A Comparison Study of Biomass Estimation Using ALOS PALSAR and LiDAR data

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- L-band (1.27 GHz)
- Quad-pol data
- Ascending mode
- Incidence Angle 23°
- Data acquisition 17 April 2007
- Ability to capture high resolution images quickly and relatively independent of lighting conditions

- Ability to collect 20,000 to 75,000 records per second

- High vertical accuracy with 15-20 cm RMS and horizontal accuracy with 20-30 cm RMS

- Data acquisition 9 June 2007
STUDY AREA – GLEN AFFRIC
Many studies on forest volume/ biomass estimation in flat areas (Kurvonen et al., 1999; Saatchi et al., 2001; Austin et al., 2003)

• The level of saturation has been found to vary as a function of polarization and forest types at L-band. (M. L. Imhoff, 1995; Luckman, 1998; L. Kurvonen, 1999)
• Studies have been done on biomass estimation using backscatter-biomass relationship (Kasischke et al., 1995; Ranson et al., 1996; Mitchard et al.)

Figure Reference: http://www.eci.ox.ac.uk/research/biodiversity/linkcarbon.php
Regression Analysis : HV-Biomass

$$HV = -14.2151 + 1.8251 \times (1 - \exp(0.0488 \times AGB)), \quad R^2 = 0.36$$
LIDAR DATA PROCESSING

CSM

CHM
LIDAR DATA PROCESSING

Canopy Cover derived from LiDAR

Height derived from LiDAR

Biomass LiDAR
AZIMUTH SLOPE REMOVAL

Circular Polarisation Method

\[ S_{RR} = (S_{HH} - S_{VV} + i S_{HV})/2 \]
\[ S_{LL} = (S_{VV} - S_{HH} + i S_{HV})/2 \]
\[ \theta = \frac{1}{4} \tan^{-1} \left( \frac{-4 \text{Re} \left( S_{HH} - S_{VV} \right) S_{HV}^*}{-\left( S_{HH} - S_{VV} \right)^2 + 4 \left( S_{HV} \right)^2} \right) + \pi \]

For \( \theta > \pi/4 \), \( \theta = \theta - \pi/2 \)

\[ [T^{\text{new}}] = [U][T][U^T] \]
\[ [U] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos 2\theta & \sin 2\theta \\ 0 & -\sin 2\theta & \cos 2\theta \end{bmatrix} \]

YAMAGUCHI MODEL

- Model-based Decomposition
- Satisfy non reflection symmetric case
\[<S_{HH}S_{HV}^*> \neq 0 \text{ and } <S_{HV}S_{VV}^*> \neq 0\]

\[
[T] = f_s [T]_{\text{surface}} + f_d [T]_{\text{double}} + f_v [T]_{\text{volume}} + f_c [T]_{\text{helix}}
\]

\[
[T] = f_s \begin{bmatrix}
1 & \beta^* & 0 \\
0 & \mid \beta \mid^2 & 0 \\
0 & 0 & 0
\end{bmatrix} + f_d \begin{bmatrix}
\alpha^2 & \alpha & 0 \\
0 & \alpha^* & 1 \\
0 & 0 & 0
\end{bmatrix} + f_v \frac{2}{4} \begin{bmatrix}
2 & 0 & 0 \\
0 & 1 & 0 \\
0 & 0 & 1
\end{bmatrix} + f_c \frac{2}{4} \begin{bmatrix}
0 & 0 & 0 \\
0 & 1 & \pm j \\
0 & \pm j & 1
\end{bmatrix}
\]

- Processed using POLSARpro, courtesy of ESA -
YAMAGUCHI MODEL

\[ P_v = f_v \]  
Volume Scattering (P_v)

\[ P_s = f_s (1 + |\beta|^2) \]  
Surface Scattering (P_s)

\[ P_d = f_d (|\alpha|^2 + 1) \]  
Double Bounce Scattering (P_d)

\[ \frac{P_v}{P_s} = 0.3604 + 0.5363(1-e^{-0.0104*AGB}), \quad R^2 = 0.74 \]

Regression Analysis

Biomass

\[ \text{Yamaguchi Vol/Odd Vs Biomass Fieldwork} \]
BIOMASS ESTIMATION: DENSE FOREST

Aerial Photograph

Canopy Cover derived from LiDAR

Biomass derived from LiDAR

DEM

Height derived from LiDAR

Biomass derived from ALOS PALSAR

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BIOMASS ESTIMATION: SPARSE AREA

Aerial Photograph

Canopy Cover derived from LiDAR

Biomass derived from LiDAR

DEM

Height derived from LiDAR

Biomass derived from ALOS PALSAR
Regression Analysis

\[ \frac{P_v}{P_s} = 0.3604 + 0.5363(1 - e^{-0.0104 \times AGB}) \], \quad R^2 = 0.74

Yamaguchi Vol/Odd Vs Biomass Fieldwork
BIOMASS ESTIMATION: SHADOW EFFECT

Aerial Photograph

Canopy Cover derived from LiDAR

Biomass derived from LiDAR

DEM

Height derived from LiDAR

Biomass derived from ALOS PALSAR
CONCLUSION

LIDAR
Total Biomass: 11025 ton
Accuracy: 86 %

ALOS PALSAR
Total Biomass: 9450 ton
CONCLUSION

• ALOS PALSAR has the potential for biomass estimation over wide coverage area but it is limited to biomass less that 150t/ha

• LiDAR is able to estimate biomass at stand level over small coverage footprint

• The results obtained from the analysis of both ALOS PALSAR and LiDAR are encouraging

• It can be extended to be incorporated into the existing mensuration models to estimate the biomass and to compare it with other remote sensing data.