Ice Cliffs: A Region Primed for Enhanced Flow or Failure?

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There is an imbalance between the glaciostatic stress and the combination of adjacent air (negligible) plus hydrostatic stresses at ice fronts, with an overall balance provided by enhanced resistive stresses within the ice. This ice-front glaciostatic-hydrostatic stress imbalance increases with cliff height, leading to a concomitant increase in internal stresses. Furthermore, across the grounding zone, reduced localized basal friction on the approach to flotation can also lead to an increase in internal stresses (forces that could otherwise be partially balanced by drag at the bed are now compensated by englacial resistive stresses) within the transition between regions of higher and lower basal drag. Here we present preliminary idealized modeling results illustrating the impact of these higher stresses on viscous thinning rates. For tall subaerial cliff faces, flow thinning is far outpaced by the nearly-instantaneous timescales associated with the limiting failure modes for ice that would control system behavior. However, for shorter-than-critical grounded ice cliffs, the timescales required to alleviate the locally-elevated stresses approach the sub-annual timescales of processes that subsequently promote failure either through local increases in internal stress or weakening of the ice (e.g., thinning to flotation and an associated loss of basal drag; loss of basal drag due to tidal pumping beneath ice that is at or near flotation; tidal flexure for ice at or near flotation; summer surface meltwater wedging open crevasses and/or lubricating failure surfaces; etc.). Therefore, our findings indicate that while higher stresses enhance flow thinning, they do not necessarily cause cliffs to go away.