IMAGe Seminar

Institute for Mathematics Applied to Geosciences at NCAR

The Origin of Nonlinear Signatures of Planetary Wave Dynamics: Mean Phase Space Tendencies and Contributions from Non-Gaussianity

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Abstract:

Mean phase space tendencies are investigated to systematically identify the origin of nonlinear signatures and the dynamical significance of small deviations from Gaussianity of planetary low-frequency waves. A general framework for the systematic investigation of mean phase space tendencies in complex geophysical systems is derived. In the special case of purely Gaussian statistics, this theory predicts that the interactions amongst the planetary waves themselves are the source of the nonlinear signatures in phase space, whereas the unresolved waves contribute only an amplitude independent forcing, and cannot contribute to any nonlinear signature.
The predictions of the general framework are studied for a simple stochastic climate model. This toy model has statistics which are very close to being Gaussian and a strong nonlinear signature in the form of a double swirl in the mean phase space tendencies of its low-frequency variables, much like recently identified signatures of nonlinear planetary wave dynamics in prototype and comprehensive atmospheric General Circulation Models (GCM). As is predicted by the general framework for the Gaussian case the double swirl results from nonlinear interactions of the low-frequency variables.
Mean phase space tendencies in a reduced space of a prototype atmospheric GCM are also investigated. Analysis of the dynamics producing nonlinear signatures in these mean tendencies shows a complex interplay between waves resolved in the subspace and unresolved waves. The interactions amongst the resolved planetary waves themselves do not produce the nonlinear signature. It is the interaction with the unresolved waves which is responsible for the nonlinear dynamics. Comparing this result with the predictions of the general framework for the Gaussian case shows that the impact of the unresolved waves is due to their small deviations from Gaussianity. This suggests that the observed deviations from Gaussianity, even though small, are dynamically relevant.

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