JST Basic Research Programs

C R E S T

(Core Research for Evolutional Science and Technology)

Annual Report for Research Work in the fiscal year 2005

Research Area :

High Performance Computing for Multi-scale and Multi-physics Phenomena

Research Theme

Global Cloud Resolving Model Simulations toward Numerical Weather Forecasting in the Tropics

Name of Research Director, Belonging and Title:

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§1. Outline of Research Work

The first “global cloud resolving simulation” in which cumulus convection in the atmosphere is directly resolved with a few km horizontal mesh over the global domain is succeeded at Frontier Research Center for Global Change, JAMSTEC, using the Earth Simulator. A newly developed Global Cloud Resolving Model, called NICAM, overcomes the difficulties in existing atmospheric global models where cumulus convection is not resolved and is represented in parameterized forms. This research project promotes development of NICAM by aiming that NICAM is practically used as a next generation weather forecasting and climate prediction model in collaboration with wide range of research groups of observational, modeling, and data analysis studies. Toward this goal, we concentrate on improvements of representation of convective-precipitation system in the tropics and the Asian monsoon region, which directly affects meteorology around Japan.

Thus far, global cloud resolving simulations with realistic land/sea distribution and topography are carried out and captured realistic behaviors cloud-precipitation system in the tropics. However, we also found problems in the simulation, such as too intensive organization of cloud system and strong precipitation. We plan to improve physical and numerical schemes by comparing with observational and satellite data, and simulate diurnal cycles, cyclogenesis of Typhoons, and intraseasonal variability in the tropics, which are key aspects of cloud-precipitation system in the tropics.

§2. Content of Research Work

The aim of this project is to promote development of the Global Cloud Resolving Model, NICAM, by improving representations of cloud-precipitation system in the tropics, in order that NICAM would be practically used as a next generation weather forecasting and climate prediction model. At the starting point of this project, an idealized global cloud resolving experiment with 3.5km mesh under an aqua planet condition is conducted at the Frontier Research Center for Global Change, JAMSTEC. Through this project, realistic global cloud resolving experiments with land/sea distribution and topography are conducted to improve behaviors of cloud-precipitation system in the tropics. The experimental results will be compared with observational data and outputs of other existing atmospheric models.

In this year, after development of NICAM by incorporating the land process and topography, two cases of experiments with realistic condition are conducted:

1. Exp. Apr. 2004: In this month, intensive field campaign is conducted in the marine time continent. To compare with observational results, an experiment with NICAM is

conducted by giving initial and boundary conditions of realistic data.

2. Exp. Perpetual July: To study statistical and climate properties of NICAM, a numerical simulation is conducted under the perpetual July condition giving an initial condition obtained by an spin-up run with a low-resolution atmospheric global model.

Figure 1 shows cloud images of the NICAM simulation with 7km-mesh for Exp. 1 and the corresponding geo-satellite image. The numerical simulation is started at 00UTC, 1 Apr. 2004, and Fig. 1 is for the 00UTC, 6 Apr. The results show that the pattern of the cloud system near the equator is similar to the satellite image; in particular, a typhoon is emerging from this cloud system in the northern hemisphere. It is also noted that organization of cloud system is relatively strong and convection over the marine time continent (Indonesia) is not well simulated. Since this is the first global cloud resolving experiment with realistic land/sea distribution, these results imply that NICAM has a potential to simulate cloud-precipitation system in the tropics though some defects are seen at this stage.

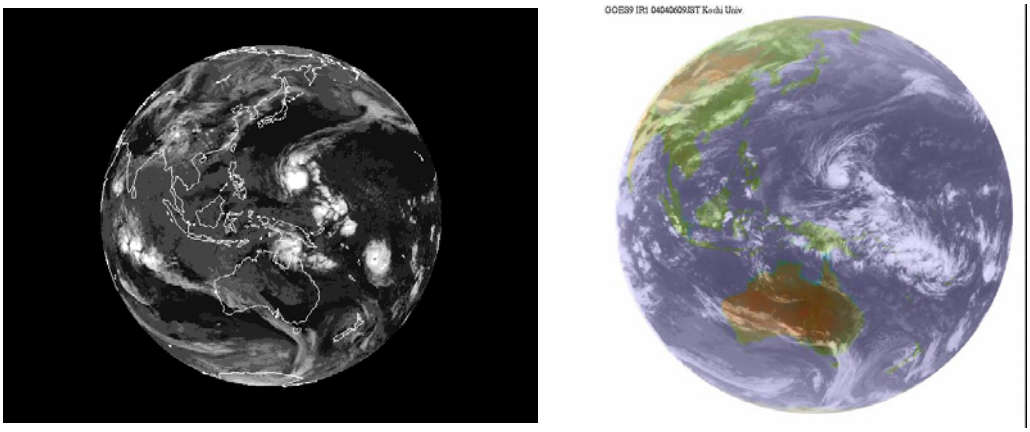

Fig 1. Global views of cloud image obtained by the global cloud resolving simulation using NICAM with 7km-mesh (left) and of GMS/GOES-9 (right, http://weather.is.kochi-u.ac.jp/) at Apr. 6, 2004, 00UTC.

Next shows the distributions of precipitation obtained by Exp. 2 for perpetual July condition. Figure 2 shows 60 days-averaged precipitation obtained with 14km mech simulation, and compared with observational data (right). This experiment is intended to obtain a statistical or climate field, so that the experiment is started from an initial condition after a long enough spin-up time with a low-resolution model. Figure 2 shows that the overall distribution of precipitation is simulated well, although the precipitation region in the Western Pacific is relatively shifted northward. In addition,

the obtained precipitation intensity is too strong. Since the 14km-mesh is too coarse to resolve meso-scale circulation and should be seen as a preliminary, we intend to do this experiment using finer grids with 7 or 3.5km-mesh, and investigate the impact of the resolution and other numerical and physical schemes.

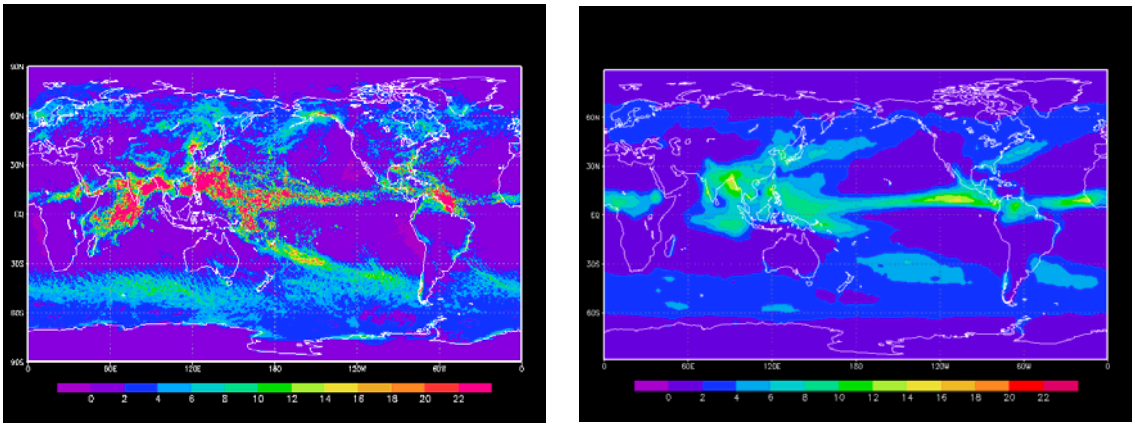

Fig. 2. Left: Time-averaged precipitation field obtained with 14km-mesh model. Right: Observer precipitation field (after Global Precipitation Climatology Project, GPCP) for July between 1979 and 2005.

In this year (FY2005), we have done the first global cloud resolving model with realistic land/sea distribution and captured realistic behaviors of tropical convective system. However, the results are preliminary and show unrealistic features such as too strong organization and precipitation. These are to be improved in the following years by investigating resolution dependency and physical and numerical schemes, such as the boundary layer schemes. We will particularly concentrate on the diurnal cycles of convection, cyclogenesis of typhoons, and intraseasonal variations in the tropics in order to develop NICAM as a practical model.

§3. Formation of Research Work

- Masaki Satoh, Japan Agency for Marine-Earth Science and Technology, Frontier Research Center for Global Change, Global Environmental Modeling Research Program, Sub-leader, Global cloud resolving modeling and data analysis
- Takao Yoshikane, Japan Agency for Marine-Earth Science and Technology, Frontier Research Center for Global Change, Hydrological Cycle Research

Program, Researcher,　Cloud resolving modeling and data analysis

- Yoko Tsushima, Japan Agency for Marine-Earth Science and Technology, Frontier Research Center for Global Change, Global Warming Research Program, Researcher, Global atmospheric modeling and data analysis
- Shuichi Mori, Japan Agency for Marine-Earth Science and Technology, Institute of Observational Research for Global Change, Hydrological Cycle Observational Research Program,　Sub-leader, Cloud resolving modeling and data analysis
- Teruyuki Nakajima, The University of Tokyo, Center for Climate System Research, , Director , Professor, Global atmospheric modeling and data analysis
- Tetsuo Nakazawa, Head, Japan Meteorological Agency, Meteorological Reseach Institute, Typhoon Research Department, The Second Research Laboratory, Data analysis

§4. Publication of Research Results

（4－1） Publication of Thesis (The original Work)

① Number of Publications (0 times-Domestic, 0 times-International)

（4－2） Patent Application

① Cumulative Number

1) Patent Applications in the fiscal year 2005 (Domestic- 0 Cases, Oversea- 0 Cases)

2) Cumulative number of Patent Applications for the research period of CREST (Domestic- 0 Cases, Oversea- 0 Cases)

3) Details for this fiscal year

a) Domestic Application (0 cases)

b) Oversea Application (0 Cases)