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Solver Challenges in AMR Ice Sheet Modeling

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Ice sheets are a prime candidate for adaptive mesh refinement (AMR) due to the combination of localized regions which demand very fine spatial resolution, like ice streams and grounding lines, combined with large quiescent regions where such fine resolution represents a waste of computational effort. BISICLES is a scalable ice-sheet model built on the Chombo framework which uses block-structured AMR to dynamically refine the computational mesh where needed to resolve the wide range of dynamical scales found in ice sheets. We use a formulation of the momentum balance based on the vertically-integrated treatment of Schoof and Hindmarsh, which produces a nonlinear coupled elliptic system which must be solved repeatedly to compute the ice velocity field. The combination of local refinement and the particular non-Newtonian character of ice produces unique challenges solving this system of equations. We have adopted a hybrid Picard-JFNK approach to the nonlinear system. While geometric multigrid (GMG) is a natural fit with AMR methods, it has struggled with the linear systems some of our applications produce, particularly in the case of marine ice sheets, leading us to explore applications of algebraic multigrid (AMG) schemes to AMR.