8.2 Representation of the subrid-scale turbulent transport in convective boundary layers at gray-zone resolutions

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Parameterization of the unresolved vertical transport in the planetary boundary layer (PBL) is one of key physics algorithms in atmospheric models. This study attempts to represent the subgrid-scale (SGS) turbulent transport in convective boundary layers (CBLs) at gray-zone resolutions by investigating the effects of grid-size dependency in the vertical heat transport parameterization for CBL simulations. The SGS transport profile is parameterized based on the conceptual derivation of Shin and Hong. First, nonlocal transport via strong updrafts and local transport via the remaining small-scale eddies are separately calculated. Second, the SGS nonlocal transport is formulated by multiplying a grid-size dependency function with the total nonlocal transport profile fitted to the large-eddy simulation (LES) output. Finally, the SGS local transport is formulated by multiplying a grid-size dependency function with the total local transport profile, which is calculated using an eddy-diffusivity formula. The new algorithm is evaluated against the LES output and compared with a conventional nonlocal PBL parameterization.
For an ideal CBL case, by considering the scale dependency in the parameterized vertical heat transport, improvements over the conventional scheme appear in mean profiles, resolved and SGS vertical transport profiles with their grid-size dependency, and the energy spectrum. Real-case simulations for convective rolls show that the simulated roll structures are more robust with stronger intensity when the new algorithm is used.