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ADVANCED TECHNIQUES FOR GRAY AREA MITIGATION IN DES SIMULATIONS AND THEIR EFFECTS ON THE SUBSONIC ROUND JET ACOUSTIC SPECTRA

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Computational AeroAcoustics (CAA) require accurate numerical solutions in the hydrodynamic region as these feed the acoustic solver. If turbulence or hydrodynamics are not well resolved, acoustics will neither be. In this context, two main issues in the numerical method can be studied: how does the numerical discretization of the differential operators affect the quality of the results and, if turbulence is modeled, how does this modelization affect the results.

As acoustics are highly sensitive on the quality of the hydrodynamic fields used to compute noise, high-order schemes are on great demand. In this sense, Bogey [1] or Shur et. al. [2, 3] both used high-order schemes when simulating jets. However, these kind of methods have two main problems: first, their implementation on general mesh, i.e. unstructured meshes, is not straightforward. And second, the kinetic energy is not well-preserved if symmetric schemes are not used. Consequently, one other option, instead of using high-order schemes, is to use 2nd order low-dissipative ones with more demanding meshes. Tyacke [4] or Fuchs [5] both used 2nd order schemes when simulating a jet. Another option is to use 2nd order higher-accuracy schemes with extended numerical stencils. Bres et. al. [6] and Duben and Kozubskaya [7] exploit algorithms based on such kind of schemes for jet aerodynamics and noise simulation.

The other issue of the algorithm that affects the acoustics is how the turbulence is modeled. Hybrid RANS-LES methods have the most interesting balance between accuracy and computational cost as they can simulate high Reynolds numbers without requiring excessively large meshes. Inside these hybrid methods, one of the most common approach is the non-zonal DES family, which is still studied and evolving nowadays. Their actual investigations are focused on solving the so-called gray area problem that appears when solving shear layers. This problem is mainly the delay of RANS-to-LES transition to the mesh-resolved turbulence. The usual methodology to mitigate the gray area phenomena is the joint usage of an special length scale,

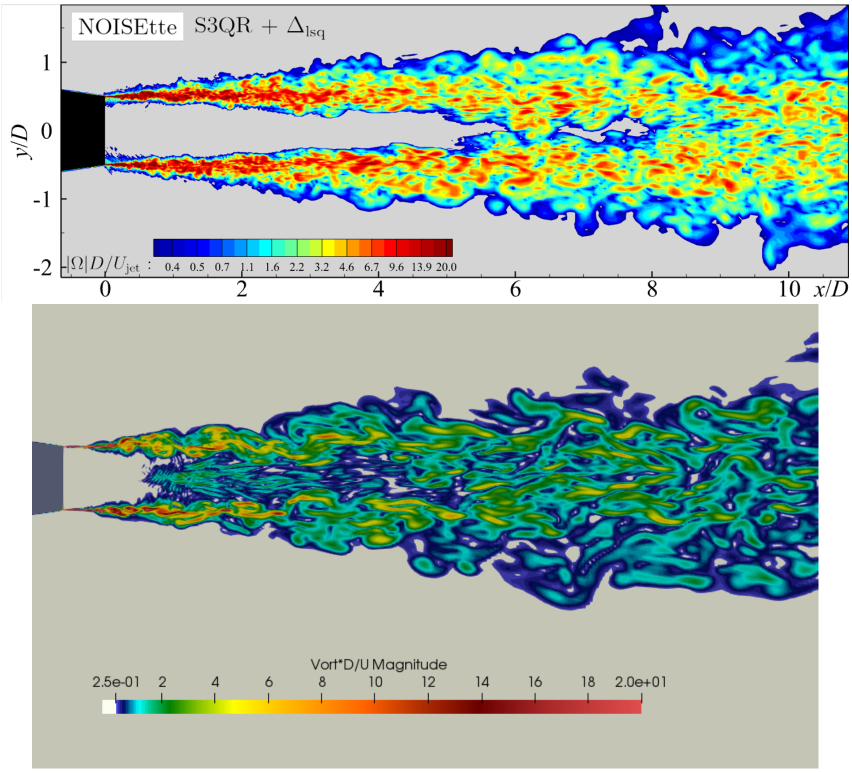

Figure 1: Non-dimensional vorticity magnitude for the finner mesh (8.8 MCV).
DES model: Δ_{lsq} with S3QR used.
Top: NOISEtte. Bottom: OpenFOAM.

such as Δ_{ω} [8] or Δ_{lsq} [9], with advanced LES models, such as σ or WALE models instead of Smagorinsky.

In this work, we will study an immersed subsonic unheated round turbulent jet with Reynolds number based on the diameter $Re_D = 1.1 \times 10^6$ and Mach number $M = 0.9$. Two different codes have been considered: NOISEtte, which uses higher accuracy schemes, and OpenFOAM, that uses 2nd order reconstruction. Three different DES models are considered: Δ_{SLA} with Smagorinsky LES model, Δ_{ω} with σ LES model and Δ_{lsq} with S3QR [9] turbulence model. Three different meshes, having each one 1.5, 4.4 and 8.8 MCV, will be used to check the effect that the mesh size have on both hydrodynamic and acoustic results. The analysis based on comparison with reference data and the results obtained using the different turbulence models includes both near field flow characteristics and far field noise. In Figure 1 we include the preliminar hydrodynamic fields obtained with both codes.

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