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Impact of the calibration period on the conceptual rainfall-runoff model parameter estimates

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A conceptual rainfall-runoff model is defined by its structure and parameters, which are commonly inferred through model calibration. Parameter estimates depend on objective function(s), optimisation method, and calibration period. Model calibration over different periods may result in dissimilar parameter estimates, while model efficiency decreases outside calibration period. Problem of model (parameter) transferability, which conditions reliability of hydrologic simulations, has been investigated for decades.

In this paper, dependence of the parameter estimates and model performance on calibration period is analysed. The main question that is addressed is: are there any changes in optimised parameters and model efficiency that can be linked to the changes in hydrologic or meteorological variables (flow, precipitation and temperature)? Conceptual, semi-distributed HBV-light model is calibrated over five-year periods shifted by a year (sliding time windows). Length of the calibration periods is selected to enable identification of all parameters. One water year of model warm-up precedes every simulation, which starts with the beginning of a water year. The model is calibrated using the built-in GAP optimisation algorithm. The objective function used for calibration is composed of Nash-Sutcliffe coefficient for flows and logarithms of flows, and volumetric error, all of which participate in the composite objective function with approximately equal weights. Same prior parameter ranges are used in all simulations. The model is calibrated against flows observed at the Slovac stream gauge on the Kolubara River in Serbia (records from 1954 to 2013). There are no trends in precipitation nor in flows, however, there is a statistically significant increasing trend in temperatures at this catchment.

Parameter variability across the calibration periods is quantified in terms of standard deviations of normalised parameters, enabling detection of the most variable parameters. Correlation coefficients among optimised model parameters and total precipitation P, mean temperature T and mean flow Q are calculated to give an insight into parameter dependence on the hydrometeorological drivers.

The results reveal high sensitivity of almost all model parameters towards calibration period. The highest variability is displayed by the refreezing coefficient, water holding capacity, and temperature gradient. The only statistically significant (decreasing) trend is detected in the evapotranspiration reduction threshold. Statistically significant correlation is detected between the precipitation gradient and precipitation depth, and between the time-area histogram base and flows. All other correlations are not statistically significant, implying that changes in optimised parameters cannot generally be linked to the changes in P, T or Q. As for the model performance, the model reproduces the observed runoff satisfactorily, though the runoff is slightly overestimated in wet periods. The Nash-Sutcliffe efficiency coefficient (NSE) ranges from 0.44 to 0.79. Higher NSE values are obtained over wetter periods, what is supported by statistically significant correlation between NSE and flows.

Overall, no systematic variations in parameters or in model performance are detected. Parameter variability may therefore rather be attributed to errors in data or inadequacies in the model structure. Further research is required to examine the impact of the calibration strategy or model structure on the variability in optimised parameters in time.