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Purpose orientated calibration by means of signature indices

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Although there exist many performance measures, calibrating models properly remains still a challenge. Each performance measure treats parts of the hydrograph differently and many performance measures evaluate performance in an all-purpose way, thereby often missing out on extreme behavior. Moreover, many objective functions have difficulties with the calibration of extreme events. In a previous study we showed that signature indices derived from the Flow Duration Curve (FDC) provide an improved diagnostic for model evaluation. The FDC is a meaningful descriptor of catchment response and signature indices derived from it can evaluate the performance for various parts of the hydrograph (e.g. extreme high flow or low flow). The use of such signature indices as purpose orientated objective functions therefore, may be a promising approach for model calibration on extreme events.
We calibrate a conceptual model generated with the SUPERFLEX framework for different basins in Rhineland-Palatinate (Germany). This leads to a good overall performance but often misses out on high flow or low flow. As alternative objective functions we use various combinations of signature indices. The performance of these combinations of objective functions is compared to the performance of the calibration.
We demonstrate for two exemplary basins that a simulation with signature indices as objective functions, achieve nearly perfect simulated FDCs. However, the simulated hydrographs turned out to be unacceptable, which was ascribed to the lack of a timing component. To implement a timing component during calibration, we include the Nash-Sutcliffe Efficiency (NSE) as an additional objective function. The combinations of signature indices and NSE as objective functions improve the performance of the simulated hydrograph considerably. Although the simulated runoff does not achieve the same good overall performance compared to the original calibration, the use of signature indices that represent an extreme part of the hydrograph increases the performance for this part. Thus, using purpose oriented signature indices (e.g. describing extreme flows) provide better model results for a specific part of the hydrograph and therefore for specific prediction purposes.