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Predictability in geophysical fluid dynamics from a phase space perspective.

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The predictability of a dynamical system can be described by the divergence of the trajectories in phase space. This is assessed in the model PUMA (Portable University Model of the Atmosphere) which represents the dynamical core of common spectral atmospheric circulation models (e.g. ECHAM). The error growth is assessed by the rate of separation of two initially close nonlinear trajectories on the attractor of the model. In a chaotic system the mean separation rate is given by the largest, positive Lyapunov exponent (LE). However, for finite intervals the separation rate can be negative indicating transient stability. The probability for the occurrence of such states with negative entropy production follows the fluctuation theorem. This 'return of skill' depends on the model resolution and vanishes for large degrees of freedom. In a high resolution model predictability is determined by a large number of positive LEs which are not accessible in general. However, even in high dimensional systems the attractor dimension can be calculated by the correlation dimension. On the other hand, the Kaplan Yorke conjecture relates the attractor dimension to the set of positive LE. We propose to estimate general properties of the spectrum of the positive LE in high dimensional systems using the Kaplan Yorke conjecture and analogies with low dimensional systems.