Estimates of Standing Volume by Microwave SAR Data in Planted Acacia Forests in Sumatra, Indonesia

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Abstract: In recent years, industrial forests plantation have been in rapid expansion in many areas of the world. Therefore, continuous investigation and monitoring are required for maintaining sustainable use of the forests. In addition, there is much demand on an estimation of forest stand volume for commercial purposes and forest management.

Our aim in this study was (1) to find a definite relationship between field-measured forest biometric parameters and microwave SAR (Synthetic Aperture Rader) data, (2) to estimate standing volume on the basis of the relationship obtained in (1) and (3) to compare the estimates with production volume. The industrial plantation area focused in this study is located in the southeastern part of Sumatra, Indonesia, and consists of a single-layer forest of *Acacia Mangium*.

We used microwave satellite data sets from the ALOS-PALSAR. The HH/HV/VV/VH quad-polarimetry data sets in 2007, 2009 and 2010 were utilized. We applied a general four-component decomposition method with unitary transformations (Singh *et al*. 2013) to obtain decomposition powers which include surface, canopy, double-bonce and helix scatterings. Decomposition powers normalized by total power were calculated to provide a basis for quantifying interrelationships of the backscatters, and thereby backscattering mechanisms, from the target.

The decomposition powers were statistically compared to ground-observed forest parameters (DBH: diameter at breast height, H: tree height, V: standing volume) on forest compartments having a permanent sample plot (PSP). Each of the decomposition powers averaged over each of the forest compartments was compared with the forest parameters in order to perform a linear correlation analysis. The multi-year PALSAR data analysis revealed a rational correlation between the forest growth and decomposition power changes as follows: as the forests grow, the surface scattering significantly decreases (R= −0.65 ~ −0.79), while canopy (R= 0.59~0.72), double-bounce (R= 0.42~0.61) and helix scatterings (R= 0.65~0.73) increase. On the whole, the decreasing exposure of the bare ground with forests growth reduces the surface scattering, while the vegetation cover growth increases the canopy and helix scatterings and tree trunk and height growths increase the double-bounce scattering.

Furthermore, we tracked the decomposition power changes on some PSPs from 2007 to 2010. The analysis results indicated a new view of the physical understanding of the polarimetric decomposition powers. It revealed that according to increases of understory vegetation, the double bounce scattering, which is generated from the ground and the trunk intersecting at a right angle, decreased at a certain period of harvesting. Based on the observations, we attempted to re-estimate the double bounce scattering which reflects the tree trunk information. And then, analysis was made to retrieve the standing volume using the re-estimated double-bounce scattering based on our empirical equation. Finally, we compared the estimated standing volume to the production volume.

Our study sheds a new light on the above ground biomass or tree trunk volume estimations by analyzing polarimetric SAR data. In our future works, we will attempt to improve our polarimetric analysis methodology for more accurate estimates of standing tree volume in industrial forests plantations.

Keywords: ALOS/PALSAR, industrial plantation forests, polarimetric decomposition image, forest standing volume, production volume