The Earth's global response: Internal/external separation of the temporal geomagnetic field

Hiroaki Toh[1]; Yozo Hamano[2]
[1] DACGSM, Kyoto Univ.; [2] JAMSTEC

Large variations of the external geomagnetic field such as geomagnetic storms can be utilized to delineate the structure of the conducting Earth irrespective to the shape of the source field, provided that the observed total field is pertinently separated into the internal and external fields. Here we report the result of internal/external separation of the global geomagnetic variations using spherical harmonics.

Even in the era of satellite observation, the land-based geomagnetic observation network is of use in the sense that it enables continuous monitoring of the global-scale geomagnetic phenomena by the Earth-locked reference frame. We used time-series of the vector geomagnetic field observed simultaneously at more than 60 geomagnetic observatories worldwide for large disturbances such as the Halloween storm event occurred in the autumn of 2003. We included data from a seafloor observatory in the northwest Pacific (Toh et al., 2004; 2006) in our spherical harmonic analysis, because the seafloor observatory has been in operation since August, 2001.

A stochastic inversion scheme using singular-value decomposition of our spherical harmonic analysis (Hamano, 2002) allowed us to estimate the internal/external Gauss coefficient of the temporal geomagnetic field up to degree 6 with time resolutions of either one minute or one hour. Preliminary analyses revealed that ${P_1}^0$ terms are still dominant at the time of geomagnetic storms both in the internal and external fields provided that contamination by Sq variations into ${P_2}^1$ terms is minimized prior to the stochastic inversion. This means that the growth of the global ring current in the magnetosphere is the major source for electromagnetic induction in the Earth in larger geomagnetic disturbances. It was also shown that the growth of the southward external field is outstanding for the large events.

The internal and external geomagnetic time variations at the time of large geomagnetic storms can be used as the output from the conducting Earth and as the three-dimensional (3-D) input that excites the conducting Earth, respectively. This implies that the present internal/external separation approach in time domain can be applied to 3-D inversions of the electrical structure of the Earth in the future. In order to pursue this possibility, sensitivity of the output internal field to the electrical structure in the Earth for arbitrary forcing by the observed 3-D source field will be further argued based on forward modeling of output from spherically symmetric earths with a heterogeneous layer on top that represents the land-sea distribution on the Earth's surface.