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Thermodynamic and fracture mechanical processes in the context of frost wedging in ice shelves

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Ice shelves, the link between ice shields or glaciers and the ocean are sensitive elements of the polar environment. The ongoing break up and disintegration of huge ice shelf parts or entire ice shelf demands for an explication of the underlying processes. The first analyses of crack growth and break up events in ice shelves date back to more than half a century. Nevertheless, the mechanisms that trigger and influence the collapse of whole ice shelf parts are not yet fully understood. Popular presumptions link ice shelf disintegration to surface meltwater and hydro fracturing, explaining break up events in warm polar seasons. Fracture events during colder seasons are possibly triggered by more complex mechanisms. A well-documented break up event at the Wilkins Ice Shelf bridge inspires the possibility of frost wedging as disintegration cause. The present study shows a two-dimensional thermo-dynamical model simulating the growth of an ice lid in a water-filled crevasse for measured surface temperatures. The influence of the crevasse geometry and the ice shelf temperature are shown. The resulting lid thickness is then used for the linear elastic fracture mechanical analysis. The maximum crack depth is estimated by comparing the computed stress intensity factors to critical values K_{Ic} obtained from literature. The thermodynamic as well as the fracture mechanical simulation are performed using the commercial finite element code COMSOL. The computation of K_I follows in post processing routines in MATLAB exploiting the benefits of the concept of configurational forces.