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Water balance simulations for major German river basins

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Accurate and reliable predictions of water fluxes and state variables such as soil moisture or evapotranspiration in large river basins are required for flood forecasting, drought mitigation, climate change impact assessment, water resource management, among others. The objective of this study is to simulate the water balance of the five largest rivers within Germany: Danube, Elbe, Rhine, Weser, and Ems. To achieve this goal, the recently developed, process based spatial distributed hydrological model mHM (Samaniego et. al., 2010, WRR) was set up in these basins. mHM uses a multiscale parameter regionalization (MPR) scheme, which relates model parameters to catchment characteristics through a set of transfer functions and few global parameters. The latter could be estimated via calibration at locations where discharge information is available. At ungauged locations, MPR offers a possibility to use the global parameters obtained at other similar locations to run the model. mHM was driven by grided fields of daily meteorological data (e.g. precipitation, temperature), which were interpolated from point measurements using external drift Kriging. Data of 5600 rain gauges and 1100 meteorological stations obtained from German Weather Service (DWD) over Germany during the period from 1950 to 2010 were used for this interpolation. Additional information at a spatial resolution of 100×100 m required to set up mHM comprise a digital elevation model DEM (BKG) and its related characteristics (e.g. slope, aspect, flow direction, flow accumulation), soil properties (BUEK, 1 : 1 000 000), CORINE land cover maps, and hydrological conductivity of geological formations (HUEK, 1 : 1 000 000). Daily stream flow of more than 100 runoff gauging stations were provided by GRDC and EWA. Model simulations were carried out on a spatial resolution of 4×4 km at hourly time steps. The model was calibrated in the period from 1990 to 2000 and evaluated in two periods: 1960-1989 and 2001-2008. Two years of data prior to both periods were set to spin-up the model. Evaluation runs showed a good approximation of the observed daily streamflow. Nash-Sutcliffe efficiencies (NSE) for these river basins varied between 0.7 and 0.9. Monthly and yearly long term water balance were satisfactorily closed. Simulated and observed values exhibited a correlation coefficient larger than 0.9 in all cases. Results of proxy basin tests (i.e. crossvalidation) indicated that mHM is able to reproduce the daily streamflow statistics reasonably well. The least NSE obtained in these tests was 0.5. Currently we are investigating the ability of the model to reproduce extreme runoff characteristics (e.g. magnitude frequency of floods and droughts) and other state variables.