• Appendix describing code

ABSTRACT

Title of Dissertation: SCENARIOS FOR THE DEVELOPMENT OF LOCALLY LOW DIMENSIONAL ATMOSPHERIC DYNAMICS

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In this dissertation we discuss the first application of a new tool for the analysis of spatio-temporal complex systems, the E-Dimension, to atmospheric dynamics. The E-Dimension is designed to quantify the complexity of a spatial system over localized regions by determining the number of modes necessary to capture the local variance in an ensemble of model solutions. In contrast to traditional notions of dimension, which are independent of space and time, the E-Dimension is a dynamical quantity that varies in space as well as time. While in the areas of low E-Dimension the error growth may be rapid, the spatial structure of the errors is always very simple. This implies that in these regions the chaos is low-dimensional, i.e. less complex than in a fully turbulent flow. An important feature of the E-Dimension is that it does not require the assumptions of linear error growth, thus it is able to identify important processes that cannot be characterized by using linear theory. We present a series of examples based on simulations of the atmospheric flow with a state-of-the-art weather prediction

model to demonstrate that locally low dimensional behavior in the atmosphere is common. We study the local energy conversion processes in the model atmosphere to show that locally low dimensional behavior is often directly related to instabilities of the atmospheric flow. Furthermore, we demonstrate that even complex nonlinear interactions can lead to locally low dimensional behavior. This is a nontrivial finding. The practical implication of our results is that there may be a wider range of weather events whose prediction can be improved by improving the initial conditions than was previously thought. This can be achieved by improving the data assimilation, the process that provides the model initial conditions by blending model and observed information, and by collecting targeted observations at adaptively selected locations.