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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, Zsófia Bakacsi, Rudi Hessel, Johanna Wetterlind, Grzegorz Siebelec and Arwyn Jones



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.**



www.ejpsoil.eu

EJP SOIL WP6 main objectives and links with EU Soil Observatory



EJP SOIL WP6

Monitoring

Mapping

Indicators &
Benchmark values

Data management

*Monitoring
Indicators
Data*

EU Soil Observatory

Monitoring

EU Dashboard

Data Center

R&I

Open forum

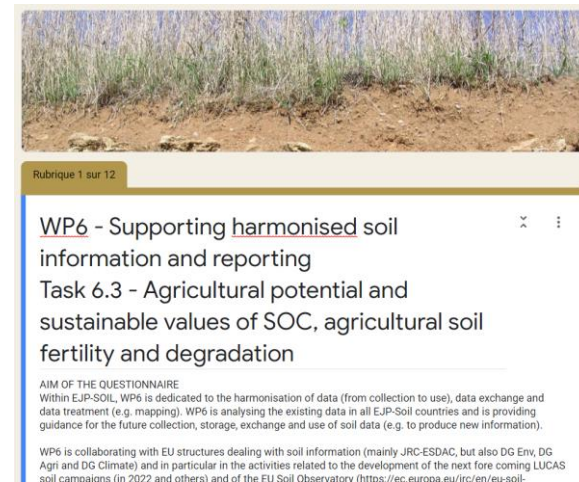


Describe and analyse Soil Monitoring Systems across EJP SOIL partners

- **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

Published on the EJP SOIL web portal:

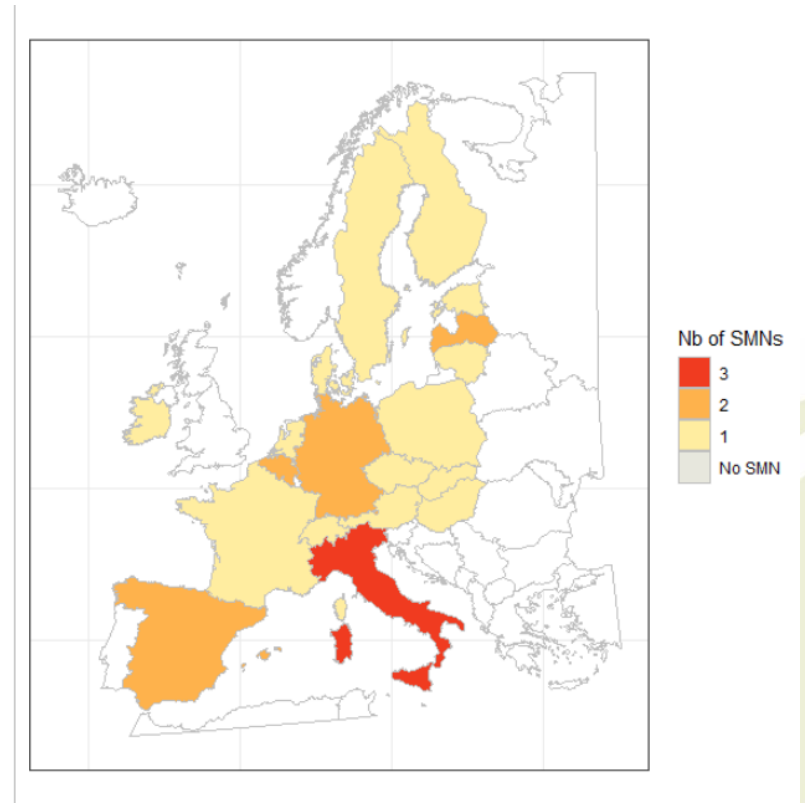
https://ejpsoil.eu/fileadmin/projects/ejpsoil/WP6/EJP_SOIL_Deliverable_6.3_Dec_2021_final.pdf



EJP SOIL Deliverable 6.3

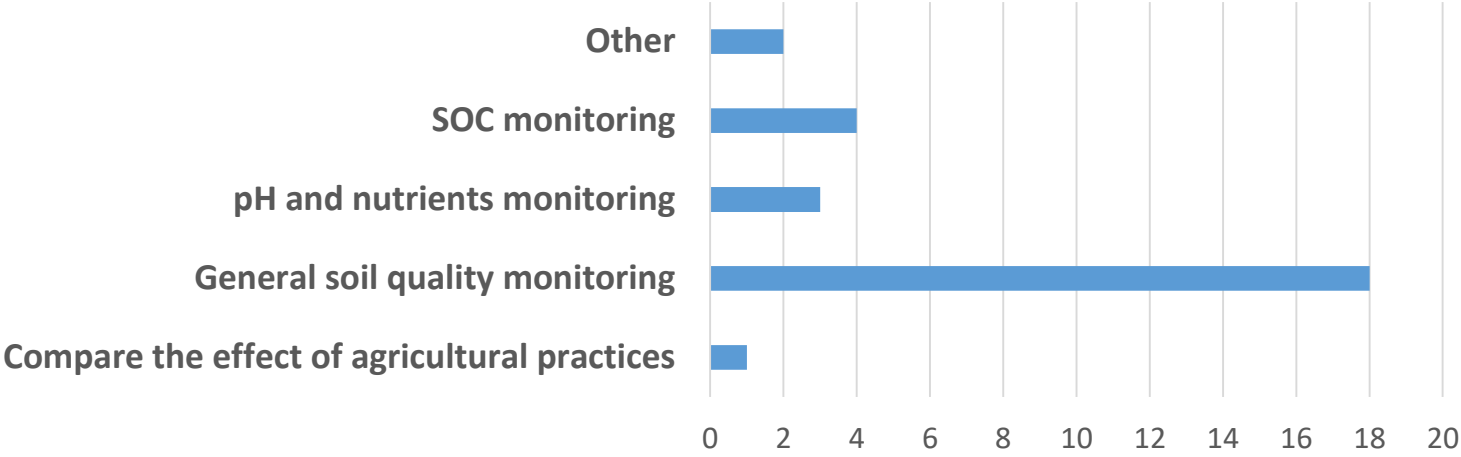
SMS in EJP SOIL countries

- 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

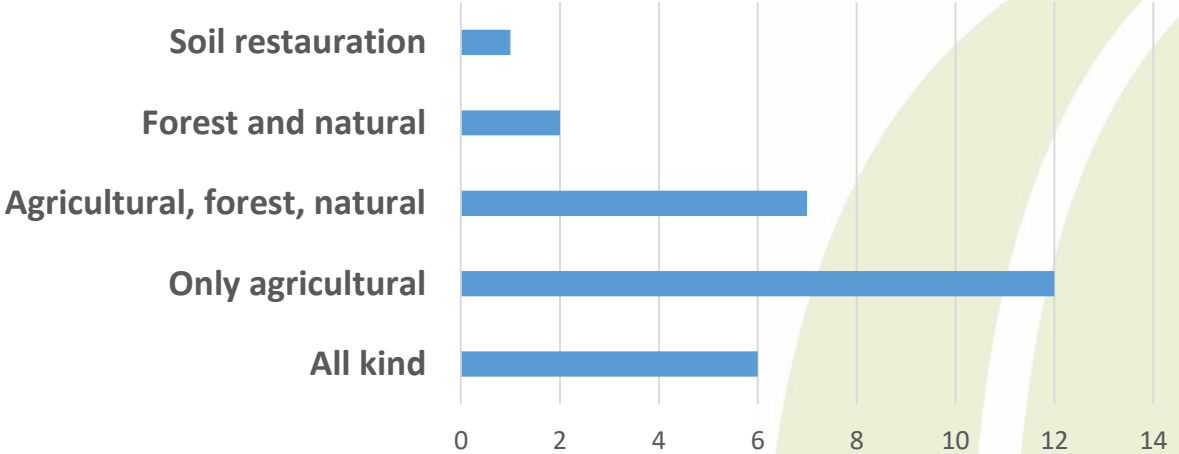


Results at a glance

Main objective of the SMS

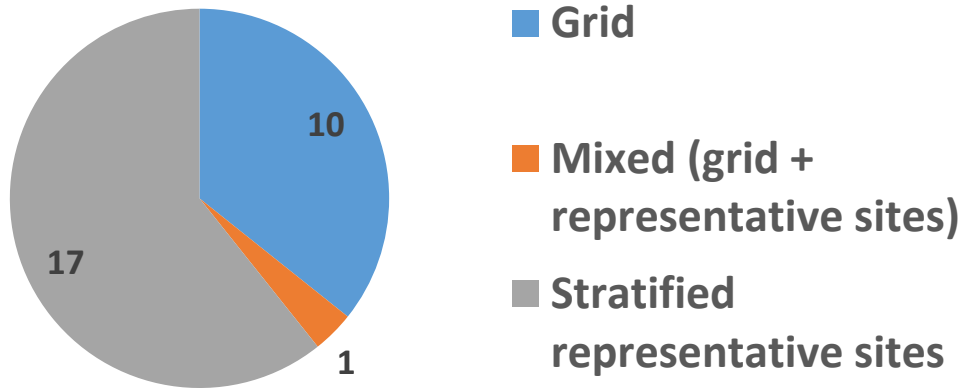


Investigated land uses

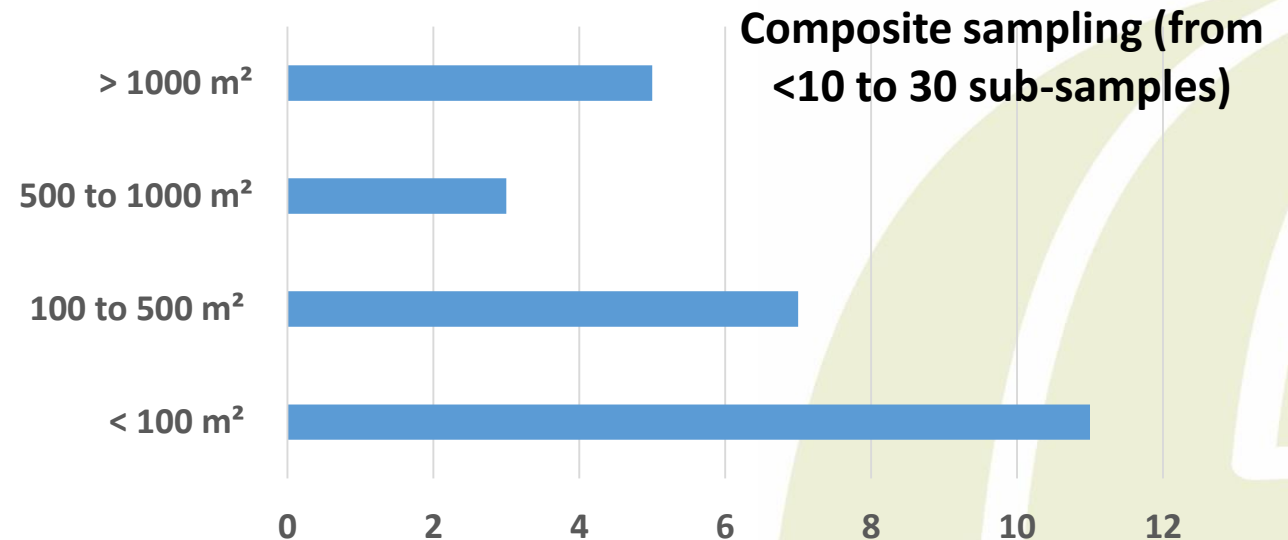


Results at a glance

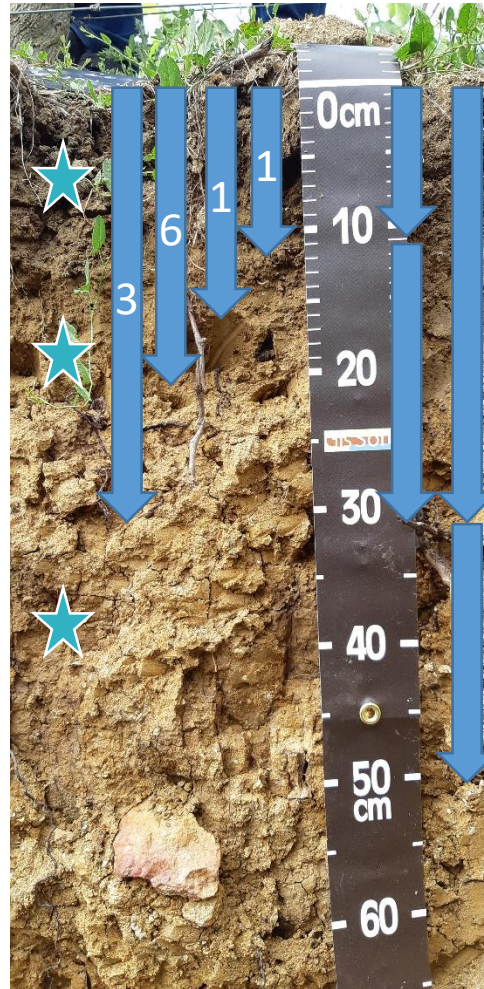
Sampling design



Sampling area



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

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	CARBIO SOL	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									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)
-
- 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)

Any change would make impossible the comparison with previous data...

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

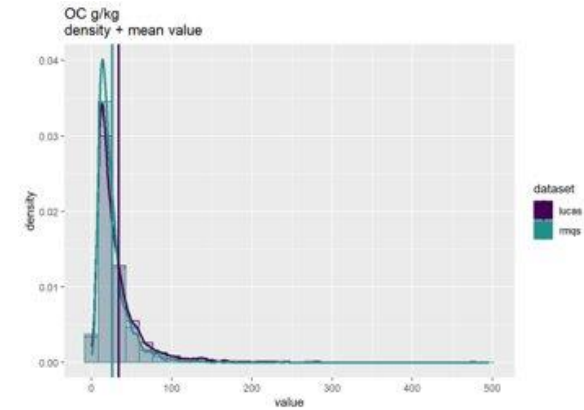
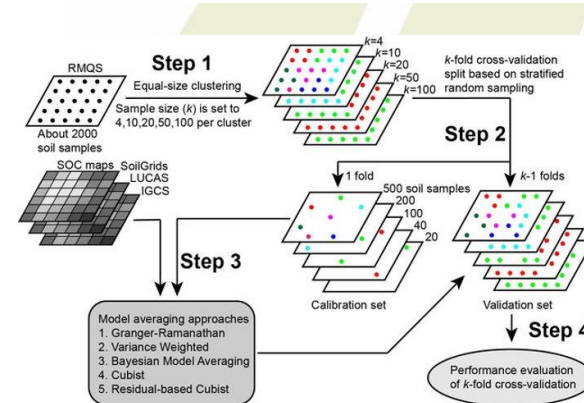


Table 3. Equations of PTFs built by partial least square regression (PLSR) for estimating Olsen P₂O₅ with their mean R² and RMSE values based on cross-validation.

R ²	RMSE (mg kg ⁻¹)	Equations
PTFs built with Joret-Hébert P ₂ O ₅ and other variables		
0.398 a	33.719aa	Olsen P ₂ O ₅ = 27.215 + 0.244*Joret-Hébert P ₂ O ₅
0.535b	29.627bb	Olsen P ₂ O ₅ = -19.619 + 0.254*Joret-Hébert P ₂ O ₅ + 0.096*Silt
0.535b	29.630bb	Olsen P ₂ O ₅ = 299.664 + 0.270*Joret-Hébert P ₂ O ₅ - 35.208* <i>p</i> H _{water}
0.666c	27.198 cc	Olsen P ₂ O ₅ = 218.385 + 0.263*Joret-Hébert P ₂ O ₅ - 29.419* <i>p</i> H _{water} + 0.079*Silt
PTFs built with Dyer P ₂ O ₅ and other variables		
0.638d	27.860dd	Olsen P ₂ O ₅ = 28.315 + 0.19*Dyer P ₂ O ₅
0.681d	26.167dd	Olsen P ₂ O ₅ = 21.5 + 0.193*Dyer P ₂ O ₅ + 35.49*exchangeable Al
0.699d	27.062dd	Olsen P ₂ O ₅ = 63.246 + 0.195*Dyer P ₂ O ₅ - 6.063* <i>p</i> H _{water}
0.685d	25.985dd	Olsen P ₂ O ₅ = 57.522 + 0.193*Dyer P ₂ O ₅ - 5.987* <i>p</i> H _{water} + 35.447*exchangeable Al

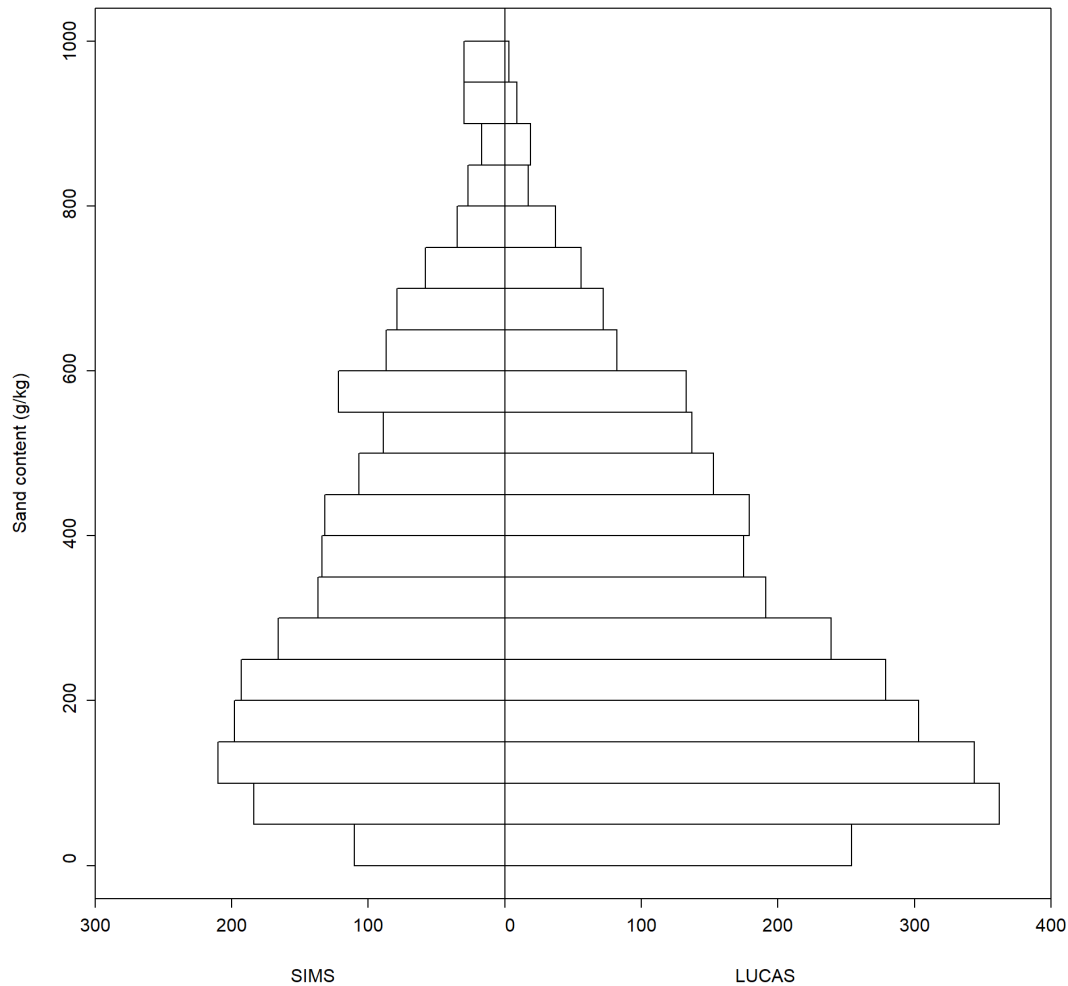
Note: R² means coefficient of determination, RMSE means root mean-square error; "a", "b", "c", "d", "aa", "bb", "cc" and "dd": letters indicating significant differences from mean comparison (α ≤ 5%) of R² and RMSE among PTFs.



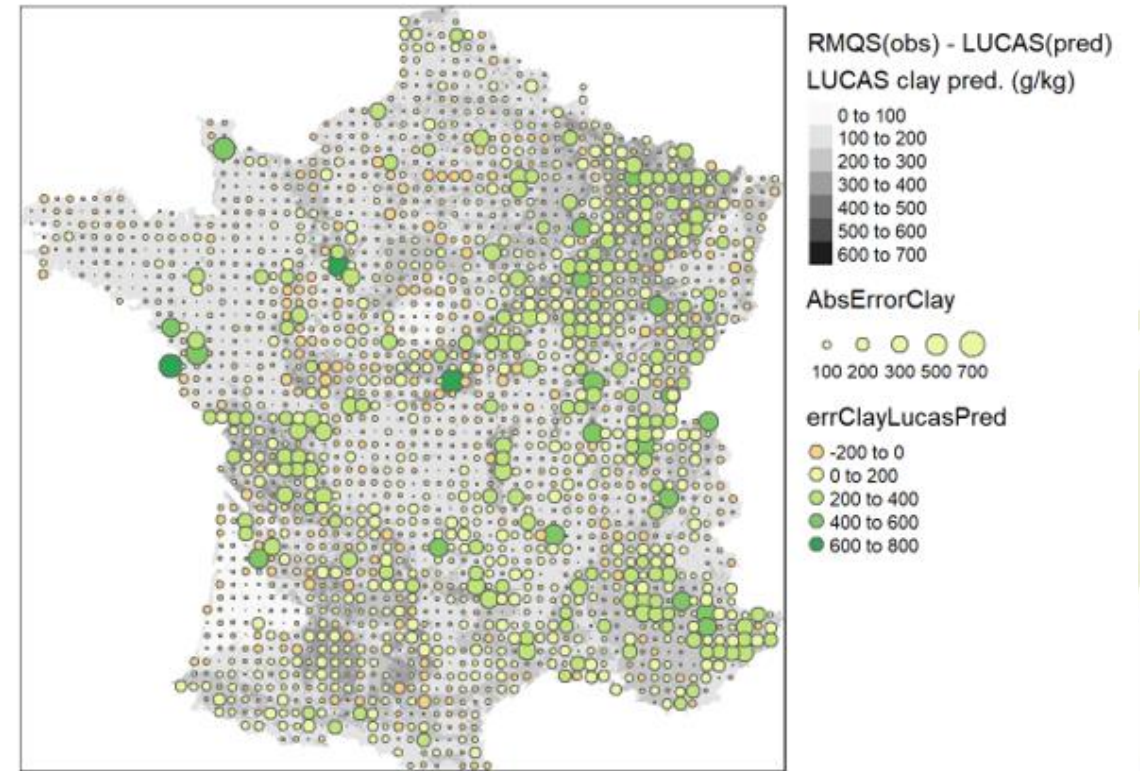
LUCAS / SIMS comparison protocol



Back-to-back histogram of sand content from SIMS and LUCAS datasets



<https://nicolassaby.pages.mia.inra.fr/ejpsoilwp6lucas/>



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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7-9 February 2023
Soil Mapping for a Sustainable Future
2nd joint Workshop of the IUSS Working Groups
Digital Soil Mapping and Global Soil Map



LOCATION
Auditorium du Musée des Beaux Arts
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45000 Orléans - FR

UNDER THE AUSPICES OF
IUSS - International Union of Soil Sciences
Digital Soil Mapping and Global Soil Map Working Groups

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**EJP SOIL meeting
Palermo – June 2022**