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Is the Thorpe and Mason model valid for drifting and blowing snow ?

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Sublimation of drifting and blowing snow has been recognized as an important component of the surface mass budget of polar and alpine regions. The Thorpe and Mason (TM) model is the basis of all existing small and largescale estimates of drifting snow sublimation. We revisit this model to test its validity for calculating sublimation from snow grains in aeolian transport.

Through simple numerical experiments, it is highlighted that the TM model is a steadystate model that reconciles well with the solution of the unsteady mass and heat balance equations of an individual snow grain, albeit after a transient regime. Next, we simulate drifting and blowing using highresolution largeeddy simulations of the atmospheric surface layer with Lagrangian snow particles, coupled with statistical models of aerodynamic, splash and rebound entrainment of particles from an underlying snow surface. It is found that the residence time of a typical saltating particle is shorter than the period of the transient regime and thus the underlying assumptions of the TM solution are not satisfied. Secondly, the TM solution neglects thermal inertia of the particulate phase, this also results in errors when compared to the explicit heat and mass exchange calculations.

In simulations with similar air and surface temperatures, these errors range between 25% for lowwind and lowsaturation conditions and 40% for highwind and highsaturation conditions. With a small temperature difference of 1 K between the air and the snow surface, the errors due to the TM model are already as high as 100% with errors rapidly increasing for larger temperature differences.