FOREST BIOMASS ESTIMATION IN NORTHEASTERN CHINA USING ALOS PALSAR DATA COMBINED RADIATIVE TRANSFER MODEL

Zhifeng Guo[1], *Wenjian Ni*[1*], *Guoqing Sun*[2]

[1]State Key Laboratory of Remote Sensing Science, Jointly Sponsored by the Institute of Remote Sensing Applications of Chinese Academy of Sciences and Beijing Normal University, Beijing 100101, China.
E-mail: nwj-100@163.com
[2]Department of Geography, University of Maryland, MD, 20742, USA

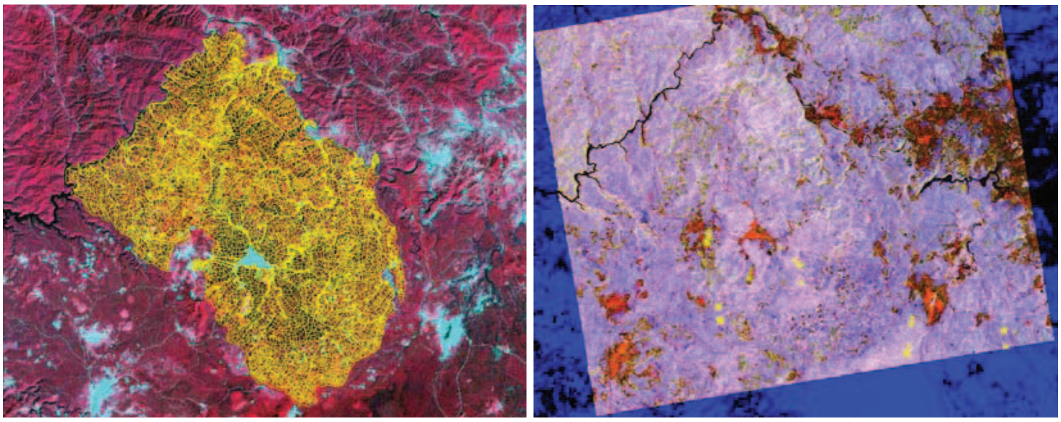
1. INTRODUCTION

Forest biomass mapping from SAR data is one of the most promising applications of microwave remote sensing, for its penetration capability and sensitivity to water content in vegetation. Radar data (both single-polarization and dual-polarization) have been used for forest biomass estimation. Most studies concentrated on flat areas with terrain effects not significant, and the developed methods and algorithms for biomass estimation are most empirical models, which depend on large field measurements.

In this research, a forest biomass estimate technique based on forest backscattering database is developed, and is used to resolve biomass inversion in mountain area. Firstly, the forest full polarization radar backscattering database is established using 3D forest radar backscattering model combined with forest growth model. Then forest aboveground biomass is estimated based on this database using statistic regression method and look up table (LUT) method. The radar backscattering model used here is an improved 3D forest radar model based on Radiative Transfer theory, which considers multiple scattering from canopy and improves model's prediction accuracy of cross-polarization backscattering. To simulate backscattering of forest stands, forest growth model, which considers typical forest characteristics of northeast china and environment conditions such as temperature and precipitation, is used to generate many stands with 30*30m scale for different species with different growth stages. Then tree structures are extracted from these stands to drive the 3D radar model to calculate backscatter coefficients according to ALOS PALSAR sensor specifications. To the LUT method, three merit functions are used to determine the final solution pixel by pixel. Namely, the minimum distance criterion, the threshold distance criterion and the threshold distance criterion combined with regression equations constraint. The inversion results derived from PALSAR FBD data shows that both the statistical regression method and minimum distance LUT method underestimate forest aboveground biomass. The third LUT method gives the better biomass estimation compared with forest inventory data, the mean absolute error (MAE) of the whole research area is less than 10 Ton/ha.

2. TEST SITE AND DATA

The Lushuihe forestry bureau (42.5°N, 127.8°E) in the northeast China near Changbai mountain Natural Preserve (42.8°N, 127.8°E) was selected as test site in this research. The whole forest area is divided into eight forestry centers with 7554 compartments. The broadleaf Korean-pine (Pinus koraiensis) mixed forest is the most diversified forest in species and ecosystem, which is the most productive ecosystem in various resources in northeast China. Forest attributes of all compartments within the Lushuihe forest were acquired through forest survey in 1999 and 2003 respectively, and some compartment attributes had been updated during the 2005. Figure 1(a) shows the whole compartments on ETM+ image. The ALOS PALSAR dual-polarization data (LHH and LHV) acquired in July, 2007 and the Landsat ETM+ data acquired in Sep, 1999 were used in this research. The ETM+ image was used to generate land classification map, which divided land covers of Lushuihe area into four types (non-forest, broadleaf forest, conifer forest and mix-forest). Then the PALSAR data and classification map were registered to generate composite image shown in Figure 1(b).



(a) (b)

Figure1. (a) The whole research area with 7554 compartment vectors overlaid on ETM+ image, (b) The composite PALSAR and forest class map for Lushuihe study area. Red:HH, Green:HV, Blue:forest class map

3. METHOD

3.1 Forest growth modeling

In this research, the GAP model – ZELIG was firstly calibrated to suit the broadleaved-Korean pine mixed forest in the Changbai mountain area, and then was used to simulate the forest successional dynamics on three soil types in our study area. Because ZELIG model simulated tree growth, mortality, regeneration in stochastic mode, five separate runs were performed to generate a range of stand responses, and model outputted at 5-year intervals from 5 years to 500 years. Each output records DBH, Height of every tree and biomass in 30*30m plot. Figure 2 gives an example of broadleaf stand scene with 60 years old. Total 4500 records were generated (3 soil types*3 forest types*5 replications*100 time steps).

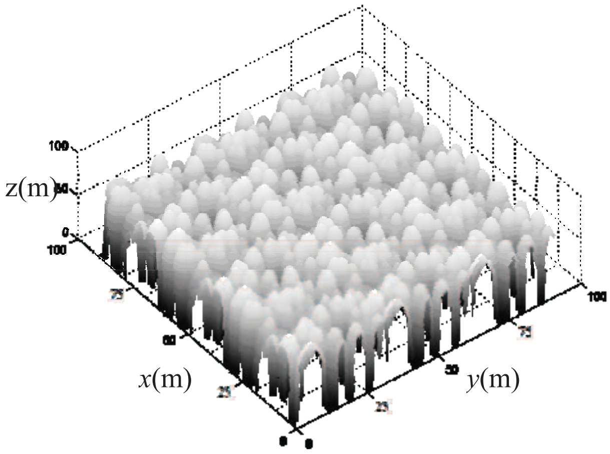


Figure2. A constructed 3D broadleaf stand scene with 60 years old according to forest growth modeling

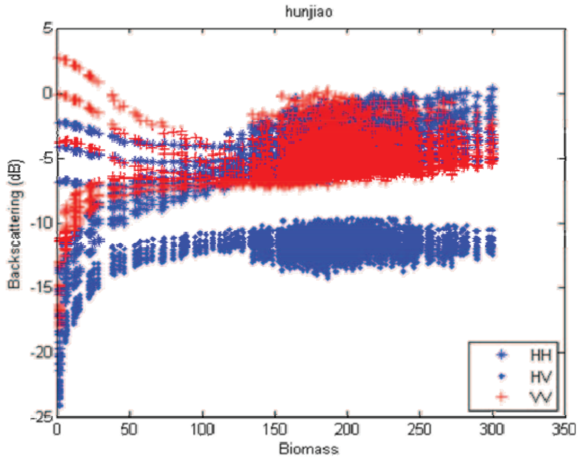


Figure3. The relationship between forest biomass and simulated radar backscattering coefficients

3.2 SAR backscattering modeling

The 3D radar backscatter model developed by Sun et al. was improved and used in this study, which increased the calculating accuracy for cross-polarized scattering. The radar backscattering coefficients were simulated with 3 surface roughness and 13 incident angle for 4500 stands according to PALSAR polarimetric image parameters, so the whole backscattering database was composed by 175500 records. The relationship between forest above ground biomass and simulated L-band radar backscattering coefficients in the database was shown in Fig 3.

4. RESULTS

In this research, statistic regression and look up table (LUT) methods were used to estimate forest biomass based on backscattering database. The backscattering coefficients and biomass in the database were used to generate inversion equations according to different forest types. The regression equation is defined as:

$$Log10(biomass)=a*HV+b*HH+c \quad (1)$$

Where, a, b and c are regression coefficients.

To the LUT approach, three merit functions were used to find the solution of biomass inversion, which are minimum distance merit function, threshold distance merit function and threshold distance combined with regression equations merit function. Figure 4 give some primary results of forest above biomass estimation using regression equation method and threshold distance criterion combined with regression equations constraint LUT method respectively.

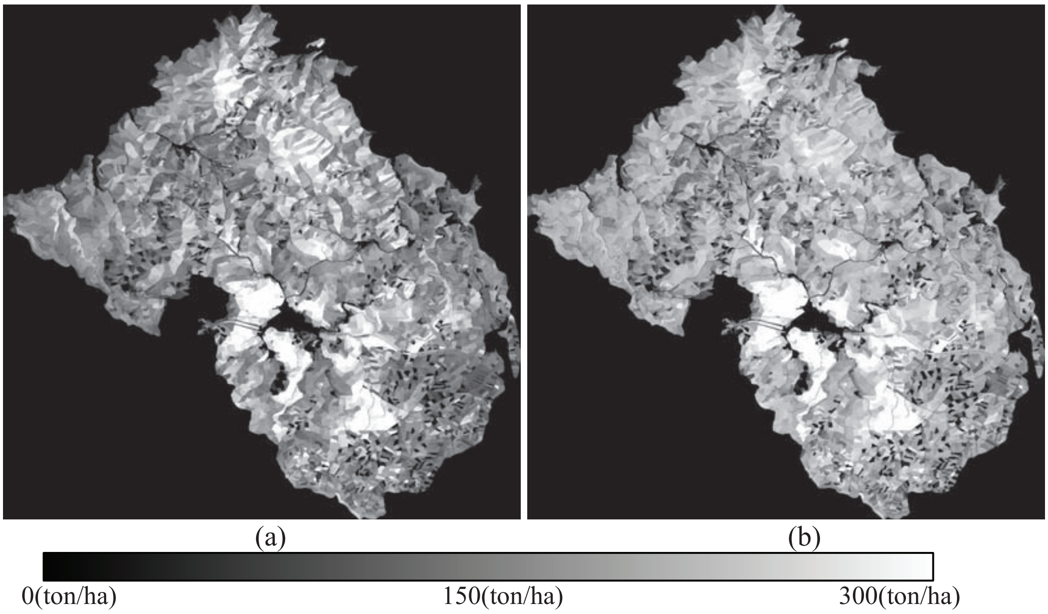


Figure4. Biomass inversion results of Lushuihe forest bureau using regression equation method (a) and threshold distance criterion combined with regression equations constraint LUT method (b)

5. REFERENCES

[1] Kasischke, E. S, Christensen, N. L., and Bourgeauchavez, L. L., Correlating radar backscatter with components of biomass in loblolly-pine forests, *IEEE Transactions on Geoscience and Remote Sensing*, 33: 643-659, 1995.

[2] Ni Wenjian, Guo zhifeng, Sun, Guoqing, Wang Fang, Improvement of 3D radar backscatter model by matrix-doubling methods, IGARSS'07.

[3] Ranson, K. J., G. Sun, J. F. Weishampel and R.G. Knox, Forest biomass from combined ecosystem and radar backscatter modeling, *Remote Sensing of Environment*, 59:118-133, 2001.

[4] Sun, G., Ranson, K. J., and Kharuk, V. I., 2001, Radiometric slope correction for forest biomass estimation from SAR data in the Western Sayani Mountains, Siberia, *Remote Sensing of Environment*, 79:279-287, 2001.

[5] Sun, G. and K. J. Ranson, A three-dimensional radar backscatter model of forest canopies. *IEEE Transactions on Geoscience and Remote Sensing,* 33: 372-382, 1995.

[6] Urban, D. L., A Versatile Model To Simulate Forest Pattern: A User Guide To ZELIG, Version 1.0, Environmental Sciences Department, University of Virginia, Charlottesville, VA 22903, 1990.