



# Field Phenomics beyond crop breeding: exploring the intersection between remote sensing and crop physiology

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# There has to be a better way to do this...



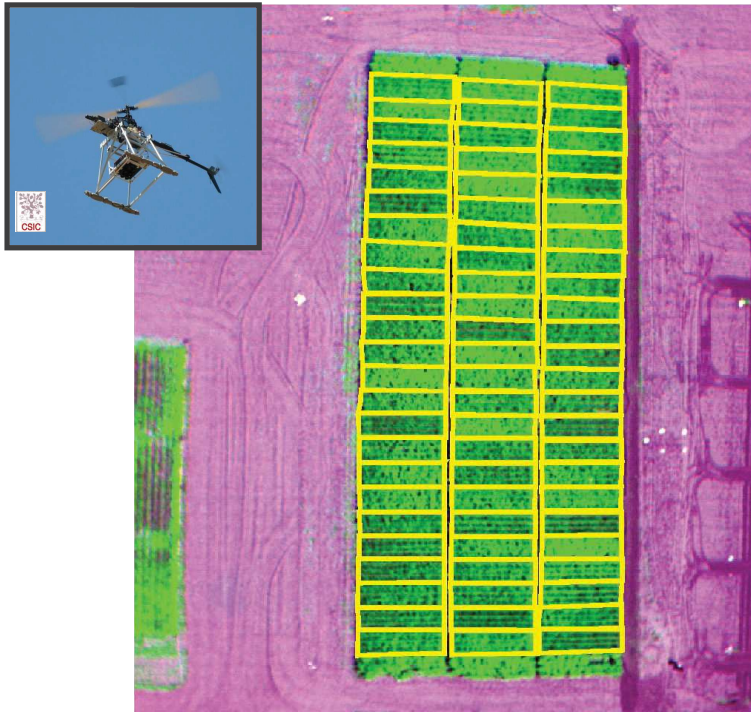
There has to be a better way to do this... YES!



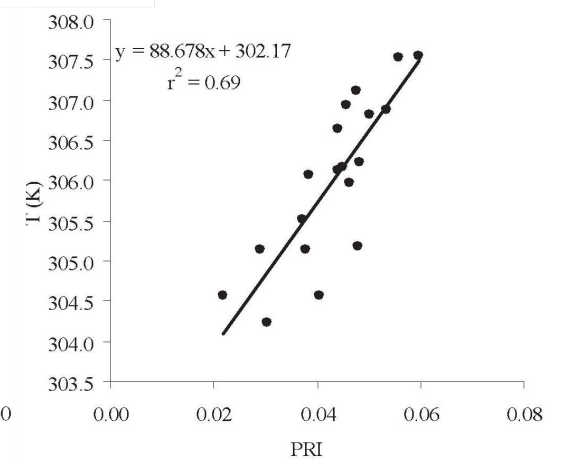
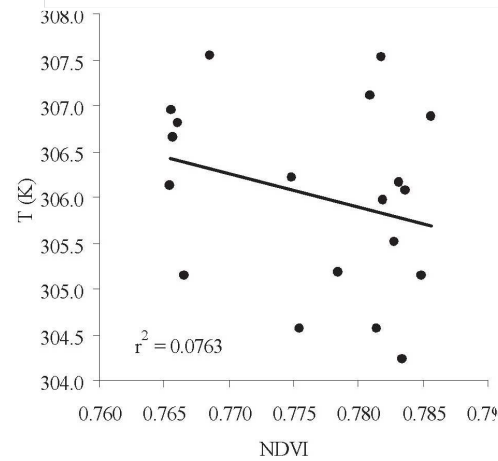
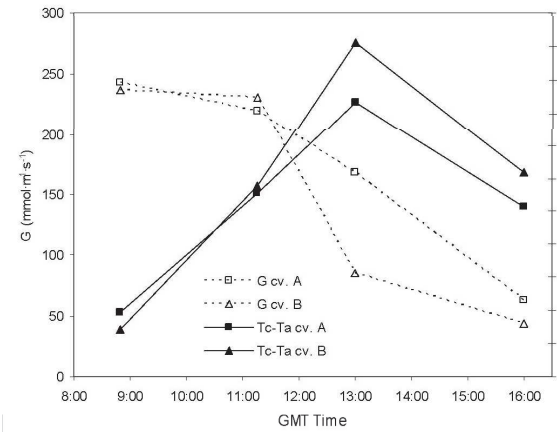


# Pre-phenomics times

2007 AD



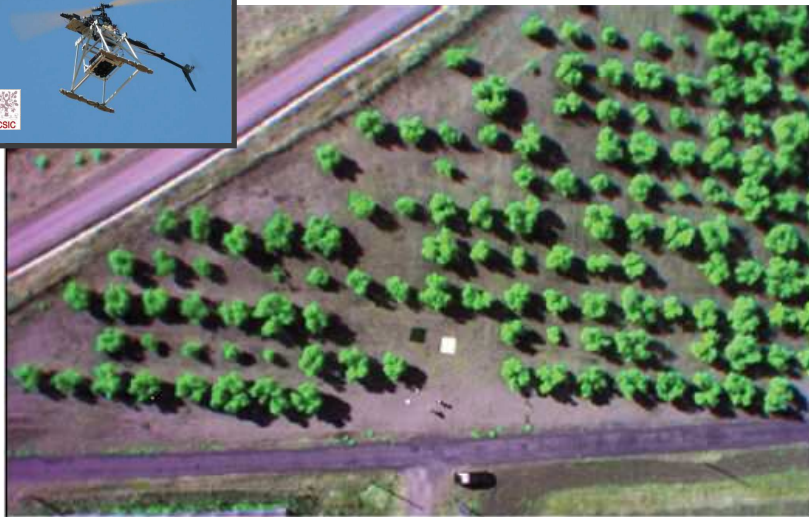
Maize trial in Cordoba, 2007



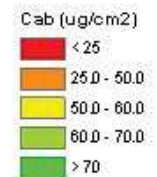
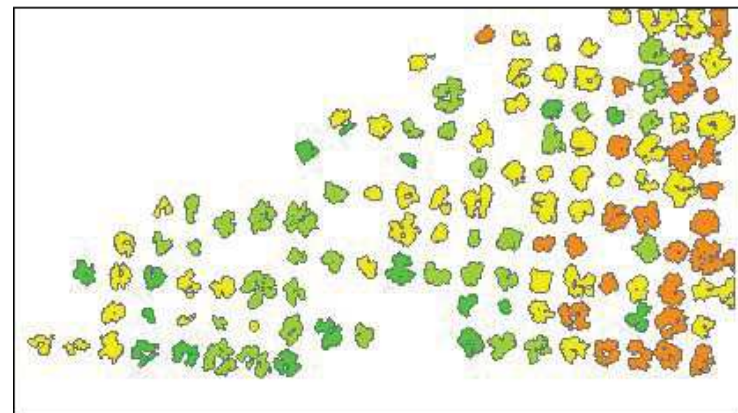
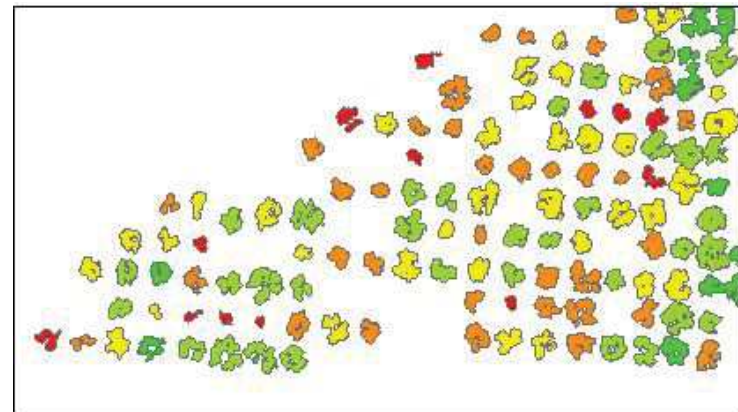
Berni, et al. 2009 (IEEE)

# Pre-phenomics times

2007 AD



Olive Germplasm Bank in Cordoba, 2007





# My phenomics epiphany



Wheat trials in Yanco, Australia, 2015



## The phenomics paradigm

$$P = G \times E \times M$$

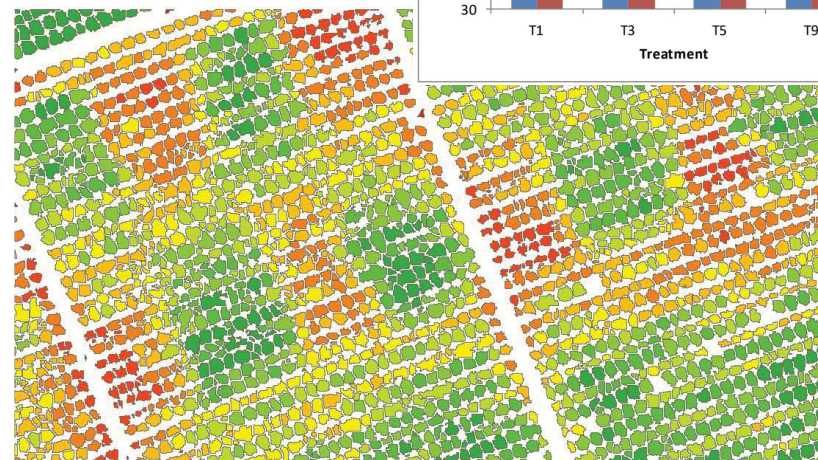
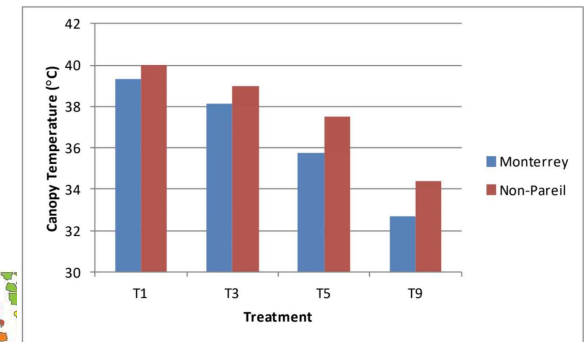
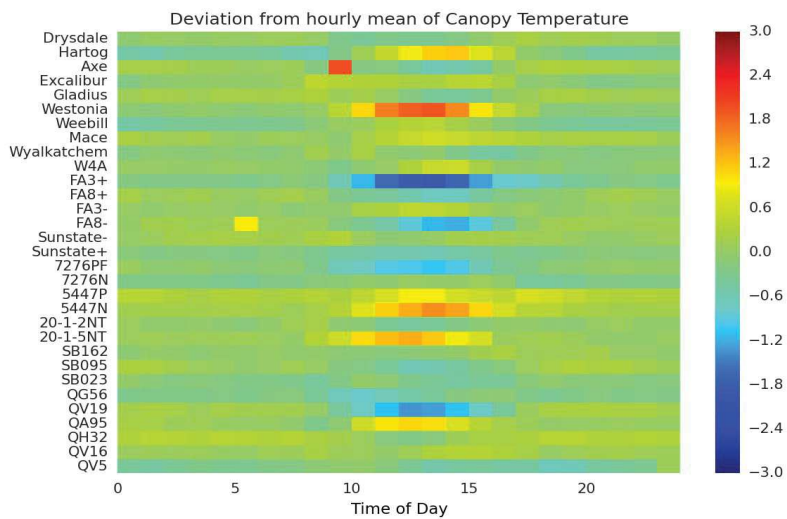
$$P_t = G \times E_t \times M_t$$



From 5 persons/day (destructive) to 1 person/hour (non-destructive) for biomass estimation



# The phenomics paradigm



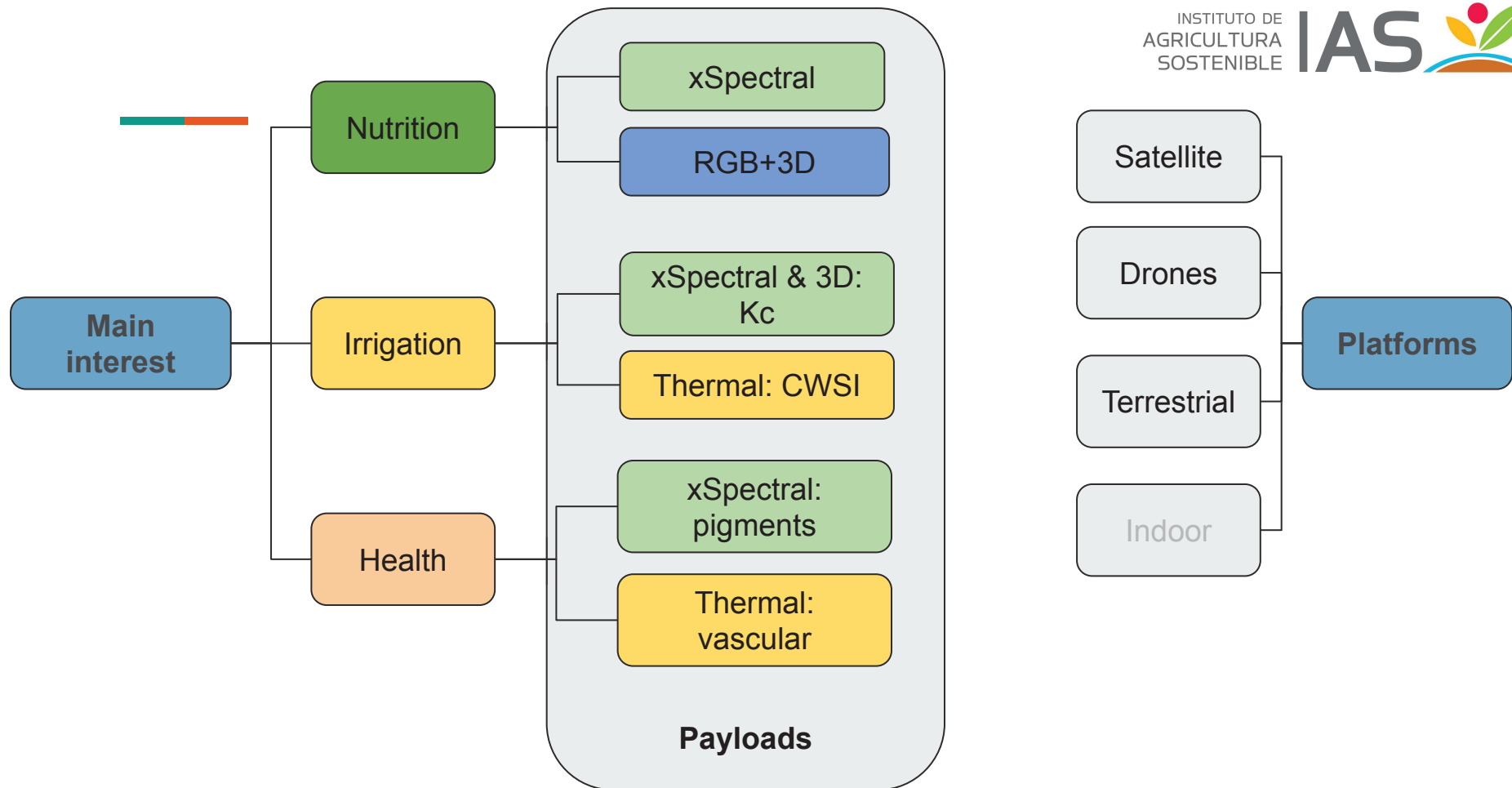
$$G = P_t / (E_t \times M_t)$$

$$M_t = P_t / (G \times E_t)$$

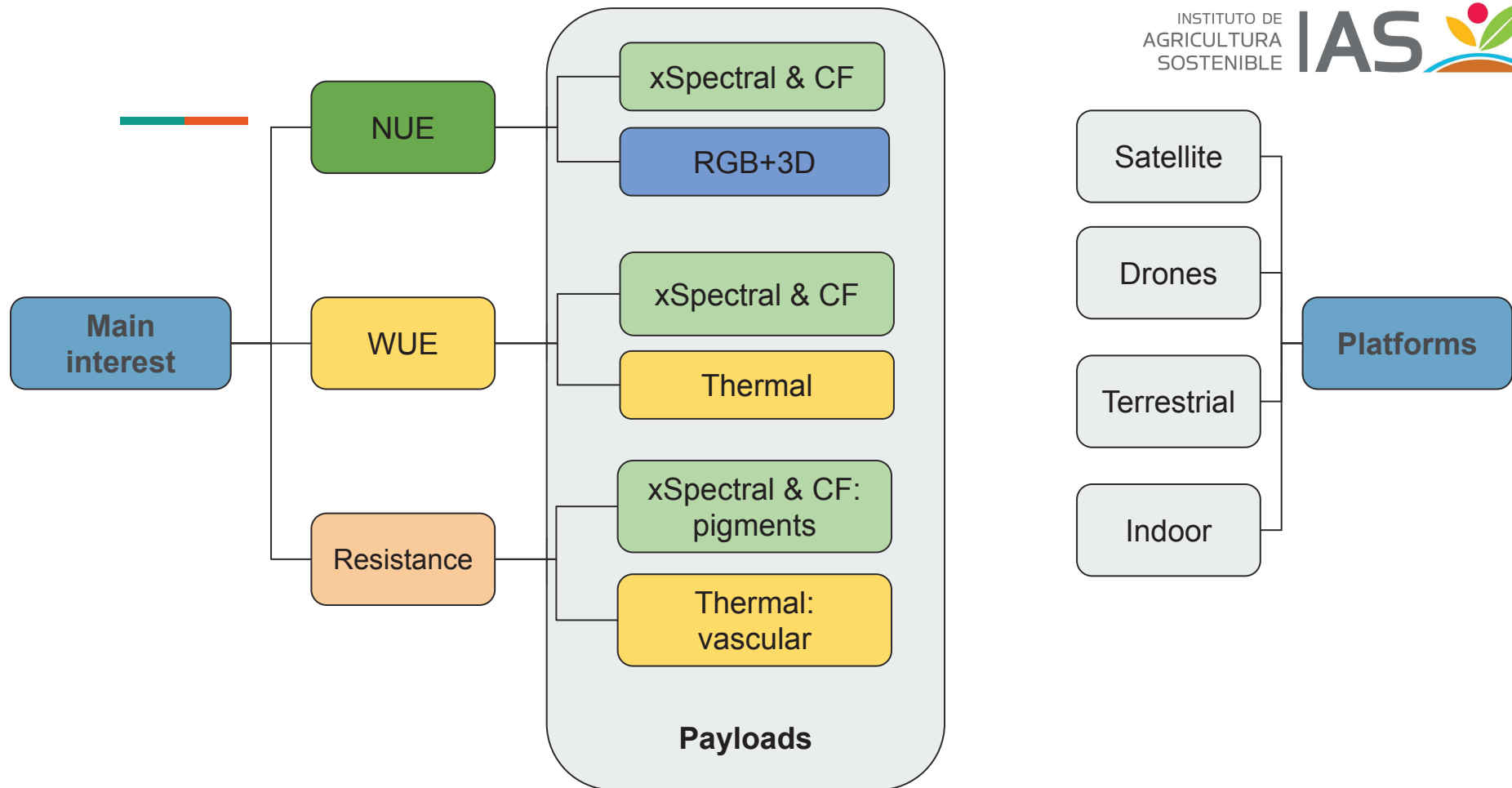
Jimenez-Berni, et al. (in preparation)



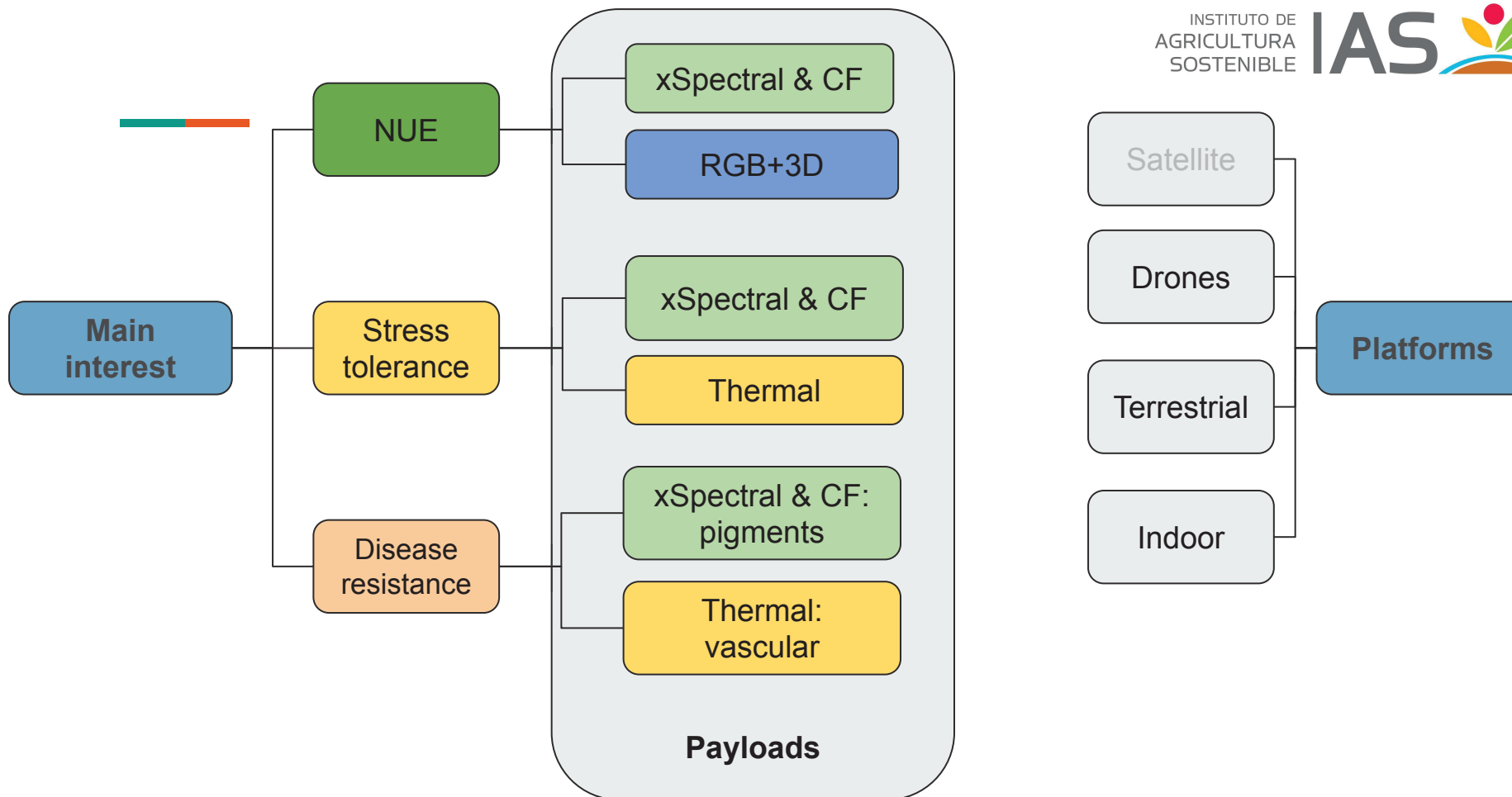
# A decision tree for agronomists



# A decision tree for physiologists

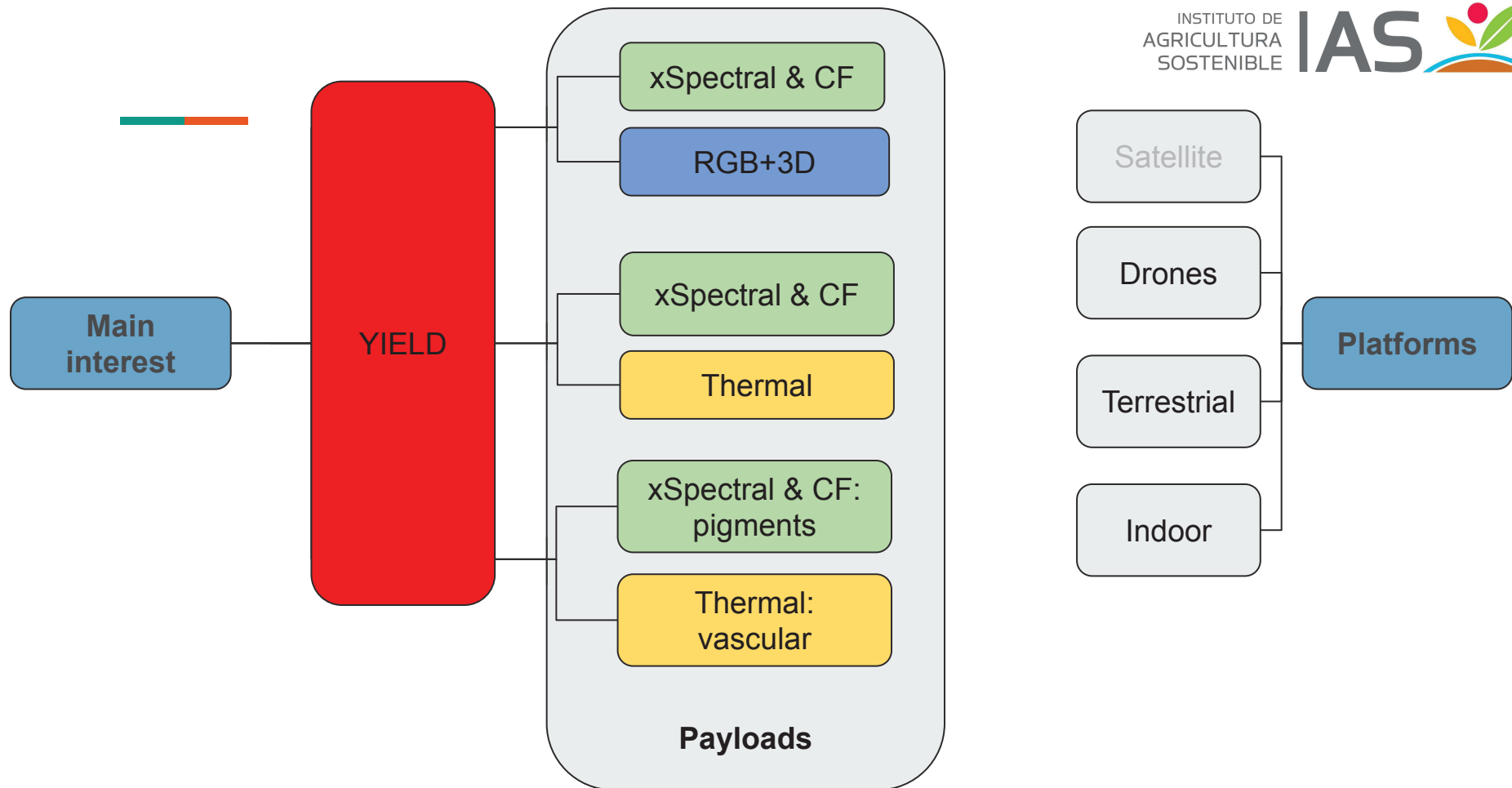


# A decision tree for breeders

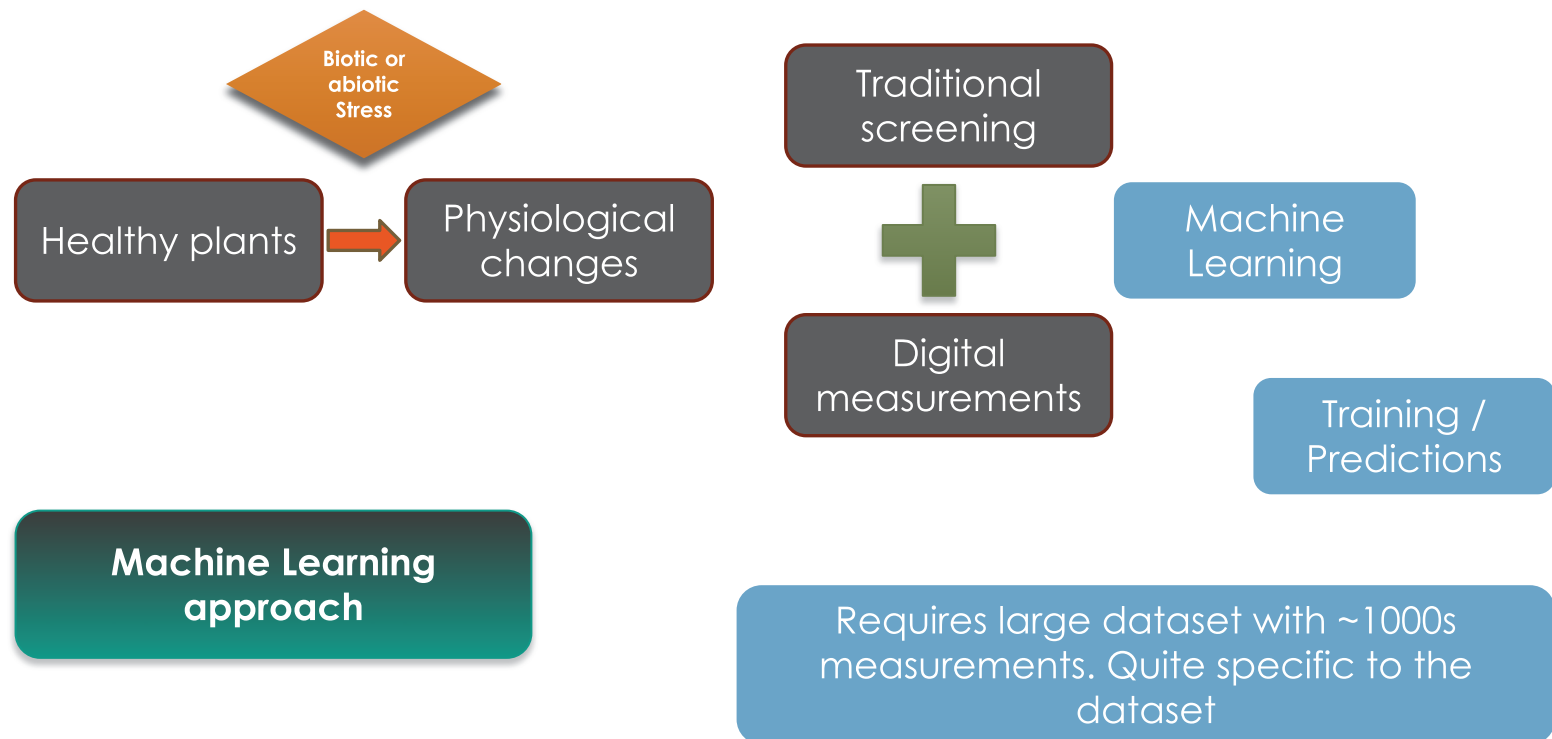




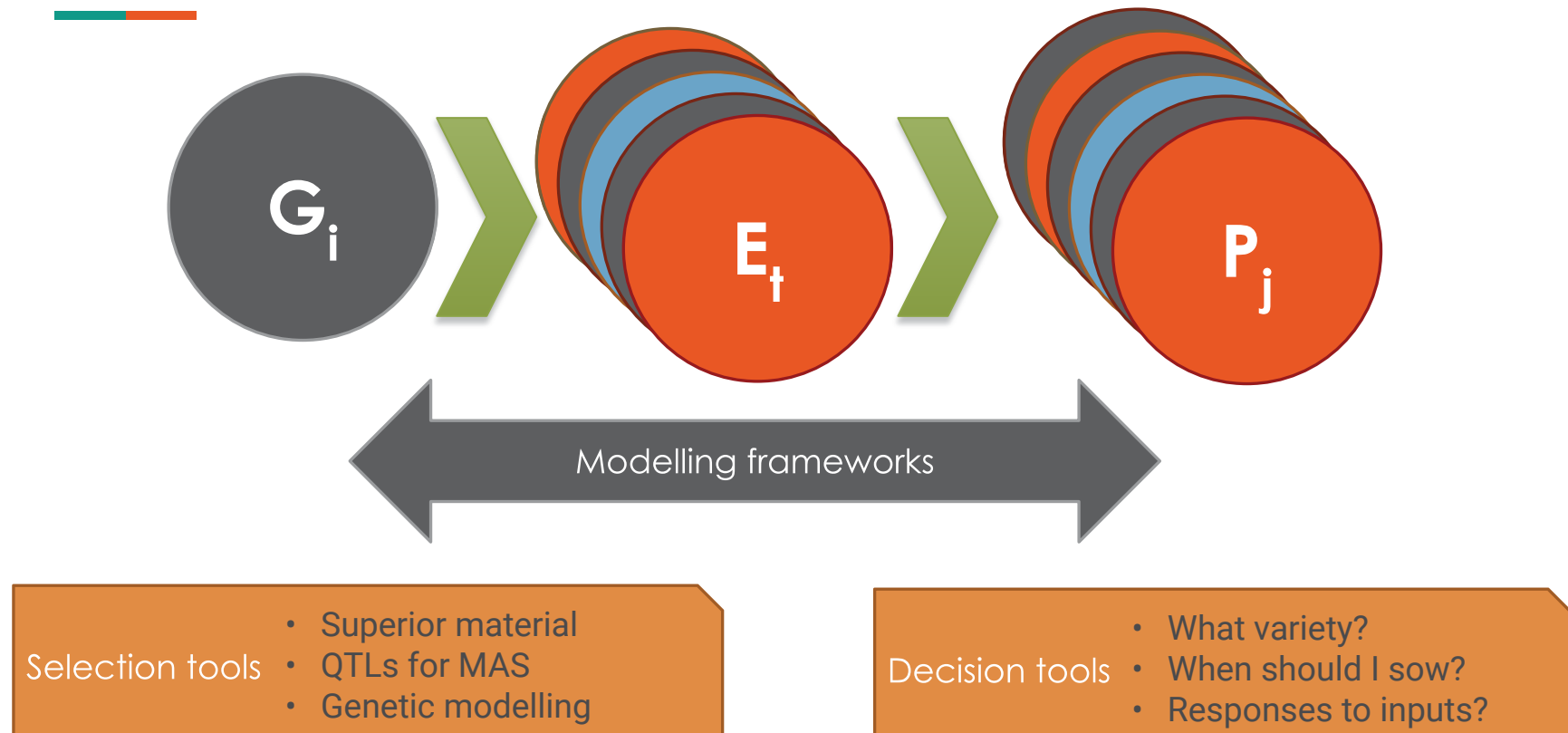
# A decision tree for breeders



# From decisions trees to random forests

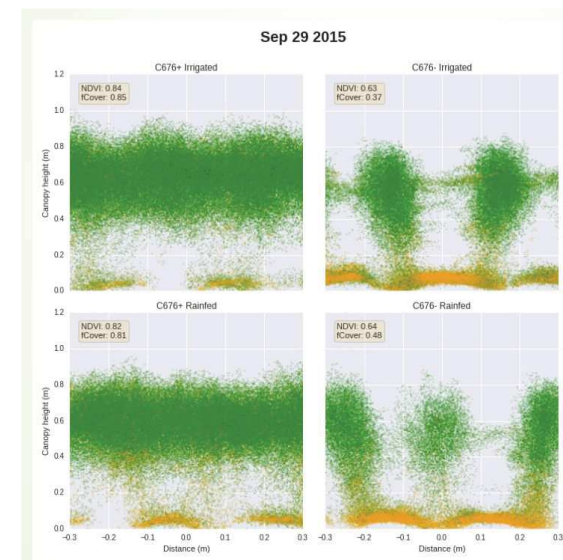
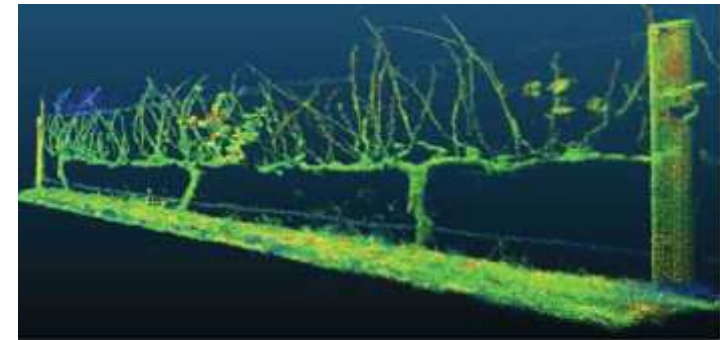


## Putting together the GxExM

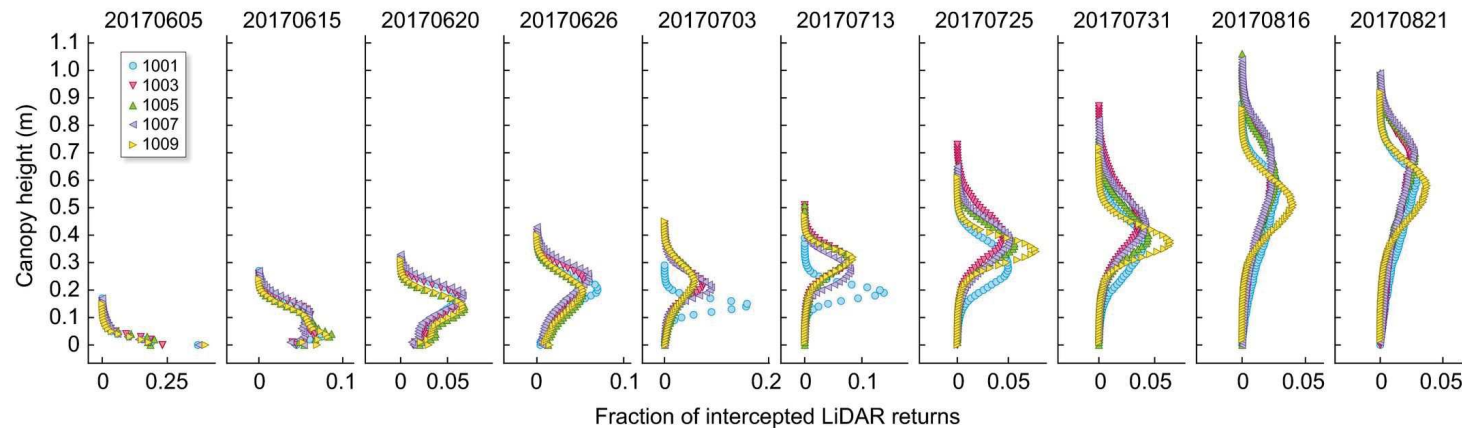
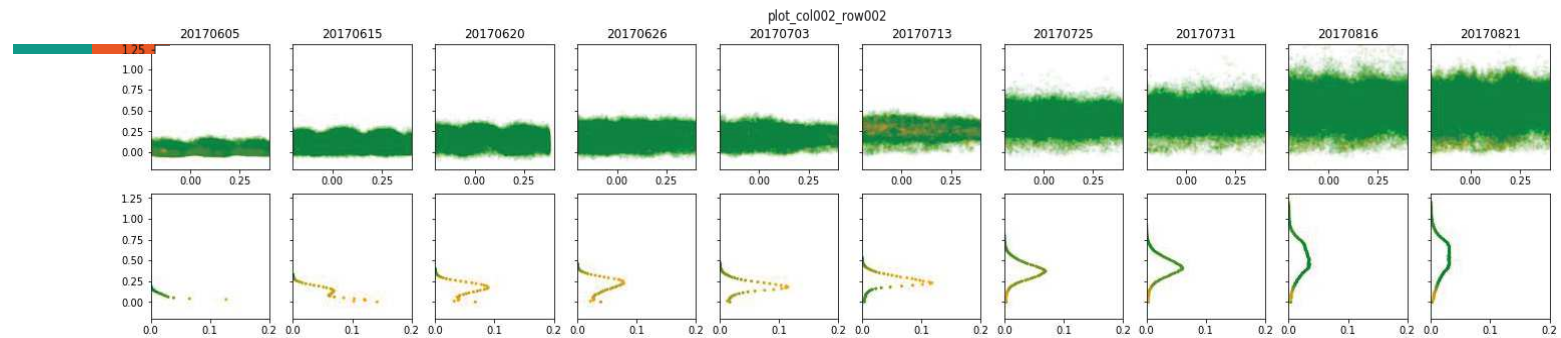




# Ground LiDAR applications



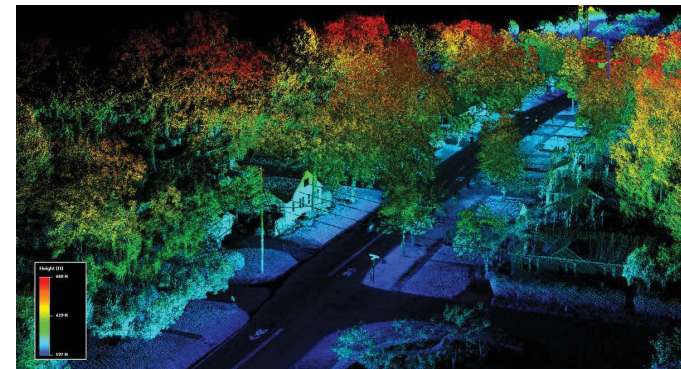
# Canopy architecture and light interception



Furbank, et al. (New Phytologist, 2019); Berni, Dreccer et al. (In preparation)

## New LiDARs and Robots

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<https://www.youtube.com/watch?v=M3SGScaShhw&t=1s>

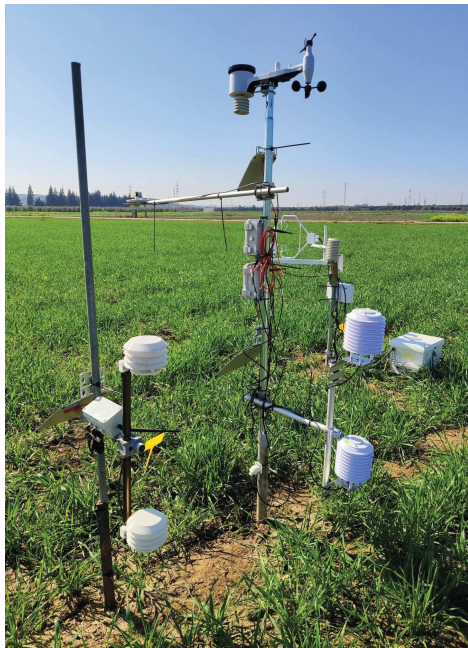


## Sensor networks

- Continuous measurements
  - Complement spatial data
- Interactions with the **environment**
  - Dynamic traits
- Real time access to data
  - Decision support
- Limitations: cost per node



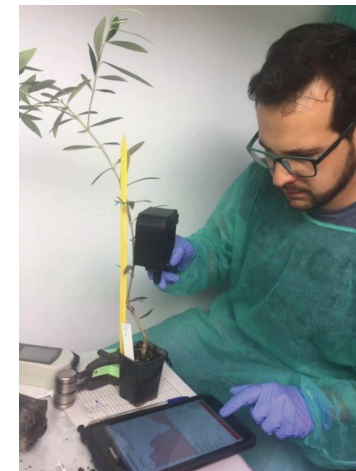
## Affordable technologies



FAO-SIDA & UCO Project for remote estimation of ET  
<https://github.com/OpenAgriTech/CORDOVA-ET-node>



- \$100k
- 15kg



- \$1.5k
- 0.5kg

Handheld SWIR spectrometer for disease screening

## Current gaps (and opportunities)

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- Lack of standard implementations for hardware and processing pipelines
  - ◆ More open-source developments. Some good examples: PlantCV
  - ◆ OpenAgriTech (for sensor networks), Agrolaser (for LiDAR-based phenomobiles)
  - ◆ Jupyter Hub, D4Science, Google Colab...
- Small validation datasets for machine learning approaches
  - ◆ More open-access shared datasets: Kraggle example
  - ◆ Fine tune of modelling (e.g. SCOPE, PROSPECT, DART, etc)
- Most models (RTM, Crop models) lack resolution for small phenotypic differences
  - ◆ Joint workshop with the modelling community?
  - ◆ More modelling effort for implementation of GxExM and validation?
- Real multidisciplinary approach
  - ◆ Curriculum for new plant scientists/remote sensing



# Thank you!



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<https://github.com/OpenAgriTech>

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