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Assimilation of surface soil moisture in a multi-layer soil model: a case study

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In climate and numerical weather prediction (NWP), surface-atmosphere interaction processes are represented by land surface models (LSM). LSM have been improved considerably in the last two decades. In this study, the ISBA LSM new soil diffusion scheme is used (with 11 soil layers represented). A Simplified Extented Kalman Filter (SEKF) is implemented to assimilate surface soil moisture (SSM) in the multi-layer LSM in order to constrain the root-zone soil moisture. In parallel, the SEKF is applied to the simpler ISBA version LSM with 2 soil layers (a thin surface layer and a bulk reservoir). Simulations are performed over a 3-yr period (2003-2005) for a bare soil field in southwestern France, at the SMOSREX experimental site. It is shown that both open-loop simulations and those integrating SSM observations are better using the multilayer model. The assimilation statistics (Kalman gain, Jacobians, and increments) are analyzed for the two models. In the case of the multilayer model, the Kalman gain is greater close to the surface, especially in dry conditions. During winters and wet periods, lower Kalman gain values are observed close to the surface but the vertical gain profile is more evenly distributed. Prior data assimilation, the preconditioning of the observations is needed. A CDF-matching technique is used, either year by year or over the whole period. The way CDF matching is implemented has a significant impact on the result of the assimilation. In order to investigate the impact of the implementation of the B matrix, two other experiments were performed, adding covariance terms between soil layers: (1) the soil layer n is linked to layers n-1 and n+1, (2) the soil layer n is linked to layers n-2, n-1, n+1 and n+2. In these experiments, Kalman gain is greater than for experiments performed with a diagonal B matrix.