Land Cover Change

Global Land Cover Mapping and Change Monitoring

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Abstract
This paper describes existing global land cover data, and on-going global land cover mapping projects; these projects are initiated by US Geological Survey, European Commission/Joint Research Centre, Boston University, Global Mapping project, and Japan Aerospace Exploration Agency (JAXA). Also, the present trend of global land cover mapping are explained. Furthermore, a study to extract/analyze land cover changed/unchanged areas using global AVHRR NDVI data from 1981 to 2000 is shown.

1. Introduction

Land cover is one of key environmental parameters for global environmental sciences/policies and it is also necessary for land use planning and agricultural area planning. Before the production of global AVHRR data (1992-1993), existing thematic maps were the main information sources for global land cover mapping. However these global land cover map without the use of satellite images had poor quality. After the use of global AVHRR data, global land cover mapping has developed rapidly. In this paper, presently available global land cover data and on-going projects are introduced and their characteristics and trends are explained. Land cover data shows usually land cover information of a specific time (year). Another necessary land cover information is that of changed/unchanged area. These changed/unchanged information can be extracted by time series satellite data. At the last section of this paper, a study to extract changed/unchanged areas using global time series AVHRR NDVI data is explained.

2. Existing global land cover data

The following four global land cover data derived from satellite data are available.

(1) IGBP-DISCover

The first 1-km global land cover data was developed by a U.S. Geological Survey (USGS) and other organizations. Working under the auspices of the IGBP, Loveland et al. (1999, 2000) developed and applied a global land cover characterization methodology using 1992-1993 1-km AVHRR NDVI data. The methodology is based on unsupervised classification with extensive post-classification refinement. The IGBP DISCover classification provides a general picture of global land cover based on a 17-class land cover legend. The accuracy of the IGBP DISCover land cover data was established through an independent IGBP accuracy assessment. Scepan (1999) determined that the DISCover overall accuracy was 59-71 percent depending on the specific validation procedures used.

(2) University of Maryland

A group of John Townshend and Ruth DeFries used the same satellite data as IGBP-DISCover to make a global land cover map with the different land cover legend from IGBP-DISCover land cover data. This group focuses now not on categorical classification but on the estimate of area percentage representation of basic land cover types in a pixel.

(3) Boston University

A group of Mark Friedl uses MODIS data for the global 1-km land cover classification with the same legend of 17 classes as the IGBP-DISCover. This group tries to make a global map every six months to detect land cover changes.

(4) GLC2000

The Joint Research Centre of European Commission coordinated the GLOBAL LAND COVER 2000 Project (GLC 2000) in collaboration with a network of partners around the world. The general objective of GLC2000 is to provide for the year 2000 a harmonized land cover database over the whole globe. The year Two Thousand is considered as a reference year for environmental assessment in relation to various activities, in particular the United Nation's Ecosystem-related International Conventions. To achieve this objective GLC 2000 makes use of a dataset of 14 months of pre-processed daily global data acquired by the VEGETATION instrument on board the SPOT 4 satellite. The legend of GLC2000 is defined by FAO's Land Cover Classification System (LCCS).

3. On-going global land cover mapping projects

The following four global land cover mapping projects are going on.

(1) USGS intiative
A new global land cover mapping project using MODIS 500 m data has started. The mapping will be completed within a few years.
(2) EC/JRC initiative
A new global land cover mapping project called "GLOBECOVER" using ENVISAT/MERIS 300 m data has started. The mapping will be completed within a few years.
(3) JAXA intiative
The initially planned global land cover mapping project using GLI 250 m data will not be achieved by the failure of ADEOS II satellite. However a project of land cover mapping for the whole Asia using GLI 250 m data from April to October 2003 continues.
(4) Global Mapping project
As Global Map version 2, a new global land cover map with the resolution of 1 km will be produced by the cooperation with other projects by 2007.

4. Trend of global land cover mapping
The present global land cover mapping projects have the following features and trends.
(1) global mapping of individual land cover classes
Some key land cover classes important for environmental studies such as wetland, paddy, mangrove, and lake are planned to be mapped individually in different projects.
(2) categorial data + percent area cover of basic land cover types
In addition to the categorical classified land cover map, percent area cover of basic land cover types in a pixel is considered to give actual information of the ground surface. Tree, grass, cropland, urban, and bare ground are examples of basic land cover types.
(3) harmonization of land cover legend
Different land cover legends are used in different projects and in different regions. In order to covert one legend to another one, we a tool to define land cover classes by a common system. The ideal tool for this is Land Cover Classification System (LCCS) developed by FAO.
(4) improvement of resolution
1 km resolution of AVHRR data was improved to 500 m of MODIS, 300 m of MERIS, and 250 m of GLI.
(5) optical sensor + SAR + lidar
In addition to optical sensor data, global SAR data or lidar data may be used for global land cover mapping. SAR data have a potential to derive information of wetland and forest, and lidar data have a potential to derive vegetation height.
(6) development of global land cover ground truth data
Quality of land cover map is mainly dependent of training sample data (ground truth data) used for the classification. However ground truth data are not exchanged and accumulated. Development of global land cover ground truth data by the cooperation of different projects and for the common use will improve the quality of a land cover map.

5. Global land cover change monitoring
Using time-series AVHRR NDVI data, extraction of land cover changed areas was tried in global area and problems of this method were identified.
5.1 Data used
Normalized Difference Vegetation Index (NDVI) of NOAA NASA Pathfinder Land Data Set (PAL data) from 1982 to 2000 were used in this study. In order to remove cloud effects, Temporal Window Operation (TWO) method (Park and Tateishi 1999) was applied to NDVI data. The TWO method is an algorithm to make a seasonally smooth change pattern for temporal variables at least longer than one year. The TWO-processed data were resampled to 4′ (approximately 8 km at the equator) grid raster data in the geographic (latitude/longitude) coordinate system.
5.2 Methodology
(1) The averages of 10-day NDVI from 1982 to 1984 were calculated, and similarly from 1998 to 2000 too.
(2) The difference from the averaged NDVI 1982-84 to the averaged NDVI 1998-2000 were calculated for the corresponding 10-day time period.
(3) The sum of the above difference was calculated for thirty-six 10-day (or one year).
(4) The positive value of the above sum is considered as areas of increasing vegetation activity, and negative value is considered as areas of decreasing vegetation activity.
(5) In order to investigate the trend of time series NDVI values, time-series NDVI curves of unchanged areas of different land cover types such as desert, snow, and forest were analyzed.
5.3 Result
By using large positive and negative threshold values, potential of land cover changed areas were extracted.

However, the following noises and distortions cause wrong results as land cover changed areas.
- high or low NDVI noises remaining after preprocessing
- misregistration along seashore lines
- difference of NDVI levels in different NOAA satellites

Examples of time-series NDVI curves of extracted real land cover changed areas are shown in Fig. 1 and Fig. 2.

6. Conclusions

- Four global land cover data are available
- several global land cover mapping projects are going on
- Trends of global land cover mapping were identified
- Time series NDVI data are effective for global land cover change detection. Noises and trend of NDVI must be eliminated.

References

Chandra Giri, Zhiliang Zhu, Thomas Loveland, 2003, Global and regional land cover characterization and mapping, Proceedings of the CEReS International Symposium on Remote Sensing, paper No.1-1, 16-17 December 2003, Chiba, Japan

GLC2000
http://www.gvm.sai.jrc.it/glc2000/defaultGLC2000.htm
accessed on 29 October 2003

Global Land Cover Ground Truth (GLCGT) Database Version 1.2
http://www.cr.chiba-u.jp/database.html

Global Mapping project
http://www1.gsi.go.jp/geowww/globalmap-gsi/globalmap-gsi.html

LCCS
http://www.fao.org/SD/2001/EN0101a_en.htm
accessed on 29 October 2003

Loveland, T.R., Zhu, Zhiliang, Ohlen, D.O., Brown, J.F., Reed, B.C., and Yang, Limin, 1999, An analysis of the IGBP global land-cover characterization process: Photogrammetric Engineering and Remote Sensing, v. 65, no. 9, p. 1,021-1,032.

Loveland, T.R., Reed, B.C., Brown, J.F., Ohlen, D.O., Zhu, Z., Yang, L., Merchant, J.W., 2000. Development of a global land cover characteristics database and IGBP DISCover from 1 km AVHRR data. International Journal of Remote Sensing 21(6/7): 1303-1330.

Park, J.G. and Tateishi, R., 1999, A proposal of the Temporal Window Operation (TWO) method to remove high-frequency noises in AVHRR NDVI time series data, Journal of the Japan Society of Photogrammetry and Remote Sensing, 38(5) , 36-47.

Rosenqvist,A., M.Shimada, T.Igarashi, M.Watanabe, T.Tadano and H.Yamamoto, 2003, Support to multi-national environmental conventions and terrestrial carbon cycle sciences by ALOS and ADEOS-II – the Kyoto & Carbon Initiative, Proc. of the Int. Geoscience and Remote Sensing Symposium (IGARSS'03), Toulouse, France, July 21-25, 2003

Scepan, J., 1999. Thematic Validation of High-Resolution Global Land-Cover Data Sets. Photogrammetric Engineering and Remote Sensing 65(9): 1051-1060.

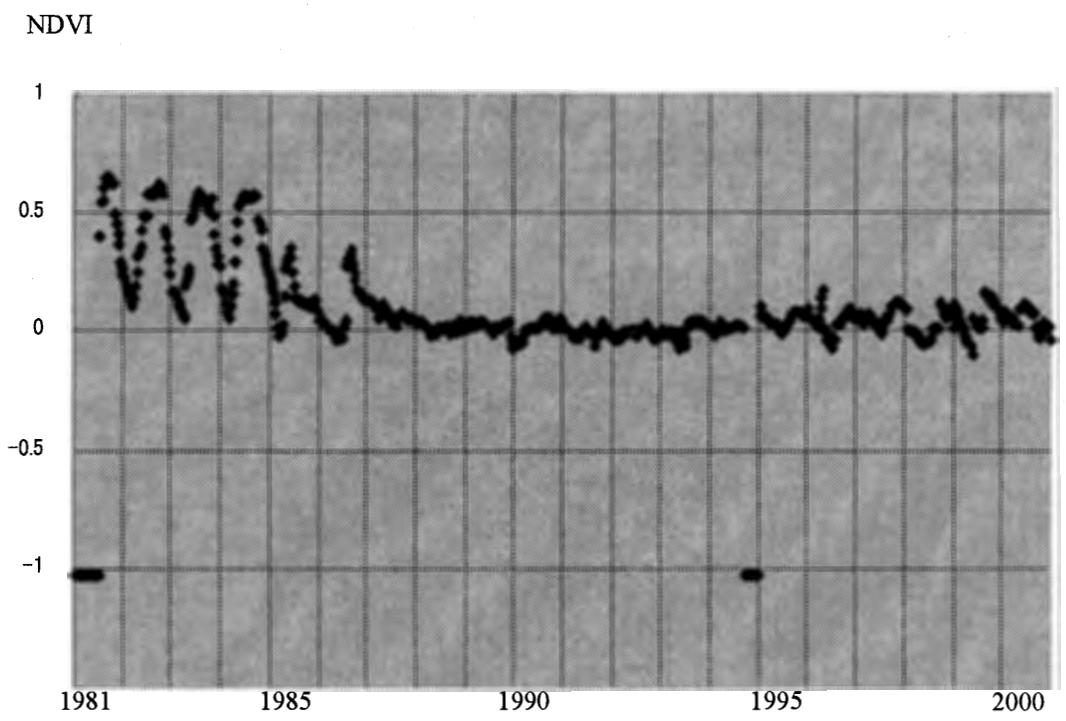

Figure 1 Time-series NDVI curve 1981-2000
Eastern Iran 31° 28'N, 61° 40'E Decease of vegetation

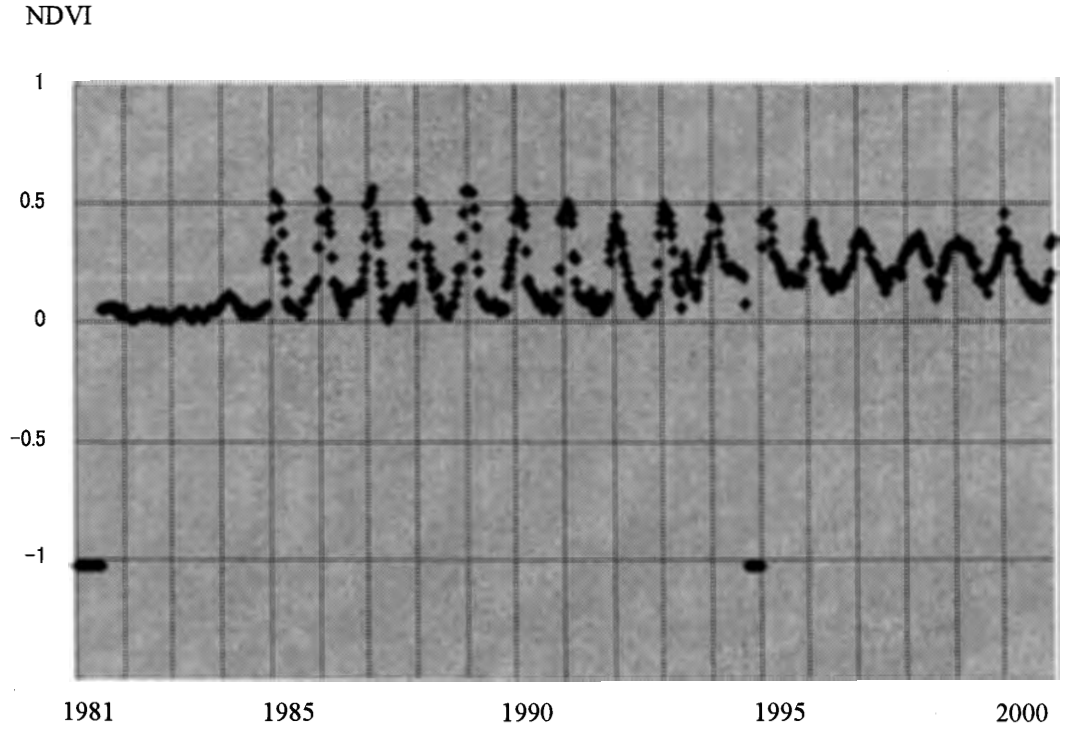

Figure 2 Time-series NDVI curve 1981-2000
Saudi Arabia 19° 52'N, 44° 48'E Irrigation