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SUBGRID-SCALE MODEL BASED ON THE INVARIANTS OF THE GRADIENT MODEL TENSOR

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The incompressible Navier-Stokes equations stand as the best mathematical model for turbulent flows. However, direct numerical simulations at high Reynolds numbers are not yet feasible because the convective term produces far too many relevant scales of motion, thus remaining limited to relatively low-Reynolds numbers. Dynamically less complex mathematical formulations have been developed for coarse-grain simulations, like the well known eddy-viscosity models. Most of these models are based on the combination of invariants of a symmetric tensor that depends on the gradient of the resolved velocity field, $\mathsf{G} = \nabla \overline{u}$, and should properly detect different flow configurations (laminar and 2D flows, near-wall behavior, transitional regime, etc.). Brand-new models have been constructed considering the first three invariants of the symmetric tensor $\mathsf{G}\mathsf{G}^T$ with excellent results [1]; hence, it is formally based on the lowest-order approximation of the subgrid stress tensor, $\tau(\overline{u}) = \frac{\Delta^2}{12}\mathsf{G}\mathsf{G}^T + O(\Delta^4)$, *i.e.* the gradient model proposed by Clark [2]. Furthermore, these models have been implemented on a pseudo-spectral algorithm with a fully-explicit second-order time-integration method [3]. The performance of this special configuration has been successfully tested for decaying isotropic turbulence and a turbulent channel flow. It is currently being developed for a semi-infinite boundary layer with periodic conditions as a previous step to carry out wind farm simulations. Details of the implementation and numerical results will be presented.

REFERENCES

[1] F. X. Trias, D. Folch, A. Gorobets, and A. Oliva. Building proper invariants for eddy-viscosity subgrid-scale models. *Physics of Fluids*, 27(6):065103, 2015.

[2] R. A. Clark, J. H. Ferziger, and W. C. Reynolds. Evaluation of subgrid-scale models using an accurately simulated turbulent flow. *Journal Fluid Mechanics*, 91:1–16, 1979.

[3] F. X. Trias, D. Folch, A. Gorobets, and A. Oliva. Spectrally-consistent regularization of Navier-Stokes equations. *Journal of Scientific Computing*, 79:992–1014, 2019.