Ecological land cover classification of the Korean peninsula using MODIS data

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Abstract: The objectives of this research are as follows. First, to investigate methods for a national-scale land cover map based on multi-temporal classification of MODIS data and multi-spectral classification of Landsat TM data. Second, to investigate methods to produce ecological zone maps of Korea based on vegetation, climate, and topographic characteristics. The results of this research can be summarized as follows. First, NDVI and EVI of MODIS can be used to ecological mapping of the country by using monthly phenological characteristics. Second, it was found that EVI is better than NDVI in terms of atmospheric correction and vegetation mapping of dense forests of the country. Third, several ecological zones of the country can be identified from the VI maps, but exact labeling requires much field works, and sufficient field data and macro-environmental data of the country. Finally, relationship between land cover types and natural environmental factors such as temperature, precipitation, elevation, and slope could be identified.

Keywords: Land cover classification, MODIS, NDVI, EVI

1. Introduction

Ecological zone has been widely used as an important basis for environmental conservation of national or regional scale. It is essential to produce good land cover maps of the site for the successful production of ecological zone maps. Multi-spectral data classification of remotely sensed data such as Landsat TM or SPOT is widely used for vegetation mapping. Though outcomes of this approach can provide relatively high spatial resolution, they have critical shortcomings. They reflect the status of land cover of a fixed time, and hard to identify ecological zones which share similar climate and topographic conditions of a region or a country. On the other hand, multi-temporal image classification can produce much better products in terms of reflecting phenological characteristics of the area. Many researchers have used AVHRR data for multi-temporal image classification in spite of two short-comings; namely low spatial resolution and difficulty of atmospheric correction.

But the MODIS (Moderate Resolution Imaging Spectroradiometer), an electro-optical sensor aboard the TERRA satellite, provide global data with high temporal resolution. The MODIS instrument provides high radiometric sensitivity (12 bit) in 36 spectral bands ranging in wavelength from 0.4 μm to 14.4 μm. The data are suitable for the multi-temporal classification of a large area.

The objectives of this research are as follows. First, to investigate methods for a national-scale land cover map based on multi-temporal classification of MODIS data and multi-spectral classification of Landsat TM data. Second, to investigate methods to produce ecological zone maps of Korea based on vegetation, climate, and topographic characteristics.

2. Data and Methodology

The MODIS data from May 2001 to April 2002 were used for this study. The data were received by MODIS Data Service Center in Univ. of Tokyo (http://webmodis.iis.u-tokyo.ac.jp/) The Software used for the analysis were ENVI 3.6 and ArcGIS 8.3.

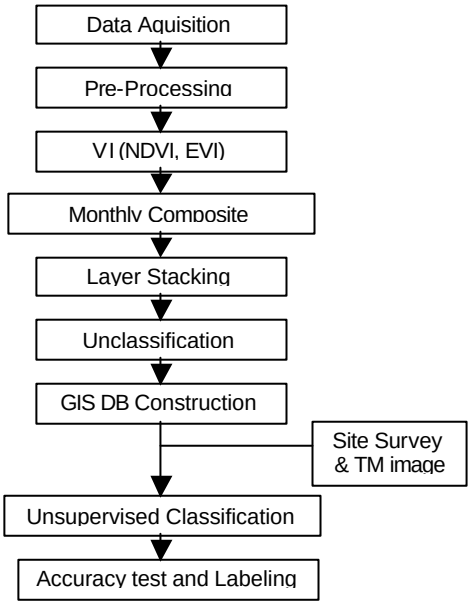

Fig. 1. Flow Chart of the research

MODIS data (Level 1b in 1000m, 500m and 250m) were transmitted via FTP. The data were transformed into ENVI format. The NDVI data were produced by using equation (1). Monthly maximum value composite of MODIS data of 250m resolution were carried out to reduce cloud effect, and to produce a data set for the multi-temporal classification. NDVI DN(-1~1) were stretched to 8 bit data(0~255).

$$NDVI = \frac{r_N - r_R}{r_N + r_R} \quad (1)$$

(r_N : NIR, r_R : $\mathrm{Re}\,d$)

Also, The EVI (Enhanced Vegetation Index) were produced by using the equation (2).

$$EVI = \frac{r_N - r_R}{r_N + C_1 r_R - C_2 r_B + L}(1+L). \quad (2)$$

$(r_N : NIR, r_R : \mathrm{Re}d, r_B : Blue, C1 : 6.0, C2 : 7.5, L : 1)$

EVI has been used to remove haze effect of MODIS data by using blue band (459~479nm) of MODIS. It is known that EVI has two other advantages over NDVI; it can classify detailed vegetation types of forests of very high density, and it is better than NDVI for the removal of atmospheric correction. Thus, this MODIS VI DATA Sets (250m) of 12 months Korea Peninsula were stacked for the classification.

First, unclassification map was obtained by MVC NDVI and EVI using ISO (Iterative Self Organizing) Data Analysis Technique. Since snow covers during winter season can cause significant errors for vegetation mapping, monthly data of January and February were eliminated from image classification process.

Reliable reference data are essential for the labeling of outcomes obtained through unsupervised image classification. The first type of ground truth was national land cover maps produced by using Landsat TM. Such maps were produced by researchers of the Ministry of Environment (MOE) and Korea Research Institute of Human Settlement (KRIHS). Such maps have 5 classes; built-up area, agricultural area, grassland, forest, and water body. We will complement the result through site survey. The second type of reference data will be collected through field survey of the country.

3. Result and Discussion

Data set of ten months, from June of 2001 to May of 2002, is shown on Fig.2 and Fig. 3. Only southern part of the country shows signs of vegetation growth during March. But seasonal growth spreads rapidly to mid and northern parts of the country during the rest of the spring season. After reaching the maximum level of NDVI during August, the process of fall colors moves from north to south during fall season. Figure 3 shows monthly fluctuation of mean, minimum and maximum values of the VI, and peak values of VI for each month of the growing season.

Fig. 4 and Fig. 5 show monthly change patterns of EVI. Generally values of EVI are much lower than those of NDVI. The possibility of distinguishing subtle variation of VI during summer season can provide better classification accuracy. The band between plus and minus one standard deviation from the monthly mean can also provide better discrimination of vegetation types.

It shows that the difference of Season influence vegetation. Generally EVI value is lower than NDVI. But Kurtosis and skewness of EVI is high.

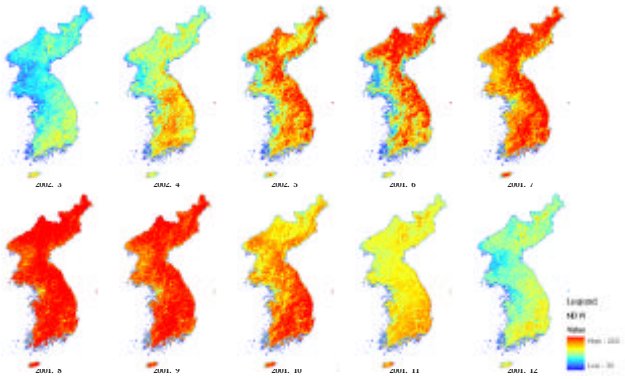

Fig. 2. MODIS NDVI MVC

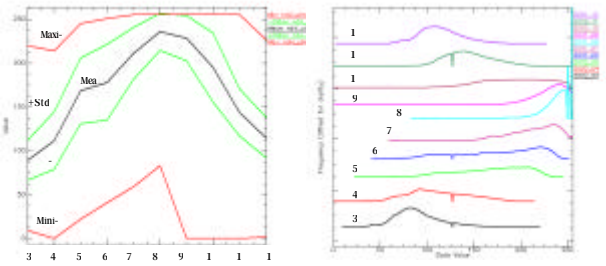

Fig. 3. Monthly NDVI variation according to month

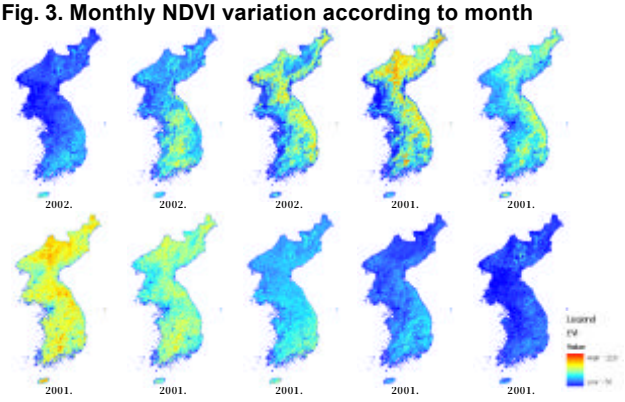

Fig. 4. MODIS EVI MVC

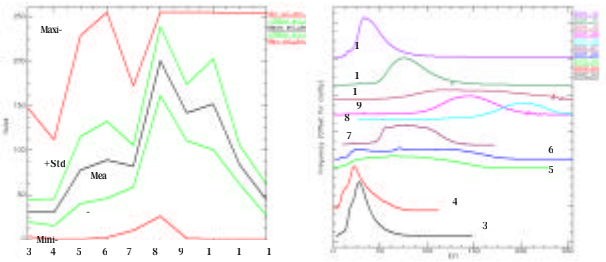

Fig. 5. Monthly EVI variation according to month

Fig. 6 and Fig. 7 show MODIS unclassified map of Korea obtained from NDVI (a), and EVI (b). It can be seen that much of the country on the right map has lower value than the left one, but spatial variation of the right map is clearer than the left one. This means EVI is better than vegetation mapping than the NDVI. We can also see the difference of vegetation covers of the southern and northern part of the country. We can also see alpine vegetation type located on the plateau near the highest

peak of the country, Mt. Baekdusan.

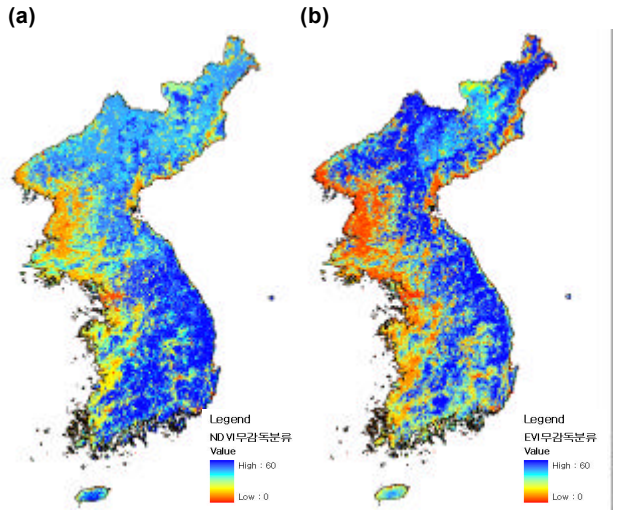

Fig. 6. MODIS unclassification Map using (a) NDVI (b) EVI

Two vegetation maps of Korea obtained through multi-temporal classification are shown on Fig. 7. The map on the left has five classes, builtup areas, agricultural, grassland, forest, and water body. The percentages of each land cover type are very close to our reference data obtained through Landsat TM classification and national statistical survey. Map on the right side shows variation of vegetation types of the nation. It is strongly believed that the MODIS data can be used to classify many forest types.

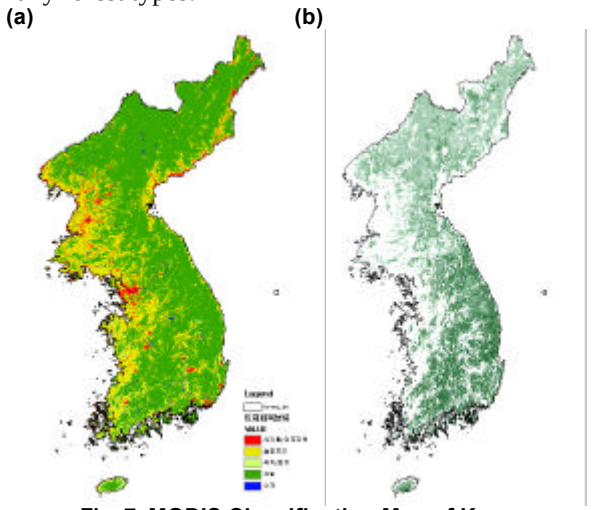

Fig. 7. MODIS Classification Map of Korea
(a) 5 classes (b) detailed classes of forest area

Table 1. The Percentage of Land Cover Classes

Class	Area (km^2)	Percentage (%)
Builtup Area	9,503	4.25%
Agricultural Area	60,445	27.03%
Grassland	6,689	2.99%
Forest Area	144,523	64.62%
Water body	2,487	1.11%
Sum	223,647	100.00%

4. Conclusion

The results of this research can be summarized as follows. First, NDVI and EVI of MODIS can be used to ecological mapping of the country by using monthly phenological characteristics. Second, it was found that EVI is better than NDVI in terms of atmospheric correction and vegetation mapping of dense forests of the country. Third, several ecological zones of the country can be identified from the VI maps, but exact labeling requires much field works, and sufficient field data and macro-environmental data of the country. Finally, relationship between land cover types and natural environmental factors such as temperature, precipitation, elevation, and slope could be identified.

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References

[1] Alfredo Huete, 1999. MODIS Vegetation Index (MOD 13)
[2] Hwang, Soon-Ook, 1997. Land cover monitoring for the extraction of agricultural area in north korea using NOAA/AVHRR Data, Seoul National Univ. Department of Landscape Architecture
[3] Lee, Kyu-Sung, 1994. "Plant distribution using seasonal AVHRR data", *Korea J. Forest*, 83(4)
[4] Nam, Ki-Deock, 1999. Calibration of the global land 1-km NDVI data of the Korean Peninsula and characterization of phenological profiles of ground cover types, Seoul National Univ. Department of Landscape Architecture
[5] Sung-Mi Park, Jung-Ho Im, and Ho-Sang Sakong, 2001. "Land Cover Classification of a Wide Area through Multi-Scene Landsat Processing", *Korea J. Remote Sensing*, 17(3)
[6] Thomas m. Lillesand, 1997. 『Remote Sensing and Image Interpretation』
[7] http://webmodis.iis.u-tokyo.ac.jp/
[8] http://modarch.gsfc.nasa.gov/
[9] http://modis-land.gsfc.nasa.gov/
[10] http://geography.bu.edu/landcover/index.html