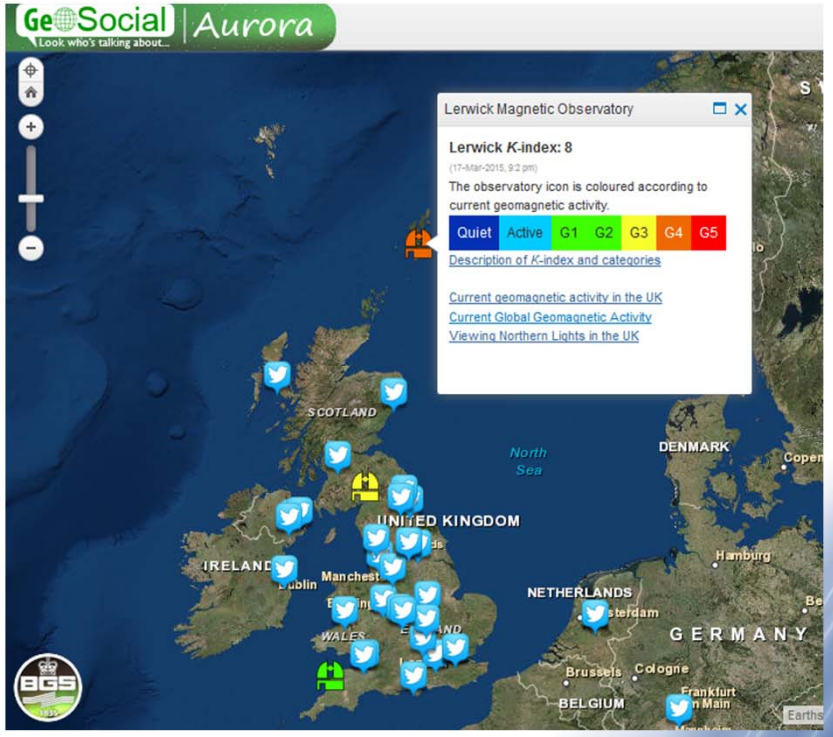
- Measurements of the electric field are made by recording the voltage difference between two points in the ground, separated by a known distance in a given orientation.

- At each site two electrode pairs are used, spaced approximately 100m apart, in a North-South and East-West configuration



17th March 2015: Eskdalemuir

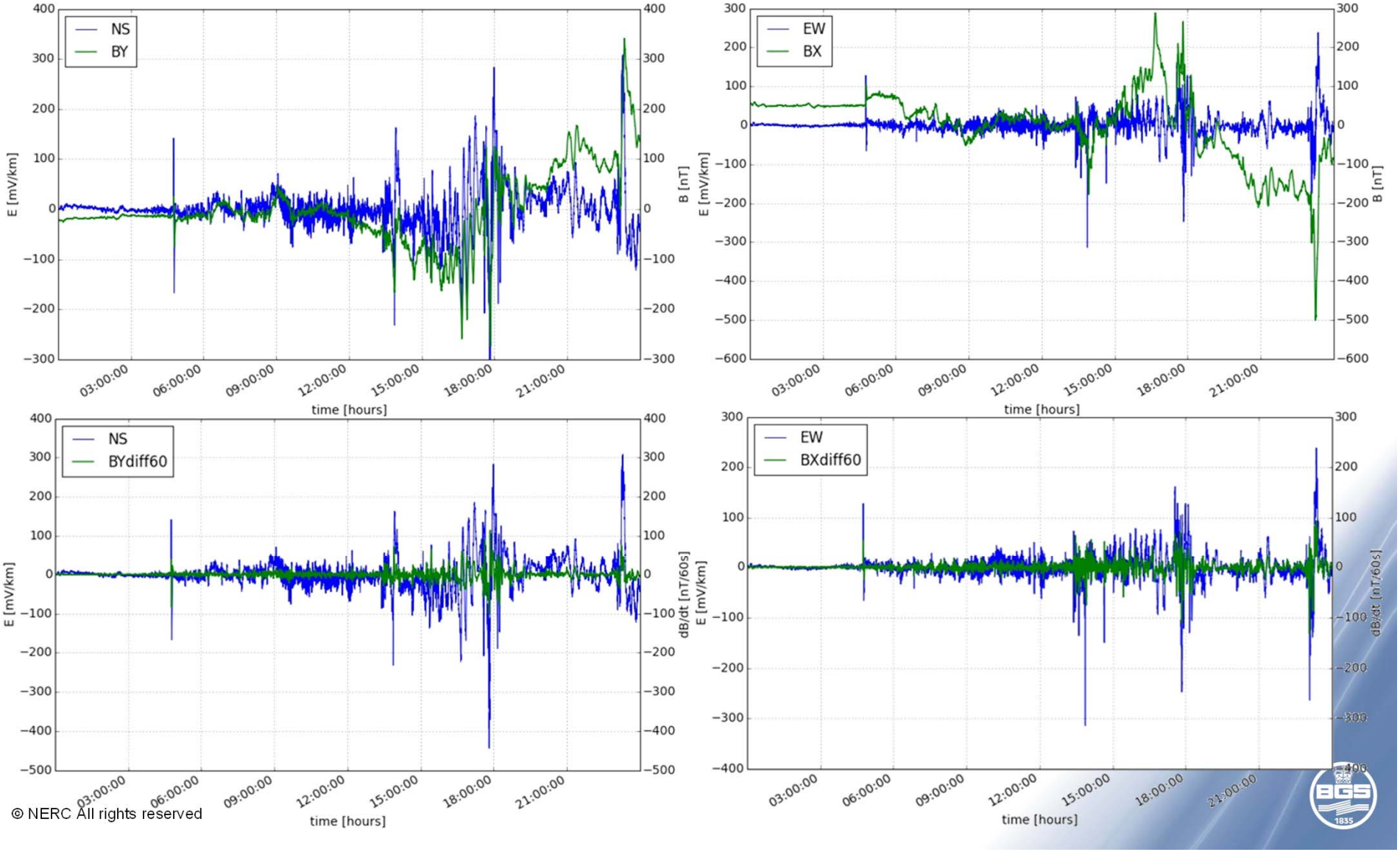




http://www.bgs.ac.uk/citizenScience/geosocial/home.html

awpt3

17th March 2015: Eskdalemuir



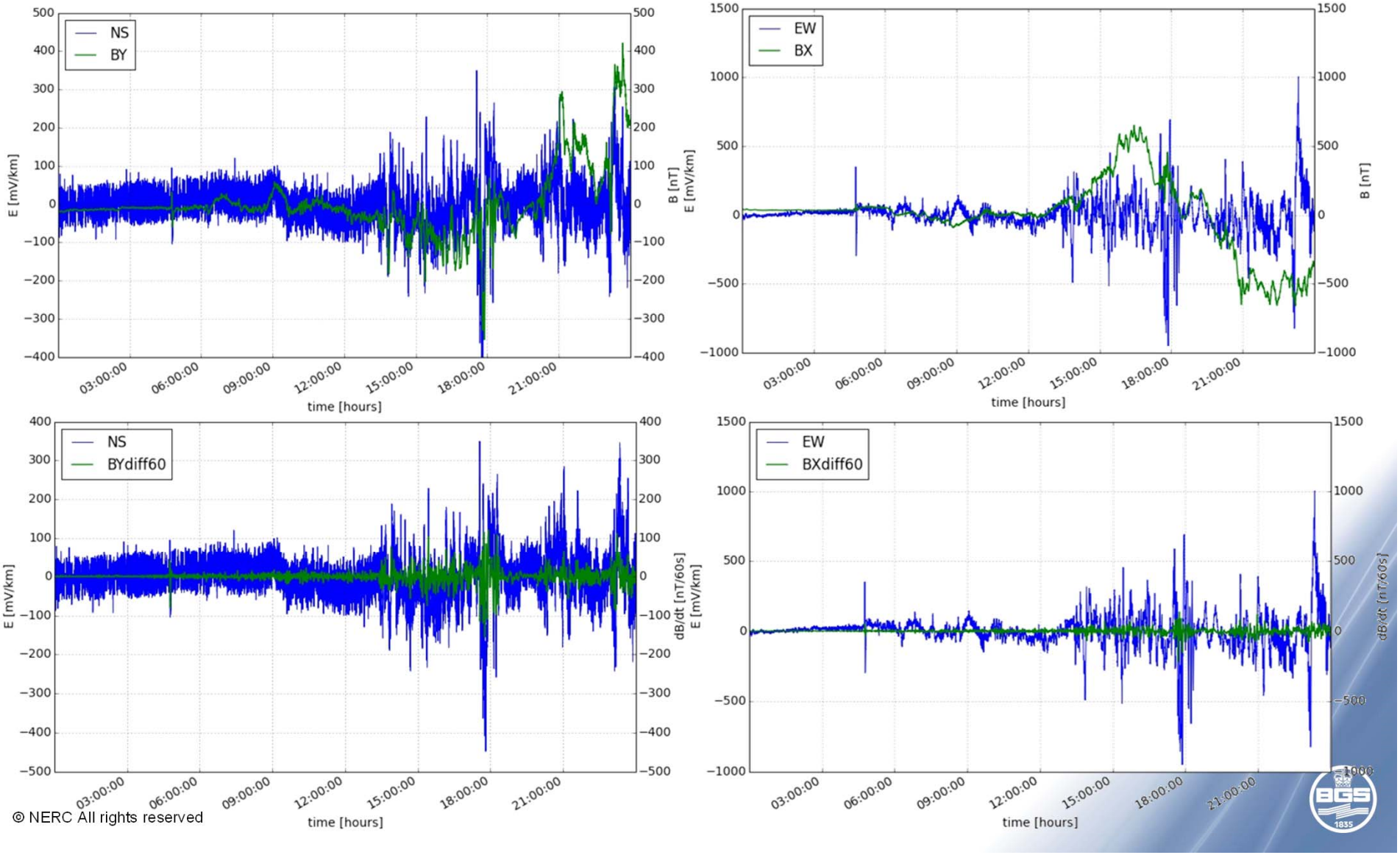
Slide 5

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

awpt3

17th March 2015: Lerwick



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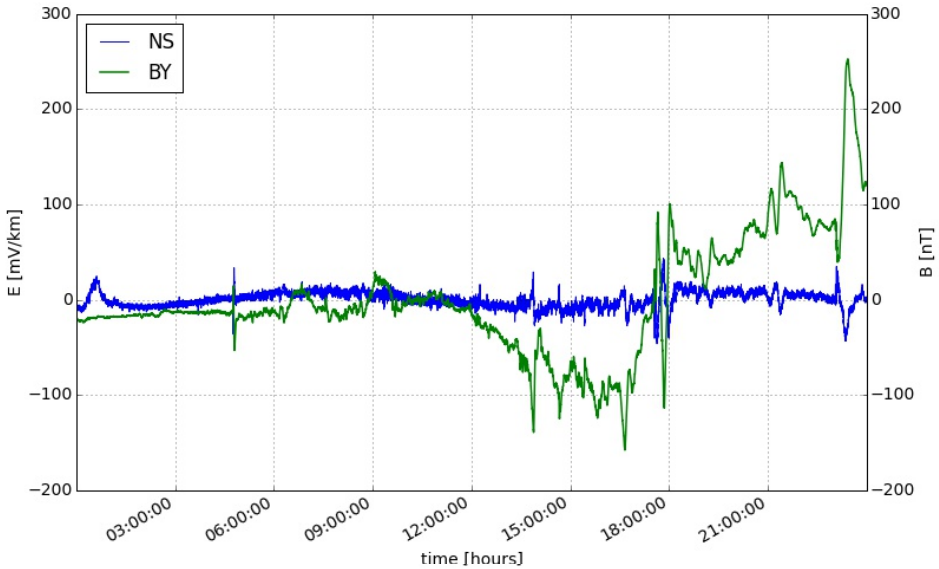
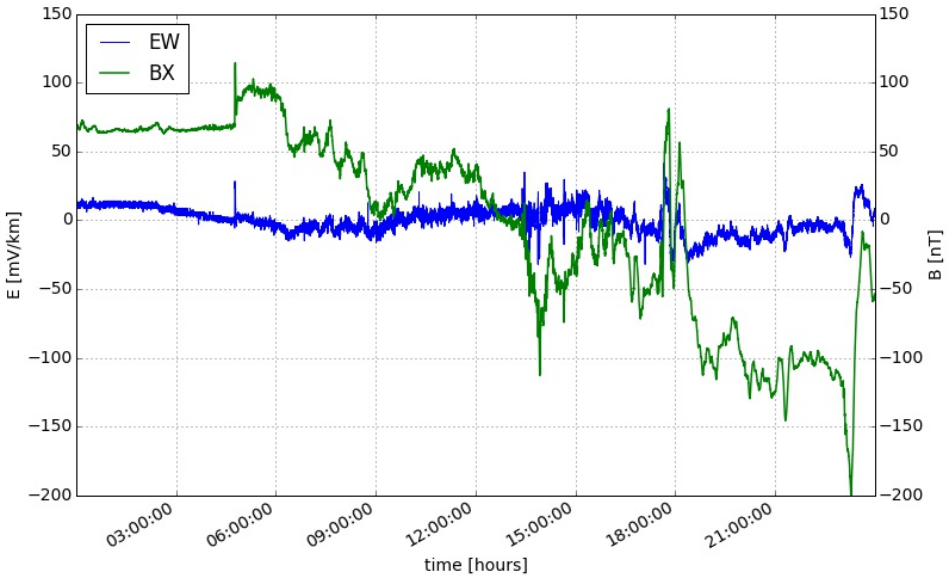
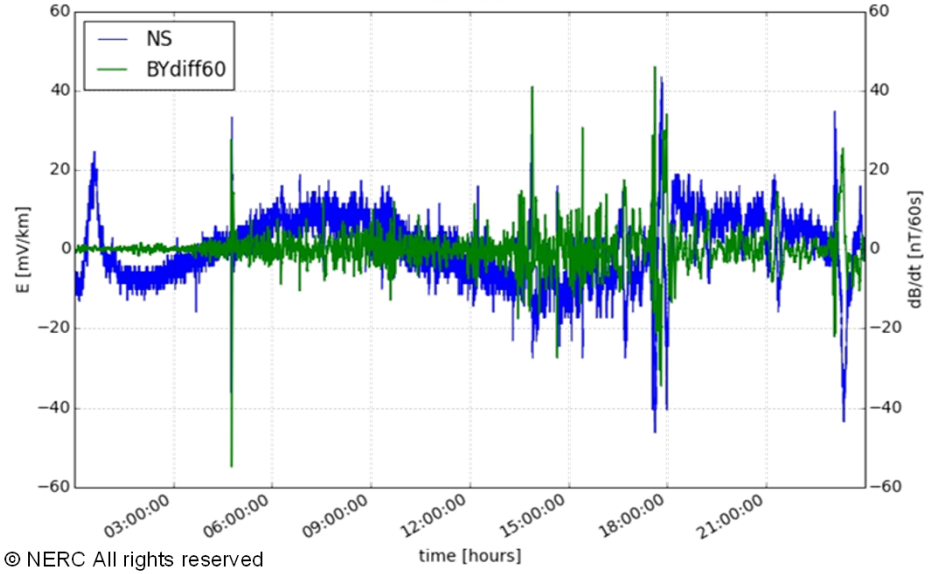
Alan Thomson, 29/04/2015

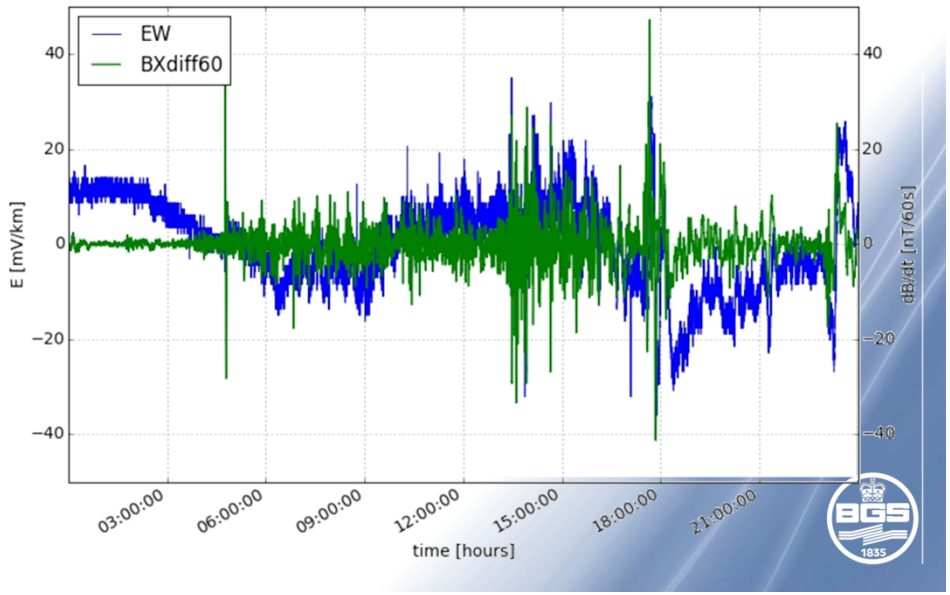
awpt3

17th March 2015: Hartland









Slide 7

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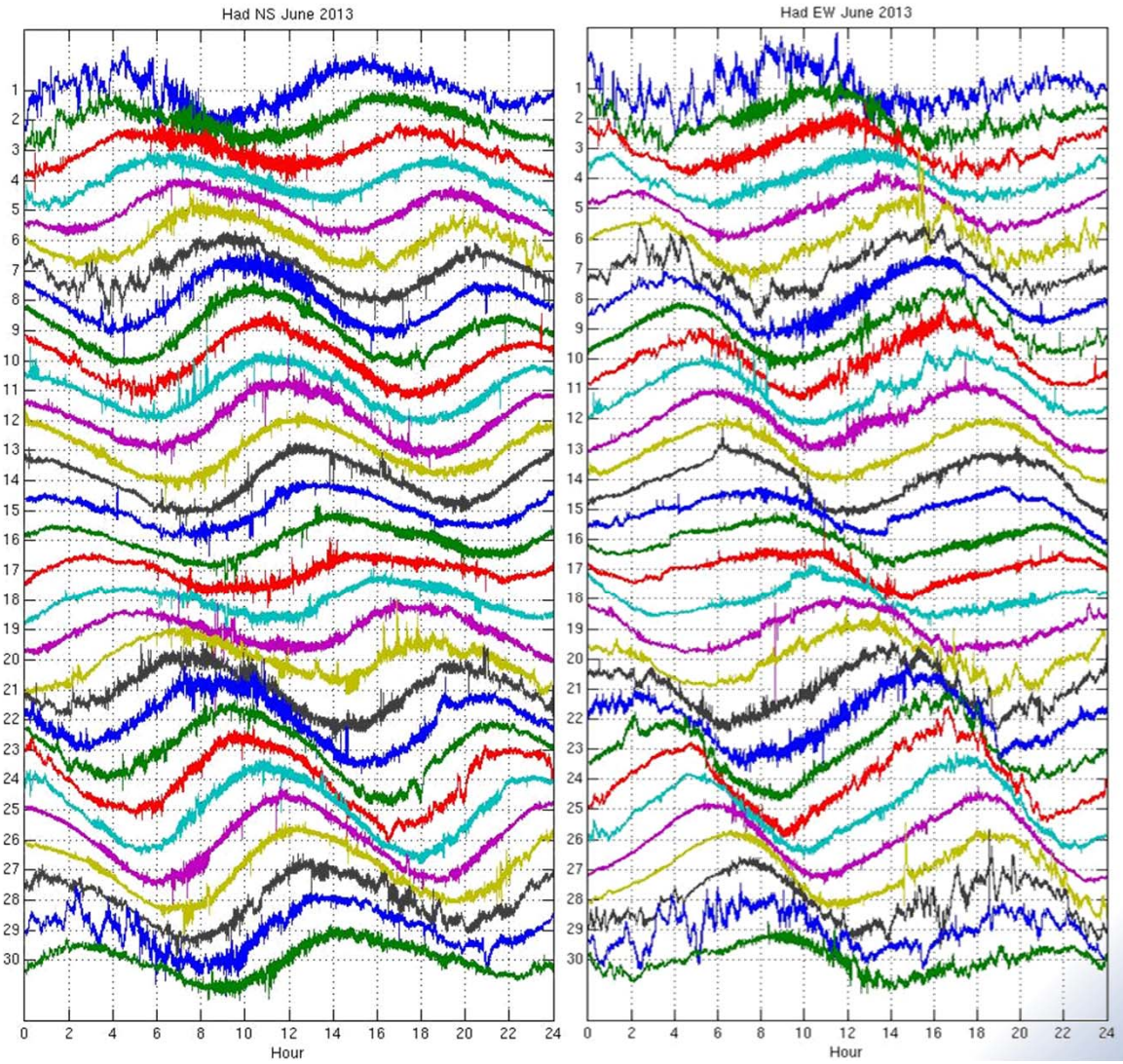
Alan Thomson, 29/04/2015

Tides

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

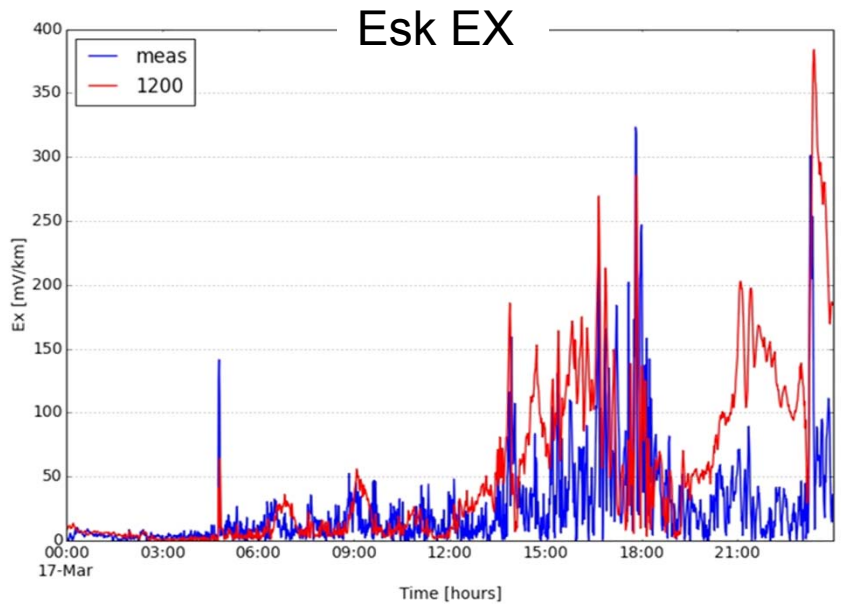
Ex

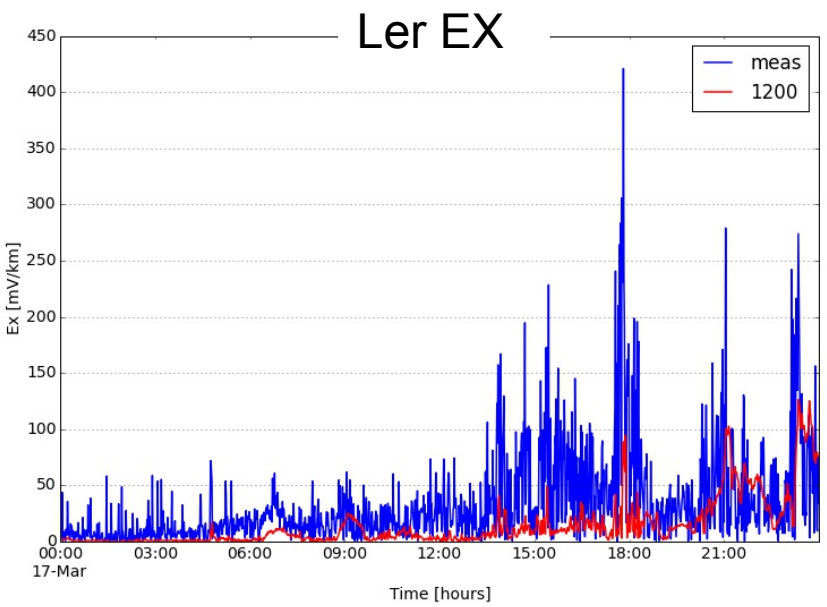


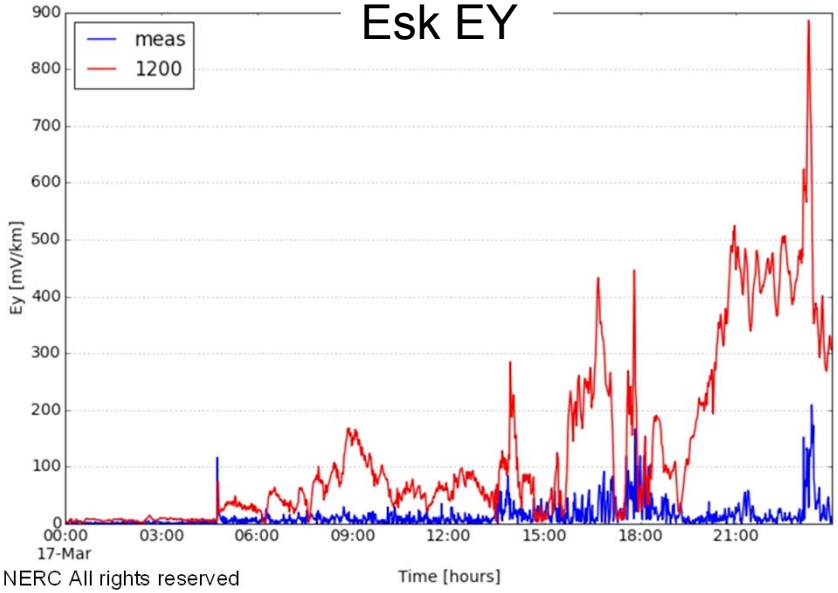
Ey

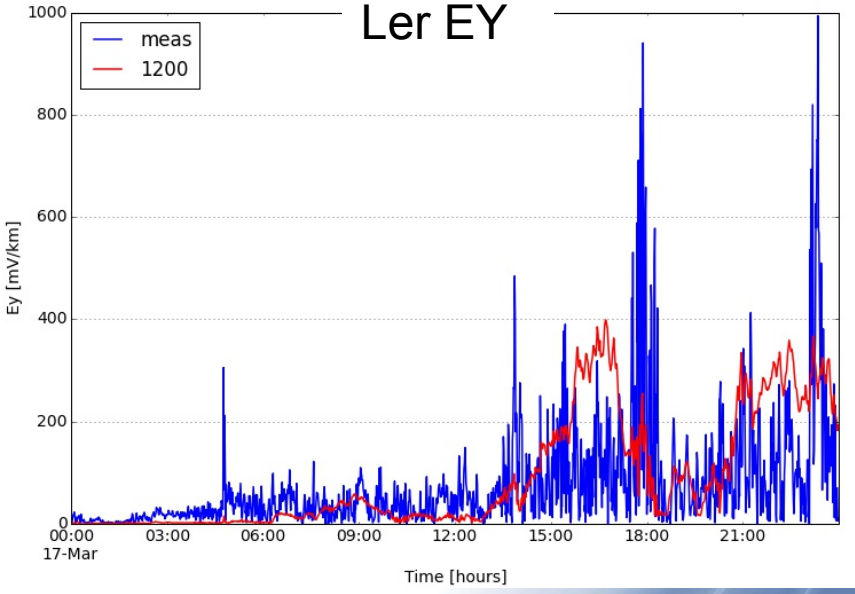
Comparison with model: 17th March 2015

SECS Source field, assumed period of 20 minutes









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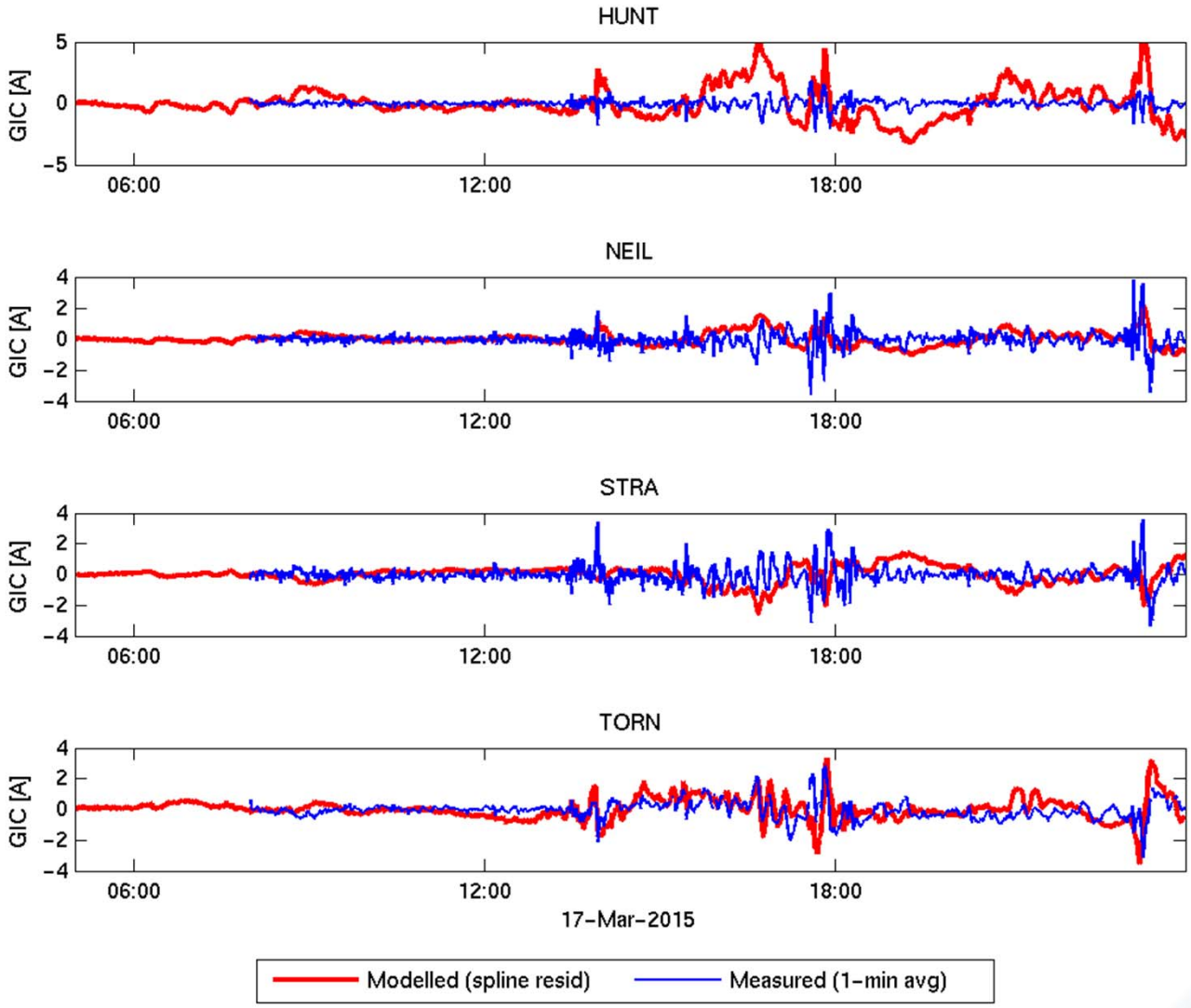
GIC model

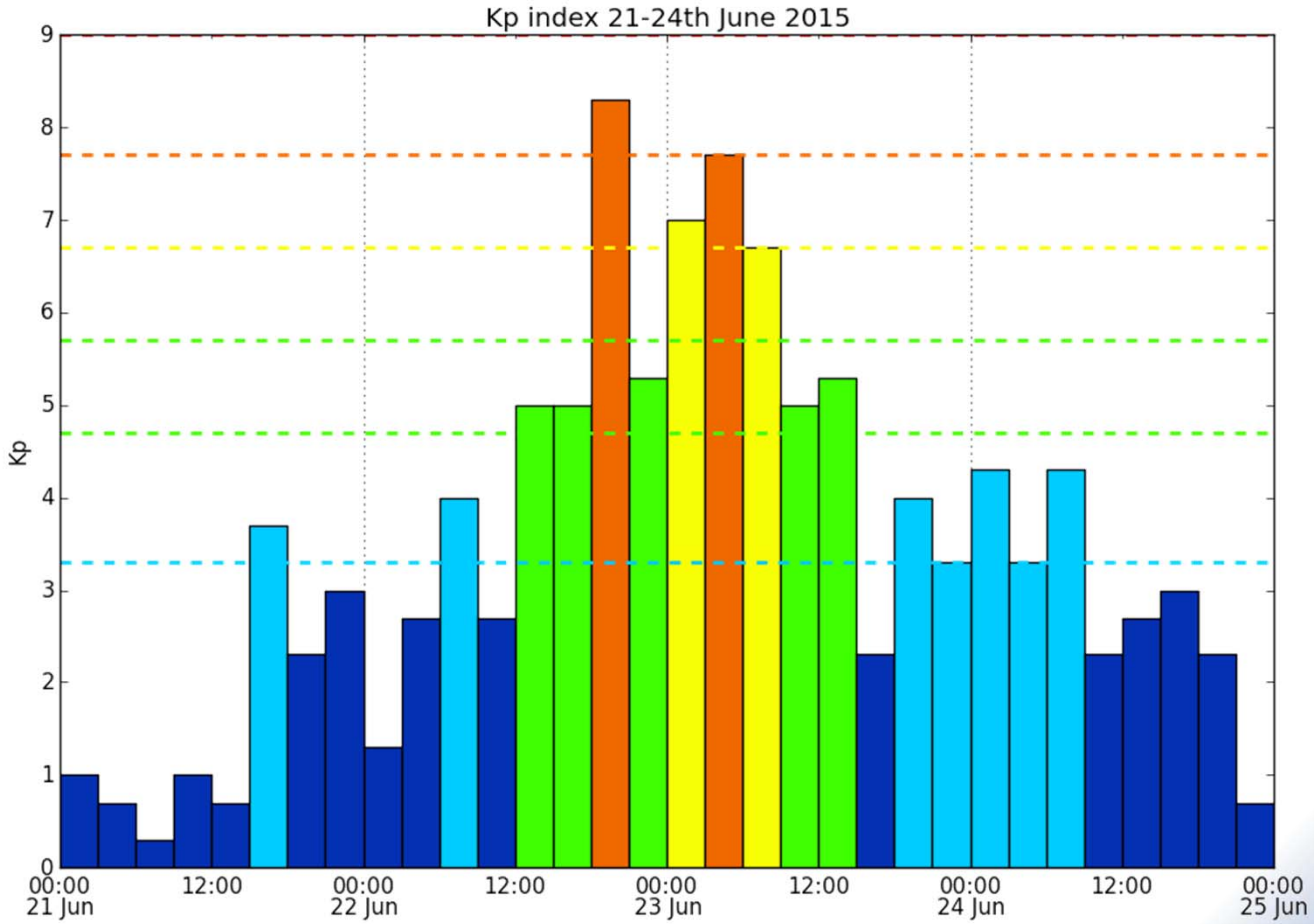


Slide 10

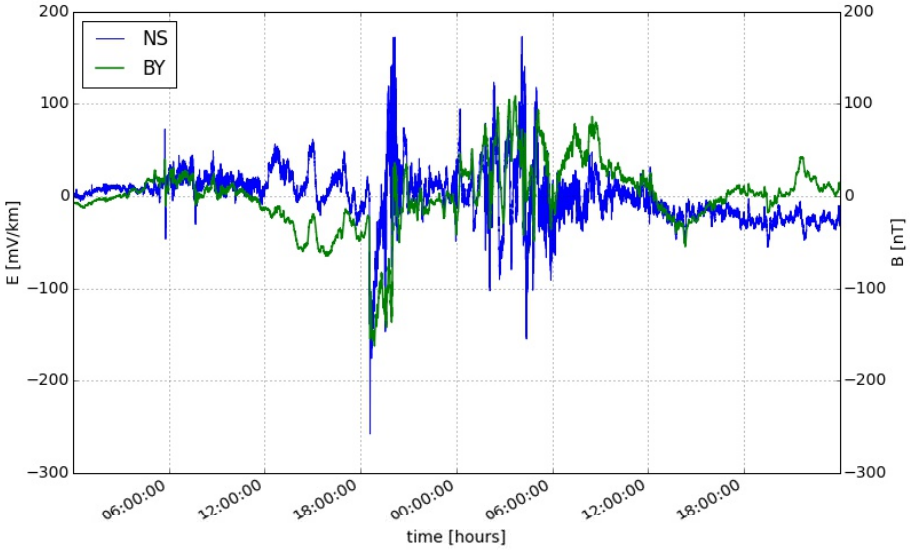
awpt6 Get Ciaran's thoughts on this before he goes off on paterntity leave, e.g. based on his modelling results

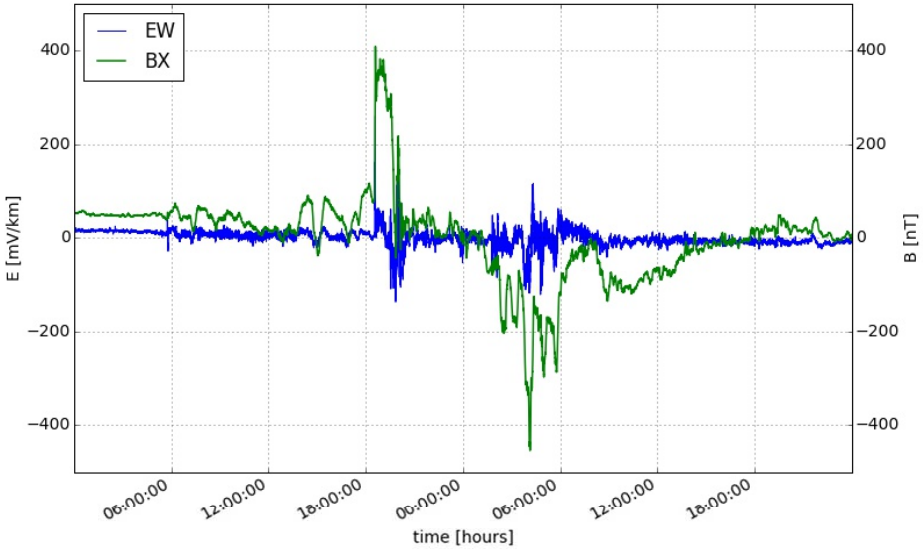
Alan Thomson, 29/04/2015

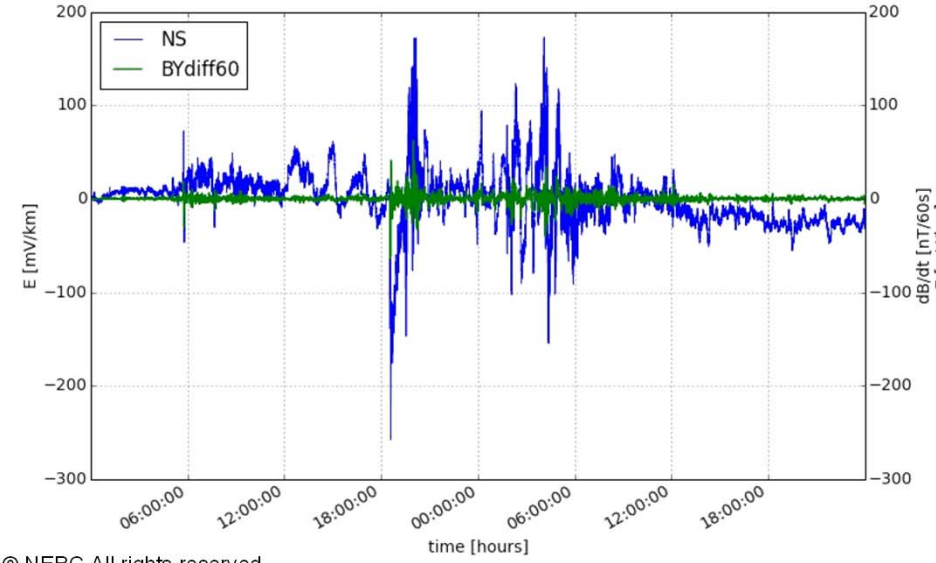
22nd-23rd June 2015

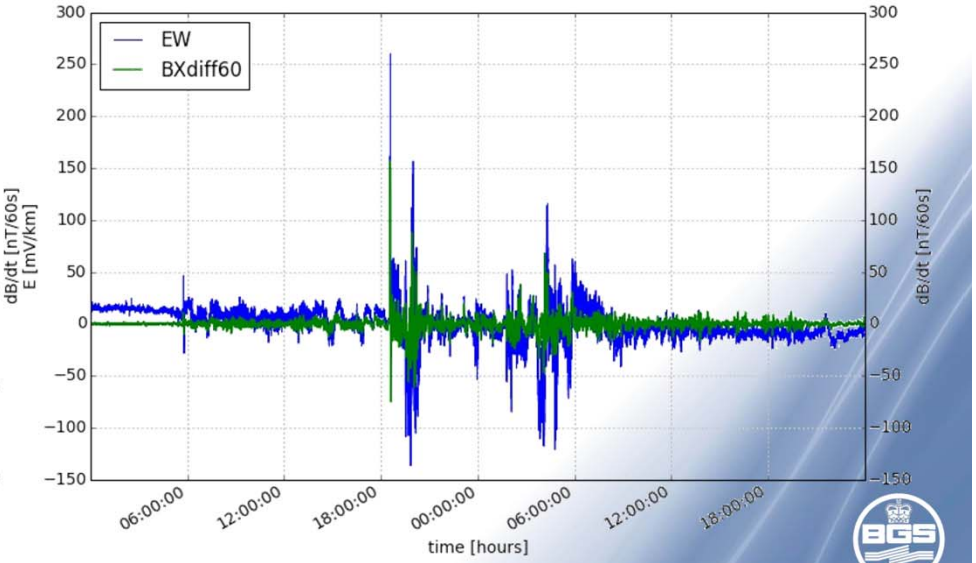


22nd-23rd June 2015: Eskdalemuir

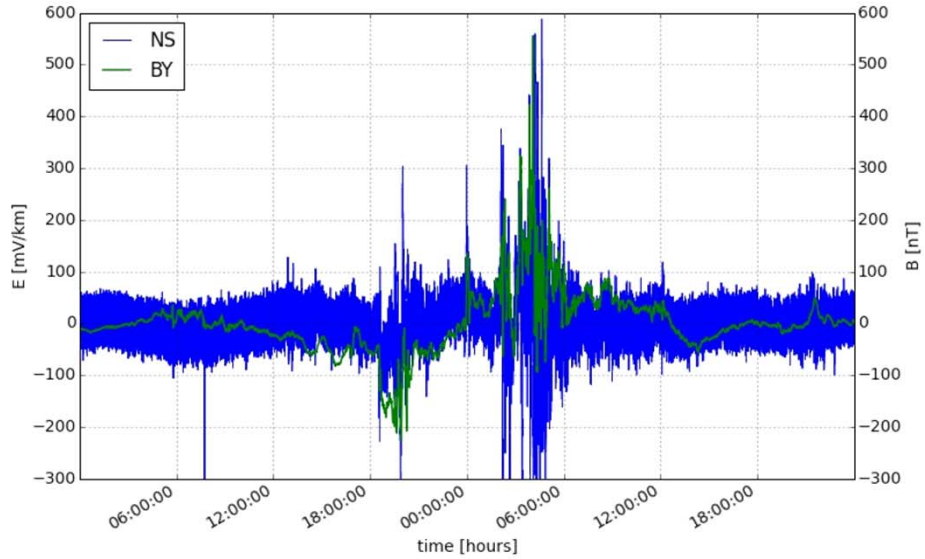


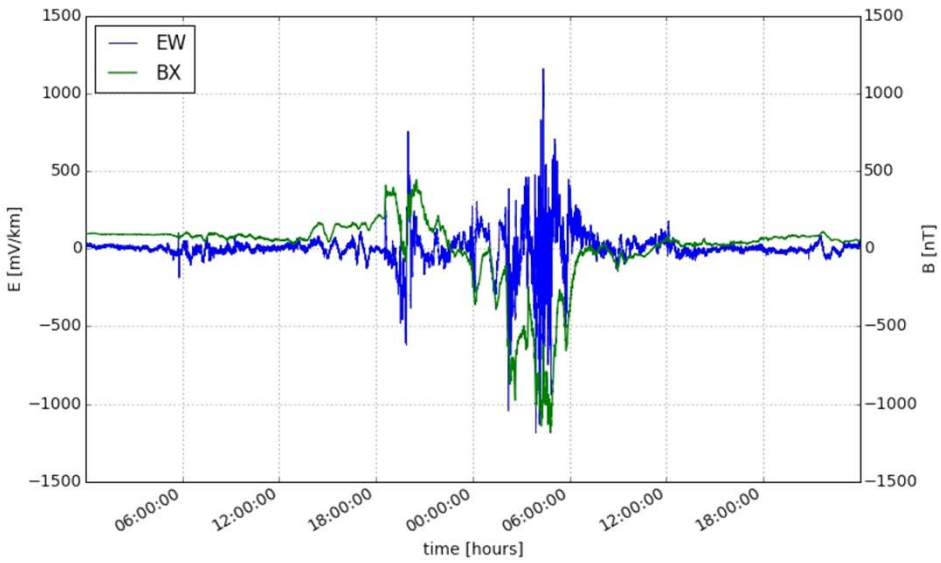


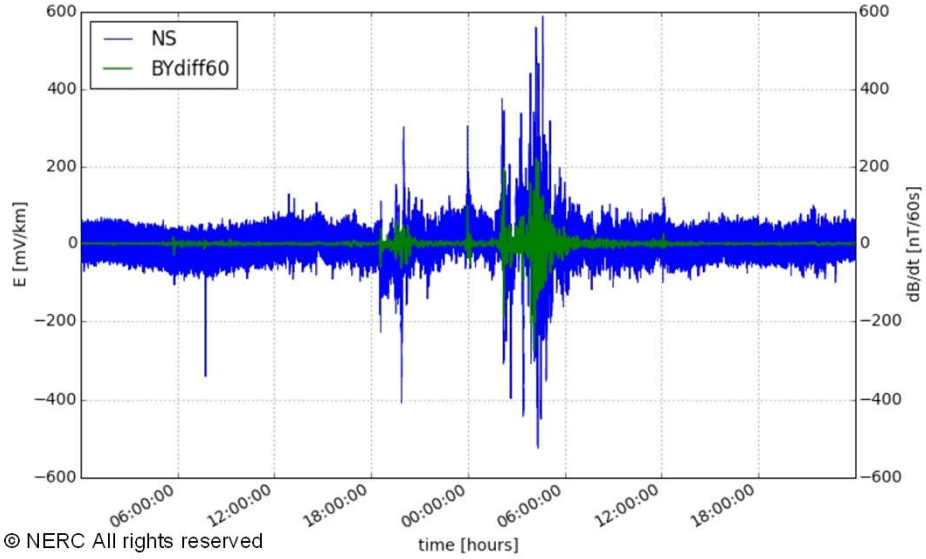


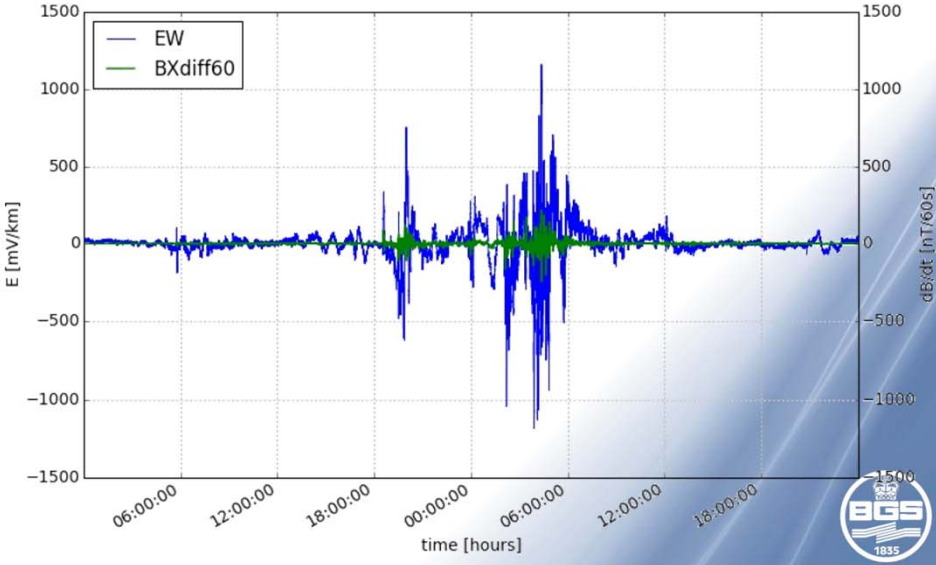


22nd-23rd June 2015: Lerwick

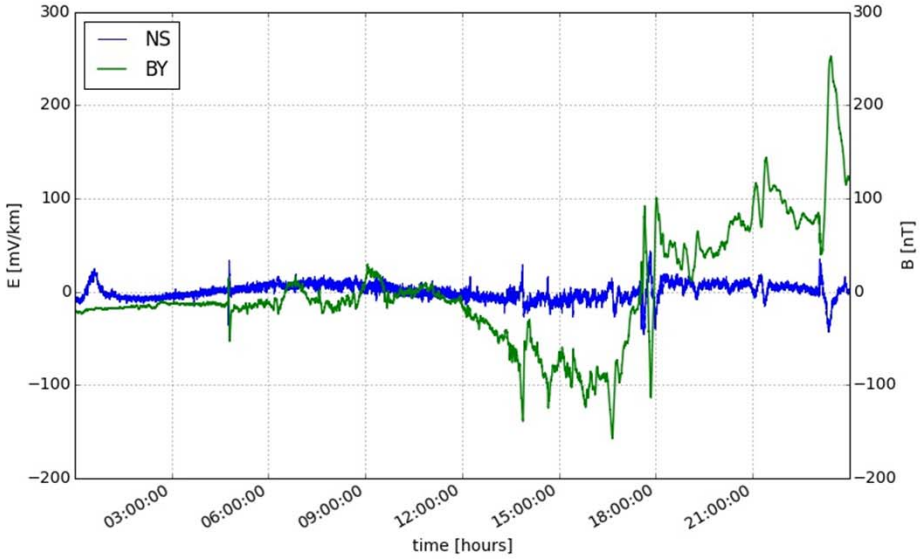


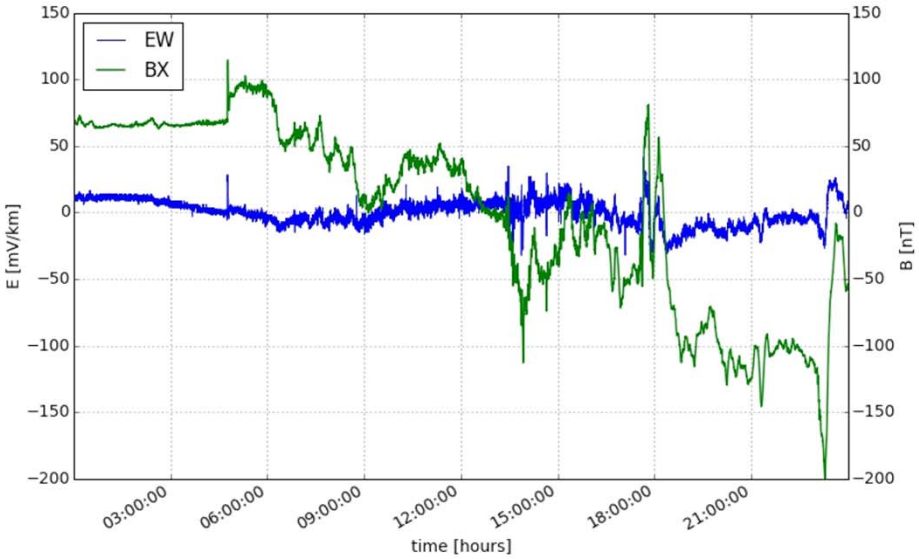


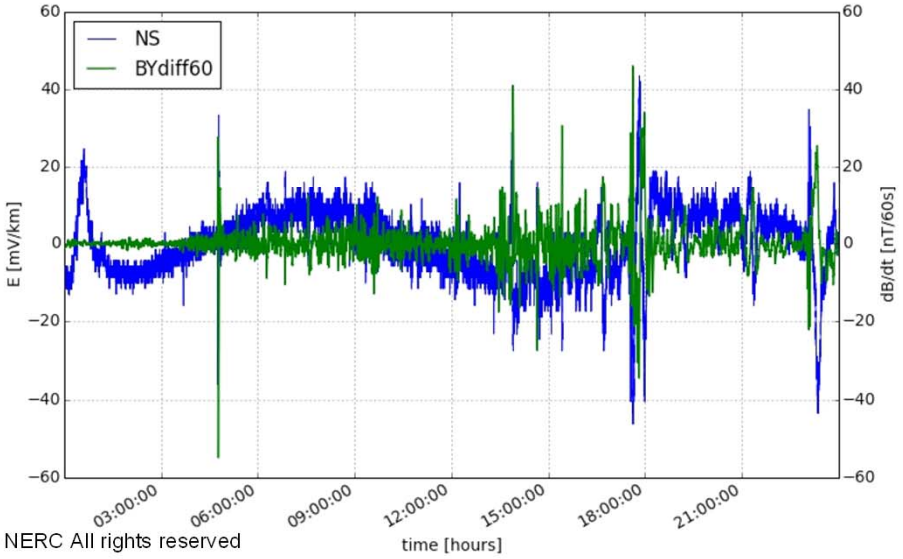


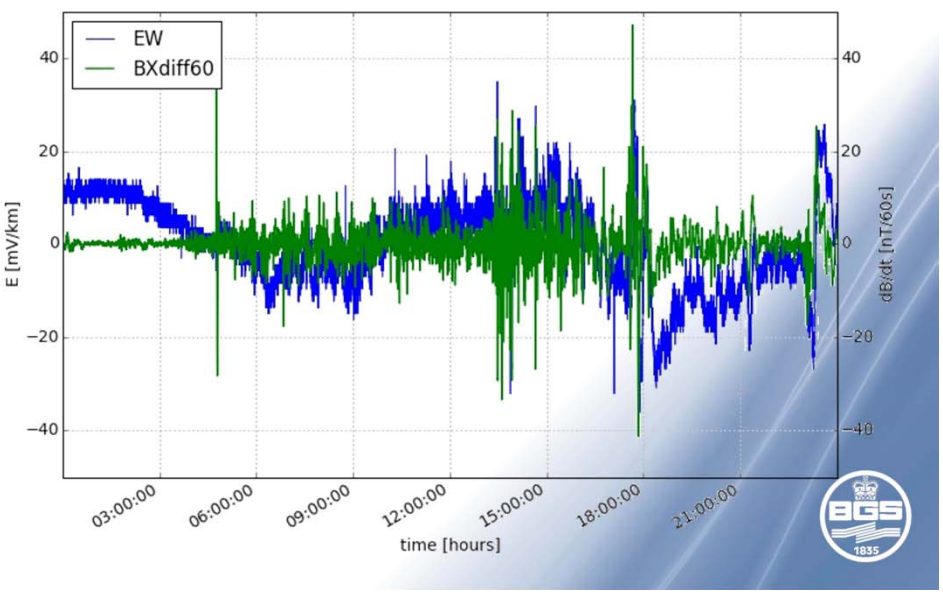


22nd-23rd June 2015: Hartland



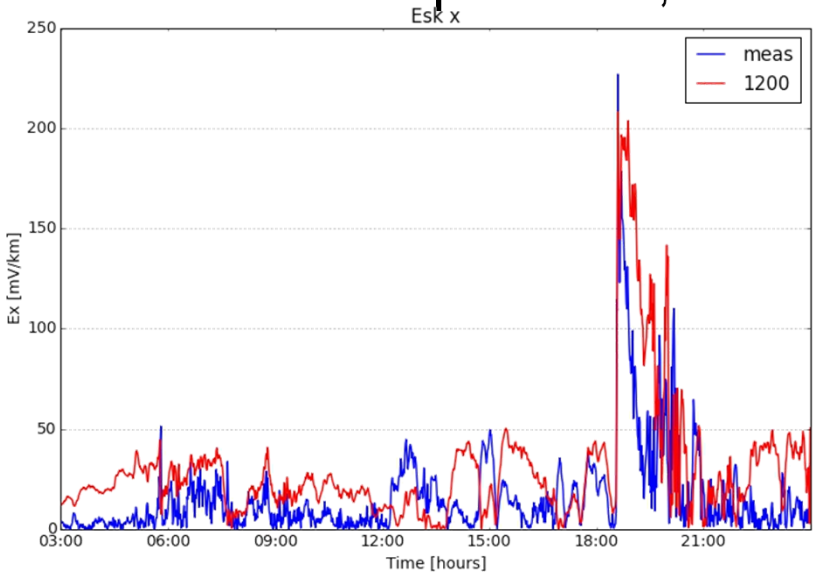


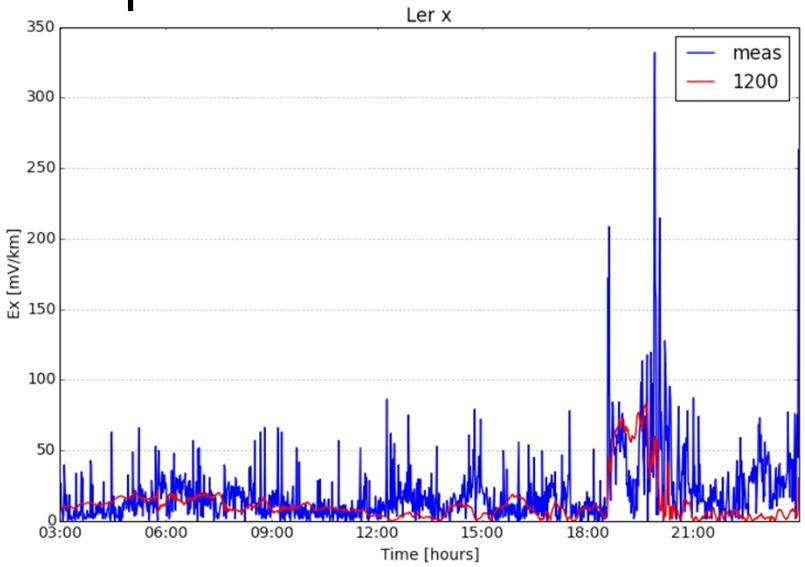


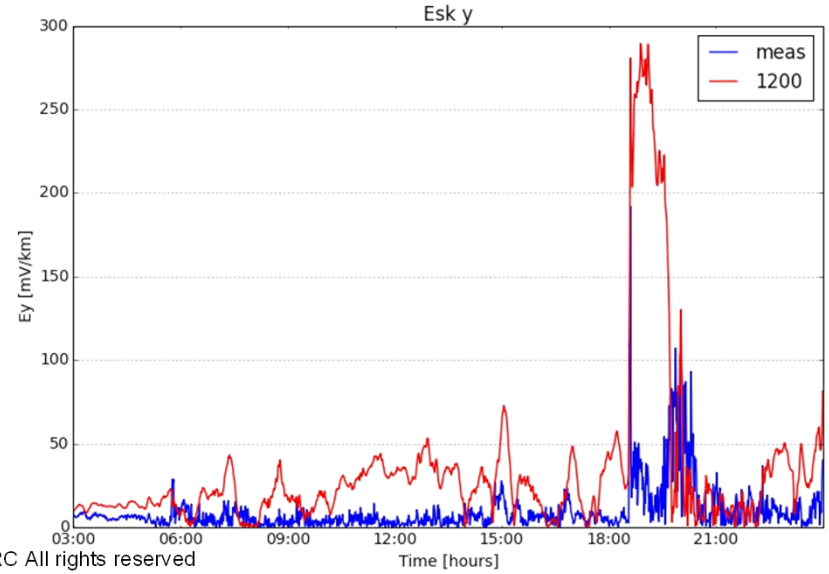


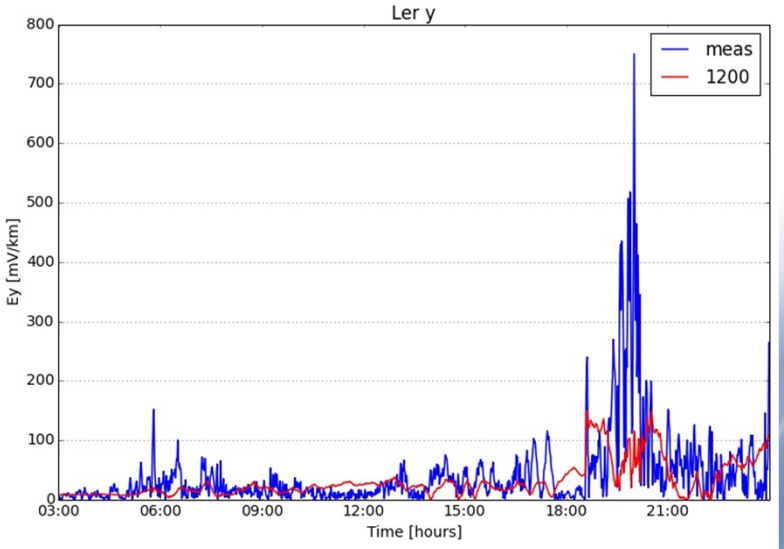
Comparison with model: 22nd June 2015

Plane wave interpolation, assumed period of 20 minutes



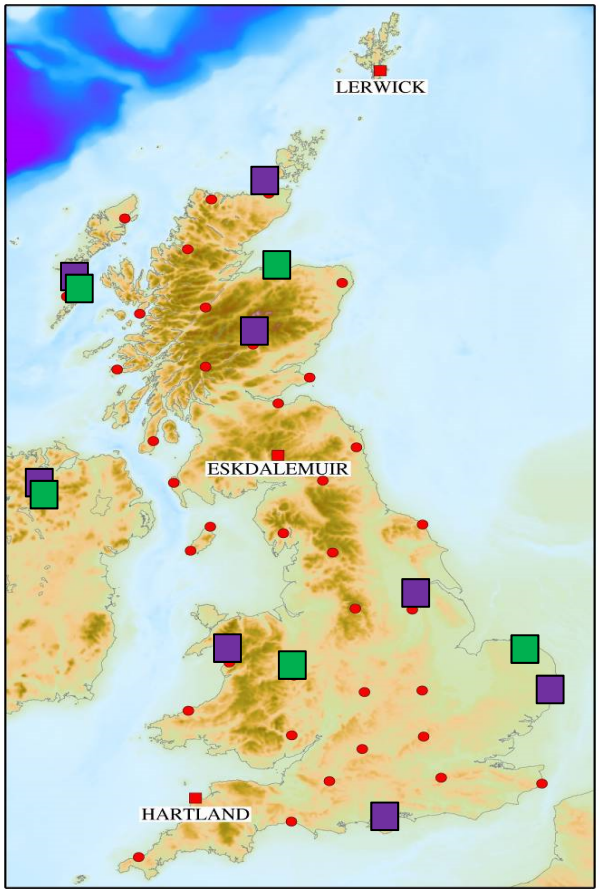






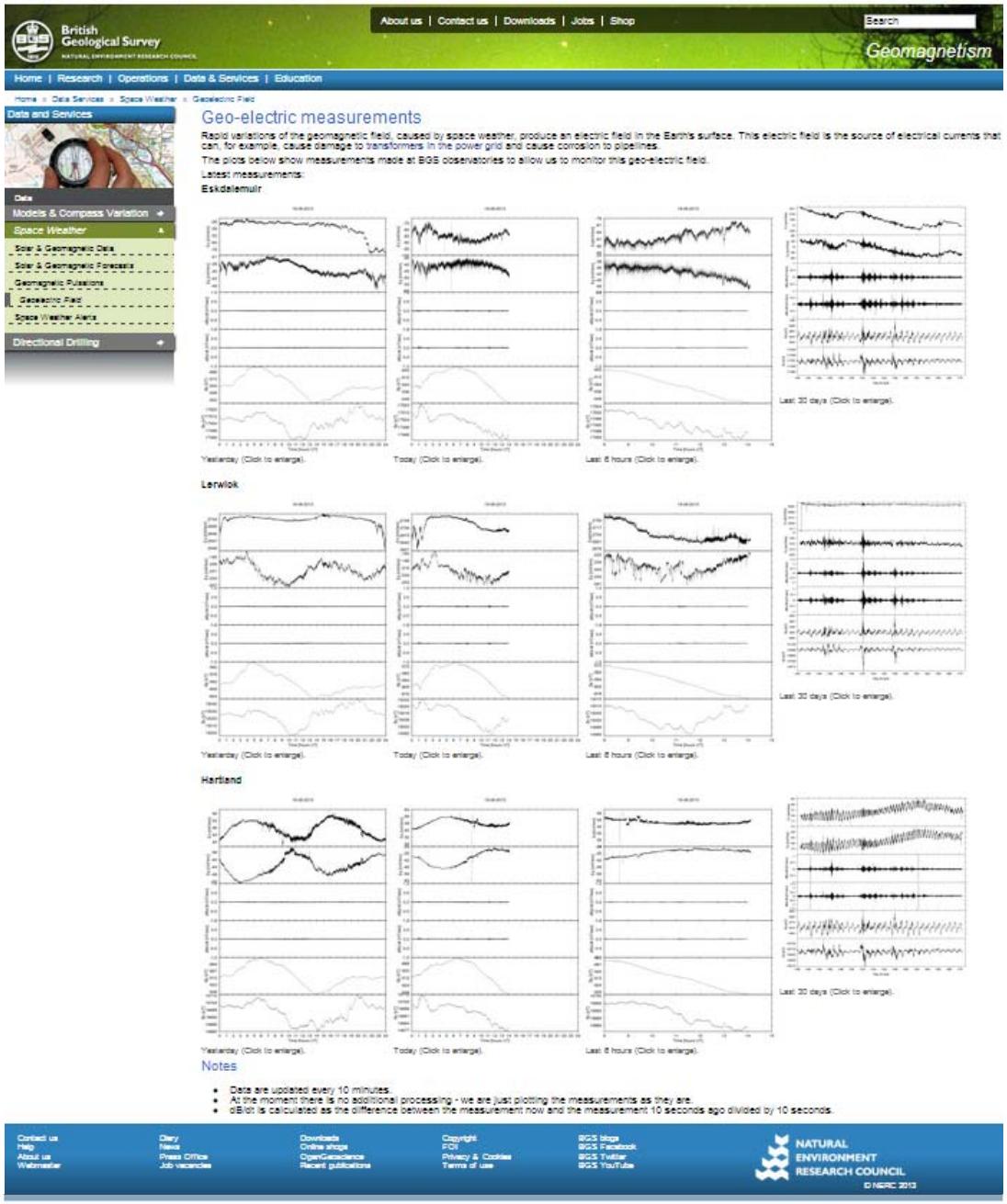
Future developments

- 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

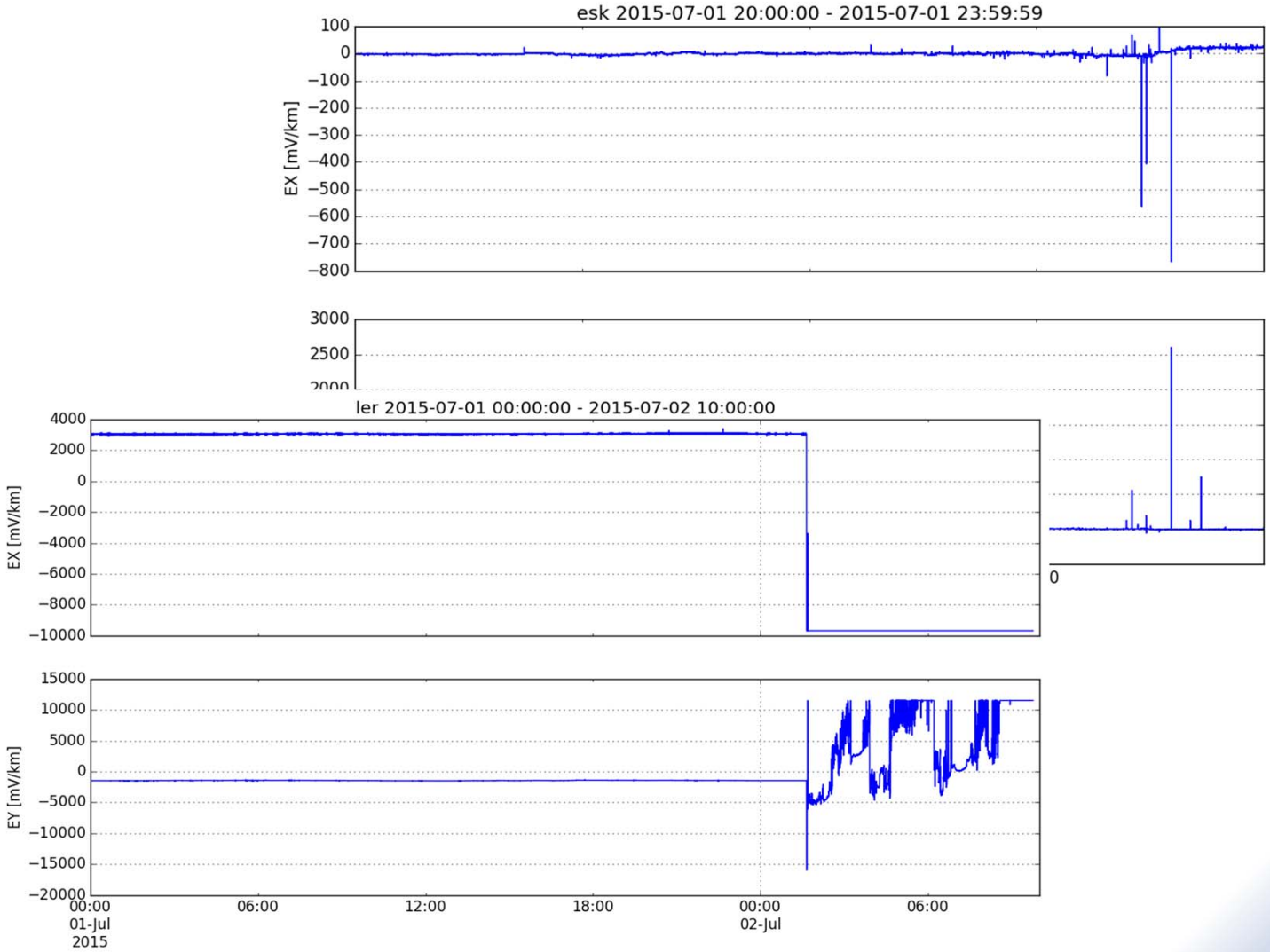
- Tides, rainfall, lightning and probably temperature variations in the data
- Other problems and noise evident in the data, this is very much a learning experience
- E-field data follows both B and dB/dt suggesting complex geology
- Comparison with the model:
  - Clear local differences w.r.t measurements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



http://ow.ly/OSaZ3

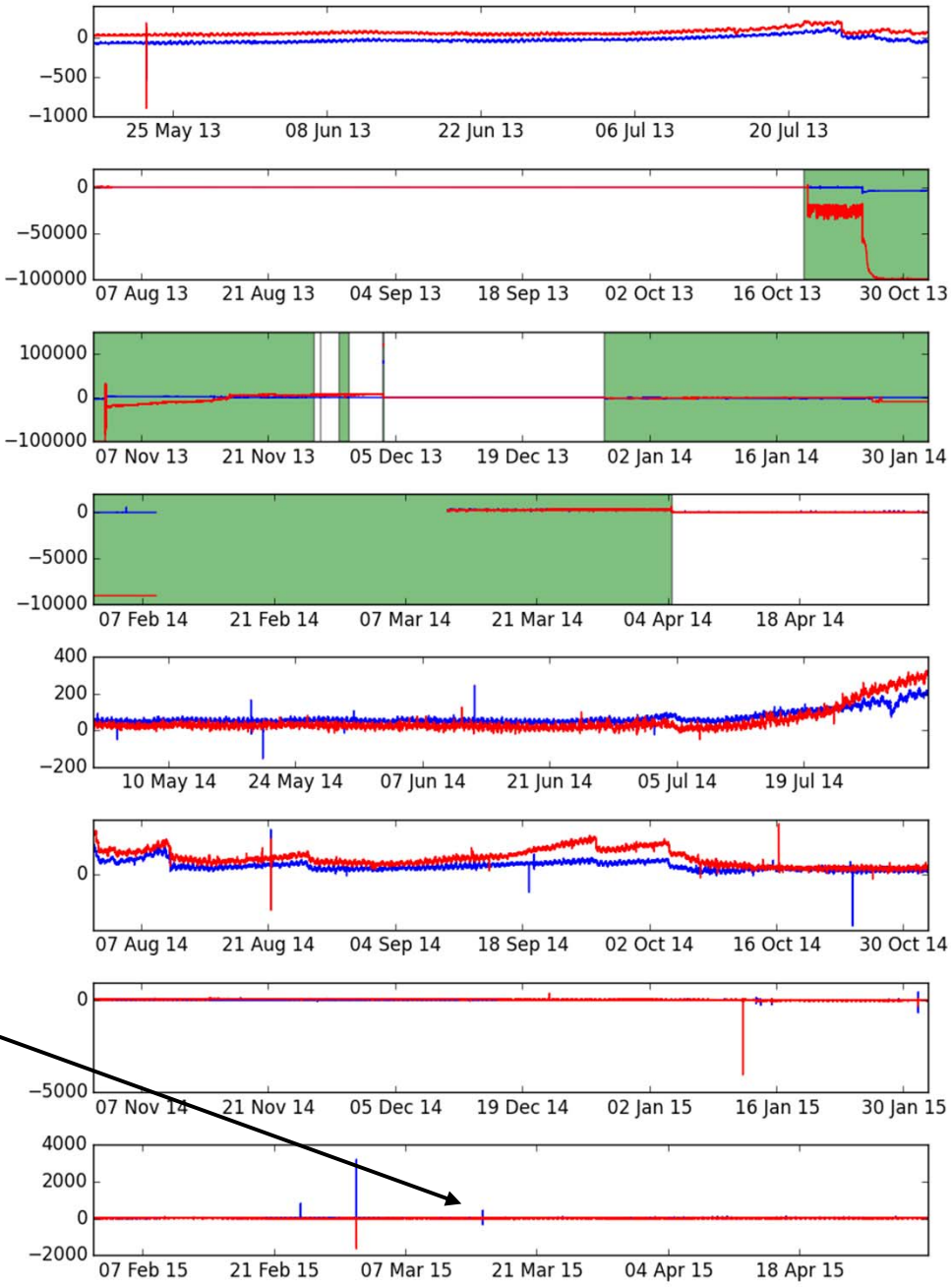
http://www.geomag.bgs.ac.uk/data_service/space_weather/geoelectric.html

Lightning



Data quality

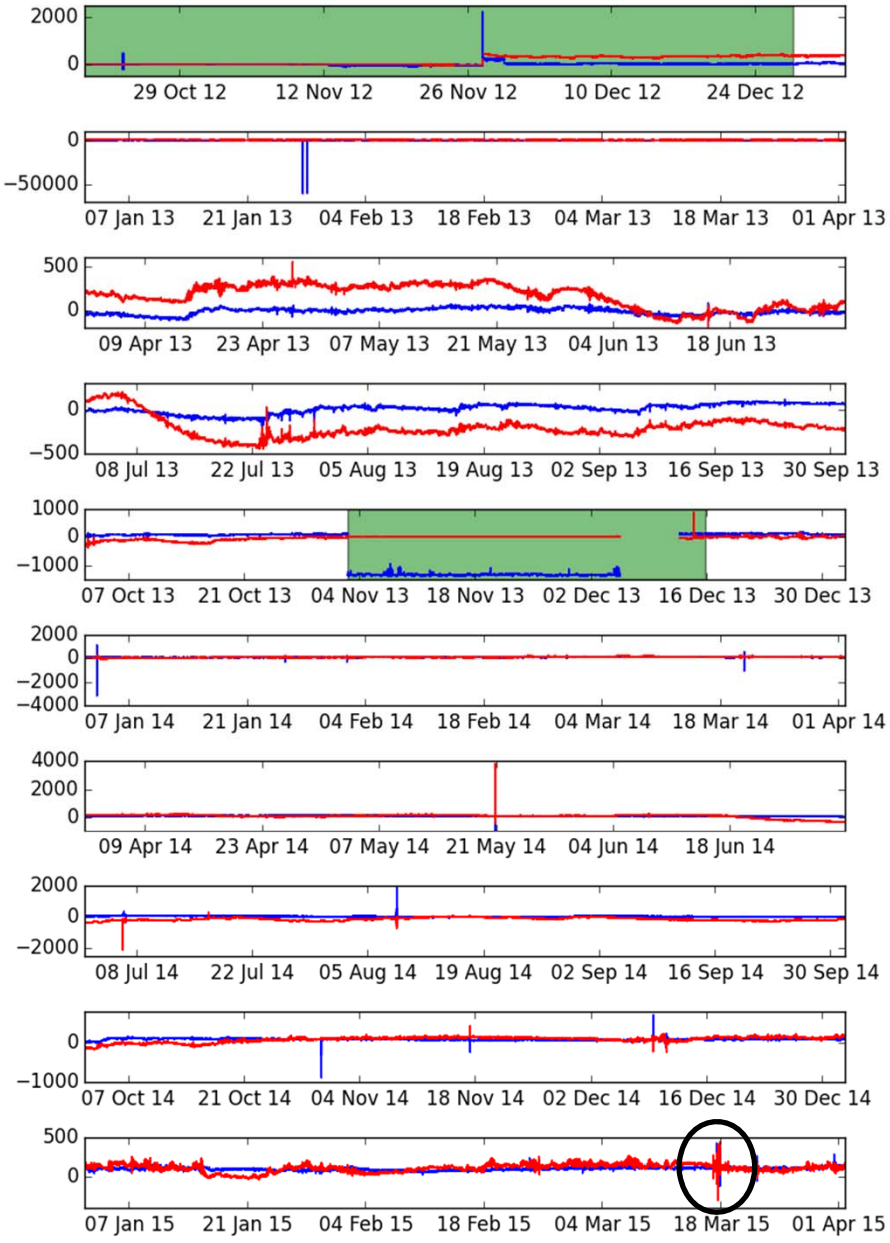
- Example of the raw data over nearly 2 years
  - Green shading shows where there are clear problems
  - Steps and spikes common
  - Note auto-scaling is used



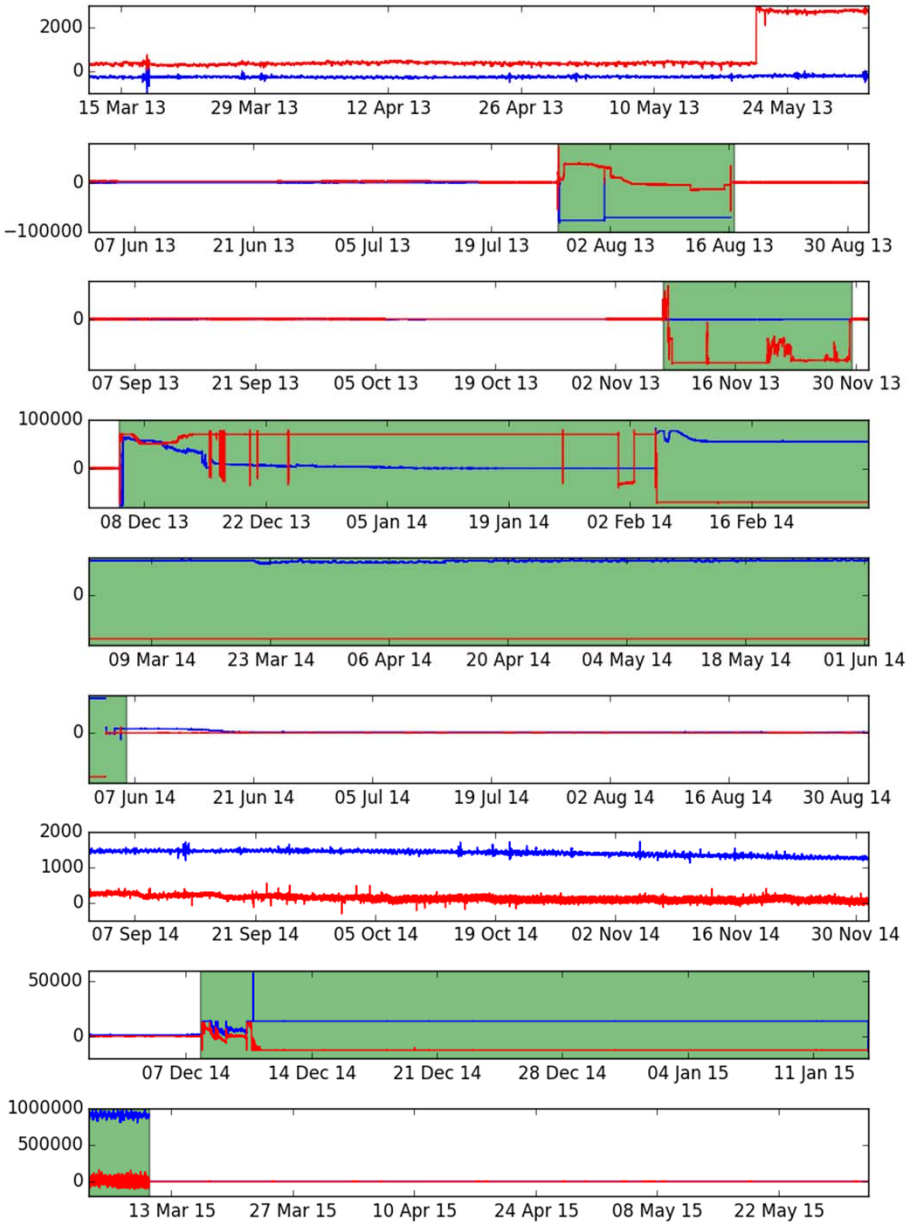
St Patrick's day magnetic storm

Hartland

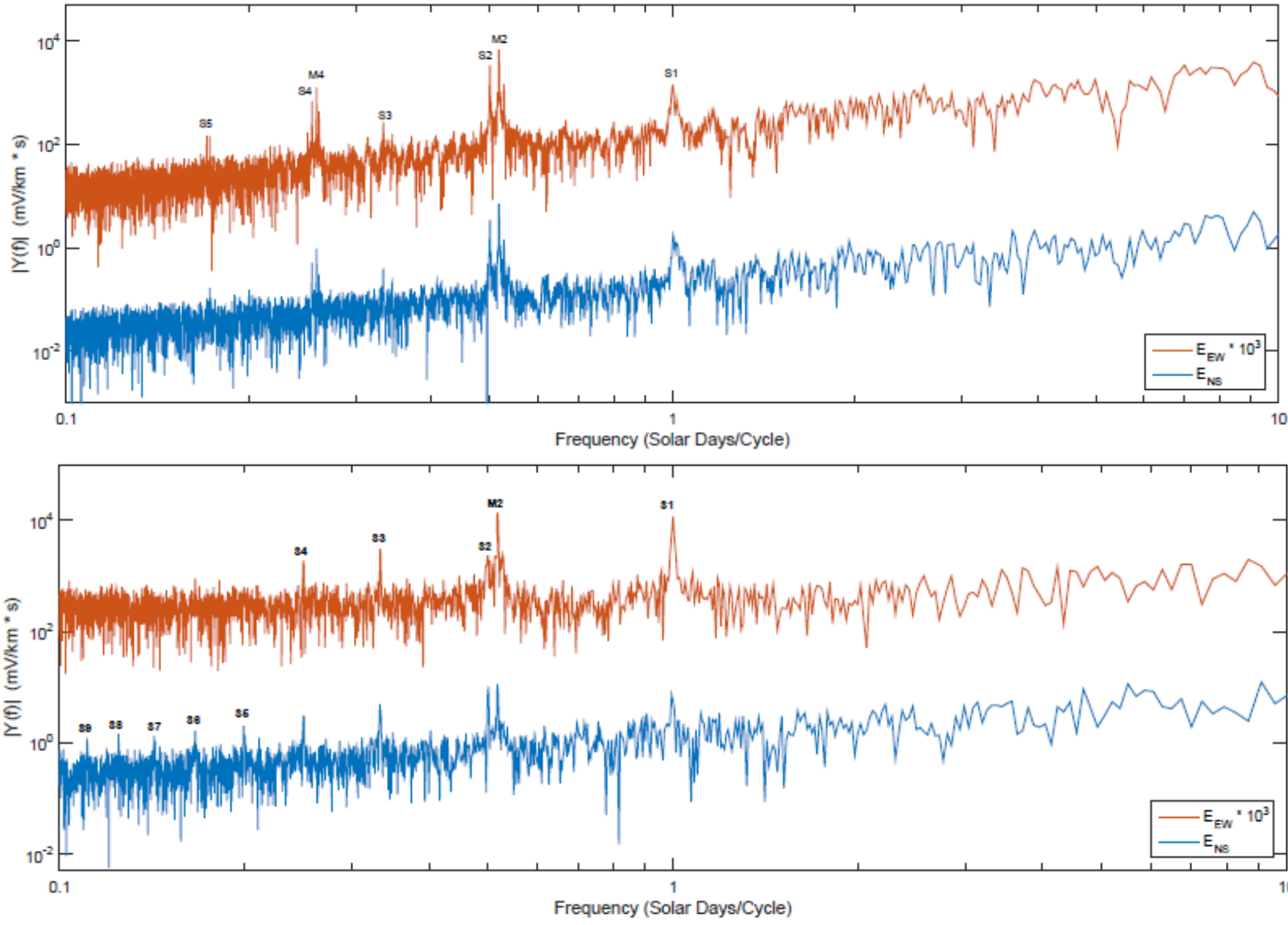
Eskdalemuir



Lerwick



Tidal Signature at Hartland & Lerwick



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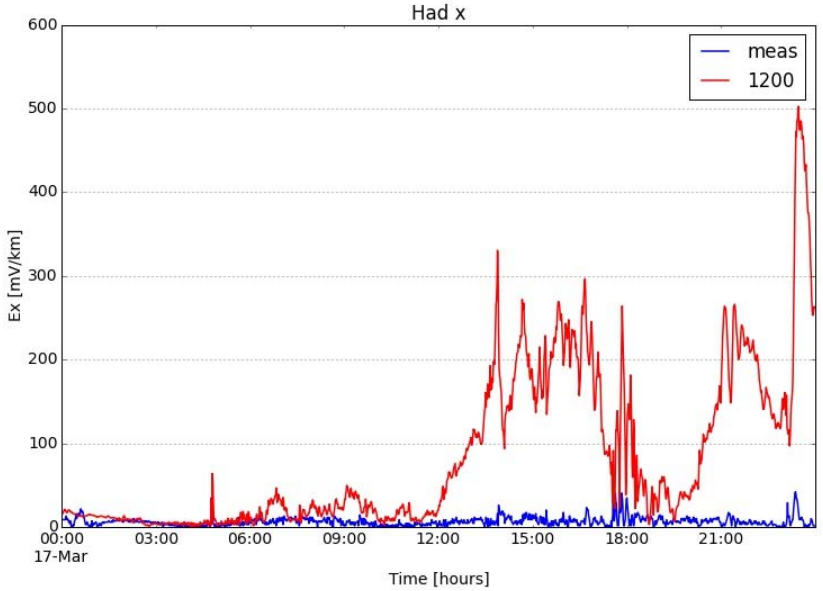
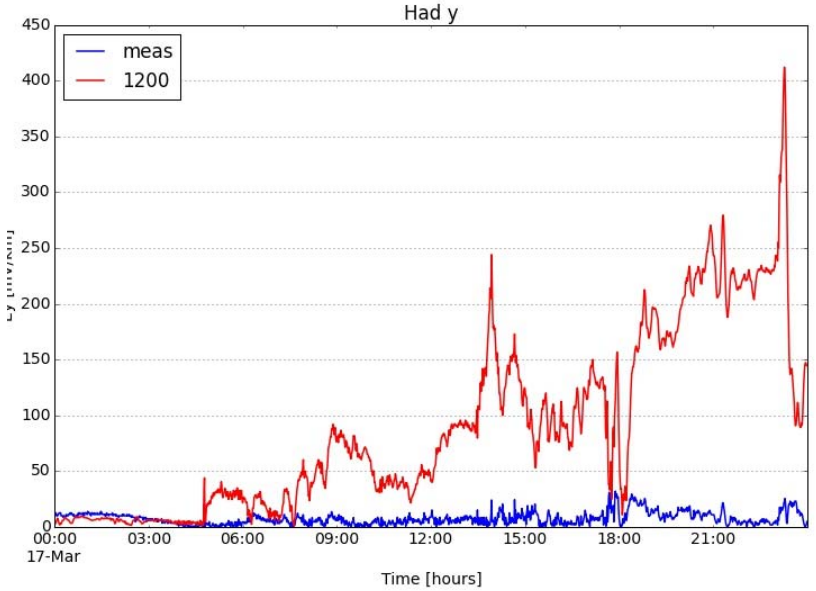
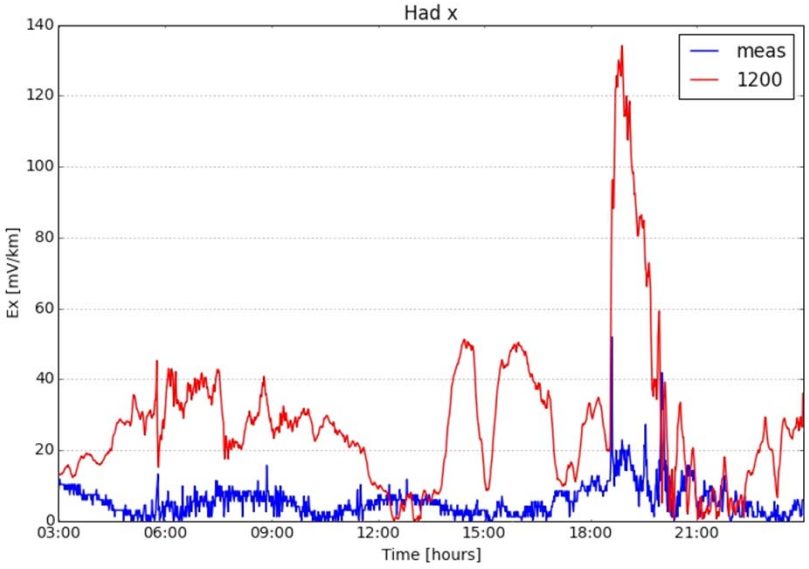
March 17th 2015: Hartland

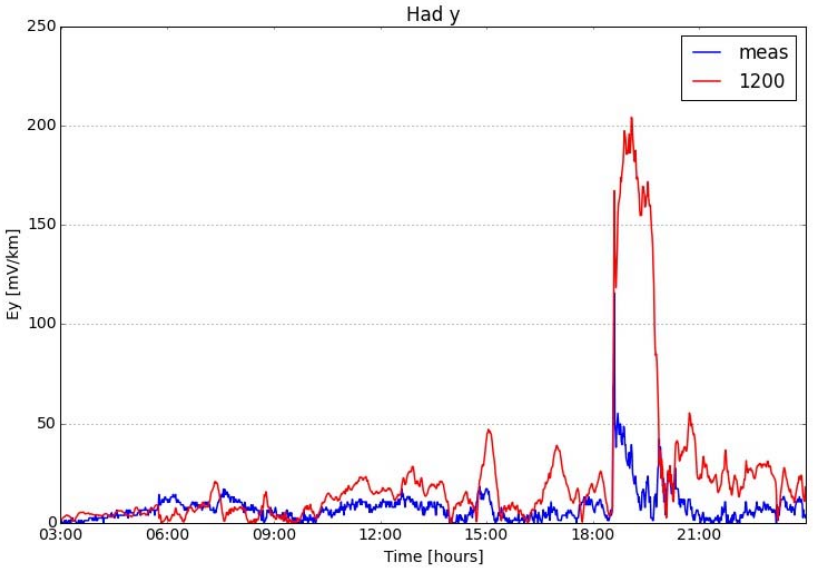




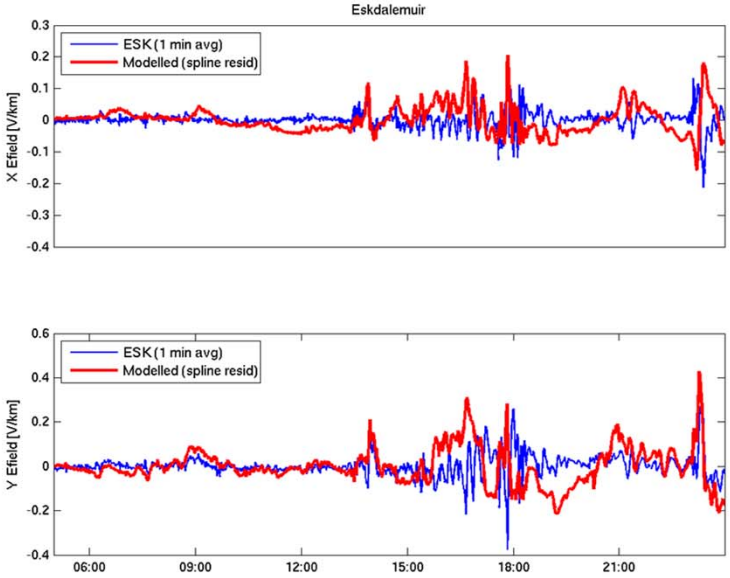
Comparison with model: 22nd June 2015

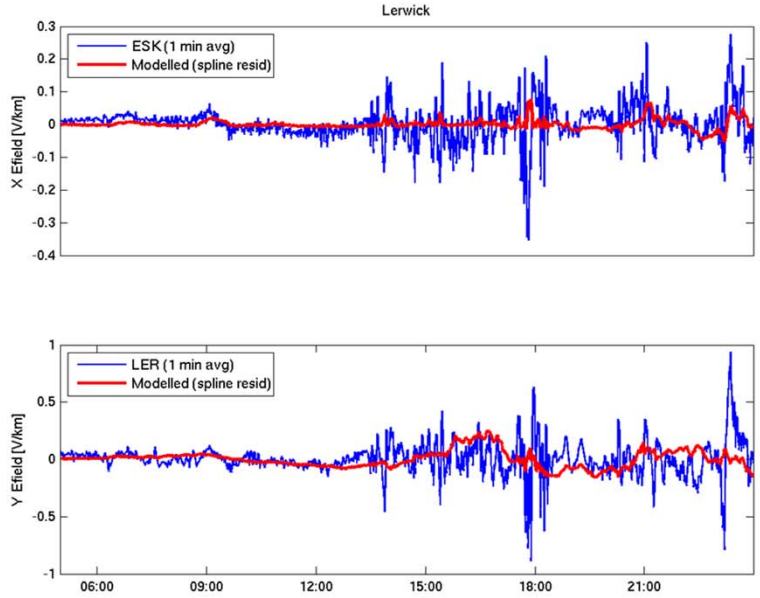
Plane wave interpolation, assumed period of 20 minutes

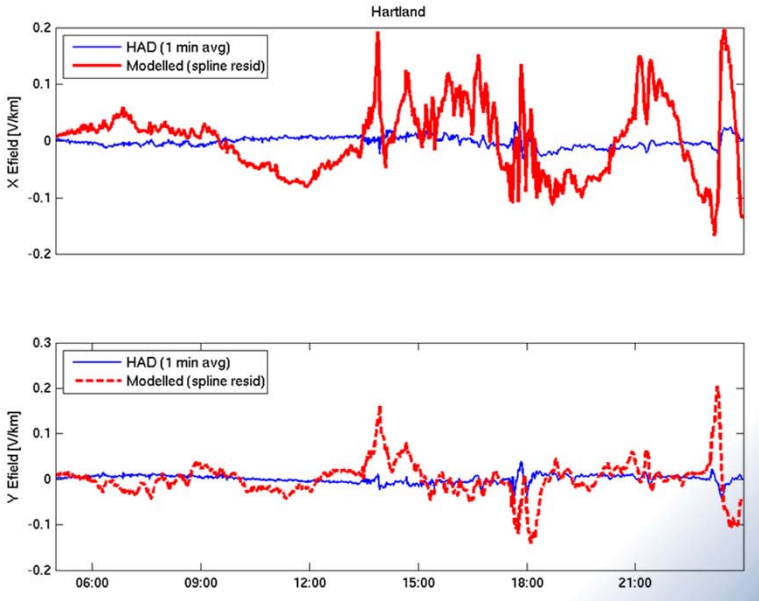




Spline fit to model to remove trend



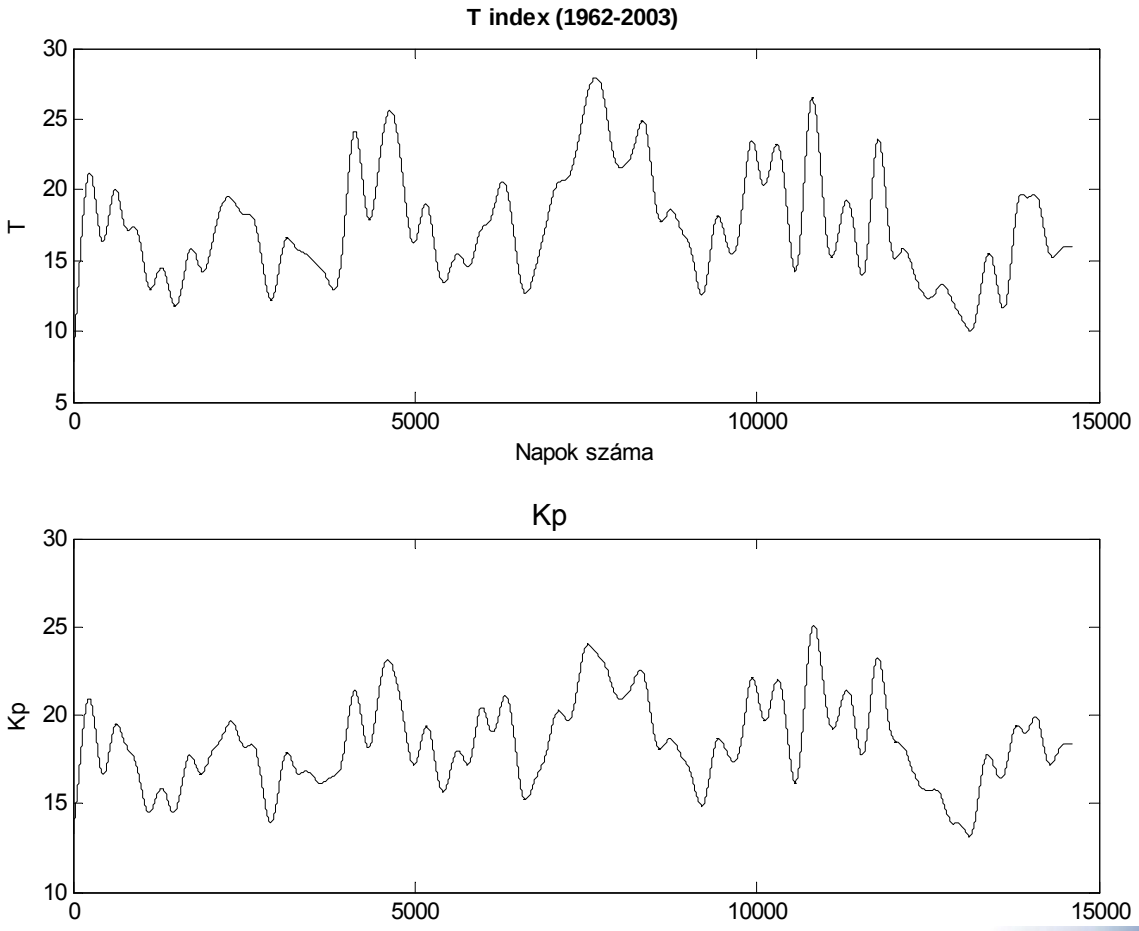




awpt2

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 Ex or Ey
- Daily sum of T is shown
- Perhaps other shorter duration indices would be better?



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

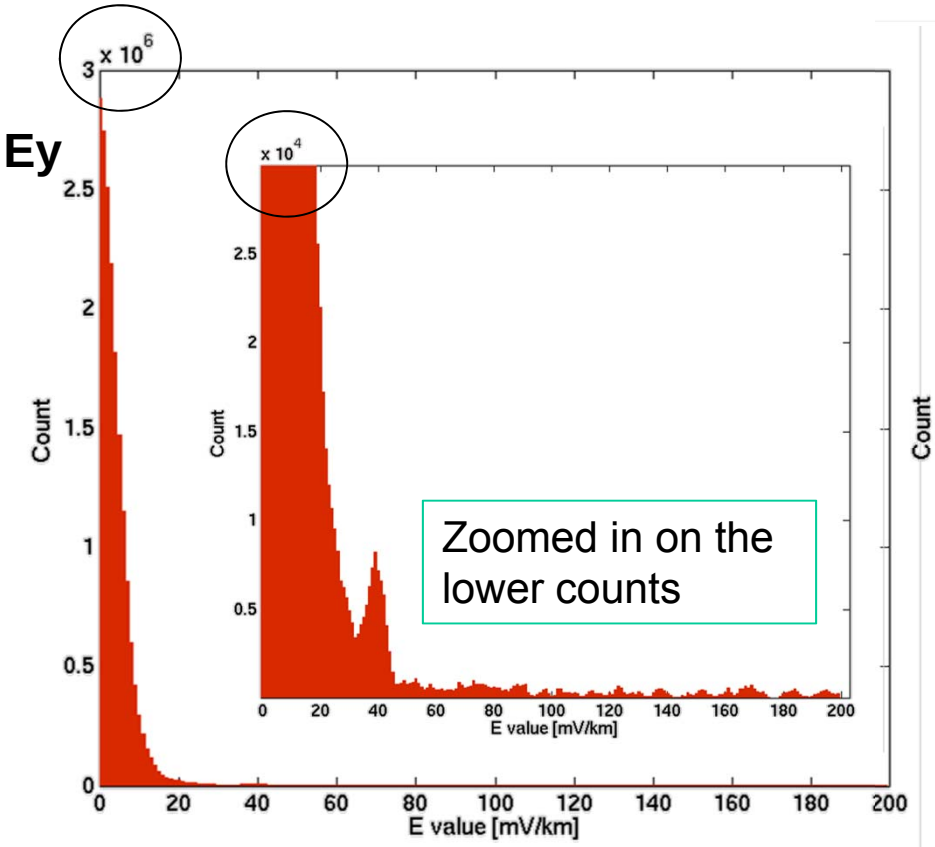
Slide 27

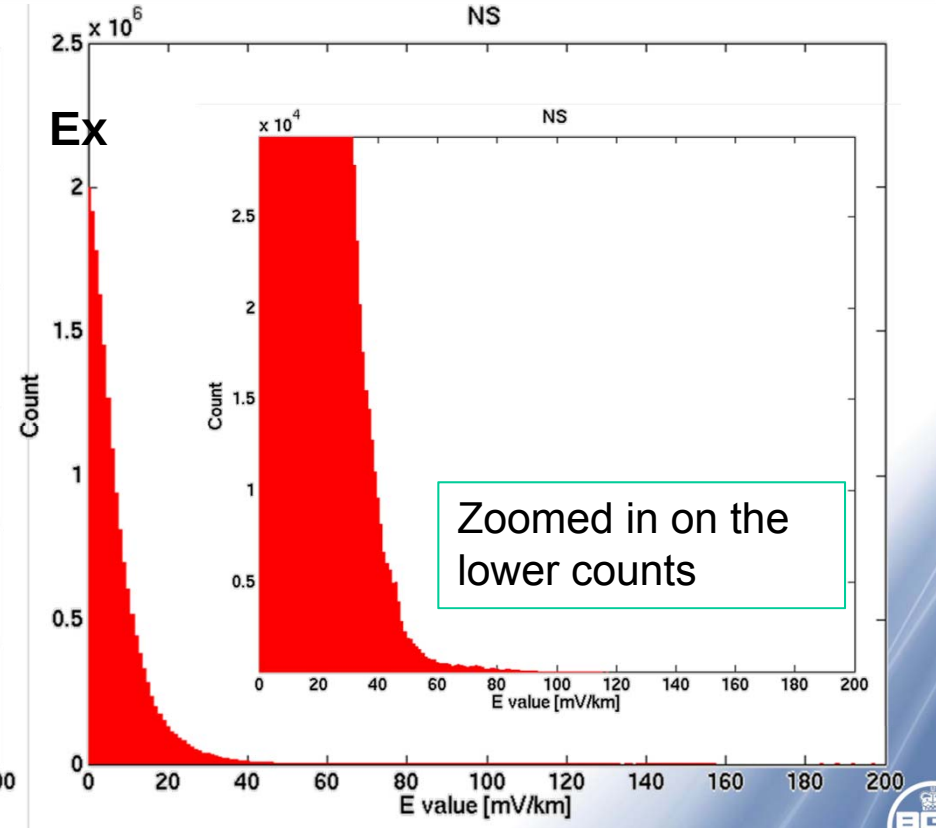
awpt2 Could you plot a distribution function of the E-field for Esk, say, over many months of data and we can see where we might put bounds to construct our own version of the T index? I wonder what the characteristics of this distribution would be, e.g. in relation to a distribution function for e.g. 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

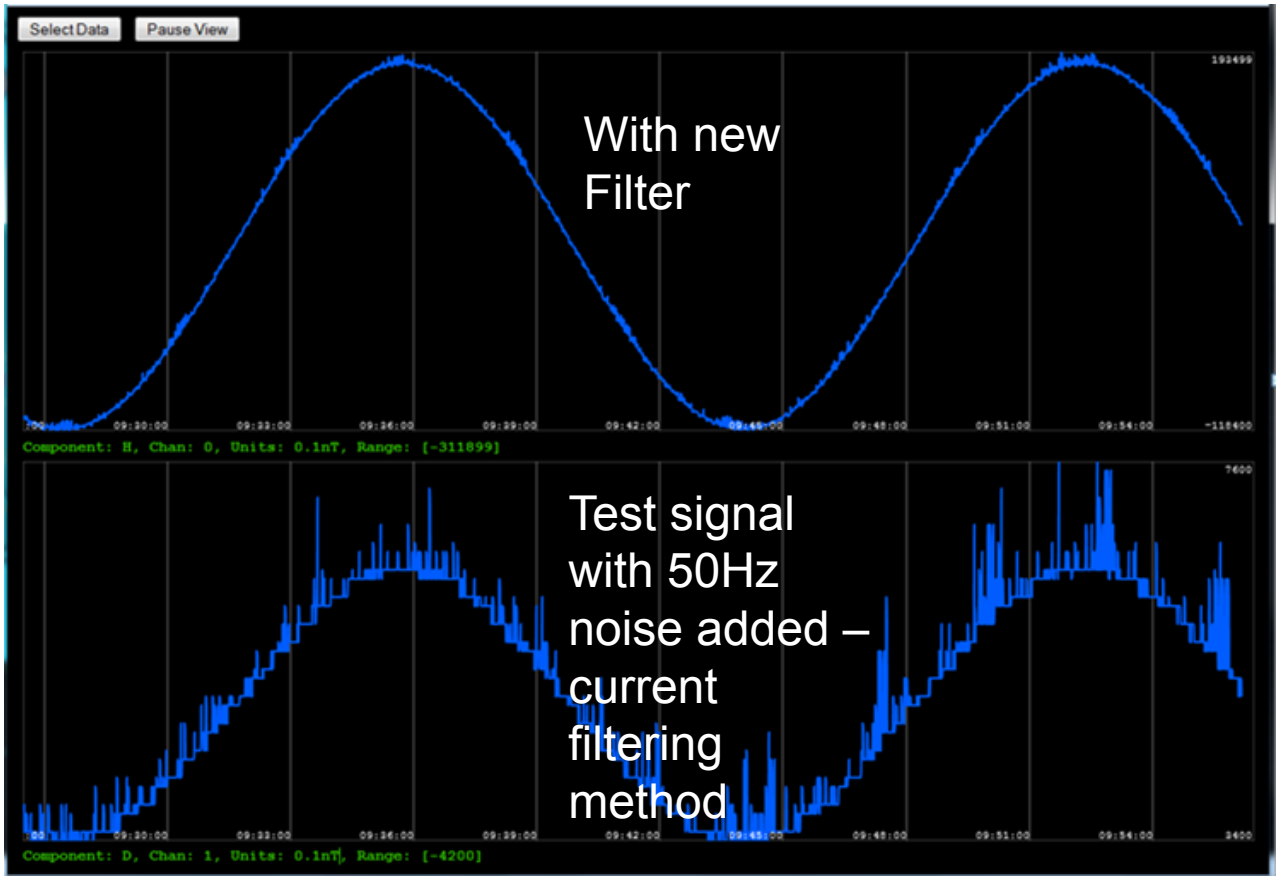




Geo-electric Field Monitoring - Details

- Electrodes maintained in a ‘neutral’ Cu-CuSO4 clay mixture to prevent polarisation/self potential effects
- Transient resistance between electrodes checked before & after installation (< 5 KΩ)
- 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 (fc = 20Hz)
  - Will be installed at all UK electric field sites