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Microstructure-based modeling of snow using the material point method and finite strain elastoplasticity

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The mechanical response of snow depends on its microstructural geometry. Parameters such as porosity and orientation (degree of anisotropy) are examples of microstructural parameters that can affect snow mechanical properties. Numerical simulations of snow microstructure obtained from X-ray computer tomography have aided researchers in investigating the elastic response and strength of snow. However, we lack insight into the post-peak and plastic response of snow, which in most previous studies have been oversimplified assuming (quasi-)brittle behavior. We propose studying both the elastic and post-peak behavior using the material point method (MPM), a hybrid Eulerian-Lagrangian continuum numerical method. A major advantage of MPM compared to the (classical) finite element method (FEM) is its ability to handle large deformation processes. Moreover, as a continuum method, it is significantly less computational expensive than the discrete element method (DEM). We independently study the influence of the microstructural parameters on macroscopic quantities, such as elastic modulus, strength, energy release rate and plasticity index, in mixed-mode shear-compression loading simulations. This is accomplished by using the leveled gaussian random field (GRF) approach to generate snow samples with desired microstructural properties. The ice matrix of the microstructure is modeled in the elastoplastic framework with a strain-softening Drucker-Prager failure criterion. Based on the relationships discovered through these numerical experiments, we aim to develop a microstructure-based homogenized constitutive snow model. This study will contribute to improve large-scale snow mechanical models with applications in the simulation of e.g. snow slab avalanche release, avalanche dynamics and snow-tire interaction.