

Non-intrusive method to estimate discretization errors on a turbulent single-phase flow

S. Gouénard¹, Pietro Marco Congedo², Olivier Le Maître³

¹Commissariat à l'Énergie Atomique, Le Barp, France

²Inria, Equipe DeFI, CMAP, Ecole Polytechnique, France

³CNRS, LIMSI, Université Paris-Saclay, France

solene.gouenard@cea.fr

The computational fluid dynamics frameworks at CEA has been extended to include systematic Verification and Validation (V&V) processes combined with Uncertainty Quantification (UQ) procedures, in order to improve the accuracy and reliability of the simulations. Along this line, we investigate the assessment of the discretization errors by means of non-intrusive methods based on an ensemble of simulations using different discretization levels.

In this work, the discretization errors are assessed using the method proposed by Eça and Hoekstra [“A procedure for the estimation of the numerical uncertainty of CFD calculations based on grid refinement studies”, *Journal of Computational Physics*, Vol. 262, p. 104-130, 2014]. This method requires a minimum of four simulations performed at four different discretization levels. These simulations are subsequently used to estimate the "exact" model solution for the quantity of interest and its error bars, through the resolution of a best-fit problem combined with an error-model selection procedure. The extent of these error bars accounts for the reliability of the error estimation and, therefore, characterizes the confidence in the model prediction.

The main objective of the present work was to investigate the behavior of the method. The simulation of a turbulent single-phase flow in a pipe, presenting a diameter reduction, has been considered for this purpose. The behavior of the method has been analyzed for both integral and local quantities. We focused, in particular, on the error bars estimation and the robustness of the approach with respect to the sequence of discretization parameters (mesh refinements) considered.