Soil Organic Carbon budget in the EU: moving across scales

Daniele De Rosa, Lugato Emanuele, Arwyn Jones

JRC LULUCF Workshop 2023
LULUCF inventories for enhanced climate action

Land **U**se and **C**overage **A**rea frame **S**urvey

Soil component

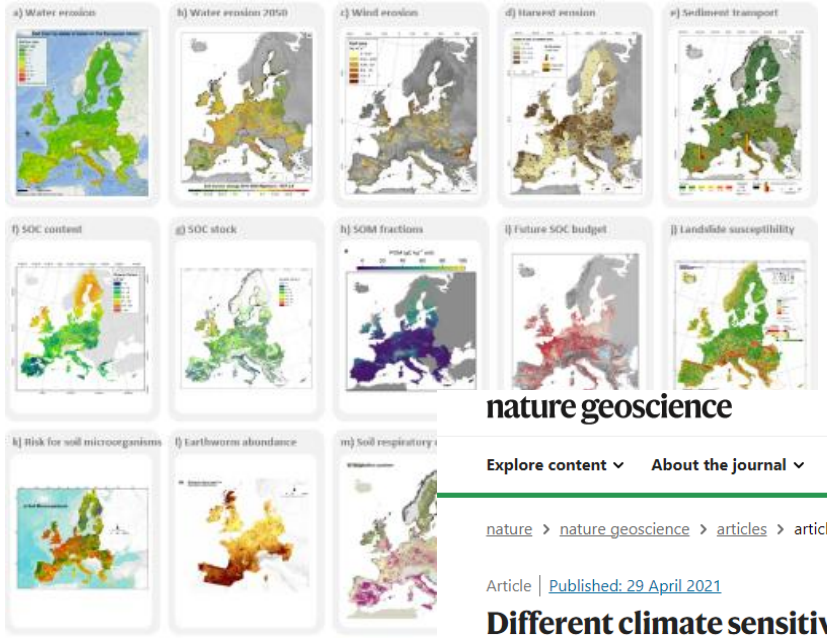
- ~ 22’000 topsoil samples
- main physico-chemical soil properties
- 2009, 2015, 2018 completed
- 2022 ongoing analysis 40K (Samp. Framework SOC)

Is it a SOC monitoring framework?

- Only topsoil 0-20 cm – For 2022 0-30cm
- No systematic bulk density – For 2022 updated
- Limited management information

European Commission

How LUCAS data are used?



ELSEVIER

Science of The Total Environment

Volume 853, 20 December 2022, 158706

Improving the phosphorus budget of European agricultural soils

Panos Panagos [a], Julia Köningner [a], Cristiano Ballabio [a], Leonidas Liakos [a], Anna Muntwyler [a], Pasquale Borrelli [b], Emanuele Lugato [a]

RESEARCH ARTICLE

Complementing the topsoil information of the Land Use/Land Cover Area Frame Survey (LUCAS) with modelled N_2O emissions

Emanuele Lugato[1]*, Lily Paniagua[1,2], Arwyn Jones[1], Wim de Vries[2,3], Adrian Leip[1]

1 European Commission, Joint Research Centre (JRC), Sustainable Resources Directorate, Ispra, Varese, Italy, **2** Wageningen University and Research, Environmental Systems Analysis Group, Wageningen, The Netherlands, **3** Wageningen University and Research, Environmental Research (Alterra), Wageningen, The Netherlands

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Article | Published: 29 April 2021

Different climate sensitivity of particulate and mineral-associated soil organic matter

Emanuele Lugato, Jocelyn M. Lavallee, Michelle L. Haddix, Panos Panagos & M. Francesca Cotrufo

Nature Geoscience **14**, 295–300 (2021) | Cite this article

11k Accesses | **74** Citations | **197** Altmetric | Metrics

ELSEVIER

Science of The Total Environment

Volume 769, 15 May 2021, 144755

A spatial assessment of mercury content in the European Union topsoil

Cristiano Ballabio [a], Martin Jiskra [b], Stefan Osterwalder [c], Pasquale Borrelli [d], Luca Montanarella [a], Panos Panagos [a]

And, many more…

European Commission

How LUCAS data are used?

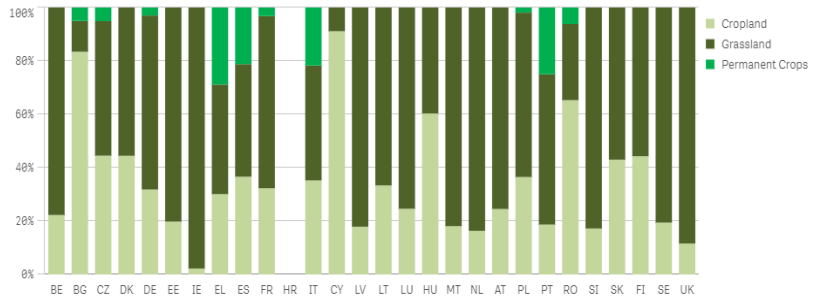
CAP performance indicators

CONTEXT INDICATOR 41 : SOIL ORGANIC MATTER IN ARABLE LAND

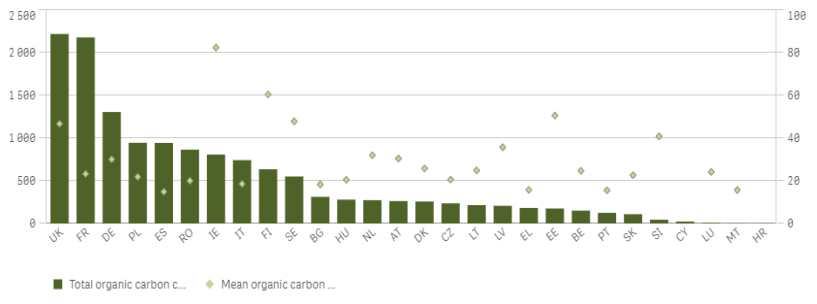
Tab1 | Map1 | Map2

Member State | Selections : Year: 2015 | Last data update : 2020

Estimate of organic carbon content in different category of arable land, 2015



Total estimates of organic carbon content in arable land, 2015

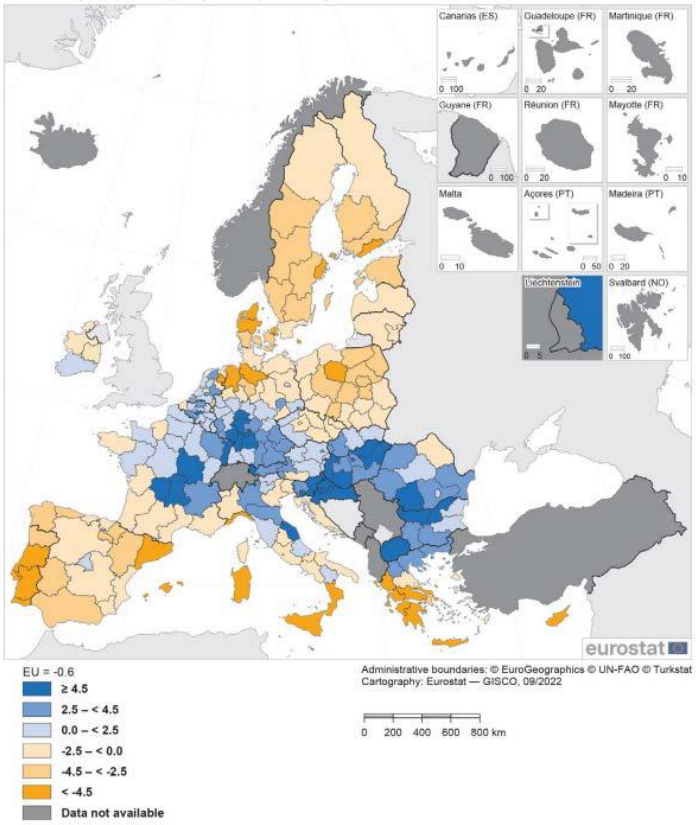


Total estimates of organic carbon content in arable land (Year - 2015)

Member State	Total estimates of organic carbon content in arable land (Mega tons)	Mean organic carbon content (g kg-1)	Cropland (Mega tons)	Grassland (Mega tons)	Permanent crops (Mega tons)
Belgium	151.18	24.71	33.68	117.50	0.00
Bulgaria	312.43	18.31	260.69	36.05	15.69
Czechia	236.46	20.58	105.25	119.17	12.04
Denmark	258.02	25.77	114.73	143.29	0.00
Germany	1 305.99	30.09	415.52	851.70	38.77
Estonia	175.86	50.57	34.82	141.04	0.00
Ireland	807.82	82.41	17.93	789.89	0.00
Greece	182.68	15.77	54.96	75.01	52.71
Spain	944.01	14.91	345.70	398.24	200.07
France	2 178.89	23.23	703.65	1 406.02	69.22
Croatia	n.a	n.a	n.a	n.a	n.a
Italy	742.29	18.58	261.70	319.30	161.29
Cyprus	23.19	n.a	21.13	2.06	0.00
Latvia	207.78	35.73	37.14	170.64	0.00
Lithuania	215.73	24.89	71.94	143.79	0.00
Luxembourg	9.22	24.20	2.27	6.95	0.00
Hungary	280.04	20.52	168.91	111.13	0.00
Malta	0.70	15.70	0.13	0.57	0.00
Netherlands	273.85	32.03	44.78	229.07	0.00
Austria	263.15	30.43	64.53	198.62	0.00
Poland	945.44	21.88	345.10	582.53	17.81
Portugal	125.09	15.55	23.37	70.45	31.27
Romania	865.03	20.05	564.76	246.86	53.41
Slovenia	44.69	40.83	7.69	37.00	0.00
Slovakia	109.41	22.63	47.04	62.37	0.00
Finland	635.79	60.46	281.69	354.10	0.00

EUROSTAT

Map 12.5: Overall change in soil organic carbon stock for agricultural soils, 2009–2018
(%, based on grams of carbon per kg of soil, by NUTS 2 regions)



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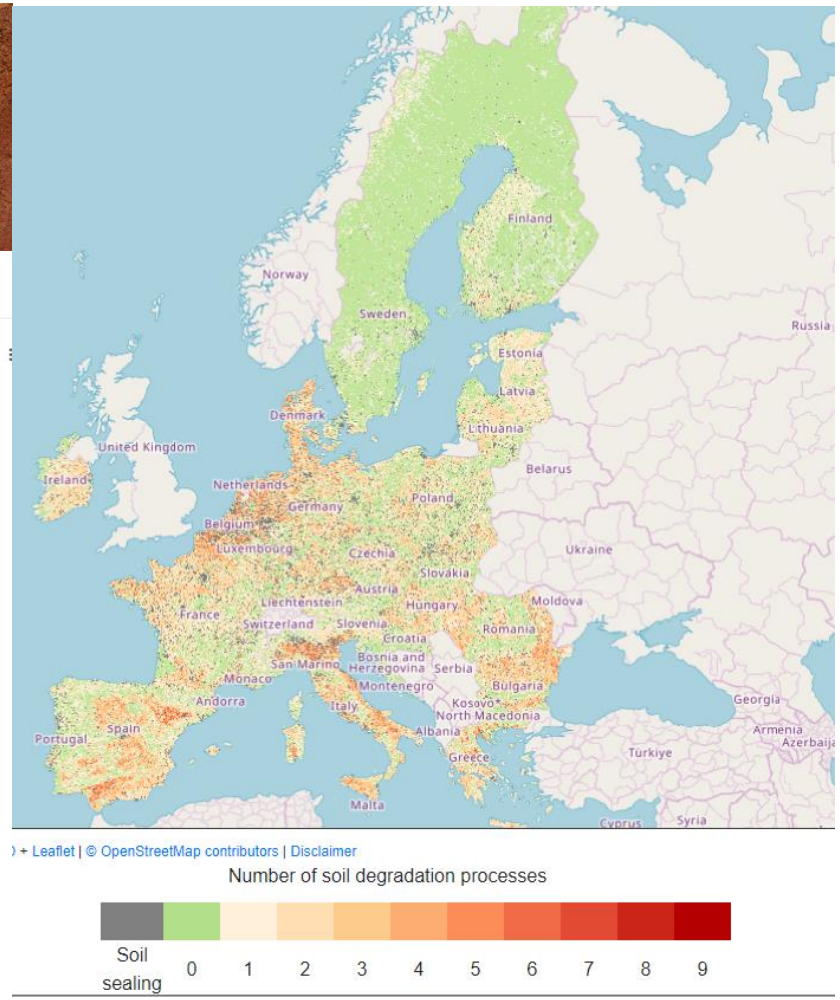
How LUCAS data are used?



Support the new Soil Health Law

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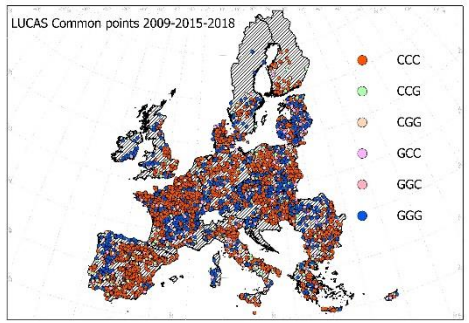
SOC CHANGES – Data-driven approach- LUCAS

1) MODEL DATA → 2) MODEL TRINING → 3) SPATIAL DEPLOYMENT

POINT DATASET

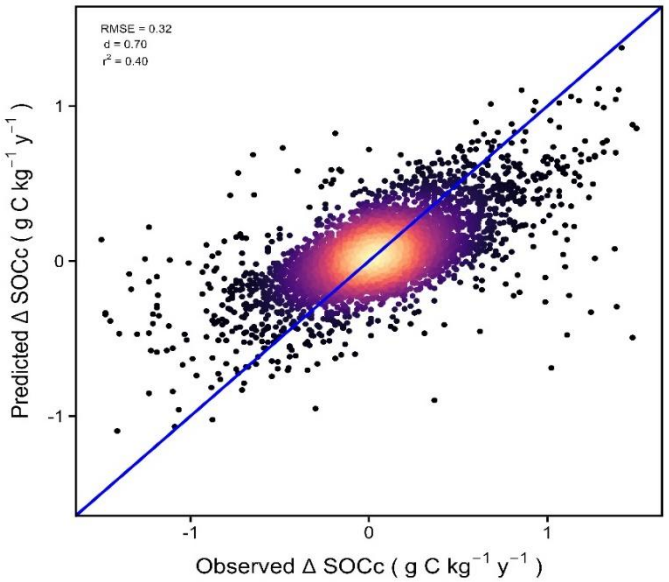
LUCAS



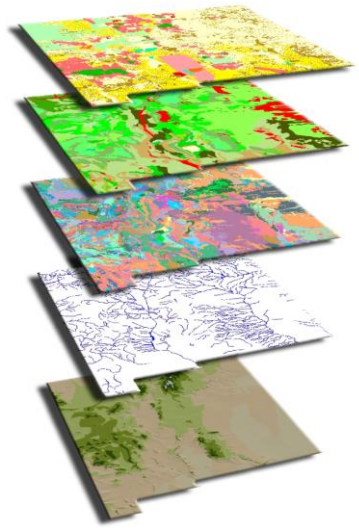
$$\Delta\ SOC\ g\ C\ kg^{-1} = SOC(2018)\text{-}SOC(2009)$$

quantile
Generalized additive model
qGAM

TESTING



GRIDDED PREDICTORS



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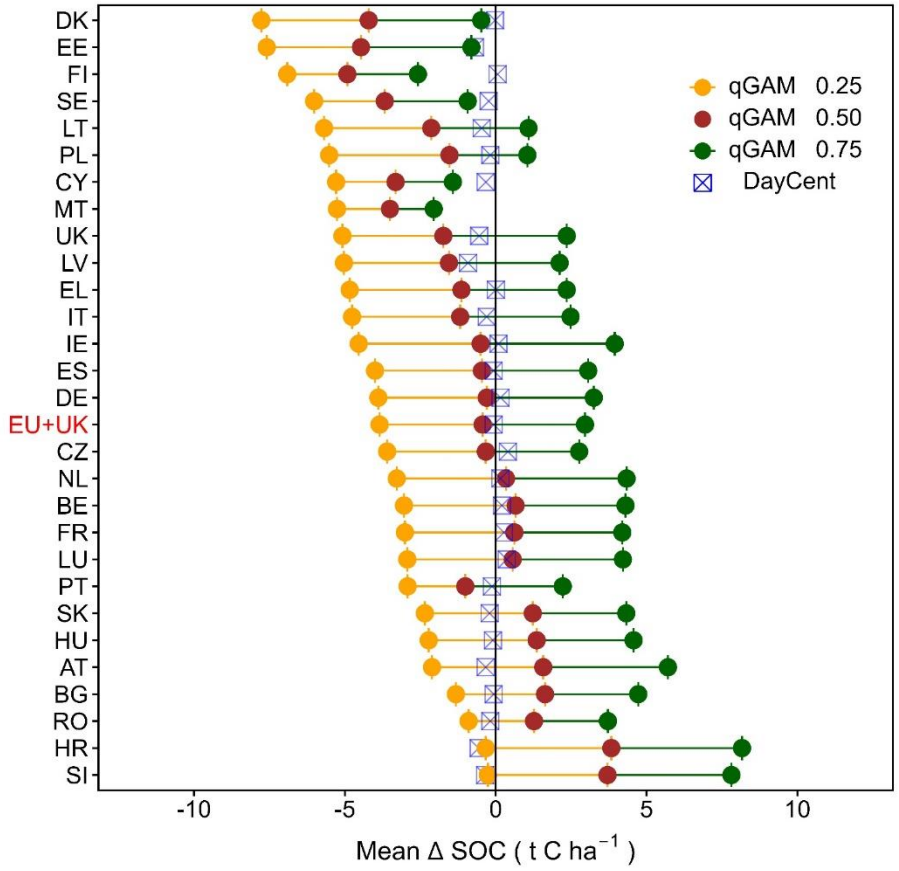
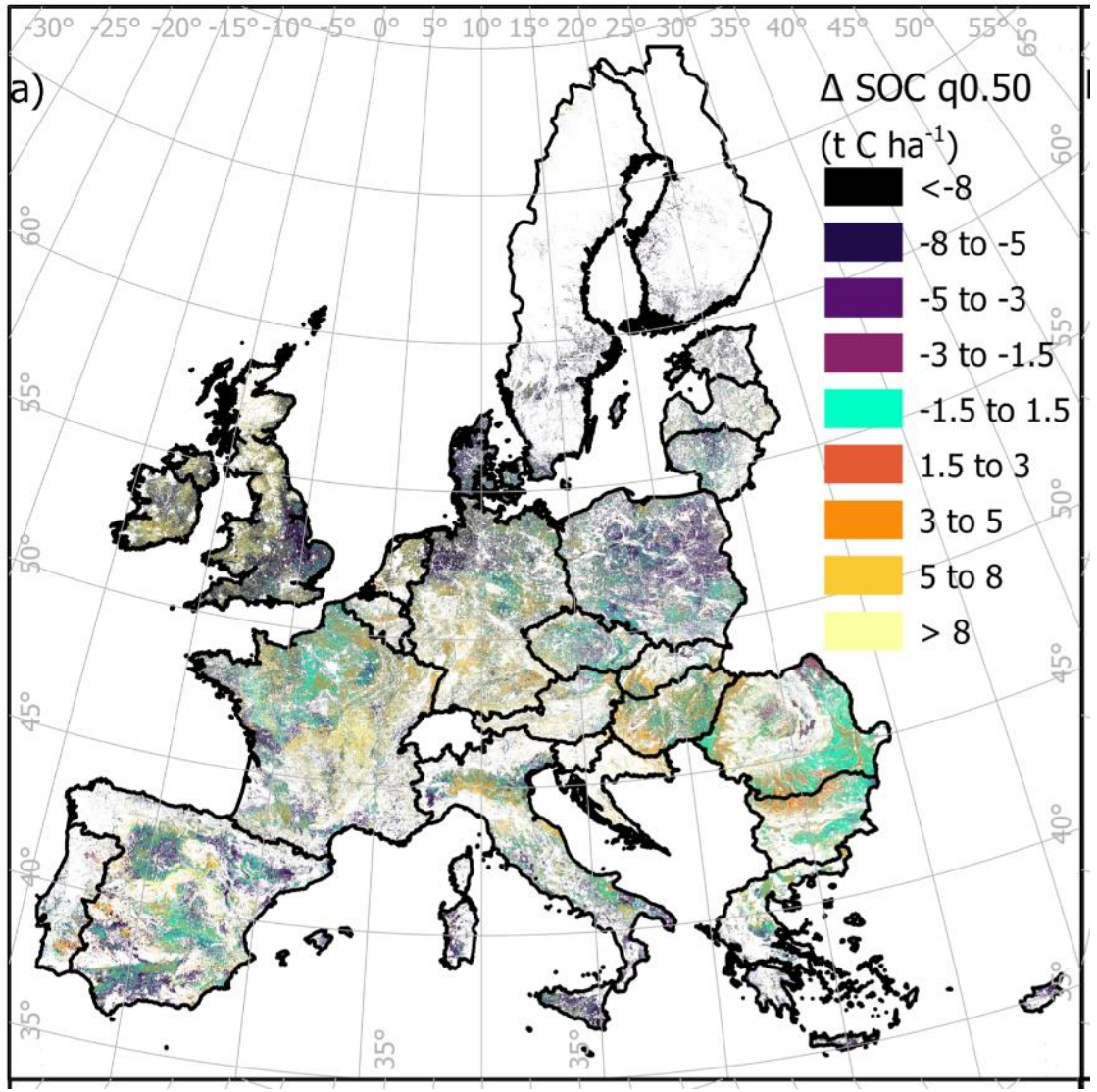
SOC, how much have we lost in the past decade?

-0.75% between 2009 and 2018

~ 70Mt C (0-0.2m depth)





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Land Use Change – Scenarios

- Conversion of Grass.L to Crop.L

$\Delta\ SOC$ up to **-4.8%** (~ 47 Mha)

- Conversion of Crop.L to Grass.L

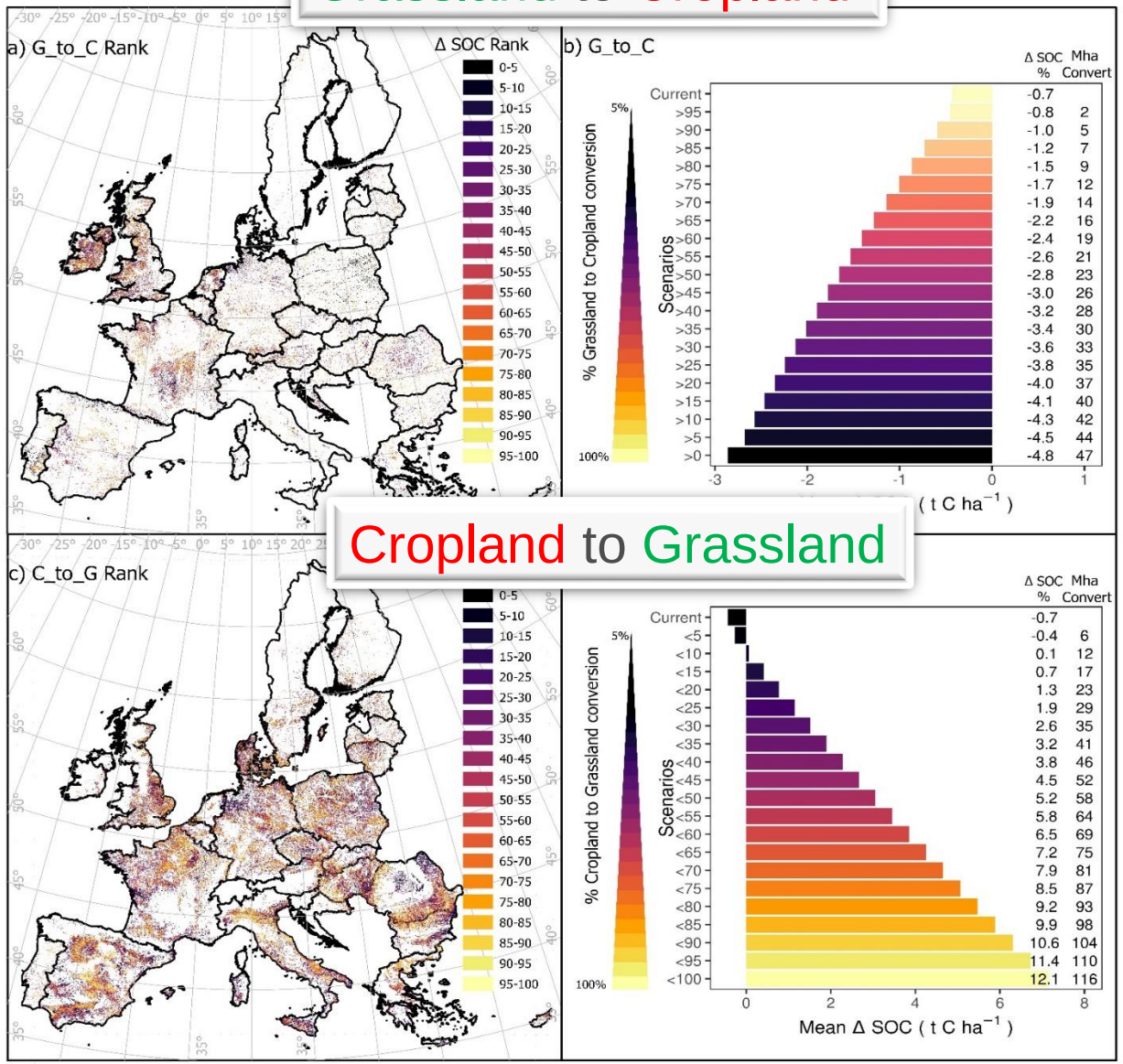
$\Delta\ SOC$ up to **+12.1%** (~ 116 Mha)

7% of Cropland to Grassland

$\Delta\ SOC$ 0

Grassland to Cropland

Cropland to Grassland



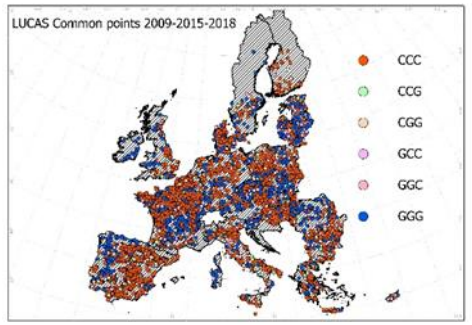
Commission

SOC - Data driven approach

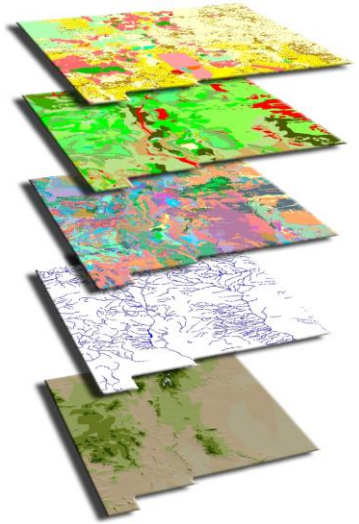
Uncertainties

POINT DATASET

LUCAS



GRIDDED PREDICTORS



- Generic set of predictors
- No specific management information
- High uncertainty when projecting Beyond the observed tam-frame

BUT
More data = High confidence

Carbon farming

*A **green business model** rewarding land managers for improved land management practices, resulting in carbon sequestration in ecosystems and reducing the release of carbon to the atmosphere.*

Benefits of carbon farming:

- Increased carbon removals
- Additional income for land managers
- More biodiversity and nature
- Increased climate resilience of farm and forest land

- **Afforestation and reforestation**
- Use of **conservation tillage, catch crops, cover crops** and increasing **landscape features**
- Restoration, rewetting and conservation of **peatlands and wetlands**
- Targeted conversion of **cropland to fallow**, or of set-aside areas to **permanent grassland**
- **Agroforestry** and other forms of mixed farming

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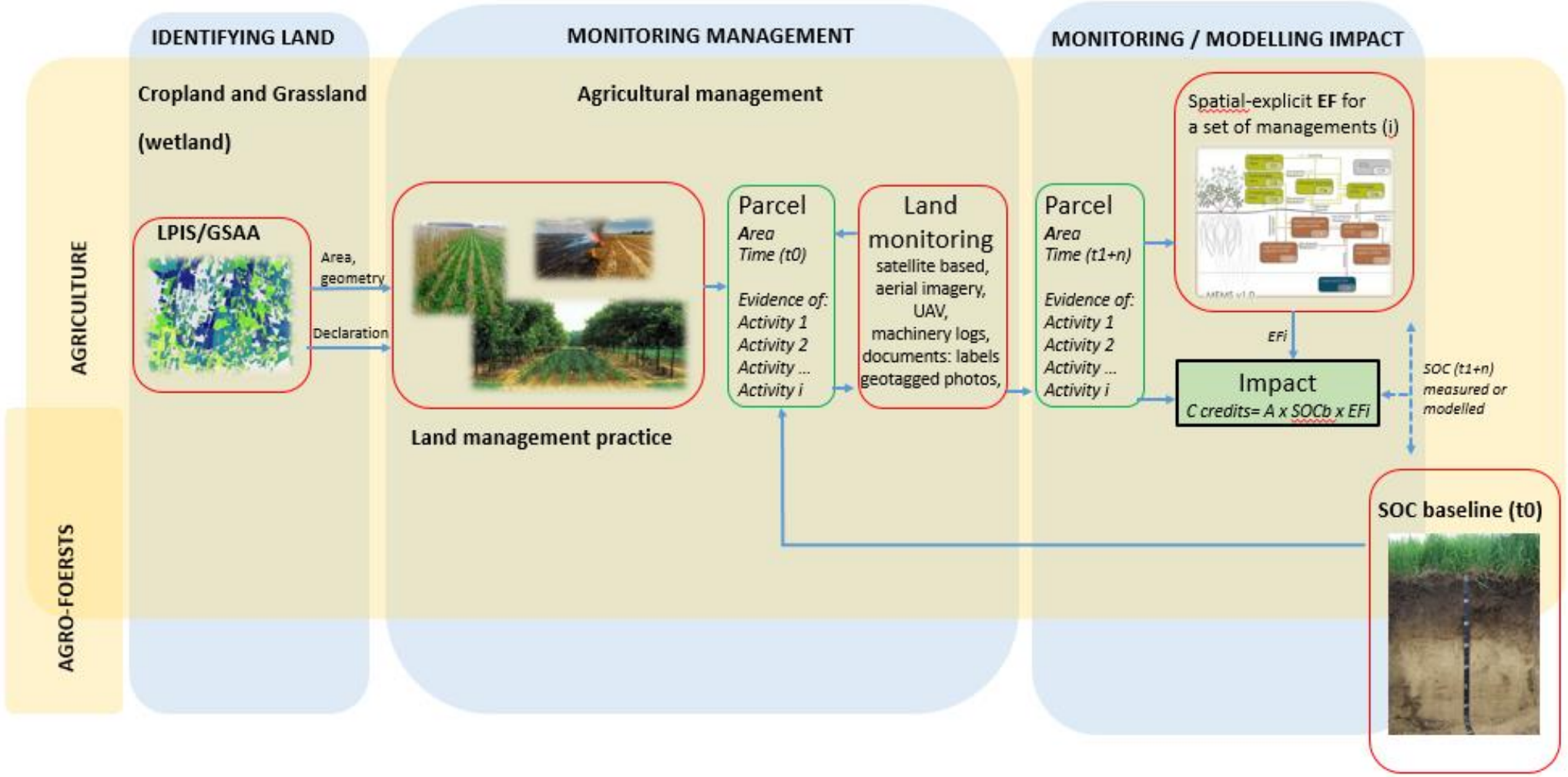
C monitoring framework



Uptake by national GHG inventories of methods and knowledge!

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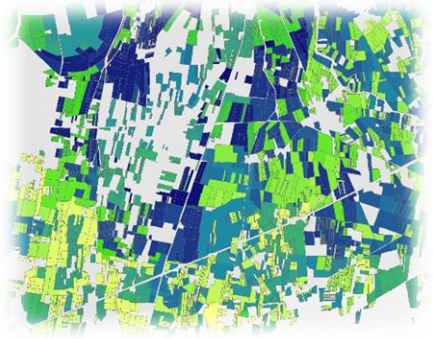
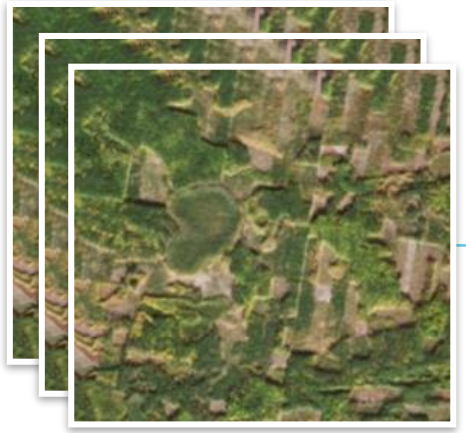
Data-approaches integration

GSAA



Sentinel 2



Spring crops

Negative Buffer

Mean NDVI per parcel

MAX NDVI winter

Threshold filter

Cover Crops

Remove unusable pixels (snow, etc.)

Remove cloudy images

Time frame Dec - Jan

LETTER

Estimation of winter soil cover by vegetation before spring-sown crops for mainland France using multispectral satellite imagery

Benjamin Nowak[1,*], Gaëlle Marliac[2] and Audrey Michaud[3]

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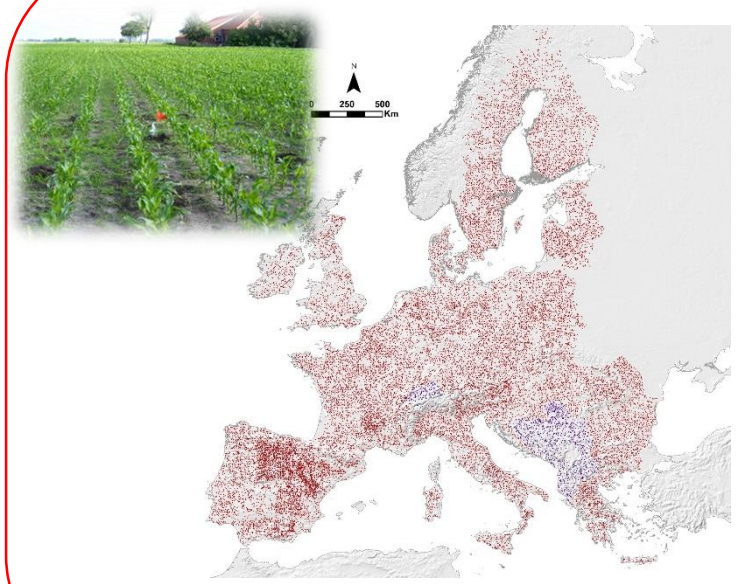
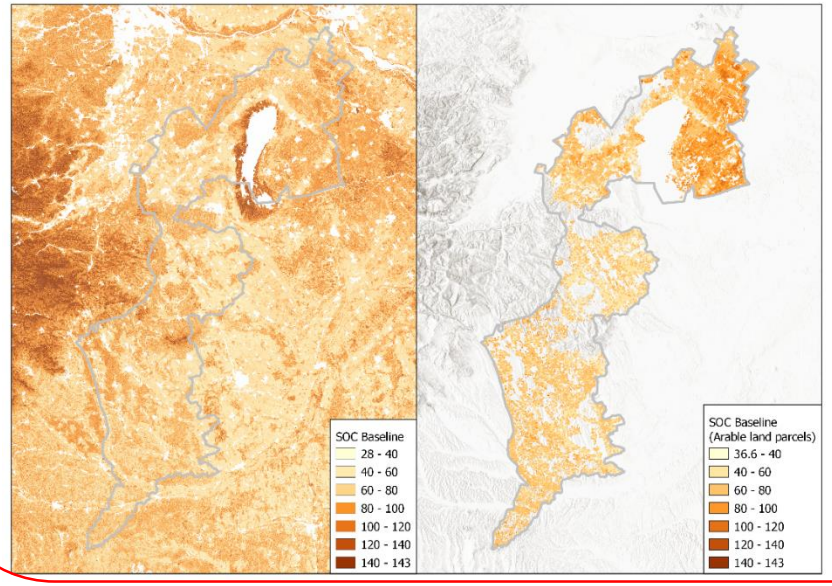
Data-approaches Integration

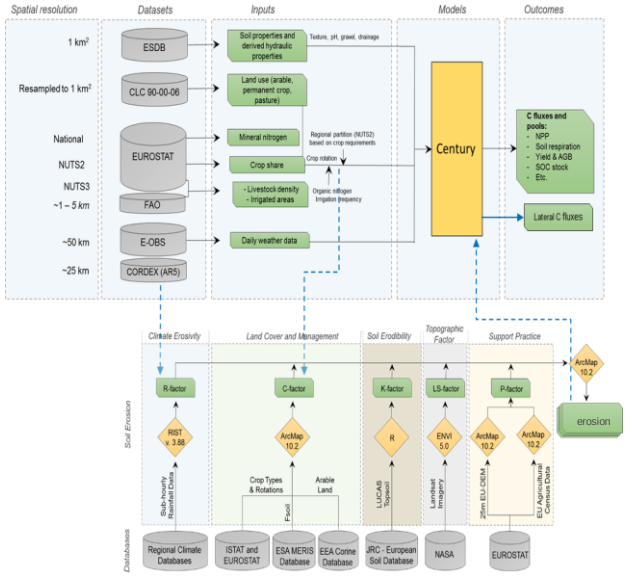


LUCAS soil data



SOC baseline

EF model-derived



LETTER • OPEN ACCESS

Maximising climate mitigation potential by carbon and radiative agricultural land management with cover crops

Emanuele Lugato[1], Alessandro Cescatti[1], Arwyn Jones[1], Guido Ceccherini[1] and Gregory Duveiller[1]

Published 28 August 2020 • © 2020 The Author(s). Published by IOP Publishing Ltd

Letter | Published: 26 February 2018

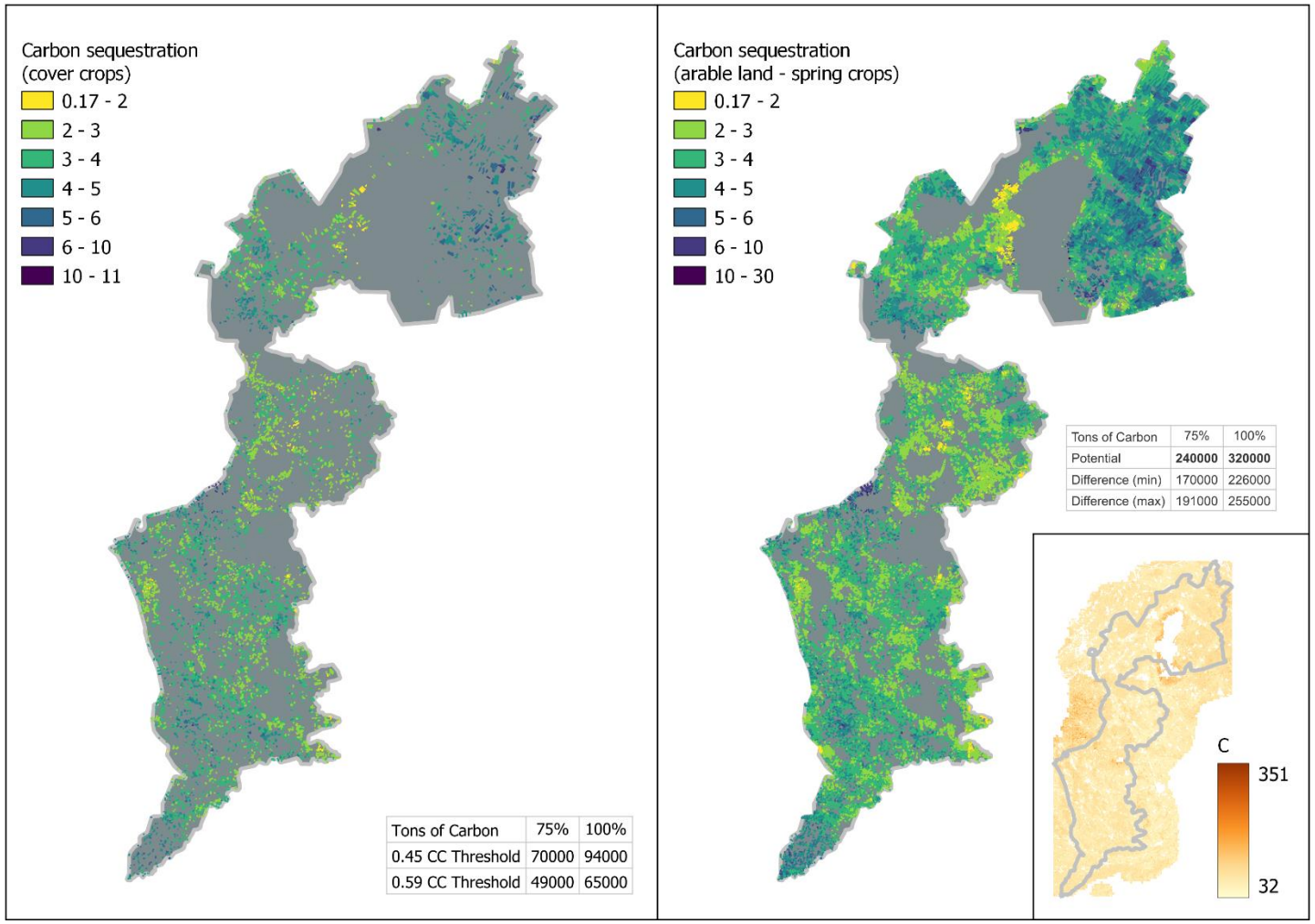
Mitigation potential of soil carbon management overestimated by neglecting N_2O emissions

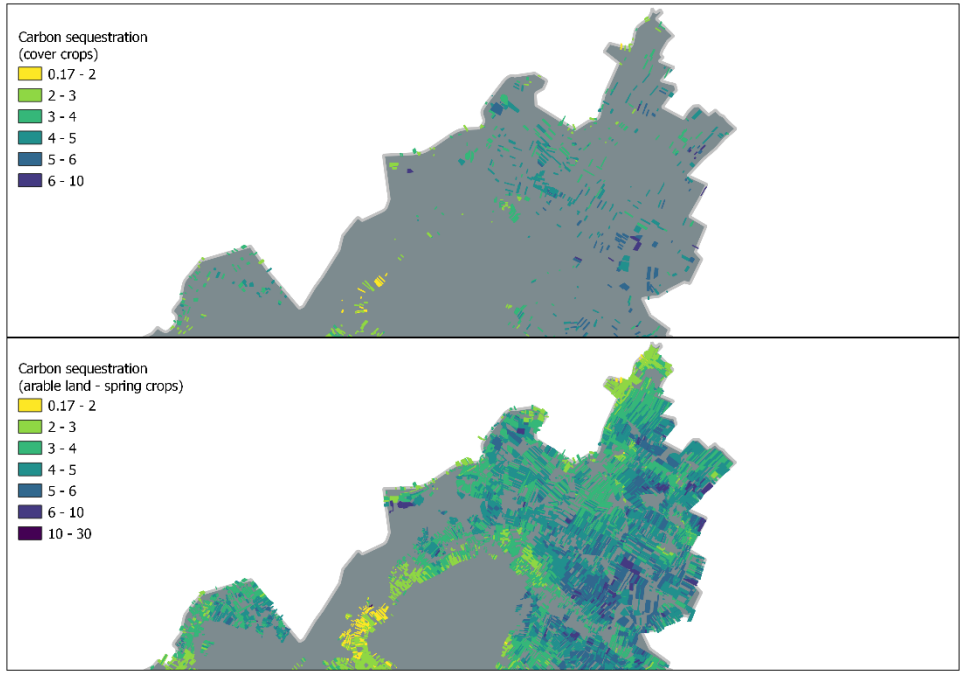
Emanuele Lugato, Adrian Leip & Arwyn Jones

Nature Climate Change **8**, 219–223 (2018) | Cite this article

European Commission

Carbon removal by cover crop





SOC sequestered over a decade

- Current application 49 - 94 kt C
- All arable 171 – 255 kt C

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Conclusions

✓ LUCAS is a wide soil monitoring framework that can be used to:

- create indicators
- complement national inventories
- detect regional trends

✓ LUCAS can also be used to create **SOC baseline**
- supporting **MRV**

✓ Take advantage of knowledge and methods that will be developed for **C farming**

Thank you

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European Commission