56th Annual Association for Tropical Biology and Conservation

Performance of laser-based electronic devices for structural analysis of Amazonian Terra-Firme forest

Authors: Iokanam Sales Pereira , Henrique E. Mendonça do Nascimento, Matheus Boni Vicari, Mathias Disney, Evan H. DeLucia , Tomas Domingues , Bart Kruijt , David Lapola , Patrick Meir, Richard J. Norby, Jean P.H.B. Ometto, Carlos A. Quesada , Anja Rammig and Florian Hofhansl

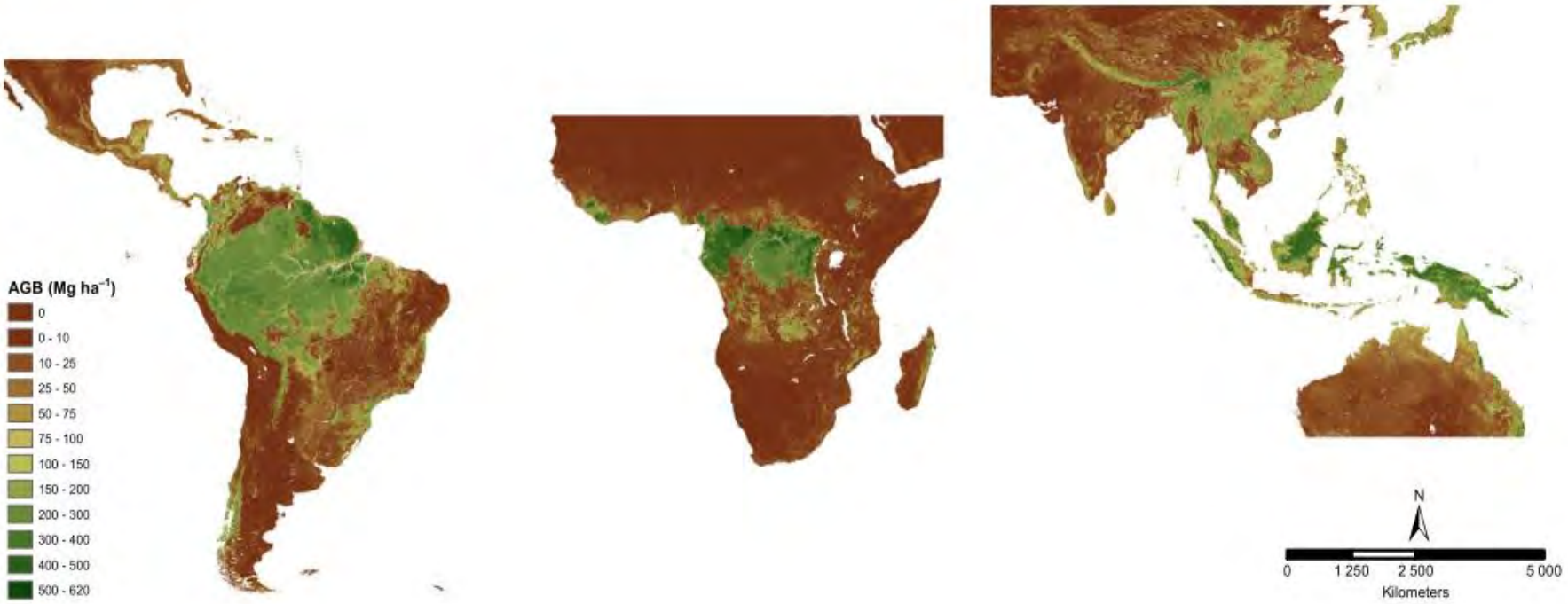
AMAZONFACE

INPA
INSTITUTO NACIONAL DE PESQUISAS DA AMAZÔNIA

IIASA
International Institute for Applied Systems Analysis
www.iiasa.ac.at

Field-Map

Tropical forests play a key role in terrestrial carbon cycle. Mainly in a scenario of climate change.



Map: Avitabile et al. 2016

AMAZONFACE

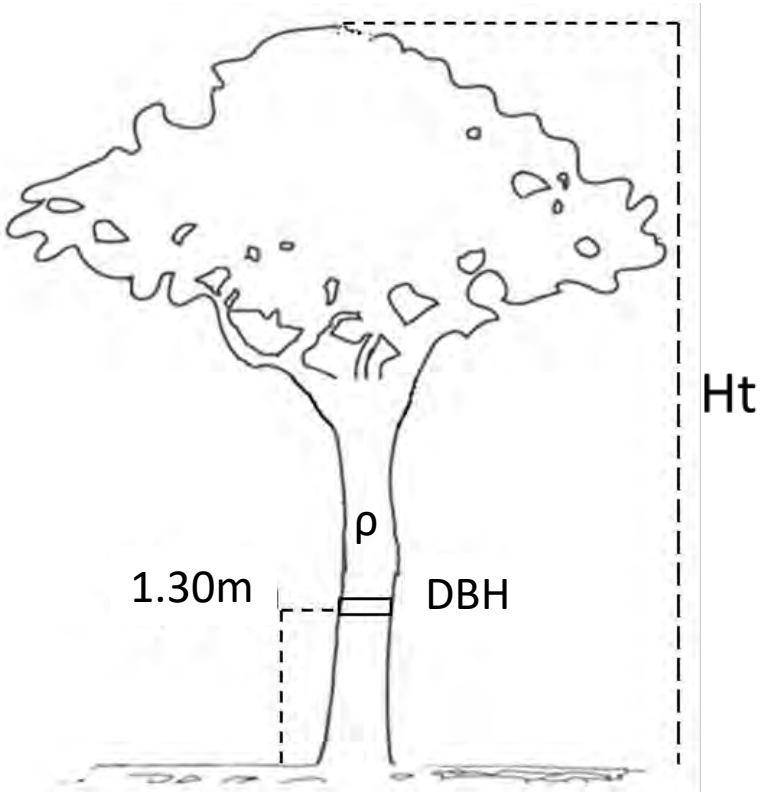
Trees

Biometrics variables in permanent plots

DBH, Ht e ρ

Allometric scaling equations[1,2,3]

Forest productivity and stock

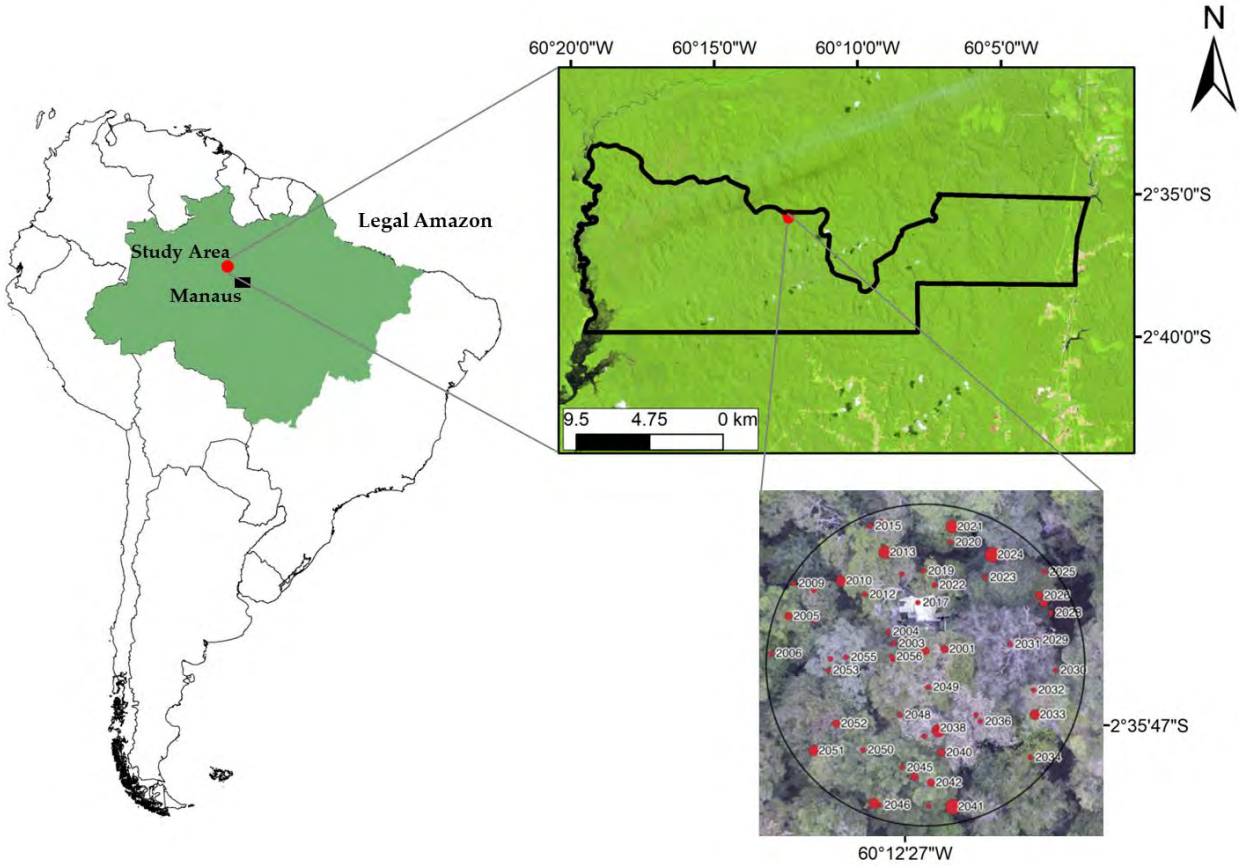


Chave et al. 2014; Disney et al. 2019

New technologies brings news approaches for forest inventory

Objectives	
Compare traditional methods with laser-based electronic devices	Quantify the total error, the systematic error and the random error

Location



- Amazon FACE program- one plot (706m^2);
- Köppen-Geiger:classification Am [1];
- Temp.: (25.8 - 27.9 °C) [2];
- Precipitation 2431 mm/ year [2];
- Ferralsol / Oxisol- low availability in nutrients [3];
- *Terra firme*- Old growth forest;
- Canopy mean height = 30 m [5];
- Basal area: 28-30 m^2/ha [5].

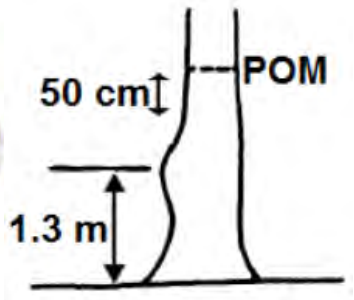
1- Peel et al. 2007; 2- Araújo et al. 2002; 3- Luizão et al. 2004; 4-IBGE 2002; 5- Vieira et al. 2004

AMAZONFACE

Traditional methods (TM) obsverd data

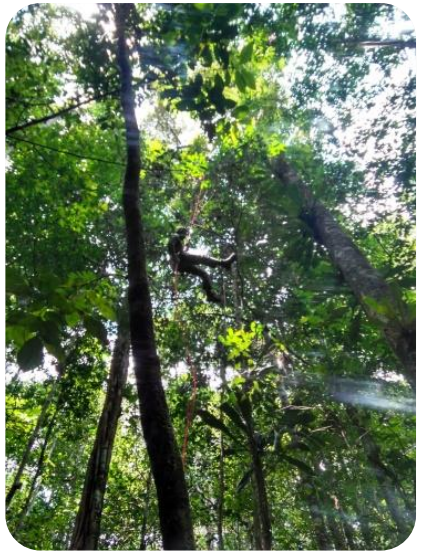
Diametric tape (DT)

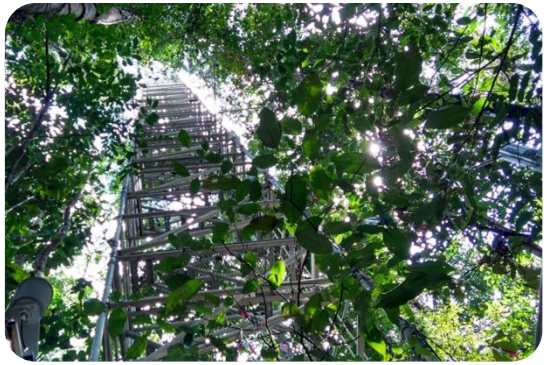
- Used for DBH (observed data);
- Following protocols [1,2];
- Fast, easy and cheap;



Metric tape (MT)

- Used for Ht (observed data);
- professional climber and central tower in plot;
- Slow, difficult and expensive.

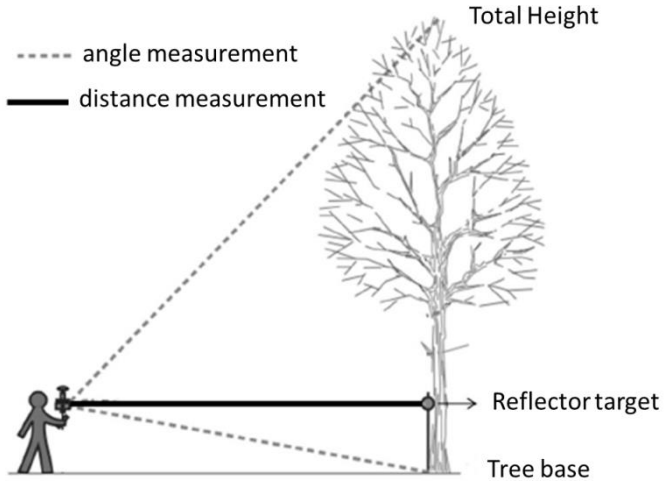




1- Marthews et al. 2014; 2- Condit 1998

Field-Map Bundle (FM)

Electronic caliper	Laser rangefinder
• Used for DBH; • Following protocols [1]; • 2 measurements per tree in the same point of DT.	• Used for Ht; • Laser beam for measures distances • Based in trigonometry [2]; • 2-3 measurements per tree.



1- Marthews et al. 2014; 2- Larjavaara, and Muller-Landau, 2013

Terrestrial Laser Scanning or terrestrial LiDAR (TLS)

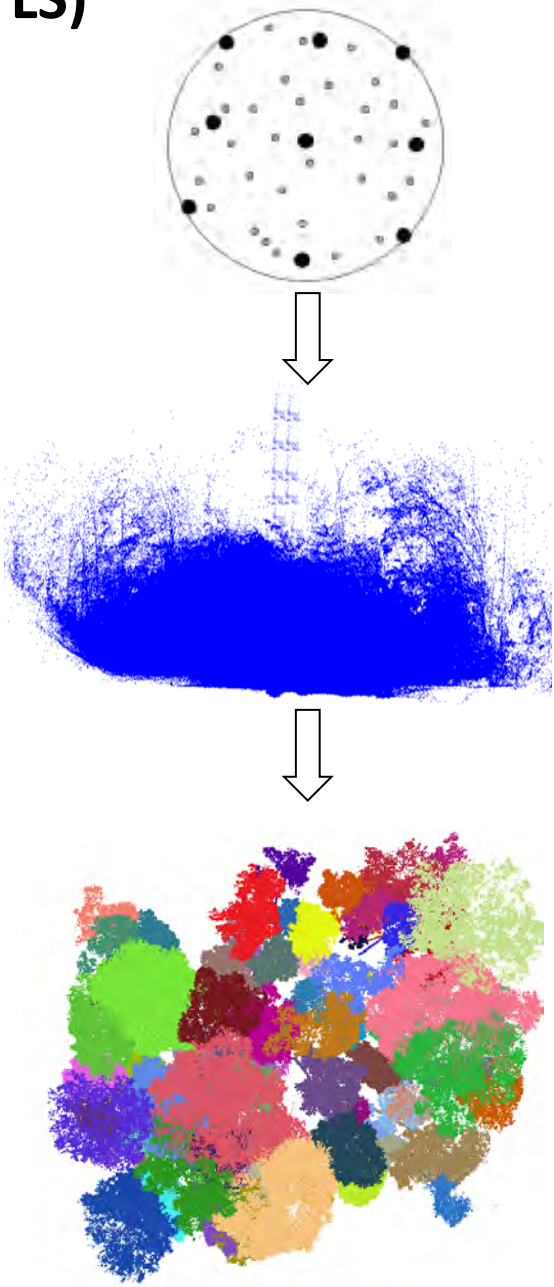
RIEGL VZ-400i

- Active sensor of the type that emits a series of pulses of laser to the environment;
- High precision clock that calculates the time of emission and return (reflection) of beams registered with precision;
- Three-dimensional coordinates (x, y, z) based on the distance of the returns to the sensor;
- Forming a cloud of points with millions of coordinates in minutes.

Terrestrial Laser Scanning or terrestrial LiDAR (TLS)

Terrestrial Laser Scanning data

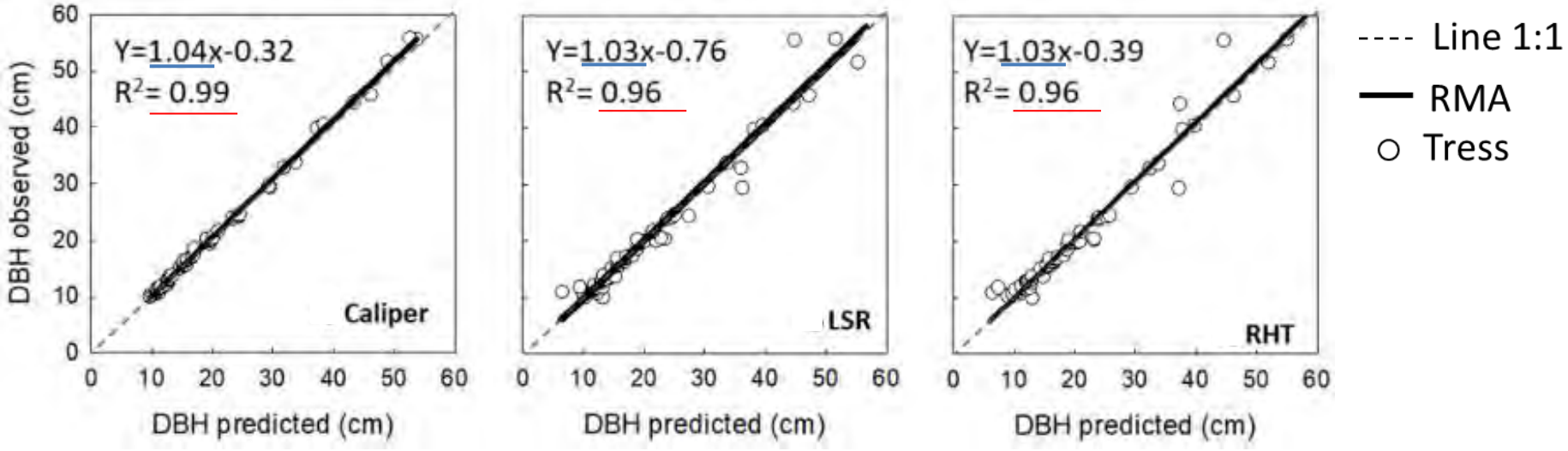
- Collecting data→ scan in different spots→ create a unique point cloud (*raw point cloud*);
- Extracting individuals trees from raw point cloud using algorithm *treeseg* [1];
- Software *3D Forest* [2] used for obtain the biometric variables:
  - DBH two ways: last square regression (LSR) and Randomized Hough Transformation (RHT);
  - Ht two ways: height of point cloud (TLS height) and length of point cloud (TLS length) .



1-Burt et al. 2019; 2- Trochta et al. 2017

AMAZONFACE

Analysis of horizontal vegetation structure (tree diameter)

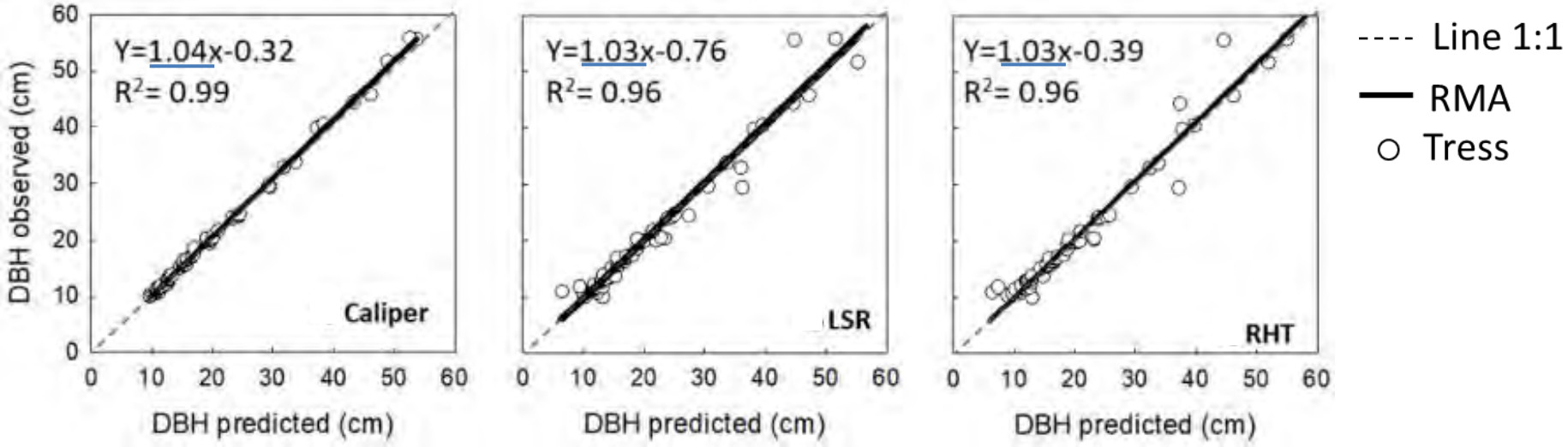


Above the line 1:1→ underestimate

Under the line 1:1 → overestimate

Methodology	Total error (Et)		Systematic error		Random error	
	Et (cm)	Et_{prop} (%)	Es (cm)	Es_{prop} (%)	Er (cm)	Er_{prop} (%)
Caliper	0.9	3.2	-0.5	-2.3	0.7	2.3
RHT	2.4	11.1	-0.4	-1.8	2.4	11.0
LSR	2.3	10.2	0.2	1.6	2.0	10.1

Analysis of horizontal vegetation structure (tree diameter)

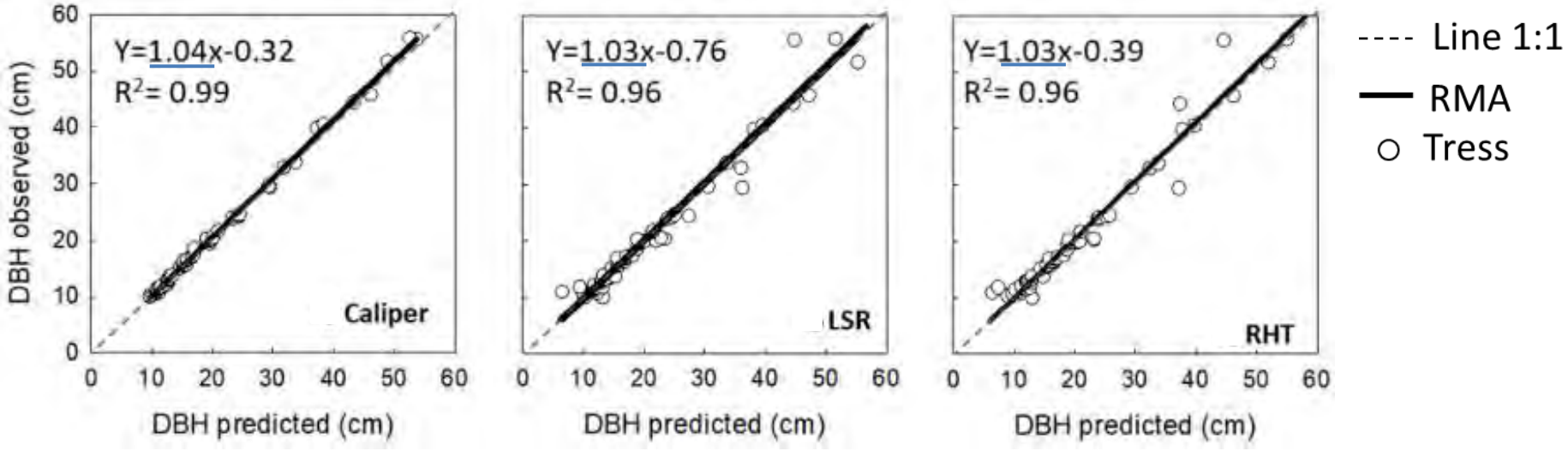


Lowest RMSE and
Random error
Highest systematic error

Highest RMSE and
Random error
Lowest systematic error

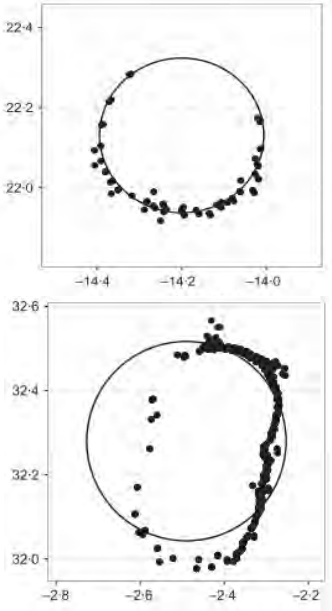
Methodology	Total error (Et)		Systematic error		Random error	
	Et (cm)	Et_{prop} (%)	Es (cm)	Es_{prop} (%)	Er (cm)	Er_{prop} (%)
Caliper	0.9	3.2	-0.5	-2.3	0.7	2.3
RHT	2.4	11.1	-0.4	-1.8	2.4	11.0
LSR	2.3	10.2	0.2	1.6	2.0	10.1

Analysis of horizontal vegetation structure (tree diameter)

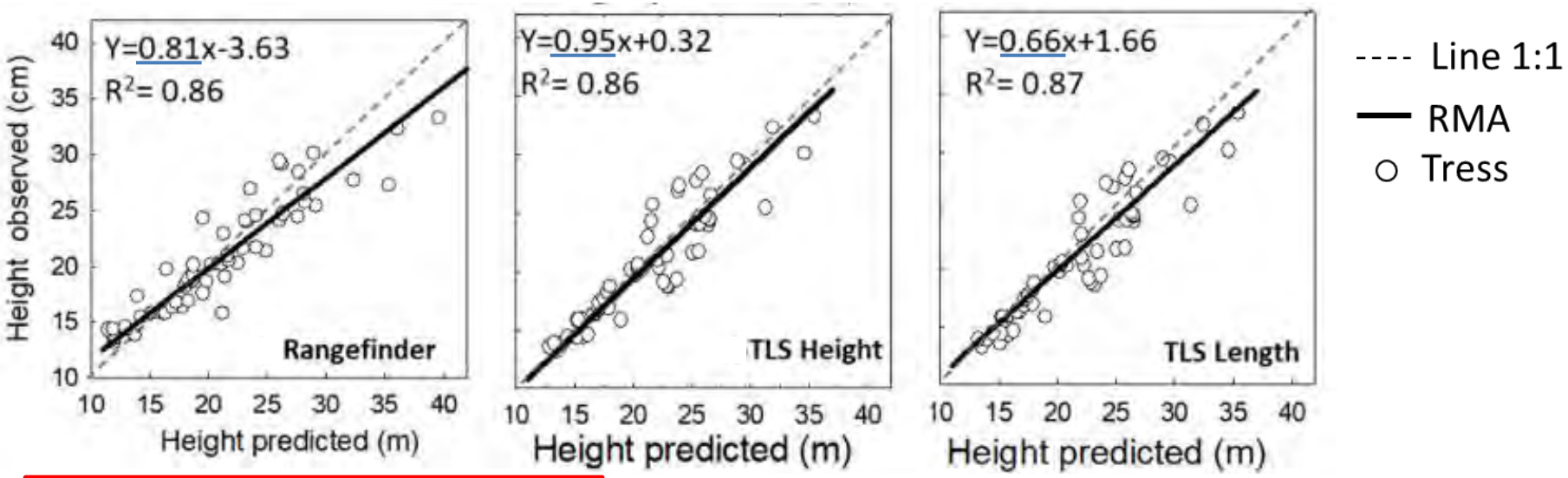


Difference between TM and devices :

- Non-circularity of trunks affect both devices ;
- TLS influenced of occlusion or noise by vegetation→ no correct fit of the circle to the tree trunk.



Analysis of vertical vegetation structure (tree height)



Highest RMSE and
Random error
Lowest systematic error

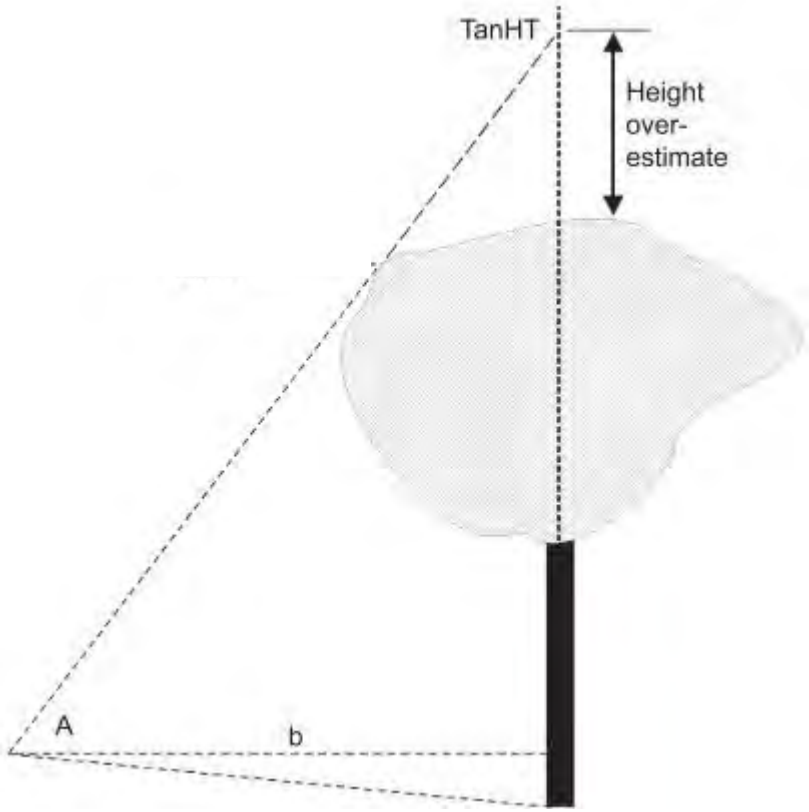
Lowest RMSE and
Random error
Highest systematic error

Methodology	Total error		Systematic error		Random error	
	Et (m)	Et_{prop} (%)	Es (m)	Es_{prop} (%)	Er (m)	Er_{prop} (%)
Rangefinder	2.6	11.7	0.4	1.1	2.6	11.8
TLS Height	2.2	10.0	0.7	3.6	1.8	9.3
TLS Length	2.2	10.1	0.9	4.5	2.0	9.1

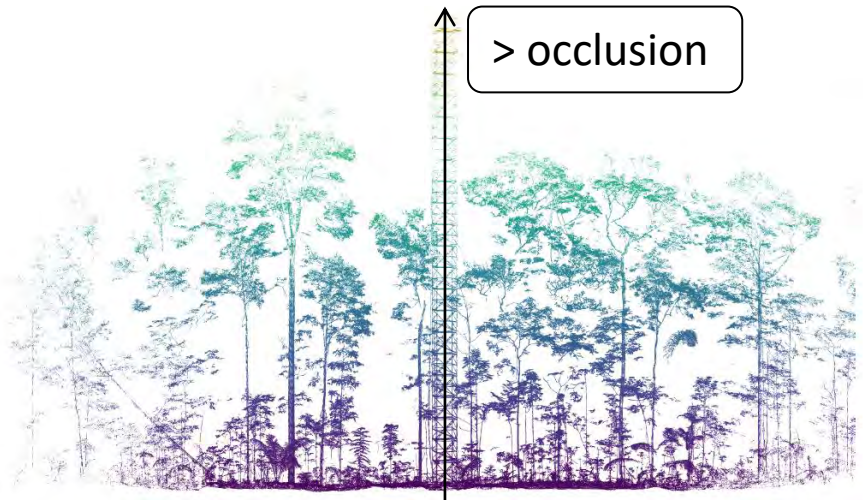
Analysis of vertical vegetation structure (tree height)

Difference between TM and devices :

- LR: related with distance to the tree of interest;
  - low distance increase the angle → overestimate;
  - High distances decrease the angle and the bias → underestimate;
- Some trees not possible to see the top from the ground.

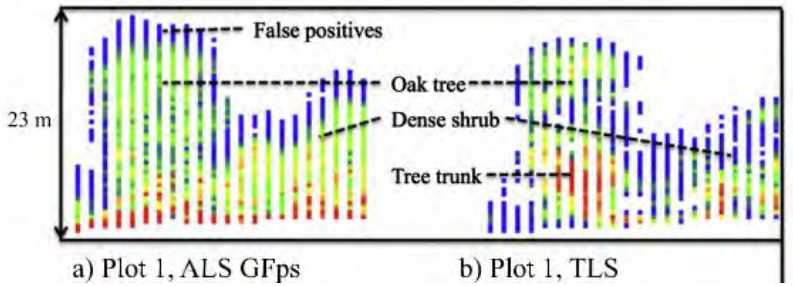


Analysis of vertical vegetation structure (tree height)



Difference between TM and devices :

- TLS: effects of the occlusion results in not good representation of the canopy [1,2,3];
- Noise caused by wind and neighborhood vegetation created a false positives [4];



1-Zhao et al. 2011; 2-- Calders et al. 2015; 3- Palace et al. 2015; 4- Hancock et al. 2017

AMAZONFACE

Satisfactory performance of both technologies evaluated:

DBH:

Field Map bundle: Highest precision and accuracy between technologies;

TLS: slightly lower precision and accuracy than caliper measurements;

Ht:

Field Map bundle : LR precision and accuracy slightly lower than TLS measurements;

TLS: better precision and accuracy between technologies and low tendency in estimates;

Technologies can be used to survey basic biometric variables for input into different models to better understand the carbon cycle within the tree component.


danke
謝謝
ngiyabonga
рахмат
teşekkür ederim
Баярлалаа
спасибо
thank you
gracias
dank je
tapadh leat
bedankt
dziękuję
hvala
mauruuru
obrigado
sukriya
kop khun krap
go raibh maith agat
arigatō
takk
dakujem
terima kasih
grazie
merci
mochchakkeram
sagolun
ευχαριστώ
감사합니다
ধন্যবাদ

AMAZONFACE

For more information (Free access)

remote sensing

MDPI

Article

Performance of Laser-Based Electronic Devices for Structural Analysis of Amazonian Terra-Firme Forests

Iokanam Sales Pereira [1], Henrique E. Mendonça do Nascimento [2], Matheus Boni Vicari [3], Mathias Disney [3,4], Evan H. DeLucia [5], Tomas Domingues [6], Bart Kruijt [7], David Lapola [8], Patrick Meir [9,10], Richard J. Norby [11], Jean P.H.B. Ometto [12], Carlos A. Quesada [1], Anja Rammig [13] and Florian Hofhansl [14,*]