



Spatial and temporal precipitation variability across scales: regional to global, decadal to centennial scales and beyond

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The investigation of changes in precipitation variability in the Anthropocene requires both data with adequate resolution and length as well as an appropriate theoretical framework, because wide ranges of scales should be explored. We suggest several ways forward to characterize precipitation variability across scales based on the systematic application of scaling fluctuation analysis to characterizing different precipitation scaling regimes (weather, macroweather, climate – from higher to lower frequencies). Our study uses three qualitatively different global scale precipitation products (from gauges, reanalyses and a satellite and gauge hybrid) that allow to investigate precipitation from monthly to centennial scales and in space from planetary down to $5^{\circ}\times 5^{\circ}$ scales. The information gathered this way on the fundamental nature of centennial and multicentennial precipitation variability is impossible to derive from proxy data.

The key finding from our study is that, in macroweather, precipitation – similarly to other atmospheric fields - have scaling properties characterized by negative temporal fluctuation exponents, which implies – contrary to the weather and climate regimes – that fluctuations tend to cancel each other out. In the pre-industrial period and the Anthropocene, the macroweather regime spans different ranges of time scales: the lower limit is about a month, but whereas the upper limit is up to ≈ 20 -30 years in the industrial period, this limit is believed to extend to centuries or longer in the pre-industrial epoch, although it is yet not well established. The improved understanding of monthly to centennial scale precipitation variability opens new perspectives to separating natural and anthropogenic precipitation variability, and quantifying anthropogenic changes in precipitation. These techniques can be applied to temperature and other climatological data.