

ACMS Applied Math Seminar



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Purdue University
Thursday, March 19, 2026
154 Hurley Hall
3:30 PM – 4:30 PM

Reduced-Order Data Assimilation Models for Predicting Probability Distributions of Multi-scale Turbulent Systems

A new strategy is presented for the statistical forecasts of multiscale nonlinear systems involving non-Gaussian probability distributions. The capability of using reduced-order models to capture key statistical features is investigated. A closed stochastic-statistical modeling framework is proposed using a high-order statistical closure enabling accurate prediction of leading-order statistical moments and probability density functions in multiscale complex turbulent systems. A new efficient 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 efficient computational strategies using the random batch method. Effective nonlinear ensemble filters are developed based on the nonlinear coupling structures of the explicit stochastic and statistical equations, which satisfy an infinite-dimensional Kalman-Bucy filter with conditional Gaussian dynamics. It is demonstrated that crucial principal statistical quantities in the most important large scales can be captured efficiently with accuracy using the new reduced-order model in various dynamical regimes of the flow field with distinct statistical structures.

The Department of Applied and Computational
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