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Crop Monitoring Using Time-series MODIS Data: Application Validation for Mekong Delta Region in South Vietnam

Phuong Le-Thi*, Phung Phi-Hoang**

* Graduate School for Creative Cities, Osaka City University,

3-3-138 Sugimoto, Sumiyoshi-ku, Osaka 558-8585, Japan. E-mail: ltphuongrs@gmail.com.

** Vietnam Southern Satellite Technology application Center, Vietnam National Satellite Center

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1. INTRODUCTION

The Mekong Delta located in the South Vietnam is the rice key region and annually produces approximately half of the country's rice production. The quantity of rice exported reached approximately five million tons in 2008 and hit the record of 7.72 million tons with value of US$ 3.546 billion in 2012. Rice production plays a critical role in terms of food supply and export. Moreover, the impacts of climate change and rice diseases are the main factors causing the crop production reduction. For these reasons, it is necessary to develop a rice monitoring system to assess rice growing area. Such quantitative information about rice cropping system might provide essential information for policy makers to devise better agricultural strategies. Remote sensing has been recognized as an important data source for crop and vegetation monitoring. MODIS is a key instrument on board the Terra and Aqua satellites, which views the entire Earth's surface every 1-2 days with 36 spectral bands acquired in wavelengths from 0.4to 14.4 μm. In this study, the Normalized Difference Vegetation Index (NDVI) derived from MODIS data was used to classify the rice area/rice cropping system in Mekong Delta. NDVI which reflects vegetation greenness and indicated levels of healthiness in the vegetation development, is the most frequently used for crop monitoring and production estimation (Ren et al., 2008; Wuttichai Gunnula et al., 2011). The time series MODIS-NDVI data have been proved that it can be successfully applied to investigate vegetation dynamics (Zhang et al., 2003). There exists a high correlation between crop and NDVI around the time of maximum green leaf biomass development (Quarmby et al., 1993). To map the cropping system in the study area, the supervised Support Vector Machine (SVM) classification method was performed. This classification is based on statistical learning theory as proposed by Vanik and Chervonenkis (1971) and widely used as non-parametric classifier.

2. DATA

MODIS/Terra Surface Reflectance 8-day L3 Global 500m SIN Grid V005 (MOD09A1) acquired from Nov 2013 to Dec 2014 were used for rice cropping classification in the study area. The data has seven bands at 500 m spatial resolution. The data were formatted using the Sinusoidal projection. Each MOD09A1 pixel contains the best possible L2G observation during an 8-day period as selected on the basis of high observation coverage, low view angle, the absence of clouds or cloud shadow. The images were re-projected to the Universal Transverse Mercator coordinate system (zone 48N). LandUse/LandCover in 2012 and statistical data were used for accuracy assessment.

3. METHOD

3.1. Constructing Smoothed Time-Series NDVI Data

The MODIS images were first re-projected into the Universal Transverse Mercator coordinate system (zone 48N) and were then subset over the study area. The NDVI index was calculated from these images using the following form:

$$NDVI = \frac{NIR-RED}{NIR+RED} \qquad (1)$$

Where NIR (841 – 876 nn) and RED (620 – 660 nn) are MODIS band 4, 3 respectively. To construct the time-series NDVI data, the NDVI for each 8-day MODIS image was first calculated. These NDVI images were then stacked into one 8-day composite scene for 2014 rice cropping seasons. In this study, the wavelet transform was applied to filter out the noise from NDVI time series due to cloud cover and impacts from atmospheric. The wavelet function is defined as:

$$\mathrm{Wf}(a,b) = \frac{1}{\sqrt{a}}\int x(t)\,\psi\left(\frac{(t-b)}{a}\right)dt \qquad (2)$$

Where ψ implies a mother wavelet, and x represents the time-step in the one-dimensional time series over which integration is performed (Zhang Shengwei et al., 2011).

The mother waveletis as following:

$$\psi_{(a,b)}(t) = \frac{1}{\sqrt{a}}\psi\left(\frac{t-b}{a}\right) \qquad (3)$$

Where a is the dilation or scaling parameter and b is the translation or shifting parameter

In this study, Coiflet wavelet with order 4 was used because it give the best result (among Daubechies and Symlet wavelet functions) for determining regional characteristics of rice phenology (Chen et al., 2011).

3.2. Image masking

In order to mask out the non-rice area, the image masking step was implemented to remove water bodies, urban, forest and, salt fields/aquaculture areas, so that only cropped-area will be focus on. For forest area, the condition of NDVI value is greater than 0.7 for at least 14 (8-day composite) MODIS-NDVI images was set. The water bodies and salt fields/aquaculture areas were removed using threshold of NDVI lower or equal 0.2 for at least 20 (8-day composite) images. And for urban areas, the NDVI value with condition $0.1 \leq NDVI \leq 0.3$ was used to mask out urban pixels. After the image masking step, the remaining areas is cropped areas and this area will be used for cropping system classification.

3.3. Classification method

SVM is a well-known supervised classification method since it can produce more accurate classification results compared to other traditional classification (Maximum Likelihood, K-mean, Threshold-based). The SVM algorithm is as below:

$$f(x) = \sum_{j=1}^{S_v} \alpha_j \, y_j \, K(x, x_j) + b \qquad (4)$$

Where α_j s are Lagrange multipliers while is the number of support vectors which are training data for which $0 \leq \alpha_j \leq C$ is a user-defined parameter that controls the trade-off between the machine complexity and the number of non-separable points. The bias b is a scalar computed by using any support vector.

The training data were first selected based on NDVI profile for different type of cropping system in the study area including single, double, triple rice crop and fruit/perennial plants (Figure 1).

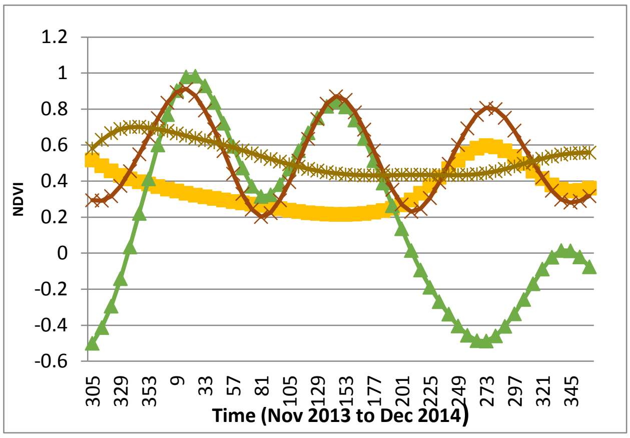

Figure 1: Smoothed NDVI profiles of training samples

4. RESULT

The crop map 2014 in the Mekong Delta, Vietnam was generated using time-series MODIS-NDVI data.

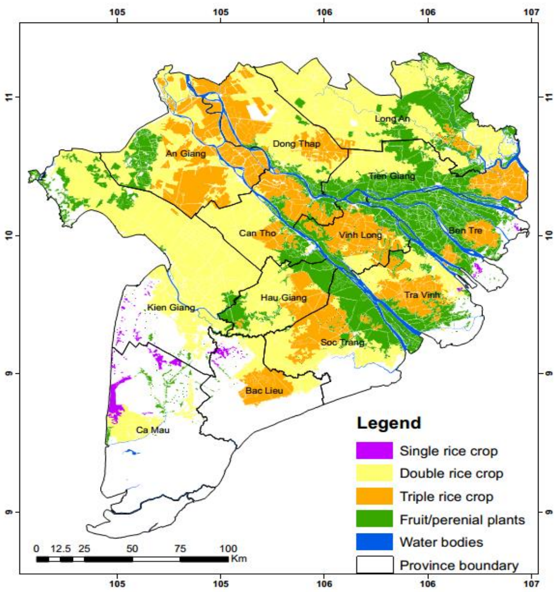

Figure 2: Crop map 2014 in Mekong Delta, Vietnam

It is shown that the cropping system in the study area is dominate by rice crop area with two typical cropping types area double and triple rice crops (Figure 2). The fruit/perennial plants are mainly distributed in Ben Tre province and near main rivers. The triple-cropped was particularly allocated along the central park of the region between two large rivers, due to the availability of water for crop irrigation. The single-cropped is practiced during the rainy season and scattered along coastal areas.

The classification map produced from the 2014 data was compared with ground reference data and showed a close agreement between two datasets. The overall accuracy and kappa coefficients were 83.1% and 0.76, respectively.

5. CONCLUSION

This study aimed to explore the applicability of time-series MODIS data for mapping crop map in Mekong Delta, Vietnam. It is indicated that the MODIS-NDVI data can be successfully used for crop monitoring/mapping at regional scale.

The variations in weather and rice diseases often damaged rice fields and other crops. Moreover, the satellite data acquired in the wet season were often contaminated by significant cloud cover and atmospheric influences that contributed to the errors of mapping results. However, the radar images can overcome the cloud problem inherent to optical sensors by using microwaves that can easily penetrate clouds will be considered as a good data for crop monitoring in tropical regions like Mekong Delta. The rice crop mapping based on radar imagery could be done in future works to improved results.

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