Dimension reduction and surrogate-modelling for uncertain auto-igniting flame simulations

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Numerical simulations have become a backbone of research and industrial design, but few are as expensive as high-fidelity combustion simulations. These combine unsteady turbulent flow and chemistry computations, meaning a few tens of transport equations on meshes of several million nodes. As a result, such simulations can cost up to several millions of CPU-hours.

Alas, all this computational complexity does not shield the results from uncertainty as many sources of variability remain. To name a few: model calibration, operating conditions, exact composition of complex fuels, geometric variability of combustion chambers...

In this context, very sample-efficient methods are needed to make uncertainty propagation even affordable.

This presentation will focus on proposing methods to propagate chemical and experimental uncertainties in simulations of an auto-igniting flame. A toy-problem subject to similar physical phenomena will be introduced. It will be used to implement some uncertain dimension reduction methods. Different surrogate modelling approaches will then be tested and compared to put forward an affordable and relevant design of experiment for this problem.

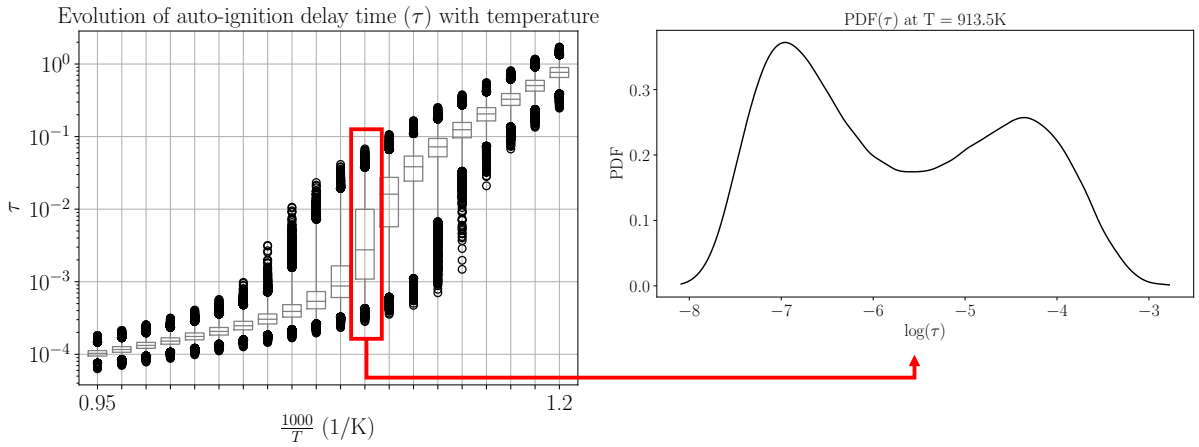

Figure 1: Box plot and PDF for the auto-ignition delay of an homogeneous reactor over a range of initial temperatures