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Vadose zone model comparision for groundwater recharge simulations: The role of observation periods for dissimilar predictions

Christian Moeck (1), Jana Von Freyberg (2), Mario Schirmer (1,3)

(1) Eawag, Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland (Christian.moeck@eawag.ch), (2) ETH Zurich, Institute of Terrestrial Ecosystems, Department of Environmental Systems Science, Zurich, Switzerland (Jana.vonfreyberg@usys.ethz.ch), (3) Centre of Hydrogeology and Geothermics (CHYN), University of Neuchâtel, Neuchâtel, Switzerland (Mario.schirmer@eawag.ch)

Numerical predictions of groundwater recharge are often based on the implicit assumption that model parameters, calibrated over historical periods, are also valid for the simulation period in the future. We review this assumption by comparing groundwater recharge simulations from four vadose zone models with varying complexity, which were calibrated using six climatically contrasting calibration periods. The four models are a linear soil water balance model, a lumped semi-mechanistic model and a physically-based model applied with two different complexities: homogenous single porosity and dual-porosity. The complexity of each model is characterized by the number of parameters, i.e. the detail of recharge process description. We calibrated all models to a 20-year seepage data set from a large weighting lysimeter in Switzerland by using a Monte Carlo approach and the inverse parameter estimation code PEST. We then systematically evaluated how model performance was affected by i) the complexity of the groundwater recharge model, ii) the parameterization and iii) the used calibration periods.

During calibration, all models performed similarly well - despite the climatically contrasting conditions. However, during validation the more complex, physically-based models predicted recharge best, even when calibration and prediction periods had very different climatic conditions. In contrast, the more simplistic soil-water balance and lumped model performed poorly under such conditions, indicating that a strong dependency on the chosen calibration period exists for these models. Our systematic comparison study showed that this sensitivity on the climatic conditions during the calibration period can have relevant implications when simplified recharge models are used as decision-making tools in a broad range of applications (e.g. water availability studies from plot- to catchment scale, climate change impact studies, water resource management, among others).