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A comprehensive elastic and fracture model for stratified snowpacks

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Dry snow slab avalanche release depends heavily on the stratification of the snow cover and the mechanical properties of the individual snow layers. This does not only concern the depth and condition of the weak-layer but also the ordering and properties of all snow layers above it.

In order to allow for a quick stability assessment of stratified snow covers, we present an analytical model for snow cover deformations, weak-layer stresses and energy release rates of cracks within the weak-layer for arbitrarily layered snowpacks. In particular, the model covers the impact of the layering order on both the extensional and bending stiffness of the slab. It can be used for skier-loaded slopes and for stability tests such as the propagation saw test. The model is highly efficient and readily allows for parameter studies and implementation into other toolchains.

Recognizing weak-layer collapse as an integral part of the fracture process prior to the release of slab avalanches is crucial and explains phenomena such as whumpf sounds and remote triggering of avalanches from low angle terrain. Finite fracture mechanics introduces a new conceptual understanding of crack nucleation. It provides a coupled stress and energy failure criterion for anticrack formation in persistent weak-layers.

Incorporating this physically sound mixed-mode failure criterion, the model allows for the prediction of skier-loads that layered snowpacks can sustain before weak-layer failure triggering is expected that can lead to avalanche release. Our analysis covers the impact of the layering order on weak-layer stresses and critical skier-loads.