2. OBSERVATION AND MONITORING

2.1 GAME Satellite Remote Sensing Program

2.1.1 Scientific goals

The variability of large-scale energy and hydrological processes of Asian monsoon system has been suggested to affect the global climate. They should be monitored from diurnal to interannual time scale at least for ten years. However, there are fewer ground observational stations in monsoon Asia. Due to dynamic behavior of the parameters for the energy and hydrological processes (i.e., cloud, water vapor, precipitation, wind, snow cover, albedo, soil moisture, surface temperature etc.), efficient monitoring is possible only by using satellite remote sensing.

In turn, the field observations and process studies related to GAME would function as a ground-truth and algorithm study for the satellite observations. The objective of the GAME satellite remote sensing project is to develop observing techniques of energy and water cycle over the Eurasian continent.

2.1.2 Program strategy

(1) Data set generation

a) The operational satellites, such as GMS, NOAA and DMSP series have already been providing us homogeneous and continuous information on the fundamental properties of the hydrosphere and atmosphere. The data set generation activities of GEWEX such as ISLSCP, GPCP and ISCCP have already released the uniform, consistent global data sets. GAME plans to generate two kinds of data sets over the Eurasian continent as follows:

- 1st order data sets: vegetation indices, surface albedo, surface temperature, surface wetness, surface roughness, snow covered area, snow water equivalent, precipitation, net radiation budget at the top-of-atmosphere
- 2nd order data sets: surface radiation budget, vertical sensible and latent heat fluxes at the surface, horizontal heat and moisture fluxes in the atmosphere

The first order data sets are produced by the operational satellites with more specific but high-order information derived from the half-operational and half-experimental satellites, LANDSAT, EERS-2, JERS-1 and RADARSAT. The second order data sets are generated by combining atmospheric and hydrologic models with the first order data sets.

b) ADEOS is the first satellite of this series and was successfully launched by NASDA on August, 1996. However, it stopped to function with unexpected problems in 1997.

c) TRMM, which is a non sun-synchronous satellite and very unique mission dedicated to measure the tropical and sub-tropical rainfall, was successfully launched by NASDA in November, 1997. may be one of the most important satellites for GAME and GEWEX. A package of a rain radar and microwave and visible/infrared radiometer is aboard TRMM. Many kinds of data products start to be generated by the TRMM project. Among them, the following products would considerably contribute to GAME.

- Rainfall Structure data sets from PR, TMI and Combined
- 30 day Surface Rainfall data sets from PR and TMI
- 30 day Rainfall Structure data sets from PR and Combined

- Monthly Regional Radiative Fluxes and Cloud data set from CERES
- Monthly TOA and SRB Averages data set from CERES

2) Algorithm development and data set verification in the regional experiments

Four regional experiments, GAME-T, HUBEX, GAME-Tibet and GAME-Siberia, focus on the development of algorithms and data set verification for the following parameters:

a) Precipitation

GAME-T, HUBEX and GAME-Tibet plan the deployment of 3-D Doppler radar, operational radar, rainguage networks and/or disdrometers for TRMM data verification. The radar observes various cloud types to precipitate, which are used to construct the algorithms to estimate precipitation area and rate from the T_{bb} distribution of geostationary satellites.

b) Vertical distribution of water vapor

HUBEX focuses of the estimation of vertical distribution of water vapor by SSM/T-2 and AMSU-B data and its verification by data of intensified radio-sonde observation.

c) Radiation budget

Radiative heating of atmosphere is an important issue over the Tibetan Plateau. To address this issue, the accuracy of estimation of the radiation budget at the land surface should be improved. GAME-Tibet plans an ad hoc lidar observation of cloud base over Tibetan Plateau for development of an improved algorithms for surface radiation budget. Surface radiation and cloud data is planned to be obtained for verification of GMS/VISSR data in GAME-T.

d) Surface soil wetness

GAME-Tropics and GAME-Tibet plan to obtain the distribution of surface soil wetness for development and evaluation of the algorithms for SARs on JERS-1, EERS-2 and RADARSAT and passive microwave sensors on DMSP and TRMM as the basis of monitoring the temporal and spatial distribution of hydrological states of frozen soil by using passive and active microwave sensors in GAME-Tibet and GAME-Siberia.

e) Snow water equivalent

Climatological characteristics of snow parameters on the Tibetan Plateau obtained by field measurements, which are planned in GAME-Tibet and GAME-Siberia, are very useful for development of algorithms for passive microwave sensors on DMSP, TRMM and ADEOS2 and SARs on JERS-1, EERS-2 and RADARSAT. In turn, those algorithms should be validated by the field measurement data.

3) Assimilation of satellite data

Further advancement of the 4DDA system will be achieved by including newly developed satellite observation data with appropriate truth data, which may compensate for the sparsity of conventional observational data. In coming several years, new earth observing satellites, such as TRMM, ADEOS and advanced TOVS system will be available as well as the currently operated GMS, NOAA, ERS1 and DMSP equipped with SSM/I. In order to use these data effectively, we are going to develop data assimilation techniques of satellite data, such as physical initialization and three or four dimensional variation methods.

2.2 GAME-Radiation Activity

2.2.1. Introduction

Redistribution of radiative energy is the main mechanism for formation of the global climate (Hansen et al., 1981; Shi et al., 1994). This mechanism of energy redistribution is especially complicated in the Asian monsoon region with monsoon circulation caused by the ocean-land contrast in continental scale. For understanding the climate formation of this region, therefore, it is important to study the effect of clouds, water vapor and surface conditions on the radiative budget of this region. There are numerical simulations, for example, indicating that upper and lower level clouds play large but different roles in the energy flow on continental scale. The effect of global warming due to greenhouse gas increase is especially large and sensitive to the radiative budget structure over land areas.

Our knowledge is, however, not enough accurate for modeling of the above mentioned processes. For example, there is a large uncertainty in estimation of the globally averaged surface radiation budget more than 20 Wm^{-2} even with the state of art modeling of the radiation processes (Stephens and Tsay, 1990; Li et al., 1995). This indicates that the diabatic heating may be poorly modeled in numerical climate models. Extensive studies of radiation processes including the solution of the anomalous absorption problem are, therefore, indispensable for improving climate modeling. It is especially important to study the effects of clouds, water vapor and surface conditions upon the radiation budget through extensive monitoring with satellite and ground-based radiometers.

Anthropogenic aerosols are an another important factor affecting the radiation budget in the Asian monsoon region. Numerical simulations have shown that an introduction of large loading of anthropogenic aerosols in this region improves the large scale simulation of temperature, precipitation and energy flux distributions (Mitchell et al., 1995; Santer et al., 1996). The radiative forcing of anthropogenic aerosols has been estimated to be comparable with the radiative forcing due to greenhouse gas increase. The globally averaged direct radiative forcing of aerosols is estimated as -0.3 to -0.9 Wm^{-2} (Charlson et al, 1992; Taylor and Penner, 1994), and the indirect forcing as about -1.3 Wm^{-2} (Jones et al., 1994). There is, however, a large uncertainty in the estimation of the forcing, especially in their indirect forcing evaluation. The indirect forcing will become even positive for continental convective cloud systems (Kaufman and Nakajima, 1993). This large uncertainty comes from our lack of knowledge on the detailed aerosol distribution over land areas and aerosol optical properties on global scale. It is, therefore, necessary to perform an extensive monitoring of anthropogenic aerosols in the Asian region.

The above discussion indicates that it is important to have an extensive study of the radiation budget and of various affecting factors in the Asian monsoon region. We, thus, set the major science objectives of the GAME Radiation Activity as follows:

(1) To understand the surface radiation budget distribution over the Asian monsoon region.
(2) To understand the role of clouds, aerosols, water vapor, and surface conditions for determining the radiation budget regime of the earth-atmosphere system in the region.
(3) To establish satellite remote sensing techniques for estimating surface radiation budget and optical properties of atmospheres and surfaces.

Since these activities have to be performed in continental scale, it is essential to have tight collaboration with ongoing international radiation programs, such as WCRP/International Satellite Cloud Climate Project (ISCCP), Baseline Surface Radiation Network (BSRN) Project, Surface Radiation Budget (SRB) Project, WMO/Global Atmospheric Watch (GAW) System, and others.

2.2.2. A plan for the GAME-Radiation activity

As discussed in the preceding section, accurate measurements of solar radiative fluxes and thermal radiative fluxes at surface of the Asian monsoon region should be performed to understand the large scale climate formation of this region. To attain this objective, the following strategy will be effective:

(1) Establish high-accuracy radiation sites to measure the surface radiation budget,
(2) collect existing radiative flux data,
(3) calibrate the existing data with data from the high-accuracy radiation sites,
(4) compare and analyze those flux data with satellite data to obtain the surface radiation budget distribution over the Asian monsoon region,
(5) and also study the effects of clouds, aerosols, water vapor and surface condition upon the obtained radiation budget distribution.

2.2.3. Surface radiation measurements

Data archives of the following radiative and related quantities in the Asian region is important to accomplish the objectives of the Activity.

(1) Sunshine duration

This is the most well measured quantity in the Asian region. We will use the existing archived data for our study.

(2) Global, direct and diffuse solar radiative fluxes

Those quantities can be measured by pyranometer and/or pyrheliometer. We will adopt the BSRN method to make accurate measurements of the global solar radiative flux, i. e., adding direct flux from pyrheliometer and diffuse flux from pyranometer with shadow disk to block the direct radiation. It is also important to collect existing data of the global solar radiative flux, since this quantity has been measured in many sites in the region without systematic archives.

(3) Longwave radiative flux

It is important to measure the longwave radiative flux for estimating the effect of cloud and water vapor on the radiation budget. Establishment of longwave flux sites is highly encouraged, since this quantity has been measured at very few sites in the Asian region.

(4) Atmospheric turbidity

This quantity can be an index of aerosol loading, and be used to correct retrievals of global solar radiative flux from sunshine duration data. Atmospheric turbidity can be measured using a sunphotometer or a sky radiometer. We will make effort to establish a sky radiometer network, since this instrument can measure the atmospheric turbidity and related aerosol microphysical quantities with better accuracy than sunphotometry for long term measurements (Nakajima et al., 1996).

(5) Ancillary data

Vertical profiles of temperature and water vapor will be obtained from the nearest sonde station. Column water vapor in clear sky conditions can be obtained by the sky radiometer. Ozone amount will be obtained from satellite measurements. Those quantities are needed to calculate radiative fluxes to compare with measured values.

There are two BSRN sites in the Asian region operated at Tsukuba, Japan and at Wudaoliang, China. Adding two to three BSRN type sites will improve the coverage of high accuracy radiation measurement network in the this region. The GAME-Radiation Activity will establish GAME high-accuracy radiation sites for accurate measurements of radiative fluxes and related ancillary quantities with the following equipments (Fig. 2.2-1):

- Upward and down looking pyranometers
- Upward and down looking pyrgeometers
- A Pyrheliometer with automatic solar tracking system
- A sky radiometer
- A Mie lidar

We will realize 1 to 5 minute samplings of instantaneous, integrated and dispersion of the corresponding quantities. The sites should be near sonde stations. To realize the accuracy shown in Table 2.2-1, pyranometers and pyrgeometers should be ventilated; upward looking pyranometer and pyrgeometer should be blocked from the direct solar radiation by a shadowing mechanism.

Table 2.2-1 Anticipated accuracy of radiation measurements.

Quantities	Accuracy (Wm^{-2})
Downward shortwave flux	10
Upward shortwave flux	10
Downward longwave flux	15
Upward longwave flux	15

A lidar system will be introduced to monitor the aerosol profile, cloud base height, and cirrus cloud structure. The latter two monitorings are important to connect surface data to satellite-received longwave radiation data. A sky radiometer (PREDE/SKR-01L) will be introduced to obtain aerosol optical properties, column water vapor and ozone amounts. Similar radiometer network has been developed by NASA/AERONET project (Holben et al., 1996).

2.2.4 Satellite remote sensing

Retrievals of surface radiation budget and optical properties of atmosphere and surface have not been studied fully over land surface area. The GAME-Radiation Activity is, therefore, concerned with comprehensive satellite data analyses to produce the large scale radiative budget field. The following parameters are planned to be retrieved for the Activity:

(1) Surface shortwave and longwave radiative fluxes: The quantities will be obtained from GMS radiances for every 1x1 degree box over the GAME area. Retrieved values will be compared and validated with ground-based measurements.

(2) Cloud microphysical parameters: Optical thickness and effective particle radius will be retrieved from AVHRR over the GAME area (Nakajima and Nakajima, 1995). It is important to investigate the radiative effects of a reduction of effective cloud particle radius over continental areas that is observed by Han et al. (1992). Partitioning of shortwave radiation absorption into visible and near-infrared spectral regions is important for studying the cause of anomalous absorption (Hayasaka et al., 1995). Further studies of clouds, water vapor and precipitation will be needed from visible-infrared sensors and microwave sensors, such as AVHRR, SSM/I and SSM/T2. A detailed validation and process

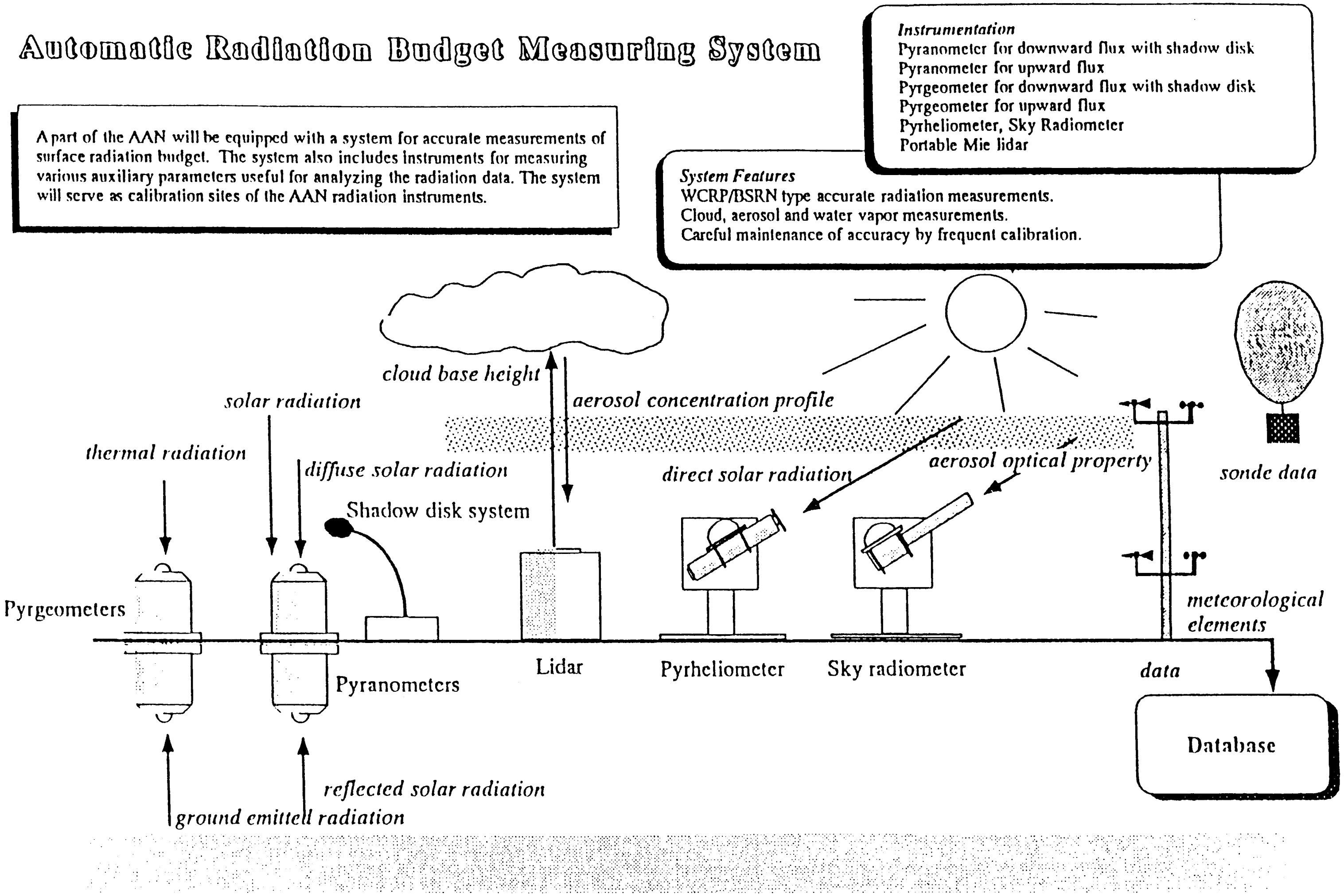

Fig. 2.2-1 The instrumentation plan of GAME radiation sites.

studies will be performed with combined satellite and ground-based data sets over the GAME area.

(3) Aerosol optical properties: It is found that Ångström exponent derived from a two channel method of AVHRR significantly increases over a large areas of several hundred kilometers near large cities (Higurashi and Nakajima, 1996). This observation suggests that aerosols generated from gases emitted from a large city are significant even in global scale. It is important to estimate land aerosols by combined analyses of AVHRR, OCTS and TOMS data.

2.2.5. Implementation schedule

Two to three GAME high accuracy radiation sites will be established in the GAME period between 1997 and 2001. For the year of 1997, we have selected the following sites:

· Thailand: Si Samrong agrometeorological station (16.9N, 99.8E). This site is close to the GAME-T measurement site and inside the GAME-T sonde network. The radiative effect of large biomass burning in dry season is one of important targets to study. We will locate a Mie lidar at this site.

· China: Shou-Xian meteorological observatory (32.6N, 116.8E). This site is one of the HUBEX measurement sites and is located in a horizontally flat area with relatively small city effect. Instruments are same as those of Si Samrong site without a lidar system. There are lidars in the Anhui Institute of Optics and Fine Mechanics, which is located about 100 km south-east of Shou-Xian site. The site is inside the HUBEX sonde network.

We were deployed our instruments, other than the lidar system, around May of 1997 after testing the system at Tohoku University. It should be noted that existing radio sonde sites are not suitable for GAME radiation sites, since those sonde sites are located in relatively large cities and are heavily affected by city air pollution. This problem should be focused more adequately for making a good radio sonde network for climate studies.

It will be important to exchange information with the Chinese BSRN site in Wudaoliang and the Chinese GAW site in Waliguan.

The GAME-Radiation Activity will pay an effort for collecting radiation data existing over China for studying continental scale radiation budget over China. It is also important to collect related data useful for the radiation budget analyses such as meteorological data and cloud base height data. Site and period of data collection will be decided by China GEWEX National sub-Committee for GAME-Radiation taking into a consideration a recognition that data of the first class radiation sites from April of 1997 to March of 2001 are of the first priority. Chinese radiation data sets to be exchanged will be subject to approval of concerned Chinese authorities.

Measurements will be also performed in tight collaboration with HUBEX and SCSMEX.

The schedule for the GAME Radiation Activity is summarized as follows:

JFY	Description of milestones
1995	- Implementation plan development
	- Radiation site system design
	- GCM radiation code development
1996	- Radiometer system evaluation
	- Selection of measurement sites (2 sites)
	- Development of satellite retrieval algorithms for surface radiation budget, clouds, aerosols, water vapor, and precipitation
1997	- Establishment of GAME radiation sites
	- Start data accumulations (ground data, satellite data)

- Start calibration activities
- Start application of satellite retrieval algorithms
- Start large scale radiation budget modeling with GCM

1998 - Start data set construction and comprehensive analyses
1999 - Continue efforts of all the components
2000 - Summarize the results

2.2.6. Participating organizations

The GAME-Radiation activity is performed by the following organizations:

China:
- National Climate Center
- Institute of Atmospheric Physics
- Anhui Institute of Optics and Fine Mechanics
- Lanzhou Institute of Plateau Atmospheric Physics

Japan:
- Center for Climate System Research, University of Tokyo
- Center for Atmospheric and Oceanic Studies, Tohoku University
- Center for Environmental Remote Sensing, Chiba University
- National Space Development Agency of Japan
- Frontier Research System for Global Change

Thailand:
- National Research Council of Thailand
- Thai Meteorological Department

2.2.7. Cooperative organizations

The following organizations have expressed their interest in supporting and/or cooperating with the GAME-Radiation activity:

- Japan Meteorological Agency
- Asia Pacific Network for Global Change Research

2.3 Asian AWS Network (AAN)

2.3.1 Objectives

The Eurasian continent, the largest continent on the earth, plays a predominant role on the seasonal cycle of the planetary-scale surface energy exchange and transport in the climate system. The diverse land surfaces and vegetations, however, characterize the extremely large seasonal and spatial variation of surface sensible and latent energy fluxes over the continent, which in turn may produce the regionality and asymmetries in the seasonal cycle over the continent.

The surface net radiation flux is a fundamental forcing of the sensible and latent energy fluxes. The estimation of these fluxes over the global surface was formerly carried out by Budyko (1956). His pioneering work should be updated by utilizing the satellite as well surface observations with higher quality and resolution over the whole of the continent, which is one of the major tasks of the GEWEX. The surface energy budgets are fundamental forcing of the seasonal march of the climate system. These elements are particularly important over the eastern half of the Eurasian continent, to unravel the role of the land/ocean heating contrast on the Asian winter and summer monsoon systems.

There has been, so far, a considerably dense routine observation network of surface meteorological station in the eastern half of this continent, maintained by operational meteorological agencies of each country. However, these station data are providing only indirect information for estimating the surface radiation and energy budgets over the broad area of the continent, based mainly upon the bulk method. In addition, the diverse and heterogeneous land surfaces of the continent make it more difficult to estimate the appropriate bulk transfer coefficients for the momentum, heat and moisture fluxes of each station.

The satellite-based SRB (Surface Radiation Budget), combined with the surface-based BSRN (Baseline Surface Radiation Network), has been continuously providing us with data sets of surface radiation elements with continental-scale coverage. The GEBA (Global Energy Balance Archive) conducted by ETH (Swiss Federal Institute of Technology) group has been archiving surface energy balance data from various parts of the world. The long-term monitoring of directly-measured energy fluxes, however, has not been undertaken except at a very few micro-meteorological stations (e.g., refer to Bulletin of ERC, Univ. of Tsukuba, 1994). The continental-scale monitoring system of surface energy fluxes and surface conditions (albedo, soil moisture, vegetation etc.), combined with the radiation network mentioned above, will provide us with key information for unraveling the physical processes of the recent climate change (e.g., rapid warming over Siberia and Mongolia) of the continental-scale. This network would also contribute greatly to the validation of surface energy conditions derived from satellites, and to the advanced 4DDA as part of the essential data input from the surface.

To remedy the current lack of a surface measurement network, it is important to construct a network of surface stations. Such network should have a major objective of the observation and the detection of seasonal and annual variations of surface fluxes of momentum, heat, and radiation as well as those of soil moisture on the continental scale as part of GAME scientific activities. At the same time, its objective should include a support for the regional studies, particularly their intensive field experiments. The latter requires the accurate determination of the above variable on a time scale of hour.

2.3.2 Strategy of AAN

Because the two major aims require different and somewhat contradictory requirements for the specification and configuration of a surface station, it has been decided to organize AAN activities in two phases.

Phase I for the year 1996-2000 will be the period for the construction, tests, and deployment of the AAN, and also for data acquisition during the intensive observations planned in 1998. For the Phase I, measurements will be made of (i) regular meteorological variables such as temperature, humidity, wind speed, etc., (ii) regular hydrologic variables such as precipitation, (iii) surface turbulent fluxes of momentum, heat and water vapor, (iv) surface radiative fluxes, and (v) soil moisture.

The subsequent Phase II (year 2000-2004) will be devoted for the long term monitoring period, and somewhat reduced number of variables will be monitored during this period.

2.3.3 Development of AWS

An important function of the AWS system is to measure the radiation and energy flux components, with the surface parameters (soil moisture, snow cover, etc.). Currently, AWS systems to fully satisfy this purpose are not available. Among the candidates as an AWS to be used during Phase I, a Portable Automated Mesonet (PAM) III station being developed at National Center for Atmospheric Research (NCAR) in the U.S., is currently a prime candidate, and scientists in AAN project are working closely with NCAR scientists and engineers to modify and improve the PAM III station to meet needs and requirements for AAN.

PAM III station uses a 3D sonic anemometer and a hygrothermometer to determine surface turbulent fluxes of momentum, heat and water vapor by applying an eddy correlation technique and bandpass covariance method. GAME-AAN is considering to add the second hygrothermometer and an infrared radiation thermometer, to allow flux evaluation by means of a Bowen ratio method, a profile method, and of a bulk method in order to increase the reliability of flux determination over a prolonged period in a remote area. In addition, sensors needed to apply time domain reflectometry (TDR) technique will be added to PAM III, in order to add capability to monitor the soil moisture. Furthermore, direct measurements of radiation budget at the surface are considered where other routine measurements are not available. Novel feature of the PAM III station is its capability to transmit the data through a geostationary satellite. This will allow real time monitoring of the status of the station as well as real time data acquisition.

In order to assess possible problems in cold climate, a prototype station was subjected to a test in a cold temperature down to -40 degrees centigrade within a controlled cold room, and it was verified that the station worked without a problem. However, it was desided to add more protection against cold temperature by empolying teflon cables wherever needed. Also, the development of another AWS system specifically designed for extreme cold environment is being considered and currently a prototype station is being tested.

For the long term monitoring during phase II, further consideration will be given to the improvements of the station with emphasis on the long term measurements based on the experience obtainable during Phase I.

2.3.4 Data requirements for AAN monitoring

To achieve the scientific objectives mentioned in 2.3.1, long-homogeneous and quality-controlled data should be obtained through the AWS network. The national GAME workshop on surface observation and AWS monitoring was held in July, 1996 at Environmental Research Center, University of Tsukuba, and an agreement was met on the guideline for the data required under GAME surface flux monitoring and regional process studies to be implemented during the phase I. The details of meteorological and hydrological elements and their time-space resolutions are listed in Table 2-3-1.

Table 2-3-1 Requirements for the surface measurement within GAME-AAN

Measurement site — Representative of the area of 10-50 km^2

Measurements and Products

- Fluxes : Sensible and latent heat, soil heat flux and momentum
- Radiation : Four components of radiation balance and surface temperature
- General meteorology: Air temperature, humidity, air pressure, wind speed and direction, and soil temperature (2-3 depths)
- Hydrology: Soil moisture, precipitation, (snow depth)
- Vegetation: Height, (Leaf Area Index), (stomatal resistance)
- Soil: Soil profiles, hydraulic conductivity, soil moisture curve, heat conductance, etc.
- Others:
  - Manual observationdata of rainfall, etc. should also be collected whenever they are available at nearby meteorological/hydrologic station
  - Field log of observations/maintenance should be kept, preferably with photos.

Observation interval and averaging period

- Fluxes, radiation, and meteorology: Continuous 30-60 minutes averages
- Vegetation: Infrequent intervals should be acceptable as long as seasonal variations can be obtained.
- Soil properties: One time observation at each station, except for soil moisture measurements

Methods and Accuracy

- Fluxes: The absolute value of 20 W/m^2 can be considered as desired accuracy. Any method of deriving fluxes can be accepted as long as the methods are fully documented.
- Meteorology and hydrology : The same standard method employed in a country where the station is located should be used whenever possible.
- Soil and vegetation: More emphasis should be placed on the detection of time variation of the soil moisture at single site. Variability of soil moisture in an area should be studied in a separate, independent experiments in an intensive observation. For the determination of physical/physiological properties of soil/vegetation, measurements by a single rover team visiting every sites are preferable.

Measurement period

From 1997 through 1999/2000.

2.3.5 Coordination for AAN

AAN project will be carried out through coordination of scientists in GAME regional studies and those in GAME/AAN. The latter forms the AAN working group (WG) which will be directly responsible for the development of an AS, data handling and initial analysis. The former will take care of the maintenance of AS installed in each regional study area. Table 2-3-2 summarizes organizations and persons in charge.

The network of AWS for measuring the surface radiation, energy fluxes and surface conditions will cover the whole of monsoon Asia, or the eastern half of the Eurasian continent. The AWSs will be arrayed fundamentally along the meridional and zonal section lines crossing over this area, which represent large gradients of climatic conditions and vegetation. The arrangement of the AWSs along the meridional section is shown in Figure 2-3-1. This meridional section crosses over the Tundra, Taiga of central Siberia, Mongolia, Tibetan plateau, the Himalayan highland and the Indo-China Peninsula, representing the temperature gradient from the polar region to the tropical monsoon region. Another site is locate in the humid subtropics in central China (Anhui Province), representing the humid subtropics in East Asia. The continuous observation of ten AWSs will be deployed over the whole Asian monsoon region within Phase I. Among the ten stations, three includes the intensive radiation monitoring mentioned in Sec. 2.2. In 1997, the AWSs at Tiksi (tundra of Siberia), Yakutuk (taiga of Siberia), Arvaikheer (grassland of Mongolia), Naqu (Tibetan Plateau), Shangboche (highland in Nepal), Sukhotai (paddy field of Thailand) and Kog Ma (monsoon forest of Thailand) have installed.

2.3.6 Data collection and control

To reliably acquire the measured variables, two data streams are under consideration. One flow of data will take place on site. All the variables measured and processed in a computer on an AWS will be recorded on a memory card. The card will be replaced and recovered at regular intervals by a scientist/engineer of a local counterpart organization responsible for the maintenance of the AWS system. These data will be sent to AAN/WG for further processing of the data.

Another data flow will be through the Japanese geostationary satellite (GMS). The AWSs will have capability to transmit data at regular intervals to the GMS, which in turn will downlink the data to the Japan Meteorological Agency (JMA). These data will then be distributed to the general scientific community through GTS (Global Telecommunication System) by JMA and through the Internet by the AAN Data and Analysis Center.

GAME/AAN scientists will check the raw data and apply necessary analysis to make raw data more reliable and usable to a general GAME scientists. These are particularly needed for the flux and soil moisture data which require careful treatment of data. These secondary data will also be archived in GAIN and will become available to GAME scientist initially, and then to general scientific community.

The types of data which will be transferred through the GMS and which will become available real time, and those which will be stored on site for later recovery, will be determined by considering available channels of GMS for GAME, requirements of scientific community and needs of data handling.

Table 2-3-2 : Organization of GAME-AAN

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1. Organization of GAME AAN project in Japan

I. GAME AAN WG

Chair	Tetsuzo Yasunari (Univ.Tsukuba)
Vice chair	Teruyuki Nakajima (Univ.Tokyo)
Secretariats	Michiaki Sugita (Univ.Tsukuba)
	Ken'ichi Ueno (Univ. Shiga Pref.)
Data transfer	Rikie Suzuki (Univ.Tsukuba)
Sensor group	
Radiation	Teruyuki Nakajima (Univ.Tokyo)
	Michiaki Sugita (Univ.Tsukuba)
Flux	Osamu Tsukamoto (Okayama Univ.)
Soil moisture	Ichirow Kaihotsu (Hiroshima Univ.)
IRT	Michiaki Sugita (Univ.Tsukuba)
Long term planning	Tetsuo Ohata (Univ.Shiga Pref.)

II. The AAN Data and Analysis Center (to be established) and secretariat of GAME AAN WG (tentative)

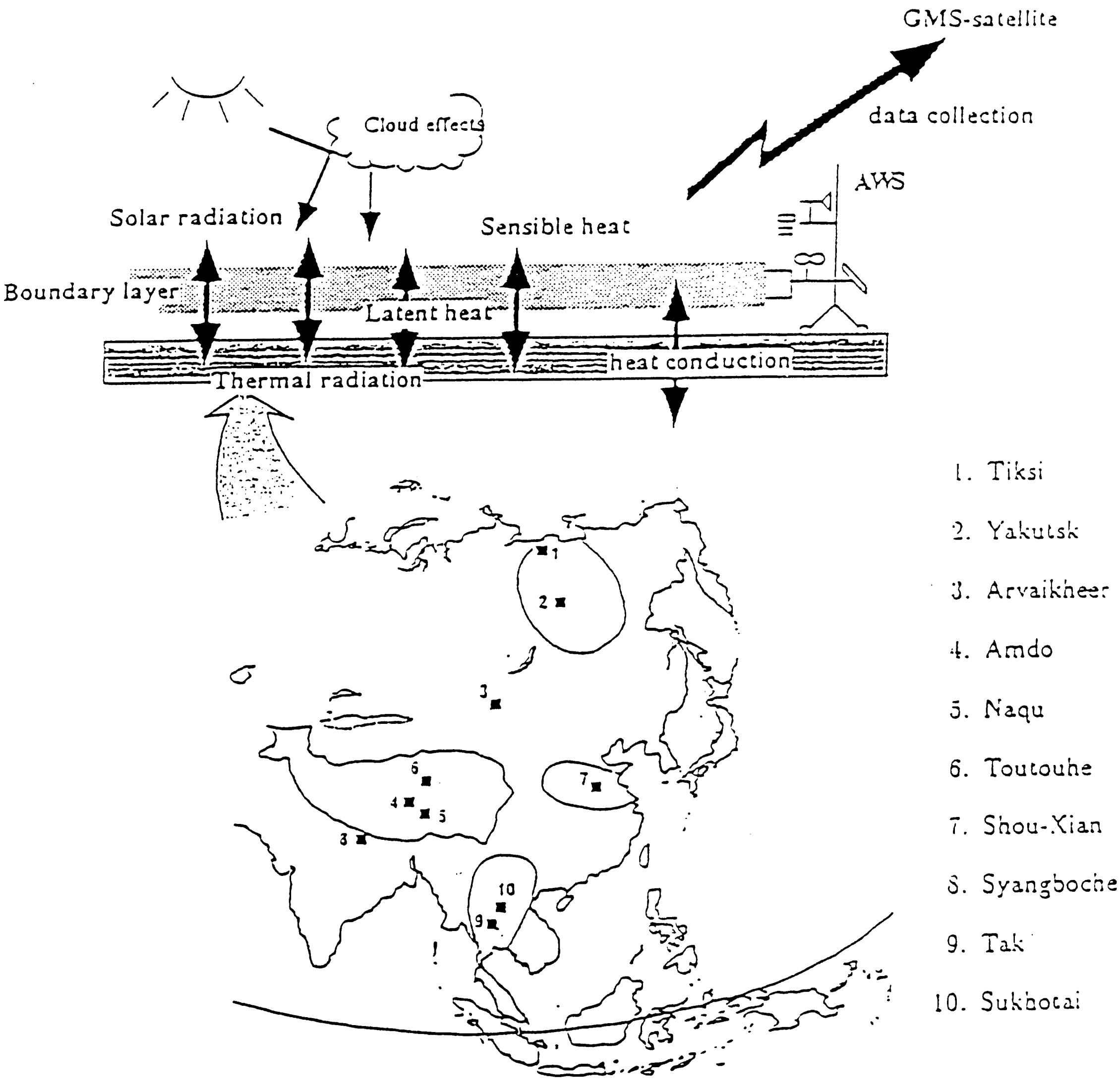
The Envrironmental Research Center, University of Tsukuba

2. Regional counterpart institutions (tentative)

Russia:	Russian Academy of Sciences
Mongolia:	Institute of Meteorology and Hydrology (IMH), Ministry of Nature and Environment
China:	Chinese Academy of Sciences
	China Meteorological Administration
Thailand:	Thai Meteorological Department
Nepal:	Department of Hydrology and Meteorology

Asian AWS Network Project

Automatic Measurements of Energy-Wter Fulx



Various climate zones and different surface conditions

Fig.2.3-1 GAME AAN plan. GAME radiation sites will be establised as a part of the AAN