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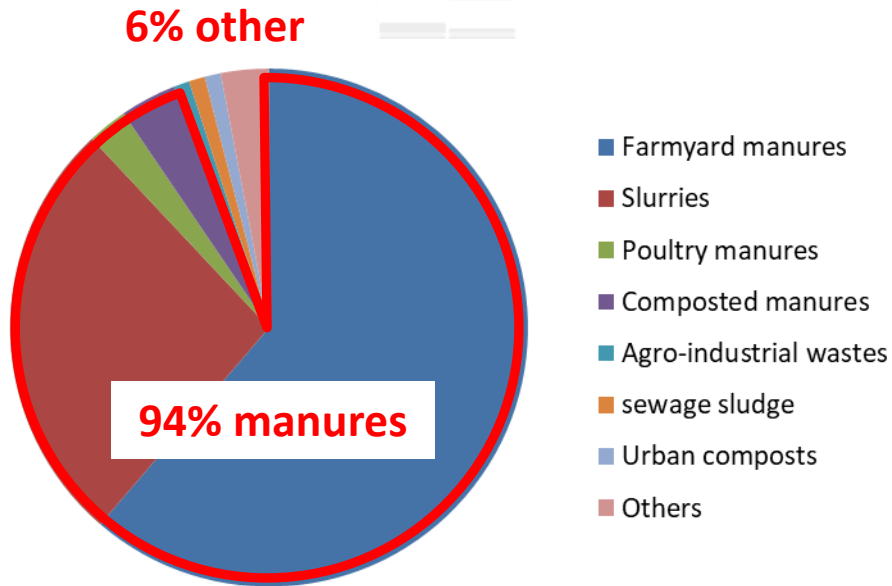
POTENTIAL C STORAGE THROUGH THE RECYCLING OF ORGANIC RESIDUES: EXPERIMENTAL EVIDENCE AND POTENTIAL EFFICIENCY AT THE FRENCH NATIONAL SCALE

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(1) INRA ECOSYS Grignon, (2) VEOLIA, (3) INRA SAS Quimper, (4) INRA ECOPUB Grignon, (5) INRA AGIR Toulouse, (6) INRA DEPE Paris, (7) INRA ISPA Bordeaux



Organic residue recycling in agriculture



- **94% animal manures**
- **6% Urban and industrial**
- **121 10⁶ tons FM**
- **12 10⁶ tons of organic C**

(Survey of agricultural practices, 2011
in Houot et al, 2014)

- Potential ressource increase ?
- Increase of urban organic residue recycling
 - organic C and nutrient recycling
 - Part of circular economy
 - **What is the potential C storage in soils?**

• **Other crop and practice efficiencies for C storage → Pellerin et al.**

Evidence of the potential efficiency

Network of long-term field experiments

<http://www6.inra.fr/valor-pro>



Detailed observation sites, instrumented
Historical sites, few / not instrumented

Evidence of C storage with regular organic residue application: QualiAgro site

- France, Ile de France, started in 1998
- Loamy soil, temperate climate, Wheat- Maize succession
- **OR Application:** Every 2 years , 4 t C/ha → **Twice usual application rates**

Treatments:

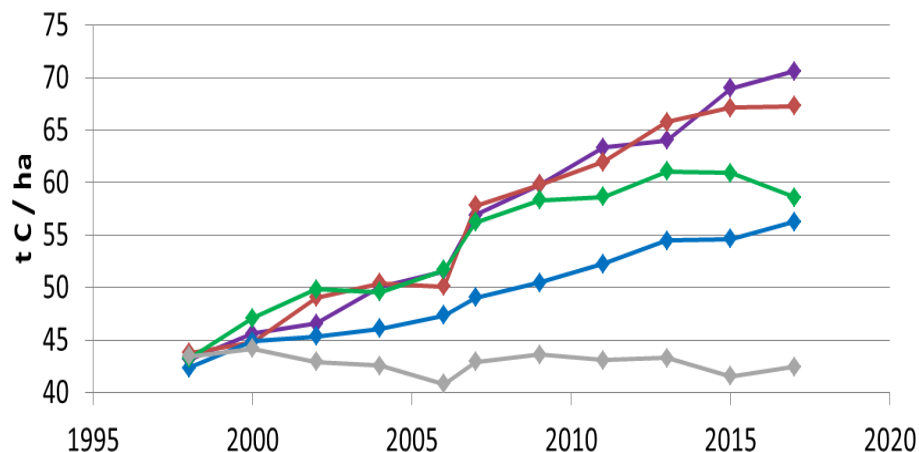
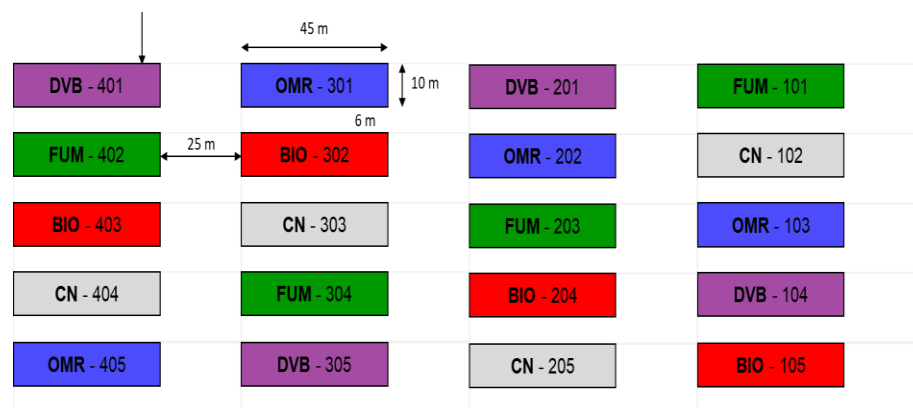
Composted sludge (DVB)

Biowaste compost (BIO)

Municipal solid waste compost (OMR)

Farmyard manure (FUM)

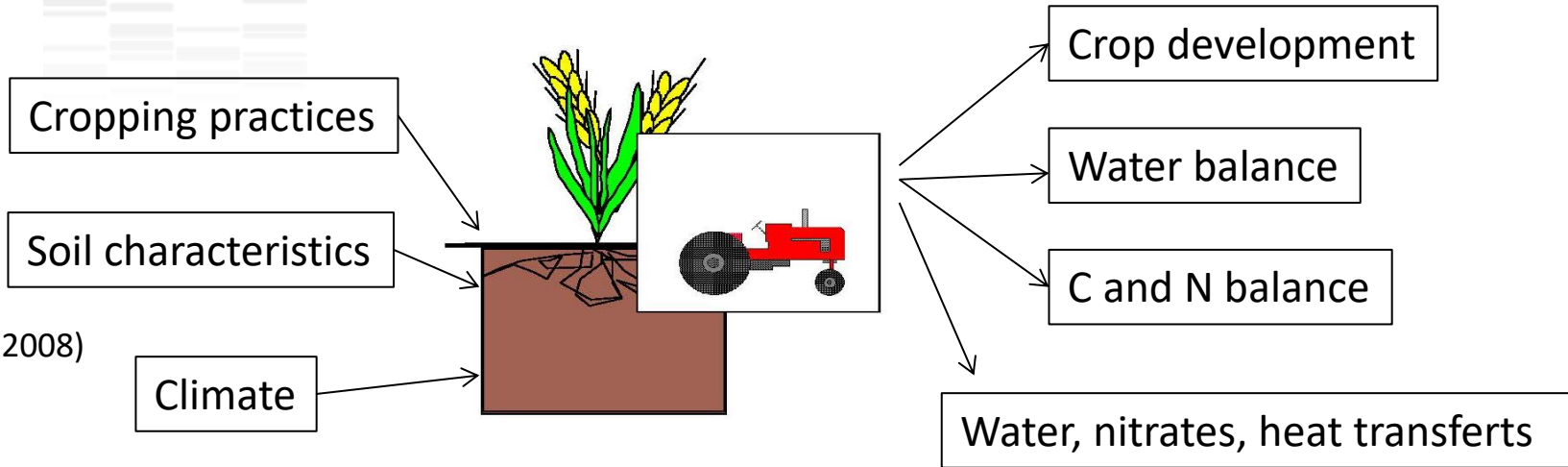
Control (CN)



**Evolution of C stocks:
+1.5 to 2.5% /year**

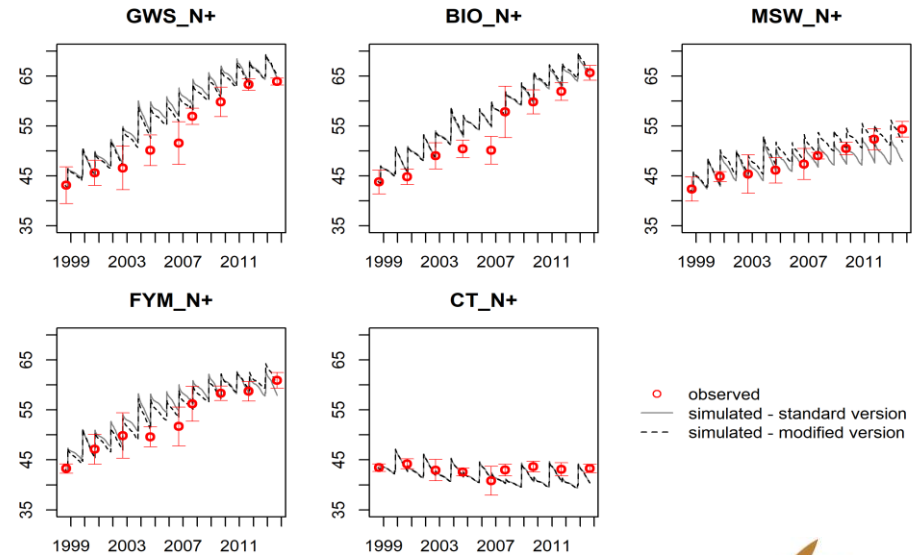
Levavasseur et al., in preparation

Parameterisation of the STICS crop model



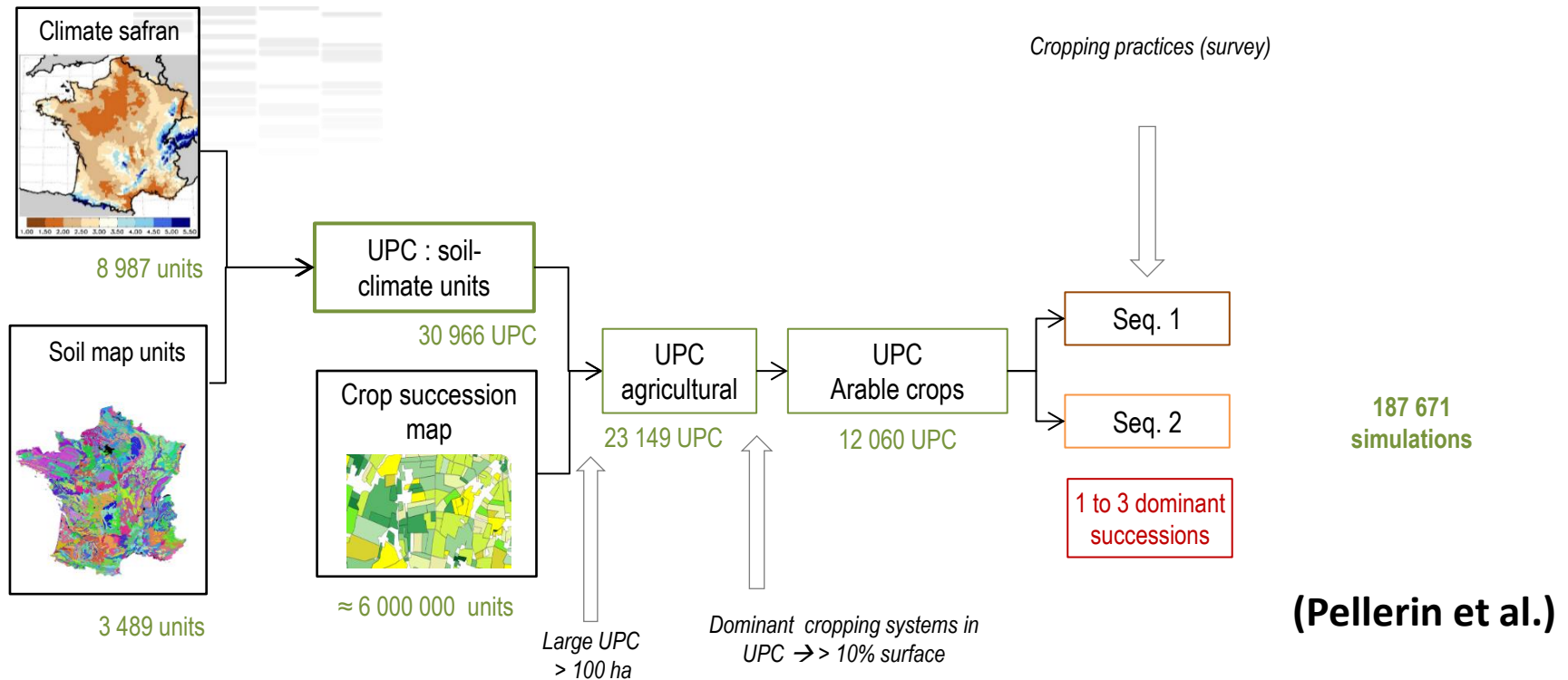
(Brisson et al., 2008)

- Organic residue decomposition
- Good simulation of crop production, **evolution of soil organic C stocks**
- Long-term experiments (QualiAgro) or laboratory incubations



○ observed
 — simulated - standard version
 - - - simulated - modified version

Simulations with STICS model



- Crop succession with organic residues (sugarbeet, rapeseed, wheat, maize)
- Slurry: 30 m³/ha; manure: 15 to 30 tons/ha....
- **5 10⁶ ha: 29% total agricultural surface**
- **Baseline: + 8 kgC/ha year in crop successions with OR compared to successions without OR**

Actual and potential additional sources of organic residues (1)

Different sources of data:

- **Manures** : Marsac et al., 2018: ELBA, evaluation of agricultural biomass and survey of farmer practices
- **Industrial Residues, collected greenwastes (GW), Sewage sludges (SS), biowastes (BIOW)**: SOLAGRO & INDDIGO, 2013. Potential biomass for anaerobic digestion (ADEME)
- **Total greenwastes**: SOLAGRO, 2014. Potential greenwastes (France Agrimer)
- **Already recycled sewage sludges and biowastes** : ADEME 2017

Data in 10⁶ tons of fresh matters

Total manures	Industrial residues	Total GW	Collected GW (9 % of total)	total SS (20% MS)	Recycled SS (70% total)	Total BIOW	Collected BIOW (10% total)
120.3	16.2	52.1	4.8	5.9	4.1	11.6	1.0

Actual and potential additional sources of organic residues (2)

Objective → Produce more composts and digestates

Data in 10⁶ tons of fresh matters

Total manures	Industrial residues	Collected GW	Total GW (9% total)	total SS (20% MS)	Recycled SS (70% total)	Collected BIOW (10% total)	Total BIOW
120.3	16.2	4.8	52.1	5.9	4.1	1.0	11.6

↓
Already recycled

↓
Increase of GW collection to 35%

↓
Increase SS composting to 70% (30% today)

↓
Increase BIOW separate collection to 50% of potential: 50% anaerobic digestion and 50% composting

Actual and potential additional sources of organic residues (3)

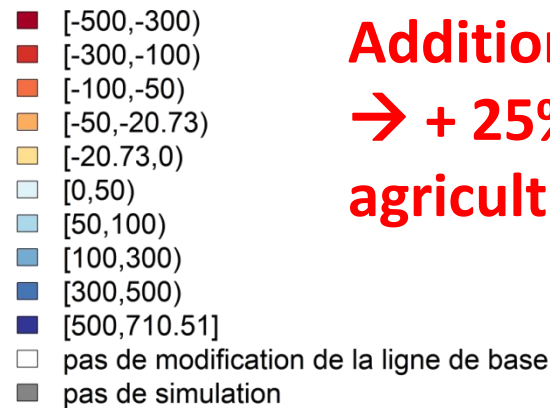
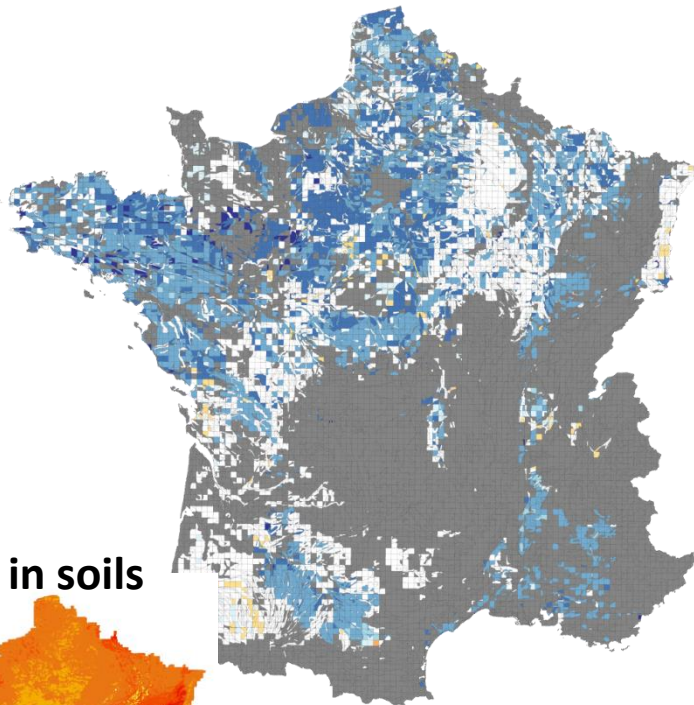
Potential additional production of composts and digestates

(10 ⁶ tons)	Today	Additional
GW composts	1	1.9
BLOW composts	1.2	2.9
SS composts	2	4.8
BLOW digestates		4.3
Total FM	4.2	13.9
Total C associated	0.6	1.6

Today, 12 10⁶ tons of C, mostly in manures → Additional 1.6 10⁶ tons of C

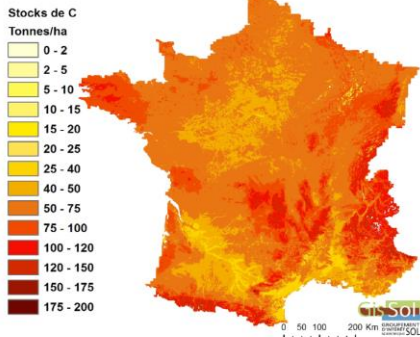
Additional C storage (kg/ha/year) with the new sources of organic residues (0-30 cm)

- Crop successions without organic residues
- Composts: 15 t FM/ha; Digestates: 25 m³/ha, every 2.5 years



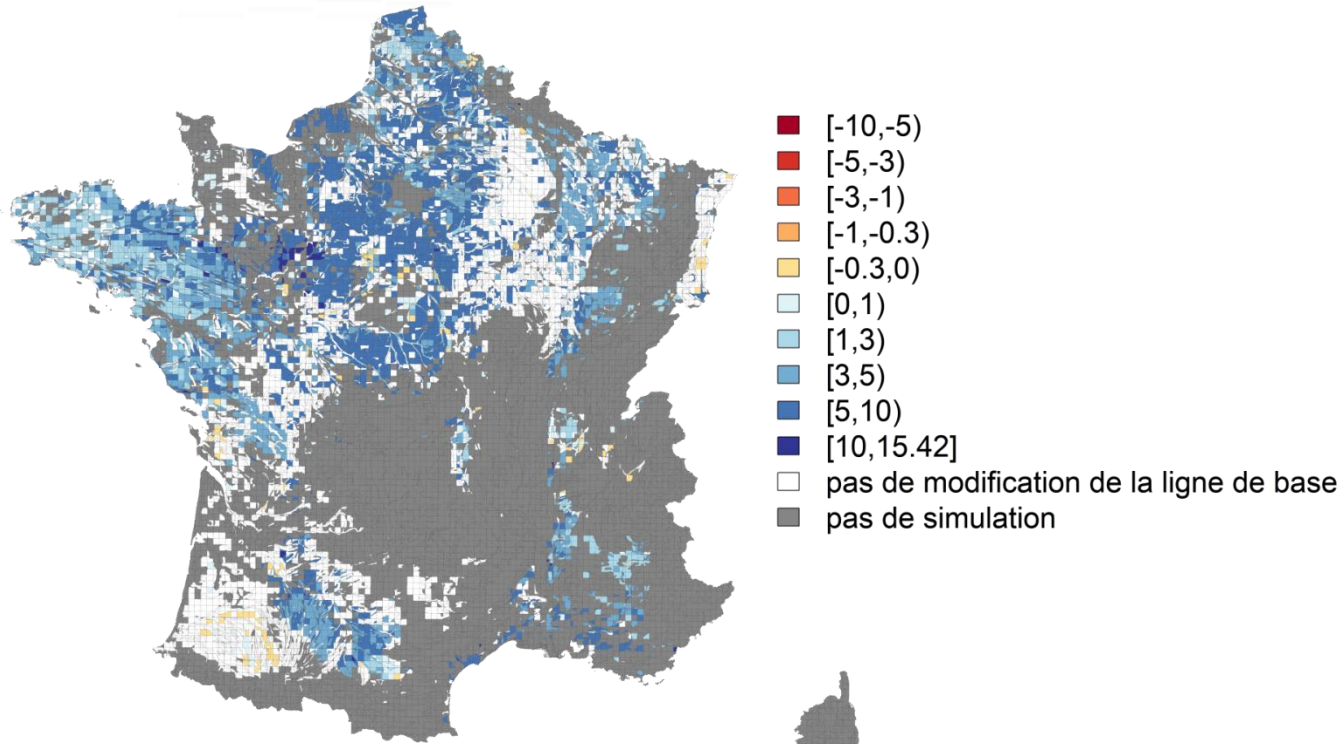
**Additional 4.2 10⁶ha
→ + 25% of total
agricultural surface**

C stocks in soils



**Average C storage
245 kg C/ha/year**

Additional relative C storage (‰/ha/year) with the new sources of organic residues (0-30 cm)



**Average relative C storage
4.5‰/ha/year**

But....

- GW used to produce the additional composts already largely returned to soils
- Additional C only coming from sludge or biowaste was calculated → average of 26% of additional C storage
- **0.243 → 0.059 tC/ha/year**
- **4.5 ‰/ha/year → 1.1 ‰/ha/year**

Total additional C storage

	Additional C	Surface	additional stored C	% of total*
Without GW	0.059 tC/ha/year	4.2 10 ⁶ ha	0.257 10 ⁶ t C/year	4.4 %
Including GW	0.243 tC/ha/year	4.2 10 ⁶ ha	1.023 10 ⁶ t C/year	15.6 %

* Total= 5.78 10⁶ t C/year. Cover crops > agroforestry > longer meadows > direct sowing and **new organic resources** (Pellerin et al., 2019)

Take home message

- Additionnal sources of organic residues: composts and digestates
→ $1.6 \cdot 10^6$ tons of C per year
- Much lower than animal manures ($12 \cdot 10^6$ tons of C per year) but necessary to recycle and interesting where animal breeding is lacking
- **Additional storage : $0.3 \rightarrow 1.0 \cdot 10^6$ tons of C/year stored depending if GW are included or not (4 à 15% of total potential additional C storage considering different practices)**
- Associated increase of crop yields but also of N leaching
- **One of the cheapest practices for farmers to increase C stocks in soils**
- Global mass balance of GHG has to be considered to calculate climate change mitigation (OK at field scale, impact of process?)
- Safe use of these new organic sources must be guaranteed