Assessing the Vulnerability of Power Grids to Space Weather – the Role of EarthScope MT Data

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The response of Earth's magnetic field to solar activity is both a source field for magnetotellurics (MT) and a potential hazard to infrastructure, particularly in response to large geomagnetic storms. The storm-time induction of electric fields in Earth's conducting lithosphere can interfere with the operation of electric-power grids, damage transformers, and sometimes cause blackouts. According to some scenarios, the future occurrence of a rare but extremely intense magnetic storm, such as occurred in 1859, would cause widespread failure of electric-power grid operations, with significant deleterious impacts for society. This has motivated the US Federal Energy Regulatory Commission to require the development of reliability standards to mitigate the impact of geomagnetically induced currents (GICs) on the operation of the US-national bulk-electric power system.

Modeling storm-induced electric fields, and the GICs which they drive, requires an understanding of (1) the spatiotemporal variability in the inducing geomagnetic field, (2) the spatiotemporal variability in the induced electric field, and (3) how induced earth currents couple into a distributed power system. MT data, in the absence of any modeling and inversion, provide the linkage between 1 and 2 at each measurement location. Over an extended area, such as the mid-continent region, it is possible to use EarthScope MT data to map out variations in electric field amplitude and polarization in response to highly simplified magnetic storms (Figure 1). Electric field amplitudes, upon which GICs scale, are observed to vary by two orders of magnitude over a distance of 100 kilometers, and in comparison with 3D conductivity models are found to be driven primarily by variations in crustal conductivity. As the EarthScope MT Transportable Array continues its march across the landscape it is improving not only our understanding of lithospheric conductivity, but also providing a unique, important and timely data set needed to mitigate infrastructure hazards associated with space weather.

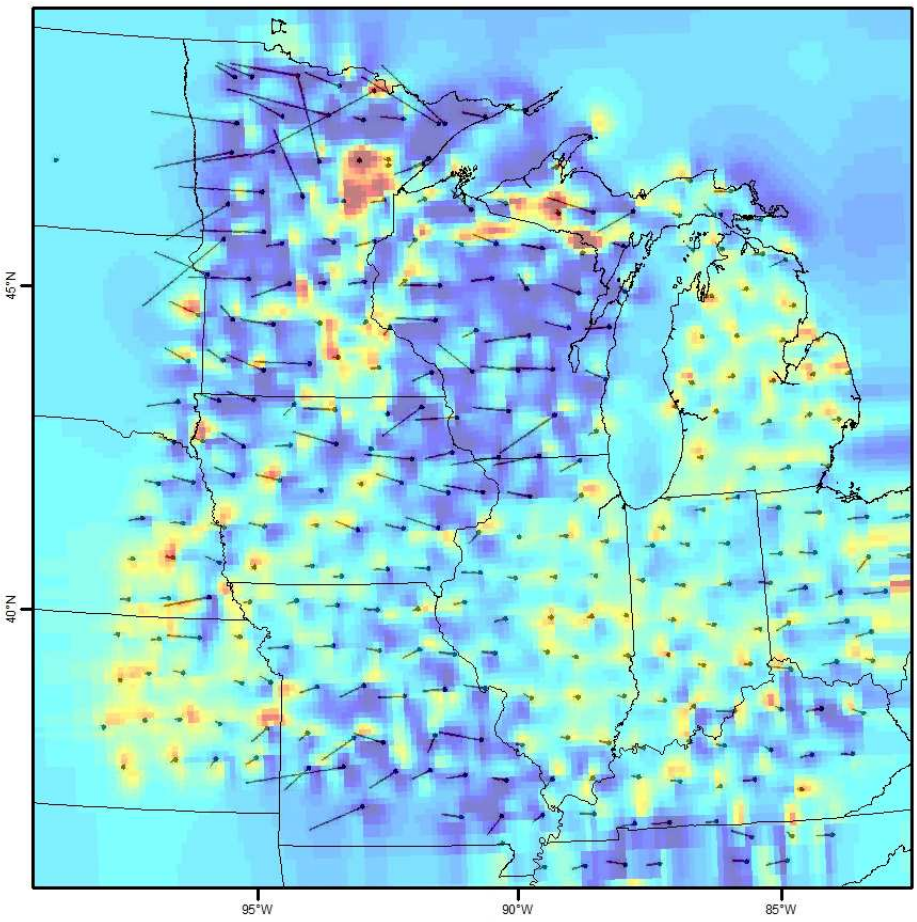

Figure 1. *Variation in electric field amplitude and direction at EarthScope MT stations within the Midwestern US associated with a 100 sec period, north-south oriented inducing magnetic field. Background color map shows modeled conductivity variations (red is conductive, blue is resistive) at 4 km depth based upon 3D inversion of the same EarthScope MT data.*