A TASSELLED CAP TRANSFORMATION FOR GEOSTATIONARY OCEAN COLOR IMAGER (GOCI): PRELIMINARY RESULT

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ABSTRACT A tasselled cap transformation has been applied as both a descriptive and analytical tool in a variety of ecological studies. It is a very traditionally method for surface monitoring and environmental change. The recently launched Geostationary Ocean Color Imager (GOCI) can acquire eight scenes per day. Although it was originally designed as ocean color monitoring sensor however, nearly half of image is observing land area with classical land observing channels in VNIR regions. Therefore it is possible to use land applications because of the advantages of great high temporal resolution. The main idea of this study is monitoring Korean peninsula and around region using tasseled cap transformation during a day and its applications. A total of forty-six thousands of samples for transformation were selected by random sampling from each forty-six Moderate Resolution Imaging Spectrometer (MODIS) Nadir BRDF-Adjusted Reflectance (NBAR MOD43A4) 16-day composite images and GOCI images in cloud free area. It was also applied geometric registration and the atmospheric correction before sampling. And these samples evaluated by ESA-GLOBCOVER 2009 land surface classification map. The initial coefficient of tasselled cap transformation was derived by a one year of GOCI PCA values. Finally GOCI PCA axes were rotated from comparing MODIS NBAR tasselled cap data. The preliminary tasselled cap coefficient from GOCI has been computed. We evaluate GOCI tasselled cap brightness, greenness and wetness values. The result of this study shows classifying land surface characteristics very well.

KEY WORDS: GOCI, Tasselled cap, Image transformation,

1. INTRODUCTION

The tasselled cap transformation is traditionally method for land surface interpretation. The tasselled cap transformation has band coefficients that uses transform highly correlated data to uncorrelated indices. They are called brightness, greenness, wetness and others. However band coefficients are sensor dependant. Because of different spectral settings make different band coefficient. Therefore the tasselled cap transformation develops for every sensor.

Since its initial derivation was developed in 1976 for Landsat Multispectral Scanner (MSS) data (Kauth and Thomas 1976). It has been applied to variety of ecological study for interpretation of soil and vegetation patterns, crop development and so on. And it has been extended to Landsat thematic mapper (TM) (Crist and Cicone, 1984), enhanced thematic mapper plus (ETM+) (Huang et al., 2002), IKONOS (Horne, 2003), and moderate-resolution imaging spectroradiometer (MODIS) (Zhang et al., 2002; Lobser and Cohen, 2007).

The recently launched Geostationary Ocean Color Imager (GOCI) can be acquiring eight scenes per day between zero to seven hour (GMT) at one hour acquisition in Korea peninsular and around regions such as China, Japan, Taiwan, and Mongolia. Although it was originally designed as ocean colour monitoring sensor with eight spectral channels in visible to near-infrared spectral region (412nm to 856nm) and half km resolution. However, nearly half of GOCI image observe land area. Therefore it can possible to use land applications with the advantages from great high temporal resolution. If the tasselled cap coefficients for GOCI will be provided, we can interpret land surface changes at near-real time in GOCI coverage.

2. OBJECTIVES

The goal of this study is develop a tasselled cap transformation coefficient for GOCI image based on its principal component axes. The main three axes were rotated to MODIS tasselled cap. Because, GOCI can acquire only regional image due to characteristic of geostationary orbit. So, we considered that GOCI tasselled cap results are compatible with Global land cover patterns.

3. TRANSFORMATION DEVELOPMENT

3.1 Data and pre-processing

A total of forty-six images GOCI L1B radiance data in 2011 March to 2012 February was used this study. The dataset was selected eight day interval in one year. It considers variety land surface conditions from seasonal effect by leaf-on to leaf-off conditions during one year cycle and comparing MODIS tasselled cap result which was used 16-day MODIS Nadir BRDF Adjusted Reflectance Data (NBAR, MOD43A4).

The data pre-processing include two steps. First, we retrieved surface reflectance from GOCI data. The GOCI L1B at-sensor radiance data should be converted to physically meaningful radiometric scale. Because of at-sensor radiance is affected by temporal variations of solar irradiance. It also means normalize dataset against temporal variations. ENVI-FLAASH atmospheric correction tool was used for calculate surface reflectance of GOCI image. Input parameters are showed Table 1. Second, we processed Cloud and Sea masking. Land/Sea masking file is provided by Korea Ocean Satellite Center (www.kosc.kordi.re.kr). But suitable cloud masking algorithm for GOCI does not yet developed for land area. So, we select threshold empirically. Reflectance value over than thirty percents was decided cloud mask area. And it also included snow cover. Additionally we made ten pixels of buffer zone for removing neighbour pixels from cloud cover for acquiring perfectly cloud free data. Finally, we obtained cloud free land surface reflectance data from every GOCI images (Figure 1.) during one year.

A thousand of random samples was extracted on each GOCI images during one year which was discarded snow, cloud, water. Finally, a total of forty-six thousands sample point data was used in this study. They represent variety land surface cover (Figure 2.).

Table 1. ENVI FLAASH input parameters for atmospheric correction

Atmospheric model	Mid-latitude summer (May to Sep.) Mid-latitude winter (Oct. to Apr.)
Aerosol model	Rural 23km
Acquisition time	4:30 (GMT)
Scene center	36N, 130E

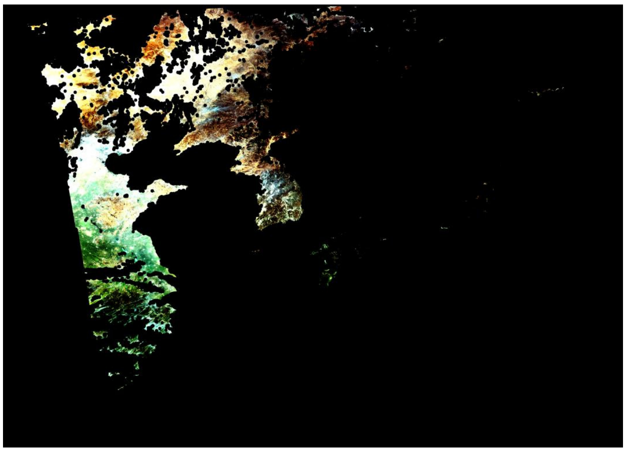
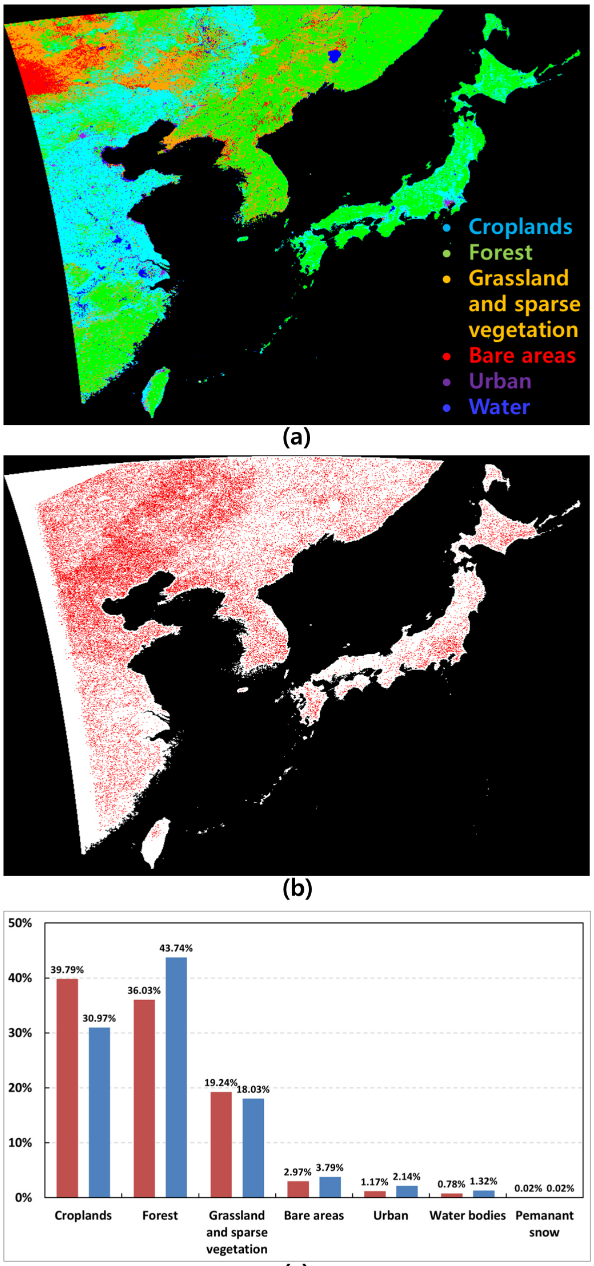


Figure 1. Cloud masked RGB composite GOCI reflectance image acquiring March, 30, 2011



(c)

Figure 2. (a) Land cover data by ESA-GLOBCOVER 2009 Product, (b) spatial distribution of 46,000 sample pixel locations in GOCI coverage, it consider overlap areas between MODIS and GOCI, (c) Comparisons between sampling data and GLOBCOVER 2009. Red bars represent sampling data distribution. And Blue bars represent GLOBCOVER 2009 distribution.

3.2 Method of tasselled cap transformation

Generally, the tasselled cap transformation is a rigid rotation of principal components derived from a representative own dataset. However, in this study we not used common traditionally processes of tasselled cap transformation which is consists of Principle Component Analysis, rotation of soil axis and orthogonalization for other axes. The reason for this will be discussed in the section 5.

In this study, we referred Lobser and Cohen's (2007) regression for developing MODIS tasselled cap. The transformed GOCI dataset by PCA was matched by same point of MODIS tasselled cap dataset by linear regressions. We calculated transform matrix which works transformation the three main axes of GOCI PCA data to three main axes of MODIS tasselled cap. Figure 3 Shows comparison of these two datasets.

4. RESULT

Table 2 shows the tasselled cap transformation coefficient for GOCI data derived by MODIS tasselled cap data. These three components represent the characteristics of brightness, greenness and wetness, respectively. Figure 4 shows examples of MODIS and GOCI tasselled cap transformed images.

Brightness is weighted sum of 5 bands between green to near infrared. However, it has 3 negative blue bands. Greenness is contrast between two large negative coefficients in red bands (5, 6) and two large positive coefficients in NIR bands (7, 8). It is very similar to vegetation reflectance pattern in red to NIR spectral region. Wetness represents large positive coefficients in blue bands (1, 2) and large negative coefficients in red bands (5, 6).

For evaluation GOCI tasselled cap coefficient, this result was tested by ESA-GLOBCOVER 2009 land cover map (Figure 5). The bare area data were distributed along Brightness (it similar to soil line). Cropland data has a large moving by seasonal variation (Figure 6). It seems to strong relationship to agricultural cycle.

5. DISCUSSION

The result of this study has two problems. It may cause controversy. First, this result shows negative coefficient value in Brightness transformation surprisingly. Originally, we calculated using conventional method. However, the main three axes of principle component of GOCI dataset cannot represent land surface characteristics. Because of the spectral setting of GOCI sensor was designed for ocean color monitoring. As you know, GOCI have eight spectral bands in VNIR regions. Each band is lies three blue bands, one green band, two red bands and two near-infrared band respectively.

Table 2. GOCI tasselled cap coefficient derived by MODIS tasselled cap data

Band	Wavelength(nm)	Brightness	Greenness	Wetness
Band 1	412nm	-0.471	0.109	0.337
Band 2	443nm	-0.281	0.031	0.186
Band 3	490nm	-0.064	-0.059	0.014
Band 4	555nm	0.194	-0.093	-0.160
Band 5	660nm	0.513	-0.360	-0.471
Band 6	680nm	0.538	-0.386	-0.498
Band 7	745nm	0.529	0.306	-0.192
Band 8	865nm	0.560	0.400	-0.171

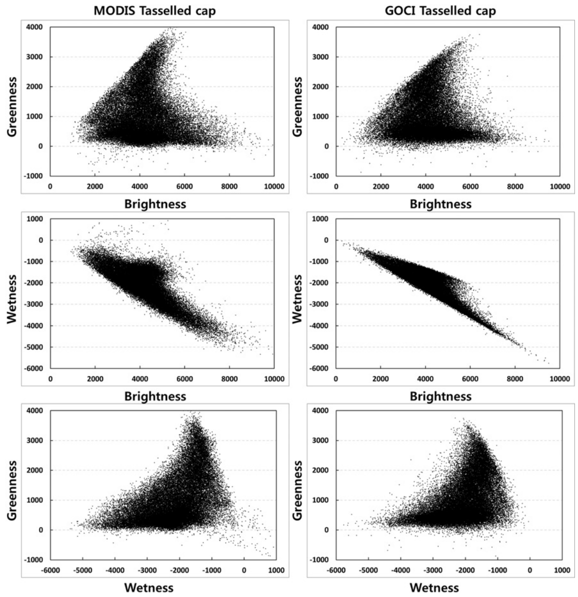


Figure 3. Pixel to pixel comparisons of MODIS and GOCI tasselled cap data. The MODIS images were transformed using Lobser and Cohen's (2007) coefficient (left). The GOCI images were regressed to MODIS tasselled cap result after PCA transformation.

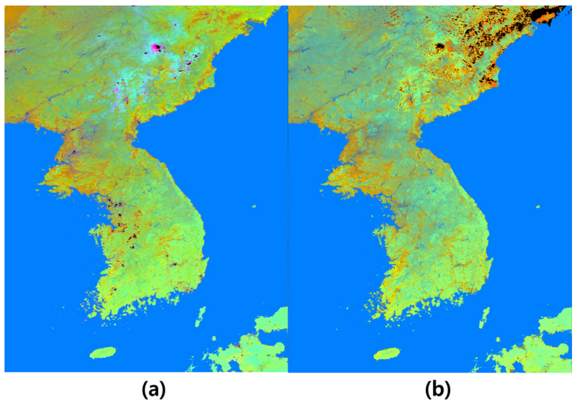


Figure 4. Examples of (a) MODIS and (b) GOCI tasselled cap images. Acquisition date is March, 30, 2011. RGB composite represent Brightness, Greenness and Wetness respectively. These two images was enhanced same color scale. Black pixels represent no data.

But, we were not given such weight factors in this study. Therefore, the spectral band setting of GOCI causes the effect of weighting factor. So, the three blue bands have too large effect to compare the other bands on the brightness coefficient (not shown). But, most of soil reflectance in blue channel is not lager than green to NIR channels.

Second, the three components of coefficient parameters not preserved orthogonality. It means that these three axes are not independent each other. So, we also tested to rotate with preserving orthogonality of GOCI PCA dataset. But, basically, these two sensors have difference settings in SWIR bands. It makes a large difference for retrieving wetness parameter. Because of the VNIR sensors only have blue bands to identify wetness.

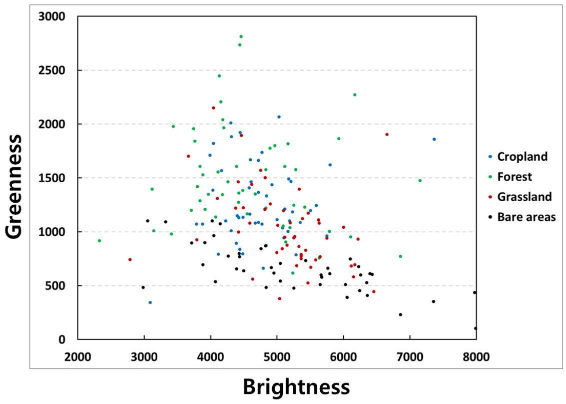


Figure 5. Distribution of difference land cover types in the plane of greenness versus brightness.

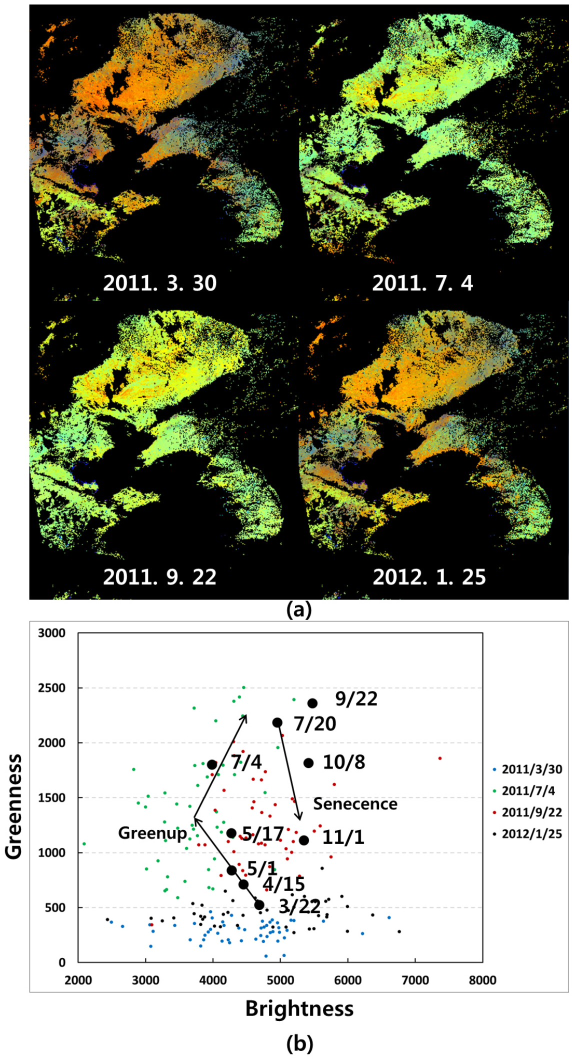


Figure 6. (a) Seasonal changes of the GOCI Tasselled cap images. RGB composite represent Brightness, Greenness and Wetness respectively. (b) Seasonal changes of cropland in the GOCI tasselled cap spaces.

Therefore, limitation of GOCI VNIR spectral setting makes a difficult to maintain of orthogonallity when MODIS data on the regression. Although, Lobser and Cohen's (2007) MODIS tasselled cap transformation was sustained orthogonality when MODIS dataset was regressed to Landsat TM tasselled cap data. Nevertheless, GOCI PCA dataset was regressed to MODIS dataset with remaining two problems. Because, the purpose of tasselled cap transformation is to identify land surface characteristics such as contents of soil, vegetation and water. Figure 5 and 6 shows classifying datasets by land surface characteristics and seasonal variations very well.

Finally, if you want to get similar MODIS tasselled cap result using GOCI data. We carefully suggest Table 3 coefficients.

In near future, we will research the meaning of PCA transform using ocean color sensor in land surface. It may help to solve the original meaning of GOCI's eight spectral bands variables for land cover identification. And the application of other acquisition time will develop to make one day time series tasselled cap data using GOCI.

6. REFERENCES

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7. ACKNOWLEDGEMENTS

This research was a part of the project tiled "Support for research and applications of Geostationary Ocean Color Imager (GOCI)" funded by the Ministry of Land, Transport and Maritime Affairs, Korea.