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Comparison of rating-curve uncertainty estimation using hydraulic modelling and power-law methods

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Establishing reliable rating curves and thereby reliable streamflow monitoring records is fundamental to much of hydrological science and water management practice. Cost-effective methods that enable rapid rating curve estimation with low uncertainty are needed given diminishing monitoring resources and increasing human-driven changes to the water cycle. Traditional power-law rating curves rely on numerous gaugings to estimate rating curves and their associated uncertainty. Hydraulically-modelled rating curves are a promising alternative to power-law methods as they rely on fewer gaugings, but they are associated with additional uncertainty sources in the hydraulic knowledge (bed slope, roughness, topography and vegetation), which need to be assessed.

Our aim with this study was to compare power-law and hydraulic-model based methods for estimating rating curves and their uncertainty. We focused on assessing their accuracy as well as the costs and time required for establishing rating curves. We compared the Rating curve Uncertainty estimation using Hydraulic Modelling (RUHM) framework with the Bayesian power-law method BaRatin. The RUHM framework combines a one-dimensional hydraulic model with Bayesian inference to incorporate information from both hydraulic knowledge and the calibration gauging data. We applied both methods to the 584 km^2 River Röån station in Sweden under nine different gauging strategies associated with different costs. The gauging strategies differed in the number and flow magnitude of the gaugings used as well as the probability of observing the gauged flows.

We found that rating curves with low uncertainty could be modelled with fewer gaugings using the RUHM framework compared to BaRatin. As few as three gaugings were needed for RUHM if these gaugings covered low and medium flows, making the estimation both cost effective and time efficient. When using all the gaugings available (i.e. a high-cost gauging strategy), the uncertainty for RUHM and BaRatin was similar at the Röån station. Furthermore, we found that BaRatin needed gaugings with lower probability of occurrence (i.e. covering a larger part of the flow range)

than needed when using hydraulic modelling (low and middle flow gaugings with high probability of occurrence gave good results). The results for this Swedish site show that hydraulic rating curve uncertainty estimation is a promising tool for quickly estimating rating curves and their uncertainties. In particular, it is useful for previously ungauged or remote sites, or at stations where there have been major temporal changes to the stage–discharge relation.