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. Application of the model will initially focus on mass balance and long term stability of ice shelves.

The ocean component is based on the Hellmer and Olbers (1989) model, which uses a two-dimensional vertical overturning streamfunction to describe the thermohaline circulation under a static ice shelf. In order to smoothly accommodate evolution of the ice shelf, the equations have been converted to a time-dependent terrain-following (sigma) vertical coordinate. The ocean is forced via salinity and (potential) temperature restoring along the open boundary at the ice front.

The ice shelf component is a model for the flow of a confined ice shelf of non-uniform thickness (Paterson, 1994), which consists of equations for longitudinal spreading rate and velocity. Following Holland (2002),the advection of shelf thickness has been modified to include separate marine and meteoric ice layers. The ice shelf is forced by imposing an inward mass flux at the grounding line and a precipitation rate along the full length of the shelf.

The ice shelf and ocean interact thermodynamically through a three-equation formulation for basal melting and freezing (Holland and Jenkins, 1999). Ice thickness is advected at each ocean timestep using the calculated meltrate as forcing, enabling the ocean model to handle the resulting evolution of the cavity geometry. The ice shelf velocity is updated on a much slower timescale of approximately a year.

The model is applied to the idealized Filchner Ice Shelf domain used by Hellmer and Olbers. The initial configuration is a steady state of the ice shelf model alone, with flow parameters chosen so that the ice shelf closely matches the static shelf of the earlier study. Following a 600 year simulation, the ice 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 ice shelf morphology are also observed, notably an increase in basal slope near the grounding line (Figure 1). These changes are accompanied by shifts in the pattern of basal melting and freezing (Figure 2). Further application of the model will focus on mass balance and long-term stability of ice shelves subject to high basal melting, and on comparison with full three-dimensional models.

Complete results of this study, including ocean warming experiments, have been submitted to *Ocean Modelling.*

References:

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Figures:

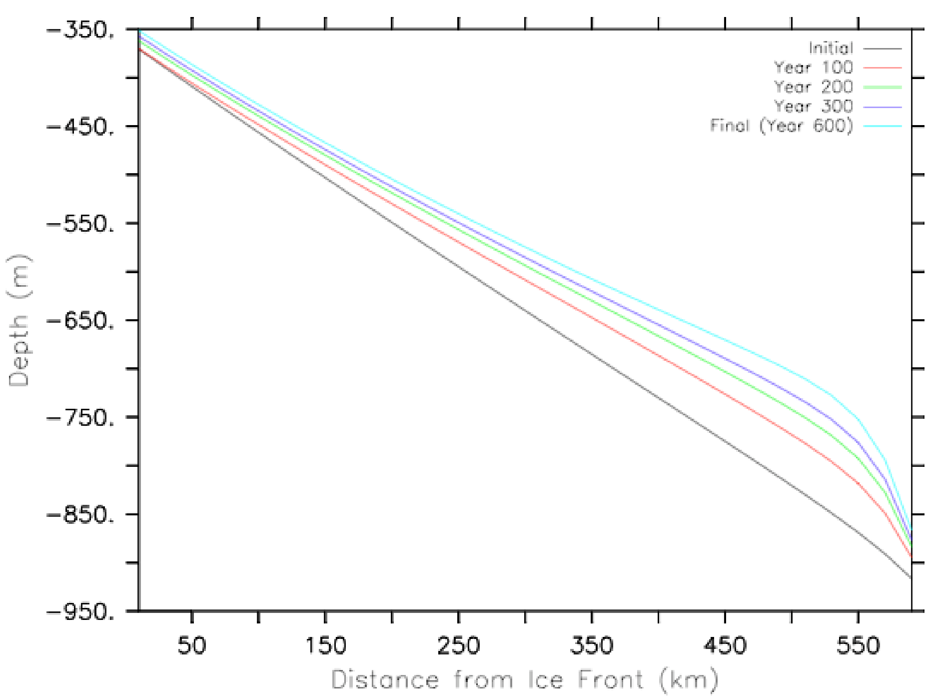

Figure 1: Ice shelf draft for the control experiment.

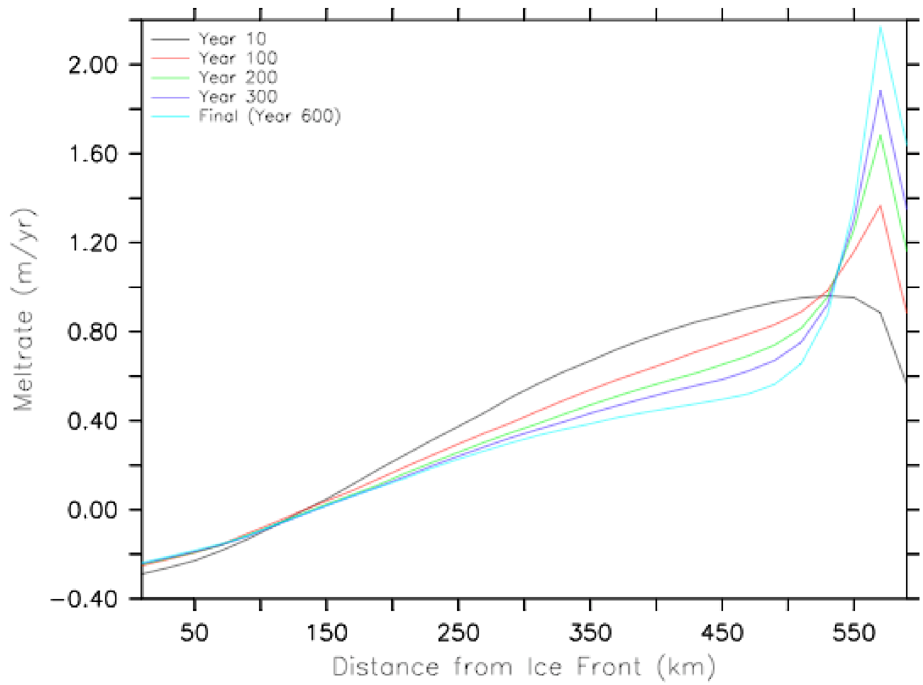

Figure 2: Basal melting for the control experiment. Note correlation between melting and basal slope as shown in Figure 1.