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Estimating rating curves and their uncertainty via hydraulic modelling and Bayesian inference

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Stage-discharge (SD) rating-curve estimation methods are traditionally used to compute streamflow records. Such methods are calibrated using gaugings, i.e. one-off stage-discharge measurements. Establishing a reliable SD rating curve can take years of data collection efforts due to the difficulty to take gaugings that cover the whole variability of the stage-discharge relation. In particular, traditional rating curves are often uncertain for high flows since they occur rarely, are often practically difficult to gauge, and the highest flows often need to be extrapolated. Hydraulic modelling can be a good alternative for estimating rating curves, in particular for more reliable high flow discharge estimation. Such hydraulic modelled rating curves can be derived with only a few gaugings, allowing the SD relation to be derived much faster than with traditional methods, which are based on numerous stage-discharge gaugings.

Building on existing Bayesian approaches we introduce a hydraulically-based model for developing SD rating curves and estimating their uncertainties at hydrometric stations. We use a one dimensional hydraulic model and calibrate it with a few gauging data and water-slope measurements. Our method incorporates information from both hydraulic knowledge (using the 1D hydraulic model) and the information available in the stage-discharge gaugings. The method provides a direct estimation of the hydraulic configuration (slope and bed roughness). Discharge time series are estimated by propagating stage records through the posterior rating curve realisations.

We applied our method to two Swedish catchments, accounting for uncertainties in the stage–discharge gauging and water-surface slope data. We focused our analyses on high-flow uncertainty and the factors that could reduce this uncertainty. In particular, we investigated which data uncertainties were most important, and at what flow conditions the gaugings should preferably be taken. First results show that posterior rating curve uncertainty results are acceptable at high flows: constraints of uncertainty intervals are similar to the ones of traditional methods and the number of gaugings used in the overall calibration process is reduce by 85% (from 20 available gaugings to only 3 used).