Super Fine Vertical Resolution Radiative-Convective Equilibrium Experiments on the High-Cloud Response to Sea Surface Temperatures

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Abstract

As the high clouds have large impacts not only on shortwave and longwave 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.

As the vertical resolution has large impacts on the representability of high clouds, it is expected to have impacts on high-cloud amount responses on global warming. In this study, we examined the vertical resolution dependency of high-cloud amount response on sea surface temperature (SST) changes. We conducted simulations with RCE configurations on the earth-like sphere domain using a nonhydrostatic global circulation model (the Nonhydrostatic Icosahedral Atmospheric Model; NICAM) and a two-moment bulk cloud microphysics scheme. Constant SSTs of 300 and 304 K were used as lower boundary conditions. We compare responses with five vertical layer configurations where the layer depths are about 1 km to 50 m.

We found that although high-cloud amounts decrease with the SST increase using relatively lower vertical resolutions configuration, they increase using higher vertical resolution configurations. A budget analysis of ice water condensate and sensitivity experiments revealed that the variability of responses were caused by the differences in the interactions between the turbulent mixing and the cloud microphysics. The results speculate that the climate sensitivity depends on the natures of both turbulence and cloud microphysics at the high altitude through the high-cloud amount responses.