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Modeling crack propagation for snow slab avalanche release with discrete elements

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Dry-snow slab avalanche release is a multi-scale fracture process. It starts with the formation of a localized failure in a highly porous weak snow layer underlying a cohesive snow slab, followed by rapid crack propagation within the weak and finally a tensile fracture through the slab leading to its detachment. We have gained a reasonable amount of knowledge on failure initiation and the onset of crack propagation from laboratory and field experiments. However, our knowledge on dynamic crack propagation is still very limited due to the complex microstructure of snow, the complex interfaces of this layered media, the non-observability without damage and 3-dimensional interactions of the crack propagation. Nevertheless, in view of predicting avalanche size, a better understanding of crack propagation processes is required. To shed more light on this issues, we used a 3D discrete element method to simulate crack propagation in snow. Using cohesive ballistic deposition, we numerically materialize a highly porous and brittle weak layer covered by a dense cohesive slab. We tuned the contact law parameters between the particles to obtain realistic macroscopic behavior of the slab and the weak layer consistent with laboratory and field experiments. We then disturbed this stable snowpack sample by cutting the weak layer with a numerical snow saw. From this perturbation, the fracture process can be studied such as a field propagation saw tests (PST). The simulations nicely reproduced the process of crack propagation observed in field PSTs. This novel numerical modeling approach is an alternative, yet complementary, to field experiments. In the future, the influence of slope angle on the crack shape and on the mode II&III velocities will be studied and analyzed.