Importance of the cloud-altitude change to the high-cloud response to sea surface temperatures

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Since it has been recognized that the uncertainty of cloud feedback is one of main contributors to the intermodel spread of climate sensitivity, the reduction of the uncertainties associated with cloud response to global warming has been one of central issues for robust projections and predictions of climate variability and change. High clouds have large impacts on the Earth's radiative energy budget, and the uncertainty of their response to global warming is known as one of large sources of the climate sensitivity spread. The conventional paradigm for high-cloud response to global warming attributes them to the change of the detrainment associated with the radiatively-driven circulation in the clear-sky region based on the so-called fixed anvil temperature hypothesis. This study examined the role of the cloud microphysics for the high-cloud response to sea surface temperatures (SSTs) based on radiative-convective equilibrium (RCE) simulations.

The RCE simulations were conducted using a nonhydrostatic global circulation model (the Nonhydrostatic Icosahedral Atmospheric Model; NICAM) with uniform SSTs of 300 and 304 K over the spherical domain for the Earth radius without rotation. The configuration with an explicit microphysics parameterization, and no cumulus was used.

It was determined that the tendency of ice cloud from cloud microphysical processes was dominated by the deposition growth and sublimation. It was also determined that the reduction of the time scale of these processes associated with the elevation of the altitude of clouds with higher SSTs reduce the high-cloud cover. Our results highlight the importance of the cloud-altitude change to the high-cloud response to global warming. It was also speculated the need for novel cloud-fraction diagnosis scheme considering the time scale of the sublimation processes, which is generally not accounted for schemes based on the saturation-adjustment approach.

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