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Fluctuation - dissipation approach in modelling the Atmosphere-Ocean interaction and in Geophysical Fluid Dynamics

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Here we introduce a dynamic approach for the study of the geophysical fluid dynamics phenomena characterized by a small interaction between the variables of interest and the rest of the system. The approach is similar to the one developed some years ago [M. Bianucci, R. Mannella, P. Grigolini and B.J. West *From dynamics to thermodynamics: Linear Response and statistical mechanics*, Phys. Rev. E **51**, 3002 (1995)] to derive statistical mechanics and thermodynamics of some macroscopic variables on interest starting from microscopic dynamics with no need of the standard *ad hoc* statistical assumption, as, for example, the the fixed given temperature and/or the Gaussian fluctuations of the mean velocity. The general theoretical framework is the Zwanzing projection method, used to obtain a Fokker-Plack Equation for the probability distribution of the variables of interest, under some general assumptions. This approach can be applied, for example, to the study of the complex ocean - atmosphere dynamics, where, changing all the scales, the role of the "microscopic" system is played by the atmosphere, while the ocean (or some ocean variables) plays the role of the macroscopic system of interest. In this case the chaotic and divergent features of the fast atmosphere dynamics remains only in the decaying properties of the correlation functions and of the response function of the atmosphere variables, while the exponential separation of the perturbed (or close) single trajectories does not play a direct role. Finally we will illustrate an example of application of this approach to the study of the ENSO phenomenon.