The influence of serial correlation and field significance in trend analyses of extreme rainfall frequency time series

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Precipitation extremes are expected to rise in a warmer climate, according to both theoretical considerations and climatic projections. These projections could be validated through inferential analyses incorporating statistical testing procedures. Recent research suggests that conducting such studies on hydrological records might lead to misleading conclusions if (i) data exhibit autocorrelation and (ii) field significance is not taken into account when tests are performed at multiple locations. In this study, we extensively investigate the impacts of these two issues focusing on the frequency (or count) of daily rainfall extremes from synthetic time series to guide the interpretation of possible trends on observed records. This is done by generating random synthetic frequency time series, characterized by different sample size, autocorrelation level, and trend magnitude, using the Poisson first-order Integer-valued AutoRegressive model, which we first show to be able to successfully reproduce serial correlation properties of worldwide observed records. Our main results are as follows. (1) While empirical autocorrelations are likely induced by the presence of trends, observed trends cannot be explained as the exclusive effect of autocorrelation, implying that serial correlation may have a limited impact on trend analyses of extreme frequency time series. (2) Accounting for field significance improves the interpretation of test results by limiting the type-I errors. (3) Parametric trend tests based on linear and Poisson regressions are more powerful than nonparametric tests, such as Mann-Kendall, in the analysis of count time series. Using these findings, we investigate the existence of trends in extreme precipitation frequency time series by employing long-term (100-year) daily precipitation records from 1087 rain gauges of the Global Historical Climate Network database. The trend tests reveal evident spatial patterns of statistically significant increasing (decreasing) trends in extreme rainfall frequency mainly located in United States and Northern Eurasia (southwestern United States, southern Europe, southern parts of Australia), which confirm and complement the findings of previous regional and global studies.