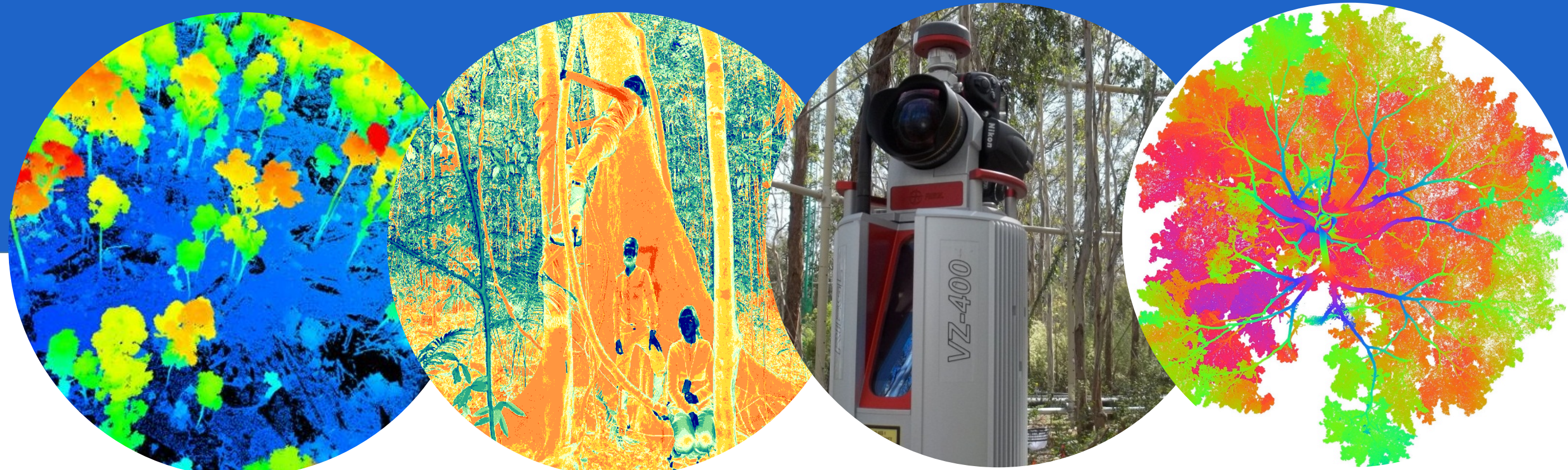


NEW TECHNOLOGIES (TLS/UAV) FOR BIOMASS VALIDATION: STATUS, OUTLOOK AND RECOMMENDATIONS

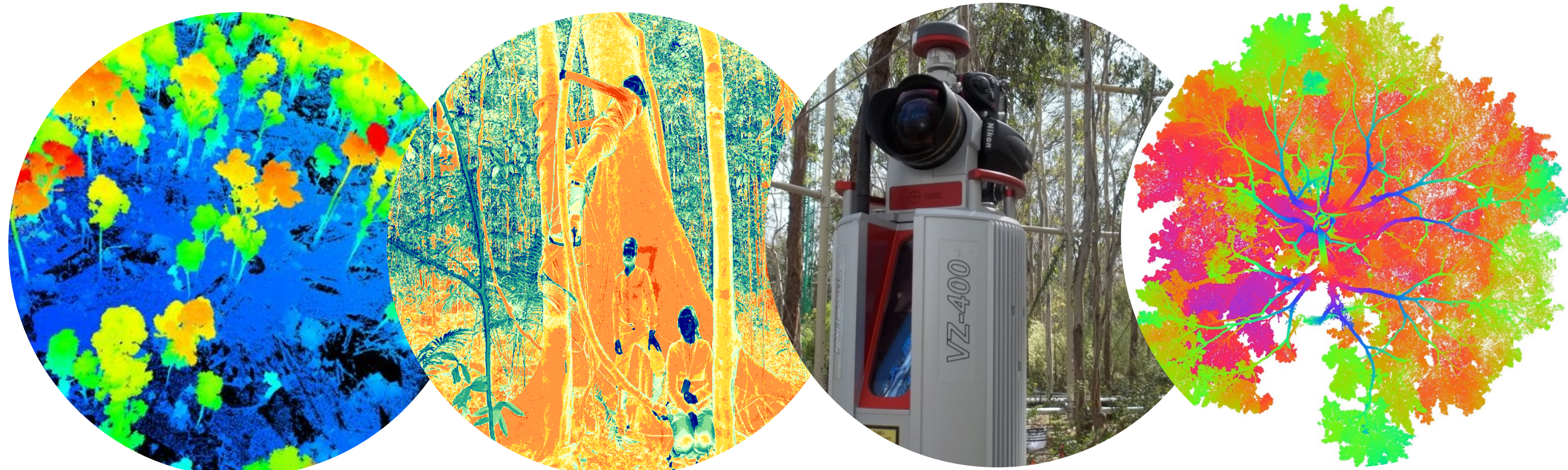
Kim Calders, Ghent University

03/03/2020
Canberra



CONTRIBUTORS

Kim Calders, Harm Bartholomeus, Glenn Newnham, Martin Herold, Simon Murphy, Darius Culvenor, Pasi Raunonen, Andrew Burt, John Armston, Valerio Avitabile, Mathias Disney, Markku Akerblom, Phil Wilkes, Matheus Boni Vicari, Jose Gonzalez de Tanago, Niall Origo, Joanne Nightingale, Alvaro Lau, Yadvinder Malhi, Atticus Stovall, Nicolas Barbier, James Kellner, Felix Morsdorf, Crystal Schaaf, Christian Thiel



LIDAR FOR FOREST MEASUREMENTS – WHY?

Measuring structure → measurement of location of basic components

LiDAR → relatively direct measurement of 3D structure
(e.g. tree & canopy height)

Trends in Ecology & Evolution

Forum

3D Imaging Insights into Forests and Coral Reefs

Kim Calders,^{1,2,@,*}
Stuart Phinn,^{2,@} Renata Ferrari,^{3,@}
Javier Leon,^{4,@} John Armston,^{5,@}
Gregory P. Asner,^{6,@}
and Mathias Disney^{7,8,@}

Forests and coral reefs are structurally complex ecosystems threatened by climate change. *In situ* 3D imaging measurements provide unprecedented, quantitative, and detailed structural information that allows testing of hypotheses relating form to function. This affords new insights into both individual organisms and their relationship to their surroundings and neighbours.

In Situ Ecos

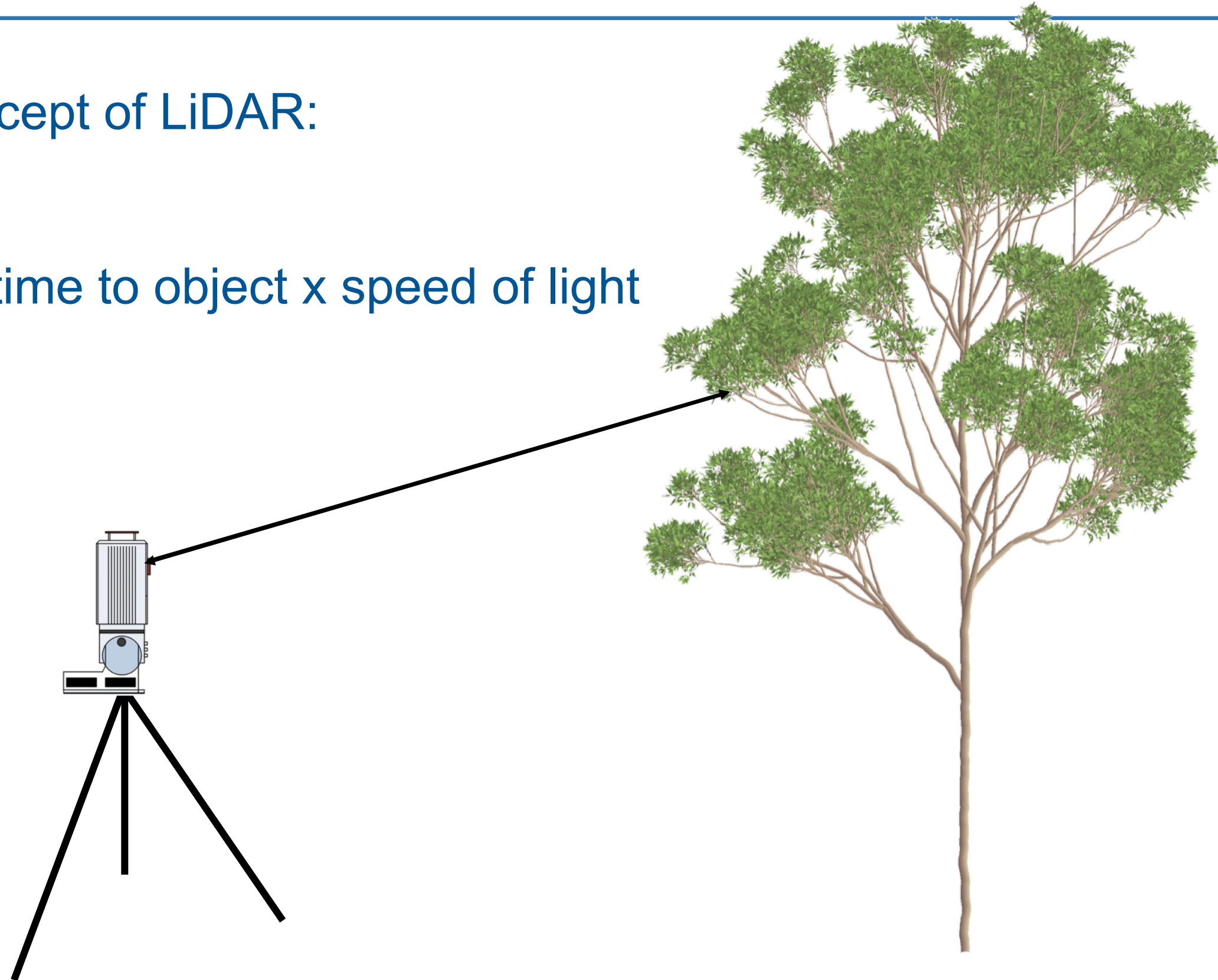
Motion
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PRINCIPLES OF LIDAR

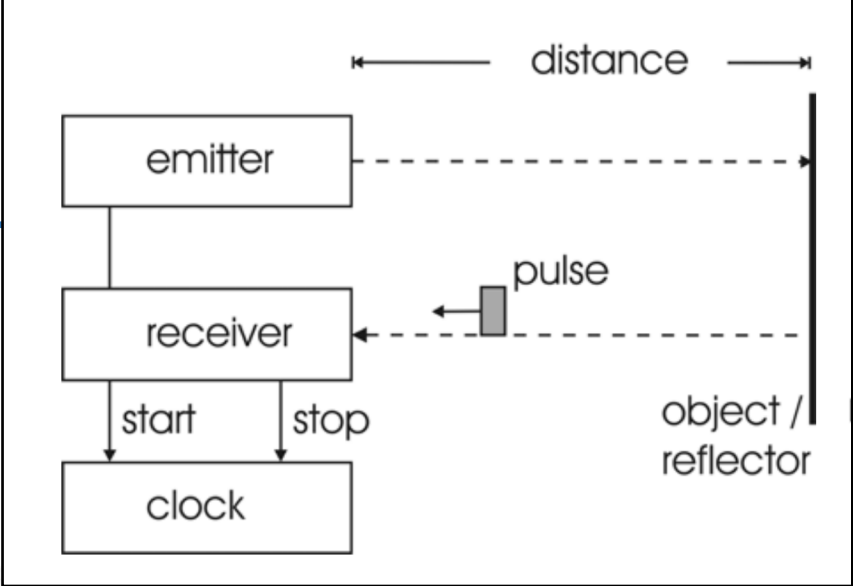
1. Time Of Flight concept of LiDAR:

- > Laser pulse
- > Distance = time to object x speed of light

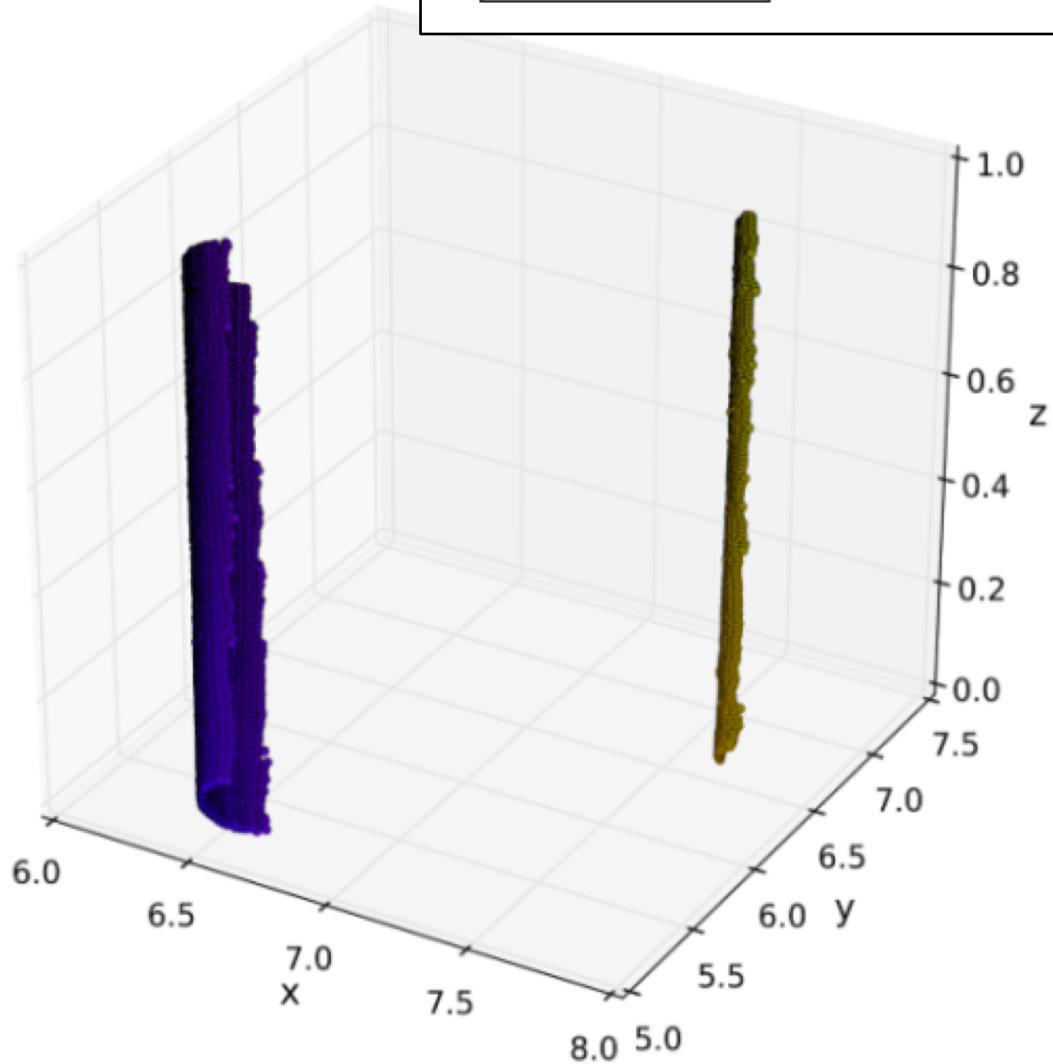
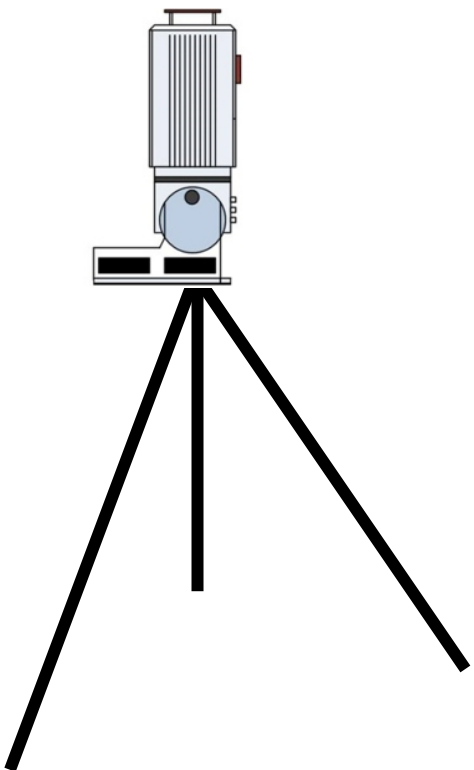
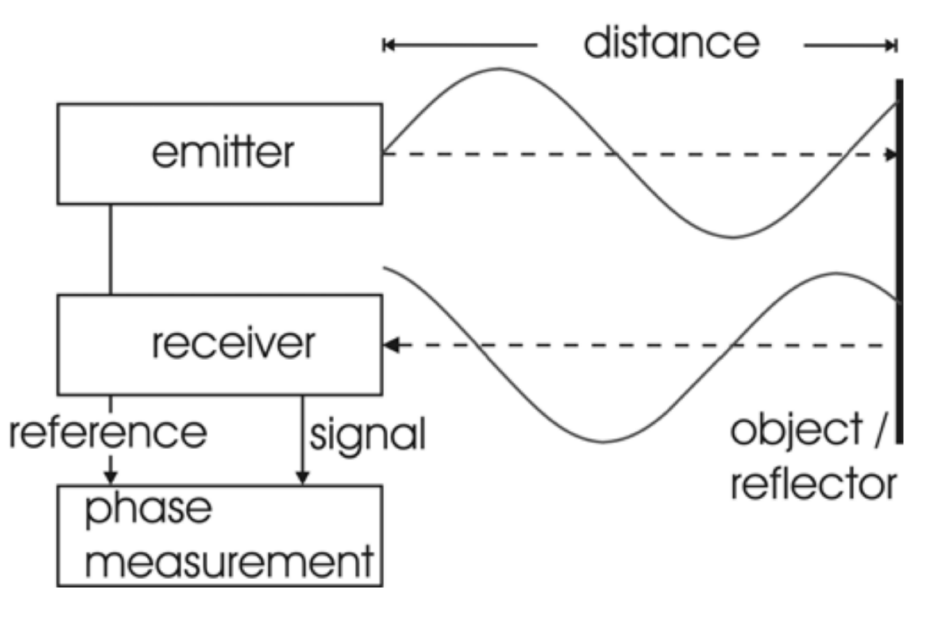


PRINCIPLES OF LIDAR

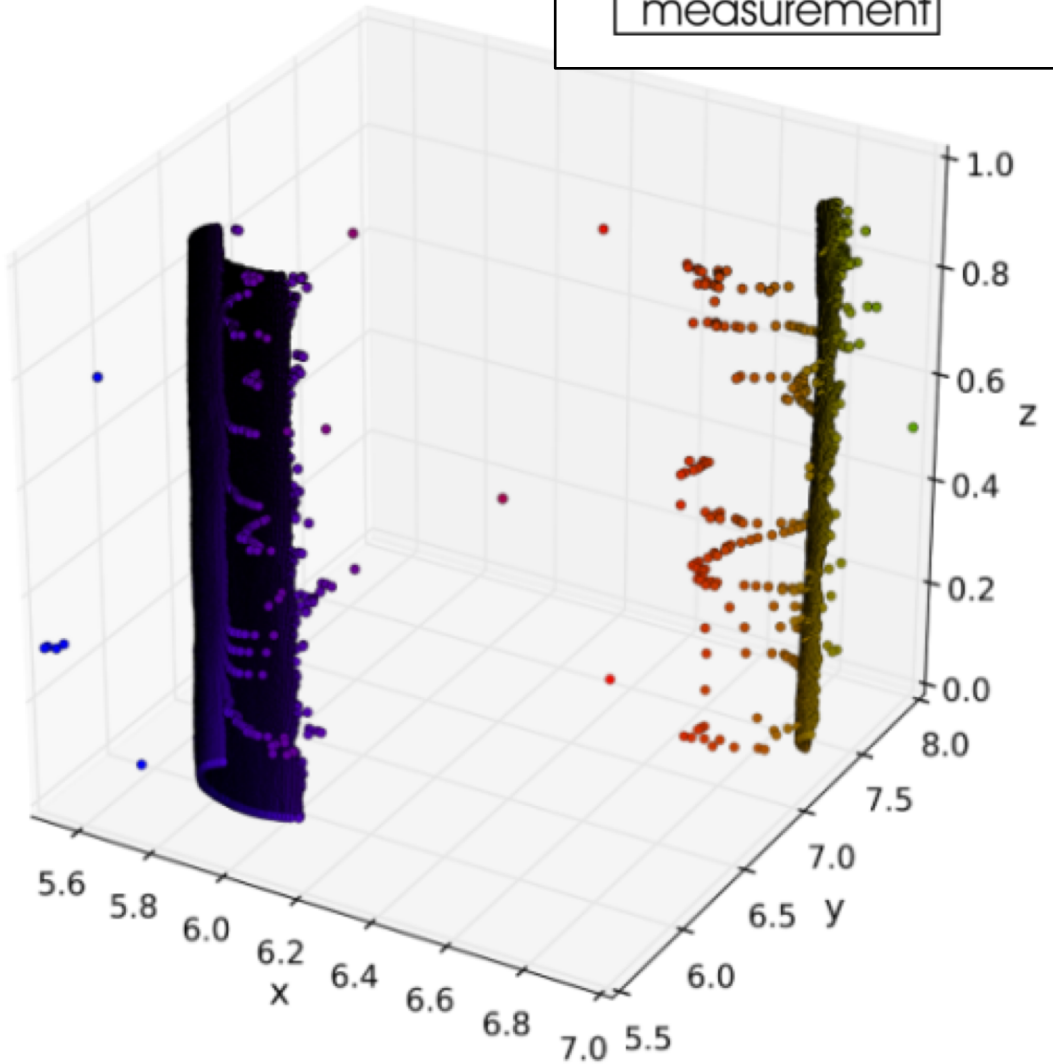
TOF vs. phase:



[source: Kahlmann et al. 2006]



TOF: Leica C10



Phase: Faro Focus3D 120

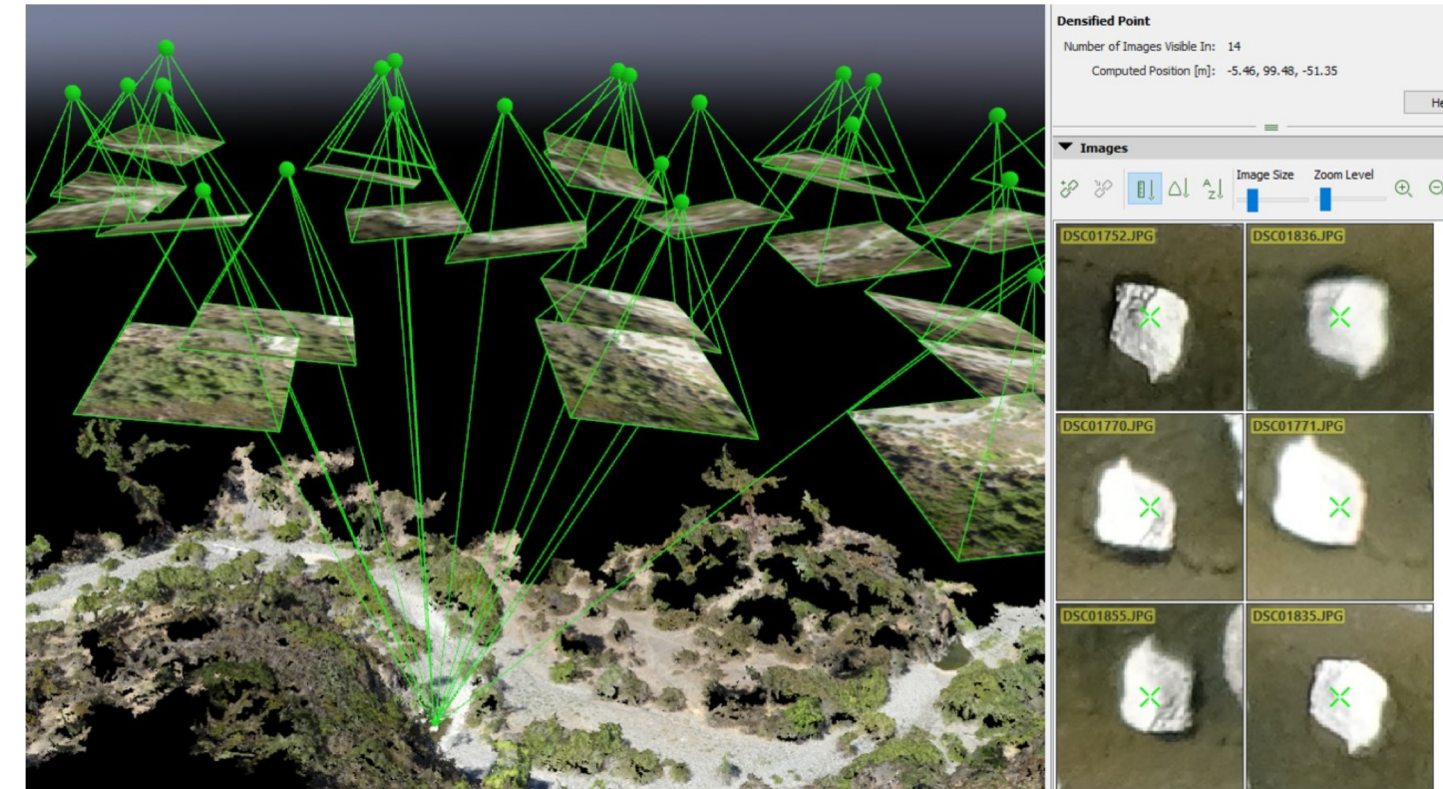
PRINCIPLES OF LIDAR

3. LiDAR alternative: Structure-from-Motion (SfM)

- > 3D measurements derived from overlapping 2D images
- > Not new, around for a while
- > Popular on drone platforms (advancements in software/processing)



[source: serc.carleton.edu/woburn/resources/aerialphotos.html]

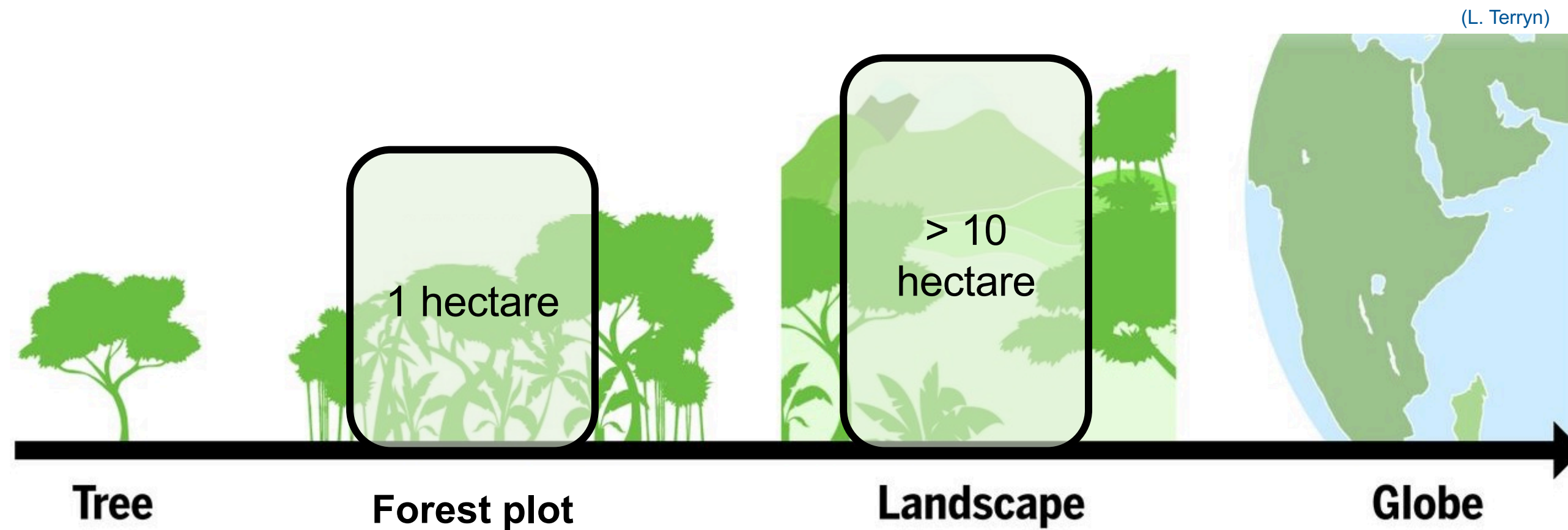
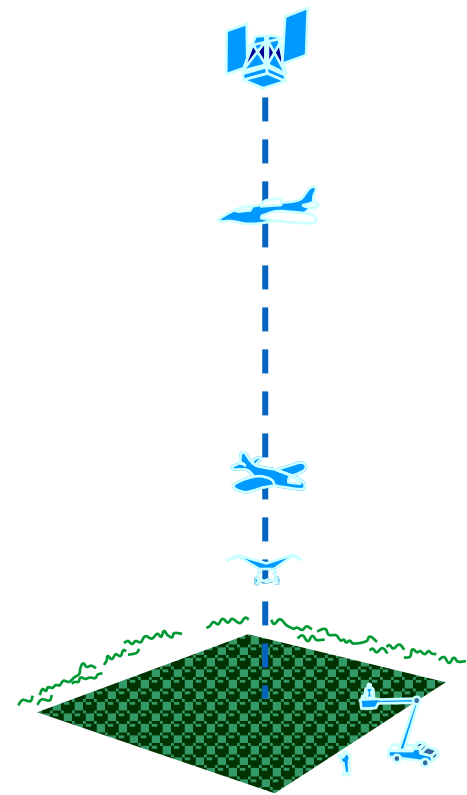


Screenshot from Pix4D software showing the identification of the same feature in multiple images. The software tracks and uses these features to estimate the photo position and build the 3-d point cloud. The images of the upper Eel River, CA were obtained via UAS. Image Credit: James Graham.

PLATFORMS

Platforms

- > Trade-off between area and detail
- > Pick right tool for the job!



PLATFORMS

TLS

Hard work, long days of scanning, carrying all your equipment through a tropical forest or swamp for hours. Back in the lodge you're tired and hungry... Then you have to backup your data and when finally back in the office you still have to align all those scans for days and days and days...



UAV-LS

Get your drone out of the car, fly using autopilot and relax...
Wear sunglasses!
Download data, put it through the automatic processing chain.
Eat ice cream - done!



TERRESTRIAL LIDAR

Early days of TLS work in Australia:



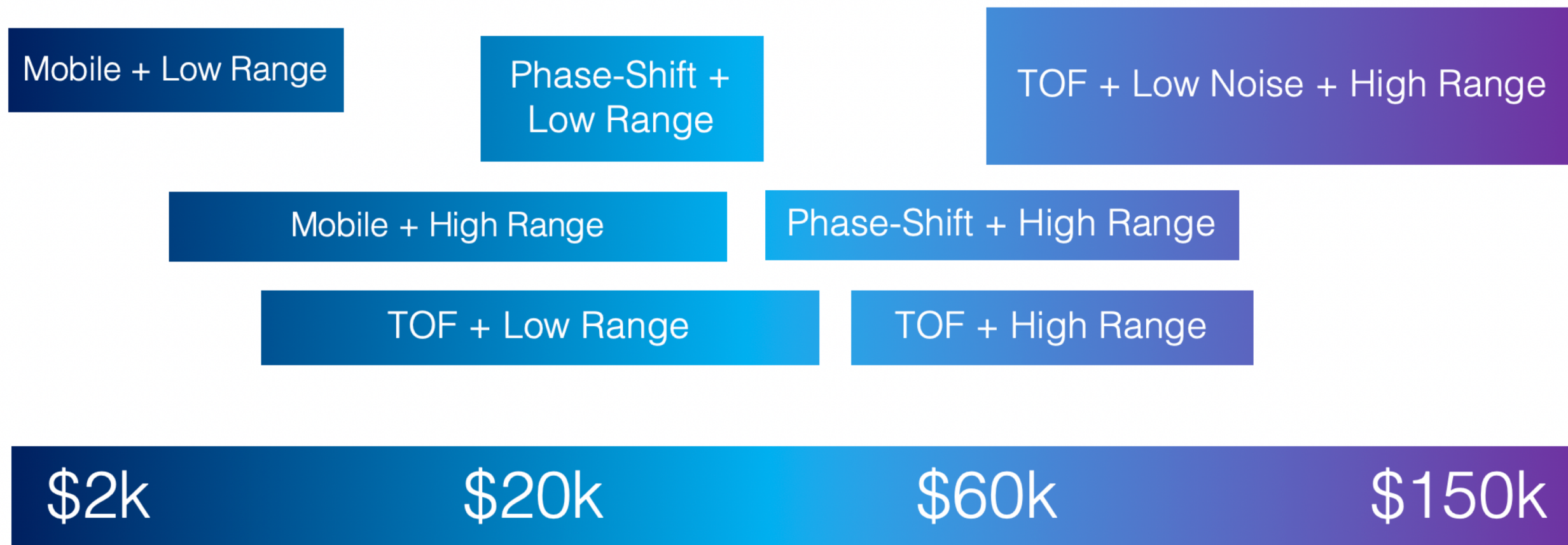
TERRESTRIAL LIDAR

A range of commercial instruments:



TERRESTRIAL LIDAR

Price varies widely depending on specifications





3D Forest Information

TERRESTRIAL LIDAR

Steps in detailed assessment of forest structure:



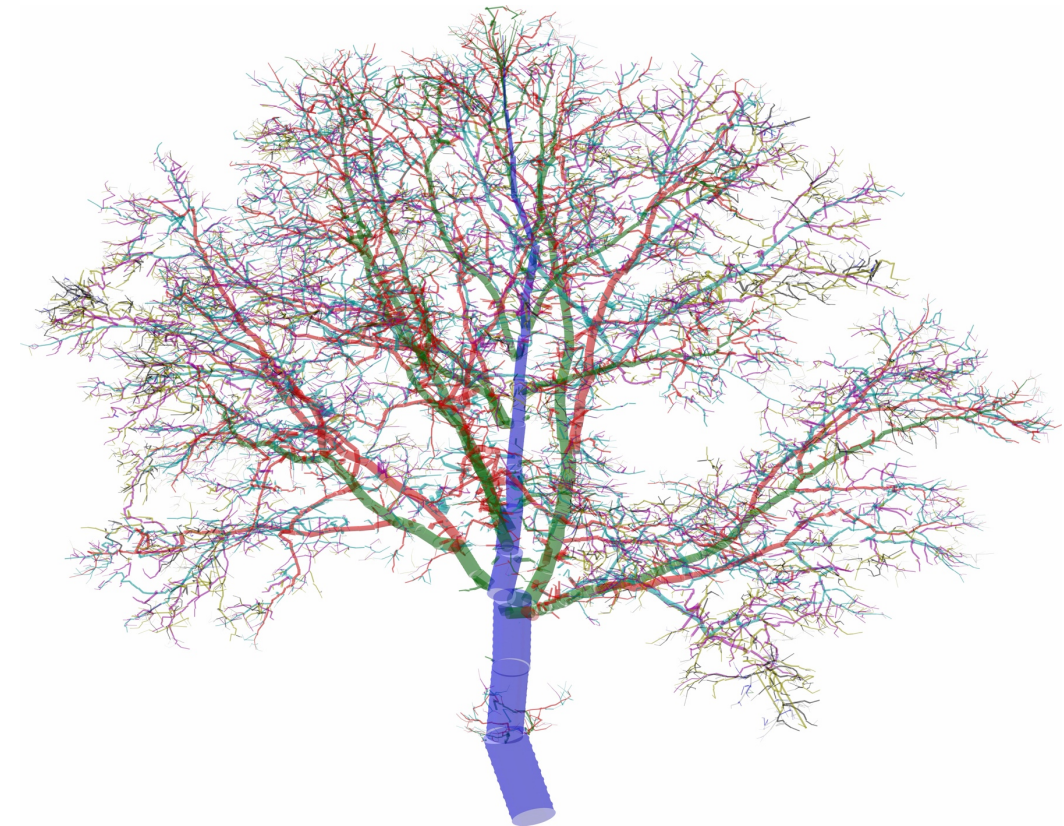
1. Data collection



2. Data registration

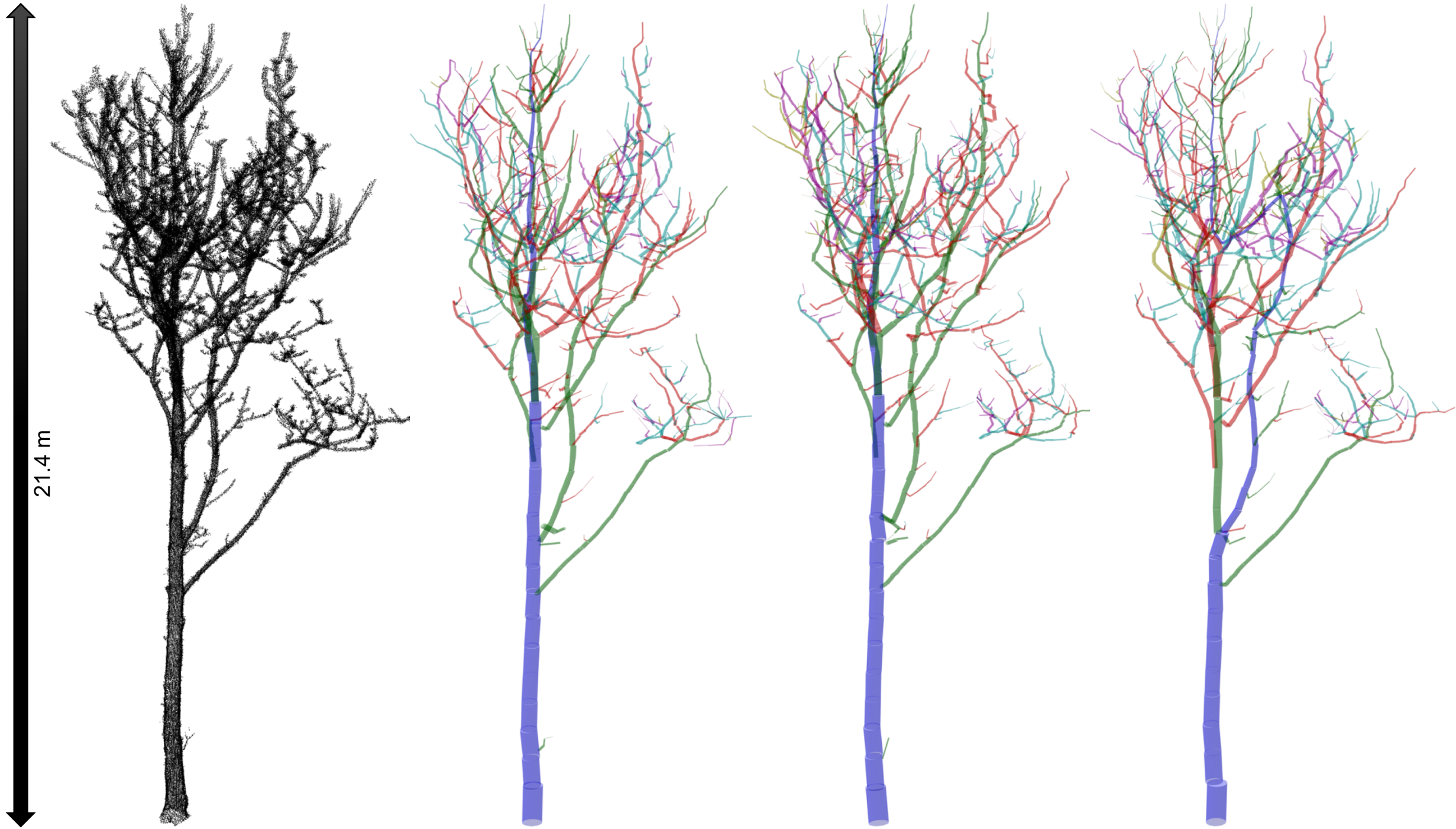


3. Segmentation



4. Analysis

QSM example:



Point Cloud (leaf off) QSM iteration 1 QSM iteration 2 QSM iteration 3

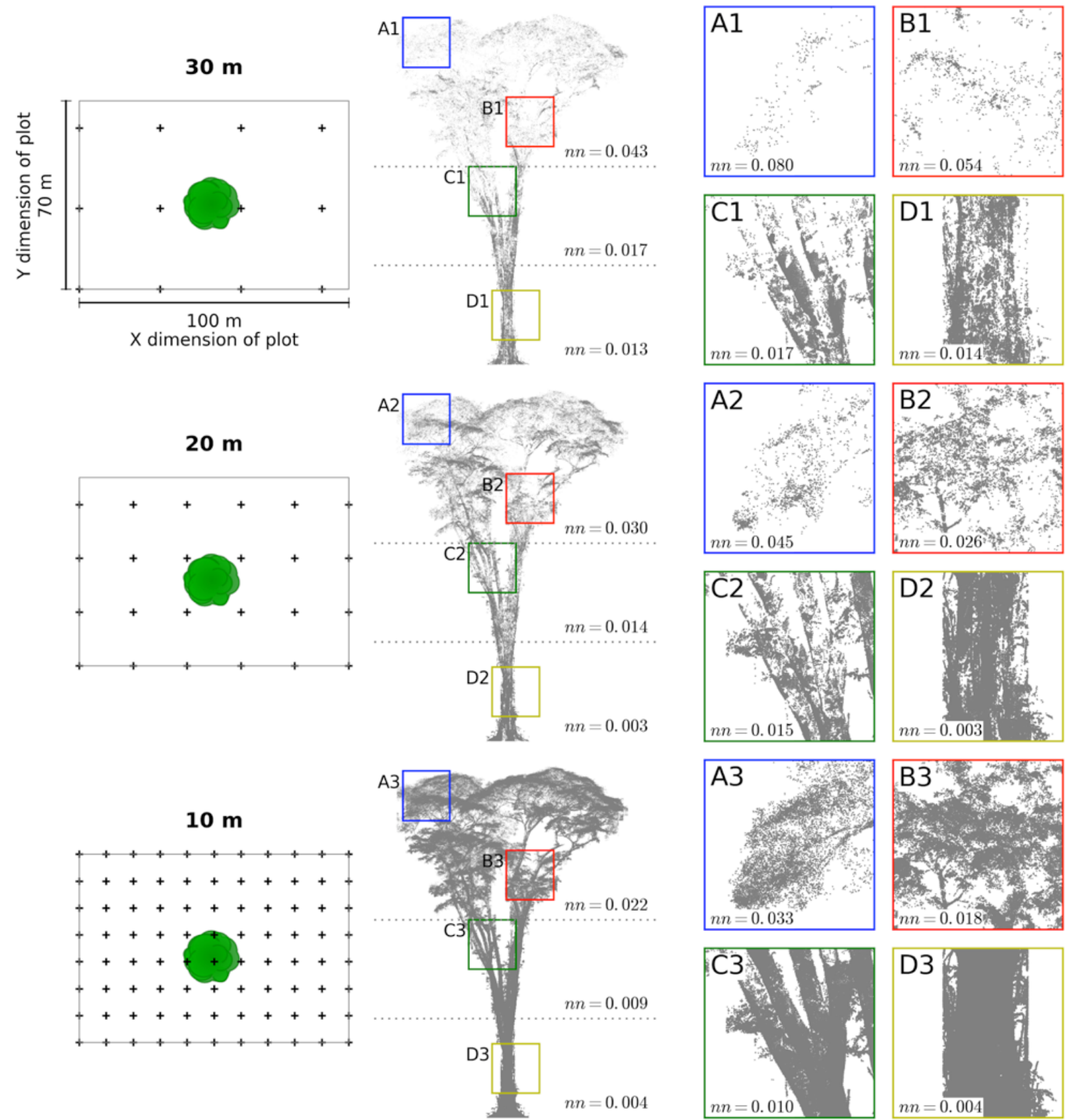
Data collection protocol:

Sampling strategies for geometric modelling of AGB reference sets should aim for **minimal occlusion** and **uniform point density** in order to provide consistent point cloud quality throughout the plot. This may require sampling over a larger area than the plot size, particularly for smaller plots. When designing a sampling strategy for capturing data at plot level, it is important to consider that the resulting point cloud needs to:

1. Capture a large proportion of the target canopy to:
 - a. be spatially representative and account for occlusion; and
 - b. sample a wide range of view angles
2. Have a uniform point density across the scanning domain.
3. Be easily co-registered/aligned with the required degree of accuracy.

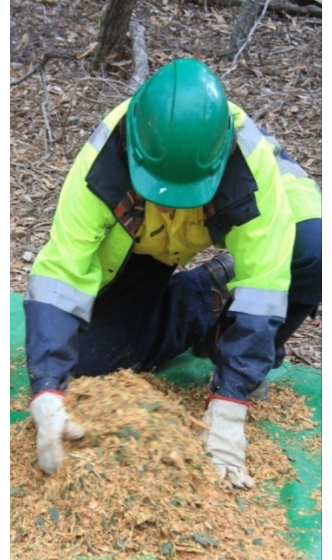
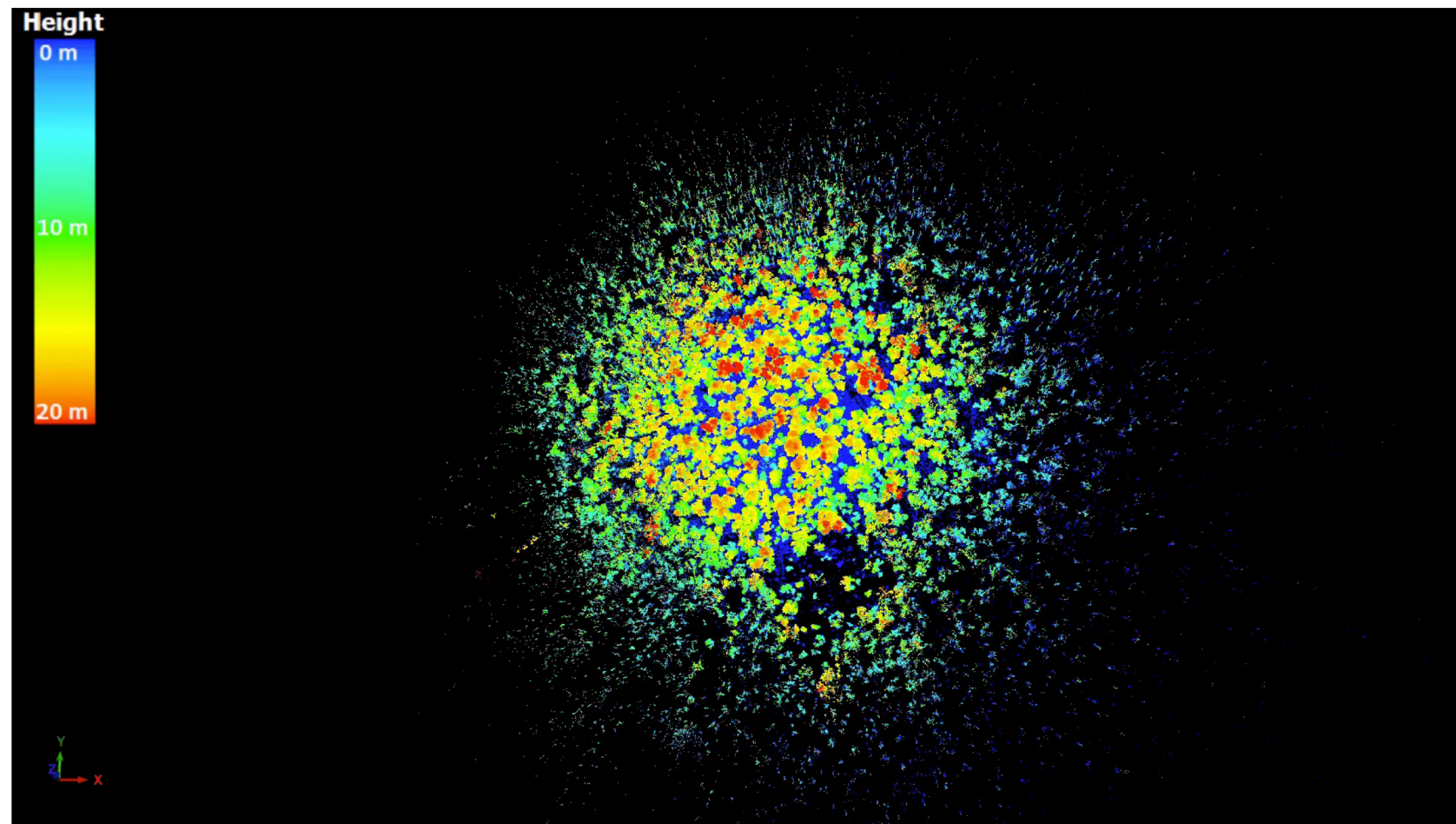
TERRESTRIAL LIDAR

Data collection protocol:



TERRESTRIAL LIDAR

How good are these QSMs?



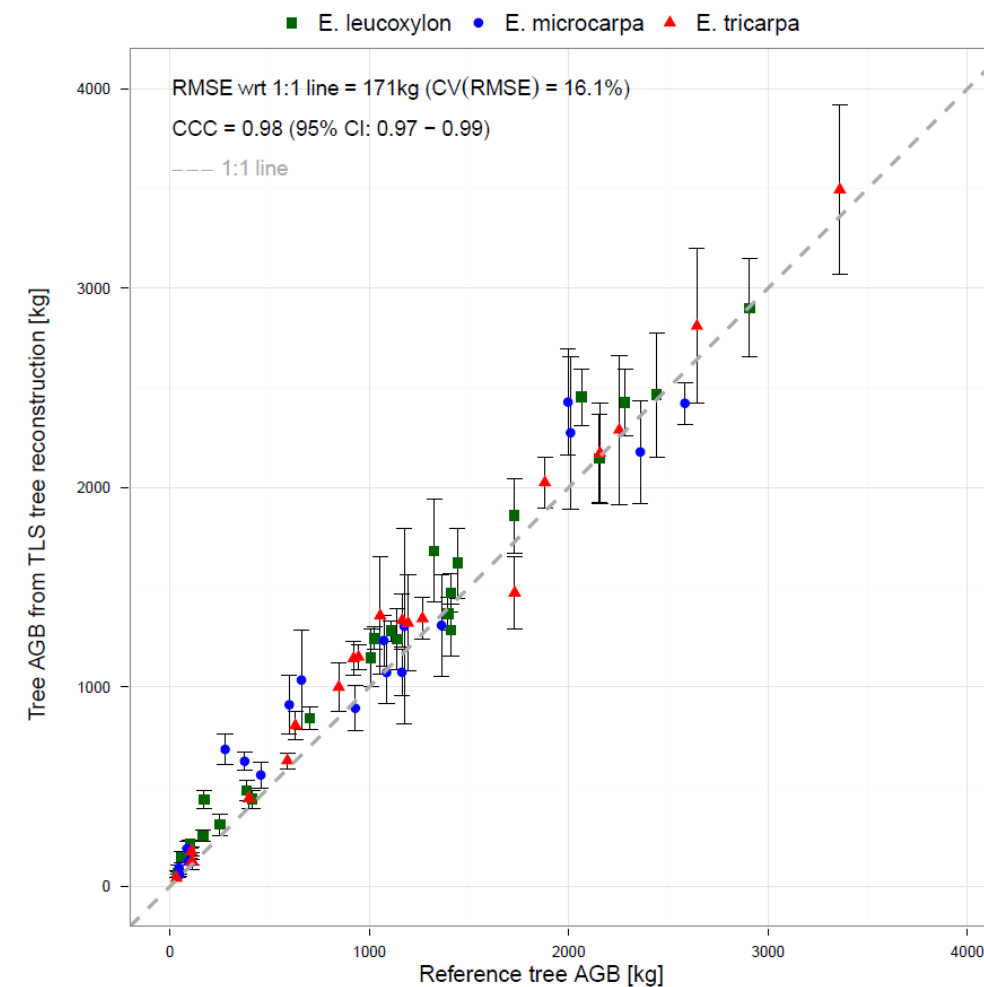
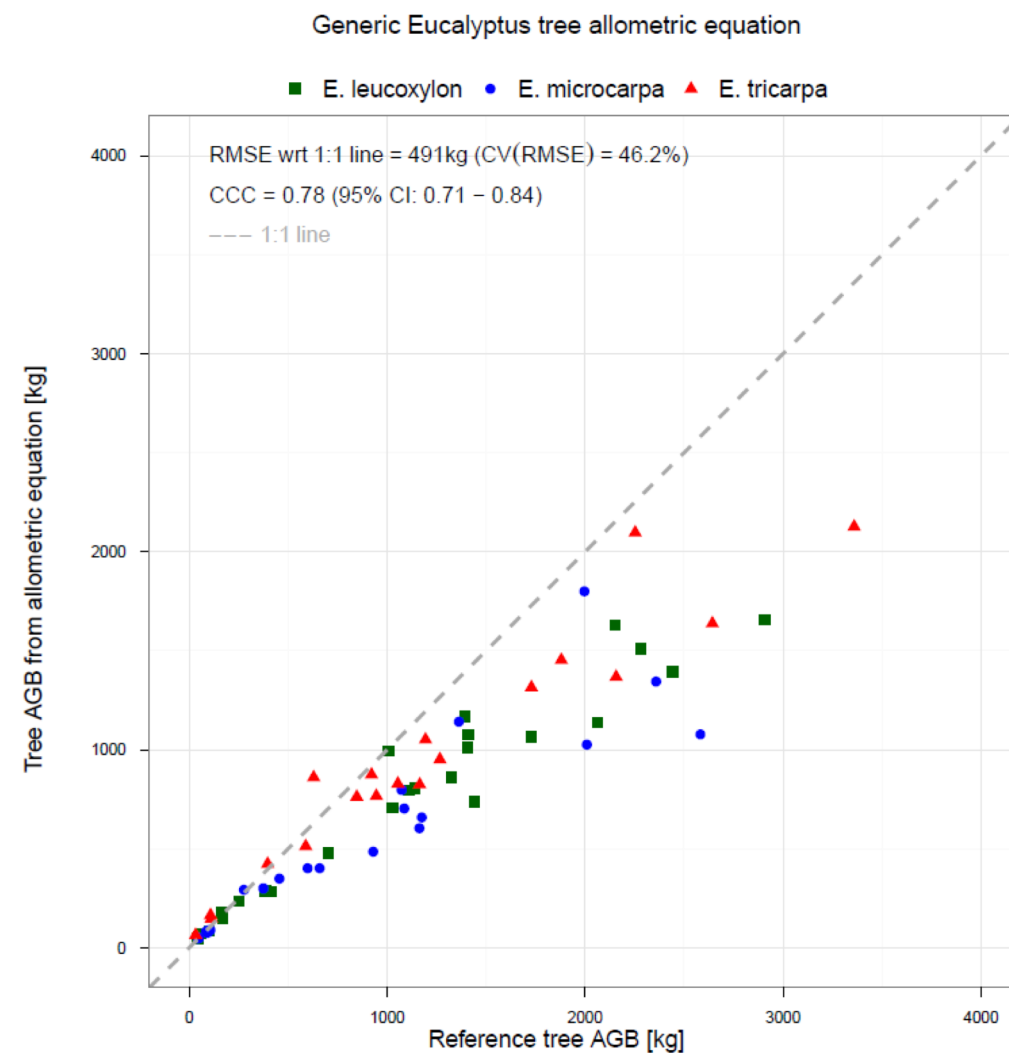
Photos: S. Murphy

TERRESTRIAL LIDAR

AGB from TLS & allometry :

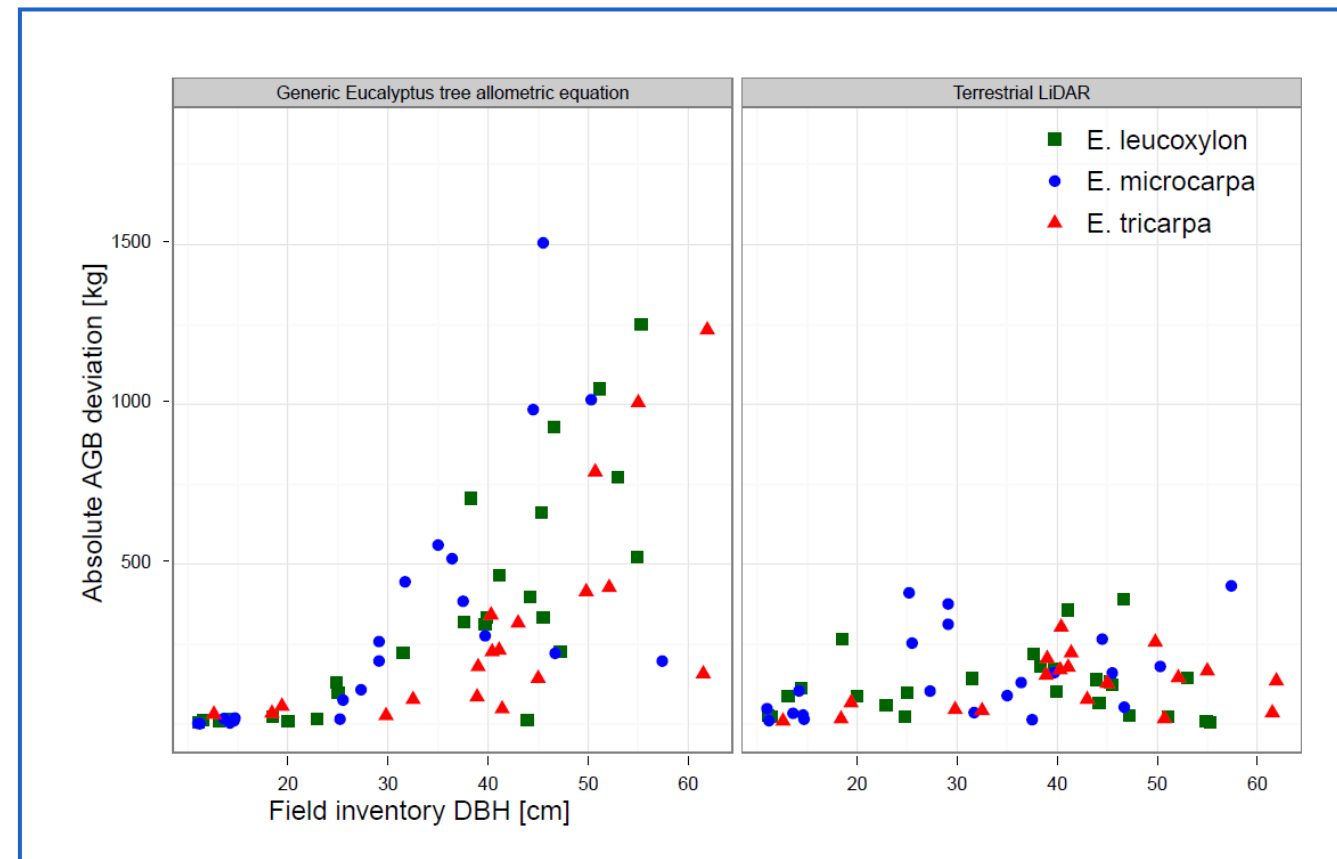
➔ At plot level:

- allometry: underestimation of 29.9 to 36.6%
- TLS: overestimation of 9.7 %



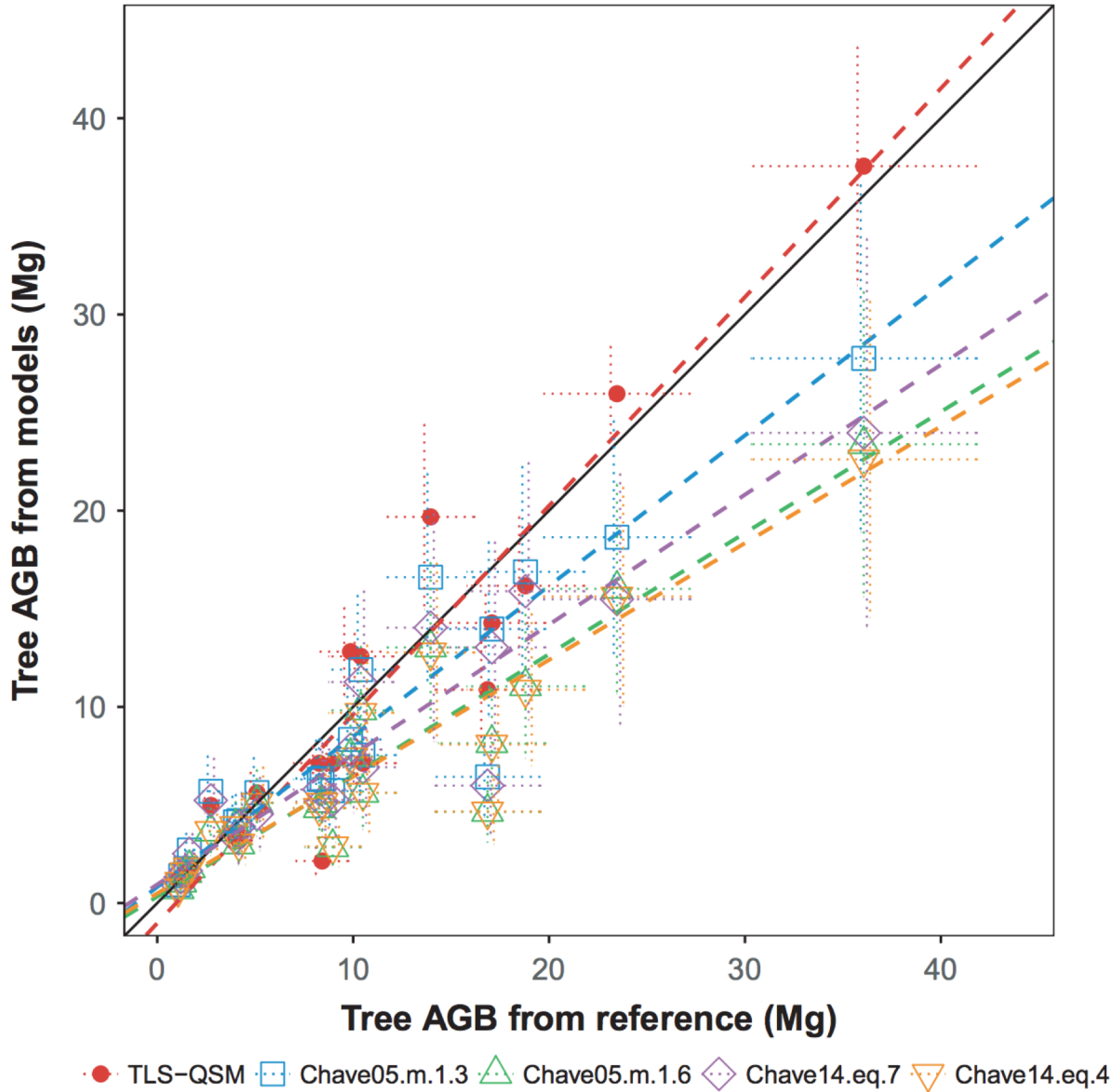
Nondestructive estimates of above-ground biomass using terrestrial laser scanning

Kim Calders^{1*}, Glenn Newnham², Andrew Burt³, Simon Murphy⁴, Pasi Raumonen⁵, Martin Herold¹, Darius Culvenor⁶, Valerio Avitabile¹, Mathias Disney^{3,7}, John Armston^{8,9} and Mikko Kaasalainen⁵



TERRESTRIAL LIDAR

How about tropical trees?



Received: 19 November 2016 | Accepted: 11 July 2017
DOI: 10.1111/2041-210X.12904

RESEARCH ARTICLE

Methods in Ecology and Evolution

Estimation of above-ground biomass of large tropical trees with terrestrial LiDAR

Jose Gonzalez de Tanago^{1,2} | Alvaro Lau^{1,2} | Harm Bartholomeus¹ | Martin Herold¹ | Valerio Avitabile¹ | Pasi Raunonen³ | Christopher Martius² | Rosa C. Goodman⁴ | Mathias Disney^{5,6} | Solichin Manuri⁷ | Andrew Burt⁵ | Kim Calders^{5,8}

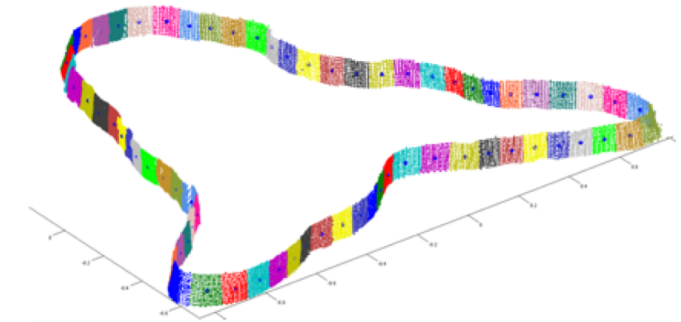
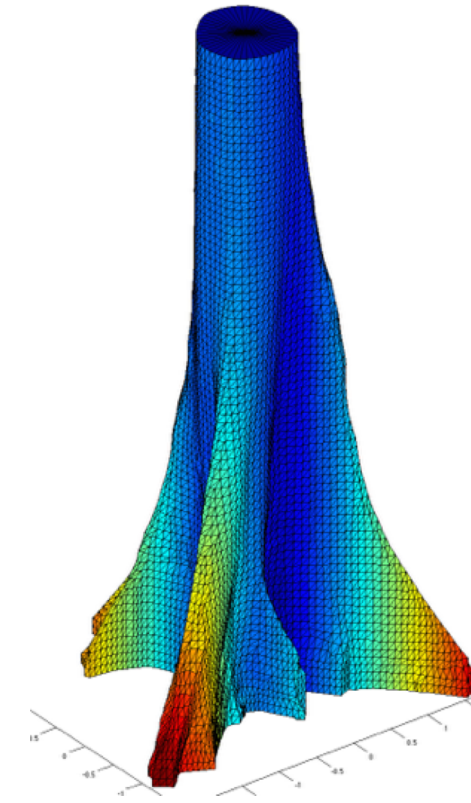
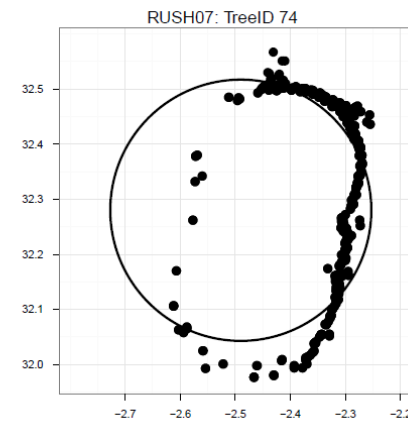
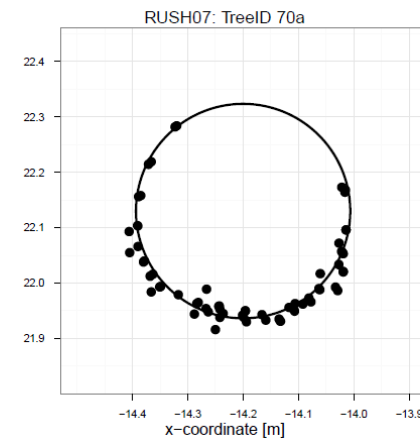
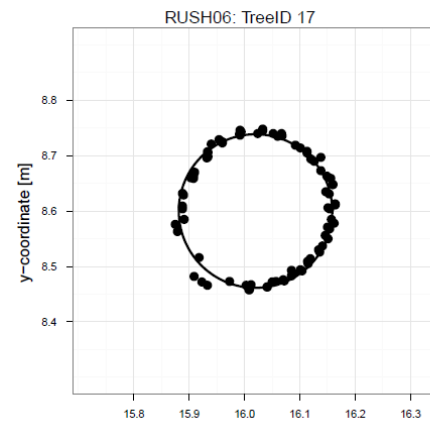
Photos: Alvaro Lau



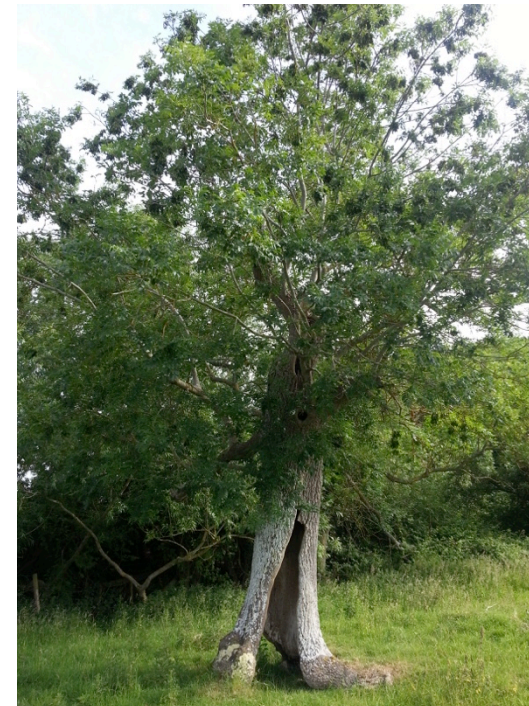
TERRESTRIAL LIDAR

Remarks:

> What is DBH? Is the shape a cylinder?



> Wood density? **Terrestrial LiDAR gives a direct estimate of volume, NOT AGB.**



TERRESTRIAL LIDAR

Remarks:

> Leaves introduce uncertainty

