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Further Analysis of Hybrid-Filtered Navier-Stokes Equations
BERNIE RAJAMANI, JOHN KIM, University of California, Los Angeles — We have shown that Germano's hybrid-filter approach is both a physically and mathematically correct method of blending the Reynolds-Averaged Navier-Stokes (RANS) and large-eddy simulation (LES). The hybrid-filtered Navier-Stokes (HFNS) equations provides correct behavior in the crossover region via three means: (1) presence of extra terms in the governing equations, (2) presence of a fluctuation-like term in the modeled part of the Reynolds shear stress, and (3) presence of a smooth blending function. In many existing hybrid methods, the governing equations were modified in an *ad hoc* manner in order to achieve improved behavior at the RANS-LES crossover. We have shown that such a fix is not necessary in the current approach. For example, our full simulation of HFNS equations showed that the extra terms enhanced the wall-normal transport of resolved turbulence fluctuations, thus alleviating the need for an artificial backscatter-like term. Further investigations of the effects of grid and blending function revealed no evidence of deterioration of the solution upon progressive refinement of the grid, contrary to many conventional hybrid methods. We also found that the blending function – its magnitude near the wall and its shape in the crossover region – must be chosen to be consistent with the grid used in these regions. Otherwise, the solution deteriorates, primarily due to its inability to resolve the LES part.

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