A new framework to estimate soil organic carbon targets in European croplands

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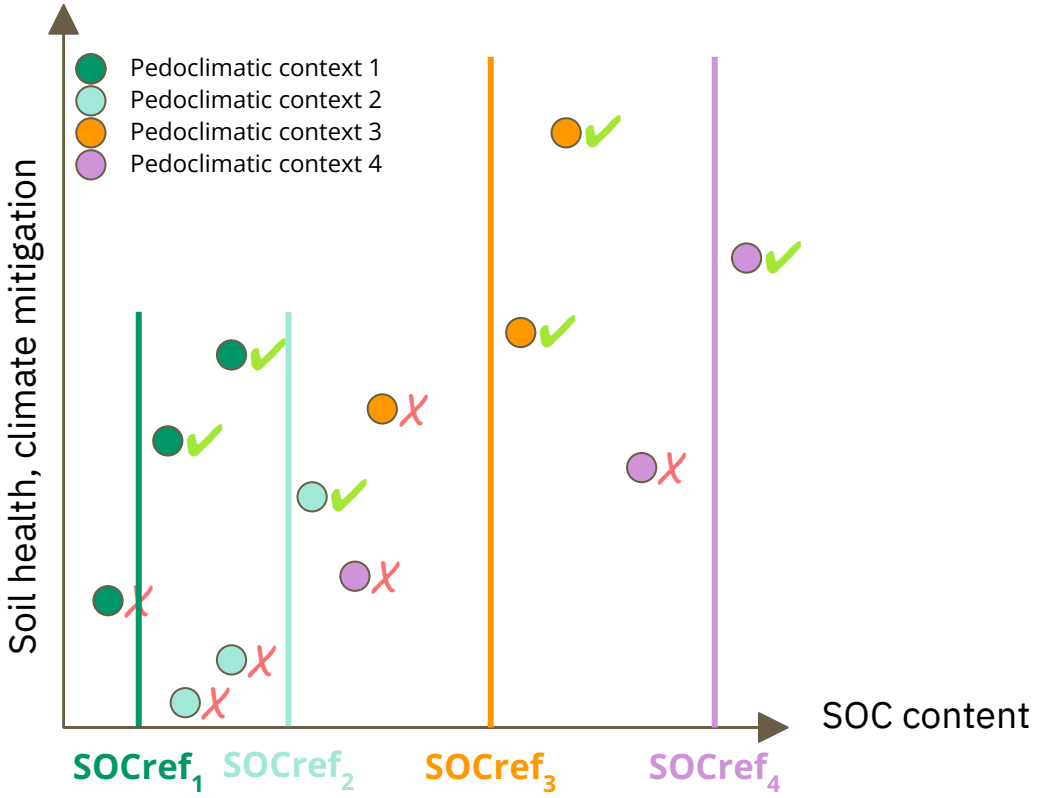
Context

- Increasing **organic carbon** content in **soils** is promoted:
  - To preserve soil ecosystem services;
  - To mitigate climate change.
- The more is the better.
- But farmers, policymakers and stakeholders need to know **how much is possible**.

Need a methodology to:

- Estimate **SOC target values**;
- Discriminate SOC-rich soils to be preserved versus SOC-poor soils to be restored.

SOC targets must be pedoclimatic-context-aware



This study

Focus

European croplands.

Goal

Estimate a **SOCref** value.

Application

Calculate an approximate SOC storage potential **ΔSOC** = SOCref - SOC.

Data

LUCAS Topsoil 2015.

Method

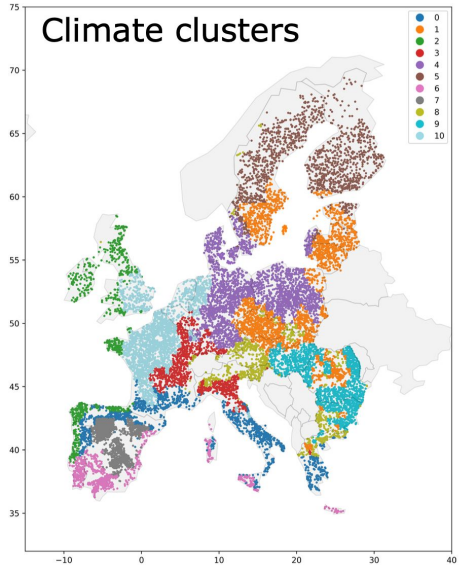
Ensemble modeling approach integrating three different methods.

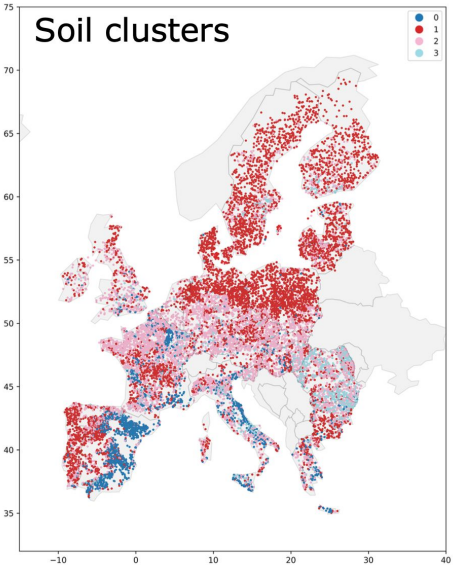
- **Natural references per pedoclimate**
- **Data-driven reciprocal modeling** (Schneider et al., 2021)
- **Carbon landscape zones** (Chen et al., 2019)

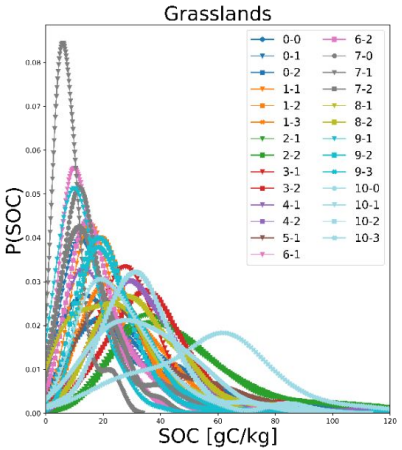
Natural references per pedoclimate

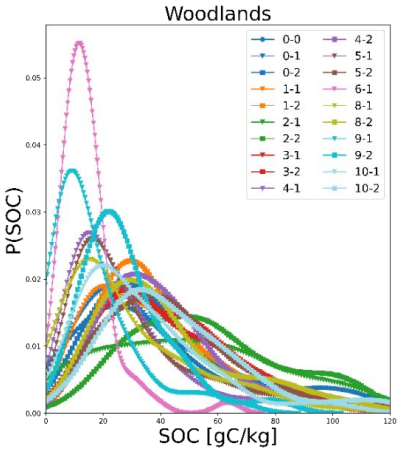
1. Clustering algorithm to define **pedoclimatic clusters** based on pedoclimatic variables.

2. The SOCref of a cropland is the **median SOC of grasslands and woodlands** that belong to the same cluster.



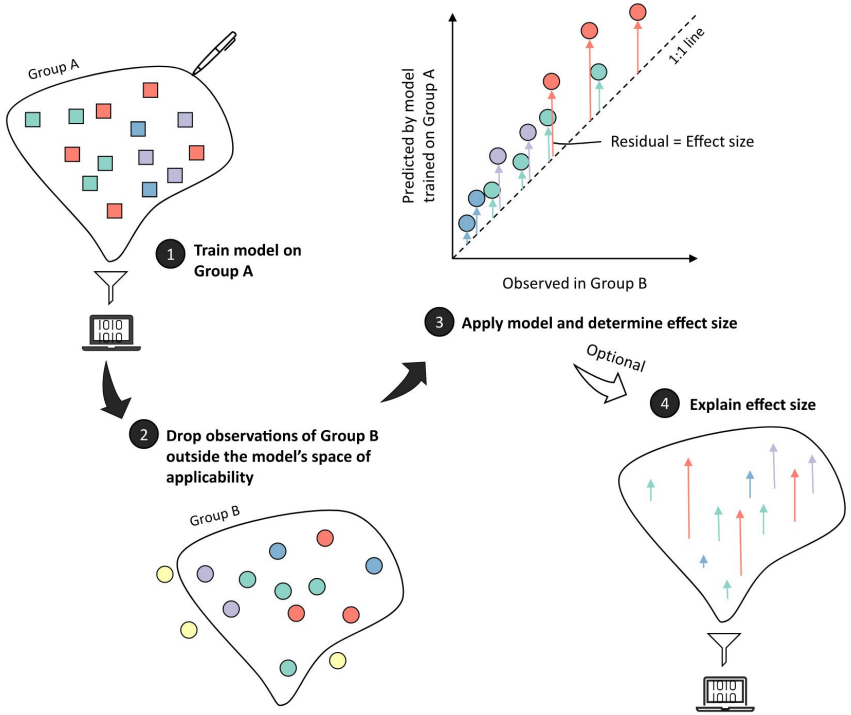






Data-driven reciprocal modeling (Schneider et al., 2021)

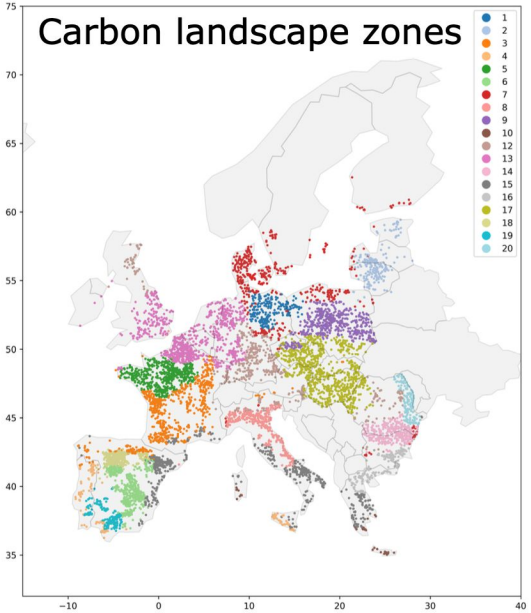
1. Random forest that **predicts the SOC of grasslands** based on pedoclimatic variables.
2. The SOCref of a cropland is the **predicted grassland-equivalent SOC**.

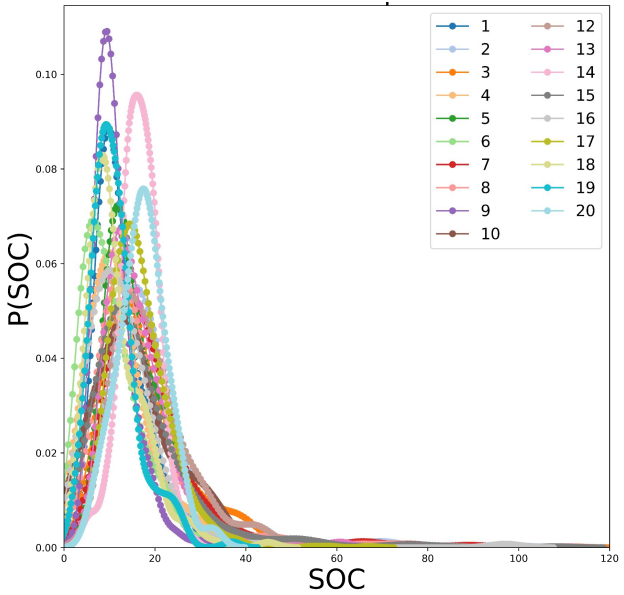


Schneider, F. et al., Predicting ecosystem responses by data-driven reciprocal modelling. *Global Change Biology*, 2021.

Carbon landscape zones (Chen et al., 2019)

1. Clustering algorithm to define **Carbon Landscape Zones** of croplands based on pedoclimatic variables and net primary production.
2. The SOCref of a cropland is the **90th percentile of SOC of croplands** that belong to the same carbon landscape zone.





Chen, S. et al., National Estimation of Soil Organic Carbon Storage Potential for Arable Soils: A Data-Driven Approach Coupled with Carbon-Landscape Zones. *Sci. Total Environ*, 2019.

Natural references per pedoclimate

Novel

Algorithm: clustering and percentile.

Variables: pedoclimatic.

Reference: grasslands and woodlands.

Data-driven reciprocal modeling

Schneider et al., 2021

Algorithm: Random Forest.

Variables: pedoclimatic.

Reference: grasslands.

Carbon landscape zones

Chen et al., 2019

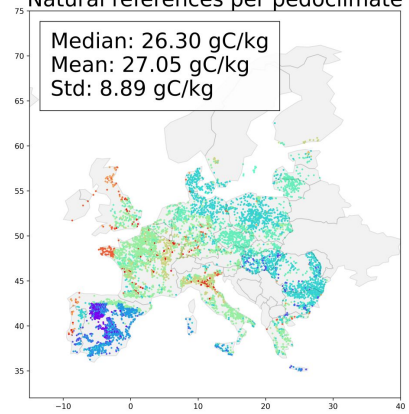
Algorithm: clustering and percentile.

Variables: pedoclimatic and NPP.

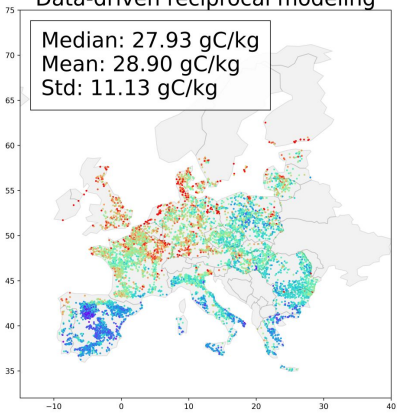
Reference: croplands.

Estimation of target SOCref for European croplands

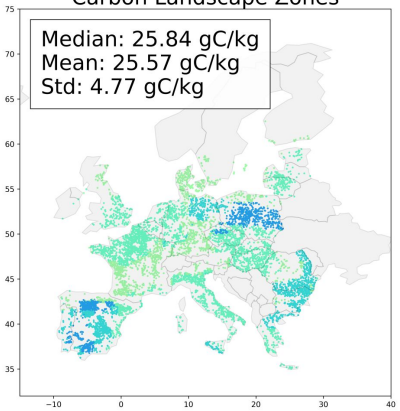
Natural references per pedoclimate



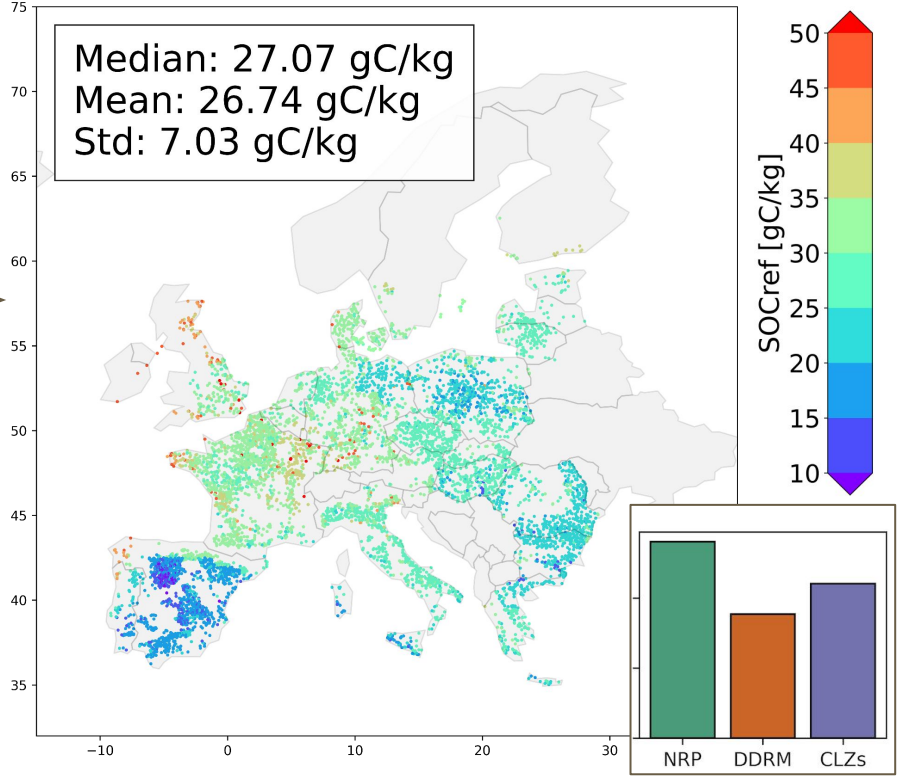
Data-driven reciprocal modeling



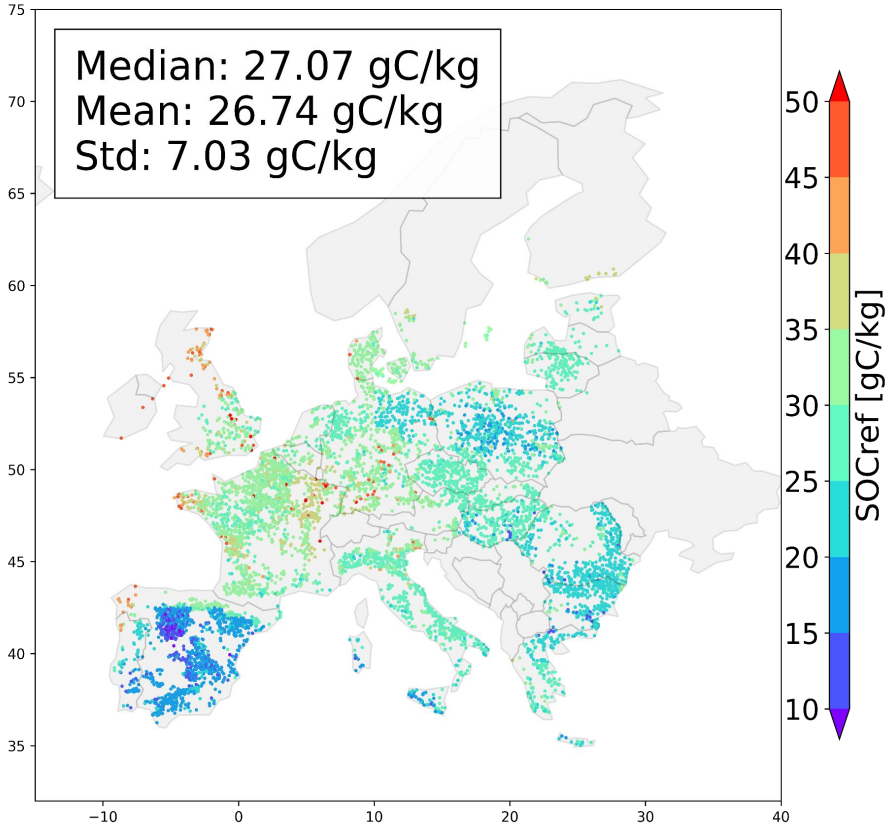
Carbon Landscape Zones

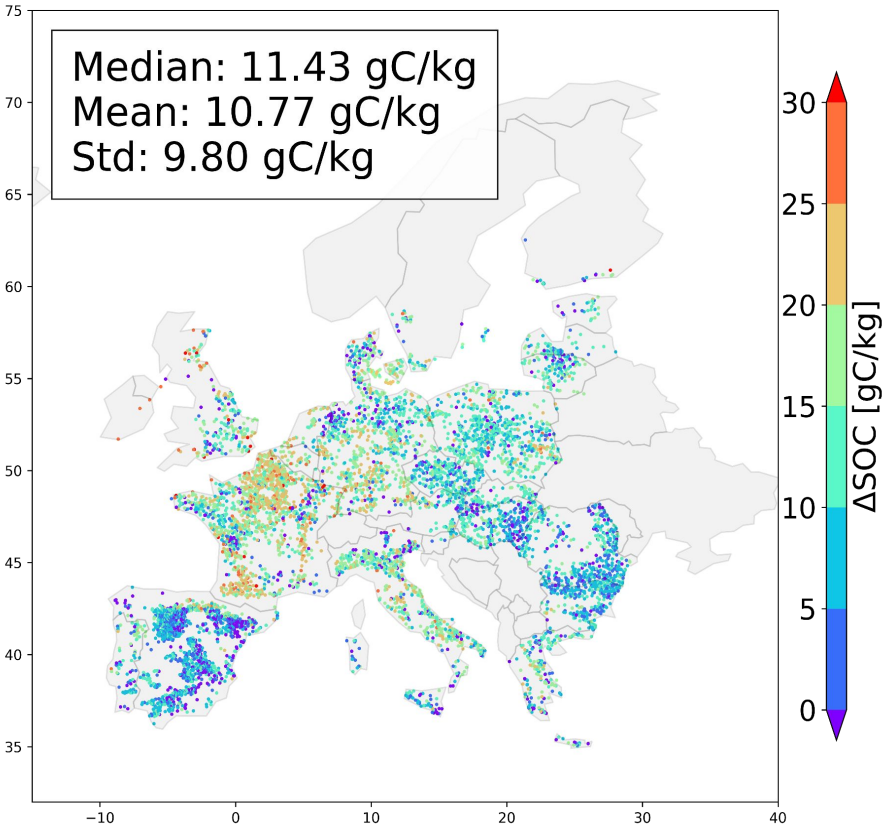


Ensemble modeling: median.
Intermediate estimate among the three.



Carbon storage potential ΔSOC = SOCref - SOC



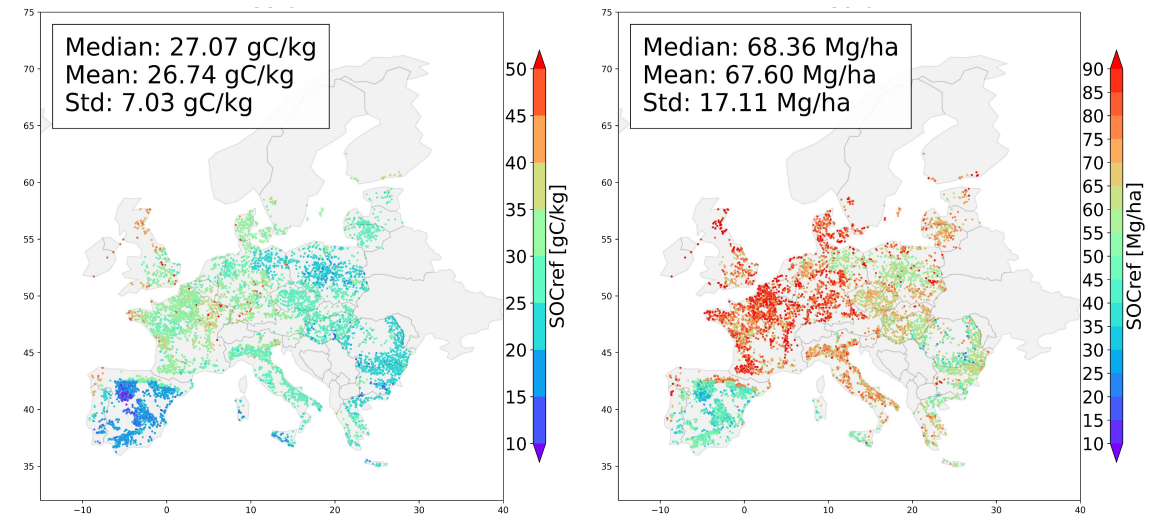


Summary and perspectives

- Different approaches to estimate target SOC values for European croplands.
- Overall consistent but with local discrepancies.
- Hard to determine which model performs best and in which contexts.
- Ensemble modeling: average-out extreme values, look for consensus.
- Future development:
  - Integrate more approaches.
  - Local models using national surveys data.
  - Challenge the current results against experimental data and refine the estimations if necessary.
  - Integrate the notion of time: how much can be stored within a timeframe.
  - A similar approach to estimate reference values for carbon fractions (FREACS project).

Thank you for your attention.

cnrs
ENS ÉCOLE NORMALE SUPÉRIEURE
PSL RESEARCH UNIVERSITY PARIS
GENESIS
FRANCE RELANCE
EJP SOIL European Joint Programme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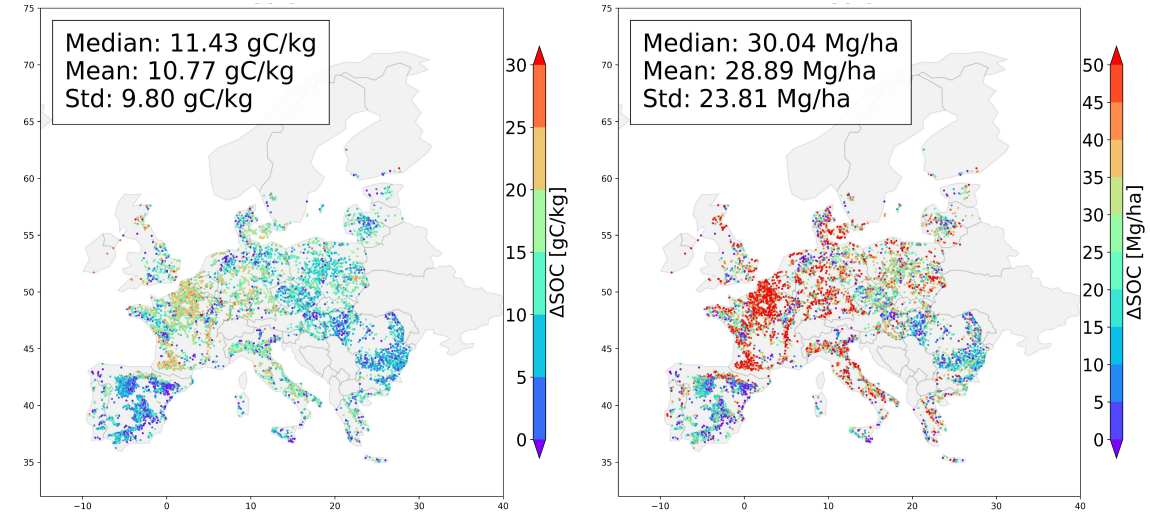
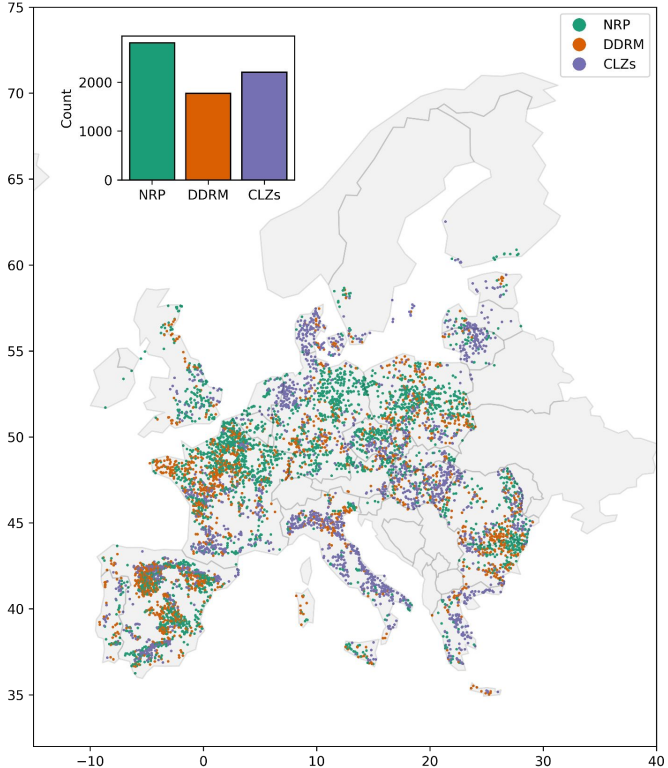
Mean: 26.74 gC/kg
Std: 7.03 gC/kg
SOCref [gC/kg]


Median: 11.43 gC/kg
Mean: 10.77 gC/kg
Std: 9.80 gC/kg
ΔSOC [gC/kg]

Median: 68.36 Mg/ha
Mean: 67.60 Mg/ha
Std: 17.11 Mg/ha
SOCref [Mg/ha]

Median: 30.04 Mg/ha
Mean: 28.89 Mg/ha
Std: 23.81 Mg/ha
ΔSOC [Mg/ha]


NRP
DDRM
CLZs
Count
2000
1000
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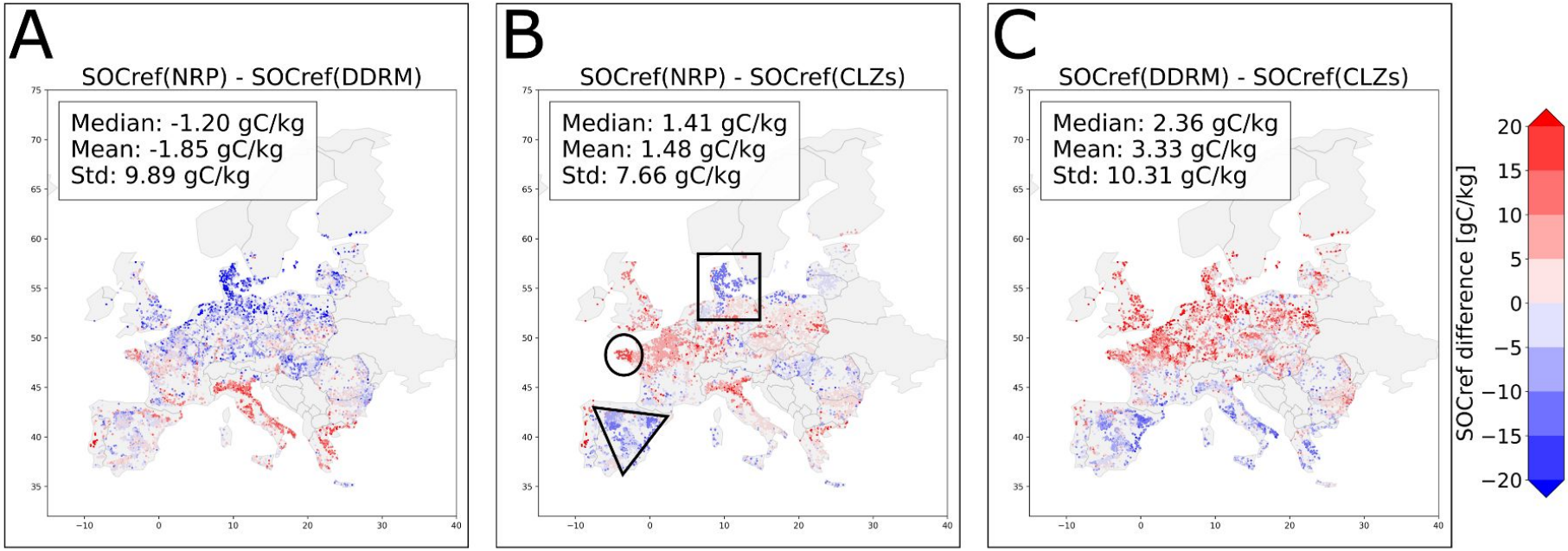
NRP
DDRM
CLZs



NRP: Natural references per pedoclimate
DDRM: Data-driven reciprocal modelling
CLZs: Carbon landscape zones