Preliminary Study of Hainan Tropical Forest Classification Using SENTINEL-1 and LANDSAT-8 Images

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KEY WORDS: Tropical Forest; Classification; SAR; Random Forest; Support Vector Machine

Abstract:
Remote sensing technique is one of important tools for large areas tropical forest mapping. However, the types of tropical forest are complicated and uneasy to identify, therefore, it is difficult to classify the tropical forest types using remote sensing data of single source. In this paper, taking Hainan, China as study area, we conduct a tropical forest classification study by combining multi-temporal synthetic aperture radar (SAR) images collected from SENTINEL-1 sensor and optical images collected from LANDSAT-8 sensor. The multi-polarization backscattering features, spectrum features and the digital elevation model (DEM) features with typical tropical forest types are analyzed, such as evergreen and deciduous broad-leaved forest, evergreen coniferous forest, tropical monsoon forest, typical tropical rain forest, and so on. In addition, a tropical forest classification strategy is proposed based on support vector machine (SVM) and random forest (RF) classifiers. Finally, the Hainan tropical forest mapping image is obtained based on the proposed classification strategy. The results can support for forest resource conservation and management project in feature.

1 INTRODUCTION

Tropical forest playes an important role in ecosystem, with its capability of reducing the amount of greenhouse gases and promoting the atmospheric circulation [1] In the last 50 years, the plantations used for production industrial resources have expanded rapidly in tropical forest regions. [2] The expansion has brought destruction to forest ecosystems and potential threat to variety of species. Getting the accurate information on tropical forest areas and spatial distribution of different forest types is necessary for tropical forest protection and utilization.

With the rapid development of remote sensing technic, monitoring and classification of tropical forest resources by using remote sensing has become a hot research tropic. The optical and synthetic aperture radar (SAR) data are often used in tropical forest classification. The optical data can provide wealth spectral information, which is useful to forest mapping and classification, however, tropical area is usually cloudy and quality of optical data is very restrict by weather conditions. SAR data collection is not affected by the weather and SAR data can provide unique information on forest enabling the characterization of the canopy architecture with scattering mechanism. [3] Because types of tropical forest are complicated and uneasy to identify, tropical forest on typical region have traditionally been divided into less types by using remote sensing technic, such as inundated forest type, non-inundated forest type, evergreen forest type and deciduous forest type. [3] [4] [6]

This paper conducts a preliminary study on tropical forest classification based on the combination of both optical LANDSAT-8 data and SENTINEL-1 SAR data with different season. More forest types are considered, such as the evergreen broad-leaved forest type, the evergreen and deciduous broad-leaved forest type, the tropical monsoon forest type, the typical tropical rain forest type and the coastal forest type.

2 MATERIAL AND METHODS

2.1 Study area

Hainan island is second largest island in China, which located by the south of continent with a geographical area of 34000km2, mostly located in a tropical area. The island belongs to tropical climate region, and the specific location is 3.30°N~20.07°N,108.15°E~120.05°E. As an important part of forest ecosystem in China, the forest resources is quite abundant on the island, and the primary forest preserved well.

Study site located in the primary and second forest area of entire island, and elevation in the area ranges from circa 100 m to circa 1800 m above sea level and terrain varies mainly from practically plain to mountainous region. There the mean annual precipitation varies between circa 1000mm and 2600mm and mean year temperature is about 25°C, which divide into rainy season and dry season belonging to tropical climate.

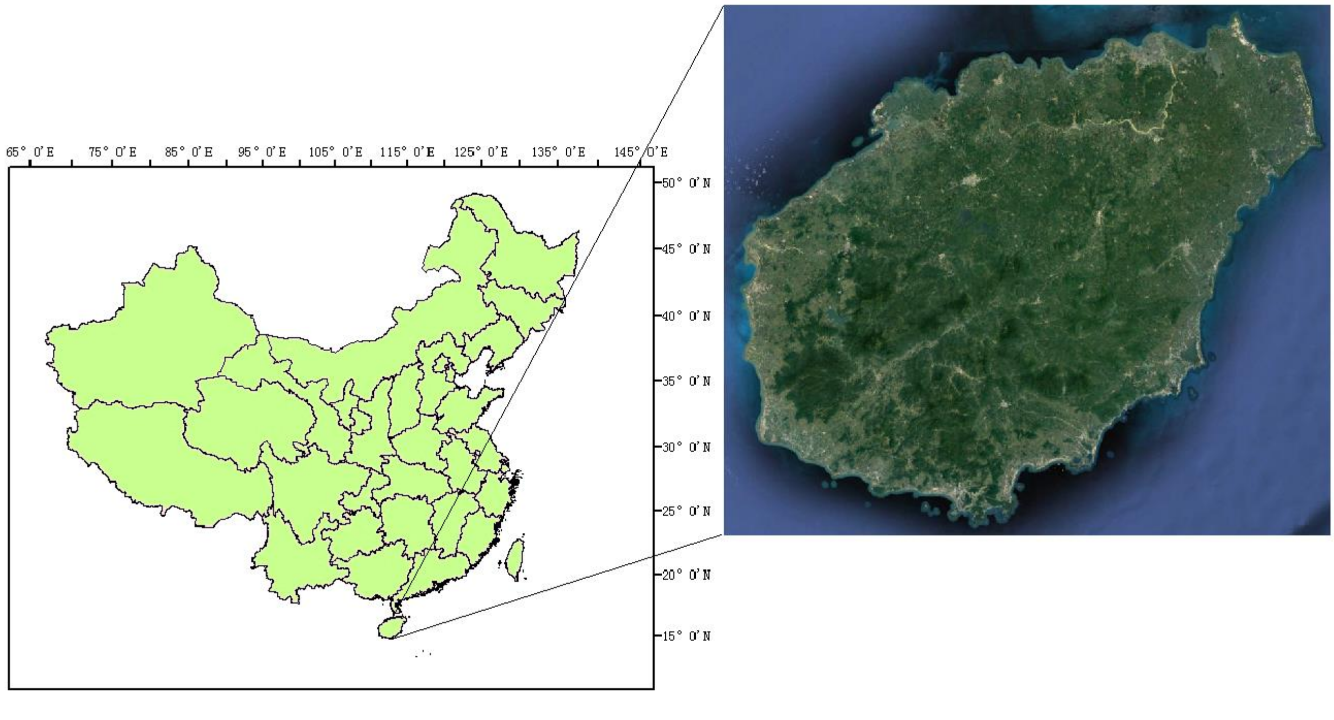

Figure 1 Location and optical image of Hainan (cite from google earth)

2.2 Data

The SAR data were acquired by SENTINEL-1 satellite for ground range detected (GRD) products with interferometric wide swath (IW) mode on different periods that was January 3, 2016 (in the middle of the dry season) and September 29, 2015 (in the middle of the rainy season), which has VV and VH polarization. The optical data were acquired by Operational land imager (OLI) of LANDSAT-8 satellite on dry season of 2015 to 2016. The SAR data and optical data are further detailed in Table 1.

Table 1 Characteristics of the selected data

	SAR data	Optical data
Satellite	SENTINEL-1	LANDSAT-8
Acquisition date	2015/9/29, 2016/1/3	Dry season of 2015 to 2016
Polarization	VV/VH	
Swath width (km)	250	185
Resolution(m)^2	5×20	30×30

3. Methodology

3.1 Data processing

The purpose of SAR data processing is obtained backscattering values of SAR in ground range geometry at quality spatial resolution. Because all the SENTINEL-1 data were multi-looked in GRD mode, the data processing began with SAR calibration. Calibration with sigma function made the radiation intensity of data response object more realistic. In order to reduce speckle of data, the refined Lee filter was applied. In this procedure, the elements of the covariance matrix are filtered by averaging the covariance matrix of neighboring pixels using a moderate window size of 7 by 7 pixels. [5] To transform the SAR geometry of data into ground range geometry, SAR-Simulation terrain correction method was applied, which generate simulated SAR image using DEM and made interpolation by the geocoding and orbit state vectors from the original SAR image. The SAR image of Hainan island finished after cutting and splicing of terrain corrected data that has backscattering values of VV and VH polarization. There were same procedures mentioned above in multi-temporal SAR data. From SAR data processing, we got the 2015 and 2016 SAR data backscattering coefficient of VV and VH polarization. The optical data processing mainly included radiometric calibration, flash atmospheric correction, cutting and splicing of data, and obtained Hainan orthophoto map retained blue, green, red, near infrared (NIR), short-wave infrared (SWIR) 1 and 2 brands with resolution 30×30m. Combining backscattering values from SAR data and seven parameters from optical data, it had nine parameters to join in classifier. After registration and fusion of both types data, the data processed of Hainan island with nine parameters were utilized to tropical forest classification. The samples, according to the rule of distinguishing extent, was selected by statistical characteristic of each band. The classifiers of classification were Support Vector Machine (SVM) [7] [8] and Random Forest (RF) [9] [10] and we got result both of two classifiers. Figure 3 shows a simplified flowchart of the proposed methodology and data processing.

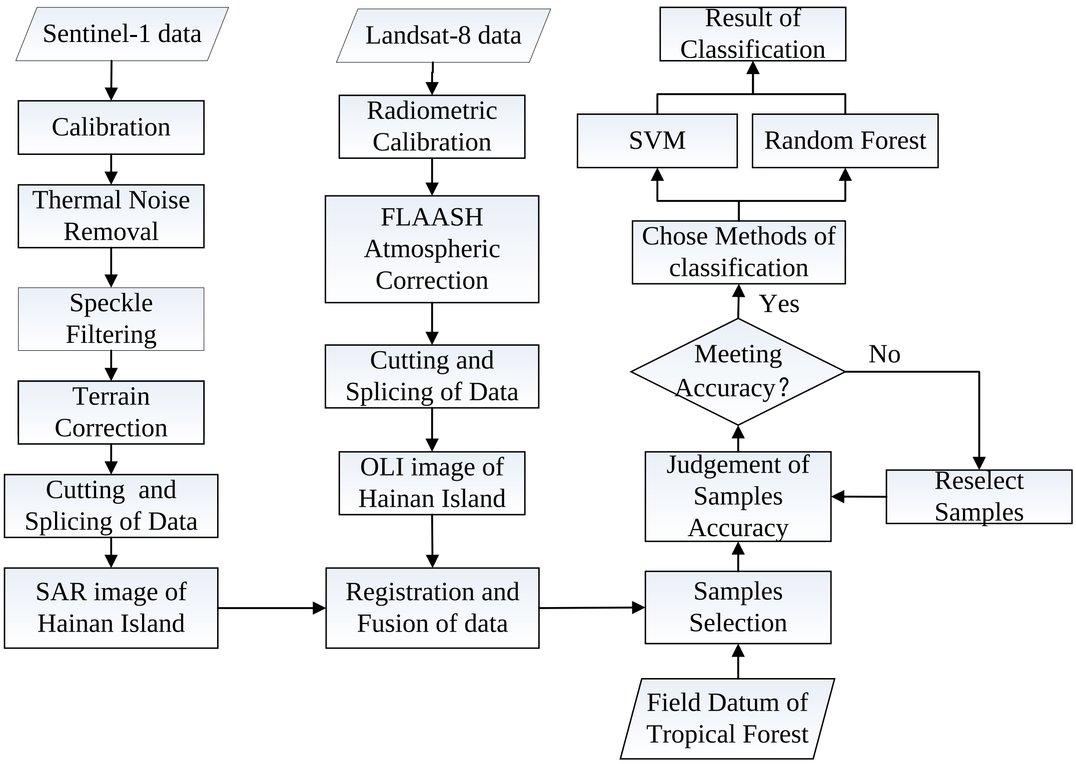

Figure 2 Flowchart of the methodology and data processing

3.2 Result

With SVM and RF classifiers based the heterogeneity of each class samples, the result had eight classes and the tropical forest of study area was divided into five types, evergreen broad- leaved forest, tropical monsoon forest, evergreen and deciduous broad-leaved forest, typical tropical rain forest, coastal forest. The figure 3 to figure 6 shows the classification result of proposed method. The result shows that evergreen broad-leaved forest occupied majority forest range and typical rain forest was scattered distribution. Compared with field survey data collected earlier, there still have low accuracy in some forest type, such as tropical monsoon forest.

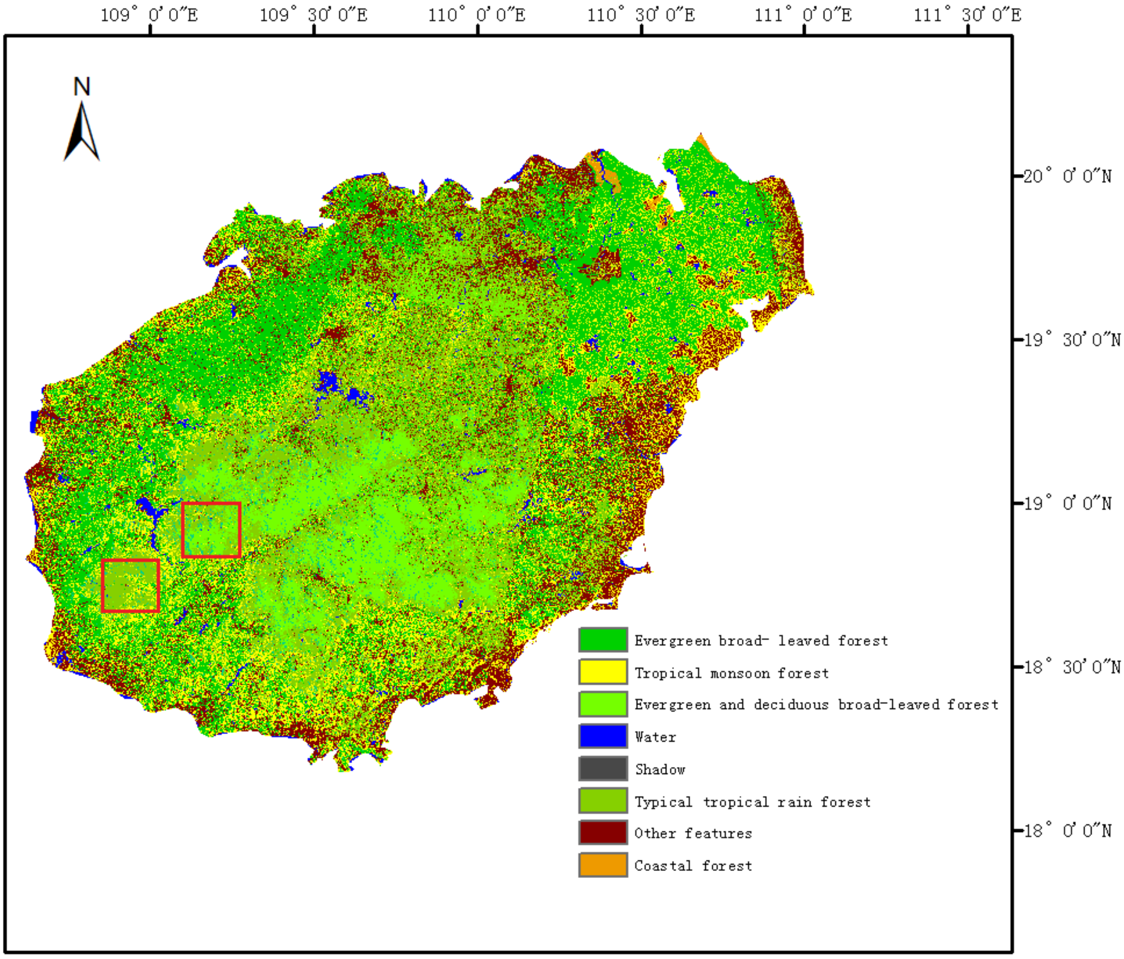

Figure 3 The classification result of RF

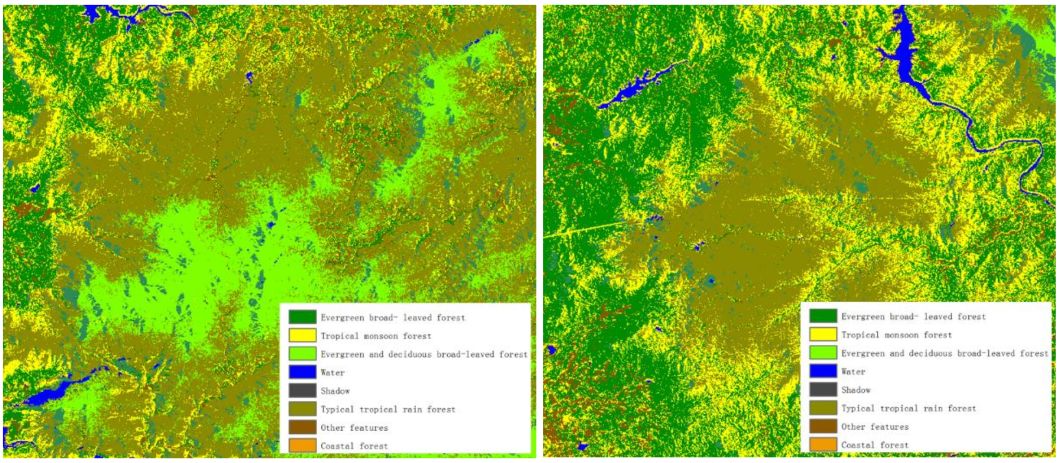

Figure 4 The detail classification result of RF

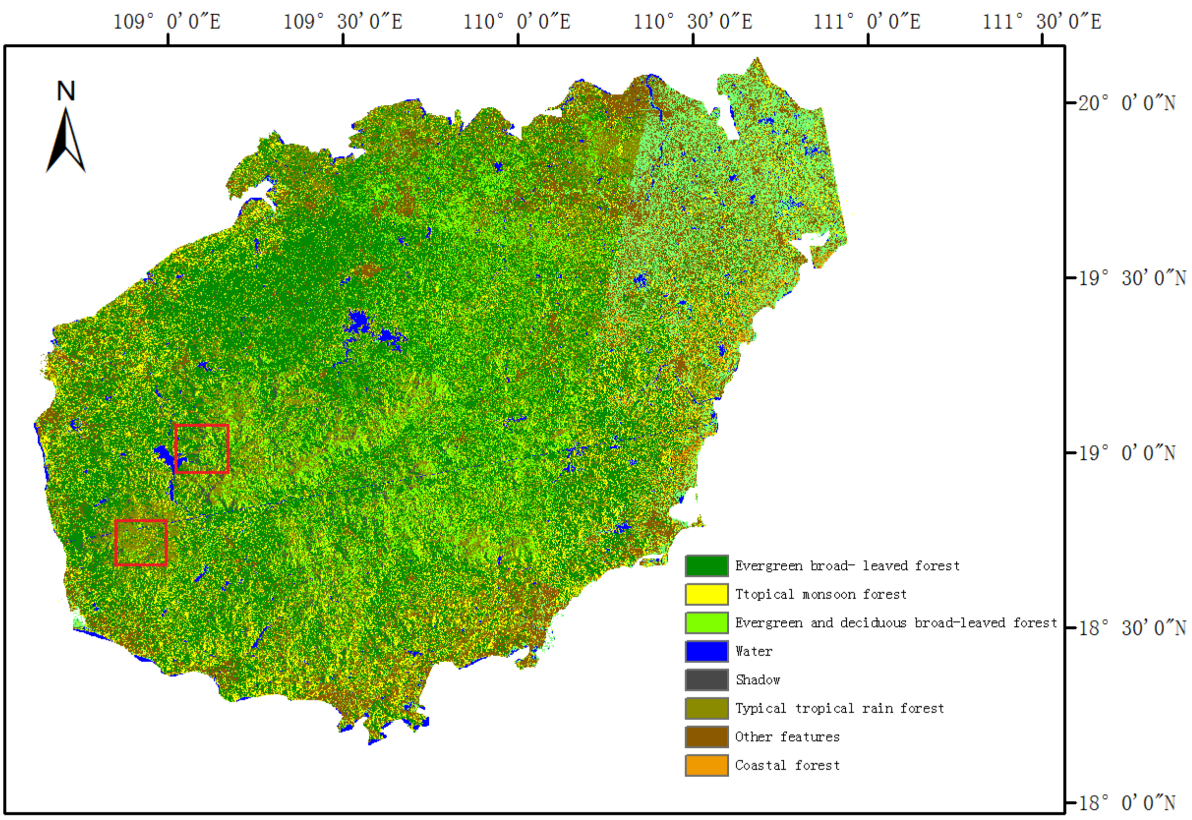

Figure 5 The classification result of SVM

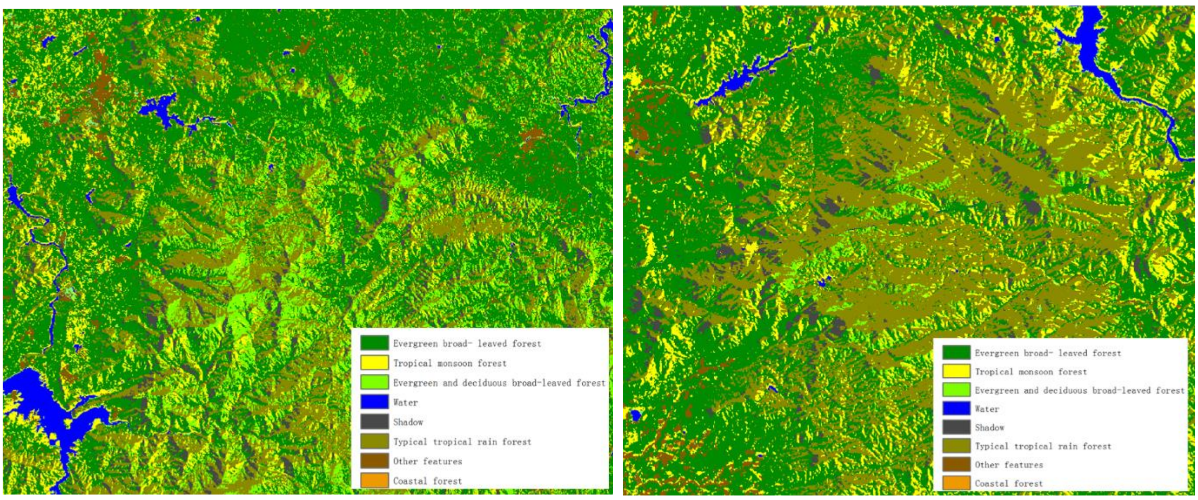

Figure 6 The detail classification result of SVM

4 CONCLUSION AND OUTLOOK

The paper demonstrated the potential of combining multi-temporal SAR data collected by SENTINEL-1 sensor and optical data collected by LANDSAT-8 sensor at the tropical forest classification. The classification result of overall object classes has reached high level in accuracy relatively and compared with google earth, objects position of classification is exhibited exactly such as forest, water and other features. Some of forest types had high accuracy according to cross-validation of samples, however, there still have low accuracy types. While the more information is extracted from combination of different source data and the more features based on statistical are applied, the accuracy of classification may enhance obviously. The cross-validation will not the only method to conduct accuracy verification, and field research will mainly support accuracy verification.

Acknowledgement

The project was financially supported by Hainan Provincial Department of Science and Technology under Grant (No. ZDKJ2016021).

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