Numerical solution of partial differential equations in random domains: an application to Wind Engineering

Claudio Canuto1,* and Davide Fransos1

1 Dipartimento di Matematica, Politecnico di Torino, C.so Duca degli Abruzzi 24, 10129 Torino, Italy.

Abstract. An application of recent uncertainty quantification techniques to Wind Engineering is presented. In particular, the study of the effects of small geometric changes in the Sunshine Skyway Bridge deck on its aerodynamic behavior is addressed. This results in the numerical solution of a proper PDE posed in a domain affected by randomness, which is handled through a mapping approach. A non-intrusive Polynomial Chaos expansion allows to transform the stochastic problem into a deterministic one, in which a commercial code is used as a black-box for the solution of a number of Reynolds-Averaged Navier-Stokes simulations. The use of proper Gauss-Patterson nested quadrature formulas with respect to a Truncated Weibull probability density function permits to limit the number of these computationally expensive simulations, though maintaining a sufficient accuracy. Polynomial Chaos approximations, statistical moments and probability density functions of time-independent quantities of interest for the engineering applications are obtained.

Key words: uncertainty quantification, stochastic partial differential equations, random domains, mapping approach, polynomial chaos, wind engineering.

*Corresponding author.
Email addresses: claudio.canuto@polito.it (C. Canuto), davide.fransos@polito.it (D. Fransos)