
Stochastic Rainfall Occurrence Generator with Long Periods of Drought

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Abstract

Stochastic weather generators (SWGs) are indispensable for risk assessment and down-scaling. Yet commonly used Markov and hidden-Markov formulations struggle to reproduce the heavy-tailed persistence of dry spells in daily rainfall records. We propose a single site rainfall-occurrence SWG based on alternating-renewal, also called spell-length, modeling. Dry and wet durations are modeled directly, assuming independence between successive spells and avoiding the exponentially decaying sojourns implied by regular Markov chains. We describe a version of our model relying on extended generalized Pareto distribution in order to have a flexible approach, modeling the entire distribution with a special focus on extremes.

Our theoretical contribution is an explicit, closed-form connection between alternating-renewal chains and a broad class of Markov models. This bridge clarifies the asymptotic behavior of the proposed class and enables the practical transfer of methods developed for any of the approach across the two frameworks.

We calibrate the model to daily rainfall-occurrence series across multiple European locations. The generator accurately reproduces persistence metrics and upper quantiles of dry-spell lengths, with notable gains in southern Europe where extreme dry spells are observed. The results illustrate the flexibility and efficiency of spell-length-based occurrence modeling for synthetic rainfall generation.

Keywords: stochastic weather generators, rainfall occurrence, alternating renewal models, dry, spell extremes, persistence

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