

## III Phase Inventory

- Motivation, Origin
- Concepts, Phases I – II – III
- Added Values
- Interfaces (Mapping, Forest Management Planning, Growth Simulation)
- TLS concept: one position & zero occlusion

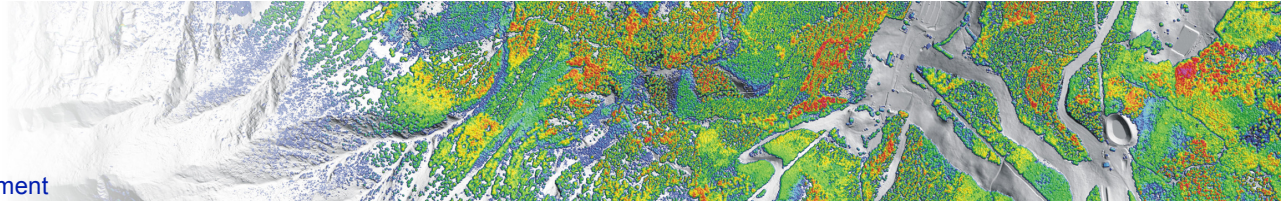


## **Günther Bronner g.bronner@umweltdata.at**

### **Professional background and experiences**

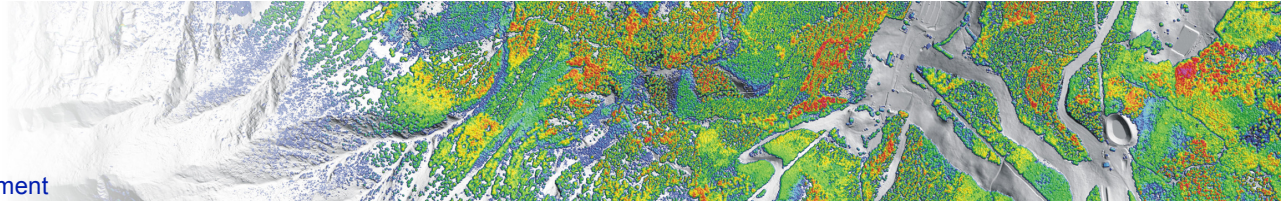
- **Austrian State Forest Agency, 1983-2000**  
**Forest Management Planning, Inventory, GIS and Remote Sensing**
- **Head of Umweltdata Ltd. Since 2001**  
**Forest Sustainability :Monitoring :Mapping :Modeling :Management**
- **>100 Forest Inventory projects, >70,000 sample plots**
- **>200 Forest Management Planning projects >1000ha**
- **Operational usage of ALS data since 2006**
- **Rapid forest inventories for land acquisition decisions**
- **Monitoring of wildlife influences and damages**
- **Growth models and monitoring on plantations (Brazil)**
- **Permanent Optimization of FI and FMP based on RS**
- **Several R&D projects, Drones in Forest Inventory**
- **Silvilaser 2010, 2012, 2013, 2017; ForestSAT 2016**





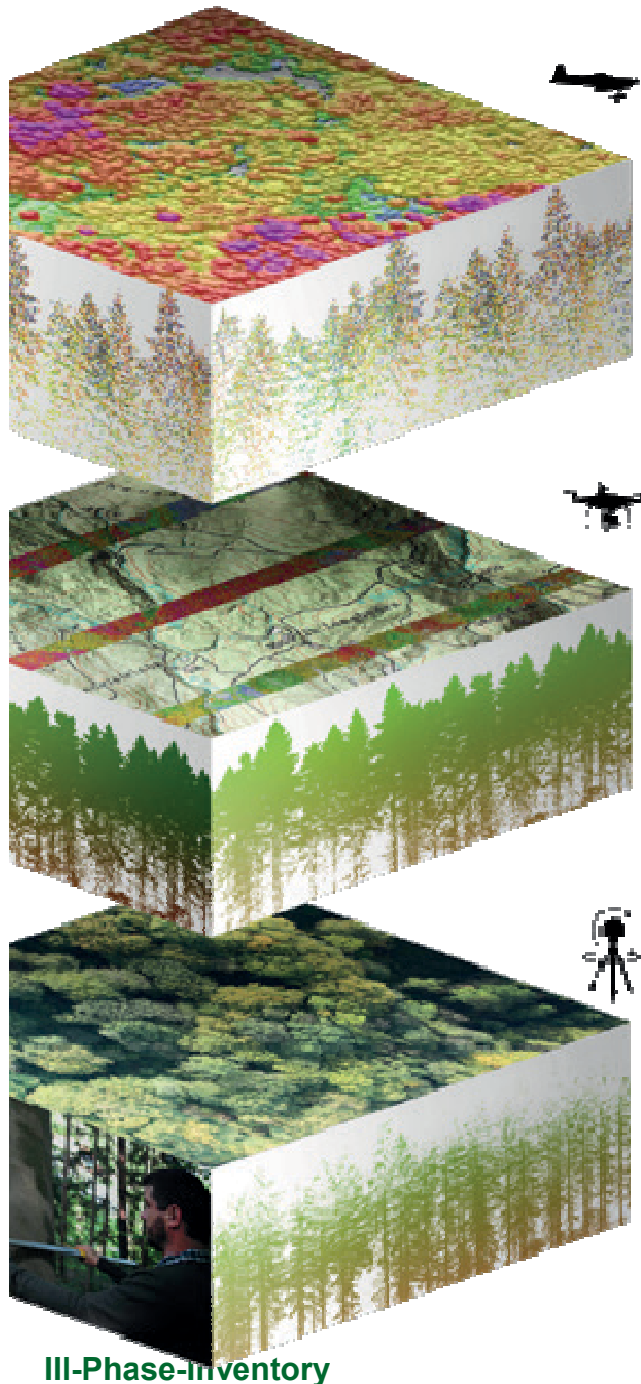
## Cooperation Partners (Austria)

- Umweltdata Ltd. (FI, RS, mapping, FMP)  
Günther Bronner, Boris Jawecki, Martin Keuschnigg
- Joanneum Research (Remote Sensing)  
Mathias Schardt, Manuela Hirschmugl
- TU Vienna, department GEO (photogrammetry)  
Norbert Pfeifer, Markus Hollaus, Martin Wieser
- E.C.O. (Monitoring of Biodiversity, Management of Protection areas) Hanns Kirchmeir, Michael Jungmeier
- Aeromap (Aviation and Aerial Remote Sensing)  
Roland Wack, Thomas Meißl



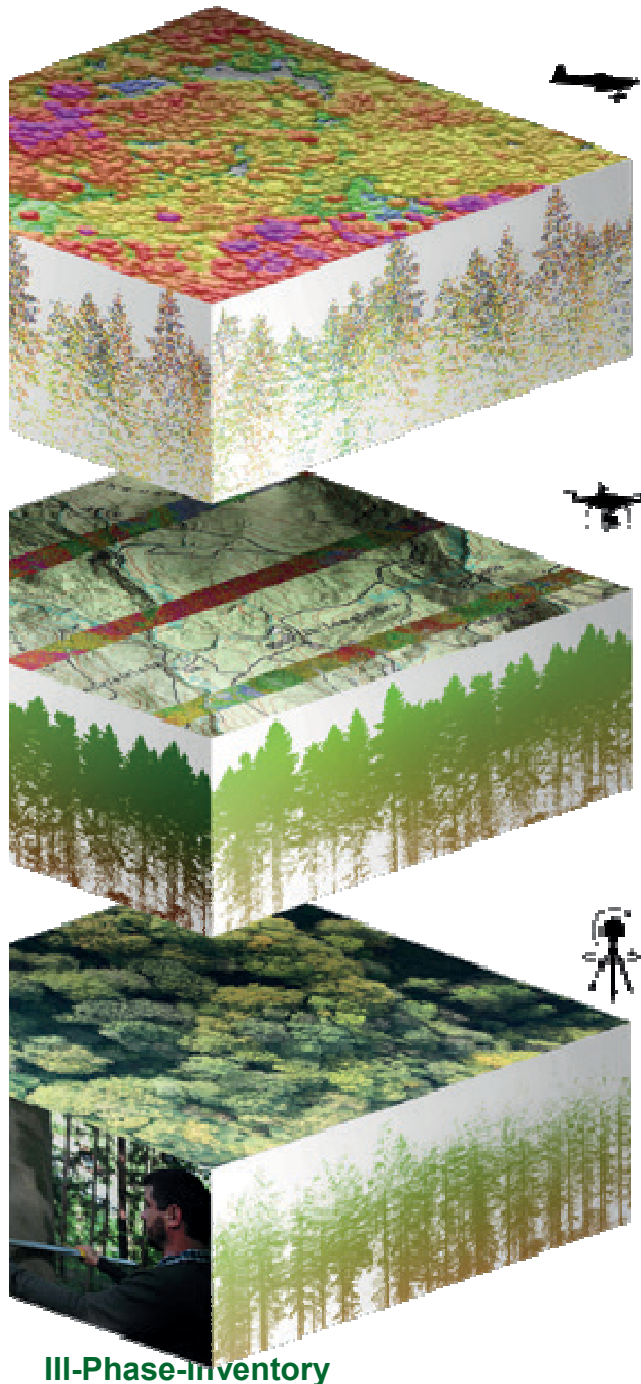
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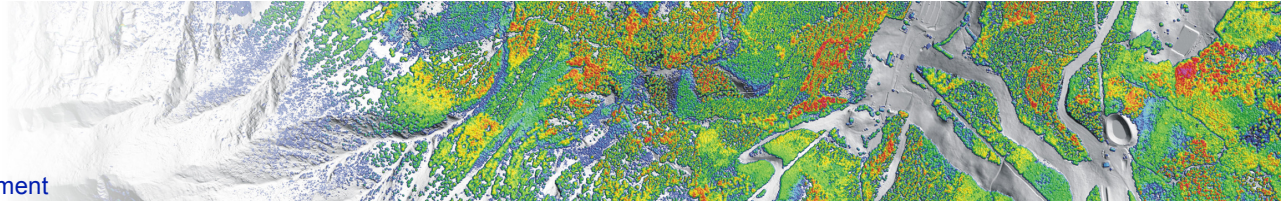
III-Phase-Inventory

- **Phase I**  
ALS wall-to-wall coverage
- **Phase II**  
ALS low altitude - high density  
drones, helicopter, light plane
- **Phase III**  
TLS and / or fieldwork



III-Phase-Inventory

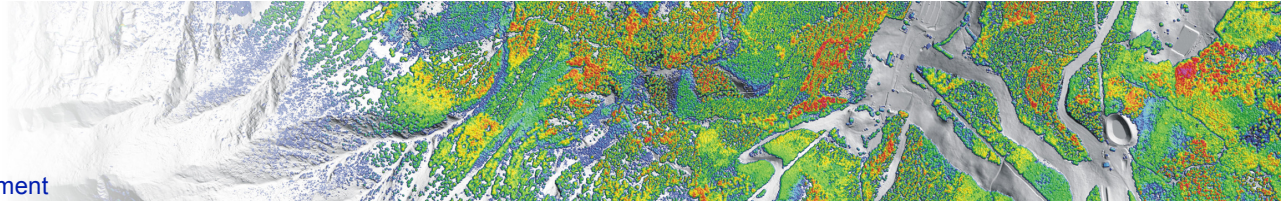
- **Phase I**  
ALS wall-to-wall coverage  
4 – 16 pulses / m<sup>2</sup>
- **Phase II**  
ALS low altitude - high density  
drones, helicopter, light plane  
100+ pulses / m<sup>2</sup>
- **Phase III**  
TLS and / or fieldwork  
10,000+ pulses / m<sup>2</sup>



# Motivation

- Optimization of forest inventory cost / benefit ratio by usage of remote sensing data
- Avoid and detect fieldwork errors / biases
- Streamline inventory, mapping and FMP
- Allow quick and easy updates
- Integrate economical and ecological sustainability criteria

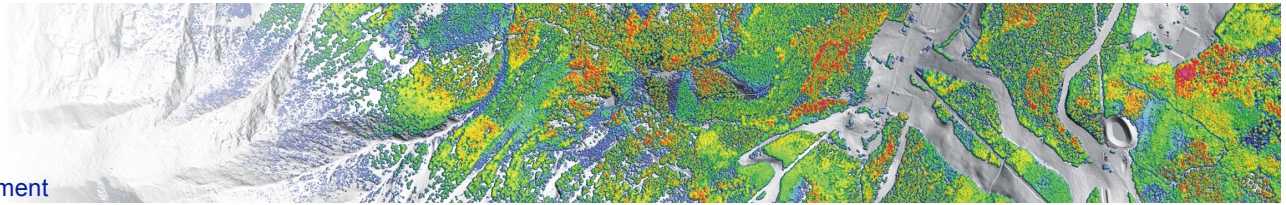




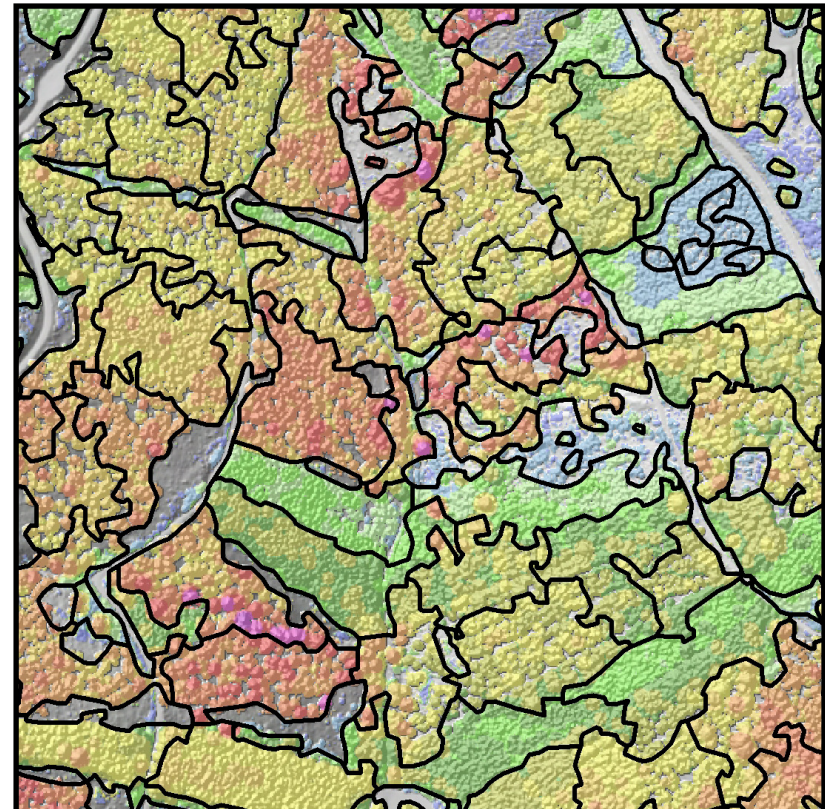
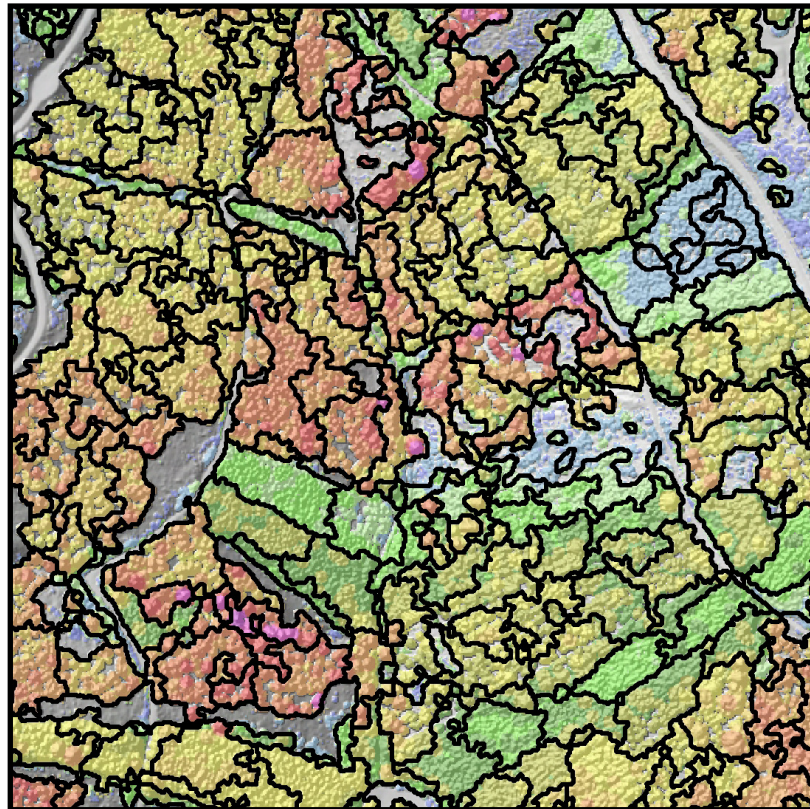
# Phase I

- ALS wall-to-wall coverage of project area  
4-16 pulses / m<sup>2</sup> off-leave condition
- Sentinel time series for tree species recognition,  
mainly percentage of coniferous / deciduous
- Automatic segmentation regarding canopy height /  
volume, canopy variation and coniferous %
- Calculation of LIDAR statistics and stratification of  
segments (different clustering concepts)
- Design of sample plots on segments

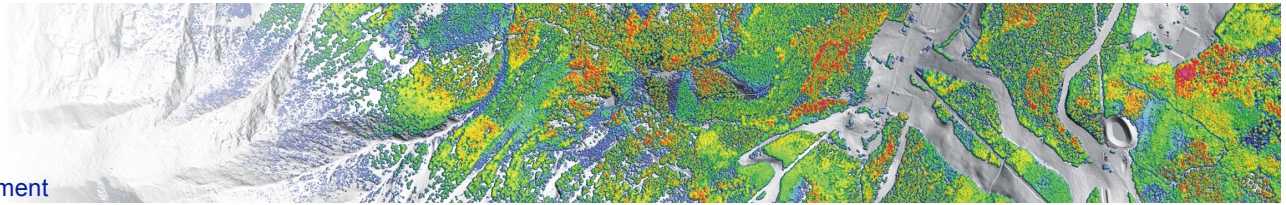




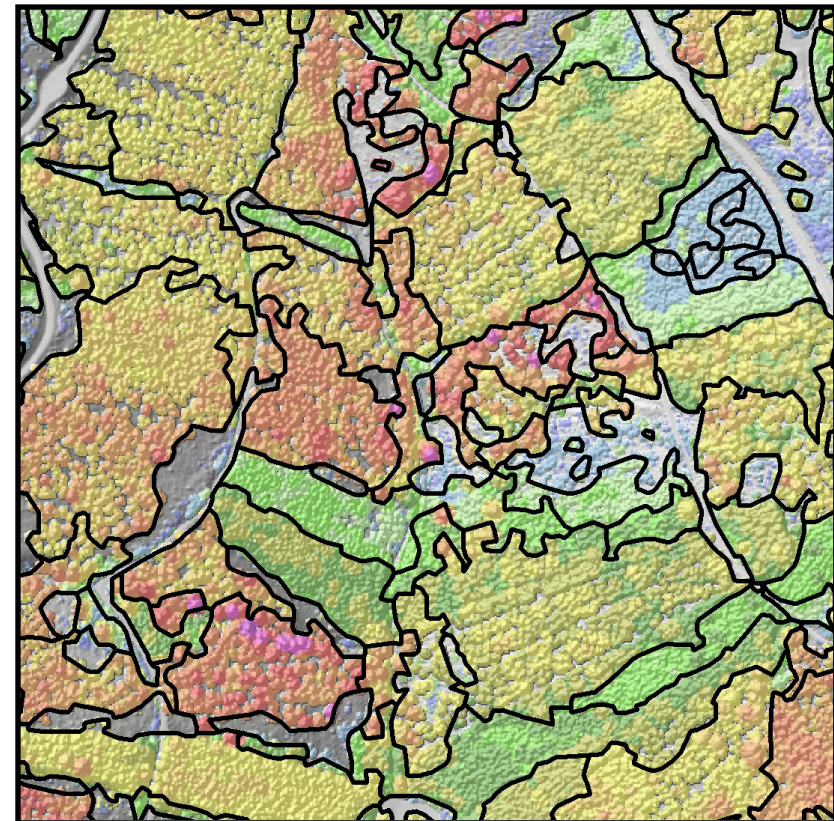
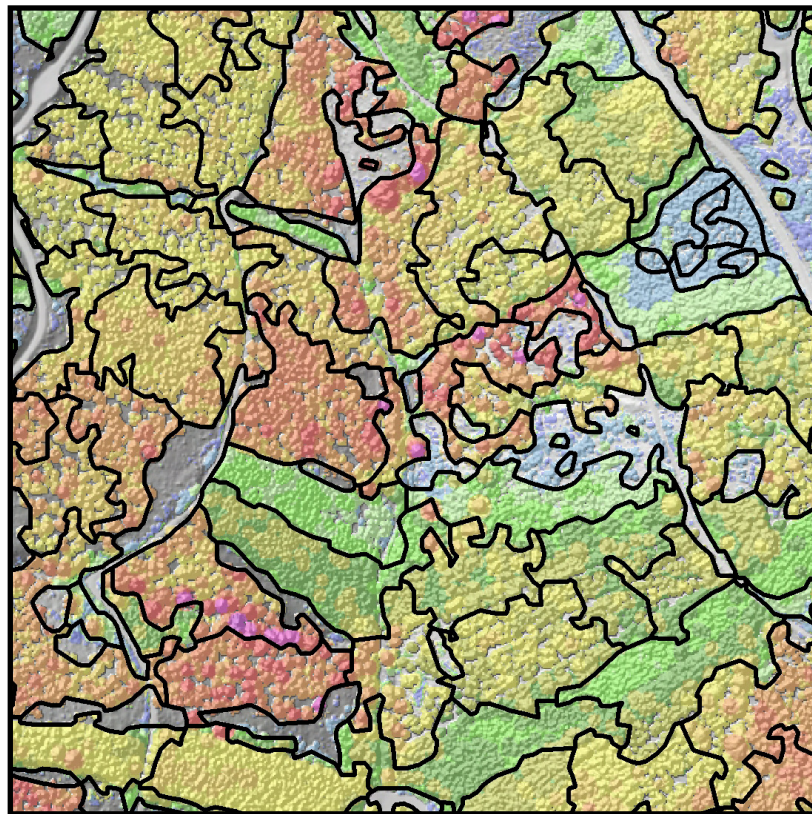
## Automatic Segmentation of Canopy Height Models (i)





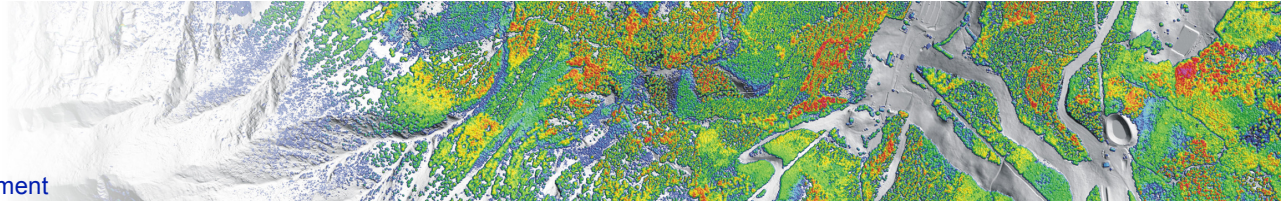


## Automatic Segmentation of Canopy Height Models (ii)



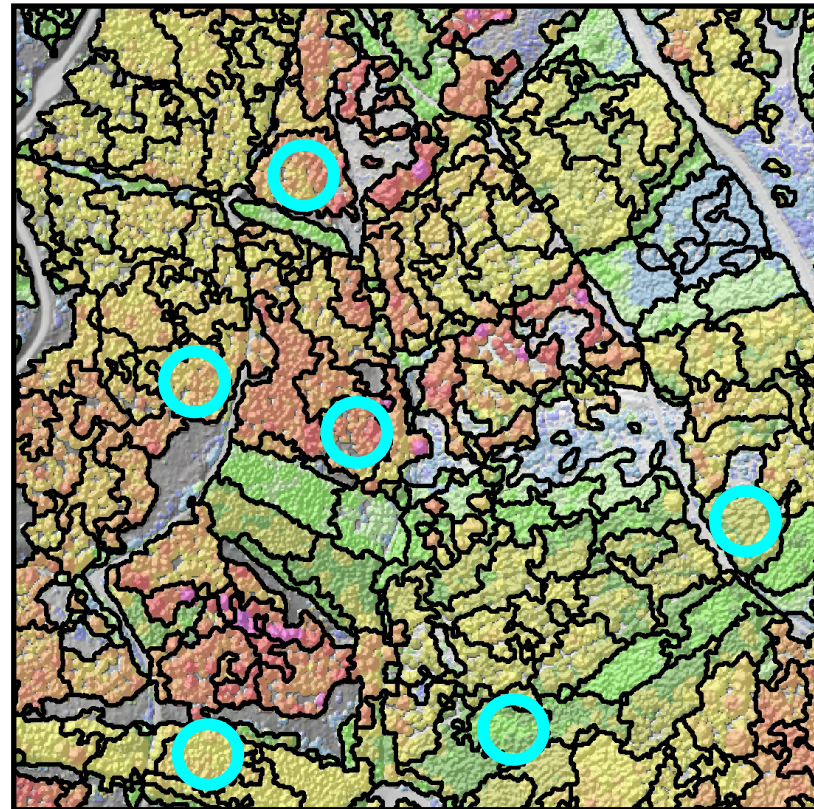
**step by step augmentation by removing edges**

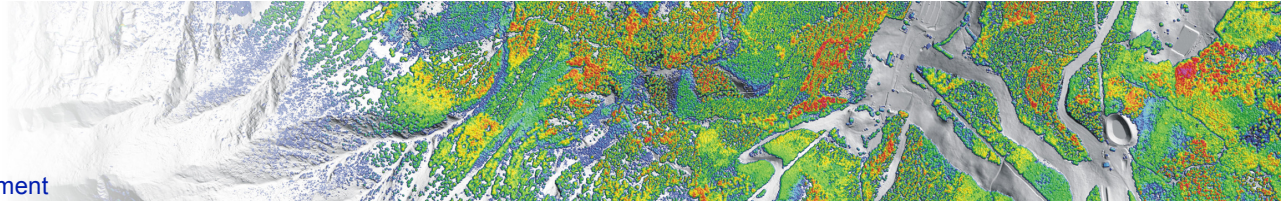




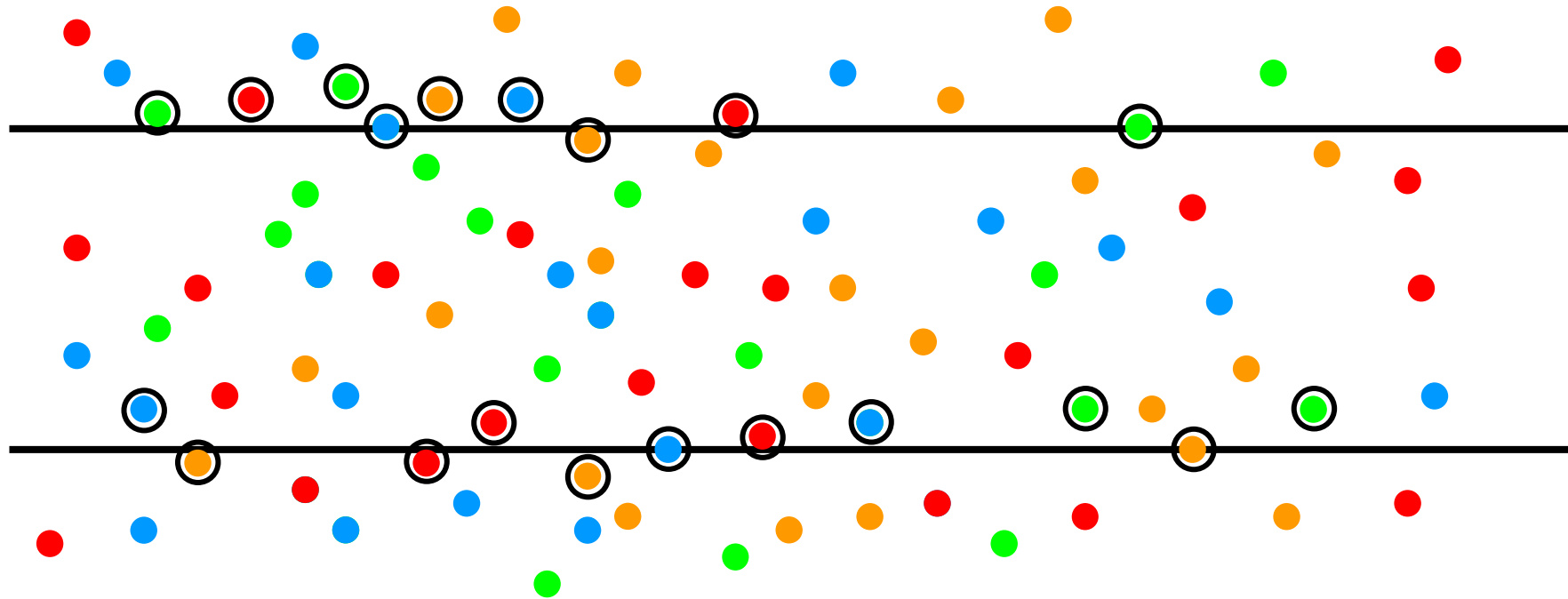
## Design of sample plots on segments

- inside buffer of segments to grant minimum size of circular sample plot (SP)
- random position within segments
- determination of desired number of SP per stratum
- reduction of potential SPs to actual SPs per stratum by minimum distance from basic lines



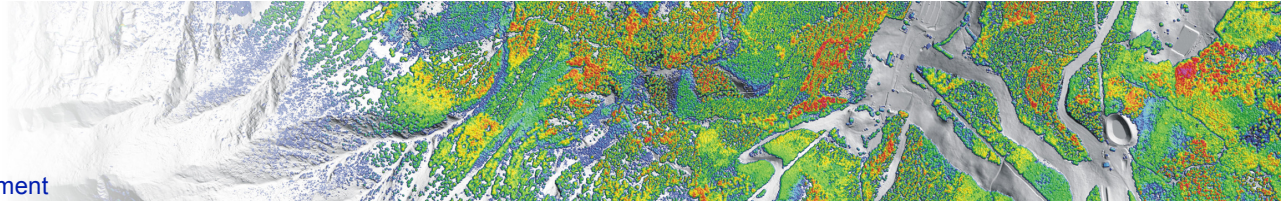


## Potential sample plots reduction by distance to line criterion



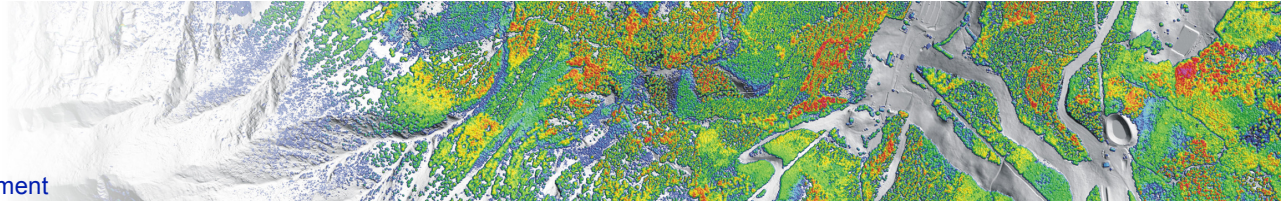
(colored by stratum)



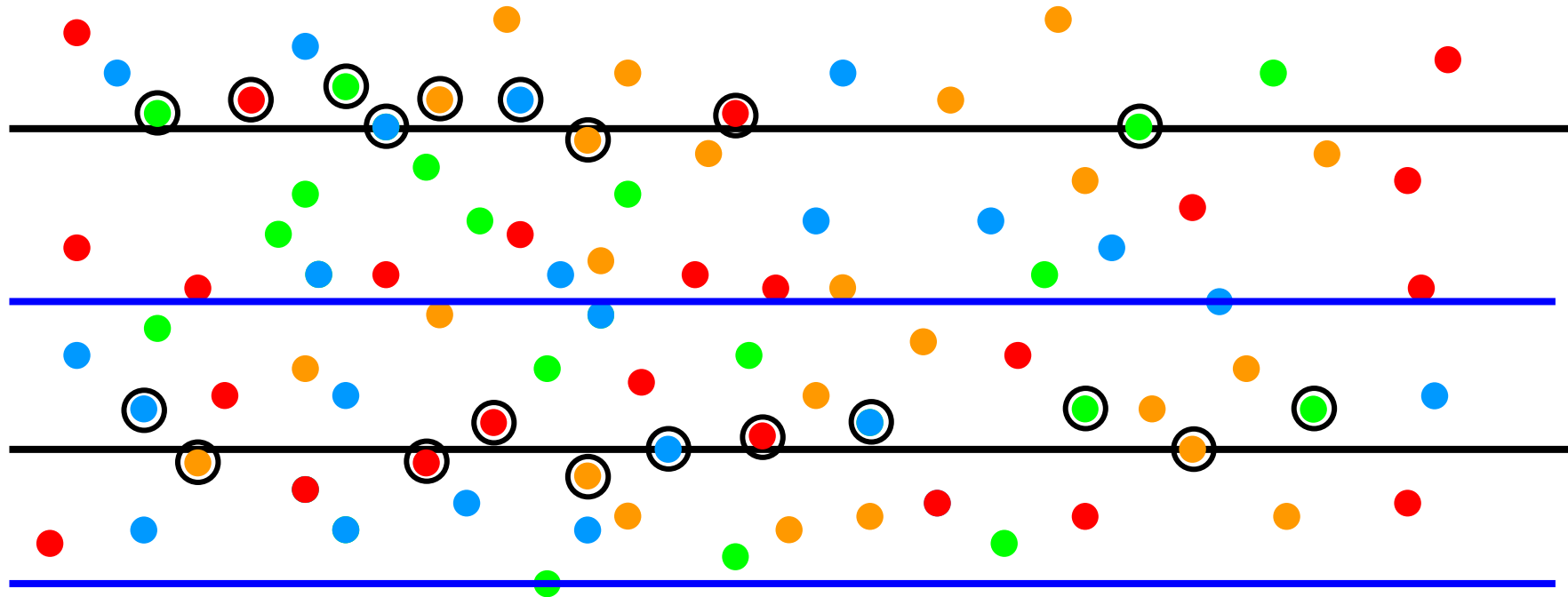


## Benefit of segment-based design

- significant reduction of fieldwork assessment and costs
- plausibility checks by LIDAR-metrics avoid / detect fieldwork errors / biases
- significantly enhanced statistical reliability (stock volume confidential interval of +/- 5% with only 200 SPs)
- scalability regarding accuracy: inventory design with step by step enhancements

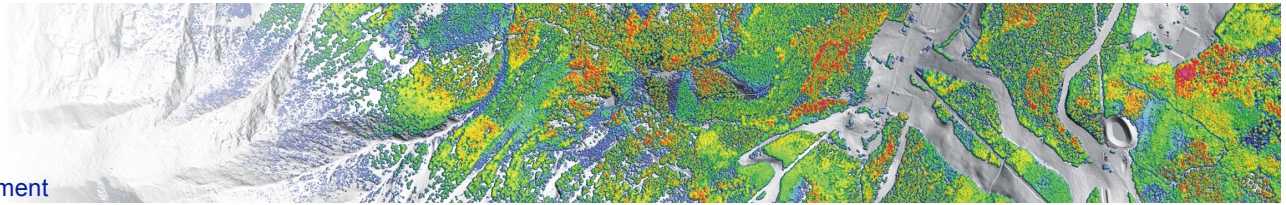


## Potential sample plots reduction by distance to line criterion



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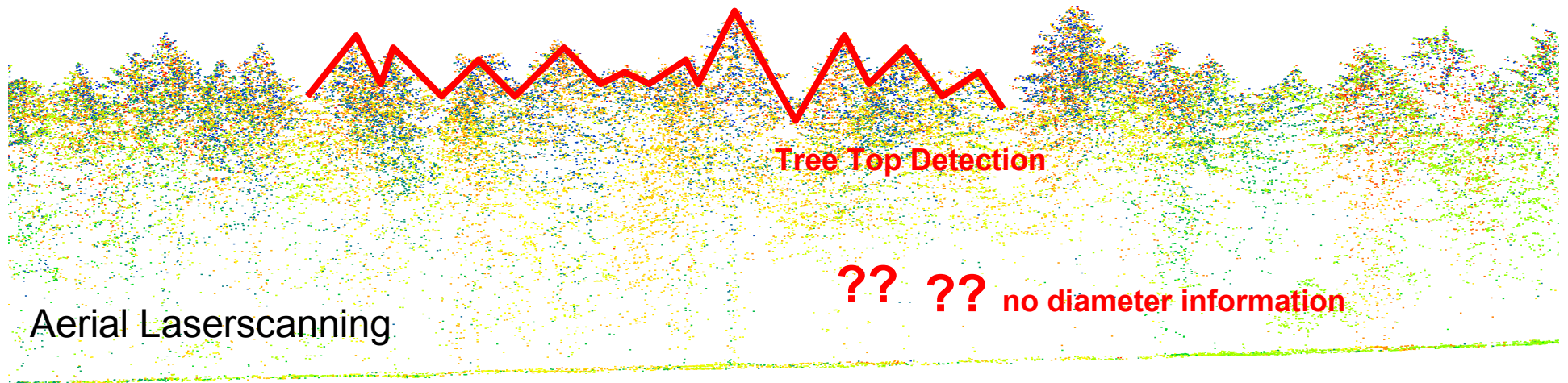


# Phase II (ALS from drone, helicopter, ultra light plane)

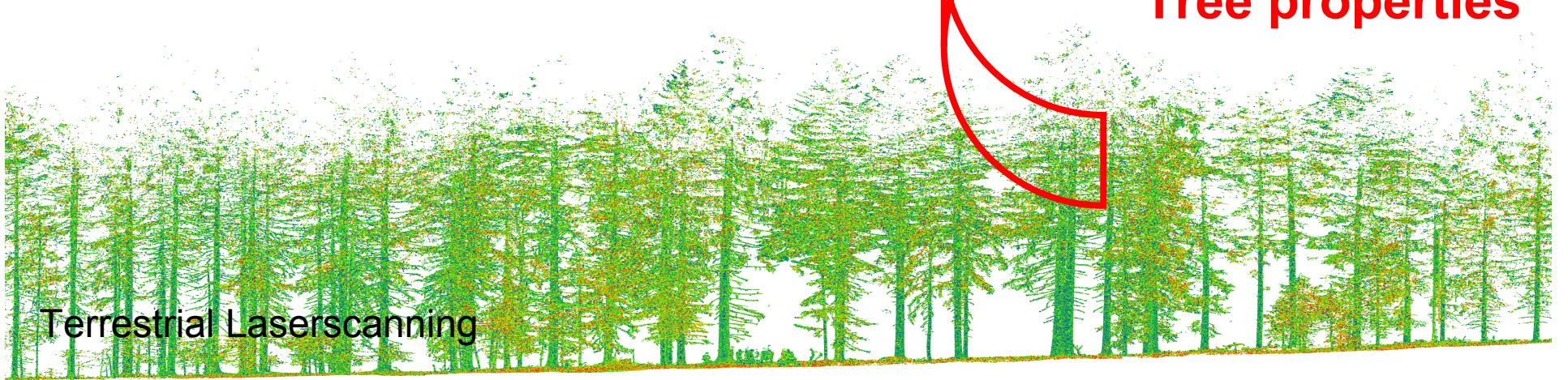
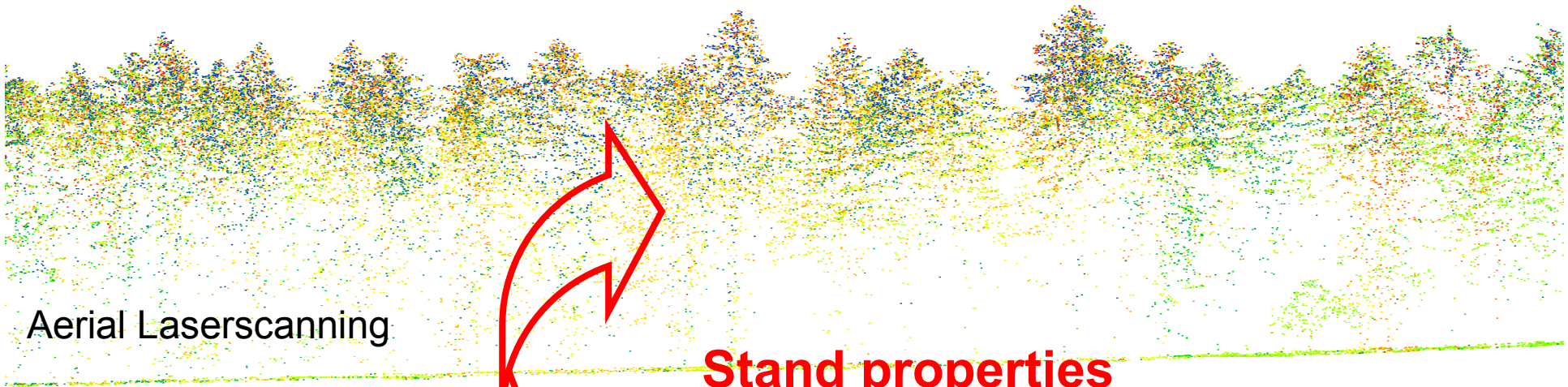
Stripes with very high resolution (vhr)ALS data ( $>100$  echos/m<sup>2</sup>) allow single tree modelling, recognition of vertical structure, dead-wood detection, identification of natural regeneration and the application of advanced tree growth modelling.



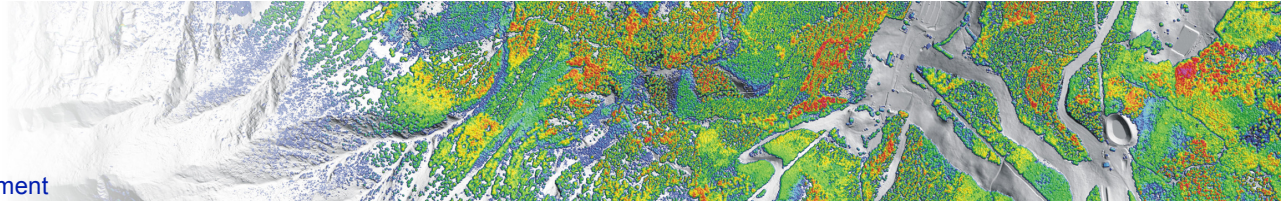












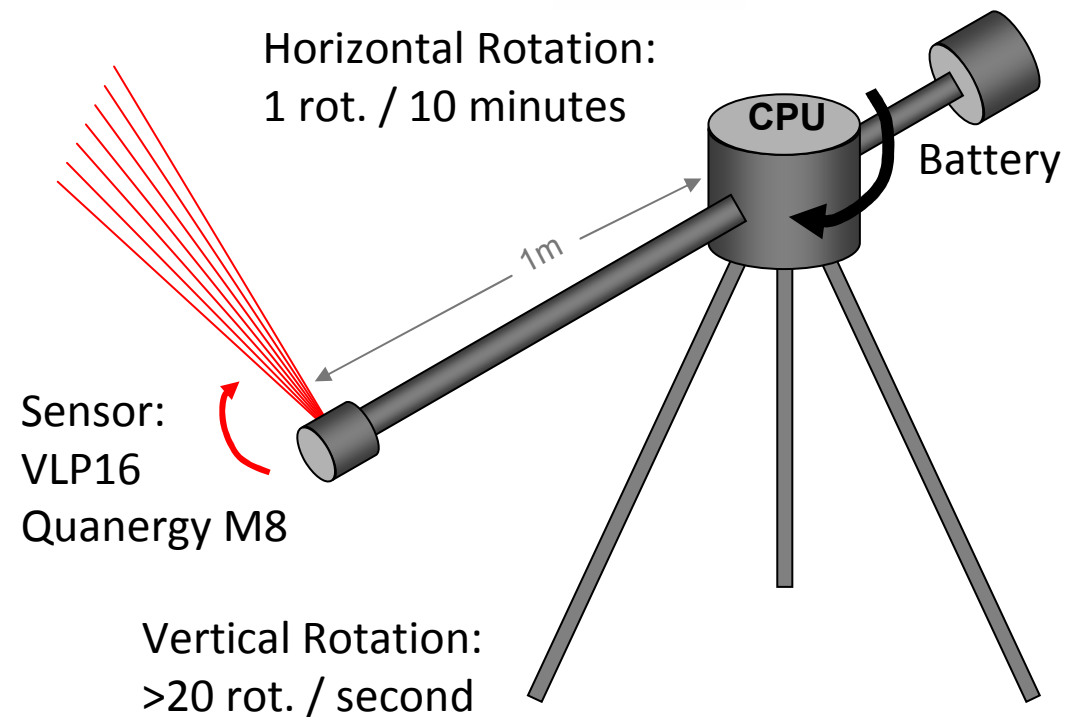
# Experiences with vhr-stripes 2018

- Tree-plots for fieldwork assessment from vhrALS tree detection
- Tree heights and coordinates per tree, DBH estimation from algometric approach
- Fieldwork along transects vs. circular plots?
- Problems with detection of leave-off trees
- GNNS accuracy below canopy does not allow easy identification of single trees
- Evaluation is still in progress

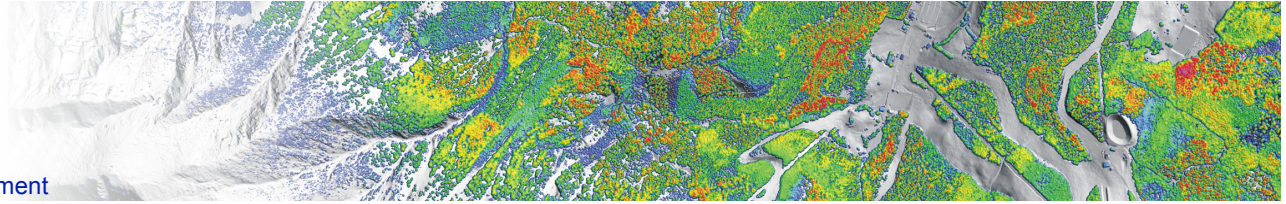
# Phase III the future of fieldwork:



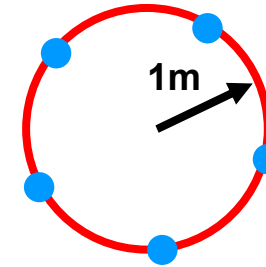
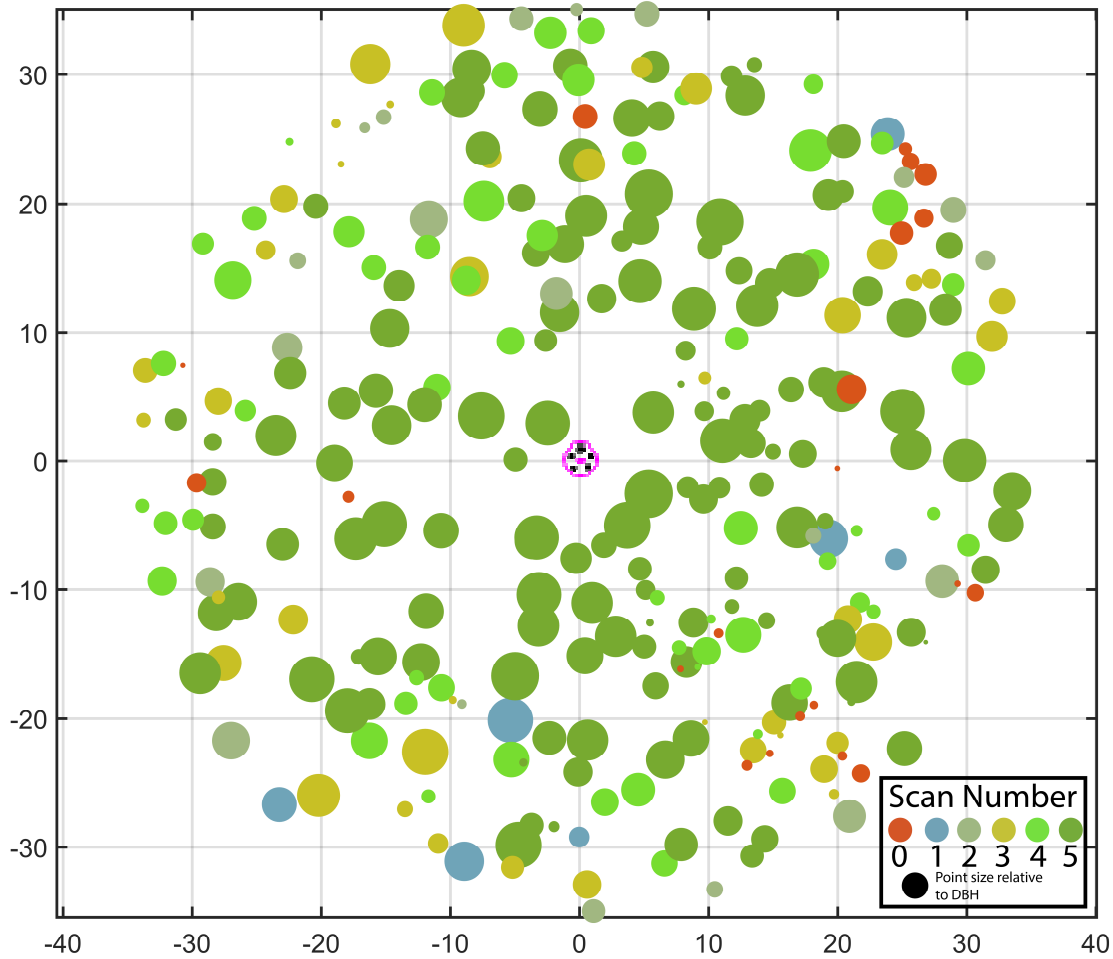
- from **single position**
- within **30m radius**
- **90% reduction of occlusion**  
from 20% to <2% in stands  
with basal area 45m<sup>2</sup>/ha
- with **Bitterlich angle count**  
basal area factor 1  
<1% trees are not detected  
(basal area 45m<sup>2</sup>/ha)
- from central perspective,  
**diameter extraction** will  
change from cylinder fitting to  
edge detection, which is more  
robust with low-cost scanners



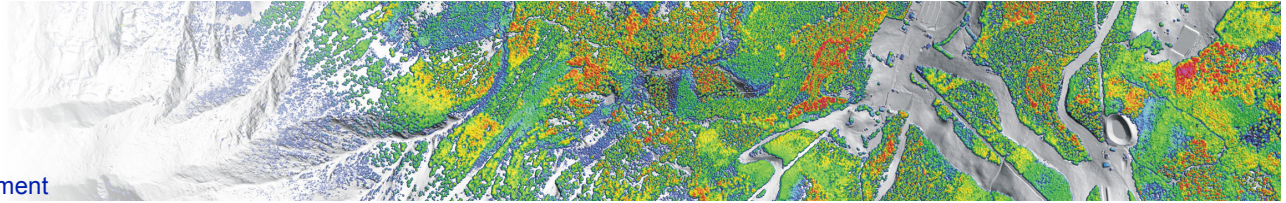
**advanced forest scanning**  
**one position - zero occlusion**



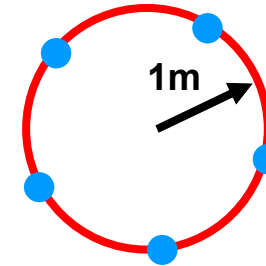
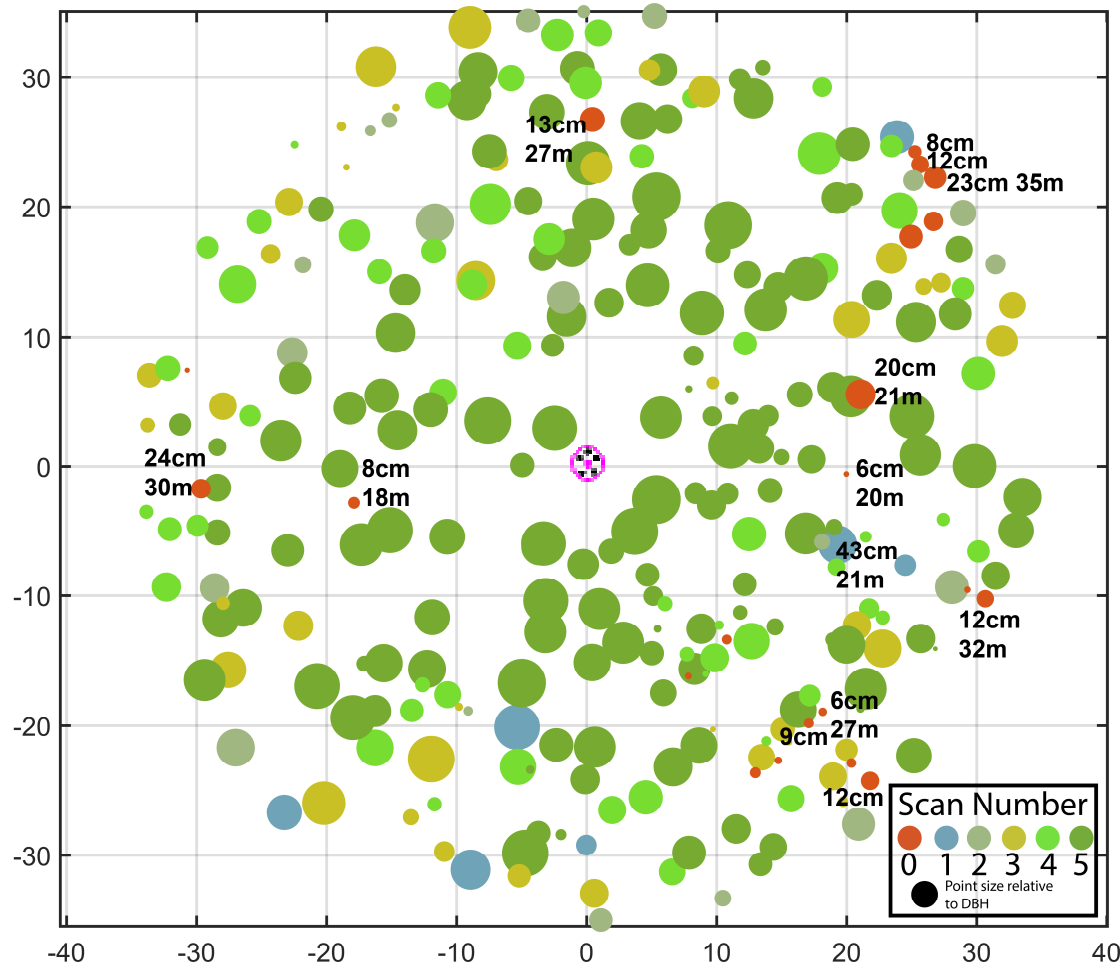
# jib-scan-simulation i)



- from **single position**
- within **35m radius**
- **only few hidden trees**

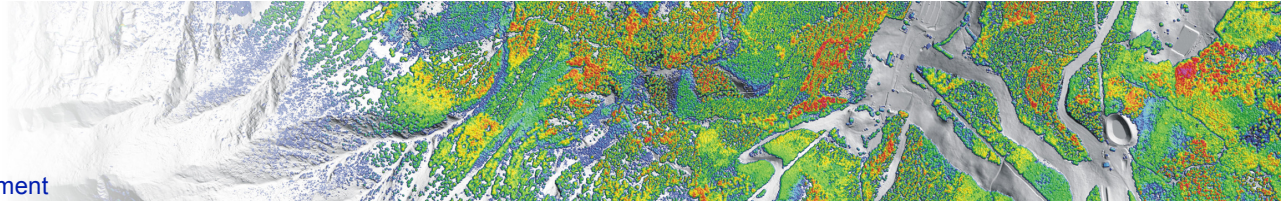


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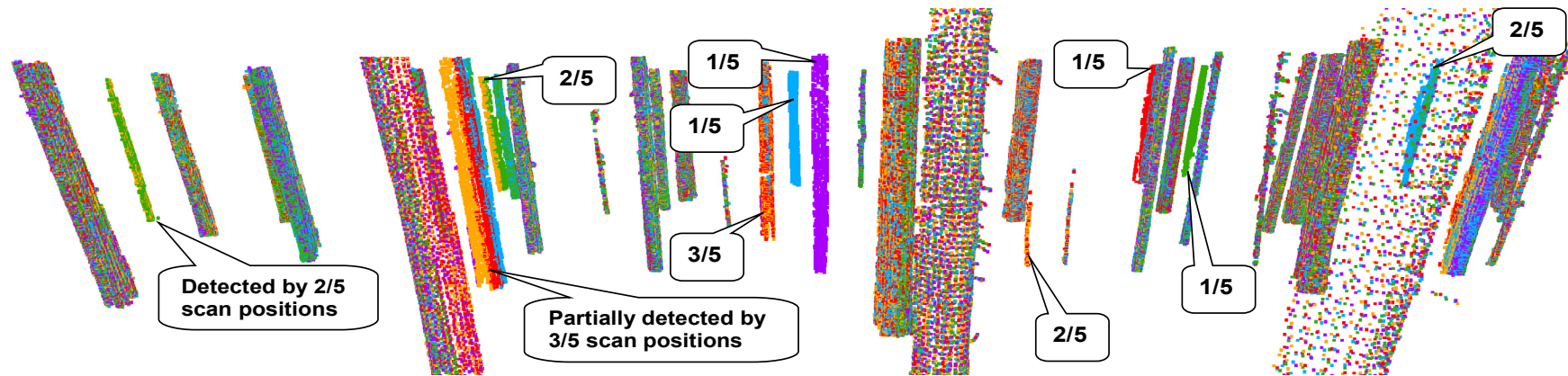
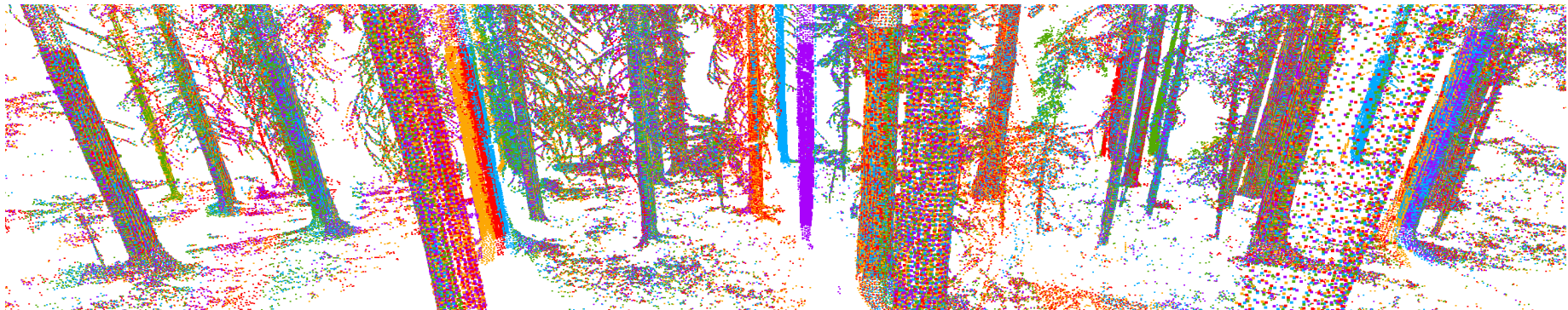
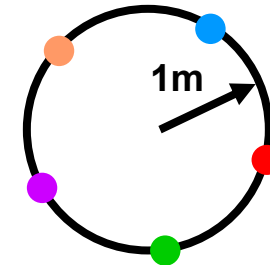


- from **single position**
- within **35m radius**
- **only few hidden trees**
- with **Bitterlich angle count**  
basal area **factor K = 1**  
none of the hidden trees  
would be counted
- with **K = 1** there are more  
than 50 trees counted  
in total

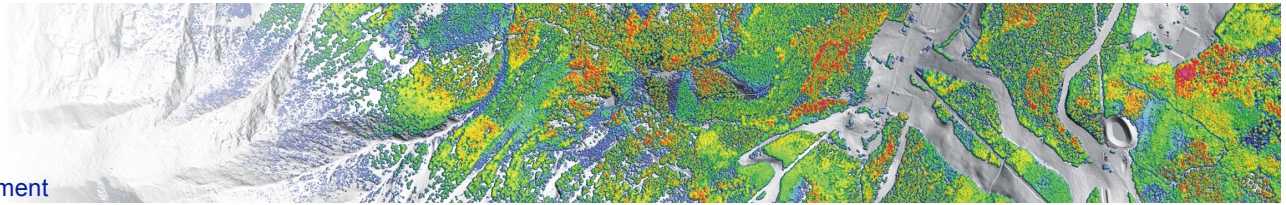




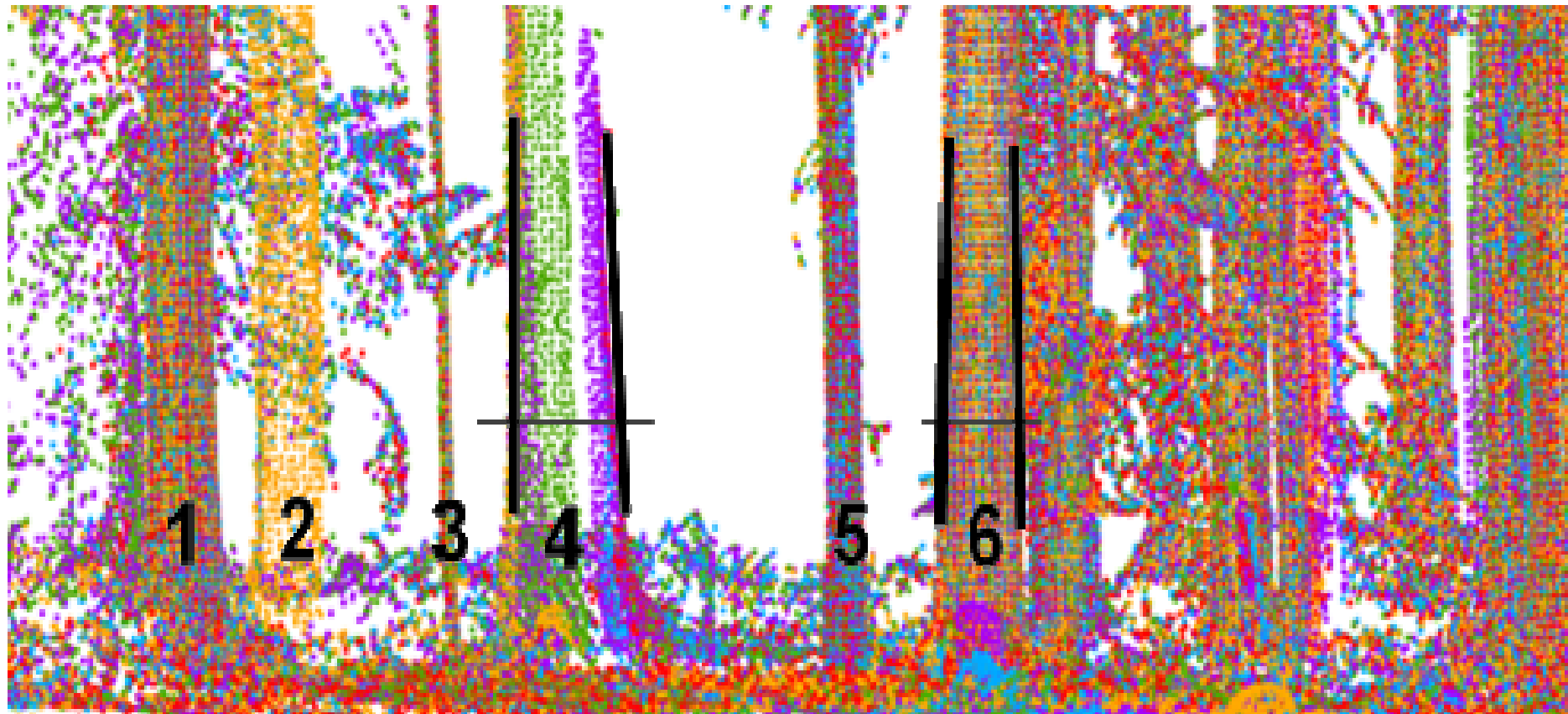
# jib-scan-simulation ii)





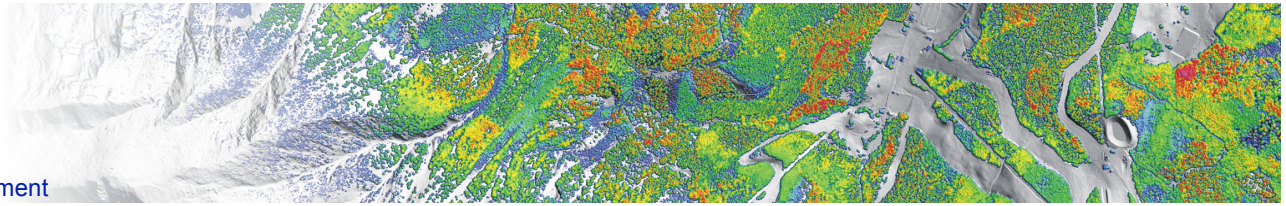


# jib-scan-simulation iii)



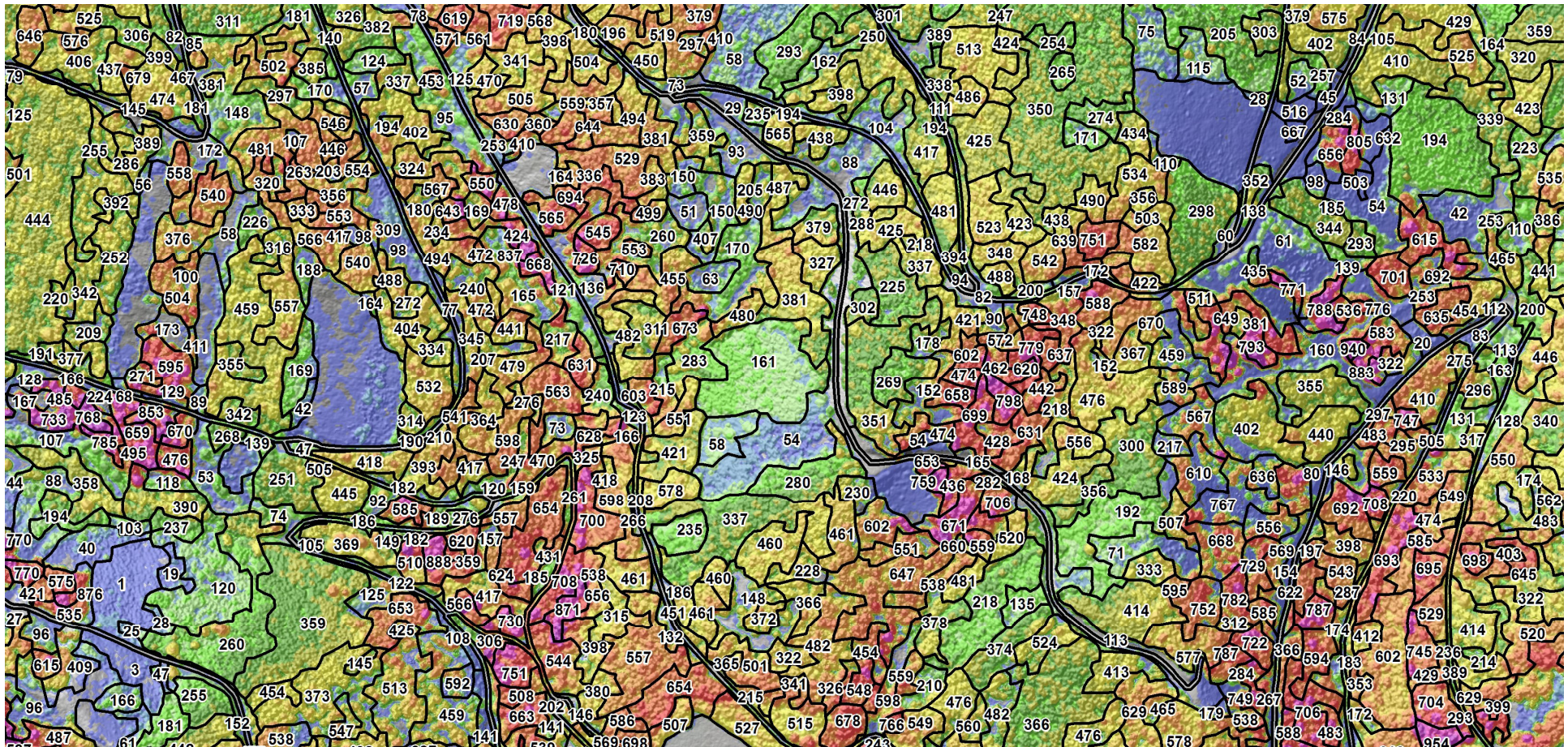
one color per TLS-position: tree 2 is detected only from one of the 5 positions



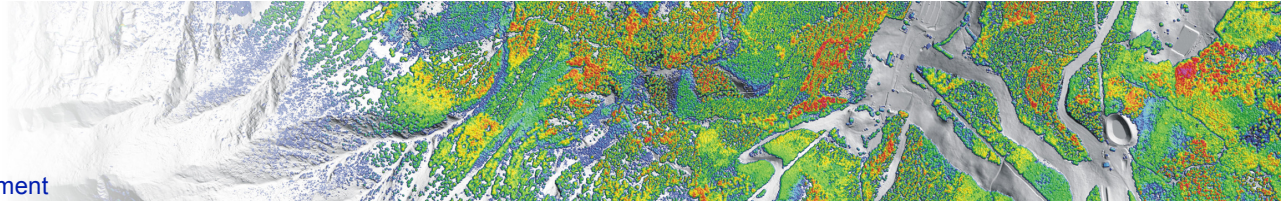


# Phase IV: calibrating segments & mapping

e.g. Stock Volume per ha

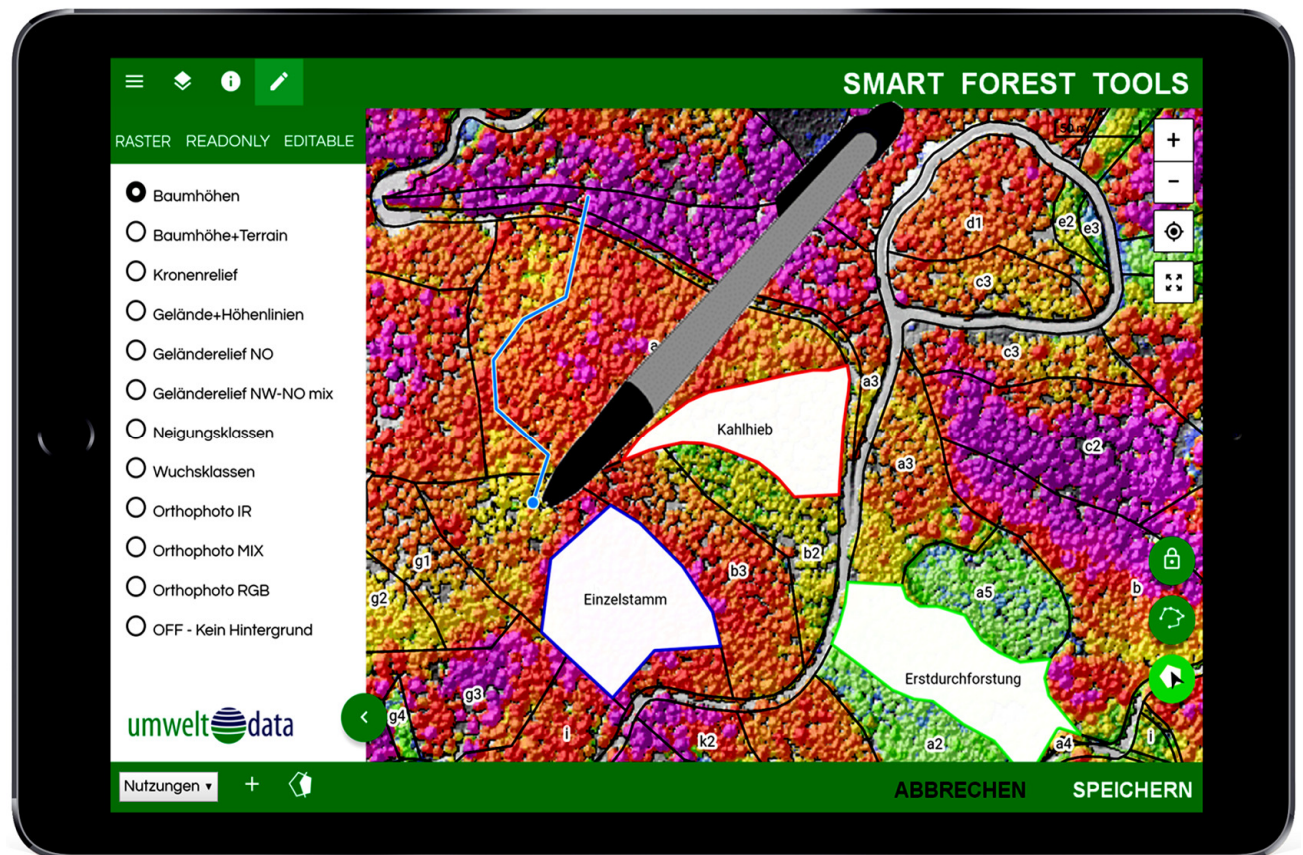




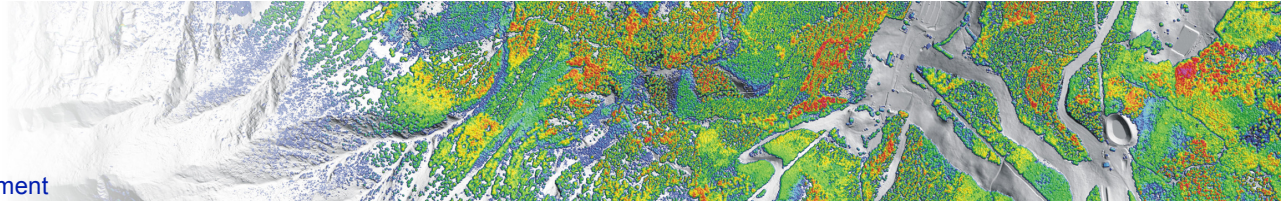


# Phase V: Forest Management Planning

- user-friendly
- flexible
- responsive
- off-line enabled
- single trees enabled
- multi-user

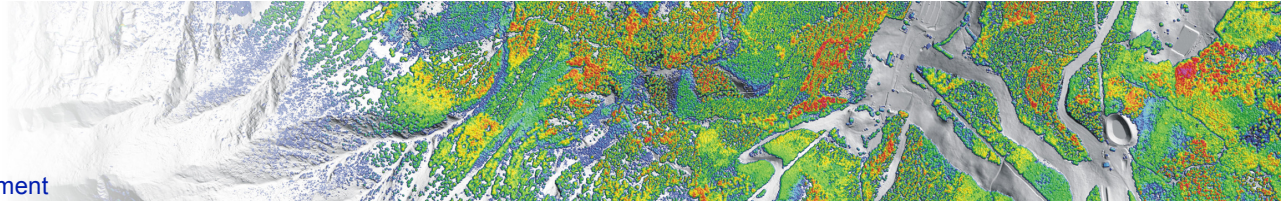






# Research questions

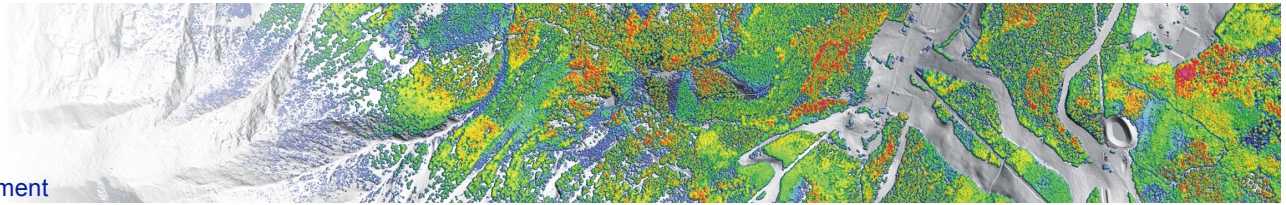
- Tree feature extraction from point clouds
- Tree species recognition
- Integration of III-Phase-FI into NFI-designs
- Statistics of mixed RS & FI designs
- **Growth Models based on AI deep learning**



## next steps:

- Evaluation of simulation scans Q4/18
- Prototype Q1-2/19
- Datasets for download available Q3/19
- jib-scan presentation at Silvilaser 2019
- Delivery of devices in 2020





**questions?**

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