

A multi-functional 3D electromagnetic solver and resolution analysis for high-frequency semi-airborne survey

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SUMMARY

Electromagnetic methods have been effectively used for a range of environmental investigations and exploration activities. In this abstract, we first present a multi-functional 3D forward solver as well as the inversion framework. Then, we will introduce the methods used for optimal survey design and inversion grid design for a high-frequency semi-airborne survey. Finally, we will demonstrate the methods in a case study.

We use edge-based nedelec elements to solve Maxwell equations in the frequency domain. Two sets of octree grids are utilized for the model meshing, with the forward grid refined based on the inversion grid. A direct solver (MUMPS) is applied to solve the resulting linear system of equations. The code is implemented in C++ and allows for easy adaptation for various sources and data types. Currently, to solve the inverse problem, we minimize the misfit using a Gauss-Newton scheme with explicit computation of the Jacobian. The implementation was built on the deal.II library, where the interface wrappers to MUMPS and PETSc facilitate numerically intensive computation, particularly the solution of the large linear systems of the forward problem and the computation of the model update. Currently, the code is parallelized using MPI throughout both forward and inverse modeling.

Our controlled-source electromagnetic inversion implementation was primarily developed to interpret the high-frequency semi-airborne data obtained in the DroneSOM project. For survey design optimization and to collect informative data, we compare the performances in terms of measures, such as the model resolution matrix, sensitivity matrix, and DOI index on a homogeneous halfspace model. We further discuss the importance of designing a valid and economic inversion grid.

Finally, we will show an application for high-frequency drone-based data.

Keywords: Semi-airborne, 3D inversion, Octree, sensitivity, resolution analysis
