Optimal LES filtering for Approximate Deconvolution in LES with dissipative and non-dissipative discretization methods

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In large eddy simulation (LES), the smaller of the resolved flow scales (RFS) near the grid cut-off wave number are affected by artefacts due to the induced filter defined by the discretisation method as well as arising from the use of an explicit filter in the time-stepping procedure. The Approximate Deconvolution Method (ADM) formulated by Stolz and Adams[1] enables an approximate reconstruction of the RFS, to be used directly for evaluating the sub-grid stress tensor $\tau_{ij} = \overline{u_i^* u_j^*} - \overline{u}_i \overline{u}_j$. Here, $\overline{u}_i = \mathcal{G} * u_i$ are filtered velocity components corresponding to a filter function $\mathcal{G}$ and u_i^* are the deconvolved counterparts in which some of the filtering artefacts have been partially corrected, e.g., using the van Cittert approximation.
The ADM framework requires explicit knowledge of the filter $\mathcal{G}$ before any deconvolution can be attempted. This is a fundamental problem for ADM as the total LES filter is usually unknown. Consequently, several proposals have been put forward in the literature, e.g., assuming *a priori* a generic filter such as the top-hat, Gaussian or finite/compact difference filter, possibly convolved with the filter induced by the numerical method. Alternatively, knowing the total numerical dissipation[2] ($\epsilon_{\rm num}$) one can try to adjust $\mathcal{G}$ to mimic the impact of $\epsilon_{\rm num}$ on the solution.

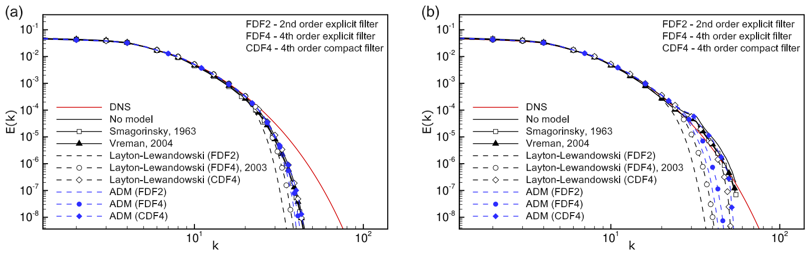

Figure 1: Energy spectrum for a dissipative (a) and a non-dissipative (b) discretisation.

The precise filter adopted in ADM can have a large impact on the smallest reconstructed scales in LES. In this contribution, we compare various selections for $\mathcal{G}$ to simulate 3D forced homogeneous isotropic turbulence. A high-order half-staggered spatial discretization method[3] is used in which the interpolation between the meshes is either dissipative, based on a compact interpolation, or non-dissipative based on Fourier interpolation. In Fig. 1(a) the velocity spectra display strongly reduced tails for the dissipative numerics while Fig. 1(b) presents much wider spectra with non-dissipative numerics. The sensitivity of the smaller reconstructed RFS on the adopted ADM filter choice is clearly expressed. In the final contribution to the conference, an optimal ADM filter will be presented minimizing the error with respect to DNS.

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