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Soil moisture data assimilation in high-resolution integrated models at the hillslope scale

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The integrated land surface-subsurface model TerrSysMP was set up with a lateral resolution of 10m for the TERENO-site Rollesbroich in the Eifel mountains in Germany. A soil moisture sensor network is installed at this site and operational since 2011; soil moisture at 5, 20 and 50cm depth is recorded. In this work, it was evaluated whether the assimilation of soil moisture data recorded by the network into the integrated land surface-subsurface model was able to improve the characterization of the water and energy balances for the site. The data were assimilated with the Ensemble Kalman Filter (EnKF) in the integrated model and different data assimilation scenarios were evaluated: (i) for the real-world case and a synthetic case which mimics the real-world case; (ii) for updating states only and updating both states and parameters; (iii) for 128 or 256 ensemble members; (iv) for saturated hydraulic conductivity as only unknown soil hydraulic parameter, or for additional uncertain Mualem-van Genuchten soil hydraulic parameters. For the real-world case it was found that the RMSE of soil moisture at the sensor network locations was at most reduced by 14 % while stream discharge estimation was not improved significantly by assimilation. Simulation results were much more favourable for the synthetic case with a RMSE reduction up to 55 % at independent verification locations in case of daily soil moisture assimilation and also stream discharge estimation improved significantly with a NSE-increase from -0.04 (open loop) to 0.61. These results show that data assimilation in combination with integrated, high resolution land surface-subsurface models can potentially improve soil moisture and discharge estimation at the hillslope scale. The worse performance for the real-world case remains nevertheless puzzling and is explained by model structural errors, like the representation of the drainage network at the site.