Advanced techniques for gray area mitigation in DES simulations and their effects on the subsonic round jet acoustic spectra

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Index of Contents

Jet Noise

A problem beginning not so long ago...

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Obtaining jet noise values

We can measure noise "directly".

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Or we can simulate it.

- Which is what **Computational AeroAcoustics (CAA)** does.

Computational AeroAcoustics

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Numerical discretization

- High-order schemes allow obtaining more accurate numerical solutions.
  - However, their implementation onto a general framework is not always possible.
  - Additionally, there is a loss of kinetic energy, i.e. not skew-symmetric.

Computational AeroAcoustics

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  - High-resolution schemes without so strict mesh requirements.

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Turbulence modelling

- RANS-LES models offer a balance between accurate solutions and computational cost.
- More precisely, non-zonal DES aproaches.
  - Extensively validated and used.
  - Their current studies focus on **Gray-Area Mitigation techniques**.

Gray-Area Mitigation

The Gray-Area problem

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  - Special length scale.
    - $\Delta\omega$ [Chauvet et. al., 2017], $\tilde{\Delta}\omega$ [Mockett et. al., 2015], Δ_{SLA} [Shur et. al., 2015], Δ_{lsq} [Trias et. al., 2017].

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  - Advanced turbulence model.
    - σ [Nicoud et. al., 2011], WALE [Nicoud et. al., 2011], S3QR [Trias et. al., 2015].

Case and turbulence models

Round jet

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Round jet

- Immersed unheated subsonic round jet at $Re_D = 1.1 \cdot 10^6$, $Ma = 0.9$.
- Profiles imposed at nozzle exit.
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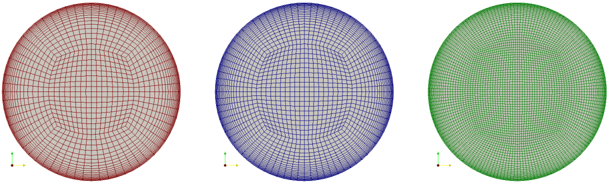
Used models

Case	Turbulence model	Length scale
1	S3QR	lsq
2	σ	$\tilde{\Delta}\omega$
3	SMG	SLA

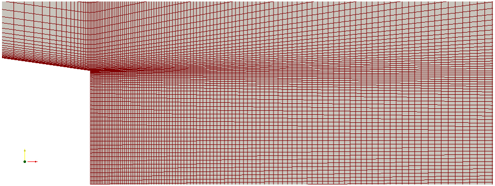
Mesh definition

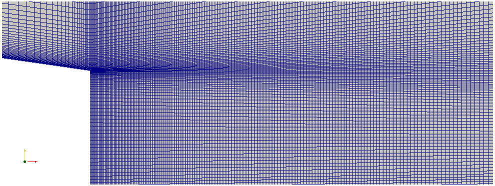
Computational meshes

Mesh characteristics	Mesh 1	Mesh 2	Mesh 3
Total cell count	1.52M	4.13M	8.87M
N_φ	64	80	160
$\Delta x/D$ at nozzle exit	0.011	0.008	0.008
Min Δr	0.003D	0.0025D	0.0025D



Mesh definition (cont.)





Numerical algorithms

The main differences between used codes are:

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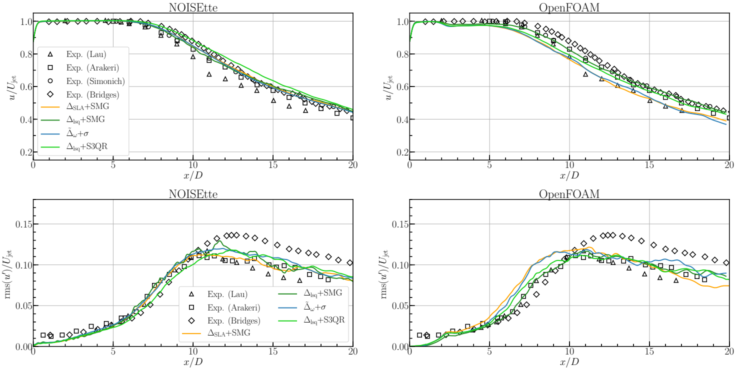
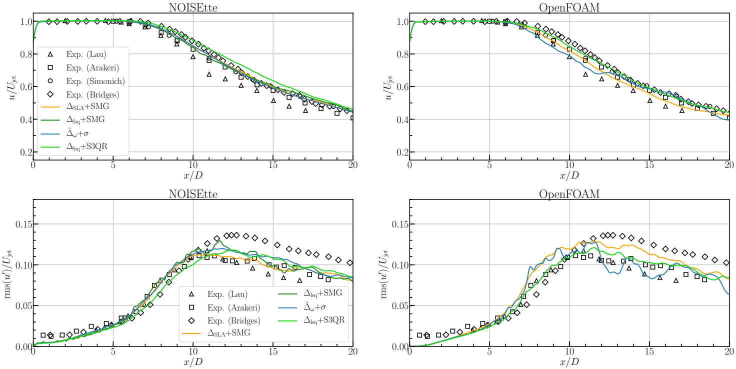
Time integration	RK 4th order	Implicit 2nd order
FWH equation	Retarded time	Phase shift

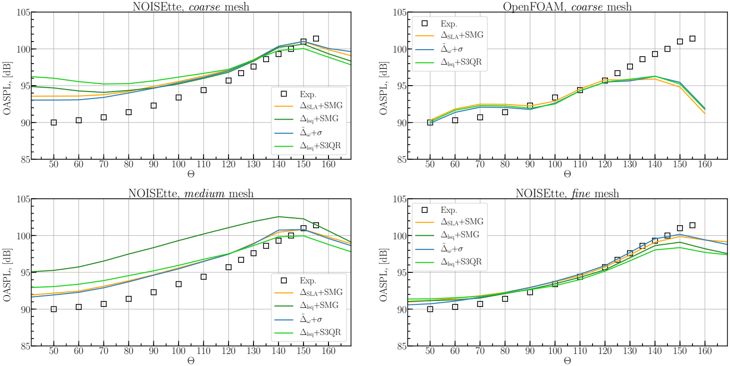
Results: Mean flow



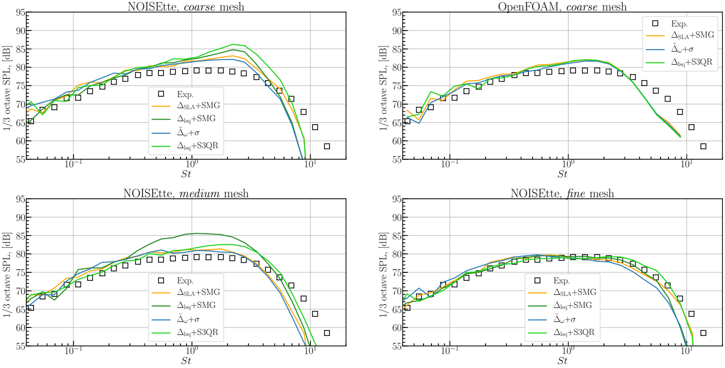
Results: Mean flow (Still converging)



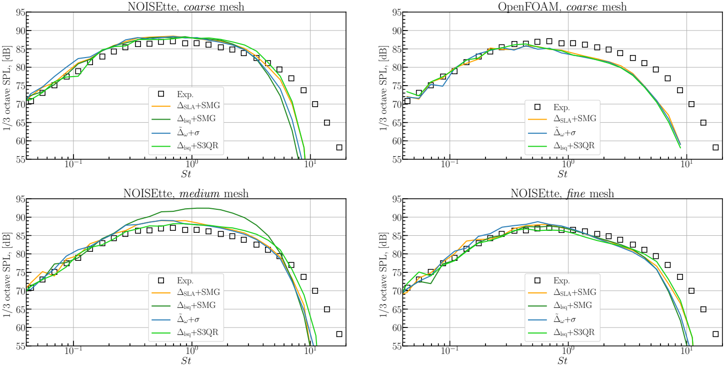
Results: OSPL



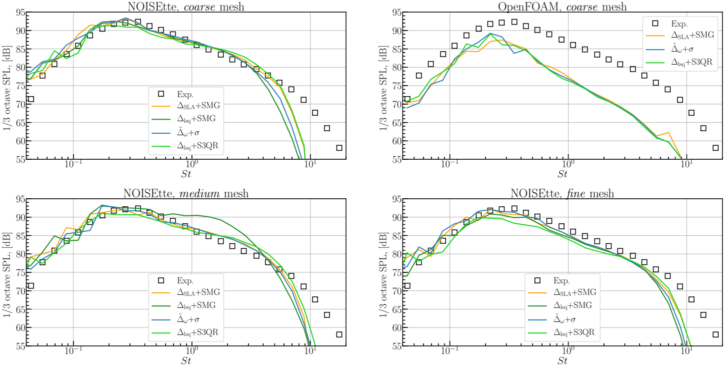
Results: SPL at 60°



Results: SPL at 130°



Results: SPL at 150°



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- Simulations on a finner mesh (G4) are to be done to obtain a better conclusion regarding results convergence.

Acknowledgements

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