Geophysical Research Abstracts,
Vol. 10, EGU2008-A-05688, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-05688
EGU General Assembly 2008

An interpretation of non-Gaussian statistics in geophysical data

P.D. Sardeshmukh (1,2), P. Sura (1,2)

(1) Climate Diagnostics Center, CIRES, University of Colorado, Boulder, CO, USA,

(2) and Earth System Research Laboratory, NOAA, Boulder, Colorado, USA

(Prashant.D.Sardeshmukh@noaa.gov / Fax: 303-497-7013 / Phone: 303-497-6248)

The statistics of climate variables are often found to be significantly non-Gaussian, and this fact is often attributed to deterministic nonlinear dynamics. Nonetheless, we find that many features of the non-Gaussian statistics can also be reconciled with linear stochastically perturbed dynamics using a mixture of additive and linear multiplicative noises. Such mixtures can produce not only symmetric but also skewed non-Gaussian distributions if the additive and multiplicative noises are correlated. Furthermore, such correlations are readily anticipated from first principles. A generic stochastically generated skewed (SGS) distribution can be analytically derived from the Fokker-Planck equation for a single-component system. In addition to skew, all such SGS distributions have power-law tails, and a striking property that the (excess) kurtosis K is always greater than 1.5 times the square of the skew S. Remarkably, this $K - S$ inequality is found to be satisfied by circulation variables even in the observed multi-component climate system. A principle of "Diagonal Dominance" in the multi-component moment equations is introduced to understand this behavior.

To clarify the nature of the stochastic noises (turbulent adiabatic versus diabatic fluctuations) responsible for the observed non-Gaussian statistics, a long 1200-winter simulation of the northern winter climate is generated using an adiabatic atmospheric general circulation model forced only with the observed long-term mean diabatic forcing as a constant forcing. Despite the complete neglect of diabatic variations, the model reproduces the observed $K - S$ relationships, and also the spatial patterns of the skew

and kurtosis of the daily vorticity variations at the jet stream level. This suggests that the stochastic generators of these higher moments of vorticity are mostly associated with the local adiabatic turbulent fluxes. The model also simulates fifth moments that are approximately 10 times the skew, and probability densities with power-law tails, as predicted by the linear theory.