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Investigating the flow and stress regime at the front of a tidewater outlet glacier

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Dynamic changes in ocean-terminating glaciers are responsible for approximately half of the current high rate of mass loss of the Greenland ice sheet. The related calving process, which occurs when the stresses at the calving front exceed the fracture toughness of ice, is still not well understood and poorly represented in current generation ice-sheet models, but is a crucial requisite to understand and model dynamics and future mass loss of the ice sheet.

Here, we use a two-dimensional finite-element model to compute the stress and flow fields near the front of a tidewater outlet glacier. First, we perform a sensitivity analysis for an idealized glacier exploring the effects of variable calving front slope, water depth and basal sliding. We then apply the model to two flowlines of Eqip Sermia, an ocean terminating outlet glacier in West Greenland. Detailed velocity and geometry measurements obtained from terrestrial radar interferometry serve as constraints to the model. These flowline geometries and velocities strongly differ. One flowline ends with a ~ 50 meter vertical cliff, close to floatation, while the other has a 150-200 meter high grounded front with a $\sim 45°$ slope and for which extrusion flow is observed. These different geometry settings lead to substantial difference in stress and flow regimes.

This stress analysis improves our understanding of how and where the ice is susceptible to failure and crevasse formation for different idealized as well as real conditions. In further work, we aim to use this information as a constraint to investigate the short-term and long-term processes related to outlet glacier calving.