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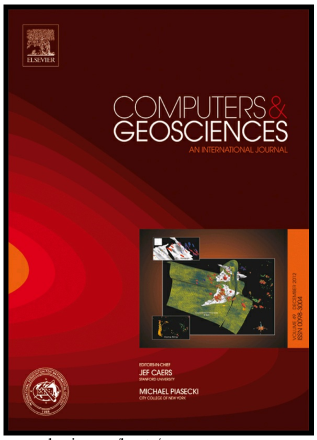

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Evaluation of parallel direct sparse linear solvers in electromagnetic geophysical problems

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ABSTRACT

High performance computing is absolutely necessary for large-scale geophysical simulations. In order to obtain a realistic image of a geologically complex area, industrial surveys collect vast amounts of data making the computational cost extremely high for the subsequent simulations. A major computational bottleneck of modeling and inversion algorithms is solving the large sparse systems of linear ill-conditioned equations in complex domains with multiple right hand sides. Recently, parallel direct solvers have been successfully applied to multi-source seismic and electromagnetic problems. These methods are robust and exhibit good performance, but often require large amounts of memory and have limited scalability. In this paper, we evaluate modern direct solvers on large-scale modeling examples that previously were considered unachievable with these methods. Performance and scalability tests utilizing up to 65 536 cores on the Blue Waters supercomputer clearly illustrate the robustness, efficiency and competitiveness of direct solvers compared to iterative techniques. Wide use of direct methods utilizing modern parallel architectures will allow modeling tools to accurately support multi-source surveys and 3D data acquisition geometries, thus promoting a more efficient use of the electromagnetic methods in geophysics.

Keywords: Numerical modeling; linear systems; direct solvers; parallel computing; controlled-source electromagnetics; geophysical exploration.

1. INTRODUCTION

Geophysical exploration techniques aim to determine various physical properties both in the shallow and deep interior of the Earth. Electromagnetic (EM) tools are applied in different areas of