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[Reduced-order modeling for uncertainty quantification]

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Abstract Uncertainty quantification (UQ) for parametrized systems is crucial in a wide range of computational science and engineering applications. Performing computations on full-order models becomes infeasible in large-scale systems with high-dimensional uncertainties. Reduced-order modeling (ROM) is a promising technique to tackle this computational bottlebeck. However, existing ROM techniques often achieve dimension reduction only on the spatial domain. In this work, we study novel space-time model reduction methods combined with classical UQ propagation approaches such as stochastic Galerkin and Monte-Carlo. We utilize the proposed method to solve advection-diffusion PDEs with random parameters. Our result shows that the methodology can boost significant speed-up in practice.

Problem Domain

UQ, predictive simulations

Technical Approach

Reduced-order modeling, stochastic UQ propagation methods.

Mission Application

Climate modeling, hypersonic aerodynamics

Preliminary results

Preliminary experiments have shown that space-time ROM has high **computation efficiency**, without the loss of accuracy and convergence property.
Given a 1D advection-diffusion problem,

$$\frac{\partial u}{\partial t} + c\,\frac{\partial u}{\partial x} = \nu\,\frac{\partial u^2}{\partial x^2} + g, \tag{1}$$

where random coefficients: $c \sim \mathcal{N}(1, 0.15)$ and $\nu \sim U[0.01, 0.02]$.

Next, we will investigate space-time ROM approach on higher dimensional parametrized systems.