APPLICATION OF DEFILTERING TECHNIQUE TO THE LARGE-EDDY SIMULATION OF WALL-BOUNDED TURBULENT FLOWS

Petr Louda*, Raimondo Giammanco, Carlo Benocci**

A defiltering technique is used to implement a family of subgrid models which can significantly improve results of large-eddy simulation. The defiltering uses procedure suggested by Shah and Ferziger as part of their S^3 subgrid stress model. The small scales obtained by defiltering are used to define subgrid viscosity stress model based on subgrid viscosity obtained from a priori tests. In such a way, defiltering technique serves to define subgrid viscosity, self-similar, and mixed subgrid stress models. The approach is tested on the case of the plane channel at equilibrium for three Reynolds numbers and satisfactory results are obtained in terms of resolved velocity fluctuations as well as wall shear stress. The results confirm advantages of mixed model in wall resolved LES, including the ability to simulate backscatter of kinetic energy of small scales.

Key words: *LES of channel flow, defiltering, S^3 subgrid stress model, mixed subgrid stress model, subgrid eddy-viscosity*

Nomenclature

u_i	velocity vector in Cartesian coordinates; alternatively u,v,w
f_i	vector of body force
H	half-width of the channel
p	modified pressure (static pressure over density + izotropic part of subgrid stress)
$\langle u_\tau \rangle$	mean friction velocity (imposed)
$\langle \tilde{u}_\tau \rangle$	mean friction velocity (computed)
x_i	Cartesian coordinates; alternatively x, y, z
z^+	z in wall coordinates: $\langle u_\tau \rangle z/\nu$
Re	Reynolds number
Re_τ	friction Reynolds number: $\langle u_\tau \rangle \delta/\nu$
S_{ij}	strain rate, $(\partial u_i/\partial x_j + \partial u_j/\partial x_i)/2$
δ_{ij}	Kronecker delta
Δ	tophat filter width
Δx	grid spacing in x direction
τ_{ij}	subgrid scale (SGS) stress tensor
ν	molecular kinematic viscosity
$\nu_{\rm sgs}$	subgrid kinematic viscosity

* P. Louda, Dept. of technical mathematics, FME CTU, Karlova nám. 13 CZ 121 35 Praha 2, Czech Republic

** R. Giammanco, C. Benocci, Von Karman Institute for Fluid Dynamics, 72 Chaussée Waterloo, B 1640 Rhode-St-Genese, Belgium