TESTING AND DEVELOPMENT OF THE EXPLICIT ALGEBRAIC SGS MODEL FOR CFD APPLICATIONS

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LES of wall-bounded flows at high Reynolds numbers has been proven to be computationally very costly since the near-wall structures need to be approximately resolved. Recently we have developed the Explicit Algebraic SGS model (EAM) [1]. The EAM is non-linear in the strain and rotation rate tensors, and is a promising model in order to reduce computational costs and attain a reasonable accuracy.

We have performed LESs of turbulent plane channel flow at two bulk Reynolds numbers corresponding to the DNSs of [4] and [5] with $Re_\tau = 550$ and 5200, based on friction velocity and channel half-width. The LESs are carried out with a pseudo-spectral (PS) code, and a coarse resolution with $\Delta x^+ \approx 160$ and $\Delta z^+ \approx 60$, in the streamwise and spanwise directions, respectively. Figure 1 (a) shows the mean velocity profiles, for the LES with DSM (the Dynamic Smagorinsky model) and EAM at $Re_\tau = 550$ and 5200. LESs with the DSM deviate significantly from the DNS for both Reynolds numbers and come closer to the DNS only when the resolution is sufficiently high (not shown here). On the other hand, LESs with the EAM show much closer agreement with DNS at both Reynolds numbers, especially in the outer region. It has also been shown that LESs with the EAM are much more resolution-independent, according to [2]. The streamwise component of the Reynolds stress tensor at $Re_\tau = 5200$ is displayed in figure 1 (b): here LES with the EAM comes closer to DNS in proximity of the inner peak and the outer layer. A paper describing in detail the LES is accepted for publication in *Phys. Rev. Fluids*.

The next study is to find out if the results obtained with a lower order, finite-difference code OpenFOAM© (OF) are consistent with the previous one given by the PS code. The LESs are performed with a fairly coarse resolution with $\Delta x^+ \approx 54$ and $\Delta z^+ \approx 27$ in the streamwise and spanwise directions respectively in wall units, and $Re_\tau = 550$. Figure 1(c) shows the streamwise component of the Reynolds stress tensor. Due to a higher numerical accuracy, PS results (in dashed lines) come closer to DNS than the OF ones. LES with the DSM/OF and LES with no SGS model (NM/OF) have essentially the same results, while the LES with the EAM/OF come closer to DNS in proximity of the inner layer peak.

In conclusion, using a PS code LESs with the EAM are in reasonably good agreement with DNS of turbulent channel flow up to $Re_\tau = 5200$ even at very coarse resolutions while LESs with the DSM substantially deviate from DNS at the same resolutions. In analogy to the similar study performed by Rasam et al [3], we are going to investigate if those promising results can be achieved as well using a finite-difference code that is suitable for complex geometries using reasonably coarse resolutions and high Reynolds numbers.

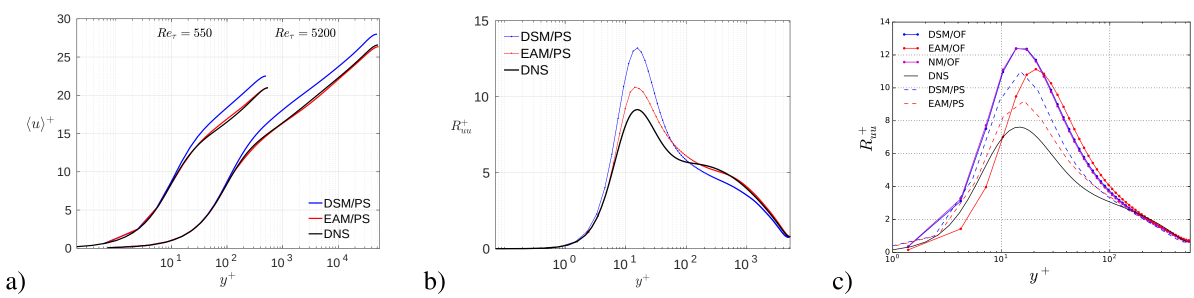

Figure 1. a) Mean velocity profiles in wall units, as a function of the inner units-scaled wall-normal direction, shifted of 10 units. b-c) Streamwise component of the Reynolds stress tensor in inner units, as a function of y-direction, at $Re_\tau = 5200$ and $Re_\tau = 550$.

References

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