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Verification and calibration of Energy- and Flux-Budget (EFB) turbulence closure model through large eddy simulations and direct numerical simulations

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We examine and validate the EFB turbulence closure model (Zilitinkevich et al., 2013), which is based on the budget equations for basic second moments, namely, two energies: turbulent kinetic energy E_K and turbulent potential energy E_P, and vertical turbulent fluxes of momentum and potential temperature, τ_i (i = 1, 2) and F_z. Instead of traditional postulation of down-gradient turbulent transport, the EFB closure determines the eddy viscosity and eddy conductivity from the steady-state version of the budget equations for τ_i and F_z. Furthermore, the EFB closure involves new prognostic equation for turbulent dissipation time scale t_T, and extends the theory to non-steady turbulence regimes accounting for non-gradient and non-local turbulent transports (when the traditional concepts of eddy viscosity and eddy conductivity become generally inconsistent).

Our special interest is in asymptotic behavior of the EFB closure in strongly stable stratification. For this purpose, we consider plane Couette flow, namely, the flow between two infinite parallel plates, one of which is moving relative to another. We use a set of Direct Numerical Simulation (DNS) experiments at the highest possible Reynolds numbers for different bulk Richardson numbers (Druzhinin et al., 2015).

To demonstrate potential improvements in Numerical Weather Prediction models, we test the new closure model in various idealized cases, varying stratification from the neutral and conventionally neutral to stable (GABLS1) running a test RANS model and HARMONIE/AROME model in single-column mode. Results are compared with DNS and LES (Large Eddy Simulation) runs and different numerical weather prediction models.