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The effect of canopy characteristics on snow cover dynamics in forests

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In forested areas, the presence of trees significantly alters the processes that shape snow cover accumulation and ablation. As a consequence, snow amounts, snow distribution patterns and the timing of snowmelt differ substantially from those observed in open areas. Since forests cover large portions of the land surface area that features seasonal snow, forest-snow processes strongly impact on the hydrological cycle from regional to global spatial scales. Understanding the interplay between forest characteristics and snow cover dynamics is particularly important in the context of ongoing climate and land-cover changes. However, forest-snow processes are complex, act and interact at very small spatial scales, and are strongly controlled by the structure of the canopy. Spatial differences in forest structure lead to a highly heterogeneous below-canopy snow cover, which presents an enormous challenge when modeling snow in forested areas.

We present observational data on the snow distribution in subalpine forests of varying canopy structure acquired during extensive snow surveys over several years in Switzerland. These data suggests that the below-canopy snow cover is considerably more variable compared to observations at adjacent open sites. This variability was found to be tightly linked to variations in canopy characteristics that impact on processes such as interception of snowfall in and longwave radiation transfer through the canopy.

Concurrent modelling was conducted using FSM (Essery, GMD, 2015), a multi-model framework that offers alternative parametrizations for the processes that determine energy and moisture fluxes to and from the snowpack. Although originally developed for open sites, FSM has recently been updated to include forest-snow processes. This model framework allows to independently test the effect of different processes and process representations on simulations of a seasonal snow cover.

We demonstrate the capabilities of FSM to capture snow distribution in forests of different canopy characteristics, aiming at spatially explicit modeling of snow cover in heterogeneous forests. By analyzing the differences between model ensemble members, we can further show to which process representations the modelled snowpack is most sensitive. We suggest multi-model frameworks such as FSM in conjunction with spatially explicit validation data to allow efficient progress in improving model performance and its transferability.