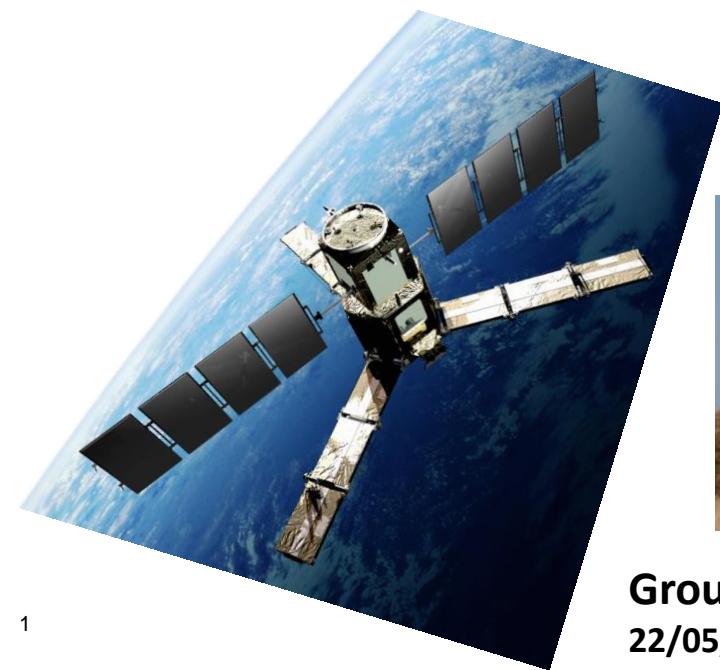


LES ACTIVITÉS EN OBSERVATION DE LA TERRE AU CESBIO ET LE LIEN AVEC LES UTILISATEURS

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CESBIO/CNES

gerard.dedieu@cesbio.cnes.fr

<http://www.cesbio.ups-tlse.fr/>



Groupe de Travail en Observation de la Terre, Jambes, Belgique
22/05/2018

CESBIO SUMMARY



- Joint public research laboratory of Toulouse III University, CNES, CNRS, IRD, + INRA. Personnel from the 5 organizations



◆ Established in 1995 to bring together scientists from the Earth's surface (ecophysiology, agronomy, hydrology) and experts in remote sensing



◆ Staff : 120 persons, 34 scientists, 28 engineers & technicians, 58 PhD- Postdocs-contract workers



◆ Main location : Toulouse. Secondary establishments in Auch, Marrakech, Tunis and Beirut



◆ Research objective : Contribute to the advancement of knowledge on the functioning of land surfaces and their interactions with climate and human activities, relying heavily on satellite data, field data and modeling



Equipes, chantiers et axes prioritaires :

Equipe 1 Modélisation du fonctionnement et télédétection des surfaces continentales	Equipe 2 « Systèmes d'observation » : vers des stratégies d'observations permettant de rendre compte de la complexité des surfaces	Conception Capitalisation des savoirs
Chantiers		
(Sud-Ouest) Fonctionnement des surfaces et gestion durable des territoires	(Sud-Med) Modélisation et données multi- sources pour la gestion des eaux en zone aride	Application des savoirs Acquisition de données
Axes prioritaires		
<ol style="list-style-type: none"> 1. Missions spatiales (SMOS, VENµS, Biomass, VGT 3, GMES) 2. Modélisation intégrée 3D (DART, SEVE) 3. Observatoire Spatial Régional (OSR, SIE, Démonstrateurs) 		

MISSIONS DUCESBIO

□ Recherche fondamentale sur le fonctionnement des surfaces continentales

- ◆ Evolution de l'occupation des terres, diagnostic et modélisation des flux et bilan d'eau, de carbone, d'énergie
- ◆ De la parcelle à la planète

□ Enseignement

- ◆ Master Aménagement du Territoire et Télédétection
- ◆ Ecole doctorale Sciences de l'Univers de l'Espace et de l'Environnement (SDU2E)

□ Recherche pour le Développement

- ◆ Laboratoires mixtes internationaux TREMA (Maroc), Naïla (Tunisie), CEFIRSE (Inde)
- ◆ Recherche en partenariat avec des pays du Sud

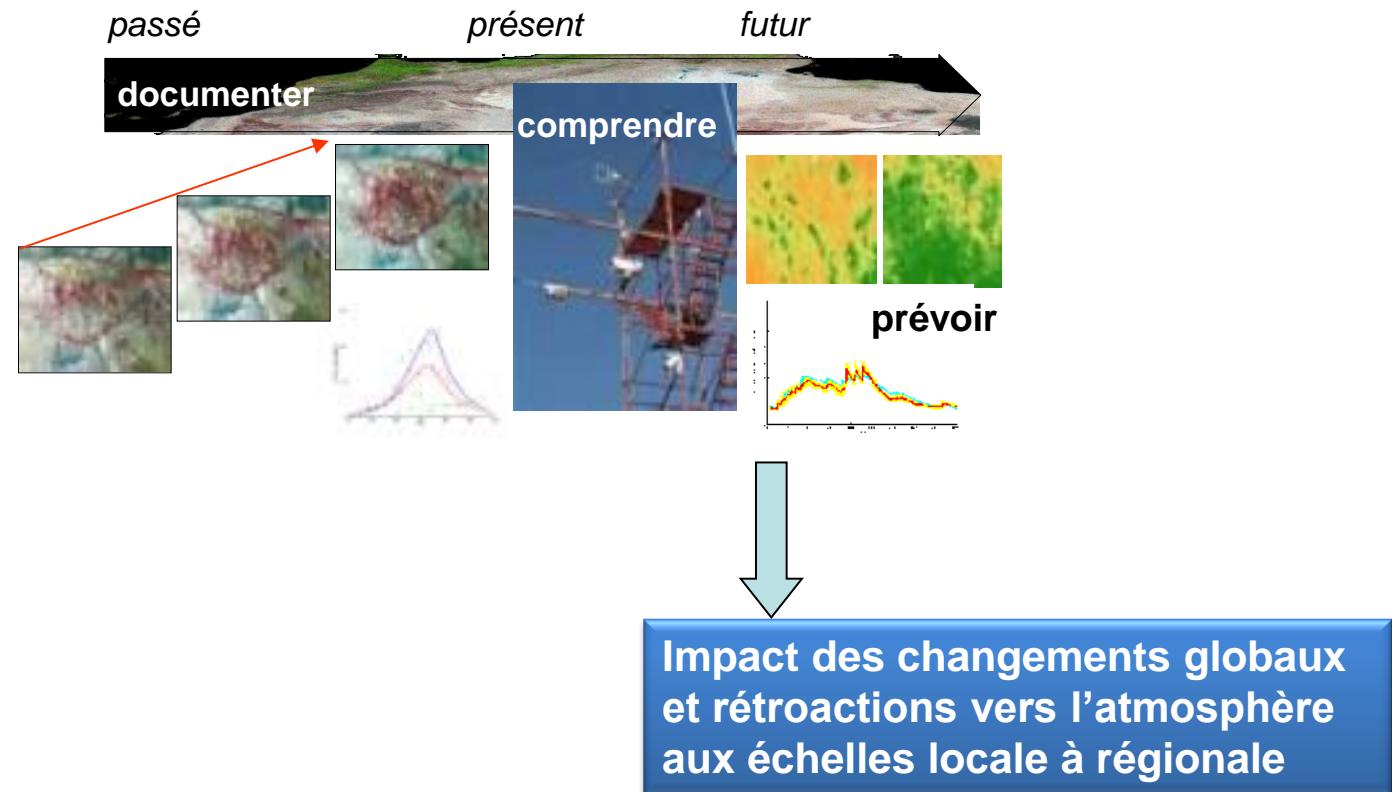
□ Télédétection spatiale

- ◆ Conception et préparation de nouvelles missions spatiales pour l'observation de la Terre.
- ◆ Valorisation des données : prétraitements, chaînes d'exploitation, valorisation thématique
- ◆ Collaborations CNES, ESA, ISA, ISRO, JAXA, NASA,

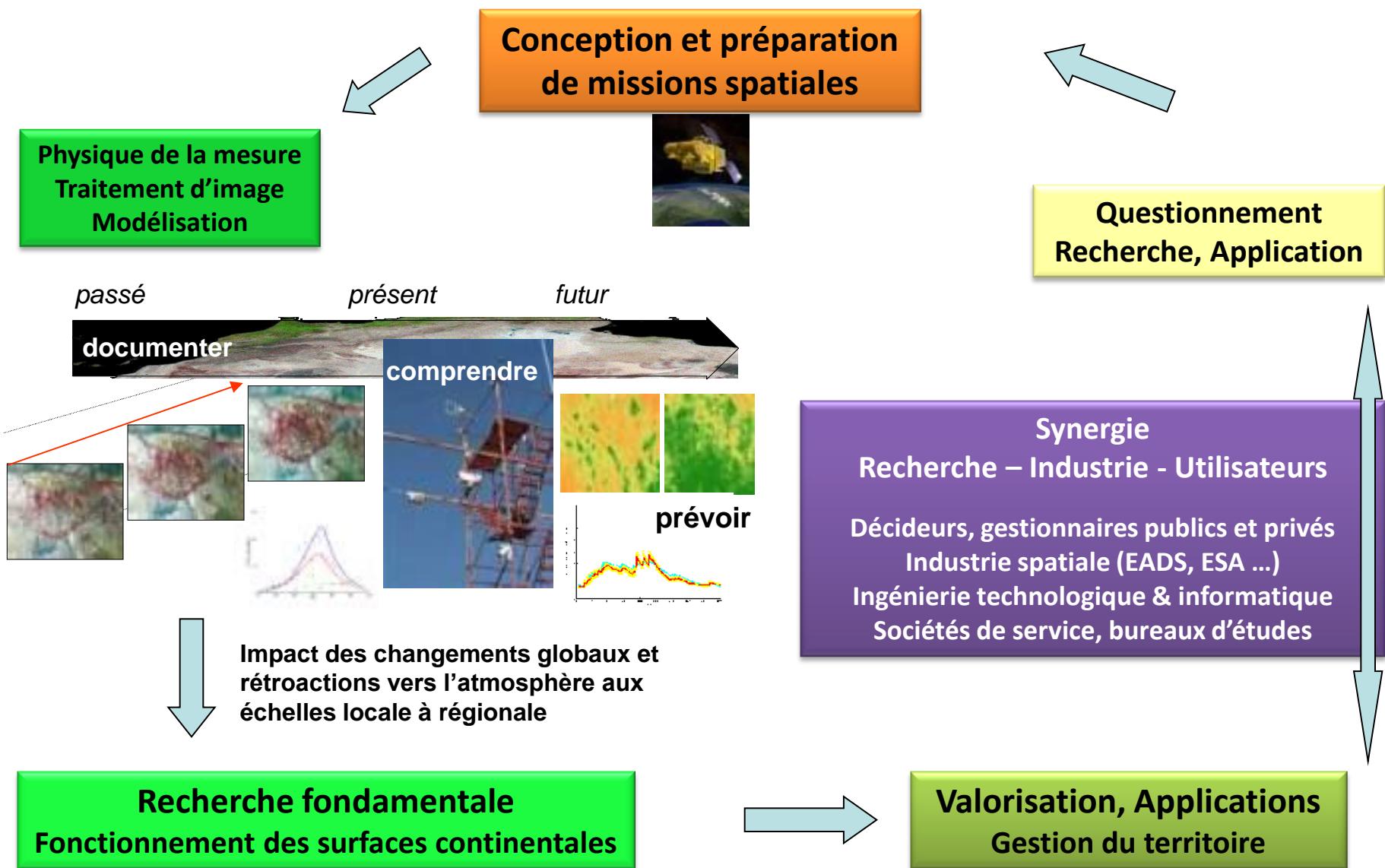
□ Valorisation des savoir-faire

- ◆ Projets collaboratifs, participation aux unités mixte technologiques « Tournesol » et « Eau », ...

Recherche fondamentale Fonctionnement des surfaces continentales



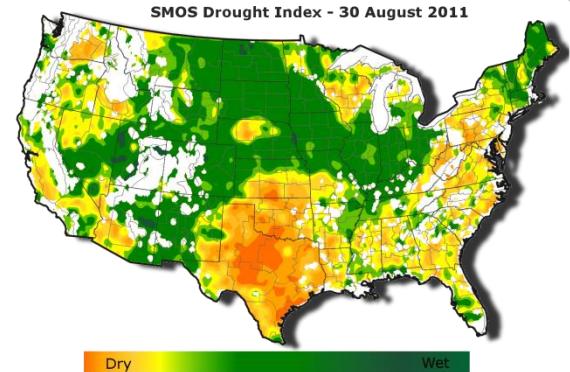
Le Centre d'Etudes Spatiales de la Biosphère



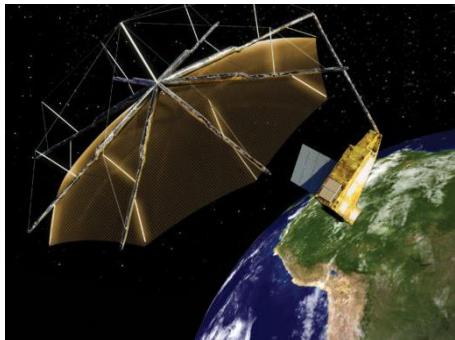
EO MISSIONS WITH CESBIO'S PI



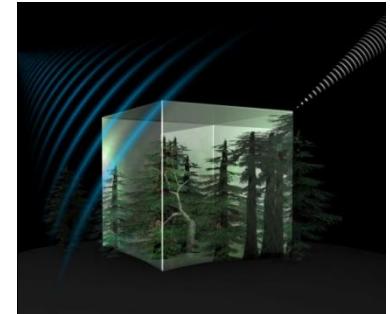
SMOS : Soil moisture and Ocean Salinity.
Launched 2009
ESA-CNES
Passive microwave radiometer.
PI : Yann Kerr (CNES)



Venüs: Vegetation and Environment monitoring
on a New Microsatellite. Launched 2017
CNES-ISA
Imaging radiometer (blue-NIR), revisit 2 days,
resolution 5m
PI : Gérard Dedieu (CNES)



BIOMASS (2021):
ESA-CNES
P band radar, resolution 50 m
PI : Thuy Le Toan (CNRS)

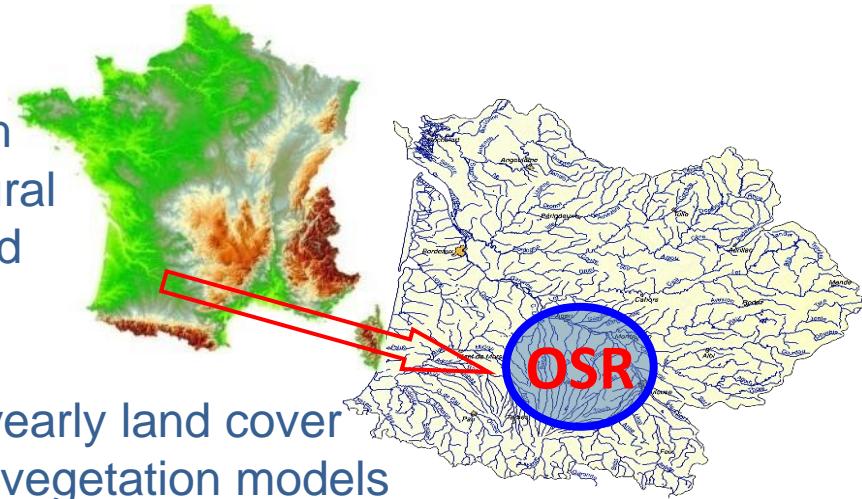


A STRUCTURING TOOL: THE REGIONAL SPACE OBSERVATORY

Observatoire Spatial Régional



- Started in 2001, certified as one of the INSU National Observation Services in 2007
- Initial objectives, over 3000 km²:
 - ◆ Long term observatory for Research on land surface functioning in agricultural landscapes (e.g. water, CO₂ fluxes and budget) under climate and human pressures
 - ◆ Satellite remote sensing methods: yearly land cover and crop mapping, assimilation within vegetation models for spatialization
 - ◆ Earth observation missions: preparation of new missions, calibration/validation, (pre)processing methods
 - ◆ Support for academic training
- Combination of intensive micro-meteorological measurements, surveys and remote sensing fully running since 2004



Lewis Radiometer (SMOS)

Two parcels

More than 135 variables measured continuously : ICOS

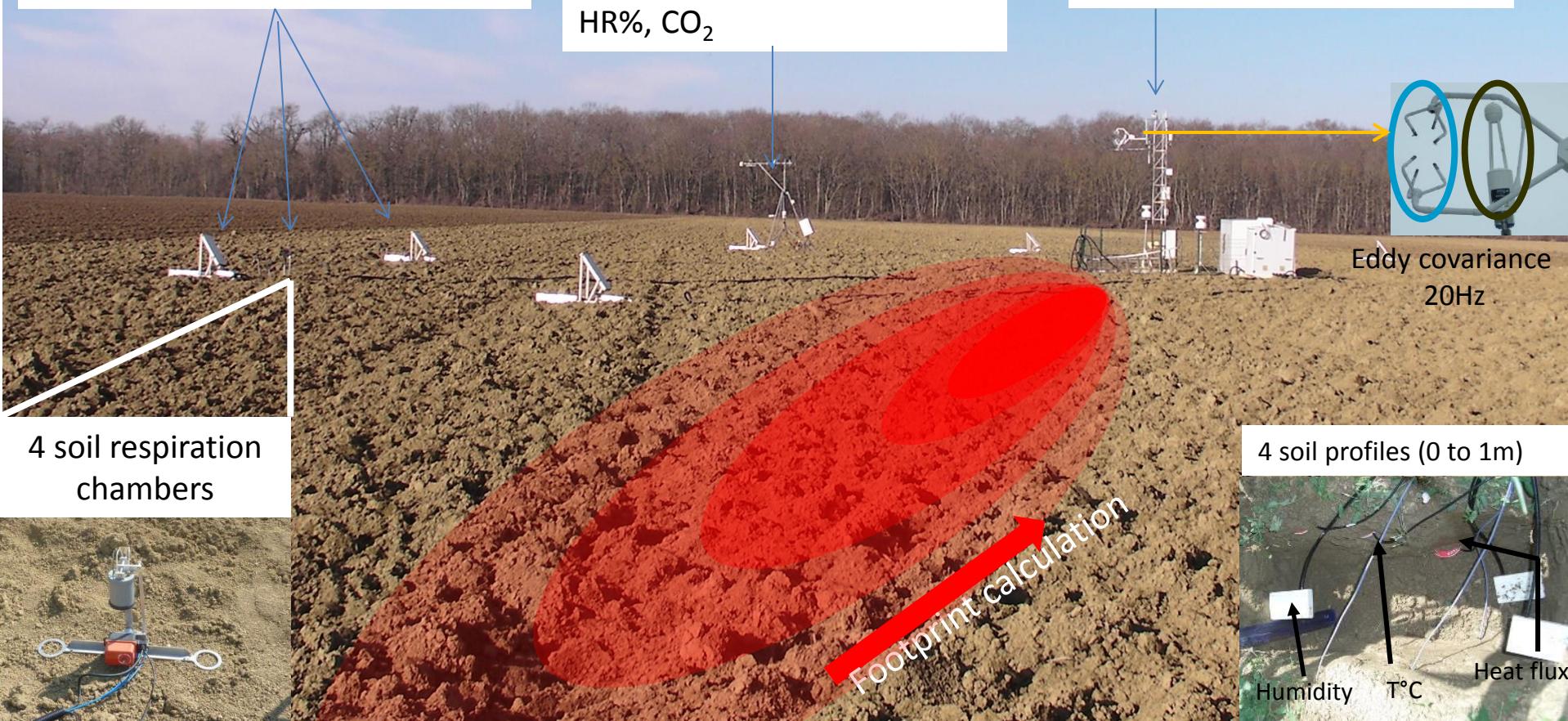


Lamasquère site

6 Automatic chambers for CO₂, N₂O

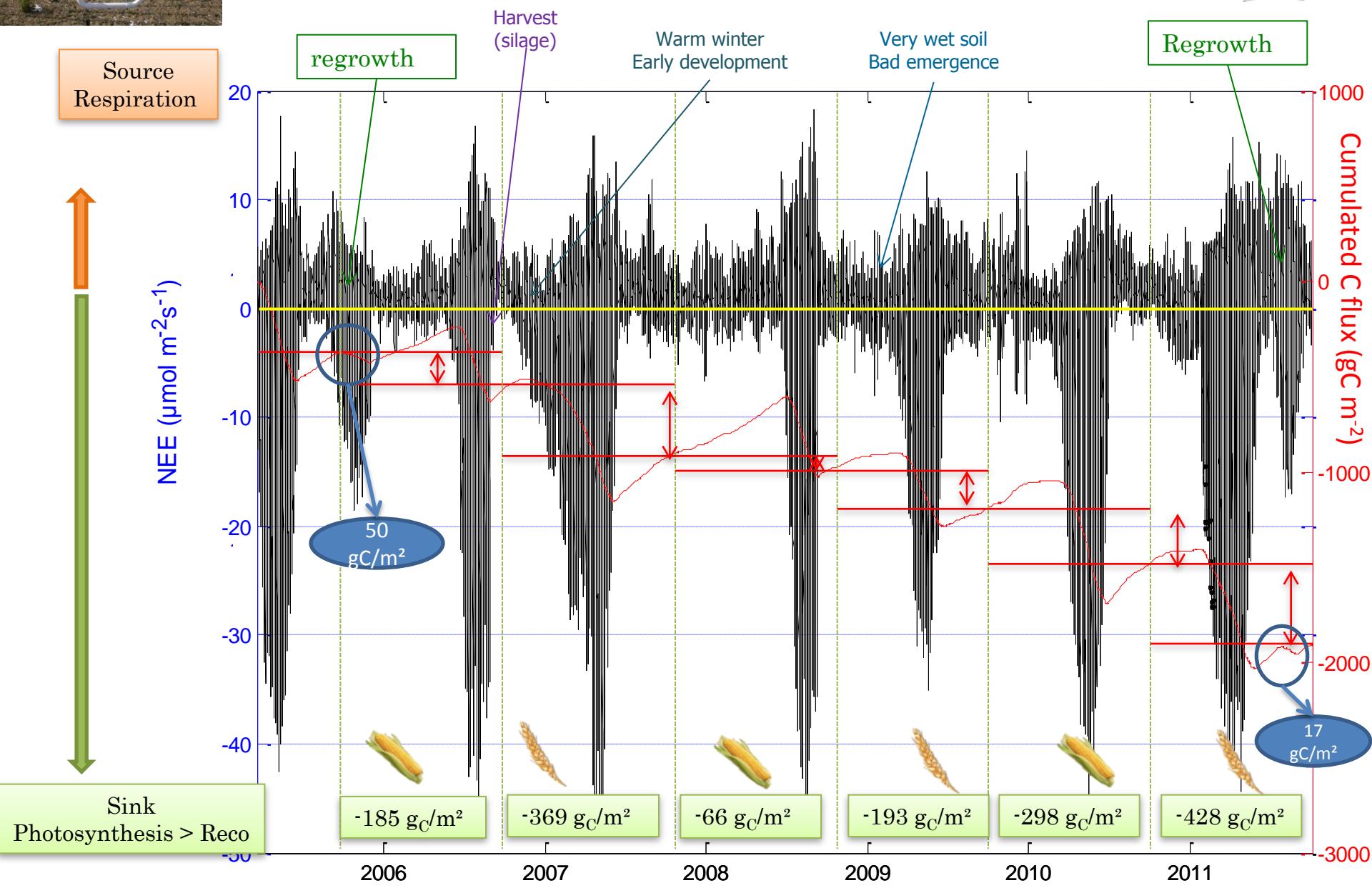
Radiation (albedo...) and vertical profiles of wind, T°C, HR%, CO₂

μmeteo variables (air/soil) + CO₂, LE, H fluxes





Analysis of net CO₂ fluxes at Lamasquère (2005 - 2011)





« MedMex » : Tensift's observatory

Functioning and hydro-ecological resources in semi-arid regions



Tensift Basin (central Morocco)

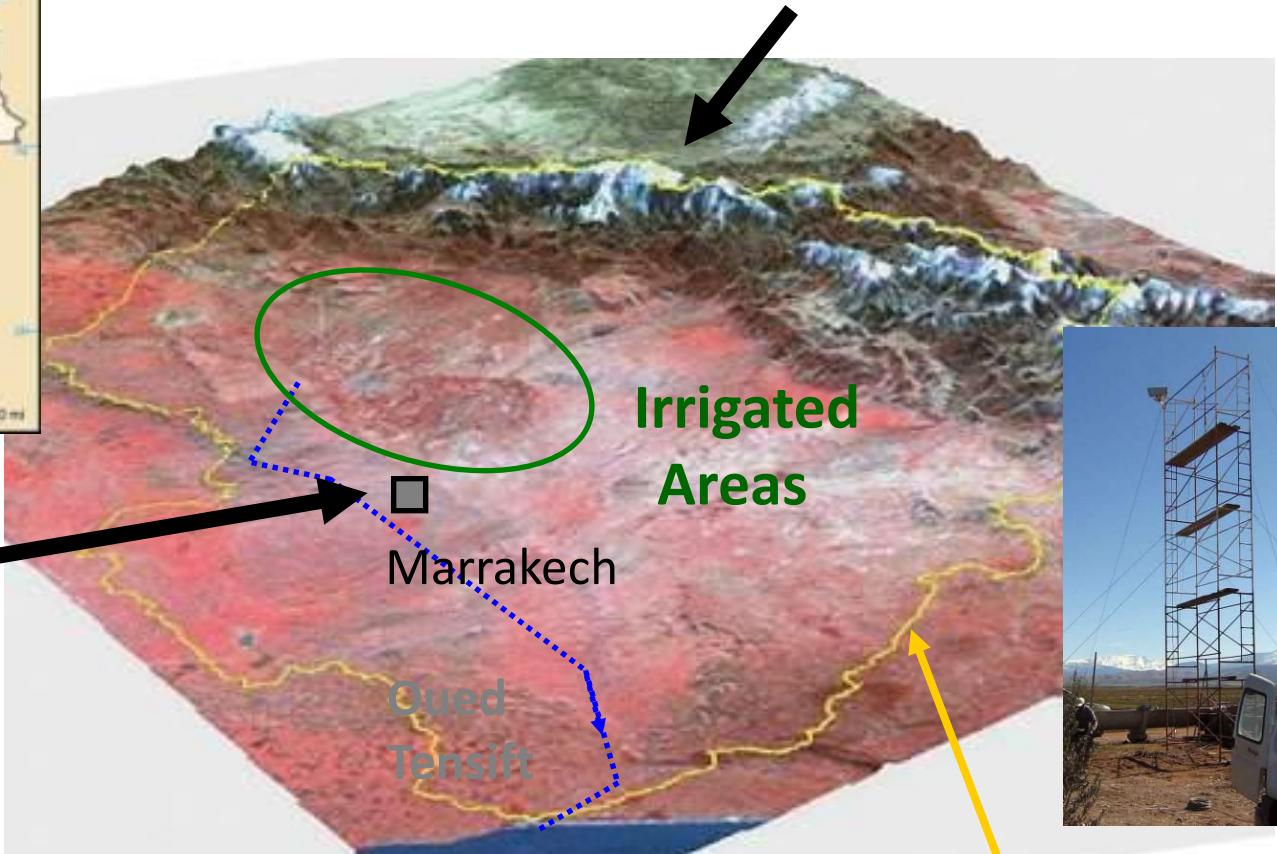
Arid Plain

Rainfall ~ 240 mm/y

PET ~ 1400 mm/y

Agriculture Uses 85% of Available Water

High Atlas Mountains up to 4200 m above sea, up to 600 mm/y precipitation



Limits of Tensift water catchment ($20,000 \text{ km}^2$)

Merguellil JECAM site (Tunisia)

CESBIO, INAT

Team: R. Amri, G. Boulet, M. Le Page, Z. Lili-Chabaane, B. Mougenot, V. Simonneaux, M. Zribi

Site description

The Kairouan plain (300 Km²) is located in the centre of Tunisia (North Africa). The site is mostly flat.

Climate: semi-arid with limited water resources

Temperature: average 19.2 °C

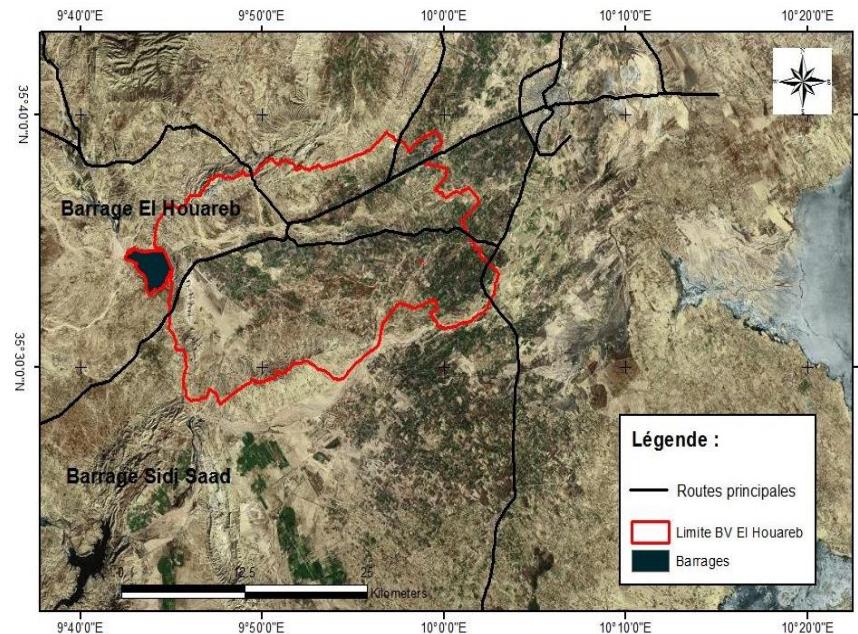
Rainfall: 300mm/y with high variability in time and space

Potential evapotranspiration (Penman-Monteith): 1600mm/year.

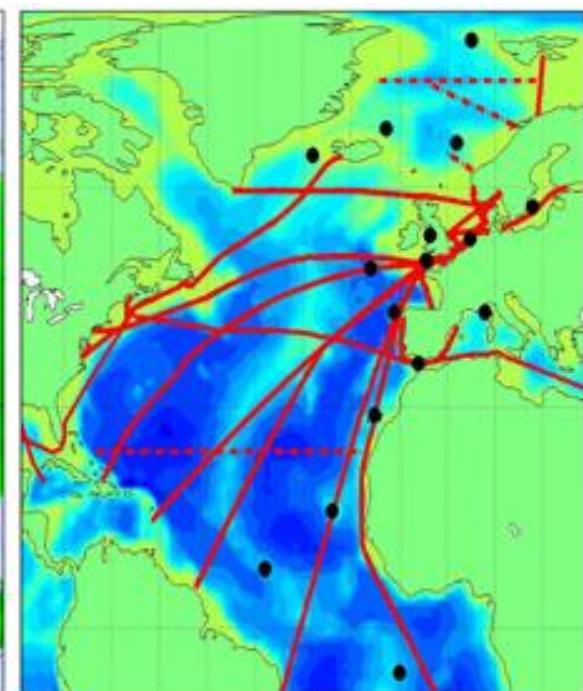
Soil texture: sandy soil mostly

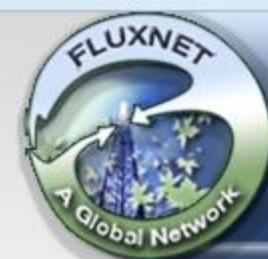
Field size: from 0.5 to 5 ha

Crops: cereals (wheat, barley), olive groves (irrigated and rainfed), vegetables (winter, summer).



Réseaux d'observation des concentrations et flux de carbone/GES

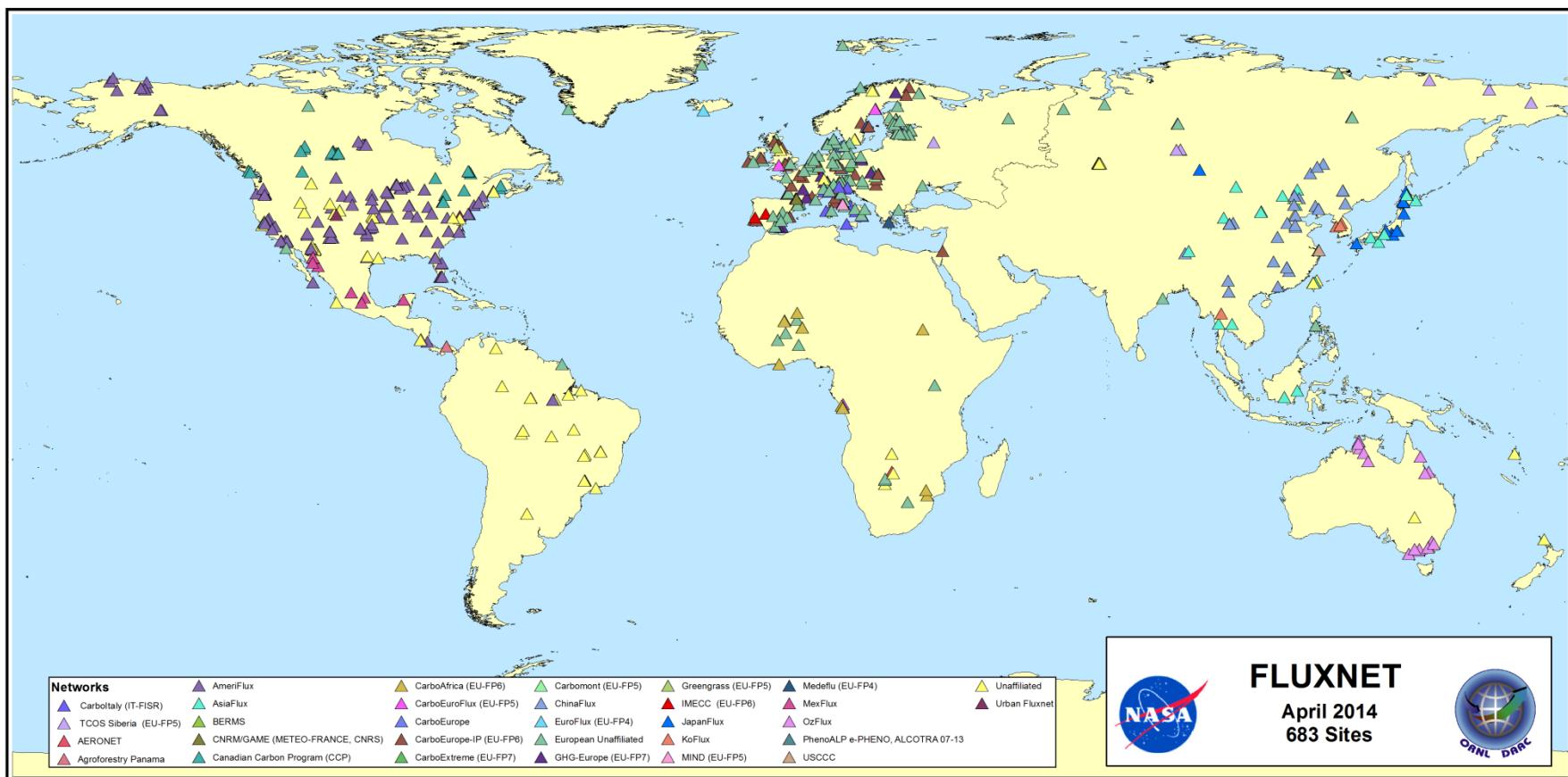




Integrating
Worldwide CO₂,
Water and Energy
Flux Measurements



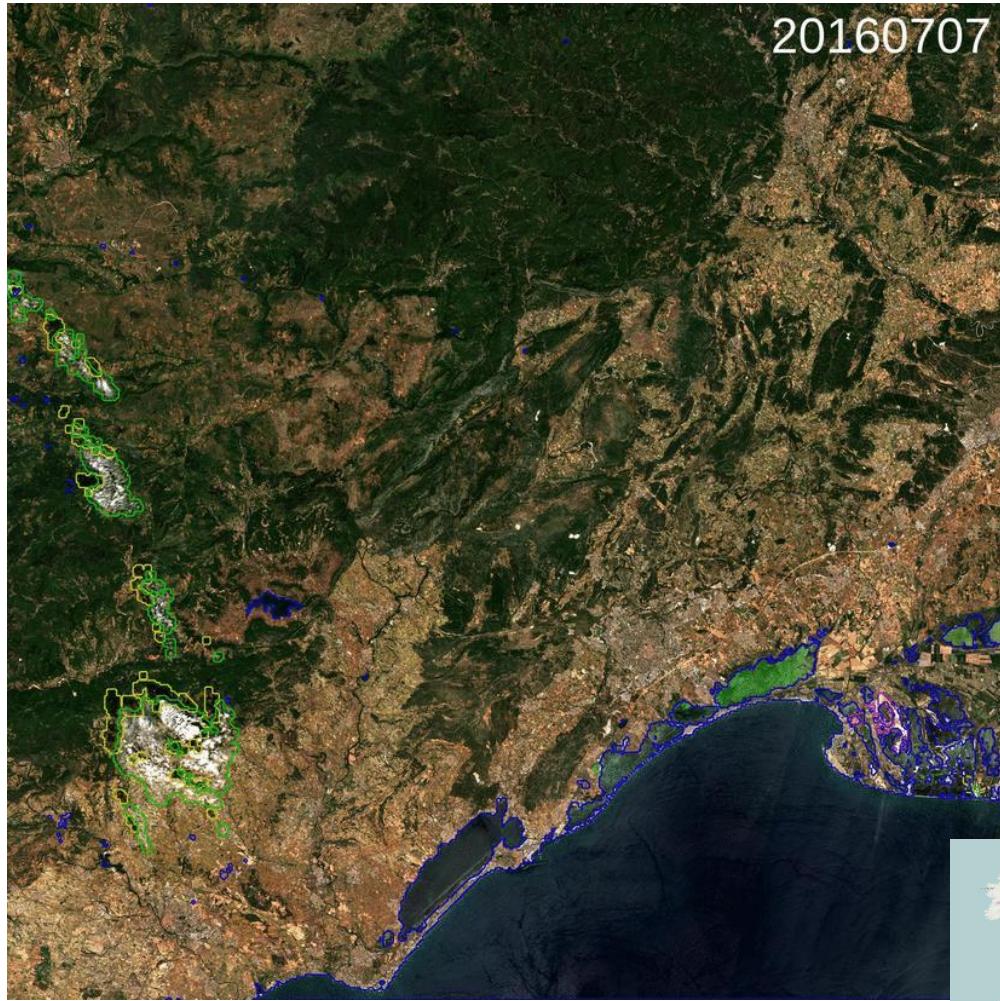
Un réseau de réseaux régionaux de station de flux turbulents (683 sites)



Un réseau international de sites pilotes dédié au développement et à la comparaison de méthodes de suivi de l'agriculture par télédétection



CESBIO: EXAMPLES OF ACTIVITIES



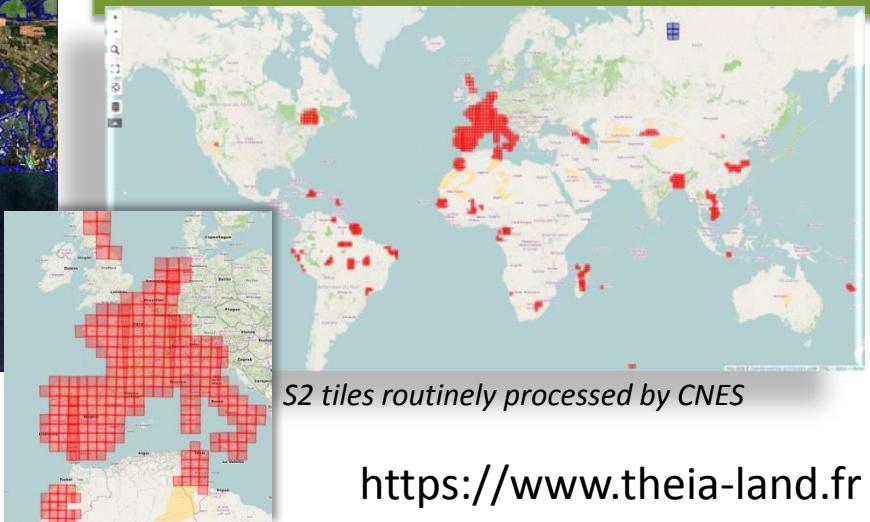
(Hagolle et al. 2017)

<https://theia.cnes.fr>

Pre-processing of Landsat, Sentinel-2 and Venus data:

- Cloud and shadow mask
- Aerosol optical depth retrieval
- Correction of atmospheric absorption and scattering effects
- Correction of terrain aspect
- Correction of BRDF (images from 2 different orbits)

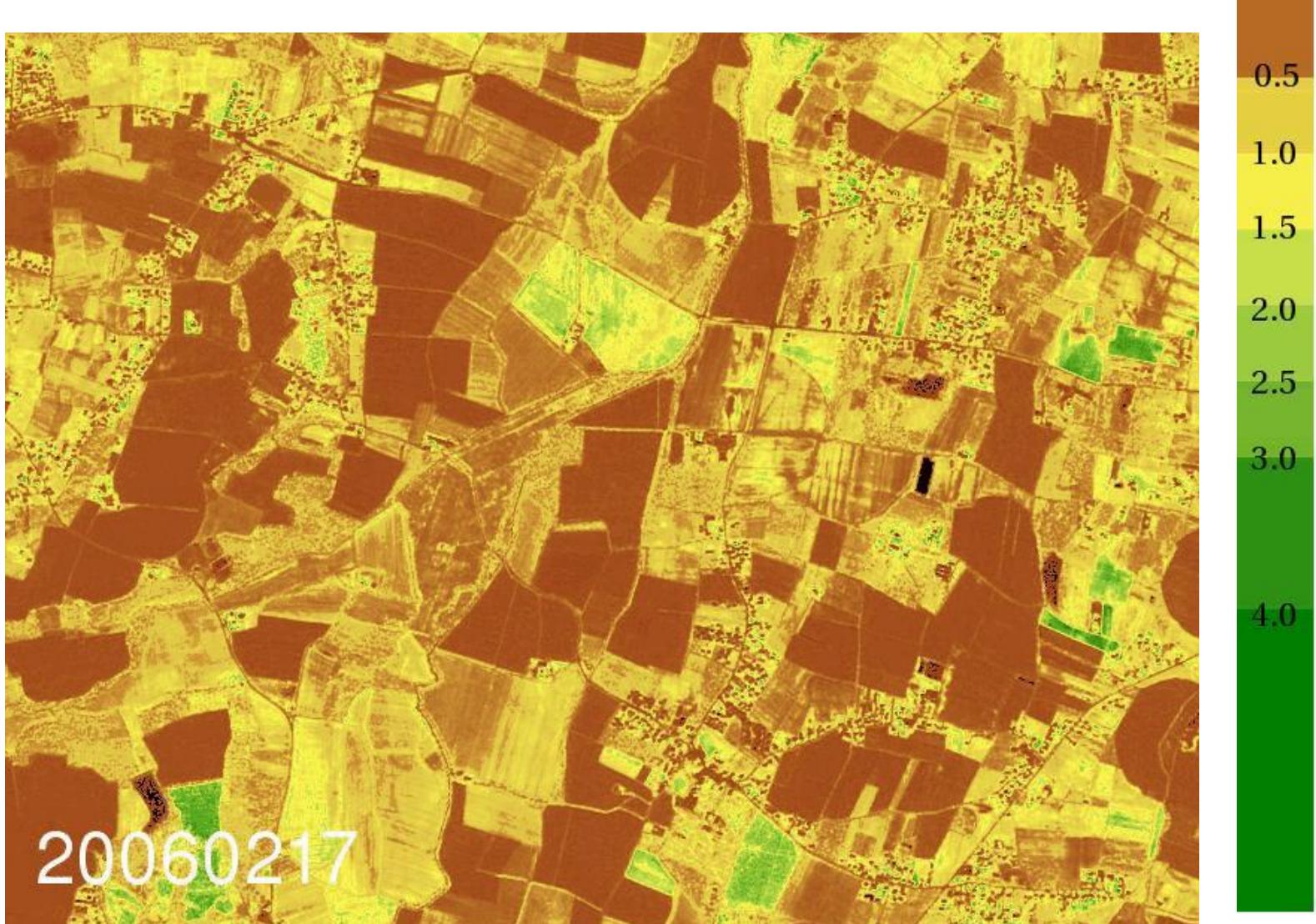
MACCS/MAJA software is operationally run by Theia/Muscate and provided with the Sen2Agri software (ESA)



S2 tiles routinely processed by CNES

<https://www.theia-land.fr>

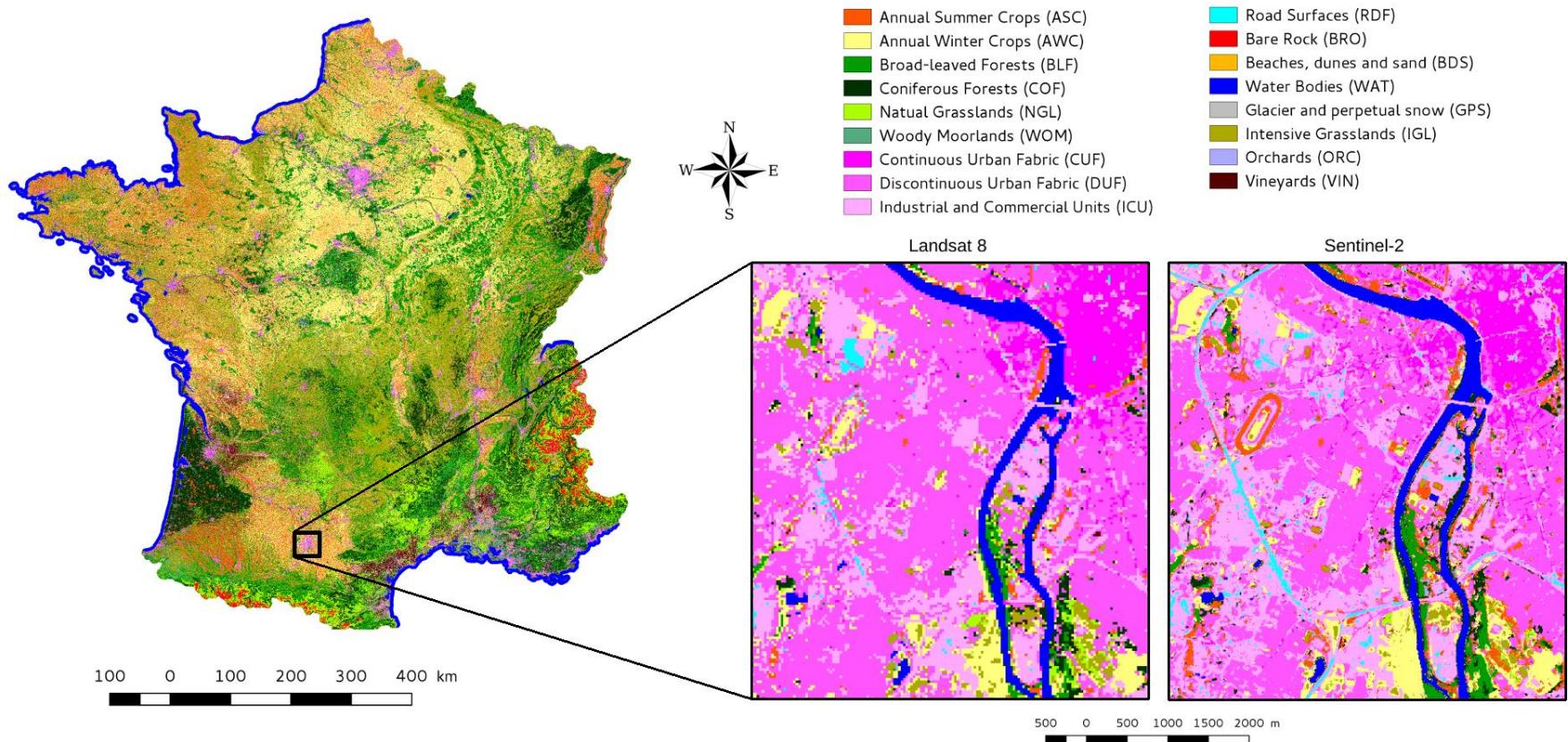
LEAF AREA INDEX 2007



Formosat 2 data – atmospherically corrected

(Demarez et al. 2008)

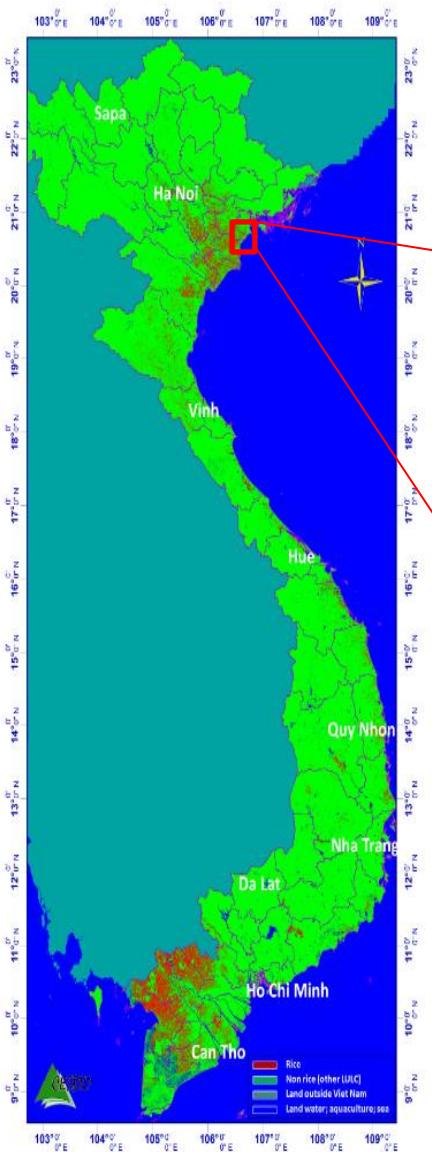
CESBIO: EXAMPLES OF ACTIVITIES



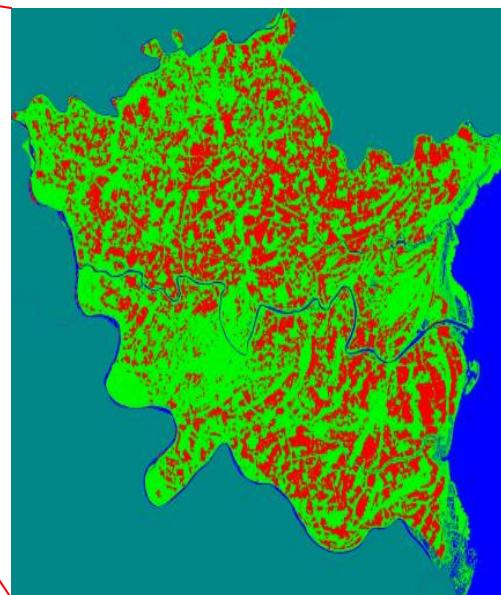
Land cover mapping with time series of Sentinel-2 data (atmospherically corrected)
10 m resolution

(Inglada et al. 2017)

RICE MAPPING AT COUNTRY SCALE: VIETNAM



Winter-Spring Rice mapping 2016

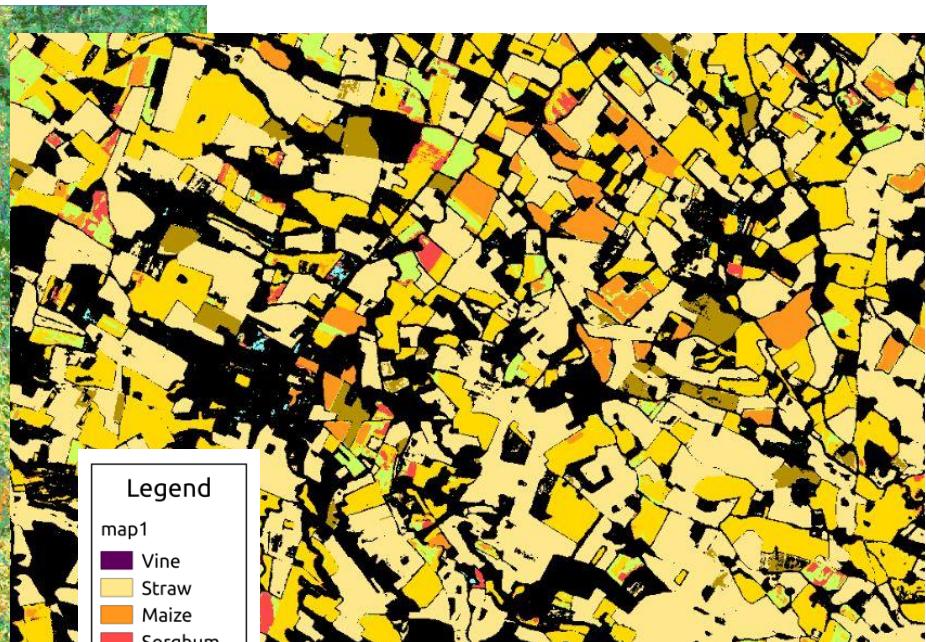
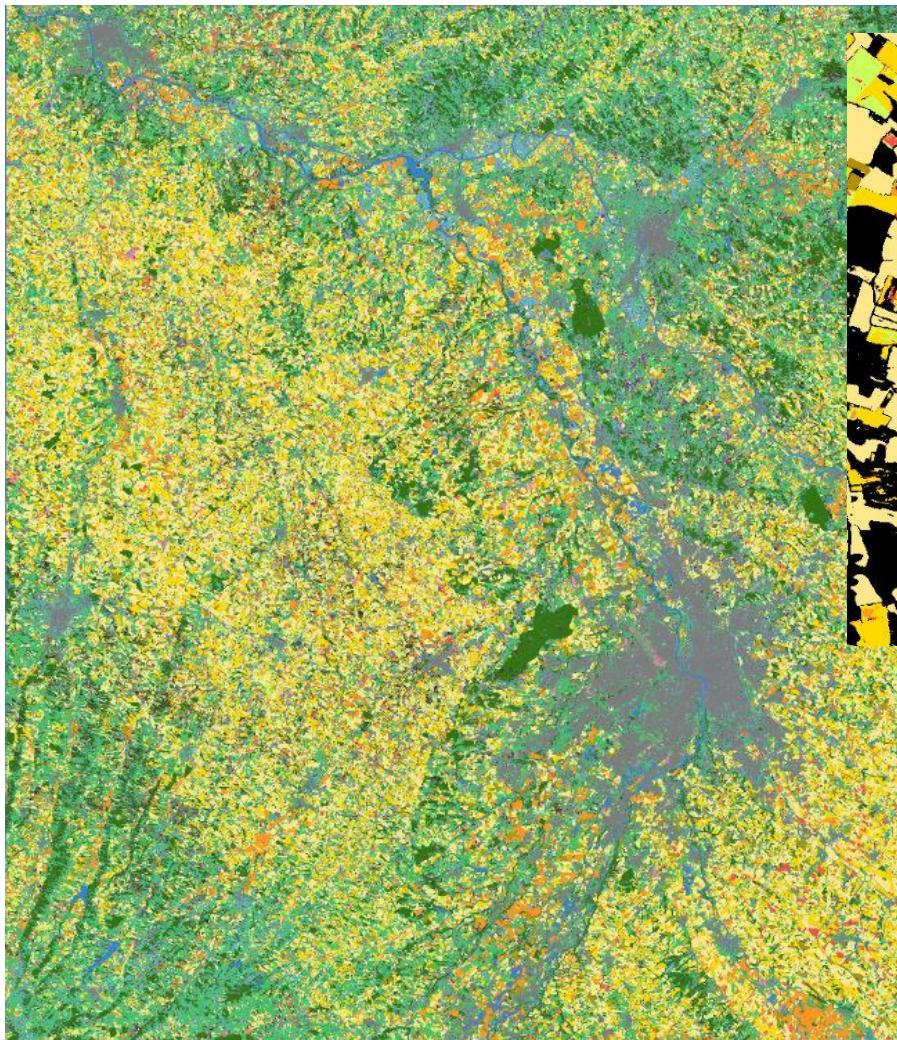


Thai Binh

Phan Thi Hoa et al



Overview of SENSAARI service: Seasonal Crop Mapping

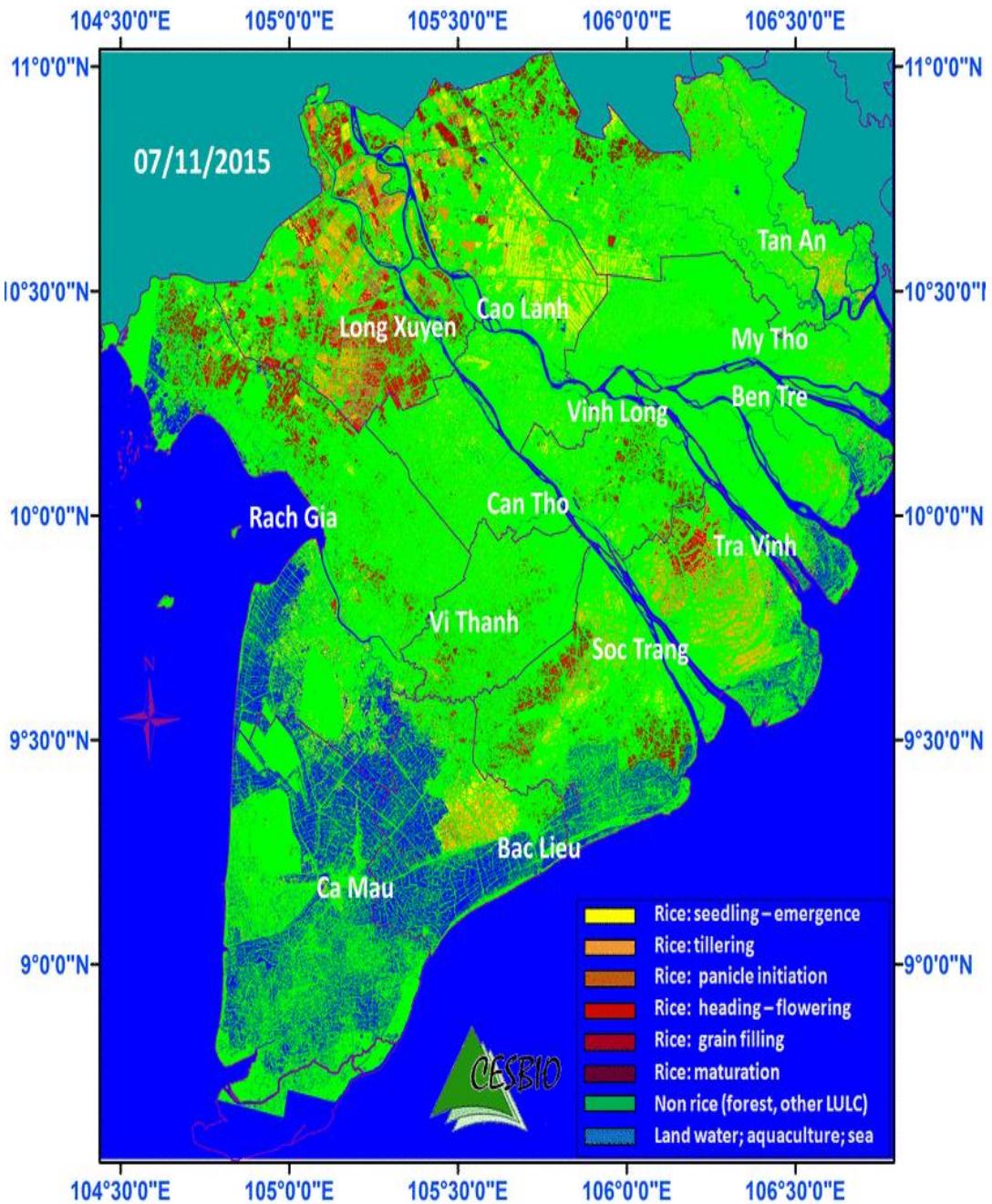


Crop type at 20m resolution

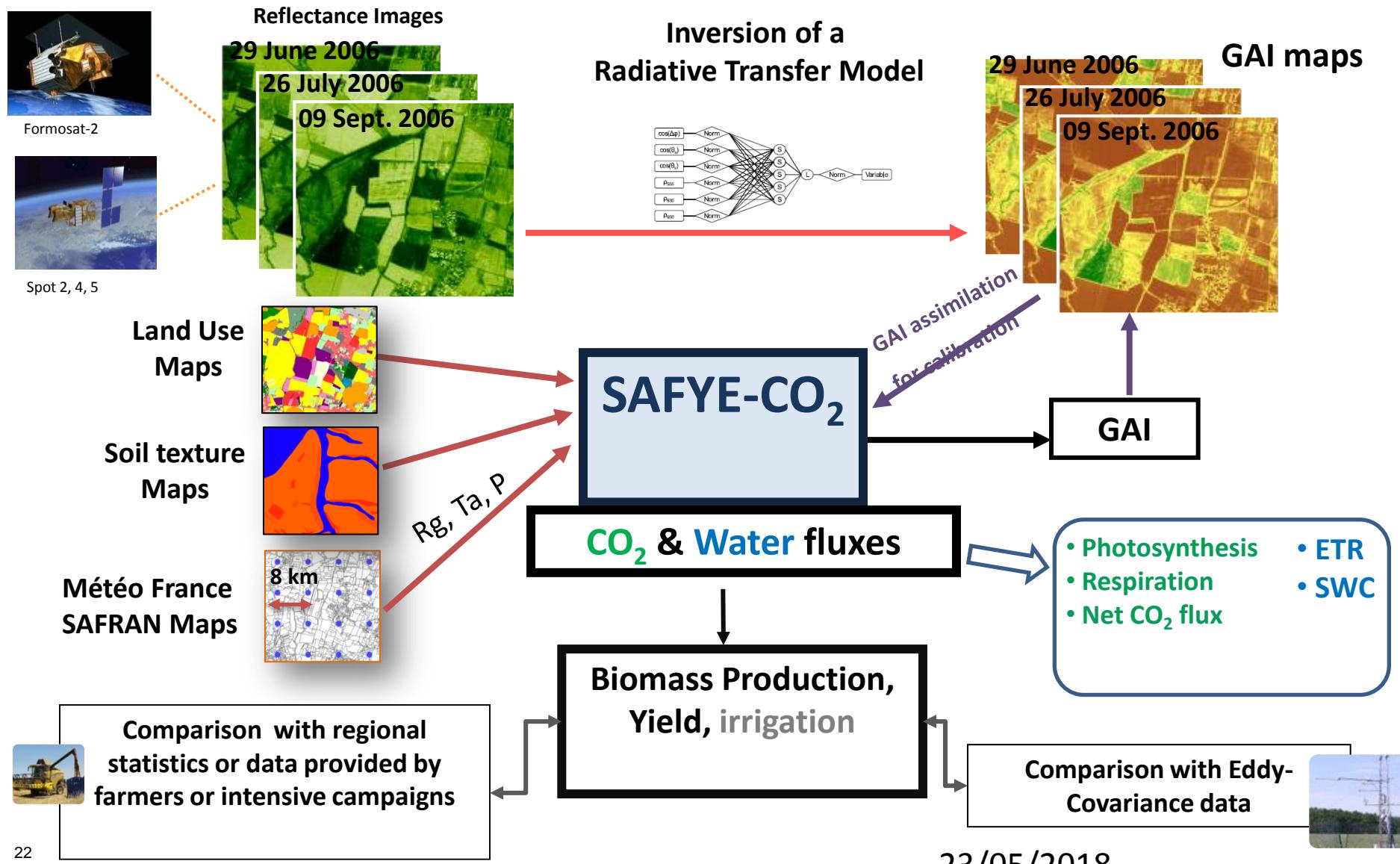
Rice monitoring using Sentinel-1A data

The Mekong Delta, Vietnam

360x360 km
20 m resolution



MODELING APPROACH

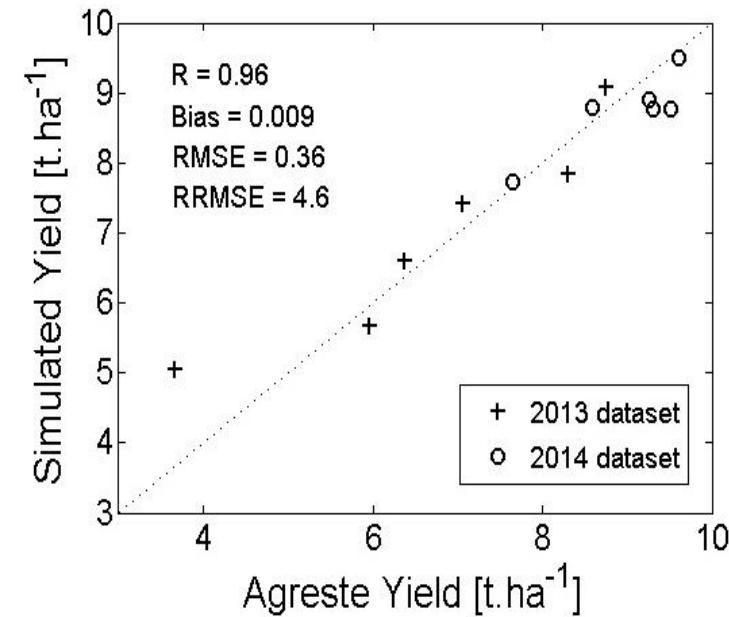
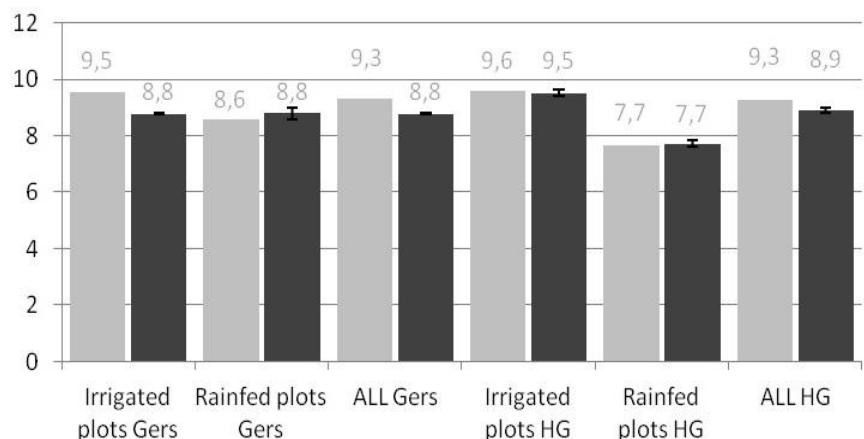
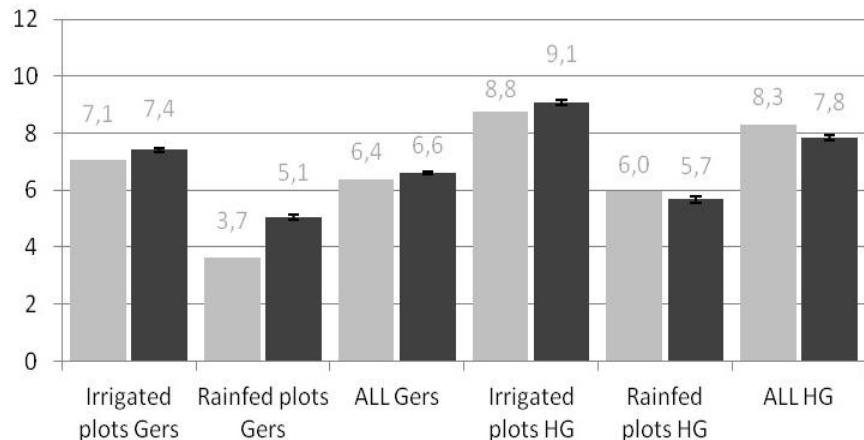


REGIONAL YIELD ESTIMATES (MAIZE)

Comparison of simulated yield and Agreste yield statistics [$\text{t} \cdot \text{ha}^{-1}$] for the Gers and the Haute-Garonne departments

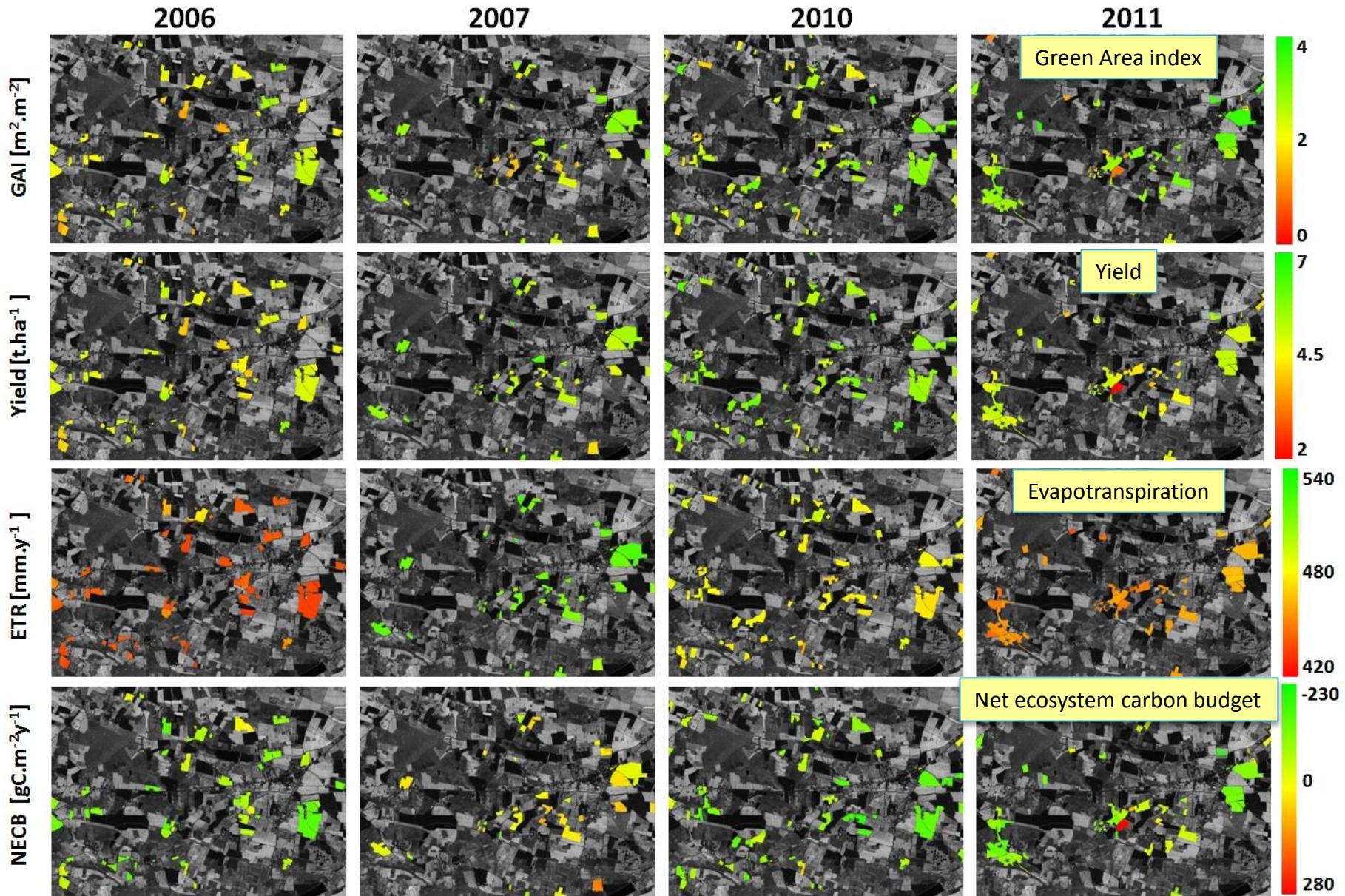


Gers
Haute-Garonne

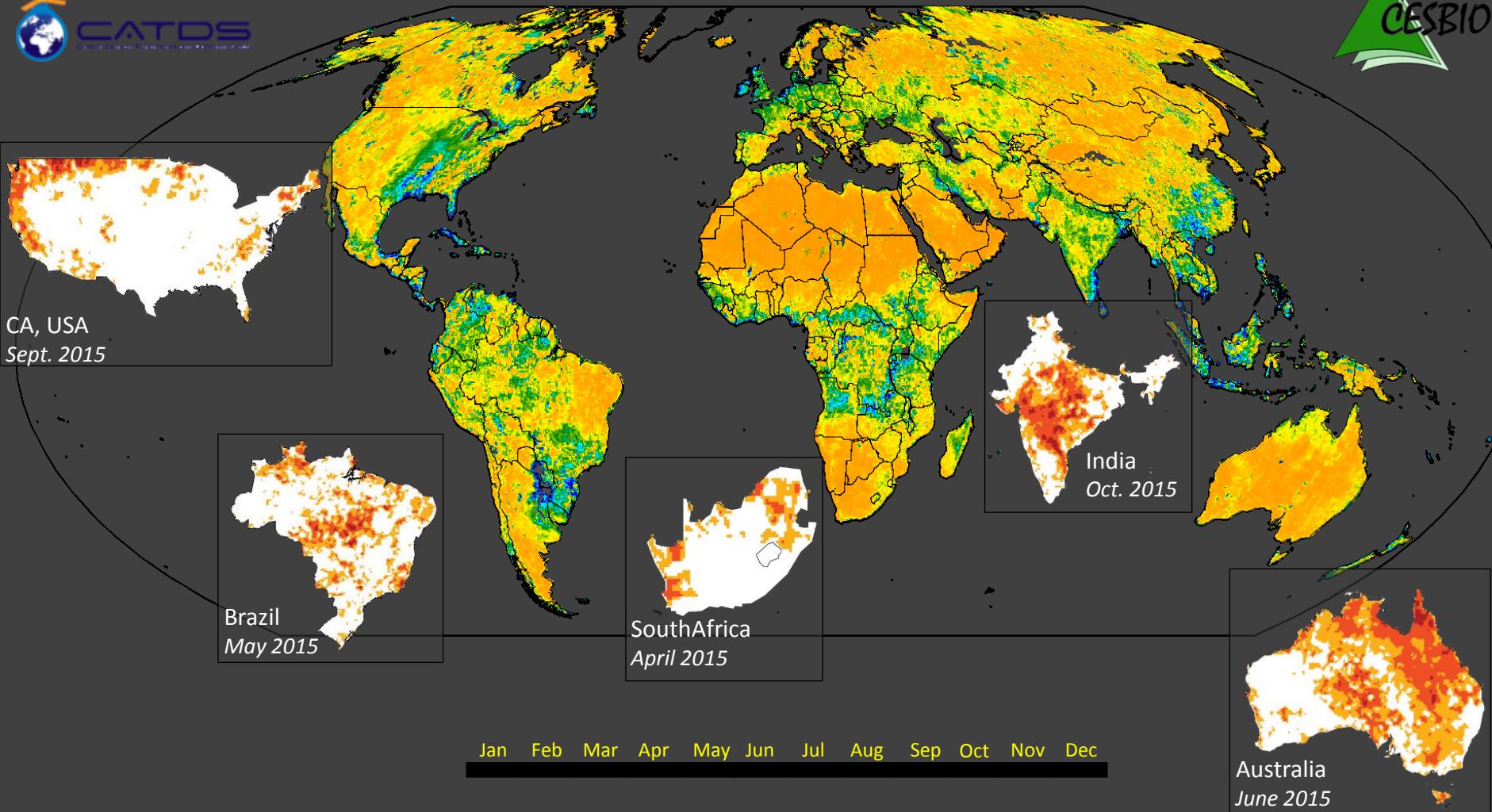


Battude et al

REGIONAL ESTIMATES (WHEAT FIELDS)



SMOS monitoring 5 major droughts in 2015



Root zone soil moisture



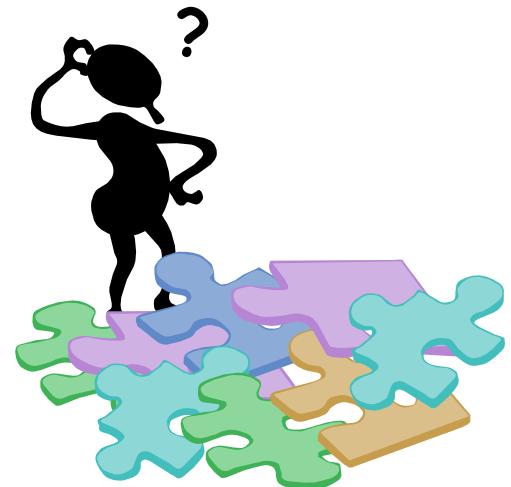
Drought index



ahmad.albitar@cesbio.cnrs.fr

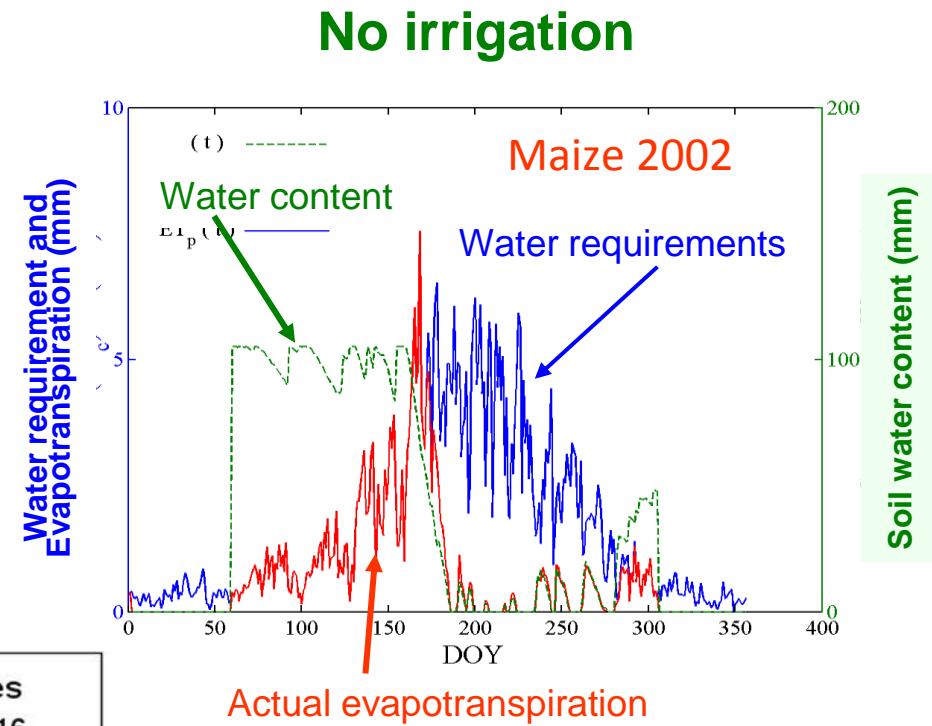
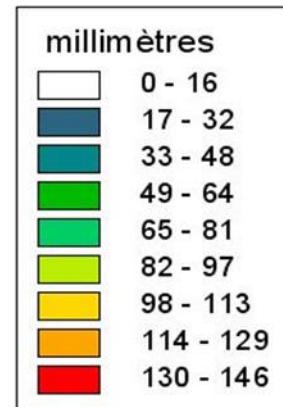
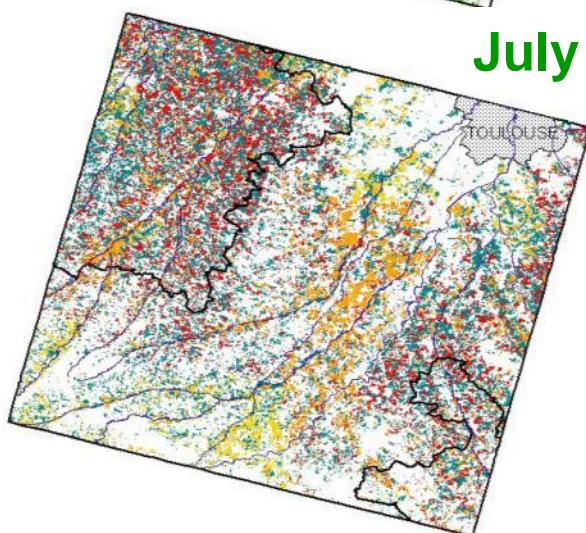
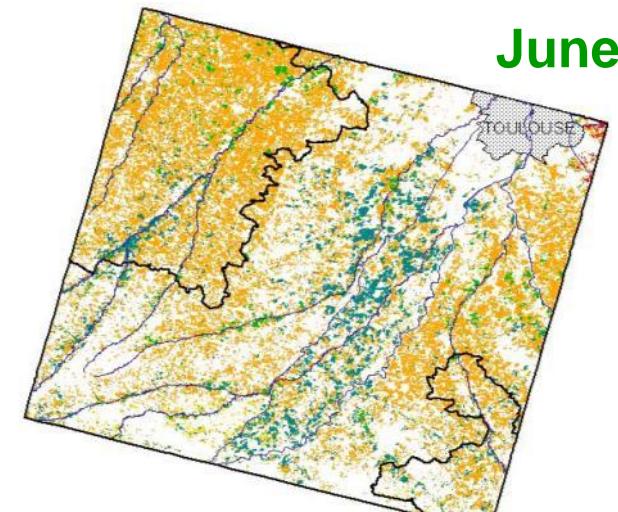
De la recherche aux applications

Un long parcours



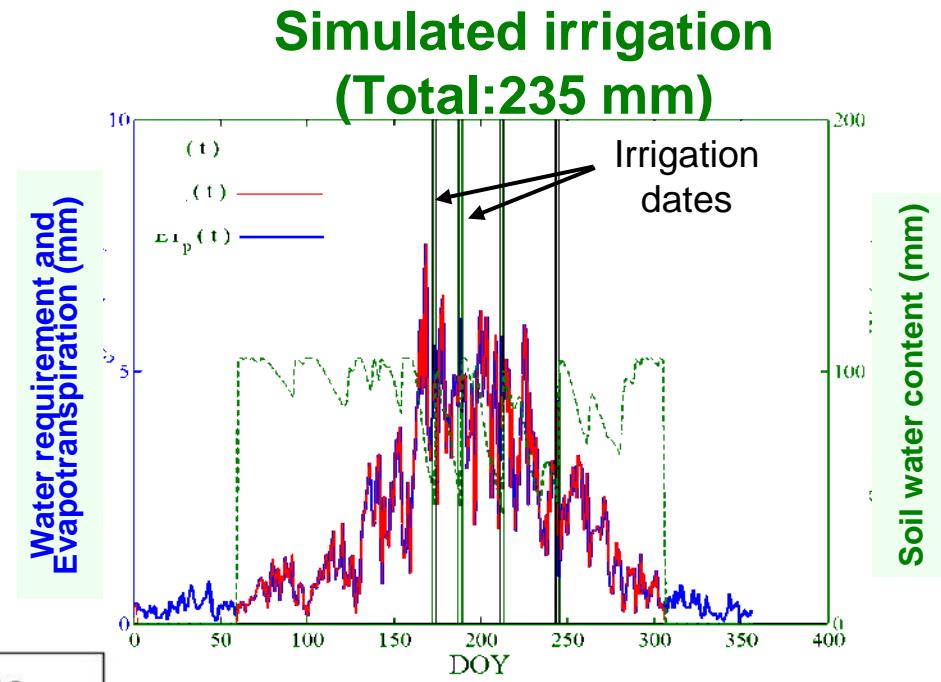
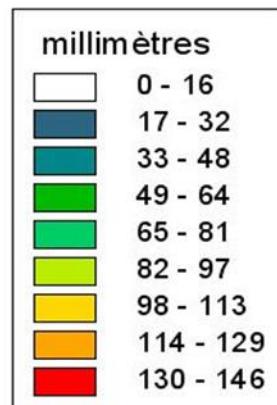
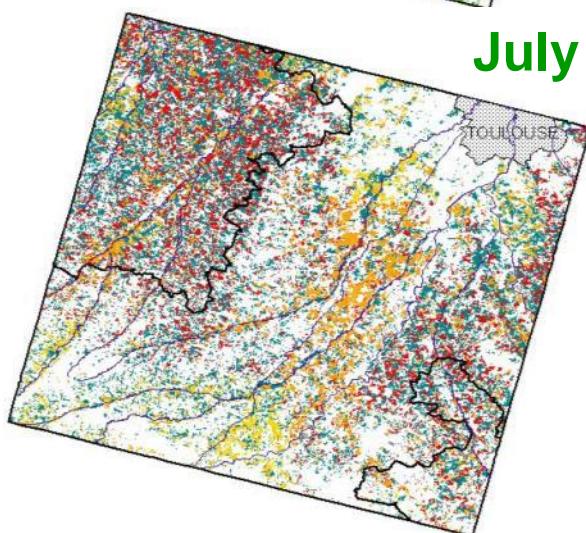
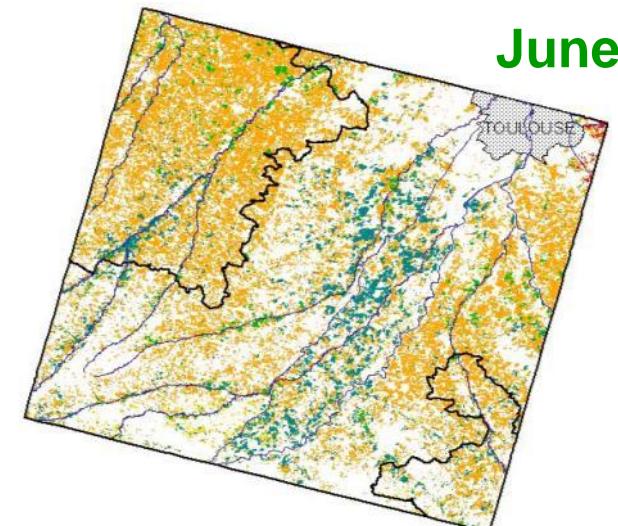
CESBIO'S EMPIRICAL EXPERIENCE: DECISION-MAKING

□ Product: crop water requirements and irrigation advices



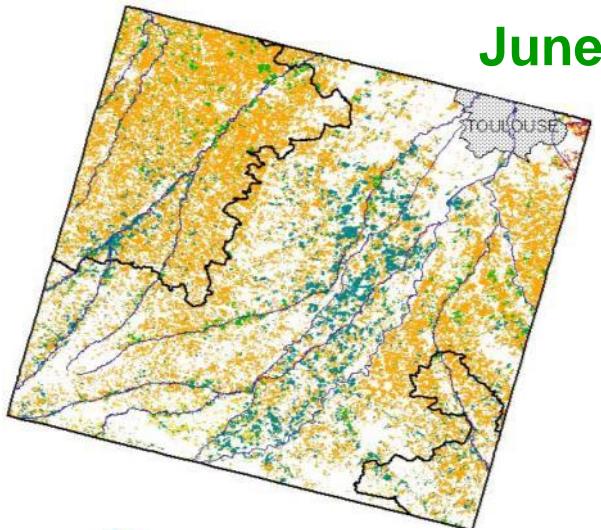
CESBIO'S EMPIRICAL EXPERIENCE: DECISION-MAKING

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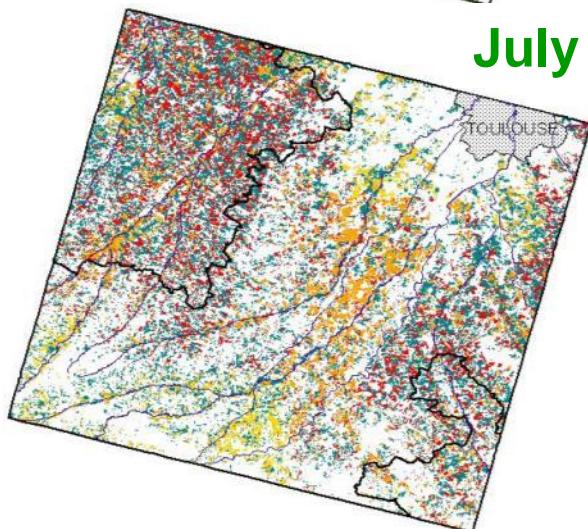


CESBIO'S EMPIRICAL EXPERIENCE: DECISION-MAKING

□ Product: crop water requirements and irrigation advices



June



July

2004

Results presented to the River Basin Authority

⇒ *“Come back when you will be able to process the entire basin (110 000 km²)”*. Now feasible with Sentinels.

2017 the River Basin Authority is funding the BAG'AGES project , carried out by a consortium of laboratories: assessment of agro-ecological practices for improving qualitative and quantitative management of water in the basin

2016: a water management company started to use CESBIO's results (limited to the mapping of irrigated crops)

=> A long process

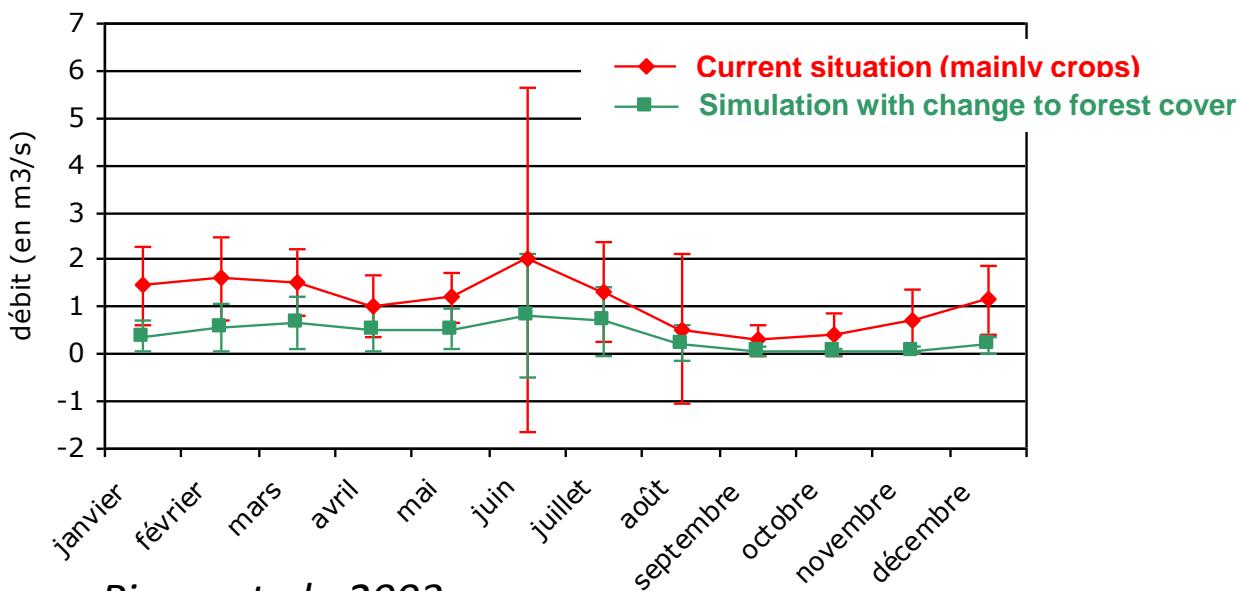
CESBIO'S EMPIRICAL EXPERIENCE: REDUCING POTENTIAL CONFLICTS

The issue: a village at the exit of a watershed is frequently facing severe flooding

The question of the local authorities, supported by regional authority and agriculture chamber: does change in land cover/land use would allow to reduce flooding risk ?

The initial positions of the actors: conflict. *"You build houses anywhere, we cannot modify our practices, and even if we do it will change nothing"*

What we did: meetings with actors, including farmers to better understand their positions and practices, mapping of land cover, hydrological modeling



Pierre et al., 2003

CESBIO'S EMPIRICAL EXPERIENCE: REDUCING POTENTIAL CONFLICTS

The issue: a village at the exit of a watershed is frequently facing severe flooding

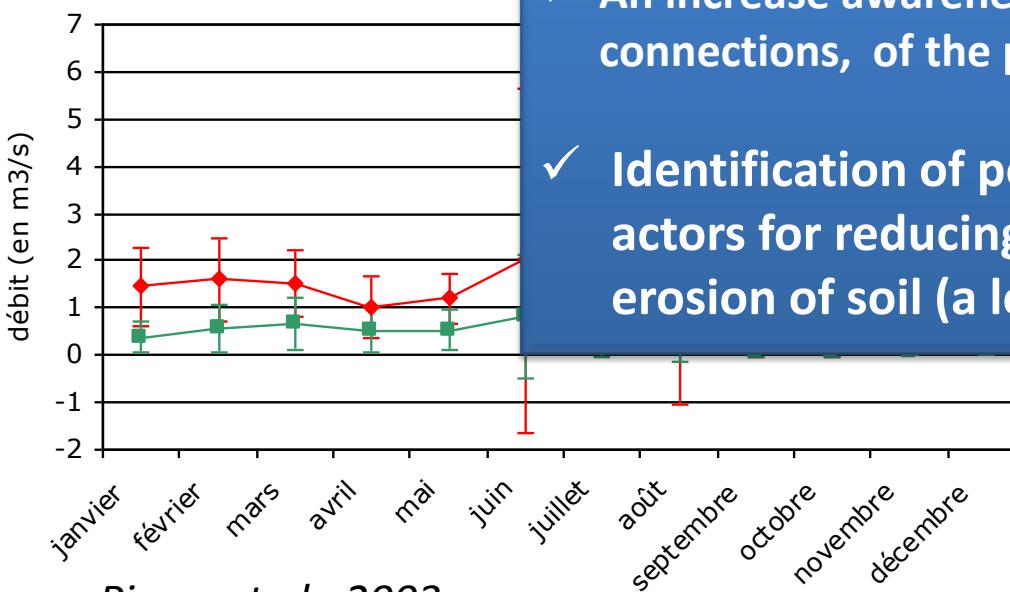
The question of the local authorities, supported by regional authority and agriculture chamber: does change in I

The initial positions of the farmers were to not modify our practices, and

What we did: meetings with farmers to discuss their positions and practices, m

The main result of the experiment was not the hydrological modeling but:

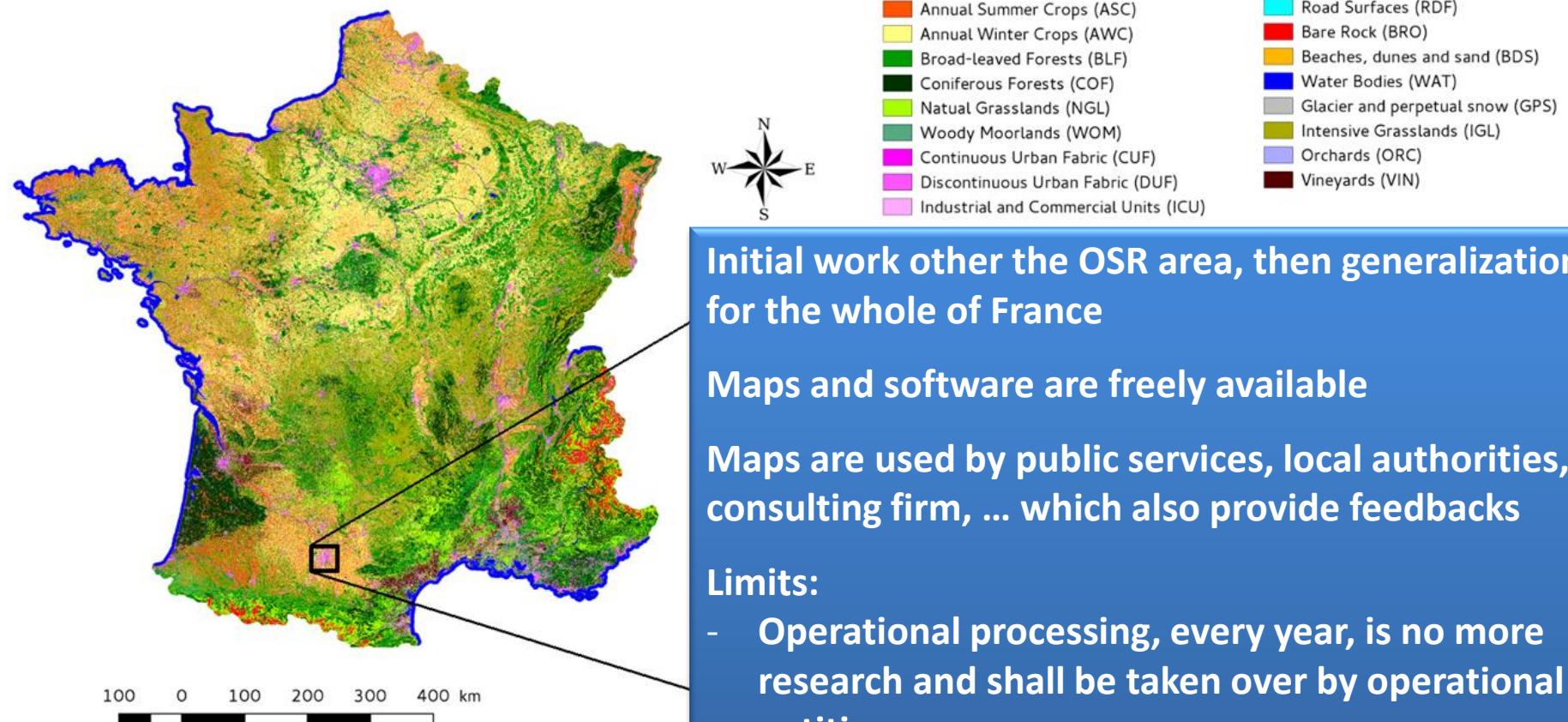
- ✓ The objectivation of the debate, through the sharing of a common vision of the issues
- ✓ An increase awareness of the upstream/downstream connections, of the processes and feedbacks
- ✓ Identification of possible common interests of the actors for reducing flooding: flooding means also erosion of soil (a loss of assets for farmers)



Pierre et al., 2003

CESBIO'S EMPIRICAL EXPERIENCE: DECISION-MAKING

- Remote sensing delivers products which can be used for decision-making



CROP TYPE MAPPING



→ AGRICULTURE



Ukraine, 2016

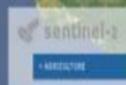
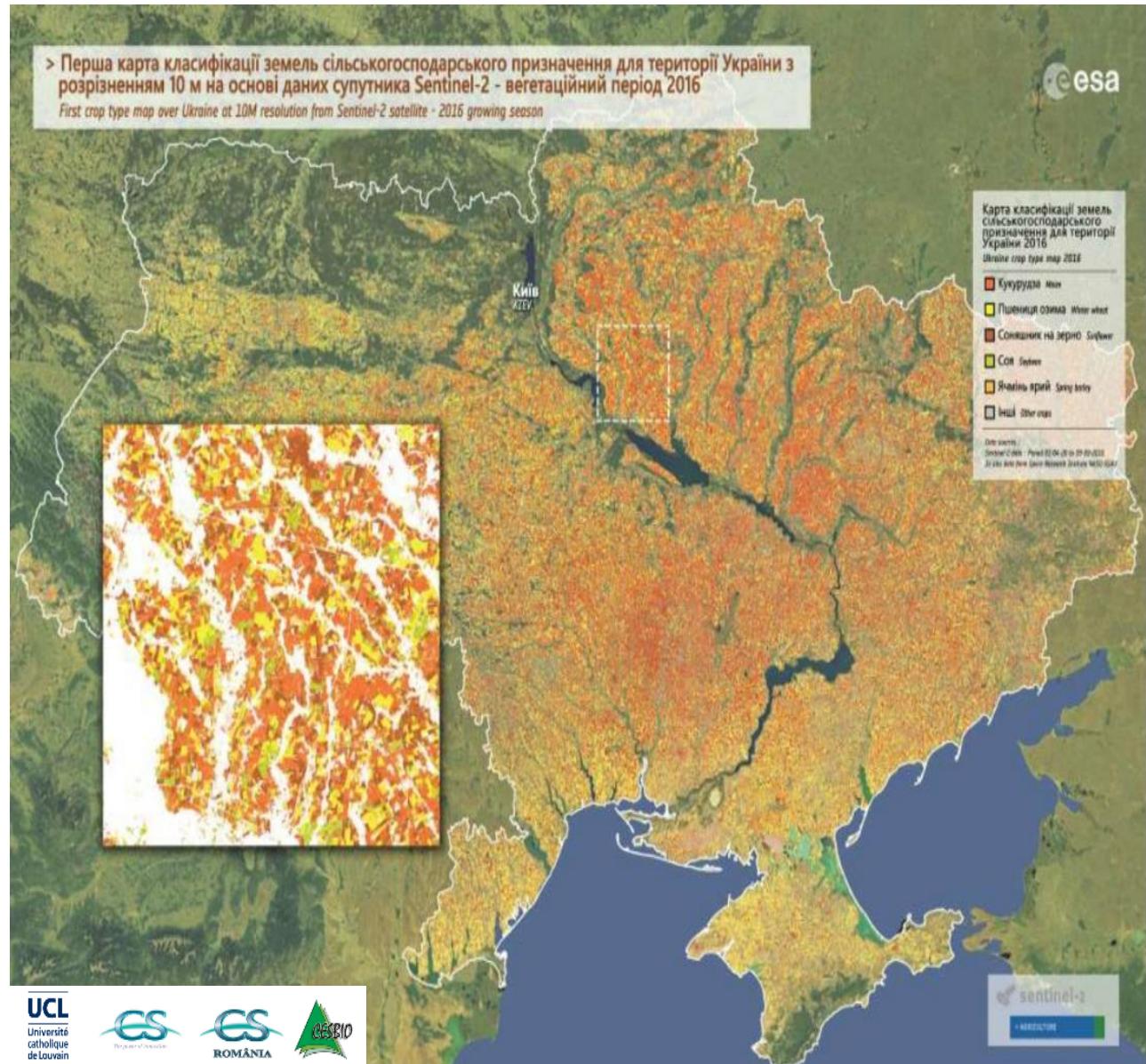
603 000 km², 10 m resolution

Sentinel-2 for Agriculture
(ESA project)

CESBIO algorithms

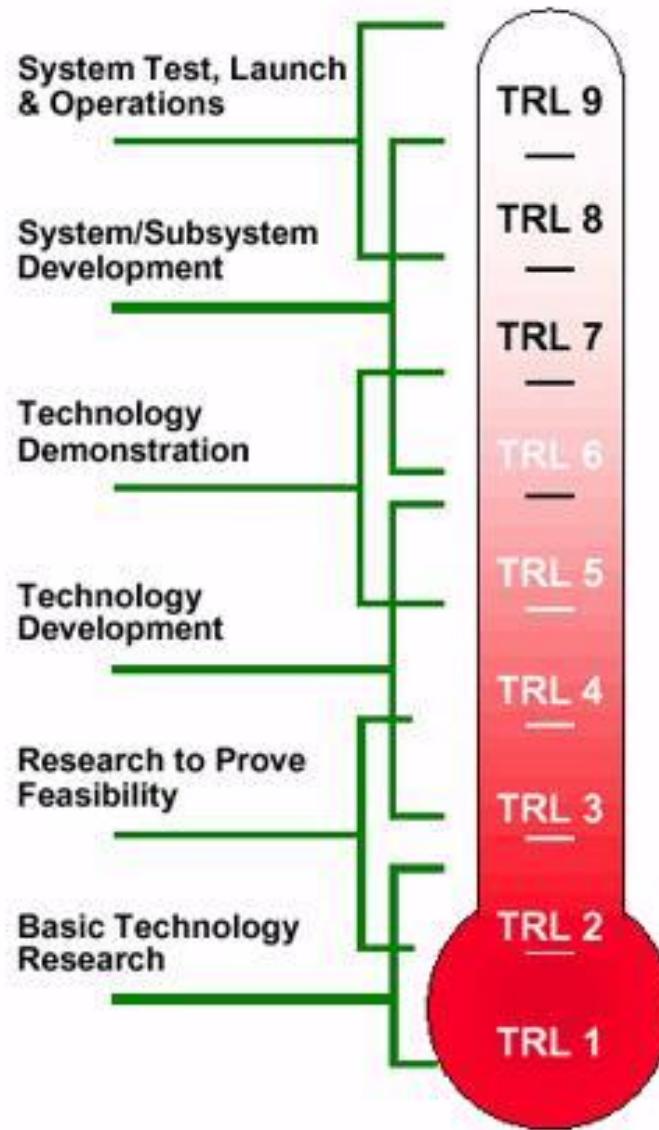
Processing by CS-Romania

Open source and free
processing chains



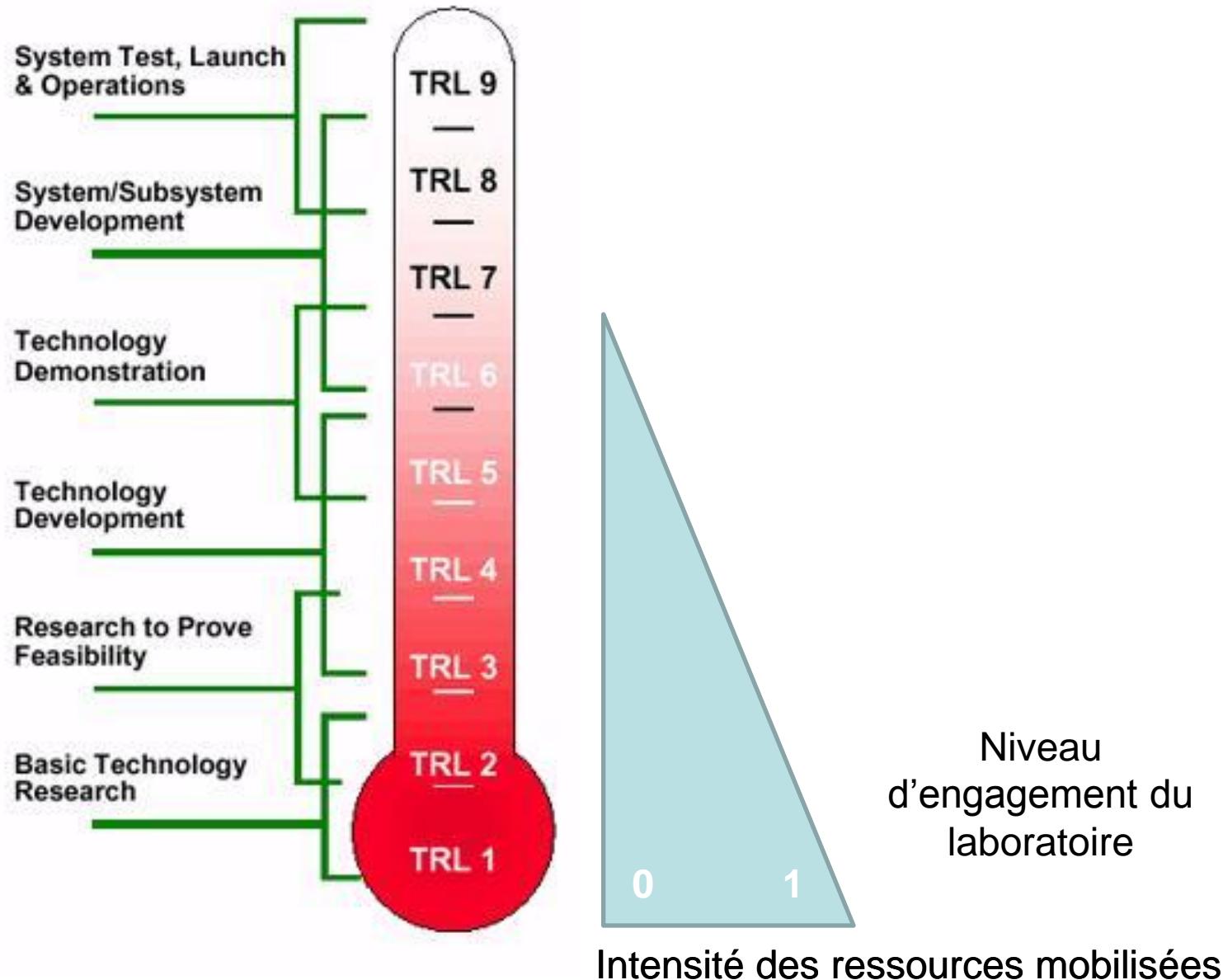
Projets collaboratifs avec l'industrie : la logique

Technology Readiness Level (TRL)



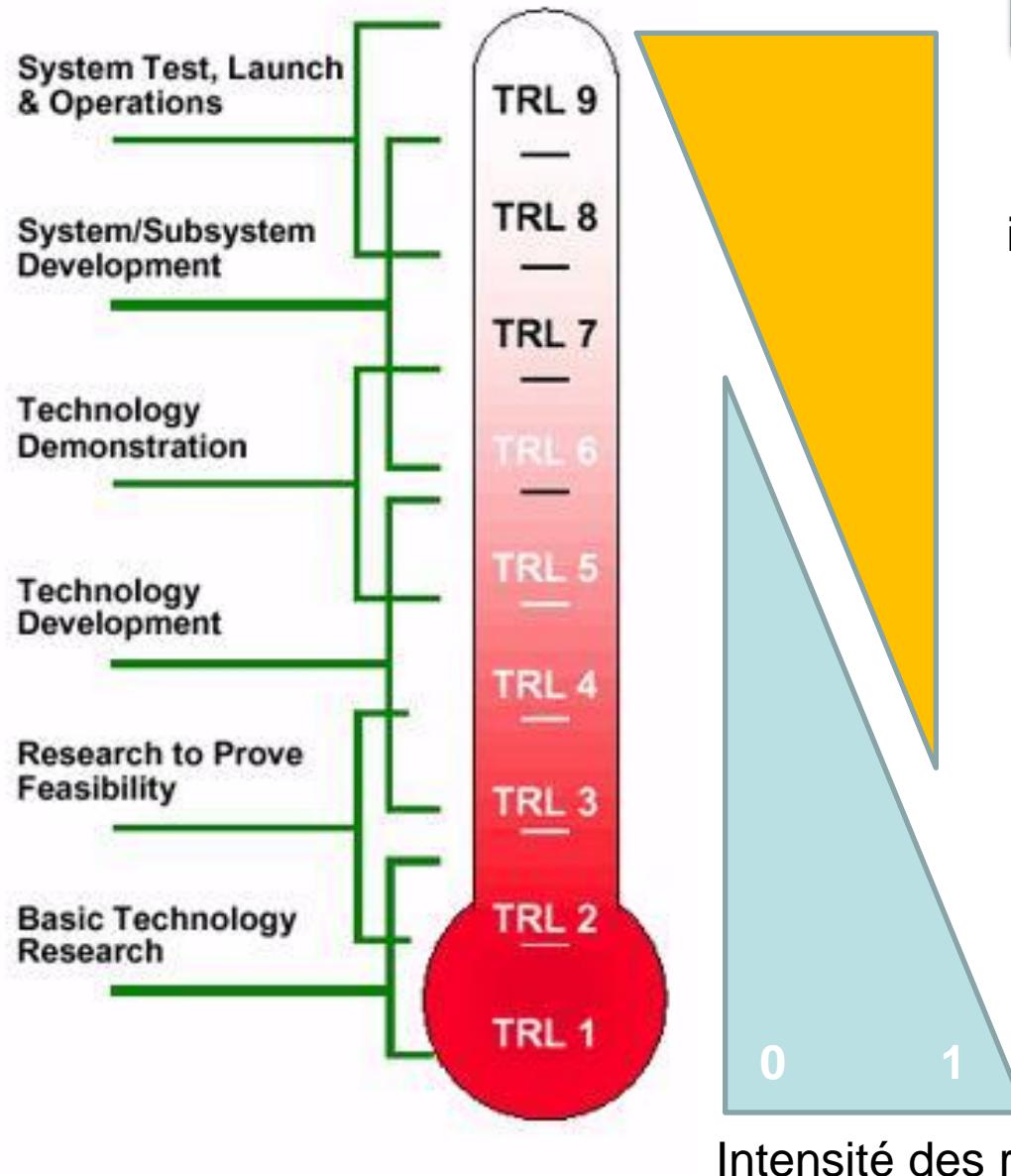
Projets collaboratifs avec l'industrie : la logique

Technology Readiness Level (TRL)



Projets collaboratifs avec l'industrie : la logique

Technology Readiness Level (TRL)



Intensité des ressources mobilisées

Utilisateurs &
clients

Implication
industriel & société
de services

Niveau
d'engagement du
laboratoire

Projets collaboratifs (valorisation, transfert) : la logique

■ Valorisation/transfert des résultats de la recherche : une mission des laboratoires

- ◆ Contribuer au développement des usages de la télédétection
- ◆ Contribuer au développement économique
- ◆ Contribuer à éclairer et résoudre des questions sociétales (eau, climat, ...)

■ Ressources budgétaires

■ Emploi des jeunes formés

■ Questionnements nouveaux

■ Consolidation des résultats

- ◆ Chaînes de traitement plus opérationnelles, conditions différentes

■ Compléter et accroître les jeux de données disponibles pour la recherche

- ◆ Augmenter la robustesse / domaine de validité des méthodes et des estimations ; améliorer la calibration / validation.

Projets collaboratifs (valo/transfert) : qq ex. 2011-2014

Zone Kalideos OSR-MiPy

- **SIRHYUS (FUI12)** : VERI, VEOLIA, EDF, GE2C, ACRI-ST, IRSTEA
- **DEMETER (MiPY)** : ARTAL, Agri-Intranet
- **SATERRE (CNES)** : C-S, Agri-Intranet, Aida, SAFER
- **DECIDAIE (PFMI)** : C-S, ARTERRIS, VIVADOUR, ACTIA, TCSD, STERELA, Météo France, LAAS, CESBIO, INRA, ECOLAB,
- **CiCC (ADEME REACTIFF)** : INRA, Aida, chambres d'agriculture
- **ESA : Sentinel-2 Agriculture (UCL, CS-F, CS-Ro)**
- **ANR RUEdes sols** : INRA, Arvalis, Cetiom...

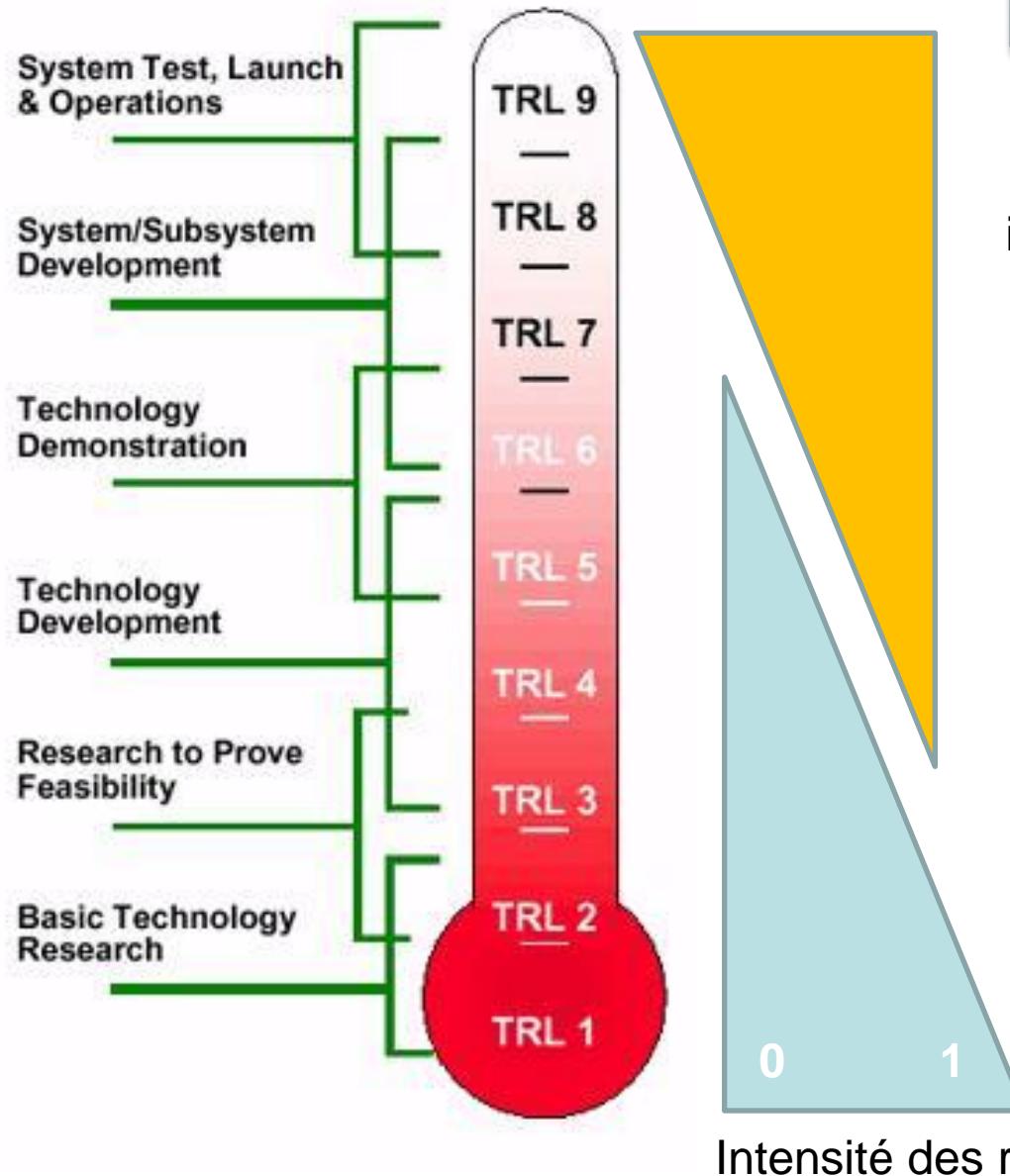
Région Midi-Pyrénées / massif Pyrénées

- **OPCC (Obs Pyrénées CC / interreg)** : El Purpan, CETE
- **MAISEO (FUI14)**: VIVADOUR, PIONEER, CACG, GEOSYS (<UMT Eau)
- **Casdar Eau et territoire (< UMT eau)** : INRA, Arvalis, chambres d'agriculture
- **Casdar prévision rendement et qualité tournesol (< UMT Tournesol)** : INRA, Cetiom, coopératives agricoles
- **PEPS (CNES)** : C-S, CETE
- **Mynerve II (MiPy)** : Geosys, FREDEC



Projets collaboratifs avec l'industrie : la logique

Technology Readiness Level (TRL)



Utilisateurs &
clients

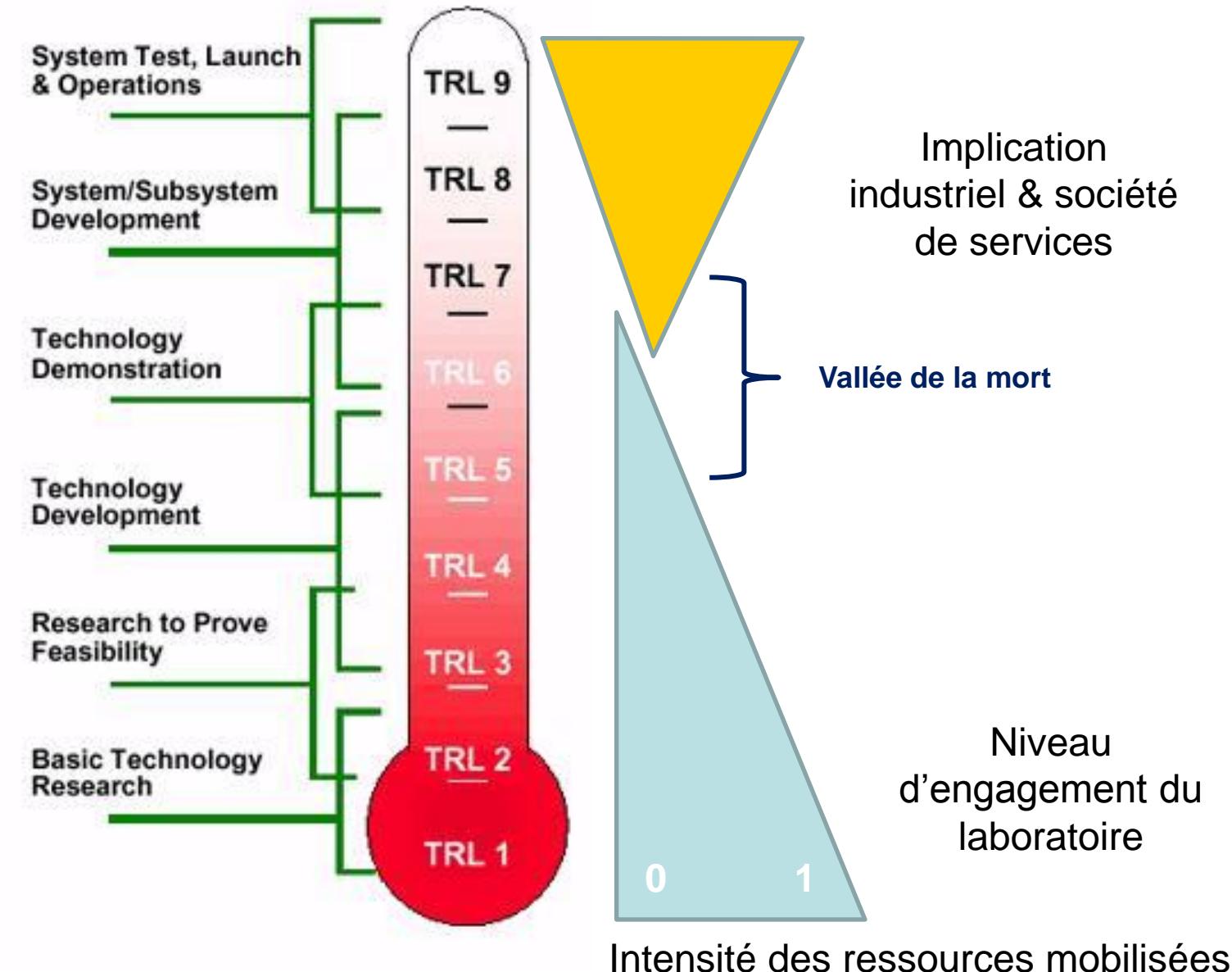
Implication
industriel & société
de services

Niveau
d'engagement du
laboratoire

Intensité des ressources mobilisées

Projets collaboratifs avec l'industrie : REX

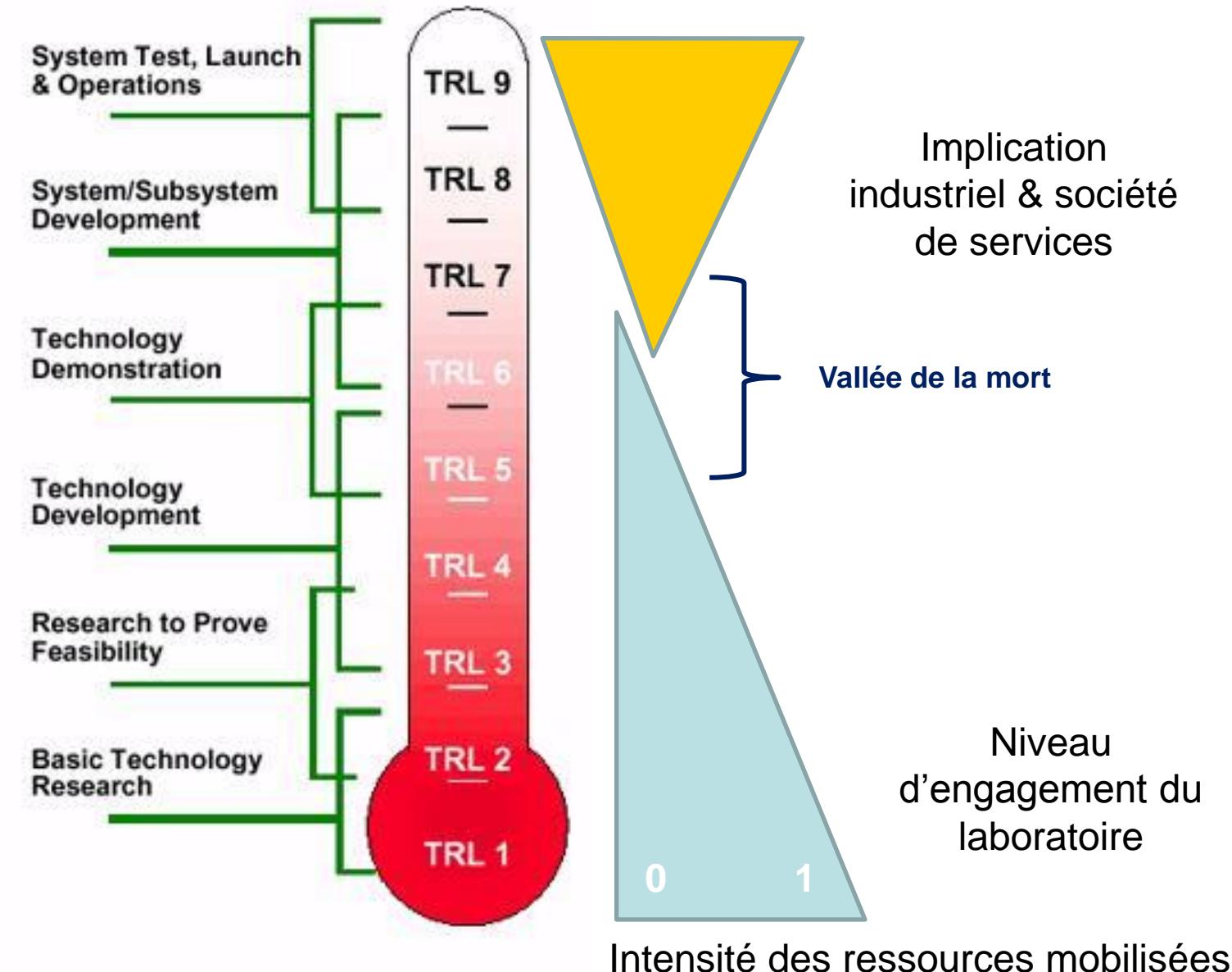
Technology Readiness Level (TRL)



Utilisat
clie

Projets collaboratifs avec l'industrie : REX

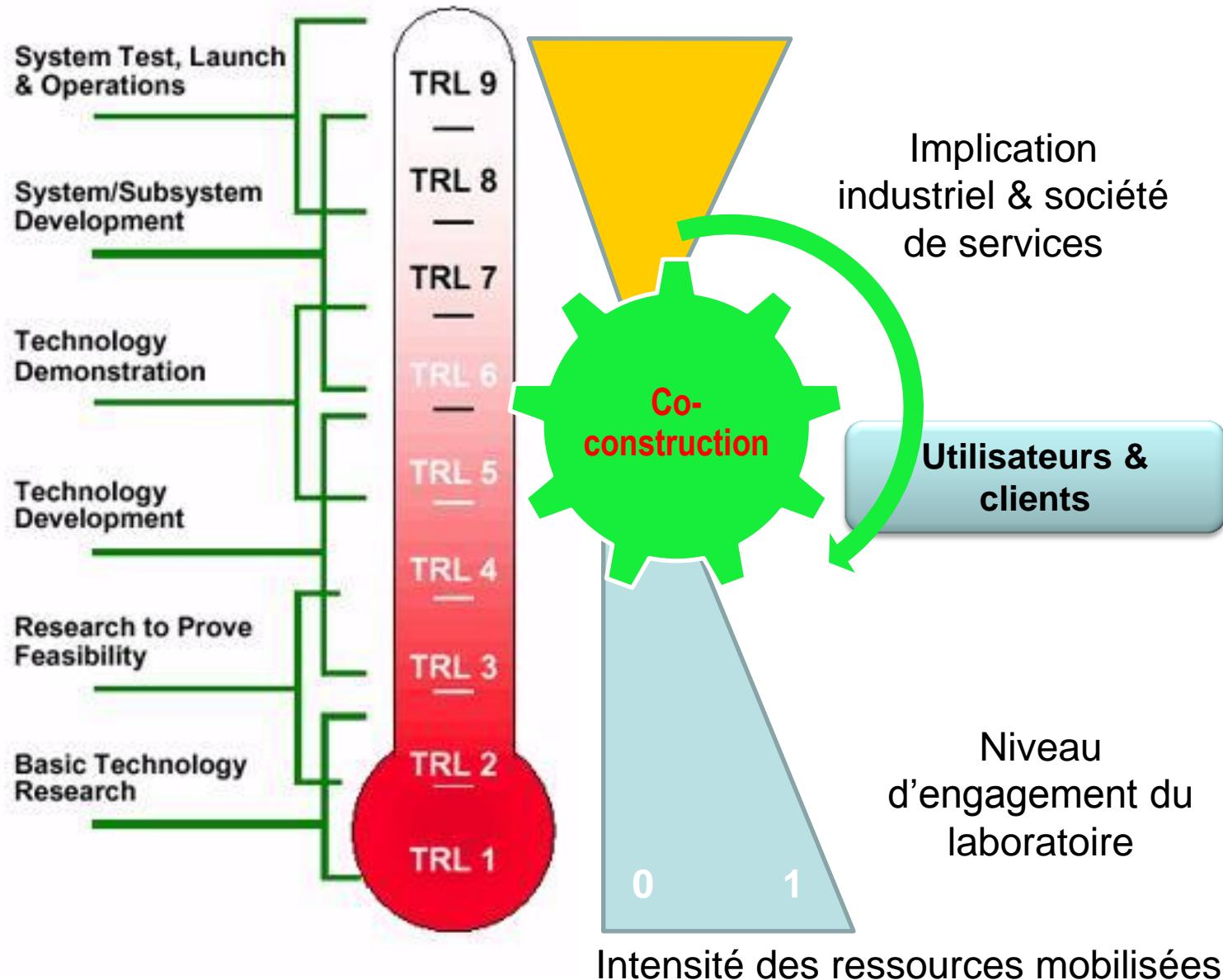
Technology Readiness Level (TRL)



Utilisat
clie

Projets collaboratifs avec l'industrie : REX

Technology Readiness Level (TRL)



CESBIO'S EMPIRICAL EXPERIENCE

- CESBIO started experimenting the “Living Lab Approach” in 2007 with a territory of 159 rural municipalities (2047 km²) with a common development project

- ◆ Initialized by policy makers, CESBIO and a consulting company, Involves policy makers, stakeholders and the governance of the territory (development council)
- ◆ Topics: agriculture, irrigation, land management and health

=> A territorial Living Lab

- A Living Lab is a real-life test and experimentation environment where users and producers co-create innovations

- ◆ Co-Creation: co-design by users and producers
- ◆ Exploration: discovering emerging usages, behaviors and market opportunities
- ◆ Experimentation: implementing live scenarios within communities of users
- ◆ Evaluation: assessment of concepts, products and services

- Living Lab have been primarily designed for producing innovative products and services with users, but we believe the concept can be adapted to governance issues

EXAMPLE OF THE APPROACH: ESTABLISHMENT OF PLANNING DOCUMENTS

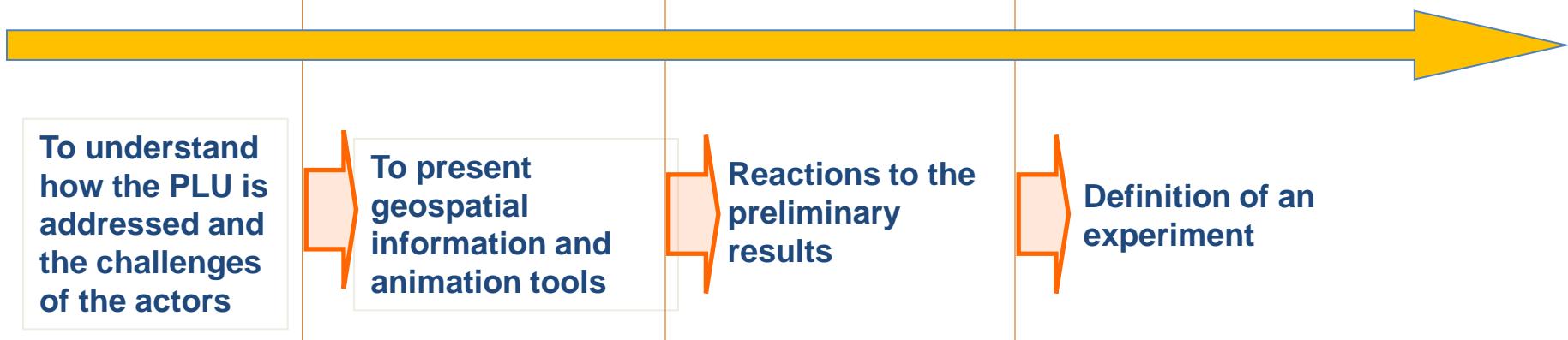
(PLU = Plan Local d'Urbanisme: Local Development Plan)

Worskop 1

Worskop 2

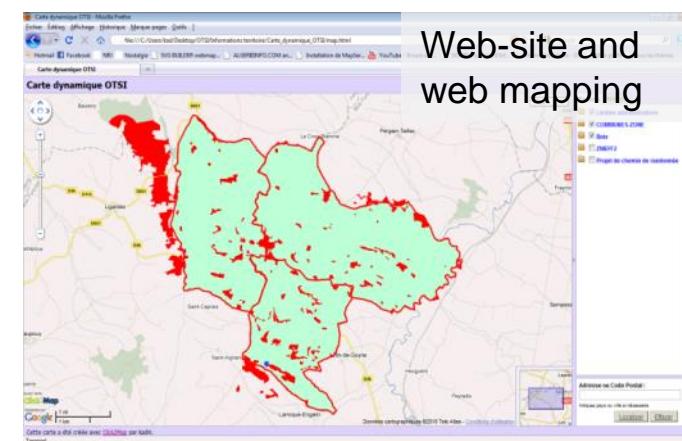
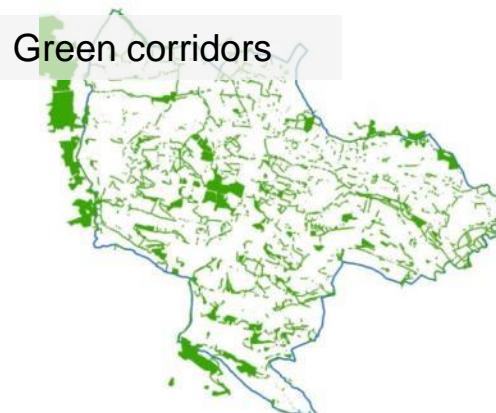
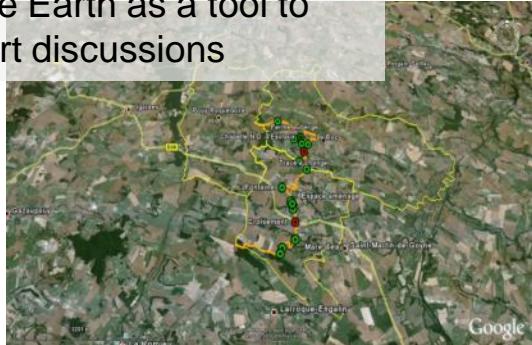
Worskop 3

Worskop 4



Three rural municipalities involved in the process, about 18 participants in every workshop (municipalities, farmers, Nature NGO, ...)

Google Earth as a tool to support discussions



Web-site and web mapping

EXAMPLE OF THE APPROACH: ESTABLISHMENT OF PLANNING DOCUMENTS

(PLU = Plan Local d'Urbanisme: Local Development Plan)

Worskop 1

Worskop 2

Worskop 3

Worskop 4

To understand how the PLU addressed a the challenges of the actors

Three ru

Google Earth as a support discussion

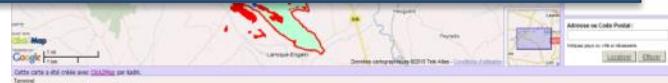


Benefits:

- Increase the knowledge of every type of actors (including scientists),
- Shared vision of the challenges, of the different points of view and interests
- Open the window on other experiences elsewhere, on new technologies, connect the actors to the scientific community
- Can probably be used to improve acceptability of new practices (e.g. cover crop)
- Generate new ideas outside or at the border of the initial topic

Limits:

- For the laboratories, funding of the approach is difficult, difficult also to stay involved for a long time
- For the local actor of rural territories : often a lack on in-house “engineering”



Retour d'expérience Living labs

ATOOTS

- **Une modalité qui mutualise valorisation et émergence de nouvelles problématiques.**
- **Plus de relations pérennes avec plus d'acteurs (données).**
- **La concrétisation de l'utilité de la recherche**

FAIBLESSES

- Les entreprises privées sont difficiles à impliquer dans un LL
 - ◆ Réticence à partager des idées, des méthodes et des logiciels
 - ◆ Réticences à rejoindre une « grappe d'entreprises » et de travailler en mode « open innovation »
- Financement:
 - ◆ Pour les entreprises « un modèle inconnu ».
 - ◆ Pour les labos modalité difficilement finançable

Retour d'expérience Living labs

OPPORTUNITES

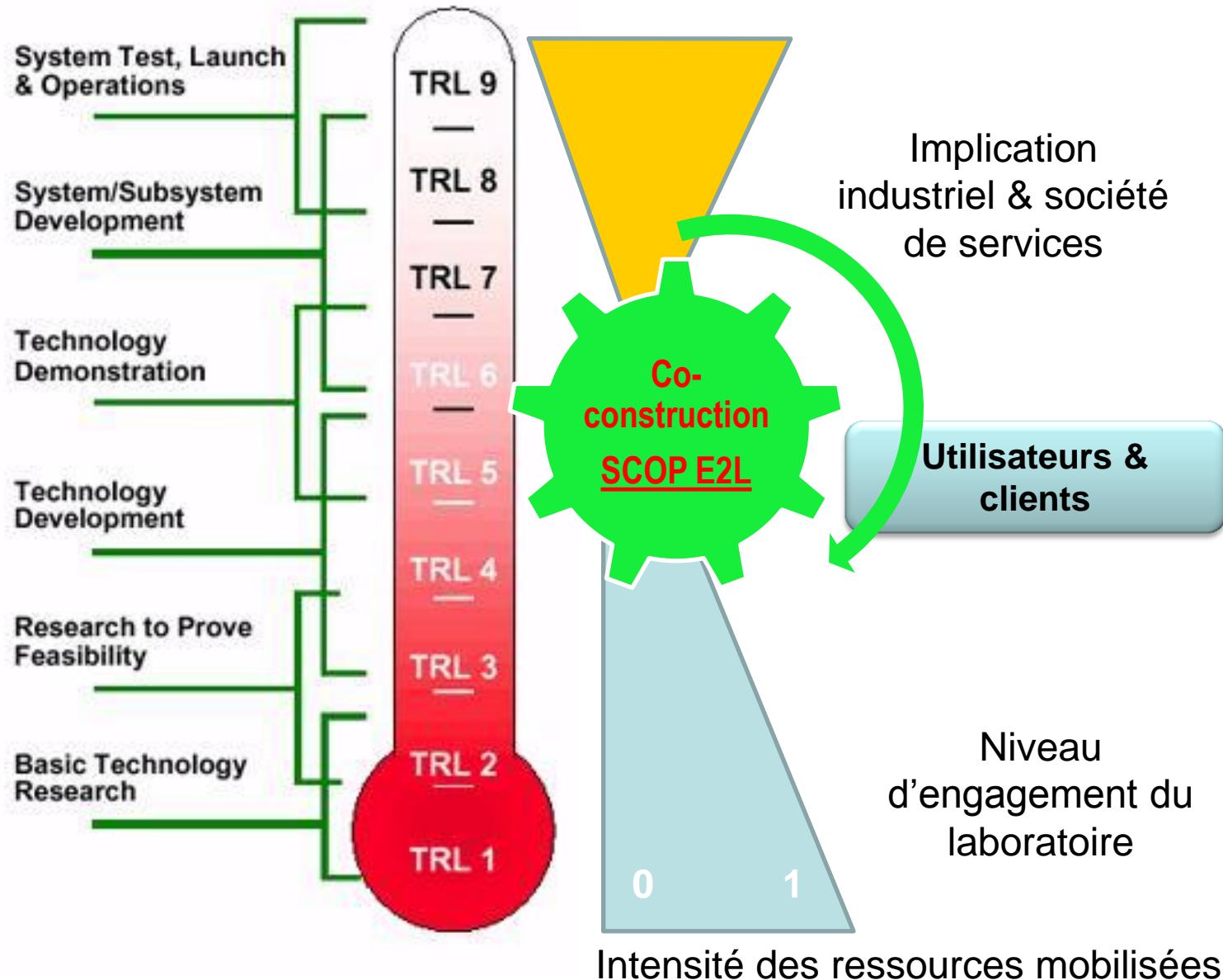
- Un mouvement international autour d'une démarche en construction où les chercheurs jouent un rôle sociétal.**
- De possibles relations nouvelles entre recherche et économie**
- La relation avec le développement territorial**

MENACES

- Risque d'instrumentalisation. (politique, industrielle)
- Juste un effet de mode (buzzword marketing)

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CONCLUSIONS ET PERSPECTIVES

Le programme Européen Copernicus introduit une rupture majeure dans l'utilisation de la télédétection par la recherche et les applications

Pour en tirer tout le potentiel, nécessité d'associer les technologies : Cloud computing, capteurs, IoT, intelligence artificielle

Nécessité également de renouveler les approches : co-construction, open design, open source, Living Labs, ...

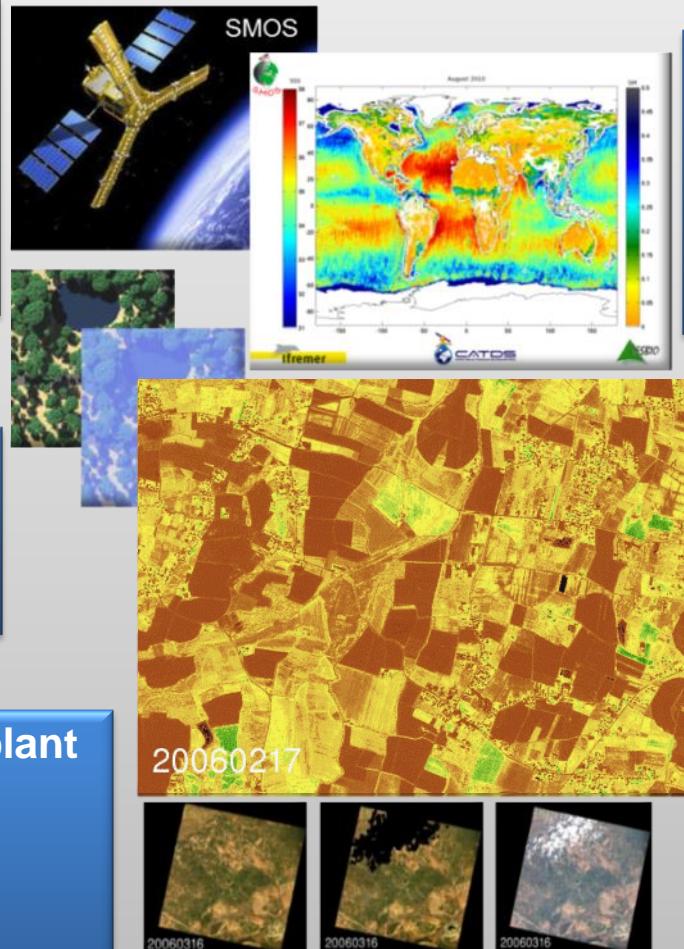
Nouvelles chaines de valeur et business models

THANK YOU

Joint public research laboratory of Toulouse University, CNES, CNRS, IRD Toulouse/Auch/Marrakech/Tunis/Beyrouth
Staff 110

Research: land surface functioning under climate and human activities pressures, with a favoured tool: satellite data

Pluridisciplinary, from plant to satellites:
Ecology, agronomy, remote sensing, physics, applied mathematics ...



Earth Observation missions: from new concepts (SMOS, Venus, BIOMASS) to pre-processing, calibration, validation and applications

University teaching, all levels

Innovation:
collaborative projects with public actors and private companies

A wide-angle photograph of a rural landscape. In the foreground, there are large, golden-brown fields with some darker, greenish areas. A small stream or river flows through one of the fields. In the middle ground, there are more fields and some clusters of trees. The background shows distant hills and a cloudy sky.

Merci de votre attention