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Approximate Bayesian Computation to Include Historical Data in Flood Frequency Estimation

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Estimating magnitudes of rare extreme flood events (such as the 1-in-100 year event) can be improved by the inclusion of historical data, especially when the return period of interest exceeds the length of systematic records. Historical records typically consist of sporadic extreme events and periods of missing data, equivalent to random censoring of the data according to some unknown threshold. Although Maximum Likelihood (ML) methods can incorporate this censored data in a flexible way, the resulting estimates sometimes do not exist for certain extreme value distributions, and standard ML methods may not converge consistently.

To this end, Approximate Bayesian Computation (ABC), first developed by Tavaré *et al.* (1997), is presented as a method of obtaining posterior distributions for parameters associated to unknown probability distributions, such as the Generalised Logistic (the standard distribution used for flood frequency in the UK) and Generalised Extreme Value (GEV) distributions. ABC is a simulation-based method which avoids using the likelihood directly, avoiding problems involving computation and convergence, particularly in high-dimensional problems where there are several parameters to estimate. Simulated peak-over-threshold or annual maxima (AMAX) series are compared to the data, and 'similar' simulations are accepted as drawn from the same distribution; similarity is determined by generating preliminary covariance matrices based on the data. Posterior distributions are obtained from weighted accepted simulations.

ABC is demonstrated through application to the River Severn at the Welsh Bridge in Shrewsbury, UK, which has experienced large disruptive floods but which currently does not have a long AMAX series from which to better estimate long return period flood magnitudes. New additional historical records have been found from local sources and incorporated into the time series. ABC is implemented and demonstrated to be as effective as ML with the benefit of guaranteed convergence, along with the availability of posterior distributions for parameters of interest, rather than solely point estimates. This method is demonstrated via a simple application but could easily be included in approaches where a likelihood is expensive or impossible to compute, but simulation is straightforward.