GLOBAL DATABASE OF KEY ENVIRONMENTAL VARIABLES

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ABSTRACT

We are in the age of the common recognition of the seriousness of global change. The first step of measures for global change is to know the present situation and the change from the past of key environmental variables. This is nothing but the development of global datasets and global database. The ISPRS WG IV/6 has started the study of global database since 1992. There are many problems to be solved for the development of better global database. These problems are identified in this paper. The next action by the ISPRS is to have linkage with other societies and project groups with a similar purpose. The possible actions by the ISPRS initiative are documentation/publication of the present situation of global database, the standardization of metadata for global datasets, and the standardization of map projection and data structure.

1. GLOBAL CHANGE

The awareness of global change was already noticed by some researchers in 1970s. It was widely recognized by general people through mass communication in 1980s. Many evidences such as the increase of the concentration of atmospheric carbon dioxides were found in 1980s. In these period, space agency of developed countries in this field started to plan to launch earth observation satellites for global change studies. Late 90s is the time to launch these satellites such as ADEOS by Japan, SPOT-4 by France, and EOS-AM1 by USA.

Global change studies have become main purpose of remote sensing. What is the final goal of global change studies? It is the establishment of a pseudo Earth system in a computer which includes a complete and sufficiently accurate global datasets of key environmental variables and a model of global environmental mechanisms. This Earth system enables us to simulate the effect to the earth environment by any scenario of human activities. Such a system may be named "the Earth II in a Computer (EIIC)" after the Biosphere II in the desert of Arizona (Figure 1).

The following four steps are a series of measure for global change.

Step 1 Estimate of the present situation or changes of key environmental variables (Production of global datasets)

Step 2 Understanding of the relations and interactions among key environmental variables (Modeling)

Step 3 Prediction of key environmental variables by human input (Simulation)

Step 4 Finding the directions and limitations of human activities for keeping sustainable or survival development (Policy making)

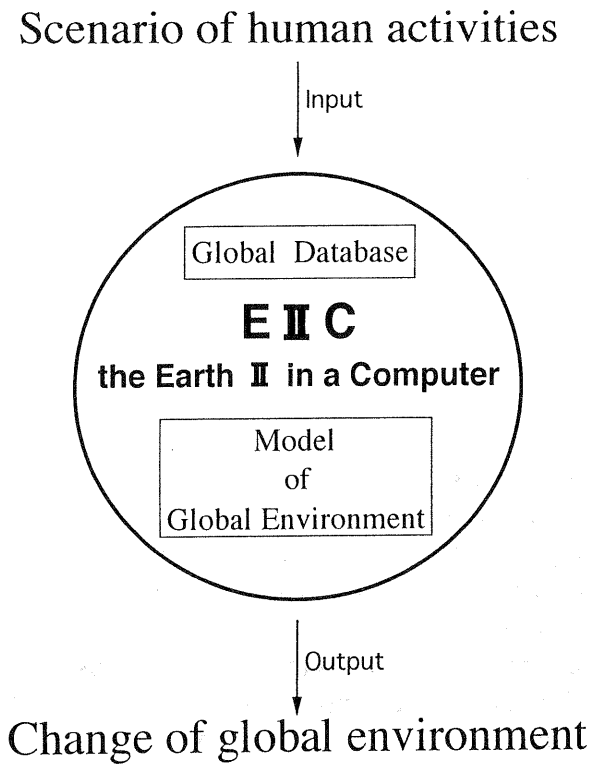

Figure 1 The Earth II in a Computer (EIIC)

2. GLOBAL DATASETS

What are key environmental variables? In 1988, the Earth System Science Committee of NASA summarized physical quantities which should be observed and measured over long duration for global change studies (NASA 1988). On the other hand, sixty-six variables were identified by panel participants of the International Symposium on Core Data Needs for Environmental Assessment and Sustainable Development Strategies which was held at Bangkok, Thailand in November 1994 (UNDP/UNEP 1994). Key environmental variables are consists of physical variables and social variables. Examples of physical one are DEM, land cover, and soil type for terrestrial variables, temperature, precipitation, and evapotranspiration for meteorological variables, concentrations of atmospheric gases, and sea surface temperature and chlorophyll for oceanographic variables. Examples of social variables are population, land use, energy consumption, water use, and industrial exhaust gas.

The production of global datasets of key environmental variables is the results of the above Step 1. The Step 2 is the understanding of the global environmental mechanisms which is the main part of global change studies. To perform the Step 2, global database including physical and social variables is necessary. The result of the Step 2 is reliable modelings of global change. After successful Step 2, Step 3 is not a difficult task. The Step 4 is not a job by only scientists but a job by all people including policy makers, scientists, and general people.

The preceding part is the description from the view point of global change studies. Next, let me focus on global datasets. What are needs for global datasets? There are scientific needs, social needs, and educational needs. The scientific needs are described in the above as the input to the Step 2. Even if we cannot understand the mechanisms of global change, we have to decide how to use land and resources. The social needs are for large scale land use planning and utilization and management of natural resources which needs the information of the present situation of the earth surfaces, that is global datasets. The last type of needs is educational needs. In order to improve knowledge of general people about global change, environmental education is important. Global datasets are the powerful tool to make people notice the seriousness of global change. Users of global datasets are scientists(scientific needs), policy makers(social needs), and general people(educational needs).

What are the information sources for global datasets? Key environmental variables can be derived from one or some of the following sources.

- existing maps (ex. DEM)
- remote sensing (ex. land cover)
- ground measurement (ex. runoff)
- census (ex. population)
- other global datasets (ex. evapotranspiration)

In the early attempt of the production of global datasets, main sources were existing maps. Examples are the global DEM, ETOPO5, by Margaret Edwards and one-degree global land cover data by M.F. Wilson and Anne Henderson-Sellers. Satellite remote sensing is a powerful tool to produce global datasets. There are many programs to launch satellite for the purpose of developing global datasets of land cover, biomass, ozone, precipitation, ocean chlorophyll, snow and ice. They are ADEOS, ADEOS-II, TRMM, EOS-AM1 and EOS-PM1, SPOT-4. Some variables such as river runoff are collected by ground measurement, and many other variables such as land cover and precipitation needs ground measurement for the ground truth. Most socio-economic data is collected by census. Since various global datasets have become available, a dataset of new variable can be estimated and derived from the existing datasets. Such an example is global dataset of 30-minute evapotranspiration (Ahn 1994).

Most global datasets in the early stage have an unit area from one degree to thirty minute grid, while the present tendency is one kilometer(or thirty second) grid. This is the same resolution as NOAA AVHRR data. Land cover data and DEM are being produced with this resolution by IGBP-DIS and GLOBE(Global Land One km Base Elevation) committee, respectively.

Who contribute to develop global datasets and global database? Dataset producers, dataset distributors, and database planners do. Dataset producers are individual researchers or a group of researchers. There are many dataset producers in different fields, different academic societies, and different countries. On the contrast, there are a few dataset distributors which are:

- UNEP/GRID
- NOAA/ National Geophysical Data Center, USA
- Rutgers University, USA
- Earth Observing System Data and Information System (EOSDIS) / Distributed Active Archive Centers (DAAC), USA

These organizations collect and distribute various global datasets, while there are some organizations which distributes a specific global dataset. The Global Runoff Data Centre of Germany is one of them.

A database planner mentioned here is a group of people who pursuit the development of better and useful global database of key environmental variables. Such groups are:

- International academic society such as ISPRS, International Geographical Union (IGU), and International Cartographic Association (ICA)
- International organizations such as United Nations Environment Programme (UNEP) and United Nations Development Programme (UNDP)
- International projects initiated by national proposal such as Global Mapping by Japan and Earth Map by USA

3. ISPRS WG IV/6

The Working Group IV/6 on "GIS and Expert Systems for Global Environmental Databases" was established at the ISPRS Washington Congress in 1992. The Working Group has put emphasis on studies of global datasets/database of key environmental variables. The activities by the Working Group from 1992 were:

- Two international workshops
- Survey of national and regional geographic data bases

The International Workshop on Global GIS was held at Tokyo, Japan from August 24-25, 1993. The workshop was jointly organized with

ISPRS Intercommission WG III/IV (Conceptual aspects of GIS) and sponsored by the Japan Society of Photogrammetry and Remote Sensing(JSPRS). Limited number of copies of the proceedings with fourteen papers are available from the author. The second workshop, the International Workshop on Global Databases, was held at Boulder, Colorado, USA from May 30-31, 1995. In this workshop, thirty participants had fruitful discussions on important subjects for the development of better global database. Discussed subjects were:

- Data requirement
- Legend/categorizations
- Accuracy/quality
- Data availability, data access and dissemination rights
- Map projection and data structure
- Integration of national mapping activities into global monitoring systems & harmonization of ongoing global mapping projects

The report of the workshop, the International Archives of Photogrammetry and Remote Sensing Volume XXX, Part 4W1, is available from RICS Books.

The survey of "National and Regional Geographic Data Bases" had unsatisfactory results because of no budget and insufficient personnel for the survey. Questionnaire was sent to all Ordinary Members of the ISPRS, and 53 answers from 18 countries were received. The questionnaire is about national data of any remote sensing products, DEM, hydrological data, land use/cover data, soils/geological data, political data, roads data, population data, and their point of contact. Since this type of survey about existing geographic data is important, an authorized international body with enough budget and personnel must have a responsibility for such a survey.

4. WHAT SHOULD WE DO?

What should we do to develop truly useful global database? Table 1 shows problems which prevent to develop better global database and their measures.

Some key environmental variables such as energy consumption, the volume of exhaust gas from factories and water volumes by irrigation are not exist as a global dataset. Many socio-economic data are lacking due to national sovereignty and technical difficulty of measurement. Researchers in many fields have to produce lacking datasets one by one.

Most countries have land use data, and many projects survey local land use. However there is

Table 1 Problems and their measures for a better global database

Problems	Measures	
- No data for some variables	Data production	Specific
- No mechanism of integration of local data	Establishment of new mechanism	Common
- Insufficient quality	Improve information sources	Specific
- Unknown quality	Evaluation and documentation of accuracy	Common
- Insufficient metadata	Standardization	Common
- Different classification system	Harmonization & standardization	Specific
- Different map projection	Standardization	Common

Specific: problem for a specific global dataset
Common: common problem for all global datasets

no mechanism to use these local data for the development of global dataset. There are many reliable local data without extended use for global dataset. Regarding categorized data, different classification systems by countries and projects prevent the use of local data. Only international authorized organization can establish new mechanism to integrate local data in various countries and projects.

ETOPO5 was the best available global DEM. This has five minute grid which is a coarse resolution even for global applications, and the accuracy is not sufficient. Then GLOBE Committee is producing a new global DEM with 30 second grid using Digital Terrain Elevation Data(DTED) which is global DEM with three second grid by Defense Mapping Agency (DMA), USA. Since DTED has also some regions with poor accuracy, remote sensing technique such as interferometry has to be used to improve the quality of data. Similarly, for other environmental variables, new better information source has to be used to improve its quality.

Most existing global datasets are not well documented about its accuracy. Without accuracy data, any result derived from global datasets cannot be evaluated in terms of reliability. Data without accuracy data is useless. Any newly produced global dataset must have a documentation about its accuracy. To do this, evaluation method of accuracy has to be standardized.

The problem about metadata is similar to the above problem. Most existing global datasets has no or not enough metadata. Metadata has to be attached to all global datasets. The International Standards Organization Technical Committee 211 (ISO/TC 211) tries to create metadata standards for geographic data as a part of their tasks. The metadata standards for global datasets has to be created by a group of datasets producers, distributors, and users.

Different classification system of categorized data such as land cover and soil type by different countries and projects prevent the integration and comparison of their data. Harmonization or standardization of classification system is indispensable. The United Nations Environmental Programme (UNEP) and the Food and Agriculture Organization (FAO) have a valuable project to harmonize existing land cover and land use classification system.

Map projection is another problem. There is no best map projection in all requirements. The evaluation method of different map projections has to be established and better map projections for data storage, data analysis, and data presentation has to be selected.

5. WHAT ACTIONS SHOULD ISPRS TAKE?

There are many organizations and project groups who recognize the above mentioned problems for better global database. They are global database planners mentioned in the section 2: IGU, ICA, UNEP, UNDP, Global Mapping(Japan), Earth Map(USA), etc. In order to avoid a duplication of efforts, The ISPRS needs linkage with other groups by having a meeting. The purpose of such a meeting would be:

- Common recognition of problems for better global database
- Survey of on-going studies and projects to solve problems
- Identify cooperative actions with other organizations and project groups, and assign initiative actions by an individual organization

What can the ISPRS do as initiative actions? The ISPRS can

- document and publish the present situation of the development of global datasets and database. This makes users, producers, and planners of global datasets understand the situation, and helps to develop better global database.
- take part in standardizing metadata
- study for selecting several map projections as

standards of global datasets

In conclusion, the first priority of actions by the ISPRS is to have linkages with other groups with the same purpose to develop better global database. The second priority is to initiate actions such as documentation/publication of the present situation of global database, the standardization of metadata for global datasets, and the standardization of map projection and data structure.

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