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Rainfall variability at different scales: consequences for downscaling, stochastic rainfall generation and hydrological 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. This contribution presents theoretical results and observational analyses connecting the variance of temporal and spatial rainfall to the scale of observation under the assumption of second-order stationarity. Previous results regarding the theoretical form of the temporal variance as a function of aggregation are refined and extended to the spatial case. It is in particular shown that the theoretically-derived form of the variance as a function of scale is incompatible with power-law relations usually assumed for the second-order statistical moment within multiscaling approaches to rainfall modelling. Predictions of the theoretical derivations are validated making use of a dataset representing a wide variety of resolutions (from 2 s to 1 hour in time and 4 km in space), climates and observation instruments. The validation shows a satisfactory agreement between observations and the theoretically-predicted forms of the variance as a function of aggregation. Such theoretical results are then applied to stochastically downscale daily rainfall observations within a study basin. Results are finally statistically compared to hourly validation observations and used in a well-tested hydrological model to derive discharge statistics.