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Implementation of a process-based distributed mesoscale hydrologic model

R. Kumar , L. Samaniego and Sabine Attinger
Helmholtz-Centre for Environmental Research-UFZ, Germany (rohini.kumar@ufz.de)

Any spatially explicit hydrological model at the mesoscale is a conceptual approximation of the hydrological cycle and its dominant process occurring at this scale. Hydrologic models have evolved in the previous decades to cope with the more extensive data sets obtained from remote sensing and increasing computational power. As a result, hydrologists have improved, in most cases, the understanding of catchment hydrological behaviour under a changing environment. This article presents several improvements of the standard HBV model (denoted as HBV-UFZ) to cope with the available remote sensing data in two German mesoscale basins.

HBV-UFZ is a distributed hydrological model representing dominant hydrologic process at the mesoscale. This model is driven by 12 h precipitation, temperature, and PET grids acquired either from satellite products or from interpolated meteorological data (EDK) and annual land cover grids. To avoid model overparameterization nonlinear transfer functions are implemented. This functions regionalize most model parameters as a function of other spatially distributed observables such as land cover (time dependent) and other time independent basin characteristics such as soil type, slope, aspect, geological formations among others. An adaptive constrained optimization algorithm based on a parallel implementation of simulated annealing(SA) is used to find good parameters sets. The efficiency of the model is evaluated with the Nash-Sutcliffe efficiency coefficient (NSE) and the RMSE obtained for daily streamflow and various seasonal high- and low-flow characteristics (e.g. total drought duration, frequency of high flows) at various gauging stations. Additionally, the parameter search was constrained with the 95% confidence bands of the seasonal runoff characteristics.

We applied this model in two German mesoscale basins: Upper Neckar and Parthe river basins covering an area of approximately 4000 km^2 and 350 km^2 respectively during the period from 1971 to 2001. The spatial and temporal resolutions employed are (1000×1000) m and 12 h intervals respectively. Results of the study indicate that the HBV-UFZ significantly improves the streamflow predictions (NSE $\approx$ 0.80 to 0.85) compared with those obtained with the standard HBV model(1996) (NSE $\approx$ 0.70 to 0.75). Moreover, the modelled spatial patterns of soil moisture compares reasonably well with the proxies derived from remote sensing data. The computational efficiency and the modularity of the model structure facilitates its implementation in other mesoscale basins.