Evaluations of thermodynamic phases of clouds in NICAM using Joint simulator and CALIPSO

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1. Introduction

It is important to evaluate and improve the cloud microphysics schemes in non-hydrostatic models such as NICAM (Satoh et al. 2014) using observation data. One of methods is a radiance-based evaluation using satellite data and a satellite simulator, which avoids making different settings of the microphysics between retrieval algorithms and NICAM.

Depolarization ratio is defined as the ratio of backscatters in the planes of polarization perpendicular and parallel to the linearly polarized incident beam. Depolarization ratio has been used for inferring the cloud phase and the nature of ice crystals. Yoshida et al. (2010) developed a method that enables discrimination of vertically resolved cloud particle types based on depolarization ratio and a new parameter (x) estimated from two attenuated backscattering coefficients in neighboring layers using a Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO). These parameters can discriminate between water and ice particles.

We evaluated thermodynamic phases of clouds in a NICAM using Joint simulator and CALIPSO following Yoshida et al. (2010).

2. Experimental design and data

NICAM is a global, non-hydrostatic model that can be applied regionally by transforming the horizontal grid system to focus on a region of interest (stretched NICAM; Tomita 2008a). The analysis domain is the region of the Southern Ocean between 45°S to 65°S and 170°E to 170°W. Mixed phased clouds are dominant and a convective system occurs. We focused on the period from 00:00 UTC on January 2 to 00:00 UTC on January 3, 2007. Two microphysics schemes, the original NICAM Single-Moment Water (NSW6) scheme (hereafter, CON; Tomita, 2008b) and the modified NSW6 scheme (hereafter, MODI) following Roh et al. (2017), were used and evaluated in this study.

For the evaluation, we used Joint simulator (Hashino et al. 2013) as a satellite simulator and developed the simulator of depolarization ratio in Joint simulator. A merged dataset for CloudSat CPR radar and CALIPSO lidar is used as observation data. (Hagihara et al. 2010, hereafter, KU data). In order to increase the sample size, the Ku data for the month of January 2007 is compared to the simulation.

3. Results

Figure shows two-dimension frequency distributions of x and depolarization ratio for mixed phased clouds between -20°C to 0°C among KU data, CON, and MODI. The observation shows frequencies of 2D plate ice clouds and super-cooled water clouds are dominant in the cloud particle diagram of Yoshida et al. 2010. The peak of frequencies located from 0% and 3% of depolarization ratio related to 2D plate ice clouds. CON and MODI shows overestimation of frequencies of 3D ice clouds than the observation data. The peak of frequencies is between 20% and 40% of depolarization ratio. Both simulations do not reproduce frequencies of the 2D plate regimes, because 2D plate ice is not considered in microphysics of NICAM and Joint simulator. It is needed to understand and consider 2D plate ice clouds in microphysics of NICAM and Joint simulator.

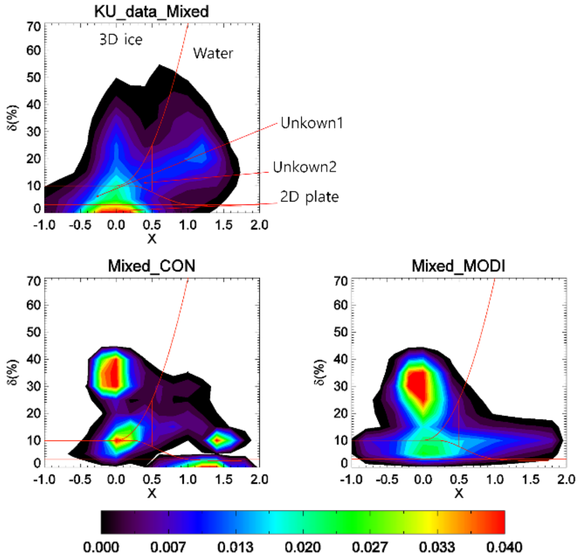

Figure. Joint histograms of clouds in terms of x and depolarization ratio (δ) between -20°C to 0°C in January 2007. a) is from CALIPSO data. b) is from CON, and c) is from MODI. PDFs of cloud occurrences are shown on the below.

MODI underestimates super cooled water clouds comparing to observation and CON. To improve the simulation of supercooled water clouds in MODI, we investigate the microphysical processes related to supercooled water clouds. We try to consider and evaluate the effects of 2D plate ice clouds in a satellite simulator.

References

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