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Crash test for groundwater recharge models: The effects of model complexity and calibration period on groundwater recharge predictions

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An important question in recharge impact studies is how model choice, structure and calibration period affect recharge predictions. It is still unclear if a certain model type or structure is less affected by running the model on time periods with different hydrological conditions compared to the calibration period. This aspect, however, is crucial to ensure reliable predictions of groundwater recharge.

In this study, we quantify and compare the effect of groundwater recharge model choice, model parametrization and calibration period in a systematic way. This analysis was possible thanks to a unique data set from a large-scale lysimeter in a pre-alpine catchment where daily long-term recharge rates are available. More specifically, the following issues are addressed:
We systematically evaluate how the choice of hydrological models influences predictions of recharge. We assess how different parameterizations of models due to parameter non-identifiability affect predictions of recharge by applying a Monte Carlo approach.
We systematically assess how the choice of calibration periods influences predictions of recharge within a differential split sample test focusing on the model performance under extreme climatic and hydrological conditions.

Results indicate that all applied models (simple lumped to complex physically based models) were able to simulate the observed recharge rates for five different calibration periods. However, there was a marked impact of the calibration period when the complete 20 years validation period was simulated. Both, seasonal and annual differences between simulated and observed daily recharge rates occurred when the hydrological conditions were different to the calibration period. These differences were, however, less distinct for the physically based models, whereas the simpler models over- or underestimate the observed recharge depending on the considered season. It is, however, possible to reduce the differences for the simple models by choosing a calibration data set that includes climatic extremes. Here we demonstrate that the impact of model choice and parameterization as well as calibration period is underestimated in many recharge impact studies, even though it can introduce relevant predictive error.