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Modelling electric fields in Ireland and UK for space weather applications

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Solar storms can significantly disturb the Earth's magnetic field, producing induced electric fields (IEF) at the Earth's surface. The IEF are the primary inputs for the estimation of geomagnetically induced currents (GICs), which can cause interruptions in electrical power distribution networks and have the potential to cause large economic losses. In this study we modelled the IEF in Ireland and UK during geomagnetic storms at particular locations assuming that no data was acquired in the selected locations during the storm. The developed approach incorporated: 1) Magnetic time series from INTERMAGNET observatories (HAD, LER, ESK, and VAL), and from the Irish magnetic observatory network MagIE (BIR and ARM) to constrain magnetic field variations during the storm, 2) Magnetotelluric (MT) geophysical data to constrain the influence of the subsurface geology, including the use of inter-station transfer functions (ITF) that related the electric and magnetic fields at specific location to the magnetic fields at the magnetic observatories, and 3) The influence of the ionospheric currents, which was modelled using spherical elementary current systems (SECS) to interpolate the magnetic field variations at the sites of interest. The use of ITF allowed us to differentiate between regional signal (affecting the whole area of study) and local signal (only affecting few magnetic observatories) associated with the geomagnetic storms. We finally evaluated the capacities and limitations of the proposed approach. Differences between measured and predicted IEF in the time and frequency domain were quantified using the correlation coefficient, the performance parameter, and root-mean-square error, also evaluating the decrease in resolution as the site of interest distant from the permanent magnetic observatories.