

3D EM modeling and inversion with a mixed finite-element and finite-difference approach to handle high topography and bathymetry variations

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SUMMARY

3D CSEM modeling is usually performed by finite-difference (FD) discretization, but new players have entered the scientific community with finite-element (FE) modeling codes. FDs are suitable for simple cases, but are unsuitable for complex geometries, while FEs are very effective in the presence of high topography and/or bathymetry variations. The open-source 3D FE modeling code custEM has demonstrated its efficiency and reliability and is freely available to the scientific community. The recent work done by its development team has made it possible to integrate the inversion part with the Gauss Newton minimization algorithm, but there is not yet enough user feedback and tools available on this new module to be operational for the general public. On the other hand, POLYEM3D is a 3D FD modeling and inversion code that has a wide range of inversion algorithms and reparametrization and regularization tools but faces numerical errors in presence of high topography or bathymetry variations such as in coastal areas or volcanic environments due to the sea/land interface and large variations in near-shore bathymetry and topography. We tested a mixed FE and FD approach that aims to reduce the modeling errors inherent in the FD scheme in such complex problems. A secondary field formulation is available in POLYEM3D and instead of classically using a semi-analytical 1D code to compute the primary field, we use 3D fields computed in a simple isotropic homogeneous model with custEM incorporating topographic and bathymetric variations. The accuracy of the mixed approach was evaluated by modeling with a simple synthetic model incorporating topographic and bathymetric variations, and comparing the responses of the FE and mixed FE/FD codes. In addition, an inversion on a complex CSEM case demonstrated the good behavior of the mixed approach in inversion thanks to the panel of reparametrization and regularization tools offered by POLYEM3D.

Keywords: 3D CSEM modeling, topography, bathymetry, Volcanic islands, Separated field, Finite-element, Finite-difference
