Non-Intrusive Algorithms for Measure-Theoretic Propagation of Uncertainties: Errors, Opportunities, and Challenges

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Models of a physical system are often used to make predictions involving a small number of quantities of interest (QoI). Uncertainties in the model inputs (e.g., initial/boundary conditions and parameters) lead to uncertainties in these QoI predictions. We represent these uncertainties on model inputs using probability distributions, which are obtained by the formulation and solution of a measure-theoretic inverse problem. The subsequent input distributions can be sampled and studied in the predictive inference problem. In this talk, we review the basic measure-theoretic framework for solving the inverse and prediction problems, describe a non-intrusive sample based algorithm for approximating non-parametric probability measures solving these problems, and outline the basic components of an posteriori error analysis that takes into account both deterministic and stochastic sources of error in the computed solution. We apply the non-intrusive algorithm to shallow water and subsurface contaminant transport models. Throughout the talk we will identify various opportunities and challenges in the algorithmic development and extensions of the main ideas.