



# CUP<sub>4</sub>SOIL - High-resolution soil property service development for National and European soil carbon reporting (FPCUP project)



Virtual User Requirement Meeting  
07.12.2023

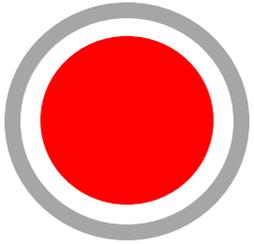


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# Meeting recordings



- You can access the video recording of the meeting here:  
<https://youtube.com/live/wWAZpqugWwM?feature=share>

# Objectives of the meeting

- Introduction to the CUP<sub>4</sub>SOIL project
- Presenting the User requirement study
- Informing about the Earth Observation-based soil information for Europe
- Contact and next activities

# Agenda

|        | Time          | Topic  |   |
|--------|---------------|--|---|
| Part 1 | 10:00 - 10:15 | Welcome and Introduction to the CUP4SOIL project | Uta Heiden (DLR)  |
|        | 10:15 - 10:20 | Questions  |   |
|        | 10:20 - 10:45 | Introduction to UR study - first findings        | Fenny van Egmond (ISRIC)<br>Uta Heiden (DLR)                        |
|        | 10:45 - 11:00 | Interactive User survey                          | Fenny van Egmond (ISRIC)  |
|        | 11:00 - 11:15 | Discussion / Questions                           |   |
|        | Part 2        | 11:15 - 11:30                                    | Data products - Earth Observation-based soil information for Europe |
|        | 11:30 - 11:40 | Webpage and data policy                          | Laura Poggio (ISRIC)  |
|        | 11:40 - 11:55 | Interactive session on soliciting case studies   | Fenny van Egmond (ISRIC)  |
|        | 11:55 - 12:00 | Next activities                                  | Uta Heiden (DLR)  |

Further project members: Pablo d'Angelo (DLR), Paul Karlshöfer (DLR)

Thaisa van der Woude (ISRIC), Emily Toner (ISRIC)

# Part 1

## Welcome and Introduction to the CUP4SOIL project



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# Introduction to the project – Funding framework

- FPCUP - Framework Partnership Agreement on Copernicus User Uptake: <https://www.copernicus-user-uptake.eu/>
- Framework started in July 2018
- Funded by the European Commission (DG DEFIS)
- 219 actions, the EU-funded projects aim at enhancing the user uptake of Copernicus data and products
- The actions comprise national and international user uptake activities as well as business solutions and innovative products and applications
- [CUP<sub>4</sub>SOIL project](#)
  - Global action, including European cross-border user uptake and international user uptake (Tier 2)
  - Application



## Information & Training Events



National and multi-national information and training events

[Read more](#)

## Building User Dialogue



Building an active user dialogue

[Read more](#)

## Applications



Developing and piloting downstream applications and services

[Read more](#)

## Innovations



Promoting national and multi-national innovative actions

[Read more](#)

# Introduction to the project - Objectives

## Title:

High-resolution soil property service development for National and European soil carbon reporting

## Timeline:

- Proposal submission in 2019, project approval in 2022
- 2-years project, **start Jan 2023**, ISRIC started in May 2023

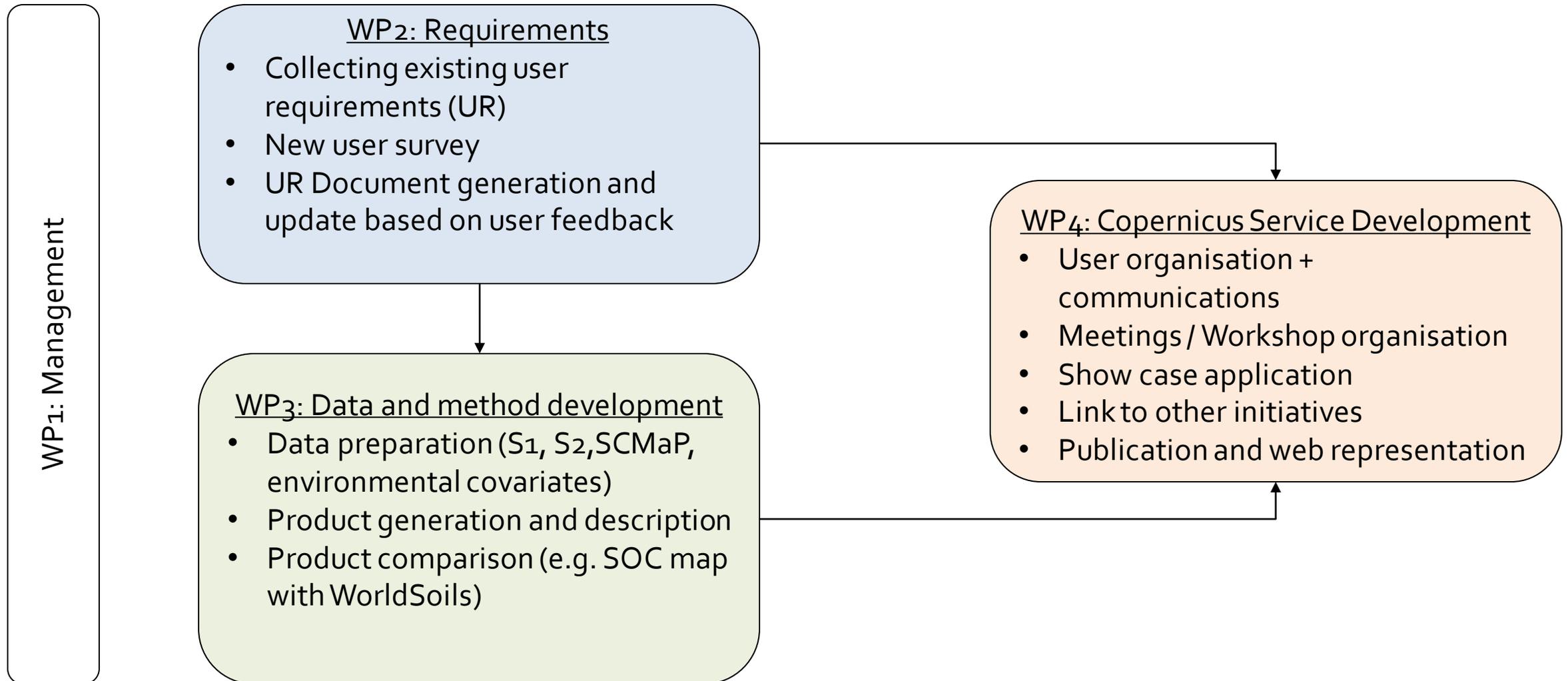
## Partner:

DLR and ISRIC

## Objectives

- Prepare a potential Copernicus downstream service to support national and European agencies for reporting on **soil health/quality**.
- Generate **European-wide example data products** characterising soil health/quality
- **Develop a user community** that tests and validates data products for soil health/quality information
- Ensure close **cooperation** with the ESA WorldSoils project activities and other related projects/initiatives such as the EJP SOIL projects and others etc. ...

# Introduction to the project - Workpackages



# Introduction to the project – Expected results

## European-wide EO data products and soil maps (20 m pixel size):

- Soil property maps (e.g. soil organic carbon, soil texture) and
- Information about soil and vegetation dynamics including quality indicators – presented in a dedicated web page

## Documents:

- (1) User requirements document tailored to the need of Copernicus Users
- (2) Key soil product description including robustness tests, product quality, feasibility for European-wide application
- (3) Showcases (example downstream applications)
- (4) Scientific and grey publications
- (5) User survey collecting feedback of the community (User requirements)

## Meeting and Workshops:

- (1) Q4/2023 – Virtual meeting for discussing and consolidating User Requirements  
*7<sup>th</sup> December 2024 - online*
- (2) Q1/2024 – First soil information products are presented, user requirements will be updated  
*6<sup>th</sup> – 7<sup>th</sup> March 2024 – during the ESA Symposium on EO for Soil Protection and Restoration*
- (3) Q4/2024 – Final project workshop to assess key user feedback, recommendations and future directions  
*TBD*

# CUP<sub>4</sub>SOIL – Welcome and Introduction

## CUP<sub>4</sub>SOIL Webpage



[About](#) [User Uptake](#) [Resources](#) [News](#) [Events](#) [Highlights](#)

[Home](#) / [User Uptake](#) / [Action details](#)

### CUP<sub>4</sub>SOIL: High-resolution soil property service development for National and European soil carbon reporting

[Survey on requirements and wishes for future soil products provided by the Copernicus Land Monitoring Service \(CLMS\).](#)

This action aims at a downstream service to support national and European agencies for reporting on soil health/quality and thus, contribute to the Land Degradation Monitoring (LDN) and Sustainable Development Goal (SDG 15.3.1) reporting. It further underpins the pre-operational Soil Monitoring System currently being developed within the ESA WorldSoils project with the potential to serve as a component of the Copernicus Land Monitoring Service. Using synergies between this action and the ESA WorldSoils project will streamline the activities and boost the user uptake. The 2-year CUP<sub>4</sub>SOIL project comprises the following objectives:

- Develop a potential Copernicus downstream service to support national and European agencies for reporting on **soil health/quality**.
- Generate **European-wide data products** and indicators characterising soil health/quality
- Prepare and **develop a user community** that tests and validates data products for soil health/quality information
- Ensure close **cooperation** with the ESA WorldSoils project activities and other related projects/initiatives such as the EJP soil project STEREOPEs, SERENA, etc.

**Initiatives and literature:** In the first step, CUP<sub>4</sub>SOIL explores the different literature and project resources to get an update about the current discussion of essential soil health indicators. This will be collected in a first version of a User Requirement Document (URD) that CUP<sub>4</sub>SOIL presents, discuss and adapt with a larger community during the first User Requirement virtual meeting. For this purpose, a specific online user survey will be developed based on the framework of the FPCUP requirements. The survey is

Source: <https://www.copernicus-user-uptake.eu/user-uptake/details/cup4soil-high-resolution-soil-property-service-development-for-national-and-european-soil-carbon-reporting-512>



Deutsches Zentrum für Luft- und Raumfahrt  
German Aerospace Center



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**Implementing Partner:** [DLR](#)  
**Implementing Country:** [Germany](#)  
**Primary Topic:** [Land](#)  
**Primary Target Users:** [Public Sector](#), [Research Sector](#)  
**Primary Target Region:** [Europe](#)  
**Type of Action:** [Developing and piloting downstream applications and services](#)  
**Action No.:** 2020-2-14  
**Duration:** Apr 2022 - Apr 2025    **Last Update:** 20 Oct 2023



# Questions to this introduction?



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# Part 1

## Introduction to User Requirement study - First findings



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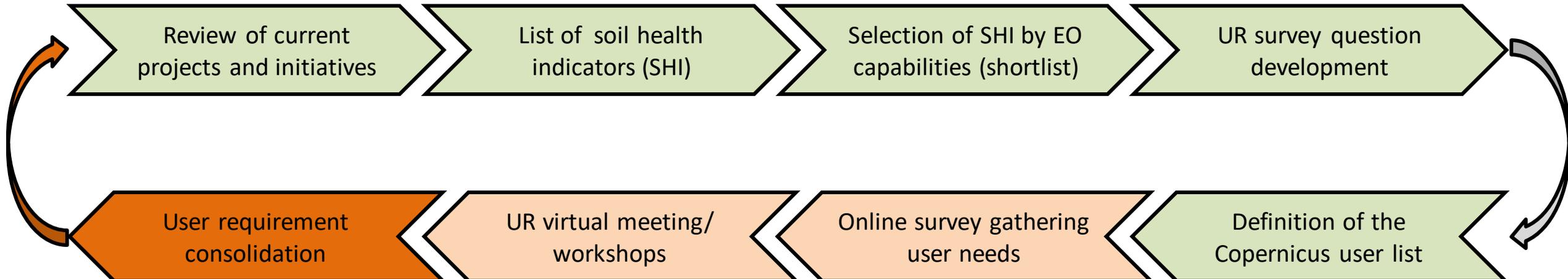
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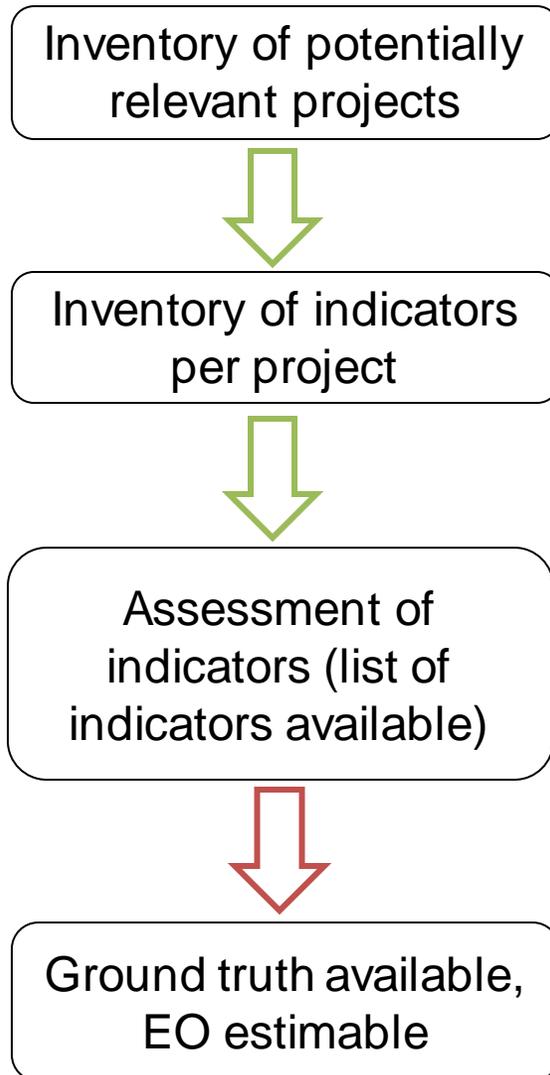
# User requirements

Iterative process:

- Reviewing existing projects and initiatives
- User requirement survey
- User requirement meeting
- Feedback from case study results



# User requirements from existing projects / initiatives



- EJP SOIL (SIREN, SERENA, MINOTAUR, WP6, STEROPES)
- WorldSoils
- EEA level<sub>1</sub>
- LUCAS
- MARVIC, MRV<sub>4</sub>SOC
- ENVASSO
- Soil Monitoring Directive
- Status of the World's Soil Resources
- LANDMARK
- ISQaPer
- RECARE
- BENCHMARKS
- AI<sub>4</sub>SoilHealth
- PREPSOIL
- Etc.

# Shortlist ...



- When listed more than 4 times in the mentioned projects, it is selected:
- Simple properties: Soil Organic Carbon (SOC), Soil Organic Matter (SOM), pH, Total Nitrogen (N), available Phosphorus (P), soil texture (clay, silt, sand), bulk density, Electrical Conductivity (EC), heavy metals (concentration)
- Complex (derived) properties: available water capacity, erosion, salinity, soil respiration, earthworms, soil biodiversity (can contain soil respiration and earthworms but not necessarily), soil sealing, soil contamination, compaction
- These 18 soil indicators have been evaluated against:

- The NextSpace Copernicus User requirements for soil in 2019 (8/19)

- EJP SOIL-SIREN (12/14)

- Mission ‘A Soil Deal for Europe’ (8/13)

- Soil Monitoring Directive (16/18)

|                                      | NextSpace Copernicus User Requirements (Soils) 2019<br><a href="https://www.copernicus.eu/en/documentation/studies-and-surveys">https://www.copernicus.eu/en/documentation/studies-and-surveys</a> | Shortlist "minimum dataset" suggested by EJP/SIREN project   | A soil deal for Europe - Implementation plan 202x                   | Soil Health Law July 2023                            | BENCHMARKS/AIS/SoilHealth   |
|--------------------------------------|--|--|---|--|---|
|                                      | Latest known Copernicus user requirement study   | The EJP SOIL program is the scientific forefront in Europe dealing with a sustainable European integrated research system and develop and deploy a reference framework on climate-smart, sustainable agricultural soil management. This is a reduced list based on an extensive review of literature, EU policies, requirements from member states and EU projects | Implementation plan of the EC to achieve 100% healthy soils in 2050 | Legal framework for the development of healthy soils | The project aims at providing a clear soil health index for benchmarking, using indicators that are pertinent to the objective of assessment, applicable to the land use and logistically feasible. |
| Reason for selection:                | Soil health indicators/parameters (24) from the currently running soil projects  |  |   |  |   |
| <b>Simple properties</b>             |  |  |   |  |   |
| SOM                                  |  |  |   |  |   |
| SOC                                  | x  |  | x   |  |   |
| pH                                   | x  |  |   |  |   |
| Total N                              | x  |  |   |  |   |
| P available                          | x  |  |   |  |   |
| Texture                              |  |  |   |  |   |
| Bulk density                         |  |  |   |  |   |
| EC                                   |  |  |   |  |   |
| heavy metals                         |  |  |   |  |   |
| <b>Complex or derived properties</b> |  |  |   |  |   |
| available water capacity             |  |  |   |  |   |
| erosion                              | x x x x x x x  |  |   |  |   |
| salinity                             |  |  |   |  |   |
| Soil respiration                     |  |  |   |  |   |
| Earthworms                           |  |  |   |  |   |
| Soil Biodiversity                    |  |  |   |  |   |
| Soil Sealing                         |  |  |   |  |   |
| Soil contamination                   |  |  |   |  |   |
| Compaction                           |  |  |   |  |   |

# User Survey - Development

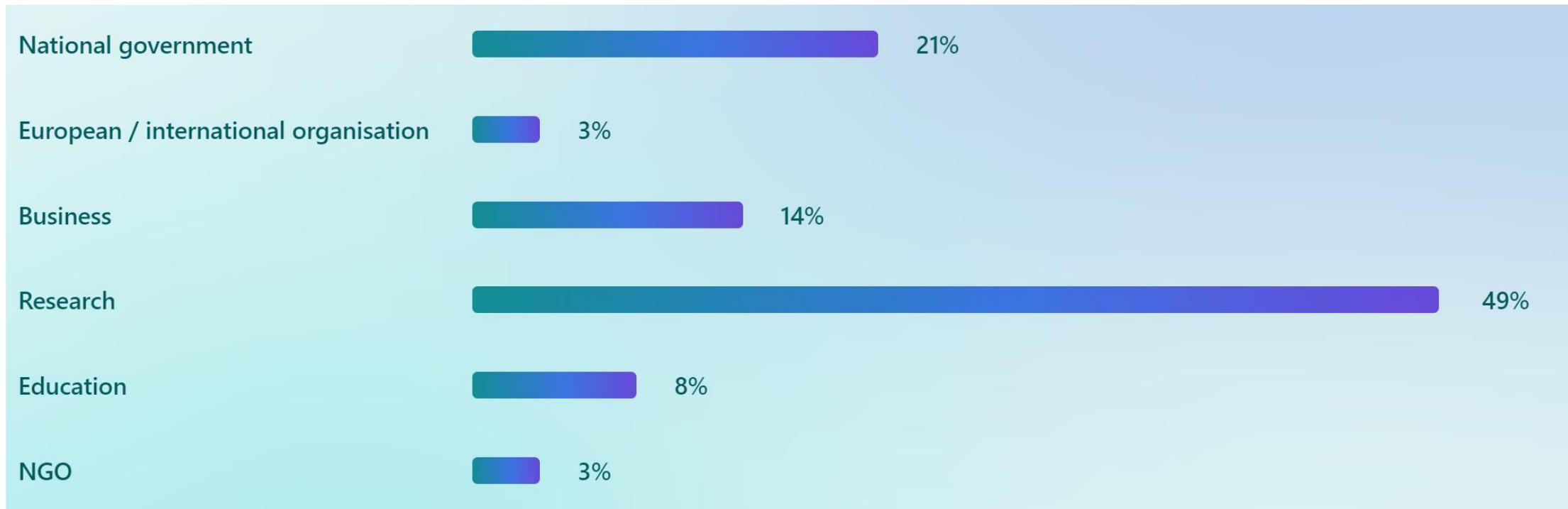
- A survey was launched to understand more about the specifications of the spatial information
- 23 questions
- Sent out to people across Europe on soils and EO
- Ongoing until the ESA Symposium on EO for Soil Protection and Restoration (06-07 March 2024)
- How are the results used?
- Presentation of the status from **6th December 2024**

User requirements survey for a future Copernicus Land Monitoring Service on soils



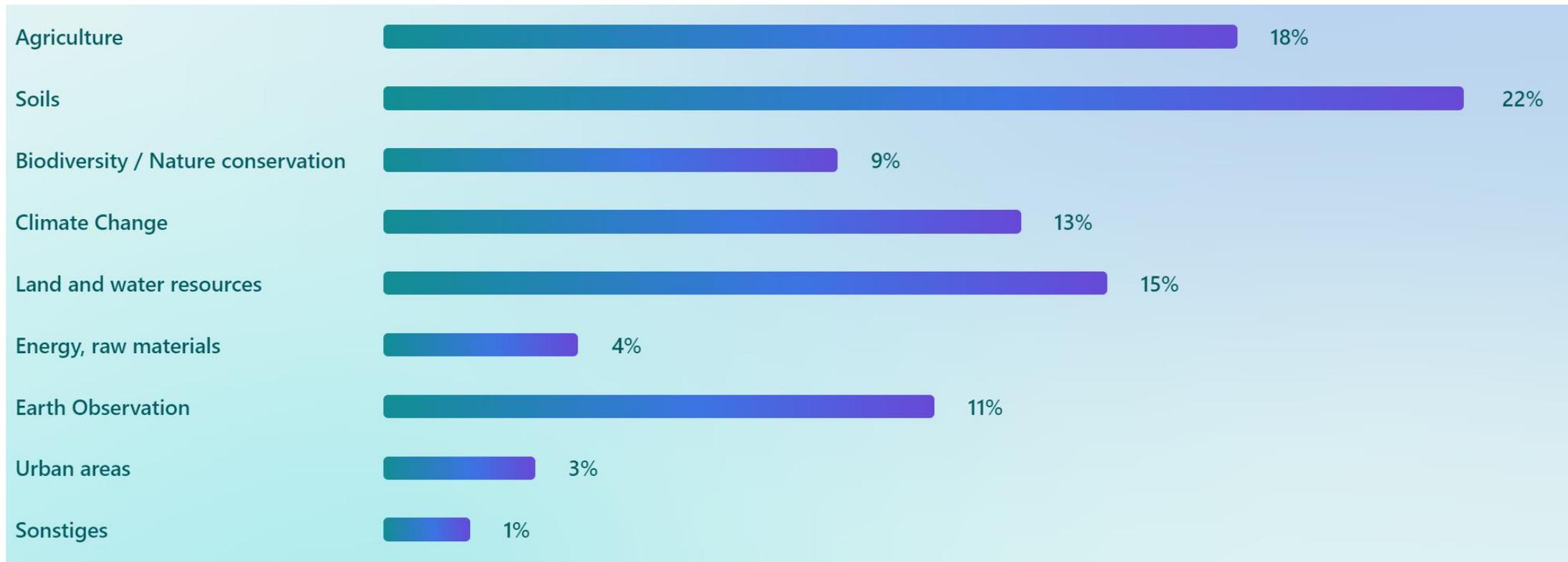
# User Survey – Results (01/12/2023)

- What best describes your organization?



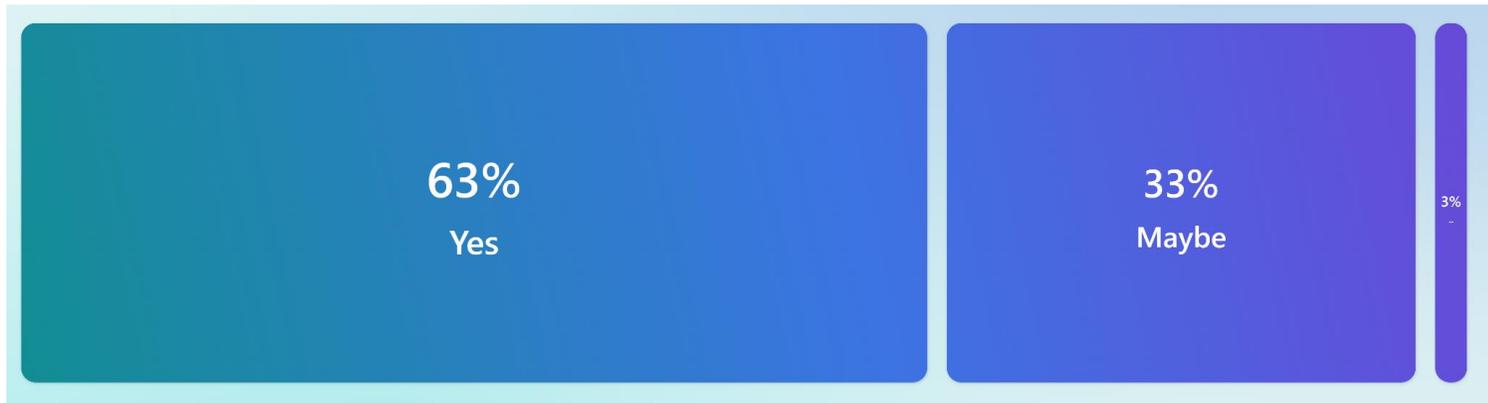
# User Survey – Results (01/12/2023)

- What are the main topics your organisation is working on?

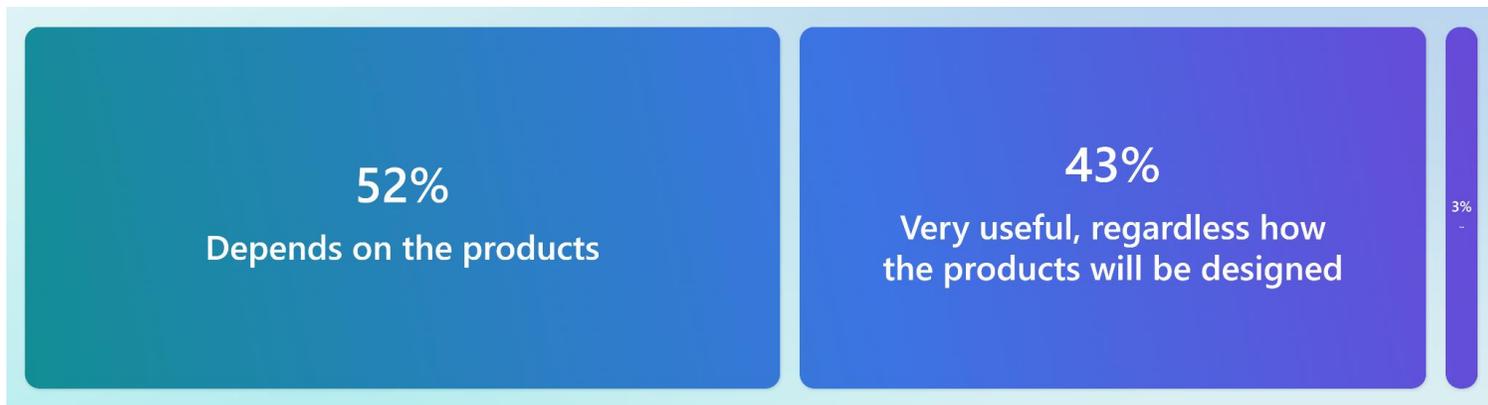


# User Survey - Results

- Are you missing soil-related information at the Copernicus Land Monitoring Service?

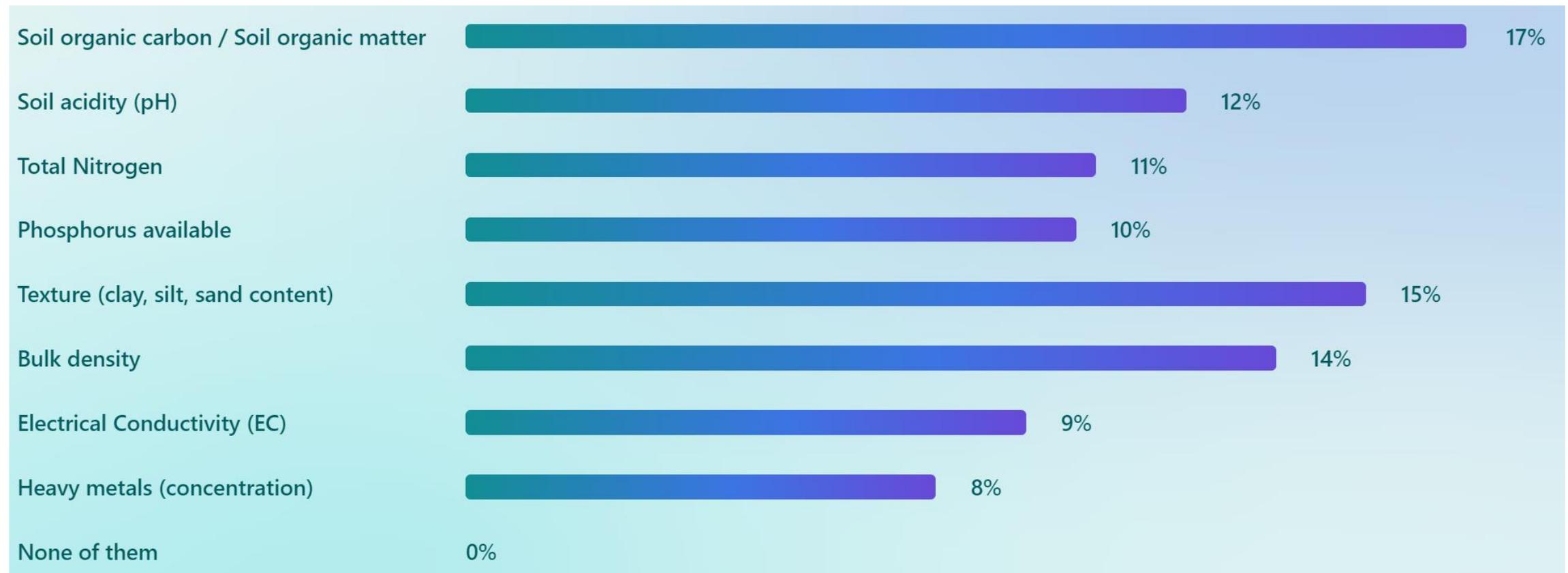


- How would you rate the use(fulness) of future soil products under the Copernicus Land Monitoring Service?



# User Survey - Results

- Which soil-related spatial information would be helpful for your work (Part 1)?  
(multiple choice)

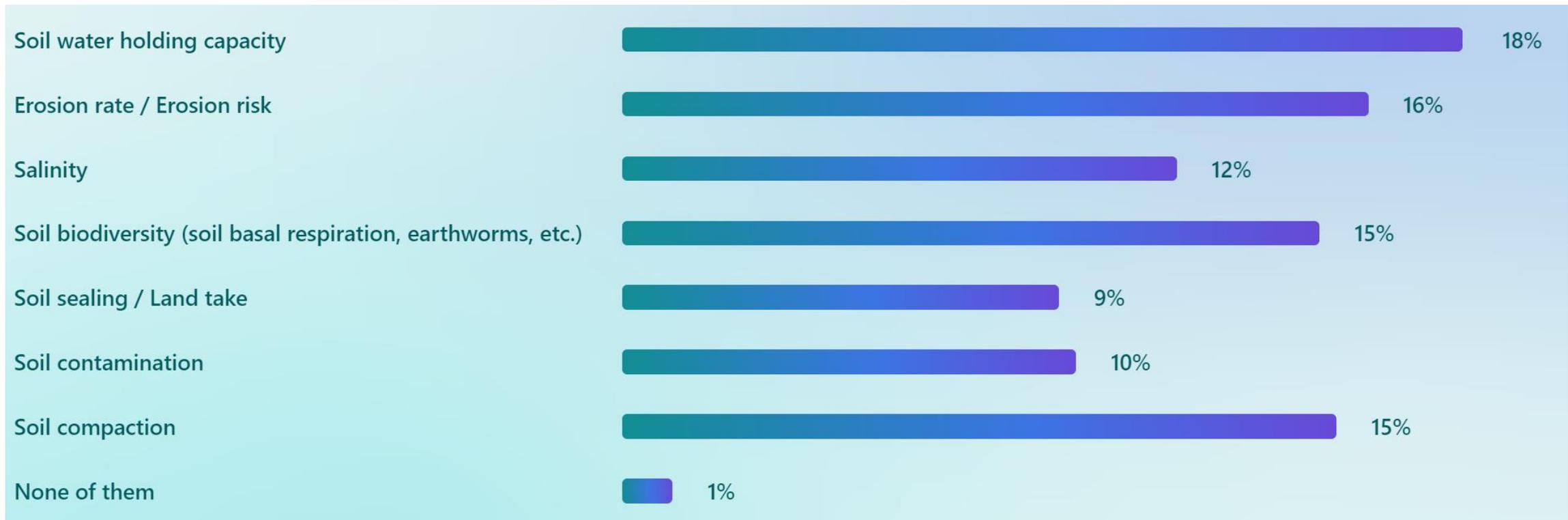


# CUP<sub>4</sub>SOIL – User Requirement Study

## User Survey - Results



- Which soil-related spatial information would be helpful for your work (Part 2)?  
(multiple choice)



# CUP<sub>4</sub>SOIL – User Requirement Study

## User Survey - Results



- Which soil-related spatial information is not listed before (Part 3)?

Related to vegetation cover and vigor

Soil Roughness

Coarse fragments, compacted layers, soil depth, cation exchange capacity, exchangeable bases, base saturation, pedodiversity, lithology

Soil Infiltration Rate

Hydraulic Conductivity

Soil organic carbon sequestration

Infiltration capacity

Soil depth, or layers depth for with the product will be given, Soil profile depth, Soil horizon depths, Water ponding

Fertilization required by soil fauna post harvest in order to build soil organic matter (SOM) rather than destroying old SOM

Soil moisture

Soil classification, Soil types at 1:25K resolution, or something related at this sub-field scale e.g. soil texture, soil parent material

Soil organisms activities, Soil cover

Soil fertility evolution

Drainage class, land use (crop type, nature,...)

Agricultural practices

Soil properties to depth (>30 cm) principally soil carbon, bulk density, stone content, depth to C horizon;

Bearing capacity

Acid soil

CaCO<sub>3</sub> - however, it may be combined with pH

Soil density

Q/I parameters

General or current Compaction Risk (eg. based on soil type or current soil conditions)

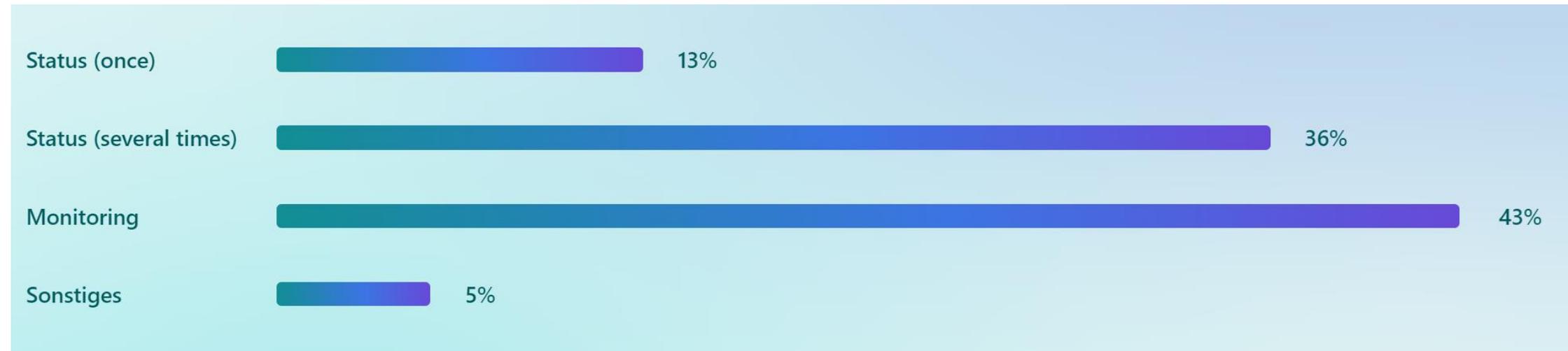
Smart farming: for decision support system related to eco-friendly used fertilizer and its technology application

Soil management, soil cover

Land use

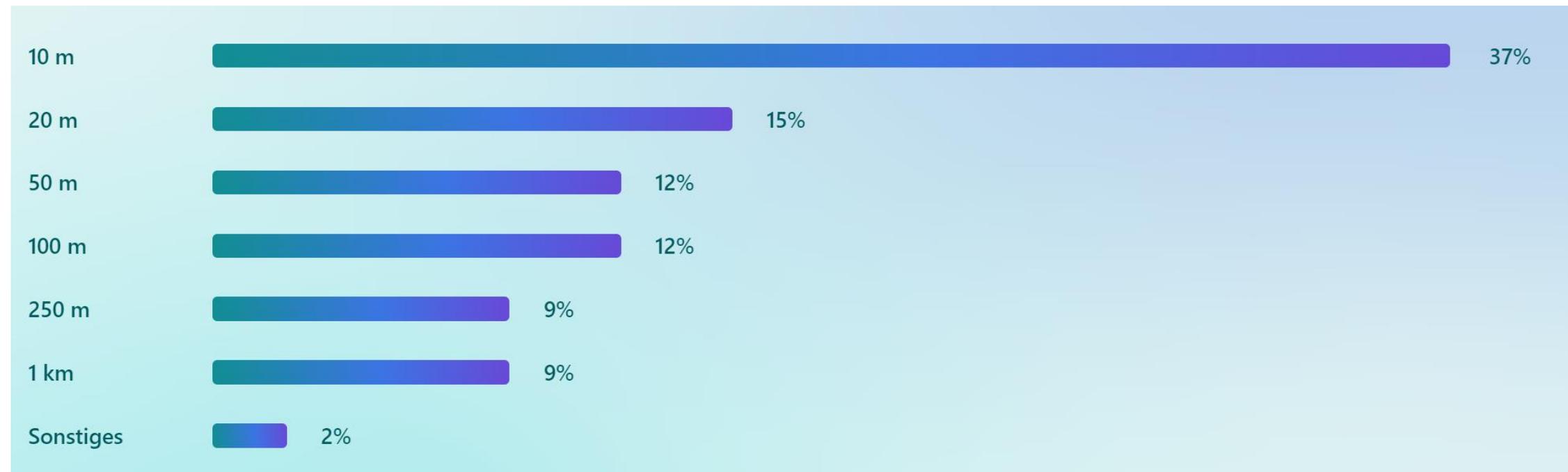
# User Survey - Results

- For which purpose do you need the soil information?



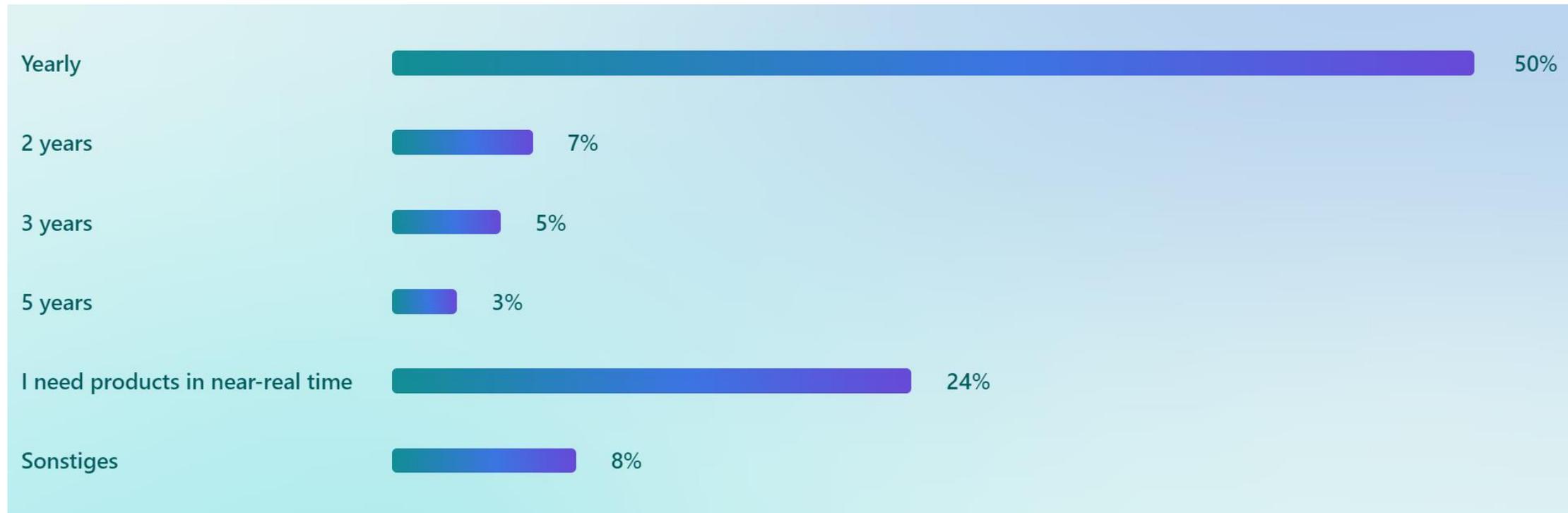
# User Survey - Results

- What is your preferred spatial resolution you are working on (in pixel sizes)?



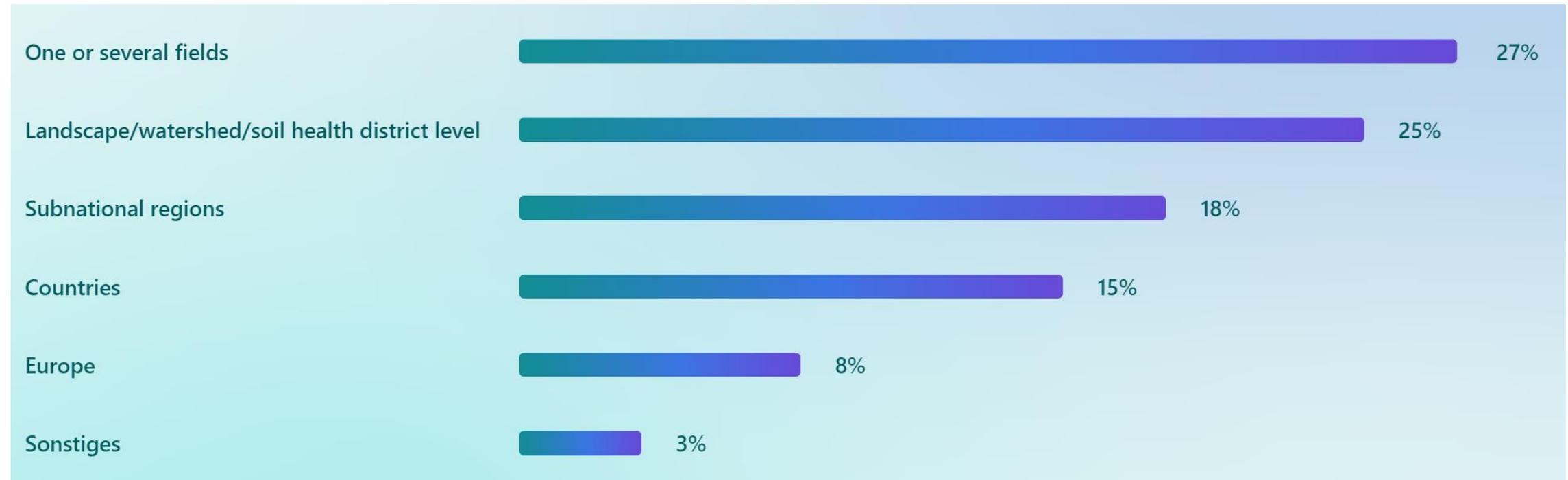
# User Survey - Results

- How regularly would you like to get updates on the soil service products?



# User Survey - Results

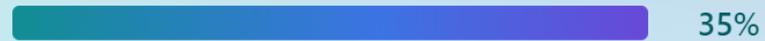
- Which scale is your organization working on?



# User Survey - Results

- What accuracy level is still useful / required for your application given the specifications above?

Spatial pattern should make sense, no absolute accuracy necessary



Correct quantitative values necessary

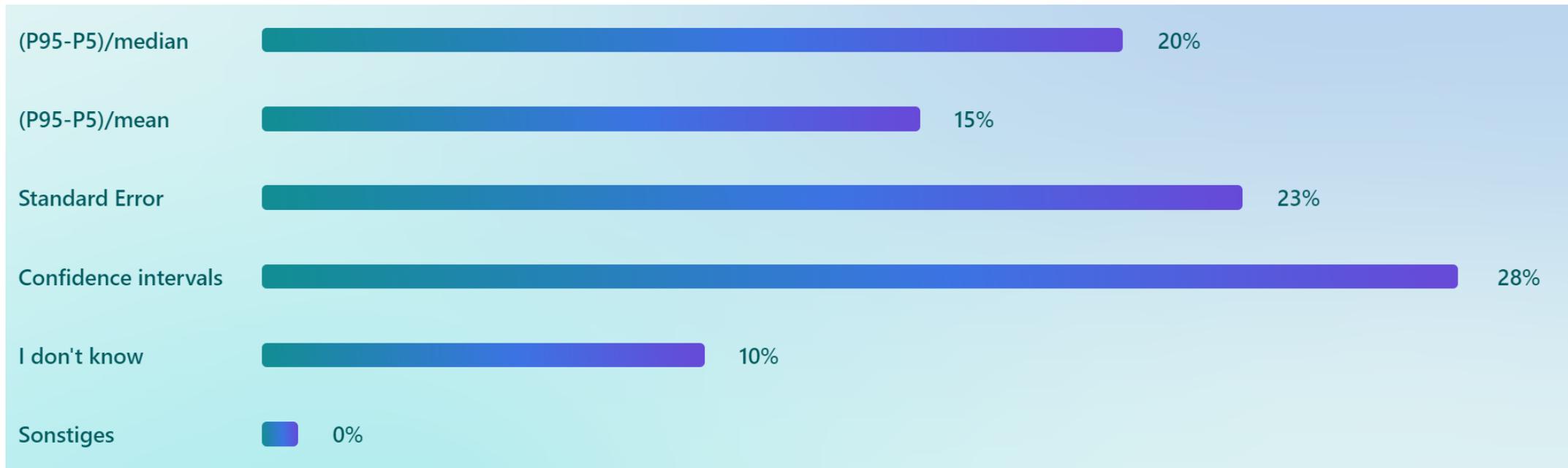


# CUP<sub>4</sub>SOIL – User Requirement Study

## User Survey - Results



- What is the uncertainty measure you would expect for the soil property maps?



# CUP4SOIL – User Requirement Study

## User Survey - Results



- What would be your preferred access?



# CUP<sub>4</sub>SOIL – User Requirement Study

## User Survey – Results



- Further comments (selection):

I would love to learn more information about Copernicus land monitoring service related to subject **smart farming and precision agriculture** learning

The processed raster data have to be **adequately validated!** We see an extreme discrepancy between millions of pixel and only some thousands of ground truthing data. The processed raster data is only so good as it can be correctly validated.

**Standardization of soil data and soil description** is urgently necessary also for the harmonized EU market. For a company it is very difficult to adapt its software / products to every federal legislation like here in Germany and therefore to develop products for the . And if the EU is not doing it it will be only the national level , which will help us companies not a bit.

As user, indeed...this tool for landscape data analysis really needed especially for our research students and project for soil pollution, management of lands quality and health. Thanks in advance. 👍

"we need better information on the **endowment of agricultural landscapes with semi-natural landscape features**. Thanks for your work and effort!"

It doesn't make sense to provide only the data. **The underlying method should be described in detail**. A measure for the accuracy is helpful (such as confidence intervals) and the underlying method should be validated with measured field data.

# User Survey – Summary of the results

- Majority of answers from the **Research** sector (~ 50% 27/54)
- 52 / 54 user are **missing** soil related information at the Copernicus service
- Most wanted **soil products** are:
  - SOC, texture and bulk density, soil water holding capacity, erosion, soil compaction, soil biodiversity
- Majority needs information for **monitoring yearly**
- Spatial resolution winner is **10 m pixel size**
- Spatial scale: Clear trend from **one or several fields** (35 / 54) to the European scale (11 / 54)
- Very important is to measure the quality/uncertainty: **Confidence interval** (28 / 54)

# Interactive session - User Requirements



Please go to [Menti.com](https://www.menti.com)  
and use code: 7768 9609

## Part 2

# Data products - Earth Observation-based soil information for Europe

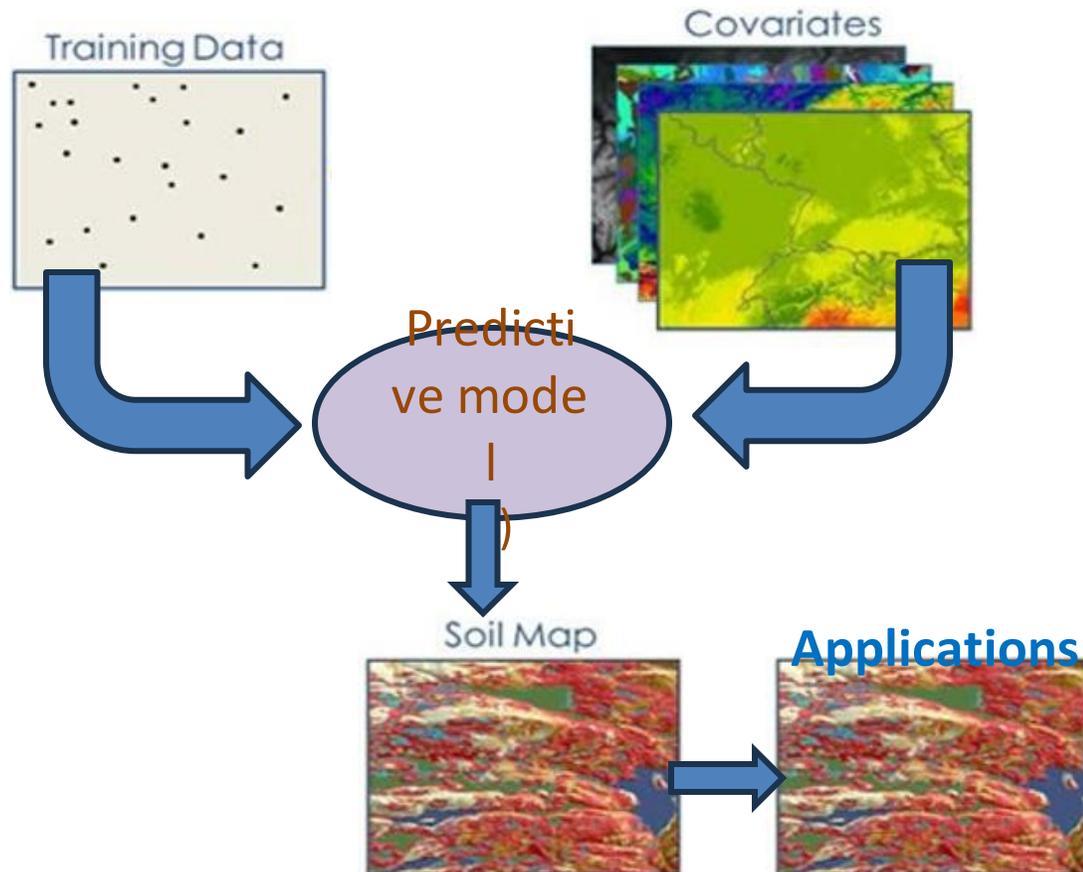


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# Earth Observation-based soil information for Europe



- **Training data:** ground observations
- **Covariates :** EO-derived data including ScMap, environmental layers
- **Predictive model:** machine learning with spatial uncertainty assessment
- **Products evaluation:**
  - Accuracy metrics
  - Uncertainty index
  - Landscape evaluation
  - Fitness for purpose



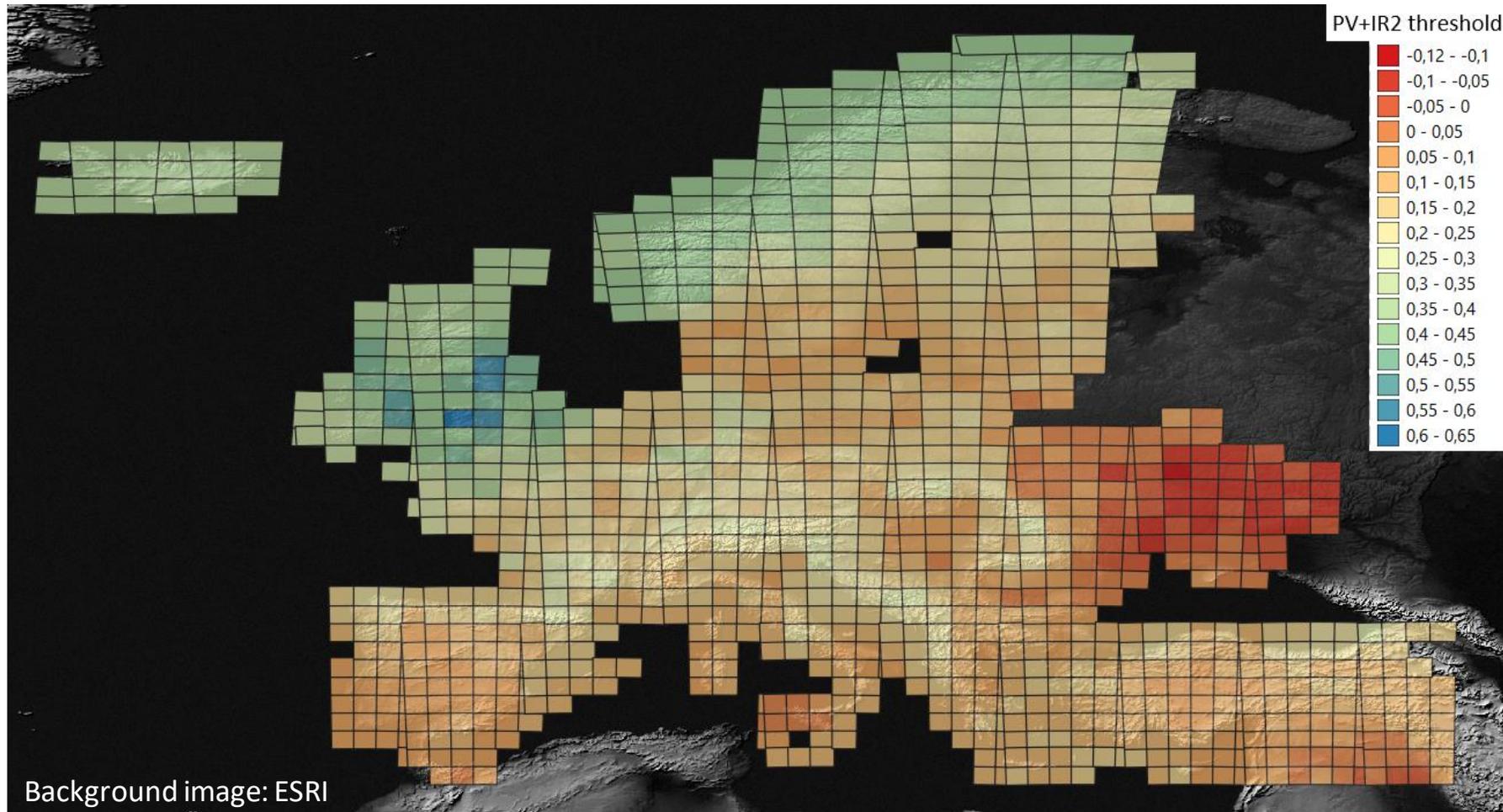
# Earth Observation-based soil information for Europe

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- Temporal composite products (SCMaP):
  - Mean reflectance composite
  - Soil reflectance composite
  - Bare soil frequency
  - Valid pixel information
- Soil properties:
  - Simple: pH, SOC, sand, silt, clay, electrical conductivity, CEC, ...
  - Derived/complex: AWC, C stocks, erosion, functional indicators, C/N
- Differences to existing products:
  - use of SCSMaP as covariates (will be made available)
  - use of more EO derived products



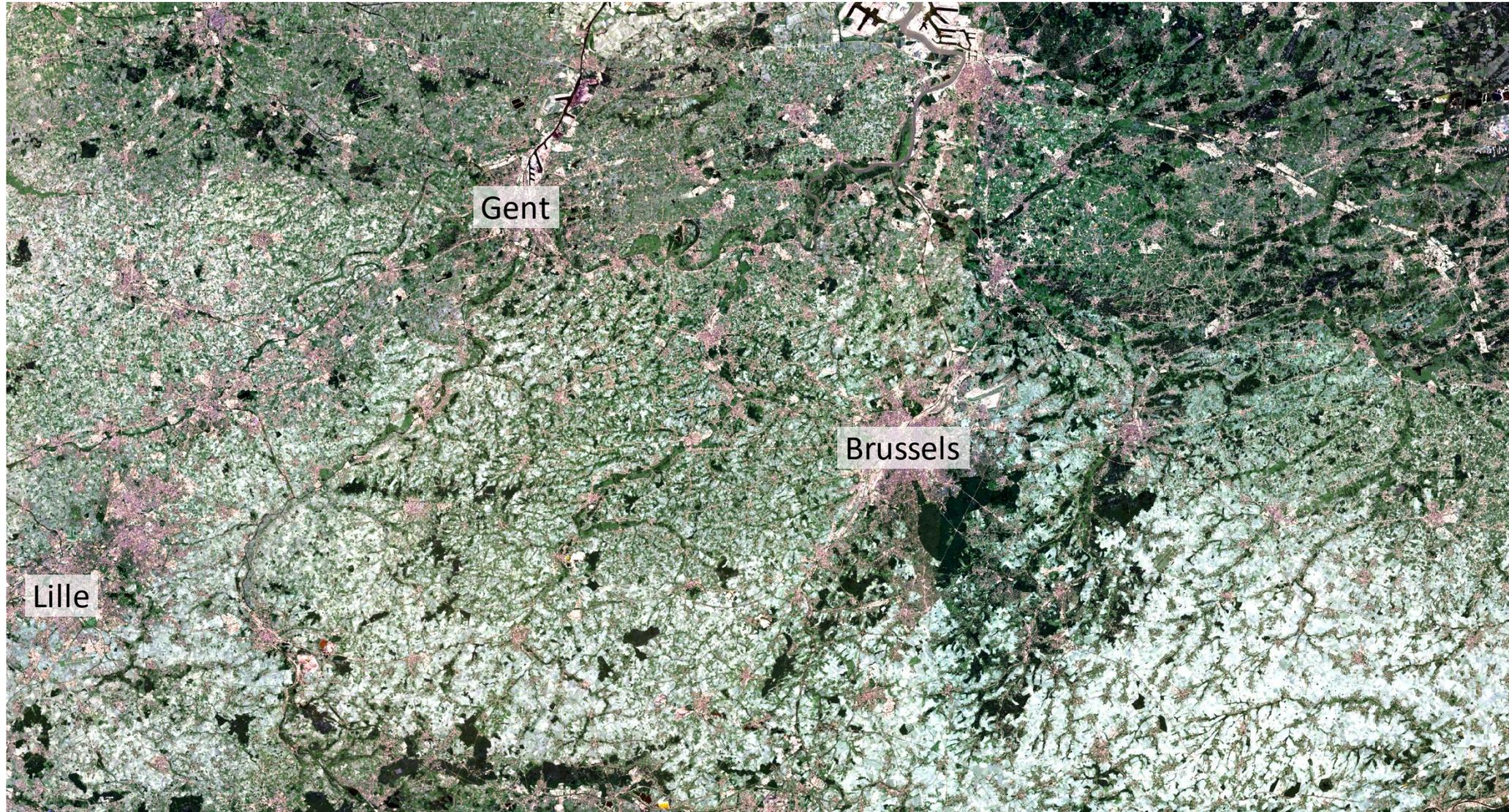
# First SCMaP examples – Bare soil selection thresholds



For bare soil selection:

- Spectral index PV+IR2:  
combines NDVI + NBR
- automated and  
regionalised threshold  
definition
- 1144 Sentinel2 tiles across  
Europe
- Derives product suite:
  - Temporal composites
  - Statistics
  - Reliability

# First examples – Belgium

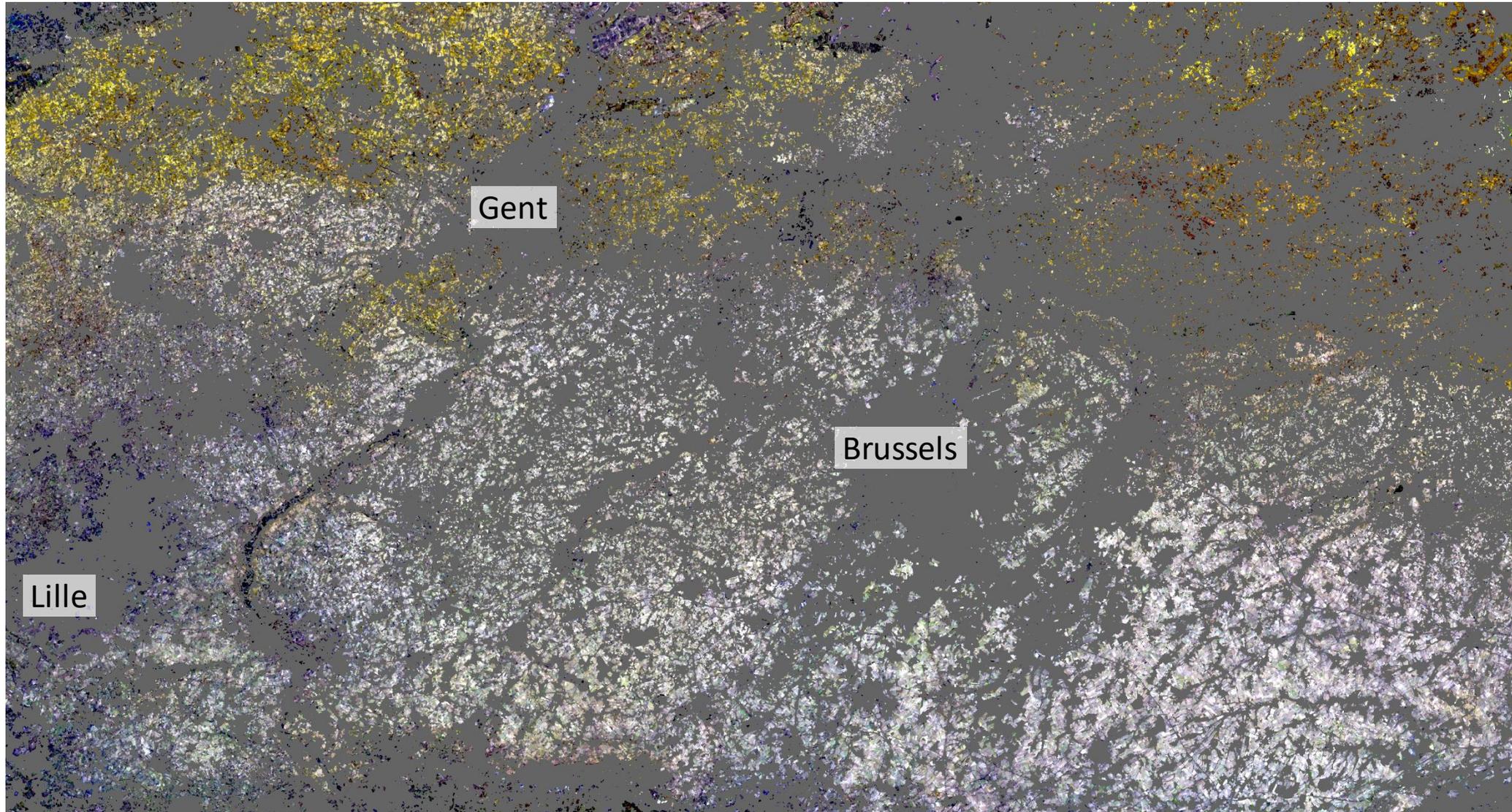


## Belgium

Mean  
Reflectance  
Composite  
(2019 – 2021)

RGB (Sentinel2):  
B4/B3/B2

# First examples – Belgium

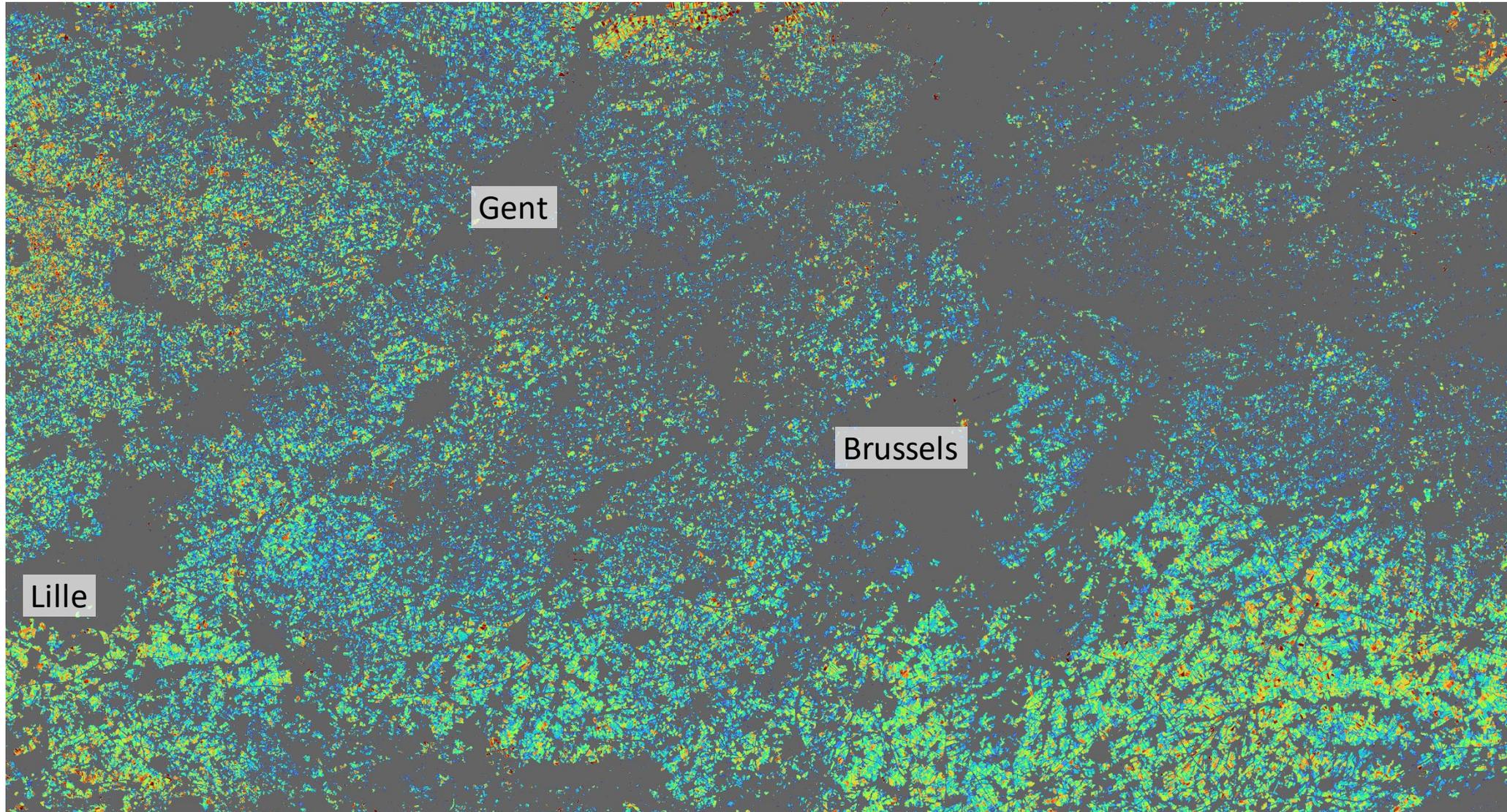


## Belgium

Soil  
Reflectance  
Composite  
(2019 – 2021)

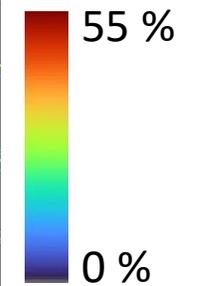
RGB (Sentinel2):  
B12/B11/B4

# First examples – Belgium

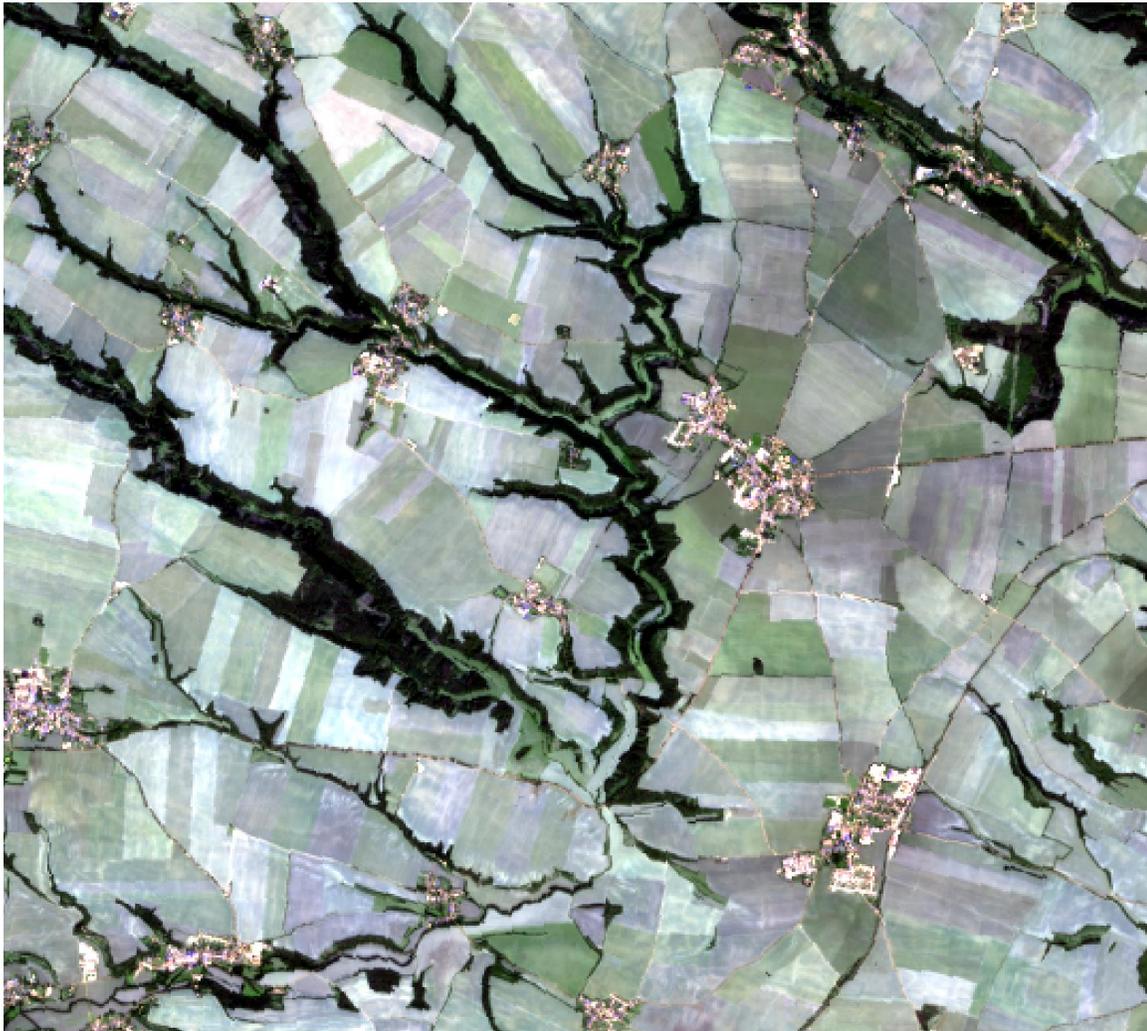


## Belgium

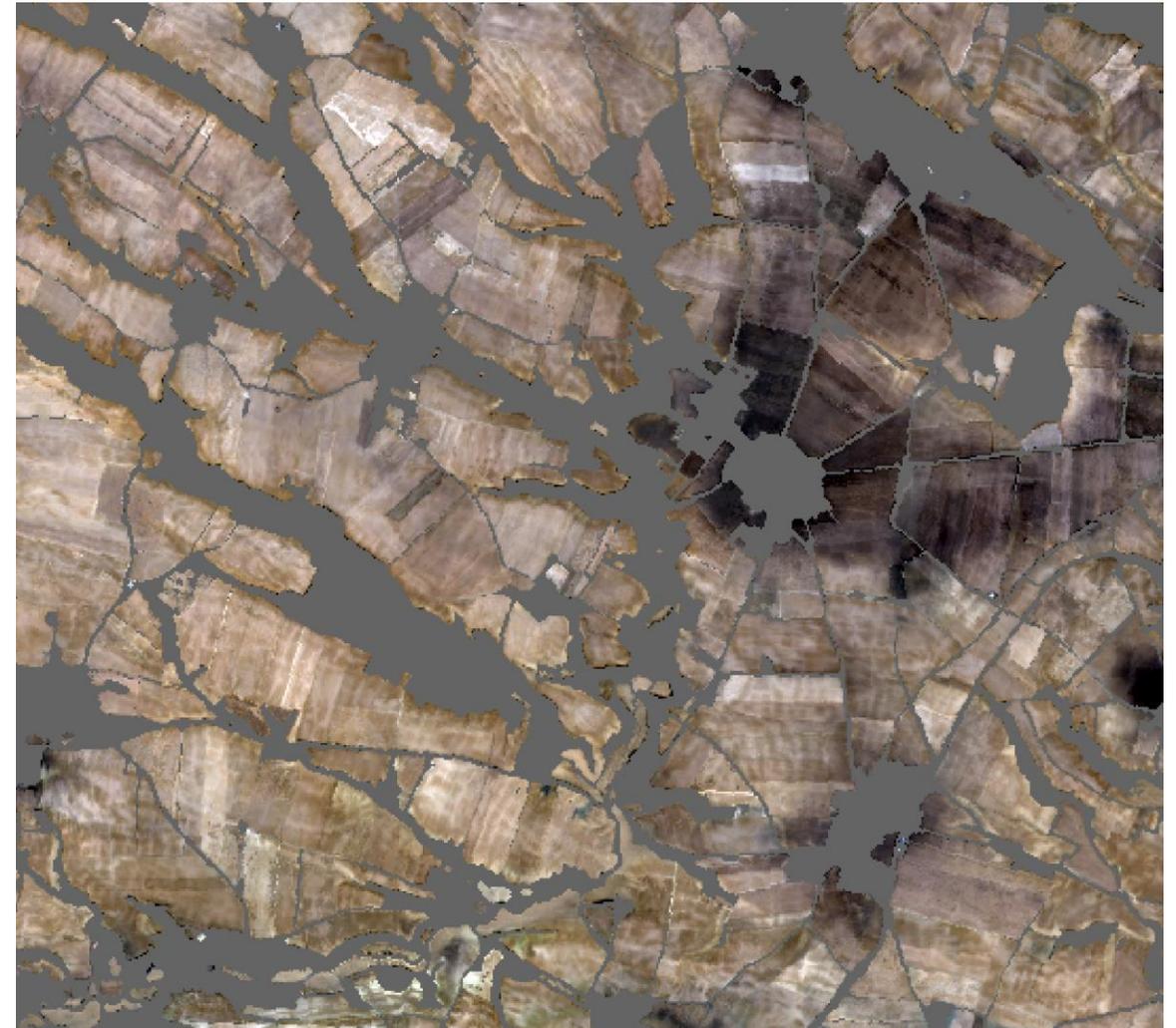
Bare  
Soil  
Frequency  
(2019 – 2021)



# First examples – Northeast of Prague (Czech Republic)



Mean Reflectance Composite (2019 – 2021)

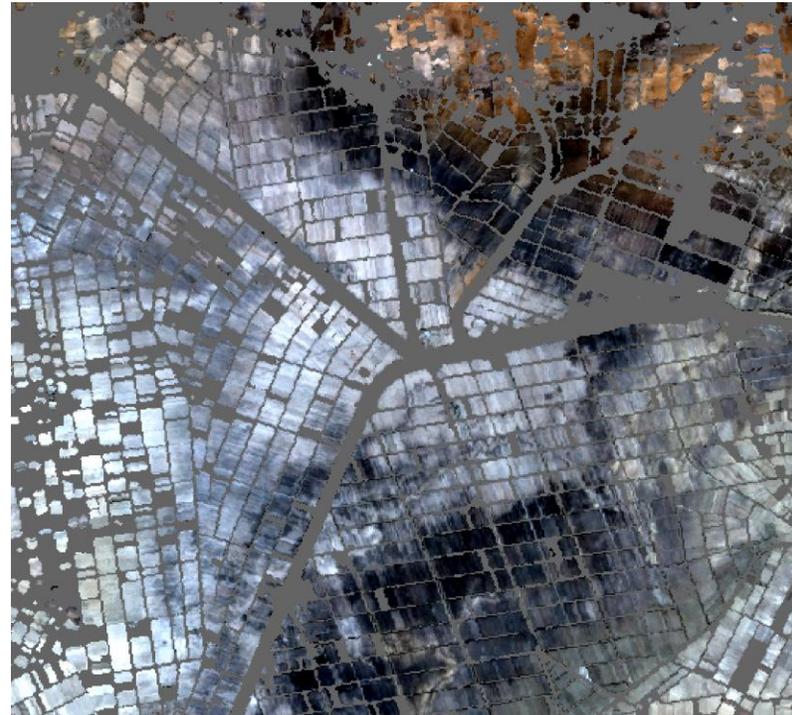


Soil Reflectance Composite (2019 – 2021)

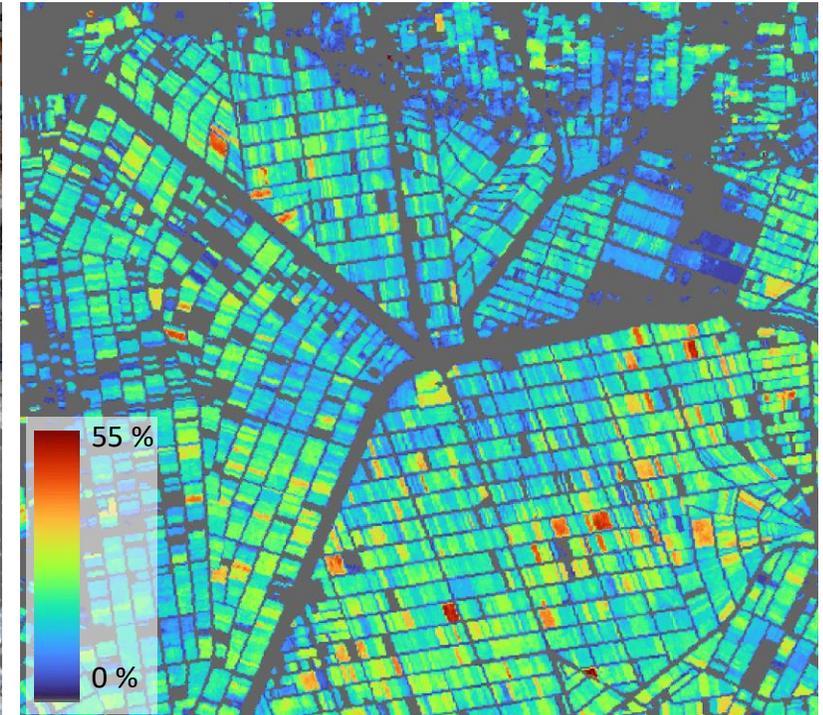
# First examples – Northwest of Thessaloniki (Greece)



Mean Reflectance Composite  
(2019 – 2021)

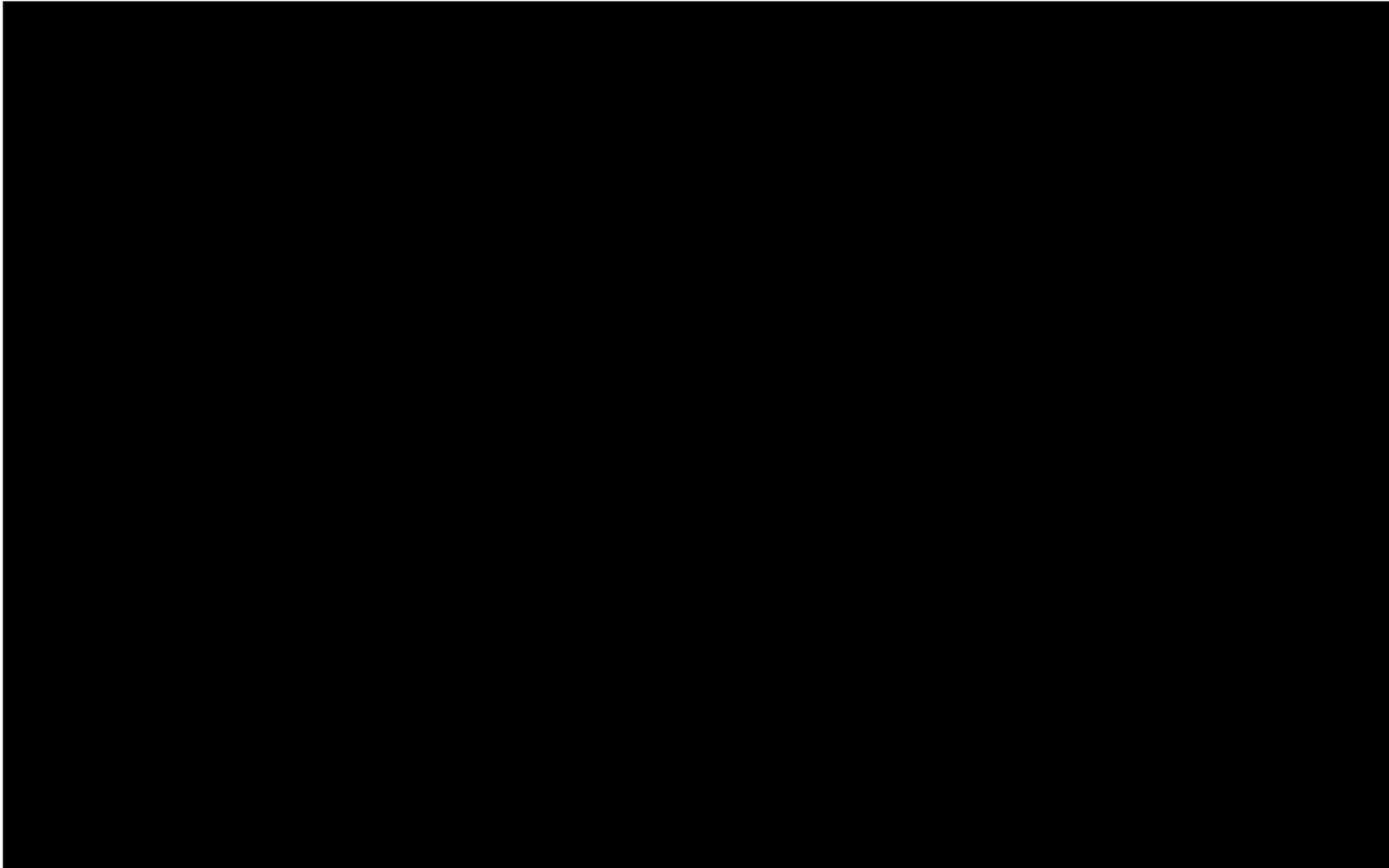


Soil Reflectance Composite  
(2019 – 2021)



Bare Soil Frequency  
(2019 – 2021)

# First examples – Bare soil selection thresholds



## Thessaloniki (Greece)

Bare Soil Frequency  
(monthly)

# Part 2

## Webpage and data policy

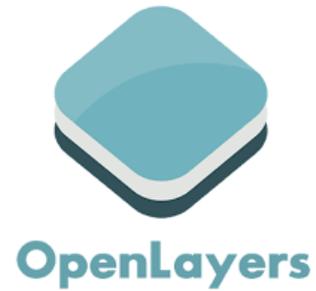


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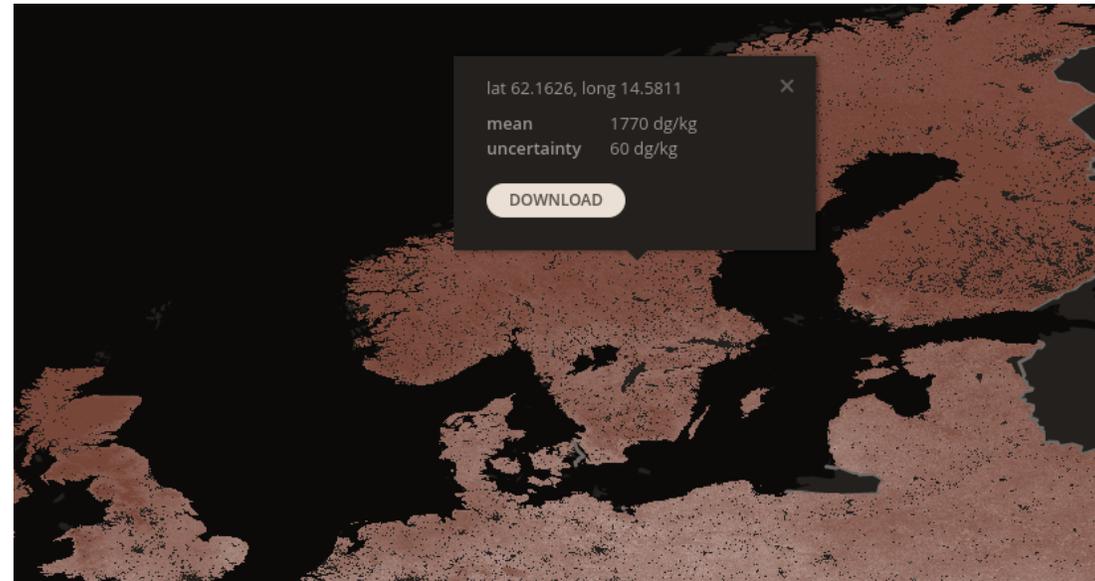
# DESCRIPTION OF COMPONENTS – FRONT END



# DESCRIPTION OF COMPONENTS – FRONT END

## Main functionalities:

- Data visualisation and inspection
- Data download

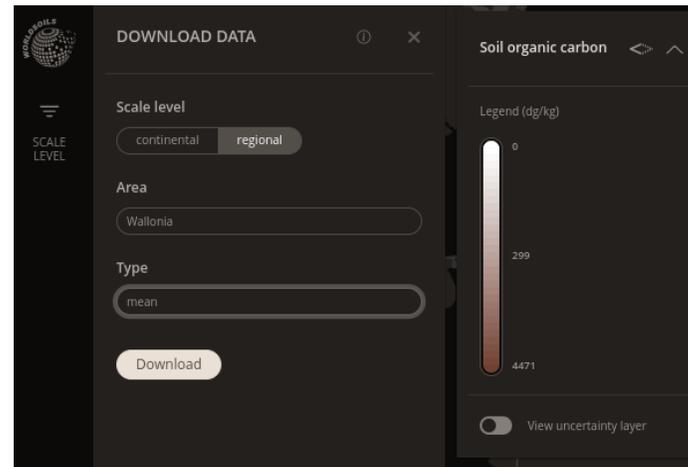


<https://gui.world-soils.com/>

# DESCRIPTION OF COMPONENTS – FRONT END

## Main functionalities:

- Data visualisation and inspection
- Data download



<https://gui.world-soils.com/>

# Data policy

- Data will follow the FAIR principles.
- Metadata will be available following OGC standards

- Final products and some intermediate products will be made public available with [CC BY-NC-SA 4.0](https://creativecommons.org/licenses/by-nc-sa/4.0/) license



# Part 2

## Interactive session on soliciting case studies



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Knowledge for Tomorrow



# Interactive session – Soliciting case studies

As an <actor>,  
I want to have/be able to <function>,  
so that I can/don't have to <business reason>.  
  
I'm satisfied (I can fulfill my application) when  
the accuracy is <% error>  
and the resolution is <m> at a minimum

As a researcher,  
I want to have a pH map at field scale,  
so that I can decide where to apply liming  
  
I'm satisfied (I can fulfill my application) when  
the accuracy is 0.5 pH point  
and the resolution is 20 m at a minimum

As a government agency,  
I want to be able to know where soil compaction occurs in my region,  
so that I can understand how much it occurs and if I need to take action  
  
I'm satisfied (I can fulfill my application) when the accuracy is within 15  
% of actual occurrence  
and the resolution is 100 m at a minimum



Please go to Menti.com  
and use code: 7768 9609

*If you are ok to be contacted for follow up questions regarding your user story, please leave your email address in the box*

# Part 2

## Next activities



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# Contact and Next Activities

- Consolidating the user requirements
- Producing European data products and publishing it on the webpage
- Organising case studies

- Next meeting:  
6.-7. March 2024



## Background

ESA is committed to monitor soils, the weathering upper surface layer of the Earth, with its key role for terrestrial life functions: plant growth, gas exchange with the atmosphere, retention of water and nutrients, in short, the habitat for organisms, a key component of terrestrial ecosystems and the source to food and timber. In July 2019 ESA hosted the *World Soils User Consultation Meeting*, followed in June 2021 by the *User Requirements Consolidation Workshop*, in the context of the WORLDSOILS project.

In the meanwhile, the EU has launched its **Soil Mission**, bringing to the forefront the role soils must play in the **Green Deal**, i.e., 75 % of soils should be healthy in 2030, and the **Paris Agreement** through *The International '4 per 1000' Initiative*, stating that **agriculture, and in particular agricultural soils, can play a crucial role in food security and climate change**.

The EU soil regulatory framework has been consolidated over the past four years, culminating on July 5<sup>th</sup> 2023, with the proposal for a Directive on Soil Monitoring and Resilience (Soil Monitoring Law), which recalls the usability of **Copernicus data** for achieving the objectives. Now, corresponds to the Earth Observation scientific community to concretise the ways EO can serve to monitor the requirements of the various soil health indicators stated in the law.

SOC is a dynamic soil property reacting to past and current land use and management procedures. The rapidly evolving capacities of orbital sensors, with unprecedented high spectral, spatial and temporal resolutions over continental areas, are an essential component for monitoring the SOC seamlessly in the context of the EU Soil monitoring Law. Moreover, SOC satellite monitoring and mapping will be one of the building blocks for a trustworthy and cost-effective reporting and verification (MRV) for carbon capture and removal.



CUP<sub>4</sub>SOIL

# Thank you very much!



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User Requirement Survey



CUP<sub>4</sub>SOIL Webpage

