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Dependence of vertical fluxes on SGS parameterization schemes in a stable boundary layer

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Large-Eddy Simulation (LES) has been widely used in numerical simulations of a planetary boundary layer. However, numerical modeling used LES becomes to be difficult in a stable boundary layer, because of a smaller characteristic scale of turbulent mixing. Kitamura (2010, JMSJ) performed numerical simulations with four types of subgrid-scale (SGS) parameterization schemes in a stable boundary layer and found that the vertical profile of momentum and heat fluxes does not converge on a unique profile, even at a higher model resolution. In the present study, we analyze what bring the spread of these fluxes among the SGS parameterization schemes.

First, we divide the horizontal mean flux into grid-scale (GS) and SGS parts. The dependence of the momentum and heat fluxes on the SGS schemes almost appears in the GS part. Furthermore, the spread of the fluxes is attributed to the GS component in lower horizontal wavenumbers except in the vicinity of the surface. This result suggests that it is important to understand the effects of the SGS schemes on the GS disturbance in the lower wavenumber region.

Dependence on the SGS schemes is observed also in the SGS part of the heat flux. The dependence can be attributed to different formulations of turbulent Prandtl number among the SGS schemes: the spread seen in the SGS heat flux vanishes when a same formulation of turbulent Prandtl number is adopted. This implies that a proper formulation of turbulent Prandtl number is necessary for SGS modeling. However, turbulent Prandtl number in strong stratification is still uncertain despite of many studies in this issue. A further study requires for determining turbulent Prandtl number in strong stratification.

Keywords: Large-Eddy Simulation, Atmospheric boundary layer, Turbulent flux, Parameterization