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Advanced ice sheet modeling: Coupling oceans and ice sheets in the Community Earth System Model

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The Community Earth System Model (CESM), released in 2010, includes a new dynamic ice sheet component, the Community Ice Sheet Model (CISM). CESM consists of five component models (atmosphere, land, ocean, sea ice, and ice sheets) that communicate through a coupler. In the initial release, CISM was coupled to the land surface model but not to the POP ocean model, because the existing version of POP did not support ocean circulation adjacent to ice shelves. POP has recently been modified to simulate ocean flow beneath ice shelves, with heat and mass exchange at the ice-ocean boundary. Also, CISM now includes a parallel, higher-order ("L1L2") dynamical core based on the Chombo adaptive-mesh-refinement software package. (These developments are described in two companion posters, "Advanced ice sheet modeling: Simulating dynamic ice shelves in a global ocean model" and "Advanced Ice Sheet Modeling: Berkeley-ISICLES -- A High-Performance, Higher-Order, Adaptive Ice Sheet Model", respectively.) Here we describe the framework for ice-sheet/ocean coupling. CISM computes the evolution of thickness and temperature in the ice sheet and adjoining ice shelves. Fields describing the ice-sheet geometry (grounded and floating ice fractions and depth of the sheet/shelf base) and basal temperature are passed from CISM to POP via the coupler, which interpolates fields to the ocean grid. POP then computes basal growth/melting rates and heat fluxes, which are mapped to the ice-sheet grid and returned to CISM. In the land model, which computes the ice-sheet surface mass balance, the land-ice fraction evolves consistently with changes in the ocean. The immersed boundary method used in POP can be adapted for a moving basal boundary, as required for simulating gravitationally self-consistent sea-level change. We show preliminary coupled model results and describe plans for future simulations.