VEGETATION CLASSIFICATIONS BY STRUCTURES ESTIMATED FROM DIFFERENCE OF BRF

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ABSTRACT

Estimating method of Vegetation structure such as coverage, height, is hoped for establishing biomass estimation model. One of the answer, BSI (Bi-directional reflectance factor Structure Index), which is a new vegetation index using BRF (Bi-directional reflectance factor), has been developed. However, BSI is involved not only height but also coverage, canopy shape and other physics affection. Then it is necessary to clear relationships between BRF and them due to estimate them.

In this study, BRF are researched some data measured by autonomous navigation helicopters, and MODIS. The result of our research showed one of the methods of estimating vegetation structure.

1. INTRODUCTION

Vegetation is a great effective factor for environments. It is important to research biomass for solve environmental problems. Most remote spectra observing techniques have been developed for estimation Leaf Aria Index (LAI), vegetation coverage, and other physically status.

On the earth, there is much vegetation zone such as grassland, cropland, and forest. Each zone have differ relations between biomass and LAI or vegetation coverage, if they have differ own structures which consisted of height, canopy shape, distribution and so on. Thus biomass estimation models should be elected in consideration of that.

From the background, Bi-directional reflectance factor Structure Index (BSI) has been developed to estimate their structures (Konda at el.,2002). BSI is used Bi-directional Reflectance Factor (BRF).

2. BSI

BSI is shown Eq. (1):

$$BSI = \frac{NIR_o - Red_o}{NIR_n - Red_n} \quad , \qquad (1)$$

where ***NIR*** and ***Red*** are reflectance or radiance of near-infrared and red. Index ***n*** and ***o*** mean these reflectance or radiances are observed from nadir and off-nadir by satellite (fig.1).This equation is developed from the following theory.

Sensor zenith angle make observed reflectance of vegetation zone change such as fig.2 when a Sensor zenith

angle is changed from 0 deg to 60 deg, because vegetation ratio composed in filed of sensor view are increased by the change. S△ in fig.2 is regarded as vegetation structure. From this, BSI is numerical terms which are developed simplify S△/ (S△+S□).

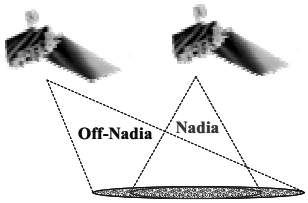


Fig.1 Nadir and Off-Nadir

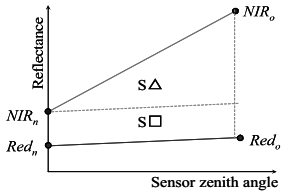
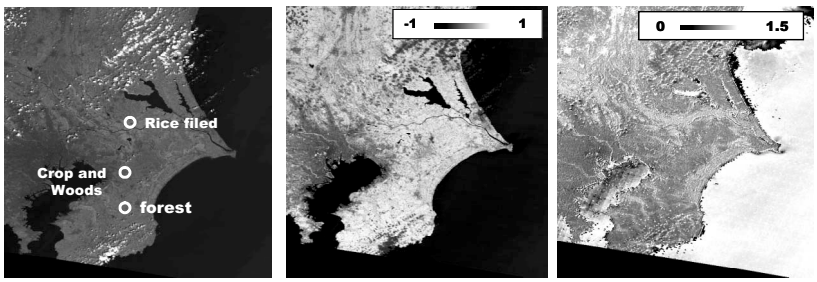


Fig.2 Concept of BSI.

Fig 3a is Bousou peninsula; Japan observed by TERRA / MODIS in August 2002 .Fig.3b and 3c calculated NDVI and BSI at the aria in 3a.Used data are Nadir is DOY 222, Off-Nadir is 223.It is impossible to seem differ between rice filed and forest in Fig 3b (NDVI image), while it is possible to seem in Fig 3c (BSI image).



(a) Observation aria (b) NDVI image (c) BSI image

Fig.3 Image of NDVI and BSI

3. OBJECTIVE

Using BSI, it is possible to research about structure of vegetation zone which NDVI is not able to show. However, in order to know physical quantities such as biomass using BSI, it is necessary to research physical means of BSI. From Eq.1, when (NIR – Red) values which are accepted at nadir observing is high value, BSI value is reduced in inversely proportional to the value. It means that some of vegetation zone which have differ structure and coverage may be not divided only using BSI. In order to divide these, it is necessary to consider not only structure status but also coverage.

Based on this standpoint, this study is more deepen concept of BSI and focuses how to observe BRF and to use observed data for detailed estimating structure of vegetation zone. For those researches, spectra data which were acquire using autonomous navigation helicopters and using TERRA / MODIS were analyzed.

4. BRF OBSERVATION USING AUTONOMOUS NAVIGATION HELICOPTERS

4.1. ABOUT THE HELICOPTERS AND FLIGHT PATTERN

To measure BRF of vegetation zones on ground truth, YAMAHA MOTORS autonomous navigation helicopters “R-MAX” is selected as platform. This platform has not only higher mobility and static stability, but also lower cost than other one, and its user can order free flight pattern by program on PC. In this

observation, helicopter is mounted equipment whose moving parts CANON digital camera "D60" and SOMA OPTICS spectrometer "S2300" are set on and flown semiglobular over target zone with measuring its reflectance. It is called "BRF flight (fig.5)". In this study, flight pattern of face to sun is called "principal", flight pattern to cross principal is called "vertical". Fig.6 is photographs taken by the flight.

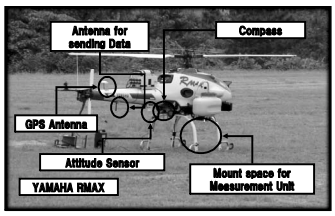


Fig.4 YAMAHA "RMAX"

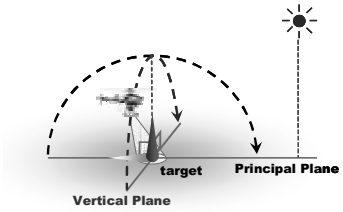


Fig.5 Flight pattern of BRF observation

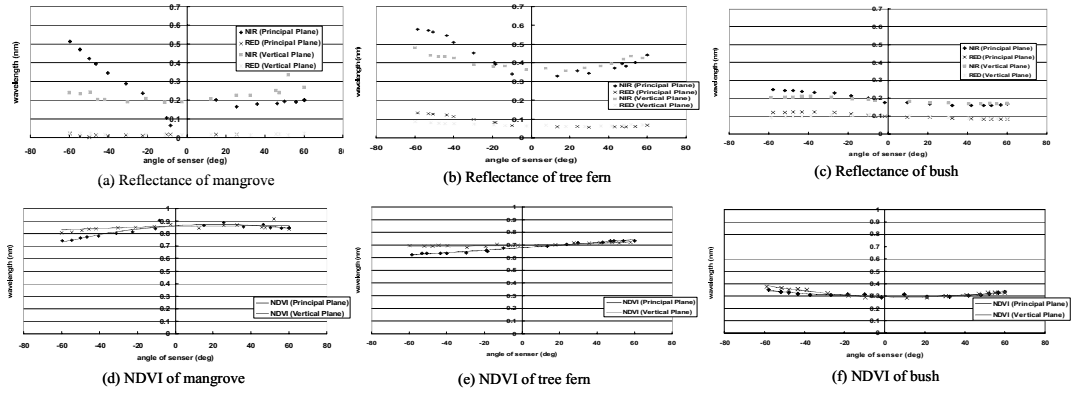
Fig.6 Multi-angel photo of broadleaf zone taken from digital camera

4.2. TARGETS OF MEASUREMENT

Measurement targets had been observed in some place such as Japan, America, Australia, etc. was selected. Measured terms of them were from September 2001 to March 2003. Including them, there were vegetations with complicacy structures such as broadleaf woods, mangrove woods, and simple structures such as glasses, cropland, and soil.

4.3. BRF AND NDVI

Each vegetation zones were measured NIR and Red reflectance from BRF flight. fig.7a - c are graphs plotted them on sensor zenith angles vs. reflectance. Fig 7d - f. are sensor zenith angles vs. NDVI Changing sensor angle make both NIR and Red reflectance of vegetations zone which have complicacy structures change bigger than simple one, while comparing NIR and RED, NDVI almost not change if theirs structures is complicacy or not.



(a) Reflectance of mangrove (b) Reflectance of tree fern (c) Reflectance of bush

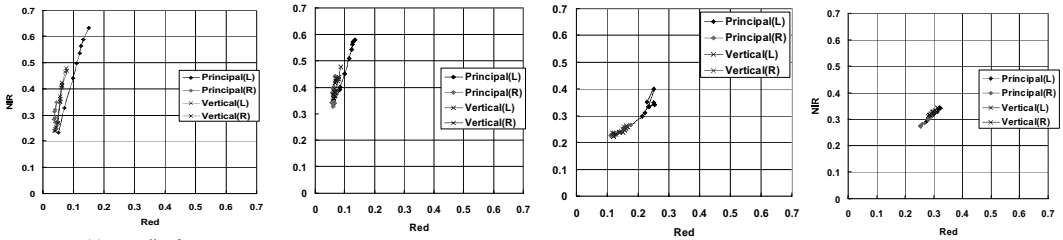
(d) NDVI of mangrove (e) NDVI of tree fern (f) NDVI of bush

Fig.7 Sensor zenith angles vs. reflectance and NDVI

4.4. CHANGING ON RED-NIR PLANE

Fig.8a-d are Red-NIR planes that Red and NIR reflectance of these targets are plotted on. Plotted lines are extended on the similar direction where lines joining Origin point to reflectance observed nadir is extended.

About the line length, Complicacy structure vegetations have longer than simply ones. and, when sensor is turned on sunlight incident direction, length are measured longest and when sensor is turned on backlight, it is shortest. It is likely this coursed that vegetation coverage of the target composed in filed of sensor view were not increased by shadow effect when sensor angles were changed. In addition to, the length seem to be effected by solar azimuth angle. It is necessary to research that in future.



(a) Broadleaf tree (b) Tree fern (c) Bush (d) Soil

Fig.8 Red-NIR planes

4.5. RED-NIR PLANE AND NDVI, LAI

NDVI has same value when measured points stand on a line which is extended from Origin point in Red-NIR planes. It means it is more difficult to seem BRF effect on NDVI value than on reflectance, which shows Fig7-8. Meanwhile, Fig6 appears that NDVI may not change even if vegetations coverage changes by changing sensor azimuth angle.

As HUETE (1988) and BARET at el (1991), were point out, NDVI can not explain LAI increasing when vegetation zone has some larger level of NDVI. That is to say, NDVI hardly change by LAI increasing at that time, and also by BRF. As a result, in order to research vegetation converges, it is important to measure not only NDVI value but also stand point of nadir reflectance on Red-NIR planes.

4.6. IMPORTANCE PARAMETER FOR STRUCTURE CLASSIFICATION

For consideration on this chapter, that to say that it is important to measure below information (Fig 9);

① Length of a line joining reflectance observed nadir to reflectance observed off-nadir on Red-NIR planes

② Slope of a line joining Origin point to reflectance observed nadir on Red-NIR planes (NDVI)

③ Length of a line joining Origin point to reflectance observed nadir on Red-NIR planes

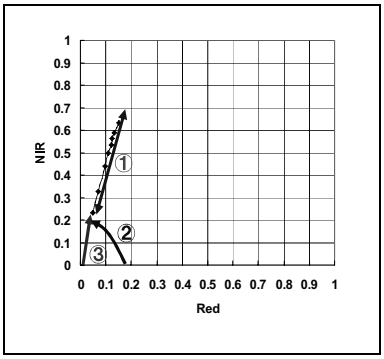


Fig.9 importance parameter for structure classification

① is parameter to show structural complicacy of vegetation zone for chapter 4.4. ② is parameter to show changing direction of the line, and it is able to use NDVI. ③ is parameter to show changing LAI or vegetation coverage which do not appear on NDVI value. BRF is changed with vegetation coverage of nadir. ③ is used to compare coverage of vegetation which have same NDVI value.

Comparing BSI and ① - ③, BSI have similar information of ① and ③ in the value. ① is structural information and ③ is coverage. Thus, BSI has information as both structural and coverage, the BSI value may be same even if differ vegetation zones are evaluated using it. Therefore it is important to evaluated with separate ① - ③ to analyze physically means.

5. BRF OBSERVATION USING TERRA/MODIS DATA

5.1. OBSERVING ARIA

Swath of MODIS is very wide as about 2330km; illumination distributions on the surface of earth are not constant in a scene. Thus, It is difficult to monitor wide aria, because ① and ③ are sensitive to illumination changing. Considering this effect, analysis is limited narrow aria in a scene, and it assumes that the aria illumination distributions are constant. In this chapter, the aria also set in Bousou- peninsula; Japan (Fig 3a).

5.2. EACH VEGETATION ZONE OF BRF AND NDVI

About 3points as rice filed zone, crops and woods zone, and forest zone, BRFs were researched (Fig 3a). Analyzed data were selected from DOY 218-231 and non-cloud data. The data already have been corrected geometry. Fig.10 shows the relationship between sensor zenith angle and solar zenith angle, relative azimuth angle. Solar zenith angle is almost constant in that term. About relative azimuth angle value, when sensor zenith angle is (+) (it means off-nadir data located in the west of nadir, satellite located in the east of observing aria), sunlight incident direction effect on principal, nadir data have. While, when sensor zenith angle is (-) (it means off-nadir data located in east, satellite located in west), nadir data have back-light direction effect on principal.

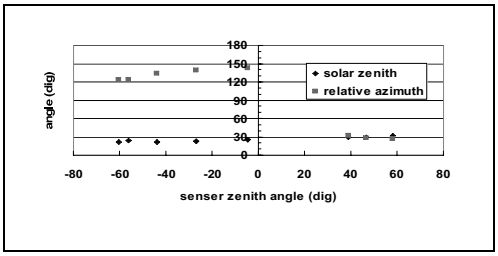


Fig.10 sensor zenith angle vs. solar zenith angle, relative azimuth angle

Fig.11a-c is graph of sensor zenith angle vs. reflectance. And Fig.11d is sensor zenith angle vs. NDVI. In Rice filed zone, which seem to have high coverage and flat structures, it is difficult to change reflectance even if sensor zenith angle is changed. In crops and woods zone, and forest zone, high reflectance value is observed at sensor zenith angle (+) and low value at sensor zenith angle (-).It is likely that, vegetation zones make shadow on themselves and satellite measure it when satellite observe from back-light direction.

In addition to, there is undulation by mountain in forest zone. It seems to be affection of undulation, it is necessary to more research in future.

About NDVI, although there are some of data spread, each point does not have big changing.

5.3. TRIMMING OF NADIR AND OFF-NADIR

From some of scenes which have been corrected geometry, Nadir and Off-nadir data were chosen and made. Nadir data was trimmed from a scene whose observation aria located center. Off-nadir data also were trimmed from a scene whose aria located edge (Fig.12). ①- ③ are calculated from the coupled data.

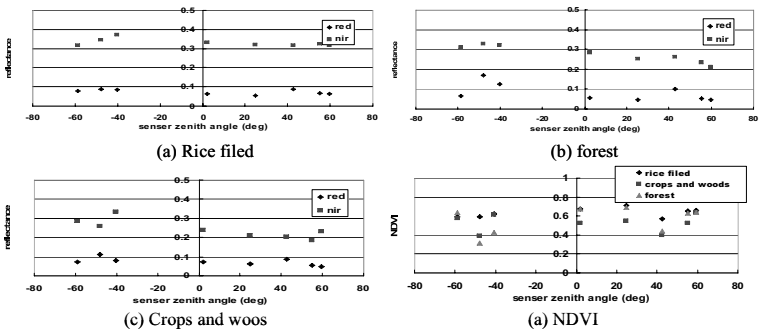


Fig.11 sensor zenith angle vs. reflectance, NDVI

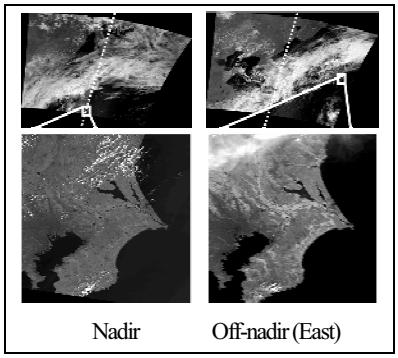


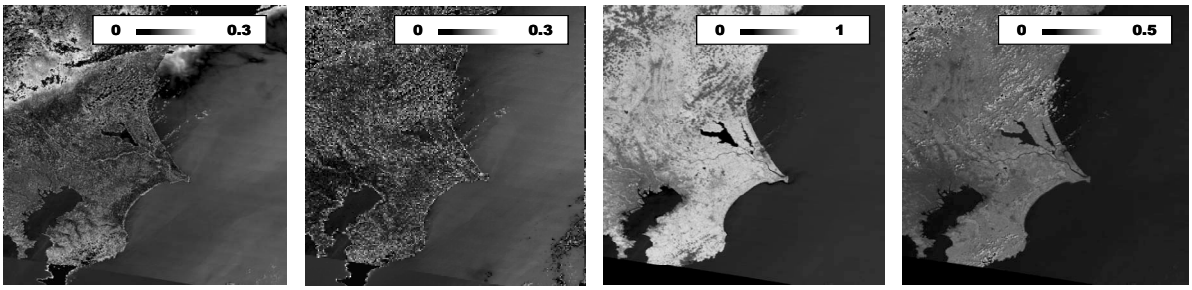
Fig.12 Trimming Images

5.4. RESULT OF PROCESSING

Fig.13a-d show result of processing. Nadir is DOY 222, Off-nadir of EAST is 223, WEST is 221. Sensor zenith angle of both Off-nadir are about 50 degrees.

Firstly, describing about vegetation cover, there are not much different about the 3points in ② (Fig.13c).However, ③(Fig.13d) shows these value is [Rice filed] > [Forest]>[Crops and woods].From these, it is possible to estimate that vegetation cover of rice filed zone is high, and crops and woods zone is low.

Secondly, about structure, East ①(Fig.13a) shows [Forest]>[Crops and woods] >[Rice filed] , it is possible to estimate that structural of rice filed zone is complicate and crops and rice filed is simple. However, there are not much different of these point in West ①(Fig.13b). It is due to changing reflectance from Nadir to Off-nadir of West is lower than to Off-nadir of East. It is necessary to research that Off-nadir of West always is difficulty change in future, although using ① is able to estimation to structural differ.



(a) ① EAST (b) ① WEST (c) ② (NDVI) (d) ③

Fig.13 Calculated Image of the method

6. CONCLUSION

In this study, a method of vegetation structures classification using BRF is considered from data which measured from spectrometer on autonomous navigation helicopters, and MODIS.

The more vegetation zone has complicacy structure, the bigger BRF change. Vegetation structures have been able to be estimate from changing some quantity which is measured on Red-NIR planes. In addition to, it is possible to estimate structures of vegetation zone using MODIS data.

The future direction of this study will research other effect which make BRF change such as Differ of Off-nadir between East and West, solar zenith angle, seasons.

ACKNOWLEDGEMENT

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