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TOWARDS PROPER SUBGRID-SCALE MODEL FOR JET AERODYNAMICS AND AEROACOUSTICS

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Computational aeroacoustics (CAA) requires very accurate numerical solution in the near-field flow region to simulate the aerodynamic noise generation mechanisms adequately. In this context, together with the computational meshes, the two main components of the corresponding scale-resolving algorithms affect the quality of the results obtained: the numerical discretization of differential operators and turbulence (i.e., subgrid-scale, SGS) model. We are mostly focused on the latter one in the research considered.

The object of investigation is the immersed unheated subsonic ($M_{\text{jet}} = 0.9$) turbulent round jet characterized by the Reynolds number $\text{Re}_D = 1.1 \cdot 10^6$. We consider the numerical set-up without proper resolved boundary layer turbulence upstream the nozzle exit. The accuracy of the turbulent jet plume aerodynamics and especially far-field noise is fully defined by the simulation correctness of the shear layer evolution. That is why the property of the SGS model to mitigate the gray-area (GAM) problem (to provoke the RANS-to-LES transition) in the initial part of the shear layer is crucial for the test case considered (with steady RANS solution upstream the nozzle exit). Of course, the behavior of the SGS model influences the simulation adequacy throughout the shear layer region which is responsible for the noise generated by the jet. The present study is a continuation of the investigation, the results of which were published in the paper [1]. We consider the recent dynamic adaptive SGS length scales (Δ_ω, $\tilde{\Delta}_\omega$, Δ_{SLA}, Δ_{lsq}) and the enhanced SGS models (σ and S3PQR models). We vary their combinations and evaluate the results compared with experimental data on both jet plume aerodynamics and far-field noise. A set of four refining meshes for the simulations is used. The two 2^{nd} order control volume numerical algorithms are exploited for the study: the higher-accuracy one realized in the code NOISEtte and the one from the lower-accuracy one from the OpenFOAM code. Based on the set of results obtained, we draw conclusions about the main characteristics of the various variants of SGS models and formulate criteria for selecting the most advanced of them, showing the pros and cons of each.

REFERENCES

[1] A. Pont-Vílchez et al., New Strategies for Mitigating the Gray Area in Delayed-Detached Eddy Simulation Models. *AIAA J.*, Vol. **59**, No. 9, pp. 3331-–3345, 2021.