The role of global/regional lithosphere conductivity models in natural geomagnetic hazard mitigation

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Summary

Increased societal reliance on technological infrastructure has recently prompted renewed interest in space weather phenomena within the international scientific community. Geomagnetic storms can interfere with satellite operations, as well as disrupt communications. They also induce electric fields in the solid Earth, and, through transformer groundings, cause currents to flow in the electric power grid. These quasi-DC currents are known as geomagnetically induced currents (GICs) and constitute a hazard to the electric power grid industry. Severe geomagnetic storms of the past have damaged transformers and led to the collapse of the entire Hydro-Quebec electric power grid in Canada in March 1989.

Mitigation and operational response to GIC hazards starts with nowcasting (and ideally, forecasting) of ground-level geoelectric fields; these can then be combined with the power-grid geometry and system parameters to estimate GICs. This review paper covers the recent developments in the international scientific community related to geoelectric field estimation and evaluation of GIC hazards, both with respect to historical geomagnetic storms (scenario analysis) and as they relate to the real-time operational setting.

We review the alternative methods for geoelectric field estimation, based upon real-time geomagnetic field measurements (mostly, geomagnetic observatory data from INTERMAGNET; Love & Chulliat [2013]) and magnetotelluric transfer functions (such as the USArray MT data; Schultz et al. [2006-2018]), which may or may not employ an Earth conductivity model as an intermediate step. We discuss the relative strengths and weaknesses of these different methods, and the state-of-the-art regional, continental and global electrical conductivity models of the subsurface. The work on the three-dimensional Earth conductivity models is ongoing as new magnetotelluric data are obtained, and new methods for improved magnetotelluric inversion are developed.

Keywords: space weather, geomagnetic hazards, magnetotelluric impedances, electrical conductivity, GICs