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Adaptative LES models using Discontinuous Galerkin methods

Marta de la Llave Plata[1] and Vincent Couaillier[2]

[1] ONERA, F-92322 Châtillon, France, marta_de_la_llave.plata@onera.fr http://www.onera.fr/
[2] ONERA, F-92322 Châtillon, France, vincent.couaillier@onera.fr http://www.onera.fr/

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Accurate simulation of turbulent flows with complex unsteady features like detachment remains out of reach for the current capabilities of industrial CFD methods. This is despite the relevance of such flow simulations for aeronautics, namely in analysing complex phenomena like buffeting or strong separations appearing with high-lift devices or control surfaces. A major challenge in simulating turbulent flows with large unsteady features is the invalidity of the common physical arguments made in RANS-type modelling of the turbulence. This requires resolving the turbulence at a reasonable level through Large Eddy Simulation (LES) implying considerably higher computational cost. Given the limitations of computational power, performing such simulations at the industrial scale requires using efficient and scalable numerical methods with geometric flexibility, like the high-order accurate discontinuous Galerkin (DG) methods. High-order DG methods in CFD have seen an increased interest in the recent years for the potential gain in efficiency they offer over conventional finite volume schemes. This potential is relevant especially for making a larger range of problems tractable in the industrial setting. ONERA has been developing its own Discontinuous Galerkin solver Aghora [1] in order to explore the possibilities offered by DG methods for the aeronautical industry.

The conventional LES methods based on filtering or non-linear viscosity are essentially regularizations of the governing equations, and in an adaptive discretization the consistency errors due to the regularizing terms need to be controlled as well, in addition to the discretization errors. While such strategies exist in different contexts,8 we avoid this complication by choosing the three scale variational multiscale method [2] (VMS), in which the coarsest scales do not suffer from consistency errors. In this work we will present the analysis for the explicit-in-time VMS-DG [3] method of compressible Navier-Stokes equations based on fundamental characteristic test cases.

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