A Micro-Structural Approach to Snow Metamorphism: Computed Tomography Experiments and Numerical Simulations

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Snow on the ground is a porous material consisting of sintering ice-grains and air filled pore-space. Snow undergoes metamorphism, where mass fluxes change the snow micro-structure and as a consequence the physical properties of snow. Understanding snow metamorphism and the impact on physical properties is crucial in snow science.

We studied metamorphosing snow under temperature gradients (TG) non-destructively using computed micro-tomography. We could observe the growth and sublimation of snow crystals within a snowpack in real-time. We developed a numerical heat and mass-transfer model for snow operating at the same length-scales and using tomography data from natural snow as geometrical input. The model uses a diffuse interface technique to handle the complex and evolving ice-matrix geometry.

From the experimental data we conclude that global mass fluxes within a snowpack can be orders of magnitude larger than the growth rates of the individual crystals. Individual snow-grains survive only short times within TG-metamorphosing snow. We studied the interplay between micro-structure, heat flow, sublimation-condensation, and mass transport using the numerical model. Locally, very high temperature and concentration gradients may occur, leading to large local fluxes and strong dynamics.

These observations require an integrated porous-media approach compared to a destructive grain based view.