Evaluating the Performance and Parameter Uncertainty of a Numerical Model for Basin-Wide Average Soil Moisture

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Abstract. This study evaluates the use of a probability-distributed model to simulate the spatial average soil moisture in a watershed through time. The model simulates local, depth-averaged soil moisture dynamics using parsimonious expressions for infiltration, evapotranspiration, and groundwater recharge when supplied with precipitation and potential evapotranspiration. The spatial average soil moisture is simulated by integrating the local behavior over a probability distribution that characterizes the spatial variability of soil moisture. One year of 30-minute meteorological and soil moisture measurements were used to evaluate the model. The data are available at 15 locations in the 813 km^2 Fort Cobb watershed in western Oklahoma. The model is first tested at the local scale comparing its performance to a more detailed, process-based model (HYDRUS 1-D) that numerically solves Richards' equation for one-dimensional vertical flow. The performance of the models is evaluated using Dynamic Identifiability Analysis (DYNIA), which identifies periods of parameter identifiability and assesses errors in the model structure. The models are also compared in their overall abilities to reproduce the observed soil moisture values. In most cases, the results for the proposed model indicate fewer structural errors, better parameter identifiability, and better agreement with the observations than HYDRUS 1-D. The probability-distributed model is then evaluated to estimate the spatial average soil moisture. The model performs with similar success when simulating the spatial average. Furthermore, the parameter that characterizes the spatial variation of the soil moisture (the standard deviation) is relatively well estimated by the calibration procedure.