Open-source 3D inversion of semi-airborne electromagnetic data

R. Rochlitz[1], T. Günther[1] and M. Becken[2]
[1]Leibniz Institute for Applied Geophysics, Hanover, Germany, raphael.rochlitz@leibniz-liag.de
[2]Department of physics, University of Münster, Germany, michael.becken@uni-muenster.de

SUMMARY

We present a new 3D inverse modeling scheme for semi-airborne controlled-source electromagnetic data building upon the open-source modeling software custEM and the open-source inversion framework pyGIMLi. The underlying geometries include arbitrarily shaped transmitters on the surface with topography and airborne receivers in the air or on the ground. The topography prohibits the exploitation of secondary-field formulations with semi-analytic primary-field solutions, such as commonly used in marine or airborne environments. We are able to account for realistic survey geometries with an irregular tetrahedral discretization of the modeling domain. We use a finite-element electric-field approach with a total-field formulation and first- or (preferably) second-order polynomial basis functions as implemented in custEM. Solving the resulting linear systems of equations with a direct solver enables us calculating explicit sensitivities with comparatively cheap back-substitutions for hundreds of airborne or ground receiver stations in multiple flight areas with several transmitters. The pyGIMLi framework provides a fast-converging Gauss-Newton minimization scheme for the inversion process. We apply our developed tools on a synthetic model and a semi-airborne data set of combined flight areas with 4 transmitters. The data with 12 frequencies in the range of 7 to 1000 Hz cover a total area of approximately 50 km2 and provide a penetration depth of up to 1000 meters. Our final 3D resistivity model matches well the available geological information. Reference inversion results from the analysis of 2D ERT and EM data on a central profile are overall consistent with the 3D inversion results but provide also insights about the limitations of 2D methods in a 3D geological environment. The developed procedure is not only applicable for semi-airborne data sets, but also capable of handling other controlled-source electromagnetic survey geometries. The presented results and tools are freely available as the underlying software.

Keywords: numerical solutions, electromagnetic theory, inversion, finite element method, controlled-source electromagnetics