# ASSESSMENT OF ALOS PALSAR $\sigma^0$ AND AVNIR-2 NDVI FOR FOREST CROWN CLOSURE ESTIMATING

*Min-Gee HONG [a], Hyo-Suk LIM [b], Yoon-Soo KIM [b], Sun-Gu LEE [b], and Choen KIM [c*]*

*[a] Graduate Student, Dept. of Applied Information Technology, Kookmin University, Seoul 136-702, Korea; Tel: + 82-2-910-5080; E-mail: hd21351@kookmin.ac.kr*

*[b] Researcher, Satellite Information Research Center, Korea Aerospace Research Institute, Daejeon 305-806, Korea; Tel: + 82-42-860-2164; E-mail: hslim, younsoo, leesg@kari.re.kr*

*[c] Professor, College of Forest Science, Kookmin University, Seoul 136-702, Korea; Tel: + 82-2-910-4813; [*]Corresponding author E-mail: choenkim@kookmin.ac.kr*

**KEY WORDS**: ALOS PALSAR, AVNIR-2, NDVI, Forest Crown Closure, Sigma-nought

**Abstract:** In this study, we have investigated relationship of forest crown closure using ALOS PALSAR backscattering coefficient ($\sigma^0$) properties and AVNIR-2 NDVI. PALSAR data were obtained on 11th June 2010 and AVNIR data acquired on 12th June 2007. The result shows the forest crown closure sensitive dependence on PALSAR data. The backscattering coefficient has different response for level of crown closure because of differences in their backscattering intensity. This dependency of backscattering coefficient shows different behaviour of PALSAR dual fine beam data. The HH polarization of backscattering coefficient shows good correlation with the forest crown closure up to the saturation limit.

## INTRODUCTION

Due to the increase in concentration of greenhouse gases, global warming is accelerated as well as the temperature of the surface of earth consistently. In 1985, UN Environmental Plan(UNEP) and World Meteorological Organization(WMO) officially announced that the main factor of global warming is the carbon dioxide(Vadrevu et al., 2007). Forest biomass is the main method for absorption of carbon dioxide that stores most of the ground carbon and by exchanging the air and carbon dioxide, it is influencing the carbon cycle of the whole earth(Fuchs et al., 2009).

Therefore, periodically monitoring the assumed visible supply of carbon from forest biomass will have a very important factor for estimating the climate change and preventing the global warming.

As a method for periodically monitoring the visible supply of carbon in the forest, remote sensing using satellite image is getting attention recently. Method using remote sensing can effectively reduce the time and labor cost compared to existing field measurement method.

Especially, in this study, the active remote sensing in SAR data was mainly used rather than passive remote sensing which uses an existing optics image. In SAR data, the longer wavelength was used compared to the optics image and it penetrates cloud and rain.

Therefore, SAR image is more appropriate for Korea to estimate forest resources since Korea has the long rainy season. Research for estimation of forest biomass using SAR data has been actively progressed.

Several studies have reported that the backscattering coefficient at L-band saturates at about 50-150 tons $ha^{-1}$. Moreover, cross polarized backscatter appears to be most sensitive to forest biomass(Lucas et al., 2010). However, backscattering coefficient shows different value depending on its conditions(Santoro et al., 2009), and especially, sloped terrain have strongest influence on(Castel et al., 2001).

However, since it is the research that analyzed the forest stem volume and backscattering coefficient relationship, in this research, not only the forest crown closure but also the relationship between AVNIR-2 NDVI and backscattering coefficient is evaluated.

## STUDY AREA AND DATA

The study area is situated in 1109ha KEF, 127° 12' 05'' North in latitude and 37° 70' 50'' - 37° 81' 32'' East in longitude. KFE was selected as the target area for this study which is well established. First, since KEF accomplished forest field survey for 5 times starting in 1964, ground truth data is accumulated which is possible to use. Second, forest crown closure is different for each stand so that it is suitable for the study.

Finally, coniferous, deciduous and mixed forests are moderately distributed in KEF. However, in this paper, 58 stands excluding mixed forests were used. Fine-Beam Dual(FBD) PALSAR ~~images collected under ascending passes and descending and almost the same incidence(34.3°)~~

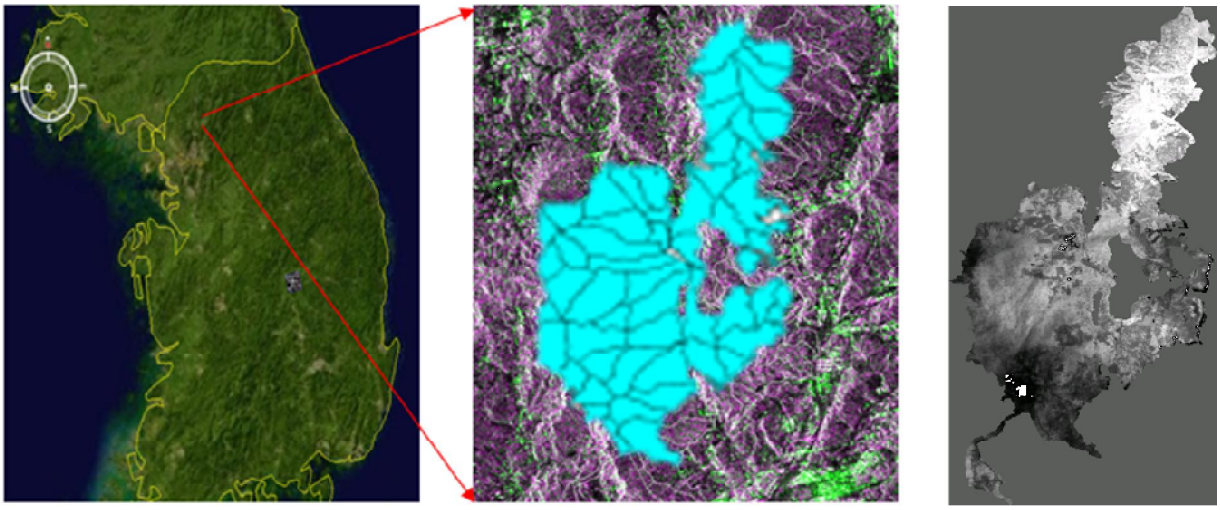

**Figure 1:** ALOS PALSAR image overlaid with digital tree species map(left) and subset covering the KEF site of the AVNIR-2 NDVI image(right)

were used in this study.

The PALSAR images was acquired in 11 June 2010 and corresponded to the FBD mode(L-HH and L-HV), 1.5 level processing available as multilook amplitude image 16 bit CEOS format.

Also, to measure the crown closure and to produce ANNIR-2 NDVI data was used(see Fig. 1)

## METHODOLOGY

In this research, forest areas were divided by the same direction and crown closure of each divided area were estimated. Forest areas were divided using the stand level of image segmentation of satellite image and digital forest map.

Estimation of crown closure of each area used techniques of texture measure and Gray Level Co-occurrence Matrix(GLCM), that bases the definition of crown closure. The basic purpose of image segmentation was grouping of pixels that show similar characteristics.

Removal of noise will be essential from the SAR data which was used in this study. The main requirements of speckle reduction methods are speckle noise reduction together with edge and texture preservation(Dong et al., 2001). In mountainous areas filtering should only be aimed at reducing the speckle noise level. Therefore, proper algorithm for the study which includes lots of mountainous areas would be Lee-filtering.

The $\sigma^0$ values, namely backscattering coefficient, were extracted from amplitude images using the equation from formula(1).

$$\sigma^0 = 10 \times \log10(DN^2) + CF \qquad (1)$$

where, conversion factor(CF) is –83 for HH and –80 for HV. According to the conversion formula(Shimada et al., 2009) with the calibration factor(CF) of -83 for HH also in this paper, the orthorecified PALSAR images were converted to the $\sigma^0$ value namely the normalized radar cross section(NRCS) in decibel(dB).

## RESULTS AND ANALYSIS

Comparative regressions of forest crown closure and PALSAR backscattering coefficient are represented in Fig.2. Also, comparison of forest crown closure and AVNIR-2 NDVI is indicated in Fig. 3.

Obviously, following the increase in crown closure, both backscattering coefficient and NDVI generally showed tendency to increase.

In comparison with the west-facing slope(fore-slope) appearing brighter aspect and the east-facing slope(far-slope) appearing darker aspect, all the backscattering coefficient of the fore-slope are much higher than those of the far-slope.

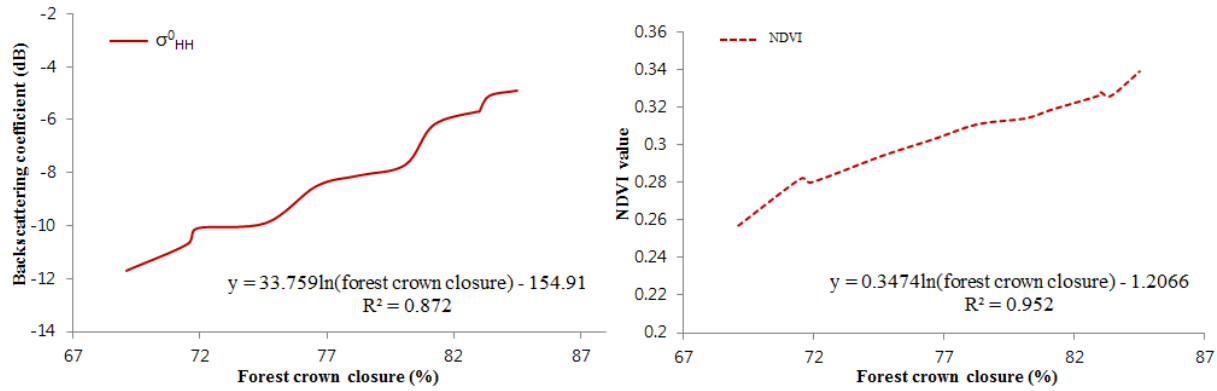


**Figure 2:** Comparison of forest crown closure between backscattering coefficient (left) and NDVI value (right) in west-facing slope

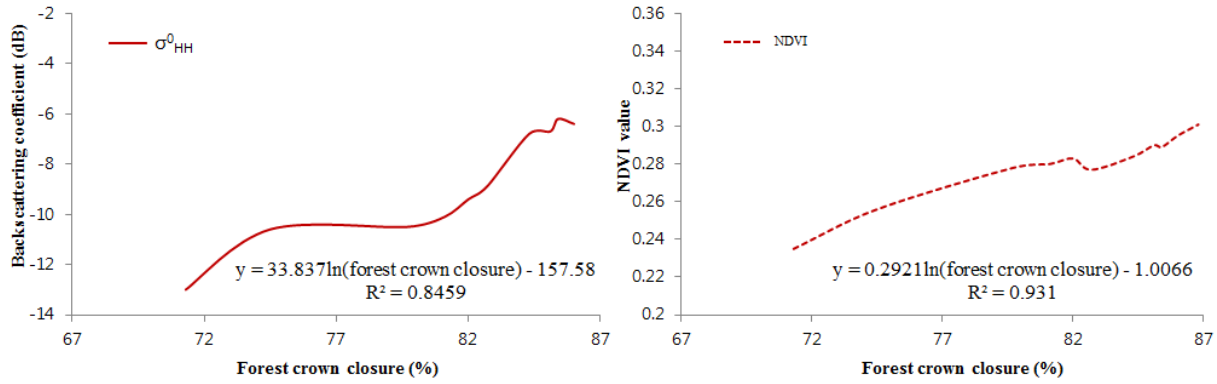


**Figure 3:** Comparison of forest crown closure between backscattering coefficient (left) and NDVI value (right) in east-facing slope

It is because shadow effects occurred in east-facing slope due to influence of incidence angle of ALOS PALSAR. Shadow effect reduces the signal of microwave so that the backscattering coefficient decreases.

Also, it was proved that AVNIR-2 NDVI has better relationship with the crown closure than that of backscattering coefficient through coefficient of determination. Such differences may be explained by the high penetration ratio of L-band, because when crown closure is high, dietary vitality is high so that is shows high correlation with NDVI.

## CONCLUSION

In this research, information of crown closure used in various field was extracted from SAR image. In measurement of crown closure, GLCM algorithm was used and relationship with each backscattering coefficient and AVNIR-2 NDVI were compared.

Crown closure of forest area has high correlation with backscattering coefficient and NDVI but shows higher correlation with NDVI than backscattering coefficient.

Generally, SAR with short wavelength is advantageous in estimating the crown closure because the long wavelengths of L-band through the crown. However, ALOS PALSAR data and AVNIR-2 are provided together that it is considered that it is more useful in analysis of forest canopy layer characteristics.

Finally, the saturation levels of all regressions between backscattering coefficient and the logarithm of crown closure are defined by the saturation criteria at 0.016dB $m^3ha^{-1}$ corresponding to about 83.1%

To increase the accuracy of suggested technique in the future, research using backscattering coefficient that eliminated directivity should be progressed.

## REFERENCES

Castel, T., A. Beaudoin, N. Stach, N. Stussi, T. Le Toan, and P. Durand, 2001. Sensitivity of space borne SAR data to forest parameters over sloping terrain, *International Journal of Remote Sensing*, 22(12): 2351-2376.

Dong, Y., A.K. MILNE, and B.C. FORSTER, 2001. Toward edge sharpening: a SAR speckle filtering algorithm. *IEEE Transactions on Geoscience and Remote Sensing*, 39, pp.851–863.

Fuchs, H., P. Magdon, C. Kleinn, and H. Flessa, 2009. Estimating aboveground carbon in a catchment of the Siberian forest tundra: Combining satellite imagery and field inventory, *Remote Sensing of Environment*, Vol.113, pp.518-531.

Lucas, R., A. John, F. Russell, F. Rod, A. Arnon, C. Joao, and K. Jack, 2010. An Evaluation of the ALOS PALSAR L-Band Backscatter-Above Ground Biomass Relationship Queensland, Australia: Impacts of Surface Moisture Condition and Vegetation Structure. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 3(4): 576-593.

Santoro, M., J.E.S. Franssaon, L.E.B. Eriksson, M. Magnusson, L.M.H. Ulander, and H. Olsson, 2009. Signatures of ALOS PALSAR L-band Backscattering in Swedish Forest, *IEEE Transactions on Geoscience and Remote Sensing*, 47(12):4001-4019.

Shimada, M., O. Isoguchi, T. Tadono, and K. Isono, 2009. PALSAR Radiometric and Geometric Calibration, *IEEE Transactions on Geoscience and Remote Sensing*, 47(12): 3915-3932.

Vadrevu, K., K.V.S. Badarinath, and E. Anuradha, 2007. Evaluation of vegetation greenness metrics for characterizing tropical forest cover types–a case study using NOAA AVHRR datasets, *Geocarto International*, 22(1):29-48.