FOREST MEASUREMENT USING LASER SCANNER AND REMOTE SENSING DATA OF MULTISPECTRAL AND HYPERSPECTRAL

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ABSTRACT

Spectral analysis in a forest area using ASTER (a spaceborne multispectral sensor) and CASI-3 (an airborne hyperspectral sensor) was conducted for the effectiveness and efficiency of the tree species classification. In addition, in order to estimate the biomass for tree height measurement, an airborne laser scanner was employed. As a result, it was confirmed that the tree species classification using CASI-3 and the biomass measurement using laser sucanner have an acceptable accuracy at a stage of reconnaissance survey.

1. INTRODUCTION

Effective forest management and conservation using remote sensing is expected in order to control green house gas absorption and preserve bio-diversity. Kyoto Protocol, adopted by the UNFCCC (COP3) in 1997, requires each participates to cut the pre-establieshed amounts of carbon dioxide (CO_2) emmision. In the UNFCCC (COP7), the members agreed offset of CO_2 emission by CO_2 absorption. In this regard, the accounted forest should be under appropriate conservation management. Meanwhile, COP6 incorporated the items regarding forest biodiversity in 2002 based on “Biodiversity Treaty” of the UNCED in 1992. There is a demand of effective tree species classification and biomass measurement in vast uninvestigated regions to meet the above requirements using remote sensing.

Developing a spaceborne hyperspectral sensor is one of missions of ERSDAC, aiming at its utilization in environmental conservation, forest management and disaster prevention. In order to study the validity of hyperspectral sensor in forest management, we estimated tree species classification and biomass using a combination of an airborne hyperspectral sensor and an airborne laser scanner. This study confirmed the effect of a hyperspectral sensor in tree species classification and a laser scanner in biomass measurement. In addition, we estimated tree species classification using a spaceborne multispectral sensor, which can observe a wider aera than an airborne sensor.

2. STUDY AREA

The study area, Tama Forest Science Garden locates in the west of Tokyo, consists of temperate belt evergreen broad-leaved trees, subarctic region broad-leaved deciduous forest and boreal conifer tree having 620 species of 6,000 trees. This study area has been conducted tree species classification and tree height by on-site measurement, so we can compere results of remote sensing with on-site measurement.

3. CLASSIFICATION OF TREE SPECIES USING HYPERSPECTRAL DATA

3.1 Method of hyperspectral analysis

CASI-3, an airborne hyperspectral sensor, manufactured by Itres was used for this study. Number of bands of CASI-3 is 72 channels, whose wavelength is from 400 to 1,050 nm. It has approximately 1-meter spatial resolution at base level (at 160 meters above) when flight altitude is approximately 2,000 meters above. The shooting date and time was between 10:14 and 10:22 on September 1st, 2004. The CASI-3 data was deal with geometric correction, conversion to spectral radiance, atmospheric correction (calculation of reflectance), and Continuum Removal (CR).

The conversion of spectral radiance was multiplyed 0.001 by the digital number of CASI-3. FLAASH was used for atmospheric correction. Regarding the correction of water vapor amounts required in atmospheric correction, we used the result of water vapor absorption band at 820 nm. CR is the method to reduce the effects caused by different spectral reflectance in a single tree. In case where a tree canopy covers several pixels and there is variance of sunlight illuminating angles (Clark and Roush, 1984). This study was conducted within the range of green wavelength where reflectance from plants increases (CRgreen: CASI-3 band 23 to 49: 484 to 675 nm) and red wavelength where chlorophyll absorption band exists (CRred: CASI-3 band 34 to 56: 546 to 763 nm).

Then, supervising trees for the classification was selected. Ten trees were selected in order to have variety of tree species and tree density taking biomass measurement into consideration. Tree species and material density are shown in the Table 1.

With regard to classification method, we used SFF (Spectral Feature Fitting) method (Clark *et al*., 2003) and SAM (Spectral Angle Mapper) method. We applied those methods to CRred and CRgreen, and selected the method and wavelength most consistent with result of on-site measurement.

Table 1. Supervisors of tree species

	Species	Tree density (kg/m^3)		Species	Tree density (kg/m^3)
S01	blue Japanese oak	950	S06	zelcova	700
S02	blue Japanese oak	950	S07	fir	450
S03	Quercus gilva Blume	900	S08	fir	450
S04	Japanese ceder	380	S09	Japanese cypress	430
S05	Japanese ceder	380	S10	pinus taeda	580

3.2 Result and conclusion of hyperspectral analysis

The examination of the supervisory tree's CR spectrum revealed that SFF method is best fit in the CRgreen classification. First, from the comparison of the selected supervisor tree's CR spectrum, the difference of each tree species spectrum is more distinct in CRgreen (See the Figure 1). As for the characteristic of plant spectrum, pigment absorption and increase of reflection in green-color are seen in CRgreen, while chlorophyll absorption is seen in CRred. This feature is considered to be the cause of this distinct spectrum in CRgreen.

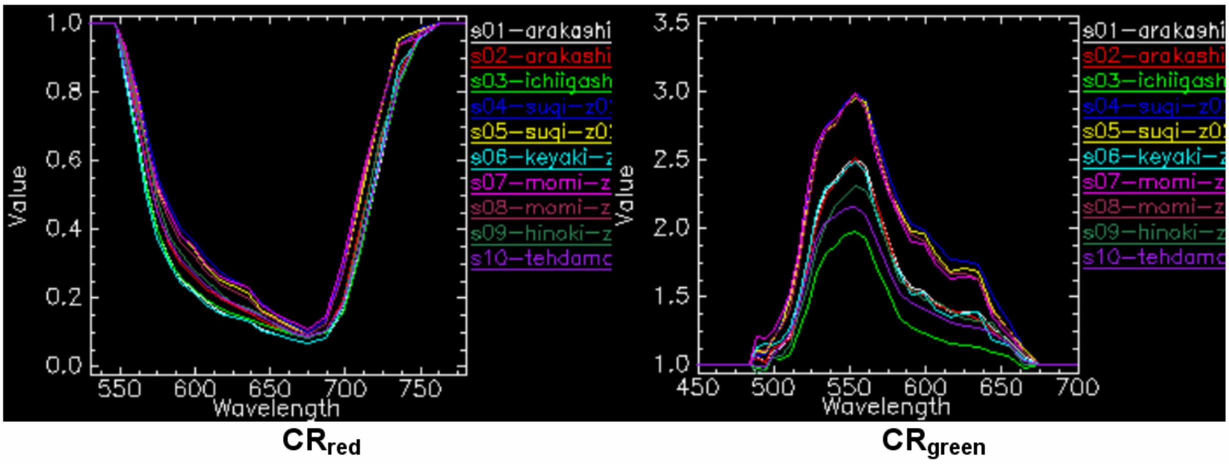

Figure 1. Separation of supervisors using green and red CR spectrum.

Second, CRgreen classification results using SFF method and SAM method are as follows. In SFF method, overall figure dose not show similarity except for ceder (S05) and fir (S08). That proved the adequacy of SFF method. In SAM method, similarity between ceder and fir, blue Japanese oak (S02) and zelcova (S06) are seen (See the Figure 2). This result leads the assessment that SFF method is superior to SAM method in this classification. The Figure 3 shows the result of tree species classification with SFF method using CRgreen.

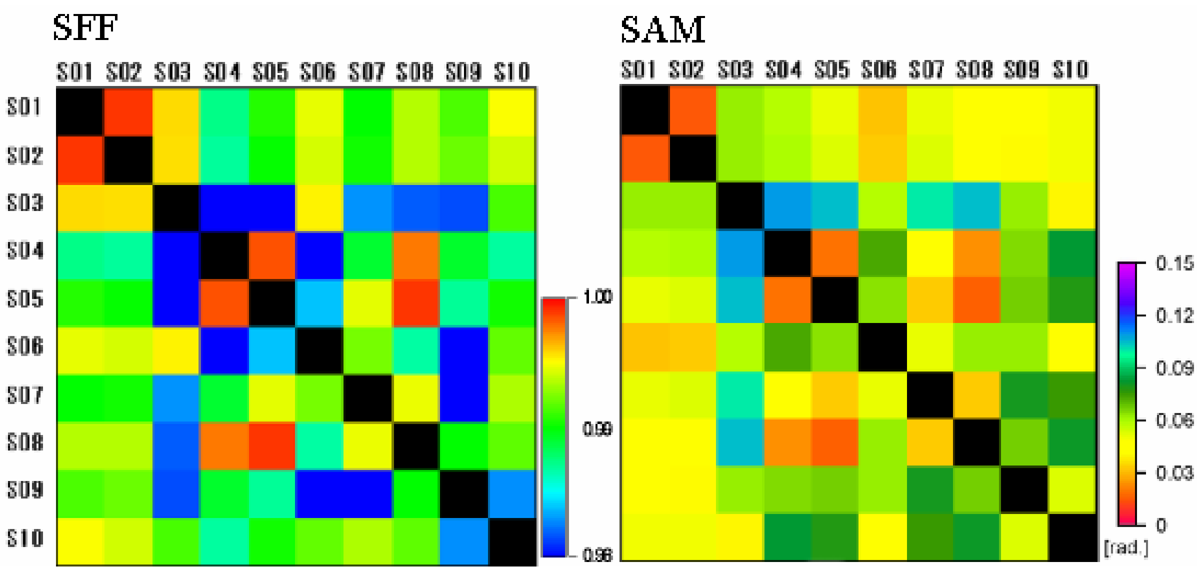

Figure 2. Similarity of CRgreen supervisor spectrum based on SFF goodness of fit and SAM angle (The numbers shown in Table 1).

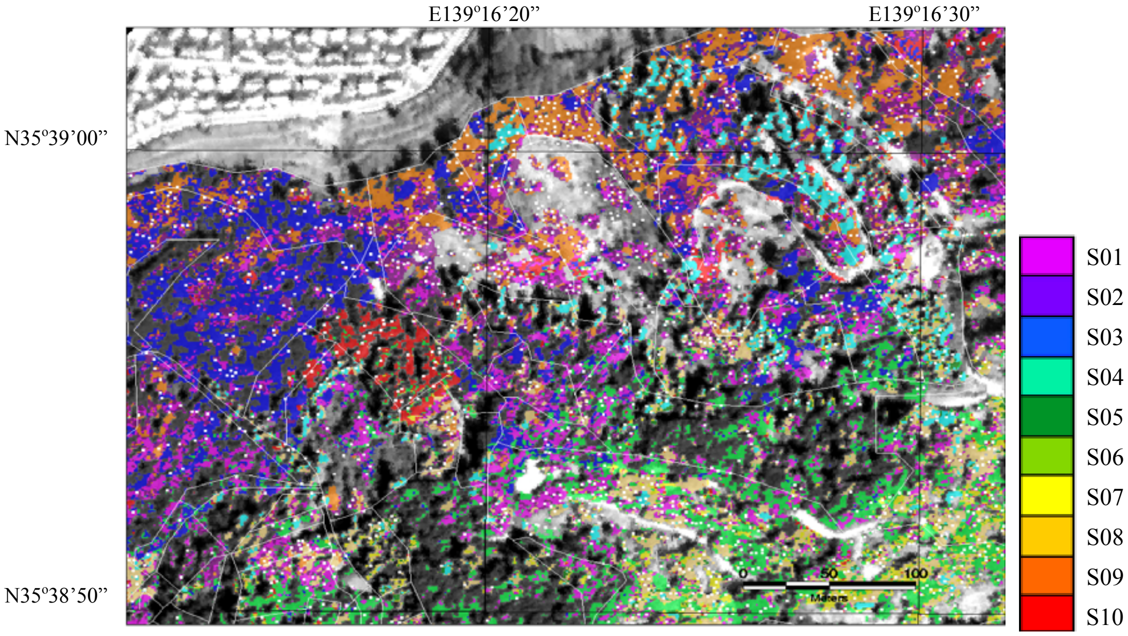

Figure 3. Classification result of tree species by SFF using CRgreen data of CASI-3.

4. CLASSIFICATION OF TREE SPECIES USING MULTISPECTRAL DATA

4.1 Method of multispectral anlysis

For the spaceborne multispectral sensor, TERRA/ASTER, developed by Ministory of Economy, Trede and Industry, was used. Granule ID of ASTER data which this study used is ASTL1B0409160132410410040669. The shooting date and time was 10:32 on September 16th, 2004. Converted CASI-3 data was used for atmospheric correction with empirical method. CASI-3 data was obtained at around the same time of this study. The pixel with high radiance and one with law radiance were selected from ASTER image. Presuming that the proper reflectance of the pixels was equals to the obtained reflectance from CASI-3, we set up the conversion equation of all bands and applied them to the whole images.

As for the supervised tree in ASTER image, we selected the same one chosen in CASI-3. ASTER has 15-meter spatial resolution, so in many cases, a tree canopy should fit in a single pixel. However it is possible that a tree canopy covers several pixels, so we conducted CR as we did in CASI-3 data to remove the effects of mixcel. We employed SAM method for classification of ASTER image.

4.2 Result and conclusion of multispectral analysis

In the classification of the selected supervisor trees in ASTER image using SAM method, blue Japanese oak (S01), Quercus gilva Blume (S03), ceder (S05), zelcova (S06), fir (S07), and Pinus Taeda (S10) showed similarity (See the Figure 4). In tree species classification using the supervisor trees in the investigation area, more than a half of the plants in this area were extracted as fir. This indicates that tree canopy needs to be large enough to occupy a whole pixel otherwise the spectral resolution capability of ASTER is unable to precisely classify tree species.

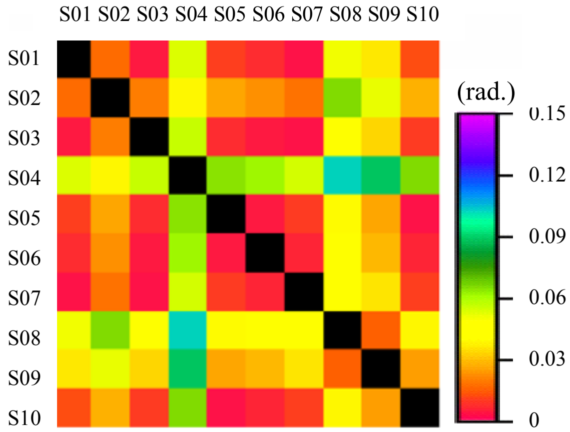

Figure 4. Similarity of ASTER supervisor spectra based on SAM angle (The numbers shown in Table 1).

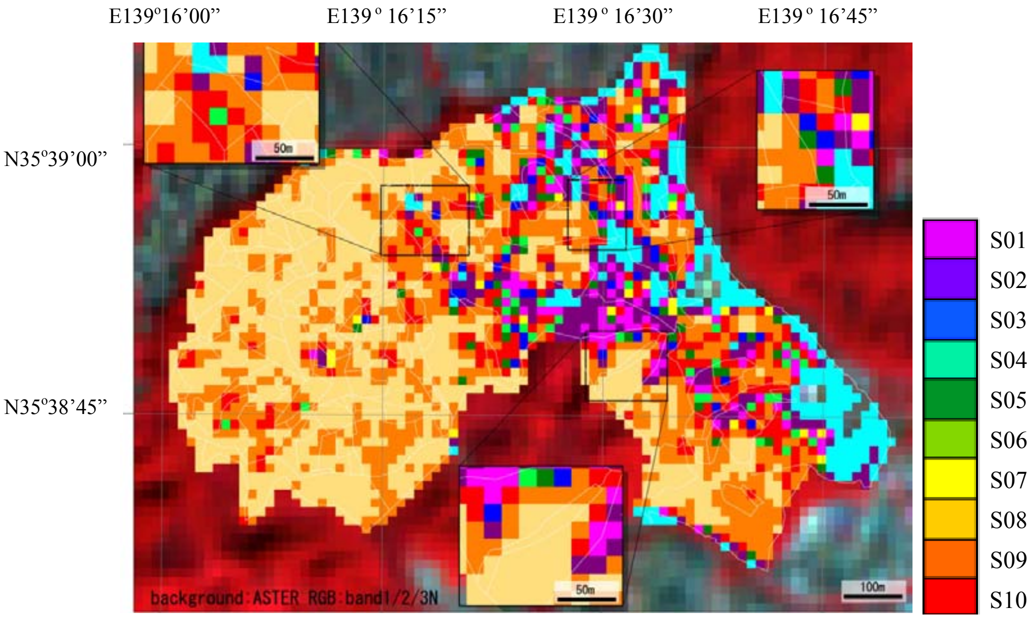

Figure 5. Classification results of tree species using ASTER data.

5. BIOMASS MEASUREMENT

5.1 Method of biomass measurement

Based on comparison between tree height by an airborne laser measurement and the tree height and diameter breast high by actual on-site measurement, we sorted tree species using remote sensing. And we measured biomass from this result. For an airborne laser scanner, ALTM2050DC manufactured by Optech was used. The irradiation density of this instrument is approximately 60-centimeter per point.

In airborne laser measurements, we created surface model, which consists of tree crown altitude, using only the first return reflected mainly from tree crowns. The ground altitude was used by commercially available 10-meter mesh DEM. The second return of laser, which penetrats tree crown, was not used becuase it does not necessarily reflect the ground surface. Tree heights were calculated using difference between the surface model (tree clown altitude) and 10-meter mesh DEM (ground altitude).

The tree height and the diameter breast high were measured on-site. We set 2-meter ranging rots beside trees and measured the tree height with visual measurement. The ratio between a tree height and a diameter breast high was measured on-site. Then a diameter breast high can be calculated from the tree height by airborne laser measurements. Biomass was measured based on the obtained tree height and the diameter breast high delived from airborne laser measurements and the material density of tree species classified by remote sensing.

5.2 Result and conclusion of biomass measurement

The biomass using the material density and dimension of the existing database is approximately 2,450 ton. The biomass calculated from tree species classification result of CASI-3 data and tree height obtained by airborne laser measurements is about 2,170 ton. By the way, the biomass using the result of tree species classification by ASTER data and tree height obtained from airborne laser measurements is approximately 2,000 ton. This result is considered to have enough accuracy for reconnaissance survey, which uses CASI-3 data.

6. DISCUSSION

It is considered that the accuracy of the biomass measurement depends on the accuracy of tree species classification. The biomass based on the existing data shows almost same values as the biomass used by CASI-3 data. This proves the effectiveness of tree species classification and biomass measurement using hyperspectral data. In the future, we will attempt to expand the investigation of supervised tree species and examine the best observation time for tree species classification. This classification using hyperspectral data will be improved by these studies. In addition, by comparision of ASTER and CASI-3 data, we will make the effective tree species classification and the best observation time to shoot ASTER data.

Based on this study, ERSDAC plans to examine application methods of a spaceborne hyperspectral sensor.

7. REFERENCES

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