UNCERTAINTY QUANTIFICATION IN COMPUTATIONAL MODELS: ENHANCING PREDICTIVE ACCURACY AND DESIGN

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ABSTRACT

Uncertainty quantification (UQ) is a valuable tool that enhances the reliability and predictive capabilities of mathematical and computational models by systematically addressing uncertainties in data and assumptions. As unpredictable natural phenomena and complex systems continue to challenge decision-making, UQ provides robust, cost-effective solutions that improve risk management and solution reliability. This session will explore UQ's growing relevance in tackling real-world challenges across various domains, particularly in hazard assessments, industrial control systems, design optimization, and data acquisition through optimal sensor placement.

Advanced UQ methodologies, such as Monte Carlo simulations, Bayesian inference, polynomial chaos expansions, and stochastic collocation, are increasingly applied to models accounting for uncertainty. These techniques enhance simulations and enable the prediction of outcome ranges, supporting complex decision-making processes. However, achieving the right balance between model accuracy and computational effort remains a challenge, particularly for large-scale or computationally demanding problems. Ongoing research aims to improve these techniques, reducing computational work while maintaining the desired accuracy, and enabling more industries to adopt UQ practices effectively. UQ applications span across various fields such as energy, aerospace, environmental monitoring, and manufacturing, where understanding and mitigating uncertainty is essential for achieving reliable and efficient outcomes.

This session will foster collaboration between academia and industry, highlighting some recent advances in UQ and demonstrating its potential in addressing real-world scientific and industrial challenges. By bridging theoretical advances with practical applications, this session aims to engage interdisciplinary discussions that lead to impactful solutions.