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A MULTISCALE APPROACH TO HYBRID RANS/LES WALL MODELING USING FUNCTION ENRICHMENT

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We present a novel approach to wall modeling based on function enrichment. The concepts of this new modeling approach have been derived for the Reynolds-average Navier–Stokes (RANS) equations in [1] and then be extended to large eddy simulation (LES) by a hybrid RANS/LES approach [2].

We present a rigorous derivation of our multiscale turbulence modeling approach in the framework of a high-order discontinuous Galerkin solver for turbulent flow [3]. In the near-wall area, the Navier–Stokes equations are explicitly solved for an LES and a RANS component in one single equation. This is done by providing the Galerkin method with an independent set of shape functions for each of these two methods; the standard high-order polynomial basis resolves turbulent eddies where the mesh is sufficiently fine and the enrichment automatically computes the ensemble-averaged flow if the LES mesh is too coarse. As a result of the derivation, the RANS model is consistently applied solely to the RANS degrees of freedom, which effectively prevents the log-layer mismatch in attached boundary layers typical of many traditional hybrid RANS/LES models. As the full Navier–Stokes equations are solved in the boundary layer, spatial refinement gradually yields wall-resolved LES with exact boundary conditions. Numerical tests show the outstanding characteristics of the wall model regarding grid independence, superiority compared to equilibrium wall models in separated flows, and achieve a speed-up by two orders of magnitude compared to wall-resolved LES.

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