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Scaling in global climate records: is the nonlinear paradigm the emperor's new clothes?

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The reigning paradigm is that scaling in climate time series is a result of internal nonlinearities in the dynamical equations and analogous to the scale-invariant cascades in turbulence. This picture is quite reasonable for the high-dimensional spatiotemporal variability of the atmosphere interacting with the mixed ocean layer up to decadal time scales. However, GCMs with, and without, full ocean circulation indicate that scaling on longer time scales in global mean temperature data depends on the heat transport into the deep ocean mediated by this circulation. The global surface temperature response involves several time constants, one involving the heat capacity of the mixed layer, and the others the heat capacities of different water masses of the ocean. A linear "N-box model" describing the heat exchange between N such masses, is capable of producing the observed scaling characteristics. In fact even a two-box model with two exponential relaxation times produces results almost indistinguishable from a power-law response model, and both provide accurate descriptions of the response of AOGCMs in the CMIP5 ensemble. The response of the global atmospheric CO_2 concentration to past and future anthropogenic emissions can also be modeled rather accurately by a power-law linear response function on time scales up to centuries. As an illustration a simple conceptual model for the global mean surface temperature response to CO_2 emissions is presented and analysed. It consists of linear long-memory models for the temperature anomaly response ΔT to radiative forcing and atmospheric CO_2-concentration response ΔC to emission rate. The responses are connected by the standard logarithmic relation between CO_2 concentration and its radiative forcing. The model depends on two sensitivity parameters, α_T and α_C, and two "inertia parameters," the memory exponents β_T and β_C. Based on observation data, and constrained by results from CMIP5 models, the likely values and range of these parameters are estimated, and projections of future warming for the parameters in this range are computed for various idealised, but instructive, emission scenarios.