Performance of algebraic subgrid-scale models in LES of the stable boundary layer

V. Fuka*

Stable stratification may strongly affect even turbulence at the filter scale of large eddy simulations (LES). This was demonstrated in field studies for the Smagorinsky model as a dependence of the ideal model constant value on the ratio of the filter width to the Ozmidov or Obukhov length[1].

This work presents tests of this dependence for a larger class of subgrid models using filtered fields of stably stratified turbulence from direct numerical simulation (DNS) computed using model ELMM[2]. A set of direct numerical simulations inspired by the GABLS1[3] setup has been performed with the Kolmogorov microscale $\eta \sim 0.5 - 1\,\mathrm{m}$ using a constant lower value viscosity of $\nu = 0.05\,\mathrm{m}^2.\mathrm{s}^{-1}$. The grid resolution is $\Delta_g = 1\,\mathrm{m}$ and $\Delta_g = 0.5\,\mathrm{m}$ and boththe second orderand the fourth order finite differences were tested. Multiple strengths of stability were achieved by varying the geostrophic wind speed. The performance of models modified by the resulting functions will also be assessed.

The analysis compares the profiles of the vertical momentum flux, vertical temperature flux and of the turbulent kinetic energy disipation from the DNS with the values predicted by simple algebraic subgrid models, namely the Smagorinsky model, the Vreman model, the σ-model and the mixed-time-scale model.

The example in Fig. 1 shows the dependence of the ratio of the modelled and DNS stresses on the filter width and the Ozmidov scale for the σ-model.

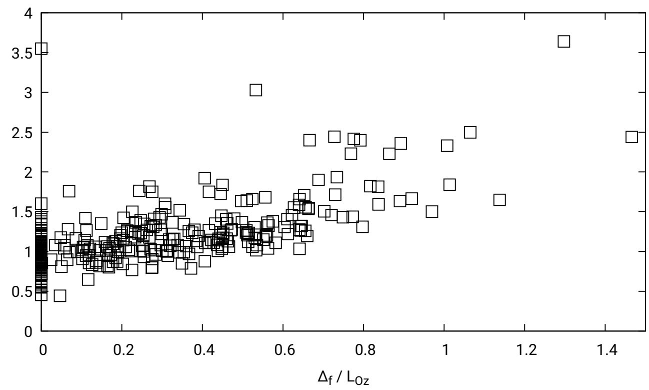

Figure 1: The ratio of the Reynolds stress modelled by the σ-model to the Reynolds stress evaluated from the DNS fields before filtering. Average values from vertical profiles based on DNS results at resolution $\Delta_g = 1\,\mathrm{m}$ with second order discretizations.

*Dep. of Atmospheric Physics, Faculty of Mathematics and Physics, Charles University in Prague, V Holesovickach 2, Prague 8, Czech Republic

[1]Bou-Zeid et al., *J. Fluid Mech.* **665**, 480 (2010).

[2]Fuka,*Applied Mathematics and Computation* **267**, 356 (2015).

[3]Beare et al.,*Boundary-Layer Meteorol.* **118**, 247 (2006).