Algebraic Multigrid Solvers for Thin-Domain Problems: Application to Ice Sheet Modeling

Raymond Tuminaro [1]

Climate applications are often concerned with thin regions in which the domain of interest has a much smaller vertical extent than its horizontal extent (e.g., the Antarctic ice sheet). These thin-structure mesh applications often give rise to highly anisotropic problems when the thin direction mesh spacing is much smaller than the broad direction mesh spacing. This talk considers the use of algebraic multigrid systems to solve the underlying linear systems that arise from the use of Newton's method within an ice sheet modeling capability. These linear systems can be quite challenging for a traditional algebraic multigrid solver due to the nature of the thin domain meshes. We discuss several problematic features in these applications and how these features generally violate assumptions that are often made when developing preconditioners.

A multigrid method is proposed that combines ideas from matrix dependent multigrid for structured grids with algebraic multigrid for unstructured grids. This solver heavily leverages the specific nature of the underlying meshes employed in ice sheet modeling to overcome the above mentioned difficulties. The first few multigrid hierarchy levels are obtained by applying matrix dependent multigrid to semi-coarsen in a structured thin-direction fashion. Here, Schur complement aspects of matrix dependent multigrid are highlighted. The semi-coarsening gives rise to a mesh containing only a single layer. Algebraic multigrid can then be employed to create additional coarse levels, as the anisotropic phenomena is not present in the single layer problem. Numerical results associated with Greenland and Antarctica simulations are given demonstrating the scalability of the resulting multigrid algorithm.

[1] Sandia National Labs, USA (rstumin@sandia.gov)