Contribution to the Development of Global Land Related Dataset from Asia

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ABSTRACT

Global land related datasets such as land use, land cover, vegetation cover percentage, forest cover percentage, are part of important global geospatial environmental datasets for global change studies. Since land cover varies place by place, continental production of dataset is a usual approach. Western academically developed countries have some projects to describe land cover related information in digital form using remote sensing technology in African, American continent and Oceania. In this paper, the author introduce his initiative to coordinate Asian scientists in order to develop land related dataset of Asia for our better understanding of the environment of Asia and for contribution to the development of global dataset. This paper explains activities by Land Cover Working Group (LCWG) of the Asian Association on Remote Sensing(AARS), Data and Information System(DIS) sub-committee of Japan national committee for the International Geosphere and Biosphere Program(IGBP), and the International Society for Photogrammetry and Remote Sensing(ISPRS) Working Group IV/6 on Global databases supporting environmental monitoring.

INTRODUCTION

There are two purposes to get land cover information. One is for environmental studies such as global change studies. The other is for land use planning. For example, the land cover project by the Land Cover Working Group of the International Geosphere Biosphere Programme(IGBP) Data and Information System(DIS) pursues global mapping with 1km resolution for global change study(Townshend 1992). On the other hand, AFRICOVER project by Food and Agriculture Organization (FAO) aims to develop the framework of land cover mapping of the African continent by deciding land cover classification system for the purpose of land use planning of each African country(Gregorio 1996). In either purpose, satellite data plays an important role in land cover mapping as a key input.

Global AVHRR GAC data is available since 1981. NOAA and NASA publishes 8km resampled AVHRR as NOAA/NASA Pathfinder AVHRR Land Data Set from 1981. This is the only available globally covered temporal satellite data at present. This data is usable for global land cover change detection with a limitation due to poor resolution. IGBP-DIS developed global 1km AVHRR data set for 18 months from April 1992. This data set is suitable for global land cover mapping in terms of resolution though undesirable effect by mosaicking remains. There are and will be some new sensors for global observation such as SPOT/VEGETATION (1998), EOS-AM1/MODIS(1998), and ADEOS-II/GLI(2000).

At present, AVHRR is the only available satellite data for global/continental land cover mapping. In the following sections, the author introduces the methods and results of global/ continental land cover mapping and Asia-Wide Land Use and Cover(AWLC) meta-database. Furthermore, necessary actions and studies are

referred for the better land cover monitoring.

1. GLOBAL LAND COVER DATA SET (4 ARC MINUTE GRID)

1.1 LCWG/AARS

The Land Cover Working Group(LCWG) of the Asian Association on Remote Sensing(AARS) started its activity in 1993 and released the first product, "AARS Global 4-minute Land Cover Data Set with Ground Truth Information" by a CD-ROM in 1997(Tateishi 1997). The CD-ROM is available from the author. The basic idea of the LCWG/AARS is to develop land cover data set of the whole Asia by Asian scientists and to contribute to the development of global data set by providing data set and information of Asia.

1.2 Land Cover Classification System

The land cover classification system was developed based on the following concepts through discussion with members of the LCWG/AARS. The LCWG/AARS proposes general land cover classification system which meets both scientific and social needs. For scientific needs, the proposed classification system has similar land cover classes to IGBP-DIS land cover classification system. Key land cover class for social needs is cropland. In the proposed LCWG/AARS classification system, cropland is basically divided into three types such as tree crops, shrub crops, and grass crops in order to match the classification system for scientific needs.

The classification system of this CD-ROM consists of 60 classes including 48 classes for vegetation, 8 classes for non vegetation, and 4 classes for water. Addition of new classes up to 255 is possible. Class code is recorded in one byte.

1.3 Ground truth collection

Ground truth data in this study means geographically specified regions which are identified one of classes in the land cover classification system by class code. Collection of good ground truth data is a key issue for reliable land cover mapping.

Ground truth data were collected mainly from existing maps by the cooperation of the working group members. Few ground truth were collected by field survey in Central Asia.

Ground truth data of 35 land cover classes were collected. Geographical regions of each ground truth data and the information sources for each ground truth data are recorded in the distributed CD-ROM.

1.4 AVHRR data and their preprocessing

Global 8 km 10 days composite AVHRR NDVI data from January 1, 1990 to December 31, 1990 were used for the development of land cover data set. The cloud flag data for each pixel were also used for composite processing. These AVHRR data are a part of the NOAA/NASA Pathfinder AVHRR Land Data Set (Agbu 1994).

The map projection of the NOAA/NASA Pathfinder AVHRR Land Data Set is based on the Interrupted Goode Homolosine projection. The data were transformed to latitude/longitude projection(Plate Carree projection) with four minutes resolution and resampled to the Digital Chart of the World(DCW) for the geometric registration . The accuracy after geometric registration is 0.6 pixels (one pixel : 4 minute grid) when compared with DCW at several points in global land area between 75 degrees north latitude and 55 degrees south latitude.

In order to produce a cloud free NDVI image and to remove noises in an image, a monthly composite data was generated from 10-days composite data. Monthly composite is carried out pixel by pixel using three 10-days composite NDVI data in a month and corresponding three cloud flag data in a month. Cloud flag data gives one of three cloud status: clear, mixed, or cloudy.

1.5 Classification

Land cover classification was performed basically by phenological information from monthly NDVI data. In this study, a clustering, k-means method, was applied for monthly composite NDVI data of 1990 independently both for global land area and for Asian and Oceanian land area. Since AVHRR data in Pathfinder Data Set in the northern high latitude region over about 55 degree north are not available in winter season because of low sun elevation angle, a clustering was also applied for monthly data from March to October. That is, the following three clusterings were carried out.

(1) 12 monthly NDVI data from January to December, 1990 for global land area
(2) 12 monthly NDVI data from January to December, 1990 for Asia and Oceania
(3) 8 monthly NDVI data from March to October, 1990 for global land area

The following three features derived from monthly NDVI were analyzed for each land cover class of ground truth data in order to decide rules of decision tree classification method.

(1) Clustering results
(2) Maximum NDVI: the maximum monthly NDVI value in twelve months
(3) Minimum NDVI: he minimum monthly NDVI value in twelve months

By the method describing above,
(1) global 4-minute land cover data set and
(2) 4-minute ground truth data set in Asia and Oceania
were produced and are being distributed.

2. LAND COVER DATA SET OF THE WHOLE ASIA (30 ARC SECOND GRID)

Thirty arc second grid land cover data set of the whole Asia is the final product by the LCWG/AARS. The developed data set will be released by CD-ROM early 1999.

2.1 Used data and information

- AVHRR data

NDVI, channel 4, and channel 5 of NOAA AVHRR 1-km 10-days composite produced by IGBP-DIS project was used in this study. The used data ranges from April 1992 to March 1993.

- Thematic maps

Maps of ecoregions, vegetation, land use, and land cover were used as the source of ground truth and as a reference. Twenty-five different types of thematic maps are used in this study.

2.2 Land Cover Classification System and Ground Truth Collection

The land cover classification system applied in this project was the same one as the four arc minute grid global land cover data set. Ground truth data were collected mainly from existing thematic maps and partly from field survey in Central Asia.

2.3 Classification

The feature extracted for land cover mapping in this study is phenological information which is monthly ratio of Ts over NDVI. Here, Ts is land surface temperature calculated by split window algorithm (Price 1984) from channel 4 and channel 5 of AVHRR. The Ts is affected by rainfall and the maximum Ts corresponds no or less rain condition. Therefore monthly Ts/NDVI is derived from maximum Ts in a month and maximum NDVI in a month.

Basic classification method is the same as the case of four arc minute except the use of the ratio Ts/NDVI instead of NDVI.

3. Asia-Wide Land Use and Cover Meta-Database (AWLC meta-database)

3.1 What is an AWLC meta-database?

An AWLC meta-database is a database of meta-data of land use, land cover, and other land surface variables in Asia. Land use is a social classification of land which describes how a man utilize land. Land cover is a physical classification of land which describes what type of surface, especially vegetation type, covers a land. Other land surface variables include vegetation cover percentage, forest cover percentage, area of land cover change, area of desertification etc. They are any kinds of variables which describe land surface characteristics. They may be category-type discrete representation of land or continuous variables of land. You can get access to the AWLC meta-database at:

http://oblbwww.cv.noda.sut.ac.jp/awlc/index.htm

3.2 Why do we need an AWLC meta-database?

Land surface characteristics is one of key environmental variables for global change studies and local environmental studies. However we do not have unified detail knowledge about land use and land cover of global area which meets the needs for global change studies. Since land cover of global area varies a lot by continent, land use and land cover of each continent should be investigated first. The AWLC meta-database is focused on Asia. Though we can get land use and land cover information from satellite image, the lack of more reliable information (or ground truth) than satellite extracted one is a common problem. On the other hand, there are many projects and individual studies which provide land use or land cover information as a final product or by-product. But, unfortunately, in most cases, these information can not be accessed by other researchers just because producer of these products think that they are only for their own project, organization or sponsor. The main reason of the development of an AWLC meta-database is to remove barrier which avoid to use the pre-acquired knowledge of land use and land cover of Asia. In other words, an AWLC meta-database changes closed knowledge of land use and land cover to open or common knowledge for Asian scientists. This common knowledge is a common property of Asian scientists and it promotes the understanding of the environment of Asia.

3.3 Who initiated AWLC meta-database?

Data and Information System(DIS) sub-committee of Japan National Committee of the International Geosphere Biosphere Program(IGBP) initiated AWLC meta-data in 1998. The author and Dr. Hirohito Kojima of Science University of Tokyo are the leading members of this project.

3.4 Contents of the AWLC meta-database

(1) Name of the dataset
(2) Location (Latitude of the north end, Latitude of the south end, Longitude of the west end, Longitude of the east end, Name of the place)
(3) Attribute (Land use / land cover class or Land surface variable)
(4) Source information
(5) Data (In case of raster data, Grid size and in case of vector data, Original scale)
(6) Any description about the dataset
(7) Availability
(8) Contact
(9) Documentation/Web site about the dataset
(10) This dataset is produced by
(11) This meta-data is contributed by
(12) Browse image of the dataset

3.5 How can you register your data to the AWLC meta-database?

You can contribute to the AWLC meta-database by sending meta-data of land use, land cover, or other land surface variables in Asia by the method described below. It would be appreciated if you could send the image data or browse image data of land use/cover or other land surface variable.

Method to send meta-data:
- Meta-data written in English language in a TEXT file(file name: ****.txt) or a HTML file(****.htm) is accepted.
- Image data in a GIF file(****.gif) or a JPEG file(****.jpg) is accepted.
- The above data can be sent either by one of the following three methods.

1. postal mail of media such as a floppy disk, CD-R, MO, or 8mm tape with the description of the recorded format information to:

   Dr. Hirohito Kojima
   Faculty of Science and Technology Science University of Tokyo
   2641 Yamazaki Noda-City Chiba 278-8510 Japan
   Phone : +81-471-24-1501(ext.5014) Fax: +81-471-23-9766

2. email message to Dr. Hirohito Kojima Email : kojima@ir.noda.sut.ac.jp
3. FTP data transfer

4. FURTHER NECESSARY ACTIONS/STUDIES FOR SUCCESSFUL LAND COVER MONITORING

There are several other subjects to do for the better global/continental land cover monitoring.

- Classification of Agricultural Land

Agricultural land is the most important class in land use planning. However this is one of the most difficult class to extract from continental scale satellite data because of small unit area and various crop calendars. One of the solutions is the use of new sensor with the middle resolution(50-200 m) and high temporal frequency(1-3

days). SAR data may be also applicable to the classification of agricultural land

- Preprocessing of time-series satellite data and land cover change detection

Land cover change detection from time series satellite data such as AVHRR is a basic information extraction. However, this is difficult due to many factors affecting image data, for example, angular geometry at observation, cloud contamination, sensor degradation, solar zenith angle, etc. To remove these effects is the main task for change detection.

- Digitization of historical land cover maps

Since globally covered satellite image exists only from 1981, historical land cover information is required for long term land cover change analysis.

- Application of SAR data

Cloud coverage is the main barrier to hinder the production of cloud free multi temporal data. The use of SAR data gives new possibility for land cover monitoring. However basic research of classification using SAR data is required.

- Development of better digital global base map

The Digital Chart of the World(DCW) is the most frequently used digital global base map. However the accuracy is about 500 meters in both longitude and latitude direction(Tateishi 1998). Therefore when we use global/continental satellite image with a resolution better than 1 km(AVHRR), better base map will be required.

- Representation of land cover by continuous variables like vegetation cover percentage

Conventional category type representation of land cover has some limitation in its ability to describe various types of land covers. The representation of land cover by continuous variables such as vegetation cover percentage or vegetation height is recommended to use jointly with category type representation.

5. CONCLUSIONS

Global/continental scale land cover monitoring is important as the input to environmental studies and also large scale land use planning. The author developed land cover data sets in global area and Asia. Also they listed up future necessary studies for global/continental land cover monitoring.

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