Multi-scale spatialization of N_2O emissions by soils and their mitigation potential in the Bourgogne Franche-Comté Region

Advantages, limits and paths of exploitation for aiding decisions in the framework of ecological transition at local-regional scales

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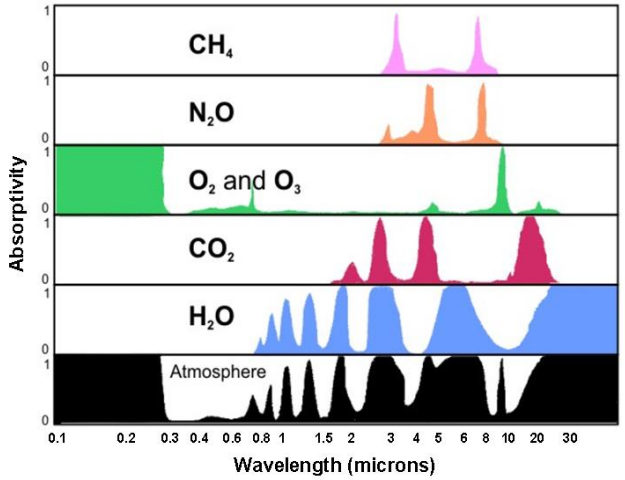
N_2O : the laughing gas … not that much funny!

- Its radiative properties
  - Absorption of IR radiations :

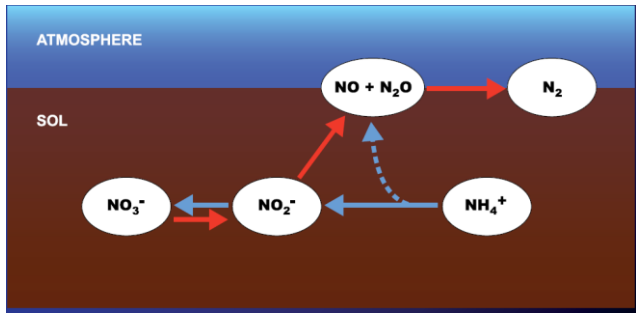
  ➔ a potent GHG with a very high GWP



Credit: David Babb

- Its reactive properties
  - With the stratospheric ozone, for example

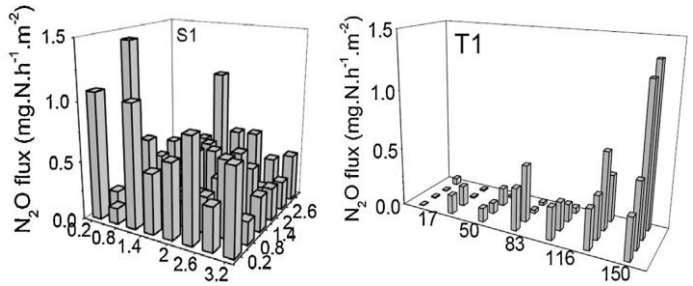
- The complexity of the mechanisms involved in its formation and destruction
  - **Alternative** microbial respiratory mechanisms



Dénitrification
Nitrification

D'après Mathieu et al., 2005

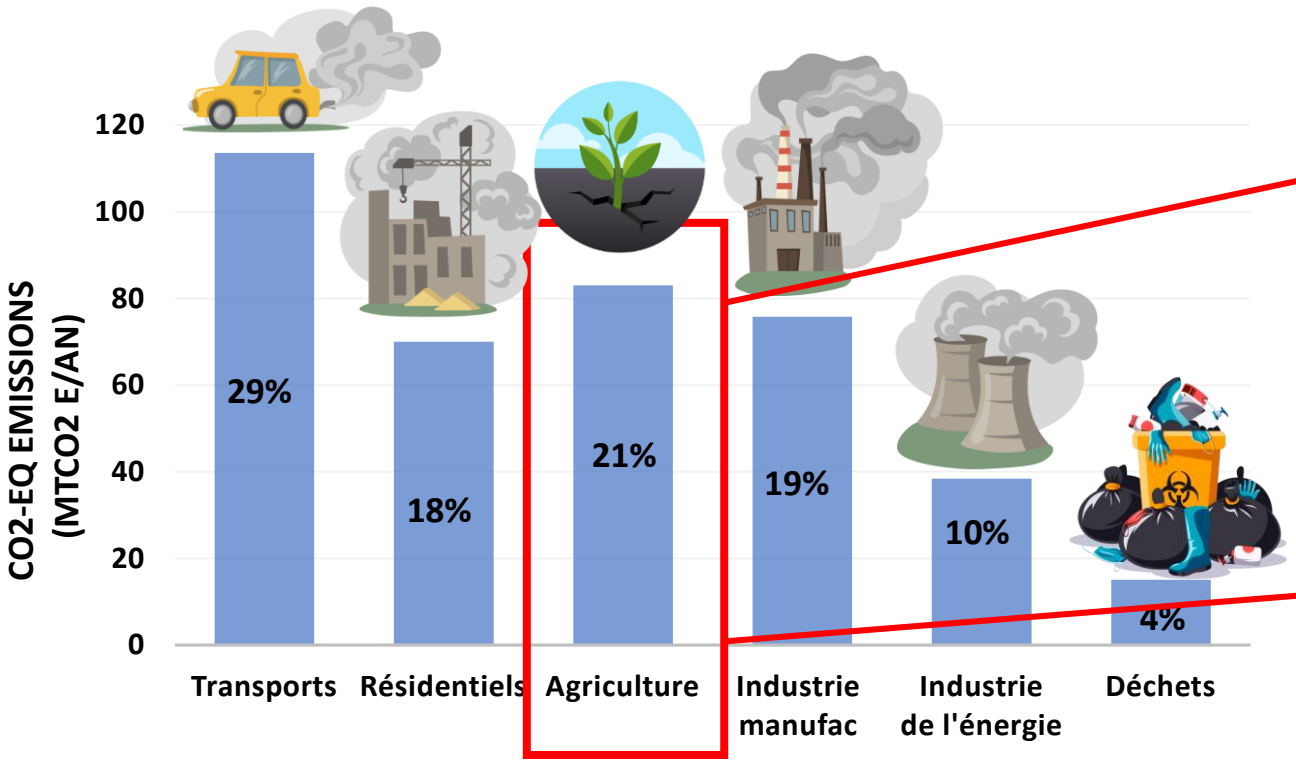
➔ Leading to a very high spatial and temporal variabilities



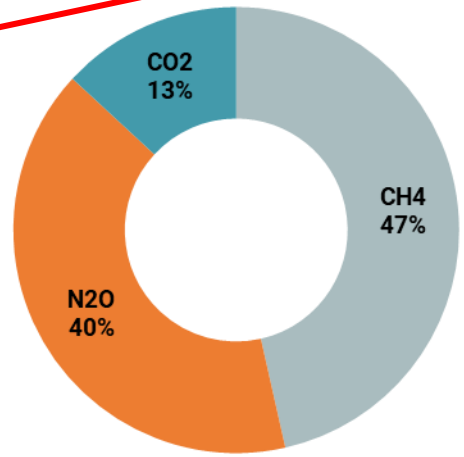
D'après Grossel et al., 2014

➔ Leading to very large uncertainties in assessments whatever the scale

N_2O in the national (France) GHG budget



Contribution of the different sectors of activities to GHG emissions, in France in 2020 (CITEPA, 2021)



GHG distribution from Forestry and Farming sectors in 2020 (Citepa – Rapport Secten ed. 2022)

Calculations performed using the Tier 1 approach (IPCC, 2019), i.e., applying an emission coefficient to the amounts of nitrogen applied to the soil

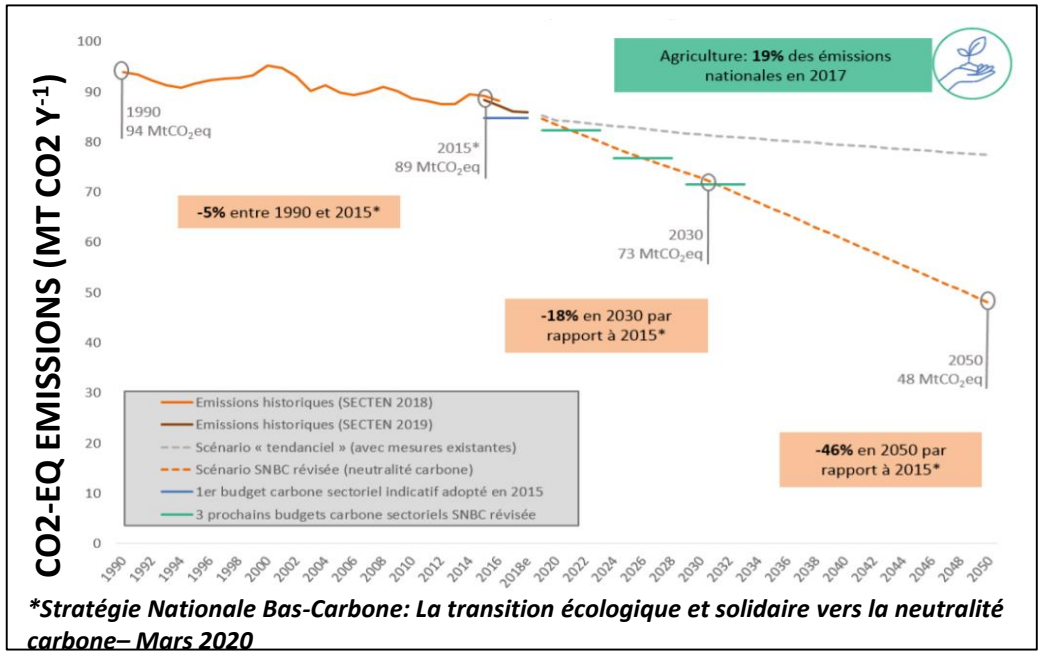
Mitigation of GES emissions : Objectives for agriculture – means of action

➔ **LCNS : Low-Carbon National Strategy ***

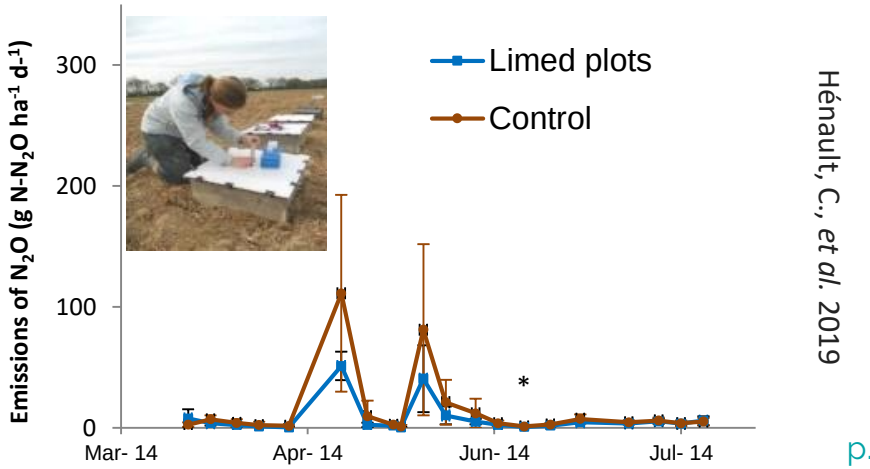
Expected results (LCNS-2020*, CR-BFC, 2020***)**
National : **- 18%** in 2030 **- 46% i**n 2050
Regional (BFC) : **- 8 %** in 2030 et de **- 32% in** 2050 (compared to 2015)

AgroEcology :
- To reduce N inputs
- To optimize the N cycle

➔ **LBCGC** :**
- To reduce N inputs
- ……
- **To add liming materials on acidic soils** (Hénault et al., 2019)



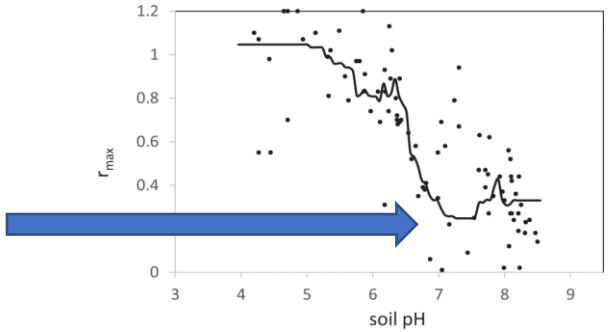
**Stratégie Nationale Bas-Carbone: La transition écologique et solidaire vers la neutralité carbone– Mars 2020*



** Stratégie Nationale Bas-Carbone: La transition écologique et solidaire vers la neutralité carbone, 2020 2/192*
*** Label bas Carbone en Grandes Cultures* - B.Soenen *et al.,* 2021

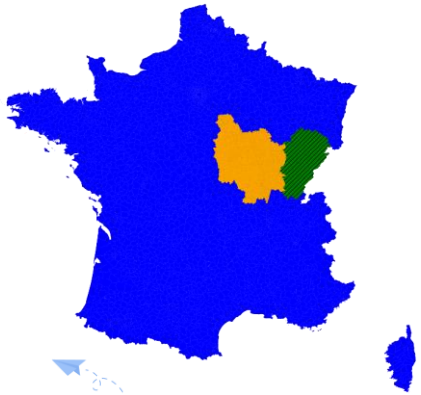
Objectives and principles

- **Quantification and spatialization of N_2O emissions and their potential abatement**
  - Abatment levers :
    - **To manage soil pH by the addition of lime materials**



Hénault, C., *et al. Sci Rep* 9, 20182 (2019).

  - Calculations
    - using different soil databases GisSol (**BDAT, IGCS**) – ESDAC (**Lucas soil**)
    - using different IPCC N_2O emission estimation methodologies (**Tier 1, Tier 2)**



  - Perimeter : intra-BFC, as large as possible regarding methodological limitations :
    - **Bourgogne with rainfall < 950 mm**

- **Dissemination of results to different stakeholders**
  academic, professional, **public politicy**, …

Models used (Tier 1 et 2)

Tier1

Tier1

Hergoualch' *et al.,* 2019

EF determined from international data

$$N_{emission} = [(N_{min} \times EFmin) + ((Norg + Nresidu + Nmineralised)_{\times} EF_{org})]$$

LBCGC

B.Soenen *et al.,* 2021

Extension of the Tier1 method

(Hergoualch' et al., 2019 ; Hénault et al., 2019)

$$N_{emission} = \boldsymbol{C\_liming}[(N_{min} \times EFmin) + ((Norg + Nresidu + Nmin_{éralisé})_{\times} EF_{org})]$$

$$\boldsymbol{C_{liming}}_{i,k} = 1 - \left[\frac{\min(pH_{final} - pH_{initial}; 0.4)}{0.4} \times \left(0.5 \times exp^{(-0.33 \times k_{liming})}\right)\right]$$

Tier2

S&B

Stehfest. E, Bouwman. L, 2006

Relation defined by a meta-analysis of international data

$$\log(N_{émission}) = \alpha + \sum_{i=1}^{n} E_i$$

- N_{min}
- N_{org}
- EF_Culture
- EF_Text
- EF_pH
- EF_Corg

Le Gall

Le Gall et al., 2016

Relation defined by an analysis of French data

$$\log(N_{émission}) = \alpha + \beta * N_{org} + \gamma * N_{min} - \delta * pH + \theta * Rain$$

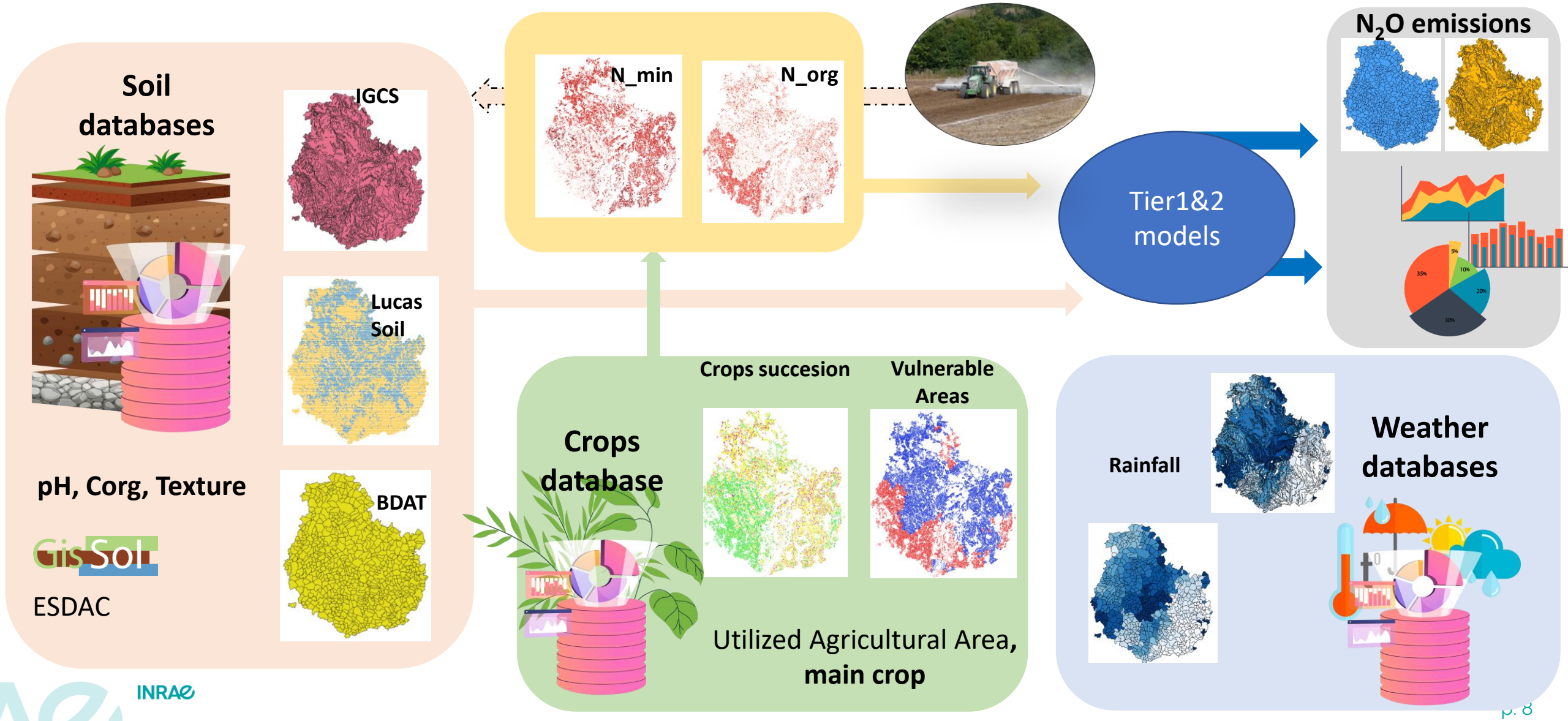
Mobilized databases

	Databases	Spatial resolution	Spatial coverage	Accessibility	Usage restrictions
Soil GisSol ESDAC	GisSol BDAT (1)	Communal	BFC/T de Belfort	agreement	Academic use only
		Cantonal			No
	ESDAC – Lucas Soil (2)	Communal	BFC	open (on request)	no
	GisSol IGCS (3)	UCS	Bourgogne	agreement	no
Culture	RPG Crop successions (4)	plot	BFC	open	no
	Dreal 2017	departmental	BFC	/	no
Weather	Drias 2020 (5)	Communal	BFC	open (on request)	no

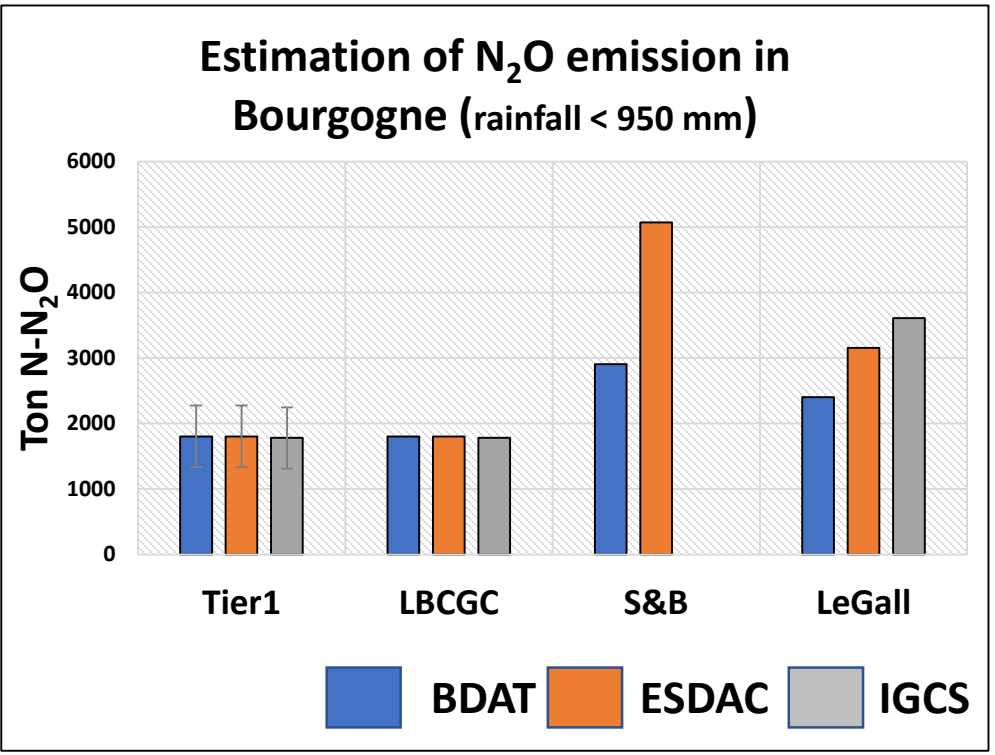
Perimeter of the study : Bourgogne (pluvio < 950 mm)

(1) Saby,N , et al. 2014. Le programme Base de Données des Analyses de Terre (BDAT) : Bilan de 20 ans de collecte de résultats d'analyses. 21, pp.141-150. ffhal-01209243f
(2) Ballabio C., et al. 2016. *Mapping topsoil physical properties at European scale using the LUCAS database (2016) Geoderma, 261 , pp. 110-123.*
(3) Bertrand, L. et al 2014. Les programmes d'inventaire cartographique : IGCS, BDGSF. Séminaire du Département Environnement et Agronomie "Les Bases de données SOL". 40 p. ffhal-02794522f
(4) Martin, P., Rabenandrasana, N.et al. 2021, RPG Explorer Crop successions France 2007-2014, 2007-2019, 2015-2019, Portail Data INRAE, V2.
(5) Lémond J., 2010. Le projet DRIAS : premières études et documents ; CNRM / GAME, Météo-France, CNRS ; Direction de la Climatologie. Réunion Comité Utilisateurs, le 29 juin 2010.

Methodological approach and data sources



Estimation of N_2O emissions from agricultural soils in 2018

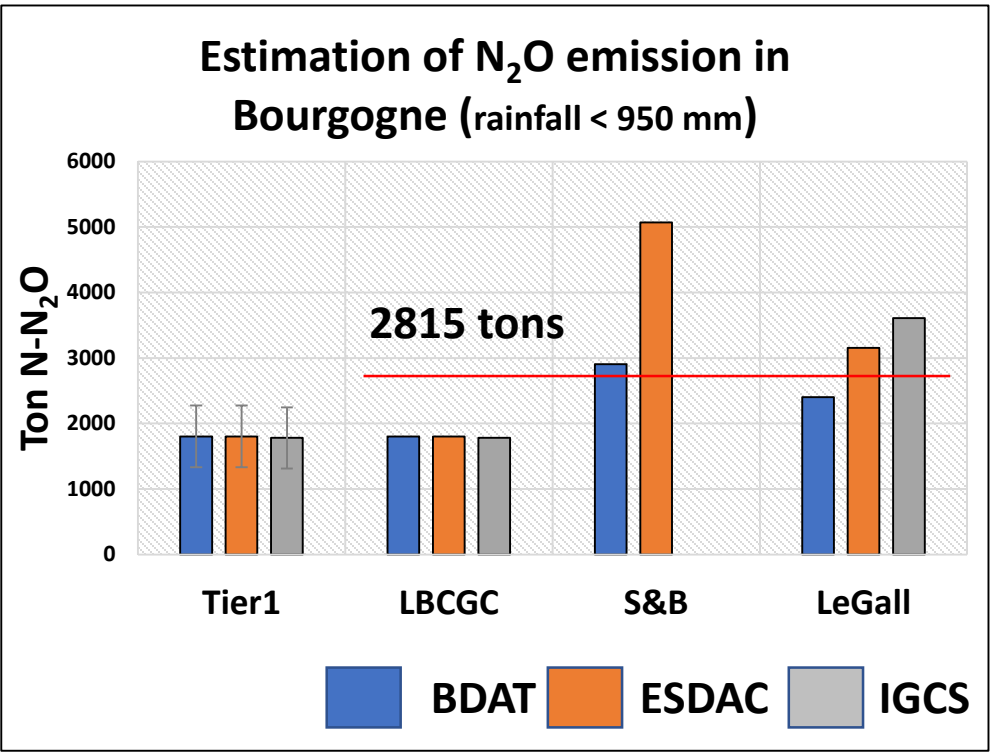


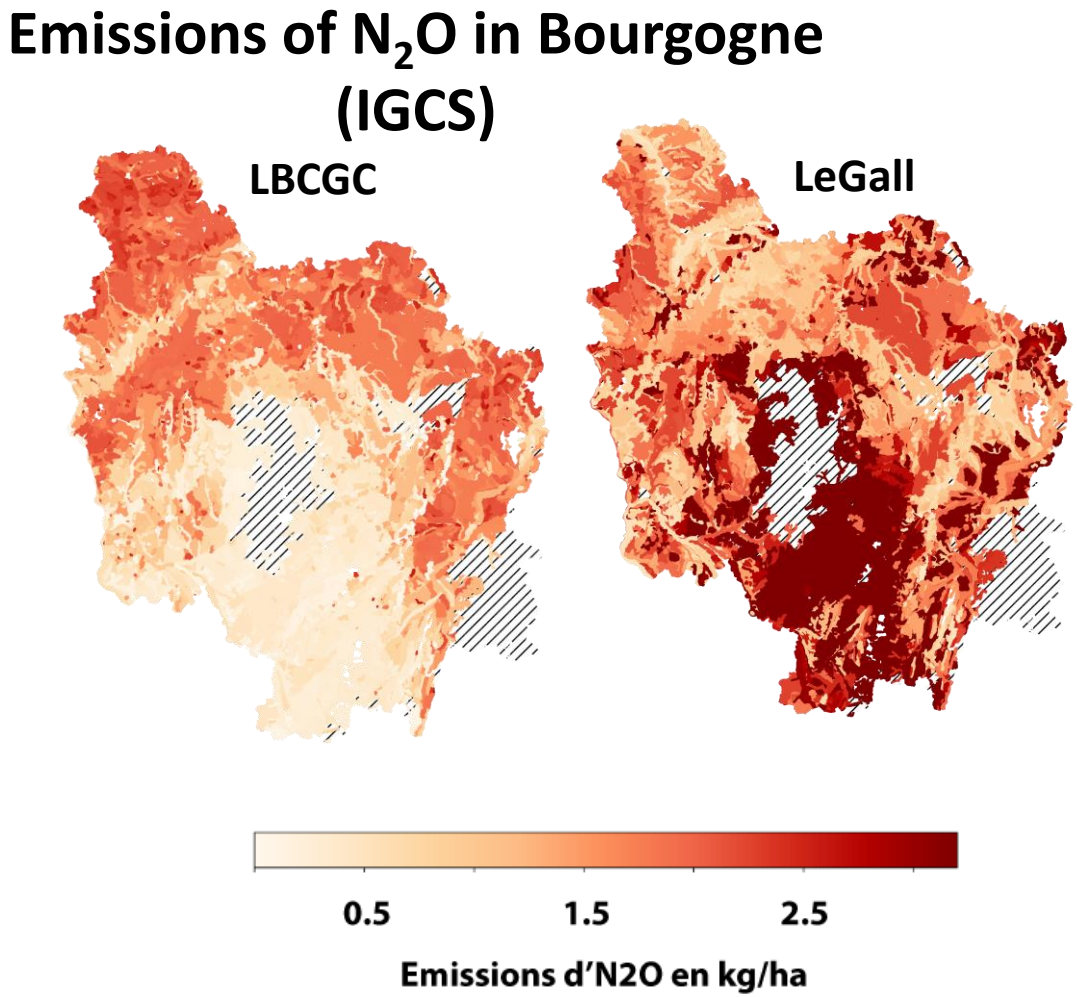
Mean estimate : **2815** tonnes N-N_2O en 2018.

- Variability between models

- Variability between soil databases

Estimation of N_2O emissions from agricultural soils in 2018





Mean estimate: **2815** tonnes N-N_2O en 2018.

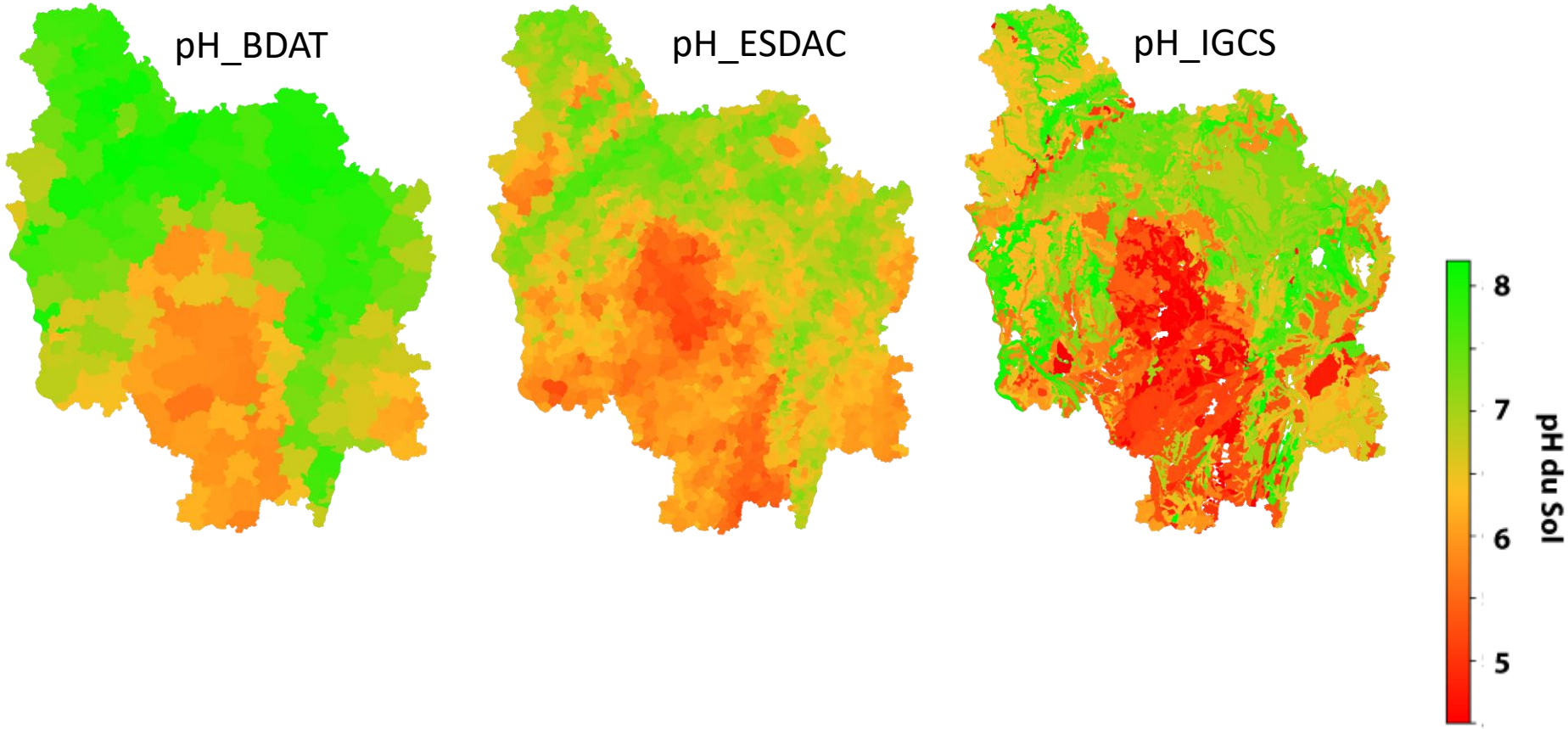
- High variability between models

- High variability between soil databases

Mobilizing the “liming of acidic soil” lever in Bourgogne (theoretical)

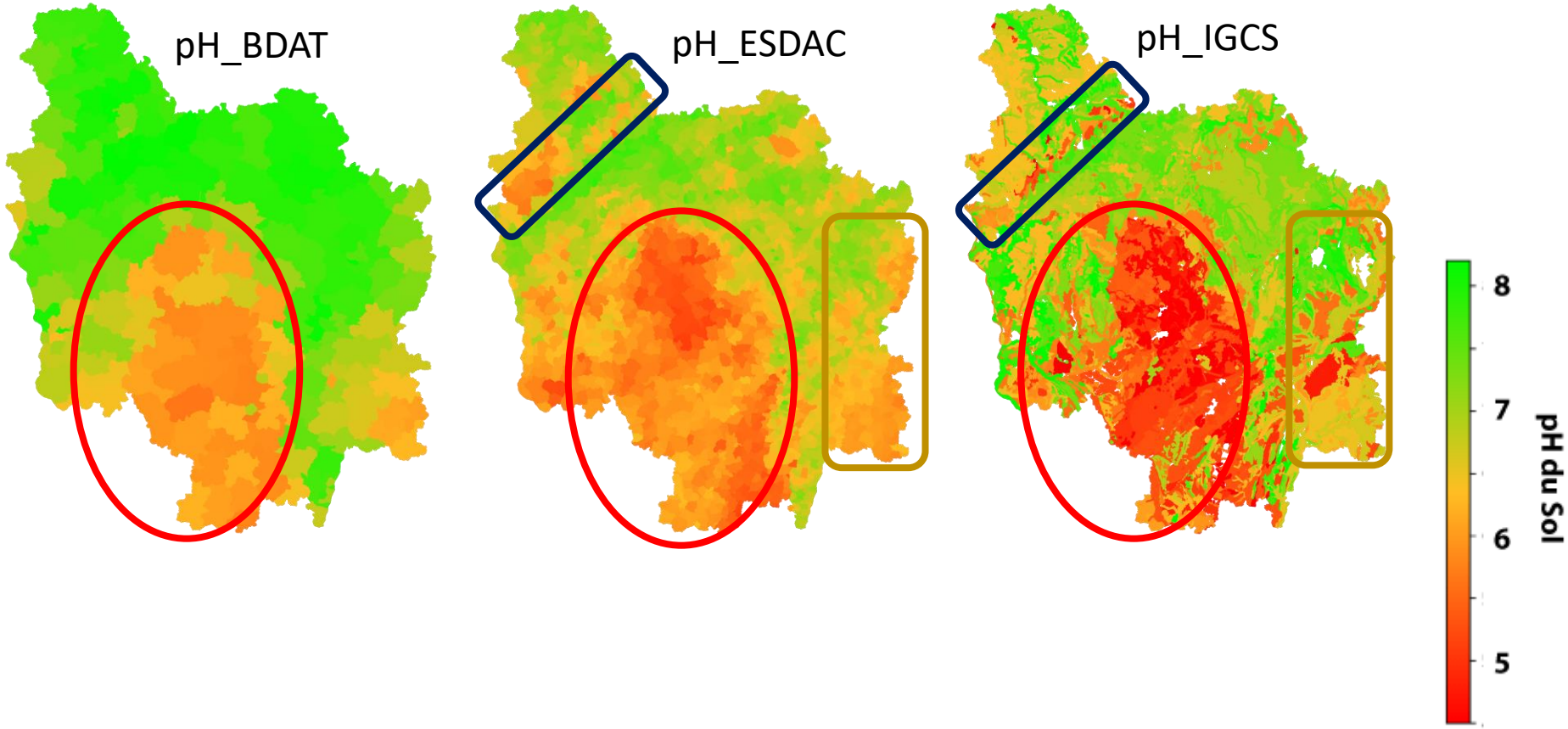
Soil pH maps

Initial values



Mobilizing the lever “liming of acidic soil” in Bourgogne (theoretical)

Soil pH maps

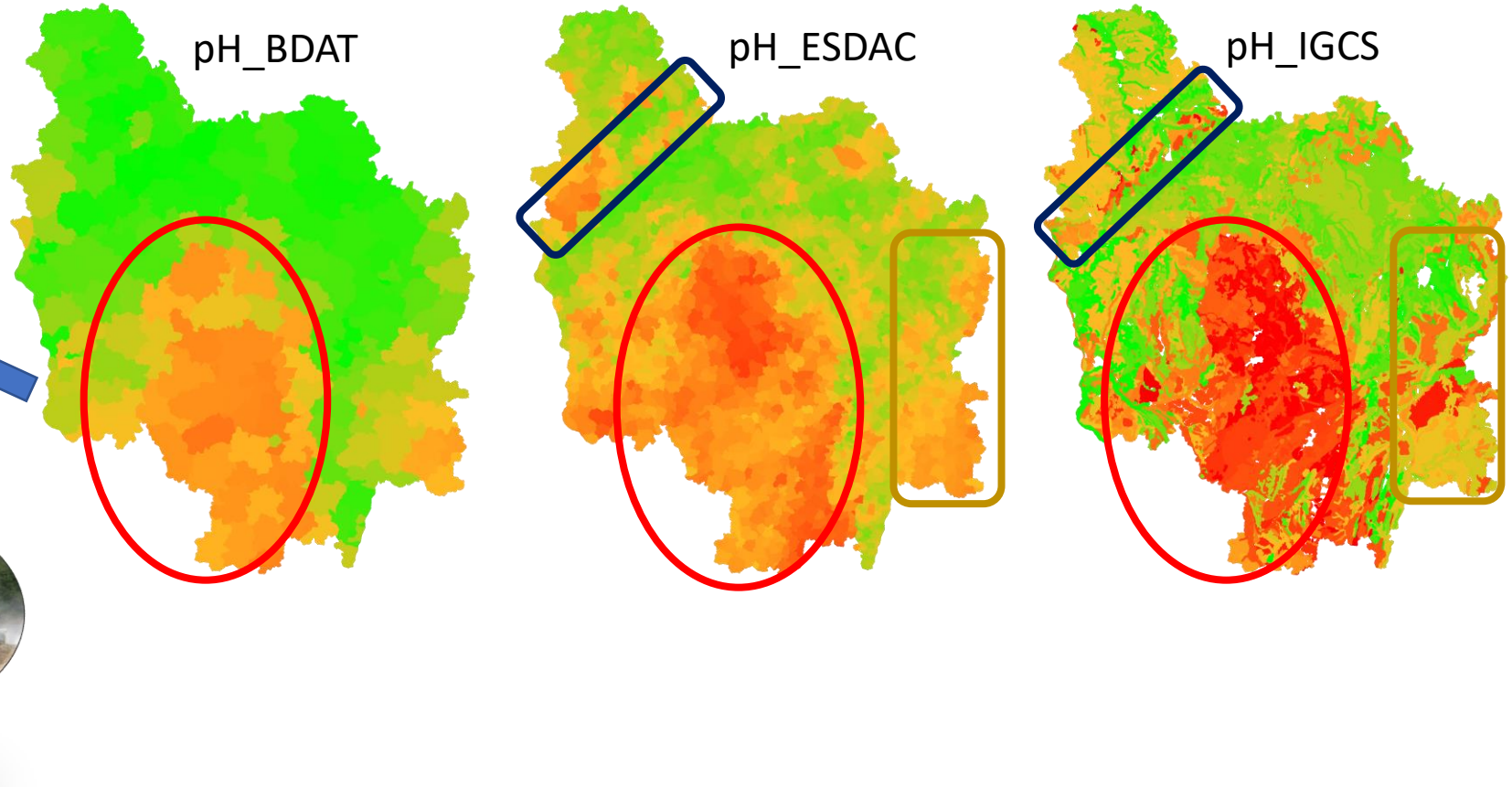


Initial values

* Acidic areas
  - Morvan
  - Fosse Bressane
  - Bande Yonne

Mobilizing the “liming of acidic soil” lever in Bourgogne (theoretical)

Soil pH maps



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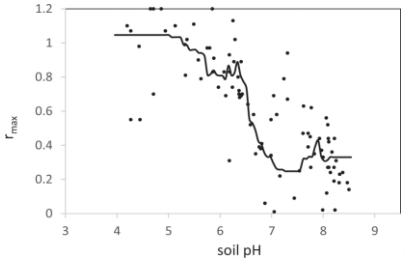


Expected pH > 6.8

Mobilizing the “liming of acidic soil” lever in Bourgogne (theoretical)

Soil pH maps

pH_BDAT

pH_ESDAC

pH_IGCS

pH du Sol

8

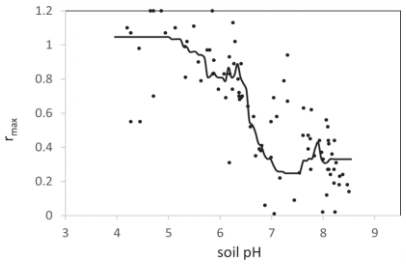
7

6

5

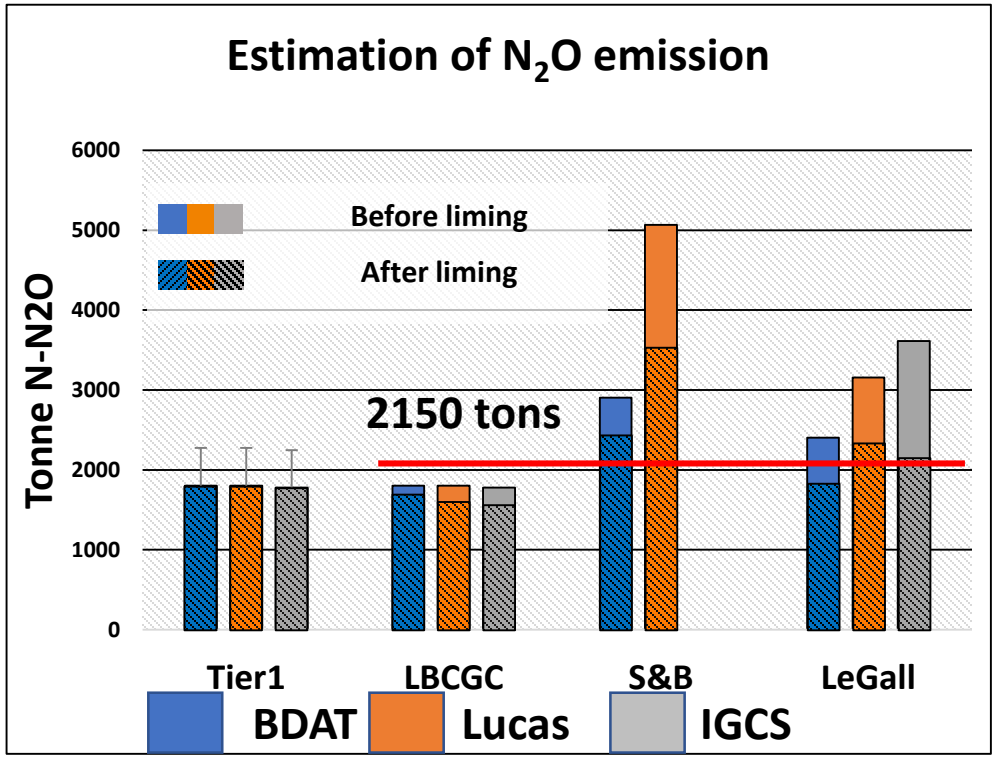
Initial values

* Acidic areas
  - Morvan
  - Fosse Bressane
  - Bande Yonne



Expected pH > 6.8

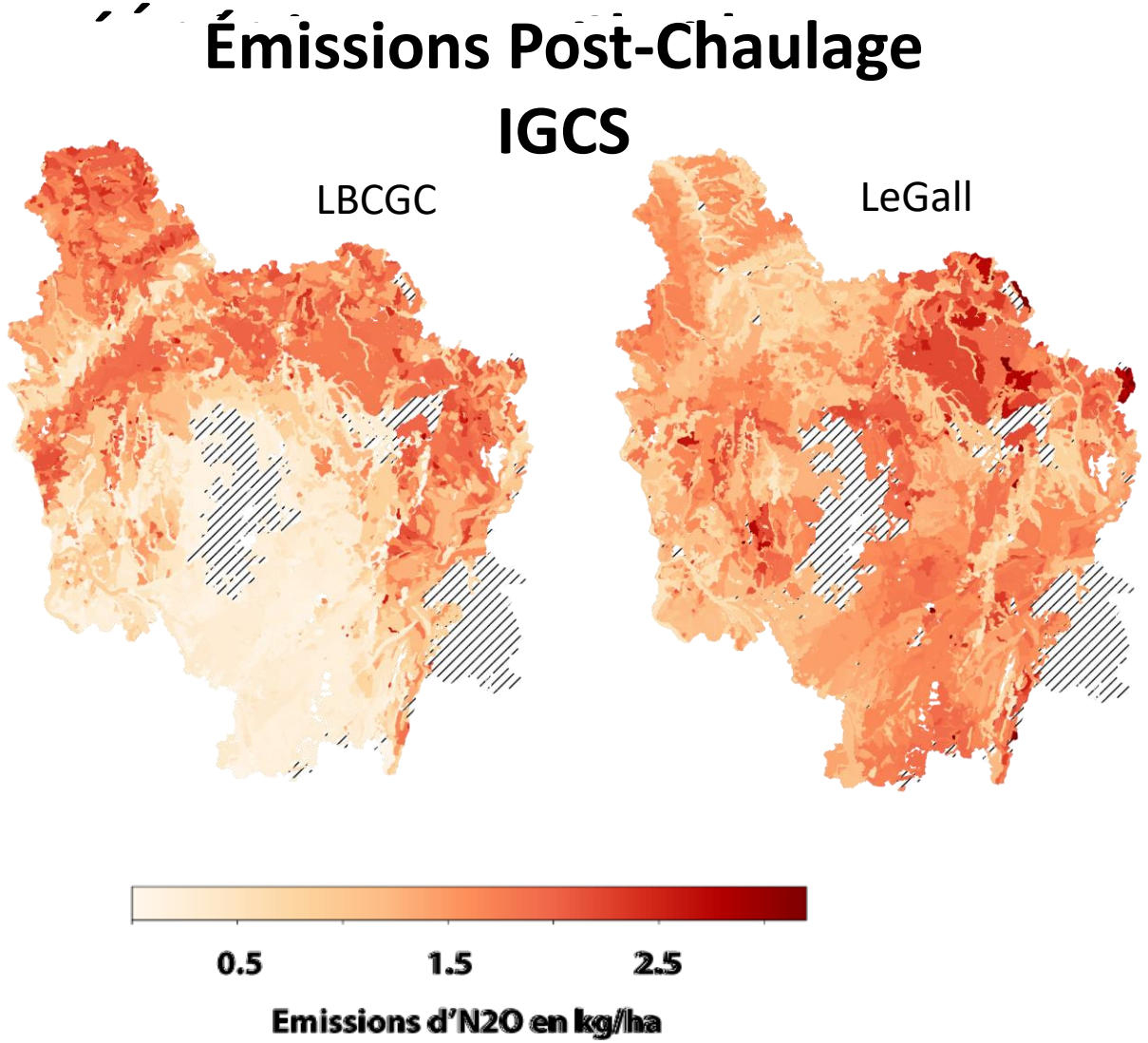
Estimations of N_2O emissions after mobilization of the “liming” lever



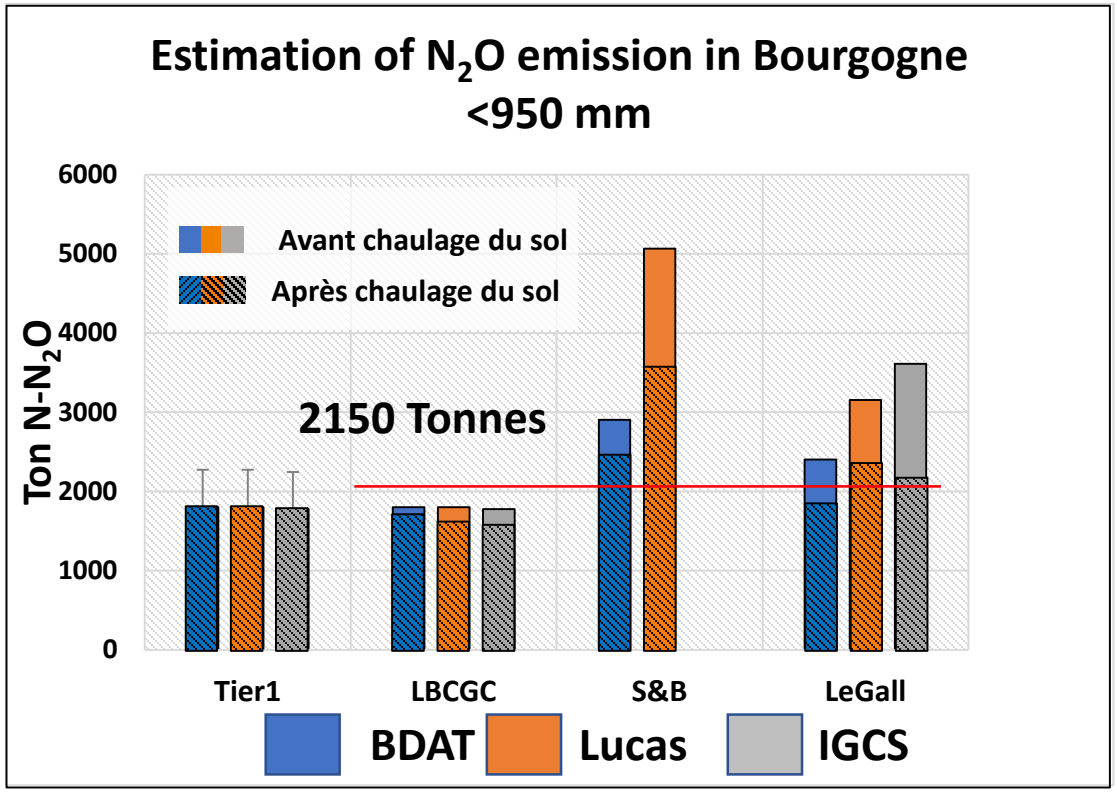
Mean of N_2O emissions: **2150** tons N-N_2O

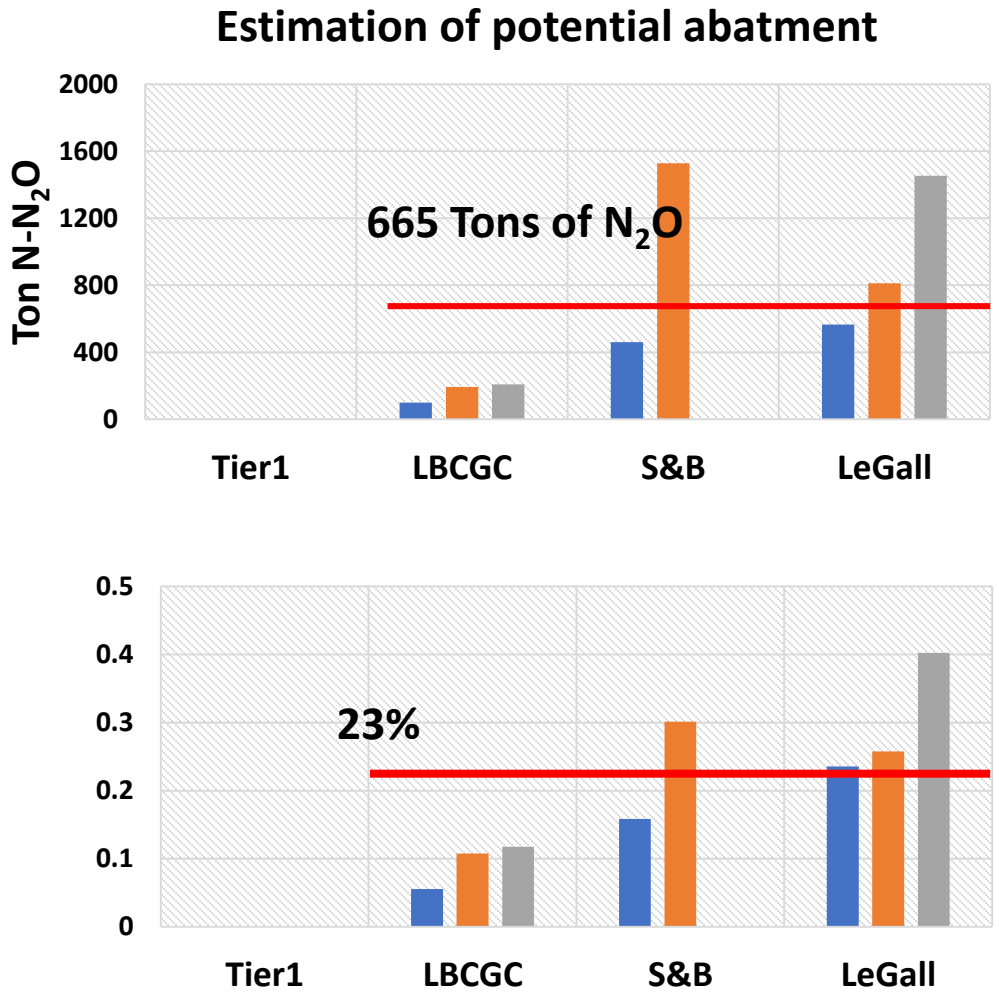
Access to the potential abatment distribution

* Location in acidic soil areas



Estimations of N_2O emissions after mobilization of the "liming" lever





Mean of N_2O emission: **2150** tons $N\text{-}N_2O$

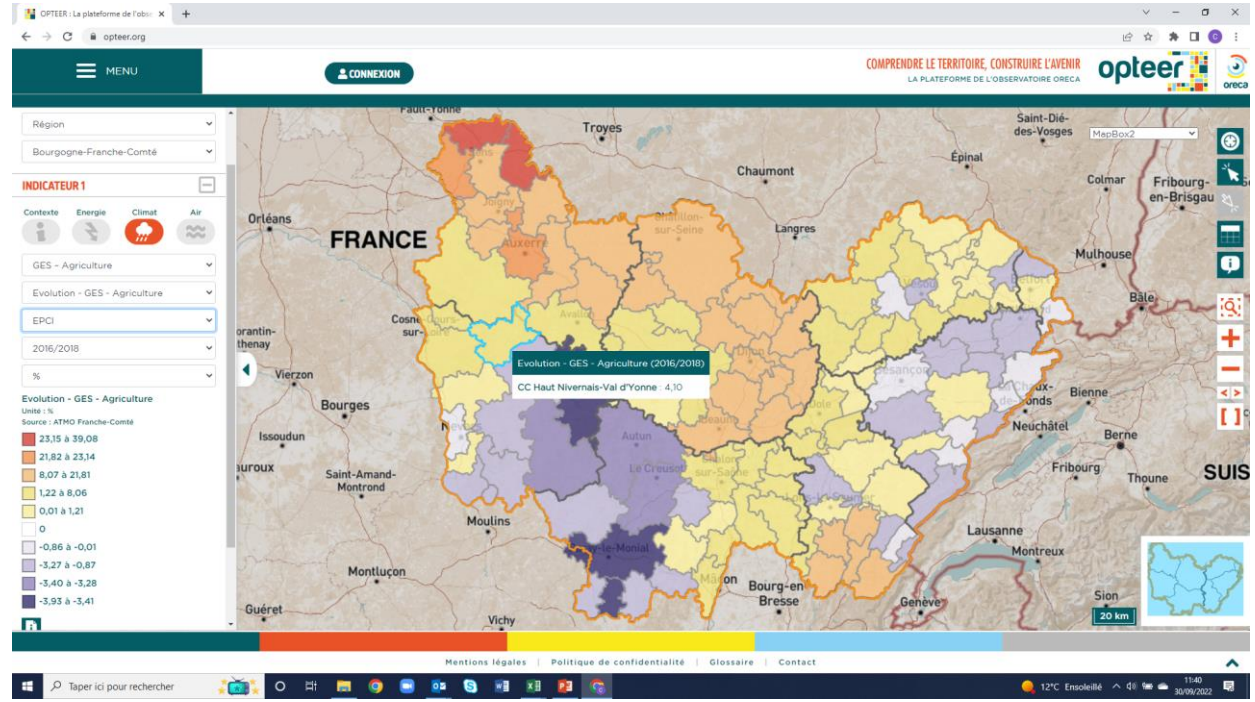
All methods, defined independantly, predict an abatment (around 20 %) by the management of soil pH

Dissemination of the results

Dissemination via different chanels

To whom : decision makers, agricultural profession

Broadcast media : The OPTEER, platform)



https://www.opteer.org/

Which informations / which resolution, in progress…

constraints (confidentiality of data, accessibilities of Databases…)

Conclusions and Perspectives

Strengths		Weaknesses
• Estimation of abatment are consistent (whatever the methodology used) • Quantitative approach • Possible analysis in view of the NSLC objectives.	• Spatialised approach with an aggregatable communal resolution • Sensitive analysis to methods and databases • Transferable approach to other regions • Evolutionary approach (calculation functions)	• Conditions to define Tier 2 functions • Heavy handling of DDBs and constraints on their confidentiality - Soil databases temporality • Variability of N_2O emission estimates (inherent in the source processes) • To be completed by taking into account possible CO_2 emissions related to the practice of liming
Opportunities		**Threats**
• Low Carbon Methodology in field crops • The Opteer Platform		• Financial support deadline / sustainability of the approach

Merci de votre attention