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Modelling the source of glacial earthquakes for a better understanding of the impact of iceberg capsize on glacier stability

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One current concern in climate science is the estimations of the amount of ice loss by glaciers each year and the corresponding rate of sea level rise. Greenland ice sheet contribution is significant with about 30% to the global ice mass losses. Ice loss in Greenland is distributed approximately equally between loss in land by surface melting and loss at the front of marine-terminating glaciers that is modulated by dynamic processes. Dynamic mass loss includes both submarine melting and iceberg calving. The processes that control ablation at tidewater glacier termini, glacier retreat and calving are complex, setting the limits to the estimation of dynamic mass loss and the relation to glacier dynamics. It involves interactions between bedrock – glaciers – icebergs – ice-mélange – water – atmosphere. Moreover, the capsize of cubic kilometer scale icebergs close to a glacier front can destabilize the glacier, generate tsunami waves, and induce mixing of the water column which can impact both the local fauna and flora.

We aim to improve the understanding of iceberg capsize using a mechanical modeling of iceberg rotation against the glacier terminus, constrained by the generated seismic waves that are recorded at teleseismic distances. To achieve this objective, we develop a fluid-structure interaction model for the capsizing iceberg. Full scale fluid-structure interaction models enable accurate simulation of complex fluid flows in presence of rigid or deformable solids and in presence of free surfaces. However, such models are computationally very expensive. Therefore, our strategy is to construct a simple solid dynamics model involving contact and friction, whose simplified interaction with water is governed by parametrized forces and moments. We fine tune these parametrized effects on an iceberg capsizing in contact with a glacier with the help of reference direct numerical simulations of fluid-structure interactions involving full resolution of Navier-Stokes equations. We assess the sensitivity of the glacier dynamics to the glacier-bedrock friction law and the conditions for triggering a stick-slip motion of the glacier due to iceberg capsize. The seismogenic sources of the capsizing iceberg in contact with a glacier simulated with

our model are then compared to the recorded seismic signals for well documented events.