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On the necessity of including vapor kinetics to model the specific surface area evolution in snow

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Vapor fluxes in snow are often inferred from the temperature field by assuming vapor concentrations in local thermodynamic equilibrium with the temperature. Here we give evidence that, at the pore scale, this picture is in clear contradiction with the observed evolution of the specific surface area (SSA) under temperature gradient metamorphism. To this end, we have calculated pore-scale temperature fields using the Finite Element Method on micro-tomography images. Subsequently, we utilized the exact volume-averaged evolution equation for the SSA to infer that the disagreement stems from the employed diffusion-limited growth law which manifests in local thermodynamic equilibrium of vapor and temperature. Via sensitivity studies we confirm that this conclusion is not affected by the involved image analysis and numerical procedures. We outline how and why attachment kinetics may resolve the observed contradiction.