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Integrated uncertainty assessment of flow predictions in a Swiss catchment

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Despite the vivid scientific debate on the suitability of RCM predictions for hydrological forecasting, impact studies relying on climatic input data and hydrological models are still the exclusive methods to provide some insight into the expected evolution of streams in the close future. While the climatic uncertainty is usually considered being dominant in such studies, more and more sophisticated uncertainty assessment methods reveal that the uncertainty of our hydrological models has been systematically underestimated by inappropriate assessment methods and that our predictive power for the present conditions can be as weak as it was considered for the future.
The integrated treatment of various uncertainty sources allows us to quantify the overall predictive uncertainty for such studies and to decide if the anticipated impacts are relevant compared to the existing uncertainty.
The Mönchaltorfer Aa catchment (46 km2) in Switzerland was modelled as a case study. A conceptual rainfall-runoff model was calibrated on measured discharge data with Bayesian parameter inference assuming a statistical error process that can account for various uncertainty sources. Climatic input data were produced by statistical downscaling from the outputs of 10 ENSEMBLES GCM-RCM model chains for the A1B emission scenario with the time horizon of 2050. Hourly rainfall data were produced with the Neyman-Scott rectangular pulses model (Rodriguez-Iturbe et al. 1987) while other weather parameters were generated on daily scale with the UKCP09 weather generator (Murphy et al. 2009). Expected landuse changes were assessed by creating divergent regional storylines from countrywide socio-economic scenarios.
Despite the good performance of the hydrological model (Nash-Sutcliffe =0.8), its total predictive uncertainty was significant even for the present conditions. Due to the significant contribution of input uncertainty, individual flood peaks could be predicted with poor confidence. However, in an aggregated sense the model performed satisfactorily with about 10% discharge error along the flow duration curve. Although the uncertainty of future inputs was even bigger, the model results suggest that on the system level the magnitude of expected changes exceed the present uncertainty. Despite the varying predictions on the seasonal distribution and amount of precipitation between the model chains, there was a consensus that extreme events (floods and low flow periods) are likely to get more severe.
The results suggest that by defining the predicted set of indicators we implicitly influence whether the predicted changes will be statistically different from the present or will be dissolved in the existing uncertainty.