SURVEY OF BIOMASS, CARBON STOCKS, BIODIVERSITY, AND ASSESSMENT OF THE HISTORIC FIRE REGIME FOR INTEGRATION INTO A FOREST MONITORING SYSTEM IN SOUTH SUMATRA, INDONESIA

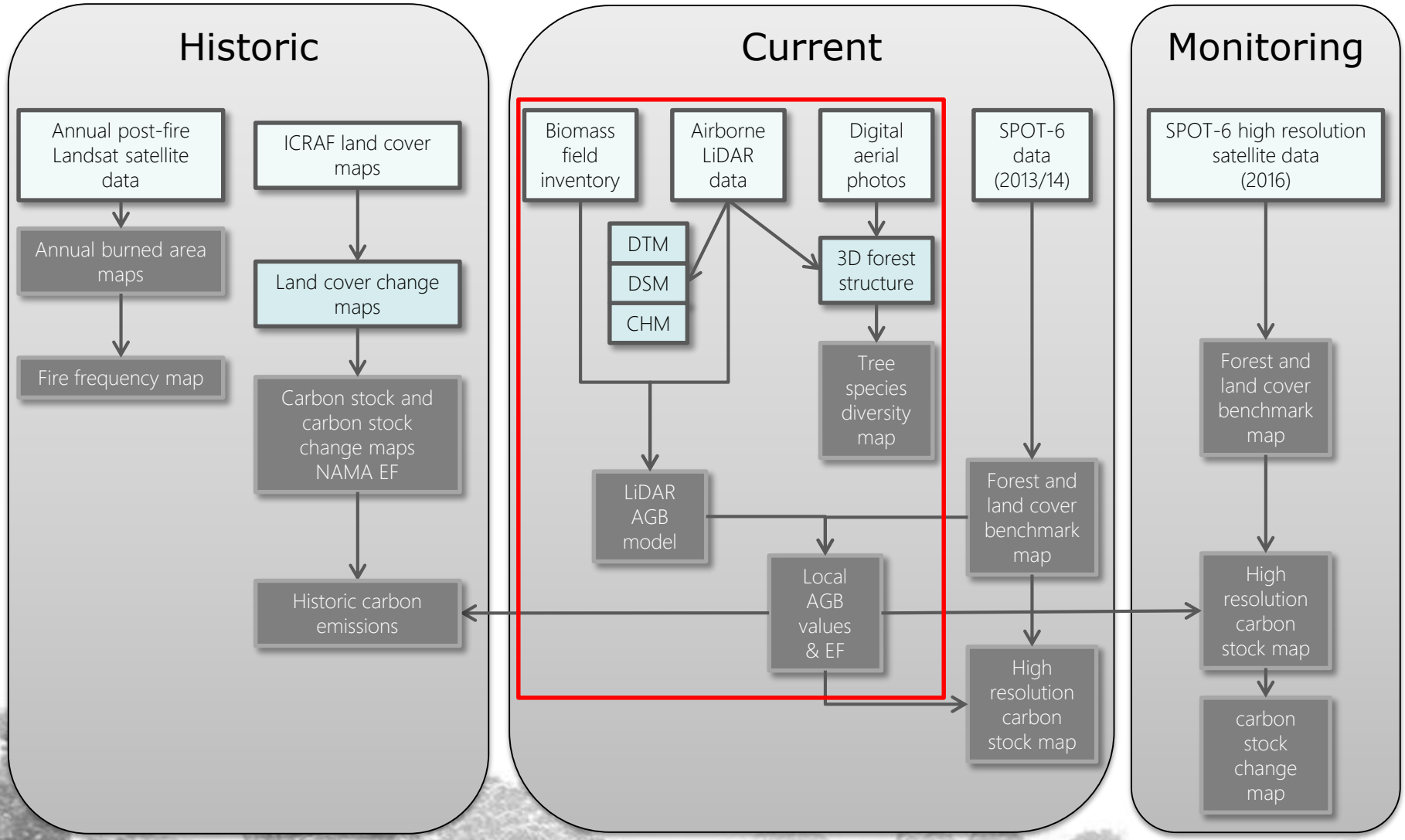
Modeling of aboveground biomass by airborne LiDAR
Current status

BIOCLIME Workshop
Palembang 21 January 2016

Peter Navratil
Werner Wiedemann
Sandra Englhart
Natalie Cornish
Florian Siegert

RSS Remote Sensing Solutions GmbH
Biodiversity and Climate Change Project

Concept of the monitoring system



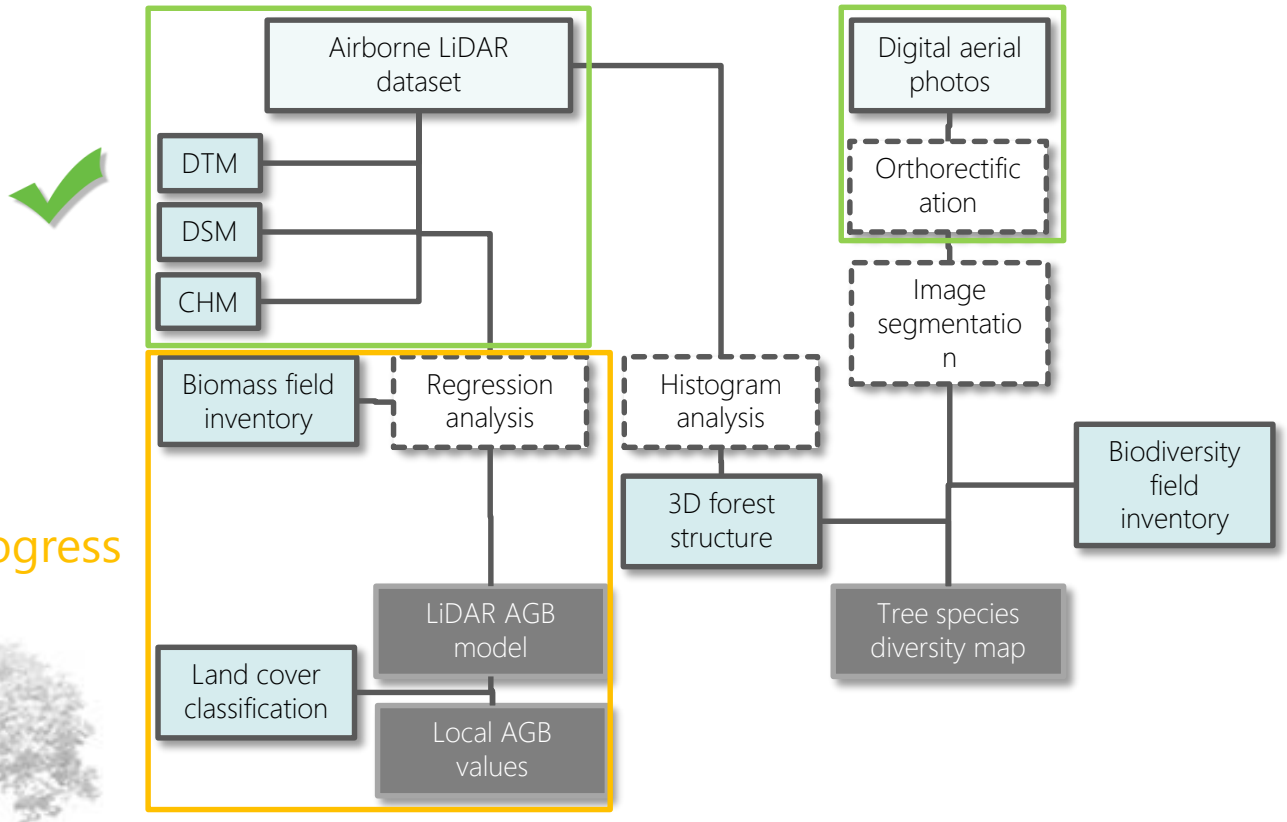
Current component: Aboveground biomass modeling

Objectives:

- Produce aboveground biomass models from airborne LiDAR data (acquired by Geosurvey)
- Advise BIOCLIME in the collection of forest inventory data for calibrating the LiDAR AGB models
- Assess AGB variability and tree species diversity by LiDAR and digital aerial photography across forest types and degradation stages

Aboveground biomass modeling Workflow

Workflow:



in progress

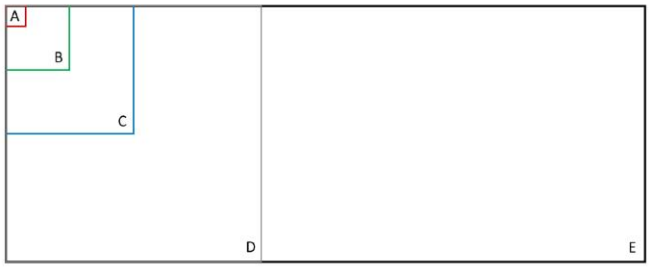
Aboveground biomass modeling: Field inventory: Plot design

Field inventory to collect biomass and biodiversity data:

- Across different forest types and degradation levels
- **Located within the LiDAR strips**
- Sampling design by IPB
- Rectangular nested plot design
- Parameters:
  - DBH, Tree height, Tree species, specific wood density
- AGB calculated by allometric equation by Chave et al. 2014

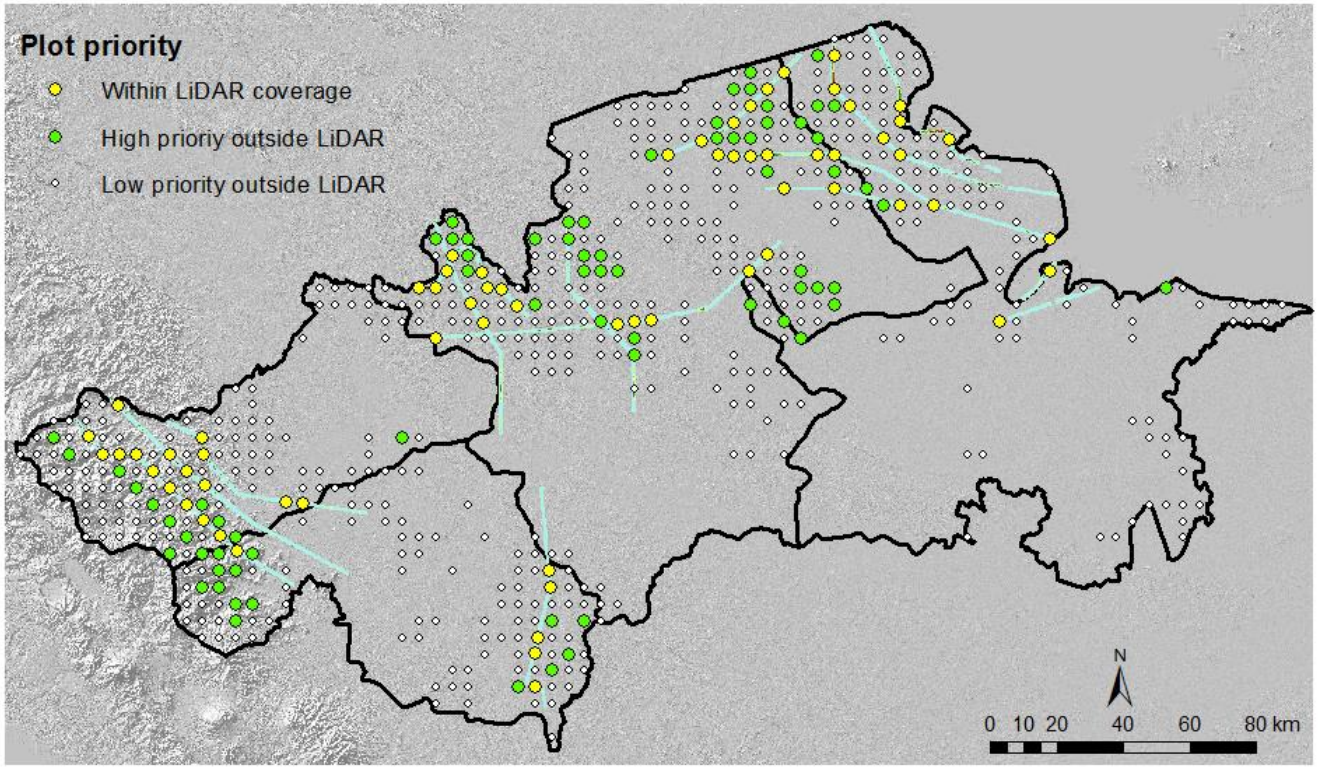
Further details on field inventory: Rusolono et al 2015

- Subplot A: 2 x 2 m (0.0004 ha), untuk pengukuran semai, serasah, dan tumbuhan bawah.
- Subplot B: 5 x 5 m (0.0025 ha), untuk pengukuran pancang (DBH 5–9).
- Subplot C: 10 x 10 m (0.01 ha), untuk pengukuran tiang (DBH 10–19 cm).
- Subplot D: 20 x 20 m (0.04 ha), untuk : pohon kecil (DBH 20–34 cm).
- Subplot E: 20 x 50 m (0.1 ha): pohon besar (DBH ≥35 cm).

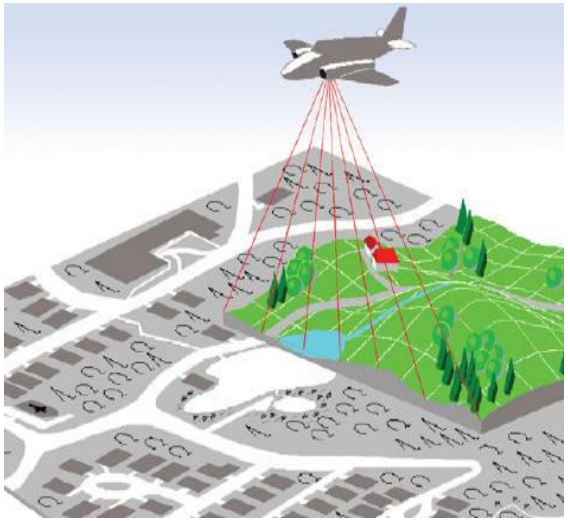


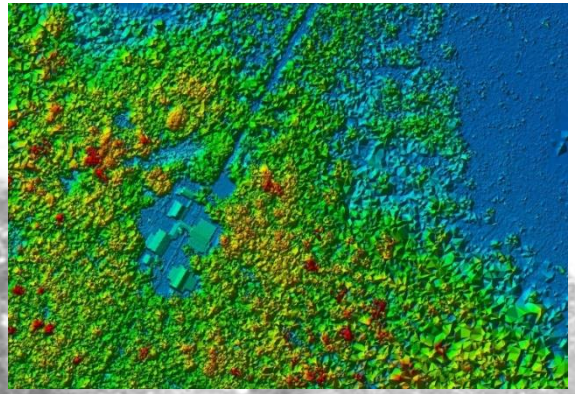
Aboveground biomass modeling: Field inventory: Sampling design

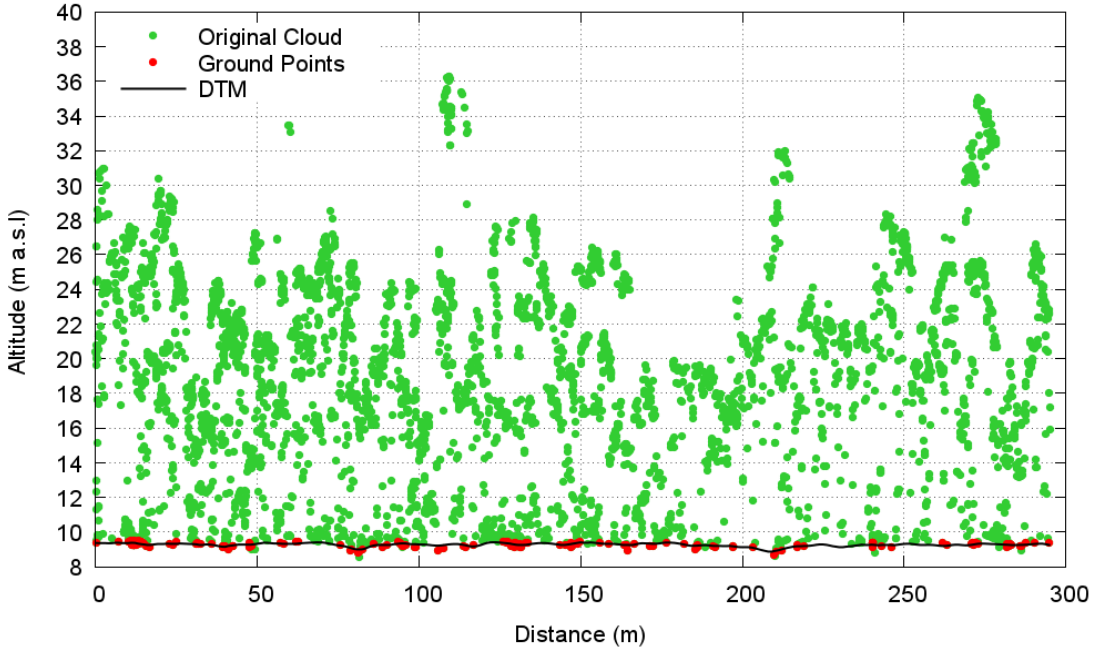
- Systematic sampling grid
- Total of 627 plot locations
- 130 with high priority
- 66 within LiDAR (15 plots sampled as of December 2015 and used in preliminary model)



Aboveground biomass modeling: LiDAR for forest structure and AGB assessment



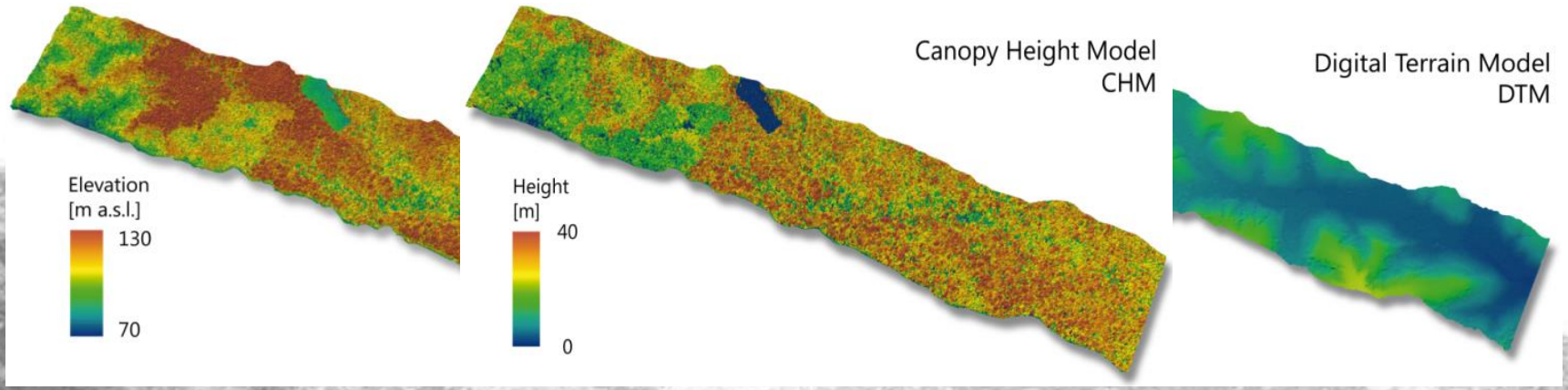




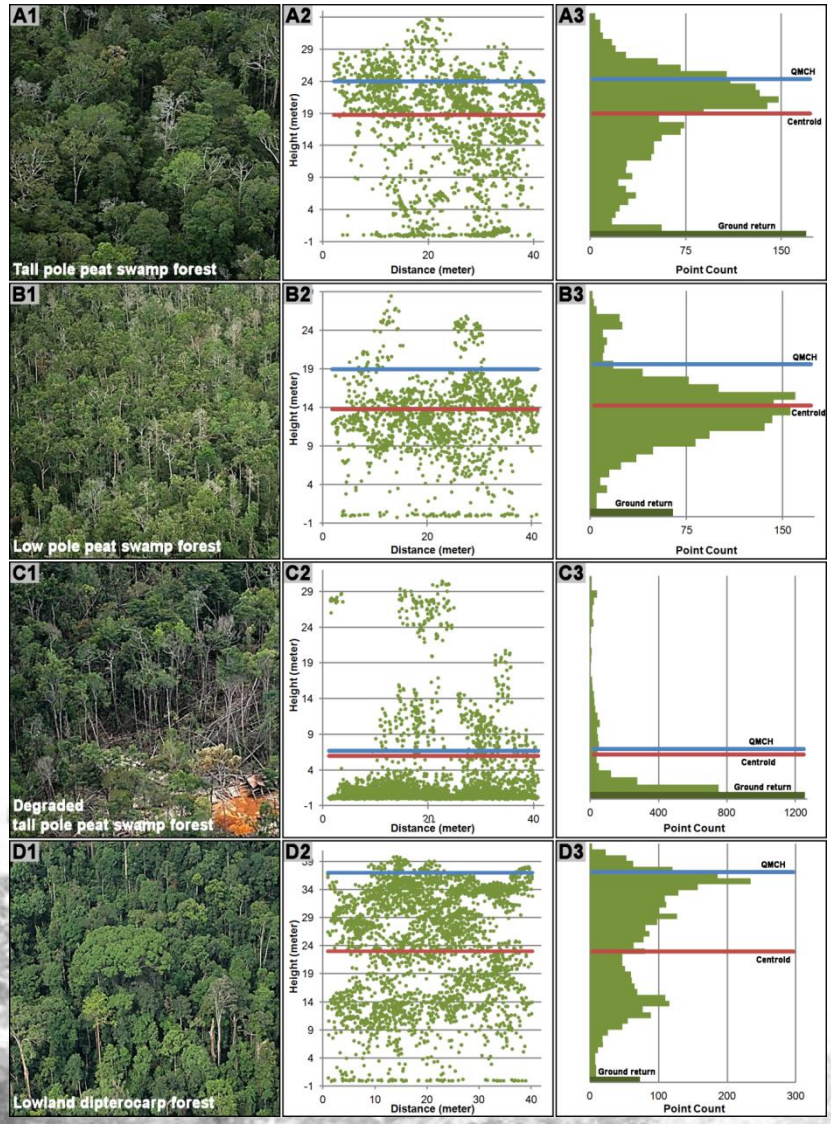
Aboveground biomass modeling: LiDAR derived elevation models

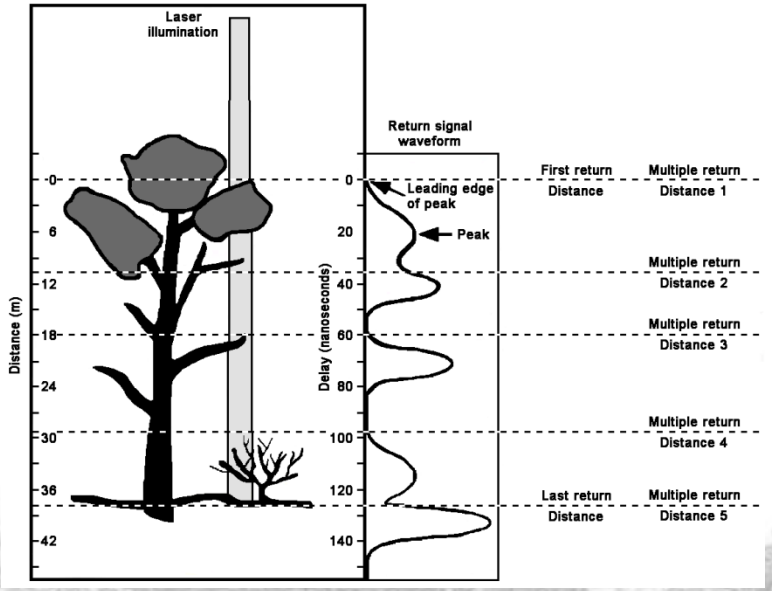
LiDAR processing and filtering:

- Hierarchic robust filtering (Pfeifer et al., 2001) to classify ground points
- Digital Surface Model (DSM) from highest points
- Digital Terrain Model (DTM) from ground points
- Canopy Height Model (CHM) by deducting DTM from DSM



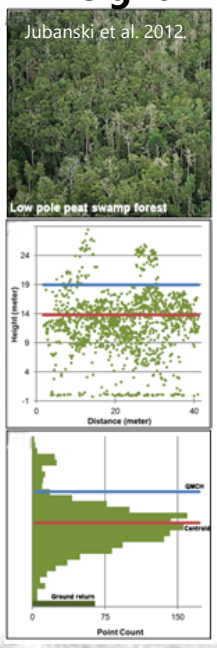
Aboveground biomass modeling: Height profiles of different forest types

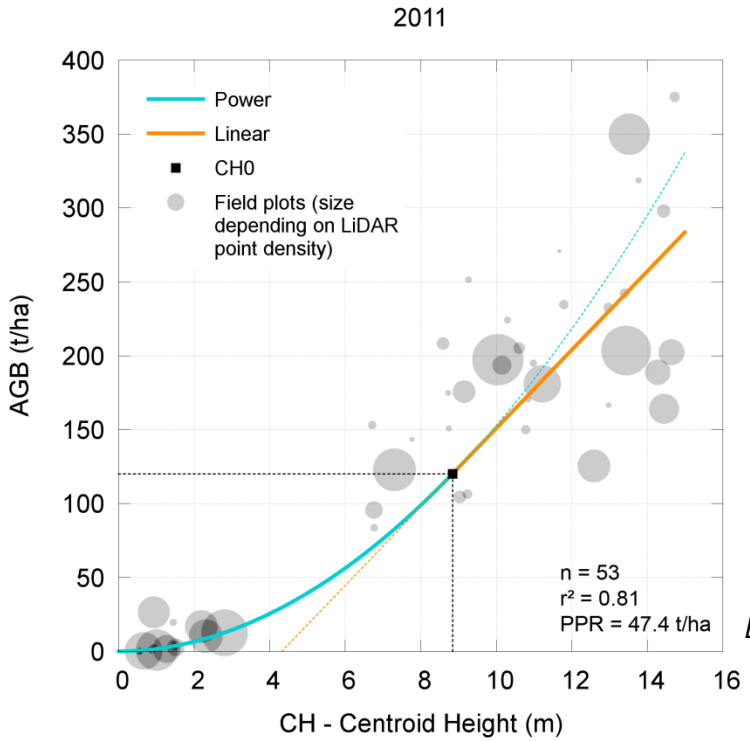




Aboveground biomass modeling: AGB regression model

Centroid Height

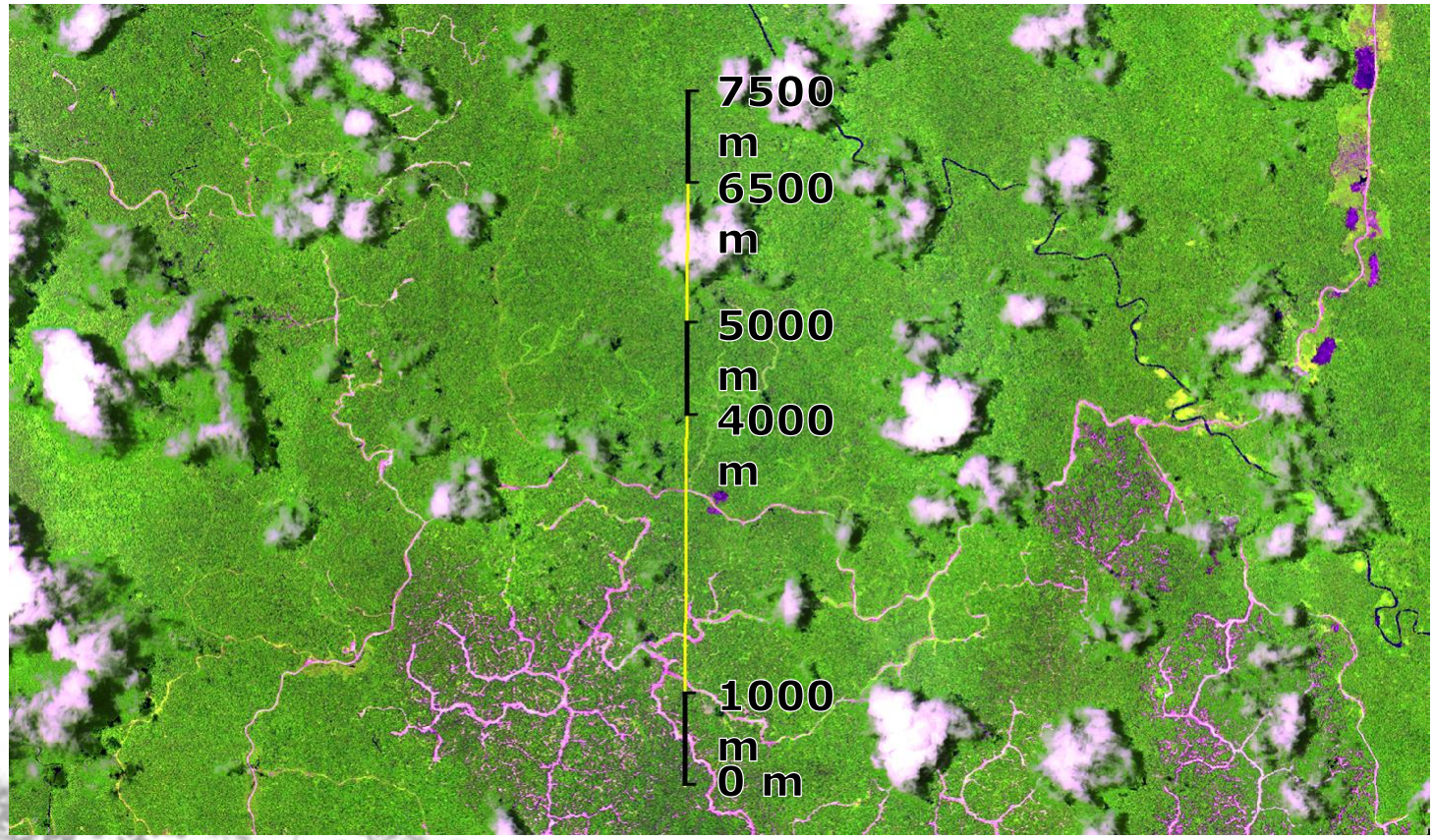




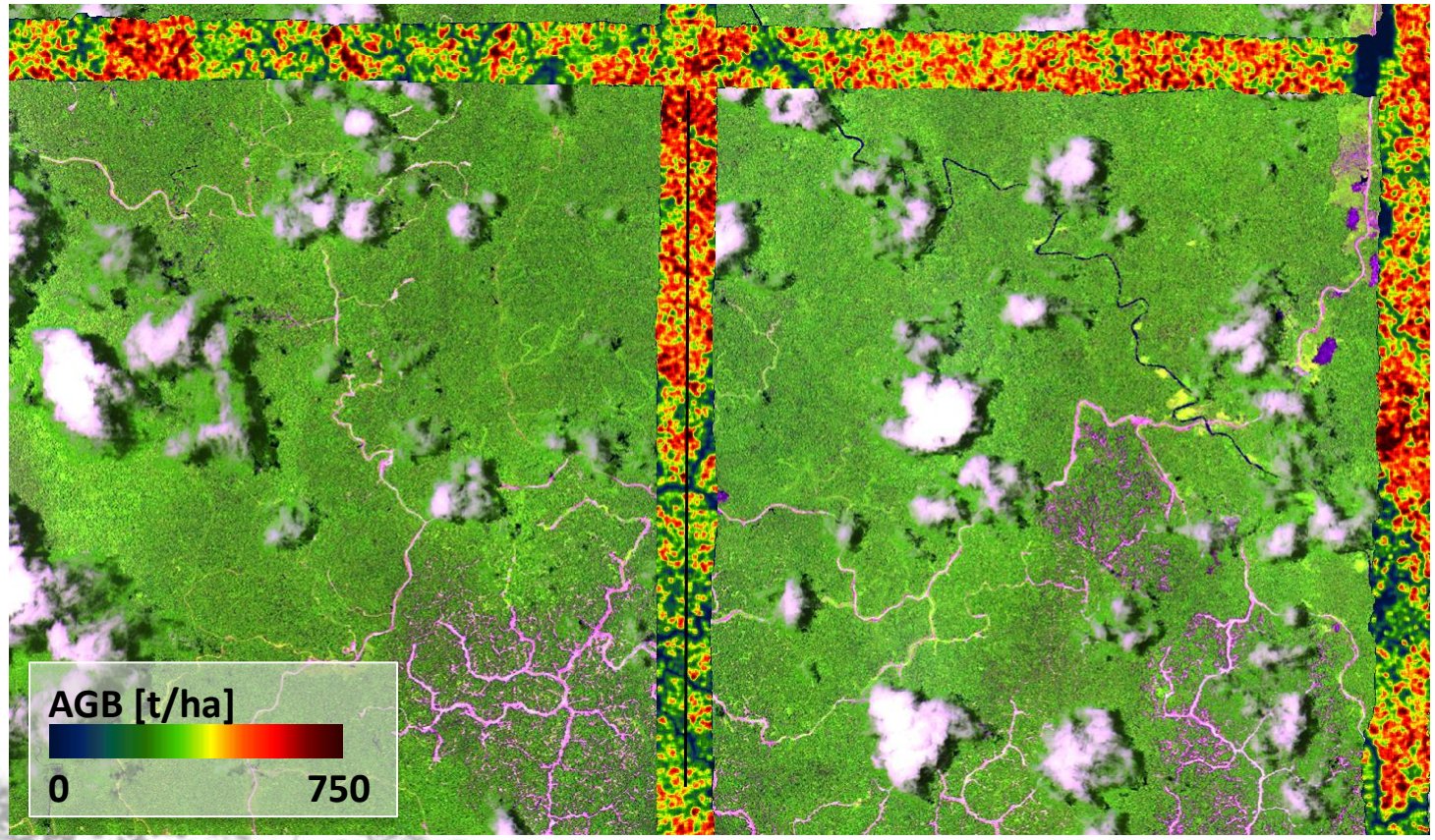
Englhart et al. 2013

- Centroid Height best parameter for peat swamp forests
- Combined power and linear function
- Stepwise determination (0.001m) of function change (CH_0)
- Including LiDAR point density

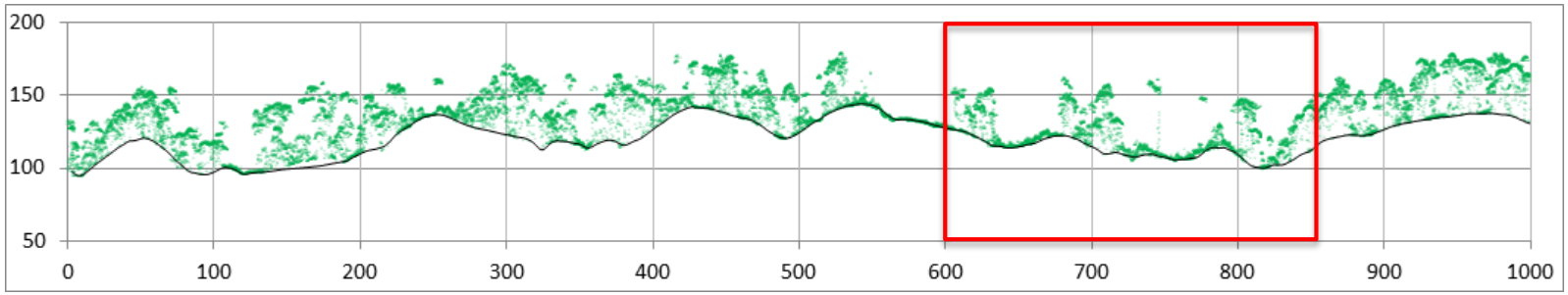
Aboveground biomass modeling: LiDAR transects to estimate AGB variability

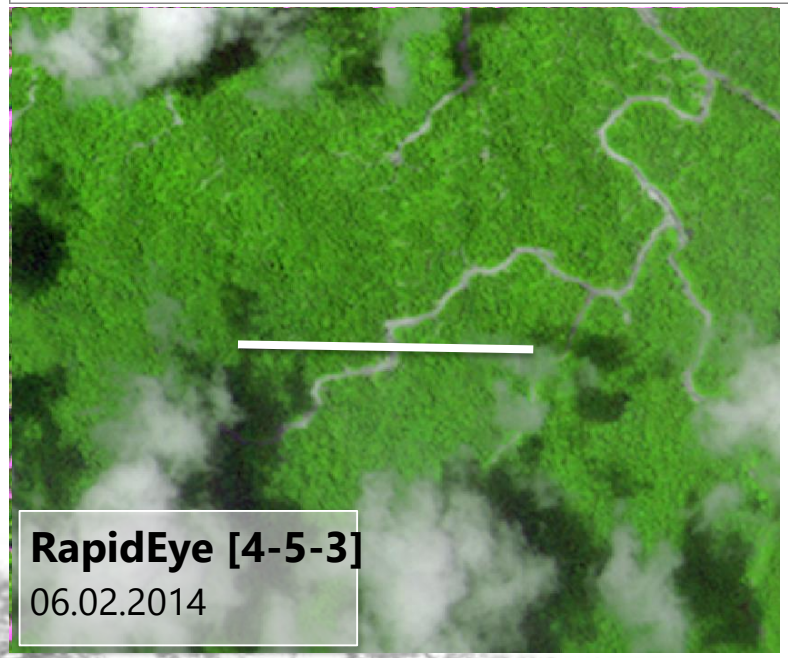


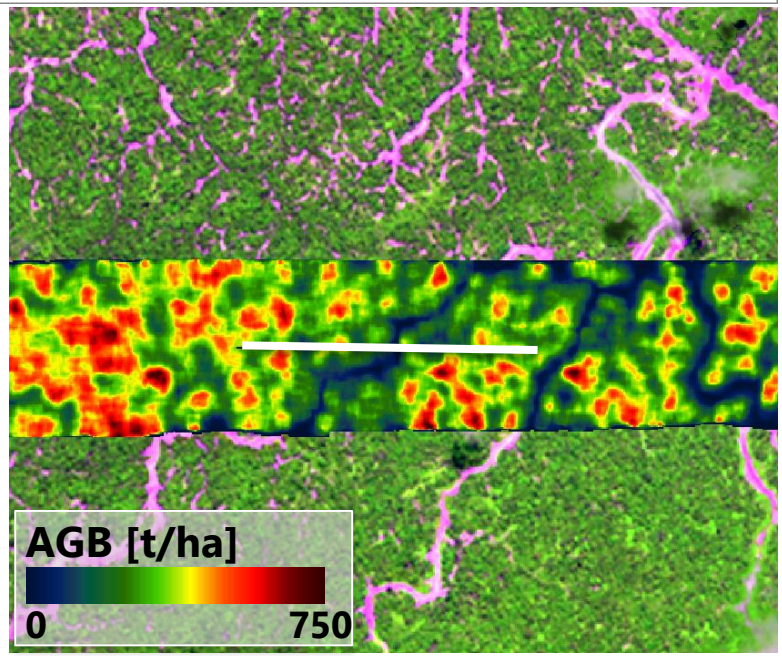
Aboveground biomass modeling: LiDAR transects to estimate AGB variability



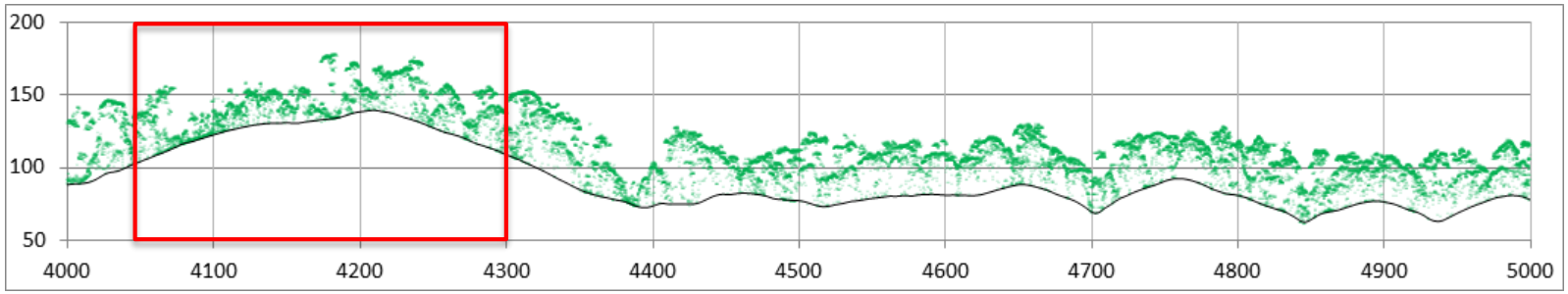
Aboveground biomass modeling: LiDAR transects to estimate AGB variability Recent logging activities (2011/2012)

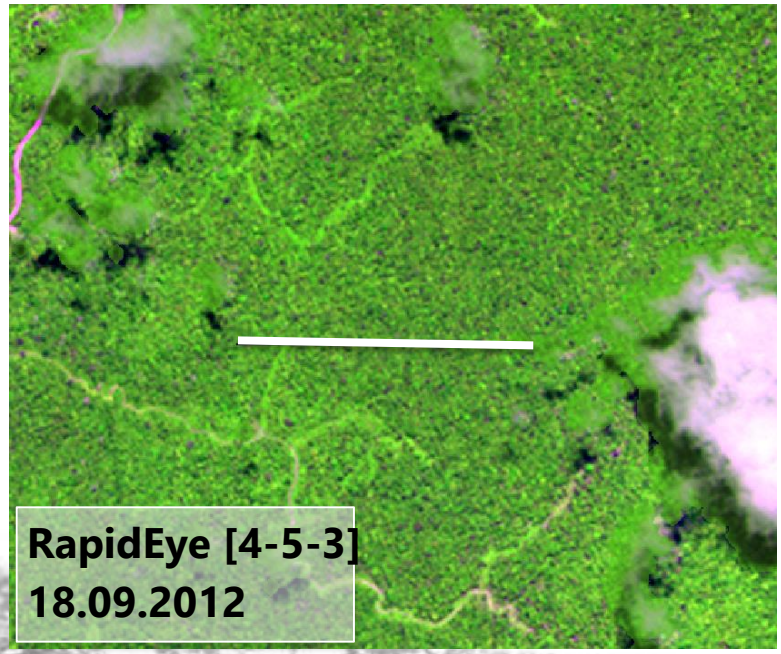


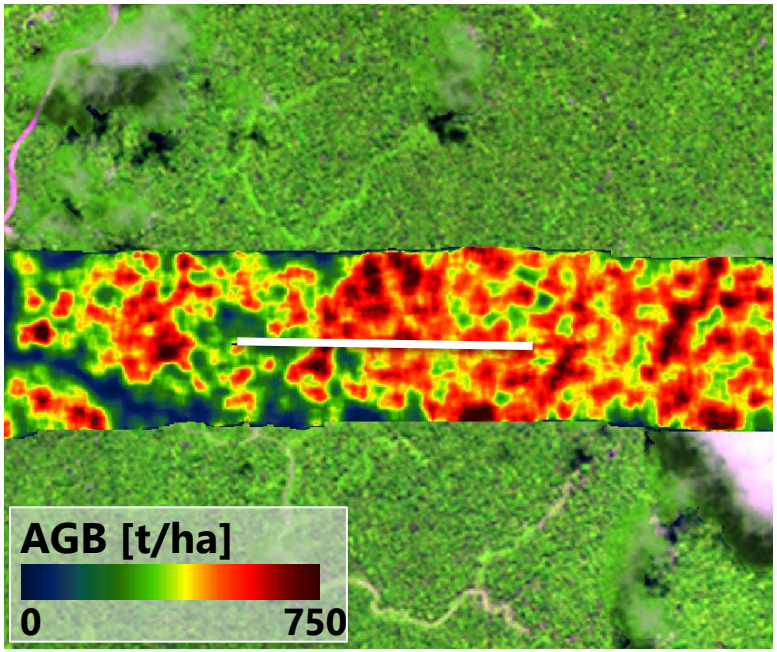




Current component:
LiDAR transects to estimate AGB variability
Former logging activities (2008/2009)



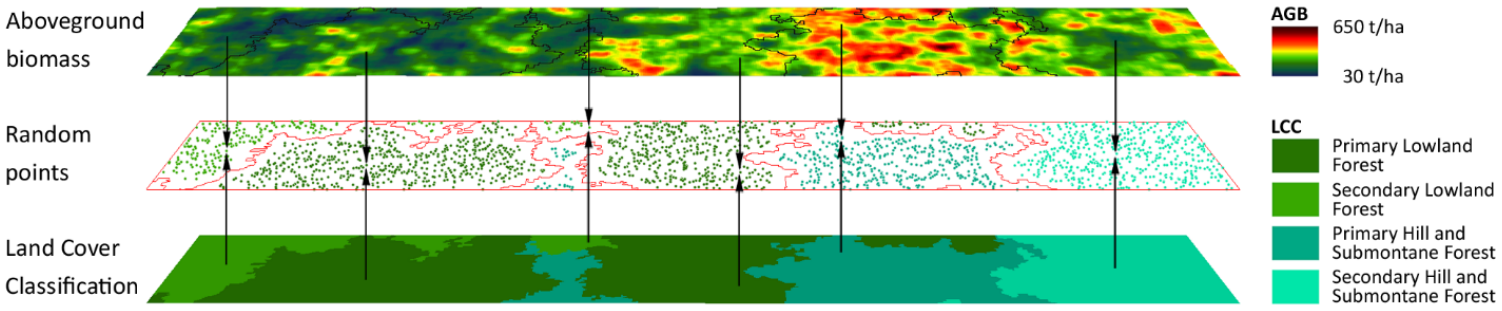




Current component: Aboveground biomass modeling

Determination of local AGB values

- Intersection of AGB model with land cover classification
- For different forest types and degradation stages

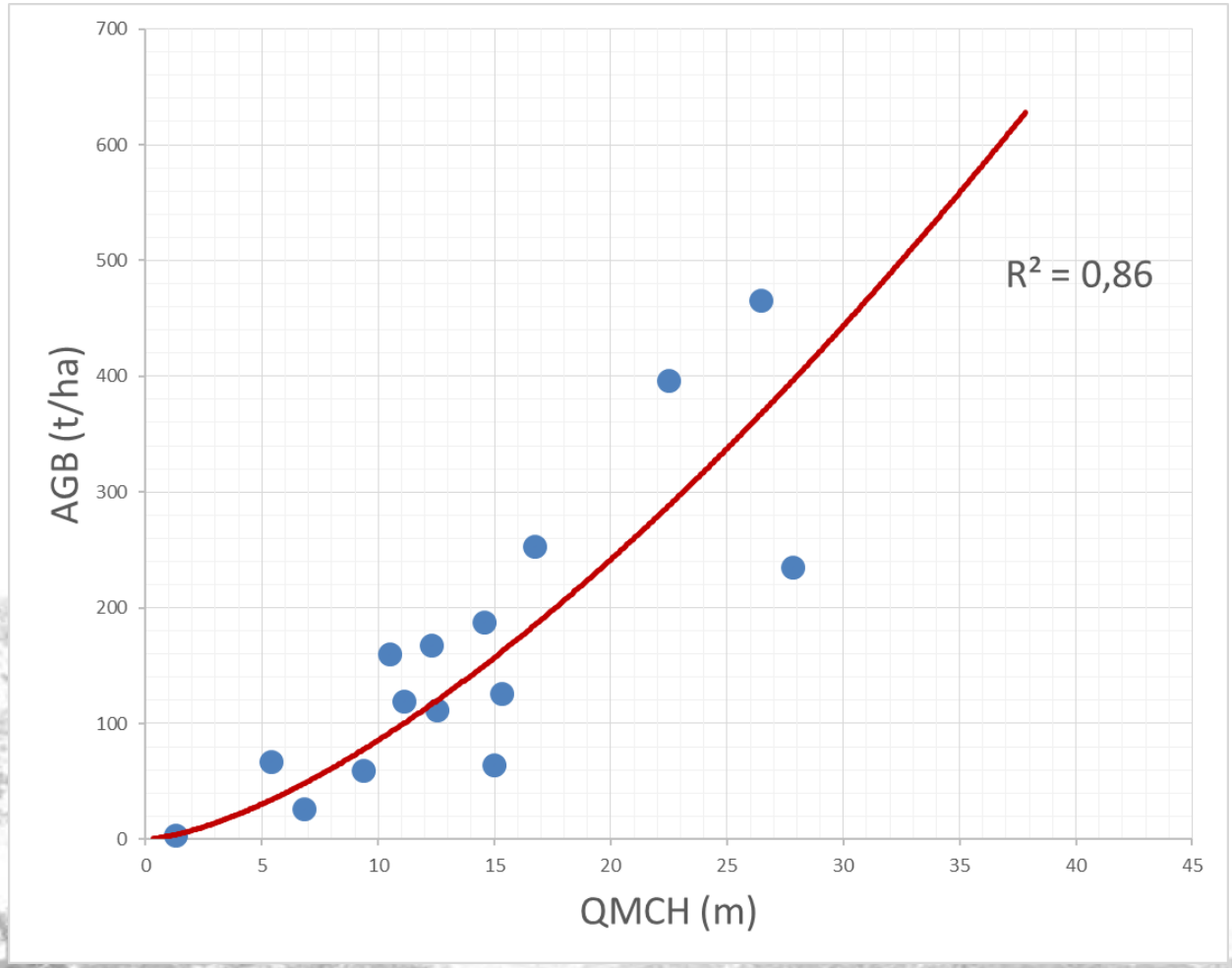


Point_ID	LCC	AGB
0	Secondary Lowland Forest	280.077545
1	Primary Hill and Submontane Forest	338.612579
2	Primary Hill and Submontane Forest	329.161087
3	Primary Lowland Forest	310.992896
4	Secondary Lowland Forest	300.068329
...		

Descriptive statistics for each class: Minimum, Maximum, Average, Standard deviation, Variance

Aboveground biomass modeling: Results

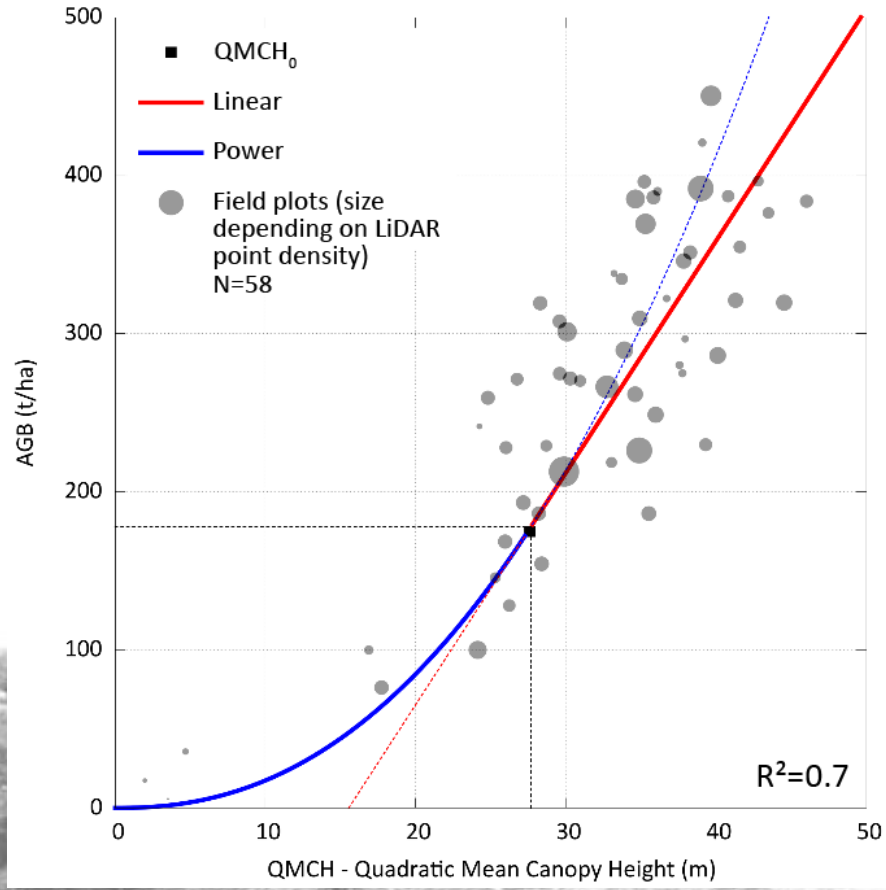
- AGB regression model



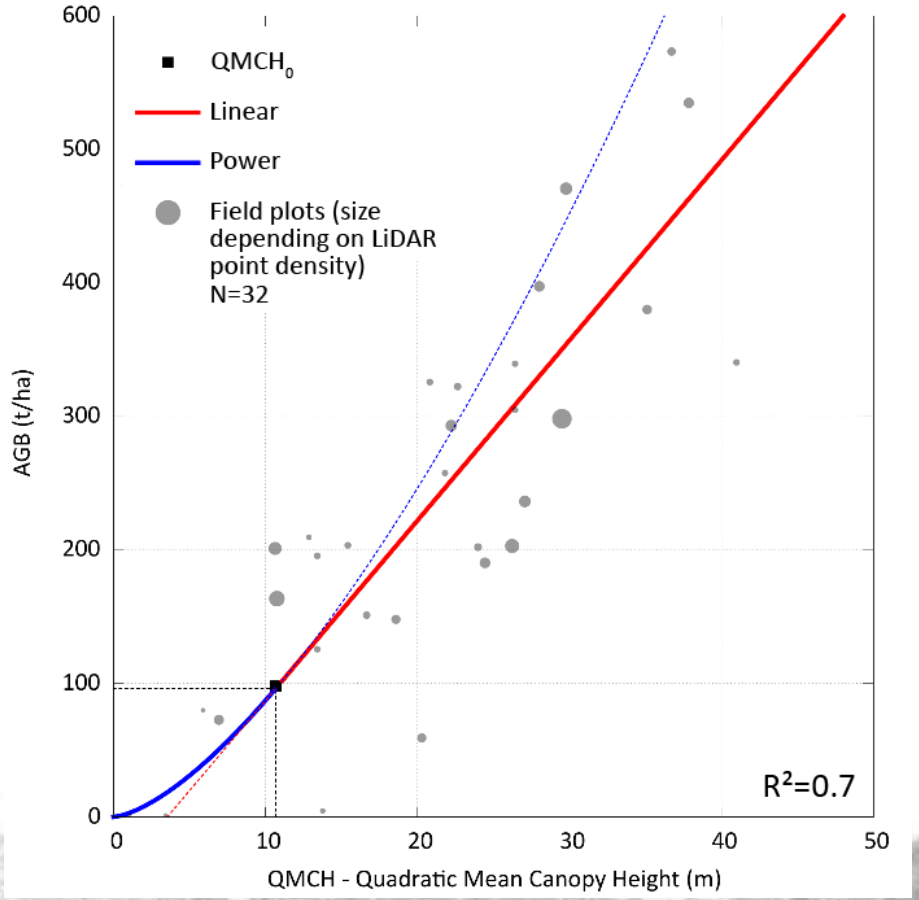
Aboveground biomass modeling: Results

- AGB regression model Berau and KH

Berau, East Kalimantan



Kapuas Hulu, West Kalimantan



Aboveground biomass modeling: Results

- Average AGB values for different forest types

Land cover class	Average	Benakat	Bentayan	Dangku	Kerinci Sebelat	Khphalalan	Lakitan	Mangrove	Reki	Sembilang
	t AGB/ha									
High-density Lowland Forest	**545**				563				393	
Medium-density Lowland Forest	**313**		121	150	430		67		223	
Low-density Lowland Forest	**145**	48	68	116	157		63		120	
High-density peat swamp forest	**232**					169				284
Low-density peat swamp forest	**72**					72				74
Regrowing peat swamp forest	**92**					54				200
Permanently inundated peat swamp forest	**194**					164				279
High-density Lower Montane Rain Forest	**621**				621					
Medium-density Lower Montane Rain Forest	**501**				501					
Mangrove 1	**193**							71		222
Mangrove 2	**162**							24		166
Degraded mangrove	**41**									41
Young mangrove	**40**							40		
Nipah palm	**69**									69
Heath forest	**201**					201				

Aboveground biomass modeling: Results

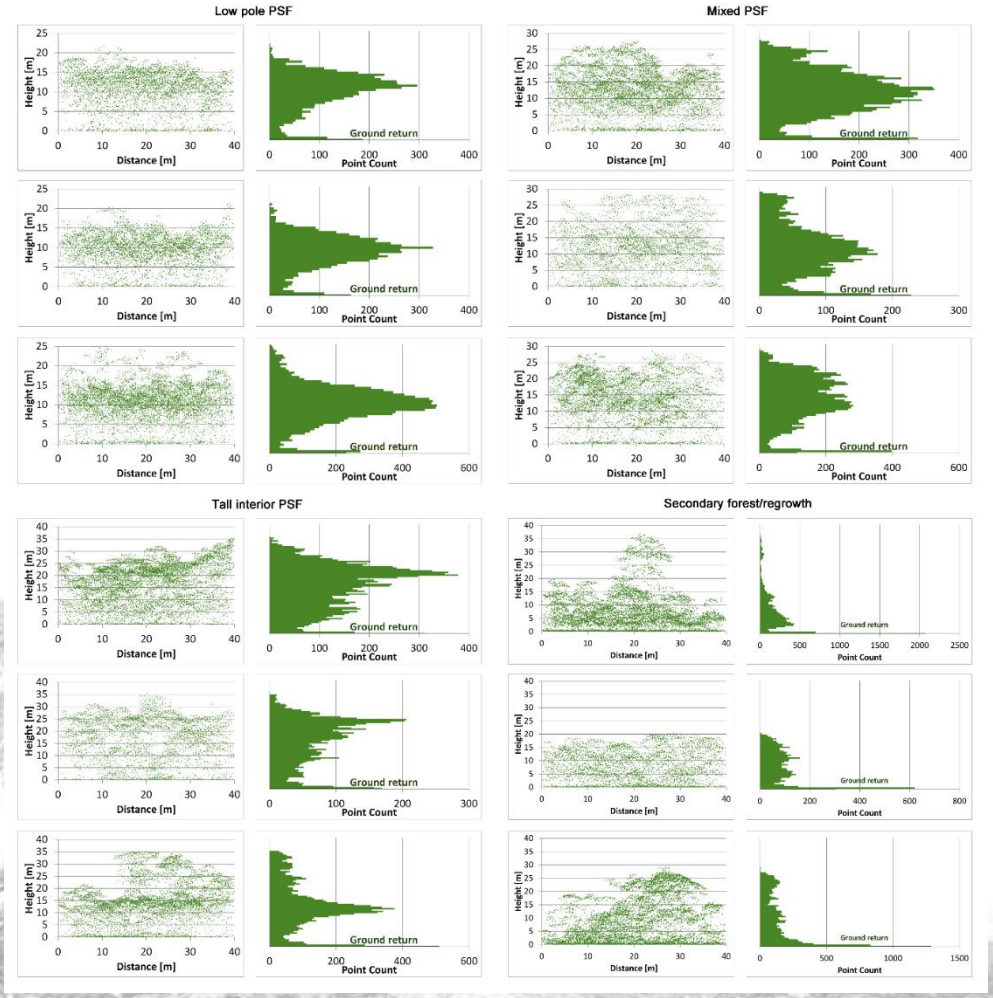
- Average AGB values for different non forest types

Land cover class	Average	Benakat	Bentayan	Dangku	Kerinci Sebelat	Khphalalan	Lakitan	Mangrove	Reki	Sembilang
	t AGB/ha									
Scrubland	28	9	6		65	28		3	37	5
Acacia Plantation*	24	21				30				19
Industrial Forest*	36	36								
Oil palm plantation*	44		44				4			
Rubber	129						129			
Coconut plantation*	30							30		
Dryland Agriculture	26	4	3		27		15		52	
Dryland Agriculture mixed with Scrub	28	11	23		48		16		40	

*** AGB stock depending on point in time within rotation cycle**

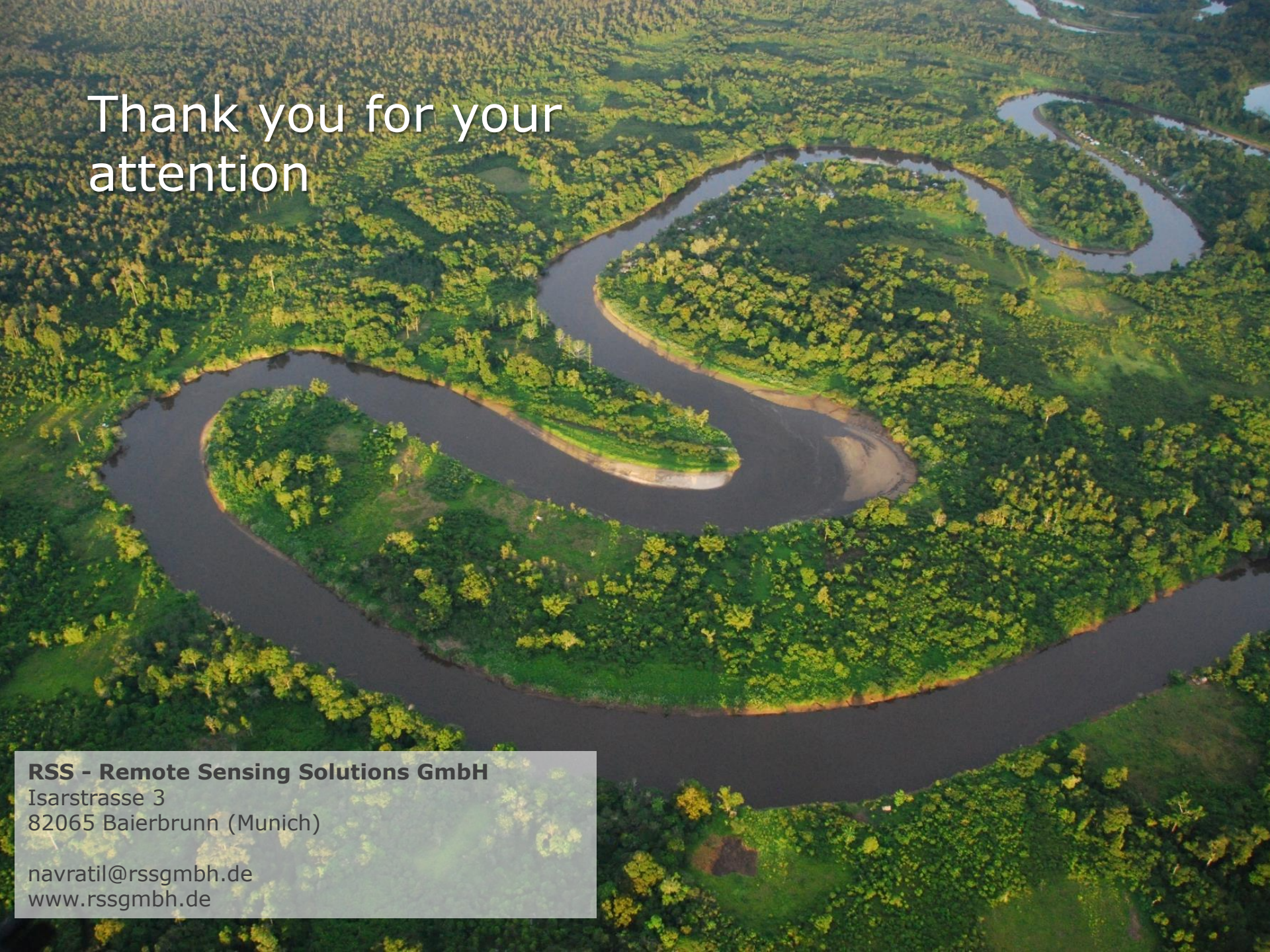
Aboveground biomass modeling
Outlook

Analysis of 3D forest structure: Vegetation height profiles



Summary and Conclusions

- Preliminary AGB model available
- Good prediction quality, but more calibration plots necessary across biomass range
- New predictive model will be established based on improved set of calibration plots
- Biodiversity analysis pending on the availability of large sample plots

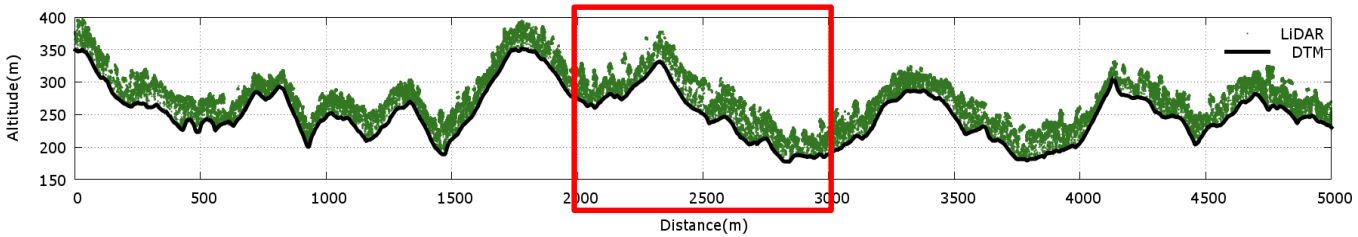


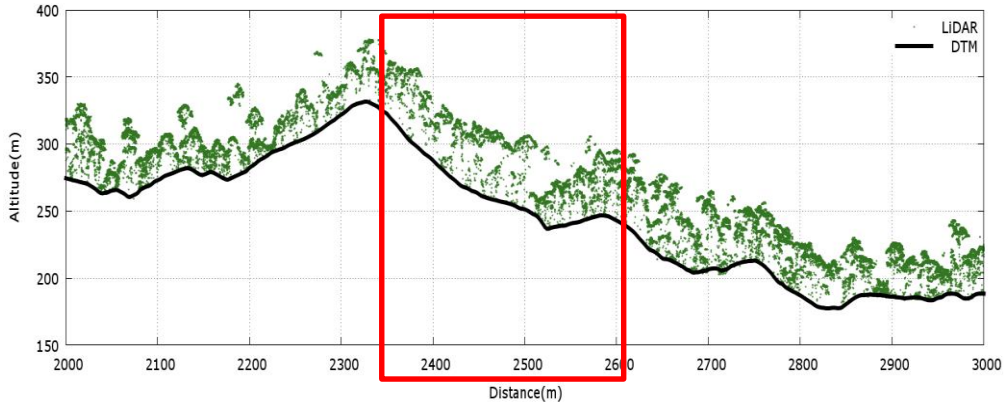
Thank you for your attention

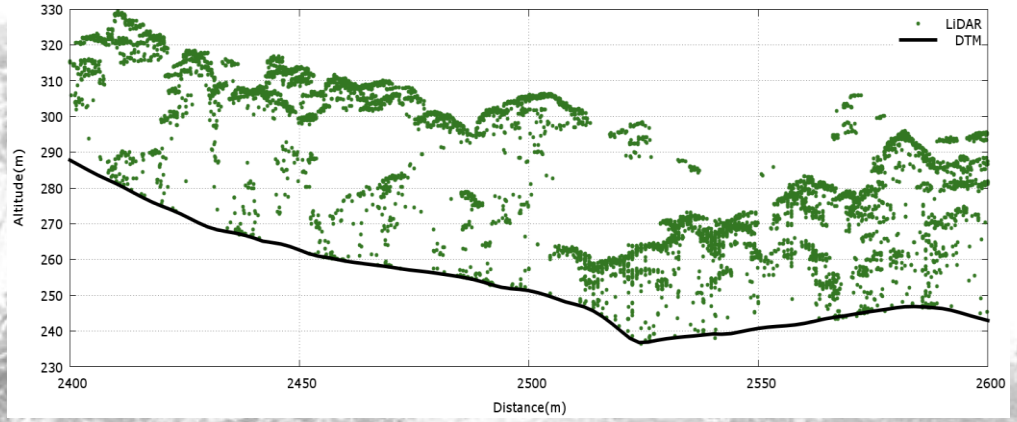
RSS - Remote Sensing Solutions GmbH
Isarstrasse 3
82065 Baierbrunn (Munich)

navratil@rssgmbh.de
www.rssgmbh.de

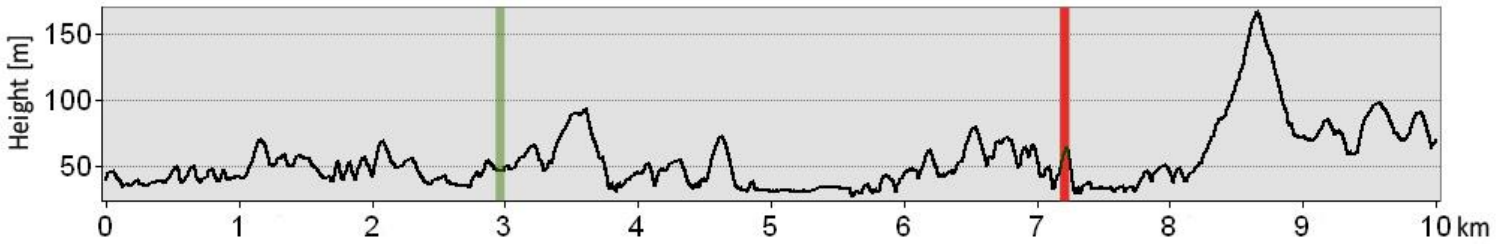
LiDAR transects

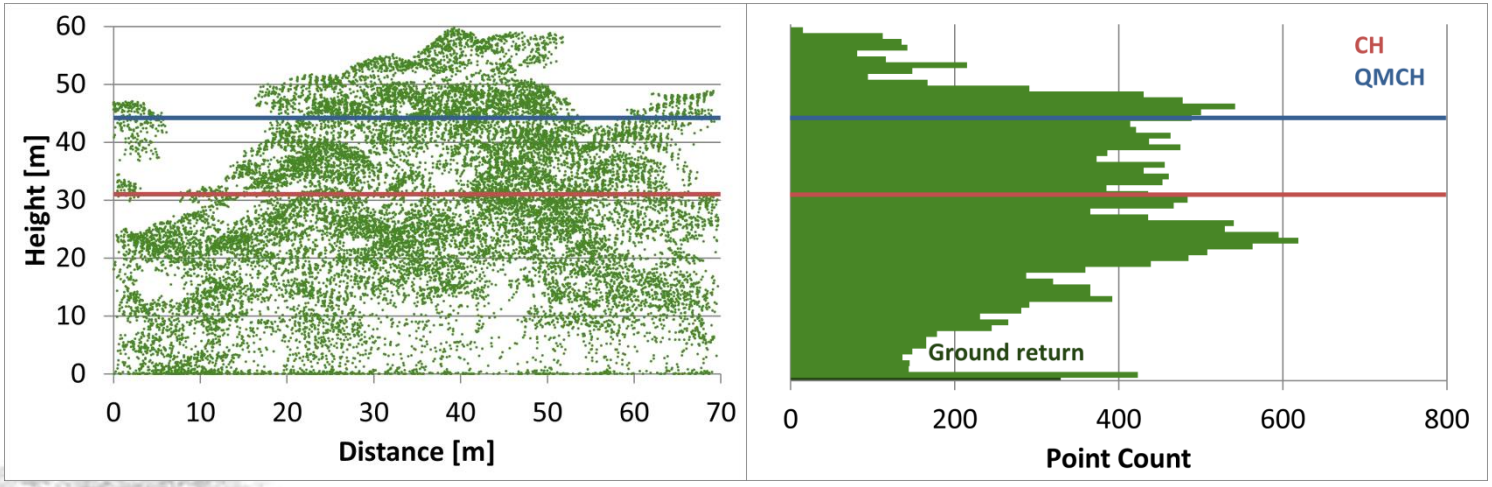






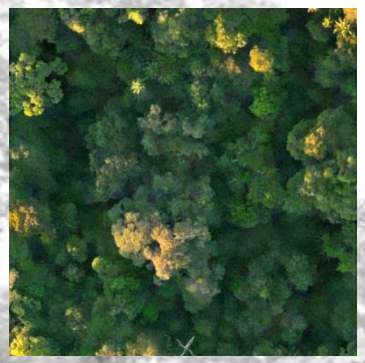
Lowland Dipterocarp Forest (0-<300 m a.s.l.)

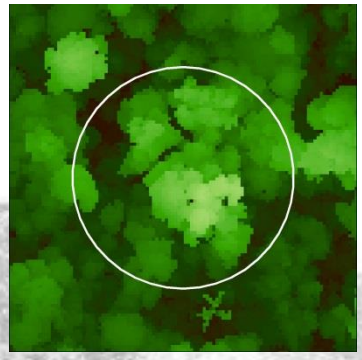


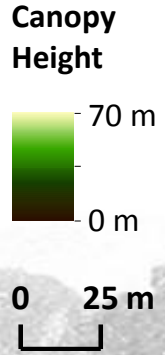


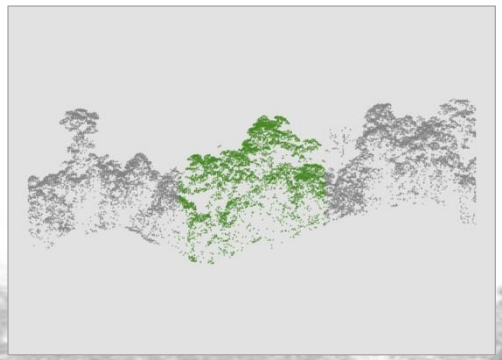
Ø Terrain Height: 40.0 m

AGB: 373.7 t/ha

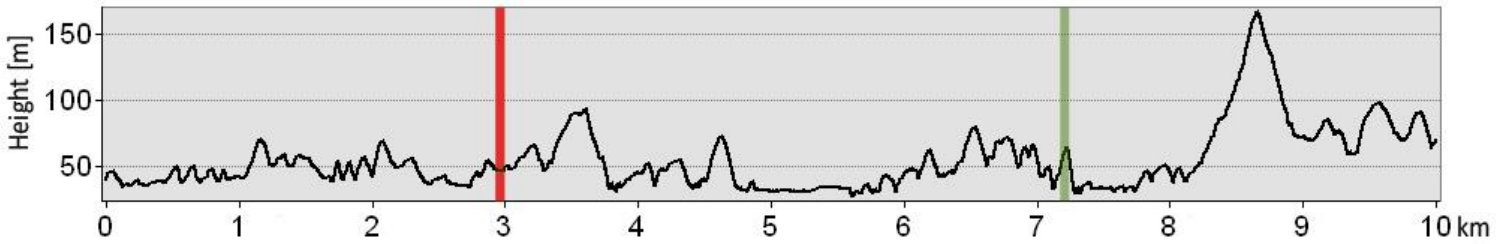






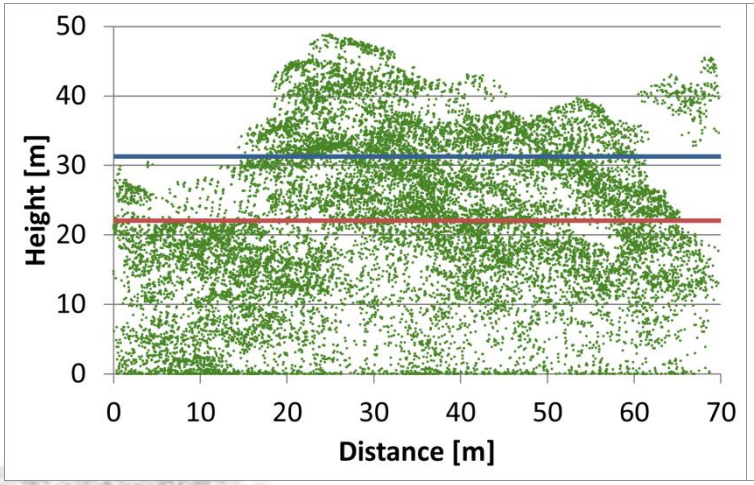


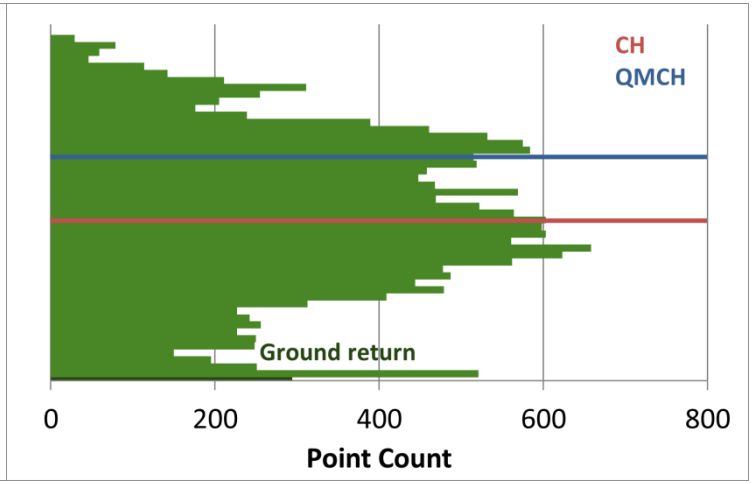
Secondary Lowland Dipterocarp Forest (0-<300 m a.s.l.)

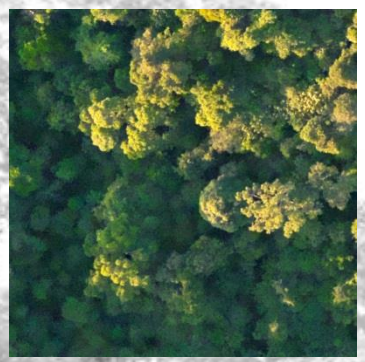


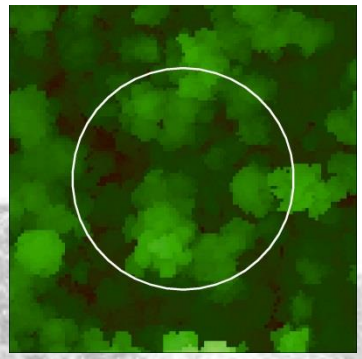
Ø Terrain Height: 47.9 m

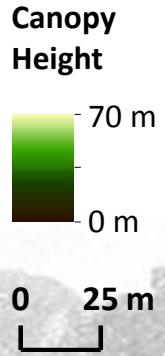
AGB: 231.9 t/ha

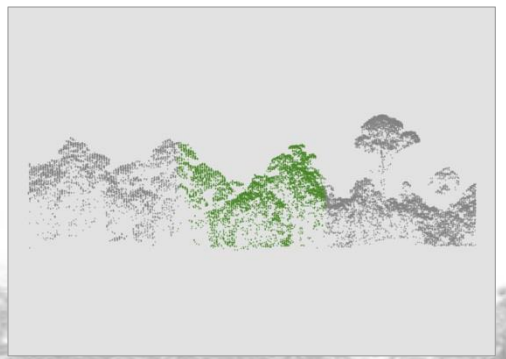




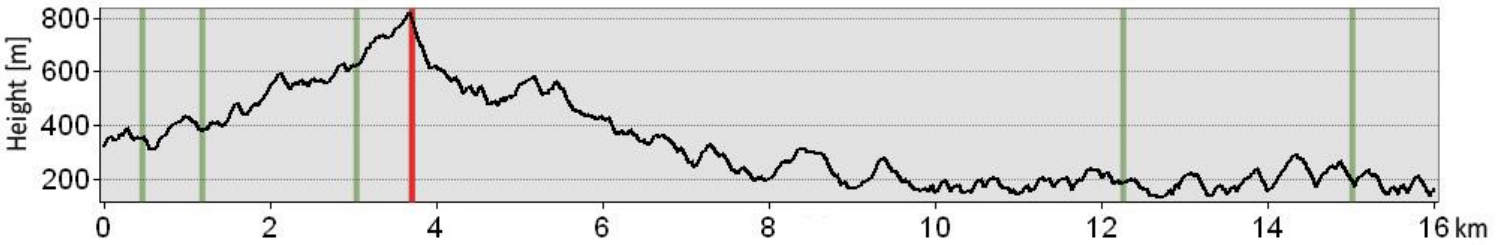


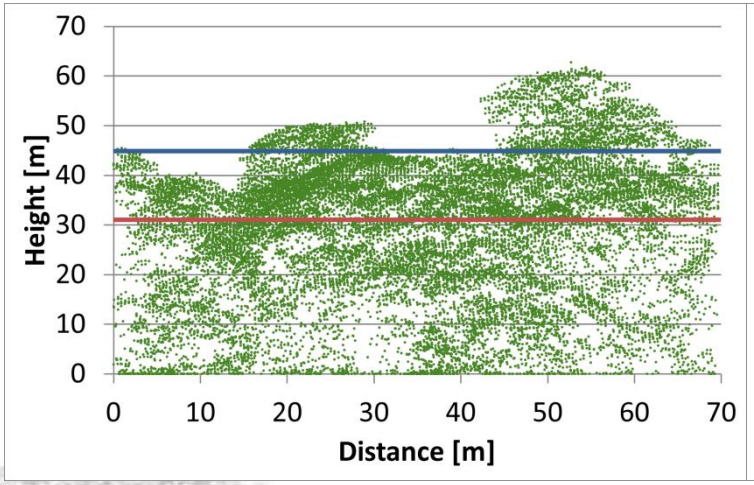


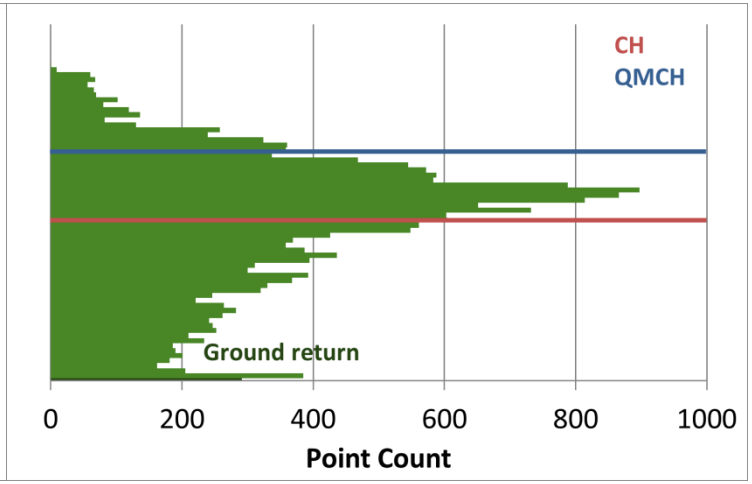




Hill and Sub-montane Dipterocarp Forest (300-<900 m a.s.l.)



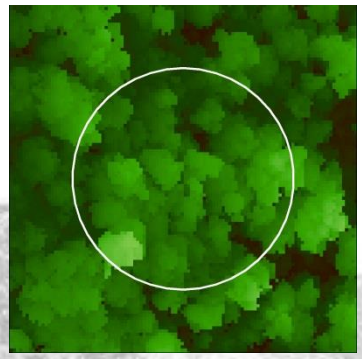


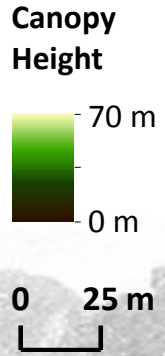


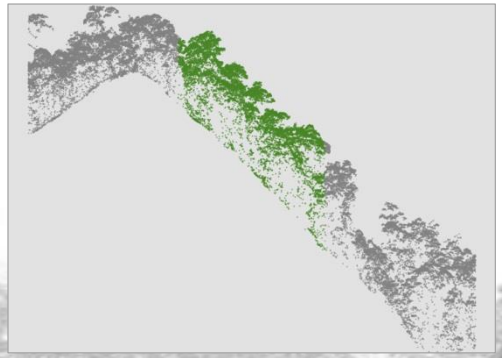
Plot ID
01_04

Ø Terrain Height:
781.2 m

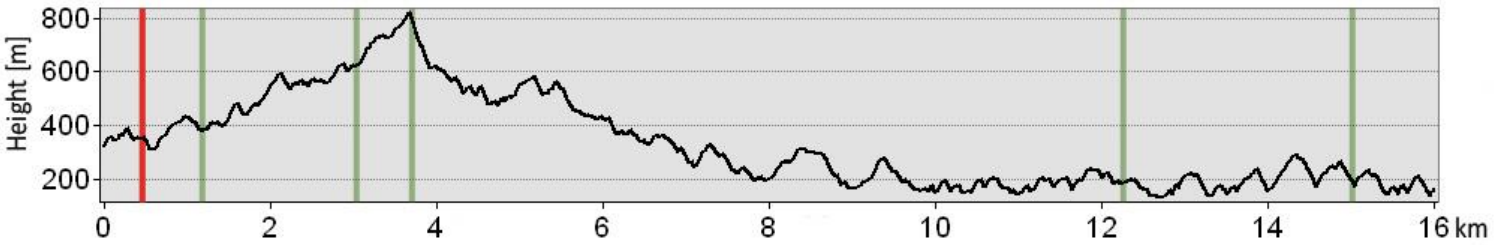
AGB:
390.4 t/ha

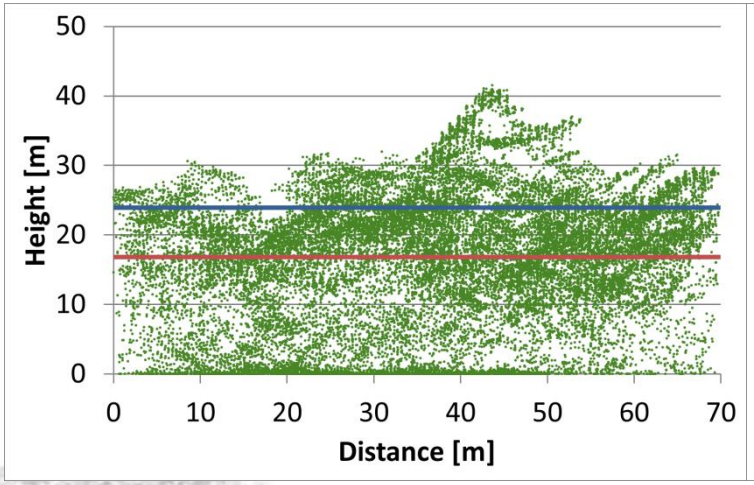


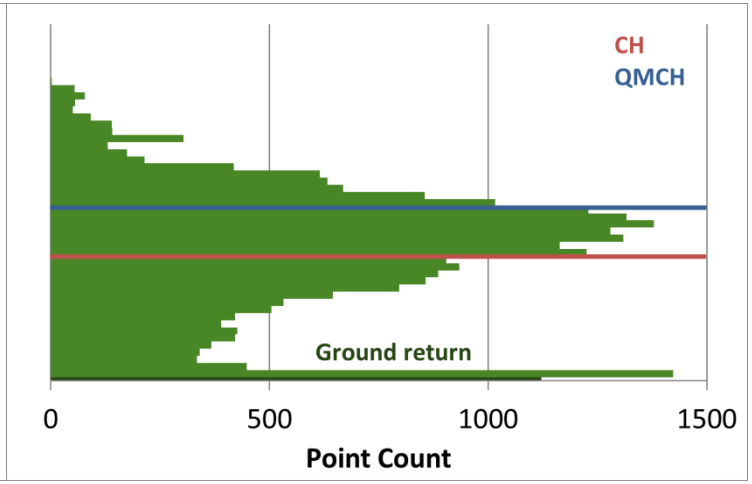




Secondary Hill and Sub-montane Dipterocarp Forest (300-<900 m a.s.l.)



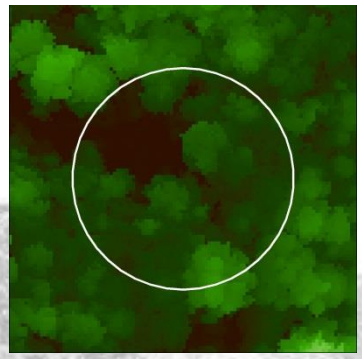


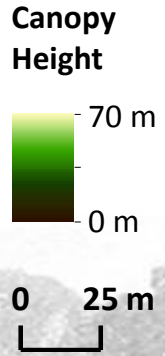


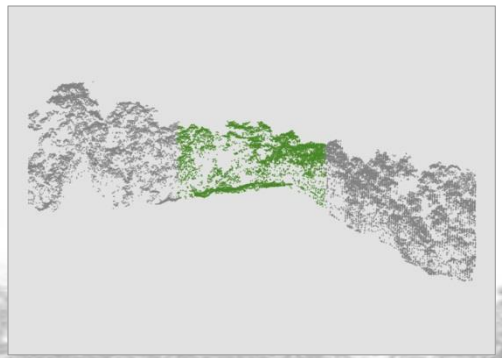
Plot ID:
01_01

Ø Terrain Height:
325.6 m

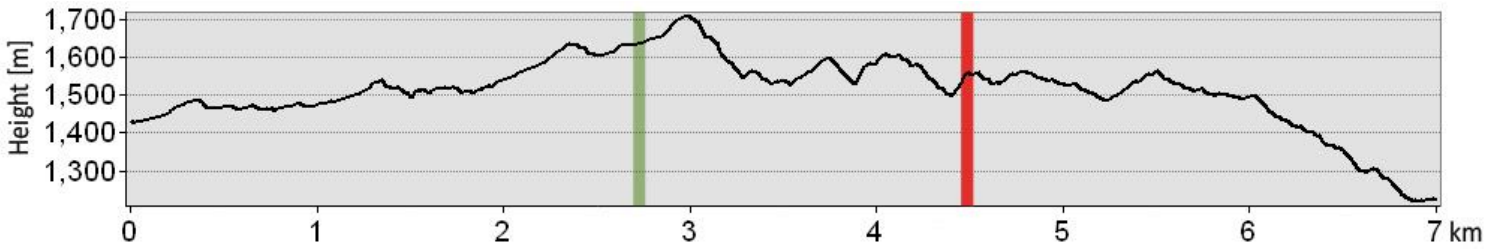
AGB:
166.3 t/ha

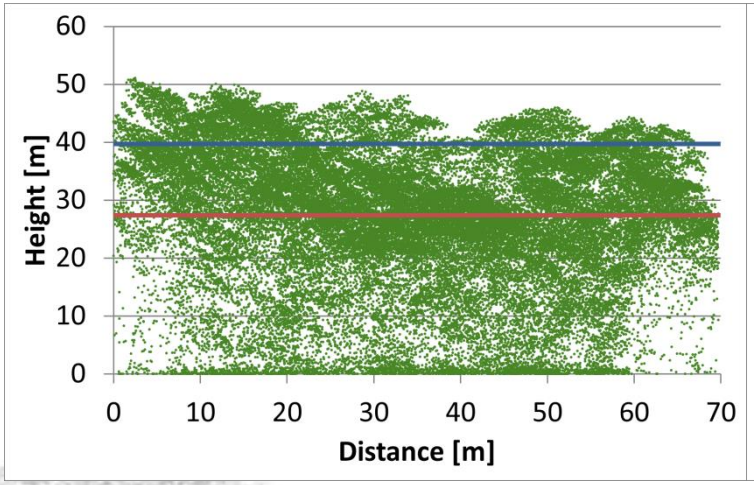


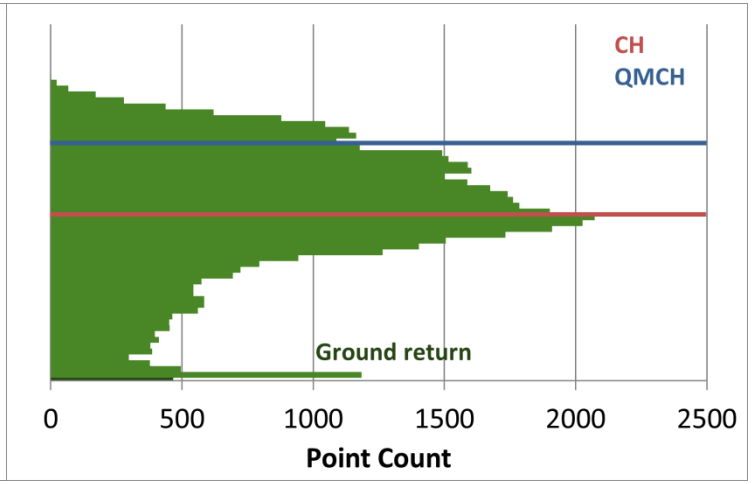




Upper Montane Rainforest (>1500 m a.s.l.)

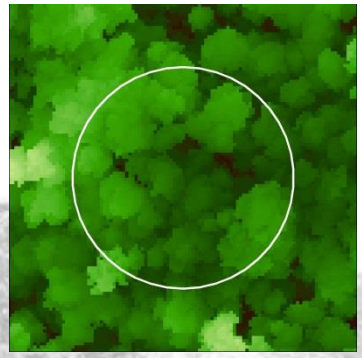


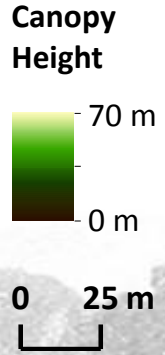


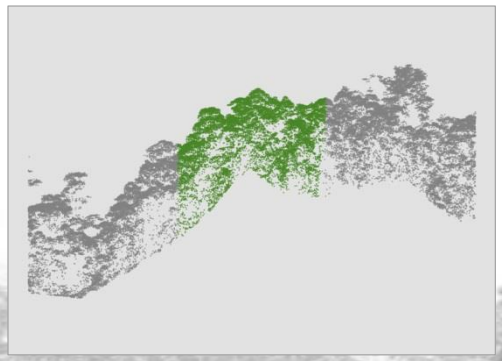


Ø Terrain Height: 1550.0 m

AGB: 226.8 t/ha

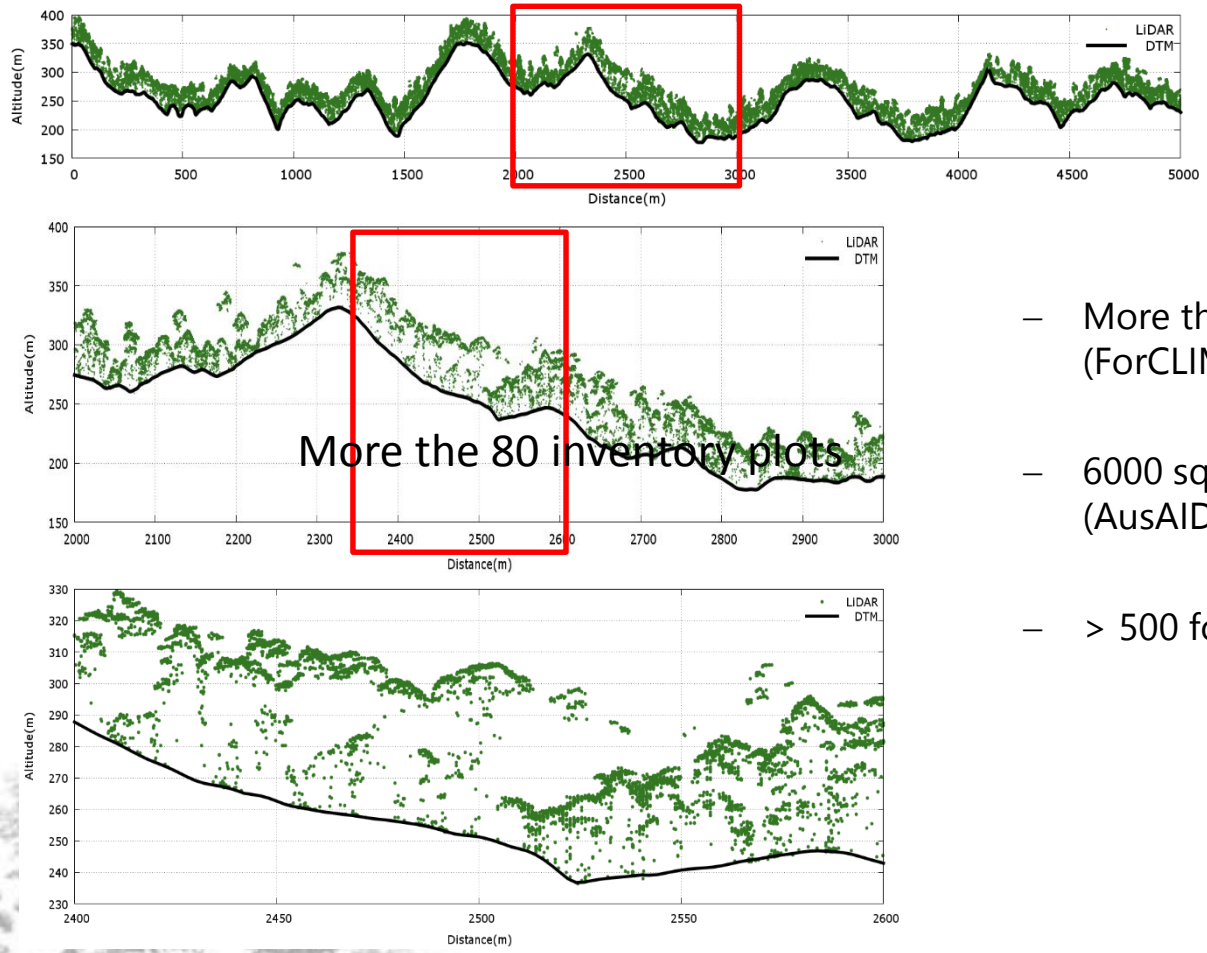






Methodological approach

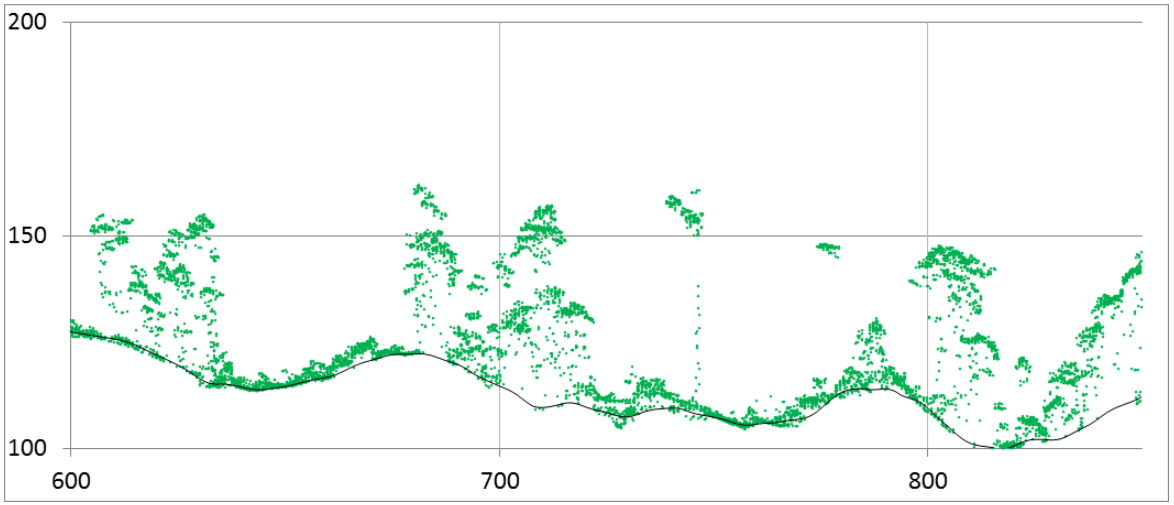
LiDAR transects to estimate AGB variability



- More than 1500 km of transsects (ForCLIME)
- 6000 sqkm full area coverage (AusAID)
- > 500 forest inventory plots

Methodological approach

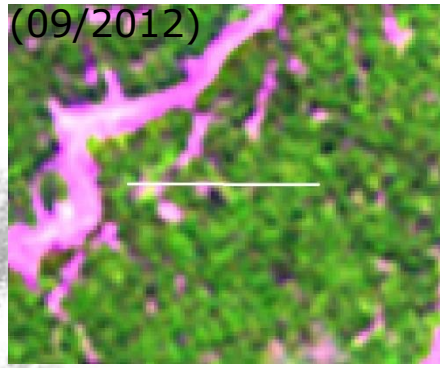
LiDAR transects to estimate AGB variability – Recent logging acticities (ca. 2011/12)



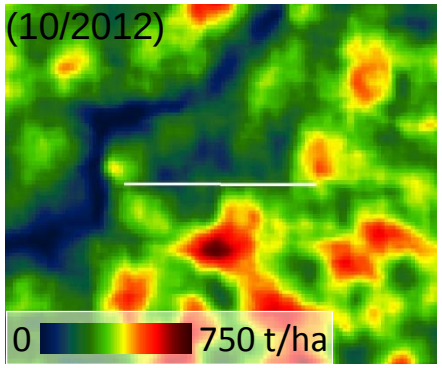
Mean AGB: 155.7 t/ha

Orthophoto (10/2012)

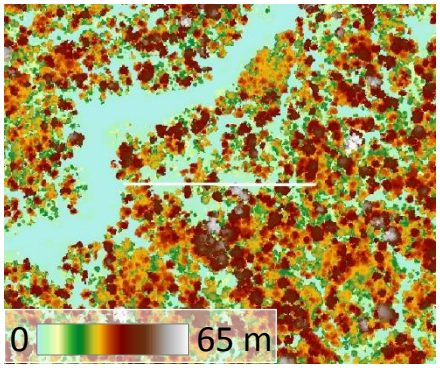
RapidEye (09/2012)



AGB Model (10/2012)

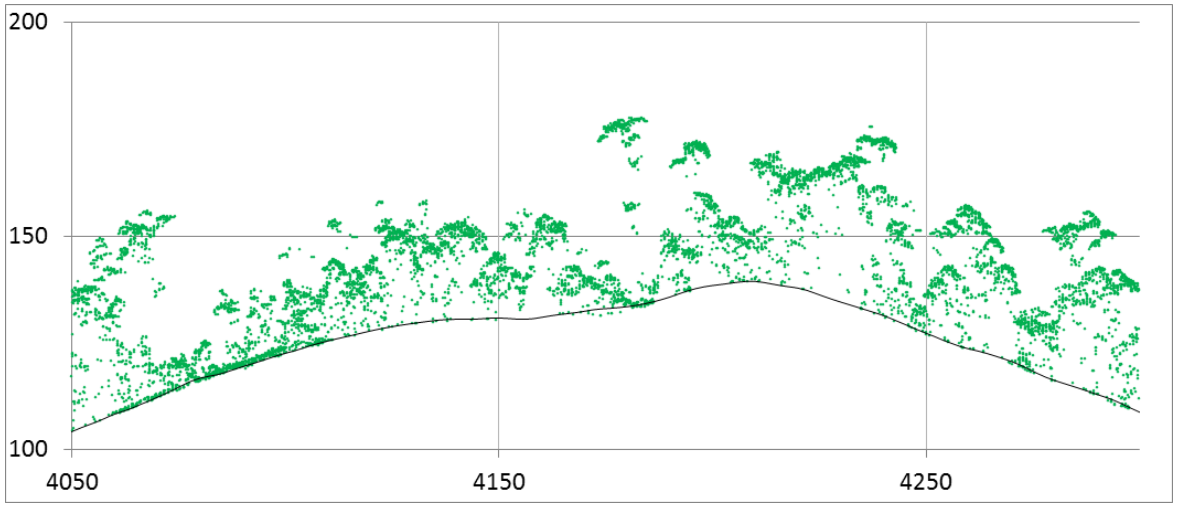


CHM (10/2012)



Methodological approach

LiDAR transects to estimate AGB variability – Former logging activities (ca. 2008/09)

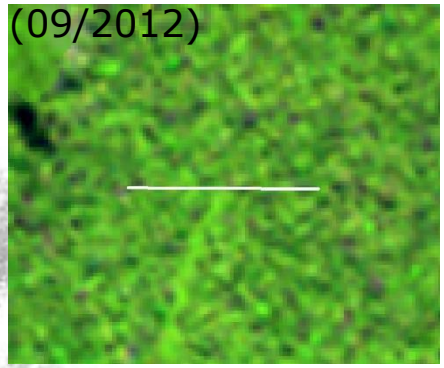


Mean AGB: 176.8 t/ha

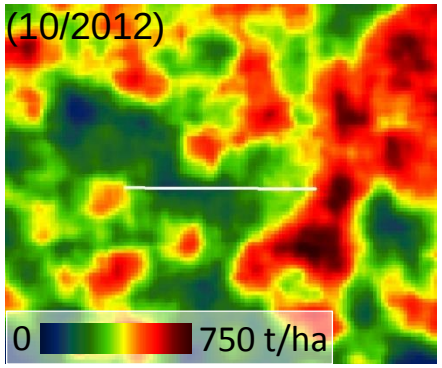
Trees up to 45 meters tall

Orthophoto (10/2012)

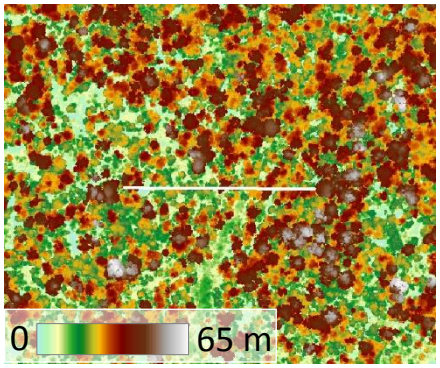
RapidEye (09/2012)



AGB Model (10/2012)

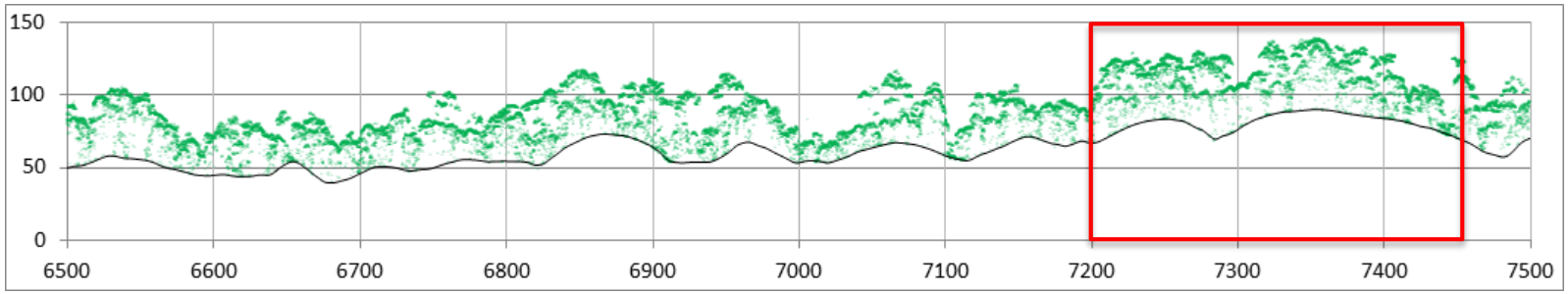


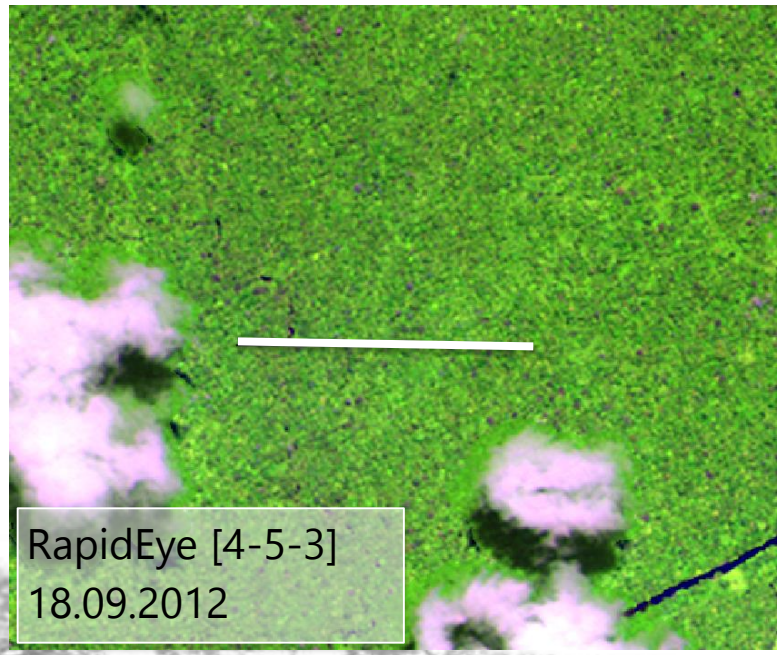
CHM (10/2012)

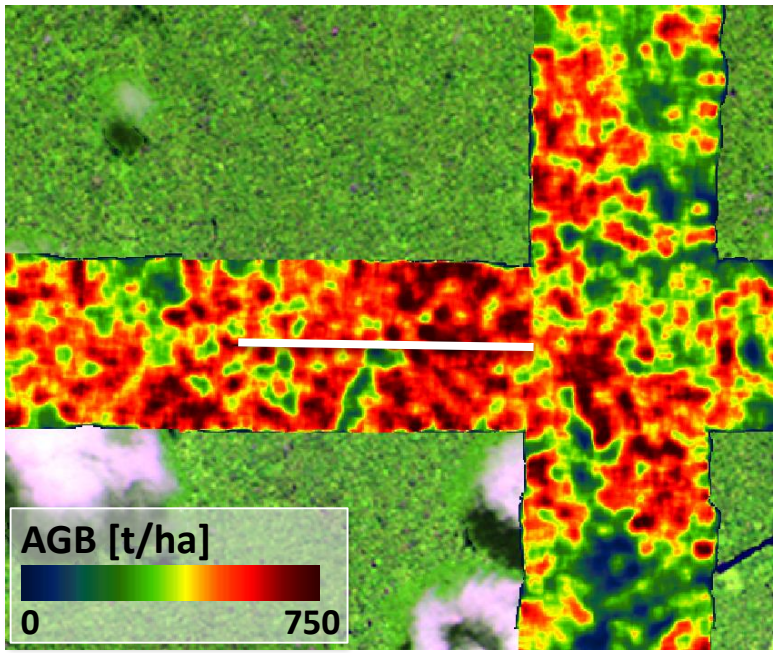


Methodological approach

LiDAR transects to estimate AGB variability – No logging activities

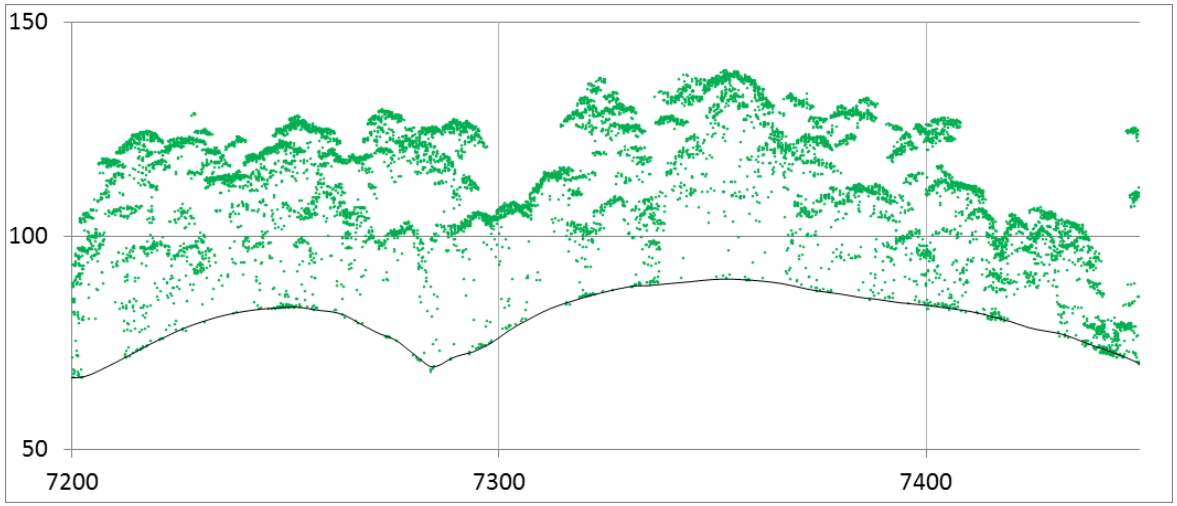






Methodological approach

LiDAR transects to estimate AGB variability – No logging activities

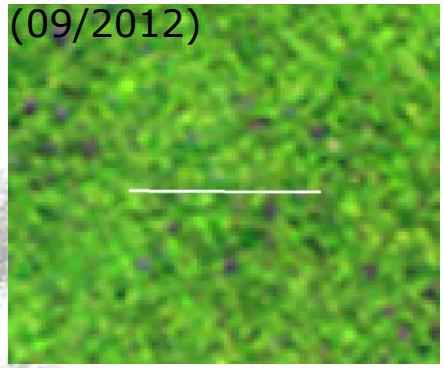


Mean AGB: 444.9 t/ha

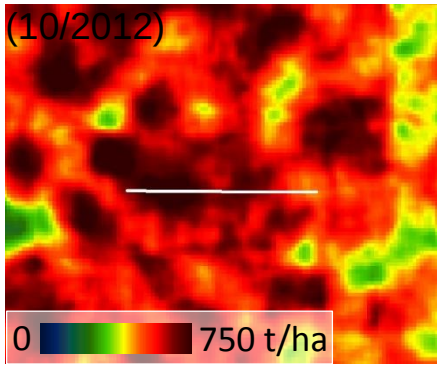
Many trees up to 55 meters tall

Orthophoto (10/2012)

RapidEye (09/2012)



AGB Model (10/2012)



CHM (10/2012)