An efficient parallel multigrid algorithm for 3D electromagnetic forward modeling

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SUMMARY

Multigrid (MG) methods are among the best choice for stable and efficient three-dimensional (3D) forward modeling of electromagnetic (EM) fields over large area due to their linear dependence of computational time on grid size. However, as the frequency decreases to near zero and/or the grid is increasingly stretched, MG solvers for EM modeling based on the curl-curl equations converge slowly or even diverge. In this paper, we develop an efficient MG algorithm combined with multi-color block-wise Gauss-Seidel (GS) smoother for finite difference forward modeling of EM fields particularly at low frequencies. In this algorithm, we group different block of the grid nodes into multiple colors with the only requirement that the components attached to the nodes of different blocks in each color should be totally decoupled and can be solved simultaneously, which can be distributed to different processors. The Dublin Test Model 1 is used to verify the accuracy of our algorithm and examine the numerical performance of our method against traditional solvers, for instance, BICGstab and Quasi-Minimal Residual (QMR) both preconditioned with block incomplete lower-upper (blockILU) decomposition (as blockILU-BICGstab and blockILU-QMR, respectively). Grids stretched to different degrees are designed to examine its ability to handle grid-stretching. Their good parallel ability is examined in the paper. The numerical performance comparison indicates its remarkable dominance in efficiency and stability.

Keywords: Multigrid, Electromagnetic, multi-color block-wise Gauss-Seidel