Summary of GAME modelling activities

A. Sumi and F. Kimura

1. Introduction

When the GAME was started, the objectives of the modelling component was defined as follows;

1) By conducting the flux observations in the various regions over the Asian Monsoon area, we can develop/improve a land-atmosphere interaction scheme, which is now used in GCM.
2) By applying the improved parametarization scheme, we can improve the prediction skill of the atmospheric flow and precipitation in the Asian Monsoon region.
3) Based on the improved models described above, we can contribute to the improvement of seasonal prediction and water-resource management, and present the detailed information about the change of water cycle in the Global Warming situation

In order to achieve these objectives, the research activities were organized in the three components;

4) One dimensional study: the land-atmosphere interaction is investigated by comparing the observations conducted in the GAME IOP and the various models such as SiB2 and the bucket model.
5) Two-dimension study: the land-atmosphere interaction is investigated by using the non-hydrostatic meso-scale model such as the RAMS and the NHM developed at the NMI/JMA. Emphasis is placed on the interaction between detailed orography and convection.
6) Three-dimensional study: the land-atmosphere interaction is investigated by using the CCSR AGCM and the CCSR/NIES Climate model.

It should be noted that research relating to study 4) and 5) is conducted in the regional studies of the GAME activities and many results are described in the other sections. Here, we will briefly summarize the achievement of the modelling component.

2. One dimensional study

- Evaluation of SiB2

Takayabu(MRI/JMA) are collecting observational data from the regional experiments and making a standard data set for comparising and evaluating the one dimensional flux schemes. He compared the observed data in the Tibet by the SiB2 result.

3. Two dimensional study

- Relation between orography and convection by two-dimensional RAMS

Sataomura (2000) investigated the diurnal variation over the Indo-China Peninsula using the two-dimensional RAMS, which is a nonhydrostatic cloud-resolving numerical model. He found out that solar-synchronized life cycle of the squall lines and their eastward movement cause the nighttime maximum of the precipitation over the inland area of the Peninsula, which has been actually observed.

Kurosaki and Kimura (2001) carried out some two-dimensional numerical experiment over a cross-section over Himaraya and Tibetan Plateau (Fig. 1). The model shows the clear diurnal variation of convective clouds over some dominant mountain ranges in the Plateau, which agree well with the satellite observations.

4. Three dimensional study

GCM study has been conducted by using the CCSR/NIES GCM. As you may expect, it is impossible that the new scheme is proposed immediately after the IOP was over. Then, emphasis is placed on the understanding of the atmosphere-land interaction by using the present CCSR/NIES GCM. Regional and mesoscale modeling are also conducted using RAMS and other numerical models.

- 1997 and 1998 Asian Monsoon Study

1997 and 1998 was the El-Nino year and the influence of the El/Nino to the Indian Monsoon was investigated by Xhen and Kimoto (1999). Besides that, it was the abnormal year when the heavy rainfall occurred in the Yantzen River. This topic was investigated by using the 1998 SST. It is concluded that SST in the Indian Ocean has a strong effect on the anomouraous precipitation over the Asian region (Kimoto *et al.,* 2000).

- Sensitivity study to the horizontal resolution for the atmosphere-land interaction

Atmosphere - land Interaction Sensitivity to the horizontal resolution is now being conducted by using T42 and T106 CCSR/NIES AGCM . The simulation was stared from the April 1, 1998 and integrated until the end of August. Sensible and latent fluxes and precipitation in the two models were compared over the different regions, such as the Tibetan lateau (80-100E, 27.5-35N), Thai (100-106E, 15-20N) and China (115-120E, 30-35N). Over the Tibetan region, difference are about 20 W/m^2 in the monthly mean. The large differences are noted in May, which are due to the differenece of the large scale flow. In China, a large difference of precipitation is noted in June. However, difference of fluxes are about 20 W/m^2 in these areas. In order to estimate the differenecs due to the internal fluctuation of model simulation, the ensemble experiment will be conducted.

- Sensitivity study to the land scheme for the Asian Monsoon Flow

As it takes some time for the new scheme to appear, we decided to use the other scheme developed at other place. We has chosen the MATSHIRO, which is now being developed by the researchers in Japan. Now the MATSHIRO model is being implemented and tested. After that, simulation study will be conducted.

- Baiu/Meiyu Front and heat contrast between Asian continent and Ocean

Yoshikane *et al.* (2000) clarified one of the formation mechanism of the Baiu Front. By a regional climate model, they showed that one of the most important mechanism of the Baiu Front is the heating contrast between land and ocean. The Baiu Front can be formed only by the interaction between global scale zonal mean flow and the contrast between them. Surface moisture of the Asian continent may affect the position and intensity of the Baiu Front.

- Hydrological and Atmospheric Modeling Studies in HUBEX

The modeling study of HUBEX (the Huaihe River Basin Experiment) includes hydrological and meteorological modelings. In particular, their coupling and water cycle modeling experiment using a coupled model are most important objectives of HUBEX. In the hydrological modeling, SiBUC (the Simple Biosphere Model including Urban Canopy) has been progressed in Kyoto University. A coupling experiment of SiBUC with a mesoscale atmospheric model was performed. To simulate movement of ground water, a runoff model also has developed. Simulation experiment of water discharge using the runoff model showed good an agreement between simulated and observed runoffs.

In the meteorological modeling study, a mesoscale simulation using JSM (the Japan Spectral Model) which was developed by the Japan Meteorological Agency has been performed to study a regional water cycle and precipitation.

Cloud and precipitation studies are the most important objectives in HUBEX. In order to study dynamics and evolution of convective clouds over the China continent, we now develop the Cloud Resolving Storm Simulator (CReSS). We performed the simulation experiment of the observed squall line using CReSS with very high resolution in a large three-dimensional domain. The inhomogeneous initial field was given by the dual Doppler radar observation and the sounding. The experimental design is as follows. The horizontal and vertical grid sizes were 300 m and 300 m, respectively with a domain of 170 km × 120 km. Cloud microphysics was the cold rain type. The boundary condition was the wave-radiating type. The result of the simulation experiment shows that CReSS successfully simulated the development and movement of the squall line (Fig. 2). The convective reading edge was maintained by the replacement of new convective cells and the simulated squall line moved to the northeast which is similar to the behavior of the observed squall line. Convective cells reached to a height of about 14 km with large production of graupel above the melting layer. The rear inflow was significant as the observation. A stratiform region extended with time behind the leading edge. Cloud extended to the southwest to form a cloud cluster.

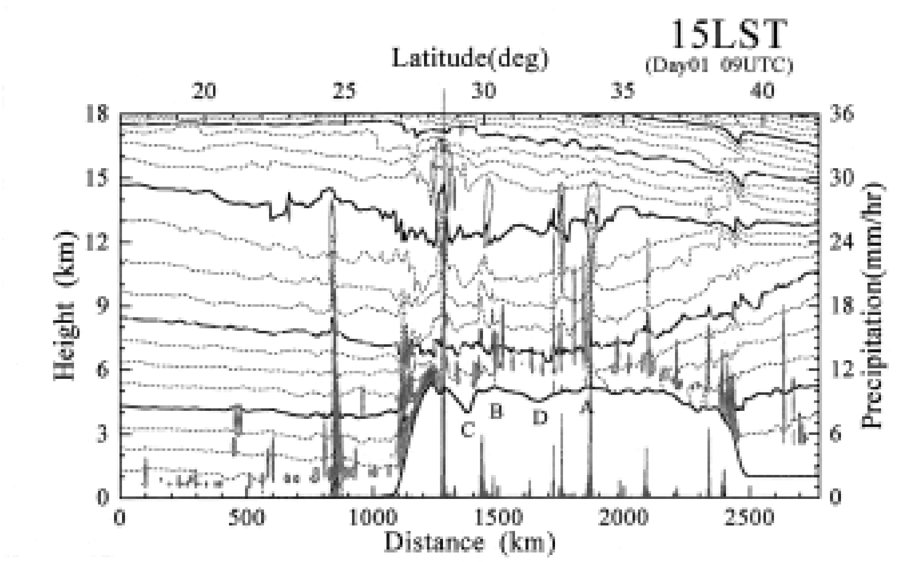

Fig. 1. Vertical cross-section of potential temperatur (broken lines), liquid/ice water content (thin lines) and precipitation (bars) at 1500 LST over Himaraya and Tibetan Plateau, simulated by the two-dimensional RAMS. Grid interval is 2 km.

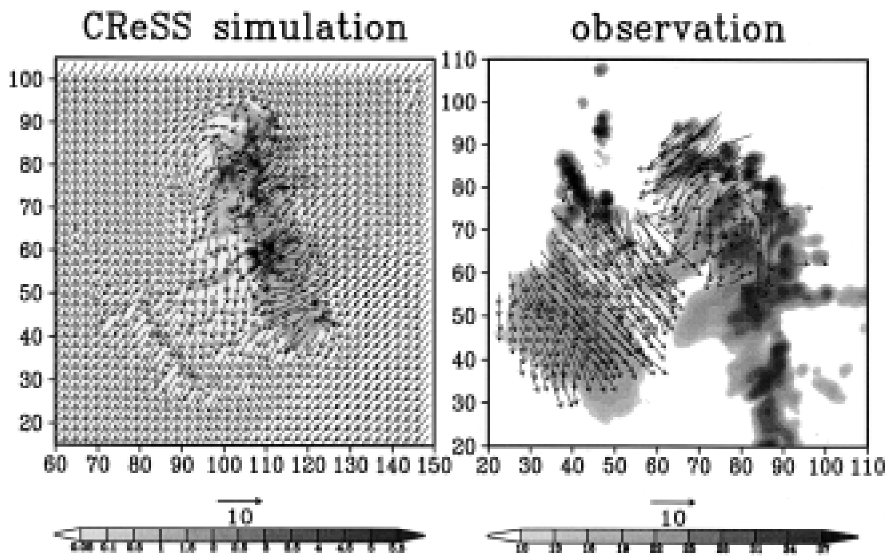

Fig. 2. Horizontal displays of the simulated squall line (left panel) and the observed squall line (right panel) at 1204UTC, 16 July 1998. Gray levels indicate total mixing ratio (g/kg) of rain, snow and graupel in the left and radar reflectivity (dBZ) in the right. Arrows are horizontal velocity.