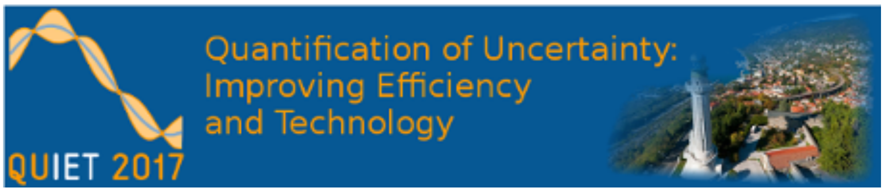

Scalable Hierarchical Sampling of Gaussian Random Fields for Large-Scale Multilevel Monte Carlo Simulations

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We consider the numerical simulation of physical phenomena governed by partial differential equations (PDEs) with uncertain input data in a multilevel Monte Carlo (MLMC) framework. Generating samples of random fields with prescribed statistical properties efficiently is an important component of MLMC methods. We present a highly scalable multilevel, hierarchical sampling technique that involves solving a mixed formulation of a stochastic partial differential equation. This formulation allows us to leverage existing scalable methods for solving the resulting sparse linear systems arising from the mixed finite element discretization. The proposed sampling technique is then used to generate different realizations of random fields to be used as input coefficient realizations within the MLMC method.

Multilevel Monte Carlo techniques typically rely on the existence of hierarchies of computational meshes obtained by successive refinement. Instead, we use specialized element-based agglomeration techniques to construct hierarchies of coarse spaces that possess stability and approximation properties for wide classes of PDEs on unstructured meshes. An application to subsurface flow using the MLMC method with algebraically coarsened spaces with the proposed sampling technique will be presented to demonstrate the scalability of the method for large-scale simulations.

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