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Benefits of incorporating spatial organisation of catchments for a semi-distributed hydrological model

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To represent the hydrological behaviour of catchments a model should reproduce/reflect the hydrologically most relevant catchment characteristics. These are heterogeneously distributed within a watershed but often interrelated and subject of a certain spatial organisation. Since common models are mostly based on fundamental assumptions about hydrological processes, the reduction of variance of catchment properties as well as the incorporation of the spatial organisation of the catchment is desirable. We have developed a method that combines the idea of the width-function used for determination of the geomorphologic unit hydrograph with information about soil or topography. With this method we are able to assess the spatial organisation of selected catchment characteristics. An algorithm was developed that structures a watershed into sub-basins and other spatial units to minimise its heterogeneity. The outcomes of this algorithm are used for the spatial setup of a semi-distributed model.
Since the spatial organisation of a catchment is not bound to a single characteristic, we have to embed information of multiple catchment properties. For this purpose we applied a fuzzy-based method to combine the spatial setup for multiple single characteristics into a union, optimal spatial differentiation. Utilizing this method, we are able to propose a spatial structure for a semi-distributed hydrological model, comprising the definition of sub-basins and a zonal classification within each sub-basin. Besides the improved spatial structuring, the performed analysis ameliorates modelling in another way. The spatial variability of catchment characteristics, which is considered by a minimum of heterogeneity in the zones, can be considered in a parameter constrained calibration scheme in a case study both options were used to explore the benefits of incorporating the spatial organisation and derived parameter constraints for the parametrisation of a HBV-96 model. We use two benchmark model setups (lumped and semi-distributed by common approaches) to address the benefits for different time and spatial scales. Moreover, the benefits for calibration effort, model performance in validation periods and process extrapolation are shown.