Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Single photon LiDAR in forestry applications

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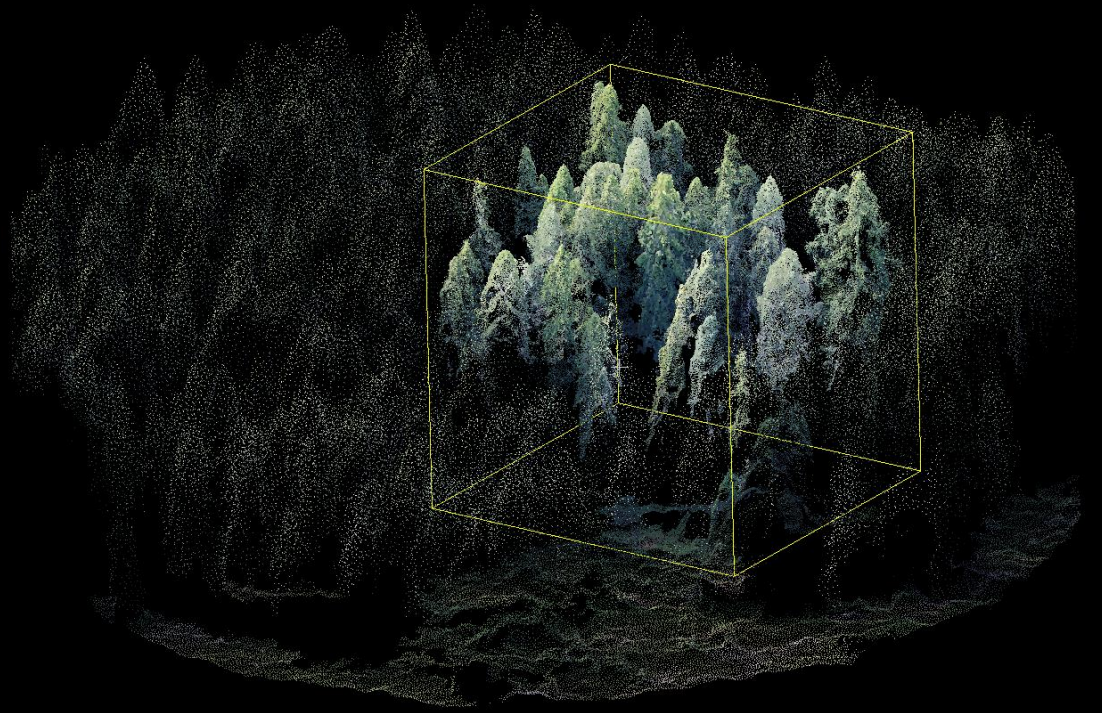
What is forest variable estimations?

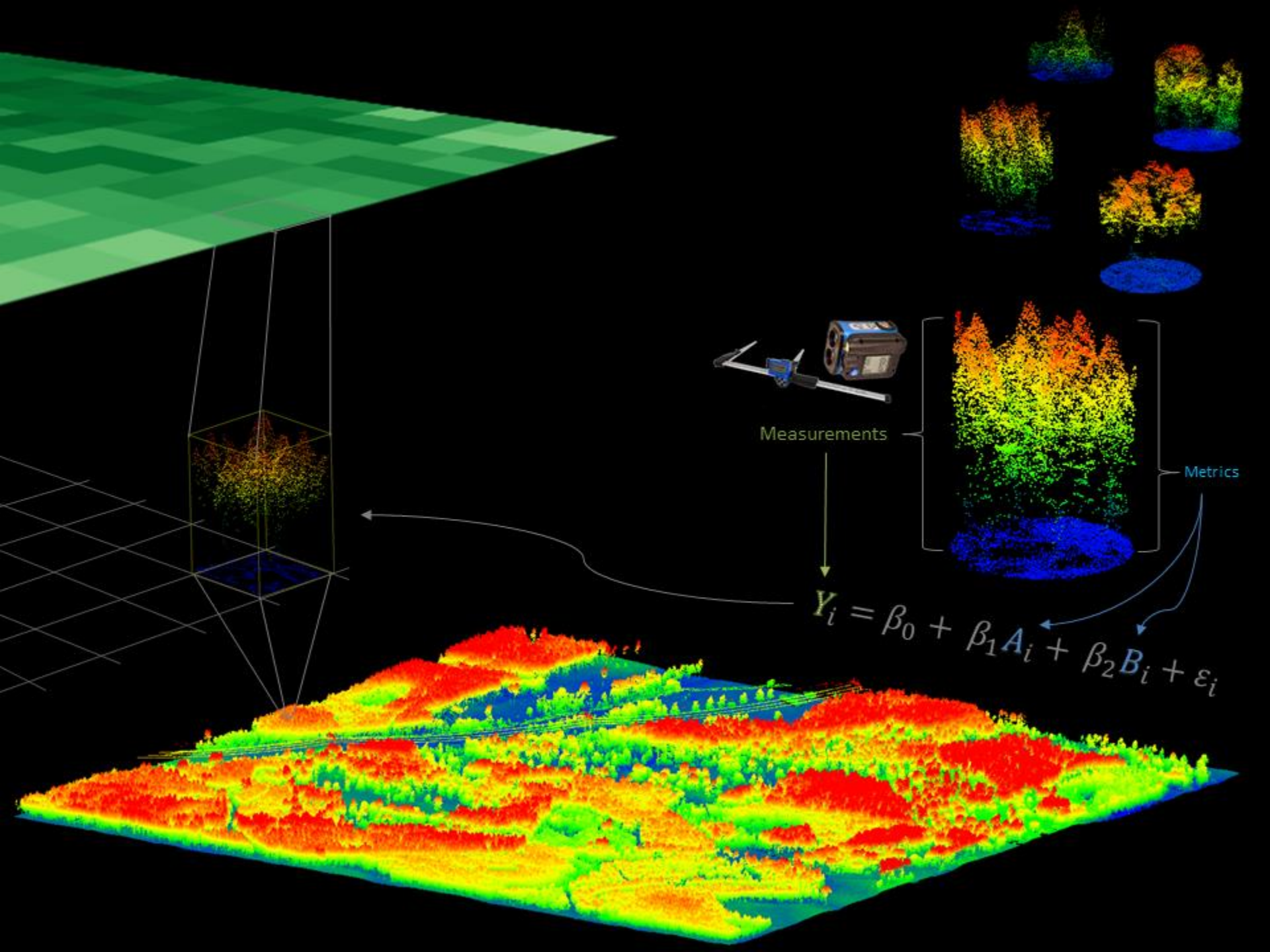


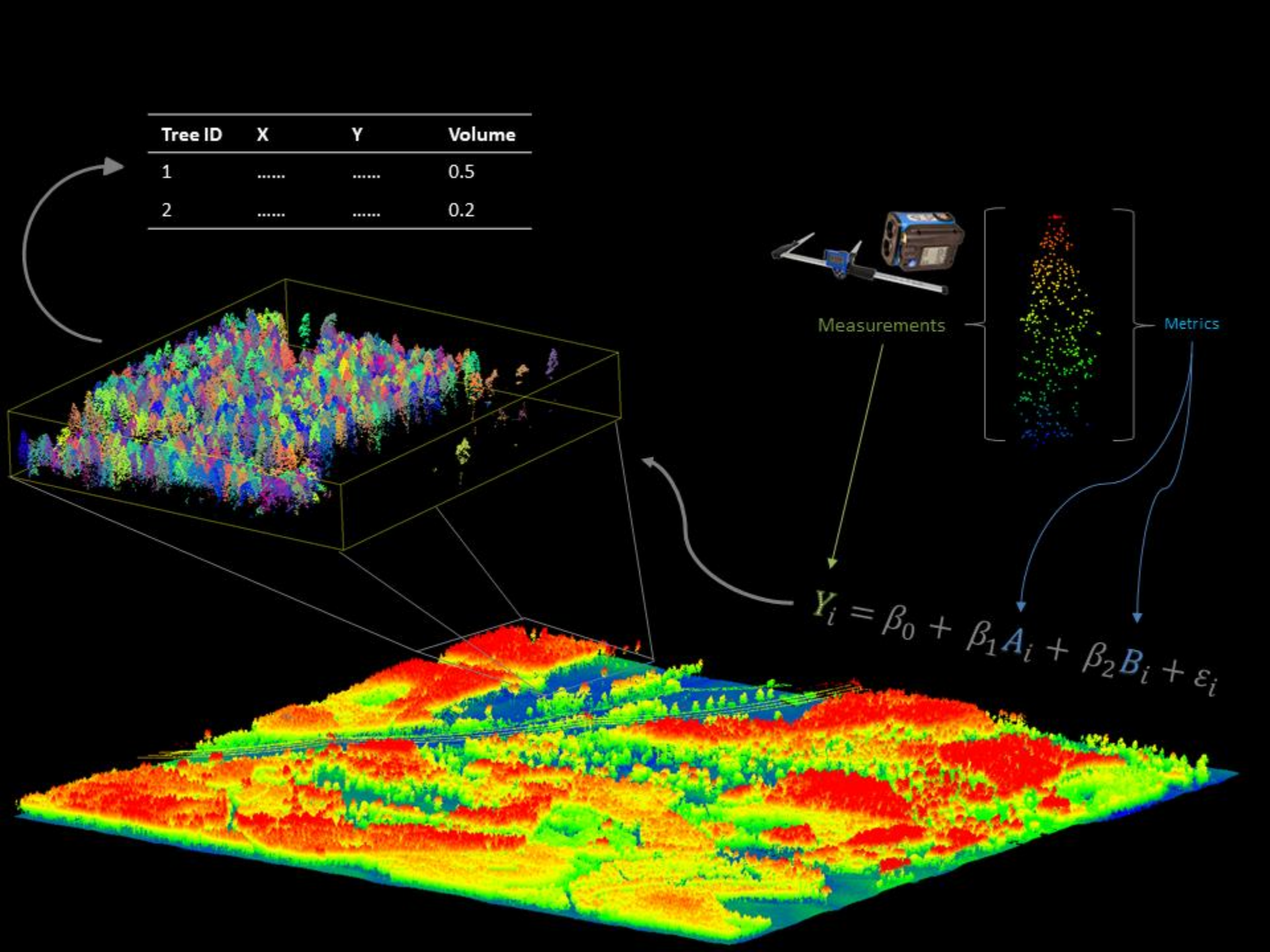
Area-based

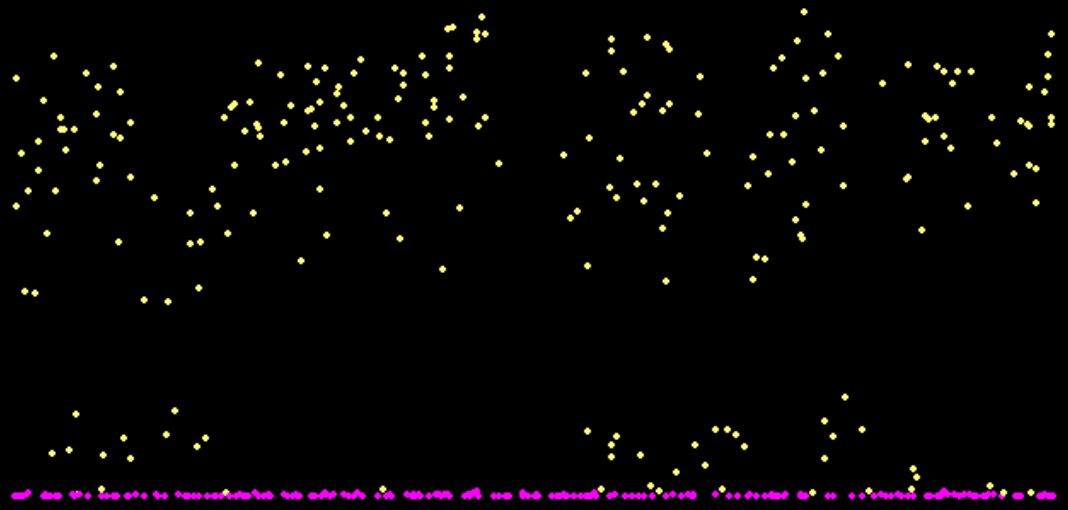
- Require lower point densities
- Robust

Single-tree

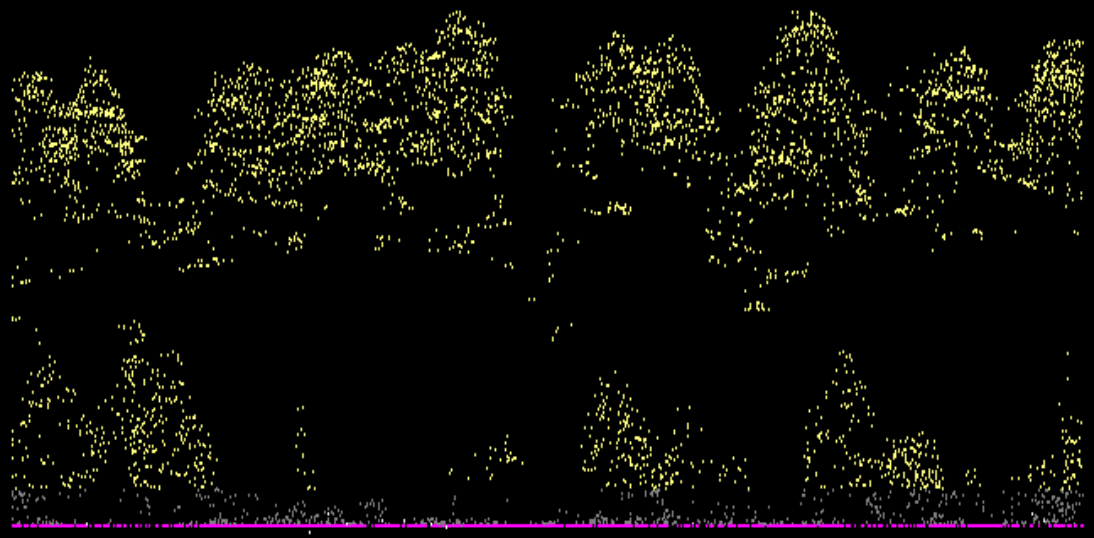
- Information stored to the individual tree, not as mean values for an area


Measurements
Metrics
$Y_i = \beta_0 + \beta_1 A_i + \beta_2 B_i + \varepsilon_i$


Tree ID X Y Volume
1 .... 0.5
2 .... 0.2
Measurements
Metrics
$Y_i = \beta_0 + \beta_1 A_i + \beta_2 B_i + \varepsilon_i$



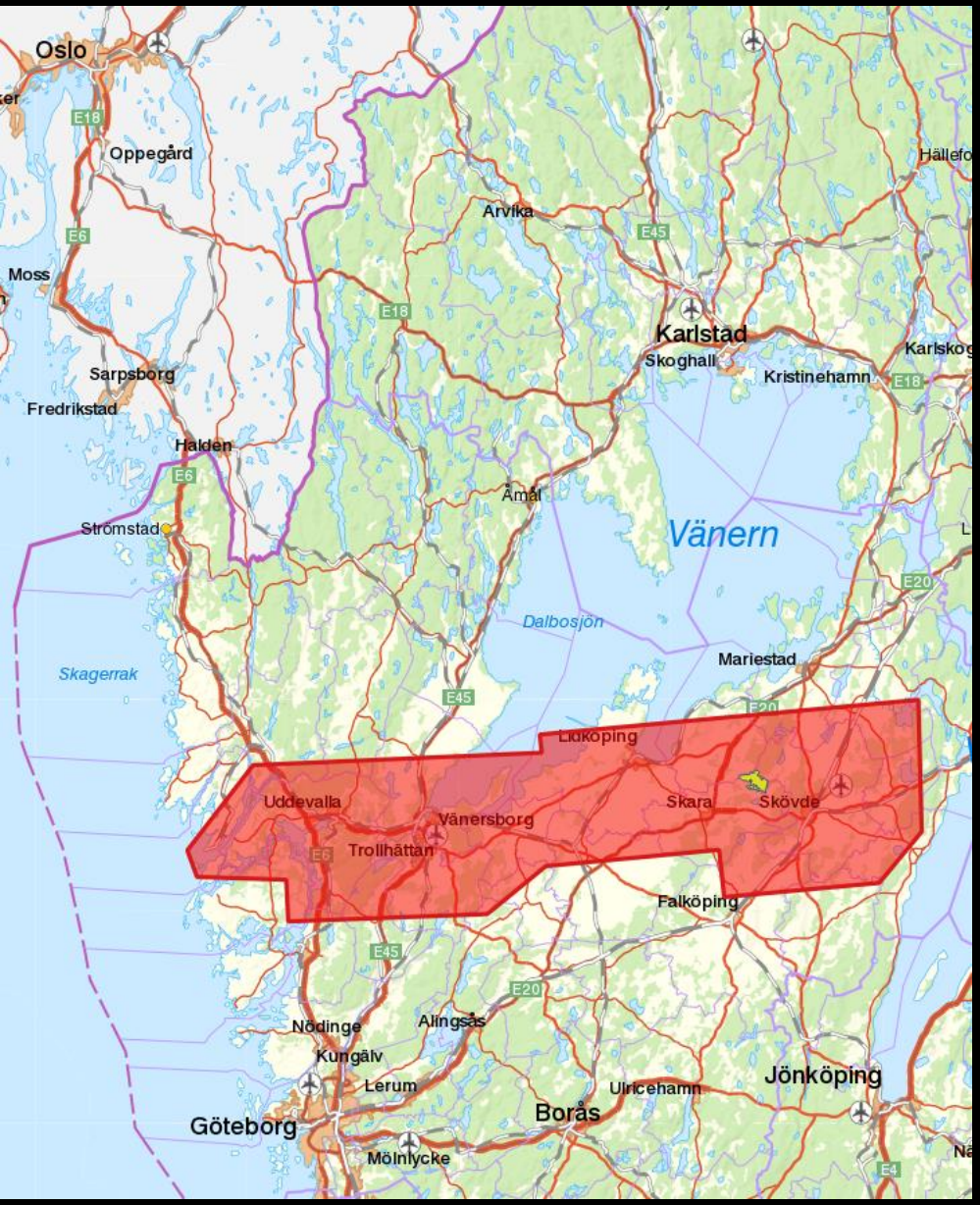
Swedish national coverage, Altitude: 2000 m



Leica SPL100, Altitude: 3800 m

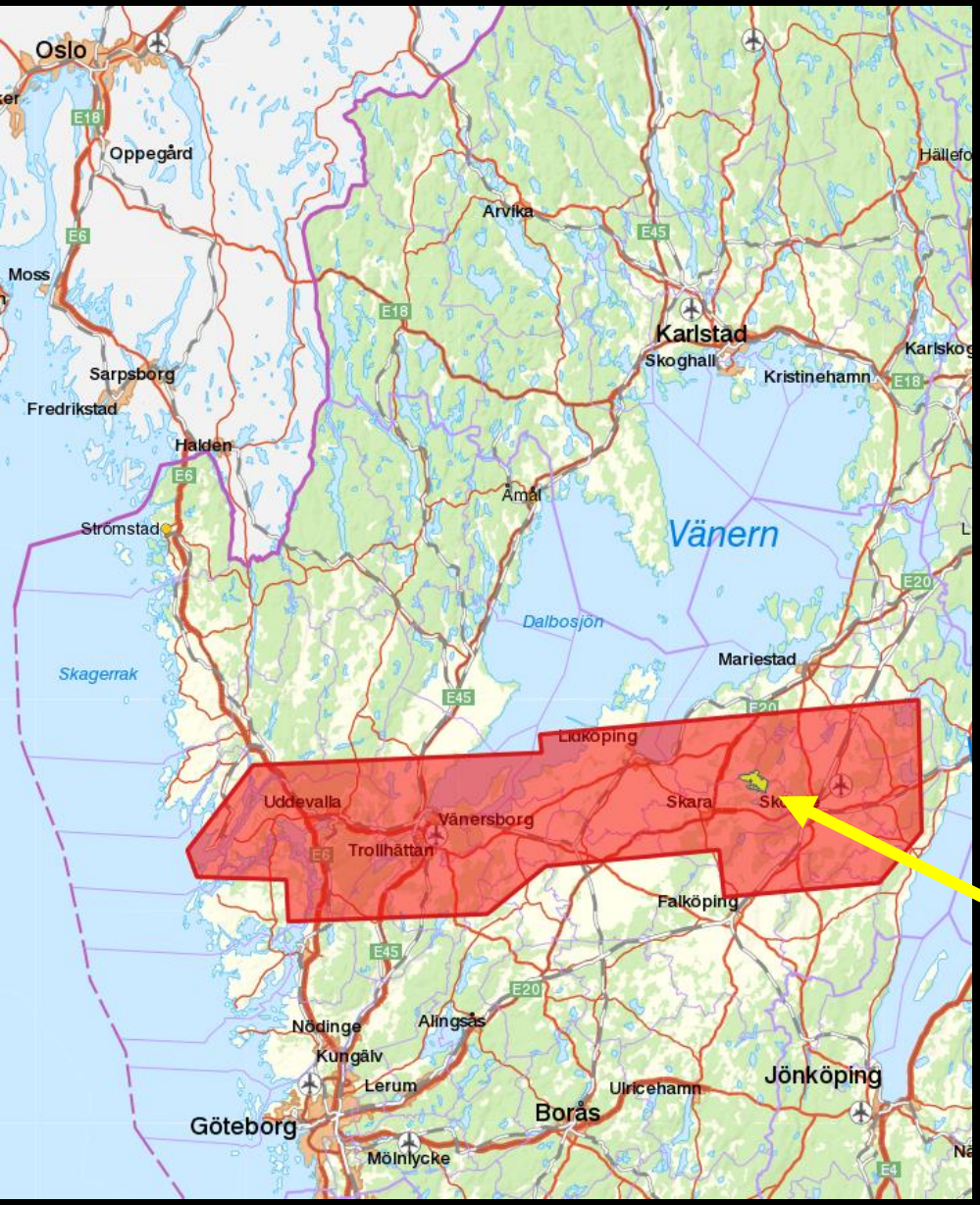
The context:

- Large areas
- Demands for high temporal resolution
- Precision forestry need higher point densities



SPL100 in Sweden

- Flown October/November 2017
- 4800 km^2
- Altitude of 3800 m



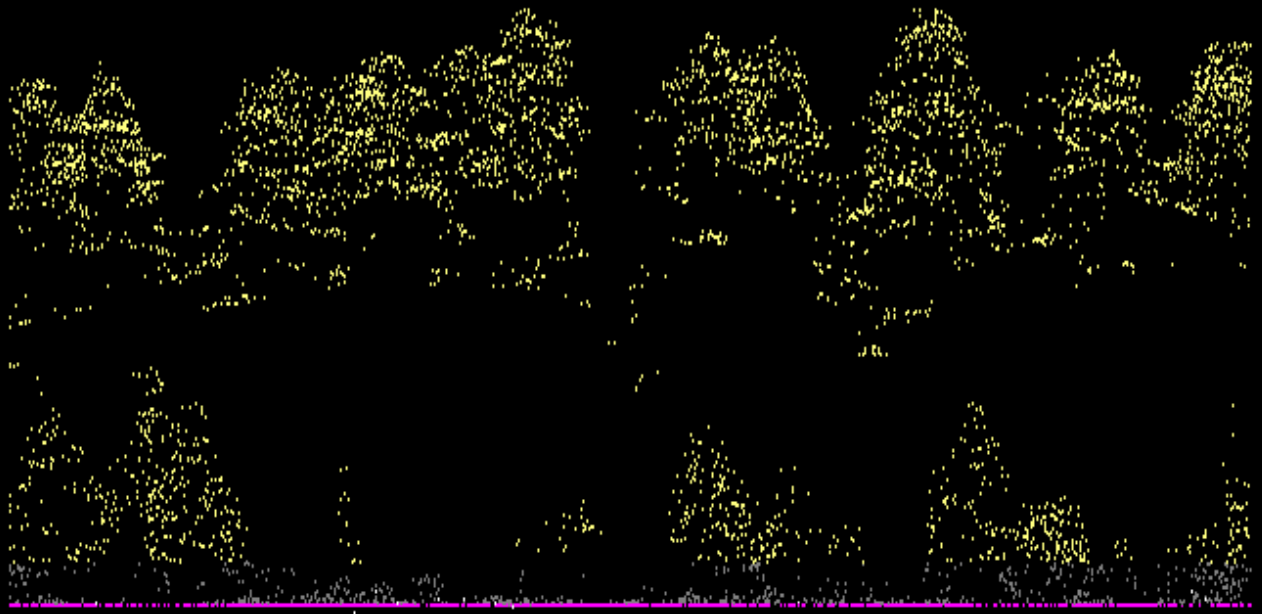
SPL100 in Sweden

- Flown October/November 2017
- 4800 km^2
- Altitude of 3800 m

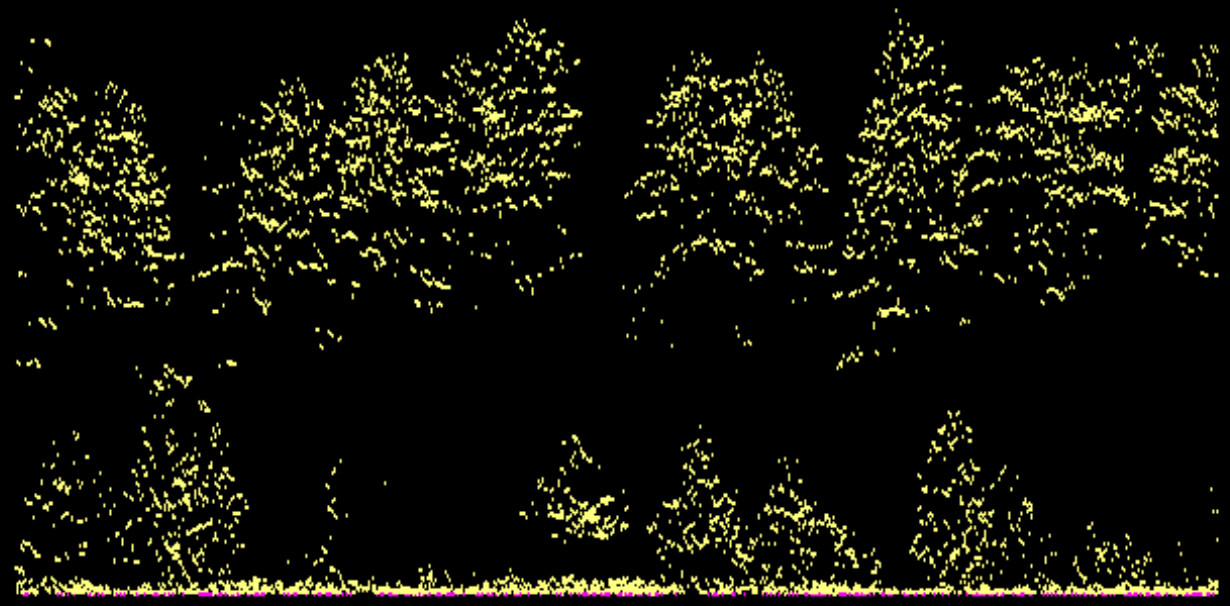
Test site

Sample plots:

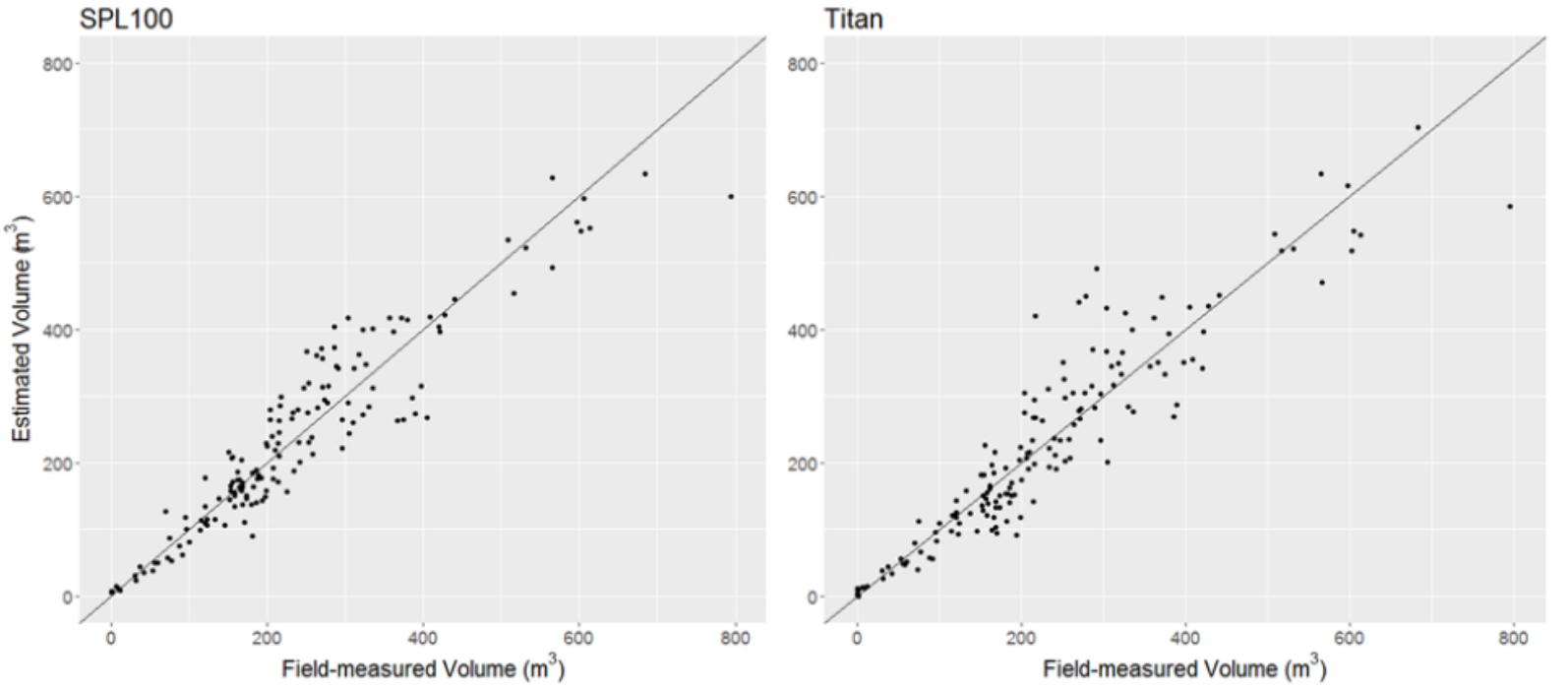
- 42 pine dominated
- 142 Spruce dominated
- Located in 138 forest stands



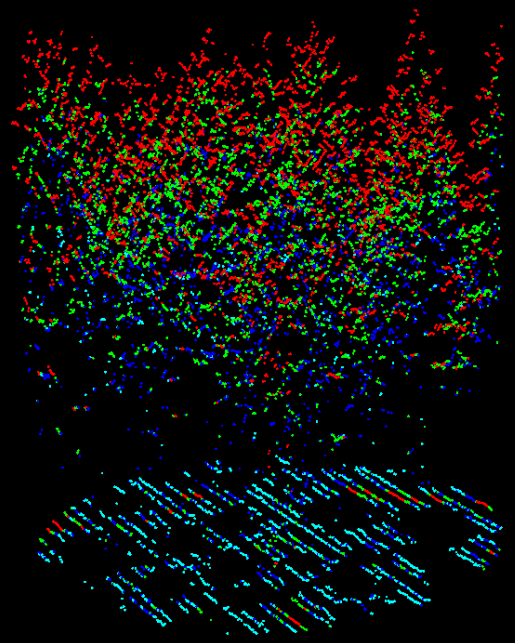
Leica SPL100
Altitude: 3800 m
Average point density: 25
Field of view: 30

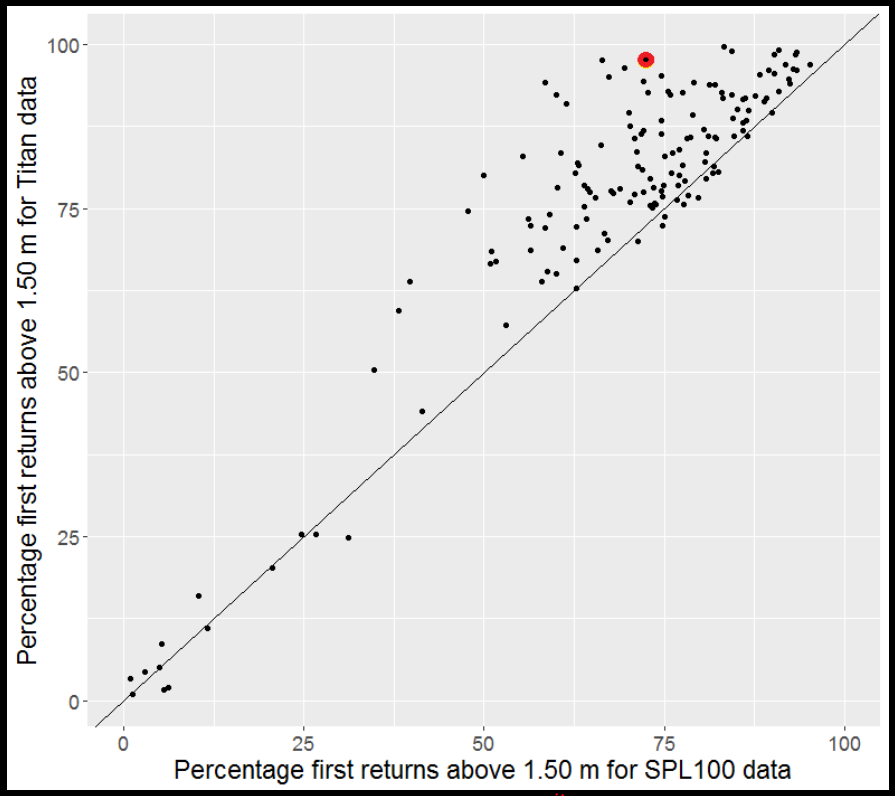


Optech Titan
Wavelength: 1064 nm
Altitude: 400 m
Average point density: 39
Field of view: 30

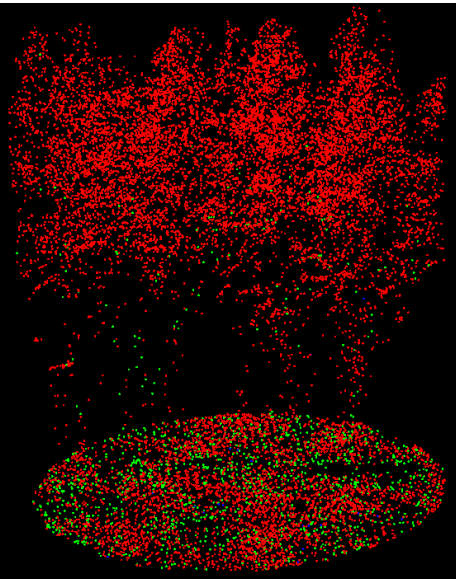


Sensor	Variable	Adj.R^2	RMSE	Relative RMSE (%)
Leica SPL100	Loreys mean height (m)	0.96	1.14	6.11
	Volume (m^3)	0.93	48.84	21.23
	Biomass (ton)	0.93	26.90	21.27
	Basal area (m^2)	0.90	5.30	21.98
	Basal area weighted diameter (cm)	0.86	3.38	13.77
Optech Titan	Loreys mean height (m)	0.96	1.16	6.24
	Volume (m^3)	0.91	55.95	24.31
	Biomass (ton)	0.94	29.02	22.94
	Basal area (m^2)	0.93	4.80	19.90
	Basal area weighted diameter (cm)	0.85	3.46	14.10




Percentage first returns above 1.50 m for Titan data
Percentage first returns above 1.50 m for SPL100 data
0
25
50
75
100


Return Number
1
2
3
4



remote sensing

MDPI

Article

Forest Variable Estimation Using a High Altitude Single Photon Lidar System

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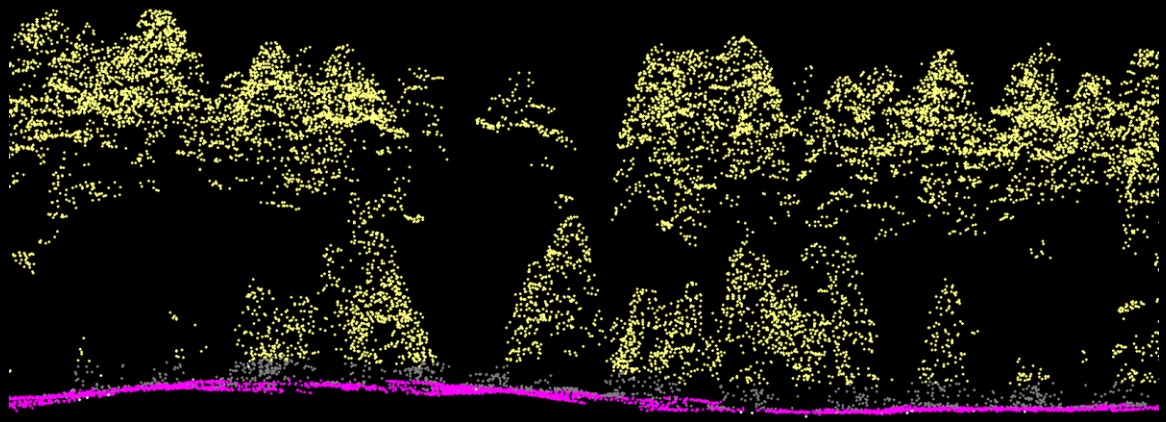
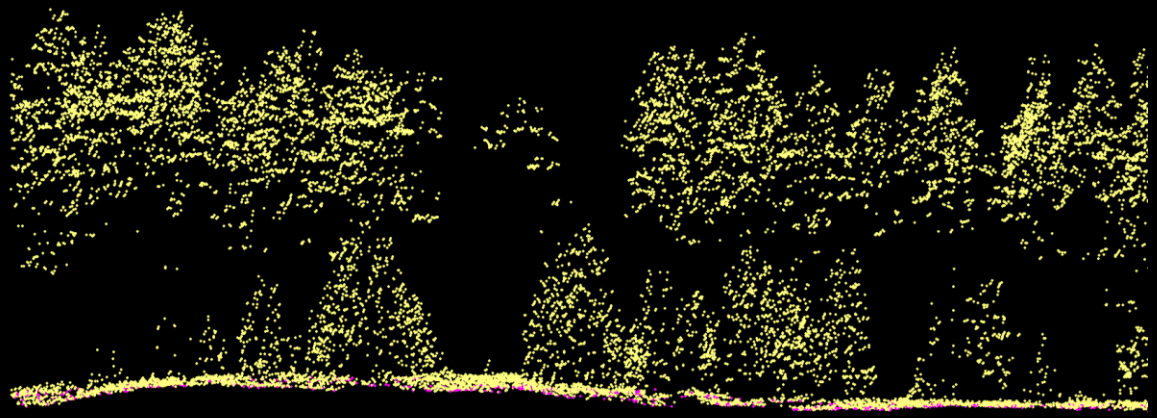
Abstract: As part of the digitalization of the forest planning process, 3D remote sensing data is an important data source. However, the demand for more detailed information with high temporal resolution and yet still being cost efficient is a challenging combination for the systems used today. A new lidar technology based on single photon counting has the possibility to meet these needs. The aim of this paper is to evaluate the new single photon lidar sensor Leica SPL100 for area-based forest variable estimations. In this study, it was found that data from the new system, operated from 3800 m above ground level, could be used for raster cell estimates with similar or slightly better accuracy than a linear system, with similar point density, operated from 400 m above ground level. The new single photon counting lidar sensor shows great potential to meet the need for efficient collection of detailed information, due to high altitude, flight speed and pulse repetition rate. Further research is needed to improve the method for extraction of information and to investigate the limitations and drawbacks with the technology. The authors emphasize solar noise filtering in forest environments and the effect of different atmospheric conditions, as interesting subjects for further research.

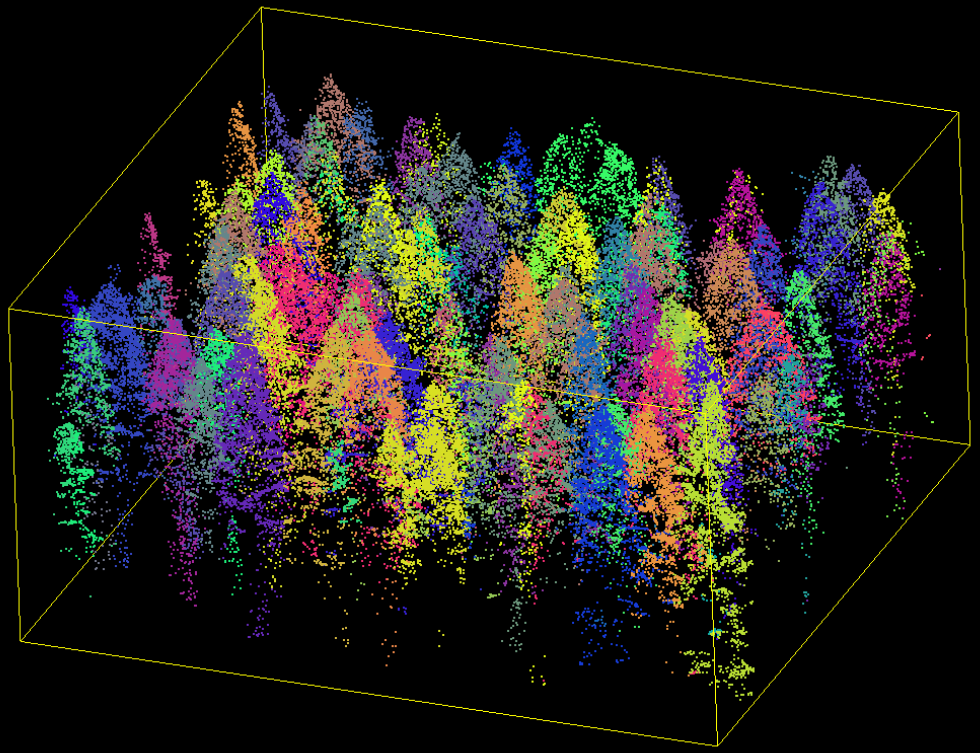
Single trees?

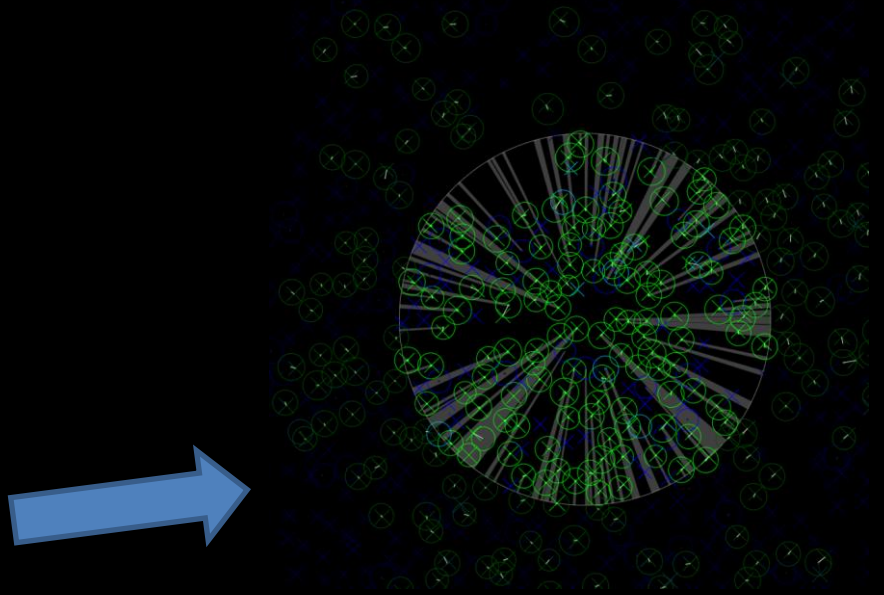


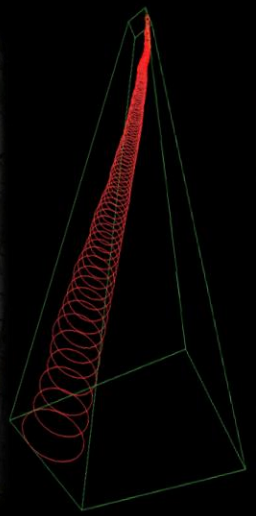
Leica SPL100
Altitude: 3800 m



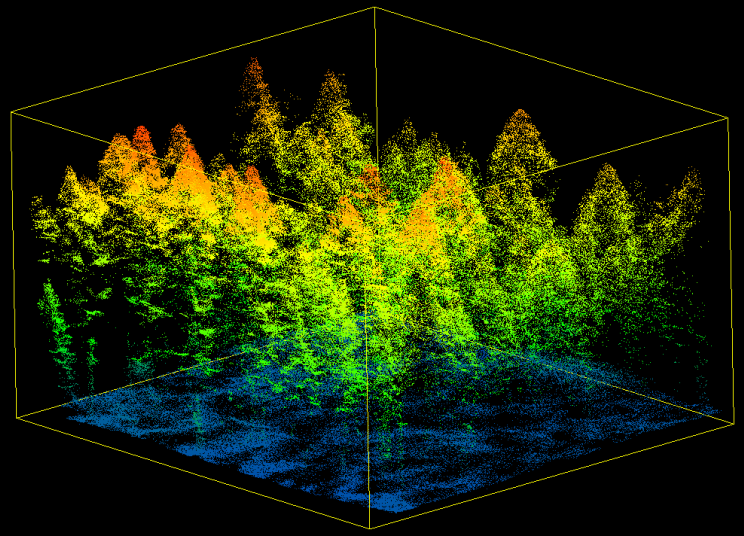
Optech Titan 1064 nm
Altitude: 400 m







Future research



- Atmospheric differences
  - Could it be a problem?
- Larger FOV
- Noise filtering
  - Forest adapted noise filtering
  - Is noise filtering always necessary?
- Very high point densities from SPL
  - What additional information can we obtain?

Thank you!

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