Improvements and Reductions in Systematic Errors Associated with Clouds in the MRI Climate Model

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Introduction

The previous version of the climate model of MRI MRI-GCGM3 (Yukimoto et al. 2012; TL159/48 in the standard configuration), which was used for CMIP5 simulations, had various systematic errors associated with clouds. In the updated version of our climate model, MRI-ESM2 (TL159/80), which is planned for use in CMIP6 simulations, some of such errors are reduced, and the representations of clouds and aerosol-cloud interactions are improved. Figures show that the biases in total cloud cover and shortwave cloud radiative effect are substantially reduced in the new version. The main improvements are briefly summarized herein.

Examples of Improvements & the Results

New stratocumulus parameterization

Low Cloud Cover

Old Sc scheme New Sc scheme Obs (SCCP)

New stratocumulus parameterization based on a stability index that considers a cloud-top entrainment criterion (Kawai 2013) was introduced in the new version. Cloud shortage over Southern Ocean was alleviated.

Suppression of Shallow Convection

Cross sections of cloud fraction along 20°S

Test: Occurrence of shallow convection is suppressed over the area where the conditions for stratocumulus occurrence are met.

Low-level cloud transition from stratocumulus to cumulus became more realistic in the new version (a model with L80 vertical resolution is used).

Summary

The major improvements are as follows:

i. Introduction of a new stratocumulus parameterization based on CTE (cloud top entrainment) criterion (Kawai 2013)

ii. Increased vertical resolution from L48 to L80

iii. Suppression of shallow convection under condition of stratocumulus occurrence

iv. Improvements in the cloud overlap scheme (introduction of PICA: Nagasawa 2012)

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vi. Abolishment of spatially reduced calculation of a radiation process

vii. Improvement of calculation of cloud ice fall (based on Kawai 2005)

viii. Calculation became more realistic & the time-step dependency of ice water content was alleviated.

Taylor diagrams

Biases in total cloud cover

MRI-GCGM3 MRI-ESM2

(%, data: SCP)

Biases in shortwave cloud radiative effect

MRI-GCGM3 MRI-ESM2

[Obs, data: CERES-EBAF]

References

Kawai, H., 2005: Improvement of a Cloud Ice Fall Scheme in GCM. CAS/JSC WGAE Research Activities in Atmospheric and Oceanic Modeling/MM5, 35, 4-11-4-12.
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