

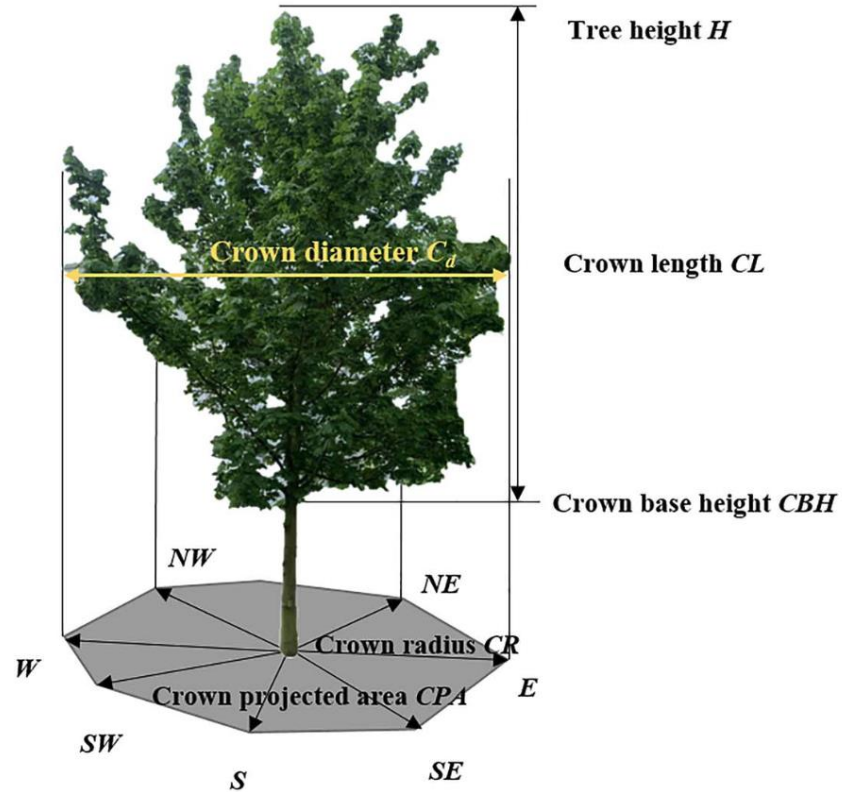


Validation Challenges in Large-Scale Tree Crown Segmentations from Remote Sensing Imagery Using Deep Learning: A Case Study in Germany

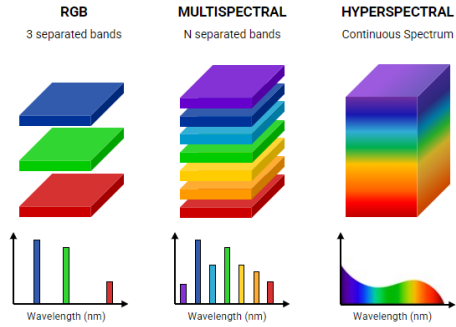
Taimur Khan¹, Jasmin Krebs, Sharad Kumar Gupta, Jonathan Renkel, Caroline Arnold, Nils Nölke

¹Data Scientist @ Community Ecology, **RU1**

About Tree Crowns



Imaging Platforms



Satellite



Aerial/airplane



Drone



Imaging Platforms

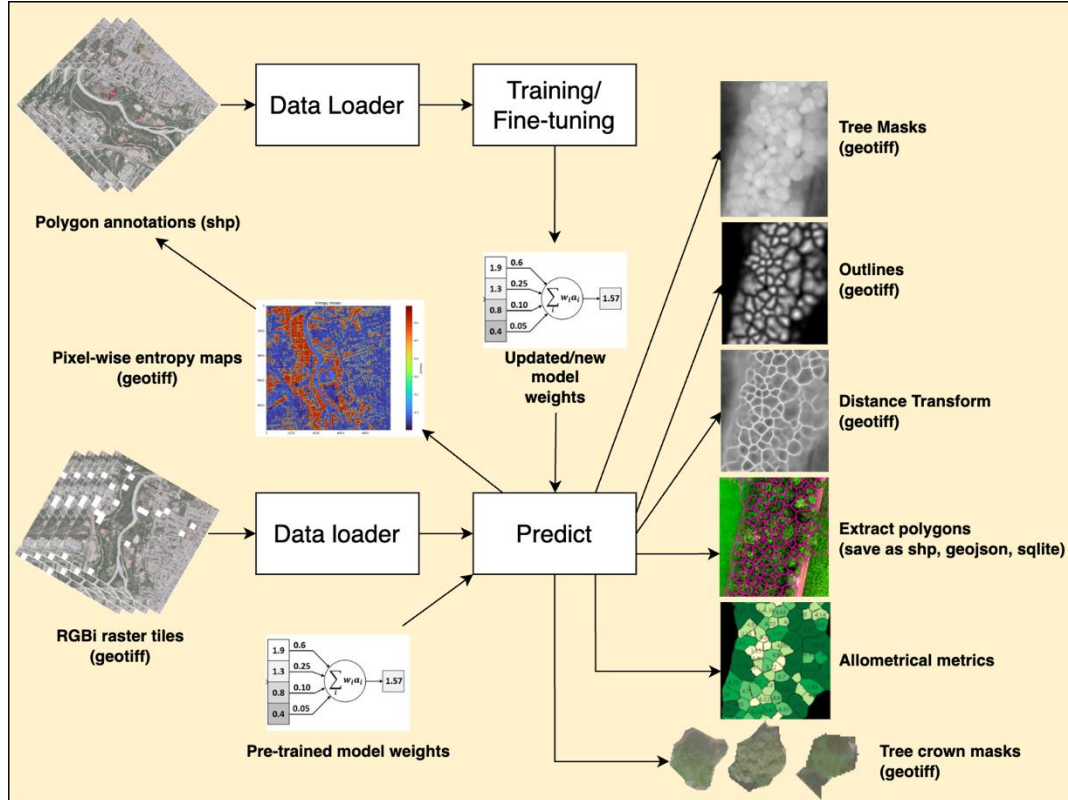


Imagine platform overview.

Source: <https://blog.aerobotics.com/drones-satellite-or-planes-which-aerial-imagery-is-right-for-farming>

DeepTrees Python Package

<https://deeptrees.de>

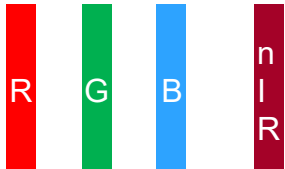


Digital Orthophotos



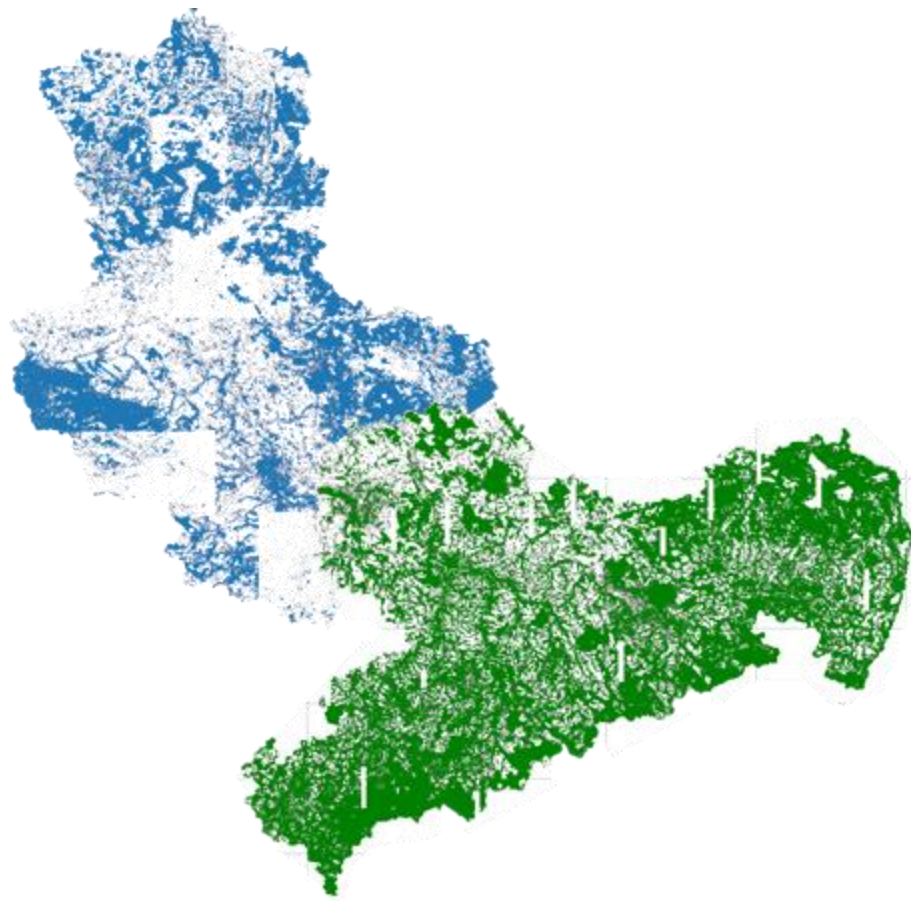
ATKIS®

Amtliches
Topographisch-
Kartographisches
Informationssystem



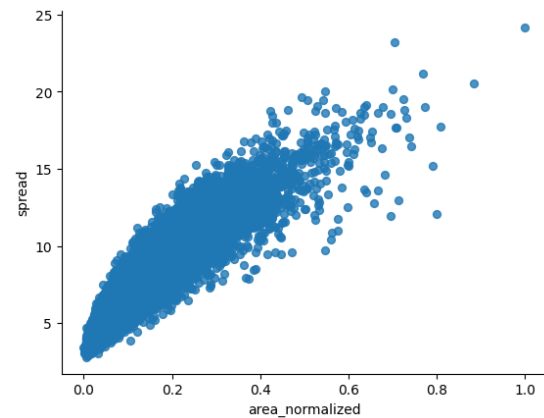
20 cm	40 cm	100 cm
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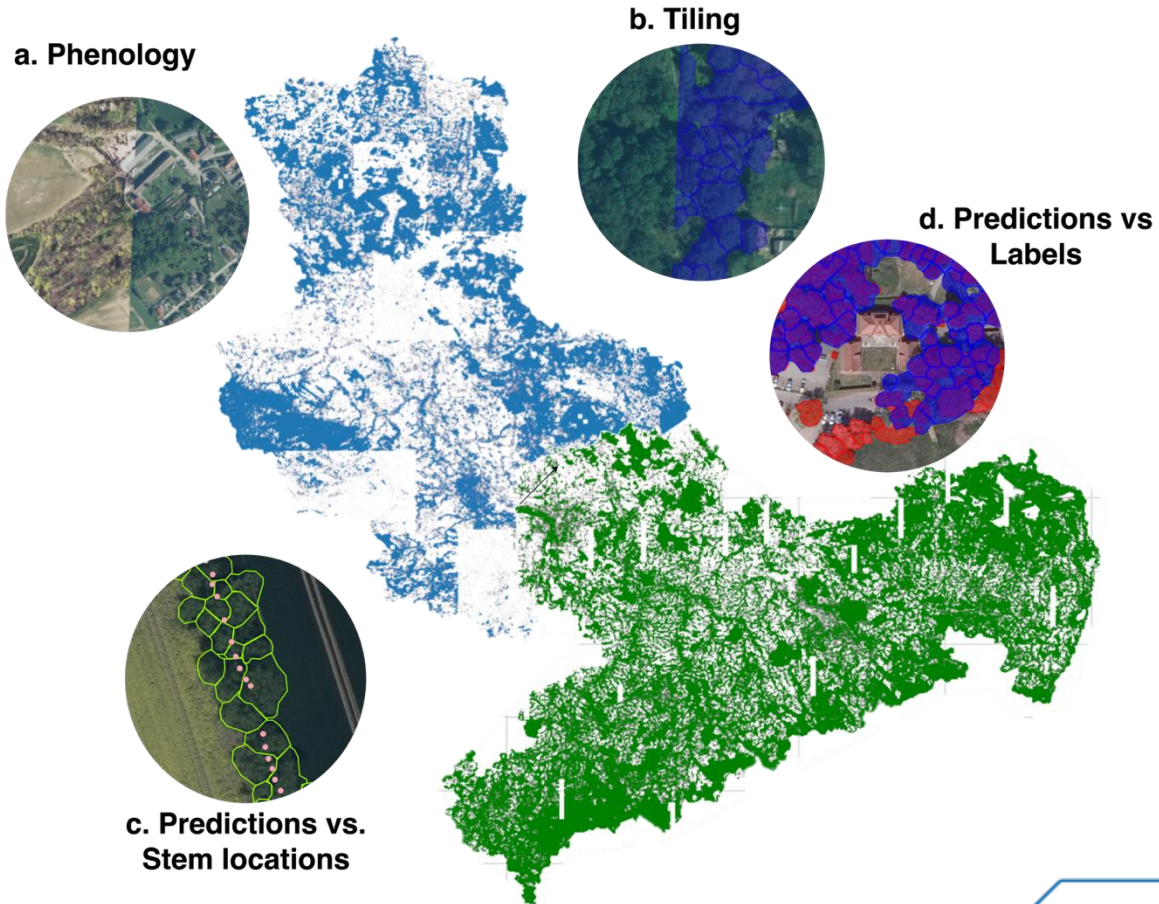


Total segmented tree crown
individuals in SN + ST:

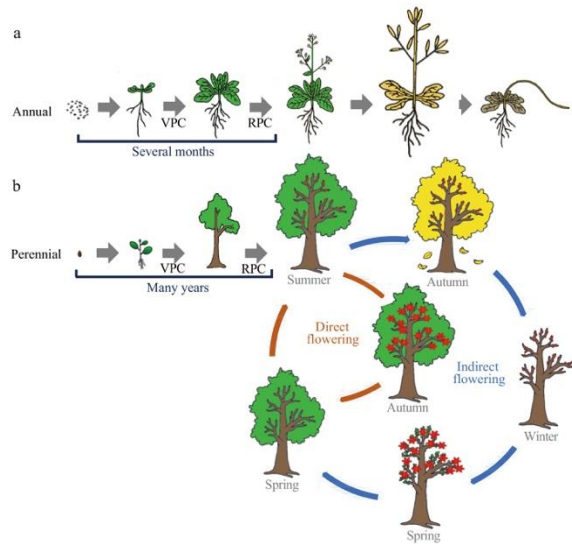
218.742.901



Challenges



Phenology



Wang 2023.

DOP Source: <https://www.lvermgeo.sachsen-anhalt.de/de/gdp-dop20-auswahl.html>



Phenology

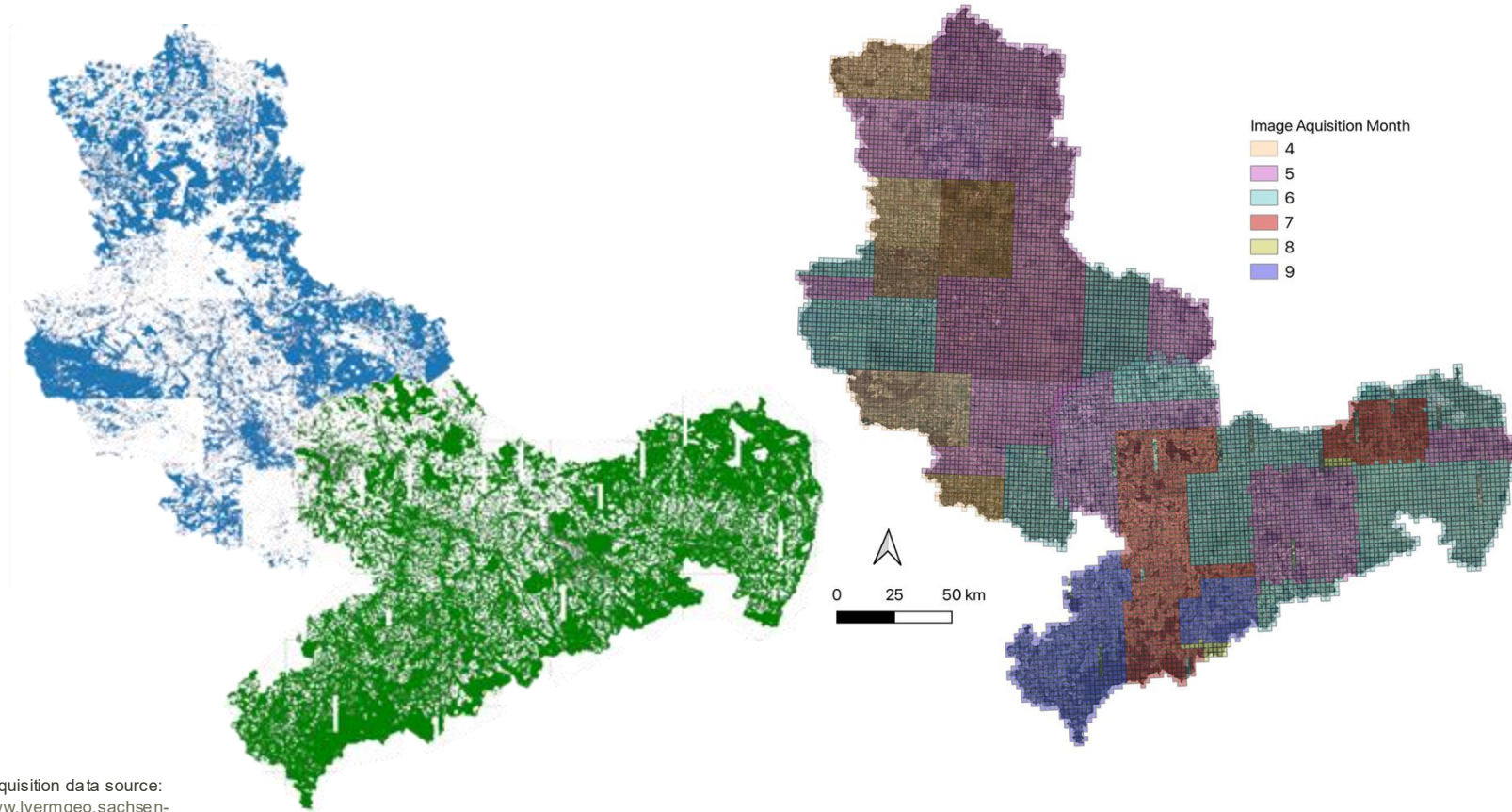
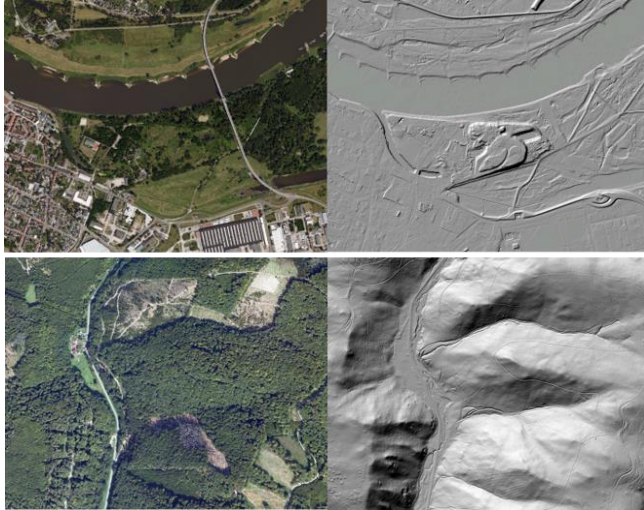


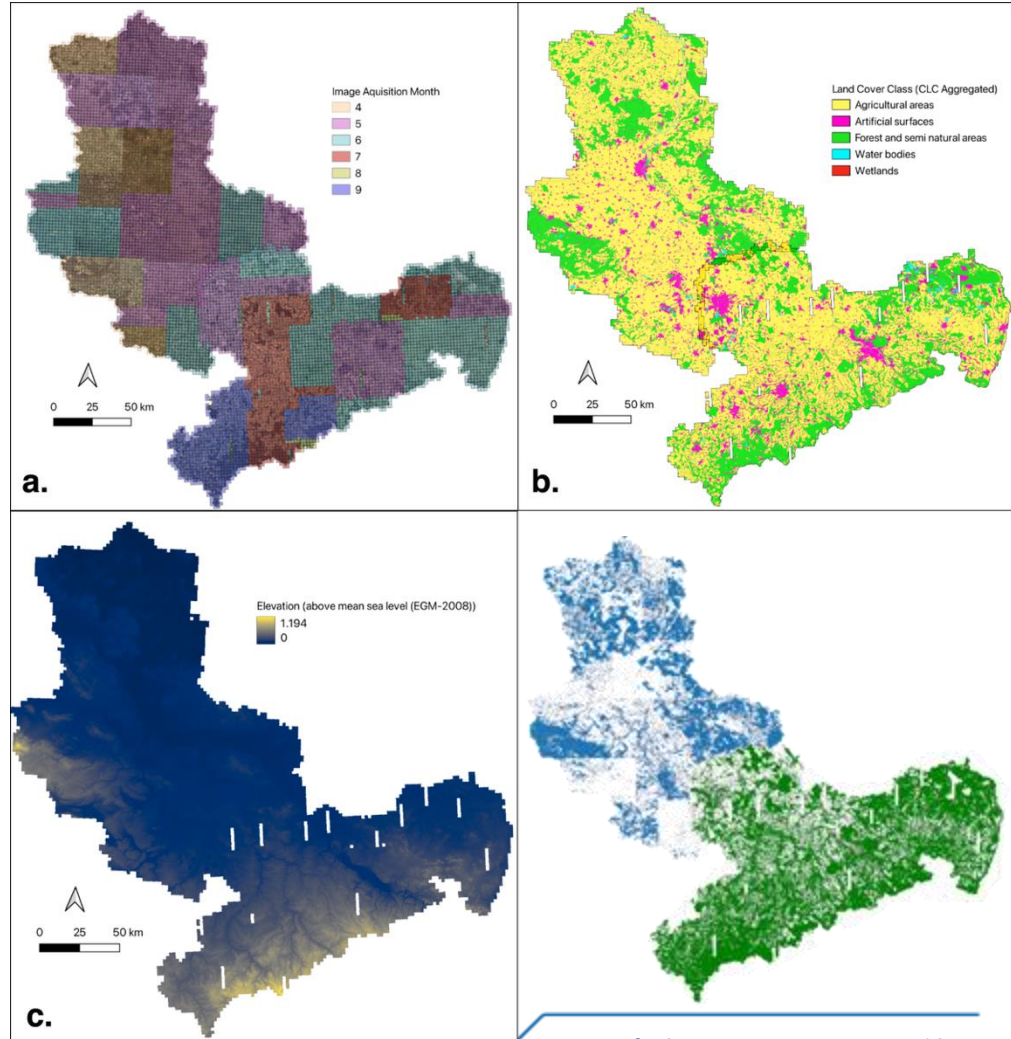
Image acquisition data source:
<https://www.lvmgeo.sachsen-anhalt.de/de/gdp-dop20-auswahl.html>

Spatial and Illumination Heterogeneity

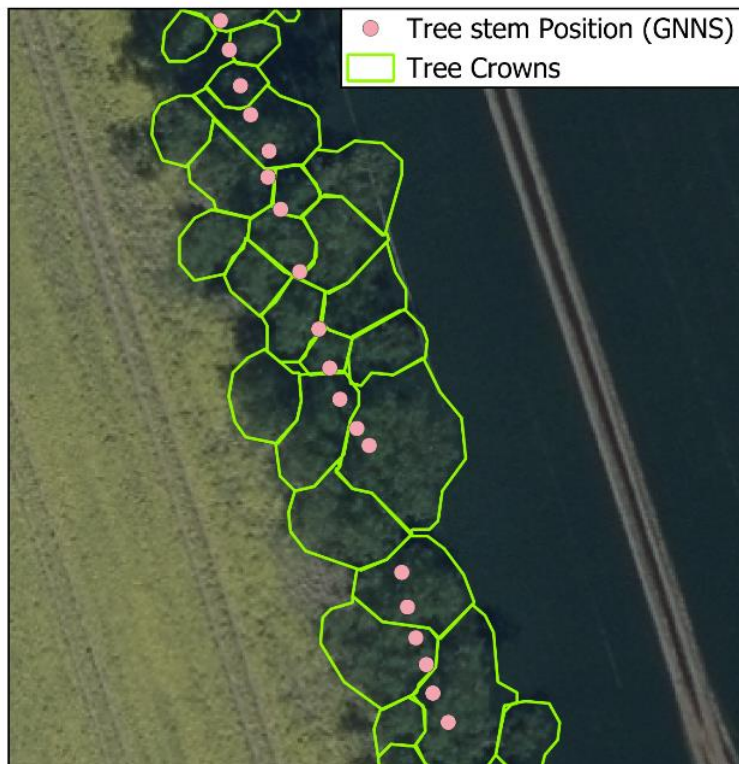


Khan et al., 2025b.

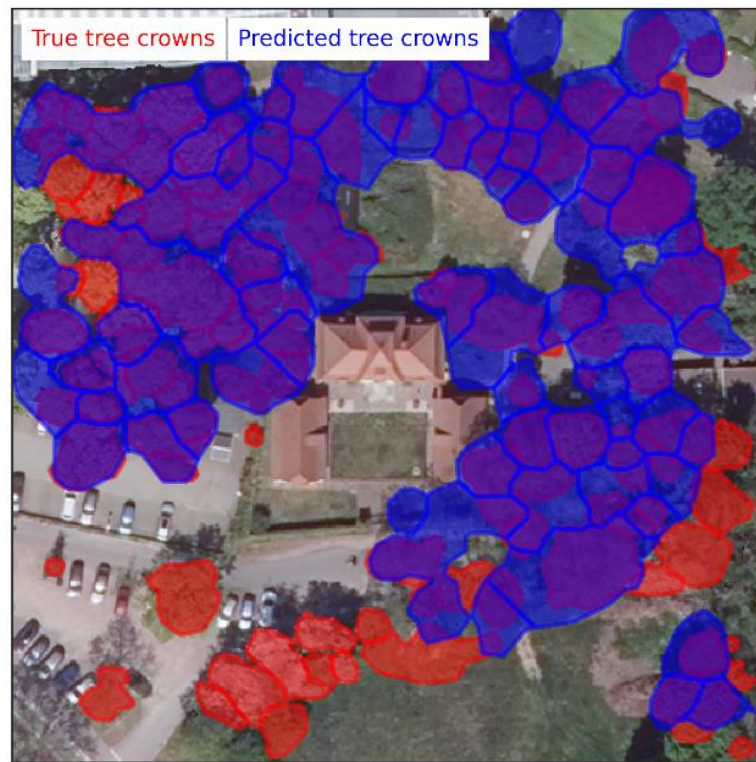
Image acquisition data source:
<https://www.lvermgeo.sachsen-anhalt.de/de/gdp-dop20-auswahl.html>



Ground Truthing

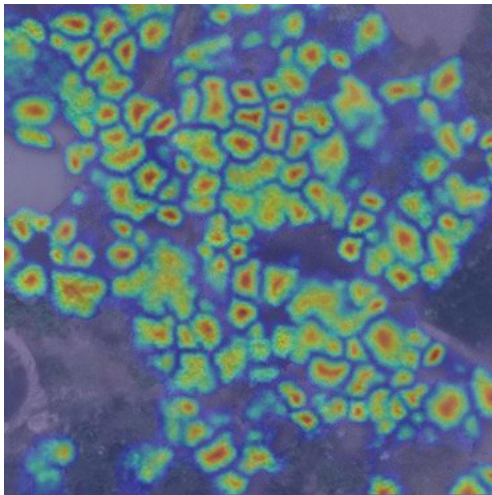


a) Predictions vs stem locations



a) Predictions vs hand-annotated polygons

Active Learning



Entropy is a measure of model confidence. White tiles need labels as they have lower mean entropy.



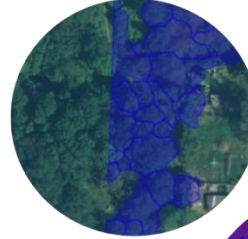
Recommendations

a. Phenology

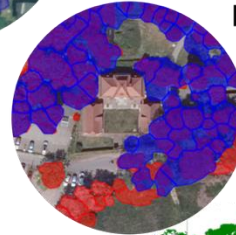


- Leverage self-supervised learning (SSL) and integrate multi-view/multi-temporal data.
- Use SSL to pre-train models on diverse, unlabelled imagery, and incorporate multi-view/multi-season data to build invariance to phenological and illumination changes. This enhances generalizability and reduces the need for extensive labelled data.

b. Tiling

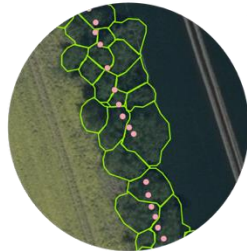


d. Predictions vs Labels

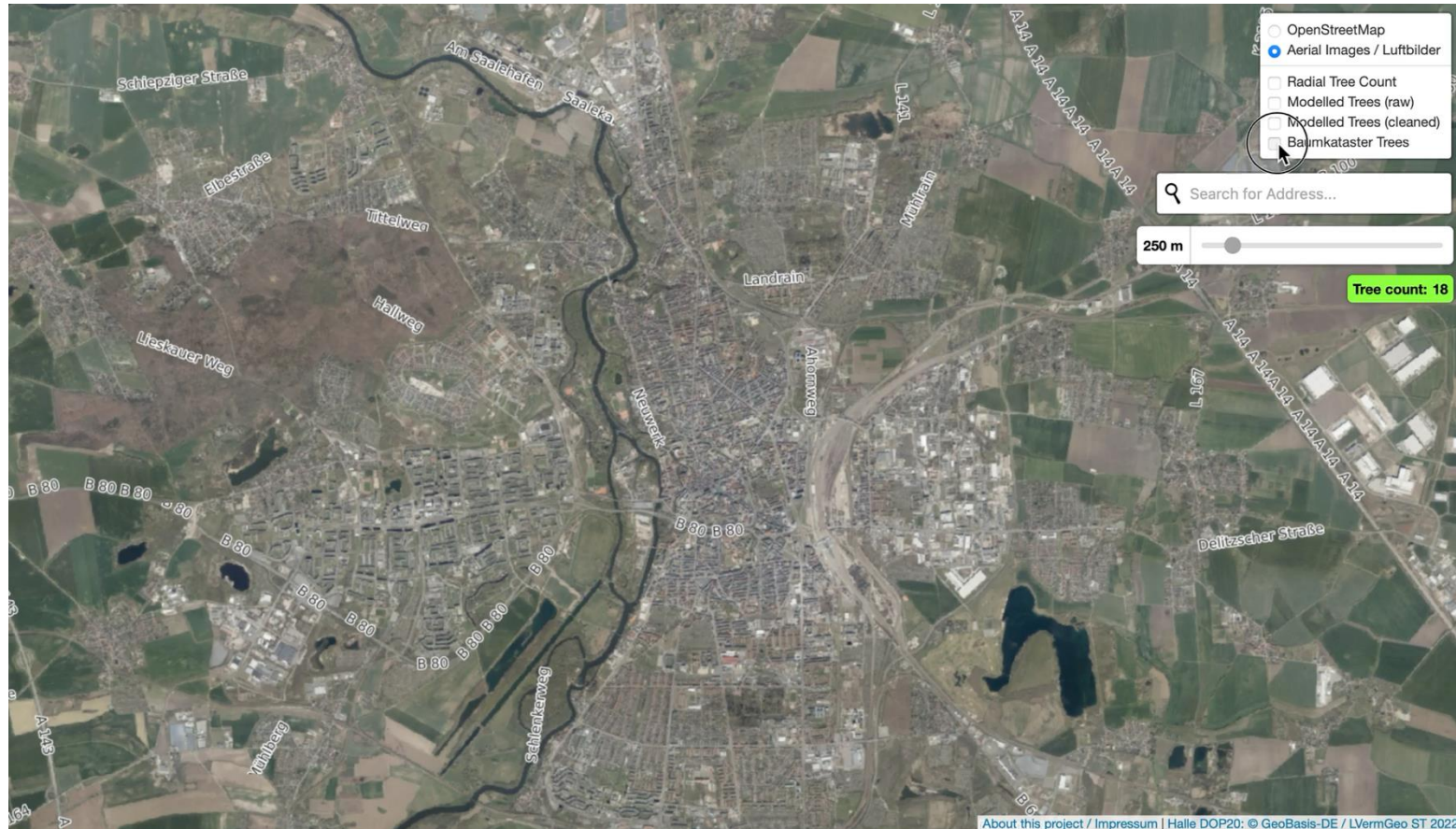


- Establish community benchmarks and evaluation frameworks. Develop standardized datasets, protocols, and metrics for tree segmentation. Community benchmarks should cover diverse landscapes and seasons, and include multi-scale and ecological consistency checks for robust, comparable validation.
- Innovate in ground-truth data collection and labelling. Combining automation (e.g., AI-equipped drones), crowdsourcing, and active learning to expand and diversify validation datasets. Open data sharing and targeted expert annotation can further close the validation gap.

c. Predictions vs. Stem locations



Visualising the “data gap”

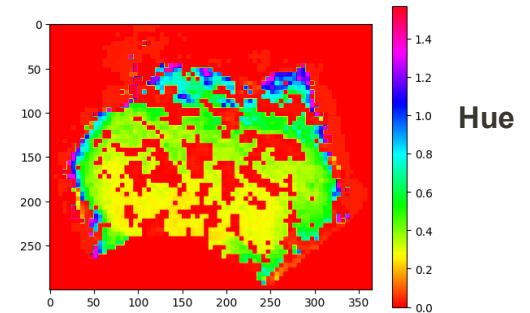
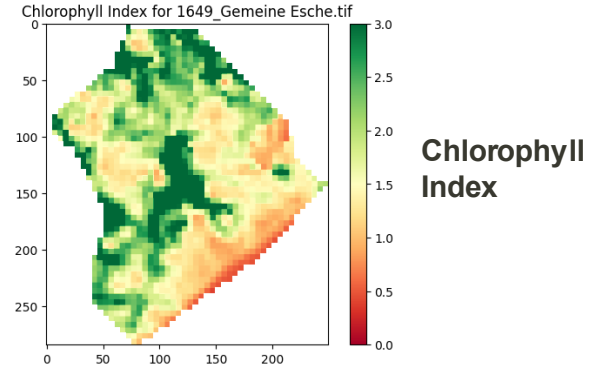
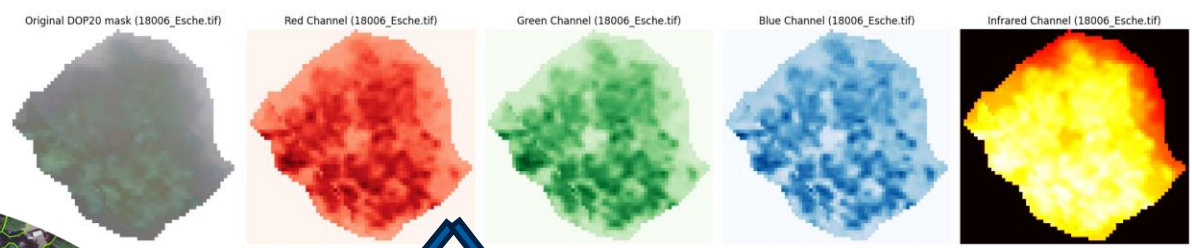
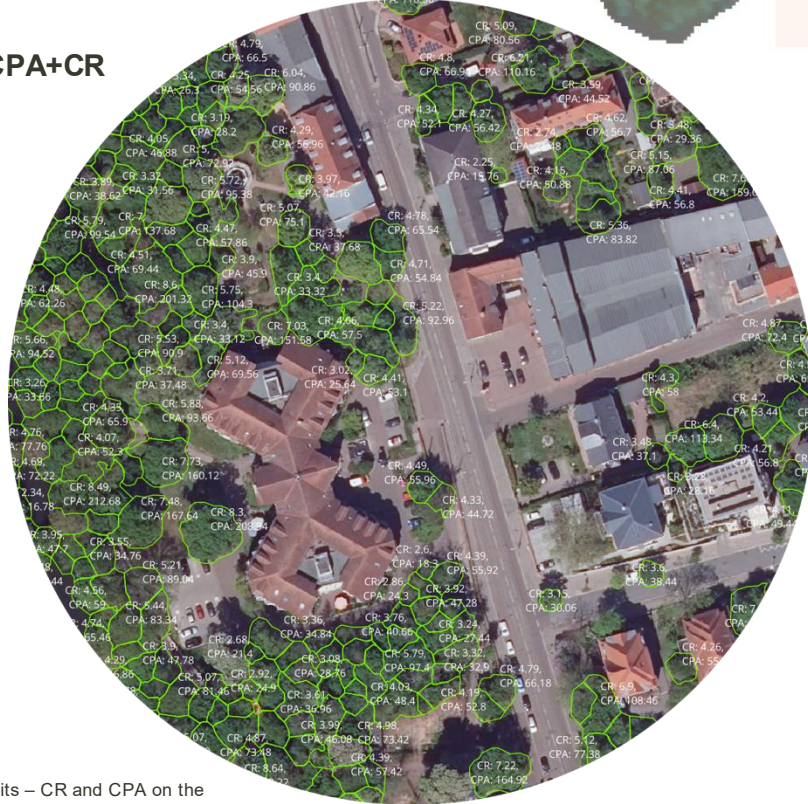


Visualisation of the Halle Baumkataster Trees and Modelled trees.

Source:
<https://halletrees.de> ©
Taimur Khan 2023. Halle
DOP20: © GeoBasis-DE /
LVermGeo ST 2022

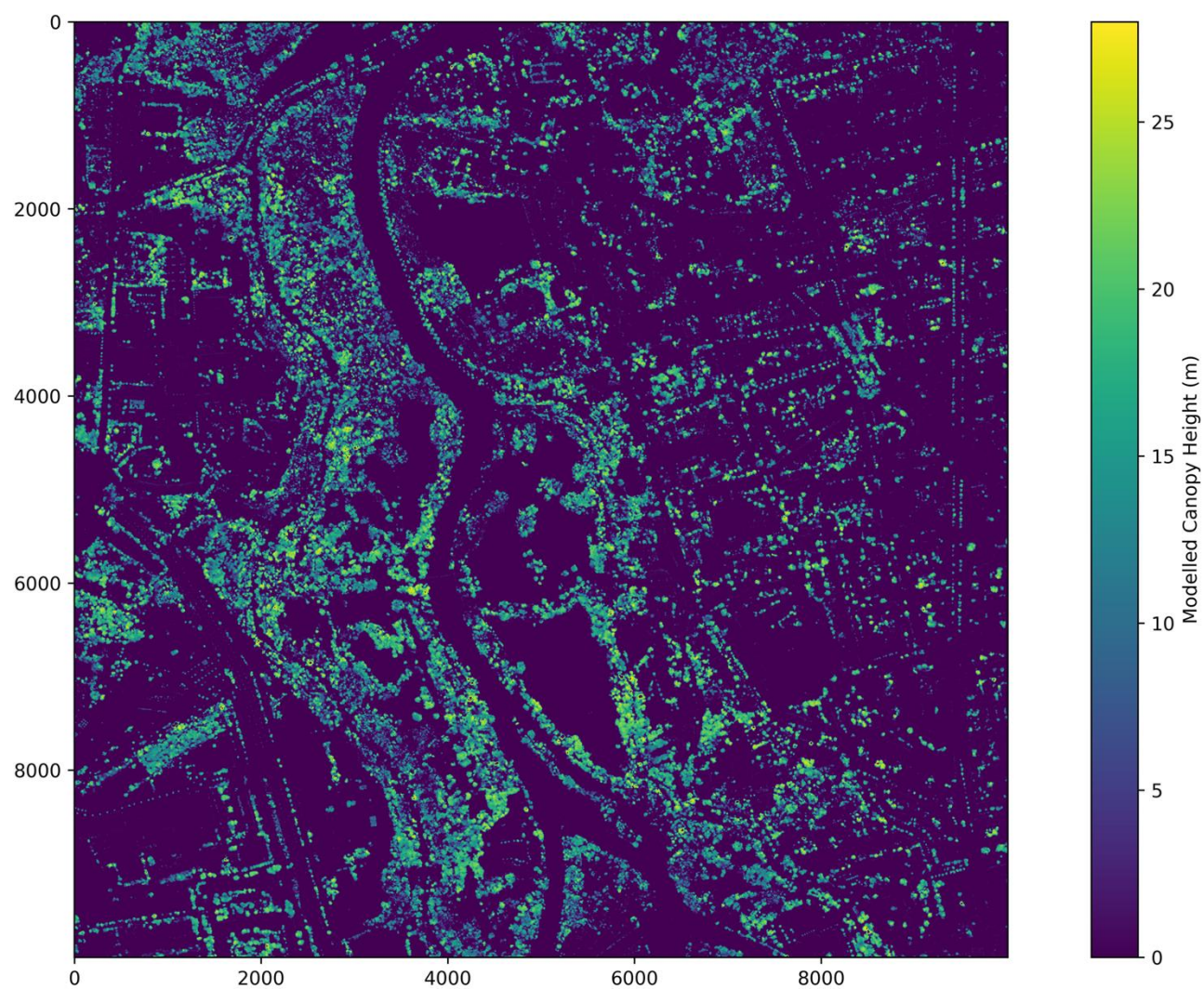
Tree traits

CPA+CR



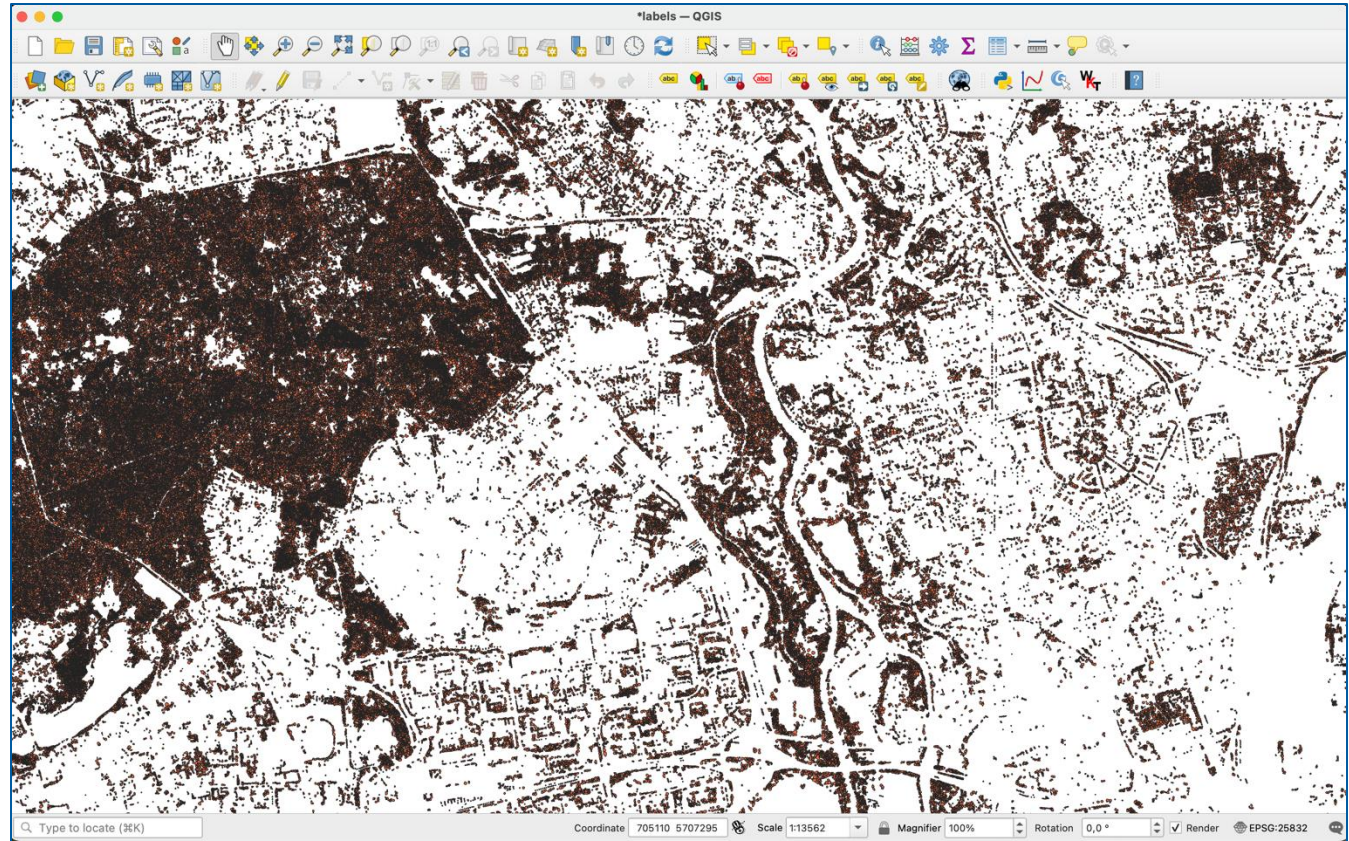
Tree traits – CR and CPA on the right, Chlorophyll Index and Hues on the left. Khan et al., 2025a.

Canopy Height Modelling (CHM)



CHM for a single DOP20 tile in Halle.
Source: Tolan et al., 2024

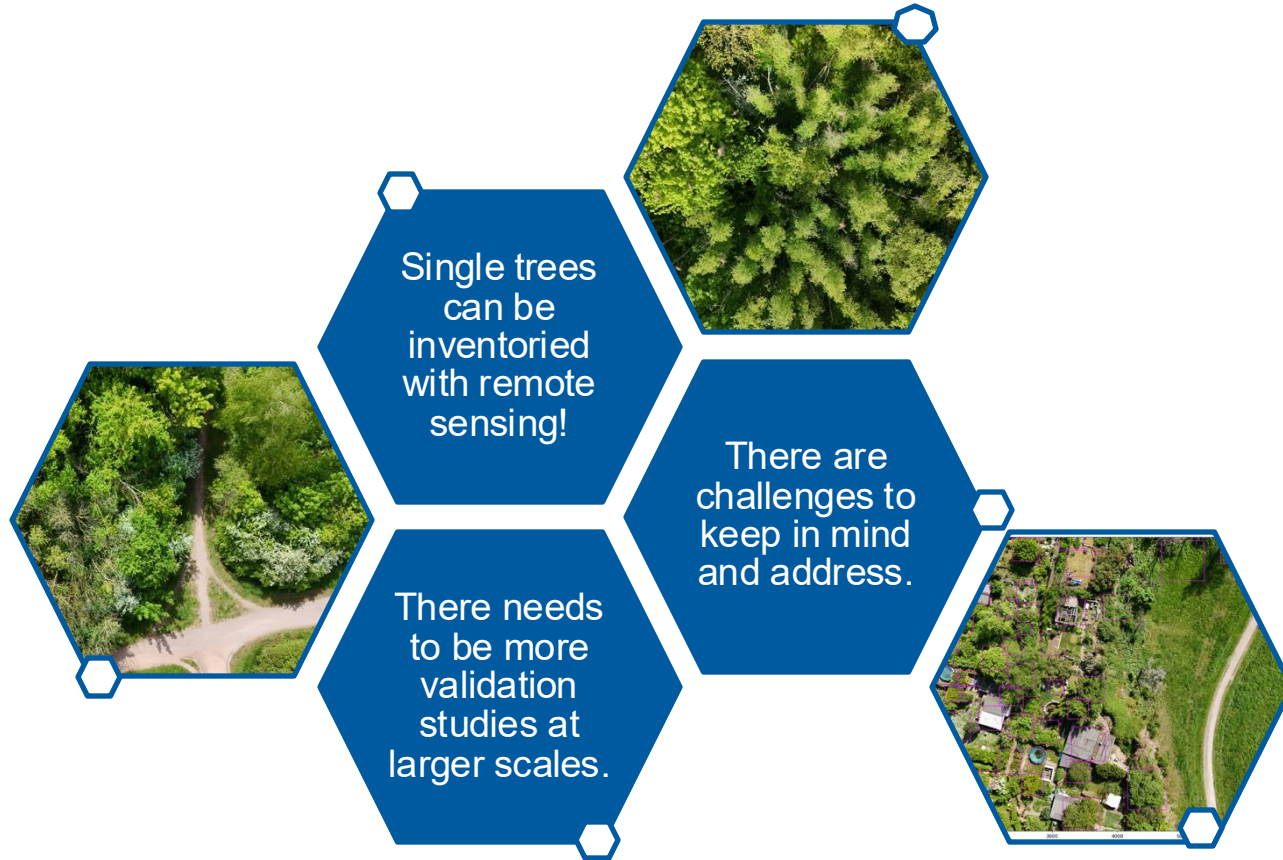
DeepTrees database



Overview of “DeepTrees” tree inventory database connected to QGIS.

Source: Taimur Khan © 2023.

Take Home



References

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DeepTrees Website



Interactive Map



Map Password: deeptrees2025

An aerial photograph of a dense forest with a variety of green trees. A light-colored dirt path winds through the trees, starting from the bottom center and branching out towards the right side of the image. The text "Thank You!" is centered in the middle of the image.

Thank You!