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Testing hypotheses of the functioning of a tropical catchment: evaluating the role of model-structural and observational uncertainties

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Knowledge about hydrological processes and the spatial and temporal distribution of water resources is the basis for water management such as hydropower, agriculture and flood-protection. Conceptual hydrological models may be used to infer knowledge on catchment functioning but are affected by uncertainties in the model representation of reality as well as in the observational data used to drive the model and to evaluate model performance. Therefore, meaningful hypotheses testing of the hydrological functioning of a catchment requires such uncertainties to be carefully estimated and accounted for in model calibration and evaluation.

We investigated the hydrological functioning of the relatively data-scarce tropical Sarapiqui catchment in Costa Rica, Central America, where water resources play a vital part for hydropower production and livelihood. Hypotheses on catchment functioning using different model structures were tested within an uncertainty estimation framework specifically accounting for observational uncertainties. The uncertainty in discharge data was estimated from a rating-curve analysis and precipitation measurement errors through scenarios relating the error to, for example, the elevation gradient. The suitability of the different model structures as hypotheses about the functioning of the catchment was evaluated in a posterior analysis of the simulations. The performance of each simulation relative to the observational uncertainties was analysed for the entire hydrograph as well as for different aspects of the hydrograph (e.g. peak flows, recession periods, and base flow). This analysis enabled the identification of periods of likely model-structural errors and periods of probable data errors. We conclude that accounting for observational uncertainties led to improved hypotheses testing, which resulted in less risk of rejecting an acceptable model structure because of uncertainties in the forcing and evaluation data.