Single-tree positioning using harvester - Experiences from an operational implementation

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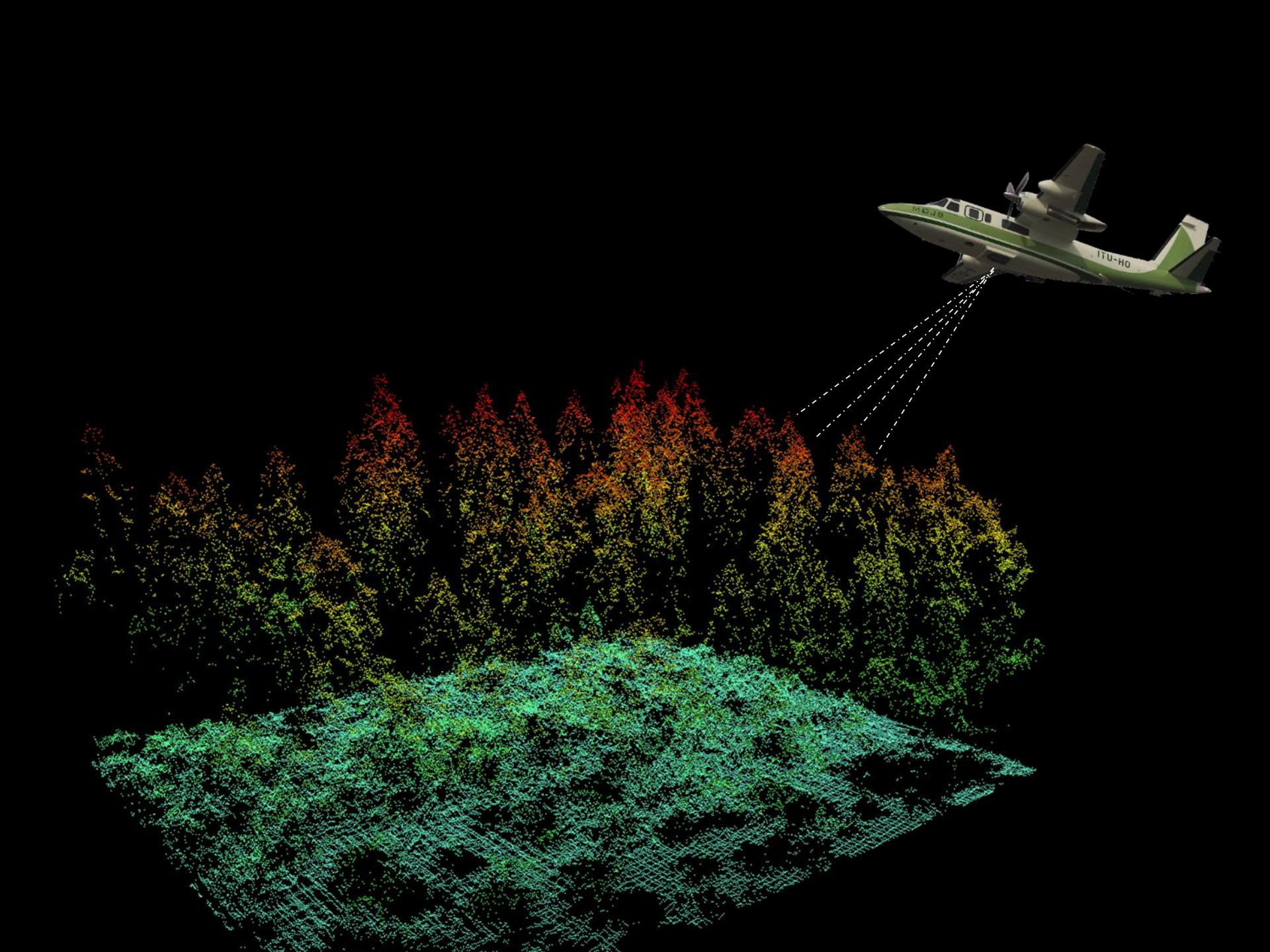
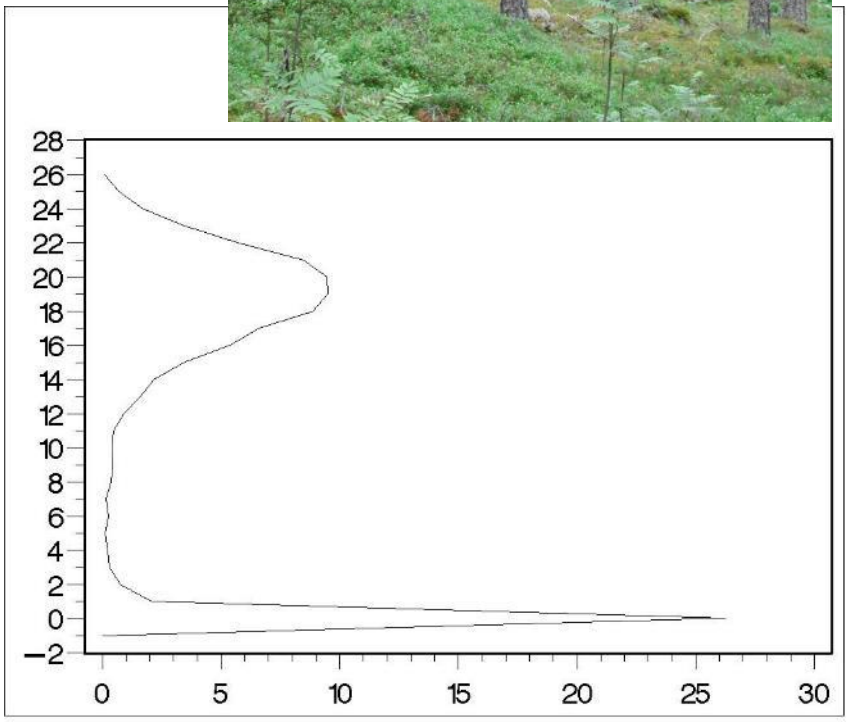
Background: Manual registrations on field plots

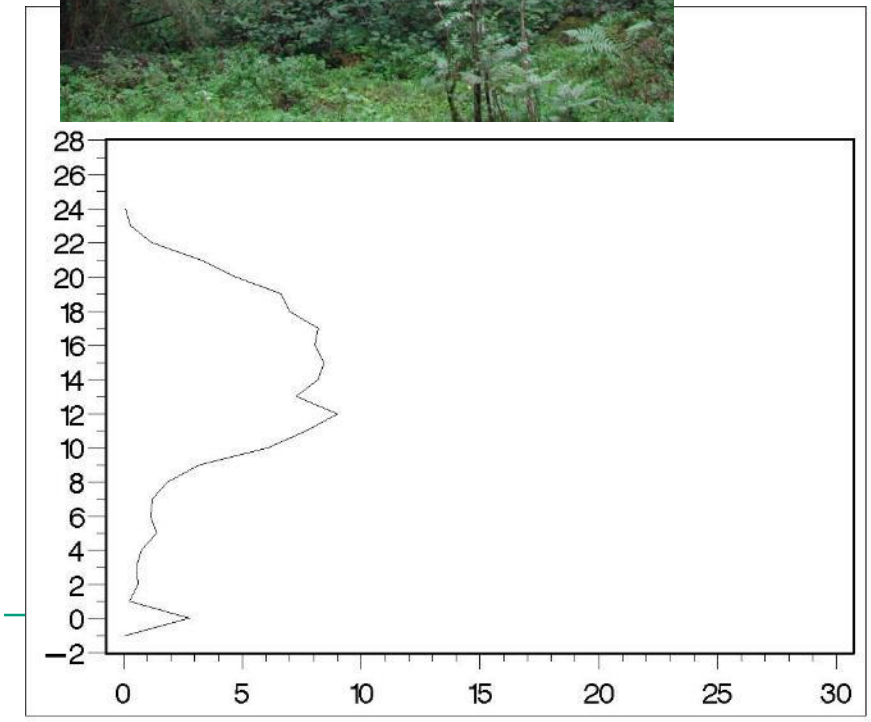
Remote sensing-based inventories typically relies on field reference data in the form of manual measurements on sample plots

- Diameter at breast height (DBH)
- Species
- Height
- Plot coordinates

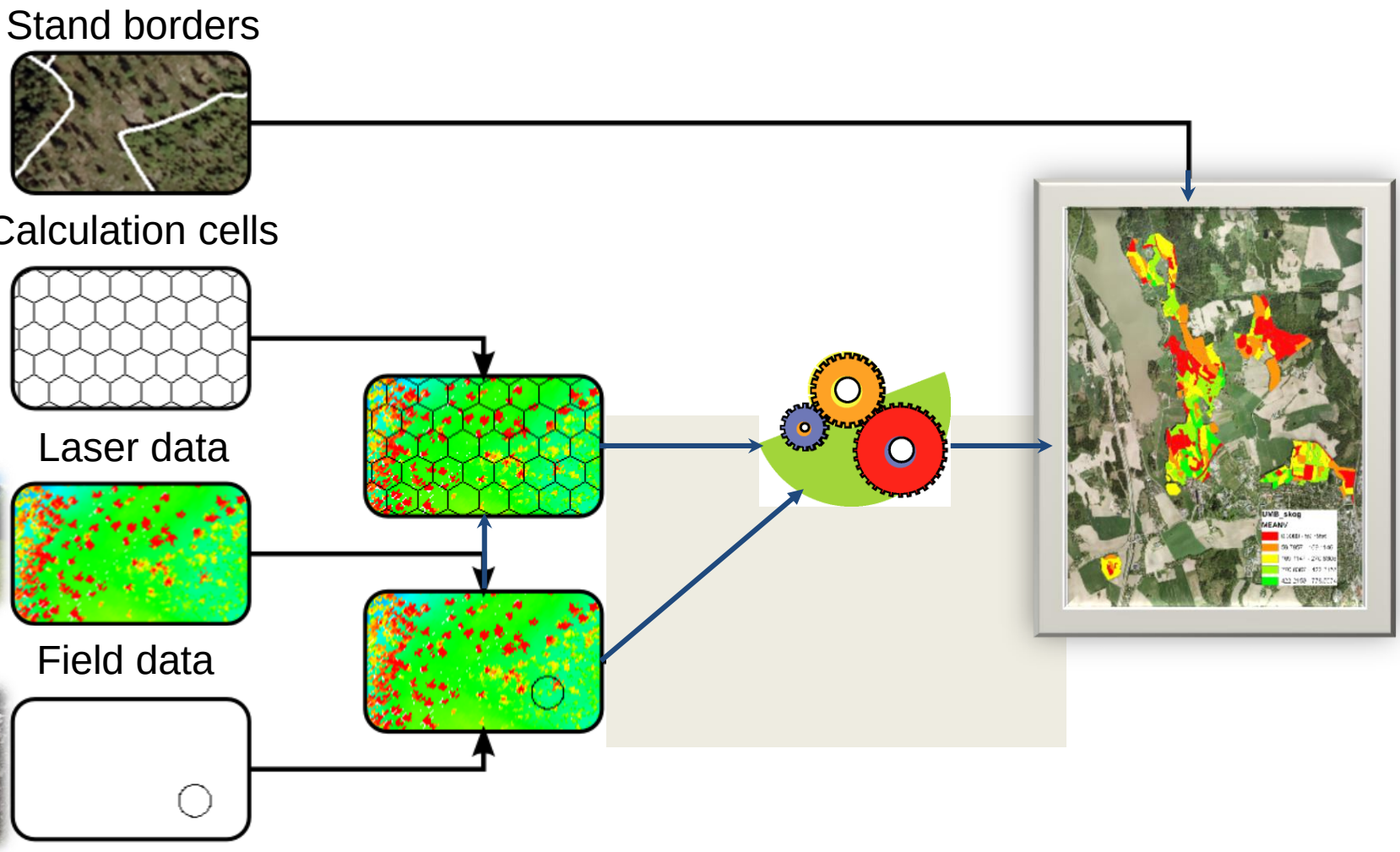

MOJS
ITU-HO

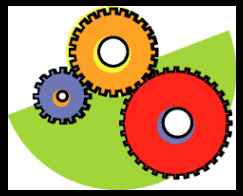
Forest inventory

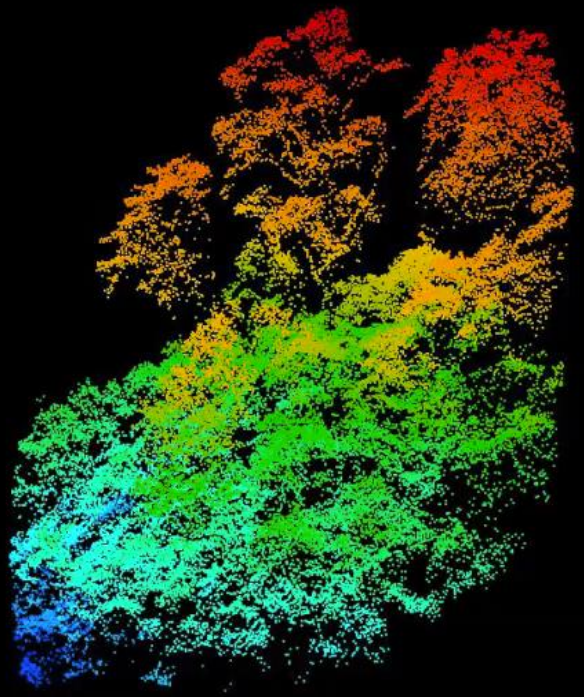


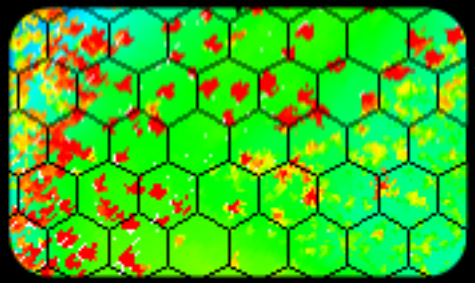


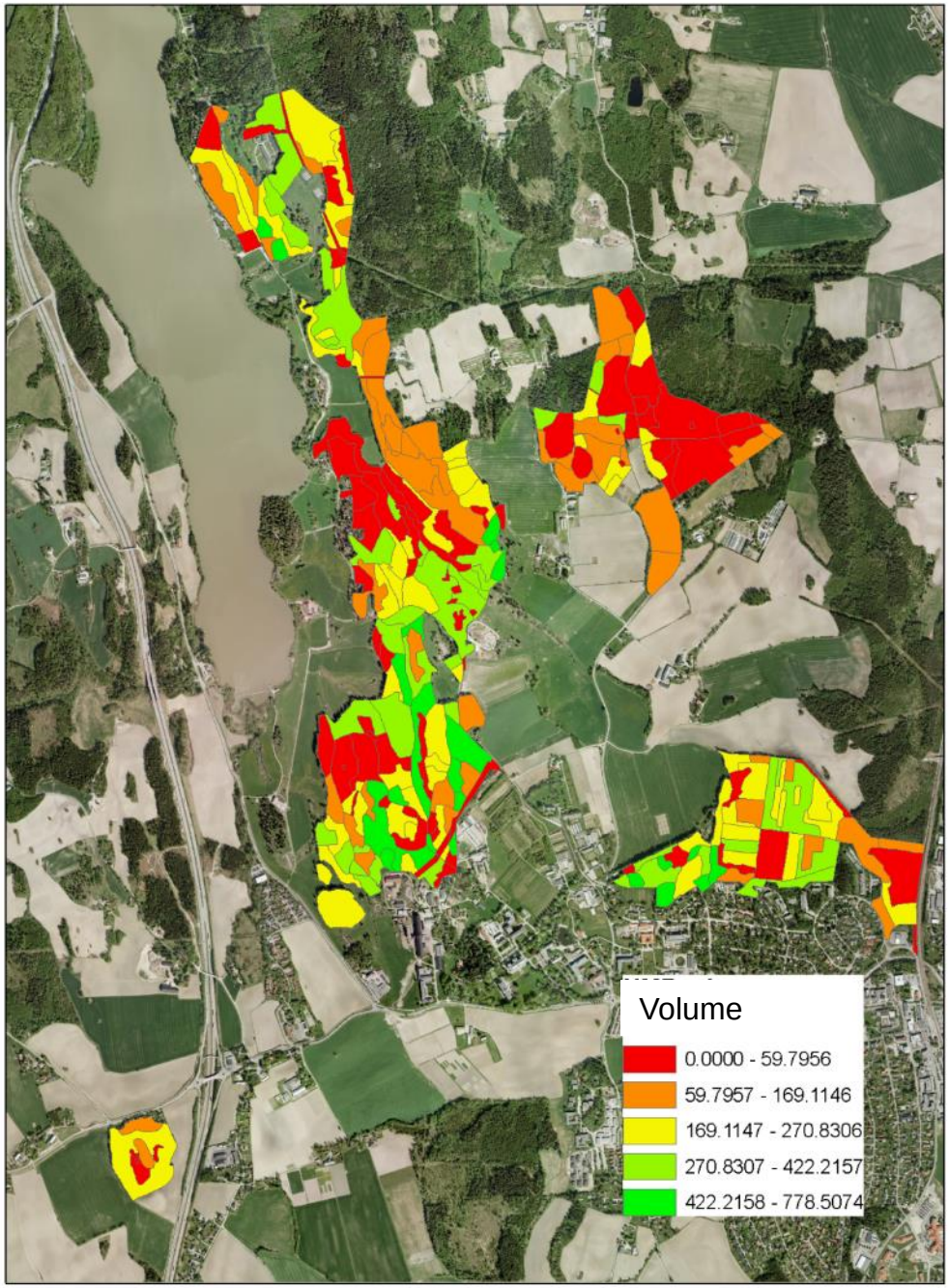
The area based approach:
Combine field, laser, and map data











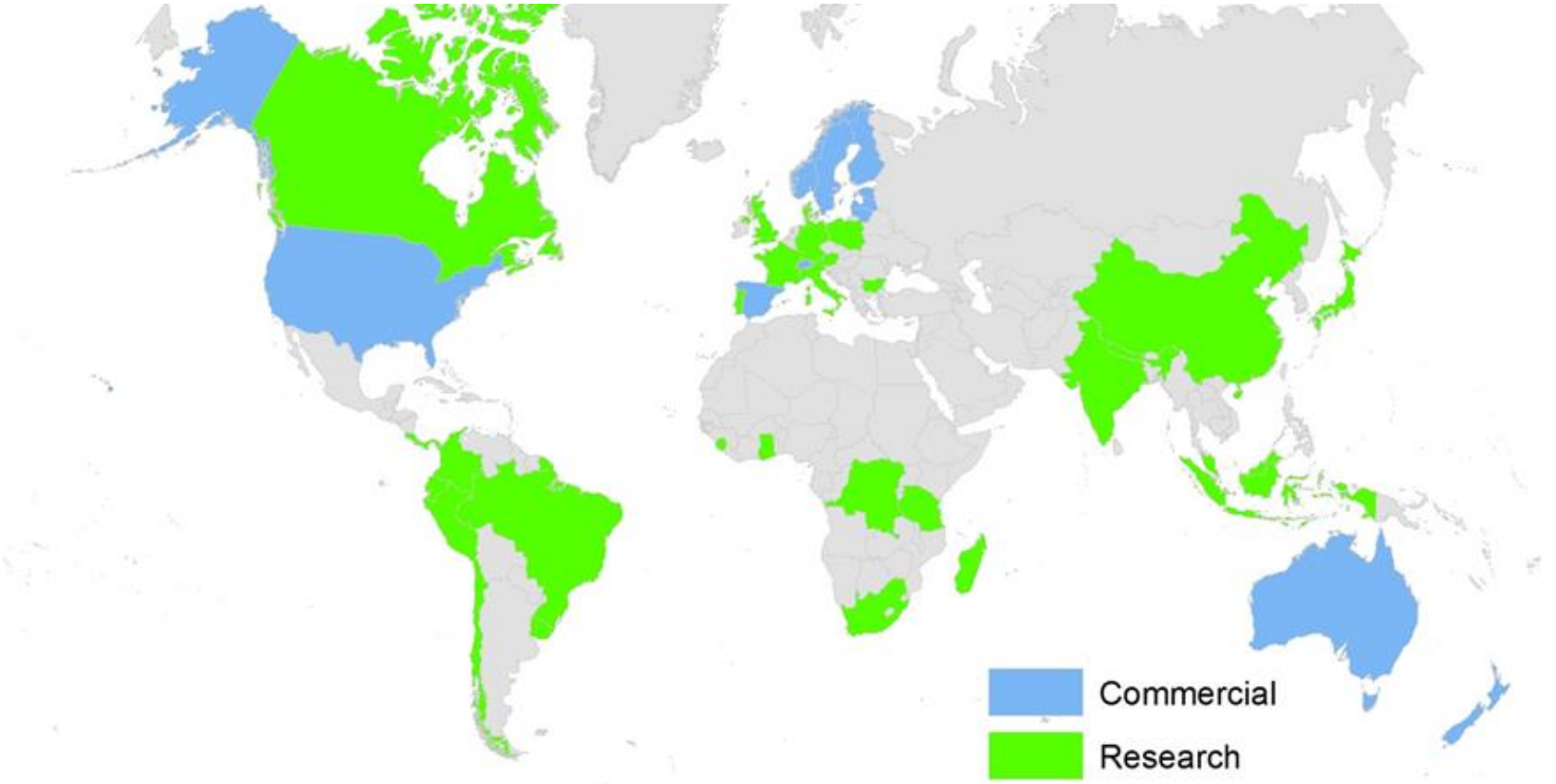
Prof Erik Næsset was awarded the 2011 Marcus Wallenberg Prize for his path breaking research that incorporates the airborne laser scanning method as an integral part of forest inventory.

The area-based approach

Countries where work has been documented or reported to be in progress

2002: Wall-to-wall FMI with ALS tested and documented (Næsset 2002).
Profitable compared to conventional methods (Eid et al. 2004).

2002: First operational and commercial FMI with ALS conducted (46,000 ha)



Costs

- The cost of the field plot inventory is a substantial part of the total inventory cost….

The harvester as a field worker

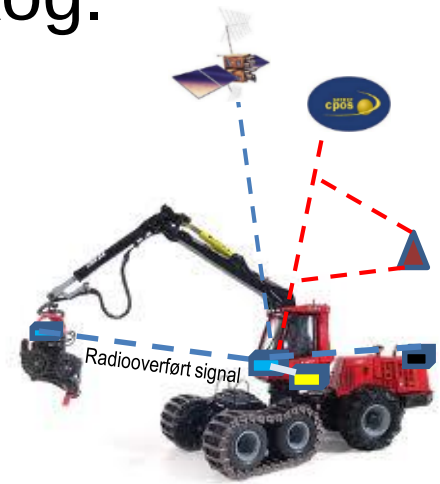
In modern harvesters information is registered for the harvested trees:

- DBH
- Species
- Length (to last cut)

However, the geo-referencing of the trees is not precise enough.

Project background

- Initiative from Viken Skog.



- Research project funded by the Norwegian research council
  - Project period: 2013-2017.

DIGPILOT — JOHN DEERE — VIKEN SKOG — Kartverket

Project tasks

- Develop a harvester head position system
- Develop a forest inventory system
- Develop methods to predict wood quality

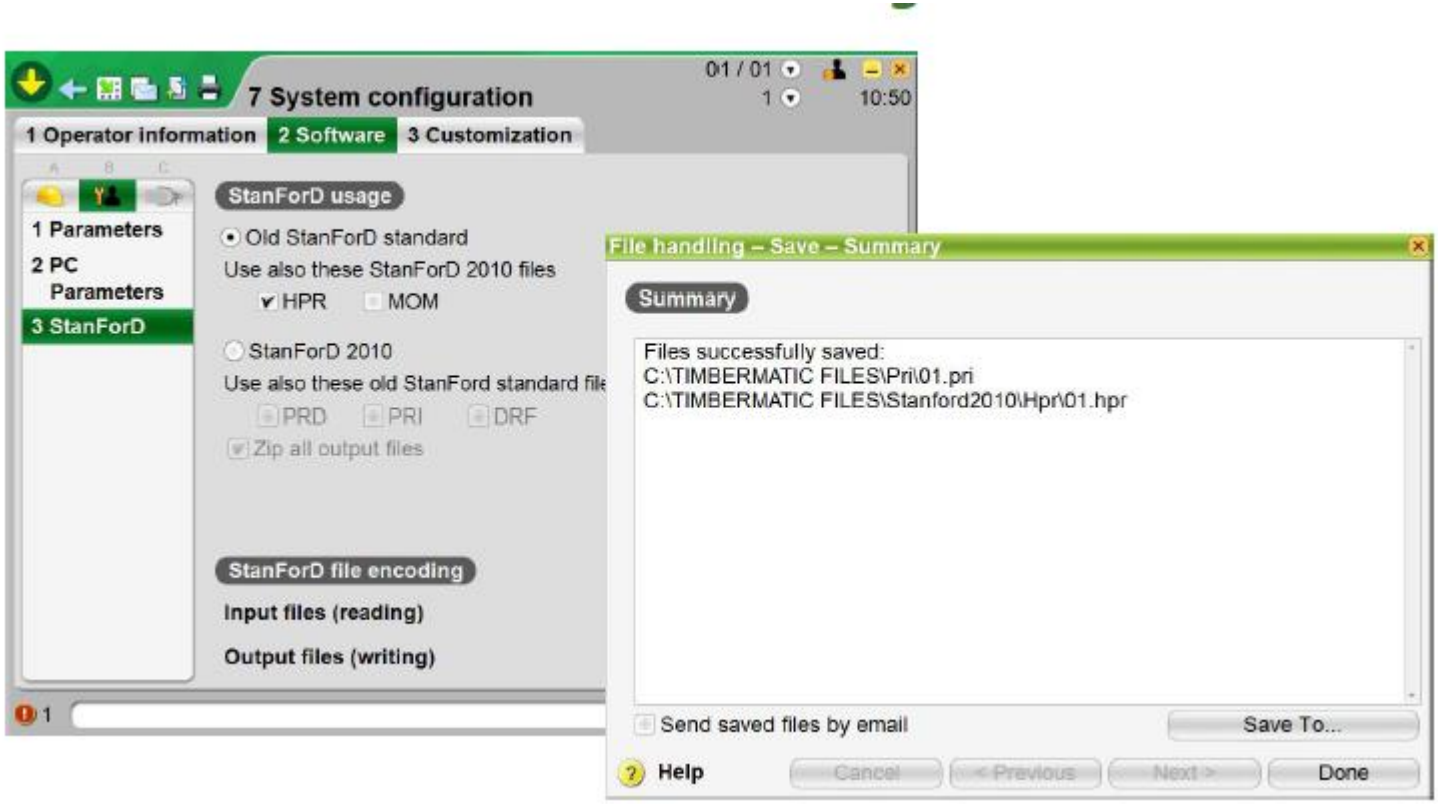
Norway GPS study

Timbermatic system update

Ilari Virtanen 2.10.2013

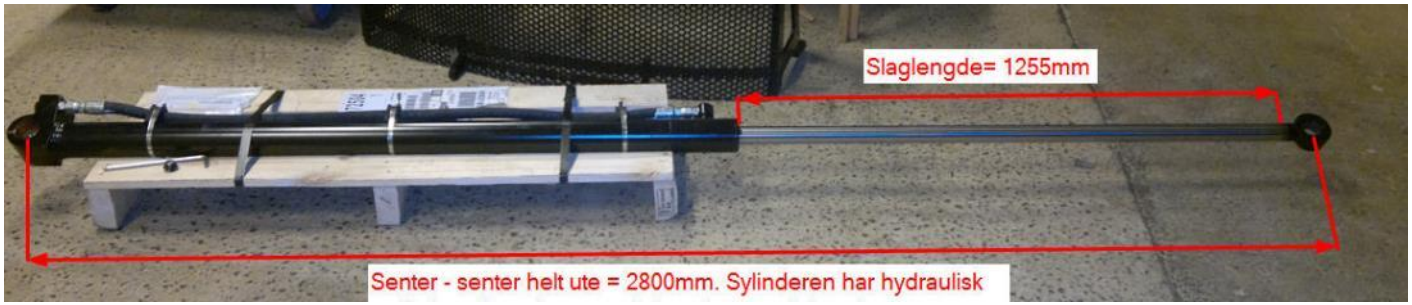
JOHN DEERE

Timbermatic selections



System

- Updated software from John Deere
  - June 2014.
- Developed a new customised cylinder to get information about the crane length.
  - February 2015.



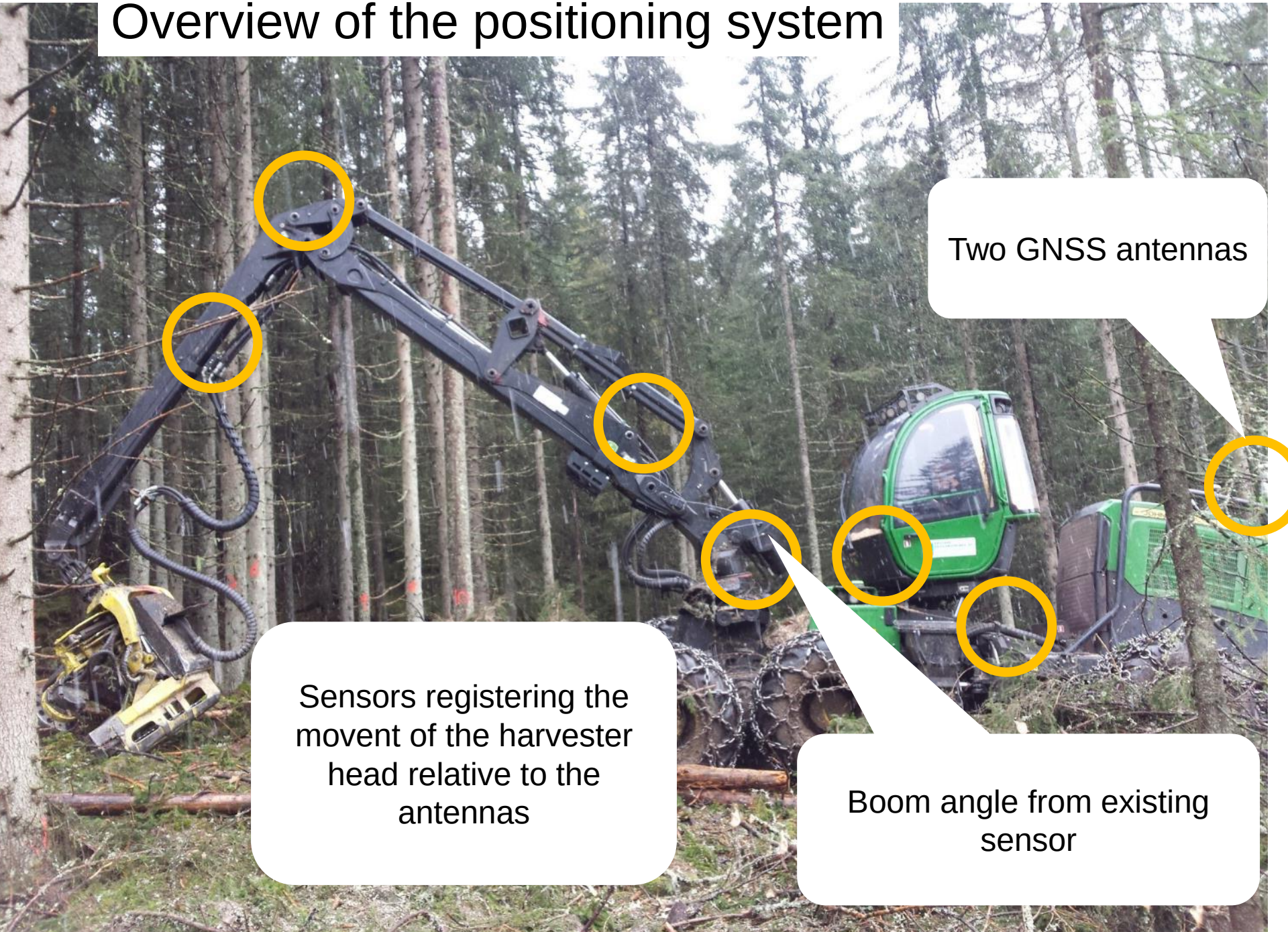
Simulator testing February 2015

Installation May 2015

Installation May 2015


Fix
RTK fix
Lengdegrad
1114.82446
Breddegrad
6010.76405
Ellipsoide høyde
244.95
Incoming JD
$CAN,T=1,S=-10,X=4.5,Y=0.
Angle boom
9.999999
Lengde stikke
4.199389
Vinkel mellom maskin
-53.63709
Vinkel stikke
41.06303

Overview of the positioning system



Simple GPS for comparison

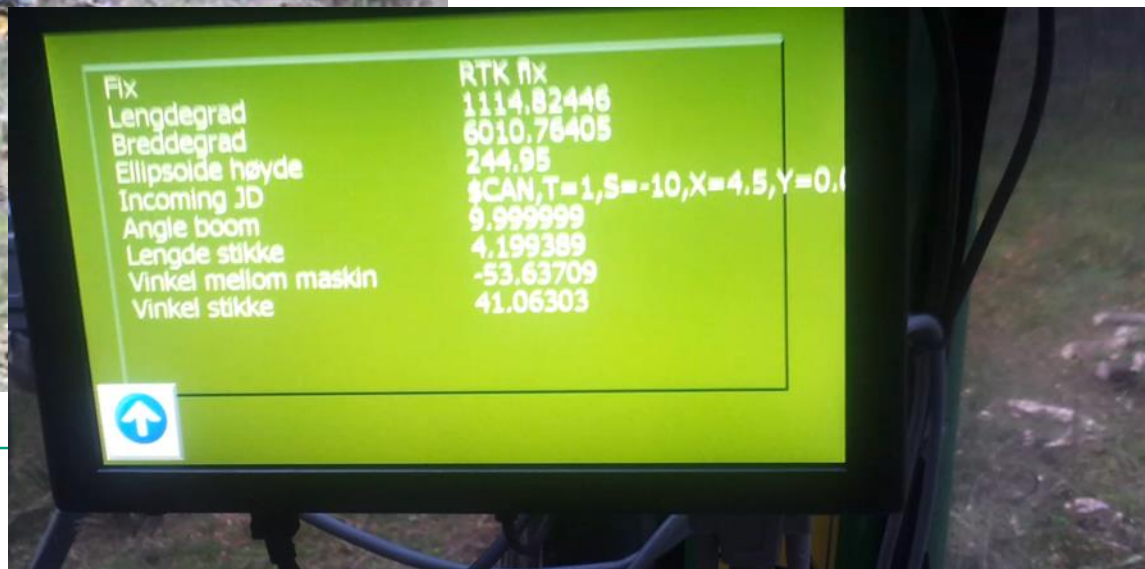
A few challenges…

- Fall 2014: Discussions regarding patents
- Spring 2015: Capasity challenges at John Deere to mount the system
- May 2015: Discussion regarding compensation to the machine owner and driver
- June 2015: Frustration reagarding:
    - Production failure cylinder.
    - Elektronical problem at the harvester.
    - GPS cable breakage
- …
- ..

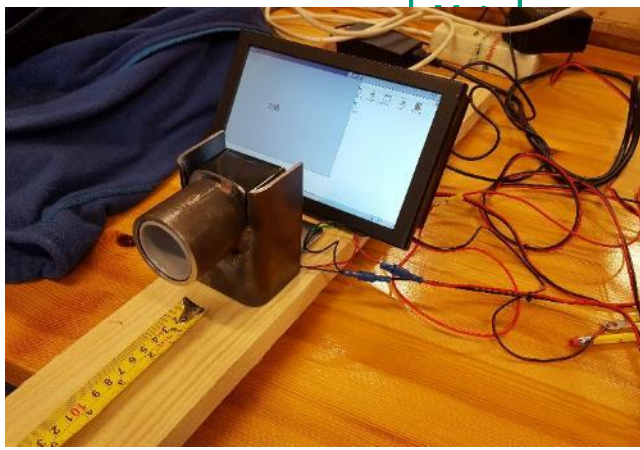
New cylinder

Control measurements

- GNSS measurements
- Video filming inside and outside the machine

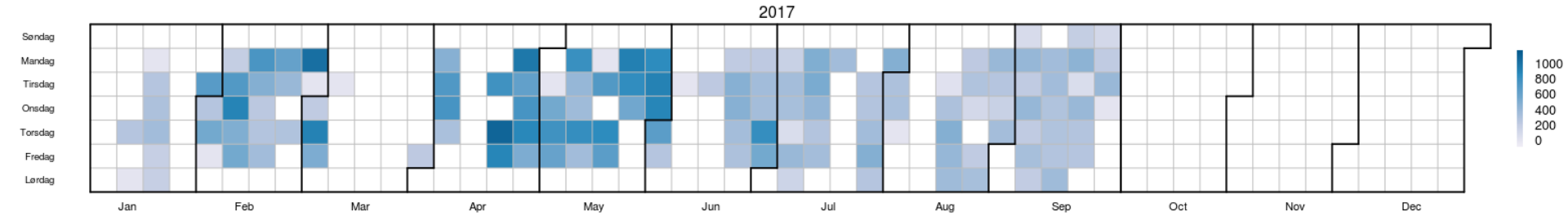


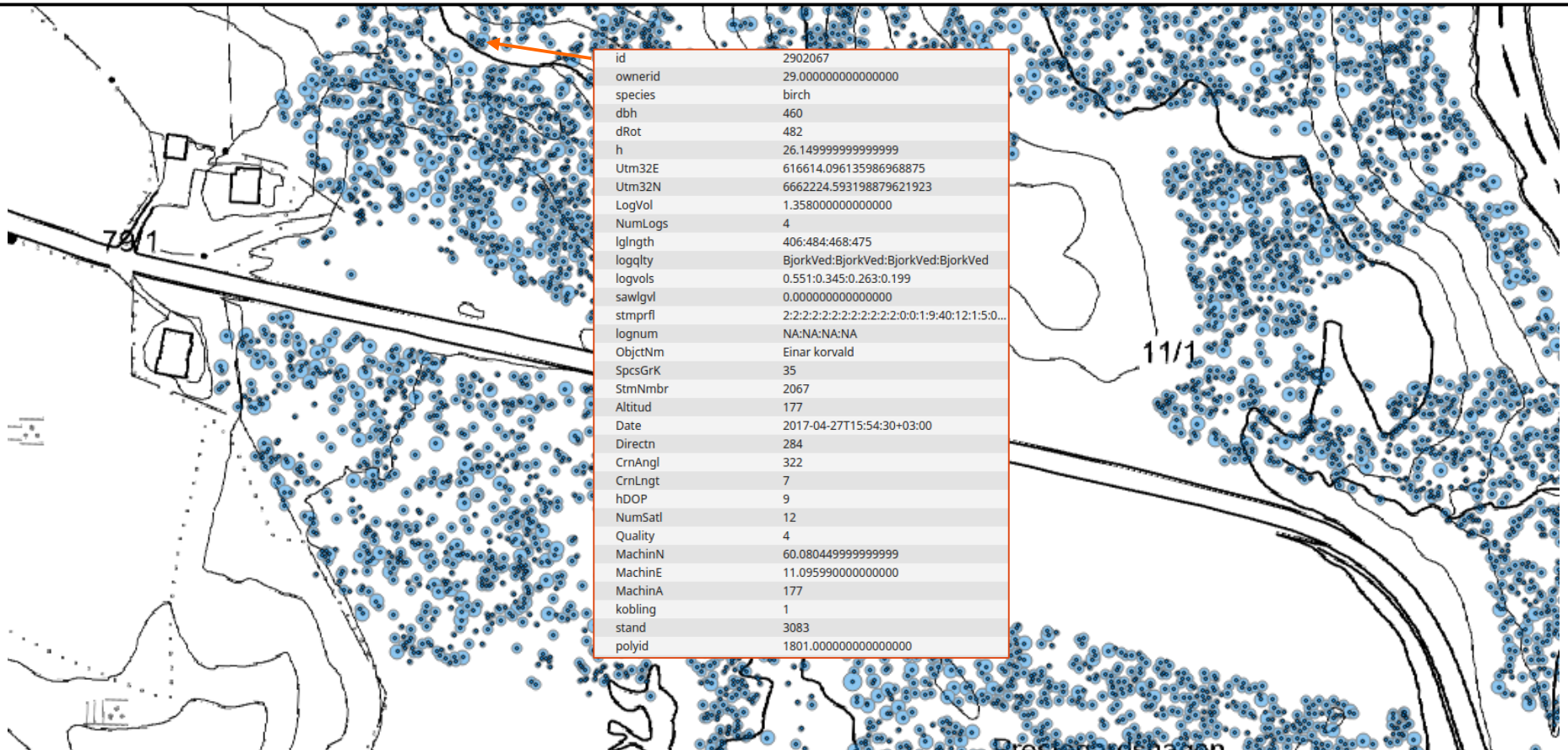
More challenges



- The crane cylinder broke several times…
  - Replaced by a sonar sensor
- Computer capasity problems
  - Save more data in the DigPilot system
- Stable system November 2016

Data collection





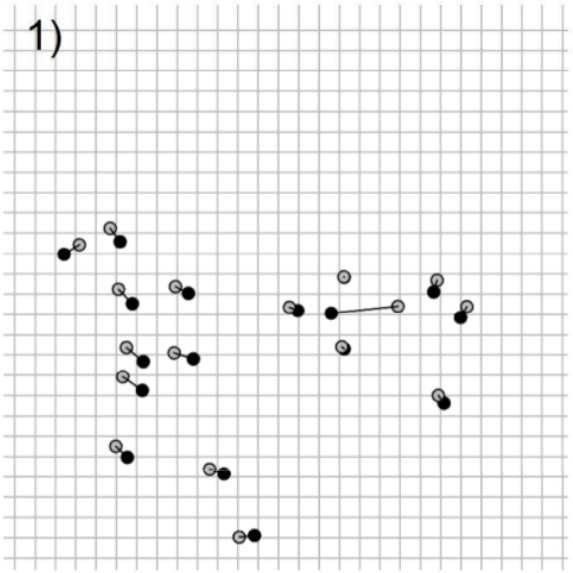
id	2902067
ownerid	29.000000000000000
species	birch
dbh	460
dRot	482
h	26.149999999999999
Utm32E	616614.096135986968875
Utm32N	6662224.593198879621923
LogVol	1.358000000000000
NumLogs	4
lglngth	406:484:468:475
logqlty	BjorkVed:BjorkVed:BjorkVed:BjorkVed
logvols	0.551:0.345:0.263:0.199
sawlgvl	0.000000000000000
stmprfl	2:2:2:2:2:2:2:2:2:2:2:2:0:0:1:9:40:12:1:5:0...
lognum	NA:NA:NA:NA
ObjctNm	Einar korvald
SpcsGrK	35
StmNmbr	2067
Altitud	177
Date	2017-04-27T15:54:30+03:00
Directn	284
CrnAngl	322
CrnLngt	7
hDOP	9
NumSatl	12
Quality	4
MachinN	60.080449999999999
MachinE	11.095990000000000
MachinA	177
kobling	1
stand	3083
polyid	1801.000000000000000

Positional accuracy

The results after comparing with multiple control measurements shows that the system obtain single tree positions with a mean error of 0.94 m.

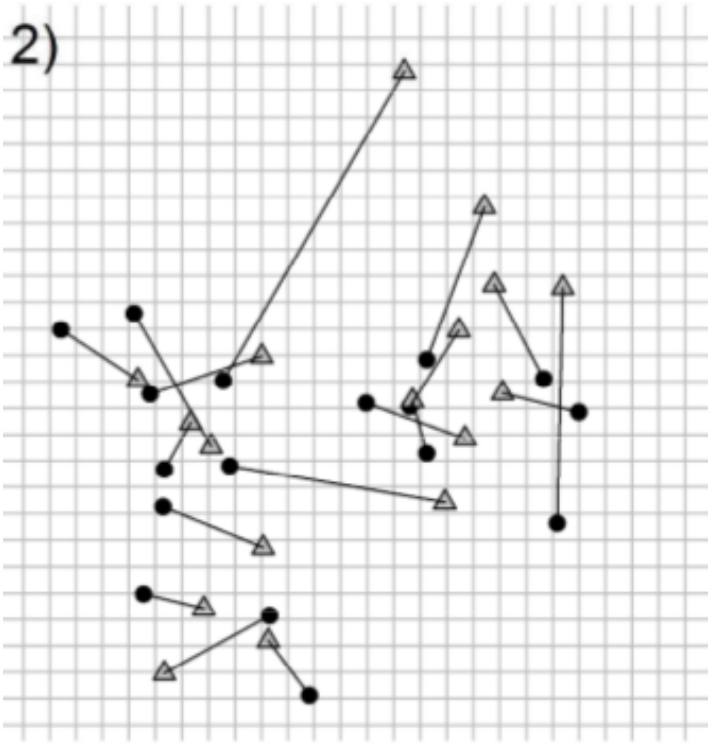
Largest error found was 3.32 m.

The first testing and evaluation of this system is documented in a published paper:



*Hauglin, M., Hansen, E.H., Næsset, E., Busterud, B.E., Gjevestad, J.G.O., Gobakken, T., **2017**. Accurate single-tree positions from a harvester: a test of two global satellite-based positioning systems. **Scandinavian Journal of Forest Research.**.*

Positional accuracy – simple GPS



- Relatively large errors.
- Mean error of 7 m
- For the 73 controlled trees we had several trees with more than 20 m error.

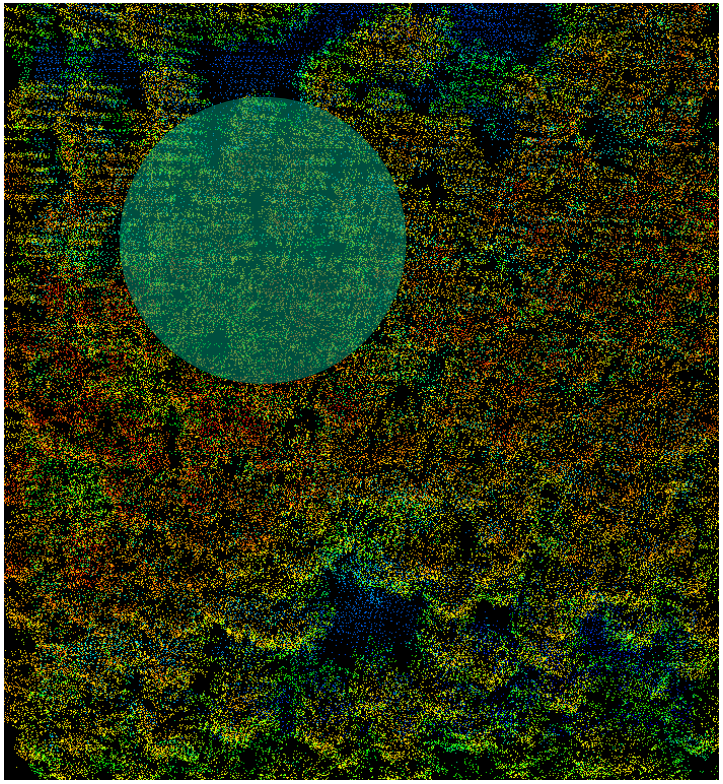
Additional available information

Additional information is available in the harvester data, such as

- Stem profile
- Assortment class / quality

Data material – ALS data

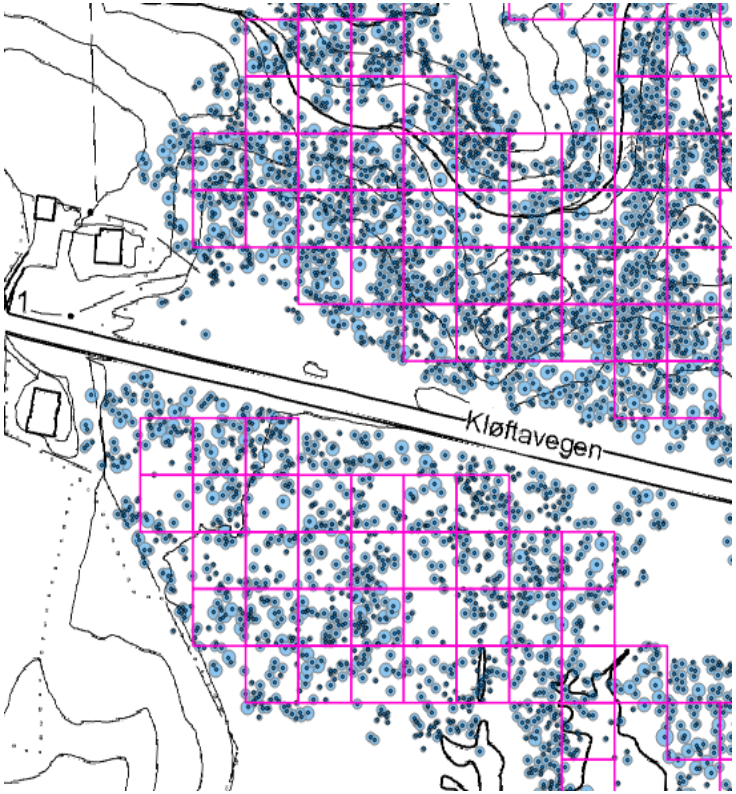
field reference plot



ALS data with a point density of 0.7 points per m^2.

Acquired in 2013 with a Leica ALS70.
Pulse repetition freq. 104.6 kHz
Scan angle +- 16º

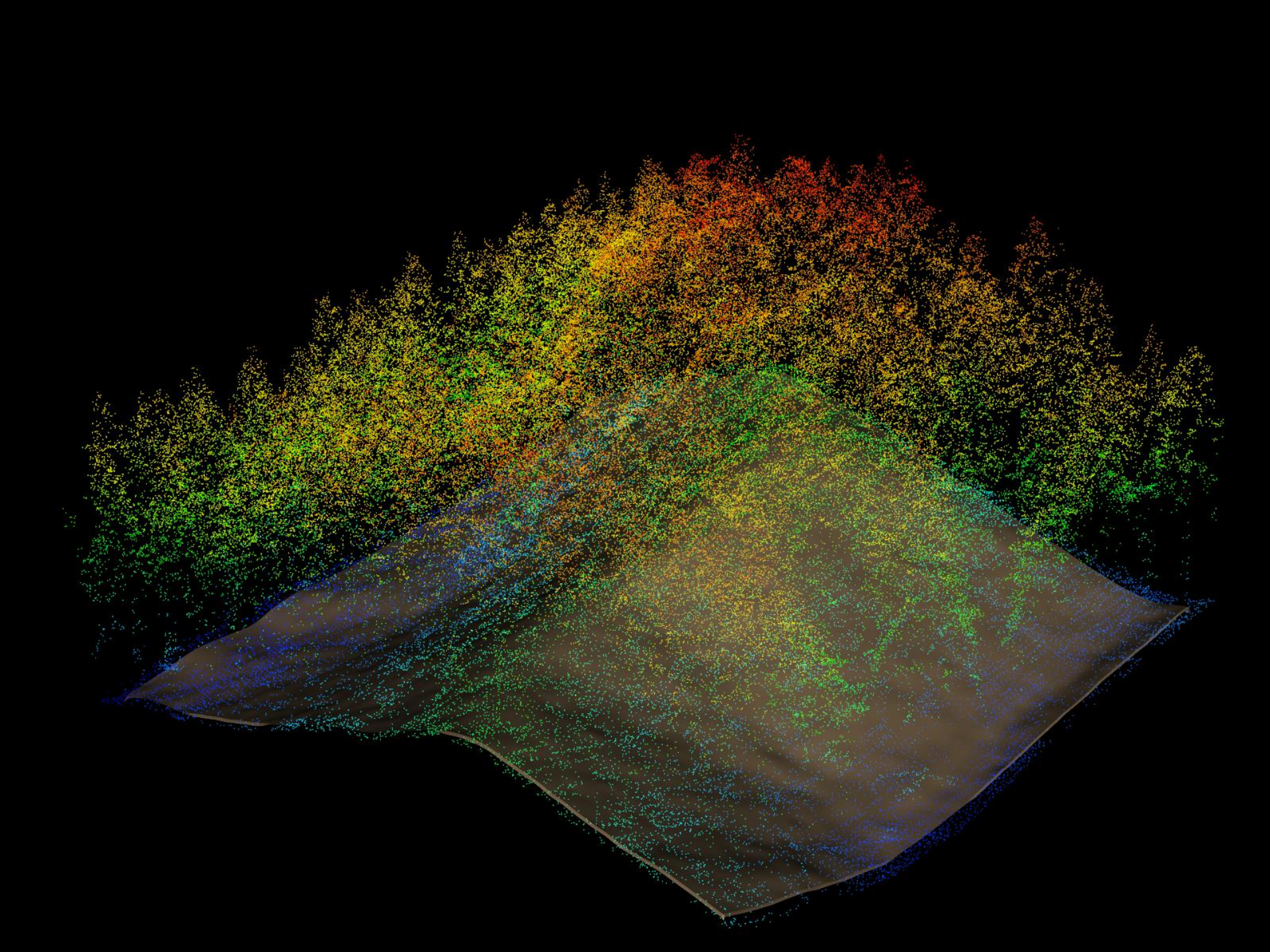
Simulated field plots from harvester data

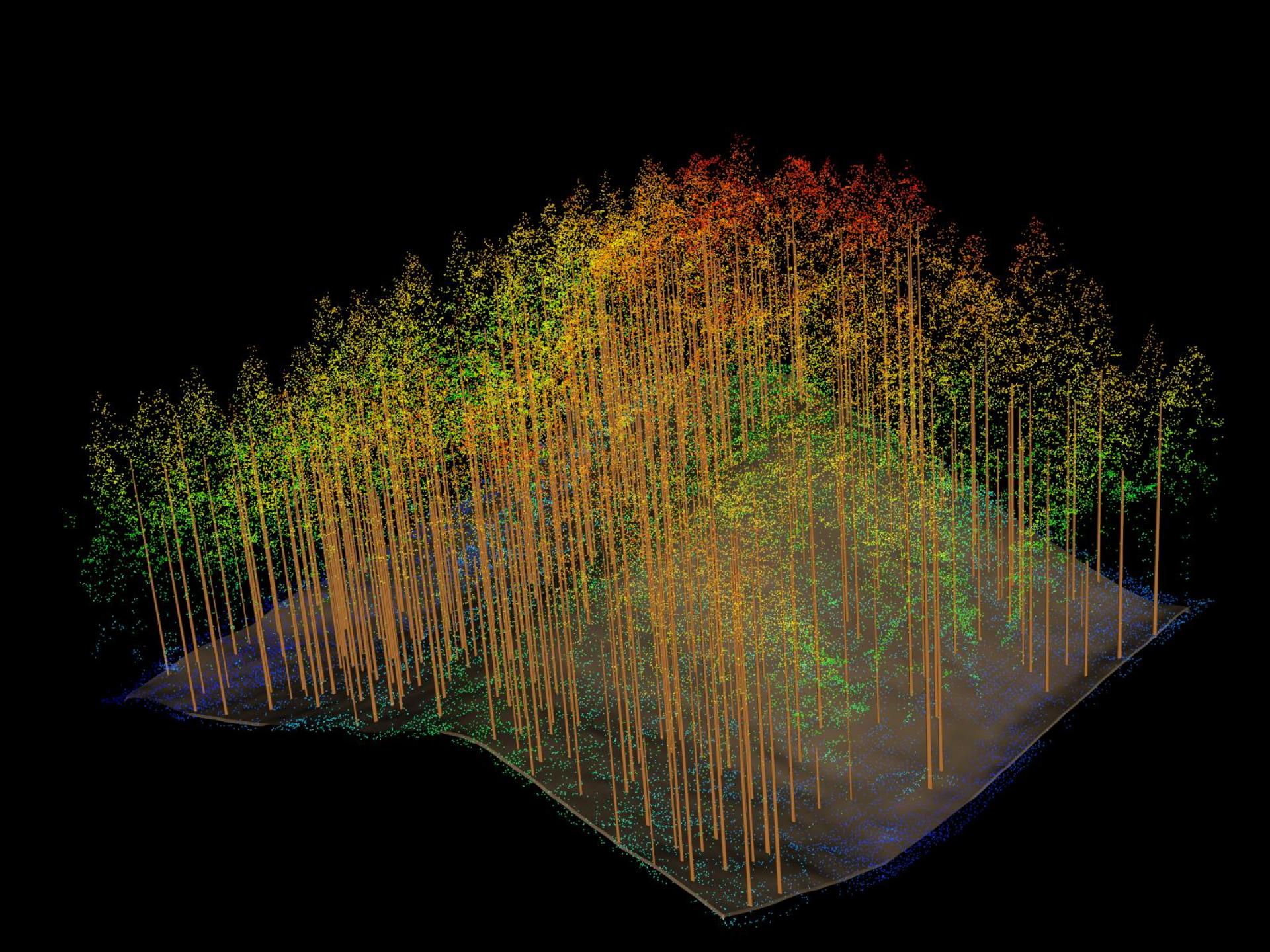


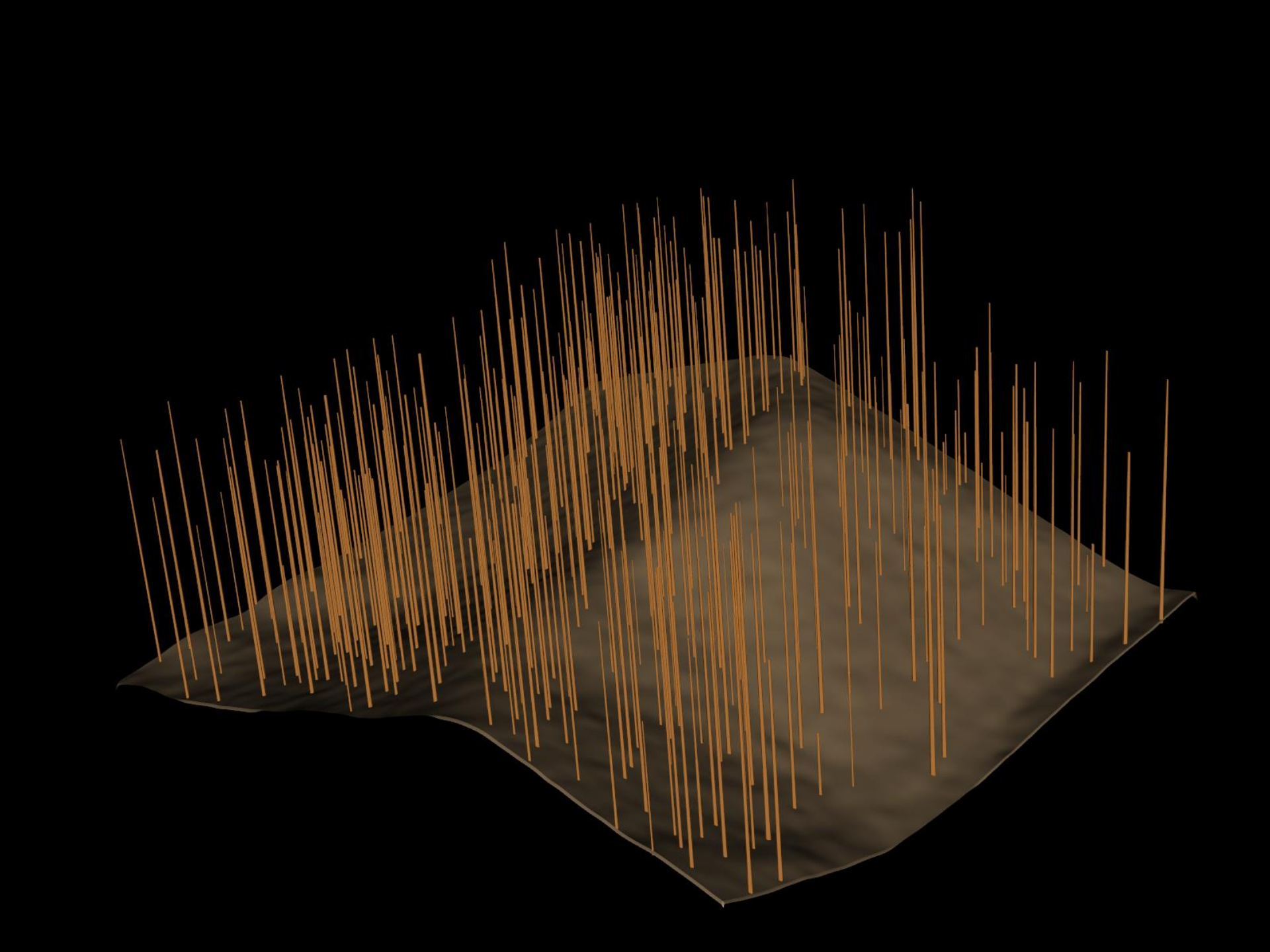
Field plots

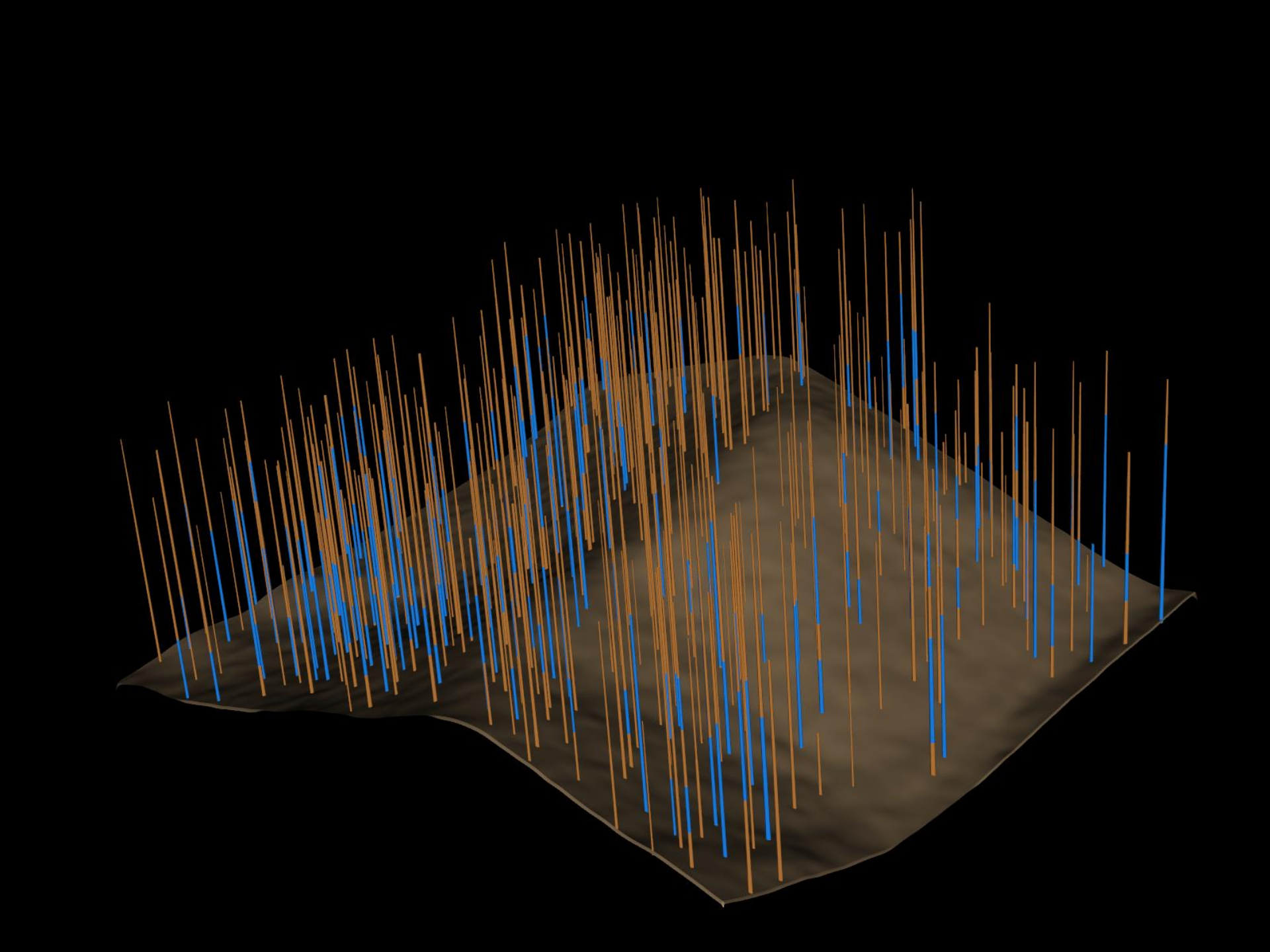
55 000 trees
75 ha

200 m^2 – 2318 plots
400 m^2 – 950 plots
900 m^2 – 285 plots
1600 m^2 – 98 plots









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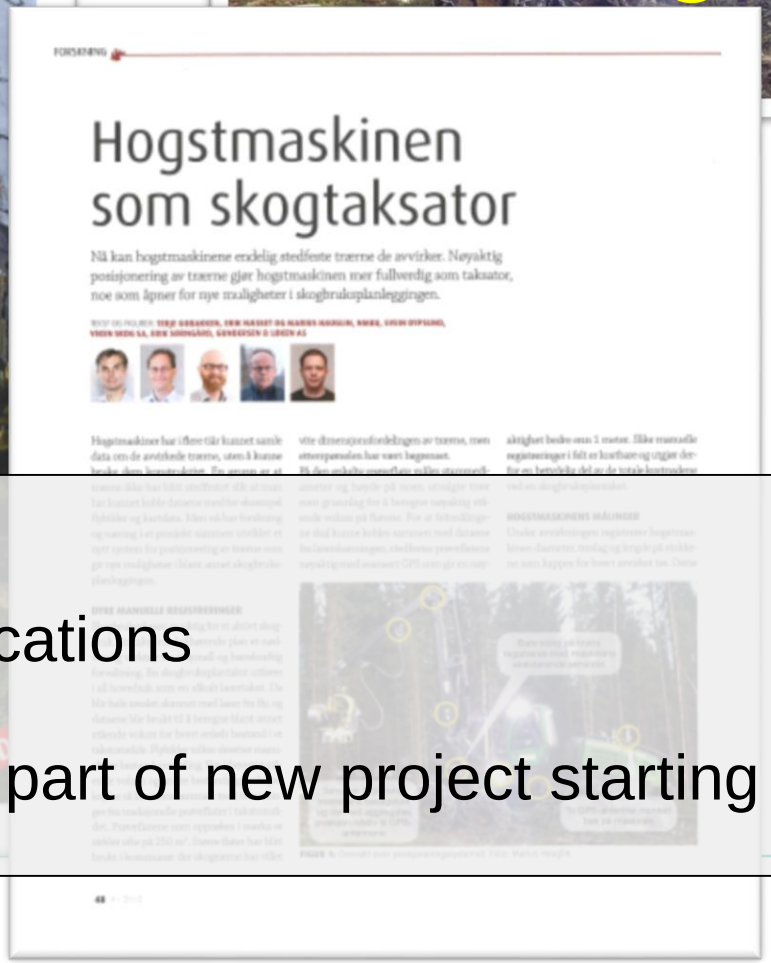
Project results…



1 Master thesis
5 Published per-review publications
+ 1 manuscript in progress
+ the system is an important part of new project starting this spring

Thank you for your attention