Statistical Properties of Cumulus Ensembles in High-Resolution Radiative-Convective Equilibrium Simulations

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This study investigates the statistical properties of cumulus ensembles in radiative-convective equilibrium states. Numerical experiments were conducted with the use of the non-hydrostatic Weather Research and Forecasting (WRF) model version 3.8.1 at horizontal grid spacing varied from 1600 m to 200 m in an area of $(200\ km)^2$, with an interactive radiative flux calculation scheme. The experiment with the horizontal grid spacing of 200 m successfully reproduced the diurnal variability of the trimodal characteristics of cumulus convection. With the decrease in the horizontal resolution, intermittent deep convection accompanied by the strong updraft and rainfall becomes dominant. The middle-to-upper troposphere appears to become stabler and drier with the decrease in the horizontal resolution. We further analyzed the cloud structures by using a three-dimensional cloud detection method. It is suggested that the vertical structure of in-cloud properties and the vertical development of cumulus ensembles are strongly affected by horizontal scales of microstructure which are constrained by horizontal resolution. Furthermore, it is suggested that the statistical properties of cumulus ensemble such as horizontal distances and size distribution are related to the horizontal heterogeneity of water vapor.

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