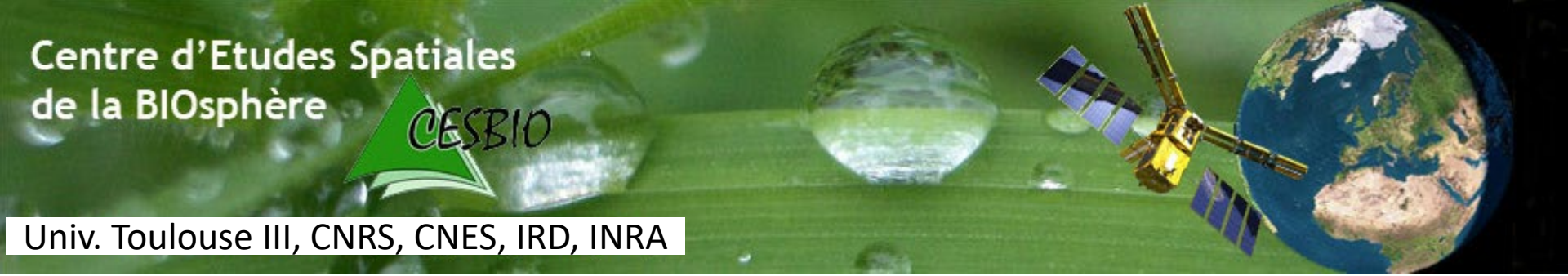
SAFYE-CO2 a model for estimating yield and the components of the carbon budgets for croplands at plot scale over large areas

Eric Ceschia, Gaétan Pique, A. Veloso, Rémy Fieuzal, Al Bitar Ahmad



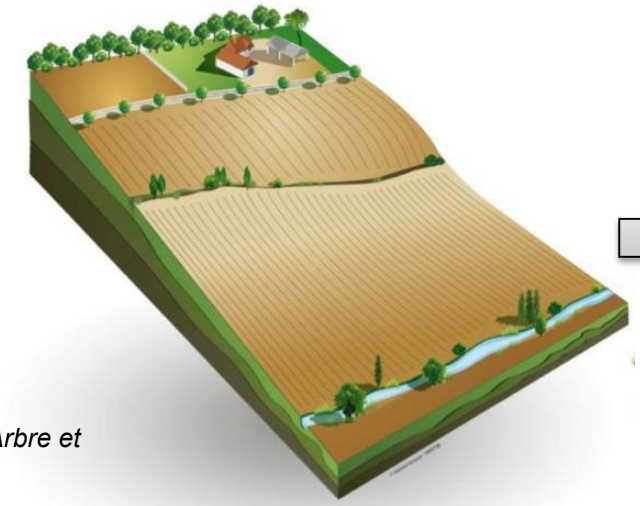
SAFYE-CO2 a model for estimating yield and the components of the carbon budgets for croplands at plot scale over large areas

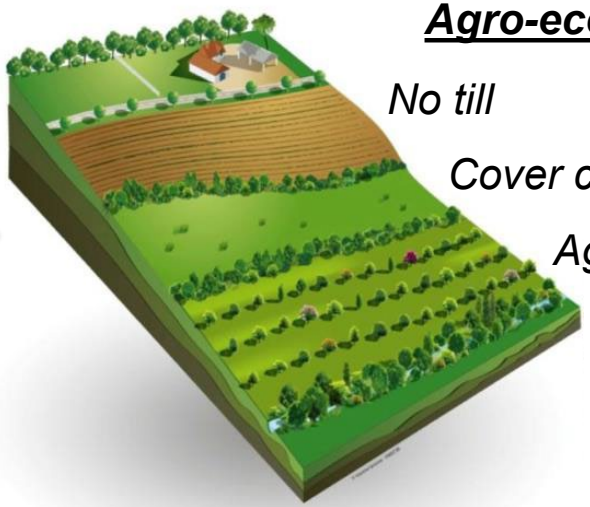
E. Ceschia, G. Pique, A. Veloso, R. Fieuzal, A. Albitar

Webinar, Monitoring Reporting Verification methods 20/09/2019

Monitoring Soil Carbon change

Questioning of the **durability of the conventional agriculture** (climate change & other environmental impacts)





Agro-ecological practices

No till

Cover crops

Agroforestery

C storage
= 4p1000

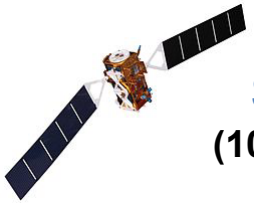
Illustrations: Arbre et Paysage 32

Lack of **large scale multi-criteria diagnostic modelling tools working at plot level** to

- ✓ Analyse cropland C budgets → Biomass, Yield & net CO_2 fluxes
- ✓ Quantify the impact of some management practices (changes in ecosystem services) and climate

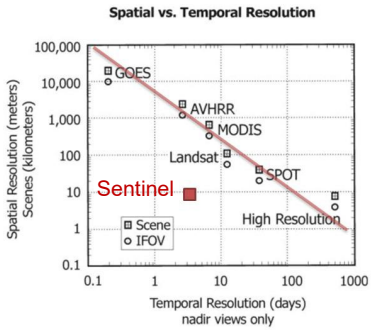
→ **SAFYE-CO_2** : **Simple Algorithm for Fluxes and Yield Estimates**, (Veloso, 2014 ; Pique G. et al. submitted to GEODERMA)

Why is it possible now ?



Sentinel 1
(10 m, 6j, Radar)

A Revolution !!! (free all over the globe)

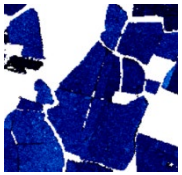


Sentinel 2
(**10 m, 5j, Optical**)

Clear or cloudy sky conditions
Rugosity & surface water content

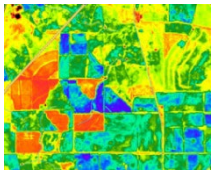
Monitored parameters

Clear sky conditions
Reflectances (13 bands)

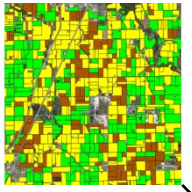


40%
2%

Soil humidity



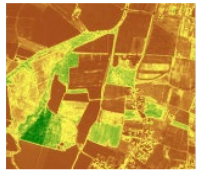
Biomass



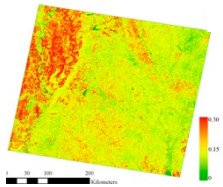
Soil work

Dynamic mapping

Land cover



LAI/ phenology



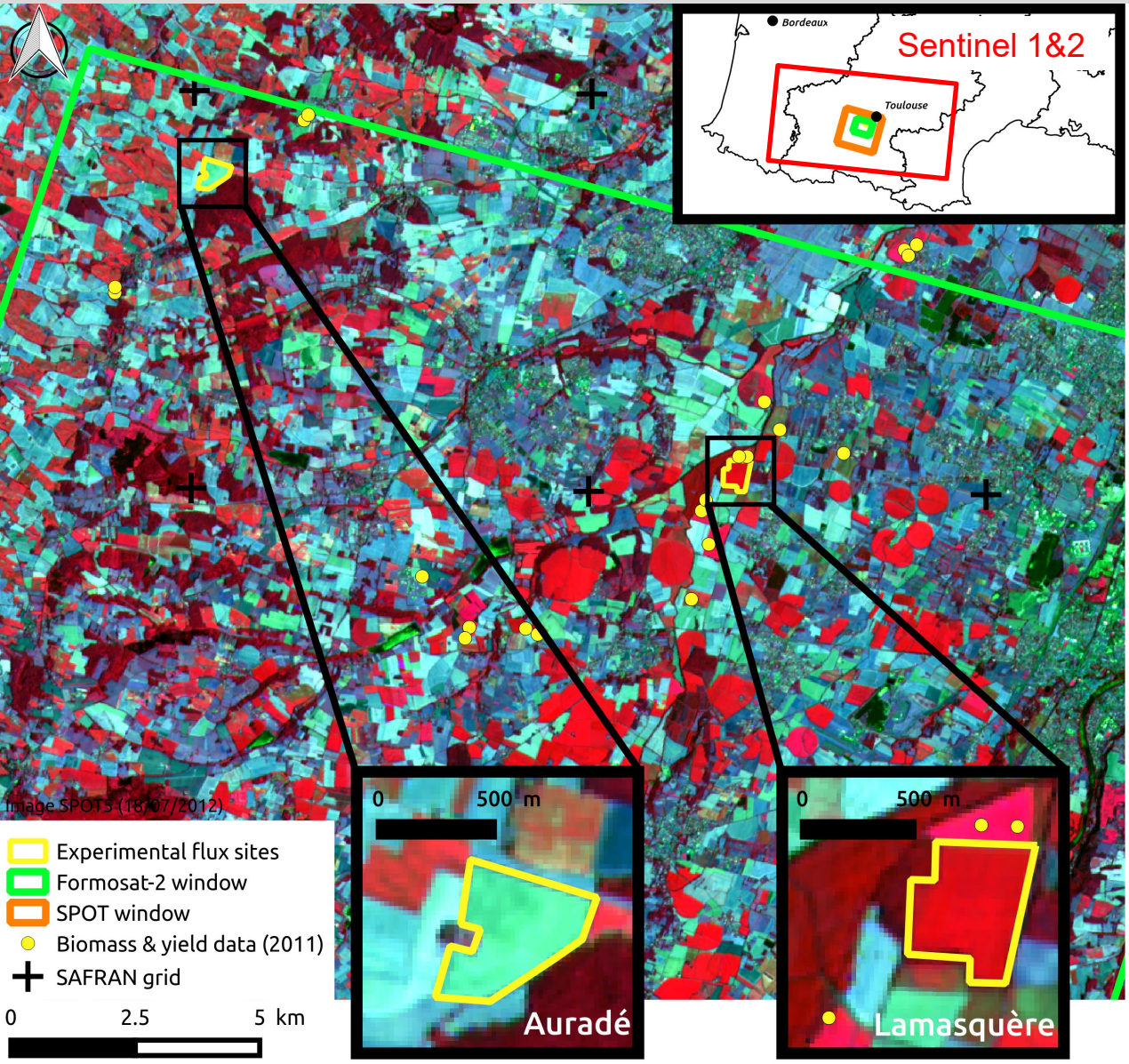
Albedo

fusion

Land use dynamic mapping

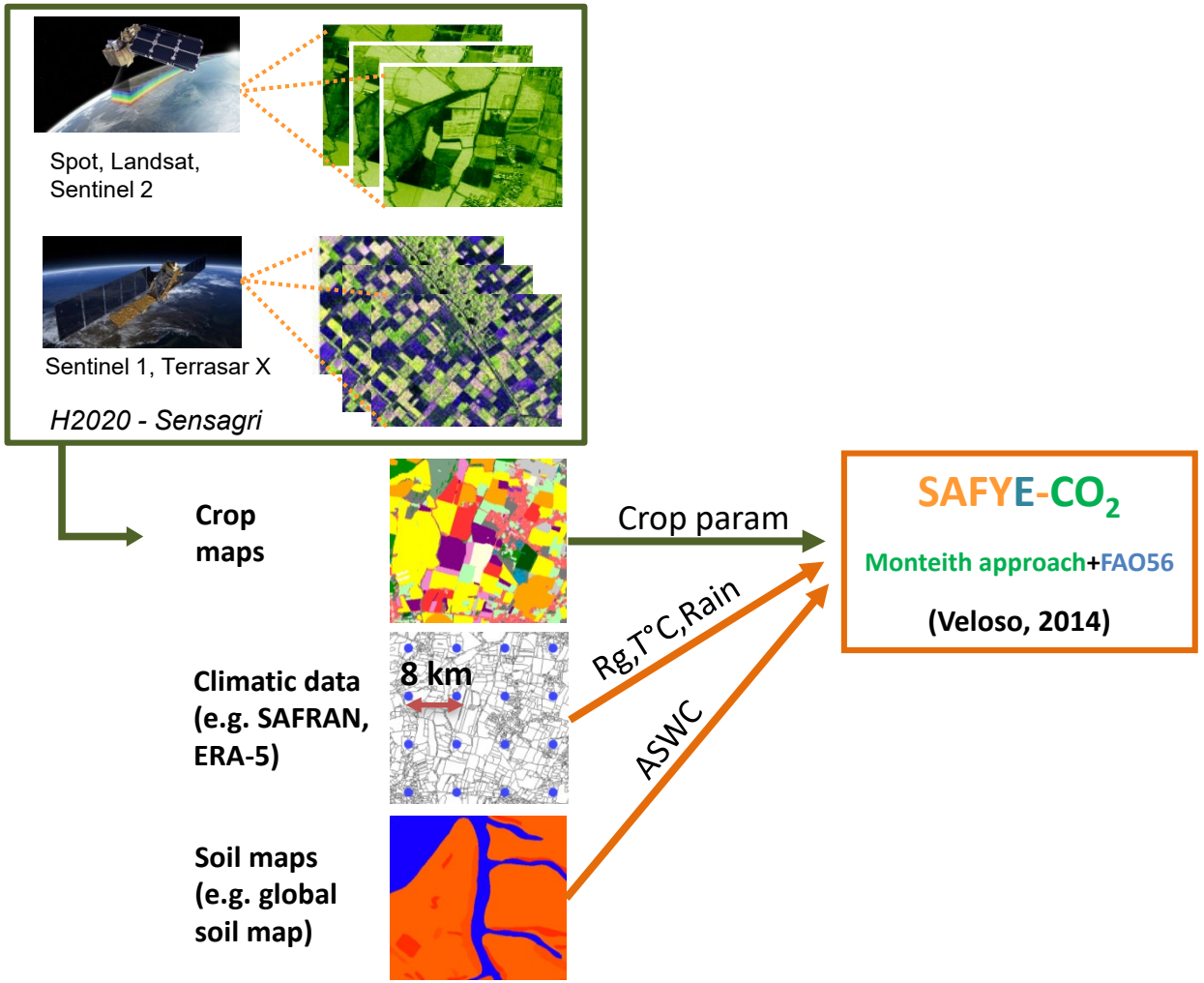
How to use those RS derived products to answer scientific and societal challenges related to agriculture ?

The Spatial Regional Observatory (SRO)

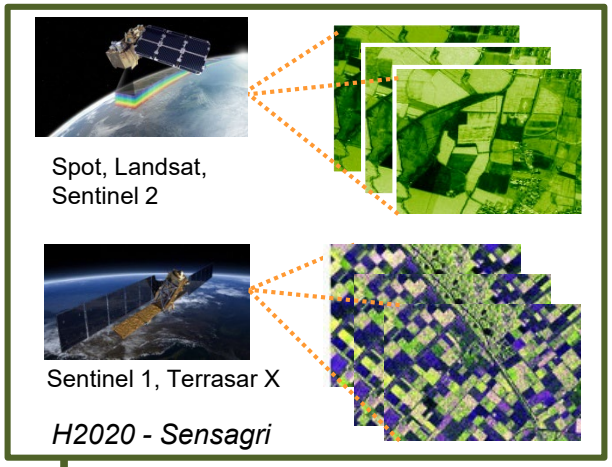


- Started in **2002**
- Part of **JECAM** & **ICOS** network
- Intensive **measurement campaigns (Biomass, LAI, yield, soil moisture)**
- Continuous **CO_2** & **H_2O flux** aquisition since **2005**

Modelling approach with SAFYE-CO_2

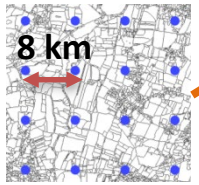


Modelling approach with SAFYE-CO_2

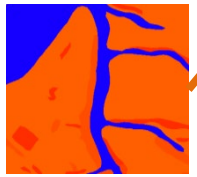


Crop maps

Climatic data (e.g. SAFRAN, ERA-INTERIM)



Soil maps (e.g. global soil map)



Crop param

Rg,T°C,Rain

ASWC

SAFYE-CO_2

Monteith approach+FAO56

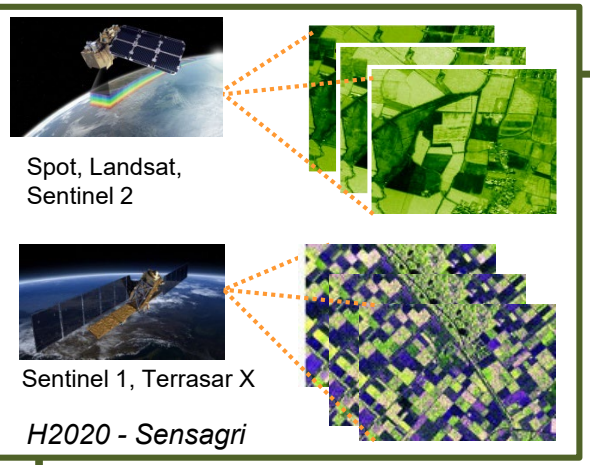
(Veloso, 2014)

Leaf Area Index

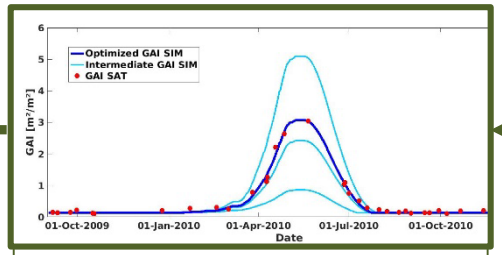
Biomass,
Yield,
irrigation

CO_2 & water fluxes
+
C & water budgets

Modelling approach with SAFYE-CO_2



Radiative transfer model, SVM…

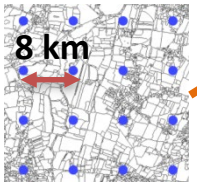


Calibration of phenological parameters & light-use efficiency parameter

Crop maps

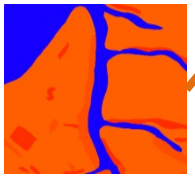
Crop param

Climatic data (e.g. SAFRAN, ERA-INTERIM)



Rg,T°C,Rain

Soil maps (e.g. global soil map)



ASWC

SAFYE-CO_2

Monteith approach+FAO56

(Veloso, 2014)

Leaf Area Index

Biomass,
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C & water budgets

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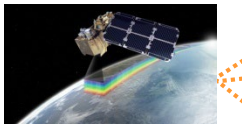
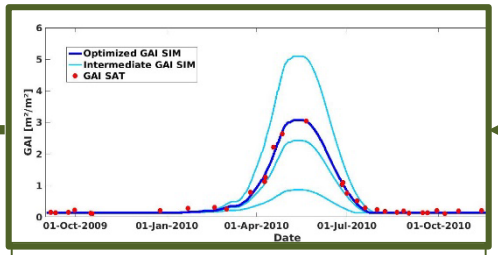


Spot, Landsat, Sentinel 2

Sentinel 1, Terrasar X

H2020 - Sensagri

Radiative transfer model, SVM…

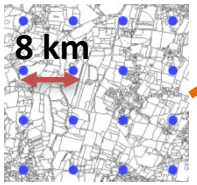


Calibration of phenological parameters & light-use efficiency parameter

Crop maps

Crop param

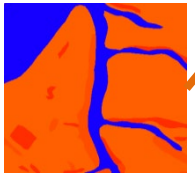
Climatic data (e.g. SAFRAN, ERA-INTERIM)



Rg,T°C,Rain

ASWC

Soil maps (e.g. global soil map)



SAFYE-CO_2

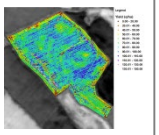
Monteith approach+FAO56

(Veloso, 2014)

Leaf Area Index

Biomass, Yield, irrigation

Validation with regional stat. (yield/irrigation)



National observatories

JECAM Network

Ecosystem component flux stations

ICOS INTEGRATED CARBON OBSERVATION SYSTEM

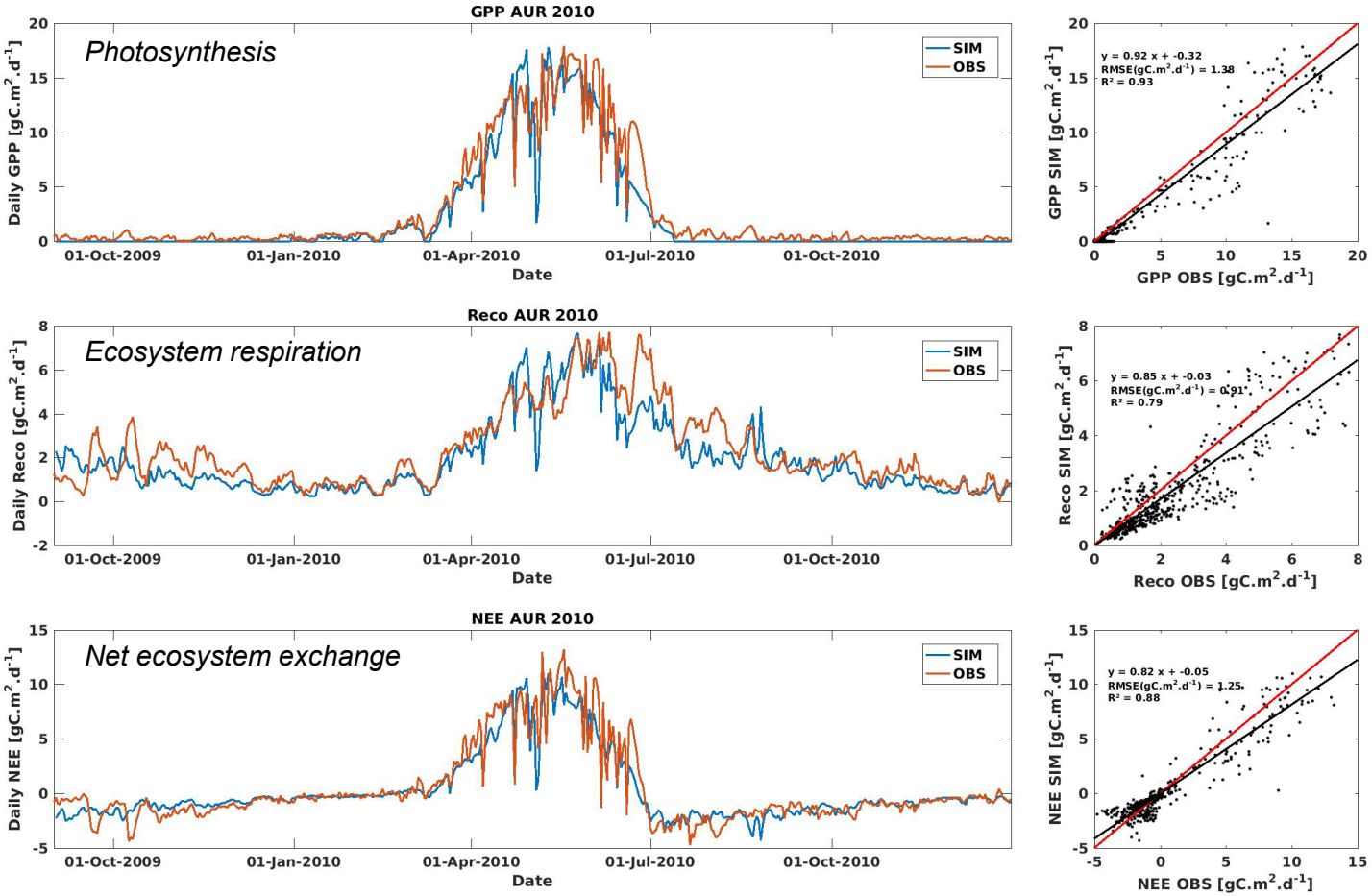
FLUXNET A Global Network

CO_2 & water fluxes + C & water budgets

Performances of our approach

SAFYE-CO_2

CO_2 fluxes dynamics at the Auradé site in 2010

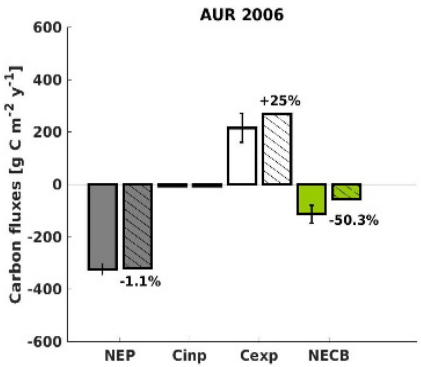


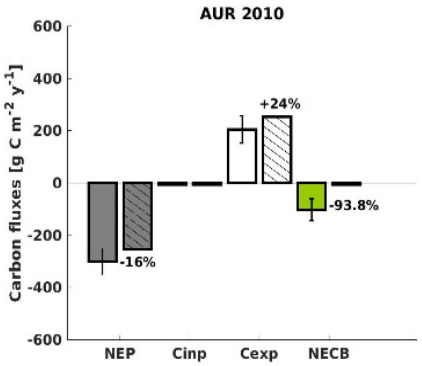
- Very good agreement with observations
- NEE statistics for 8 cropping years of wheat : **R^2 = 0,86** ; **RMSE = 1,29gC.m^{-2}.d^{-1}**
- Possibility to compute carbon budget over cultural year

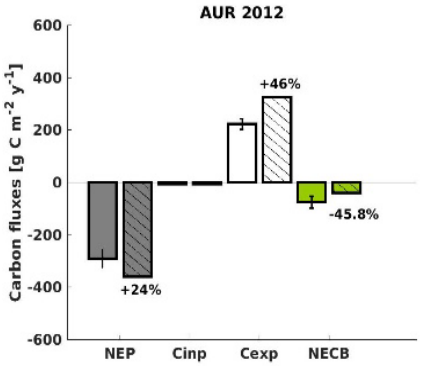
Performances of our approach

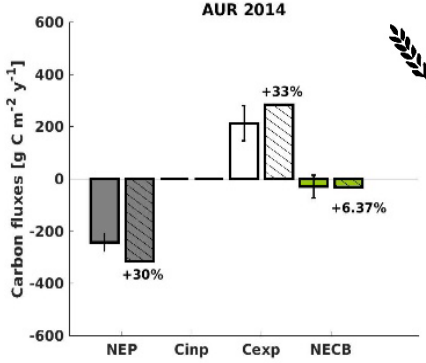
Annual carbon budget over 8 winter wheat cropping years
Lamasquère & Auradé sites

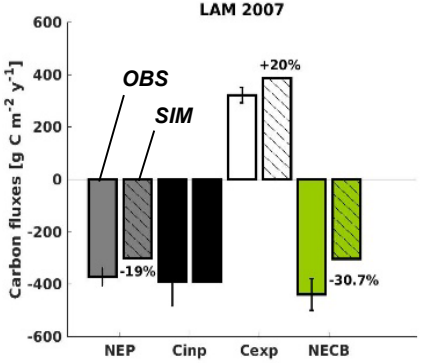
SAFYE-CO_2

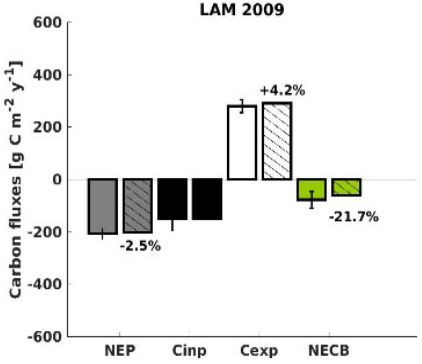


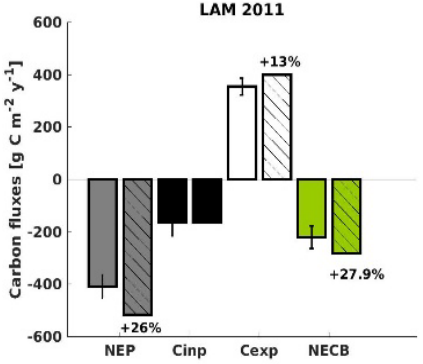


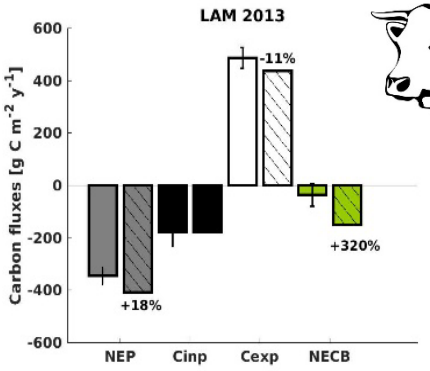


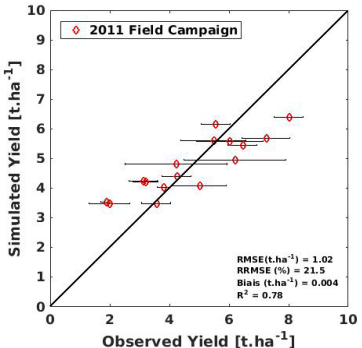








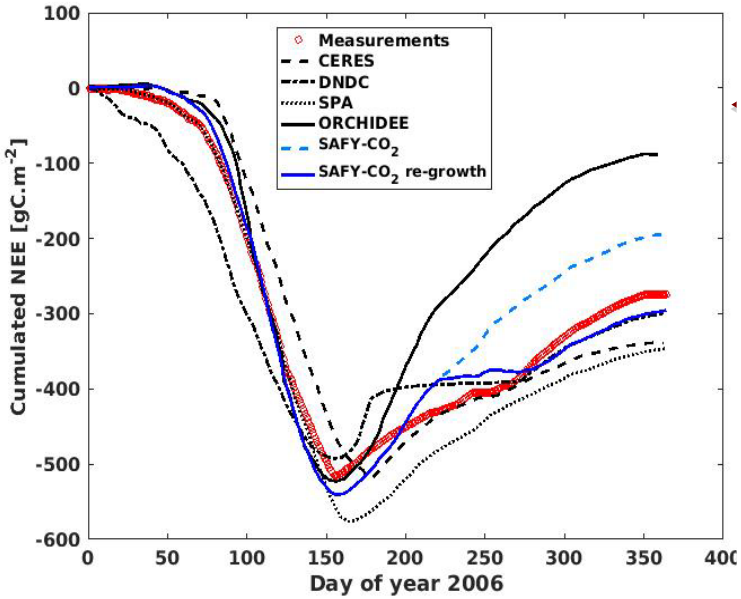




- ΔCarbon budget ϵ [**1,8 ; 134,8**] gC.m^{-2}.yr^{-1}
- Uncertainties on in situ Cexp
- Estimation of soil C variation
- RMSE (TC/ha/an) = 0.77

Performances/Originality of our approach

With and without accounting for regrowth events



Wattenbach et al. (2010)
Pique et al. (in prep)

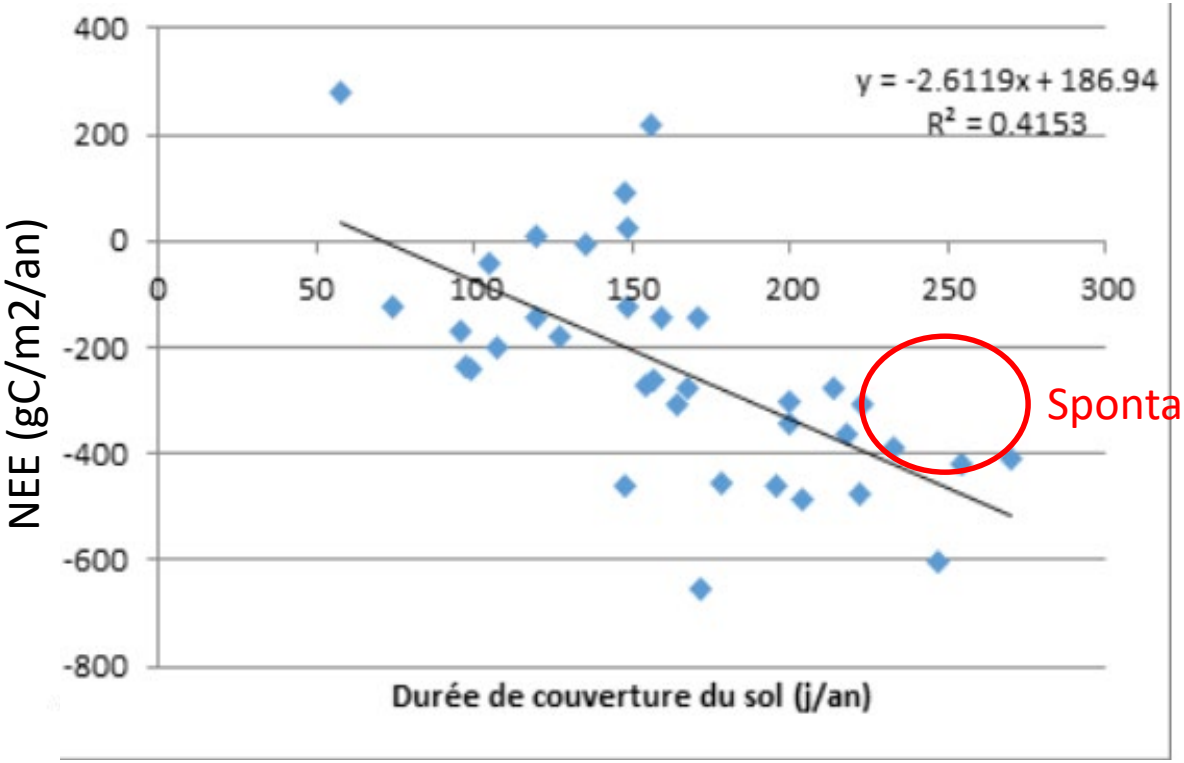
Very good performance of this simple modelling approach that does not require data on management (fertilisation, sowing date..) or on SOC (no soil Corg module) compared to other models.

Shows the power of remote sensing for constraining this crop model

Performances/Originality of our approach

$$C\ budget = NEE + C_{harvested} - C_{amendements}$$

Farmers data



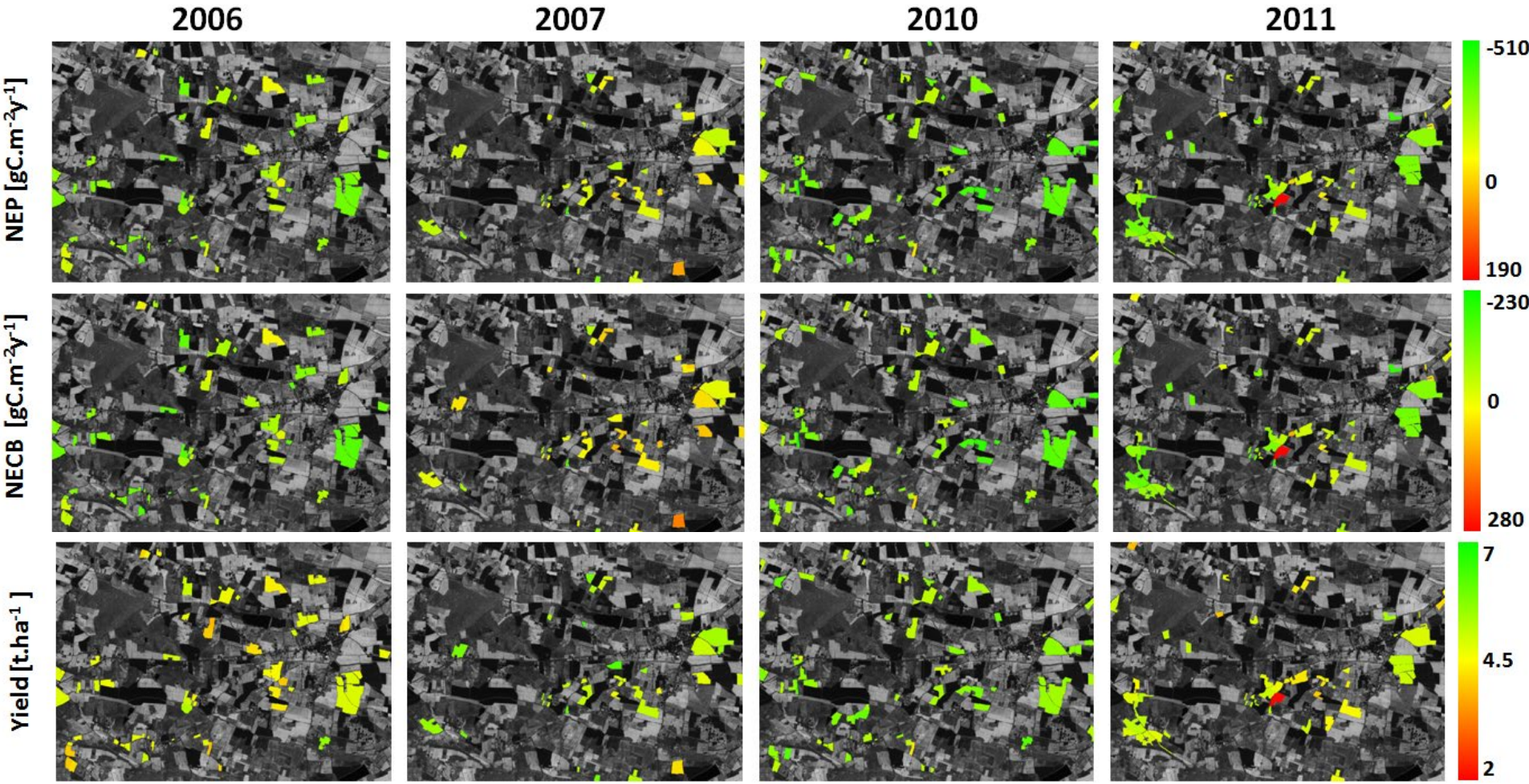
Number of days of active vegetation

Spontaneous regrowth

15 European flux sites (Italy to Danemark), 43 site-years (Ceschia 2010), 15 different crop species

Plot scale regional estimates for winter wheat

Net CO_2 fluxes (NEP), C budgets (NECB), Yield



Limits of the approach

- Diagnostic approach : but some scenarii can be tested
- Optical RS data must be combined with radar data (Sentinel 1) in cloudy areas & for strong crop development (optical RS saturates for high LAI values); ongoing research ➔ H2020 Sensagri
- Not suited for areas with animal farming : impossible to quantify organic fertilization from RS and very difficult to locate fields where straw is exported ➔ main causes of uncertainties on the C budget

** Integrated Administration & Control System*

Conclusions

- This approach was developed in the perspective of generalizing it by using Sentinel data/products (for model input) and the JECAM & ICOS networks (for validation); with some limits… and some challenges (huge amount of RS data…➔ DIAS*),
- Well suited for assessing the effects of straw management and cover crops on cropland C budgets,
- The transposability of this modelling approach has been verified (Morocco, Mexico, India…) for the SAFYE** version, next is to test SAFY-CO_2 over other areas (e.g. JECAM & ICOS crop sites),
- The model is currently tested for several other crops in order to simulate crop rotations,
- Research tool that needs improvements before it can be used in operational mode for mapping ecosystem services.

* *Data Integrated & Analysis System*
** *SAFYE = SAFY-WB (Claverie et al., 2012)*

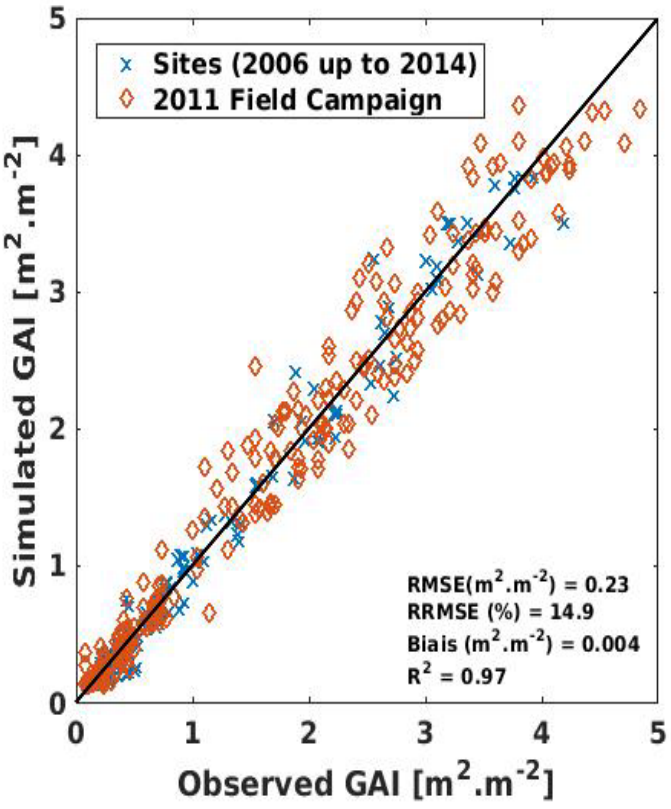
Thanks for your attention and thanks to our financers

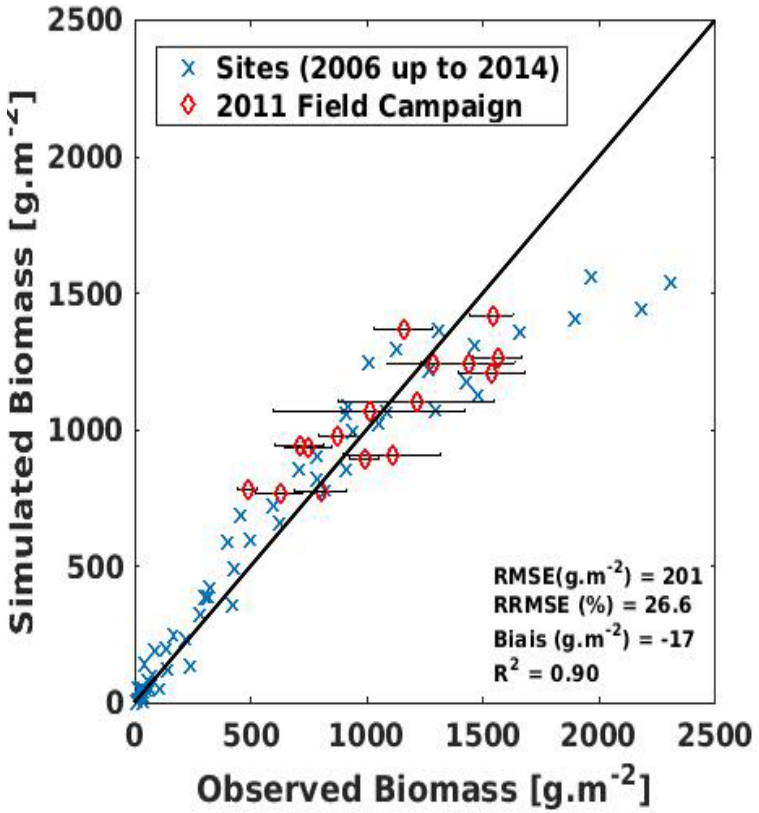
If you want to have more details concerning our work please contact me at :
eric.ceschia@cesbio.cnes.fr

For complete description of the model see : http://www.cesbio.ups-tlse.fr/data_all/theses/Th_Veloso_2014.pdf

Supplementary materials

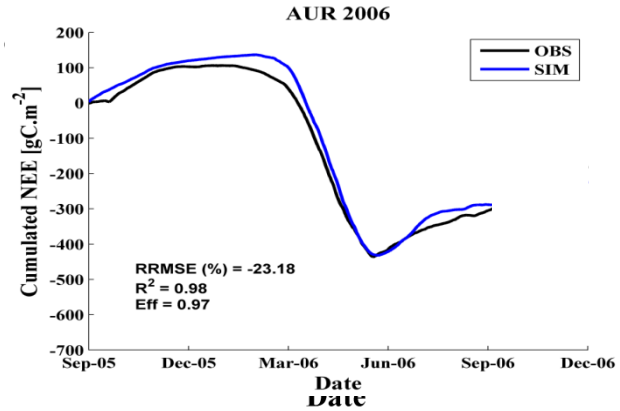
- Field campaign 2011 : 21 points, 16 fields
- Good estimations of LAI & biomass

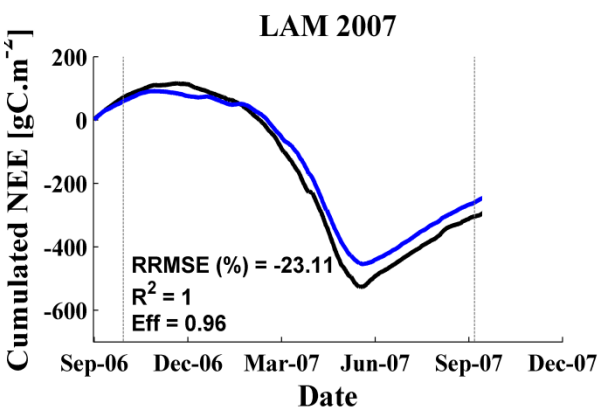


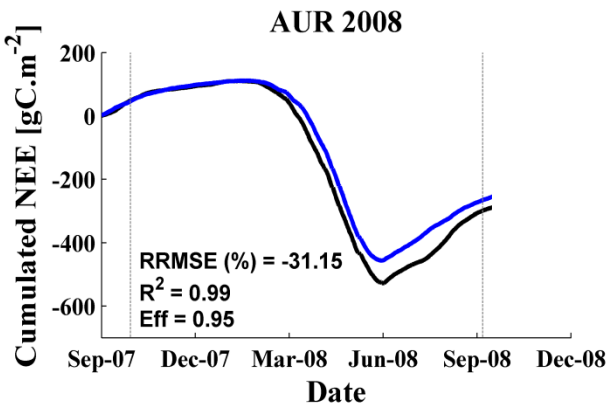


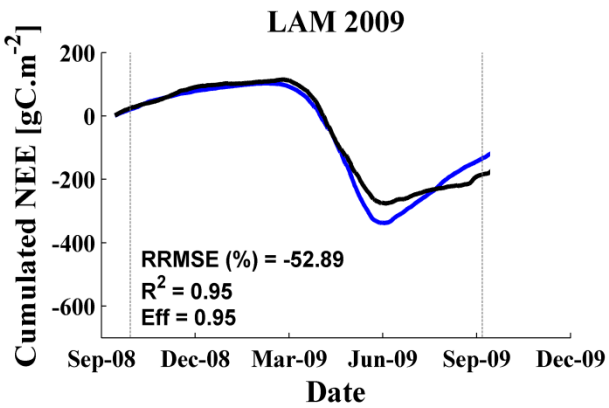
Supplementary materials

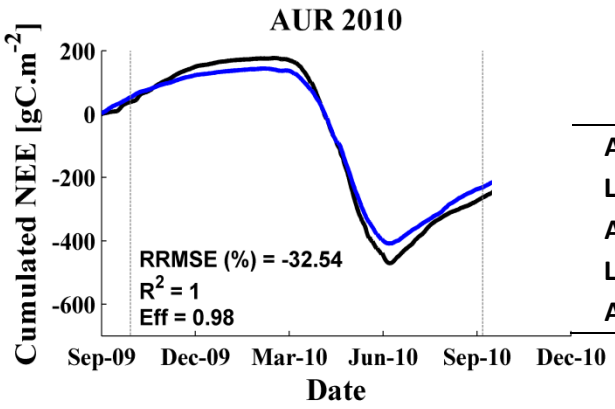
SAFYE-CO_2











	NEE		
	R^2	RMSE*	Slope
AUR2006	0.85	1.21	1.02
LAM2007	0.87	1.06	0.81
AUR2008	0.89	1.05	0.87
LAM2009	0.79	1.19	0.88
AUR2010	0.88	1.28	0.79

OBS
SIM

SAFYE-CO_2

cumulated ETR

SAFYE-CO_2