Updates and lessons learned from the **French spatially explicit approach** for LULUCF inventories

Mélanie JUILLARD

melanie.juillard@citepa.org

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Citepa

1 Current reporting state

Land monitoring, and representation in LULUCF

Current reporting state

Before NGHGI edition 2023 :
Land use change detection based on field survey

“Teruti LUCAS”

Since 2023 submission:
Geographically explicit monitoring

= combination between EO data and spatialized (geographic) statistical data

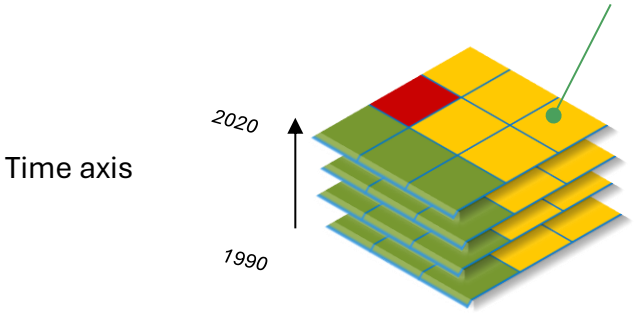
- **Implemented** to comply with LULUCF Regulation UE 2018/841
- 3 existing versions for **2023**, **2024** and **2025** submissions
- 4th version ongoing for the next inventory

Model overview

- Systematic gridded model for land use change monitoring & resulting carbon stock changes

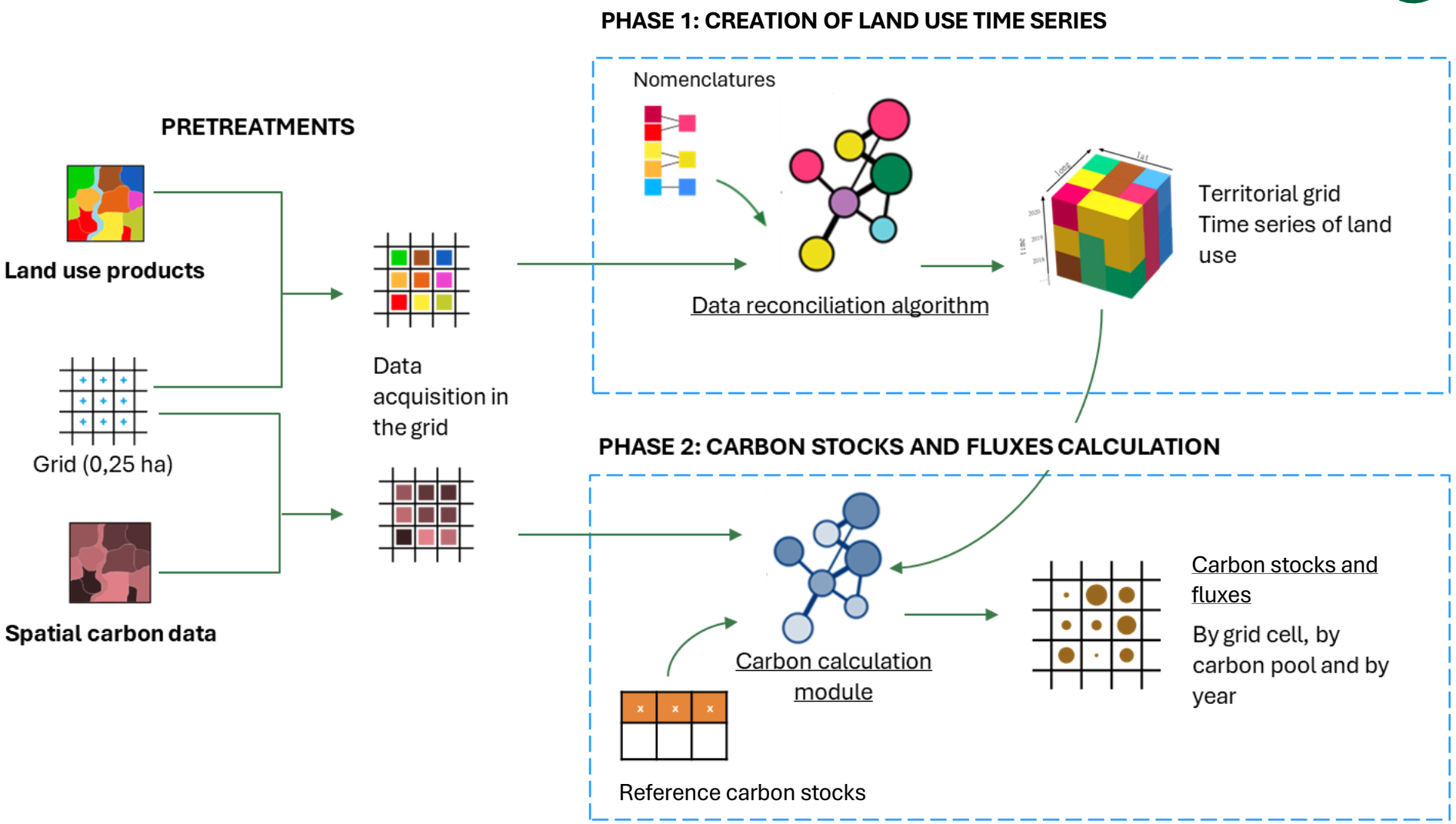
- Basic mapping unit : 0,25 ha grid (220 M° cells)

0,25 ha cell : 50m * 50m, and their centroids



→ Allows to easily collect any kind of spatialized data for each centroid : land use ; specific carbon stocks ; regional management practices ...

Model overview



Products integrated

Data	Data producer	Product year	Perimeter	Pertinent use	Continuous or discontinuous
BD Forêt (national forest maps)	IGN	*variable*	*National*	*Forests*	*only covers forest lands*
RPG (« LPIS »)	IGN	2010 to 2022	*National*	*Agricultural lands*	*only covers agricultural lands*
Urban Atlas & change map	CLMS	2006-2012, 2012-2018 (& annual : 2018)	European	*Settlements*	*Continuous, but only available for urban areas*
Corine Land Cover change map	CLMS	1990-2000, 2000-2006, 2006-2012, 2012-2018	European	*all*	*Continuous*
Natura 2000 & change map	CLMS	2006-2012, 2012-2018 (& annual : 2018)	European	*Natural areas*	*Continuous, but only available for specific areas*
Bdcarto	IGN	2018	*National*	*all*	*Continuous*
BDtopage	IGN OFB	2024	*National*	*Wetlands*	*Discontinuous*
BDtopo	IGN	2024	*National*	*Settlements*	*Discontinuous*

Nomenclature

72 sub-classes

3 levels of nomenclature

Cross reference tables created for each land use input data set

Why these categories ?

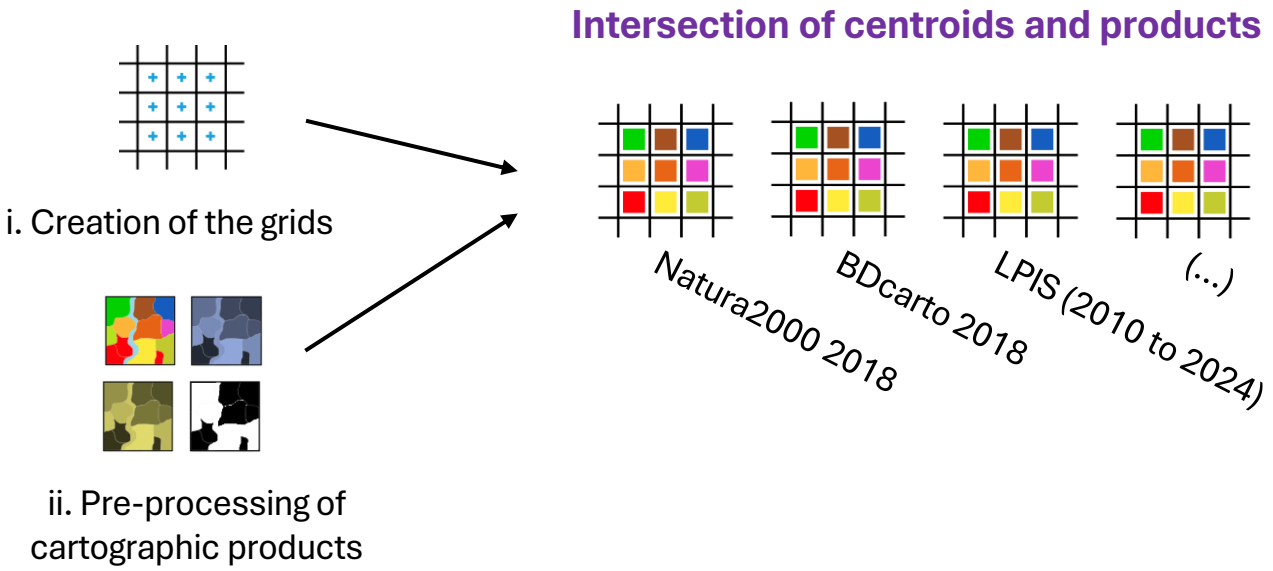
→ Distinction of a subcategory when a carbon stock / or management practice statistic is available and relevant for the carbon calculations

Niveau 1 (usage général)			Niveau 2 (usage précis)			Niveau 3 (occupation) - utile pour le calcul	
1		Agricole	10		Agricole à définir	100	Agricole indéfini
			11		Cultures annuelles, légumes et fleurs	110	Cultures annuelles, légumes et fleurs indéfinies
						11bh	Blé tendre d'hiver
						11bp	Blé tendre de printemps
						11dh	Blé dur d'hiver
						11dp	Blé dur de printemps
						11cz	Colza
						11ah	Avoine d'hiver
						11ap	Avoine de printemps
						11lf	Légumes ou fleurs
						11be	Betterave industrielle
						11cf	Choux, racines et tubercules fourragers
						11ci	Autres cultures industrielles
						11ls	Légumes secs
						11mf	Maïs fourrage
						11mg	Maïs grain
						11oh	Orge d'hiver
						11op	Orge de printemps
						11xc	Autres céréales
						11pf	Plantes à fibres
						11pg	Pois protéagineux
						11pm	Pomme de terre
						11sh	Seigle d'hiver
						11so	Sorgho

2 General description

Land use model description

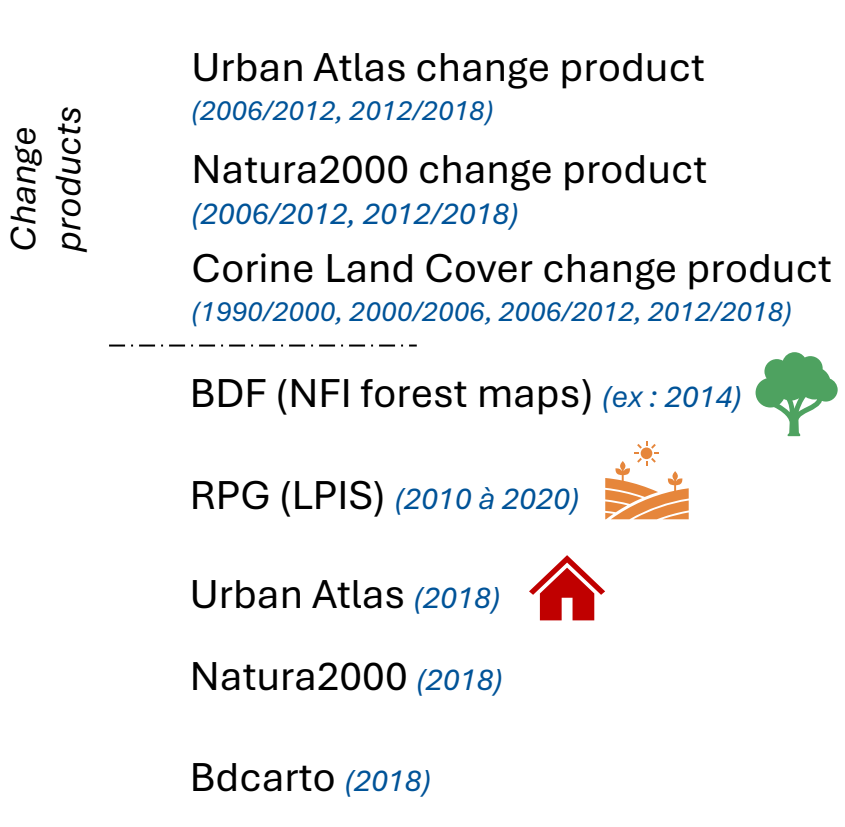
Step 1 : Intersection of centroids with products to collect land use information



Land use model description

Step 2 : Assignation of a reference use for each centroid, based on available information, and a hierarchy established between products

The reference land use of the centroid is set as the highest ranked product usage available for the centroid.

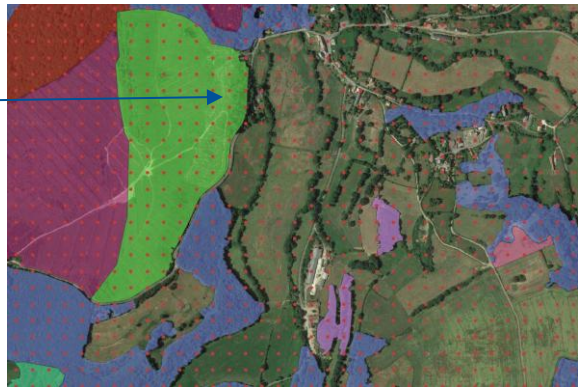


Product hierarchy

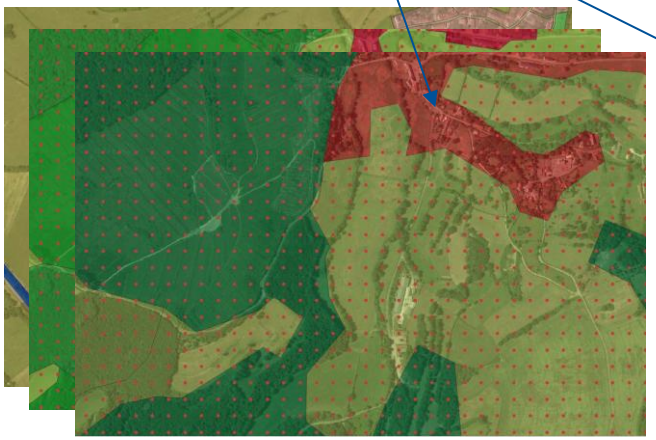
Chosen due to the hierarchy of IPCC LULUCF land use classes definitions, and the relevance of the products

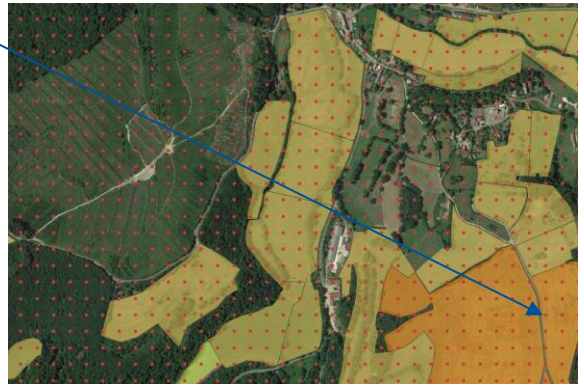
Land use model description

- Example of land use product used



Discontinus and highly relevant **for forest land use** :
'BD Forest' *(French national forest inventory)*





Discontinus and highly relevant **for agricultural land use** :
LPIS data *(used for CAP declarations)*

Continus products (Copernicus : Urban Atlas, Natura 2000 -when available on the area-, Corine Land Cover) ; Bdcarto (French generalist product)
for settlements and the remaining unfilled areas

Land use model description

Change products

Urban Atlas change product *(2006/2012, 2012/2018)*

Natura2000 change product *(2006/2012, 2012/2018)*

Corine Land Cover change product *(1990/2000, 2000/2006, 2006/2012, 2012/2018)*

BDF (NFI forest maps) *(ex : 2014)*

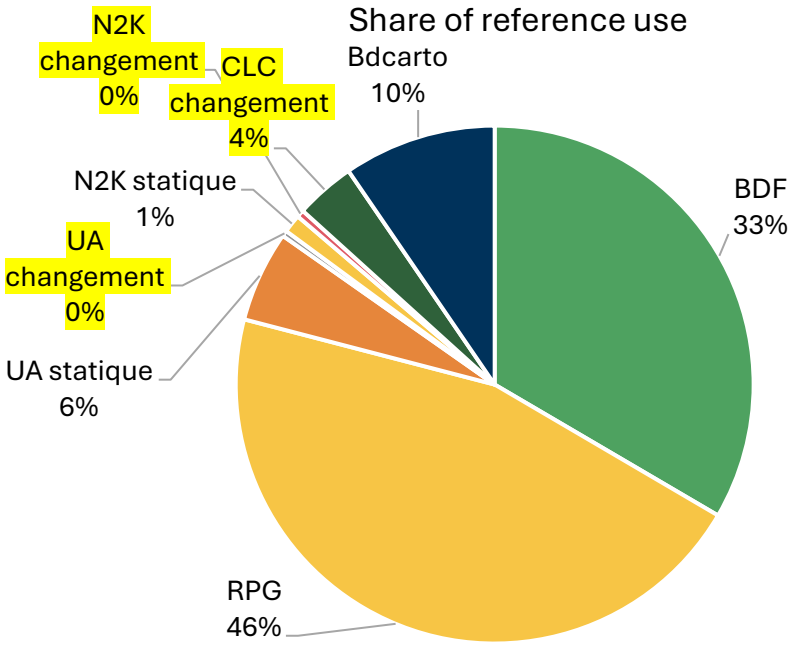
RPG (LPIS) *(2010 à 2020)*

Urban Atlas *(2018)*

Natura2000 *(2018)*

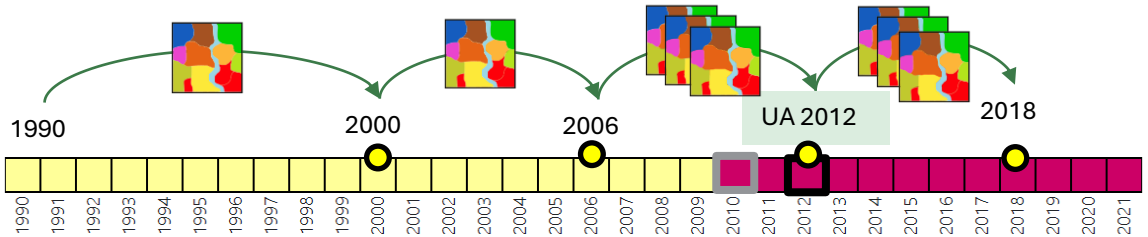
Bdcarto *(2018)*

5% of centroids with a change detection by CLMS product at least once since 1990



Application of CLMS change products

Step 3 : Land use change application by period for the relevant centroids thanks to the CLMS change products (Urban Atlas, Natura2000, CLC)



xx Product used to determine the reference use

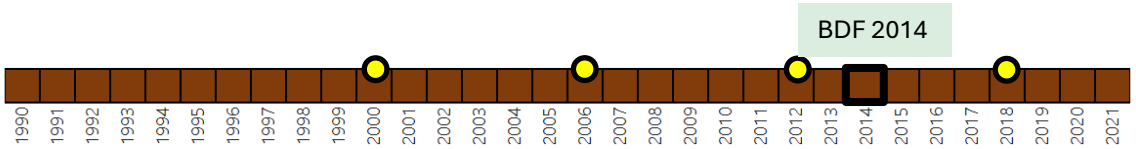
Reference year

Year of change

Compatibility checks

CLMS Change product

- Change detection by change products for each sub-period (2012-2018; 2006-2012; 2000-2006; 1990-2000)
- Application of changes : a year of change is picked randomly within the sub-period



- When no change is detected the land use is extended to the whole time series

Conclusions after the general model based on CLMS change products

- **Very low detection of forest changes** (more than 10 time lower than NFI data for land converted to forest land), with more deforestation than afforestation (opposite trend compared to NFI statistics)

→ Addition of afforestation/deforestation dynamics (based on wall-to-wall from NFI maps)

- **Low detection of new settlements** (compared to land registry statistics),

→ Addition of a module for artificialization dynamics (based on national buildings mapping database)

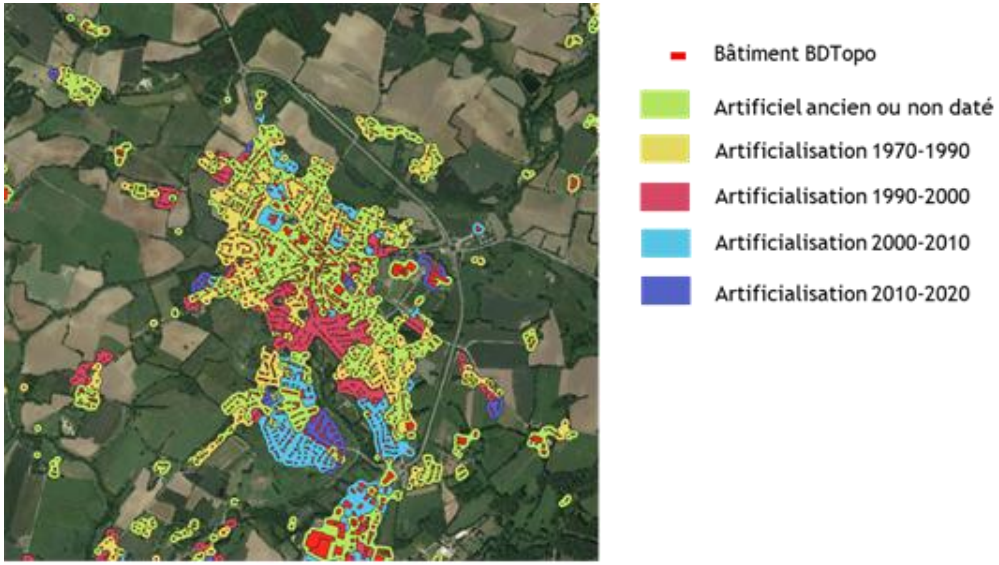
- **Almost no conversion between agricultural uses**

→ Addition of a module from agricultural rotations (based on LPIS data)

Improvement of specific dynamics

Modelling of new settlements

Buffers applied to each building to create precise urban areas and collect the year of construction of the building



Addition of afforestation and deforestation dynamics

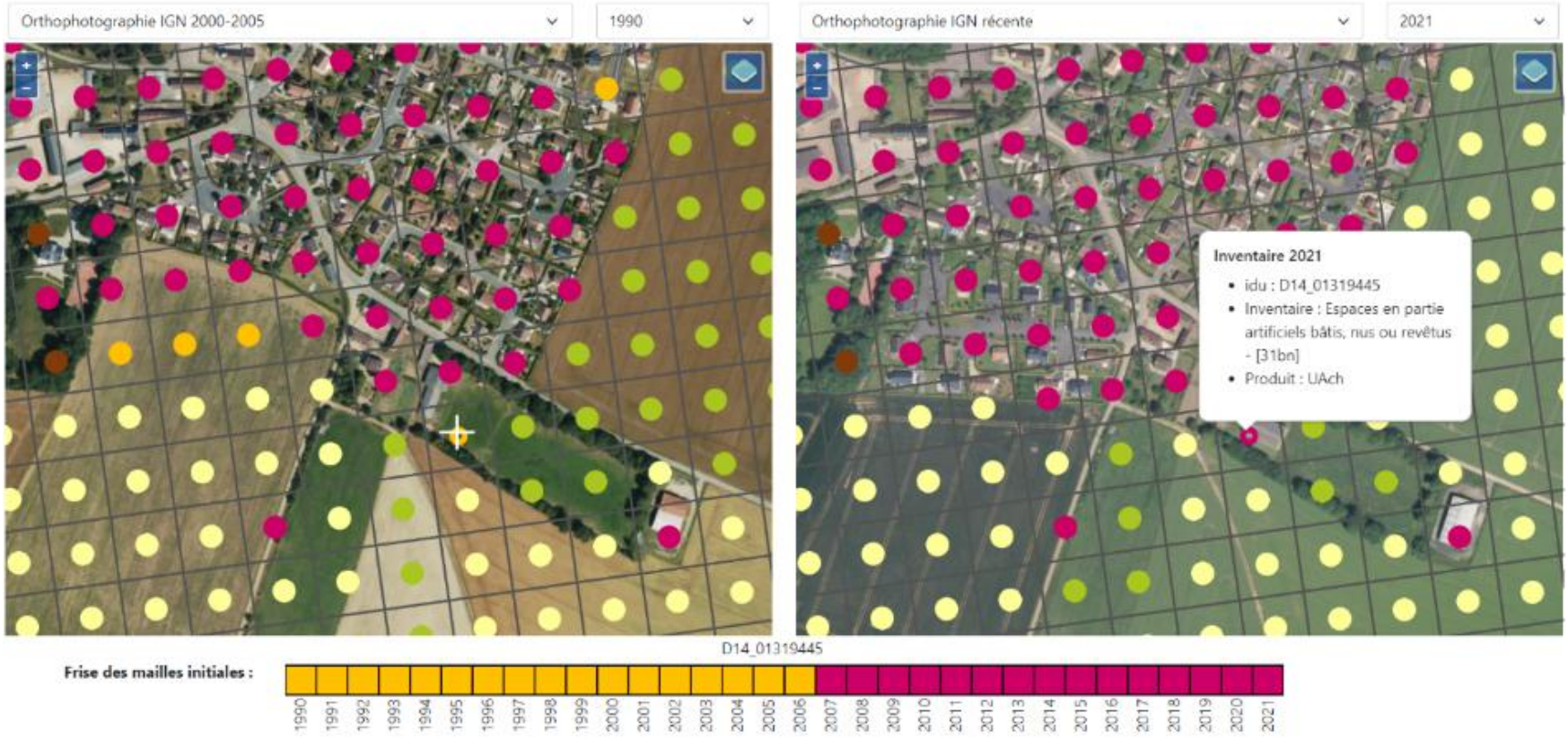
Comparison (wall to wall) of 2 editions of the NFI maps, adding treatments to limit false changes.

Agricultural rotations

Direct use of LPIS crop type after 2015 (intersection of LPIS polygons)

Before 2015 : crop rotation model (trained on recent conversions, fitting with crop statistics – Markov chains)

Visualization tool



- Visualization tool : output of the model overlaid on orthophoto → transparency

Lessons learned (land use model)

High impact on land use change rate of :

- Choice of the products and their nomenclatures
- Parameters (e.g. buffers) for wall-to-wall modules

Necessity of having validation datasets

Main advantages :

- The grid allows interoperability and easy integration of new datasets
- Opportunities : forecasting, diffusion of land use changes at municipality scale
- Direct link between land use and carbon calculation model
- Transparency (visualization tool)

Lessons learned (land use model)

Main difficulties / issues :

- Trade-off between detecting only “true” changes, and not detecting enough changes

→ Risk of false changes when doing direct wall-to-wall methodologies with our available data

→ CLMS validated changes : low dynamics compared with statistical data

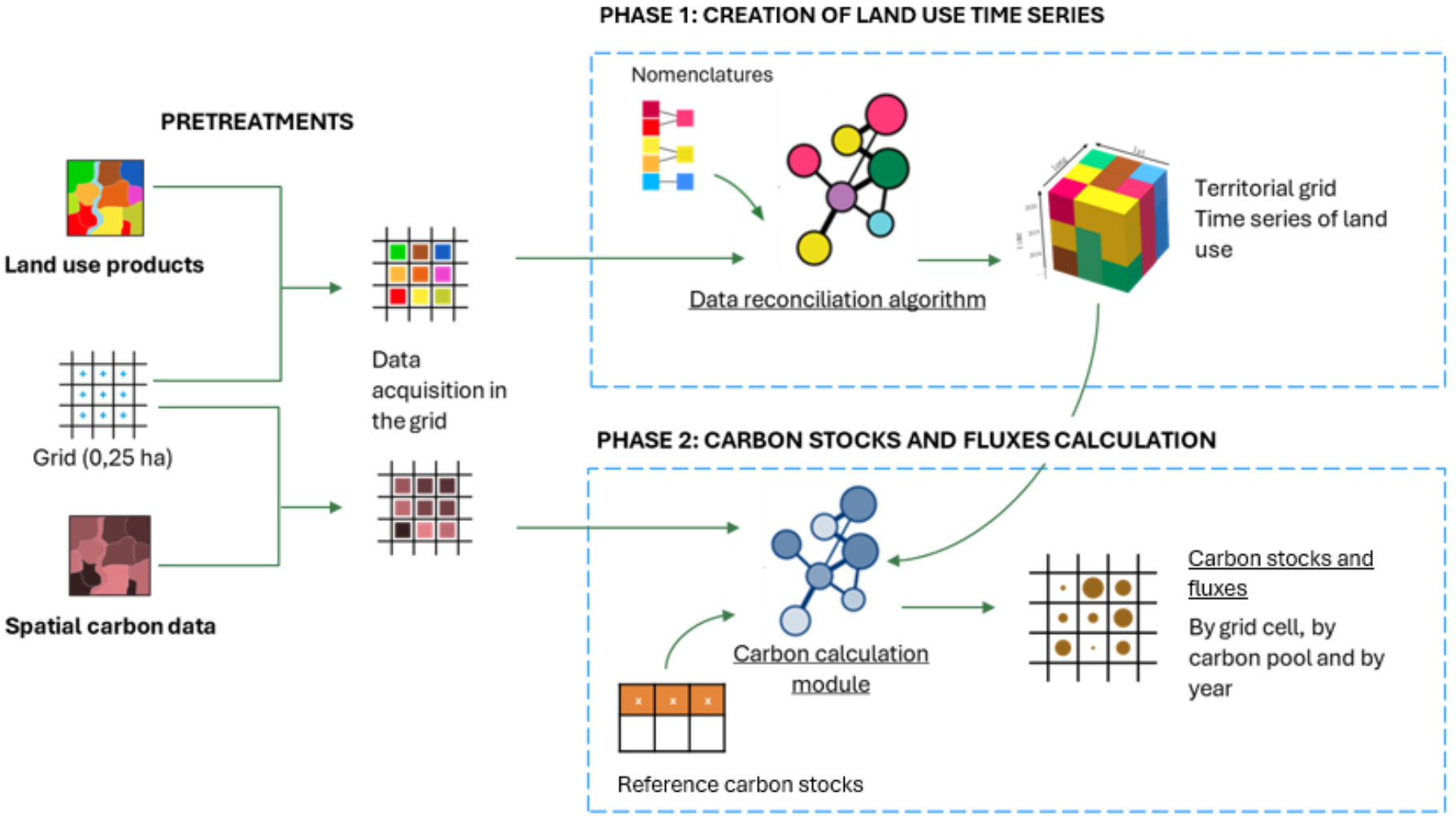
- Lack of data for the period 1990-2000 and post 2018.
    1. Necessity to add some non cartographic adjustments = final result is not totally spatially explicit
    2. Temporal consistency is an issue

Increase of **complexity** compared to the old method :

1. pre-processing, calculation times, data storage
2. need to maintain a remote server

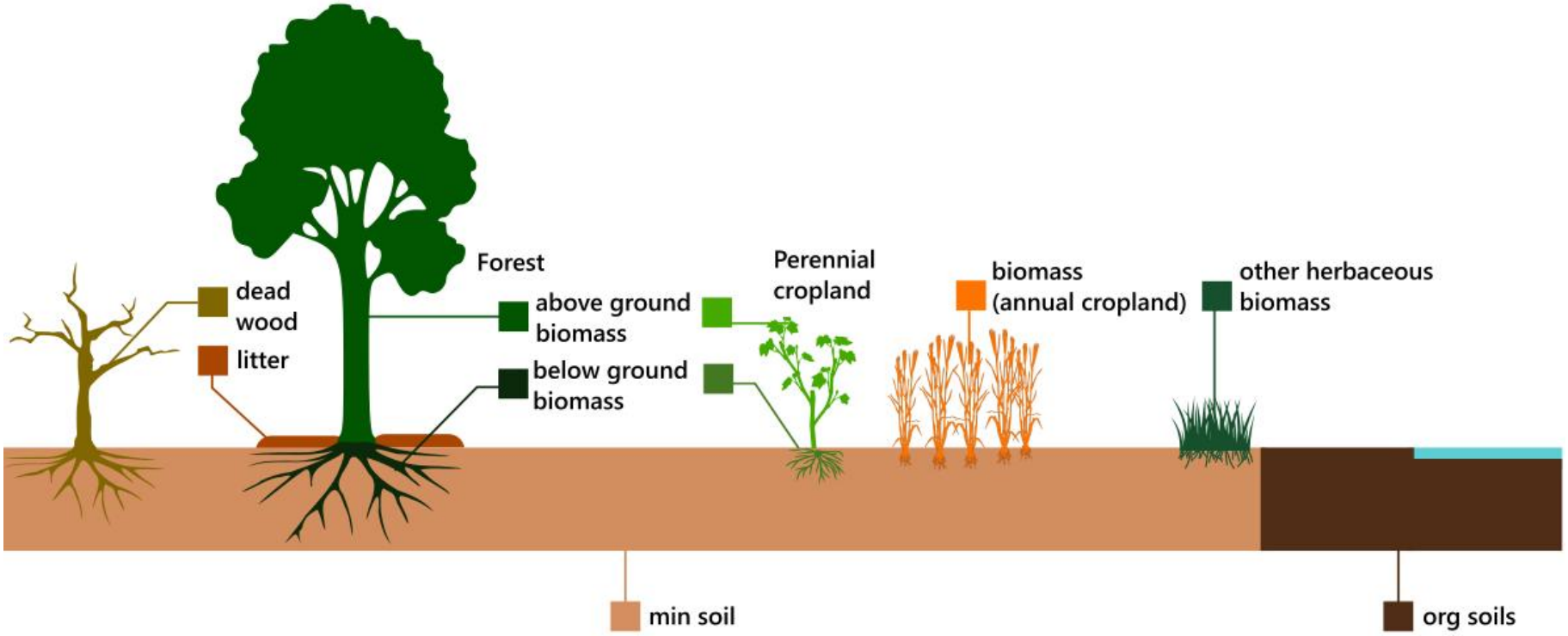
3 Gridded carbon stock change model

Carbon stocks and fluxes calculation



Carbon pools

- Distinction of specific carbon pools



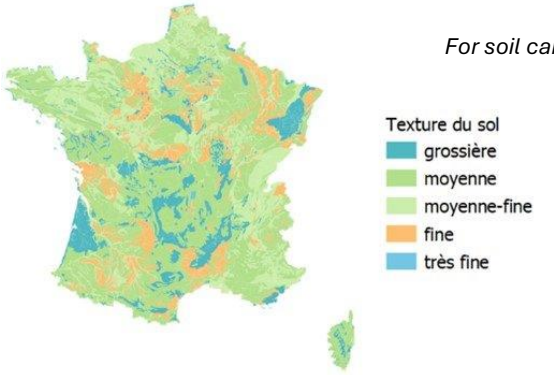
Carbon stock initialization

Initialization of stocks in 1990: Allocation of carbon stocks, by carbon pool according to: land use, different zoning, agricultural practices

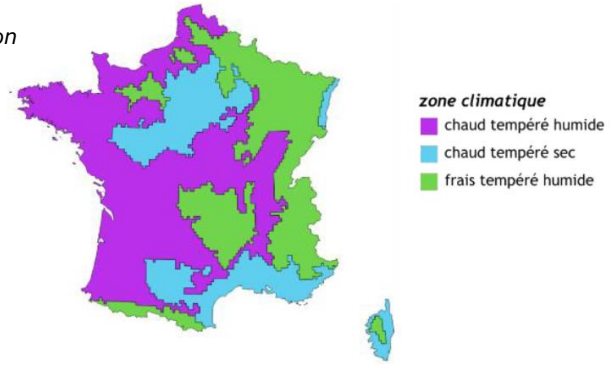
Different zoning used for the spatialization of carbon stocks

Mapping of sylvo-ecoregions (IGN)
For forest biomass and deadwood

For soil carbon

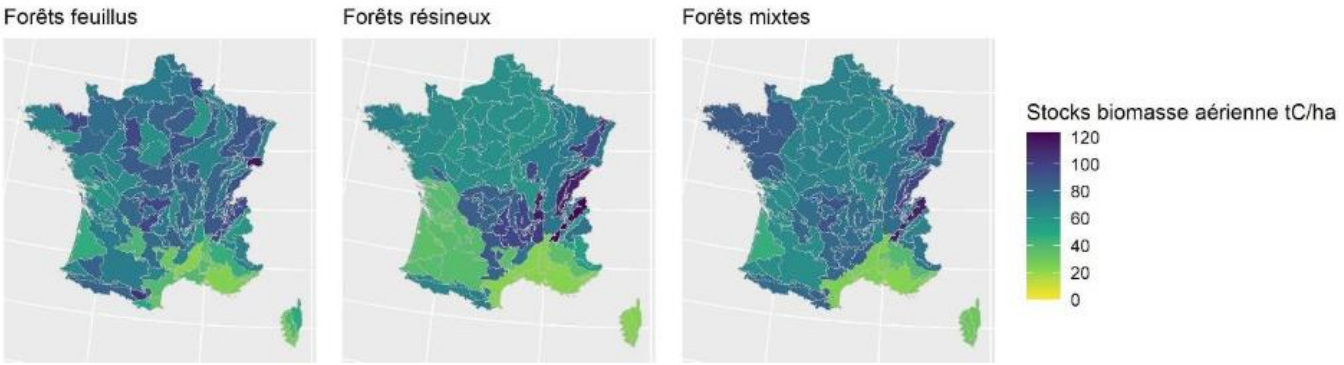


Soil texture mapping [BDGSF - Citepa]



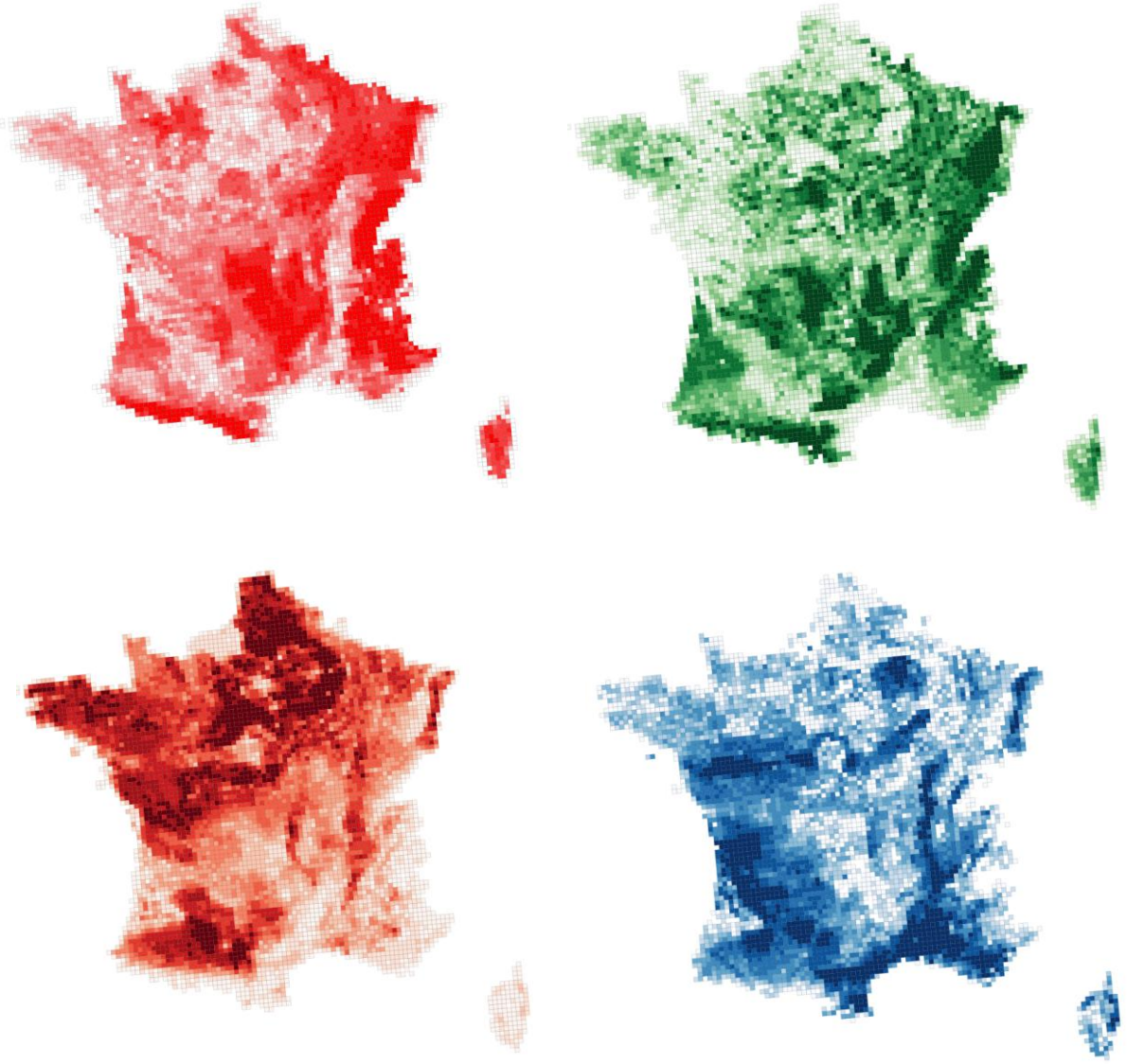
Mapping of climate zones [JRC according to IPCC 2006]

Spatialization of the carbon stock in forest biomass by forest type



Carbon stock initialization

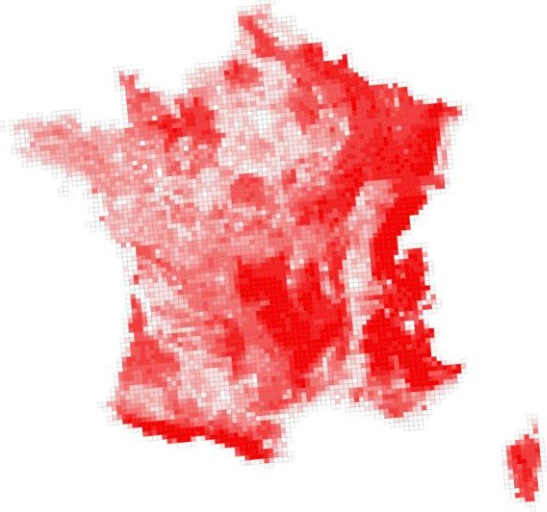
*Land use * carbon reference stock by carbon pool*



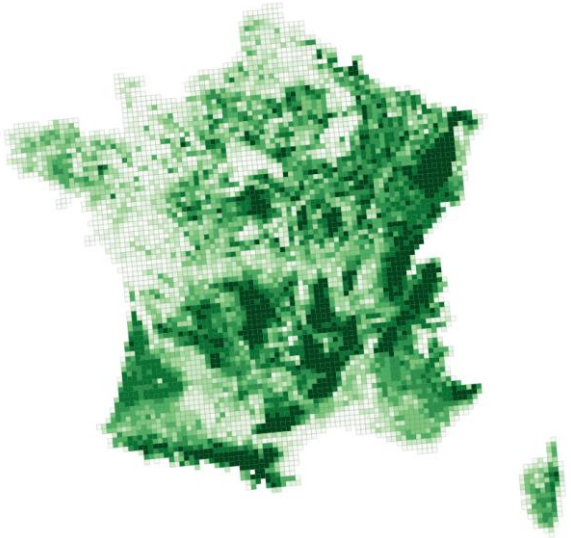
Aggregations of carbon stocks for specific carbon pools (on 10km² grid for visualization)

Carbon stock initialization

Mineral soils

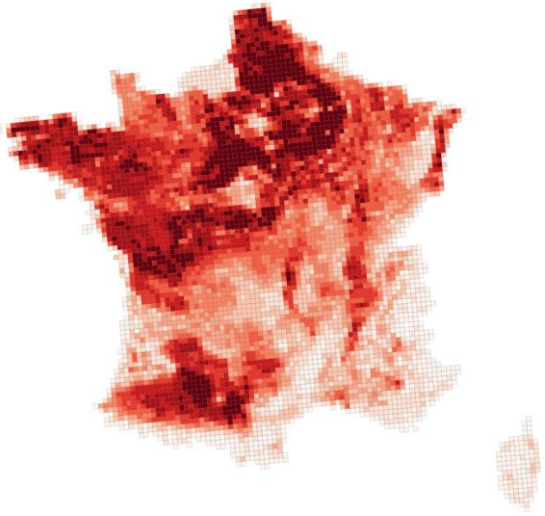


Biomass in forest biomass

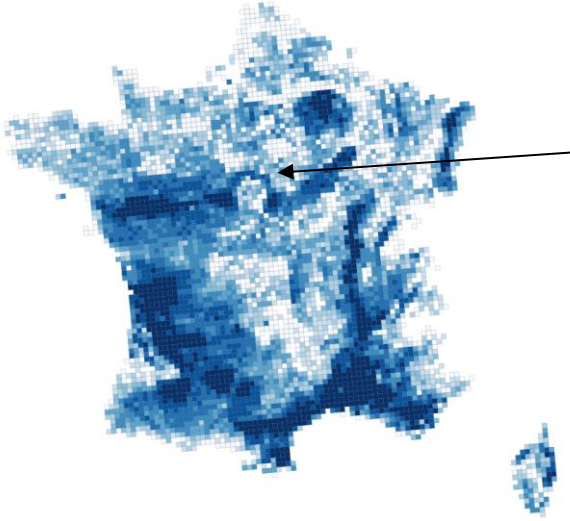


Aggregations of carbon stocks for specific carbon pools (on 10km² grid for visualization)

Biomass in annual cropland

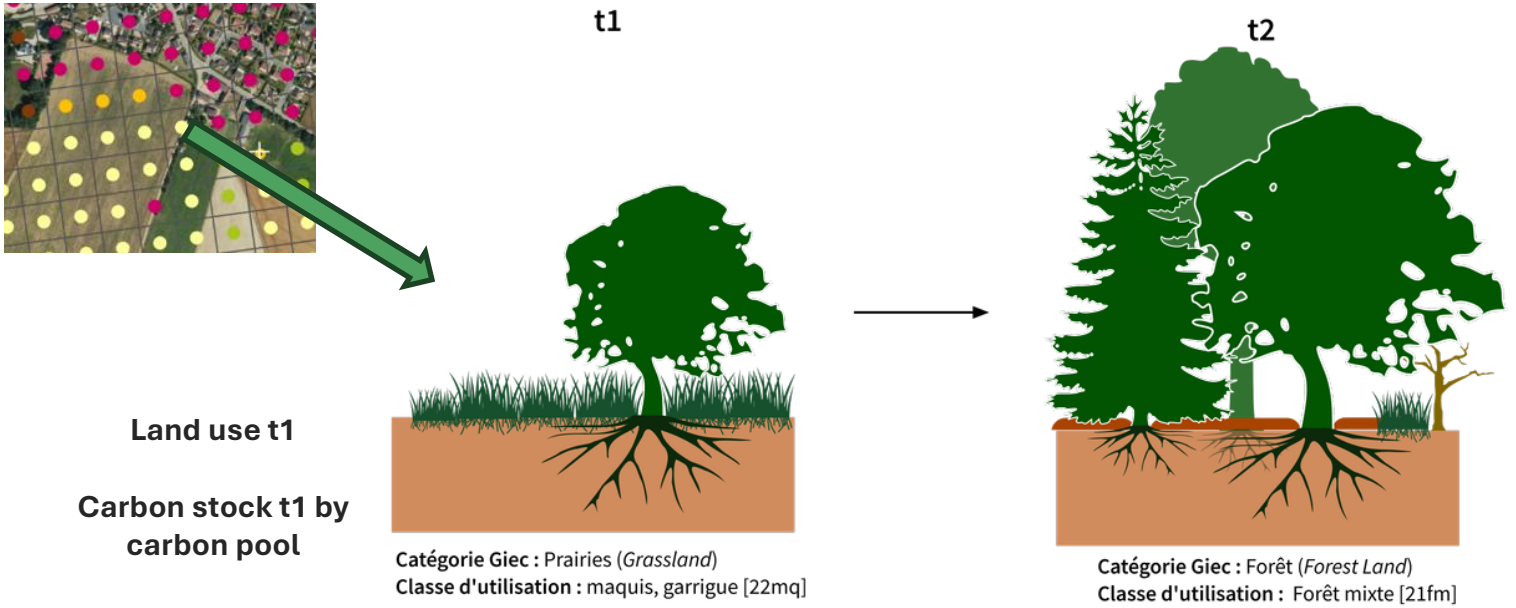


Biomass in perennial cropland

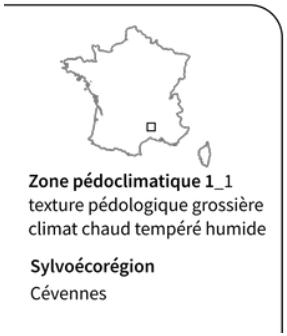


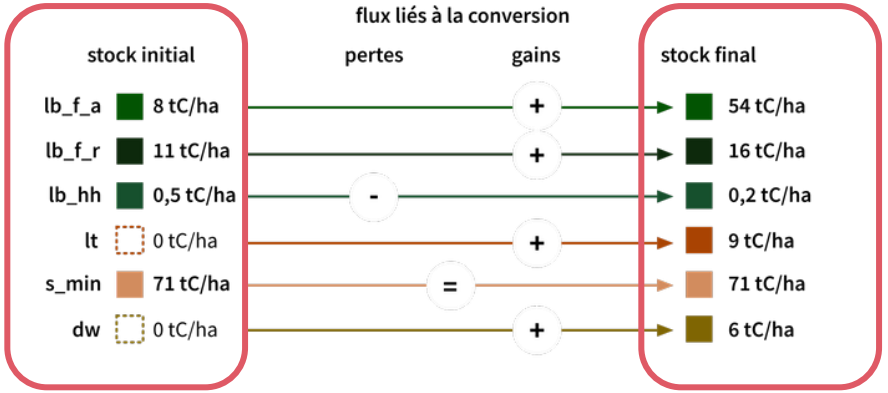
Carbon stock changes

For each year, comparison of the inherited stock with the new stock (related to the new land use, or different management practices in the area) → **Resulting emissions or removals are computed for each cell**



- The carbon stock change can be interrupted by another land use change.





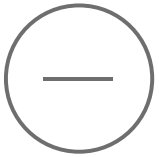
Lessons learned (carbon calculations)

Flexibility of the method to be **combined with spatialized stocks, management practices…**

Distinction of biomass types (correct gains and losses methods)

Harmonization of the calculation for all land use changes, all pools, and changes in management for agricultural soils.

Increase of **complexity** compared to the old method (calculation times, data storage)



High impact of :

1. The choice of the speed of conversion to the new carbon reference stock
2. The decision whether to differentiate stocks between subcategories (e.g. herbaceous stocks among cropland types)

4 Planned improvements and other uses

Improvements of the land use model in the last publications

Past submissions

2024 submission :

- new dataset for **road infrastructure** detection and related land use changes (new settlements)
- new dataset for detection of **water bodies** and related land use changes

2025 submission :

- new dataset for **organic soils** and detection of drainage

Planned developments

- Improvement of **green features detection in settlements** and related carbon stock changes
- Switch to the use of a new dataset with whole coverage for France (OCSGE), and difference maps (with validated changes)
- Application of the gridded approach for the Oversea territories
- Use of new activity data products for agricultural practices

Use of the results (current state and possible developments)

The gridded data (land use changes and carbon fluxes) is **currently used :**

- For the **LULUCF UNFCCC reporting** : at the country level, but with publication of data by region

- For **forecasting** : land use patterns are analyzed at the grid level, and reproduced for forecasting the LULUCF sink (projections for 2050), with a possible user constraint

→ Use for the update of the National low-carbon strategy

- At the **municipality scale** : land use changes and carbon fluxes are extracted by municipality to allow the tracking of local policies *[first publication this year, combined with the spatial disaggregation of other LULUCF carbon sink components]*

Possible developments (in study) :

- R&D : link with **adaptation and biodiversity** → the land use timeseries can be used to define risk indicators and the gridded approach allow for easy intersection with other types of dataset

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Citepa
Guider l'action Air&Climat

42 rue de Paradis
75010 Paris

01 44 83 68 83
infos@citepa.org

citepa.org