

GLOBAL/CONTINENTAL LAND COVER MAPPING AND MONITORING

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Working Group IV/6

KEY WORDS: Land cover, AVHRR, Ground truth.

ABSTRACT

Land cover is one of the key parameters for global change studies. NOAA AVHRR time series data provide phenological information for larger areas. Authors developed, as the product of the Land Cover Working Group (Chairman: R.Tateishi) of the Asian Association on Remote Sensing (AARS), land cover dataset of the whole Asia using 1-km AVHRR NDVI and surface temperature (Ts) data derived from AVHRR channel 4 and channel 5. The basic information for the classification is clustering results of monthly ratio Ts/NDVI. The classification was carried out based on the hierarchical classification system. The classified land cover dataset is mapped to 30 arc second grid, and it is being distributed widely to researchers. For the improvement of land cover dataset, the development of Global Land Cover Ground Truth Data Base (GLCGT-DB) is proposed.

1 Land cover mapping of Asia

1.1 Used data

Global NOAA AVHRR 1-km 10-day composite dataset from April, 1992 to March, 1993 (Eidenshink *et al.*, 1994) are the main data used in this study. In addition, digital elevation data and national/regional level of vegetation and land use maps were also used for the analysis of land cover classification.

(1) AVHRR Data

Global NOAA AVHRR 1-km 10-day composite NDVI, channel 4 and channel 5 data from April, 1992 to March, 1993 were used in this study for land cover mapping. The NOAA AVHRR 1-km dataset is based on the Interrupted Goode Homolosine map projection, and it was transformed to latitude/longitude map projection (Plate Carree Projection) with 30-second degree grid by using the nearest-neighbors method. In order to prepare the data of the whole Asia, the NDVI,

channel 4 and channel 5 data were extracted from 25 degree East to 165 degree West in longitude, and 90 degree North to 15 degree South in latitude.

(2) Digital Elevation Model (DEM) data

Generally, elevation data is used to model ecological governing natural vegetation distribution, and is important for identifying land cover types and stratifying seasonal regions representing two or more disparate vegetation types. In this study, a Digital Elevation Model, GLOBE Version 1 (January 1998), which comprises a global 30 arc-second latitude/longitude array, was used (Hastings 1998) .

(3) Thematic maps

In this study, maps of ecoregions, vegetation, land use, and land cover were used as reference data to collect ground truth information and to modify the classification result in post-classification processing.

(4) Ground Truth data

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

In this study, ground truth data were collected mainly from existing land cover maps and land use maps of various Asian countries. Also limited parts of ground truth data were collected by field survey in Central Asia .

1.2 Relationship between Ts and NDVI

Authors used multi-temporal NDVI calculated from channel 1 and channel 2, and land surface temperature Ts calculated from channel 4 and channel 5 using the split window algorithm (Price, 1984):

$$T_s = T_4 + 3.33 * (T_4 - T_5)$$

Where T4 and T5 are brightness temperature of AVHRR channel 4 and channel 5 (in degree kelvin).

Authors applied a maximum value composite (Holben, 1986) to the NDVI and surface temperature (Ts) data, selecting the maximum value of the 10-day composite NDVI and Ts independently for every month. Ts responds both to short-term variations in energy balance related to rainfall events and changes in soil moisture, and to seasonal changes (Lambin and Ehrlich, 1995). The monthly composite data of Ts artificially removes the short time scale variations in 10-day composite Ts, leaving only the seasonal trend. It mainly includes lower frequency information, which is related to land cover types (Lambin and Ehrlich, 1995). Since Ts displays the opposite trend to NDVI when moving from sparse to dense vegetation landscapes, the use of ratio between Ts and NDVI increases the capability of discrimination among vegetation classes. The ratio of Ts/NDVI has been interpreted biophysically as regional surface resistance to evapotranspiration (Nemani and Running, 1989). This provides theoretical support for using this ratio in land cover analysis. The ratio of the maximum Ts and maximum NDVI ratio (Ts/NDVI) were then computed for monthly period in

this study.

1.3 Classification

Land cover classification was carried out using mainly the phenological information from the multi-temporal ratio between monthly land surface temperature T_s and NDVI data. Ground truth data itself remains in the final classified result.

(1) Land Cover Classification System

A land cover classification system was developed as the activity of Land Cover Working Group (LCWG) of the Asian Association on Remote Sensing (AARS) (Tateishi and Wen, 1997). One feature of the classification system in this study is the hierarchical structure. When a pixel is difficult to classify land cover type A or B, this pixel can be assigned to higher level of land cover which includes A and B. This is the main advantage of the hierarchical structure.

(2) Unsupervised classification

The initial segmentation of the ratio between T_s and NDVI composites is performed using minimum distance unsupervised clustering. One hundred clusters were acquired as the result. Since AVHRR of winter period has poor quality due to high solar zenith angle, monthly data for seven months from April to October 1992 were used for clustering.

(3) Classification rules

The most important thing in decision tree classification rules based on clustering result is to provide a general understanding of the characteristics of each cluster based on the ground truth data. In this study, the following ancillary datasets were used:

- (a) Digital Elevation Model (DEM)
- (b) Maximum NDVI: the maximum monthly NDVI value in twelve months
- (c) Minimum NDVI: the minimum monthly NDVI value in twelve month

2 Global land cover monitoring

There is a potential in time series globally covered satellite data to monitor land cover, that is to detect land cover changes. AVHRR data is the only satellite data to cover global area for more than fifteen years so far. For successful change detection of land cover, preprocessing of time series satellite data is prerequisite. The study about this by the authors is reported in another paper in this Archives: Analysis of the factor which gives influence to AVHRR NDVI data by Jong-geol Park & Ryutaro Tateishi.

3 Improvement of land cover mapping and monitoring

In order to improve land cover information of global/continental area, the following three things are necessary.

- a. Development of ground truth database
- b. Development of methodology for preprocessing of time-series global/continental satellite data
- c. Establishment of the methodology to extract land cover information from satellite data

a. Development of ground truth database:

The collection of ground truth of land cover in global/continental area is important as training samples for classification and as true data for accuracy assessment after classification. However the collection of ground truth need much time and work. One method is to collect ground truth data by the visual interpretation of higher resolution satellite images such as Landsat TM. The advantage of this method is the uniformity in quality of ground truth data. On the other hand, there are many reliable local/regional land cover information which were prepared by research institutes, projects, or individual researchers. The proposed idea in this paper is to collect available reliable land cover information of local/regional area from existing information by the cooperation with institutes, projects, and individual researchers and to develop the Global land cover ground truth database(GLCGT-DB). In this proposed method, the following information will be collected.

- well defined land cover type or vegetation type
- geographic location (identification of the location by the flag on geographical grid data is recommended)
- source information for individual ground truth data
- legend and its explanation
- any other information about this place including ground photographs

The two features of GLCGT-DB are cooperative data collection and common use. Since the definition of land cover types vary, we need to harmonize them and to extract common land cover classes from various inputs.

b. Development of methodology for preprocessing of time-series global/continental satellite data

For the purpose of land cover mapping and monitoring, factors affecting satellite data such as solar zenith angles, sensor degradation, change of sensors, cloud, atmosphere must be investigated and this effect must be removed. Part of these effects are described in the paper in this Archives as the title of "Analysis of the factor which gives influence to AVHRR NDVI data" by Jong-geol Park & Ryutaro Tateishi.

c. Establishment of the methodology to extract land cover information from satellite data

Main information to extract land cover information from satellite data is as follows.

- Phenology(ex. Seasonal NDVI)
- Physiognomic features (vegetation cover and height)
- Spectral features (reflectance)
- Thermal features

Conventional studies have focused on spectral features, and sometimes uses thermal features. For global/continental study, phenology was used by temporal NDVI data. Physiognomic information such as vegetation area cover percentage

and vegetation height can be new information, which can improve land cover mapping/monitoring. Vegetation height can be obtained by lidar.

4 Conclusions

As shown in Figure 1, a land cover map of the whole Asia (<http://asiaserv.cr.chiba-u.ac.jp/cd/index.htm>) which is in 30-second grid in latitude/longitude and consists of 37 land cover classes of classification system was produced by using NOAA AVHRR 1-km dataset. In order to improve the classification result, reliable ground truth data should be collected more. For this reason, authors plan to publish the used ground truth data. In order to improve the accuracy of land cover mapping/monitoring for further research, authors recommend development of the global land cover ground truth database (GLCGT-DB) by the cooperation of many projects and researchers.

References

- Brown, J.F., Loveland, T.R., Merchant, J.W., Reed, B.C., 1993, Using Multisource Data In Global Land Cover Characterization. *Photogrammetric Engineering and Remote Sensing*, 59, 977-987.
- Eidenshink, J.C., Faundeen, J.L., 1994, Global Land 1-KM AVHRR Data Set Project. *International Journal of Remote Sensing*, 15, 3443-3462.
- Gregory, J.H., Brian, C.H., and Kenneth, C.M., 1999, Landsat Thematic Mapper Registration Accuracy and its Efforts on the IGBP validation. *Photogrammetric Engineering and Remote Sensing*, Vol 65, N9, 1033-1039.
- Hastings, D., 1998 The Global Land One-km Base Elevation (GLOBE) Project.
<http://www.ngdc.noaa.gov/seg/topo/global.shtml>.
- Holben, B.N., 1986, Characteristics of maximum-value composite image from temporal AVHRR data. *International Journal of Remote Sensing*, 7, 1417-1434.
- Kerber, A.G., and Schutt, J.B., 1986, Utility of AVHRR channel 3 and 4 in land cover mapping. *Photogrammetric Engineering and Remote Sensing*. 52, 1877-1883.
- Lambin, E.F., and Ehrlich, D., 1995, Combining vegetation indices and surface temperature for land cover mapping at broad spatial scales. *International Journal of Remote Sensing*, 16, 573-579.
- Loveland, D., T.R. Merchant, J.W., Ohlean, D.O., and Brown, J., 1991, Development of a land cover database for conterminous U.S. *Photogrammetric Engineering and Remote Sensing*, 57, 1453-1463.
- Nemani, R, and Running, S., 1989, Estimation of surface resistance to evapotranspiration from NDVI and thermal-IR AVHRR data. *Journal of Applied Meteorology*, 28, 276-284.
- Price, J.C., 1984, Land surface temperature measurements from the split-window channels of the NOAA-7 Advanced Very High Resolution Radiometer. *Journal of Geophysical Research*. 89, 7231-7237.
- Tateishi, R. and Wen, C.G., 1997, Global Four Minute Land Cover Data Set. *Journal of the Japan Society Photogrammetry and Remote Sensing*, VOL 36, No 4, 62-74.
- Tucker, C.J., Townshend, J.R., and Goff, T.E., 1985, African land cover classification using satellite data. *Science*, 227, 369-375.

