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A stochastic model for tropical precipitation clustering and connections to branching processes

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Tropical convective organization in space is here addressed by examining precipitation clusters —spatially continuous regions exceeding a threshold precipitation. The probability distributions of the area and of the cluster power —the total rainfall integrated over the cluster —follow a power law (with slope ~ -1.5) bounded by a large-event cutoff. We show how a minimal stochastic model of tropical dynamics can reproduce these probability distributions. The model prognoses column water vapor that is coupled to temperature through the weak temperature gradient approximation. Parameter perturbation experiments reveal that the power law slope of ~-1.5 is fairly robust; the model cluster size and power cutoffs are, however, sensitive to the multiple model parameters. We find that a probabilistic process called the Branching Process is a useful analog for observed precipitation clustering. This process explains the apparent robustness of the power law slope and suggests the creation of a nearest-neighbor metric that is unreasonably effective at explaining the parametric sensitivity of the cluster distribution cutoffs. Regimes exhibiting lines or blobs of precipitating points similar to those termed "self-aggregating"are examined for contrast with the regime that is a closer match to observations for which the analogy to self organized criticality is much more apt.

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