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The role of hydrological extremes in ecohydrological model optimization

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Our society is highly impacted by the occurrence of floods and droughts. However, in addition to the direct impact on the hydrological system, also ecology is influenced by the occurrence of floods and droughts. In particular, extreme conditions largely impact the composition of riverine species. To establish the response of aquatic species to both hydrological extremes, flow time series are translated to indicators that can describe the extreme behaviour such as duration, frequency, magnitude, rate and timing of extreme flow events. These indicators are used to explain species presence and/or absence.

To consider impacts of global change on hydrological extremes as well as on species occurrence, models are required to accurately represent hydrological extremes in the simulated time series. It is well-known that the model accuracy in particular for extreme values depends on the model optimization and the selection of the objection functions. However, appropriate model simulations for high and low flows in the same run is challenging. We therefore suggested a novel approach to improve the use of eco-hydrological models for simulating both extremes. In a first step, we introduce indicators describing extreme event for both high and low flows into the optimization process. This significantly improved the model's prediction of hydrological extremes as opposed to optimizing to standard performance criteria. However, when including both indicators for drought and flood extremes into hydrological model optimization, the resulting parameterization is a trade-off. Therefore, in a second step, we investigated the significance of this trade-off. We found that a considerable range in indicator values occurs, up to implausible indicator depictions if an unbalanced indicator selection is carried out.

Having applied the methodology to three catchments in different ecoregions, this study shows first, how hydrological models can be effectively optimized to both extremes and second, that the modeler has to carefully assess the compromise originating from calibrating to both high and low flow extremes. Doing so can yield a rewarding result in terms of a more robust parameterization, and ultimately, a better prediction of aquatic species response to extreme events.