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Investigation in the iceberg capsizing force responsible for glacial earthquakes and ice-volume discharge estimation from seismic records and a numerical modeling

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Glacial earthquakes is a class of seismic events of magnitude up to 5, occurring primarily in Greenland, in the margins of large marine-terminated glaciers with near-grounded termini. They are caused by calving of kilometer-scale unstable icebergs which penetrate the full-glacier thickness and, driven by the buoyancy forces, capsize against the calving front. These phenomena produce seismic energy including surface waves which last between 2 and 10 min, with dominant energy between 10-100 s of period. The source responsible for generation of such seismic waves is compatible with the contact force exerted on the terminus by the iceberg while it capsizes. We develop a 2D finite element model which takes into account the effect of water on solid structures. Using realistic rheological laws that describe ice behavior, we model iceberg capsize and investigate the forces applied on the solid Earth during this phenomenon, and generated seismic waves. We investigate the force variations with iceberg dimensions, initial buoyant conditions and direction of capsize rotation. We find that top-out iceberg capsize exerts a force on the glacier terminus which largely differs from the bottom-out capsize force in terms of amplitude and force waveforms but only in the seismic frequency band. For realistic iceberg dimensions, we compute a catalog of capsize forces whose magnitudes are consistent with seismic observations. Finally, by exploring the geometric parameters which control the capsize dynamics (height and width of the iceberg, and its initial buoyant condition), we are able to accurately reproduce the observed seismic wavefield and estimate the calved iceberg volume.