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On the large-eddy simulation with wall modelled support for massive separated flows at high Reynolds numbers

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In this work two different wall-flux models are assessed in massive separated flows at high Reynolds numbers. The selected test cases are: first, the NASA Common Research Model at high angle of attacks ($AoA = 12°$ and $18°$), $Re_c = 11$M, and Ma=0.25; and second, the DrivAer car at $Re = 4$M with rotating wheels and ground simulation. These models are non-equilibrium and equilibrium models [1]. The non-equilibrium model in the most general form solves the complete 3D, unsteady flow equations on a regular grid defined in the near-wall region to obtain the wall-shear stress provided to the LES. The equilibrium wall model is derived from the non-equilibrium model by neglecting all the terms except for the wall-normal diffusion. The wall models are implemented into the multi-physics finite element (FE) code Alya developed at BSC [2]. A finite element Galerkin approximation is used for the space discretization with a non-incremental fractional step method to stabilize pressure. This allows for the use of finite element pairs that do not satisfy the inf-sup condition, such as equal order interpolation for the velocity and pressure used in this work. The convective term is discretized using the EMAC discretization [3] that allows to conserve kinetic energy, momentum and angular momentum. Temporal discretization is performed through an explicit third-order Runge-Kutta scheme combined with an eigenvalue based time step estimator [4]. The formulation is closed by the eddy-viscosity model proposed by Vreman [5].

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