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Field measurements and modeling of wave propagation and subsequent weak layer failure in snow due to explosive loading

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Avalanche control by explosives is among the key temporary preventive measures. Yet, little is known about the mechanism involved in releasing avalanches by the effect of an explosion. Here, we test the hypothesis that the stress induced by acoustic waves exceeds the strength of weak snow layers. Consequently the snow fails and the onset of rapid crack propagation might finally lead to the release of a snow slab avalanche.

We performed experiments with explosive charges over a snowpack. We installed microphones above the snowpack to measure near-surface air pressure and accelerometers within three snow pits. We also recorded pit walls of each pit with high speed cameras to detect weak layer failure. Empirical relationships and a priori information from ice and air were used to characterize a porous layered model from density measurements of snow profiles in the snow pits. This model was used to perform two-dimensional numerical simulations of wave propagation in Biot-type porous material. Locations of snow failure were identified in the simulation by comparing the axial and deviatoric stress field of the simulation to the corresponding snow strength. The identified snow failure locations corresponded well with the observed failure locations in the experiment. The acceleration measured in the snowpack best correlated with the modeled acceleration of the fluid relative to the ice frame. Even though the near field of the explosion is expected to be governed by non-linear effects as for example the observed supersonic wave propagation in the air above the snow surface, the results of the linear poroelastic simulation fit well with the measured air pressure and snowpack accelerations.

The results of this comparison are an important step towards quantifying the effectiveness of avalanche control by explosives.