

Reproducibility of the geomagnetically induced currents in Hokkaido with a two-layer conductivity model

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Watari et al. [SW 2009], based on the GIC measurements in Hokkaido, Japan (35.7 GM Lat), found that the GIC is well correlated with the y-component magnetic field (B_y) (correlation coefficients > 0.8) and poor correlations with $B_{x,z}$ and $dB_{x,y,z}/dt$. The good correlation between the GIC and B_y would help predict the GIC if we have capabilities of reproducing the magnetosphere-ionosphere currents responsible for ground magnetic disturbances. To use the GIC- B_y relationship for the GIC prediction, we need to clarify if the good correlation is valid for any period/time scale (T) of disturbances. To address this issue, we made correlation analyses for the geomagnetic sudden commencements and pulsations ($T=1-10m$), substorm positive bays (30m), quasi-periodic DP2 fluctuations (20-60m), and geomagnetic storms (1-20h) as well as quiet-time diurnal variations (3-12h). We found that the correlation is good for short period ($cc > 0.8$ for $T < 1$ h), but poor for long periods ($cc < 0.3$ for $T > 6$ hours). Using the conventional induction theory based on the Faraday's, Ampere's and Ohm's laws, we calculated the electric field (GIE) induced by B_y as a convolution of dB_y/dt and step response of a uniform conductor. The GIE is found to be better correlated with the GIC for the long-period disturbances ($cc > 0.9$), whereas the correlation with B_y remains better for short period disturbances. This result requires us to use two models depending on the period of disturbances. To obtain a model applicable to any period, we made constructed a two-layer model with higher conductivity on the top. We show that the two-layer model is capable of reproducing the GIC with high correlations ($cc > 0.9$) for any period of disturbances ranging from 1 min to 10 hours. It should be noted; however, the capability of the model may depend on the direction of the power transmission line relative to the coast line and also depend on the structure of the Earth's conductivity.

Keywords: geomagnetically induced current, Hokkaido, two-layer conductivity model