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On the effect of undercutting on calving rate using continuum damage mechanics.

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Several studies have shown that mechanical ice loss through calving is responsible for most of ice discharge from glaciers and ice sheets. However calving processes are complex and still poorly understood. Representation of calving into ice flow models is still limited and the estimation of future ice loss of Greenland and Antarctic ice sheets is therefore inaccurate: state-of-the-art in calving modelling is the result of strong approximations or empirically-based laws.

Calving is the main mechanism controlling the position of the terminus, but melting at the front below the waterline can be seen as a second order process modulating the calving rate. Observations have shown that variation of frontal melting exists in Greenland as well as in Antarctica, and is an important factor in explaining the maximal advance and the short term variations of the glacier front. Here, we used a continuum damage mechanics (CDM) framework to investigate the response of a glacier terminus to submarine perturbation. This CMD model is implemented into the Elmer/Ice full-Stokes ice-flow model. This work is initiated in a two-dimensional flowline approach. The damage evolves depending on the stress field in the ice and propagates through the media thanks to an advection equation. As a consequence, the viscosity of the ice is modified via a change of an enhancement factor.

In our simulation, an initial grounded-terminated glacier is perturbed by an increase in subaqueous melting. Melting of subaqueous part of the glacier front results in the development of a bloc of ice overhanging the waterline, leading to the calving of the aerial part: this phenomenon is called undercutting. The upper surface of the glacier and the vertical front are defined as free surfaces. Sensitivity in terms of stress and damage fields evolutions through time are investigated in response to the various melting perturbations. Implications on calving rate are discussed.