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Single-site vs. multi-site rainfall generation and the role of parametric rainfall distributions in lumped hydrological modelling

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It was examined whether a lumped hydrological model driven with lumped daily precipitation time series from a single-site rainfall generator can produce equally good simulation results compared to using a multi-site rainfall generator, where synthetic precipitation is first generated at multiple sites and subsequently lumped. Driving a lumped hydrological model with synthetic rainfall time series from stochastic rainfall generation is a fast methodology in hydrological impact assessment, for example for the assessment of low frequent extreme flows when long synthetic discharge time series are required. The use of a lumped hydrological model appears to justify the application of a straightforward single-site “Richardson type” rainfall generator, where rainfall observations from several sites in the catchment are first lumped and then used for parametric distribution fitting. An alternative approach is the application of a multi-site rainfall generator, where rainfall is first generated at all available rainfall sites and subsequently lumped to feed the hydrological model. The higher complexity of multi-site rainfall generators makes the application of a single-site approach attractive as the latter can be set up fairly easily.

This study revealed, however, that well-established parametric rainfall distributions for single-site rainfall observations are not suitable for lumped rainfall time series in the Alpine catchments examined, and can lead to bias in the simulation of extreme flows when using a single-site rainfall generator. The issue can be avoided by either using a multi-site rainfall generator, which is considerably less sensitive to the choice of the parametric rainfall distribution or by a careful choice of the parametric rainfall distribution fitted to lumped rainfall time series when using a single-site rainfall generator. In this study three different rainfall generators were tested: two different single-site "Richardson type" models (one with and one without an improved simulation of the rainfall autocorrelation) and the multi-site rainfall generator TripleM, whose source code is now available to the public. Four different parametric distributions were examined for single-site and multi-site rainfall simulations, which were the often applied Gamma, Weibull and Exponential distributions as well as a combined distribution consisting of the empirical distribution for low and the Generalized Pareto distribution for higher and extreme rainfall amounts. The study areas in this research were two catchments in the Austrian and French Alps with altitude ranges between 350 and 3600m above sea level.