A review of existing soil monitoring systems to pave the way for the EU Soil Observatory

Antonio Bispo, Maria Fantappiè, Fenny van Egmond, Bozena Smreczak, Zsofia Bakacsi, Rudi Hessel, Johanna Wetterlind, Grzegorz Siebelec, Arwyn T. Jones

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EJP SOIL
European Joint Programme

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What is EJP SOIL?

- A European Joint Programme Cofund on Agricultural Soil Management contributing to **key societal challenges** including climate change, water and future food security.

- The EJP SOIL consortium consists of **26 partners from 24 countries** ensuring a large representation of European countries.

- The main aim of EJP SOIL is to develop a **sustainable framework for an integrated community of researchers working on related aspects of agricultural soil management.**

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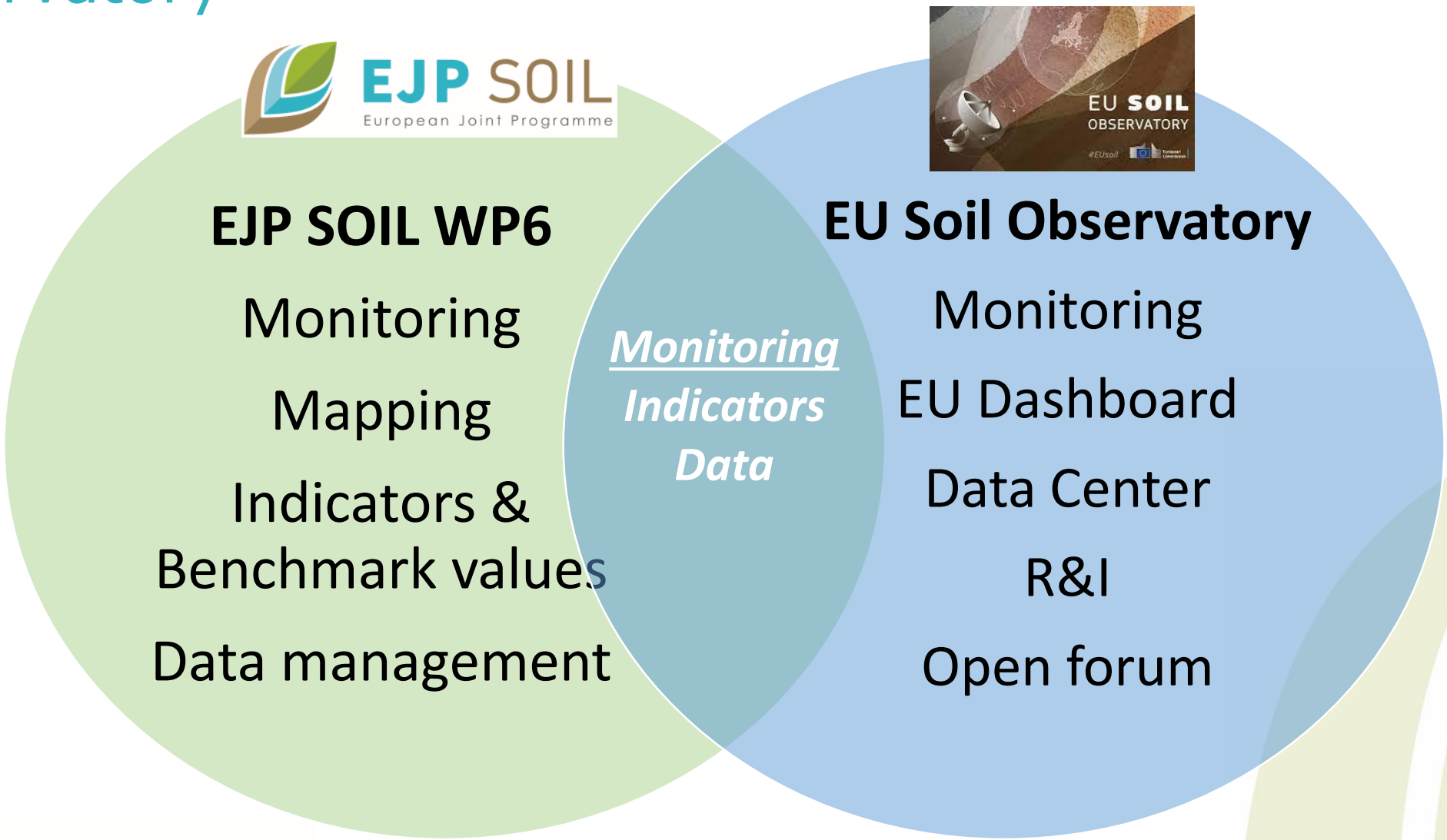
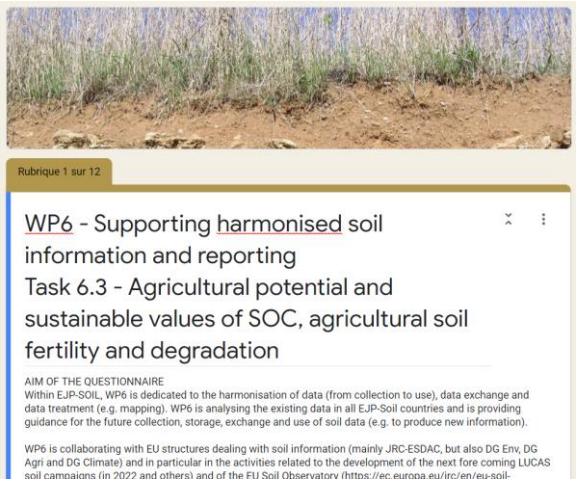
EJP SOIL WP6 main objectives and links with EU Soil Observatory



Describe and analyse Soil Monitoring Systems across EJP SOIL partners



- **Stocktake** the description of monitoring networks across EJP SOIL partners through the use of a **questionnaire**
  - Institution identification
  - SMS short description
  - Site information
  - Sampling protocol
  - Sampling for bulk density
  - Soil description
  - Soil sample preparation and conservation
  - Litter sample
  - Analyses and methods
  - *Harmonization options*
  - *Collaborations and/or synergies between Member States and LUCAS*
- 20 answers, 41 contributors

EJP SOIL Delivarable 6.3

Published on the EJP SOIL web portal:
https://ejpsoil.eu/fileadmin/projects/ejpsoil/WP6/EJP_SOIL_Deliverable_6.3_Dec_2021_final.pdf

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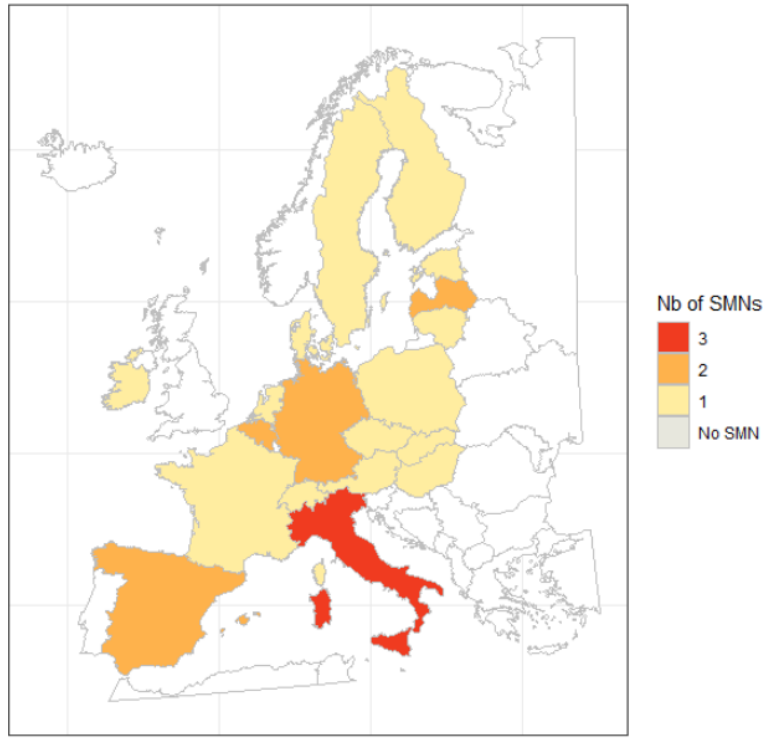
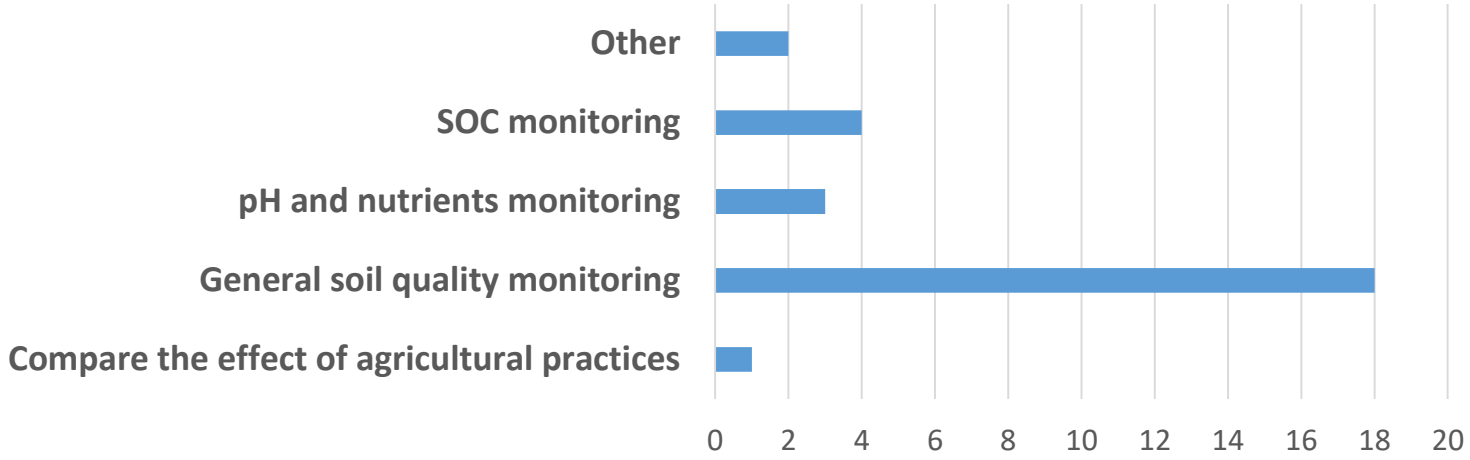
SMS in EJP SOIL countries

- 20 countries answered out of 24 (ending with 27 declared SMS)
- Turkey and Portugal do not have SMS
- Five countries have 2 or 3 monitoring systems
  - SMS managed at regional scale
  - SMS with different purposes (e.g. agricultural *vs* forest, monitoring trace element *vs* agricultural parameters, monitoring a network of highly instrumented sites *vs* network agricultural soils)
- Caution: Not all countries declared their forest SMS

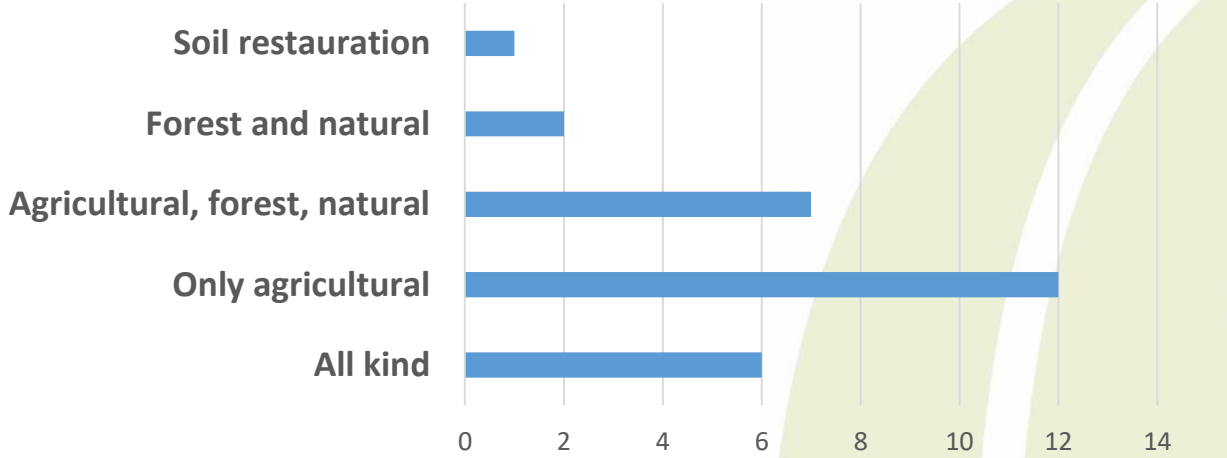


Results at a glance

Main objective of the SMS

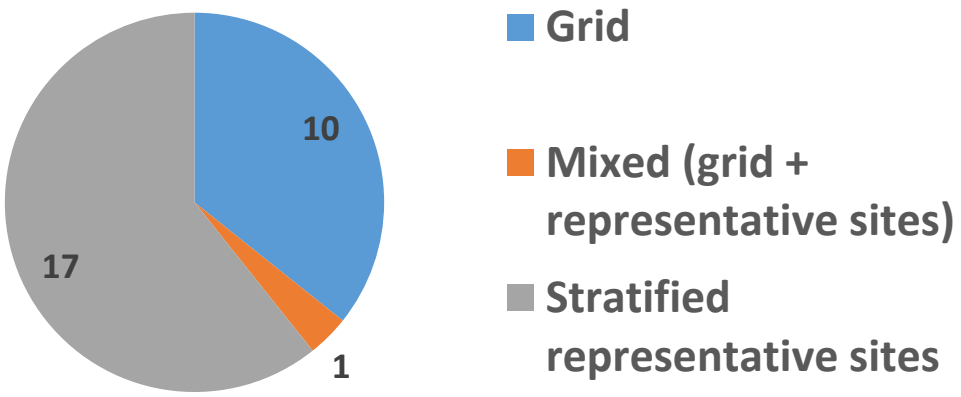


Investigated land uses



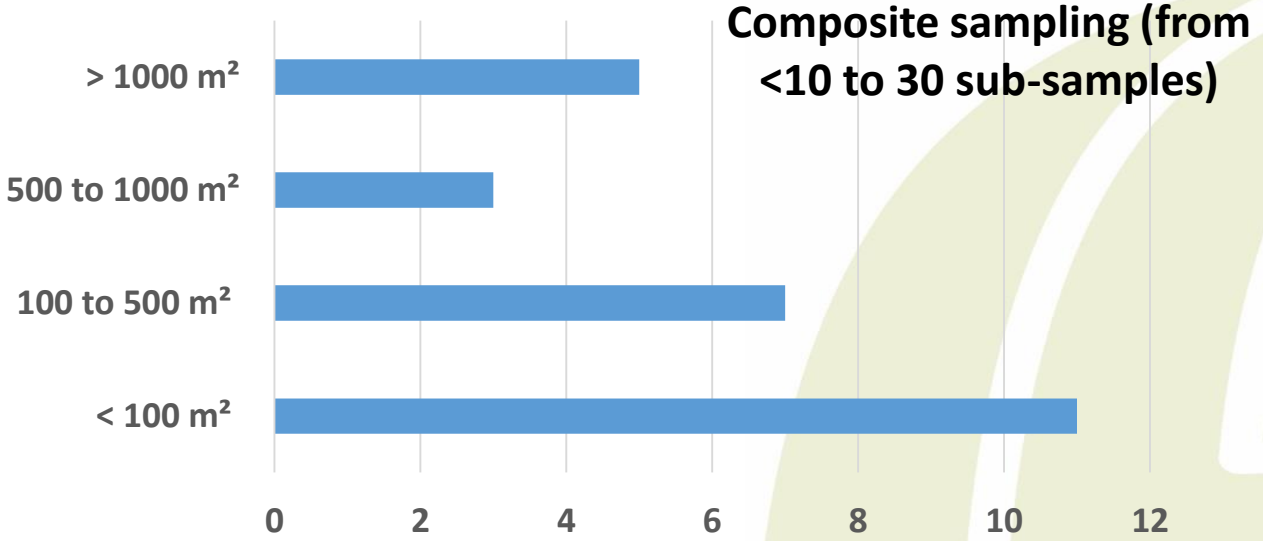
Results at a glance

Sampling design



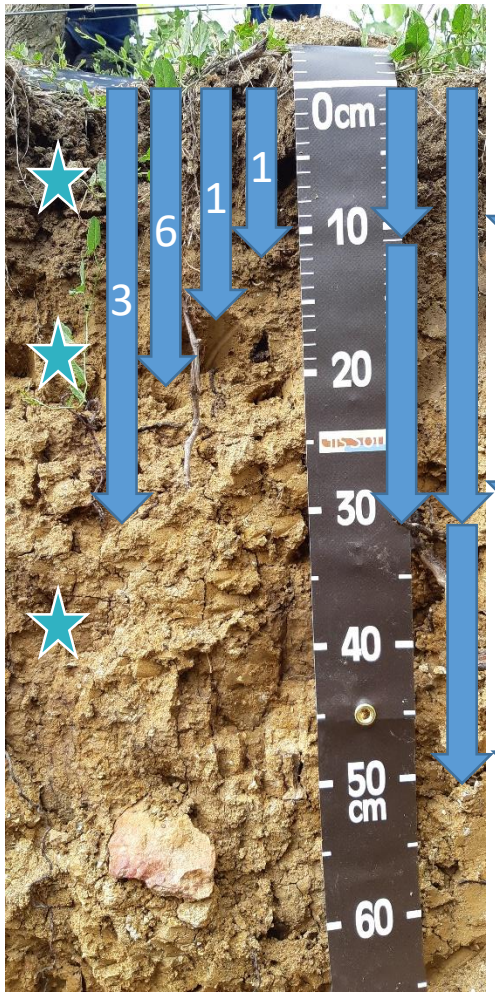
Sampling area

Composite sampling (from <10 to 30 sub-samples)



Results at a glance - Sampling depths

4 according to horizons



11 one fixed depth

14 different fixed depths

to 1 m

16 MS sample for bulk density

13 MS are sampling deeper than 30 cm

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Analytical methods (still to be completed)

	Countries	Sweden	France	EU-JRC	Czech Republic	Latvia		Lithuania	Belgium - Wallonia	Belgium - Flanders	Netherlands	Slovakia	Denmark	Germany	TOTAL
	Name of the Soil Monitoring System	Soil & Crop Inventory	RMQS	LUCAS$_a$	Basal soil monitoring	SPPS	SPPS N	Dirv_DR10LT	CARBIOSOL	Koolst of monitoring netwerk	Netherlands Soil Sampling Program (NSSP)	CMS-P	DSMDB	Boden-Dauerbeobachtung$_b$	
Main soil properties, according to Global Soil Map specifications, 2015	total profile depth		x												6
	plant exploitable (effective) soil depth		x												4
	organic carbon	**x**	**x**	**x**											**13**
	pH in water	**x**	**x**	**x**											**10**
	sand	**x**	**x**	**x**											**10**
	silt	**x**	**x**	**x**											**10**
	clay	**x**	**x**	**x**											**10**
	gravel		x	x											6
	ECEC	x	x	x											9
	bulk density of the fine earth (< 2 mm) fraction (excludes gravel)		x												5
	bulk density of the whole soil in situ (includes gravel)		x	x											7
	available water capacity														2
	Electrical Conductivity		x												6
Other soil properties	**calcium-carbonate content**	**x**	**x**	**x**											**10**
	Field capacity (mm)														2
	Plant available amounts of macro and micro nutrients	**x**	**x**	**x**											**12**
	Total amounts of macro and micro nutrients/trace elements	x	x	x											8
	quality of clay minerals (e.g. type or ratio of illite, smectite, montmorillonite in clay fraction…etc)			x											2
	distribution of soil organisms		x	x							x		x	x	5
	properties for NIR and MIR (near and mid infrared)	x	x	x						x	x				5

Main « common » parameters:

- Organic carbon
- pH (in water)
- Soil texture
- Calcium/carbonate content
- Macro/micronutrients

… but different methods are applied… (see also Deliverable D6.1 from EJP SOIL)

Harmonization options

Can you modify:

- the sampling design of your SMS => NO but we may add new points (#12)
- the sampling area => NO (#20)
- the sampling depths => NO (#18) but we may sample deeper (#4)
- the soil sample preparation, before analysis => NO (#21)
- the analytical methods => NO (#16)

Any change would make impossible the comparison with previous data…

- Can you consider collecting new information on the monitoring sites?
  - YES: (#24)
- Can you improve soil description on the monitoring sites?
  - YES: (#16)
- Can you add extra analytical parameters?
  - YES: (#21)

But this will require more funds …

Main recommendations

ONGOING

- Compare national and LUCAS sampling strategies/schemes
- Compare national and LUCAS data, country/country
- Develop transfer functions (from sampling to analytical methods), taking the opportunity of LUCAS 2022
- Identify / test methods to merge national and LUCAS datasets and/or existing maps
- Develop / test benchmark values/scoring approaches

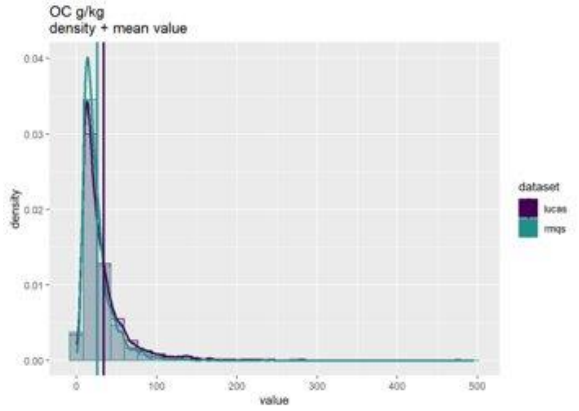
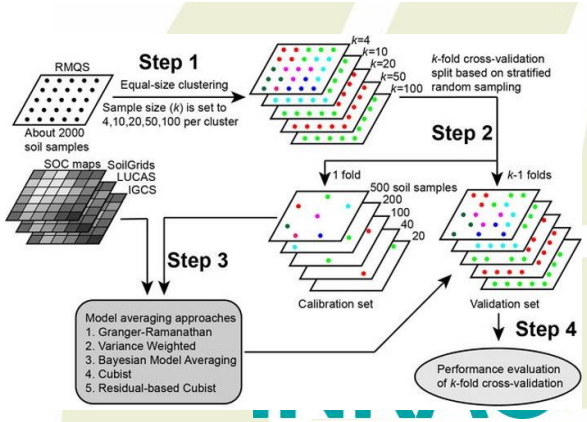


Table 3. Equations of PTFs built by partial least square regression (PLSR) for estimating Olsen P_2O_5 with their mean R^2 and RMSE values based on cross-validation.

R^2	RMSE (mg kg^{-1})	Equations
PTFs built with Joret-Hébert P_2O_5 and other variables		
0.398 a	33.719aa	Olsen P_2O_5 = 27.215 + 0.244*Joret-Hébert P_2O_5
0.535b	29.627bb	Olsen P_2O_5 = -19.619 + 0.254*Joret-Hébert P_2O_5 + 0.096*Silt
0.535b	29.630bb	Olsen P_2O_5 = 299.664 + 0.270*Joret-Hébert P_2O_5 – 35.208*pH_{water}
0.608c	27.198 cc	Olsen P_2O_5 = 218.385 + 0.263*Joret-Hébert P_2O_5 – 29.419*pH_{water} + 0.079*Silt
PTFs built with Dyer P_2O_5 and other variables		
0.638d	27.860dd	Olsen P_2O_5 = 28.315 + 0.19*Dyer P_2O_5
0.681d	26.167dd	Olsen P_2O_5 = 21.5 + 0.193*Dyer P_2O_5 + 35.49*exchangeable Al
0.659d	27.062dd	Olsen P_2O_5 = 63.246 + 0.195*Dyer P_2O_5 – 6.063*pH_{water}
0.685d	25.985dd	Olsen P_2O_5 = 57.522 + 0.193*Dyer P_2O_5 – 5.987*pH_{water} + 35.447*exchangeable Al

Note: R^2 means coefficient of determination, RMSE means root mean-square error; "a","b","c",d","aa", "bb", "cc" and "dd": letters indicating significant differences from mean comparison ($\alpha \leq 5\%$) of R^2 and RMSE among PTFs.



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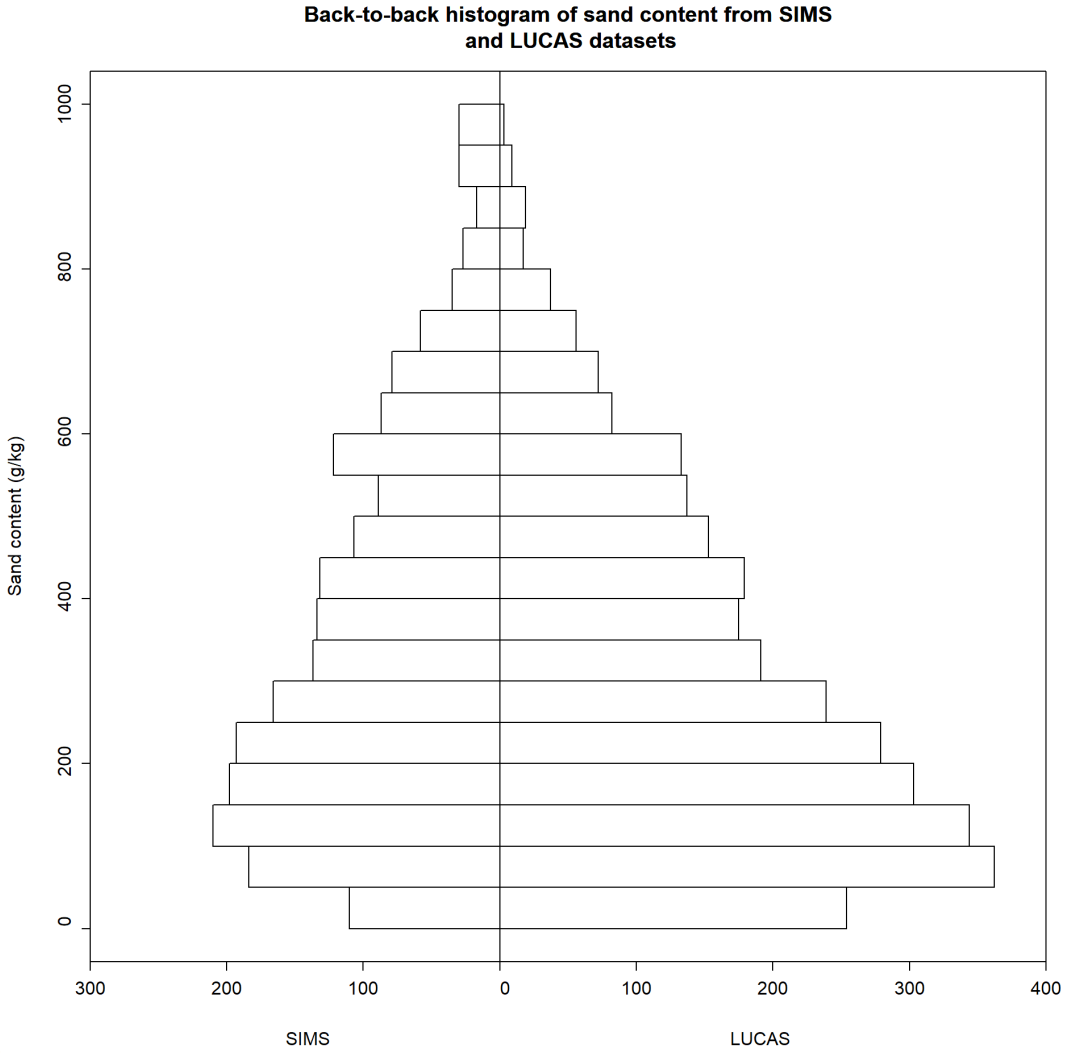
LUCAS / SIMS comparison protocol



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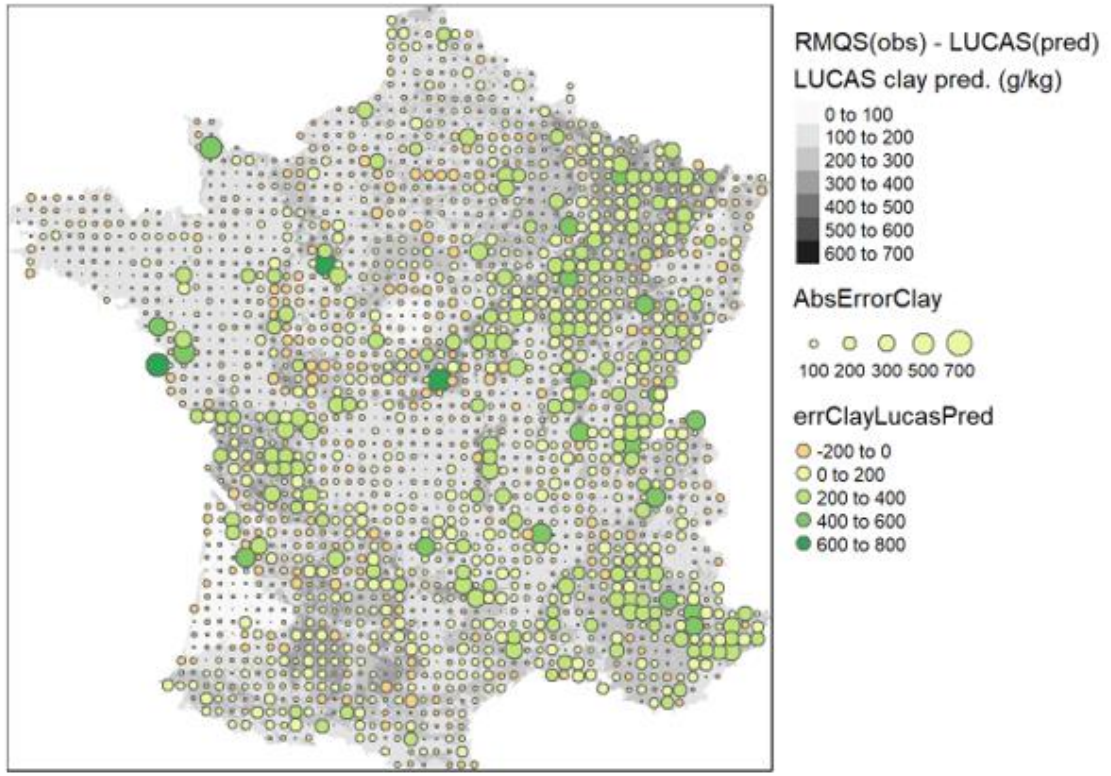

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EJP SOIL partners investment in the development of transfert functions (in link with LUCAS SOIL 2022)

Analytical procedures

- Double samples obtained from LUCAS 2022 samplers
- Between 100 and 200 sites will be analyzed depending on the countries
- 17 countries involved
- Comparison of EU and national results

Sampling and analytical procedures

- Sampling (on national SMS and/or on LUCAS 2022 points) according to national and LUCAS sampling protocols
- 6 countries involved
- Compare the overall process

Conclusions

- Updated overview of SMS in EJP SOIL countries
- Based on the questionnaire: full harmonization seems impossible
- Next steps:
  - Common sites may be implemented to compare soil monitoring systems
  - Ways to take advantage of national/EU data are currently being tested as
    - Merging datasets / maps knowing and understanding the differences (by the end of this year)
    - Transfer functions to be developed next year using the LUCAS 2022 sampling campaign
    - Scoring functions to transform the data obtained through different ways (next year)
- Results can be later used to implement and populate the EU Soil Observatory!

Thank you for your attention

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