Toward GAME Synthesis

Tetsuzo Yasunari
Institute of Geoscience, University of Tsukuba, and
Frontier Research System for Global Change

1. Introduction

Nearly five years have passed since GAME started in 1996. The regional experiments on energy and water cycle processes have been conducted in Thailand (GAME-Tropics), in the Huai-he river basin in China (GAME-Hubex), in the Tibetan Plateau (GAME-Tibet) and in the Lena river basin in Siberia (GAME-Siberia). The long-term radiation and energy fluxes in various sites of the monsoon Asian region have been operated by the automatic weather stations (AWS) as the Asian AWS Network (GAME-AAN).

In 1998, we conducted the Intensive Observing Period (IOP) in cooperation with many Asian countries and the international/national projects such as South China Sea Monsoon Experiment (SCSMEX), Chinese Tibetan Plateau Experiment (TIPEX) and Korean Monsoon Experiment (KORMEX). The enhanced radiosonde observations, as well as surface hydrometeorological observations, were operated at more than hundred stations in the monsoon Asian countries. We conducted the 4-dimensional data assimilation (4DDA) of the atmospheric field over the whole monsoon Asia, and the first version of this reanalysis data have been released as version 1 of GAME-reanalysis. Some scientific results, particularly from GAME-Tropics and GAME-Tibet were reported in the special issue of Journal of the Meteorological Society of Japan (Yasunari, ed., 2001).

These data obtained through the regional experiments, AAN, including the reanalysis data for the IOP have been compiled and archived as part of GAME Information and Archive Network (GAIN). Some data are being released to the international science community under the data policy of World Meteorological Organization (WMO).

As documented in the GAME Letters (No. 3 and this letter), we have obtained various new scientific results on the hydro-meteorological processes in the Asian monsoon region from the Tropics to the Siberian Arctic region. Particularly, the land-atmosphere interaction processes in some typical climate and vegetation in monsoon Asia have been revealed in diurnal through seasonal time scales. Cloud and precipitation processes have also been scrutinized in the tropical region, the Meiyu-Baiu frontal zone in the subtropical China and on the Tibetan Plateau area.

What we have to do now and from now is to synthesize these scientific results to reach the final goals and objectives of GAME (GAME International Science Panel, 1998). The fifth session of the GAME International Science Panel (GISP) held in June, 2000 in Tokyo proposed the GAME Phase-II for further research, including data analysis, some additional process studies and modeling needed for the synthesis of the overall GAME objectives. Here, I would like to briefly comment on some key issues for the synthesis of GAME.

2. Large-scale land-atmosphere interaction and regional/continental-scale climate

Energy and water cycle processes in various plot-scale and meso-scale regions have been revealed in the diurnal to seasonal time scales. In some areas, year-to-year variability has also been obtained. An important issue, as a next step, may be how to scale-up or integrate these surface processes in a small area to larger-scale processes in the atmosphere. The IOP of GAME-Siberia in the spring/summer of 2000 conducted the aircraft measurement of heat and CO_2 fluxes over the meso-scale region near Yakutsk. These data will help us to understand the time-space structure of the atmospheric boundary layer in terms of the land surface energy and water fluxes. The comparison and validation of surface fluxes in the models and observations are also being conducted, from the viewpoint of scaling-up and down. In this respect, GAME will contribute to modeling activity of the GEWEX Atmospheric Boundary Layer Study (GABLS), which is a new initiative of the GEWEX Modeling and Prediction Panel.

3. Cloud and precipitation processes and large-scale monsoon circulation

Another key issue for the energy and water cycle of monsoon Asia is cloud and precipitation processes and its interaction with large-scale atmospheric circulation. In the GAME region, the interaction with the monsoon circulation, including the influence of surface topography and vegetation is the most important process. As part of GAME-Hubex and GAME-Tibet, the intensive observation of the 3-dimensional cloud/ precipitating systems were observed by using the Doppler-radar systems, with the enhanced radiosonde observations. The interaction between the meso-scale cloud/ precipitation systems and the large-scale monsoon circulation are being investigated combining the objectively analyzed reanalysis data. The regional 4DDA analysis for the Hubex region is planned for the detailed interactive processes between the meso-scale cloud systems and the ambient monsoon and westerly flow regimes.

Another issue may be the interaction between the cloud/precipitation system and the land surface conditions, including topography and land use/land cover conditions. One important problem we have noticed may the important role of water-fed rice paddy field, which is a typical land surface condition in monsoon Asia, in the development and/or modifying the precipitation systems. The observational as well as model-based evidences of this aspect have been suggested in the tropical (GAME-Tropics) and sub-tropical (GAME-Hubex) region. The large-scale and regional-scale topography is also a key factor controlling the precipitation system in the monsoon region. The observational as well as modeling studies in the tropics (GAME-Tropics) and in the Tibetan Plateau (GAME-Tibet) have presented some interesting processes in the diurnal as well as in the synoptic-scale. The regional model studies are essential for these problems, including improvement of land-surface schemes and the atmospheric boundary layer processes based on the GAME data sets.

4. Key processes related to the interannual variability of the Asian monsoon

GAME has focused the interaction and feedback processes between land and atmosphere. In fact, the observational results of the regional experiments have revealed some important processes on the land-atmosphere interaction, including the roles of snow cover, soil moisture and vegetation. For example, the regional and continental-scale vegetation, such as tropical monsoon forest in southeast Asia, and the boreal forest in east Siberia, have been suggested to play an important role in controlling seasonal surface energy and water balance. This role of vegetation, in turn, modifies the seasonal cycle of the climate and atmospheric circulation. Some model experiments also have strongly suggested these processes.

GAME data sets include the full seasonal data of two or three years since 1997. Particularly, the data of 1998, the IOP year, can be compared, in many aspects, with those of 1999, when the secondary IOP was conducted in GAME-Tropics and GAME- Hubex region. The anomalies of the overall monsoon circulation and precipitation between these two years are well contrastive, so that the inter-comparison of the processes related to the monsoon activity in each region seems to be very beneficial for understanding the interannual variability of the Asian monsoon.

To fully understand the seasonal cycle and interannual variation of the Asian monsoon, we need to include the large-scale atmosphere-ocean processes and their interaction with land surface processes. GAME modeling activity includes these processes using atmospheric GCMs and coupled atmosphere-ocean GCMs. However, almost all the current GCMs have very large systematic errors in simulating the mean monsoon climate and circulation (Kang *et al.,* 2001). For example, the simulated monsoon precipitation on land, particularly near the coast in south and southeast Asia tend to be far larger than the observation, whereas that over the warm pool region in the western Pacific tend to be smaller compared to the observation. These defects in GCMs both in the seasonal cycle and spatial distribution need to overcome by improving land-atmosphere as well as ocean-atmosphere processes. The forthcoming CEOP (Coordinated Enhanced Observing Period) under World Climate Research Programme (WCRP) to be held in 2001 to 2003 will provide us a good opportunity for providing sufficient data for further understanding the Asian monsoon with its interannual variability.

References

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