Sensitivity studies of cloud responses on SSTs in RCE experiments using a high-resolution global nonhydrostatic model

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As the variation in climate sensitivity among global climate models (GCM) is largely attributable to differences in cloud feedback, better understanding of the response of clouds to climate changes provides important insights into climate science. The radiative-convective equilibrium (RCE) is one of key ingredients in order to understand the role of moist convection in the atmosphere. To reduce the uncertainties of the response of clouds to climate changes, simulations with RCE configurations are examined using a high-resolution nonhydrostatic global circulation model (the Nonhydrostatic Icosahedral Atmospheric Model; NICAM; Satoh et al., 2014). The configurations with fixed SSTs, explicit microphysics parameterizations, and no cumulus parameterization are used. Especially, the sensitivity of the high clouds, liquid water path, and ice water path to vertical grid spacings are studied using fixed SST configurations, as previous studies showed high clouds responses are different between NICAM and other coarse resolution climate models. In addition, it was found that vertical grid spacings of 400 m or less are necessary to resolve the bulk structure of cirrus clouds, we also examine sensitivities to vertical resolutions (Seiki et al., 2015).

It is found that amounts of high cloud increase as associated with the increase of SST in the simulations with different cloud microphysics schemes, although the heights of high clouds and detrainment speeds near the convective region depend on microphysics schemes used. The responses of the amount of high cloud are consistent with those of the tropical cloud of the study of Satoh et al. (2012) based on the global simulations. However, the response of the amount of high cloud in simulations with higher vertical resolutions vary with cloud microphysics schemes, although the heights of high clouds and detrainment speeds near the convective region are similar to those of simulations with relatively lower vertical resolutions. These results indicate that differences of properties of clouds such as effective radii of hydrometeors and their dependencies for the vertical resolution are possible cause of variations of the response of clouds to climate changes. In addition, they suggest the possible existence of uncertainties of the results of studies based on the simulations with conventional GCMs which do not consider the microphysical properties.

Keywords: radiative-convective equilibrium

