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BISICLES – A Scalable Finite-Volume Adaptive Mesh Refinement Ice Sheet Model

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Understanding the changing behavior of land ice sheets is essential for accurate projection of sea-level change. The dynamics of ice sheets span a wide range of scales. Localized regions such as grounding lines and ice streams require extremely fine (better than 1 km) resolution to correctly capture the dynamics. Resolving such features using a uniform computational mesh would be prohibitively expensive. Conversely, there are large regions where such fine resolution is unnecessary and represents a waste of computational resources. This makes ice sheets a prime candidate for adaptive mesh refinement (AMR), in which finer spatial resolution is added only where needed, enabling the efficient use of computing resources. The Berkeley ISICLES (BISICLES) project is a collaboration among the Lawrence Berkeley and Los Alamos National Laboratories in the U.S. and the University of Bristol in the U.K.

We are constructing a high-performance scalable AMR ice sheet model using the Chombo parallel AMR framework. The placement of refined meshes can easily adapt dynamically to follow the changing and evolving features of the ice sheets. We also use a vertically-integrated treatment of the momentum equation based on that of Schoof and Hindmarsh (2010), which permits additional computational efficiency. Using Chombo enables us to take advantage of existing scalable multigrid-based AMR elliptic solvers and PPM-based AMR hyperbolic solvers. Linking to the existing Glimmer-CISM community ice sheet model as an alternative dynamical core allows use of many features of the existing Glimmer-CISM model, including a coupler to CESM. We present results showing the effectiveness of our approach, both for simple benchmark problems which validate our approach, and for application to regional and continental-scale ice-sheet modeling.