Estimation of biophysical variables and cartography of irrigated surfaces with high temporal and spatial resolution images

Perspective of Sentinel-2 mission

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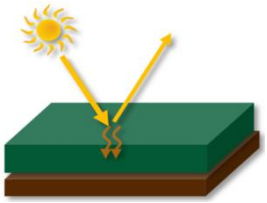
CESBIO

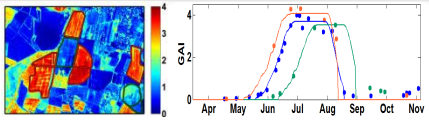
INTRODUCTION

HRST images

Remote sensing Data



Biophysical Variables Maps and profiles



Spatialised Biomass, Yield Water needs/supplies

- Green Area Index (GAI)
- Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)
- Fraction of vegetation cover (FCover)

→ Vegetation status, spatial and temporal, used as input for models

Monitoring agriculture
- Crop scale for cal/val
- Watershed and regional scale = decision, management

INTRODUCTION

Parameterization, calibration
Validation

HRST images

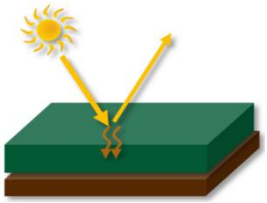
1

BVnet
Inversion of radiative transfer model

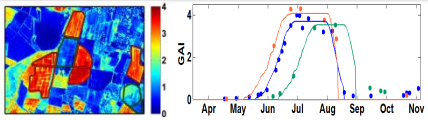
2

SAFY(E)
Agro-meteo model
+ land cover maps
(irrigated areas)

Remote sensing Data



Biophysical Variables
Maps and profiles



Spatialised
Biomass, Yield
Water needs/supplies

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Monitoring agriculture
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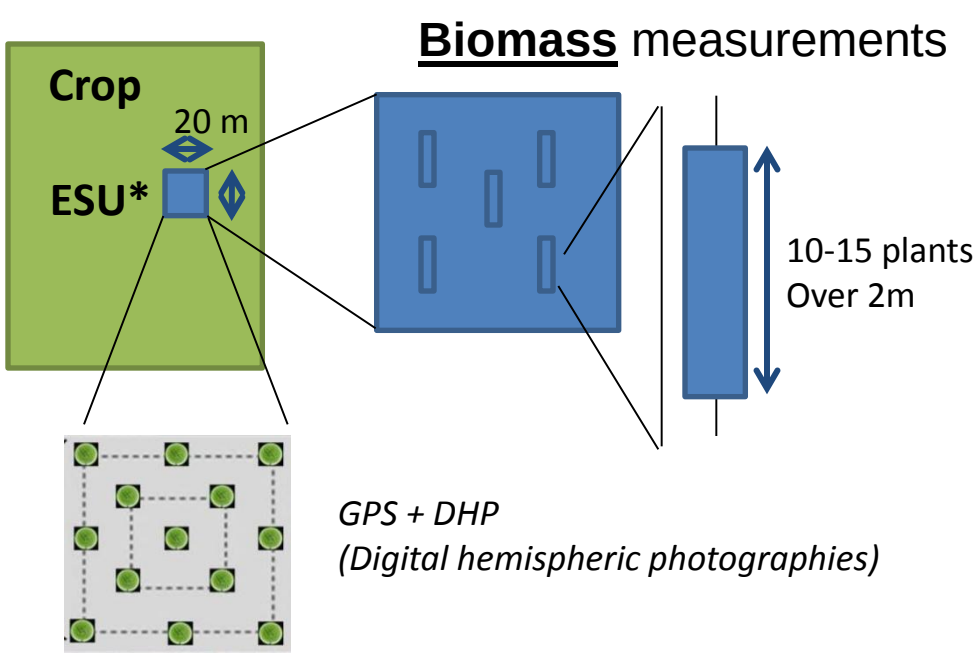
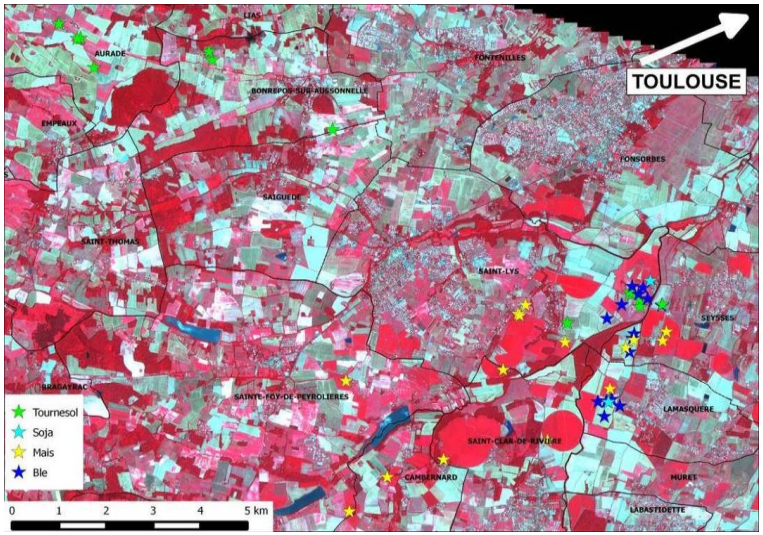
These works were done in the framework of **CALVADOVS (TOSCA-CNES) and MAISEO (FUI)** projetcs.

BIOPHYSICAL VARIABLES : in situ measurements

In situ measurements : GAI/FAPAR/FCOVER + Biomass



* *Elementary Sampling Unit*



ESU repartition in South-West
Formosat-2 image

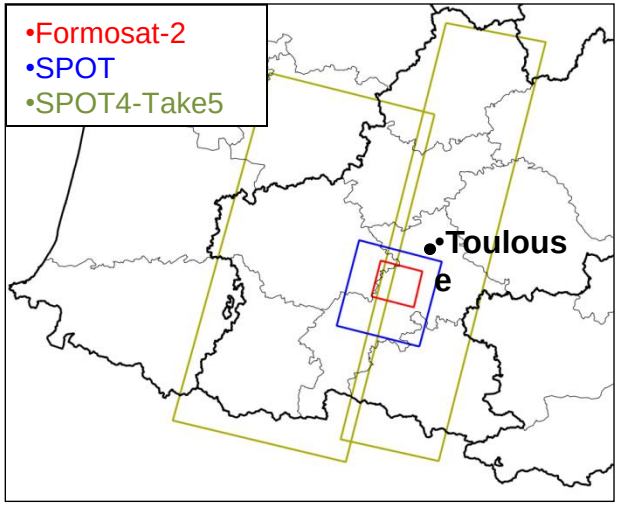
Processing DHP with Can-Eye software
→ Estimation of **GAI, FAPAR, FCOVER**

BIOPHYSICAL VARIABLES : in situ measurements

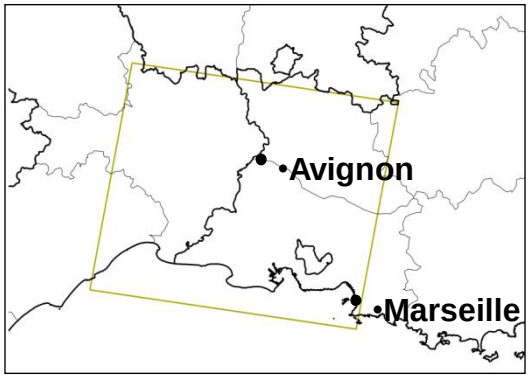
Taking advantage from SPOT4-Take5 to perform an important ground measurement campaign in 2013

- Sunflower, maize and wheat in South-West (CESBIO)
  250 DHP measurements in 2013, 50 for biomass
  + 100 DHPs, ~50 biomass in archives
- Irrigated meadows in South-East (INRA paca)
  70 measurements in 2013

South West (SO)



→ Large and varied reference dataset



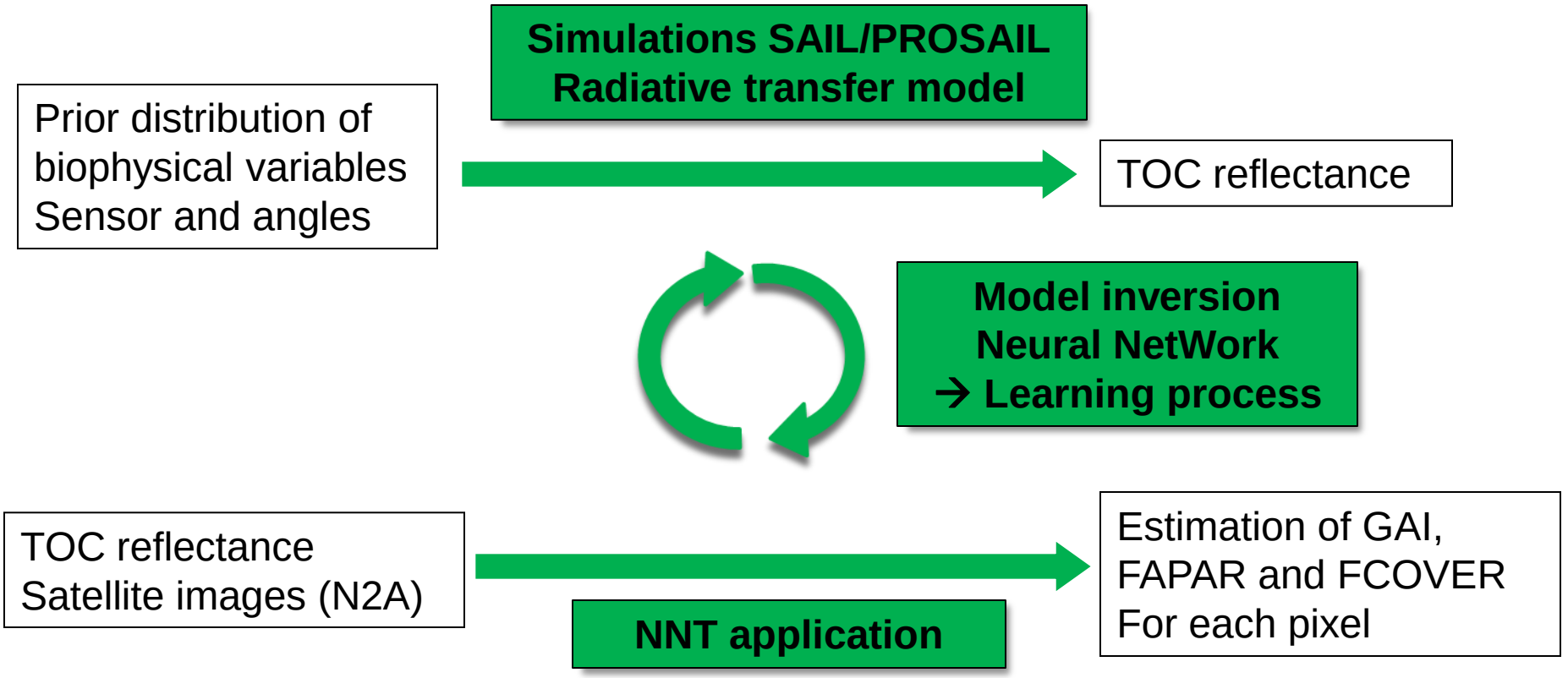
South East (SE)

	Maize	Sunflower	Soybean	Wheat	Meadows	**total**
DHPs estimations	115	83	18	64	72	**352**
Direct measurements LAI	23	23	12	15		**73**
Biomasse 2013	6	35		11		**52**

Measurements 2006 to 2013

BIOPHYSICAL VARIABLES : with remote sensing data

Estimation of GAI, FAPAR and FCOVER from satellite images
→**BVNET** (Biophysical Variable Neural NETwork)
Developed by INRA (EMMAH, Avignon)



BIOPHYSICAL VARIABLES : with remote sensing data

Work on parameters :
Sensibility of differents variables → distributions, class, affected crop, …
Objective : move toward a single configuration, operational context

Prior distribution of biophysical variables
Sensor and angles

	Variable	Minimum	Maximum	Mode	Std	Nb.class	Law
Cover structure	LAI	0	15	2	2	6	Normale
	ALA (°)	5	80	40	20	8	Normale
	Hotspot	0.1	0.5	0.2	0.5	1	Normale
Leaf optical properties	N	1.2	2.2	1.5	0.3	3	Normale
	Cab (µg.m^{-2})	20	90	45	30	4	Normale
	Cdm (g.m-2)	0.003	0.011	0.005	0.005	4	Normale
	Cw	0.6	0.85	0.75	0.08	4	Uniforme
	Cbp	0	2	0	0.3	3	Normale
Soil properties	Bs	0.5	3.5	1.2	2	4	Normale

Input variables distribution for learning database creation

TOC reflectance
Satellite images (N2A)

60 images processed for the validation
6 different sensors
2006, 2008, and 2013

Sensor	Resolution	Bands used
Formosat2	8m	Green, red, NIR
SPOT2	20m	Green, red, NIR
SPOT4	20m	Green, red, NIR, MIR
SPOT5	10m	Green, red, NIR, MIR
Landsat8	30m	Green, red, NIR, MIR1
Landsat7	30m	Green, red, NIR

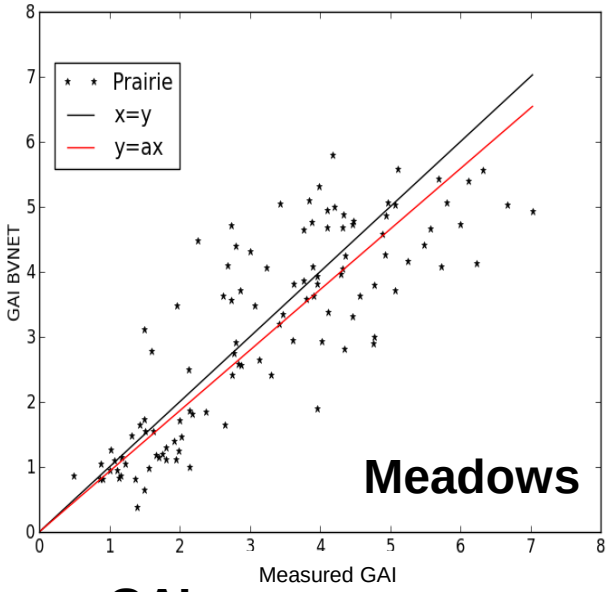
BIOPHYSICAL VARIABLES : with remote sensing data

Validation results

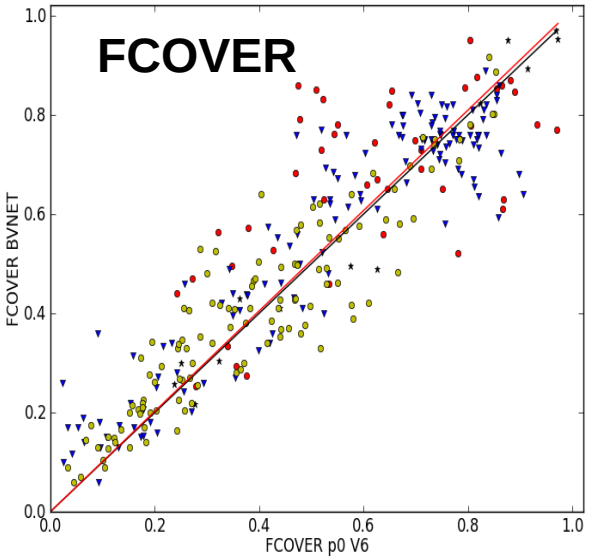
Overall good results for later use in models
- Single configuration for all crops and years in South-West
- ALA* parameter changed for irrigated meadows
  *(Average Leaf Angle)

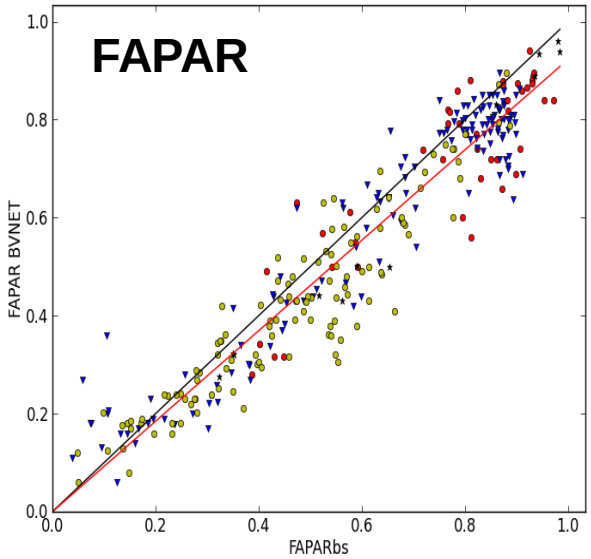
Relative error :
GAI : 28%
FAPAR : 14%
FCOVER : 22%

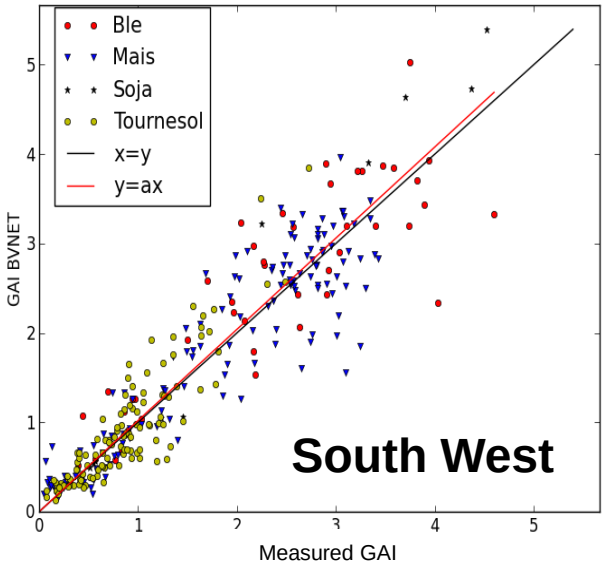
	RRMSE (%)		
Crop	GAI	FAPAR	FCOVER
Wheat	26.0	13.2	27.9
Maize	23.3	13.3	18.2
Soybean	26.4	11.3	9.8
Sunflower	36.9	19.1	21.5
Irrigated meadows	27.7	10.7	23.7



GAI







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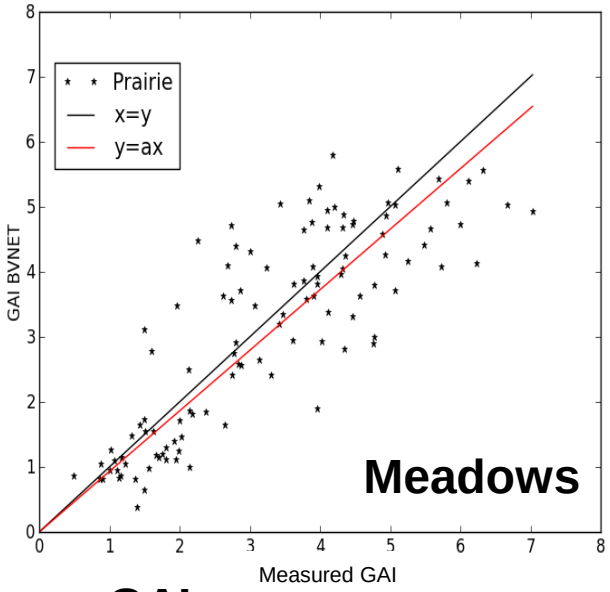
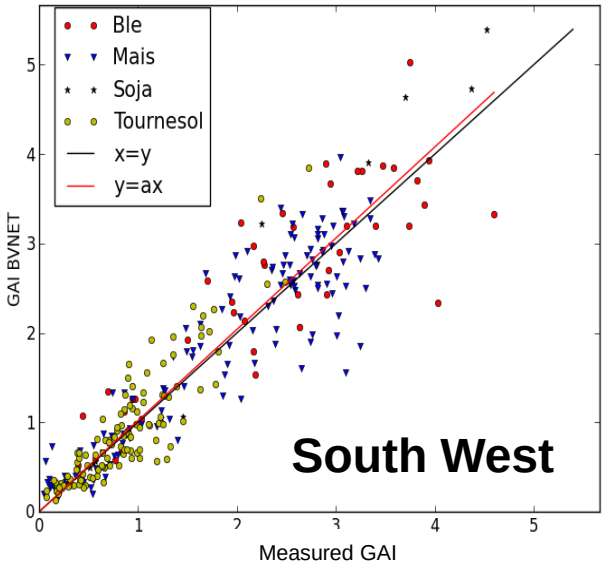


GAI

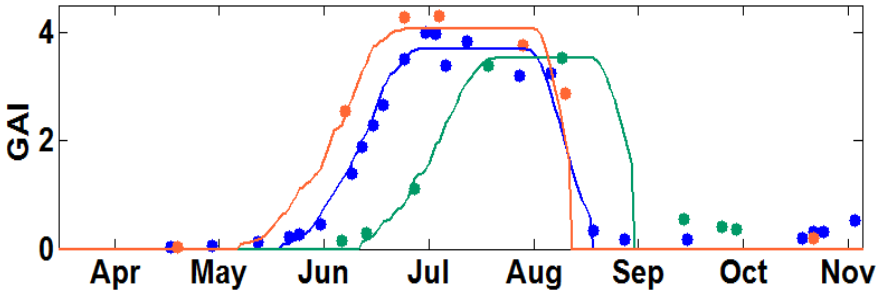
Perspectives :

- Include BVNET in OTB (processing time gains, OpenSource)
- Further evaluation of BVNET model for correcting sensor effect
- Contribution of MIR for BV estimations
- Crops specific parameters distribution if land cover maps
- Validation in other sites = **Sentinel 2 for agriculture**

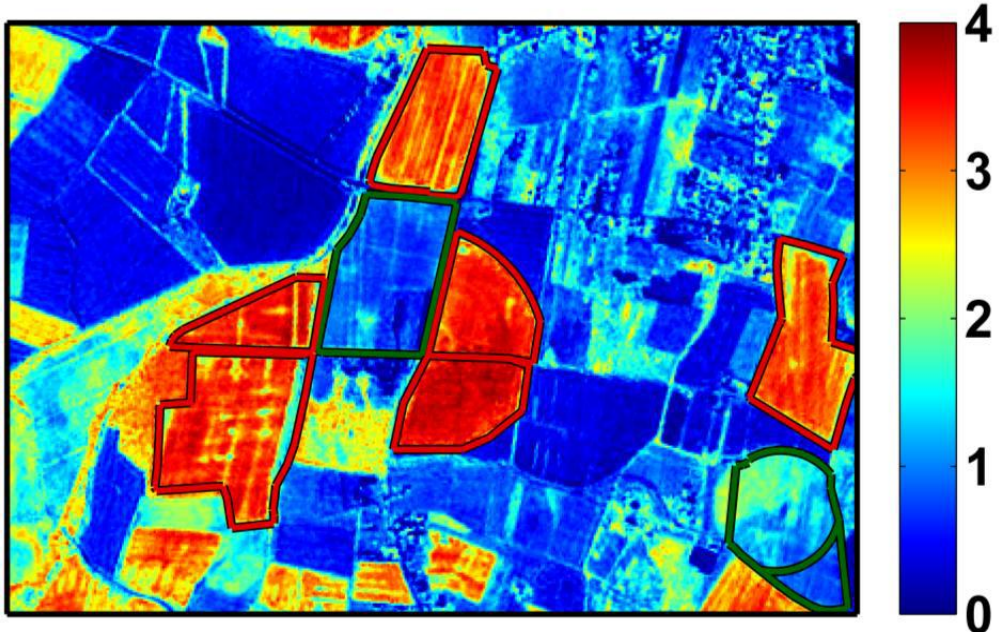


BIOPHYSICAL VARIABLES

What uses ?



Temporal profiles
→Model inputs

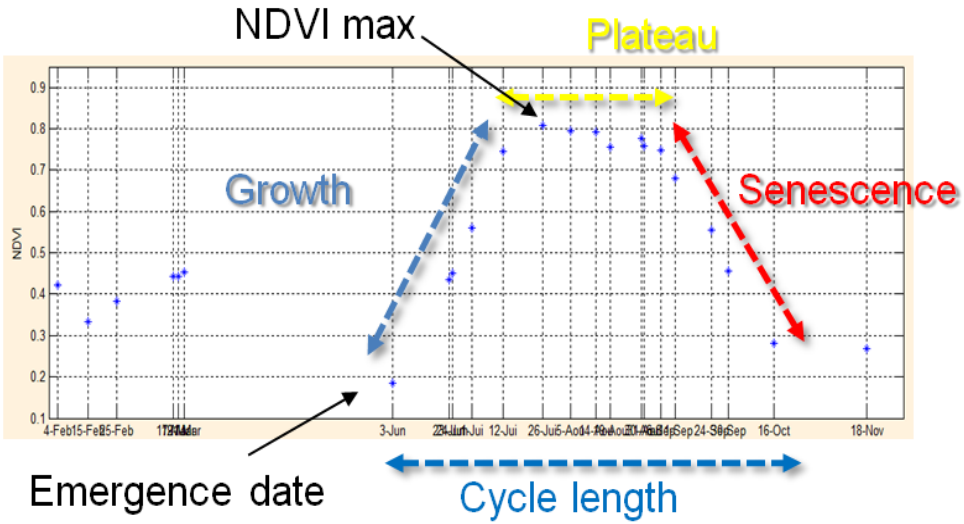


Maps
→ Spatialize model output

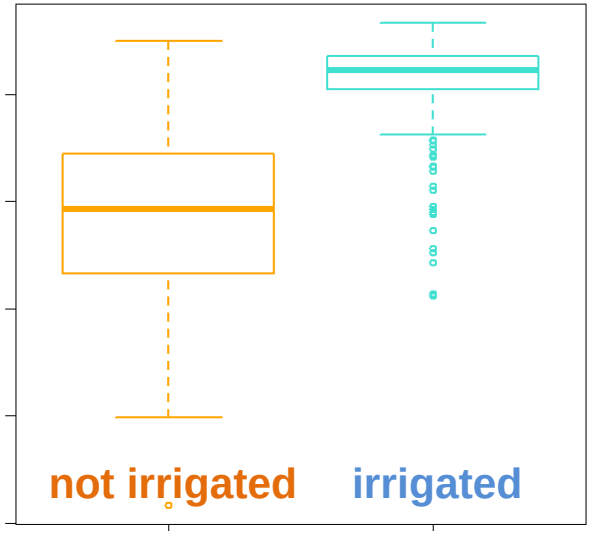
IRRIGATED CROPS – phenological indicators

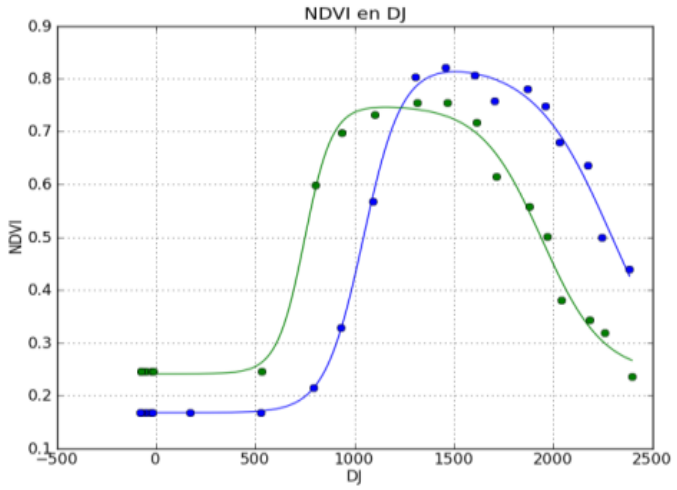
Cartography of irrigated crops

Work on phenological indicators for the discrimination of irrigated crops
- daily temperature accumulation
- double logistic interpolation



Ex for NDVI accumulation





Double logistic interpolation
Irrigated in blue, not irrigated in green

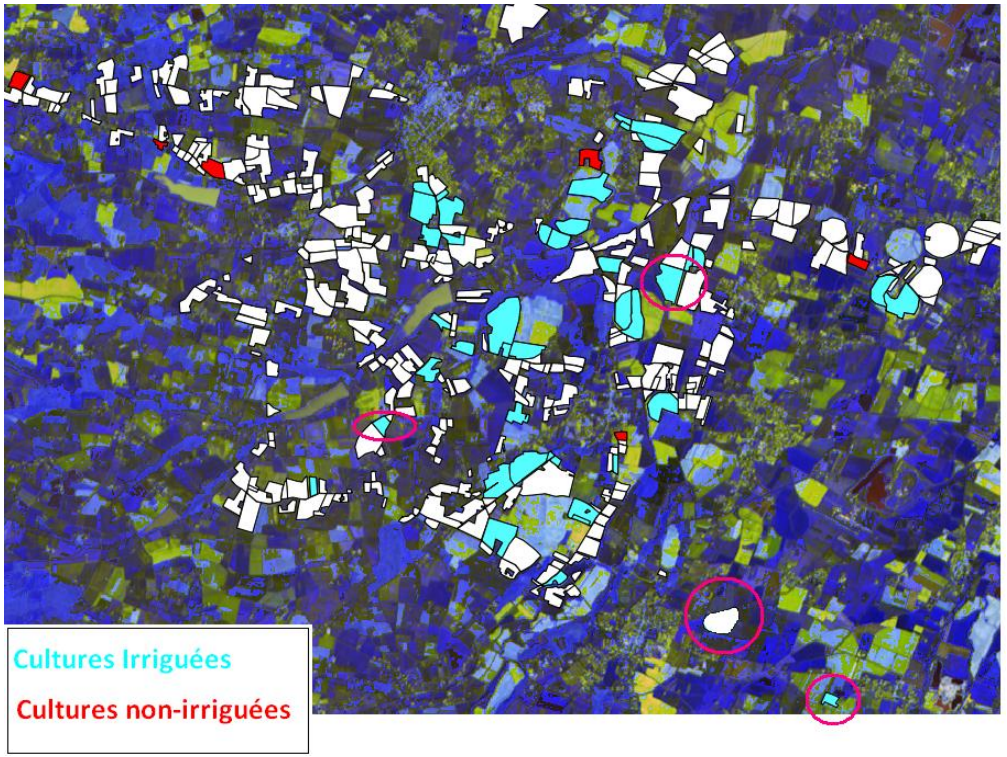
IRRIGATED CROPS – preliminary results

Preliminary results :

Error < 20% by mid July

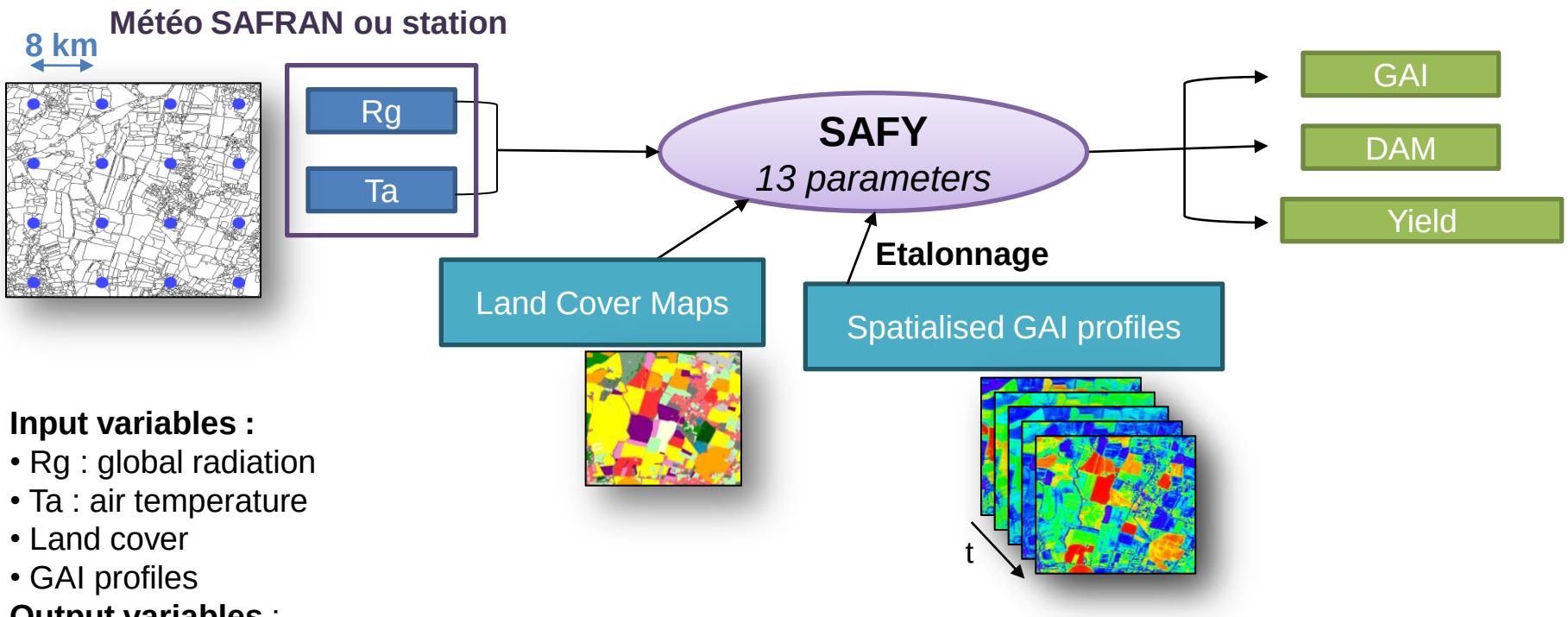
- Good perspectives for the discrimination of irrigated crops
- validation work to continue in 2015
- automatisation of processing chain

Exemple of classiffication irrigated/not-irrg. crops



BIOMASS ESTIMATION - SAFY

SAFY* : agro-meteorological model
- Limited number of simulated processes and parameters: 13
- Suitable for use of remote sensing data
- daily step



Input variables :
- Rg : global radiation
- Ta : air temperature
- Land cover
- GAI profiles

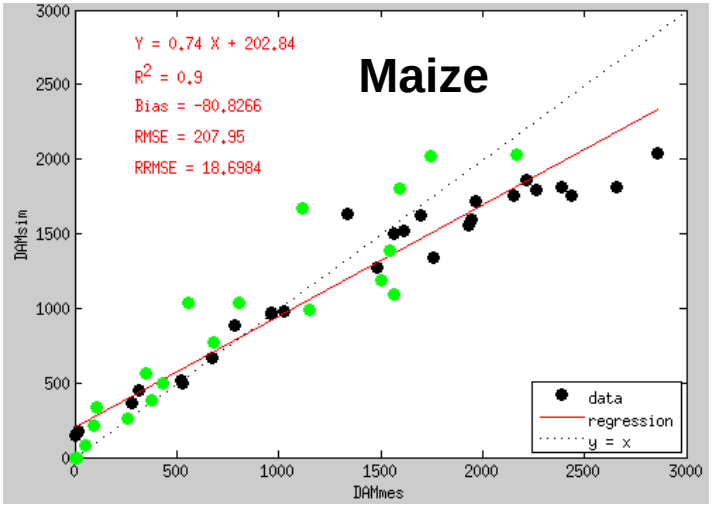
Output variables :
- GAI (Green Area Index)
- DAM (Dry Aboveground Mass = biomass)
- Yield

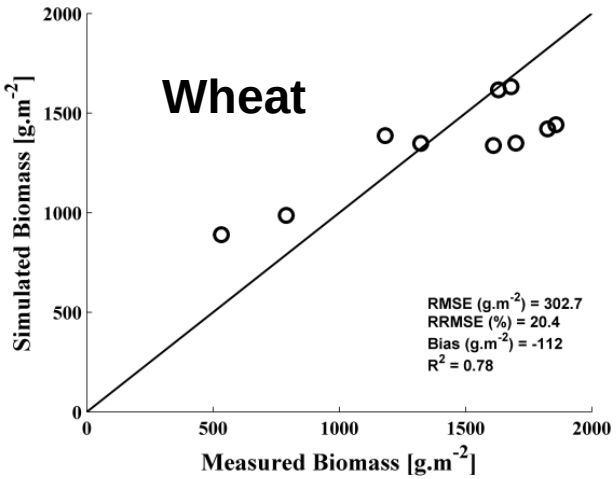
** Simple Algorithm for Yield Estimates* ; Duchemin et al. (2008)

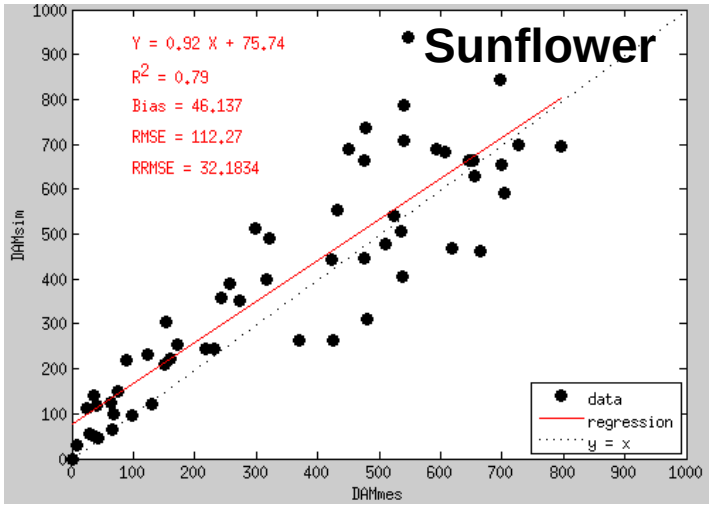
BIOMASS ESTIMATION - validation

Preliminary results for biomass estimation
Validation of SAFY model :

- 32% RRMSE for sunflower
- 19% for maize
- 20% for wheat





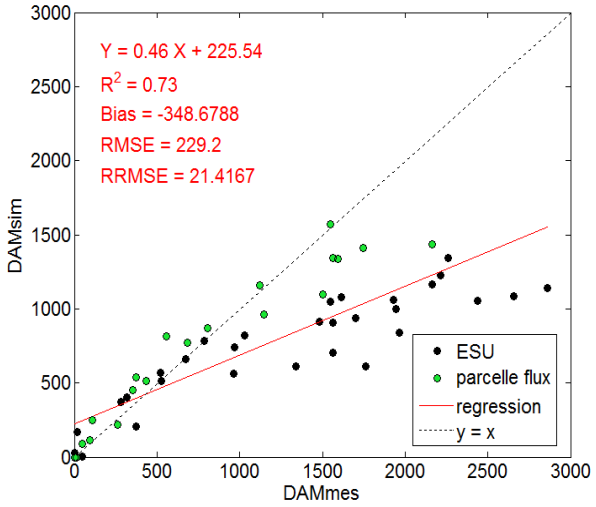


BIOMASS ESTIMATION – conclusions and perspectives

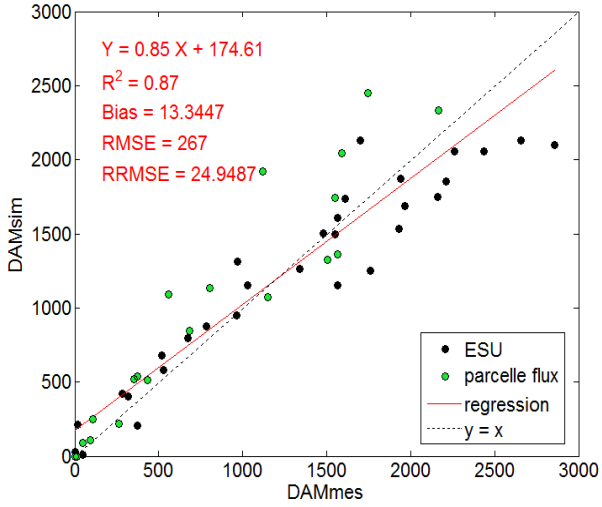
- Work will continue on calibration and validation
- Efforts for an operational use with limited in-situ data
- Incorporation of water in the model = SAFY**E**
  → water needs and supplies estimation

First results for calibration of SAFYE on maize :

No irrigation in model



Irrigation information



Conclusions and perspectives

Conclusions

• Very good dataset for reference data biophysical variables
• Correct results with BVNET for biophysical variables estimation with remote sensing data -> good temporal profile for use as input in models
• Good estimation of biomass, and perspectives for improvement and automatisation with current work
• Promissing results for water needs and supplies estimation with SAFYE

Perspectives

• **BVNET** in OTB
• continue work to evaluate the interest of BVNet
→ correction sensor effect on multi-sensor series
→ contribution of MIR band
→ specific configuration for each crop

SAFYE :

• continue work on parameters optimization
• Calibration and validation for water needs and supplies
• Yield : bad reference data, need new dataset

• Need to continue work on cartography of **irrigated areas** with large dataset, especialy SPOT4-Take5 series

Thank you for your attention

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