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

Narat Soontranon*, Siam Lawawirojwong, Panwadee Tangpattanakul, Panu Srestasathier and Preesan Rakwatn
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.
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.

- 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].

![Phenology from FS (daily images) based on ExG: (a) Phenology, (b) Smooth phenology.](image)

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

![Comparison of the phenology curves between (a) MODIS and (b) FS images.](image)

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

![R squared (0.65) is computed from two phenological curves in figure 4.](image)

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>
<thead>
<tr>
<th>Location (Lat/Long)</th>
<th>Paddy type</th>
<th>MODIS- NDVI</th>
<th>MODIS- ExG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roi-Et (15.5611/103.6796)</td>
<td>In-season rice</td>
<td>0.6516</td>
<td>0.5251</td>
</tr>
<tr>
<td>Suphanburi (14.4304/100.0192)</td>
<td>Off-season rice</td>
<td>0.4232</td>
<td>0.0033</td>
</tr>
</tbody>
</table>

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.

References
The 2015 International Electrical Engineering Congress
18 - 20 March 2015
Phuket, Thailand

The International Electrical Engineering Congress (IEECON) is a premier international academic conference organized by EBAAIT, the Electrical Engineering Academic Association (Thailand). The IEECON 2015 will provide a forum for researchers, engineers, and industry experts to discuss recent developments, new ideas, and breakthroughs in Electrical Engineering technologies. It comprises 5 conferences: Communication, Power & Energy, Electronic & Control, Digital Signal Processing and Computer & IT.


The IEECON2015 will be held in Phuket, Thailand's premier beach destination. Participants will also experience the variety of entertainment and beach activities.

INTERNATIONAL CONFERENCE ON COMMUNICATIONS

INTERNATIONAL CONFERENCE ON ELECTRONICS & CONTROL

INTERNATIONAL CONFERENCE ON DIGITAL SIGNAL PROCESSING
Image and Video Processing, Audio and Speech Processing, Pattern Recognition, Biomedical Signal Processing, Computer Vision and Pattern Recognition, Adaptive Signal Processing, Machine Learning for Signal Processing, etc.

INTERNATIONAL CONFERENCE ON POWER & ENERGY

INTERNATIONAL CONFERENCE ON COMPUTER & IT

IMPORTANT DATES
Special session proposal deadline: August 30, 2014
Special session notification: September 13, 2014
Paper submission deadline: October 13, 2014
Paper acceptance notification: November 22, 2014
Camera-ready submission deadline: December 22, 2014
Early-bird registration deadline: December 22, 2014
Conference dates: March 18-20, 2015

For more information, please refer to the conference website: www.ieecon.org
ตารางแสดงรายละเอียดค่าใช้จ่ายในการเดินทางเข้าร่วมกิจกรรมและเข้าร่วมประชุมวิชาการ

<table>
<thead>
<tr>
<th>ลำดับ</th>
<th>รายการ</th>
<th>งบประมาณ (บาท)</th>
<th>หมายเหตุ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ค่าเบี้ยเช่าห้อง (400 บาท/คืน* 3 คืน* 1 คน)</td>
<td>1,200.00</td>
<td>1. เดินทางโดยเครื่องบิน เนื่องจากใช้เวลาเดินทางเกิน 8 ชั่วโมง</td>
</tr>
<tr>
<td>2</td>
<td>ค่าที่พัก (2000 บาท/คืน* 2 คน* 1 คืน)</td>
<td>4,000.00</td>
<td>2. ค่าลงทะเบียนต้องชำระภายในวันที่ 22 ตุลาคม 2557</td>
</tr>
<tr>
<td>3</td>
<td>ค่าพาหนะ</td>
<td>6,000.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ค่าตั๋วเครื่องบินขึ้น-ลง (ไป-กลับ) กรุงเทพฯ-ภูเก็ต 5,000.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ค่าที่พัก (ไป-กลับ) ที่พัก: สนามบินตองมีอง 500.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ค่าที่พัก (ไป-กลับ) สนามบินภูเก็ต - ที่พัก 500.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ค่าใช้จ่ายอื่นๆ</td>
<td>9,000.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ค่าลงทะเบียน</td>
<td>9,000.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>รวมเป็นเงินทั้งสิ้น</strong></td>
<td><strong>20,200.00</strong></td>
<td>ดำฉ่ายทุกรายการ</td>
</tr>
</tbody>
</table>

หมายเหตุ: ข้อมูลประมาณการค่าใช้จ่าย ณ วันที่ 4 พฤศจิกายน 2557
Thailand's political situation is now safe and peaceful. Many tourist areas are not under martial law such as Phuket, Pattaya, Krabi and Bangkok. Due to the large amount of requests, paper submission deadline is extended to November 3, 2014.

Conference Venue

Thailand, the essence of hospitality, is a beautiful country to visit. The conference will be held in the luxury hotel in Phuket, the beautiful beach city in Thailand. From the conference location, it is convenient to travel to many interesting places around Phuket.

Phuket is one of the hottest beach-resort destinations in Thailand. Phuket may not be idyllic but it certainly makes up for it with a wide variety of activities, accommodation, and nightlife venues. While Phuket once had a well deserved reputation for its seedy nightlife, local authorities have, in recent years, improved the quality of the beaches and reinvented the resort, to some degree, as a more family friendly destination. Today, hundreds of thousands of visitors are drawn each year to Phuket to windsurf, water ski, swim, sunbathe, snorkel, sail, or take trips to nearby islands. Other activities include Bungee jumping, cycling, skydiving, go-Karting, Muay Thai (Thai boxing), and Paintball (to name only a few). Another major draw for visitors to Phuket is the wide selection of restaurants serving some of Thailand's freshest seafood. For more information about Phuket, see http://www.tourismthailand.org/Where-to-Go/Phuket.

IEEECON2015 will be arranged at the Phuket Graceland Resort & Spa, located on Patong beach in Phuket city.

>>> For the hotel information, please see http://www.phuketgraceland.com.
Registration / iEECON2015

iEECON2015 The 2015 International Electrical Engineering Congress
March 18-20, 2015, Phuket, Thailand

CONFERENCE SCHEDULE
Special session proposal deadline: August 30, 2014
Special session notification: September 13, 2014
Paper submission deadline: November 3, 2014
Paper acceptance notification: December 1, 2014
Camera-ready submission deadline: December 22, 2014
Early-bird registration deadline: December 22, 2014
Conference dates: March 18-20, 2015

Registration

EEAT has arranged the iEECON2015 to mainly gather all experts around the world in the field of Electrical Engineering to come to Thailand for their experience sharing among community. Therefore, the registration fee of the conference is quite lower than the other conference due to the subsidy from EEAAT and sponsors.

Conference Registration

Registration Fees for iEECON2015

<table>
<thead>
<tr>
<th>Categories</th>
<th>Early-Bird Registration</th>
<th>In-Time Registration</th>
<th>On-Site Registration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Before 22 Dec 14)</td>
<td>(23 Dec 14-17 Mar 15)</td>
<td></td>
</tr>
<tr>
<td>Regular</td>
<td>9,000 THB (340 $)</td>
<td>10,000 THB (370 $)</td>
<td>11,000 THB (400 $)</td>
</tr>
<tr>
<td>EIEE/EEAAT Member</td>
<td>7,500 THB (280 $)</td>
<td>8,500 THB (310 $)</td>
<td>9,500 THB (340 $)</td>
</tr>
<tr>
<td>Student</td>
<td>5,500 THB (210 $)</td>
<td>6,000 THB (230 $)</td>
<td>6,500 THB (250 $)</td>
</tr>
<tr>
<td>Accompanying Person</td>
<td>4,500 THB (170 $)</td>
<td>5,000 THB (190 $)</td>
<td>5,500 THB (210 $)</td>
</tr>
</tbody>
</table>

Note:
At least one author of every accepted paper must register for the conference by the Early-Bird registration date.

Payment method:
1. Registration payment can be made via Bank transfer with the following information:

   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: SCOTHBK

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.

http://www.ieecon.org/ieecon2015/registration.php

Sponsored By
The International Electrical Engineering Congress (iEECON) is a premier international academic conference organized by EEAAT, the Electrical Engineering Academic Association (Thailand). The iEECON2015 will provide a forum for researchers, engineers, and industry experts to discuss recent development, new ideas, and breakthroughs in Electrical Engineering technologies. It comprises 5 conferences: Communication, Power & Energy, Electronic & Control, Digital Signal Processing and Computer & IT.

All accepted and presented papers will be published in the abstract book of iEECON2015 and will be published in a periodic journal Advanced Materials Research (AMR), indexed by Elsevier: SCOPUS www.scopus.com and EI Compendex (CPX) www.ei.org; Cambridge Scientific Abstracts (CSA) www.csa.com; Chemical Abstracts (CA) www.cas.org, Google and Google Scholar google.com; ISI (ISTP, CPC, Web of Science) www.isinet.com, Institution of Electrical Engineers (IEEE) www.ieee.org, etc., after each paper is reviewed and (if any) satisfactorily modified according to the reviewer comments.

The iEECON2015 will be held in Phuket, Thailand’s premier beach destination. Participants will also experience sun with the variety of entertainment and beach activities.

INTERNATIONAL CONFERENCE ON COMMUNICATIONS
Communication Theory, Antennas and Propagation, Optical Communications, Microwave, Wireless Communications, Signal Processing for Communication, Channel Coding, Multimedia Communications, Remote Sensing and Applications, Metamaterials, etc.

INTERNATIONAL CONFERENCE ON POWER & ENERGY

INTERNATIONAL CONFERENCE ON ELECTRONICS & CONTROL

INTERNATIONAL CONFERENCE ON DIGITAL SIGNAL PROCESSING
Image and Video Processing, Audio and Speech Processing, Pattern Recognition, Biomedical Signal Processing, Computer Vision and Pattern Recognition, Adaptive Signal Processing, Machine Learning for Signal Processing, etc.

For more information, please refer to the conference website:
www.ieecon.org

IMPORTANT DATES
Special session proposal deadline: August 30, 2014
Special session notification: September 13, 2014
Paper submission deadline: October 13, 2014
Paper acceptance notification: November 22, 2014
Camera-ready submission deadline: December 22, 2014
Early-bird registration deadline: December 22, 2014
Conference dates: March 18-20, 2015
Registration

EEAAT has arranged the IEECON2015 to mainly gather all experts around the world in the field of Electrical Engineering to come to Thailand for their experience sharing among community. Therefore, the registration fee of the conference is quite lower than the other conference due to the subsidy from the EEAAT and sponsors.

Conference Registration

Registration Fees for IEECON2015

<table>
<thead>
<tr>
<th>Categories</th>
<th>Early-Bird Registration (Before 22 Dec 14)</th>
<th>In-Time Registration (23Dec14-17Mar15)</th>
<th>On-Site Registration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td>9,000 THB (340 $)</td>
<td>10,000 THB (370 $)</td>
<td>11,000 THB (400 $)</td>
</tr>
<tr>
<td>EEEAAT Member</td>
<td>7,500 THB (280 $)</td>
<td>8,500 THB (310 $)</td>
<td>9,500 THB (340 $)</td>
</tr>
<tr>
<td>Student</td>
<td>5,500 THB (210 $)</td>
<td>6,000 THB (230 $)</td>
<td>6,500 THB (250 $)</td>
</tr>
<tr>
<td>Accompanying Person</td>
<td>4,500 THB (170 $)</td>
<td>5,000 THB (190 $)</td>
<td>5,500 THB (210 $)</td>
</tr>
</tbody>
</table>

Note: At least one author of every accepted paper must register for the conference by the Early-Bird registration date.

Payment method:
1. Registration payment can be made via Bank transfer with the following information:

   - Bank Name: The Siam Commercial Bank Public Company Limited (SCB)
   - Branch: Bang Bua, Bangkok
   - Account Name: The International Electrical Engineering Congress (IEECON)
   - Account No.: 053-410763-5
   - SWIFT Code: SCOTTHBK

2. Registration will only be confirmed upon receipt of payment.
3. Please scan the copy or 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.