Accurate discharge records are essential for flood frequency analyses, hydraulic model calibration and flood forecasting. Discharge records are often obtained via a transformation of water levels to discharges using a rating curve. For accurate rating curves, a physical basis is important, particularly in the extrapolation domain towards extreme discharges. In this study, physical processes and constraints are incorporated in a rating curve model: water balance closure at a bifurcation and bed level degradation. The aim is to assess the effect of incorporating these physical processes and constraints for rating curves at two bifurcations of the Rhine river in the Netherlands. Intermittent gaugings are available for a 31 year period at these bifurcations. Bayesian inference and Markov Chain Monte Carlo sampling is used to estimate the posterior distributions of the rating curves. If rating curves are constructed independently, they show a large water balance error at bifurcations of up to 10%. Incorporating bed level degradation is required for accurate rating curves as it reduces the residual errors by up to 50%. If explicitly accounting for water balance closure, the water balance error can be reduced to 1%, while residual errors remain equally small. As water balance closure is a physical constraint at a river bifurcation, the rating curves that account for water balance closure are expected to be more physically realistic. Therefore, it is recommended to specifically gauge at river bifurcations and confluences, such that the constraint of water balance closure can be used to improve the accuracy of rating curves and discharge records.

Keywords: Rating curves, River bifurcation, Water balance, Uncertainty analysis, Rhine river.

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