# Tensorial viscosity model for LES of complex flows

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In the Large Eddy Simulation (LES) approach to the numerical solution of the equations for a turbulent flow, the sub-grid scale (SGS) stress tensor $\tau_{ij} = \overline{u_i u_j} - \overline{u}_i \overline{u}_j$ , deriving from the filtering of the nonlinear terms of Navier-Stokes equations, represents the effect of the small unresolved scales on the resolved motion, and it must be modeled. The turbulent flows of practical interest are generally inhomogeneous and anisotropic, also at the small scales of motion. A SGS models should take in account this anisotropic character of unresolved turbulent structures. The tensorial viscosity model (TVM) [1] [2] $\tau_{ij} = -\nu_{hj}\partial_h \overline{u}_i - \nu_{hi}\partial_h \overline{u}_j$, where the eddy viscosity is a tensor modelled as $\nu_{hi} = [(I_{kh} - 1/2Tr(I))\delta_{kh}]/(2\Omega)\partial_k \overline{u}_i$ in function of the inertial tensor $I$ of the grid element $\Omega$, takes into account this aspect. Indeed the meshes usually adopted for numerical simulations reflect the anisotropy and inhomogeneity of the flow and could be used to represent the features of small scale turbulence. The application of the model to complex flows as the BARC test case (Fig. 1(a)) [3] and the blade-vortex interaction (BVI) phenomenon [4] (Fig. 1(b)) will be presented highlighting the advantages of the TVM model. Moreover the application of the model to compressible turbulence, in the form for variable density flows recently analysed in an a priori test [5], will be exploited.

a) b)

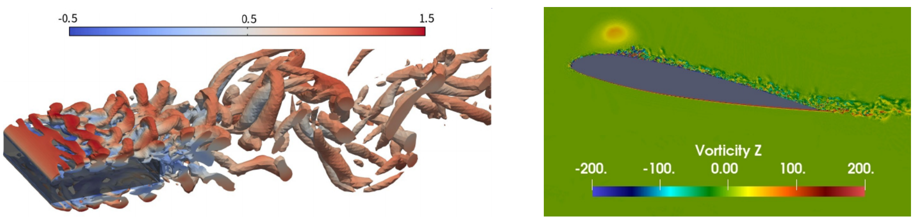


Figure 1: (a) Instantaneous flow field in the BARC test case. (b) Spanwise vorticity in the BVI.

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[1]Cimarelli et al., *J. Fluid Mech.* **866**, 865 (2019).
[2]Abbà et al., *Phys. Fluids* **34**, 025109 (2022).
[3]Urrecha, *Master thesis*, University of Modena and Reggio Emilia (2022)
[4]Colli et al., *48th ERF*, 096 (2022)
[5]Aliyoldashi, *Master thesis*, Politecnico di Milano (2022)