Implicit large eddy simulations with a high-order TENO scheme

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ABSTRACT

Although TENO schemes, proposed by Fu et al. (2016), show promising results for turbulence reproduction, they are unsuitable to function as a reliable subgrid LES model by generating excessive dissipation. Meanwhile, the state-of-the-art implicit LES models, e.g. the localized artificial diffusivity scheme by Kawai et al. (2010), typically depend on shock sensors, which are case-dependent and fail to retain the monotonicity near discontinuities. The difficulty locates on scale-separating the low-wavenumber smooth regions, high-wavenumber fluctuations and discontinuities sufficiently and incorporating adequate dissipation into numerical schemes correspondingly. In this paper, we propose a new 8-point 6th-order TENO8-A scheme, which is motivated for gas dynamics and physics-consistent for incompressible and compressible turbulence modeling. While the low-wavenumber smooth region is handled by the optimized linear scheme, with the measurement of local flow scales, the high-wavenumber fluctuations and discontinuities are predicted with adaptive nonlinear dissipation. The new scheme is Galilean invariant and free from physics-based sensors rendering its high generality. Benchmark simulations demonstrate that, while the TENO8-A scheme exhibits exceptional performance in gas dynamics, it faithfully reproduces the kinetic energy evolution for incompressible turbulence and predicts the vorticity, entropy and acoustic modes as good as the physics-motivated ILES models for compressible turbulence decay.

REFERENCES