Benchmark modeling of the influence of 2-D and 3-D conductive ocean on geomagnetically induced currents

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SUMMARY

Geomagnetically induced currents (GICs) in power networks can cause damage to transformers, voltage instability and power outages. GICs are driven by an e.m.f. in transmission lines related to the induced surface geoelectric field parallel to the line. It is well-known that the presence of an electrically conductive ocean increases the geoelectric field magnitude on the landward side. However, limited work has been done to elucidate how the coast effect impacts GICs in a realistic power network. Using a well-known hypothetical benchmark network, we model GICs under three scenarios: (1) no ocean present, (2) coastal network adjacent to an ocean and, (3) island network surrounded by an ocean. Contrary to the notion that GIC risk is higher in coastal areas, we show that the ocean causes a de-crease in maximum GIC at substations in both coastal and island networks relative to the network with no ocean. This is because the geoelectric field only increases in the component perpendicular to the coast and decreases parallel to the coast. Thus, transmission lines parallel to coastlines experience a net decrease in e.m.f. along their entire length, while transmission lines perpendicular to coastlines experience a self-limiting in-crease in e.m.f. as distance from the coast increases.

Keywords: magnetotellurics, geomagnetically induced currents, space weather, geoelectric fields