

A Two-Dimensional Coupled Model for Ice Shelf-Ocean Interaction

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A simplified coupled model of ice shelf-ocean interaction including an evolving ice shelf is presented. This model is well suited to climate simulation, as it is computationally inexpensive and capable of handling significant changes to the shape of the sub-ice shelf cavity as the shelf profile evolves. The ocean component uses a two-dimensional vertical overturning streamfunction to describe the thermohaline circulation. In order to smoothly accommodate evolution of the shelf, the equations have been converted to a time-dependent terrain-following (σ) vertical coordinate. The shelf component is a model for the flow of a confined ice shelf of non-uniform thickness, which consists of equations for longitudinal spreading rate and velocity. The advection of ice thickness has been modified to include separate marine and meteoric layers. The ice shelf and ocean interact thermodynamically through a three-equation formulation for basal melting and freezing.

The model is applied to an idealization of Filchner Ice Shelf, Antarctica. Following a 600 year simulation, the shelf is found to have reached an equilibrium which represents a loss of approximately 10% of mass relative to its steady state when ocean interaction is not considered. Significant changes in the shelf morphology are also observed, notably an increase in basal slope near the grounding line. These changes are accompanied by shifts in the pattern of basal melting and freezing. Warming of the ocean produces a greater than linear increase in basal melting on decadal timescales, gradually slowing to linear over centuries.