Food and Agriculture Organization of the United Nations

18th Working Session of the Intergovernmental Technical Panel on Soils (ITPS)

21-23 March 2023
Fao Headquarters
Rome, Italy

Updates from the Global Soil Laboratory Network (GLOSOLAN)

Ms. Nopmanee Suvannang

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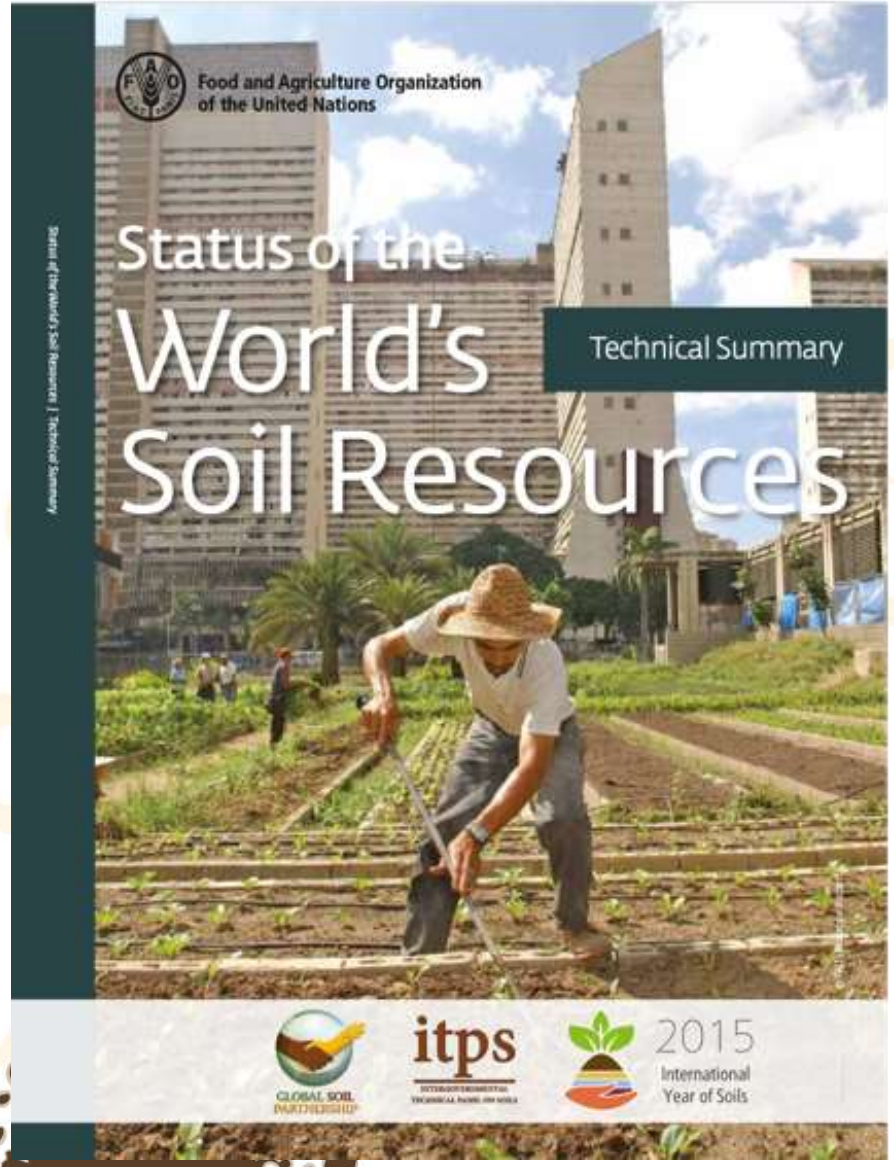
GLOBAL SOIL PARTNERSHIP



2015

The way forward

More specifically, the ITPS draws attention to the priorities outlined in the plans of action for the Pillars of the Global Soil Partnership.[51]

These are key steps towards:

- **a dramatic improvement in our observation and forecasting systems** for determining when and where soil function is being compromised (Pillars 4 and 5);
- **implementation of sustainable soil management** across large regions with urgent priority being given to regions where livelihoods are vulnerable and heavily dependent on subsistence agriculture (Pillars 1, 2 and 3);
- **improved governance** and the **development** of more effective institutional arrangements for the implementation of sustainable soil management (starting with the preparation of voluntary guidelines) (Pillars 1 and 2);
- **mobilization of resources and the training** of a new generation of soil specialists (Pillars 1 to 4).

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2015 => Pillar 5: "**harmonisation and standardisation**"

For relevant assessment of soil resources, priority on the implementation of standards and norms is suggested.

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Nov. 2017

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GLOBAL SOIL LABORATORY NETWORK

2015 => Pillar 5: "harmonisation and standardisation"

For relevant assessment of soil resources ITPS suggested to put priority on the implementation of standards and norms.

Nov. 2017

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General goal: **for a given soil sample, every laboratories should provide the same analytical results (within the range of uncertainty).**

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2017

GLOSOLAN

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To reach this goal, different objectives:

(1) build a set of agreed harmonised and standardised procedures,

(2) transfer knowledge and build capacities in laboratories which need it,

(3) improve data quality by dissemination QA/QC procedures.

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STEP 1: increase the knowledge concerning the world laboratories

No information existed about the characteristics of the soil laboratories in the different regions of the world

Feb/March 2018

GLOSOLAN made the first worldwide assessment (on-line)

The questionnaire was viewed > 700 times (in 2 months), demonstrating that a large worldwide interest appeared very quickly for the GLOSOLAN initiative.

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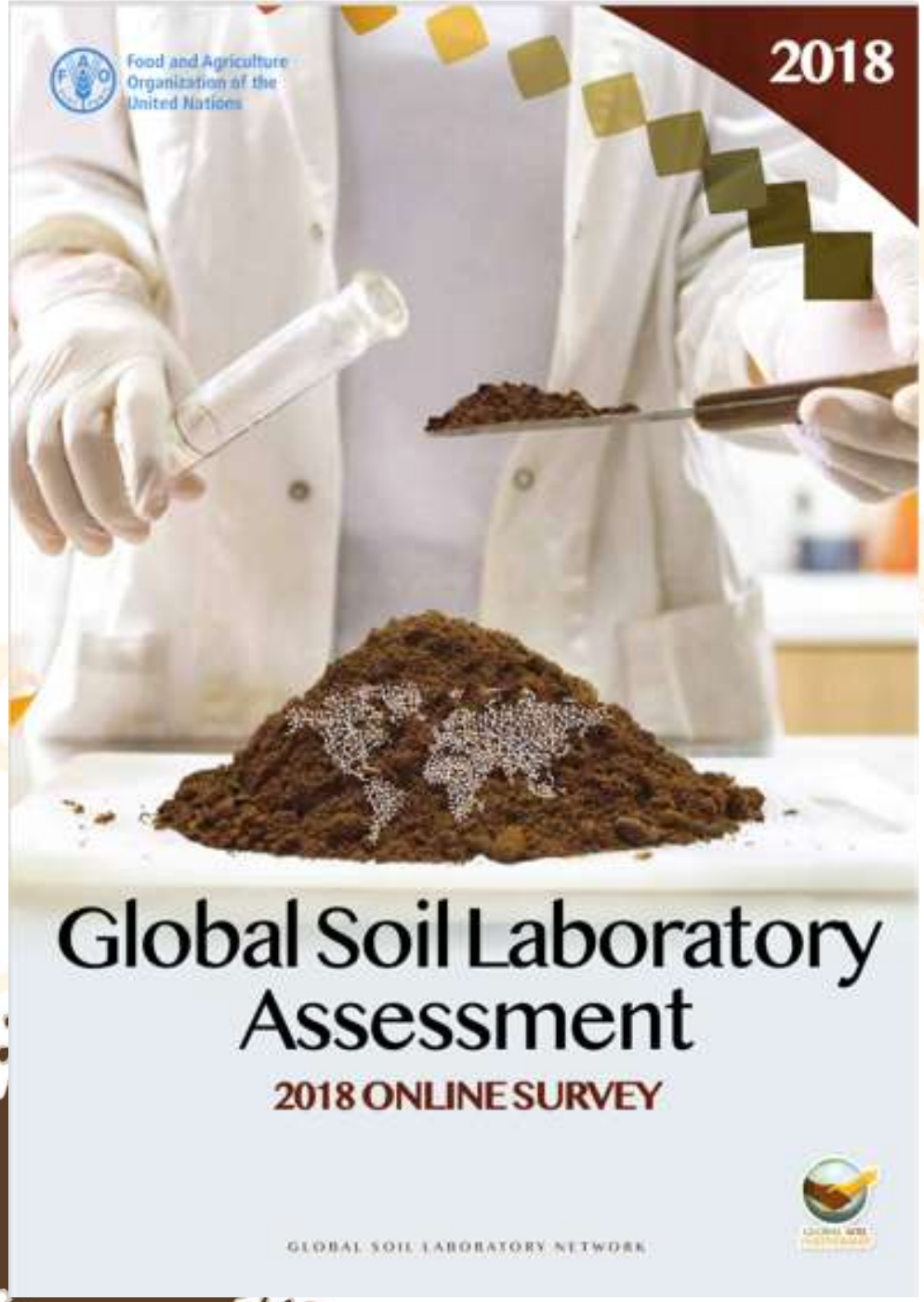

111 completed questionnaires

Key findings

Equipment

- Appropriate facilities in most ca

Staff

- Formal educat highly between regions.
- Turnov high => low retention of experienced staff
- Absen of regular trainings

capacity building is needed

Methods and proce

- Limited number of m
- High number res for a given method (difficulties for comparing ts at the global, regional level, even between laboratories located in a single country)

standardisation is poor

Quality control and qual rance (QA/QC)

- Apparantly implemented i ty of laboratories but... the frequency of t is too low to guarantee data

interlab. comparisons are needed

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Methods and procedures:

A low number of METHODS:

pH in suspension in water or KCl
EC in suspension in water
C by sulfochromique oxydation (Walkley & Black) or dry combustion (Dumas)
N by Kjeldahl or dry combustion
P by Olsen, Bray1 or Mehlich methods
CEC in NH_4 acetate
Texture by pipette or hydrometer

But for each methods, different PROCEDURES; example of pH

soil:water ratio
duration/type of shaking
resting time
measuring depth etc...

Harmonized Standard Operating Procedures (SOPs) are needed

Priorities for SOPs ?

Top 5 analyses:

pH
EC
Total N
Texture
Organic C

Number of laboratories

Parameter	Number of laboratories
pH in H_2O	88
Electrical conductivity (EC)	83
Total nitrogen	81
Texture analysis	80
Organic carbon	78
Organic matter	72
Micro elements	67
N-NO3 and N-NH4	63
pH in KCl	61
Trace elements	60

Number of analyses

Parameter	Number of analysis
Avaliable P_other	335 480
Organic matter	272 927
pH in H_2O	239 293
pH in KCl	224 857
Exch. K – NH40-Ac	221 608
Exchangeable acidity	214 755
Organic carbon	189 948
Texture analysis	180 213
Micro elements	174 230
Electrical conductivity (EC)	160 600

avail. P
Organic matter
pH H_2O
pH KCl
Exch. K

STEP 1: increase the knowledge concerning the world laboratories

STEP 2: produce the Harmonized GLOSOLAN SOPs

to have all laboratories analysing samples in the same way

SOPs were decided through a consensus between the lab managers, including small/poor countries generally excluded from decision making

=> high probability to be largely adopted

>100 authors from 60 countries representing all regions participated to the 'Walkley & Black' SOP

Already published:	**20**	**(+ 18 ongoing)**
• sample pre-treatment:	1	
• chemical parameters:	17	(+7 ongoing)
• physical parameterss:	1	(+5 ongoing)
• biological parameters:	1	(+6 ongoing)

open access

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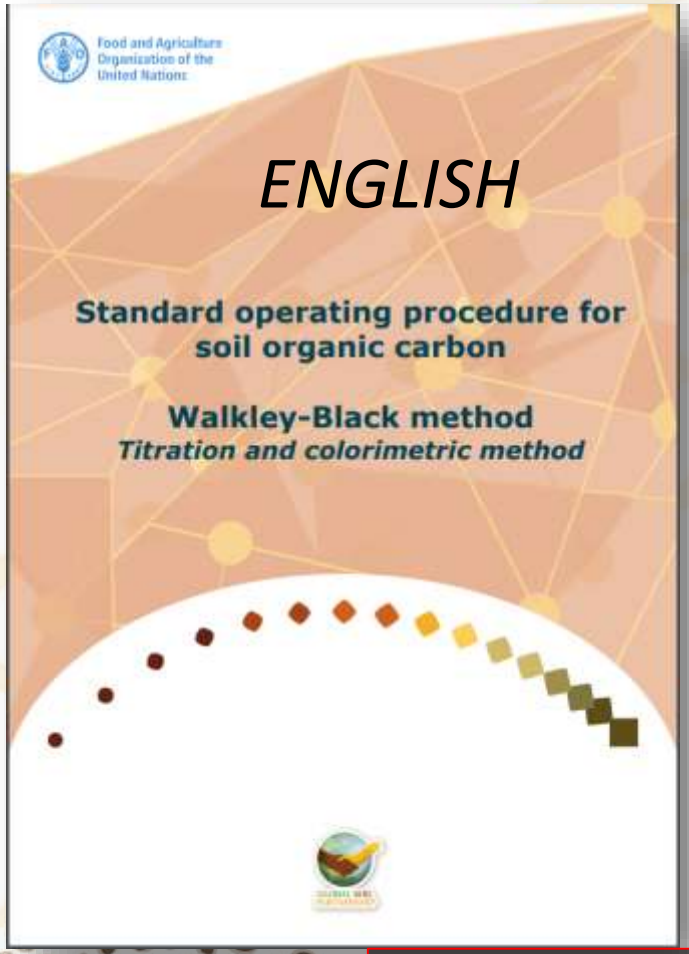
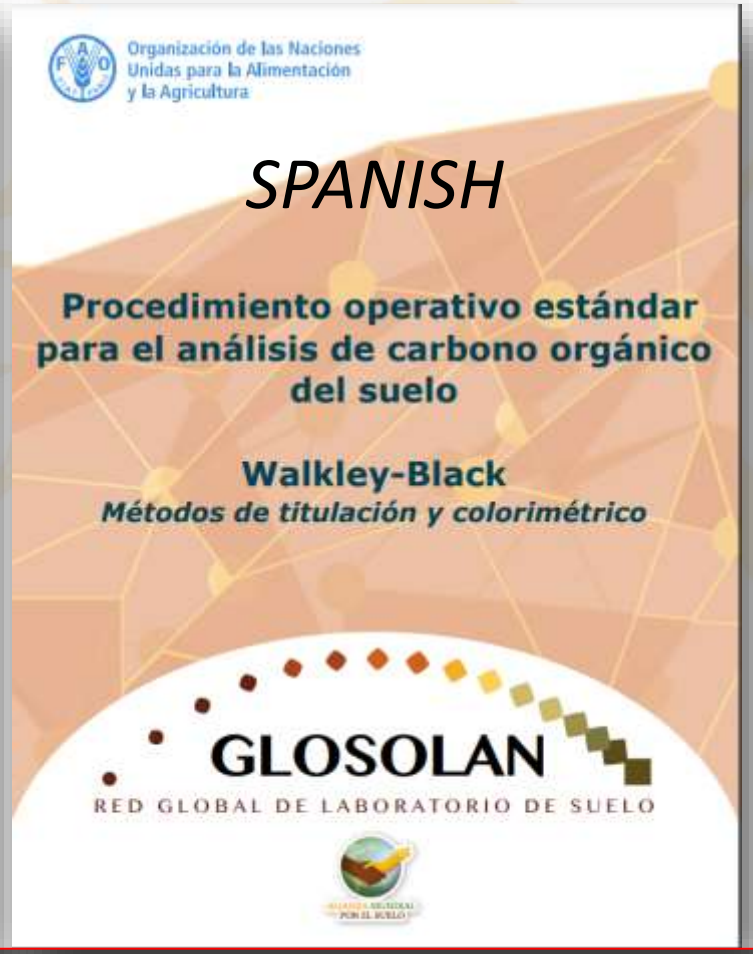
SOPS are available in multiple languages





etc...

open access

Increased partnership, increased visibility & worldwide accessibility

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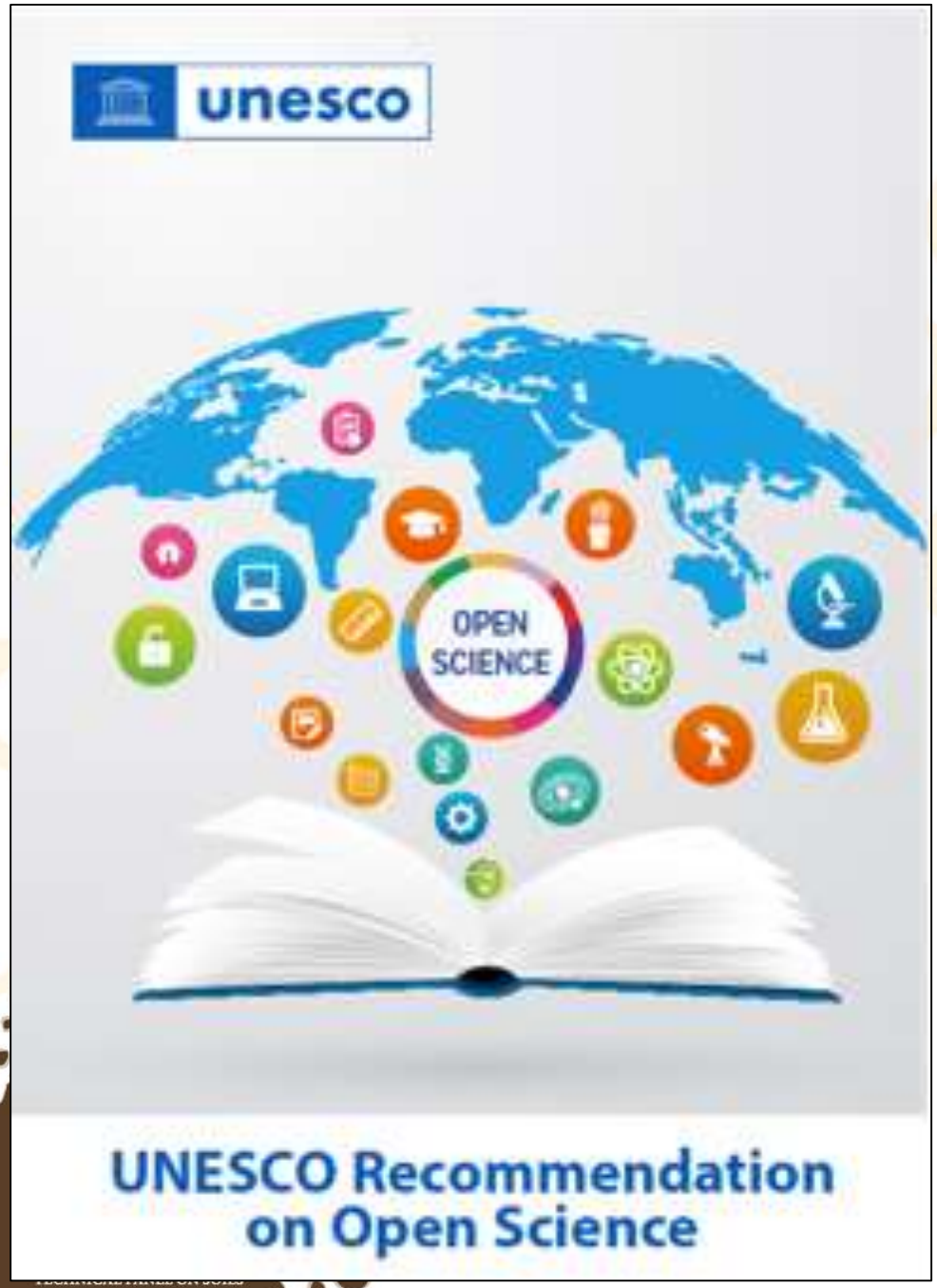
Inclusive: all GLOSOLAN members could join

Translated in UN languages + local languages

Open access on FAO website

(Brazil student and Lao technician can use the same SOPs)



GLOSOLAN SOPs are : fitting with UNESCO recommendation on open science (2022)

sharing information for the benefits of science and society

opens the processes of scientific knowledge creation beyond the traditional scientific community

makes multilingual scientic knowledge available, accessible and reusable for everyone

STEP 1: increase the knowledge concerning the world laboratories

STEP 2: produce the GLOSOLAN standard operating procedures (SOPs)

STEP 3: disseminate GLOSOLAN (SOPs) & facilitate their implementation + build capacity & transfer knowledge

Written SOPs and documents are not sufficient: to avoid misinterpretation and allow users to interact with other GLOSOLAN members

- **free access webinars were organised in different languages**

(about the SOPs + internal quality control, health and safety, etc..)

- **videos were produced showing step by step how to do some analyses**

- **trainings were organised on several subjects**

(training also provided for JICA on their requested)

*2019: **171** participants from **79** countries attended the trainings*
*2020: **746** participants from **107** countries attended the trainings*

Thanks to all trainers!!!

24 trainers from 16 different countries (6 regions)

STEP 1: increase the knowledge concerning the world laboratories

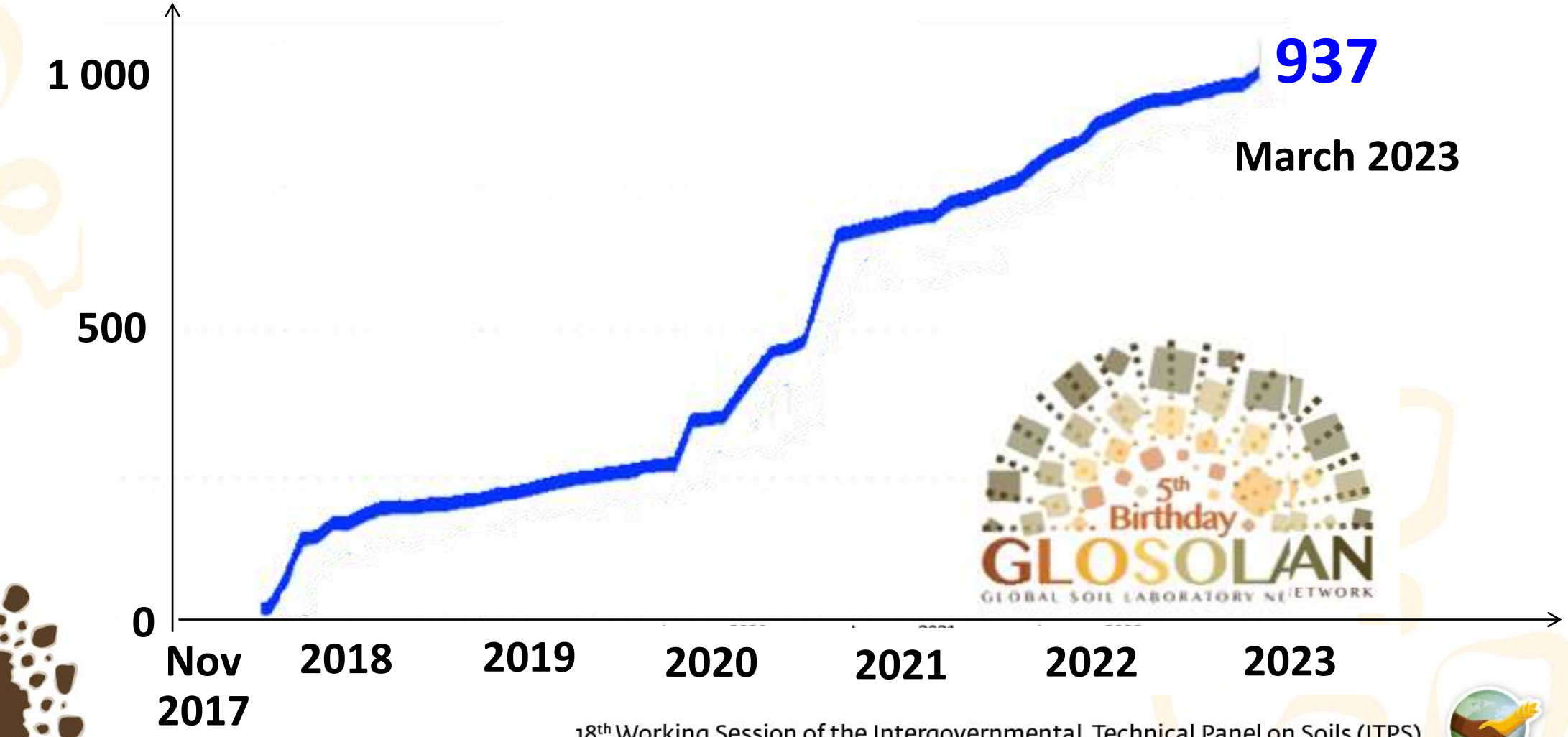
STEP 2: produce the GLOSOLAN standard operating procedures (SOPs)

STEP 3: disseminate GLOSOLAN **(SOPs) + capacity building & knowledge transfer**

These activities were a lot of effort and a lot of time dedicated by many volunteers and experts worldwide

Have these efforts been successful?

VERY SUCCESSFUL



Members are coming from all regions

North America	LATSOLAN (Latin Am. & Carabean)	AFRILAB	NENALAB (Near East & North Afr.)	EUROSOLAN	SEALNET (Asia)	PACIFIC
17	223	172	101	217	130	77

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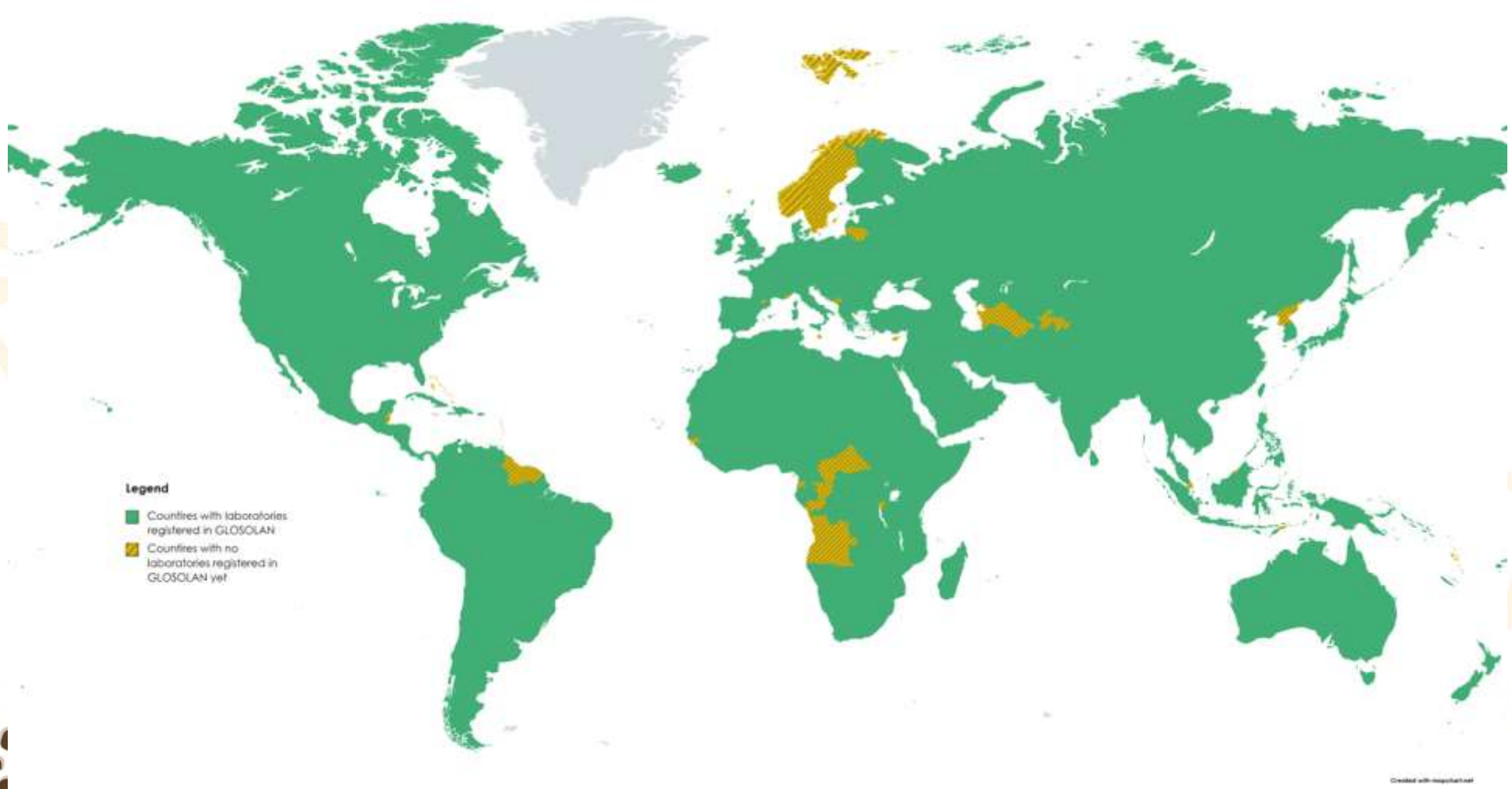
> 150 countries ≈ 80 % of UN countries



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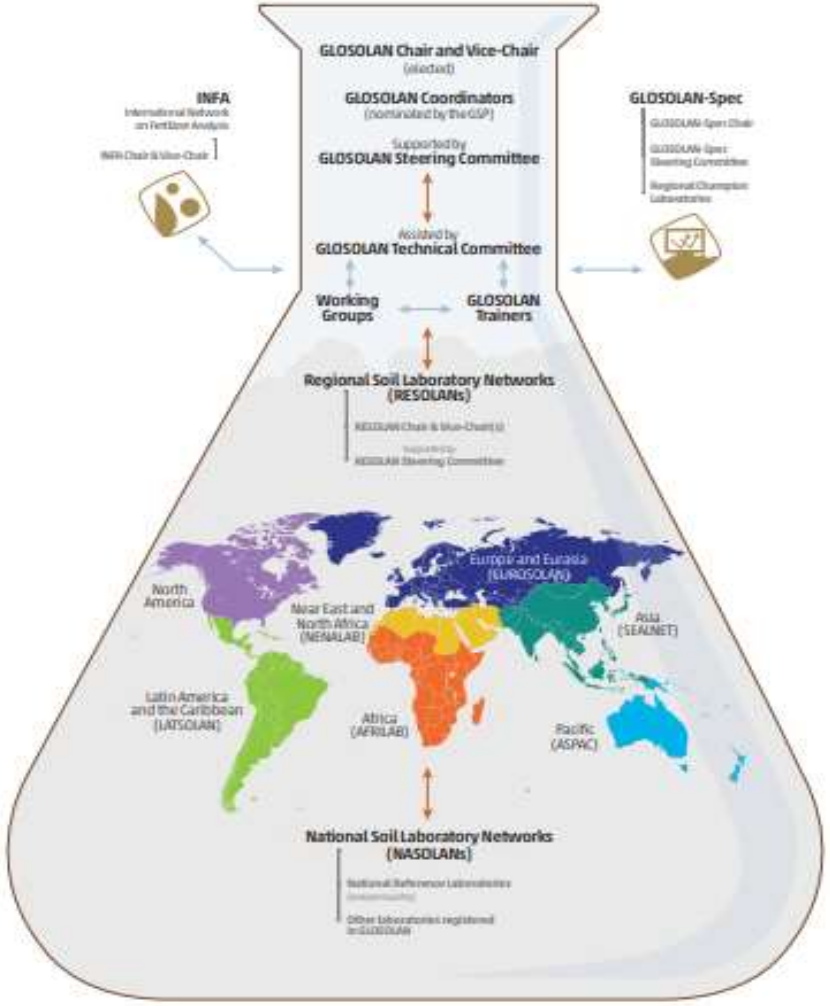
GLOSOLAN fast growth demonstrates this network fulfilled a need

Routine and research labs have a high interest in GLOSOLAN because:

1. **In a global world, labs cannot remain isolated, labs need to be involved in networks to get information on methods, techniques, etc**

2. **GLOSOLAN, that is open access and inclusive, represents an opportunity to get support from a global community, without paying high cost to private companies.**

GLOSOLAN operate at all levels



GLOBAL

REGIONAL

NATIONAL

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All these GLOSOLAN activities have the final goal of

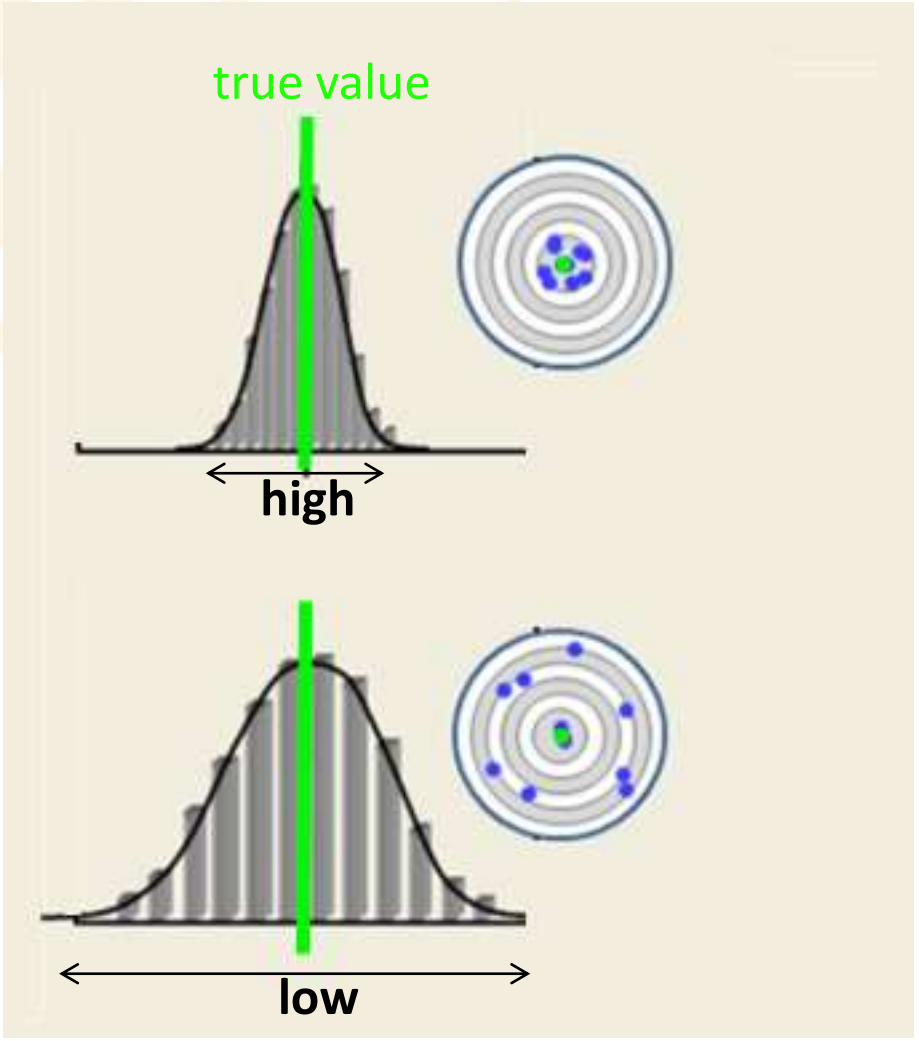
improving the quality of the soil data,

i.e. precision and accuracy.

Proficiency:

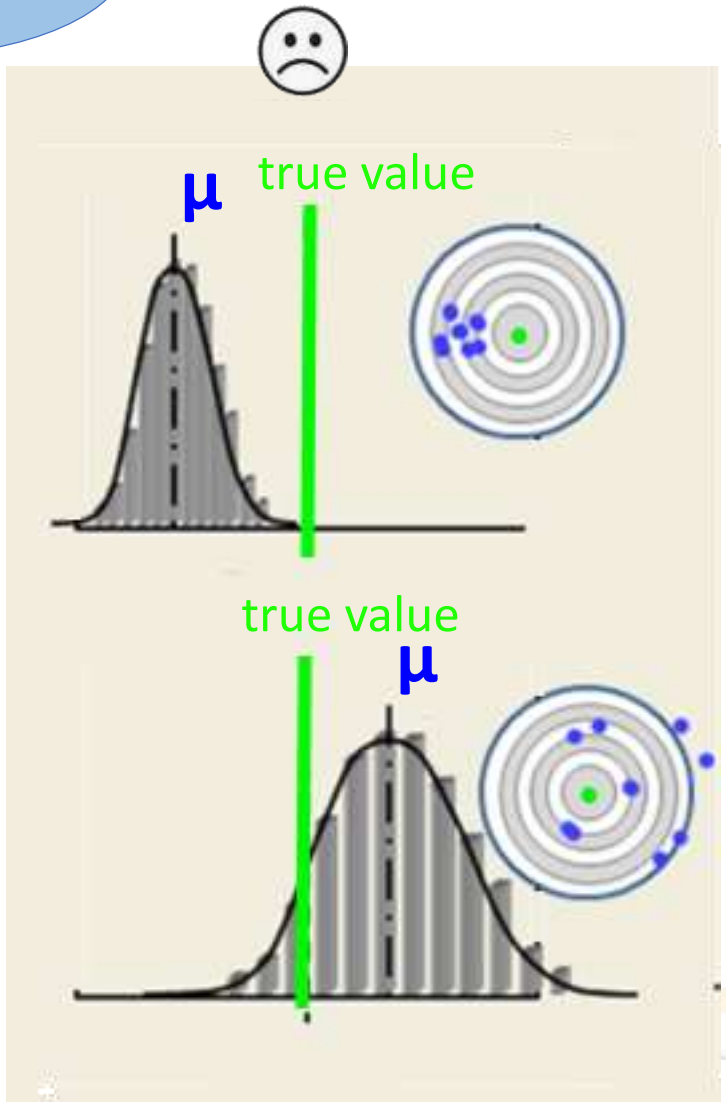
Precision

(dispersion of the replicates)



Proficiency:

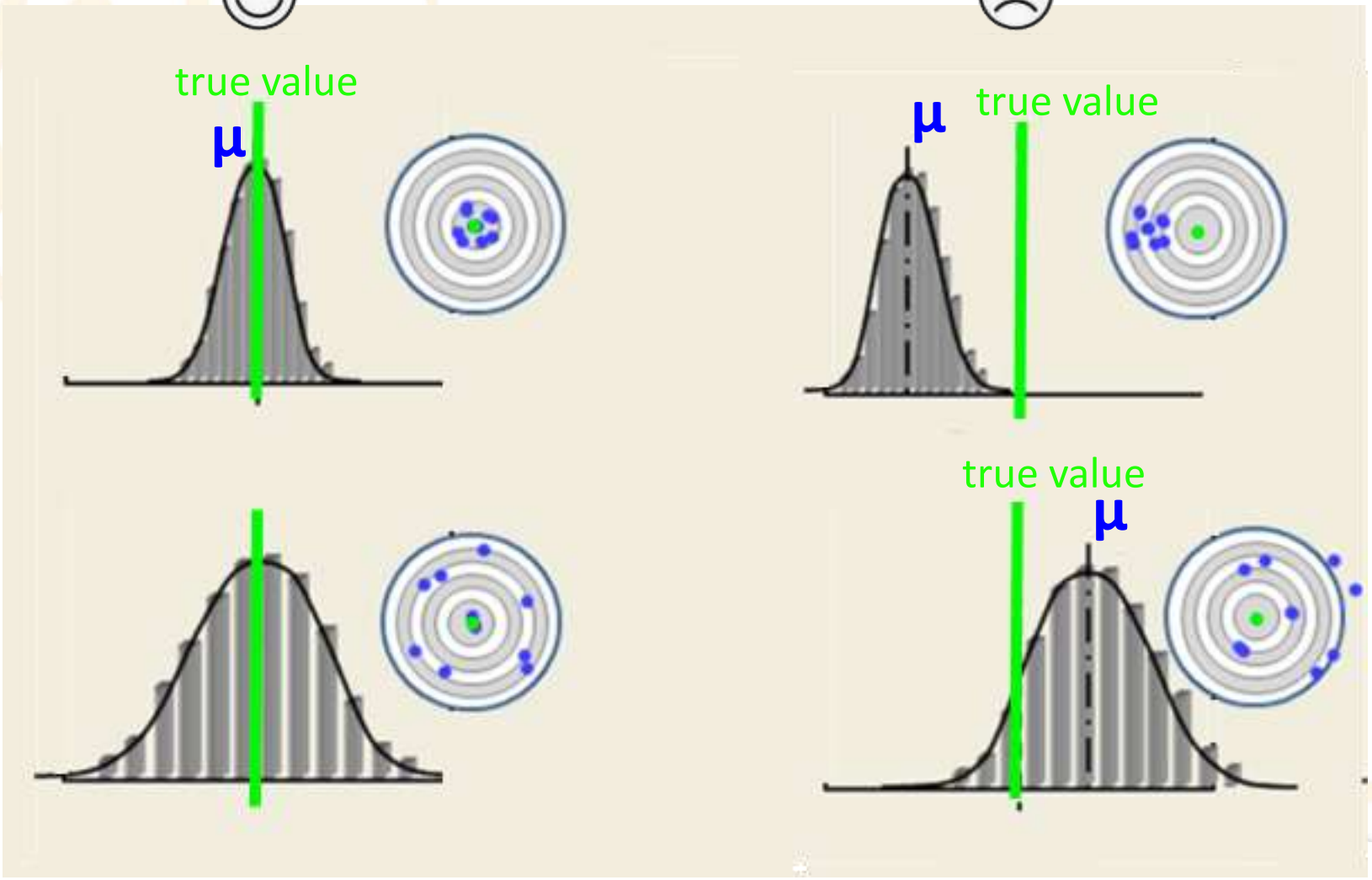
Accuracy (proximity with the 'true' value)



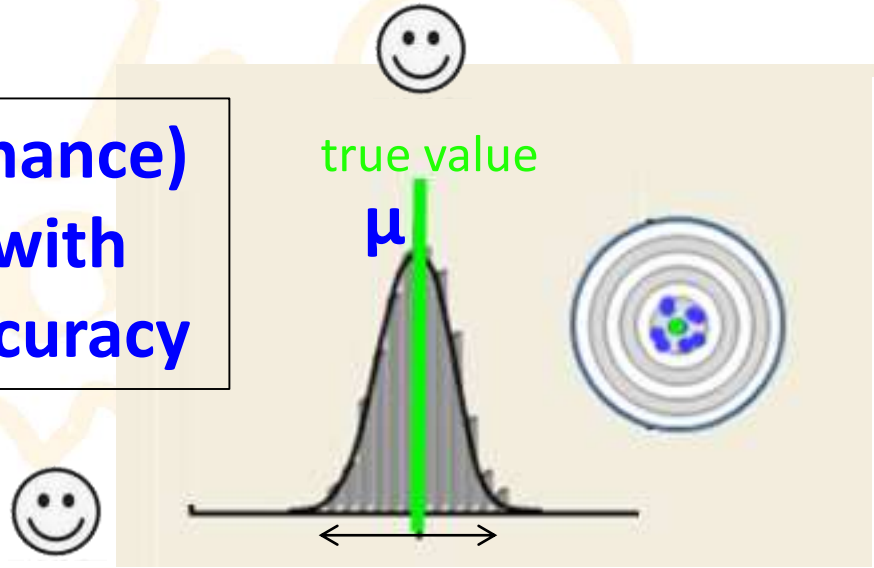
Different combinations:

Accuracy

Precision



Good (high performance) lab provide data with high precision & accuracy



such ‘good’ data is necessary for relevant conclusions/decisions

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GLOSOLAN wanted to evaluate & monitor the soil lab proficiency

(i.e. quality of the data)

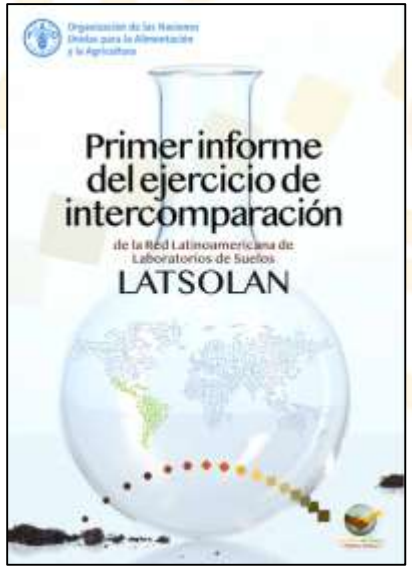
through inter-laboratory comparison

or 'PT' (proficiency testing)

Proficiency testing: GLOSOLAN PT

- **2018: 32 labs in 2 Regions (6 soils)**
- **2019: 85 labs in 66 countries (4 soils)**
- **2020: --------**
- **2021: --------**
- **2022: 220 labs in 110 countries (6 soils)**

Asia



Latin America

Many parameters were tested

Table 1. Agreed method endorsed during the first meeting of laboratories' managers in Bogor (Indonesia) in 2017 (* agreed method that was recommended).

Soil testing parameter	Method	Noted	Unit
pH in water	1:2.5	Adjust the soil :water to 1:2.5 and follow your regular SOP	NA
OC	Walkley & Black*	Follow your regular SOP and report which method that you have used	percent
	Dry combustion		
Avail P	Olsen P*	Follow your regular SOP and report which method that you have used	mg/kg
	Bray 1 P		
	Bray 2 P		
Exch K	NH_4OAc*	Used your regular SOP	mg/kg or cmolc/kg

Table 3.1. The list of the 14 parameters the participants had to analyze.

Soil parameters to analyze	code	Unit
pH (1:2.5 soil:water suspension)	pH	-
Organic carbon (Walkley & Black method)	OC_WB	%
Total carbon (dry combustion)	OC_COMB	%
Nitrogen (Kjeldahl method)	N Kjel	%
Nitrogen (dry combustion, Dumas method)	N Dum	%
Available phosphorous (Olsen method)	P_Olsen	mg kg^{-1}
Available phosphorous (Bray 1 method)	P_Bray.1	mg kg^{-1}
Available phosphorous (Bray 2 method)	P_Bray.2	mg kg^{-1}
Exchangeable K^+ in ammonium acetate	K_exch	cmol(+) kg^{-1}
Exchangeable Ca^{++} in ammonium acetate	Ca_exch	cmol(+) kg^{-1}
Exchangeable Na^+ in ammonium acetate	Na_exch	cmol(+) kg^{-1}
Exchangeable Mg^{++} in ammonium acetate	Mg_exch	cmol(+) kg^{-1}
Electrical conduct. (1:5 soil:water suspension)	EC	dS m^{-1}
Inorganic carbon (Bernard calcimeter)	C_Min	% $CaCO_3$ equivalent

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All PTs included carbon measurement

Different methods:

- Walkley & Black (sulfochromic oxidation)
- Dumas (dry combustion)
- LOI (loss of ignition)

Focus on carbon because:

1. it is a **global main issue** that encompasses soil science
2. it is a criteria for **assessment of sustainable soil management**

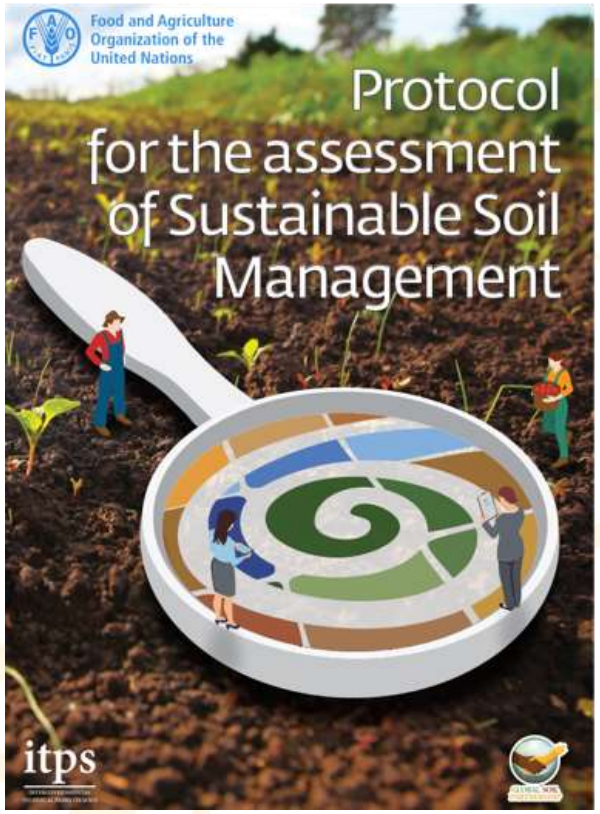

Table 1. Recommended indicators that can be monitored to assess Sustainable Soil Management [1]

Indicator	Parameter/ metric	Measurement methods[2]	Sample characteristics[3]
Soil productivity	Agricultural productivity or biomass in dry matter (t ha^{-1} year^{-1})	Dry weight of vegetation quadrats, or yield measurements	Quadrat method or yield measurement
Soil organic carbon	Organic carbon (%)	Walkley- Black method or Dumas method	Representative soil sample
Soil physical properties	Bulk density (kg dm^{-3}) In some cases, bulk density can be complemented by available water capacity, or other relevant soil physical properties *(See additional indicators)*	The Core Method	Undisturbed representative sample with known volume
Soil biological activity	Soil respiration rate (gCO_2 m^{-2} d^{-1}) Ideally combined with at least one other biological indicator *(See soil biological activity p. 4 and 5)*	Laboratory based soil respiration measurement (static or dynamic) The most common methods will be presented in the annex.	Representative soil sample to be analyzed within hours or refrigerated

It is a key indicator for the assessment of sustainability

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Current commercial PTs are done several times/year on regular basis => they test:

- accuracy on each round (difference of each results from the true value)
- precision only sometimes (dispersion between replicates)

GLOSOLAN PTs depend on donors => cannot plan for several years
=> only 1 round/year could be organised

=> accuracy & precision had to be tested at the same time.

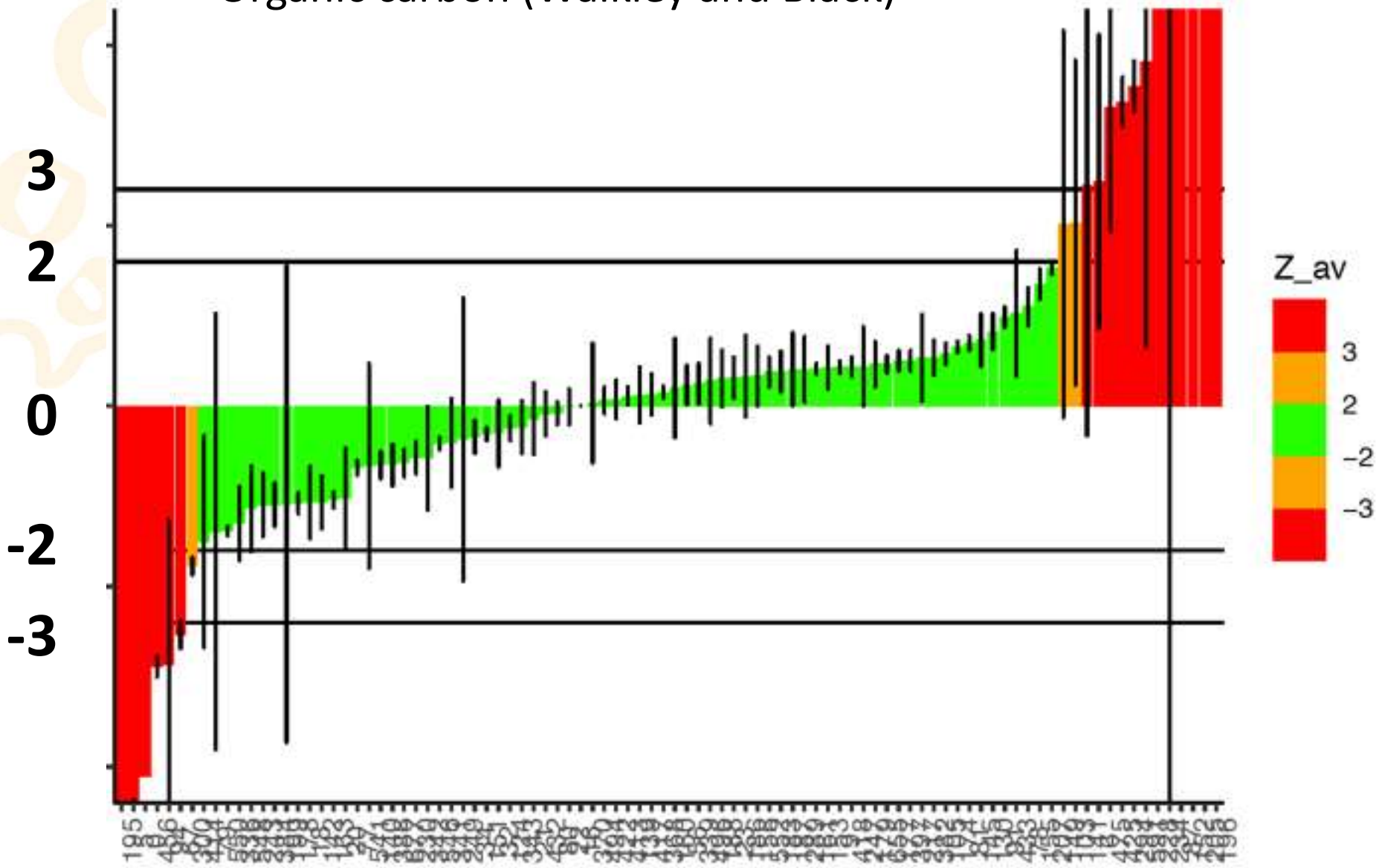
Whenever possible:

10 to 12 soil samples, including 3 to 5 blind replicates

were sent to participants

Z score

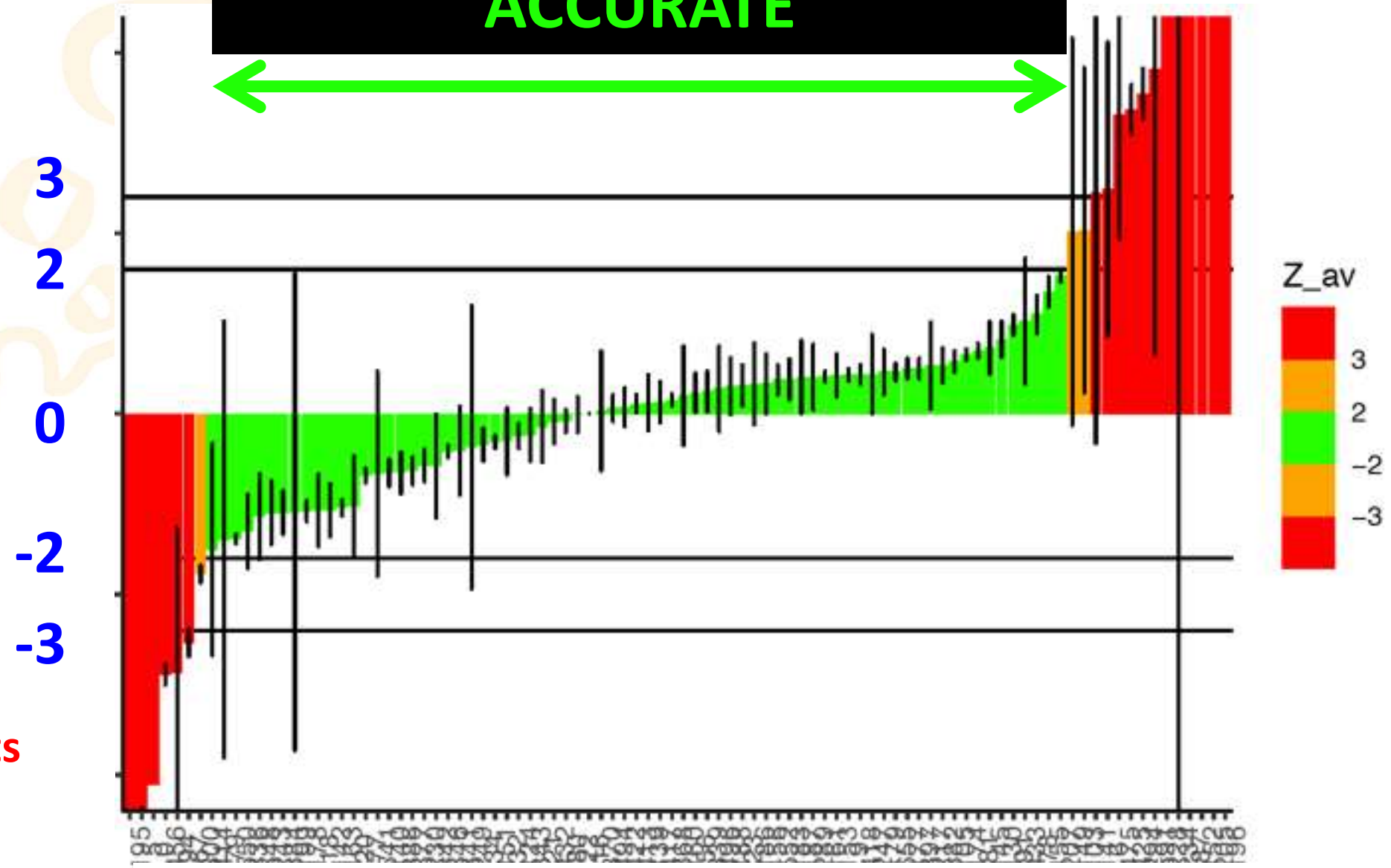
Organic carbon (Walkley and Black)



Laboratory confidential number

ACCURATE

Wrong results



Wrong results

Too many labs provide wrong results !

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ome, Italy

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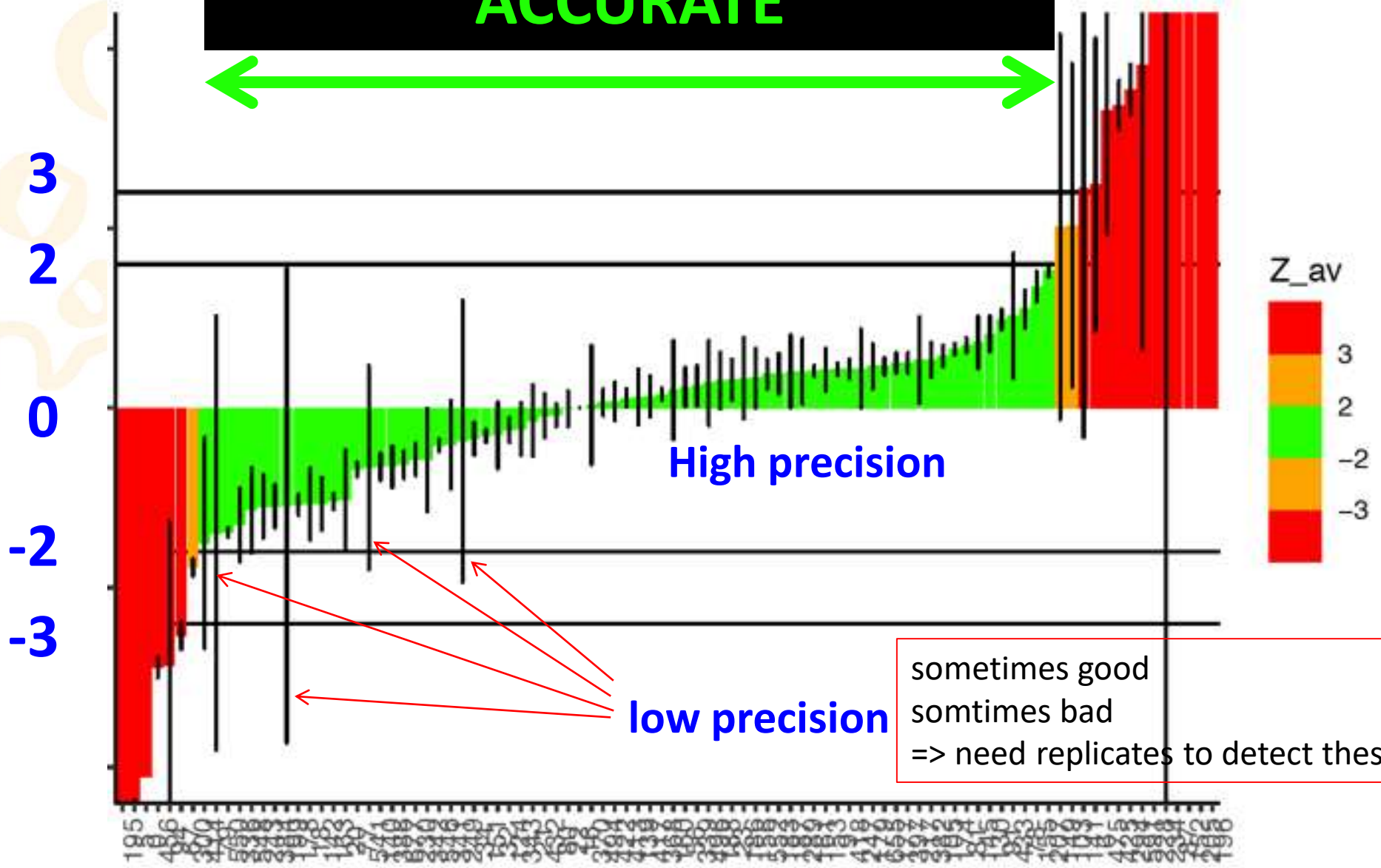
ACCURATE



sometimes good
somtimes bad
=> need replicates to detect these labs

Our PTs show that:

- only ≈ 1/2 of the labs have good accuracy and precision

- ≈ 1/4 have low precision => no efficient internal quality control

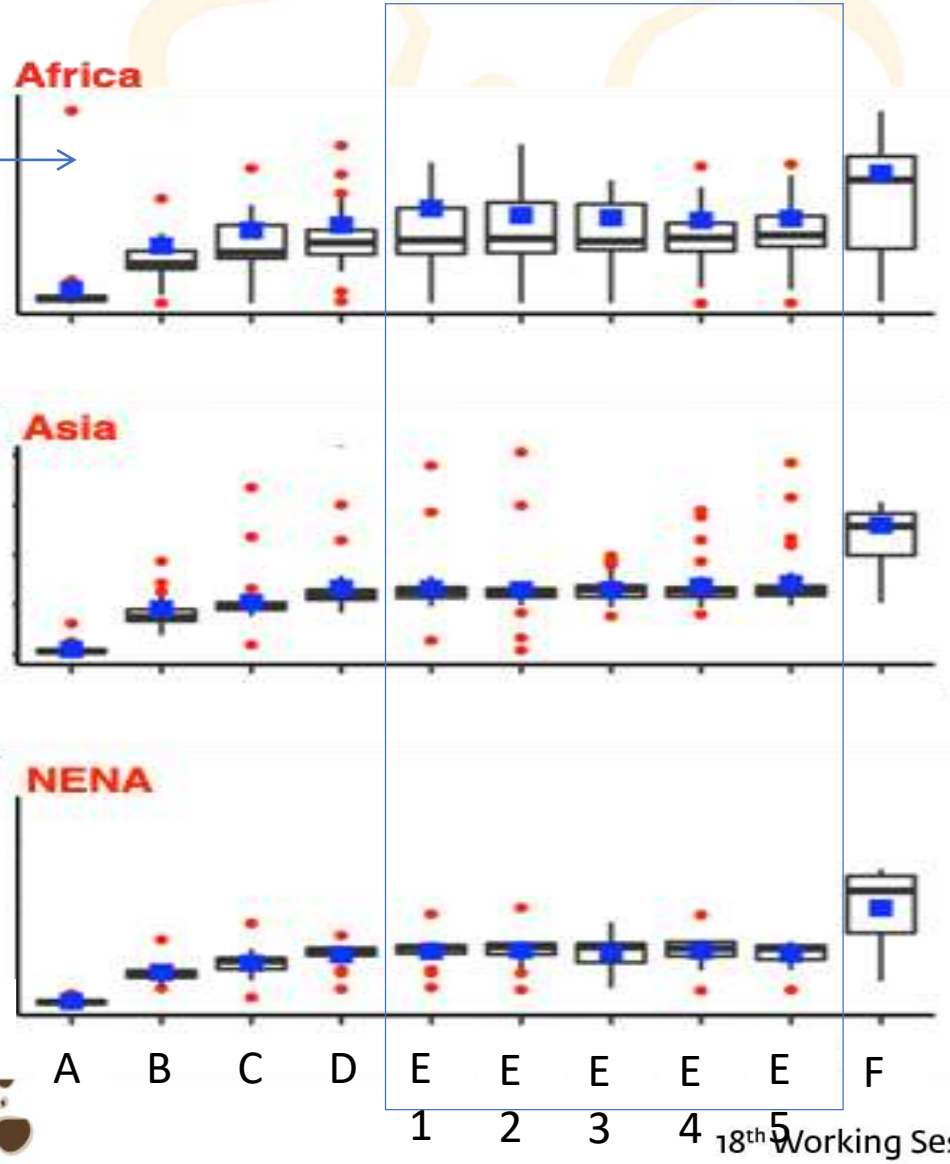
- ≈ 1/3 have low accuracy => need re-calibration (external QC)

Datasets mixing results from many laboratories will have large uncertainty and high probability of including many outliers

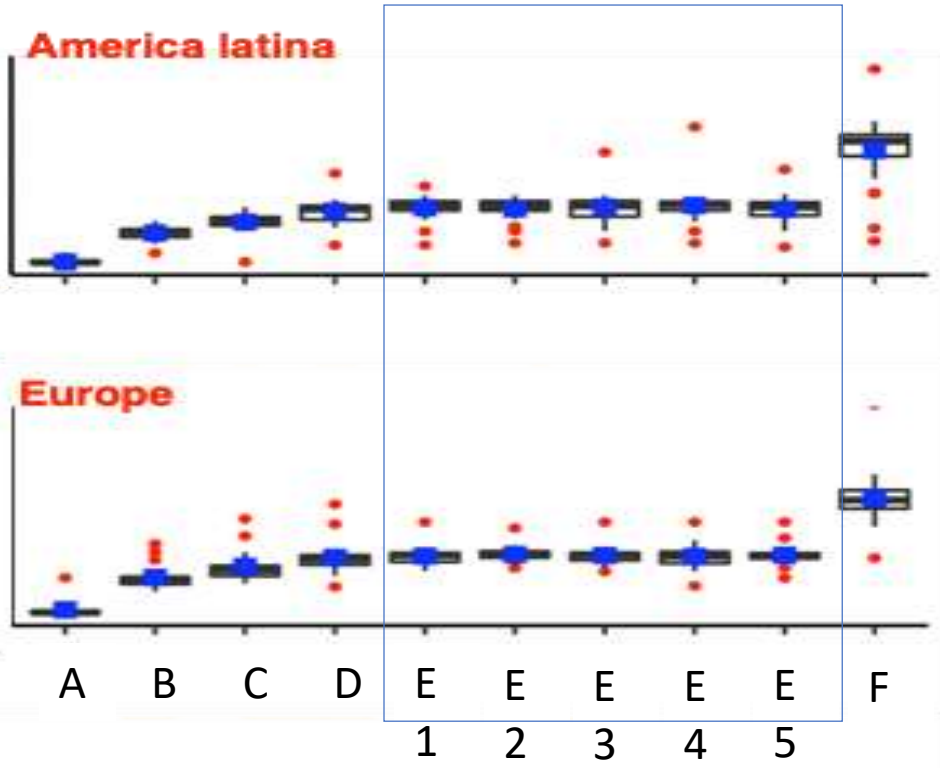
Are there regional differences?

Box plots: results provided by lab of each region (red dots = outliers)

Excessive dispersion of the results



5 replicates



Results are similar in all regions, except Africa => special effort for SOP implementation and staff training is needed.

Can automatic machines solve the problem = improve precision + avoid outliers?

we compared:

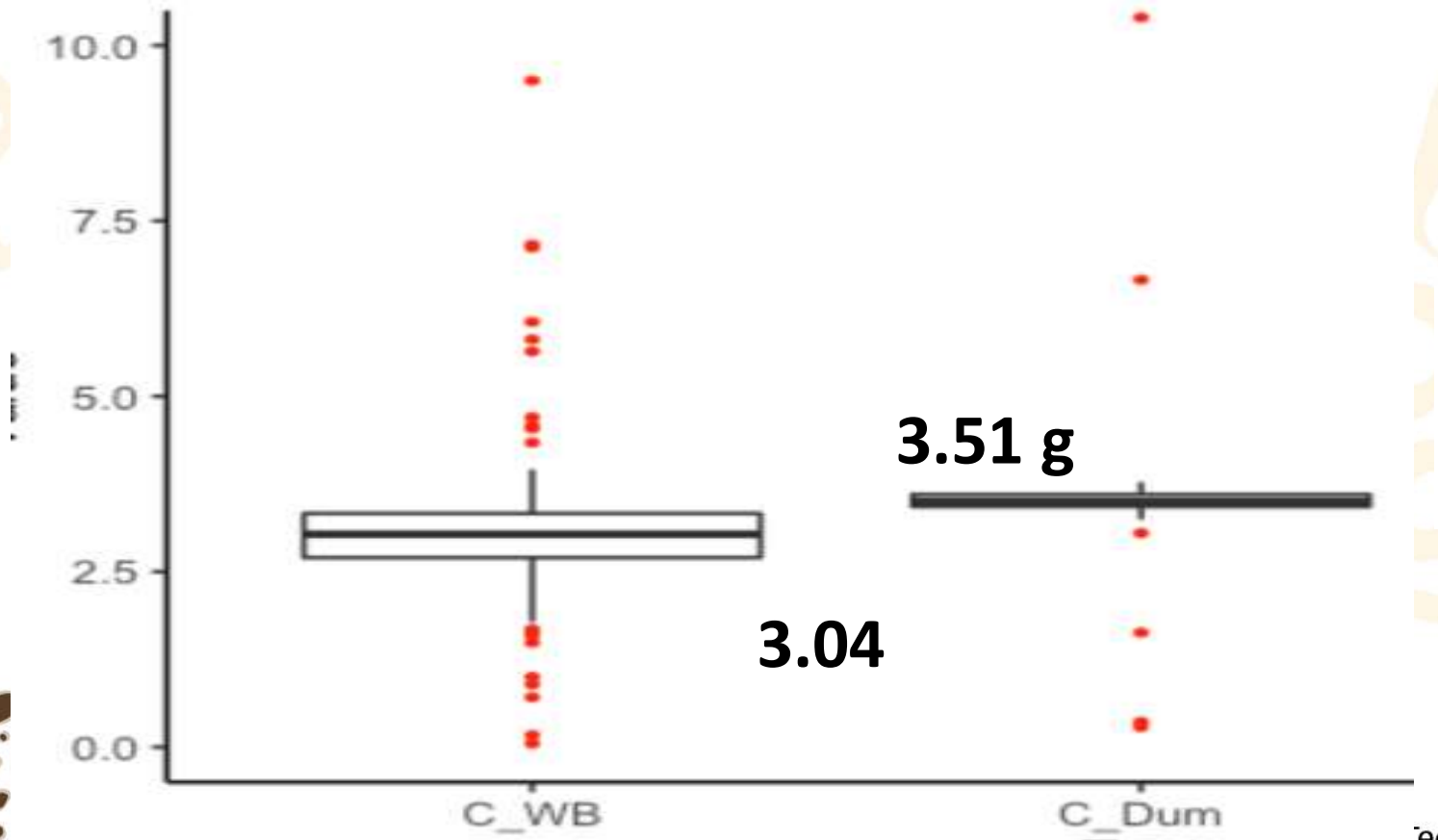
wet chemistry — mainly ‘by hand’ — C_{WB}

C_{Dum} — mainly automatic — **dry combustion**

wet chemistry

dry combustion

Carbon (g C / 100 g soil)



Lab performance is better with Dumas but few labs used it in Africa. Why? because it is too expensive

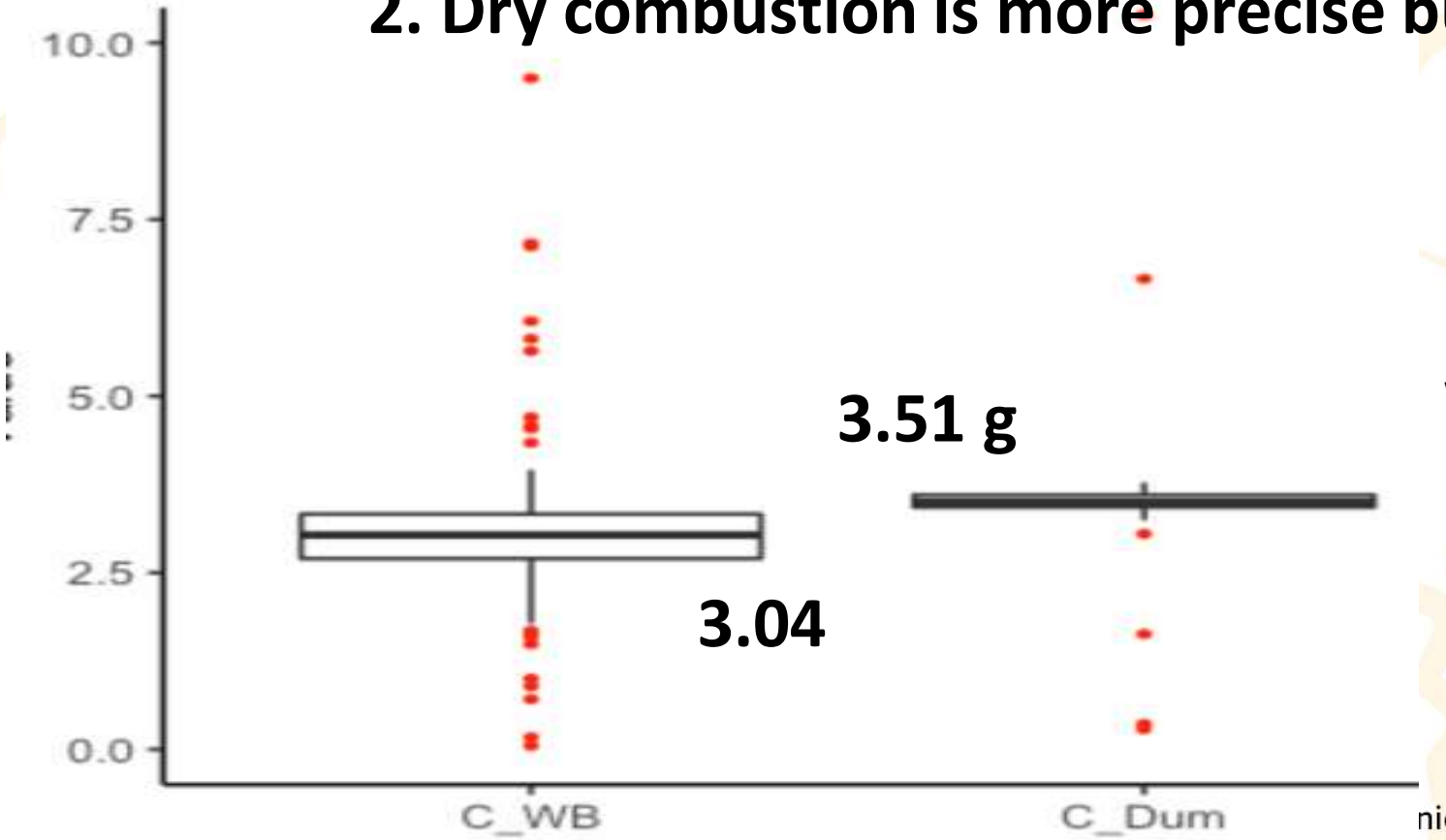
wet chemistry

dry combustion

Carbon (g C / 100 g soil)

1. Different methods => different results

2. Dry combustion is more precise but...



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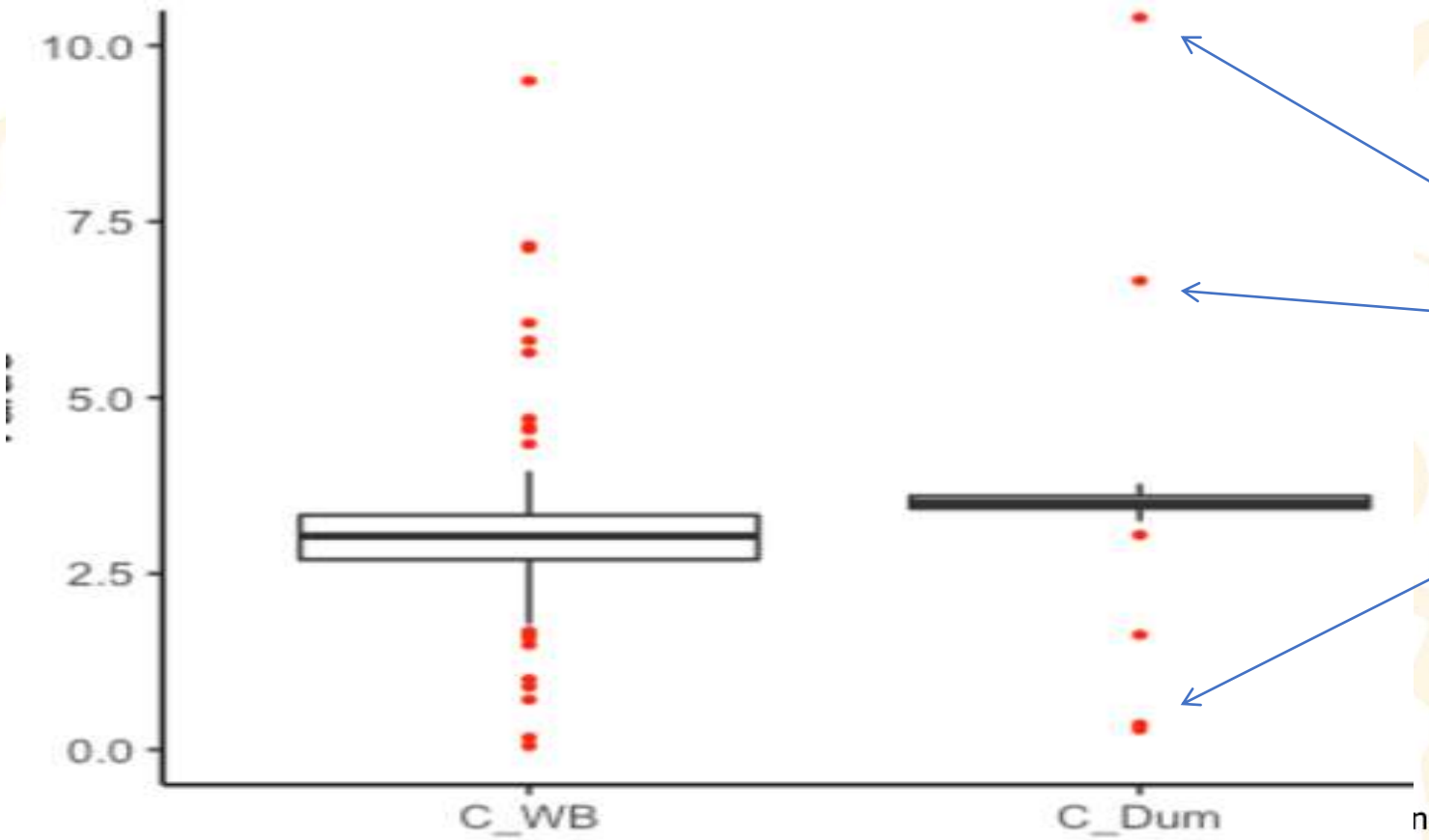
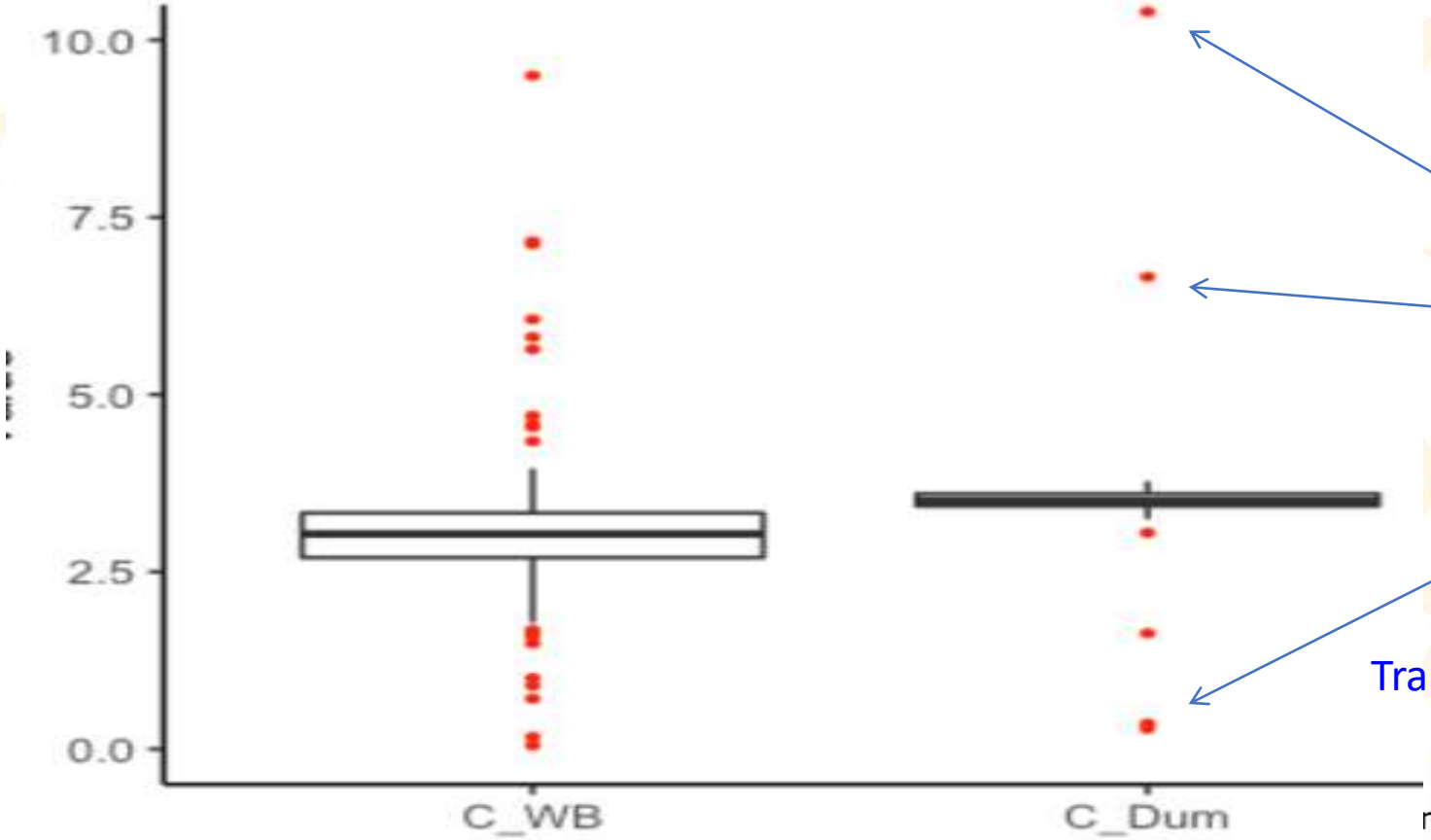


automatic techniques do not solve all problems !

Carbon
(g C / 100 g soil)

Quality control is necessary even with automatic (expensive) techniques

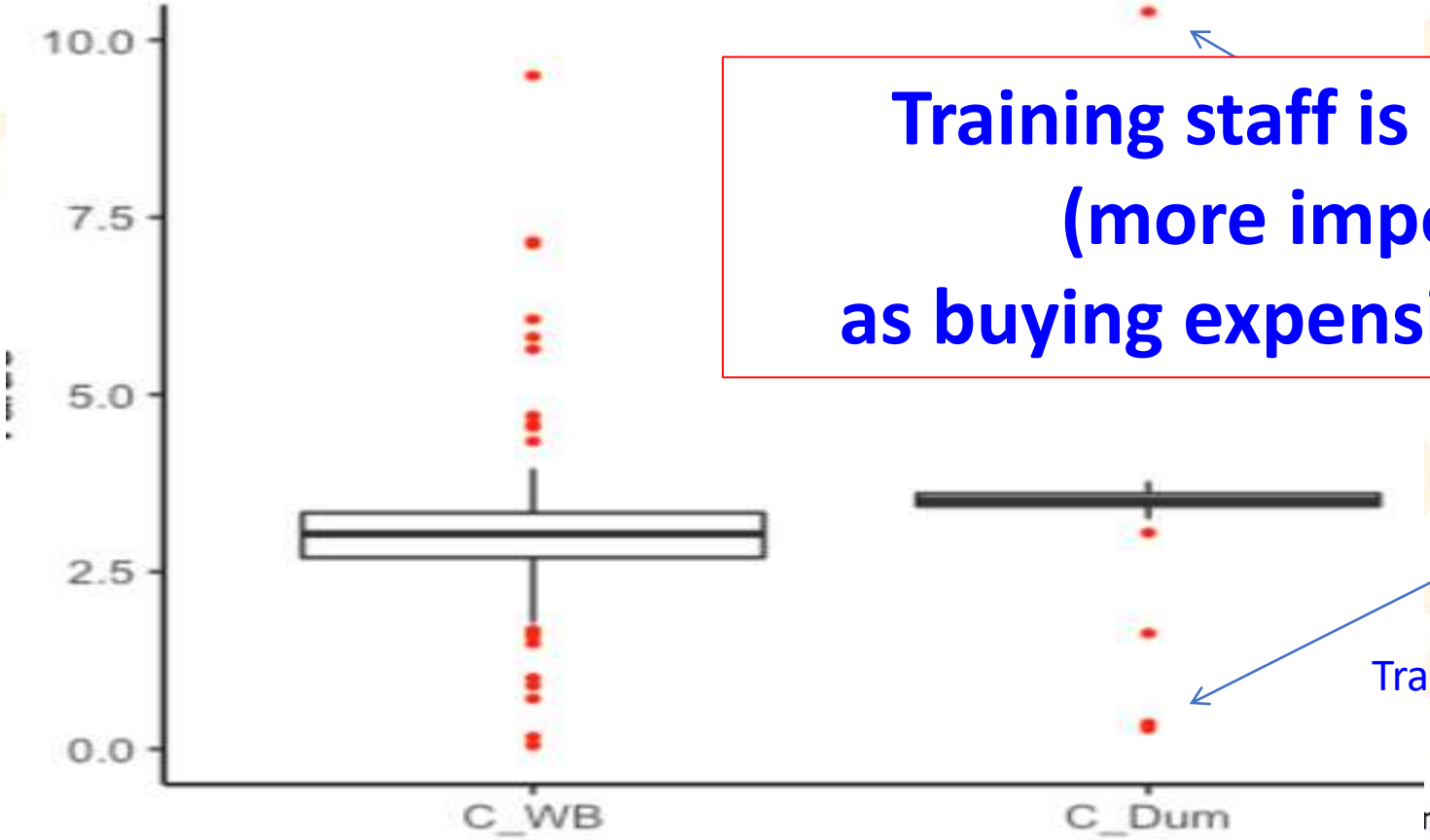


automatic techniques do not solve all the problems !

Transcription problems?

Carbon
(g C / 100 g soil)

Quality control is necessary even with automatic (expensive) techniques



Training staff is as important (more important?) as buying expensive equipment

not solve all the problems !

Transcription problems?

to make scientific conclusions/relevant recommandations, uncertainty is essential

Walkley & Black

3.04 g

+/- 1.0 g

Dumas

3.51 g

+/- 0.3

95% of the labs will provide results between

2 and 4 g

3.2 and 3.8 g

uncertainty is currently too large
to detect changes in soil carbon content

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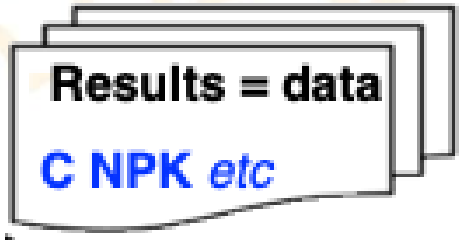
Soil data are used for decision and/or action

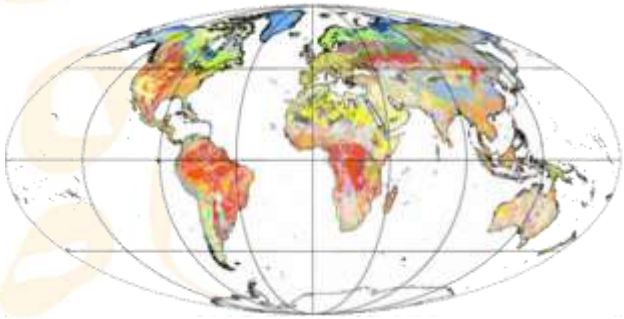
but changes have occurred during the last decades



Data

Traditionally (use locally)

- **Fertilisation**
- **Classification**



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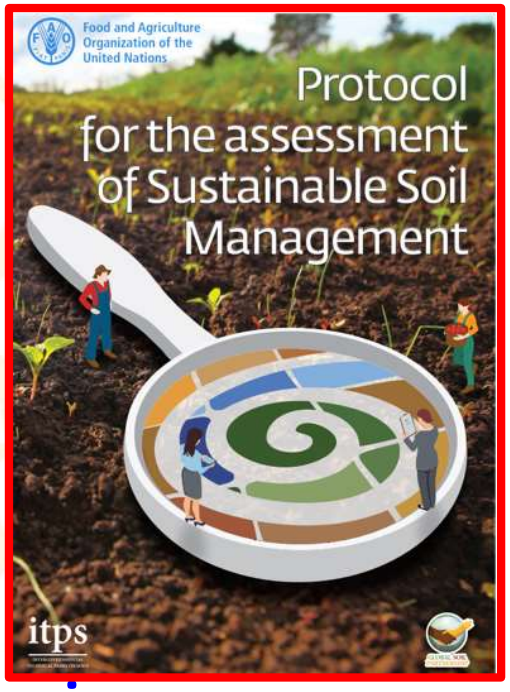

Results = data

C NPK *etc*

Data

Decisions Actions

Quantifying

ODD Targets

Ecosystem services

Traditionally (use locally)

- Fertilisation
- Classification

Nowadays use globaly

- Scientific conclusions
- Payment for ecosystem services
- *etc…*

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NOTE: accuracy must fit with the purpose

Accuracy can be different depending on the impact of your decision

Low accuracy data is enough

High accuracy data is necessary

https://legacy.eagronom.com/en/blog/5-tips-on-soil-carbon-credits/

16.06.2022 - 6 minute reac
Jazz Rosende

Soil carbon credits for farming are becoming a hot topic these days. How does soil carbon affect climate change? What are the benefits of using soil carbon? And how can farmers earn carbon credits?

Generating **income from soil carbon credits** begins with support from a carbon program. Unlike most services, we offer early payments in carbon credits for farmers to ensure the success of the farmer.

Get in touch with us about carbon farming by filling in the contact form below.

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Challenges also exist for soil laboratories....

at the moment a minority of labs could perform relevant C analysis for:

- **making relevant conclusions on the sustainability of farming practices**
- **making decisions for the payment of C sequestration**

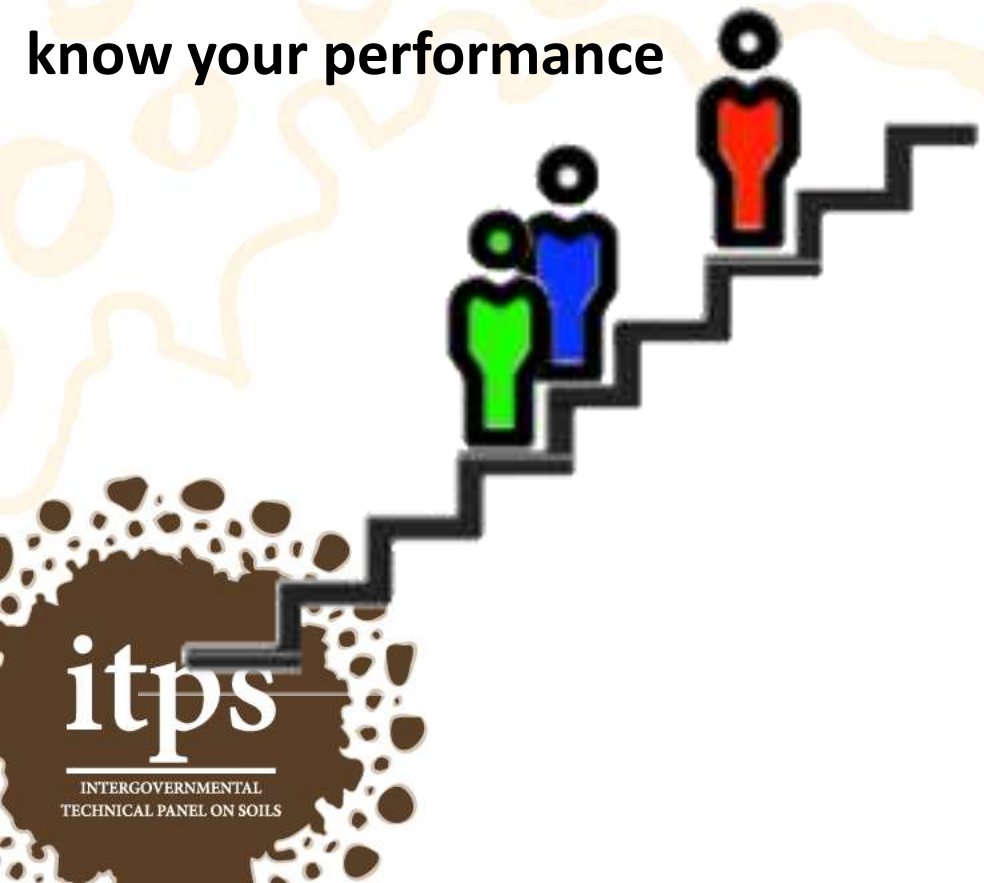
OPPORTUNITIES also exist to easily improve the situation:

- **GLOSOLAN SOPs can easily be used worldwide....**
- **volunteers able to teach and train QC exist**

GLOSOLAN
GLOBAL SOIL LABORATORY NETWORK

PTs not only help the participants to know their performance but the network is organised so that high performing labs can help less performing labs

GLOSOLAN PTs:
know your performance



GLOSOLAN network:
share many free support to reach the top

(SOPs, videos, trainings, webinars, etc.)

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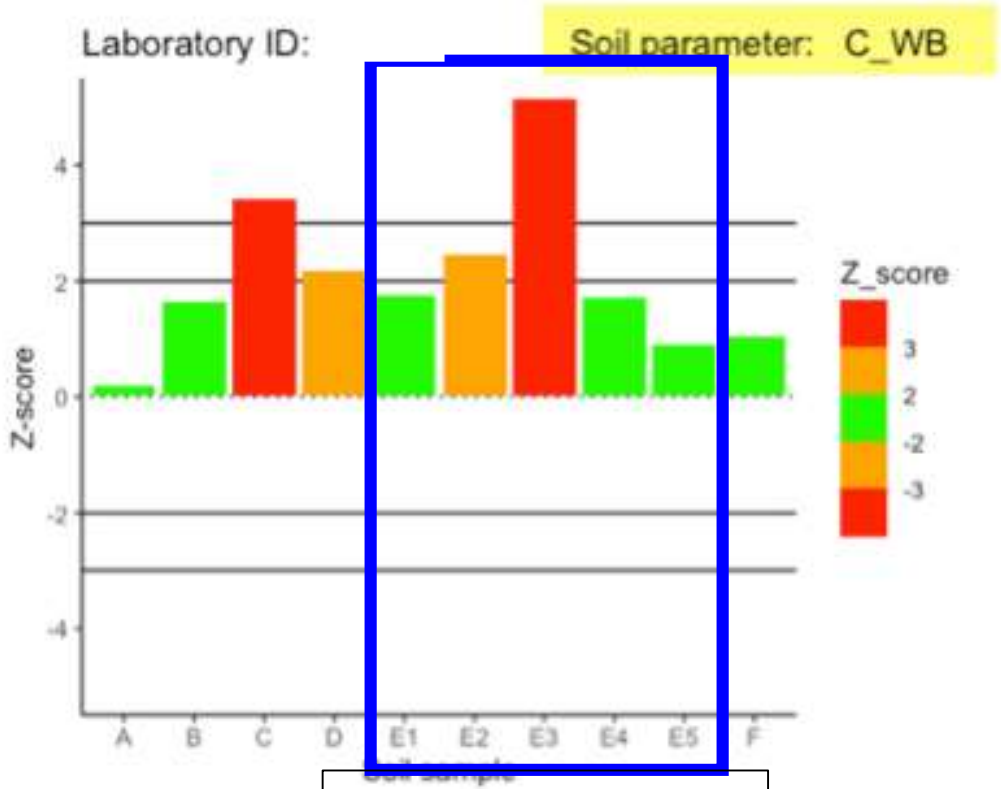
18th Working Session of the Intergovernmental Technical Panel on Soils (ITPS)
21-23 March 2023 | Fao Headquarters | Rome, Italy

GLOBAL SOIL PARTNERSHIP

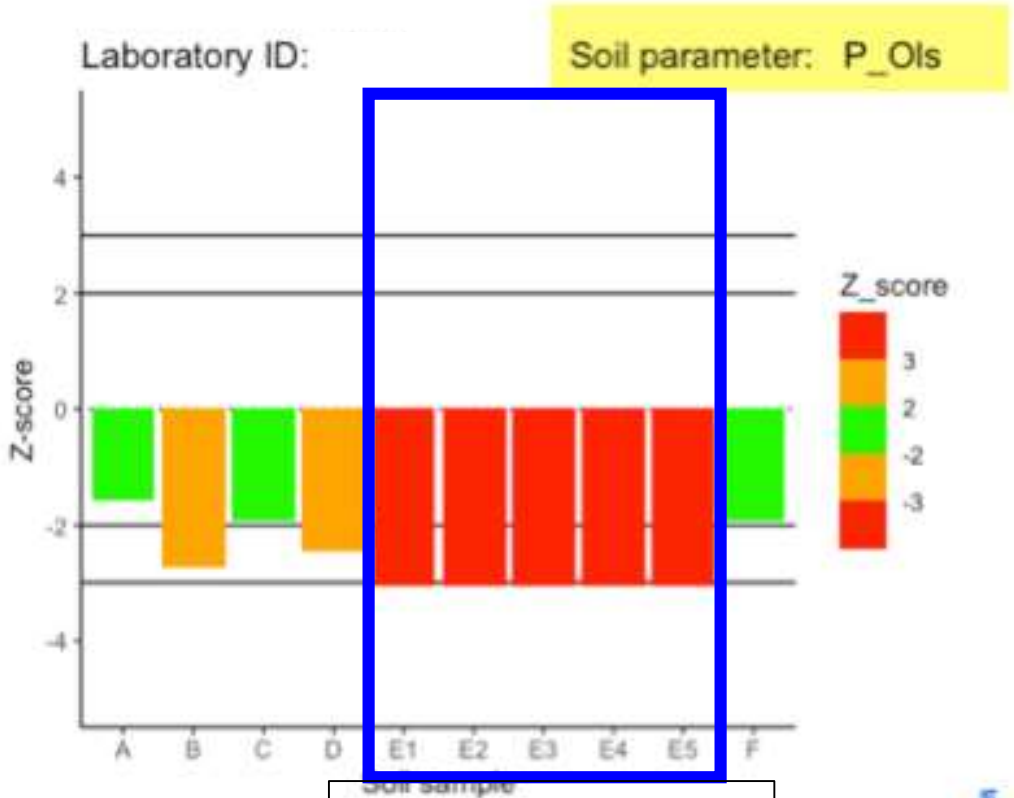
GLOSOLAN PTs from the lab point of view

Shortly after the end of PT, each lab receives a record of its performances

Examples:



Precision + accuracy problems



Excellent precision but low accuracy (bias ?)

know your performance

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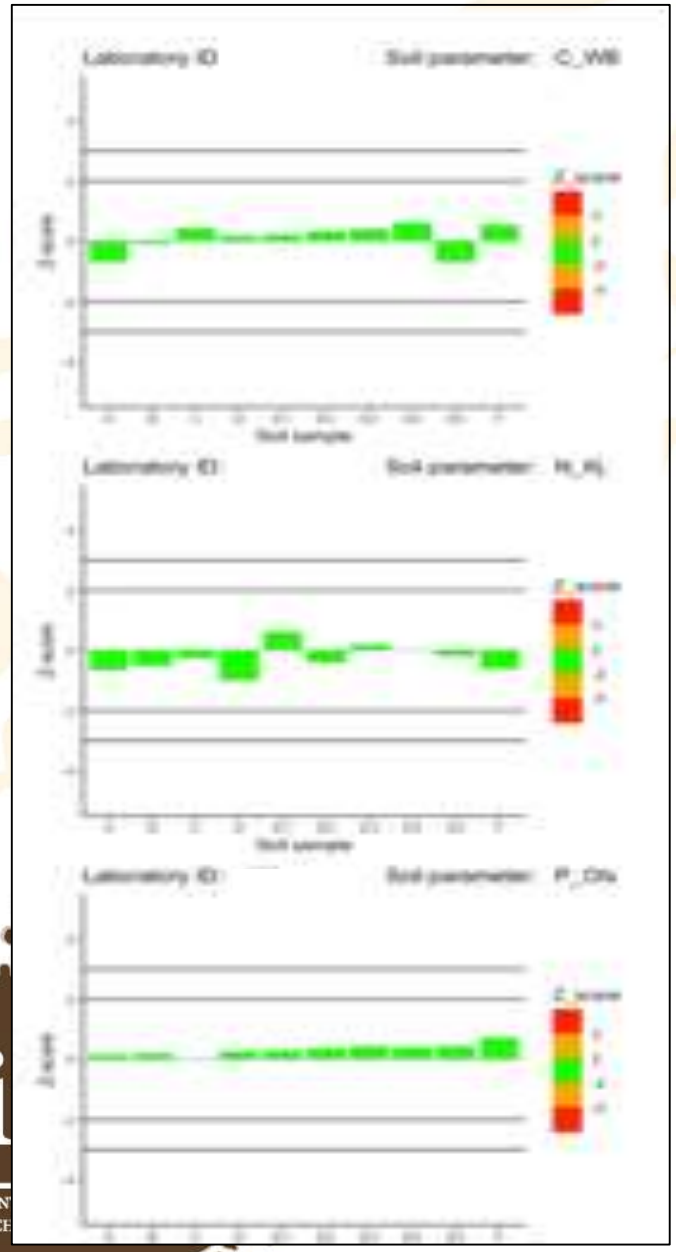
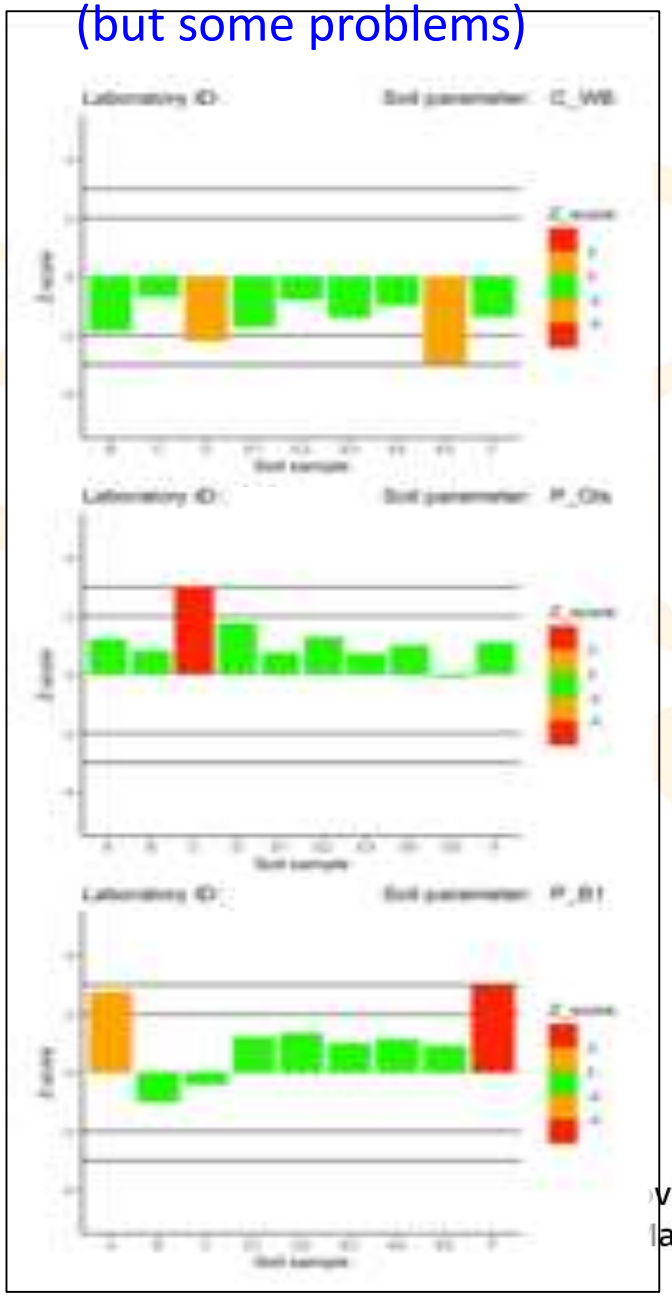
High performance lab

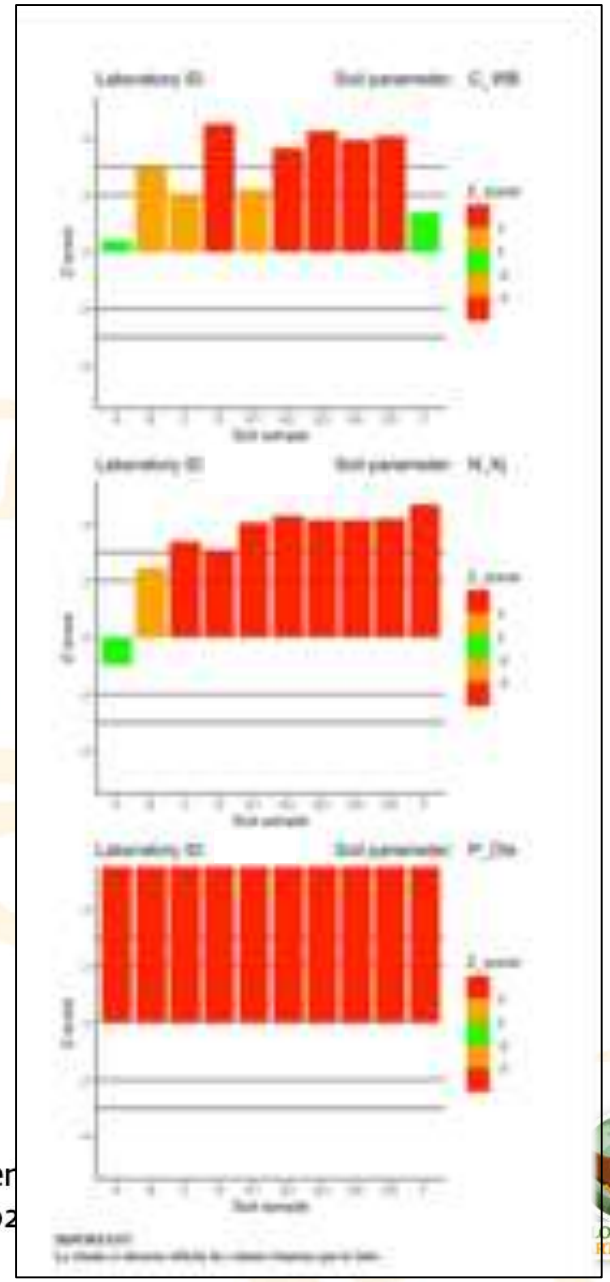


Good performance

(but some problems)



Low performance lab



get free support
to reach the top
(at least to improve...)

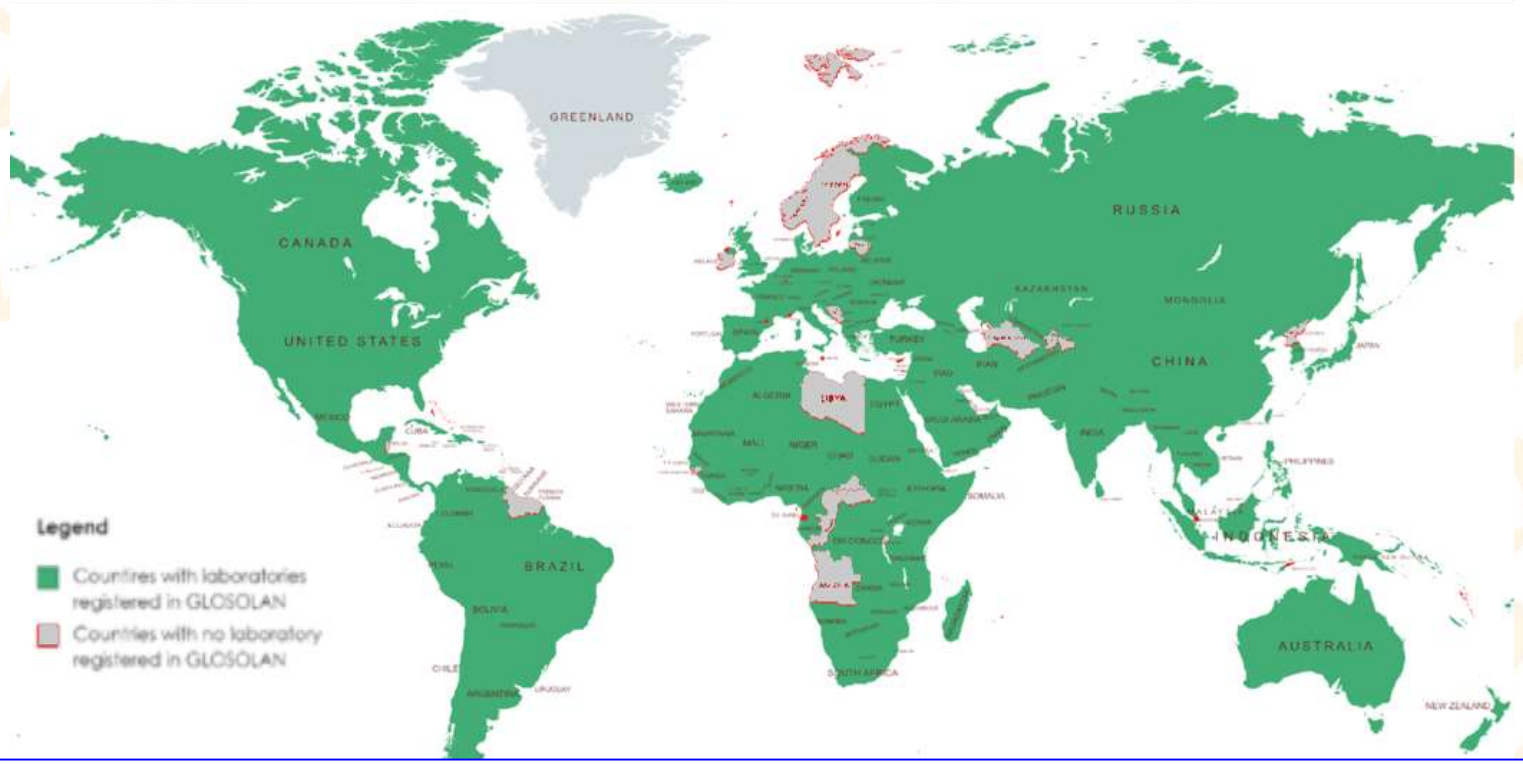
(this is not provided by any other PT organisers...)

For low performing labs, send questionnaire + recommendations:

- **to make a diagnosis of the situation**
- **to try to understand the origin of the problems**
- **to suggest a solution**

To monitor the improvements, PTs must be organized regularly

sending soil samples around the world is costly and difficult..



RESOLANs must be active in organising their PTs !

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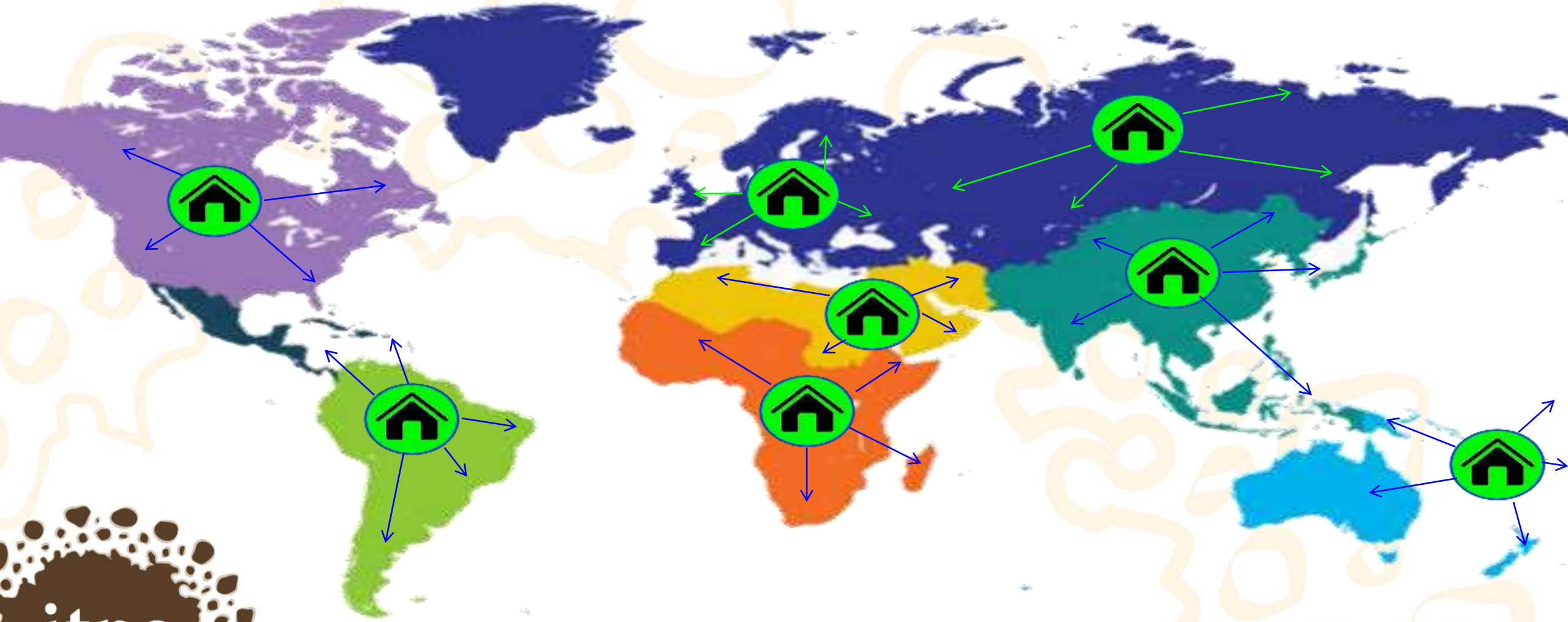
PT must be organised WITHIN Regions



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GLOBAL SOIL PARTNERSHIP

GLOSOLAN works on collaboration with the GSP technical networks

- development of the GLOSOLAN SOPs
- Training (INSAS training in Uzbekistan) and capacity building (webinar with INSOP and GLOSOLAN Spec.)
- Potential for relevant parameters and soils to be included in future PTs

GLOSOLAN Soil spectroscopy: main achievements

- 6 online webinars hosted in 2021
- 5 online webinars hosted in 2022

SESSION 1: An Introduction to Soil Spectroscopy

Monday, 6 September 2021 | 15:00 CET

Guest speaker: Bo Stenberg

Biography: Bo Stenberg is an associate professor in soil science from the Swedish University of Agricultural Sciences. He is the research leader at 'Precision Agriculture and Pedometrics', Department of Soil and Environment. His research interests focus on digital soil mapping and variable rate fertiliser application in precision agriculture system, farm soil mapping, proximal soil sensing, diffuse near infrared spectroscopy for soil analysis, three dimensional soil mapping.

Abstract: This webinar will review the basic mechanisms for soil visible-near infrared (vis-NIR) spectroscopy. I will also provide information on applications related to precision agriculture and the use of large regional soil spectral libraries for estimating small scale variations.

Register here | Details of the event

SESSION 2: Soil Spectroscopy for accurate measurement of soil physical and chemical soil properties

Thursday, 16 September 2021 | 09:00 CET

Guest speaker: Budiman Minasny

Biography: Budiman Minasny is a professor in soil-landscape modelling at the University of Sydney. He is the theme leader of soil, carbon, and water at Sydney Institute of Agriculture. He is a soil scientist, previously awarded the QEII and the Future Fellowships from the Australian Research Council. He is recognised as a Highly Cited Researcher in 2019 by the Web of Science. He is passionate about the role of soil in managing climate change, food, water, energy security, and maintaining biodiversity.

Abstract: This webinar will present how soil spectroscopy can characterize extensive different soil physical and chemical soil properties.

Register here | Details of the event

SESSION 3: A future for soil spectral inference

Thursday, 23 September 2021 | 08:00 CET

Guest speaker: Alex McBratney

Biography: Alex McBratney is a world leading soil scientist who conceived and developed pedometrics, digital soil mapping and soil security, radically strengthening the knowledge base of soil science. He established new theory and empirical models of soil variation in landscapes and developed their applications. His contributions have revolutionised the availability of soil information and led to improved agricultural practices with reduced environmental impacts and enhanced security of the world's soil.

Abstract: This webinar will present the definition and role of soil spectroscopy for laboratory as well as field measurement and will speculate on possible novel approaches.

Register here | Details of the event

Soil spectral primer:
More than 800 downloads

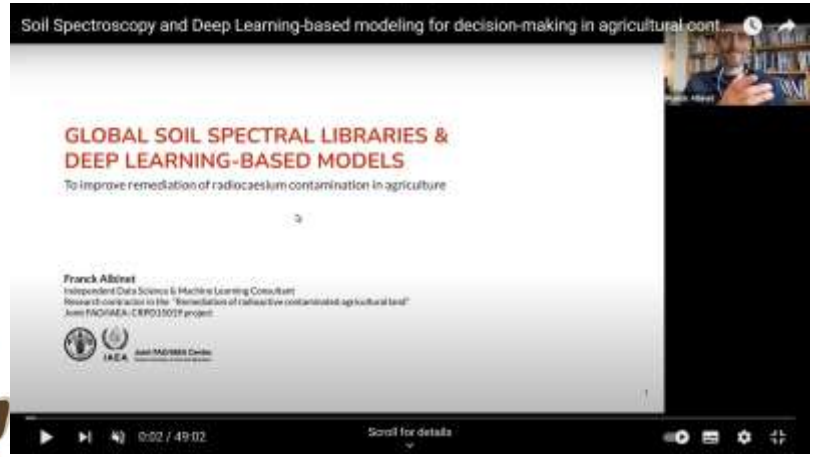
- Six sessions to provide training in soil spectral modelling in R
- Over 900 views

#SDGs #Agenda2030 #GlobalGoals

EduSoils - Soil spectral data analysis (Level I) - Introduction #1

GLOSOLAN-Spec (Dry Chemistry) Recent events/publications:

- First webinar of the 2023 series March 3rd)-
- 250 attendees, 26 technical questions and 30 minutes of technical discussion



- Primer available in French, Russian, and Chinese

GLOSOLAN-Spec (Dry Chemistry) Priorities for 2023

- Guides to available soil spectral resources (existing open-source soil spectral libraries and soil spectral estimation services)
- Additional guides in the style of the primer
- Publication of standard operating procedures on spectroscopy
- Webinar series with spotlight on state-of-art research and discussion
- Publications and advocacy- work with IAEA, scientific report on initiative

GLOSOLAN Activities for 2023

PRIORITIES

1. Make the network more visible for increased SOPs adoption by users and inform them on need to improve
   - ISSPA: 1 KeyNote + 4 oral presentation
   - peer reviewed articles to demonstrate scientific quality

Limited cost because mainly volunteers (researchers)

Thanks to the financial support from GSP, FAO; IRD, France and the University of Zagreb Faculty of Agriculture

2. Follow up with labs who had low performances (this is never done by PT organisers)

No/limited cost because mainly volunteers but 'time' consuming (lab managers)

3. PTs/interlab comparisons
   - Regional
     - Asia (led by the BSWM of the Philippines)
     - Eurasia (led by the NRL of the Russian Federation)
     - Africa + NENA (supported by IRD and BGS)

4. Organize an event on quality control (launch of the PT report, and webinars on PT organization)
   - towards the International Symposium on Soil Data Quality

GLOSOLAN Activities for 2023

CURRENT

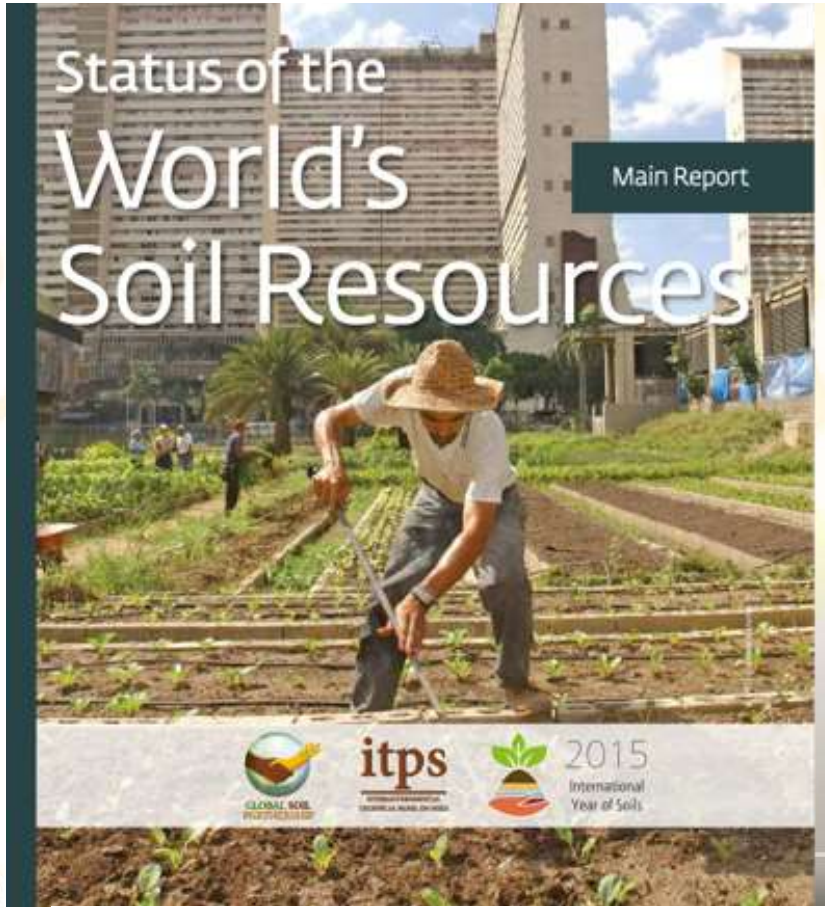
1. Knowledge transfer
   - SOP publishing
   - Release of new key technical documents and tools (the FAO Soil Bulletin – 74
   - Database Platform to host visiting lab technicians

2. Capacity building
   - Webinars Guidelines and supportive documents
   - In-person training sessions:
     EUROSOLAN Uzbekistan (focus on salinity and sodicity),
     AFRILAB Dakar

3. Launch of the Global Assessment of soil laboratories capacities and needs 2023

In conclusion...

What can GLOSOLAN bring to ITPS?



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2015

Global Labs situation was unclear

2023 **a huge amount of information was collected that provides a new perspective on:**

- **the uncertainty associated to many types of soil data produced in labs,**
  - provide the uncertainty for our predictions on soil evolution.
  - The revised global map can be more precise under the comparable SOPs and can integrate the data uncertainty
- **the strengths and weaknesses of many laboratories around the world.**
  - strengths: staff motivation, generally good equipment
  - weaknesses: lack of staff training, lack of quality control

2023:

This network of motivated & skilled people can be activated if needed by ITPS for some specific request.

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ITPS support to GLOSOLAN:

- Support the development of transfer functions between different SOPs
- Join the reviewing process of GLOSOLAN's documents (particularly technical review of document which have been translated into local languages)
- Motivate laboratories (particularly from countries with no registered labs) to join
- Motivate routine and research labs to use GLOSOLAN SOPs and to implement Quality Control, if not yet done.

Food and Agriculture Organization of the United Nations

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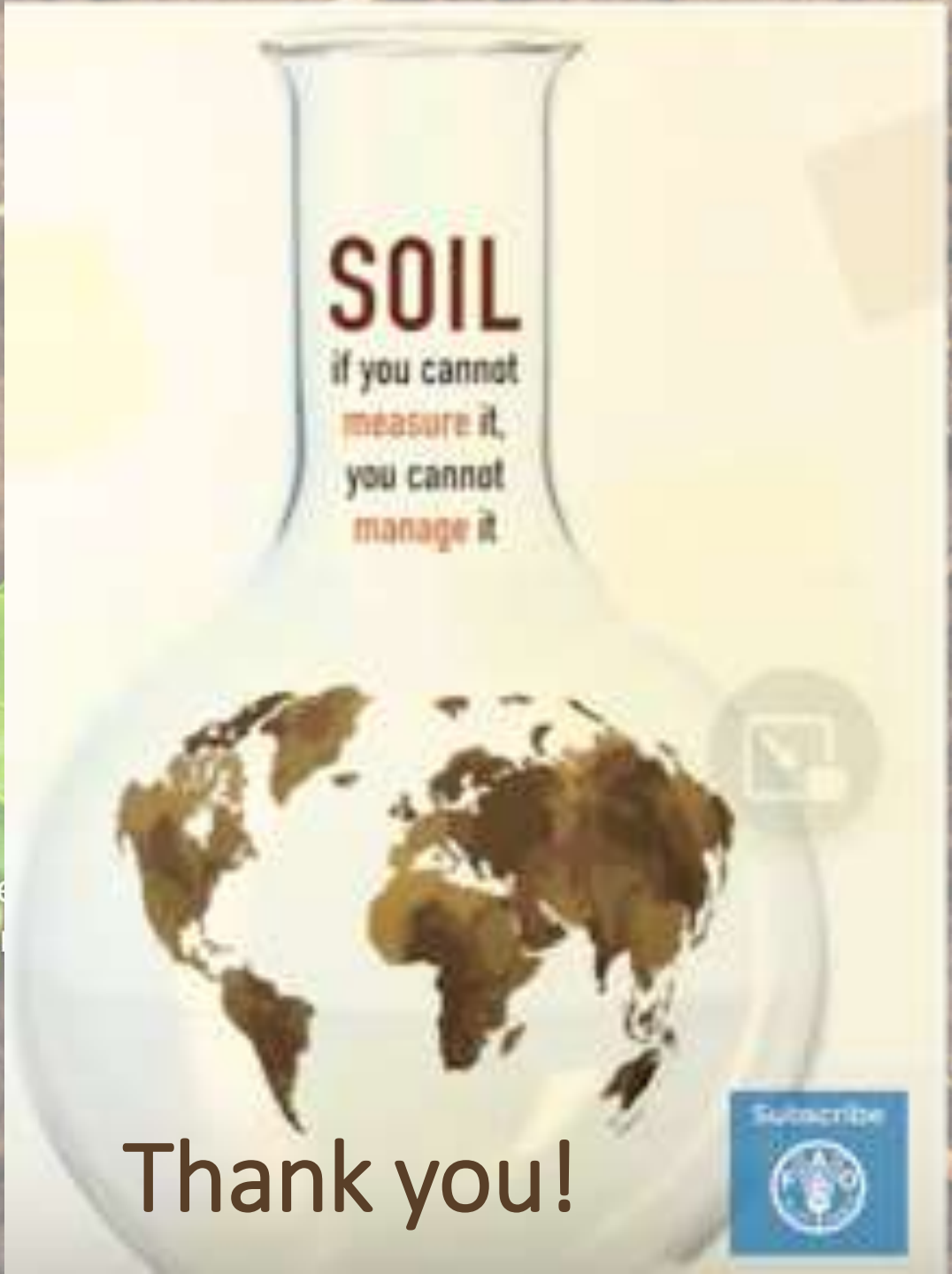

Thank you!

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