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Simulating the snowpack at point and catchment scale for hydrological applications

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In many environments, an accurate description of the hydrological system requires a numerical representation of the accumulation, redistribution, and ablation of a seasonal snowpack. Many model representations exist to mimic physical snowpack processes such as the absorption of radiation, snow densification, liquid water transport, turbulent energy transfer and heat conduction within the snowpack. With the Factorial Snow Model (FSM) the impact of different process representations on the snowpack simulation results can be investigated systematically by switching on and off respective parametrizations. However, both the required meteorological forcing data (i.e. precipitation, air temperature, relative humidity, wind speed, and radiative fluxes) as well as the chosen model parameter sets imply some degree of uncertainty. In order to identify appropriate and robust model structures in the light of the parameter choice and input data uncertainty, we include these effects in the presented model experiments. For each snow model structure, parameter sets are chosen via a standard latin hypercube sampling technique from a physically meaningful parameter space, and model configurations are realized for various input error scenarios. We present a performance test of a large ensemble of model realizations (n > 40000) consisting of 32 different FSM structures, various parameter sets and forcing error scenarios. Model results are compared to automated point-scale observations of snow mass, snow depth, snowpack runoff and snow temperature at the snow monitoring station Kühtai (1920 m a.s.l., Tyrol, Austria) and to observations of discharge and snow cover fraction in the adjacent catchment of the Längentalbach (9.2 km^2). By analyzing a Pareto optimal ensemble subset for each forcing error scenario we aim to reveal compensation effects and find robust model structures. Ultimately, this study will help to increase our understanding of how the snow models behave for different boundary conditions and to gain knowledge of what governs a high model performance.