Exchange event between the European phenomic community and industry

Progress on novel techniques and methods for environmental and plant measurements

Xavier Draye (UCLouvain, Belgium)

Part I – Proper environmental characterization in phenotyping experiments is a cost-effective way to turn nuisance effects into benefits

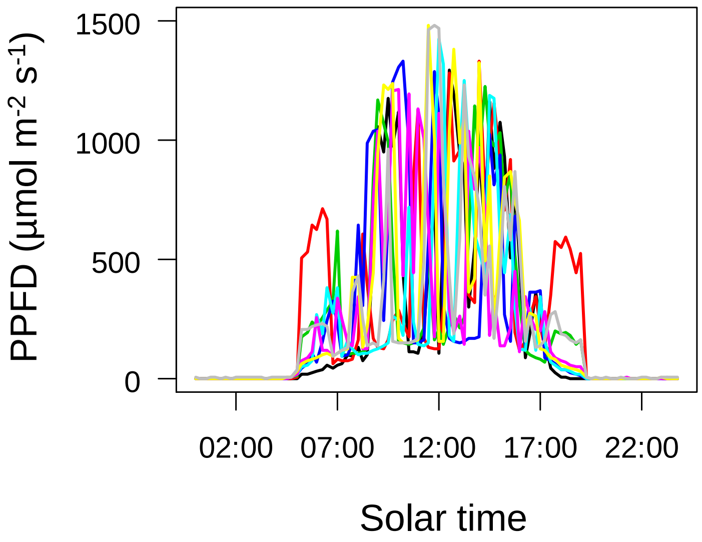
- Spatial and temporal variability in statistical analysis
- Feed plant/canopy/plot dynamic variables into models
- Assemble phenotype-rich datasets from complementary platforms
- Combine similar datasets from different platforms (repeatability)
- Re-use existing data

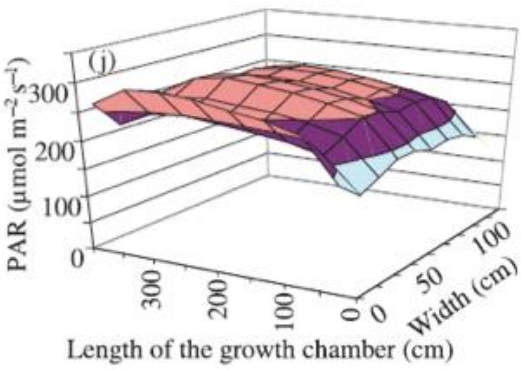
Radiation is heterogeneous / dynamic in PP

Phenotyping fields

Greenhouses

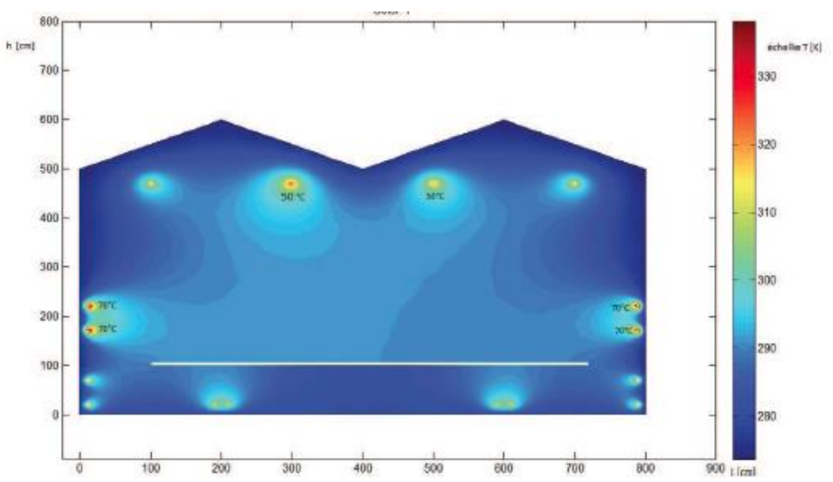
Growth chambers

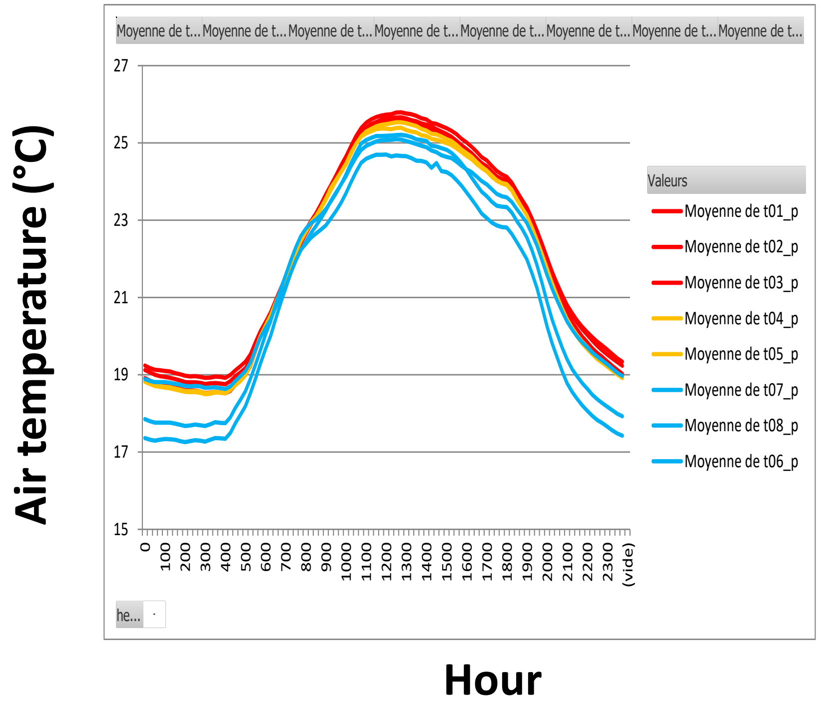


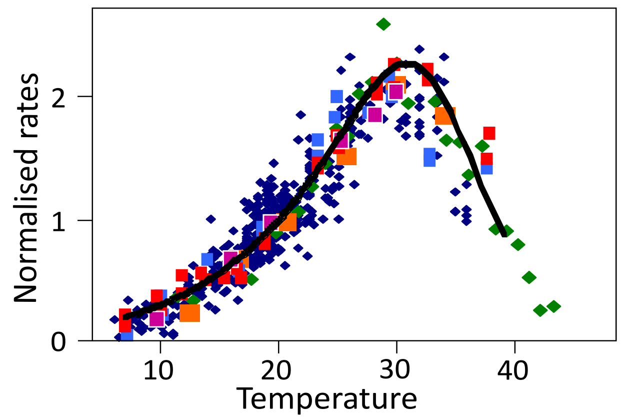


Granier et al 2006

Temperature is heterogeneous / dynamic in PP







Leaf elongation

Seedlings elongation

Lehenbauer 1914

Cell division

Ben Haj Salah 1995

Leaf initiation

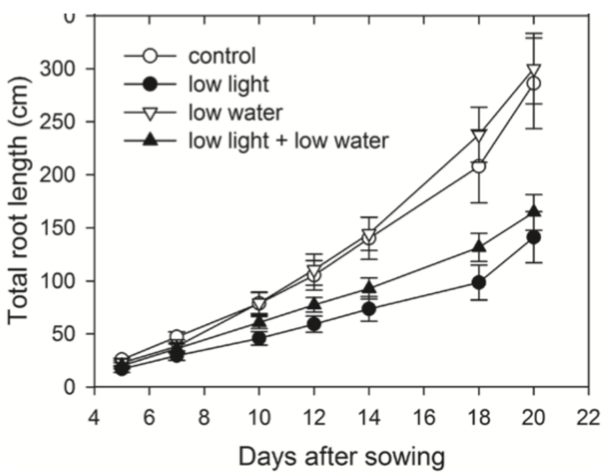
Warrington 1983

Leaf appearance

Warrington 1983

Germination

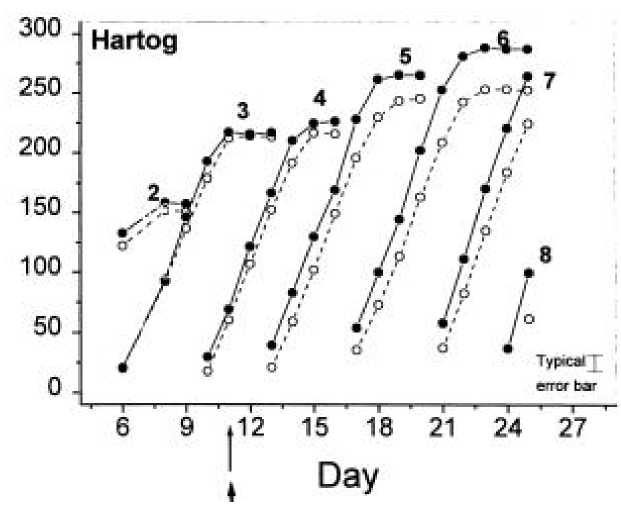
Parent et al. 2009 J. Exp Bot



High light

Low light

Nagel et al. 2015 J. Exp. Bot.



High CO2

Low CO2

Masle 2000 Plant Physiol

Challenges, attitudes and options

Nuisance

↕

Opportunities

EPPN 2020 EMPHASIS ⇒

Option 1: control (platform design, hard to change)

Option 2: monitor (experiment management)

Option 3: do nothing (and sign the death certificate…)

Strategy

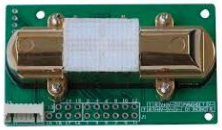
Step 1 – Agree on targets

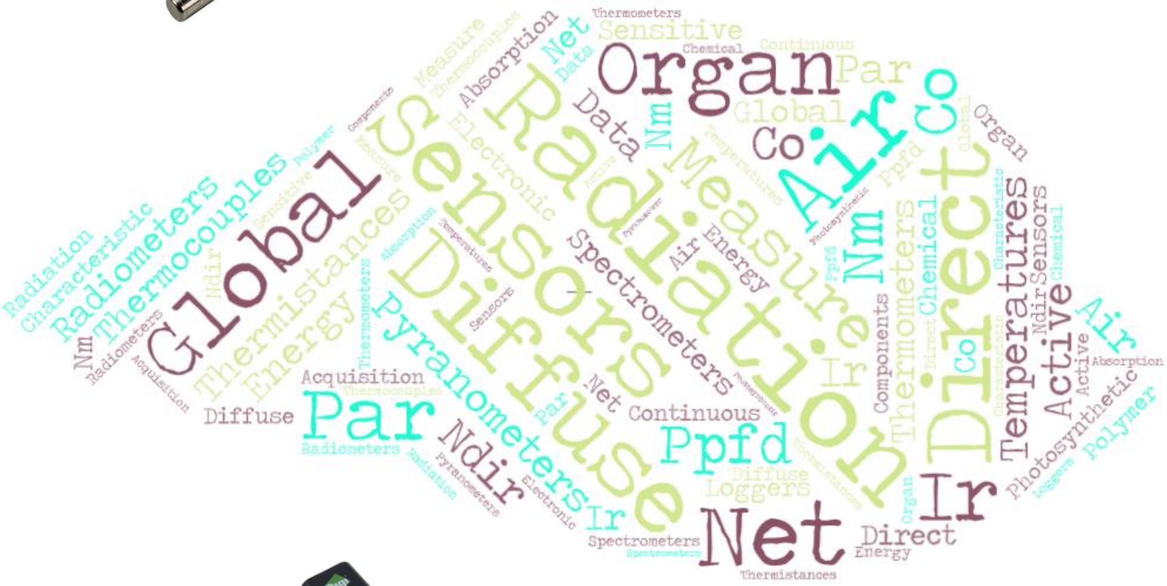
Level 1 (awareness of heterogeneity) – Year 2
Level 2 (maps) – Year 5

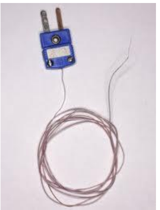
Step 2 – Monitor progress of individual platforms

2	Installation	Country	Last update	Parameter	Type of sensor	Units	Location in installation	Number of sensors in installation	Logging interval (hh:mm)	Data transfer	Storage
3	4PMI	France	03-2020	Light	PAR sensor	umoles/m2.s	Inside (fixed)	50	00:005	Wireless	Database
4	4PMI	France	03-2020	Air temperature	Thermistance	°C	Inside (fixed)	10	0:05	Cable	Database
5	4PMI	France	03-2020	Air temperature	Thermocouple	°C	Inside (fixed)	50	0:05	Wireless	Database
6	4PMI	France	03-2020	Air humidity	Humidity sensor (capacity)	%	Inside (fixed)	10	0:05	Cable	Database
7	Pheno3C	France	03-2020	Light	Pyranometer	W/m2	Outside	2	0:15	Cable	Text files
8	Pheno3C	France	03-2020	Light	PAR sensor	umoles/m2.s	Outside	2	0:15	Cable	Text files
9	Pheno3C	France	03-2020	Light	Diffuse / Direct sensor	umoles/m2.s	Outside	2	0:15	Cable	Text files
10	Pheno3C	France	03-2020	Air temperature	Other	°C	Outside	5	0:15	Wireless	Text files
11	Pheno3C	France	03-2020	Air temperature	Thermistance	°C	Outside	2	1:00	Wireless	Database
12	Pheno3C	France	03-2020	Air humidity	Humidity sensor (capacity)	%	Outside	5	0:15	Wireless	Text files
13	Pheno3C	France	03-2020	Air humidity	Humidity sensor (capacity)	%	Outside	1	1:00	Wireless	Database
14	Pheno3C	France	03-2020	CO2	CO2 Sensor	ppm	Outside	8		Cable	Text files
15	Pheno3C	France	03-2020	Organ temp.	Thermocouple	°C		10	0:15	Wireless	Text files
16	Pheno3C	France	03-2020	Soil humidity	TDR	m3/m3	Outside	72	0:15	Cable	Text files
17	Pheno3C	France	03-2020	Soil humidity	TDR	m3/m4	Outside	120	1:15	Wireless	Text files
18	Pheno3C	France	03-2020	Soil temperature	Thermistance	°C	Outside	72	0:15	Cable	Text files
19	Pheno3C	France	03-2020	Soil temperature	Thermistance	°C	Outside	120	1:15	Wireless	Text files
20	Pheno3C	France	03-2020	Wind	Sonic	m/s	Outside	1	0:15	Cable	Text files
21	Pheno3C	France	03-2020	Wind	cup	m/s	Outside	1	1:00	Wireless	Database
22	Pheno3C	France	03-2020	Rain	Gauge	mm	Outside	12	0:15	Wireless	Text files

Documentation






Documentation

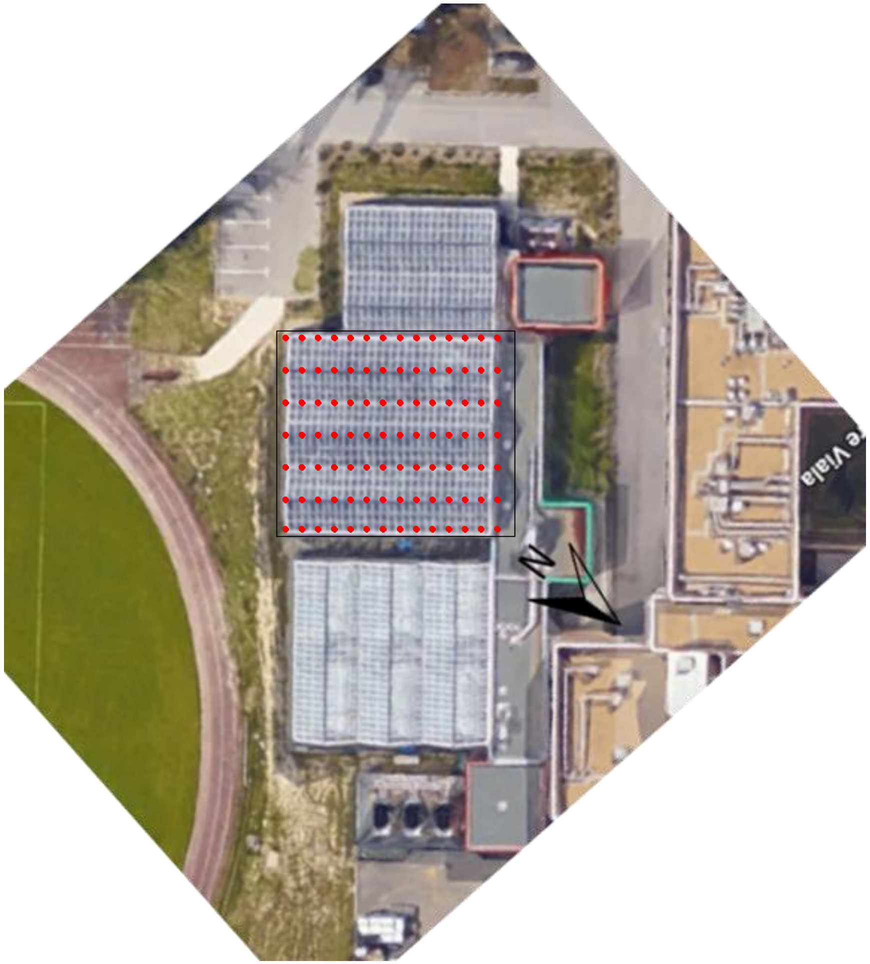
	A	B	C	D	E	F	G
1	Go to sensors (fo	Conductivity					
2	Air humidity	Light					
3	Air pressure	Rain					
4	Air temperature	Soil moisture					
5	CO2	Wind speed					
6	Parameter	Type of sensor	Brand	Model + link to doc	Price	Installation	User feedback
72	Light	Quantum senso	Licor	LI-190 and LI1400		Phenovator	
73	Light	Quantum sensor	Skye Instruments	SKP 215		Phenoarch + Phenopsis	
74	Light	Quantum sensor	Licor	Li 190SA		GS-Rhizo (A-HTR-R2) + GS-Chambers + B	
75	Light	QuantumSensor	Apogee	SQ-212 PAR		ALSIA	
76	Light	QuantumSensor	Aria Horticulture	SD-PAR-2500u.E		RootPhAir	
77	Light	QuantumSensor	Skye	SKP 215		Pheno3C + PhenoArch + Phenodyn	
78	Light	spectrometer	Licor	Li-180		Hounsfield	
79	Light	spectrometer	PSI	SpectraPen mini		MTA	
80	Light	Spectrometer	Newport	OSM2-400UV/VIS-U		ExpoSCREEN + SunSCREEN	
81	Light	UVB Meter	Gigahertz-Optik	Radiometer Messkopf UV 3702		ExpoSCREEN	
82	Light	UVB Meter	Deka Sensor + Tec	DK-UVB		SunSCREEN	
83	Light		CambridgeHOK			NPCC_Lemnatec	
84							
85	Rain	Rain gauge	Young	Pluvio 52203		Pheno3C	
86	Rain	Heated rain gauge	Young	Pluvio 52202		Pheno3C	
87							
88	Soil Moisture	Humidity sensor (capacity)	Decagon	EC-5		Growscreen + BreedFACE	
89	Soil moisture + temperature		Campbell Scientif	CS655		Pheno3C	
90	Soil Temperature	Digital thermometer	Dallas	DS18B20		Growscreen + BreedFACE	
91							
92	Wind speed	Sonic	Gill instrument	Windsonic 4		Pheno3C	

Tools and methods (Level 2)

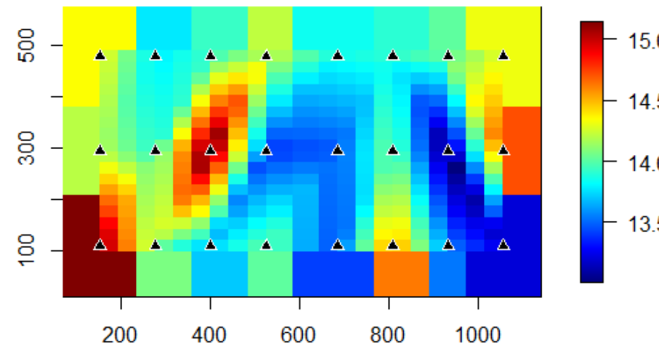
Step 1 – Test / develop

Step 2 – Deploy

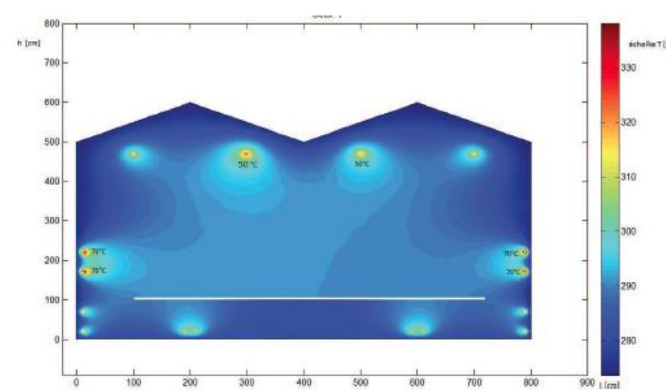
1. Maps of temperature (GH)
2. Maps of light (GH)
3. Maps of CO2 (FACE)



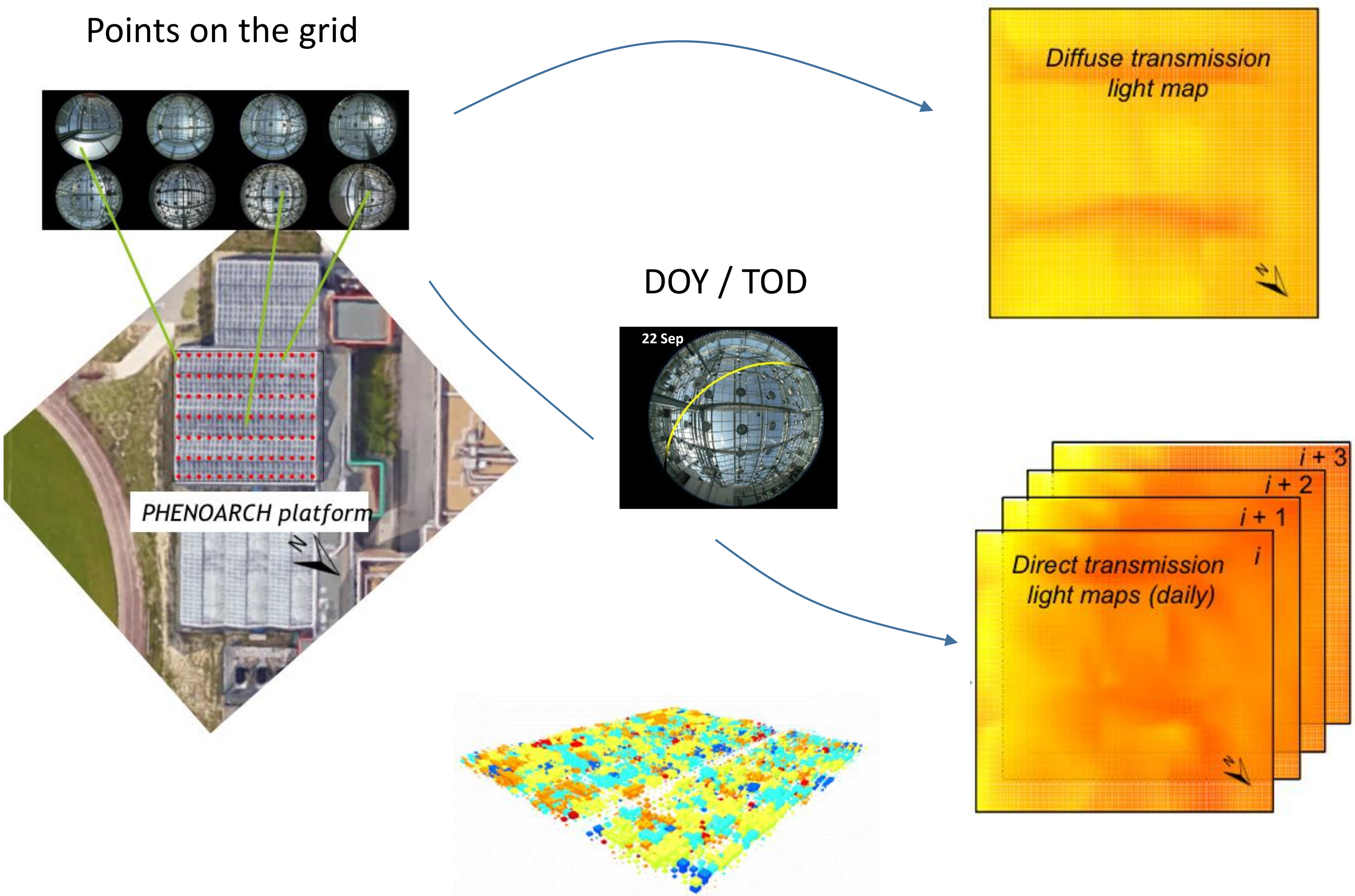
Spatial interpolation
Grid of sensors (IoT)



Modelling GH climate

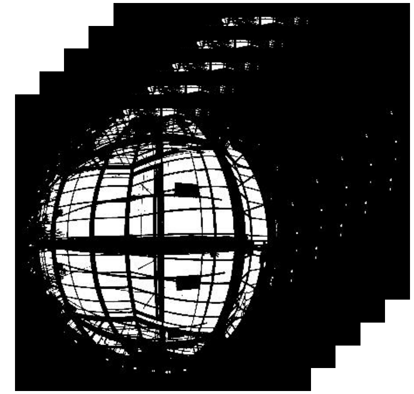


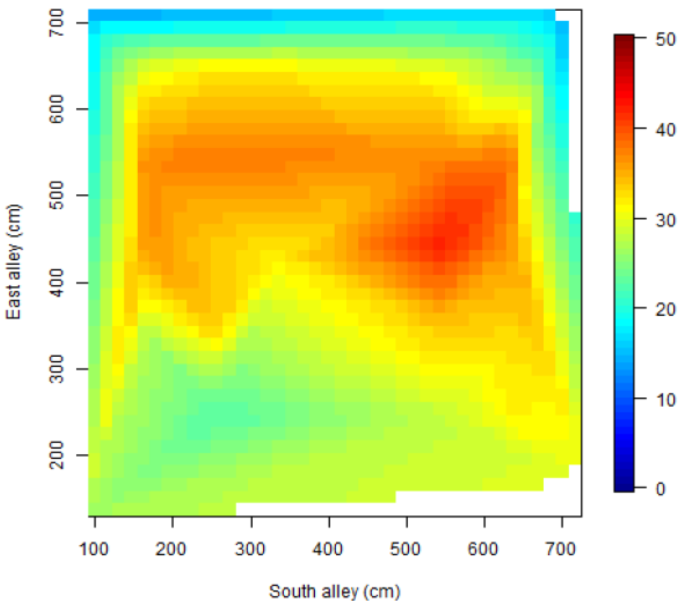
Tool for light mapping via simulation

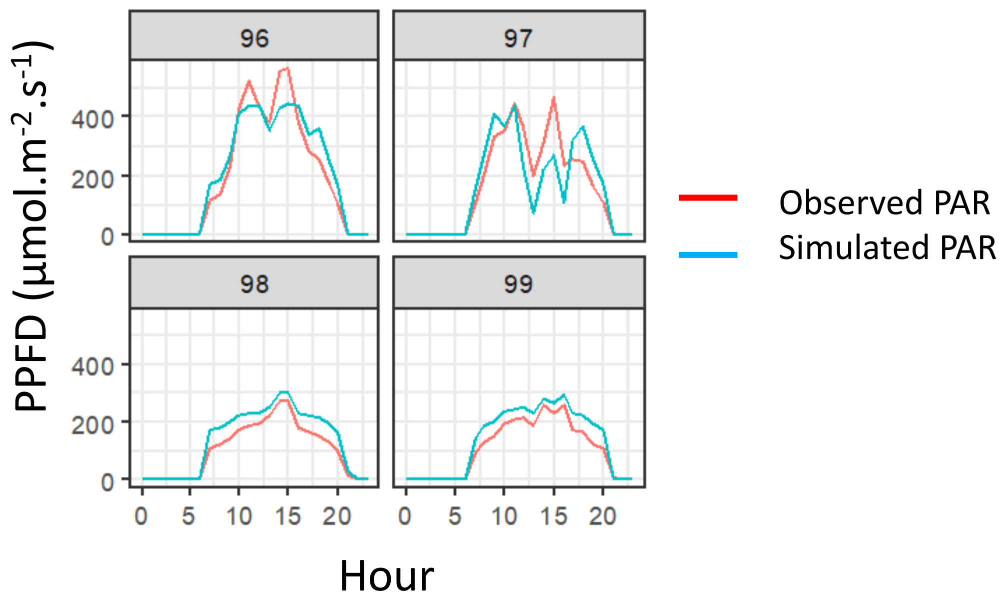


Test and deployment at other PP

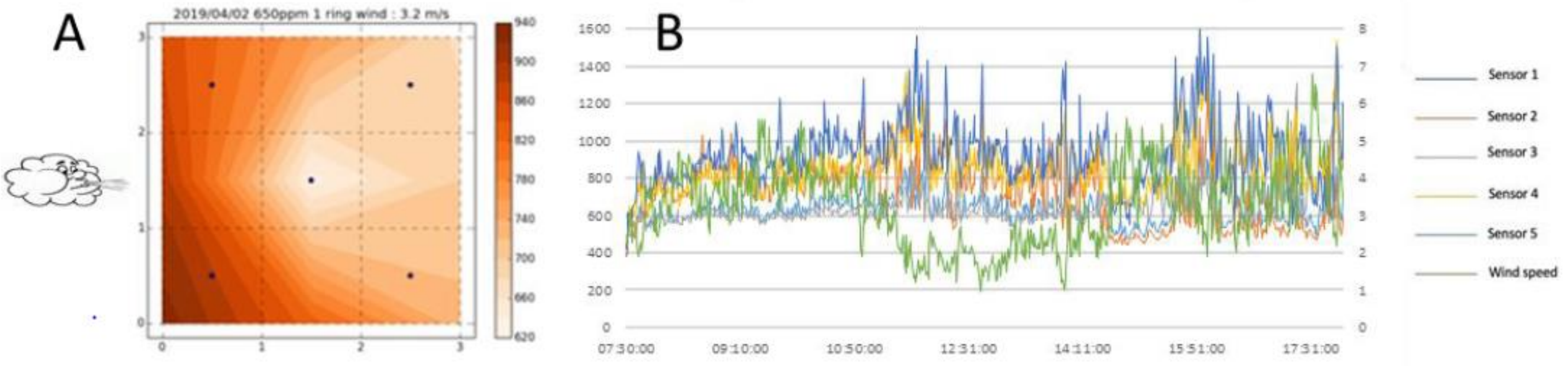
Tutorial
EPPN 2020





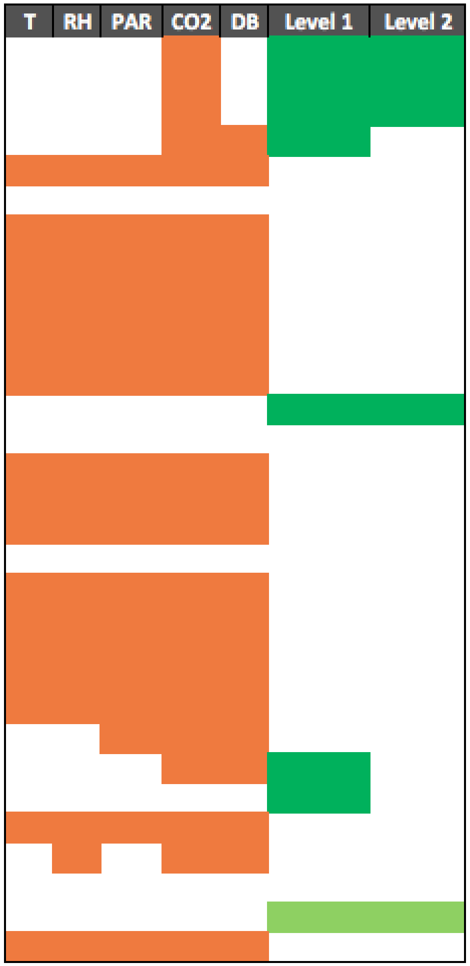


Evaluation of methods in FACE

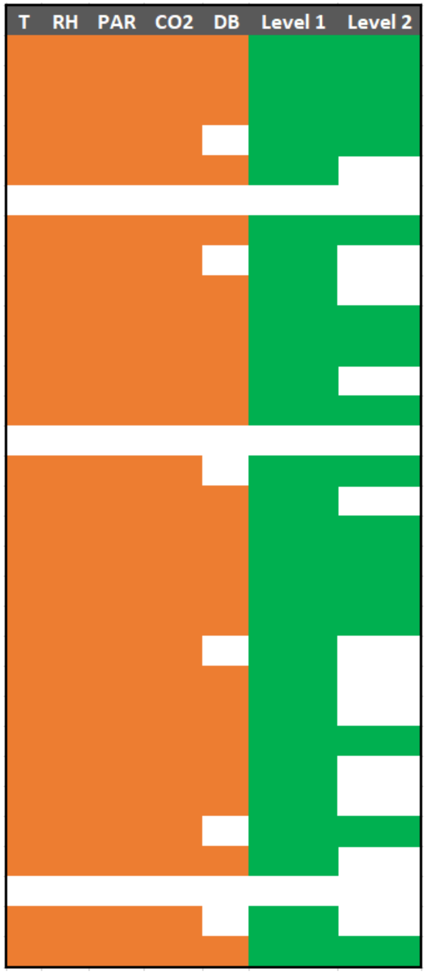


Did we reach our target ?

EPPN2020 Kick off meeting



Four years later



Part II – Suitable calibration is a pre-requisite to data fusion from different experiments or PP

Level 1

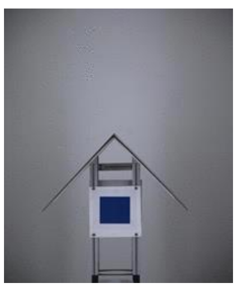
1) Grow a set of plants in the installation
2) Measure using imaging procedures (pixels)
3) Measure physical traits manually/in lab (cm)
4) Establish regression equation of (3) to (2)

5) Perform the real experiment (pixels)
6) Predict physical variables from (5) using (4)

An online calibration tool for 2D camera systems

~~1) Grow a set of plants in the installation~~
2) Measure using imaging procedures (pixels)
3) Measure physical traits manually/in lab (cm)
4) Establish regression equation of (3) to (2)

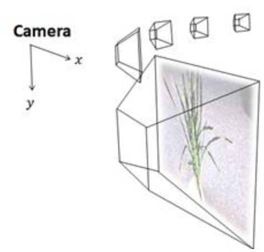
All PP use the same plants !!



Capture target images

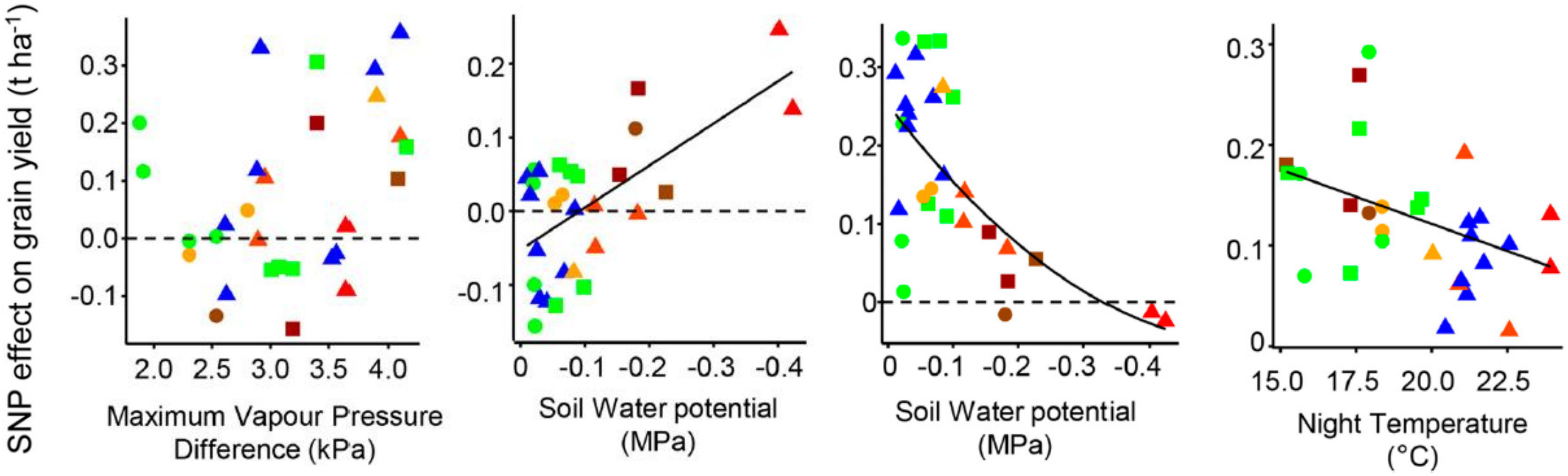
Compute camera settings

Simulate images of virtual plants with virtual camera



Example of benefits

Improved QTL detection from a network of 29 field experiments following proper calibration of wheather stations and soil sensors + data management + statistics



DROPS

Plant Physiol. 172-749

EPPN 2020 productions presents

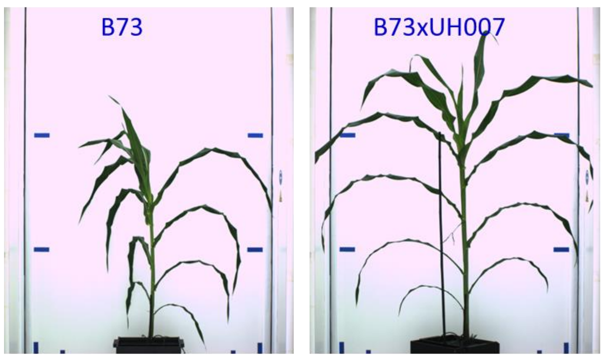
Joint platform experiment II

Featuring

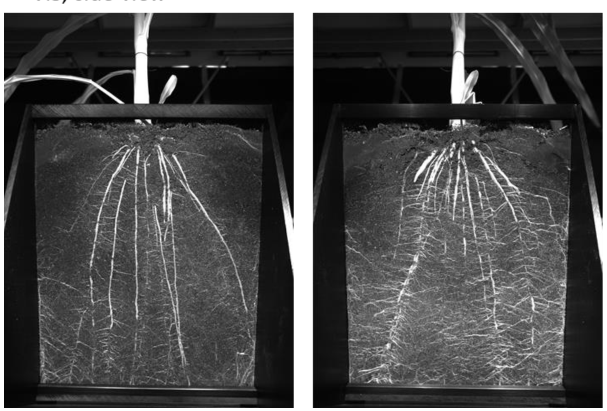
ABER
4PMI
M3P
GrowScreenRhizo
IPK
RootPhAir
DIAPHEN
NaPPI
SPPU
MTA
WUR

Joint platform experiment

Proper environmental characterisation procedures
Suitable statistical designs
Compatible data management
Common set of (up to) 31 maize genotypes
Complementarity of PP capabilities (root and shoot, GH and field).



VIS, side view



Objectives

Real-life test of joint experiment (whole process)

Design / replication in rhizotron experiments

Dimensionality of root architecture phenotypes

Whole plant integrated analysis of water uptake, transpiration and growth