MEO-Carbon: A Multi-Scale EO-Based Tool for Monitoring and Assessing Carbon Sequestration from Land Use Change and Farming Practices

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Earth monitoring services

MEO-Carbon

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AGENDA

- Compagny presentation
- Climate Urgency and the Need for High-Resolution Spatial Tools
- Methodology Overview
- Meo-Carbon results in Dep-13(France)
- Limits & Perspectives
- Conclusion

Company presentation

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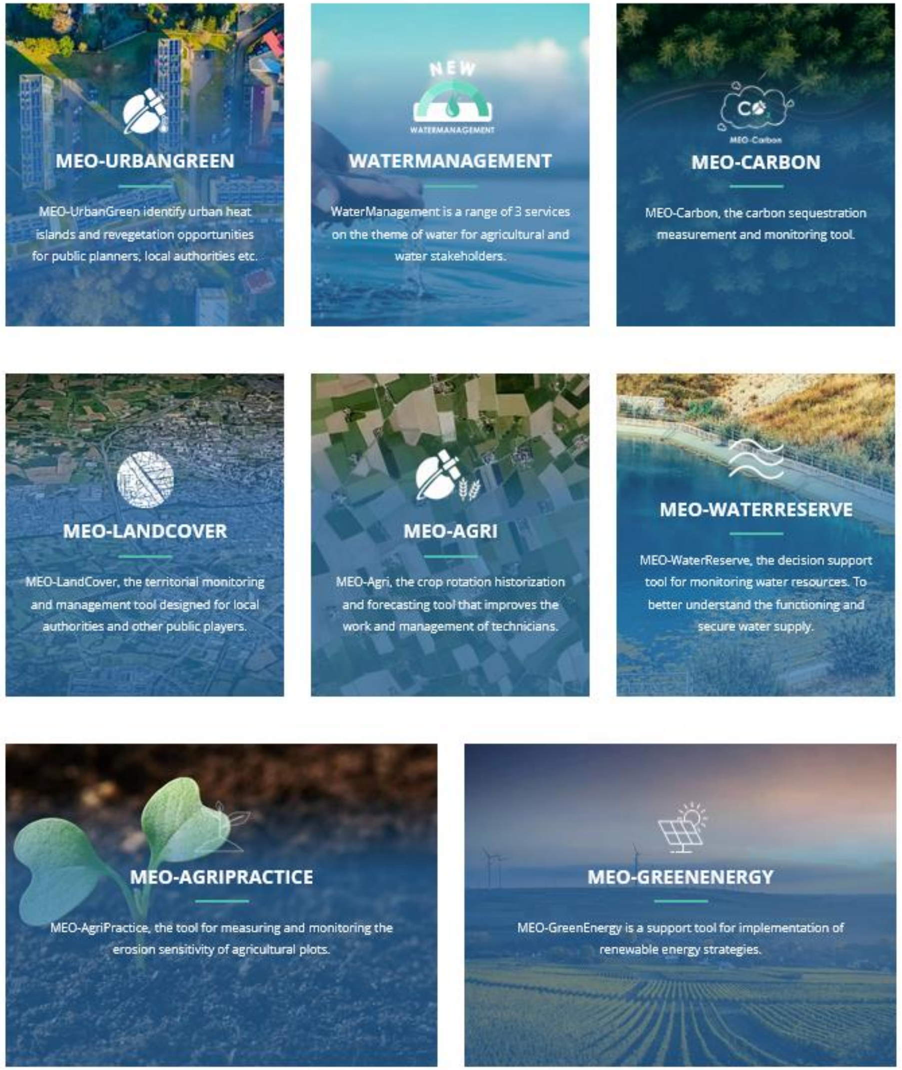
Toulouse | France

Development of **climate services** based on satellite data & Artificial Intelligence (AI)

Work focused on the **observation** component of satellite techniques (optical and radar)

Climate change monitoring and adaptation: Water Management, Carbon Stocks & Flux Land Cover & Use…

Multidisciplinary and complementary team
16 employees with 50 % women



Ecosystem & main partners

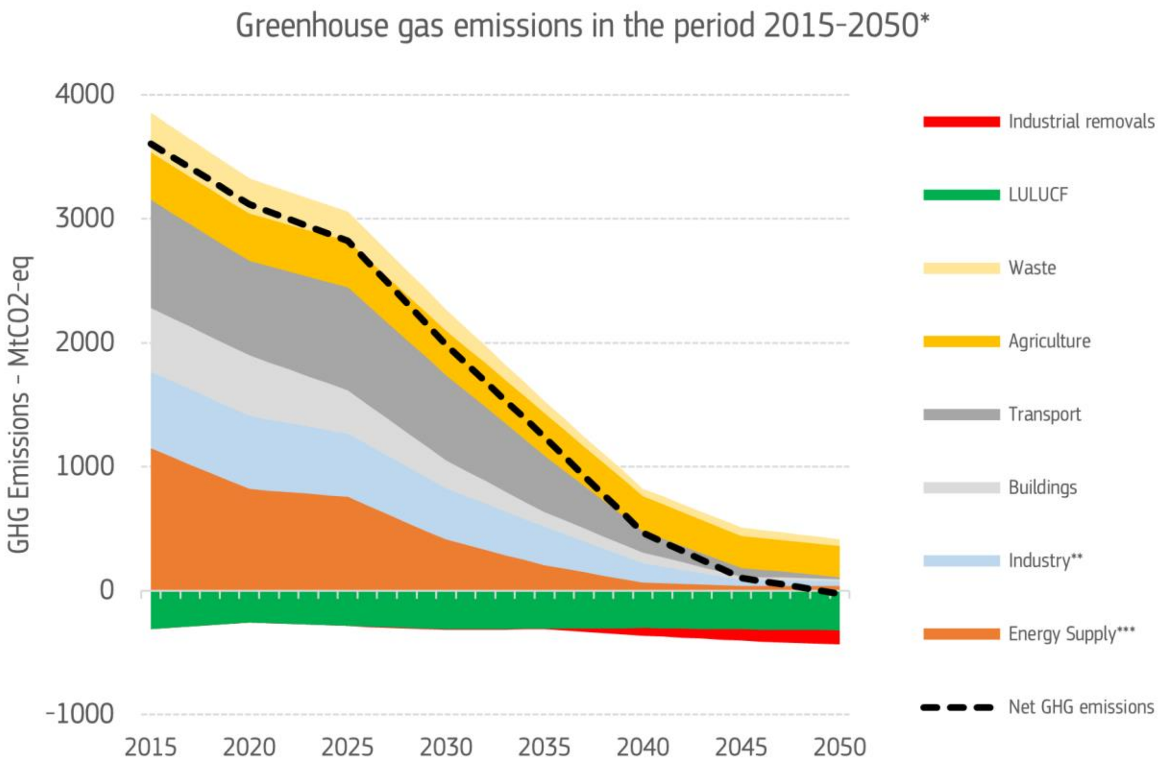
esa | cnes | Copernicus accelerator | CESBIO | SCO SPACE FOR CLIMATE OBSERVATORY | FRANCE Water Team Pôle de compétitivité de la filière de l'eau | La FRENCH TECH | GREENTECH INNOVATION

Climate Urgency and the Need for High-Resolution Spatial Tools

Why We Need Spatial Carbon Tools — From Climate Targets to Local Action

- **Reaching carbon neutrality requires more than cutting emissions**
  → It also means increasing natural carbon sinks like forests, soils, and hedgerows
- **Ecosystems are under growing pressure**
  → Climate and land use changes reduce their ability to store carbon and support biodiversity
- **We need to know where carbon is gained or lost**
  → Monitoring carbon dynamics requires clear, spatially explicit information
- **Existing land cover data is often outdated or too generic**
  → This limits its usefulness for climate-oriented planning

MEO-Carbon bridges the gap
→ It links land cover change to carbon stocks and fluxes, helping target actions more effectively



*Source: PRIMES, GAINS, GLOBIOM
**Excluding non-BECCS industrial removals
***Including Bioenergy with carbon capture and storage (BECCS)

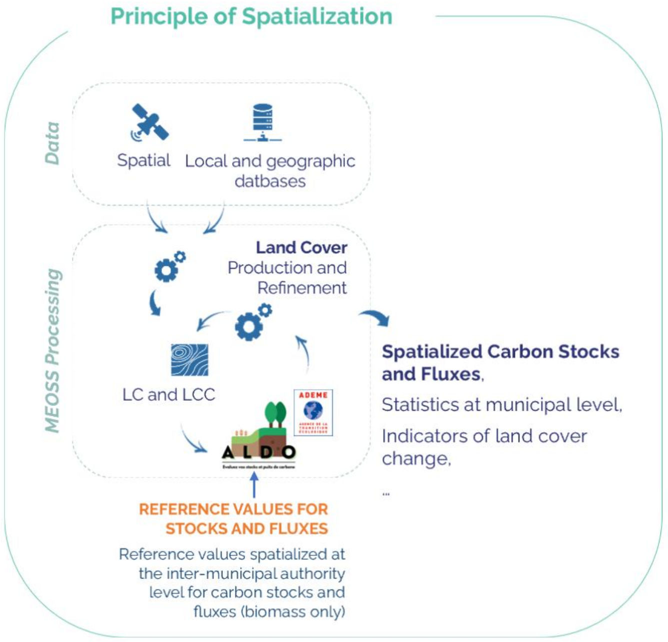
Source: Commission impact assessment

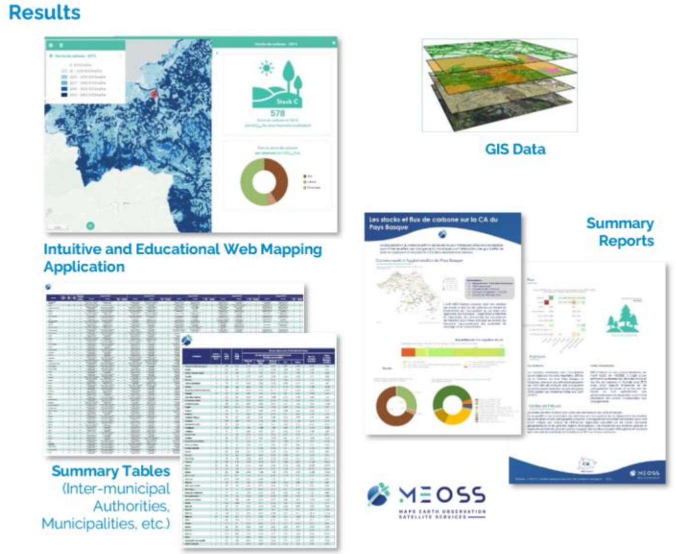
MEO-Carbon: Methodology Overview

MEO-Carbon consist in two components:

- **Core system - produces spatialized maps of carbon stocks and fluxes**
  - **LC maps** Combine high- and very-high-resolution satellite imagery (Sentinel-2, Pléiades, HRL) with national geospatial datasets (BD TOPO, RPG…).
  - **Spatialized carbon stocks and fluxes** Estimation of stocks and fluxes is performed with the ***ALDO tool (ADEME)***, ensuring robust and comparable quantification across territories

- **Farming practices - quantifies additional, practice-driven carbon contributions**
  - **Cover Crops** Map current/potential from Sentinel-2 images: estimates or simulates biomass from weather data using ***AgriCarbon-EO (CESBIO)*** and converts to soil carbon.
  - **Agroforestry potential** Identify parcels suitable for agroforestry, classifying potential as high / good / moderate based on land use and soil criteria (non-saline, non-hydromorphic soils, soil depth, extractable water reserve).
  - **Hedgerows mapping** Detect linear woody features with ***HedgeTools (Dynafor)*** using Ortho IRC and a DHM, and quantifies additional carbon stocks





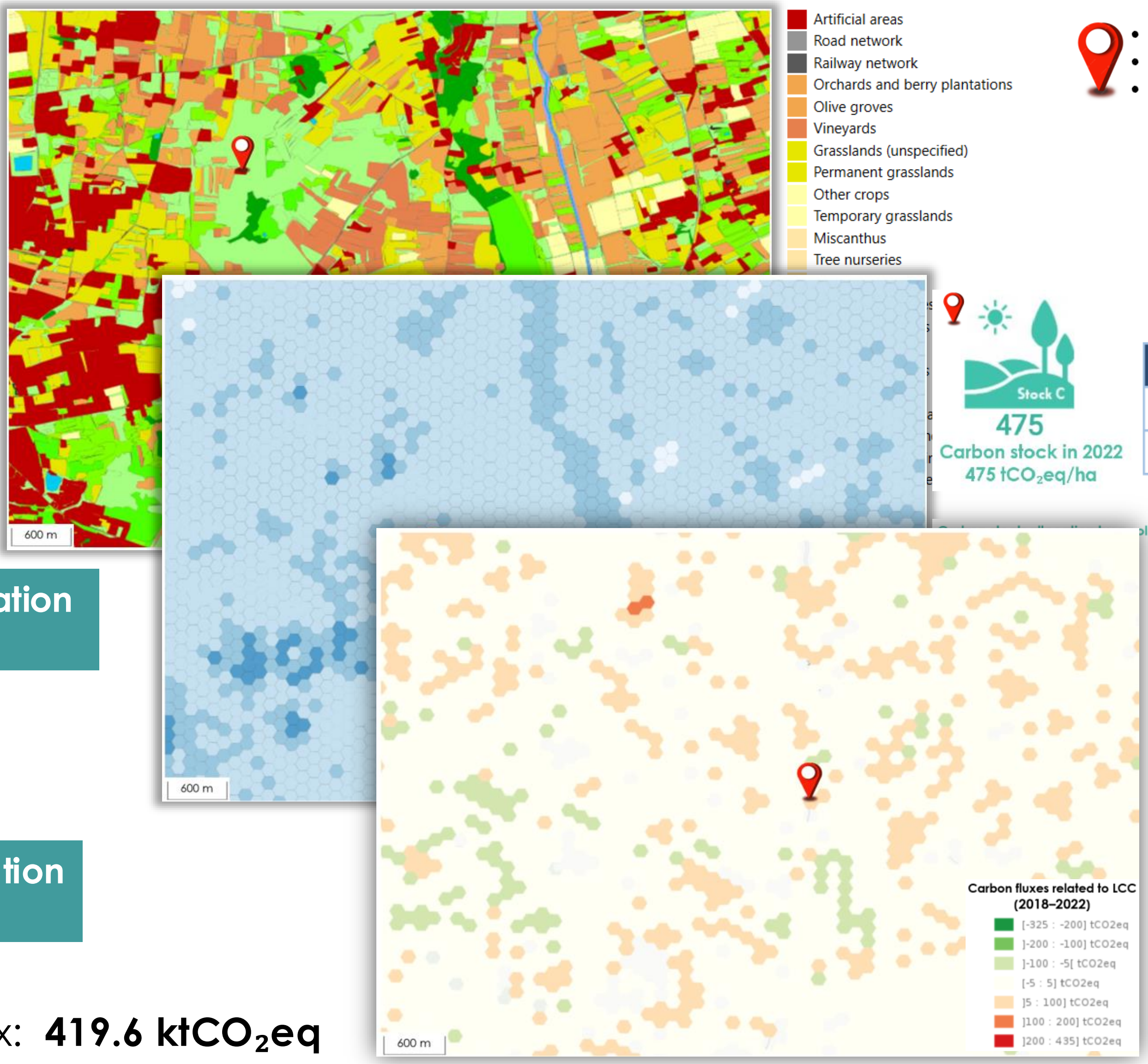
Core: Land cover, carbon stocks and fluxes

Landcover maps

- For 2 reference years (ex : **2018 & 2022**)
- Minimum Mapping Unit : **500 m²**
- Processed area : **5087 Km²**

Carbon stocks spatialization (1-ha cells)

Carbon fluxes spatialization (1-ha cells)



- Total flux: **419.6 ktCO_2eq**

- **Impermeabilized soils: 26 %**
- **Grass-covered soils: 69 %**
- **Tree-covered soils: 5 %**

Stock C
475
Carbon stock in 2022
475 tCO_2eq/ha

Department-level Carbon Stocks

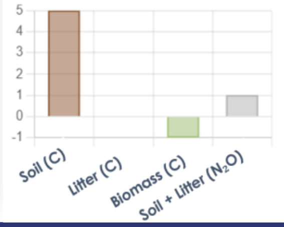
	Carbon stocks per pool (MtCO_2eq)				
Year	**Soil**	**Litter**	**Biomass**	**For. Biomass**	**Total**
2018	127	4,7	5	20	156,7
2022	129,2	4,9	5,4	21,3	160,8

Carbon and N_2O Fluxes from LCC, 2018–2022

Cell major change:
vineyards => grassland

+ 5.19
Carbon flux 2018–2022, excluding annual fluxes related to forest biomass (in tCO_2eq)

Breakdown of total flux by carbon pool (in tCO_2eq)



	Forests	Grasslands	Crops	Orchards	Vineyards	Wetlands	Artif. areas	Imperm. soils	Other
Forests		18	2	1	2	-8	121	10	
Grasslands	-47	59	41	-2	5	-102	78	10	
Crops	-4	-34		-5	-3	-34	-17	0	
Orchards	-1	58	8		3	-1	32	0	
Vineyards	-1	7	1	-0		-1	1	0	
Wetlands	43	252	18	2	1		4	2	
Artif. areas	-4	62	2	-0	1	-10		14	
Imperm. soils	-0	-1		-0	-0	-2	-9		
Other	-24	-61	-2	-1	-1	-18	-42	-2	

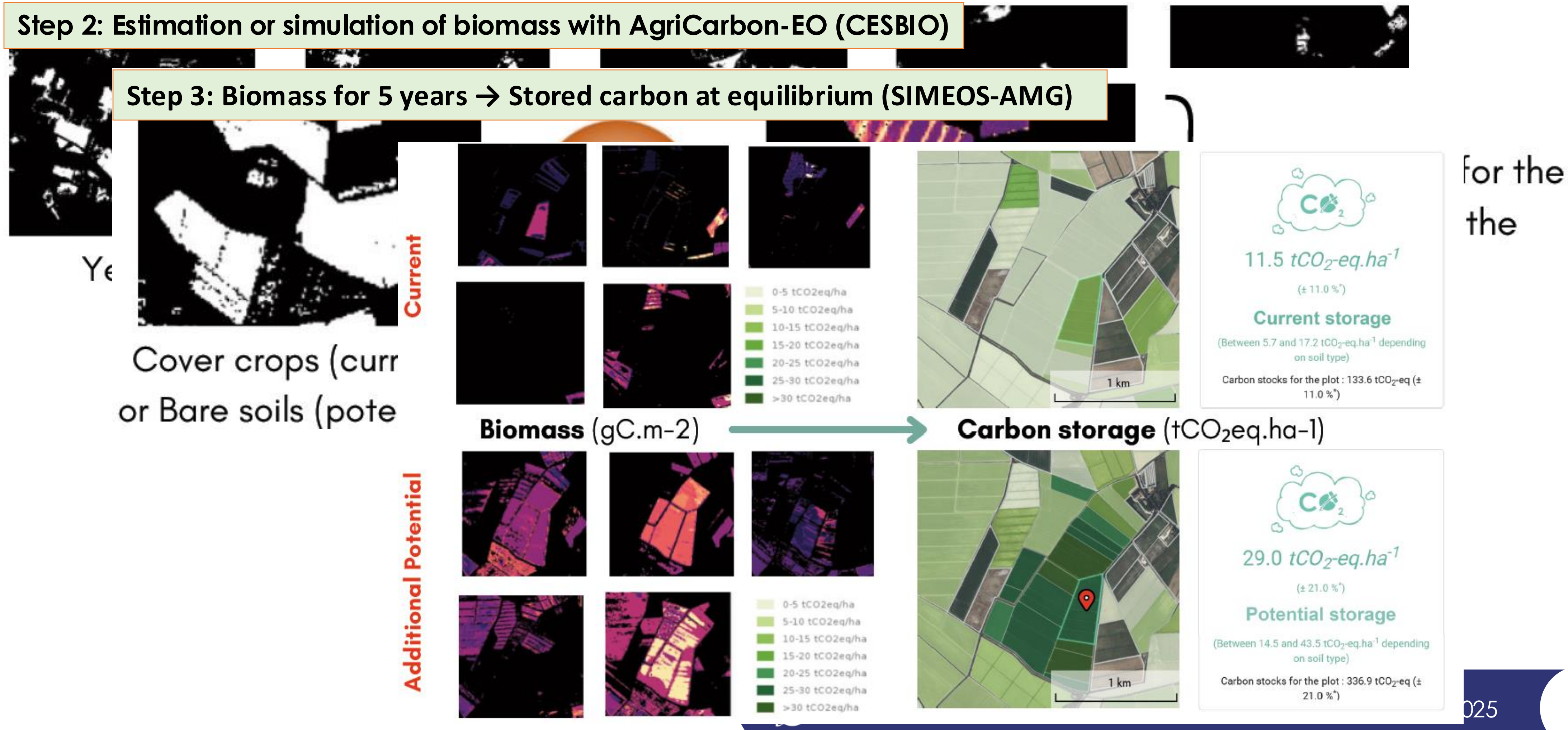
Farming practices

A - Cover Crop : current and potential carbon storage

Step 1: Detection of current and potential cover crop areas

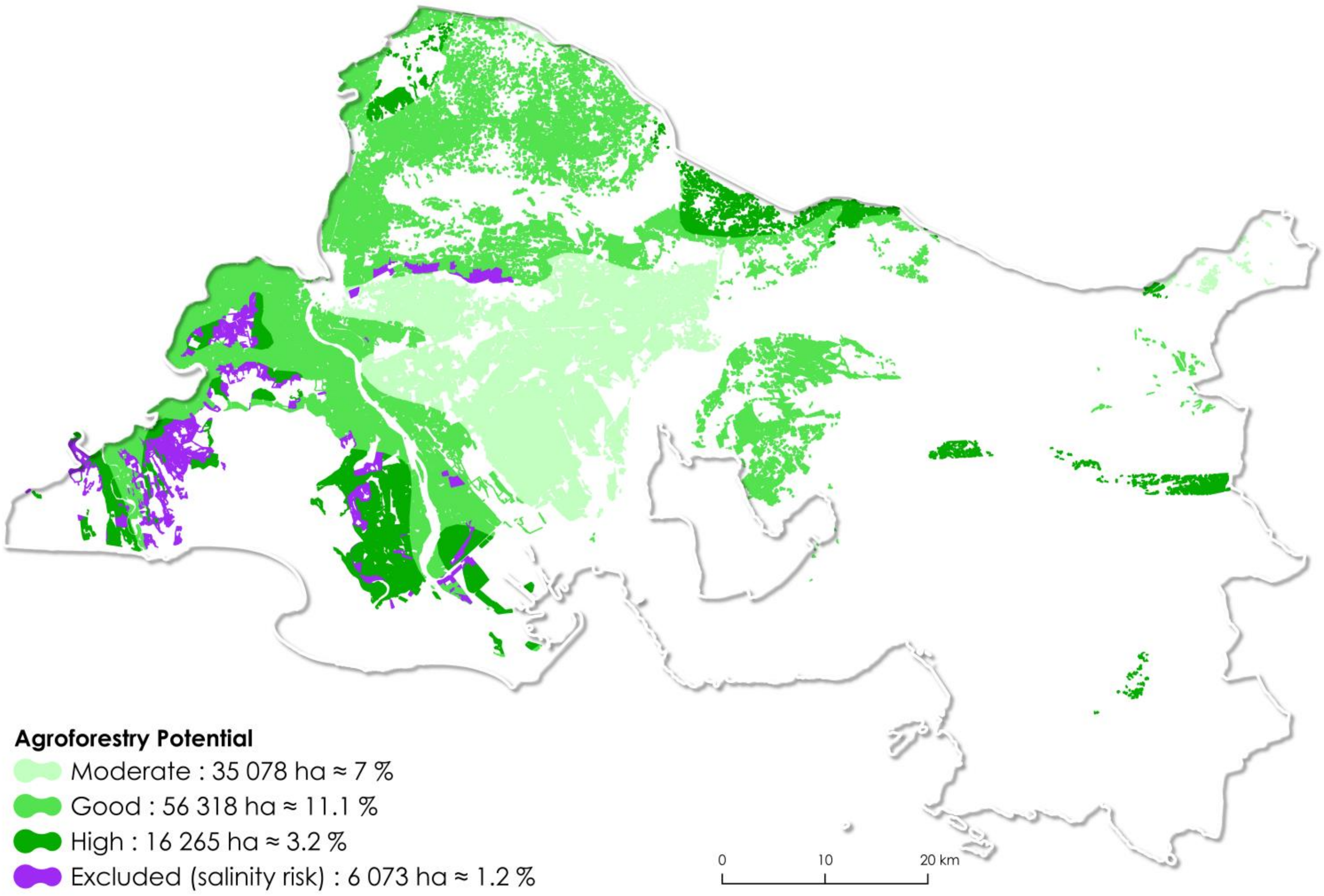
Step 2: Estimation or simulation of biomass with AgriCarbon-EO (CESBIO)

Step 3: Biomass for 5 years → Stored carbon at equilibrium (SIMEOS-AMG)



Farming practices

B - Agroforestry potential : Suitable parcels and gain pathways



- **Maps suitable parcels** for tree-based systems (*Moderate*, *Good*, *High*)
- **Adapts to local constraints**, e.g. salinization risk near the coast (< 1 m elevation)
- **Guides advice and funding** toward the most promising locations
- **Monitors vegetation dynamics** via satellite imagery and targeted field checks
- **Avoids double counting** with existing hedgerows

Farming practices

C - Hedgerows detection : Status, trends, and densification potential

- **Mapped as linear features,** converted into carbon stocks (biomass + soil) → e.g. ***59 m/ha ≈ 25 tCO_2eq***
- **Tracks change between 2018 and 2022** → losses, new plantings, active sequestration
- **Identifies densification potential** → available space for new hedges (verges, field edges, corridors)
- **Supports decision-making** → restoration (filling gaps) vs. extension (new links), with co-benefits
- **Toward better carbon accounting** → improving biomass estimates, documenting management, avoiding double counting

Limits & Perspectives

- **Challenges:**
  - Data availability (especially for soil and agricultural practices)
  - Uncertainty in carbon estimates (linked to local variability)
  - Need for field validation and stakeholder calibration

- **Next steps:**
  - Integration into regional platforms and territorial observatories
  - Extension to more regions and European partners
  - Cover crops: integration of soil maps to refine the conversion of biomass into stored carbon

Conclusion

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MEO-Carbon

- **MEO-Carbon** is not just a carbon mapping tool ➔ it's a modular, science-based platform that brings **spatial intelligence** to climate-oriented land use decisions.

- By linking satellite observations with proven carbon models and thematic layers, it offers a unique capacity to support **realistic, place-based climate strategies**.

"Better land-use decisions start with better spatial knowledge
➔ MEO-Carbon turns data into action."

Main References

- ADEME. (2021). Carbocage : Vers la neutralité carbone des territoires. Récupéré sur https://librairie.ademe.fr/changement-climatique-et-energie/36-carbocage-vers-la-neutralite-carbone-des-territoires.html
- ADEME. (2023). Récupéré sur Documentation Aldo: https://docs.datagir.ademe.fr/documentation-aldo
- Bachevillier, L., & al. (2015). L'agroforesterie : un outil carbone pour les PCET - Mettre en placeune démarche d'agroforesterie sur le territoire d'un PCET. https://www.researchgate.net/publication/303672021_L'agroforesterie_un_outil_carbone_pour_les_PCET_-_Mettre_en_place_une_demarche_d'agroforesterie_sur_le_territoire_d'un_PCET
- Martel, S., Mousset, P., Grimault, J., Bourdareau, H., & Tronquet, C. (2025). Le Label Bas-Carbone.
- Wijmer, T., Al Bitar, A., Arnaud, L., Fieuzal, R., & Ceschia, E. (2024). AgriCarbon-EO v1. 0.1: large-scale and high-resolution simulation of carbon fluxes by assimilation of Sentinel-2 and Landsat-8 reflectances using a Bayesian approach. Geoscientific Model Development, 17(3), 997-1021.

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THANK YOU FOR YOUR ATTENTION !

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