Modelling geomagnetically induced electric fields using a 3-D electrical conductivity model and AusLAMP data

L. Wang, G. Paskos, J. Duan, A. Lewis, T. Kemp, W. Jones

1Geoscience Australia, GPO Box 378 Canberra Australia, liejun.wang@ga.gov.au

SUMMARY

Geomagnetically induced currents (GICs) in the Earth surface and interior are caused by geomagnetic storms and other natural field variations. GICs in the Australian region are distorted by conductivity contrasts caused by oceans, geology and enhanced crustal conductivity structures.

This study provided a regional indicator of geomagnetic induction hazards across Australia by modelling the distribution of induced surface electric field using a continental-scale 3-D electrical conductivity model of Australia. The model includes broad electrical structures of the oceans, resistive cratons, sedimentary basins and enhanced conductivity anomalies beneath the continent. The amplitude and orientation of the induced electric field at periods of 360 s and 1800 s are presented and compared to those derived from a simplified ocean-continent electrical conductivity model.

In Australia, the geophysical step of GICs modelling commonly involves calculating induced electric fields based on geomagnetic field data from the closest geomagnetic observatory and then applying the “plane wave” approach on 1-D electrical conductivity models. A 1-D model provides a useful first-order approximation for the effect on surface electric field, but the Australian continent's internal structure has a complex three-dimensional distribution of electrical resistivity, which affects the electric field and can change the predicted values by up to a factor of 4 in some places when compared to 1-D modeling.

We developed a telluric field prediction system by using the Geoscience Australia geomagnetic observatory network and data from the Australian Lithospheric Architecture Magnetotelluric Project (AusLAMP). The AusLAMP data allows comparison between the observed telluric field and the predicted telluric field using a half-space, local 1-D models or 3-D telluric tensors based on the first available continental-scale 3D electrical conductivity model. Our study, made using MT tensors derived from 3-D modelling of an electrical conductivity model, shows the estimation method based on 1-D assumptions may be valid in central and southeast Australia where electric fields are less distorted, but will lead to inaccurate GIC estimates in Western Australia, some inland areas, and coastal areas. Estimation of the geomagnetically induced electric fields across the Australian continent requires detailed modeling of the 3-D lithospheric conductivity structure using AusLAMP data.

Keywords: Geomagnetic Induction Hazards; Geomagnetically induced fields, 3-D modelling, Australian Continent; AusLAMP.