Forest Change Mapping in Northeast China Using SAR and INSAR Data

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Abstract - One of the objectives of Forest Dragon 2 project is the generation of a forest cover change map between 1990s and 2000s for Northeast China based on ERS-1/2 tandem data and ENVISAT ASAR data. For the 1990s' map, an automatic and seasonal-adaptive retrieval of forest biomass method was used to produce a forest biomass map based on the ERS tandem interferometric coherence. The biomass map was integrated into two categories (forest and nonforest). For the 2000s' map, an object-based classification method was developed for ASAR HH/HV images acquired on a single date. Post-classification comparison method for change detection was adopted based on the two forest/nonforest maps.

Keywords: SAR, InSAR, Forest, Classification, Change detection

1. INTRODUCTION

The forests of Northeast China, which represent one of the most important wood supplies in China, have been undergoing constant pressure for several decades. These forests have experienced significant changes during the past decades which should be monitored for a better forest management and for the ecosystem. Satellite images can provide quick and accurate mapping for these changes at large scale. One of the objectives of Forest Dragon 2 (Li, 2005; Tian, 2008) is to map the forest cover change in Northeast China using ESA's SAR data. In this paper, the methods for forest/nonforest mapping and change detection using space-borne Synthetic Aperture Radar data will be discussed.

The paper is structured as follows: after a description of the test site and the data available (Section 2), the forest biomass retrieval method from ERS tandem InSAR coherence is discussed (Section 3). The object-based forest and nonforest classification method for ENVISAT ASAR HH/HV intensity images is presented in Section 4. In section 5, the preliminary change detection results are presented. Finally, conclusions are drawn on the forest/nonforest classification on SAR and InSAR, as well as the forest change detection (Section 6).

2. TEST SITE AND DATA

Northeast China includes eastern Inner Mongolia, Heilongjiang, Jilin and Liaoning provinces. The forests are mainly distributed over the Daxinganling, Xiaoxinganling and Changbai mountains, accounting for more than 1/3 total stocking volume in China.

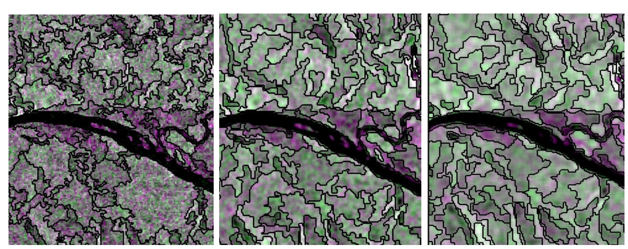
The ERS-1/2 SAR dataset covering this area consisted of 223 coherence images with baselines <400m and acquired in two periods between winter 1995 and summer 1998. The ENVISAT ASAR data were acquired between September 2004 and February 2005 in AP IS2 mode (HH/HV polarization, 23.5^o incidence angle). In total, 138 images for single date were used for the whole coverage of Northeast China. The preprocessing of the data consists of calibration, coregistration, multilooking, geocoding and radiometric normalization, as well as interferogram generation and coherence estimation for InSAR data. A Landsat TM mosaic was referenced for geocoding of the images in flat terrain area, while SRTM DEM was used for geocoding most of the images.

3. GROWING STEM VOLUME MAPPING USING ERS TANDEM DATA

The method of forest biomass retrieval from ERS-1/2 tandem data in 1990s was based on the Dragon-1 final paper (Cartus, 2008). In this paper, the semi-empirical Interferometric Water Cloud Model (IWCM) was trained on the basis of frame by frame using the MODIS Vegetation Continuous Field product. The classification was done by applying simple thresholds to the stem volumes retrieved by inverting the trained models. The forest stem volume map was produced by 5 classes: 0~20, 20~50, 50~80, >80 m^3/ha and water. For the comparison with the ASAR-based map, the classes were integrated into two classes: forest and non-forest. The Producer's accuracy of the highest stem volume class was always high in the range of 90%. The accuracy of the lowest class, i.e. 0-20 m^3/ha, was in the range of 80% as long as no overestimation of ground coherence occurred.

4. FOREST NONFOREST CLASSIFICATION USING ENVISAT ASAR DATA

eCognition software was used for the development of an automatic, robust and transferable approach for forest/nonforest classification using ENVISAT ASAR HH/HV at single-date acquisiton.



(a) (b) (c)

Figure 1. Filtering effects on image segmentation with same scale factor ((a) unfiltered; (b) GammaMAP filter with window 3×3; (c) GammaMAP filter with window 5×5)

4.1 Filtering

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The basic for object-based classification in eCognition is image segmentation, which clusters adjacent homogenous pixels into objects. The speckle noise complicates the processing and analysis of SAR data. The effect analysis of speckle filtering on segmentation was performed and assessed by visual comparison (Figure 1).

It can be seen from Figure 1 that segmentation (a) based on the unfiltered images are more random than the filtered ones ((b) and (c)), for example, the big object in the center of the picture. The objective of filtering is to minimize speckle while preserving spatial resolution. Finally the filtering strategy before segmentation was set as follows after comparison:

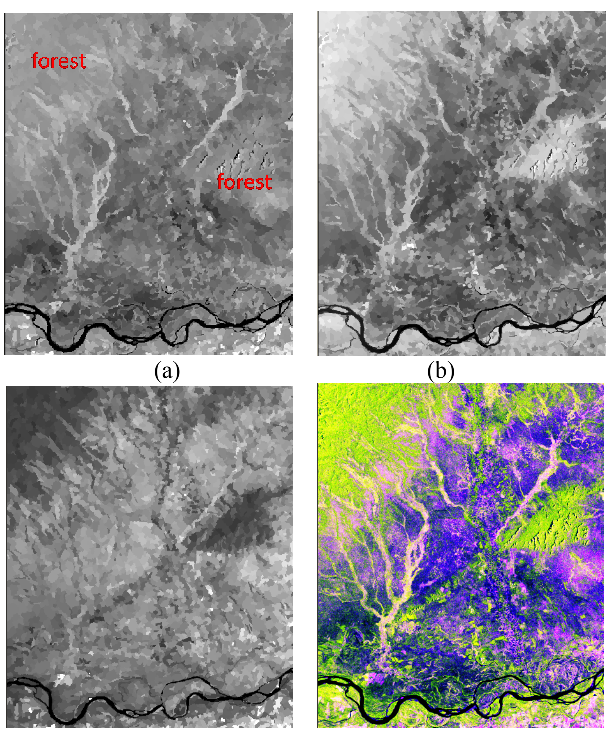
1) Multichannel filtering (Quegan and Yu, 2001) with HH and HV image for the same data to increase the ENL by 2;
2) GammaMAP filtering (3×3) to further suppress the speckle.

4.2 The ratio image

For a single date ASAR HH/HV image, the ratio $\hat{r}$ was calculated using Equation (1) and used as input to eCognition, together with HH and HV intensity.

$$\hat{r} = \frac{\hat{I}_{HH}}{\hat{I}_{HV}} = \frac{\frac{1}{M_{HH}}\sum_{k=1}^{M_2} I_{HH,k}}{\frac{1}{M_{HV}}\sum_{l=1}^{M_1} I_{HV,l}} \tag{1}$$

where $\hat{I}_{HH}$ and $\hat{I}_{HV}$ are the mean intensity of HH and HV image in a computing window.



(a) (b)

(b) (d)

Figure 2. ASAR images of Sep.23, 2004 ((a) HH; (b) HV; (c) ratio; (d) color composite with (a), (b), (c) as R, G, B)

A good feature analysis is a basic prerequisite for successful work in object-based image analysis. In most cases, feature analysis is performed empirically by trial and error. SAR images are the representation of the result of the interaction between microwaves and earth targets. Understanding of the physic process can help us selecting the optimal features for classification rule setting. The three inputs, HH, HV and ratio image, are shown in Figure 2 as well as the color composite image. As we can see in Figure 2 (a), the contrast between forest and non-forest is very low, particularly with the agricultural fields to the south of the river having high HH values. In HV image (Figure 2 (b)) forest areas show bright color with high intensity because of the volume scattering. For agricultural area, it depends on the crop species. Some crops provide strong volume scattering as well because of the relatively short wavelength for C-band (5.6cm for ERS-1/2 and ENVISAT ASAR). Thus, it is difficult to separate forest from agriculture using either HH or HV polarization image. Figure 2 (c) shows the combination of the two polarizations by ratio, which presents the best contrast between the forest and nonforest except the water. The feature space optimization function in eCognition confirmed this by giving the feature ratio as the optimum single feature. Color composite with the ratio in Figure 2 (d) gives very good visualization with the forest areas green.

4.3 Classification with eCognition

Multiresolution segmentation method (Baatz, and Schape, 2000) was applied to the images. With the ratio giving the best contrast following the HV, the layer weights for segmentation were set to 1, 0.8 and 0.5 separately to ratio, HV and HH image. The scale parameter was 5.

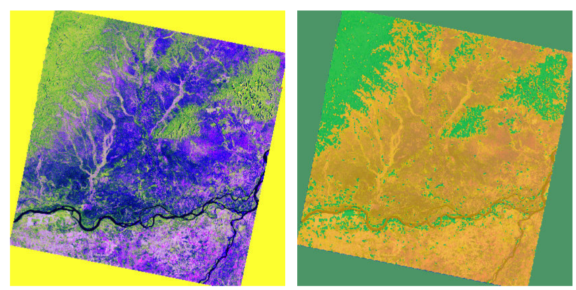


Figure 3. ASAR image and derived forest cover map (transparent map laid on the intensity data, acquisition date: Sep.23, 2004)

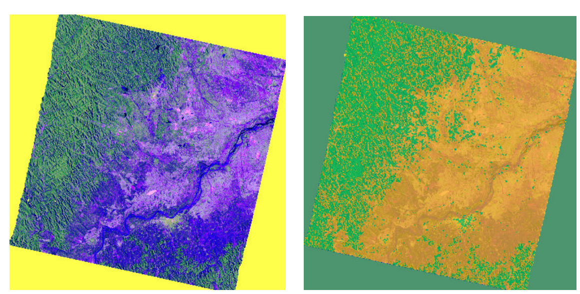


Figure 4. ASAR image and derived forest cover map (transparent map laid on the intensity data, acquisition date: Sep.26, 2004)

The classification process consists of two steps. One is the separation of the image area from the background. The other is the classification of forest area. Two rules were set for the class forest:

1) the ratio greater than 3.76 dB and less than 6.55 dB and 2) HV greater than -13.85 dB. The second rule was used to exclude some agricultural areas which were misclassified by 1) as forest. A processing tree was developed with eCognition including segmentation, classification of background, classification of forest and result export. Figure 3 shows an example of a color composite image and the derived forest map, based on which the processing tree was developed. Most of the forest areas were classified correctly. Figure 4 shows another image and the corresponding derived forest map using the same processing tree. The robustness and transferability are satisfactory as can be seen from the good classification result.

5. FOREST CHANGE ANALYSIS

Based on the two forest cover maps, the forest change detection can be performed using post-classification comparison method. Some preliminary results were achieved, etc. the changes due to the great forest fire in Daxinganling more than 20 years ago.

6. CONLCULSIONS

The general idea of the forest cover change mapping method of Forest Dragon 2 was discussed in this paper, with a brief introduction to the forest cover map production from ERS-1/2 tandem coherence and emphasis on the object-based classification method for forest cover mapping using ENVISAT ASAR HH/HV single-date data. Some conclusions can be drawn: 1) ERS-1/2 tandem coherence provides very good accuracy for forest cover mapping; 2) The ratio image of HH and HV polarization is the best feature for forest/nonforest classification using ENVISAT ASAR HH/HV single-date data; 3) The proposed forest/nonforest classification method, including image filtering, feature extraction (ratio) and a transferable eCognition processing tree, provides robust and accuracy results for different images. The validation of the classification method will be carried out with more images and more detailed reference data. Further work will be focused on the forest change mapping and validation based on the ERS forest cover map and the ASAR forest cover map.

REFERENCES

[1] M. Baatz, and A. Schape. “Multiresolution segmentation - An optimization approach for high quality multi-Scale image segmentation,” Angewandte Geographische Information sverarbeitung XII, Ed. J. Strobl et al. AGIT Symposium, Salzburg, Germany, 2000. pp. 12-23.

[2] O. Cartus, M. Santoro,C. Schmullius, Y. Pang, E. Chen, and Z. Li. “Creation of large area forest biomass maps for Northeast China using ERS-1/2 tandem coherence”, Proceedings of the Dragon 1 Programm Final Results 2004-2007, 21 – 25 April 2008, Beijing.

[3] S. Quegan and J.J. Yu. "Filtering of multichannel SAR images," IEEE Transactions on Geoscience and Remote Sensing, 39, 2373 - 2379 , 2001.

[4] X. Tian, Z. Li, E. Chen. et.al. “larege-scale forest mapping in northeast China and map updating by using ERS-1/2 and ENVISAT ASAR data,” Proc. Dragon 1 Programme Final Results 2004–2007, Beijing, P.R. China 21– 25 April 2008 (ESA SP-655, April 2008)

[5] Z. Li, Y. Pang, C. Schmullius, and M. Santoro. “Forest mapping using ENVISAT and ERS SAR data in Northeast of China,” Geoscience and Remote Sensing Symposium, IGARSS '05. Proceedings., 5670 – 5673, 2005.

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