

## **Spatial Propagation of Uncertainty in the Stability Analysis of Supersonic Jets with Stochastic Base-flows as Reduce-Order Models**

<sup>1</sup>F.-J. Granados-Ortiz, <sup>2</sup>C. Airiau, <sup>3</sup>J. Ortega-Casanova

<sup>1</sup>*Department of Engineering, University of Almería, 04120 Almería, Spain*

<sup>2</sup>*Institut de Mécanique des Fluides de Toulouse, Université de Toulouse, 31400 Toulouse, France*

<sup>3</sup>*Department of Mechanical, Thermal and Fluid Engineering, University of Málaga, 29071 Málaga, Spain*

### **Abstract**

Decision-making in industrial applications that involve Computational Fluid Dynamics (CFD) is usually carried out on RANS simulations. However, these are often deployed in a poor reliability environment, which does not account for experimental variability and modelling inaccuracies (uncertainty), thus providing estimations without error margins. A specific example is the study of large coherent structures in supersonic jet flows, which can be done by the combination of two different techniques: CFD RANS and the use of Parabolized Stability Equations (PSE). The PSE method combines the mean base-flow CFD simulations with a perturbation flow (which has a wave-like exponential term and an amplitude function that varies slowly with the axial coordinate) to construct the total flow field. Therefore, if experimental and turbulence model uncertainties are considered in the CFD RANS phase, these are to be propagated to the stability analysis phase. The present investigation deals with such scenario, aiming to provide a valid alternative for robust stability analysis. In this work, the Generalised Polynomial Chaos Expansion method is used to perform the uncertainty quantification, upon which a stochastic base-flow is built as Reduce-Order Model “to feed” the PSE method. This allows to quantify the impact of CFD-related uncertainty onto the PSE equations suitably. The framework has been successfully tested and it has demonstrated to be an efficient approach to perform spatial propagation of uncertainties and sensitivity analysis, as well as to gain insights on the impact of experimental and modelling uncertainty on Kelvin-Helmholtz stability at different Strouhal numbers.

**Keywords:** Uncertainty Quantification, Stability Analysis, Reduced-Order Modelling, CFD, Jets