Special Program in Applied Mathematics and Applied Mechanics

Resolution-dependent behavior of subgrid-scale vertical transport in the Zhang-McFarlane convection parameterization

2015 - 12 - 02 (Wed.)
15:00 - 18:00
308, Mathematics Research Center Building (ori. New Math. Bldg.)

In this study we develop a diagnostic framework to examine the resolution-dependence of subgrid-scale vertical transport of moist static energy as parameterized by the Zhang-McFarlane convection parameterization (ZM). ZM is subgrid-scale parameterization of atmospheric moist convection commonly used in global climate models. In our framework, we feed the standalone ZM parameterization with grid-scale input supplied by coarsening output from cloud resolving model (CRM) simulations onto sub-domains ranging in size from 8×8 to 256×256 km^2. Then the ZM-produced subgrid-scale vertical transport of moist static energy for different sub-domain sizes is compared to that directly calculated from the CRM simulations. We find that (1) the ensemble mean of CRM-produced subgrid-scale transport decreases by more than half as the sub-domain size decreases from 128x128 to 8x8 km^2 while that of ZM-produced subgrid-scale transport decreases with sub-domain size only for strong convection cases and increases for weaker cases. Our analysis shows that this behavior can be explained by the behavior of grid-scale CAPE tendency used in the convective quasi-equilibrium based closure. We introduce a simple averaging algorithm that enables the consistent application of convective quasi-equilibrium-based closure at high resolution and improves the resolution dependence of ZM-produced subgrid-scale transport significantly; (2) the overall variability of CRM-produced subgrid-scale transport increases very significantly as resolution increases. ZM cannot capture this increase, suggesting the need for stochastic treatment of convection at relatively high spatial resolution (8 or 16 km).