When the Bough Breaks: Implementing an Empirical Calving Rule in a Dynamic Stream/Shelf Model

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Given the ability of ice shelves to buttress the outflow of ice sheets, it is imperative to study the dynamic behavior of ice shelves if we wish to predict the contributions of ice sheets to future sea-level variations. Ice-shelf buttressing comes from frictional dissipation, both at the lateral margins of the shelf and any local pinning points or ice rises within the shelf. Disintegration of all or a portion of an ice shelf is one of the most direct ways to reduce ice-shelf buttressing, as evidenced by the accelerations of glaciers feeding the collapsed portion of the Larsen B ice shelf (Rignot and others, 2004; Scambos and others, 2004). This leads directly to the consideration of iceberg calving, as ice-shelf disintegration is simply an extreme calving event.

Here we apply an empirically derived calving rule to ice-shelf/ice-stream dynamics. The shelf/stream model couples dynamic mass balance and stress equilibrium component models for a depth and width-integrated stream/shelf system. The calving rule relates the ice-shelf velocity and a maximum (or yield) strain rate. The character of rule has this yield strain rate increasing with increasing velocity. Implementation of the calving rule within the shelf/stream model involves allowing calving at any point of the ice shelf where the longitudinal strain rate exceeds the yield value for the velocity distribution. We perform numerical experiments to examine the potential for rapid loss of ice-shelf extent due to slight to moderate disturbances in the stress state of the shelf/stream system. The implications for the stability of stream/shelf systems are considered in light of these experiments.