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Snow cover and soil moisture in mountains

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Soil moisture is an important parameter of the climate system. It constrains evapotranspiration of plants and it functions as a storage of water, giving it an economic value, e.g. for agriculture. Furthermore, soil moisture is an important factor for predicting flood risk. In mountainous areas with a seasonal snow cover, the spatial distribution of snow depth is strongly influencing the spatial variation of soil moisture. To assess potential flooding situations during snow melt and rain on snow events in particular but for any heavy precipitation event in the mountains, it is important to understand the influence of the snow cover on soil status with respect to liquid and solid water. Only if this is known, the reaction of the soil i.e. amount of runoff, storage or melt, on additional water input can be assessed.

For an operational assessment of the soil moisture state in the Swiss Alps at 140 measurement sites for snow and avalanche forecasting (IMIS network), the SNOWPACK model has been extended with a soil module, solving the Richards equation for the matrix flow. The modelling is validated with vertical profile measurements of soil moisture at meteorological stations in an Alpine catchment near Davos, Switzerland.

It was found that the combination of a physical based snowpack model with a Richards equation solver seems to provide an adequate description of soil moisture fluctuations, especially in near surface layers. Soil moisture fluctuations, both measured and modelled, are strongly reduced when a snow cover is present. The measurements also revealed a strong increase in soil moisture, accompanied by a daily cycle in soil moisture during snow melt, extending down to 120cm depth. When soil properties from literature were assumed for the soil type in the vertical profile, the daily cycle in the model during snow melt was restricted mainly to the top layers, while observations show also a reaction in deeper layers. These observations are consistent with the assumption of the existence of preferential flow paths, which are not modelled by the Richards equation. This discrepancy between observations and model results during the melt phase may cause an underestimation of the soil storage capacity and an overestimation of the surface run-off in the model.