Project name：Numerical study on cloud systems using NICAM

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Research period：April 2021～March 2022

1. Research purpose

It is important to evaluate and improve the cloud properties in global non-hydrostatic models like a Nonhydrostatic ICosahedral Atmospheric Model (NICAM, Satoh et al. 2014) using observation data. One of the methods is a radiance-based evaluation using satellite data and a satellite simulator (here Joint simulator, Hashino et al. 2013), which avoids making different settings of the microphysics between retrieval algorithms and NICAM.

The satellite data with active sensors has a limitation to observe the specific case of cloud and precipitation systems. And it is needed to validate satellite observations using in-situ observation. There are intensive observation stations over the Kanto region. The ULTIMATE (ULTra sIte for Measuring Atmosphere of Tokyo metropolitan Environment) is proposed to verify and improve high resolution numerical simulations based on these observation data.

This research is for evaluation and improvement of clouds and precipitation systems in NICAM using the intensive observation data over the Kato area.

2. Research plan

There are several observation instruments over the Kanto region. Figure 1 shows the ultra-site observation networks in Kanto area. In the previous fiscal, we achieved the observation data like C-band polarimetric radars in Narita and Haneda airport and WINDAS data. And we got the observation data of the Cloud Profiling Radar (CPR, 94 GHz) in NICT.

POLArimetric Radar Retrieval and Instrument Simulator (POLARRIS, Matsui et. al. 2019) was implemented in Joint simulator. The POLARRIS can simulate differential reflectivity (Zdr), specific differential phase shift (Kdp), co-polar cross-correlation coefficient (ρhv), and Doppler velocity of a polarimetric radar using Mueller scattering matrix.

We used the stretched version of NICAM. We selected three cases for September 2019. We calculate the signals of polarimetric radar using Joint simulator.

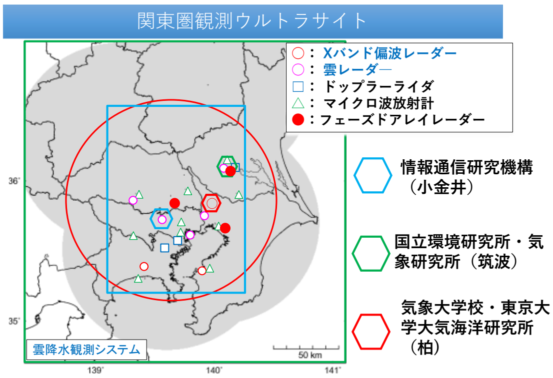

Fig. 1. Ultra-site observation networks in Kanto area.

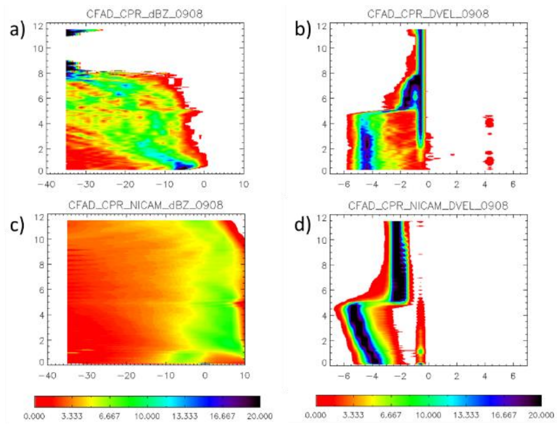

Fig. 2. The Contoured Frequency by Altitude Diagrams (CFADs) of radar reflectivity (left) and Doppler velocity (right) between NICT CPR (top) and NICAM GL8 (bottom) for the TC Faxai. The unit of y-axis is km. The units of x-axis are dBZ (radar reflectivity) and m/s (Doppler velocity).

This year, we evaluated microphysics schemes in NICAM. We developed a new evaluation method of rain microphysics using C-band polarimetric radar.

The next step of this project is an improvement of microphysics schemes about rain microphysics schemes like evaporation process and coalescence processes of rain. And we will improve riming progress in NICAM using observation data.

3. Research progress

This year, we evaluated two kinds of microphysics schemes like a single moment (NSW6) and a double moment (NDW6) schemes in NICAM

We evaluated two microphysics schemes using a polarimetric radars and the CPR. The figure 2 shows the Contoured Frequency by Altitude Diagrams (CFADs) of radar reflectivity and Doppler velocity between observation and NICAM NSW6. The observed maximum radar reflectivity is less than 2 dBZ in the tropical cyclone Faxai case. The reason for the weak radar reflectivity is attenuation from rain on the antenna. The in-situ CPR has limitation to observe the precipitating clouds because of rain attenuation. NICAM shows the similar distributions of CFADs of Doppler velocity like fast terminal velocity of rain and slow terminal velocity of ice hydrometeors. We found three issues about mismatches of microphysics of NICAM. The first issue is overestimation of Doppler velocity above 8 km altitude. The observation shows less than 1 m/s, but the NICAM reproduced Doppler velocity within 1 and 2 m/s. The second issue is the rimming process from 5 km to 8 km in the observation. The observation shows the increase of Doppler velocity from the rimming process. NICAM does not shows this characteristic. The third issue is the decrease of Doppler velocity from 4 km to the ground in NICAM. The observation does not show this pattern. We speculate this bias is from the evaporation and coalescence processes of rain.

We introduced a new evaluation method for rain microphysics in terms of radar reflectivity and Zdr using C-band polarimetric radar and Joint simulator.

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4. Future plan

We will improve the warm rain microphysics in NDW6 using C-band polarimetric radar. We will evaluate NICAM using X-band polarimetric radar and Ka-band polarimetric radar. And we will consider how to use these radar data for evaluation and improvement of microphysics schemes in NICAM.

We will consider the simulations of WINDAS using Joint simulator.

5. Previous project name

Numerical study on cloud systems using NICAM（Project leader：Masaki Satoh）

（NICAM による雲降水システムの研究（課題代表者 : 佐藤正樹））

6. Record of supercomputer use （November 1, 2020～October 31, 2021）

Number of Users: 3

VE node time product v_debug: 0.00 hours, v_normal: 0.00 hours, Total: 0.00 hours,（Occupancy rate of the whole VE node time product: 0.0 %）