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Long-range Memory Effect and Generalized Scaling in the Distribution of Dry Intervals in Gauge-derived Rainfall Time Series

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It is common experience that rainfall is intermittent in space and time. This is reflected by the fact that the statistics of area- and/or time-averaged rain rate is described by a mixed distribution with a nonzero probability of having a sharp value zero. In this work we have explored the dependence of the probability of zero rain $p_0(T)$ on the time scale T in a large multi-year data set based on observations from more than 300 tipping bucket gauges situated in south Florida, supplemented by information from a small number of Joss-Waldvogel impact disdrometers.

In a rather wide range of T between $T = 1$ min and 3 days, our results can be summarized by the simple stretched exponential formula $p_0(T) = \alpha_0 \exp[-(T/T_0)^\chi]$, where α_0 and χ are dimensionless parameters and T_0 is a characteristic time scale. For all the data sets studied the exponent χ is found to be in the narrow range $0.7 - 0.9$. The parameter α_0, which is determined by the behavior of $p_0(T)$ at small T, is found to be slightly less than unity and is estimated to be in the range $0.95 - 0.995$ for our data sets. The characteristic time T_0 is found to vary considerably from one data set to another and appears to have a seasonal dependence. The probability of nonzero rain $p_1(T) = 1 - p_0(T)$ has an approximate power law scaling behavior with exponent χ only within a limited range of scales $(1 - \alpha_0)^{1/\chi} T_0 \ll T \ll T_0$. The quantity $1 - \alpha_0$ represents the limiting value of $p_1(T)$ for small T and the fact that it is nonzero signifies that the support of the rain field is not quite a set of measure zero as is sometimes supposed.

We also propose a simple probabilistic model to explain the observed behavior of $p_0(T)$ based on the premise that rainfall process has an intrinsic memory. The experimental fact that $\chi < 1$ reveals an interesting aspect of the rainfall process that can be interpreted as a phenomenon of "persistence of drought", namely, the longer a zero rain period, the less likely it is for it to end.