SEASONAL EFFECT OF THE CLOUD DETECTION METHOD OVER LAND SURFACE BASED ON TIME-SERIES NDVI DATA

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Abstract: In this paper, we proposed a cloud detection method over land surface using multi-temporal NDVI data. The time-series NDVI were used to determined clouds pixel by an algorithm based on 10days average NDVI. We applied this method on GOCI images for different season (April, July 2011). To validate the proposed method, we compared with MODIS cloud mask product (MYD35). In the season of active vegetation growth, the proposed method was more effective. The proposed method works very well to detect cloud pixels over vegetative area while it shows certain limitation over non-vegetation areas.

1. INTRODUCTION

Cloud detection and removals are an important preprocessing step in land remote sensing. We need cloud-free images to analyze accurate spectral signal of land surface such as extraction of biophysical variables, change detection, classification. To generate cloud-free vegetation index (VI), MODIS VI product (MOD13, MYD13) is composited VI over 16day periods using BRDF, CM-MVC, MVC methods (Huete et al, 2002). However, it still included a lot of cloud pixels varying by season and places.

Cloud detection over land surface is more difficult than ocean. Since land surface has high spectral variations by mixed cover types (forest, bare soil, desert, urban, inland water, snow), the spectral signal of cloud is not well separated from land surface (Hagolle et al, 2010). Ocean has relatively homogeneous spectral characteristics and, therefore, cloud detection is rather easy as compared to land.

A well known cloud detection method over land is to use cloud mask provided by MODerate resolution Imaging Spectroradiometer (MODIS) and Advanced Very High Resolution Radiometer (AVHRR). It detects clouds mainly using multispectral threshold of thermal infrared (TIR) and short wave infra red (SWIR) signals. Since the spectral characteristics of clouds are separated well from land surface in TIR and SWIR wavelengths, the cloud mask has a high accuracy to detect clouds (Ackerman et al, 2006). However, if TIR and SWIR bands are not included in image such as the Geostationary Ocean Color Imager (GOCI), accurate cloud detection is not easy. Therefore, alternative cloud detection method is necessary for such types of image data. Hogolle (2010) proposed land cloud detection method using multi-temporal images based on the spectral signatures in blue wavelength. This method does not consider seasonal variation of vegetation (growth, harvest), and requires a cloud-free image. The NDVI threshold method is simple method to detect clouds. However, it has limitation because the NDVI is different to season and types of vegetation.

In this study, we proposed a cloud detection method over land surface using multi-temporal NDVI data. Proposed method considers to seasonal variation and types of vegetation because the threshold changes adaptively. It has advantage that it does not require either cloud-free image or TIR/SWIR band. We applied this method to the datasets of April and July when vegetation conditions are quite different.

DATASET

We used GOCI data provided by the KIOST. The GOCI has great potential for monitoring over land area (Lee et al, 2012). It has high temporal resolution (8 times per day) and large geographical coverage including the whole Korea and Japan and partial areas of China, Mongolia, and Russia. We produced NDVI image using GOCI band 5 (red) and band 8 (NIR) reflectance images after applying sun angle normalization and Rayleigh scattering correction. To compare cloud detection results of different season, we used total 61 images of different two season data from April 1 to April 30 and July 1 to July 31 in 2011. The status of vegetation is more active in July than in April. Since July is rainy season, the July images always include large amounts of clouds. We used GOCI image obtained at 13:00 o'clock, because the GOCI acquisition time is almost matched with MODIS aqua cloud mask images (MYD35). The MODIS cloud mask (MYD35) was used to verify the proposed method. It consist of 48 bits, the first 2 bits have an information about "clear", "probably clear", "uncertain" or "cloudy" (Frey et al, 2008). We only used "cloudy" information considered as clouds.

2. METHOD

Multi-temporal Normalized Difference Vegetation Index (NDVI) data can be used to monitor relative changes of vegetation (Tang et al, 2007). We can analyze natural phenomena, such as drought, growth or harvest timing, onsets over land surface using variation of multi-temporal NDVI (Leeuwen et al, 1999; Huete et al, 2002). When clouds obscure the land surface, NDVI is lower than clear condition. In multi-temporal NDVI, the drastic decrease of NDVI is suspected as clouds (Figure 1: black line). Using this principle, we can determine whether clouds pixel or clear pixel.

We suggested a cloud detection method over land surface using multi-temporal NDVI data. When the current NDVI is lower than average of 10 days NDVI (before and after 5 days except current day), this NDVI is considered as cloud pixel (equation.1). As seen in Figure 1, when the black line is lower than the red line, the NDVI value is determined as clouds. Proposed method has an advantage to consider seasonal variation and types of vegetation by using multi-temporal NDVI.

If $\quad \mathrm{NDVI_i} < \overline{\mathrm{NDVI}}_{\mathrm{10day}}$ (equation.1)

Then Clouds, else Clear

Where $\mathrm{NDVI_i}$ = i days NDVI
$\overline{\mathrm{NDVI}}_{\mathrm{10day}}$ = average of 10days NDVI
10 day = i-5, i-4, , , i+4, i+5 $\neq$ i

We applied the proposed method for April and July GOCI daily NDVI data and checked up for various vegetation targets, as shown in Figure 1. The black line was separated well from red line in active vegetation targets like barely fields. In contrast, it was less distinguished in non-active vegetation over desert areas. The maximum NDVI value of July is higher than April NDVI because the vegetation growth is more active in July.

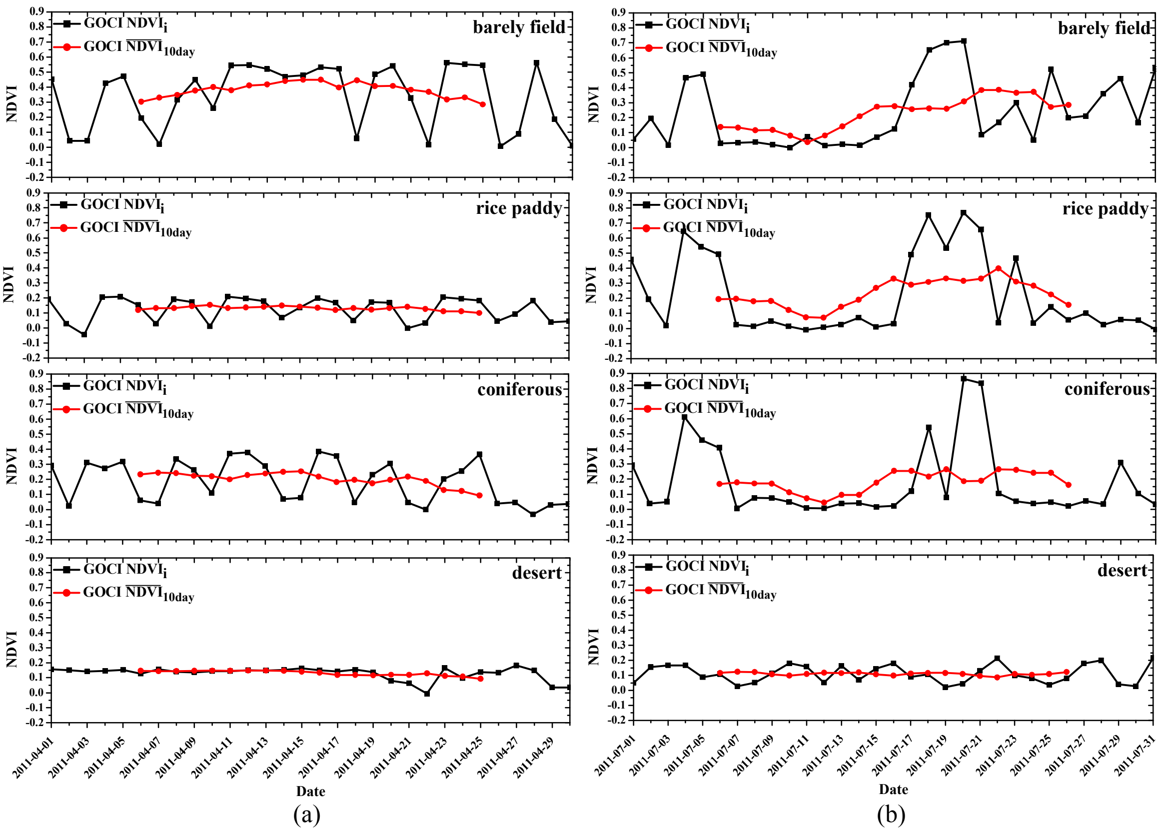
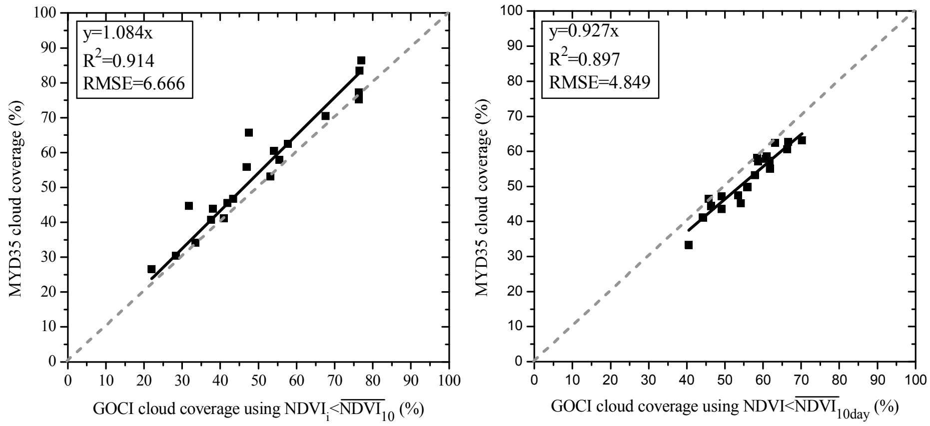


Figure 1: Multi-temporal profile of GOCI NDVI and the statistics of the proposed cloud detection method for various vegetation targets (2x2 pixel) (a) In April 2011 (b) In July 2011.

3. RESULT & DISCUSSION

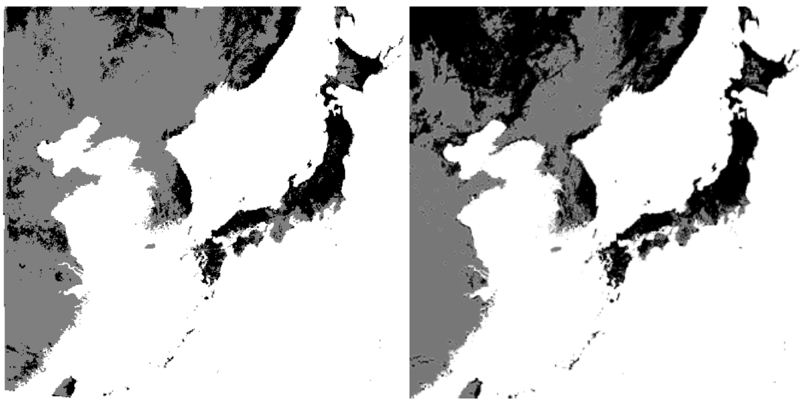
To validate the effectiveness of the proposed method, we compared cloud detection results from the proposed method with MODIS aqua cloud mask (MYD35). Initially, we analyzed the relationship of cloud coverage obtained from proposed methods and MODIS aqua cloud mask (MYD35) product. As seen in Figure 2(a), the proposed method underestimate the cloud coverage as compared to the MYD35 product as the slope is 1.084 in April. Proposed method in April is fairly well matched with MYD35 as the determinant of coefficient is 0.914 and the RMSE is 6.666. In Figure 2(b), the proposed method overestimates the cloud coverage than the MYD35 product, as the slope is 0.927, which is somewhat different result with April data. The RMSE of 4.849, show a better results than the April. Because the vegetation growth is more active the July than the April, the red line is separated well from the black line (Figure 1). Therefore, the accuracy of the proposed cloud detection method improved. The R squared value is 0.897, which is slightly lower than the April data. The distribution of cloud coverage in April is larger than July (April: 20% ~85%, July: 40%~70%).



(a) (b)

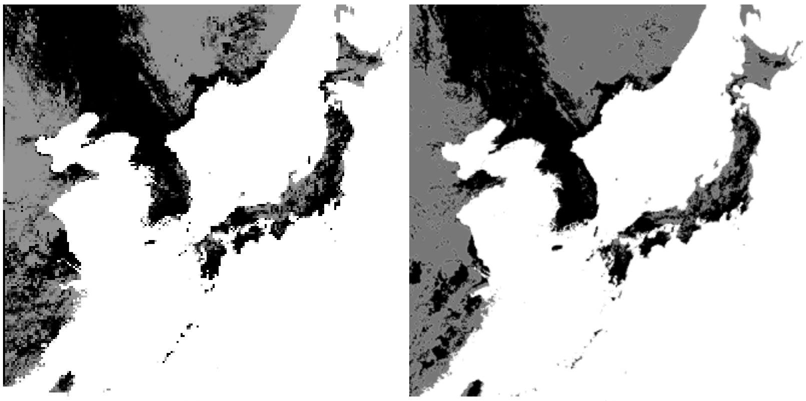
Figure 2: The relationship of cloud coverage estimated from proposed methods and MODIS aqua cloud mask (MYD35) (a) In April 2011 (b) In July 2011

Secondly, we compared the spatial distribution of cloud. Generally the cloud distributions obtained from the proposed method were similar with the MYD35 product. As seen in Figure.3, we found noticeable results from April 19 data. The most area of Mongolia was detected as clouds in MYD35, while they were not cloud with the proposed methods. This area is mainly deserts. Since the effect of clouds pixel during April 20 to 23, the average NDVI of 10days is decreased in April 19 (Figure 1(a), desert). It leads to underestimate the clouds. Also, the threshold of proposed method is sensitive at the non-vegetative area like desert. In July, the distributions of clouds with the proposed method were well matched with the MYD35 product (Figure 4). This is because the proposed method work more effective when the vegetation growth is active.



(a) (b)

Figure 3: Spatial distribution of clouds of April 19 obtained from
(a) the proposed method, clouds coverage : 37.31% (b)MYD35, clouds coverage : 44.68%



(a) (b)

Figure 4: Spatial distribution of clouds of July 26 obtained from
(a) the proposed method, clouds coverage : 54.16% (b) MYD35, clouds coverage : 45.22%

4. CONCLUSIONS

In this paper, we proposed cloud detection method over land surface using multi-temporal NDVI data. We applied this method for different season (April and July) with GOCI imager. To validate the effectiveness of the methods, we compared the cloud detection results with the MODIS aqua cloud mask product (MYD35). The proposed method was well matched with the MYD35 product and showed better results in July than in April. The proposed method is effective when the vegetation growth is active although it has certain limitation over the non-vegetative area like desert.

The advantage of multi-temporal NDVI based cloud detection method is based on the adaptive decision criteria which is independent of any fixed threshold, seasonal variation, and the vegetation types. It requires only the NDVI data without TIR, SWIR and reference data. In Further study, we will apply this method for a long-term NDVI data that include winter seasons and another sensor such as MODIS, AVHRR.

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