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Why are hard snow slabs more prone to wide-scale crack propagation?

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The evaluation of the size of a snow slab avalanche in a potential starting zone is an important factor in hazard assessment. Dry-snow slab avalanches are generally caused by a sequence of fracture processes including (1) failure initiation in a weak snow layer underlying a cohesive slab, (2) crack propagation within the weak layer and (3) slab tensile fracture which leads to its detachment. The size of the avalanche is closely linked to crack propagation propensity which mostly depends on weak layer and slab properties as well as their variability. In this study, the finite element method is used to investigate the respective drivers of crack propagation and slab tensile fracture. Two competitive contributing factors are the elastic modulus and the tensile strength of the snow slab. Contrary to what may be expected, our results show that high values of slab stiffness prevent crack propagation. On the other hand, high tensile strength prevents slab tensile fracture so that the crack in the weak layer below the slab can propagate further. However, for a material such as snow, stiffness and strength are related; both increase with increasing snow density resulting in more complex mechanical interactions. Ultimately, we demonstrate that the size of a snow slab avalanche increases with increasing slab density and hardness – in agreement with observations.