

Linking lithospheric structure and ground impacts of space weather: The first 3D conductivity model of Britain based on long-period magnetotelluric data

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SUMMARY

Nation-wide magnetotelluric (MT) surveys are becoming more popular and, with them, the ability to address large-scale geological research questions. From lithospheric studies to resource exploration and, more recently, monitoring and forecasting geohazards, the MT method continues to be an excellent tool for providing new knowledge of the Earth's crust and upper mantle. Advances in computational capabilities allow full 3D inversion over large modelling areas and thorough testing of all inversion parameters to minimize uncertainties and provide geologically meaningful interpretation of the conductivity models.

New long-period MT data at 53 sites were collected across the island of Britain as part of a major UK space weather programme to develop a new geoelectric field (GEF) model to assess, monitor and forecast effects on ground-based infrastructure during geomagnetic storms. We have built the first 3D conductivity model of Britain through the inversion of this newly collected dataset, also including some legacy data, to improve the GEF model and study the lithospheric structure. We introduce the inversion workflow to find the best fitting model which includes tests of the prior model and the smoothing inversion parameters, as well as the inclusion of variable conductivity of marine sediments around the British coast. We suggest a series of steps that can be generalised to optimise the inversion workflow of any MT dataset. The final model images both anomalies that are aligned with well-known geological features, e.g., the lateral extent of geological terranes, as well as previously undetected anomalies providing new insights into the lithospheric structure of Britain. The model reflects the complexity of the geological history with significant lateral resistivity contrasts. These contrasts are one of the causes of enhanced GEFs during severe space weather. Using the predicted impedances from the final conductivity model and magnetic fields measured at geomagnetic observatories and variometer sites in and around the UK, we modelled GEFs for the major storm of September 2017 showing rapid variations and peak values (± 500 mV/km) all over Britain.

Keywords: conductivity model, Britain, long-period MT, inversion workflow, geoelectric fields, space weather
