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Process refinements in HYPE model set-up for the Niger River basin

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To be applicable for predictions in a changing environment, it is important that the hydrological model is right for the right reason. In this study, we examine a method to improve a process-oriented hydrological model concept when applied to another region than it was first developed for (Andersson et al., 2017). In principle, we propose to analyze and refine each major hydrological process separately, sequentially, and iteratively when developing models for estimation and prediction.

We test this approach by applying the HYPE model concept (HYdrological Predictions for the Environment), originally developed for Sweden, to the data-sparse Niger River basin in West Africa. We analyzed errors in our baseline Niger-HYPE model to identify inadequately described processes. In a set of experiments, we then isolated and refined these process descriptions through concept development, input data enhancement, and multi-variable calibration. The refinements were guided by in situ discharge observations, earth observations, local expert knowledge and previous studies. We found that the original model concept could simulate the annual cycle of discharge, but not the magnitudes or daily dynamics (56-station average NSE: $^{-1}$).

The main processes requiring improved descriptions were precipitation, evaporation, surface runoff, infiltration, soil storage, reservoir regulations, aquifer recharge, and flooding and river-atmosphere exchange in the Inner Niger Delta. Of these, evaporation, flooding and river-atmosphere exchange differ so much between Sweden and the Niger River that the model concept had to be refined. All refinements were synthesized in a new model version (Niger-HYPE2.0) performing significantly better across the basin (56-station average NSE: 0.4). In this study, we demonstrate the danger of applying a model 'off the shelf', and the obligation to carefully evaluate and revise process descriptions when applying a model concept to a new region or during changing conditions. Moreover, we find that our approach to separately, sequentially, and iteratively refine processes together with local experts substantially improve confidence in process-oriented hydrological models.

Reference:
Andersson, J.C.M., Arheimer, B., Traoré, F., Gustafsson, D., and Ali, A., 2017. Process refinements improve a hydrological model concept applied to the Niger River basin. Manuscript in Revision for Hydrological Processes.