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Joint State and Parameter Estimation for Two Land Surface Models Using the Ensemble Kalman Filter and Particle Filter

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Land surface models (LSMs) resolve the water and energy balance with different parameters and state variables. Many of the parameters of these models cannot be measured directly in the field, and require calibration against flux and soil moisture data. Two LSMs are used in our work: Variable Infiltration Capacity Hydrologic Model (VIC) and the Community Land Model (CLM). Temporal variations in soil moisture content at 5, 20 and 50 cm depth in the Rollesbroich experimental watershed in Germany are simulated in both LSMs. Data assimilation (DA) provides a good way to jointly estimate soil moisture content and soil properties of the resolved soil domain. Four DA methods combined with the two LSMs are used in our work: the Ensemble Kalman Filter (EnKF) using state augmentation or dual estimation, the Residual Resampling Particle Filter (RRPF) and Markov chain Monte Carlo Particle Filter (MCMCPF). These four DA methods are tuned and calibrated for a five month period, and subsequently evaluated for another five month period. Performances of the two LSMs and the four DA methods are compared. Our results show that all DA methods improve the estimation of soil moisture content of the VIC and CLM models, especially if the soil hydraulic properties (VIC), the maximum baseflow velocity (VIC) and/or soil texture (CLM) are jointly estimated with soil moisture content. The augmentation and dual estimation methods performed slightly better than RRPF and MCMCPF in the evaluation period. The differences in simulated soil moisture content between CLM and VIC were larger than variations among the DA methods. The CLM performed better than the VIC model. The strong underestimation of soil moisture content in the third layer of the VIC model is likely related to an inadequate parameterization of groundwater drainage.