Project name：Numerical study on cloud systems using NICAM (NICAMによる雲降水システムの研究)

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Research period：April 2023～March 2024

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 Earth Clouds, Aerosol, and Radiation Explorer (EarthCARE) satellite is a joint mission of the Japanese Aerospace Exploration Agencies (JAXA) and the European Space Agency (ESA) (Illingworth et al. 2015, Wehr et al. 2023). The satellite will carry four instruments: a 94 GHz cloud-profiling radar (CPR), a 355 nm atmospheric lidar (ATLID), a seven-channel multispectral imager (MSI), and a broadband radiometer (BBR).

New observations, such as the Doppler velocity from EarthCARE, will provide new insights into the evaluation and improvement of NICAM. Before launching the satellite, it is important to understand how to use the information on the Doppler velocity to evaluate NICAM.

In this study, we use the observation of the Doppler velocity by a cloud radar installed on the ground and investigate the methodology of evaluation of NICAM using a sensor simulator for the Doppler velocity.

2. Research plan

In our previous research, we evaluated a single moment scheme (NSW6) in NICAM using the CPR in Japan and investigated the performance of the EarthCARE CPR using a random error based on the observation window.

We evaluated rain size distribution in a double moment scheme (NDW6) using a polarimetric radar and Joint simulator. For interpretation of the results, we had sensitivity tests of rain microphysics scheme in for the coalescence and evaporation process. We found the overestimation of rain diameter related to the evaporation process, and the mismatch of the frequencies in the regime 4 related to a coalescence process parameter.

In this fiscal year, we develop a new evaluation method for a cloud microphysics scheme using the vertical profile of the Doppler velocity on the ground. We use the ground observation data, but the methodology can be applied to the EarthCARE observation. We evaluate two types of cloud

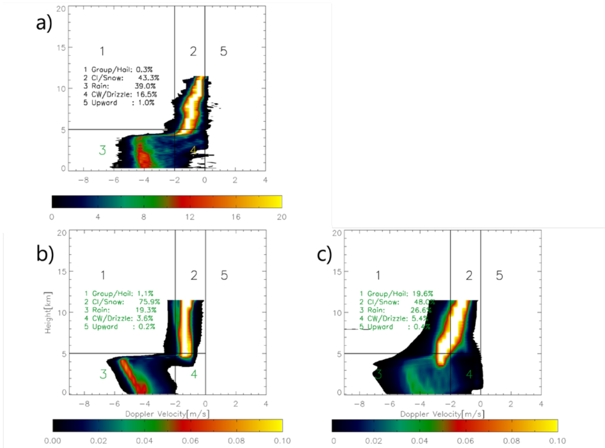

Fig. 1. The categorizations of the hydrometeors using the joint histogram between Doppler velocity and height among observation(a), NSW6(b), and NDW6(c) for the weak precipitation case.

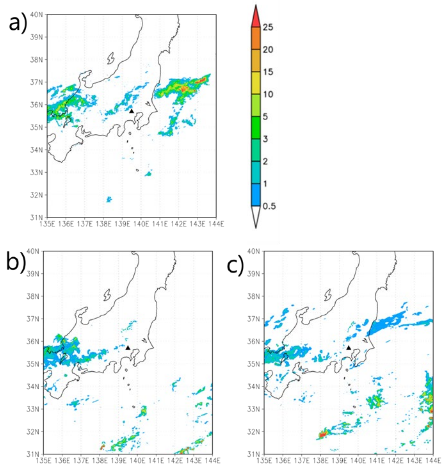

Fig. 2. The horizontal distributions of the precipitation of the weak precipitation case for the observation (a), NSW6(b), and NDW6(c). The black triangle indicates the location of the CPR in NICT. The contour is the precipitation amount [mm hr^{-1}].

microphysical schemes using this method. We investigate the EarthCARE-like simulations using the Joint simulator and discuss the results with different instrument settings with random errors.

3. Research progress

We applied the Joint simulator to the NICAM simulation data with two cloud microphysics schemes and analyzed the simulated Doppler velocity data using this categorizing method (fig. 1). These simulations produced a similar horizontal distribution of precipitation to the observation (fig. 2). The cloud microphysics schemes strongly impact the probability frequency of Doppler velocity in terms of heights, particularly for the heavy precipitation case. The double moment scheme reproduced a higher fraction of the graupel/hail regime than the observation and the single moment scheme.

We expanded this evaluation method using the simulated Doppler velocities of the EarthCARE satellite. The results were consistent with the ground observation data. The maximum observation height of the EarthCARE CPR was higher than the ground observation. We took a test about the threshold of radar reflectivity with -15 dBZ for the Doppler velocity. The results were consistent with the ground observation data. However, there was an increase of fraction with ice hydrometeors and a decrease of the CW/drizzle because of the increase of the observation range and the threshold of the radar reflectivity.

We considered the observation windows and random errors associated with the Pulse Repetition Frequencies (PRFs). When we added the random error based on the observation window, the Doppler velocities diverged from the results without error. The 16 km observation window mode has the higher pulse repetition frequency (PRFs) and reproduced consistent results similarly to the results without error. The differences between the two cloud microphysics schemes were apparent, such as the difference between the ground observation and the simulation with the 16 km observation window. In contrast, the 20 km observation window produces more random errors, and it was difficult to distinguish the different characteristics between the two cloud microphysics. For the evaluation of cloud microphysics, the 16 km observation window is preferable, but higher clouds than the 16 km altitude would be no longer omitted over the tropical region.

4. Future plan

We will start our analysis with a global large-eddy simulation (GLES) with a 220m mesh. We will focus on the usefulness of GLES for the EarthCARE satellite and the detailed structure of mesoscale convective systems.

We will lead the intercomparison project of global storm-resolving models using the EarthCARE and field campaign data (PRECUSSION and BOW-TIE).

5. Record of supercomputer use （April 1, 2023～October 31, 2023）

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