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Numerical Simulation of Calving Events at Antarctic Ice Shelves

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Ice shelves are the floating ice masses with a marine terminus at which icebergs are calving off. For a better understanding of the influence of environmental parameters on calving processes, the nature and frequency of calving events are examined from a fracture mechanical perspective. The stresses in the vicinity of the calving front are evaluated to estimate the position of a calving event as well as the calving rate. Factors, which presumably influence the calving rate, are the rate of spreading and the width and thickness of the ice shelf. There exists two predominant approaches to model ice: on long time scales ice is modeled as a viscous fluid and on short time scales as an elastic solid. One aim of the work is to combine both approaches in a viscoelastic model, which can be used for the analysis of the calving rate of ice shelves and which might lead to more realistic results.

As fracturing processes occur at a very short time scale, the elastic response is important and as a first approach linear elastic fracture mechanics can be applied. For our analysis, the ice shelf is modeled as a two dimensional block loaded by gravity, water pressure at the ice front and buoyancy forces at the bottom of the ice shelf. The influence of different boundary conditions is analyzed using the Finite Element program COMSOL with a linear elastic material behavior. It shows that the position of the maximum tensile stress and therefore the most probable location for a calving event is at a distance of about two-thirds of the ice thickness away from the ice front.

A refined model uses a viscoelastic generalized Maxwell model to consider also the creep behavior of the ice shelf after a calving event. This event influences the stress field and the flow velocities of the remaining ice shelf. Therefore the time period until the system reaches the critical state again is simulated and compared to the flow distance in this time period.