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Land-cover Change detection on Korean Peninsula using NOAA AVHRR data

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NOAA AVHRR 자료를 이용한 한반도 토지피복 변화 연구

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ABSTRACT : This study has been on detection of land-cover change on Korean peninsula (including the area of north Korean territory) between May of 1990 year and that of 1995 year using NOAA AVHRR data. It was necessary that imagery data should be registered to each other and should not be deviated much in seasonal variation in order to recognize land-cover change.

Atmosphic effect such as clould and dirt was erased by maximum NDVI(Normalized Difference Vegetation Index) method the equation of which was as following.

$$NDVI(i,j,d) = \frac{ch2(j,j,d) - ch1(i,j,d)}{ch2(i,j,d) + ch1(i,j,d)}$$

Each image of maximum NDVI of '90 year and '95 year was classifed onto 8 categories using iso-clustering method each of which was water, wet barren and urban, crop field, field, mixed vegetation, shrub, forest and evergreen.

요 약

1990년도와 1995년도 5월달의 NOAA AVHRR자료를 이용하여 한반도의 토지 토지 피복변화 양상을 구하였다. 토지 피복 변화를 알기위해서는 영상들이 서로 정합(registration)이 되어야 하며 계절적으로 변화가 일어나지 않은 영상이 필요하다.

영상들을 비교하기 위해서 사용된 모든 자료들은 지도 좌표 체계로 공간적으로 정합이 되었으며, resampling 과정은 nearest-neighbor방법을 사용하였다. 구름, 먼지 등과 같은 대기의 영향은 maximum NDVI 방법을 사용하여 보정을 하였다. Maximum NDVI 방법은 각 영상의 NDVI 값을 구하고 각 화소의 제일 큰 값을 선택하여 영상을 합성하는 방법으로 영상들은 계절적으로 변화가 일어나지 않아야 한다. NDVI (Normalized Difference Vegetation Index)는 다음과 같은 식을 이용하여 구한다.

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$$NDVI(i,j,d)=\frac{ch2(j,j,d)-ch1(i,j,d)}{ch2(i,j,d)+ch1(i,j,d)}$$

지표면의 토지 피복 변화 양상을 구하는 것은 많은 방법이 있으나 본 연구에서는 post-classification 방법을 사용하여 구하였다. 먼저 '90년도와 '95년도에 한 maximum NDVI 영상들을 분류 방법 중 isoclustering 방법을 사용하여 8가지 항목으로 나누었다. 항목들은 water, wet barren and urban, crop field, field, mixed vegetation, shrub, forest, evergreen으로 분류되었으며 식생에 대한 참고문헌은 국립지리원에서 발간된 식생도를 이용하였다.

Introduction

In this study, Land-cover change has been mapped in a term of 5 years using NOAA AVHRR data(1 Km resolution) of 1990 and 1995 year on Korean peninsula(including north Korean terrain).

One of the unsupervised method have been used in each of '90 and '95 year mapping in order to detect the change of land-cover in 1995 year comparing to that of 1990(5 years ago). Detection of land-cover change has been proceeded pixel by pixel base covering the whole scene.

Procedure

To obtain results of land-cover change detection on Korean Peninsula, AVHRR image data sets were chosen(top left corner 42.995d N, 123.717d E, bottom right corner 33.005d N, 130.683d E). The principal land cover types on Korean Peninsula includes crop field, field, mixed vegetation, shrub, forest(coniferous and decidious). AVHRR image data sets of the study area recorded on two groups of seasonally similar dates were used in the image processing. The used data were channel 1 and channel 2 of AVHRR. The scan time of data was described in Table 1.

Table 1. Images used for composite test.

Date	Scan time	Satellite
09/05/90	04 : 29	NOAA No. 9
15/05/90	05 : 04	NOAA No. 9
03/05/95	03 : 58	NOAA No. 14
05/05/95	00 : 32	NOAA No. 11
06/05/95	05 : 05	NOAA No. 14
07/05/95	04 : 54	NOAA No. 14

Two basic processing were performed in order to geometrically rectify a AVHRR images to a map coordinate system. First, all images were spatially rectified by referenced topographic maps. Second, the original data were then resampled using a nearest-neighbor method alogrithm. The daily processed AVHRR images have a fundamental limitation due to degradation of the satellite signal caused by clouds, haze, dust, or other attenuating factors (Thomas and Donald, 1993). To remove atmospheric effects, maximum NDVI composite technique was used. To overcome data effected by atmospheric problems, composite data sets processed by multiple daily images are required. The time constraint for composing data should not permit the variation of seasional phenomena. The composite data sets should be prepared to minimize the contaminating data so that they were collected within the composite period. Using a maximum NDVI(Normalized Difference Vegeation Index) composing technique, the data corresponding to the highest NDVI value per pixels are selected for the composite data set. The NDVI for a pixel(i, j) on date d was calculated from calibrated values of channels 1 and 2 using the following relationship(Cihlar et al, 1992).

$$NDVI(i, j, d) = \{ch2(i, j, d) - ch1(i, j, d)\}/\{ch2(i, j, d) + ch1(i, j, d)\}$$

where ch1 and ch2 represent data from AVHRR channels 1 and 2, preferably expressed in terms of radiance or reflectance. d is date of AVHRR image.

Vegetated areas will commonly show high values for vegetation index. In contrast, clouds, water and snow yield negative index values. Rock and bare soil areas have similar reflectances in the channels 1 and 2, thus resulting in vegetation indices near zero (Thomas and Ralph, 1994).

In this study, we acquired each of two maximum NDVI value by using image at 9, 15, May, 1990 and at 3, 5, 6, 7, May, 1995 of which clouds were free. The basic statistical values were described in Table 2.

Table 2. The basic statistical values for maximum NDVI value.

maximum NDVI	min. value	max. value	mean value	standard deviation
NDVI image in 1990	−0.21	0.79	0.084	0.18
NDVI image in 1995	−0.25	0.42	0.005	0.12

This might be one of the most obvious method of change detection which requires the comparison of independently produced classification maps. An algorithm is that it simply compares the two classification maps utilizing class pairs on the base of pixel and generates a map indicating areas of change detected(Jensen, 1986). By properly coding the changing results between times of 1990 and of 1995, land cover change table, which show a matrix of changes, can be produced. Therefore, any changes of land cover which may be of interest can be identified by grouping of the classification results. Classification comparision must be pre−processed because data from two dates are separately classified, so that it minimizes the problem of normalizing for at mospheric and sensor differences between two dates (Singh, 1989). Weismiller et al. (1977) implied that the classification comparison for change detection procedures was the most suitable means fo recording change among several mehtods tested.

The process of spectral classification may be performed using either of two methods:supervised classification and unsupervised classification. In this study, we performed isoclustering method among unsupervised classification methods using for maximum NDVI spectral images and classified images were compared each other to identify the pattern of land cover change between two dates. Classification category is largely divided by water, wet barren and urban, crop field, field, mixed vegetation, shrub, forest, evergreen.

Results.

Every pixel of maximum NDVI value in the study area was then classified and assigned to the class category. The outputs of classification are defined and the categorical class values are given to each pixel. These class values were assingned integer values and successively viewed on the color image map.

The characteristic of land cover classification results on Korean Penninsula in each year were described as following table 3. The information of 8 classes of land cover was given with the frame of reference to land use map published by Korean National Geographic Institute. Spatial distribution of land−cover in 1990 is as the Fig. 1 whereas that of land−cover in 1995 is as the Fig. 2. The descrimination of wet barren and urban area was difficult, since the NDVI value was almost same.

Table 3(A). The classification result for image of 1990.

CLUSTER	PIXEL	MEAN POSITION
1. water	274553	−0.081
2. wet barren & urban	13663	0.034
3. crop field	47333	0.111
4. field	65503	0.195
5. mixed vegetation	38636	0.255
6. shrub	36854	0.296
7. forest	60961	0.358
8. evergreen forest	12497	0.427

Table 3(B). The classification result for image of 1995.

CLUSTER	PIXEL	MEAN POSITION
1. water	276210	−0.112
2. wet barren & urban	25506	0.018
3. crop field	45740	0.059
4. field	63686	0.086
5. mixed vegetation	46469	0.111
6. shrub	29399	0.139
7. forest	51503	0.203
8. evergreen forest	11487	0.307

From these maximum NDVI values, it is possible to generate statistics that represent a measure of land cover change. To describe fully the land cover changes between the images of two dates, the data was represented in the change matrix table. In table 4, the changes between two dates are numerically seen. With this matrix table of change type, it is practicable to interpret change of all change classes (including non changed classes).

Table 4. '90—'95 change—type matrix.

From \ To	Water	Wet barren & urban	Crop field	Field	Mixed veg.	Shrub	Forest	Evergreen forest	Total
Water	272213	1521	428	197	91	52	50	1	274553
Wet barren & urban	2784	6470	1934	1064	568	558	273	12	13663
Crop field	1028	14822	16766	7471	4106	1929	1174	37	47333
Field	163	2248	16798	19186	12030	7876	6817	385	65503
Mixed veg.	6	261	4300	11250	7524	5449	9253	593	38636
Shrub	8	105	2823	10381	8163	4284	9820	1270	36854
Forest	5	75	2600	13301	12732	8172	18652	5424	60961
Evergreen forest	3	4	91	836	1255	1079	5464	3765	12497
Total	276210	25506	45740	63686	46469	29399	51503	11487	550000

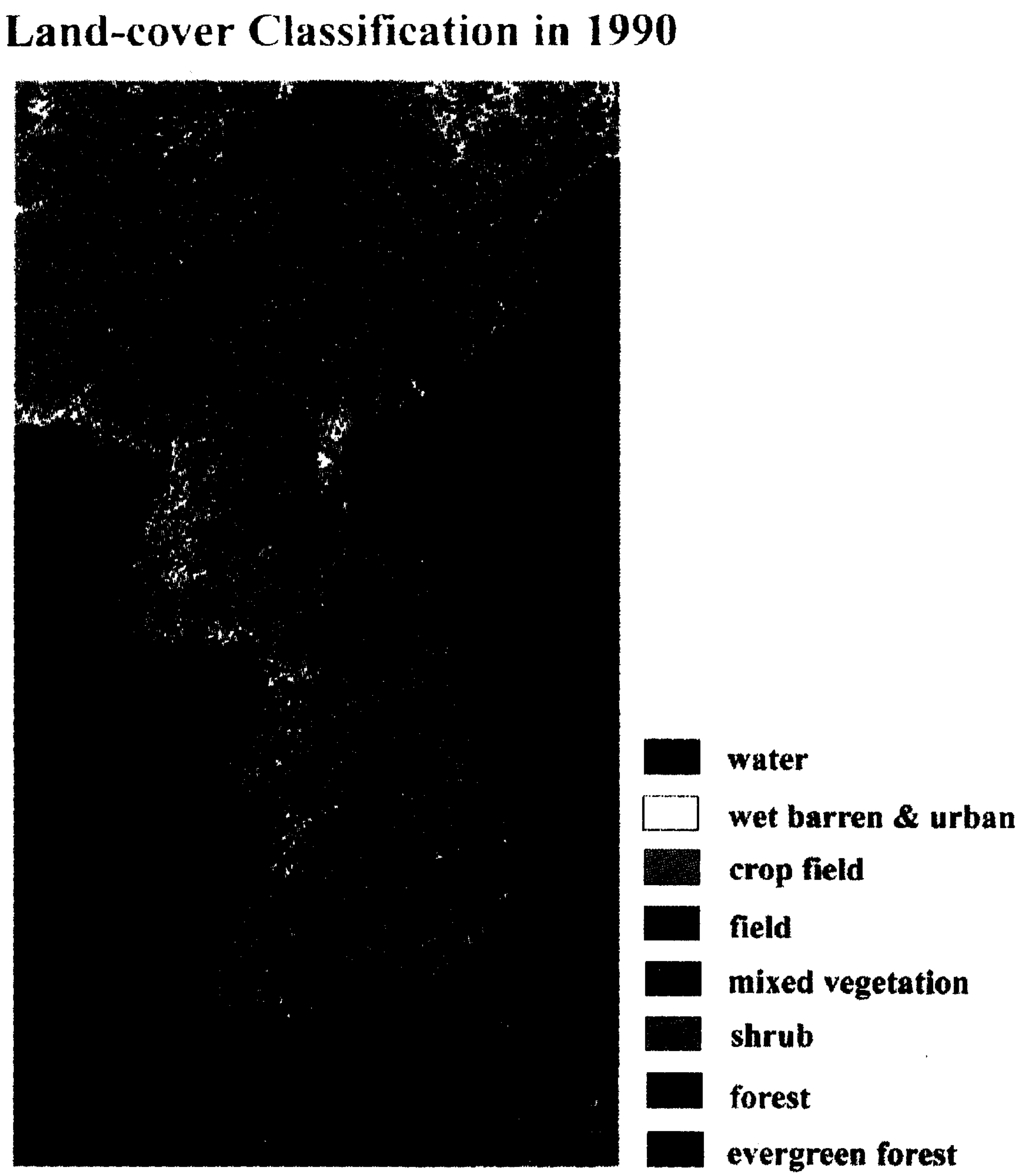

Fig. 1. Land-cover classification in 1990 year

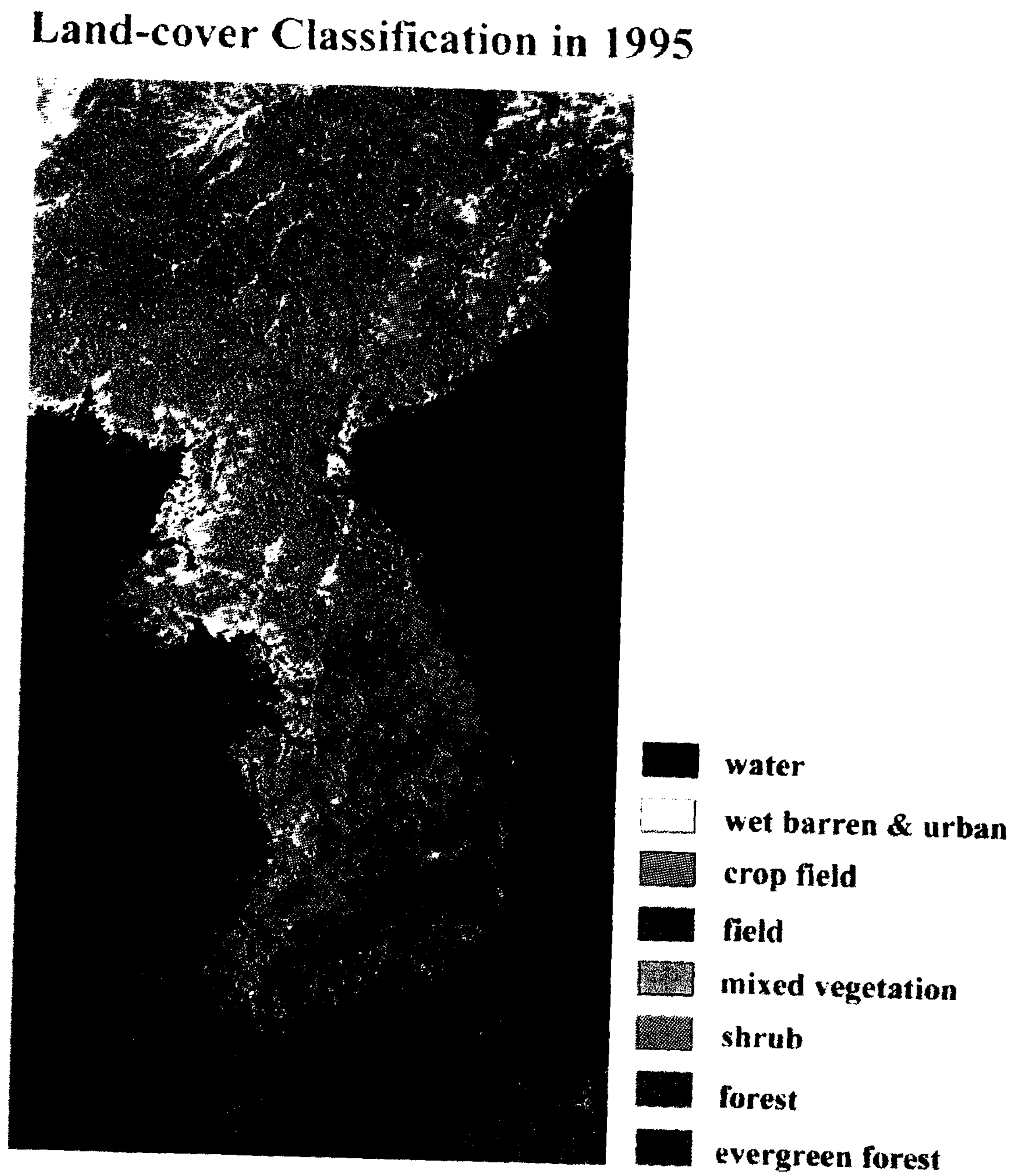

Fig. 2. Land-cover classification in 1995 year

Land-cover Change Detection

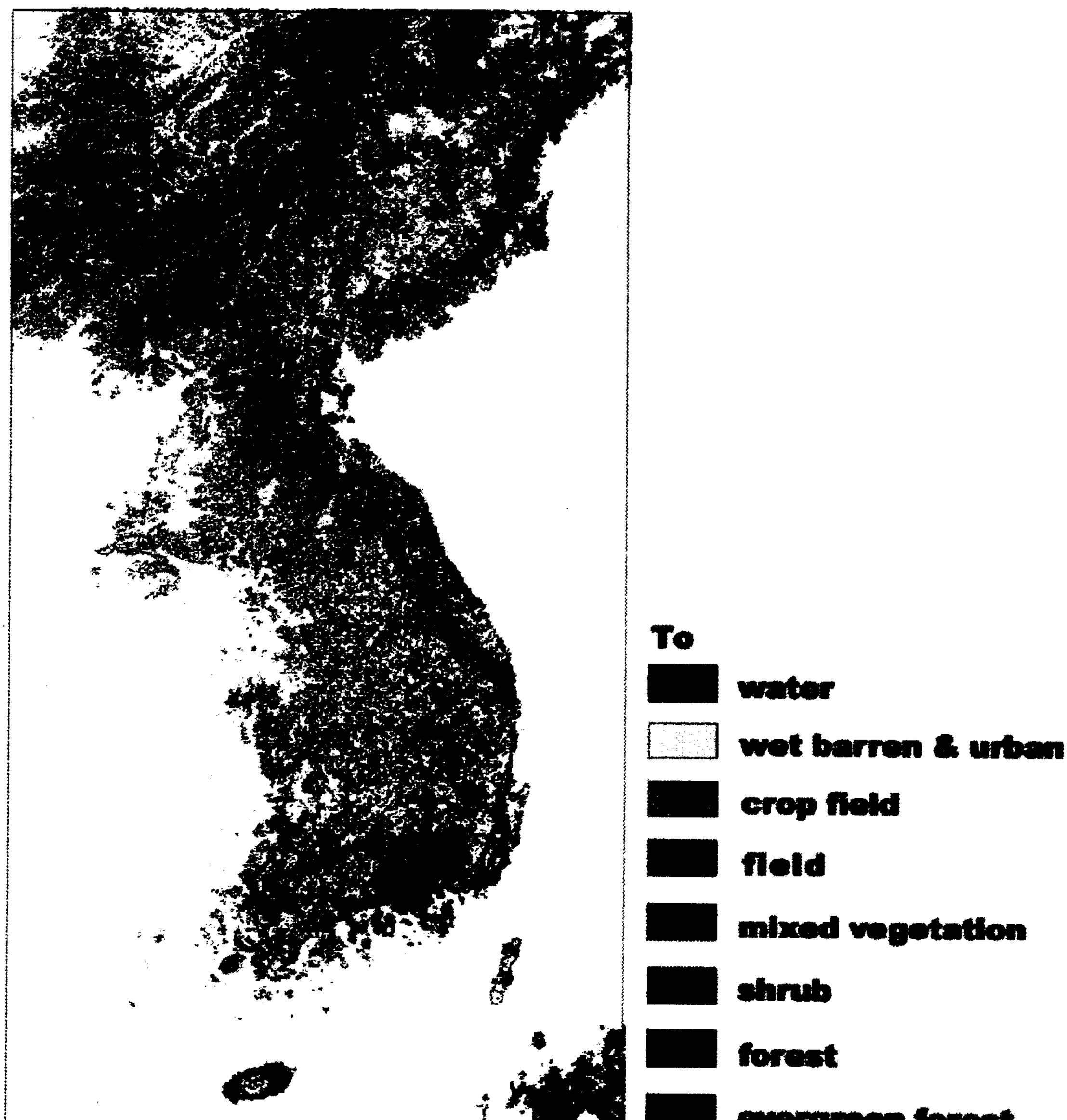

Fig. 3. Land-cover change detected from 1990 to year

Spatial distribution of land cover change between 1990 year and 1995 year is as the Fig. 3. The accuracy of change detection is dependent upon mehtod of classification, the accuracy of initial classifications and the geometric rectification of images. To determine the accuracy of the classification, it is important to choose a procedure that refers to field or aerial photography. However in this study, these supplement activity is not carried.

Conclusion

NDVI composite techniques was used to remove clouds now that ordinary unsupervised method such as clustering techniques could not be used.

The distribution range of NDVI values was different from each other of 1990 year and 1995 year so that NDVI value had to be standardized to adjust between each classification.

1Km resolution of NOAA Data was too coarse for land-cover classification on Korean Peninsula itself.

The forecasting method of another term of 5 years after could be suggested on the basis of synthetic techniques integrating supervised method (maximum likelyhood algorithm) and Markov transition matrix.

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