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Spatial consistency of simulated rainfall at various spatial scales using a nested simulated annealing approach

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For various hydrological applications, including that of rainfall runoff modelling, long continuous time series of precipitation are often required. Generally, available rain gauge data is too short or at an insufficient temporal resolution to be of use within these applications. This problem can be compounded when considering applications requiring multiple sites as available data should be concurrent. As an alternative, stochastic precipitation time series can be used, an example being the alternating renewal precipitation model. The use of simulated precipitation for a single site is generally unproblematic, however problems arise when spatial consistency is required across multiple sites, as is indeed the case for many hydrological applications.

In this study, long hourly time series are first generated independently for many sites across the state of Lower Saxony in Germany using an alternating renewal model, where rainfall is described as a series of wet and dry spells.

As a second step, a simulated annealing based multi-site resampling procedure is applied on the generated time series to reproduce the spatial dependence structure of rainfall. An objective function using three bivariate spatial rainfall characteristics is used to optimise the resampling of rainfall events.

Previous studies have shown the effectiveness of this approach, but were limited in either the number of stations used during the resampling or the spatial extent of the sites, generally due to the computational expense of the procedure.

This study aims to improve on previous work by using a nested approach, where stations are first allocated to defined spatial regions and representative stations selected for each. The simulated annealing procedure is then first applied intra-regionally to these representative sites, and then inter-regionally to all sites within each region. To test the performance of this approach, results are compared between the nested and non-nested simulated annealing methods at varying spatial scales of between 100 km^2 to 50,000 km^2.