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

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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 3.5 km 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 a spin-up run with a low-resolution atmospheric global model.

Figure 1 shows cloud images of the NICAM simulation with 7 km-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 distri-

bution, these results imply that NICAM has a potential to simulate cloud-precipitation system in the tropics though some defects are seen at this stage.

Next shows the distributions of precipitation obtained by Exp. 2 for perpetual July condition. Figure 2 shows 60 days-averaged precipitation obtained with 14 km 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 14 km-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 3.5 km-mesh, and investigate the impact of the resolution and other numerical and physical schemes.

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

Research Director or Main Research Collaborator, and Items of Research

- 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

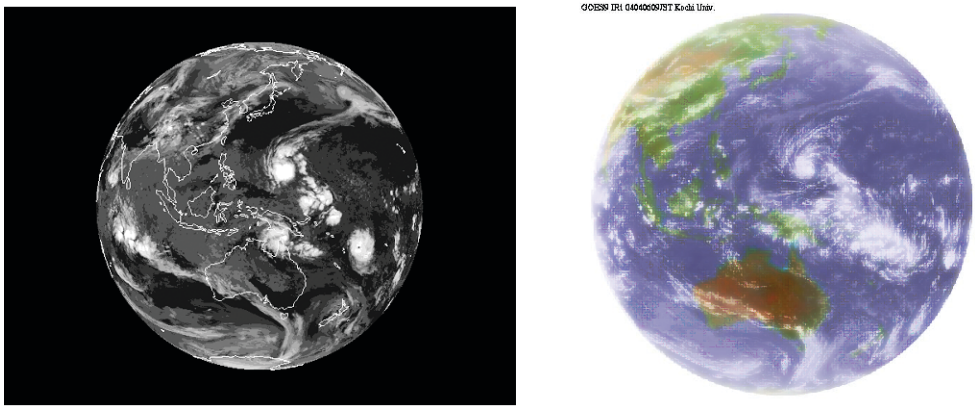

Fig. 1 Global views of cloud image obtained by the global cloud resolving simulation using NICAM with 7km-mesh (left) and of GMS/GOES-9 (right), http://weather.is.kochi-u.ac.jp/) at Apr. 6, 2004, 00UTC.

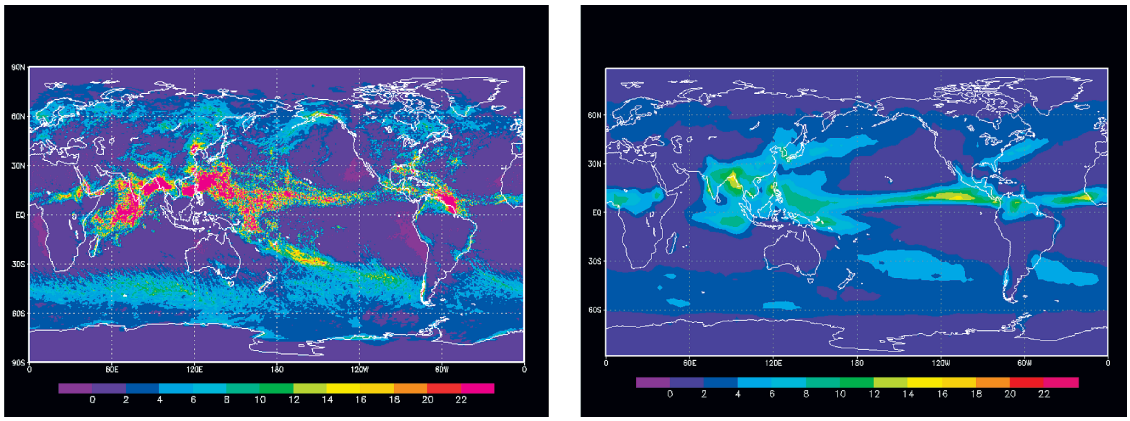

Fig. 2 Left: Time-averaged precipitation field obtained with 14 km-mesh model. Right: Observer precipitation field (after Global Precipitation Climatology Project, GPCP) for July between 1979 and 2005.

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全球雲解像大気モデルの熱帯気象予測への実利用化に関する研究

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地球大気における熱帯では積雲が組織化した積雲クラスターが盛衰を繰り返しており、これらの挙動は直接・間接的に日本に影響を及ぼしている。従来の粗い分解能の大気モデルでは、このような熱帯の雲降水システムを表現するためにパラメタリゼーションを導入せざるをえず、モデルの予測精度向上の障害になっていた。大気モデルによる気象予測の信頼性を高めるためには、熱帯の雲降水システムのシミュレーションを改善することが必要である。地球環境フロンティア研究センターでは、地球シミュレータを最大限活用することによって全球数kmメッシュで対流雲を直接計算する「全球雲解像モデル」による大気循環のシミュレーションに世界で初めて成功した。長い間大気モデリングの難関であった積雲対流のパラメタリゼーションを解消したこの新しいモデルを用い、従来の観測研究、モデル研究両グループの枠を超えた多くの研究者の協力のもと次世代の気象・気候予測モデルとしての実利用化を目指し、特に熱帯・アジアモンスーン域における気象予測における課題を解決することにより、世界の大気モデリング研究に新しい時代を開こうとするのが本研究の構想である。今年度は、海陸分布、地形を与えた現実的な全球雲解像モデルによる実験を実施した。得られた結果によると、熱帯の雲降水システムについて観測とよく一致する特徴がみられた。しかし、対流の組織化が強く、降水強度が強いなどいくつか改善すべき課題も明らかになった。これらは本研究による初めての実験結果であり、今後、物理過程、数値スキームを改善し、観測・衛星データと比較しながらモデルの改良を行う。特に、熱帯の雲降水システムの重要な現象である日変化、台風の発生、季節内変動のシミュレーションの向上に努め、モデルによる予測性能の高度化をめざす。