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A Three-Dimensional Scale-adaptive Turbulent Kinetic Energy Model in ARW-WRF Model

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A new three-dimensional (3D) turbulent kinetic energy (TKE) subgrid mixing model is developed to address the problem of simulating the convective boundary layer (CBL) across the terra incognita in the Advanced Research version of the Weather Research and Forecasting Model (ARW-WRF). The new model combines the horizontal and vertical subgrid turbulent mixing into a single energetically consistent framework, in contrast to the convectional one-dimensional (1D) planetary boundary layer (PBL) schemes. The transition between large-eddy simulation (LES) and mesoscale limit is accomplished in the new scale-adaptive model.
A series of dry CBL and real-time simulations using the WRF model are carried out, in which the newly-developed, scale-adaptive, more general and energetically consistent TKE-based model is compared with the conventional 1D TKE-based PBL schemes for parameterizing vertical subgrid turbulent mixing against the WRF LES dataset and observations. The characteristics of the WRF-simulated results using the new and conventional schemes are compared. The importance of including the nonlocal component in the vertical buoyancy specification in the newly-developed general TKE-based scheme is illustrated. The improvements of the new scheme over convectional PBL schemes across the terra incognita can be seen in the partitioning of vertical flux profiles. Through comparing the results from the simulations against the WRF LES dataset and observations, we will show the feasibility of using the new scheme in the WRF model in the lieu of the conventional PBL parameterization schemes.