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Numerical evaluation of the failure envelope of weak snow layers using the discrete element method

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The release of dry-snow slab avalanches is initiated by a local failure in a weak snow layer underlying a cohesive slab followed by crack propagation within the weak layer. Our understanding of these processes is limited by the complex microstructure of snow. The observation of the structural collapse of weak layers has raised the question of the origin of the initial failure, whether it is in shear, as assumed for years, or in compression. However, as the damage in the weak layer is due to bond breaking at the microscopic scale, the stress distribution due to mixed-mode shear and compression loading on a slope is likely to be highly complex due to the non-uniform distribution of snow grains in the weak layer.
To shed more light on this issue, we use the discrete element (DE) method to investigate the failure criterion of different types of model weak snowpack layers. As the DE model mimics the high porosity of snow, the collapse of the structure in the weak layer during fracture can be studied. Simple loading simulations were carried out for different slope angles and thus different proportions between shear and compressive stress. The numerical simulations revealed that the failure mode can be described by a complete mixed-mode shear compression failure envelope which, despite the simplicity of the model, was found in good agreement with laboratory experiments.