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A stochastical event-based continuous time step rainfall generator based on Poisson rectangular pulse and microcanonical random cascade models

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Rainfall variability within a storm is of major importance for fast hydrological processes, e.g. surface runoff, erosion and solute dissipation from surface soils. To investigate and simulate the impacts of within-storm variabilities on these processes, long time series of rainfall with high resolution are required. Yet, observed precipitation records of hourly or higher resolution are in most cases available only for a small number of stations and only for a few years. To obtain long time series of alternating rainfall events and interstorm periods while conserving the statistics of observed rainfall events, the Poisson model can be used. Multiplicative microcanonical random cascades have been widely applied to disaggregate rainfall time series from coarse to fine temporal resolution.
We present a new coupling approach of the Poisson rectangular pulse model and the multiplicative microcanonical random cascade model that preserves the characteristics of rainfall events as well as inter-storm periods. In the first step, a Poisson rectangular pulse model is applied to generate discrete rainfall events (duration and mean intensity) and inter-storm periods (duration). The rainfall events are subsequently disaggregated to high-resolution time series (user-specified, e.g. 10 min resolution) by a multiplicative microcanonical random cascade model. One of the challenges of coupling these models is to parameterize the cascade model for the event durations generated by the Poisson model. In fact, the cascade model is best suited to downscale rainfall data with constant time step such as daily precipitation data. Without starting from a fixed time step duration (e.g. daily), the disaggregation of events requires some modifications of the multiplicative microcanonical random cascade model proposed by Olsson (1998): Firstly, the parameterization of the cascade model for events of different durations requires continuous functions for the probabilities of the multiplicative weights, which we implemented through sigmoid functions. Secondly, the branching of the first and last box is constrained to preserve the rainfall event durations generated by the Poisson rectangular pulse model.
The event-based continuous time step rainfall generator has been developed and tested using 10 min and hourly rainfall data of four stations in North-Eastern Germany. The model performs well in comparison to observed rainfall in terms of event durations and mean event intensities as well as wet spell and dry spell durations. It is currently being tested using data from other stations across Germany and in different climate zones. Furthermore, the rainfall event generator is being applied in modelling approaches aimed at understanding the impact of rainfall variability on hydrological processes.

Reference

Olsson, J.: Evaluation of a scaling cascade model for temporal rainfall disaggregation, Hydrology and Earth System Sciences, 2, 19.30