PARALLELIZED 3D INVERSION OF AIRBORNE AND GROUND-BASED TIME DOMAIN ELECTROMAGNETIC DATA USING EFFICIENT FINITE ELEMENT METHOD

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The transient electromagnetic method (TEM) is an effective tool for subsurface imaging. The application of the method extends from groundwater mapping to mineral exploration. A typical survey (e.g., airborne EM) usually contains large amounts of data at different stations. A full 3D inversion of such a large amount of data is time consuming and computationally expensive and 1D inversion is most often used. However, the 1D approximation may not be valid and it may produce artificial or wrong subsurface structures in non-layered geological environments.

To address the above problem, we developed a 3D modeling and inversion code based on the vector finite element method. In the forward modeling, we solve Maxwell's equation directly in the time domain using the stable backward Euler stencil. We adopt the unstructured tetrahedral mesh to accurately approximate the complex subsurface structures and topography. To speed up the forward modeling, we adopt a 3-level MPI and OpenMP parallelization. At first, the whole modeling domain is divided into a series of sub-domains. The numerical modeling of each subdomain is independent and parallelized using MPI. Secondly, the time channels are divided into several time segments and each segment is calculated using the finite element method with different time step sizes. For a specific subdomain and time segment, the finite element solver is parallelized using OpenMP. To further reduce the computation cost for each sub-domain, we consider a primary-field-based boundary condition. We combine the forward modeling engine and the calculated sensitivity matrix with our voxel inversion algorithm in the code AarhusInv to produce a flexible 3D inversion environment.

In the presentation, we discuss the numerical implementation of our 3D modeling and inversion algorithm. We also present the application of the developed algorithm based on airborne SkyTEM data and ground based tTEM data.