11th. World Congress on Computational Mechanics (WCCM2014)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

UNCERTAINTY QUANTIFICATION TECHNIQUES FOR FLUID-FLOW PROBLEMS

REMI ABGRALL*, PIETRO MARCO CONGEDO*

AND GIANLUCA IACCARINO†

* INRIA Bordeaux Sud-Ouest
200 Avenue de la Vieille Tour, 33000 Talence, France
{remi.agrall,pietro.congedo}@inria.fr

† Mechanical Engineering Dept, Stanford University
Bld 500, CA 94305-3035, USA
jops@stanford.edu

Key words: Uncertainty Quantification, Robust design optimization, Fluid Dynamics, Complex flows.

ABSTRACT

Optimization and design in the presence of uncertain operating conditions, material properties and manufacturing tolerances poses a tremendous challenge to the scientific computing community. In many industry-relevant situations the performance metrics depend in a complex, non-linear fashion on those factors and the construction of an accurate representation of this relationship is difficult.

In addition to that, the numerical simulation in Fluid Mechanics is far to be predictive because of the presence of numerous sources of uncertainty, in particular in shock-dominated turbulent flows. In this case, the problem is to find an efficient representation of the stochastic solution, when the flow presents some discontinuities, thus producing a shock evolving in the coupled physical/stochastic space. As a consequence, developing efficient numerical techniques for handling uncertainties in fluid-flow problems is very challenging.

Probabilistic uncertainty quantification (UQ) approaches represent the inputs as random variables and seek to construct a statistical characterization of few quantities of interest. Among the UQ techniques, the polynomial chaos (PC) has shown its efficiency in the case of smooth responses [1]. Regarding discontinuous surfaces, an adaptive class of methods based on local basis functions has been introduced in [2]. Unsteady stochastic problems have been solved recently by means of multi-elements techniques, employing the collocation simplex method [3]. In all these approaches, adaptivity is applied in the stochastic space according to the regularity of the stochastic solution.

Recently, a numerical method for solving efficiently sPDE with discontinuous response surfaces has been illustrated, that is obtained by reducing the number of points employed in the physical/stochastic space by means of a classical MR framework of Harten extended to the stochastic space [4,5,6].

This mini-symposium is intended to be an exchange forum for scientists working on innovative and efficient techniques for uncertainty quantification and robust design in Fluid Mechanics. More precisely, we hope that this could be source of inspiration for improving and develop new ideas in the following areas:

Uncertainty propagation;

Structural-form and model uncertainty;

Modelling of experimental errors.;

Robust optimization and robust design with uncertain computational model;

Treatment of discontinuities in the stochastic space;

Reduced-Order Models for UQ;

Application to complex flows: turbulent, unsteady, discontinuous, with real-gas effects, ...

REFERENCES

[1] O. Le Maitre, O. Knio, *Spectral Methods for Uncertainty Quantification: With Applications to Computational Fluid Dynamics*. Springer Verlag, 2010.

[2] J. Foo, and G.E. Karniadakis, "Multi-element probabilistic collocation method in high dimensions", *Journal of Computational Physics*, Vol. **229**, pp. 1536–1557, (2010).

[3] J.A.S. Witteveen and G. Iaccarino, "Simplex stochastic collocation with random sampling and extrapolation for nonhypercube probability spaces", *SIAM Journal on Scientific Computing*, Vol. **34**, pp. A814–A838, (2012).

[4] R. Abgrall, P.M. Congedo, "A semi-intrusive deterministic approach to uncertainty quantification in non-linear fluid flow problems", in press on *Journal of Computational Physics*, (2012).

[5] R. Abgrall, P.M. Congedo, G. Geraci, "Toward a Unified Multiresolution Scheme in the Combined Physical/Stochastic Space for Stochastic Differential Equations", INRIA *Research Report*, RR-7996, (2012).

[6] R. Abgrall, P.M. Congedo, G. Geraci, G. Iaccarino, "Adaptive strategy in multiresolution framework for uncertainty quantification", Center for Turbulence Research, Proceedings of the Summer Program 2012, pp. 209-218, (2012).