Comparative results of Phenology Obtained from Satellite and Ground Observation Images on Paddy Field

Narut Soontranon*, Siam Lawawirojwong, Panwadee Tangpattanakul,
Panu Srestasathiern and Preesan Rakwatin

Geo-Informatics and Space Technology Development Agency (Public Organization)

120 The Government Complex, Building B 6-7th floor,
Chaeng Wattana Road, Lak Si, Bangkok 10210, Thailand

*narut@gistda.or.th

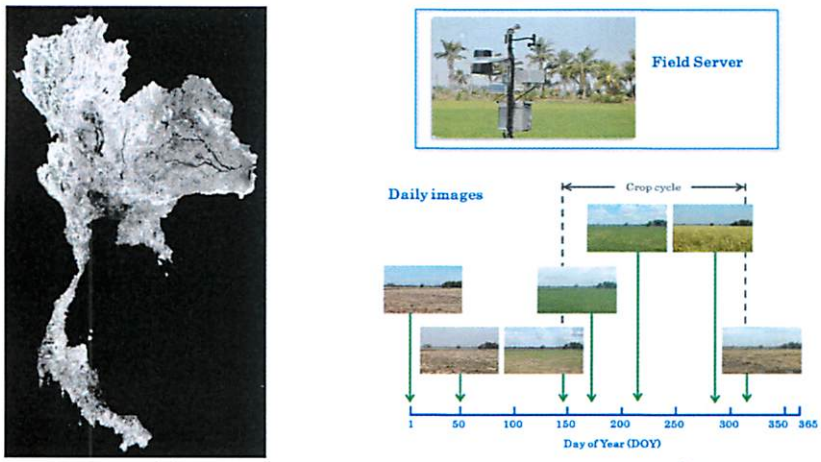
Keywords: Field Server, MODIS, Phenology, Vegetation Index, Excessive Green.

Abstract. Rice is the most significant economic crops in Thailand, which is required to monitor and estimate the growing area in a wide region. Regarding to the remote sensing technology, satellite images are used to analyze for classifying the paddy area. To validate the results of the paddy area, it is necessary to have the ground collection data. For the ground data, instead of field staffs, an equipment called Field Server has been installed and used to obtain daily images on the paddy. In this paper, the comparative results of satellite and Field Server images are experimented in order to understand the correlation between two platforms. Based on the vegetation index computation, satellite and field server images are computed to two phenological curves in an observation period. Two phenology curves are compared by using a simple linear regression method (R squared), which can be described the correlation between each other.

Introduction

Thailand is an agricultural country who supplies food resources for several countries around the world. Rice is one of the economic crops, which is the most significant crop in Thailand. To prevent the damages from various factors (e.g. global warming, disasters, diseases of plants), which are directly effect to the quantity and quality of rice and other crops, it is necessary to use the technology for monitoring and managing for the agricultural production. Regarding to the remote sensing technology, images obtained from Earth Observation Satellite (EOS) are used as input data for the rice monitoring system. A well-known EOS image used for plant observation is referred to MODIS (Moderate Resolution Imaging Spectroradiometer) image as shown in figure 1a. In general, MODIS images are computed for the vegetation index (VI) in an Area of Interest (AOI). The vegetation index is able to describe the stages of plant (rice) [4]. The vegetation index plotting in a period is known as the phenology [1,3,4], which can be used to describe the rice growing cycle. Given a set of time-series images obtained from the MODIS, the images can be computed to the phenology and classified for the paddy area. However, the MODIS images are degraded during bad weather conditions such as rain, cloud, fog, etc. A significant task used to verify the results of the paddy area is called filed data collection process. The process generally collects the data from the sample (paddy) fields which composed of stages of paddy, geo-coordinates (latitude/longitude), acquisition date & time; which is able to compare with satellite images for the data verification. To support the data collection process, instead of field staffs, an equipment known as Field Server (FS) is able to use for the data collection in a long period [4] as shown in figure 1b. Given the images obtained from two platforms (MODIS and FS), two phenological curves are compared by using the vegetation index in an observation period.

The rest of the paper is organized as follows. For the next section, the phenological curves obtained from MODIS and FS images are described. Obtaining two phenology curves at the same paddy, the comparative results are experimented. Finally, the paper is concluded and the perspective work is discussed.



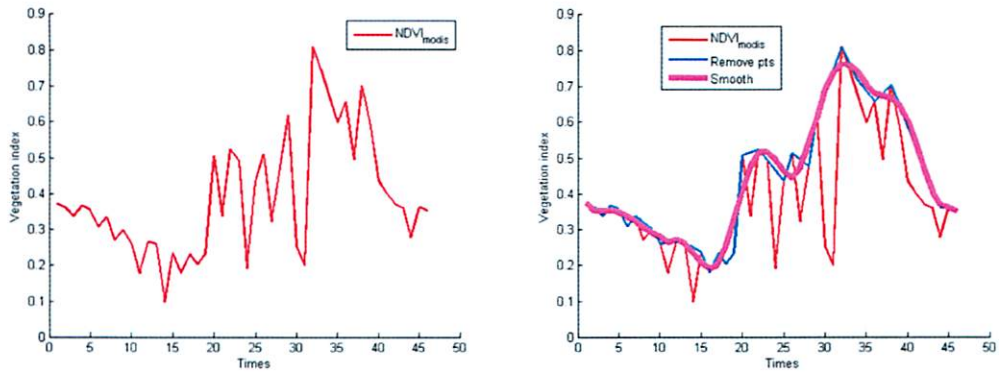
(a) (b)

Fig. 1 a) NDVI intensity from MODIS, map of Thailand. b) FS equipment and images.

Phenology of MODIS and FS images

For the images acquired in 2013, the vegetation phenologies computed from MODIS and FS are compared. Considering to two sets of images, MODIS provides images at 500 meters of spatial resolution with 8 day composite and FS provides daily images in JPEG format. For the comparative results, the temporal index is referred to DOY obtained from MODIS which is less temporal resolution than FS. Then, FS phenology is re-sampled and mapped to the MODIS phenology.

MODIS images. A well-known EOS images used for plant observation is referred to MODIS, which is a type of time-series images. For more details, the images are available for downloading from NASA's website [5]. To obtain the phenology, MODIS images at 500 meters with 8 day composite will be used for the experiments. The NDVI obtained from MODIS is shown in figure 2a, which consist of some degraded points by cloud, rain, etc. The smooth phenology is computed as shown in figure 2b. The computation steps are as follows.



(a) (b)

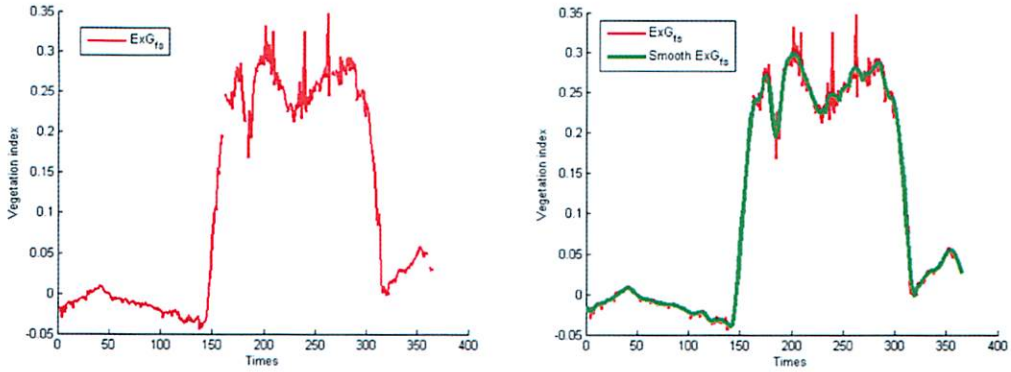
Fig.2 Phenology from MODIS based on NDVI: a) Phenology. b) Smooth phenology.

- Obtain the vegetation indices, NDVI and ExG (Excessive green) are computed on the corresponding pixel referring to the same location of FS image.
- Remove the points that are assumed the acquisition time during bad weather conditions such as cloud, rain. These points provide the low/high intensity values, which should be removed.
- Fill in the missing points (interpolation) and smooth the phenology by Savitzky-Golay [2].

FS images. The ground observation images are obtained from FS, which provides daily images taken at 10:00 a.m. The FS is included with a camera for acquiring RGB images. It should be noted

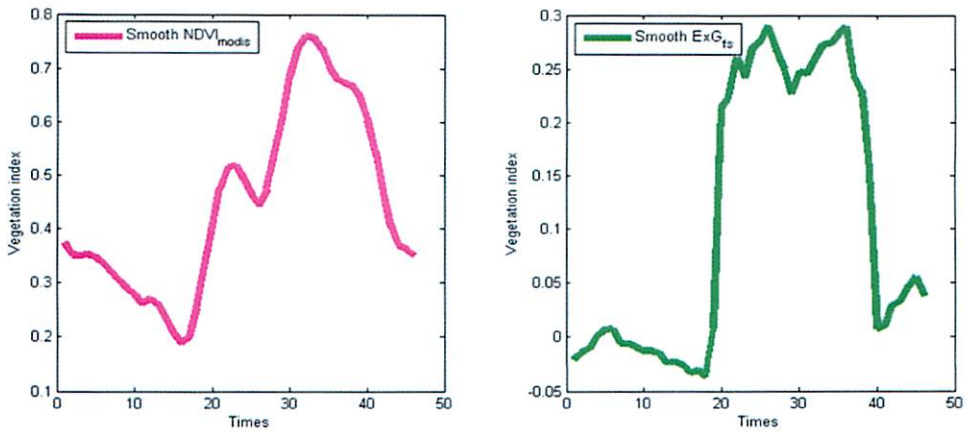
that the near-infrared (NIR) band is not included in the images. The FS images cannot compute for the NDVI, the vegetation index will be relied on ExG index [4]. To obtain the phenology from FS images as shown in figure 3, the computation steps are as follows.

- Determine the paddy region on FS image (paddy segmentation).
- Compute the vegetation index from daily image, the ExG index is used for the FS images.
- Fill in the missing points (interpolation) and smooth the phenology by Savitzky-Golay [2].



(a) (b)

Fig.3 Phenology from FS (daily images) based on ExG: a) Phenology b) Smooth phenology.



(a) (b)

Fig.4 Comparison of the phenology curves between (a) MODIS and (b) FS images.

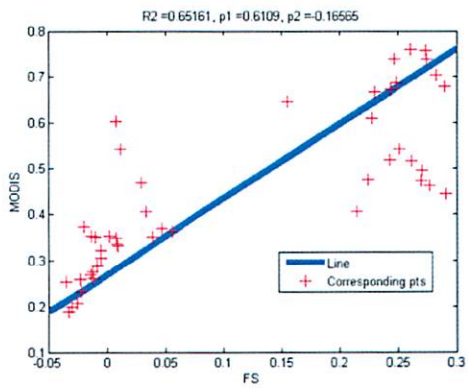


Fig.5 R squared (0.65) is computed from two phenological curves in figure 4.

Comparative method. Regarding to the phenology obtained from two datasets, MODIS provide the phenology based on 8 day composite images while FS provide the phenology based on daily images. To compare between MODIS and FS, the DOYs extracted from MODIS images are used for the temporal index reference. As shown in figure 4, two phenology curves between MODIS and FS images are compared for the corresponding DOYs. It should be noted that the FS phenology is re-sampled and mapped to the MODIS phenology. In figure 5, R squared is used for the simple linear regression. The R squared value is approximately 0.65.

Experimental results

According to FS images, two stations located in Suphanburi (Central) and Roi-Et (North-east) provinces, Thailand are used for the experiments. For MODIS images, they are computed for two phenological curves based on NDVI and ExG index, respectively. The phenology (only ExG index) obtained from FS images is mapped to the corresponding DOYs. Using R squared, the comparative results are shown in table 1. The correlation of paddy fields in Roi-Et is obtained better results than in Suphaburi because the fields in Roi-Et are homogeneous regarding with the neighbor areas (same starting & ending crop date) since the results have compared with MODIS 500 meters resolution. According to the results, ExG (MODIS) in Suphanburi cannot use to understand the rice crop cycle.

Table 1. R squared computed between MODIS (NDVI, ExG) and FS (ExG) phenologies

Location (Lat/Long)	Paddy type	MODIS- NDVI	MODIS- ExG
Roi-Et (15.5611/103.6796)	In-season rice	0. 6516	0.5251
Suphanburi (14.4304/100.0192)	Off-season rice	0.4232	0.0033

Conclusions and future work

In this paper, using the satellite and ground images on the paddy fields, the comparative results of phenology are experimented. The satellite images are referred to MODIS at 500 meters. The ground images are obtained from the Field Server (FS). The correlation are measured by using the simple linear regression (R squared). Relying on MODIS images, NDVI (NIR and Red bands) is more efficient than ExG (RGB bands) for obtaining the correlation with FS images. However, the maximum of R squared value is approximately 0.65 because the comparison of two datasets has several challenges such as; MODIS are captured from top view but FS are captured from side view, Coverage areas of paddy field between MODIS and FS images are required to calibrate and precise.

For the future work, the comparison with the other satellite platforms (MODIS with other resolutions, Landsat 8) will be tested. The correlation of two platforms will be used to accurately estimate the paddy area on satellite images. The estimated area in a wide region can be obtained.

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Bank Name :	The Siam Commercial Bank Public Company Limited (SCB)
Branch :	Bang Bua, Bangkok
Account Name :	The International Electrical Engineering Congress (iEECON)
Account No.	053-430783-5
SWIFT Code :	SICOTHBK

2. Registration will only be confirmed upon receipt of payment.
3. Please scan the copied of transfer slip as an image file.(jpeg or pdf file) and upload during the registering procedure.
4. The receipt of registration will be given at the conference site

Note :

- **One regular or IEEE/EEAAT member registration** covers a **maximum of two accepted papers** by the same registered author.
- **A student registration** (applies to either IEEE or EEAAT Student Member) covers **only one accepted paper**. An additional registration fee must be paid by the same author for each additional paper to be presented at the conference and included in the proceedings if the additional paper(s) have no other registered authors. The student who is not an IEEE/EEAAT member must pay the **regular registration fee** for the paper(s) to be presented at the conference.
- **Accompanying person** refers to the participant whose name is not included as an author in any accepted paper and who wants to partially or fully attend the conference.
- Participant who registers to the conference will receive the **conference souvenir kit** consisting of 1 bag, 1 CD (or USB) Proceedings, 1 reception ticket (on March 18, 2015), 1 banquet ticket (on March 19, 2015), 2 luncheon tickets (on March 19-20, 2015), etc. Drinks and snack served at the coffee-breaks are also included to all **registered** attendees.