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Hydrological model adaptivity to inputs of varied quality

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Hydrological models serve as useful tools to describe current conditions and to predict future conditions in a catchment. However, the errors from input data including precipitation and potential evapotranspiration (PET) and model parameterization can lead to huge uncertainties on the model outputs. Although it is challenging to quantify the effect from individual sections due to the high non-linearity of hydrological processes, the potential compensations among different inputs and model parameters may provide valuable insights into the input data correction and the model calibration.

In this study, we aim to improve the understanding of the adaptation mechanisms between model parameters and the quality of inputs during the hydrological simulation. The objectives are to investigate: (1) the most effective metrics needed to characterize the hydrological applicability of input sources; (2) the hydrological model adaptivity to input sources of varied quality; (3) the compensating interaction of different inputs on the hydrological modelling. We demonstrate our approach to the widely used conceptual Xin'anjiang (XAJ) hydrological model. Rainfall estimations from multiple sources are collected for a headwater catchment in the Southern United States and the Brue catchment in Southwest England, from rain gauges, weather radars, satellites, reanalysis products, and Weather Research and Forecasting (WRF) model dynamic downscaling.

Results suggest that: (1) The total water balance is a poor indicator of rainfall data quality for hydrological simulations. Instead, the event-based water balance shows a stronger influence on representing the differences in hydrological applicability, especially for heavy storm events; (2) A high compensation relation exists among the quality of rainfall data, the model's initial soil moisture state, and water balance-related parameters in the XAJ model, allowing the poor WRF rainfall datasets to generate good streamflow simulations; (3) A new hydrological proxy (term), called Compensating Interaction Angle (CIA) between different inputs is diagnosed to quantitatively measure the trade-off between their quality in producing satisfactory hydrological performance. The proposed CIA is recommended to apply in other regions and hydrological models to validate if a general pattern exists and how it varies regionally.