Calculating the Floating Fraction of Basal Ice Along Byrd Glacier, Antarctica, Using Only the Force Balance

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A geometrical force balance for stream flow in ice sheets was used to equate floating fraction phi of basal ice with the ratio of ice thickness at an ice-shelf grounding line to ice thickness at any distance upslope along an ice stream supplying the ice shelf. This simple formula for calculating floating fraction phi was then applied to Byrd Glacier, which supplies East Antarctic ice to the Ross Ice Shelf. The method is described for obtaining phi from gravitational forcing that is resisted by basal and side shear and by longitudinal tension and compression along an ice flowband. Then phi is calculated from the ice-thickness profile for Byrd Glacier along a radio-echo flightline up Byrd Glacier that gave nearly continuous top and bottom reflections. This gives a first-order determination of the floating fraction of Byrd Glacier along the flightline from the ice-shelf grounding line to the beginning of stream flow. Experiments are presented comparing the calculated phi variation with continuous phi variations that may have a theoretical explanation. A good fit is obtained with a phi curve that decreases with distance upslope from the grounding line as half-a-period of a cosine squared function that gives smooth transitions from the convex profile for sheet flow to the concave profile for stream flow to the flat profile for shelf flow.