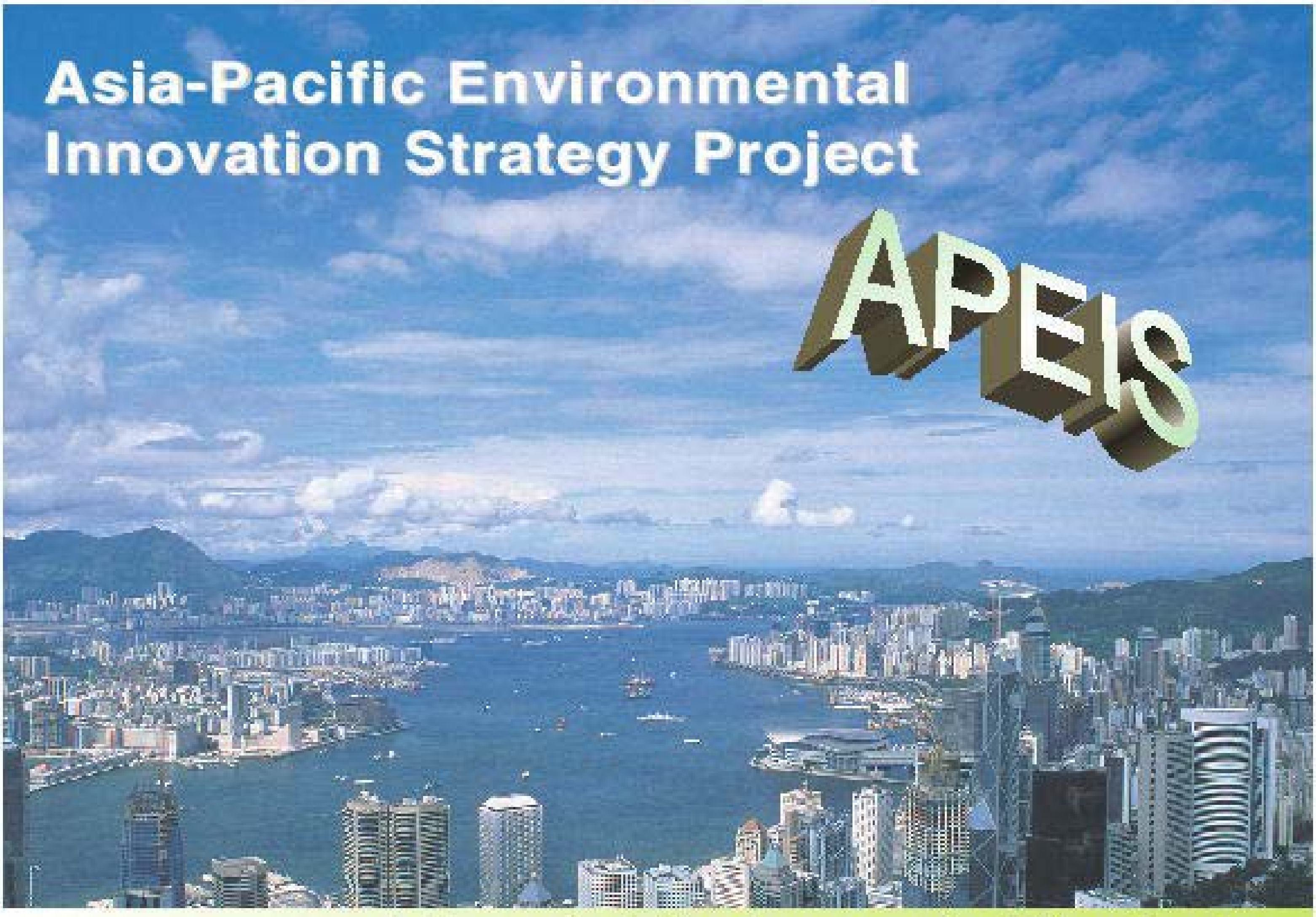
Asia-Pacific Environmental Innovation Strategy Project

APEIS



Integrated Environmental Monitoring (IEM)

Technical Summary

June 2003

APEIS

1. What is APEIS-IEM?

1.1 Objectives

Environmental Conditions are deteriorating in the Asia-Pacific region, home to about 60 percent of the world's population and currently experiencing rapid population and economic growth. The fact that many countries in the region are at different stages of economic development creates a complex set of problems that seriously constrain balanced and sustainable economic development. Examples are the health impacts of industrial pollution, degradation of natural resources through industrial development, increased pollution associated with greater use of motor vehicles and the concentration of populations in cities, and increased greenhouse gas emissions. If we are to take effective countermeasures against such environmental depletion and degradation we need to examine the present environmental conditions and changes in natural resources (Fig. 1).

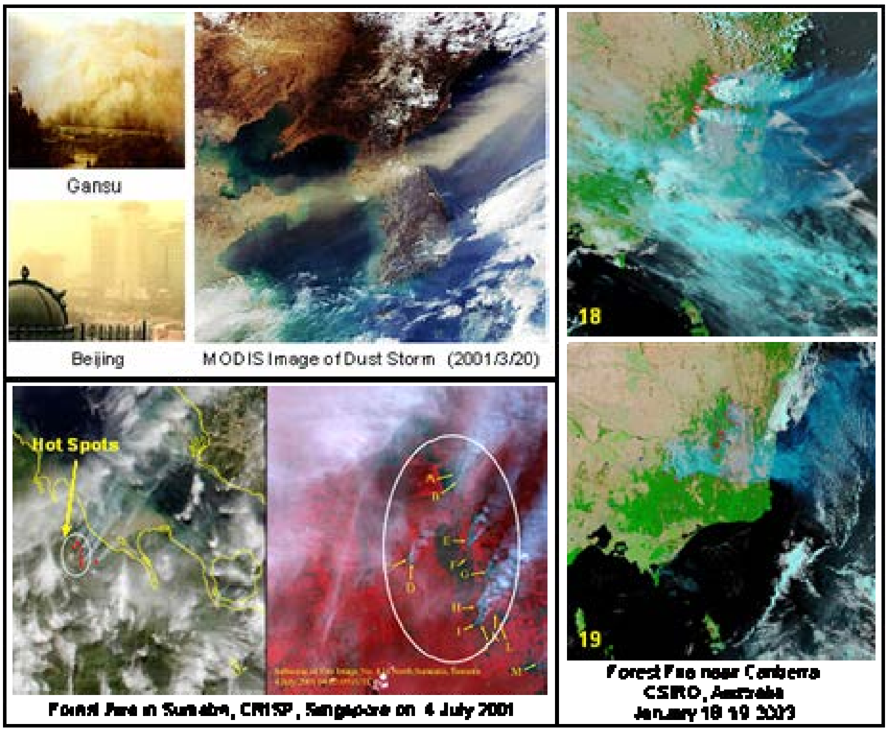


Figure 1 Examples of recent environmental disasters in the Asia-Pacific region

As one step toward solving these problems, the Asia-Pacific Environmental Innovation Strategy Project (APEIS) was proposed at ECO ASIA 2001. APEIS seeks to develop and promote practical, science-based tools and policy options for enhancing environmental innovation, and thus sustainable development, in the region through Integrated Environmental Management. In addition, APEIS aims to promote capacity-building and international cooperation in the region. As mentioned in the Plan of Implementation of the World Summit on Sustainable Development (WSSD), the basic concept of APEIS is to assist developing countries, through international cooperation, to enhance their capacity to address issues pertaining to environmental protection and their ability to formulate and implement policies for environmental management and protection. This includes taking action at all levels to: (a) improve their use of science and technology for environmental monitoring, construction of assessment models, and creation of accurate databases and integrated information systems; and (b) promote and, where appropriate, improve their use of satellite technologies for quality data collection, verification, and updating, and for further improvement of aerial and ground-based observations, in support of their efforts to collect high-quality, accurate, long-term, consistent, and reliable data.

To achieve these aims, the National Institute for Environmental Studies (NIES) in Japan and the Institute for Geographical Sciences and Natural Resources Research (IGSNRR) of the Chinese Academy of Science joined forces in 2001 and set up collaborative research to develop an IEM network system. This collaboration was further expanded in 2002 with the formal participation of the National University of Singapore and the Earth Observation Centre of the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. The system employs data covering the entire Asia-Pacific region, primarily from the MODIS (MODerate resolution Imaging Spectrometer) sensor mounted on the Earth Observation System (EOS)–Terra/Aqua satellite, but also from ground observations. The monitoring system will involve the following processes (Fig. 2):

- Establishing an integrated network of satellite data receiving stations and analytical systems for MODIS data that covers the Asia-Pacific region.
- Developing a ground-truth observation network for various ecosystem types to validate satellite remote-sensing data.
- Developing a data-processing software system to derive environmental indices that can be used to monitor environmental disasters and degradation.
- Developing an integrated model to simulate territorial ecological processes, water resources, and agricultural productivity at a catchment scale.

The implementation of this system will enable the monitoring of ground cover status over time, soil erosion, water resources, environmental disasters, and agricultural production.

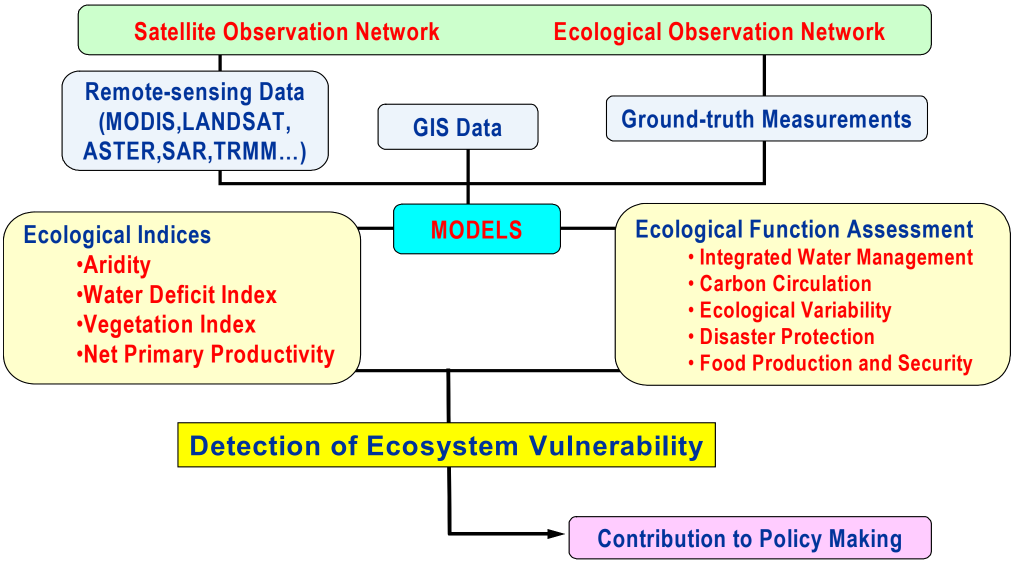


Figure 2 Flowchart for the integrated monitoring system

1.2 Expected outcomes

The expected outcomes of IEM include the following:

- Providing policymakers with precise monitoring data from both MODIS and ecological stations through the Internet (http://www.nies.go.jp/basin/index-e.html) for early warning or detection of environmental disasters and degradation.
- Establishment of a regional information system that can provide regionally standardized high-level MODIS products.
- Submission of reports and proposals for sustainable management to the governments of the countries involved. For example, a cooperative study has been conducted between IEM and the China Council for International Cooperation on Environment and Development (CCICED) and the Changjiang Water Resources Commission of China. Through this cooperation, IEM will develop an integrated model based on scientific observations, MODIS data, and research into the ecological functions of the upstream Changjiang river basins, and will use this model to forecast the effects of construction of the Three Gorges Dam on regional ecology. The simulated results will be presented to CCICED and the Changjiang Water Resources Commission of China.

2. What Are the Expected Products, Scientific Contributions and Current Progress?

2.1 Integrated monitoring network

The integrated network system (Fig. 3) was originally composed of two satellite data receiving stations (at Beijing and Urumqi, China), two data-analysis centers (at IGSNRR and NIES), and five ground-truth monitoring stations (at Yucheng in Shandong Province, Fukang in the Xinjiang Vigor Autonomous Region, Taoyuan in Hunan Province, Haibei in Qinghai Province, and Qianyanzhou in Jiangxi Province, China). The network has now expanded to cover the entire Asia-Pacific Region owing to the formal participation of Singapore and Australia. The data-analysis centers at IGSNRR and NIES store a database that includes satellite data (e.g. MODIS, LANDSAT, ASTER, NOAA, TRMM), Giographic Information System (GIS) data, and measurements from ground-truth ecological stations.

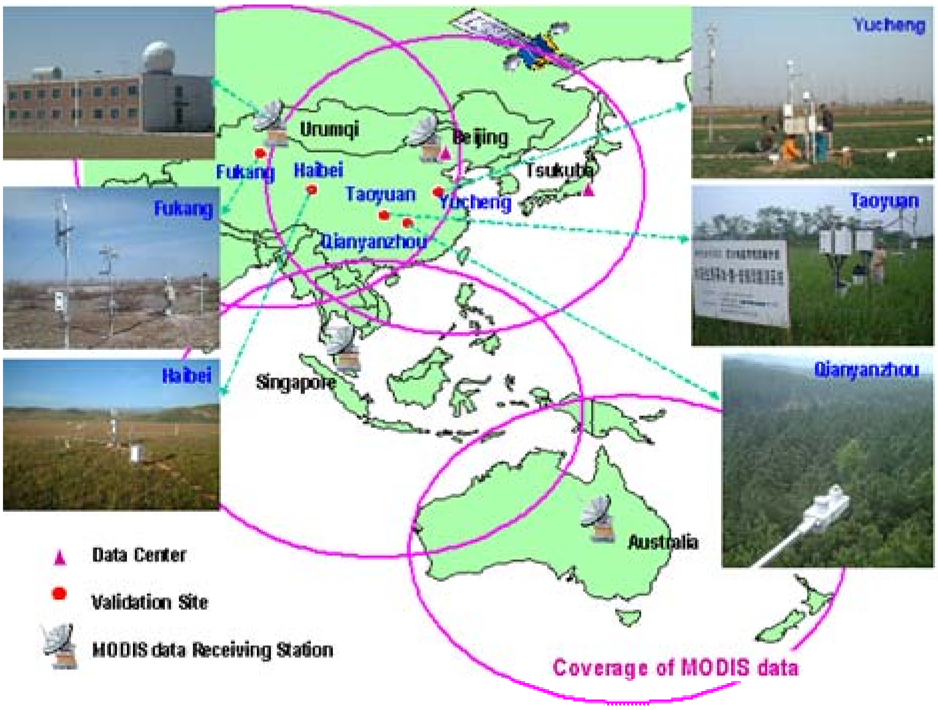


Figure 3 The APEIS integrated monitoring system

2.2 IEM products

IEM can offer the following products:

- MODIS data covering the entire Asia-Pacific region, received by a network of MODIS receiving stations.
- MODIS high-order products developed by a data-processing system at the Data Analysis Center at NIES, Japan; they include data on many important ecological functions, such as land surface reflectance; land

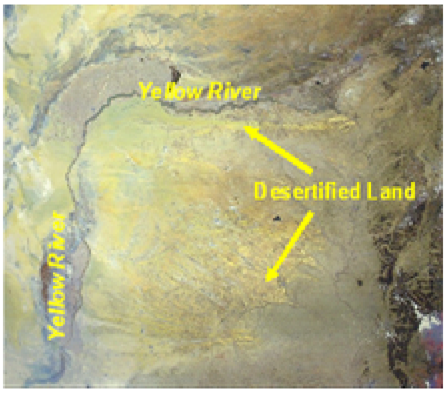
surface temperature; land cover; vegetation indices; thermal anomalies, fires, and biomass burning; and leaf area index and photosynthesis/net primary productivity.

- Ecological indices of environmental vulnerability, such as water deficit index, aridity, index of desertification, and occurrence of dust storms.
- An integrated catchment management model for assessing conditions and changes in ecological goods and services, such as freshwater resources and food production. By using this model and the above information, strategic policy options for sustainable catchment management will be explored.

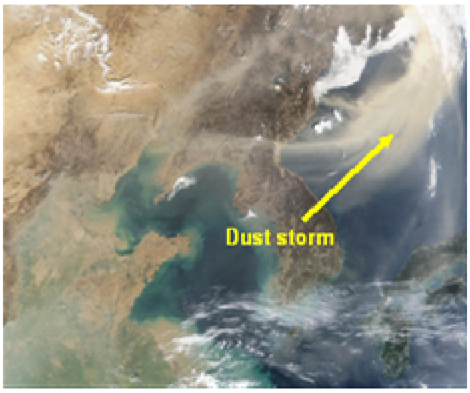
2.3 Contribution to scientific and technological progress

2.3.1 Monitoring of disasters and environmental degradation

In eastern Asia, serious disasters occur frequently on large regional scales owing to environmental degradation. For example, dust storms now occur on a larger scale, and the damage they cause increases each year. Meanwhile, desertification and grassland degradation are becoming more severe thanks to human-driven factors such as overcultivation, overgrazing, over-exploitation, and misuse of water resources. Satellite observation is a tool that can help us to monitor these phenomena over time (Fig. 4).



MODIS Image: **Desertification**
Date 2001/04/13



MODIS Image **Dust Storm**
Date 2002/04/01

Figure4 Environmental degradation monitoring from MODIS images

Spatially wide and temporally long observations by satellite data enable us not only to monitor a natural disaster, but also to detect the land use and land cover changes that occur as a result of human activities. IEM estimated the surface area and volume of Eastern Dongting Lake in eastern China by using NOAA-AVHRR and MODIS data coupled with a digital elevation model (Fig. 5).

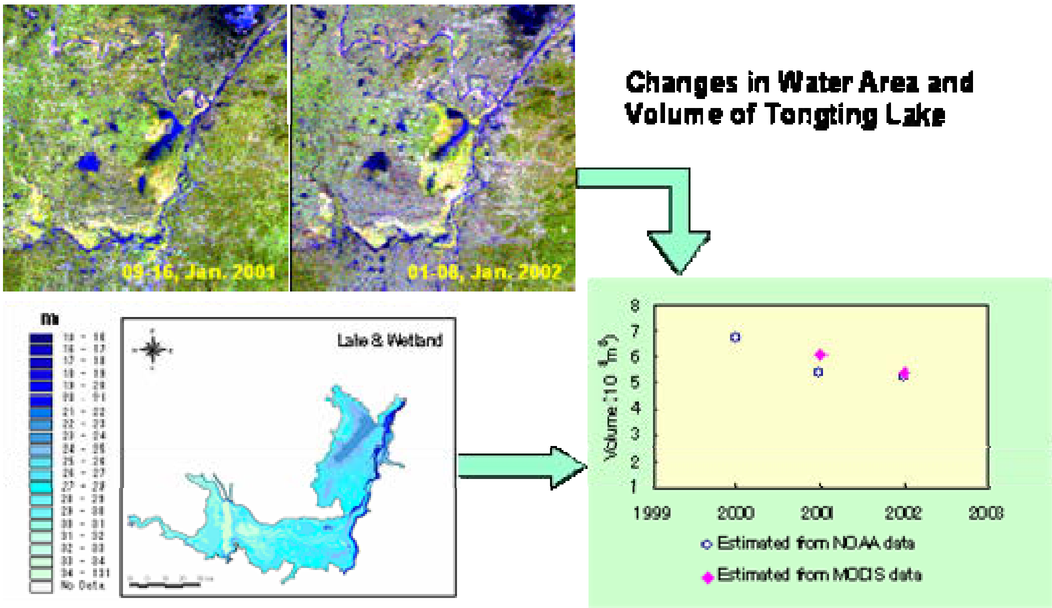


Figure 5 Estimation of surface area and volume of Eastern Dongting Lake in China from satellite data (NOAA–AVHRR and MODIS) and a high-resolution digital elevation model

2.3.2 Integrated modeling of ecological functions and sustainability

There is an emerging need to support policy formulation and decision-making for environmental management on large geographic scales. Typical issues are global change impact assessment and formulation of mitigating measures, water resource allocation in river basins at a sub-continental scale, and environmental impact assessment of agricultural activities in large river basins. To develop a decision-support system, we first need to model the biophysical processes and human interactions. For example, the model should simulate how environmental changes, such as climate change and soil erosion, may influence crop yield, and how changes in cropping pattern, cultivation intensity, and management practices may affect the environment over time. For sound management and decision-making with regard to the Changjiang River catchment in China, catchment-based ecosystem assessment that emphasizes the importance of hydro-biogeochemical processes and ecosystem functions has been accepted as a sub-global project of the Millennium Ecosystem Assessment (MA). Its principal aim is to answer the following questions: 1) what are the main pressures on ecosystem function? 2) What are the main impacts on ecosystem function, goods and services (such as water and food), biodiversity, carbon sequestration, and flood protection? 3) What kind of policy can be implemented to achieve sustainability in the Changjiang River catchment?

To answer the above questions, we need to develop a catchment-based integrated model to estimate the spatial and temporal distributions of the water cycle, carbon cycle, heat fluxes, element and nutrient cycles, sediment transport, and land productivity on both regional and catchment scales. By using the model we can predict future impacts on ecosystem function under various scenarios, such as: 1) decreased crop production because of water cycle change; or 2) increased soil erosion, desertification, dust storms, and flood events because of land use or land cover changes.

2.4 Current progress in the development of major tools

2.4.1 Establishment and expansion of a network of satellite data receiving stations

MODIS is the key instrument aboard the Terra satellite, which views the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands between 0.405 and 14.385 μm, and at three spatial resolutions, 250 m (Bands 1–2), 500 m (Bands 3–7), and 1000 m (Bands 8–36). MODIS data can be used for up-to-date monitoring of environmental degradation and land use or land cover changes, and for developing integrated models for environmental assessment. The MODIS data-receiving station in Beijing was set up in February 2001, and another station in Urumqi was completed in April 2002. The two stations can receive data twice a day covering a vast area, including Japan, China, Mongolia, Korea, and Western Asia. Data received by both stations are transported to the Data Analysis Centre at IGSNRR in China and at NIES in Japan. After a difficult period of testing and systematic adjustment, data from January 2003 are available. The MODIS network was expanded in 2002 through the formal participation of two other stations in Singapore and Australia and now covers the entire Asia-Pacific region (Fig. 3).

2.4.2 Development of a data-processing system for the derivation of environmental indices

MODIS products are being used by scientists from a variety of disciplines, including oceanography, biology, and atmospheric science. The MODIS Science Team at NASA has already developed high-order products, but most of them have not yet been completely calibrated or validated by ground-truth data in various ecological systems. Developing the next generation of high-quality data sets for the study of regional environmental change and ecological system assessment in the Asia-Pacific Region is our new challenge. At the NIES data center we have already developed a data-analysis system based on NASA's algorithm, and we now produce the following high-order land products of MODIS: MOD 09 – Surface Reflectance; MOD 11 – Land Surface Temperature (LST) and Emissivity; MOD 12 – Land Cover and Land Cover Change; MOD 13 – Vegetation Indices; MOD 14 – Thermal Anomalies, Fires and Biomass Burning; MOD 15 – Leaf Area Index (LAI) and Fraction of Photosynthetically Active Radiation Absorbed by Vegetation (FPAR); and MOD 17 – Net Photosynthesis (PSN) and Net Primary Productivity (NPP) (Fig. 6).

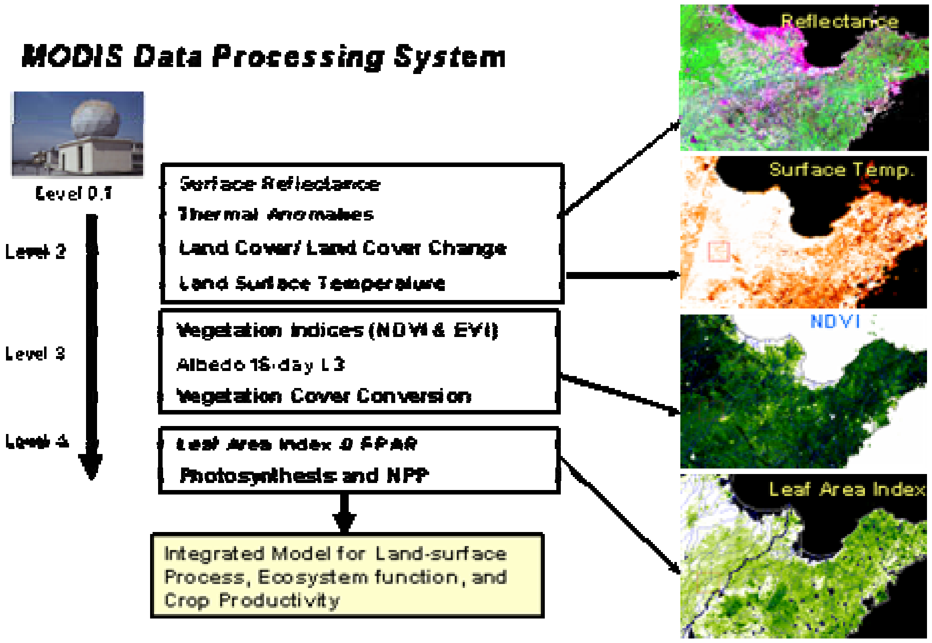


Figure 6 Diagram of MODIS data processing at the NIES Data Analysis Center

The MODIS Surface Reflectance product (MOD 09) is computed from the MODIS Level 1B land bands 1, 2, 3, 4, 5, 6, and 7 (648 nm, 858 nm, 470 nm, 555 nm, 1240 nm, 1640 nm, and 2130 nm, respectively). The product is an estimate of the surface spectral reflectance for each band as it would have been measured at ground level if there were no atmospheric scattering or absorption.

LST and Emissivity (MOD 11) information is retrieved from MODIS data at spatial resolutions of 1 km over land surfaces under clear-sky conditions. A physically based day–night LST algorithm has been used to simultaneously retrieve surface band emissivity and temperatures from a pair of daytime and night-time MODIS observations in bands 20, 22, 23, 29, and 31–33 over all types of land cover.

Land cover and its changes (MOD 12), which affect many aspects of the environmental system such as energy balance, biogeochemical cycles, hydrological cycles, and climate, are considered to be critical elements of global change studies. MOD 12 will be produced at a 1-km resolution on a quarterly basis. The land cover parameter identifies 17 categories of land cover following the IGBP global vegetation database, which defines nine classes of natural vegetation, three classes of developed land, two classes of mosaic land, and three classes of unvegetated land (snow or ice, bare soil or rocks, and water).

The product of vegetation indices (MOD 13) will provide consistent spatial and temporal comparisons that will be used to monitor terrestrial photosynthetic vegetation activity in support of change detection and phenologic and biophysical interpretations. Vegetation index maps depicting spatial and temporal variations in vegetation activity are derived at 8-day, 16-day, and monthly intervals for precise seasonal and inter-annual monitoring. A time-series dataset of the normalized difference vegetation index (NDVI) derived from NOAA/AVHRR, SPOT/VEGETATION, TERRA, or AQUA/MODIS is useful for the extraction of reliable information on land cover change at the global, continental, and large regional scales, because the dataset can cover large areas and long periods from 1980 to the present, with high temporal resolution and at low cost. In light of the above need, we have developed a new land-cover-change detection method based on an NDVI dataset (Fig. 7). It includes three stages: image-to-image geometric registration; reconstruction of high-quality NDVI time-series by use of a Savitzky–Golay filter; and land-cover-change detection by cross correlogram spectral matching (CCSM). The new method is based on the assumption that different land cover types have different NDVI temporal profiles (Fig. 8).

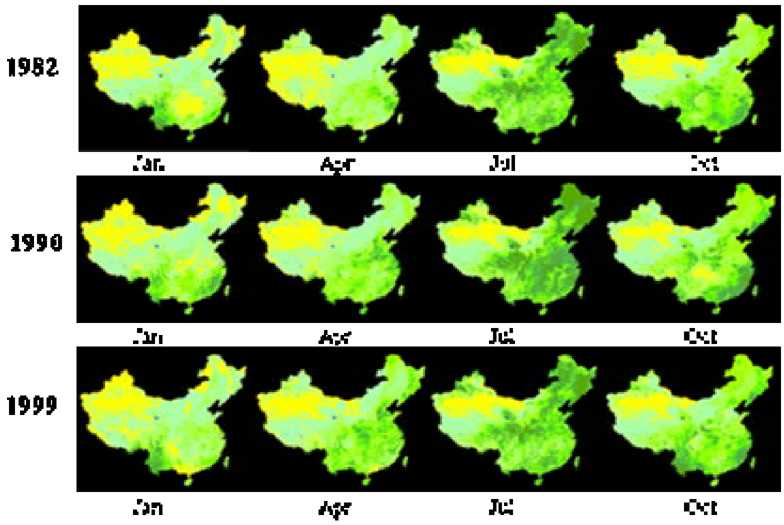


Figure 7 NDVI dataset from NOAA/AVHRR for the period 1982–1999

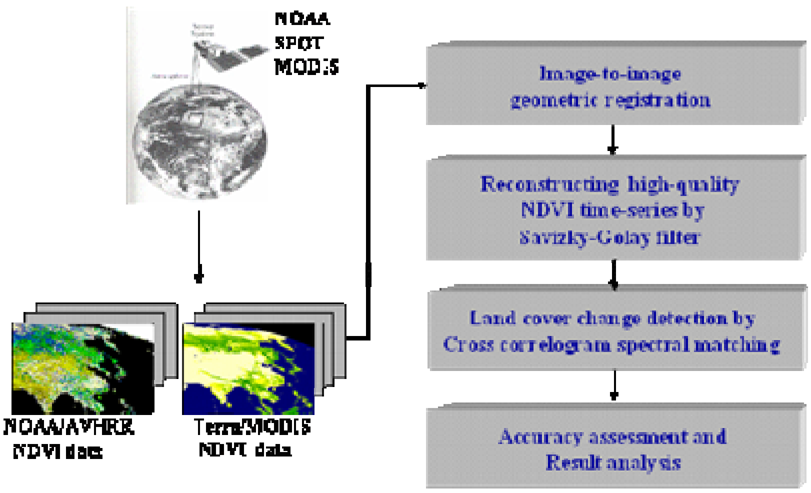


Figure 8 A new method of detecting long-term land cover change

LAI and FPAR (MOD 15) are 1-km-resolution products provided on a daily and an 8-day basis. LAI defines an important structural property of the plant canopy, namely the one-sided leaf area per unit ground area. FPAR measures the proportion of available radiation in the photosynthetically active wavelengths (400 to 700 nm) that a canopy absorbs. The two indices are very useful for monitoring crop growth.

The PSN and NPP product (MOD 17) is a Level 4 product consisting of 8-day net PSN and NPP. Annual NPP is the time integral of the PSN product over a year, and is a very important index for measuring plant productivity. Seasonal changes in some MODIS high-order products are shown in Figure 9.

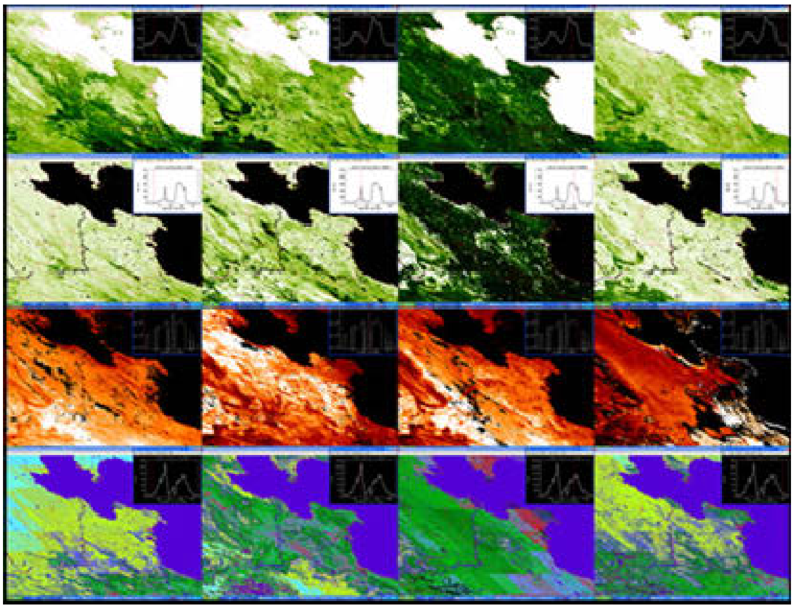


Figure 9 Seasonal changes in some MODIS high-order products on the North China Plain

(From top to bottom: MOD 13 – Vegetation Indice; MOD15 – Leaf Area Index; MOD 11 – Land Surface Temperature; and MOD 17 – Net Primary Productivity

Although we can produce MODIS high-order products by a data processing system, most of them have not yet been calibrated or validated by ground-truth data in various ecological systems, and this validation is the next step in our project. Figure 10 shows the annual changes in FPAR and LAI at each of five validation stations, and Figure 11 shows the results of validation; such results indicate that the MODIS products must be validated before they are put into use.

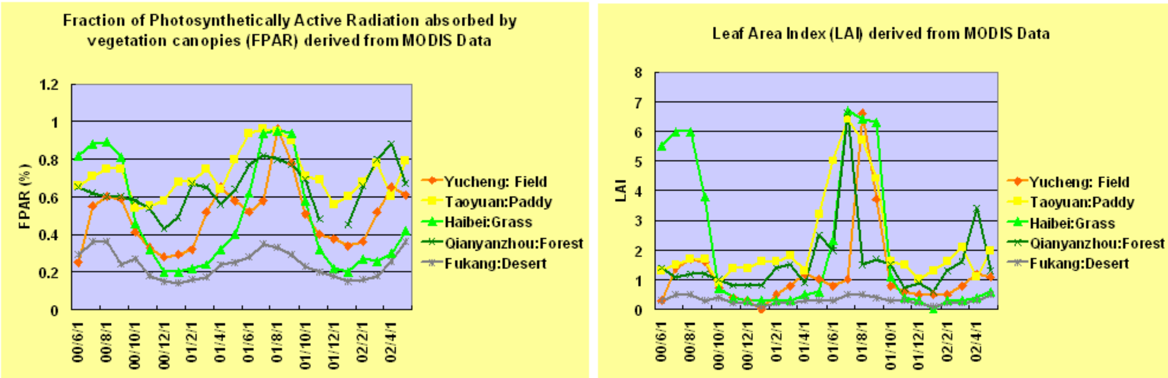


Figure 10 Annual changes in fraction of photosynthetically active radiation absorbed by vegetation canopies (FPAR) and leaf area index (LAI) derived from MODIS data at five validation sites

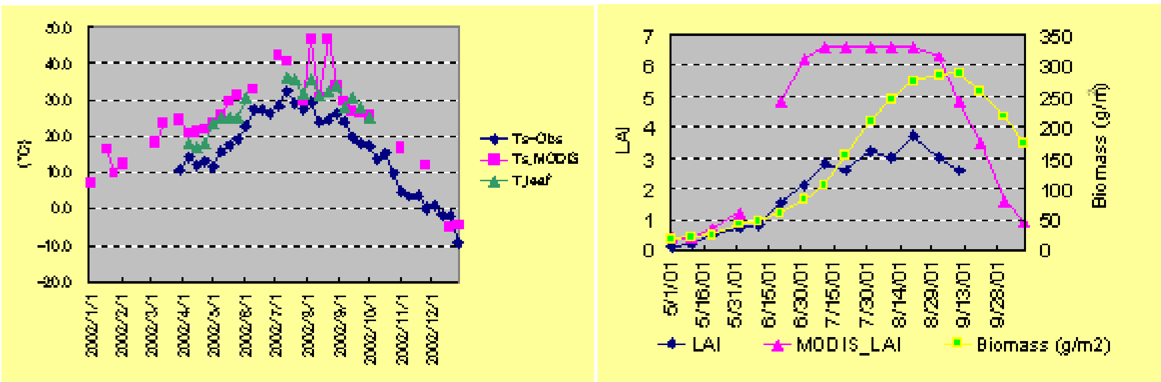


Figure 11 Comparison between observed land surface temperature (left: Yucheng site), and leaf area index (LAI) (right: Haibei Site) with MODIS products in 2001

2.4.3 Development of a ground-truth observation network for various ecosystem types

To validate satellite remote-sensing data, in 2002 we established a ground-truth observation network through which long-term measurements of water vapor, energy exchange, and carbon dioxide from a variety of ecosystems – at Haibei (grassland), Yucheng (irrigated fields), Taoyuan (paddy fields), Qianyanzhou (forest), and Fukang (desert, in China – are measured and integrated into a consistent, quality-assured, and documented dataset. The dataset includes micrometeorological factors, eddy covariance fluxes, vegetation characteristics, and soil physical and chemical properties (Table 1).

Table 1 Types of dataset measurements taken at four ground-truth monitoring stations in China

Validation site:	**Yucheng Station** **(irrigated field)**	**Taoyuan Station** **(paddy field)**	**Fukang Station** **(Desert)**	**Haibei Station** **(grassland)**
Location:	Lat 36.95^{o}N, long 116.60^{o}E, 20 m	Lat 28.92^{o}N, long 111.50^{o}E, 20 m	Lat 43.75^{o}N, long 87.75^{o}E, 1600 m	Lat 37.48^{o}N, long 101.20^{o}E, 3200 m
Vegetation characteristics:	**Type:** crops **Fetch:** 300–500 m **Dominant species:** wheat, corn **Canopy height:** 1–2 m **Diameter:** 0–5 mm **Age:** 1 y **LAI :** 0–4	**Type:** crops **Fetch:** 300–500 m **Dominant species:** rice **Canopy height:** 1 m **Diameter:** 0–5 mm **Age:** 1 y **LAI:** 0–4	**Type:** crops **Fetch:** 300–800 m **Dominant species:** shrubs **Canopy height:** 1–3 m **Diameter:** 0–50 mm **Age:** many years **LAI:** 0–2	**Type:** crops **Fetch:** 500–2000 m **Dominant species:** grass **Canopy height:** 1 m **Diameter:** 0–3 mm **Age:** 1 y **LAI:** 0–6
Observation period:	**Test**: from October 2001 **Monitoring:** from April 2002	**Test**: from February 2002 **Monitoring:** from April 2002	**Test**: from February 2002 **Monitoring:** from April 2002	**Test**: from August 2001 **Monitoring:** from April 2002
Infrastructure:	**Tower:** 7 m (flux and meteorological site) **Electricity:** 220 V AC **Communication:** phone and e-mail	**Tower:** 3 m (flux and meteorological site) **Electricity:** 220 V AC **Communication:** phone and e-mail		**Tower:** 2.5 m (flux and meteorological site) **Electricity:** 220 V AC
Observed items:	**Radiation factors:** global radiation, reflected solar radiation, PAR, downward long-wave radiation, upward long-wave radiation, net radiation **Meteorological factors:** wind speed, wind direction, air temperature, humidity, precipitation, surface temperature, soil temperature, soil heat flux, sensible heat flux, latent heat flux, atmospheric pressure, soil moisture, evaporation, transpiration,			
Eddy correlation method:	**CO_2 and H_2O analysis:** open-path method; **Wind speed, friction velocity, temperature fluctuation:** 3-D sonic anemometer – thermometer; **Sampling:** frequency of 10 Hz and averaging time of 30 min; **Data:** All data are recorded on a data-logger; **Data analysis method:** coordinate rotation, line averaging, sensor separation, humidity effect, air density			
Vegetation factors:	Photosynthesis, coverage, leaf area index, biomass, leaf conductance, root density, soil nutrients, salinity			
Data recording method:	**Recording data:** All data are recorded on a data-logger **Archiving method:** Data can be downloaded through telecommunication.			

An example of the observed heat, water, and CO_2 fluxes at Yucheng Station in 2002 is shown in Figure 12. Clearly, marked CO_2 absorption and H_2O evapotranspiration occurred during the crop growth season.

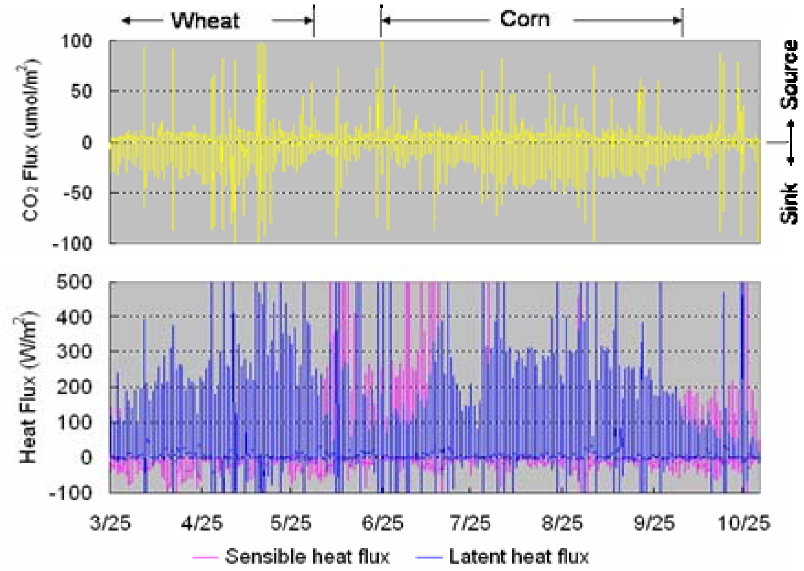


Figure 12 CO_2 sinks and crop evapotranspiration observed at the Yucheng, China, validation site in 2002

2.4.4 Development of an integrated catchment management model that combines a MODIS-based ecosystem model and a DSSAT (Decision Support System for Agro-technology Transfer) model

Soil moisture plays the most important role in the soil–vegetation–atmosphere continuum. However, it is one of the factors most difficult to estimate at a regional scale because of the heterogeneity of land surface characteristics. As most studies determining soil moisture address observational data analysis and biophysical mechanism modeling at one site or on a micro-scale, up-scaling to a regional or macro-scale is very difficult. Satellite data provide great potential for solving this problem, and accordingly an observation scheme has been designed at Haibei Ecological Station, in China (Fig. 13).

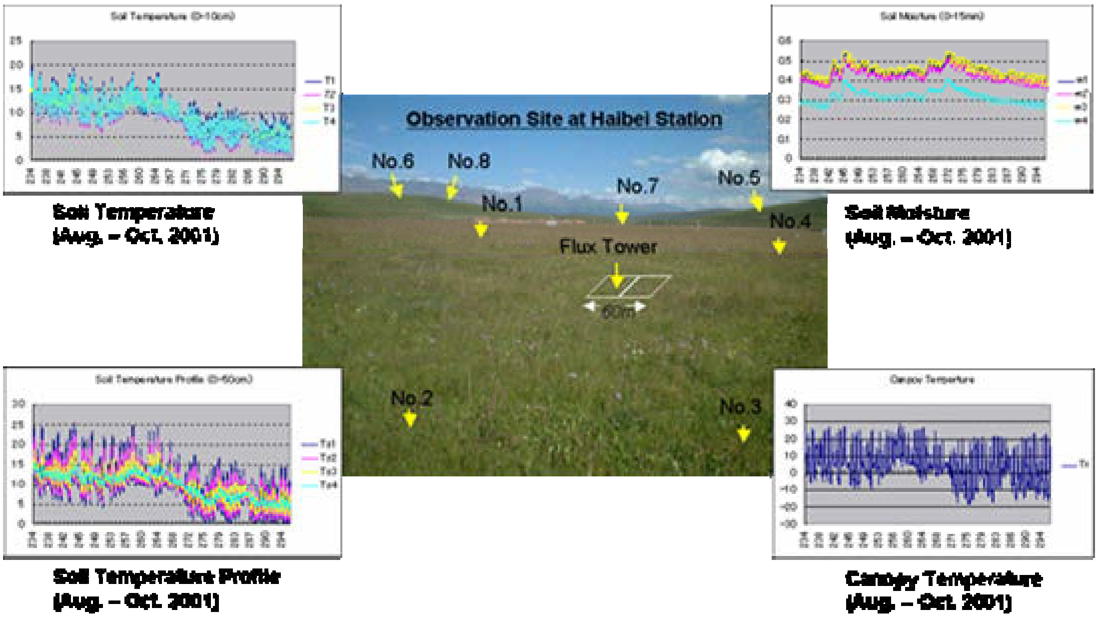


Figure 13 Observation scheme set up at Haibei Station, China

Further, integrated models that simulate ecological functions have been developed for use in decision-support systems for sustainable development, biophysical processes, and human interactions (Fig. 14). For example, (1) a MODIS-based ecosystem model has been developed to simulate water, heat, and carbon cycles, sediment transport, and agricultural production; and (2) A sophisticated DSSAT model has been used to simulate agricultural production. Simulations show that, through scientific irrigation scheduling, water use efficiency (WUE) can be greatly improved and water resources can be saved with no effect on wheat yield. Further, the drawdown of groundwater can be effectively controlled by adoption of new irrigation technology. These findings were derived from the following simulation.

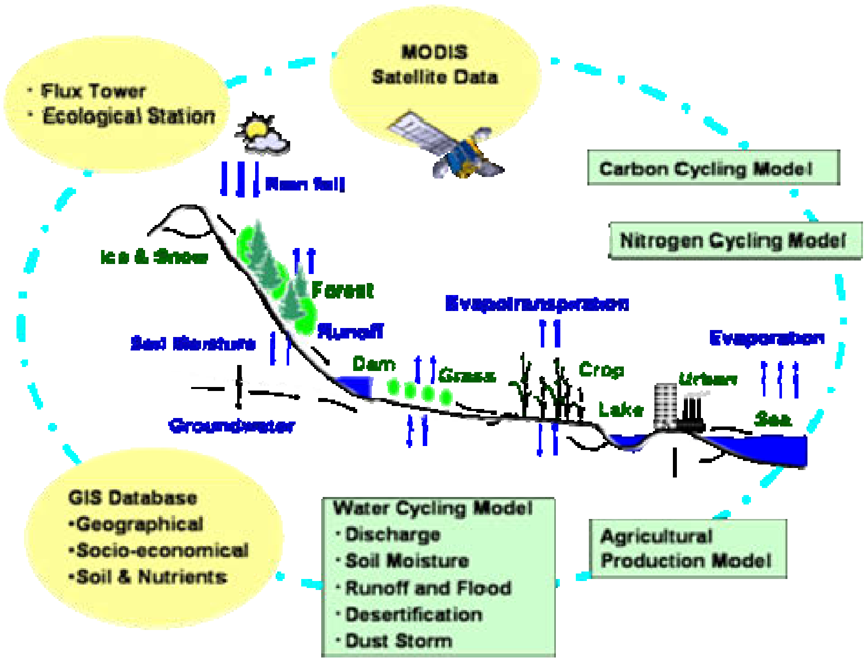


Figure 14 Structure of the integrated catchment management model

A simulation was applied to wheat production on the North China Plain, one of the largest bases of crop production in China. The widely distributed irrigation networks rely on the use of groundwater, and this has caused a rapid decline in the water table in the region. Figure 15 (left side) shows the average water table fluctuation observed in 22 wells during 1974–2001 in Gaocheng County, which indicates that the groundwater level dropped 19.7 m in a 28-year period. Groundwater drawdown takes place mainly in March–June, which coincides with the wheat-growing season (Fig. 15, right side). Sustainable development of agriculture in this area is facing huge challenges. In such areas, it is very important for us to find out the best irrigation scheme to decrease the amount of water used for irrigation. Our strategy is to produce the highest or near-highest yield with the smallest amount of irrigation water through the improvement of WUE.

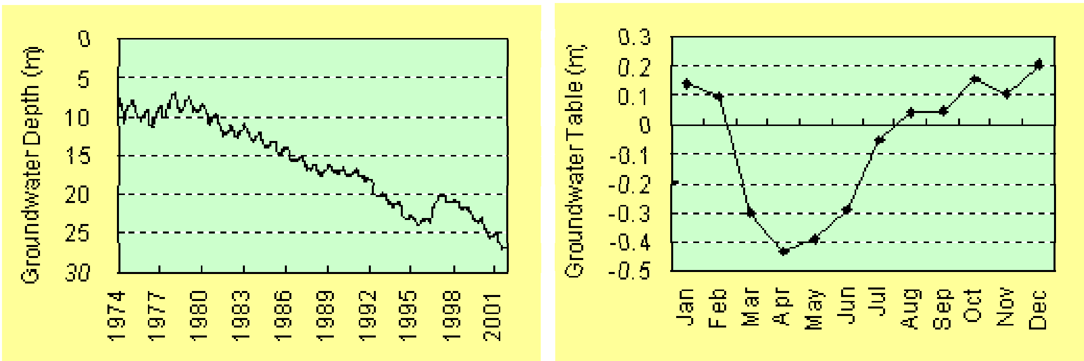


Figure 15 Inter-annual and average monthly variation of groundwater level in Gaocheng County, on the North China Plain, during 1974–2001

The model can simulate, in daily steps, wheat phenological development from planting through to germination, maturity and harvest; photosynthesis and plant growth; carbon allocation to the root, stem, leaf, and grains; and soil water and nutrient movement. To test the validity of the model in the study region, experimental data from the 2000–2001 wheat-growing seasons were used. Comparisons of the simulation results and the measured results are shown in Table 2 and in Figure 16. They indicate that the model simulation is acceptable in the study region for winter wheat management.

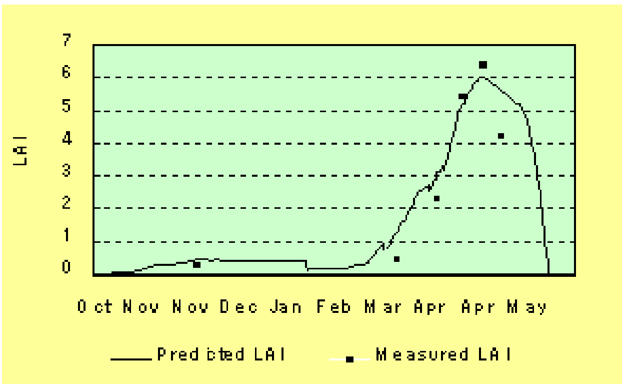


Figure 16 Measured and simulated leaf area index (LAI) of wheat in Gaocheng County, China

Table 2 Comparison of simulated results from adjusted DSSAT wheat model with measured data, Gaocheng County, China

Factor	Simulation	Measurement
Yield (kg/ha)	6608	6330
Weight per grain (g)	0.029	0.029
Grain number (grain/m^2)	22488	21828
Grains per ear	38	38
Maximum leaf are index	6.1	6.4

The simulation results indicate that this model is a strong tool to determine the wise use of ecological goods and services such as freshwater resources (irrigation) for crop production. It can provide information on the amount and timing of irrigation to produce the highest crop yield. For example, it was examined that the best timing of irrigation with same amount of water resource between single time and twice time (Fig.17). According to the simulation, the highest yield was achieved by single time irrigation on May 1, and by twice time divided irrigation on April 10 and May 1, which is more efficient than single time irrigation. Finally, through scientific irrigation scheduling, water use efficiency could be improved and irrigation water can be possibly saved with high wheat yield.

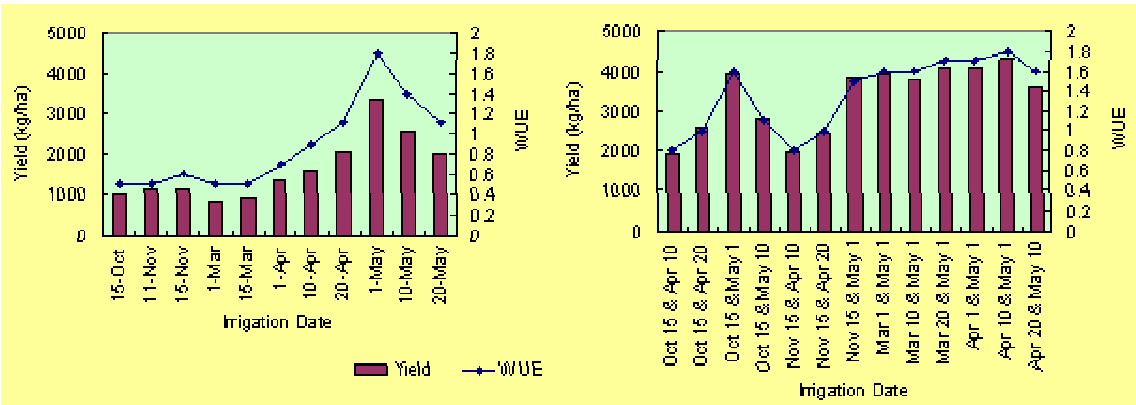


Figure 17 Results of DSSAT model simulation of wheat yield and water use efficiency with one or two irrigations in Gaocheng County, China

2.5 Capacity-Building and Networking

To disseminate information on IEM, two international meetings – in Beijing and Tokyo – were organized in 2002. One was the APEIS Capacity-Building Workshop on Integrated Environmental Monitoring in the Asia-Pacific Region, held on 20–21 September 2002 in Beijing. About 50 representatives from 10 countries attended this meeting, and experts from some famous international organizations, such as NASA, APN, and CSIRO, participated and presented papers. The other meeting was the Workshop on Sustainable Environmental Management of Catchment Ecosystems in the Asia-Pacific Region, held on 25–26 November 2002 at the United Nations University in Tokyo. This workshop was jointly organized by the IEM sub-project and the MA sub-global assessment project of China. To promote cooperation between members of different countries, an APEIS Capacity-Building Workshop is scheduled to be held in Australia in October 2003. Meanwhile, the outcomes of IEM products will be published in international journals and newspapers and on Internet sites.

3. How can the APEIS-IEM products be applied for policy formulation/implementation works?

IEM environmental monitoring data can provide early warning of environmental disasters such as dust storms and forest fires, and can be used to detect slowly worsening environmental degradation such as desertification, salinization, and other ecosystem changes resulting from human pressures. To ensure sustainable water supplies, entire catchment ecosystems must be protected, because they naturally capture, filter, store, and release water. The IEM integrated model offers a scientific tool for exploring policy options related to sustainable catchment management, which includes the efficient and recycled use of water and nutrients.

IEM products can be applied to the development of preparedness policies for both environmental disasters and environmental degradation in the following ways.

From satellite data and ground observations, we will develop methods of measuring parameters such as vegetation distribution, land surface temperature, snow accumulation, rainfall distribution, and soil water content, which are important to our understanding of the circulation of water and other substances. We will verify models of land cover and land use change as keys to more accurate balancing of water and heat energy cycles, and we will develop models for estimating the dynamic fluxes of water, heat, and carbon, land-use changes, and agricultural production. The results of all of this research will be submitted to the related departments of the Chinese Government to help them to formulate water- and land-use policies.

By developing methods of detecting the effects of global warming, we will try to assess how changes in the environment affect biodiversity and the carbon cycle. For instance, we can develop an ecological management model to forecast how human alterations to water circulation affect ecological functions such as the carrying capacity of land and the preservation of water resources. We will also try to promote the development of spatially distributed water and heat energy circulation models and use them to forecast soil water deficits and salt accumulation, as well as land-based pollution loads and substances, such as sediments, nitrogen and carbon in river, lake, and dam ecosystems. These results will be submitted to the Chinese Environmental Protection Agency, and will help them to plan for environmental reconstruction.

We will use an integrated catchment management model to evaluate the impact on river basin ecosystems and water resources of human activities such as dam construction, water transport between the Yellow River and Changjiang basins, afforestation, water-conserving agriculture, and environmental preservation, including industrial and residential waste water processing. This model will be used as a basis for proposing environmental management policies that support sustainable river basin development. The simulated results will be presented to the related departments of the Chinese Government, such as CCICED and the Changjiang Water Resources Commission of China.

4. Relevant Information (front/back covers)

Participating organizations:

National Institute for Environmental Studies (NIES), Japan

Institute for Geographical Sciences and Natural Resources Research (IGSNRR), Chinese Academy of Science (CAS), China

National University of Singapore (NUS), Singapore

Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia

Chinese Ecosystem Research Network (CERN), China

Xinjiang Institute of Ecology and Geography (XIEG), CAS, China

Institute of Subtropical Agriculture (ISA), CAS, China

Northwest Plateau Institute of Biology (NPIB), CAS, China

Web site: http://www.nies.go.jp/basin/index-e.html

Web site

Integrated Environmental Monitoring（IEM） http://www.nies.go.jp/basin/index-e.html

This picture is painted by Yuri Nakajima

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