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Ensemble Kalman filtering to perform data assimilation with soil water content probes and pedotransfer functions in modeling water flow in variably saturated soils

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Data from modern soil water contents probes can be used for data assimilation in soil water flow modeling, i.e. continual correction of the flow model performance based on observations. The ensemble Kalman filter appears to be an appropriate method for that. The method requires estimates of the uncertainty in modeling results and in measurements. The uncertainty in modeling results is estimated from the ensemble of plausible soil water flow models. The uncertainty in measurement results can be inferred from the spatial variability in the probe data complemented with an estimate of sensor error. The objective of this work was to evaluate the effect of the number and depths of sensor positions on the data assimilation results. Sixty time domain reflectometry (TDR) probes (two rods) were installed along the trench in loamy soil at 12 locations with 50-cm horizontal spacing at five depths (15, 35, 55, 75, and 95 cm). Water content and weather parameters were monitored for one year with 15 min frequency. Soil water flow was simulated using the HYDRUS6 code. Measured water contents were averaged across the trench at each observation depth and mean daily values of these averages were used in data assimilation. Twelve pedotransfer functions for water retention and five for hydraulic conductivity were applied to generate model ensembles to evaluate the uncertainty in simulation results, whereas the replicated measurements at each of measurement depths were used to characterize the uncertainty in data. We observed that even assimilating measurements from one depth only provided substantial improvement in simulations at other observation depths. The accuracy of data assimilation results improved as the number of sensors (depths) increased. Best assimilation depths appeared to be different depending on whether simulations are carried out to estimate soil water dynamics in root zone or to estimate infiltration losses beyond this zone. Soil moisture sensor data assimilation in soil flow modeling allows one to avoid calibration of overparameterized models and to correct simulation on the go which can be beneficial in many applications. Using pedotransfer functions in ensemble Kalman filter resulted in the efficient data assimilation in this work.