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Assessment of structural model and parameter uncertainty with a multi-model system for soil water balance models

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Water for agriculture is strongly limited in arid and semi-arid regions and often of low quality in terms of salinity. The application of saline waters for irrigation increases the salt load in the rooting zone and has to be managed by leaching to maintain a healthy soil, i.e. to wash out salts by additional irrigation. Dynamic simulation models are helpful tools to calculate the root zone water fluxes and soil salinity content in order to investigate best management practices. However, there is little information on structural and parameter uncertainty for simulations regarding the water and salt balance of saline irrigation. Hence, we established a multi-model system with four different models (AquaCrop, RZWQM, SWAP, Hydrus1D/UNSATCHEM) to analyze the structural and parameter uncertainty by using the Global Likelihood and Uncertainty Estimation (GLUE) method. Hydrus1D/UNSATCHEM and SWAP were set up with multiple sets of different implemented functions (e.g. matric and osmotic stress for root water uptake) which results in a broad range of different model structures. The simulations were evaluated against soil water and salinity content observations. The posterior distribution of the GLUE analysis gives behavioral parameters sets and reveals uncertainty intervals for parameter uncertainty. Throughout all of the model sets, most parameters accounting for the soil water balance show a low uncertainty, only one or two out of five to six parameters in each model set displays a high uncertainty (e.g. pore-size distribution index in SWAP and Hydrus1D/UNSATCHEM). The differences between the models and model setups reveal the structural uncertainty. The highest structural uncertainty is observed for deep percolation fluxes between the model sets of Hydrus1D/UNSATCHEM (∼200 mm) and RZWQM (∼500 mm) that are more than twice as high for the latter. The model sets show a high variation in uncertainty intervals for deep percolation as well, with an interquartile range (IQR) of ∼100 mm for SWAP and <10 mm for AquaCrop. Both findings show the strong variety in model structures and the effects on simulation performance. In general, the results of this study indicate a greater impact of conceptual than parameter uncertainty and demonstrate the need for further research concerning water balance modeling for irrigation management.