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Effectsof convection schemes on hybrid RANS-LES calculations

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Nowadays it is commonly accepted to report on convections schemes in the case of Large Eddy Simulation (LES) calculations. For example, the second order central differencing (CD) scheme is commonly used and then the blending factor quantifying the part of CD in the blending upwind-CD scheme is reported. Results obtained with values lower than 0.98 or 0.96 are already taken with suspicious. On the other hand, and in the case of the hybrid RANS-LES calculation, the same discussion seems not to be relevant assuming that calculations are anyway performed on the coarser grids. This paper will show that this is important to take into account. We choose here the partially averaged Navier–Stokes (PANS) modelformulated by Girimaji (2003;*ASME Paper* 45336, 2006;*Journal of Applied Mechanics*, 73(3): pp. 413–421). as the representative hybrid RANS-LES model but the conclusions derived in this work are equally applicable to other methods.It was shown in previous studies that the implied cut-off for the PANS method can be placed in any part of the spectrum including the dissipation range. This is done by varying the unresolved-to-total ratios of kinetic energy (f_k) and dissipation (f_e). In practice, the parameter which determines the unresolved-to-total kinetic energy ratio is defined by using the grid spacing and calculated integral length scale of turbulence.If the resolution parameters, f_k and f_e, are equal unity, the PANS model recovers the RANS model. On the other side, if the resolution parameters are very low, then the modeling of the small unresolved scales will affect the overall solutions less. The main target of such an approach is to have an optimum turbulence model for any mesh used in calculations. This paper will show if the resolution parameter f_k can be also used as the blending scheme factor, thus

$$\phi_f = \phi_f^{SMART/MINMOD} f_k + (1 - f_k)\phi_f^{CD}$$

where two schemes, SMART and MINMOD, which are based on Convection Boundedness Criterion (CBC) and Total Variation Diminishing (TVD) constraints,

are in general used in conjunction with RANS models. Another approach would be to use the step function as

$$\phi_f = \phi_f^{SMART/MINMOD} \quad f_k \geq 0.4$$

$$\phi_f = \phi_f^{CD} \quad f_k < 0.4$$

The results will be presented for the flow around the square cylinder. Measurements and DNS data are available for comparisons.

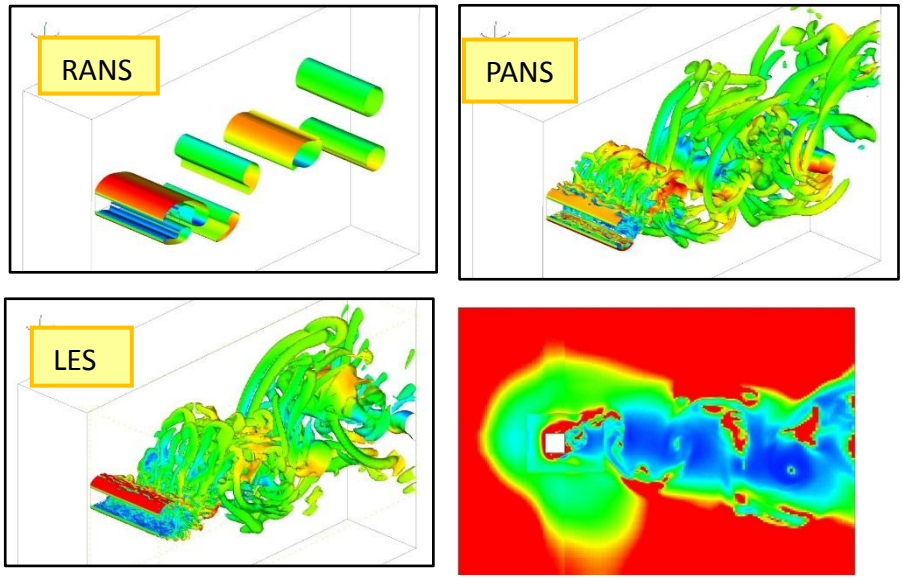

Figure 1:A square cylinder – computed instantaneous isosurface of the second invariant of the velocity gradient for RANS, PANS and LES, and the instantaneous resolution parameter f_k (right bottom).

Calculation results obtained with LES and the same differencing schemes as used for RANS and PANS will be presented as well.