Czech University of Life Sciences Prague

A novel protocol for in-field monitoring of soil carbon stock, based on proximal sensors and soil spectral libraries – **ProbeField**

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Fenny van Egmond, Asa Gholizadeh, Eyal Ben Dor, Fabio Castaldi,
Konrad Metzger, Frank Liebisch, Maria Fantappiè and whole ProbeField consortium

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European Joint Programme

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 652615.

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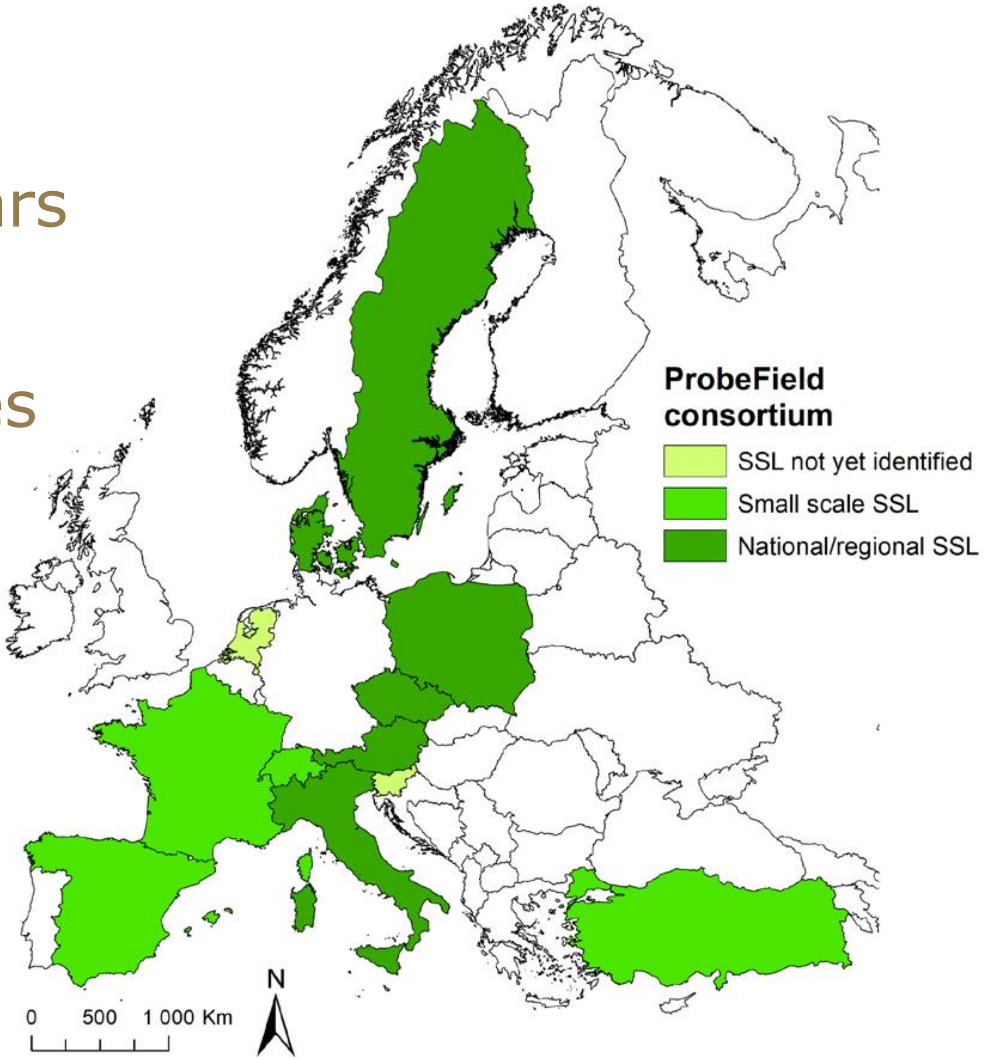
ProbeField

*A novel protocol for robust **in field monitoring** of carbon stock and soil quality properties based on **proximal sensors** and existing soil **spectral libraries***

- Start: November 1, 2021, duration: 3 years
- Coordinator: **Bo Stenberg**, Swedish University of Agricultural Sciences (SLU), Sweden
- Co-Leader: **Maria Knadel**, Aarhus University (AU), Denmark



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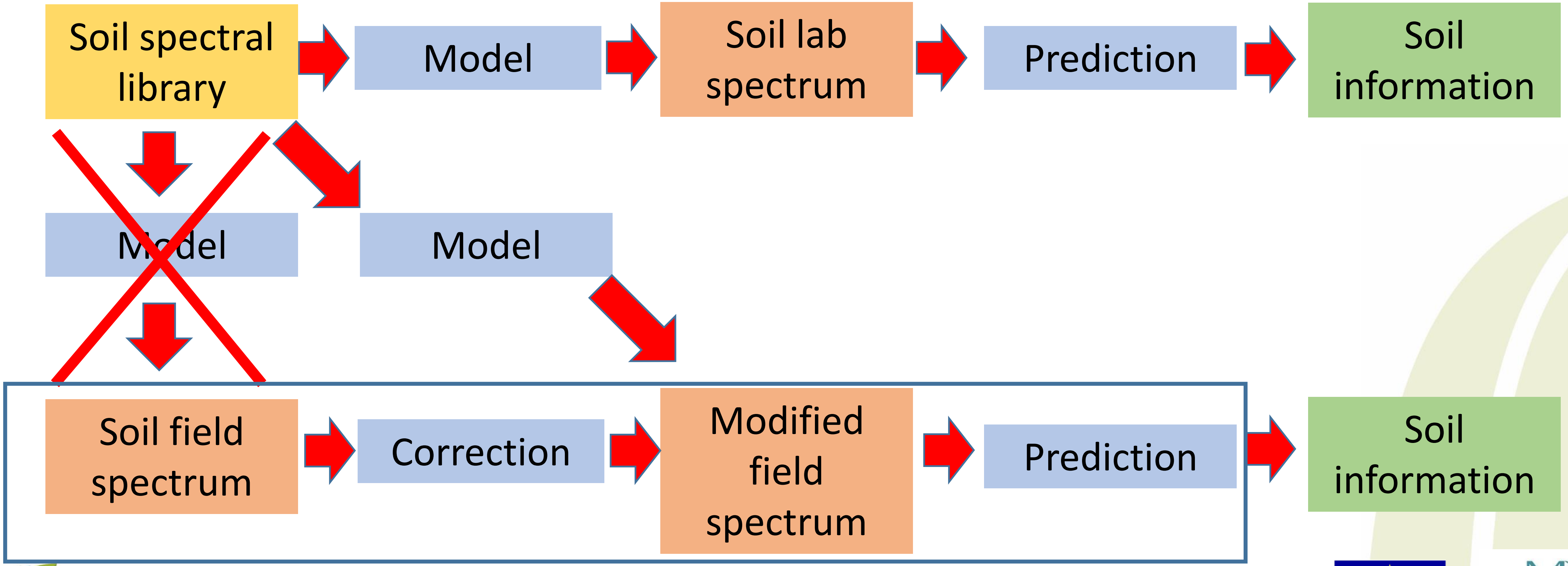
ProbeField background and motivation

Field spectra measurement:
+ faster, cheaper, no or little disturbance
- effect of moisture, texture, structure, solar radiation…



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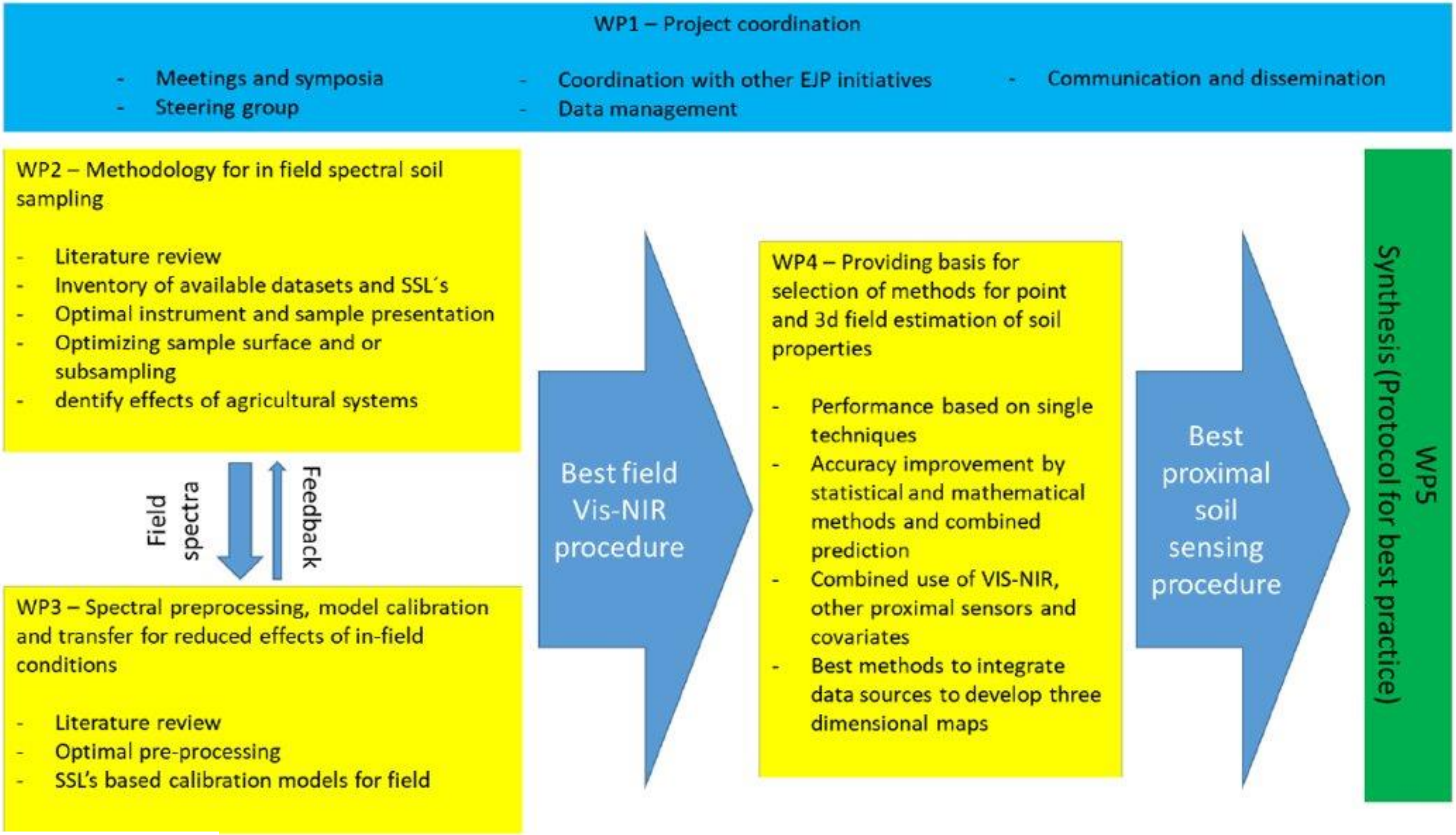
ProbeField


WP1 – Project coordination
- Meetings and symposia
- Steering group
- Coordination with other EJP initiatives
- Data management
- Communication and dissemination
WP2 – Methodology for in field spectral soil sampling
- Literature review
- Inventory of available datasets and SSL´s
- Optimal instrument and sample presentation
- Optimizing sample surface and or subsampling
- dentify effects of agricultural systems
Field spectra
Feedback
WP3 – Spectral preprocessing, model calibration and transfer for reduced effects of in-field conditions
- Literature review
- Optimal pre-processing
- SSL's based calibration models for field
Best field Vis-NIR procedure
WP4 – Providing basis for selection of methods for point and 3d field estimation of soil properties
- Performance based on single techniques
- Accuracy improvement by statistical and mathematical methods and combined prediction
- Combined use of VIS-NIR, other proximal sensors and covariates
- Best methods to integrate data sources to develop three dimensional maps
Best proximal soil sensing procedure
WP5
Synthesis (Protocol for best practice)

T2.4 Optimizing sample surface tests

Manipulation of soil surface experiments:

-Field protocol document developed

-Experimental campaigns in Italy, Denmark and Switzerland

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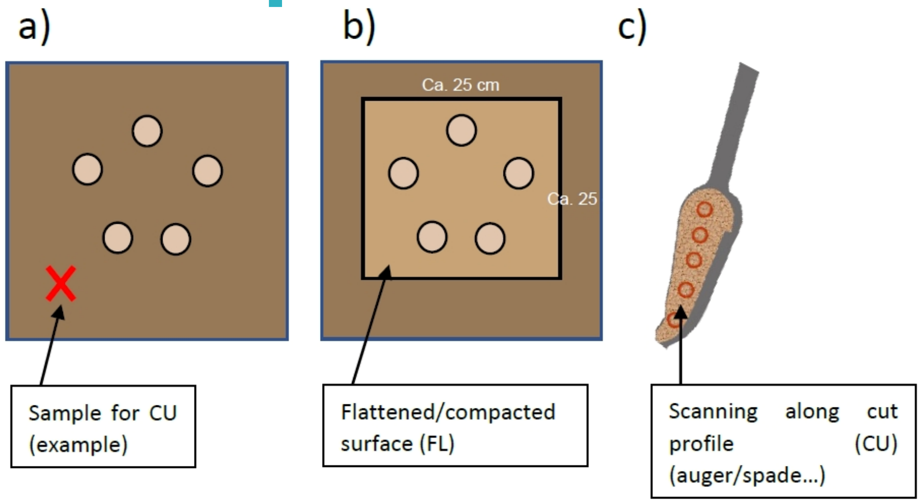
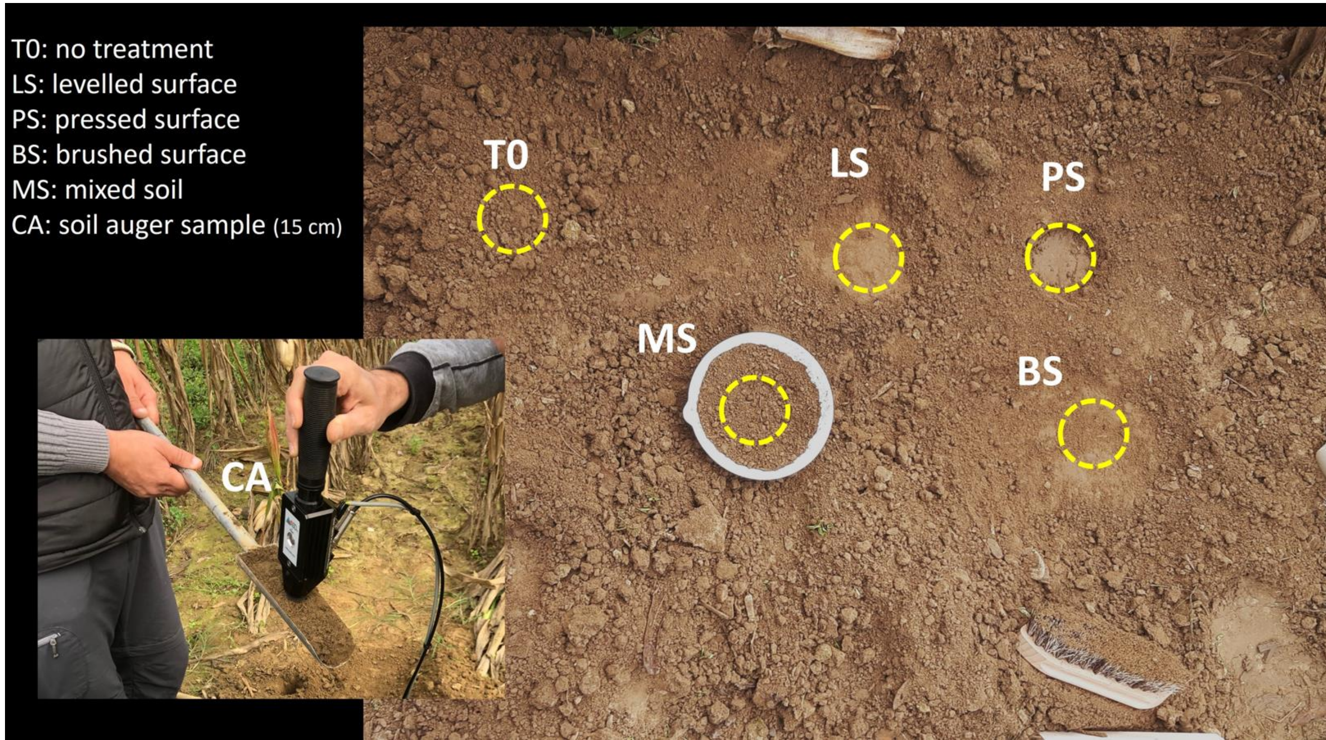
T2.4 Optimizing sample surface tests - protocol

Soil surface pre-treatments:

1. **T0** – NO (least possible) treatment
2. **FL** – flattened/compacted
3. **CU** Cut – along core/spade surface
4. **MX** Mixed – field moist
5. **DU** Air dry - unsieved
6. **DS** Air dry – sieved <2 mm
7. **DL** Soil Spectral Library (national, regional SSL) protocol procedure





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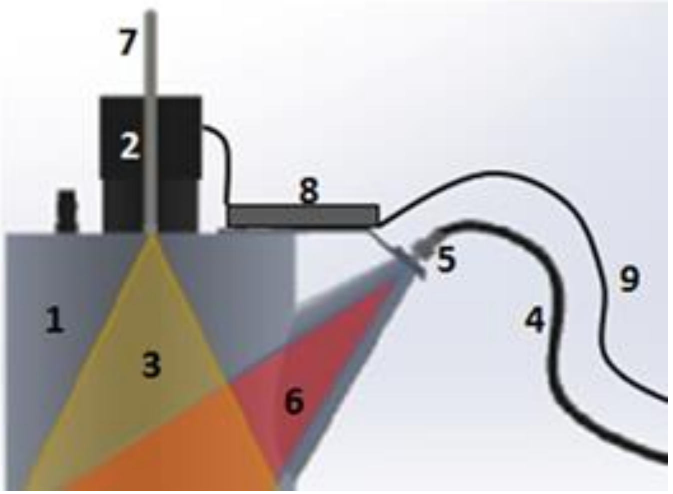
SoilPRO instrument

- Invented by Eyal Ben Dor et al. (Tel Aviv University, Israel)
- US patent
- Testing
  - „Field spectra of laboratory quality"
- Advantages:
  - Larger sensed area
  - No surface disturbance
  - No external light effect
  - Stable measurement



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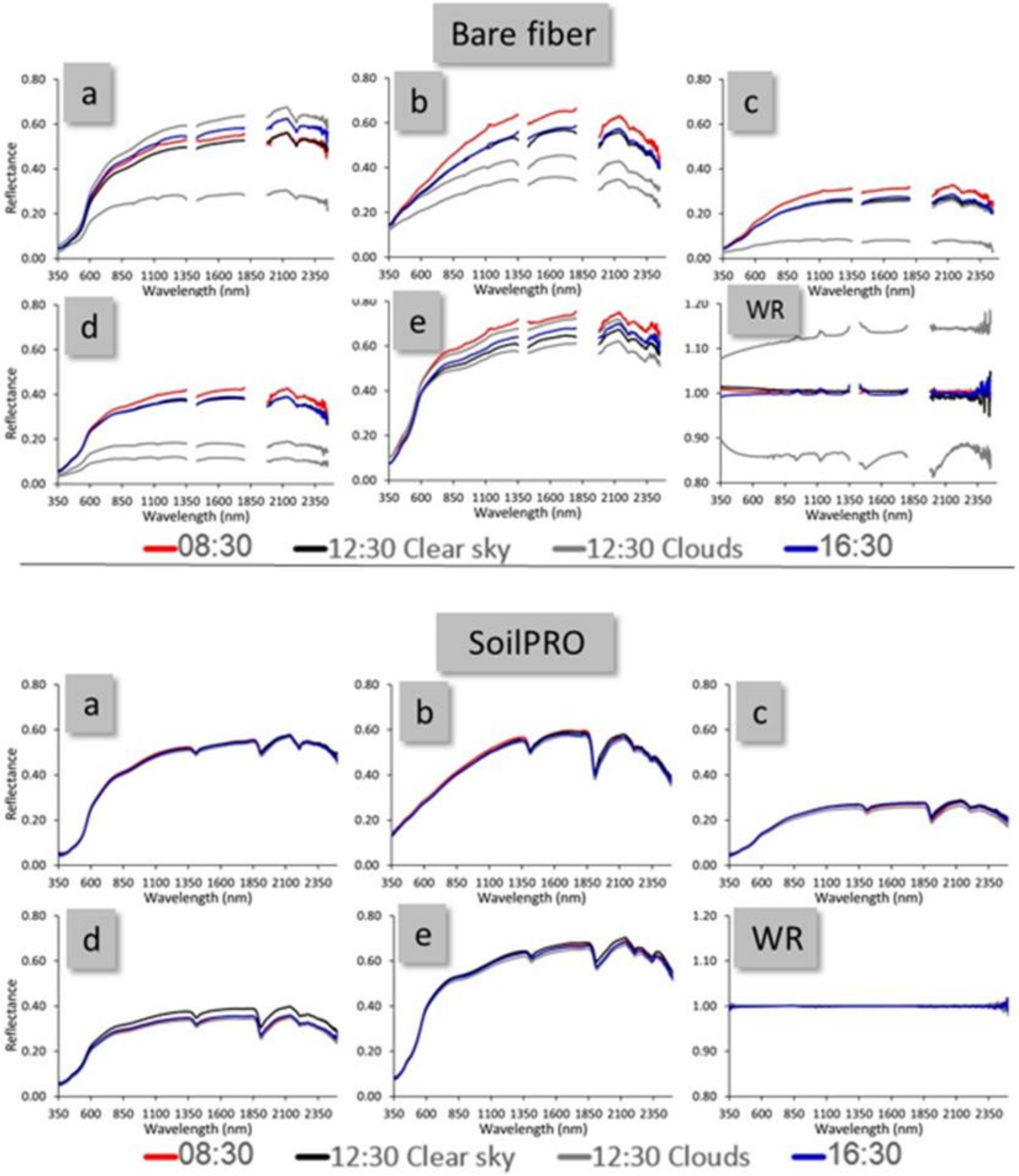


WP3 Spectral preprocessing

T3.1 Literature review

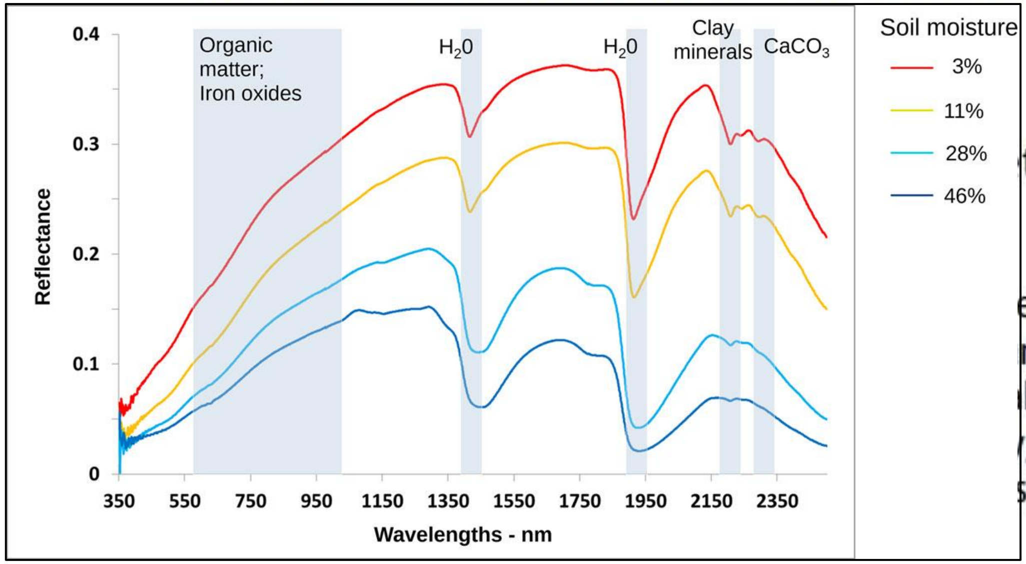
Aim: To identify existing techniques to remove moisture effects from soil spectra

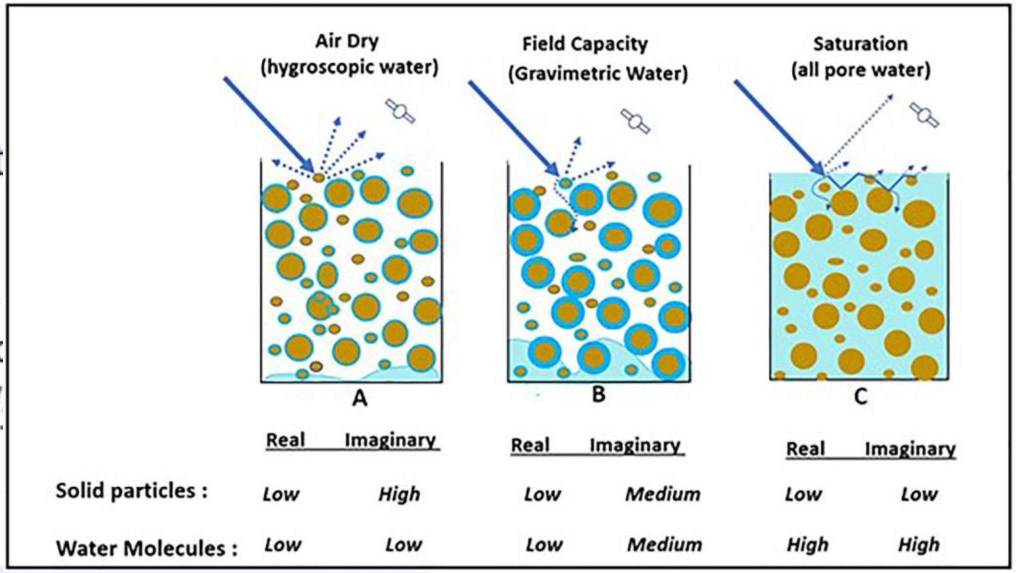
APPLIED SPECTROSCOPY REVIEWS
https://doi.org/10.1080/05704928.2022.2128365

Taylor & Francis
Taylor & Francis Group

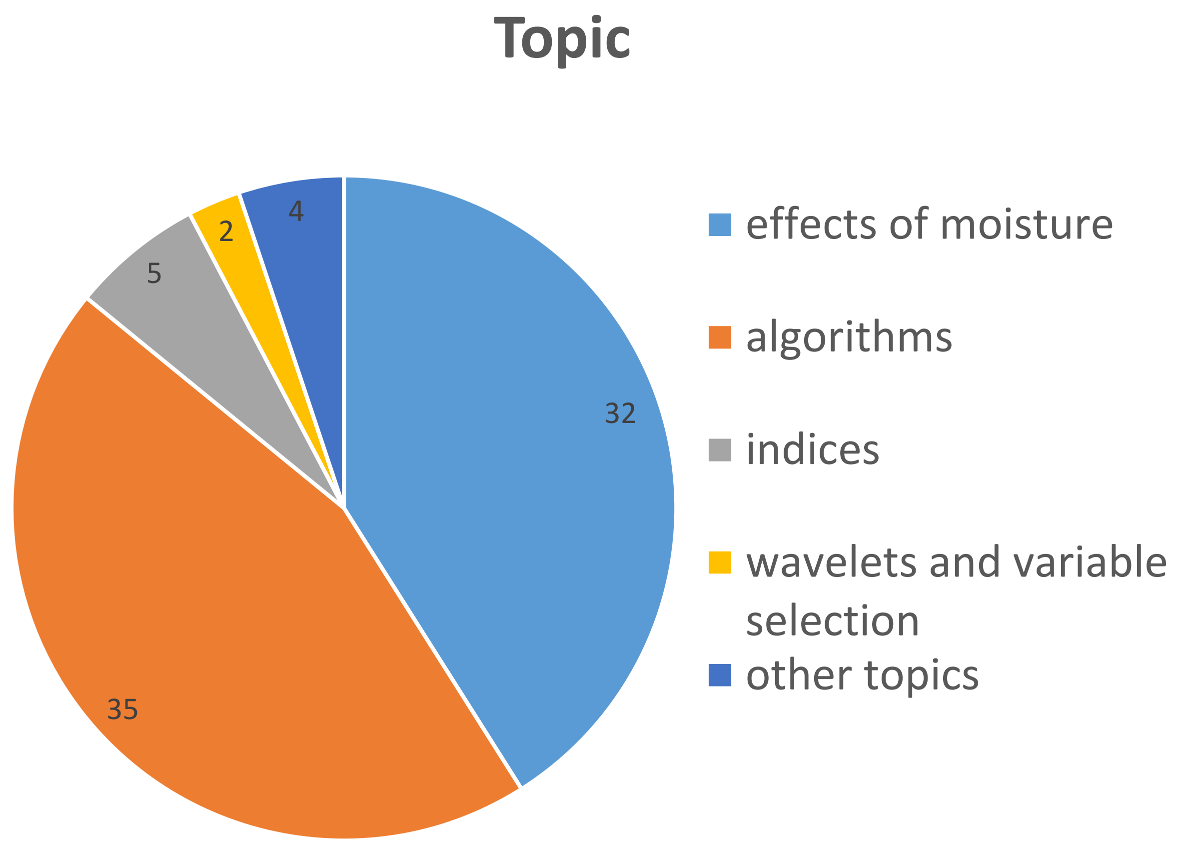
Check for updates

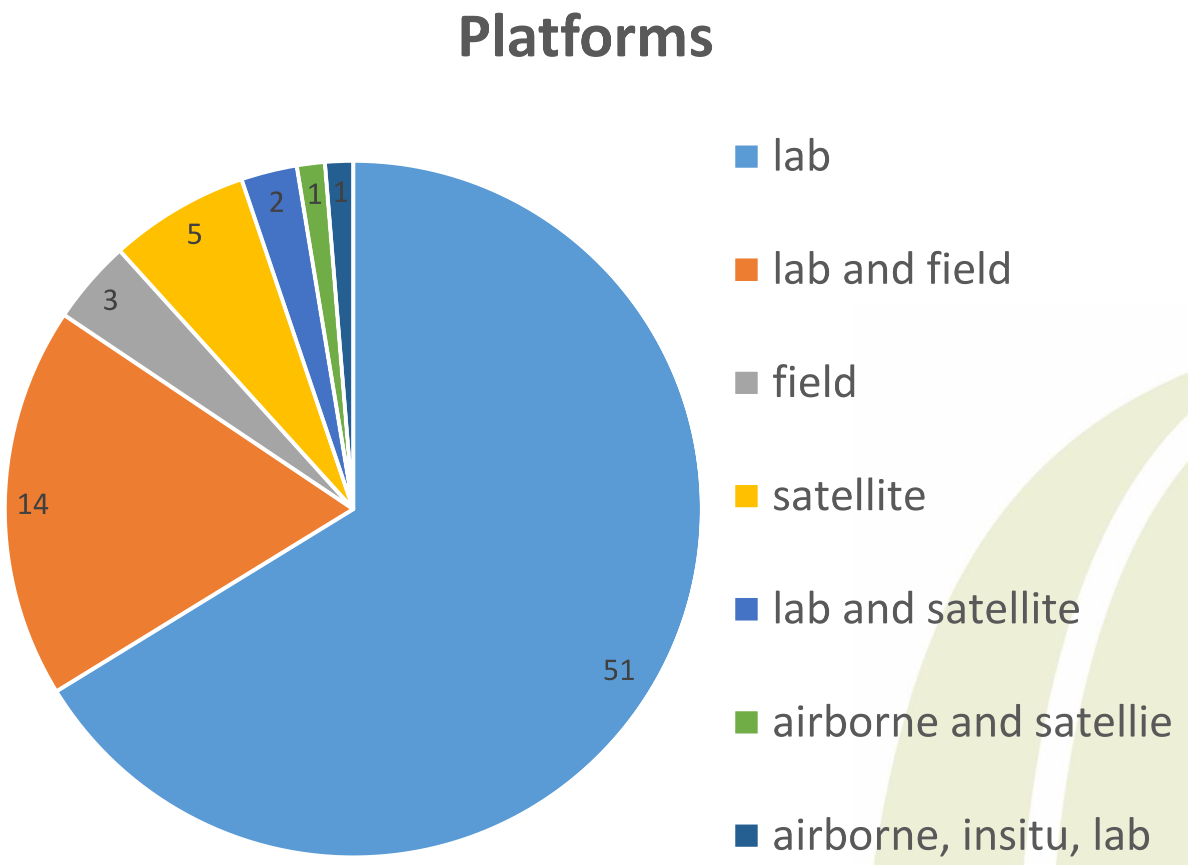
Mathematical techniques to remove moisture effects from visible–near-infrared–shortwave-infrared soil





T3.1 Literature review summary





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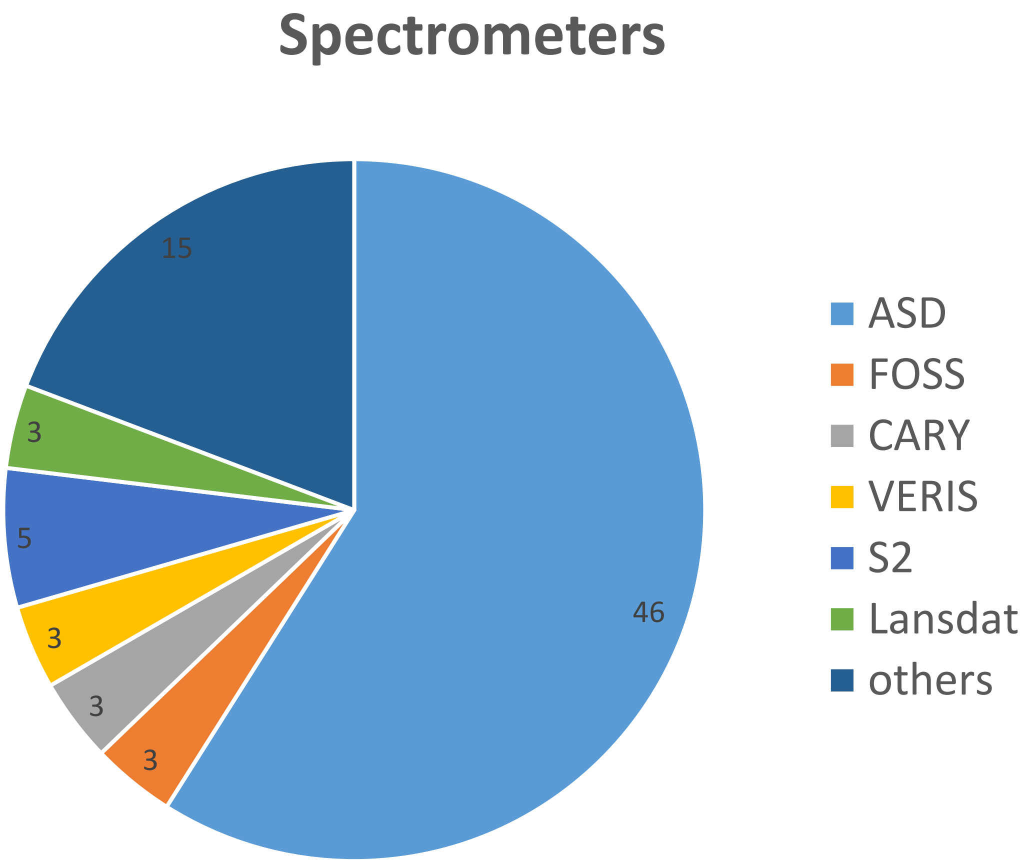
T3.1 Literature review summary



Spectral range: 90% using 350-2500nm

Scale:

- 32 local/field + 9 regional,
- 27 regional,
- 3 national,
- 1 European

Origin:

17 USA, 14 China, 5 France, 5 Brazil, rest <5

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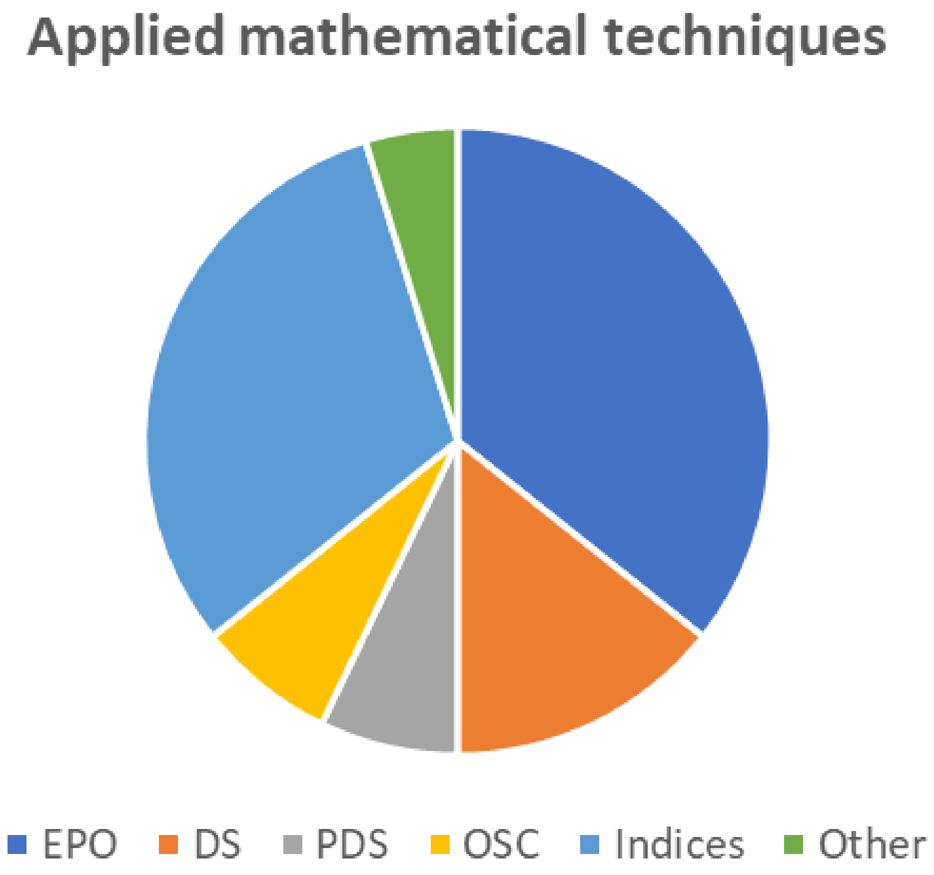
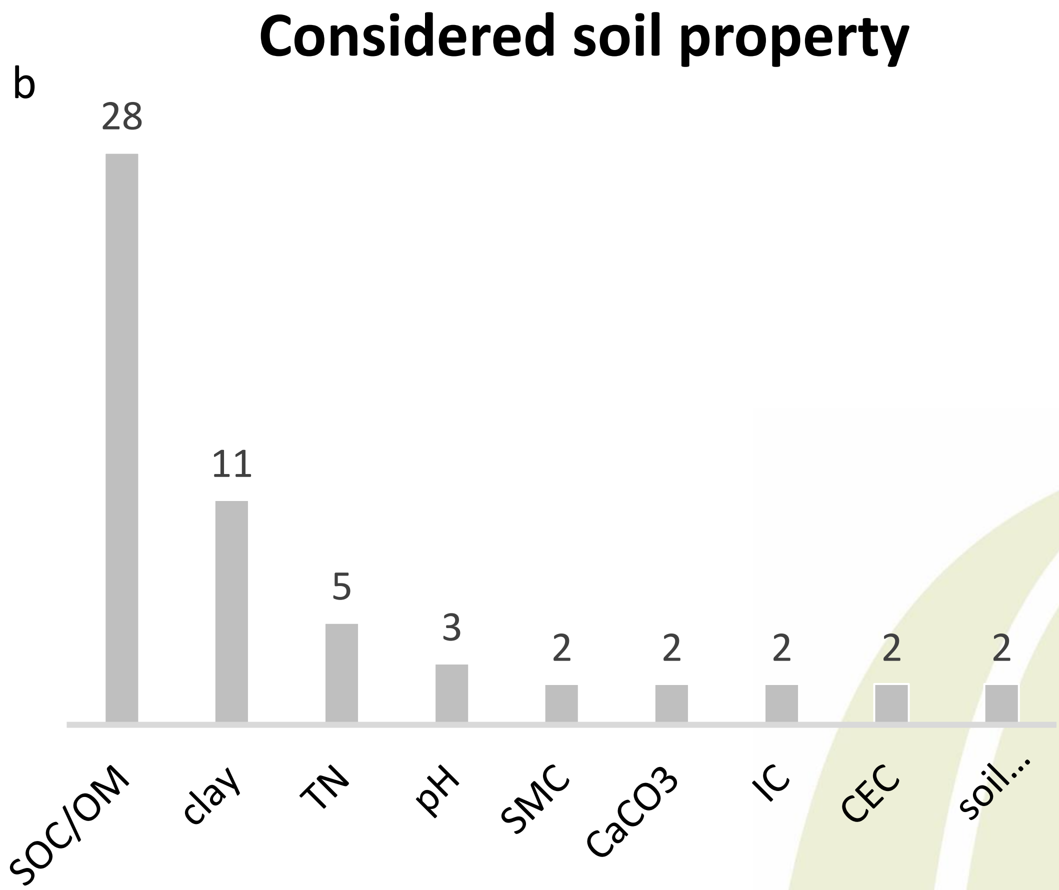
T3.1 42 papers on techniques to remove moisture - summary





EPO = external parameter orthogonalization, DS = direct standardization, OSC = orthogonal signal correction, PDS = piecewise direct standardization

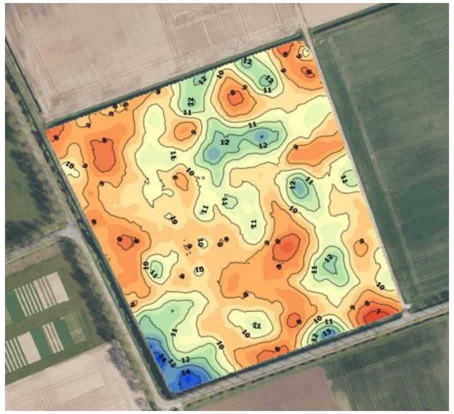
WP 4 Providing basis for selection of methods for point and 3d field estimation of soil properties

Aims:

- Evaluation of costs and accuracy for using single and multiple proximal soil sensing techniques for estimation of soil properties
- Compositional analysis of soil properties
- 3D mapping of soil properties based on proximal soil sensing

Soil properties:
SOC, soil inorganic C
Clay, sand, silt
Water content
EC
Coarse fragments
Bulk Density
Soil depth/ comp. layer

Sensing:
Near infrared
Gamma-ray
EMI
GPR



Methods:
Literature survey
Company survey
Field analyses

Read by	DOI	Authors	Title	Year	Relevant (yes/no)	3d map (yes/no	d sensors (yes/no	Sensor	Manufacturing compan	type (lab, in-situ, UVA, satelite)
Melis	https://doi.org/10.1016/j.geoderma.2021.114981	Moura-Bueno et al	Environmental covariates improve the spectral predictions of organic carbon in subtropical soils in southern Brazil	2021	yes	no	no	FieldSpec 3 spectroradiometer	(Analytical Spectral Devices, Boulder, USA)	lab
Roberto	https://doi.org/10.1016/j.geoderma.2019.113900	Hutengs et al 2019	In situ and laboratory soil spectroscopy with portable visible-to-near-infrared and mid-infrared instruments for the assessment of organic carbon in soil	2019	yes	no	no	high-performance handheld MIR spectrometers, and Vis-Nir spectrometer	Agilent Handheld FTIR series (Agilent Technologies, Santa Clara, USA), that cover the 4000–650 cm−1 and ASD FieldSpec	in-situ and lab

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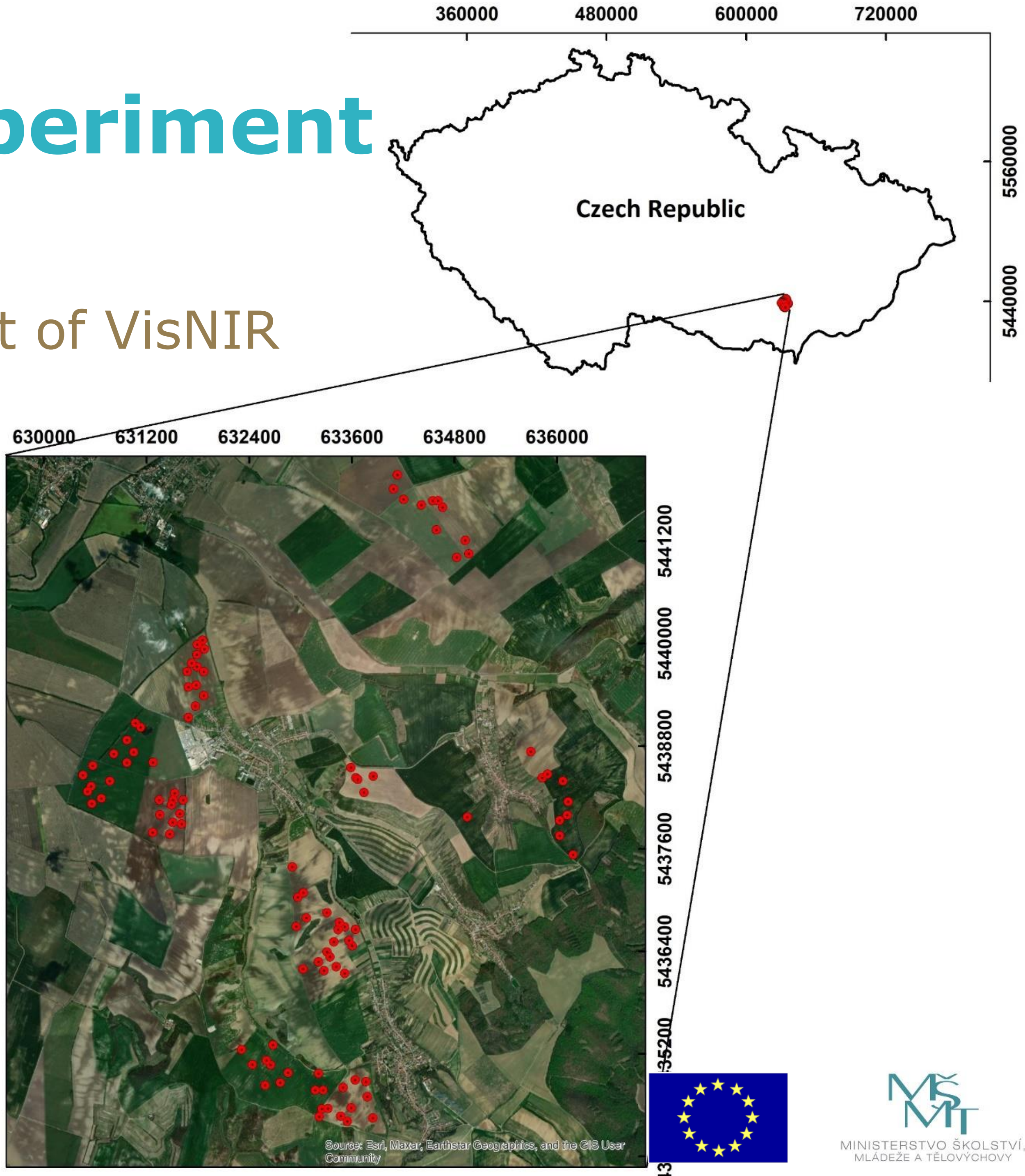
ProbeField – Czech experiment

- Otnice (mostly Chernozem)
- Field vs. laboratory measurement of VisNIR spectra (106 sampling sites)
- Effect of moisture, texture….
- Soil spectral library exploitation
- SoilPRO instrument



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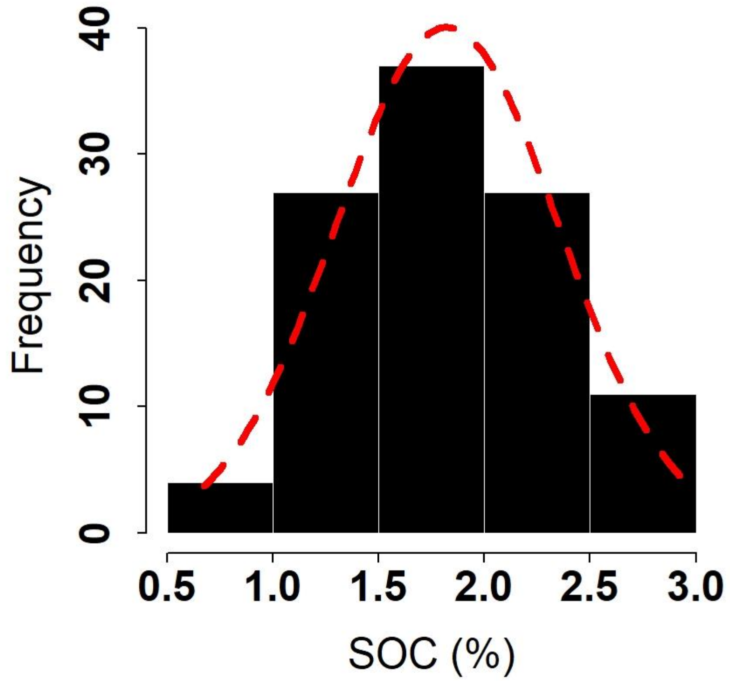
Soil organic carbon content statistics

SOC statistics

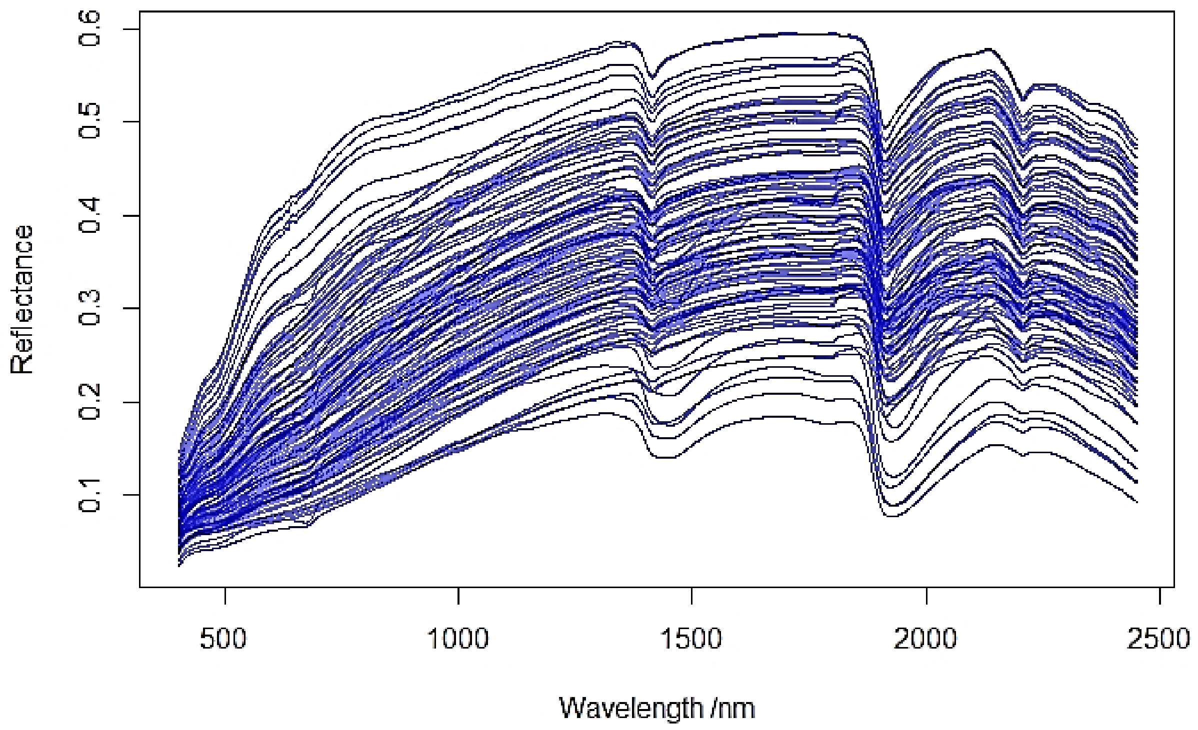
Minimum	0.67
Maximum	2.96
Mean	1.82
Standard deviation	0.53
Range	2.29
Skewness	0.16
Kurtosis	-0.61
Coefficient of variation	0.29

SOC histogram

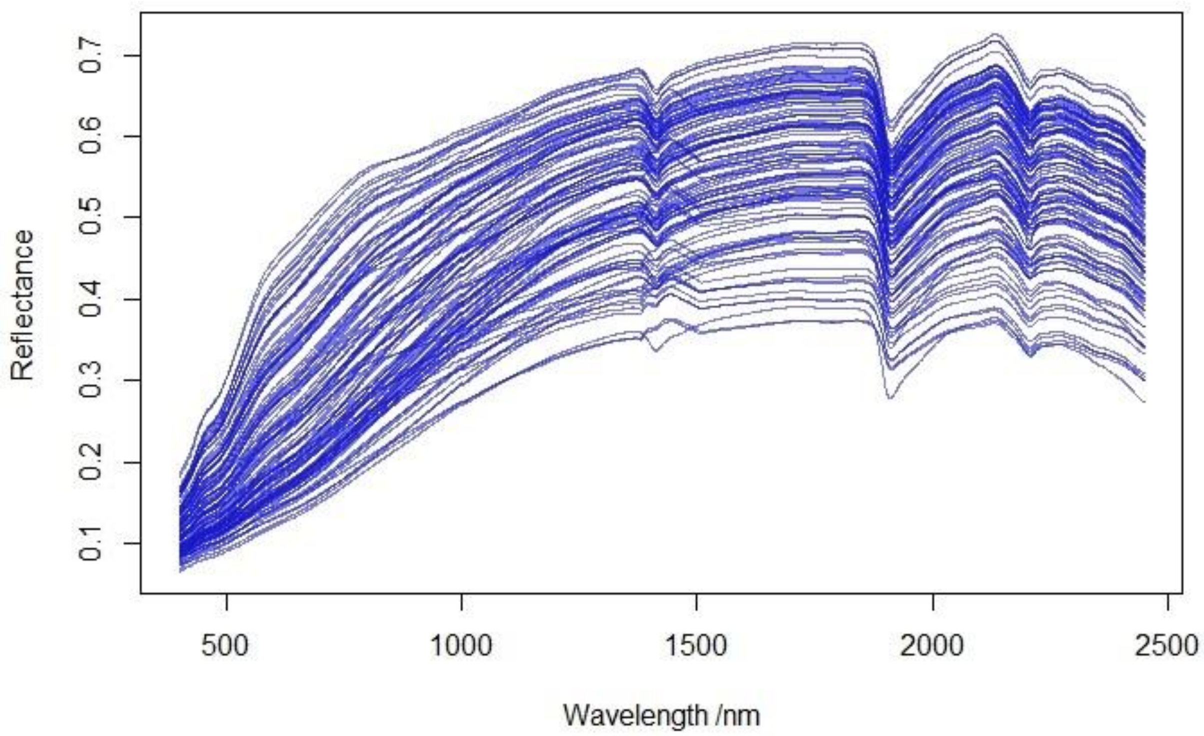


Sample reflectance spectra
(ASD FieldSpec 3, Contact Probe)

Field spectra

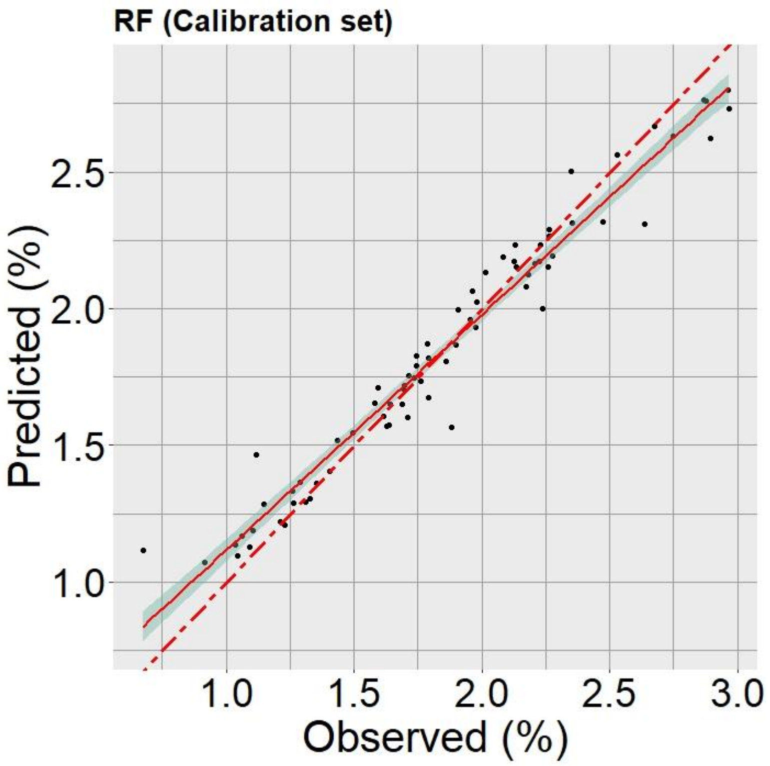


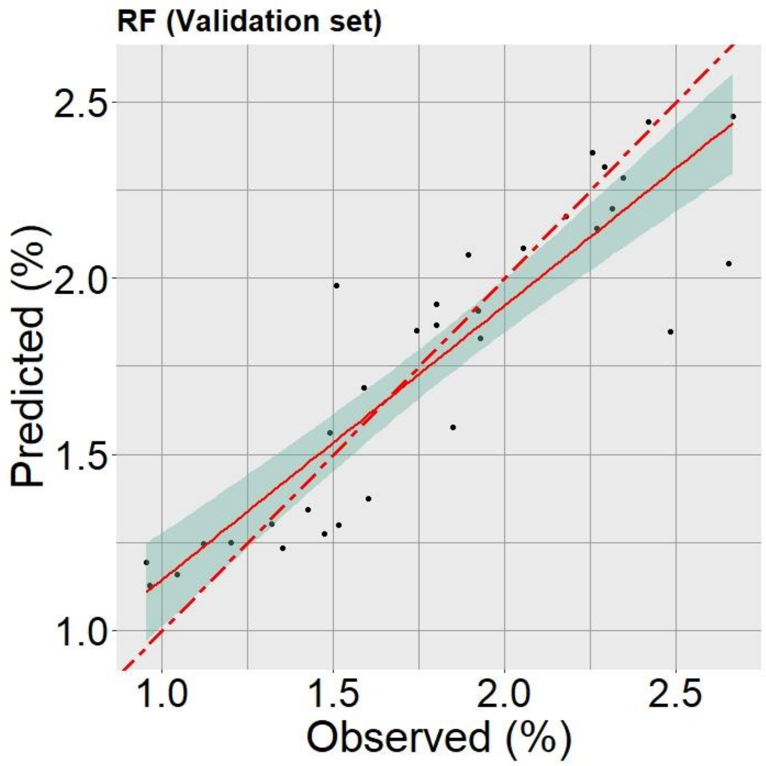
Laboratory spectra

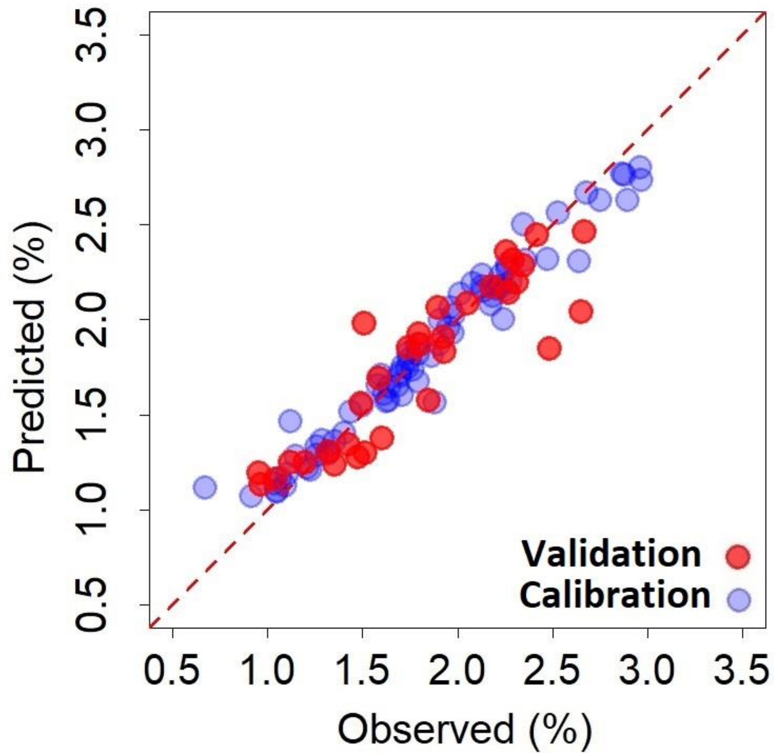


Modeling results (RF – field spectra)

Method	Dataset	ME	RMSE	R^2	LCCC	RPD	RPIQ
RF	Calibration	0	0.12	0.95	0.97	4.47	6.63
	Validation	-0.03	0.22	0.80	0.89	2.27	3.65







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Modeling results in brief (Validation set)

Algorithm	Lab spectra	Field spectra
PLSR	R^2 = 0.80, RMSE = 0.22	R^2 = 0.75, RMSE = 0.24
RF	R^2 = 0.88, RMSE = 0.17	R^2 = 0.80, RMSE = 0.22
SVR	R^2 = 0.74, RMSE = 0.29	R^2 = 0.73, RMSE = 0.25

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Thanks to all contributors
Thank you for your attention

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