ANALYSIS OF SENTINEL-1 SAR DATA FOR MAPPING RICE CROP IN THE MEKONG DELTA, VIETNAM

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ABSTRACT

Rice cropping information is critical for food supply and crop management. Synthetic Aperture Radar (SAR) has been widely applied for crop monitoring. This study aims to develop an approach for mapping rice extent areas MD Vietnam (a test case in An Giang province), Vietnam using multi-temporal Sentinel-1 SAR images. Sentinel-1 SAR data collected in C-band dual-polarized (VV/VH) at Interferometric Wide (IW) swath mode with spatial resolution of 20m. The data acquired during Autumn-Winter growing season was analyzed to delineate rice cultivated areas in the study region using temporal change method. By investigating the temporal backscatter characteristic of rice sampling fields at two different polarizations VV and VH, the temporal backscatter change of the cross polarized VH showed a better suit to rice growing phenological stages compared to that of VV. The rice map was generated from multi-temporal Sentinel-1A images using maximum temporal method. The result indicated a close agreement between rice areas derived from SAR data and rice areas from government statistic with overall accuracy of 91% and Kappa coefficient is 0.83. This demonstrates the potential of Sentinel-1 SAR imagery and our approach for rice detection in the study area. The information of rice growing area could provide quantitative information for crop management and monitor agriculture practices. The data and methodology will be further improve for rice delineation at regional scale and transferable to other regions.

Keywords: *SAR, rice mapping, time-series, Mekong Delta*

1. INTRODUTION

Rice cultivation is the main crop in Vietnam, providing food for more than 90 million people and strongly contributing to the country's rice export. The majority of rice is produced in Mekong Delta (MD) which is the rice bowl located in the Southern part. According FAO 2010, Vietnam is one of the largest rice producers and supplier on the Earth, annually produces approximately 39.9 million tons of grain rice (GSO, 2010). In recent years, the crops have been threatened by the impact of climate change and human activities that caused deceasing of rice crop production. These raise a need to develop a more effectively monitoring approach for rice cropping system.

SAR has been recognized as a good data source for rice monitoring with advantage characteristic of cloud penetration, high spatial and temporal resolution. In this study, time-series sentinel-1A data acquired during Autumn-Winter (AW) crop is used for mapping rice cultivated area in An Giang province. The radar backscattering coefficients are examined for rice crop mapping with strongly correlated to rice plant height and rice biomass during the vegetative stage (Ribbes and Le-Toan 1999a). Multi-year Envisat ASAR imagery was used for mapping rice seasonality in Mekong Delta with high accuracy (Nguyen et al., 2015) and extract rice crop phenological information for mapping rice in Red river delta, Vietnam (Nguyen et al., 2015). SAR data alsocan be successfully used for rice crop yield estimation (Kajalainen et al., 2000, Kropff et al., 1994; Yang et al., 2012). The relationship between the backscatter coefficient and biomass of rice was investigated for development of prediction model with more than 90% of accuracy check (Li et al., 2003).

The information on rice cropping activities and growing areas plays a critical role for crop management and agriculture development. This study aims to analyze Sentinel -1 SAR data for its potential to map rice growing areas in An Giang province during Autumn-Winter season 2014 from Oct/Nov to Dec/Jan.

2. STUDY AREA

The study region is An Giang province located in the upper part of MD Vietnam, covering about 3536.7 km2 (Figure 1). Majority of agriculture land is allocated for rice cultivation. There are three crop seasons are annually practiced, including winter-spring, summer-autumn and autumn-winter crops. The length of a rice cycle in this region generally lasts 90-110 days.

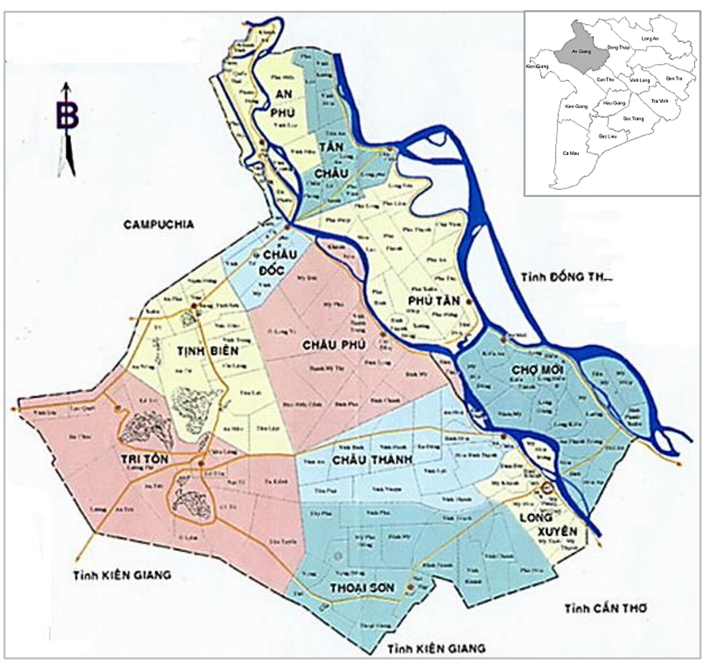


Figure1. The location of the study area

3. DATA

In this study, Sentinel-1A C-band data collected in the Interferometric Wide swath (IW) mode was used. The Sentinel-1 SAR instrument operates at 5.405 GHz (C-band, 5.6 cm) with VH and VV polarizations with revisit cycle of 12 days. There are total 7 images acquired during Autumn-Winter rice crop 2014 were used in this study (06/10/2014; 18/10/2014; 30/10/2014; 11/11/2014; 23/11/2014; 05/12/2014; 17/12/2014).

The rice statistics were also collected from General Statistic Office and used to verify the consistency with the mapping results.

4. METHODS

4.1. Data pre-processing

The data pre-processing includes three main steps: (1) radiometric calibration to convert digital pixel values of VV/VH polarizations to sigma naught (σ^o); (2) Terrain correction using bilinear interpolation and SRTM 1sec as Digital Elevation Model. There was 7 to 9 shifted pixels in longitude, therefore, the ground control points were used to georeferenced the shifted data; (3) Multi-temporal filtering using Refine Lee filter. The flowchart for data pre-processing is shown below:

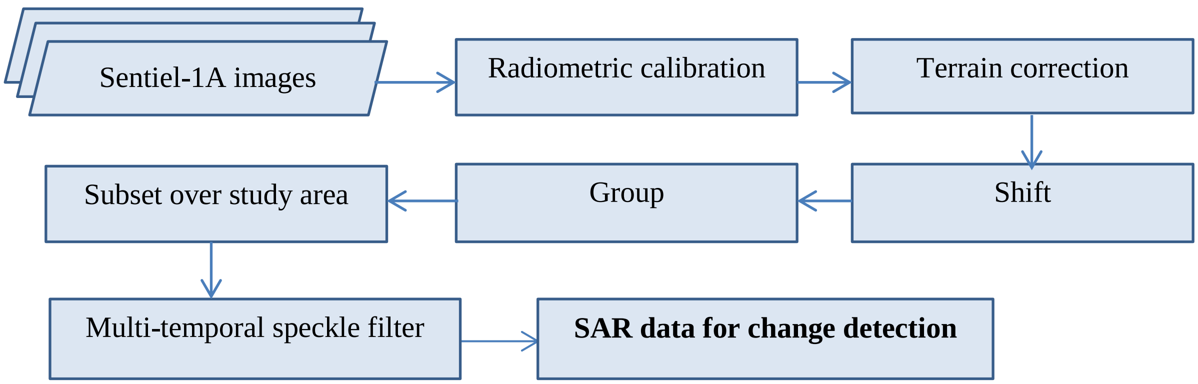


Figure 2: Sentinel-1 SAR pre-processing steps

4.2. Rice Backscatter Analysis

The VV and VH polarized backscatter are extracted from the Sentinel-1 SAR time-series data and plotted in figure 3. Compared to the VV-polarized backscatter, the cross-polarized VH backscatter is better suit for rice crop monitoring. Specifically, the VH backscattering coefficients were relatively low due to standing water over the fields during the sowing period. After sowing, the rice plants grow quickly and its backscatter significantly increases during the vegetative stage, reaching the maximum backscatter on heading time and begin to decrease when rice plants completely emerged and rice leaves start to die.

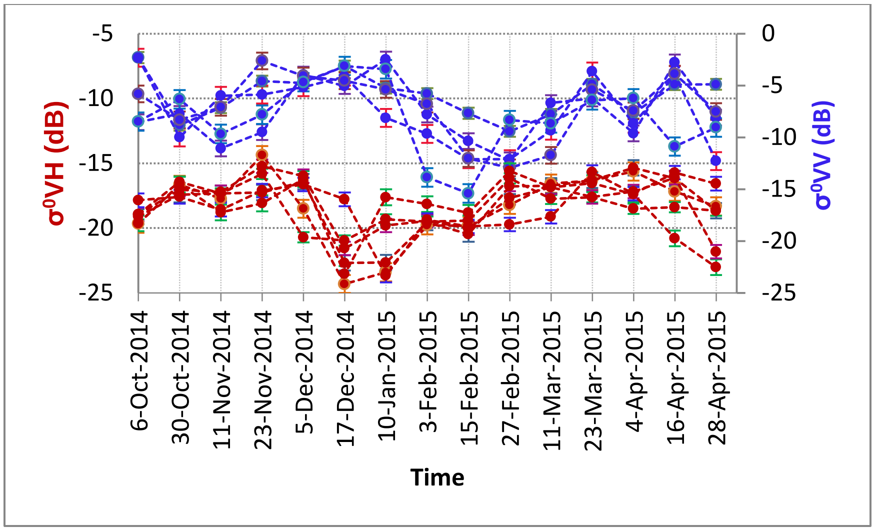
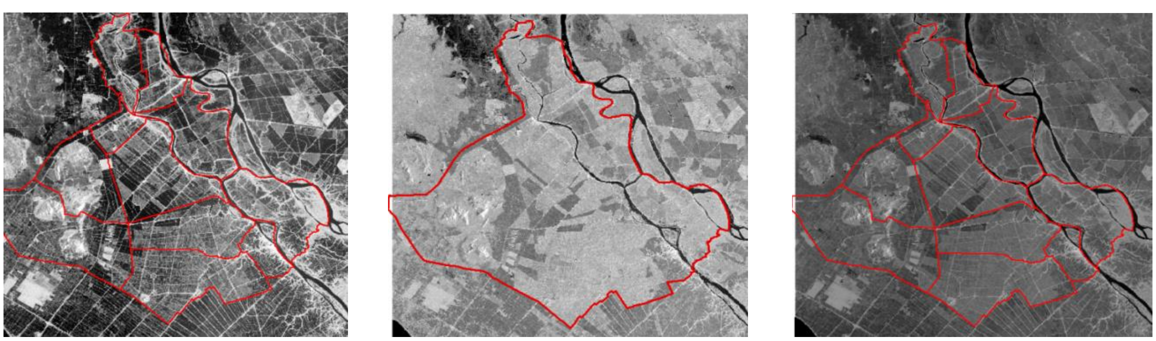


Figure 3. Temporal backscatter signature at rice sampling fields extracted from time-series Sentinel-1 SAR data.

4.3. Delineation of rice area

Rice has distinctive temporal feature compare to other land cover classes like forest, grass, water, etc. and we can monitor its changing over time by using the multi-temporal images acquired over a rice cycle. At C-band, the backscatter during land preparation and transplanting period is low because of the rice fields are irrigated. After that, the rice density, height and biomass quickly increase resulting in higher and stronger backscatter signal. At the end of ripening period, a slight decrease in returned backscatters due to wilting of rice leaves and some part of plant.

Based on this characteristic, the temporal change method was applied in this study to map rice growing areas in Autumn-Winter crop season 2014 (from Oct 2014 to Jan 2015). The estimators (including minimum, maximum and mean) for backscatter temporal variability were computed from 7 aforementioned images and are tested to identify rice area in the study area (Figure 5).



(a) (b) (c)

Figure 5. Temporal estimators computed from 7 images during Autumn-Winter rice crop. (a) Minimum backscatter, (b) Maximum backscatter, (c) Mean backscatter

5. RESULT

The 2014 Autumn-Winter rice map in An Giang province, delineated from multiple Sentinel-1SAR images using maximum temporal change method was shown as figure 6. Generally, rice was cultivated in most of the study area's land. The classification result was evaluated by comparing obtained rice areas from Sentinel-1 SAR data and the government rice area statistics. The result indicated a close agreement between these two datasets during autumn-winter rice growing season. The overall accuracy and Kappa coefficient were 91 % and 0.83 respectively.

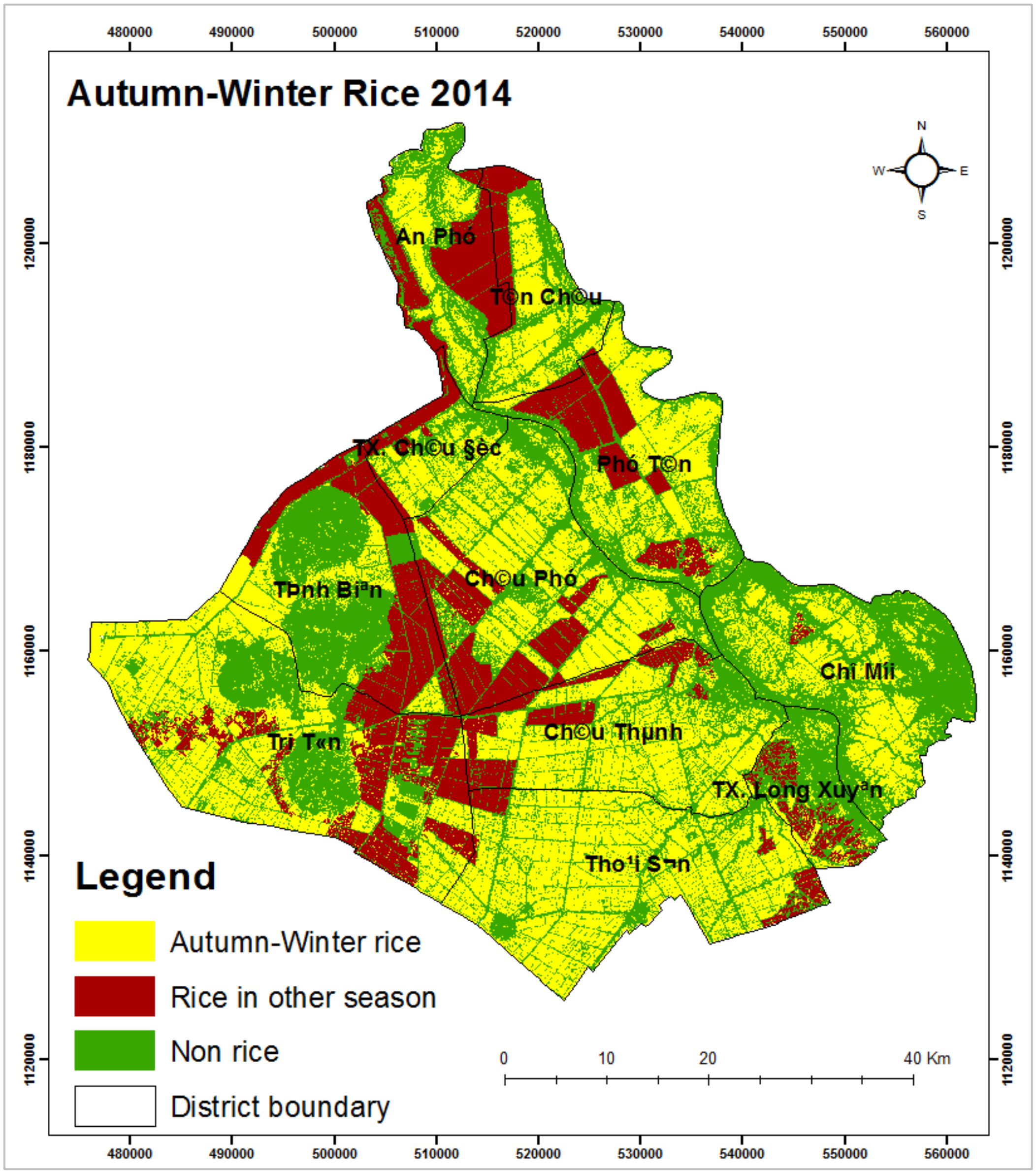


Figure 6. Rice growing areas in An Giang province derived from multi-temporal Sentinel-1 SAR data during Autumn-Winter season 2014

6. CONCLUSION

This study aims to delineate rice growing area from multi-temporal SAR images and develop a procedure for reliable processing of Sentinel-1SAR data for crop monitoring. By investigating the multi-temporal backscatter properties over rice field, we can understand how it changes over time as the basis for the purpose of rice mapping. The obtained result showed a good correlation between rice areas achieved from multi-temporal SAR data and rice area statistic using maximum temporal change method with overall accuracy of 91%.

This paper presented a first attempt to access a new freely Sentinel-1 SAR imagery for rice crop monitoring and the result are promising and giving a high accuracy that revealed the potential of data source and methodology for rice delineation. The methodology will be improved in further to explore and access the usefulness of new available data collected by Sentinel satellite for rice mapping. The results could provide useful information about rice growing area that are necessary for agronomic planners to monitor agricultural practices and production estimation in the study area.

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