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How Temporal Rainfall Scales (and How to Estimate the Scaling Properties)

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The discovery that rainfall has renormalization properties has produced new statistical models, new forecasting and downscaling methods, and new approaches to rainfall extremes. Yet, the scaling properties of temporal rainfall remain unclear. Published results vary widely, calling into question whether rainfall indeed obeys scaling laws and whether the laws have some degree of universality. This study aims at understanding the sources of these differences and establishing proper scaling analysis procedures.

The main factor that affects the estimates of rainfall scaling is whether one analyzes the continuous record inclusive of storms and dry inter-storm periods ("continuous analysis") or only the portion of the record within storms ("within-storm analysis"). Compared to within-storm analysis, continuous analysis produces much smaller fractal dimensions of the rain support and much weaker intensity fluctuations (less intermittency) when it rains. The difference in the estimated fractal dimension is linked to the fact that the wet fraction is much higher inside the storms than in the continuous process, whereas the difference in the estimated intermittency is more intriguing because the same nonzero rain values are used in both analyses. By using actual and synthetic rainfall records as well as simple toy models of rainfall, we show that all differences originate from the fact that rainfall scales within storms but does not scale as a continuous process.

Continuous analysis methods are well codified, but those for within-storm analysis are not. A second objective of this study is to develop robust procedures for within-storm scaling analysis.

Many past analyses have used log-Levy multifractal models and have reported different values of the Levy index $0 < \alpha \leq 2$. We examine the bias in the estimation of α in continuous and within-storm analysis and provide support for the hypothesis that for rainfall α may be taken as 2 (lognormal model).