Parallel and vectorized code for CSEM surveys in geophysics: An edge-based approach

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ABSTRACT

The last decade has been a period of rapid increase in the use of electromagnetic methods (EM) in geophysics. In particular, the marine Controlled-Source Electromagnetic Method (CSEM) has become an important technique for reducing ambiguities in data interpretation in hydrocarbon exploration. However, the state of the art is marked by a relative scarcity in practice of robust codes to simulate 3D CSEM surveys in geophysics. Furthermore, in real scenarios the 3D CSEM modeling can easily overwhelm single core and modest multicore computing resources. Therefore, we developed a parallel and vectorized code for the modeling of 3D CSEM surveys in the frequency domain. The framework is based on Edge Finite Element Method (EFEM) for tetrahedral meshes because has become very popular for solving electromagnetic field problems. Furthermore, EFEM is able to deal with many drawbacks that are encountered in the modeling (particularly eliminating spurious solutions) and they yield accurate results with a substantial reduction of the computational modeling cost.

In order to avoid the source singularity, the electric field was decomposed into primary (Ep) and secondary (Es) field. The Ep is calculated analytically using an horizontal layered-earth model and the Es is discretized by EFEM. Recent trends in parallel computing techniques were investigated for their use in mitigating the computational overburden associated with the modeling. As a result, the computation of the Ep was parallelized over the computational domain using a parallel-vectorized model. The solution to the linear system of equations was obtained using iterative solvers.

The code's structure is modular, simple and flexible which allows to exploit the embarrassingly-parallel tasks and the advantages of the geometric flexibility. The result is an implementation that allows users to specify edge-based variational forms of H(curl) for the simulation of electromagnetic fields in CSEM surveys. The code's performance and accuracy is studied through a scalability tests and comparisons to other results respectively.

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