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Direct Evidence for the Scaling of Rain From 20,000 to 5 km using TRMM Satellite Radar

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The key hydrological input to surface and subsurface hydrology is the precipitation field; it's statistical properties as functions of scale are therefore of fundamental significance. Numerous studies have shown that over various space-time ranges, rain is (multi) scaling; the statistical moments of various orders are power law functions of scale. This includes stereophotography of rain drops – which directly determine the inner "relaxation scale" (typically around 30-50cm) where drops "decouple from the turbulent wind field, and ground based radar (up to around two hundred kilometers). Beyond 100 kilometers, the evidence for scaling has been indirect; coming from satellite cloud radiances which are nonlinearly coupled with rain. We use radar reflectivities from the 10 year Tropical Rainfall Monitoring Mission (TRMM) to extend this to the full planetary scale. We find that with the exception of very low order moment dominated by (nominally) zero rain reflectivity, that the multiscaling holds remarkably well. Indeed, over the observed range 5-20000km, the moments $<Z_\lambda^q>\approx \lambda^{K(q)}$ for 0.5<q<2 are predicted to within a maximum deviation of $\pm$6% where λ=L_{eff}/L_{res} L_{res}, is the resolution of the reflectivities and L_{eff} is the effective outer scale of the cascade (see the figure). We find $L_{eff} \approx$ 40000km indicating that at planetary scales (20000km), there is residual variability from other interactions. We show that the scaling moment function K(q) is well reproduced by a theoretically predicted two parameter ("universal") form, with co-dimension of the mean field C_1 $\approx$0.63 and Levy index α (characterizing the degree of multifractality) $\approx$1.5. Finally over the range 20,000 - 5km using multifractal simulations we show that if the minimum detectable signal is roughly half the mean then the slight deviations in the scaling of the low order

moments are explained to within 7%.