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Three-dimensional high resolution joint inversion of gravity and magnetotelluric data

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AbstractGravity and magnetotelluric methods are pivotal geophysical techniques used to study the distribution of density and electrical conductivity within the Earth's interior. These methods have been widely used in multi-scale explorations for various engineering and academic applications. Considering the varying resolution capabilities of different geophysical methods in delineating near-surface geological structures, we propose a three-dimensional parallel joint inversion framework for gravity and MT data, based on Gramian structural constraints. The framework discretizes the inversion model with an unstructured tetrahedral mesh, enhancing the efficiency of forward modeling and sensitivity calculations for both gravity and MT data via a parallelized approach. To achieve sharper and more focused subsurface imaging, we incorporate a zero-order minimum entropy constraint into the objective function of the joint inversion. The objective function is minimized using the Gauss-Newton method, with model updates facilitated by the MINRES solver and line search techniques. Results from synthetic models show that joint inversion significantly improves the results for gravity and MT data, revealing a stronger correlation between residual density and resistivity. The zero-order minimum entropy constraint delivers more distinct model boundaries compared to traditional regularization method.