Considering electrical anisotropy in magnetotelluric inversion with synthetic and real data

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SUMMARY

Electrical anisotropy defines variation of electrical conductivity with spatial orientation, which may be a generic feature of the Earth's materials. We developed MT inversion code considering electrical anisotropy. The forward procedure is based on a staggered-grid finite-difference method and solves the governing equation for the electric fields with a direct method. The objective function and its gradient could then be calculated. The inversion procedure was completed with an open-source, well-developed subroutine of non-linear conjugate gradient method.

Influences of electrical anisotropy on MT responses and inversions were systematically studied with synthetic models. Both isotropic and anisotropic inversions were applied to the synthetic data from two-dimensional (2D) and three-dimensional (3D) models containing isotropic or anisotropic anomalies. The results show that both isotropic and anisotropic inversions are able to recover the isotropic anomalies, whereas the isotropic inversion of data from anisotropic models will produce false structure. We compared different (vertical, azimuthal, and general) anisotropic inversions in recovering various (vertical, azimuthal, and general) anisotropic anomalies, and found that the general anisotropic model cannot be recovered with our code, the vertical anisotropic inversion will produce false structure in recovering azimuthal or general anisotropic anomalies. All these indicate that a suitable anisotropic inversion is needed in order to reveal the underground structure correctly. In our synthetic tests, it is difficult to perfectly recover the bottom shapes of anisotropic anomalies, the vertical resolution decreases with depth, especially for the low-resistivity component. The anisotropic strike angle is not as stable as the principal resistivities in the inversion processes. Under the same changes in model parameters, the strike angle may cause larger deviations of the responses than the principal horizontal resistivities.

We proposed a strategy for selection of the regularization parameters in anisotropic inversion. That is, the initial structural regularization parameter is firstly determined by isotropic inversions; the anisotropic regularization parameter is determined according to the variations of anisotropic constraint term in anisotropic inversion results.

Electrical anisotropy may be in genetic relation with structural anisotropy. It has been mentioned that the structures with preferred orientations may induce the direction-dependent connection of the electrically conductive component and cause electrical anisotropy in the Earth's interior. We applied the inversion code to study such special structures as active faults, old sutures, and ductile shear zones in the northern Tibetan Plateau and its neighbor areas. The electrical anisotropy provides another perspective for evaluating the underground structure. We can analyze deformation and activities related to these geological units.

Acknowledgements: The research has been supported by the National Natural Science Foundation of China (Grant No. U2344215, 41974091).