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Interplay between frictional sliding and cracking in a block-spring model of large ice masses instabilities

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In order to understand the physical mechanisms leading to accelerated motions and seismic activity before glacier collapse, we have built a numerical model based on the discretization of a glacier in terms of blocs and springs forming a two-dimensional network sliding on an inclined slope. Each block, which can slide, is connected to its four neighbours by springs that can fail, depending on the history of displacements and damage. We develop faithful physical models describing the frictional sliding of blocks on the plane and the tensile failures of the springs between blocs proxying for crack opening. Frictional sliding is modelled with a state-and-velocity weakening friction law with threshold. Crack formation is modelled with a time-dependent cumulative damage law with thermal activation including stress corrosion. In order to reproduce icequake activity and dynamical effects, all equations of motion (including inertia) for each block are solved simultaneously. Simulations of the models scaled with realistic parameters reproduce the different regimes observed in real-life situations, including stable and unstable behaviour and acceleration of icequakes activity prior to collapse.

Our results suggest that the different behaviours observed preceding glacier collapse can be seen as different members of a continuous family of behaviours resulting from the competition between friction-mediated and crack-mediated instabilities and their interplay. Our unifying framework should provide a better understanding of rupture

mechanisms in heterogeneous media and improve the forecast of the final rupture of gravity driven systems.