

Efficient Uncertainty Quantification in Computational Fluid-Structure Interactions: The Probabilistic Collocation Method in a Two Step Approach

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Abstract. Uncertainty quantification in complex flow and fluid-structure interaction simulations requires efficient uncertainty quantification methods. In addition, a desirable property of an uncertainty quantification method is non-intrusiveness, which means that existing deterministic solvers can be used for uncertainty quantification. In this paper the Probabilistic Collocation method is introduced, which is non-intrusive like Monte Carlo simulation and shows exponential convergence for arbitrary probability distributions like the Galerkin Polynomial Chaos method. Due to the exponential convergence, the Probabilistic Collocation method requires only a few deterministic samples for a high accuracy. The strength of the Probabilistic Collocation method is demonstrated by solving steady flow around a NACA0012 airfoil with an uncertain free stream Mach number using a commercial flow solver. Different representations of the stochastic solution show the potential use of uncertainty quantification.

In the second part of the paper a Two Step approach for efficient uncertainty quantification in computational fluid-structure interactions is followed. In Step I, a Sensitivity Analysis is used to efficiently narrow the problem down from multiple uncertain parameters to one parameter which has the largest influence on the solution. In Step II, for this most important parameter the Probabilistic Collocation method is employed to obtain the stochastic response of the solution. The efficiency of this Two Step approach is demonstrated for the linear piston problem with an unsteady boundary condition. A speed-up of a factor of 100 is obtained compared to a full uncertainty analysis for all parameters.

Key words: *Uncertainty quantification, Fluid-structure interactions.*

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