Geophysical Research Abstracts
Vol. 12, EGU2010-13785-2, 2010
EGU General Assembly 2010

Scale-wise evolution of rainfall probability density functions fingerprints the rainfall generation mechanism

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Possible linkages between climatic fluctuations in rainfall at low frequencies and local intensity fluctuations within single storms is now receiving significant attention in climate change research. To progress on a narrower scope of this problem, the cross-scale probabilistic structure of rainfall intensity records collected over time scales ranging from hours to decades at sites dominated by either convective or frontal systems is investigated. Across these sites, intermittency buildup from slow to fast time-scales is analyzed in terms of its heavy tailed and asymmetric signatures in the scale-wise evolution of rainfall probability density functions (pdfs). The analysis demonstrates that rainfall records dominated by convective storms develop heavier-tailed power law pdfs across finer scales when compared with their frontal systems counterpart. A concomitant marked asymmetry buildup also emerges across finer time scales necessitating skewed probability laws for quantifying the scale-wise evolution of rainfall pdfs. A scale-dependent probabilistic description of such fat tails, peakedness and asymmetry appearance is proposed and tested by using a modified q-Gaussian model, able to describe the scale wise evolution of rainfall pdfs in terms of the nonextensivity parameter q, a lacunarity (intermittency) correction γ and a tail asymmetry coefficient c, also functions of q.