An algebraic multigrid linear solver for extruded meshes: application to ice sheet simulation

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Climate applications are generally 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 or the troposphere). Further, these climate applications frequently employ extruded meshes that are obtained by taking a two-dimensional mesh and extending it in the vertical direction. Thin-structure extruded 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 to solve the underlying linear systems that arise from the use of Newton's method within an ice sheet modeling capability. These linear systems are quite challenging for a traditional algebraic multigrid solver due to the anisotropic nature of the discrete representation. A multigrid method is proposed that combines ideas from matrix dependent multigrid for structured grids with algebraic multigrid for unstructured grids. Specifically, the first few multigrid hierarchy levels are obtained by applying matrix dependent multigrid to semi-coarsen in a structured thin-direction fashion. This 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. The overall approach gives rise to a highly scalable solver and remains algebraic, facilitating solver/application integration, with the minor exception that additional information is needed to determine the extruded direction.