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Towards a new representation of snow metamorphism in macroscopic snowpack models

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Snow on the ground is a complex porous medium that dramatically modify the energy balance of the surface and the chemical composition of the overlying atmosphere. This impact on climate and atmospheric chemistry is determined in part by the snow physical properties, which in turn depend on the size of snow grains, their shapes, their spacing and the strength of their interconnections. All these microscopic quantities are reflected, on a macroscopic scale, in several state variables: density, specific surface area (SSA, the total area at the ice/air interface per unit mass), thermal conductivity (k), shear resistance, etc. From snowfall to snowmelt, the progressive transformation of snow illustrates the fact that snow is also a dynamic medium whose properties evolve over time through “snow metamorphism”. Sustained efforts have been made in the past to characterize these processes, from both a microstructural and macroscopic viewpoint. However, fully bridging the gap between the microscopic and macroscopic scales still remains an open challenge.

The detailed snowpack model Crocus was developed at CNRM-GAME/CEN in the 1980s. It is able to simulate the energy and mass balance of the snowpack and its main purpose is to accurately describe the time evolution of the physical properties of the inner snowpack for operational avalanche prediction as well as for studying snow hydrology and snow/climate interactions.

This contribution presents the initial step of current work aiming at replacing the Crocus semi-quantitative description of the snow grains along metamorphism by the incorporation of new quantitative variables (SSA, k) as state variables describing the physical and microstructural properties of snow, in lieu of the previously used semi-quantitative variables dendricity and sphericity. Given the measurable nature of the variables chosen, this approach paves the way to easier improvement cycles of the model including data assimilation. Concepts and rationales behind this idea will be exposed and preliminary results will be compared to experimental data obtained in cold room experiments as well as in the field.