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The Influence of Vapor Attachment Kinetics on Snow Effective Properties

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Proper modelling of heat and mass transfer in snow is a prerequisite for understanding snow metamorphism and simulating the mass and energy budget of a snowpack and the underlying ground. The transfer of heat and water vapor in snow can be described with macroscopic conservation equations, which include effective coefficients such as the snow thermal conductivity or the snow water vapor diffusion coefficient. Here, we investigate the impact of the surface kinetics of water vapor sublimation and deposition at the microscopic scale on these macroscopic equations, restraining ourselves to the limiting cases of slow and fast kinetics. In particular, we show that under the assumption of fast kinetics the thermal behavior of snow is similar to that of a regular inert medium, but with an enhanced conduction in the pores, due to latent heat transported with water vapor. Besides, faster kinetics increases the effective water vapor diffusion coefficient, which nonetheless remains less than that in free air. Most (but not all) available experimental investigations suggest that in snow, fast surface kinetics prevails, so that our results have numerous implications for the proper simulation of heat and mass transfer in snow.