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# A High-Resolution Dataset of Water Fluxes and States for Germany accounting for Uncertainties in the Parameter Estimation

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Long term, high-resolution data of hydrologic fluxes and states are needed for many hydrological applications such as i) impact assessment studies (e.g. drought, flood or climate change analyses), ii) studies that need the state or variability of hydrometeorological or hydrologic variables (e.g. downscaling of climate model outputs), iii) modeling studies that need hydrologic variables as input or boundary conditions (e.g. recharge for groundwater modeling). Since long-term, large-scale observations of such fluxes and states are not feasible, hydrological or land surface models are applied to derive them. Usually such datasets are provided as single model realization without accounting for input, model structural or uncertainty caused by equifinal model parameter sets.

This study aims to analyze and provide a high resolution dataset of hydrological fluxes and states accounting for uncertainties caused by the estimation of model parameters. Furthermore, the spatiotemporal distribution of uncertainties in various hydrological variables as well as the superposition of uncertainties through different model compartments is investigated.

The hydrological variables of interest are evapotranspiration, soil moisture, recharge, and generated discharge. They are estimated for entire Germany in the period 1950 - 2010 employing the mesoscale hydrological model mHM (www.ufz.de/mhm). The spatial resolution is 4 km and the temporal resolution is 1 day. The ensemble of 100 model realization is based on 700 parameter sets which are derived from 100 calibration runs in the seven, major German river basins. These 700 parameter sets are filtered for those exceeding a Nash-Sutcliffe efficiency (NSE) of 0.65 in each of the seven catchments, which leads to the final 100 parameter sets.

The model is evaluated against observed runoff in 222 additional catchments. In this catchments the mean and the standard deviation are for daily discharge 0.68 and 0.09 and for monthly discharge 0.81 and 0.09, respectively. Modeled evapotranspiration is evaluated against eddy covariance stations. The estimated evapotranspiration exhibits the largest error in spring (RMSE = 0.39 mm $d^{-1}$) during the onset of the vegetation period compared to the other seasons, which have an average RMSE value of 0.07 mm $d^{-1}$. This may be explained by the absence of a dynamic vegetation model within mHM. The uncertainty of the fluxes and states is assessed by the coefficient of variation of the 100 ensemble members. The lowest uncertainty is observed for evapotranspiration with an average coefficient of variation of 0.02, while the highest uncertainty is observed for recharge with an average coefficient of variation of 0.2. The uncertainty of the hydrologic variables varies throughout the course of a year with exception of evapotranspiration, which stays almost constant. For example, the generated discharge exhibits its largest uncertainty in the end of summer and beginning of autumn. At this time the amount of water in the soil and groundwater reservoir is lowest and thus the slow interflow and baseflow is lowest. Furthermore, we found that the magnitudes of uncertainty of evapotranspiration, soil moisture or recharge do not superpose to the modeled discharge.