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MULTILEVEL-MULTIFIDELITY APPROACHES FOR UNCERTAINTY QUANTIFICATION IN COMPUTATIONAL FLUID DYNAMICS APPLICATIONS

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In computational fluid dynamics (CFD), multiple model forms of varying fidelity and resolution are commonly available. For example, common CFD model fidelities include potential flow, inviscid Euler, Reynolds-averaged Navier-Stokes, and large eddy simulation, each potentially supporting a variety of spatio-temporal resolutions / discretizations. While we seek analysis results that are consistent with the highest fidelity and finest discretization, the computational cost of directly applying uncertainty quantification (UQ) in high random dimensions quickly becomes prohibitive. In this presentation, we will describe the development of multilevel-multifidelity (MLMF) approaches that combine information from multiple fidelities and resolutions in order to reduce the overall computational burden.

We are interested in both Monte Carlo sampling approaches that demonstrate robustness and scalability and in expansion-based approaches (e.g., polynomial chaos) that can exploit available structure (sparsity via compressed sensing, low rank via tensor train) to accelerate convergence. In the former case, we explore methods tailored to multidimensional hierarchies with both model forms and discretization levels, and in the latter case, we explore multilevel approaches based on optimal resource allocation, sufficient recovery, and greedy refinement. Performance of these different MLMF strategies will be described for both model problems and engineered systems such as integrated aircraft nozzles and scramjets.