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The Study on Vegetation Structure Index using BRF Property with Satellite Sensors

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Abstracts: This study proposes new Vegetation Index. As for new Vegetation Index, Vegetation cover ratio that was difficult to show in Vegetation Index (NDVI etc.) until now is same and height etc. differ such, structure shows the difference of vegetation that differs. BRF that measures BRF with Field Experiments in, this study and be able to observe a/the satellite from the result was calculated by using a/the BRF model. Grasping the characteristic of BRF that is able to observe a/the satellite from this result, index that shows the difference of Structure of Vegetation was proposed. In this study, BSI is calculated by using the data of NOAA/AVHRR and the efficacy was confirmed.

1. Introduction

It is very important to know Land Vegetation, Land cover change, and Land cover use, to tackle with the global environmental problem. And, as the means that grasps these it is said that Satellite Remote Sensing be effective. However, it is difficult in the method that used Vegetation Index of existing. Vegetation Index of the existence Vegetation cover ratio is same, to have Vegetation cover ratio and correlation and be the difference of Vegetation that the structure differs because it cannot distinguish it. For example, it is the difference between the difference and shrub and Sparse Grassland of the paddy field and forest.

Bi-Directional Reflectance Factor (BRF) has the characteristic that relays on Structure of direction and wavelength and target. It was conceivable that satellite is caught the difference of the structure of target, if satellite is able to observe the difference of BRF from satellite.

2. Objects

The purpose of this study is to observe the difference of Structure of Vegetation by using Satellite Remote Sensing. The study for that is following.

i) It was observed BRF of various vegetations with Field Experiments.
ii) It was expressed BRF that I observed with Field Experiments from BRF Model with the difference of Vegetation.
iii) It expressed BRF that is able to observe satellite by using BRF Model.
iv) Development of new Vegetation Index that shows Structure of Vegetation more, BRF that is able to observe satellite.
v) Confirmation of the efficacy of new Vegetation Index.

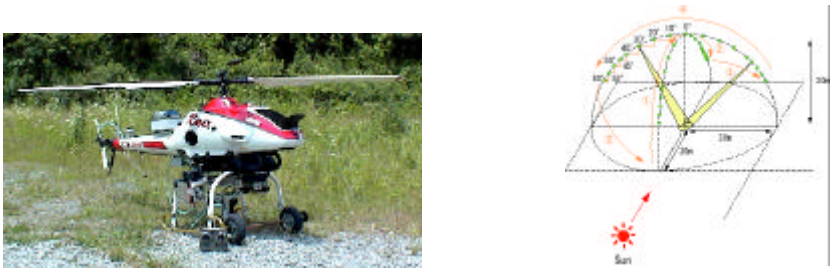
3. Methods

3.1 Field Experiments

The study area is around Montana in U.S. Measurement in Fore types of vegetation was conducted around Montana. Those are Needleleaf Forest, Broadleaf Forest, Bush and grassland (Fig.1). Data obtained by RC Helicopter measurement system is used in this study. Fig.2 shows Summary of Measurement. Spectrometer (Soma Optics Inc) can measure in visible/near infrared between 350nm and 1050nm (measured with 512ch. mode). Fig. 5 shows Result of Field Experiments. BRF of various Vegetation able to be observed.

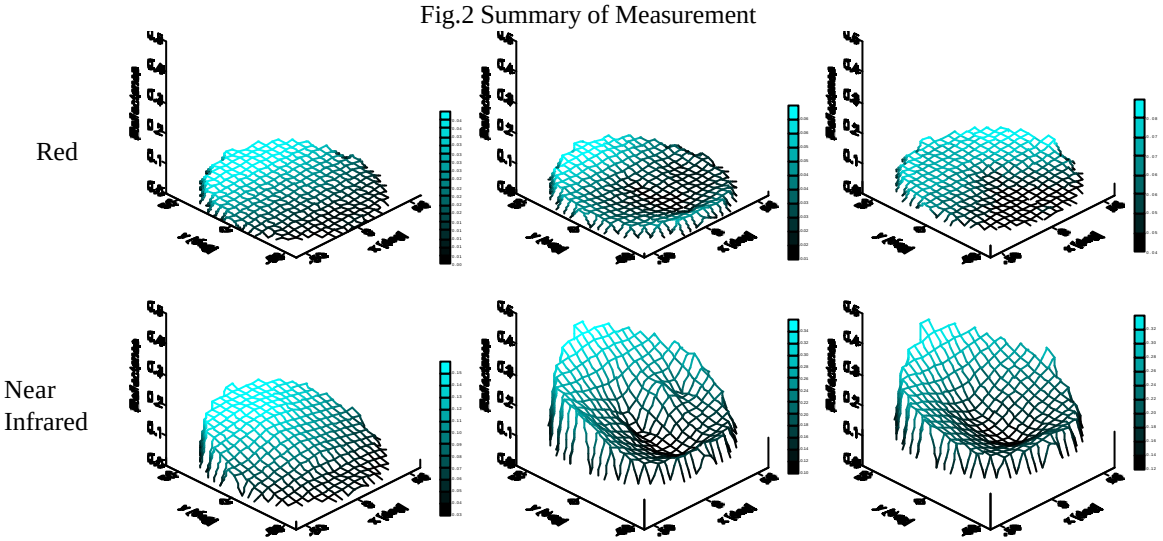
(A) Needleleaf Forest (B) Grassland (C) Broadleaf Forest (D) Bush (Mixed)

Fig.1 Vegetation type of BRF Field Experiments



(A) RC Helicopter Measurement System (B) Measurement Method

Fig.2 Summary of Measurement



(A) Neddleleaf Forest (B) Broadleaf Forest (C) Bush (Mixed)

Fig.3 Results of Field Experiments

3.2 BRF Model

Our using model is a simple layer model based on four-flux theory like the Suits model (1) and the SAIL model (2). The four-flux theory is written by:

$$\text{Speclar Flux}: \frac{dE_s}{dx} = kE_s$$

$$\text{Unward Diffuse Flux}: \frac{dE_-}{dx} = -sE_s + aE_- - \acute{o}E_+$$

$$\text{Downword Diffuse Flux}: \frac{dE_+}{dx} = s'E_s + \acute{o}E_- - aE_+$$

$$\text{Radiation Flux}: \frac{dE_o}{dx} = wE_s + vE_- + uE_+ - KE_o$$

We expressed Field Experiment data by using this model. This model is called cylinder model.

Fig.4 shows results of calculated BRF Model in Broadleaf Forest. It is clearly that did BRF Model calculate Field Experiment data. Fig.5 shows results of calculated BRF Model in another vegetation. It can be said that BRF that the satellite observes is expressed with Linear regression equation. Table.1 shows Linear regression equation of BRF of satellite.

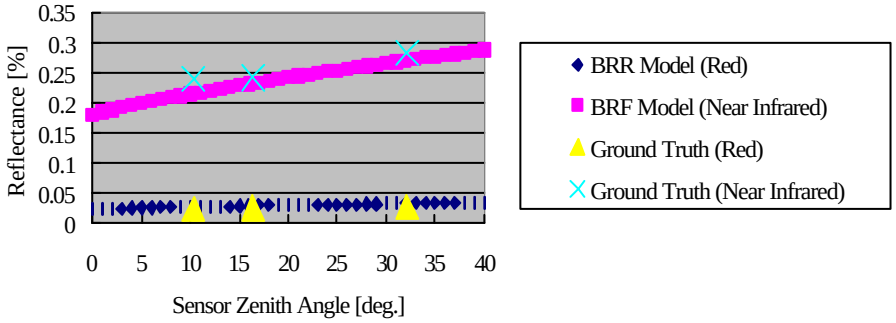


Fig.4 Calculated BRF Model and Field Experiment data (Broadleaf Forest)

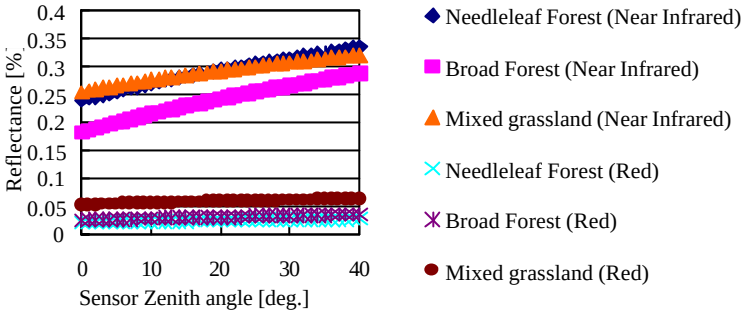


Fig.5 Calculated BRF Model

Table.1 Linear regression equation

	Linear regression equation (Red)	R^2	Linear regression equation (Near Infrared)	R^2
Coniferous Forest	y=0.0002x+0.0207	0.9977	y=0.0023x+0.2436	0.9944
Broad Forest	y=0.0003x+0.0245	0.9957	y=0.0026x+0.1869	0.9927
Bush	y=0.0003x+0.0515	0.9977	y=0.0016+0.2576	0.9942

3.3 Proposal of Structure Index

Fig.6 shows outline of BRF in satellite data. From Fig. 6, the difference of BRF for each vegetation can show with the ratio of the area that is painted with linear regression equation like Fig. 7.

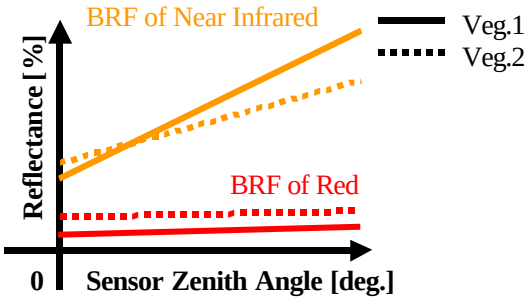


Fig.6 Outline of BRF in satellite data

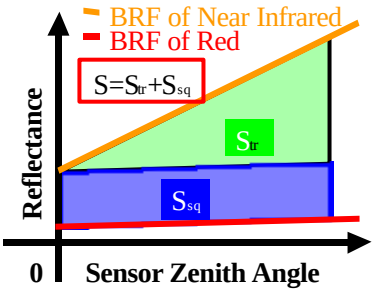


Fig.7 Area that is expressed by Linear of BRF

The ratio of the area is following,

Component that shows the difference of structure $= \dfrac{S}{S_{sq}}$ eq. (1)

S is calculated as the following equation,

$$S = S_{tr} + S_{sq} \quad \text{eq. (2)}$$

S_{tr} and S_{sq} are calculated as the following equation,

$$S_{tr} = \frac{1}{2}(\theta_o - \theta_n) \times \{N_o - (N_n - R_n + R_o)\} = \frac{1}{2}(\theta_o - \theta_n) \times \{(N_o - N_n) + R_n - R_o)\} \quad \text{eq. (3)}$$

$$S_{sq} = (\theta_o - \theta_n) \times (N_n - R_n) \quad \text{eq. (4)}$$

θ_o : Sensor Zenith Angle of off nadir data
θ_n : Sensor Zenith Angle of nadir data
N_o : Near Infrared Band data of off nadir
N_n : Near Infrared Band data of nadir

R_o : Red Band data of off nadir
R_n : Red Band data of nadir

Eq.(1) is calculated as the following equation from eq.(1)~(3),

$$\frac{S}{S_{sq}} = \frac{S_{tr}+S_{sq}}{S_{sq}} = 1+\frac{S_{tr}}{S_{sq}}$$

$$= 1+\frac{\frac{1}{2}(\rho_o-\rho_n)\times\{(N_o-N_n)+R_n-R_o)\}}{(\rho_o-\rho_n)\times(N_n-R_n)} \qquad \text{eq. (5)}$$

$$= \frac{1}{2}\times\frac{2\times(N_n-R_n)+\{(N_o-N_n)+R_n-R_o)\}}{(N_n-R_n)}$$

$$= \frac{1}{2}\times\left(1+\frac{N_o-R_o}{N_n-R_n}\right)$$

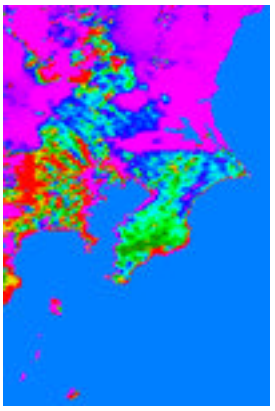
Transform equation in eq.(5) are following that named Bi-directional Reflectance Structure Index (BSI),

$$BSI = \frac{N_o-R_o}{N_n-R_n} \qquad \text{eq.(6)}$$

4. Results

Fig.8 shows calculated BSI using NOAA AVHRR DATA around Chiba in Japan. Fig.9, 10 show comparison between BSI and NDVI, Global Map. These are clear that BSI is making bare the distribution different from NDVI. And, it is clear to be expressing the difference of Broadleaf Forest and Mixed Forest, the paddy field and forest, field and forest where BSI could not show in NDVI.

Next we explored it, to confirm the difference of vegetation that BSI shows. Fig.11 shows exploration site. Fig.12 shows BSI and NDVI in exploration site. Fig.12 shows vegetation type in exploration site. It is clear to be expressing the difference of difficult Vegetation that BSI shows it in NDVI.



Upper N35 deg., E137 deg., Bottom N37 deg., E139 deg.
Nadir Image 2000/8/1, East Image2000/8/2

Fig.8 BSI Image

Fig. 9 BSI vs. NDVI and Global map (East Chiba)

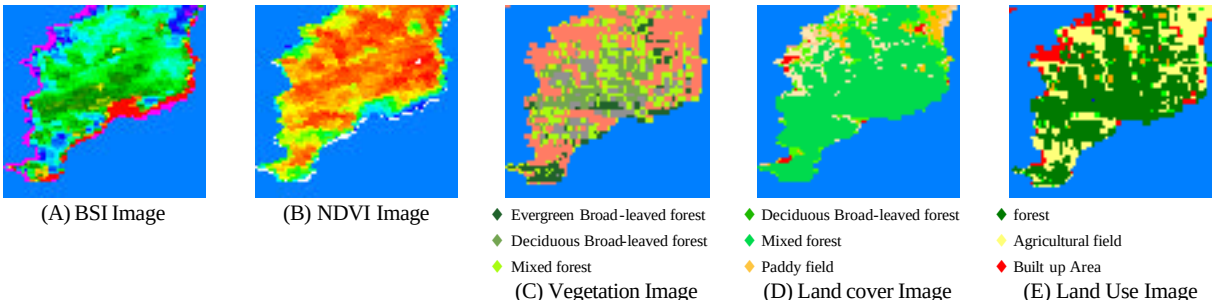


Fig. 10 BSI vs. NDVI and Global map (South Chiba)

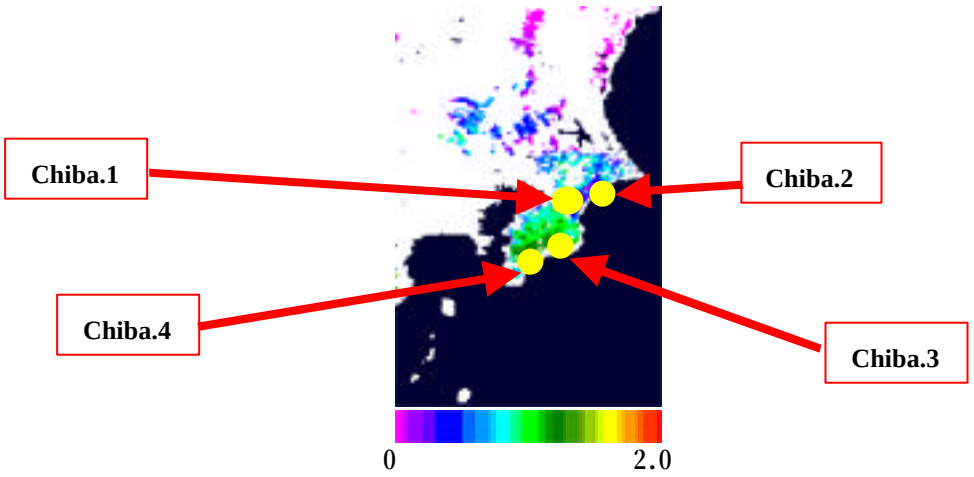


Fig.11 Exploration site

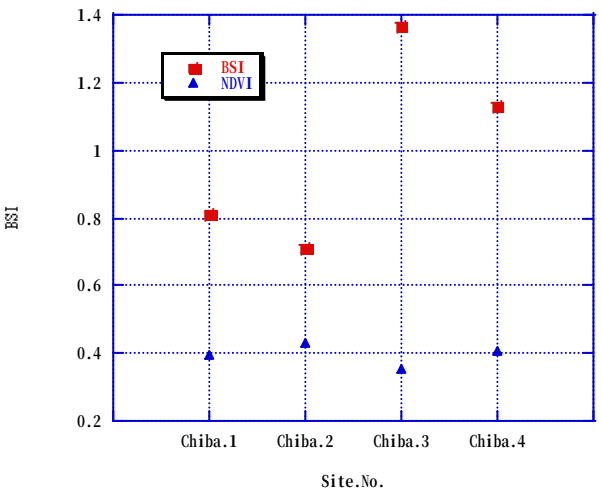


Fig. 12 BSI and NDVI in exploration site

(A) Chiba.1 field and forest (B) Chiba.2 Paddy field (C) Chiba.3 Mixed Forest (D) Chiba.4 Broad Forest

Fig. 12 Vegetation type in exploration site

5. Conclusions

i) New Vegetation Index (BSI) that shows the difference of Structure of Vegetation was proposed.
ii) BSI was able to show the difference of Vegetation that was difficult to show in NDVI.
iii) BSI expressed the difference of the paddy field and forest, Broadleaf Forest and Mixed Forest.

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