Introduction

...Évaluation critique de la capacité de modèles de prairies et cultures pour reproduire l'effet de différents agents de forçage anthropiques sur les émissions de gaz à effet de serre et le stockage de carbone à différents échelles.

1. Animal Change

► Draw sustainable scenarios for livestock production and reduce uncertainties in GHG emissions. European scale

2. AEGES

► Reduction of uncertainties associated with the prediction of GHG emissions, C storage and N content in the agro-ecosystems. French scale.
One of the major uncertainties to be tested is the evaluation of the impact of future climate projections

- on crop and grassland systems,
- soil carbon sequestration,
- GHG emissions.

To achieve that, a combined modelling approach is used at European scale

**PaSim**: The Pasture Simulation Model.
- Simulate the dynamics and the interactions of grasslands and breed herbivorous.
- Simulate the dynamics of nutrients, heat and water in soil and plant

**CERES-EGC**: The Crop Model.
- Simulate the growth of arable crops (maize, wheat, barley, rapeseed, sorghum, sunflower, pea, sugar-beet and soya),
- Simulate the dynamics of nutrients, heat and water in soil and plant
• Historical data (1951-2004)
• Climate change projection data (2005-2099)

- Aggregated 0.5° × 0.5° ~ 55 x 55 km
  - Min et Max air temperature
  - Global solar radiation
  - Rainfall
  - Wind speed
  - Relative humidity
  - CO₂

anthropogenic perturbation of the climate system of +4.5 and +8.5 W m⁻².
Climat scénario RCP 4p5

Rain Evolution

Solar Radiation Evolution

Evolution température minimale

Evolution temperature maximale
Climat scénario RCP 8p5

Rain Evolution

Solar Radiation Evolution

Evolution température minimale

Evolution temperature maximale
SOIL EUROPEAN SOIL DATA BASE

PaSim
- Multilayer data aggregated in 6 layers:
  - Depth
  - Sand, Silt, Clay, Gravel
  - C content
  - Bulk density
  - pH
- Estimation of parameters
- 1 km × 1 km
- Aggregated at 0.25°

CERES-EGC
- 2 profiles, top- and sub-soil data in 5 layers:
  - Depth
  - Sand, Silt, Clay, Gravel
  - C content
  - Bulk density
  - pH
- Estimation of parameters
- 1 km × 1 km
- Aggregated at 0.25°
Grassland cutting date, amount and type of fertilisation, animal management and stocking densities data, obtained from the CAPRI modelling system (Common Agricultural Policy Regionalised Impact). 30 years.

Only one fertilisation management. 1km x 1km.

Crop and fertilisation data are obtained by identifying the two main crop rotations for each mesh of the reference grid, starting from a 1km x 1km resolution database derived by EuroStat. 30 years.

Management as a function of meteo conditions and crop:
- Sowing date / Crop type
- Fertilisation date
GHG fluxes ($N_2O$, $CO_2$, $CH_4$)

Carbon stocks

Crop productivity

Grassland productivity

Animal productivity

CERES-EGC MODELLING

Spatialisation

Mitigation Scenarios
Biomass

Pastures
99.6% Percentage of pasture with different stocking rate

Grasslands
91% Percentage of fertilised crops
Crop behaviour: Yield, harvest, irrigation volumes needed
.. next steps

- Determine N$_2$O and CO$_2$ budget in Europe (surfaces)
- Comparison Grassland and Cropland outputs with IPCC 2013 inventory.
- Performance of CERES and PaSim models ("sensitivity" analysis by using extreme data: dry/humid, warm/cold years)
A variety of options exist to mitigate GHG emissions in agriculture. The most prominent options are the improvement of crop and grazing land management in upland soil (agronomic practices, crop selection, tillage and residue management) and the restoration of degraded soils.

The introduction of temporary grasslands in crop rotations is one of the prominent options to improve both soil organic matter (SOM) and biodiversity, conversely the effects in N$_2$O emissions, together with the quality of SOM, can be highly variable.

**PaSim**: The Pasture Simulation Model.
- Simulate the dynamics and the interactions of grasslands and breed herbivorous.

**FarmSim**: The Crop Model.
- Simulate the growth of arable crops (maize, wheat, barley, rapeseed, sorghum, sunflower, pea, sugar-beet and soya),
- Simulate the dynamics of nutrients, heat and water in soil and plant.
FarmSim

The model, FarmSim, is a simulation framework allowing the description of a mixed crop, grassland and ruminant system and buildings and calculating the losses from the biogeochemical cycles at field scale with multiple plots.

• The model FarmSim allows to create rotations at field scale, tillage operation and grassland sowing.

• The models for grassland-livestock (PaSim) and for croplands (CERES-EGC) work independently

• a subsequent and automatic parameterisation mediate the passage from grassland to cropland and vice versa:
  • Soil C and N pools
  • Water contents
  • N₂O pool
  • Residues
  • Plant development
GUI
Les traitements expérimentaux

**Dispositif en blocs** (20 parcelles de 4000 m²)

- T1 : culture
- T2 : séquence prairie de 3 ans, N+, fauche
- **T3 : séquence prairie de 6 ans, N+, fauche**
- T4 : séquence prairie de 6 ans, N-, fauche
- T5 : prairie 20 ans, N+, fauche

6 years of grassland
2005-2011

3 years of crops
2011 Maize
2011 Wheat
2012 Barley
<table>
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<tr>
<th>Parameter</th>
<th>MAE</th>
<th>RRMSE</th>
<th>EF</th>
<th>CRM</th>
<th>CD</th>
<th>Slope</th>
<th>Intercep</th>
<th>R2</th>
<th>Signif.</th>
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<th>Sim Mean</th>
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SWC

Grassland | Crop
### Parameter Summary

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<th>Parameter</th>
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Test Site -> Extension to Europe

CH – Chamaau, ETH-Zurich
Description: grassland restoration.
Years: 2002-2012

FR – Lusignan, INRA SOERE-ACBB
Description: P2: grassland restoration; P1: grassland to cropland
Years: 2005-2014

UK – Tulloch, SAC, Craibstone Estate
Description: grassland to cropland
Years: 1995–2006

UK – Easter Bush, CEH ???
Description: grassland 2002-2010; grassland restoration 2012
Years: 2002-2010 / 2012
next steps

– Extension to the French scale, supposing mitigation scenarios (rotation / restoration)

Merci de votre attention!