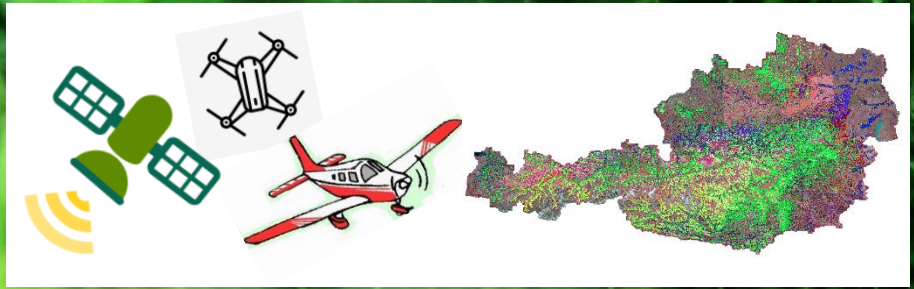
BFW
Bundesforschungszentrum für Wald



Remote sensing applications within the Austrian NFI

Klemens Schadauer
Department of Forest Inventory

Meeting on using remote sensing methods for National Forest Inventory

Ukraine, 14th August 2024

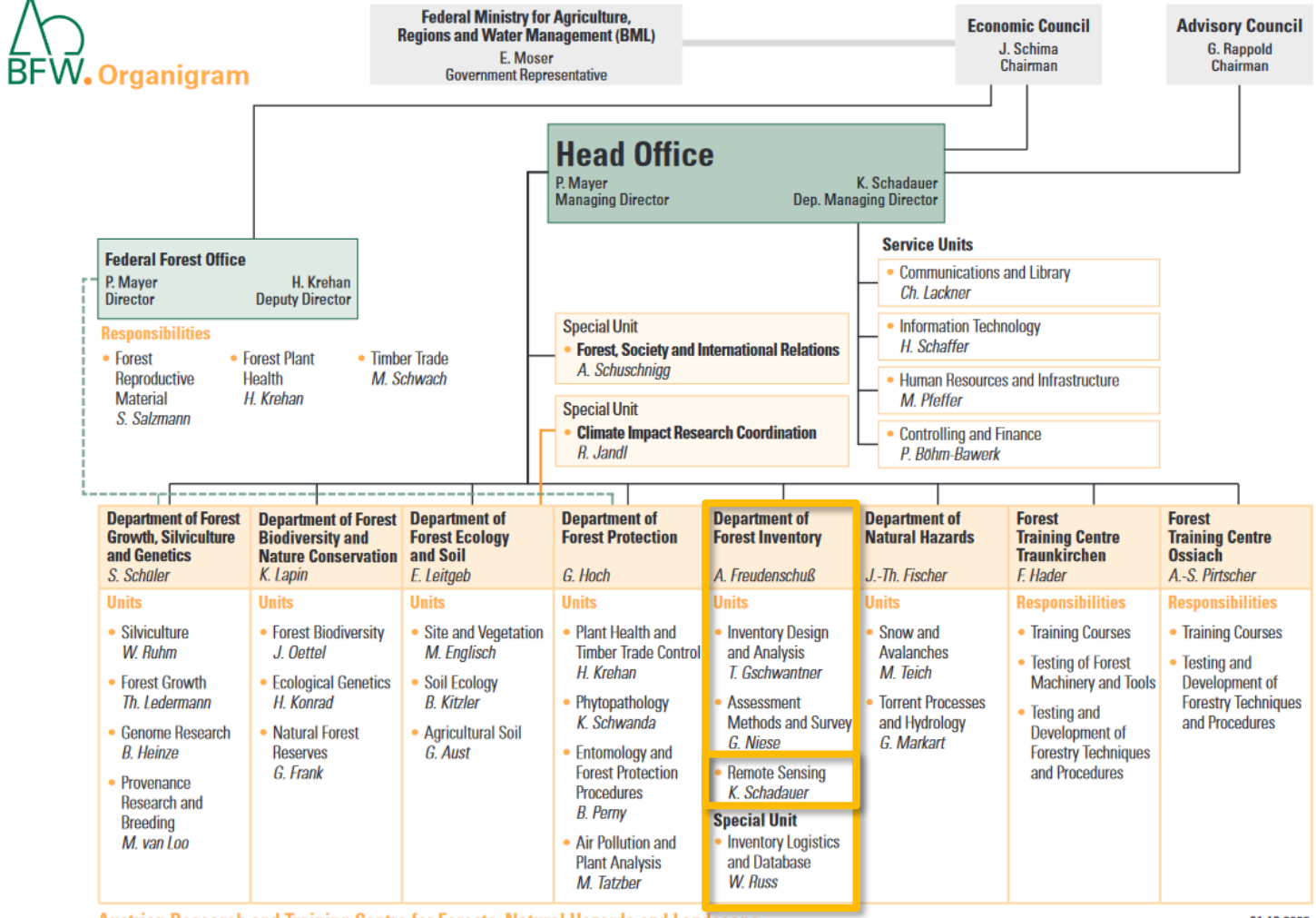
Austrian Research Centre for forests

The BFW is an Austrian, multidisciplinary training and research centre of the federal government in the legal form of a “public law institution”. We consist of

- six departments
- two forestry training centres
- up to 400 employees

BFW
Bundesforschungszentrum für Wald

BFW. Organigram



Austrian Research and Training Centre for Forests, Natural Hazards and Landscape

01.12.2023

Austrian NFI Remote Sensing - General Concept

- Remote sensing unit is part of the NFI (no competition)
- Work on 2d and 3d applications and on combinations
- For some new and special developments use co-operations inside and outside Austrian Research Centre for forests
- Integration into sample based NFI
  - As far as possible use sound statistical estimates
- Maps can be used as additional timely information source for forest administration and forest managers

Remote sensing technologies

- Sensors
  - LIDAR
  - Optical
  - Radar

- Platforms
  - Person
  - Drone
  - Airplane
  - Satellite

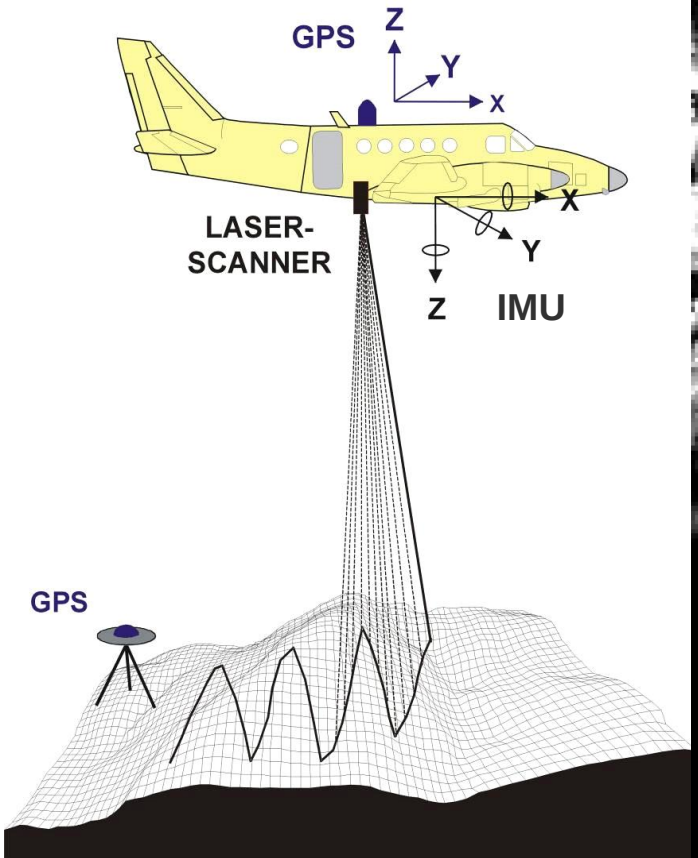
Remote sensing technologies

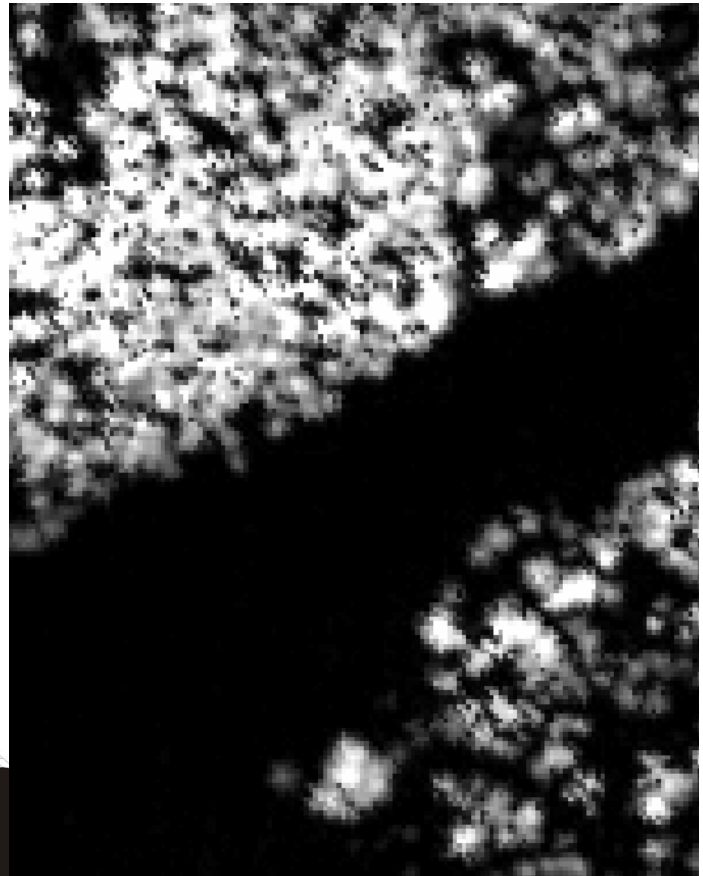
- Sensors
  - LIDAR
  - Optical
  - Radar

- Platforms
  - Person
  - Drone
  - Airplane
  - Satellite

Remote Sensing data

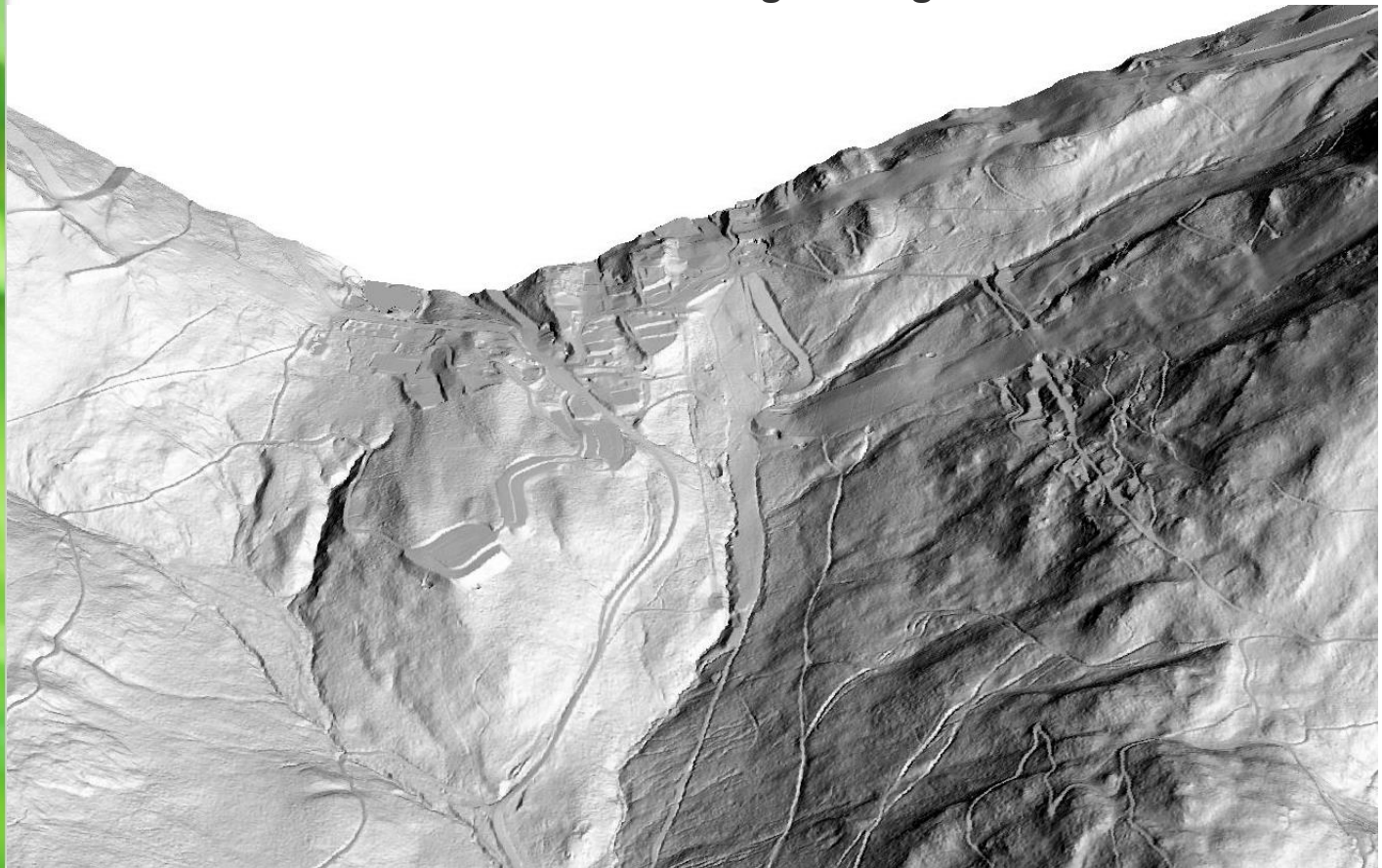
Airborne Laserscanning (LIDAR)





Remote Sensing data

Creation of digital height models



Digital

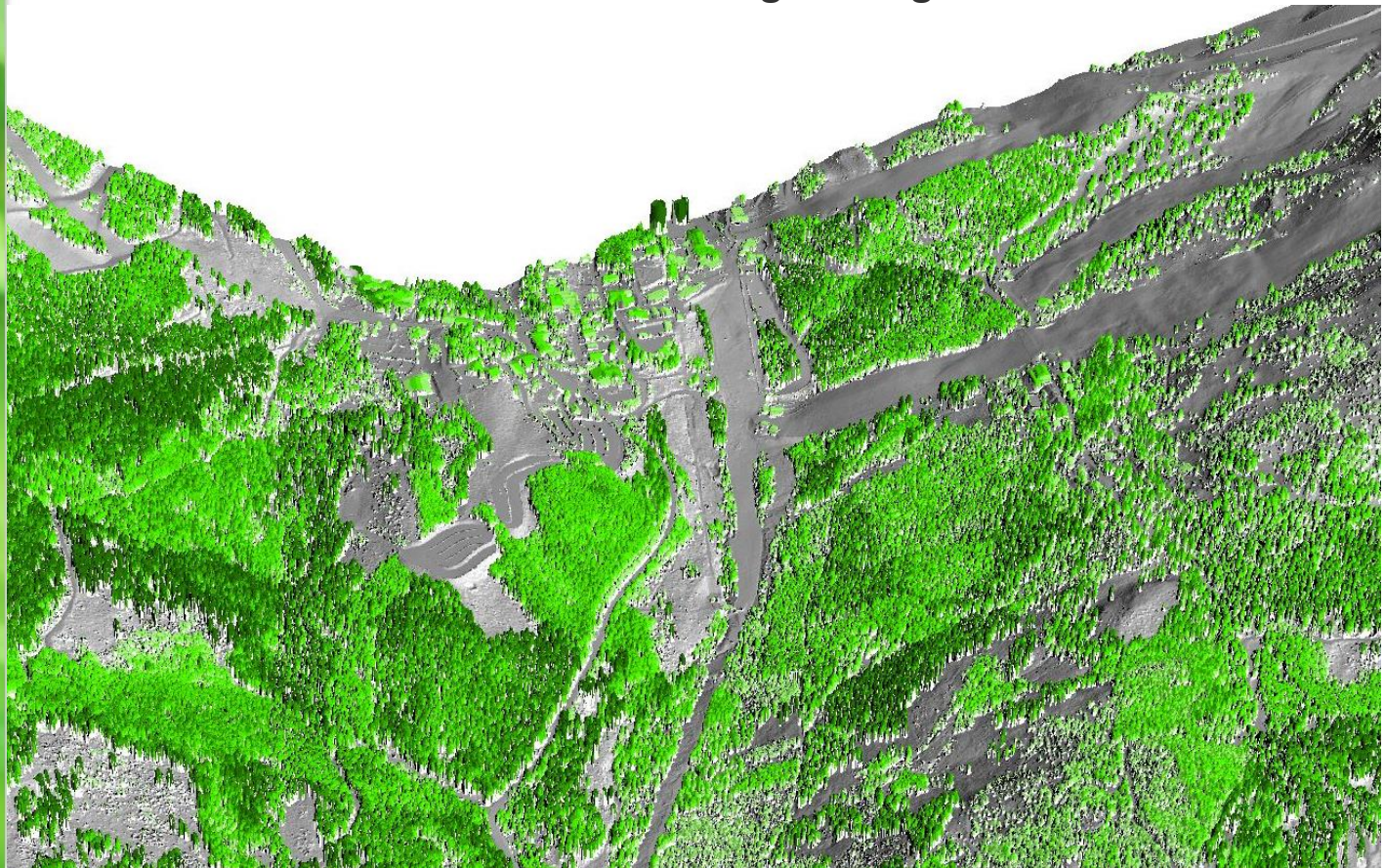
Terrain

Model

DTM

Remote Sensing data

Creation of digital height models



Digital

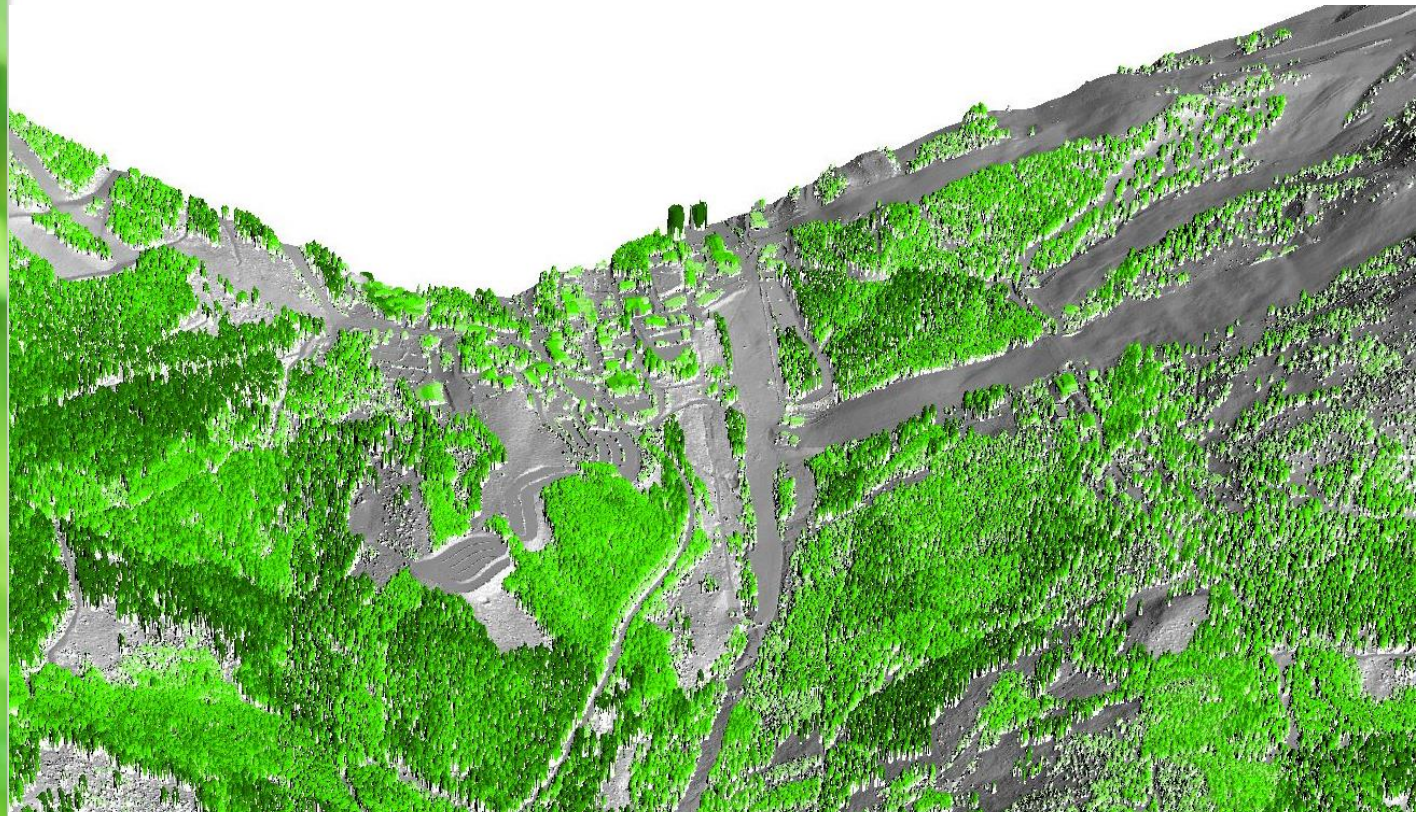
Surface

Model

DSM

Remote Sensing data

Derivation of the nDSM



Digital

Surface

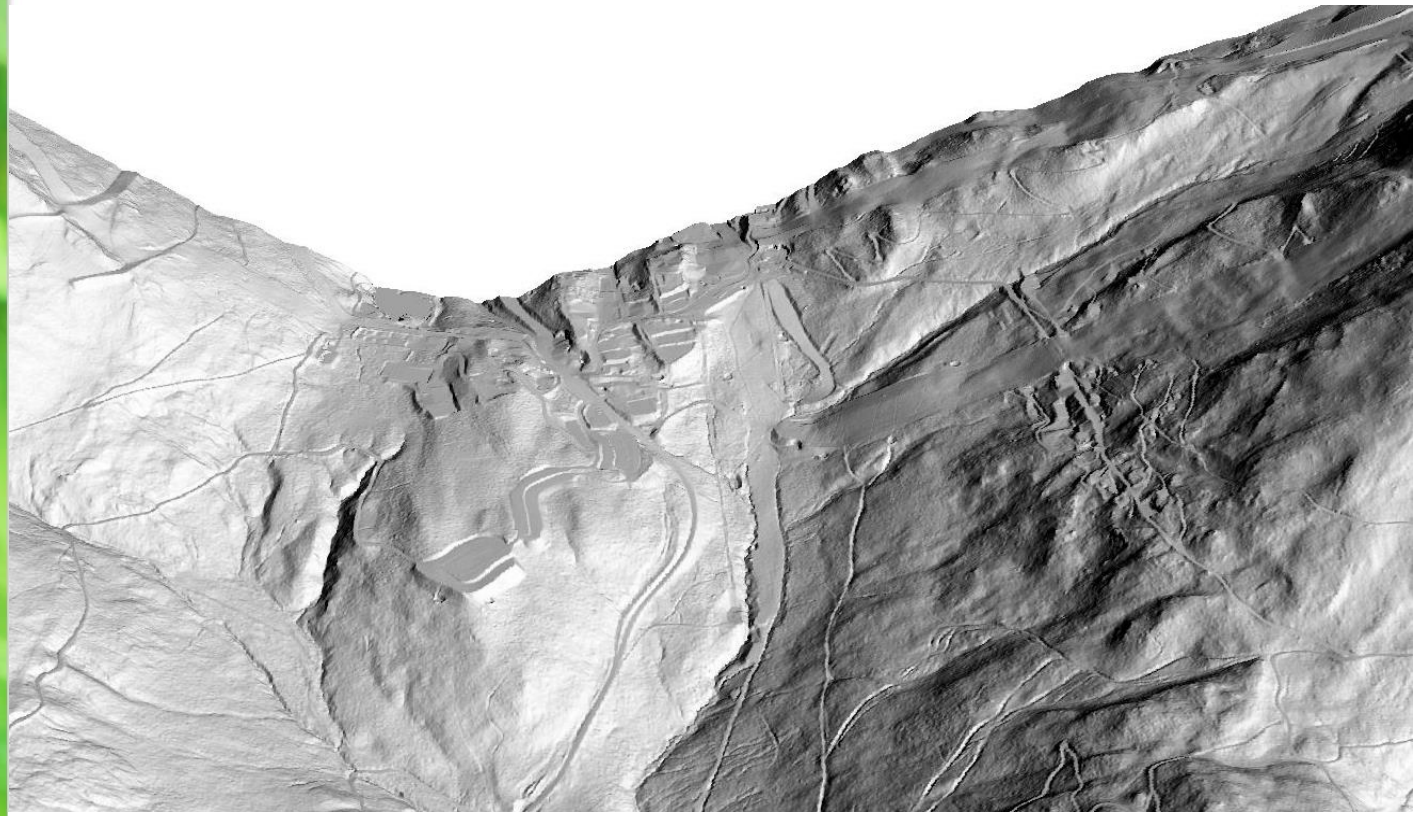
Model

DSM

DSM

Remote Sensing data

Derivation of the nDSM



Digital

Surface

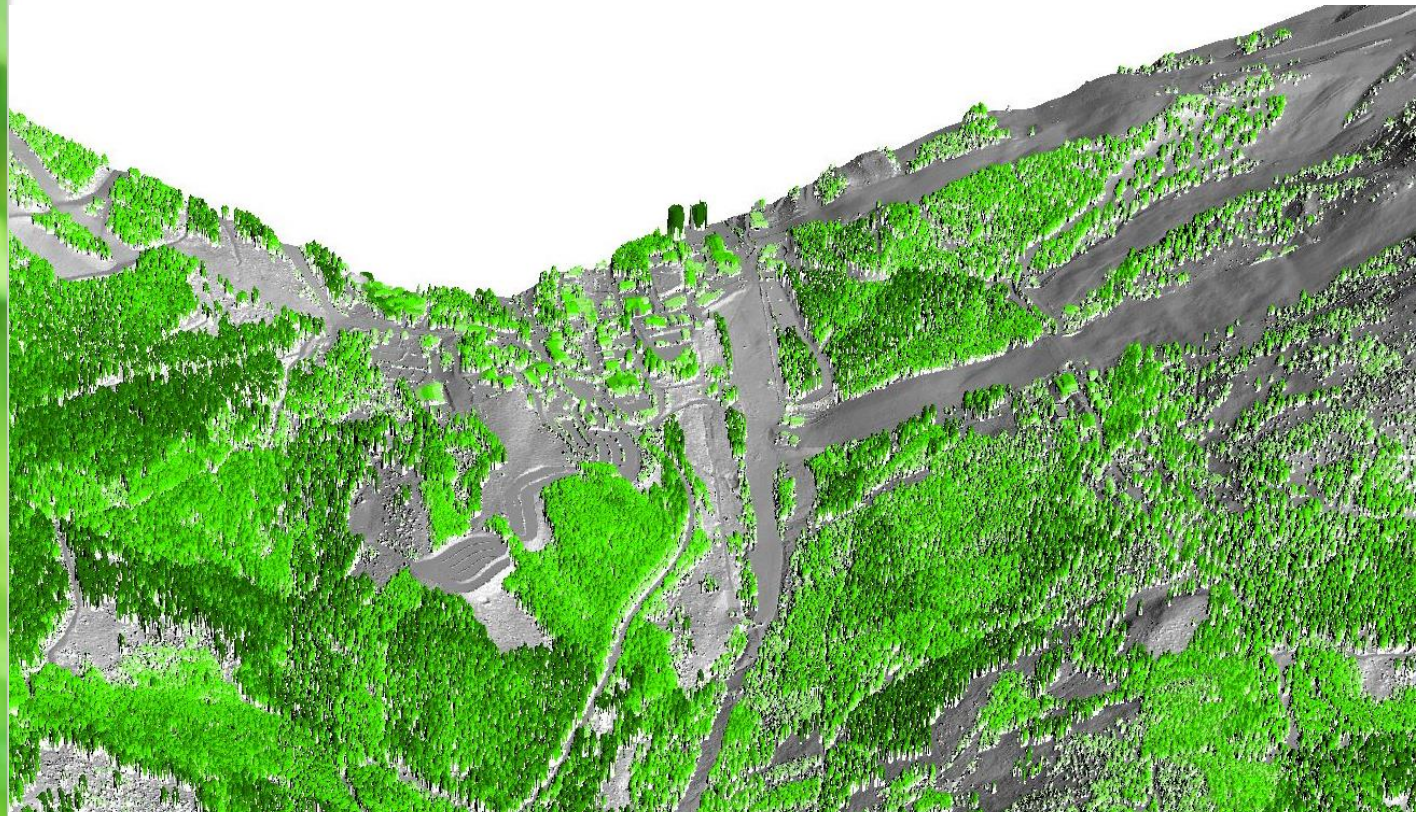
Model

DSM

DSM - DTM

Remote Sensing data

Derivation of the nDSM



normalised

Digital

Surface

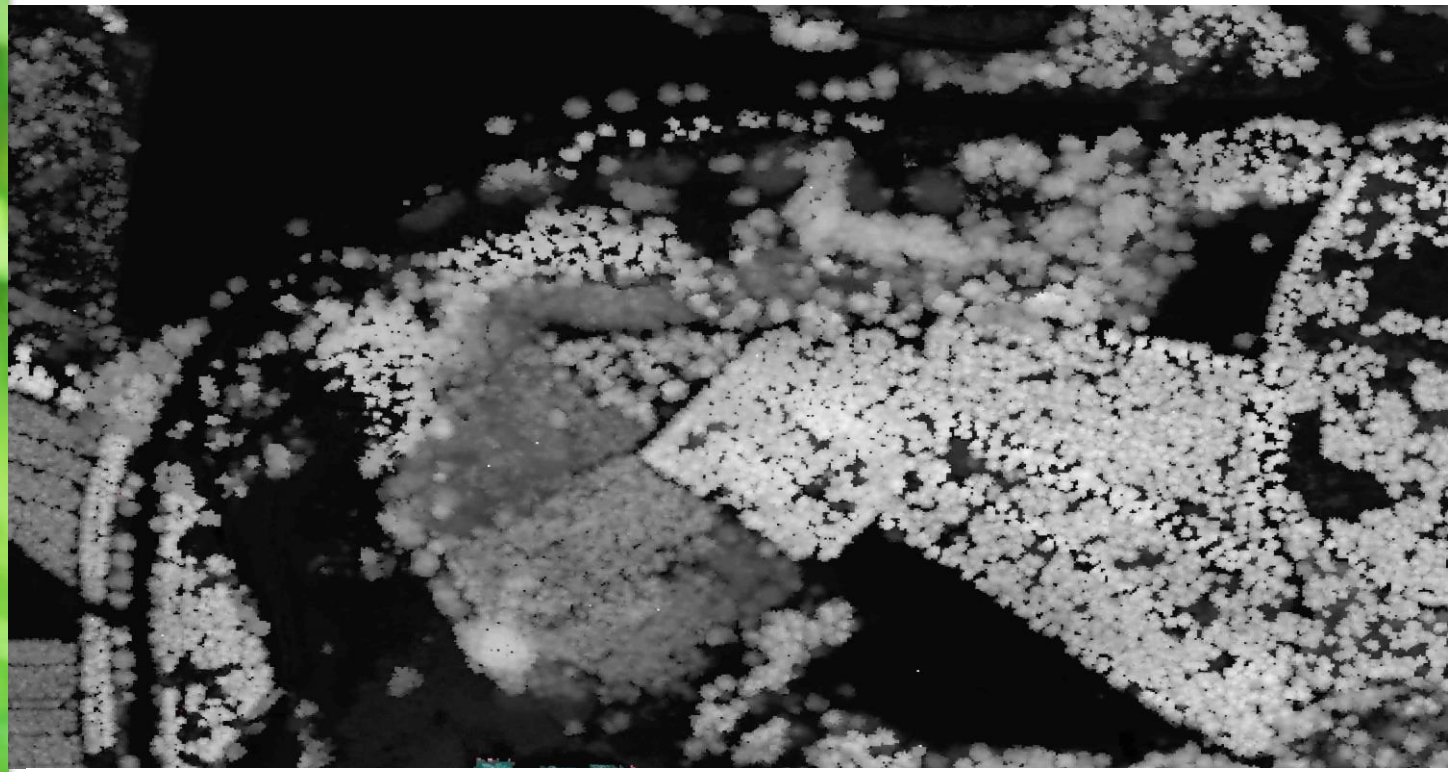
Model

DSM

DSM – DTM = nDSM

Remote Sensing data

Derivation of the nDSM (LIDAR)



32m

0m

nDSM = DSM - DTM

Remote Sensing data

Airborne Laserscanning (LIDAR)

But:

- No regular LIDAR flight-campaings for all of Austria
- Mainly used for the Digital Terrain Model DTM
- Regular updates are not so essential

nDSM = DSM - DTM

Remote sensing technologies

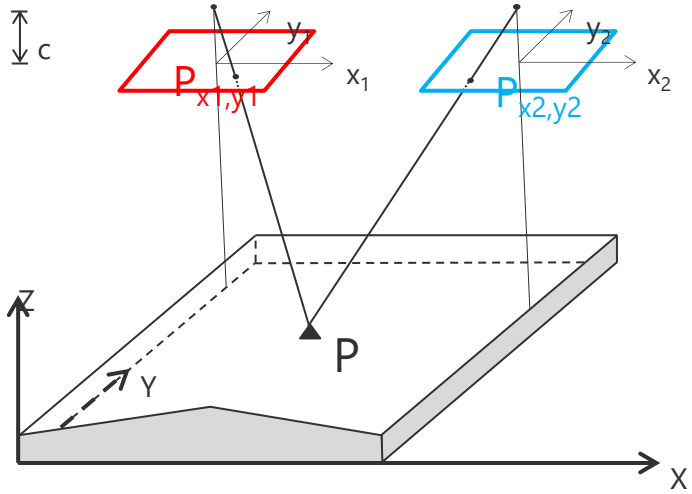
- Sensors
  - LIDAR
  - Optical
  - Radar

- Platforms
  - Person
  - Drone
  - Airplane
  - Satellite

Remote Sensing data

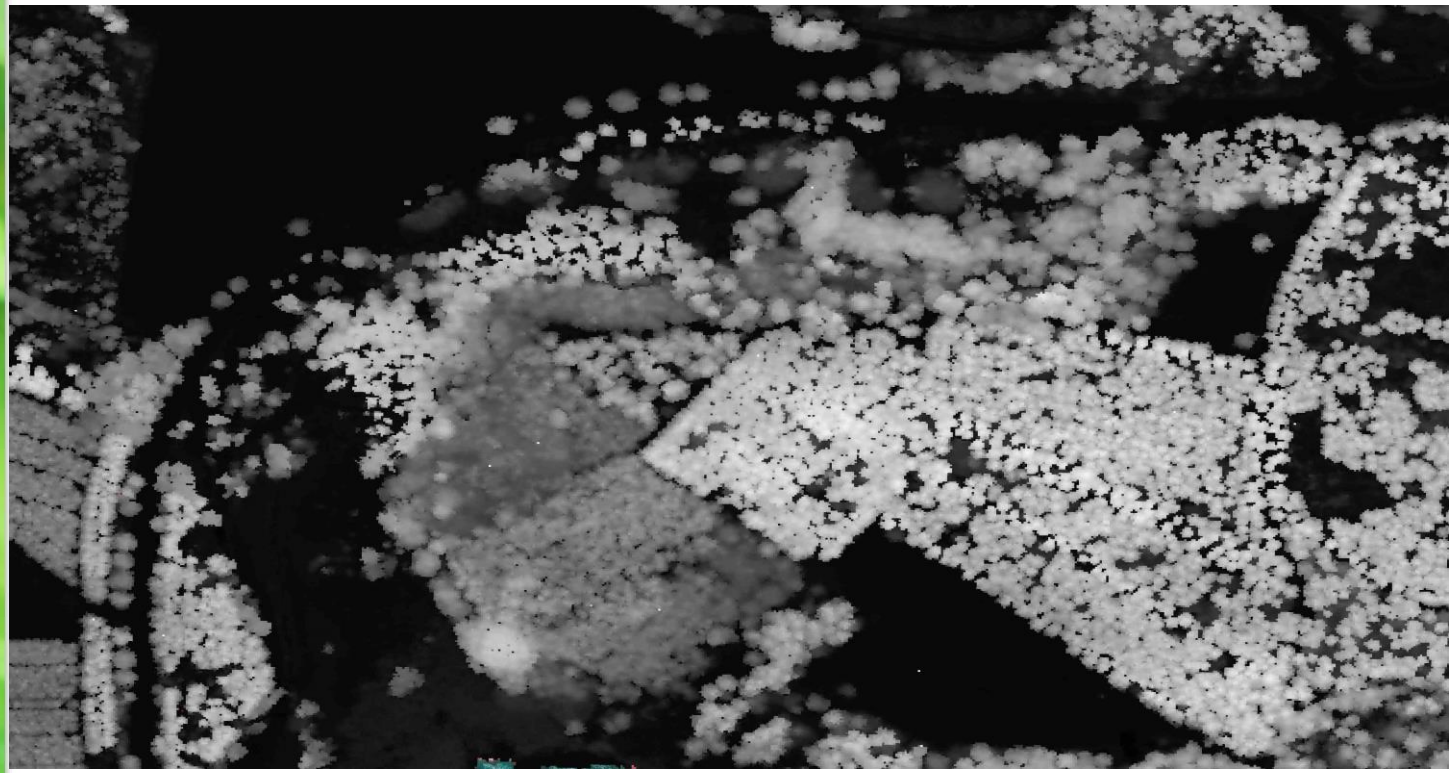
Image Matching

- Automated calculation of height – image pairs (stereo images)
- Based on two images with high overlapping in flightdirection
- Correlation with the help of features (grey values, patterns)



Remote Sensing data

Airborne Laserscanning and Image Matching



nDSM = DSM - DTM

3D Pointcloud from Image Matching

- Very high resolution 20cm

BFW Punktwolke Demo

file:///C:/Schadauer/Institut/Fernerkundung/Punktwolke Animation/_Vis03_rgb_cir_clas_2Dateien/_Vis03_rgb_cir_clas_2Dateien/BFW Punktwolke Demo Gebiet

Box
Lock view

Tools

Measurement

Clipping

Clip Task
None | Highlight | Inside | Outside

Clip Method
Inside Any | Inside All

Navigation

Camera Projection
Perspective | Orthographic

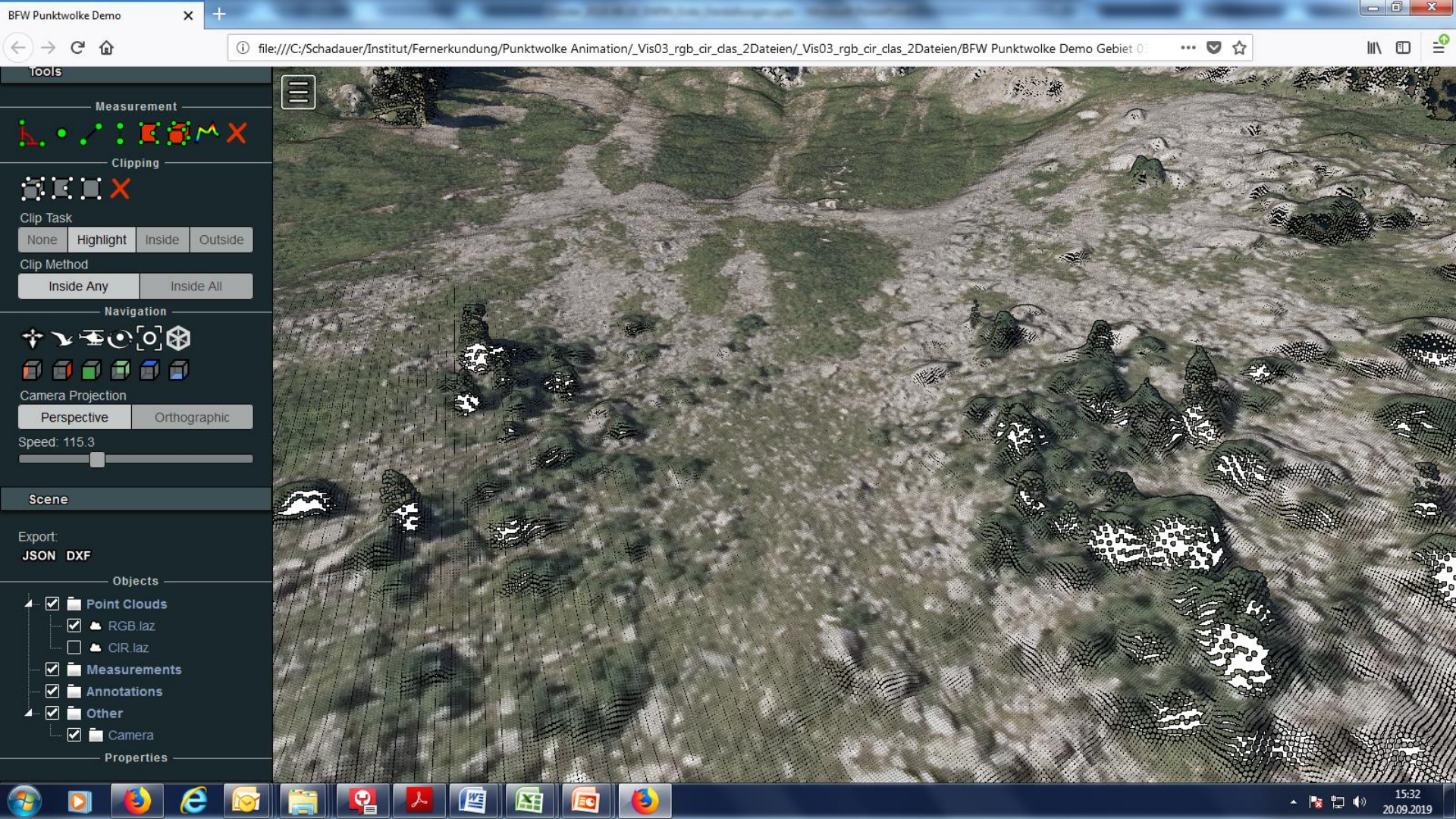
Speed: 557.5

Scene

Export:
JSON DXF

Objects
- Point Clouds
  - RGB.laz
  - CIR.laz
- Measurements

14:14
20.09.2019


BFW Punktwolke Demo
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Clip Method
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Navigation
Camera Projection
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Orthographic
Speed: 115.3
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Measurements
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Camera
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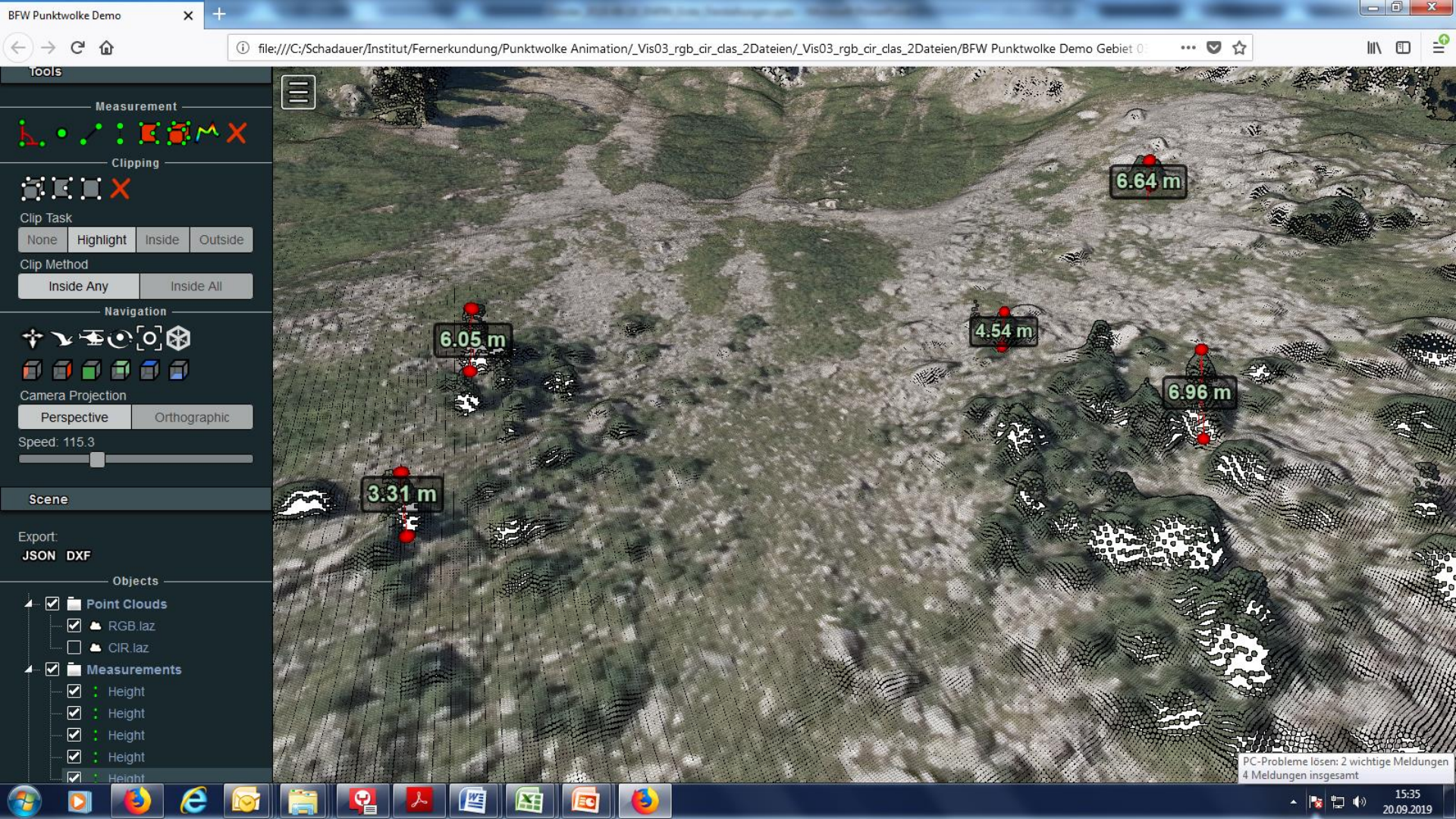
15:32
20.09.2019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CIR.laz
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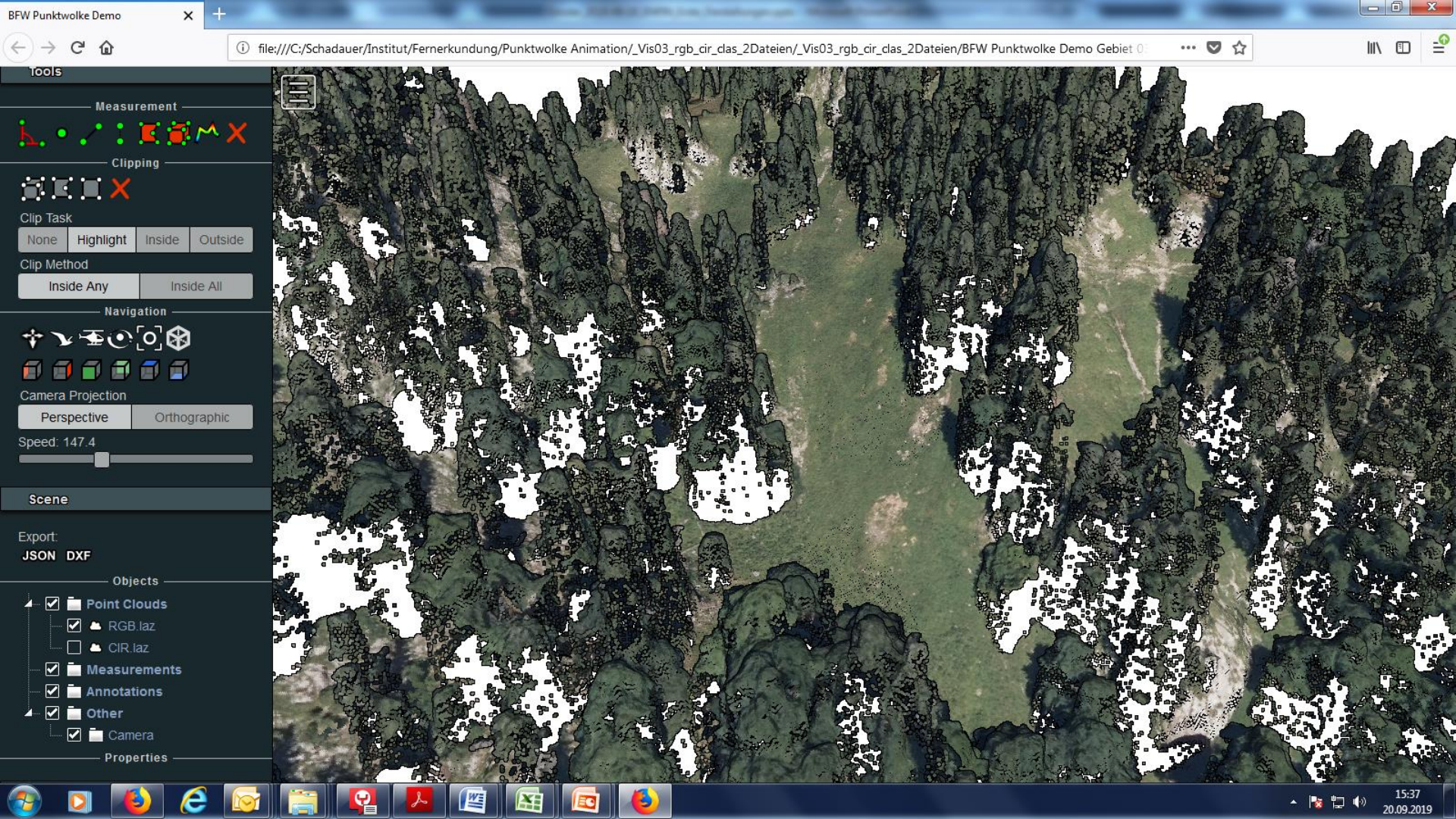
6.64 m
6.05 m
4.54 m
6.96 m
3.31 m
PC-Probleme lösen: 2 wichtige Meldungen
4 Meldungen insgesamt
15:35
20.09.2019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Annotations
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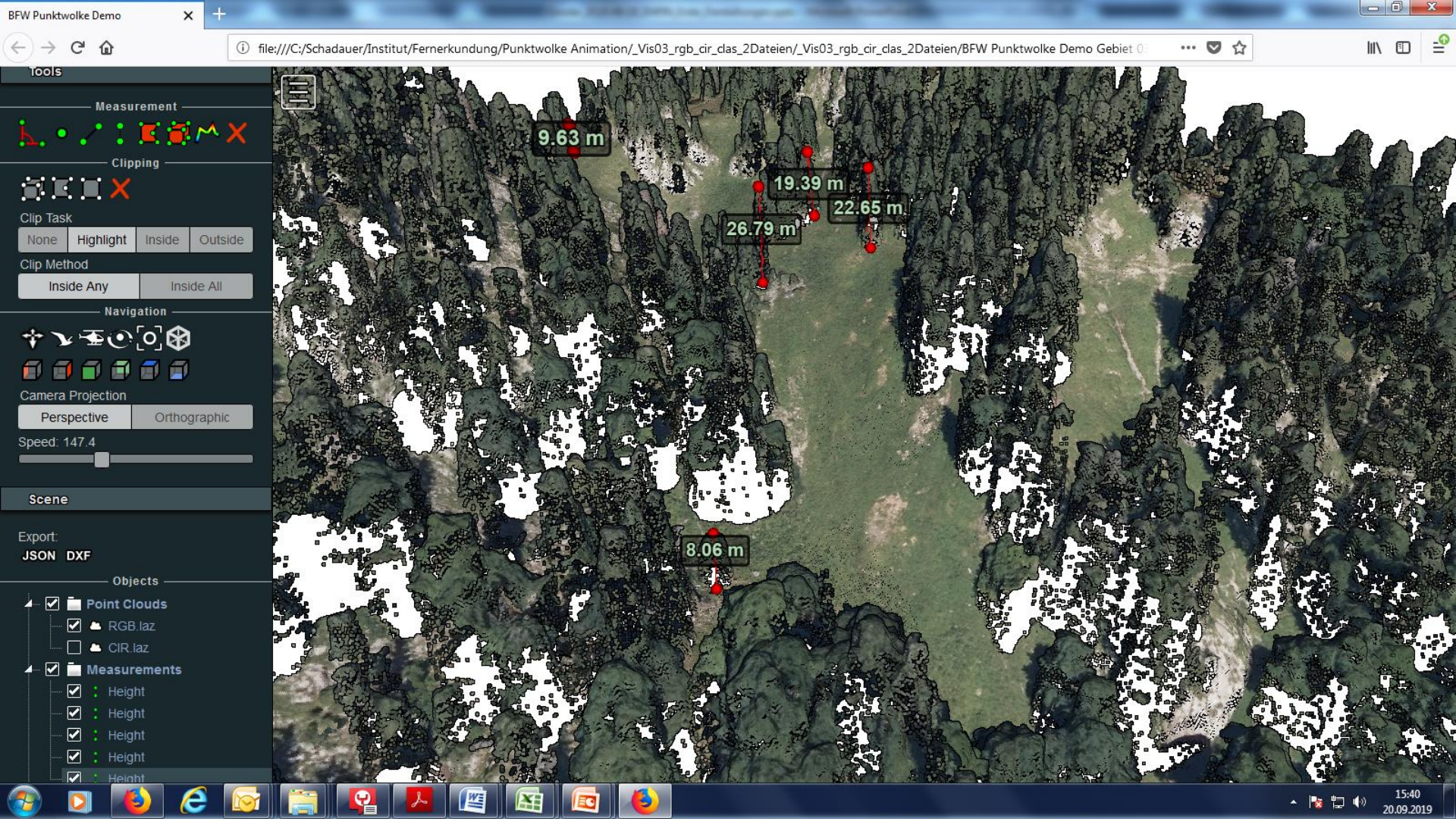
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Speed: 147.4
Scene
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JSON DXF
Objects
Point Clouds
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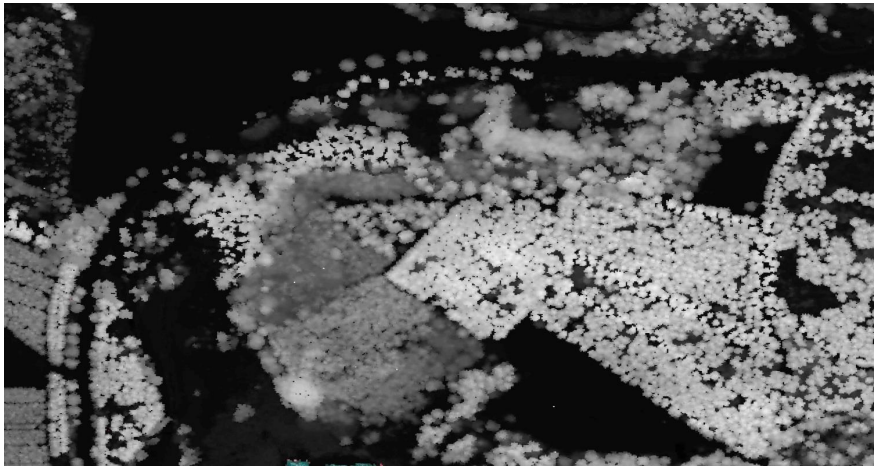
CIR.laz
Measurements
Height
Height
Height
Height
Height
9.63 m
19.39 m
22.65 m
26.79 m
8.06 m
15:40
20.09.2019

Remote Sensing data

Airborne Laserscanning and Image Matching

- regular aerial-photo flight-campaigns for all of Austria
- Operational derivation of the DSM and nDSM every three years
- Basis for several RS products

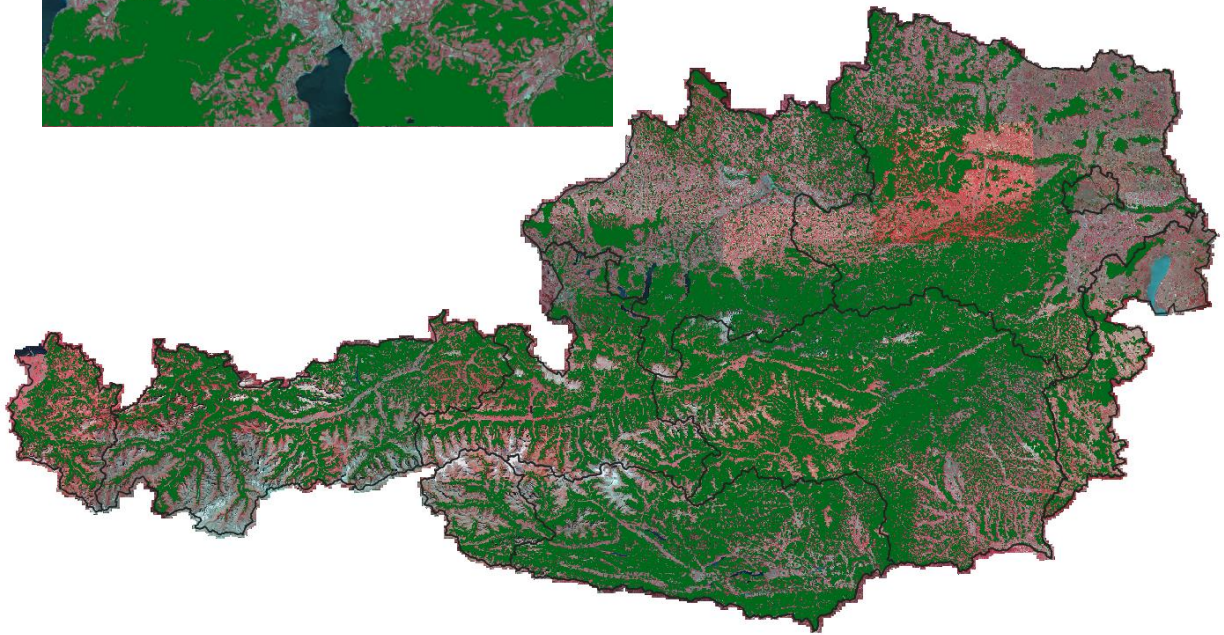


nDSM = DSM - DTM

Creating a forest map

- Fully automated attempts failed

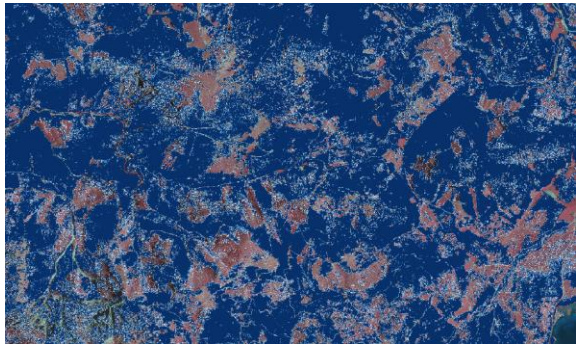
Manually digitised!!



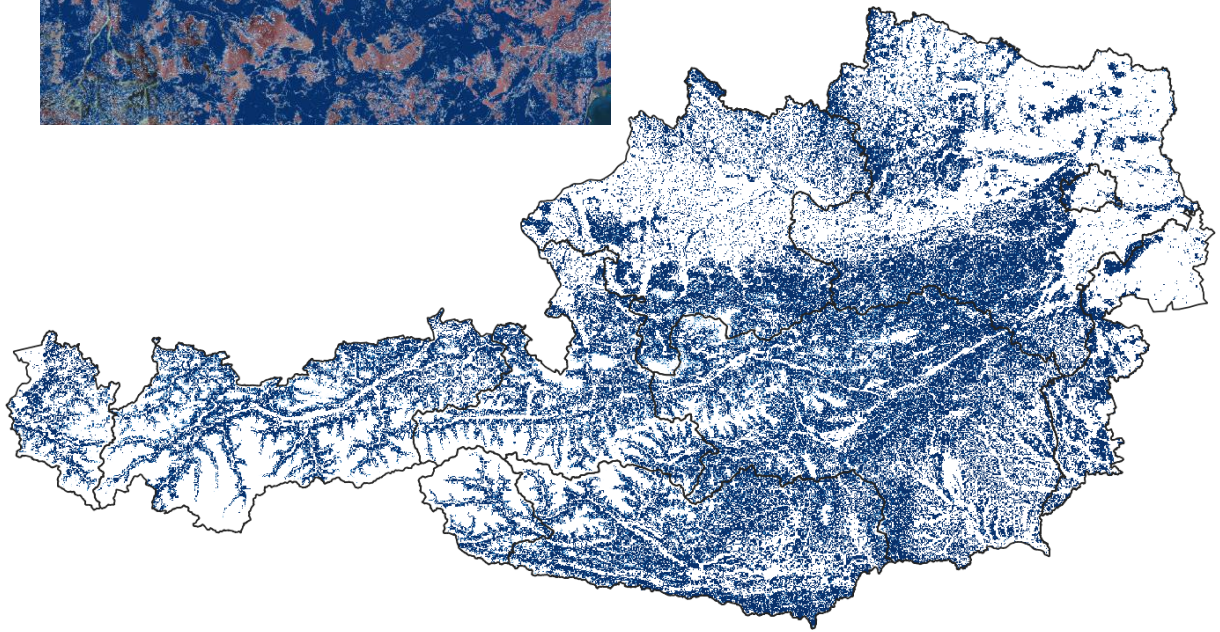
Developments based on the nDSM

Maps for

- Crown cover



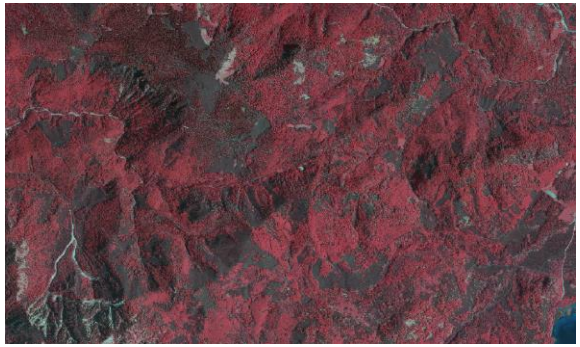
Fully automated



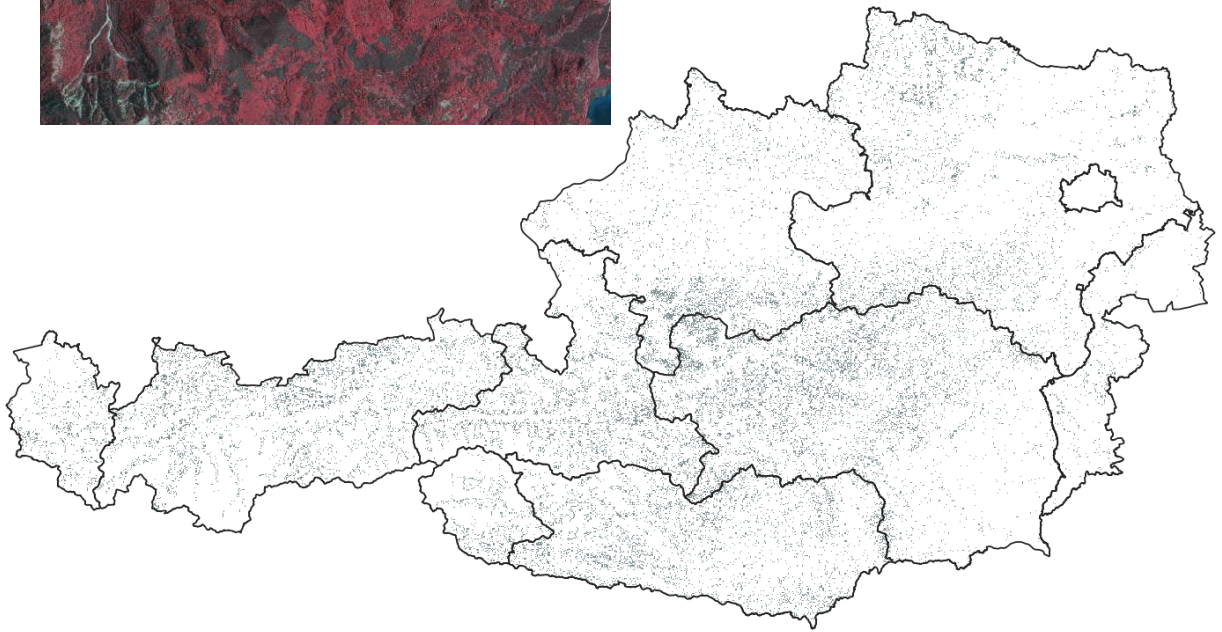
Developments based on the nDSM

Maps for

- Crown cover
- Forest gaps



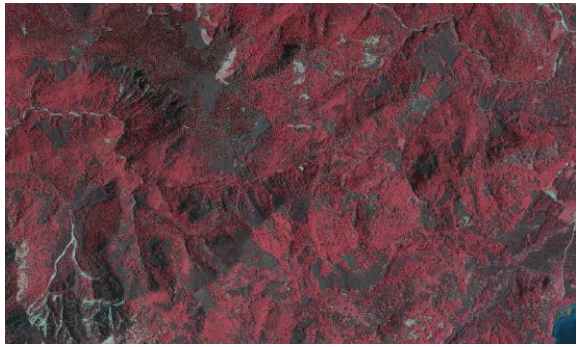
Fully automated



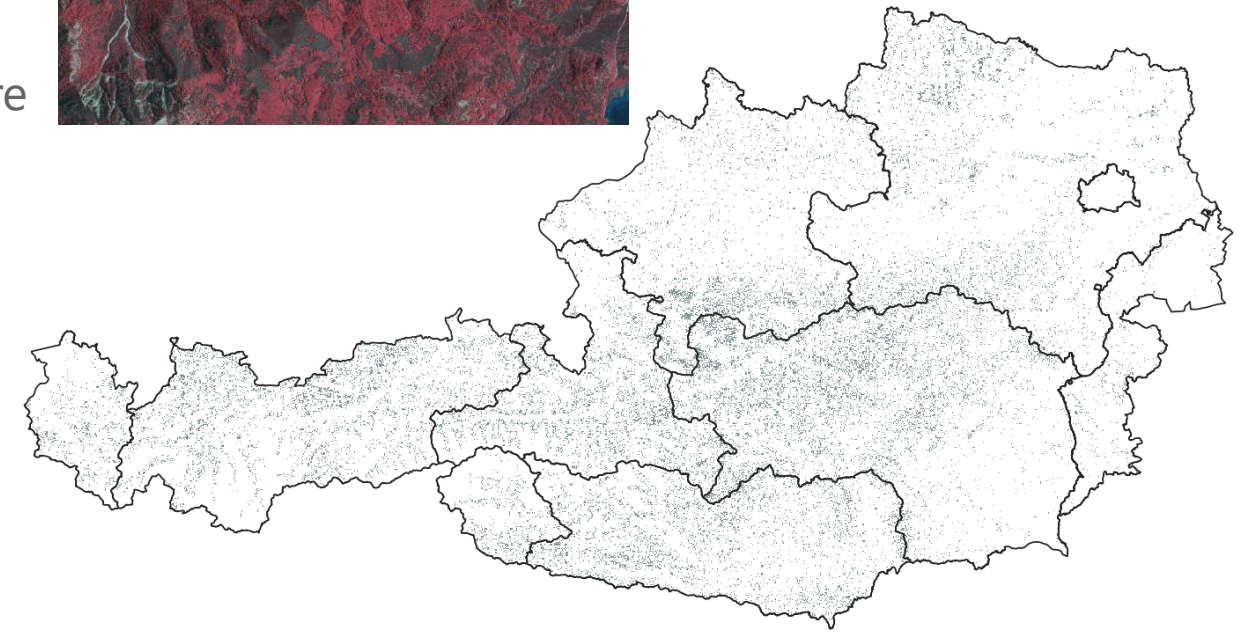
Developments based on the nDSM

Maps for

- Crown cover
- Forest gaps
- Forest structure

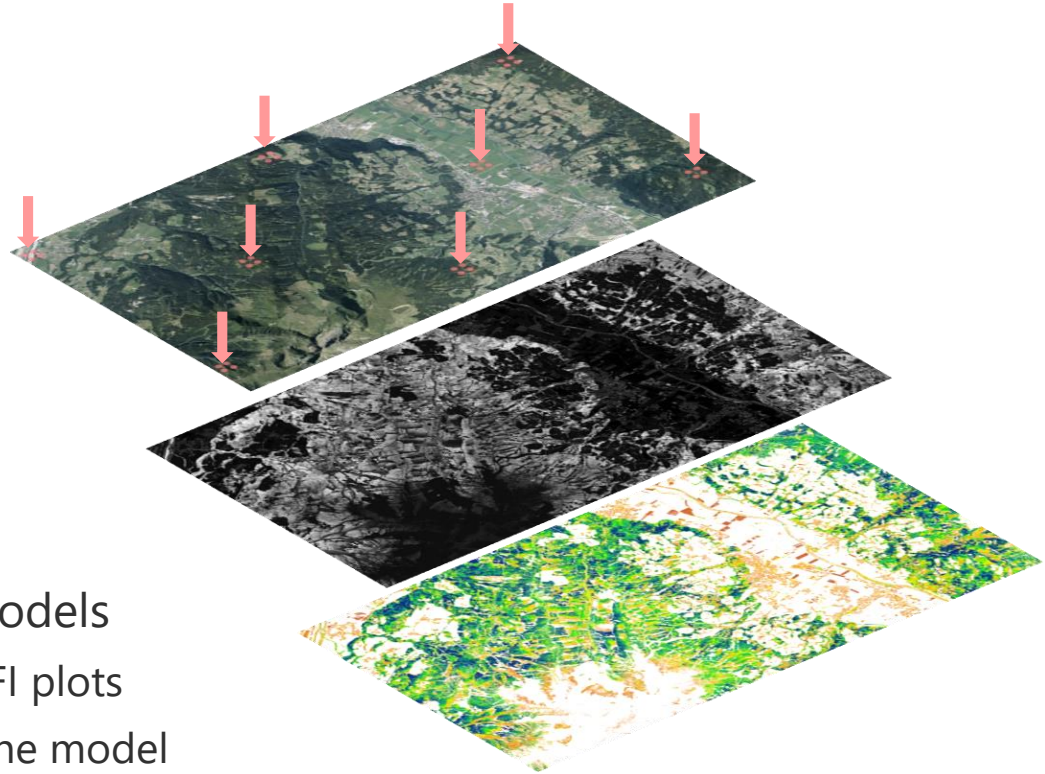


Not yet for all of Austria



Combining Field plots and RS

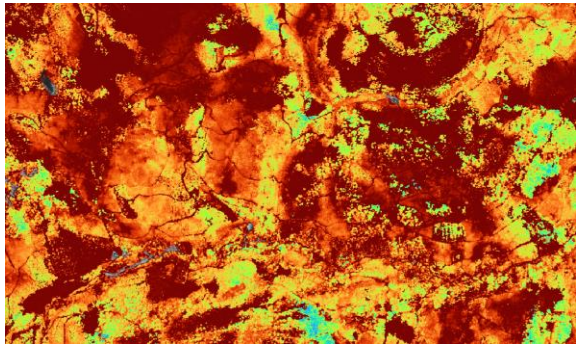
- Field plots
- Remote sensing
- Combining with models
  - Training with NFI plots
  - Application of the model
  - Estimate for the area of interest
  - Mapping



Developments based on the nDSM

Maps for

- Crown cover
- Forest gaps
- Forest structure
- Standing volume



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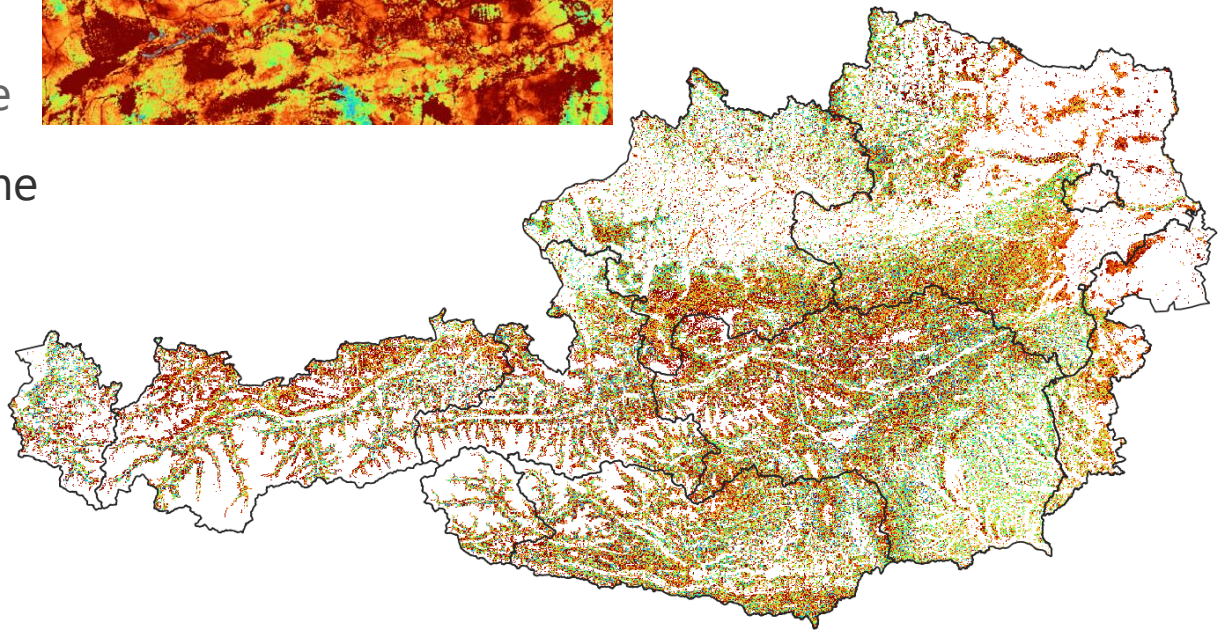


Standing Volume - Model for mapping

- Linear Regression model
- Parametrised with NFI plot data
- Applied on the pixel level
- Input variables from Remote Sensing:

$$\hat{y} = \sum \beta_i \cdot x_i$$

β_i ... coefficients

x_i ... Inputvariables

Variable	Description
nDSM	Normalised Digital Surface Model (Vegetation-height)
$nDSM^2$	Quadrat des nDSM
BL_share	Share of broadleaved trees
$nDSM^2$ x BL_share	Interaction between broadleaved trees und quadratic nDSM
Sea	Height above sea level
Slope	slope
South	South-inclination of the slope

Application of the Volume Model

- Reduction of the uncertainty
  - Large sample or even wall-to-wall data from remote sensing
  - Higher R^2 of the model → smaller confidence interval
- Can be applied to an arbitrary area, even to areas without field plots
  - Used for local forest administration
  - Used for forest management planning

Application of the Volume Model

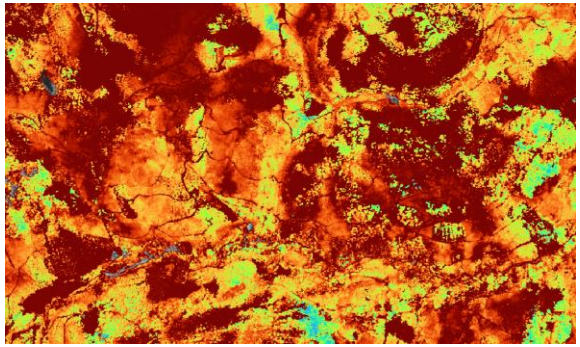
- Statistical framework changes in that case
  - Model assisted vs model based or synthetic estimators
  - Uncertainty often underestimated by synthetic estimators

- Extensive work by Mandallaz, Hill, Massey from WSL / ETH Zurich

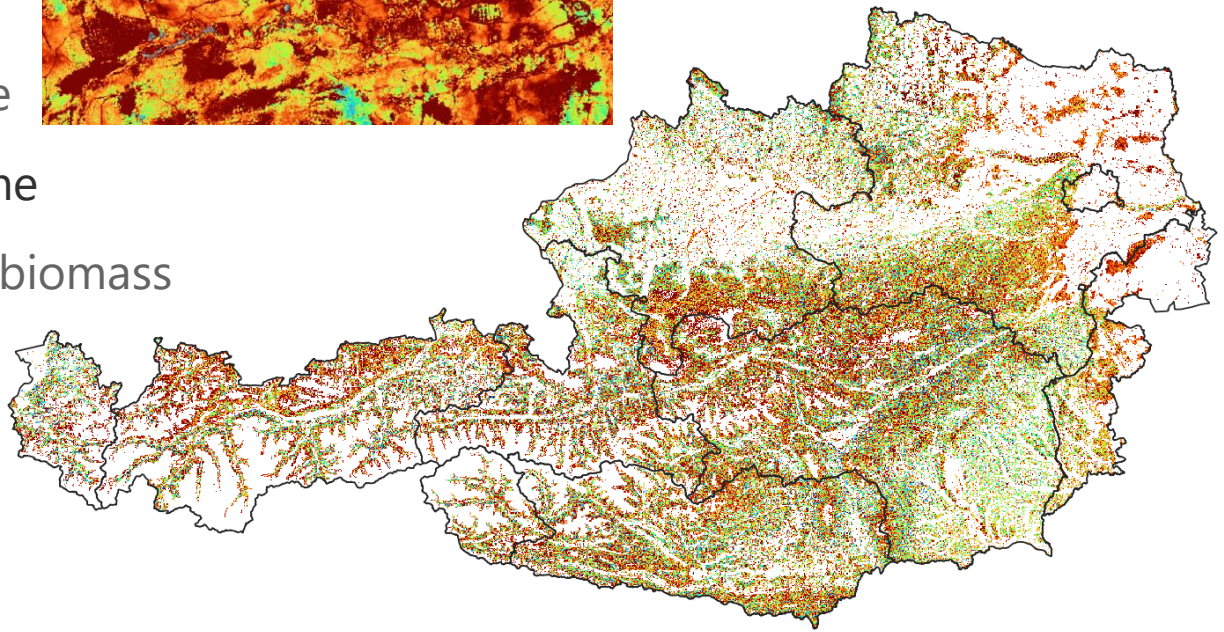
Developments based on the nDSM

Maps for

- Crown cover
- Forest gaps
- Forest structure
- Standing volume
- Above ground biomass



Fully automated



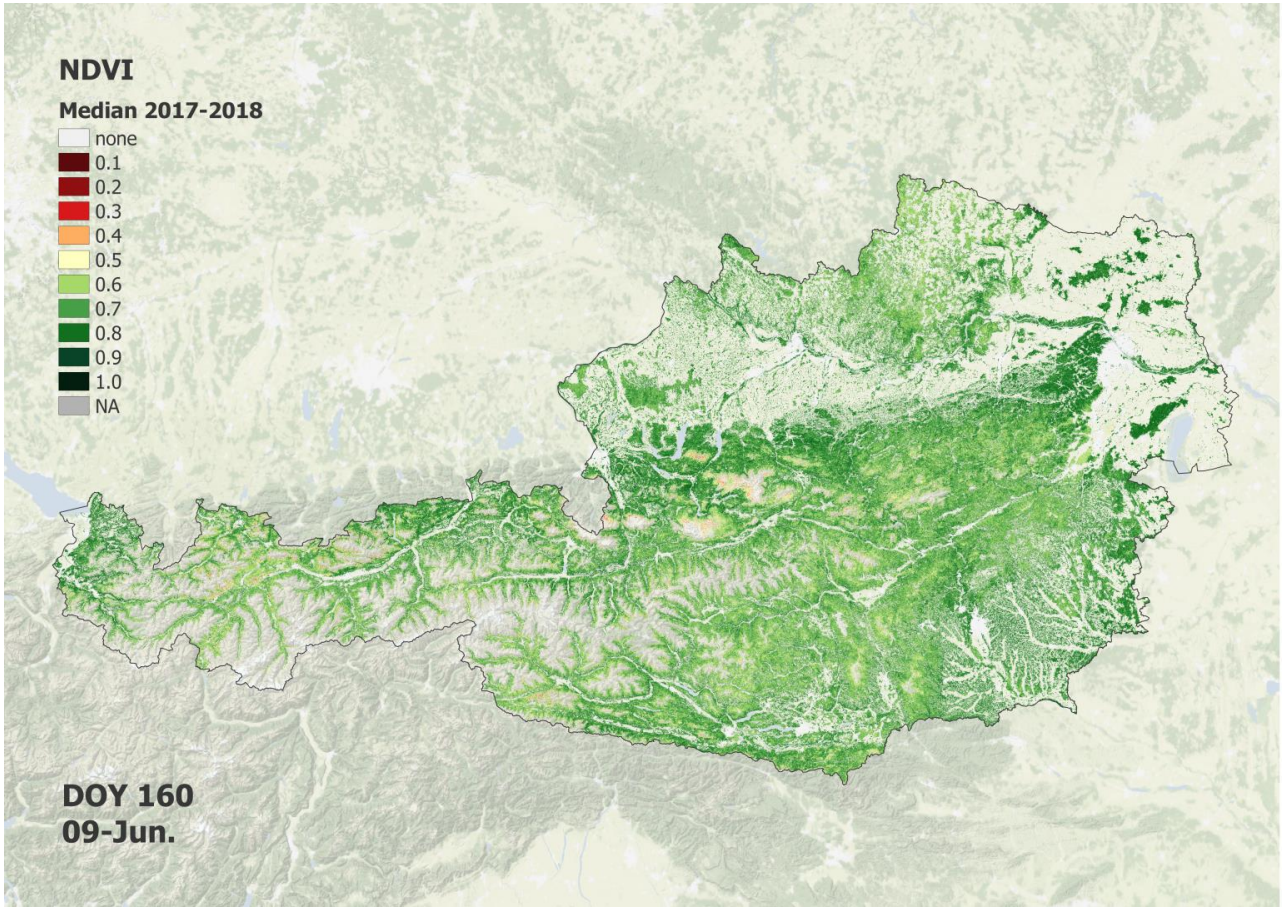
Remote sensing technologies

- Sensors
  - LIDAR
  - Optical
  - Radar

- Platforms
  - Person
  - Drone
  - Airplane
  - Satellite

Satellite/Sentinel 2 applications

- Sentinel 2 technology
- Pixel based Models for Vegetation Indexes
- 400. Mio. models inside forest

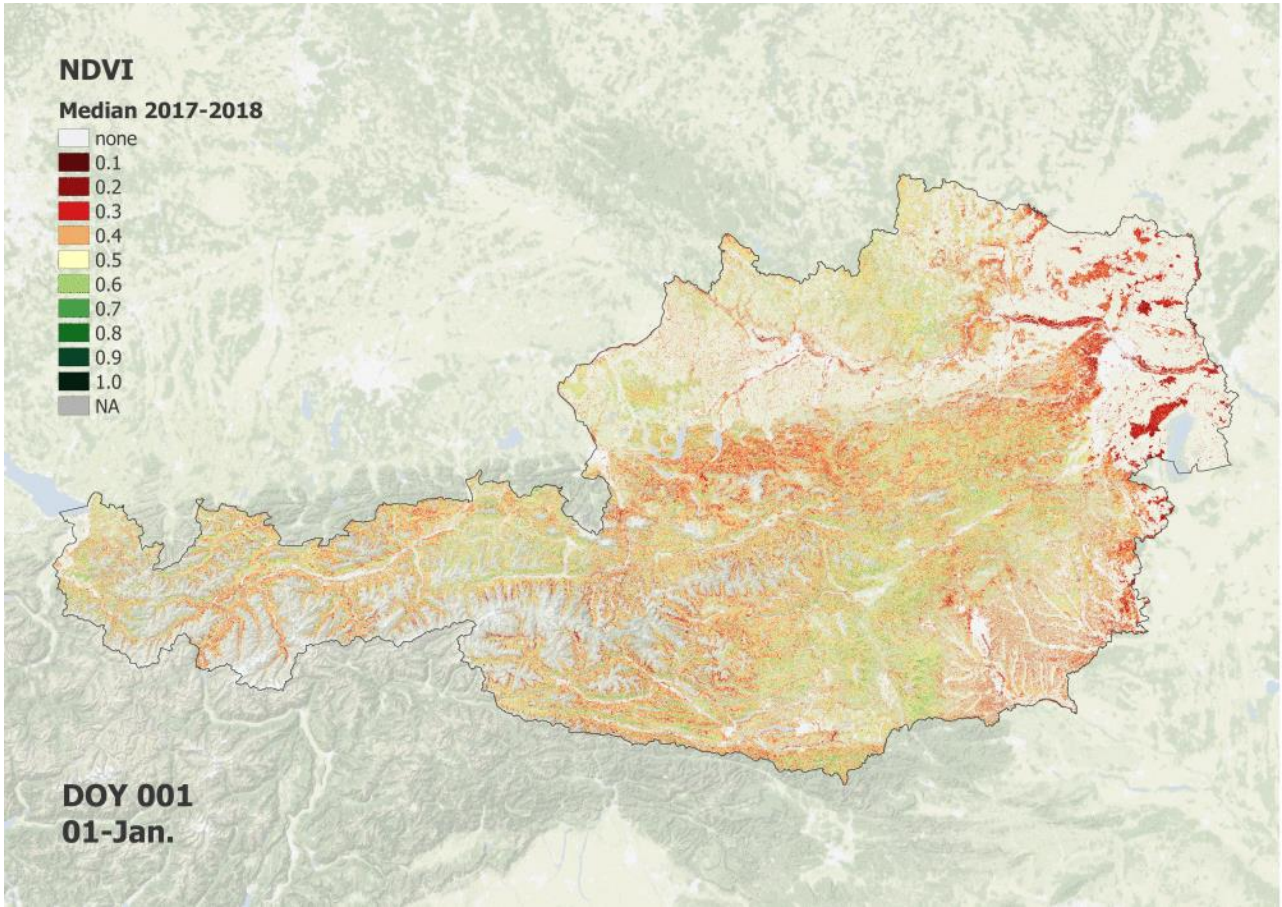


Satellite Sentinel 2 applications

Phenology model

Two applications:

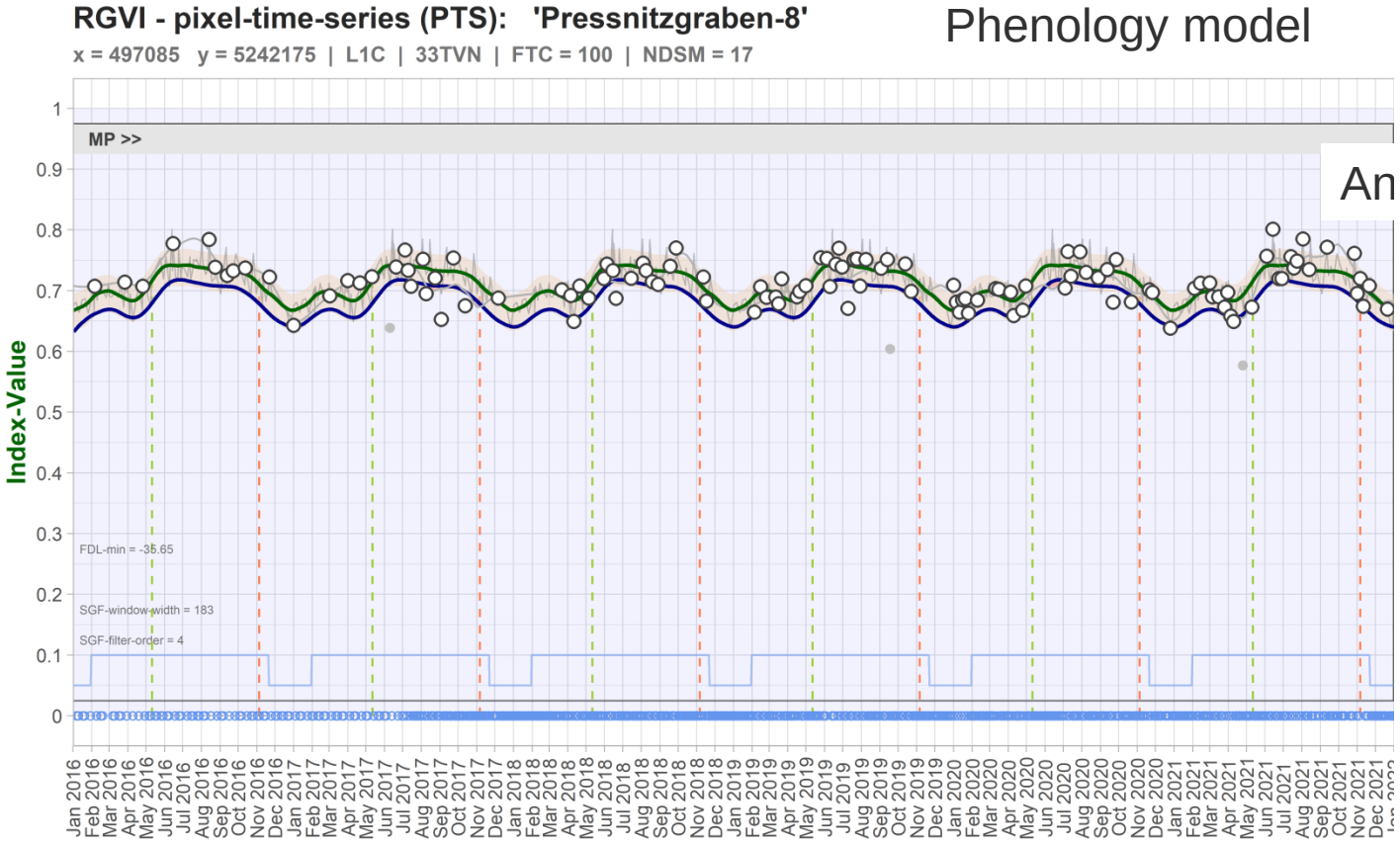
- Anomaly detection
- Trees species mapping



Sentinel 2 - Anomaly Detection

- Time series analyses starting from 2017 using a fitted model instead of original data
- Derivation of the beginning date of the anomaly
- Splitting the model into a calibration and an anomaly period
- Quantification of the intensity of the anomaly

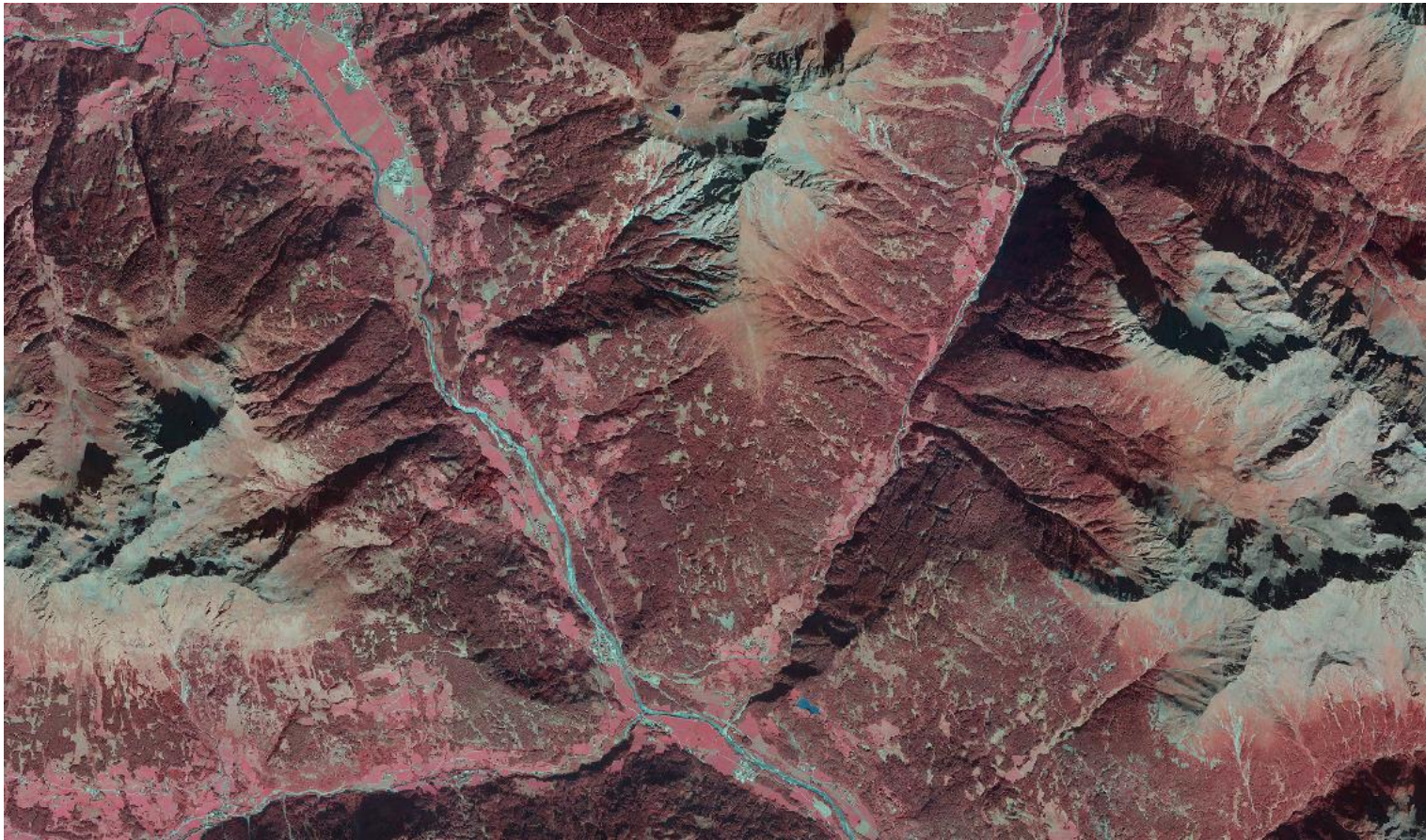
Sentinel 2 - Anomaly Detection



Sentinel 2 - Anomaly Detection

Summer 2018

CIR Ortho



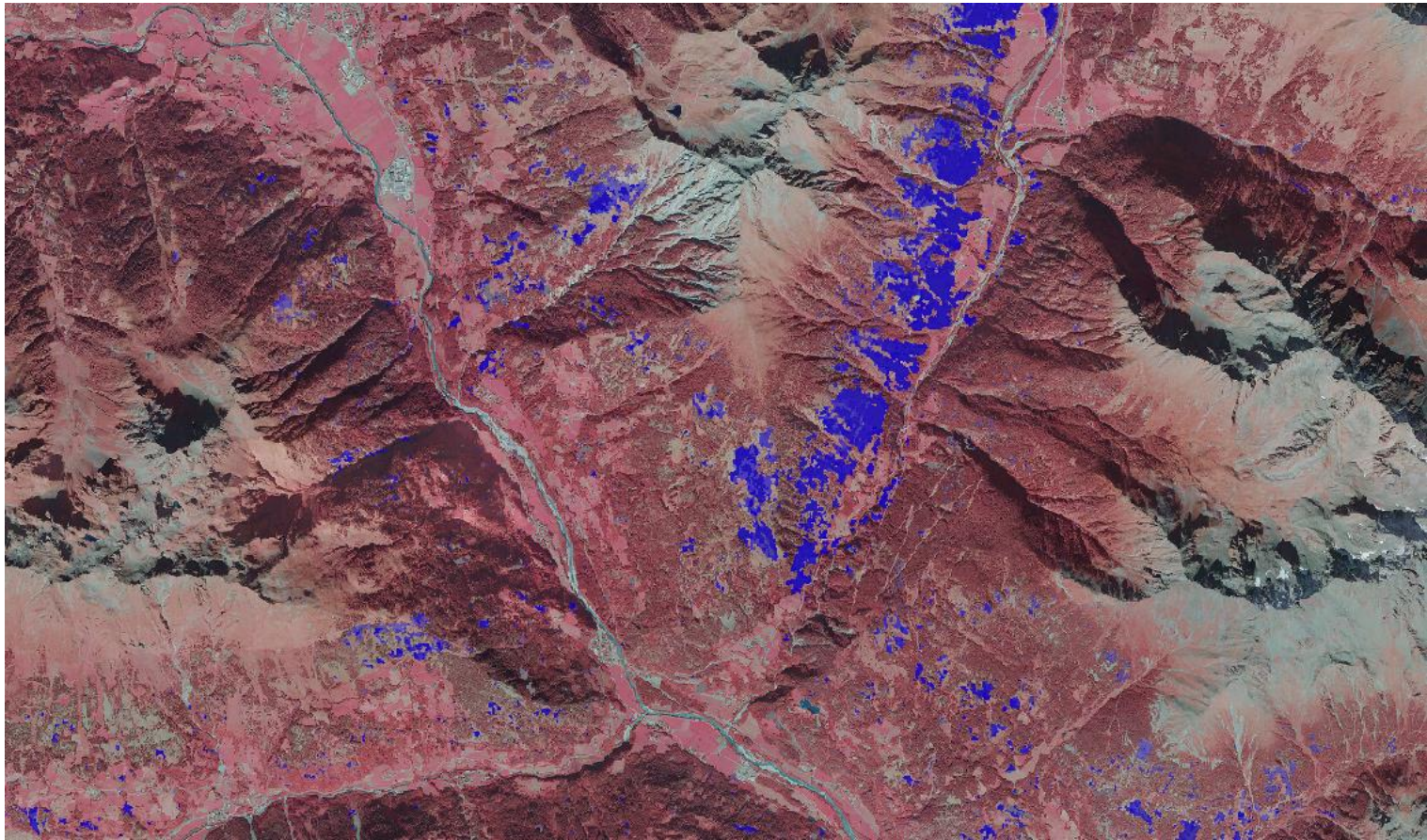
Sentinel 2 - Anomaly Detection

Summer 2021

CIR Ortho

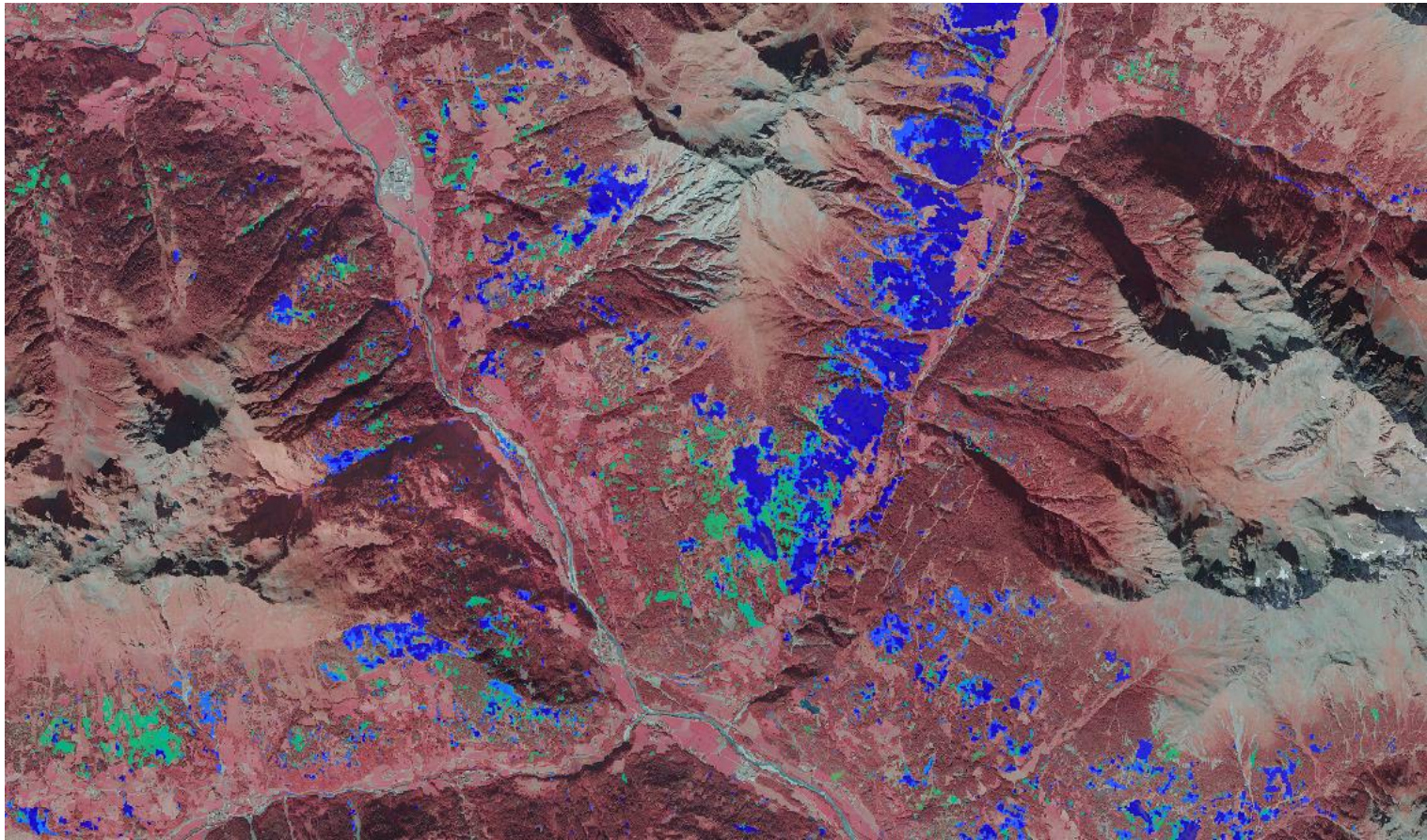
Sentinel 2 - Anomaly Detection

Autumn
2018



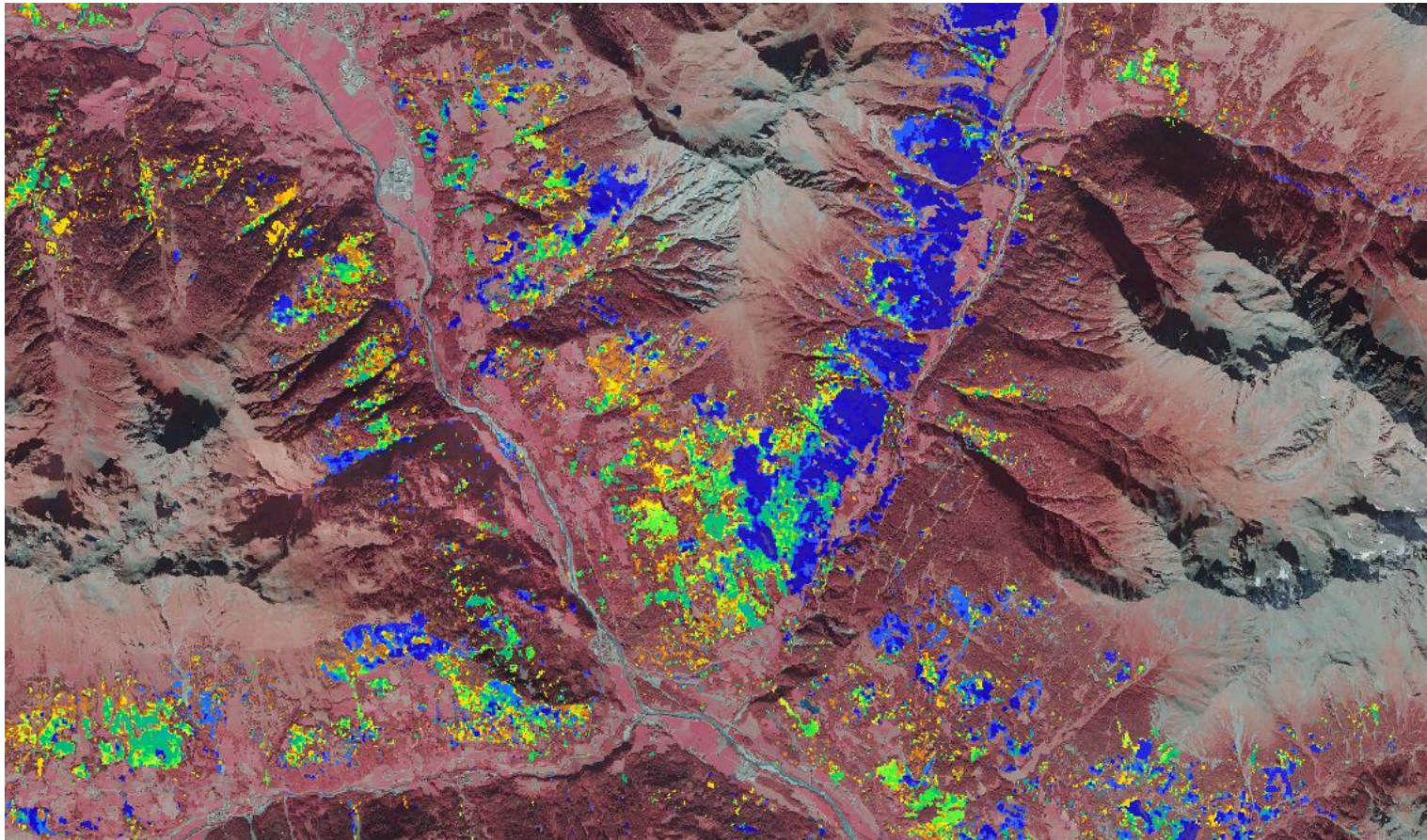
Sentinel 2 - Anomaly Detection

2019



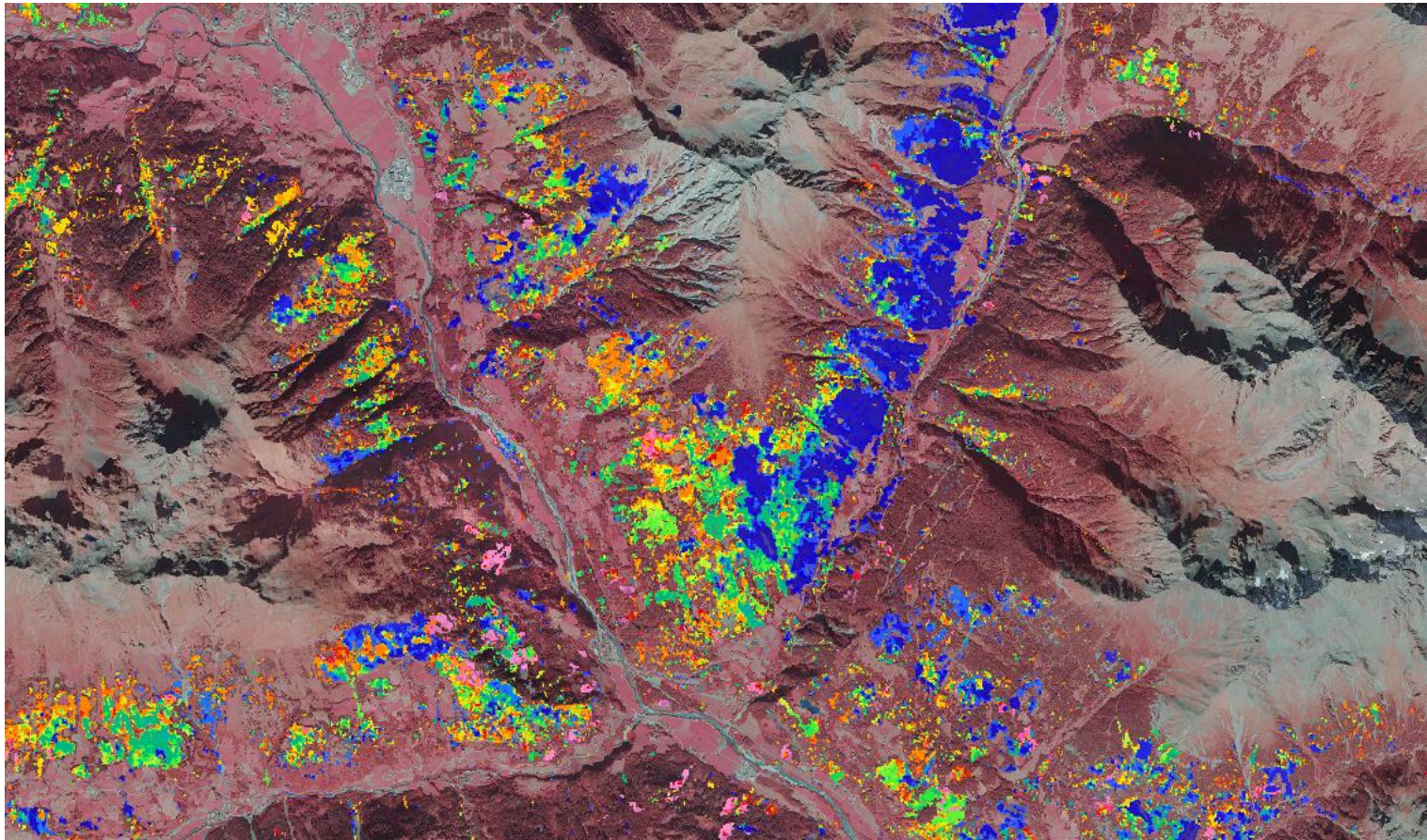
Sentinel 2 - Anomaly Detection

2020



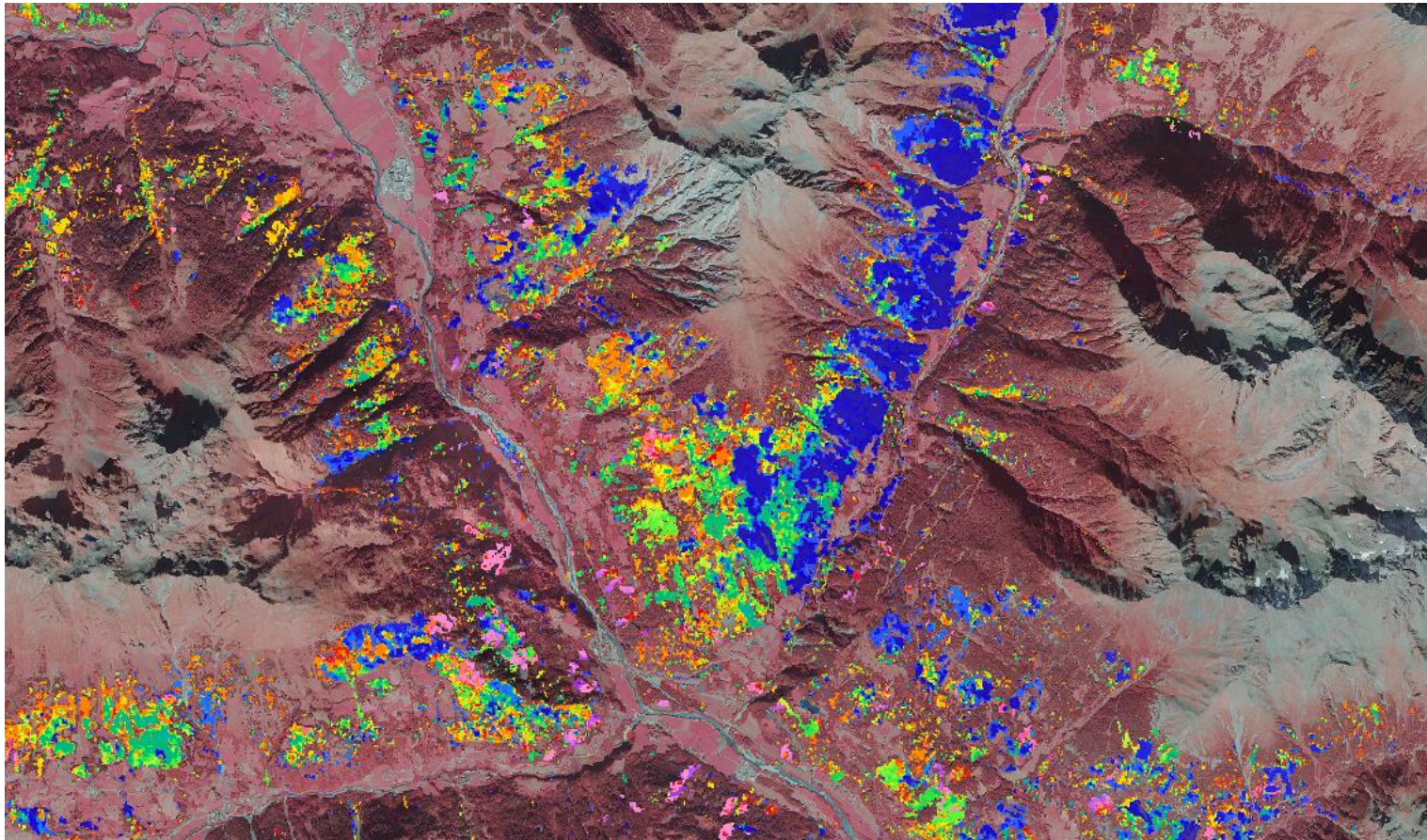
Sentinel 2 - Anomaly Detection

2021

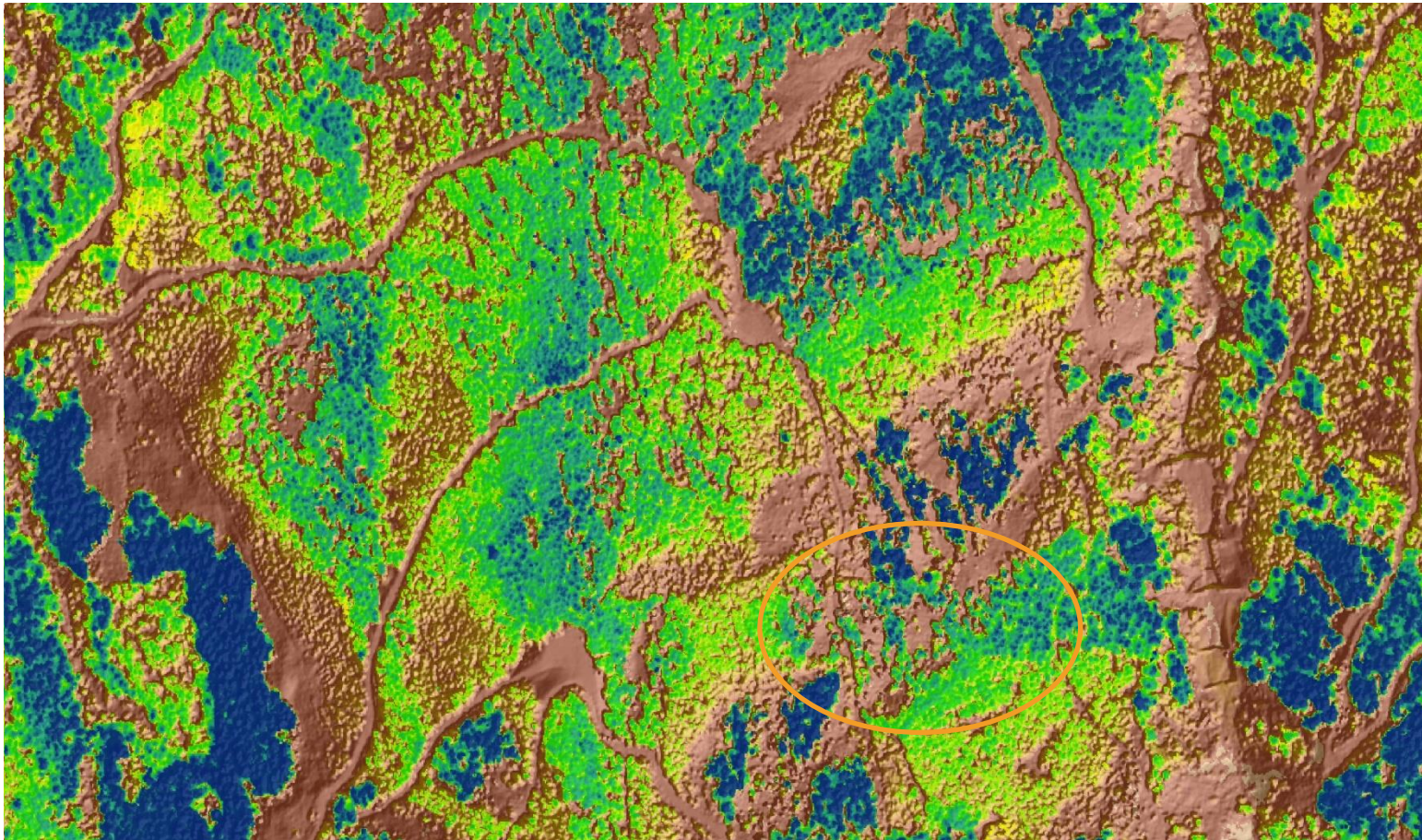


Sentinel 2 - Anomaly Detection

2022

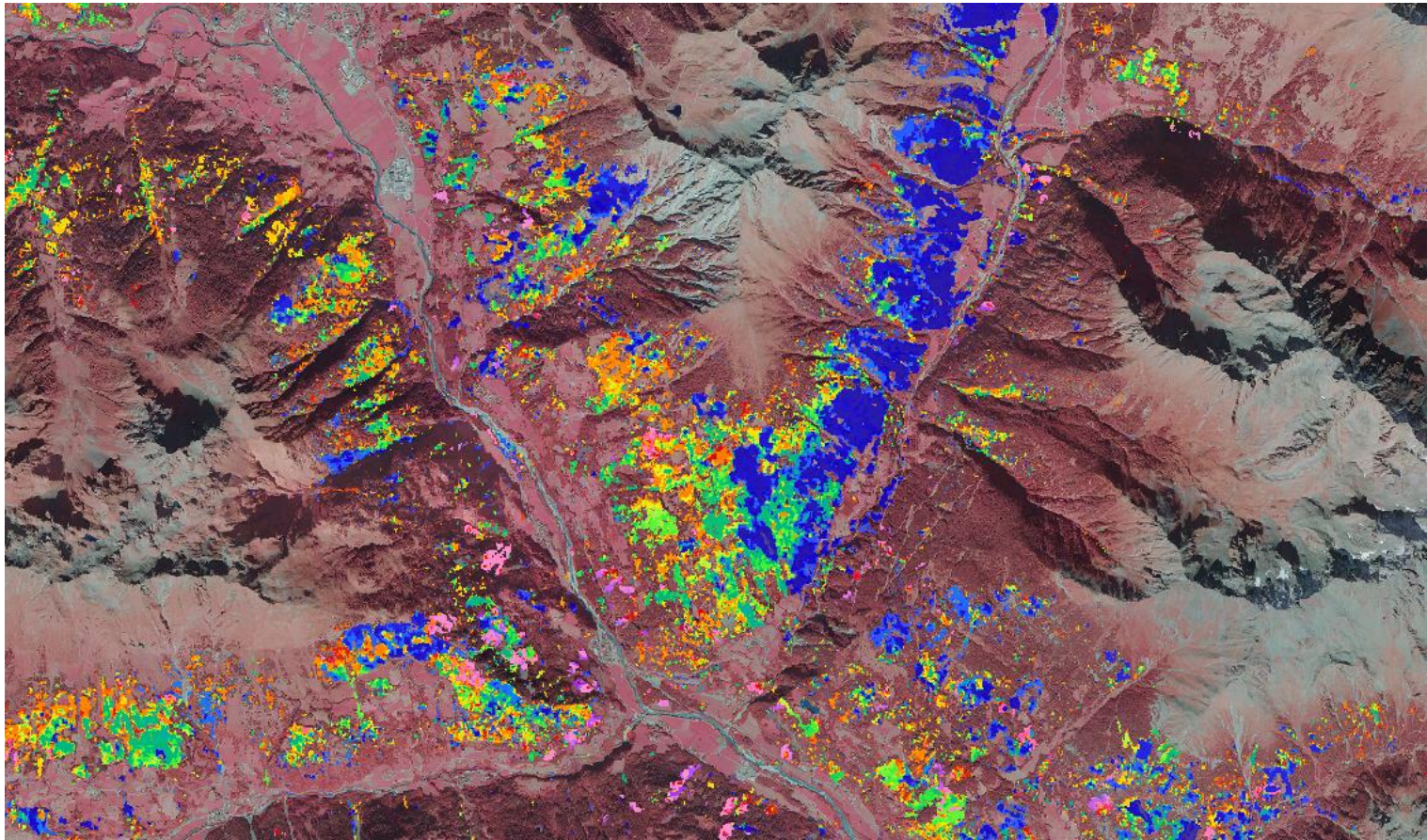


Standing Volume over Time



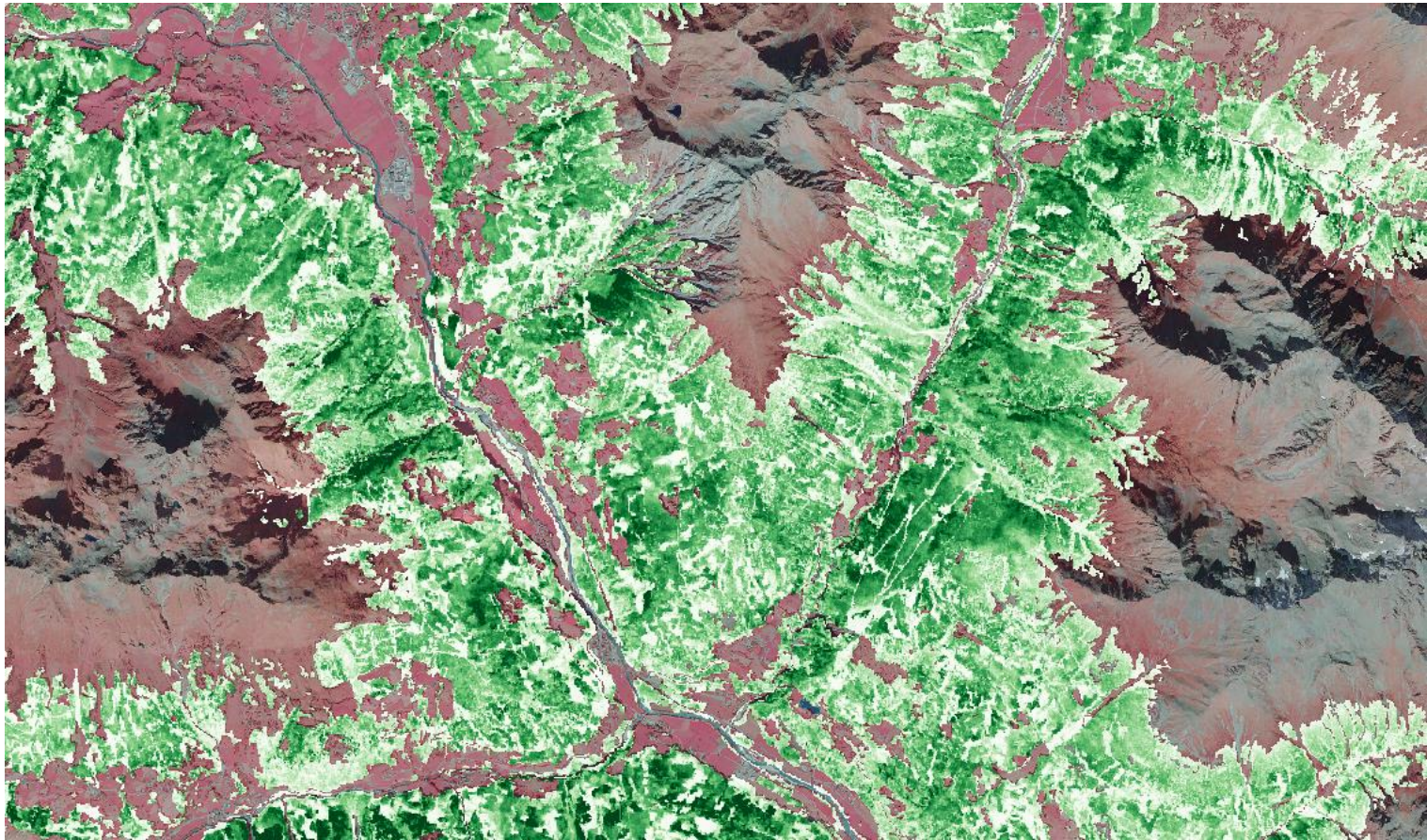
Combine Anomalies and Volume Maps

2022



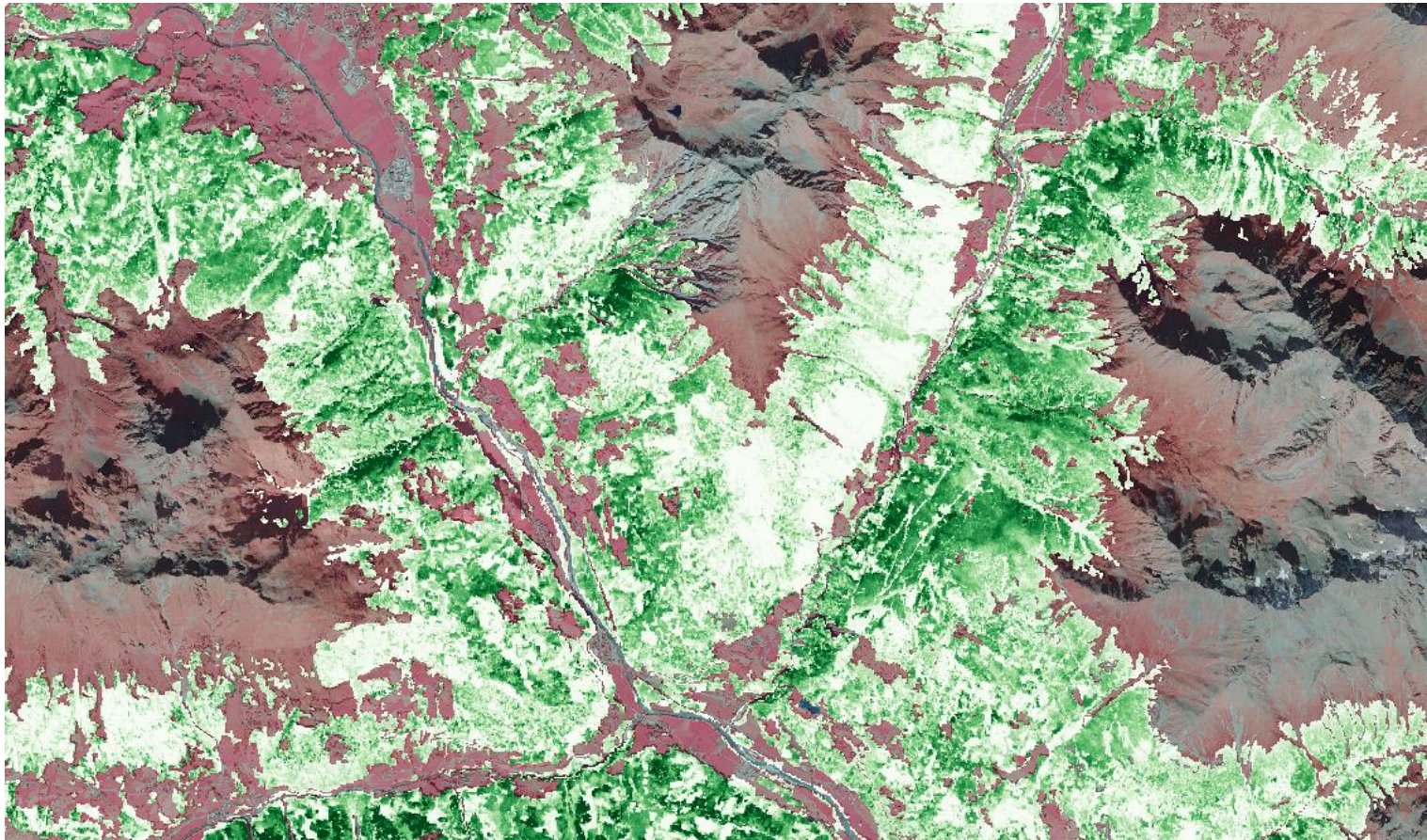
Combine Anomalies and Volume Maps

Growing Stock 2018



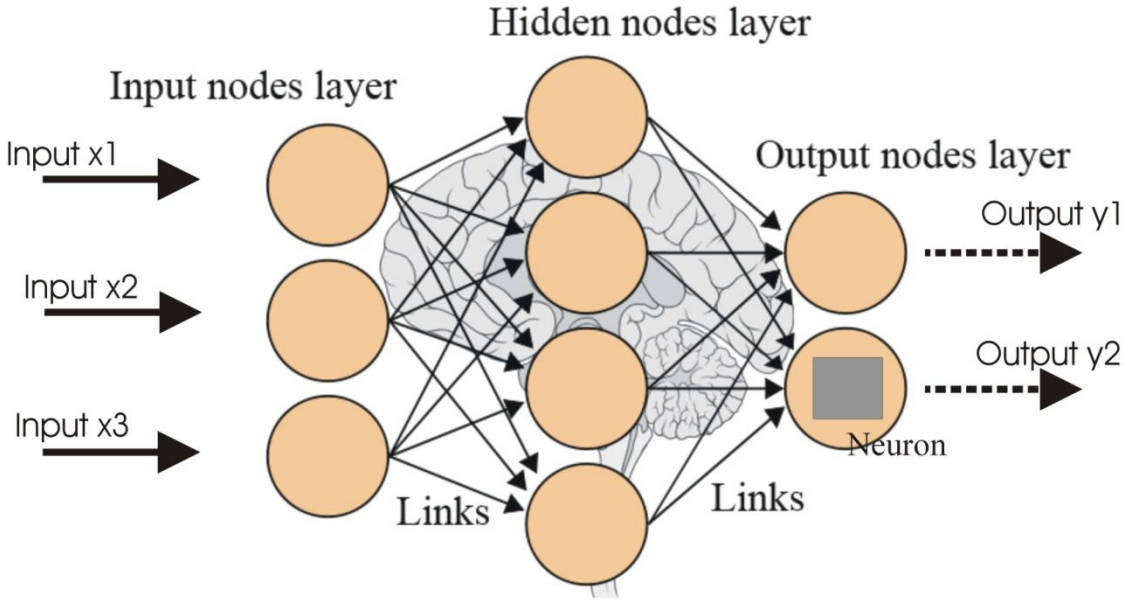
Combine Anomalies and Volume Maps

Growing Stock 2022



Tree species maps

Neural Network Technique



https://www.analyticsvidhya.com

Tree species maps

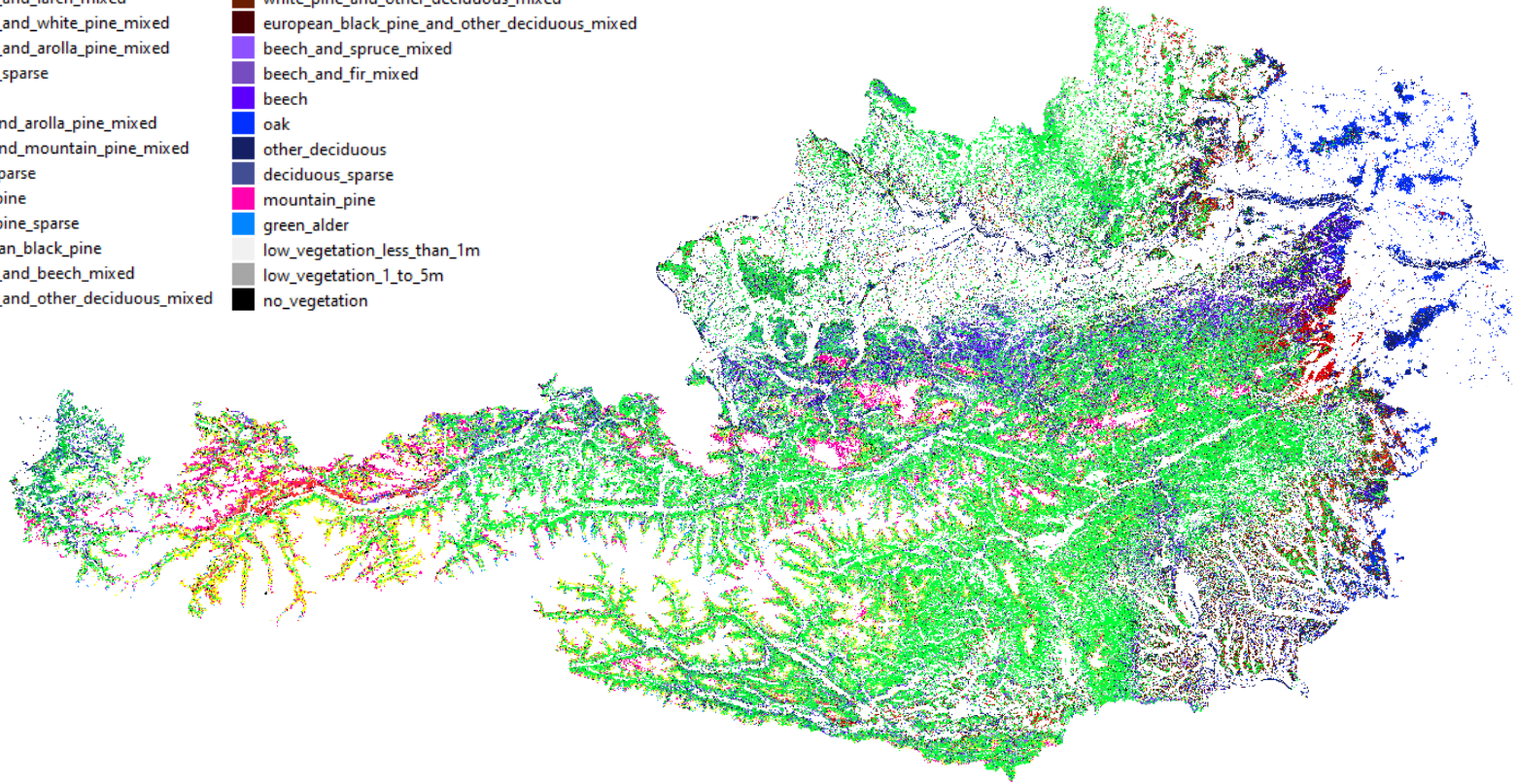
Neural Network Technique

- 26 tree species classes are classified
- 10 by 10m resolution over complete federal territory of Austria
- Phenology time series and structural data as input for neural networks
- Training data is generated via aerial photography interpretation

Schadauer et al. (2024): Evaluating Tree Species Mapping: Probability Sampling Validation of Pure and Mixed Species Classes Using Convolutional Neural Networks and Sentinel-2 Time Series. Remote Sens. 16, 2887. https://doi.org/10.3390/rs16162887

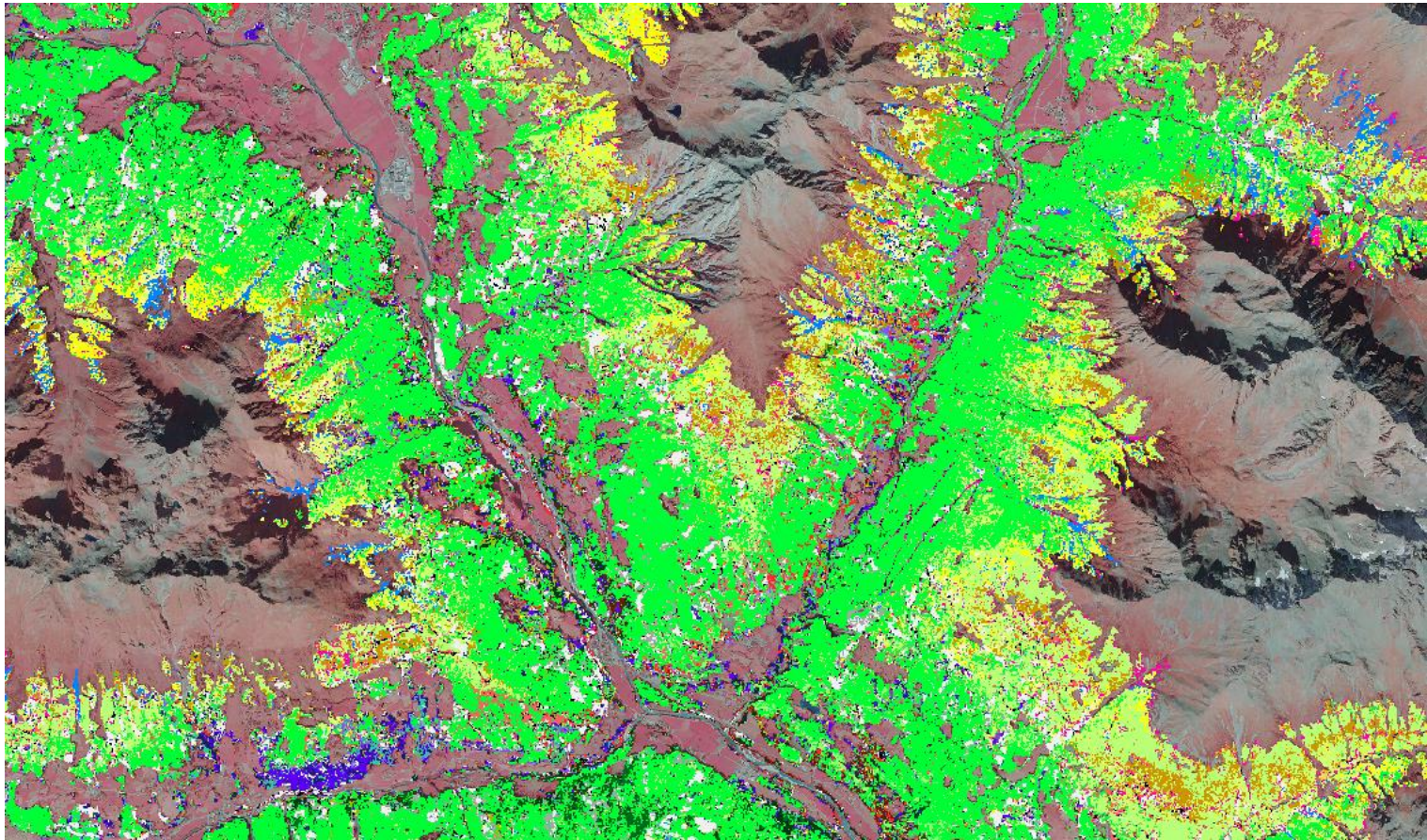
Tree species maps

- spruce
- spruce_and_fir_mixed
- spruce_and_larch_mixed
- spruce_and_white_pine_mixed
- spruce_and_arolla_pine_mixed
- spruce_sparse
- larch
- larch_and_arolla_pine_mixed
- larch_and_mountain_pine_mixed
- larch_sparse
- white_pine
- white_pine_sparse
- european_black_pine
- spruce_and_beech_mixed
- spruce_and_other_deciduous_mixed
- larch_and_other_deciduous_mixed
- white_pine_and_oak_mixed
- white_pine_and_other_deciduous_mixed
- european_black_pine_and_other_deciduous_mixed
- beech_and_spruce_mixed
- beech_and_fir_mixed
- beech
- oak
- other_deciduous
- deciduous_sparse
- mountain_pine
- green_alder
- low_vegetation_less_than_1m
- low_vegetation_1_to_5m
- no_vegetation



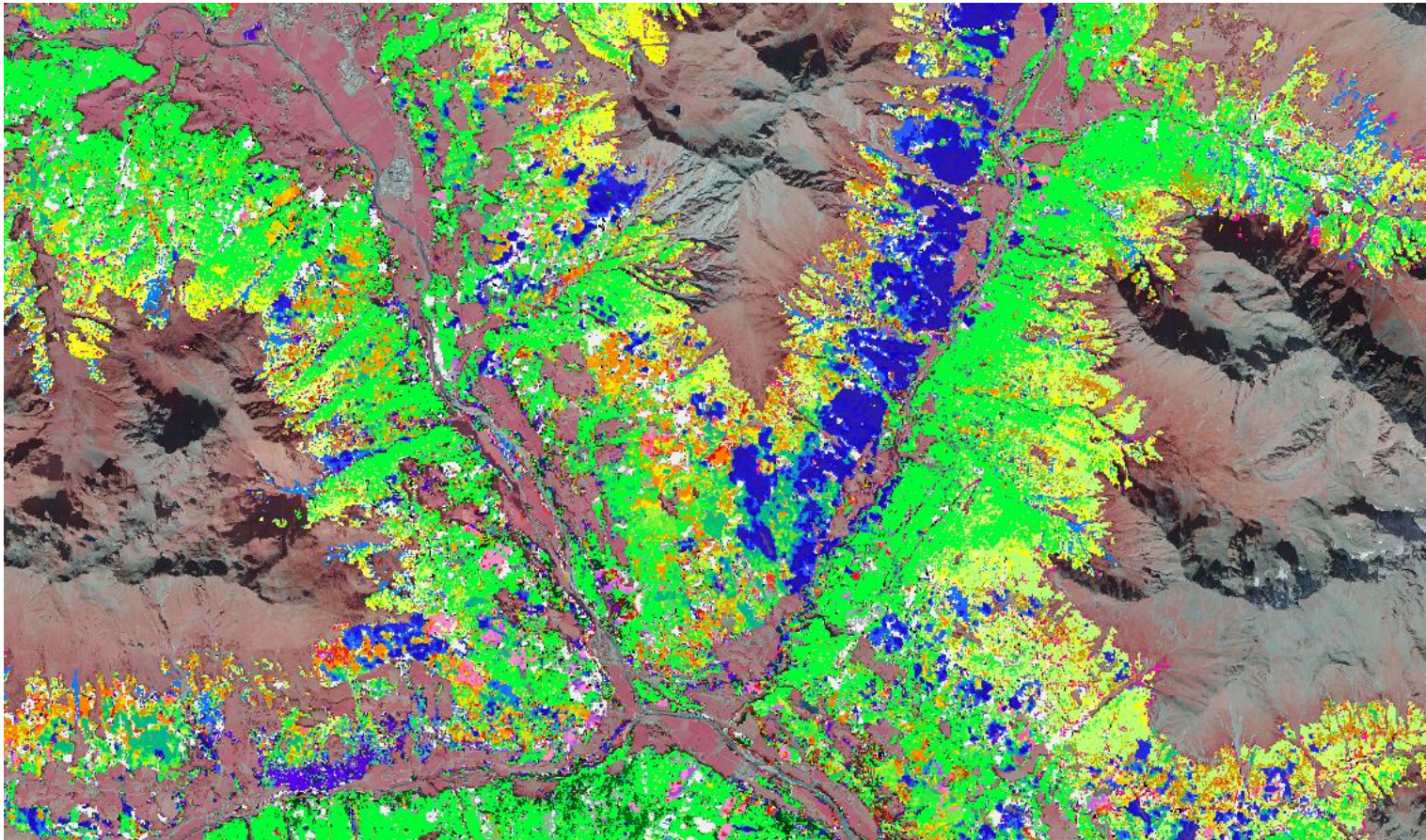
Combine Anomalies and Tree Species

Species



Combine Anomalies and Tree Species

Species
Damages
until 2022



Ongoing projects

- Attempt to distinguish between different reasons for the anomaly (regular cutting, storm, bark beetle, …
- Detect anomalies with slow developments
- Include Sentinel 1 into the anomaly detection
- Detect Biodiversity hotspots
- Risk mapping for
  - Natural hazards
  - Bark beetle
  - Fire events

Use of European or Global RS products

- Started with the validation/evaluation of some products
- Quality is often not convincing or even misleading
- For some products a deeper look is worthwhile (e.g. Tree cover density map or Global Forest Watch loss map)


Thank you
very much!