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Subgrid-Scale Turbulent Transport in Convective Boundary Layers at Gray-Zone Resolutions

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The parameterization of the unresolved vertical transport in 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 to the CBL simulations. The SGS transport profile is parameterized based on the conceptual derivation of Shin and Hong. First, nonlocal transport by the strong updrafts and local transport by remaining small-scale eddies are separately calculated. Second, SGS nonlocal transport is formulated by multiplying a grid-size dependency function to total nonlocal transport profile fitted to the large-eddy simulation (LES) output. Finally, SGS local transport is reduced according to the grid size decrease by multiplying a grid-size dependency function to total local transport profile that is calculated by 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 and their grid-size dependency, as well as 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.