CRT3DMT: A three-dimensional magnetotelluric inversion package with adaptively refined unstructured inversion grid and an application to lithospheric conductivity structure beneath North China

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SUMMARY

Currently, three-dimensional magnetotelluric inversion often uses a fixed inversion grid. Too sparse inversion grid cannot accurately describe the distribution of the complex subsurface conductivities, and may also lead to inversion results failing to converge. While, too inversion grids will increase not only the computational cost, but also the non-uniqueness of the inversion. Aiming to solve the above problems brought by using fixed inversion grid, we have developed a three-dimensional magnetotelluric adaptive inversion algorithm and package with adaptively refined unstructured inversion grid. Firstly, based on the unstructured finite element method, the highly accurate forward responses of the three-dimensional geo-electric model with arbitrary complex topography and conductivity distributions can be obtained. Then, the nested forward and inversion tetrahedral grids are utilized to satisfy their different requirements on grid density. The Thikhonov regularization objective function with smooth constraint is established and minimized by using limited memory BFGS algorithm with inexact line search procedure, where the gradient of the objective function is solved by using the adjoint principle. Most importantly, an inversion grid refinement strategy commonly driven by the data fit gradient and the model parameter gradient is proposed, which is used to guide the automatic refinement of inversion grid in the optimization process. Successively, several synthetic models are used to validate and test the performance of the developed adaptive inversion algorithm and package. The results show that the developed algorithm and package can significantly improve the accuracy and convergence rate of three-dimensional magnetotelluric inversion with less inversion knowns. Finally, a geologically significant three-dimensional lithospheric conductivity structure beneath North China is obtained by using the developed package.

Keywords: Magnetotellurics; Finite element method; Unstructured grids; Adaptive inversion; L-BFGS