

1. FRAMEWORK OF GAME IMPLEMENTATION

1.1 Introduction

The human life, economics, agriculture and ecosystem in Asia/Australia region depend deeply upon the monsoon climate and its variability. About 60% of the people on the earth live under the influence of this monsoon climate. Droughts and floods associated with the monsoon rainfall variability frequently cause serious damages for the human life and ecosystem in these regions. The seasonal forecasting of monsoon rainfall and the control of water has been a matter of great concern for the people and countries in these regions.

On the other hand, the recent extensive studies have proved that the Asian summer and winter monsoon plays a major role in the global climate system and its variability, through the energy and hydrological cycle in the atmosphere-ocean-land system of this region. There have been ample evidences (Meehl, 1987; Yasunari, 1990; Yasunari and Seki, 1992; Webster and Yang, 1992, etc.) that the interannual variability of the Asian monsoon plays a key role on triggering and modulating the ENSO in the equatorial Pacific. The variability of the monsoon, in turn, is likely to be strongly affected by the land-surface processes (snow cover, soil moisture, etc.) over the Eurasian continent (Hahn and Shukla, 1976; Yeh et al., 1983; Barnett et al., 1989; Yasunari et al., 1991, etc.).

Without understanding these processes and feedbacks involved in this complex system, we are not able to fully understand the mechanisms of the interannual variability of the Asian monsoon. The basis for the seasonal forecast of the monsoon rainfall and water resources, therefore, needs long-term monitoring and modeling effort on the whole Asian monsoon system, including the atmosphere, hydrosphere and land surface conditions. This effort is very essential for reducing uncertainties in predicting regional-scale monsoon rainfall variability under the changing global climate system, which might be caused at least partly by the anthropogenically increasing greenhouse gases.

There is a long history of studies on the Asian monsoon, including the seasonal prediction since the end of the nineteenth century. To understand various aspects of the monsoon, some large-scale experiments were also conducted, e.g. the Monsoon Experiment (MONEX) in 1979 as part of the Global Weather Experiment (GWE). MONEX was the first comprehensive experiment on the Asian monsoon, though this experiment focused mainly on some meteorological disturbances related to the monsoon onset and short-term variability.

The Global Energy and Water Cycle Experiment (GEWEX) is now being implemented since 1990, as a major sub-program of the World Climate Research Programme (WCRP). The GEWEX aims to understand the basic physical processes, particularly energy transfer and hydrological cycle, involved in the fast component of the climate system, covering the time scales of a week to several years.

As part of GEWEX, the GEWEX Asian Monsoon Experiment (GAME) is proposed and has been approved by WCRP, to understand the role of the Asian monsoon as a major component of the global energy and water cycle, and to understand the feedback processes, i.e., radiation, cloud, precipitation and land surface hydrology, in the diurnal cycle, and intraseasonal, seasonal to interannual variabilities of the Asian monsoon. To determine the impact of the large-scale Asian monsoon variability on regional or basin-scale hydrological cycle and water resources is another essential issue of GAME.

1.2 Scientific Objectives

The main objectives of GAME are summarized as follows;

A. To understand the role of Asian monsoon in the global energy and water cycle.

B. To improve the simulation and seasonal prediction of Asian monsoon and regional water resources.

The objective A will be based upon global-scale satellite observation, analysis of four-dimensional data assimilation (4DDA) data and GCM-based model studies. To accomplish this objective, we need to understand multi-scale interactions in the energy and hydrological cycles in the Asian monsoon region.

The objective B will be based on the global and regional atmospheric models, combined with macro-scale hydrological models. To improve the simulations and prediction of regional monsoon climate and hydrological conditions, intensive field-based process studies are required on cloud, precipitation and land-surface hydrological processes, with spatial resolution of 10 to 50 km horizontal scale.

1.3 Strategy for GAME Implementation

To achieve the objectives of GAME, we have proposed four strategies for implementation as follows;

(1) Deployment of new monitoring and observing systems for hydro-meteorological conditions over the Asian monsoon region.

In addition to conventional meteorological and hydrological observing network of operational agencies and satellites, new satellite and in-situ observation systems will be utilized for GAME. One important satellite will be TRMM (Tropical Rainfall Measuring Mission), which can measure rainfall rate by a satellite-borne meteorological radar. The ADEOS series of NASDA will observe some important hydrological parameters at the land surface as well as in the atmosphere.

One new in-situ observing system named Asian AWS Network (AAN) is being initiated, which aims to monitor radiation and energy budgets at various land surfaces of monsoon Asia, by deploying special Automatic Weather Stations (AWS) for measuring radiation and sensible and latent heat fluxes directly.

(2) Intensive field-based regional experiments for multi-scale energy and water cycle processes

The four regions of different climate and surface conditions, i.e., Chao Praya river basin in Thailand, Huai-He river basin in central China, Tibetan Plateau and Lena river basin in east Siberia, are selected, to make intensive process study for energy and moisture fluxes at the surface and the planetary boundary layer (PBL), with horizontal scales of 1 to 1,000 km, and basin-scale water cycle. At least one or two full annual cycles will be continuously observed, with one unified Intensive Observing Period (IOP) for understanding the seasonal evolution of the monsoon in each region.

(3) 4DDA of atmospheric and hydrospheric parameters over the Asian monsoon region.

The 4DDA will be performed by using the advanced global forecasting model (T213L30) of JMA, with horizontal grid-scale of about 50 km. One of the objectives of IOP, which should include enhanced radiosonde observation over the whole Asian monsoon region, is to obtain highly qualified assimilated data for estimating energy and water cycle processes of the monsoon system. 4DDA is also an important tool for optimizing the observed data information for modeling and numerical forecasting.

- (4) Modelling studies on the hydrometeorological processes based on global and regional atmospheric models, combined with macro-scale hydrological models.

To understand the multi-scale interactions of energy and water between the land surface, PBL and the troposphere, regional modeling and regionally-nested 4DDA will be essential. Some regional models will be developed and utilized, as part of the regional experiments. The results of these regional modeling will be extended and applied for GCM-based studies on monsoon simulation and prediction.

- (5) Data archive and deployment of information network (GAIN)

Various kinds of meteorological and hydrological data obtained and collected through the implementation of GAME will serve us a huge data archive, that should easily and quickly be accessed and utilized by scientists and operational engineers of the concerned countries. For this purpose, GAME Archive Information Network (GAIN) has been proposed and being prepared, based on the concept of the state-of-the art information network available for all over the world.

The structure and inter-relation of strategies for GAME implementation are schematically shown in Figure 1.

1.4 Organization Framework of GAME

1.4.1 GAME International Science Panel (GAME-ISP)

The establishment of GAME International Science Panel (hereafter referred to as ISP) was recommended and agreed at the second International Study Conference on GEWEX in Asia and GAME, held in March 6-10, 1995 at Pattaya, Thailand. The first session of the ISP was held in March 6-9, 1996 at NASDA/EORC in Tokyo, and the terms of reference and functions of the ISP were discussed. The summary of the ISP meeting is available in the GEWEX News, Vol. 6, No. 2, 1996. The members of ISP were nominated from the 10 countries (Japan, China, Thailand, Russia, India, Malaysia, Korea, Singapore, Hongkong and USA/GCIP), which have high potential to contribute GAME.

The ISP should play an role of promoting the implementation of GAME, as well as of functioning as an international node of cooperation and coordination for GAME. Main tasks of ISP will be to promote and coordinate international as well as multi-national cooperation of regional experiments, IOP and data exchanges. To promote scientific activity related to GAME, the ISP also can organize international sub-panel or committee for each component of GAME, scientific meetings, workshops etc. The ISP meeting will be held once per year. The terms of reference were decided at the first meeting of ISP as follows:

Terms of Reference for GAME International Science Panel (GISP)

The GISP is the principal group within GEWEX for considering scientific issues and promoting scientific activities associated with the implementation of GAME. The aims of GAME are to understand the role of the Asian monsoon as a major component of the global energy and water cycle and to improve the seasonal forecasting of monsoon and regional water resources, along with the feedback processes associated with the variability of the monsoon.

The main task of the GISP is to improve the scientific contribution of GAME to fulfill the requirements of GEWEX by:

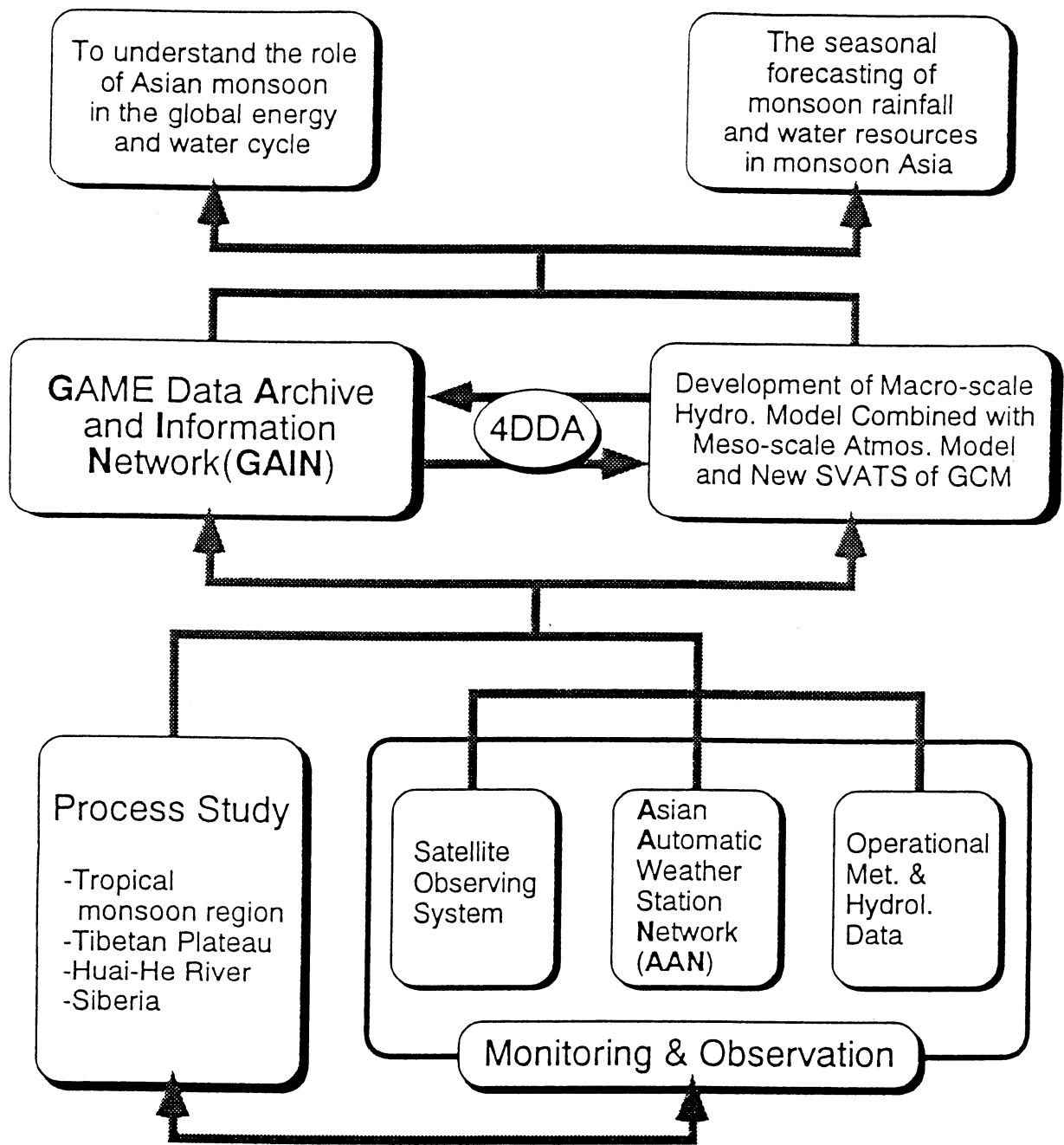


Fig.1 Structure and inter-relationship of strategies for GAME implementation

- a. determining and integrating an overall strategy for implementation of GAME, ensuring contribution to GEWEX and WCRP objectives.
(e.g., data management, ...)
- b. promoting and coordinating scientific activities, and facilitating the exchange of information within all the components of GAME.
(e.g., IOP, data formats, workshop, model-intercomparisons, ...)
- c. co-ordinating and fostering interaction among different countries and programs participating in GAME through establishment of subpanels and science working groups.
- d. providing the focus for the international cooperation with other related international programs and scientific activities.
(e.g., with SCSMEX, IGBP, ...)

Membership of GAME-ISP:

The GAME-ISP is to be formed by the representatives from the scientific group and/or operational agencies of the countries participating in GAME, the leading scientific experts of each component of GAME, and ex-officio representatives from WCRP/GEWEX, GHP, etc. The members will be selected for 3 year terms with possibility of extension.

The GISP meeting will be held once per year.

Sub-panels:

The ISP will have some sub-panels, in case these sub-groups are required to efficiently promote some components of GAME, or some specific scientific topics related to GAME. The chairman of the sub-panel is expected to be a member of the ISP.

1.4.2 GAME International Project Office (GAME-IPO)

At the Pattaya meeting, the GAME international secretariat (GIS) or project office was also proposed, and at the first session meeting the agreement was met on the GAME International Project Office (IPO) to be established at IHAS (Institute of Hydrospheric-Atmospheric Sciences) of Nagoya University. Currently, the IPO is being conducted by Prof. K. Nakamura, the secretary general.

The role of IPO will be to support the activity of ISP, and to control the information and coordination related to the international activity of GAME. Another task of the IPO will be to organize and/or coordinate the international scientific conferences and workshops related to GAME. The IPO will also promote the international seminars and scientific exchange visits among GAME-related countries, as part of the post-IOP and observation phase of GAME, when a high quality data set would be available to the global scientific community, including those participating in GAME. The recent activities and staff-members of the IPO are introduced in the appendix of this Implementation Plan.

The IPO currently holds one position of post-doc. foreign scientist who will be to work with the secretary general.

1.4.3 National organization for GAME in Japan

The Japan National Committee for GAME (hereafter referred to as NC; chair: Prof. T. Yasunari, about 20 members), under National Research Council of Japan, is responsible for planning and implementation of GAME in Japan. The four sub-committees have been organized under NC, for

GAME-Tropics, GAME-HUBEX, GAME-Tibet and GAME-Siberia, and several working groups have been approved under NC. The national project office for GAME is located at IHAS, Nagoya University (Prof. Y. Fukushima, the secretary general).

Concurrently, the GEWEX National Office has been established at the Earth Observation and Research Center (EORC) of National Space Development Agency (NASDA), whose main tasks will be to coordinate the national activity related to GEWEX and to act as an international node of information exchange related to GEWEX/GAME in Asia.

The main funding agencies for GAME and GAME-related activity are Ministry of Education, Science, Sports and Culture (MESSC), Science and Technology Agency (STA), NASDA, and the Frontier Research System for Global Change, which has recently been established under the cooperation of NASDA and JAMSTEC (Japan Marine Science and Technology Center). The APN (Asian-Pacific Network for Global Change Research) is also supporting the GAME-AAN. The Japan Meteorological Agency (JMA) will host 4DDA, some part of modeling and data archive as GAIN-Hub (refer to 7.3.).

1.4.4 National organizations in other countries

China has established GEWEX working committee (chair: Prof. Zhao Bolin), which particularly deals with Chinese part of GAME-HUBEX. At the same time, TIPEX (Tibetan Plateau hydrometeorological EXperiment) has been started, which is a Chinese national project, of which scientific objectives are very common to those of GAME-Tibet. The Joint Coordination Committee (JCC) for TIPEX and GAME-Tibet was established, where Chinese and Japanese scientists discussed about the details of the cooperation and coordination on the Tibetan Plateau hydro-meteorological processes. The two session meetings (the 1st meeting in July, 1996, Beijing, China; the 2nd meeting in December, Kyoto, Japan) were held.

In Thailand, the sub-committee for GAME-T has established under NRCT, whose chairman was Dr. Suvit Vibulsresth.

In India, the national coordination committee for GAME was established chaired by Dr. N. Sen Roy, Director General of Meteorology.

In Korea, the Korean Monsoon Climate Committee has been established, to implement the Korean Monsoon Experiment (KORMEX), which aims to study the energy and water cycle processes of the monsoon in Korea, particularly the Changma. KORMEX is planning to cooperate with GAME-HUBEX.

In Russia, the national committee for GAME (chair: Prof. Kotlyakov, Institute of Geography, Russian Academy of Sciences) has been established as a Russian counterpart body to GAME-Siberia.

1.5 Time Phasing of GAME Implementation

The implementation of GAME has been formally started from 1996, including the four regional experiments. The field-based regional experiments will be implemented for 5 years from 1996 to 2000. In 1997 summer, most of the regional experiments deployed in-situ (surface) observing systems (PBL towers, AWS, radars, etc.), and in spring through summer of 1998, the intensive observations of the common IOP, including that of SCSMEX, will be implemented. AAN test has been started and expanded continuously from 1997, in conjunction with the regional experiments, but the full deployment will hopefully be kept even after 2000, for long-term monitoring. The data archive and modelling will be started from 1998, and will continue to 2000 or further longer.

1.6 Linkages to Other Related International Programs and Projects

SCSMEX

GAME and SCSMEX (South China Sea Monsoon Experiment) have common and complementary scientific objectives. In the Pattaya conference and the workshop for SCSMEX (June, 1995, Beijing), a tight coordination between GAME and SCSMEX was agreed, particularly for their common IOP (1998 spring to summer). To facilitate further cooperation, ISP has decided to have an ad-hoc committee for GAME/SCSMEX IOP, co-chaired by T. Yasunari and K. M. Lau (NASA).

CLIVAR/GOALS

CLIVAR (Climate Variability and Predictability Program) has a component of GOALS (Global Ocean Atmosphere Land System), focusing on the interannual variability of the climate system. In the first meeting of the CLIVAR monsoon panel held in Goa, India, in November 1996, GAME was re-confirmed as a GEWEX-side major counterpart project for the CLIVAR/GOALS ENSO-monsoon study program.

ACSYS

GAME-Siberia has a potential to contribute to some aspect of ACSYS, particularly to the issue of fresh water supply to the Arctic. At the GEWEX Science Steering Group (SSG) meeting at Irvine, CA, USA, held in January 1996, SSG has decided to have a coordination group between GEWEX and ACSYS, where GAME (Siberia) and MAGS, and BALTEX are main counterparts of GEWEX.

IGBP/NES

IGBP/NES Siberian Transect Study Group (lead by Dr. Will Steffen of GCTE and Dr. Pavel Kabat of BAHC) aims to study and monitor the biogeochemical and hydrological processes over Siberia. At the international IGBP/NES meeting held at NIES (Tsukuba, Japan) in November 1995, the strong cooperation between GAME, particularly GAME Siberia and IGBP/NES was agreed, particularly for in-situ monitoring in Siberia. In November 1996 in Kyoto, further discussion on cooperation was made between GAME Siberia and NES group in IGBP/BAHC.

START/TEACOM AND APN

START is a non-governmental international organization for promoting the three global change research programs, i.e., WCRP, IGBP, and IHDP. GAME has been recommended as one of the major activities of TEACOM (Temperate East Asia Committee of START), which is compatible to the basic idea of monsoon driven ecosystem proposed by Dr. C. Fu, chairman of TEACOM. In March 1996, the science promotion group (SPG) meeting of APN (the Asian-Pacific Network for global change research), which is the inter-governmental organization for supporting START/TEACOM activity, has endorsed GAME as a major project to be supported with a high priority, and has started some substantial support for GAME-AAN.