Reduced Order Models for Prediction and Data Assimilation of Turbulent Geophysical Systems

*Di Qi[1]

1. Purdue University

Understanding the large-time behavior of turbulent geophysical aows is notoriously diGcult, and the myriad approaches to this problem are vast and interconnected. The capability of using imperfect stochastic and statistical reduced-order models to capture key statistical features in multiscale nonlinear dynamical systems is investigated. A new eGcient ensemble forecast algorithm is developed dealing with the nonlinear multiscale coupling mechanism as a characteristic feature in high- dimensional turbulent systems. To address challenges associated with closely coupled spatio-temporal scales in turbulent states and expensive large ensemble simulation for high-dimensional complex systems, we introduce eGcient computational strategies using the so-called random batch method. It is demonstrated that crucial principal statistical quantities in the most important large scales can be captured eGciently with accuracy using the new reduced-order model in various dynamical regimes of the aow Held with distinct statistical structures. Finally, the proposed model is applied for a wide range of problems in uncertainty quantiHcation, data assimilation, and control.

Keywords: Reduced-order models, nonlinear filtering, complex turbulent systems, multiscale dynamics

