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

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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. Webinar CIRCASA Monitoring Reporting Verification methods, INRAE, Sep 2019, Online (Paris), France. hal-04221025

HAL Id: hal-04221025

<https://hal.inrae.fr/hal-04221025>

Submitted on 28 Sep 2023

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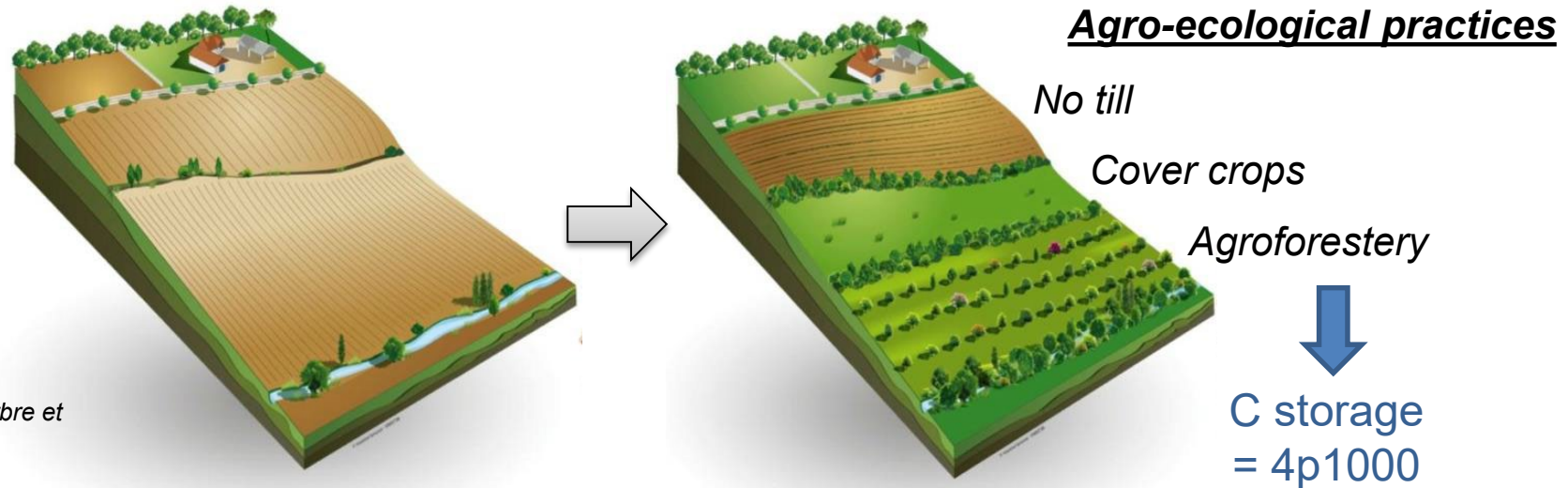
SAFYE-CO2 a model for estimating yield and the components of the carbon budgets for croplands at plot scale over large areas

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)



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

- ✓ Analyse cropland C budgets → Biomass, Yield & net CO₂ fluxes
- ✓ Quantify the impact of some management practices (changes in ecosystem services) and climate

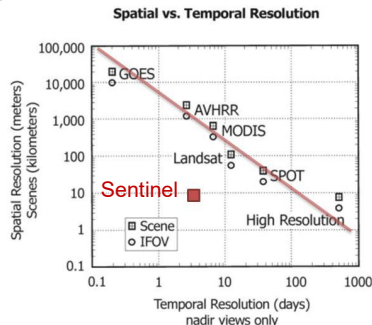
➔ **SAFYE-CO₂** : Simple Algorithm for Fluxes and Yield Estimates, (Veloso, 2014 ; Pique G. et al. submitted to GEODERMA)

Why is it possible now ?



Sentinel 1
(10 m, 6j, Radar)

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



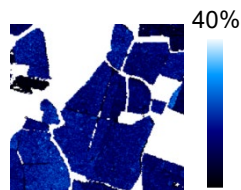
Sentinel 2
(10 m, 5j, Optical)



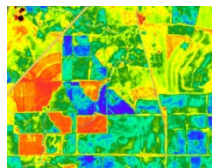
Clear or cloudy sky conditions
Rugosity & surface water content

Monitored
parameters

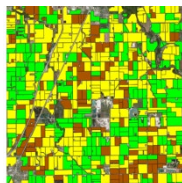
Clear sky conditions
Reflectances (13 bands)



Soil
humidity



Biomass

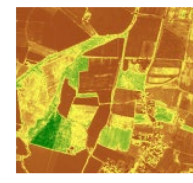


Soil work

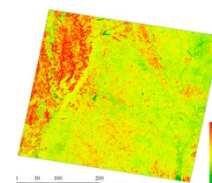
Dynamic mapping



Land cover



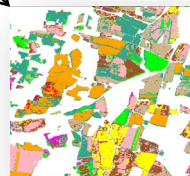
LAI/
phenology



Albedo

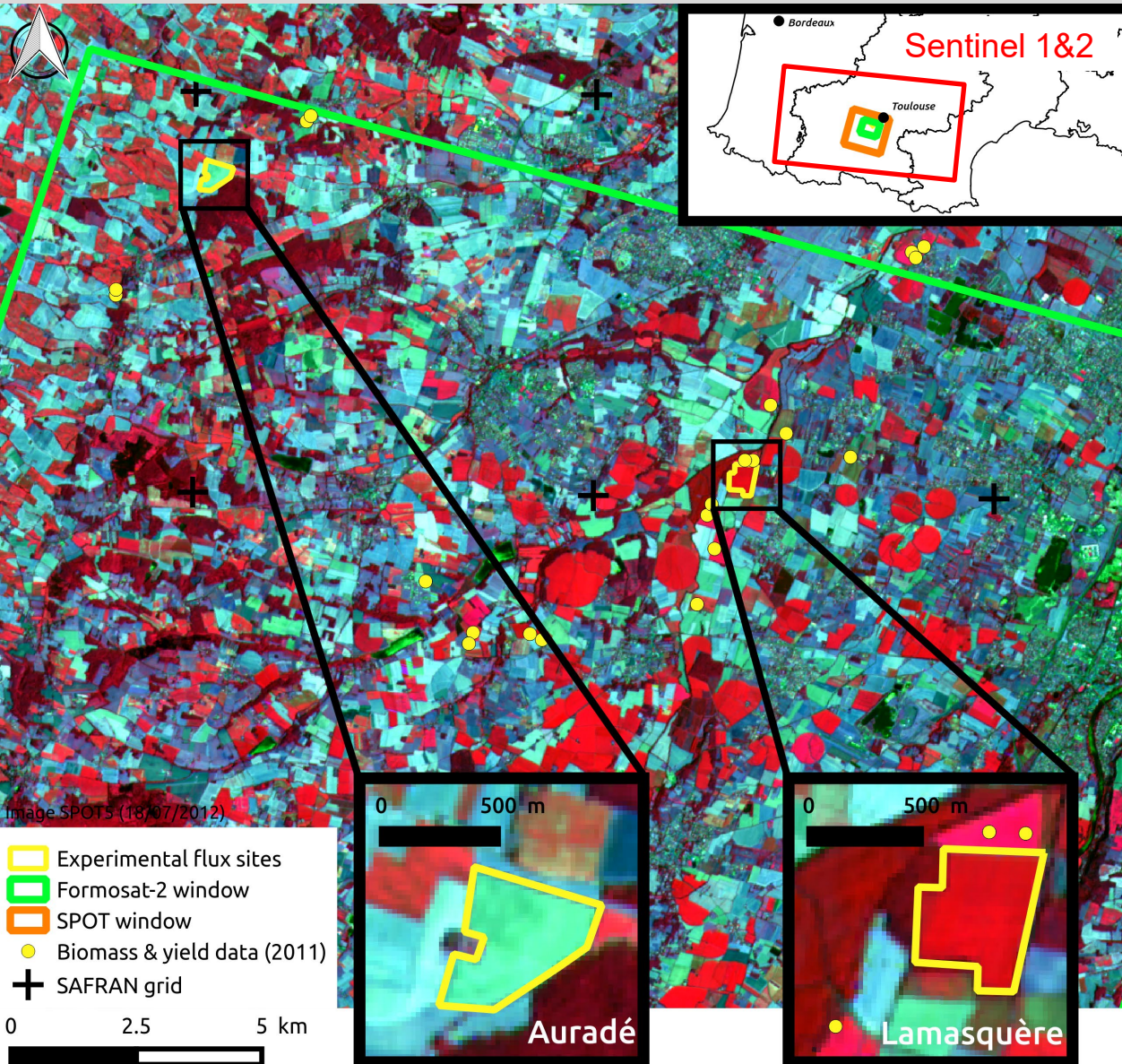
fusion

Land use dynamic mapping



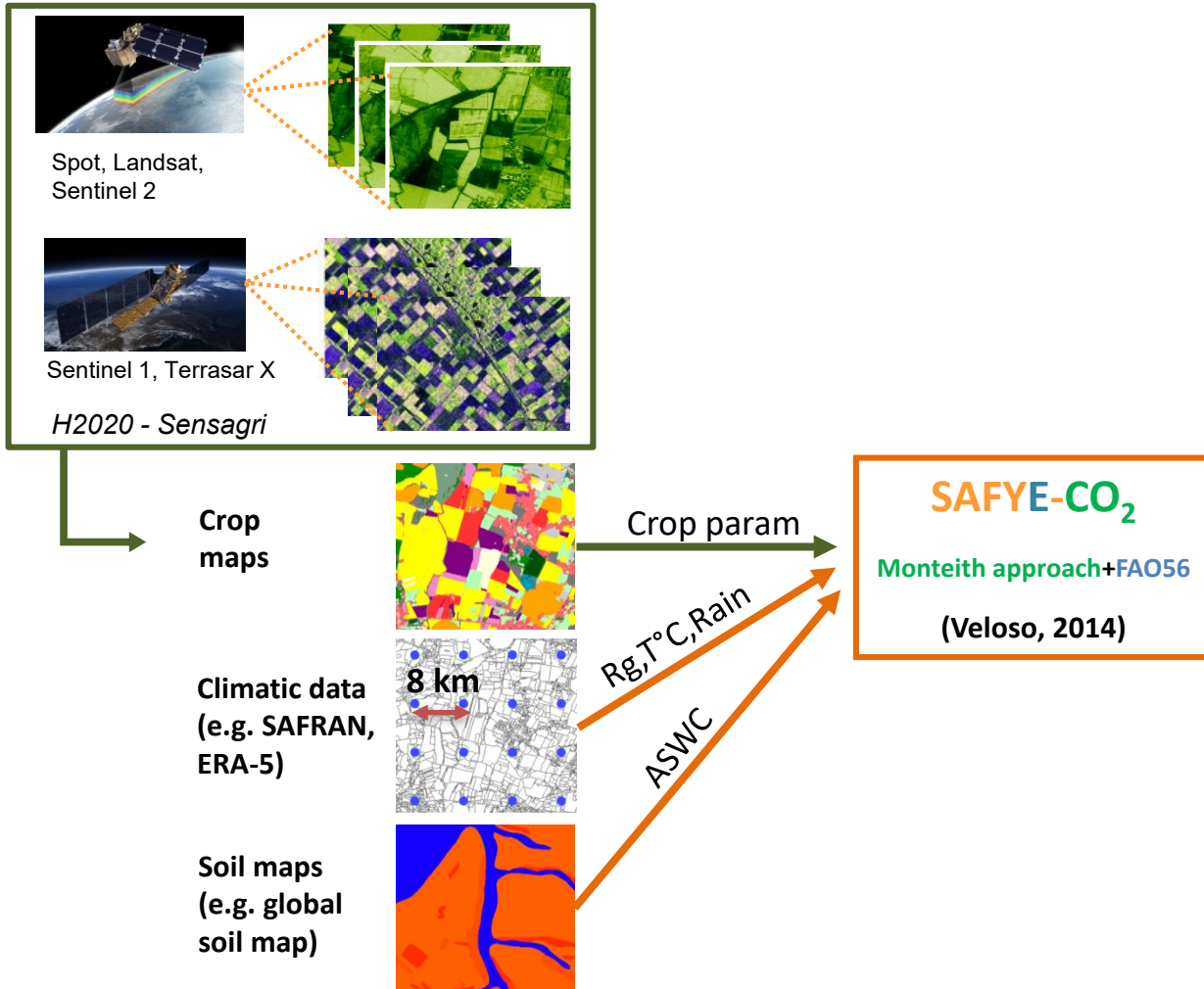
How to use those RS derived products to answer scientific and societal challenges related to agriculture ?

The Spatial Regional Observatory (SRO)

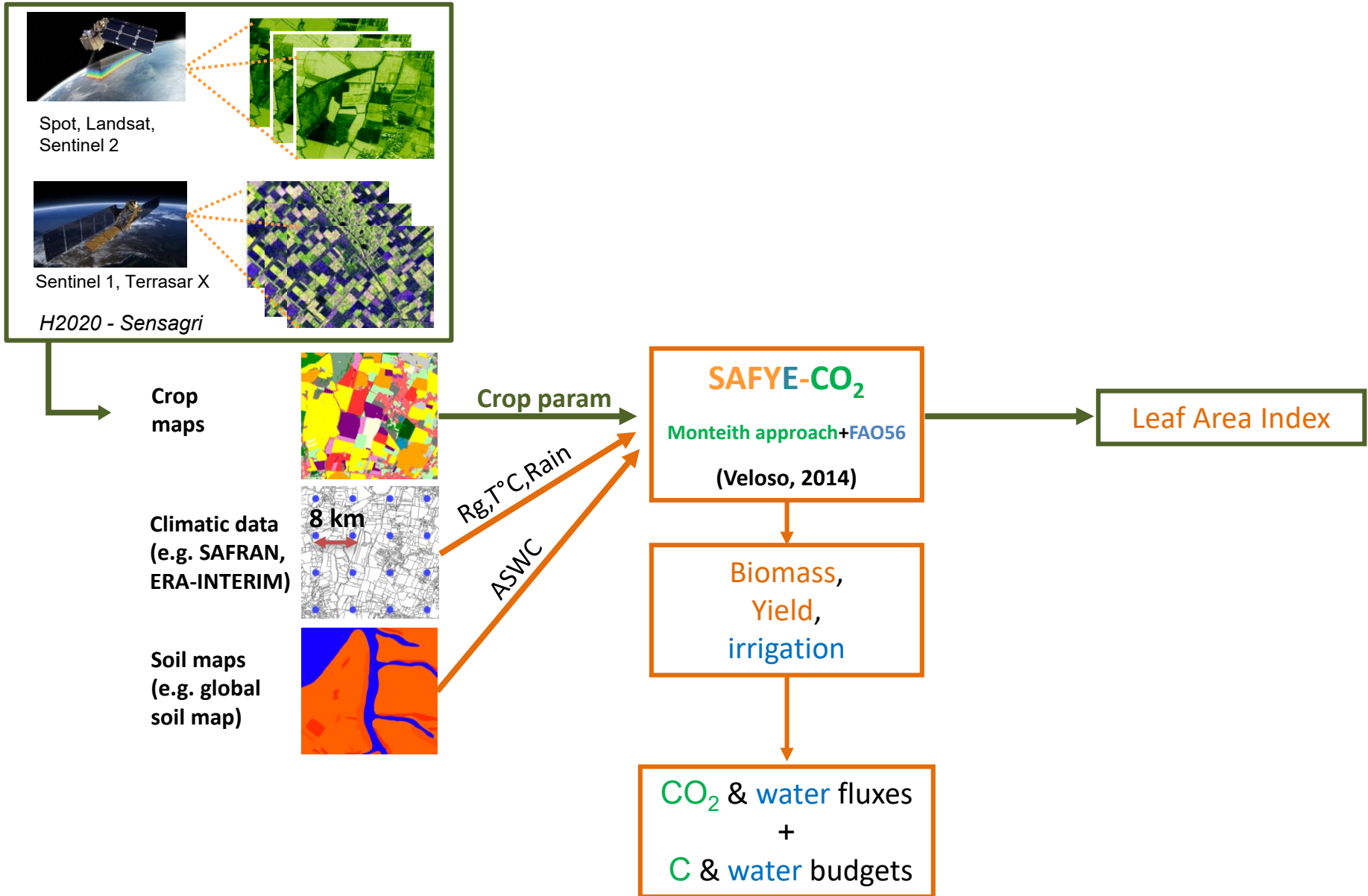


- Started in **2002**
- Part of **JECAM & ICOS** network
- Intensive **measurement campaigns** (Biomass, LAI, yield, soil moisture)
- Continuous **CO₂ & H₂O flux** acquisition since **2005**

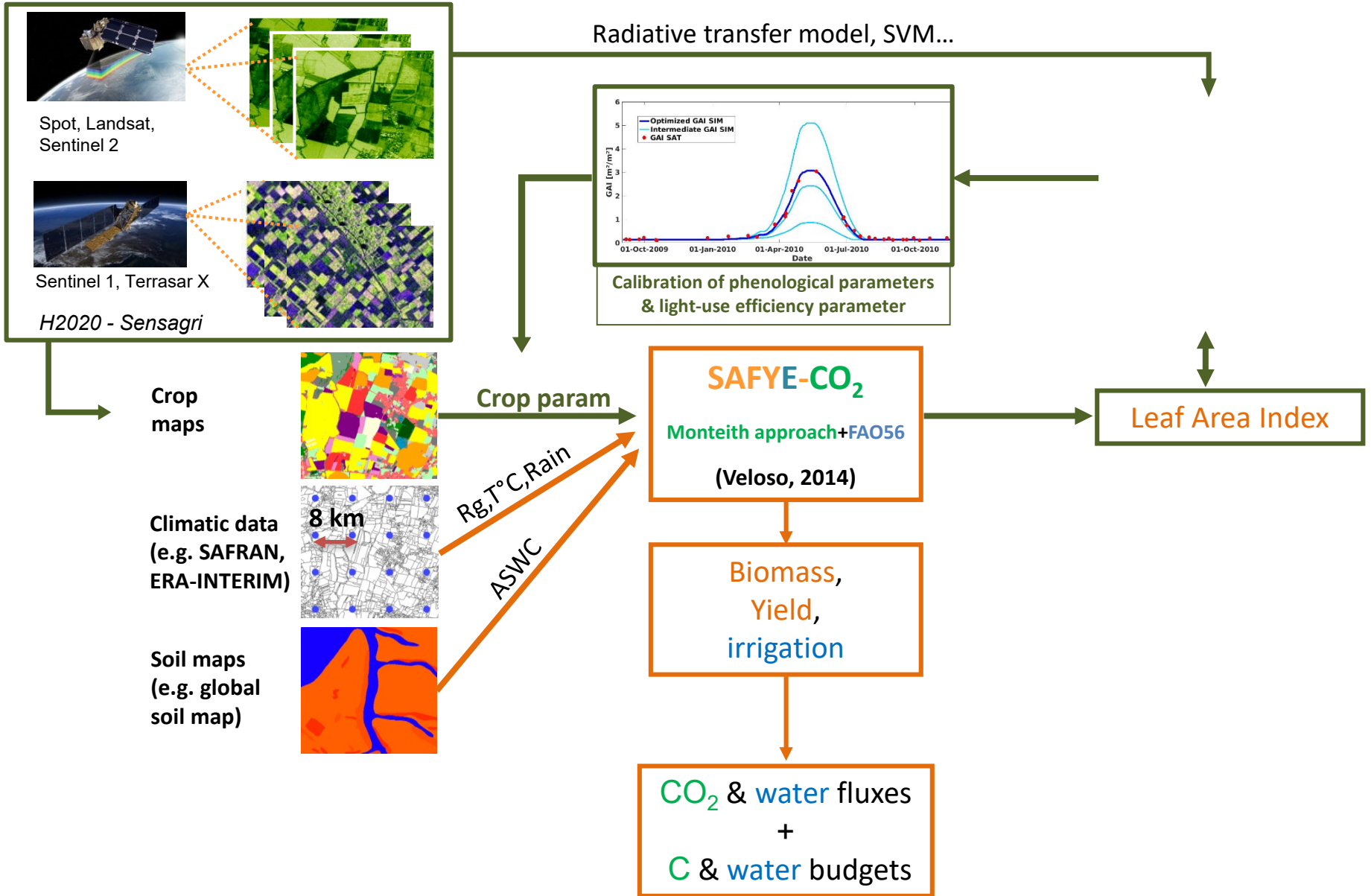
Modelling approach with SAFYE-CO₂



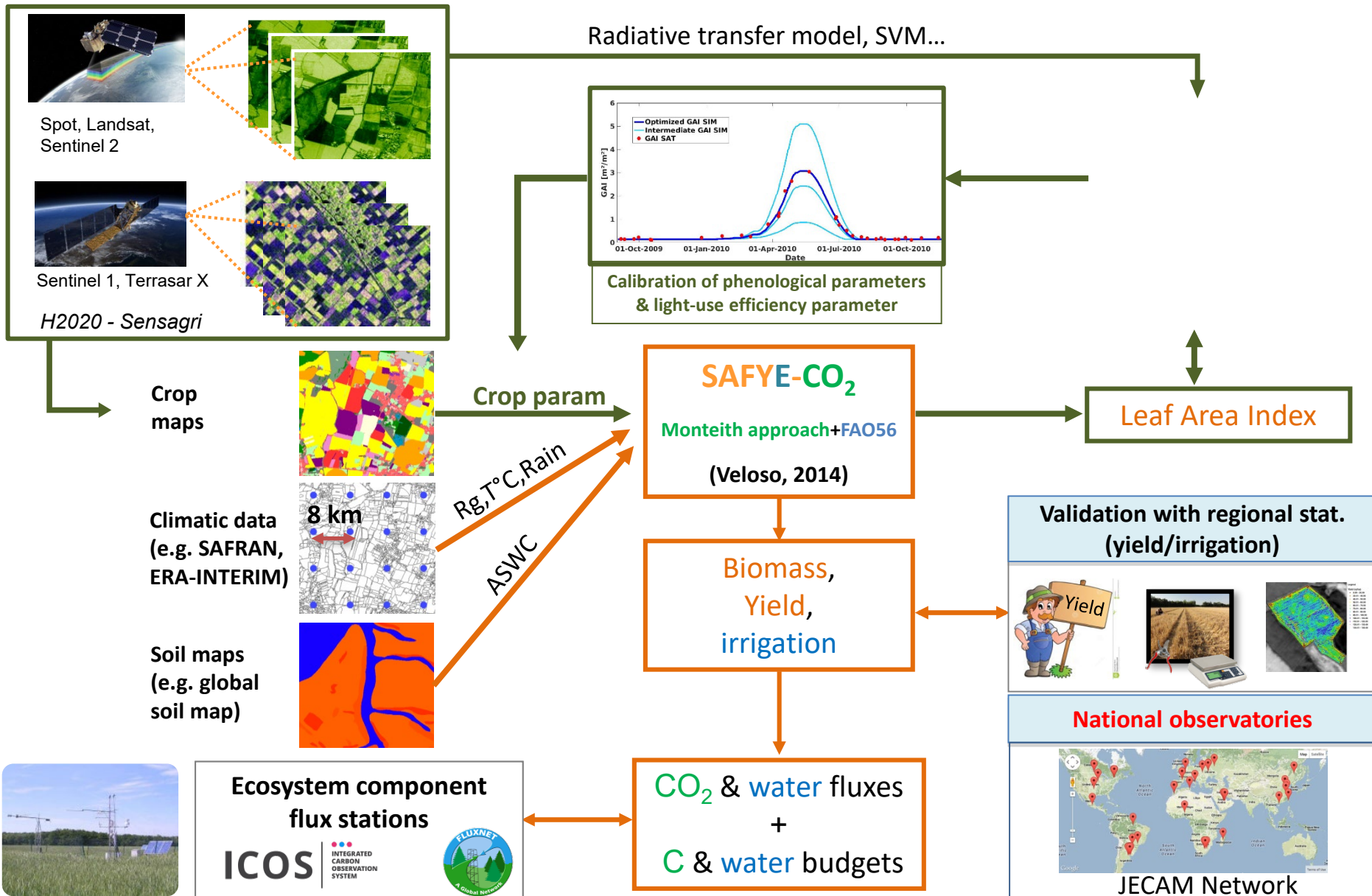
Modelling approach with SAFYE-CO₂



Modelling approach with SAFYE-CO₂

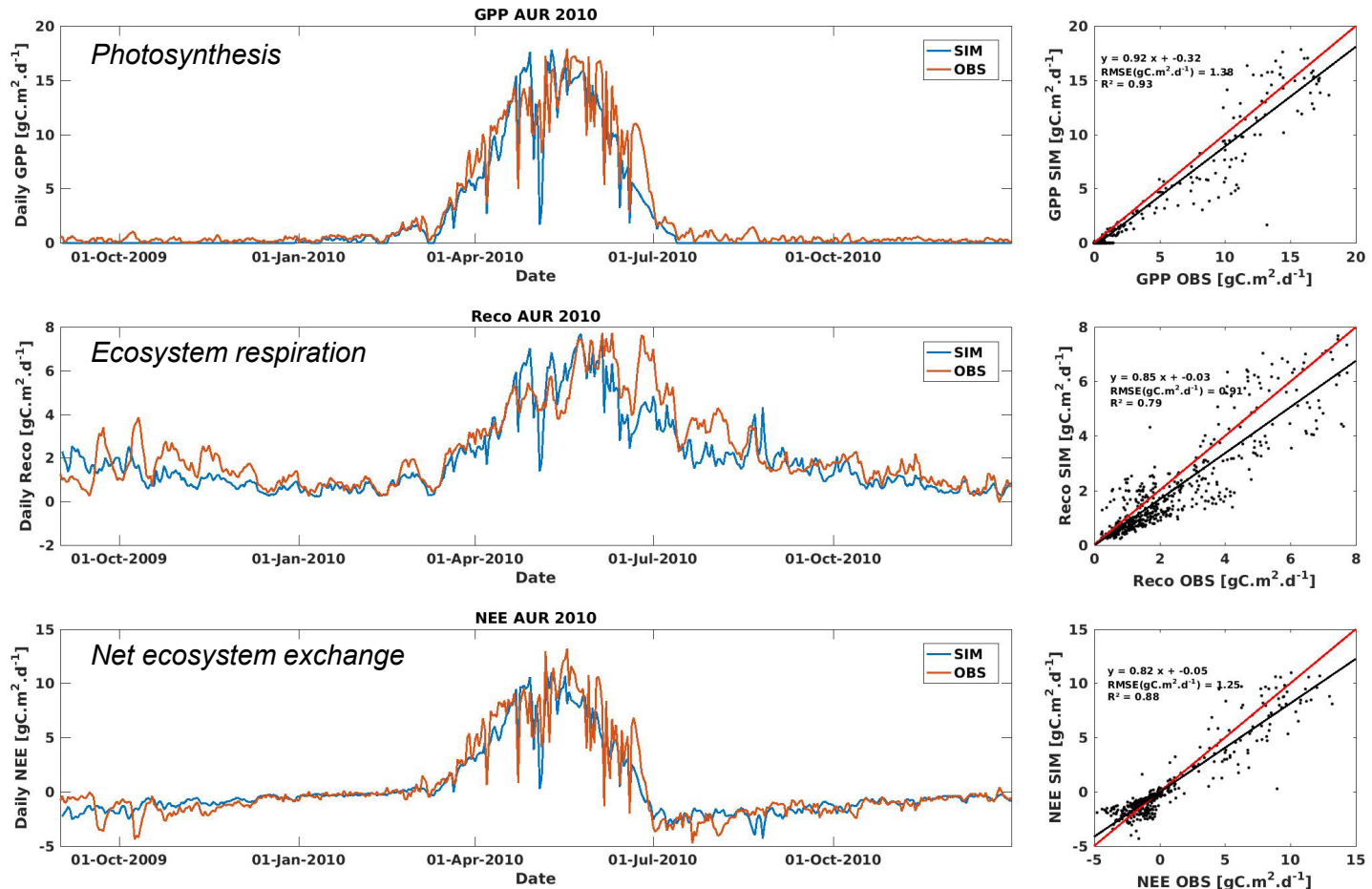


Modelling approach with SAFYE-CO₂



CO₂ fluxes dynamics at the Auradé site in 2010

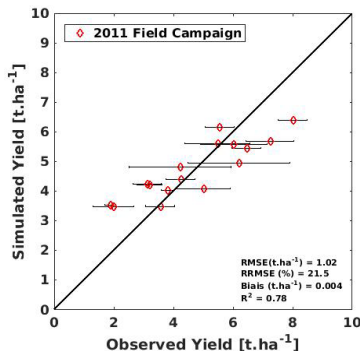
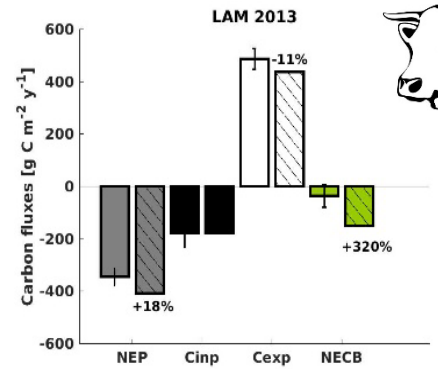
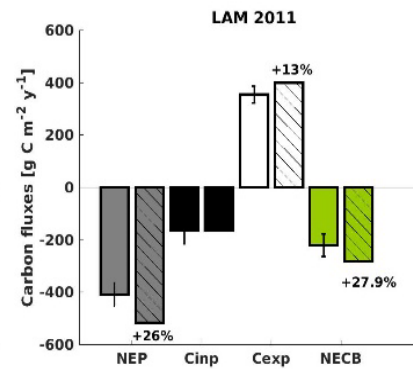
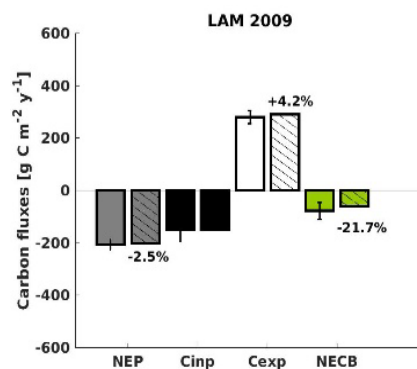
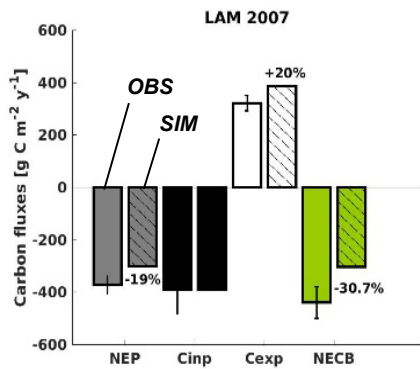
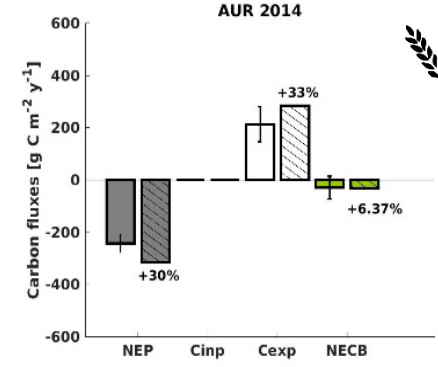
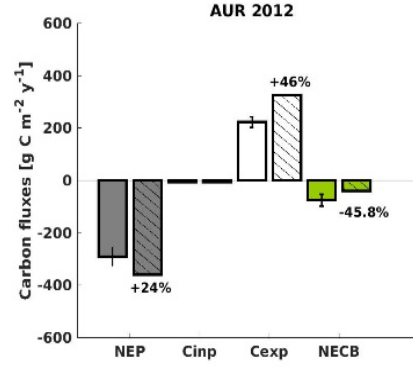
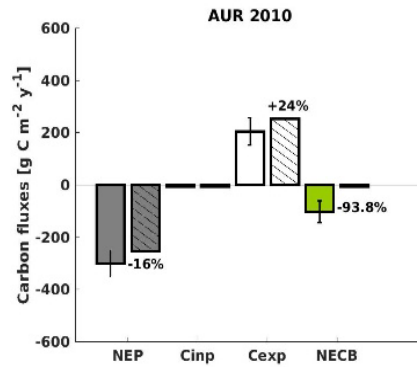
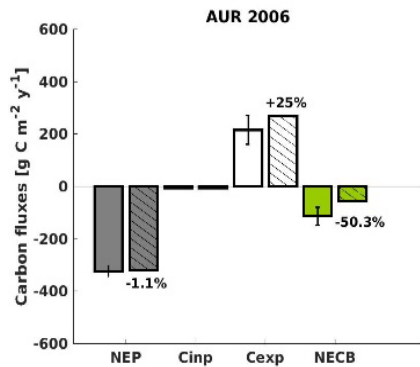
SAFYE-
CO₂



- 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

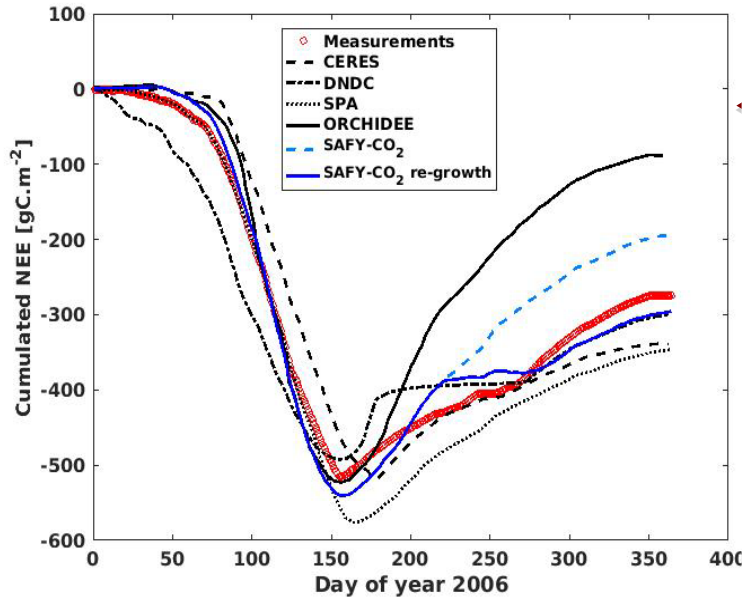
Performances of our approach

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



- Δ Carbon budget $\in [1,8 ; 134,8]$ gC.m⁻².yr⁻¹
- Uncertainties on in situ Cexp
- Estimation of soil C variation
- RMSE (TC/ha/an) = 0.77

With and without accounting for regrowth events



Wattenbach et al. (2010)

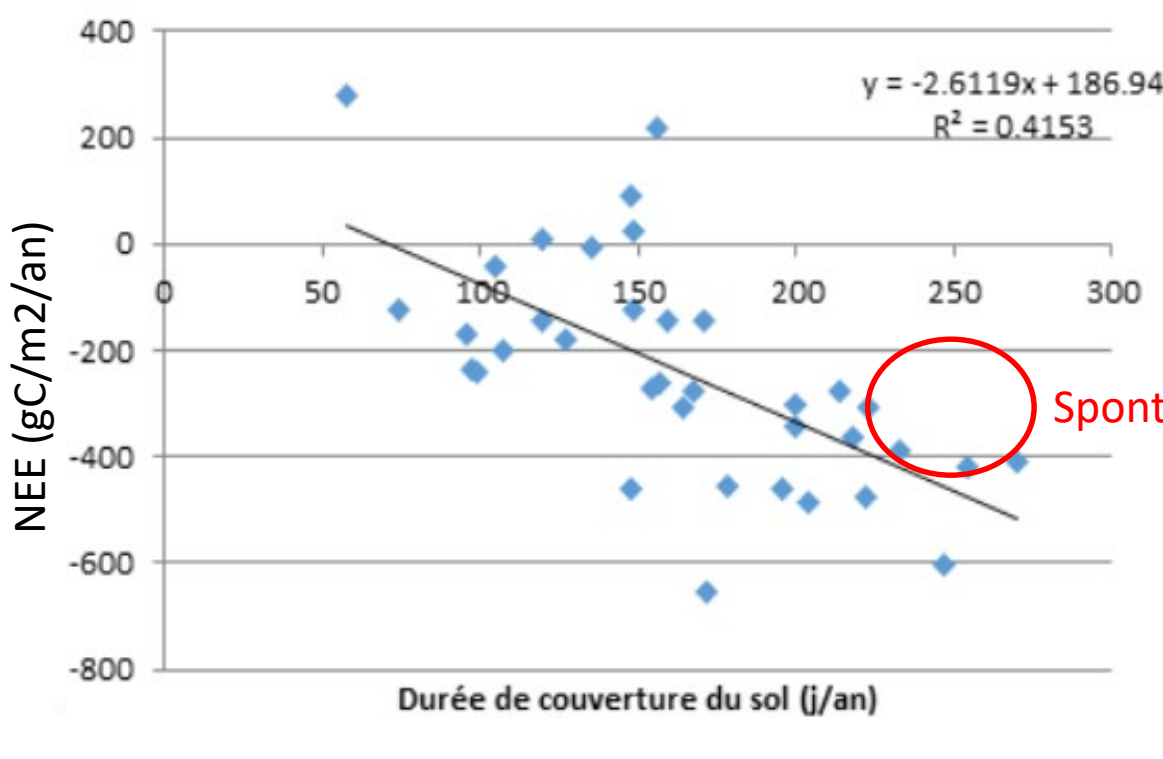
Pique et al. (in prep)

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

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

Farmers data

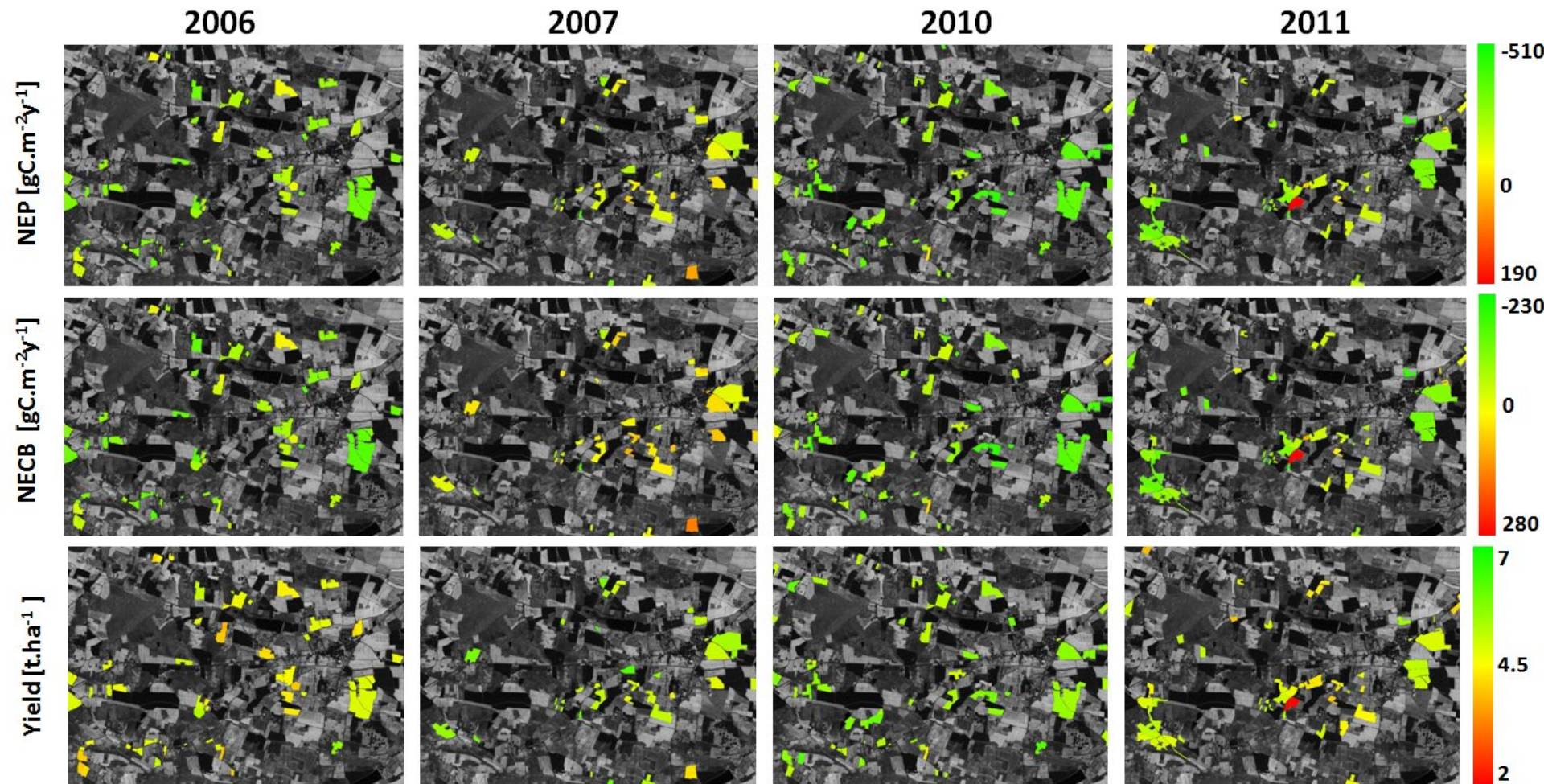


Number of days of active vegetation

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

Plot scale regional estimates for winter wheat

Net CO₂ fluxes (NEP), C budgets (NECB), Yield



- 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



Conclusions

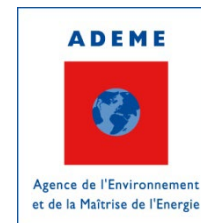
- This approach was developed in the perspective of generalizing it by using Sentinel data/products (for model input) and the JECAM & ICOS networks (for validation); with some limits... and some challenges (huge amount of RS data... → DIAS*),
- Well suited for assessing the effects of straw management 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-CO₂ 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

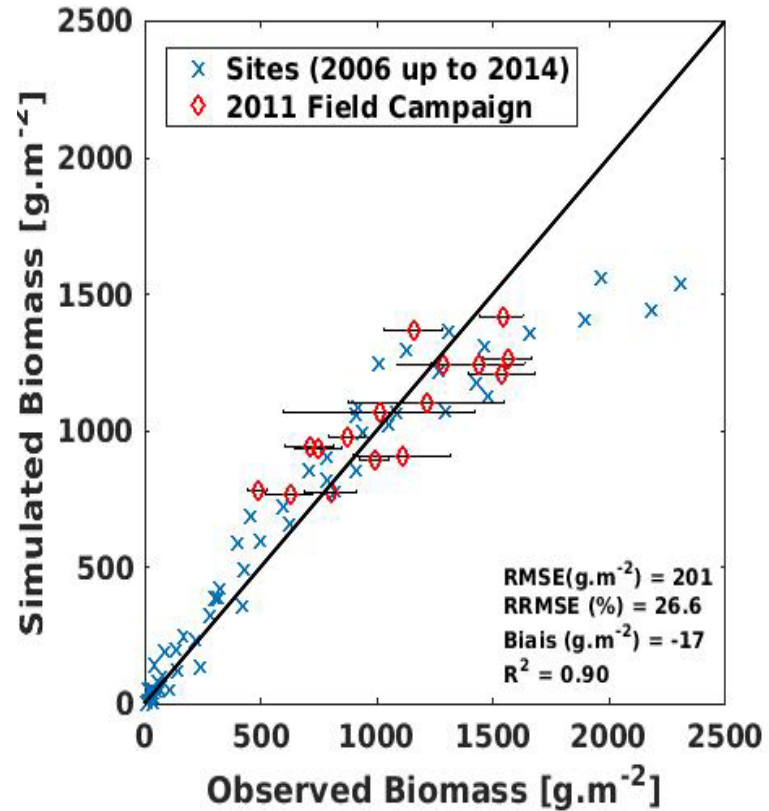
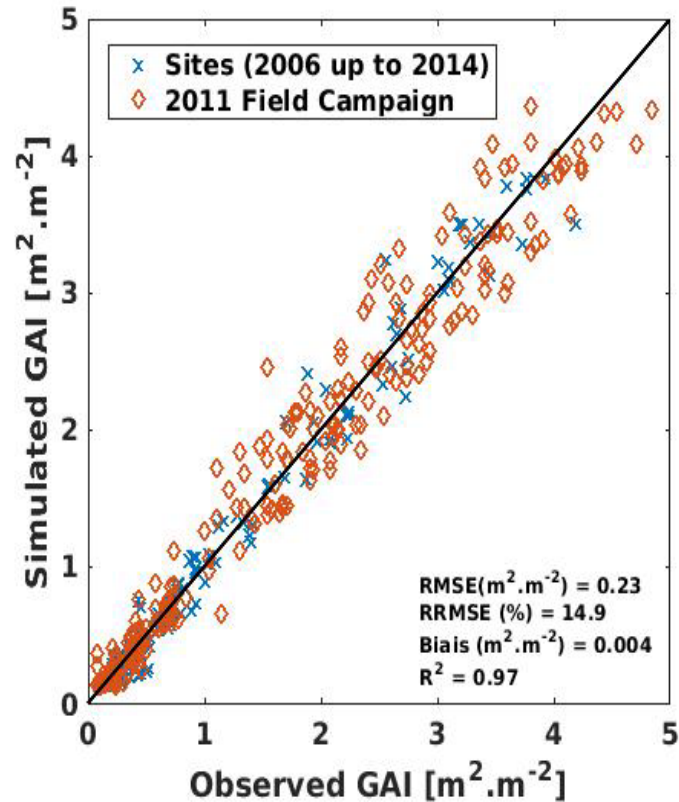


If you want to have more details concerning our work please contact me at :
eric.ceschia@cesbio.cnes.fr

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

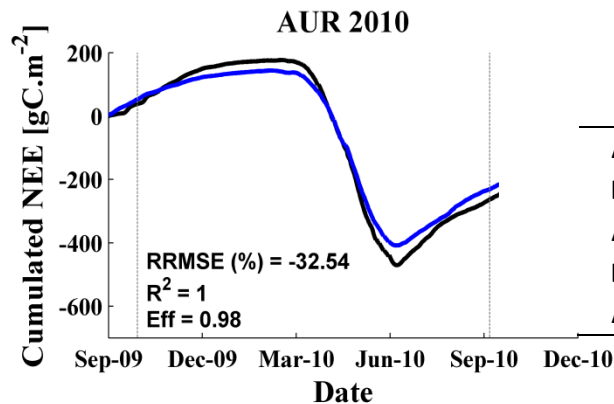
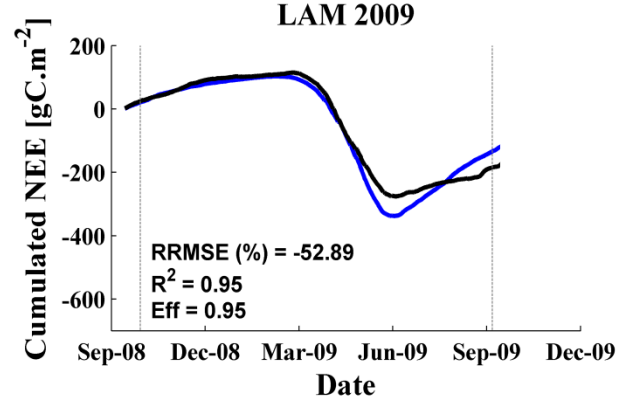
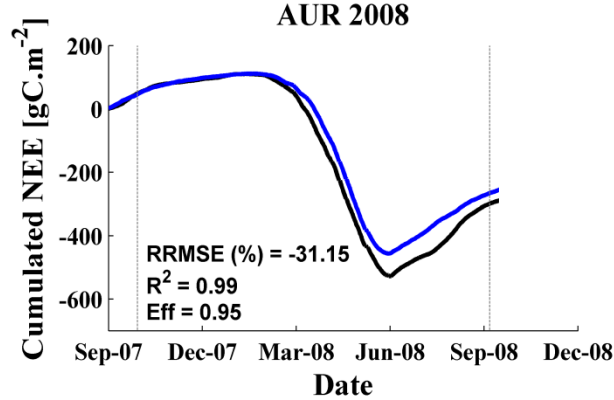
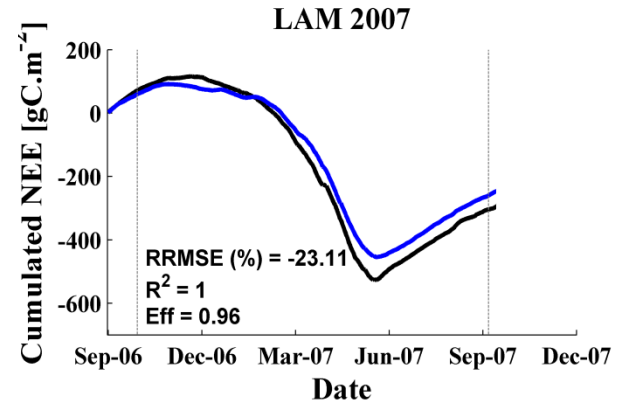
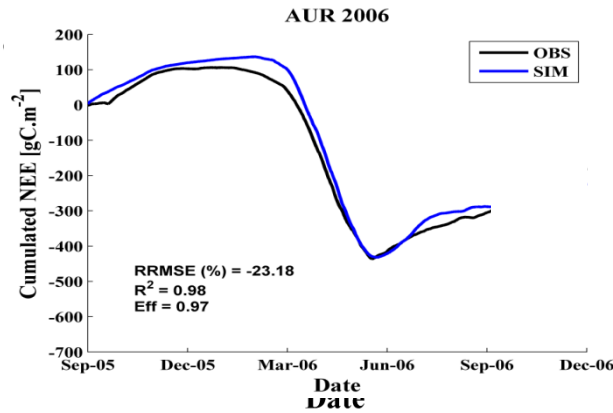
Supplementary materials

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



Supplementary materials

SAFYE-
CO₂



	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

Supplementary materials

cumulated ETR

SAFYE-
CO₂

SAFYE-
CO₂

