UAS LIDAR IN AGRICULTURE

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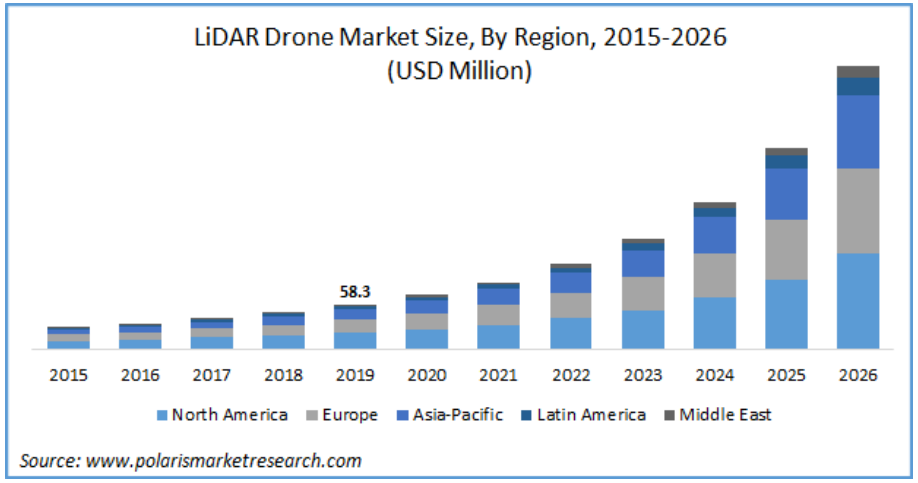
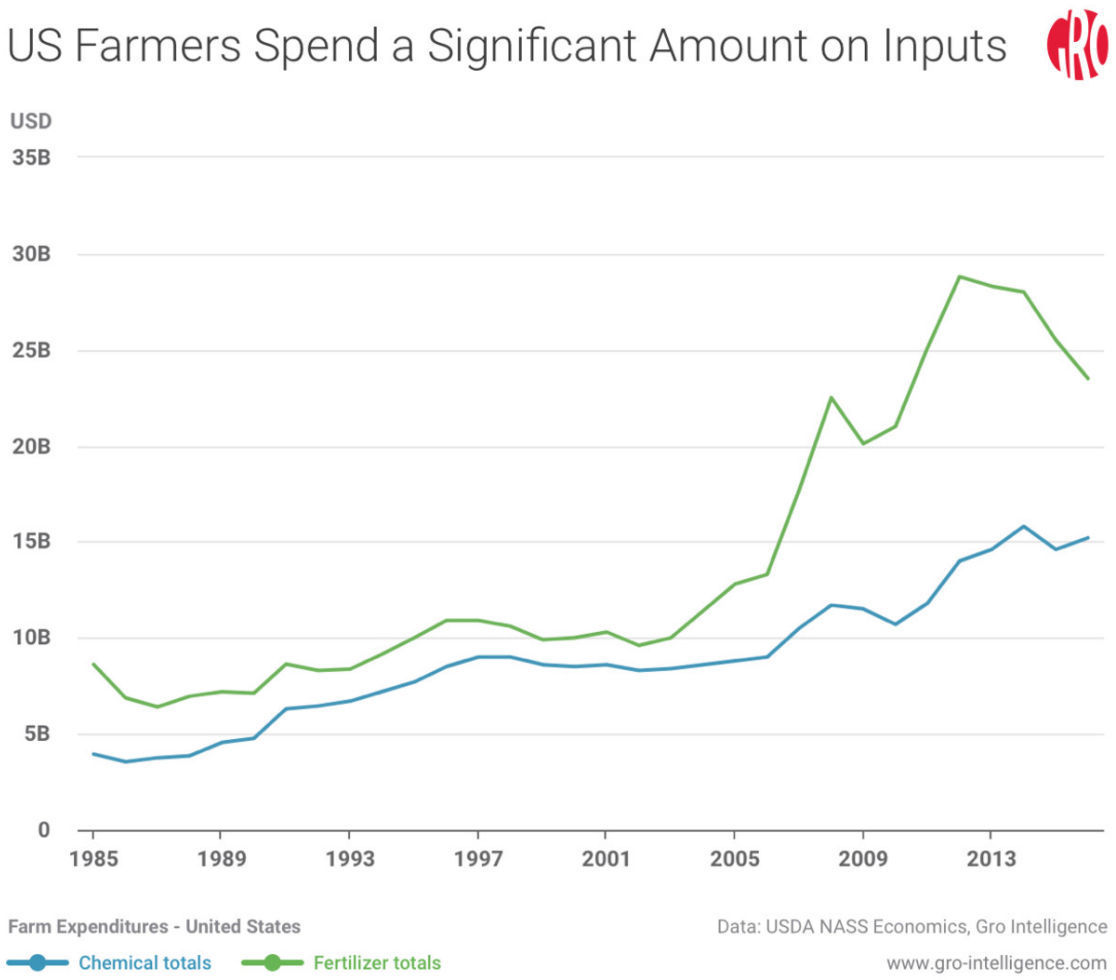
IMPORTANCE OF DRONES IN AGRICULTURE

- Population and food demand increasing
- Pesticide and fertilizer use increasing
- Need for technologies to increase efficiency and precision
- UAS's provide on demand high resolution data
- LiDAR UAS adaptation increasing





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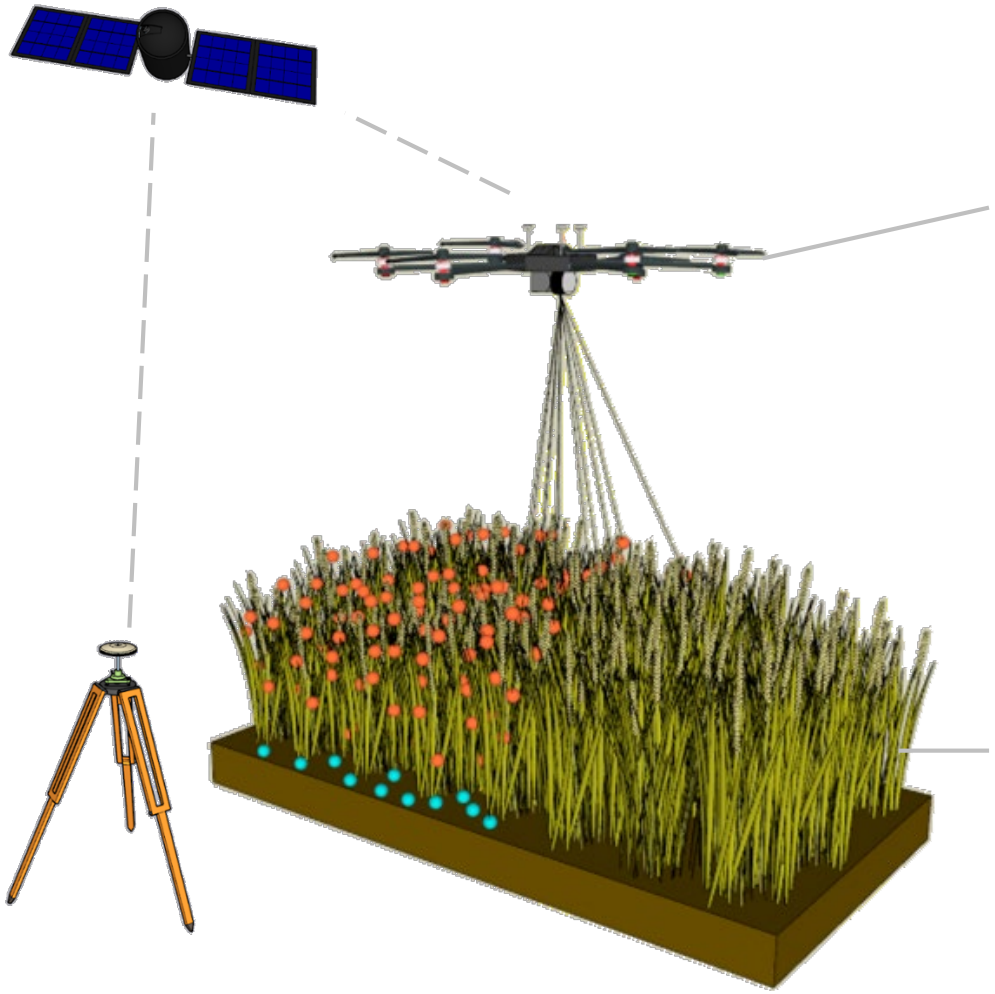
EQUIPMENT OVERVIEW

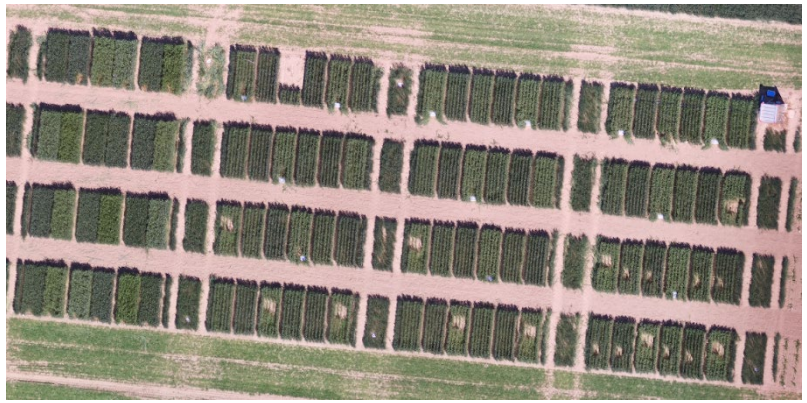


LiDAR	YellowScan Surveyor
Flight Altitude	50m
Flight Speed	8 m/s
Point density	85 pts/sqm
Accuracy	5 cm
Scan Angle Used	24-30 degrees

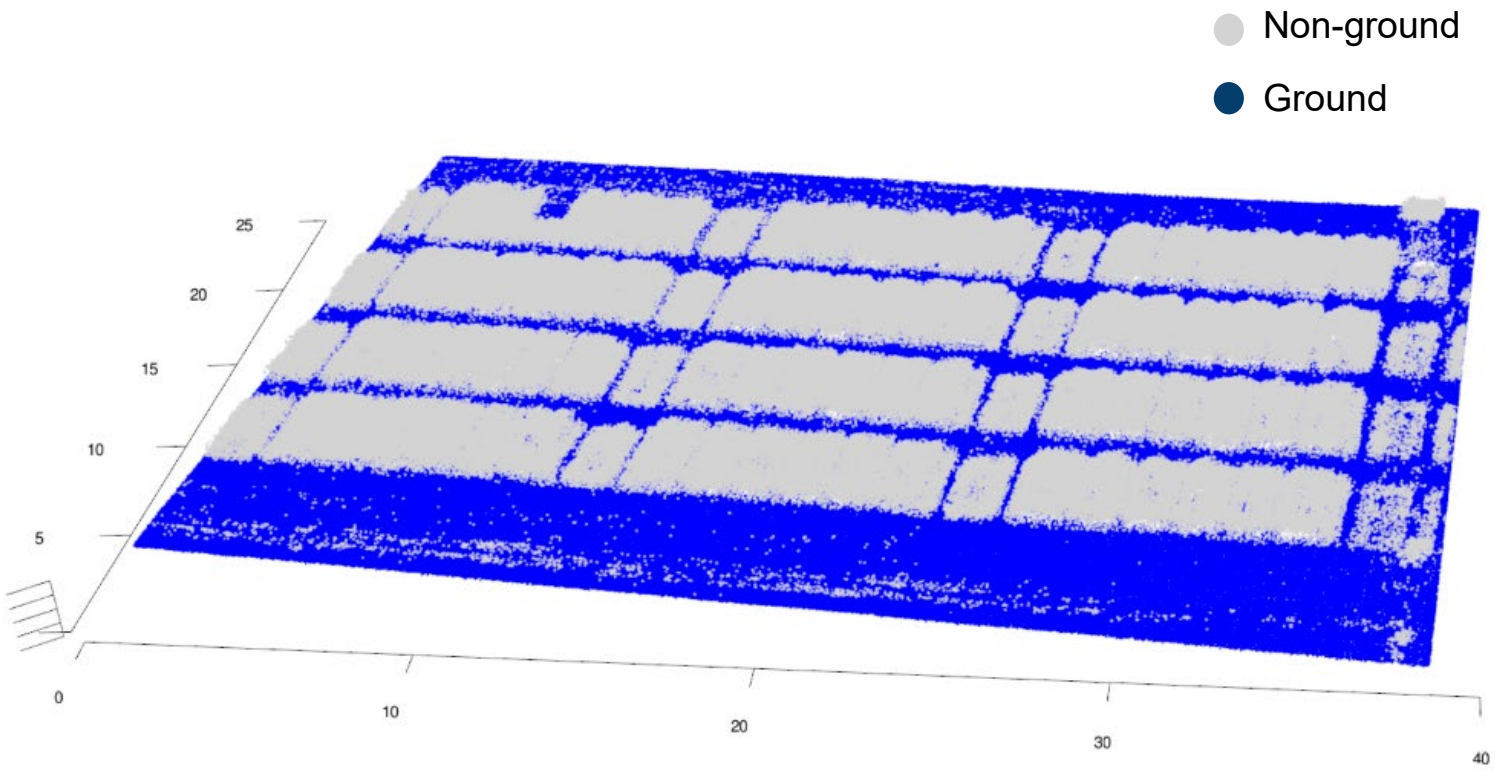
GROUND SEGMENTATION

- Segmenting ground from vegetation is important for deriving several vegetation metrics

- Here Cloth Simulation Filter (CSF) is used.
  (Zhang et al. 2021).



Campus Klien Altendorf, Germany
PhenoRob Central Experiment



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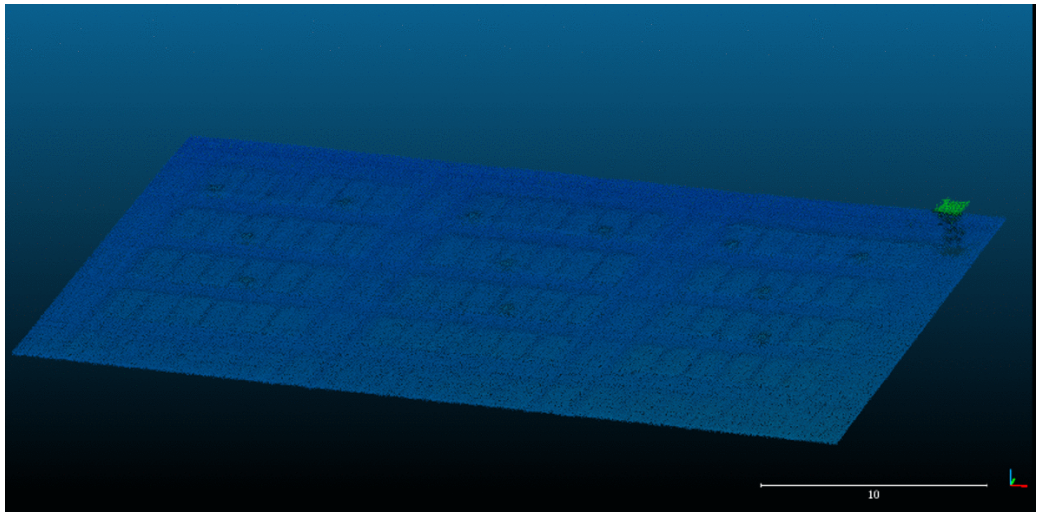
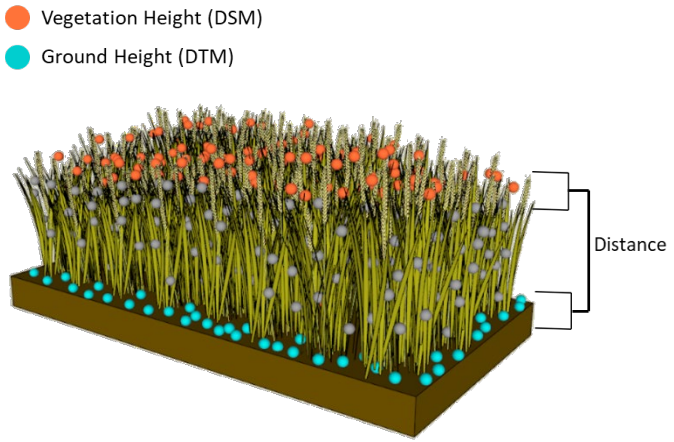
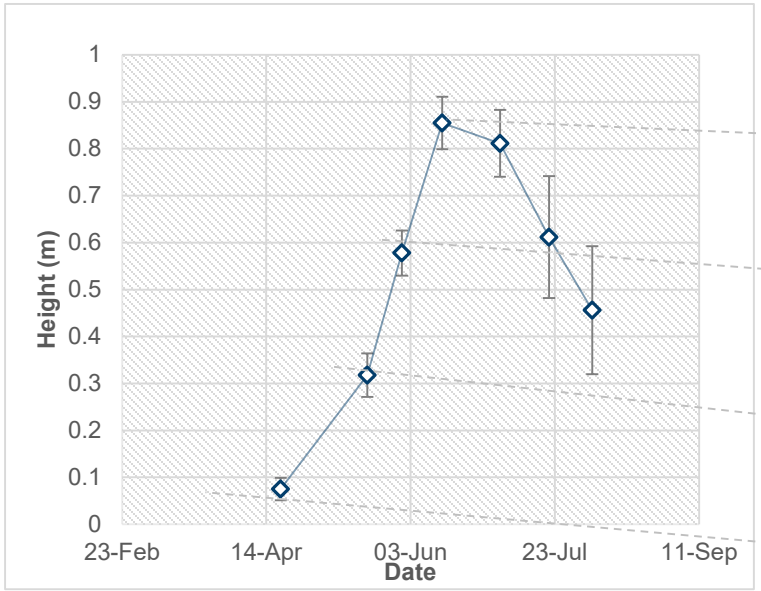
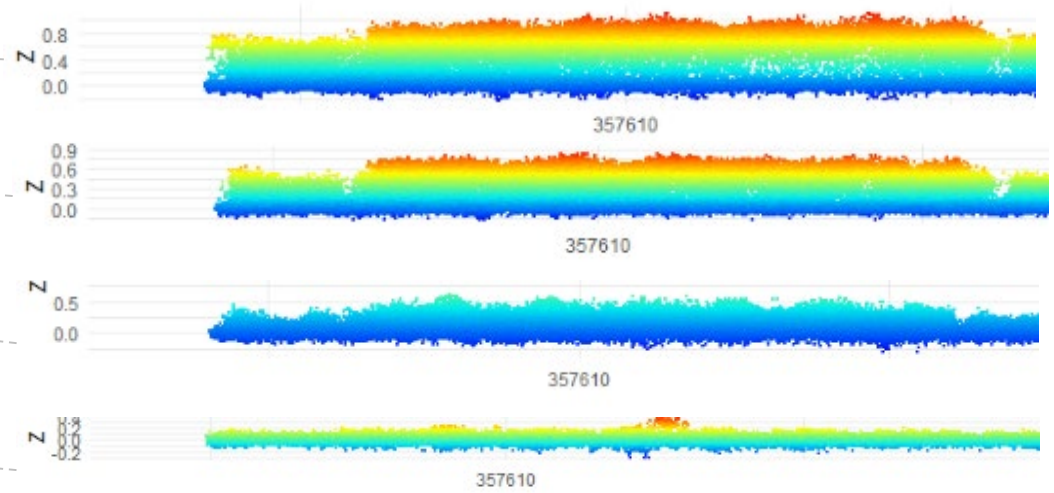
CROP HEIGHT

- Most common crop metric with LiDAR
- Crop Height Models (CHM) with Difference of DEMs (DoD) most common
- Other methods also used such as Cloud to Cloud (C2C) with 3D point clouds







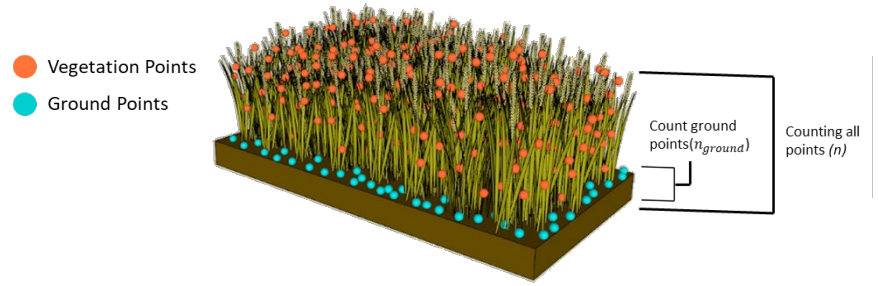


GAP FRACTION – CANOPY DENSITY

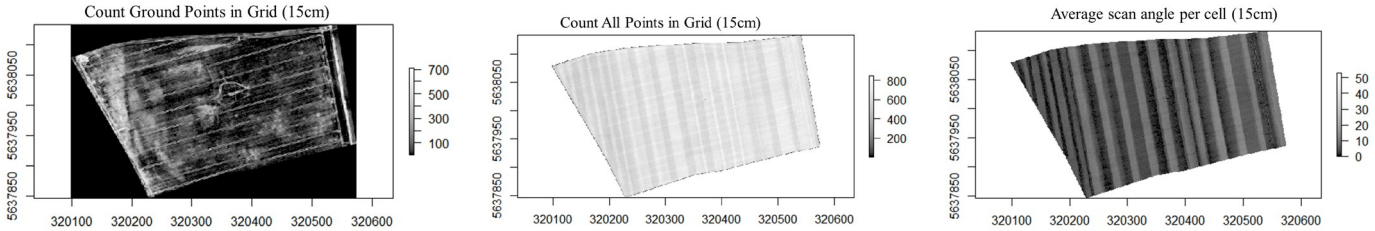
- Used LiDAR gap fraction to estimated canopy density
- Similar method to hemispherical cameras used in forestry
- Modified Beer-Lambert equation used to relate the rate of laser penetration through the canopy to **Plant Area Index (PAI).**

  (Jonckheere et al. 2005)

  (Richardson et al. 2009)

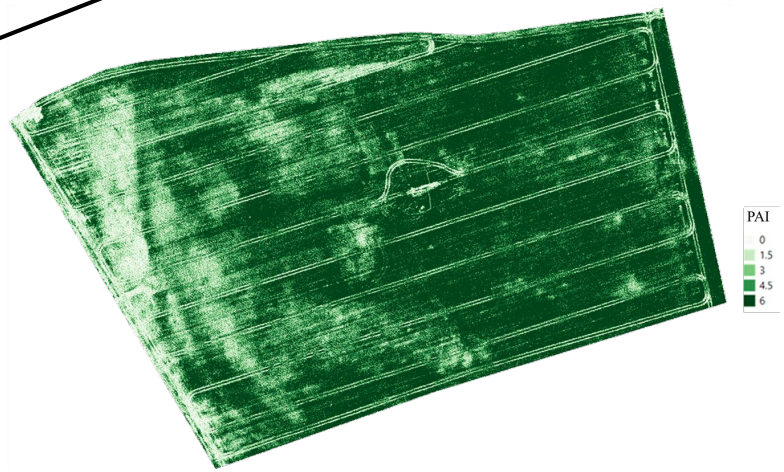


$$GF = \frac{n_{ground}}{n}$$



$$PAI_{LiDAR} = -\frac{cos(\bar{\theta}) \times In(GF)}{k}$$

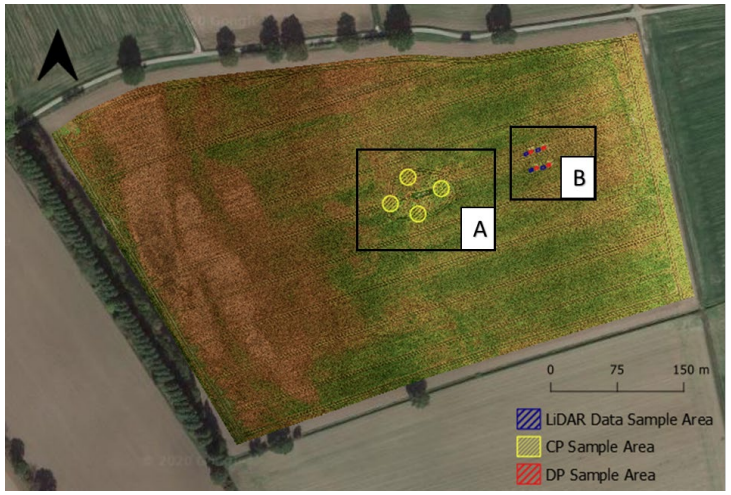
Modified Beer-Lambert Equation

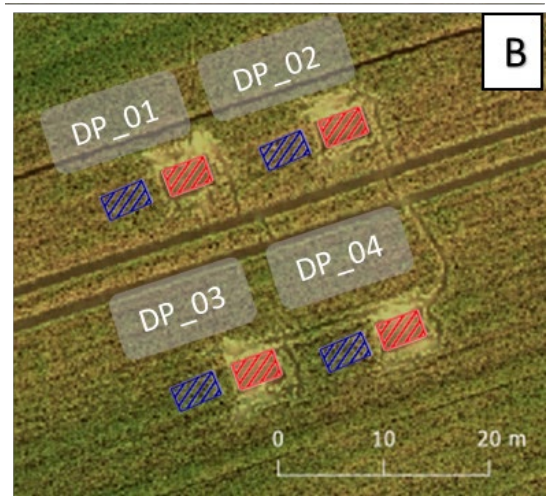


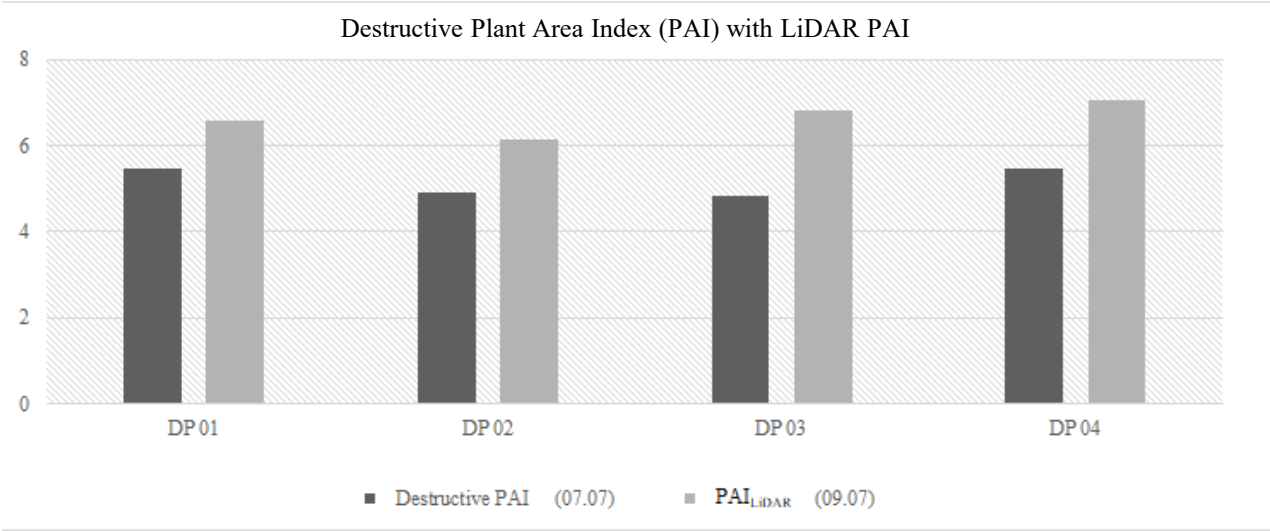
LEAF AREA INDEX (LAI

- Compared LiDAR PAI to ground destructive measurements (B).
- **28% error** from LiDAR in overestimating later in the growing season. Better performance earlier in the growing season (**3-12%** before senescence with comparison to ceptometer).
- Provides evidence that LiDAR can used to calculate PAI or LAI like metrics for winter wheat
- Can be **improved** upon with flight parameters and processing variables

Selhausen, Germany FZJ Test Site







(Bates et al. 2021).

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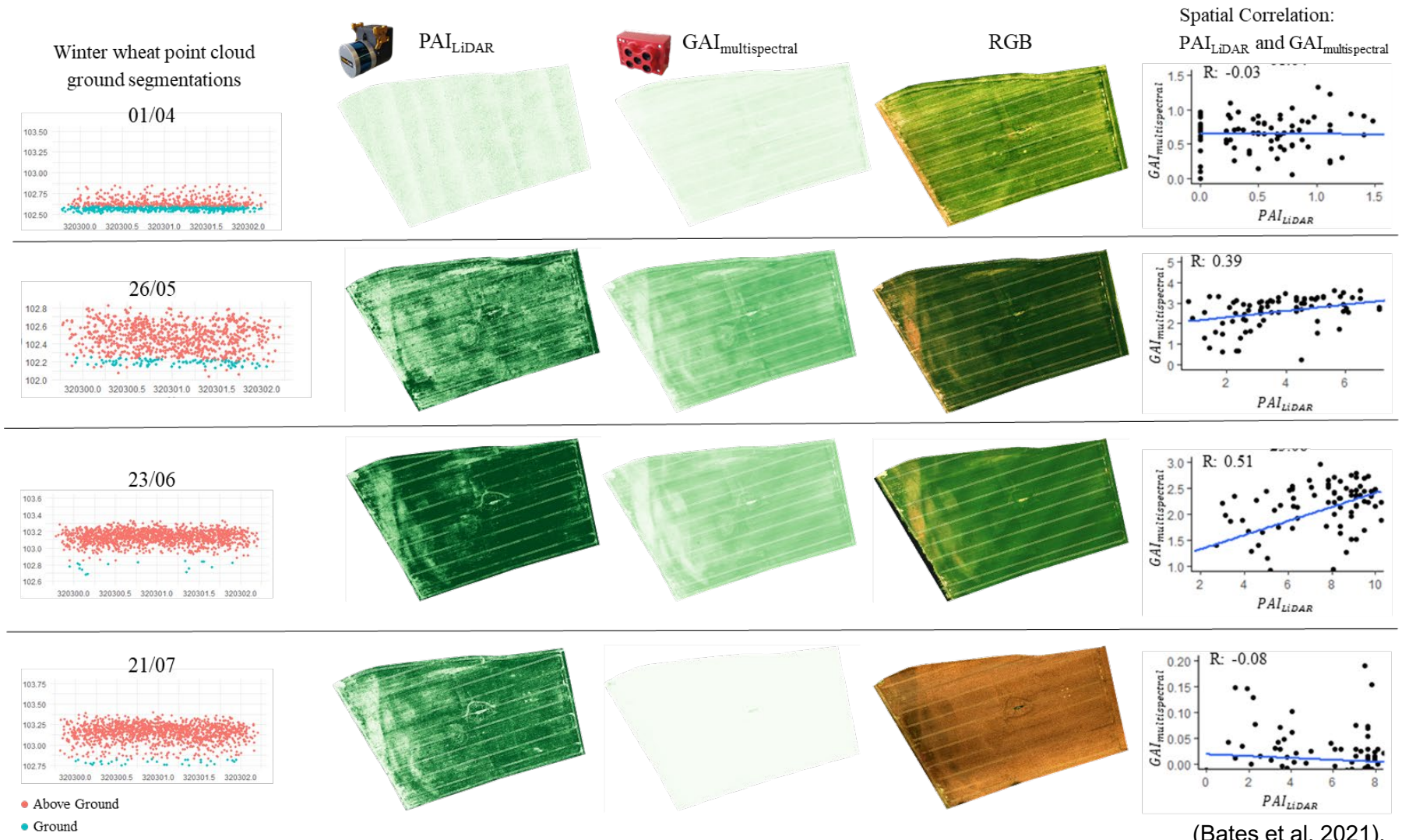
LIDAR VS. PASSIVE OPTICAL SENSORS

- The LiDAR variability was compared to multispectral **Green Area Index (GAI)**
- GAI is based on **leaf pigment** while LiDAR PAI method is sensing **plant structure**
- The LiDAR is still able to sense variation in canopy structure after full senescence



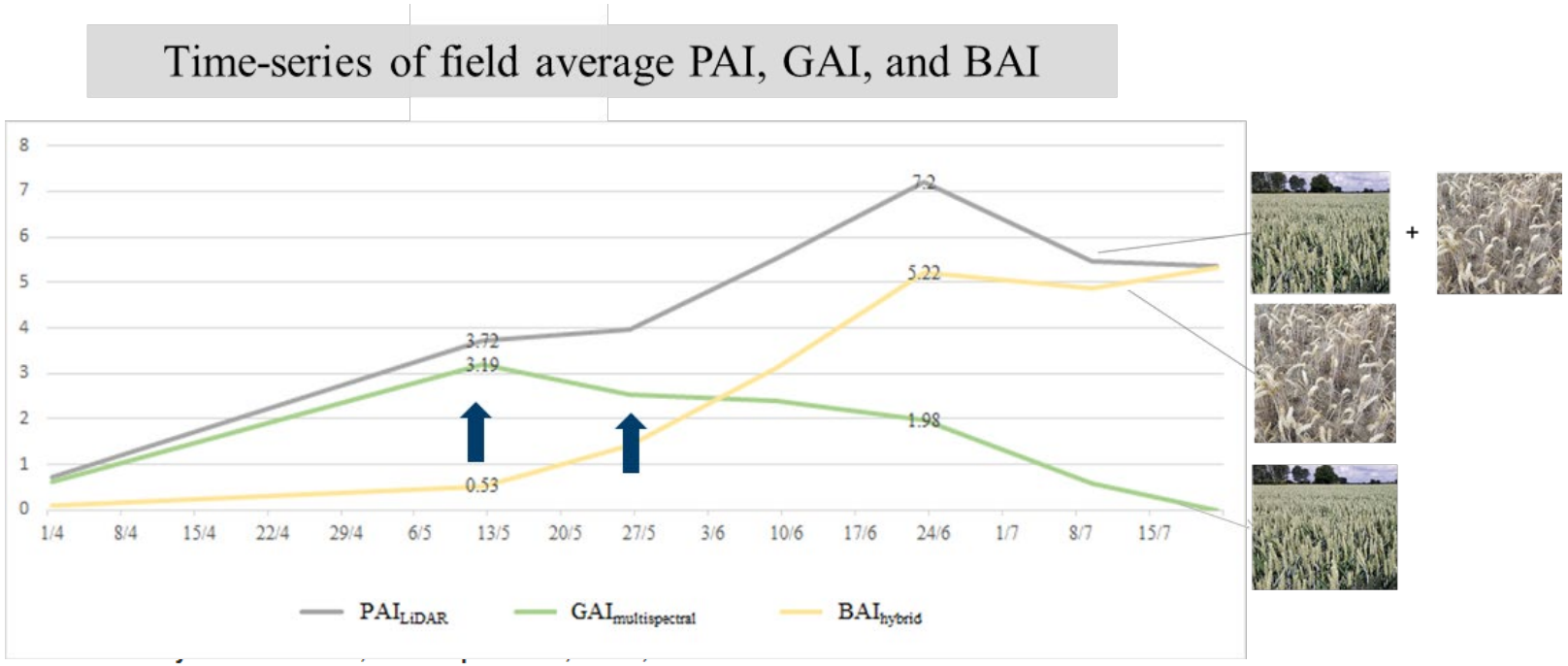
(Bates et al. 2021).

MULTI-SENSOR USE

- Difference between PAI LiDAR and GAI multispectral methods allowed for hybrid estimation of Brown Area Index (BAI)

- Concept of multi-sensor use in combination with the advantages of UAS high spatial and temporal resolutions that provide a more complete picture for farming management

- For more info, please check out our publication.



Open Access Article

Estimating Canopy Density Parameters Time-Series for Winter Wheat Using UAS Mounted LiDAR

by Jordan Steven Bates [1,*], Carsten Montzka [1], Marius Schmidt [1] and François Jonard [1,2]

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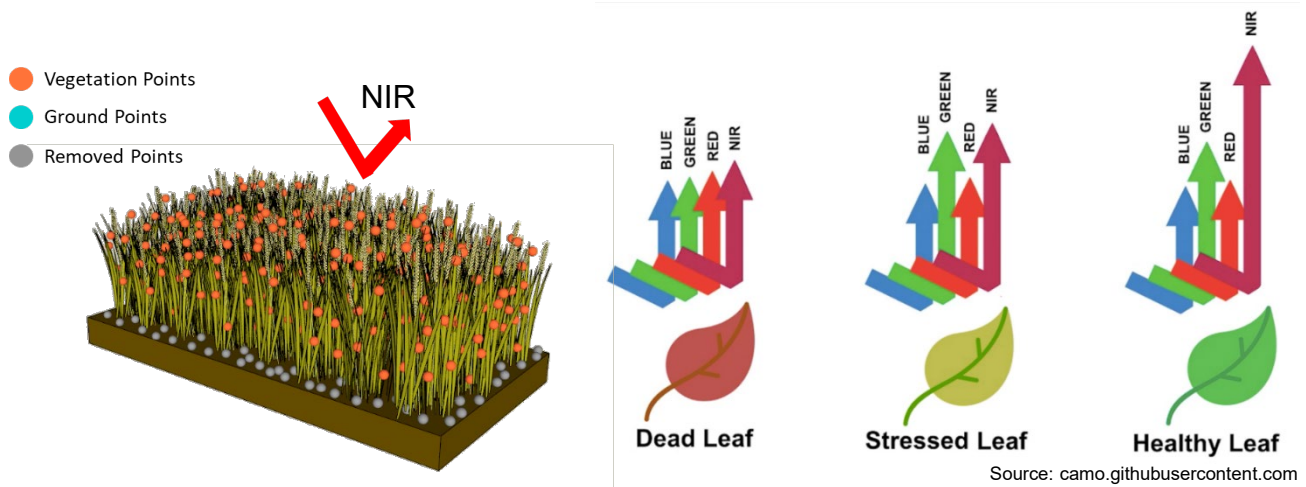
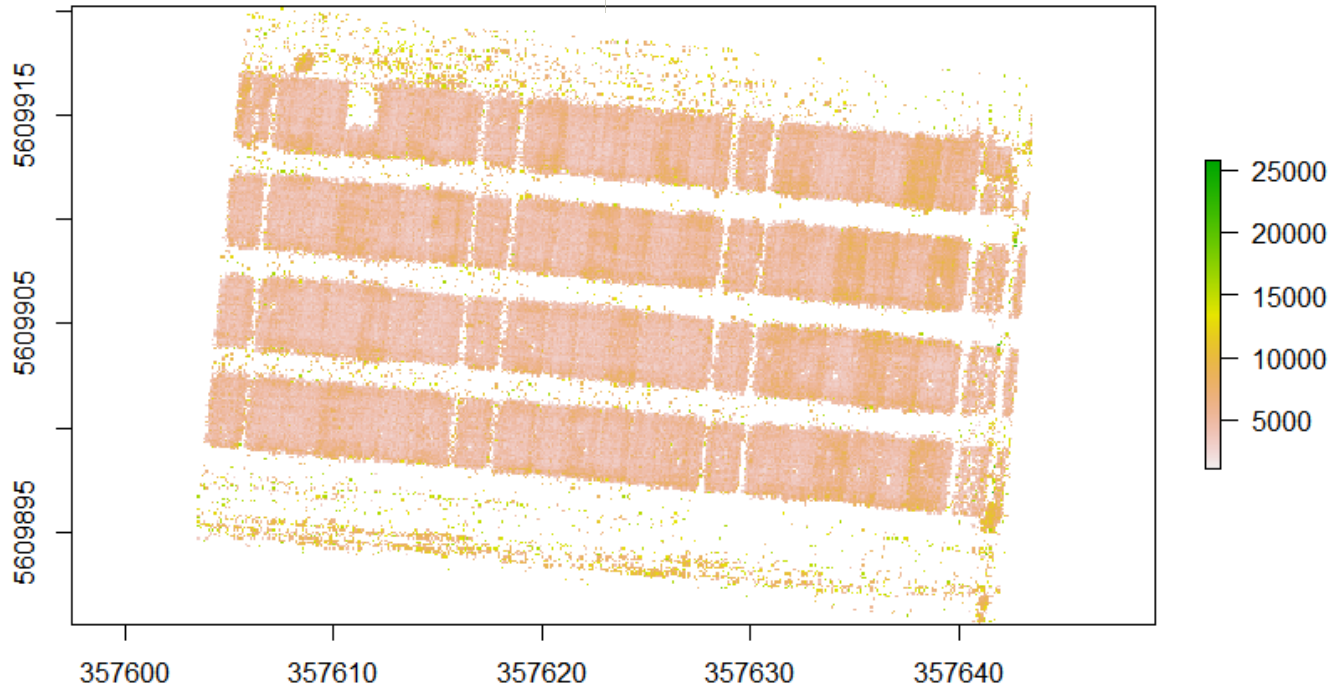
LIDAR INTENSITY

- The recorded strength of the returning signal
- YellowScan Surveyor's electromagnetic spectrum bandwidth is positioned around **908nm – NIR**
- Ground intensity values between dead and heathy winter wheat
- Once ground is removes, information on vegetation chlorophyll status appears



Source: camo.githubusercontent.com



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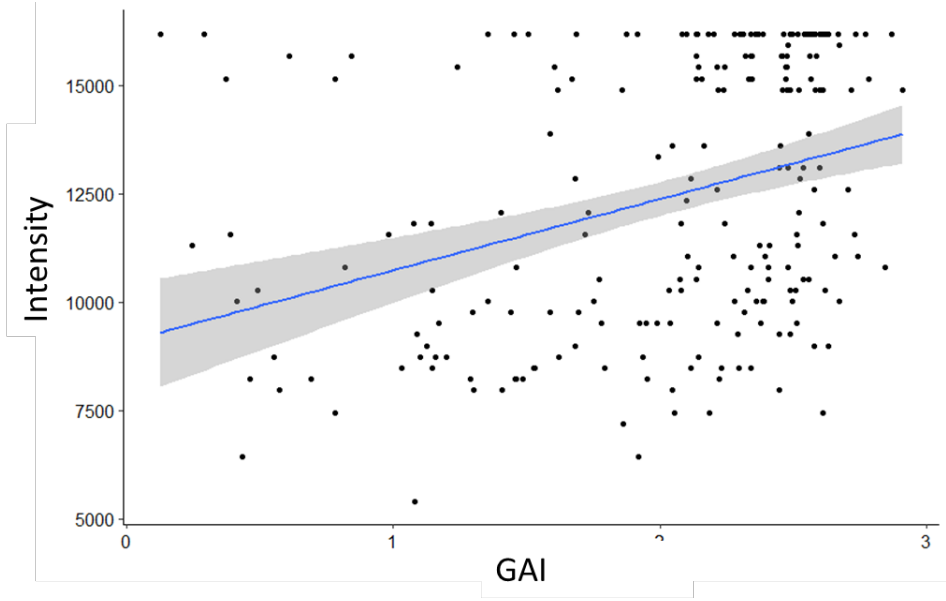
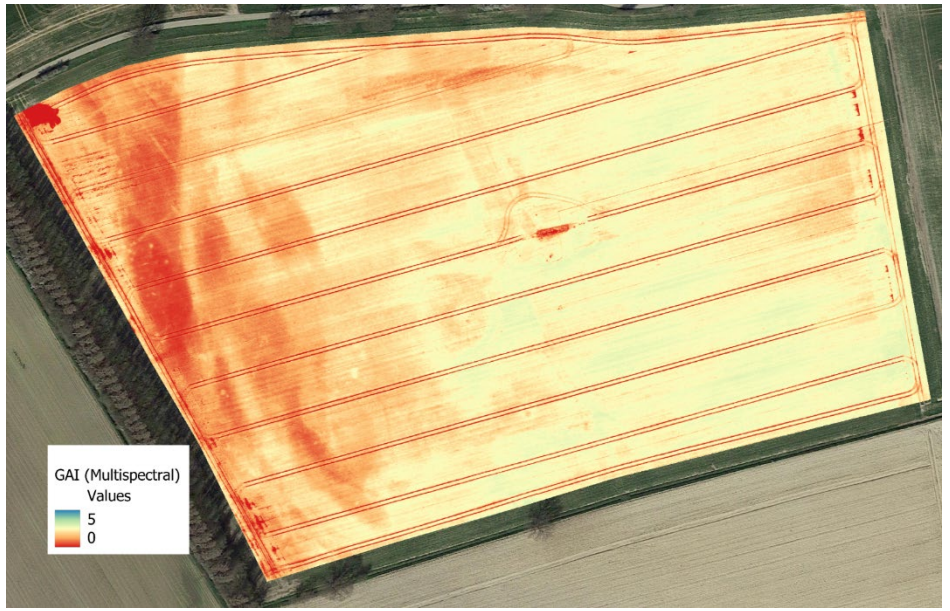
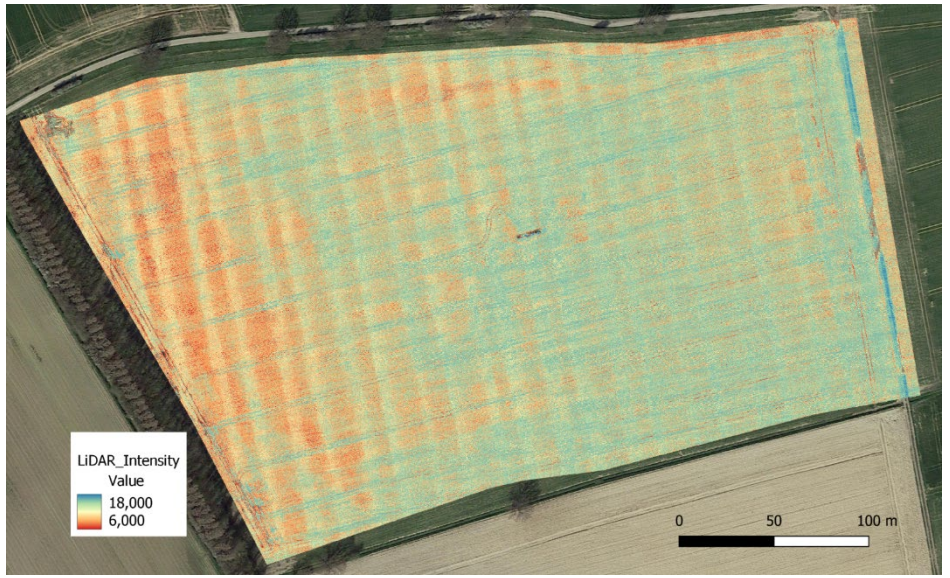
INTENSITY POTENTIAL

- Coloration between LiDAR intensity and multispectral GAI showing potential to further implement LiDAR for crop status

- Plans to use the intensity in place of multispectral methods to identify and quantify senescence locations







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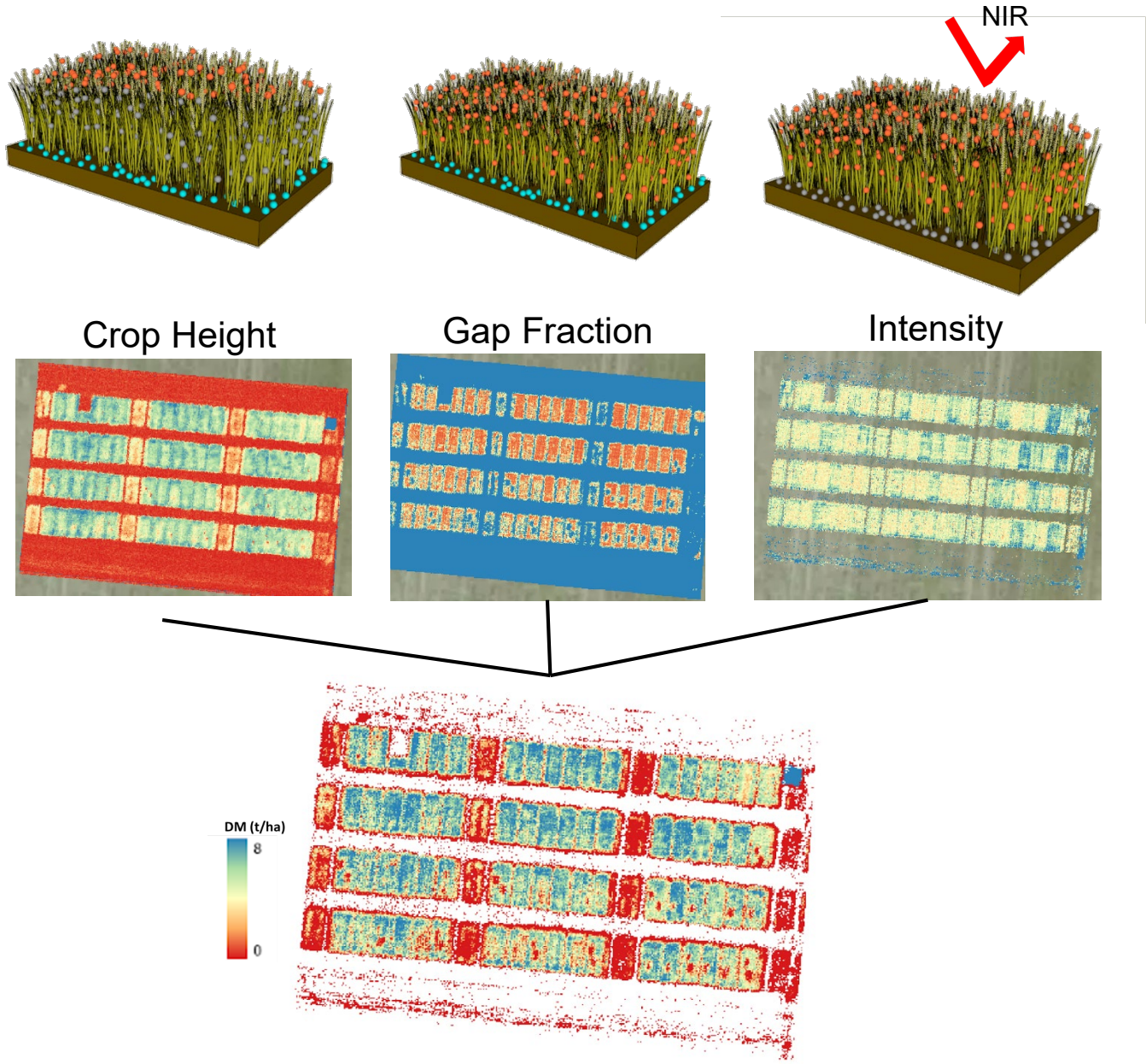
BIOMASS

- Plans to use **crop height (vertical information), gap fraction (lateral density), intensity (chlorophyll content),** and several other LiDAR metrics as predictors in for machine learning models

- Current method delivered a standard error of .5 (t/ha)

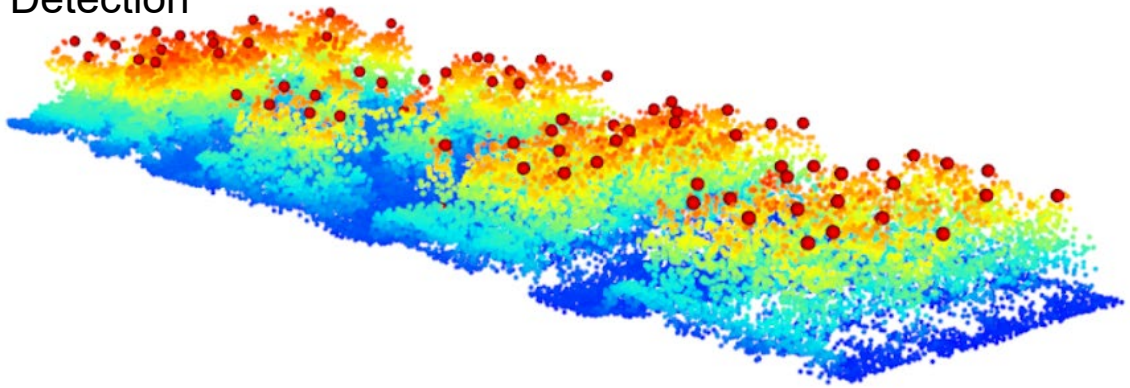


CROP DETECTION

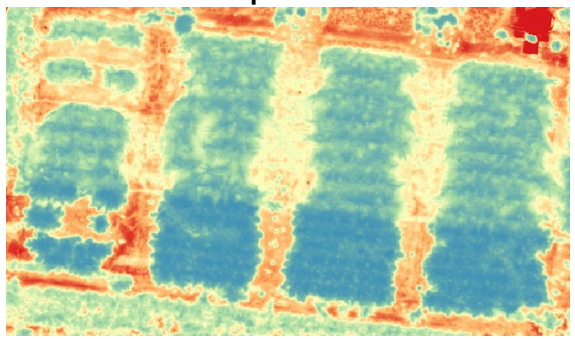
- The height information can be used for crop detection and segmentation for certain crops.
- Can be intercepted with multispectral and thermal IR data.
- Can show which and how many plants are affected by water stress and etc.

Example: Maize @ CKA

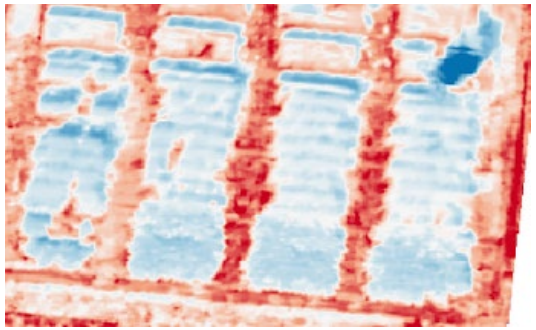
Individual Maize Detection



NDVI: Multispectral



LST: Thermal IR



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OUTLOOK

- LiDAR has the potential to provide crop height, canopy density (PAI), chlorophyll content (GAI), Biomass, and crop detection.

- FZJ is testing fully automatic UAV collections for farming applications.

- On-site housing and powering hubs further the practicality this technology with high temporal collections while lessening logistics and specialized training.

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