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Scale-separation models for the larger eddies in turbulent flow[1]

ROEL VERSTAPPEN, University of Groningen — Large-eddy simulation (LES) seeks to predict the dynamics of spatially filtered turbulent flows. The very essence of LES is that the LES-field contains only scales of size $\geq \delta$, where δ denotes the (user-chosen) length of the spatial filter. In the present approach we continue the work that was conducted during the 2010 CTR Summer Program by addressing the following two basic questions: (a) when does a LES-model stop the production of smaller scales of motion from continuing at the filter scale; and (b) when does it dissipate any disturbances having a length scale smaller than δ initially. In this way we find two scale separation conditions that ensure that all subfilter scales are dynamically insignificant. These conditions can be applied to any type of LES-model. In case of a mixed model, for instance, they imply that the eddy viscosity ν_t has to depend on the invariants $q = \frac{1}{2}\mathrm{tr}(S2)$ and $r = -\frac{1}{3}\mathrm{tr}(S3)$ of the (filtered) strain rate tensor S. The simplest model is then given by $\nu_t = \frac{1}{96}\,\delta 2|r|/q$. This model is successfully tested for a turbulent channel flow (Re_τ=590 and 1,000).

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