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Non-power-law scale properties of time rainfall: consequences for downscaling and stochastic generation models

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The identification of general relationships linking statistical properties of rainfall aggregated at different temporal and spatial scales possesses clear theoretical and practical relevance. Among other properties it is important to characterize the scale dependence of rainfall variability, which may, for many purposes, be summarized by its variance. Previous theoretical results are revised to characterize the connection of the temporal variance of rainfall to the scale of observation under the assumption of second-order stationarity. We validate the predictions of the theoretical derivations making use of a dataset representing a wide variety of resolutions (from 2 s to 1 hour), climates and observation instruments. We then apply the theoretical and observational results to develop a method to estimate the hourly variance from daily observations. Tests of different assumptions on the autocorrelation structure indicate that an optimal estimator should be based on a power-law-tailed autocorrelation function, yielding unbiased estimates with minimal error variance in the large dataset explored. The hourly rainfall estimates are then used, together with daily statistics (e.g. mean, variance, proportion dry, etc.), to calibrate a stochastic rainfall model. Comparisons of the properties of the synthetic rainfall generated by the model show substantial improvements in the reproduction of the observed hourly variance with respect to a calibration which only makes use of daily statistics.