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Experimental and model based investigation of the links between snow bidirectional reflectance and snow microstructure

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Snow optical properties are unique among Earth surfaces and crucial for a wide range of applications. The bi-directional reflectance factor, hereafter BRF, of snow is sensible to snow microstructure. However the complex interplays between different parameters of snow microstructure, namely size and shape parameters, on reflectance are challenging to disentangle both theoretically and experimentally. An accurate understanding and modelling of snow BRF is required to correctly process satellite data. BRF measurements might also provide means to characterize the snow morphology. This study presents one of the very few dataset that combines bi-directional reflectance measurements over 500-2500 nm and X-ray tomography of the snow microstructure for three different snow samples and two snow types. The dataset is used to evaluate the approach from Malinka,2014 that relates snow optical properties to the chord length distribution in the snow microstructure. For low and medium absorption, the model simulated BRDF accurately reproduces the measurements but tends to slighltly overestimate the anisotropy of the reflectance. The simulated reflectance is strongly affected by the uncertainties in the imaginary part of the ice refractive index for several wavelengths ranges. The model indicates that the deviation of the ice chord length distribution from the exponential one, that can be understood as related to snow types, does not impact the reflectance for such absorptions. The study also indicates that crystal habits might play a significant role for the reflectance under high absorption and oblique viewing and incidence. However, quantitative relationship between crystal habits and reflectance alongside with potential optical methodologies to classify snow morphology, would require an extended dataset over more snow types. It might be achieved by means of ray tracing models on tomography images of the snow microstructure.

Significance statement

This study present a unique dataset that combine micro-tomographic images of snow microstructure with measurements of bi-directional reflectance in the solar spectrum.

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