EVALUATION OF PADDY YIELD AND QUALITY ESTIMATION METHODS BASED ON VARIOUS VEGETATION INDICES, NDSI AND PLS USING BRDF-CORRECTED AIRBORNE HYPERSPECTRAL DATA

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1. INTRODUCTION

Ministry of Economy, Trade and Industry (METI) of Japan plans to launch a spaceborne hyperspectral sensor in 2013. A hyperspectral sensor is effectively and precisive for rice yield and quality estimation. This study aimed to develop paddy yield and quality estimation methods using an airborne hyperspectral sensor prior to the launch of the spaceborne hyperspectral sensor. As the swath of the spaceborne hyperspectral sensor is narrower than that of a spaceborne multispectral sensor, pointing function will be utilized to augment the coverage. Pointing function causes an apparent reflectance changes due to the Bidirectional Reflectance Distribution Function (BRDF). In our previous report in IGARSS08, we investigated the method of BRDF correction using an airborne hyperspectral sensor having a wide Field Of View (FOV) [1]. This study weighs estimation methods of paddy yield and quality based on various Vegetation Indices (VI), Normalized Difference Spectral Index (NDSI) and Partial Least Squares (PLS), using the airborne hyperspectral data corrected with BRDF correction as well as field validation data.

2. STUDY AREA

The study area is located in Miyagi prefecture, the northeast Japan. The study area extends about 3 x 2 km. The land is generally flat and used for paddy fields with the size of each agricultural field approximately 80 m east-west x 120 m north-south.

3. FIELD STUDY

At important stages of rice growth, paddy fields were measured by an airborne hyperspectral sensor “AISA” and a field-portable spectrometer “FieldSpec pro FR”. Those stages in Japan are in July (panicle initiation stage), August (heading stage), and September (maturing stage).

AISA were acquired with the wavelength range of 400-2500 nm and average wavelength resolution of 8.9 nm in VNIR and 11.4 nm in SWIR (190 bands), a Field Of View (FOV) of 22 degrees. Spatial resolution was 1.5 m and swath width was 443 m at a flight altitude of about 1,000 m. Accordingly, this study area has 13 north-south flight lines and one east-west flight line which due to correct the radiance of those lines.

Fifty sites were selected for validation. The quadrat (5 x 5 m) was set on near-uniform growth place at least 10 m inside from the edge of paddy field, because border effects make variety of rice growth. In order to record the growth, the rice plant was taken a photograph vertically by a digital camera and the plant height was measured at 10 samples in each quadrat. After harvesting, paddy yield and quality, which is crude protein of brown rice, were measured.

Average FieldSpec data of paddy rice was provided by 10 points measurement in each site. The wavelength range, wavelength resolution and FOV of FieldSpec were 350-2,500 nm, 1 nm and 20 degrees, respectively. Observation height was 10-20 cm upper from paddy rice canopy.

4. ANALYSIS METHOD

BRDF characteristic curve was calculated using pixel values, the sensor orientation and solar angle of the overlaps between each flight line. BRDF effect was corrected for each flight line [2].

The correlation between the reflectance and rice yield and quality data was assessed by 16 kinds of VI, NDSI and PLS. VI were used in reflectance of wavelength determined in each index. NDSI was used thorough combinations of two wavelengths (NDSI [i, j] = (Rj – Ri) / (Rj +Ri) using reflectance values Ri and Rj at i and j nm wavelengths). And distribution of correlation coefficient was derived using the relation expression of NDSI. Bands used the PLS were selected from the band with simple regression coefficient of 0.4 or more.

5. RESULT AND DISCUSSION

Correlation coefficients of VI are shown in Table 1. In the analysis of AISA data, mNDVI (= (R750 – R705) / (R750 + R705)) showed the highest correlation with paddy yield and quality, followed by PI2 (= R695 / R760). In the analysis of FieldSpec data, NDVI (= (R845 – R665) / (R845 + R665)), followed by SIPI (= (R800 – R445) / (R800 – R680)), had the highest correlation with yield, while mNDVI, followed by PI3 (= R440 / R690), had the highest correlation with paddy quality.

The result of NDSI is shown in Figure 1. This demonstrated that combination of 730-750 nm and 770-1,100 nm gave a high correlation (correlation coefficient of approximately 0.8) with paddy quality for both AISA and FieldSpec data. Correlation with yield was not as good as that with quality.

As a result of analysis, the strongest correlation between actual measurement, which is paddy yield and quality, and estimation values, which are VI and NDSI, is found in the NIR wavelength range, which covers the red edge and reflects the vegetation structure. PLS analysis is currently underway the details of AISA and FieldSpec data and the results will be revealed in February 2009.

6. FUTURE PLANS

We will examine the most accurate method to estimate the yield and quality by integrating and comparing to the results of the VI, NDSI and PLS analysis findings by March. In the PLS analysis, band selective PLS (IPLS) will be employed for comparison. By this investigation, we will intend to develop a more simple, convenient and reliable estimation method for a spaceborne hyperspectral sensor.

7. REFERENCES

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[2] T. Suhama, A. Rikimaru, and K. Takahashi, "Brightness gradients correction in airborne hyperspectral data by using empirical BRDF model", *Journal of the Japan Society of Photogrammetry and Remote Sensing*, 46, 4, pp. 55-60, 2007 (in Japanese)

Table 1 Correlation coefficients of VI

Index		FieldSpec		AISA	
		Yield	Quality	Yield	Quality
Pigment	SR	0.33	0.48	0.38	0.56
	NDVI	0.43	0.42	0.41	0.50
	mNDVI	0.37	0.69	0.41	0.61
	SGR	0.02	0.14	0.00	0.01
	PRI	0.18	0.43	0.03	0.22
	RGR	0.16	0.02	0.13	0.27
	NPCI	0.29	0.39	0.01	0.02
	SRPI	0.27	0.41	0.01	0.01
	NPQI	0.35	0.30	0.01	0.09
	SIPI	0.41	0.33	0.36	0.35
	PI1	0.34	0.59	0.04	0.14
	PI2	0.40	0.58	0.41	0.53
	PI3	0.29	0.63	0.03	0.03
	PI4	0.32	0.18	0.22	0.18
Water	NDWI	0.02	0.02	0.15	0.23
	WBI	0.07	0.16	0.12	0.00

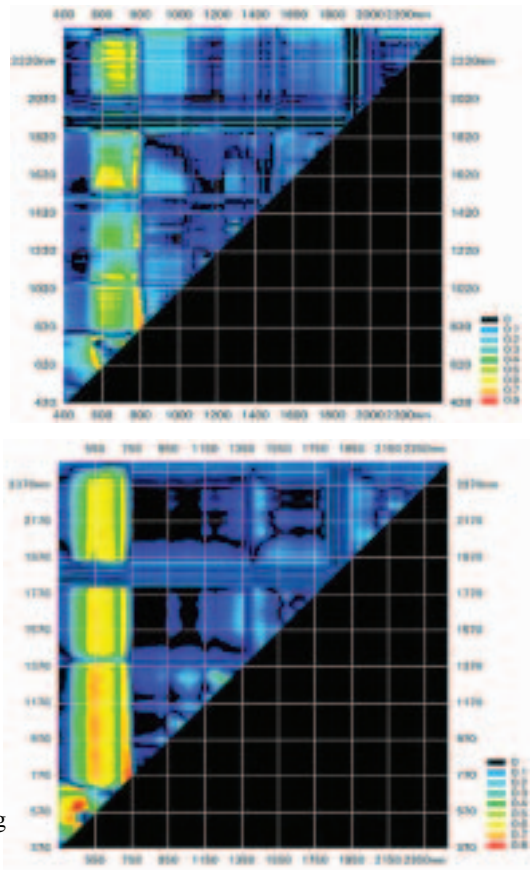

Fig. 1 Distribution of correlation coefficient of paddy quality using NDSI. Upper is AISA, Lower is FieldSpec data.