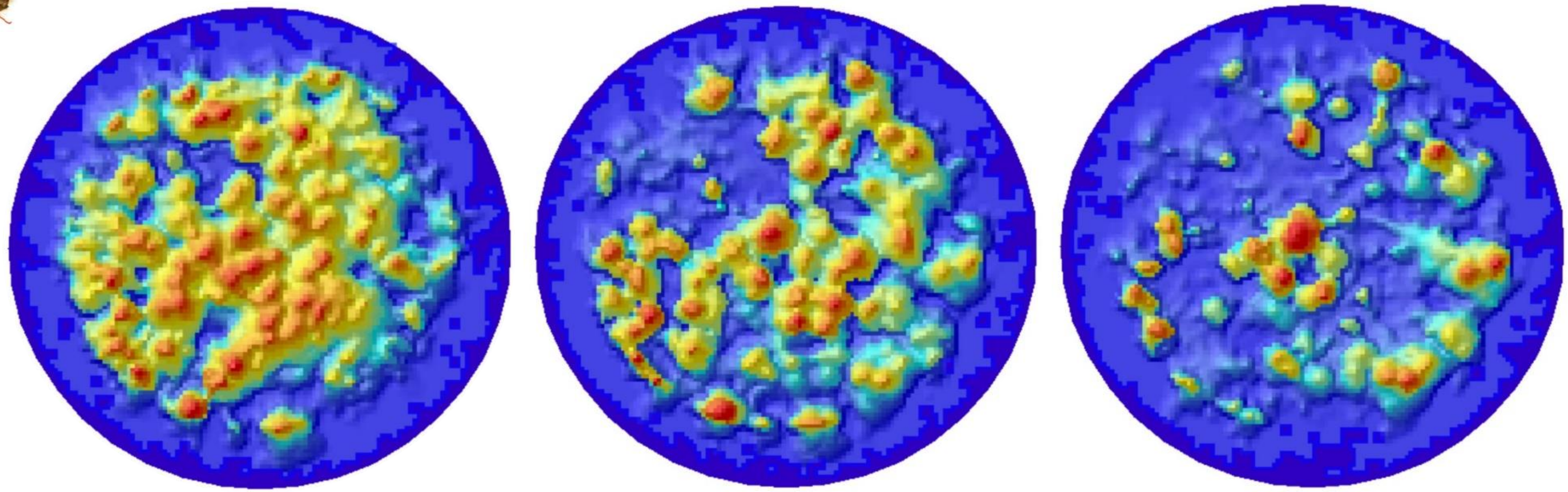
Using LiDAR and photogrammetry approach for bark beetle infestation detection



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piotr.wezyk@urk.edu.pl

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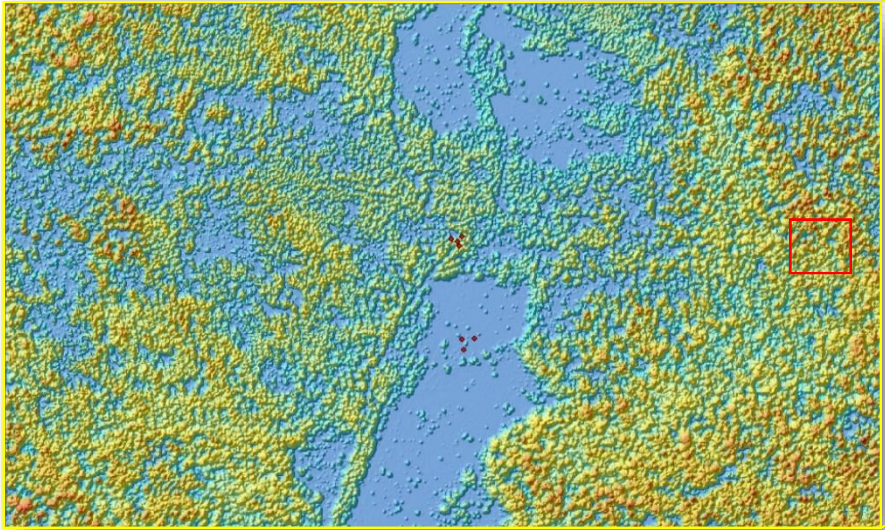
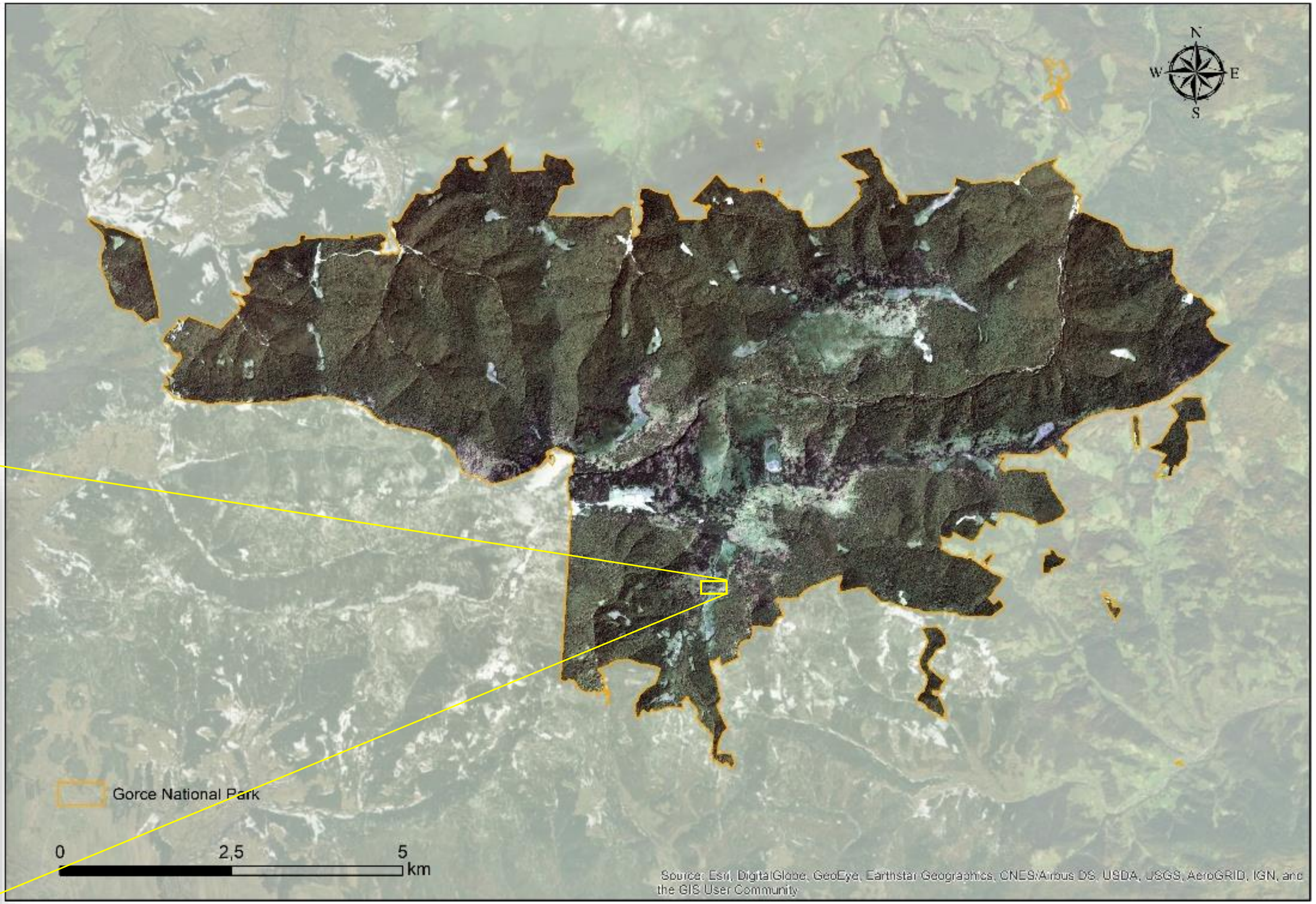
University of Agriculture in Krakow, Poland

LABORATORIUM
GEOMATYKI

TLS LiDAR inventory of „bark beetle nest” Gorce National Park (South Poland)



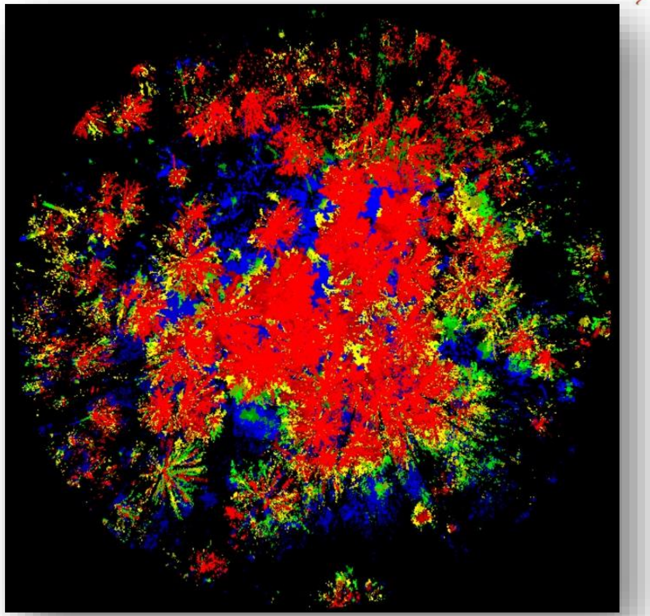


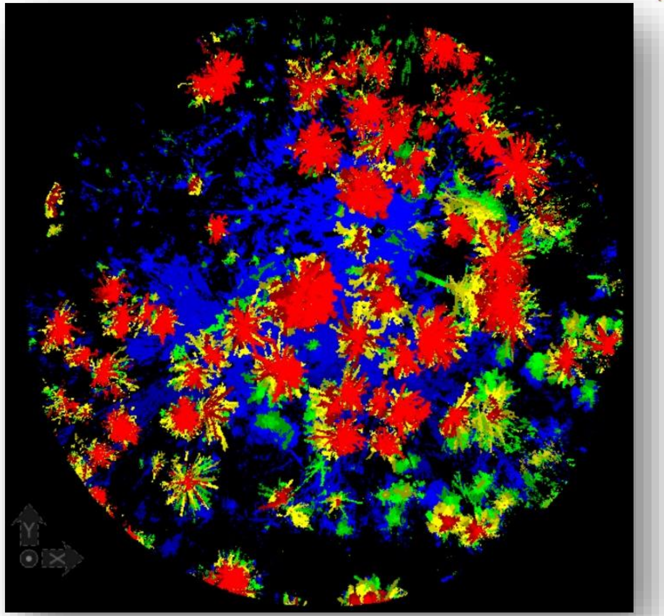
TLS LiDAR inventory of „bark beetle nest" – FAFO Focus Gorce National Park 2012/2016/2018

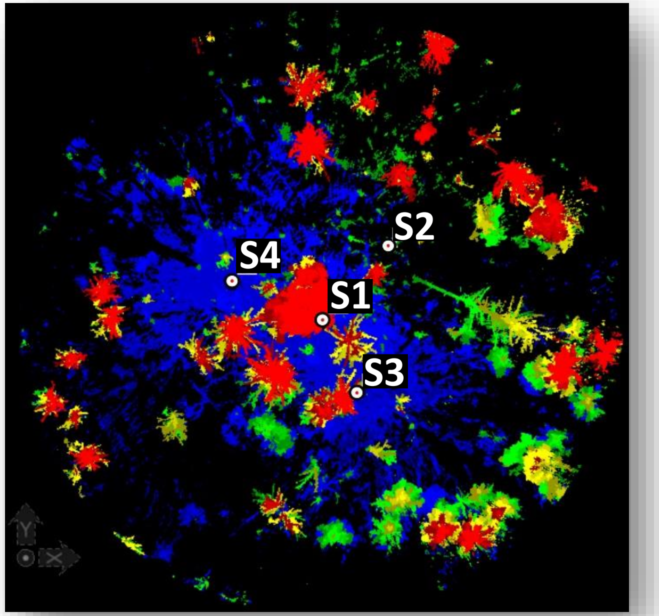
2012

2016

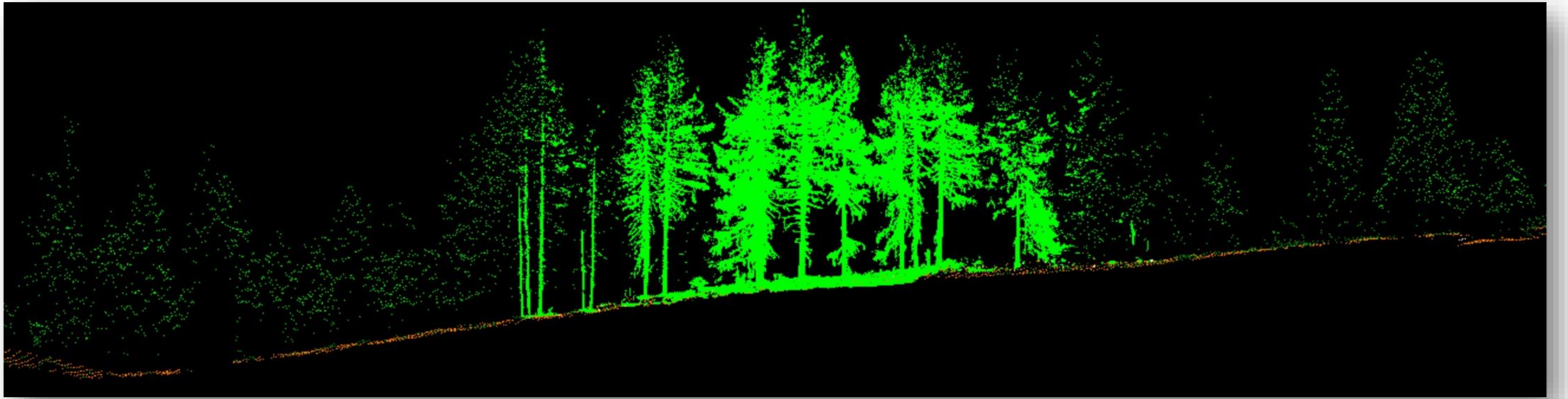
2018



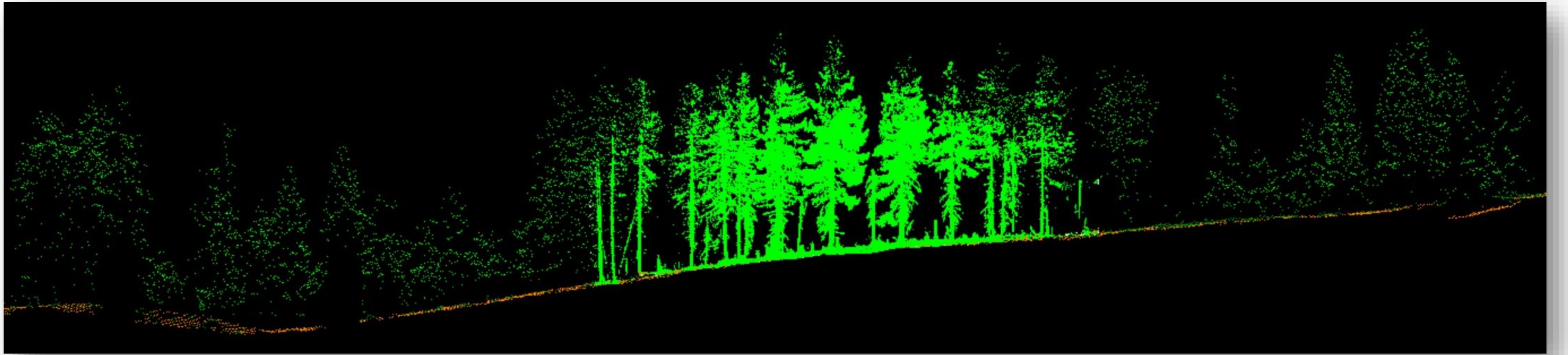




ALS LiDAR (2013) and TLS LiDAR (2012) integration
Test site Gorce National Park



ALS point cloud (ISOK, 2013) – 4pkt/m^2, color by classification; TLS (2013) – light green color

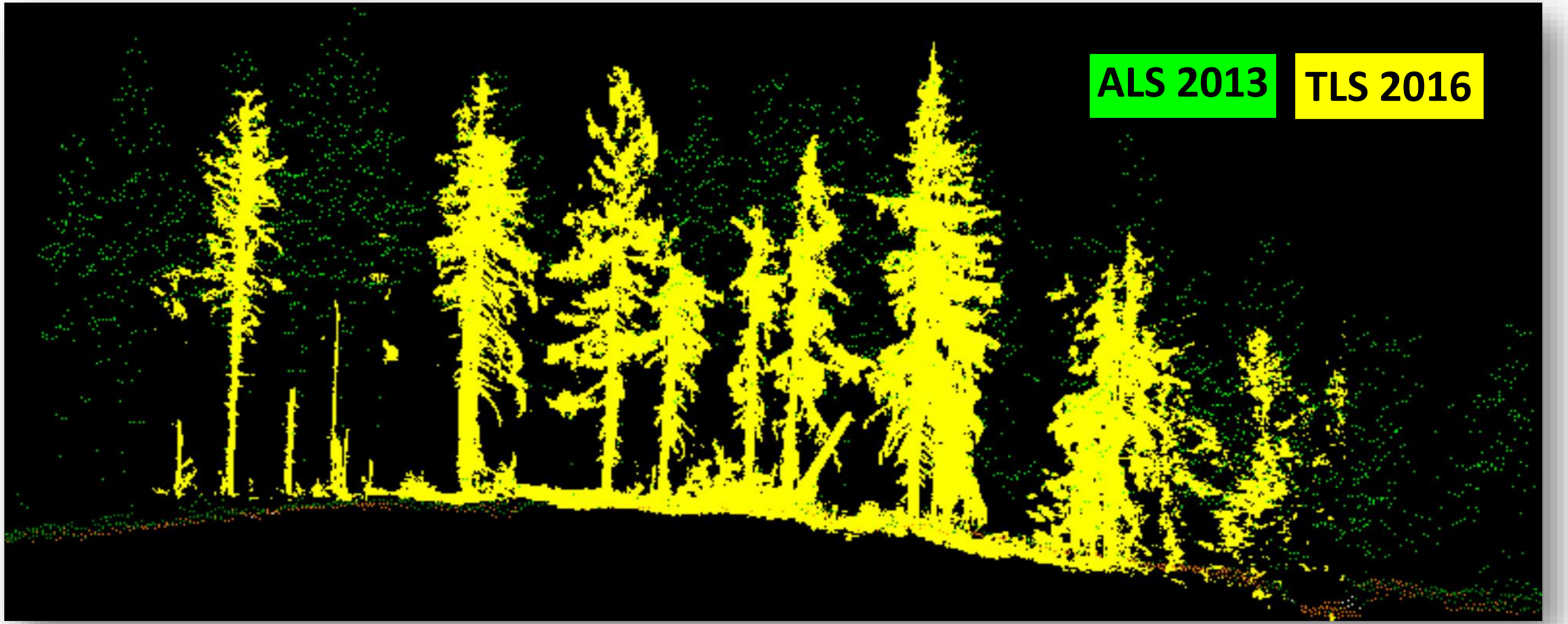


TLS point cloud 2016 and 2018 - Gorce National Park

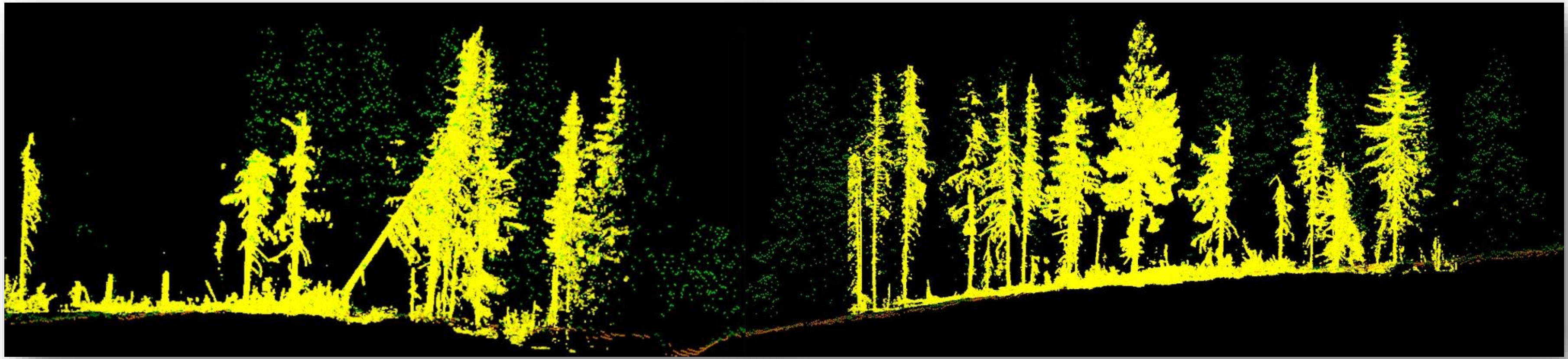
TLS point cloud (2016) – color by RGB

TLS point cloud (2018) – color by RGB

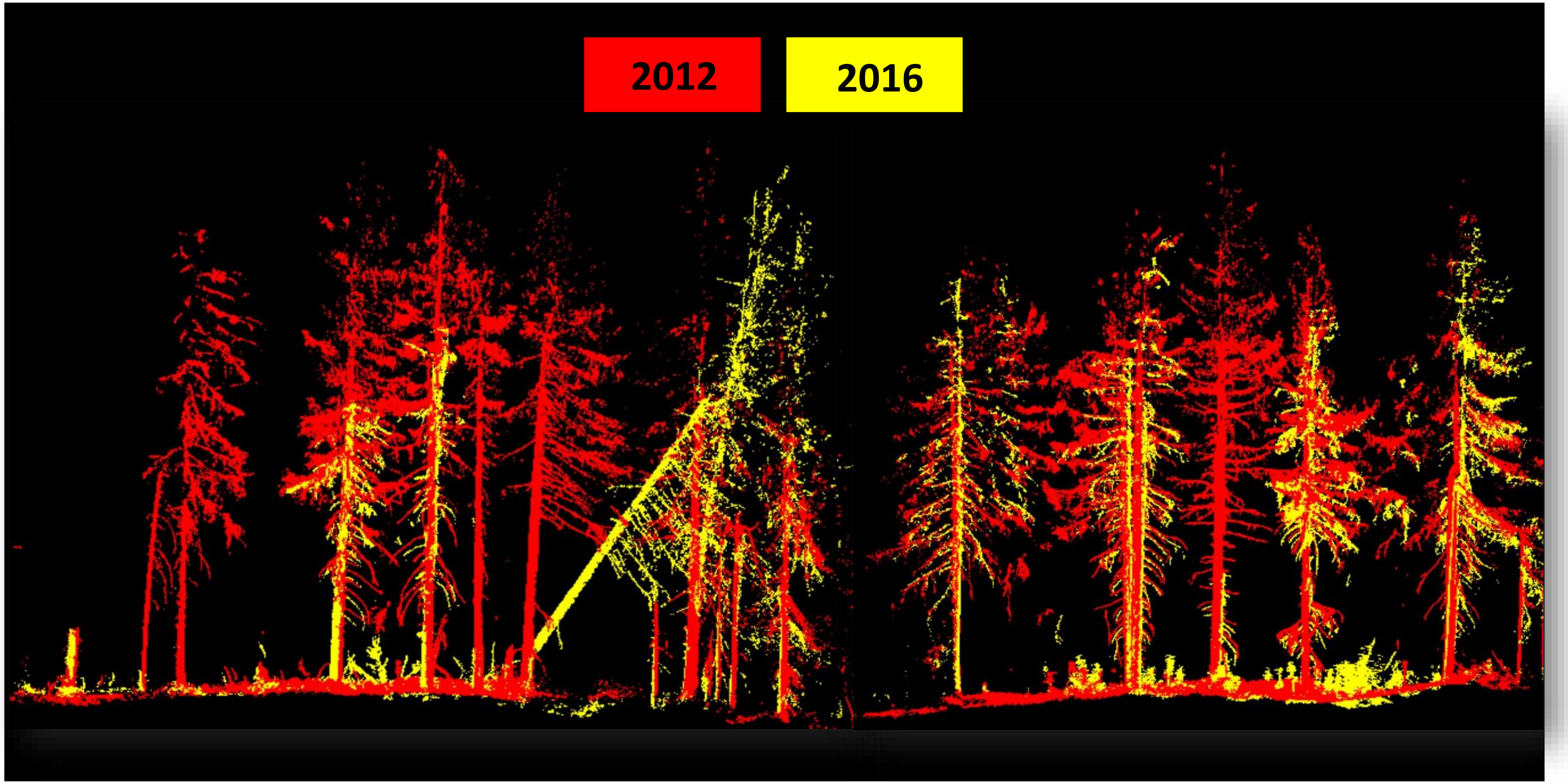
ALS (2013) and TLS (2016) integration



ALS point cloud (ISOK, 2013) – 4pkt/m^2, color by classification; TLS (2016) – yellow color

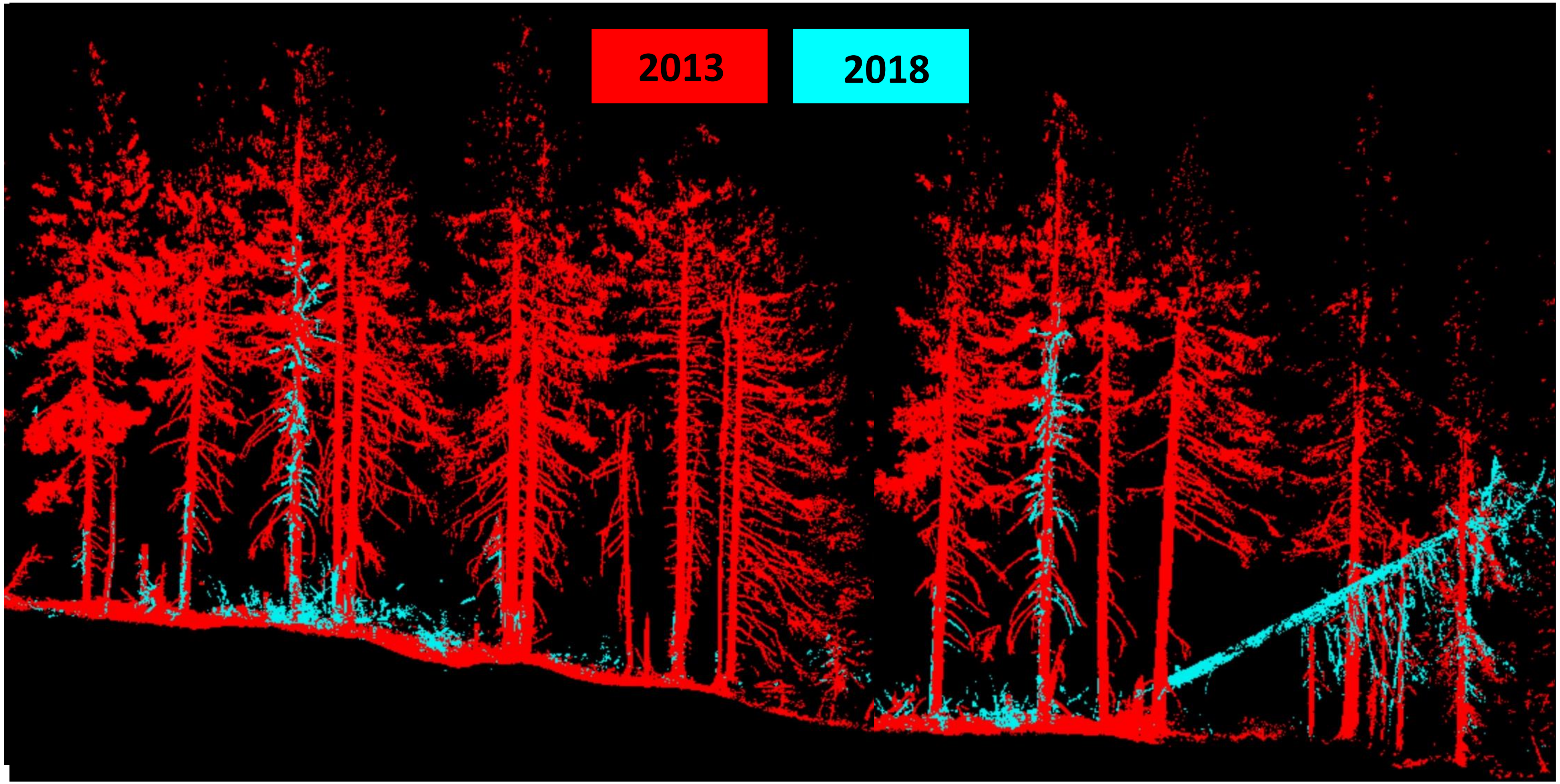


Comparison of TLS point clouds 2012 and 2016
Gorce National Park



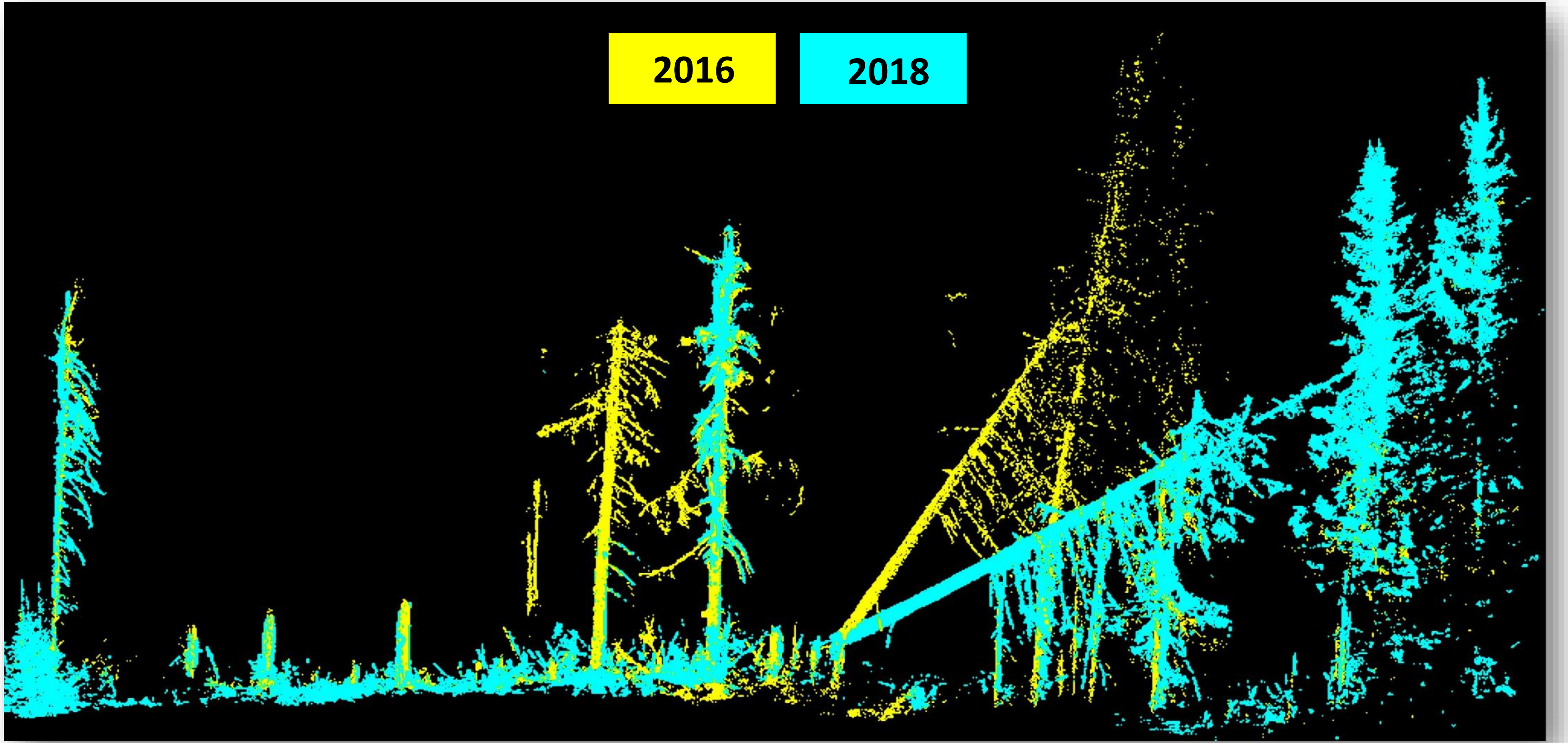
TLS point clouds (red – 2013; yellow – 2016)

Comparison of TLS point clouds 2012 and 2018
Gorce National Park



TLS point clouds (red – 2013; blue – 2018)

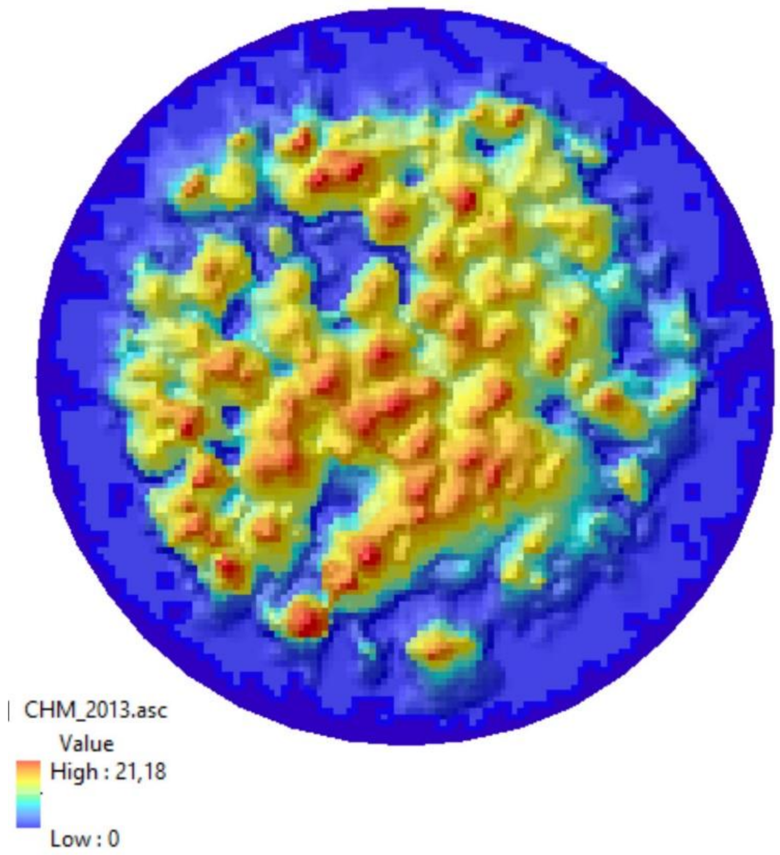
Comparison of TLS point clouds 2016 and 2018
Gorce National Park



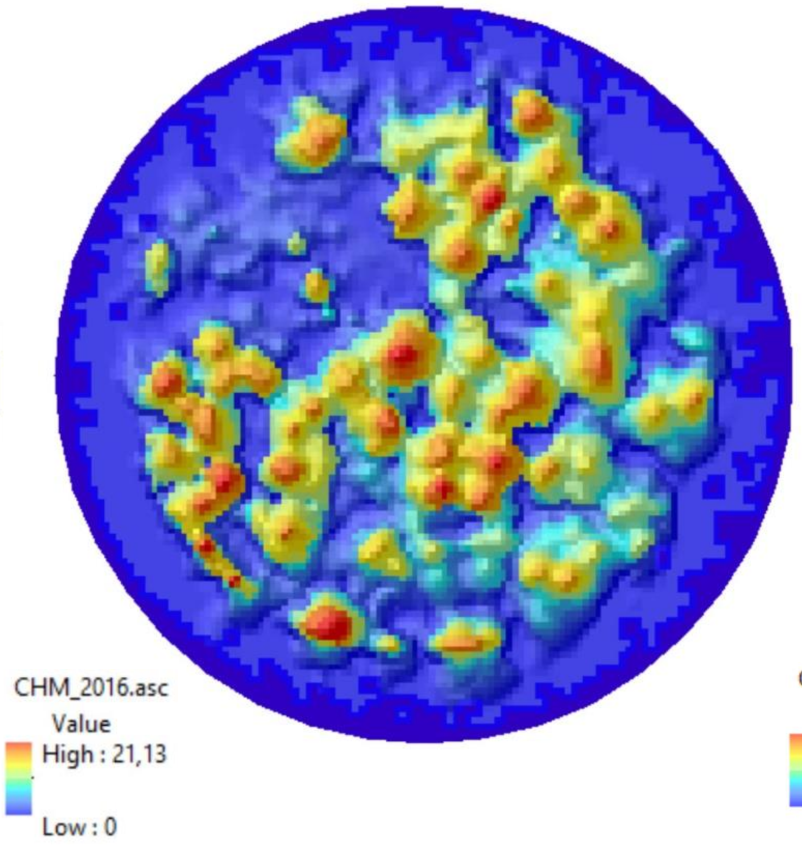
TLS point clouds (yellow – 2016; blue – 2018)

Canopy Height Model (CHM) based on TLS 2012 – 2016 - 2018

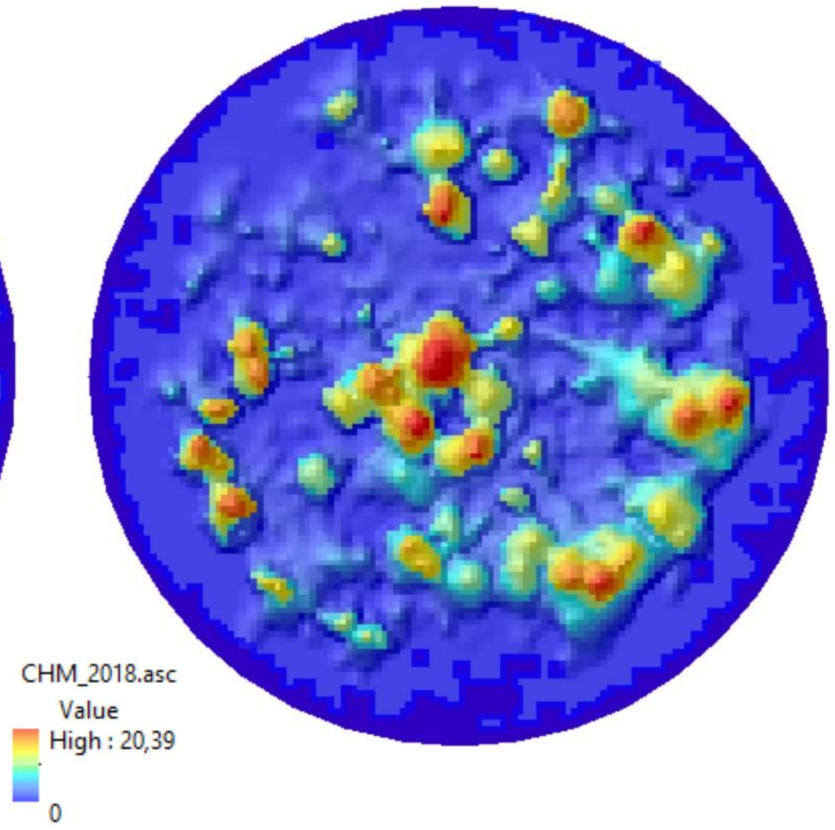
2012



2016



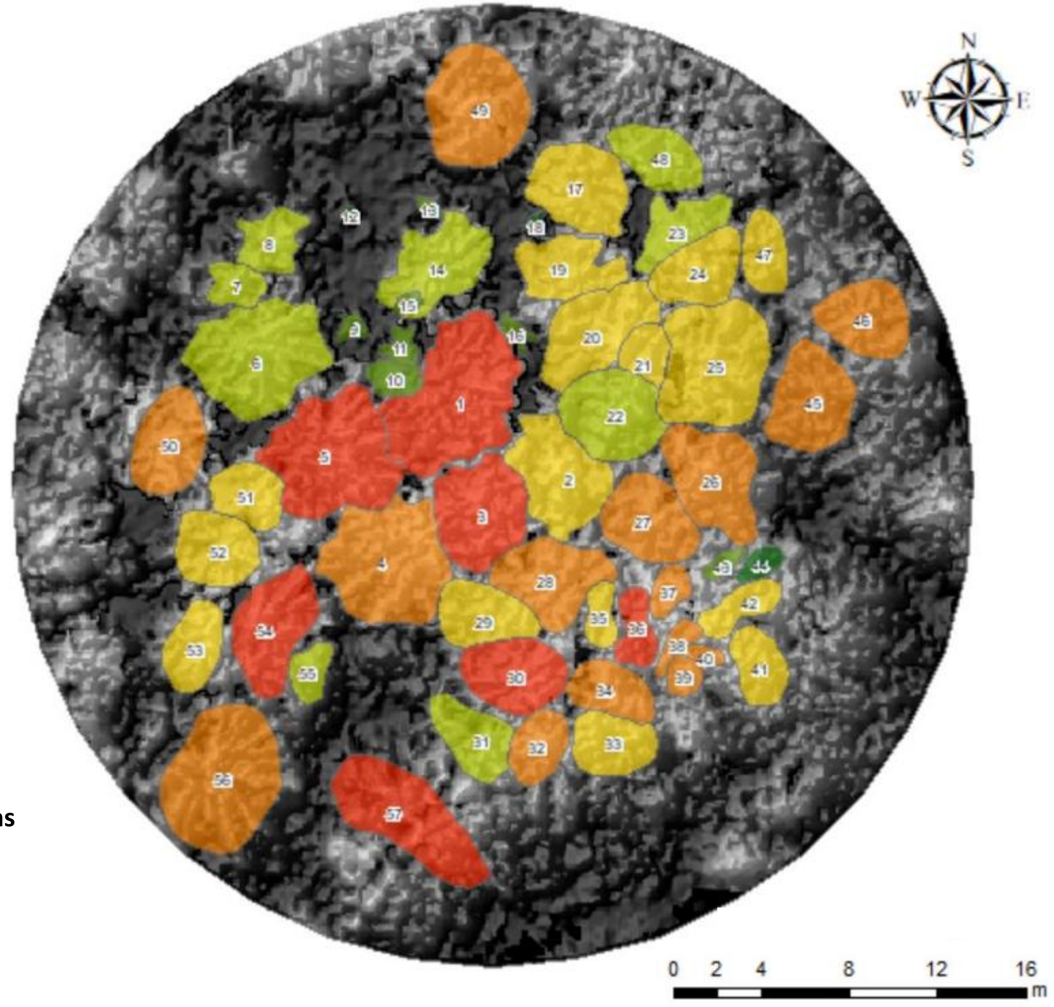
2018



nDSM - Difference between DSM and DTM, which is the height of vegetation

Inventory of „bark beetle nest”
Tree height in 2012

2012



nD SM
Value
High : 21,43
Low : 0

Range of tree crowns (2013)
Height [m]

2,70 - 6,00
7,50 - 12,00
13,20 - 16,00
16,10 - 18,00
18,30 - 20,00
20,20 - 21,20

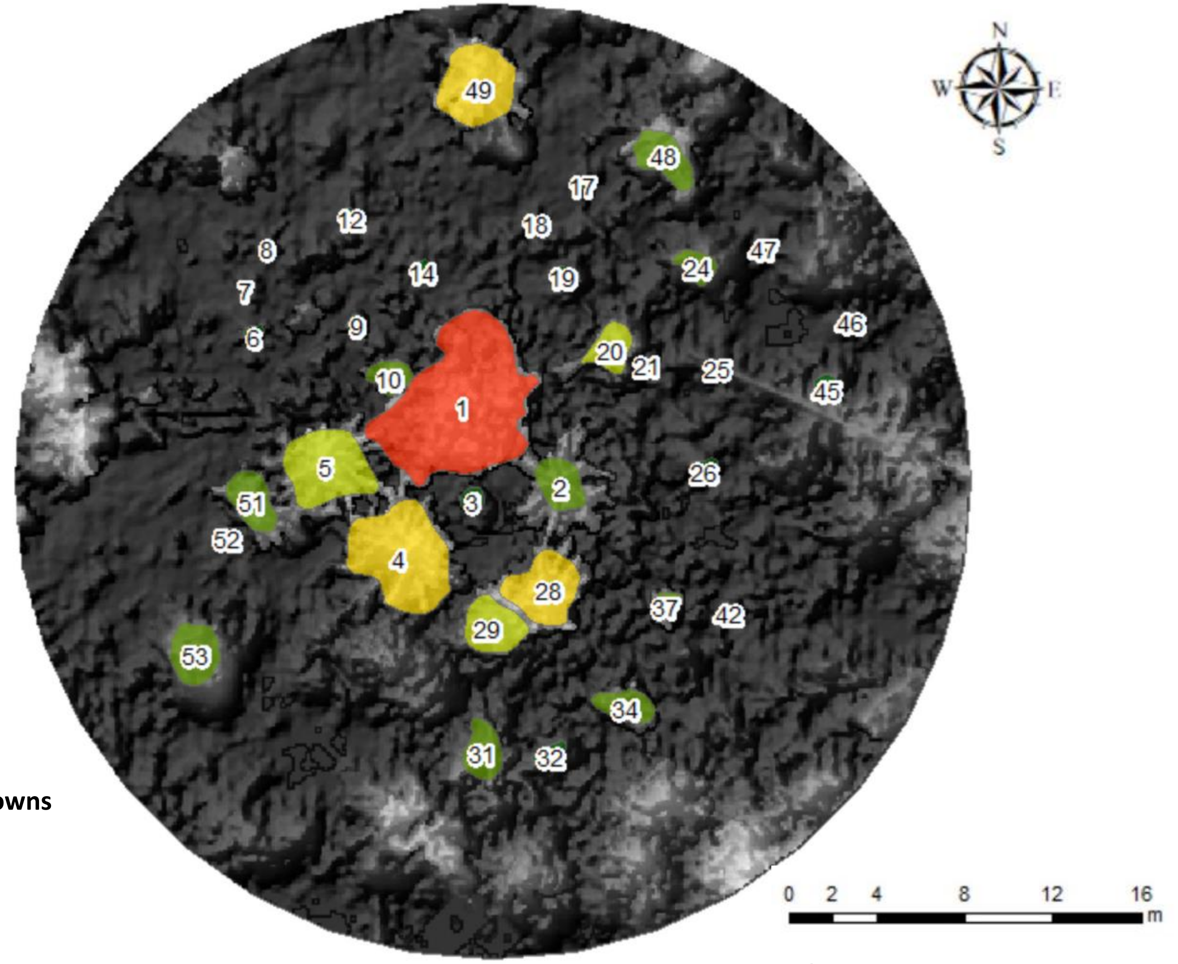
Height SUM: 915.17 m

Tree number	H [m]
1	20,3
2	17,5
3	20,8
4	18,8
5	21,2
6	15,1
7	13,2
8	15,2
9	7,6
10	10,4
11	8,2
12	2,7
13	7,6
14	15,4
15	8,5
16	7,5
17	17,7
18	5,7
19	16,8
20	17,8
21	17,1
22	15,2
23	15,17
24	17,5
25	17,8
26	19,9
27	18,5
28	19,3
29	16,9

Tree number	H [m]
30	20,7
31	15,9
32	19,7
33	17,8
34	20
35	16,3
36	20,5
37	18,3
38	18,9
39	19,3
40	18,8
41	16,1
42	17,1
43	8,3
44	4,6
45	18,9
46	19,6
47	16,9
48	15,8
49	18,8
50	18,9
51	18
52	17,7
53	17,6
54	20,2
55	14,4
56	19,5
57	21,2
Mean	**16,05**

Inventory of „bark beetle nest
Difference between 2012-2018

2018



nDSM

Value

High : 20,52

Low : 0

Range of tree crowns (Height [m])

- 1,20 - 6,00
- 6,01 - 12,00
- 12,01 - 16,00
- 16,01 - 18,00
- 18,01 - 20,00
- 20,01 - 20,40

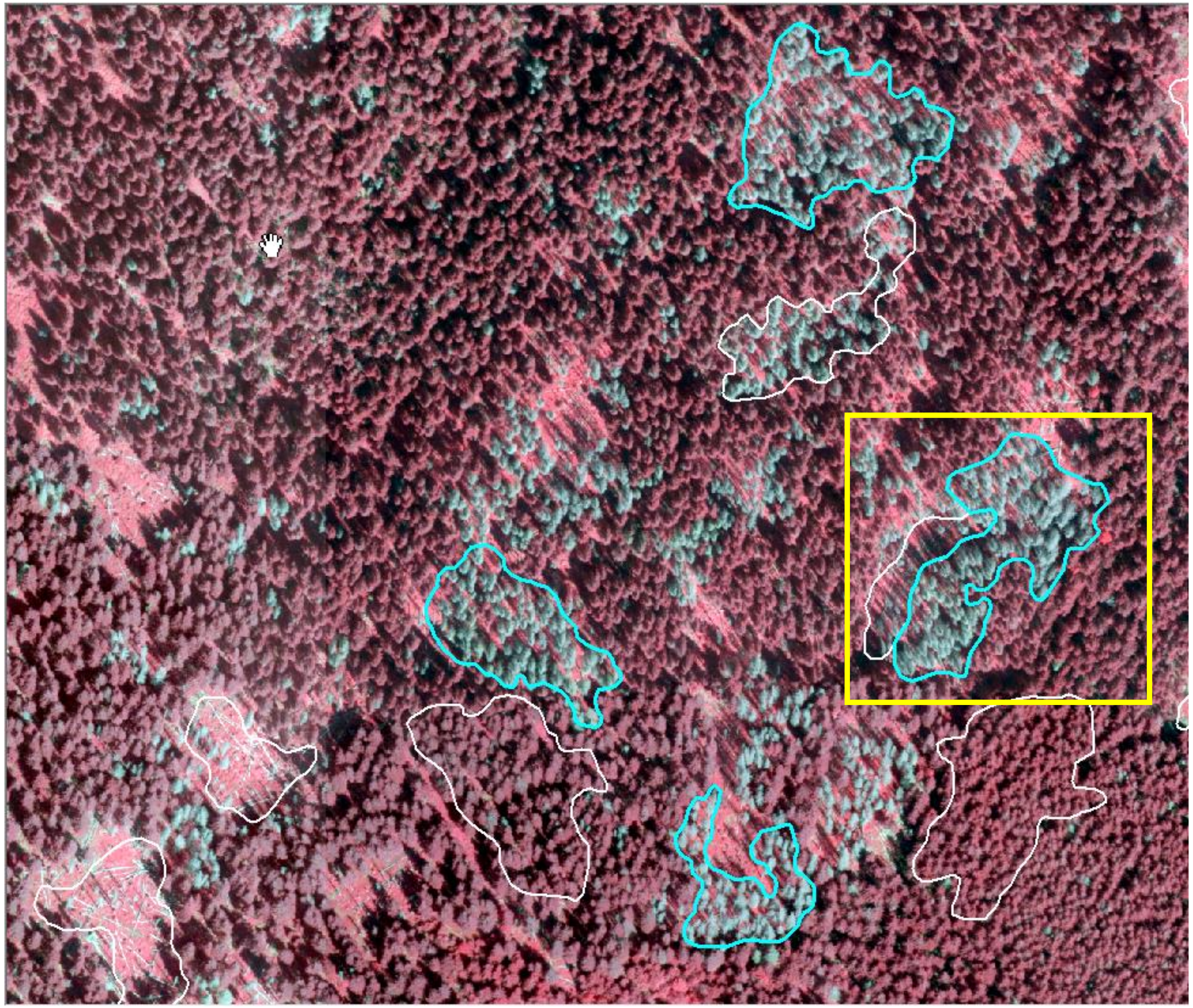
Height SUM: 264.50 m

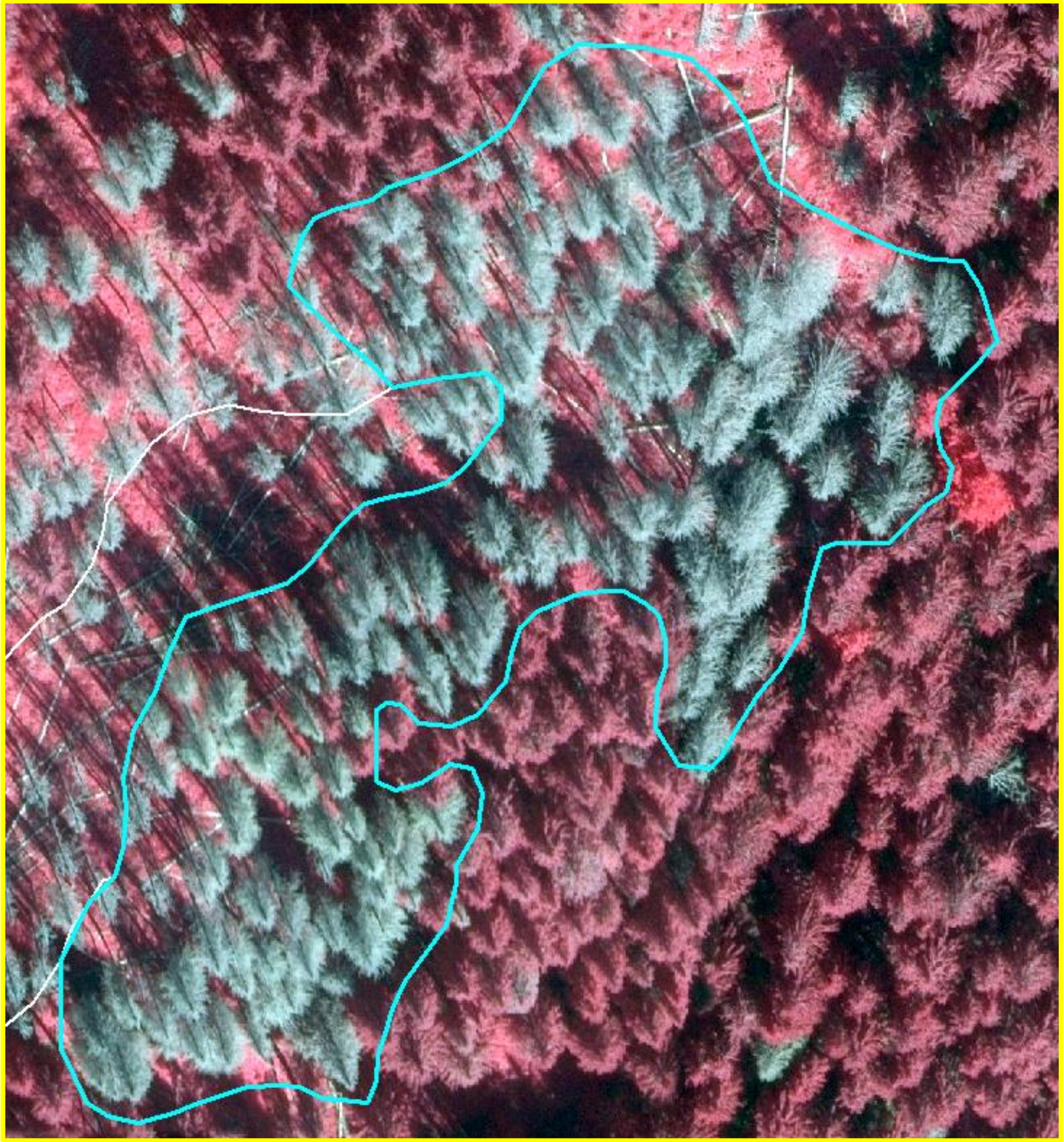
Decreasing : 71% ↓

Tree number	H [m]
1	20,4
2	10,8
3	4,5
4	18
5	15,2
6	1,8
7	1,6
8	2,9
9	4,8
10	10,4
11	0
12	2,5
13	0
14	2,5
15	0
16	0
17	2,6
18	4,5
19	4,1
20	12,2
21	1,6
22	0
23	0
24	6,9
25	1,2
26	4,2
27	0
28	17,1
29	12,5

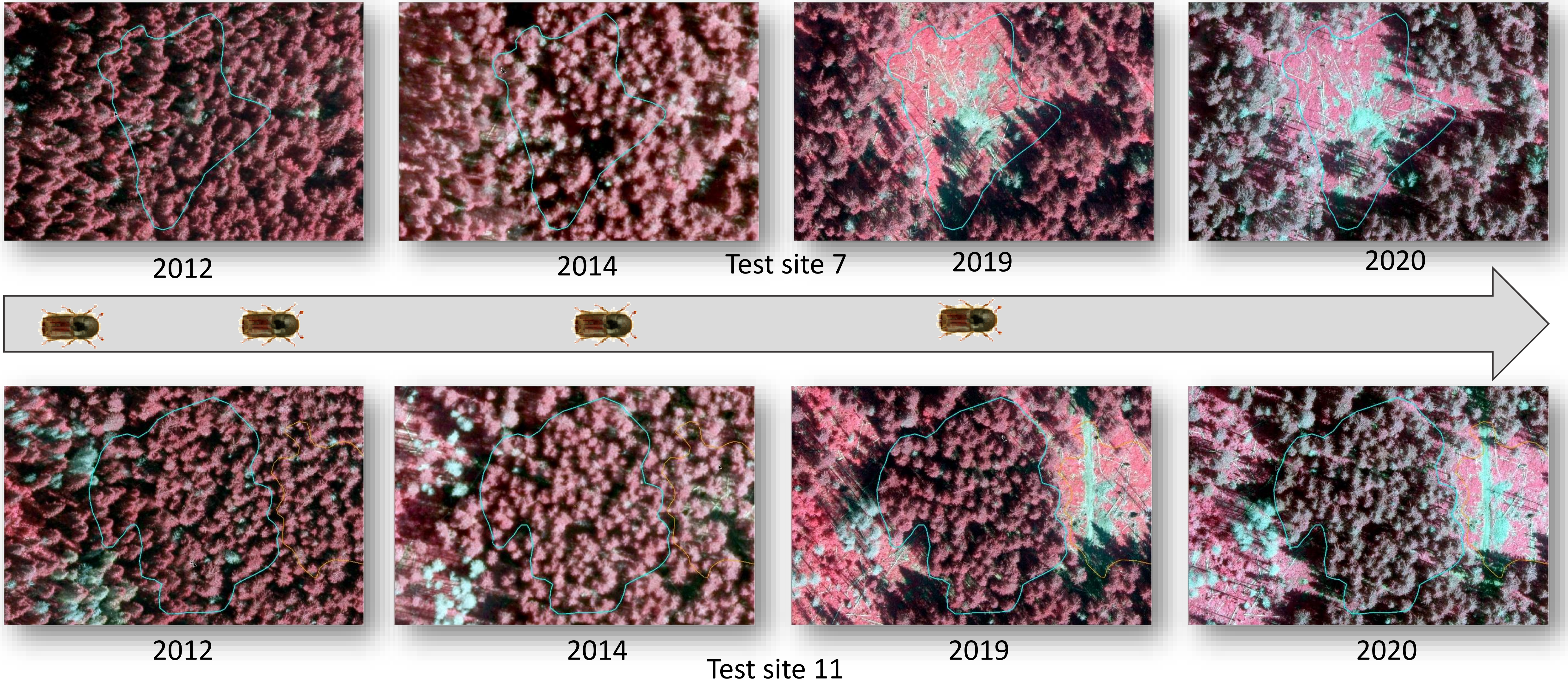
Tree number	H [m]
30	0
31	7,6
32	4,1
33	0
34	8,8
35	0
36	0
37	9,3
38	0
39	0
40	0
41	0
42	2,3
43	0
44	0
45	4,5
46	1,6
47	1,2
48	10,2
49	17,3
50	0
51	11,3
52	1,2
53	8,3
54	0
55	0
56	1,3
57	13,2
Mean	**4,64**

ALS LiDAR very dense point cloud - case study 2018
High resolution CIR aerial orthophos GSD 10 cm (Sept. 04, 2019)

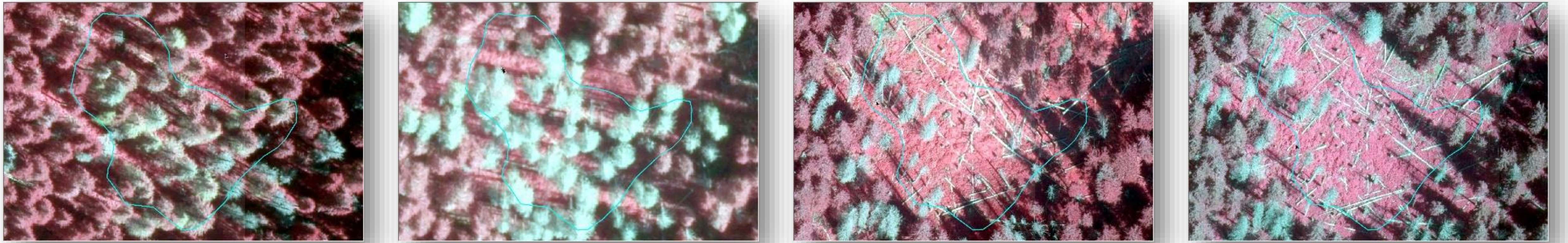




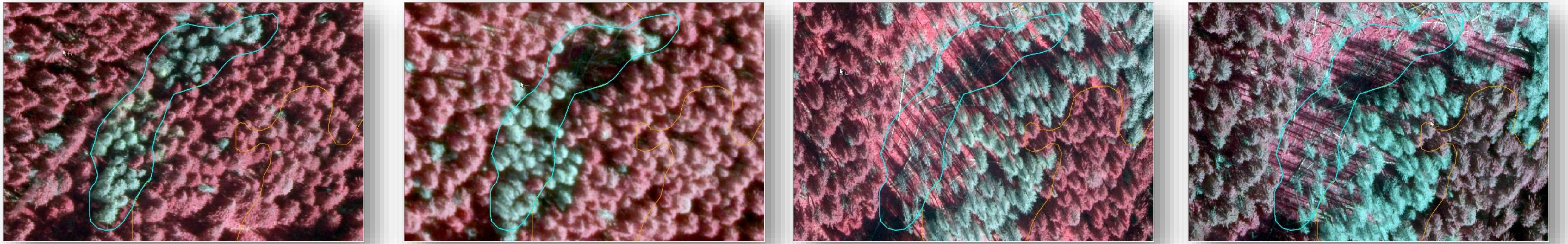
ALS LiDAR very dense point cloud - case study 2018
High resolution CIR aerial orthophos GSD 10 cm (Sept. 04, 2019)



ALS LiDAR very dense point cloud - case study 2018
High resolution CIR aerial orthophos GSD 10 cm (Sept. 04, 2019)

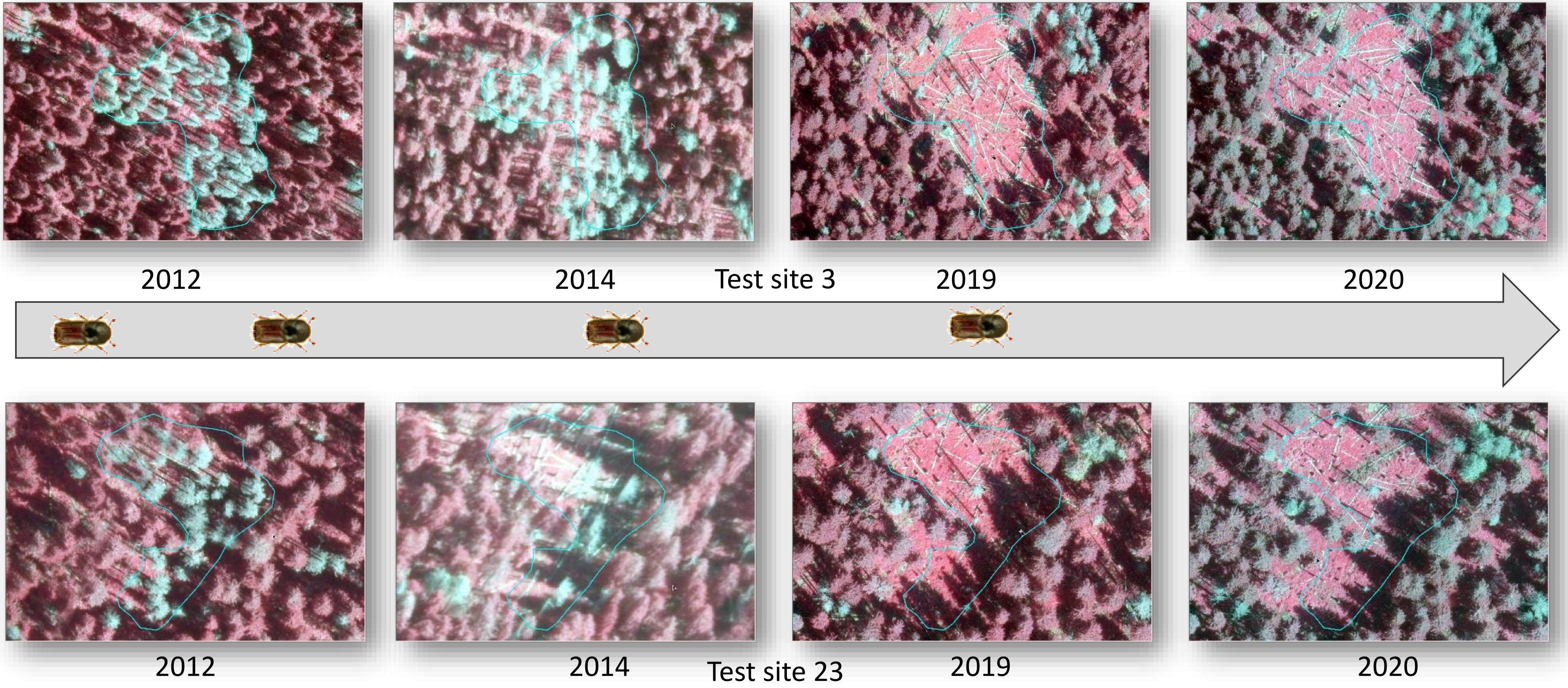


2012 2014 Test site 2 2019 2020

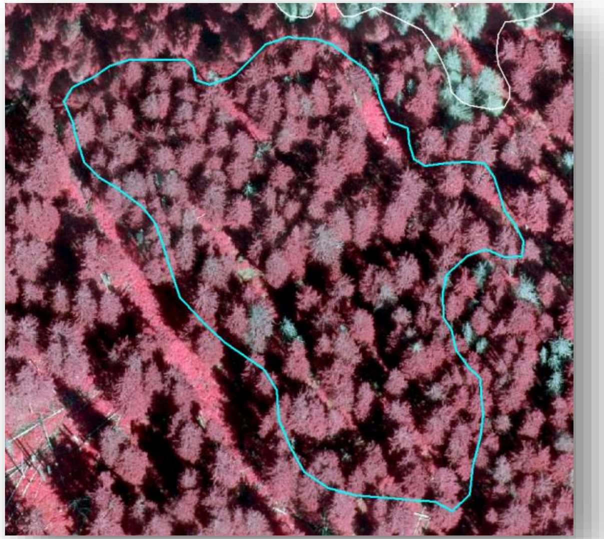
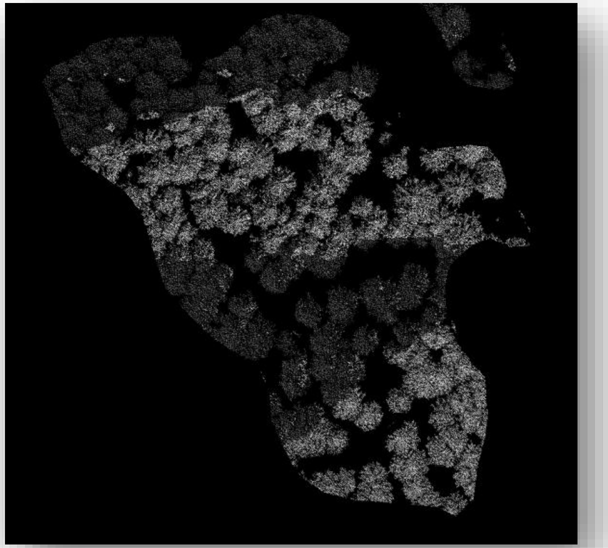
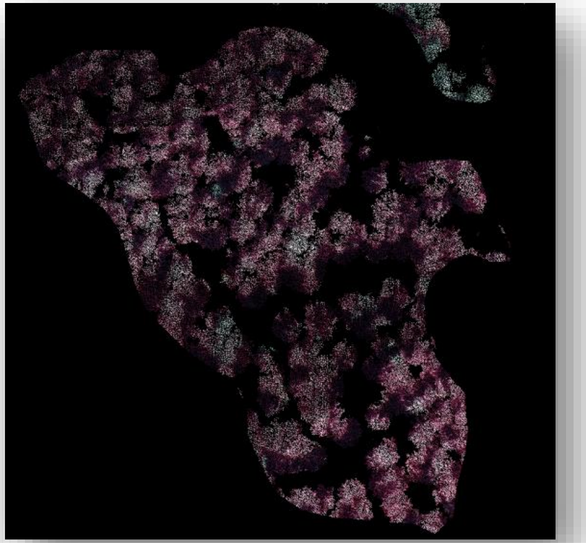
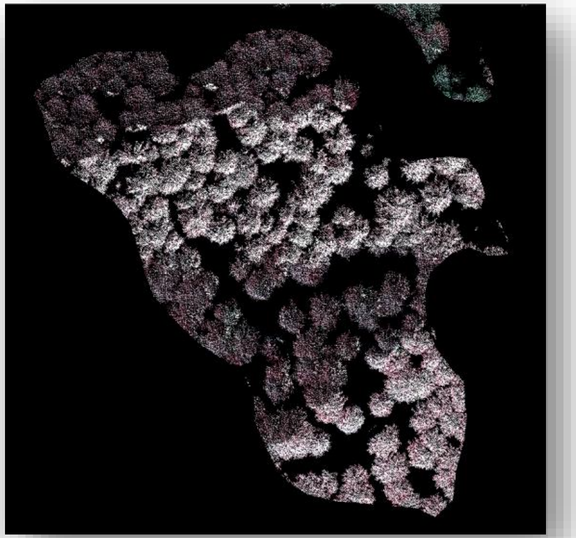


2012 2014 Test site 5 2019 2020

ALS LiDAR very dense point cloud - case study 2018
High resolution CIR aerial orthophos GSD 10 cm (Sept. 04, 2019)



ALS LiDAR very dense point cloud - case study 2018

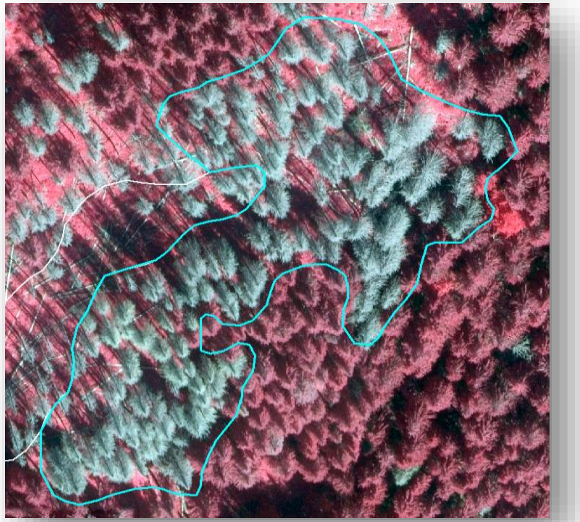
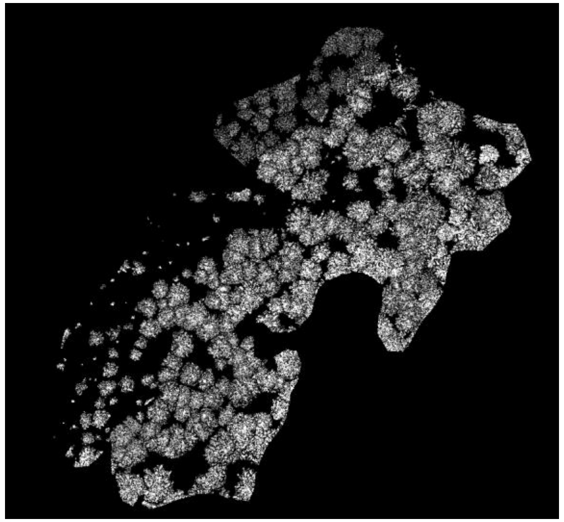
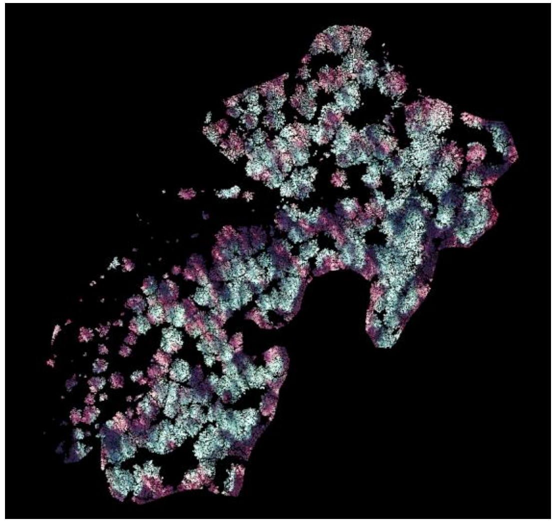
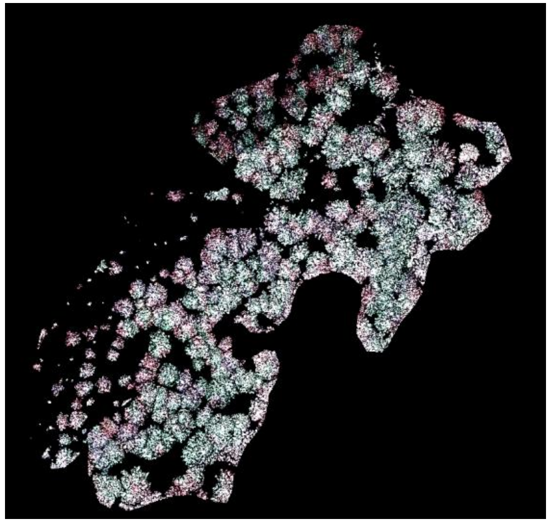





CIR orthopoto 10cm GSD

ALS Intensity

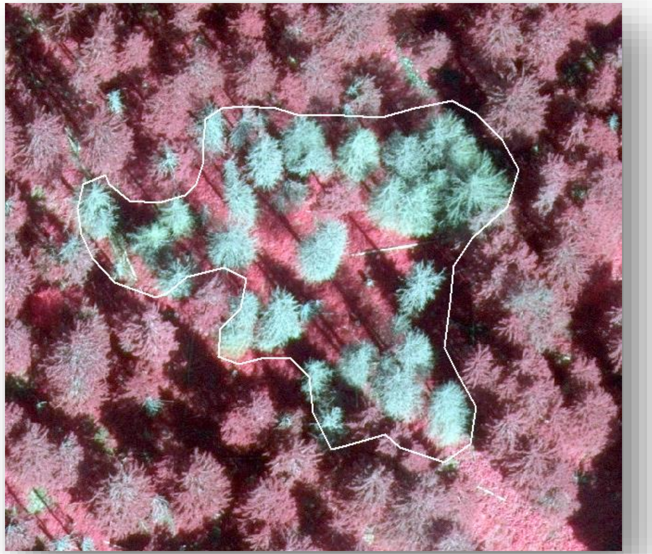
ALS color CIR colorised

ALS color + Intensity

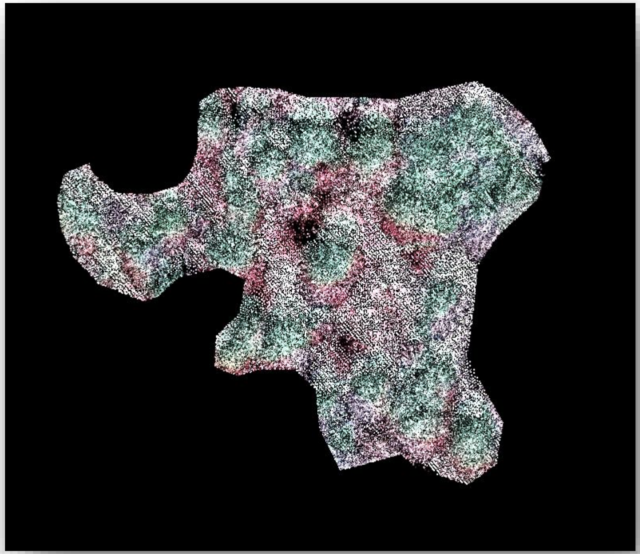





ALS LiDAR very dense point cloud - case study 2018
Coloring of LiDAR point clouds

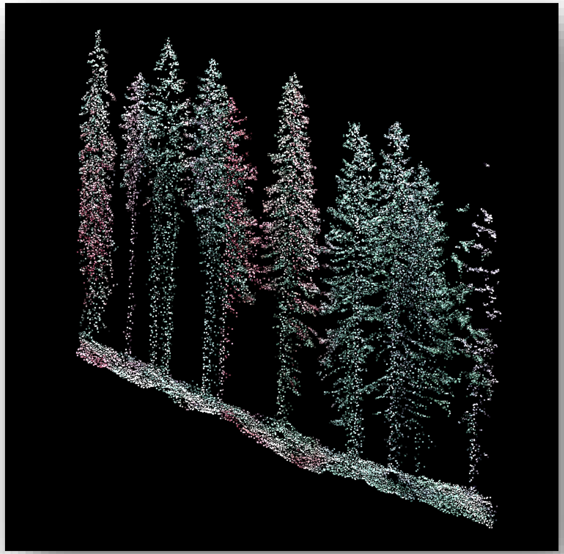
Coloring the ALS point cloud with digital photogrammetric photos in mountainous areas often causes problems with incorrect colors of tree crowns or ground. Correct EO (external orientation) calculated for a single aerial photo is absolutely required, preferably during the INS readings as the ALS LiDAR platform. The best way is to use aerial photos (medium format cameras) and obtain a dense point cloud at the same time.



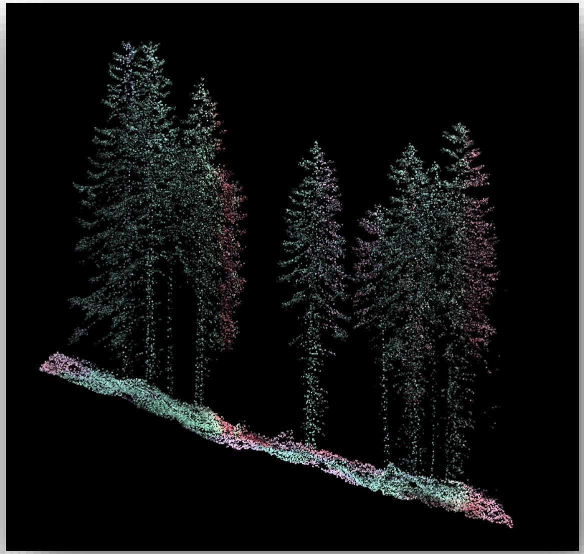
CIR true orthophoto



Colorized dense ALS point cloud

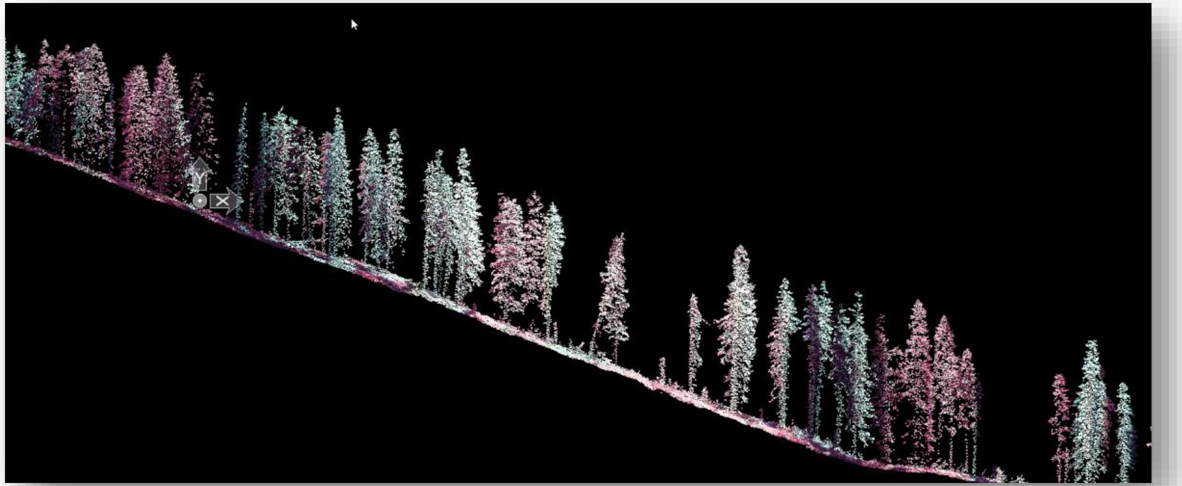


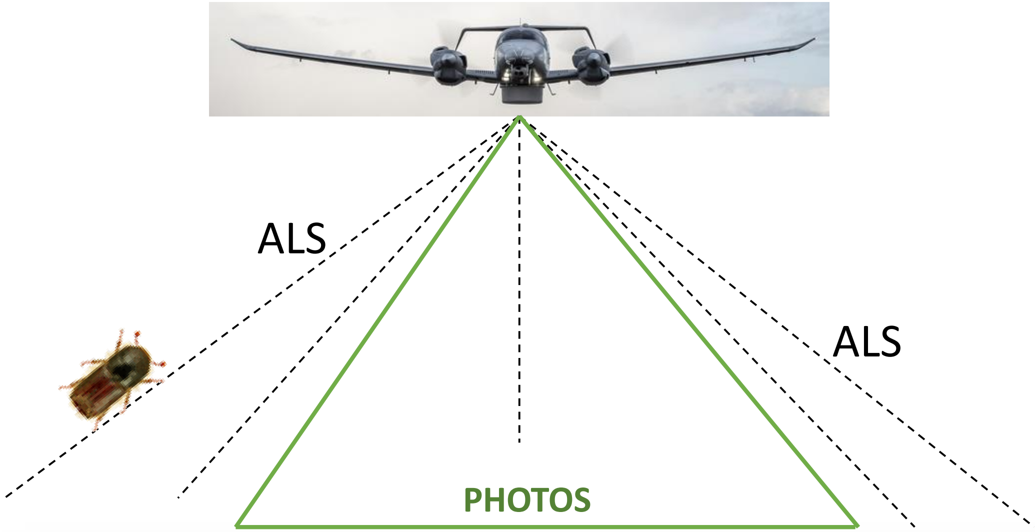
Cross-section 1, some problems with coloring

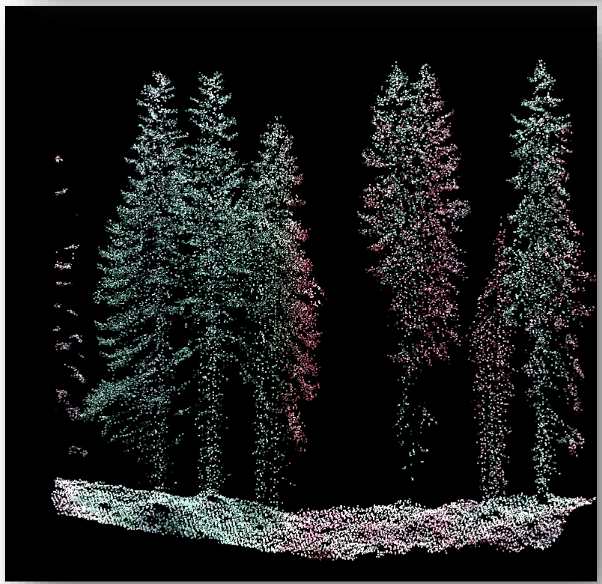


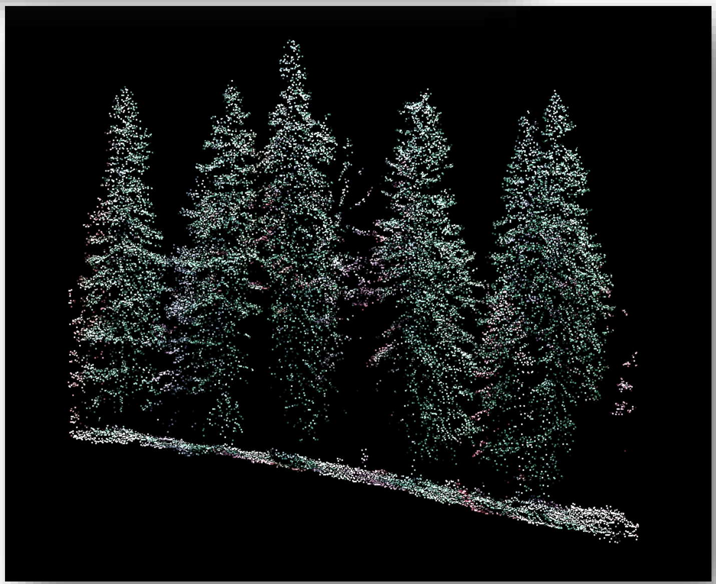
Cross-section 2, some problems with coloring

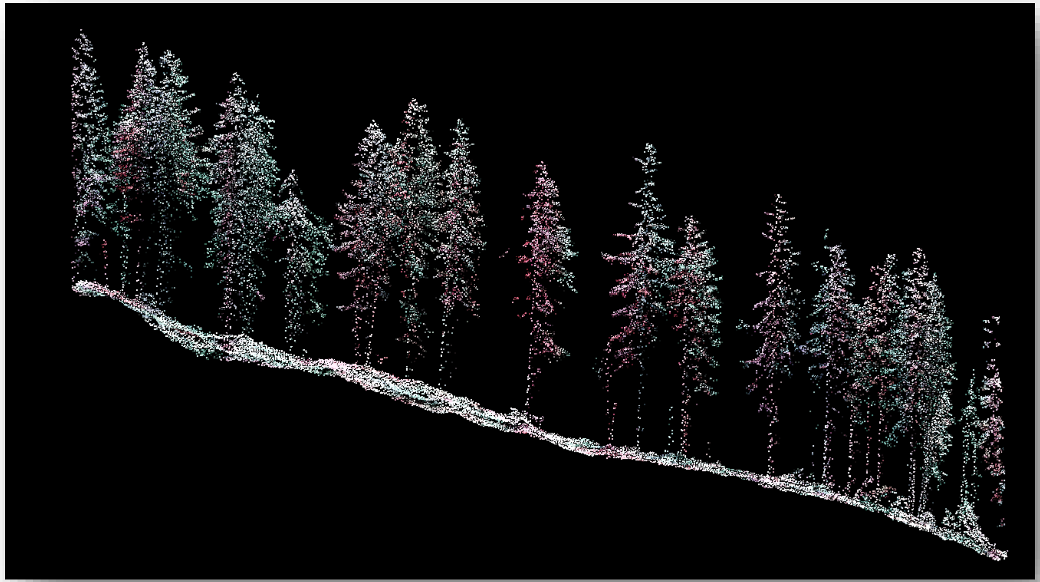
ALS LiDAR very dense point cloud - case study 2018
Coloring of LiDAR point clouds





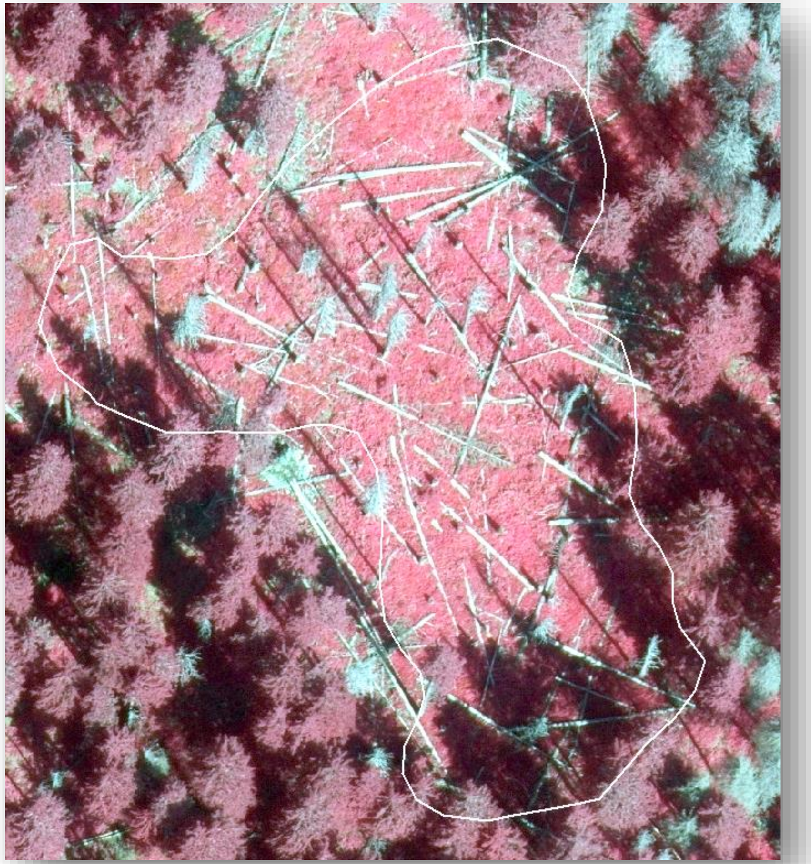






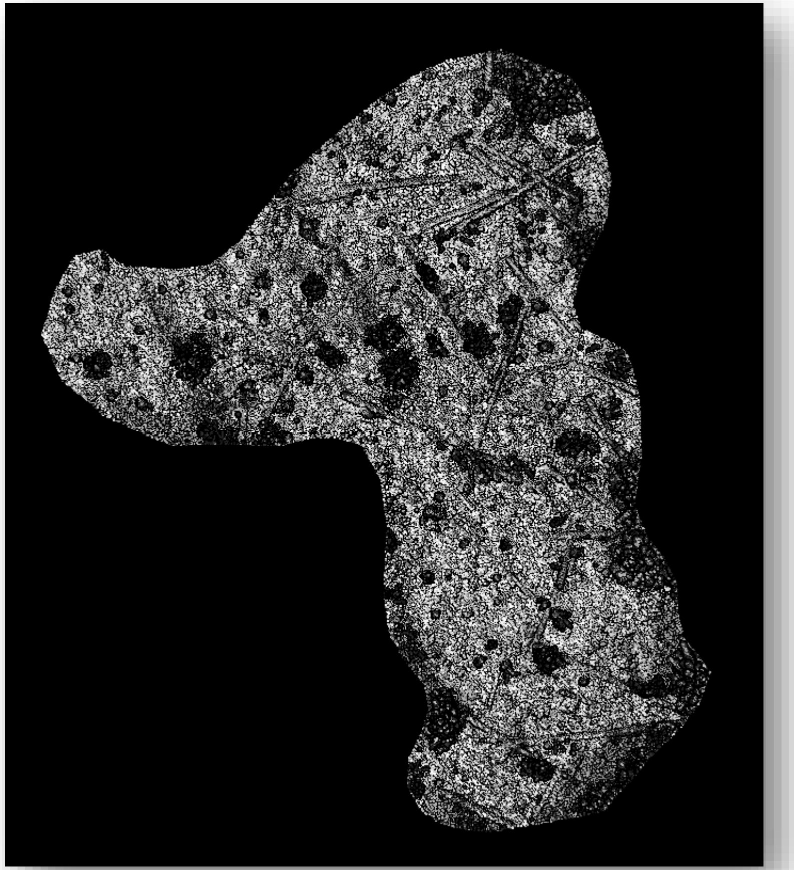
ALS LiDAR very dense point cloud - case study 2018
Visualisation – TerrasScan (Terrasolid)

TerraScan



CIR orthopoto 10cm GSD

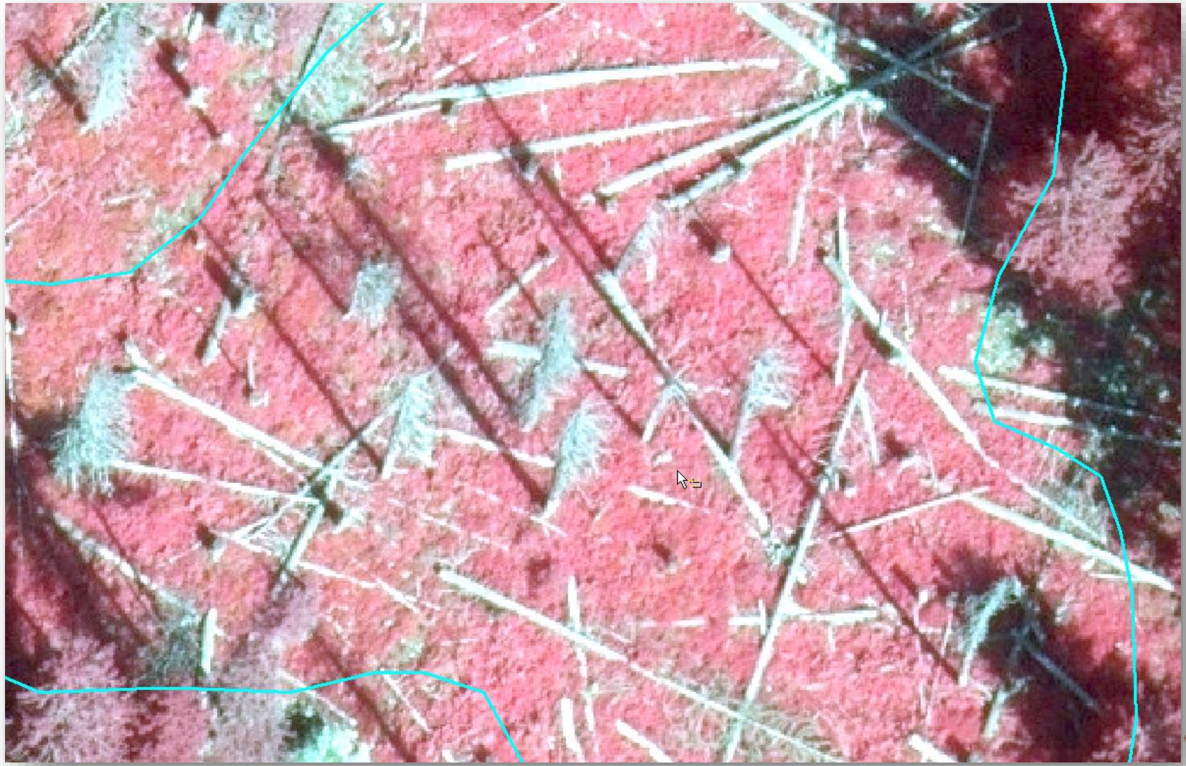
ALS color + Intensity



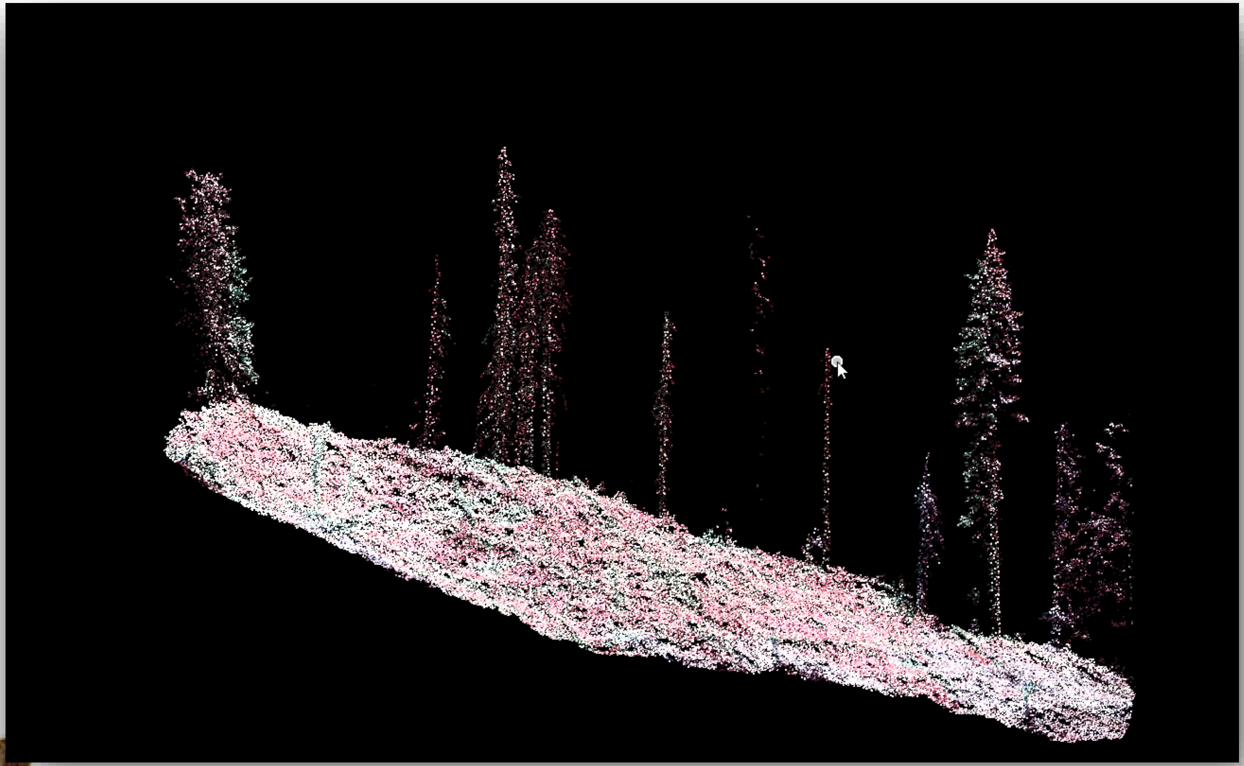
ALS Intensity

ALS LiDAR very dense point cloud - case study 2018
Single crown visualisation – TerrasScan (Terrasolid)

TerraScan

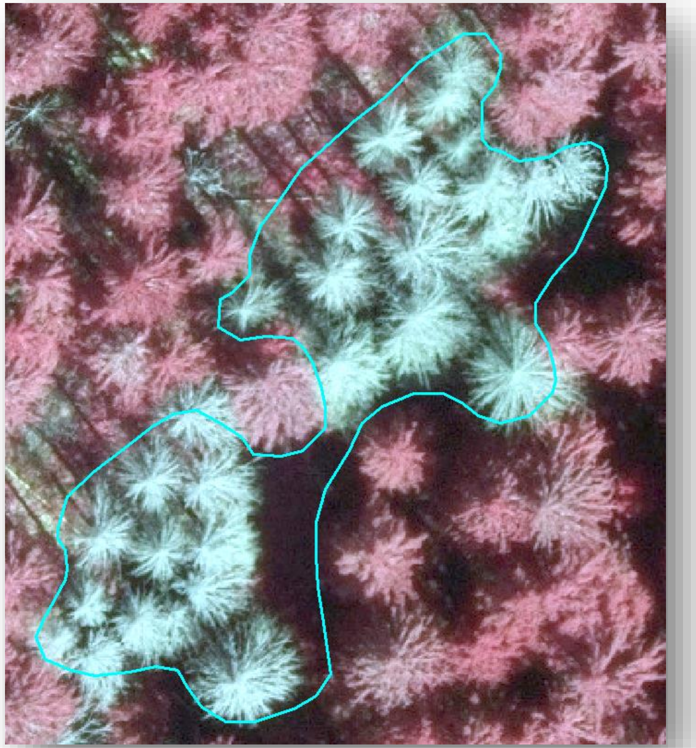


Dead trees – no full crown
CIR orthopoto 10cm GSD

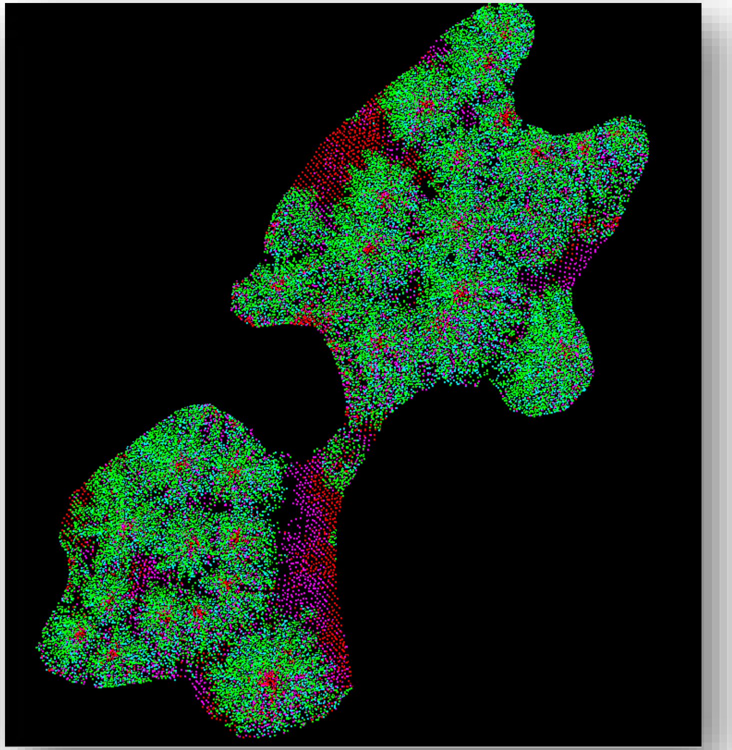


ALS color + Intensity

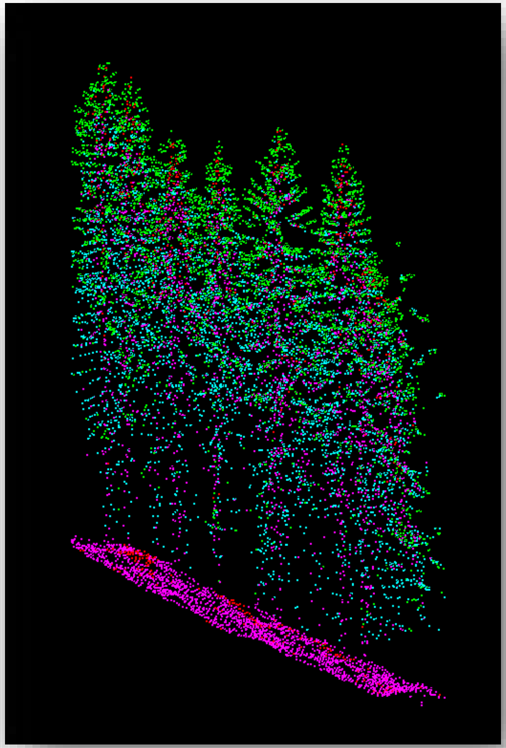
ALS LiDAR very dense point cloud - case study 2018
Echo (Return) visualisation – TerrasScan (Terrasolid)



CIR orthopoto 10cm GSD



ALS Echo (TOP)

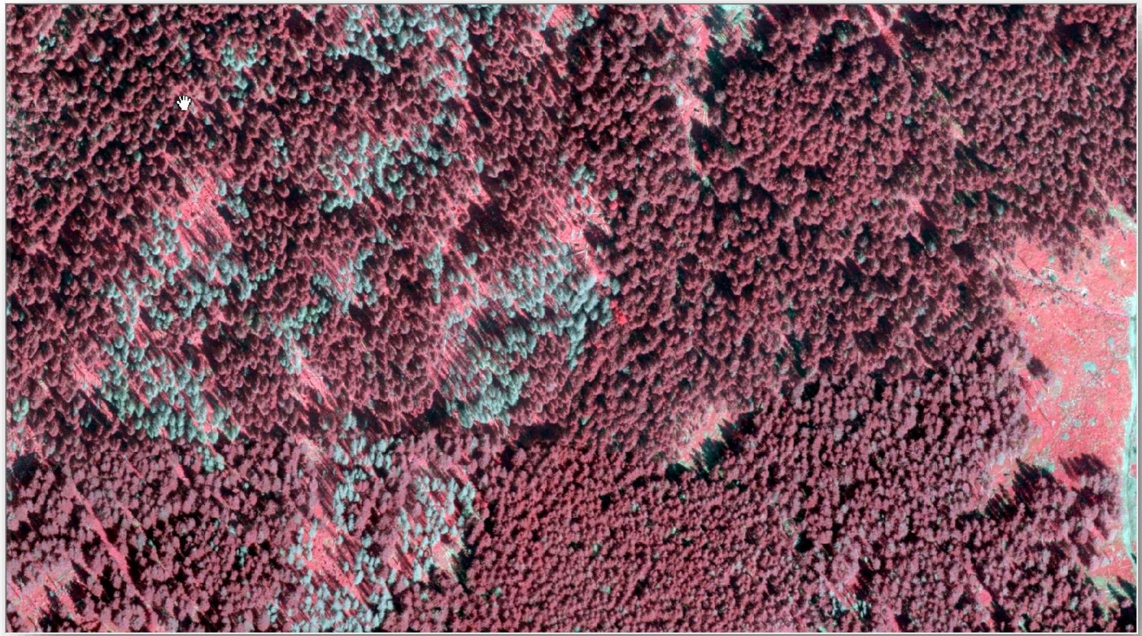


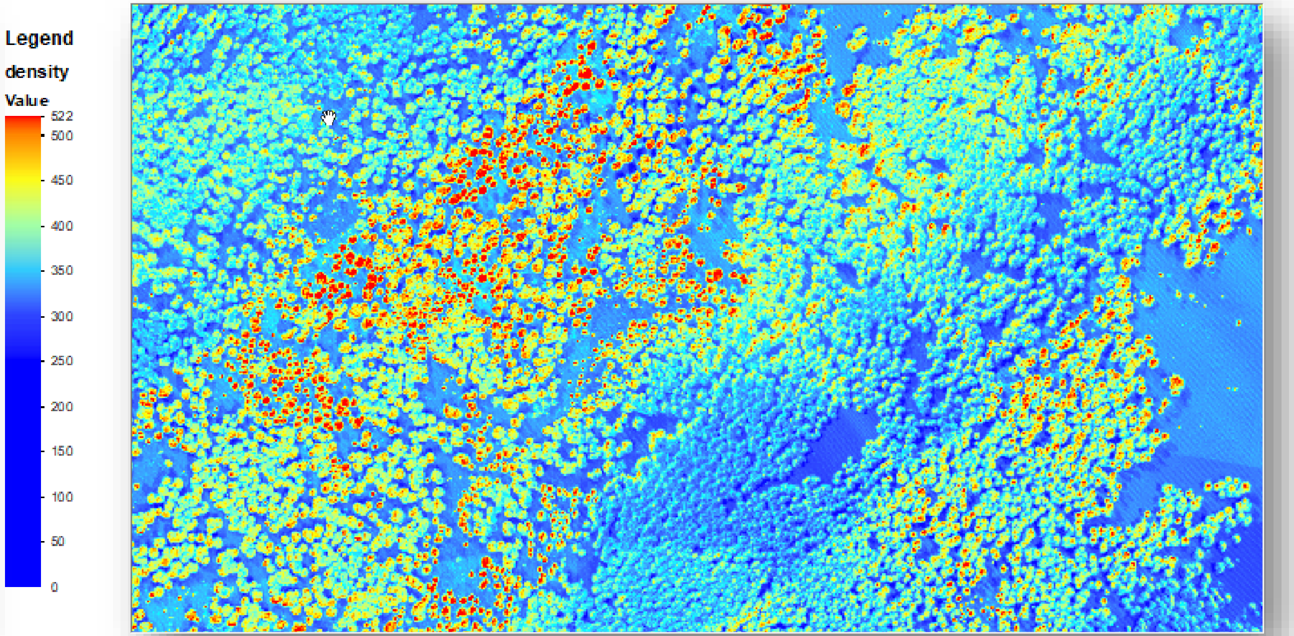
ALS Echo (cross-section)

ALS Intensity

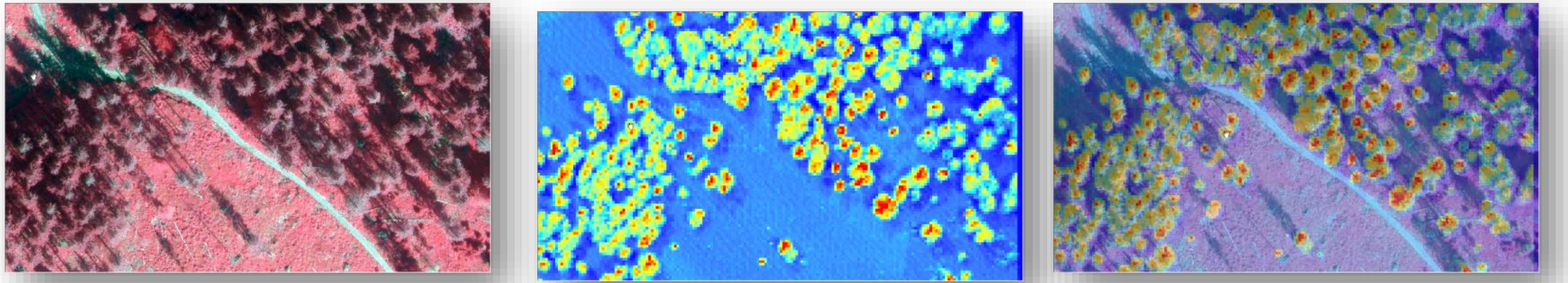
The loss of the assimilation apparatus by dying spruce trees causes a greater penetration of the laser beam through the tree crowns and thus a greater number of indirect reflections (echoes) before the laser beam reaches the ground. This feature allows for better detection of places with increased density (richer structure of laser-illuminated branches)

Classification of death trees based on ALS point density





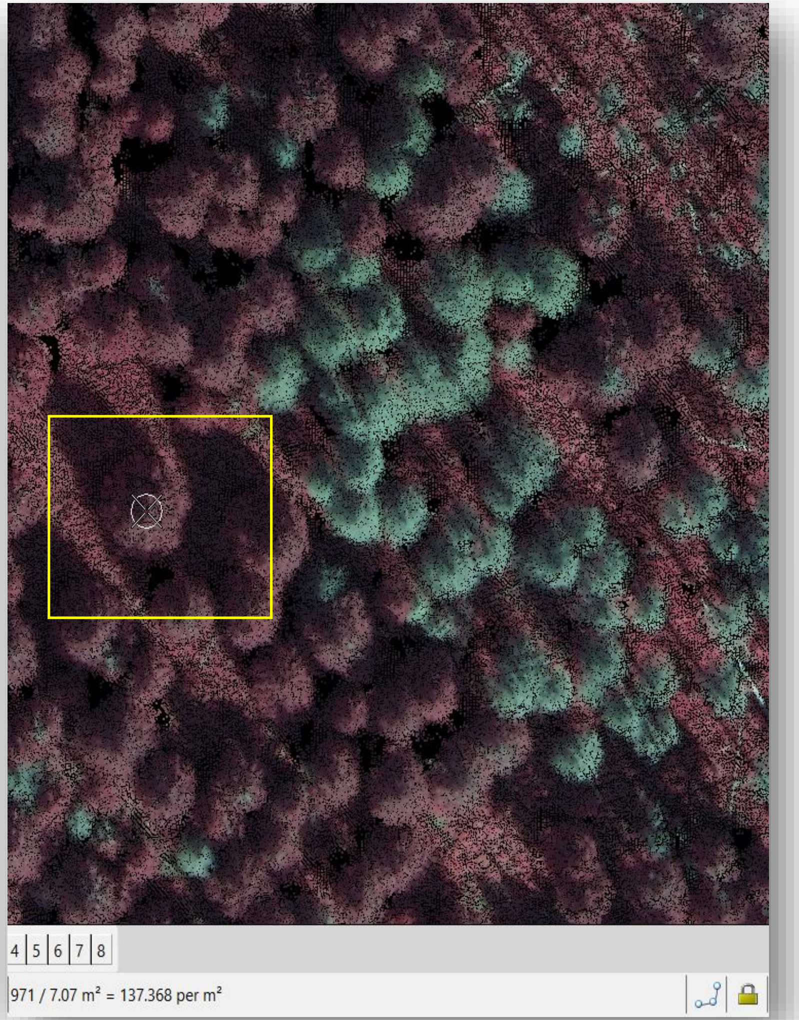
The ALS LiDAR point density of bark beetle dead trees is apporx. 200-300% higher then the density of health Norway spruces.



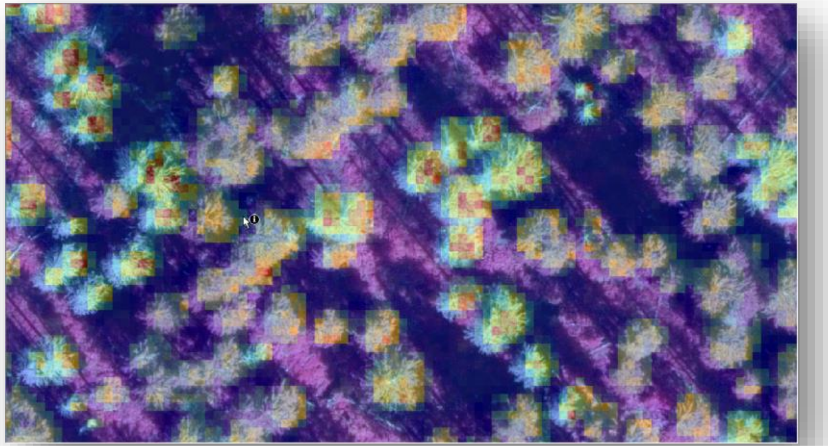
TerraScan

Classification of death trees based on ALS point density

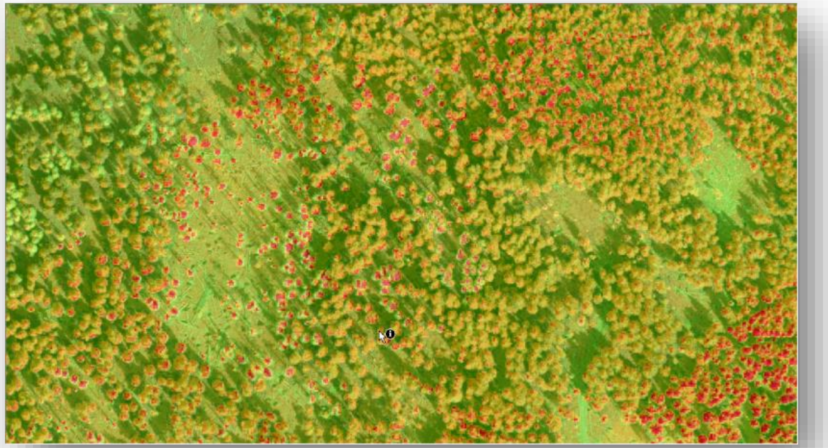
Dead Norway spruce = 270 pt/m²



Healthly Norway spruce = 130 pt/m²

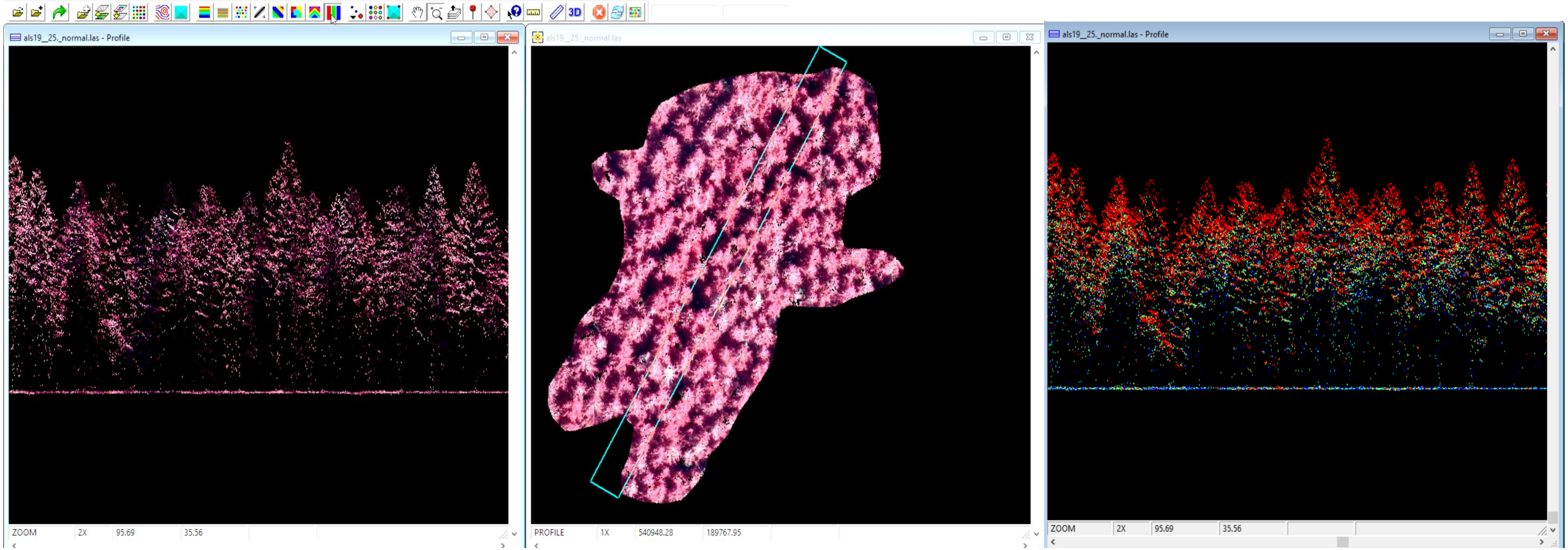


Density of ALS point cloud transparent on true orthophoto



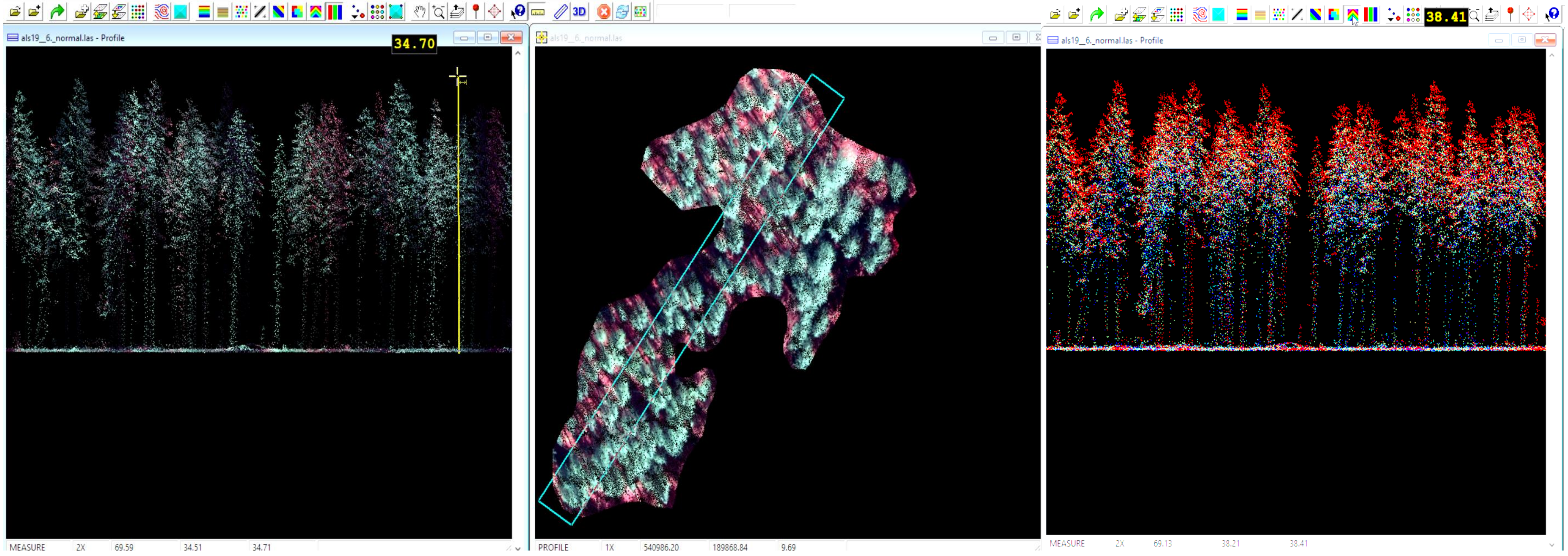
Classification based on denisty

ALS point density & echos – healthly Norway spruce

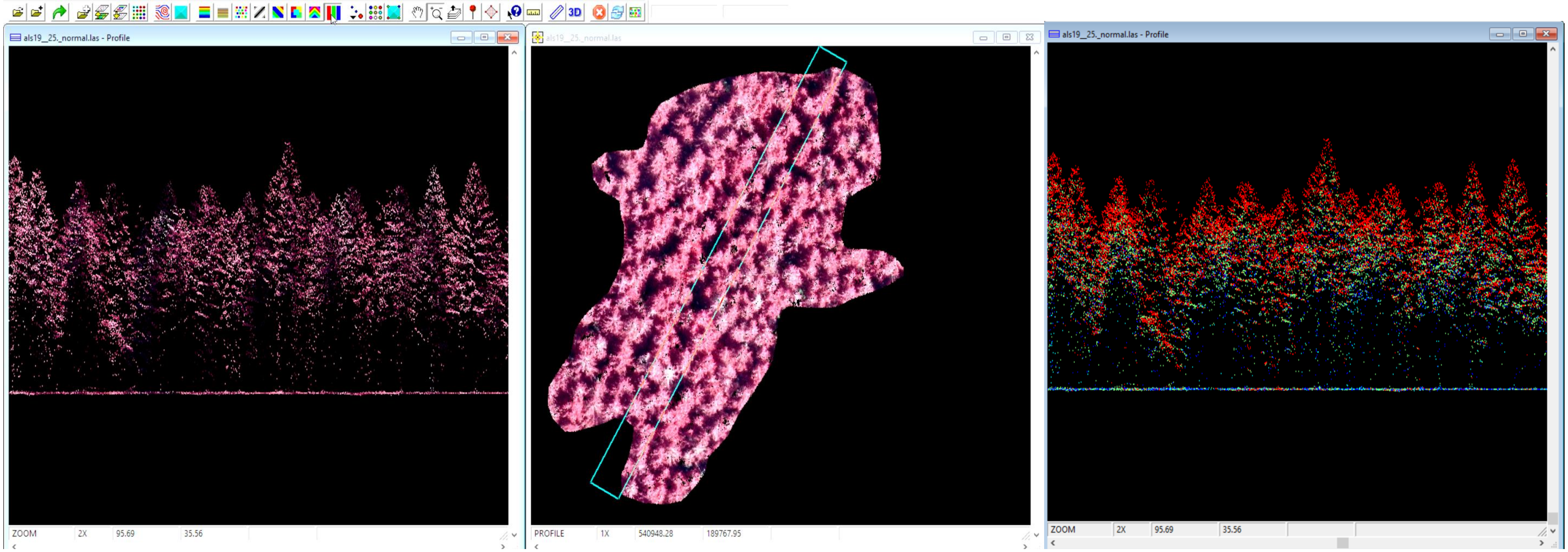


Healthly forest Norwy spruce stands (AOI = 25) survived the bark beetle attack. Lef: Cross-section trough the normalised colorised ALS point cloud (Sept. 2019; density > 70 pts sqm); right: first echos (in red) at the upper external part of tree crown

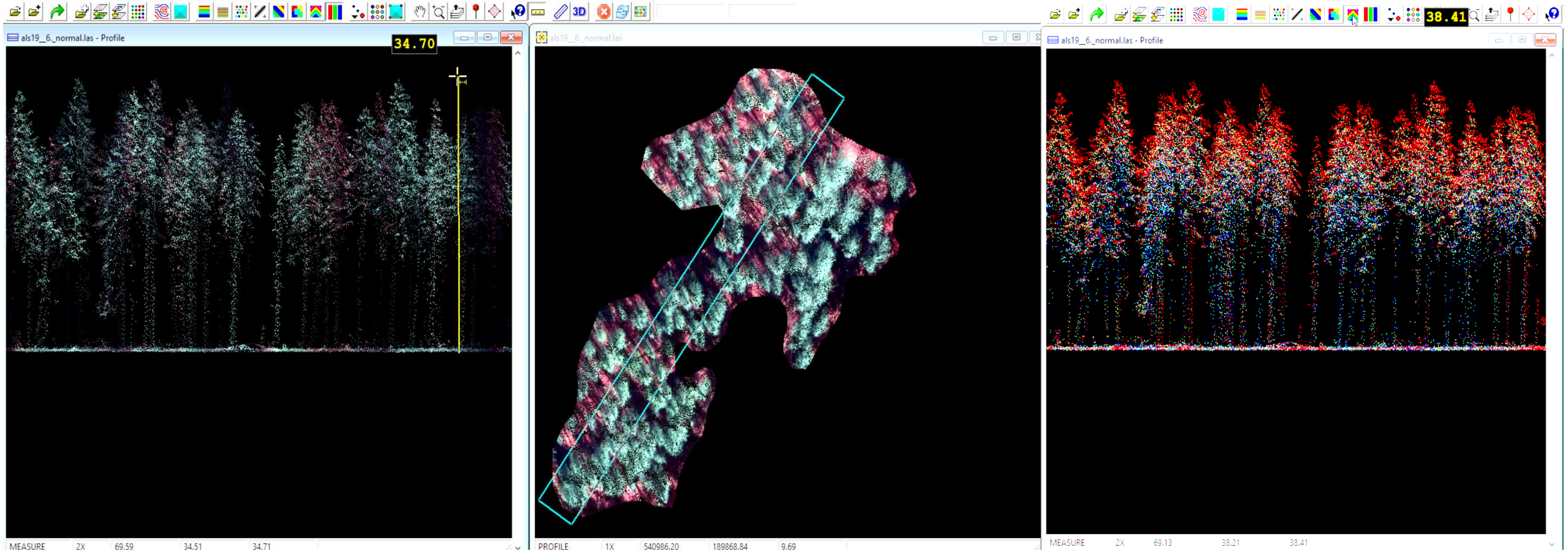
ALS point density & echos – dead Norway spruce



Dead forest Norwy spruce stands after bark beetle attack. Lef: Cross-section trough the normalised ALS pointcloud (Sept. 2019; density > 70 pts sqm); right: different echos in the full tree crown range



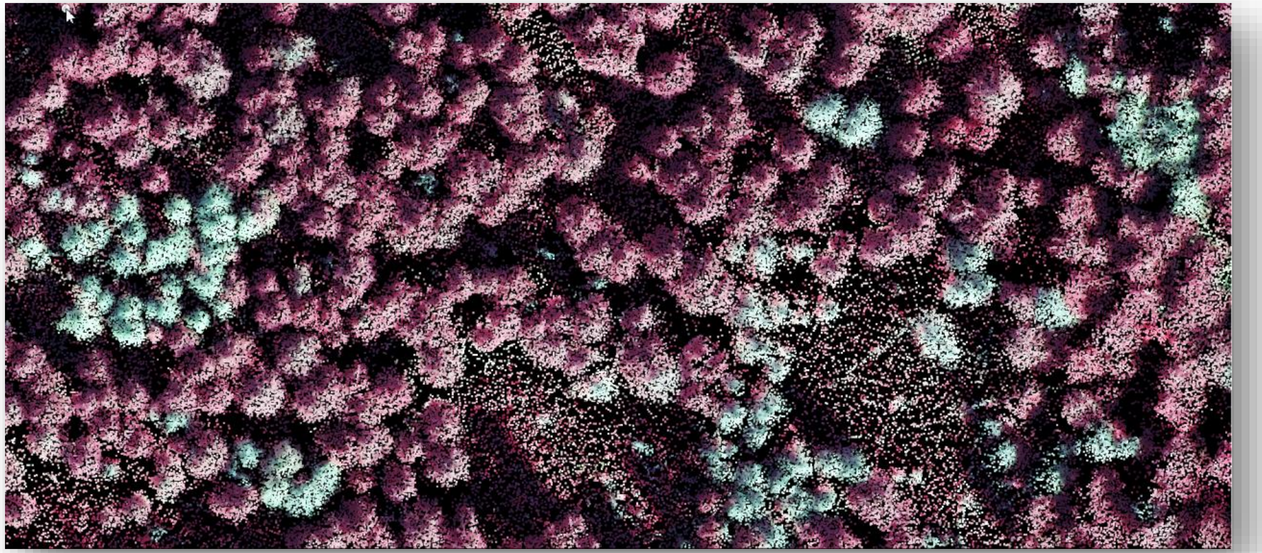
Healthly forest Norwy spruce stands (AOI = 25) survived the bark beetle attack. Lef: Cross-section trough the normalised colorised ALS point cloud (Sept. 2019; density > 70 pts sqm); right: first echos (in red) at the upper external part of tree crown



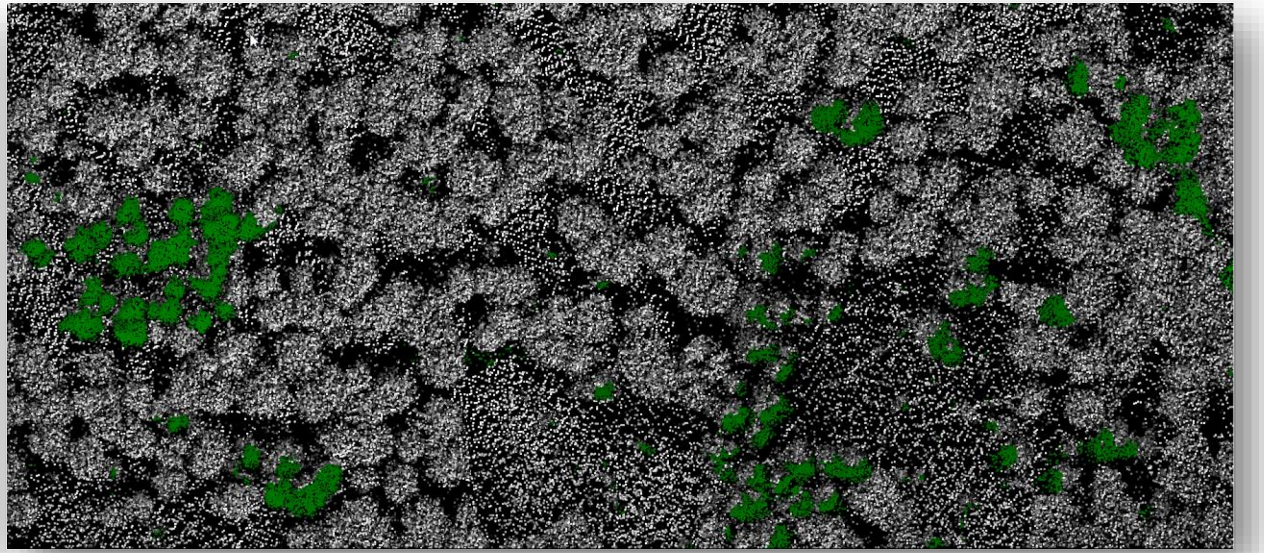
Dead forest Norwy spruce stands after bark beetle attack. Lef: Cross-section trough the normalised ALS pointcloud (Sept. 2019; density > 70 pts sqm); right: different echos in the full tree crown range

NDVI point cloud classification of dead trees
NDVI = (NIR – RED) / (NIR + RED)

TerraScan



ALS LiDAR dense cloud (> 70 ppsqm) colorised with aerial photographs

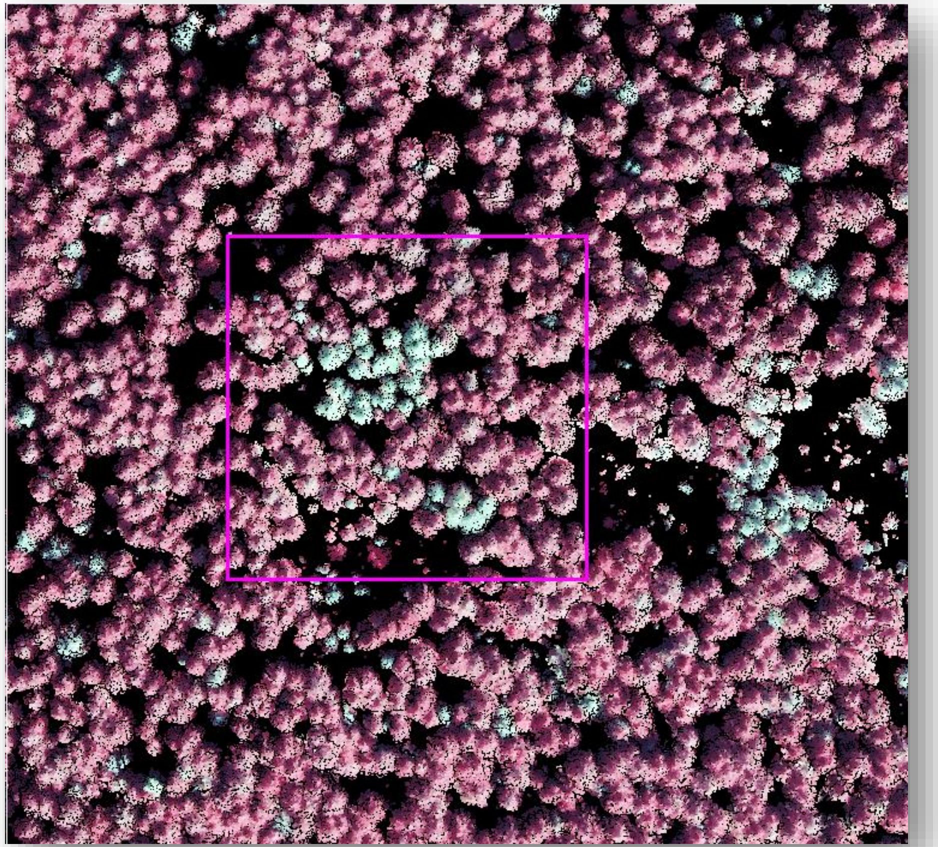


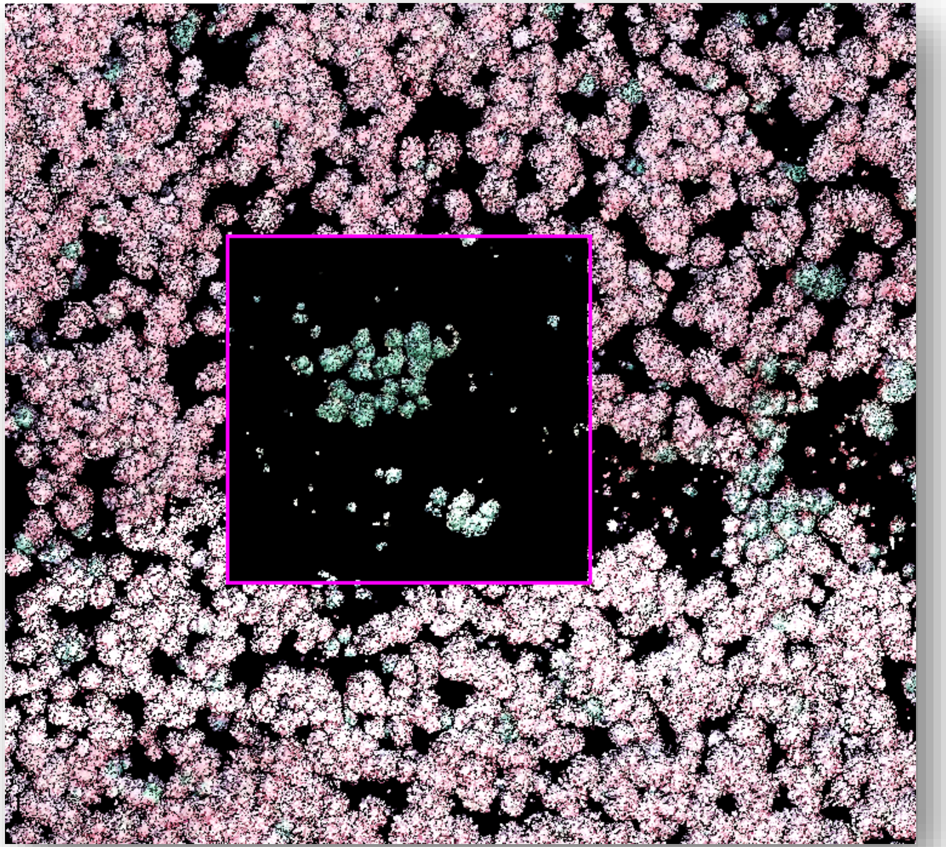
ALS LiDAR dense cloud (> 70 ppsqm) visualisation using the NDVI ratio

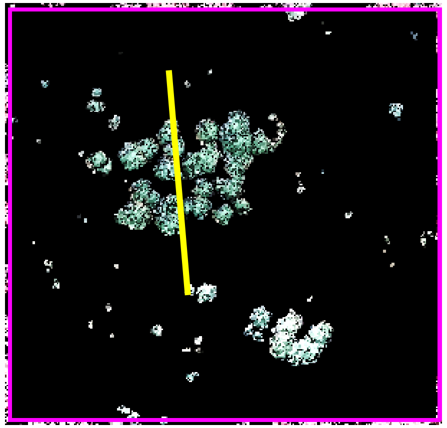
NDVI point cloud classification of dead trees

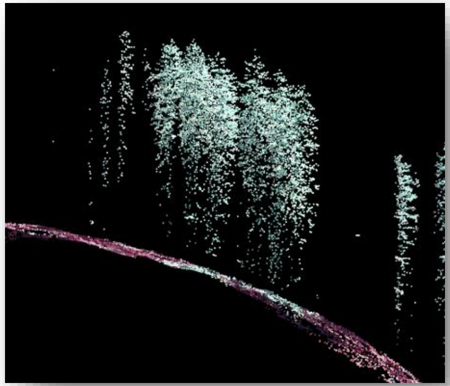
NDVI = (NIR – RED) / (NIR + RED)

TerraScan









NDVI based point classification

Image-based point clouds
QC : RSG – AGISFOFT - ALS

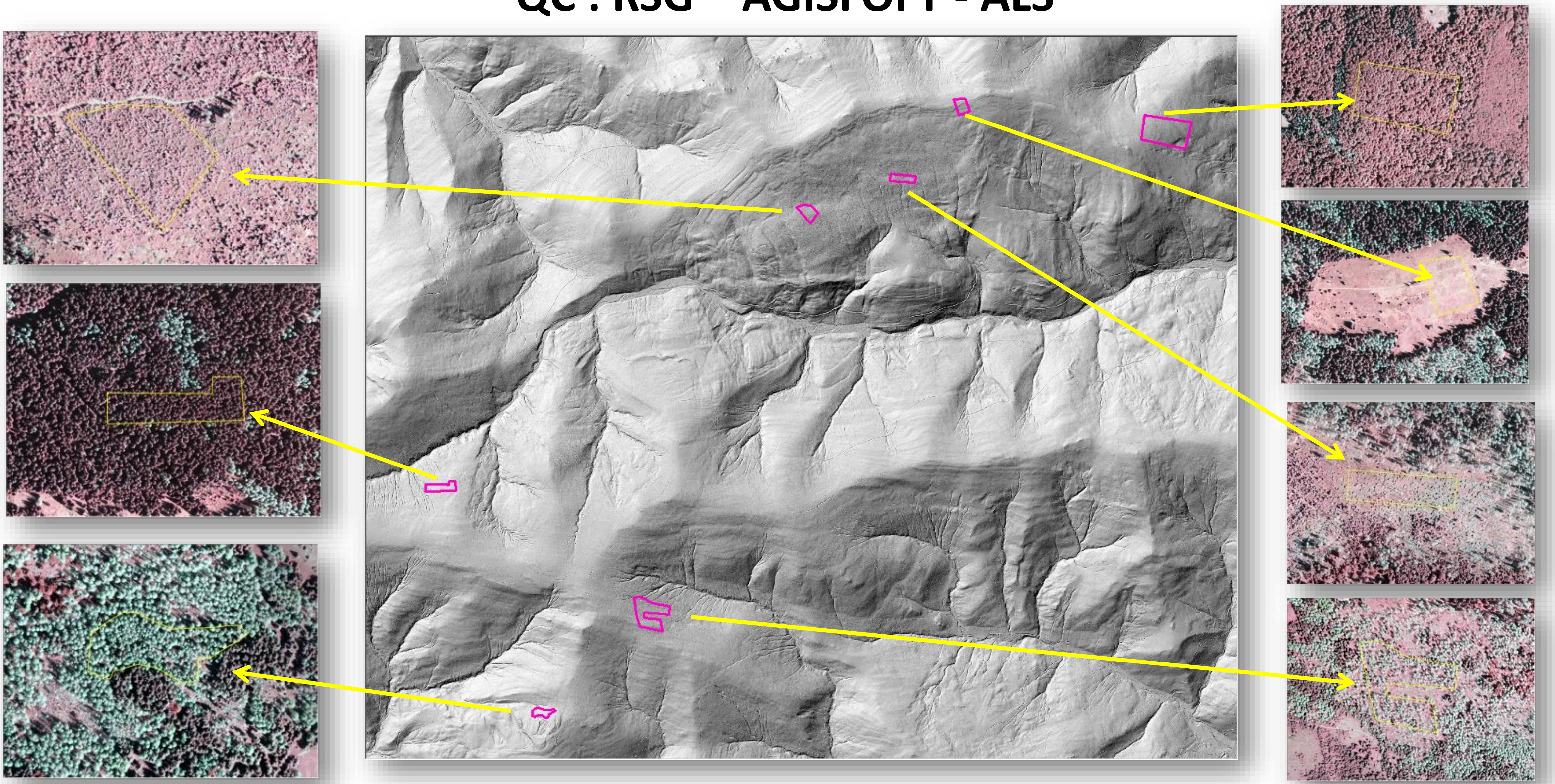
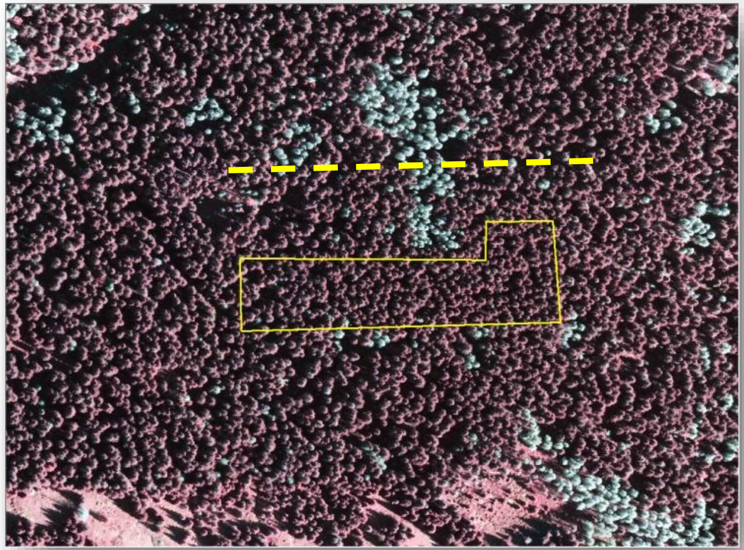
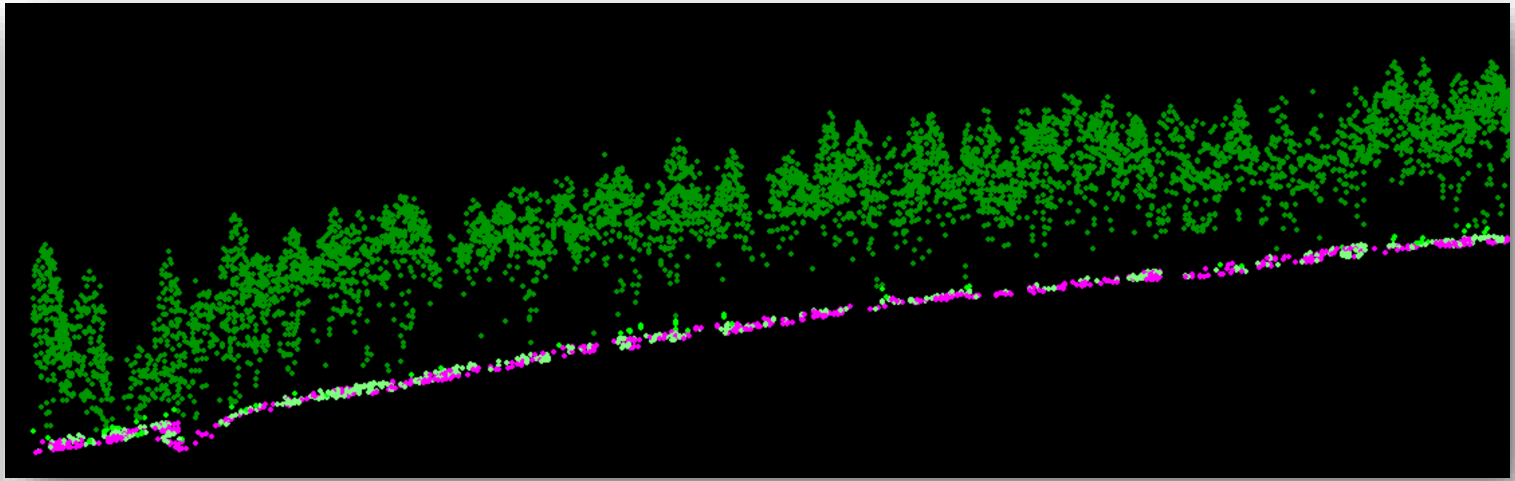


Image-based point clouds
Norway spruce stands in Gorce NP





ALS ISOK point cloud before normalisation

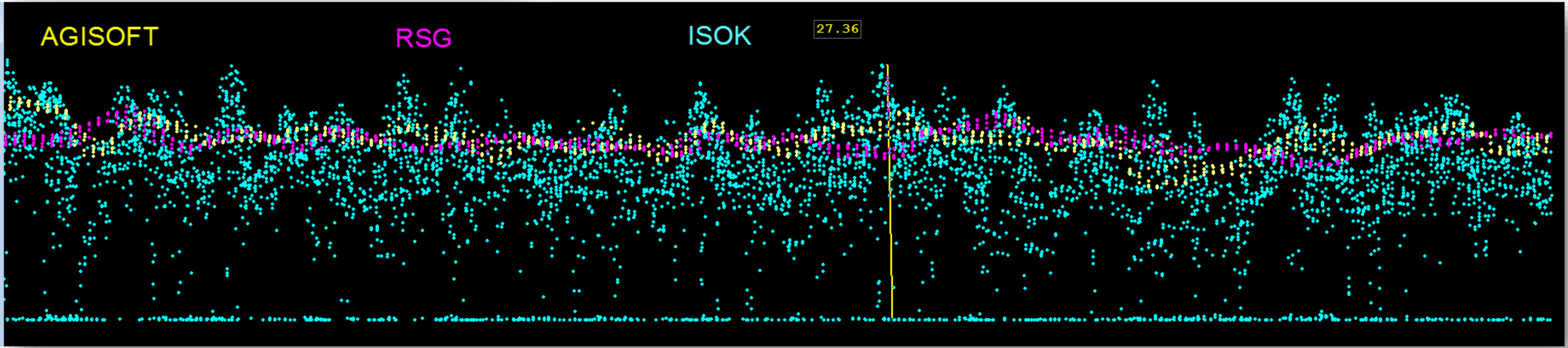
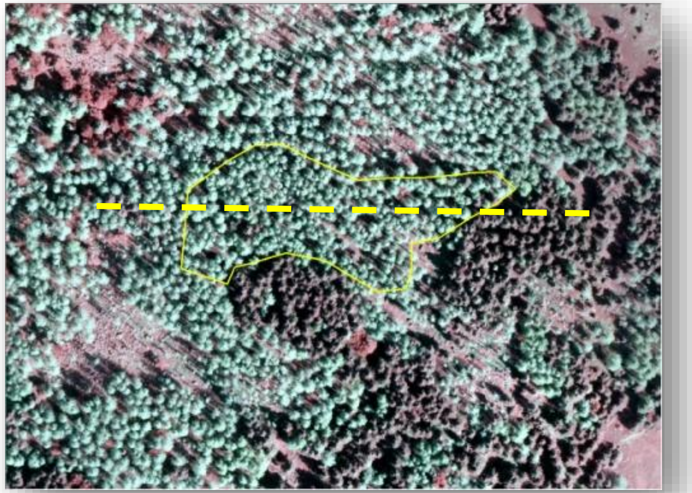
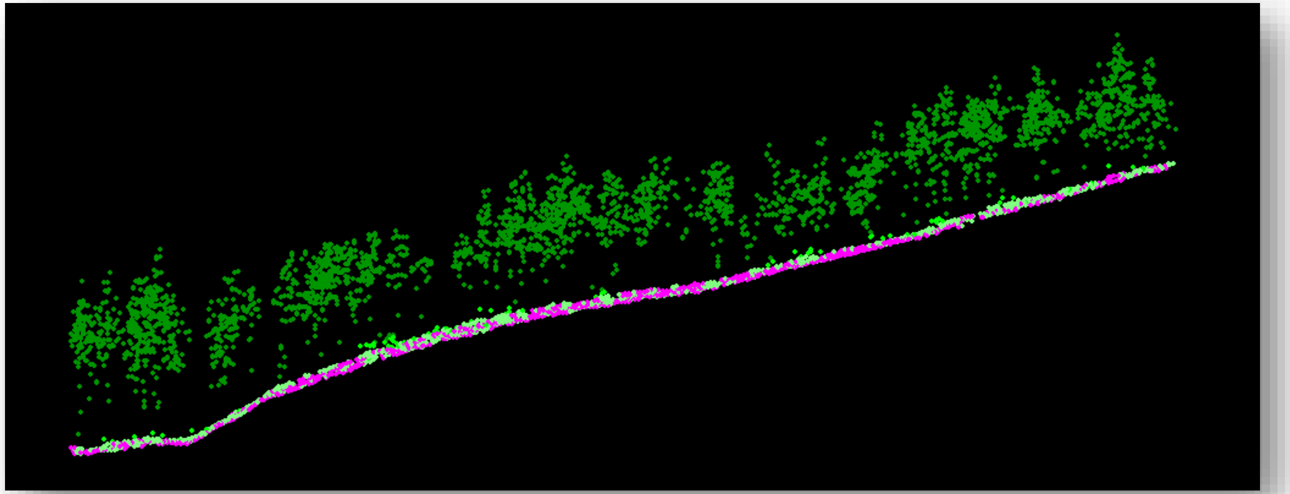


Image-based point clouds
„Dead bark beetle trees – dense stands”





ALS ISOK point cloud before normalisation

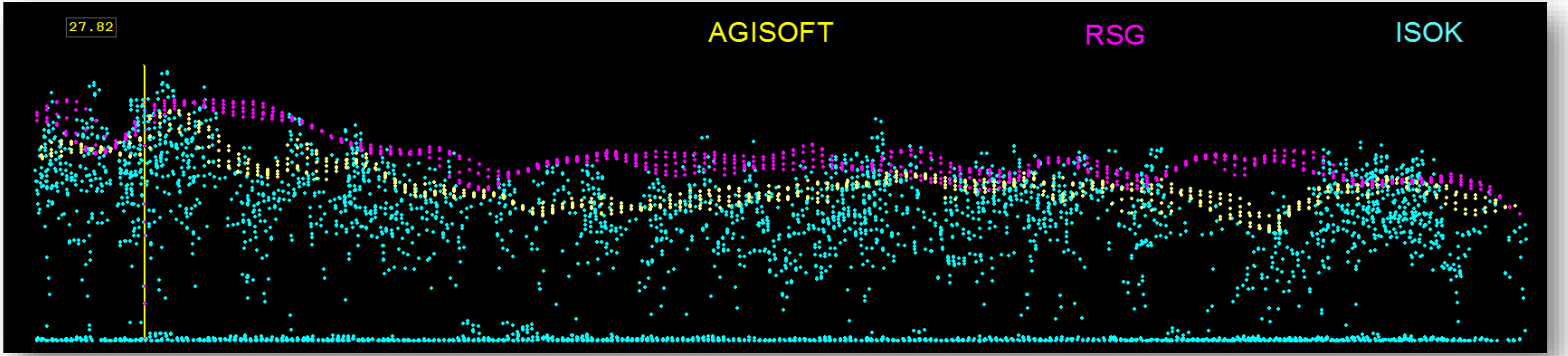
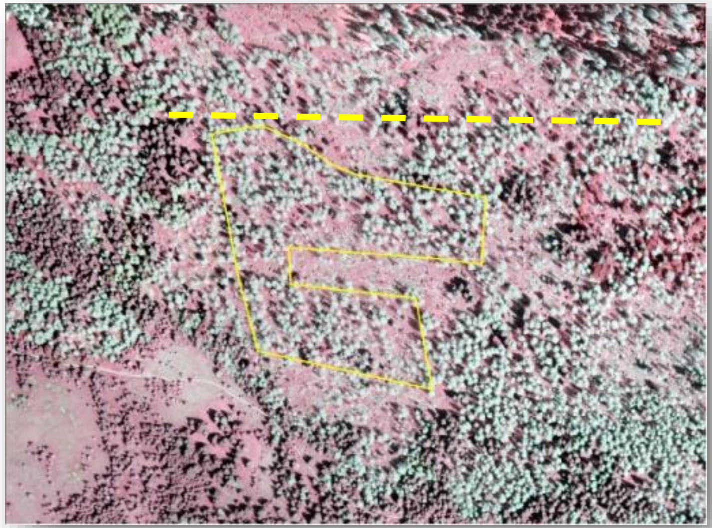
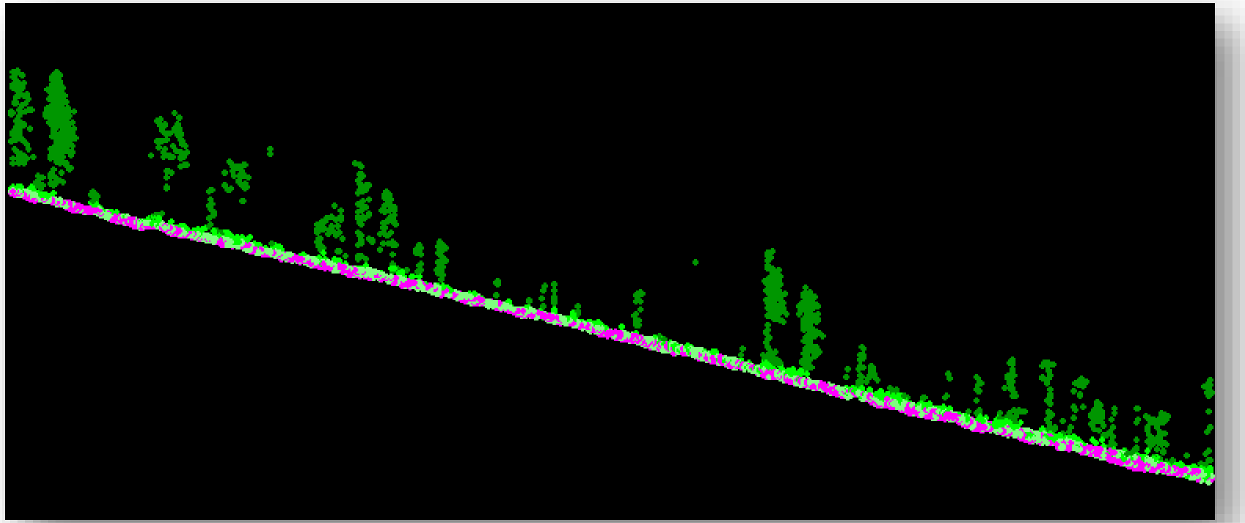


Image-based point clouds - dead trees sparse





ALS ISOK point cloud before normalisation

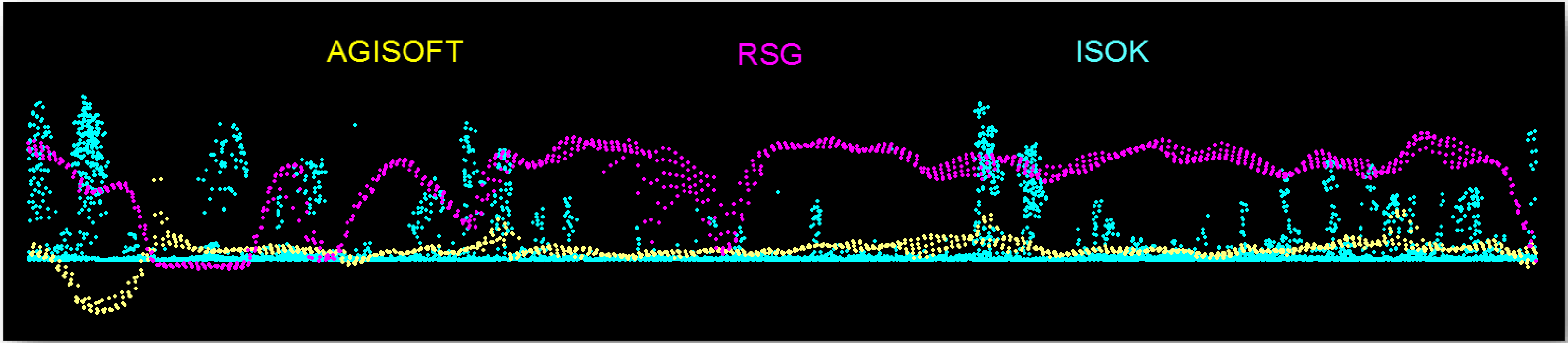
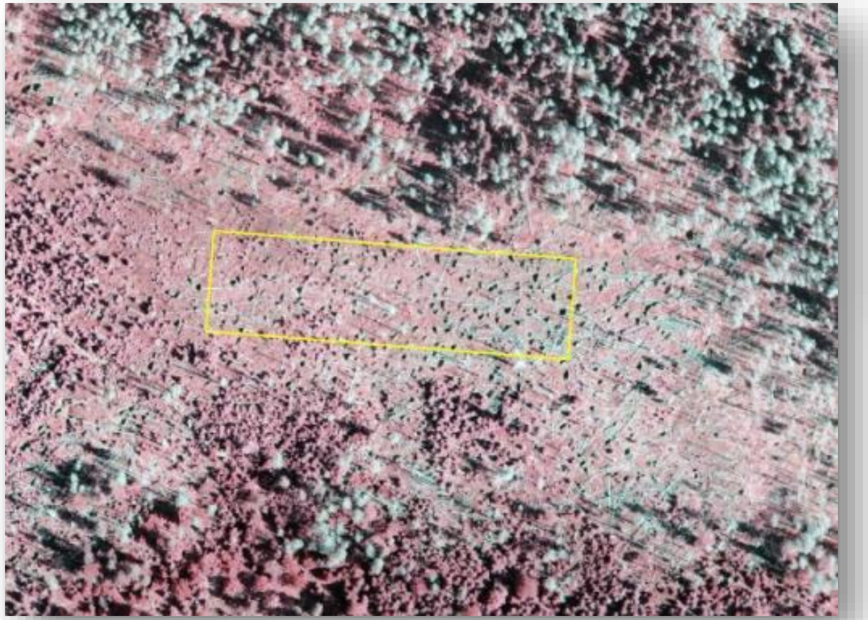
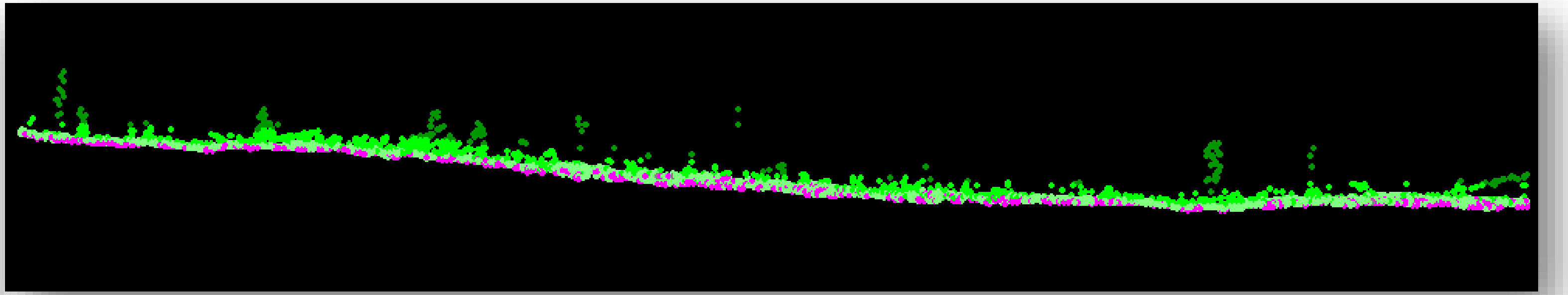
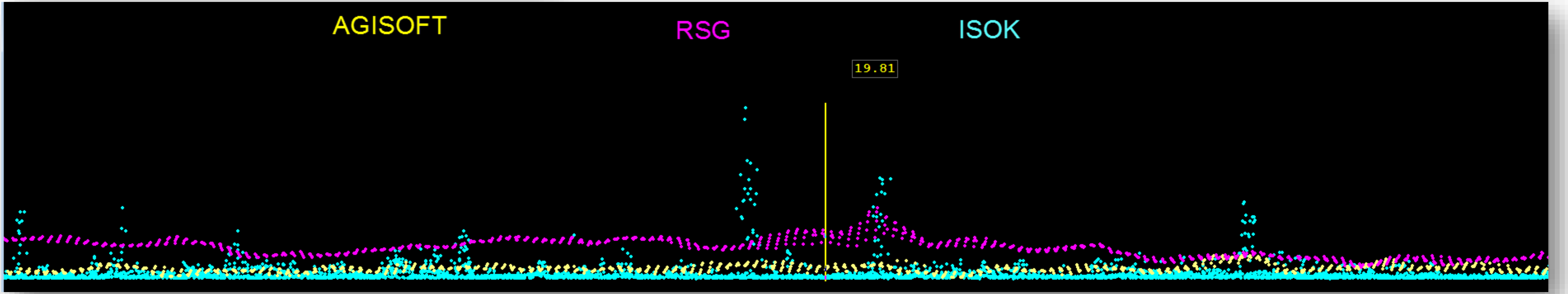


Image-based point clouds – destroed stands





ALS ISOK point cloud before normalisation



Stereomatching approach – SGM
Difference between DSM $_{RSG}$ - DSM $_{ALS\ ISOK}$