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# Monitoring Reporting and Verification issues and technologies for decision makers in the context of carbon sequestration: towards a MRV operational system for soil Carbon monitoring

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Monitoring Reporting and Verification issues and technologies for decision makers in the context of carbon sequestration :  
towards a MRV operational system for soil Carbon monitoring



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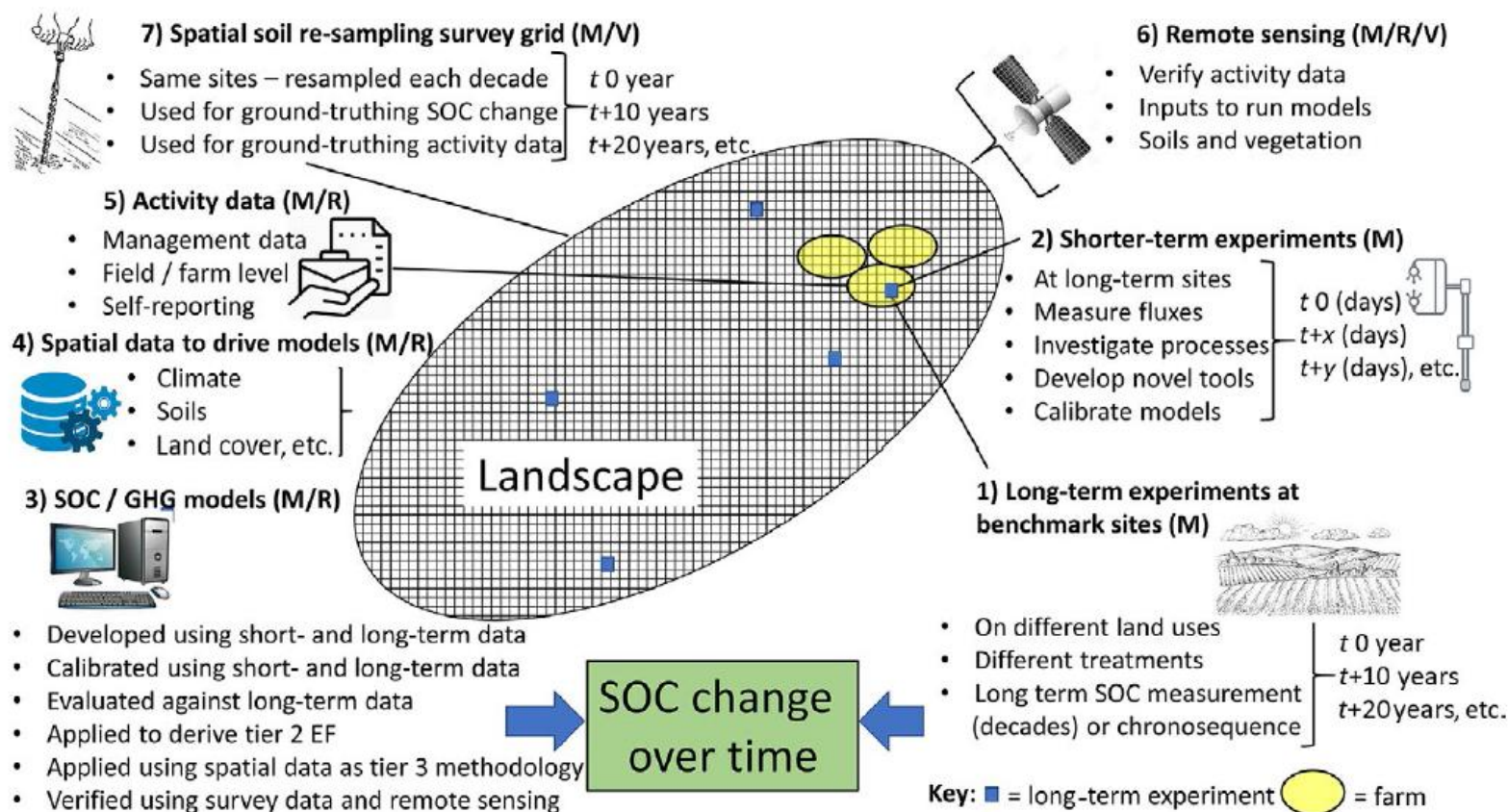
- Growing international interest in better managing soils to increase soil organic carbon (SOC) → contribute to climate change mitigation, enhance resilience to climate change and to underpin food security (e.g. '4p1000' initiative, FAO's Global assessment of SOC sequestration potential programme),
- Yet, changes in SOC content of soils are difficult to measure → key barrier to implementing programmes to increase SOC at large scale,



➡ Need for credible and reliable measurement/monitoring, reporting and verification (MRV) platforms, both for national reporting (NDCs) and for emissions trading.

- Most operational MRV systems allowing national scale quantification are based on in-situ soil sampling networks (reference approach) but heterogeneous protocols (+ uncertainties), low sampling frequency (5-10 yr), expensive, not exhaustive (not all plots monitored)
- ➔ issue for attributing SOC stock changes to specific driver and concerning the suitability of using those networks for monitoring absolute SOC stock changes and for international negotiations,
- On the other hand, for a range of applications (agri-environmental monitoring for the CAP, carbon market...) the development of MRV methods and tools based on the plot scale annual estimation of the C balance and its components (e.g. photosynthesis, biomass inputs to the soil...) is needed.
- Other approaches like soil modeling approaches, direct estimates by remote sensing... have their pros and cons (cost of implementation, operationnality, accuracy, accessibility of the data), and some are easier to implement at large scale than others; also they are rather complementary and to some extent the weakness of one approach can be compensated by the others.

# international MRV framework for Soil Carbon

→ CIRCASA (Smith, Soussana et al., 2019) proposed to combine a range of approaches and suggested a common theoretical framework for MRV at global scale.



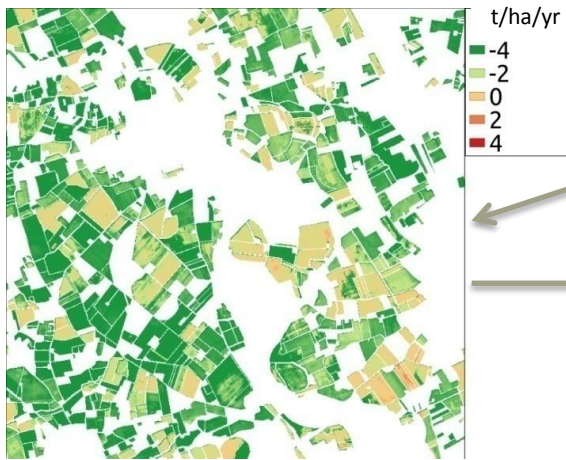
- Many bricks already exist (e.g. COMET-Farm (US) and SIMEOS-AMG (France) as modeling tools for soil C budget and GHG inventories at farm level, international flux tower networks, new generation of high spatial & temporal resolution satellite missions → biomass estimates...),
- ...but need to define an integrated methodological MRV framework and develop tools having:
  - large acceptability & adapted to a large range of stakeholders,
  - meeting the highest scientific standards,
  - the possibility of large scale application (or even global) with comparable/identical protocols/systems of observation (e.g. earth observation),
  - at low cost of implementation,
  - adaptative, with several levels of complexity depending on the context of application (e.g. availability of input data...) → TIERS with TIER 1 being applied everywhere.
- Some MRV prototypes are under development : FiON (Finland), AgriCarbon-EO (France) →  NIVA and Soil Carbon Farming (  eit Climate-KIC ).

The AgriCarbon-EO processing chain (H2020 NIVA project) → 10m resolution annual biomass, CO<sub>2</sub> flux & C budget estimates at regional/national scale

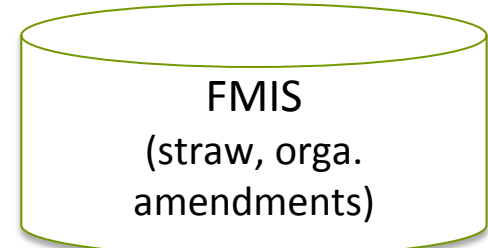
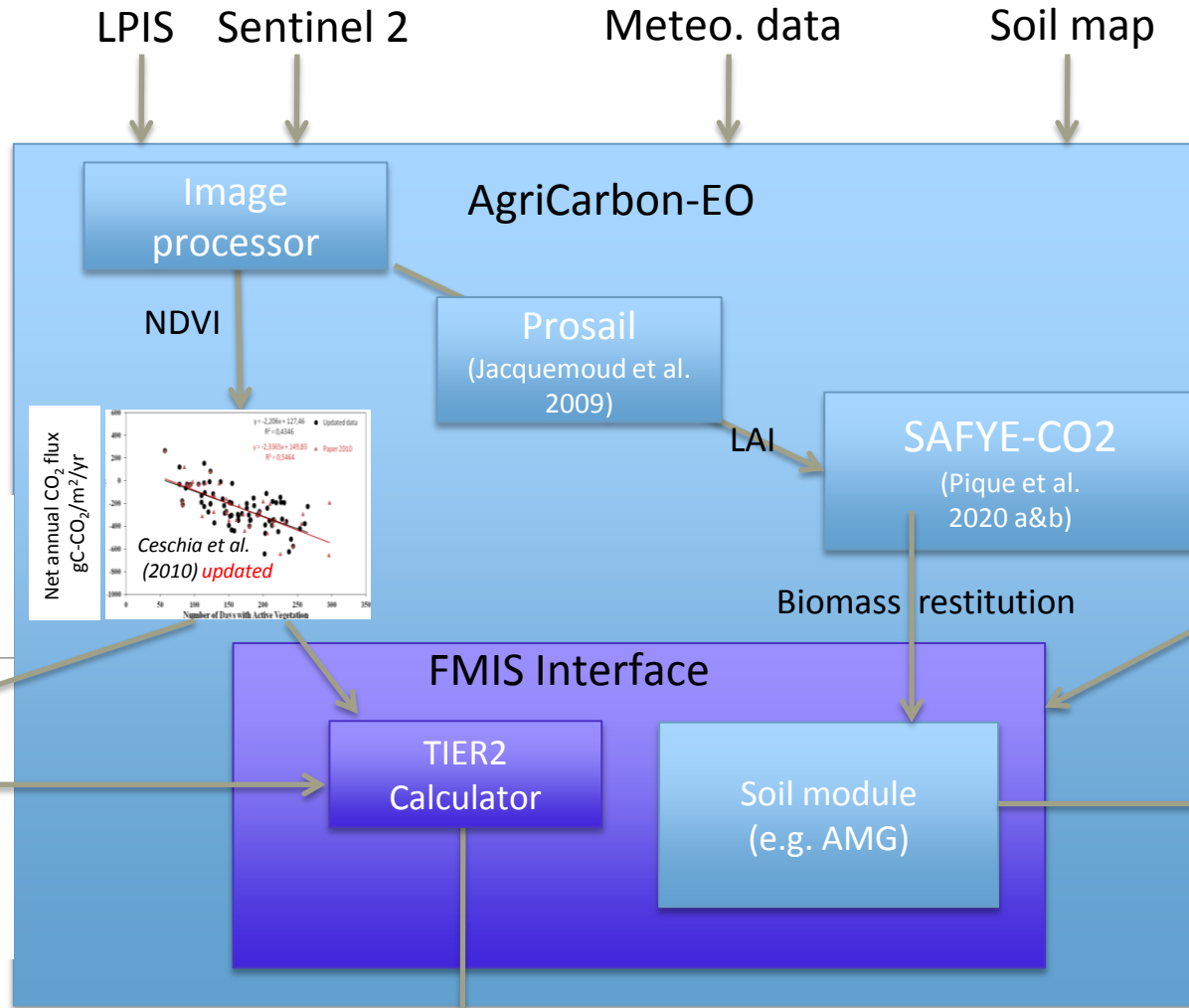
### Level of readiness

- Tested in France
- Under development

All major crops except rice



CO<sub>2</sub> fixation/emission



Pixel scale C budget (gC.m<sup>-2</sup>)



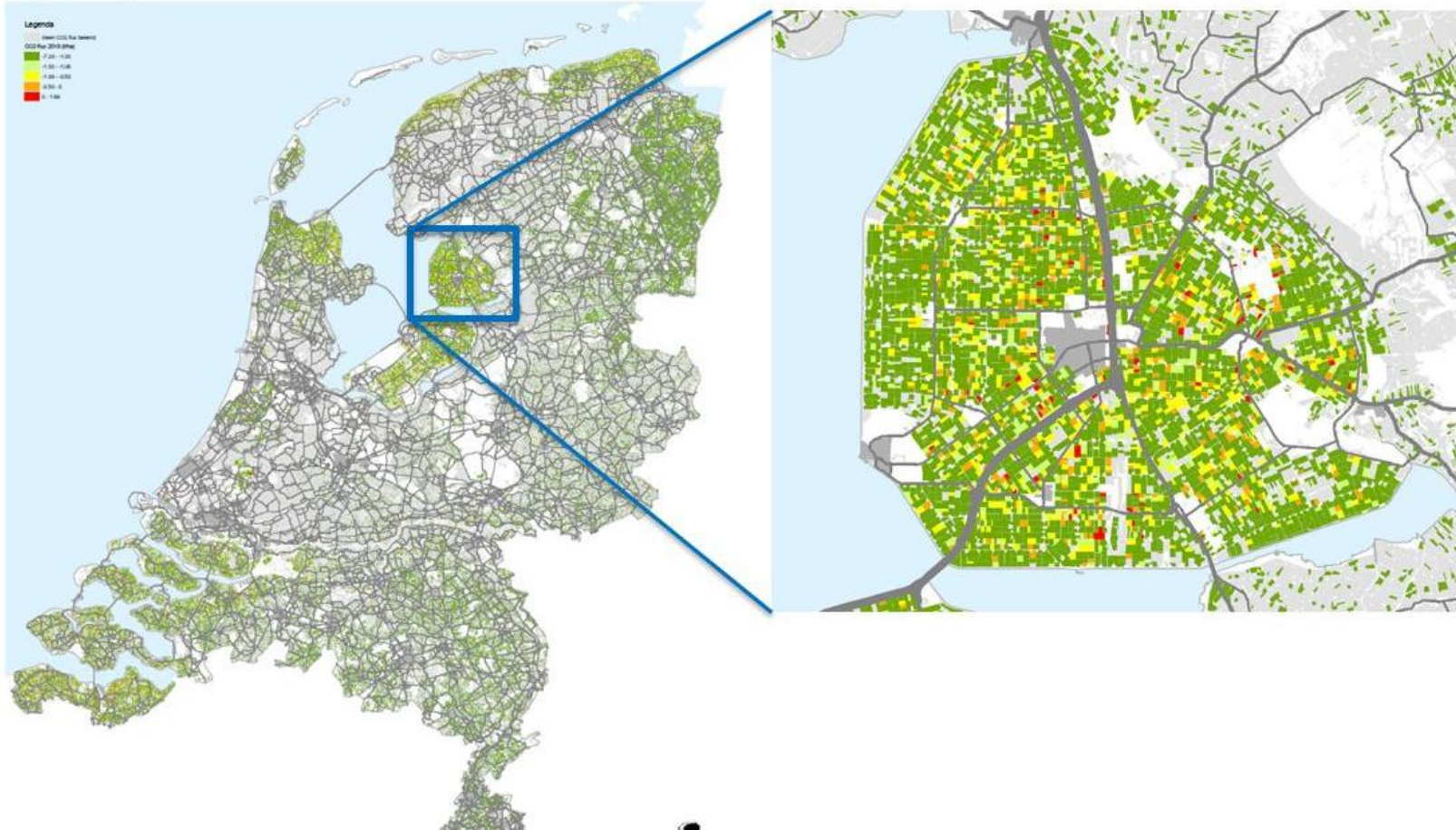
+ uncertainties

TIER 1 plot map (net CO<sub>2</sub> flux)

TIER 2 plot map (C budget)

TIER 3 pixel map (C budget)

Map of the net annual CO<sub>2</sub> fluxes for cropland in 2018 over the Netherlands



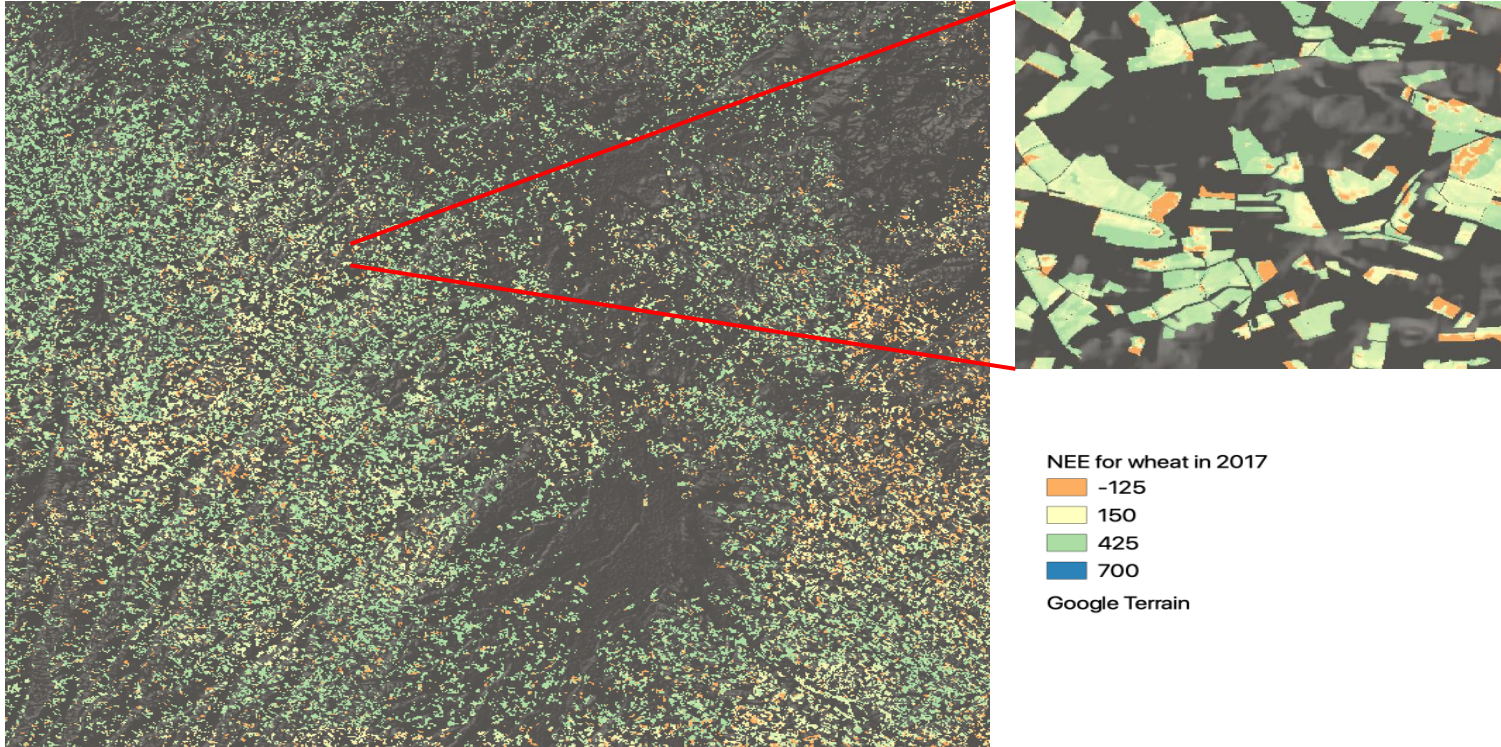
Net annual CO<sub>2</sub> fixation 😊  
Net annual CO<sub>2</sub> losses 😞

In collab with  Ministerie van Economische Zaken en Klimaat  
IGN and ASP for the  NIVA project



# Mapping cropland components of the C budget (Tier 3)

Map of the net annual CO<sub>2</sub> fluxes for straw cereals in 2017 in South West France over an entire Sentinel 2 Tile (31TCJ)



Cover crop biomass → C storage



High resolution C budget map for cover crop/maize/wheat crop rotations at the Bézéril farm



- Method compliant with Verra’s Certified Carbon Standard VCM0042,
- Only parametrised for a few crops species so far.

- The MRV approach/tool should be flexible (possibility to adapt to the context of application) and modular (possibility to change the bricks) → increases the acceptability & accuracy,
- Access to farmer's activity at large scale (needed to calculate SOC stock changes) is a challenge in many contexts → need 1) for coordinated actions relative to farmer's data access, standardisation, consent management...(e.g. AgDatahub) and 2) still produce indicators related to the C budget (TIER 1) that can be implemented easily, at low cost, everywhere (current actions in NIVA and with Planet A),
- Huge volume of data to handle (e.g. remote sensing) & need for intensive computing → dedicate infrastructure, need for sophisticated algorithms for EO data assimilation in the models...,
- Guaranty the security, traceability & transparency of the approach,
- Need to involve a large panel of potential users & stakeholders to define → ensure the largest possible accession.

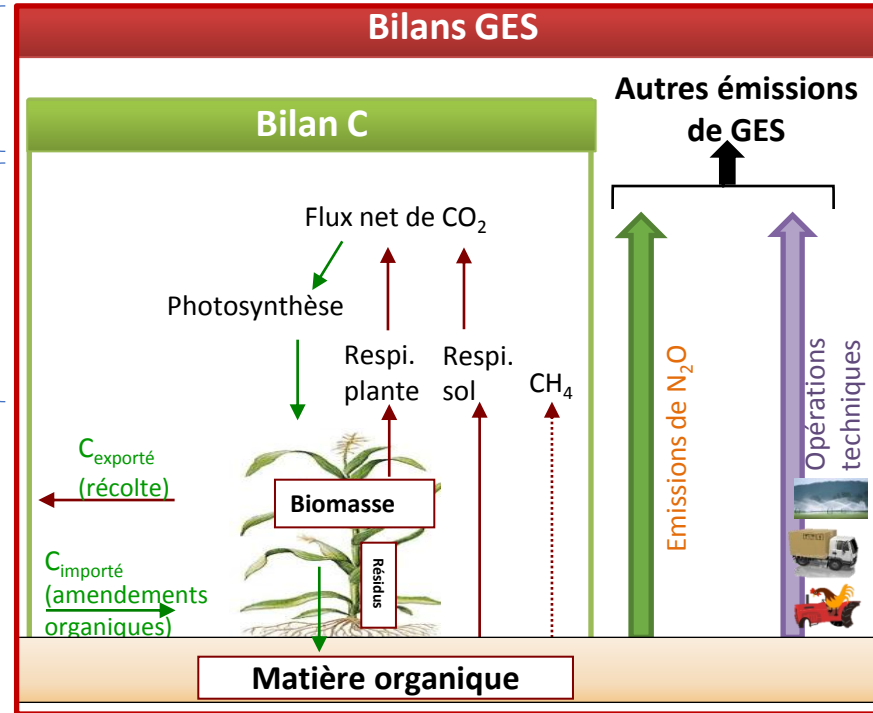
- Large consensus about the need for a coordinated action about MRV for soil carbon  
→ the IRC Soil Carbon should start in 2023,
- A shared vision of which bricks should constitute the MRV methodological framework and several already exist/are operational,
- Need to assemble them and to propose a modular/flexible approach/set of tools adapted to different context of applications, meeting the demand of various potential users/stakeholders (e.g. NGOs, companies involved in the C market)
- But many technological challenges yet to overcome → need for a major technological breakthrough supported by an international action involving research agencies, space agencies, private foundations and companies as well as a large panel of scientists.

**Thanks for your attention**

Rappel : bilan GES, bilan carbone (C) et flux de CO<sub>2</sub> quelle différence ?

Le Label bas C s'intéresse au bilans de C et de GES des parcelles agricoles

L'indicateur SOCCROP quantifie le flux net annuel de CO<sub>2</sub> des grandes cultures

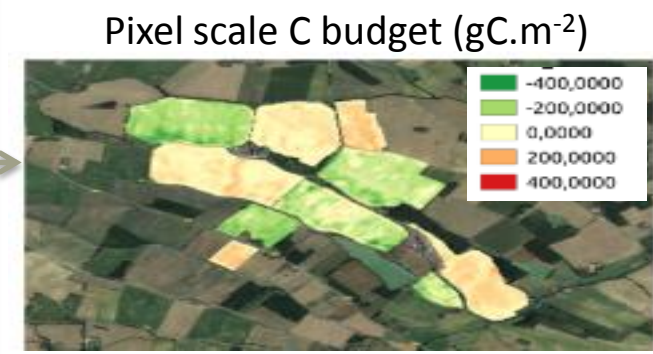
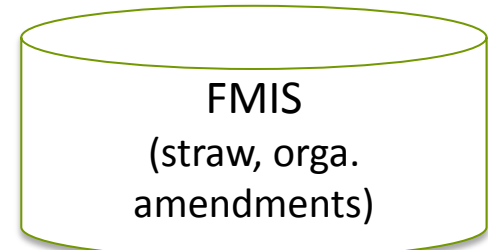
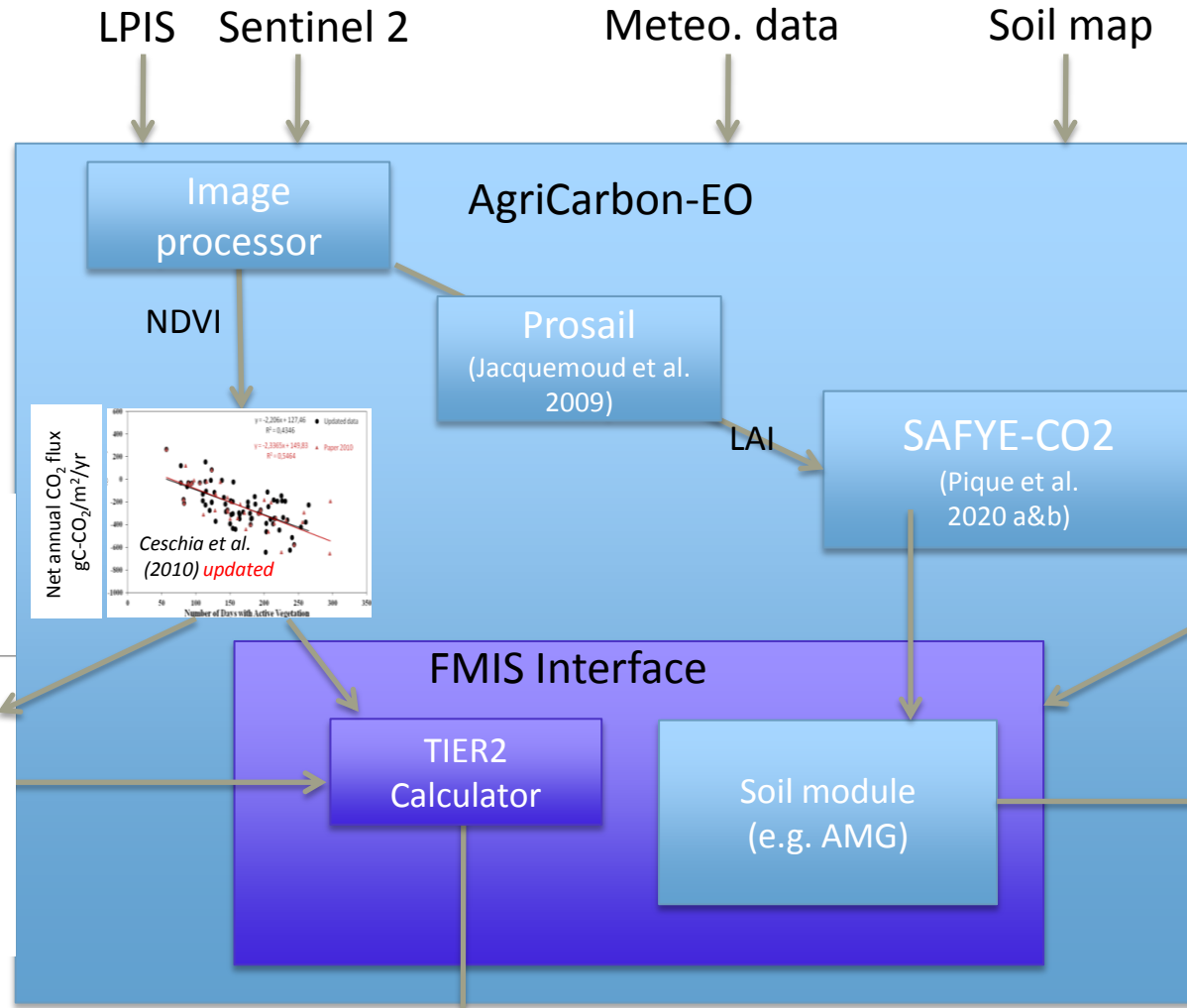
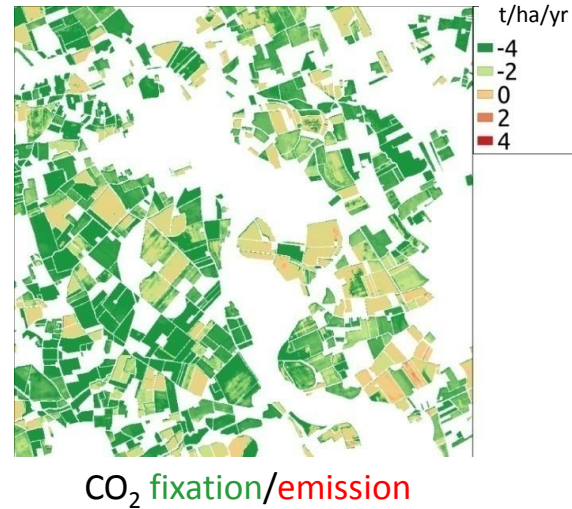


Le bilan de carbone représente la variation de stock de C présent dans la matière organique du sol entre le début et la fin d'une période que l'on définit (année culturale, rotation de culture...). C'est comme un compte en banque avec des entrées et des sorties : flux verticaux de CO<sub>2</sub> et de biomasse (incorporation des résidus dans le sol, flux latéraux de matière organique (récolte, amendements organiques)).

# Carbon budgets tools

## Level of readiness

- Tested in France
- To be developed



TIER 1 plot map (net CO<sub>2</sub> flux)

TIER 2 plot map (C budget)

TIER 3 pixel map (C budget)