Precision crop phenotyping using drones: experiences at ILVO

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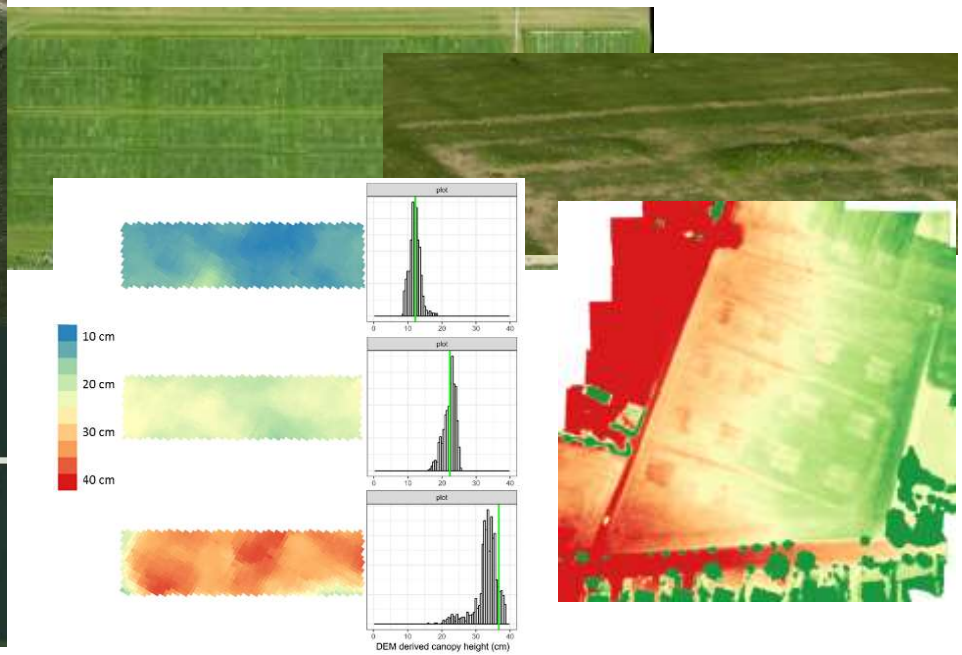
Why?

Precision Crop Farming/Precision Crop Phenotyping

- **Aim: monitor crops/plants with high spatial and temperal resolution in an objective and kwantitative manner for:**
  - Farmer (crop management) → Precision Crop Farming
    - management tasks can performed at the right place, with the right intensity and at the right time(e.g. task maps for fertilization, crop protection, weed control, …)
  - Breeder (plant/crop monitoring) → Precision Crop Phenotyping
    - assessments of plants, plots, trials for genotype selection or variety testing



How – sensors and cariers?

Spectra en sensoren

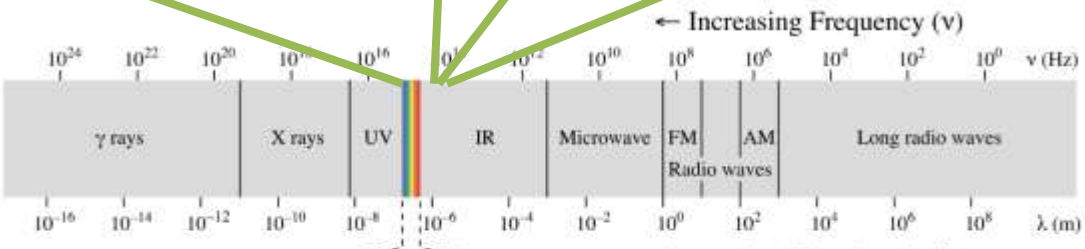
1280 x 960 pixels
b.v. 550, 660, 735, 790 nm

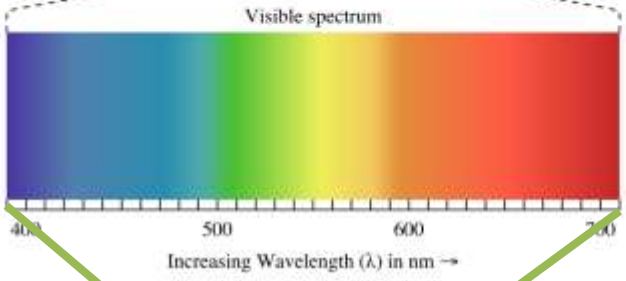
409 x 218 pixels
25-40 bands between 400-1000 nm

640 x 512 pixels
8-13µm
temperature

Hyperspectral camera
Multispectral camera

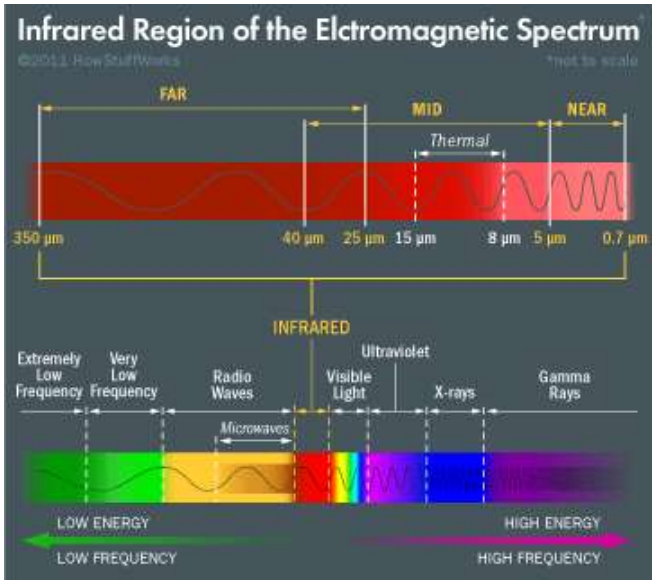
Thermal camera





RGB camera

6000 x 4000 pixels
RGB bands



(Adapted from Wikipedia)

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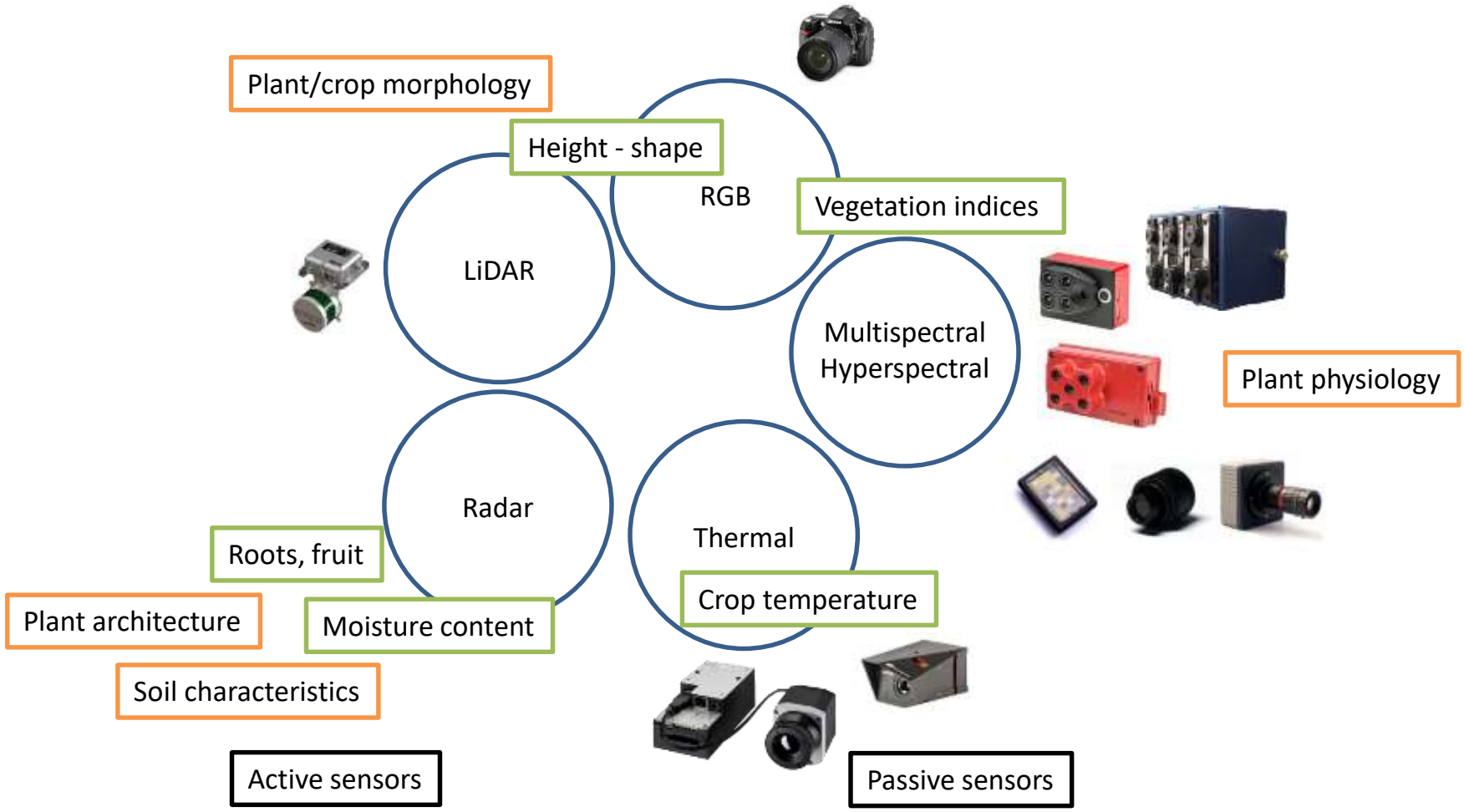
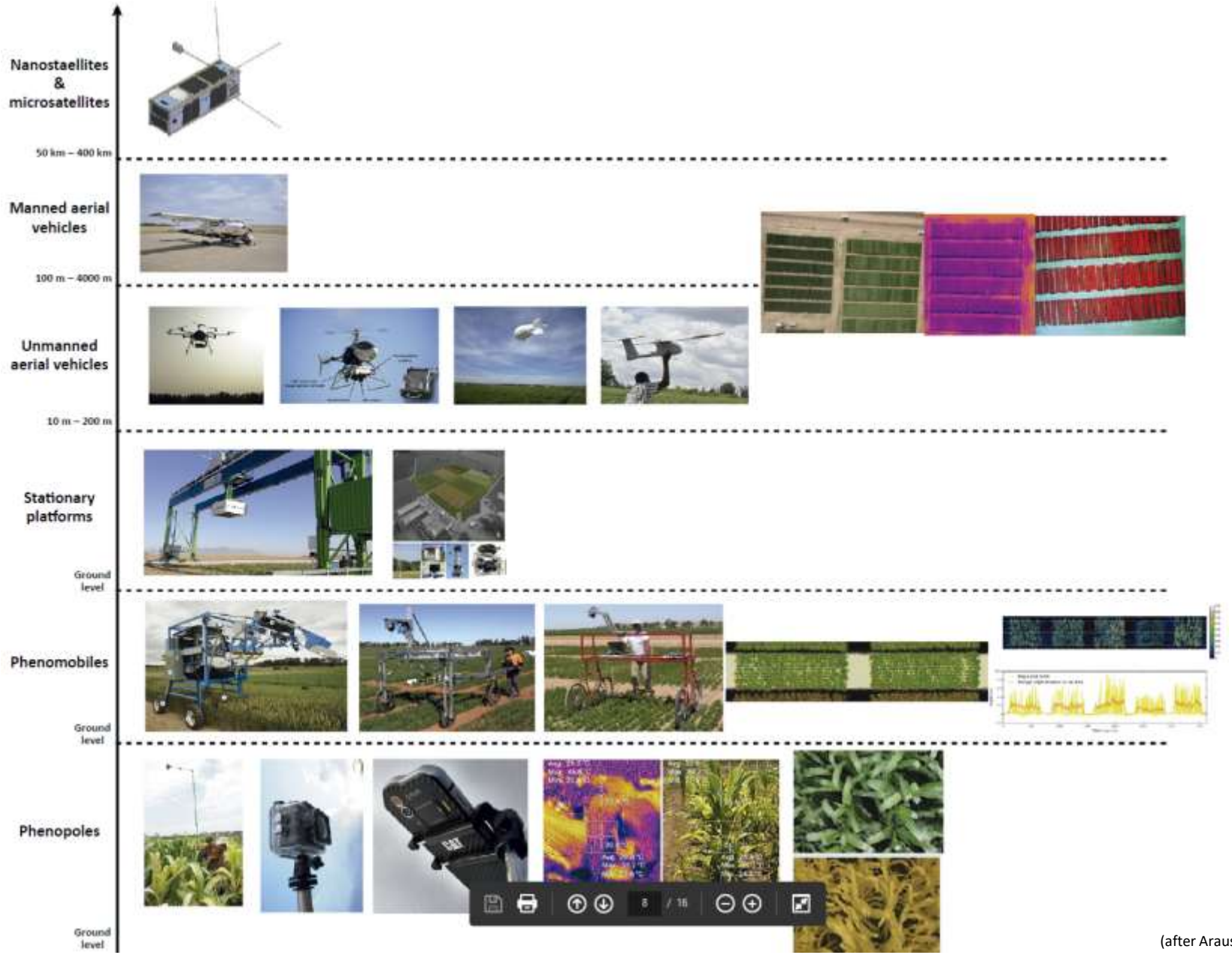
Sensors and what can they measure?



Carrier/platforms for sensors



(after Araus et al. 2018)

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How – from drone flight to data?

From flight plan to orthomosaic or height model

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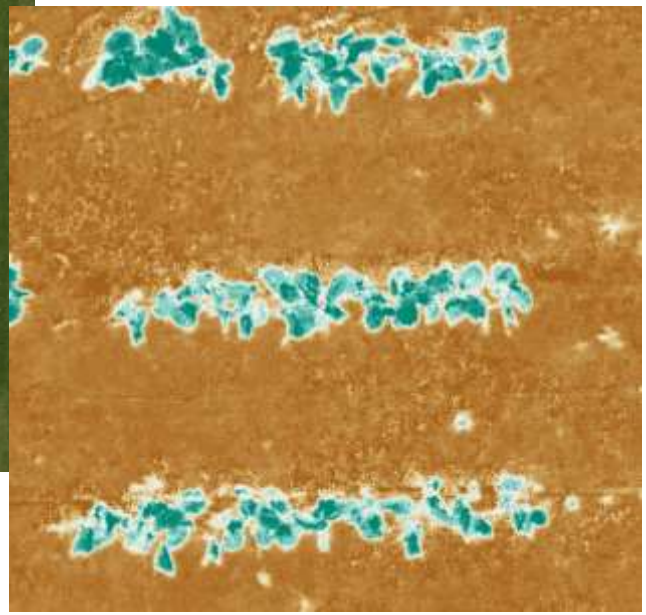
From orthomosaic to vegetation index:
soybean – ground cover/early vigor

Normalised vegetation indices (ExG)

$$ExG(2) = {(2 * G - R - B)}/{(R + G + B)}$$



RGB sensor

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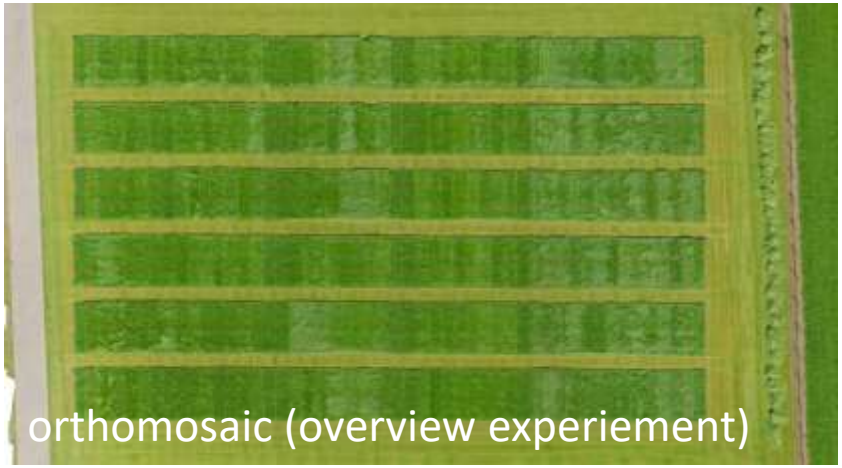
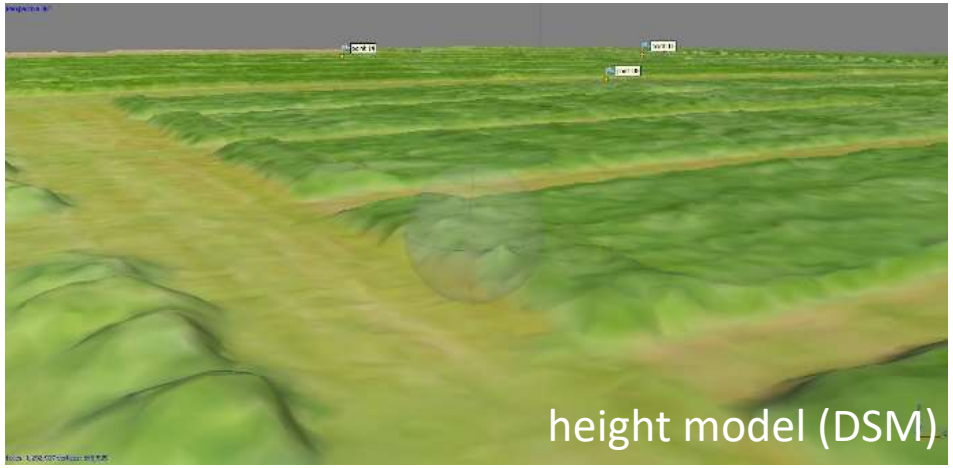
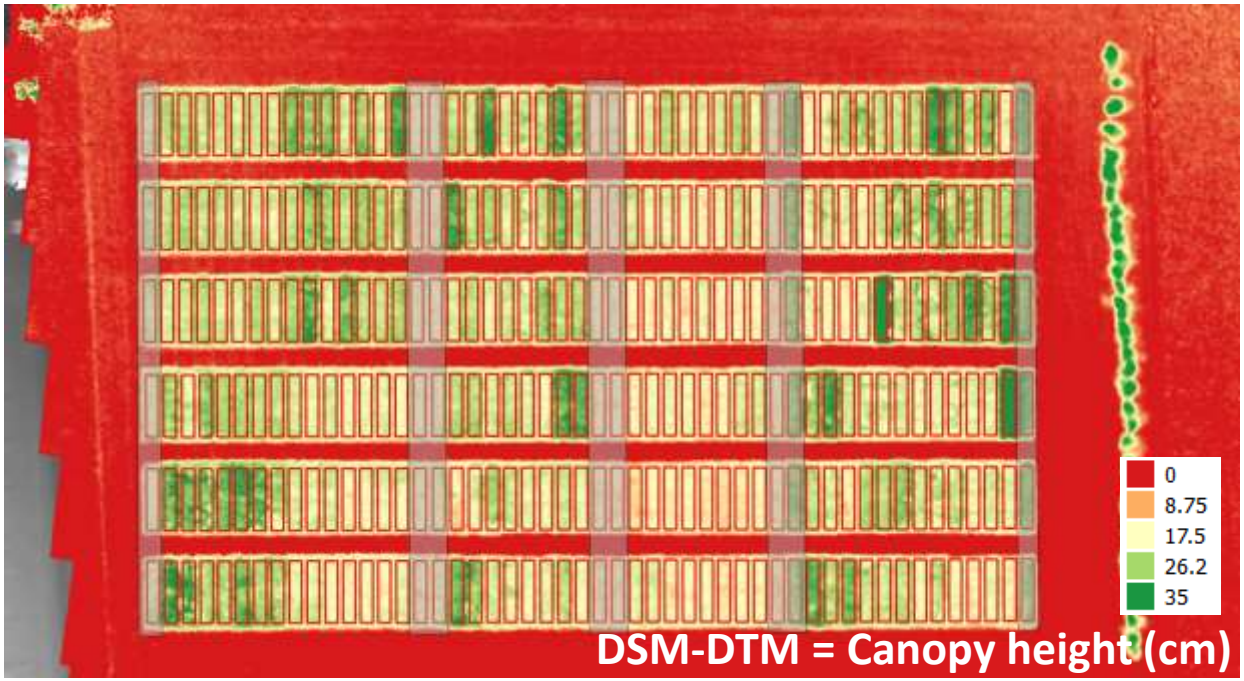
From heightmodel(DEM) to crop/plant height:
plots forage grasses







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Forage grass precision crop phenotyping

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Evaluation of persistency of forage grasses (RGB)

Spatial resolution possible up to = 2 mm

Each breeder scores consitent but different

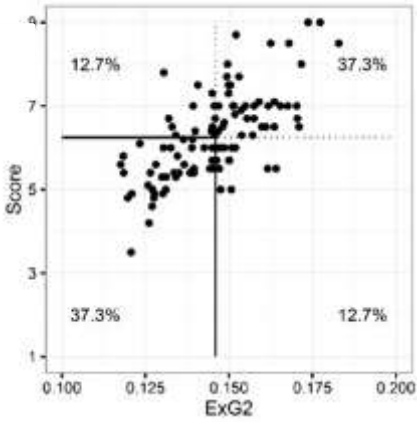
	Breeder 1	Breeder 2
Breeder 1	0.754	0.243
Breeder 2	0.243	0.760

High correlations between flights (flights done on different days with different weather/light conditions)

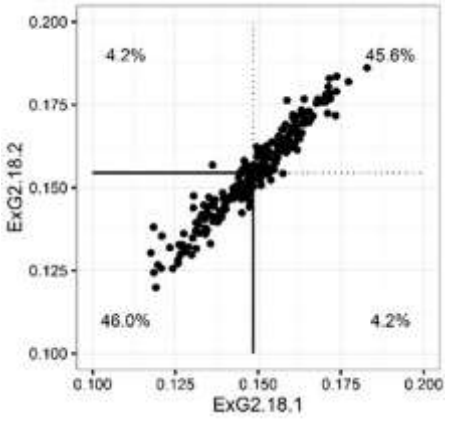
Index	ExG2 18-1	ExG2 18-2	ExG2 22-1
ExG2 18-2	0.957		
ExG2 22-1	0.948	0.930	
ExG2 22-2	0.871	0.876	0.919

Agreement of the selection with the breeder

VI-UAV vs Score-Breeder



VI-UAV vs VI-UAV



PhD Irene Borra-Serrano (ILVO)

(Borra-Serrano et al. 2018, Euphytica)

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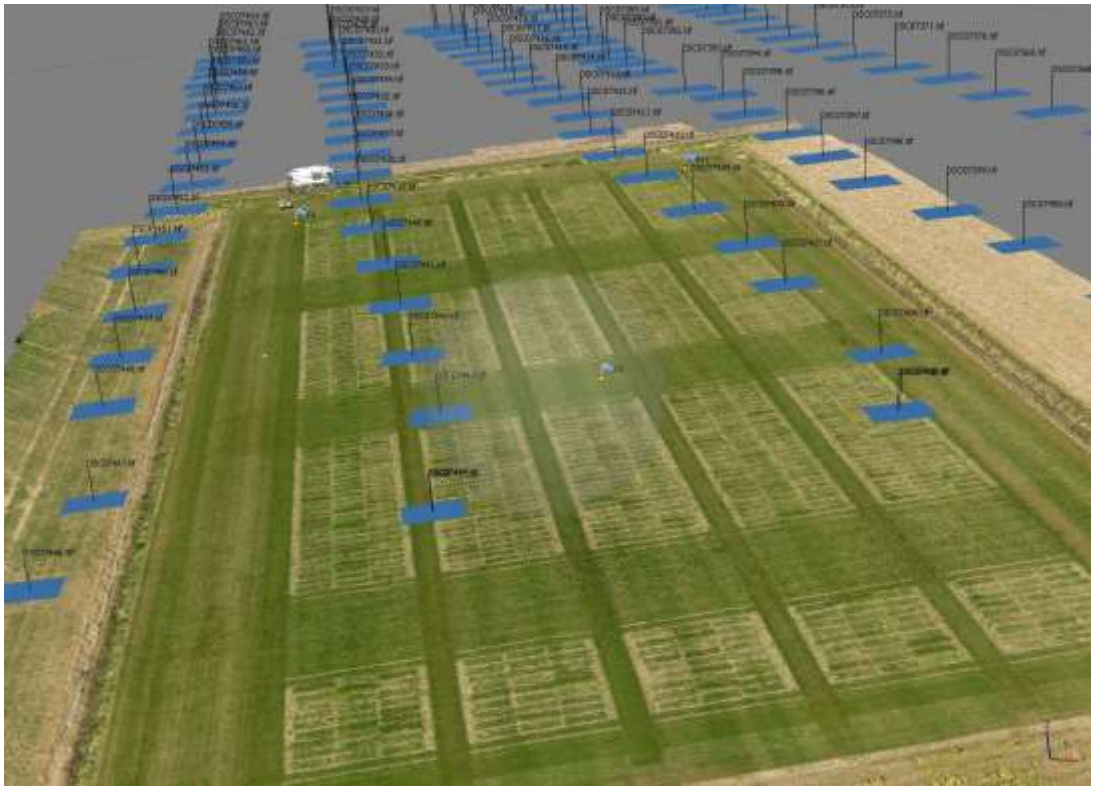
Estimation of canopy height and biomass of forage grasses (RGB)

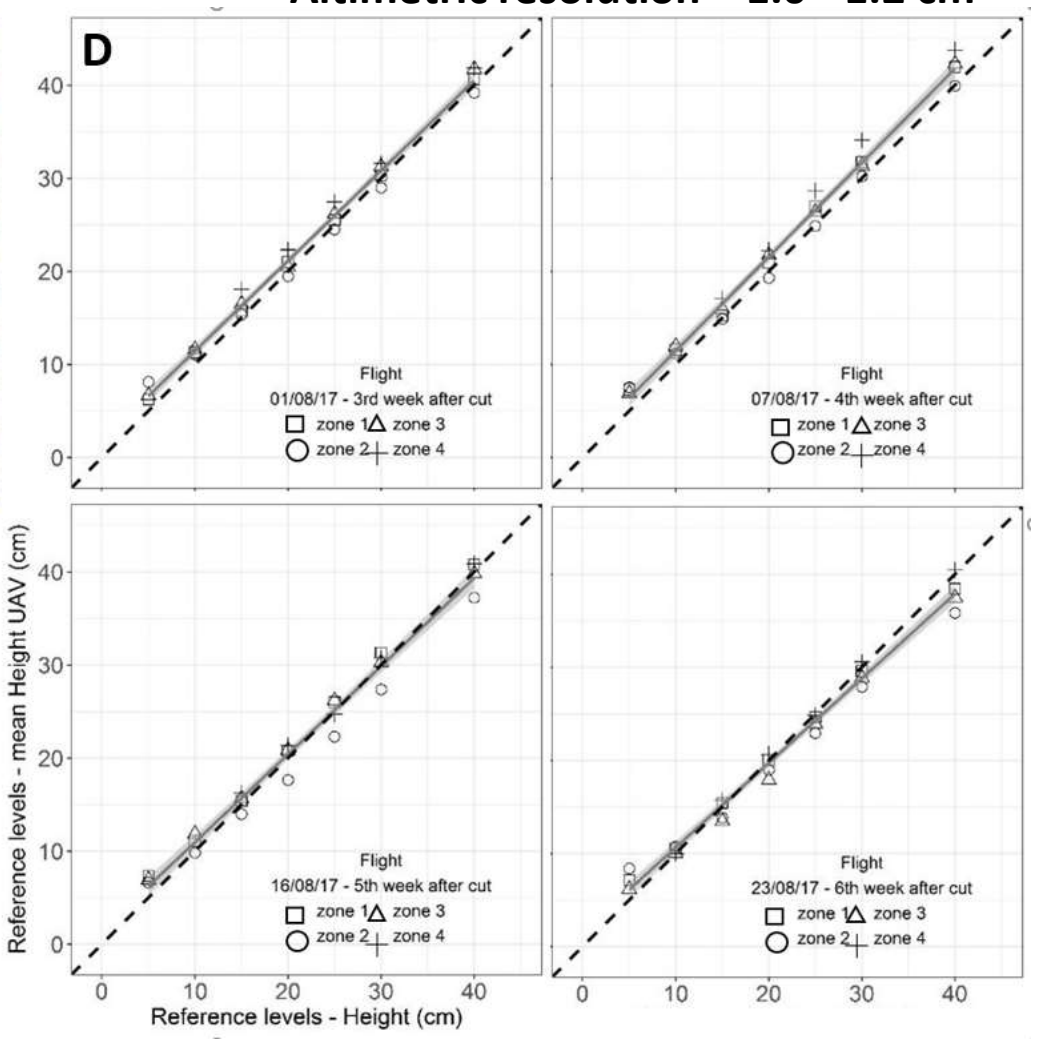
Traditional height measurement with a ‘rising-plate meter’



(Borra-Serrano et al. 2019, Grassland and Forage Science)

Estimation of canopy height and biomass of forage grasses (RGB)

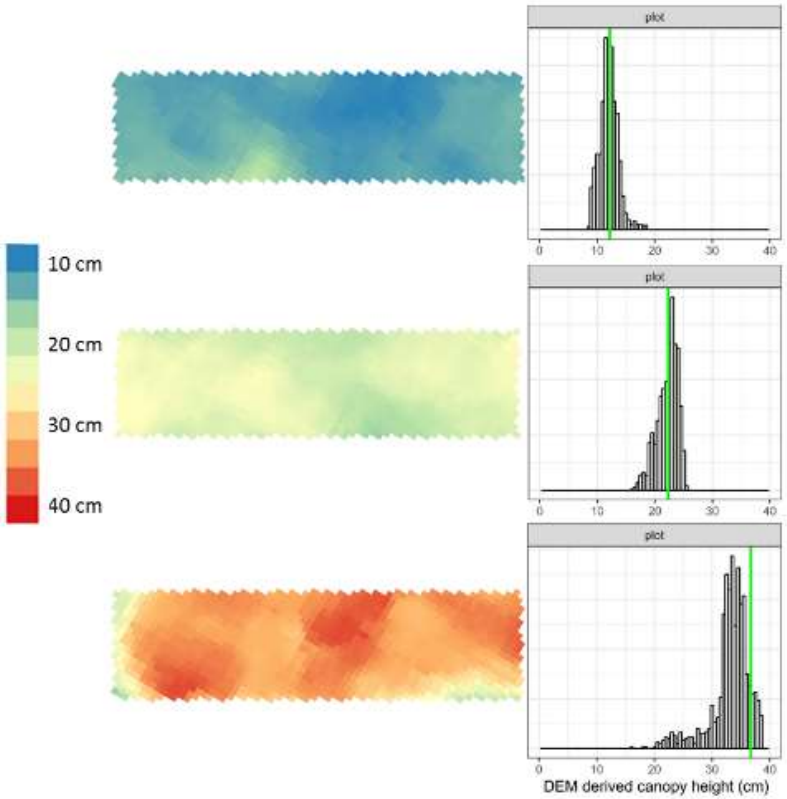
Correct estimation height references
Spatial resolution = 0.5 - 0.7 cm
Altimetric resolution = 1.0 - 1.2 cm

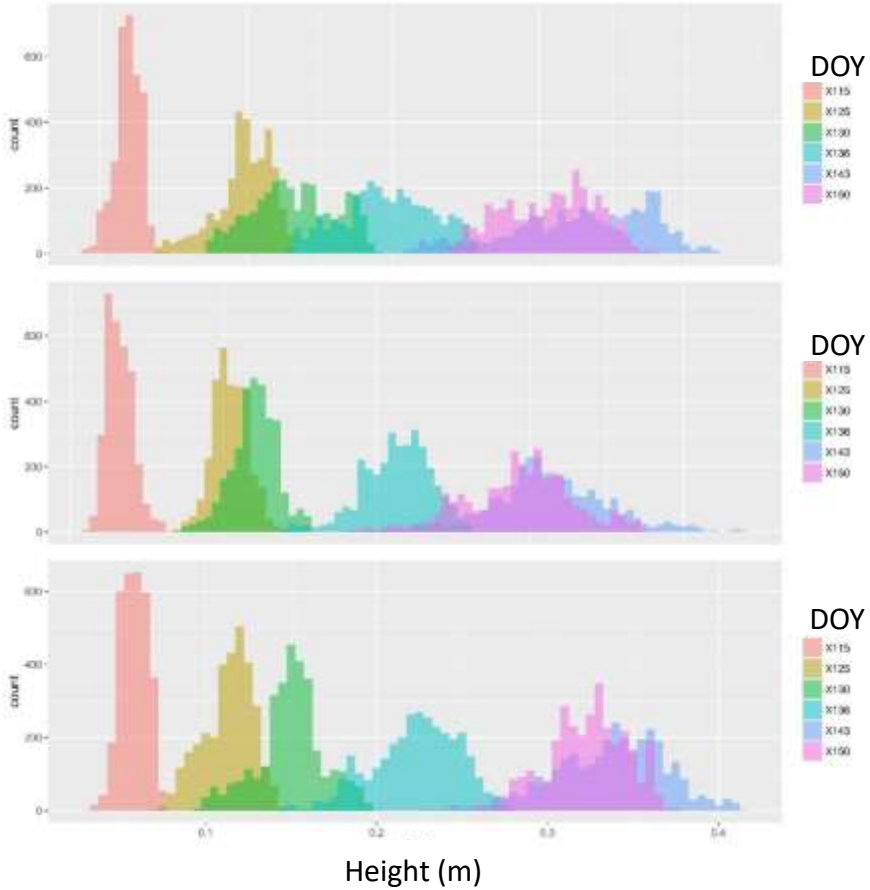


(Borra-Serrano et al. 2019, Grassland and Forage Science)

Estimation of canopy height and biomass of forage grasses (RGB)

Spatial variation of growth over time



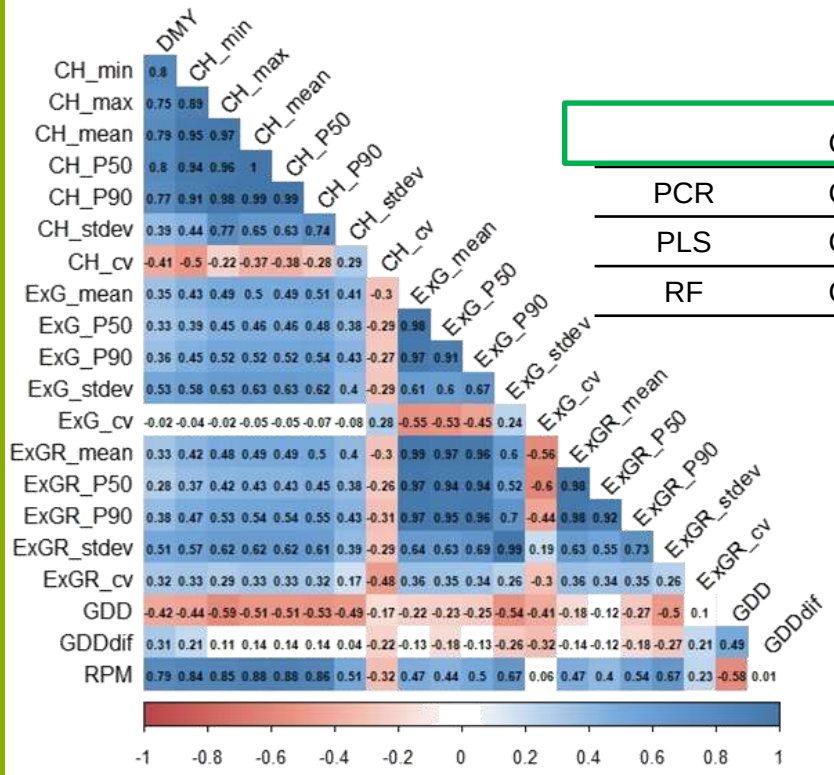


(Borra-Serrano et al. 2019, Grassland and Forage Science)

Estimation of canopy height and biomass of forage grasses (RGB)

Several methods statistical models evaluated to estimate biomass

Model type	Variables	RMSE (kg ha^{-1})	NRMSE (%)	R^2
LR	RPM	986	31.0	0.60
	CHMv – CH_P50	876	27.6	0.67
MLR	CHMv	825	26.0	0.71
	CHMv + VIv	822	25.9	0.71
	CHMv + VIv + RPM	857	27.0	0.69
	CHMv + VIv + GDDv	679	21.3	0.81
PCR	CHMv + VIv + GDDv	714	22.5	-
PLS	CHMv + VIv + GDDv	739	23.3	(0.58)
RF	CHMv + VIv + GDDv	769	24.2	(0.70)



FACCEJI – GrassLandscape/PhD Irene Borra-Serrano (ILVO)

(Borra-Serrano et al. 2019, Grassland and Forage Science)

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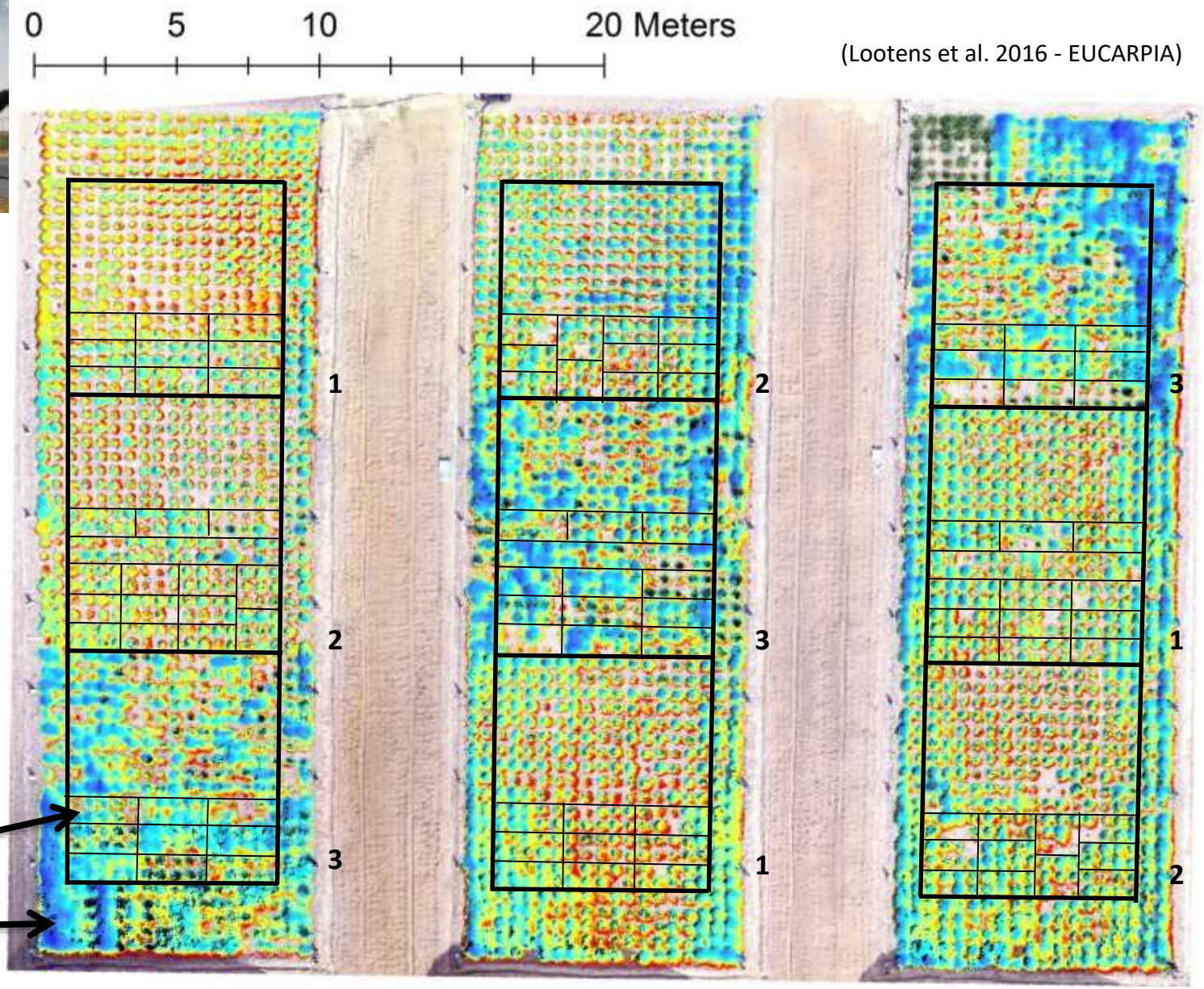
Drought tolerance of individual plants (thermal)



(Lootens et al. 2016 - EUCARPIA)

1 = Lolium perenne, 2n
2 = Lolium perenne, 4n
3 = Festuca arundinacea

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Take home messages

1. Discuss with the crop expert which crop trait need to be monitored
2. Start with ‘plug-and-play’ sensors

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EUC LEG ECOFE

Future Arctic

INVITE
INnovations in plant VarIety Testing

WIKILEEKS

Thank you!
Question?

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