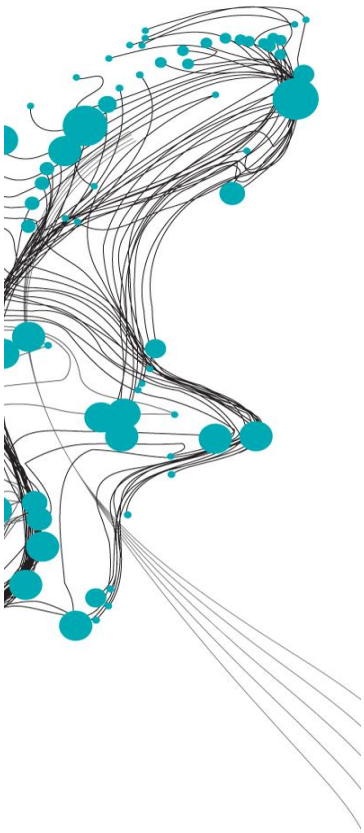
Water balance in the Dutch river Rhine and uncertainty of rating curves



Accurate rating curves are essential for a wide range of river management purposes, particularly as a basis for flood risk management. For this thesis, the three largest Dutch river Rhine branches (Bovenrijn, Waal and Pannerdensch Kanaal) and the bifurcation point Pannerdense Kop are studied. Comparing the operational rating curves of 2018 for these branches shows that the water balance is not closing (up to 5% error) (Figure 1). This gives a direct indication of the uncertainty in the operational rating curves. The locations are only 5km apart without intermediate tributaries or significant water storage areas. Therefore, between the locations a nearly perfect water balance would be expected. The objective of this research is to determine the uncertainty of single rating curves as related to flow measurement errors and to explore how water balance considerations can influence the uncertainty of rating curves.

Firstly, the uncertainty associated with single rating curves has been quantified, using Bayesian inference and Markov chain Monte Carlo (MCMC) simulations, as based on homogenized measurement data. All available stage-discharge measurements from Rijkswaterstaat over a period from 1988 to 2018 have been used. In the measured domain of the obtained rating curves, the 95% total uncertainty bands are relatively narrow with values of around 430m^3s^{-1}, 360m^3s^{-1}, 200m^3s^{-1} for the branches, Bovenrijn, Waal, Pannerdensch Kanaal, respectively. Secondly, the uncertainty associated with single rating curves, as related to flow measurement errors, has been quantified. Therefore, flow measurement error values (3 and 5%), obtained from ISO reports and scientific literature, are imposed in Bayesian inference and MCMC simulations. It was found that flow measurement errors are a dominant source of uncertainty for single rating curves. Finally, in this thesis a new method is developed for establishing rating curves based on water balance closure. In todays practice only locally measured flows are considered for rating curve construction. The new method also includes flow measurements from other locations to incorporate a closing water balance in the separate rating curves. The new method clearly reduces the systematic error in water balance and thereby it provides more consistent rating curves for the river network of the Dutch Rhine. The trade-off of this improvement is that the uncertainty bands of the individual rating curves have increased. However, since rating curves are essential in the construction of discharge time-series from water levels and in the calibration of river models, it is important that systematic errors in rating curves are removed as much as possible. Especially if these discharge time-series and calibrated models are used to define and hydraulically model design flood events.

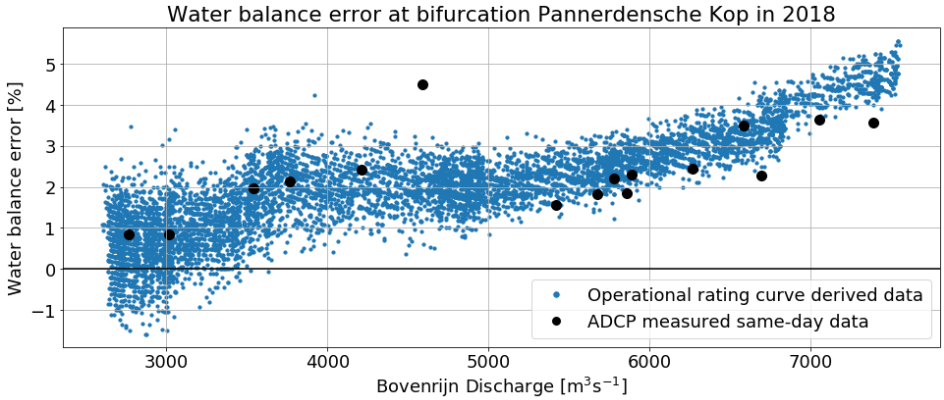


Figure 1. Water balance error at bifurcation Pannerdense Kop for discharge data derived from operational rating curves (source: https://waterinfo.rws.nl/) and for same-day ADCP flow measurements. The figure presents the discharge domain without weir effects for year 2018.

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