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Revisiting the crevasse-depth calving law in the presence of melt undercutting

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For tidewater glaciers worldwide, calving is a principal mechanism of mass loss. In turn, undercutting of tidewater glacier termini by submarine melting is understood to be a principal driver of calving. Yet, we currently have no practical and widely-accepted parameterisations that can represent the impact of submarine melting on calving in ice sheet models that are used for sea level projection, reducing confidence in their predictions.

The ‘crevasse-depth calving law’ that broadly relates depth-mean stress to a crevasse depth has been very widely used in models of tidewater glaciers, but this law does not fully account for the impact of submarine melt undercutting on the near-terminus stress field, which may be the key link between tidewater glaciers and the ocean. As such, we here work to incorporate the full impact of melt undercutting into a revised crevasse-depth calving law.

We combine elastic beam theory, linear elastic fracture mechanics and Elmer/Ice simulations to study the propagation of surface and basal crevasses near the front of tidewater glaciers in response to melt undercutting. We work to parameterise these results through a simple revision of the existing crevasse-depth calving law. The revised law explicitly accounts for the impact of melt undercutting on crevasses near the terminus, without increasing the computational demand on ice sheet models that might incorporate such a law, representing an important step towards better projection of ice sheet mass loss driven by the ocean.