POLYEM3D : A flexible 3D CSEM and MT modeling and inversion code

F. Bretaudeau [1,*], F. Dubois [1], J. Porté [1,2,3], S. Védrine [1,4]

[1]BRGM (French Geological Survey) f.bretaudeau@brgm.fr
[2] Strasbourg University, ITES-CNRS, UMR7063, France
[3] Formerly 1 & 2, now at SINTEF Industry, Norway
[4] University of Western Britany - EO-OCEAN, UMR6538, France

SUMMARY

We developed the massively parallel 3D finite-volume modeling and inversion software POLYEM3D, dedicated to the modeling and inversion of various type of EM data. POLYEM3D relies on a separated primary/secondary fields approach and can therefore handle both MT, and CSEM with very flexible acquisition configurations for sources and receivers: far or near field, marine, land, coastal, dipoles, long wires, loops and interactions with boreholes and metallic pipes. Coupling with other modeling codes such as FE to improve topography/bathymetry modeling or interactions with complex structures such as casings are possible.
The algorithm includes various solvers (MUMPS, WSMP) and can support both gradient-based (l-BFGS) and Gauss-Newton optimization to adapt to the data and computation constraints.
Many tools are available to tune the inversion of real world data, such as flexible parameterization with arbitrary 1D/2D/3D splines of several orders, automatic and user-defined inversion preconditioners, data reformulations and weighting, various L2 and robust norms, joint MT and CSEM, fast check 1D modeling/inversion, as well as including prior and constrains from borehole or AEM.

POLYEM3D was designed to be operational and efficient with real EM data, but also as an open research tool. In particular, it made it possible to explore new possibilities for EM such as 3D CSEM complex resistivity inversion (Porté et al. 2021), CSEM/MT inversion in a coastal context (Védrine et al. 2022, Védrine et al. EMIW22), joint inversion of several EM methods (Védrine et al. EMIW22), CSEM time-lapse differential inversion (Bretaudeau et al. 2021), CSEM deep imaging for geothermal energy in urbanized areas and sedimentary environments (Bretaudeau et al. 2022, Darnet et al. 2022), or CO_2 storage and monitoring, or other shallow land CSEM configurations.

Keywords: 3D modeling, 3D inversion, MT, Controlled Source EM, direct solver, flexible, land, marine, coastal, joint inversion, IP inversion, topography, bathymetry, geothermal exploration