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Scaling of weather and climate fluctuations: CAPE, river discharges, and ice cores

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Scaling of weather and climate variability occurs from hourly to millennial time scales. For exponents $b > 0$ in the power spectrum, $S(f) \sim f^{-b}$, scaling is associated with long term memory (LTM). Modeling and observational data analysis focus on three time scales:

(i) On intra-annual time scales: 1/f-scaling ranges from clouds to ENSO in the tropics, which is demonstrated by convective variability (measuring the degree of convective instability), boundary layer moisture, wind speed and temperature during a 4-month period over the western Pacific. A first theoretical explanation of the 1/f-noise observed is a conceptual boundary layer recharge-discharge model based on pulse-like events.

(ii) From intra- to inter-annual time scales: Daily Yangtze discharge constitutes a two-regime behavior of the flow variability, separated by the annual cycle. 1/f scaling occurs within time scales from one week to one year. Since precipitation in this region follows a white spectrum (S = const), the origin of 1/f-noise is possibly related to a broad distribution of time scales in the subsurface flow. On inter-annual time scales weak long-term memory shows $b = 0.3$.

(iii) From decadal to millennial time scales: LTM is mainly found in sea surface temperatures of the Southern Ocean and the N-Atlantic. Quantitative agreement with Greenland ice core fluctuations is attained up to time scales of 1000 years. Conceptual models for the observed LTM are given by a linear diffusion models with several compartments.

Quantitative simulation of LTM is possible beyond inter-annual time scales by coupled AO-GCMs (near surfaces air temperatures, Greenland ice cores, and Yangtze discharges). On shorter time scales the observed scaling has implications for global climate modeling, in particular for stochastic parameterization of subgrid-scale processes and extreme events.