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Modeling the evolution of the structural anisotropy of snow

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The structural anisotropy of snow characterizes the microscopic, spatially anisotropic distribution of the ice matrix and pore space and is developed from different physical processes. It is well known that physical properties of snow like e.g. mechanical stability or thermal conductivity are affected by the structural anisotropy and that their parametrizations can be considerably improved with it.

To exploit these advancements in snowpack modeling, a dynamical model for the structural anisotropy is required. To this end we propose a minimal, phenomenological model to describe the evolution of the structural anisotropy. The model implements rate equations for each snow layer and accounts for settling and temperature gradient metamorphism, which have been identified as the main drivers for the evolution of the structural anisotropy. The model is formulated in terms of common macroscopic, thermodynamic fields to allow for an immediate implementation into common snowpack models. For the present work we drive the model with the output data of the model SNOWPACK and used a comprehensive measurement dataset comprising meteorological, radar and computer tomography data for calibration and validation. The calibration of the model was done with an available time series of the depth-averaged anisotropy spanning four different winter seasons in Finland. These anisotropy measurements were obtained from polarimetric radar data measuring the dielectric anisotropy of snow. The model is validated against full-depth vertical profiles of anisotropy measurements obtained from computer tomography data. The results show that the simple model solely based on meteorological variables is able to trace the radar measured anisotropy time series in detail and to predict the CT-measured anisotropy profiles very well.