# Center for Environmental & Applied Fluid Mechanics

## "Stochastic Dynamical Modeling of Turbulent Flows over Rough Surfaces"

**Prof. Armin Zare**
**University of Texas, Dallas**
**Mechanical Engineering**

**Abstract:** Advanced measurement techniques and high-performance computing have made large data sets available for a broad range of turbulent flows in engineering applications. Drawing on this abundance of data, dynamical models that reproduce structural and statistical features of turbulent flows enable effective model-based flow control strategies. One class of such control-oriented models are given by the linearized Navier-Stokes equations around base profiles that either describe a steady-state solution or a long-time averaged mean of a simulation- or experiment-based flow field. In these models, deterministic or stochastic forcing is commonly used to compensate for the neglected nonlinear terms and evaluate the input-output features of the linearized dynamics. However, uncertainty in both the base profile and nature of the inputs challenge the effectiveness of linearized models for analysis and control design. In this talk, we demonstrate how modeling such sources of additive and multiplicative uncertainty can enable reduced-order turbulence modeling and physical discovery. We first describe an optimization-based framework for completing partially observed second-order statistics of turbulent flows through the identification of colored-in-time stochastic forcing, which account for and reconcile the linearized dynamics with available data. We demonstrate the efficacy of this approach in modeling turbulence over riblets. We then demonstrate how uncertainty quantification with highly structured, random base flow perturbations can uncover transition trends in channel flows and facilitate the analysis of random surface roughness.

## Fall 2024 CEAFM Seminar Series

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