Assessing carbon stock changes in French top soils in croplands and grasslands: comparison of fixed depth and equivalent soil mass.

José-Luis Munera-Echeverri, Manuel P Martin, Line Boulonne, Nicolas P. A. Saby, Dominique Arrouays

Assessing carbon stock changes in French top soils in croplands and grasslands: comparison of fixed depth and equivalent soil mass.

Munera-Echeverri JL [1], Martin M [1], Boulonne L[1], Saby N[1], Arrouays D[1].
[1] INRAE, InfoSol, 45075, Orléans, France

Introduction

- We use data from the first (2000-2009) and second (2016-2027) campaign of the French soil quality monitoring network (RMQS) to compare soil organic carbon (SOC) stock changes based on equivalent soil mass (ESM) and fixed-depth (FD) in top soils (30 cm depth) in croplands and grasslands.

Materials and methods

Soil sampling

- Sites were selected based on the availability of data of the second campaign, and where the soil physical parameters were determined by the cylinder method in both campaigns.
- Composite soil sample for carbon analysis were taken from a 400 m^2 systematic unaligned grid every 4 m (Figure 1A).
- Soil pit adjacent to the grid. Three cylinders (500 cm^3) were used estimate bulk density (BD) and coarse fragments (CF) at 0-30cm (Figure 2 B). Time between campaigns: 7-16 years.

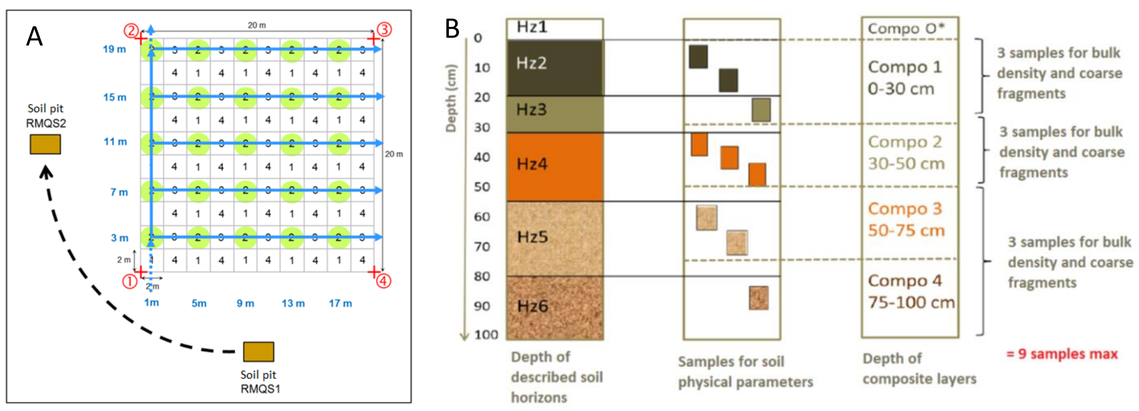

Figure 1. A) Composite sampling and adjacent pits. B) Soil pit for bulk density and coarse fragments. From Jolivet et al. 2018.

Stocks and equivalent soil mass calculation

- SOC stock FD (Mg ha^{-1}) = BD * depth * SOC conc * (1-CF/100) /10

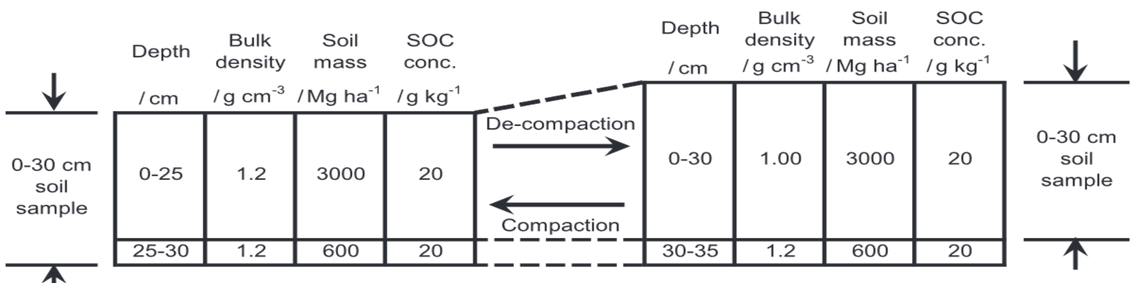

Figure 2. Principle behind the evaluation of SOC stock changes based on equivalent soil mass and fixed depth. Taken from Wendt & Hauser 2013.

Statistical analyses

- Linear mixed model fit by residual maximum likelihood (REML)
- Student test corrected for spatial autocorrelation (Moran Index)

Results

Data inspection

- Sites distributed in a large proportion of France (Figure 3 A).
- Good correspondence of SOC content and CF between campaigns, and less good for BD (Figure 3 B,C, and D).

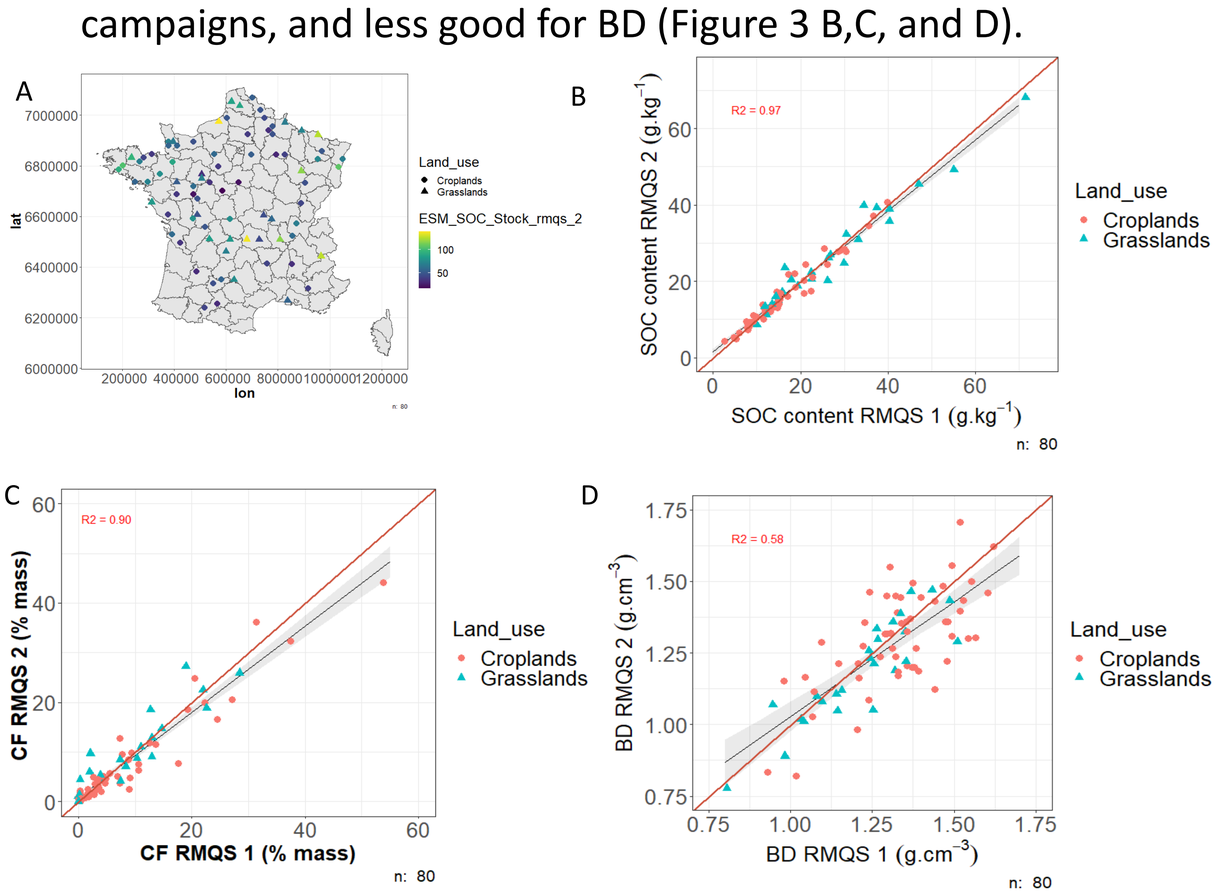

Figure 3. A) Spatial distribution of the sites. B) Soil organic carbon content, C) coarse fragments, and D) bulk density of RMQS 2 as a function of the values of RMQS 1 (black lines). Red lines are 1:1.

- ESM slightly improves the prediction of SOC stocks of the second campaign compared to FD (Figure 4 & table 1).

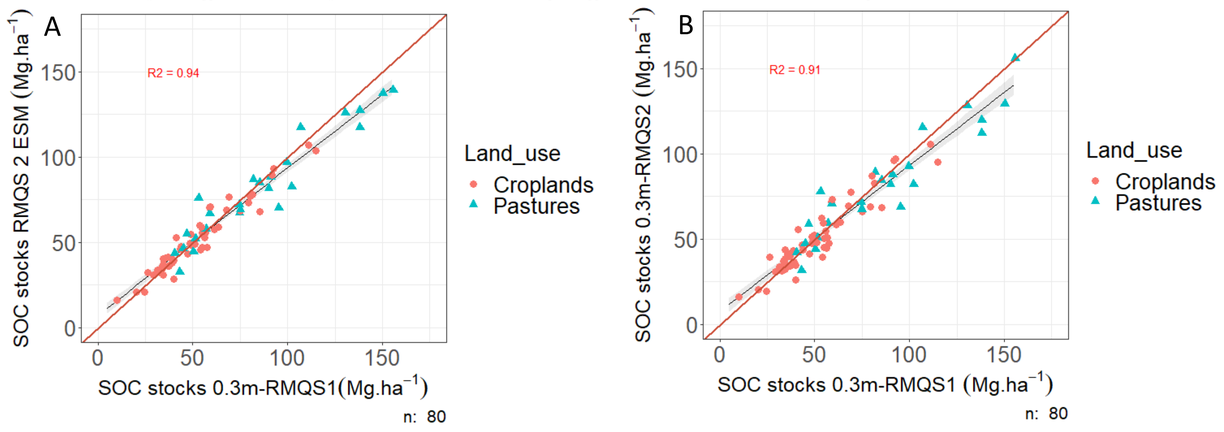

Figure 4. SOC stocks of RMQS 2 estimated based on A) ESM and B) FD as function of SOC stocks of RMQS 1 (black lines). Red lines are 1:1.

Table 1. Model comparison of SOC stocks in the RMQS 2 as a function of the stocks in RMQS 1 based on ESM and FS.

	Intercept	Slope	Res. s.e	BIC	AIC	logLik	R2
ESM	7.261	0.863	6.581	551.632	539.849	-264.924	0.944
FD	7.392	0.859	8.398	590.388	578.604	-284.302	0.91

Land use effect on SOC stock changes

- No significant change of SOC stocks between campaigns by either ESM or FD in croplands (Table 2).
- Significant decrease of SOC stocks in grasslands by ESM *($p<0.05$) and by FD ($p<0.1$; table 2).*

Table 2. Mean SOC stock change estimated by ESM and FD in croplands and grasslands.

Land use	Approach	p_val	Mean difference Mg ha^{-1}	se	n
Croplands	ESM	0.4238	-0.1484	0.7696	55
Croplands	FD	0.4172	-0.2146	1.0224	55
Grasslands	ESM	**0.0440**	-3.8267	2.1562	25
Grasslands	FD	**0.0611**	-3.9521	2.4717	25

- SOC loss rate in grasslands was **surprisingly large (0.39 Mg ha^{-1} yr^{-1})** based on both approaches (Table 3).

Table 3. Mean annual change of SOC stocks in croplands and grasslands estimated by ESM and FD.

Land use	Approach	p_val	Rate Mg ha^{-1} yr^{-1}	se	n
Croplands	ESM	0.3163	-0.0372	0.0775	55
Croplands	FD	0.3324	-0.0435	0.0999	55
Grasslands	ESM	**0.0377**	**-0.3911**	0.2108	25
Grasslands	FD	**0.0550**	**-0.3908**	0.2358	25

Discussion

- The correspondence of SOC content between RMQS 1 and RMQS 2 suggests that the composite sampling accounts well for the spatial variability in the sampling area.
- Good correspondence of CF between campaigns. By choosing only the sites where the ring was used we selected sites with low CF content and presumably with low CF uncertainty.
- It is challenging to know whether the changes of BD between campaigns are linked to land management practices or to the spatial variability between the different soil pits.
- ESM approach is promising for the future RMQS data.
- Further work is needed to determine if ESM is valid when other BD and CF methods are used in national soil monitoring networks. Particularly, the excavation method that is adapted for soils with large CF content.
- Stock change in grasslands is high and unexepected and remains to be confirmed by further measurements.

References

- Jolivet, Claudy C., Jose-Luis Almeida Falcon, Philippe Berche, Line Boulonne, Marie Fontaine, Laëtitia Gouny, Sébastien Lehmann, et al. 2018. *Manuel du Réseau de Mesures de la Qualité des Sols (RMQS)*. https://hal.inrae.fr/hal-02791718.
- Wendt, J.W., Hauser, S., 2013. An equivalent soil mass procedure for monitoring soil organic carbon in multiple soil layers. Eur. J. Soil Sci. 64, 58–65. https://doi.org/10.1111/ejss.12002