

Numerical modelling of motionally induced electromagnetic field in the Japan region

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Since Faraday's attempt in the Thames, it has been recognized that a motion of the conductive water through the geomagnetic field causes a dynamo effect and induces electric and magnetic fields. For instance, an extra electric current in a cable under a fast water stream is well known among engineers who have constructed submarine telecommunication cable systems. Significant variations of the geoelectric and geomagnetic fields are observed in the Miyake-jima island, Japan, when the Kuroshio current meanders near the island. Theoretical considerations on the effect have revealed that the motionally induced electric field mainly reflects a total flux of the sea water, that resulted in several experimental studies to easily obtain water fluxes from voltage differences observed in the sea.

However, little is known on the motionally induced field, especially on its distribution and influence on land observations. On the other hand, realistic regional models of the seawater velocity got available in recent years, that makes numerical modellings of the motionally induced field in a regional scale possible. The numerically estimate of the motionally induced field can be used as a measure to detect the field from the observed field.

In this study, I aim to model the motionally induced electric and magnetic fields in the Japan region by using a fine regional model of the sea water velocity distribution as well as realistic distributions of topography and sediment. A simple case is considered as a first step such as a slow water current whose horizontal scale is much larger than its vertical one. When the conductivity of the Earth's deep interior is neglected, the thin sheet approximation by Price can be applied to the Maxwell's equations. That significantly simplifies the system so that a single Poisson equation of the magnetic potential at the surface of the Earth is to be numerically solved.

The seawater velocity distribution used here is a product of the Ocean Comprehensive Analysis System of Japan Meteorological Agency. Three vector components of sea water velocity, salinity, and temperature in 7 layers from the surface to 1000m deep are available daily on every 0.25 degree in the Northwest region at the period from March 1, 2001 to September 30, 2002. The electrical conductivity of the sea water is obtained from the salinity and temperature by using the equation provided by UNESCO. The topography was based on ETOPO5 and a sediment thickness model was provided by the Harvard University. The depth integrated velocity and conductance were computed in a thin sheet at the surface of the Earth and were projected on a plane which is centered in the vicinity of Japan. Then, the magnetic potential was computed at the surface of the sheet with the finite element method. Finally, the motionally induced magnetic field at the sheet surface and the electric field and current in the sheet are obtained by using the magnetic potential.

Regional characteristics on the computed motionally induced fields will be presented. It can be useful to make a realistic estimate of possible effects on the geoelectromagnetic observations in the Japan region.