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PHYSICS-INFORMED UNCERTAINTY QUANTIFICATION

A MINISYMPOSIUM WITHIN TRACK 800 - UNCERTAINTY QUANTIFICATION, RELIABILITY AND ERROR ESTIMATION

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ABSTRACT

This minisymposium will be dedicated to the discussion of methods and applications for the quantification of uncertainty in the simulation of comptutaional mechanics, in a manner that is constrained or otherwise informed by measured data and theory of the fundamental physics of the constituent models.

In recent decades, computational sciences have become increasingly reliant upon for predictive capabilities for complex problems. This paradigm shift has resulted in simulations being widely accepted as predictive tools where experimental observations are either unavailable or infeasible. As such, it is becoming common practice to develop integrated simulations that are represented with sets of high fidelity sub-models to define physics processes. The advantage of such an approach is that it is frequently possible to perform small-scale experiments to validate the adequacy of the physics represented in a sub-model, which can then be used to inform the integrated simulations.

It is thus imperative to ensure that the sub-models are defined to appropriately represent the physics of interest, as constrained by theory and/or empirical evidence. If multiple sub-models within an integrated simulation are defined inappropriately, there exists the possibility of producing compounding (or compensating) errors that can significantly influence the overall prediction. This issue becomes even more significant when performing uncertainty quantification (UQ) to quantify how simulation uncertainty influences predictions.

Standard UQ practices often explore uncertainties in the parameters for the physics sub-models, and forward propagate these uncertainties to bound uncertainties in the behavior of the system. However these approaches suffer from a few limitations. The first is that combinations of parameters across multiple sub-models can often lead to unphysical regimes. Additionally, when model form uncertainty overwhelms those due to uncertainties in parameters, the traditional approaches under-predict system uncertainties. To date, many UQ strategies have focused on the development of methods that are appropriate for a simulation that utilizes single-physics processes. Some of the existing methods developed by the UQ community may not be appropriate for cases where multiple sub-models feed into a larger-scale, integrated simulation.

In this session, we invite the discussion of ideas and results that demonstrate UQ methodologies for integrated physics simulations, constrained by physics theory and data.