INNOVATION IN HYDROMETRY ■ FROM IDEAS TO OPERATION

IAHS MEASUREMENTS AND OBSERVATIONS IN THE XXI CENTURY (MOXXI) AND WMO HYDROHUB JOINT MEETING 2017

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UAV-based Remote Sensing for Monitoring Bioenergy Crops Responses to Water Stress in a Changing Climate

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WMO, Geneva, Switzerland

TREE IMPROVEMENT PROGRAM

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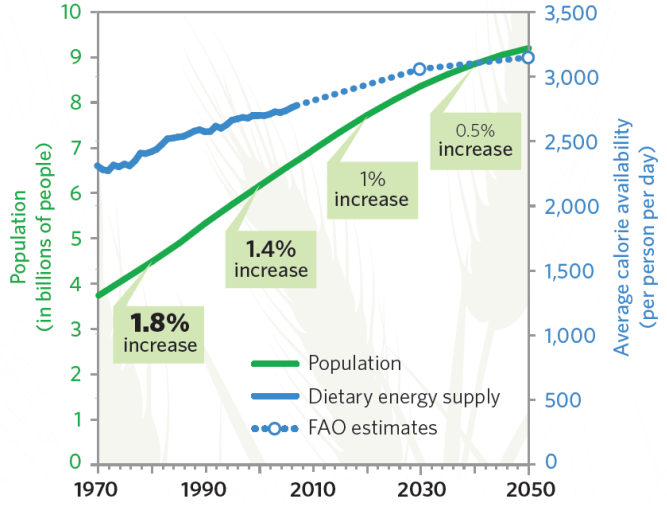
What **Challenges** do agriculture face today?

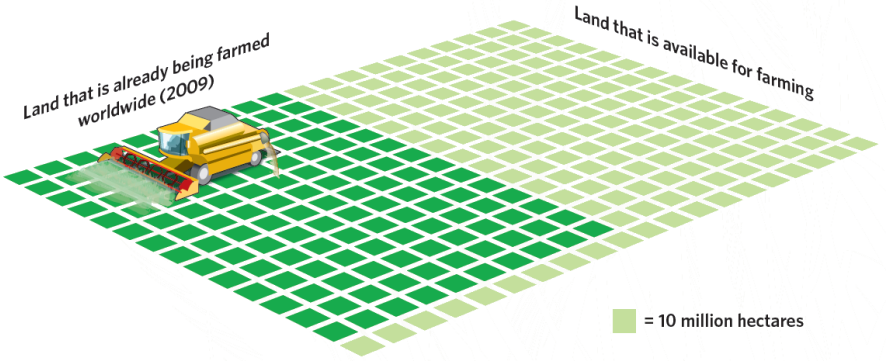
A growing body of **evidence**

Population growth



Sources: UN population division; FAO
News Feature Food: Nature, Vol 466:29 July 2010

Arable land shortage



Source: FAO/OECD
News Feature Food: Nature, Vol 466:29 July 2010

nature International weekly journal of science

Top climate change concerns by region

Pew Research Center

	Droughts or water shortages	Severe weather, like floods or intense storms	Long periods of unusually hot weather	Rising Sea Levels
LATIN AMERICA	59%	21%	12%	5%
AFRICA	59%	18%	16%	3%
U.S.	50%	16%	11%	17%
ASIA/ PACIFIC	41%	34%	13%	6%
MIDDLE EAST	38%	24%	19%	5%
EUROPE	35%	27%	8%	15%
GLOBAL	44%	25%	14%	6%

Note: Russia and Ukraine not included in Europe median.
Source: Spring 2015 Global Attitudes Survey, Q32
Date: Pew Research Center, November 2015,
"Global Concern about Climate Change, Broad Support for Limiting Emissions"

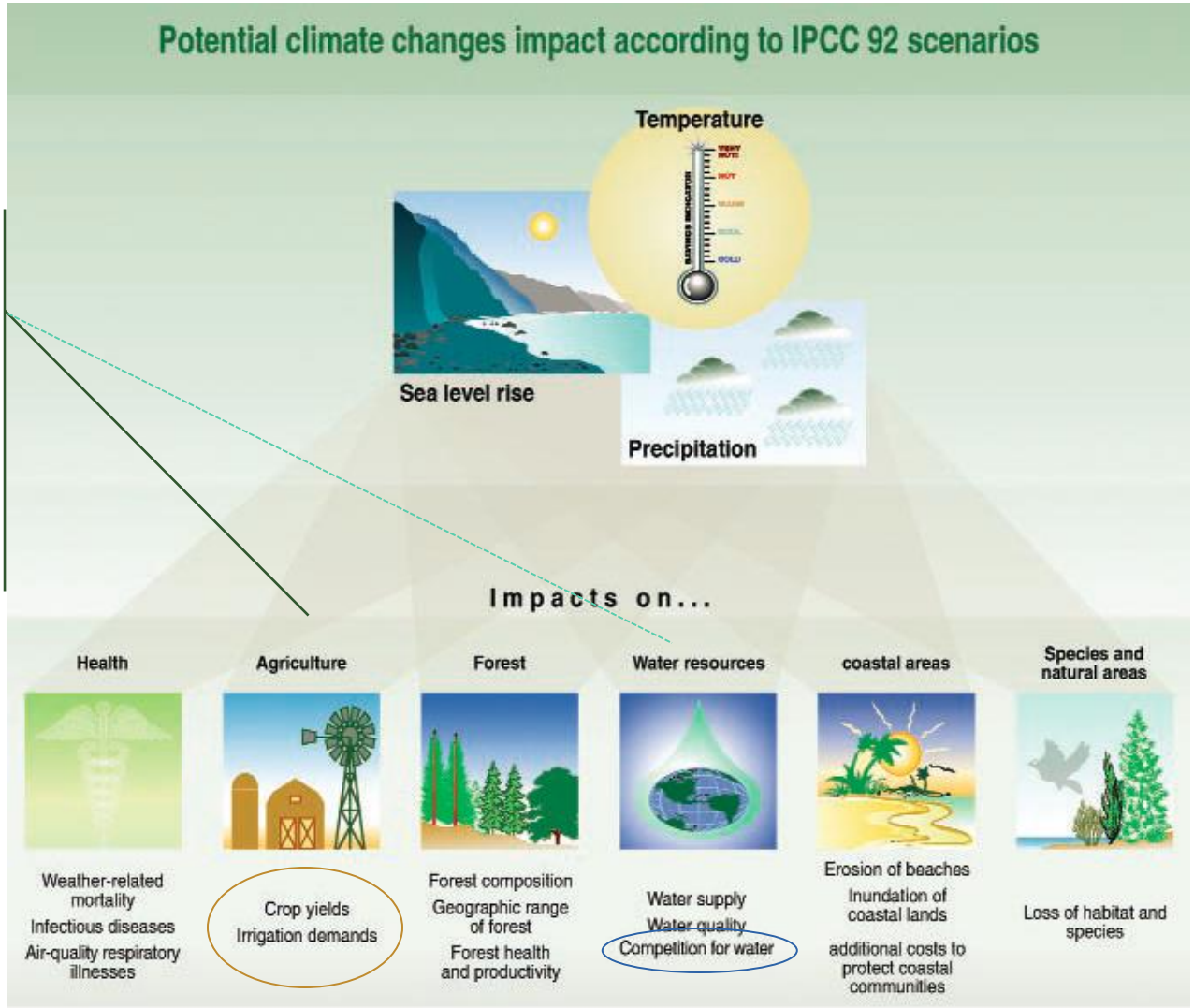
Drought or water shortages worry people most

Water scarcity

News Feature Food: Nature, Vol 466:29 July 2010

Climate change impacts will be uneven

- What could we do to prepare for the impacts of climate change
- What steps we are taking to slow it down



October 2005. Copyright 2005 The National Academy of Sciences.

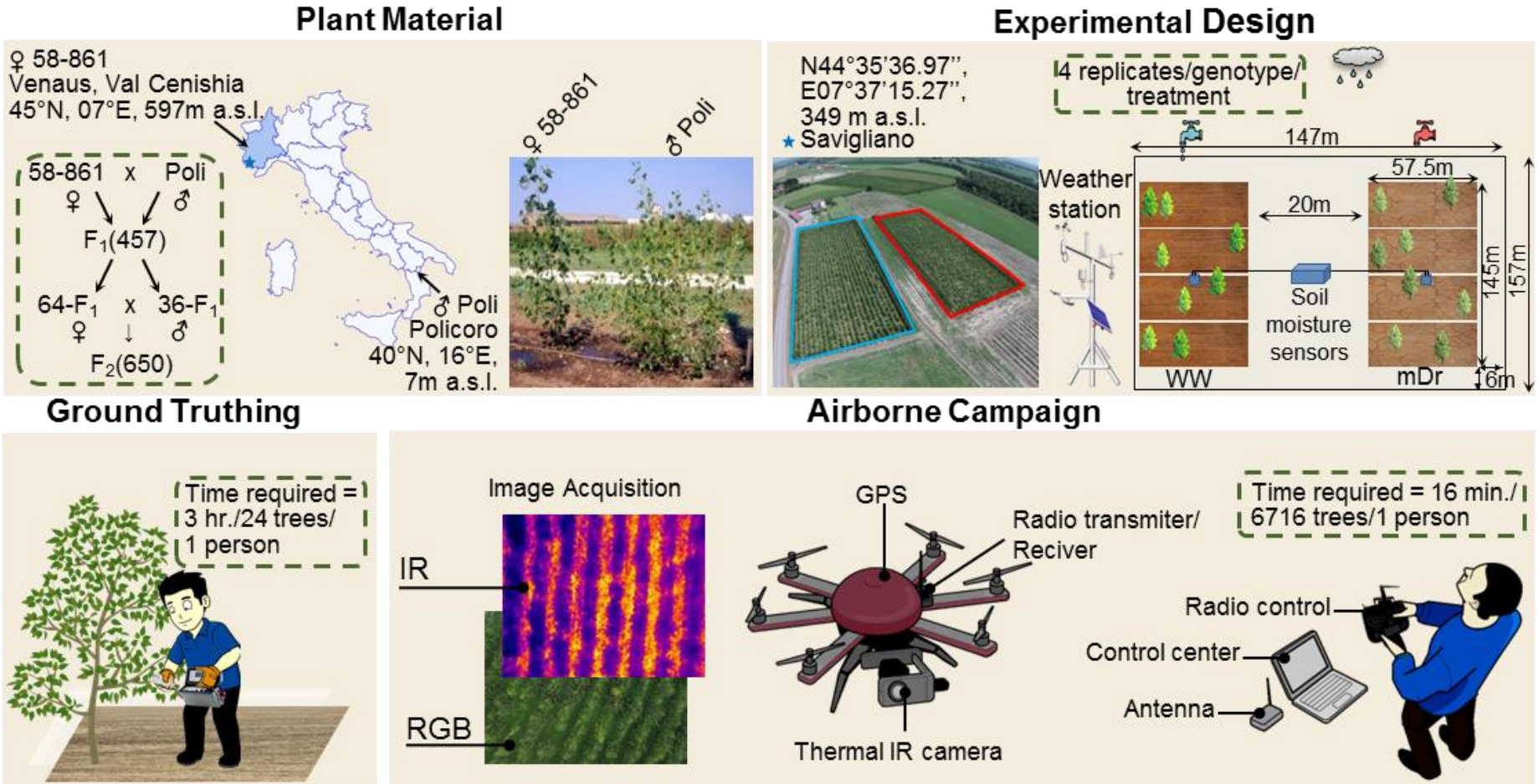
What **Solutions** are available to face these challenges?

How the **Sience** is done?

What are we **up to?**

UAV-based thermal imaging for high-throughput field phenotyping of black poplar response to drought

Workflow of the high-throughput field phenotyping (HTFP) methodology



Ludovisi R, Tauro F, Salvati R, Khoury S, Scarascia Mugnozza G, Harfouche A. (2017). Front Plant Sci. 2017 Sep 27;8:1681. doi: 10.3389/fpls.2017.01681. eCollection 2017.

UAV Flight Planning

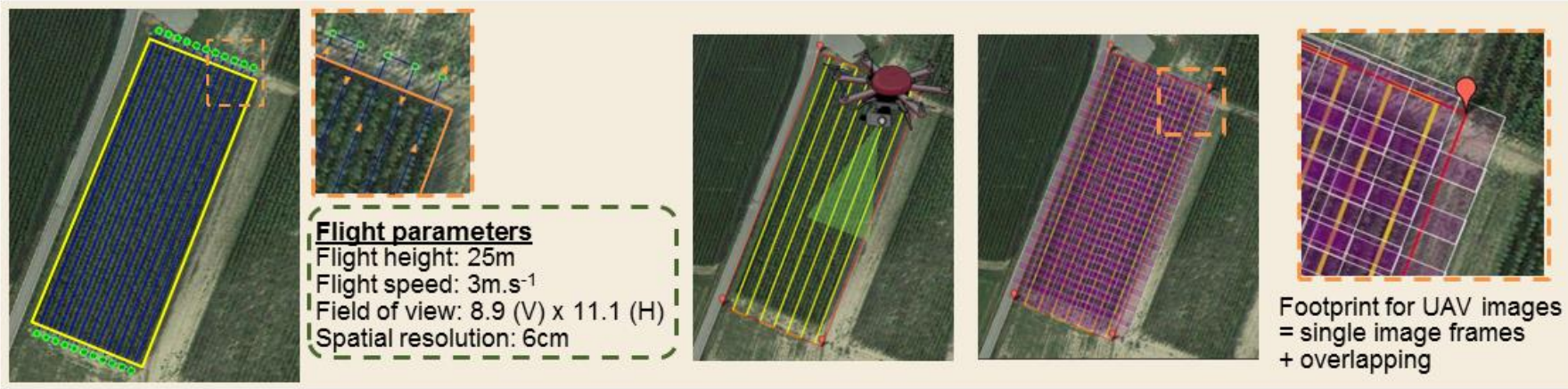
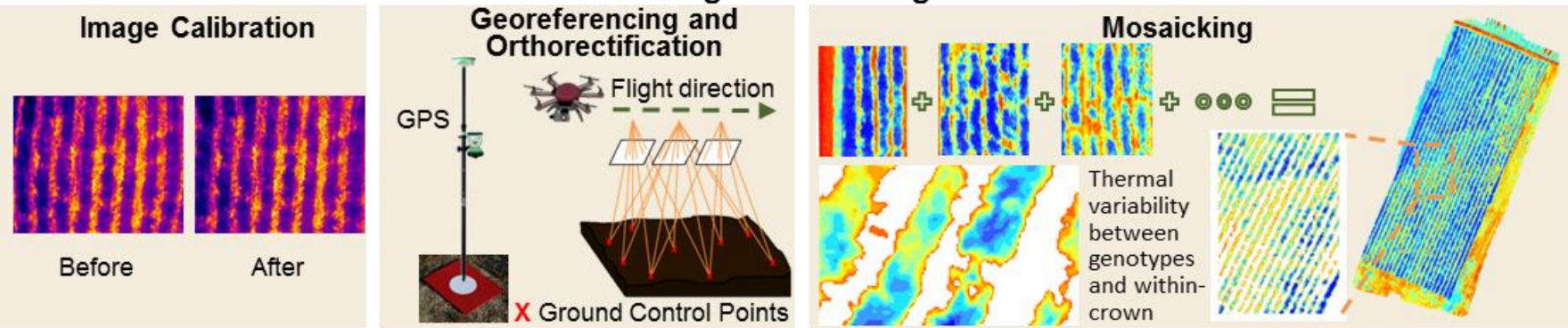
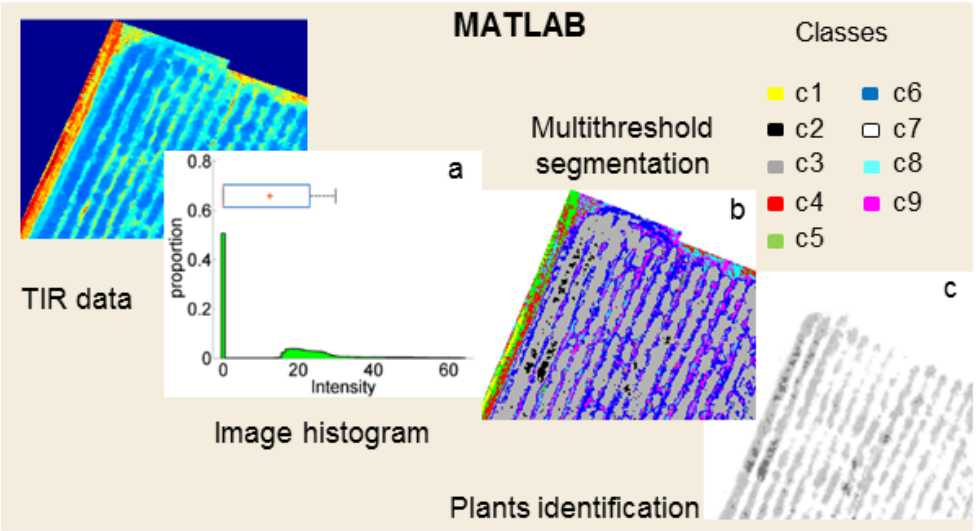
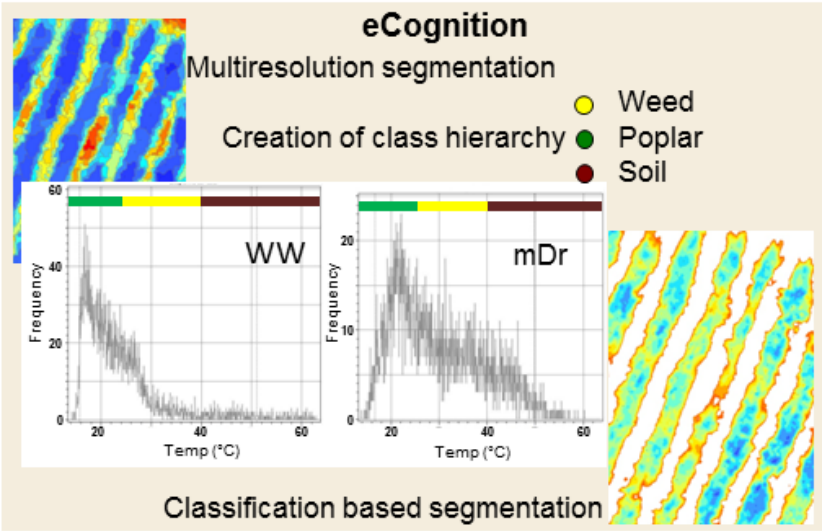


Image Processing



Segmentation Analysis

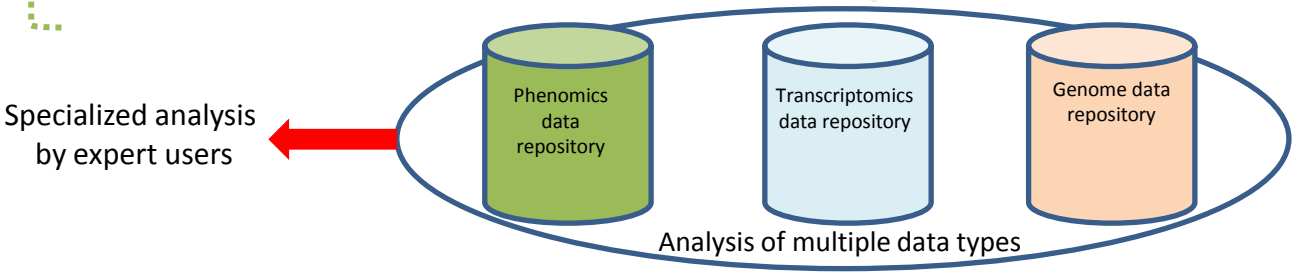




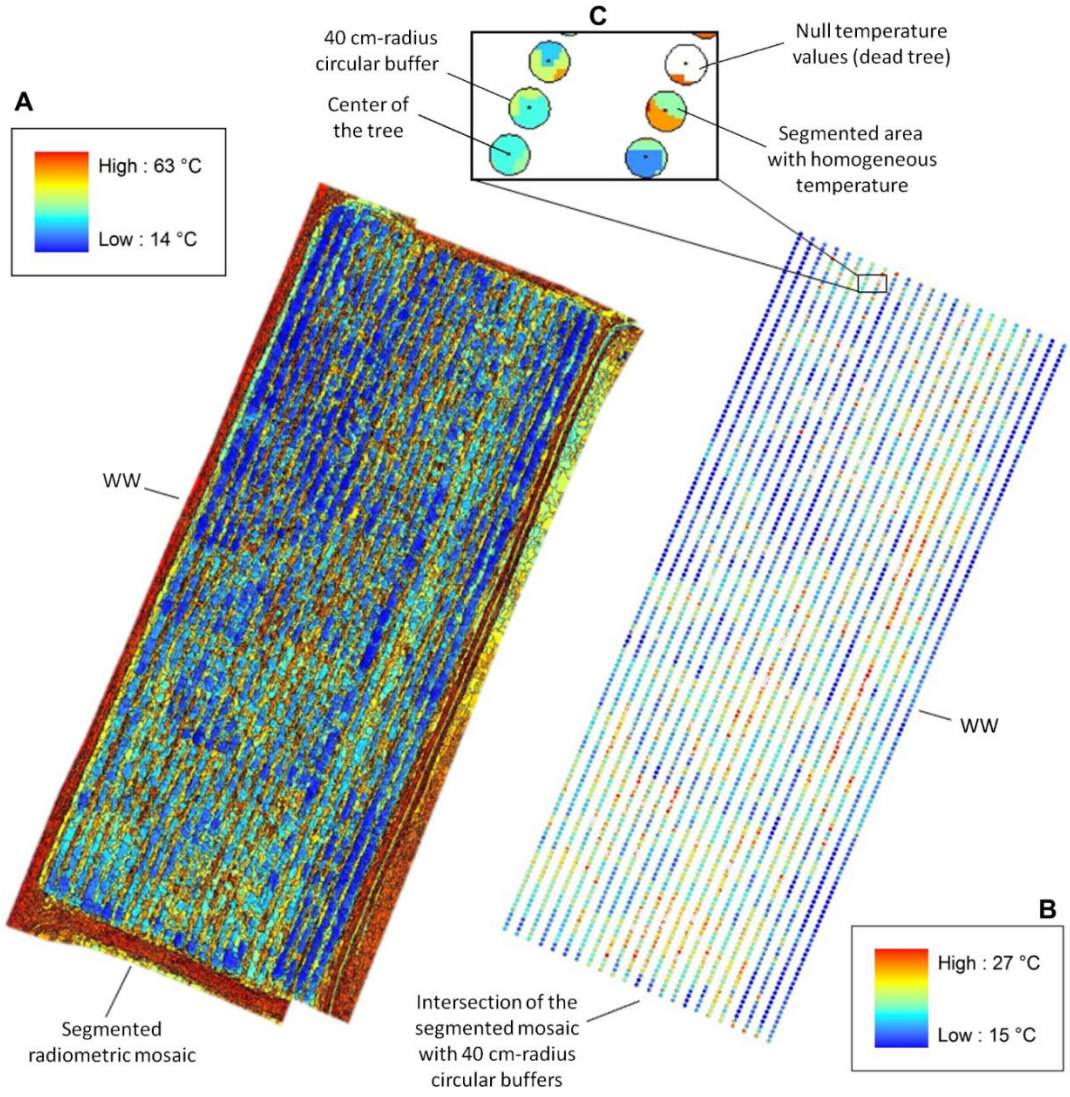
Results/End products

Data extraction
Statistical analysis of field-truth/UAV data correlations

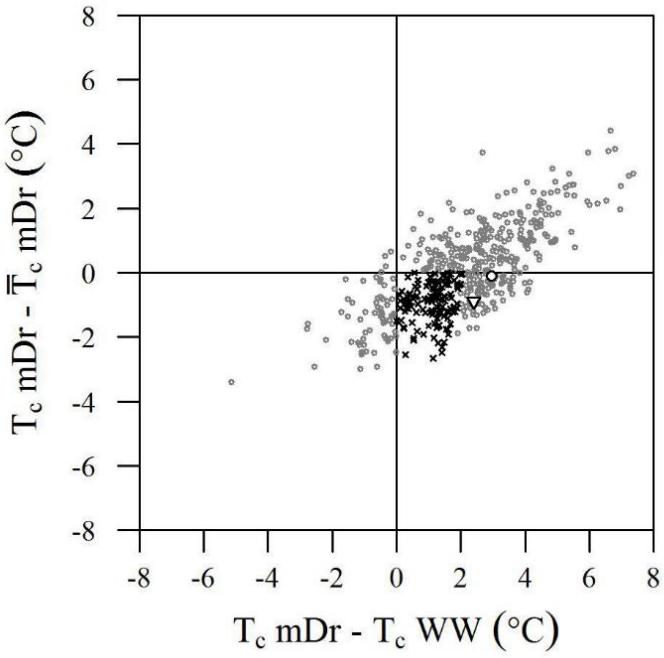
Map desired variables of plant trait or status



Canopy temperature (Tc) extracted from segmented radiometric mosaics



Breeding selection
Biplot of genotype performance in response to drought stress

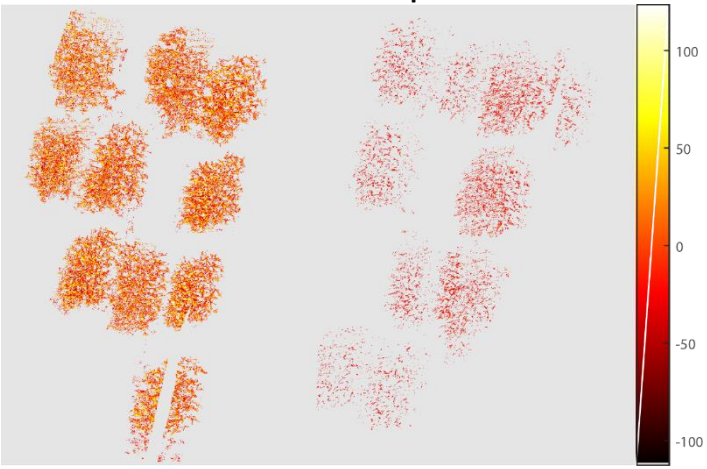


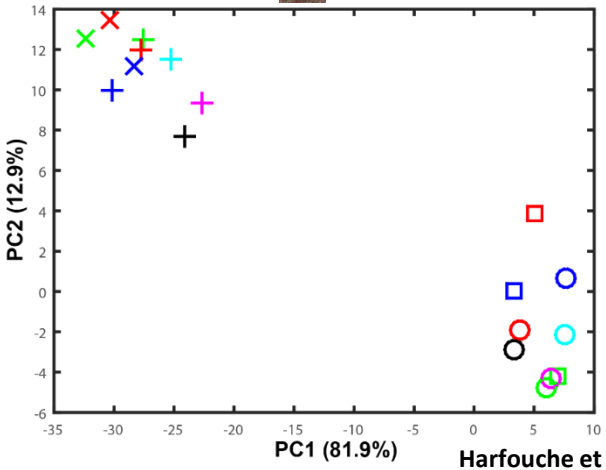
PhenoDrone™: A UAV-based thermal + RGB phenomics platform

Hyperspectral imaging in VIS-NIR for the detection of drought stress in the bioenergy crop *Arundo donax*

PhenoDrone™: A UAV-based hyperspectral + LiDAR phenomics platform

PC1 Map

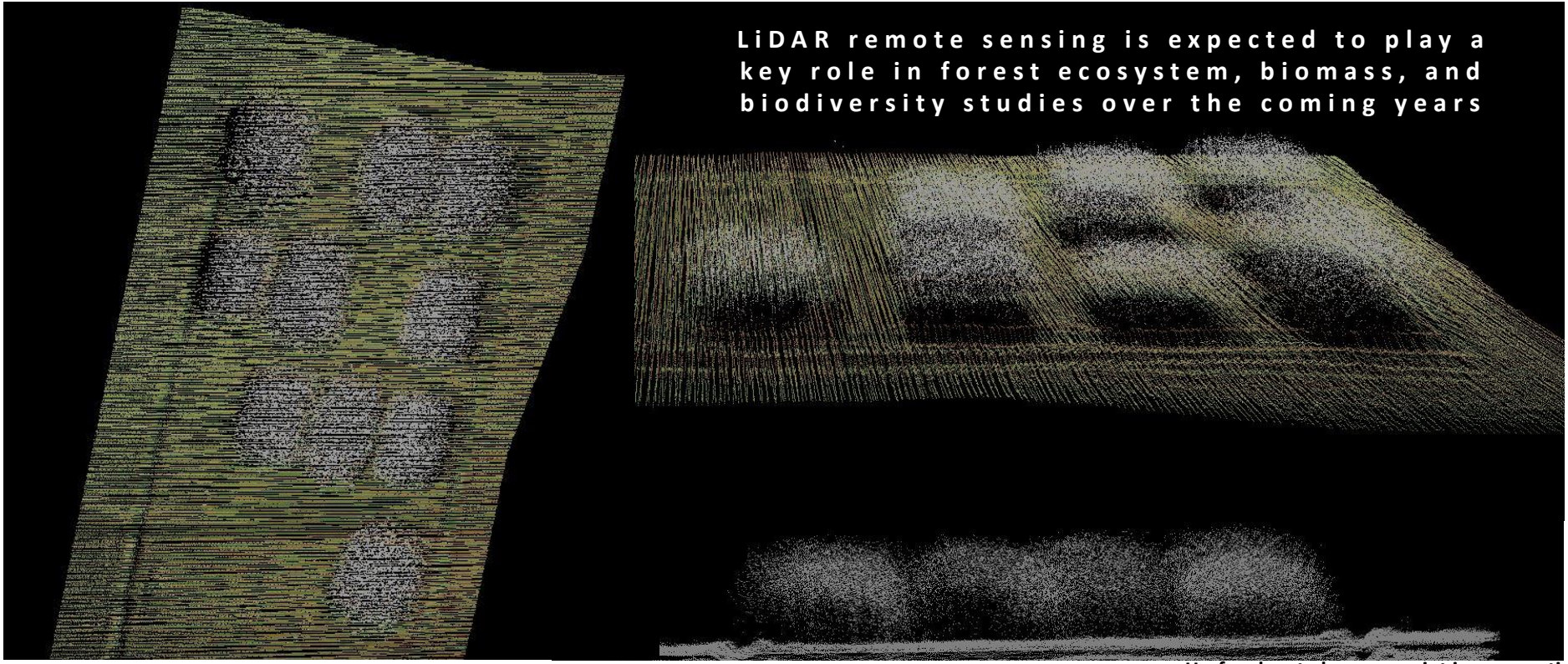




Harfouche et al., manuscript in preparation

High-throughput phenotyping of *Arundo donax* plant height and estimation of biomass using PhenoDrone-based LiDAR scanning

3D-point clouds of *Arundo donax* plot



Harfouche et al., manuscript in preparation

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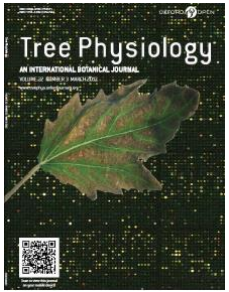

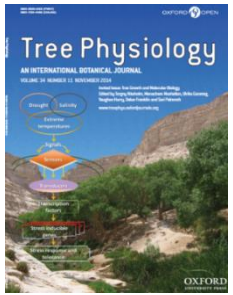

Our work has been featured on the covers of several journals

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