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Measuring and modelling the impact of the bark beetle forest disturbance on snow accumulation and ablation at a plot scale

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The knowledge of water volume stored in the snowpack and its spatial distribution is important to predict the snowmelt runoff. The objective of this study was to quantify the role of different forest structures on the snowpack distribution at a plot scale during snow accumulation and snow ablation periods. Special interest was put in the role of the forest affected by the bark beetle (Ips typographus). We performed repeated detailed manual field survey at selected mountain plots with different canopy structure located at the same elevation and without influence of topography and wind on the snow distribution. The forest canopy structure was described using parameters calculated from hemispherical photographs, such as canopy closure, leaf area index (LAI) and potential irradiance. Additionally, we used shortwave radiation measured using CNR4 Net radiometers placed in plots with different canopy structure. Two snow accumulation and ablation models were set-up to simulate the snow water equivalent (SWE) in plots with different vegetation cover. First model was physically-based using the energy balance approach, second model was conceptual and it was based on the degree-day approach. Both models accounted for snow interception in different forest types using LAI as a parameter.

The measured SWE in the plot with healthy forest was on average by 41% lower than in open area during snow accumulation period. The disturbed forest caused the SWE reduction by 22% compared to open area indicating increasing snow storage after forest defoliation. The snow ablation in healthy forest was by 32% slower compared to open area. On the contrary, the snow ablation in disturbed forest (due to the bark beetle) was on average only by 7% slower than in open area. The relative decrease in incoming solar radiation in the forest compared to open area was much bigger compared to the relative decrease in snowmelt rates. This indicated that the decrease in snowmelt rates cannot be explained only by the decrease in incoming solar radiation. Both models simulated sufficiently compared to observations with slightly accurate simulations in open area compared to healthy forest. This was expected, since both models were forced to fit with observations. However, the energy balance approach simulated snowmelt in the forest environment accurately since it accounts also for longwave radiation which might largely influence snowmelt in the forested plots. Both models showed faster snowmelt after forest defoliation which also resulted in earlier snow melt-out in the disturbed forest compared to the healthy coniferous forest.