INVESTIGATION OF SELF-SIMILAR SUBGRID MODELS FOR LES

Petr Louda, Czech Republic
Supervisors: C. Benocci & R. Giammanco

In the large eddy simulation (LES) of turbulent flows, large flow structures interacting directly with the specific problem's geometry are simulated directly whereas smaller structures are represented by the subgrid model. Common subgrid models -- of eddy-viscosity type --simulate badly anisotropy of subgrid motion and does not allow transfer of energy from subgrid to large scale motion (backscatter). Self-similar models investigated in this project enable modeling of both of these phenomena.

The self-similar models are based on the hypothesis that the interaction between resolved and subgrid scales takes place mostly between smallest resolved and biggest subgrid scales. The basic scale-similar model due to Bardina expresses the subgrid stress by means of resolved (once filtered) and double filtered velocity as

$$\tau_{ij} = \overline{\overline{u_i u_j}} - \overline{\overline{u_i}}\,\overline{\overline{u_j}}.$$

In contrast to eddy-viscosity models, the self-similar ones can naturally simulate anisotropy of small structures and kinetic energy transfer from small to large structures -- the effects being of importance for near-wall and transitional flows.

The objective of the project was to enhance the subgrid modeling capabilities of VKI LES code, which already included several eddy-viscosity models, by implementing scale-similar type of subgridmodels.

The behavior of model by Bardina supplemented by an eddy-viscosity term (mixed model) was investigated in equilibrium channel flow at $\mathrm{Re}_\tau = 200{,}395$ and 590. The generalization of Bardina model, where an approximation of the whole velocity field is first estimated from resolved velocity and in the second step used in the definition of subgrid stress as proposed by Shah and Ferziger, was investigated in channel flow as well. New models provided satisfactory results and showed their capabilities superior over eddy-viscosity models.