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Constraint of the limited information content of discharge measurements on the benefits of rating curve models with increased complexities

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Discharge assessment through rating curves is a widespread technique in the field of hydrologic monitoring. In practical applications, this technique often consists of the use of one or multiple power laws, based on rather stringent assumptions concerning the nature of the prevailing flow conditions. In reality, those assumptions are regularly violated, inducing considerable uncertainties in the calculated discharges. It is thus important to estimate the effect of those simplifications when performing an overall uncertainty analysis of rating curve discharges. In this study, different rating curve formulations are compared based on both results of a hydrodynamic model and measured water levels and discharges.

The results of a hydrodynamic model are used to justify the applicability of several rating curve models with increased complexity as an alternative for a single power law equation. With the hydrodynamic model, situations are simulated that correspond to steady state conditions and to minimal effect of downstream boundaries. Comparison of simulations results with those of measurement-driven simulations leads to an increased understanding of the rating curve dynamics. It allows for evaluation of rating curve formulations accounting for the influences of hysteresis and backwater effects which are neglected in power law rating curves. Subsequently, the performance of those rating curve models and the identifiability of their parameters are assessed based on available stage-discharge measurements and their accompanying uncertainties as described in literature. This assessment is performed based on the Generalised Likelihood Uncertainty Estimation (GLUE). Rejection criteria to distinguish behavioural from non-behavioural models are defined by uncertainties on both water levels and discharge measurements that envelop measured data points.

The results of the hydrodynamic model clearly indicate benefits of adding complexity to the rating curve model, mainly by accounting for backwater effects. The GLUE evaluation based on available measurements however does not demonstrate this increased performance. The evaluation further reveals that complex rating curve models face parameterization problems when using field data. This inconsistency between evaluations based on the model and on in situ data should be attributed to the limited information content of the water level and discharge measurements. Despite of a measurement station with a highly stable cross section in time and more than 200 available measurements, these in situ data do not include every flow condition and the measurements contain errors. Consequently, the information content of the measured data turns out to be inadequate to distinguish the effects of increased complexity of rating curve models. This study reveals the importance of evaluating rating curve model formulations with regard to the informative content of their input and calibration data and demonstrates the usefulness of the GLUE methodology in this respect.