Final Conference of LIFE PROGNOSES :

Characteristics and Ecosystem Services of European Old-Growth Beech Forests



Identifying European old-growth forests with remote sensing techniques

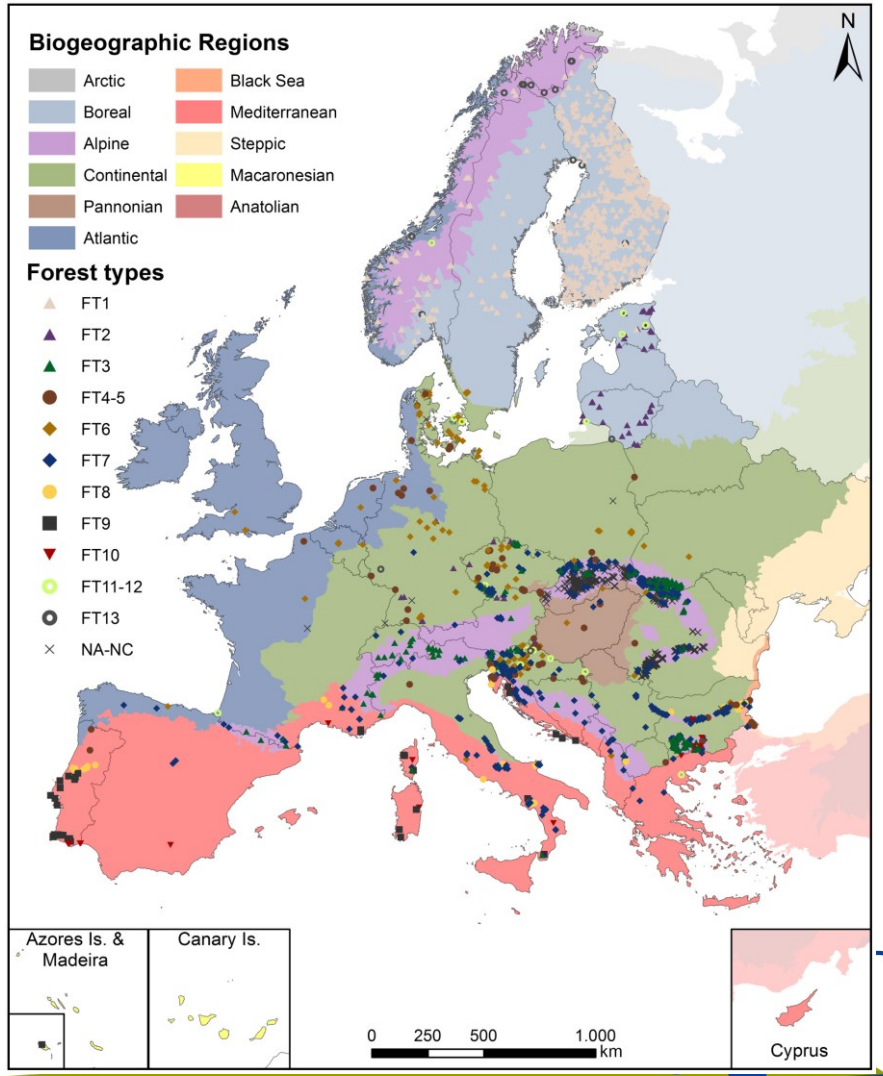
Ass.-Prof. Dr. Manuela Hirschmugl (Joanneum Research, Univ. of Graz, Austria)

Content:

- Introduction - why remote sensing (RS)
- Parameters, which can be mapped by RS
- Test sites and data used for the exercise
- Workflow
- Preliminary results:
  - comparison with/without Lidar
  - comparison with validation data and/or aerial imagery/photos
- Outlook

Introduction – why RS?

- OGF in Europe is small, scattered and often located in remote and inaccessible (mountainous) areas
- Primary forests < 1% of Europe's forests (Sabatini et al., 2018)
- Knowledge on potential OGFs can improve protection
- Wall-to-wall information helps to build stepping stones and guide restoration measures



Source: Sabatini et al., 2018
https://doi.org/10.1111/ddi.12778

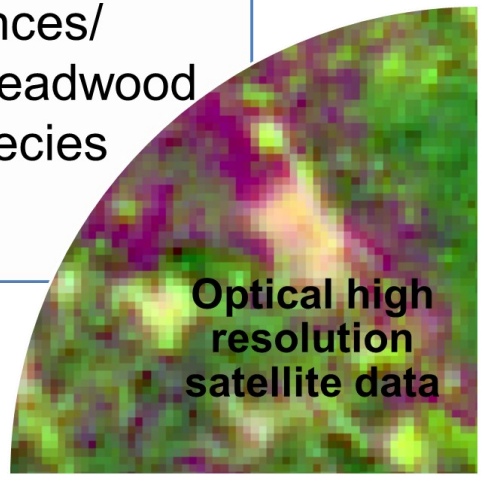
Parameters defining OGF → mapability with remote sensing?

OGF criter					to
Large and	Structural complexity and diversity of living stand	Above ground biomass (AGB)	Living and deadwood volume [m^3/ha]; [Mg/ha]	[11, 37, 42, 61]	*Canopy cover* *Stand Height* *Height distribution, AGB*	n
		Diameter size distribution of living trees	Inter-quartile range (IQR); size range (min–max) – diameter distribution; Gini coefficient; coefficient of variation; DBH skewness; De Camino homogeneity index, established regeneration	[12, 13, 17, 37, 42, 58, 61, 62]	DBH as a function of *individual tree height* and/or crown size (*tree crown delineation*)	
		Spatial distribution pattern of trees	Spacing of individual trees	[39, 40]	*Canopy cover* *Individual tree detection*	
Deadwoo			Canopy gap size distribution and total cover (gap share)	[11, 39, 40, 63]	*Canopy cover* *Gap detection*	
			Canopy irregularity (= Upper canopy height distribution)	[33, 40]	Derived indicator from *canopy cover* and *tree/stand height*	
		Vertical structure	Tree height range and distribution (Classes in 5 m ranges)	[11, 39, 40, 64]	*Vertical structure* based on ALS point distribution or *individual tree distribution*	
	Tree species composition	Dominance of native late-successional tree species	Species composition per plot in comparison to potential natural tree species composition	[58]	*Tree species* classification	
		Presence of non-native species	Share of non-native species on living trees [%]	[39, 40]		

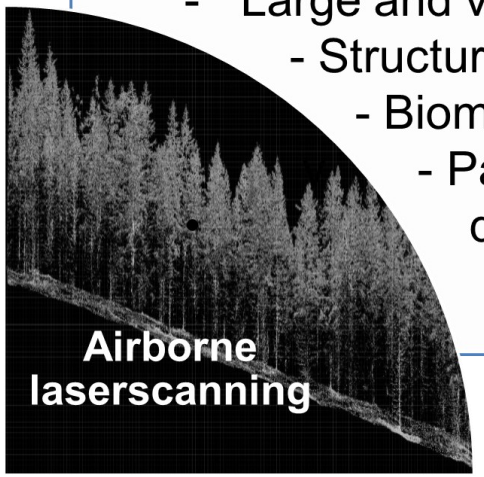
Source: Hirschmugl et al. 2023 https://doi.org/10.1007/s10666-023-09897-y

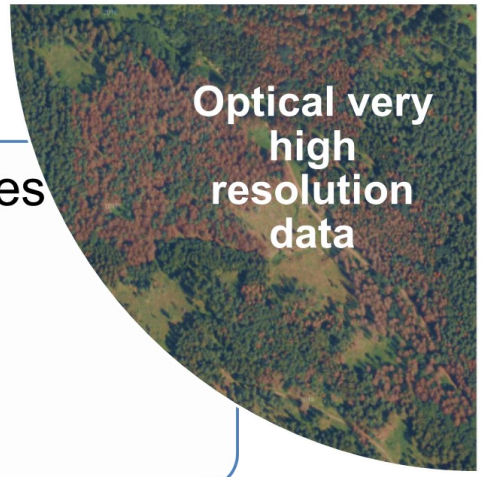
Which RS data for which parameters?

- Disturbances/ standing deadwood
- Tree species (groups)



- Large and very large trees
- Structural complexity
- Biomass
- Partly lying deadwood





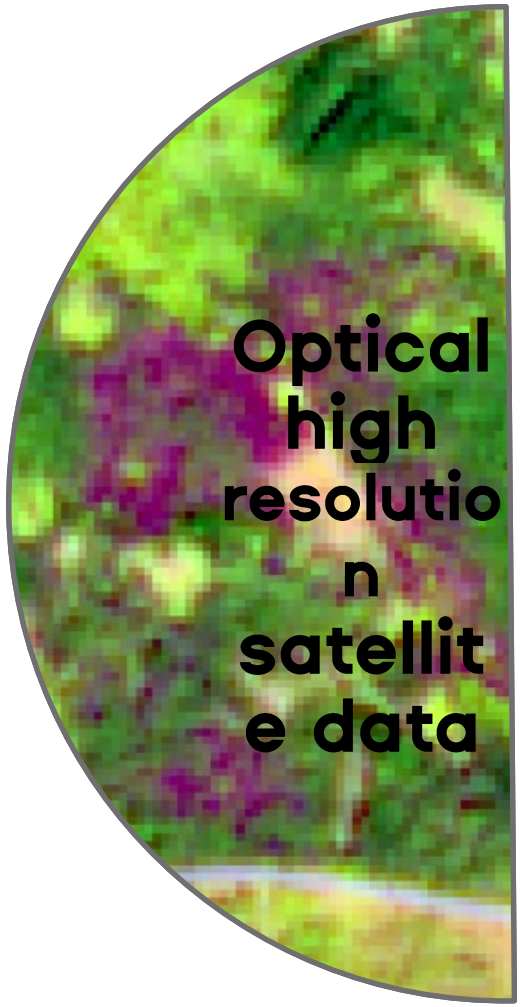
- Tree species
- Standing deadwood
- Structural parameters



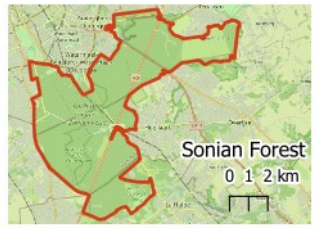
- Structural complexity
- Partly biomass

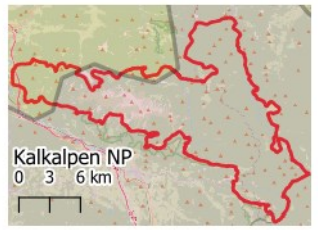
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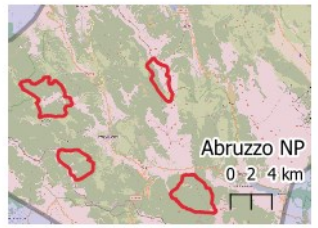
Test sites and data used in PROGNOSES

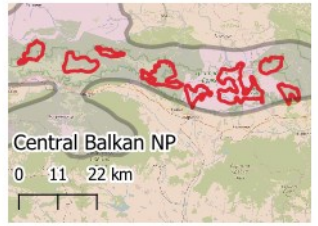












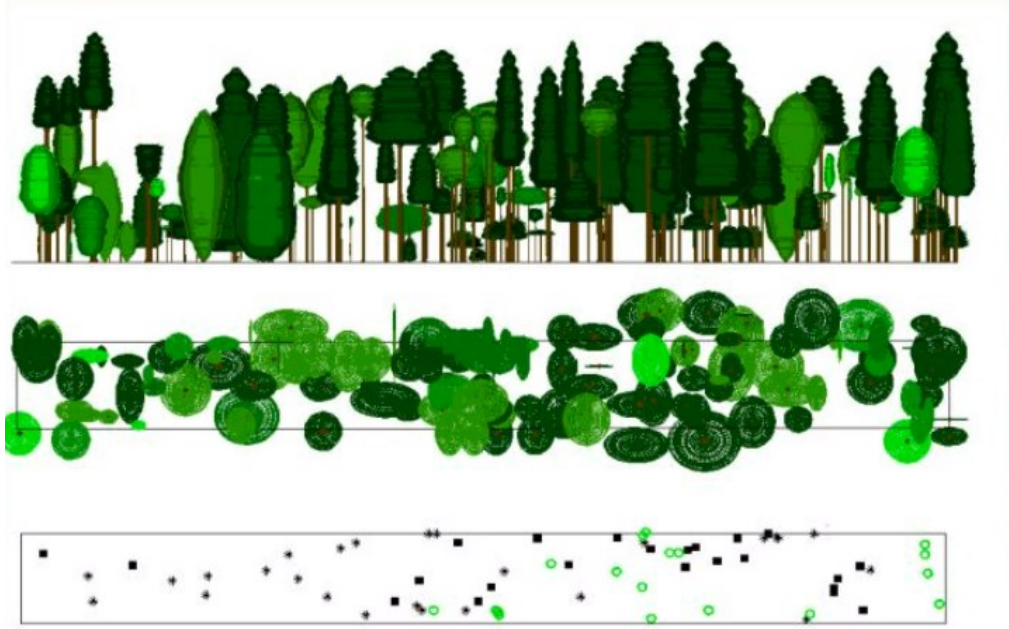


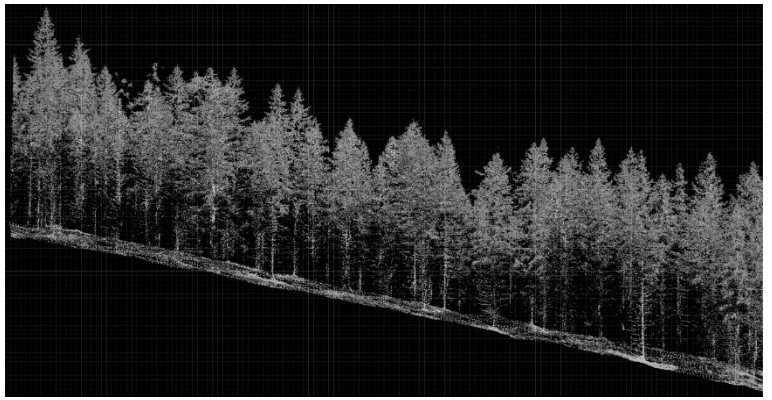
Airborne LiDAR data for forest structure assessment

What is forest structure?

- Tree density and -distribution
- Vegetation indices and -distribution
- Height and –distribution (std, variability, …)
- Gaps: deep gaps, gap sizes, gap distribution,
- Canopy cover -fraction, canopy clumping, rugosity, …
- Vertical parameters:
  - (effective) number of layers
  - Vertical distribution (std, stdstd)
  - Height /DBH distribution/diversity

→ LiDAR data needed



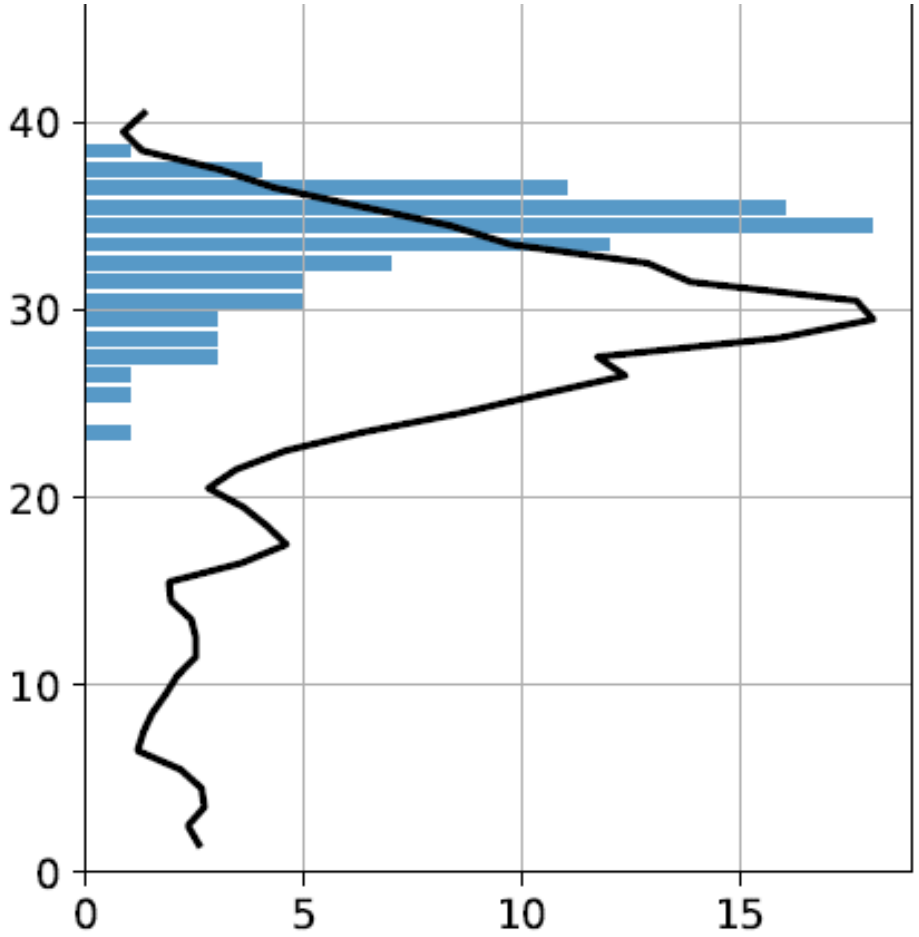


Source: Atkins et al., 2018: https://doi.org/10.1111/2041-210X.13061,adapted. Pic source from Alannah Gillian O'Brien

Airborne LiDAR data for forest structure assessment

- Field: One layer, low vertical structure

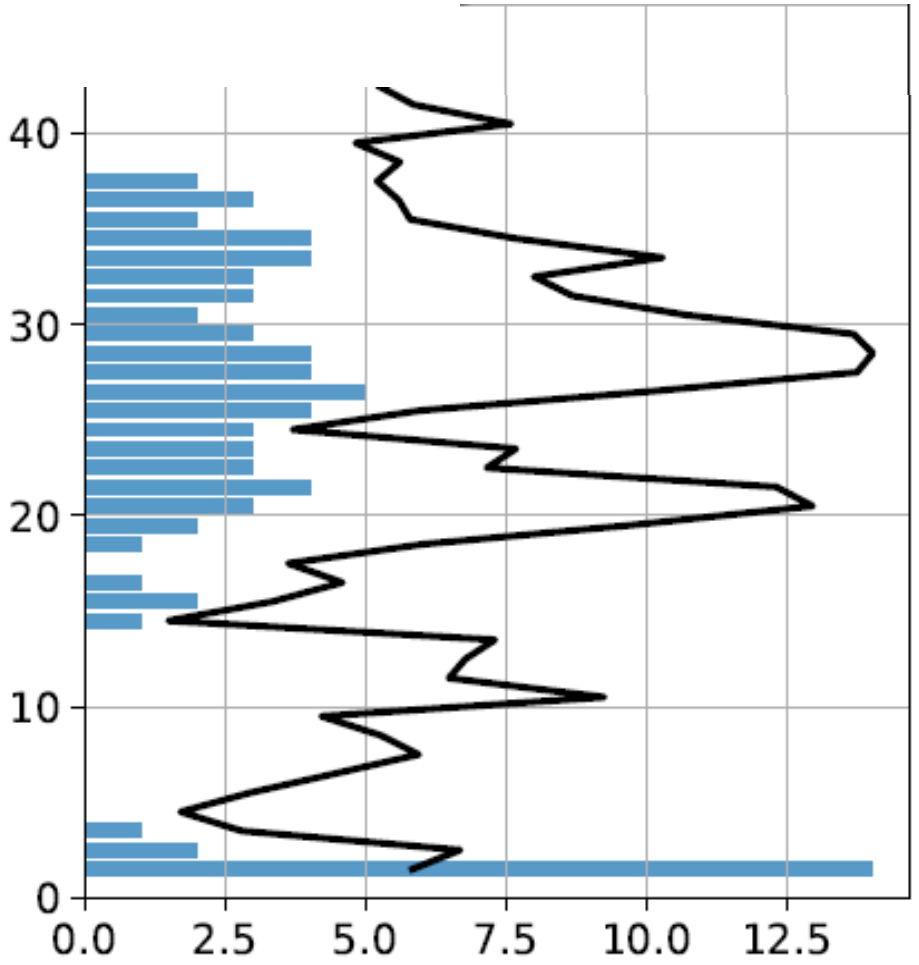




Airborne LiDAR data for forest structure assessment

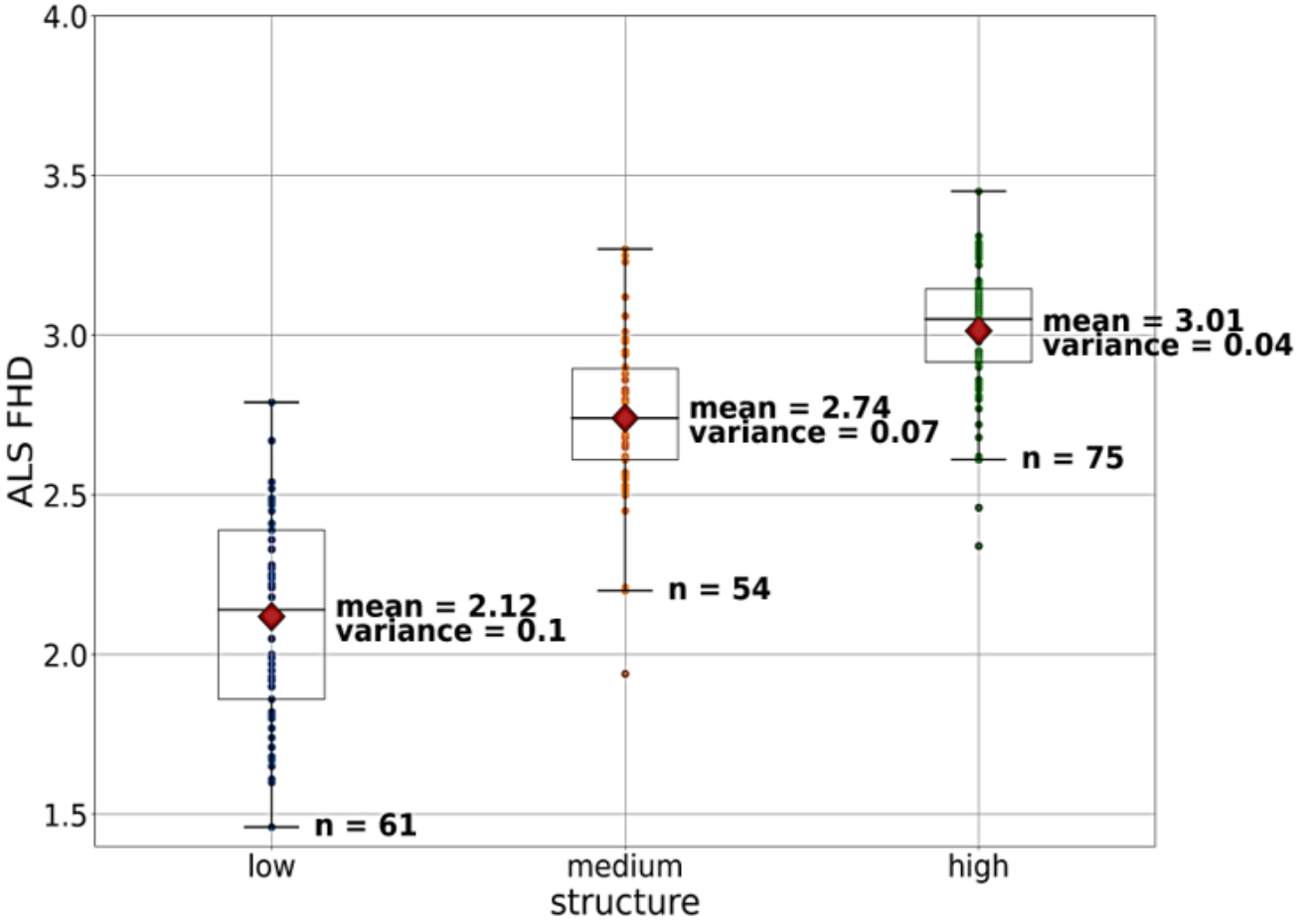
- Field: Two layers, high vertical structure





Airborne LiDAR data for forest structure assessment

- Foliage Height Diversity (FHD) for vertical structure
- Trend clearly visible
- FHD can be a useful information source



Assessing the Vertical Structure of Forests Using Airborne and Spaceborne LiDAR Data in the Austrian Alps

by Manuela Hirschmugl [1,2,*], Florian Lippl [1] and Carina Sobe [2]

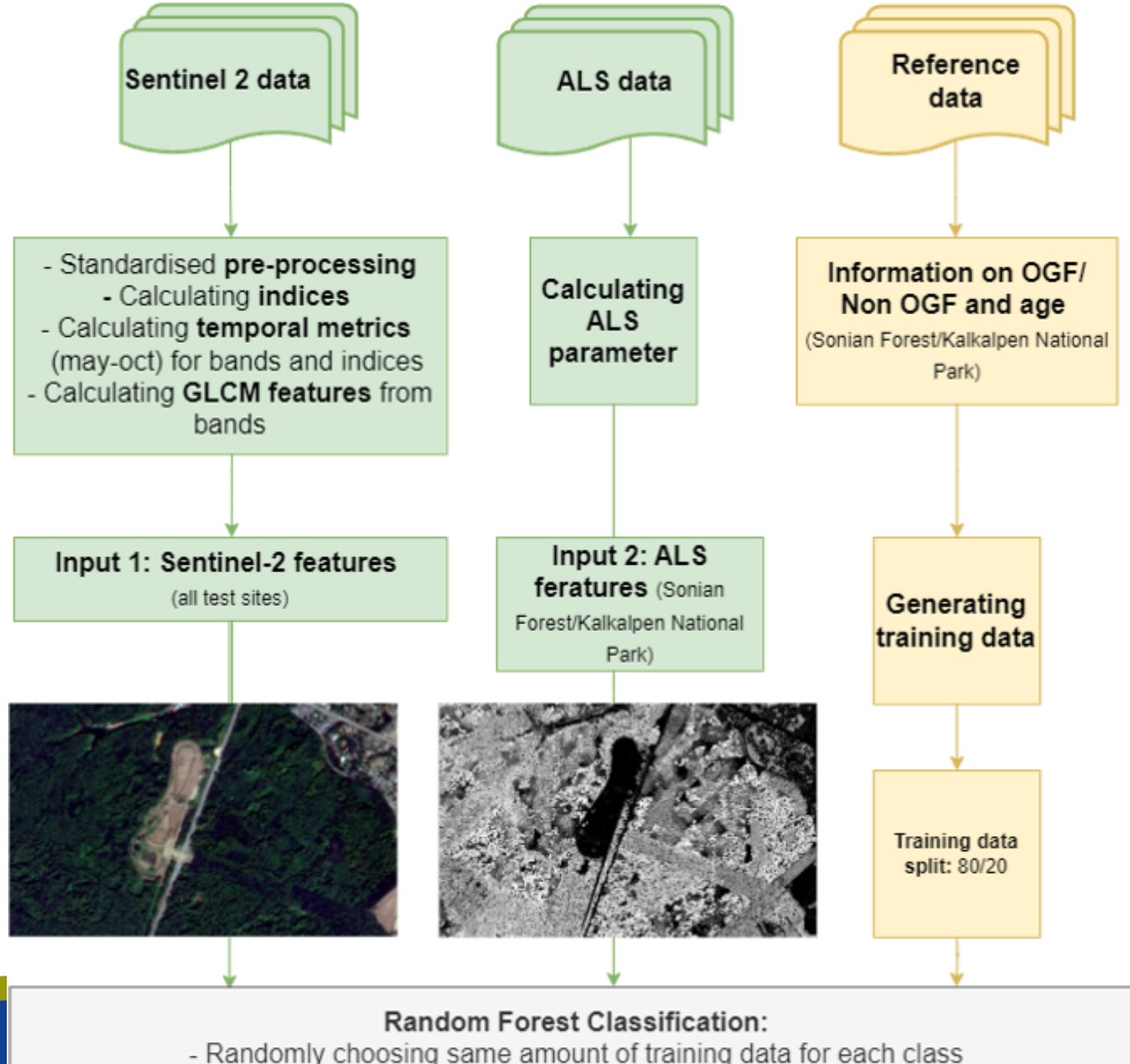
[1] Institute for Geography and Regional Sciences, University of Graz, 8010 Graz, Austria

[2] Joanneum Research Forschungsgesellschaft mbH, DIGITAL–Institute for Digital Technologies, 8010 Graz, Austria

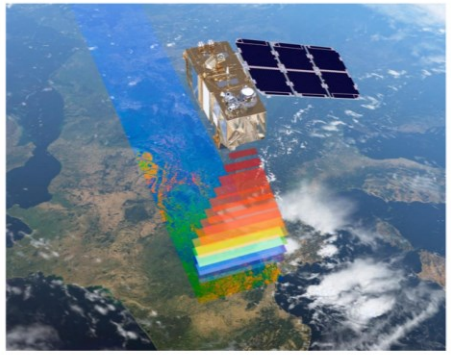
* Author to whom correspondence should be addressed.

Remote Sens. **2023**, *15*(3), 664; **https://doi.org/10.3390/rs15030664**

Workflow


Sentinel 2 data
ALS data
Reference data
- Standardised pre-processing
- Calculating indices
- Calculating temporal metrics (may-oct) for bands and indices
- Calculating GLCM features from bands
Calculating ALS parameter
Information on OGF/ Non OGF and age (Sonian Forest/Kalkalpen National Park)
Input 1: Sentinel-2 features (all test sites)
Input 2: ALS feratures (Sonian Forest/Kalkalpen National Park)
Generating training data
Training data split: 80/20
Random Forest Classification:
- Randomly choosing same amount of training data for each class

Sentinel-2 satellite input data



Sentinel-2, © ESA

Sentinel-2 (2018)

Temporal Statistics Bands

- Band 2 – Blue
- Band 3 – Green
- Band 4 – Red
- Band 5 – Vegetation Red Edge
- Band 6 – Vegetation Red Edge
- Band 7 – Vegetation Red Edge
- Band 8 – NIR
- Band 8A – Vegetation Red Edge
- Band 11 – SWIR
- Band 12 – SWIR

Indices

- NDVI
- TCG
- BrightnessRGB
- GNDVI
- NDRE1

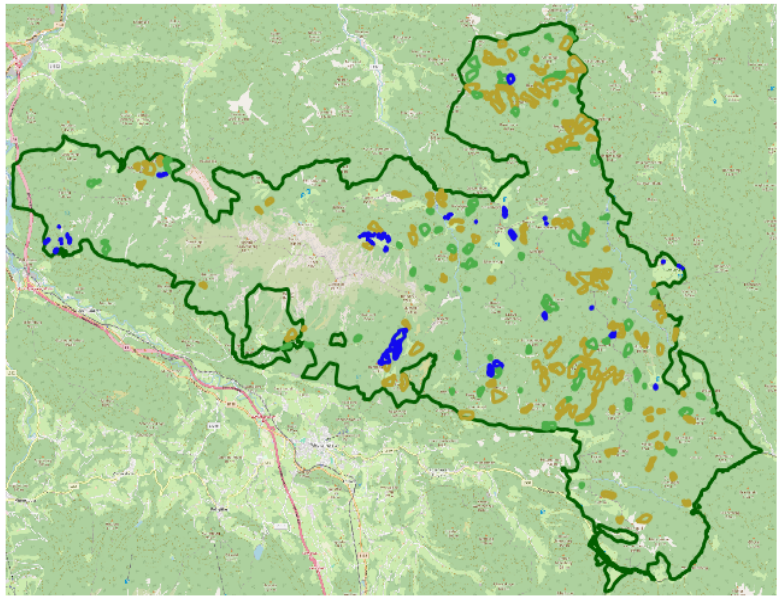
Texture

8 GLCM features of median image per band → 80 bands

- Band 1 – Minimum
- Band 2 – Maximum
- Band 3 – Mean
- Band 4 – Median
- Band 5 – Standard Deviation
- Band 6 – Variance

Workflow

Old Growth Forest Reference Data



Author: Selina Schaar (2024)

Background: OSM (2024)

Sentinel 2 data

ALS data

Reference data

- Standardised **pre-processing**
- Calculating **indices**
- Calculating **temporal metrics** (may-oct) for bands and indices
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Calculating ALS parameter

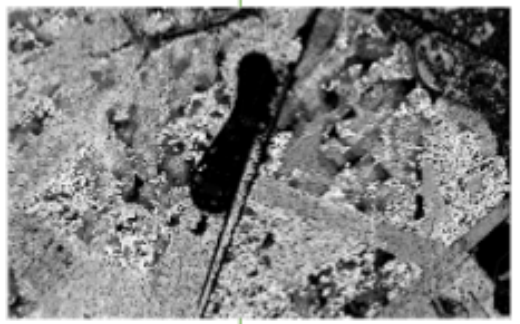
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Generating training data



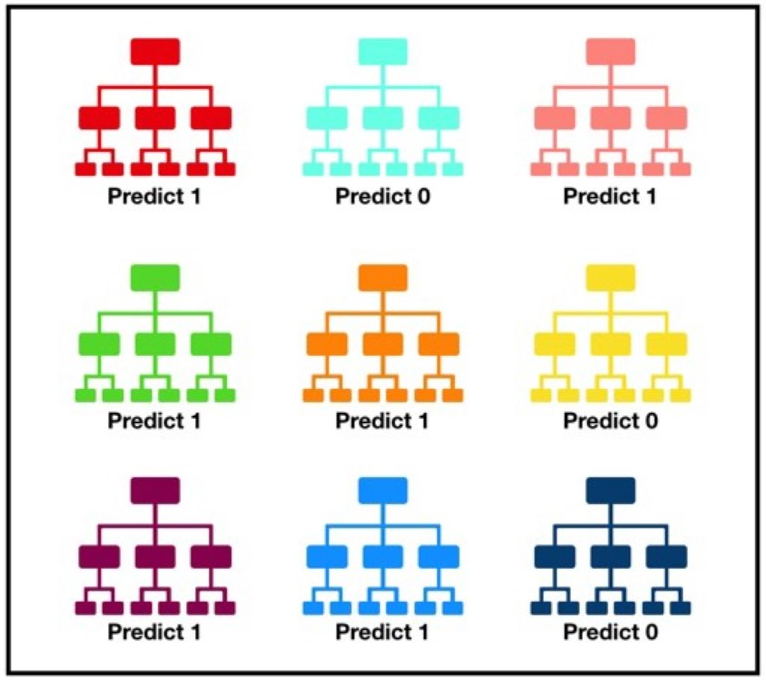


Training data split: 80/20

Random Forest Classification:

- Randomly choosing same amount of training data for each class

Workflow



Tally: Six 1s and Three 0s
Prediction: 1 Source: Yiu (2019)

- Calculating **indices**
- Calculating **temporal metrics** (may-oct) for bands and indices
- Calculating **GLCM features** from bands

Calculating ALS parameter

Non OGF and age
(Sonian Forest/Kalkalpen National Park)

Input 1: Sentinel-2 features
(all test sites)

Input 2: ALS feratures (Sonian Forest/Kalkalpen National Park)

Generating training data

Training data split: 80/20

Random Forest Classification:
- Randomly choosing same amount of training data for each class
- threshold of importance 1%

Old Growth map
(all test sites)

Age map
(Sonian Forest/Kalkalpen National Park)

Wor

Sentinel 2 data

ALS data

Reference data

Validation data

- Standardised **pre-processing**
- Calculating **indices**
- Calculating **temporal metrics** (may-oct) for bands and indices
- Calculating **GLCM features** from bands

Calculating ALS parameter

Information on OGF/ Non OGF and age (Sonian Forest/Kalkalpen National Park)

Generation of harmonised areas which are validated by field inspections - these are then transformed into points

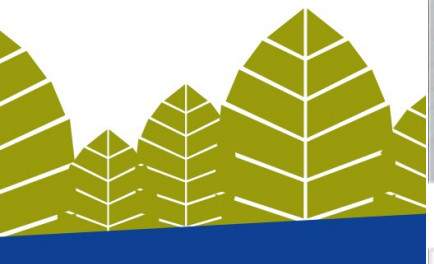
„OGI light“

Input 1: Sentinel-2 features (all test sites)

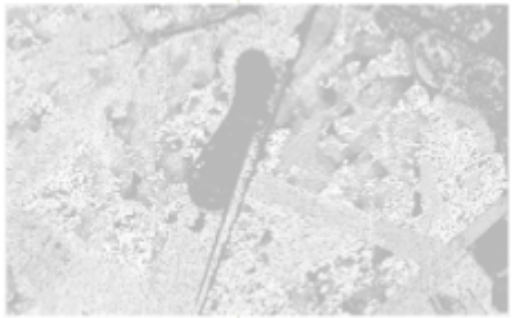
Input 2: ALS feratures (Sonian Forest/Kalkalpen National Park)

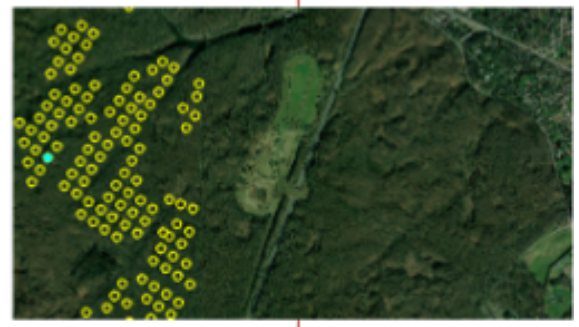
Generat… training data

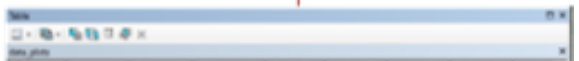
Training data split: 80/20











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Training data split: 80/20



Random Forest Classification:
- Randomly choosing same amount of training data for each class
- threshold of importance 1%

Old Growth map
(all test sites)

Age map
(Sonian Forest/Kalkalpen National Park)

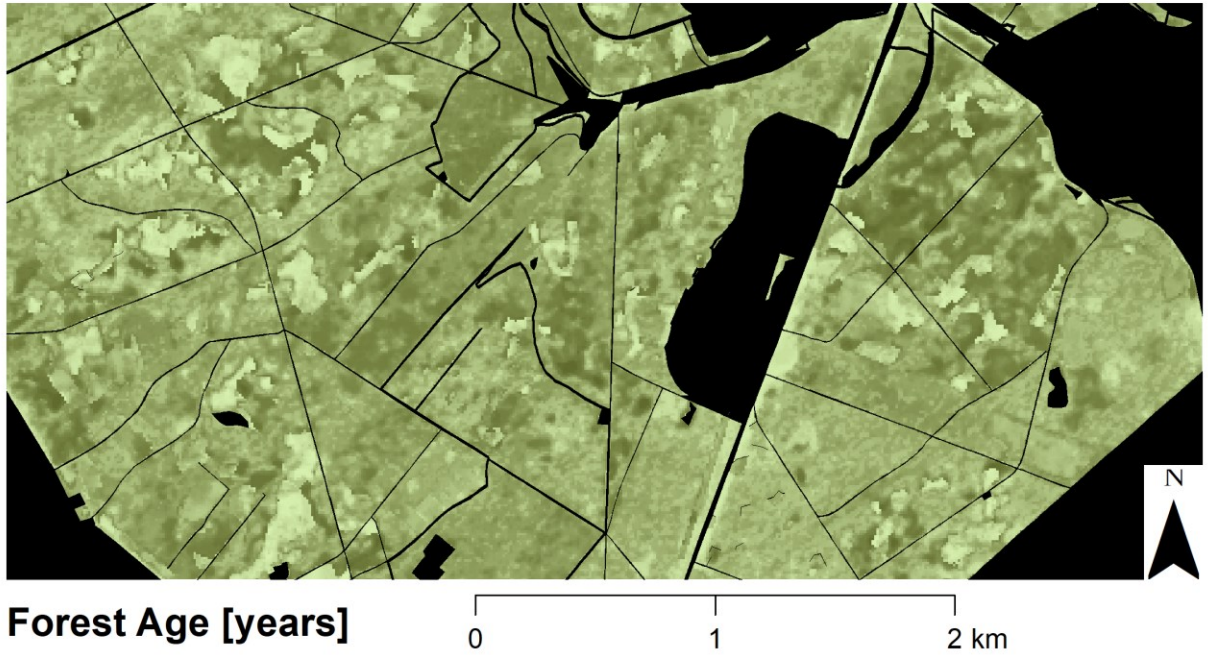
Comparing results with reference data

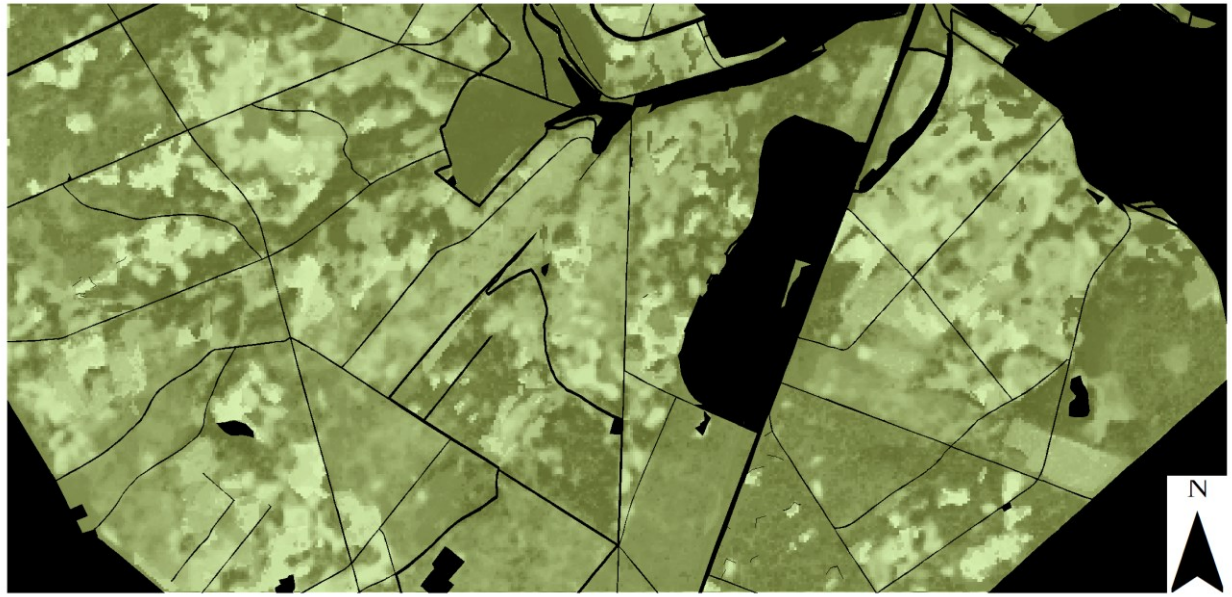
Comparing results with validation data

Accuracy Values

Preliminary results – example Sonian Forest

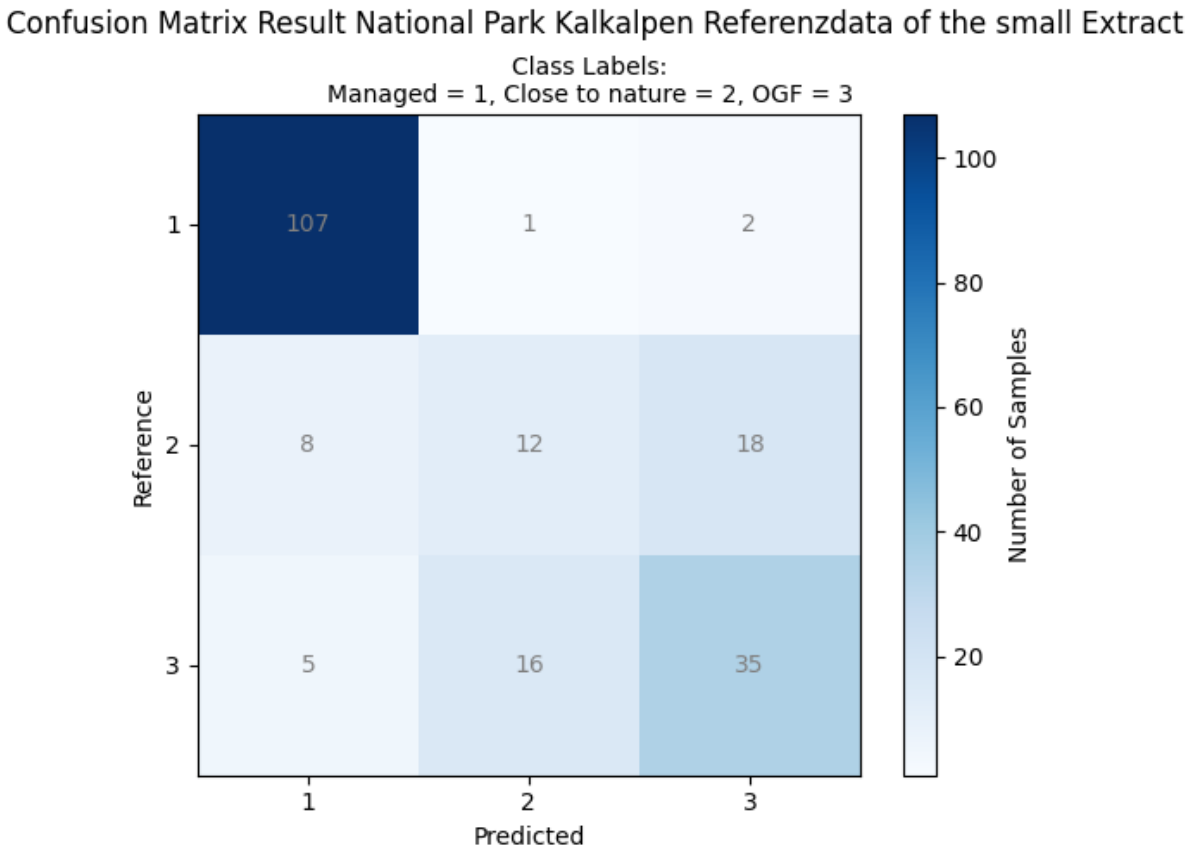
- Comparison of results without (left) /with (right) ALS data

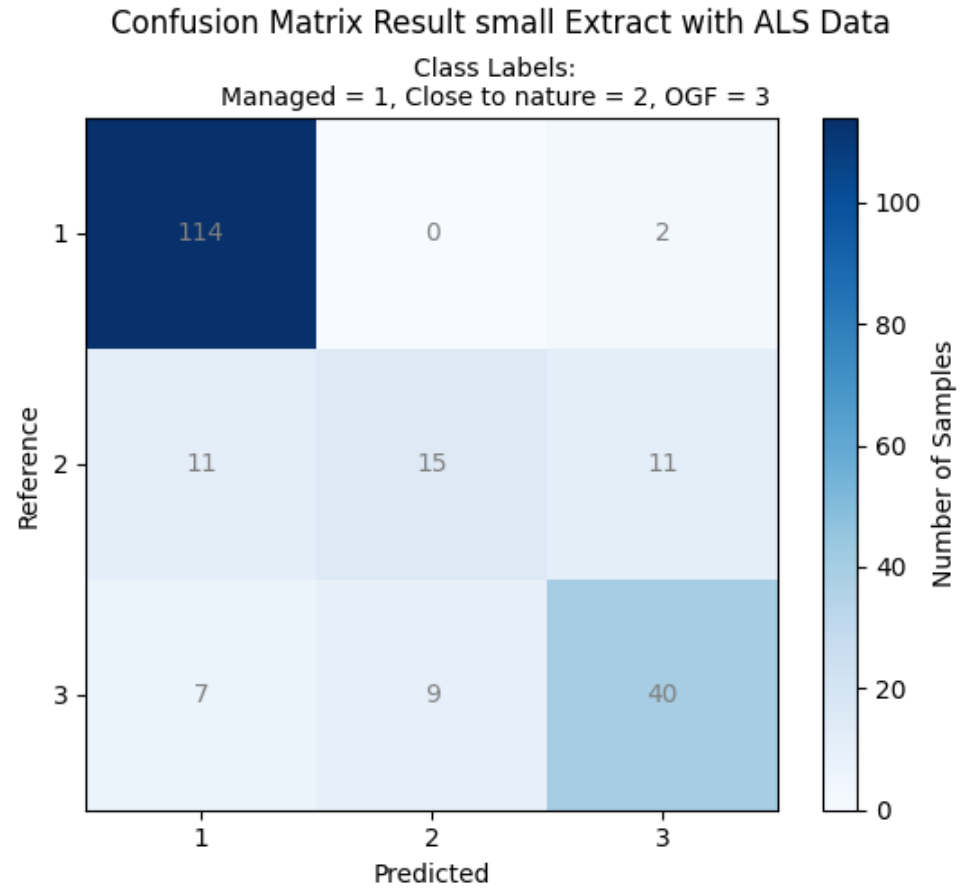




- Similar spectral reflectance in Sentinel-2 data of OGF and NOGF beech forests
- Overestimation of young/underestimation of old forests ('cushioning effect')
- Much better representation including height and structure from ALS

Preliminary results – example Kalkalpen





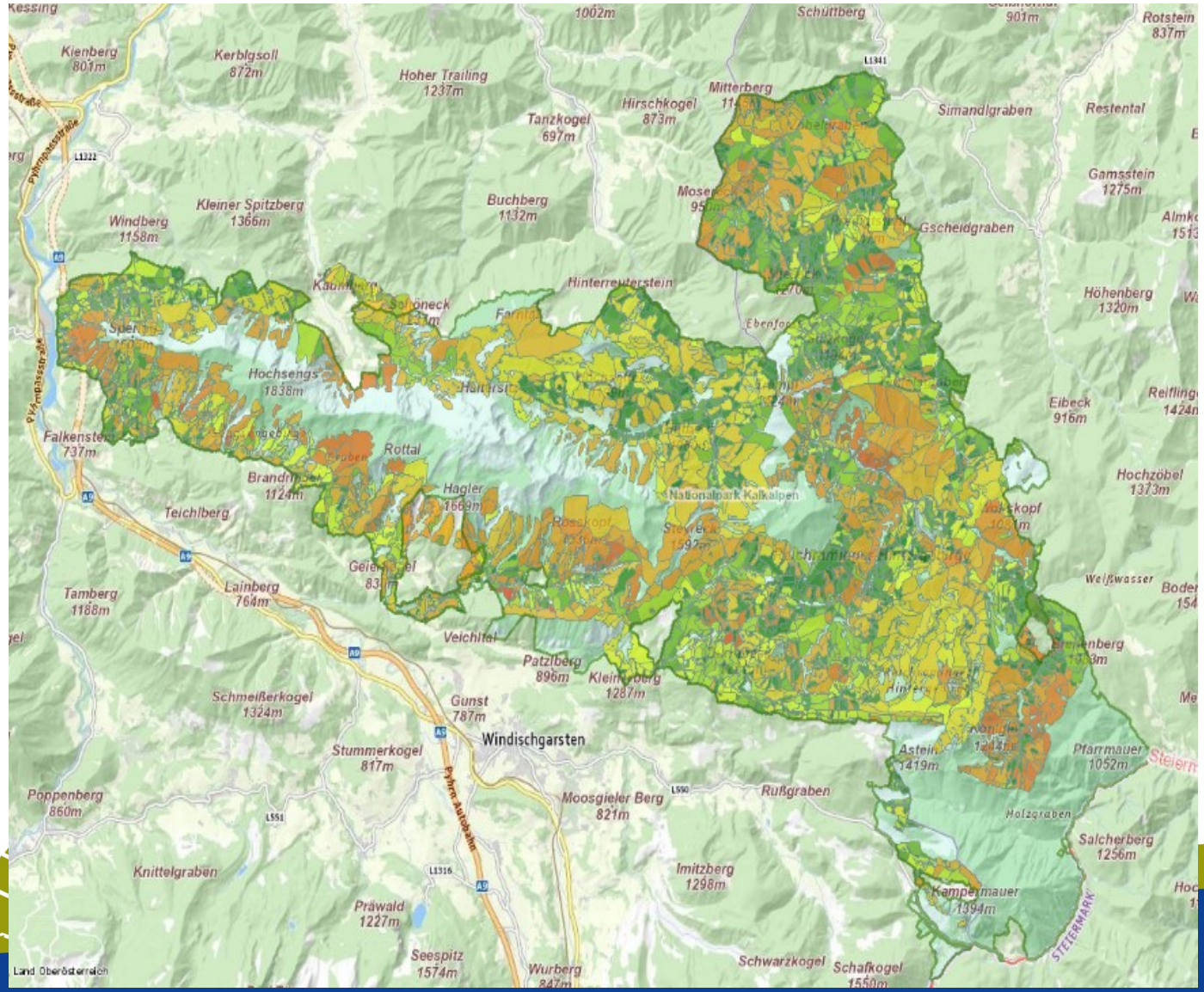
Sentinel-2 overall accuracy 82.78%

Sentinel-2 & ALS overall accuracy 80.86%

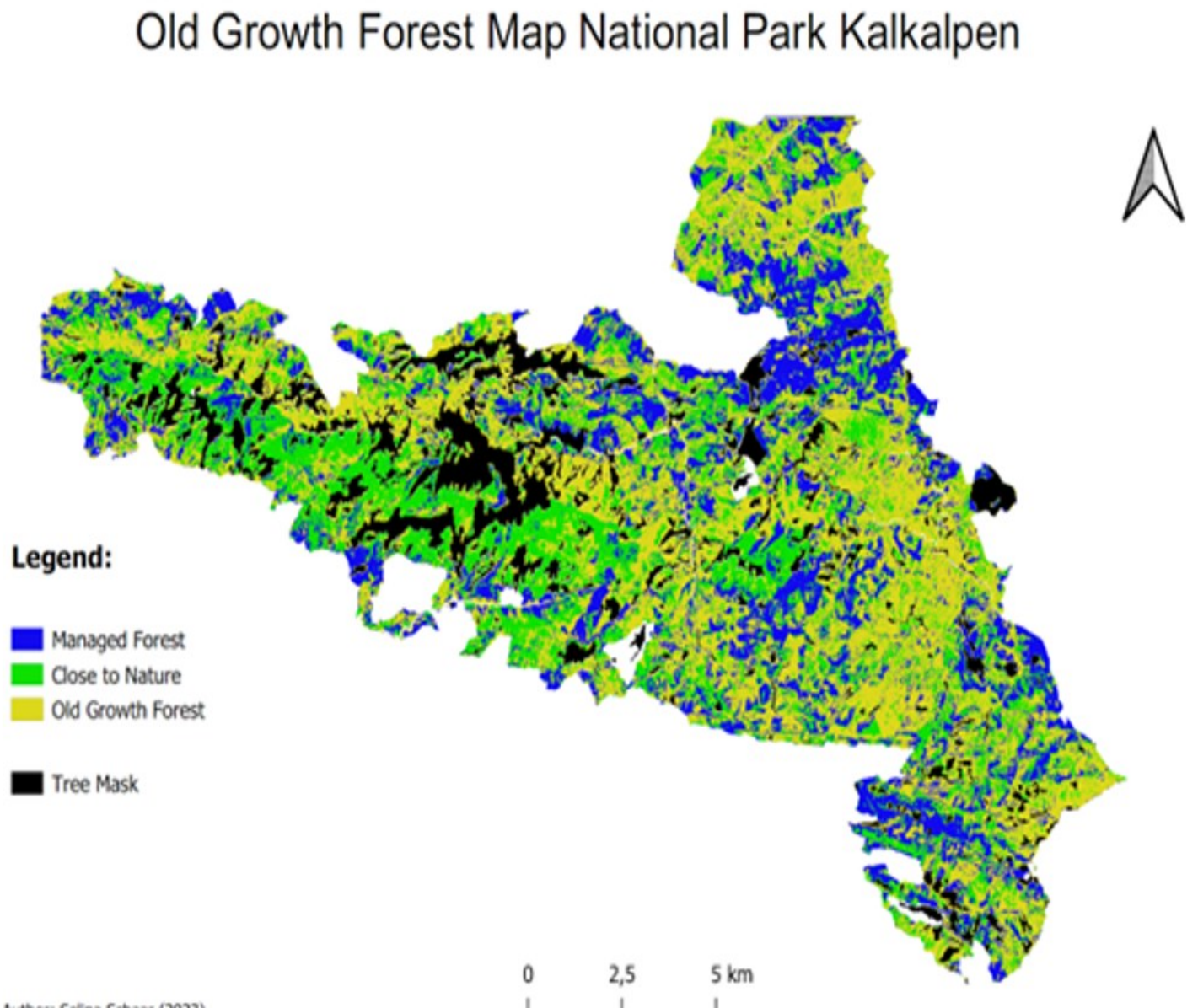
Main reason: Natural disturbances (avalanches, windthrows) resulting in lower tree heights for OGF

Class ‘close-to-nature’ is an intermediate class, reflects the gradient between managed and OGF

Preliminary results – example Kalkalpen



Preliminary results – example Kalkalpen



Concluding remarks

- Validation of maps with OGI reference data from field measurement plots
- Detailed analysis of the contribution of ALS and texture features
- Discussion on the suitability of various features in different biogeographical regions

→ Publication in progress



Q&A

Thank you for your attention

