Resultater av tester med fotonlaser

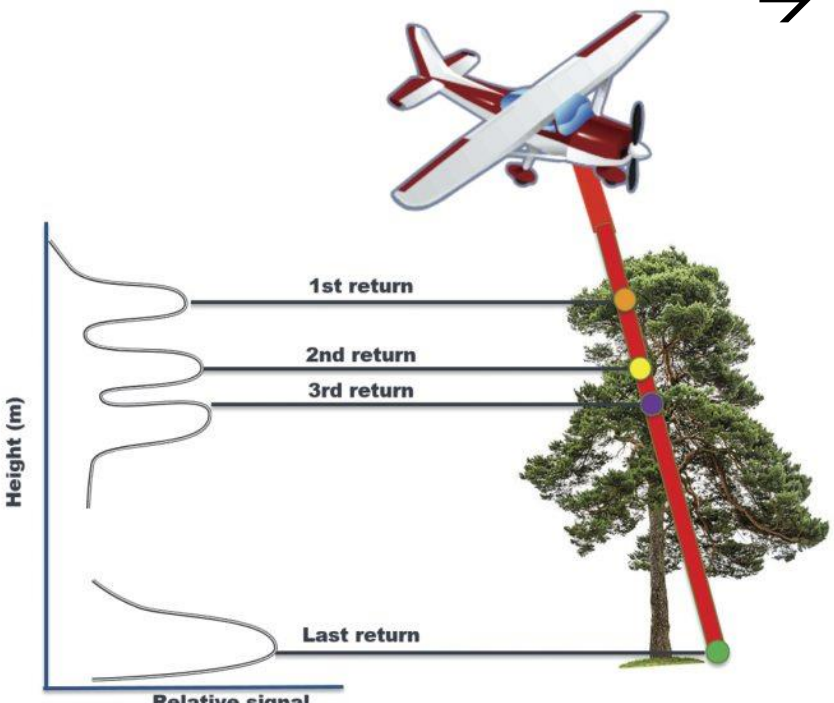
Skogplanseminar 6-7 mars 2025

Holmen Fjordhotell

Terje Gobakken

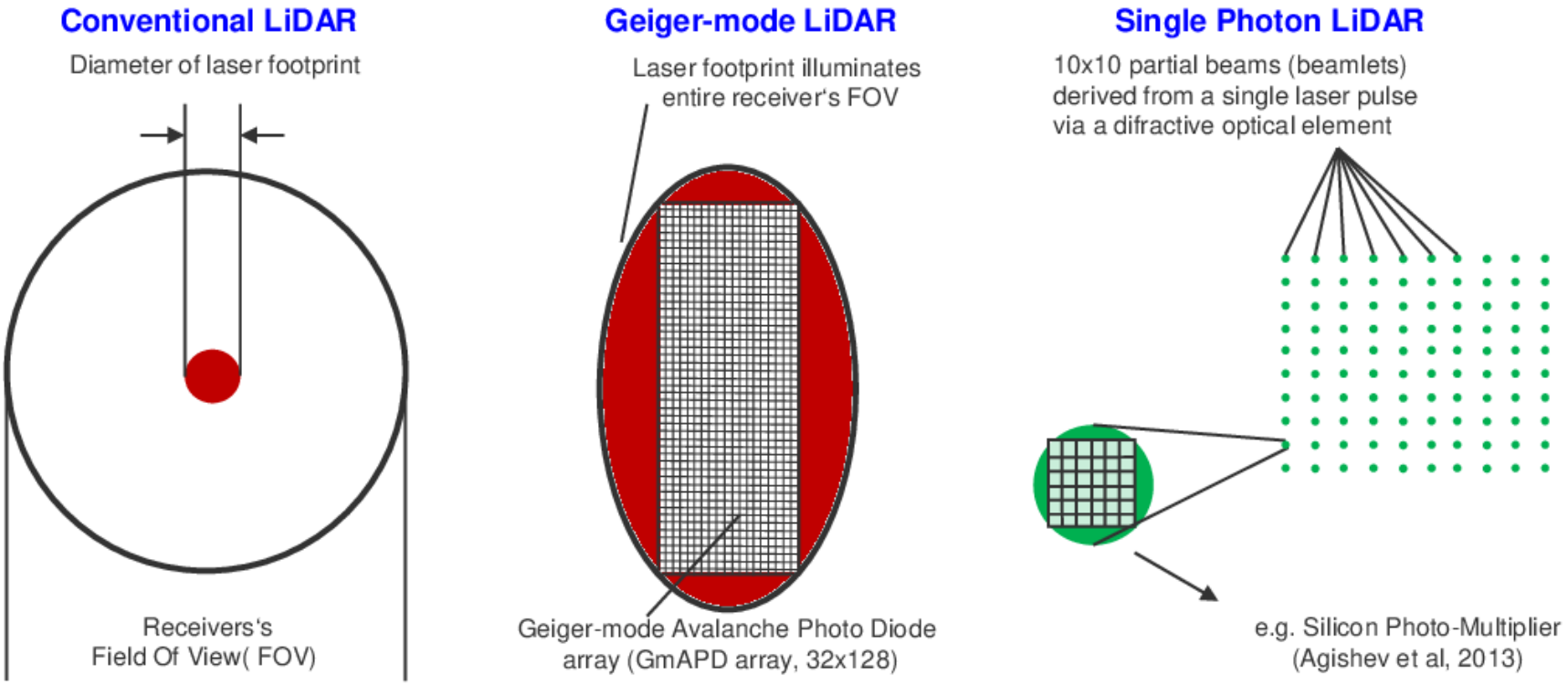
Laserdata

- Vanlig/konvensjonell/lineær laser
  → En sensor



(https://www.newport.com/n/lidar)

Laserdata



(Mandlburger, G., Lehner, H., & Pfeifer, N. (2019). A comparison of single photon and full waveform lidar. *ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., IV-2/W5, 397-404)*

Fotonlaser (Single Photon LIDAR = SPL)

- Ekstremt følsom og kan detektere enkeltfotoner som returnerer fra laserpulsen.

Foton er den minste energimengde man kan forbinde med lys som sendes ut med en bestemt frekvens.

- Kan samle inn data over store områder med høy oppløsning og nøyaktighet, selv under utfordrende forhold som tykt løvverk eller lav reflektivitet.

(Mandlburger et al. 2019)

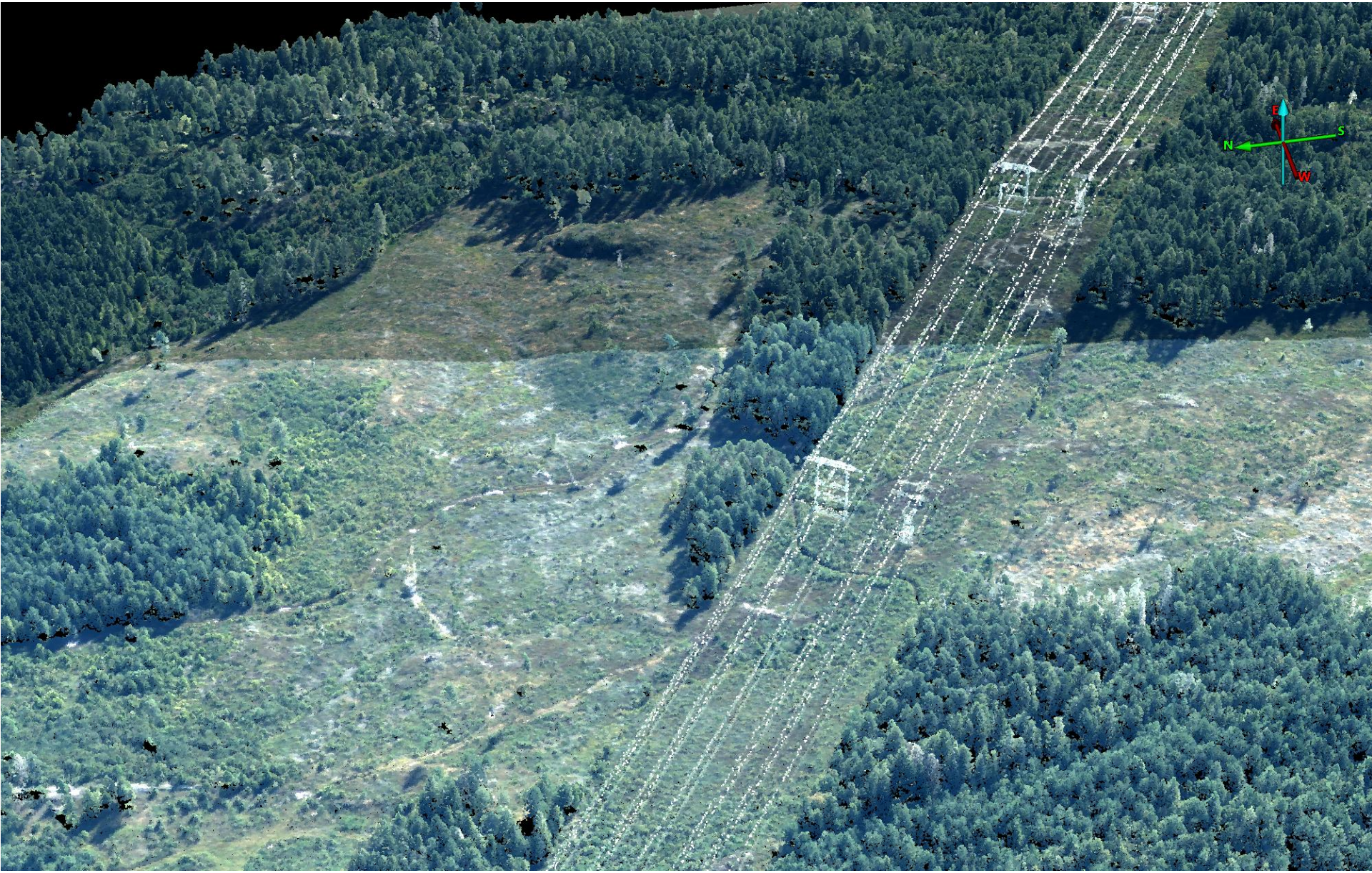
SPL100 (Leica)

- Lansert 2017

- Testet med arealmetoden i:
  - Sverige, Finland og Canada i 2017/18.

- Konklusjon: nøyaktighetsnivå for prediksjoner av skoglige variabler på linje med resultat fra vanlig laser
  - Ved ca 30 punkt pr m^2

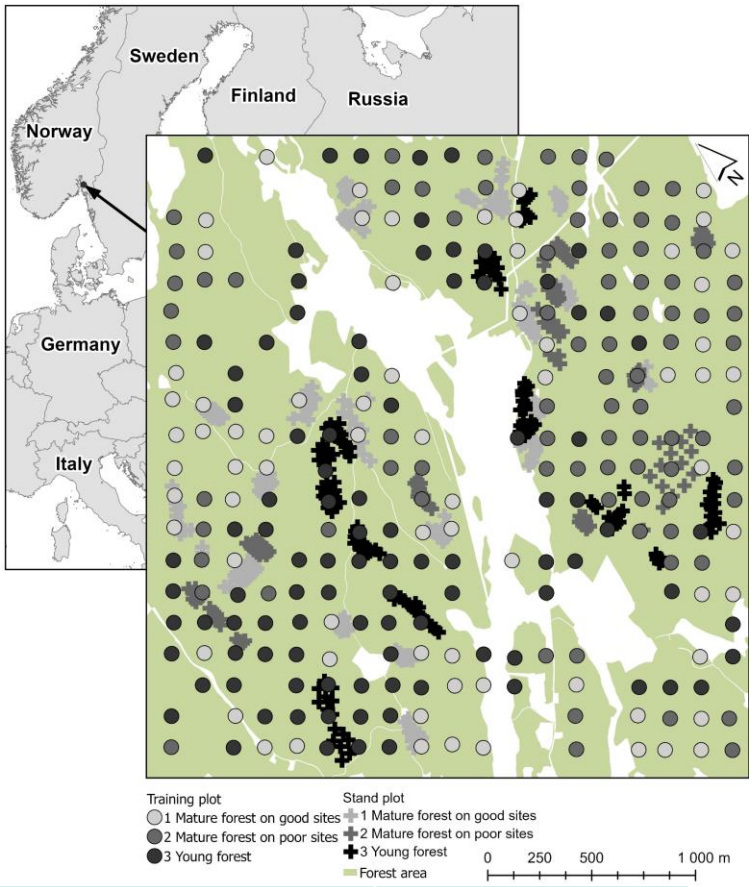
Ulemper:
- Støy i dataene
- En leverandør
- Kostbart


E
N
S
W

Feltdata

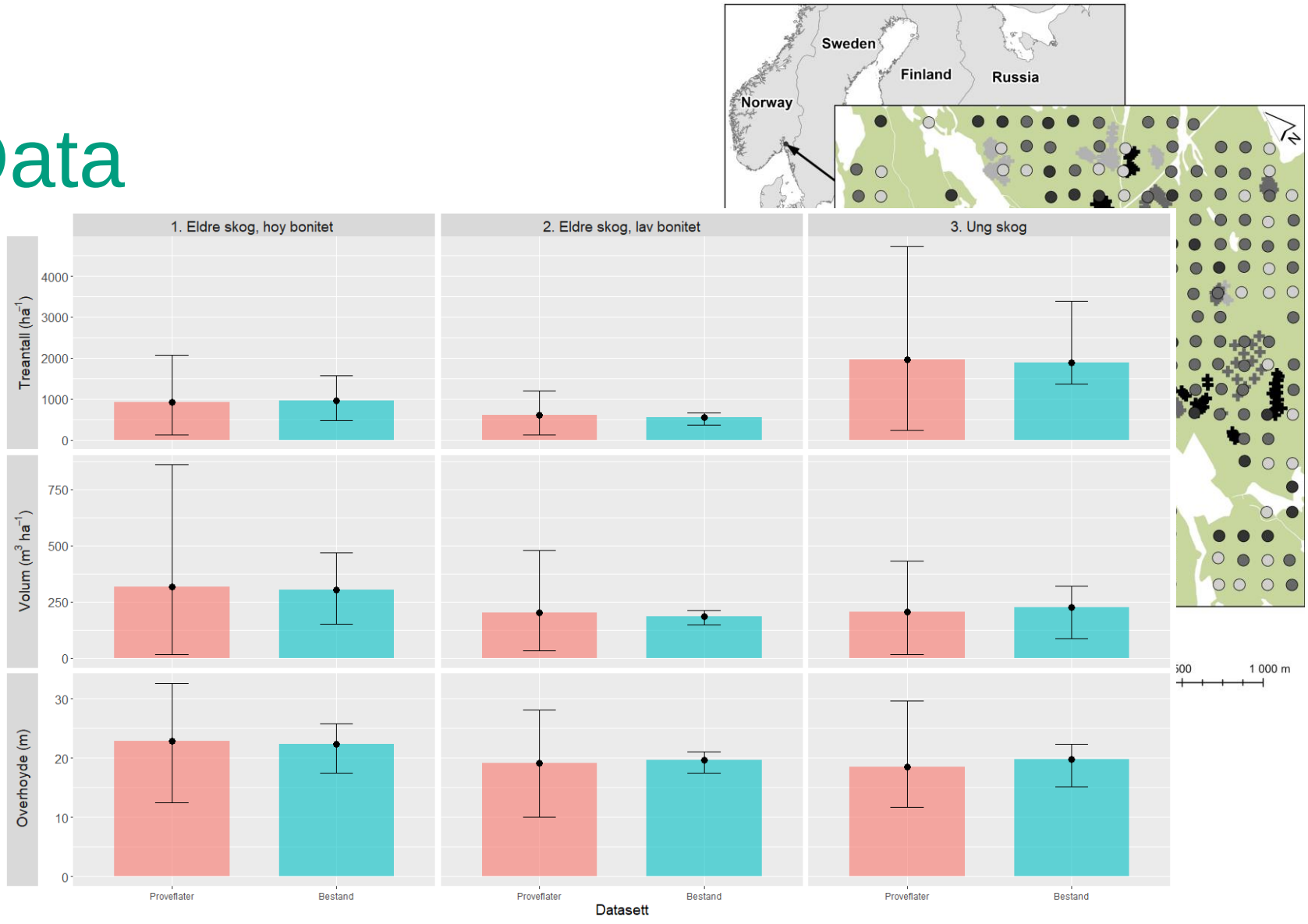
- 249 Systematiske prøveflater, 400 m^2, posisjonerte trær, 5 cm klavegrense
  - Vi benytter
    - 250 m^2 flater
    - 10 cm klavegrense i hogstklasse 4 og 5.
- 530 bestandsflater lagt ut i 47 bestand i 1998 – justert med siste skogbruksplan og nye fjernanalysedata
  - 250 m^2
  - 3-20 flater pr. bestand – Gjennomsnitt: 11.3
  - Bruker flategjennomsnitt som bestandsverdi.

Data



Stratum	Prøveflater	Bestand
1. Eldre skog, høy bonitet (14 og høyere)	70	24
2. Eldre skog, lav bonitet (11 og lavere)	83	10
3. Ung skog (Hogstklasse 3)	96	13
	249	47

Data


Sweden
Finland
Russia
Norway
1. Eldre skog, hoy bonitet
2. Eldre skog, lav bonitet
3. Ung skog
Treantall (ha-1)
Volum (m3 ha-1)
Overhoyde (m)
Proveflater
Bestand
Datasett
1 000 m

Fjernanalysedata (6 datasett)

Laserdata

- Vanlig laser
  - 2 flyhøyder

Bildedata

- Fotonlaser
  - 3 flyhøyder

1	2	3	4	5	6
ALS low density	ALS high density	DAP	SPL low density	SPL medium density	SPL high density

Fjernanalysedata

	Technical specifications					
Dataset	ALS low density	ALS high density	DAP	SPL low density	SPL medium density	SPL high density
Platform (fixed-wing aircraft)	Piper Navajo			Cessna 340A		
Sensor	Riegl LMS Q-1560	Riegl LMS Q-1560	Vexcel UltraCam Osprey 4.1	Leica SPL100	Leica SPL100	Leica SPL100
Acqusition date	08.07.2022	08.07.2022	08.07.2022	16.08.2024	16.08.2024	16.08.2024
Mean flying speed ($m\ s^{-1}$)	80	60	80	60	60	60
Flying altitude above ground (m)	3500	940	3500	4877	3414	3139
Number of flight lines	3	18	3	3	4	7
Side overlap (%)	20	81	53	21.2	21.7	55.6
Forward overlap (%)	-	-	80	60	60	60
Scan rate (lines per second)	83	267	-	-	-	-
Half-scan angle (degrees)	16	29.3	-	15.0	15.0	15.0
Swath width (m)	2007	1053		2600	2000	1500
Pulse repetition frequency (kHz)	500	2000	-	50	50	60
Max. number of echoes per pulse[a]	8	9	-	15	13	15
Pulse density (m^{-2})[a]	4.2	145.8	61.4	17.0	37.1	72.4
Spatial resolution (cm)[b]	81	22	16.5[c]	39	27	25

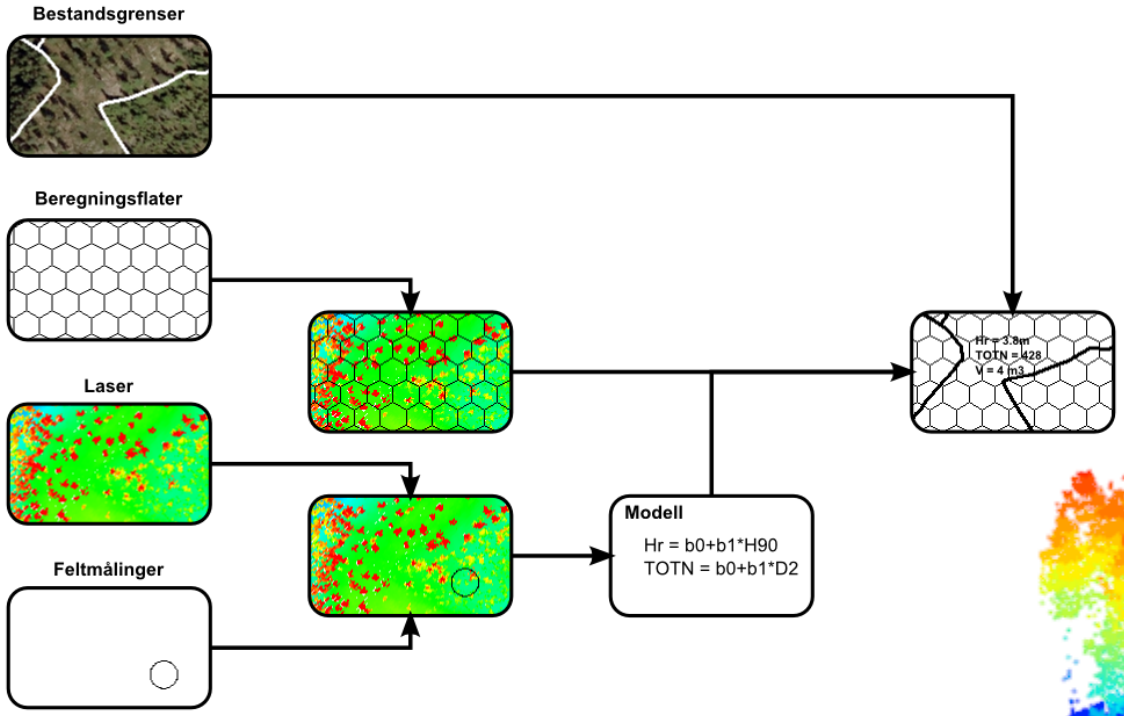
[a] Based on the sample plots.

[b] Laser footprint diameter (cm) computed after (Baltsavias 1999) based on mean acquisition settings.

[c] Ground sampling distance.

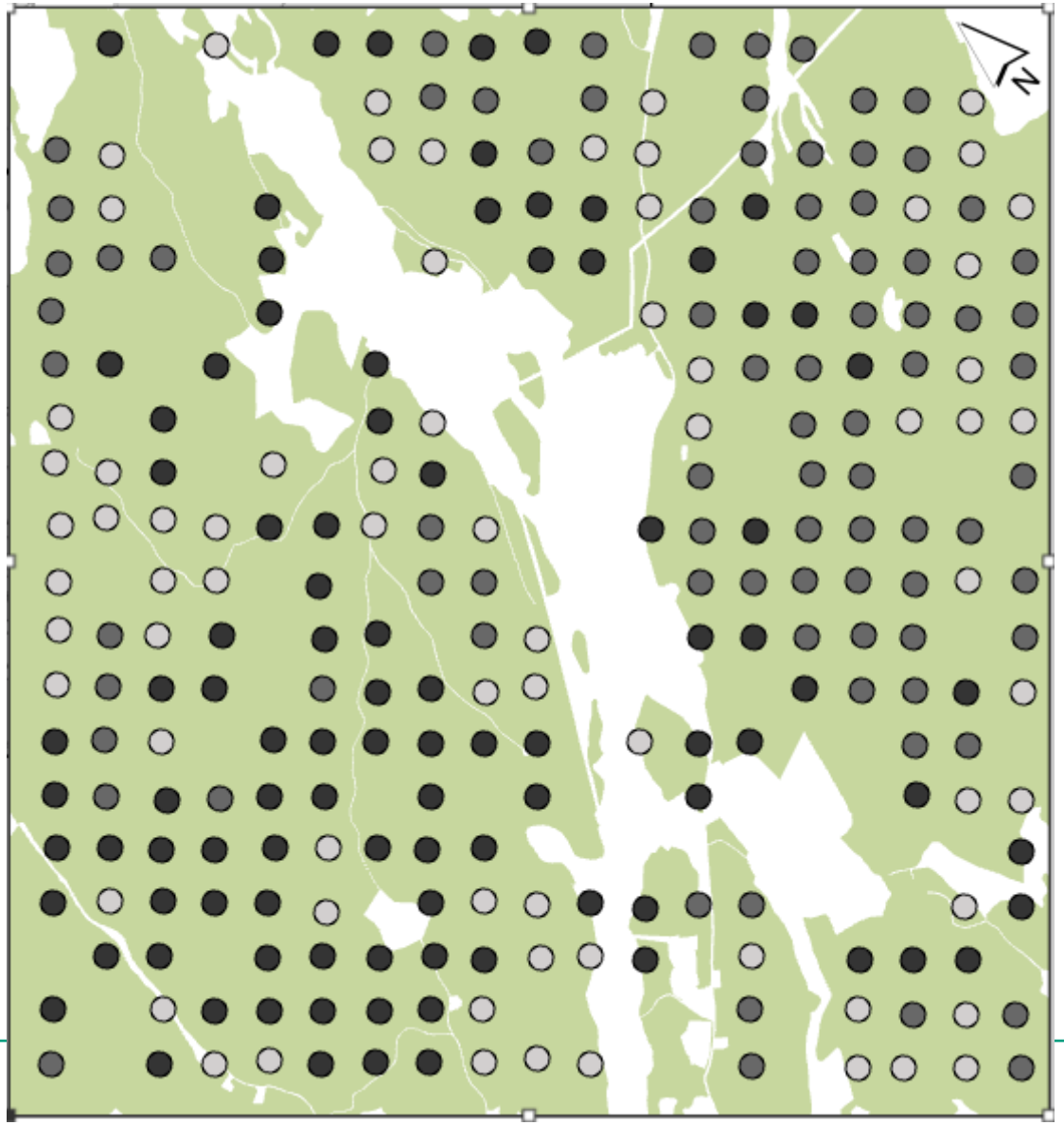
Metode

- Arealmetoden med noen justeringer på grunn av utdatert bestandsinndeling for våre bestandsflater som vi følger over tid

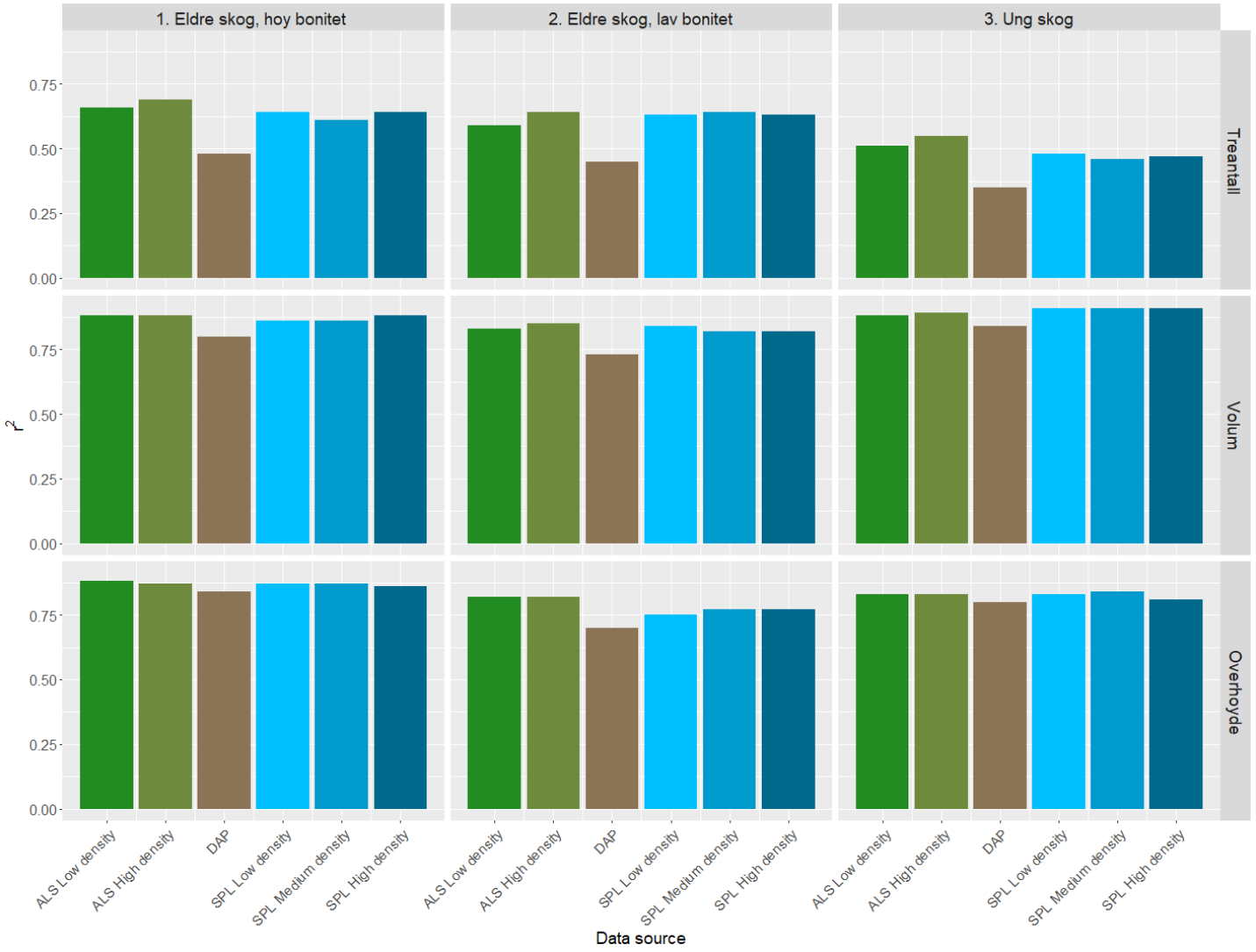


Resultat

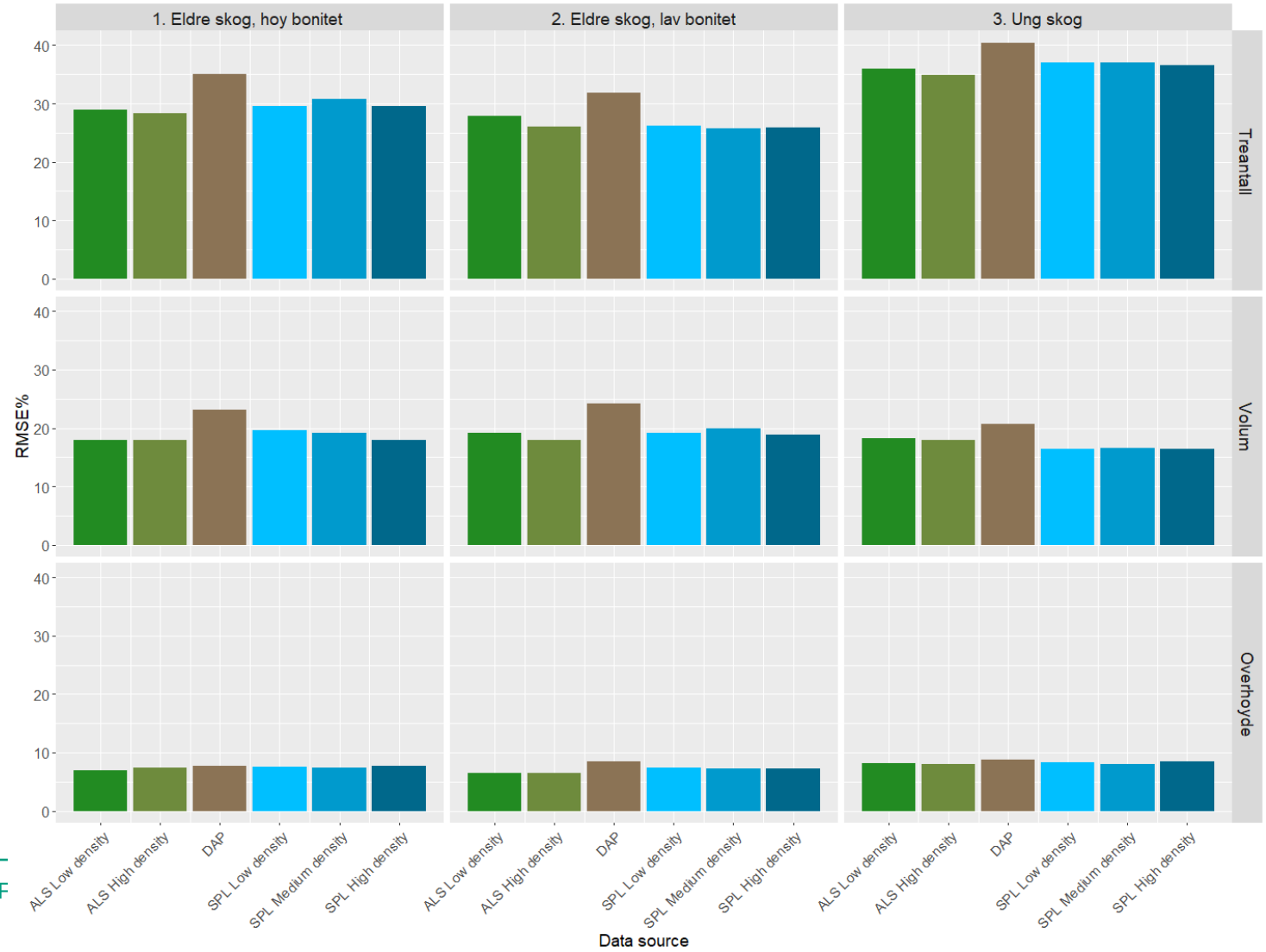
- Validering på:
  - Prøveflater



Resultat

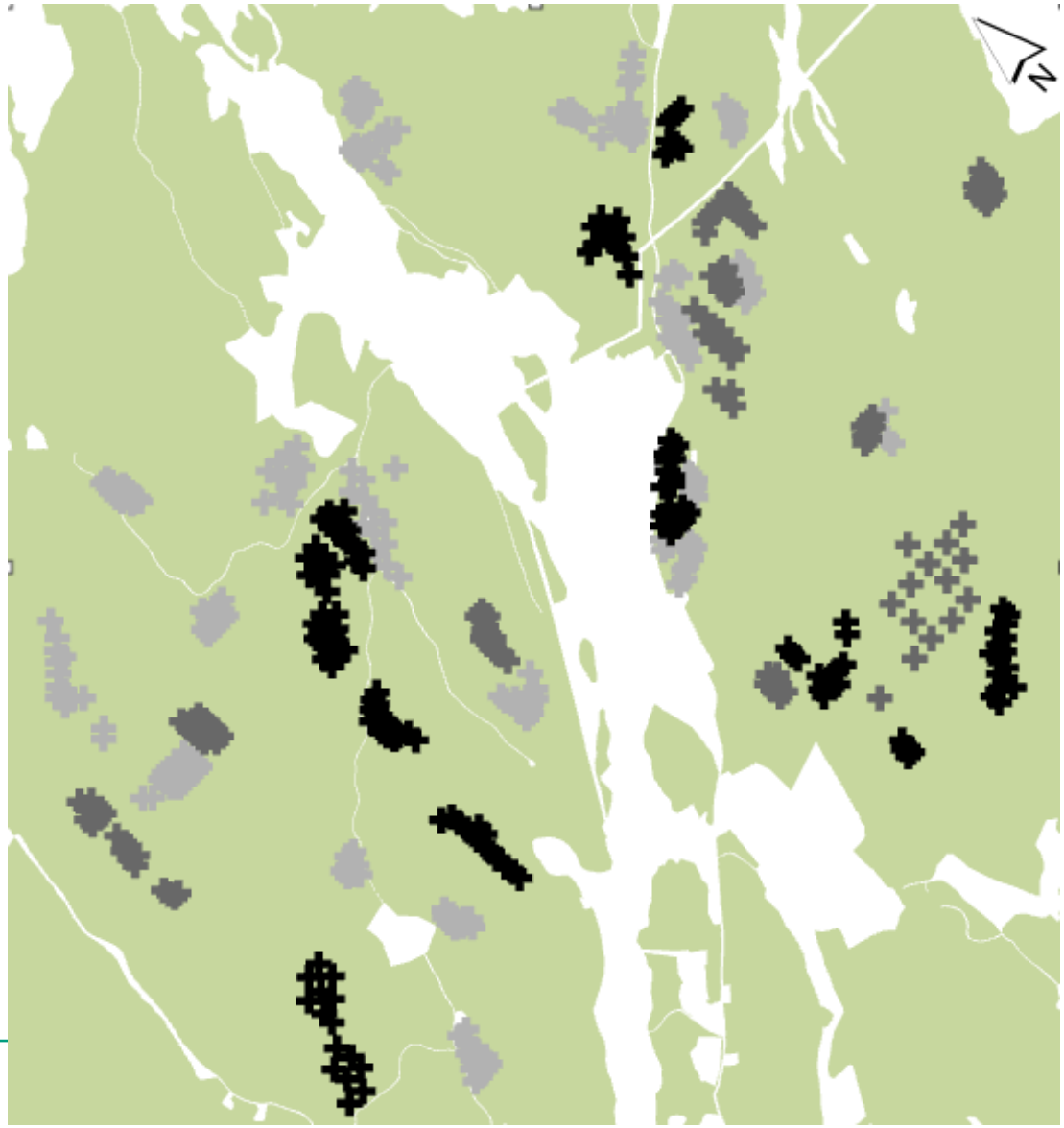

1. Eldre skog, hoy bonitet
2. Eldre skog, lav bonitet
3. Ung skog
Treantall
Volum
Overhoyde
r^2
0.00
0.25
0.50
0.75
ALS Low density
ALS High density
DAP
SPL Low density
SPL Medium density
SPL High density
Data source

Resultat

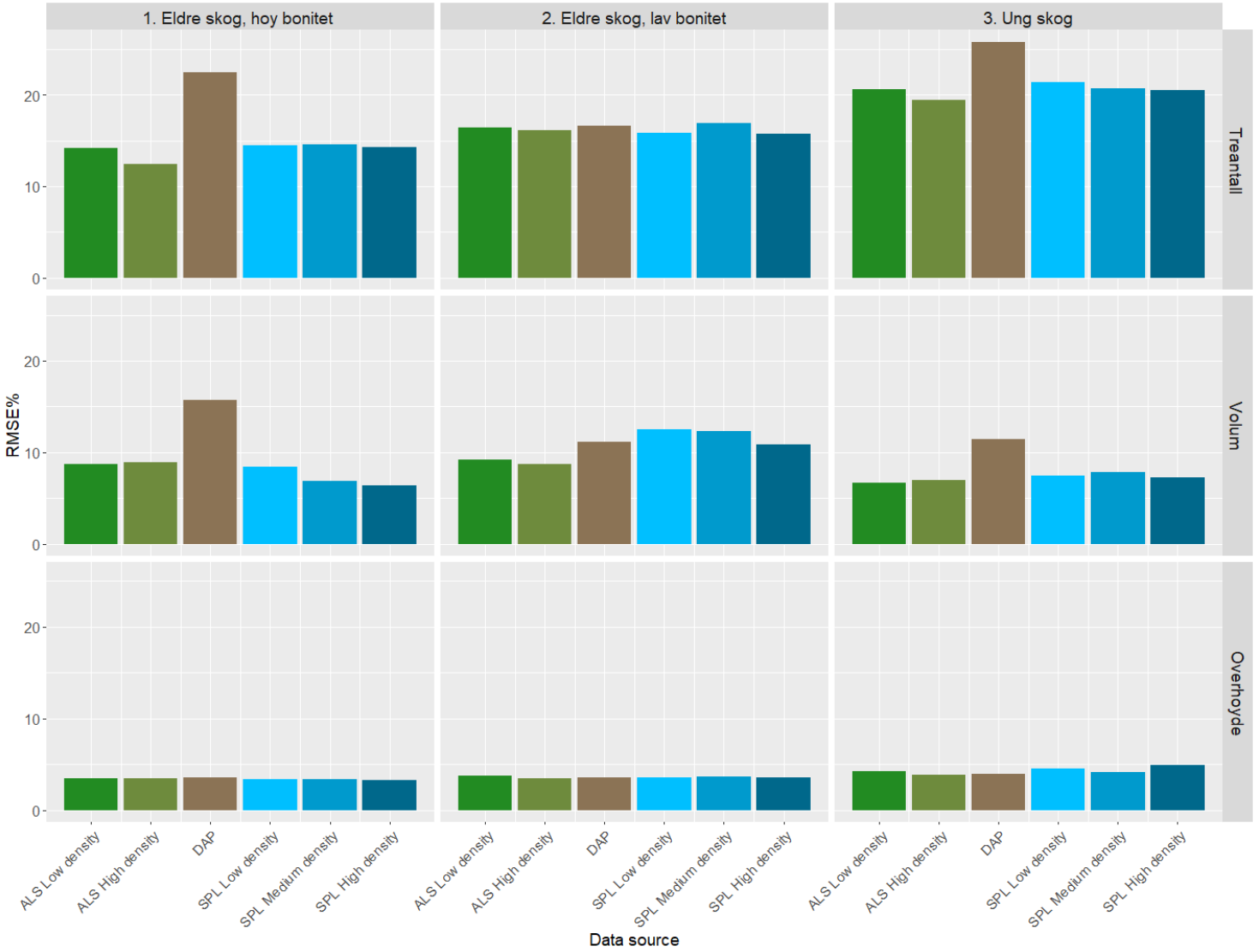

1. Eldre skog, hoy bonitet
2. Eldre skog, lav bonitet
3. Ung skog
Treantall
Volum
Overhoyde
RMSE%
0
10
20
30
40
ALS Low density
ALS High density
DAP
SPL Low density
SPL Medium density
SPL High density
Data source

Resultat

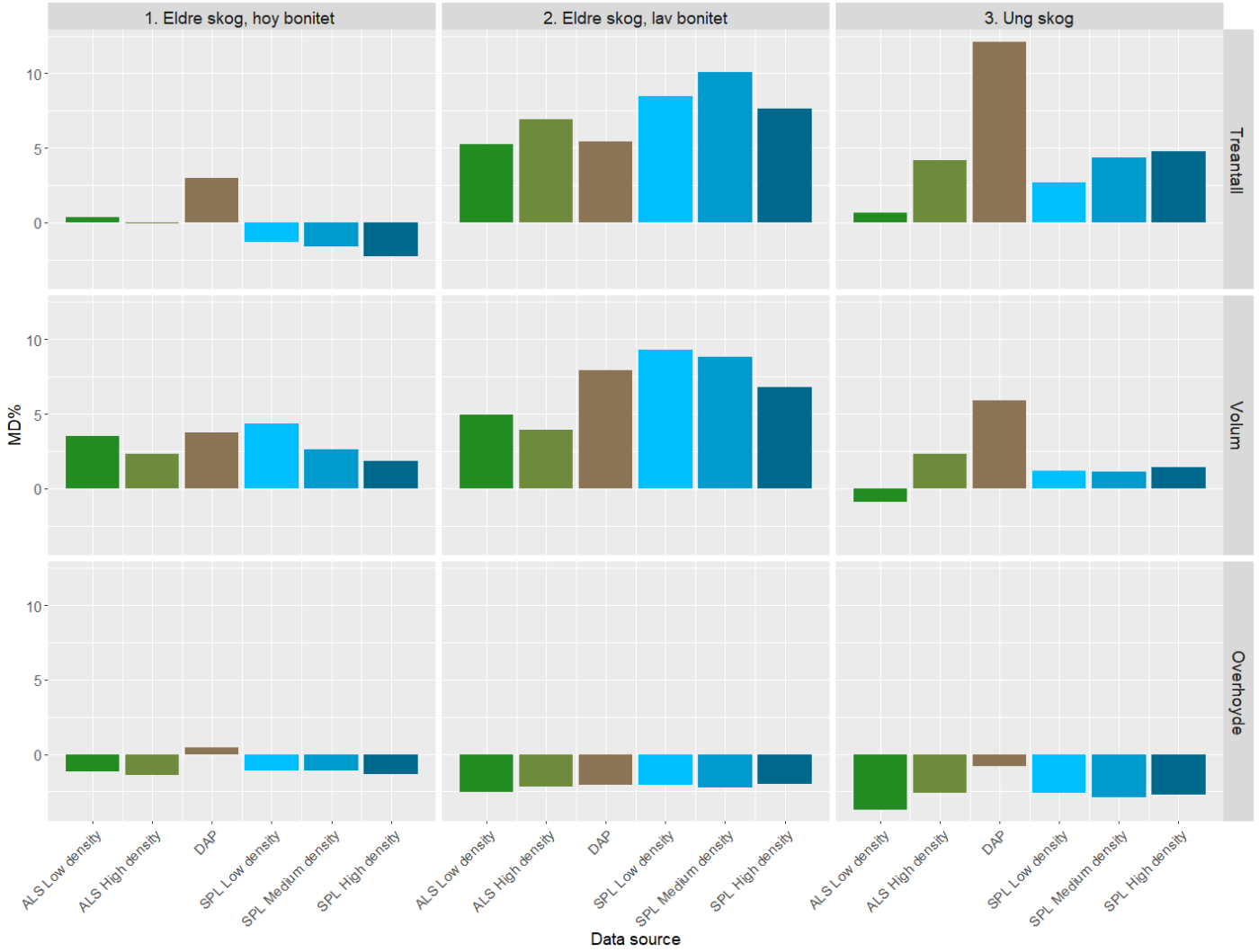
- Validering på:
  - bestandsflater



Resultat


1. Eldre skog, hoy bonitet
2. Eldre skog, lav bonitet
3. Ung skog
Treantall
Volum
Overhoyde
RMSE%
0
10
20
ALS Low density
ALS High density
DAP
SPL Low density
SPL Medium density
SPL High density
Data source

Resultat


1. Eldre skog, hoy bonitet
2. Eldre skog, lav bonitet
3. Ung skog
Treantall
Volum
Overhoyde
MD%
10
5
0
ALS Low density
ALS High density
DAP
SPL Low density
SPL Medium density
SPL High density
Data source

Diskusjon

- Fotonlaser
  - Nøyaktighetsnivå for prediksjoner av skoglige variabler på linje med resultat fra vanlig laser
  - Vesentlig bedre enn bildematching
- Hvorfor samlet vi ikke data fra enda større flyhøyde?

Konklusjon

- Det bør være mulig å få lasersensorer i fremtiden som er bedre tilpasset skogkartlegging!

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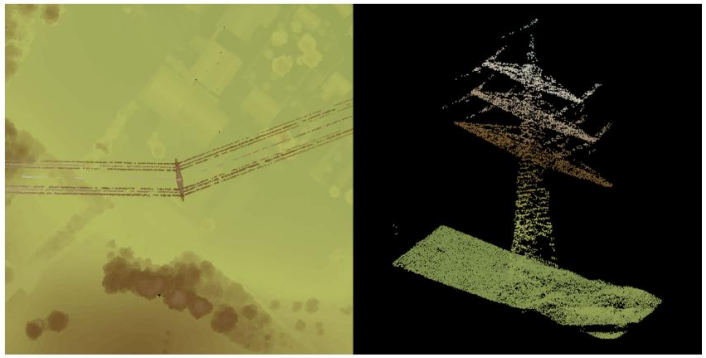
New single photon LiDAR technology boosts the efficiency of large-area airborne mapping projects

24 September 2024

(Heerbrugg, 24/09/2024) Leica Geosystems, part of Hexagon, today announced a new high-performance single photon LiDAR (SPL) technology that can be integrated into hybrid sensors to boost the efficiency of country-wide geospatial data collection.

With an expanded 60-degree field of view and over 500 measurement channels, the new single photon LiDAR technology significantly surpasses the capability of the previous version, delivering unmatched data collection performance over large areas in less time. The new SPL module was designed to integrate into a hybrid sensor; it is fully compatible with all Leica Geosystems peripherals, including the Leica PAV200 gyro-stabilised mount.

By collecting over 14 million measurements per second, the new SPL provides more than a fivefold increase in LIDAR collection rates compared to traditional linear-mode LiDAR. This advancement allows users to significantly expand the availability and timeliness of high-resolution LiDAR data.



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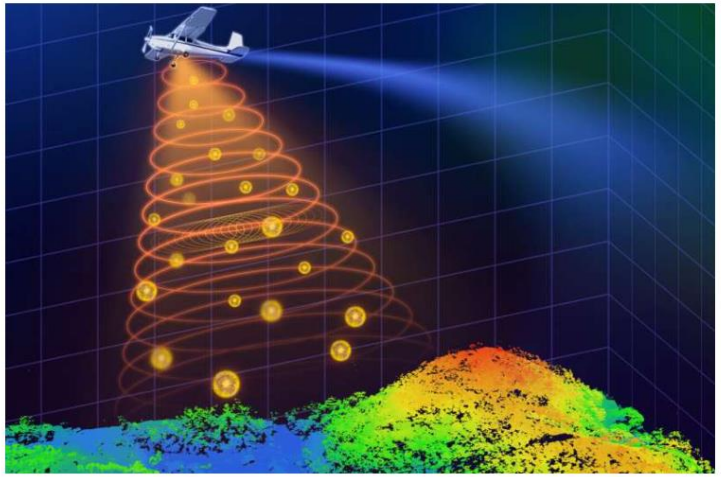
APRIL 25, 2024 Editors' notes

Airborne single-photon lidar system achieves high-resolution 3D imaging

by Optica



A new compact and lightweight single-photon airborne lidar system could make single-photon lidar prac...

Takk for oppmerksomheten!