

A new geoelectric field model for the UK based on long-period magnetotelluric data to assess and forecast ground-based space weather effects

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SUMMARY

In the last decades, ground-based impacts of solar activity through the interaction of the Earth's magnetic field with the solar wind have been classified as a major natural hazard in many mid-high latitude countries. The observed effects are closely coupled to local geology due to the varying electrical conductivity of different rocks. The regional conductivity distribution can be estimated from magnetotelluric (MT) measurements, which in turn is used for large-scale modelling of the time-varying ground electric field. This geoelectric field model serves as the input for the impact analysis of Space Weather on ground-based systems such as the high voltage power grid, gas pipelines and railways. Previous efforts in the UK had been based on a thin-sheet approach, but MT data better captures the true conductivity variations in the Earth's crust and mantle that drive geoelectric fields during space weather activity.

Within the UK-funded SWIMMR programme, we collected long-period MT data at 50 sites with site spacing of 50-70km in Britain during a field campaign in 2021-23, adding to a few existing legacy data sets. Following a frequency-domain approach and geomagnetic field observations from the UK geomagnetic observatories and variometer sites we can derive models of the geoelectric field during geomagnetic active times. Using the new MT data, we revisit GIC estimates for both historic and modern geomagnetic storms, perform extreme value analysis of both geoelectric fields and GICs, and implement a fast now- and forecasting of ground effects within the SWIMMR framework.

Keywords: Geomagnetically induced currents, Space Weather, magnetotellurics
