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

Anne-Isabelle Graux, Patrick Chabrier, Eric Casellas, Klervi Le-Floch, Patrice Lecharpentier, Renan Le Roux, Fabien Ferchaud

# 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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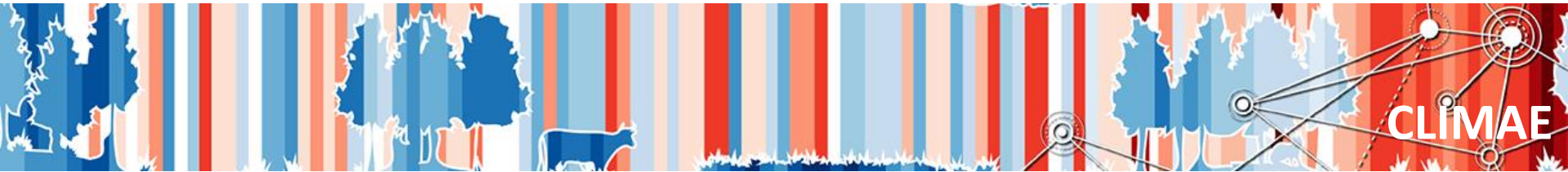
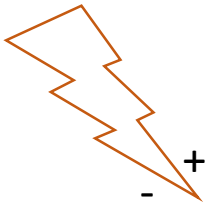


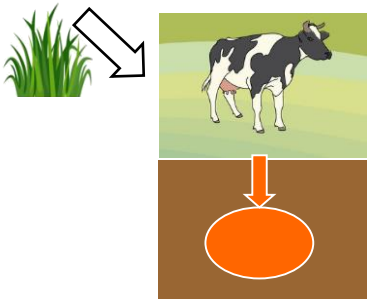
# Background

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**

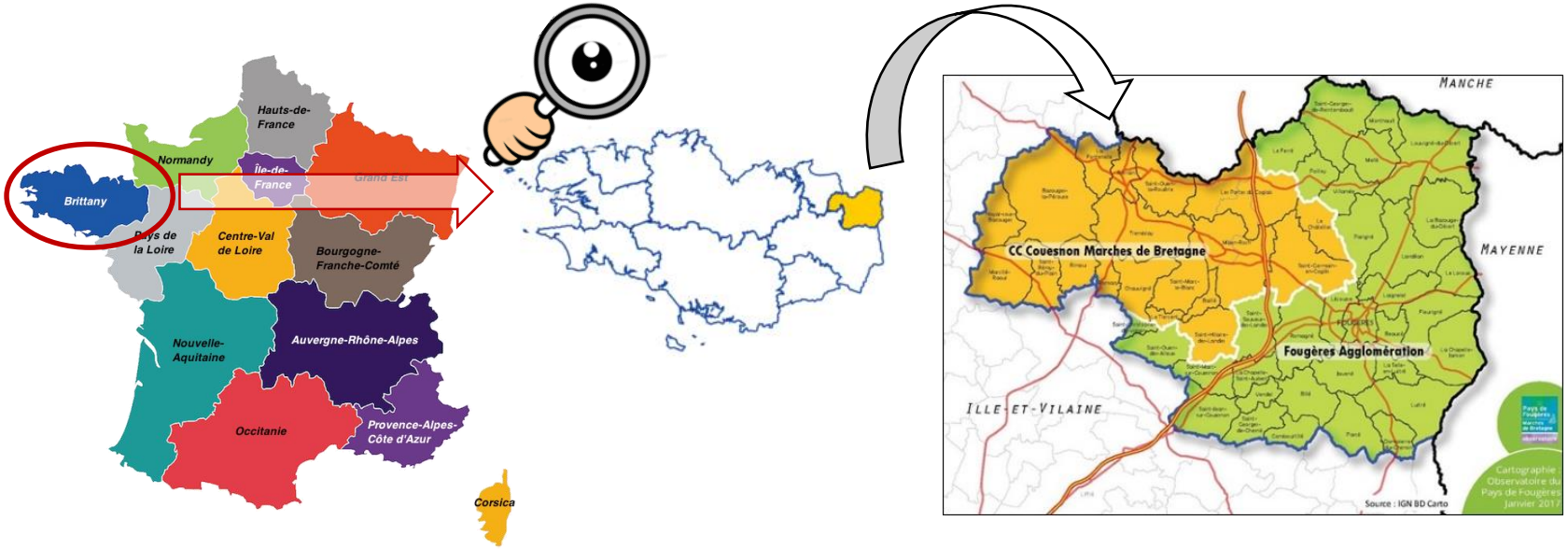
CAP'2ER®

- **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



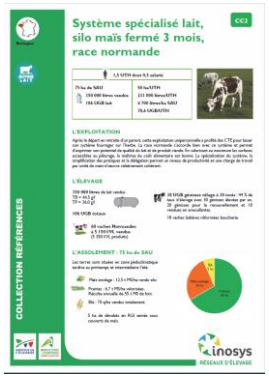

- A small (940 km$^2$) area in Brittany: the Pays de Fougères
  - High **dairy farm density**, **interest** shown by **local stakeholders** in our questions
  - **Agricultural** territory, **soil and** (oceanic temperate) **climate favorable** to production
  - Drawn up a **territorial CAEP** => halve agricultural GHG emissions by 2050

# REDELAC's study is limited to

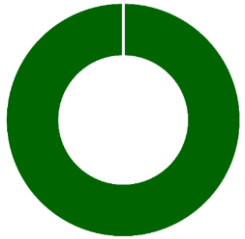
- 3 dairy farms representative of farms in Brittany (not real farms)
  - **≠ forage systems**

| 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 |

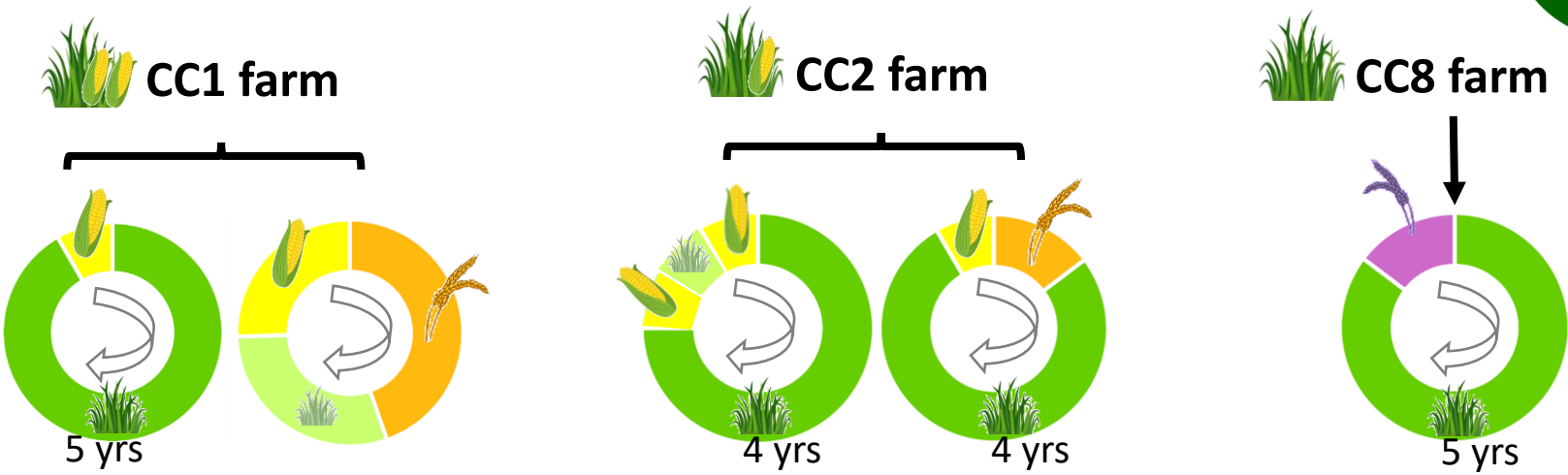
- **Well described** by the "Chambre d'Agriculture de Bretagne"


# 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

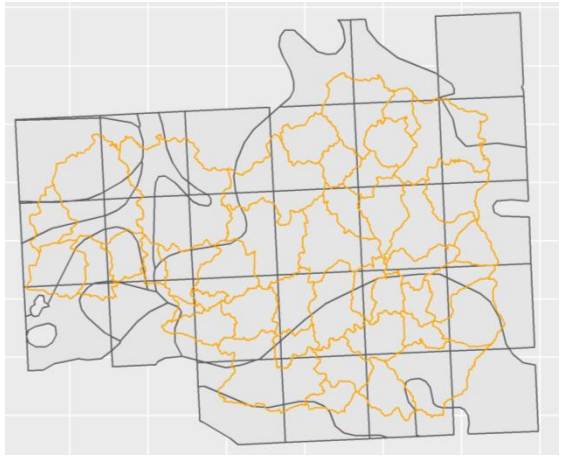
# STICS simulations

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

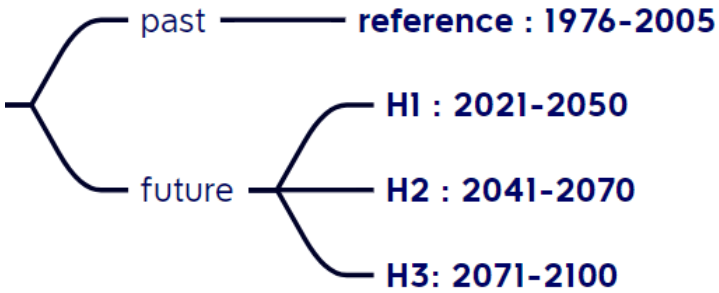
- Resolution:
  - **Pedoclimatic units (PCU)**

  = 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**

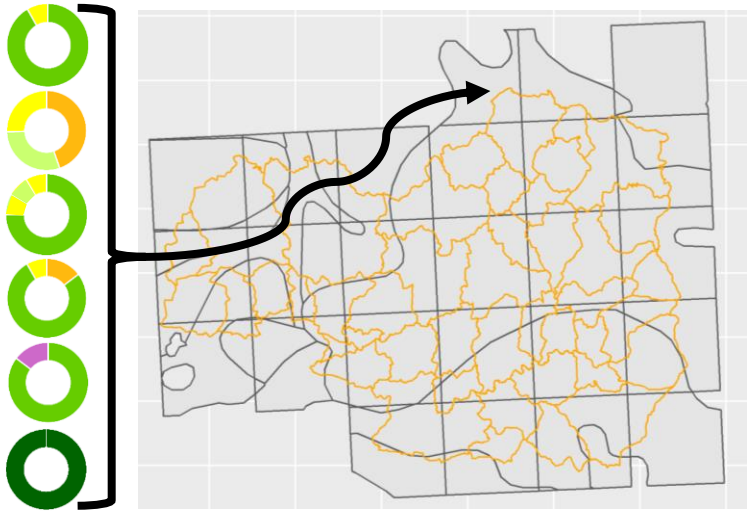
**Preliminary results**

**Each head of the rotation**

⇒ Crop/grassland yield each year

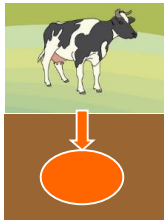
**2 uses of temporary grassland**

⇒ grazing, hay/ silage



# Analysis of results

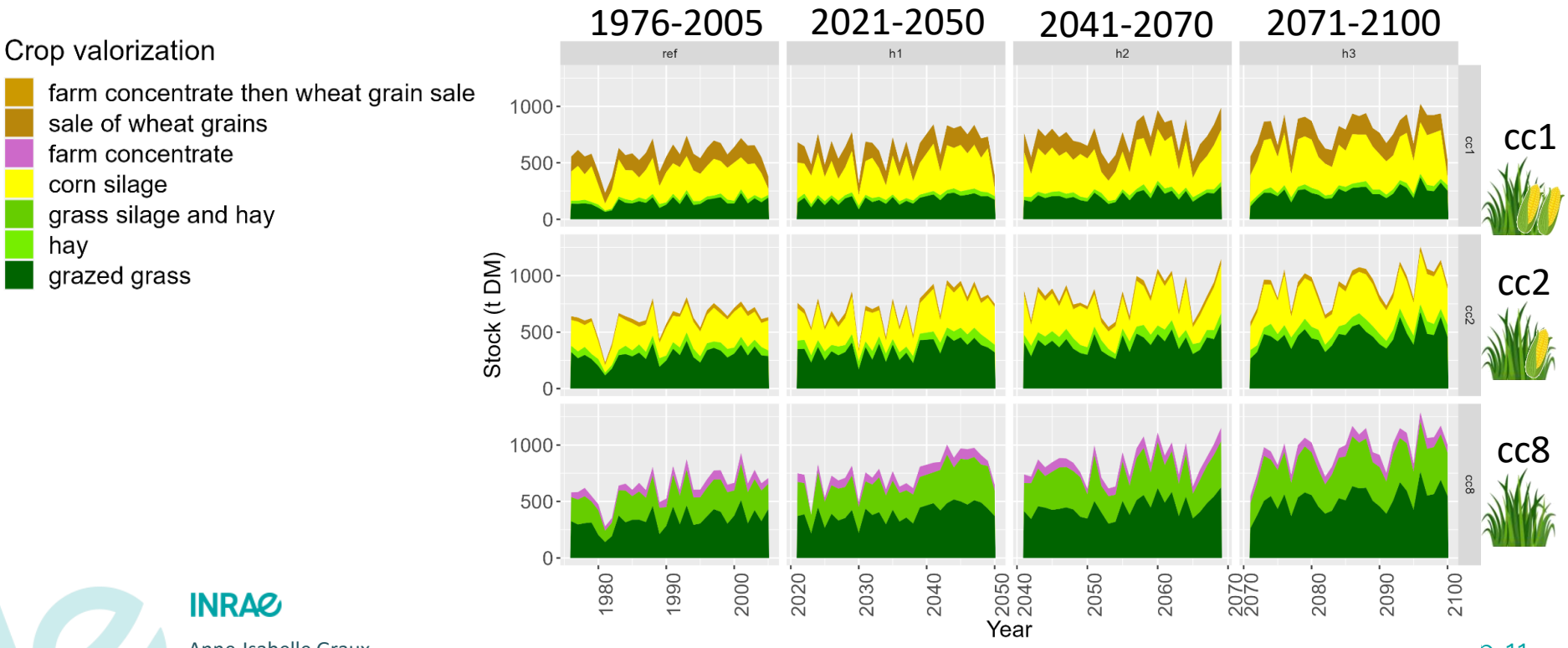
- Calculation of annual feed and soil C stocks at farm scale
  - Based on **areas** allocated to each rotation and **grassland/crop yield** or **soil C stock simulated** by STICS



  - **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

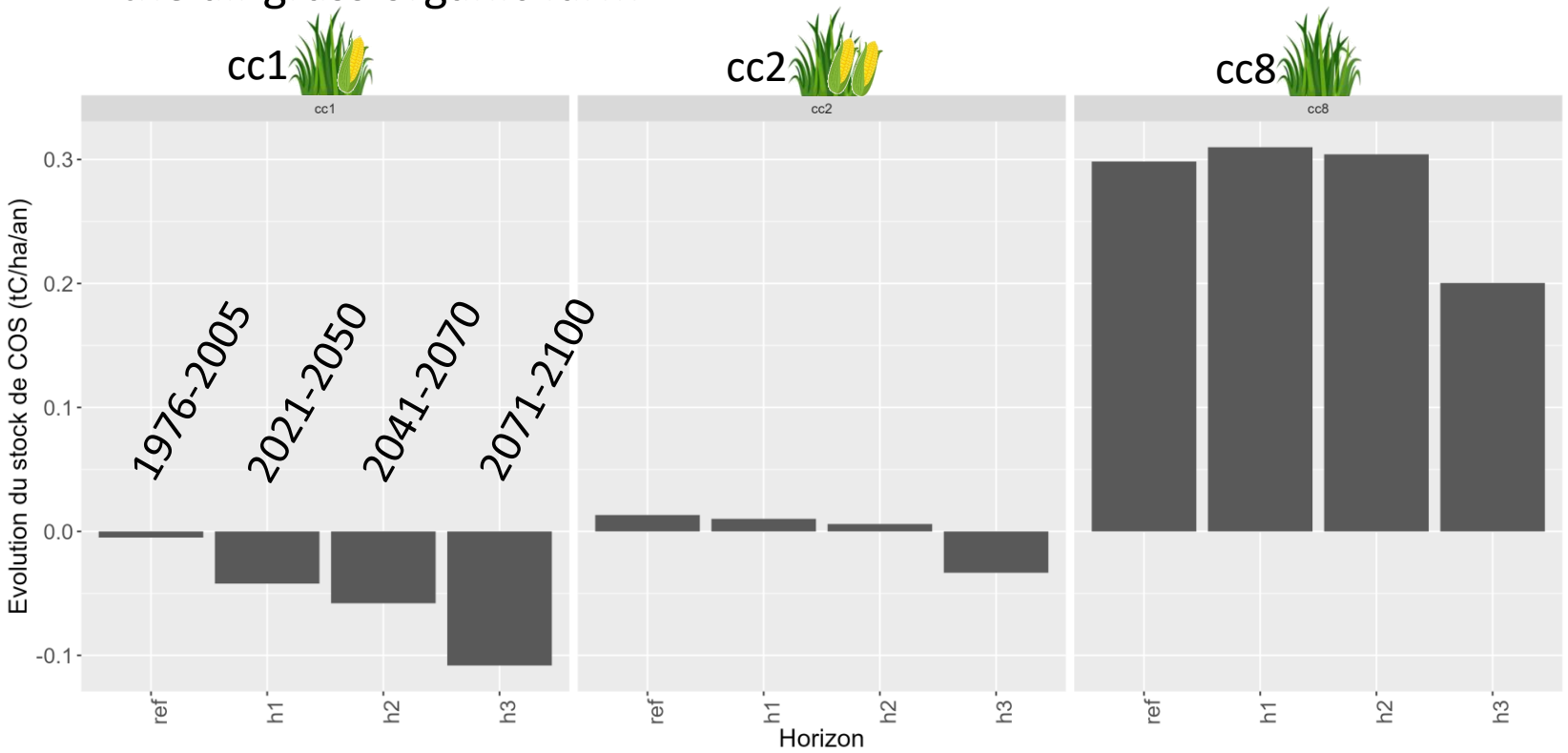
# Evolution of feed production service on the scale of the farm's cultivated area

- **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** ↗)



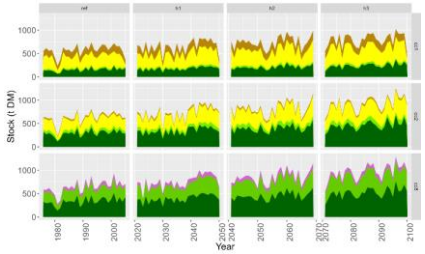
# Evolution of C storage service on the scale of the farm's cultivated area

- 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

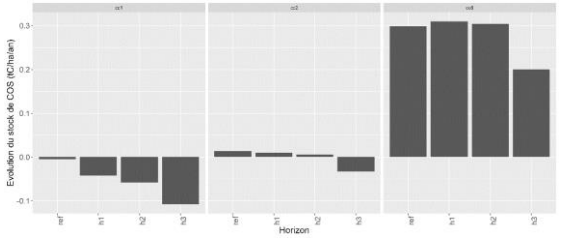



  - **Slight ↗** in annual **rainfall** (changes in distribution)
  - **↗ in temperature**
  - ↗ in PET but **stable actual ET** due to $CO_2$ effect

| 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 | | cc2 | | cc8 | |
|---|---|---|---|---|---|---|
| **Period** | **Min. (t C/ha)** | **Inputs (t C/ha)** | **Min. (t C/ha)** | **Inputs (t C/ha)** | **Min. (t C/ha)** | **Inputs (t C/ha)** |
| ref | 3.5 | 4.0 | 3.6 | 4.1 | 4.5 | 5.4 |
| h1 | + 0.4 | + 0.4 | + 0.5 | + 0.5 | + 0.5 | + 0.6 |
| h2 | + 0.8 | + 0.9 | + 0.9 | + 1.1 | + 1.0 | + 1.2 |
| h3 | + 1.3 | + 1.4 | + 1.4 | + 1.6 | + 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?

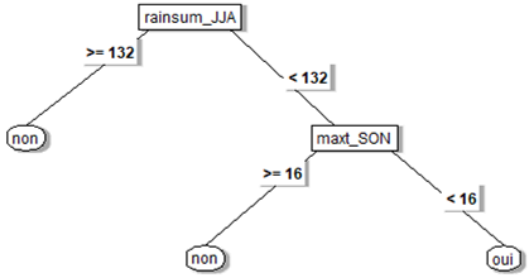
# Prospects

- 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