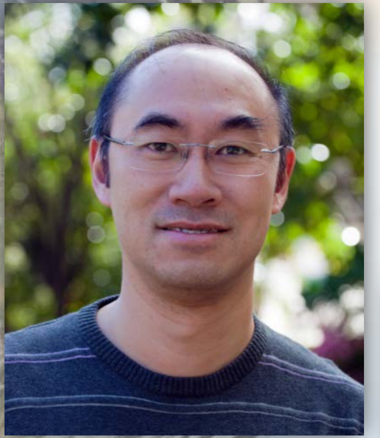
Temporal and Spatial Scaling of Rain and Rain Clusters: Critical Phenomena?



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This talk will first discuss the spectral scaling of a heavy rainfall event based on 10, 5 and 1 min aggregate rainfall data from rain gauge stations and simulated rainfall on 0.9, 0.3 and 0.1 km grids by a Numerical Weather Prediction model. The simulated and observed rain rates were compared via Fourier and wavelet analyses. A scaling regime was noted in the observed rainfall spectra in the timescales between 60 min and 2 min. The scaling exponent obtained from the observed spectra has a value of about 2, which may be indicative of the physics of turbulence and raindrop coalescence. At 0.9 km resolution, the model rainfall spectra showed similar scaling to the observed down to about 10 min, below which a fall-off in variance was noted as compared to observations. Higher spatial resolution of up to 0.1 km was crucial to improve the ability of the model to resolve the shorter timescale variability. We suggest that the evaluation of dynamical models in the spectral domain is a crucial step in the validation of quantitative precipitation forecasts.

Next, such scaling analysis of rain is extended to the spatial domain. Using multiyear satellite rainfall estimates, the distributions of the area, and the total rain rate of rain clusters over the equatorial Indian, Pacific, and Atlantic Oceans is found to exhibit a power law $f(s) \sim s^{\zeta}$, in which s represents either the cluster area or the cluster total rain rate and f(s) denotes the probability density function of finding an event of size s. The scaling exponents ζ are estimated to be 1.66 ± 0.06 and 1.48 ± 0.13 for the cluster area and cluster total rain rate, respectively. The two exponents were further found to be related via the expected total rain rate given a cluster area. These results suggest that convection over the tropical oceans is organized into rain clusters with universal scaling properties. They are also related through a simple scaling relation consistent with classical self-organized critical phenomena. The results from this study suggest that mesoscale rain clusters tend to grow by increasing in size and intensity, while larger clusters tend to grow by self-organizing without intensification.

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