Reliability estimation of MT-data inversion using principal component analysis

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Magnetotelluric (MT) method, one of electromagnetic survey methods, is used for resource exploration and active fault survey. At the estimation of subsurface resistivity structure, inversion algorithms based on the least-square scheme are adopted to the observed apparent resistivity and phase. The optimal resistivity model obtained by the inversion is recognized as the approximate solution of true structure, because of the noise at measurement and the constraints at inversion. Therefore, the reliability of resistivity model is mandatory. In previous researches, the reliability could be confirmed with changing a part of the optimal model, how apparent resistivity and phase calculated from the modified model differ from the observed ones. However, this reliability test is qualitative and subjective. In this research, we develop a new way to test the reliability of the resistivity model objectively and quantitatively.
Evaluating an enormous number of model parameters takes much amount of computation time. On the other hand, reliability test of major resistivity anomalies makes the time shorter. In this research, we use principle component analysis (PCA), which can extract the primary structure from data, and try extraction of the major anomalies in an optimal model obtained by inversion. Concretely, a two-dimensional resistivity model is split into series of one-dimensional models for PCA. The principle components show the common features of resistivity distribution in horizontal or vertical direction. To modify the optimal model, we modify the principal components and the scores. Finally, we created thirty different resistivity models from the optimal model. Based these new models, a root mean square error between the observed and calculated apparent resistivity and phase are used to discuss the reliability of optimal model, as usually done in the previous studies.
In order to examine the validity of this technique, we used MT synthetic data (TE mode) on a model having high and low resistivity anomalies. We found that the assumed two resistivity anomalies in the inverted model appeared in the first principle component in PCA. We changed the principle component scores, and succeeded in shifting the anomalies vertically and horizontally. Moreover, we tried to visualize the reliability range of position/values of anomalies. The obtained reliability map corresponds to sensitivity trend of MT inversion in TE mode.
We also applied this technique to more complicated resistivity model. As a result, anomalies in the models were also detected properly, and the quantitative reliability of each anomaly was evaluated automatically. In future prospects, we will improve this technique for more quantitative estimation of reliability of models, and adopt it to MT inversion with real data.

Keywords: magnetotellurics, PCA, 2-D inversion

