COMPARISONOF SURFACE REFLECTACE BETWEEN FIELD SPECTRORADIOMETERAND MULTI SATELLITE IMAGE FOR CROP MONITORING

Woranut Chansury[1]YootthapoomPotiracha[2]and Anusorn Rungsipanich[3]

Geo-informatics and Space Technology Development Agency (Public Organization)
120 The Government Complex Commemorating His Majesty The King's 80th Birthday Anniversary,
5th December, B.E.2550(2007) Building B 6th and 7th Floor, ChaengWattana Road,
Lak Si, Bangkok 10210, Thailand;
Tel:.+66(0)2141-4536 ; Fax: +66 (0) 2143-9605;
E-mail:woranut_c@gistda.or.th[1], ypoti@gistda.or.th[2] and anusorn@gistda.or.th[3]

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ABSTRACT: Multispectral images are a good source of crop, soil, and ground coverage information. Spectral reflectance provides a useful tool for monitoring crop growing status. A series of optical image were obtained by Landsat multispectral imaging system on the maize field.Landsat TM data acquired with a ground based from FieldSpec® at the same period, for based on the absolute radiometric calibration of the multispectral and the use of a radiative transfer program for atmospheric correction.The study is aims to collect and to analyze spectral surface reflectance characteristics of maize at Pattananikom district, Lopburi province in the central of Thailand. Field spectroradiometer of spectral surface reflectance measures different growth stages of crop in the wavelength range 350 - 1075 nm. Following surface reflectance in bands includingBLUE, GREEN, RED and NIR calculated to compare between field spectroradiometer and satellite imagery.The spectral reflectance of the wavelength relatebetween the reflectance of the FieldSpec® and satellite imagery.

1.INTRODUCTION

Spectral reflectances in the visible and near infrared bands (400–2500 nm) haveidentified as a popular method to sense localized factors relating to the soil and crop. Results from spectral reflectance measurements have been widely used in arable research such as: soil properties (Barnes & Baker, 2000), crop density (Basso et al., 2001) and crop nitrogen (Oberti & De Baerdemaeker, 2000). However, spectral reflectance techniques are still not widely used for commercial research andapplications.

This paper presents the results obtained for investigating a life cycle of maize at Pattananikom district, Lopburi province in the central of Thailand using field spectroradiometer. The spectral signature of crops has been acquired in-situ data from beginning of growth stage until flowering stage.

2.OBJECTIVE

(1) Measure the reflectance of maize in difference growing stage using the FieldSpec ® Hand Held.
(2) Atmospheric and radiometric correction of Landsat TM 5 data using the COST model
(3) Comparison of surface reflectance between FieldSpec ® Hand Held and LANDSAT TM and MODIS Aqua satellite data for difference stage of maize

3. STUDY AREA

This case study area following the aim of paper is located at Pattananikom district, Lopburi province in the central of Thailand (Figure 1). The selected area is a traditionally agricultural area with a diversity of annual cultivation and irrigation system from Pasak Chonlasit dam, one of the biggest dams of Thailand.

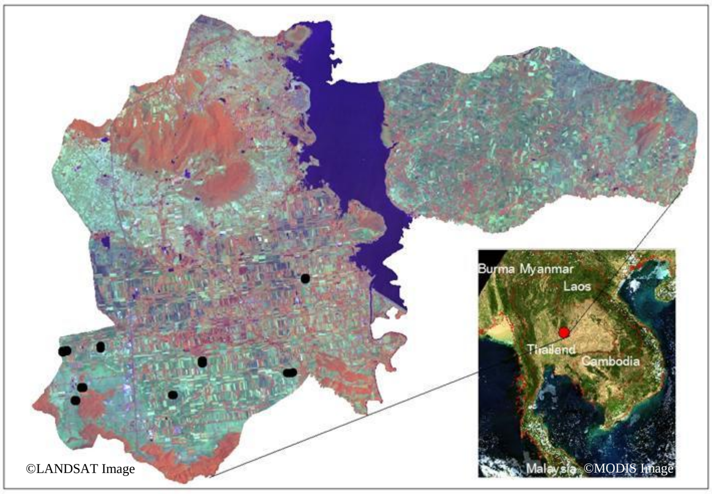

Figure 1. Landsat TM image of study area at Pattananikom district, Lopburi province in the central of Thailand

4. MATERIAL

4.1 Spectroradiometer (FieldSpec®)

4.2 ViewSpec Software

4.3 Satellite data using in this study are MODIS Aqua and Landsat TM during May to July (Table1.)

Table 1. The satellite data of MODIS and Landsat TM

No	Satellite/Acquisition date
1	MODIS Aqua 14 May 2011
2	MODIS Aqua 4 July 2011
3	Landsat TM 14 May 2011
4	Landsat TM 4 July 2011

5. METHODOLOGY

Methodology showing in Figure 2 operates in two parts. First, Field spectroradiometer measures directly above the canopy of maize in every stage. The results are surface reflectance value in clearly day and atmospheric condition during 10.00 am to 14.00 pm. Second, Multi-spectral satellite images (Landsat TM and MODIS Aqau.) running in two steps are pre and post-processing. Pre-processing step compose of radiometric and geometric process from Remote sensing software. Post-processing step, Digital number in satellite pixels converted to reflectance value. Finally, we compared and correlated surface reflectance from FieldSpec® with multi-spectral satellite images.

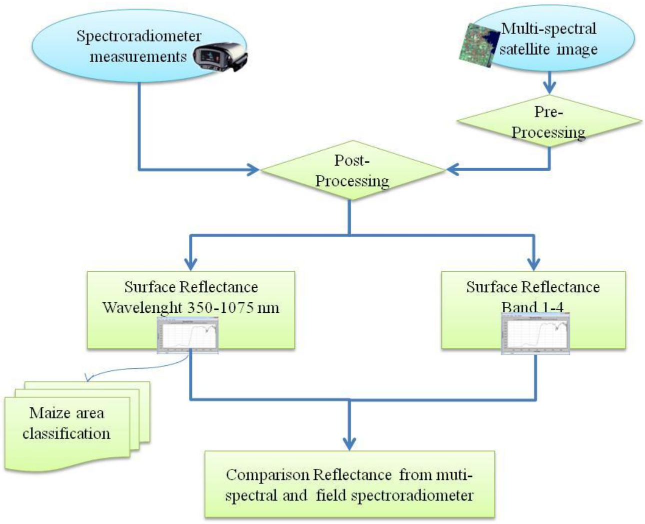

Figure 2. Flow Chart of Methodology

5.1 Field Spectroradiometer Reflectance Data

Spectroradiometer measurements have been used to indicate surface reflectance during different growing stage of maize in the study area as shown in Figure 3. Indeed the FieldSpec® wavelength are covering the ultraviolet, visible and near infrared bands from 350 nm to 1075 nm. The suitable duration to measure is begin of May (growth stage) to the end of July (flowering stage) which dense canopy surface area.

Growth Stage | Vegetative Stage | Flowering Stage

Figure 3. Field Spectroradiometer measurements

5.2 CALCULATION OF SURFACE REFLECTANCE

5.2.1 LANDSAT-5 TM Atmospheric and Radiometric Correction

Atmospheric and radiometric correction of Landsat TM 5 Data used the COST model of Chavez, 1996", S. M. Skirvin

(1) The first model converts each minimum DN value to an at-satellite minimum spectral radiance

$$L_{\lambda,min} = LMIN_{\lambda} + QCAL \times \left(\frac{LMAX_{\lambda} - LMIN_{\lambda}}{QCALMAX}\right) \quad \text{------------(1)}$$

$$L_{\lambda,sat} = LMIN_{\lambda} + DN \times \left(\frac{LMAX_{\lambda} - LMIN_{\lambda}}{QCALMAX}\right) \quad \text{------------(2)}$$

Where QCAL = Calibrated and quantized scaled radiance in unit of DN
QCALMAX = Range of rescaled radiance in DN (255)
$LMIN_{\lambda}LMAX_{\lambda}$ = Table 2(a) of Markham and Barker (1986) Minimum and Maximum Radiance at Sensor
DN = Satellite Imagery in DN value

(2) A haze correction is computed using the computed dark object values (Chavez 1996) :

$$L_{\lambda;1\%} = \left(\frac{0.01.d^2.\cos^2\theta_s}{ESUN_{\lambda}.\pi}\right) \quad \text{------------(3)}$$

$$L_{\lambda,Haze} = L_{\lambda,min} - L_{\lambda,1\%} \quad \text{------------(4)}$$

Where ESUN = mean solar Exoatmospheric given from table 2(b) Markham and Barker (1986)
d = is the sun-earth distance (Astronomical Unit) given from table 2(c)
θ = Solar Zenith Angle (90-sun elevation)

(3) The fundamental radiance to reflectance (rho) equation (eq. 2 of Chavez 1996) is:

$$\rho_p = \frac{\pi \cdot (L_{\lambda;sat} - L_{\lambda;haze}) \cdot d^2}{ESUN_{\lambda} \cdot \cos\theta_s} \quad \text{------------(5)}$$

$$\rho_p = \frac{\pi \cdot \left(L_{MIN\lambda} + DN \times \left(\frac{L_{MAX\lambda} - L_{MIN\lambda}}{255}\right) - L_{\lambda;haze} \cdot d^2\right.}{ESUN_{\lambda} \cdot \cos\theta_s} \quad \text{------------(6)}$$

Where ρ_P = reflectance value

Table2. (a) TM Post-Calibration Dynamic Ranges for U.S. Processed Data, (b) Solar Exoatmospheric Spectral Irradiances $ESUN_\lambda$ and (c) Sun-Earth distance in Astronomical Unit

Band	**TM Post-Calibration Dynamic Ranges for U.S. Processed Data ($Mw*cm^{-2}*ster^{-1}*\mu m^{-1}$) After 15 Jan 1984 (a)**		**Solar Exoatmospheric Spectral Irradiances $ESUN_\lambda$ ($mW.cm^{-2}.\ \mu m^{-1}$) Markham and Barker, 1986 (b)**	**Sun-Earth distance in Astronomical Unit (c)**	
	LMIN $_\lambda$	**LMIN $_\lambda$**		**Distance**	**Julian Day**
TM1	-0.150	-0.150	195.7	182	1.0167
TM2	-0.280	-0.280	182.9	196	1.0165
TM3	-0.120	-0.120	155.7	213	1.0149
TM4	-0.150	-0.150	104.7	227	1.0128
TM5	-0.037	-0.037	21.93	242	1.0092
TM6	0.123	0.123	7.452	258	1.0057

5.2.2 MODIS

The MODIS data were received from the Geo-informatics and Space Technology Development Agency (GISTDA) ground station at Ladkrabang in Bangkok, Thailand. The MODIS Aqua specification has 36 spectral bands between 0.405 and 14.385 µm. For this paper, select Level 2 products in two spatial resolutions are 250 m and 500 m. This product including reflectance and radian value in this study point to reflectance value.

5.3 Comparison of Field Spectroradiometer and Multi-spectral Reflectance

The surface reflectance measurement sites by FieldSpec® amount 30 samples covers all study area in difference stage of maize. We recorded a coordinates of sampling points from GPS Handle. Then,there are analyzed and correlated with the surface reflectancevalue from satellite imagery.

6. RESULT AND DISCUSSION

6.1 Field Spectroradiometer Reflectance

The surface reflectance value from Field Spectroradiometer measurements can plot different graph in each growing stage (Figure 4); Growth stage vegetative stage and flowering stage respectively draw in red green and blue line.

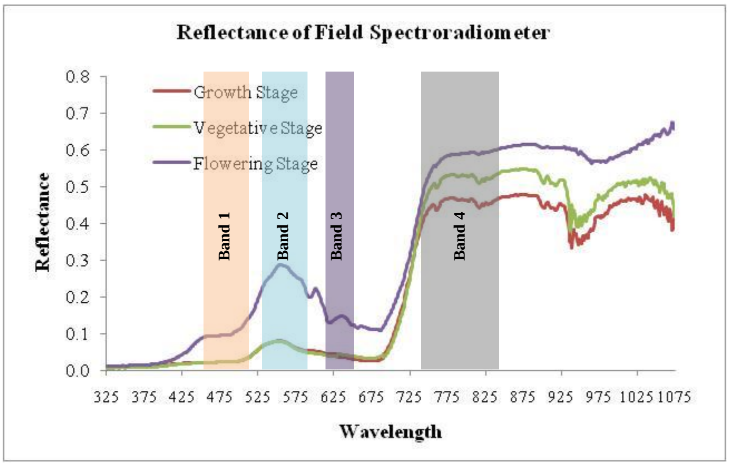

Figure 4. Maize's surface reflectance as given from FieldSpec®

Figure4. FieldSpec® result illustrates different surface reflectance of maize in blue green red and NIR bands (Wavelength 450-900 nm). In visible band, It is difficult to separate reflectance values in each growing stage.The surface reflectance especially in band 4 (760-900 nm) get higher potential to classify maize planting than another bands.

6.2 Calculation Surface Reflectance

Surface reflectance values calculated from satellite images (Landsat TM and MODIS Aqua)which following in same trend. The minimum and maximum reflectance values in band 1, 2, 3 and 4 shown in Table 3.

Table 3. In Band surface reflectance of Multi-optical image of maize.

	Landsat TM				**MODIS**			
	B1	**B2**	**B3**	**B4**	**B1**	**B2**	**B3**	**B4**
MIN	0.05255	0.06652	0.05337	0.19253	0.13156	0.10095	0.06883	0.27091
MAX	0.09124	0.11765	0.14011	0.50218	0.28739	0.26908	0.25498	0.42478

The spectral signature of the maize defines from reflectance interval of bands, which used for many applications such as irrigation demand, landuse/landcover classification. The maize classification using remote sensing technique has 226.54 km^2 in Pattananikom district (Figure 5).

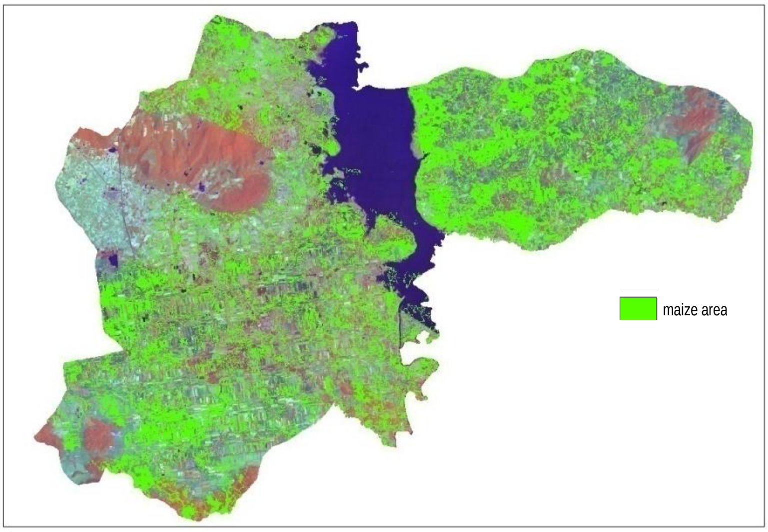

Figure5. Maize area classification usingsurface reflectance of Landsat TM

6.3 Comparison of Field Spectroradiometer and Multi-Spectral Image Reflectance

The comparison of surface reflectance value between FieldSpec® and satellite image are related in near infrared band but irrelevantin visible bands. The relationship analysis as follows;

For Landsat TM the equation is Y = 4.545x - 1.385, highest correlation is R^2 = 0.843 and coefficient 0.05

And MODIS Aqua the equation is Y = 9.76x - 0.647, highest correlation is R^2 = 0.758

The analysis results have affected from internal factors (amount of samples, fields survey duration and acquisition date of satellite data) and external factors (physical factors and atmosphere condition). Table 4 and 5 shown average surface reflectance in each bands

Table4. Comparison of Field Spectroradiometer and Landsat TM surface Reflectance in growth stage

Accusition Date	**Stage**		**TM1**	**TM2**	**TM3**	**TM4**
FieldSpec®	Growth		0.0251	0.0650	0.0309	**0.4649**
Landsat TM 14 May 2011	Stage1		0.0680	0.0800	0.1054	**0.4011**
FieldSpec®	Vegetative		0.0249	0.0631	0.0379	**0.5329**
Landsat TM 4 July 2011	Stage2		0.0912	0.1177	0.1401	**0.4435**
FieldSpec®	Flowering		0.1069	0.2430	0.5329	**0.5963**
Landsat TM 4 July 2011	Stage3		0.0758	0.0934	0.0751	**0.5022**

Table5. Comparison of Field Spectroradiometer and MODIS Aqua surface Reflectance in growth stage

Accusition Date	**Stage**		**Band1**	**Band 2**	**Band 3**	**Band 4**
FieldSpec®	Growth		0.0216	0.0779	0.0332	**0.4742**
MODIS Aqua 14 May 2011	Stage1		0.1338	0.1027	0.0719	**0.3204**
FieldSpec®	Vegetative		0.0211	0.0766	0.0376	**0.5447**
MODIS Aqua 4 July 2011	Stage2		0.1733	0.1465	0.1179	**0.3123**
FieldSpec®	Flowering		0.0935	0.2806	0.1298	**0.6077**
MODIS Aqua 4 July 2011	Stage3		0.1712	0.1464	0.1192	**0.3359**

7. Conclusions

Generally, differential morphology of crop would have individual surface reflectance. The spectral signature of maize that vital importance knowledge in Remote Sensing and classification technique extract from of spectroradiometer measurements and satellite imagery. In each stage of maize, it is obviously pattern and color similar to fields survey and satellite images.Future study will plan to make spectral library of maize in order to indentify ages, species and yields prediction.

Thisstudy,a surface reflectance value few differ in maize planting because of limited samples and bandwidths, thus there are necessary to used hyper-spectral satellite image for classification.

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