Evaluation of cloud cluster properties of NICAM using T3EF and split window
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1. Introduction
The cloud cluster is one of the main sources of rain and cloudiness over the Tropics. It occurs in connection with an ensemble of small thunderstorms and produces a contiguous precipitation area about 100 km or more in horizontal scale. Thus cloud resolving models (CRMs) are needed to explicitly resolve convective cloud systems with a horizontal grid spacing of a few kilometers for the simulation of cloud clusters. Satellite observations are also used to study tropical cloud systems such as TRMM and geostationary satellite data and compare with numerical simulations. It is preferable to compare cloud radiance with calculated radiances from numerical simulations using satellite simulators, because retrieved physical products from satellite data have different estimation methods and microphysics assumption in comparison with CRMs. Matsui et al. (2009) proposed the TRMM Triple Sensor ThreeStep Evaluation Framework (T3EF) for the systematic evaluation of precipitating cloud types and microphysics in CRMs. However, it is difficult to investigate relationship between the high clouds and each cloud types in detail. Inoue et al. (1987) developed split window technique based on temperature between the 11 and 12 μm (BTD). It can classify optically thin cirrus clouds and optically thick clouds.

In this study, we evaluate precipitating clouds of cloud cluster in NICAM using T3EF and investigate the relationship between precipitating clouds and high clouds using split window technique.

2. Data
2.1 NICAM
NICAM simulations are performed from 00 UTC 1 January to 12 UTC 5 January 2007. The actual analysis was made for the period of from 00 UTC 2 to 12 UTC 5 January. The central point of the simulation is 180E on the equator and analysis domain is 20S-20N and 160E-160S. We used the stretched grid system, and the minimum horizontal grid are set to 7 km, and maximum grid are set to 112km. The range of analysis domain is from 7km to almost 15 km. The vertical grid number is 40 and it covers from surface to 40 km. The vertical resolution become coarser to the upper level. The vertical analysis range is to 20km, grid number is 32. We used the initial data as a GPV (Grid Point Values) by JMA (the Japan Meteorological Agency). We analyze hourly data.

2.2 TRMM data
TRMM PR 13.8 GHz attenuation corrected reflectivity from the TRMM 2A25, TMI 85.5 GHz dual-polarization microwave brightness temperature from TRMM 1B11, 12 μm infrared brightness temperature from TRMM 1B01 are used for analysis for T3EF methods.

2.3 Satellite simulator
The Satellite Data Simulation Unit (SDSU) is a multi-sensor and multi-spectral satellite simulator package, developed by Masunaga et al. It simulates microwave brightness temperature, radar reflectivity, and visible/infrared radiance as measured by meteorological satellite sensors.

2.4 MTSAT and Split windows
Hourly 11μm and 12μm data acquired by MTSAT was used for the life cycle of cloud clusters and cloud classification by the split window.

3. Results
NICAM reproduces two convective cluster bands corresponding to infrared brightness temperatures (TBB) and 85 GHz polarization corrected brightness temperatures in TRMM.

![Figure. Probability distributions of precipitatin rates for each category in T3EF.](image)

<table>
<thead>
<tr>
<th>Table. Percentage of each category in T3EF</th>
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<tbody>
<tr>
<td>Shallow</td>
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<td>TRMM</td>
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<td>NICAM</td>
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The simulated probability distribution of precipitation rate has similar patterns with TRMM's orbital precipitation rate (Figure). NICAM has a good agreement with frequency precipitation rates of shallow and deep category. However, the more than 50% of rainfall amount in NICAM occurs in deep cloud category (35.7% in TRMM). Micolod category in NICAM underestimates the precipitation (2.9% in NICAM, 24.2% in TRMM). The frequency of percentage for each category of T3EF shows there are a discrepancy of micolod and deep category between observations and simulations (Table).

We would have sensitivity tests to improve disagreements of simulation results. Furthermore, we would investigate life cycles of a tracking method using 11 μm TBB using a satellite simulator and factors related to the life cycle of cloud clusters.