

# Tasseled Cap Transformation-based Specific shadow Error Calibration Using a Weight per Each Band Through Factor Analysis

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## ABSTRACT

This intent of this study was to analyze the nature of the errors that occur as a result of shadows during the process of NDVI calculation using high-resolution satellite images of Cheongju City obtained from QuickBird, in order to calibrate such errors, and to verify the results. This study have two steps, first is to calibrate the shadow errors by utilizing the relationship between the Greenness above Bare Soil (GRABS) calculated through Tasseled-Cap transformation and the original NDVI. Second is to use factor analysis method for measuring a weight per each band of the imagery. To verify the accuracy of the results, this study has compared the shadow area extracted by the difference between before and after calibration of NDVI, with the original shadow area.

The results of this study can be summarized as follows. Initially, the NDVI value converged on the value of -1.0, representing water, because shadow areas could not accept the reflection value from each band. However, after performing Tasseled-Cap transformation, the NDVIs of shadow areas that had converged on -1.0 prior to calibration had increased to a level similar to the NDVI of neighboring areas. In addition, the average NDVI in general had increased from -0.08 to -0.01. Finally, the shadow area drawn out was almost matched to the original one, meaning that the NDVI calibration method employed turned out to be highly accurate in extracting shadow areas.

Keywords : RS, Tasseled Cap, Calibration shadow error

## 1. Introduction

A range of remote sensors located on the satellite record specific wavelengths of the electromagnetic spectrum. All types of land (rock, water bodies, etc.) absorb a distinct portion of the electromagnetic spectrum, giving each land type a distinguishable electromagnetic radiation signature.

The recorded data is widely used for the calculation of NDVI in RS/GIS fields. Due to its ease of calculation and the simplicity of the principle, it has been widely used in many fields.

However, the image data obtained from the satellite

frequently contains errors due to clouds, smog, aerosol, and so on. These factors can cause errors in the calculation of NDVI, thus leading to biased information. To eliminate the pixels from an image that will give rise to errors, several statistical methods are used.

There have been some previous studies related to the correction of errors caused not only by topology but also by physical objects such as buildings.

In this study, for correcting the errors caused by buildings in Cheongju City, Tasseled Cap Transformation and GRABS method were used. However, this method also has a limitation in the accuracy of shadow correction, because of not considering the character of each band. In this study, factor analysis was considered as a method of improving image data accuracy after correction. According to the factor analysis, each band can be weighted.

Through these processes, the procedures needed to

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## 2. Methodology

### 2.1 Satellite Imagery

In this study, satellite imagery of Cheongju City obtained from the QuickBird satellite is used for calibration shadow error. The spatial resolution of the imagery is 0.6m. It contains 4 bands, ranging from a visible ray(0.4~0.7) to near-infrared ray(0.7~0.2).

A shadow area(50\*50 pixels) was partially extracted from the whole imagery (6187\*5395 pixels) for efficiency of data operation and the NDVI value was calculated according to the land cover type.

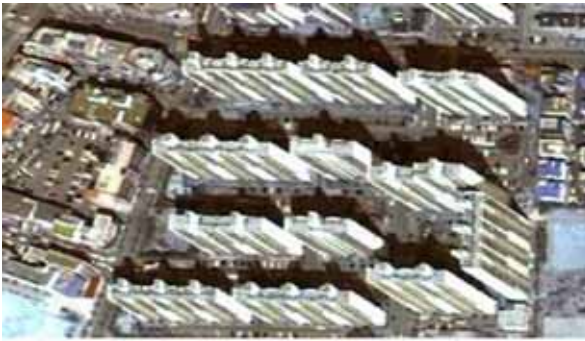


Fig. 1 RGB composite image of study region

### 2.2 Tasseled Cap Transformation Model and GRABS

In this study, satellite imagery of the entire band in the spatial region are plotted and converted to the 3 axes of Soil Brightness, Green Vegetation, None-Such Wetness Index through the Tasseled Cap model. In addition, a new conversion index is operated and converted by 4 bands of QuickBird on the basis of 6 bands from the former Landsat TM data(James H. Horne, 2003)

$$SBI = 0.326 * B1 + 0.509 * B2 + 0.560 * B3 + 0.567 * B4 \text{-----(1)}$$

$$GVI = -0.311 * B1 - 0.356 * B2 - 0.325 * B3 + 0.819 * B4 \text{----(2)}$$

$$NWI = -0.612 * B1 - 0.312 * B2 + 0.722 * B3 - 0.081 * B4 \text{---(3)}$$

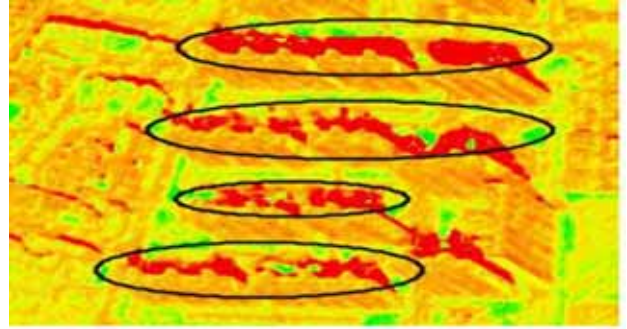
In the above equations, B1, B2, B3, B4 refer to Band1, Band2, Band3 and Band4, respectively, from QuickBird satellite image.

Hay et al.(1979) presented GRABS, which used GVI and NWI from MSS data that had already been revised, and gave convincing answers through Tasseled-Cap. However, in this study, GRABS was calculated by application of Tasseled Cap.

$$GRABS = GVI - 0.09178 * NWI + 5.58959 \text{-----(4)}$$

Fig. 2 Shadow error on NDVI

### 2.3 Regression analysis



The correlation between GRABS and NDVI is used as a methodology to revise NDVI errors resulting from shadowed regions. It used the Tasseled Cap model from the formulas (1)~(3). In addition, (4) is compared with the DN value from a randomly selected NDVI satellite image, and used to create a spatial distribution in the revised NDVI Fig 3 shows this procedure.

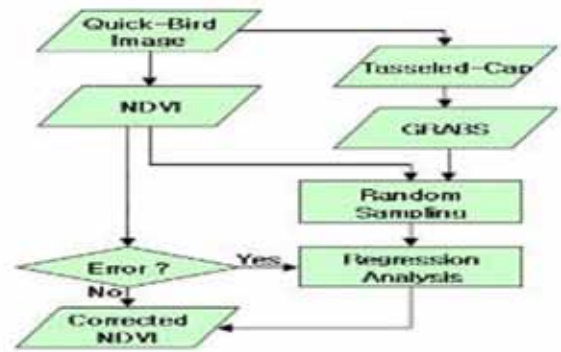


Fig. 3 Process of correcting NDVI error Using regression

### 2.3 Factor Analysis

In order to analyze the factor, each band should be checked for finding the main axis of correction. In this study, some areas were extracted for finding the charter of each pixel value according to the band. Through checking pixel value of each band, we expect to find which factor is affected from the before and after correction. To verify the correction, error matrix is used to check the increasing the accuracy.

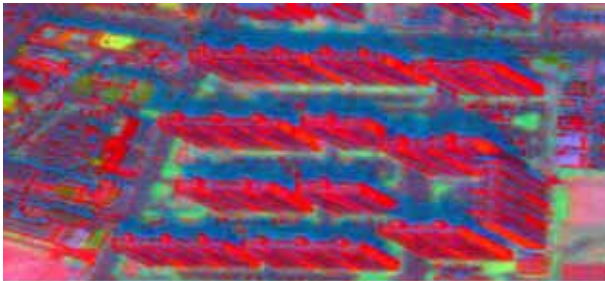
## 3. Analysis and Result

### 3.1 NDVI error at the shadow region.

Surface material such as a footpath or asphalt is found in

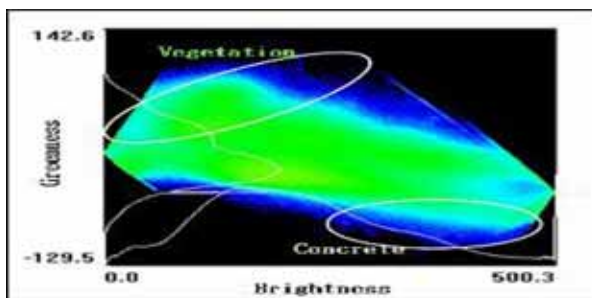
the areas around apartment buildings. According to Part et al.(2006), each material has a different wavelength, some of which are as follows; forest:0.5~0.6, field: 0.38~0.49, urban area: -0.09~-0.08, water:-0.1~-0.35. However, Fig. 2 shows that there is an erroneous NDVI value that is contracted as -0.1 due to a lack of acquisition. These error values give rise to negative influences, by providing incorrect information regarding the image, both statistically and environmentally.

### 3.2 Tasseled Cap Transformation and GRABS calculation



**Fig. 4 Tasseled Cap Transform**

Fig 4 is a multi spectral image of a Tasseled Cap conversion model, Fig 5 is a scatter diagram of DN which presents Brightness and Greenness as the X and Y axis among the deducted three indexes. Fig. 4 shows that an apartment building may be presented as a red channel, indicating the highly re-flexible characteristic of concrete,



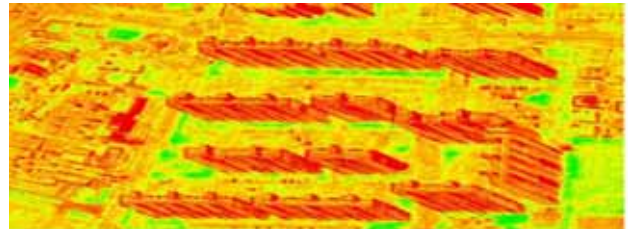
**Fig. 5 Relationship between B and G**

However, the shadow region is nearby to the blue channel, water, because it is determined that the impact of shadow which originated from the concrete near the

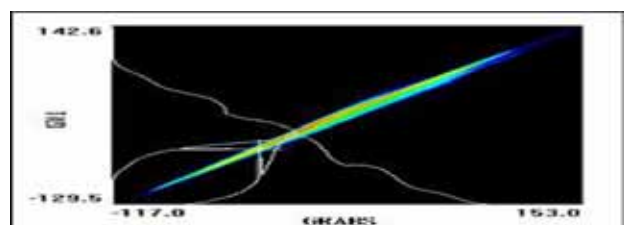
apartment building is wholly considered, and is represented as a material with a high re-flexibility, such as water.

Fig. 5 is a scatter diagram, which provides a useful interpretation in accordance with the size and direction of data; there is a higher brightness value and a lower greenness value, there is no vegetation, and thus there are probably barren objects, such as concrete. On the other hand, a higher density of vegetation and a lower reflection indicates a forest or a field. Otherwise, the uniqueness and patterns of the targeted region in the image are presented and applied to the wide range of approach through two-dimensional data distribution and direction with 3 axes.

GRABS was calculated using the Greenness and Brightness indexes from Tasseled Cap. The value of GRABS is finally similar to the Green Vegetation Index from Tasseled Cap. Fig. 6 shows the spatial distribution of GRABS. Fig.7 presents the relationship between GVI and GRABS. It also shows that GRABS and GIV has a regular correlation.



**Fig. 6 Spatial distribution of GRABS**



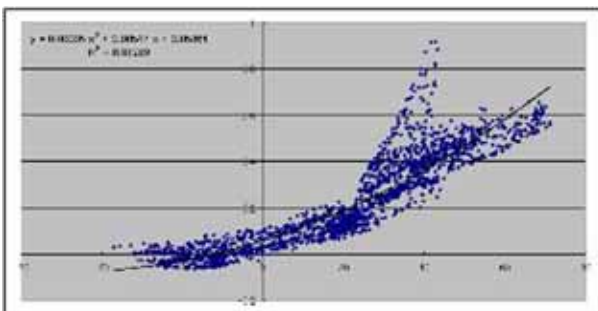
**Fig. 7 Relationship between GVI and GRABS**

### 3.2 Corrected NDVI using GRABS

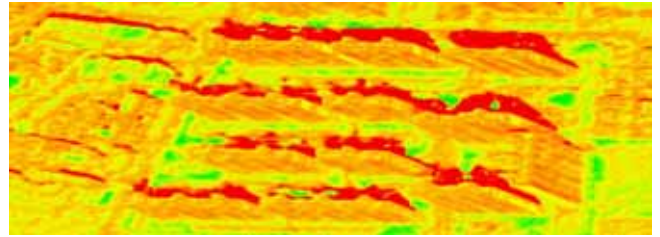
After Calculating the Corrected NDVI using GRABS, an expression of the relation between Greenness and

Brightness from the Tasseled-Cap conversion model. The distribution of NDVI was presumed through the comparison with original NDVI. Fig. 8 is a histogram scatter diagram of GRABS and NDVI. As shown in Fig. 3 NDVI value regarded as an error was observed -1.0. However, considering that general values of concrete is higher than -0.1, those values could be considered as error pixels caused by shadow and relational expressions originate from a comparison between GRABS and NDVI after a random choice except error pixel.

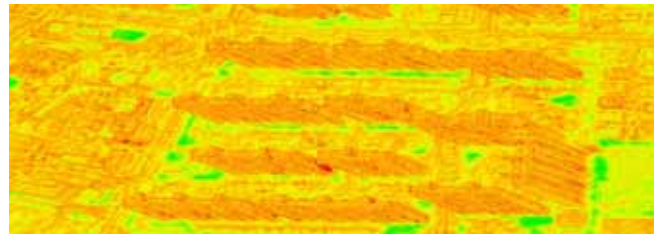
Fig. 9-(1,2) shows the spatial distribution of the relational expression of GRABS and NDVI from Fig 8. Compared to the former NDVI, the NDVI in the non-corrected shadow region is astringent to -1.0, however, the NDVI after revision is similar to the concrete region, -0.08~-0.1. The average NDVI after revision increased from -0.08 to -0.01 and its minimum value also increased from -1.0 to -0.09. It is revised to -1.0 to -0.09 in shadowed regions, and the average value of NDVI is increased by over 0.05 altogether. However, the maximum value of NDVI does not show any change compared to period of revision. Fig. 10 is a distribution chart of the cross-section that includes the shadowed region, considering before and after revision. Through a comparison between before and after the revision through the distribution chart, the NDVI from the shadowed region is revised and has a similar level to the NDVI in regions nearby



**Fig. 8 Relationship between GRABS and NDVI**



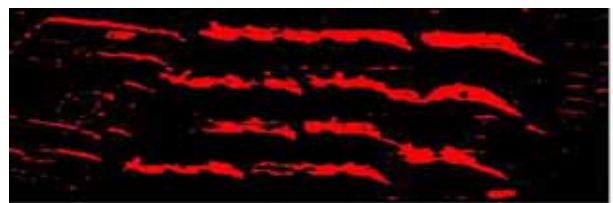
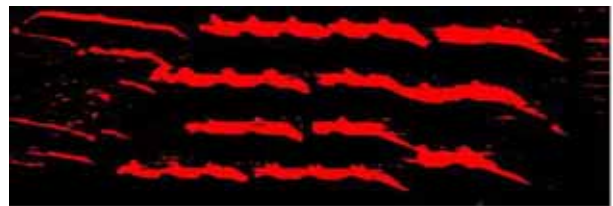
**Fig. 9-1 Non-Corrected NDVI(Spatial distribution of NDVI)**



**Fig. 9-2 Corrected NDVI(Spatial distribution of NDVI)**

### 3.3 Extract shadow region

Fig. 10(a) shows shadow region by unsupervised classification, 10(b) is the extracted shadow region by change detection. Matching accuracy between the two images is 83.2%, and this means that the corrected NDVI can contribute to the extraction of shadow region with a high degree of accuracy.



**Fig. 10 Extract shadow region suing Unsupervised Classification(a), Change Detection(b)**



#### 4. Summary and Expected Conclusions

This purpose of this study was to examine the efficiency of the Tasseled-Cap conversion model through correlation between GRABS and NDVI using Quick Bird satellite imagery. The results are as follows:

- 1) In the shadow region, there is error which ascribes the value of NDVI as -1.0 due to the acquisition x of each band. These erroneous values not only have a negative influence on the statistical value but also provide incorrect information to the environmental facts associated with NDVI
- 2) As a result of the Tasseled-Cap conversion model, apartment buildings have the characteristics of concrete, which has a high re-flexibility and a red color, while in the shadowed regions nearby, the value is close to the water region with a blue color. It is determined that the effect of shadow is applied to the electromagnetic waves from the concrete region around the apartment building, giving it a similar characteristic to water, which has high absorption.
- 3) GIV and GRABS have a significant regular correlation, which means that GRABS also has a similar correlation with NDVI.
- 4) Comparing before and after revision, NDVI from the shadowed region is revised to a similar level with the NDVI nearby
- 5) After revision, the average NDVI is changed from -0.08 to -0.01. Minimum value is

increased from -1.0 to -0.09. In the revised results, NDVI error is revised from -0.1 to -0.09 in shadow region, and the average value is increased by over 0.05.

- 6) In a conclusion, the shadow region extracted is almost the same as the shadow region from the original image. This means that the correction method of NDVI has high fidelity to the extract of the shadow region.
- 7) From this study, the expected result of correction using the high resolution imagery is the increasing of accuracy in the residual areas in inner city, such as apartment housing containing shadow region.

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