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Institute of Photogrammetry and Remote Sensing

Analysis of laser scanning point clouds acquired over ChangeHabitats2 areas

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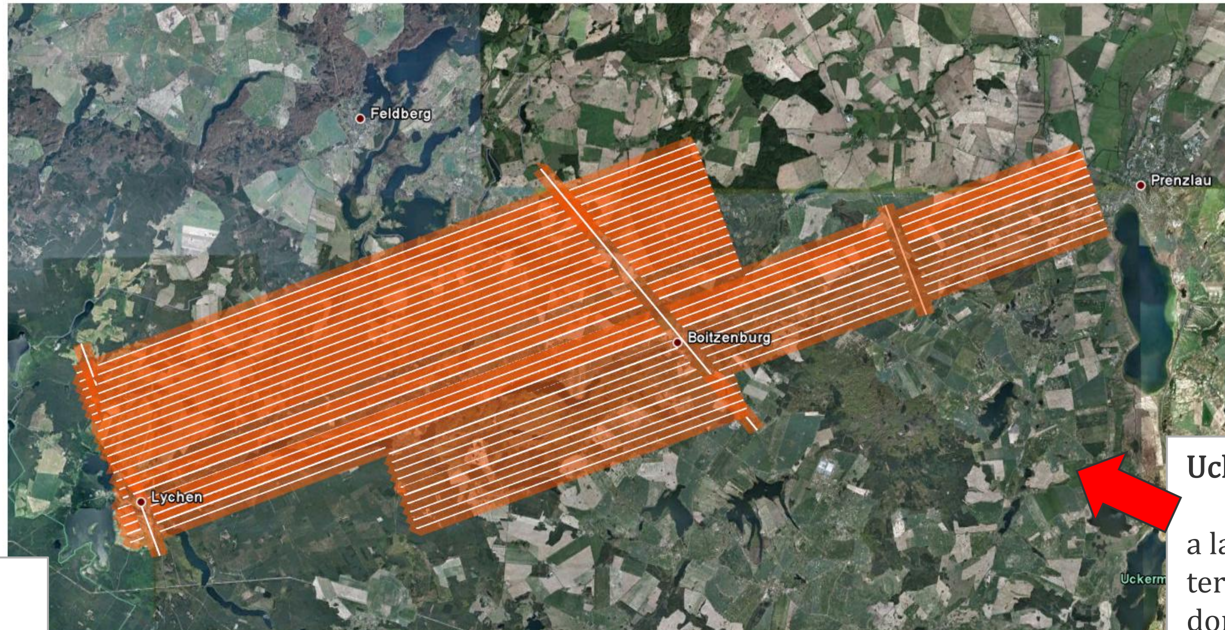
Overview of the ALS flights



Uckermark / Germany:

a lake and forest territory north of Berlin dominated by beech forests (i.e. the respective FFH habitat types)

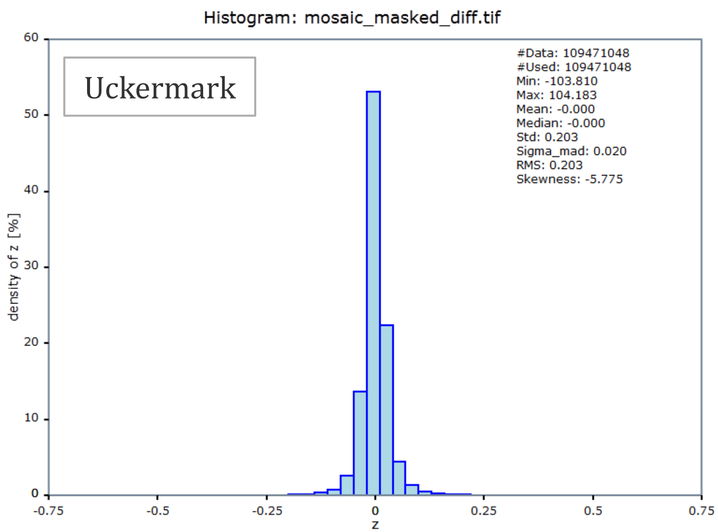
Sopron / Hungary:

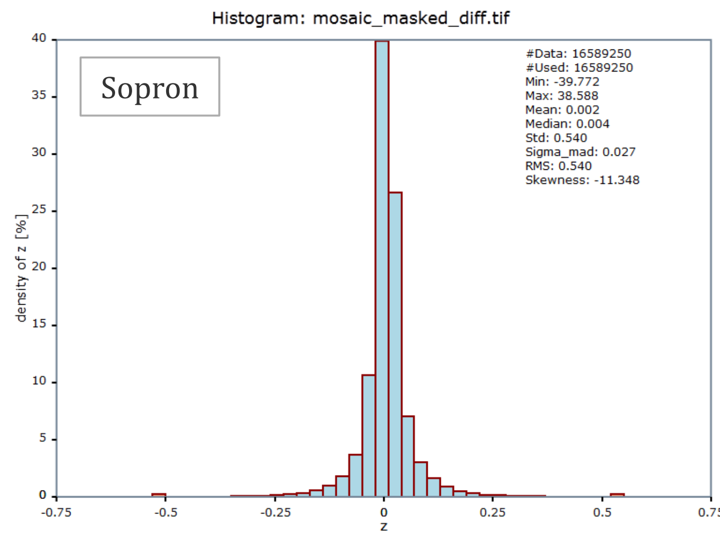
A hilly and forested area

Overview of the ALS flights

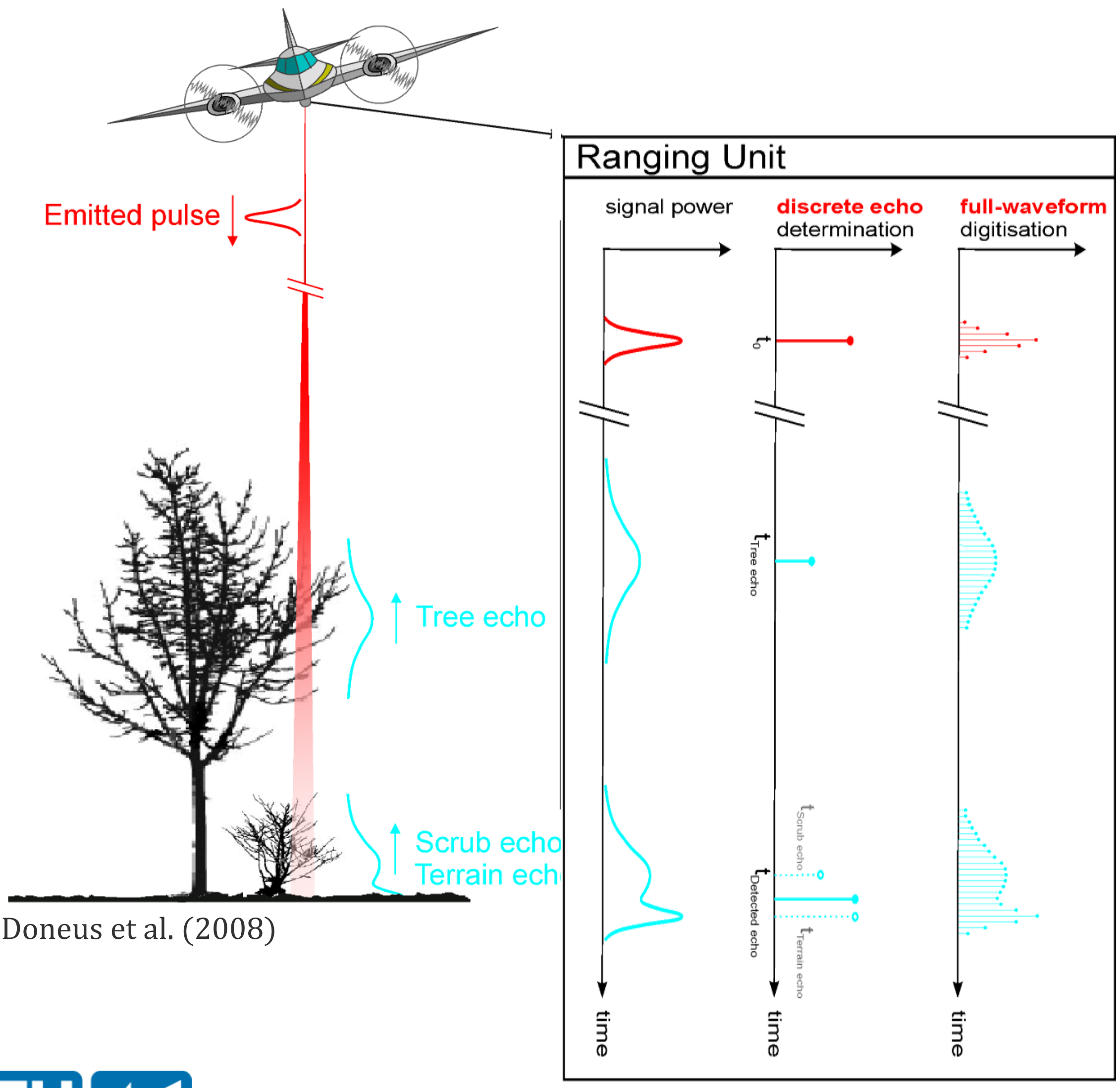
	Uckermark / Germany	Sopron / Hungary
Sensor:	RIEGL LMS-Q680 (full-waveform)	RIEGL LMS-Q680 (full-waveform)
Acquisition time:	May 2011 (leaf-on)	July 2011 (leaf-on)
Number of ALS strips:	35	22
Area covered (approx.):	290 km^2	90 km^2
Mean point density (last echoes)	21.9 pts / m^2	12.8 pts / m^2

Relative accuracy (strip differences):





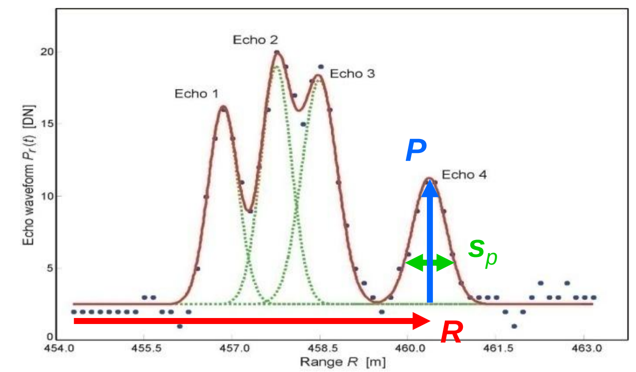
Full-waveform laser scanning



Doneus et al. (2008)

Gaussian decomposition

- ➢ Detection of echoes by fitting of Gaussians
- ➢ Information per echo:
  - Range R [m]
  - Echo width s_p [ns]
  - Amplitude (Intensity) P [DN]
  - Backscatter cross-section (computed)



Wagner et al. (2006)

Full-waveform laser scanning

- Magnitude of local maximum ➔ **amplitude**
  - Radiometric properties of the surface
- Width of curve ➔ **echo width**
  - Height variations of small scattering elements within the surface of the laser beam

Gaussian decomposition

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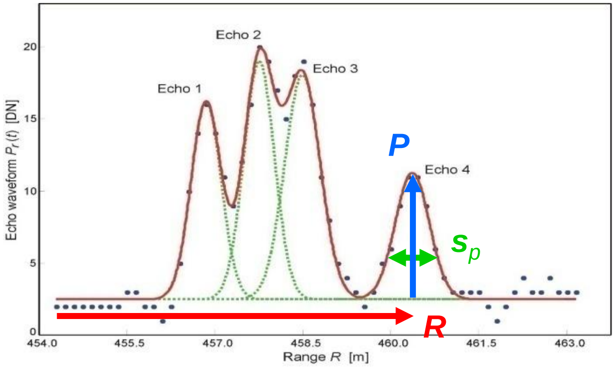
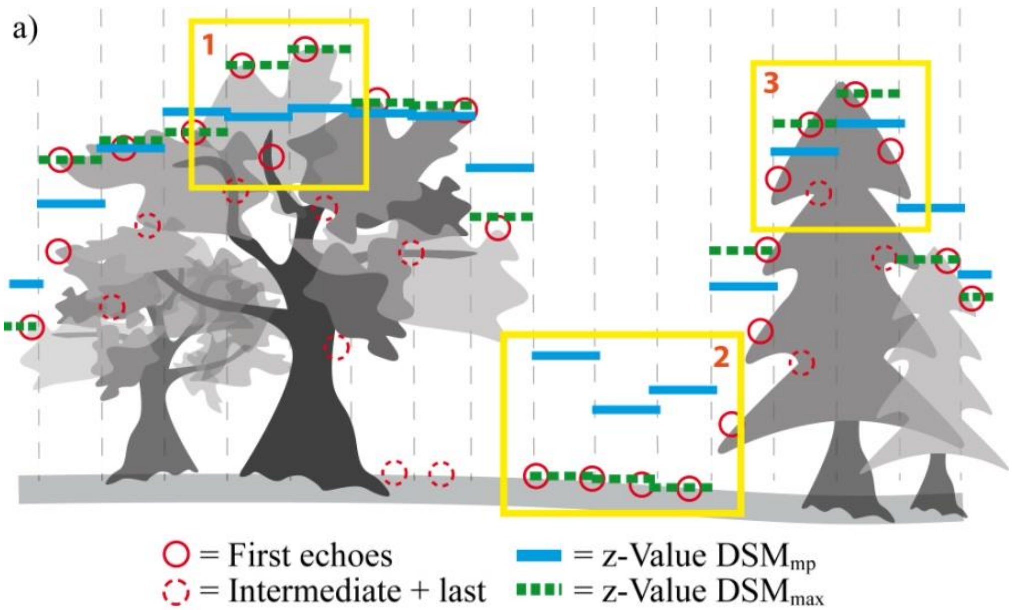


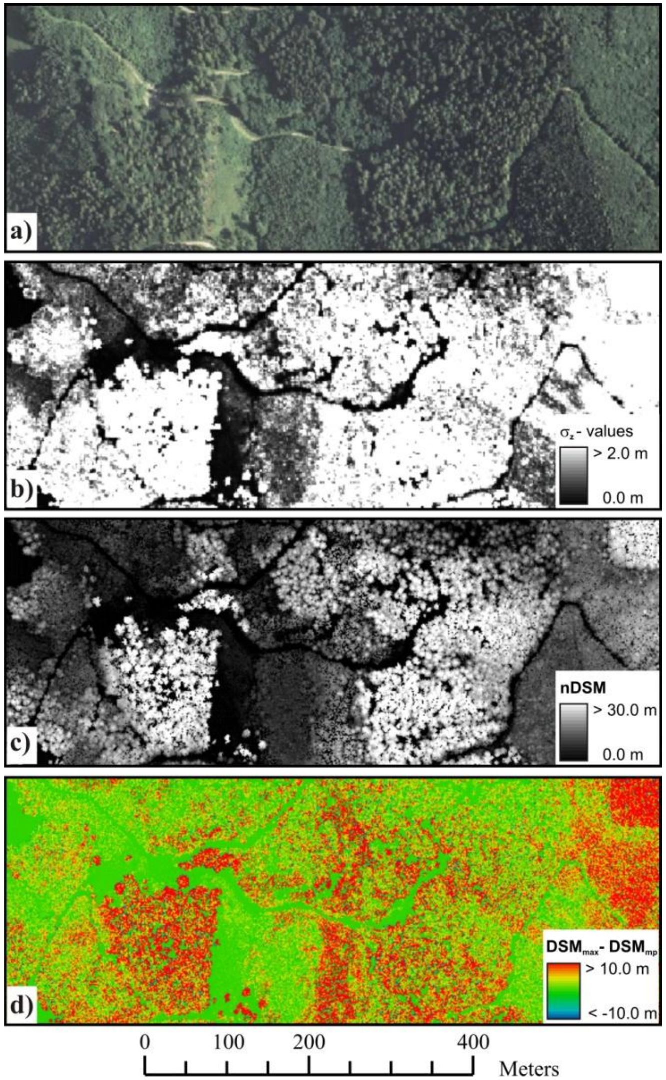
Wagner et al. (2006)

Digital surface model (DSM)

DSM_{max}, DSM_{mls}, DSM_{sigma} → $DSM_{combined}$

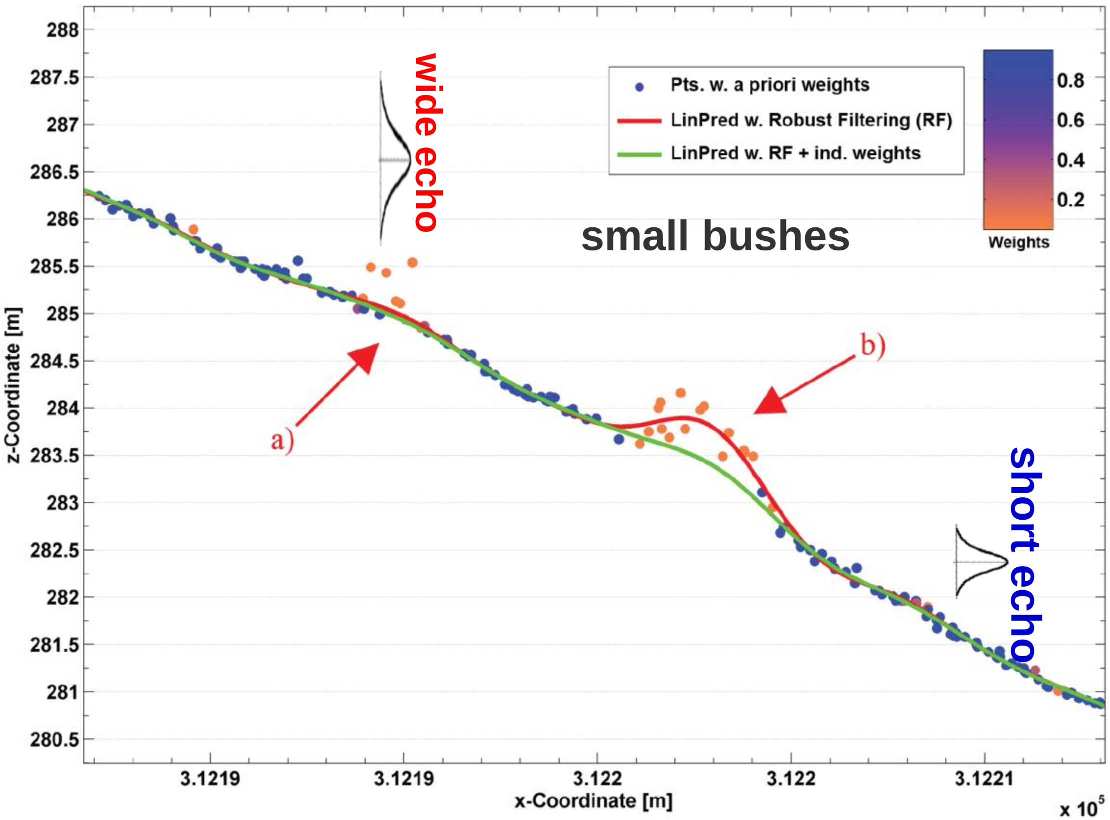


Hollaus et al. (2010)

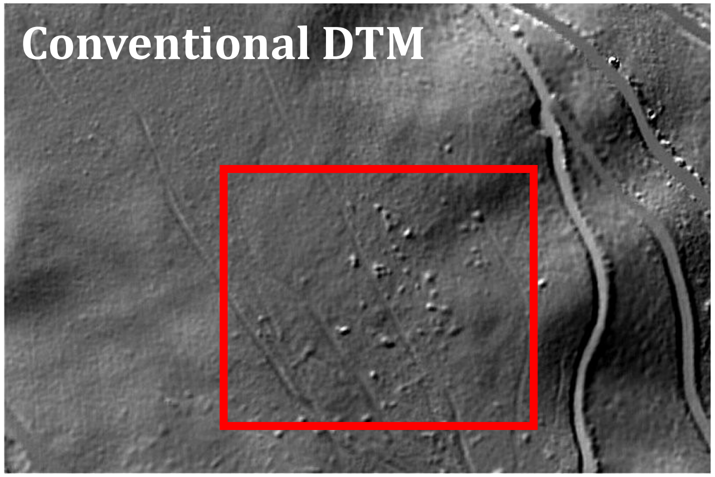


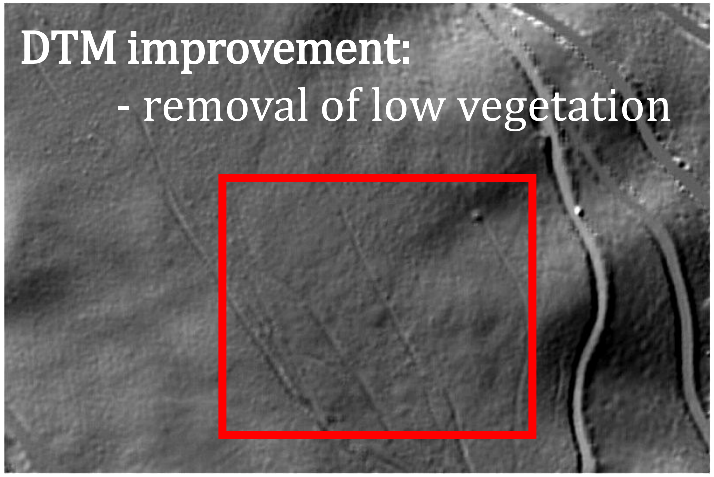
Digital terrain model (DTM)

- Waveform-based DTM improvements



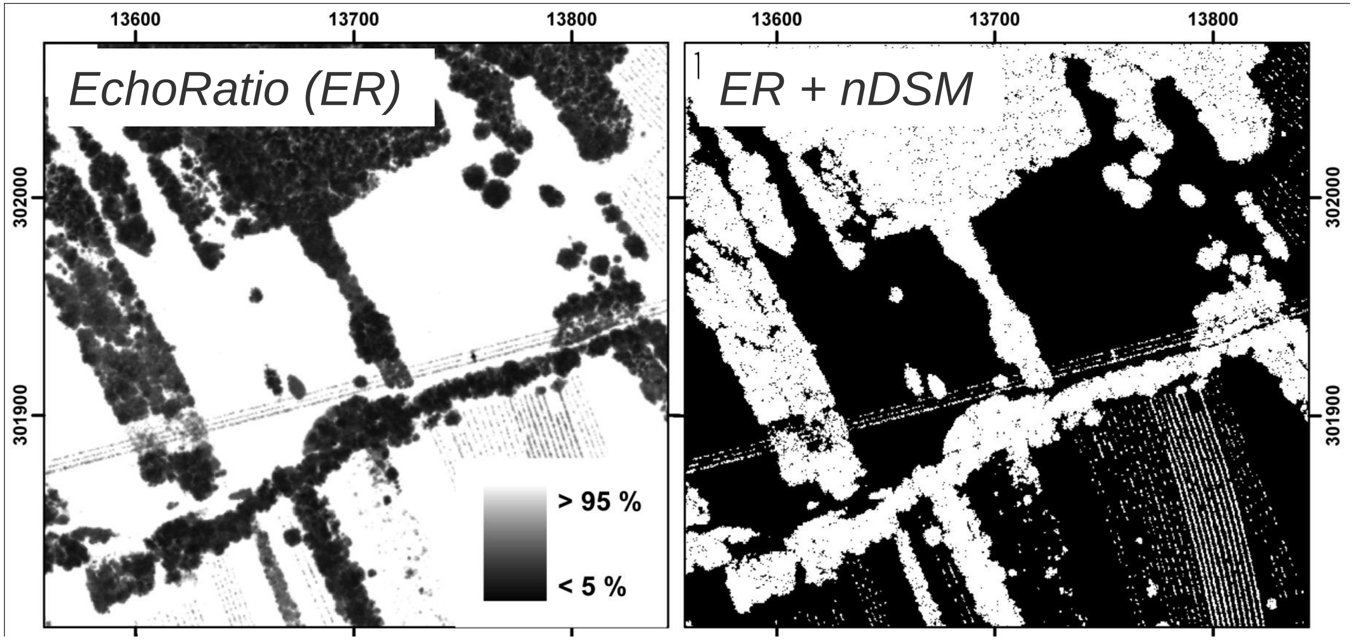
Mücke (2008)





Vegetation mask

- ***Echo ratio (ER):*** measure for local **transparency** and **roughness** (height variation) (Höfle et al. [2009])
  ➔ Buildings are not penetrable: ER = 100%
  ➔ Vegetation is (in most cases) penetrable: ER < 100%
- Used to create a vegetation mask (ER + normalized DSM = DSM - DTM)



Mücke et al. (2010)

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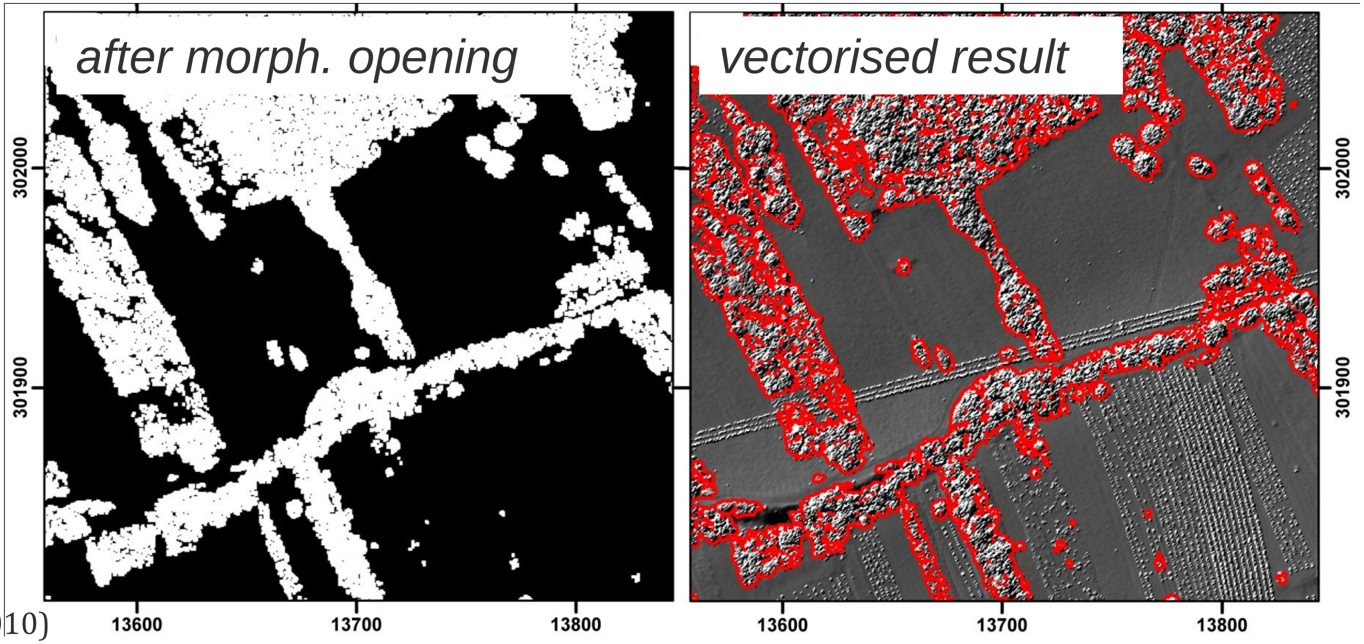
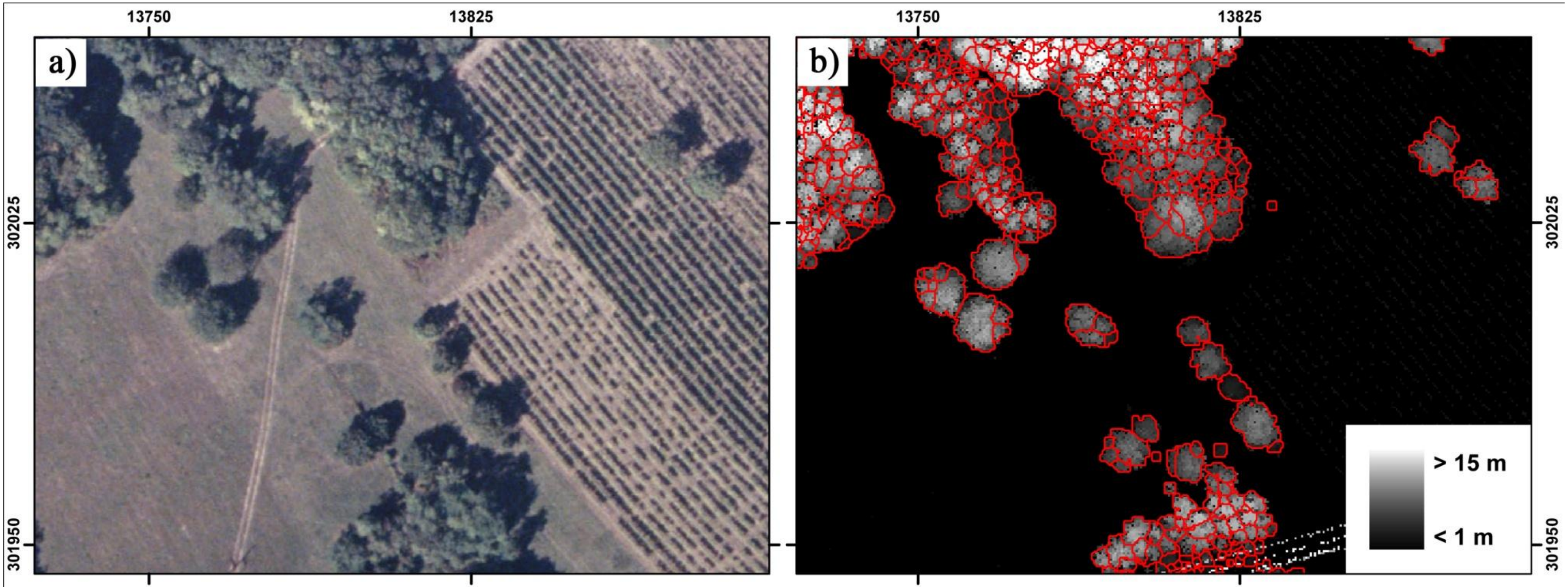


Mücke et al. (2010)

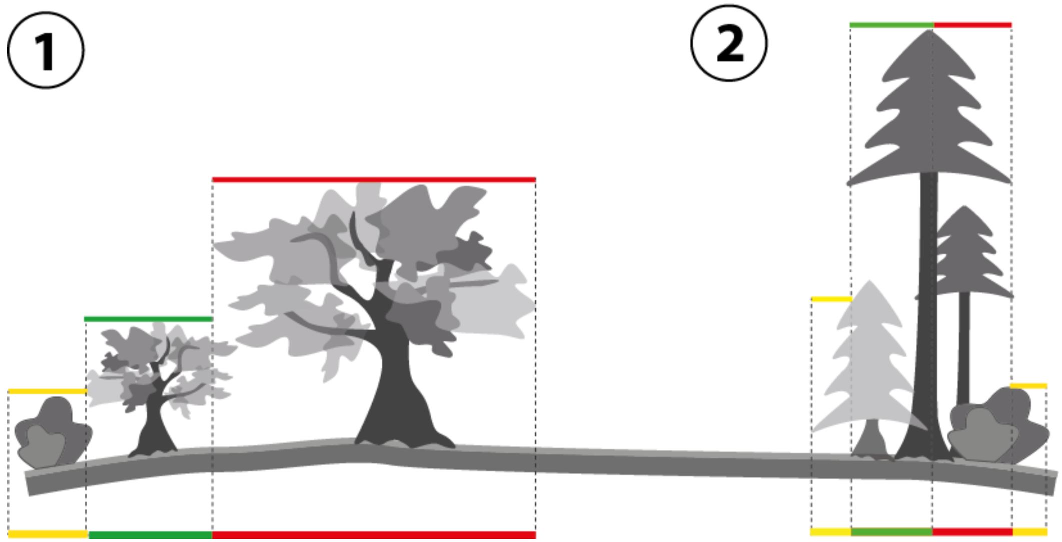
Single tree segmentation

- Aim:
  - use as a spatially well represented reference unit
  - meant to extract features like shrubs, single tree crowns or sub-tree crowns
- Delineation of convex objects in *nDSM*
- Constraint:
  - minimum curvatures



Selected FFH relevant parameters: **Layer structure**

- Definition of „vegetation layers“ in a multi layered forest



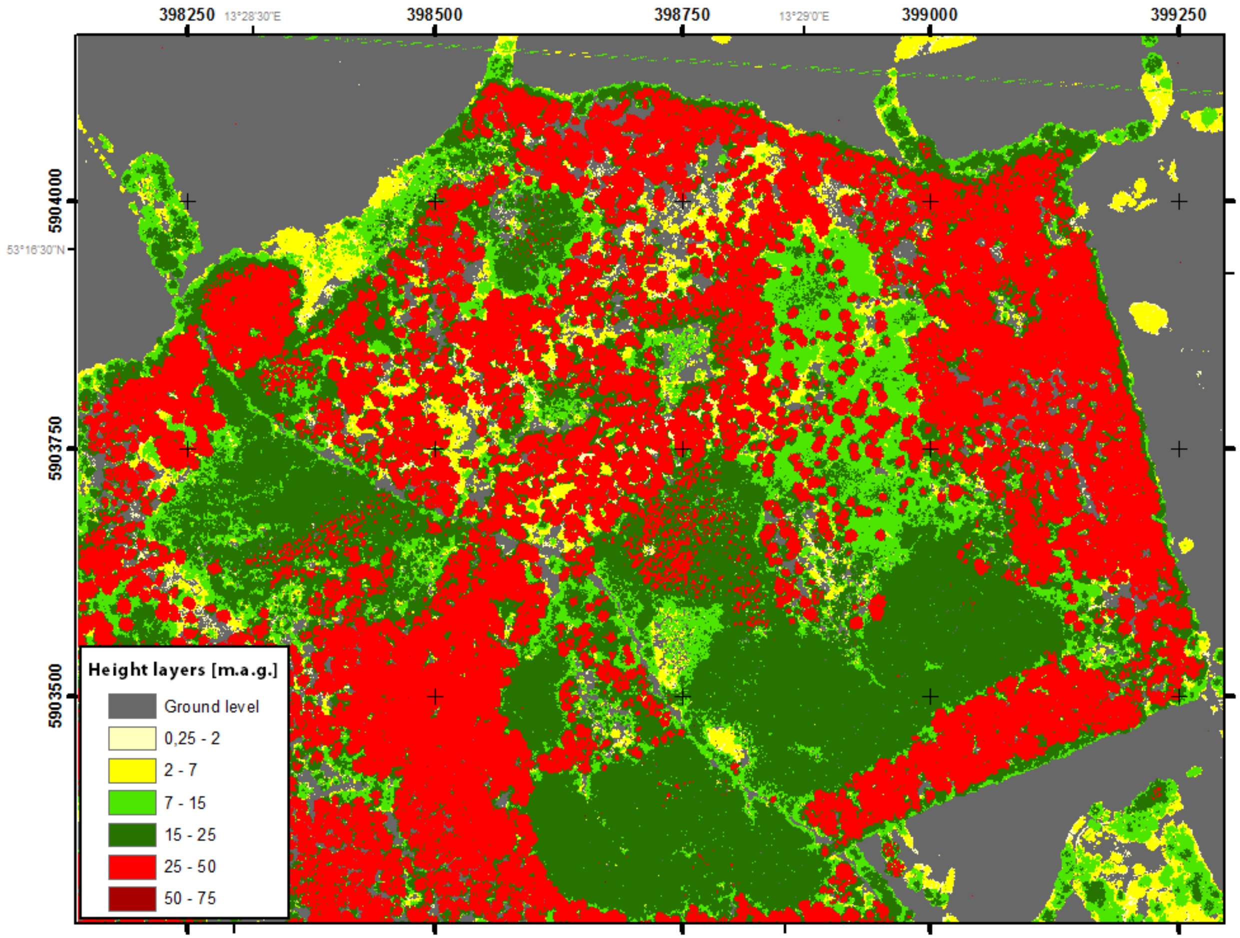
1. Stand consisting of clearly distinguished trees of different height
   - (Probably) also classifiable with airborne imagery
2. Stand with trees covering and growing into each other
   - Only classifiable with ALS due to penetration of the top most canopy

Selected FFH relevant parameters: **Layer structure**

Testsite:

Uckermark /

Ungeteilte Heide



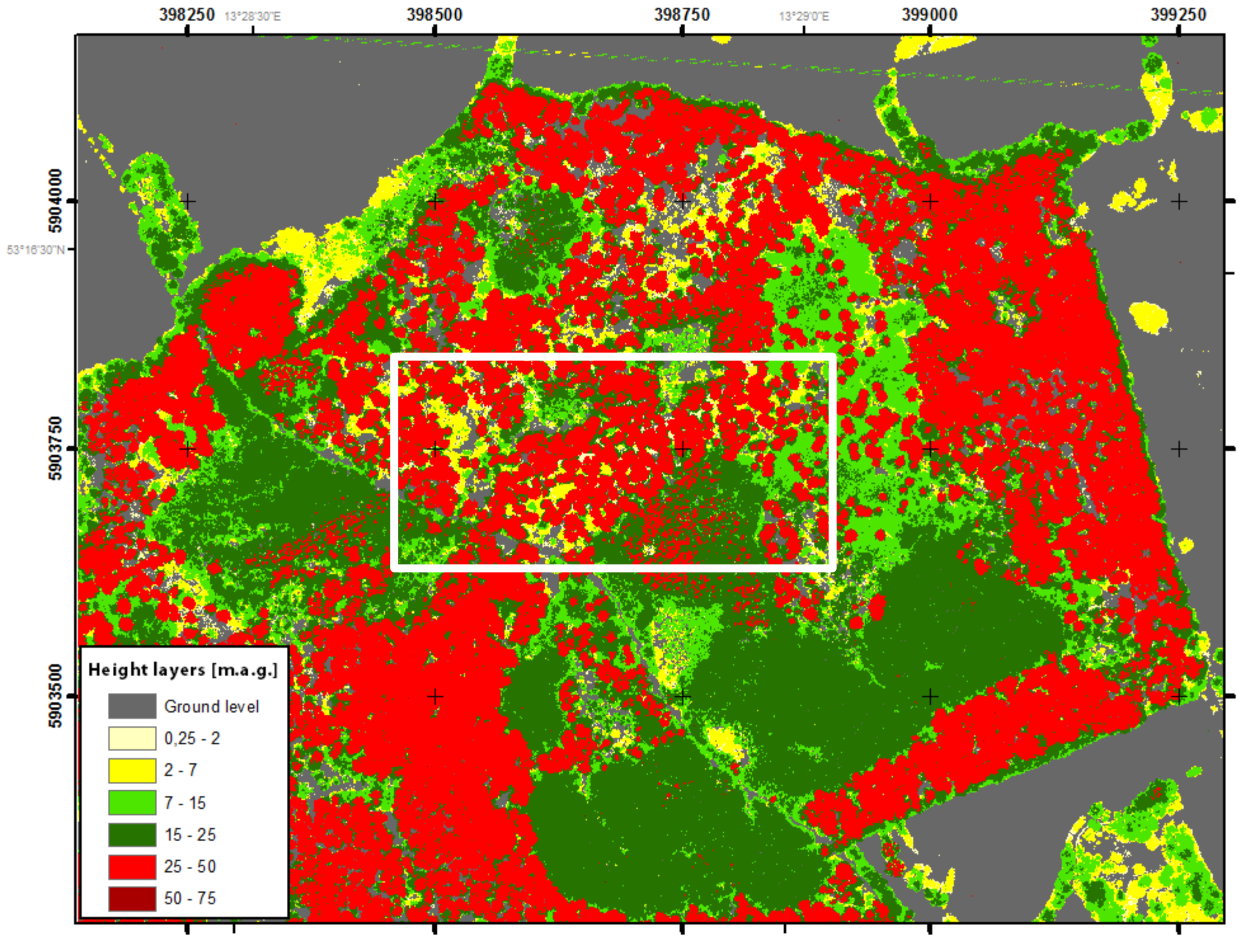
nDSM based determination of forest height layers

Selected FFH relevant parameters: **Layer structure**

Testsite:

<u>Uckermark /</u>

<u>Ungeteilte Heide</u>



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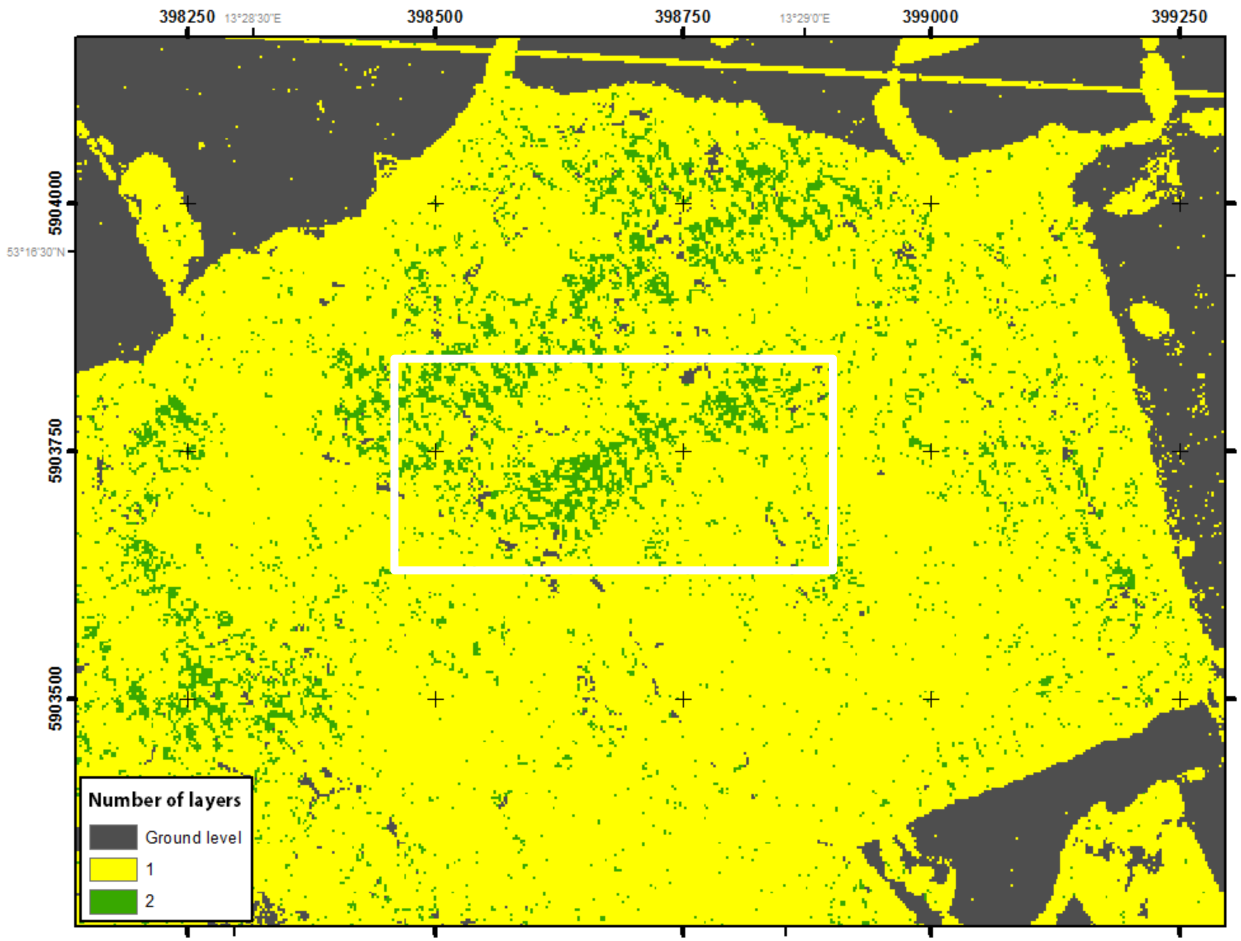


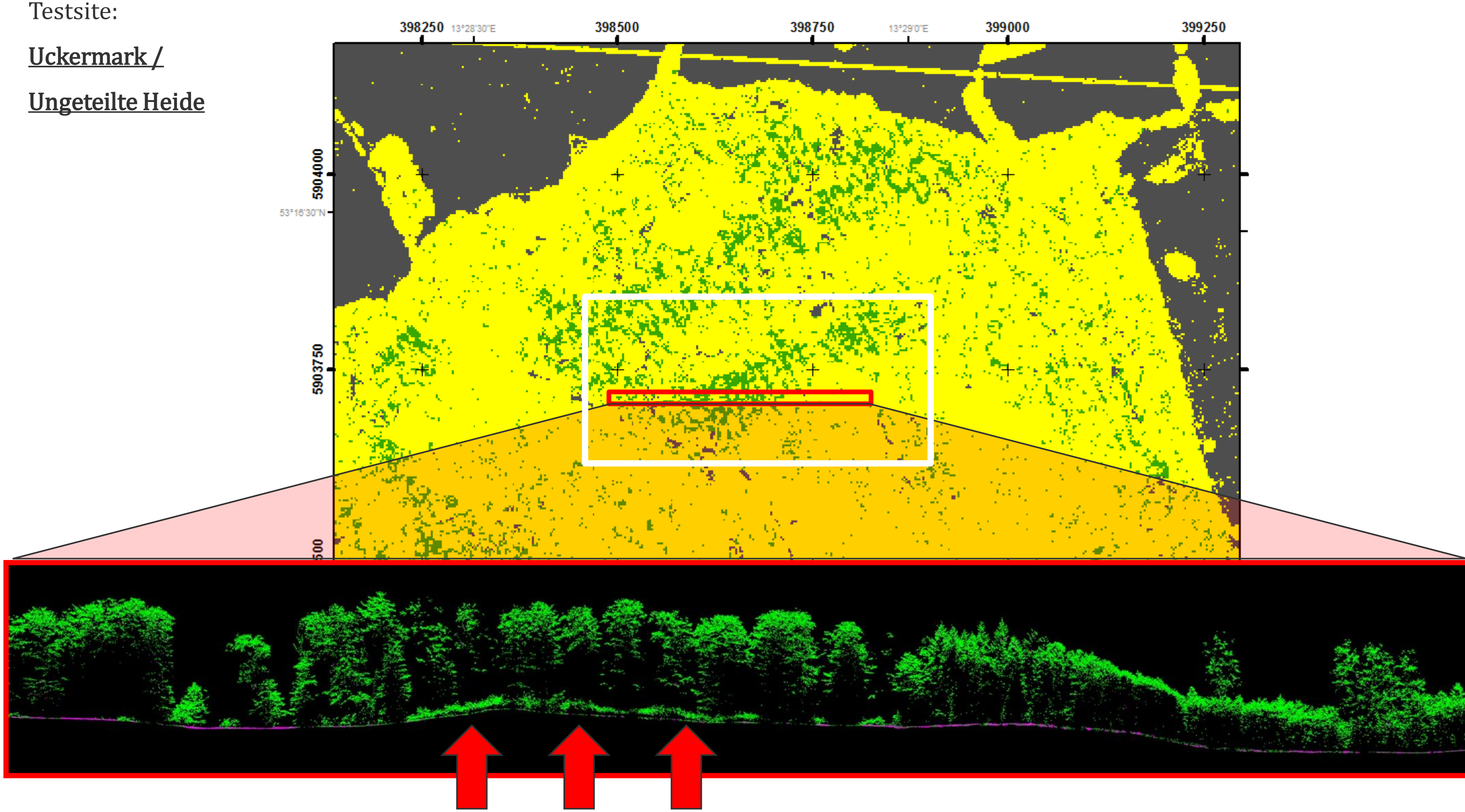
Point cloud based estimation of occluded vegetation layers

Selected FFH relevant parameters: **Layer structure**

Testsite:

<u>Uckermark /</u>

<u>Ungeteilte Heide</u>



Multi-layered (shrub, ~5m and high trees ~ 30m)

Selected FFH relevant parameters: **Age classes**

- Tree age classes are indirectly described via tree diameter (FFH-mapping instructions Brandenburg, 2010)
- Functional relationship between tree height and stem diameter

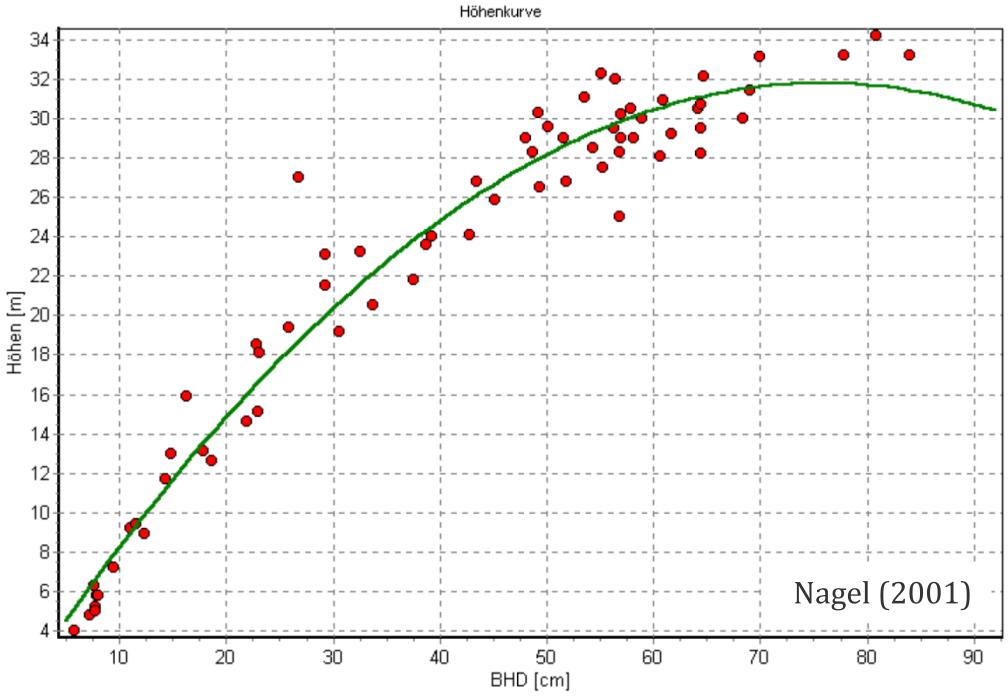
  ➔ **stand height curves**

$$h = a_0 + a_1 . d + a_2 . d^2$$

$$h = a_0 + a_1 . ln(d)$$

with a_i = regression coefficients

- Derive diameters from ALS height measurements (i.e. local maxima = tree positions)



Selected FFH relevant parameters: **Dead wood**

1. Fallen dead trees (or very coarse woody debris)
2. Standing dead trees (with or without crown branches)

Fallen dead trees

Testsite:

<u>Uckermark /</u>

<u>Ungeteilte Heide</u>

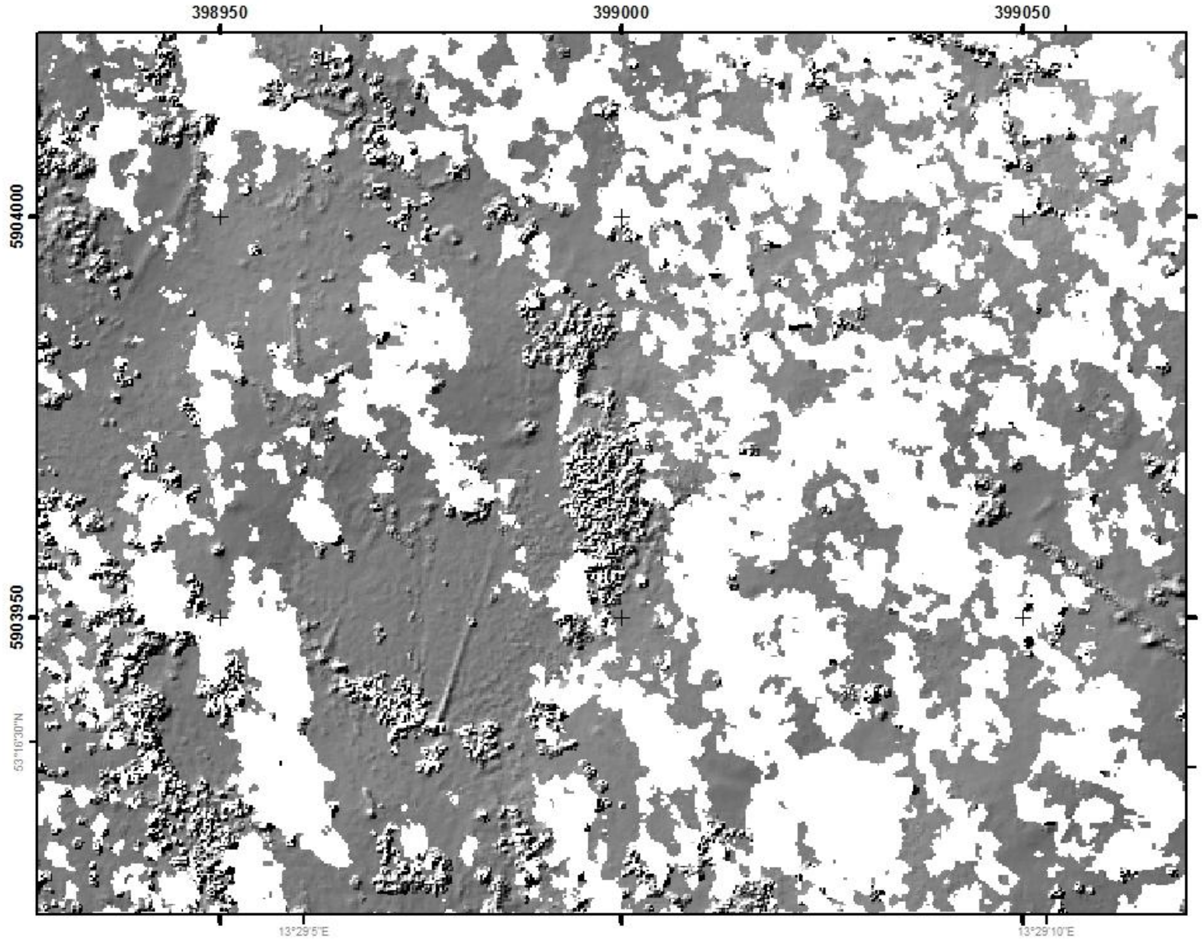
DSM created from

Leaf-on

data and from

all echoes where

dZ_DTM <= 2m



Fallen dead trees

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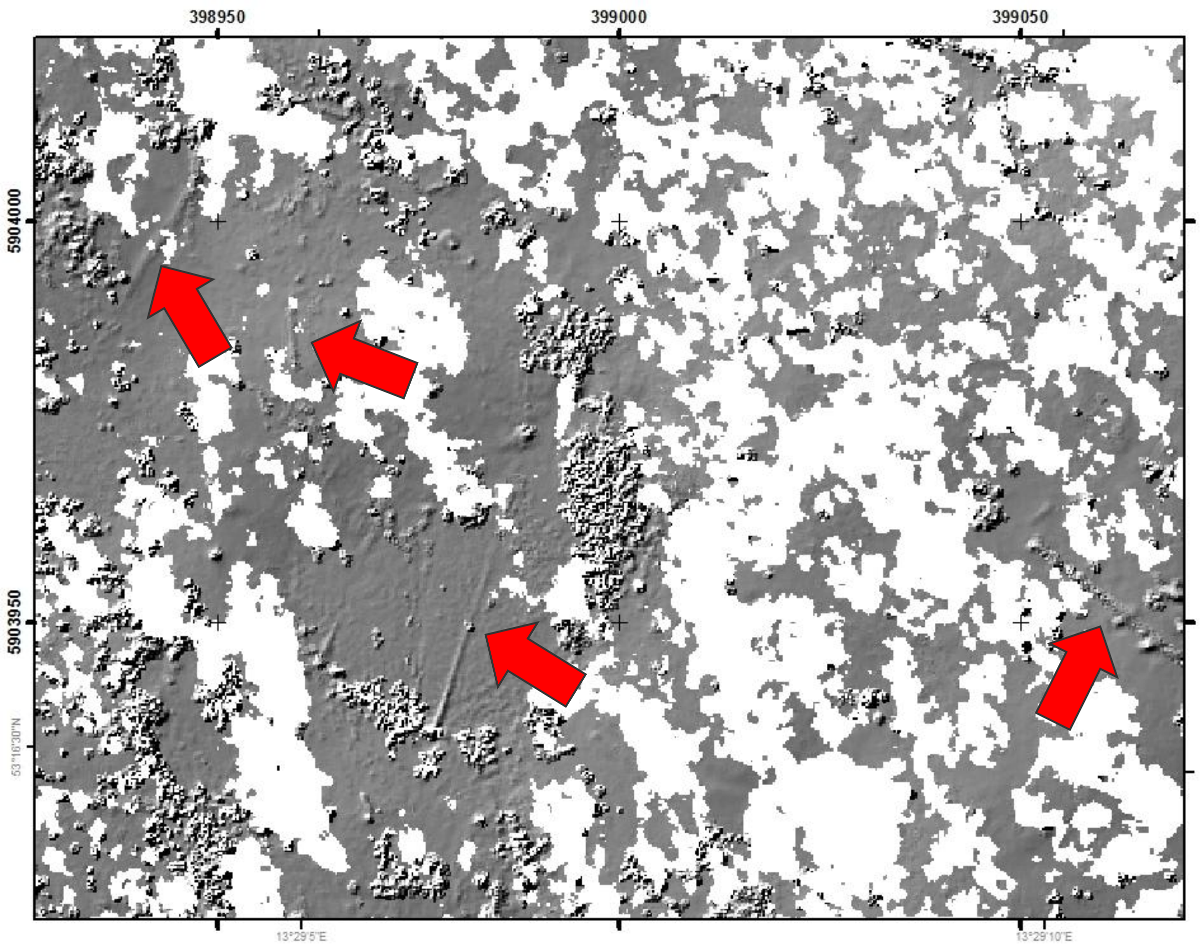

Fallen dead trees

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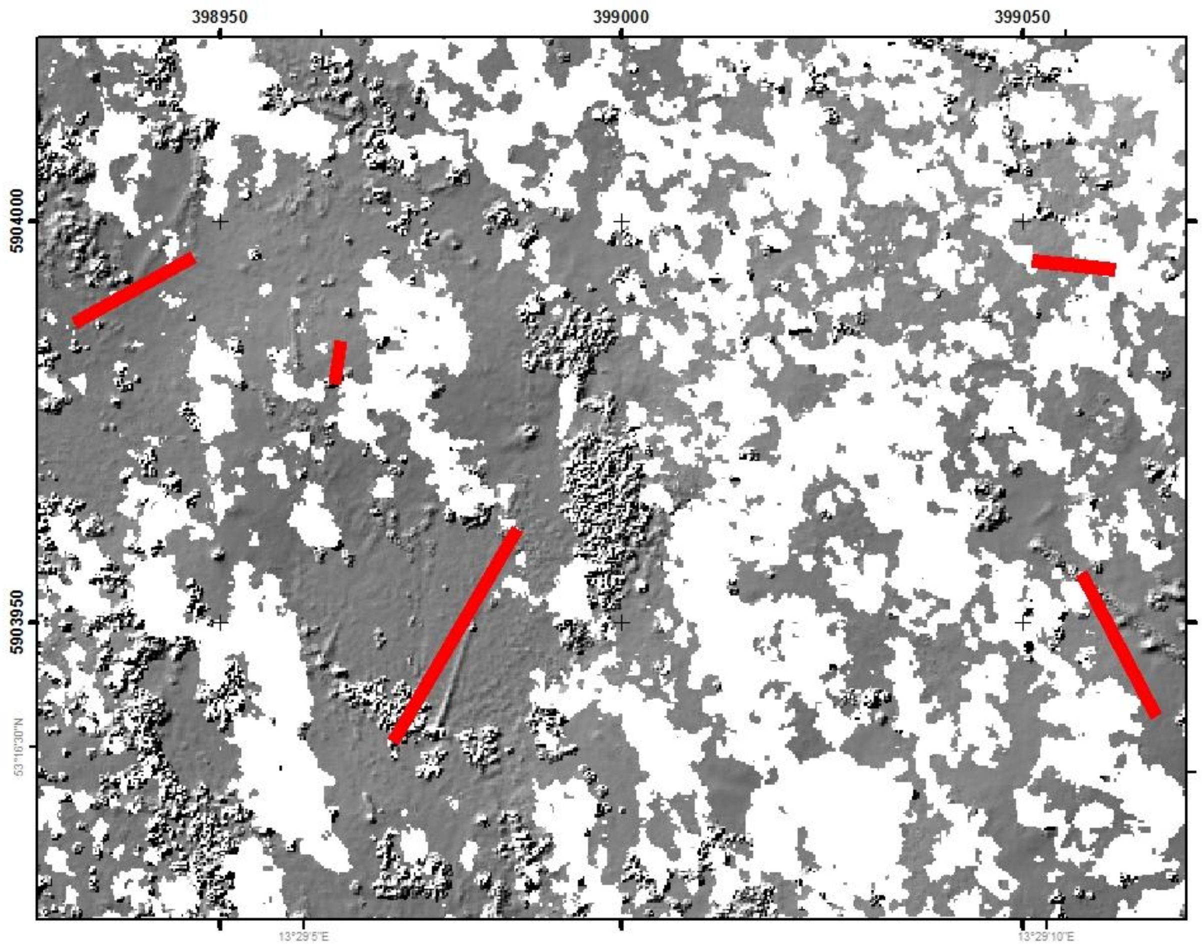


GPS measured fallen trees (diameter > 30 cm)

Fallen dead trees

Testsite:

Uckermark /

Ungeteilte Heide

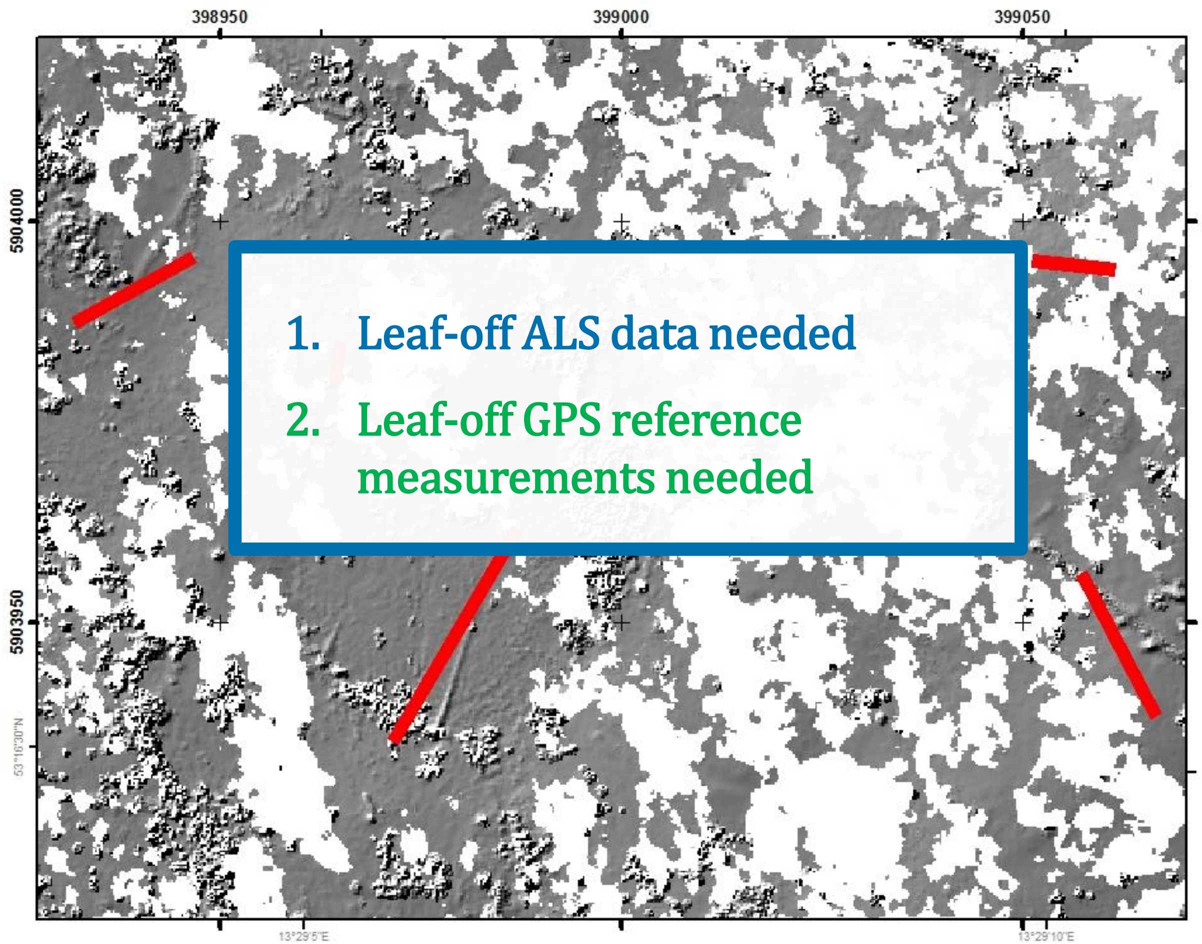
DSM created from

Leaf-on

data and from

all echoes where

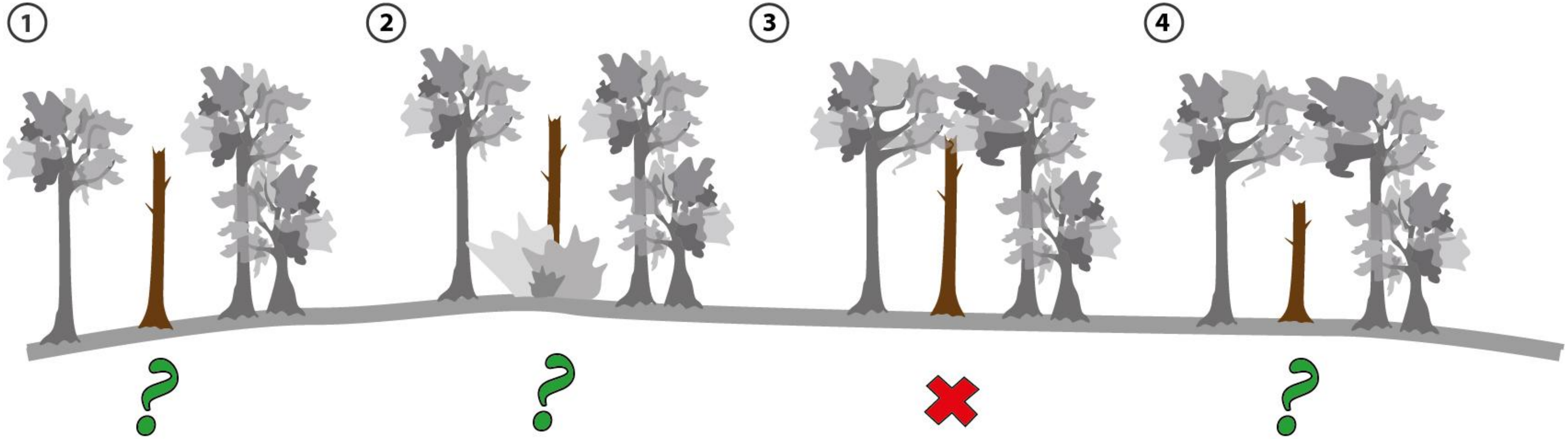
dZ_DTM <= 2m



1. Leaf-off ALS data needed
2. Leaf-off GPS reference measurements needed

GPS measured fallen trees (diameter > 30 cm)

Standing dead trees

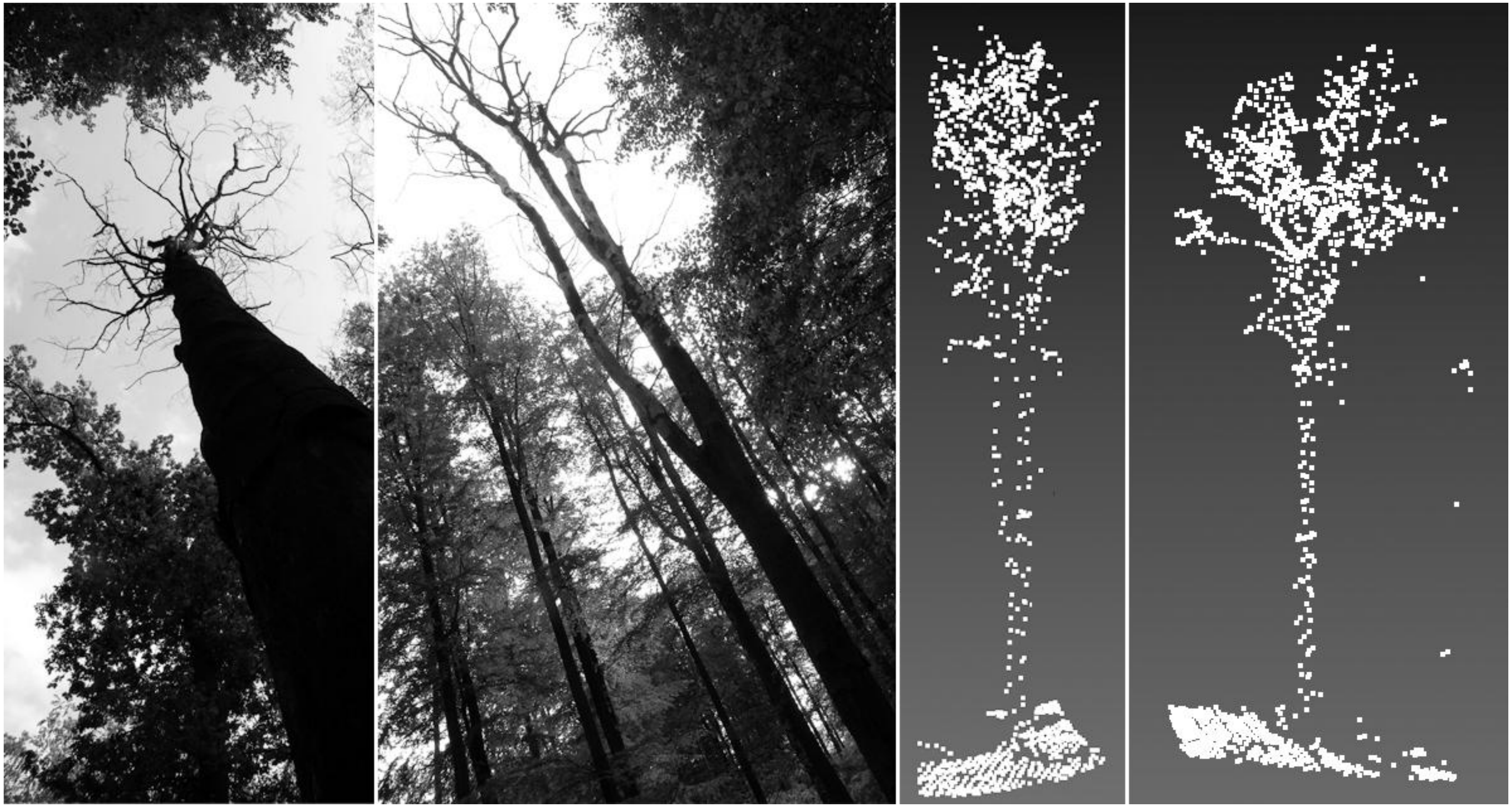


Dead tree (with or without crown) and

1. No canopy cover
2. No canopy cover and significant amount of under storey (shrub layer)
3. Healthy trees growing into and over it
4. Healthy trees growing over, but not into it

Standing dead trees

- Example from the point cloud



Thank you for your attention!

- Concluding remarks
  - ALS is an already accepted method for derivation of forest metrics
  - Potential for FFH-monitoring in forest / landscape ecology is demonstrated
  - Colaboration between ecology and Earth observation is highly relevant

- Literature

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