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# Flood estimation and comprehensive hydrological assessment on basis of process-oriented continuous simulation

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This contribution provides an overview of a comprehensive effort in process-oriented flood estimation that makes extensive use of the advantages of continuous simulation. On the basis of the hydrological modelling system PREVAH (Viviroli et al., 2009), continuous hydrographs of 23 years duration each were simulated for 450 catchments in Switzerland, laying the bases for a complementary national flood estimation procedure for ungauged catchments. This extensive set of catchments covers approx. 90% of the hydrologically relevant meso-scale catchments in the Swiss River Rhine basin and represents a wide range of pluvial, nival and glacial regime types. To ensure applicability for flood estimation, all simulations were performed at hourly time-step.

To achieve modelling and flood estimation for ungauged sites, a robust regionalisation scheme was developed on the basis of model calibrations for 140 sites with long-term hourly gauge records. The main challenge met both in calibration and regionalisation was arriving at simulations that show good skill in representing annual hourly peak flow and are still hydrologically sound. This was achieved by employing a combination of selected standard skill scores and peak-flow specific skill scores. Jack-knife validation of the regionalisation scheme for 61 catchments with hourly long-term gauge records shows a median Nash Sutcliffe efficiency of 0.71 for overall model performance and a median error for estimation of a 100 year flood ($HQ_{100}$) of 9%. There is thus only a slight tendency for underestimation of large floods, and in almost half of the catchments tested, the $HQ_{100}$ estimated from continuous simulation lies within the 90% confidence interval of the $HQ_{100}$ extrapolated from the observed record.

Thanks to the extensive simulation data available, it is possible to assess in great detail the hydrological simulations as a whole as well as the peak flow estimations derived from them. In particular, model and flood estimation results can be compared to simulation data from catchments located in the same river basin as well as to peak flow and water balance estimates derived from alternative modelling approaches. This range of auxiliary information is unique yet for flood estimation and greatly enhances transparency and verifiability of the flood estimations achieved as compared to present-day statistical and empirical flood estimation procedures. It is furthermore possible to precisely identify limitations of this implementation of the process-oriented flood estimation approach. The most important restriction is a minimum drainage area of about 25 $km^2$, below which both process representation in PREVAH as well as accuracy of precipitation data are insufficient. All of the data mentioned are readily available to the end user in the form of pre-processed tables and graphs.

Efforts to explore the added value resulting from using the process-based framework instead of simple statistical and empirical approaches are under way and show encouraging results. The hydrographs simulated have already been proven suitable for estimation of extreme direct runoff volumes and exceedance of stage thresholds. Further work in progress concerns implementation of anticipated changes in climate and land use, allowing for the identification of catchments sensitive to the changes mentioned.

Reference:

Viviroli, D., Zappa, M., Gurtz, J., and Weingartner, R. 2009. An introduction to the hydrological modelling system PREVAH and its pre- and post-processing tools. Environmental Modelling & Software, 24, 1209–1222. doi:10.1016/j.envsoft.2009.04.001