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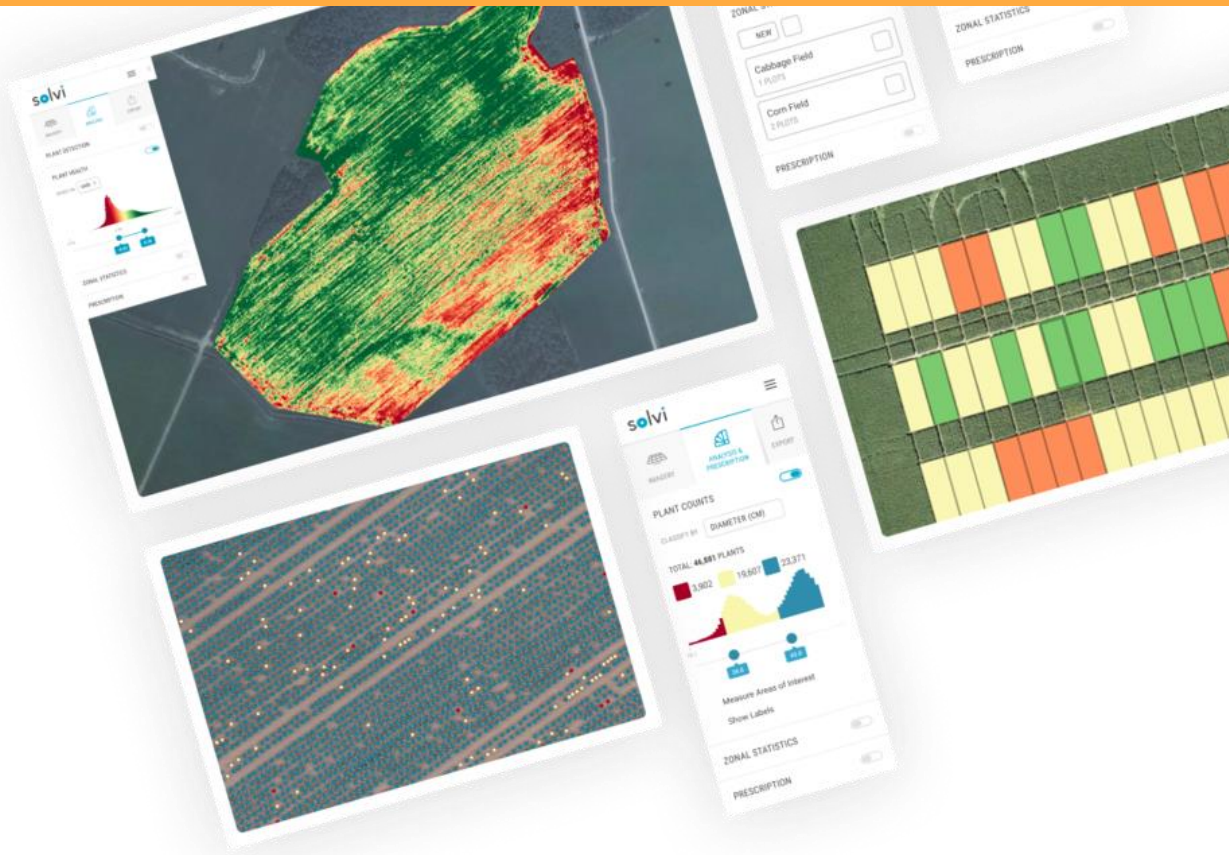
Crop Height Measurements with Drone Imagery in Field Trials



Igor Tihonov
Founder, Solvi

March 4, 2025
NFTN Conference
Helsinki

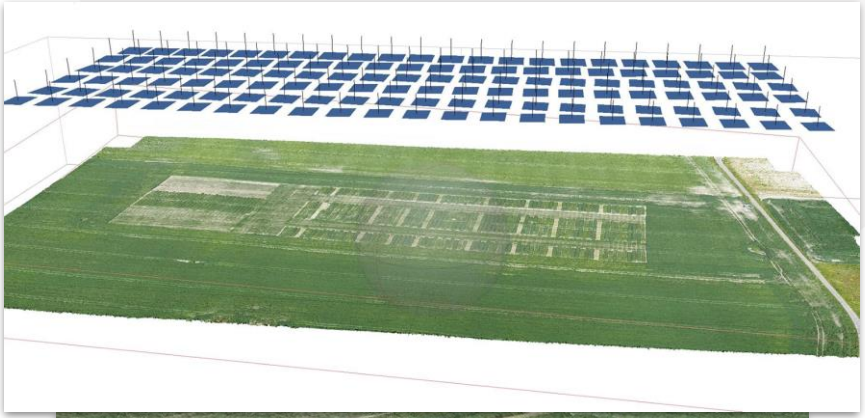
It all started in 2015

2015	2016	2017	2018	2019	2021	2025
Solvi founded	Pilot project with SLU	Official Release	Plant counts & Size Estimations	Zonal Statistics & Research tools	Plant AI™	Users in 50+ countries

Crop Height from Drone Images? But how? 🤔

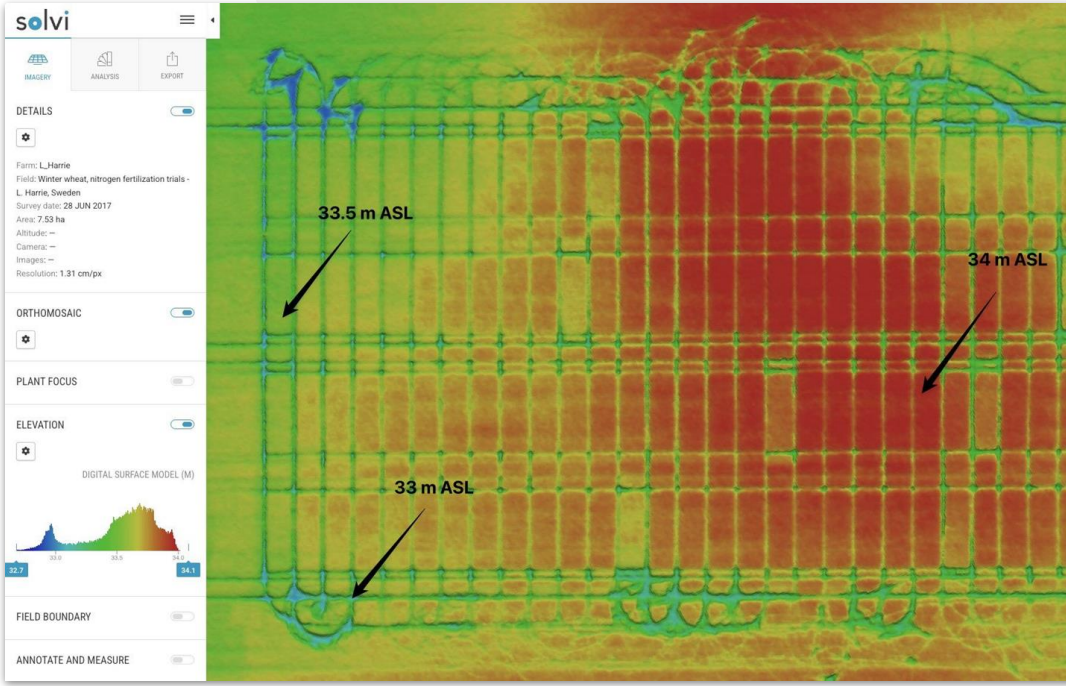
The Photogrammetry Pipeline

- To “stitch” the images into a field map, images are run through the **photogrammetry** pipeline
- Photogrammetry pipeline:
  - Position of the cameras in space are calculated by matching overlapping images
  - Depth from each image is extracted and a dense point cloud is created
  - From a point cloud, an Elevation map is generated
  - Orthomosaic is created by projecting pixel data from the images onto the Elevation map



Elevation map

- Elevation map is a 1-band raster map (GeoTIFF)
- Each pixel value represents altitude above sea level (ASL)
- Accuracy of the Elevation data depends on accuracy of drone's GPS
- RTK GPS and/or Ground Control Points give best accuracy



What is DSM, DTM, CHM?

- **DSM (Digital Surface Model)** - an elevation map that includes terrain and everything on top of it (trees, houses, cars, etc)
- **DTM (Digital Terrain Model)** - an elevation map that only includes terrain (ground level)
- **CHM (Canopy Height Model)** is a diff between DSM and CHM and represents height of the crops on a perfectly flat surface

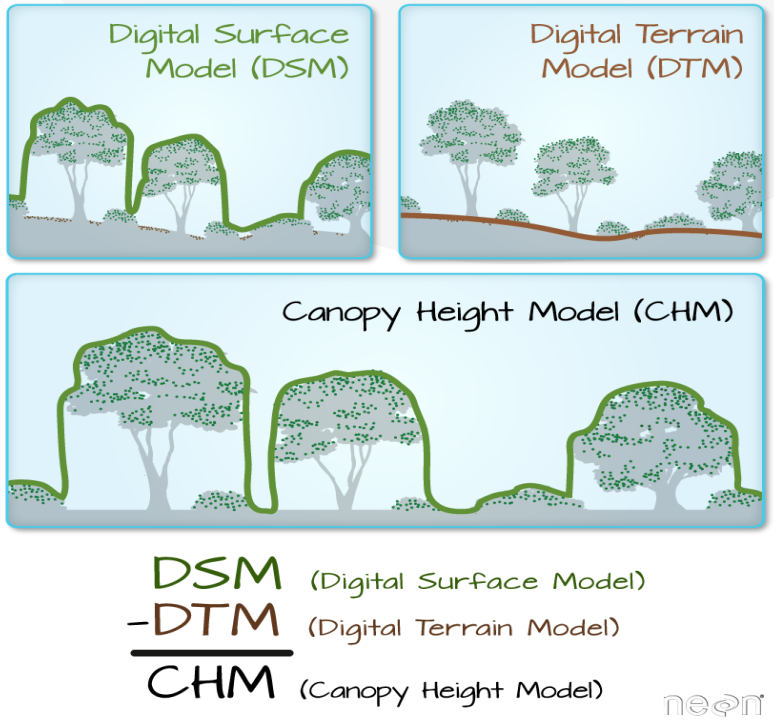
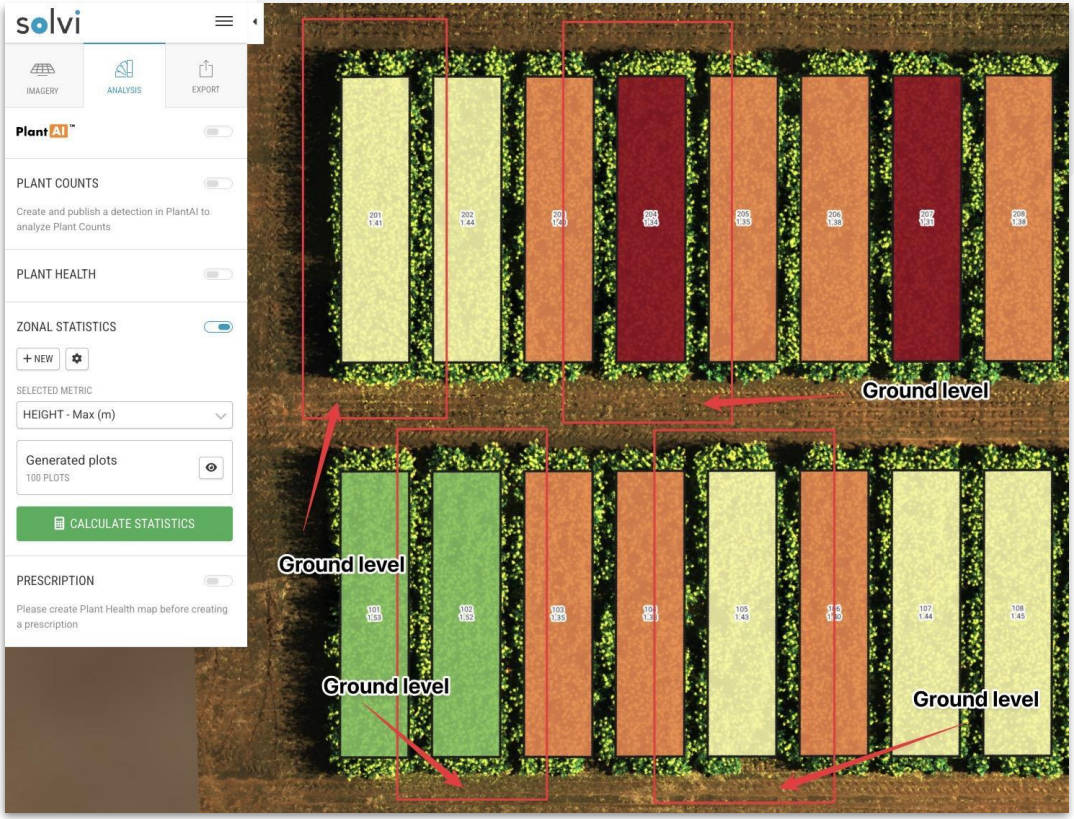


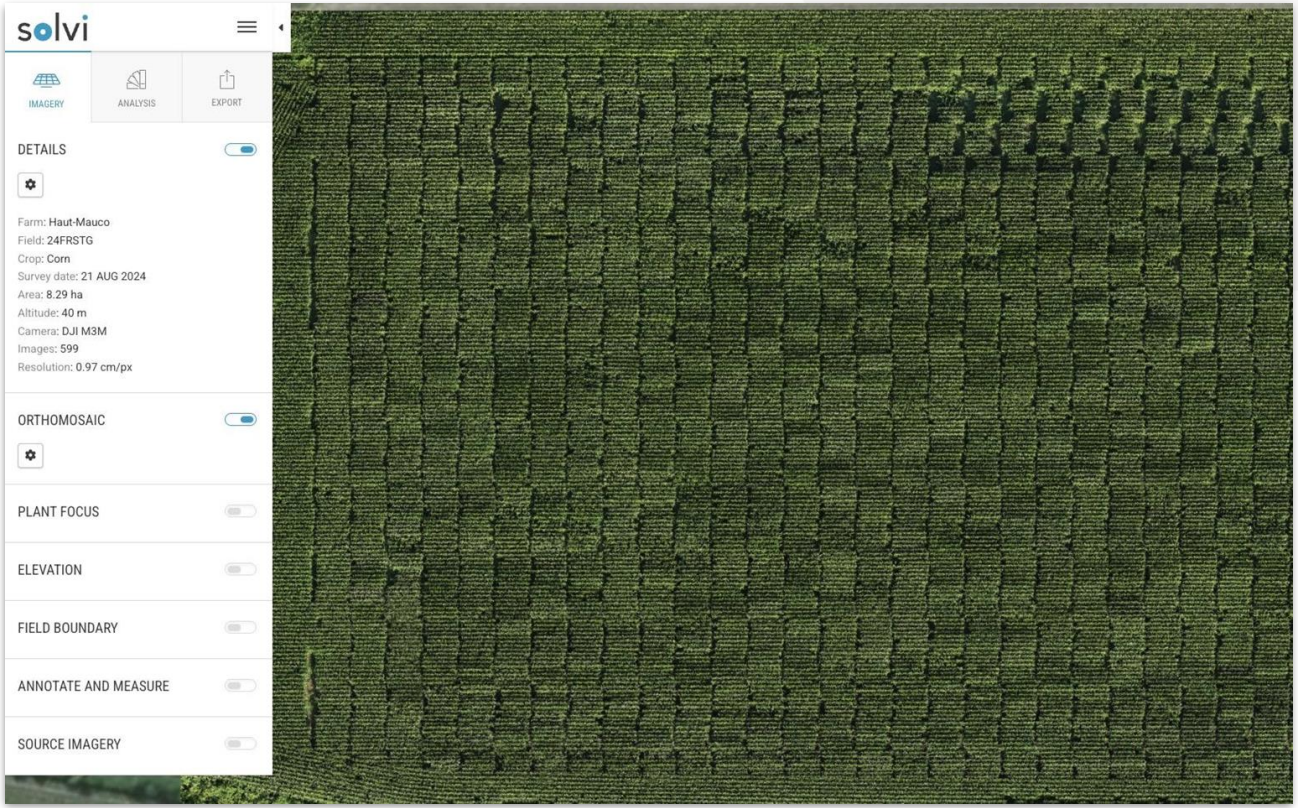
Image source - https://www.neonscience.org/resources/learning-hub/tutorials/chm-dsm-dtm

How to Measure Crop Height from DSM?

- Each plot is buffered by 0.5 - 1 meters
- Lowest point within the buffered area represents ground level
- Crop height is measure by subtracting lowest point from the highest
- Only works when ground level outside of each plot is visible

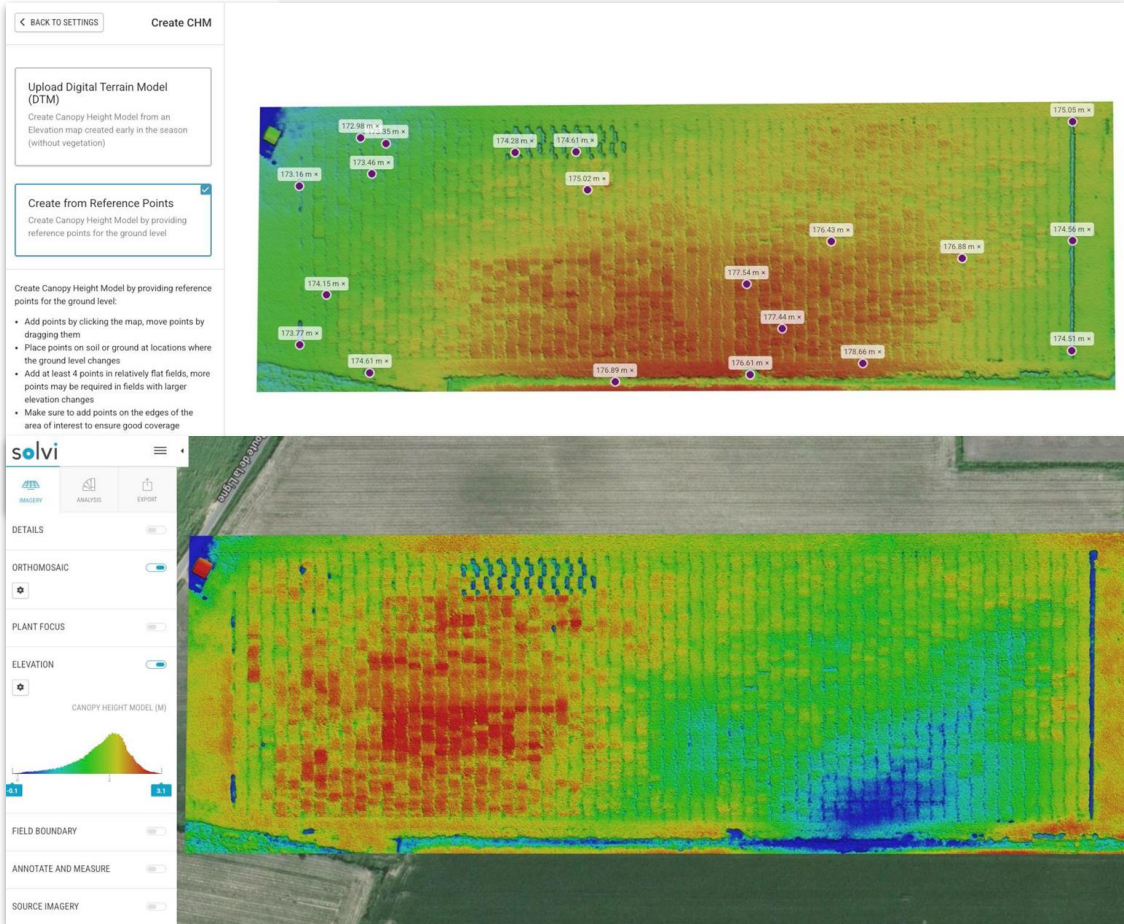


What if the ground level is not visible?



CHM from Manual Reference Points

- Manual reference points are placed throughout the field where ground level is visible
- DTM is created by interpolating the data between the reference points
- CHM is created by subtracting DTM from DSM



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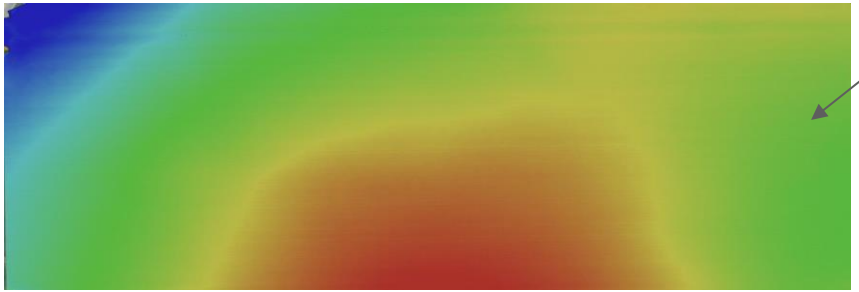
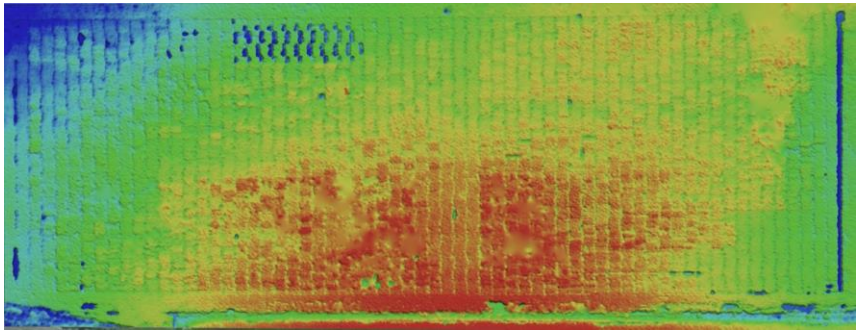
CHM from Early Season Flight (DTM)

DSM - May 28

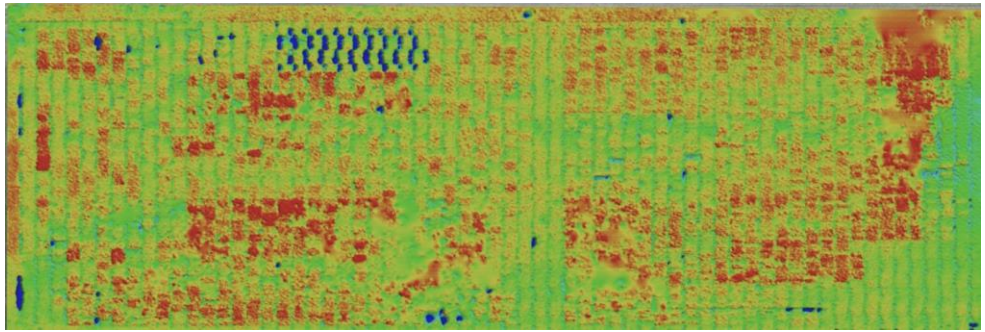


- DTM (bare soil) from the early season flight can be used to create a more accurate CHM
- CHM is created by subtracting accurate DTM from DSM
- Requires highly accurate GPS data for both early and late season flights (RTK or GCPs)

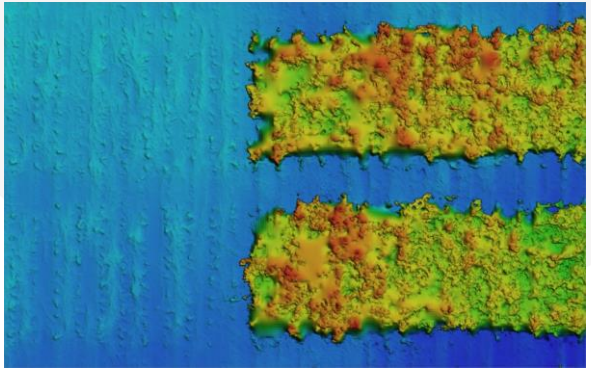
DSM - August 13



CHM - August 13

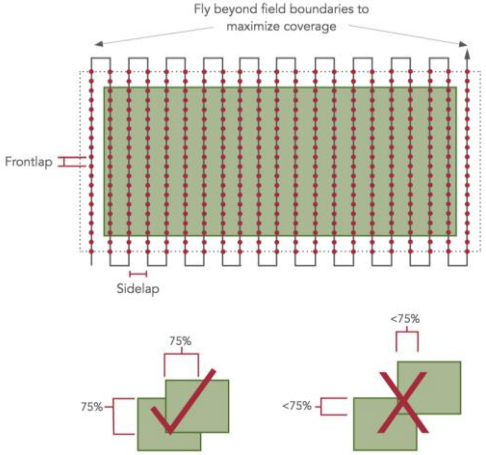


How accurate are drone-based height measurements?



It depends on:

- Resolution of the imagery - the higher, the better (40-50 m flight altitude recommended)
- High front and side image overlap (80-85% recommended)
- RTK-enabled drone recommended for all flights during the season
- Lidar data can be used for more detailed elevation maps and (potentially) more accurate measurements



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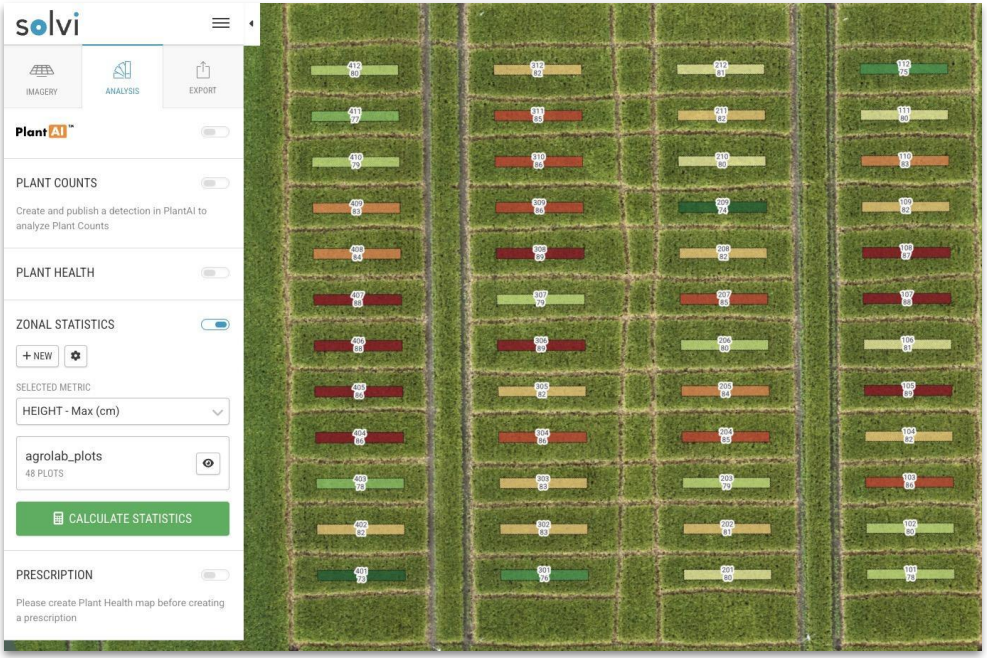
A Practical Example from Agrolab

Average_Ruler	Average Drone	Max_Ruler	Max Drone	Min_Ruler	Min Drone
79,9	70.70	85.00	78.10	74.00	63.20
78,85	73.30	85.00	79.60	70.00	65.70
78,25	75.40	86.00	86.00	71.00	67.10
74,5	73.80	81.00	82.20	67.00	63.90
78,85	78.50	88.00	89.40	72.00	71.70
70,65	73.30	77.00	80.60	62.00	68.50
79,8	81.30	90.00	88.40	75.00	74.90
79,6	81.50	85.00	86.80	73.00	75.30
74,15	76.40	82.00	81.70	70.00	66.70
78,9	76.90	87.00	83.30	74.00	63.70
78,75	74.70	84.00	79.80	70.00	67.90
73,65	69.30	81.00	75.20	66.00	62.50
79,15	74.90	87.00	80.20	72.00	69.00
74,15	77.10	79.00	81.40	66.00	73.00
75,95	75.90	82.00	79.10	68.00	71.80
80,6	80.40	89.00	85.30	72.00	74.60
76,6	79.70	82.00	84.30	72.00	75.90
73,35	74.00	78.00	79.50	66.00	69.30
79,45	80.10	84.00	85.00	74.00	74.60



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Let’s validate Height Measurements Together!

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