When iceberg calving matters: An investigation into the feedback between iceberg calving and dynamic changes in the flow of inland ice

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Iceberg calving provides an efficient mechanism to transfer larges amounts of ice to the ocean in a near instantaneous fashion, thereby not only drastically changing the mass balance of a glacier/ice sheet, but the geometry of the glacial system. These changes can have a profound effect on the flow of inland ice through a variety of feedbacks. For example, removal of sections of ice can (i) reduce the back-pressure or "buttressing" of inland ice or (ii) perturb basal hydrology and alter the basal sliding conditions. Furthermore, because iceberg calving tends to be important in regions with high longitudinal stresses, the non-local nature of these stresses allows the possibility that perturbations are transmitted far into the interior of the glacier or ice sheet. As a first step towards understanding the interaction between iceberg calving and flow dynamics, we have developed a depth-integrated flowline model that includes both vertical shear and longitudinal stresses. Unlike traditional, higher-order, models that explicitly solve for all stress components (at great computation cost), we assume that the vertical velocity profile varies weakly in comparison to variations in basal sliding. This approximation reduces the governing equation to a nonlinear ODE that, for different limits in the ratio of the bed-to-ice strength, happily reduces to the traditional shallow ice approximation (strong bed), the ice-stream approximation (weak bed) and ice shelf approximations (very weak bed). The simplicity and computational efficiency of the model provides the potential to explore the time-dependent behavior of a variety of simple parameterizations of iceberg calving in combination with different basal sliding laws and stress regimes. We present preliminary results, using this model to evaluate the interplay between ice dynamics and calving using idealized "rules" to determine when calving events occur in combination with simple basal sliding laws.