
Continuous simulation of hourly areal rainfall over a wide range of French catchments: methodology, applications and validation at multi-temporal scales.

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Abstract

Rainfall represents one of the most complex climatic variable to model, owing to its marked spatiotemporal variability, intermittency, the extreme amplitude of rare events, and the limitations of observational datasets-particularly at fine temporal resolutions. Robust analysis of hydrometeorological risks therefore requires tools capable of faithfully reproducing the structure of precipitation, which varies strongly across timescales, for a range of values from frequent, moderate rainfall to rare, extreme events.

Fine-timescale rainfall series generators directly address this need by generating realistic time series essential for feeding hydrological models and assessing the impact of rainfall events on watersheds. These synthetic rainfall series enable exploration of hydrological responses to various scenarios, integrating interannual variability, seasonality and temporal autocorrelation of rainfall at multiple timescales.

The generator proposed in this study is designed to replicate the full range of temporal characteristics of rainfall, from hourly to annual scales. It is based on an event-based model that simulates significant rainfall episodes at an hourly time step, embedded within a continuous series that incorporates dry inter-event periods and lower-intensity rainfall. Calibration was conducted using areal rainfall series whose temporal structure varies depending on the spatial aggregation scale.

The generator's performance is assessed at various temporal resolutions, from hourly to annual, by evaluating its ability to reproduce key rainfall properties including seasonality, temporal autocorrelation, and quantile distribution, from moderate to extreme values. Applied to over 2,100 watersheds, ranging in area from 1 to 10,000 km², the model demonstrates robust performance for simulating the different temporal characteristics of rainfall in highly contrasting climatic contexts.

These long hourly rainfall synthetic rainfall series, respecting precipitation properties at different scales, will be used to drive a hydrological model to produce long hourly synthetic flow series. Such simulations are essential for the robust assessment of hydrological hazards and risk mitigation.

Keywords: hourly rainfall generator, areal rainfall, multi, temporal scales

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