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Uncertainty in hydrological signatures

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Information that summarises the hydrological behaviour or flow regime of a catchment is essential for comparing responses of different catchments to understand catchment organisation and similarity, and for many other modelling and water-management applications. Such information types derived as an index value from observed data are known as hydrological signatures, and can include descriptors of high flows (e.g. mean annual flood), low flows (e.g. mean annual low flow, recession shape), the flow variability, flow duration curve, and runoff ratio. Because the hydrological signatures are calculated from observed data such as rainfall and flow records, they are affected by uncertainty in those data. Subjective choices in the method used to calculate the signatures create a further source of uncertainty. Uncertainties in the signatures may affect our ability to compare different locations, to detect changes, or to compare future water resource management scenarios.

The aim of this study was to contribute to the hydrological community's awareness and knowledge of data uncertainty in hydrological signatures, including typical sources, magnitude and methods for its assessment. We proposed a generally applicable method to calculate these uncertainties based on Monte Carlo sampling and demonstrated it for a variety of commonly used signatures. The study was made for two data rich catchments, the 50 km2 Mahurangi catchment in New Zealand and the 135 km2 Brue catchment in the UK. For rainfall data the uncertainty sources included point measurement uncertainty, the number of gauges used in calculation of the catchment spatial average, and uncertainties relating to lack of quality control. For flow data the uncertainty sources included uncertainties in stage/discharge measurement and in the approximation of the true stage-discharge relation by a rating curve.

The resulting uncertainties were compared across the different signatures and catchments, to quantify uncertainty magnitude and bias, and to test how uncertainty depended on the density of the raingauge network and flow gauging station characteristics. The uncertainties were sometimes large (i.e. typical intervals of $\pm$10–40% relative uncertainty) and highly variable between signatures. Uncertainty in the mean discharge was around $\pm$10% for both catchments, while signatures describing the flow variability had much higher uncertainties in the Mahurangi where there was a fast rainfall–runoff response and greater high-flow rating uncertainty. Event and total runoff ratios had uncertainties from $\pm$10% to $\pm$15% depending on the number of rain gauges used; precipitation uncertainty was related to interpolation rather than point uncertainty. Uncertainty distributions in these signatures were skewed, and meant that differences in signature values between these catchments were often not significant. We hope that this study encourages others to use signatures in a way that is robust to data uncertainty.