Principal Component Analysis and Its Application on Banana Fields Mapping Using ENVISAT ASAR Data in Zhangzhou, Fujian Province

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Abstract  Banana is one of the main economic agrotypes in Zhangzhou, Fujian Province. The multi-temporal ENVISAT ASAR data with different polarization are used to classify the banana fields in this paper. Principal component analysis (PCA) was applied for six pairs of ASAR dual-polarization data. For its large leaves, banana has high backscatter. So the value of banana fields is high and shows very bright in the 1st component, which makes it much easier for banana fields extraction. Dual-polarization data provide more information, and the VV and VH backscatter of banana show different characters with other land covers. Based on the analysis of the radar signature of banana fields and other land covers and the 1st component, banana fields are classified using object-oriented classifier. Compared to the field survey data and ASTER data, the accuracy of banana fields in the study area is 83.5%. It shows that the principal component analysis provides the useful information in SAR images analysis and makes the extraction of banana fields easier.

Keywords  ENVISAT ASAR; principle component analysis (PCA); dual-polarization data; banana fields

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Introduction

Because of its cloudy and rainy weather, Synthetic Aperture Radar (SAR) is anticipated to become the dominant high-resolution remote sensing data source for agriculture applications in tropical and subtropical regions. Land cover mapping and the retrieval of biophysical and geophysical information, including land use, soil, crop and forest parameters from space-borne SAR have become important applications over the last 10 years. Banana is one of the main fruits in China, and Fujian is one of the main preponderant areas for banana production. The distribution of banana fields is a very important information for local agriculture departments.

The potential of SAR in discriminating among different agricultural crop types has been demonstrated in several studies[1-3]. In order to successfully classify land cover types or discriminate among different agriculture types, a variety of classification schemes have been proposed and used[2-7]. The accuracy of
classification depends on the sensitivity of the used backscattering coefficients to the differences of the biomorphological structures of the plants, hence to the different interaction behavior between the electromagnetic wave and the structure of the canopy\cite{3}. One SAR image at a given frequency, polarization and incidence angle, is often inadequate to attain the required accuracy of classification. Improvements are expected by multi-temporal and/or multi-polarization and/or multi-angle SAR images. The advanced SAR (ASAR) aboard ENVISAT works at C-band and can provide multi-polarization SAR images. Its Alternating Polarization Mode (AP Mode) product contains two co-registered images with different polarization.

As one of the most important types of image enhancement methods, PCA is a procedure for transforming a set of correlated variables into a new set of uncorrelated variables. It has proved to be of value in the analysis of multi-channel remotely-sensed data. With multi-temporal and dual-polarization ASAR data, there are many channels for analysis and the volume of data is very large. So it needs to reduce the data volume. The PCA is a good choice, and the method is seldom used for SAR data classification. Reference\cite{8} used several pairs of ENVISAT ASAR data for the classification of rice, banana and water bamboo in a small area in Zhangzhou. The results showed that the ASAR data were good potential for banana fields mapping. Based on PCA and object-oriented classifier, we used multi-temporal ASAR AP products to identify banana fields in much larger area in Zhangzhou, Fujian Province, China in this paper.

1 Study area and ASAR data basis

Our research was conducted in Zhangzhou District, south of Fujian Province in southeastern China. A 5 645 km$^2$ area was selected for our analysis (Fig.1). In 2003, the banana producing area in Zhangzhou was 2.43×10$^4$ ha and the yield was 7.77×10$^8$ kg, respectively 83.22% and 92.7% in Fujian.

In our study, we use multi-temporal AP products with VV and VH data obtained in 2004. The orbit direction was ascending with an incidence angle of 19.2–26.7 degrees (IS2). The acquired dates are May 29, August 7, September 11, October 16, November 20 and December 25.

ASTER images acquired on April 5, 2004, 1:50 000 DEM data and slope data deduced from DEM are also used in our study.

2 Radar signature and PCA

Multi-temporal ASAR image preprocessing includes raw data input into image processing software, radiometric calibration, speckle suppression, orthorectification and conversion of data format from amplitude to dB\cite{9}. The temporal behaviors of VV and VH backscatter for some typical land covers are shown in Fig.2 and Fig.3.

Banana is a kind of herb throughout the year and changes little with seasons, so the backscatter changes little with season too. Because of its big leaves, its backscatter is very high. This character of banana is quite different from that of many other land covers. For example, the backscatter of water body is very low, the backscatter of forest is temporally stable, while the backscatter of rice is temporally variable.

In VV polarization, banana’s backscatter is a little lower than that of residential area, but higher than other land covers. In VH polarization, the backscatters of banana and residential area are still very high. In most of the dates, the VH backscatter of banana is a little lower than that of residential area, but for dates in August and September, the VH backscatter is higher than that of residential area. Dual-polarization data provide more information and will improve the accuracy of agriculture classification. The difference
characters of VV and VH will help to discriminate banana fields and residential area.

Principal component analysis is adopted for analysis. The first component (PC1) is the weighted sum of different channel images, minor principal components reflect the land cover changes. Because of its large leaves, banana has a high backscatter and changes little. So, in PC1, the banana fields are very bright (Fig.4). This character will improve the separability of banana and other land covers.

3 Object-oriented classification and results

To successfully discriminate among different agriculture types, suitable classification algorithms should be used, which are capable of exploiting the information embedded in multi-temporal and multi-polarization SAR measurements. The object-oriented approach incorporates both spectral information (tone, color) as well as spatial arrangements (size, shape, texture, pattern, association with neighboring objects), which will increase classification accuracy. It is often used for high-resolution imagery with more spatial information and less spectral information. For SAR data, the spectral information is poor and spatial information is rich. So in this paper, we use object-oriented multi-scale image analysis method embedded in the software eCognition[10] to classify the ASAR data.

The relationships are represented with fuzzy rules, which are capable of dealing with vague models and well suited to describe dependencies between different kinds of information. The eCognition software consists of two main steps, multi-resolution segmentation and objects based classification. The first step is a segmentation of the image based on three parameters: scale, color (spectral information), and shape (smoothness and compactness), where color and shape parameters can be weighted from 0 to 1. Within the shape setting, smoothness and compactness can also be weighted from 0 to 1. Scale is a unitless parameter related to the image resolution. The segmentation used in eCognition is bottom-up region merging technique[11].

Image objects are assigned to classes using a fuzzy rule base. The workflow of image analysis is described in Fig.5. With the first principal component and one date dual-polarization data, the banana fields may be classified quickly (Fig.6, black area).
The classification assessment was carried out based on field survey data obtained in November, 2004 and ASTER data acquired on April 5, 2004. The accuracy of banana fields in the study area is 83.5% and the Kappa coefficient is 0.812. This means that the object-oriented classifier is suitable for SAR data classification and the principal component analysis provides useful information in SAR data analysis.

**4 Conclusion**

This paper investigates the potential of ENVISAT ASAR data for banana fields mapping. Banana fields are very bright in the first component. Based on the principal analysis and the temporal behaviors of ASAR data, banana fields are classified using object-oriented classifier. It shows that the principal component analysis provides the useful information in SAR images analysis.

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