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Large-eddy Simulation Analysis of Shallow Cumulus Convection at Gray-Zone Resolutions

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The representation of shallow cumulus convection is an important issue for numerical weather prediction (NWP) models. As the resolution of NWP models steadily increases, such that grid size becomes comparable to the typical size of the energy-containing eddies, the grid sizes fall within the gray zone. How to represent the effect of shallow convection in NWP models at gray-zone resolutions presents a number of challenges.
To deal with the challenges, two large-eddy simulations (LES) of shallow convection are carried out at 25m*25m*20m resolution in this study. Reference data for vertical subgrid fluxes are coarse-grained from the LES output.The subgrid flux can be decomposed into three terms: the first term is the turbulent flux in cloud, the second describes the environmental turbulence, and the third term describes the organized turbulence term. We examine the grid-size dependency and relative importance of each term in shallow convection for different horizontal grid sizes.We also assess the sensitivity of the subgrid flux to three different conditional sampling methods. The results from this study show that the cloud fraction and the partition of total subgrid flux in shallow convection are very sensitive to sampling methods.