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Structural improvement of a simple rainfall-runoff model based on time-variable parameters

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Hydrological models are used in water quality and catchment modeling as backbone model components describing the most important drivers of contaminant transport. Creating an integrated management framework is only possible if the building model blocks are robust and have a coverable data demand. The combination of simplicity and robustness can be achieved when the model structure is adapted to local circumstances based on a data-driven modification procedure.

Large environmental model frameworks are often constructed to deliver predictions on the future behavior of the inspected system in case of an altered external forcing (like climate change or socio-economic development). As the uncertainty present in separate building blocks propagates through the system, the reliability of final predictions can be only estimated properly if all identified sources of model uncertainty (input, structural/parameter and output uncertainty in general categories) were accounted for. This is especially true for those model blocks like hydrology, which provide crucial inputs to other components.

Our aim was to provide reliable hydrologic inputs for a complex model system together with proper estimates of uncertainties. We started with the evaluation of the logSPM conceptual rainfall runoff model (Kuczera et al. 2006) on two small test-catchments (46 and 117 km^2) on the Swiss Plateau. Parameter optimisation was done using an autoregressive likelihood function that accounted for measurement errors in precipitation data based on a stochastic rainfall multiplier concept. The model provided an acceptable goodness of fit (0.85 and 0.67 in terms of Nash-Sutcliffe index for the Mönchaltorfer Aa and the Gürbe, respectively), but the structure of residuals suggested that there is place for structural improvement.

The initial model was tailored to achieve a better representation of the measured discharge series with introducing time-variable model parameters and analysing their impact on the likelihood. Full resolution time variability was not applied since even the original model was able to simulate short sections (typically a few weeks) of the measured discharge series with almost perfect fit (Nash-Sutcliffe index above 0.95). Instead, parameters were varied from one storm event to the other. Parameters were varied individually, keeping the others fixed. This way their individual capability for increasing the likelihood could be analysed. The presented approach helped to avoid introducing unnecessary detail in the model structure wherever it was not absolutely essential.

The simulation and prediction uncertainty of the modified model structure with time-invariant parameters will be assessed finally with a stochastic model bias description technique. We will present the results of this final step with realistic uncertainty bands for predictions.