Geophysical Research Abstracts, Vol. 8, 00172, 2006
SRef-ID: 1607-7962/gra/EGU06-A-00172

Ensemble prediction and the statistical dynamics of two-dimensional inhomogeneous turbulent flow regimes

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A recently developed statistical dynamical closure model for inhomogeneous 2-D turbulent Rossby wave flow over topography is used, in conjunction with ensemble averaged direct numerical simulations, to examine the predictability of atmospheric barotropic flows when rapidly growing instabilities due to the formation of large scale coherent structures are present. In atmospheric flows the formation and decay of high-low dipole blocking events have typically been associated with a loss of predictability due to enhanced error growth. Using the inhomogeneous quasi-diagonal direct interaction approximation (QDIA) in cumulant update form we investigate the role of non-Gaussian correlations and off-diagonal elements in error growth for flow on the Northern Hemisphere during the formation of a large and persistent blocking event over the Gulf of Alaska during early November 1979.

The relative contributions to transient growth from inhomogeneities and non-Gaussian correlations are able to be quantified using the statistical closure model. This approach enables distinct regimes of error/transient growth to be identified for the full range of turbulent flows from strongly non-Gaussian homogeneous turbulence to fully inhomogeneous atmospheric flows. We further contrast the relative cumulative contributions of the two and three point cumulant terms to transient growth via a comprehensive study of these various flow regimes. We also examine the use of bred initial perturbations in order to examine the role of fast growing flow instabilities on error growth. Issues of maintaining spread in the perturbation field and the use of stochastic backscatter forcing are also discussed. In addition we describe the underlying methods ie renormalization and regularization, and assumptions (quasi-diagonality) upon which the QDIA and its variants are based.