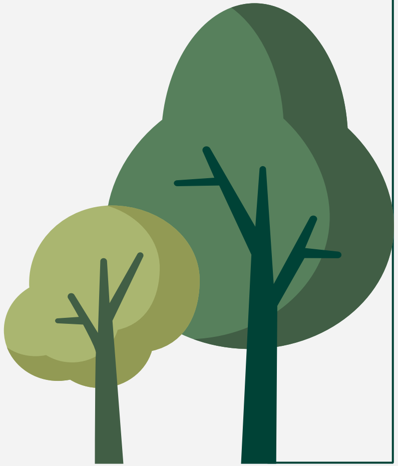
Données, Algorithmes et Applications 3d

Towards large scale forest inventory

Scaling up precision using 3D data



Alvin Opler - 18/03/2025

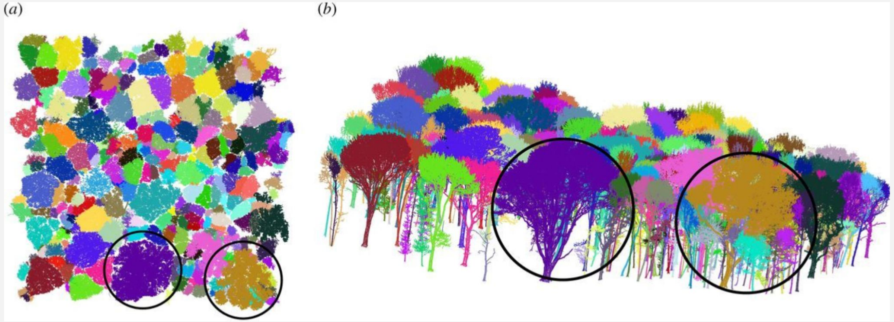
Introduction: Why use 3d data in forestry ?

Wide availability of open-data

Cf all european data open-access

Enables tasks previously hard:

Segmentation
Biomass estimation
Species
Calibration of space-based models
etc.



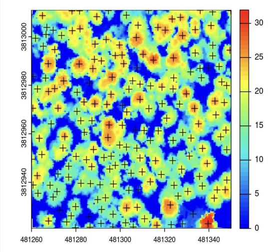
Calders et al. 2024

https://hub.flai.ai/

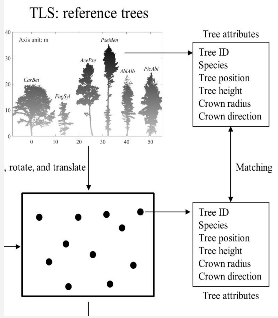
Introduction: Why use 3d data in forestry ?

ALS-like data

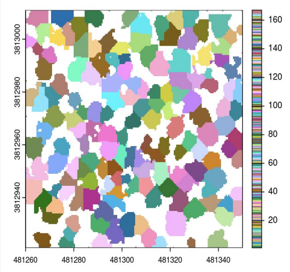
Step 1: Top of canopy detection



Step 2: Tree extraction



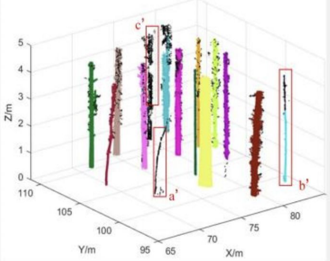
or



Li et al 2024

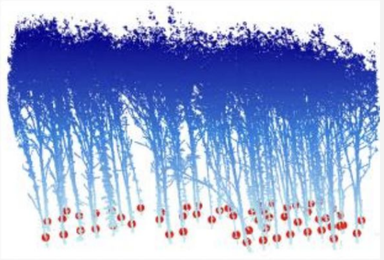
TLS-like data

Step 1: Trunk detection



Initial trunk detection based on DBSCAN

Step 2: Tree extraction



Seed Points

to

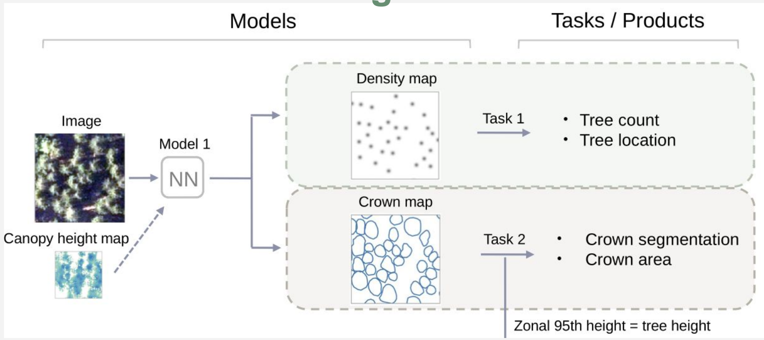
Segmentation results

Chen et al 2024

Introduction: Why use 3d data in forestry ?

ALS-like data

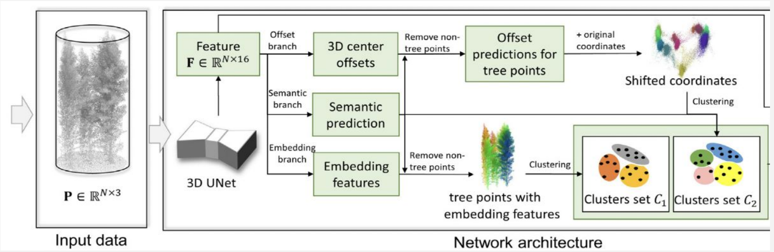
From 3d data to Height model



Li et al 2024.

TLS-like data

Using full 3d data

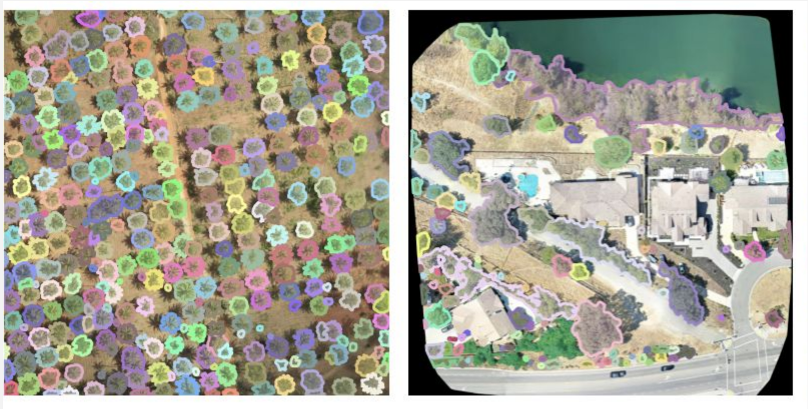


Wang et al 2024.

All supervised learning...

Introduction: Why use 3d data in forestry ?

… but with which dataset ?



Veitch-Michaelis et al. 2024

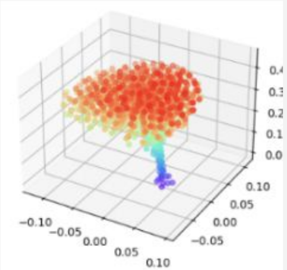
From the largest dataset of tree crowns (280k):

“Since we do not have ground truth for the data, there is some inherent subjectivity in the labels [...] we advise that they be used for open canopy tree mapping only. [...] We make it quite explicit that our model does not delineate dense groups of trees that are touching (closed canopy). [...] you should not use our models for things like tree counting in closed canopy forest.”

Our work: Overview for a self-supervised individual tree segmentation method

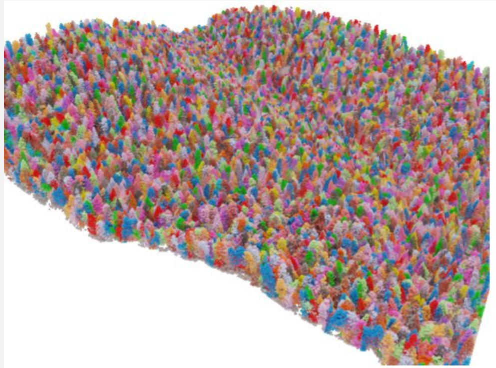
Step 1: Create (a) good 3d tree prototype(s)

- Dataset and method
- Downstream tasks
- Comparison with other methods



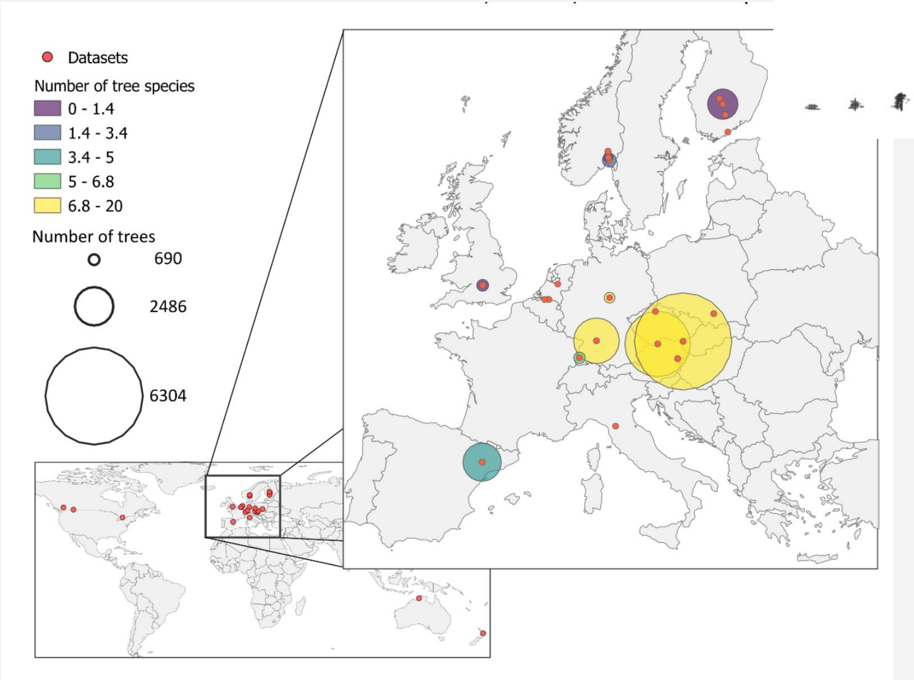
Step 2: Fit the prototype(s) on the Lidar (work in progress)

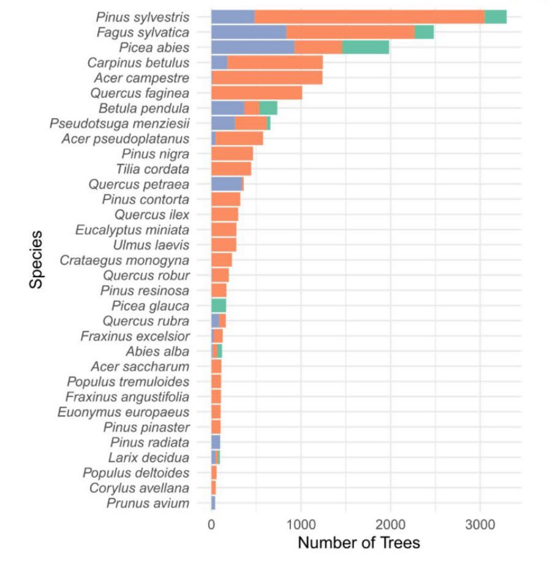
- Method only



I. The prototypes: Dataset

For-Species 20K

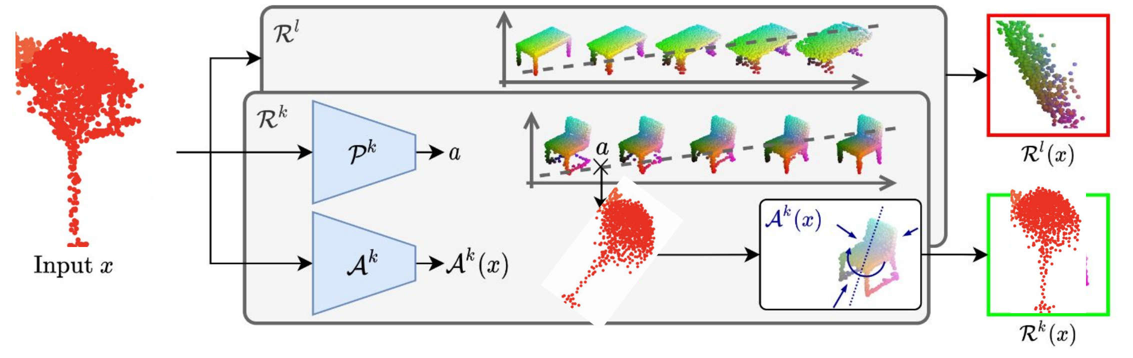




Puliti et al. 2024

I. The prototypes: Method (Model)

What we do...



- K=1 (one prototype)
- D=5 (5 types of deformations)
- Train one model for all species (for now)
- Additional transfo: Anisoscaling, rot Euler 2d
- N_proto = 2000

What we minimise...

$$\mathcal{L}(\mathcal{R}) = \sum_{x \in x_1, \ldots, x_N} \min_{k=1}^{K} d\left(x, \mathcal{R}^k(x)\right)$$

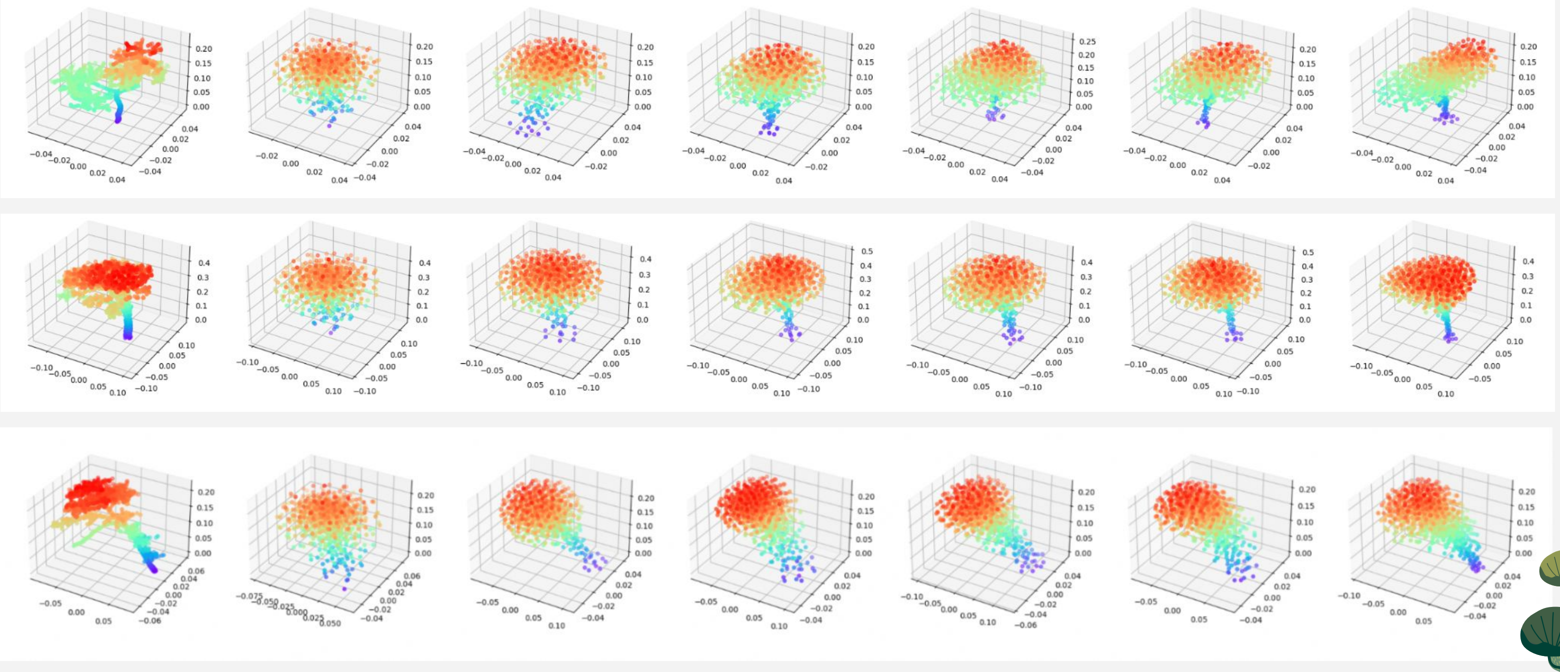
How we do...

$$\mathcal{R}^k(x) = c^k + \sum_{i=1}^{D} a_i \, v_i^k$$

Loiseau et al. 2021

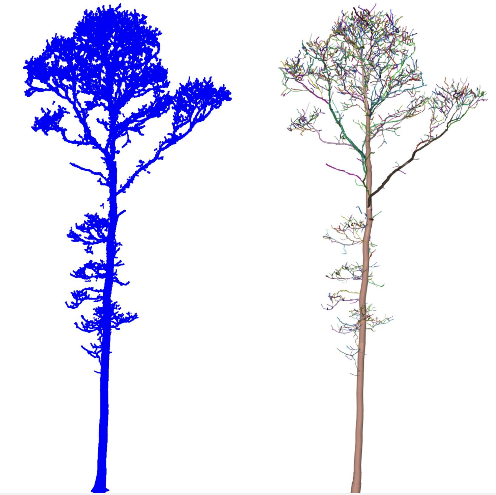
I. The prototypes: Reconstruction

Input D=1 D=2 D=3 D=4 D=5 D=20



I. a) Downstream task: Volume estimation
The contenders of our method

Tree QSM



Pros: Very good precision
Cons: Slow (2 m 30s per cloud), need consequent storage

Allometric equations

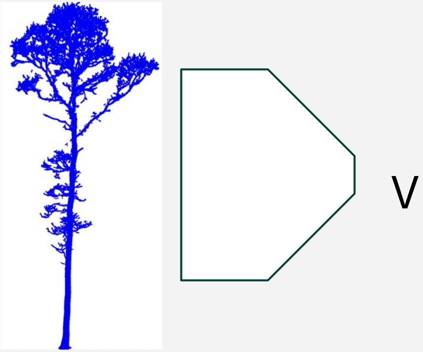
$$\text{Model 1 } (m1): V = A_0 \, D^{a_1}$$

$$\text{Model 2 } (m2): V = B_0 \, D^{b_1} H^{b_2}$$

$$\text{Model 3 } (m3): V = C_0 \, D^{c_1} H^{c_2} CA^{c_3}.$$

Pros: Easy, can have a biomass value from CA and H only
Cons: Underestimation of big trees, not so reliable...

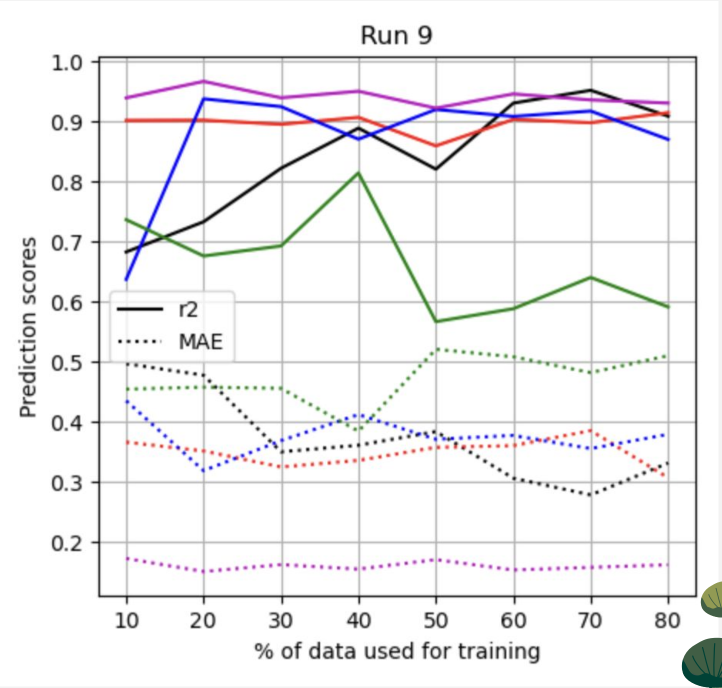
Deep regressor



Pros: Good precision
Cons: In the next slide...

I. a) Downstream task: Volume estimation Comparison

Exp name	ForSpecies20k	Volume data (Calders)
Ours (transfer)	100%	x%
Ours (no transfer)	NA	x%
Deep regressor	NA	x%
Allometries (H,D,CA)	NA	x%
Allometries (H,CA)	NA	x%

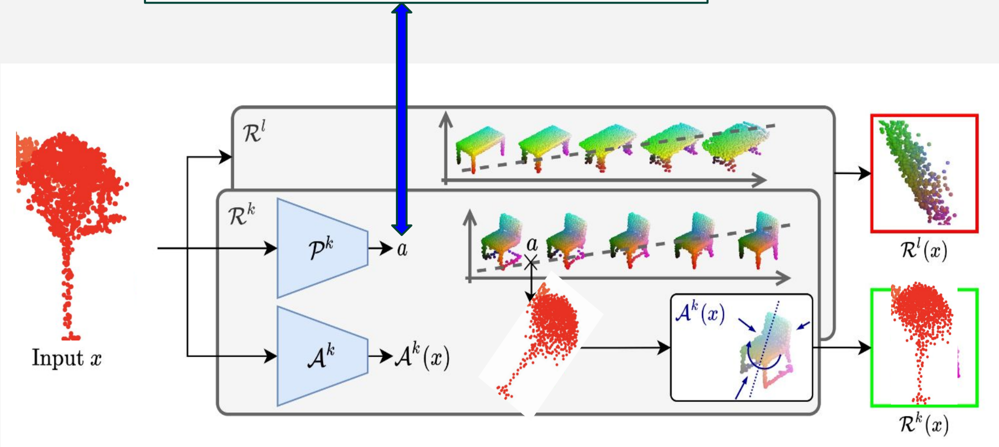


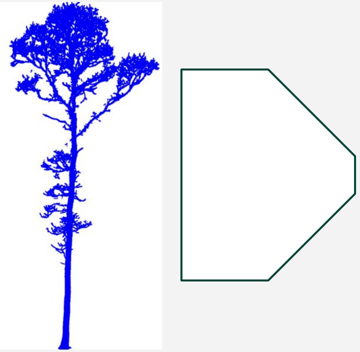
I. b) Downstream task: Species prediction methods

Ours (modified)

Classifier

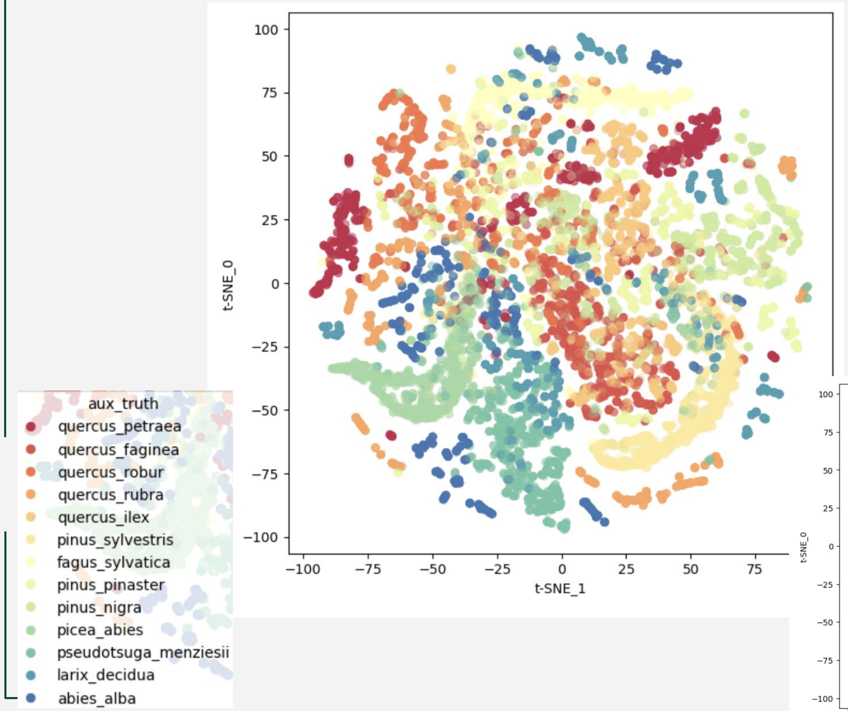
Contrastive loss between the a



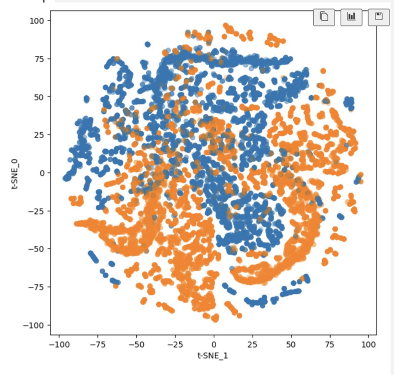


Class

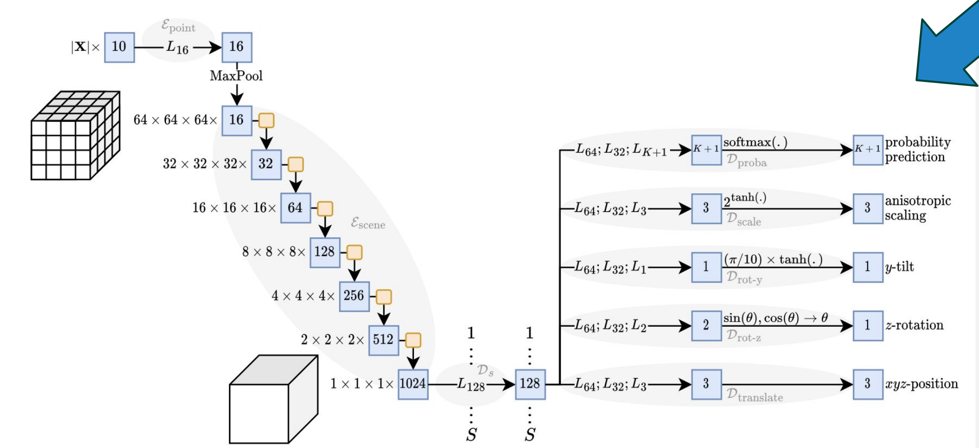
I. b) Downstream task: Species prediction Comparison

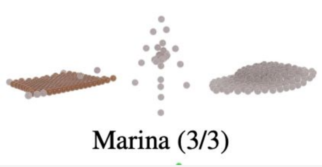


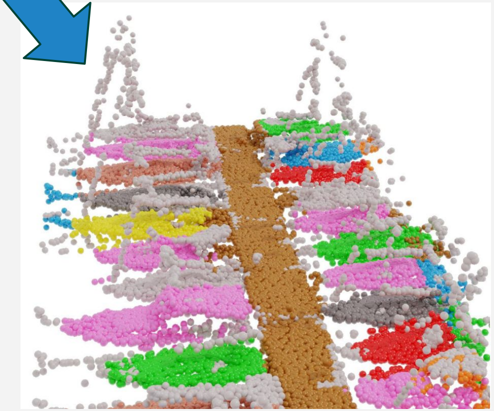
Method	Ours (D=5)	Classifier
OA	0.67	0.7
Best class F1	0.86	0.79



II. Fitting of the prototypes
Learnable Earth Parser



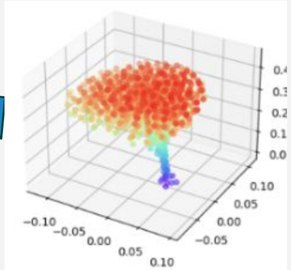


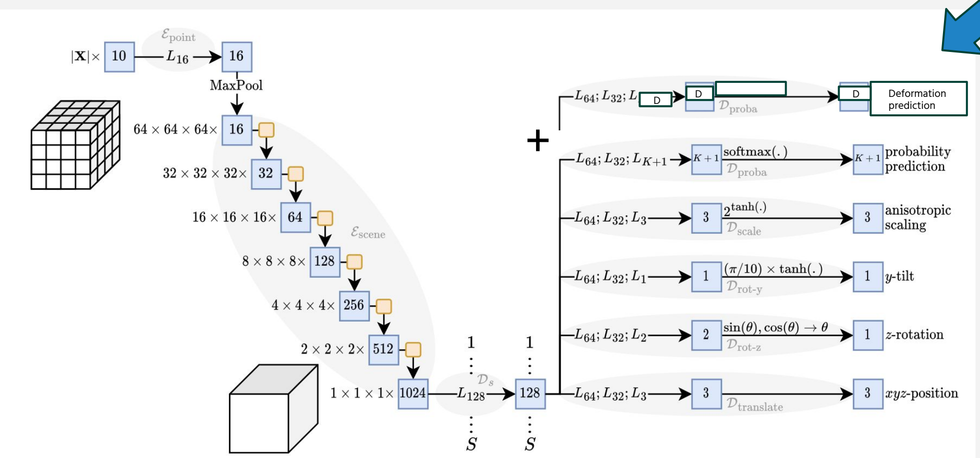


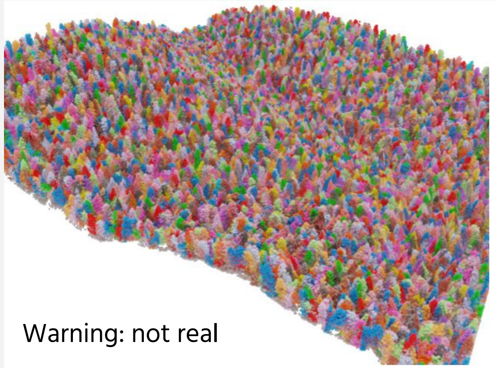
Loiseau et al 2024

II. Fitting of the prototypes (Work in progress)

Learnable TREE Parser







Conclusion

We developed an new **alternative to QSMs**
- Can be applied on large scale (low storage, low latency)
- Keep gross **structure of tree**
- Can be used to extract a estimation of the tree specie

We are developing a large scale use of these prototypes
- So we can extract single tree from point cloud **in an unsupervised way**
- While keeping essential individual tree info
  - LAI, Specie, Biomass, etc.

Thank you !!