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On Non-Gaussianity and Stochastic Modeling in Geophysics

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Many geophysical phenomena, such as SST variability and atmospheric low-frequency variability, can be considered to be the response of a more or less complex, slowly-varying dynamical system to rapidly-varying stochastic perturbations. Within this concept, deviations from non-Gaussianity are often used as a tool to investigate the nonlinearity of the slowly-varying dynamical system forced by noise. For example, it is routinely assumed that the ENSO signal (that is, ENSO SST variability) would be normally distributed if the coupled Pacific ocean-atmosphere were a linear system forced by weather noise. This is, however, a highly misleading assumption as a given probability distribution is shaped by both the slow (deterministic) dynamical system and the potentially state-dependent (multiplicative) structure of the noise forcing.

In this talk it is shown by several examples (such as midlatitude SST variability and atmospheric regime behavior) that non-Gaussian probability distributions do not necessarily imply that the slow manifold of the stochastically forced system is nonlinear. It is demonstrated how simple linear systems with multiplicative noise can produce realistic departures from Gaussian distributions, and that these models are consistent with observations. The presence of non-Gaussianity, therefore, does not itself imply that a system has a potentially predictable nonlinear slow manifold.