Biomass Mapping of Tropical Rainforest Using Airborne LiDAR

By:
Jarot Pandu Panji Asmoro
Balai Penelitian Kehutanan Manokwari

INTERNATIONAL CONFERENCE
OF INDONESIA FORESTRY RESEARCHERS III – 2015
21-22 OCTOBER 2015

Outline

- Introduction
- Methods
  - Research methodology
  - LiDAR Data Processing
  - Field Data Collection
  - Segmentation
  - Model Development and Map Generation
- Results and Discussions
- Conclusions and recommendations
Introduction

- Under the United Nations Convention Framework on Climate Change (UNFCCC), countries must report regularly the condition of their forest resources through a variety of mechanisms.
- Require an estimation results in carbon stocks both temporal and spatial reliable.
- Combining ground data measurements and remote-sensing of trees attributes were the most powerful carbon stock estimation.
- The result can be scaled up into national carbon stocks estimation.
- LIDAR provide three-dimensional structure of vegetation (Song, 2007) able to provide an accurate estimation of forest structural characteristics such as: canopy height, stand volume, basal area and AGB.
- The ability of LiDAR is not entirely confirmed in the case of tropical rain forest.

Methods
(Research methodology)

Airborne LiDAR
- DTM (1 m resolution)
- DSM (1 m resolution)
- CHM (1 m resolution)

Field data collection
- (species, dbh, height, crown diameter)

Biomass
- Allometric equation

Classification
- (trees, non trees)

CHM Pit Removal

Segmentation
- Manual crown deliniation
- CPA segmentation

Accuracy

Carbon Stock
- Regression Model

Q1
- CPA segmentation

Q2
- Area and Height

Q3

Q4

Biomass and Carbon stock maps

Study Area
Methods
(Field Data Collection, Segmentation, Model Development, Map generation)

- Simple random sampling
- Nested circular plot (500, 100, 25 m²)

Other:
- Segmentation based on: colour, shape, texture, size and context

Methods:
- Field Data Collection
- Segmentation
- Model Development
- Map generation

Results and Discussions (1)

- One meter spatial resolution was chosen - maintain the shape of canopy and has fewer pits in the images
- Nearest Neighbour interpolation and 5% threshold-pit removal - optimal

Generic allometric model

\[ AGB = 0.0509 \times D^2 \times H \] (IPCC, 2006)
Results and Discussions (2)

- 52% segmentation accuracy; 83% over segmentation, 17% under segmentation
- the use of one scale parameter, finding the top and bottom of the crown of deciduous trees, multi layers of canopy.

50 tree samples were taken to develop the regression model and 17 trees were selected to validate the model.

Results and Discussions (3)

- 40 plots, 272 trees sample, 9 dominant genus
- The un-normal distribution of the Dbh data (positive skew/ left) can be caused by condition of the tree where in log over area

no significant different between height of tree in field (H) and derived from LiDAR (CHM) at confidence level 95%.
Results and Discussions (4)

- field data height (H) and CHM ($R^2$)=0.86 and root mean square error (RMSE)=3.28
- indicates 3.28 m difference between heights measured from the field and height of CHM
- Low density LiDAR point clouds can lead to underestimation of the tree height by CHM
- Time difference between LiDAR data acquisition and the field work

Summary of fit

<table>
<thead>
<tr>
<th>Summary of fit</th>
<th></th>
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<tbody>
<tr>
<td>Correlation coefficient</td>
<td>0.9250</td>
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<tr>
<td>R Square</td>
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<td>Adjusted R Square</td>
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<td>Root Mean Square Error</td>
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<td>Intercept</td>
<td>0.9338</td>
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<td>Slope</td>
<td>1.719</td>
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<tr>
<td>Observation</td>
<td>50</td>
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</tbody>
</table>

AGB Prediction Model

\[
\hat{A_{GB}} = 0.4343369 + 2.272626\ln(CHM) - 0.0919337\ln(CPA)
\]

- above ground biomass of the study area was approximately 312 MgHa$^{-1}$ with RMSE 2.1
- Comparison:
  - IPCC guidelines: 120-680 MgHa$^{-1}$
  - Chave et al. (2005): 378 MgHa$^{-1}$ (unmanaged forest) and 316 MgHa$^{-1}$ (secondary forest)
Conclusions/ Recommendations

- Despite the complexity of tropical rain forest, airborne LiDAR data as remote sensing source was the promising and very reliable solution for large-scale above ground biomass estimation in tropical rain forest.
- Combining field data and LiDAR data can improve the accuracy of biomass and carbon estimation and reduce the uncertainty of the model. LiDAR had been able to explain 86% of the height of the tree in the field measurement.
- by using LiDAR assist estimation in up-scaling AGB estimation to large-scale geographic areas.
- LiDAR could be cost effective to derive more accurately biomass estimation for the area where is the amount of in situ field data is limited, like Indonesia.