LANDCOVER CHANGE DETECTION USING MODIS TEMPORAL PROFILE DATA SUPPORED BY ASTER NDVI

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ABSTRACT MODIS images have a great advantage of high temporal resolution to monitor land cover changes in a large area. The moderate and low spatial resolution satellite images are incomparably economic than high resolution satellite images. As diverse satellite images are provided recently, strategies using satellite images are necessary for continuous, effective and long-term land monitoring. This research purposed to use MODIS images to monitor land cover in Korean peninsula for long-term and continuous change detection. To maximize the advantages of high temporal resolution, the change detection was based on the MODIS temporal profiles of the surface reflectance for one year. In this study as the reflectance patterns of year 2005 were compared with the reflectance patterns of year 2007, the changed pixels could be detected during two years. To set up the threshold value for the decision of change, ASTER images with the higher spatial resolution, 15m, were used for this study. The test area covered the suburban area of metropolitan city, Seoul, where the landcover changes have been frequently happened.

KEY WORDS: MODIS, change detection, temporal profile, ASTER, NDVI

1. INTRODUCTION

MODIS images have a great advantage of temporal resolution to monitor land cover changes in a large area frequently. Another advantage of the moderate and low spatial resolution satellite images are incomparably economic than high resolution satellite images. As diverse satellite images are provided, monitoring strategies using satellite images are necessary for continuous, effective and long-term land monitoring.

Land cover changes around us are mainly divided into two groups: natural and slow changes, and dramatic changes. Natural and slow changes include seasonal changes of vegetation and crops and long term changes due to meteorological factors. In the other hand, dramatic changes imply the changes resulted from human activities such as urbanization and clearing the land for cultivation and changes by disasters such as fires, floods, etc. Satellite images have been used to detect land cover changes for a long time, which is called 'change detection'. Coppin et al. (2004) summarized the change detection methods developed for years. They explained the change detection methods as two groups: bi-temporal methods and temporal profile methods. Bi-temporal methods compare images obtained in two different times to recognize the land cover differences between the times. Temporal profile methods make profiles over a long term period to characterize the changes with in the time. Temporal profile methodology appears with the supply of the mid and low resolution satellite images because of the temporal resolution.

Since the mid and low resolution satellite images does not have good spatial resolution, they have a limitation to detect land cover types. Zhan et al. (2000, 2002) introduced the algorithms of Vegetation Cover Change (VCC) and defined the land cover and changes types to be able to detect by MODIS images. They defined the land cover types as five classes: forest, non-forest, bare, water and burn. The change types were seven such as vegetation re-growth, urbanization, deforestation, flooding, water retreat, burn, agricultural expansion. Although there are the limitations by the coarse spatial resolution of mid and low satellite images, the meaningful purpose of change detection of mid and low spatial resolution images is to play a role of an alarm system to inform the places and events that the high resolution data is necessary. Therefore, once the satellite images with the mid and low spatial resolution and high temporal resolution detect and verify the land cover changes and location, it informed the places and events worthwhile to pay attentions to notice the attributes of the changes.

This research purposed to use MODIS images to monitor Korean peninsula for long-term and continuous change detection. The methodology is based on the temporal profiles based on the high temporal resolutions of MODIS. The temporal profiles in 2005 and 2007 were compared each other and detected landcover changes with the big differences between two years. Since the reflectance of a pixel showed variation in 2005 and 2007 even if it was not changed pixel and it could not be verified visually because of low spatial resolution, ASTER images were introduced to be basis of the decision.

2. DATA

2.1 Study data

MODIS (Moderate Resolution Imaging Spectroradiometer) is one of instruments installed on the satellite Terra and Aqua launched in 1999 and 2002, respectively. MODIS acquires optical images composed of 36 bands ranged from 0.405 to 14.385 micrometer. The radiometric resolution is 12 bits and three spatial resolutions of MODIS images are provided: 250, 500 and 1000 m. In this study, 250 m resolution 8day reflectance composite images of red (620~670nm) and near infrared (NIR) (841~876nm) bands were used. Surface reflectance images (MOD09) is one of land products of MODIS, which are removed the atmospheric and cloud effect. This research used reflectance composite images in every 8 days as shown in figure 1: one of 8 days NIR composite images. The 8-day reflectance composite images were obtained from Earth Observing System Data Gateway.

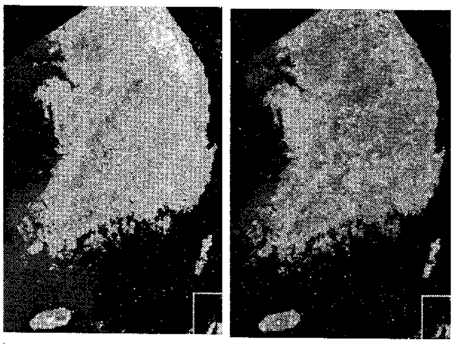

Figure 1. MODIS reflectance (MOD 09) data: 2005 (left) and 2007 (right)

2.2 Reflectance patterns: seasonal

Because the temporal reflectance profiles were accumulated for one year the seasonal change patterns of reflectance were monitored for water, city, coniferous, deciduous and crop classes. Invariant targets such as water and city have almost constant reflectance over four seasons, while forest and crop have different seasonal difference. Especially, deciduous and crop have manifest changes of reflectance. To investigate the seasonal reflectance changes, samples of the five classes were determined and figure 2 shows the reflectance changes of the five classes from October 2006 to September 2007, the whole one year. Based on the reflectance pattern in figure 2, every pixel can be identified and ascertained whether the pixel was changed or not.

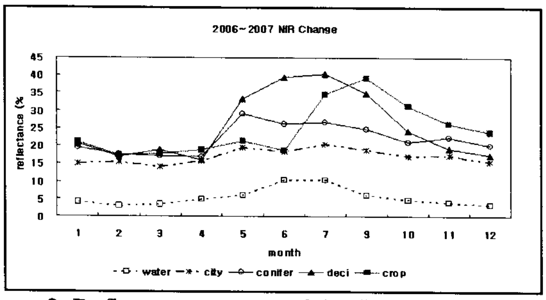

Figure 2. Reflectance pattern of the five class in one year

2.3 ASTER

Since the spatial resolution of MODIS is about 250 m, it is difficult to determine and verify whether a pixel was changed or not. In order to investigate MODIS pixels, ASTER images were introduced because ASTER has the higher spatial resolution than that of MODIS. Two scenes of ASTER, October 2004 and October 2006, were searched as the closest to the period of the reflectance profiles of MODIS was 2005 and 2007. Figure 3 shows the NIR color composite of two scenes searched out.

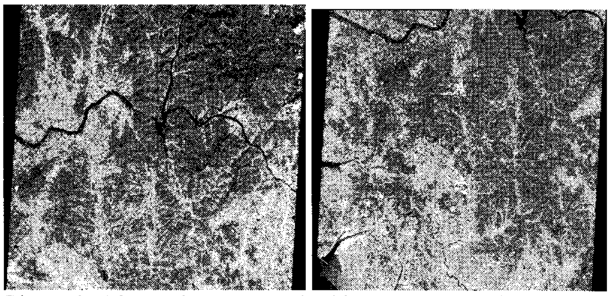

Figure 3. ASTER images acquired in Oct. 2004 and Oct. 2006 respectively (top and bottom)

3. METHODOLOGY

To detect landcover changes, this study utilized MODIS reflectance profiles of 2005 and 2007. As the reflectance profiles of 2005 were compared with the reflectance profiles of 2007 in every pixel, the pixel with the big difference each other could be detected. However, it is necessary to set up the threshold values of amount of the reflectance change. Two ASTER images in Oct. 2004 and Oct. 2006 were introduced to support the setting up the threshold value of MODIS reflectance. Figure 4 illustrated the procedures of the change detection.

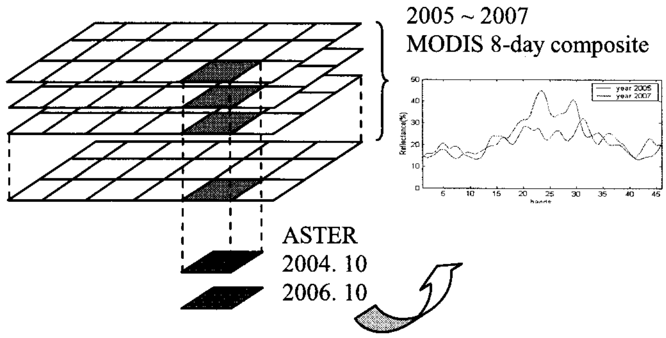

Figure 4. Workflows of the processing

3.1 Unchanged and changed pixels from MODIS

Based on the reflectance pattern of the five classes, the common pattern of reflectance is defined. If a pixel underwent dramatic changes such as fire, flood, and urbanization, the reflectance of the pixel should be changed in a different pattern from the previous reflectance. Figure 5 shows the reflectance pattern of unchanged pixel between 2005 and 2007. Solid circle is the reflectance from 2005 and circle is the reflectance of 2007.

If the area has been dramatically and suddenly changed, the reflectance of pixels would be changed right after the change was happened. Figure 6 shows the reflectance changes of changed pixel. The left side of Figure 6 shows the reflectance of a pixel expected as vegetation has changed to other landcover in 2007 showing the reduced reflectance in summer period while the right side of figure 6 shows reflectance of a pixel had increase during summer expecting turning to vegetation.

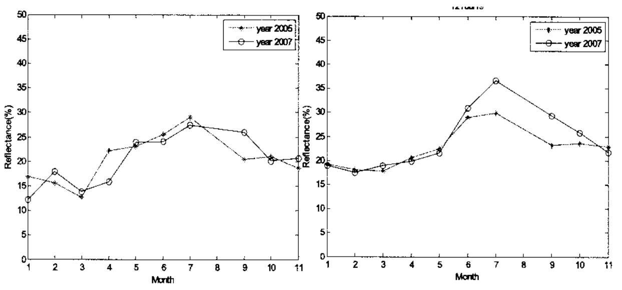

Figure 5. Unchanged pixel between 2005(-x-) and 2007(-o-).

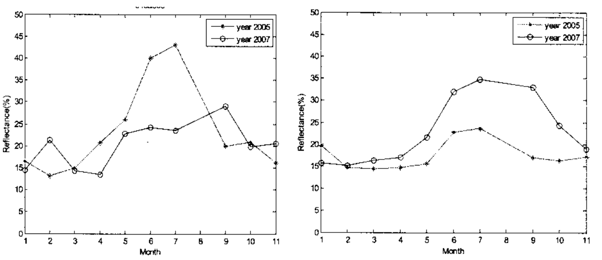

Figure 6. Changed pixel between 2005(-x-) and 2007(-o-)

3.2 Relationship between ASTER NDVI and MODI reflectance

Even though the pixel was not changed, the reflectance varied in some degree during one year. To determine whether a pixel was changed or not, the difference of reflectance should be observed in detail. However, because the resolution of MODIS image is about 250 m, it is very difficult to decide landcover changes only with MODIS. This study utilized ASTER images with 15 m spatial resolution. One pixel of MODIS, actually 235 m spatial resolution corresponded to about 16 by 16 ASTER pixels with 15 m resolutions. Therefore, one pixel of MODIS is composed of about 256 pixels of ASTER. Figure 7 shows one of the MODIS NIR band of 2005 (left) and 2007 (right), and the red box pointed out the Pankyo area that was recently developed near Seoul metropolitan city. Figure 8 shows the Pankyo area in ASTER. Since the Pankyo area was developed during 2005 and 2007, the area was apparently different in both ASTER images even though the MODIS pixels in 2005 and 2007 in figure 7 did not show big differences. The pixel of 2005(left) and 2007(right) shown in the bottom of figure 7 corresponded to the area shown in bottom of figure 8: left image in 2004 and right image in 2006.

In this study, NDVI of ASTER was calculated using 2004 and 2006 images respectively. The NDVI difference between two images indicated the urbanization. That is, if the NDVI decreased during the time, the reflectance of MODIS pixel decreased as well and indicated urbanized area. Reversely, if NDVI increased in the two ASTER images, the reflectance of MODIS pixel might be increased indicating forested pixel. Figure 9 shows the relationship between NDVI differences of ASTER images and the MODIS reflectance difference between 2005 and 2007 MODIS images. Because one MODIS pixel was composed of about 250 pixels of ASTER, the NDVI differences of figure 9 were averaged NDVI differences of all ASTER pixels included in one MODIS pixel. In addition, the MODIS reflectance in figure 9 is the summation of reflectance differences during summer between 2005 and 2007.

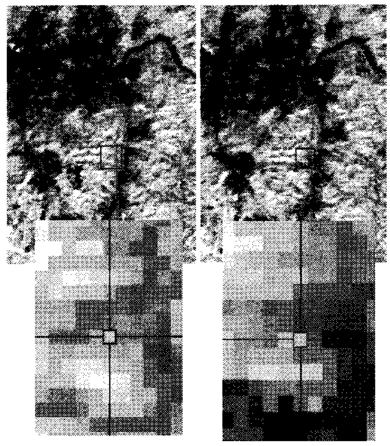

Figure 7. MODIS NIR reflectance of near Seoul area: 2005 (left) and 2007(right)

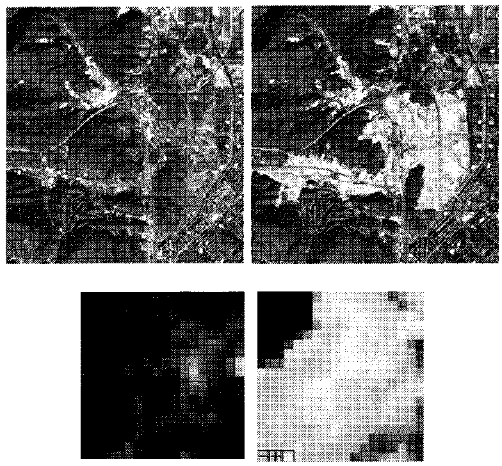

Figure 8. The corresponding location of Figure 7 (Pankyo area): Oct. 2004 (left) and Oct. 2006 (right)

In figure 9, the left bottom points should be told the pixels indicated urbanized location. That is, negative NDVI difference (decreased from 2004 to 2006) indicates the decrease of the summation of MODIS reflectance differences from 2005 to 2007. The upper right points indicated the forested location with increase of NDVI and the positive summation of MODIS reflectance differences. The NDVI information of ASTER provides the intuition of reflectance variation of NODIS for the change detection. Through the further investigation with the relationship between ASTER NDVI and MODIS reflectance, threshold for the determination of changes will be provided.

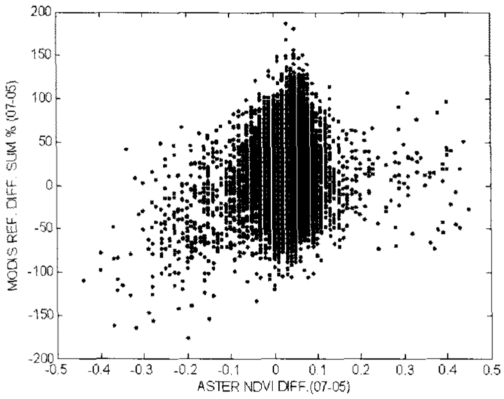

Figure 9. ASTER NDVI vs. MODIS reflectance difference

4. CONCLUSION

In this research, common patterns of MODIS reflectance in one year were investigated to detect landcover changes. Based on the reflectance pattern, changed and unchanged pixel can be recognized between two times: 2005 and 2007. Even though the reflectance data were composted in every 8 days, the reflectance variation shows large during one year. To support the set up threshold value of MODIS reflectance difference, this study introduced ASTER images acquired similar time span. Based on the NDVI variation during two years, change area could be detected. Therefore, the relationship between ASTER NDVI and MODIS reflectance will provide the intuition to determine whether a pixel was changed or not. The threshold value will be provided through further investigation between MODIS reflectance and ASTER NDVI with the verification of image pixels on ASTER with high spatial resolution.

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