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Special Issue on Uncertainty Quantification in Multiscale System Design and Simulation

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The importance of uncertainty has been recognized in various modeling, simulation, and analysis applications, where assumptions and simplifications affect the accuracy of model predictions for physical phenomena. Different uncertainty quantification (UQ) methods such as adaptive sampling, sensitivity analysis, stochastic expansions, reliability methods, surrogate modeling, and Bayesian approaches have been applied to assess uncertainty associated with mathematical and computational models. Yet developing both accurate and efficient UQ methods for multiscale simulation still faces challenges. For instance, quantifying model-form uncertainty in quantum mechanics simulation requires in-depth knowledge of simulation mechanisms, since non-intrusive UQ methods and sensitive analysis will be very costly. Molecular dynamics simulation output is very sensitive to the selection of empirical inter-atomic potential functions, calibration process relies on empirical and ad hoc methods, and the lack of verifiable experimental data that match simulation conditions at atomistic scales is common. Continuum scale simulations employ various simplifications for complex and nonlinear phenomena such as fracture in heterogeneous materials and fluid flow in random media, and there is a lack of scalability for large system prediction.

This special issue intends to focus on the state-of-the-art of methods to quantify model-form and parameter uncertainties for simulations at multiple scales. Better understanding of both probabilistic and non-probabilistic approaches to assess and improve the confidence of simulation-based predictions is the goal. Contributions addressing the following topics are especially welcome:

- Mathematical and computational advancement of uncertainty quantification in simulations
- New approaches to quantify errors in stochastic ordinary and partial differential equations
- Representations and analysis methods for input uncertainties (e.g. model form, parameter, boundary condition, unknown dependency) and numerical errors in simulation models
- Verifiable algorithms to quantify model-form and numerical errors for large-scale simulations and high performance computing
- Uncertainty propagation and model calibration in simulations at multiple length and time scales
- Applications of reliable simulation (e.g. in design, optimization, manufacturing, porous and random materials, process engineering, and others)

Timeline

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Manuscript submission Links

For Part B:
http://journaltool.asme.org/Content/JournalDescriptions.cfm?journalId=27&Journal=RISK