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Cloud-resolving numerical experiments on large-scale organization of convection

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Organization of moist convection in a large domain O(1000 km) is investigated by cloud resolving numerical experiments. In particular, dominant mode of convection is highlighted. A series of experiments were conducted taking the 1000-, 5000-, and 40000-km zonal domain (100-km in meridional) with the horizontal resolution of 2 km, using the massively parallel version of the Japan Meteorological Agency Non-hydrostatic Model (JMA-NHM) on the Earth Simulator. A simple setup of radiative-convective equilibrium experiments (Tompkins 2001) is applied; with uniform radiative cooling of 2 K day^{-1} below the 12-km height, fixed sea surface temperature of 300 K, and omitting Coriolis force.

In the 1000-km domain case, a convective system coupled with a large-scale (1000-km wave length) gravity wave domiated at a nearly steady state (after 40-day integration). Clouds are locked to the upward phase of the gravity wave, and propagated at a phase velocity of about 11 m s^{-1}. Consistent with previous studies, the gravity wave had a boomerang-shaped vertical structure, and the cloud region is characterized by positive (negative) temperature anomaly in the upper (lower) troposphere.

In the 5000-km and 40000-km domain runs, where the domain-averaged sounding of the 1000-km run at the final time was initially given, cloud systems similar to those in the 1000-km case were obtained. Moreover, multi-scale organization was also observed in these experiments; several groups of clouds (about 200-km width) were embedded in the upward phase of gravity waves (about 5000-km wave length), and the each group moved in the opposite direction to the propagation of the wave. Interestingly, the dominant wave length in the 40000-km domain run was comparable to the 5000-km counterpart, at least during the 7-day period of the simulation.

Finally, the results are compared with those from global cloud-resolving (3.5-km horizontal resolution) numerical experiments under an aqua-planet setup (using the Non-hydrostatic Icosahedral Atmospheric Mdoel, NICAM; Tomita et al., in this session). It should be remarked that the convective systems as described above were also predominant in the aqua-planet experiments, though the latter also captured the planetary (40000-km) scale structure. Although the experimental setup was highly simplified, the results obtained in this study by resolving clouds will provide a useful clue to understand the cloud organization on the global scale.