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GEWEX-RELATED ASIAN MONSOON EXPERIMENT (GAME)

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Abstract

The Asian summer and winter monsoon system has a great role in the global energy and water cycle and the climate system. The variability of the global climate system, such as the ENSO, has also been proved to be closely associated with the variability of the monsoon system. The physical processes involved in the seasonal as well as the interannual monsoon variabilities have not, however, been well understood yet. The role of the atmosphere/land surface interactions, e.g., soil moisture, snow cover, over the Eurasian continent seems to be an essential component of these processes. The GEWEX-related Asian monsoon Experiment (GAME) is being proposed as one of the international projects under the GEWEX program, to understand these processes associated with the energy and hydrological cycle of the Asian monsoon system and its variability.

1. Energy and Water cycle of Asian Monsoon System

The Asian summer and winter monsoon system is characterized as a huge circulation system in the global atmosphere, which plays a major role in the exchange and transport of energy and water between the largest ocean and the largest continent, between the tropics and the middle/high latitudes and between the two hemispheres. This circulation system is fundamentally forced and maintained by latent heat energy supplied and released through the water cycle induced by this system itself as shown in Figure 1. This system includes the seasonal migration of gigantic heat source of the global atmosphere over the warm water pool region of the western tropical Pacific. In this sense, the Asian, or more comprehensively, the Asian/Australian monsoon system consists of a major and key component of the global energy and water cycle.

The seasonal and interannual variabilities of this monsoon system has recently been proved to be closely associated with those of the coupled atmosphere/ocean system in the tropical Pacific, typically manifested as the ENSO (El Nino/Southern Oscillation) (Yasunari, 1990: Webster and Yang, 1992). That is, a weaker (stronger) than normal condition of the Asian summer monsoon seems to lead the atmosphere/ocean system to a favorable condition of the El Nino (La Nina) in the central/eastern equatorial Pacific, presumably through the modulation of the tropical east/west atmospheric circulation along the equatorial Indian/Pacific Oceans and/or the subtropical high over the Pacific. Although the physical mechanisms underlined in this ENSO/monsoon connec-

tion have not fully been understood yet, the seasonal and interannual modulation of the heating contrast between the Eurasian continent and the surrounding two oceans may have a clue for this issue.

The interannual variability of the Asian summer monsoon is, on the other hand, strongly influenced by the anomalous state of seasonal land surface conditions, i.e., snow cover, soil moisture and possibly permafrost, of the Eurasian continent (Hahn and Shukla, 1976, Barnett et al, 1989; Yasunari et al, 1991). These anomalous surface conditions are provided chiefly by the anomalous mid-latitude westerly flow regime in the preceding winter and spring (Morinaga and Yasunari, 1987). It is noteworthy to state that these land surface hydrological parameters influencing the monsoon variability are also major components of the water cycle over the Eurasian continent.

In th global climate system, the Asian monsoon has, in this manner, an important role of two-way interactions between the tropics and the extratropics. It conveys climate signals from the extratropics to the tropics through the anomalous land surface forcing in the northern summer, and reversely from the tropics to the extratropics through the anomalous dynamical forcing of the monsoon/atmosphere/ocean system (e.g., Rossby wave propagations) mainly in the northern winter (Yasunari and Seki, 1992). The processes mentioned above are schematically summarized in Figure 1. The assessment and validation of the energy and water cycle and its variability over the larger domain of the Asian monsoon should be, thus, undoubtedly an urgent and indispensable task for understanding the physical processes of the seasonal and interannual variations of the global climate system. The real mechanisms of land-surface processes affecting the atmosphere of later seasons should be solved as part of this task.

2. Heterogeneity of monsoon Asia

On the other hand, the energy and water cycle of the Asian monsoon system affects ,and also, is affected by the heterogeneous and complex land surface conditions, which as a result forms various regional climates over monsoon Asia. The physical process study and quantitative assessment of the basin-scale and regional-scale hydrological cycles and their temporal and spatial variabilities under various climatic conditions of monsoon Asia are essential for the up-scaling and down-scaling of the water cycle over the whole Asian monsoon region. The different characteristics of seasonal hydrologic cycle from region to region may have some clue for understanding the interactive processes among multi-scale water cycles. These studies are also particularly important for water-resource control and water management of the Asian countries, where people depend their life and production chiefly upon paddy field cultivation.

3. Data sets for the GAME

The meteorological, hydrological and oceanographical data sets available for the studies related to the energy and water cycle of the Asian monsoon system are, however, entirely insufficient, particularly if we consider the heterogeneity of land surface conditions in monsoon Asia. The utility of satellite data is an essential component of the GAME, including the development of algorithms for detecting hydro-meteorological parameters as well as the land-surface informations. The TRMM

(Tropical Rainfall Measuring Mission) satellite is one of the most expected tool for this purpose. Some other satellites with the active and passive micro-wave sensors, high-resolution multi-channel spectrometers for infrared and near infrared spectral bands are also necessary for surveying complex and variable land-surface conditions.

The field experimental study of energy and water cycle in some river basins and regions under different climate conditions and their inter-comparisons are important and necessary strategy for understanding the integrated effect of the heterogeneous and complex terrain of the Eurasian continent on the energy and water cycle of the entire monsoon system. This study should also provides the surface or "near-surface" truth data sets for satellite soundings. The typical study areas essential for the large-scale aspects of the monsoon system and land-surface processes may include the cryosphere of the Tibetan plateau, the subtropical polar frontal rain belt (i.e, Baiu or Meiyu region), the semiarid steppes of central Asia with seasonal snow cover, the permafrost zone of Siberia and the monsoon rainfall forest region of southeast Asia.

4. Sub-programs of the GAME

Based upon the aforementioned outline of the GAME, the main subprograms of the GAME will be proposed as follows:

(1) Monitoring of Asian monsoon system

The variability of large-scale moist processes of Asian monsoon system should be monitored from the diurnal to the interannual time scale, basically by utilizing the geo-stationary satellite, the TRMM and other satellites. The dense network of surface precipitation monitoring system should also be established. This study will provide fundamental informations for the diagnosis of the energy and water cycle of the Asian monsoon.

(2) Monitoring and process study of large-scale atmosphere/land surface interactions

The variability of large-scale land surface condition and surface or near-surface hydrological parameters from daily to the interannual time scale should be also monitored over the Eurasian continent, based upon the sensings and soundings by as many satellites as possible. The snow cover and soil moisture informations are the most essential parameters. The modelling and parametarization of land surface hydrology are also included in this program. The role of permafrost on the seasonal and interannual variability of the monsoon system may be a new aspect of the cryosphere/atmosphere interaction to be examined.

(3) Modelling and process study of the Monsoon and atmosphere/ ocean system coupling

The physical processes underlined in the seasonal and interannual coupling between the monsoon system and the atmosphere/ ocean system in the Indian/Pacific Ocean sector should be studied based upon the observed data sets and the model experiments by the coupled ocean/atmosphere GCMs. This program may be positioned as part of the post TOGA program, in a narrow sense.

(4) Modelling and process study of meso-scale convective systems

and regional hydrological cycle

The detailed observational and modelling studies of meso-scale convective systems embedded in the ITCZ in the tropics and the polar frontal system called Baiu (or Meiyu) front and their impacts on regional or basin-scale hydrological cycle are essential for understanding the up-scale and down-scale of the energy and water cycles in monsoon Asia.

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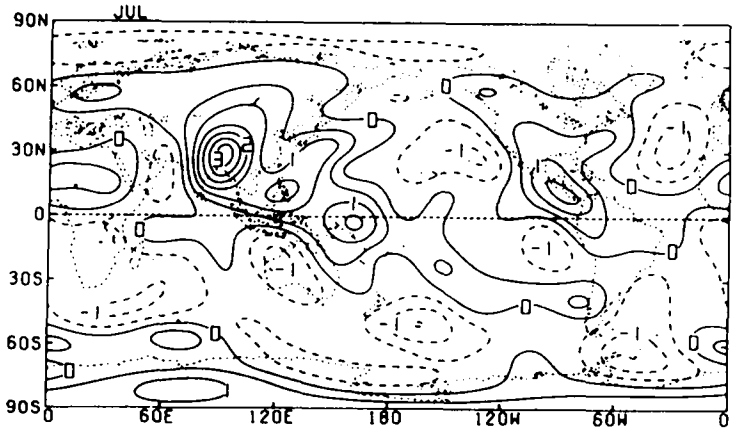

Fig.1: Mass-weighted vertically averaged diabatic heating rate (K/day) for July 1979. Negative values are shown with dashed lines. (Johnson et al., 1987).

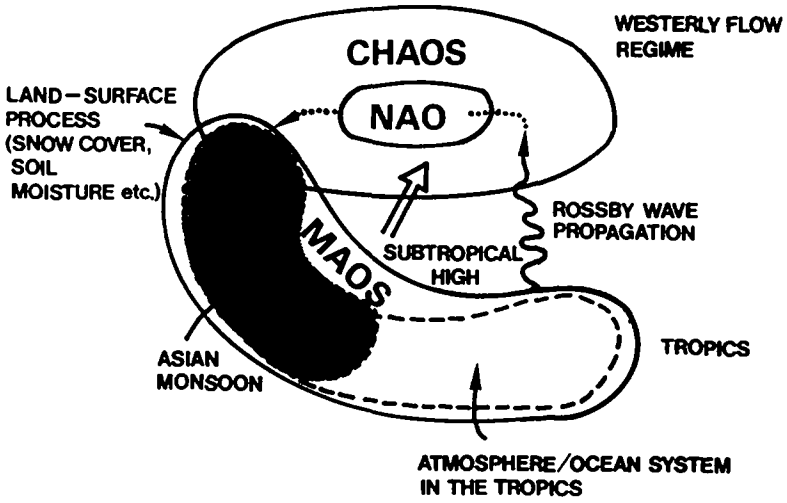

Fig. 2: Schematic diagram of the interactions between th4e MAOS (Monsoon and the Atmosphere/Ocean System in the tropics) and the chaotic westerly flow regime (indicated as CHAOS) in the middle and high latitudes. (after Yasunari and Seki, 1992)