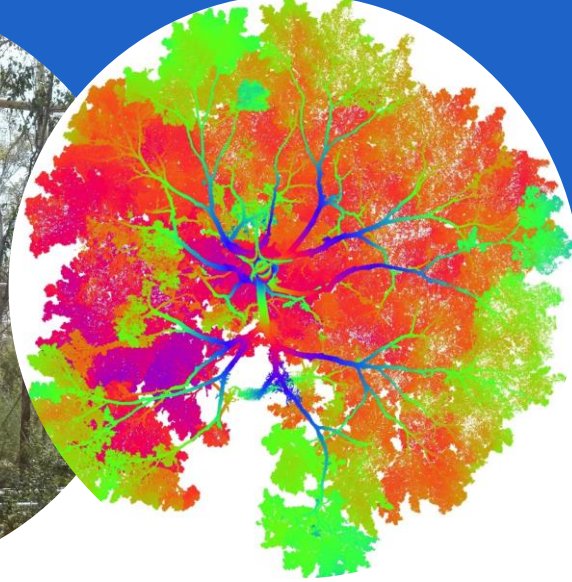
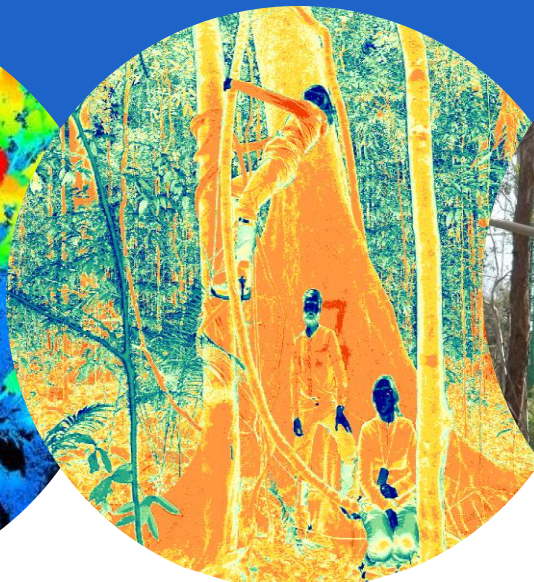
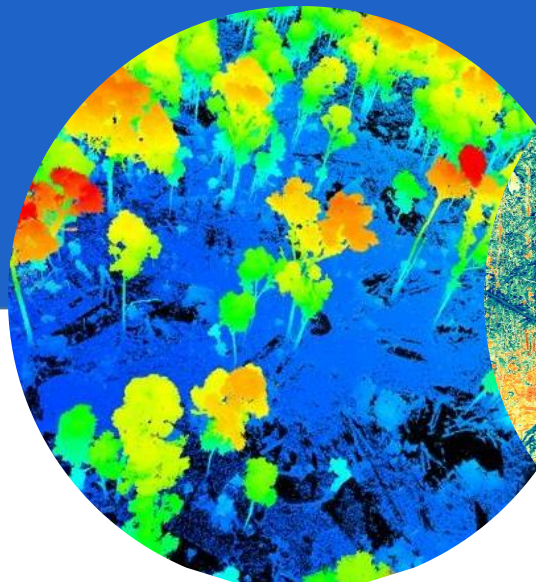


Upscaling forest biomass to larger areas by combining terrestrial and UAV liDAR data

Sruthi M. Krishna Moorthy, Kim Calders, Hans Verbeeck, Harm Bartholomeus & Martin Herold



How to measure AGB:



CONTEXT

In practice: use allometry:

- > size to mass relationships (big things weigh more. Usually!)
- > Find relationships between volume (diameter D , height H) & mass
- > Many measurements of DBH but H & ρ quite hard



Photo by A. Cuni-Sanchez

BUT: allometry relies on VERY limited measurements of trees we have actually cut down and weighed, mostly biased towards to smaller trees

Can we do better? YES – Lasers!

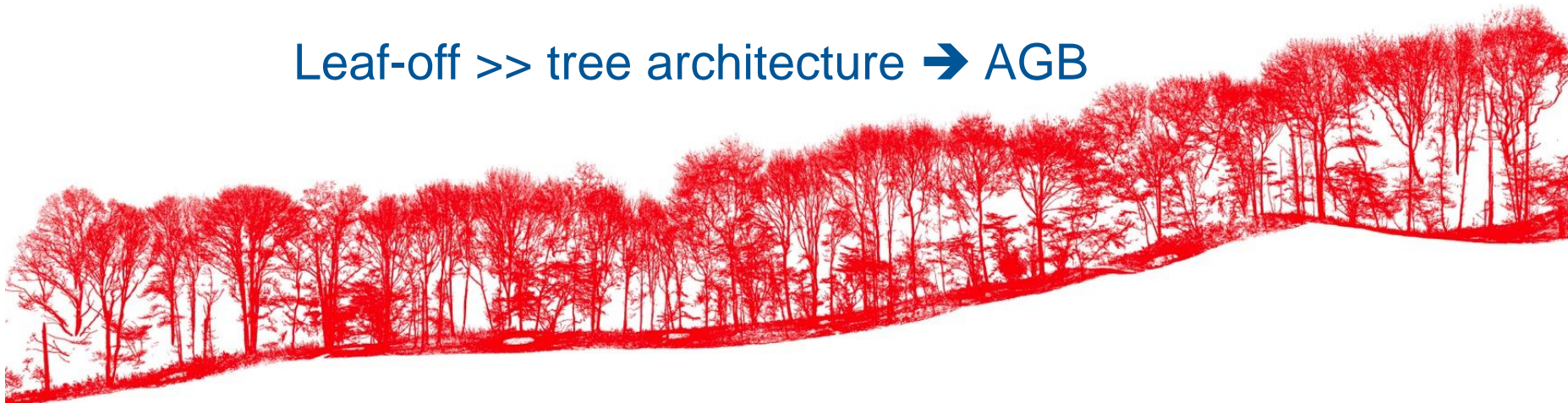


TLS data from a 1 ha area in Wytham woods

Leaf-on

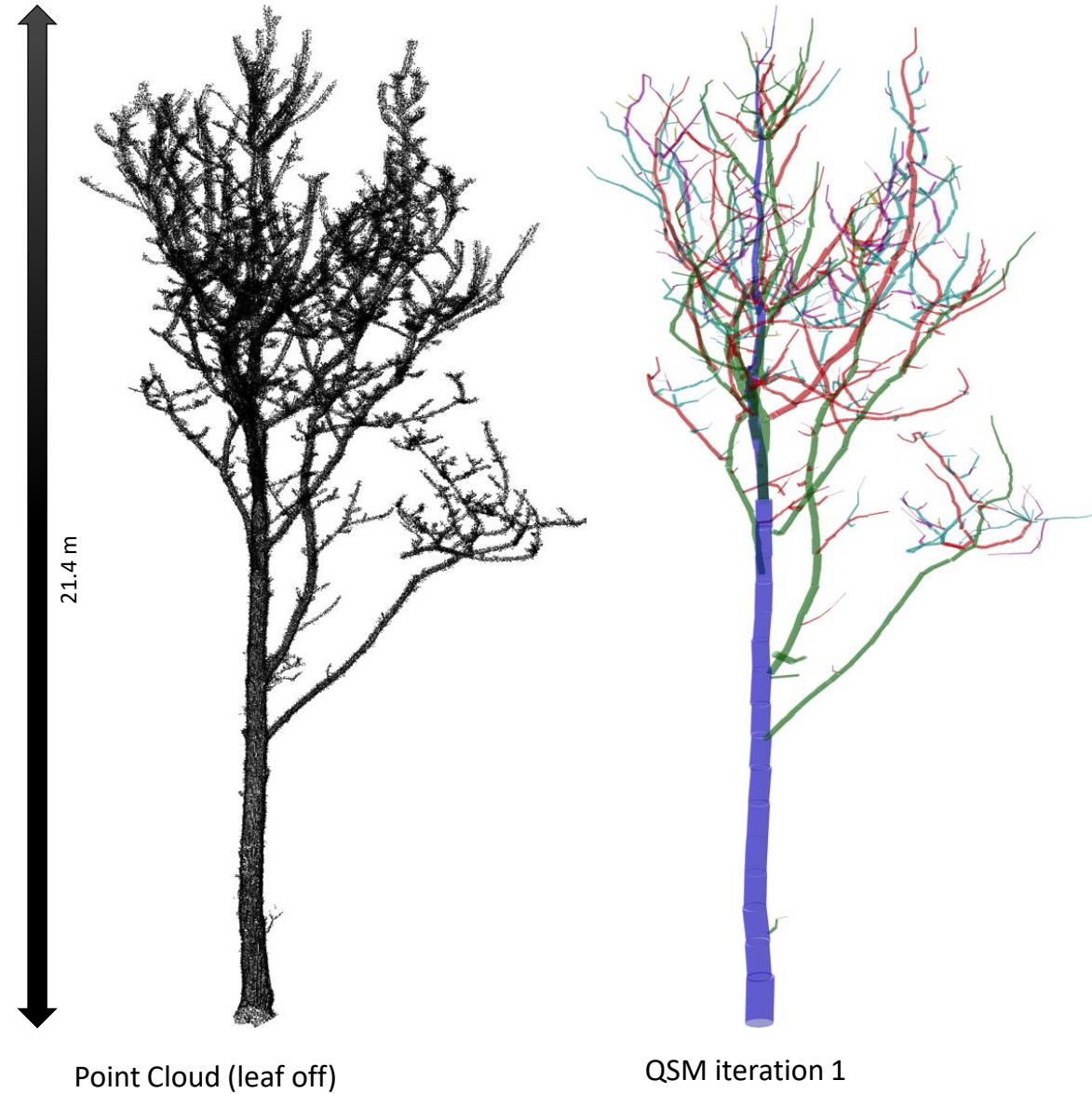


Leaf-off >> tree architecture → AGB



Volume and biomass estimation from TLS data

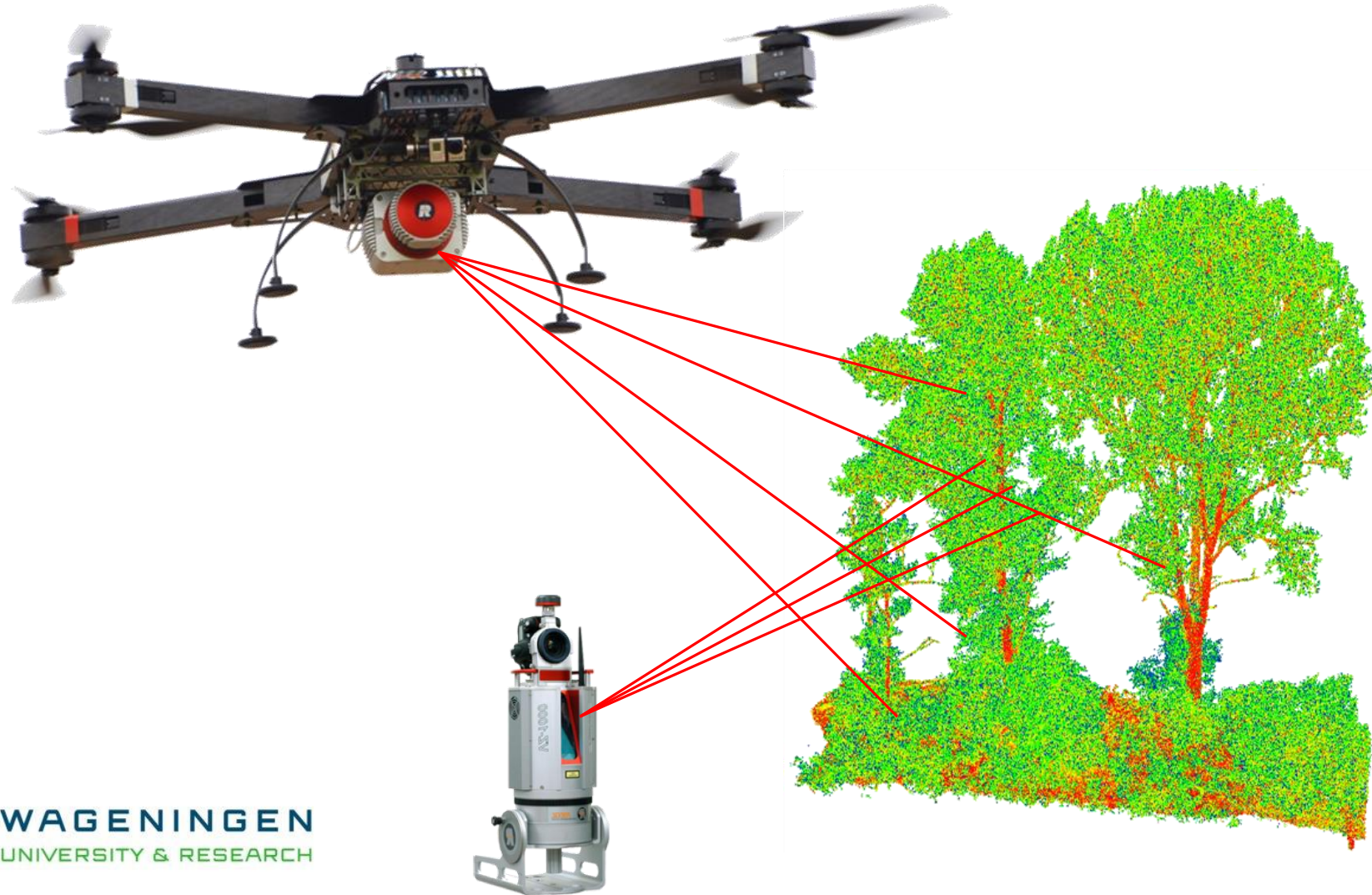
Aboveground biomass = Total tree volume *
wood density



TLS field work... Is really hard work!



Solution: let's use drones!



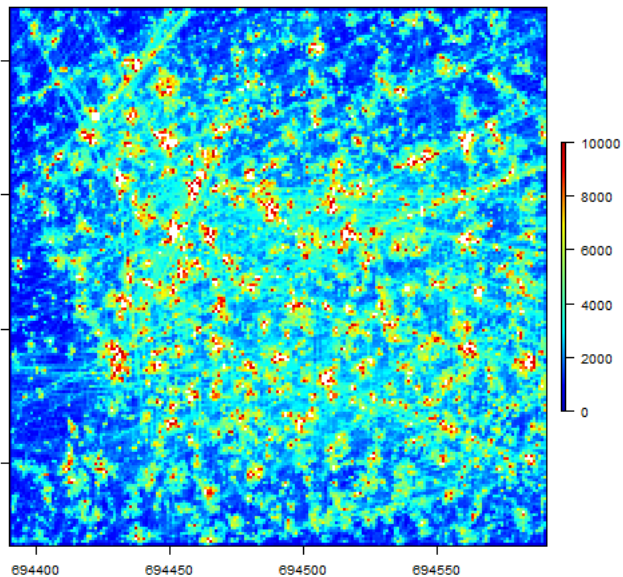
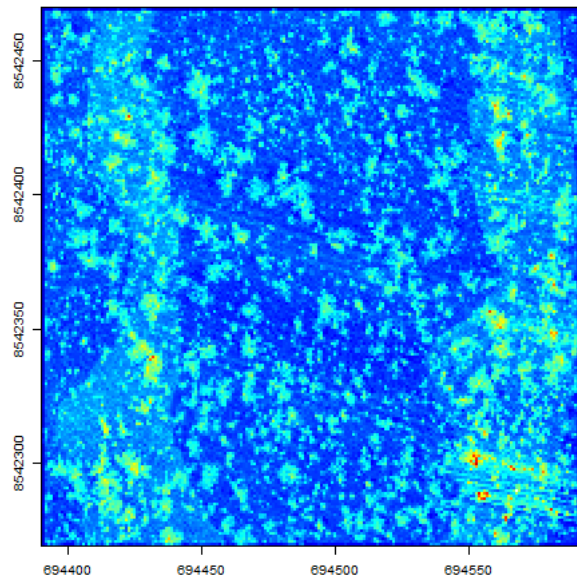
But there are many UAV-LS scanning systems on the market



Comparison at Litchfield Supersite

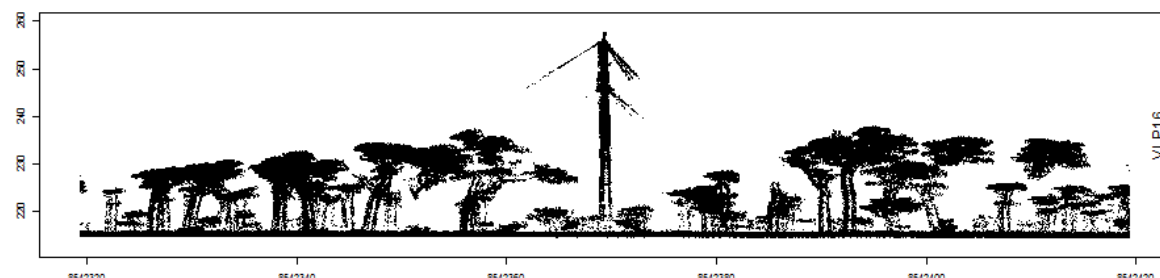
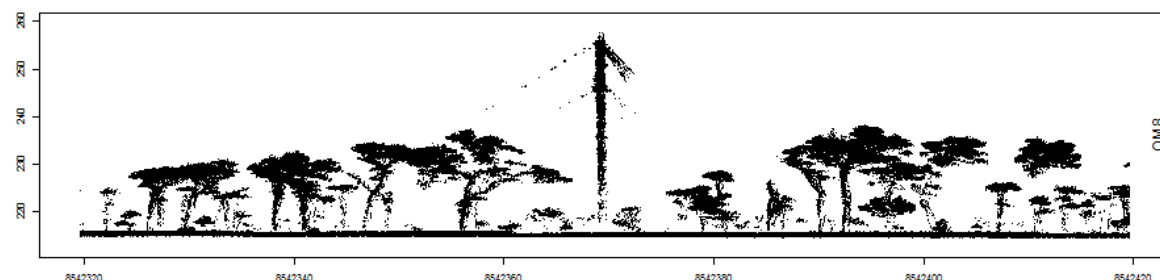
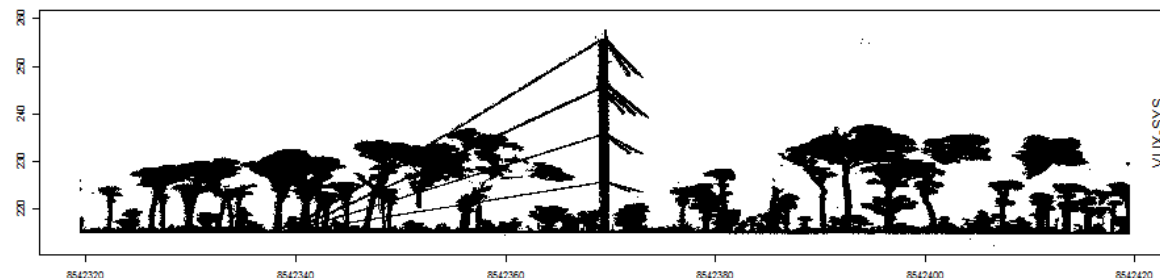
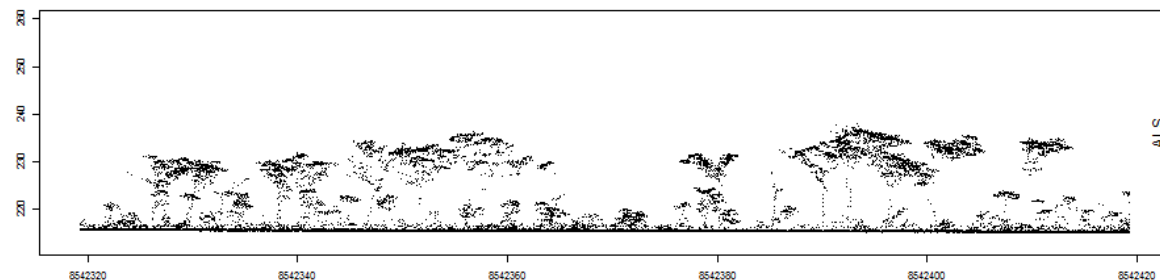
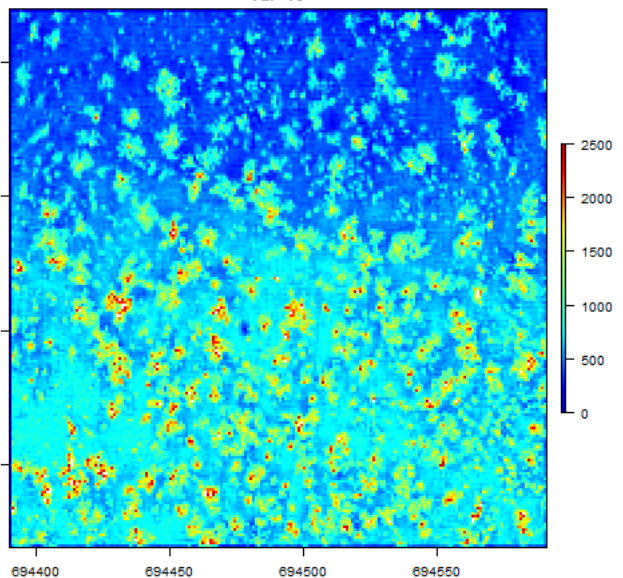
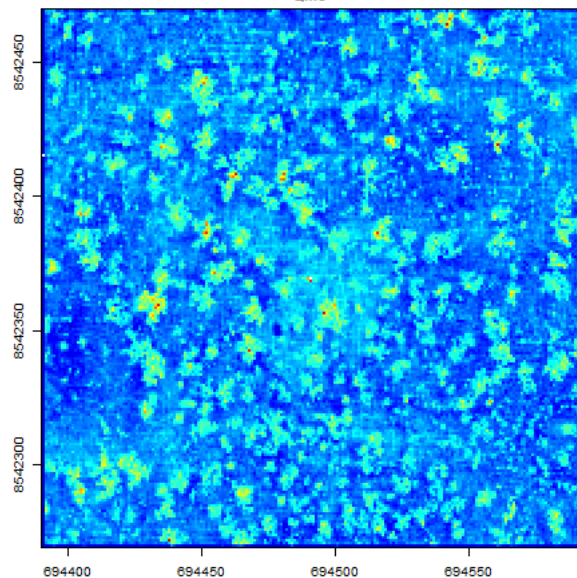
ALS

RIEGL VUX-SYS



QM8

VLP-16

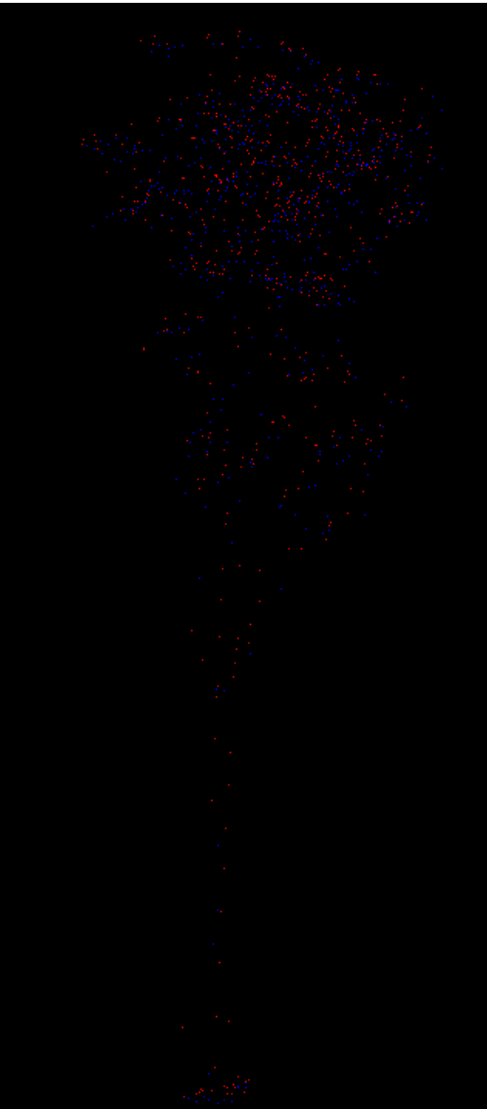


1.083 pts

226.161pts

35.832 pts

97.497 pts



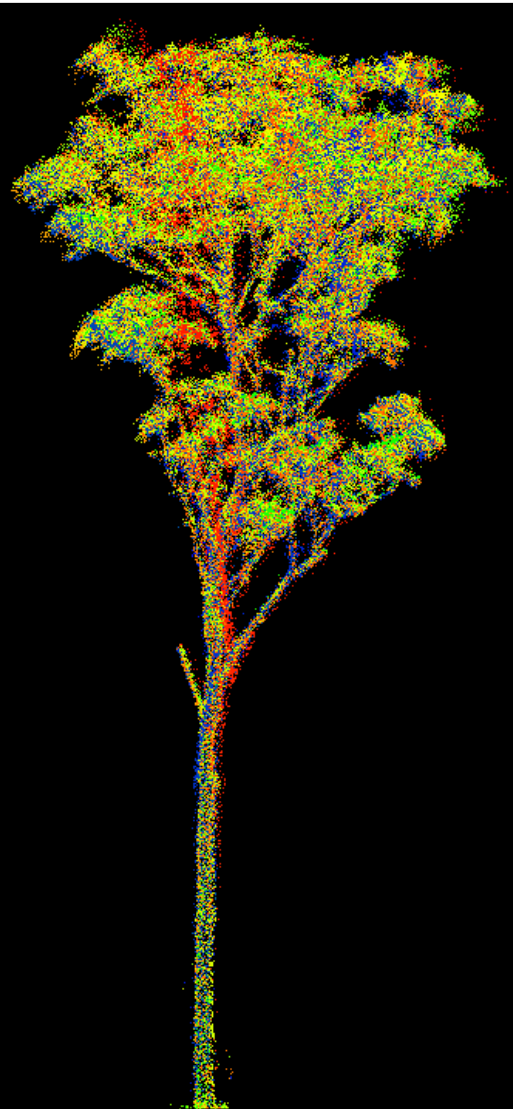
ALS

9



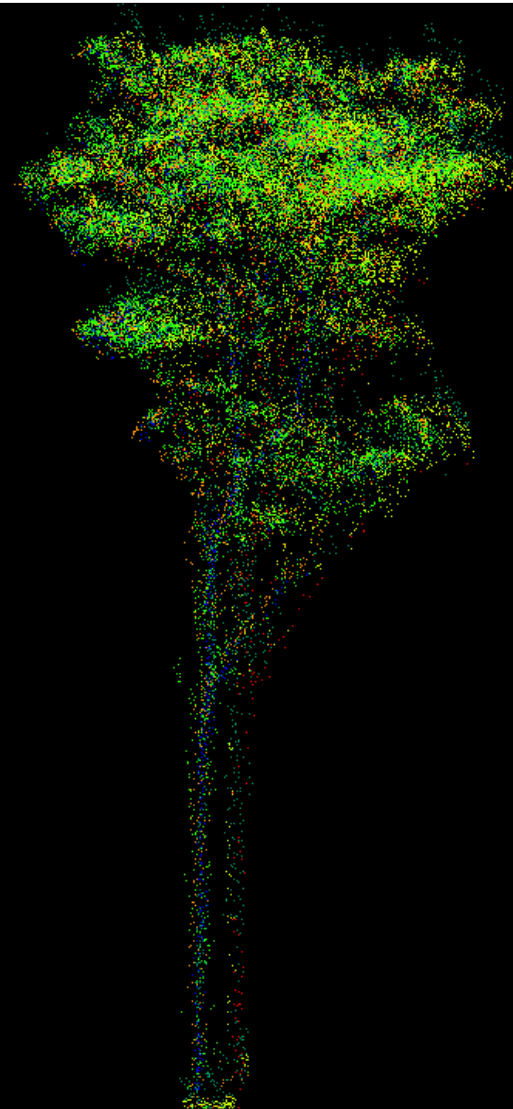
VUX-SYS

9



VLP16

9



QM8

9



Riegl RiCOPTER / VUX-1 LiDAR



RIEGL VUX[®]-SYS Technical Data

Scanner Performance (for details refer to the corresponding RIEGL data sheets)

RIEGL VUX-1 Series Sensor

Maximum Range
Minimum Range
Accuracy / Precision
Laser Pulse Repetition Rate
Max. Effective Measurement Rate
Field of View (selectable) ⁴⁾
Max. Scan Speed

VUX-1UAV	
920 m ²	
3 m	
10 mm / 5 mm	
up to 550 kHz	
up to 500,000 meas./sec.	up
up to 330°	
200 scans/sec	

- **“low density flight”**:
- ~400 points/m² / 30 mins = 25-30 ha
- 4 battery packs - > ~100 ha/day
- **“high density”**:
- ~7000 points/m² / 30ms = 2-3 ha



www.wur.eu/uarsf



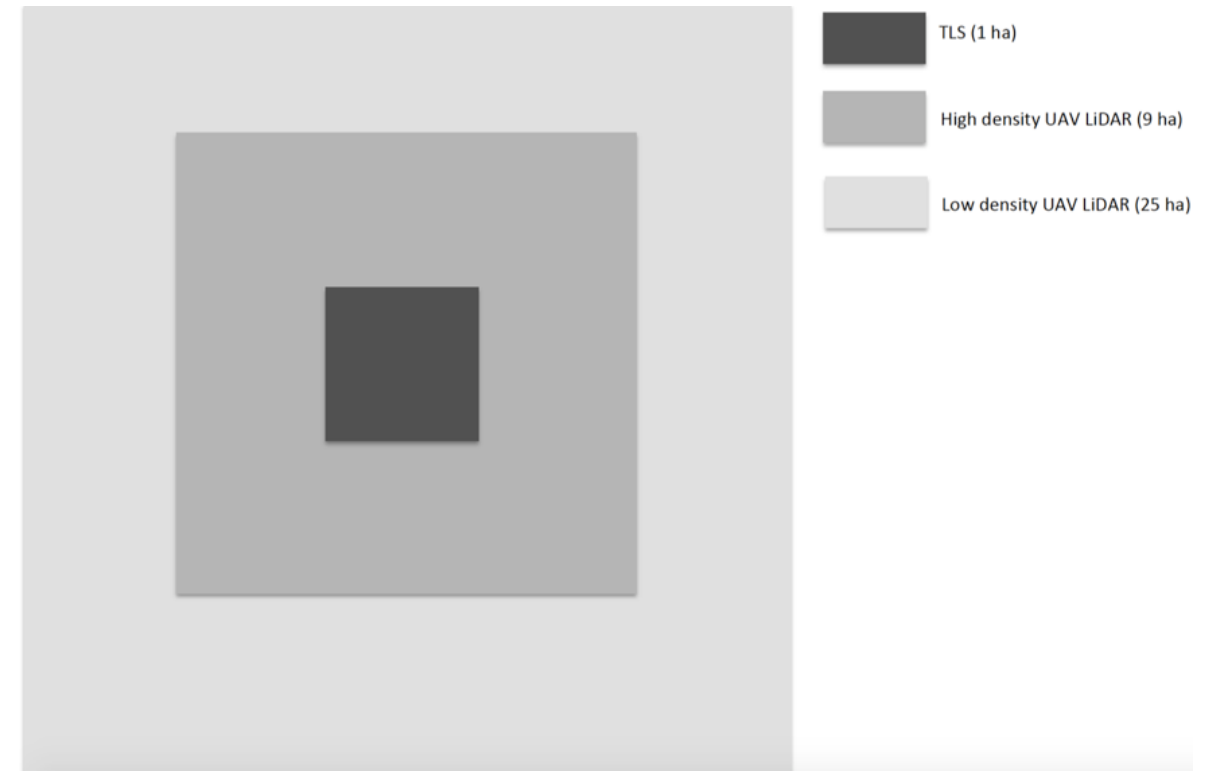
Can we use UAV-LS data to upscale biomass?: A case study from a Savannah site



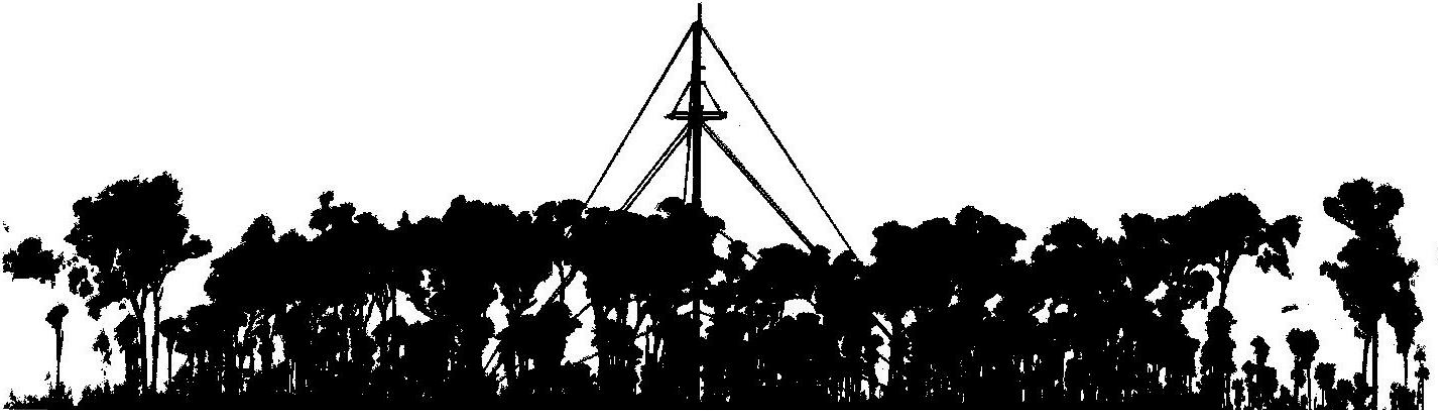
Data collection in Australia:

> TLS data collection

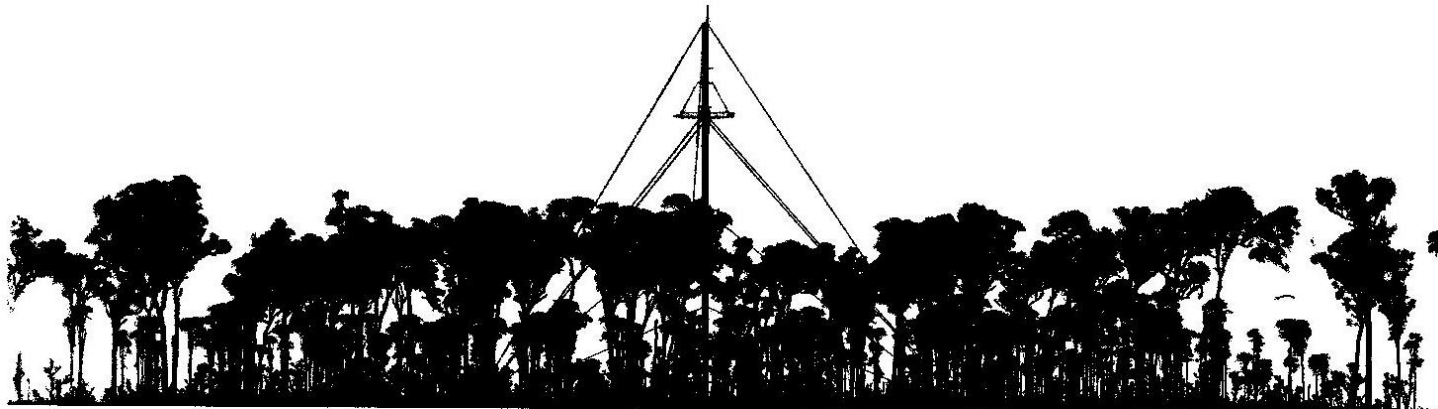
> UAV-LS data collection



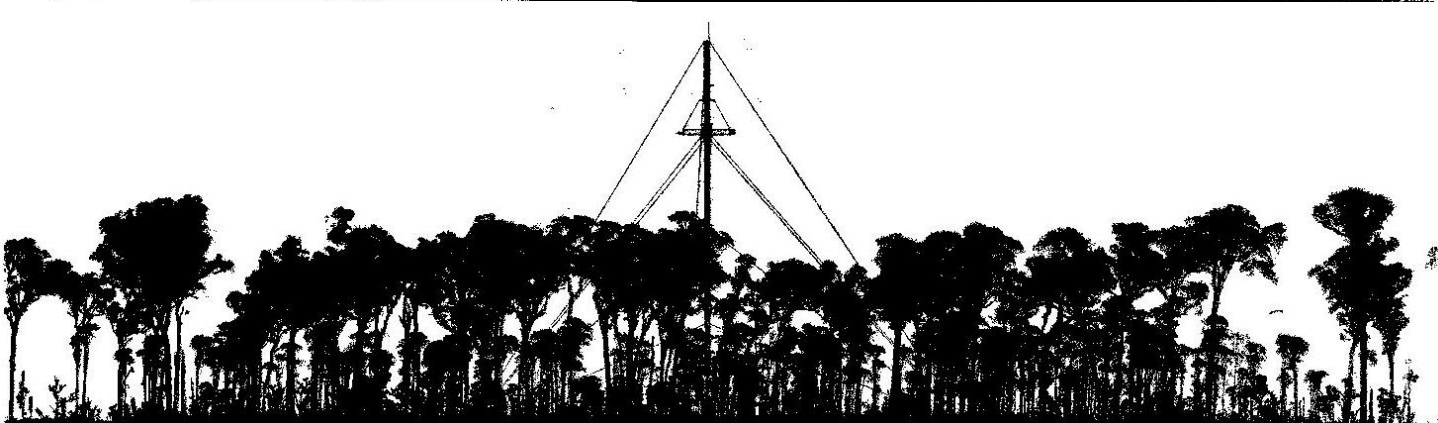
Litchfield savanna supersite



TLS data

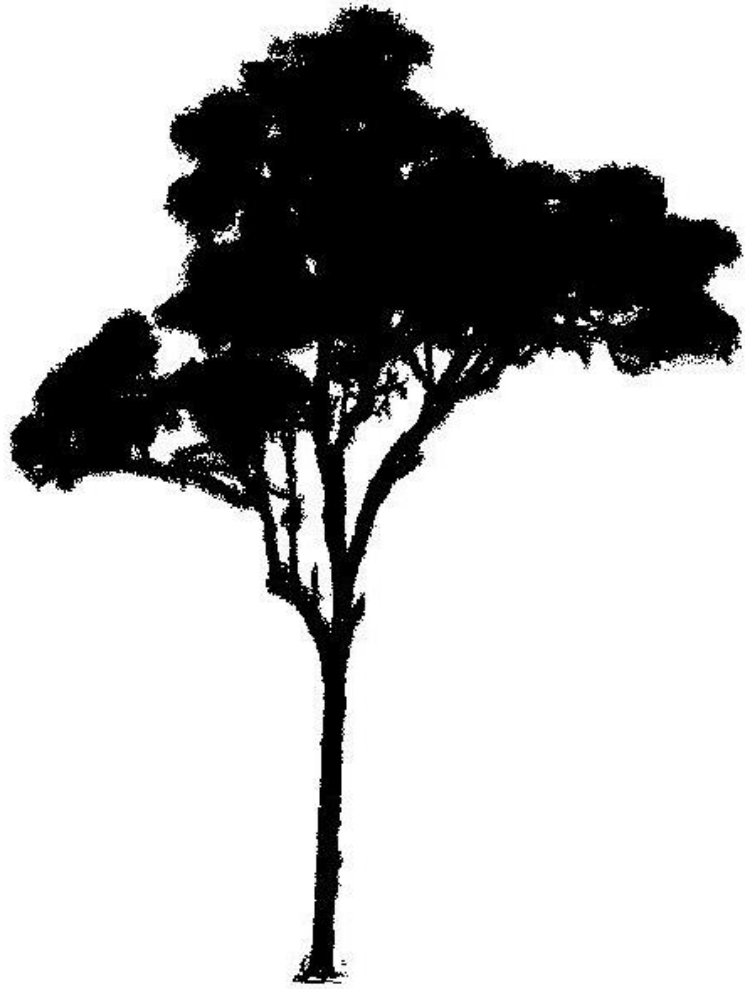


HR UAV LS data
(1000 to 2000 pts/m²)

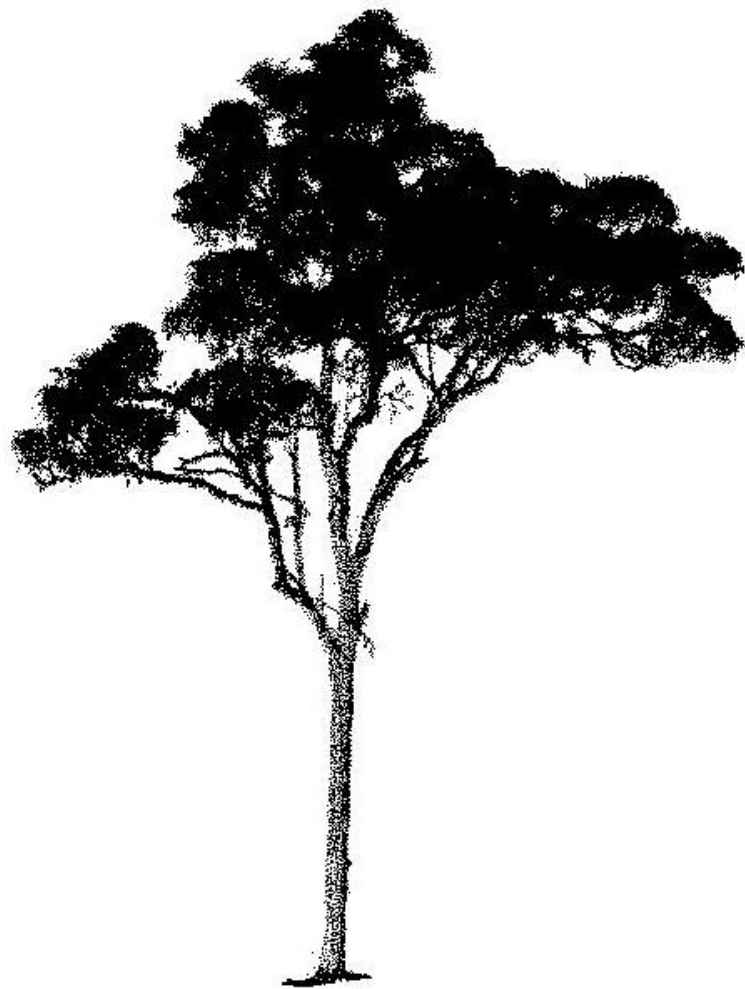


LR UAV LS data
(200 to 400 pts/m²)

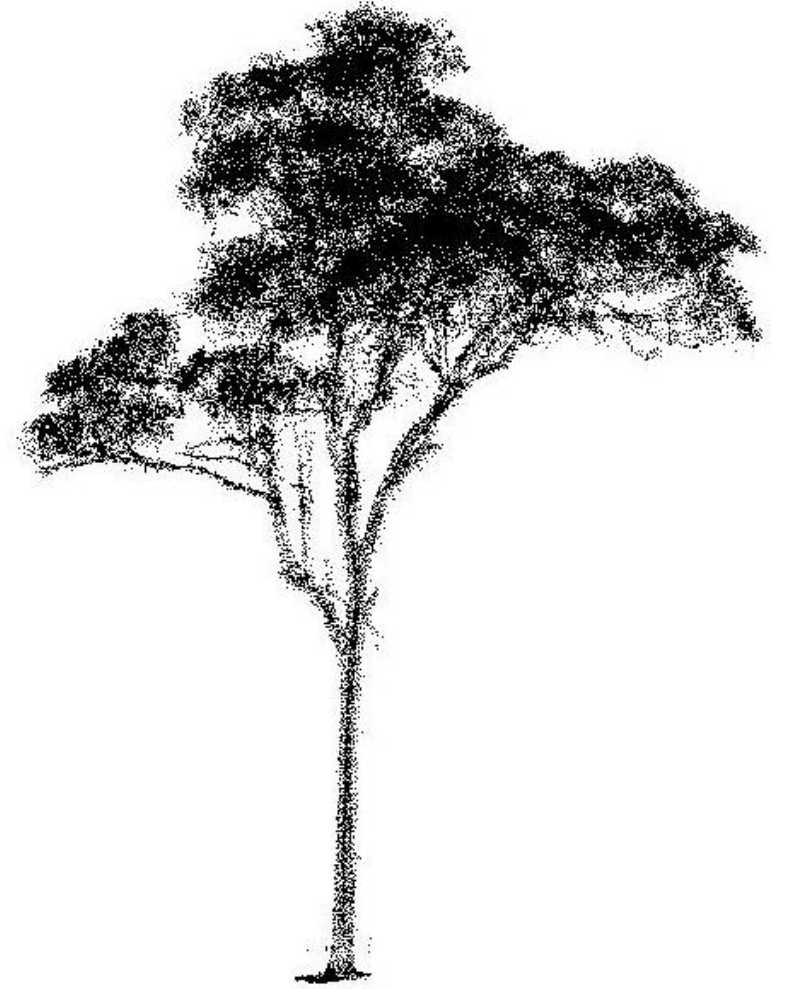
Individual tree-level information



TLS data



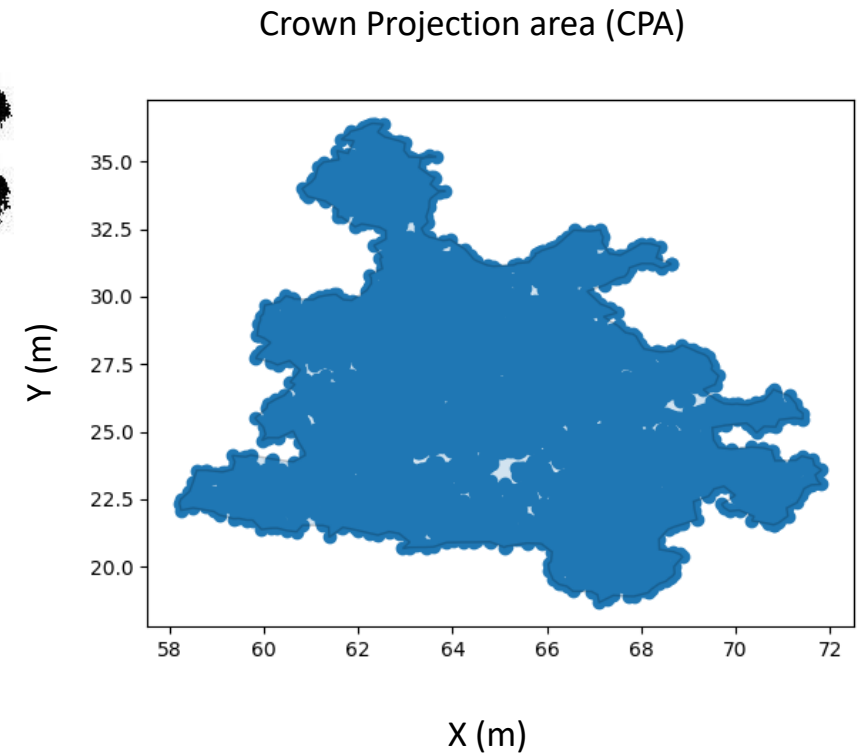
HR UAV LS data



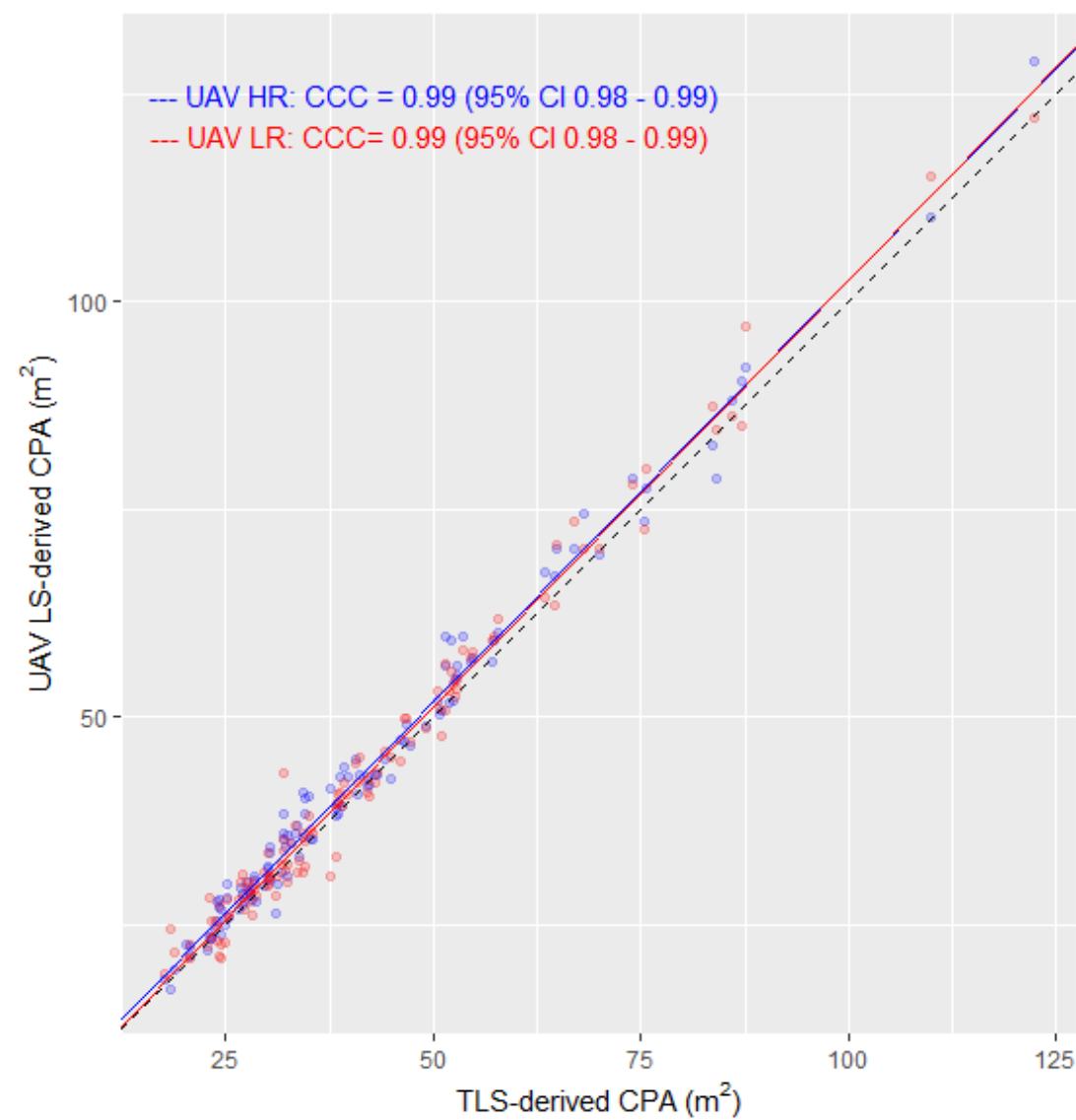
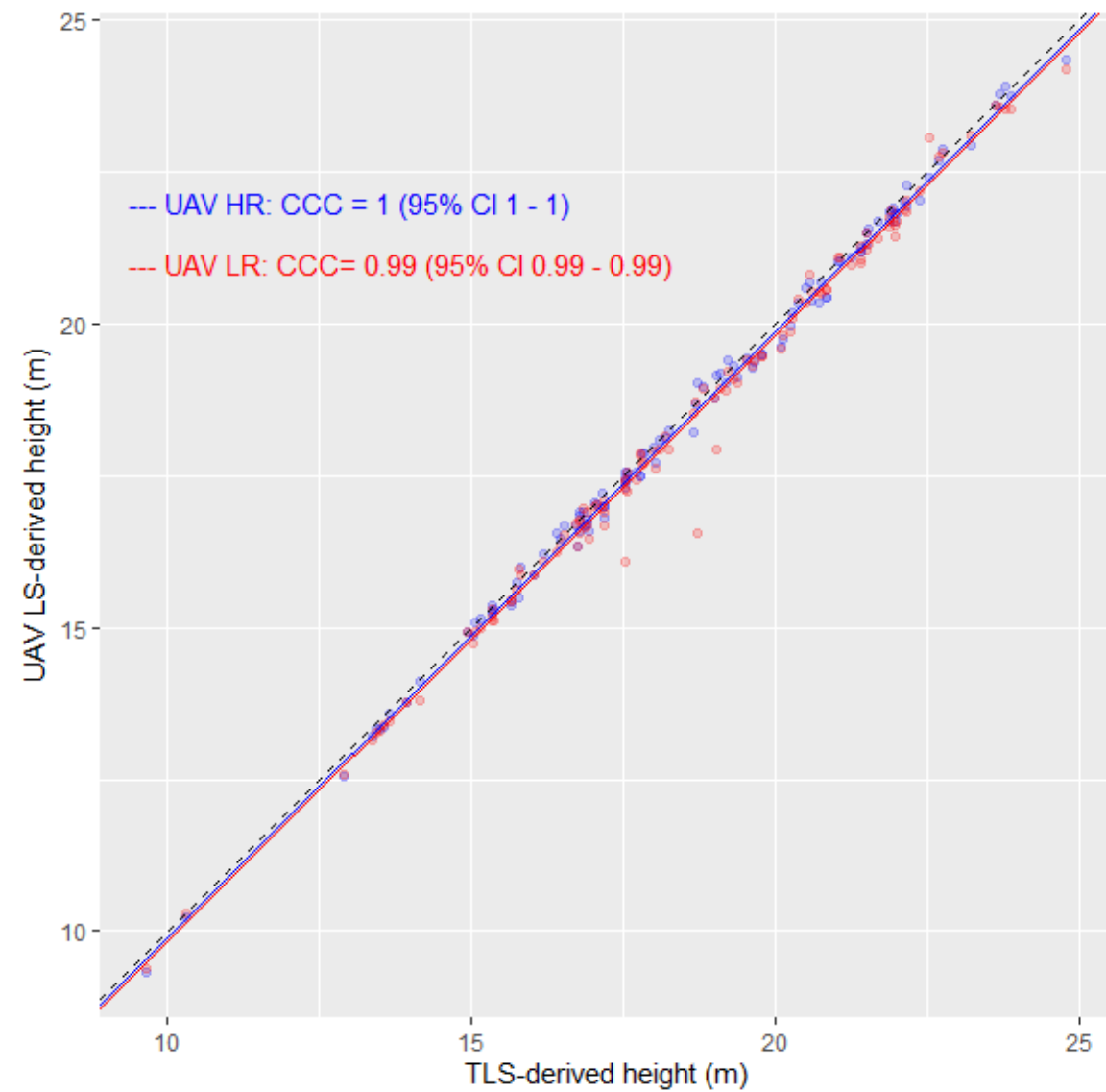
LR UAV LS data

TLS- and UAV LS-derived structural metrics

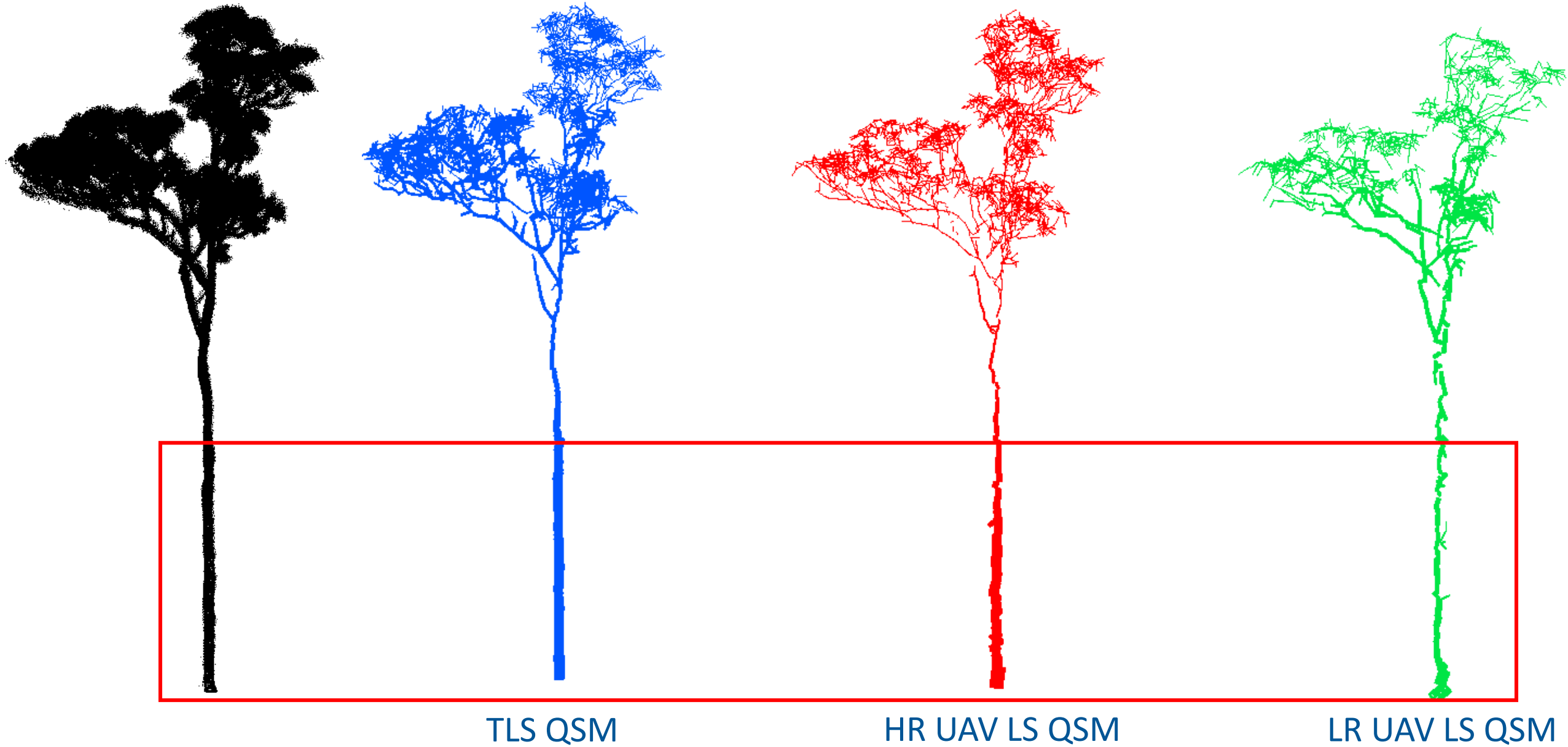
- Height
- Crown projection area
- Volume



TLS- and UAV LS-derived structural metrics



TLS- and UAV LS-derived volume



TLS- and UAV LS-derived volume



TLS QSM

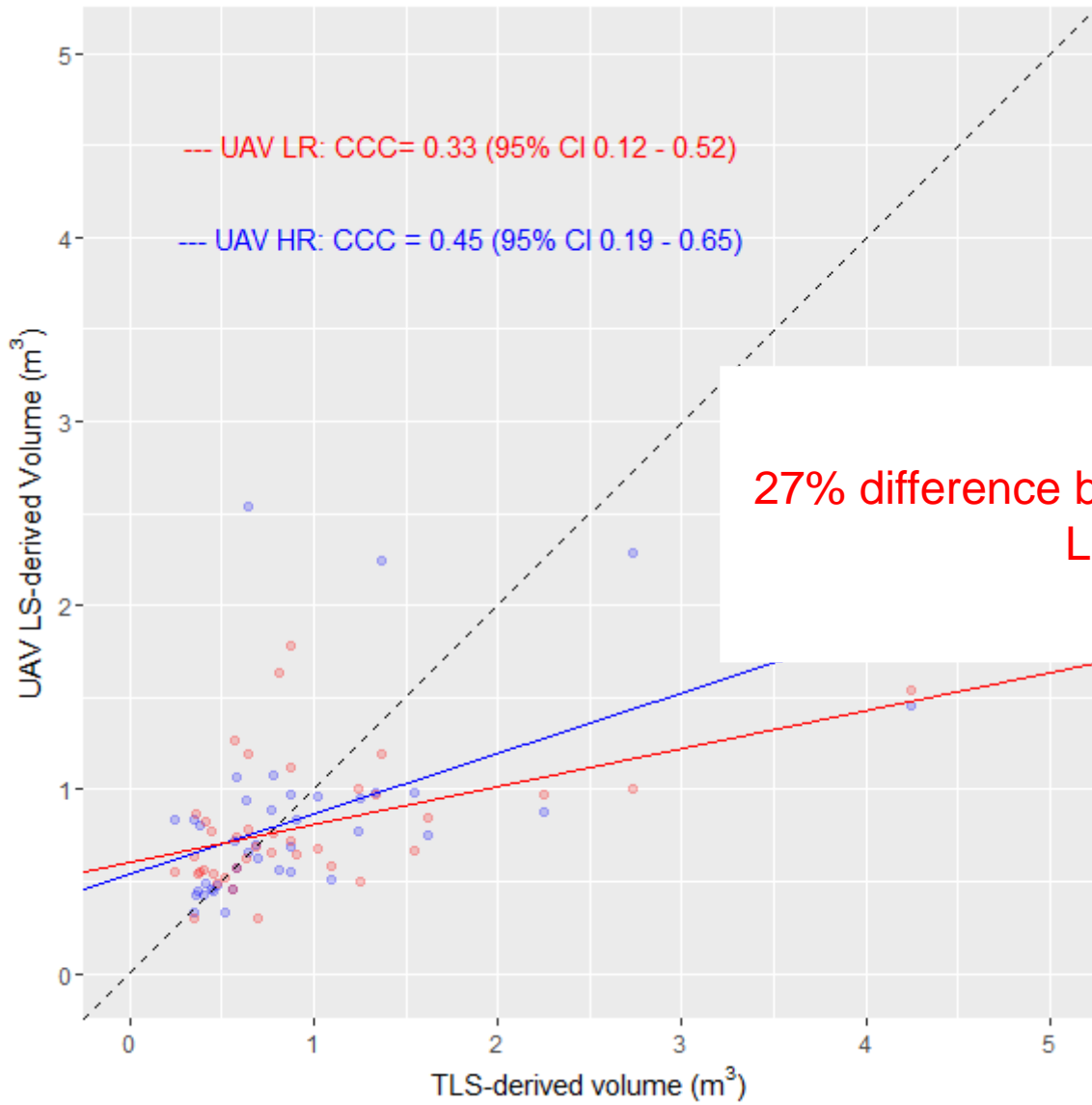


HR UAV LS QSM

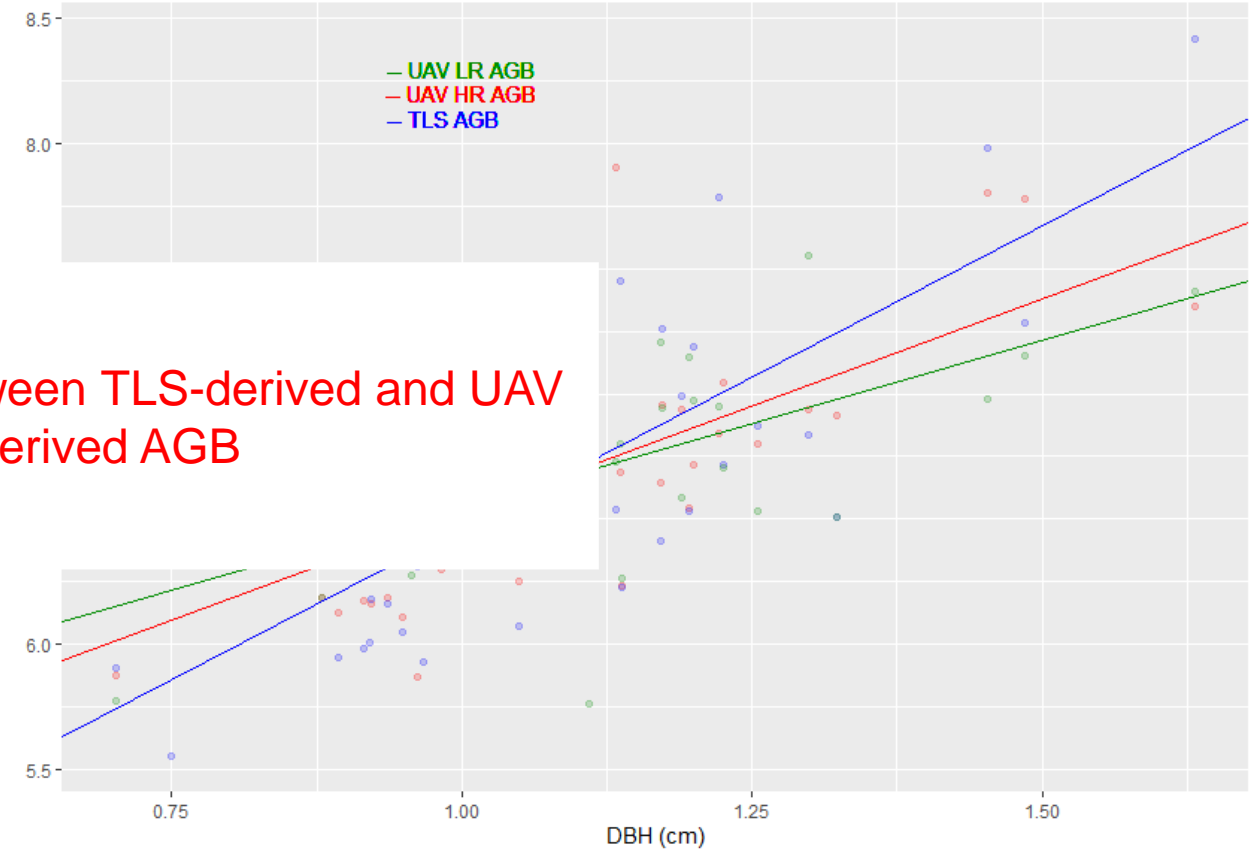


LR UAV LS QSM

TLS- and UAV LS-derived structural metrics



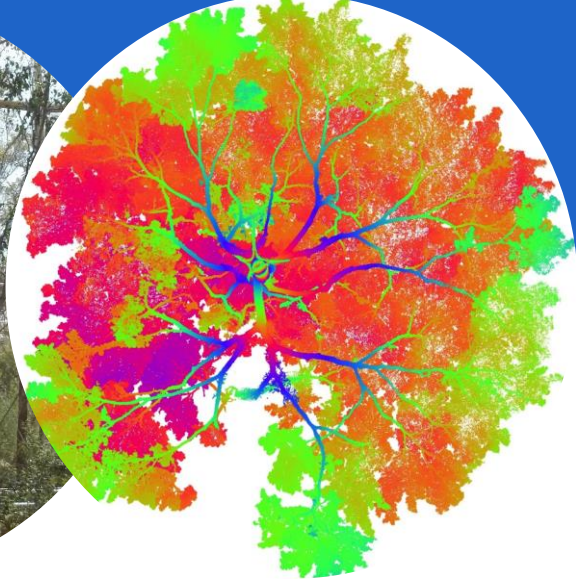
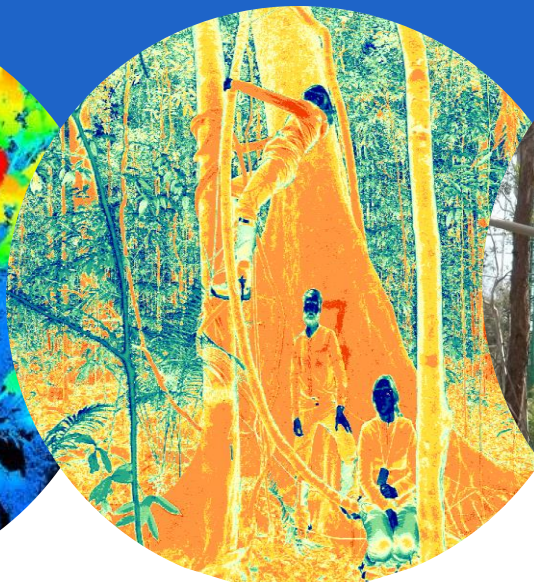
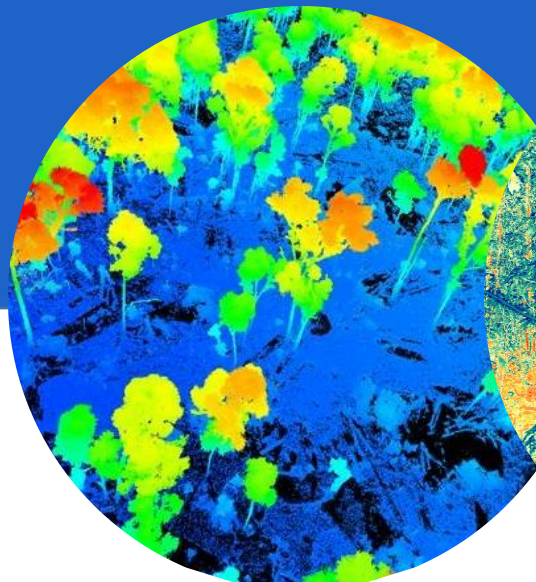
27% difference between TLS-derived and UAV LS-derived AGB



	TLS	UAV-LS
Speed	-	Way faster (neglecting paperwork..)
Quality	++	It depends...
Ease of use	++	Trained people, lot of paperwork... “High” risks...
Changes through time	Not for large areas	++
Large areas	Maybe once, but not multiple times a year	+ (~10ha in a single flight)
Analysis / Algorithms	Pretty well established	Needs development!

Questions?

Sruthi M. Krishna Moorthy, Kim Calders, Hans Verbeeck, Harm Bartholomeus & Martin Herold



Extracting individual trees from UAV-LS



Remote Sensing of Environment

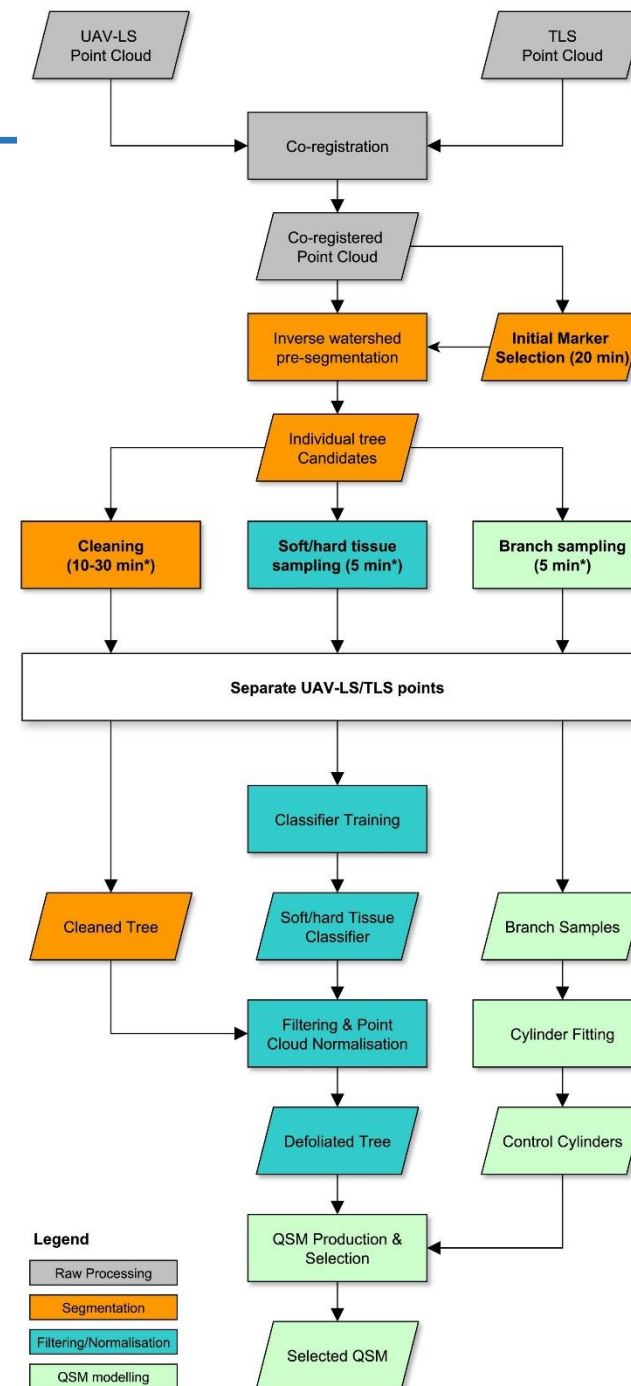
Volume 233, November 2019, 111355



Non-destructive tree volume estimation through quantitative structure modelling: Comparing UAV laser scanning with terrestrial LIDAR

Benjamin Brede ^a, Kim Calders ^b, Alvaro Lau ^a, Pasi Raumonen ^c, Harm M. Bartholomeus ^a, Martin Herold ^a, Lammert Kooistra ^a

Show more



Individual tree-level information



TLS data



HR UAV LS data
(1000 to 2000 pts/m²)



LR UAV LS data
(200 to 400 pts/m²)

TLS fieldwork

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 still 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...

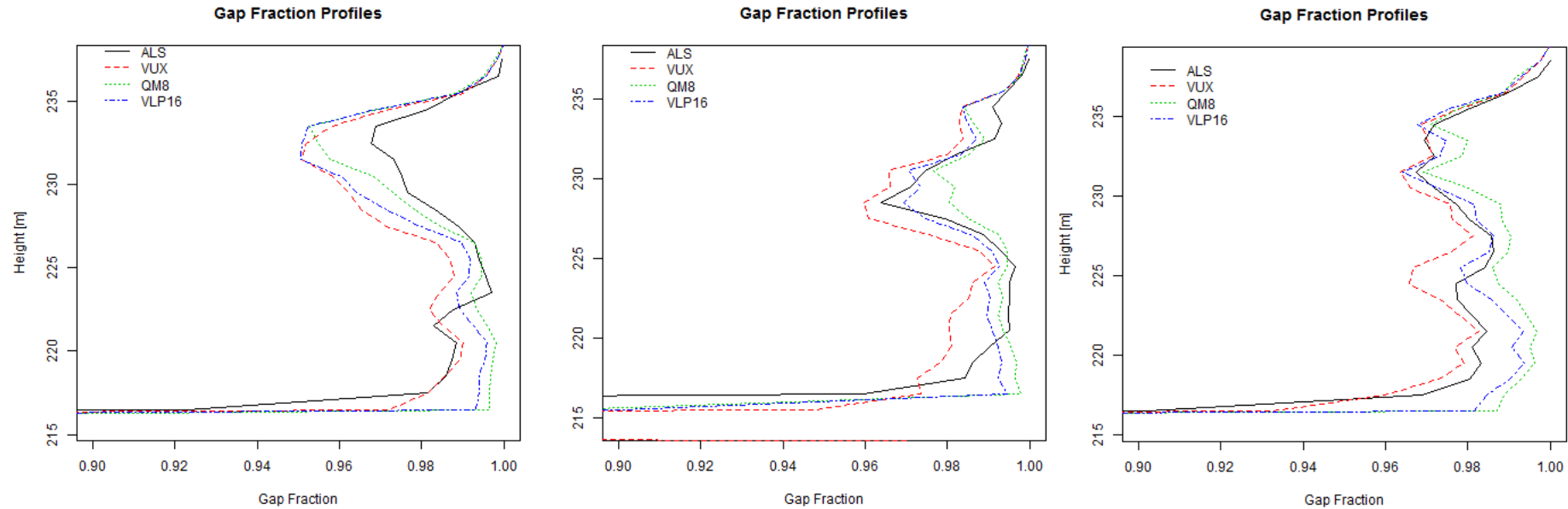


UAV-LS

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!



Differences in gap-fraction per sensor



- Especially differences in the lower parts of the forest

How can we upscale?

- ~~• Can UAV's help here?~~
- ~~• Couple of slides about different types of UAV sensor?~~
- ~~• Comparison of point cloud quality across different UAV sensors~~
- how even the one that has the highest resolution do not yield comparable results with TLS volume
- For volume, the best way to go forward is probably to use height and CPA from UAV to estimate biomass.