Geophysical Research Abstracts,
Vol. 11, EGU2009-1261, 2009
EGU General Assembly 2009

Buttressing and stability of marine Ice sheets

D. Goldberg (1), D. M. Holland (2), and C. Schoof (3)

(1) Courant Institute of Mathematical Sciences, New York University, New York, USA (dgoldberg@cims.nyu.edu), (2) Courant Institute of Mathematical Sciences, New York University, New York, USA (dgoldberg@cims.nyu.edu), (3) Earth and Ocean Sciences, University of British Columbia, Vancouver, CA (cschoof@eos.ubc.ca)

The West Antarctic Ice Sheet is marine in nature, meaning most of its base is below sea level. At the grounding line (where it becomes thin enough to float), its outlet streams flow into large ice shelves. Gravitational stress in the shelf is transmitted back to the grounding line, and largely balanced by basal friction in the transition zone. The details of this force balance control the evolution of both the thickness and grounded extent of the ice sheet, and can lead to Weertman's (1974) Marine Instability for a foredeepened bedrock (one that deepens inland). However, the presence of rigid sidewalls and locally grounded regions in the shelf can reduce the longitudinal stresses felt at the grounding line (a phenomenon called buttressing). Thomas (1979) and others pointed out that Marine Instability may be lessened or reversed by ice shelf buttressing.

When modelling marine ice sheets numerically, the physics of the grounded-to-floating transition must be represented and the associated small length scales must be resolved (Schoof, 2007). Failing to do so can result in nonphysical or numerically inconsistent behavior (Vieli and Payne, 2005). While several methods have been developed to treat these issues (Vieli and Payne, 2005; Pattyn et al, 2006; Schoof, 2007) they are limited to flowline models. We present a model that represents the physics of the grounded-to-floating transition in a time-dependent three-dimensional marine ice sheet, using mesh adaption to resolve the transition zone. We show that in the special case of a two-dimensional sheet our model reproduces the theoretical results of the MISMIP experiments, and that it produces robust results when both horizontal dimensions are resolved.

In idealized experiments in a channel with rigid sidewalls and a foredeepened bed, we narrow the channel to determine whether buttressing is sufficient to reverse instability. We find that for strong beds (high friction coefficients), while the timescales and dynamics are affected greatly by buttressing, true stability reversal is still not seen even as the channel becomes quite narrow. However, for weaker beds, stability is seen, though it can be shown that sufficient ocean melting can still cause collapse. Experiments with more complicated bed topography show that locally grounded areas (ice rises) have similar dynamic effects to rigid sidewalls.