BLACK FOREST FORECASTER

Classifying leaf trees
using remote sensing data and neural networks

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The Team

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Outline

01 **About the project**
Forest monitoring, data product

02 **The basics**
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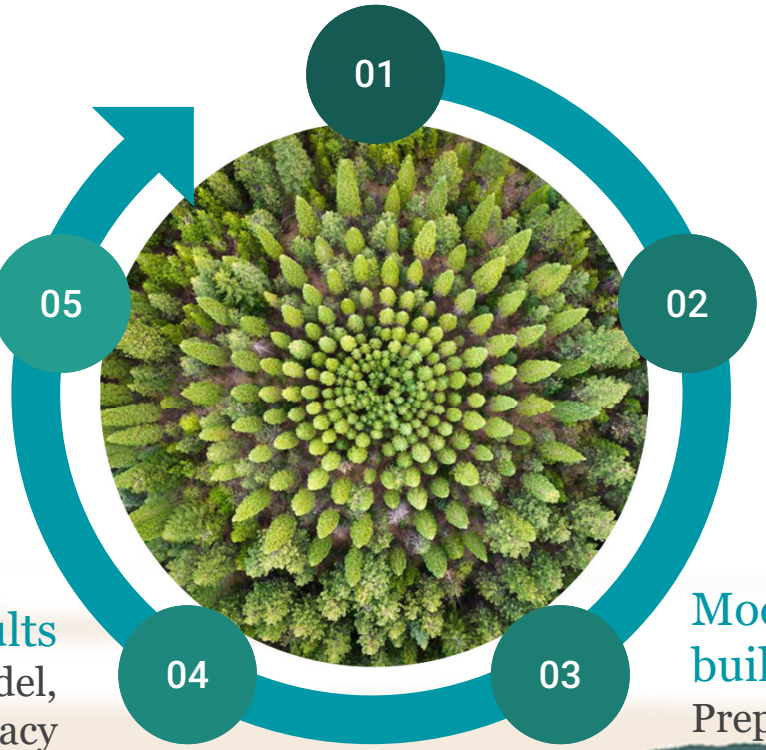
03 **Model building**
Preprocessing, baseline

04 **Results**
Best model, classification accuracy

05 **Outlook**
Where to go from here



Forest monitoring

- Economical and ecological reasons for forest monitoring

- 5% (~ 5000 km²) forest loss in Germany (2018 - 2021)
  due to storms, heat waves, diseases, infestations…
  -> 13 billion Euros

➡ Identification, mapping and monitoring
of tree species

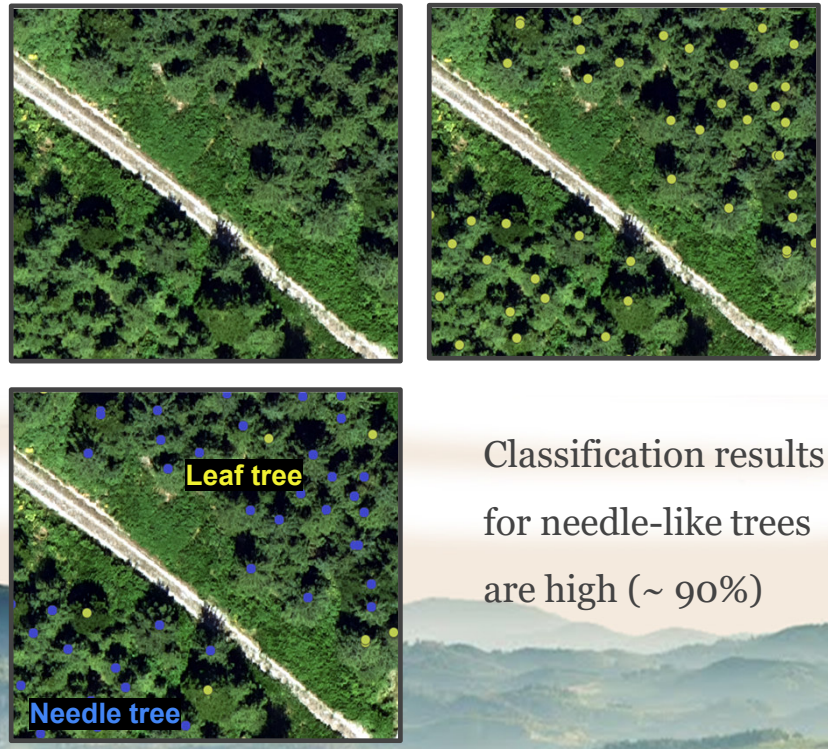
➡ Cost-efficient and applicable on a large scale

Nationalpark Schwarzwald

- Established 2014
- First national park in Baden-Wurttemberg
- Location: main ridge of northern Black Forest
- Size: 100.62 km²
- Large parts covered by mixed mountain forests

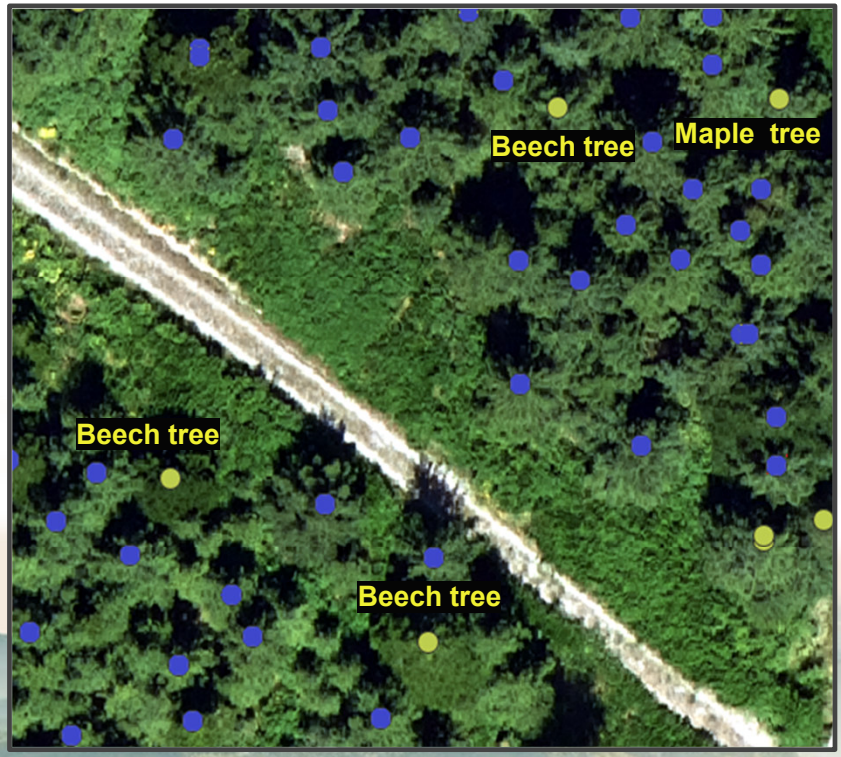
Data products

01 System that automatically extracts individual leaf trees along with their coordinates from an aerial image



Classification results for needle-like trees are high (~ 90%)

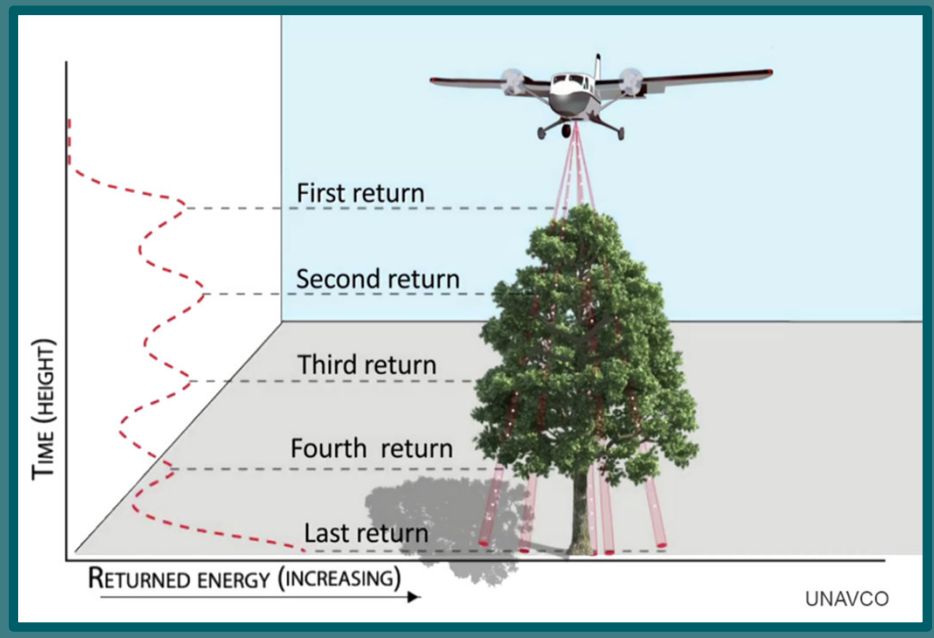
02 A system that can distinguish three types of leaf trees and calculate their frequency in a selected area

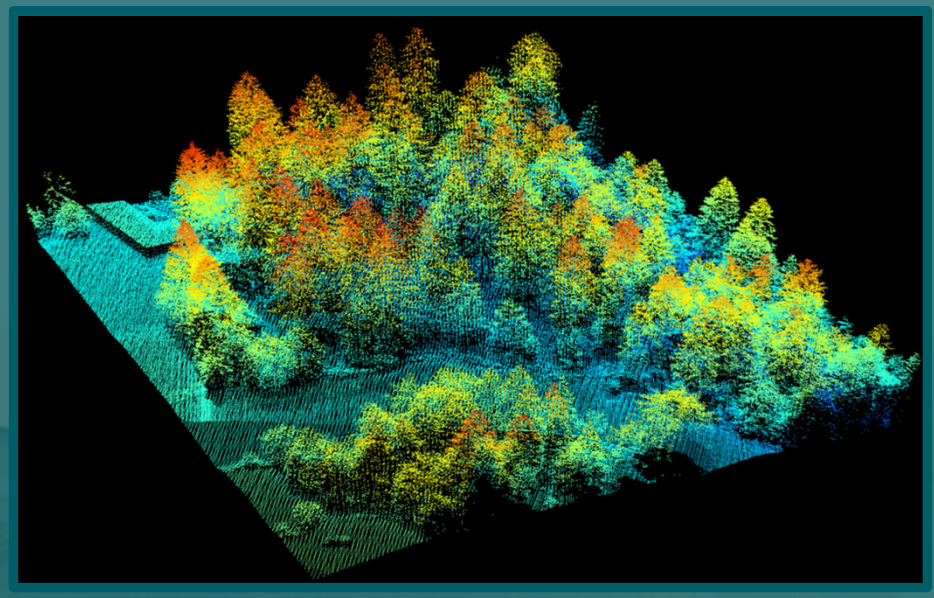


Remote sensing

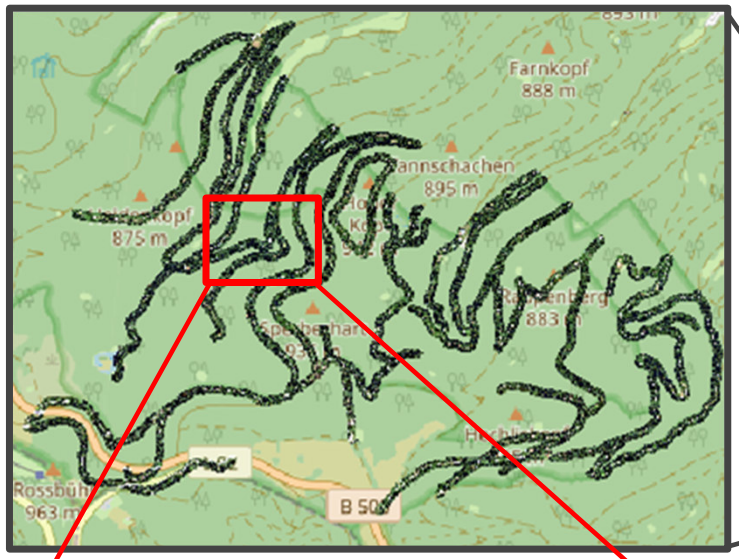
Data collection with sensors that are mounted on an aircraft

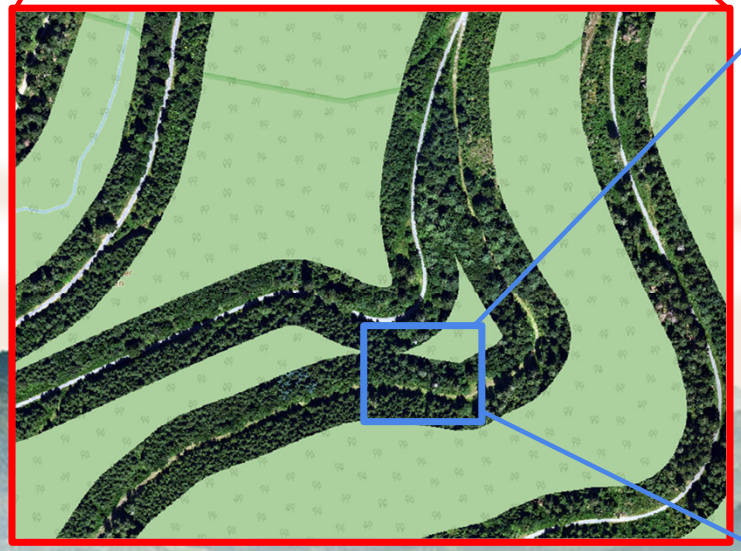
- RGB-IR camera
- Light detection and ranging unit (LiDAR): Detection of reflected pulses of laser beams from which point clouds of the ground and its objects can be created

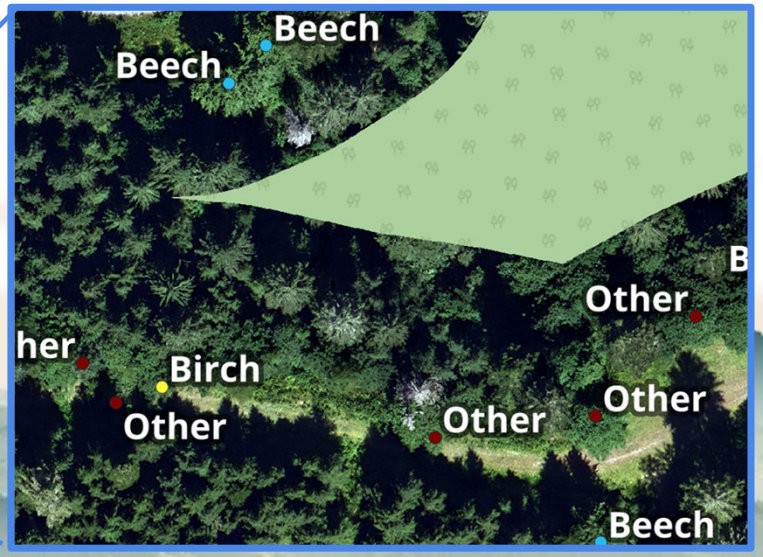




Data basis

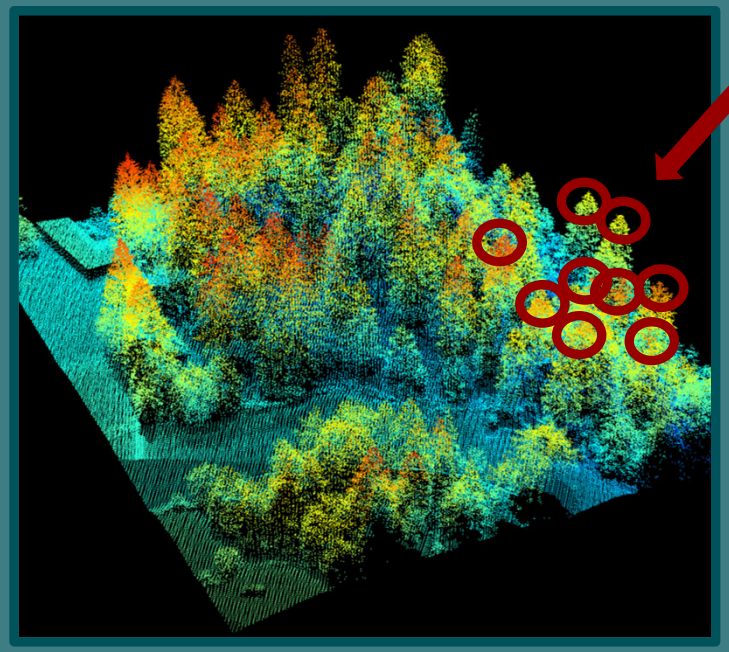




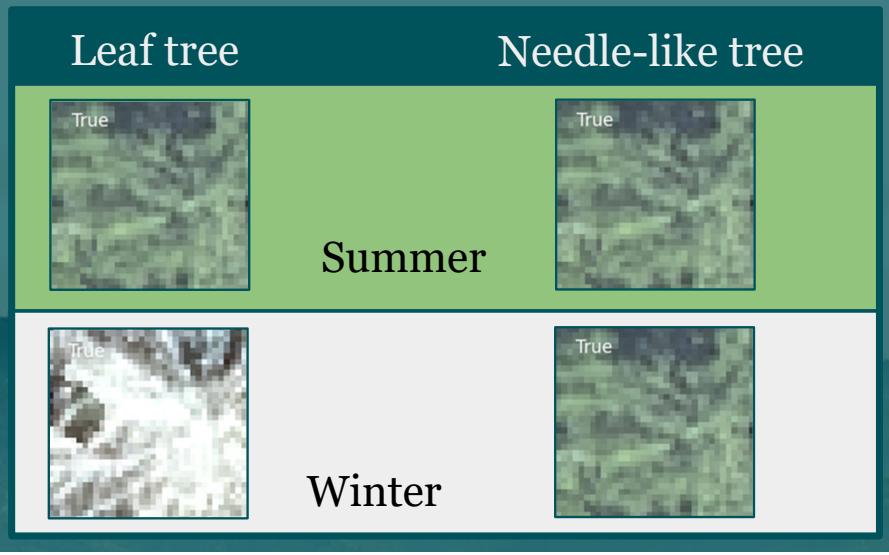


- RGB-IR photos (2014 to 2022)
- LiDAR data (2015 + 2021)
- coordinates of ~ 1700 labeled trees

Data preprocessing



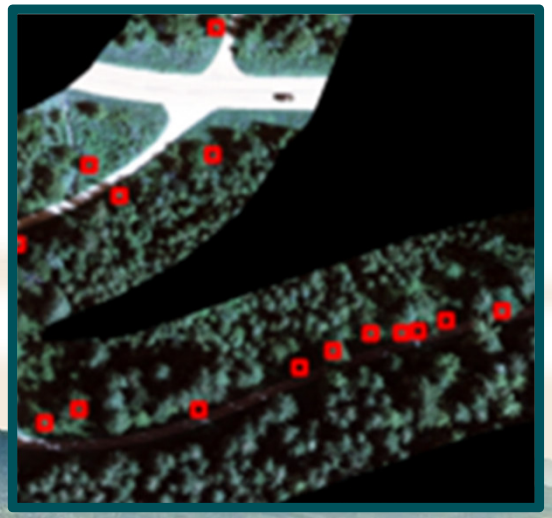
- Identification of treetops
  - Using canopy height to find tree top



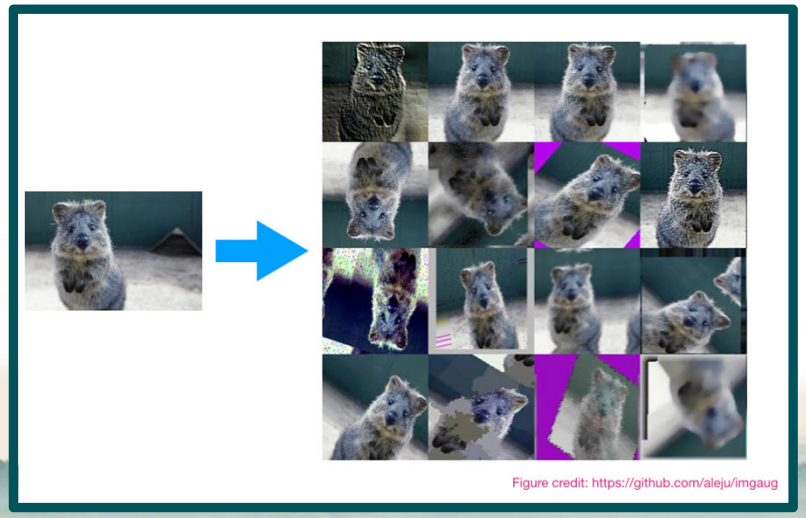
- Distinction between treetops that belong to needle-like and leaf trees
  - compare summer/winter data

Data preprocessing

- Use tree coordinates to create box images of each treetops

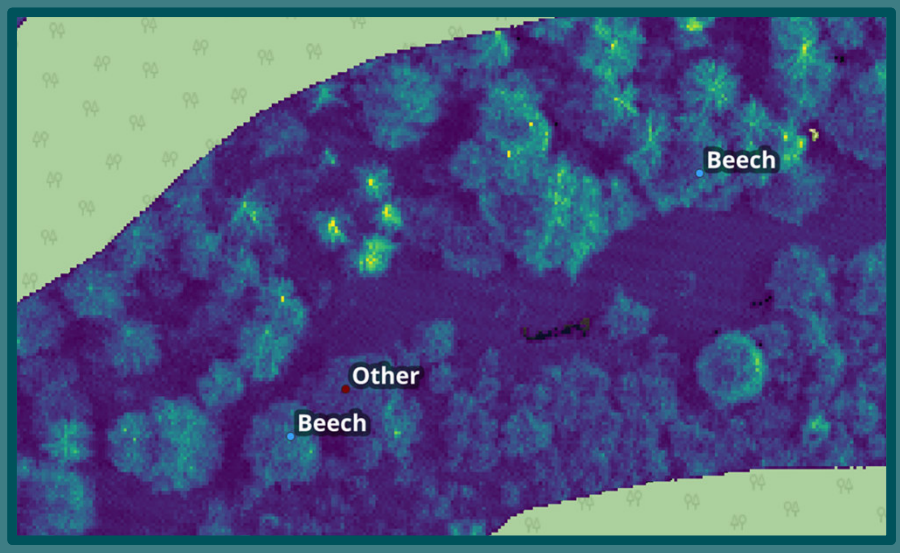


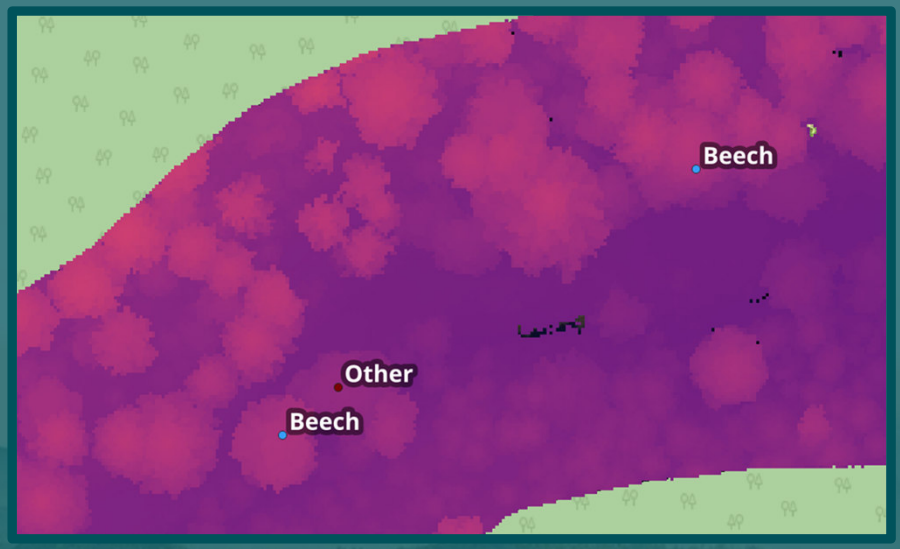
- Class imbalance: oversampling
- Augment existing images → rotating, blurring, ...



Data modelling

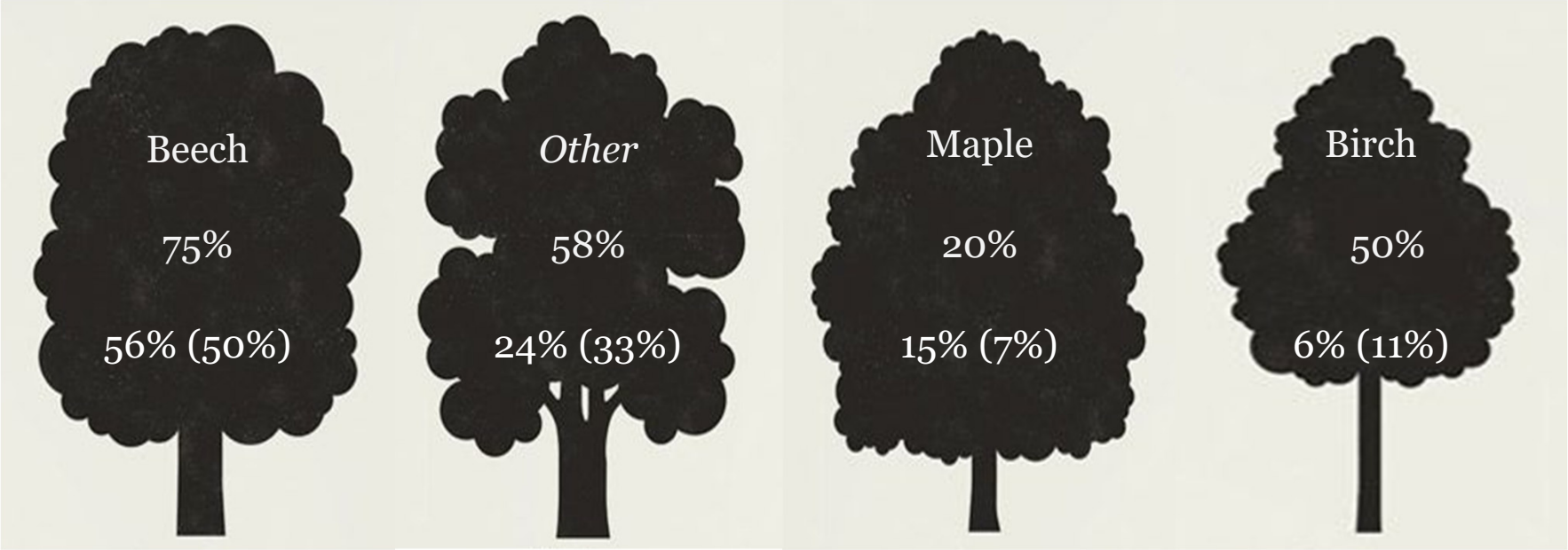
- Baseline heuristic: all trees classified as beech (55% accuracy)
- Main model: CNN using RGBI + vegetation height
- Extended model: additional information (elevation, slope, density)



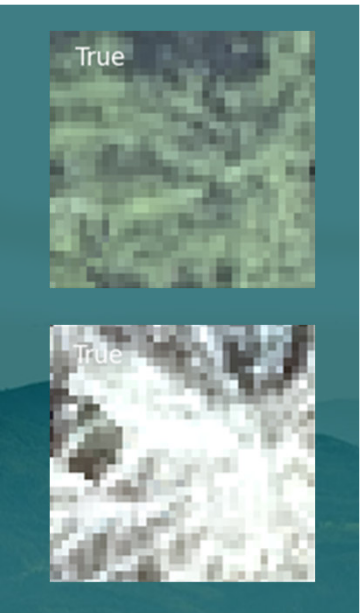


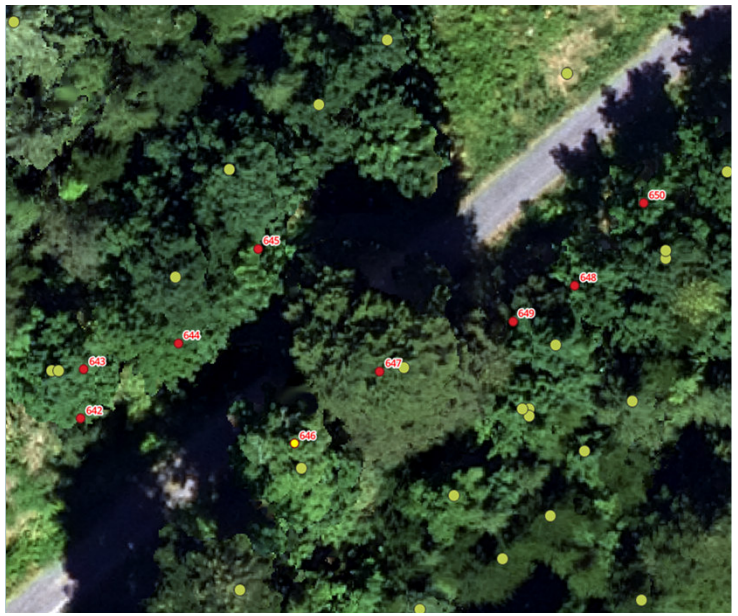
Results

Correct classification overall: 61 - 68%



Species	Beech	*Other*	Maple	Birch
Correct classification	75%	58%	20%	50%
Frequency	56% (50%)	24% (33%)	15% (7%)	6% (11%)
Misclassified as:	Other	~	Other / Beech	Other
	18%	~	40% / 38%	50%





Take Home Message

- Increasing importance of forest monitoring
- Use remote sensing data for a cost-effective data acquisition and automatized analysis
- O1: Locate single leaf trees in an aerial image and extract coordinates
- O2: Classify individual leaf trees into several categories of tree species

Outlook

Current restrictions:

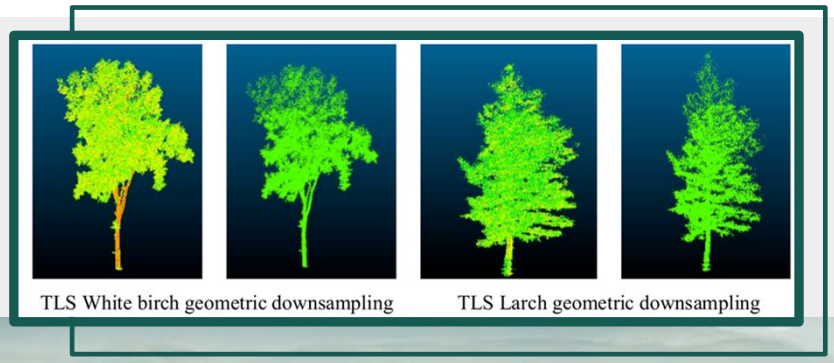
- Model performs best on years whose aerial images show a similar colouring and shadowing

How to improve data basis?

- Collect more labelled data (esp. for “other” trees)
- More spectral data from different times in the same year (esp. autumn) at 12:00 (no shadow)

How to improve our model with the data we have:

- Add 3D information on tree crowns
- Use winter data
- …

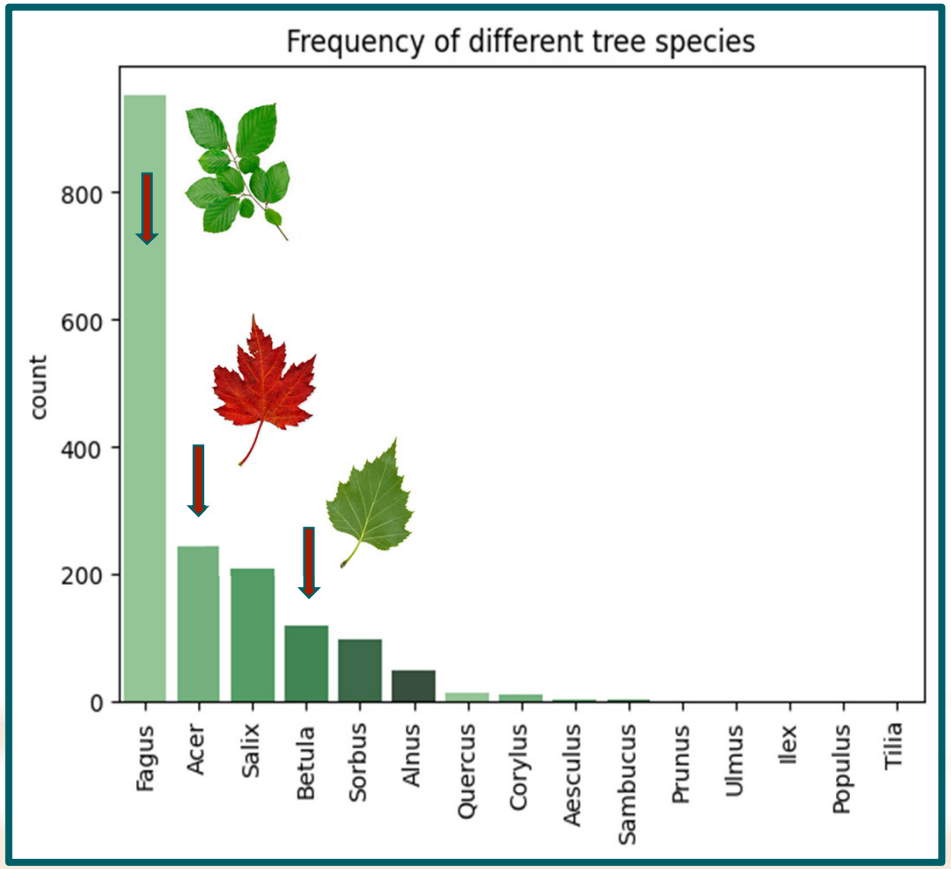


Thanks to…

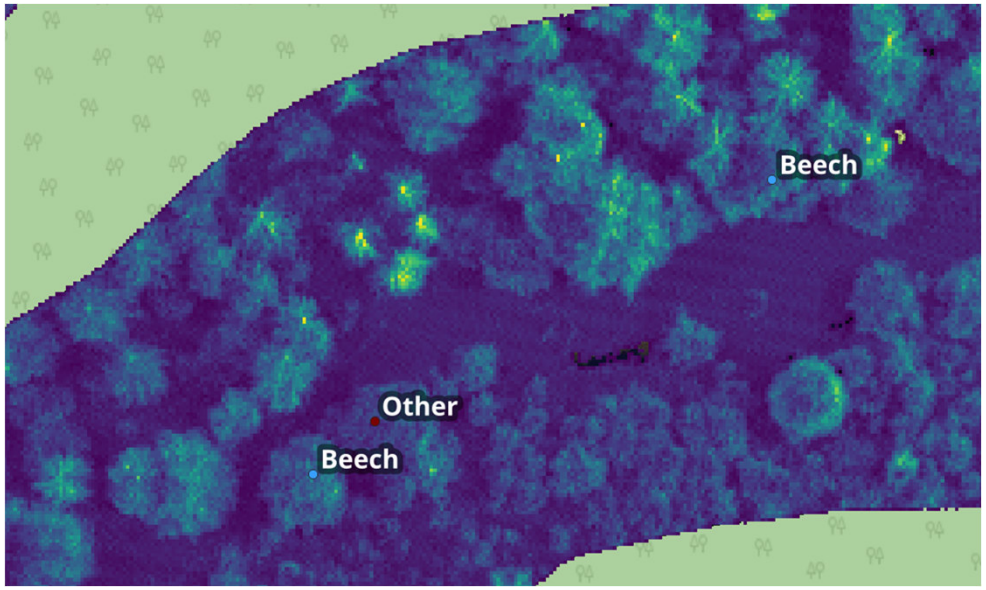
Nationalpark Schwarzwald

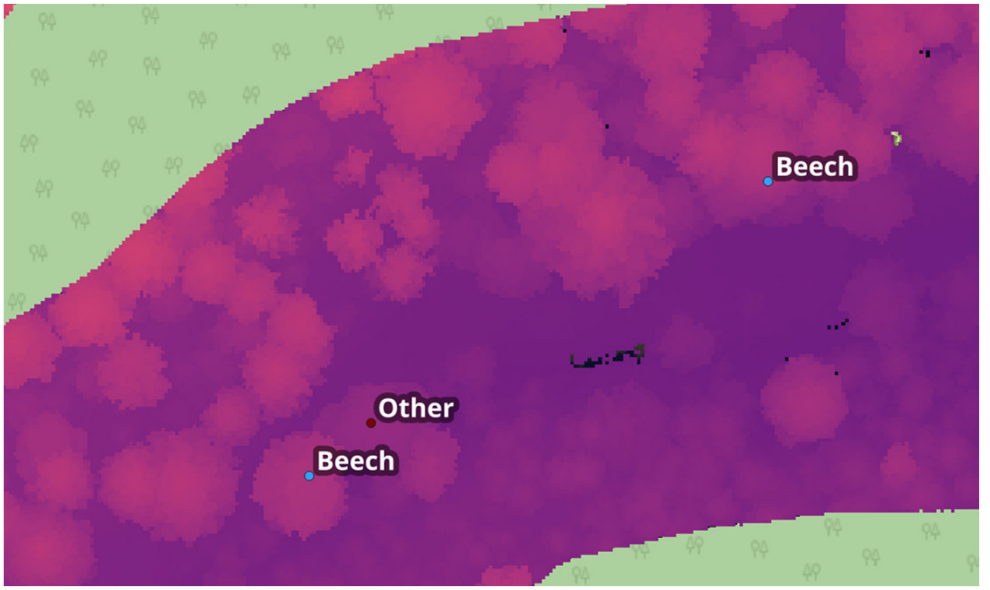
» neue fische
School and Pool for Digital Talent

Project aim



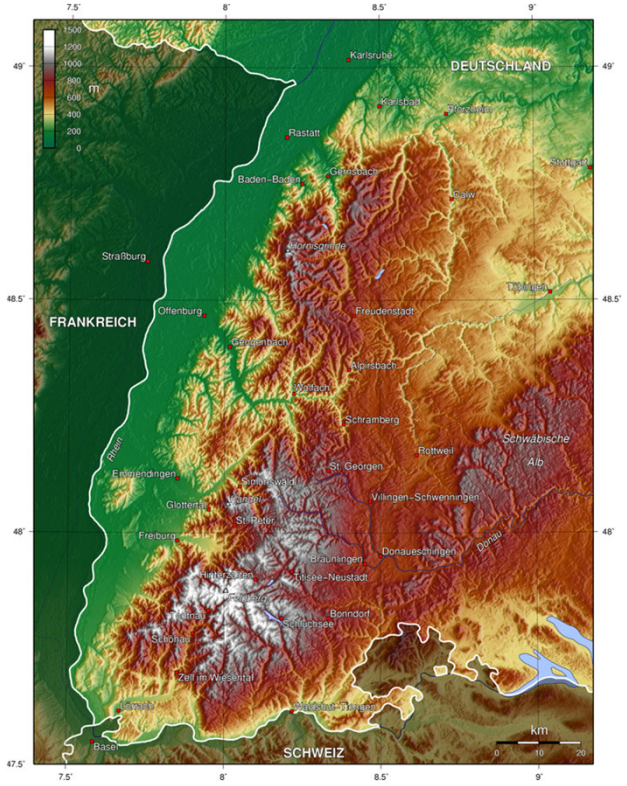
Classification of 3 most important deciduous tree species using remote sensing data and convolutional neural networks (CNNs)

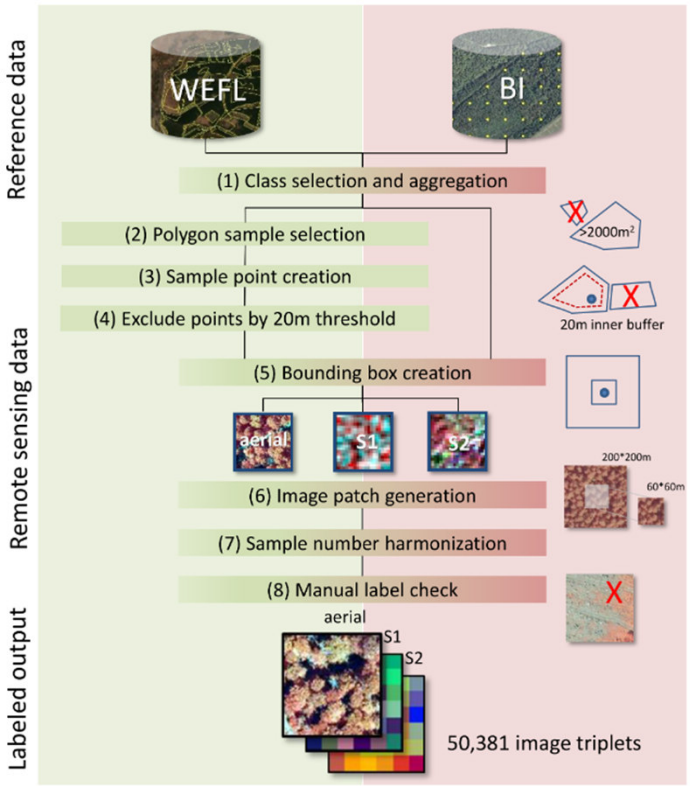

Beech
Other
Beech


Beech
Other
Beech


Beech
Other
Beech


HEIMISCHE BAUMARTEN
Ahorn
Apfel
Birke
Buche
Eiche
Erle
Esche
Fichte
Kiefer
Lärche
Linde
Pappel
Rosskastanie
Tanne
Wacholder
Weide


DEUTSCHLAND
FRANKREICH
SCHWEIZ
Karlsruhe
Rastatt
Baden-Baden
Straßburg
Offenburg
Freudenstadt
Schramberg
Villingen-Schwenningen
Freiburg
Donaueschingen
Titisee-Neustadt
Schluchsee
Bonndorf
Basel
Schwäbische Alb
Donau
Rhein
km


Reference data
Remote sensing data
Labeled output
WEFL
BI
(1) Class selection and aggregation
(2) Polygon sample selection
(3) Sample point creation
(4) Exclude points by 20m threshold
(5) Bounding box creation
(6) Image patch generation
(7) Sample number harmonization
(8) Manual label check
>2000m²
20m inner buffer
aerial
S1
S2
200*200m
60*60m
50,381 image triplets

How good is our model compared to others

Species	Precision	Recall	F_1	mAP	Support
Acer	53.99	53.66	53.82	32.00	2517
Betula	71.43	43.41	54.01	35.02	2675
Fagus	84.10	60.68	70.50	59.94	8482

Ahlswede et al. 2023

Add comparison table

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