Evolution under climate change of the resilience of the services provided by the cultivated areas of the Pays de Fougères

REDELAC (2023 -2024) - Resilience And Sustainability Of Lowland Dairy Farms To Climate Hazards

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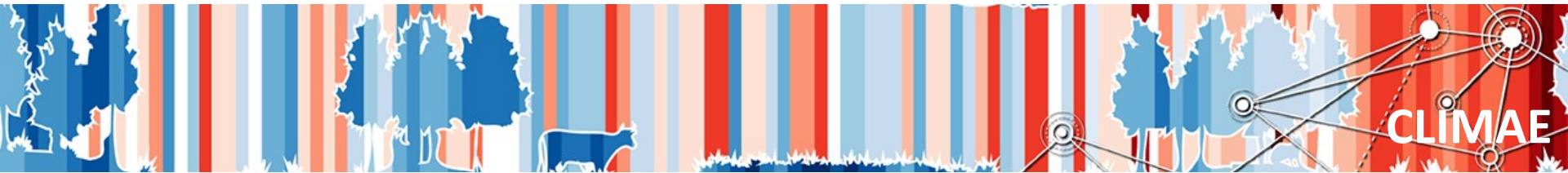
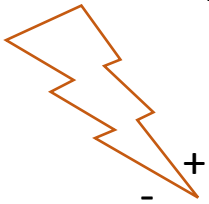


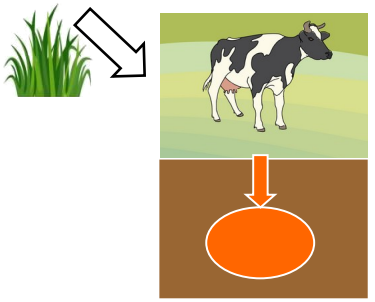
Background

Climate change
(climate hazards)



Dairy farming provides services

Food production, which depends on **feed production**



Mitigate GHG emissions by storing C

Impacts and adaptations depend on the forage system, local climatic conditions and seasons, as well as the public climate policies

REDELAC objectives

- Study the **impact** of future climate and anticipate the **adaptive evolution** of dairy farms
- **Test a methodology** based on models/tools

STICS Indicators

- **availability of feeds** and the evolution of **soil C stocks**
- evolution of **climate and feasibility** of crop/grassland **management** practices

AQAL-farm

- **adaptation of farms to feed resources**, and the consequences for **milk production** and **forage autonomy**

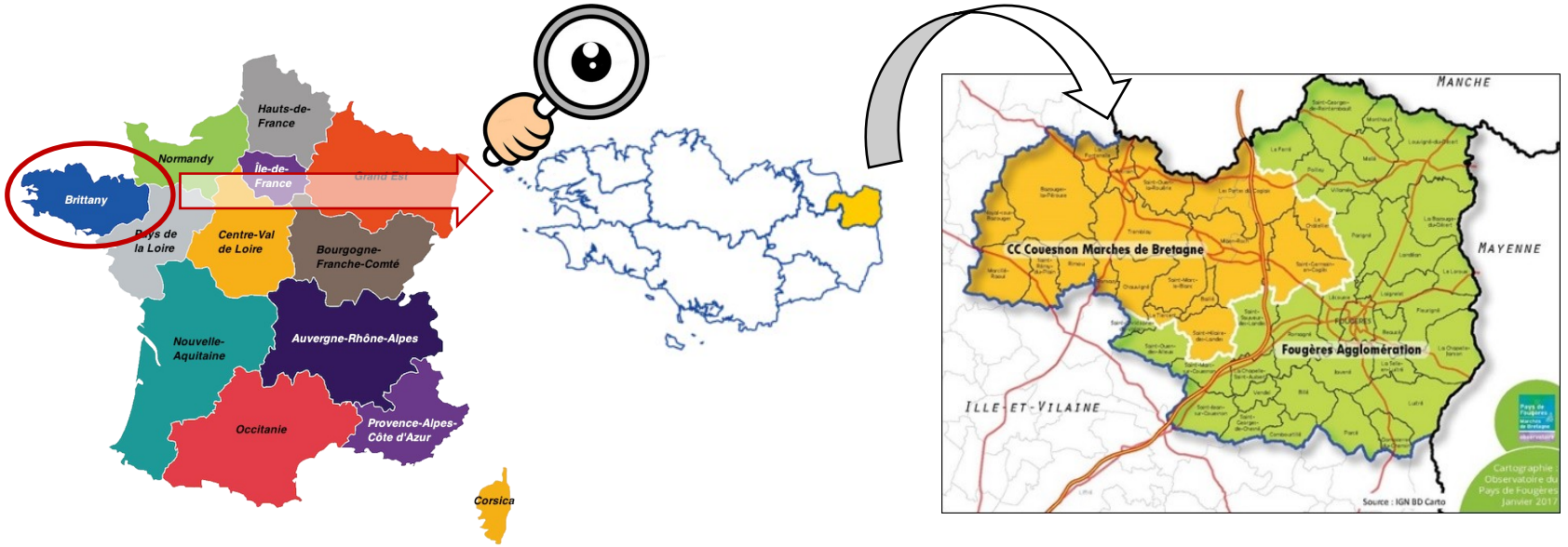
CAP'2ER®

- **changes in the environmental footprint of farms** under climate change

Questions

- How can **feed production** and **C storage services** evolve on the scale of the farm's cultivated area?
- What **differences** can be expected between
  - **farms** with **different forage systems**?
  - future **climates scenarios** and **time horizons?**
  - **locations** within a territory?
- Will dairy farms experience **more or less years** when the **herd's feed requirements** are **not met**? And where **C stock** is **moving away** from its trend?
- **What climatic conditions** explain these exceptional years in terms of feed production? And C stock change ?

REDELAC's study is limited to



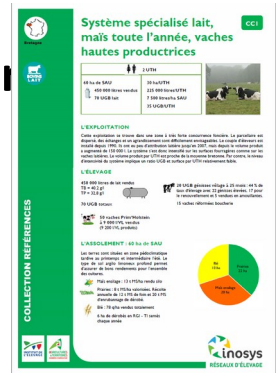
- A small (940 km²) area in Brittany: the Pays de Fougères
  - High **dairy farm density**, **interest** shown by **local stakeholders** in our questions
  - **Agricultural** territory, **soil and** (oceanic temperate) **climate favorable** to production
  - Drawn up a **territorial CAEP** => halve agricultural GHG emissions by 2050

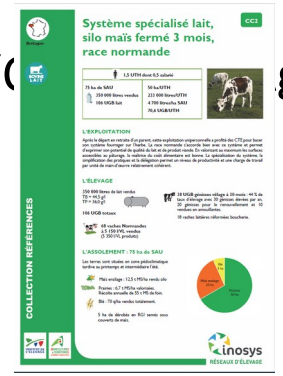
REDELAC's study is limited to

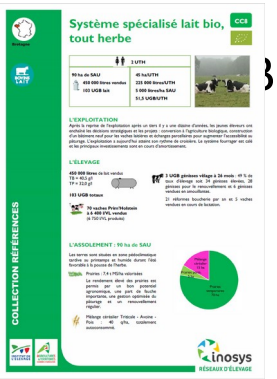
- 3 dairy farms representative of farms in Brittany (not real farms)
  - **≠ forage systems**

Farm	Description	Corn in forage area (%)
cc1	Conventional, corn all year round	48
cc2	Conventional, corn silo closed 3 months	29
cc8	Organic, all-grass	0

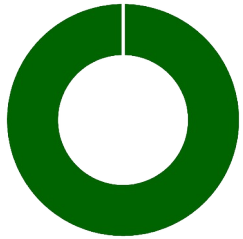
- **Well desc** “(gr Bretagne”



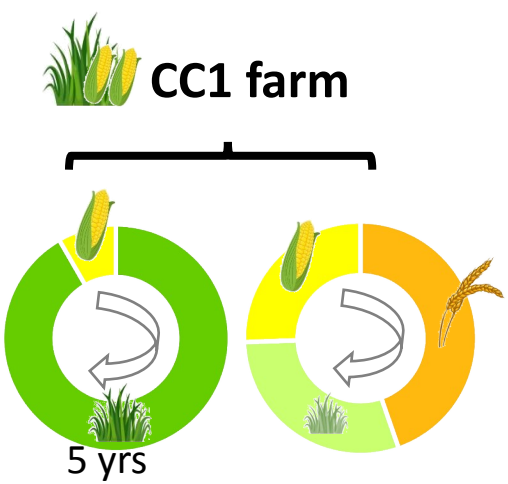


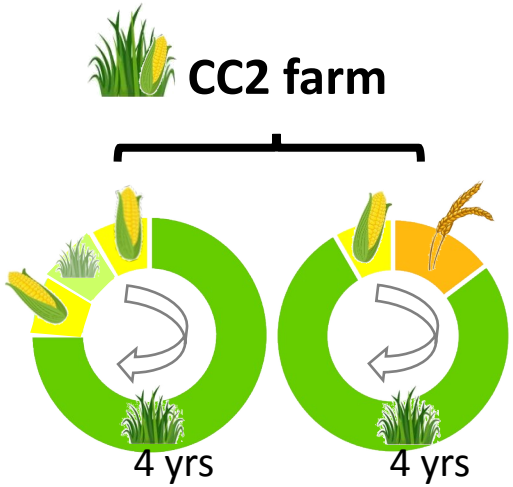


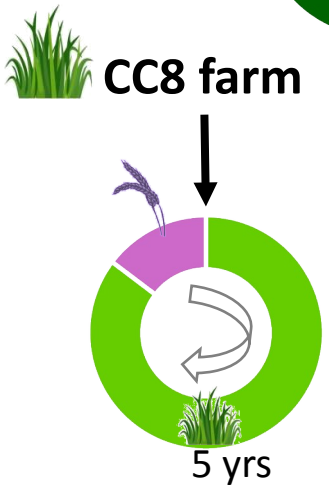
The land on each farm



- Cultivated in **1 or 2 rotations**, with a **few ha in perm. grassland**







- Most crops/grasslands are used to produce **feed for the herd**
  - Corn => corn silage
  - Grass => Grazing hay or grass silage
  - Wheat => sale, farm concentrate
  - Meslin => farm concentrate

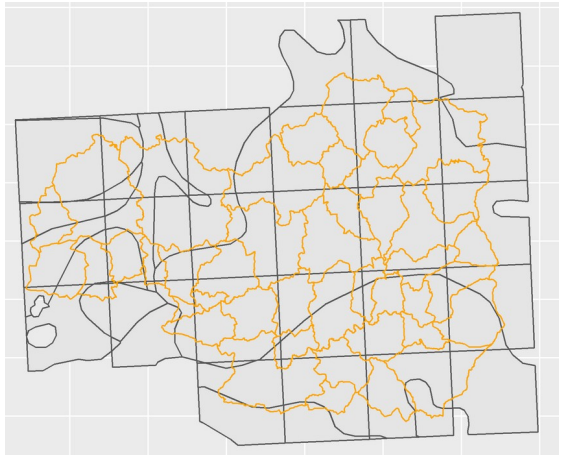
STICS simulations

- **Research version** derived from v10.0, which fixes some bugs
- **Improved parameterisation** of grasslands
  - **BNF activation** to simulate **white clover** in ryegrass-clover associations

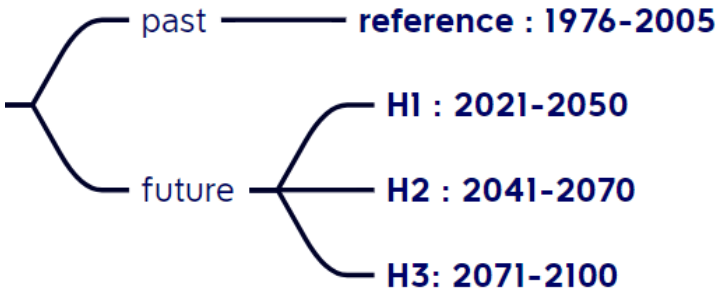
- Resolution:
  - **Pedoclimatic units (PCU)**

  = intersection of climate & soil resolution

  grays polygones



- **30-year time horizons**



STICS simulations

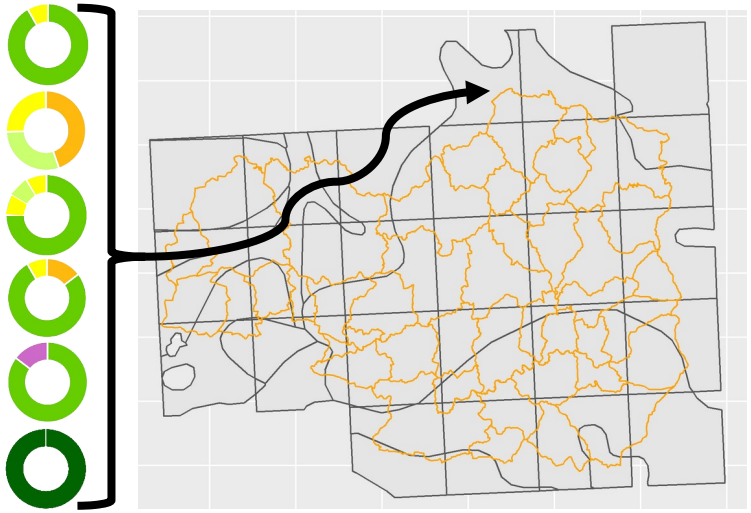
- Simulations of rotations and permanent grasslands for
  - **1 PCU** (soil with WHC=80mm **<=** geographic database of French soils + previous studies)
  - **1 climate scenario** <= DRIAS-2020 dataset
    - 1 global-regional climate model pair: **CNRM-CM5/ALADIN63**
    - 1 GHG emission scenario: **rcp8.5** (no climate regulation, +5°C by 2100)

WARNING

Preliminary results

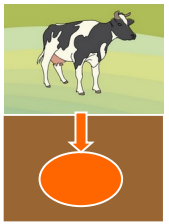
Each head of the rotation
⇒ Crop/grassland yield each year

2 uses of temporary grassland
⇒ grazing, hay/ silage



Analysis of results

- Calculation of annual feed and soil C stocks at farm scale
  - Based on **areas** allocated to each rotation and **grassland/crop yield** or **soil C stock simulated** by STICS

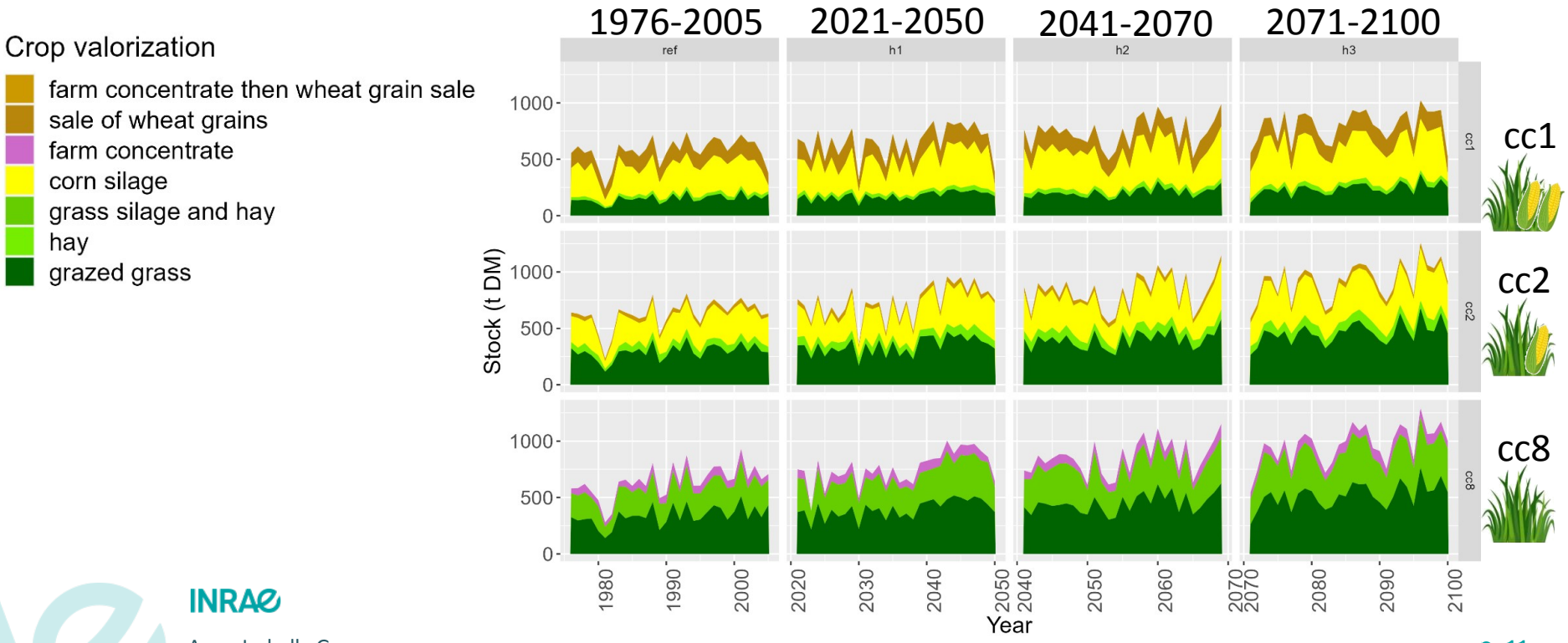


  - **Losses** from field to animal, excepted from grazed grass

- Other resilience indicators
  - **Theoretical herd feed requirements** based on herd size/composition and theoretical feed intake of heifers/cows
  - **"Deficit" years** = years when feed stocks from the year's production < feed requirements
  - **"Resistance"** = feed stocks from the year's production / feed requirements in deficit years

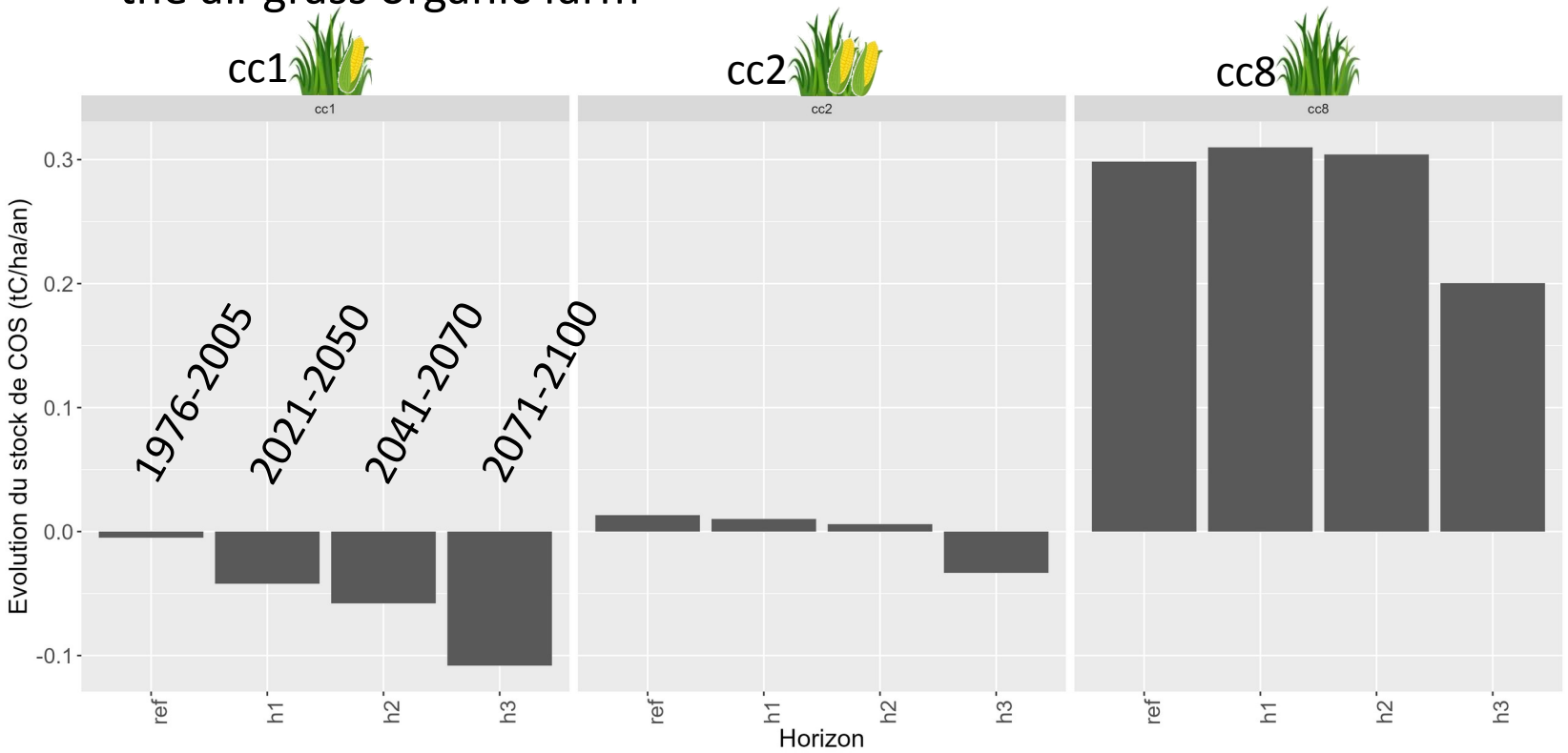
Evolution of feed production service on the scale of the farm's cultivated area

- **Feed stocks** ↗ by **+15%** in h1, **+30%** in h2 and by **+40%** in h3
- **Fewer years** for which production does not meet the herd's DM feed requirements (↘ **deficit years** and **resistance** ↗)



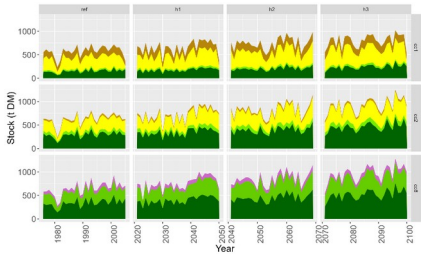
Evolution of C storage service on the scale of the farm's cultivated area

- Ref. period: the **all-grass** organic farm **stores C**, unlike the other 2 farms whose C stocks are stable
- Future: trend towards **soil C depletion** or lower stock increase for the all-grass organic farm



What explains these evolutions at farm scale ?

- ↗ in feed stocks

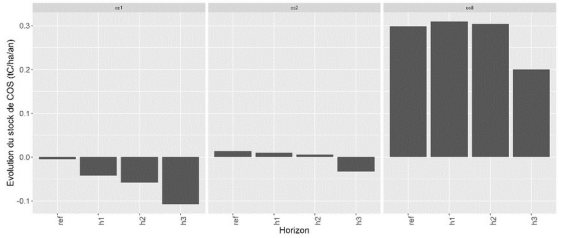


- **Slight ↗** in annual **rainfall** (changes in distribution)
- **↗ in temperature**
- ↗ in PET but **stable actual ET** due to CO_2 effect

Period	R (mm)	T (°C)	PET (mm)	CO_2 (ppm)
ref	1015	10.8	805	354
h1	+15	+0.9	+78	+119
h2	+29	+1.7	+113	+224
h3	+55	+3.3	+200	+453

What explains these evolutions at farm scale ?

- Trend towards lower soil C stocks



- ↗ **SOC mineralization** not fully offset by ↗ **C inputs** (with only a fraction stabilised in SOM)

cc1

Period	Min. (t C/ha)	Inputs (t C/ha)
ref	3.5	4.0
h1	+ 0.4	+ 0.4
h2	+ 0.8	+ 0.9
h3	+ 1.3	+ 1.4

cc2

Min. (t C/ha)	Inputs (t C/ha)
3.6	4.1
+ 0.5	+ 0.5
+ 0.9	+ 1.1
+ 1.4	+ 1.6

cc8

Min. (t C/ha)	Inputs (t C/ha)
4.5	5.4
+ 0.5	+ 0.6
+ 1.0	+ 1.2
+ 1.7	+ 1.9

Conclusions

Based on the simulated example (one PCU and one climate scenario), in the Pays de Fougères:

- **Climate still favorable** to production in the future
- **Increase in overall feed stocks** and better coverage of herd feed requirements
- **C destocking** or lower C stocking for all-grass organic farms
- **N_2O emissions slightly enhanced** by climate change

⇒ Possible **antagonism** between **food security/local consumption** issues and **C footprint reduction**?

⇒ Possible evolution of farms towards **greater proportion of grass** and **fewer concentrates** in the animal diet?

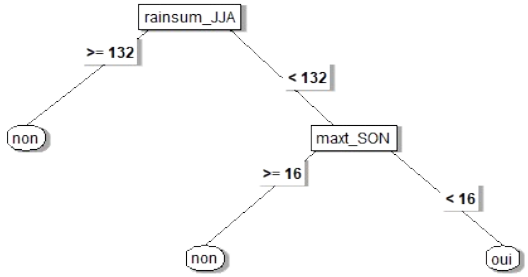
Prospects

- Extension of STICS simulations to the entire plan
  - Simulation for **all PCU** in the territory and **all** future **climate scenarios**

3 global-regional model pairs
- **CNRM-CM5/ALADIN63**
- **CNRM-CM5/RACMO22E**
- **EC-EARTH/RACMO22E**

2 GHG emission scenarios
- **RCP2.6** — low emissions +2°C by 2100
- **RCP8.5** — no climate regulation +5°C by 2100

Prospects



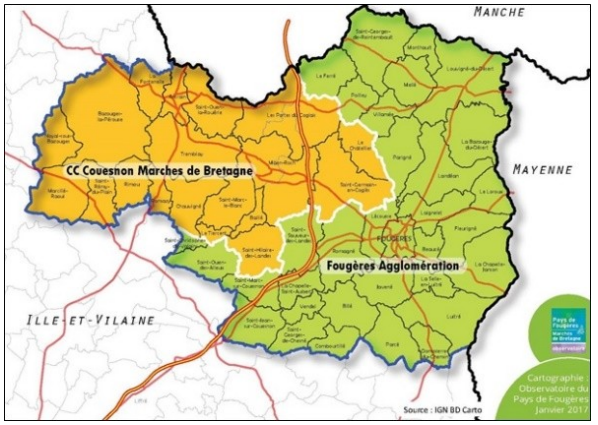
- Additional analysis of results
  - **Resilience** of **soil C storage**
  - Changes in **forage quality**
  - **Accessibility of grass** for grazing (soil bearing capacity)
  - Animal **heat stress**
- Supply of information required for AQAL-farm model simulations
  - **Grass growth** and **accessibility**
  - Annual **feed stocks**
  - Forecast **feeding plan**, etc.

Thank you for your attention

The Pays de Fougères territory

- Key figures (sources: INSEE 2019, RA 2020)

2 intercommunalités (since 2017) grouping 44 communes

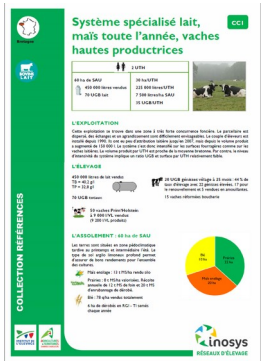


	Couesnon Marches de Bretagne	Fougères Agglo.	Total
Population (hab.)	21951	55 874	77825
Area (km2)	400	540	940
UAA (ha)	28 719	40566	69285 (74%)
Farms	426	750	1176
Dairy farms	191	316	507 (43%)
Farmers	744	917	1661

Crop and grassland management

For each crop/grassland in a rotation or permanent grassland

Management <= several sources of information



- **descriptive sheets** => nature and annual quantities of mineral and organic fertilizers
- **existing managements for similar rotations** in Brittany, as defined in Pellerin et al. (2019) => sown varieties, type and calendar of operations
- chamber of agriculture **expertise**

- **Fixed calendar** of operations **except for crop/grassland harvesting** and grassland **grazing** dates
- **Fixed quantities** of fertilizers, **except for animal restitutions**, which are calculated on the basis of grass production

Study limits

- STICS model
  - Rotations have been adapted
- Simulations
  - Simulated yields have been corrected to approximate herd theoretical feed requirements over the reference period
  - The possible diversification of forage systems in the future, and the expansion of cultivated areas are not accounted for
  - Soil C stock values were reset at the beginning of each time horizon

Feed stocks

- obtained by multiplying the **yield of a crop/grassland** simulated by STICS by the **area allocated to it** annually in each crop rotation.

Farm	Crop	Crop valorization	Rotation	Area (ha)
cc1	corn	corn silage	rot1.1a	3.3
			rot1.1b	0.7
			rot1.2	18
	grassland	hay	rot1.1b	3.5
		grazing	rot1.3	2
			rot1.1a	16.5
	wheat	sale wheat grains	rot1.2	18

Feed stocks

Farm	Crop	Crop valorization	Rotation	Area (ha)
cc2	wheat	farm concentrate then wheat grain sale	rot2.2a	4
			rot2.2b	1
	corn	corn silage	rot2.1a	12
			rot2.1b	3
			rot2.2a	4
			rot2.2b	1
	grassland	hay	rot2.1b	6
			rot2.2b	3
		grazing	rot2.3	5
			rot2.1a	24
			rot2.2a	12
cc8	meslin	farm concentrate	rot8.1a	7.5
			rot8.1b	7.5
	grassland	grass silage and hay	rot8.1b	35
		grazing	rot8.2	5
			rot8.1a	35

Herd's theoretical feed requirements

- calculated on the basis of the **number of cows and heifers** and the **feed distributed** to them (information provided by the descriptive sheets)

Farm	Crop	Crop valorization	Feed requirements (t DM)
cc1	corn	corn silage	258
	wheat	sale wheat grains	0
	grassland	grazing	144
		hay	28
cc2	corn	corn silage	231
	wheat	farm concentrate then wheat grain sale	7
	grassland	grazing	301
		hay	59
cc8	meslin	farm concentrate	66
	grassland	grazing	319
		grass silage and hay	238