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Recent developments in wall-resolved and wall-modeled ILES based on high-order DG methods

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Wall-resolved Large Eddy Simulations (LES) are feasible for small and moderate Reynolds numbers but become computationally expensive for larger Reynolds numbers. The EU H2020 TILDA project targeted this problem with dedicated developments. In particular, we performed implicit LES (ILES) based on high-order Discontinuous Galerkin methods, we implemented implicit Runge-Kutta (SDIRK) schemes and compared them to explicit Runge-Kutta schemes in terms of accuracy and computational efficiency; we performed ILES on near-wall locally refined meshes for a near-wall improved resolution of the flow field, and we developed a wall-modeling approach in which the inner boundary layer (up to 20% of the boundary layer thickness, $y \leq 0.2\delta$) is modeled and the remaining part ($y > 0.2\delta$, including the output boundary layer) is resolved[1].

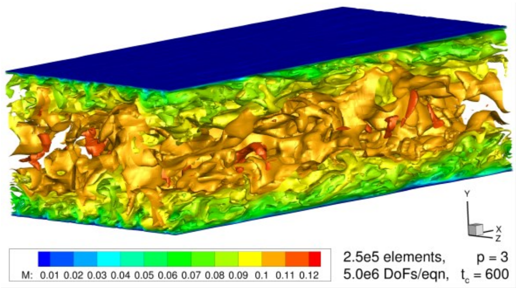

Fig. 1 ILES for the channel flow at Re=395

The wall-modeled LES approach developed [2] is based on a wall-stress prescribing boundary condition. In particular, the no-slip boundary condition is replaced by a slip-wall boundary condition and the freedom gained is used to prescribe the wall shear stress in the viscous boundary flux. The wall shear stress imposed is determined by solving the near-wall velocity profile $u^+(y^+)$ for y^+ with flow data taken from 20% of the boundary layer thickness off the wall where we expect the flow field still to be resolved. We consider various versions of such wall-stress prescribing boundary conditions. In particular, a wall-stress model based on an approximate near-wall velocity profile (the Reichardt's function) is compared to a wall-stress model based on the exact near-wall velocity profile (as extracted from

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existing DNS results). This allows to separate the error introduced by the wall-stress prescribing boundary condition from the error introduced by the (in general only approximate) near-wall velocity profile. Computed with high-order Discontinuous Galerkin methods we will compare wall-modeled ILES results with wall-resolved ILES results, and discuss problems and possible limitations of the approach chosen.

Test cases considered with ILES are the channel flow, the 2D periodic hill test case and the Boeing Rudimentary Landing Gear (cf. Figures 1-3).

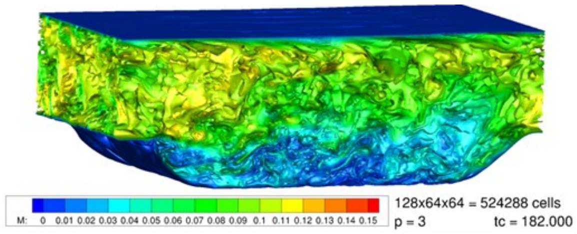

Fig. 2 ILES for the 2D periodic hill at Re=2800

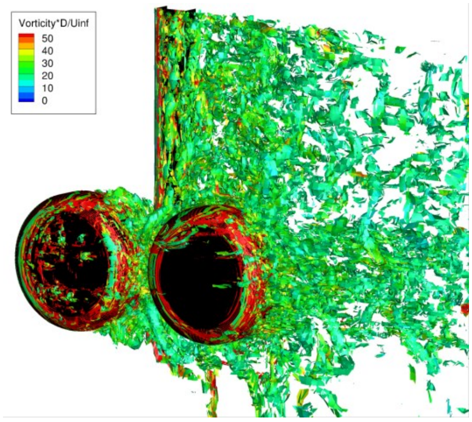

Fig. 3 ILES for the Boeing Rudimentary Landing Gear at Re=10^6

References

[1] J. Larsson, S. Kawai, J. Bodart, and I. Bermejo-Moreno. Large eddy simulation with modeled wall-stress: recent progress and future directions. Mech. Eng. Reviews, Vol. 3(1), 2016.

[2] R. Hartmann. Wall-resolved and wall-modeled ILES based on high-order DG. Proceedings of the ECCOMAS (ECCM-ECFD) 2018 Conference, 11.-15. June 2018, Glasgow, UK, 2018.