Multi-temporal RADARSAT for Crop Monitoring

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Abstract: On several occasions, optical sensor is particularly difficult to be utilized due to cloud cover during rainy season. Synthetic Aperture Radar (SAR), onboard RADARSAT satellite, can provide the desired information, especially for agriculture in Thailand. Crop monitoring is very significant to Thailand and radar remote sensing can be useful for this purpose. The objective of this study was to apply RADARSAT imagery and geo-informatics data to analyze crop area in the high land occupying the North of Thailand. The test site is located in Chaing Rai province which is in parts of Muaeng Chiang Rai district and Thoeng district. RADARSAT-1 imagery were used with relevant geo-informatic data to test their suitability for crop monitoring. This study utilized multi-temporal RADARSAT data to determine crop area. Band combination of multi-temporal RADARSAT C-HH acquired on October 15, November 8, and December 19, 2003 were processed to determine crop area. These imagery were processed and visually interpreted. With the composite imagery, crop area can be clearly identified and were validated by comparing with the existing land use map. The results found that the total crop area was 89 square kilometers. Most of the crop area was found in the part of Ngiu sub-district, Thoeng district, with an area of 24 square kilometers. The rest of the crop area distributed in Doi Lan sub-district, Muaeng Chiang Rai district with an area of 21 square kilometers, Chiang Kian and Plong sub-district with an area of 21 and 23 square kilometers respectively. The results of this study show that SAR data can be used for planning and monitoring agricultural area in the future.
Keywords: Multi-temporal RADARSAT, Crop monitoring

1. Introduction

For several occasions, satellite optical imagery can provide essential information for crop monitoring. These imagery can be useful for effective management of agricultural resources, and preparation of accurate estimation of crop production. Particularly in Thailand, economic crop is an export commodity and necessary for planning trade-off. However, for the current situation of optical satellites, it can be difficult to acquire cloud free imagery throughout the growing season. Several research studies have repeatedly demonstrated that timing of image acquisition is very important to the success of crop mapping with optical imagery available during key stages of crop development. These data can provide the desired information for operational crop monitoring (Canada Centre for Remote Sensing, 2005).

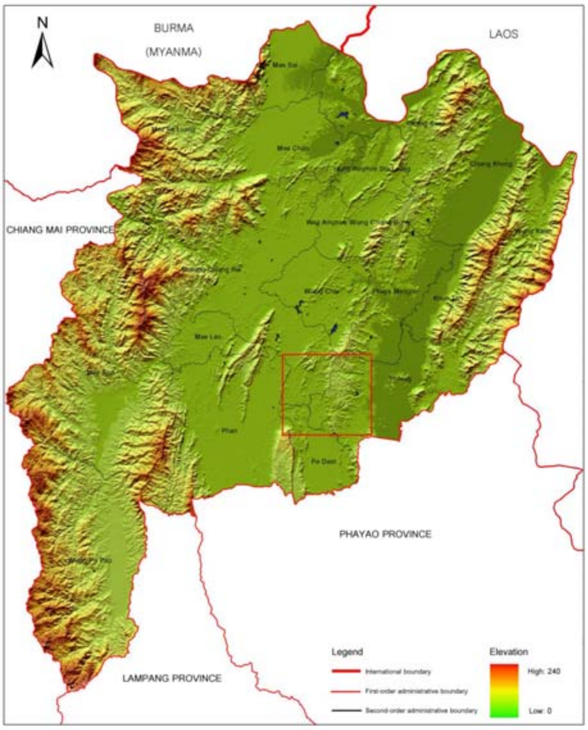
Because the agricultural applications is very significant, so the usefulness of remote sensing data for crop monitoring, throughout vegetation parameters and soil conditions, has been demonstrated by both optical and radar satellite systems (Canadian Space Agency [CSA], 2005). Previous researches in Thailand used satellite imagery to accurately determine crop types. However, in several occasions, optical satellite sensors can not always provide the desired information due to persistent and frequent cloud cover during the growing season. Since microwaves penetrate cloud cover, and are sensitive to the structure of crops (size and geometry of the leaves, stalks) and moisture, so SAR acquisitions are far more reliable. As a result, radar imagery could be an important component of a crop monitoring system. This fact was shown by experience with previous project in Thailand; for example, GISTDA, Thailand (2004) demonstrated that the use of multi-temporal RADARSAT-1 data for rice crop monitoring and its yield estimation in four test sites which are a representative of each region of Thailand. Therefore, multi-temporal RADARSAT data can be useful for crop area acreage throughout the crop growing season. This study applies RADARSAT-1 imagery and geo-informatics data to monitor economic crop types, and demonstrates the knowledge and technology of SAR data, which will be provided for applications of end-users (including the government agencies and institutes). Moreover, the expected results can be used to support for decision-making in Thailand.

2. Objectives

The first objective of this study is to apply RADARSAT-1 imagery and geo-informatics data for monitoring crop types, the final objective is to promote and encourage the use of RADARSAT data for agriculture in Thailand. Moreover, the expected results of this study are crop mapping in the study area, the increasing the use of RADARSAT-1 data for yield estimation, and support to working group in other departments.

3. Study area

The study area is located in Chiang Rai province, particularly 4 sub-districts namely; Doi Lan, Ngiu, Plong, and Chiang Kian. In each site, Doi Lan sub-district is located in Muaeng Chiang Rai district, and Ngew, Plong, Chiang Kian sub-districts are located in Thoeng district (shown in Fig. 1). These sites area coverage are 340 square kilometers (34,000 hectares). The topographical characteristics are hilly and mountainous. As for the climatic condition, the winter season is during October - February, hot season during March – May, and rainy season during June - October. For the period of 30 years (1997-2000), the average rainfall is 1,702 m.m., average temperature 24.2 degree celcius, the maximum and minimum temperature are 40.8 and 1.5 degree celcius respectively. The soil characteristic is clay whose properties are good drainage, with low fertilization. The land use types are usually agricultural area such as crop and orchards.



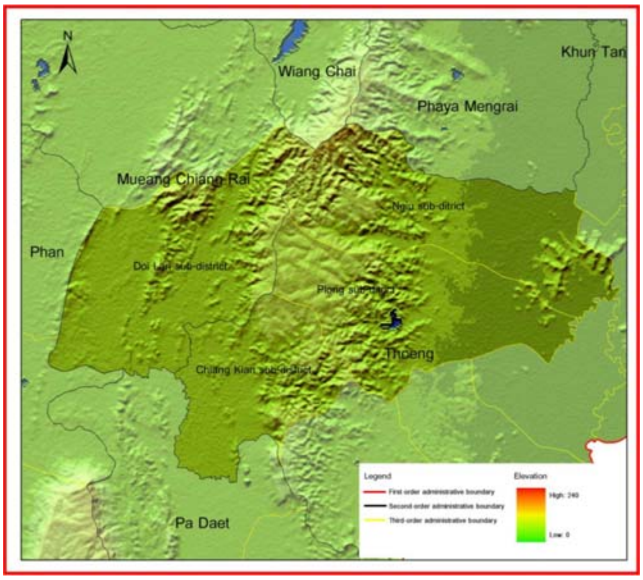


Fig. 1 The study area of multi-temporal RADARSAT for crop monitoring

4. Approach

The approach of this study was started by pre-processing RADARSAT data for analysis and classification. For the classification of RADARSAT data, this study selected both visual and automated interpretation. The five main steps of crop monitoring from multi-temporal RADARSAT data are as follows.

4.1 Data acquisition and supporting data collection.

This study aims to determine crop acreage using RADARSAT-1 imagery. However, this study utilized existing imagery from the previous study (Estimation of Rainfed Rice Yield in 2003 using RADARSAT data Project by GISTDA, Thailand, 2004), there was no imagery showing the crop during harvesting stage. Fine mode RADARSAT imagery (resolution of 8 metres) acquired in 2003 were selected from different growth stages. Moreover, RADARSAT-1 imagery were used with relevant geo-informatics data to analyze crop acreage. All of the data used in this study are shown in Table 1.

Table 1 RADARSAT-1 imagery (C-HH band) and supporting data used in this study

Main Data	Acquisition	Beam Mode	Inc. Angle	Crop Stages
RADARSAT-1 imagery	October 15, 2003	Fine	41.06	Tillering
	November 8, 2003	Fine	44.38	Vegetative
	December 19, 2003	Fine	41.06	Flowering and Podding
Supporting data	**GIS themes**	**Data Type**	**Scale**	**Data Source**
GIS data	DEM	Raster	1:25,000	GISTDA
	Topographic Map	Raster	1:50,000	Royal Thai Survey Department
	Administrative boundary	Polygon	1:50,000	Royal Thai Survey Department
	Land use map	Polygon	1:50,000	Land Develop Department
	Stream	Line	1:50,000	Royal Thai Survey Department
	Road	Line	1:50,000	Royal Thai Survey Department

4.2 Field investigation for ground truth.

This study used GPS to collect data from field survey. These data consist of date of planting, date of harvesting, crop type, climatic condition etc.

4.3 Satellite data preprocessing and processing.

The first preprocessing was data input which used only one method for SAR data. Since the SAR imagery require orbital parameters and GCPs for analysis radar backscatter (decibel unit). The Next data processing was image enhancement. This processing was for enhancing the radar backscatter value to make it easy for classification. Then, these imagery were geometrically-corrected. This process oriented these imagery in the correct direction. These imagery can be referenced to a topographic map. Lastly, the processing was speckle noise filtering. This process is very important for SAR data. Since the SAR data would be troubled by a multiple signal, this result would affect to the speckle noise on the RADARSAT-1 imagery, making it was difficult to analyze and classify the difference of data type, especially when the area was homogeneous. The SAR imagery were processed by speckle noise filtering using Khun Filtering, which is 5 x 5 size.

4.4 Satellite data analysis

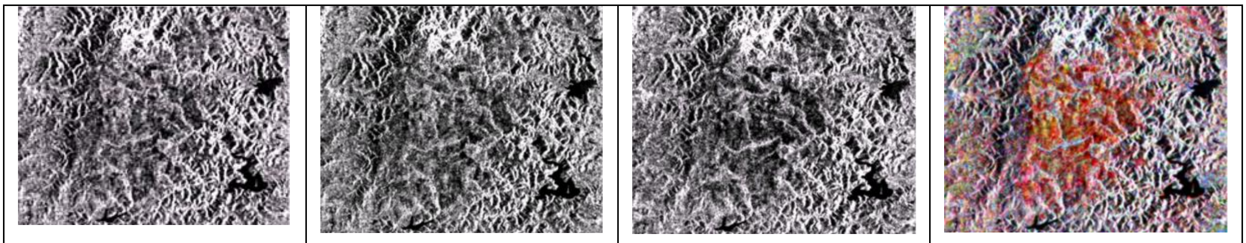
Crop in Chiang Rai province were monitored using SAR imagery to determine crop area. Visual interpretation was used for creating crop mask as a bit map, then these masks were analyzed and classified for crop area determination using maximum likelihood within PCI Geomatica system.

4.5 Crop mapping

Multi-temporal RADARSAT imagery can be produced into the three dimensions image (3D image), and crop area were derived from RADARSAT-1 imagery, producing crop mapping of the study area.

4. Result and Discussion

RADARSAT-1 imagery were acquired over an agricultural part of the study area. These data were used to address the information content of RADARSAT-1 imagery for crop mapping, and for providing information on crop condition. For this study, crop is defined as "maize" which the difference of radar backscatter from the canopy can be noticed. The multi-temporal RADARSAT imagery were utilized to generate color composite imagery. The imagery of different growth stage showed the radar backscatter in each stage. This study showed that the best color composite was derived using October 15 image in red, November 8 in green and December 19 in blue (see Fig. 2). Various colors in the multi-temporal image represent the difference in growth stages. Then, the multi-temporal RADARSAT were classified using maximum likelihood.

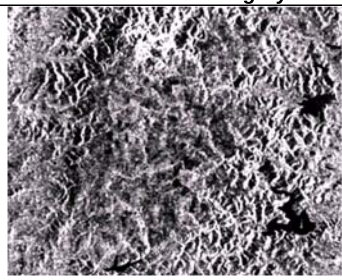
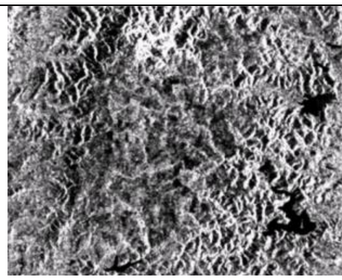
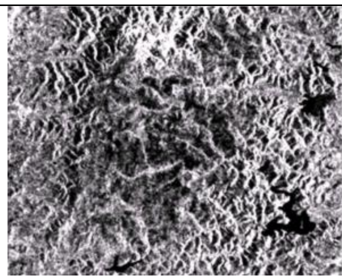


October 15, 2003	November 8, 2003	December 19, 2003	Multi-temporal RADARSAT

Fig. 2 The radar backscatter of difference dates from RADARSAT-1 imagery

The crop areas were derived from RADARSAT-1 imagery by using maximum likelihood, the results of which are as follows. The tillering stage yielded the high radar backscatter because of high soil moisture content, and corner reflector. The vegetative stage yielded medium radar backscatter of canopy, RADARSAT imagery appeared as a gray color. The lastly imagery showing the flowering and podding stage demonstrated low radar backscatter, due to thick leaves and declining moisture content from the top of canopy (see Table 2).

Table 2 Comparison of the photo image and RADARSAT-1 imagery showing the canopy of different growth stage

Acquisition	Photo image	RADARSAT-1 imagery
Acquisition: October 15, 2003 **Stage: Tillering**		
Acquisition: November 8, 2003 **Stage: Vegetative**		
Acquisition: December 19, 2003 **Stage: Flowering and Podding**		

The results showed that the total crop area was 89 square kilometers (8,900 hectares) (shown in Table 3). Most of the crop area was found Ngiu sub-district, Thoeng district, with an area on 24 square kilometers. The rest of the crop area was distributed in Doi Lan sub-district, Muaeng Chiang Rai district with an area of 21 square kilometers, Chiang Kian and Plong sub-districts have an area 21 and 23 square kilometers respectively (see Table 3). These results can be used to produce the mapping of multi-temporal RADARSAT and crop (see Fig. 3 and Fig. 4). Furthermore, this study produced a three dimensioned image (3D image) from RADARSAT data (see Fig. 5). This image can reveal the physical characteristics of planting crop in upland area. These areas usually face soil erosion and poor fertilization problems. The results of this study show that SAR data can be used for planning and monitoring agricultural in the future.

Table 3 Crop area derived from multi-temporal RADARSAT-1 imagery

District	Sub-district	Area	
		Sq. km.	ha
Mueang Chiang Rai	Doi Lan	21	2,100
Thoeng	Ngiu	24	2,380
	Plong	23	2,250
	Chiang Kian	21	2,130
Total area		89	8,860

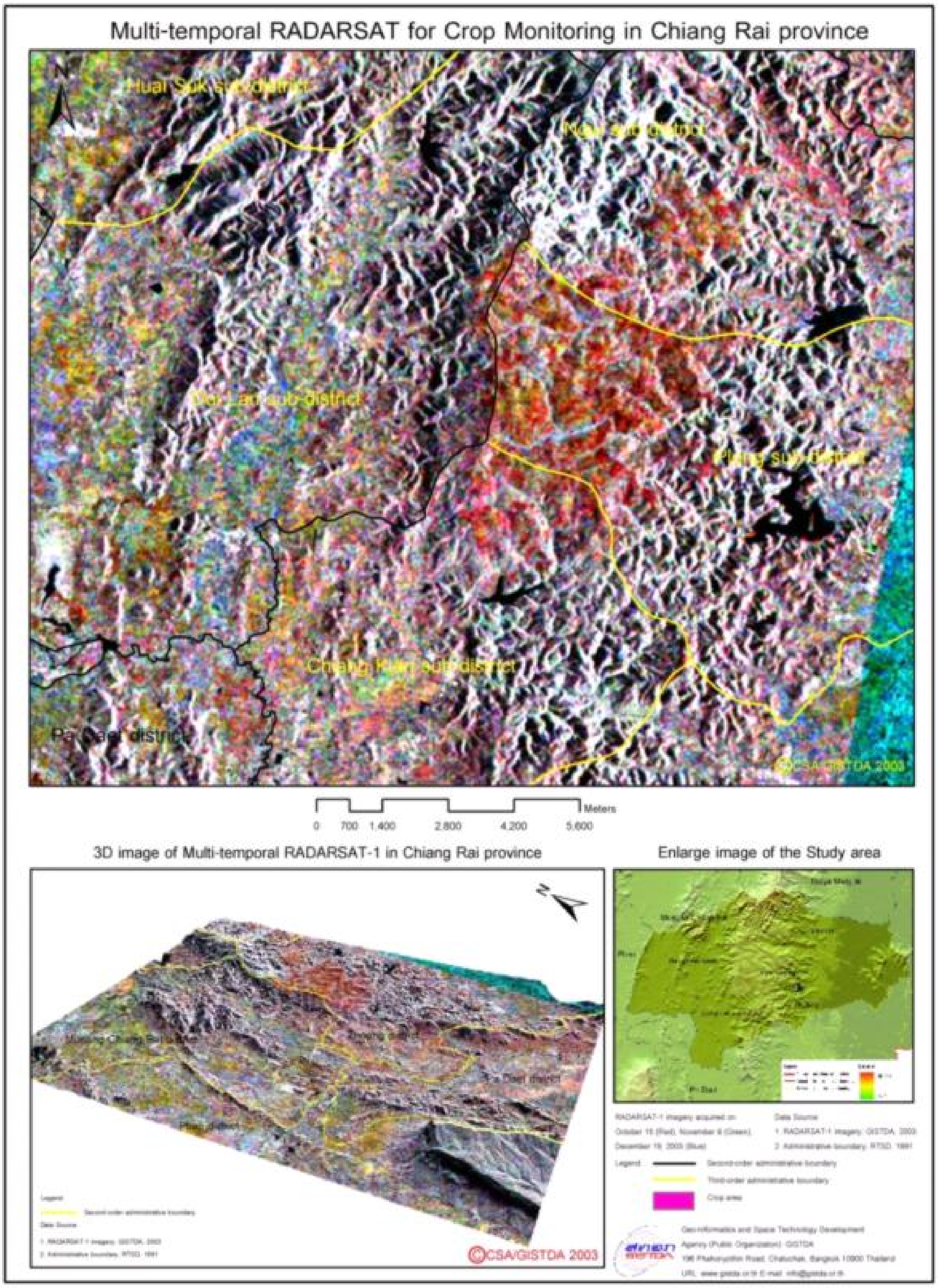


Fig. 3 Multi-temporal RADARSAT-1 imagery acquired on October 15 (Red), November 8 (Green), and December 19, 2003 (Blue) showing crop area

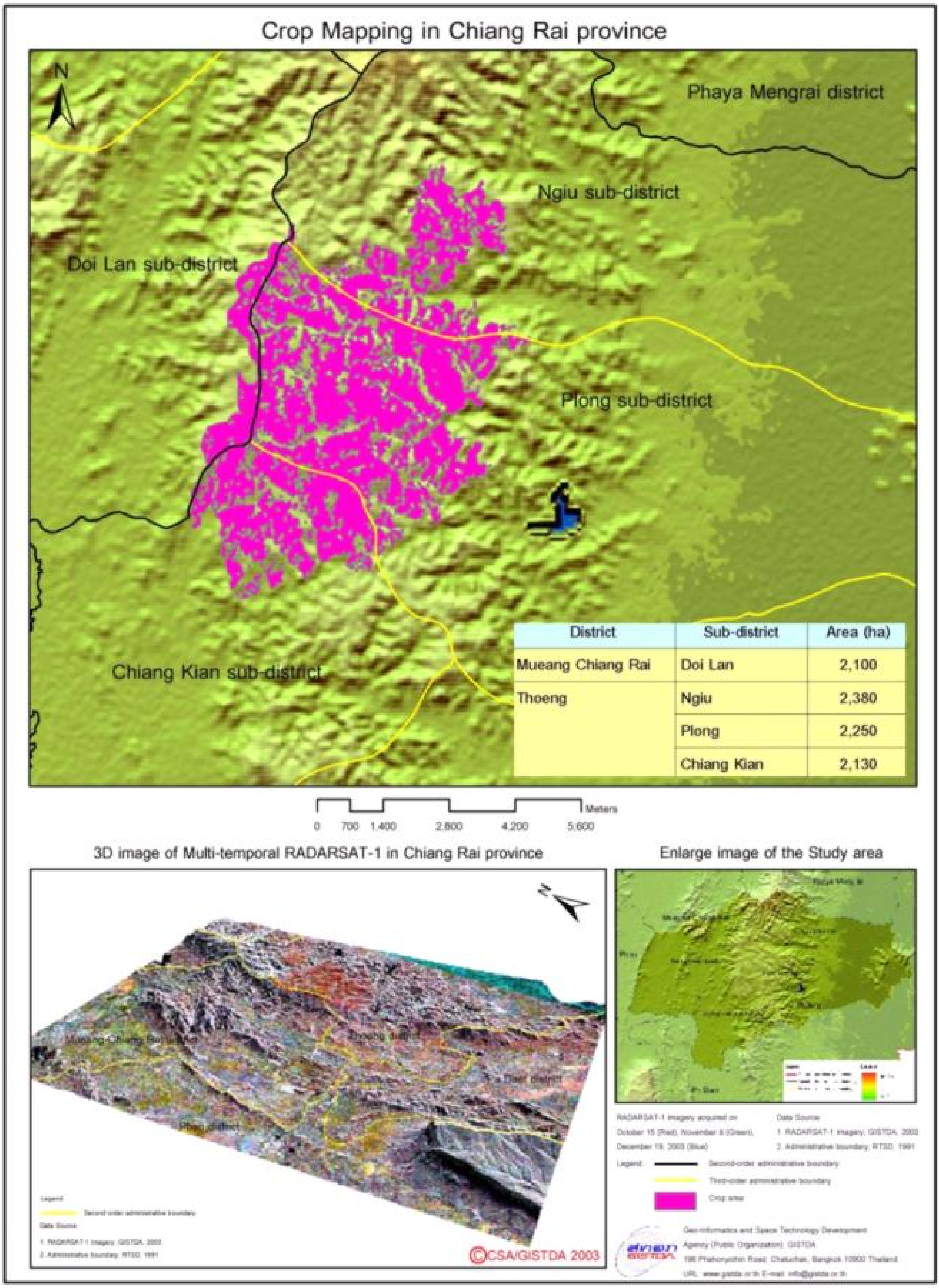


Fig. 4 Multi-temporal RADARSAT-1 imagery acquired on October 15 (Red), November 8 (Green), and December 19, 2003 (Blue) showing crop area

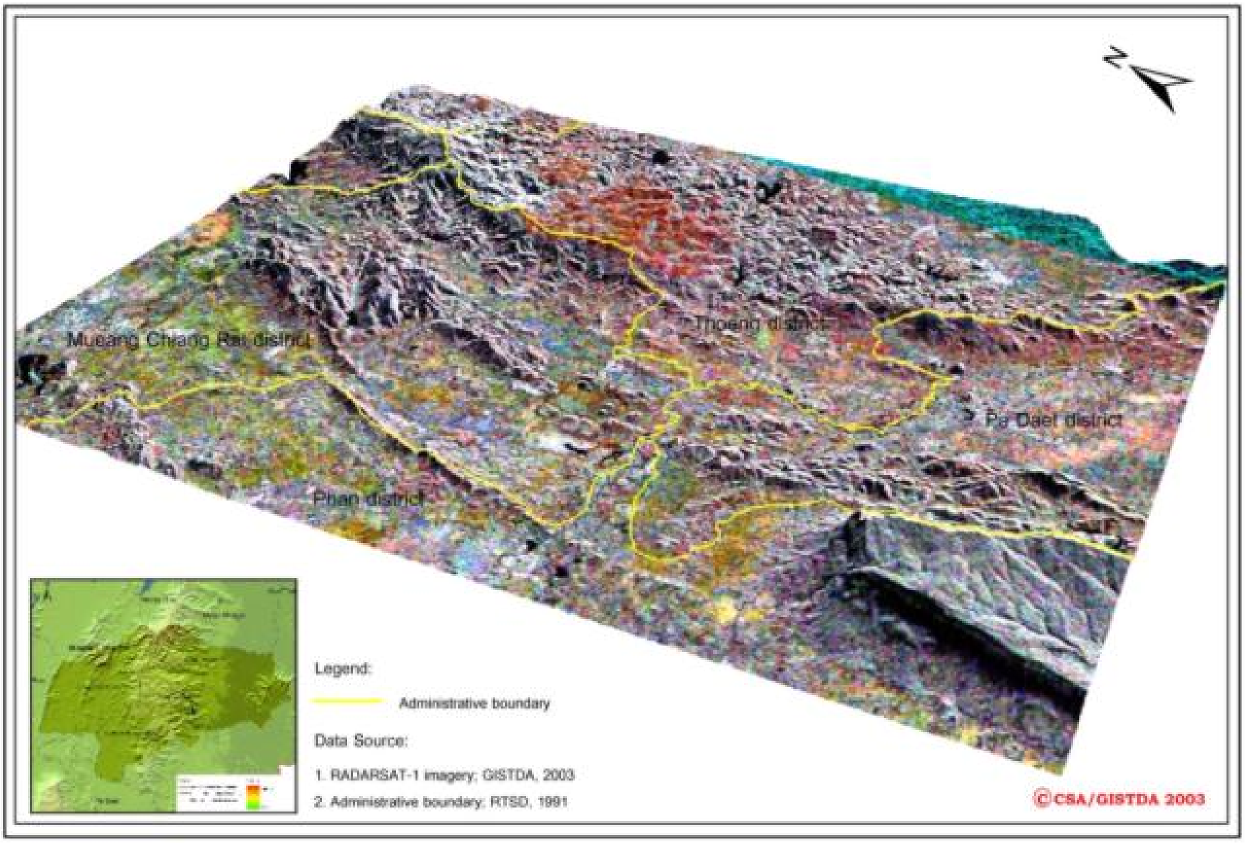


Fig. 5 3D image of multi-temporal RADARSAT-1 imagery acquired on October 15 (Red), November 8 (Green), and December 19, 2003 (Blue) showing crop area

5. Conclusion

Based on the multi-temporal RADARSAT imagery, these imagery can be used to derive accurate information on crop types. Similarly, timing of image acquisition was important and the greatest success at separating crop types was achieved with imagery gathered during the period of seed development. Then, the results indicate that RADARSAT-1 imagery can be useful for crop monitoring, particularly during the growing season.

Moreover, the results of this study will be transferred to other involved agencies such as Ministry of Agriculture and Cooperatives, Office of Agricultural Economic, and Land Development Department. Likewise, the results can be moved into operational processes including organizing a workshop in order to promote and encourage the use of RADARSAT-1 data and its application as well as to exchange ideas on technological advances in the field of geo-informatics. A training course for relevant end user group can be organized, to assist end-user in establishing an operational system of crop monitoring using SAR data.

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