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Assessment of parameter regionalization methods for modeling flash floods in China

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Rainstorm flash floods are a common and serious phenomenon during the summer months in many hilly and mountainous regions of China. For this study, we develop a modeling strategy for simulating flood events in small river basins of four Chinese provinces (Shanxi, Henan, Beijing, Fujian). The presented research is part of preliminary investigations for the development of a national operational model for predicting and forecasting hydrological extremes in basins of size 10 – 2000 km2, whereas most of these basins are ungauged or poorly gauged. The project is supported by the China Institute of Water Resources and Hydropower Research within the framework of the national initiative for flood prediction and early warning system for mountainous regions in China (research project SHZH-IWHR-73).

We use the USGS Precipitation-Runoff Modeling System (PRMS) as implemented in the Java modeling framework Object Modeling System (OMS). PRMS can operate at both daily and storm timescales, switching between the two using a precipitation threshold. This functionality allows the model to perform continuous simulations over several years and to switch to the storm mode to simulate storm response in greater detail. The model was set up for fifteen watersheds for which hourly precipitation and runoff data were available. First, automatic calibration based on the Shuffled Complex Evolution method was applied to different hydrological response unit (HRU) configurations. The Nash-Sutcliffe efficiency (NSE) was used as assessment criteria, whereas only runoff data from storm events were considered. HRU configurations reflect the drainage-basin characteristics and depend on assumptions regarding drainage density and minimum HRU size. We then assessed the sensitivity of optimal parameters to different HRU configurations. Finally, the transferability to other watersheds of optimal model parameters that were not sensitive to HRU configurations was evaluated.

Model calibration for the 15 catchments resulted in good model performance (NSE > 0.5) in 10 and medium performance (NSE > 0.2) in 3 catchments. Optimal model parameters proofed to be relatively insensitive to different HRU configurations. This suggests that dominant controls on hydrologic parameter transfer can potentially be identified based on catchment attributes describing meteorological, geological or landscape characteristics. Parameter regionalization based on a principal component analysis (PCA) nearest neighbor search (using all available catchment attributes) resulted in a 54% success rate in transferring optimal parameter sets and still yielding acceptable model performance. Data from more catchments are required to further increase the parameter transferability success rate or to develop regionalization strategies for individual parameters.