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Scaling as enhanced uncertainty

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Scaling behaviours have been detected in many geophysical processes and are typically represented as power laws of different statistical properties such as distribution tails, autocorrelograms, periodograms and climacograms. The independent variables in such power laws could be different quantities such as random variates (representing states of a system), temporal scale, spatial scale, frequency, or time lag. These delineate different (albeit often confused) types of scaling, i.e. scaling in state, time and space. The power laws are applicable either on the entire domain of the variable of interest or asymptotically. Clearly, power laws contrast exponential laws. The omnipresence of scaling behaviours has been often regarded as a mystery and has been interpreted by analogous ways, e.g. by invoking a "self-organizing" power of natural systems (cf. "self-organized criticalities"). In another view, these behaviours are just manifestations of enhanced uncertainty and are consistent with the principle of maximum entropy, which notably is the basis of the second law of thermodynamics. Depending on the type of scaling, the enhanced uncertainty manifests itself in the frequency of extreme events, as well as in the variability of a process at aggregated scales, spatial or temporal (e.g. in climate). The enhanced uncertainty also applies to statistical estimation from available records and to statistical prediction—but this is often missed in the literature. A few examples demonstrate, on the one hand, the emergence of scaling from maximum entropy considerations and, on the other hand, the enhancement of uncertainty in estimation and prediction due to scaling.