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Reduced-complexity multi-site rainfall generation: one million years over night using the model TripleM

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We assess uncertainties of multi-site rainfall generation across spatial scales and different climatic conditions. Many research subjects in earth sciences such as floods, droughts or water balance simulations require the generation of long rainfall time series. In large study areas the simulation at multiple sites becomes indispensable to account for the spatial rainfall variability, but becomes more complex compared to a single site due to the intermittent nature of rainfall. Weather generators can be used for extrapolating rainfall time series, and various models have been presented in the literature. Even though the large majority of multi-site rainfall generators is based on similar methods, such as resampling techniques or Markovian processes, they often become too complex. We think that this complexity has been a limit for the application of such tools. Furthermore, the majority of multi-site rainfall generators found in the literature are either not publicly available or intended for being applied at small geographical scales, often only in temperate climates.

Here we present a revised, and now publicly available, version of a multi-site rainfall generation code first applied in 2014 in Austria and France, which we call TripleM (Multisite Markov Model). We test this fast and robust code with daily rainfall observations from the United States, in a subtropical, tropical and temperate climate, using rain gauge networks with a maximum site distance above 1,000km, thereby generating one million years of synthetic time series. The modelling of these one million years takes one night on a recent desktop computer. In this research, we first start the simulations with a small station network of three sites and progressively increase the number of sites and the spatial extent, and analyze the changing uncertainties for multiple statistical metrics such as dry and wet spells, rainfall autocorrelation, lagged cross correlations and the inter-annual rainfall variability. Our study contributes to the scientific community of earth sciences and the ongoing debate on extreme precipitation in a changing climate by making a stable, and very easily applicable, multi-site rainfall generation code available to the research community and providing a better understanding of the performance of multi-site rainfall generation depending on spatial scales and climatic conditions.