Evaluations of the Parameterized Deep Convection using a Cloud-Resolving Model

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With explicit representation of deep convection, cloud-resolving models (CRMs) have been widely used to understand the relationship between cloud formation and precipitation processes, as well as to validate and improve physical parameterizations in numerical prediction models. Using the Goddard cumulus ensemble (GCE) model run as a reference, which is driven by observed large-scale forcing data collected during intensive observing periods in the past field campaigns, this study examines the simulation of precipitation, cloud, and hydrometeors by various types of cumulus convection scheme implemented in the Weather Research and Forecasting (WRF) model. For the comparison with GCE, the identical observed large-scale forcing data are prescribed to the WRF model simulation in the single column model (SCM) framework. Tested cases include the case of Atmospheric Radiation Measurement (ARM) at South Great Plain (SGP) during the continental summer season in mid-latitude, and the case of Tropical Warm Pool/International Cloud Experiment (TWP/ICE) during tropical summer monsoon season.

In the evaluation, the GCE model tends to reproduce the observed variation of precipitation and vertical profiles of heating and moistening rates fairly well, which suggests that the GCE simulation can be a good reference for evaluating deep convection schemes and WRF. WRF SCMs with the different convection schemes show in general better performances in the TWP/ICE case, which is mostly driven by grid-scale precipitation in the model. On the other hand in mid-latitude continental convection, they exhibit larger bias with less agreement across the SCMs, largely caused by differences and deficiencies in the parameterized deep convection scheme. Even though the microphysics and radiation schemes are identical in the GCE and WRF runs, the simulated vertical distribution of hydrometeors show wide spread due to the difference in convection schemes. This study further examined the diurnal cycle of rainfall simulated by various convection schemes to identify the deficiency in the parameterization and explore the possibility of improvement.

Key words: Cloud-resolving model, Single column model, Cumulus physics, Precipitation