実際的な 3 次元構造に対する MT フォワード計算の不確定性評価

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Evaluation of the uncertainty in MT forward modeling for practical three-dimensional conductivity structure

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Abstract

This report summarizes a study in an article submitted to a journal (Baba, submitted to Earth, Planets and Space). The forward calculation of magnetotelluric (MT) responses is generally assumed to be sufficiently accurate compared with typical observational errors in practical modeling and inversion studies. Although the uncertainty of the forward calculation may be examined by comparison with analytical or other numerical solutions for some simple models, such an examination does not guarantee that the uncertainty is similar for more realistic complex structures. In this study, I propose a simple method to evaluate the random component of the uncertainty of MT forward modeling for practical three dimensional (3D) conductivity structure models in a Cartesian coordinate system. The method is based on the idea that the horizontal coordinate system can be selected arbitrarily for a general 3D structure. The synthesized MT responses are ideally identical irrespective of the selection but are different because of the difference in discretization angles, boundary values, and numerical errors. By synthesizing MT responses to the model in several different coordinate systems, the mean, standard deviation, and coefficient of variation can be calculated. These statistics provide quantitative information on how stably the forward calculations synthesize MT responses under the given conditions of the structure model, observation array, periods, numerical algorithm for the forward modeling, and mesh design. The proposed method was applied to two practical situations of seafloor MT arrays in the northwestern Pacific and southern Atlantic. I used 3D models consisting of 3D topography and bathymetry over subsurface layered structures given in previous studies. The results show that the uncertainty is comparable to real observation errors and is significantly dependent on the MT impedance element, period, site, structure model, and horizontal coordinate system. The uncertainty of the forward calculation should be considered for each element, period, and site to quantitatively evaluate how well a given model explains the data. I propose a new root-mean-square in which the residuals are normalized by both the standard errors of the MT responses observed and synthesized. This would help avoid overfitting data in the inversion analysis by ignoring the uncertainty of the forward calculation. This method is also useful for testing the appropriate selection of the coordinate system and mesh design.

Reference

Baba, K. A simple method to evaluate the uncertainty of magnetotelluric forward modeling for practical three-dimensional conductivity structure models, submitted to Earth Planets Space, https://doi.org/10.21203/rs.3.rs-2270559/v1