CUP₄SOIL
User requirements for a Copernicus Land Monitoring Service including soils

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ESA SYMPOSIUM ON EARTH OBSERVATION FOR SOIL PROTECTION AND RESTORATION
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CUP4SOIL – Welcome and Introduction

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

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. …

Partner:
DLR and ISRIC

Funded by:
FPCUP - Framework Partnership Agreement on Copernicus User Uptake: https://www.copernicus-user-uptake.eu/
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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
   7th December 2023 – online
2. Q1/2024 – First soil information products are presented, user requirements will be updated
   6th – 7th 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
User Requirement study - First findings
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User requirements

Iterative process:

• Reviewing existing projects and initiatives
• User requirement survey
• User requirement meeting
• Feedback from case study results
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User requirements from existing projects / initiatives

- EJP SOIL (SIREN, SERENA, MINOTAUR, WP6, STEROPES)
- WorldSoils
- EEA level1
- LUCAS
- MARVIC, MRV4SOC
- ENVASSO
- EU Soil Monitoring Directive
- Status of the World's Soil Resources (GSP)
- LANDMARK
- ISQaPer
- RECARE
- BENCHMARKS, AI4SoilHealth
- PREPPOSEL
- Etc.
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Shortlist …

• When listed more than 4 times in the mentioned projects, the indicator 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)
  • Proposed EU Soil Monitoring Directive (16/18)
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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)
• Results presented here and in report
• Presentation of the status February/March 2024
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User Requirement Meeting

• 2 hour workshop on 7 December 2023

• 148 registered participants - 80 real participants

What best describes your organisation?
User survey

2. What best describes your organization?

- National government: 23
- European / international organization: 3
- Business: 10
- Research: 39
- Education: 6
- NGO: 2

83 responses so far

Partitioning across sectors is quite similar to the workshop participation partitioning.

Majority of participants from Europe, also some from all other continents.
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User Survey - Workshop

What are the main topics your organisation is working on?

- Agriculture: 54
- Soils: 69
- Biodiversity / Nature conservation: 33
- Climate Change: 41
- Land and water resources: 48
- Energy, raw materials: 11
- Earth Observation: 38
- Urban areas: 9
- Other: 6

Same top four
Which soil-related spatial information would be helpful for your work (basic soil properties)?

- Soil organic carbon / Soil organic matter: 81
- Soil acidity (pH): 56
- Total Nitrogen: 52
- Phosphorus available: 48
- Texture (clay, silt, sand content): 74
- Bulk density: 63
- Electrical Conductivity (EC): 44
- Heavy metals (concentration): 37
- None of them: 0

Same prioritisation
Which soil-related spatial information would be helpful for your work (derived/complex properties)?

- Soil water holding capacity: 69
- Erosion rate / Erosion risk: 61
- Salinity: 43
- Soil biodiversity (soil basal res...: 56
- Soil sealing / Land take: 37
- Soil contamination: 37
- Soil compaction: 59
- None of them: 4

Same top three
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User Survey – Familiarity with Copernicus

4. Do you know about the Copernicus Land Monitoring service?
   - Yes: 66
   - No: 17

5. Have you used the Copernicus Land Monitoring service before?
   - Yes: 41
   - Yes, but it is a long time ago: 14
   - No: 28

6. Have you used Copernicus Earth Observation data (e.g. Sentinel missions, Contributing mission) before?
   - Yes: 59
   - No: 10
   - No, but I would like to learn more: 14

7. Have you used Copernicus in-situ data before?
   - Yes: 19
   - No: 32
   - No, but I would like to learn more: 32
8. Does soil health and/or soil quality fall into your area of expertise?
- Yes: 74
- No: 2
- No, but I would like to learn more: 7

9. Are you missing soil-related information at the Copernicus Land Monitoring Service?
- Yes: 54
- No: 2
- Maybe: 27

10. How would you rate the usefulness of future soil products under the Copernicus land monitoring service?
- Very useful, regardless how they are presented: 34
- Depends on the products: 47
- I will not use it: 2
What is your preferred spatial resolution you are working on (in pixel sizes)?

- 10 m: 68
- 20 m: 31
- 50 m: 18
- 100 m: 18
- 250 m: 11
- 1 km: 11
- Other: 4

Finer resolutions are always desirable, but what are the coarsest resolutions that would still work for your use? (with accuracy matching resolution)

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

- Spatial pattern should make sense, no absolute accuracy necessary: 34
- Correct quantitative values necessary: 49
17. Which scale is your organization working on?

- One or several fields: 50
- Landscape/watershed/soil hea...: 46
- Subnational regions: 41
- Countries: 33
- Europe: 15
- Other: 6
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User Survey – Update frequency

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

- Yearly: 41
- 2 years: 5
- 3 years: 7
- 5 years: 4
- I need products in near-real time: 17
- Other: 9

If it is not feasible or meaningful to make yearly or near-real time updates to the products, is a longer (5/10 years) update period still useful?

14. For which purpose do you need the soil information?

- Status (once): 22
- Status (several times): 51
- Monitoring: 64
- Other: 6

Yes: 37
No: 4
User Survey – Update frequency

Why do you need yearly or near real time updates? (eg. CAP, land management, MRV, national or EU regulations, other)

38 responses
User Survey – Uncertainty measure

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

Same top three
20. What would be your preferred data format?

- Cloud-optimised GEOTIFF: 77
- Other: 13

21. What would be your preferred access?

- Mapviewer: 32
- Data download via ftp: 46
- Webservices (WMS, WCS, WPS...): 43
- API: 35
- Other: 4

What would be your preferred access?
Which soil-related spatial information is not listed before?

- exchangeable bases
- soil infiltration rate
- nitrogen mineralization
- drainage class
- soil fertility evolution
- soil cover
- bearing capacity
- soil moisture capacity
- soil management
- pedodiversity
- agricultural index/quality value
- water table
- smart farming
- fertility depth
- base saturation
- lithology
- infiltration capacity
- carbonates
- surface temperature
- compaction risk
- biomass inputs to the soil
- soil color
- soil classification
- soil density
- soil use
- soil roughness
- soil moisture
- coarse fragments
- pH
- CEC
- soil organisms activities
- water ponding
- soil type
- stone content
- acid soil
- indirect soil management
- soil depth
- soil mineralogy
- soil horizon depths
- compacted layers
- stone fraction
- soil properties to depth (>30 cm) principally soil carbon
- Q/I parameters
- indirect plant indicators
- SOC sequestration
- related to vegetation cover and vigor
- agricultural practices
- soil depth to C horizon
- carbon stocks

Mineralogy
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User Survey – Summary of the results

• Up to half of the answers are from the Research sector
• Copernicus products are well known and used (59/83), in situ products less (19/83), Land Monitoring Service is well known (61/83), but less recently used (41/83)
• 54 / 83 users are missing soil related information at the Copernicus service
• Most wanted soil products are:
  o SOC, texture and bulk density, soil water holding capacity, erosion, soil compaction, pH, soil biodiversity
• Soil moisture, soil depth, carbonates, mineralogy
• Spatial patterns are useful but quantitative correct values are more important
• Majority needs information for monitoring yearly, but if not possible less often is still useful. Purposes are MRV, monitoring, CAP
• Spatial resolution winner is 10-20 m pixel size, but coarser pixel sizes are still useful
• Various ways of access to cloud-optimised geotiff’s is desirable
User requirements

User stories

As an actor, I want to have/be able to function, so that I can/don’t have to business reason.

As a paying agency officer, I want to have soil erosion layer for CAP compliance at field level of 10 meter resolution.

As a sustainable water management company, I want to provide accurate water balance information at a parcel scale, so that farmers can manage water usage in a sustainable way for irrigation.

As an ag-tech company, I want to be able to use soil texture and SOM to generate seeding maps. So, a good data layer for the farmers. I'm satisfied when the accuracy is 0.5% (SOM) at 10 m.

As a researcher, I want to predict SOC to be used for providing maps and plans for farmers at regional and national level in cooperation with governments. I'm satisfied with 20 m resolution and 10% error.

As a company that gives a economic rewards to farmers who try to increase the carbon content, we want to be able to track changes in the soil carbon content to reduce sampling costs.

The resolution is not so much the question, the question is how valid, how accurate is the model.
Thank you very much!

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Discussion questions

• Accuracy versus resolution? What is good enough for which purpose?
• What is useful/feasible in update frequency?
• Which user stories/applications are we missing?
What best describes your organisation?

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<thead>
<tr>
<th>National government</th>
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CUP4SOIL - Thank you very much!
Contact: [email]