EGU2020-20604, updated on 22 Oct 2020
https://doi.org/10.5194/egusphere-egu2020-20604
EGU General Assembly 2020

Sharp transition in modes of dynamic crack propagation in dry-snow slab avalanche release

Bertil Trottet[1], Alec van Herwijnen[2], Stephanie Wang[3], Chenfanfu Jiang[4], Joseph Teran[3], and Johan Gaume[1,2]
[1]School of Architecture, Civil and Environmental Engineering, Swiss Federal Institute of Technology, 1015 Lausanne, Switzerland.
[2]WSL Institute for Snow andAvalanche Research SLF, Flüelastrasse 11, Davos Dorf, Switzerland.
[3]Department of Mathematics, University of California, Los Angeles, CA 90095, USA.
[4]Computer and Information Science Department, University of Pennsylvania, Philadelphia, PA 19104, USA.

Dry-snow slab avalanche release can be separated in four distinct phases : (i) failure initiation in a weak snow layer buried below a cohesive snow slab, (ii) onset, (iii) dynamics of crack propagation in the weak layer and eventually (iv) slab release. While a lot has been done to study the first two phases, less is known about dynamic crack propagation and slab release, especially at slope scale.

In this study, we used the Material Point Method and elastoplasticity to simulate the dynamics of 20 m long centered Propagation Saw Tests (PST). We improved the recent constitutive snow model of Gaume et al. (2018) by developing a new softening law based on the total plastic deformation (volumetric and deviatoric parts) to remove artifacts observed in failure modes.

Interestingly, several regimes of propagations are observed depending on slope angle Θ. For slope angles smaller than the friction angle ($\Theta < \Phi$), crack propagates faster in the downslope direction than upslope. The propagation speed increases with slope angle and appears closely related to the bending mechanism which sustains the propagation. For slope angles higher than the friction angle ($\Theta > \Phi$), a sharp transition is observed once the crack reaches a critical length l_f. We interpret this transition as a change from slab bending to slab tension due to the increasing load in the downslope direction. An estimation of l_f is proposed using a basic analytical shear model with residual friction similar to the one developped by McClung in 1979. In this case, the crack propagation speed seems to be mostly related to the P-wave speed in the slab. In this study, we explain the gap between propagation speeds based on 2 m PSTs and some observations of avalanche triggering. Finally, our results show the relevance of shear models which appear sufficient to describe slab avalanche release on steep terrain.