Computational error-analysis of a discontinuous Galerkin discretization applied to large-eddy simulation of homogeneous turbulence

Abstract:
A computational error-assessment of large-eddy simulation (LES) in combination with a discontinuous Galerkin finite element method is presented for homogeneous, isotropic, decaying turbulence. The error-landscape database approach is used to quantify the total simulation error that arises from the use of the Smagorinsky eddy-viscosity model in combination with the Galerkin discretization. We adopt a modified HLLC flux, allowing an explicit control over the dissipative component of the numerical flux. The optimal dependence of the Smagorinsky parameter on the spatial resolution is determined for second and third order accurate Galerkin methods. In particular, the role of the numerical dissipation relative to the contribution from the Smagorinsky dissipation is investigated. We observed an 'exchange of dissipation' principle in the sense that an increased numerical dissipation implied a reduction in the optimal Smagorinsky parameter. The predictions based on Galerkin discretization with fully stabilized HLLC flux were found to be less accurate than when a central discretization with (mainly) Smagorinsky dissipation was
used. This was observed for both the second and third order Galerkin discretization, suggesting to emphasize central discretization of the convective nonlinearity and stabilization that mimics eddy-viscosity as sub-filter dissipation.

Stichworte:
Large-eddy simulation, Computational error-assessment, Discontinuous Galerkin finite element method, Eddy-viscosity modeling, Turbulence

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