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Modeling of falling snow properties for snowpack models: towards a better link between falling snow and snow on the ground

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Falling snow is made of different types of solid hydrometeors including single ice crystals, aggregates at different riming stages and graupel. This variability results from complex in-cloud processes (deposition, riming and aggregation) and sub-cloud processes (melting and sublimation). It has consequences for the properties of fresh fallen snow accumulating on the ground including density and specific surface area (SSA). These properties strongly affect the evolution of snow on the ground by modifying for example the albedo and the thermal conductivity. Detailed snowpack models such as Crocus or SNOWPACK use near-surface wind speed, air temperature and humidity to compute the density and SSA of falling snow. The shape, size and degree of riming of falling solid hydrometeors are not directly taken into account, which limit the accurate determination of properties of fresh fallen snow.

An alternative is offered by new bulk cloud microphysics schemes implemented in numerical weather prediction system that can be used to drive snowpack model. In particular, the scheme P3 (Predicted Particle Properties) proposes an innovative representation of all ice-phase particles by predicting several physical properties (e.g. size, rime fraction, rime density ...). In this study, we first theoretically analyze the strengths and limitations of P3 to represent the density and SSA of falling snow. Parameterizations are then proposed to derive density and SSA from P3 output. Finally, P3 implemented in the Canadian Global Environmental Multiscale (GEM) weather prediction model is used to simulate snowfall events observed at the Falling Snow Observatory (Nagoaka, Japan). Model predictions are compared with (i) observations of the type of falling snow particles derived from disdrometer data and (ii) manual measurements of fresh fallen snow density and SSA.

This study is a first step towards the development of a more integrated approach between falling snow and snow on the ground.