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Global scale precipitation from monthly to centennial scales: empirical space-time scaling analysis, anthropogenic effects

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The characterization of precipitation scaling regimes represents a key contribution to the improved understanding of space-time precipitation variability, which is the focus here. We conduct space-time scaling analyses of spectra and Haar fluctuations in precipitation, using three global scale precipitation products (one instrument based, one reanalysis based, one satellite and gauge based), from monthly to centennial scales and planetary down to several hundred kilometers in spatial scale. Results show the presence – similarly to other atmospheric fields - of an intermediate "macroweather" regime between the familiar weather and climate regimes: we characterize systematically the macroweather precipitation temporal and spatial, and joint space-time statistics and variability, and the outer scale limit of temporal scaling. These regimes qualitatively and quantitatively alternate in the way fluctuations vary with scale. In the macroweather regime, the fluctuations diminish with time scale (this is important for seasonal, annual, and decadal forecasts) while anthropogenic effects increase with time scale. Our approach determines the time scale at which the anthropogenic signal can be detected above the natural variability noise: the critical scale is about 20 - 40 yrs (depending on the product, on the spatial scale). This explains for example why studies that use data covering only a few decades do not easily give evidence of anthropogenic changes in precipitation, as a consequence of warming: the period is too short.

Overall, while showing that precipitation can be modeled with space-time scaling processes, our results clarify the different precipitation scaling regimes and further allow us to quantify the agreement (and lack of agreement) of the precipitation products as a function of space and time scales. Moreover, this work contributes to clarify a basic problem in hydro-climatology, which is to measure precipitation trends at decadal and longer scales and to distinguish anthropogenic and natural variability in precipitation records, and to quantify both as functions of scale.