Climate Change and Climate Variability: A Unified Framework

The “death of stationarity” poses a substantial challenge to climate predictability and to the climate sciences in general. This challenge is addressed herein by formulating the problems of change in the climate’s intrinsic variability within the framework of the theory of nonautonomous and random dynamical systems (NDS and RDS) with time-dependent forcing. A key role in this theory is played by the pullback attractors (PBAs) that replace the strange attractors of the more familiar theory of autonomous dynamical systems, in which there is no explicit time dependence of either forcing or coefficients.

The concepts and methods of the NDS and RDS approach will be introduced and will be illustrated using a stochastically perturbed version of the Lorenz (1963) convection model. This illustration will be followed by applications to models of the wind-driven ocean circulation and the El Niño–Southern Oscillation (ENSO). One finds that two local PBAs, a quiescent and a chaotic one, coexist within the wind-driven ocean model’s decadally modulated global PBA, whereas a critical transition between two types of chaotic behavior occurs in the seasonally forced ENSO model.

Implications for the climate sciences in the era of anthropogenic change will be discussed.

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