Nested mesoscale-to-LES modeling of the atmospheric boundary layer in the presence of under-resolved convective structures

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Abstract

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Multi-scale atmospheric simulations can be computationally prohibitive, as they require large domains and fine spatio-temporal resolutions. Grid-nesting can alleviate this by bridging mesoscales and microscales, but one turbulence scheme must run at resolutions within a range of scales known as the terra incognita (TI). TI grid-cell sizes can violate both mesoscale and microscale subgrid-scale parametrization assumptions, resulting in unrealistic flow structures. Herein we assess the impact of unrealistic lateral boundary conditions from parent mesoscale simulations at TI resolutions on nested large eddy simulations (LES), to determine whether parent domains bias the nested LES. We present a series of idealized nested mesoscale-to-LES runs of a dry convective boundary layer (CBL) with different parent resolutions in the TI. We compare the nested LES with a stand-alone LES with periodic boundary conditions. The nested LES domains develop ~20% smaller convective structures, while potential temperature profiles are nearly identical for both the mesoscales and LES simulations. The horizontal wind speed and surface wind shear in the nested simulations closely resemble the reference LES. Heat fluxes are overestimated by up to ~0.01 K m s^{-1} in the top half of the PBL for all nested simulations. Overestimates of turbulent kinetic energy (TKE) and Reynolds stress in the nested domains are proportional to the parent domain's grid-cell size, and are almost eliminated for the simulation with the finest parent grid-cell size. Based on these results, we recommend that LES of the CBL be forced by mesoscale simulations with the finest practical resolution.

References (Times New Roman 9 pt font**)**

1. Mazzaro, L. J., D. Muñoz-Esparza, J. K. Lundquist, *and* R. R. Linn *(2017), Nested mesoscale-to-LES modeling of the atmospheric boundary layer in the presence of under-resolved convective structures, J. Adv. Model. Earth Syst., 9, doi:10.1002/2017MS000912.*