UAV imaging spectroscopy in support of crop trait retrieval and growth monitoring

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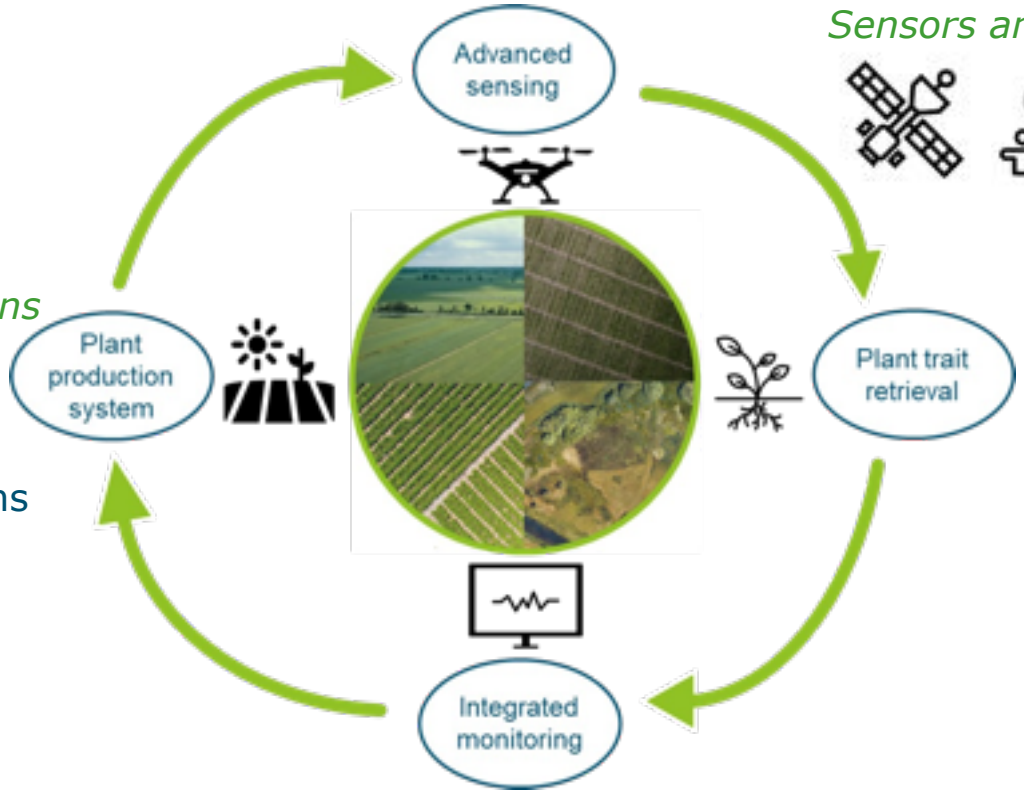
Sensing crop traits for system understanding

Concepts & applications
Phenotyping
Plant-soil feedback
Strip cropping
Nature-based solutions
Smart farming



Sensors and platforms

Traits and processes
Structure
Height
Biomass
Chlorophyll
Nitrogen
Growth-yield
Photosynthesis

Improved **understanding** of plant production systems through **advanced sensing** systems and **modelling** methods by characterising relevant plant **traits and functioning**

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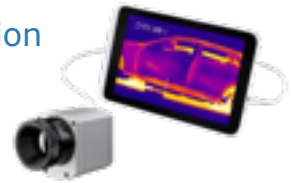
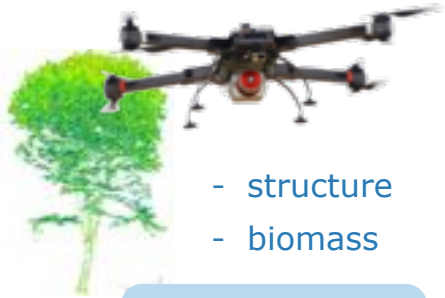
Availability and development of UAV sensors

- transpiration rate





- structure
- biomass

- photosynthetic activity

Thermal cameras

Laser scanning

Fluorescence sensors

Off-the-shelf RGB cameras

Multispectral cameras

- leaf biochemical properties
- biomass
- structure* (through SfM)

Imaging spectroscopy cameras

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Current status:

fully operational | developing | experimental

UAV spectroscopy and surface reflectance validation

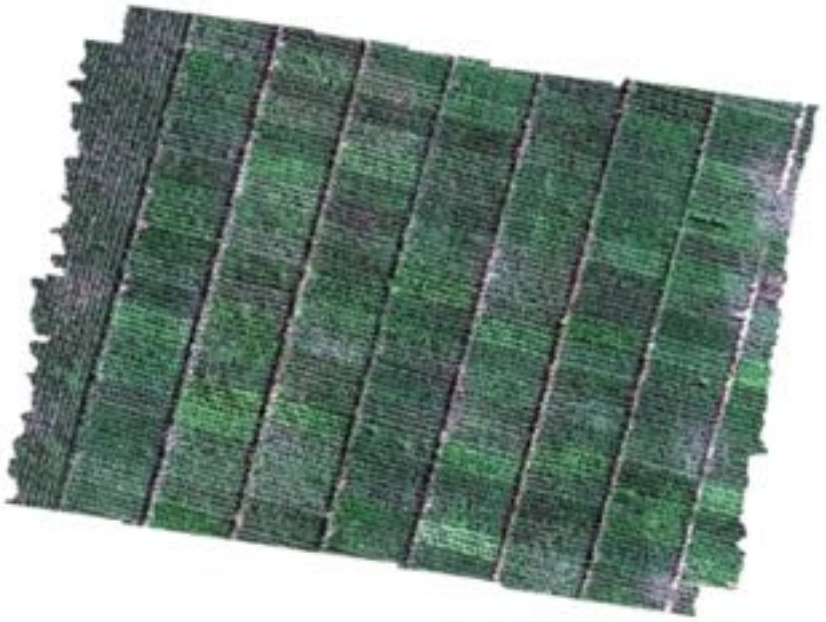
UAV imaging spectroscopy for validation of satellite surface reflectance products.

Benefits:

- ✓Covering greater area,
- ✓More detailed surveys,
- ✓Removing site disturbance,
- ✓Measuring complicated sites.

BUT no community-agreed field data collection protocols for UAV spectroscopy exist yet.

Headwall Nano-Hyperspec VNIR
Spectral range: 400 – 1000 nm
270 spectral bands



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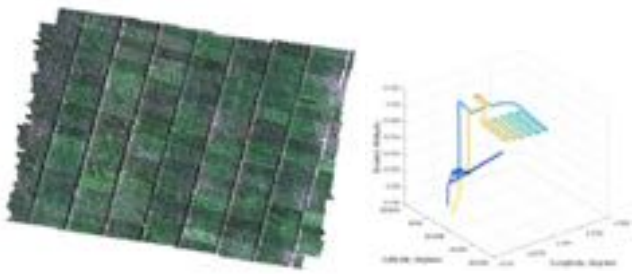
UAV spectroscopy and surface reflectance validation

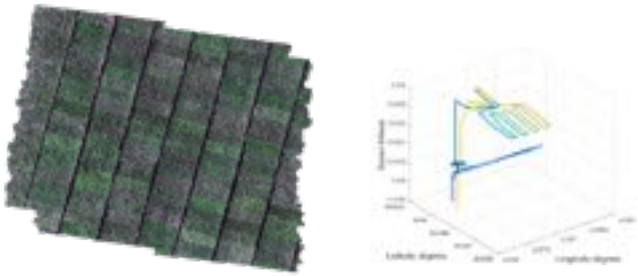
SRIX4VEG UAV inter-comparison exercise:

- Assess the variability associated with different teams undertaking the same validation work,
- Help design Fiducial Reference Measurements (FRM) protocols for surface reflectance validation using UAVs.

Protocol 1 (pre-defined):



Protocol 2 (own):



NPL National Physical Laboratory

esa

fiducial reference measurements for vegetation

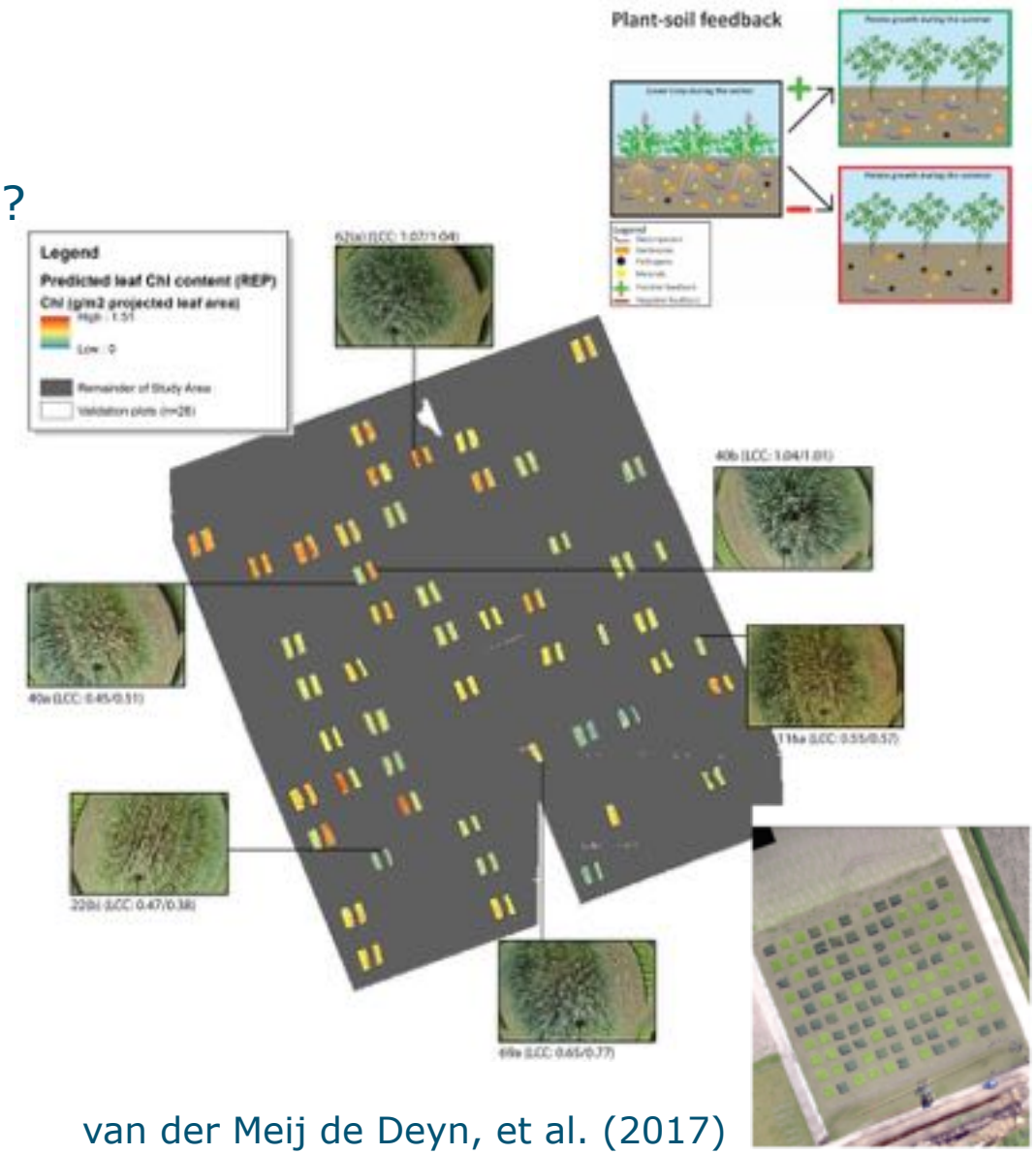
IDEAS-QA4EO

Plant-soil feedback: cover crops effects on plant traits

Can UAV hyperspectral data characterise plant traits sufficiently well to be used instead of field measurements?

Benefits:

- ✓ Information on spatial distribution of plant traits
- ✓ Temporal flexibility: diurnal observations



Hyperspectral Mapping System (HYMSY)
450-950 nm
30 bands

Machine learning Model (PLS)

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van der Meij de Deyn, et al. (2017)

Field vs. UAV-based field traits

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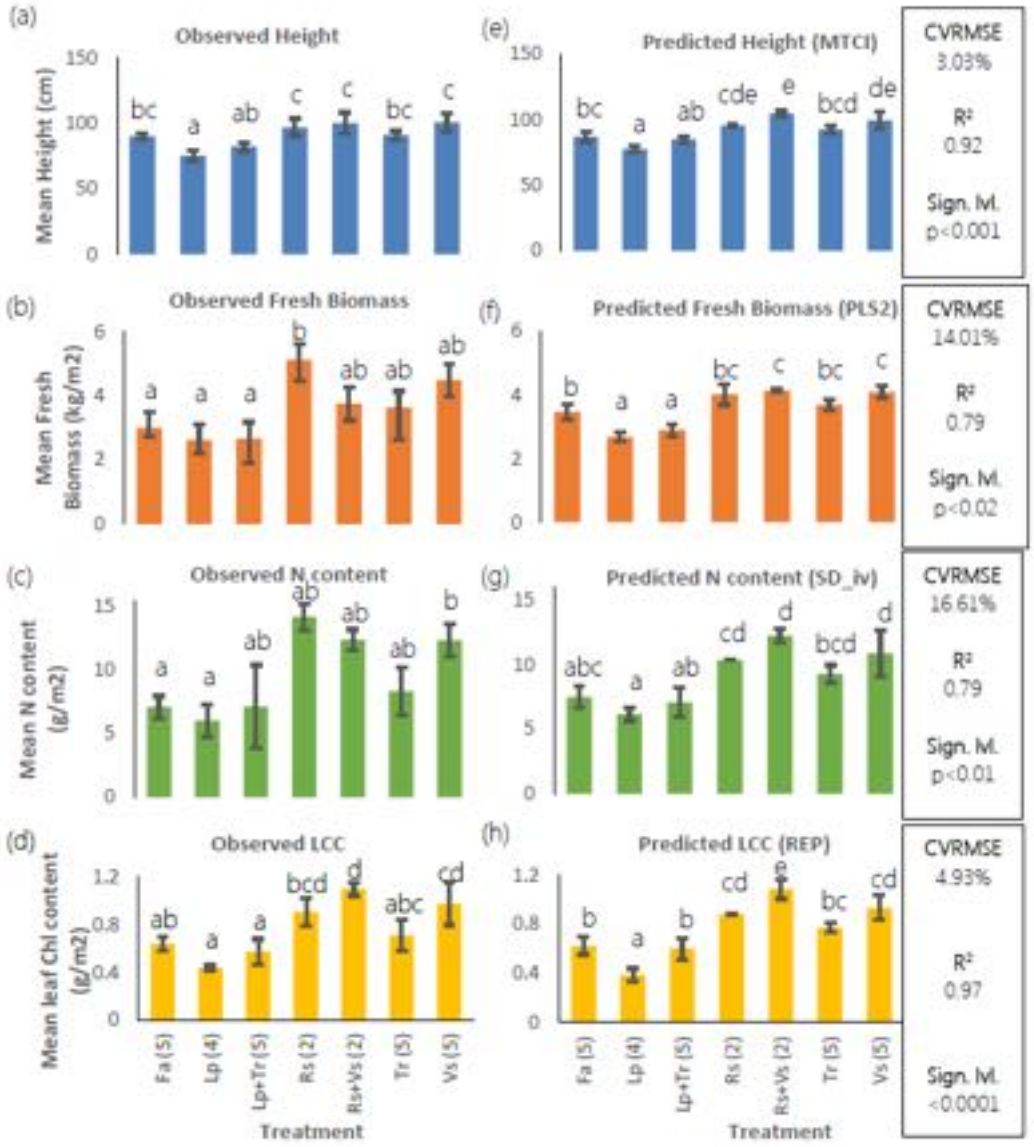

van der Meij de Deyn, et al. (2017)

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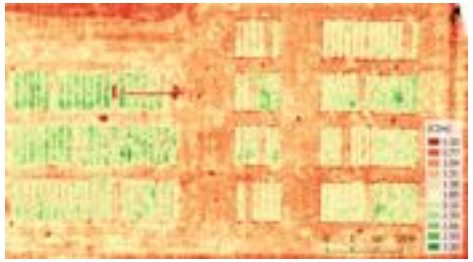
Grassland trait variation and retrieval

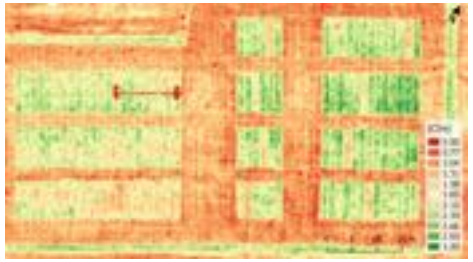
CI red-edge
[0.14 m]

09-May
2017

30-Aug
2017

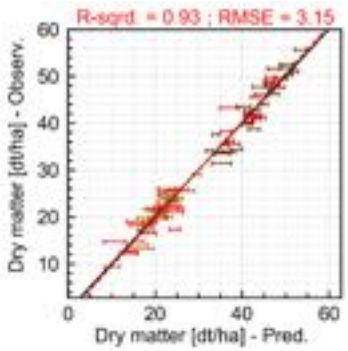


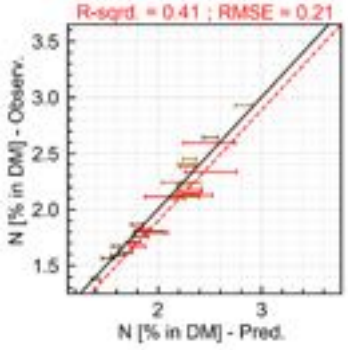
26-Oct
2017



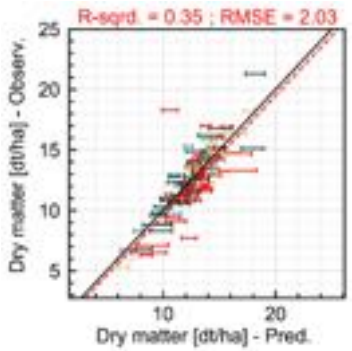
Grassland trait retrieval – one vs. multi-year
top: [Dry matter] bottom: [N%]

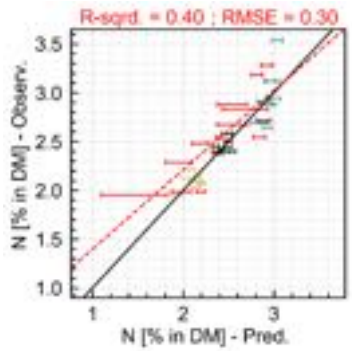
2014



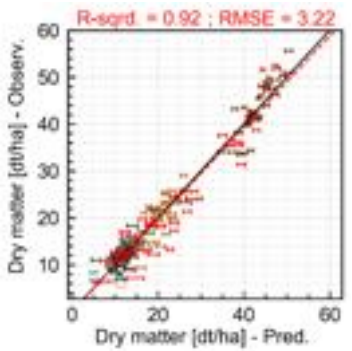


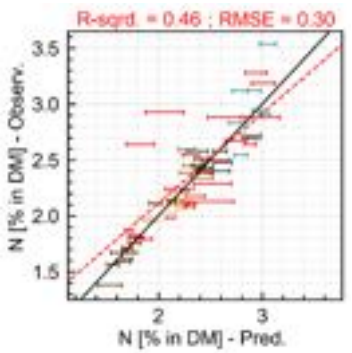
2017





2014 + 2017





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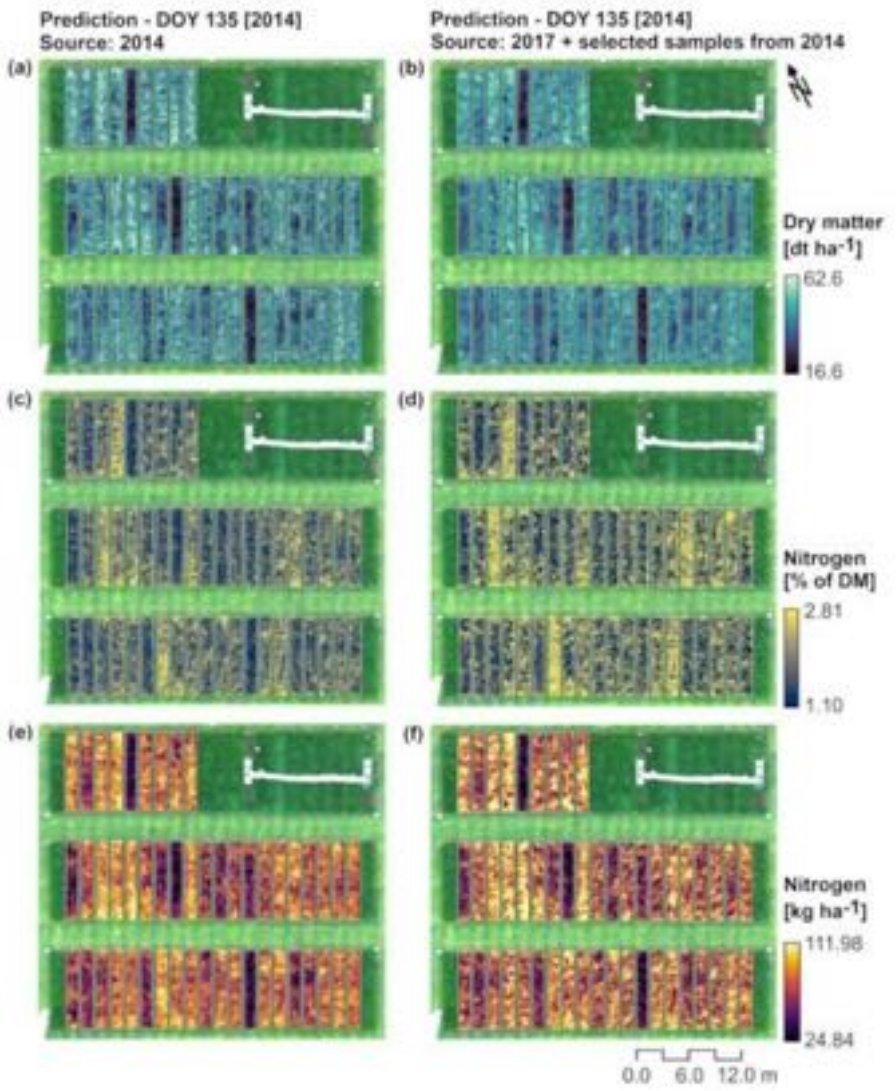
Source: Franceschini et al., 2022

Pixel-wise prediction of grassland traits



UAVs as a potential validation platform for satellite-based IS products:

- ✓ Comprehensive ground reference
- ✓ Insight into spatial variability
- ✓ Temporal flexibility: diurnal observations

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Source: Franceschini et al., 2022

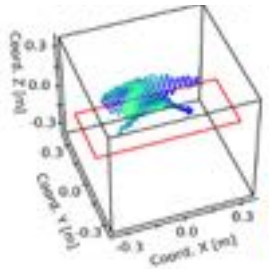
Multi-sensor approach for disease assessment

UAVs are valuable experimentation platforms for:

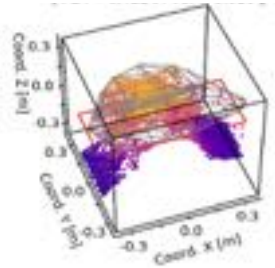
- Developing multi-sensor acquisition strategies

Erwinia infected plant colour and structure

Sensor 1: Spectral sensor (VI)



Sensor 2: 3D model (SfM)



Sensor 3: 3D model (LiDAR)

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Source: Siebring et al., 2019

Multi-sensor approach for disease assessment

UAVs are valuable experimentation platforms for:

- Developing multi-sensor acquisition strategies

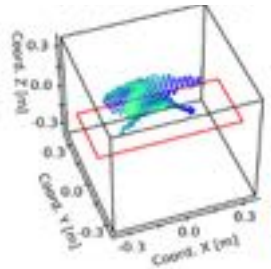
Single vs. multi-sensor scenario

Metric	Features				
	VIs	LiDAR	SfM	VIs+ LiDAR	VIs+ SfM
Accuracy	0.782	0.761	0.708	0.859	0.789

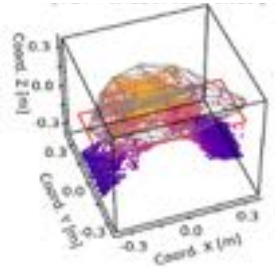
Model: Support Vector Machines
Vegetation indices (76) + Lidar (51) or SfM (30) features
Training (132) and validation (72)
Source: Franceschini et al. (submitted)

Erwinia infected plant colour and structure

Sensor 1: Spectral sensor (VI)



Sensor 2: 3D model (SfM)



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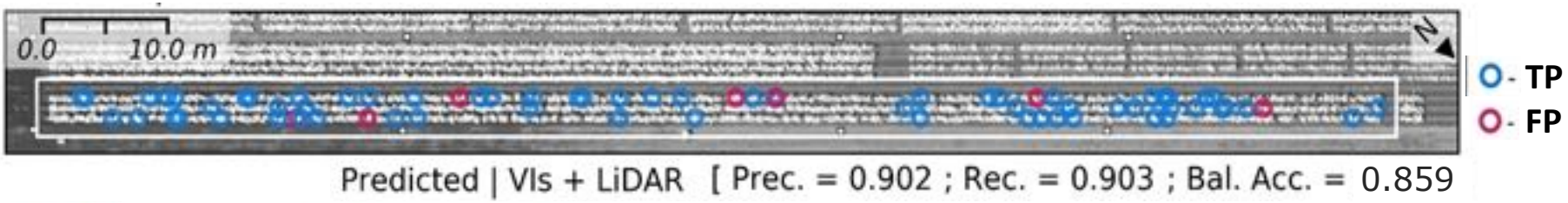


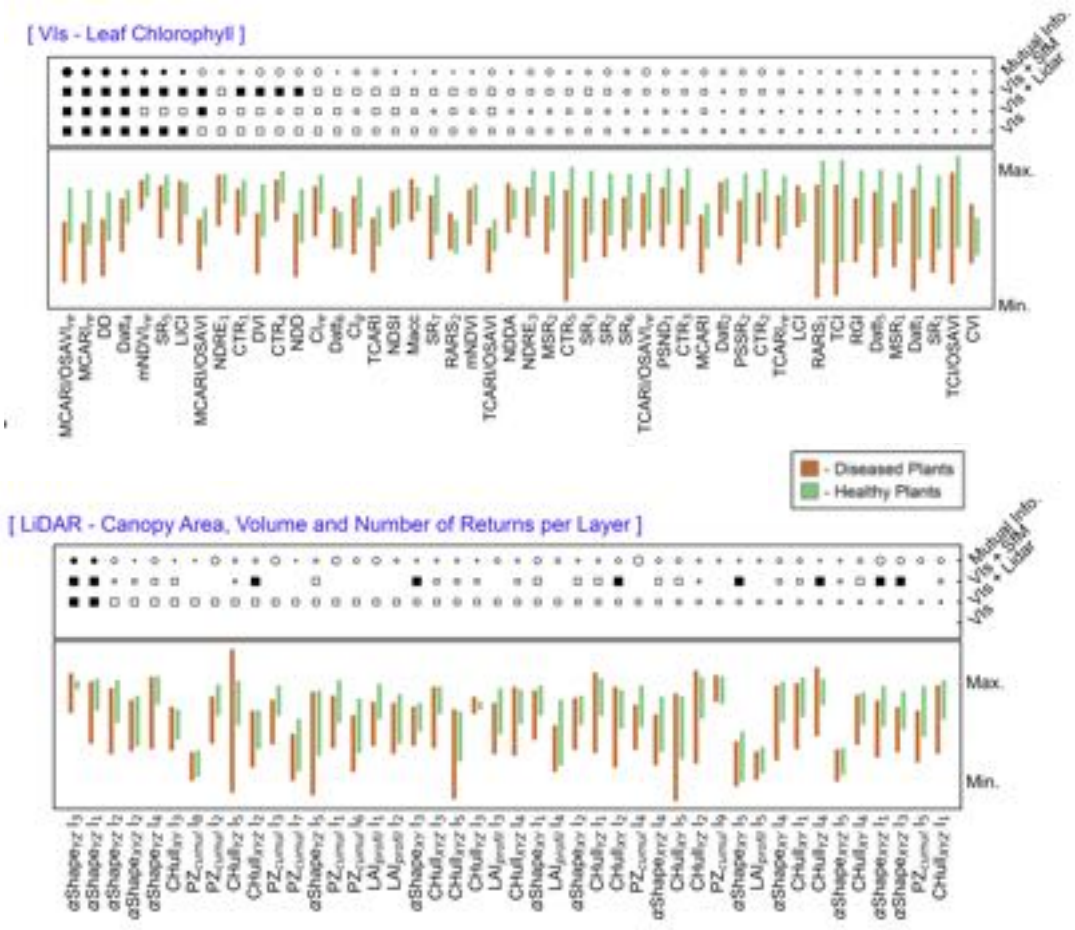
Multi-sensor approach for disease assessment

UAVs are valuable experimentation platforms for:

- Developing multi-sensor acquisition strategies
- Identification of feature importance

Erwinia infected plant colour and structure

Feature ranking according to the importance for disease incidence classification (RFE-CV: Recursive Feature Elimination with Cross Validation)



Source: Franceschini et al., (submitted)

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Outlook for UAV-based imaging spectroscopy

- Validation platform for satellite-based IS products offering **comprehensive ground reference,** insight into **spatial variability,** and **temporal flexibility**

- Experimentation platform for **comparison of plant trait retrieval approaches,** identification of **feature importance** and **multi-sensor acquisition strategies**

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