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Uncertainty in hydrological signatures for characterising rainfall-runoff processes

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Information about the characteristics of the runoff processes in a catchment is essential for most hydrological analyses, modelling and water-management applications. Such information derived from observed data is known as a hydrological or diagnostic signature, and have been used in a variety of studies for e.g. catchment classification, model-structural identification, model calibration and regionalisation – and in particular when using large hydrological datasets. Different sources of uncertainty in the observed data – including measurement error and representativeness as well as errors relating to data processing and management – propagate to the values of the derived signatures and reduce their information content. Subjective choices in the method used to calculate the signatures create a further source of uncertainty.

The aim of this study was to contribute to the community's awareness and knowledge of observational uncertainty in hydrological signatures, including typical sources, magnitude and methods for its assessment. We first reviewed the sources and nature of uncertainties relevant to the calculation of different signatures based on rainfall and flow data. We then proposed a generally applicable method to calculate these uncertainties based on Monte Carlo sampling and demonstrated it for a number of commonly used signatures including thresholds in rainfall-runoff response, recession analysis and basic descriptive signatures such as total runoff ratio, and high/low flow statistics.

The study was made for two data rich catchments, the 135 km2 Brue catchment in the UK and the 50 km2 Mahurangi catchment in New Zealand that are both densely monitored. For rainfall data the uncertainty sources included point measurement uncertainty, the number of gauges used in calculation of the catchment areal average, and epistemic 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 understand how the uncertainties may change with the sources of the uncertainty in the observed data and the active runoff processes. Finally we considered whether the uncertainties found would change the way that the signatures were interpreted to give information about catchment response