Towards the automatic 3D characterization of forest plots

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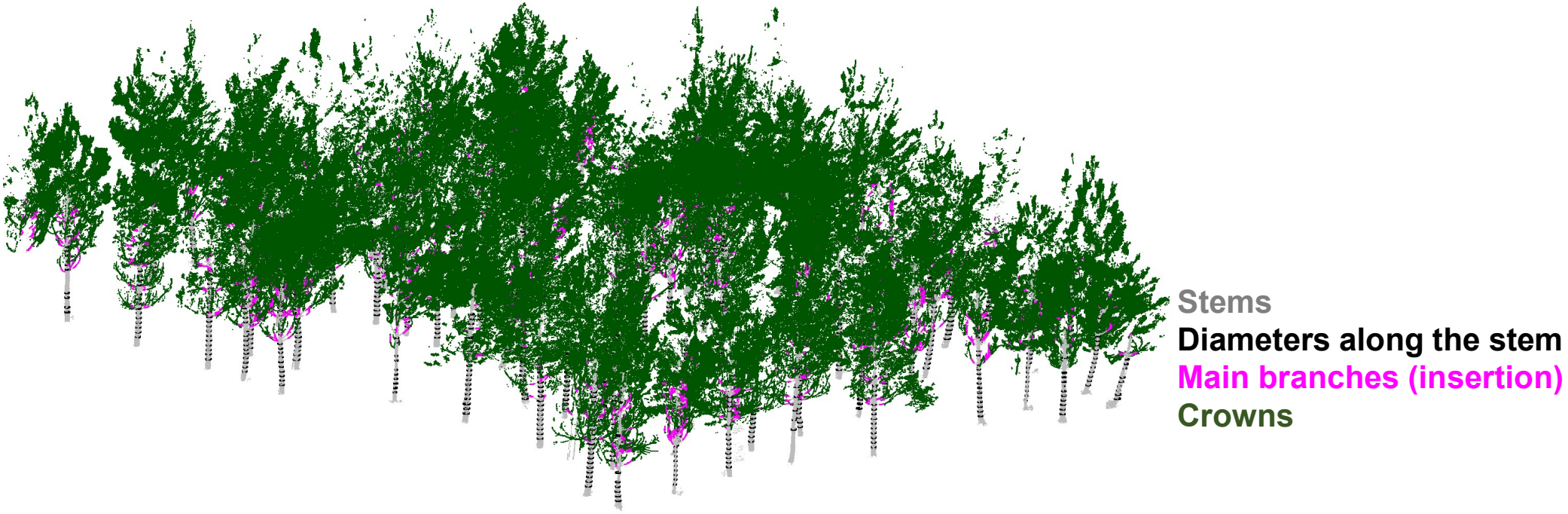
Our Aim: 3D characterization of vegetation in forest plots using point clouds datasets

How: development of automatic algorithms for 3D fuels and forest inventory:



Our Aim: 3D characterization of vegetation in forest plots using point clouds datasets

How: development of automatic algorithms for 3D fuels and forest inventory:

Based on previous work by Cabo *et al*:

1.-**Automatic forestry measurements** at plot level from terrestrial laser scanning (TLS) point clouds
Automatic dendrometry: Tree detection, tree height and diameter estimation using terrestrial laser scanning.
Cabo, et al.(2018) *International journal of applied earth observation and geoinformation*,

2.-**Comparison between TLS and WLS** for DBH and tree height (TH) at plot level:
Comparing TLS and wearable laser scanning (WLS) for individual tree modeling at plot level.
Cabo, et al.(2018) *Remote Sensing*

3.-**Point cloud classification** (including ground/stems/branches classification):
Multiscale Supervised Classification of Point Clouds with Urban and Forest Applications.
Cabo, et al.(2019) *Sensors*

Input data collection

TLS

UAV LiDAR

WLS

UAV SfM

Our Method

1.- **Data fusion** [aerial]+[ground-based]

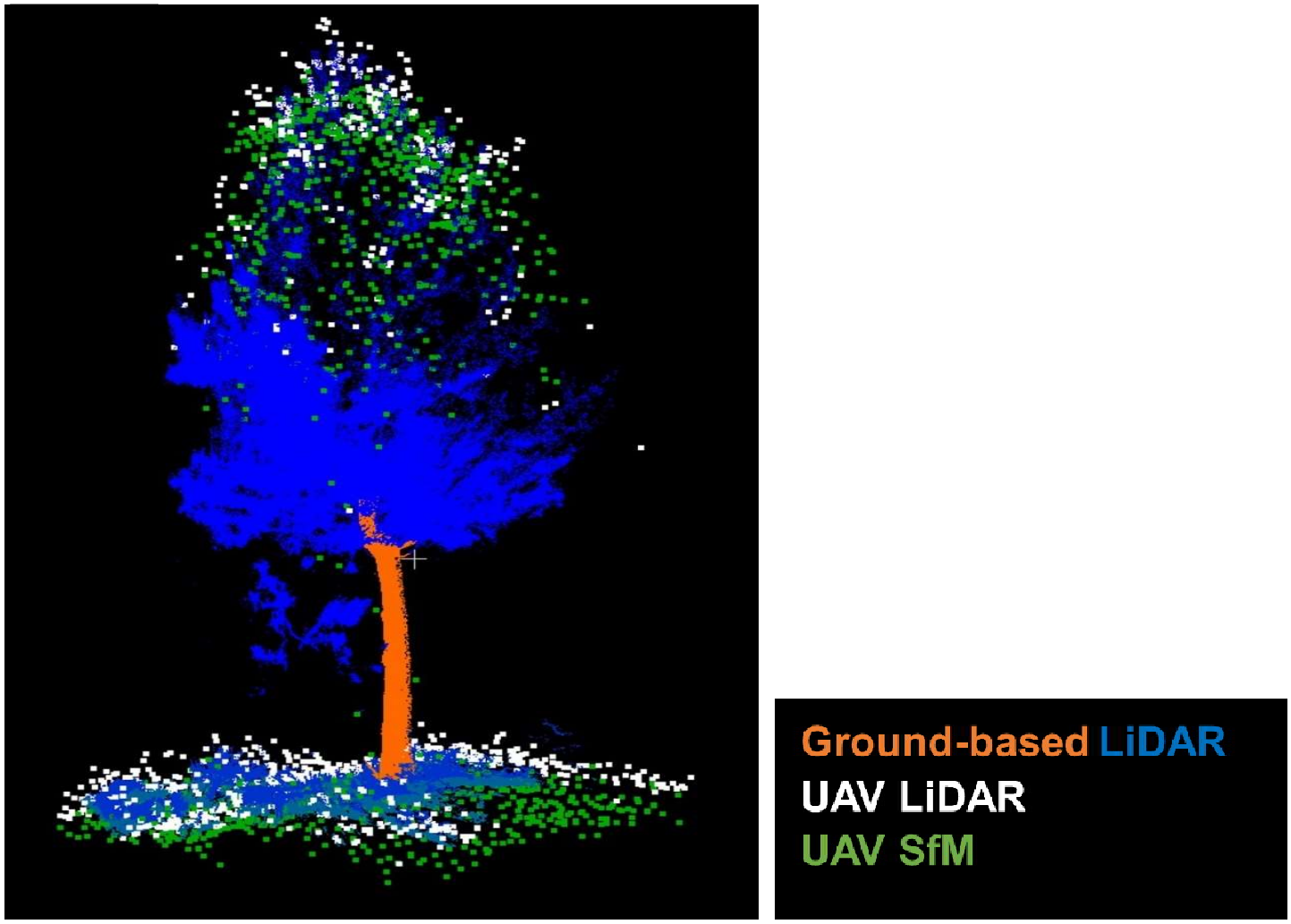
2.- **Tree stem detection and characterization**:

- 2a.- Cleaning and initial point cloud classification
- 2b.- Tree individualization
- 2c.- Stem axis estimation
- 2d.- Diameter modelling along the stems
- 2e.- Main branches detection (stem insertions)

3.- **Classification**: Stem/crown/understorey/main branches

4.- **Parameter estimation:** taper volumes, branches insertion angle, stem inclination and curvature, …

1.- Data fusion [aerial]+[ground-based]



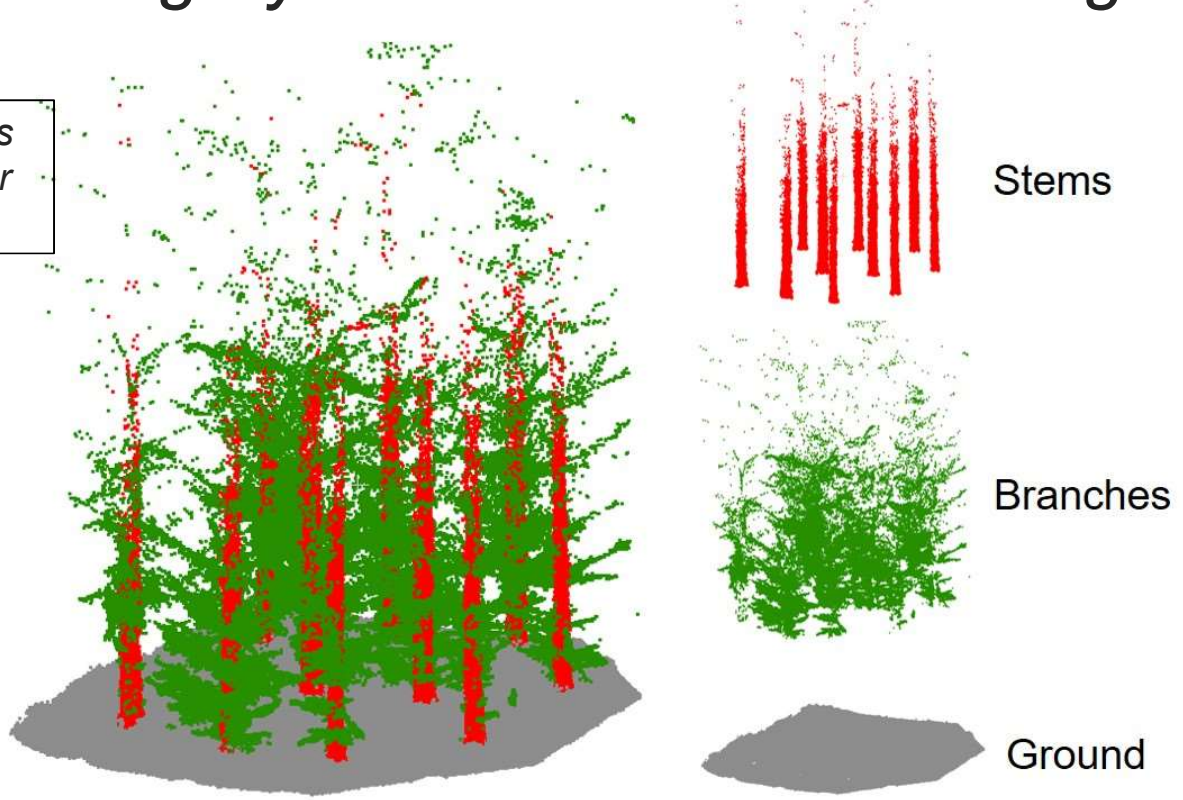
2.- Tree stem detection and characterization:

2a.- Cleaning and initial point cloud classification :

Most probably category: stems vs branches vs ground

Only used as an initial step in plots with very dense low canopy and/or vertical fuel continuity

Multiscale classification based on local shapes

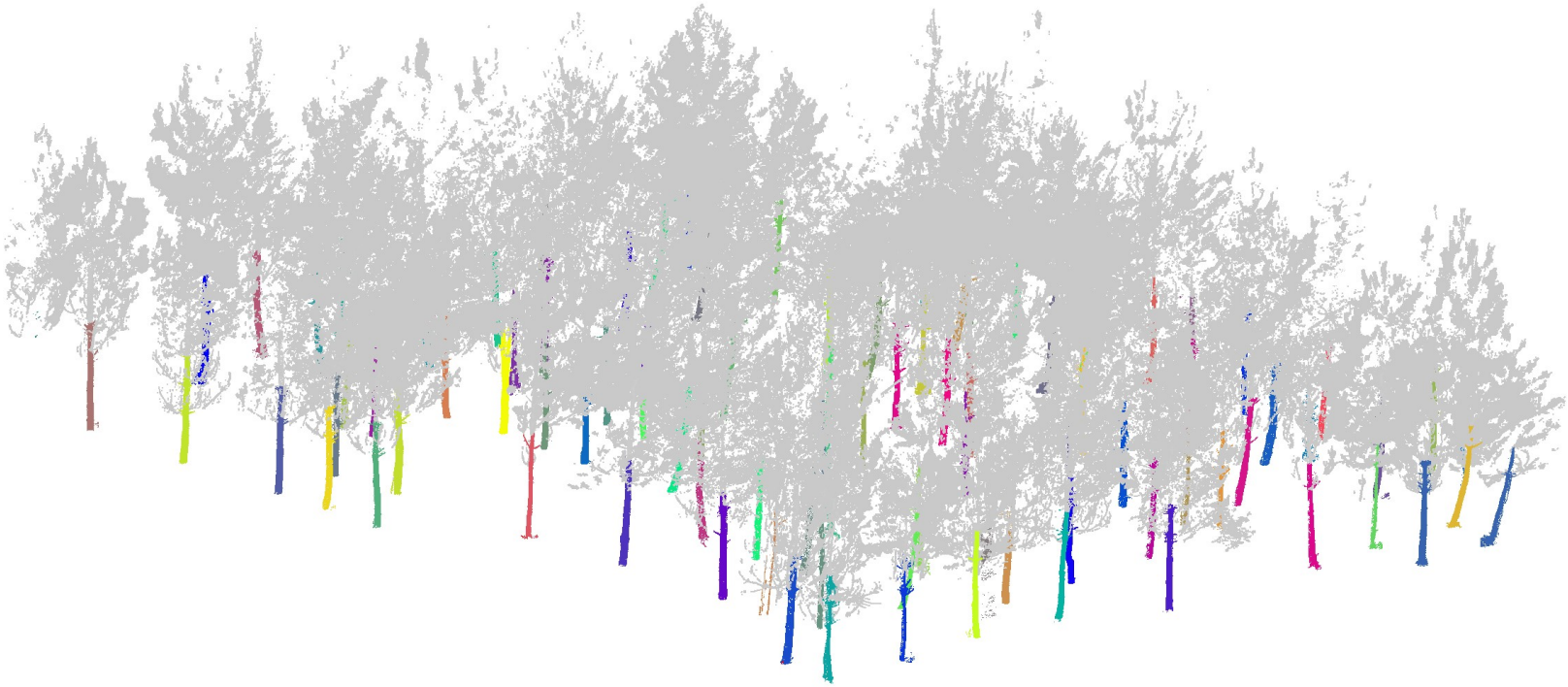


Based on Cabo, et al.(2019) *Sensors*

2.- **Tree stem detection and characterization**:

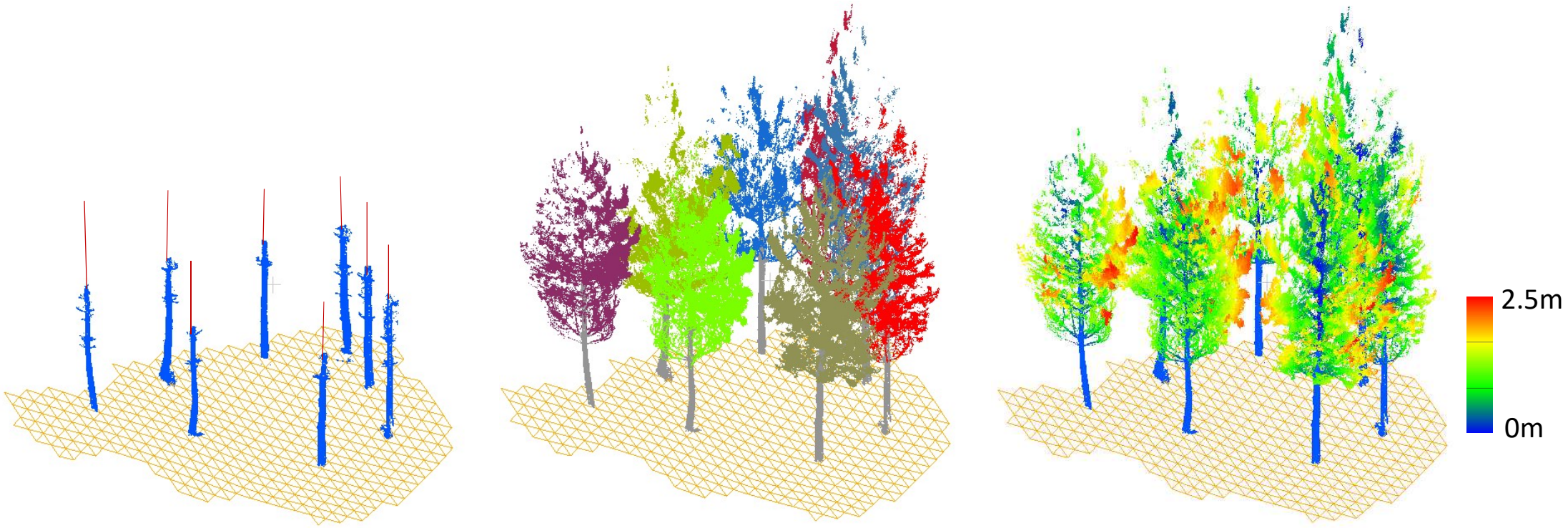
2b.- Tree individualization

Point clustering based on density and distance



2.- Tree stem detection and characterization:

2c.- Stem axis estimation



Tree stem axes
(PCA→1st PC)

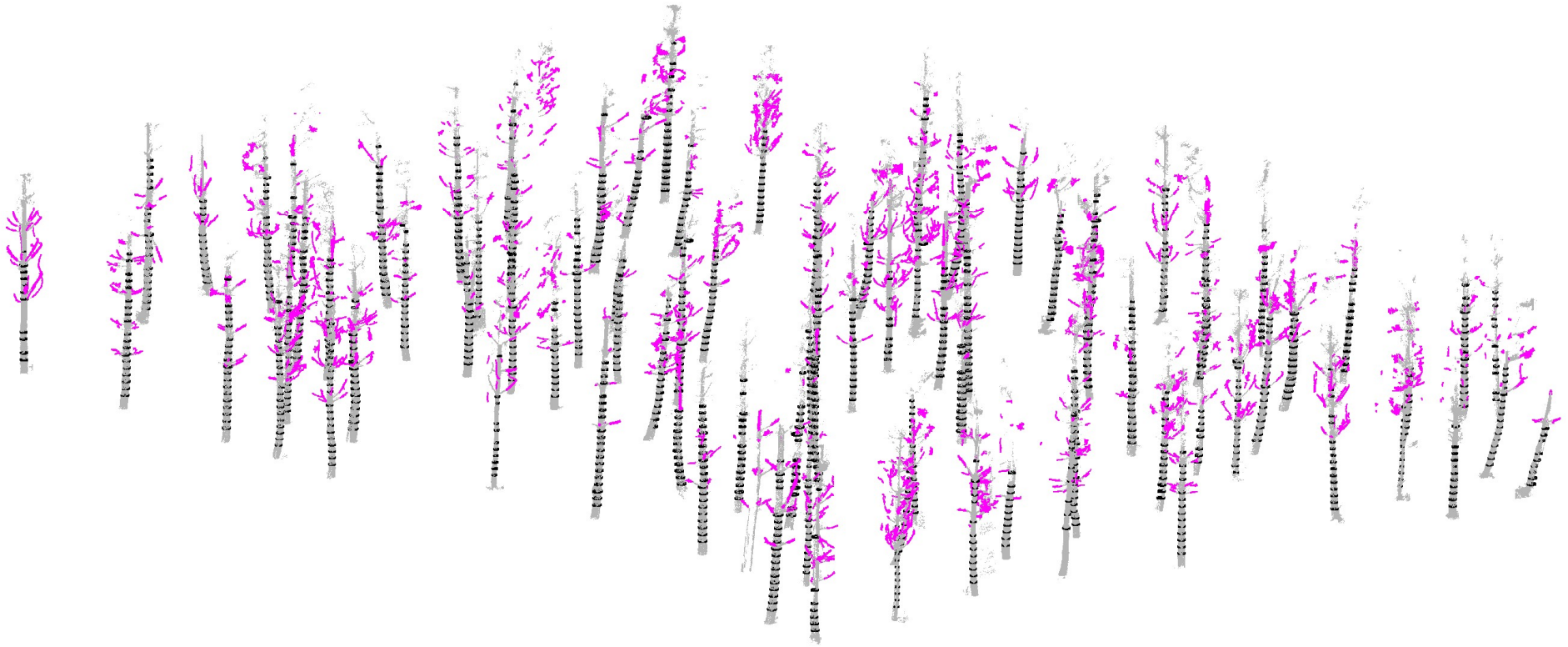
Individualization

Distance
[Point] - [Closest tree stem axis]

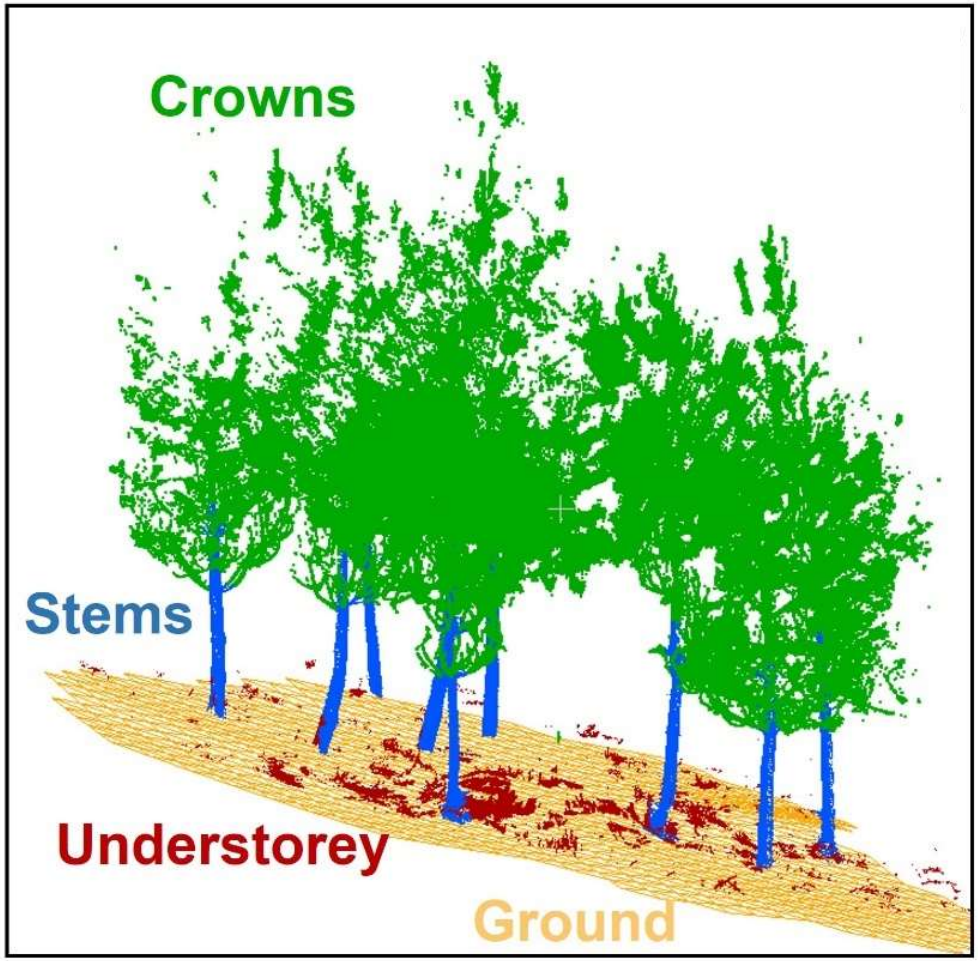
2.- Tree stem detection and characterization:
2d.- Diameter modelling along the stems

2.- Tree stem detection and characterization:

2e.- Main branches detection (stem insertions)



3.- Classification (1): 3D FUELS

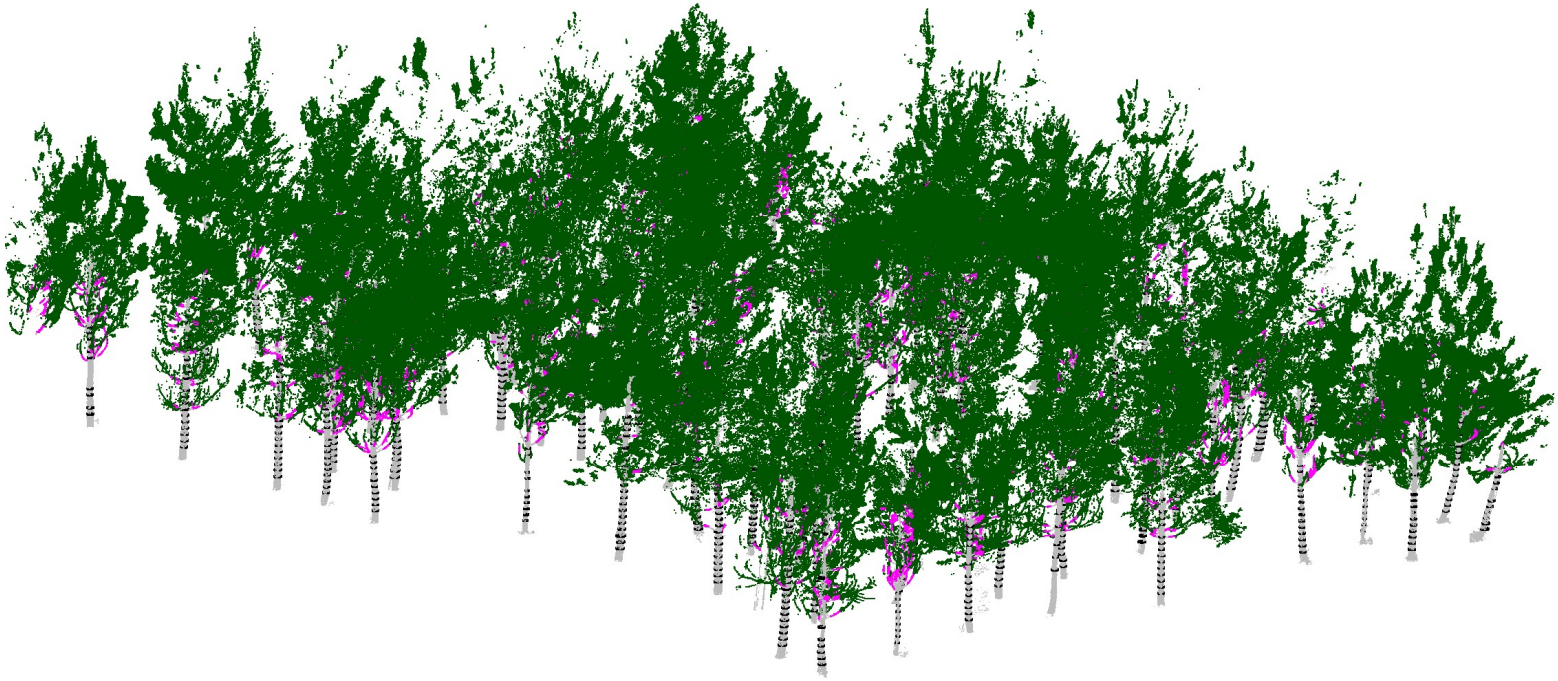


- **Stems** [previous steps]

According to distances from diameters:

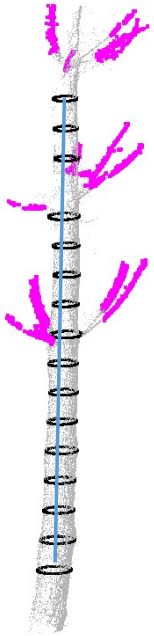
- **Ground** [low points; e.g. <20cm]
- **Crown** [high points not in stems]
- **Understorey** [low points not in stems]

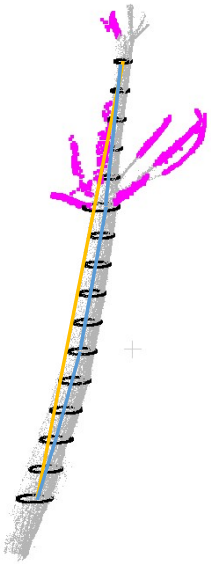
3.- Classification (2): FOREST INVENTORY



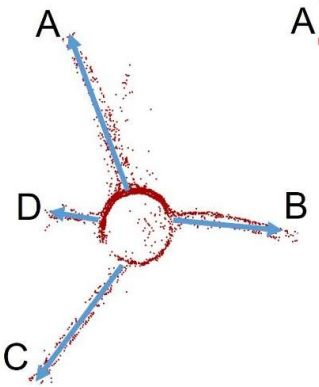
Stems
Diameters along the stem
Main branches (insertion)
Crowns

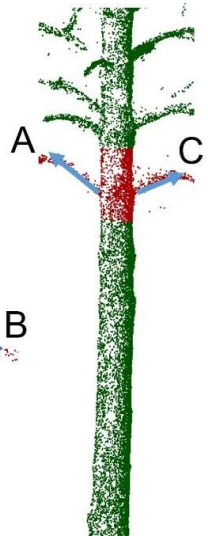
4.- Parameter estimation:

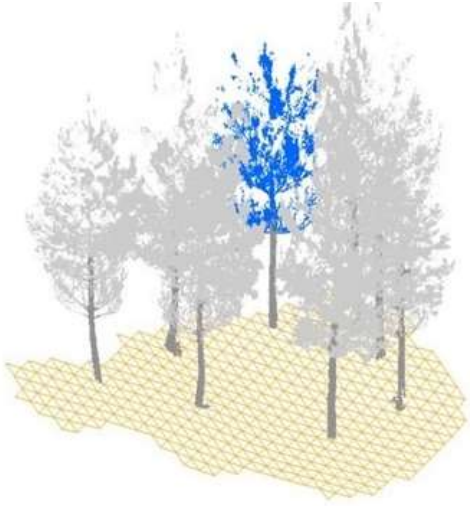


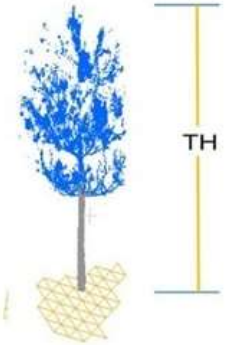


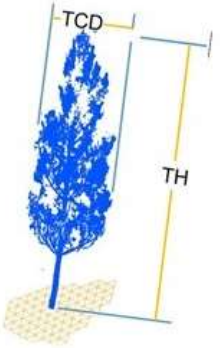
- Taper volumes
- Branches insertion angle
- Stem inclination and curvature
- Tree crown diameter



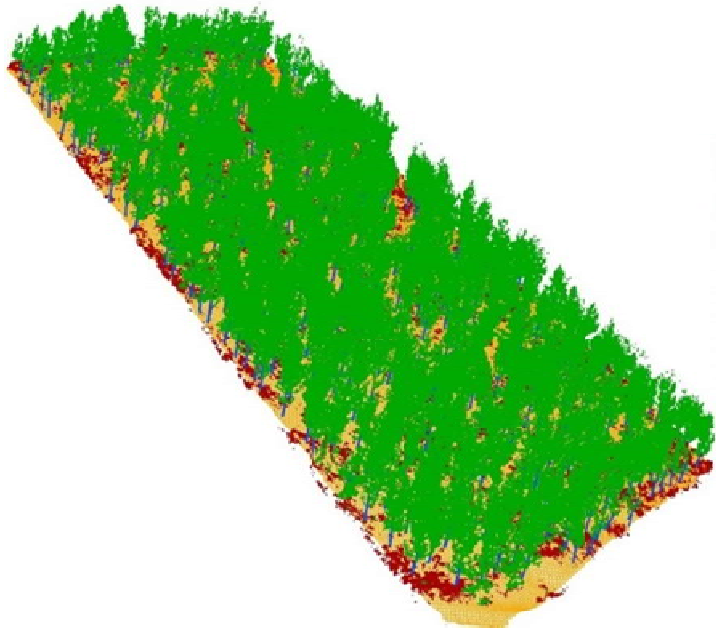




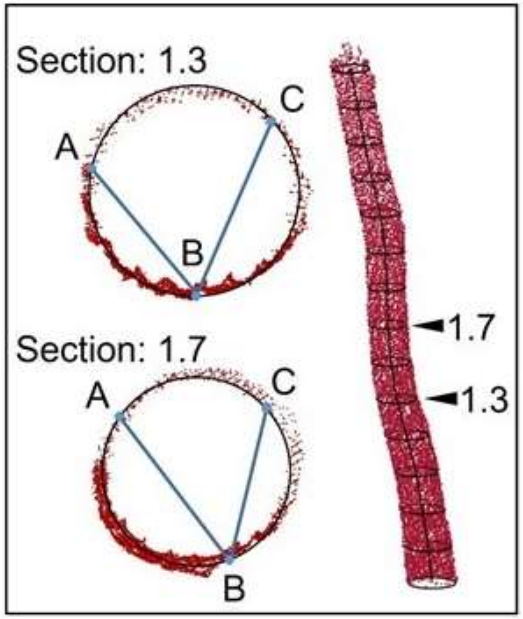




Some results in a test plot



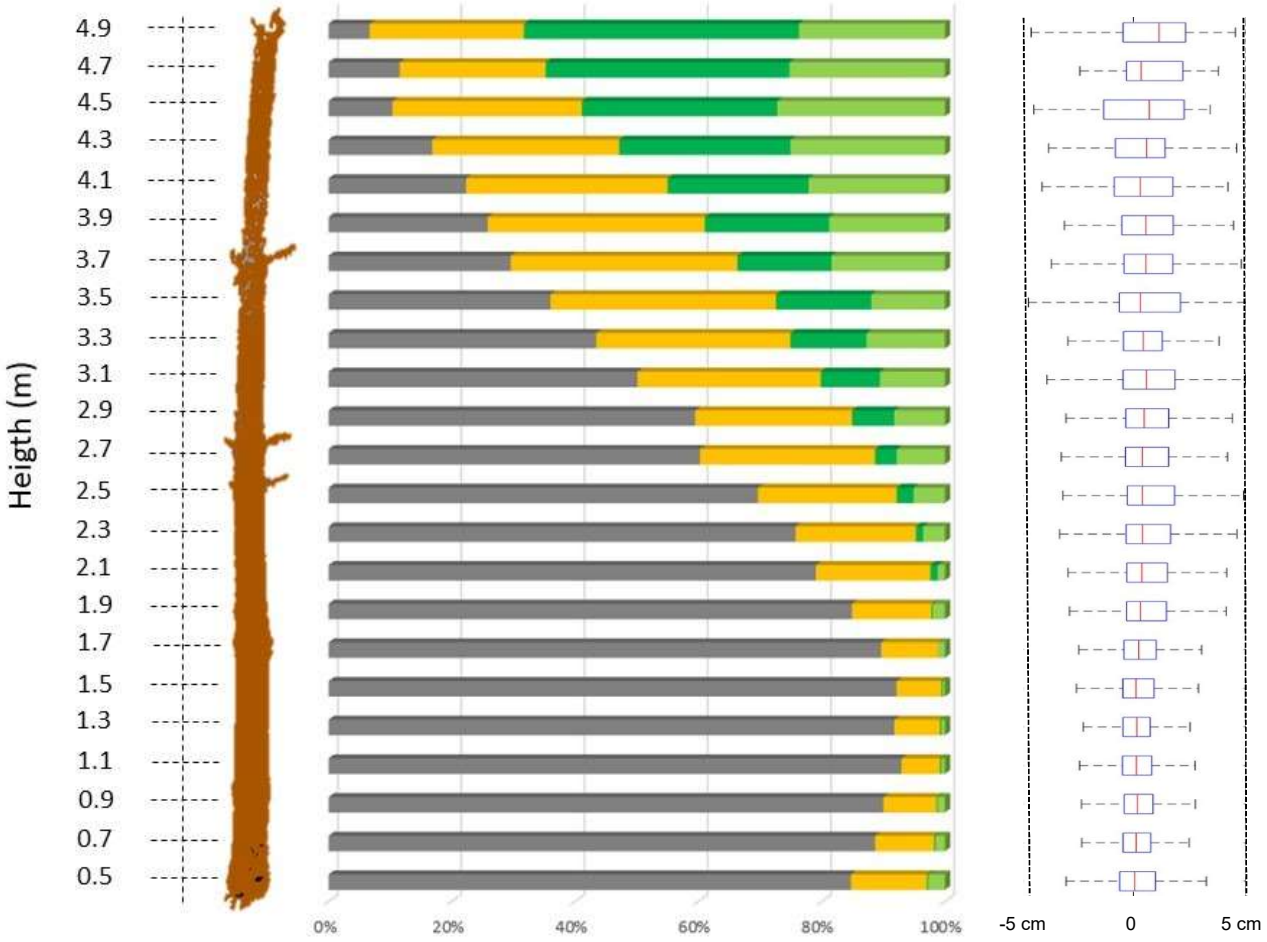
Test data from visual inspection of the point clouds (2 different operators), land surveying and field work



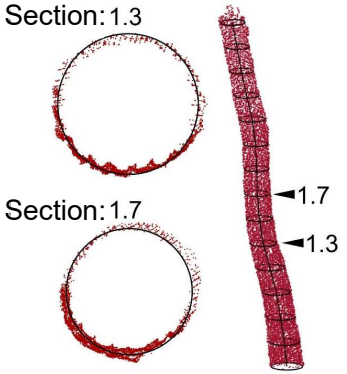
E.g. <u>Pinus radiata</u>
Plot 0.7ha
511 trees
Steep terrain (slope >30%)

Tree detection:
Completeness 97%
Correctness >99%

Some results in a test plot



Boxplot:
differences in diameter estimation
ALGORITHM-OPERATORS



- Labelled as ‘OK’ by the algorithm
- Labelled as ‘needing revision’ by the algorithm
- No posible estimation by the algorithm
- No posible estimation by the operators

Developments linked to the project:

Advancing 3D Fuel Mapping for Wildfire Behaviour and Risk Mitigation Modelling

- UK Project (funded by National Environmental Research Council)
- 3 years (January 2020 – Dec. 2022); £650,000

Swansea University
Prifysgol Abertawe

Project Partners

Met Office

Forestry Commission

Cyfoeth Naturiol Cymru
Natural Resources Wales

Forest Research

FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE

Thanks very much for your attention!

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