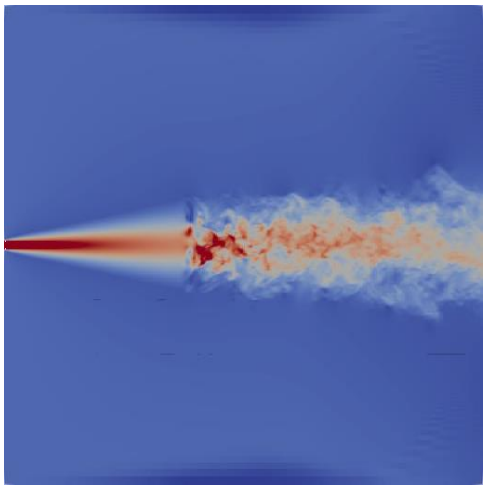
Master 2 Internship

MINES Paris | PSL

Expected profile

- Student of Master of Science or equivalent in applied mathematics, physics, or mechanical. engineering, with competences in fluid dynamics and machine learning.
- Experience with Python and ML tools.



Working conditions

The proposed work will be carried out in the research group *Computing & Fluids*. This grant covers a 6-month internship starting first semester 2025.
Location: CEMEF - MINES Paris PSL, 1 Rue Claude Daunesse, Sophia-Antipolis, France

Contact and application procedure

For further information, please contact:
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Deadline for application:March 31. 2025

Generation of velocity fluctuation correlations in hybrid RANS/LES models using forcing terms

Simulation of incompressible turbulent flow problems can be performed using different approaches depending on the temporal and spatial scales resolved. Direct Numerical Simulation (DNS) by means of numerical methods not affected by the Gibbs phenomenon aims at resolving the entire energy spectrum and therefore can only be applied to so-called “die” simulations due to the computing requirements. Consequently, two main approaches have been used in practice for applications in engineering: Reynolds Averaged Navier-Stokes models (RANS), and Large Eddy Simulation (LES). The first approach is based on ensemble averaging and relies often on the computation of a turbulent viscosity based on one or more turbulent scales which are governed by balance equations, e.g. k the turbulent kinetic energy and epsilon the dissipation rate of the energy. The computed velocity and pressure fields can therefore be seen as averaged in space (below the mesh resolution), and in time (in a sense to be defined), so that it does not retain dynamic features of the flow. The second approach is based on filtering the Navier-Stokes equations so that the energy of vortices is captured down to the scale defined by the mesh resolution [1], so that its cost is higher than RANS. Another problem lies in enforcing the correct behavior at wall boundaries, which is addressed by RANS models using wall-laws, while LES may require excessive refinement at the boundary.
To overcome the limitations of each method, hybrid approaches combining RANS and LES using either zonal [2] or blended techniques have been developed. The flow dynamics are resolved in regions of interest with LES, whileANS is active in regions where the averaging procedure does not degrade the flow features, or in the near-wall region. The difficulty of this hybrid approach is to generate velocity fluctuations corresponding to the dynamics of the LES flow in a buffer region between the RANS and LES zones, for which strategies based on linear forcing have been proposed by collaborators at IRSN [3], see figure. The objective of the project is to evaluate different forcing techniques on plane duct and nozzle configurations in order to optimize the generation velocity fluctuations correlating with the flow dynamics.

References:
[1] A. Ramanathan Krishnan, Explicit algebraic subfilter scale modeling for DES-like methods and extension to variable density flows, Thèse de doctorat, Université Aix-Marseille, 2019
[2] J. Janin, F. Duval, C. Friess, P. Sagaut, A new linear forcing method for isotropic turbulence with controlled integral length scale. Physics of Fluids, 33(4), 2021
[3] J. Janin, Forçage volumique basé sur une méthode de type reconstruction pour un modèle de fermeture algébrique hybride RANS/LES, Thèse de doctorat, Université Aix-Marseille, 2023