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A strategy for estimating yield and the components of the carbon and water budgets for croplands at plot scale over large areas

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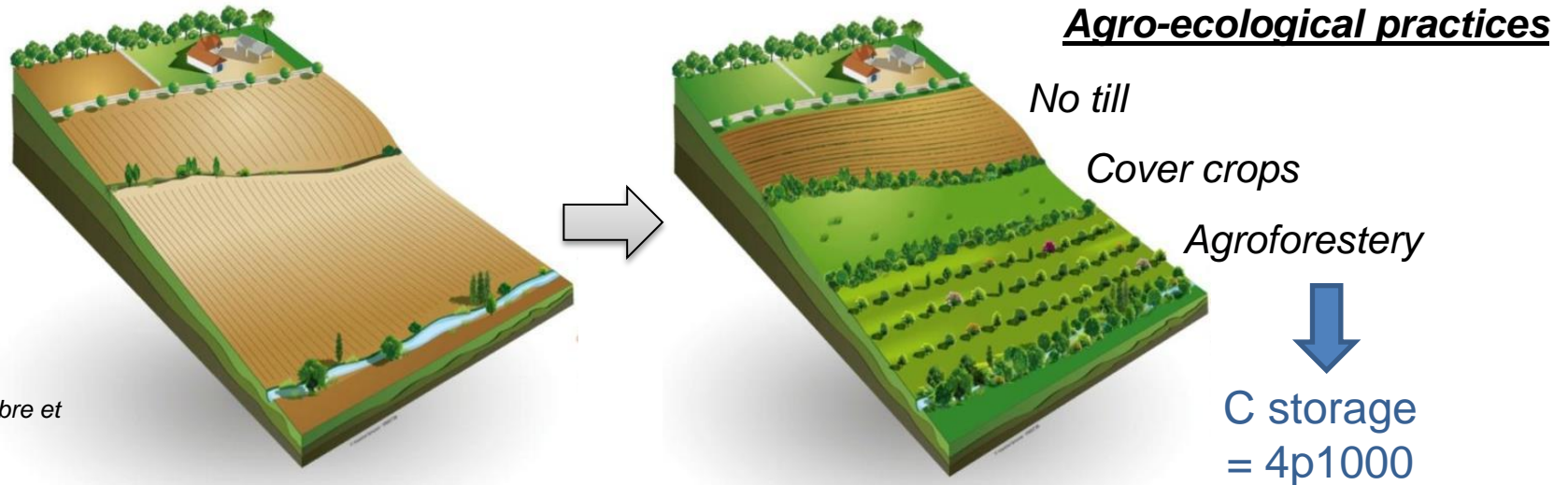


A strategy for estimating yield and the components of the carbon and water budgets for croplands at plot scale over large areas

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with contributions from A. Brut, T. Tallec, V. Demarez, O. Hagolle, H. Gibrin, B.
Zawilski, C. Marais-Sicre, N. Claverie, F. Granouillac.

Context/Societal challenges

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 ecosystem services → Biomass, Yield & C storage
- ✓ Quantify the impact of some management practices (changes in ecosystem services)

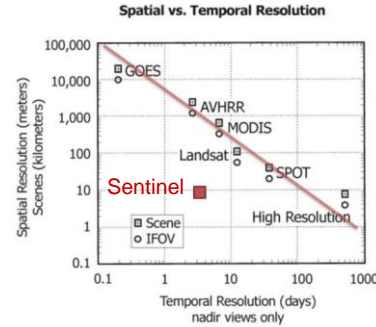
➔ **SAFYE-CO₂** : Simple Algorithm for Fluxes and Yield Estimates, (Veloso, 2014 ; Pique G. et al. in prep)

Why is it possible now ?



Sentinel 1
(10 m, 6j, Radar)

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



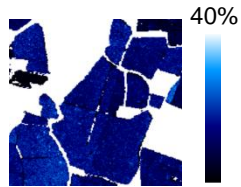
Sentinel 2
(10 m, 5j, Optical)



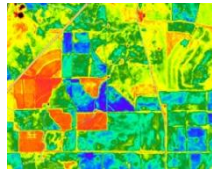
Clear or cloudy sky conditions
Rugosity & surface water content

Monitored
parameters

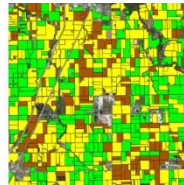
Clear sky conditions
Reflectances (13 bands)



Soil
humidity



Biomass

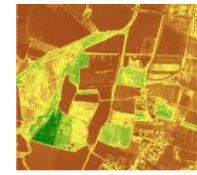


Soil work

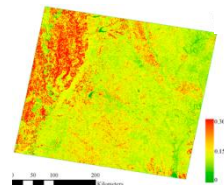
Dynamic mapping



Land cover



LAI/
phenology



Albedo

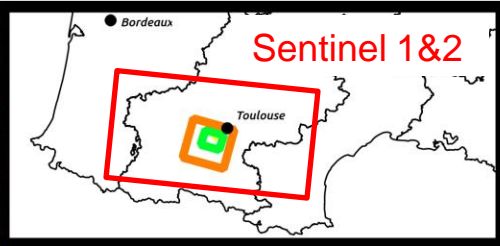
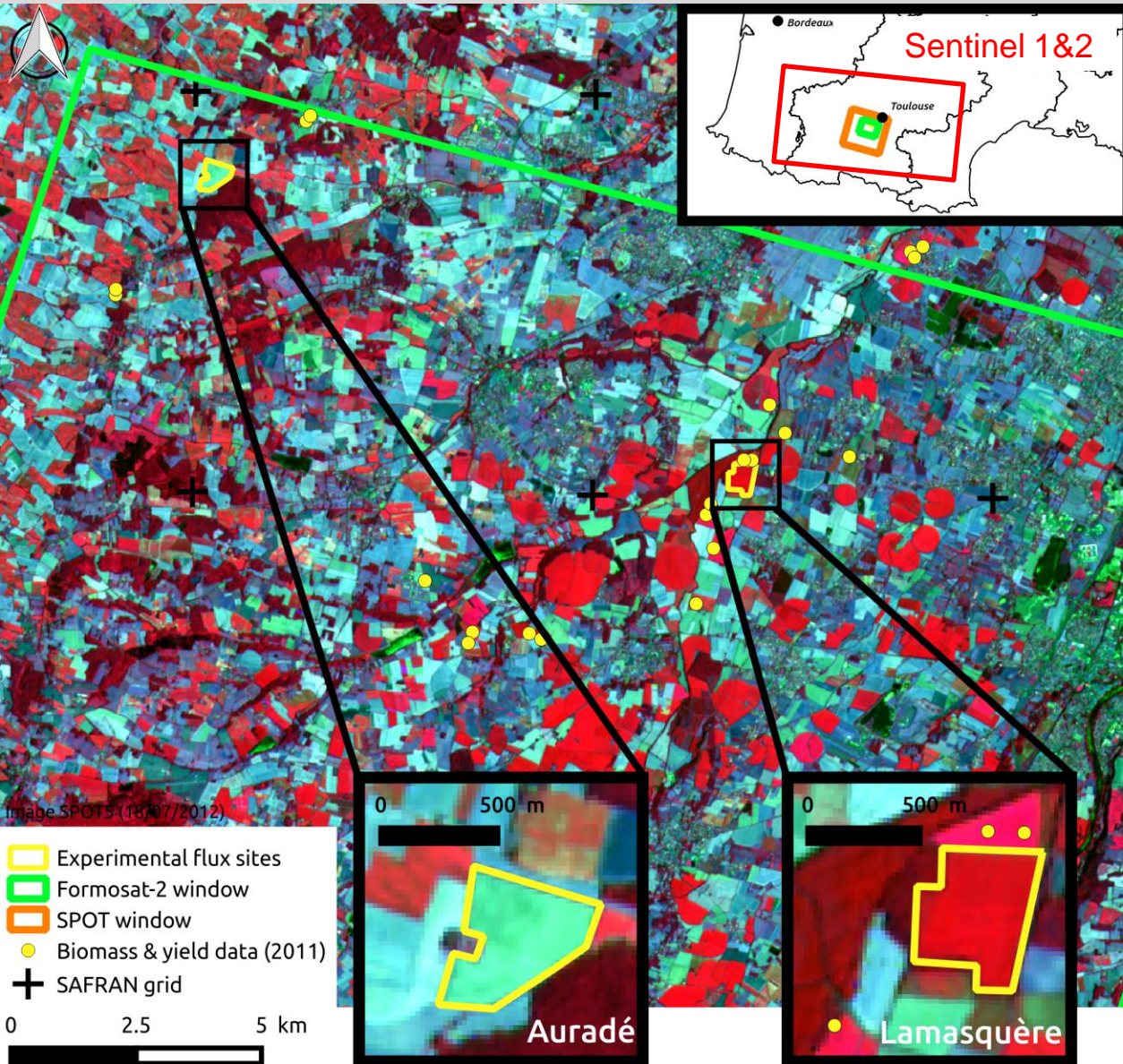
fusion



Land use dynamic mapping

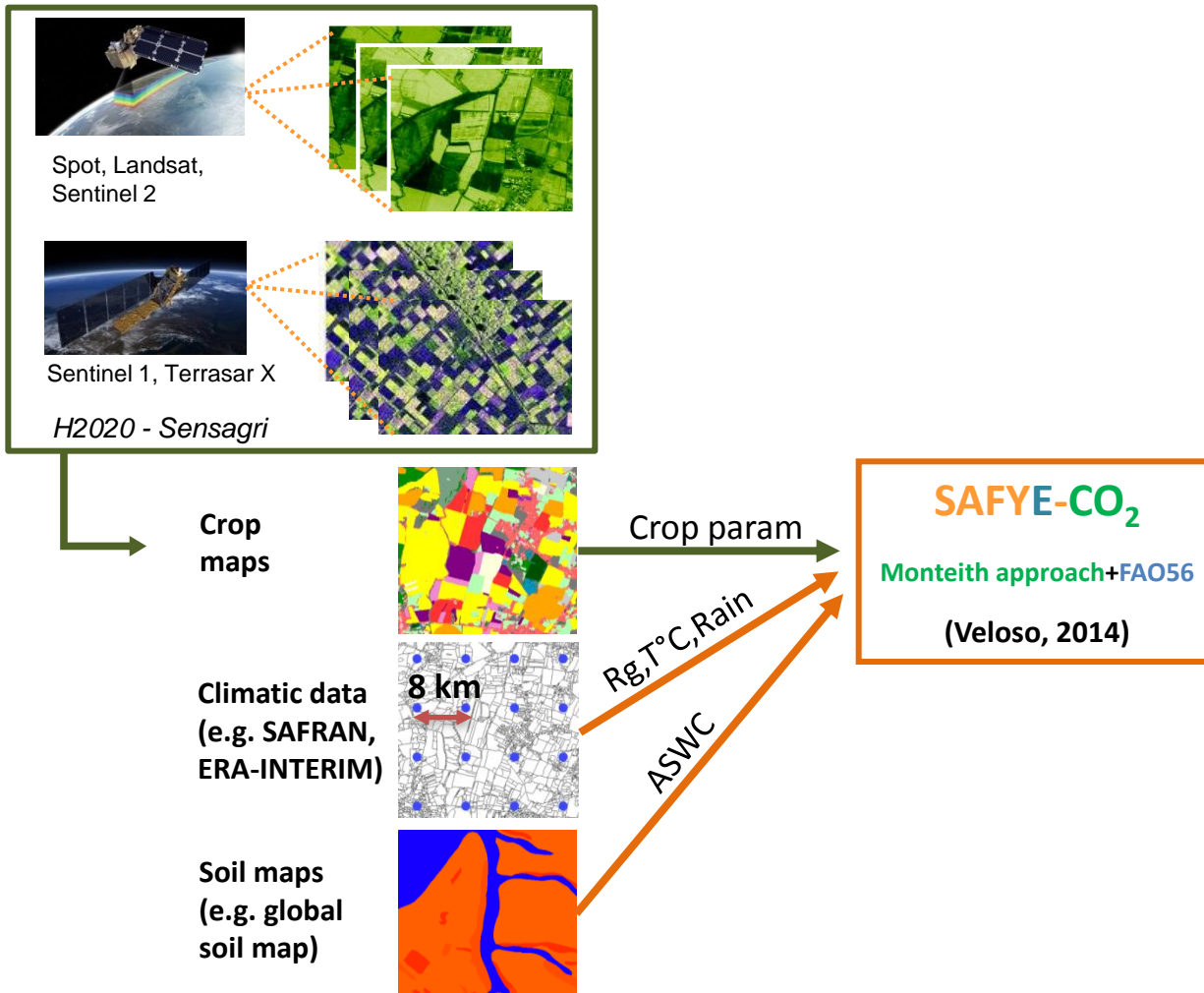
How to use those RS derived products to answer scientific and societal challenges related to agriculture ?

CESBIO The Spatial Regional Observatory (SRO)

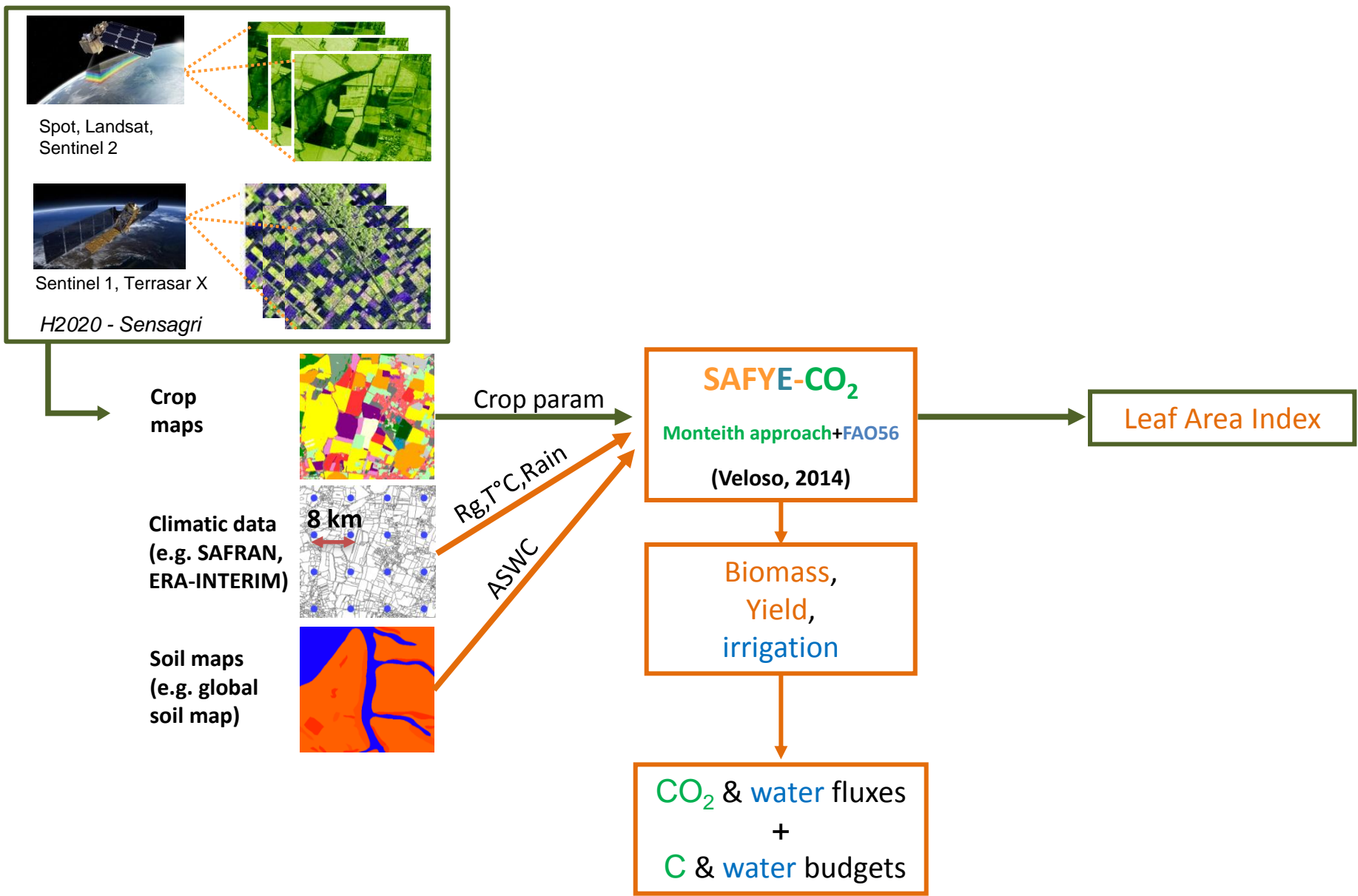


- Started in **2002**
- Part of **JECAM & ICOS** network
- Intensive **measurement campaign**
- Continuous **CO₂ & H₂O flux** acquisition since **2005**

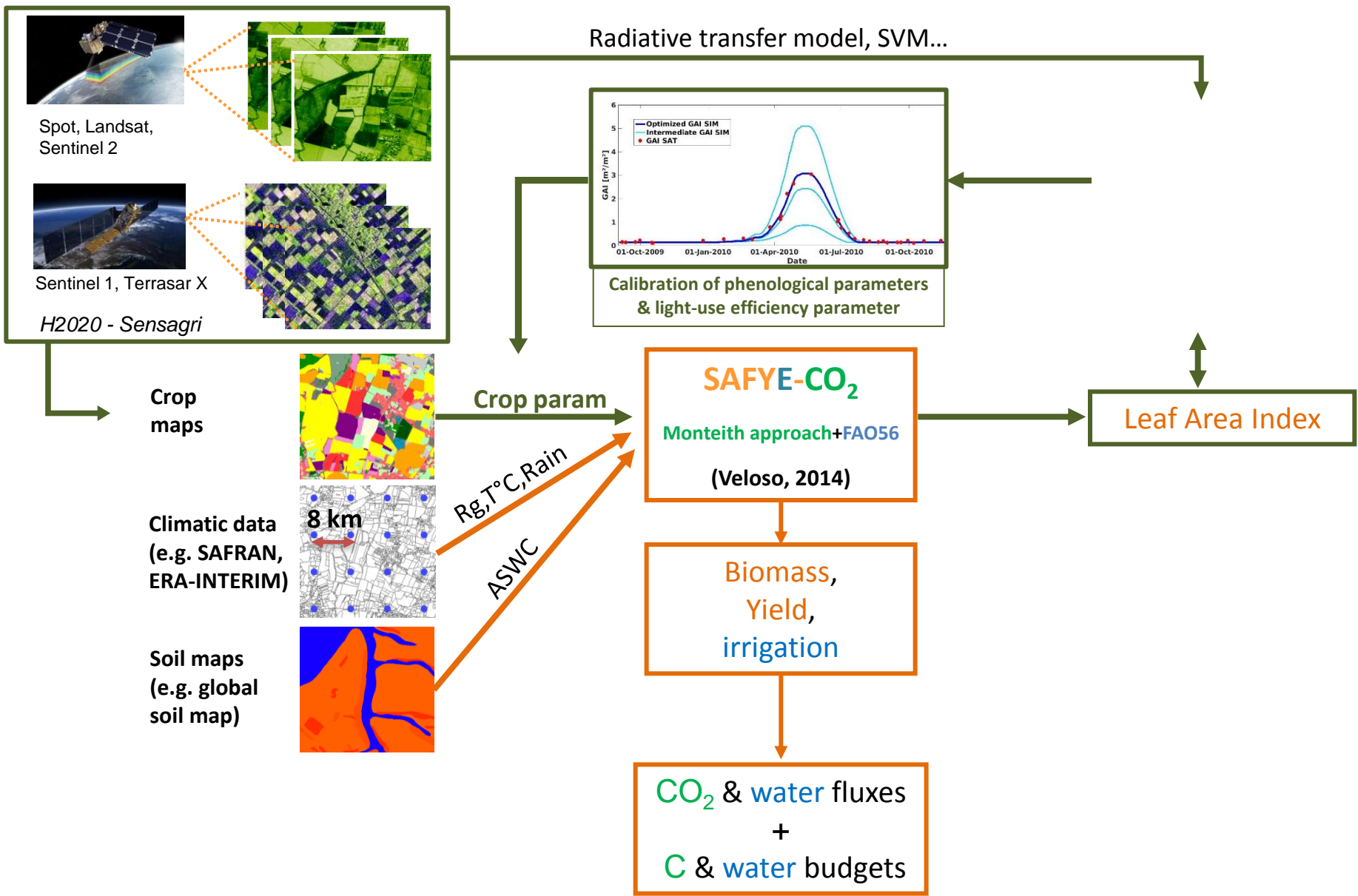
Modelling approach with SAFYE-CO₂



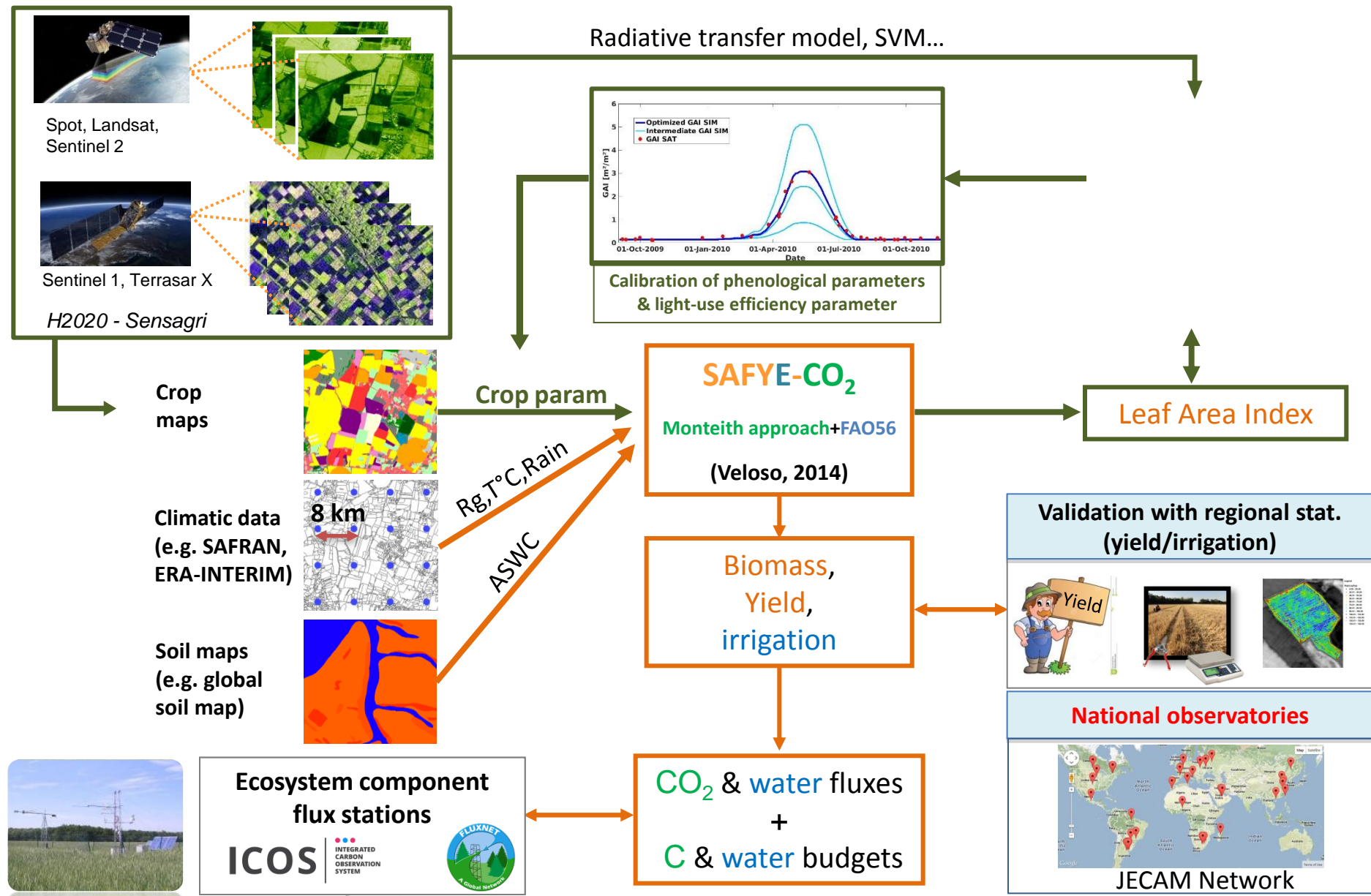
Modelling approach with SAFYE-CO₂



Modelling approach with SAFYE-CO₂

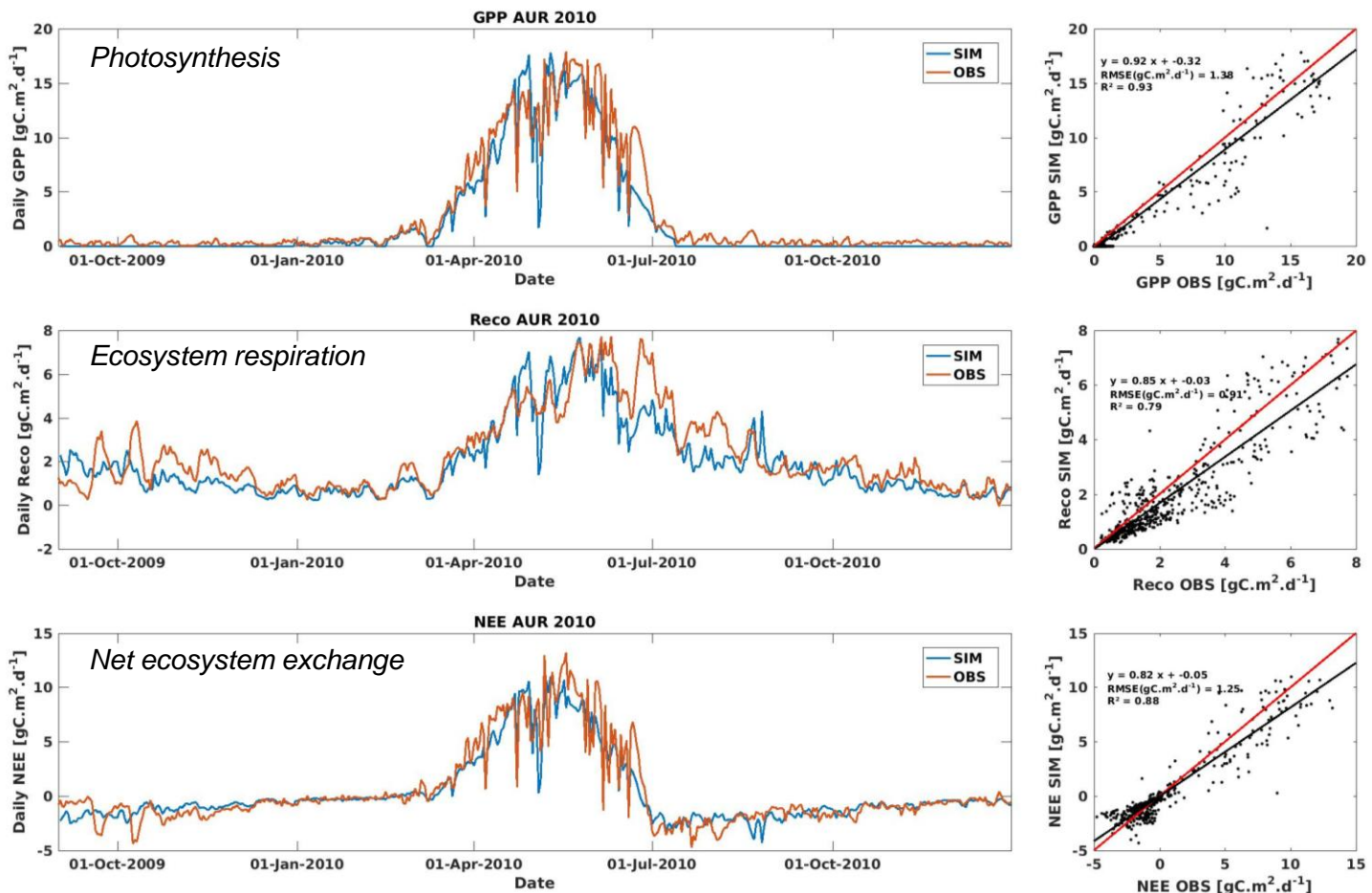


Modelling approach with SAFYE-CO₂



C flux dynamics at Auradé site in 2010

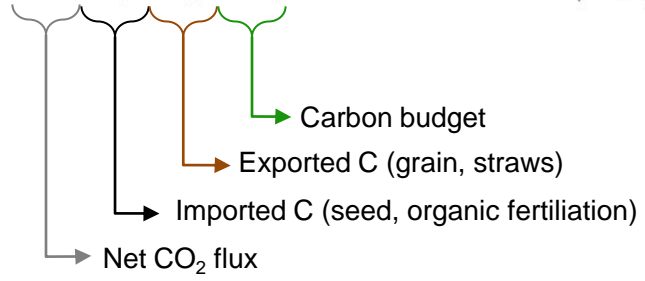
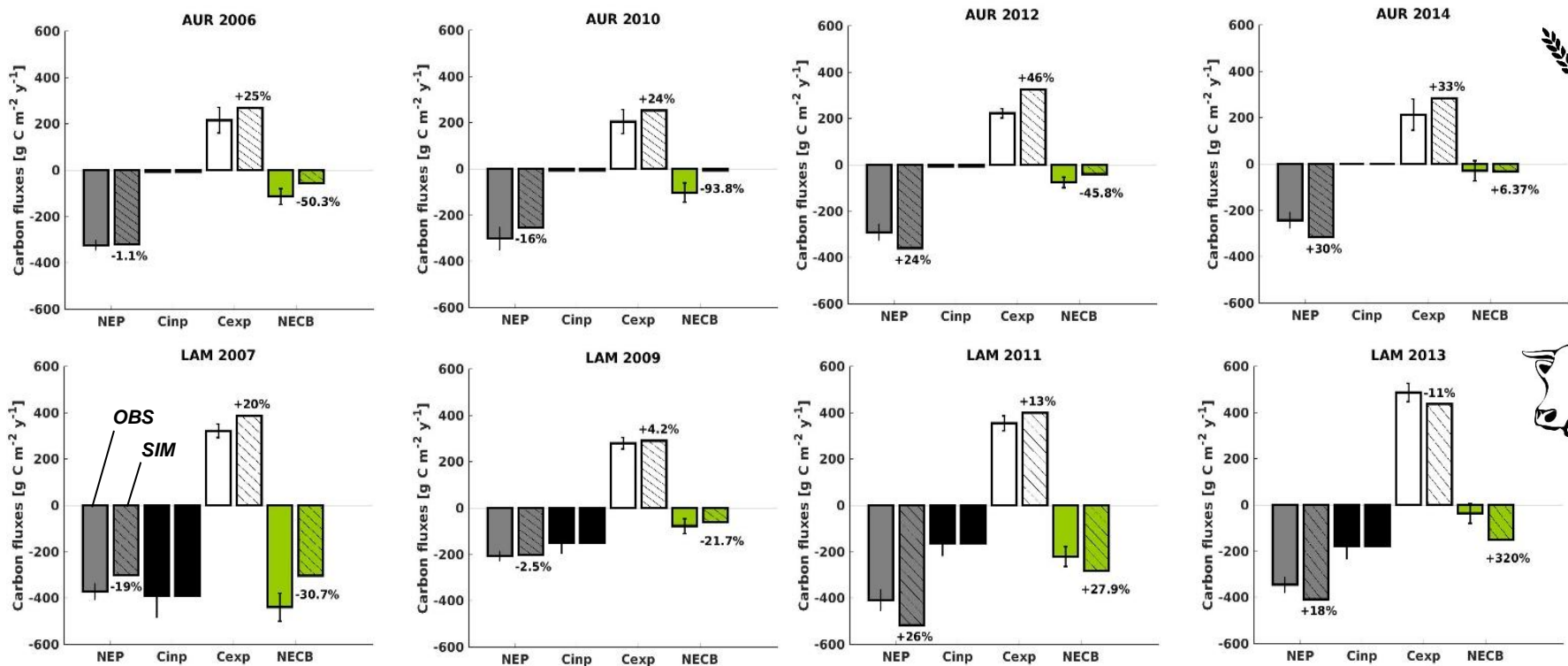
SAFYE-
CO₂



- 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

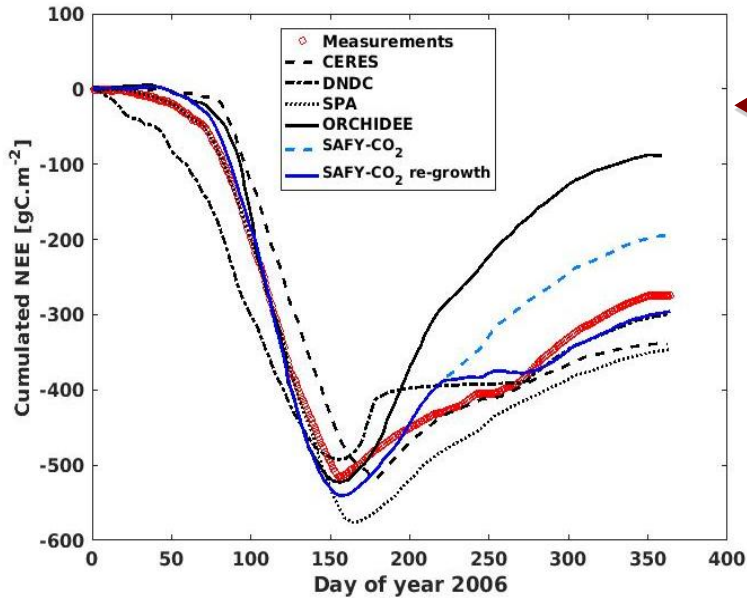
Annual carbon budgets over 8 winter wheat cropping years
Lamasquère & Auradé sites



- Δ Carbon budget $\in [1,8 ; 134,8]$ gC.m⁻².yr⁻¹
- RMSE = 77 gC.m⁻².yr⁻¹
- Uncertainties on Cexp
- Estimation of soil C variation

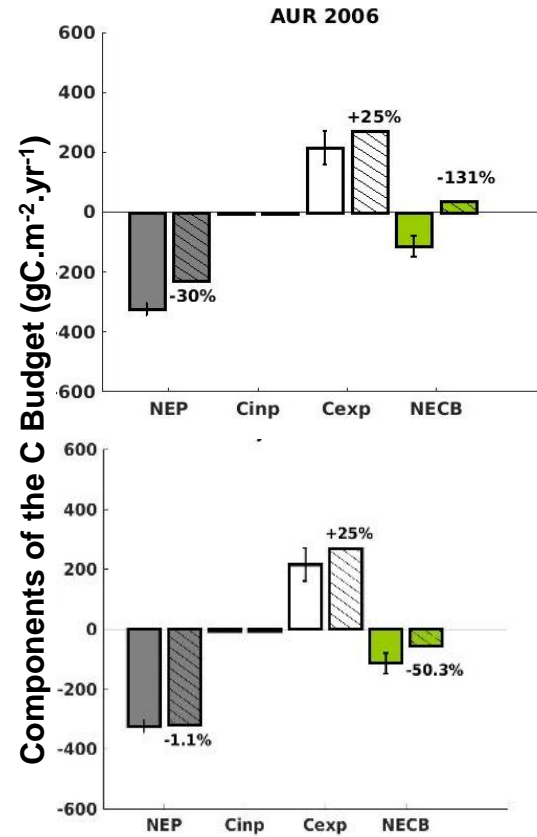
Performances/Originality of our approach

With and without accounting for regrowth events



Wattenbach et al. (2010)
Pique et al. (under review)

Observations
VS
Simulations



No accounting for regrowth, cover crops or weeds

Accounting for regrowth, cover crops, weeds from remote sensing



Very good performance of this simple modelling approach that does not require data on management (fertilisation, sowing date..) compared to other models.

Shows the power of remote sensing for constraining this crop model

Limits of the approach

- Diagnostic approach : **but some scenarii can be tested**
- Need for a SOC evolution model for crop rotations
- 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 at other ICOS crop sites
- Needs to calibrate the model for several crop in order to simulate crop rotation
- Research tool that needs improvements before it can be used in operational mode for mapping ecosystem services.



Thanks for your attention and thanks to our financers

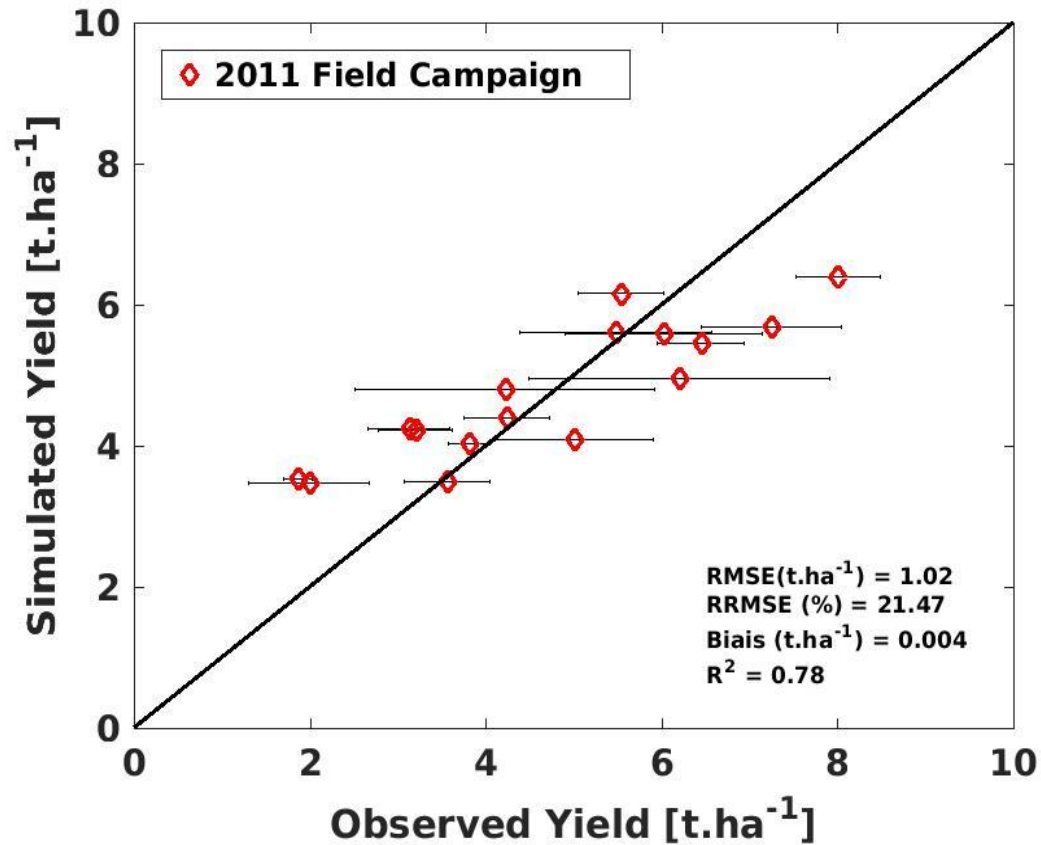


If you want to have more details concerning our work please contact me at :
piqueg@cesbio.cnes.fr

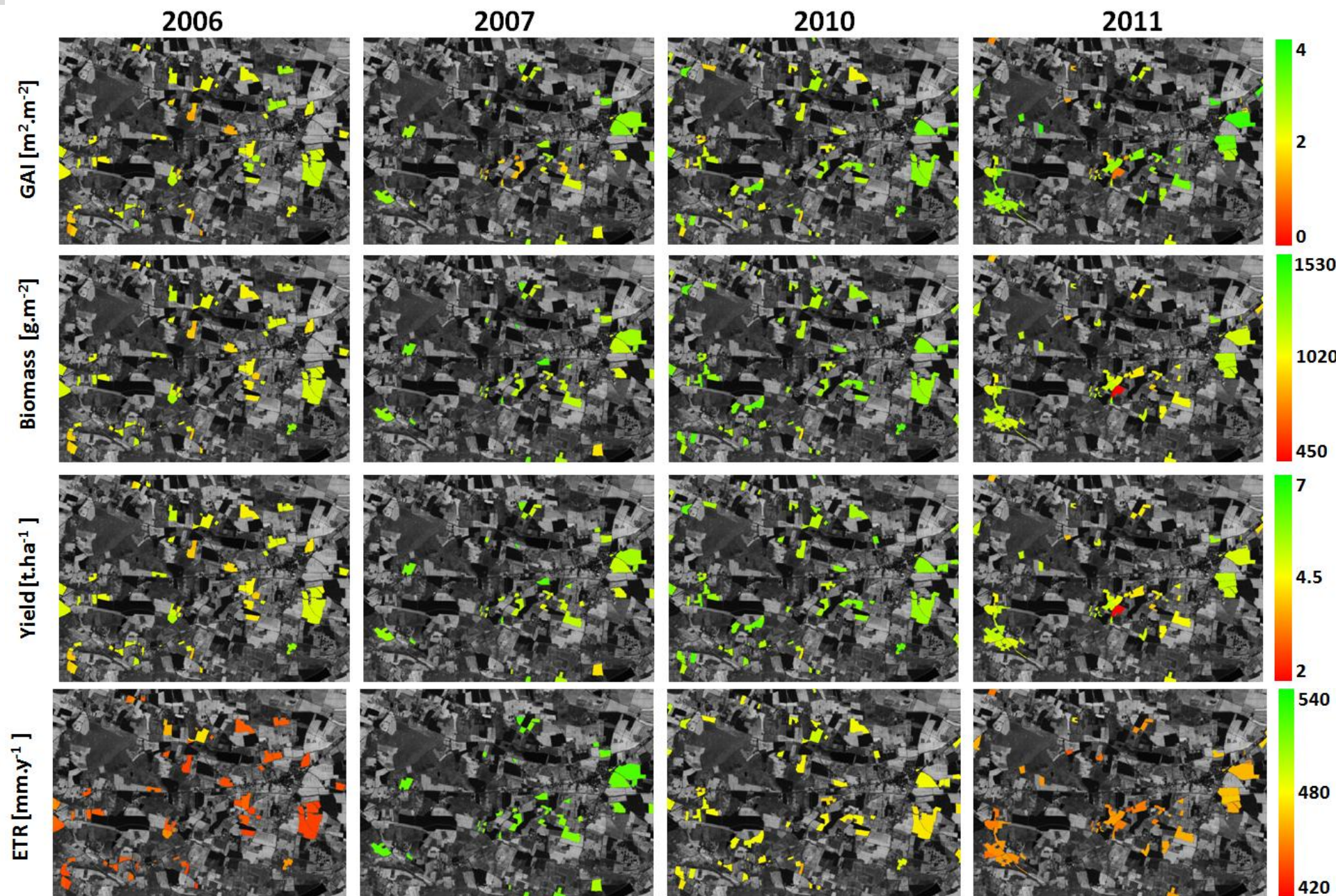
For complete description of the model see : http://www.cesbio.ups-tlse.fr/data_all/theses/Th_Veloso_2014.pdf

Supplementary materials

- Field campaign 2011 : 21 points, 16 fields
- Good estimations of yield

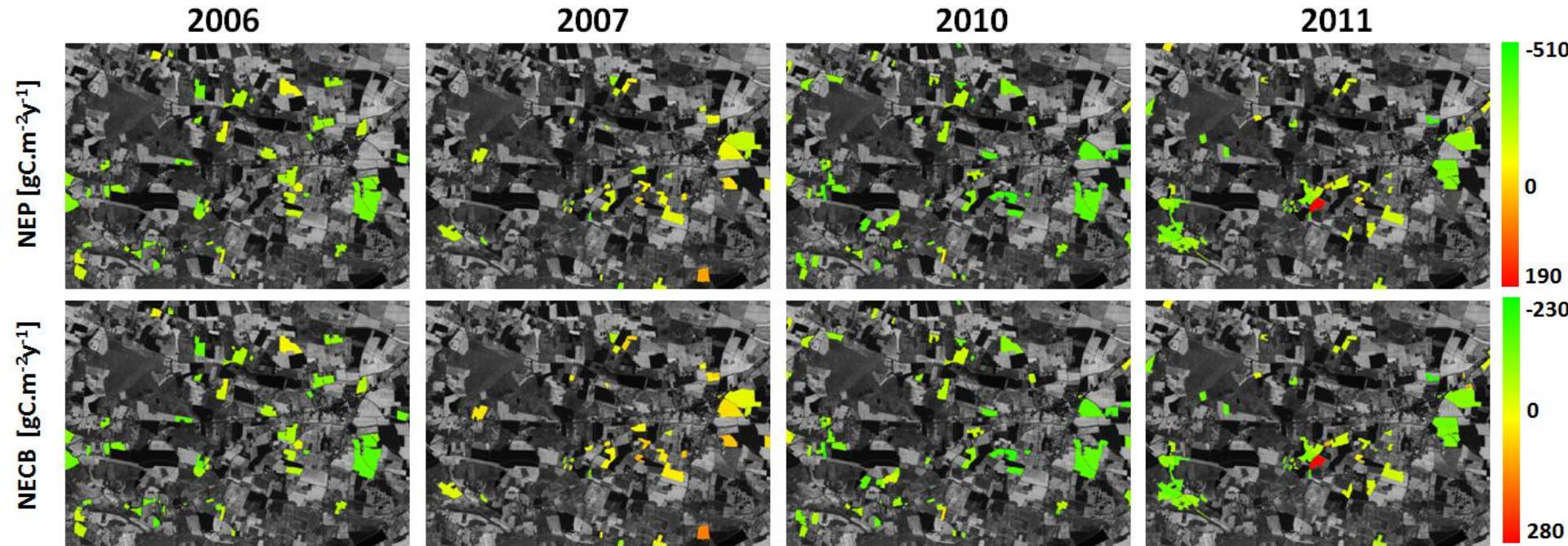


Supplementary materials



Supplementary materials

Net CO₂ fluxes (NEP) & C budget (NECB)

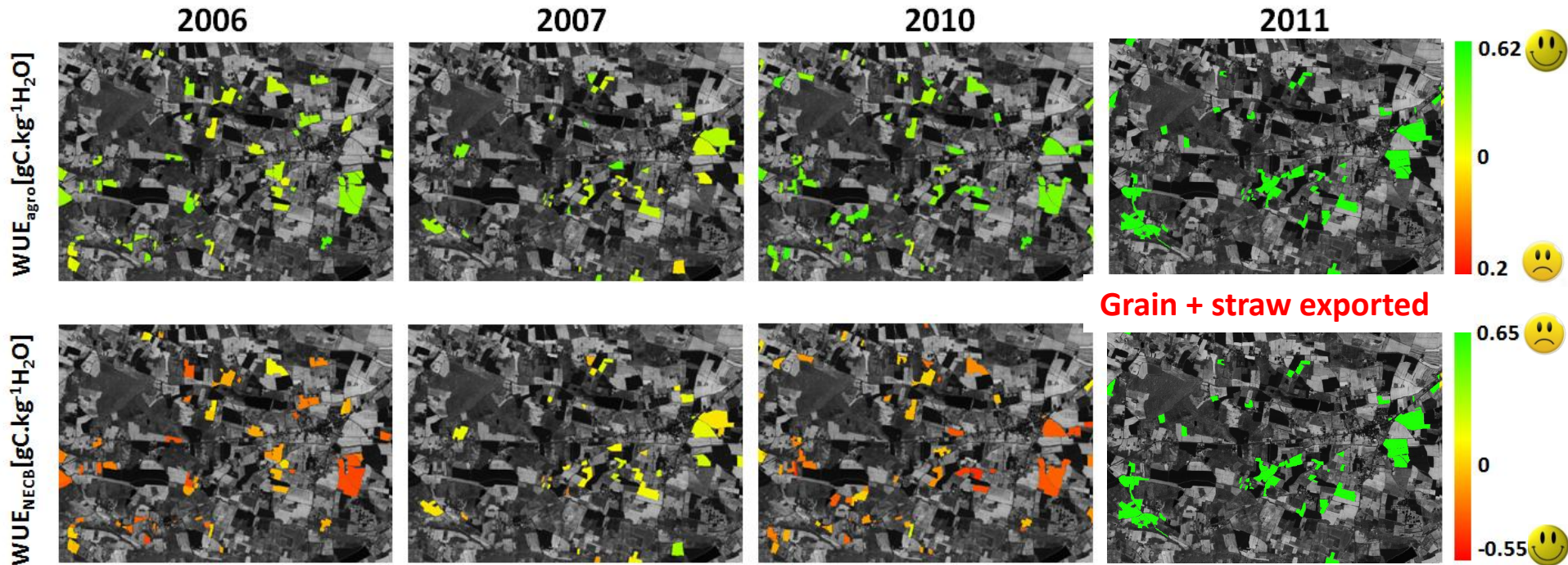


Supplementary materials

$$WUE_{\text{agronomical}} = \text{yield or biomass exported} / \text{ETR}$$
$$WUE_{\text{environnemental}} = \text{C budget} / \text{ETR}$$

Tallec et al (2013)
in AFM

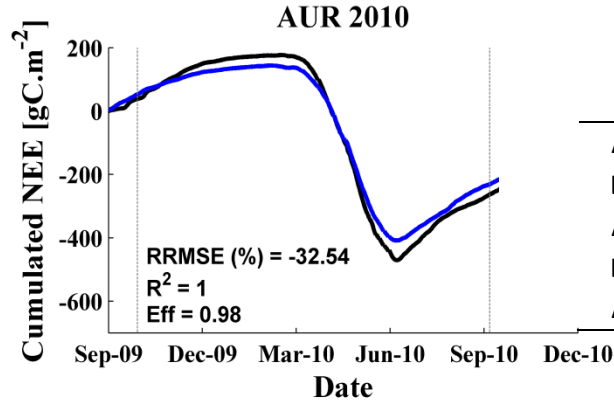
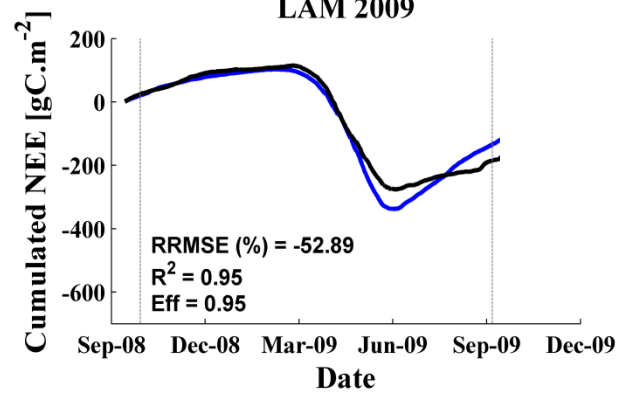
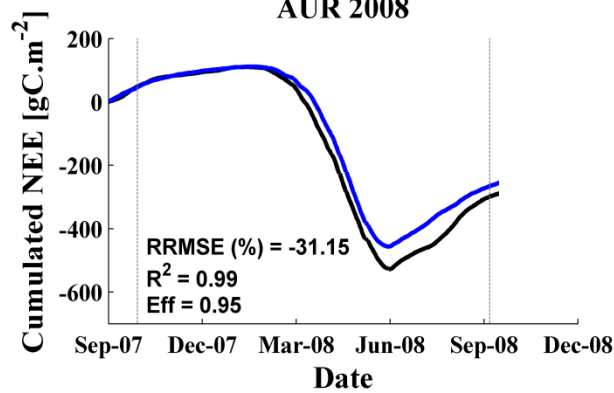
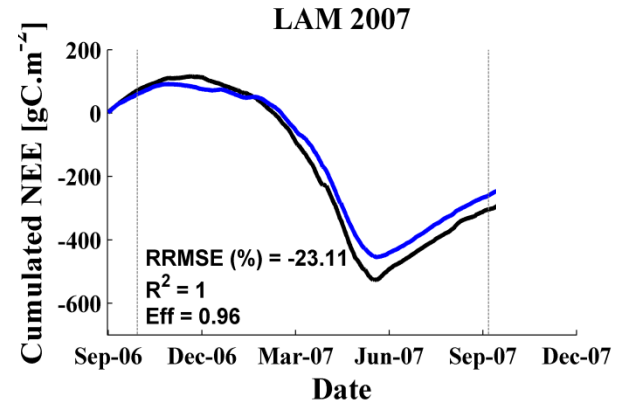
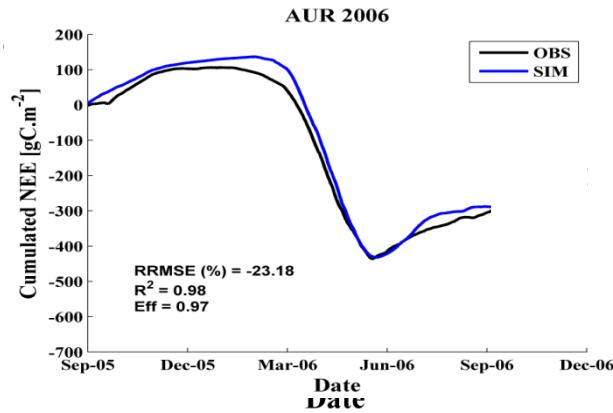
SAFYE-
CO₂



Usefull approach to find compromises between productive and environmental ecosystem services.

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

