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A Hybrid Operator Dependent MG / AMG Approach: Application to Ice Sheet Modeling

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A multigrid method is proposed that combines ideas of operator dependent multigrid for structured grids and algebraic multigrid for unstructured grids. It is intend for problems where the three dimensional mesh can be viewed as an extrusion of a two dimensional unstructured mesh in a third dimension. That is, the mesh is logically regular in the third dimension. Our motivation comes generally from the modeling of thin structures via finite elements and more specifically by land-based ice sheet simulations. Extruded meshes are relatively common for thin structures such as ice sheets and often give rise to problems with an anisotropic nature when the thin direction mesh spacing is much smaller than the wide direction mesh spacing. Within our approach, the first few multigrid hierarchy levels are obtained by applying operator dependent multigrid to semi-coarsen in a structured fashion. It is well-known that semi-coarsening can successfully address anisotropic problems. After sufficient structured coarsening, the resulting lower resolution mesh contains only a single layer corresponding to a two dimensional unstructured mesh of the wide dimensions. AMG can now be employed successfully to create further coarse levels, as the anisotropic phenomena is no longer present in the single layer problem.

Numerical comparisons with standard smoothed aggregation AMG are presented demonstrating the effectiveness of the approach on several ice sheet problems. Overall, the convergence of the new procedure is relatively insensitive to a number of problem and mesh features.