Change in the horizontal scales of convection due to the self-aggregation of clouds under the radiative convective equilibrium

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Idealized explicit convection simulations in radiative convective equilibrium (RCE) has been applied to research on tropical convection. Recent studies using three-dimensional cloud-resolving model in RCE conditions show convection can aggregate into a single region, when the domain is sufficiently large and the sea surface temperature (SST) is warm enough. The phenomenon is called as ‘self-aggregation’. Convective organization modifies the mean vertical profiles of temperature, water vapor, and radiative fluxes. The mean climate change into dry and warm after self-aggregation occurs. Self-aggregation is sensitive to the SST, domain size, and horizontal resolution. Previous studies show aggregations favor relatively high SST and large domain size. However, these dependency is not clearly understood. In this study, we are attempt to determine the sizes of a moist region after aggregated and research the SST dependency of them.
We use SCALE-RM model which is non-hydrostatic cloud resolving model developed by RIKEN AICS. The horizontal spacing is 4 km, with 80 vertical levels. Simulations have a domain size of 512 km X 512 km with doubly periodic lateral boundaries, fixed incoming solar radiation. These were conducted in which SST was changed from 292 K to 310 K every 2 K. Self-aggregation occurs in SST over 304 K. The horizontal length scale is determined spatial autocorrelation is larger than 1/e about various two-dimensional variables. Horizontal scales about perceptible water, OLR lowest model level water vape mixing ratio (Qv) are about 200 km when aggregation occurs (SST is larger than 304K) in this study at all aggregate case. However, these about 35m (lowest model level) temperature decrease with increasing SST. In no aggregate cases, the same trend is observed. In these cases, scales of Qv are about 30 km, but these of T are 30~100 km. Self-aggregation seems to be selected when Qv and T scale are same. Furthermore, simulations with water vapor nudging with horizontal mean water vapor shows low troposphere humidity anomaly is important for self-aggregation. Furthermore, simulations with water vapor nudging with horizontal mean water vapor shows low troposphere humidity anomaly is important for self-aggregation. These results show self-aggregation depends on low troposphere and boundary layer process.

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