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The case for characterising stage-discharge rating curve uncertainties for large-sample hydrological model predictions

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Increasingly, hydrologists are evaluating models and data over large numbers of catchments in an effort to better understand regional differences in catchment behaviour and drivers of hydrological processes. Large sample hydrology unlocks some exciting possibilities within hydrological sciences, yet, the evaluation of models and data over large numbers of catchments also raises some key challenges. When incorporating data from many different catchments, the need to quantify observational data uncertainties becomes imperative as comparisons between catchments may be incorrect or biased in the face of erroneous or disinformative data. Critically however, is the need to incorporate and account for these uncertainties in the modelling process and to explore in what circumstances do these place-specific uncertainties matter when evaluating models and making hydrological predictions.

In this study, we aim to address these questions by assessing the impact of different observational discharge uncertainty estimates on model identification and evaluation for a large number of UK catchments. To achieve this, we utilise 21 years of rainfall and potential evapotranspiration data from over 50 UK catchments as input to 78 hydrological models obtained from the Framework for Understanding Structural Errors (FUSE). The model simulations are evaluated against discharge data for different estimates of observational discharge uncertainties in an uncertainty evaluation framework. Specifically, we test scenarios of 1) a constant estimate of discharge uncertainty and 2) discharge uncertainties calculated from the available stage-discharge measurements with a) extrapolation and b) removing all extrapolated flow periods from model evaluation. We evaluate the models against different aspects of catchment behaviour in the limits of acceptability framework to understand how the different treatment of discharge uncertainties affects model selection. We achieve this for different model diagnostics and investigate differences between catchments, across the flow range and throughout the time series. This study constitutes a first step towards incorporating observational data uncertainties in large sample hydrology and the implications arising from this.