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The importance of modelled processes in the evolution of snow cover versus snow mass

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Conventional wisdom holds that confidence in future projections of snow cover extent and snow mass requires an understanding of the expected changes in future snow characteristics as a function of modelled snow processes. We will highlight contrasting results which suggest differing importance in the role of sub-grid scale processes on simulations of seasonal snow.

The first study is an evaluation of simulated snow cover extent projections from models participating in the 6th phase of the World Climate Research Programme Coupled Model Inter-comparison Project (CMIP-6). We demonstrate a single linear relationship between projected spring snow extent and global surface air temperature (GSAT) changes, which is valid across all future climate scenarios. This finding suggests that Northern Hemisphere spring snow extent will decrease by about 8% relative to the 1995-2014 level per °C of GSAT increase. The sensitivity of snow to temperature forcing largely explains the absence of any climate change pathway dependency, similar to other fast response components of the cryosphere such as sea ice and near surface permafrost.

The second study makes use of an ensemble of land surface models, downscaled to 5 km resolution across North America over the 2009-2017 period. In this case, uncertainty in total North American snow mass is dominated by differences among land surface model configurations. While the largest absolute spread in snow mass is found in mountainous regions, heavily vegetated boreal regions have the largest fractional spread compared to climatological values. In particular, differences in rain-snow partitioning and sublimation rates control the largest portions of the total uncertainty. These results suggest that projections of future snow mass depend specifically on how such processes are modelled and parameterized.