Radiative-convective Equilibrium Study with a Global Nonhydrostatic Model: Sensitivity of High Clouds to Cloud Microphysics and Vertical Resolution

*Tomoki Ohno[1], Masaki Satoh[2,1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Atmosphere and Ocean Research Institute, The University of Tokyo

As the high clouds have large impacts not only on short- and long-wave radiation, but also on the environmental fields for the convective activity, it is important to improve the understanding of the high cloud changes in response to warmer climates. Radiative-convective equilibrium (RCE) experiments are a unique set of experiments to study uncertainties of cloud feedback, particularly that of high clouds associated with deep moist convection.
We conducted simulations with RCE configurations using a high-resolution nonhydrostatic global circulation model (the Nonhydrostatic Icosahedral Atmospheric Model; NICAM). The experiments are conducted with horizontal resolution of 14 km with the earth-like sphere. Sea surface temperatures (SSTs) are fixed at 300K and 304K and two kinds of cloud microphysics scheme (single- and double-moment bulk scheme) are compared. We used no cumulus parameterization scheme.
We found that high cloud amount generally increases with SST at the control simulation with a single-momentum bulk scheme, as consistent with the previous NICAM studies. However, the sign of the response becomes inverse when a double momentum scheme with higher vertical resolution. The results indicate that differences of cloud properties such as effective radii of hydrometeors and their dependencies on the vertical resolution are possible cause of variations of the response of high clouds. It was determined that increasing vertical resolution generally reduced high clouds. It was also determined that cloud-radiation interaction causes the increase of cloud amount associated with increase of SST, although pressure dependencies of cloud microphysical processes tend to reduce cloud amount. This study indicates importance of cloud microphysics processes to understand high cloud responses with climate change.

Keywords: Radiative-convective equilibrium, high cloud changes, global cloud resolving model