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Uncertainties in snowpack predictions - assessing the impact of model complexity, parametrization, forcing and validation data error magnitude on point-scale energy-balance snow model performance

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Many energy-balance snow models have been developed over the last three decades with varying degrees of complexity. Typically, process-based models are not calibrated, relying on their parameters being physically meaningful and determinable in the field. In reality, however, many parameters of snow models are abstract, not easy to measure, or the respective observations are lacking. Meteorological forcings needed to run the models are also prone to errors, especially when they have to be interpolated from surrounding climate station recordings. Model skill is often evaluated using automated measurements at the point-scale (e.g. sonic ranger, snow pillow, temperature profile). However, due to topographic and micro-climatic effects on accumulation, redistribution and ablation processes, the snow cover is spatially heterogeneous even at very small scales introducing an uncertainty in the validation data.

In this study we assess the impact of the above described uncertainties on 1D snow simulations within a global variance-based sensitivity analysis framework. The factorial snow model (FSM) provides the possibility for systematic alteration of process representations with varying degrees of complexity (i.e solar radiation transfer, heat conduction, compaction, heat transfer at the snow atmosphere interface and refreezing of meltwater). Here, we use all its 32 possible combinations to mirror the influence of model structure. Uncertainty ranges of model parametrization, input and validation data are extracted from the literature. We evaluate a suite of 60000 model realisations at the snow monitoring station Kühtai (Tyrol, Austria, 1920 m a.s.l.) over the course of 25 winter seasons (1991-2015). First results show throughout the whole period and different model output metrics (i.e. SWE, snow depth, surface albedo, snow pack temperature and snow pack runoff) that the influence of forcing data uncertainty (main effect) and its interactions (total effect) dominates the model performance (highest sensitivity indices in 95% of all cases). Most of the time (86%) total sensitivity indices are in the general order of parametrization < model structure < < forcing error. The influence of validation data error appears much more inconsistent between the years. The results show a considerable inter-annual variability of the interaction effect, indicating for years with high interactions that a improvement of knowledge (i.e. reduction of uncertainty) of one factor alone might not improve model results.