Arctic Snow Modeling with a New Parameterization of Crocus to Improve Vertical Density Stratification and Soil Temperature Simulations

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ABSTRACT

Arctic snowpacks often exhibit a strong vertical density stratification. Due to the high wind speed conditions that are often met in these regions, hard wind slabs form on the top of the snow cover, whereas depth hoar, with a low density, develops at the bottom. On the contrary, alpine snowpack often evolved toward vertical density stratification inverse to that of the Arctic snowpack. Detailed snowpack models were first developed to study alpine snowpack for avalanche forecasting and thus fail in simulating the density profile of arctic snowpacks. In addition, snow is an important insulator for soils of the Arctic regions. As the thermal conductivity of snow is directly linked to its density, the soil temperature is also affected by large uncertainties in simulations. In Arctic areas, soil temperature is a key parameter, which is linked to e.g. permafrost evolution and ecosystems. Here, we implement a new parameterization of some physical processes in the detailed snowpack model Crocus to better reproduce the vertical density stratification of snow and thus the simulated soil temperature. The wind compaction of snow was increased and the model takes vegetation height into account which stops the compaction when the snow is protected. Also, the snow thermal conductivity from Sturm *et al*. (1997) was implemented and used which differs from the standards options in Crocus. Results show significant improvements in density and soil temperature at three evaluation sites over several years: Cambridge Bay (Nunavut, Canada), Bylot Island (Nunavut, Canada) and Samoylov (Siberia). The RMSE between density observations and simulations is reduced by 29% with this new Crocus parameterization, compared to the default parameterization. Similarly, the simulated soil temperature with the default parameterization yields a mean bias of 9.2 K, whereas the new parameterization yields a mean bias of 2.4 K. Correlations between measurements and observations are also increased with the new parameterization. This will improve the snow and soil evolution analysis in high northern latitude over time, using this new Crocus version driven by a re-analysis dataset.

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