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 (By) (correlation coefficients > 0.8) and poor correlations with Bx,z and dBx,y,z/dt. The good correlation between the GIC and By would help predict the GIC if we have capabilities of reproducing the magnetosphere-ionosphere currents responsible for ground magnetic disturbances. To use the GIC- By 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 By as a convolution of dBy/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 By 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.

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