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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1. Research purpose

An evaluation and improvement of cloud properties in the cloud system resolving model is important for the mesoscale and climate study. In the previous research, the microphysics of a stretched NICAM is evaluated and improved using a satellite simulator over the tropical open ocean. The purpose of this research is to investigate how the regionally improved microphysics scheme simulates cloud systems in the other tropical regions and mid-latitude areas. The cloud structures of a global cloud system resolving model over the globe are evaluated using a satellite simulator.

2. Research plan

The NICAM simulations are carried out using a global version of NICAM with 3.5 km horizontal resolution using a supercomputer with the modified microphysics. The horizontal distribution of precipitation and OLR is investigated. The T3EF (Matsui et al. 2009) analyses are carried out over the tropic. The other satellite data are investigated for the evaluation of cloud properties in NICAM.

3. Research progress

The NICAM simulation was carried out using a global version of NICAM with a 3.5 km horizontal resolution for June 2008 case. The improved microphysics with a regional cloud system resolving model is tested with a global cloud system resolving model for the entire tropical region and limited middle latitudes covered by TRMM. The control experiment (CON) and modified microphysics experiment (MODI) simulate a realistic horizontal distribution of clouds comparing observed the 11 μm brightness temperature (TBB). However, The MODI simulation reproduces larger cloud systems than the CON experiment. The locations of accumulated simulated precipitations are well reproduced compared to TRMM 3B42 data, although the simulations overestimated the accumulated precipitation sizes and amounts. On the large scale, the accumulated precipitation distribution is not sensitive to the modification of the microphysics scheme. The cross section of tropical cyclone Fengshen is evaluated in CON and MODI using TRMM and CloudSat. The clouds of CON are more isolated than MODI. The simulated vertical profiles of 13.8 GHz and 94 GHz signals reduced some biases of radar reflectivities, such as the overestimation of 13.8 GHz radar echo top heights, and the underestimation of 94 GHz maximum radar reflectivity.

The joint histogram of TBB and precipitation top height (PTH) and CFADs of deep clouds over the entire tropics

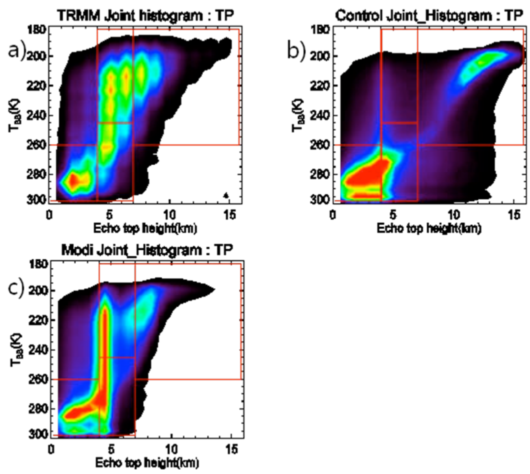

Fig. 1: The joint histogram of PTH and TBB for the TRMM observation (a), CON (b), and MODI (c) for the 2 day simulation over the entire tropics.

are similar to the regional results described in the previous research. The joint histogram of MODI shows similar features to that over the tropical open ocean. The fraction of mid-cold and shallow clouds is improved in MODI compared to observations, whereas the fraction of deep clouds is underestimated (Fig. 1). The regional differences are found in the tropic. The difference originates from the surface condition of the land and ocean area in the observation; the fraction of shallow clouds is lower in the land areas than in the oceans. The pattern of contrast between land and ocean is similar to observation for both simulations, although the contrast is more evident in MODI than in CON.

Seasonal differences between the southern and northern middle latitudes are found in observation. The joint histogram of the southern part in the winter season is shrank compared to the tropics and the northern part in boreal summer season. We speculate that the differences of tropopause heights and melting layers lead to the seasonal difference in the joint histogram. We found that the simulation results clearly reproduced the seasonal difference in the joint histogram, similar to the observation.

Finally, an additional analysis using the 94 GHz signals of CloudSat was carried out. The results of this analysis show that MODI improves the joint histogram and CFADs calculated for 94 GHz radar reflectivities.

4. Future plan

MODI would be compared with double moment scheme (NDW6, Mitsui et al. 2013) using a T3EF method. Hashino et al. (2013) introduces the new method of cloud microphysics evaluation method called BETTER using CloudSat and CALIPSO. This method could evaluate the simulated water content and effective radius having different radar reflectivity, lidar backscattering and temperature. MODI and NDW6 are also evaluated using BETTER method.

It is known the depolarization ratio of lidar has the information about ice and liquid phase of cloud and also distinguishes 2D and 3D shapes of ice particle (Yoshida et al. 2010). The parameterization of depolarization ratio would be implemented in a joint simulator. The evaluation of depolarization of NICAM would be done using the joint simulator.

5. Record of supercomputer use （1st April ～ 30th November 2014）

Number of users: 4

CPU hours v_deb: 11.76 hours, v_cpu: 0 hours, v_8cpu: 8.87 hours, v_16cpu: 0 hours, Total: 20.62 hours

6. Summary of last year's research project

6.1. Previous project name

Numerical study on cloud systems using NICAM

6.2. Previous research purpose

It is important to reproduce the realistic cloud precipitation systems of a numerical model for improving the prediction skills of climate models and data assimilation of satellite data. It is possible for the global nonhydrostatic model NICAM to simulate global cloud systems explicitly with various levels of temporal and spatial resolution, and it is expected to be the next GCM to predict climate and hydrology cycles. This research aims at evaluating the cloud precipitation systems of NICAM using satellite data and a satellite simulator for the understanding of the physical processes of clouds and precipitation.

6.3. Outline of the previous research project

Deep convective systems over the tropical open ocean were evaluated in terms of the joint histogram of cloud-top temperature and precipitation echo-top heights, which were simulated by the NICAM using a satellite simulator. The control experiment showed biases related to an underestimation of stratiform precipitation and a higher frequency of precipitating deep clouds whose top height was higher than 12 km compared with the TRMM data, although it showed good agreement for the horizontal distribution and statistical cloud size distribution of deep convective systems. The biases in the joint histogram were improved by changing the cloud microphysics parameters in the framework of a single-moment bulk microphysics scheme. In particular, the effects of the size distribution of precipitating hydrometeors were examined.

We examined how the modifications of the size distributions of snow, graupel, and rain affected the joint histograms and CFADs of deep clouds using sensitivity tests. We found the single moment bulk microphysics of a cloud system resolving model is improved using the modified size distributions of precipitating hydrometeors with a satellite simulator.

6.4. Previous record of supercomputer use（1st June 2013 ～ 31th March 2014 ）

Number of users: 4

CPU hours v_deb: 74.69 hours, v_cpu: 0 hours, v_8cpu: 146.45 hours, v_16cpu: 1,485.06 hours, Total: 1,706.21 hours