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Investigation into tidally induced geoelectric fields at three sites in the UK

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Electric fields are generated by the motions of sea water through the geomagnetic field. Continuous geoelectric field monitoring began at the three UK magnetic observatories in 2012/2013 alongside the standard geomagnetic field measurements. Each observatory lies in a substantially different setting in relation to the seas surrounding the British Isles and hence the new data allow investigation of tidally generated signals. More generally, the new electric field measurements also provide ground-truth data to test the accuracy of geoelectric field estimates, calculated using the magnetic field data and models of the ground conductivity structure, for space weather applications.

In this work, we investigate the effects of strongly periodic phenomena, revealing signals with solar and lunar origins. Firstly, we use Superposed Epoch Analysis at each station. We find the results for Hartland observatory (Devon) are consistent with the findings of previous experiments in the English Channel, with regard to the magnitude of solar and lunar semi-diurnal (S2 and M2) variations and offer new results on the tidal influence at Eskdalemuir (Scottish Borders) and Lerwick (Shetland Islands) observatories.

Secondly, we use the fast Fourier transform to find the dominant frequencies present in the electric field data, again identifying known Sq-harmonics and the dominant motion-induced M2 tidal period at each station. As there are difficulties in carrying out conventional Fourier analysis because of gaps in the data, we use Lomb-Scargle periodograms to investigate the spectrum as this method is robust to short periods of missing measurements. We calculate the correlation between the geoelectric field components and tidal records from the closest gauge stations to each site. For example, at Hartland, we find the daily correlation coefficient is typically around 0.8 with the electric field variations lagging by about 45 minutes.

Using accurate tidal models, we attempt to remove the predictable tidal component of the geoelectric field variations to isolate the externally induced signal.

We will carry out an MT analysis of the data to characterise the local conductivity structure and determine the galvanic distortion matrices at each site.