International Workshop
New remote sensing techniques for 3D forest structure mapping and wildfire modeling
Valencia 2024

Terrestrial laser scanner for shrub-canopy interface characterization

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Forest, Wildfires and TLS

✓**Wildfires** are becoming **more intense, severe and recurrent**.

✓In 2022, there were 10,507 forest fires in Spain; **57** were **large fires** (>500 ha) and accounted for **80.78% of the total area affected**.

✓Register the **three-dimensional structure of the ecosystems in detail**.

✓**Quick scanning** sensors in the field and more and more **processing software**.

✓ There is **much research on trees**, but **not enough for shrubs**.

✓Relevant works:

- Yun et al. 2022., Stratifying Forest Overstory and Understory for 3-D Segmentation Using Terrestrial Laser Scanning Data.
- Zhou et., 2019, Waveformlidar: An R Package for Waveform LiDAR Processing and Analysis.
- Wang et al., 2021, A waveform decomposition technique based on wavelet function and differential cuckoo search algorithm.

FireMode: Spectral and Structural 3D Mapping of Mediterranean Fuels for Forest Fire Behavior Modelling.

- Compilation, acquisition, and processing of remote sensing data.
- Characterization of the vegetation structure and, specifically, the interface between the understory and overstory.

Two Natural Parks: Sierra de Espadán y Sierra Calderona

- Two Regions: **Valencia** and **Castellon**
- **SALCA:** Different points were distributed in the province of Valencia.
- **Heterogeneous forest stands**, mainly coetaneous, where the dominant tree species are *Pinus halepensis* Mill. and *P. pinaster* Aiton, with occasional presence of *Quercus suber* L. and *Q. ilex* L.
- The variability in the density and thickness of the tree canopy has resulted in large **differences in the distribution, density and diversity of shrub species**. The predominant species are *Genista scorpius* (L.) DC, *Cistus albidus* L., *Rosmarinus officinalis* L., *Pistacia lentiscus* L., *Quercus coccifera* L., *Calicotome* sp., *Lavandula stoechas* L., *Daphne gnidium* L., and *Ruscus aculeatus* L.

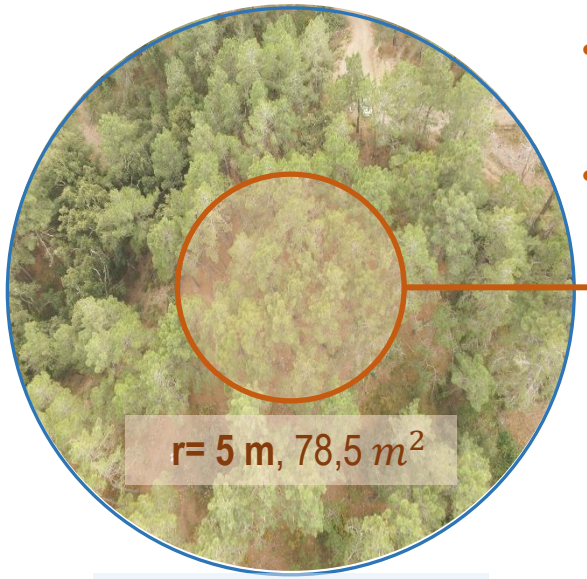


On the field

- 27 Plots in Espadán and 27 plots in Calderona

Concentric plots with two different radius:

- **Identification of tree species**
- **DBH > 5 cm**
- **Position of the 7 thickest trees**
- **Height and CBH (7 thickest trees)**

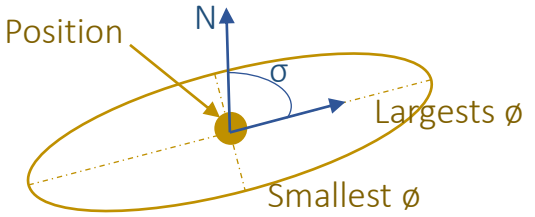


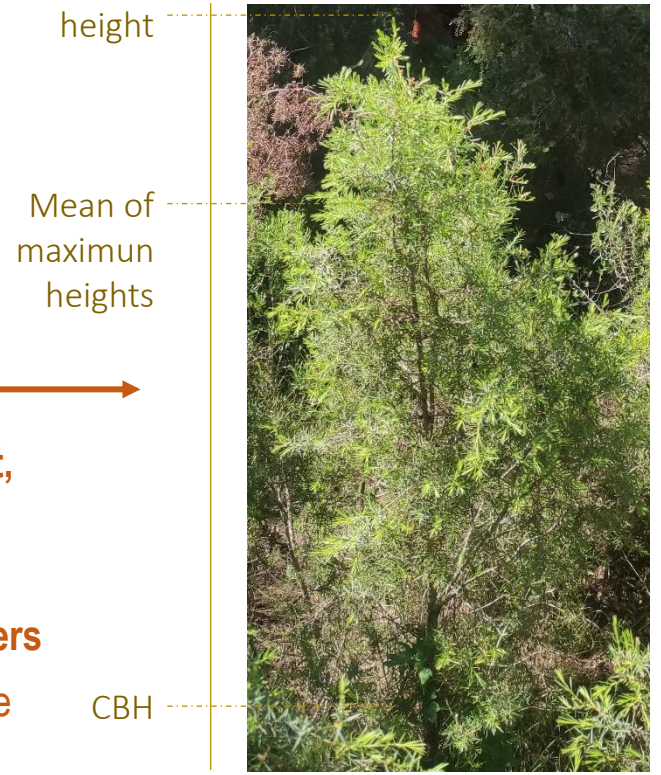
r = 15 m, 706 m^2

- **Position** of all **trees** and **shrubs**
- **Identification** of all **species**
- **Height and CBH** of all **trees**

shrubs

- **Maximum height, mean** and **CBH**
- **Largest** and **smallest diameters**
- **Orientation** of the **largest diameter**



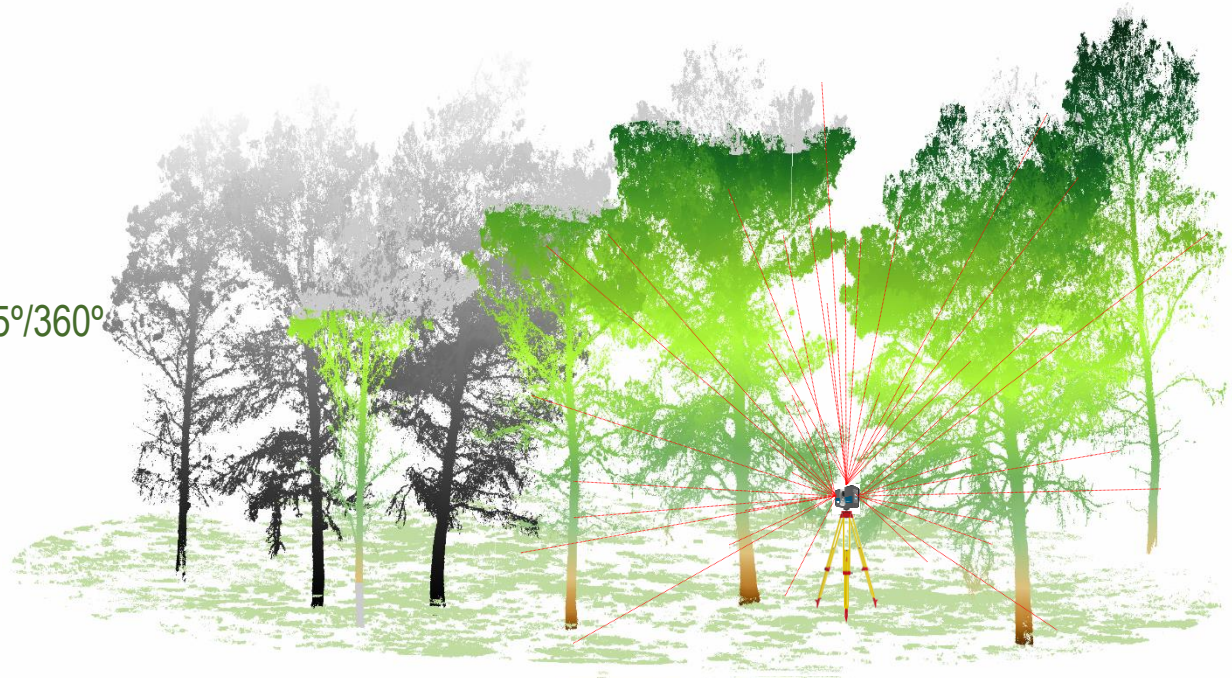


Juniperus oxycedrus

In the lab, more than 50 allometric functions have been compiled for the calculation of biomass and fuel load for tree and shrub species.

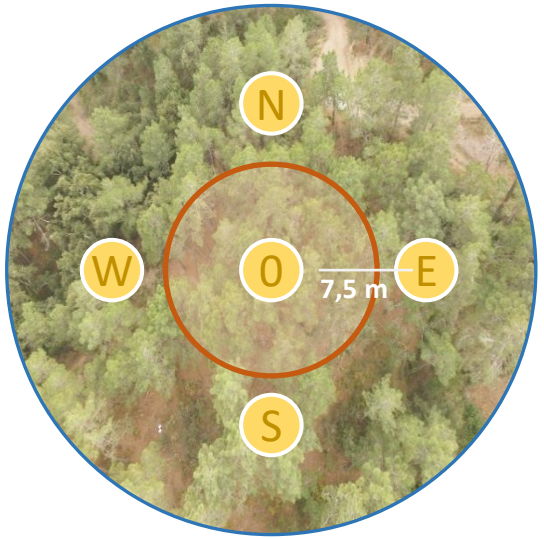
TLS Specifications

- **Faro Focus 3D 120**
  - **Range:** 0,6 a 120 m
  - **Ranging error:** ± 2 mm
  - **Laser power (cw Ø):** 20mW
  - **Vertical/horizontal field of view:** 305°/360°
  - **Wavelength:** 905 nm
  - **Beam divergence:** 0.19mrad (0.011°
  - **Instrument weight:** 5 kg



Register settings

- **5 scanner positions**:
  - 1 position in the center of the plot
  - 4 positions at 7.5 meters in the cardinal points



- At least **5 white spheres** visible from each scan for registering and georeferencing.

Torralba, J.; Carbonell-Rivera, J.P.; Ruiz, L.Á.; Crespo-Peremarch, P. Analyzing TLS Scan Distribution and Point Density for the Estimation of Forest Stand Structural Parameters. Forests 2022, 13, 2115. https://doi.org/10.3390/f13122115

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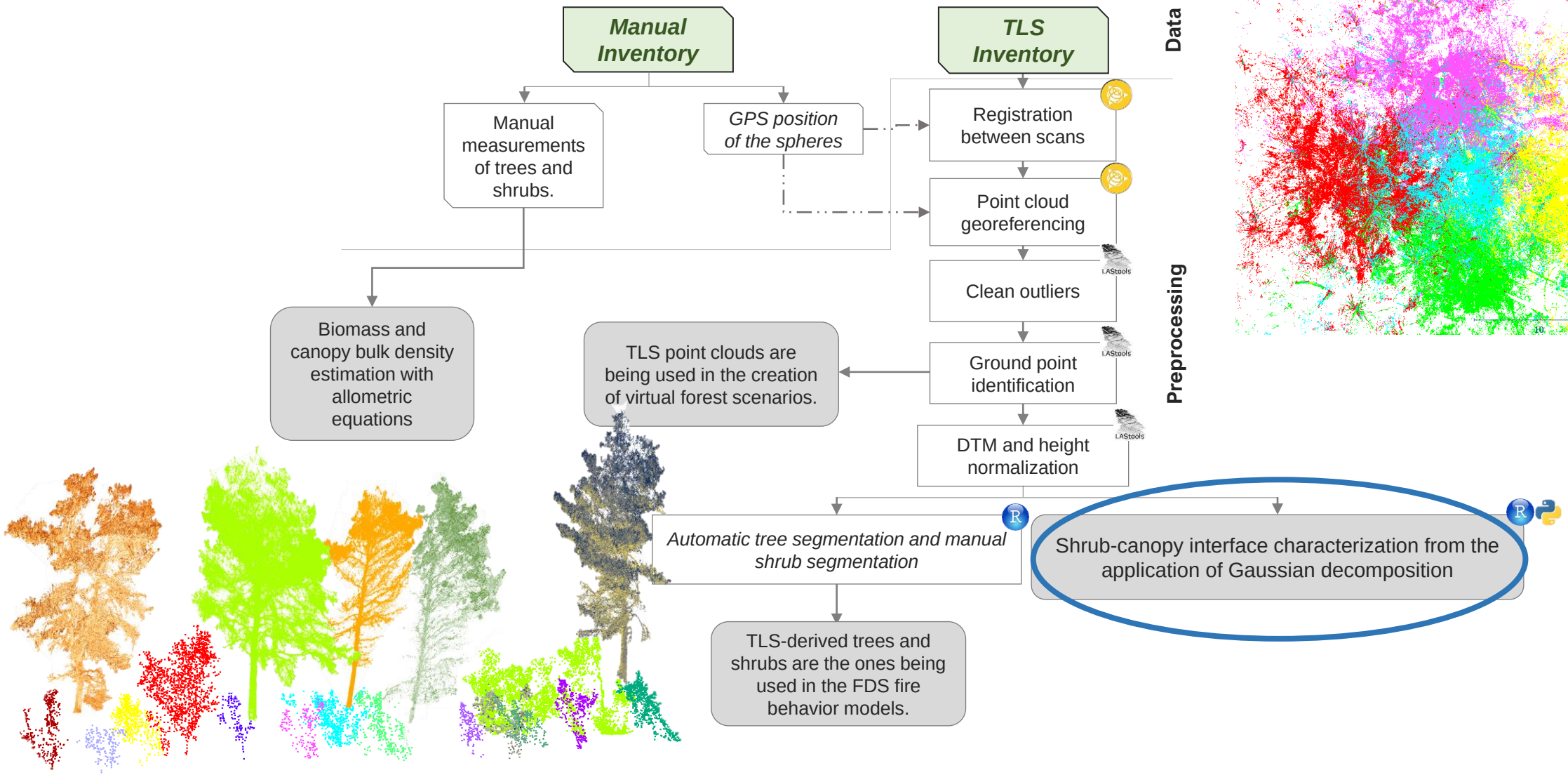
Pre-processing of all Manual and TLS data

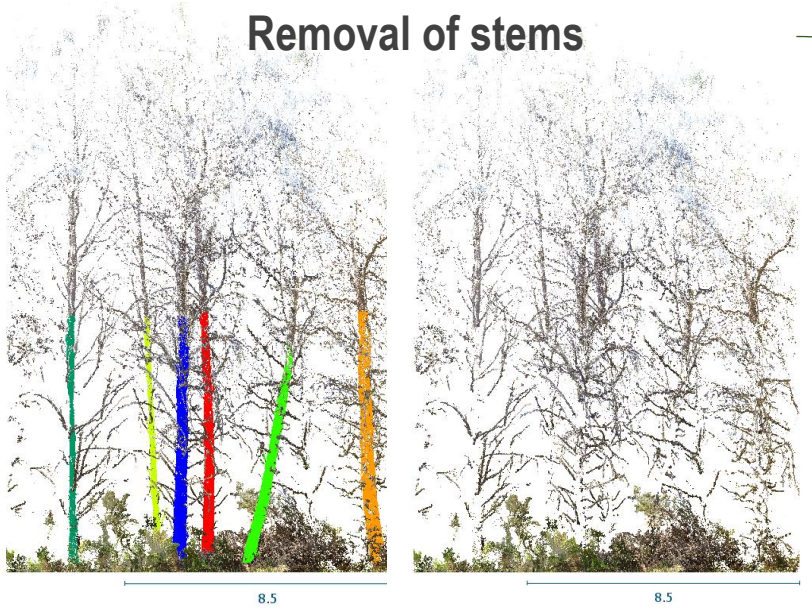


Shrub-canopy interface characterization from the application of Gaussian decomposition

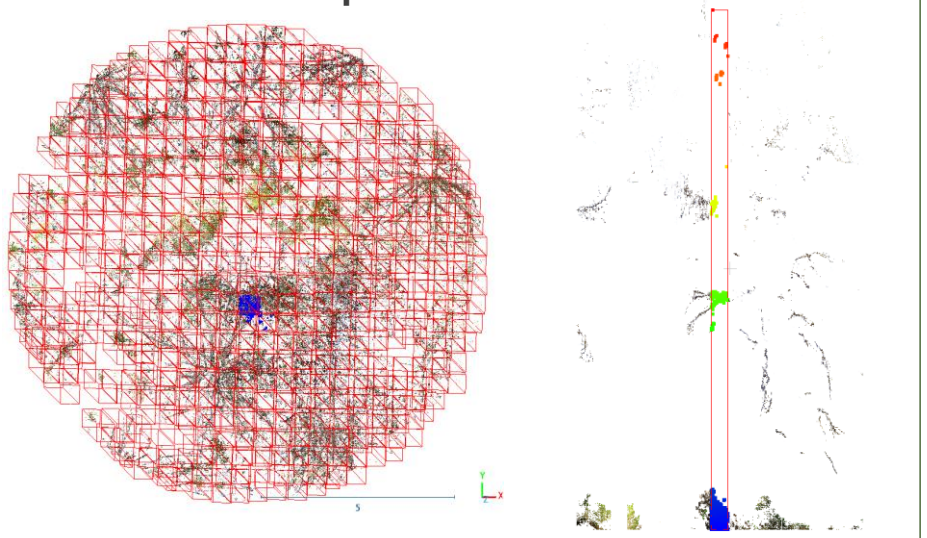
TLS 2015

TLS 2022

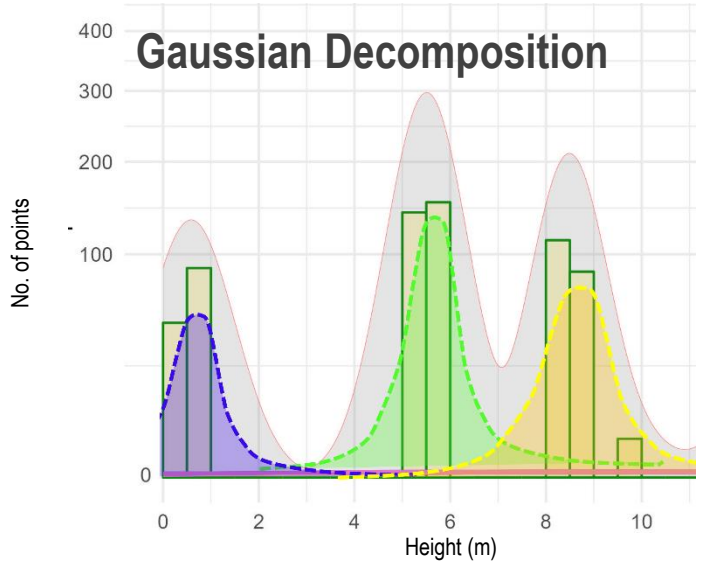
Removal of stems



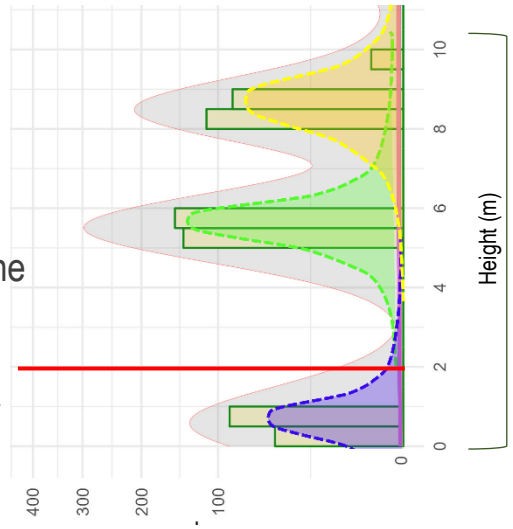
Division of the plots in columns of 0.25 m²



Gaussian Decomposition



- Max. 3 Gaussians
- Mean, standard deviation, and upper and lower limits (95%)



- Possible overlapping of Gaussian curves -- point of intersection.
- Maximum height of the shrubs is close to 2 meters.
- Identification of the upper limit for the shrub curve and the lower limit for the canopy curve.
- Comparison between the two study years

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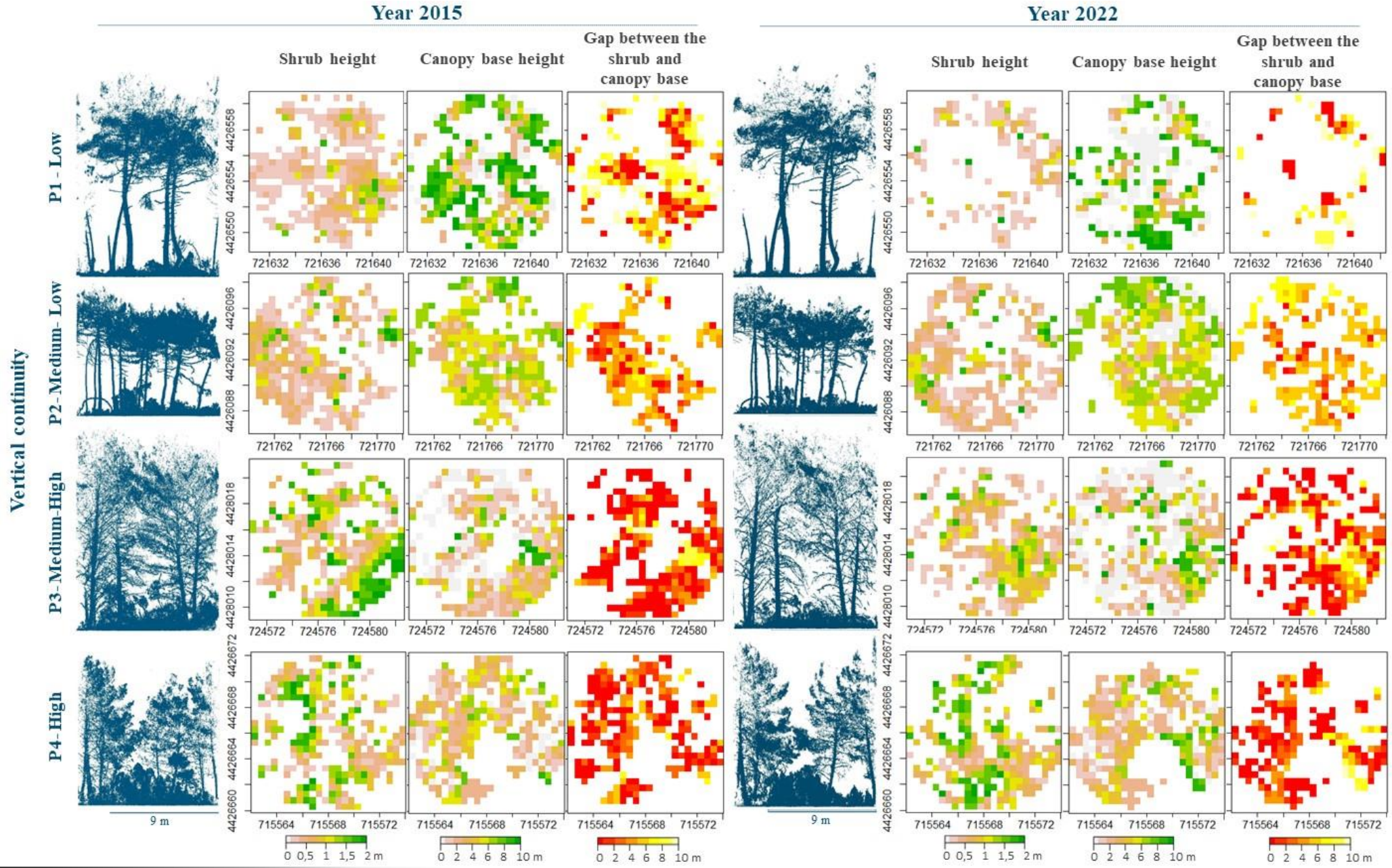
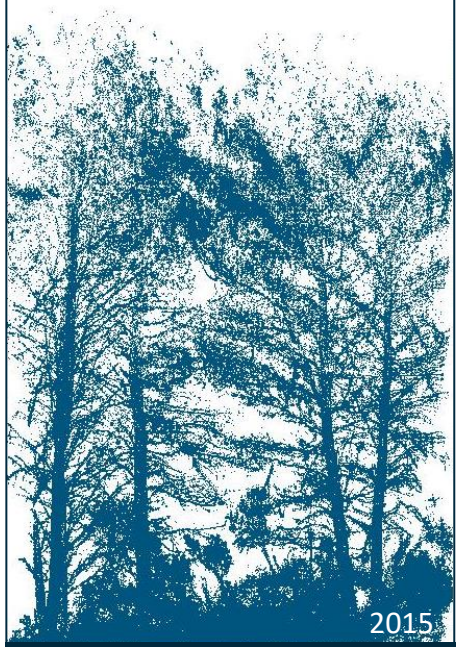
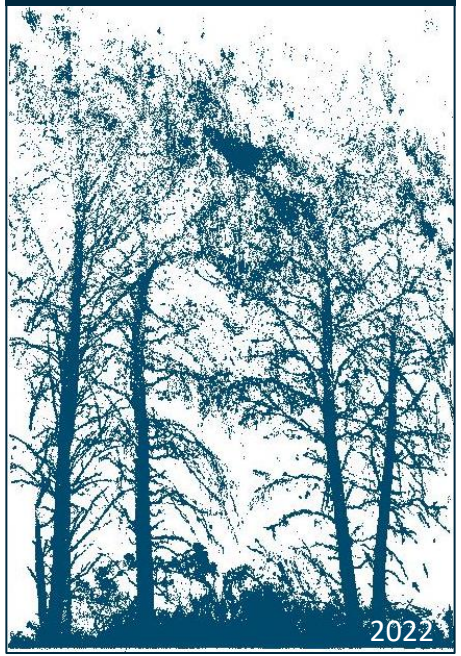
Preliminary results





Work in progress



- Applying Gaussian decomposition allows for efficient discrimination of the shrub from the tree canopy to quantify the variations in connectivity between these strata over years.
- The proposed method is allowing us to analyze the multitemporal variation of the vertical structure using TLS data.

Work to do:

- Validate the results with field data or other methodologies.
- Testing different column sizes and see the most operative size for applying the Gaussian decomposition.
- Better understand density profiles and mapping derived metrics.
- Make a single code to process the data and to distribute.

Acknowledgments

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Thanks!

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