R003-P03
ポスター 3：11/26　PM2/PM3（14:50-18:25）

趙 崇進 [1], #張 羅磊 [1], 于 鵬 [1], 黄 祖偉 [1], 歌田 久司 [2]
([1] 同済大学, ([2] 東京大学地震研究所

Reconciling Cartesian and Spherical Coordinate Approaches in Magnetotelluric Modeling: Source Conditions and Impedance Formulation

Chongjin Zhao[1], #Luolei Zhang[1], Peng Yu[1], Zuwei Huang[1], Hisashi UTADA[2]
([1]Tongji University, ([2]Earthquake Research Institute, The University of Tokyo

Since Cagniard (1953) first presented the basic theory of the magnetotelluric (MT) method, model calculations have traditionally been carried out in Cartesian coordinates, assuming plane-wave sources. However, because MT observations are made on the Earth, the fundamental theory and modeling tools should first be constructed in spherical coordinates, and the Cartesian framework, even if adopted for reasons of computational convenience, should be used only while maintaining consistency with the spherical-coordinate formulation.

In general, modeling in spherical coordinates employs an external dipole as the source. A set of three orthogonal external dipoles with unit amplitude is used as basis for representing arbitrary sources. The magnetic field generated by an external dipole has the simplest possible spatial structure (spatially uniform) that can physically exist. For a dipole oriented in the north – south direction, it is well known that the tangential component of the magnetic field at any point on the Earth's surface is proportional to the cosine of the latitude, while the radial component is proportional to the sine. This implies that assuming a plane-wave source in Cartesian coordinates represents a spatial structure even simpler than that of any external magnetic field that can exist in reality. At the very least, modeling with plane-wave sources in Cartesian coordinates cannot be regarded as consistent with modeling using dipole sources in spherical coordinates.

In this study, we approximately represent an external dipole source in spherical coordinates by finite-wavenumber sine/cosine functions in Cartesian coordinates, and investigate how deviations from the plane-wave assumption affect the impedance and tipper. Following Srivastava (1966), the source effect is expressed by approximating the wavenumber ν_n= √ (n(n+1))/a, which corresponds to a given spherical harmonic degree n. Using this framework, we systematically examined through numerical experiments the following four issues:

(1)the appropriate treatment of the space above the Earth's surface in numerical models when the wavenumber is finite;

(2)the lower bound of source harmonic degree (wavenumber) for which the plane-wave approximation holds;

(3)the appropriate choice of a set of basis sources for representing an arbitrary source in a Cartesian coordinate system; and

(4)the uniqueness of impedance and tipper in the presence of source dimension effects.

The results show that:

(1)when the wavenumber is nonzero, the conductivity values in the region above the Earth's surface have no significant influence on the calculation results; and

(2)the lower bound of the source order for which the plane-wave approximation holds depends on frequency, and that within the frequency band relevant to MT observations, the plane-wave approximation is generally valid for external dipole sources.

For issues (3) and (4), no definitive conclusions have been reached at this stage, and further investigation is required.