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Advanced ice sheet modeling: Berkeley-ISICLES -- A high-performance, higher-order, adaptive ice sheet model

Daniel Martin[†]; Stephen Cornford; Esmond Ng; William Lipscomb
[†] Lawrence Berkeley National Laboratory, USA
Leading author: DFMartin@lbl.gov

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. Conversely, there are large regions where such fine resolution represents a waste of resources. This makes ice sheets a prime candidate for adaptive mesh refinement (AMR), in which finer spatial resolution is added where needed, enabling the efficient use of computing resources. The Berkeley ISICLES (BISICLES) project is a collaboration among the Lawrence Berkeley National Laboratory, Los Alamos National Laboratory, and the University of Bristol in the U.K. Our goal is the construction of a high-performance scalable AMR ice sheet model using the Chombo parallel AMR framework. We also use the higher-order vertically-integrated "L1L2" treatment of the momentum equation due to Schoof and Hindmarsh (2010), which is computationally similar in cost to the MacAyeal (shallow-shelf) model but is similar in accuracy to the Blatter-Pattyn model as an approximation to the full Stokes model. Autotuning techniques are being deployed to improve performance of key computational kernels. We present examples showing the effectiveness of our approach. The BISICLES dynamical core (dyCore) has been coupled with the Glimmer Community Ice Sheet Model (Glimmer-CISM) as an alternative dynamical core, allowing its use in CESM climate simulations, using the existing CESM-CISM coupler.