3.3 Subtropical Region (GAME-HUBEX)

3.3.1 Scientific goals

The energy and water cycle in the subtropical monsoon region of the East Asia is characterized largely by the Baiu/Meiyu front in the summer. It is one of subtropical fronts and a unique subsystem of the Asian monsoon (Ninomiya, 1984). The Baiu/Meiyu front brings heavy rainfalls and causes floods very frequently in the region from Changjiang-Huaihe River Basin to the Japan Islands. A comprehensive review of rainfall in China associated with the summer monsoon is given by Ding (1992). The year-to-year variability of the frontal activity is very large. While extreme heavy rainfall events occurred in some years, severe drought events occurred in other years. Such variabilities are largely associated with those of global-scale systems (Lau, 1992; Tian and Yasunari, 1992).

Various scale of cloud/precipitation systems are formed and play major role in the energy and water cycles in this frontal zone (Kato et al, 1997). The rainfall systems in the Baiu/Meiyu frontal zone show a significant multi-scale structure ranging from the synoptic-scale to meso-scale (Akiyama, 1984ab; Ninomiya et al., 1981, 1984ab). A strong interaction between these scales could be important for the water cycle in the area. Heavy rainstorm events are caused by the meso-β-scale convective systems. Most of them are embedded in the meso-α-scale systems. The ensemble of the meso-β-scale systems could affect the basin-scale water cycle though the effects on the meso-α-scale systems. On the other hand, a change of the global- and/or regional-scale factors would influence the meso-β-scale systems through the meso-α-scale systems (Huang and Sun, 1992).

The behavior of the cloud/precipitation systems is also associated with the complicated processes between the air and the land-surface. The interaction between the atmosphere and the land-surface systems is also important for the water cycle around the Changjiang-Huaihe River Basin in various scales. Precipitation changes the fluxes of heat and water vapor from the ground. The cloud/precipitation systems are, in turn, strongly influenced by the surface conditions. The meso-β-scale convective systems are the most important parts of the precipitation systems Their interaction with the hydrological processes and its modeling are crucial issues for the prediction of the energy and water cycle in the Baiu/Meiyu frontal zone.

The Huaihe River Basin in China is selected as the most appropriate area of the research in the subtropical region, because there are advanced networks of meteorological and hydrological stations.

The followings are main scientific goals of the research.

A. To understand deeply multi-scale processes of energy and water cycle in the Huaihe river Basin and its surrounding area, and their response to the variation in continental-scale Asian monsoon

(1) Study of regional-scale energy and water cycles

a. Impact of the variation in continental-scale Asian monsoon on water budget in the subtropical frontal zone/the Huaihe River Basin
b. Influence of the change in continental-scale land-surface condition on the energy and water-vapor fluxes into the Basin
c. Roles of regional-scale energy and water cycle in the variation of continental- scale Asian monsoon
d. Prediction and simulation of rainfall distribution in the Huaihe River Basin

(2) Study of the evolution of meso-scale cloud systems

a. Roles of meso-α/meso-β scale cloud systems in the time variation of regional-scale energy and water cycle
b. Evolution of meso-α/meso-β scale cloud systems and their response to the variation of regional-scale energy and water cycle
c. Effect of land-surface processes on their evolution

(3) Study of land-surface hydrological processes

a. Diurnal, day-to-day and seasonal variation of land-surface heat/water fluxes in different land-use areas in the Huaihe River Basin
b. Roles of land-surface processes in regional-scale energy and water cycle
c. Influence of meso-scale cloud systems on land-surface processes
d. Prediction and simulation of floods in the Huaihe River Basin

B. To contribute to the observational study of continental-scale Asian monsoon variability

(1) Intensified observation of the structure of atmosphere in the Huaihe River Basin and its surrounding area

(2) Long-term monitoring of land-surface heat/water fluxes in the Huaihe River Basin

(3) Parameterization of processes related to energy and water cycle

a. Parameterization of vertical heat transport, vertical distribution of latent-heat release and rainfall in the meso-β/meso-γ scale cloud systems
b. Parameterization of land-surface heat/water fluxes in the broad area

3.3.2 Outline of HUBEX

A. Period of the experiment

HUBEX-ETO (Extended Time Observation): From May to August in 1996 ~ 2000

HUBEX-IFO (Intensive Field Observation):
From May to August in 1998 (If we have little precipitation in 1998, we will discuss whether HUBEX-IFO will be carried out again in 1999 or not)

B. Expected products

In addition to the deeper understanding of multi-scale physical processes of energy and water cycle in the Huaihe River Basin and its surrounding area, the following products are expected.

(a) Regional-scale 4DDA data sets
(b) Meso-scale cloud system 4DDA data sets
(c) Nested meteorological/hydrological model
Regional-scale coupled meteorological/hydrological model
Meso-scale cloud-resolving meteorological model

Land-surface hydrological model

(d) Rainfall data in the Huaihe River Basin including radar-raingauge composite data
(e) Long-term monitoring AWS data
(f) Satellite data in the Huaihe River Basin and its surrounding area

3.3.3 Strategy of HUBEX

A. Required observational data-base

(1) Global Reanalysis Data

These data will be used in the regional-scale 4DDA, and as the initial and boundary values of regional-scale coupled meteorological/hydrological model.

Data: Reanalysis data made by JMA global numerical-forecasting model

Period: May to August in 1996 ~2000

(2) Data of intensified radio-sonde observation

These data will be used as the input data in the regional-scale 4DDA and meso-scale 4DDA.

Period: HUBEX-IFO

21 stations in the Huaihe River Basin and its surrouding area (Fig. 3.3-1)
(21stations, 2 x 3 weeks, 4 times/day)

(3) 6-hour rainfall data

These data will be used for the initialization and verification of the regional-scale 4DDA.

Period: HUBEX-IFO

Weather stations in the Huaihe River Basin and its surrounding area (Fig. 3.3-2)

(4) Digital radar data in the Huaihe River Basin

These data will be also used in the initialization and verification of the regional-scale 4DDA.

Period: HUBEX-IFO

Radar stations: Huaihe River Basin (Fig. 3.3-3)

Four radars in Nanjing, Yangcheng, Lianyungang and Xuzhou have been digitized and the radar in Fuyang is being digitized.

(5) Hourly rainfall data

These data will be used in the verification of TRMM data, and initialization and verification of meso-scale cloud-resolving meteorological model.

Period: HBEX-IFO

Data: Hourly rainfall at raingauge stations in the intensive-field observation area of the Huaihe River Basin, including additional 13 raingauge stations

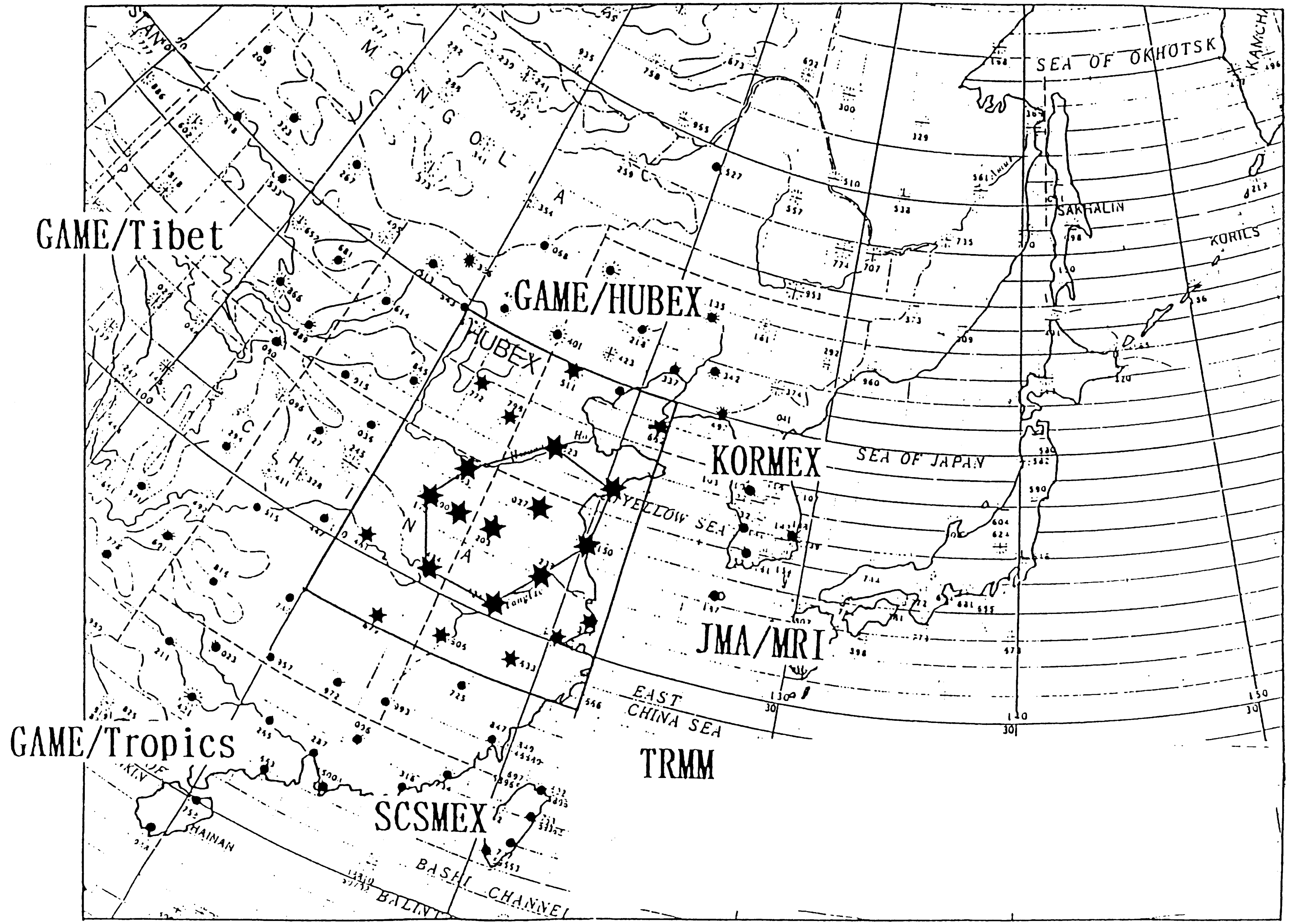

Fig. 3.3-1 Sites of intensified radio-sonde observation in GAME/HUBEX.

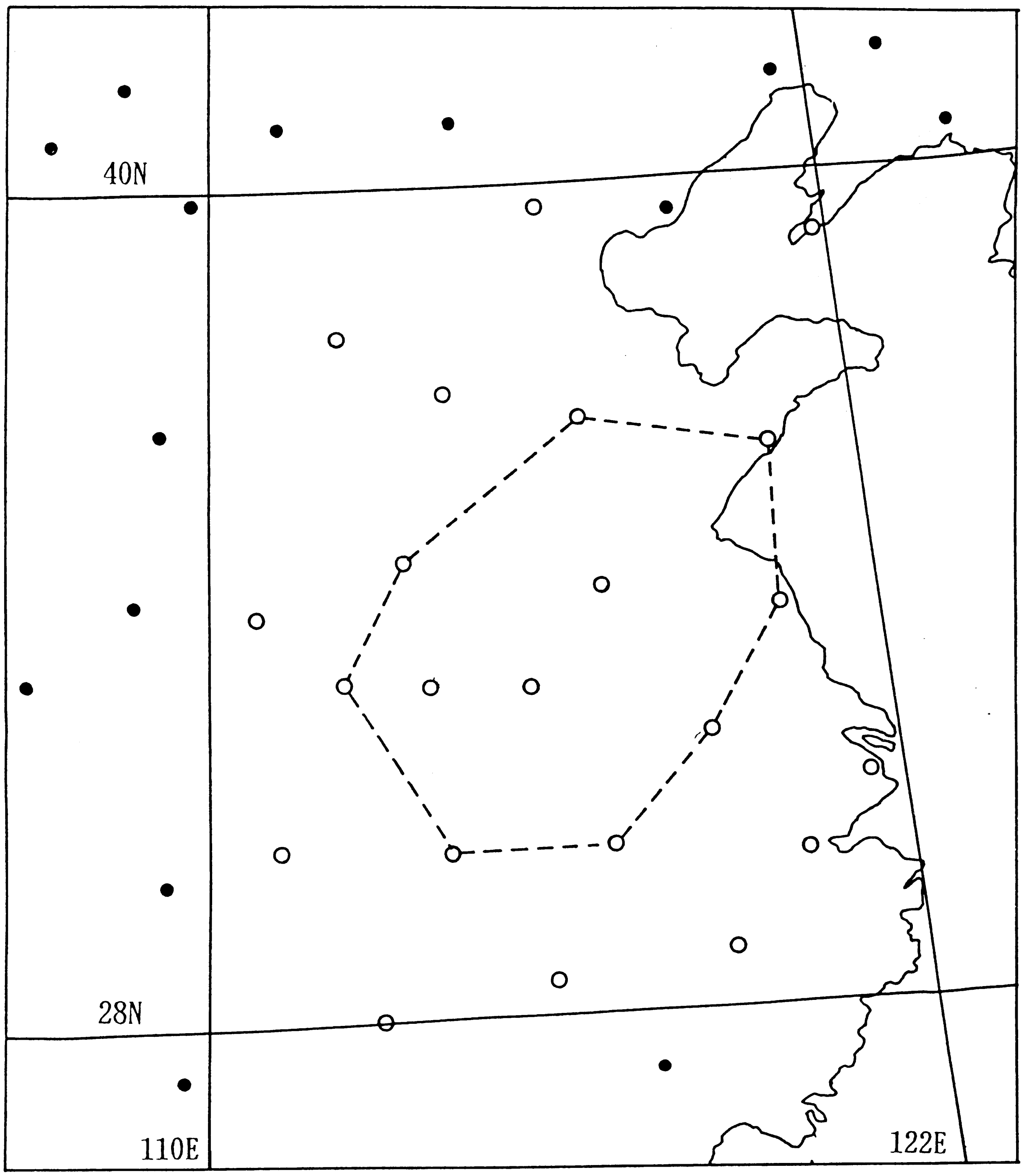

Fig. 3.3-2 Collection points of 6-hourly rainfall data.

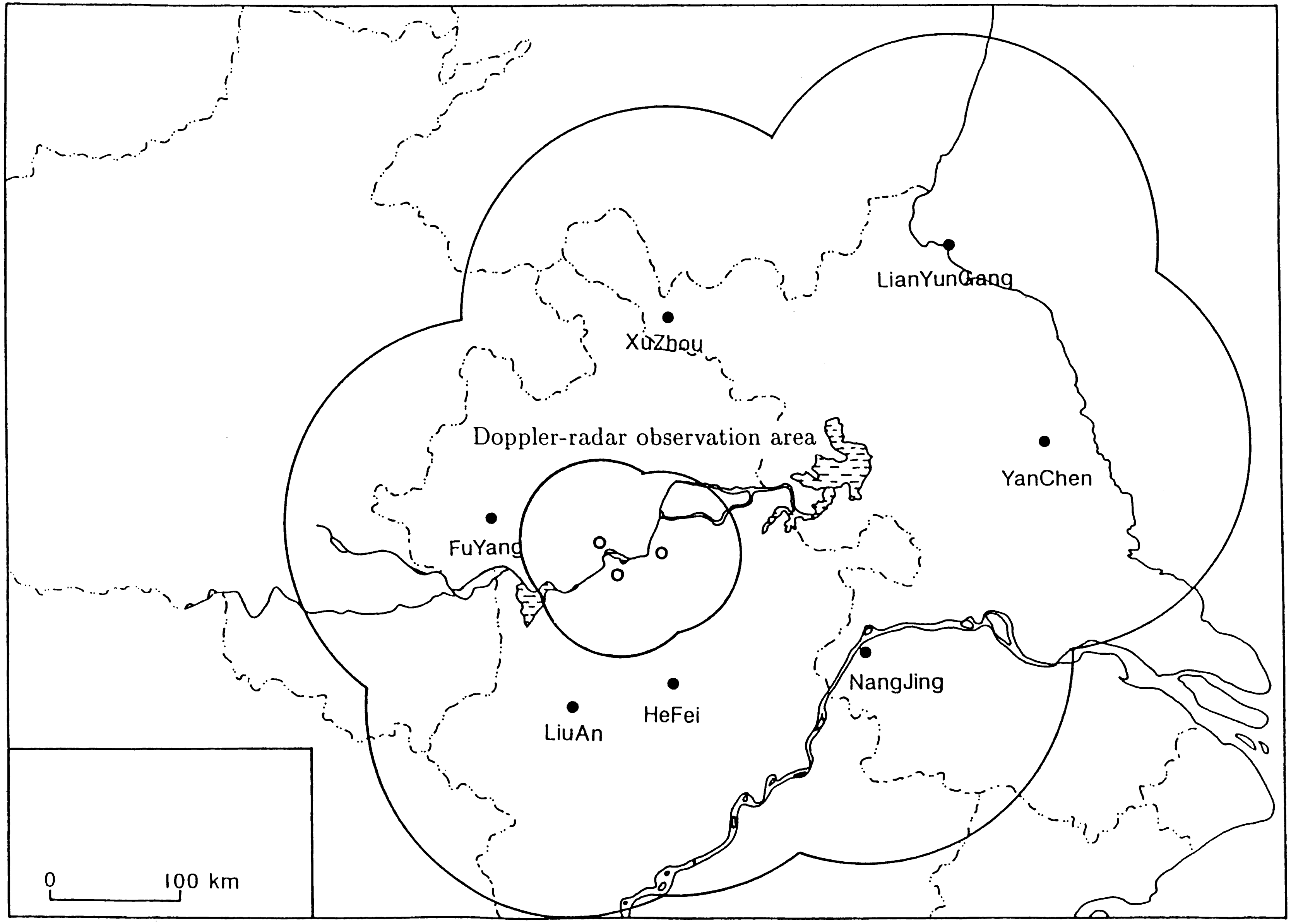

Fig. 3.3-3 Chinese radar network and the coverage area of Japanese multi Doppler radars in GAME/HUBEX.

(6) Doppler radar data

These data will be used for the initialization (especially, the vertical distribution of latent-heat release) of regional-scale 4DDA, regional-scale coupled meteorological/hydrological model and meso-scale cloud resolving model.

Period: HUBEX-IFO

Domain: Multi Doppler-radar coverage area (Fig. 3.3-3)

(7) Rainfall data in the Shiguang River Basin

These data will be used for the scale-up and verification of land-surface hydrological model. 48 raingauge stations in the Basin, including additional 11 raingauge stations

Data: Hourly rainfall from June to September in 1998 , and daily rainfall amount from January to December in 1998

(8) Geographical data of the Huaihe River Basin

These data (land-use coverage, topography, river channel) will be used for the scale-up and verification of land-surface hydrological model, and the coupling of

meteorological and hydrological models.

Domain: Huaihe River Basin

Reduced scale: 1/200,000

(9) Every 6-hour meteorological data

These data will be used for the comparison with the output data of regional-scale 4DDA or meso-scale cloud system 4DDA, and the estimation of surface fluxes in the Huaihe River Basin.

Period: From 1 January, 1998, to 30 April, 1999

Weather stations in the Huaihe River Basin and its surrounding area

Components: Solar radiation, air temperature, humidity, wind velocity and direction, surface temperature and soil temperature

(10) Hourly meteorological data

These data will be used in the estimation of surface fluxes in the basin.

Period: From June to September in 1998

18 weather stations in the Huaihe River Basin and its surrounding area Components: Same with (9)

(11) Satellite data

These data will be used in the estimation of broad-area rainfall and water-vapor amount distributions, and the initialization of regional-scale 4DDA and the comparison with its output data

Period: HUBEX-IFO

Domain: Huaihe River Basin and its surrounding area

Data: GMS, FY-2, NOAA, TRMM, SSM/T-2, AMSU-B

(12) Daily hydrological data

These data will be used for the scale-up and verification of regional-scale 4DDA and land-surface hydrological model.

Period: From January to December in 1998

Hydrological stations in the Shiguang River Basin

Data: Daily data of rainfall, river discharge, evaporation and others

(13) Meteorological/hydrological data in the Shiguang River Basin

These data will be used for the scale-up and verification of land-surface hydrological model.

Stations in the Shiguang River Basin

Data: Hourly data from May to August in 1998

B. Numerical models and 4-dimensional data assimilation

(1) Regional-scale 4DDA (Fig.3.3-4)

Domain: Huaihe River Basin and its surrounding area

Period: GAME-IOP

Resolution: 20 – 30 km (horizontal), 16 – 18 layers (vertical), 6 hours (time)

Numerical model: Chinese and Japanese regional-scale models

Input data: Global reanalysis data of 50 km mesh, data of intensified radiosonde observation in GAME-IOP/HUBEX-IFO, rainfall data (including radar data, satellite data), vertical distribution of latent heat release (as derived from meso- scale cloud system 4DDA)

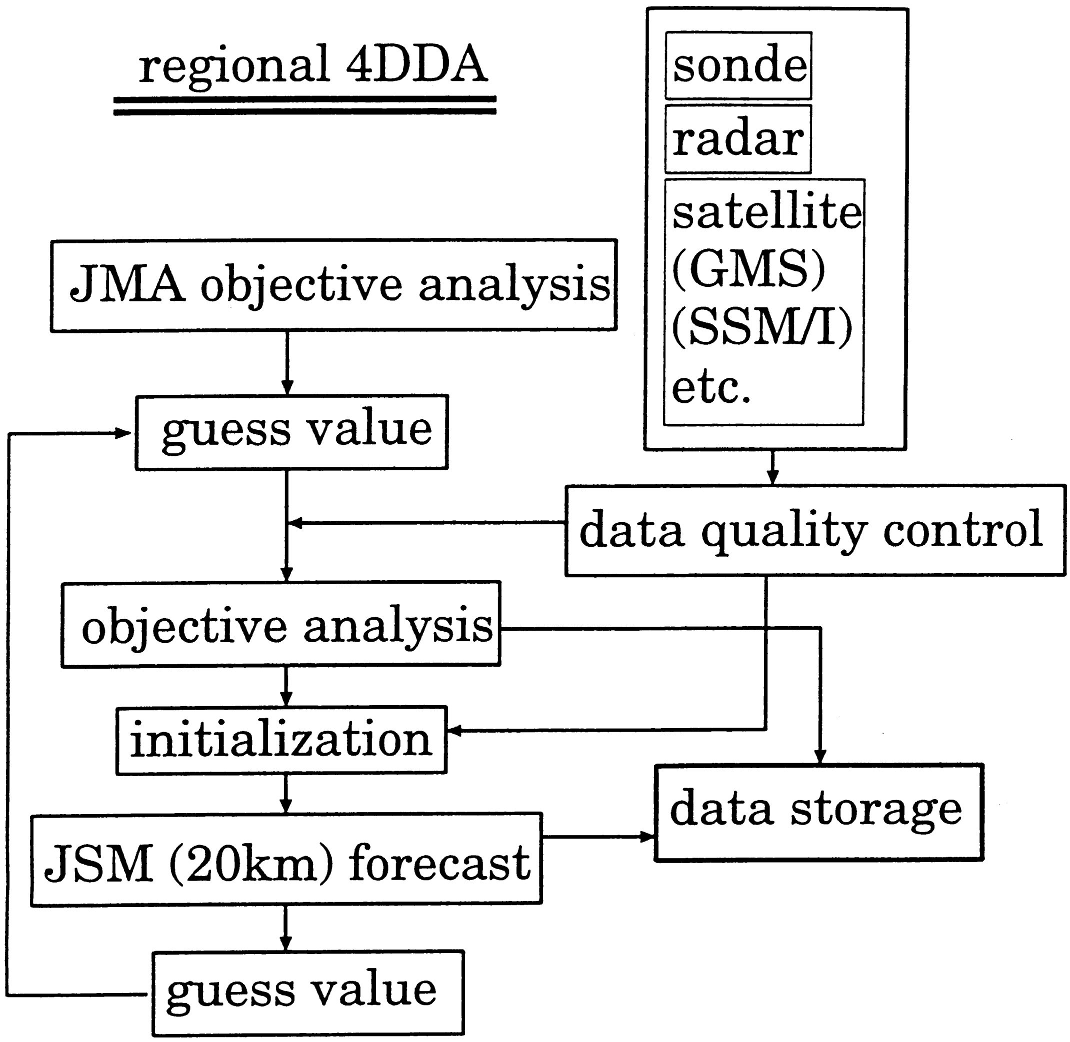

Fig. 3.3-4 Flowchart of regional-scale 4DDA.

Output data: 3-dimesional distribution of geopotential height, temperature, humidity, wind velocity and direction, rainfall amount; vertical distribution of diabatic heating rate, moistening rate and condensation rate; fluxes of sensible heat, latent heat and momentum near the land surface

Verification data: 6-hourly rainfall

Data for comparison: Data of conventional meteorological observation, upward radiation at the top of the atmosphere (satellite data)

(2) Meso-scale cloud system 4DDA data

Domain: 100 km x 100 km ~ 500 km x 500 km

Period: HUBEX-IFO

Horizontal resolution: 1 km

Numerical model: Cloud-resolving models (see (3))

Input data: Regional-scale 4DDA data; data of intensified radiosonde observation, special Doppler radar observation and special radar observation

Output data: Thermodynamical parameters, cloud-water and precipitation water contents

Verification data: Radar-raingauge composite hourly rainfall

(3) Nested meteorological/hydrological model (Fig. 3.3.5)

a. Regional-scale coupled meteorological/hydrological model

It will be used in the regional-scale 4DDA, the simulation of rainfall distribution in the Huaihe River Basin and the physical study of energy and water cycle.

Resolution: 20 – 30 km (horizontal), 16 – 18 layers (vertical)

Domain size: 2000 km x 2000 km ~ 4000 km x 4000 km

Numerical models: Regional model of NMC, MM4/MM5 and others (Chinese side); Regional spectral model of Meteorological Research Institute of JMA or revised one of 1988 JMA regional spectral model (Japanese side,); SiBUC of Kyoto University, a hydrological model of Hohai University and others

Research subjects: Improvement of land-surface hydrological processes with tuning parameterization of convection; parameterization of radiative-cooling formulation of convective- and layer-cloud types

Input physical parameters from meteorological model to hydrological model: Wind velocity and direction, air temperature and humidity at the lowest level of the model atmosphere, downward long-wave radiation and solar radiation, rainfall amount

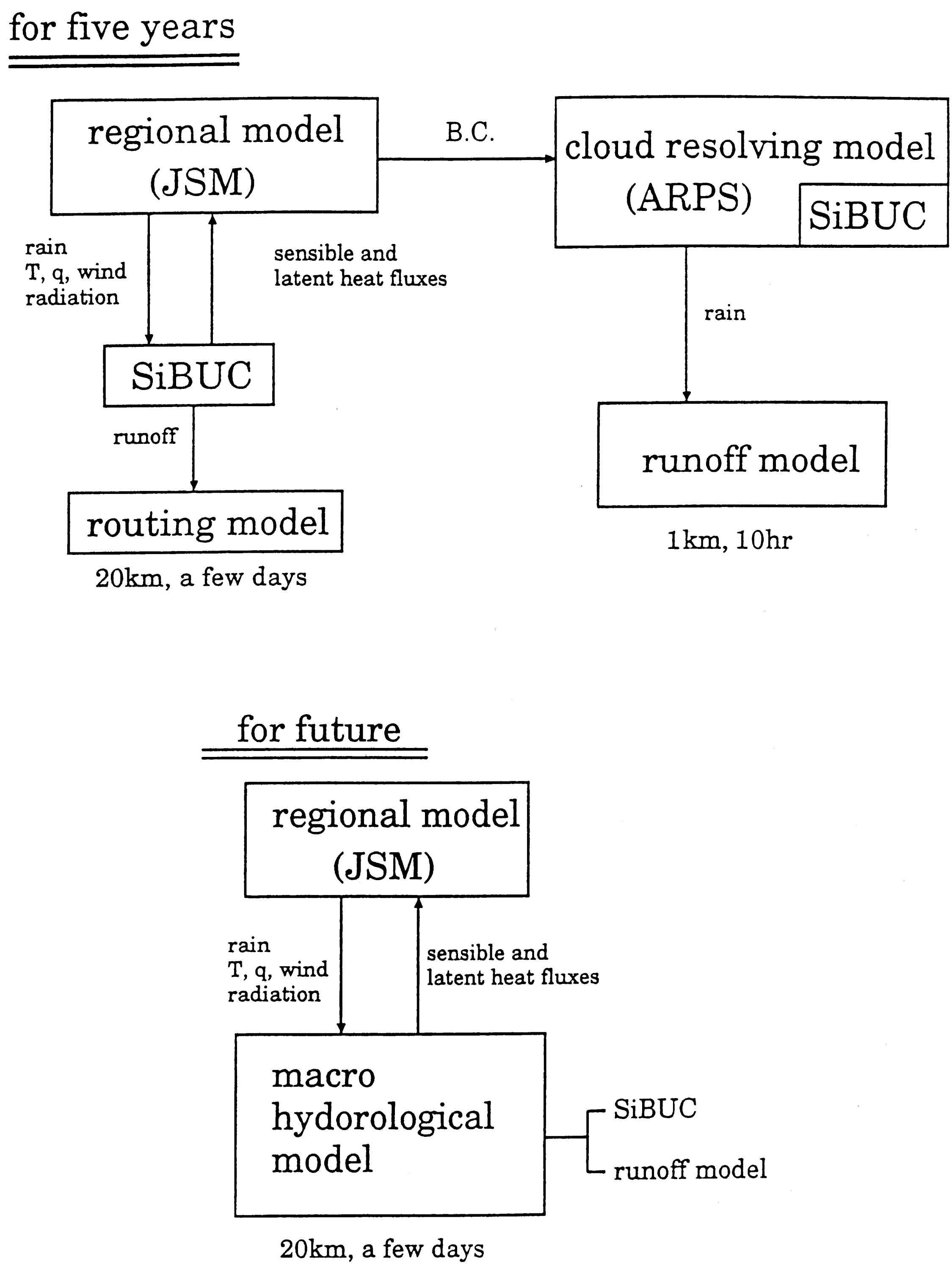

Fig. 3.3-5 Coupling of meteorological/hydrological mesoscale models.

Input physical parameters from hydrological model to meteorological model: Fluxes of sensible heat, latent heat and momentum

b. Meso-scale cloud-resolving meteorological model

It will be used in the meso-scale cloud-system 4DDA and the study of energy and water cycle. Horizontal resolution: 1 km

Numerical model: Cloud-resolving meteorological model (for example, ARPS)

Research subjects: Parameterization of cloud-physical processes

(4) Land-surface hydrological model

a. Land-surface flux model

The model will be applied to the experimental area of Shiguang River Basin.

Numerical model: SiBUC (Simple Biosphere Model including Urban Canopy) of Kyoto University, a model of Hohai University and the others

Horizontal resolution: 1 km

Parameters of model: Parameters will be adjusted for each land-use using heat/water fluxes observed in the GAME-IOP/HUBEX-IFO

Verification data: Data of special meteorological / hydrological observation

Required information: Land-use coverage, topography and river channel network with horizontal resolution of 1 km

b. Distributed hydrological model

Horizontal resolution: 1 km

Energy and water exchange among the atmosphere, land-surface, soil and river-channels will be given in each 1 km x 1 km area in the experimental area of Shiguang River Basin.

c. Parameterization of land-surface heat/water fluxes in the broad area and macro-scale hydrological model

Horizontal resolution of fluxes: 1 km ~ 20 km in Shuguang River Basin, 20 km ~ 100 km in Huaihe River Basin

Verification data of macro-scale hydrological model: Discharge at the lower-stream area in the experimental area

3.3.4 Intensive field observation

A. Intensified radio-sonde observation

Domain: Huaihe River Basin and its surrounding area
Stations: 22 stations
Period: 3 seeks (twice) in GAME-IOP from May to August in 1998
Observation: Every 6 hours

B. Intensified radar observation

(1) β1 observation area

Domain: The area surrounded by Fuyang, Bengbu, Hefei and Jinzai (Fig.3.3-6)
Radars: Fuyang (C-band), Bengbu (X-band), Hefei (S-band), Liuan (X-band), Huang-shan (S-band) , Nanjing (C-band Doppler)
Raingauges: Stations of Anhui Meteorlogical Bureau and Huiahe River Commission, additional Japanese raingauges

(2) β2 observation area

Domain: Inside the β1 area (Fig.3.3-6)

3 Japanese Doppler radars at Huai-nan, Shou-xian and Feng-tai
Additional Japanese raingauges
One Japanese distromter (raindrop size distribution)
Additional Japanese meteorological instruments

(3) Intensive hydrological observations (Fig.3.3-7)

a. Special observation of heat/water fluxes

4 sites of different land-use conditions: Yangang (paddy field), Yuji (farm field), Tangquanchi (forest cover), Nianyushan (lake) in β1 observation area and Shiguang River Basin

August, 1997: Summer test
December, 1997: Winter test
April - May, 1998: Spring observation
July - August, 1998: Summer observation
October - November, 1998: Autumn observation
November - December, 1998: Winter observation

Observation items: Vertical profiles (air temperature, relative humidity, wind speed, wind direction), radiation Flux (net radiation, up- and downward shortwave, up- and downward longwave), underground (soil temperature, heat conduction flux, soil moisture), turbulent flux (momentum, sensible heat, latent heat, CO_2), others (atmospheric pressure, rainfall intensity)

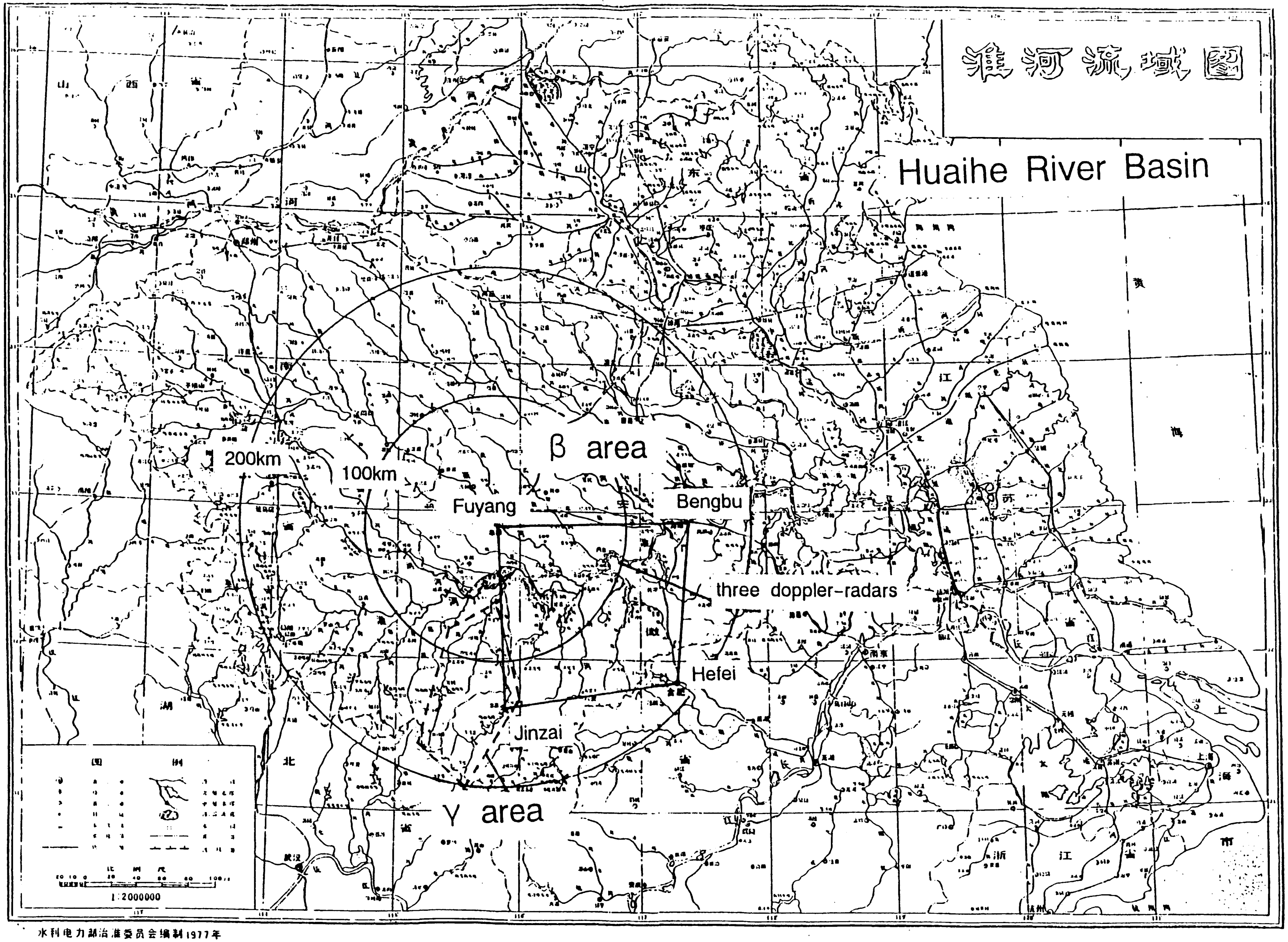

Fig. 3.3-6 β 1 and β 2 areas for intensive field observation in GAME/HUBEX.

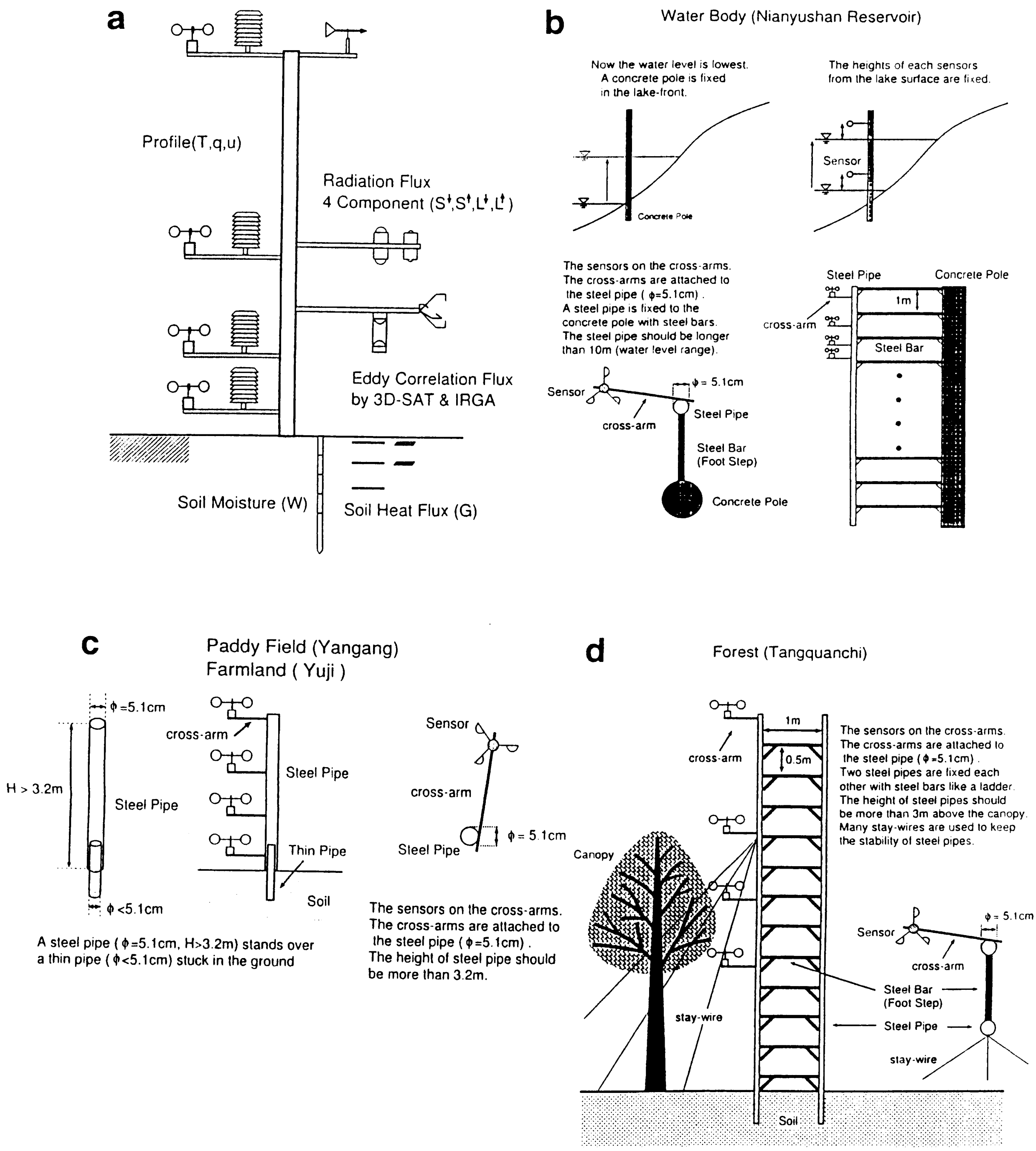

Fig. 3.3-7 Deployment of intensive hydrological observations.

b. Special observation of runoff and water budget

Area: Shiguan River Basin
Stations: Raingauge stations, hydrological stations and the others
Additional Japanese instruments (water-level current, flow velocity, and discharge)

c. Long-term monitoring

Site: Shou-Xian
Instrument: AWS (automatic wather station) as one of AAN (Asian AWS Network)
The relationship among each component of HUBEX is summarized in Fig.3.3-8.

3.3.5 Organization and coordination of HUBEX

A. Participating institutions

(1) P. R. China
- Beijing University
- China Meteorological Administration
- National Climate Center
- Chinese Academy of Meteorological Sciences
- Meteorological Bureau of Anhui Province
- Huaihe river Commission, Ministry of Water Resources of China
- Water Information Center, Ministry of Water Resources of China
- Institute of Geography, Academic Sinica
- Institute of Atmospheric Physics, Academic Sinica
- Hohai University
- Nanjing University
- Nanjing Institute of Meteorology
- Nanjing Institute of Geography and Limnology, Academic Sinica

(2) Japan
- Hokkaido University
- Kyoto University
- Nagaoka University of Technology
- Nagoya University
- Okayama University
- Tokyo Metropolitan University
- Tokyo Gakugei University
- Tohoku University
- University of Tokyo
- University of Tsukuba
- Meteorological Research Institute, Japan Meteorological Agency
- Frontier Research System for Global Change
- National Research Institute for Earth Science and Disaster Prevention

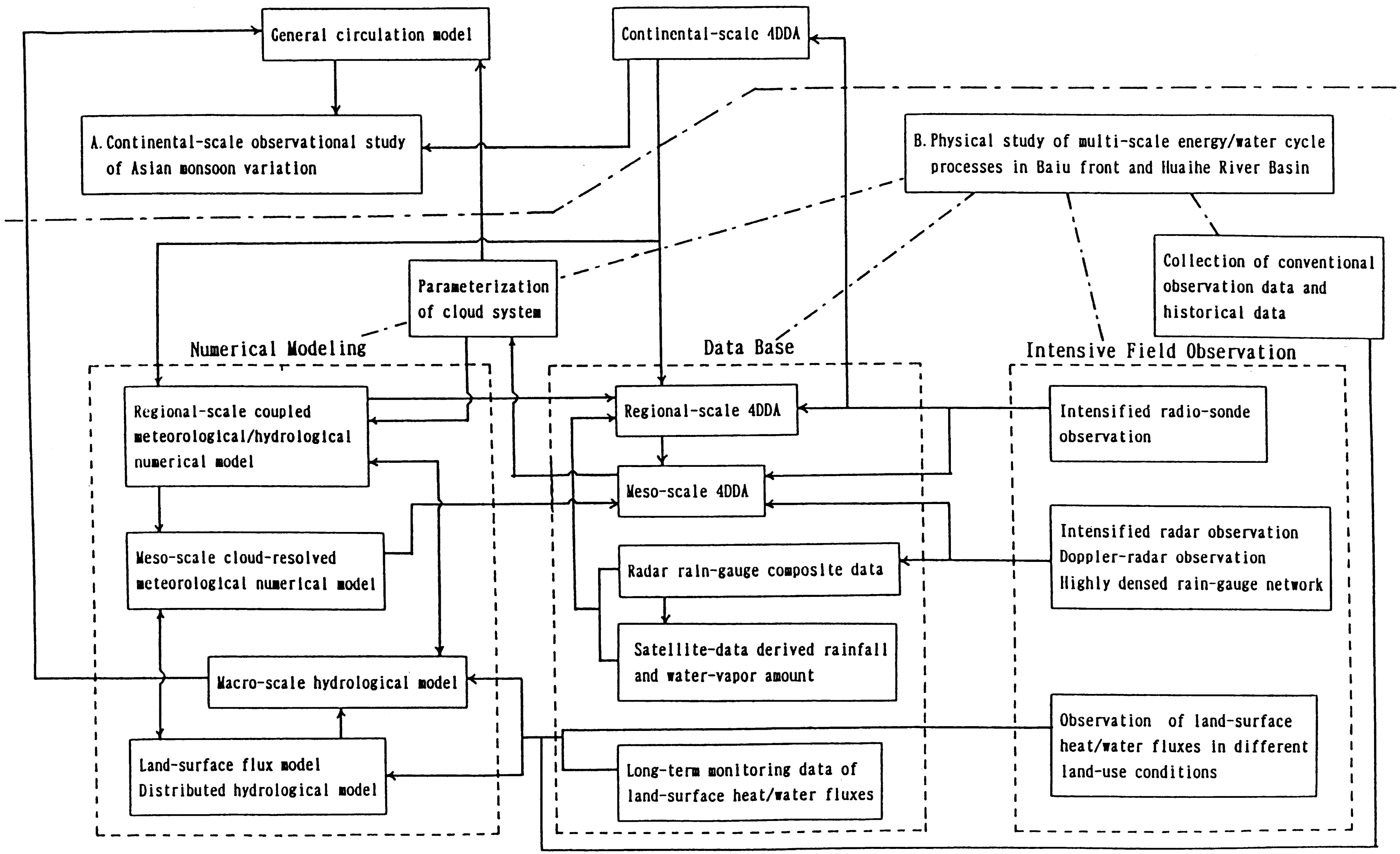

Fig. 3.3-8 Components of GAME/HUBEX implementation plan.

B. Data center

(1) HUBEX Data Center

Main HUBEX DATA Center will be established in Beijing, and Sub-center will be in Nagoya. These centers will collect HUBEX-related data from HUBEX-IFO Data Center and HUBEX-related institutions, edit and store them. Data format and utilization system will be adjusted through connection with GAIN Center.
Following the data exchange policy of GAME, these data will be opened to HUBEX-related, GAME-related and GEWEX-related scientists.

(2) HUBEX-IFO Data Center

Two Centers will be established in Meteorological Bureau of Anhui Province (meteorological data) and Huaihe River Commission (hydrological data). Meteorological and hydrological observation data in the period of HUBEX-IFO will be collected and stored in the Center. Part of the data will be transmitted to the HUBEX DATA Center in Beijing.

C. HUBEX Project Office

(1) HUBEX Executive Committee

The Committee will be composed of members from HUBEX-related institutions in each country. Subjects associated with the execution of HUBEX collaborative plan will be discussed and decided in the Committee.

(2) HUBEX-IFO Headquarters

The Headquarters will be established in Beijing. The Headquarters will give the adjustment and instruction, which will be necessary for the execution of collaborative HUBEX-IFO plan, to each group judging from HUBEX-related meteorological and hydrological information.

(3) HUBEX Project Office

The Office was established in Beijing (National Climate Center of China). The office will keep connection with all participating institutions and adjust their on-going activities.