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The Novel High-Performance 3-D Magnetotelluric Inverse Solver Based on an Integral Equation Approach

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Abstract

Magnetotellurics (MT) is a frequency-domain electromagnetic (EM) method aimed at studying the electrical conductivity distribution inside the Earth. During an MT survey, naturally-occurring variations of the electric and the magnetic field are measured which furthermore - via appropriate inversion tool - are translated into a map of the subsurface conductivity. To date, the MT method is widely used at local, regional and even continental scales for a large variety of academic and applied problems, including detecting hydrocarbon and geothermal reservoirs. Starting with 1-D and 2-D MT inversions, nowadays 3-D MT inversions are common practice. However, 3-D interpretation of MT data with realistic levels of complexity, accuracy and spatial detail remain challenging from the computational point of view.

We present novel, robust and high-performance (HP), 3-D MT inverse code which is written using modern programming techniques to make the code as efficient, readable, maintainable and extendable as possible. As a forward 3-D modeling engine an integral equation solver is used, and the (regularized) inversion is based on an iterative gradient-type optimization method. The adjoint approach is invoked for fast calculation of the gradient of the misfit. The solver supports massive parallelization, is able to deal with highly detailed and contrasting models, and allows for working with any type of MT responses. We report results of 3-D numerical experiments aimed at analyzing the robustness, performance and scalability of the code. In particular our computational experiments performed at different platforms ranging from modern laptops to HP cluster Piz Daint (6th supercomputer in the world) demonstrate practically linear scalability of the code up to thousands of nodes.