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On dissipation rates of turbulent second-order moments

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Most of the currently used turbulence closure theories employ the concept of downgradient turbulent transport, implying that vertical turbulent fluxes of momentum $\tau_{x,y}$, potential temperature F_z and other scalars are proportional to their mean gradients. The proportionality coefficients in such relations, called eddy viscosity K_M, eddy conductivity K_H and eddy diffusivity K_D, are just the unknowns to be determined. Recently Zilitinkevich et al. (2013) have developed a new energy- and flux-budget (EFB) turbulence closure based on the budget equations for the basic second moments. Then, the flux-budget equations are used instead of traditional postulation of turbulent exchange coefficients as proportional to the turbulent velocity scale multiplied by the mixing-length scale.

To comprehensively validate the EFB turbulence closure we performed direct numerical simulation (DNS) of stably stratified Couette flow. The results disclosed quite unexpected fact. According to the conventional vision of turbulence originated to Kolmogorov-1941, all turbulent time scales defined as the ratios of the second moment in question to its dissipation rate are assumed to be proportional to each other, so that their ratios are just universal constants. However, according to our DNS, this is the case only for the pair: total turbulent kinetic energy (TKE) and vertical turbulent flux of momentum. For any other pairs, the ratios of dissipation time scales depend on stratification and represent functions of a dimensionless stability parameter such as gradient Richardson number, Ri, or flux Richardson number, Ri_f.

Following Zilitinkevich et al. (2019) we propose new formulation of the dissipation rates of the major second moments and present the advanced version of EFB turbulence closure accounting for the just revealed stability dependencies of different dissipation time scales.

Zilitinkevich S., Elperin T., Kleeorin N., Rogachevskii I., and Esau I., 2013: A Hierarchy of Energy- and Flux-Budget (EFB) Turbulence Closure Models for Stably-Stratified Geophysical Flows. *Boundary-Layer Meteorol*, **146**, 341-373.

Zilitinkevich S., Druzhinin O., Glazunov A., Kadantsev E., Mortikov E., Repina I., and Troitskaya Y., 2019: Dissipation rate of turbulent kinetic energy in stably stratified sheared flows. *Atmos. Chem. Phys.*, **19**, 2489-2496, https://doi.org/10.5194/acp-19-2489-2019.