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Modeling snow isothermal metamorphism at the pore scale with the phase-field model Snow3D

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Representing snow isothermal metamorphism is key to model the evolution and properties of the snow cover. Recently, a new phase-field model allowing to describe 3D microstructure induced by curvature effects has been proposed (Bretin et al, Esiam: M2an, 2019). In the present work, this model is used to simulate isothermal metamorphism of snow at the pore scale, considering the only process of moving interfaces by sublimation-deposition driven by curvatures. This model runs on real 3D microtomographic images and gives a temporal series of 3D images simulating isothermal metamorphism. To determine the condensation coefficient to use in the model, which shows complex dependencies and is still poorly known, we calibrated it by reproducing the time evolution of the specific surface area (SSA) measured during an isothermal experimental time-series at -2°C (Flin et al., Ann. Glaciol., 2004). This calibration has led to a value of the condensation coefficient of 9.9 ± 0.6 10−4. Using this calibration, we obtained a good agreement between simulations and an independent series of isothermal metamorphism at -2°C (Hagenmuller et al., The Cryosphere, 2019). Finally, 4 images representing different types of snow microstructure have been chosen as input to simulate isothermal metamorphism at -2°C during 75 days. The obtained temporal series of 3D images were then used to calculate microstructural (porosity, SSA, covariance lengths) and physical transport properties (thermal conductivity, effective diffusion, permeability) evolution. Comparing our numerical estimations of physical properties to current parameterizations gives overall good agreement. An interesting new result arising from the simulations is the conservation or enhancement of the structural anisotropy under isothermal conditions for the samples that were initially strongly anisotropic.