Global cloud resolving simulation of aerosol-cloud interaction with NICAM-SPRINTARS coupled model

Kentaroh Suzuki (Colorado State University) e-mail: kenta@atmos.colostate.edu

T. Nakajima and M. Satoh (CCSR/U.Tokyo), H. Tomita and Y. Tsushima (FRCGC), T. Takemura(RIAM/Kyushu U), and G. L. Stephens (CSU)

1. Introduction

Previous global studies of aerosol-cloud interaction are based on conventional GCMs with coarse grid size (~100km) focusing only on stratiform clouds. In this study we used a next-generation global cloud resolving model NICAM (Satoh 2002, 2003; Tomita and Satoh, 2004) running on Earth Simulator with implementation of aerosol transport model SPRINTARS (Takemura et al., 2000, 2002). The aerosol effects are incorporated into the model through parameterization (Suzuki et al., 2004) not only for stratiform clouds but also for cumulus clouds. This new model allows us to study aerosol effect on cloud, radiation and precipitation at global scale in context of cloud resolving model. The global cloud resolving experiment was performed on Earth Simulator with horizontal resolution of 14km and 7km for 10days and 8days, respectively, with initial condition of July 1st, 2006. The early results from 14km experiment are shown in this paper.

2. Cloud and Precipitation Field

NICAM model reasonably reproduces the distribution of clouds with three representative heights except for low clouds over subsidence regions (Fig.1). The precipitation field is also compared with CMAP observation and new CloudSat analysis (Fig.2). High clouds are simulated to have more contribution to surface accumulated rain than low and middle clouds comparing with CloudSat analysis. This feature is similar to those of other GCMs.

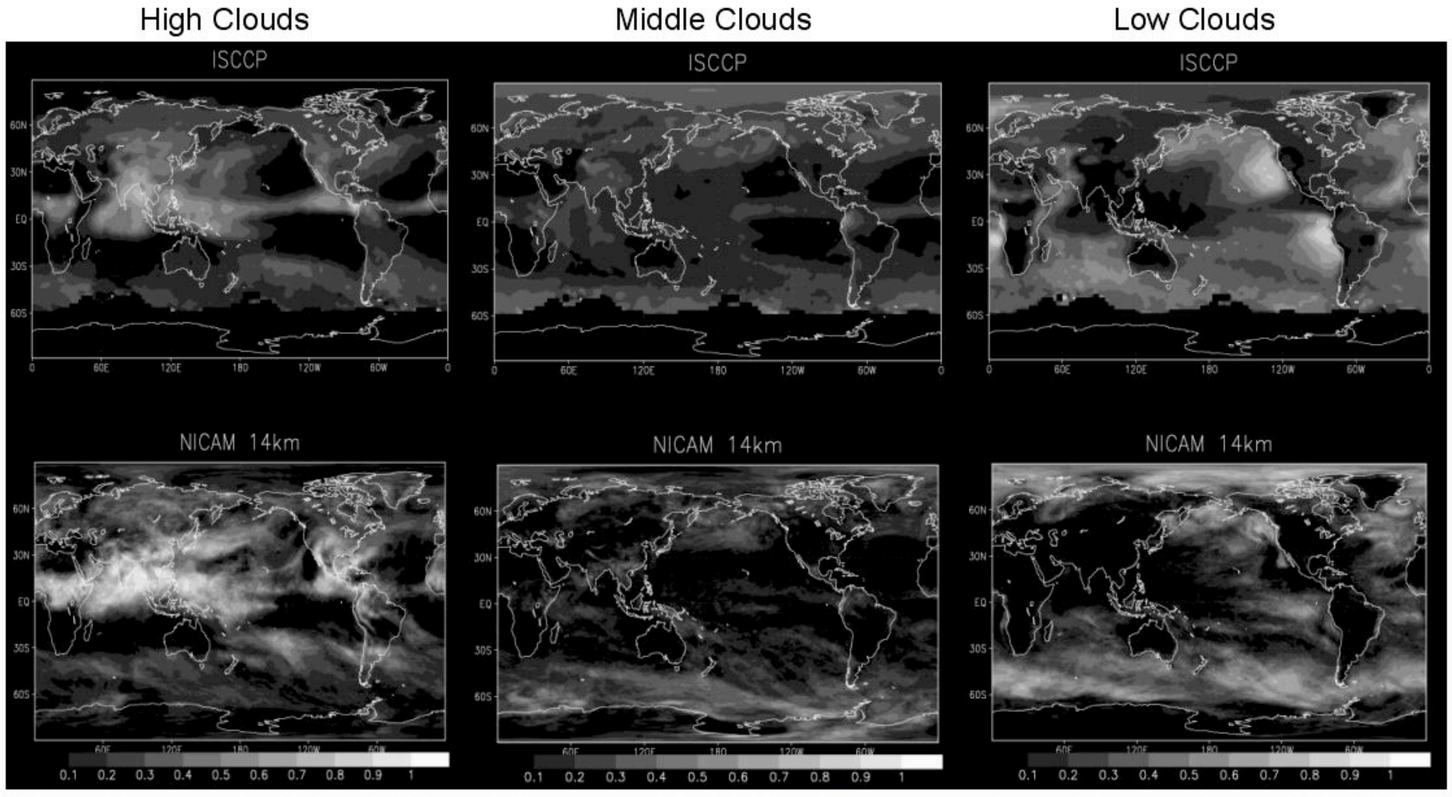

Fig.1: Comparison of High (left), Middle (center) and Low (right) cloud frequencies obtained from ISCCP simulator embedded in the NICAM model (lower) with ISCCP D2 July climatology data (upper)

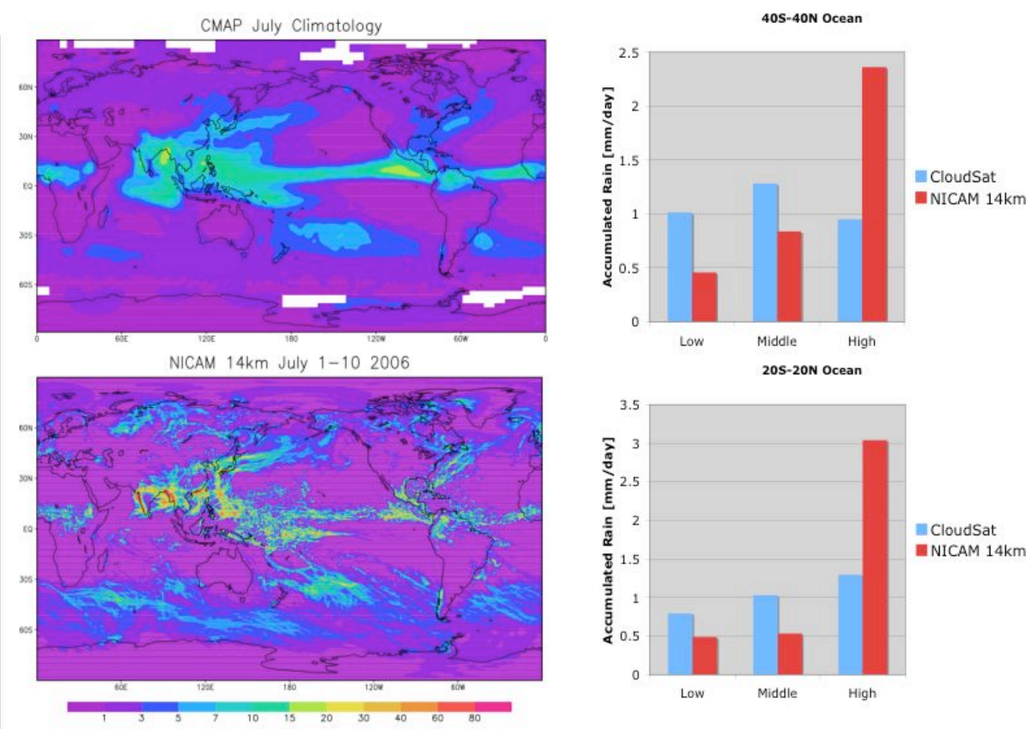

Fig.2: Geography of precipitation (left) simulated by NICAM (lower) in comparison with CMAP july climatology (upper). Also shown are contributions in terms of surface accumulated rain from clouds with different top heights (right) obtained from NICAM and CloudSat analysis.

3. Aerosol-Cloud Interaction Analysis

Global feature of Angstrom Exponent and cloud particle effective radius (Fig.3) is reasonably simulated although absolute value of effective radius is systematically smaller than MODIS analysis, suggesting the necessity of some more tuning in our model.

Correlation statistics are made from the simulated results for investigating the aerosol-cloud interaction. We separated the convective and stratiform clouds according to difference in OLR between whole and clear skies. The OLR difference larger and smaller than 100 W/m^2 are assigned as 'convective' and 'stratiform' clouds, respectively. The scatter plot shown in Fig.4 provides the aerosol-cloud correlation for the stratiform and convective clouds separately.

Vertical growth pattern of particle size is investigated by analyzing the relationship between cloud top temperature T_c and effective radius r_e suggested by Rosenfeld and Lensky (1998) as shown in Fig.5. We determined 'T_{14}' as a critical temperature where r_e exceeds 14 micron by linear fitting to the T_c-r_e plot.

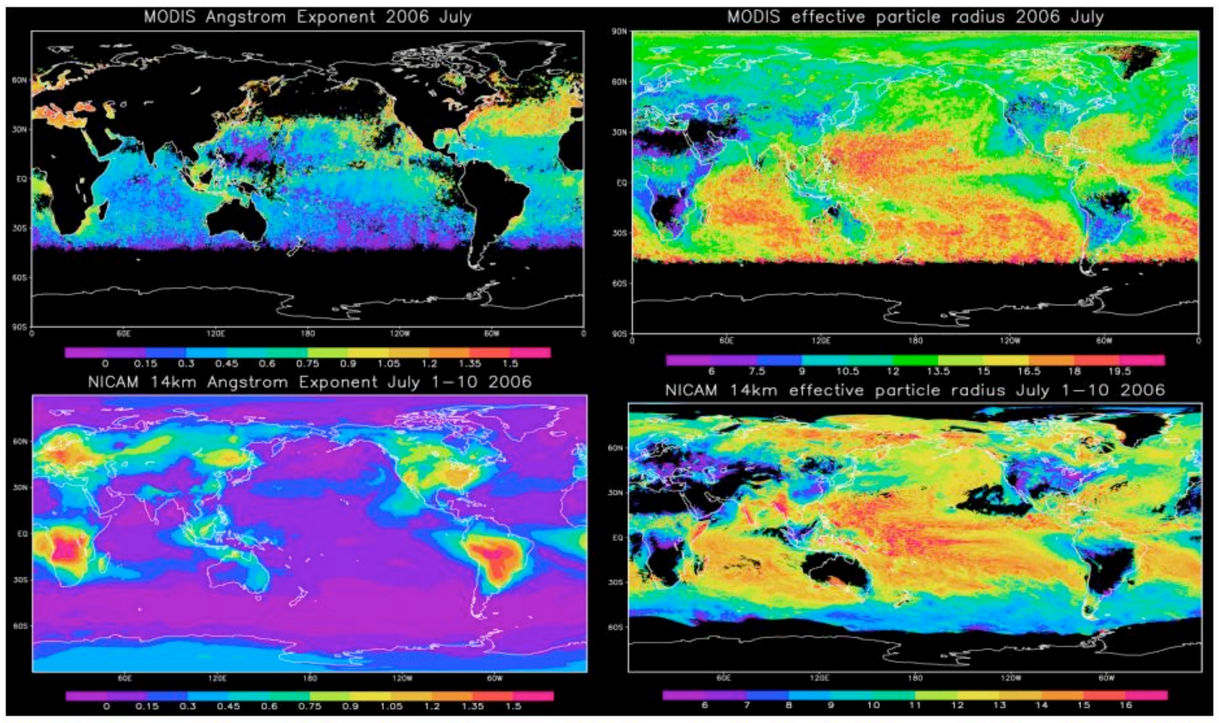

Fig.3: Geography of Angstrom Exponent (left) and cloud effective particle radius (right) obtained from MODIS retrieval (upper) and NICAM model (lower).

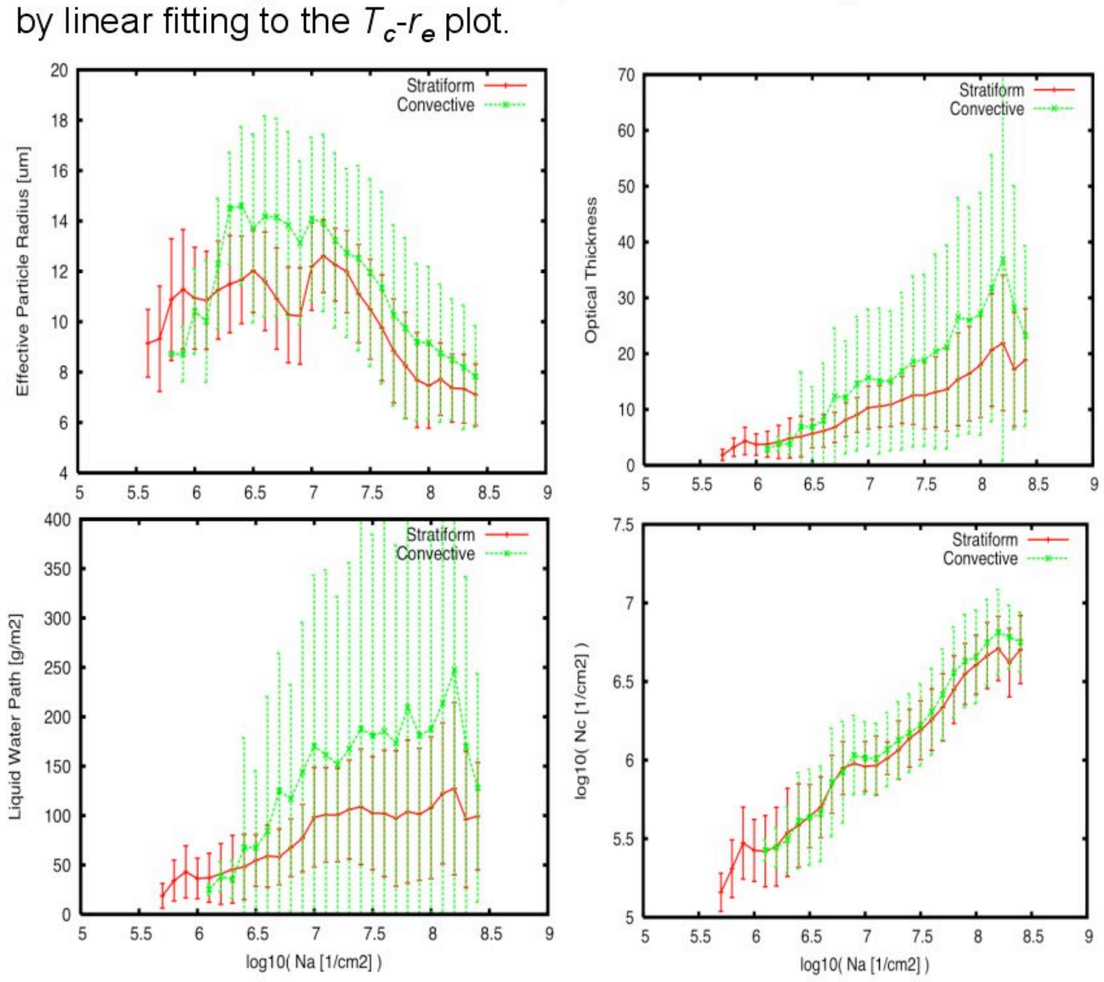

Fig.4: Scatter plot of cloud properties as a function of column aerosol particle number obtained from the simulation.

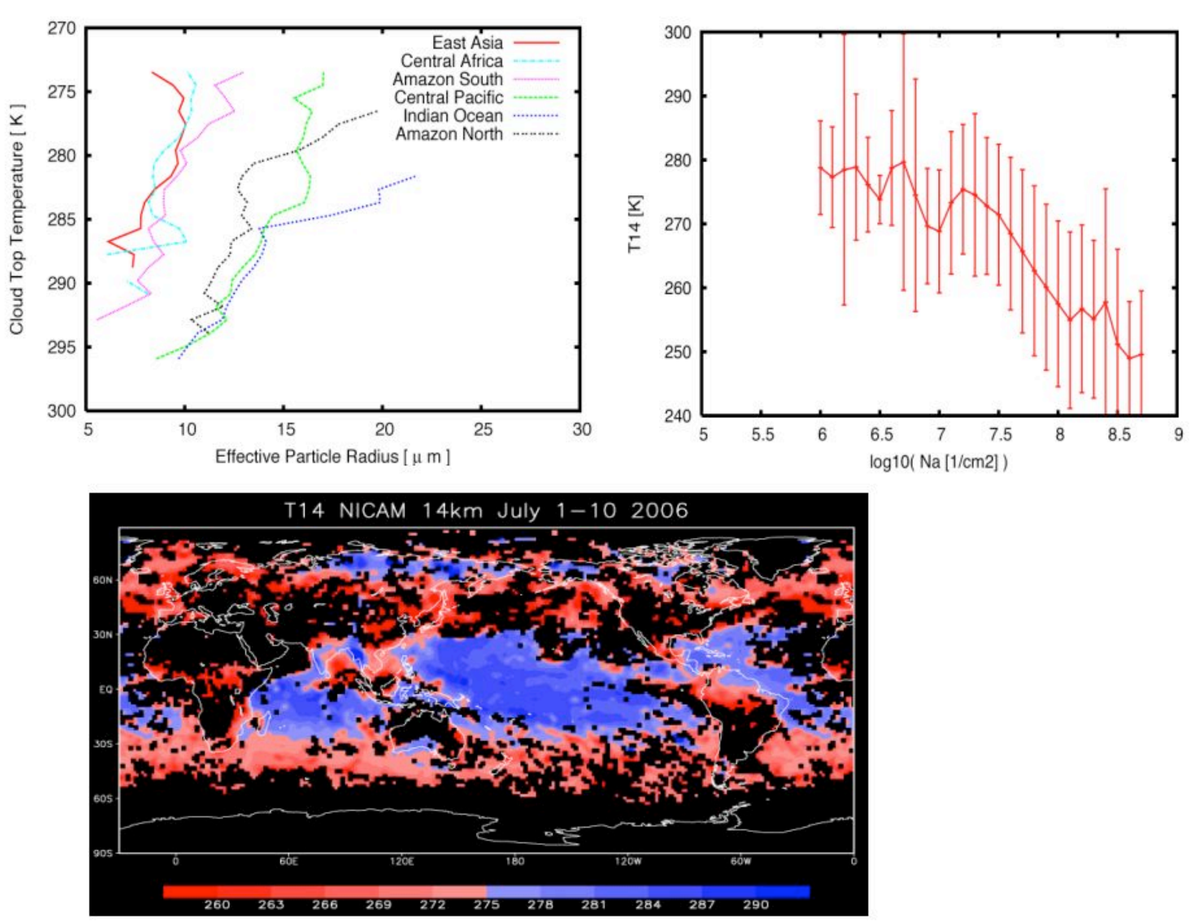

Fig.5: Diagram between cloud top temperature and effective particle radius for several regions (upper left), scatter plot of critical temperature 'T_{14}' as a function of column aerosol particle number (upper right) and global distribution of 'T_{14}' (lower).