The Interaction between Cumulus Convection and its Environment over the Indian Ocean during the CINDY2011/DYNAMO period as Revealed by 100-m-Mesh Convection-Resolving Simulations

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The activity of cumulus convection in the tropical oceanic regions is strongly regulated by the larger-scale environmental atmosphere, while at the same time cumulus convection influences the larger-scale atmosphere. It is recognized that the spatial and temporal variability of moisture content play an important role in determining such interaction processes: the down-scale regulation and up-scale influence. This study investigates the interaction between tropical cumulus convection and its environmental atmosphere by conducting 100-m-mesh numerical simulations intended to sufficiently resolve mixing processes between cumulus clouds and their environments in the tropical Indian Ocean region during the active and in-active phases of Madden-Julian Oscillation. The cases from the Cooperative Indian Ocean experiment on intraseasonal variability in the Year 2011 (CINDY2012)/Dynamics of MJO (DYNAMO) are examined. Numerical simulations are conducted with the use of the Weather Research and Forecasting (WRF)/the Advanced Research WRF (ARW) model with the nesting capability to resolve the area of interest at high resolutions. The computational domains cover the area of 2500 km by 2250 km, 1200 km by 1000 km, 300 km by 300 km, and 100 km by 60 km at 12.5-km, 2.5-km, 500-m, and 100-m horizontal resolution, respectively. The subgrid-scale model of Deardorff (1980), a LES-type scheme, is used for parameterizing turbulent mixing. The computational domains at the 500-m and 100-m grids are centered at the R/V Mirai observation site. The relationship among the tropospheric moisture variation, the diurnal variation of the atmospheric boundary layer, and the development and evolution of cumulus convection is specifically focused. Downscale regulation of environmental conditions on cumulus convection and upscale organization from boundary-layer disturbances to mesoscale convective systems are investigated from a turbulence mixing perspective. It is shown that the development and organization of cumulus clouds are significantly affected by moisture variability and the deep convective activity influences moisture fields at the larger-scales. It is also demonstrated that the existence of undiluted updraft cores plays a key role in the interaction processes.