CUP4SOIL
High-resolution product presentation and data access

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ESA SYMPOSIUM ON EARTH OBSERVATION FOR SOIL PROTECTION AND RESTORATION
07.02.2024

Introduction

CUP4SOIL general objective

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. …

- Intermediate SCMaP soil products
- Current possibility of EO-based soil parameter
- Deviations from user requirements

- Data package to “play around”
- Develop show cases

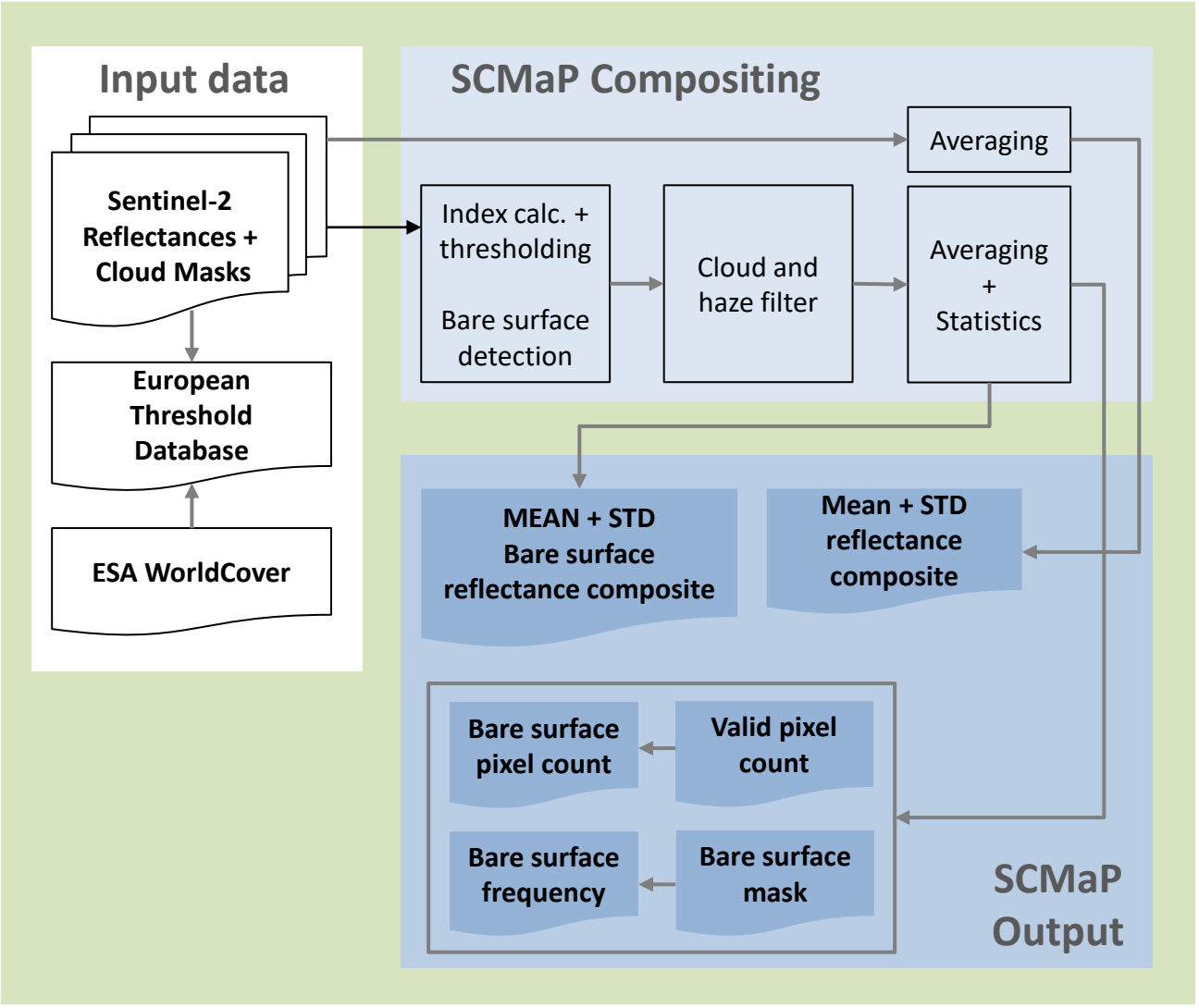
Introduction

CUP4SOIL and WorldSoils

	WorldSoils (ESA)	CUP4SOIL (EU - FPCUP)
Lead	GMV	DLR
Main objective	Development of a pre-operational system for SOC monitoring	Prepare future soil products within the Copernicus Land Monitoring Service (CLMS)
Soil parameter	SOC content	SOC content pH, bulk density, nitrogen, texture, coarse fragments, … (maybe more)
Soil prediction model	Spectral soil mapping (bare soil) Digital soil mapping (vegetated areas) -> Including SCMaP products	Digital soil mapping (all areas) -> Including SCMaP products
Spatial resolution	50 m (Europe) 100 m (Global)	20 m (Europe)
Spatial coverage	Europe	Europe +
Sentinel-2 L2A input data	Sen2Cor	MAJA

Methodology

General overview



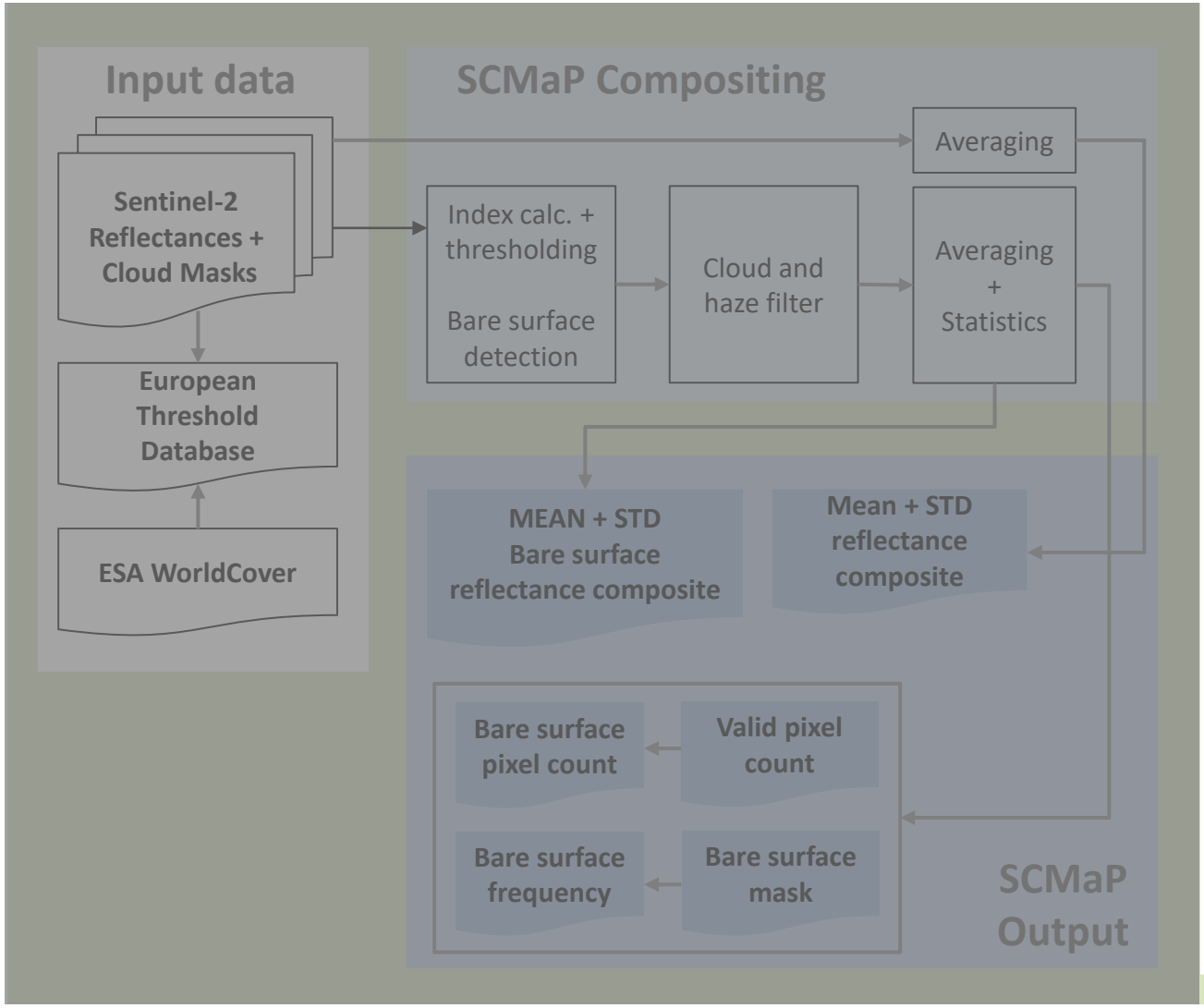
- All Sentinel–2 images in L2A format -> processed with MAJA from 2018 – 2022
- Larger Europe including Ukraine
- Spectral Index based (e.g. Diek et al. 2017, Rogge et al. 2018, Demattê et al., 2018)
- Used index: PV+IR2 (Heiden et al. 2022, Möller, M. et al. 2022, Dvorakova, K., et al., 2023)

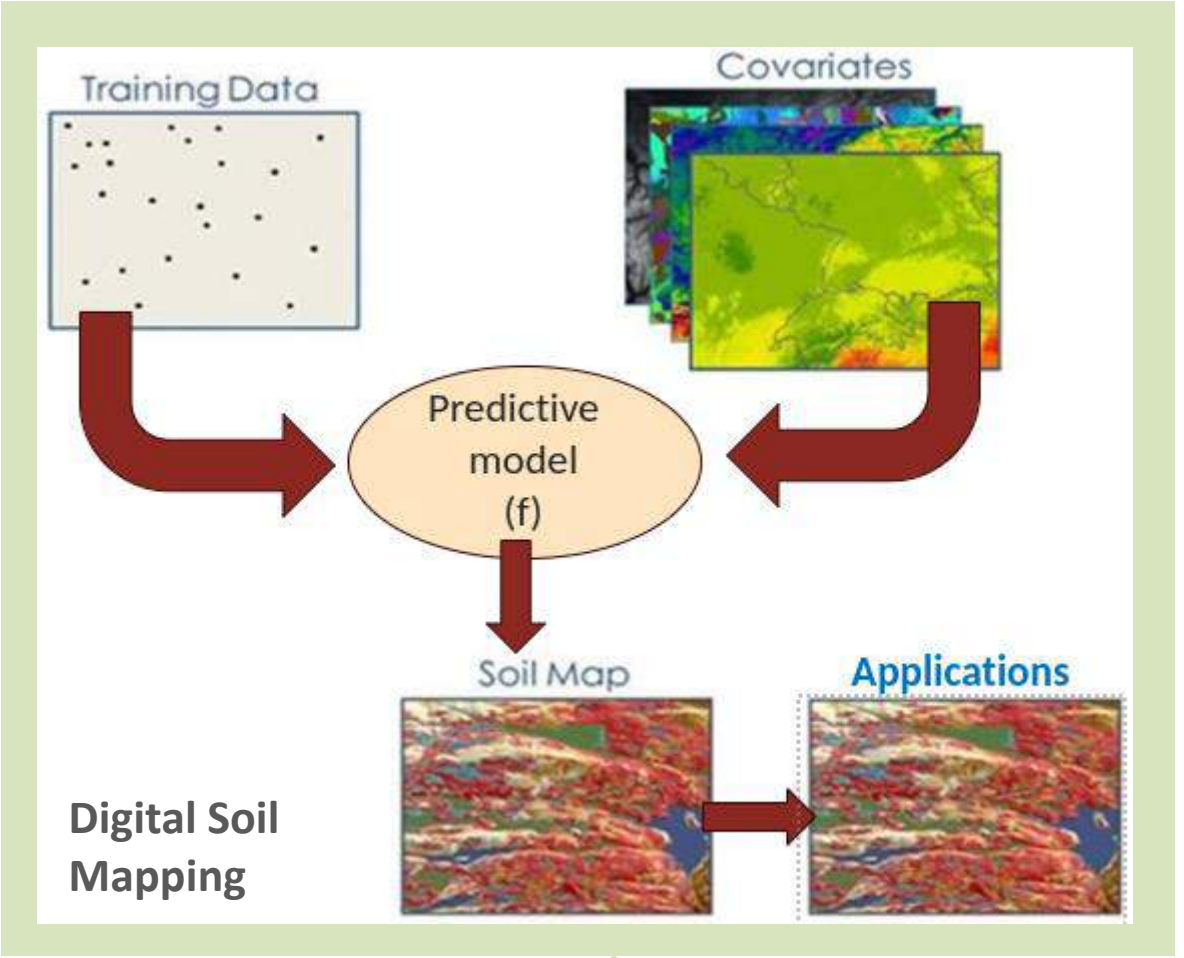
$$PV+IR2 = \frac{B8 - B4}{B8 + B4} + \frac{B8 - B12}{B8 + B12}$$

- Regionalised thresholds (Karlshöfer et al., in preparation)
- 5-years composite products

Methodology

General overview



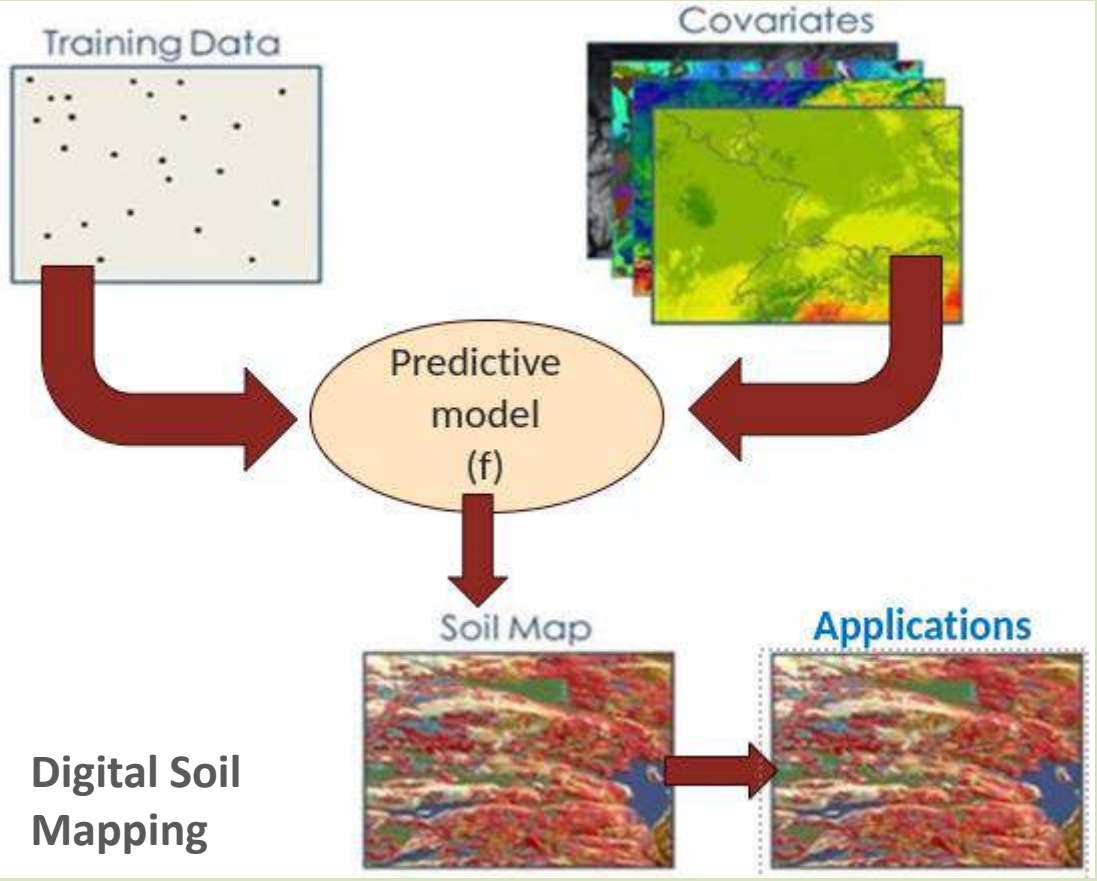


Methodology

Digital Soil Mapping – some notes

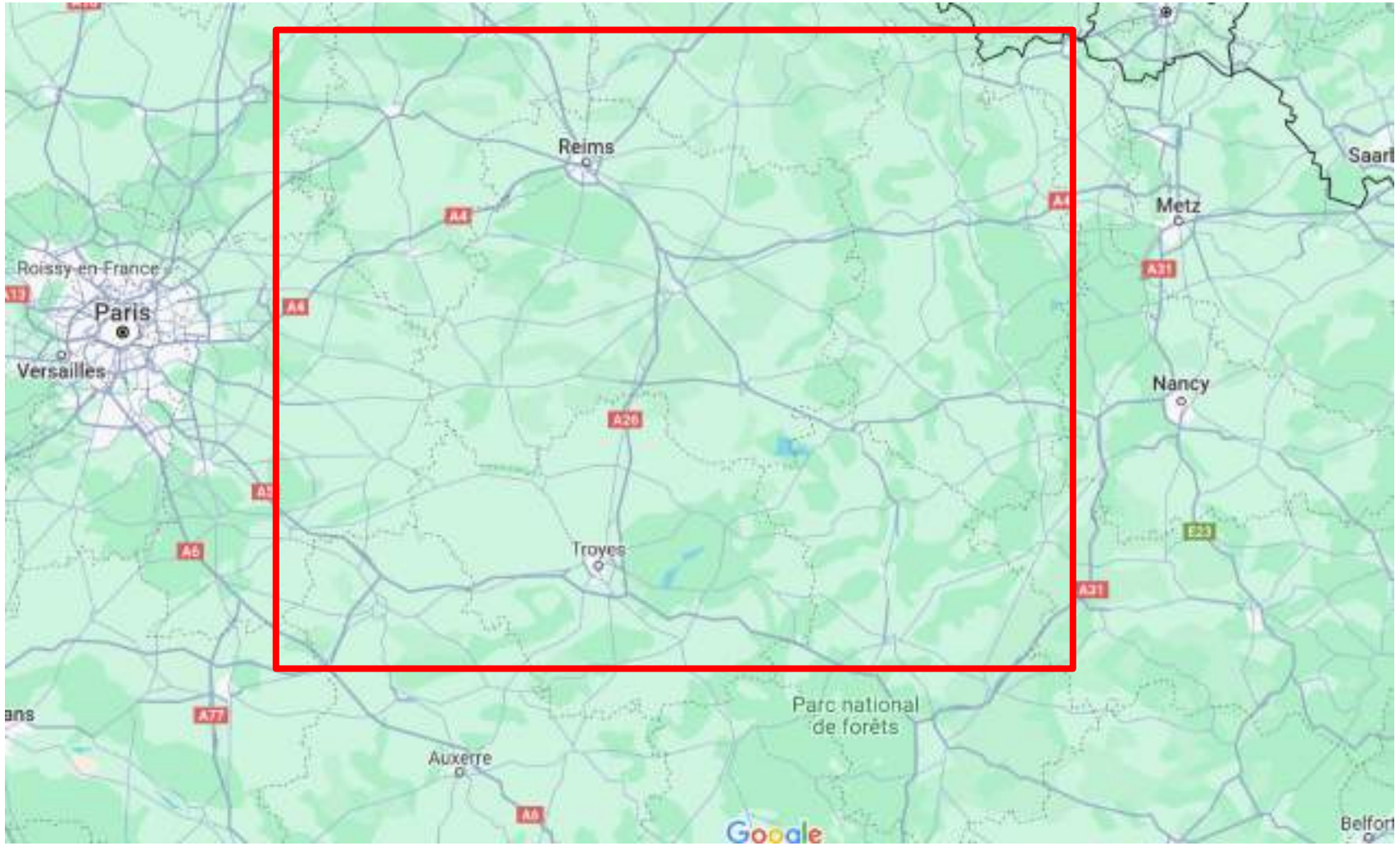
- Input data from LUCAS (and other sources in WoSIS if relevant)
- Covariates:
  - Data prepared by DLR
  - Data available from Copernicus (DEM, land cover)
  - Geology/parent material (JRC)
  - Simple radar products from Sentinel1

- Model: quantile random forest (robust approach allowing pixel-based uncertainty assessment)
- Outputs:
  - Primary soil properties
  - Uncertainty index
  - Other uncertainty measures (to be further developed)



Example Data

France

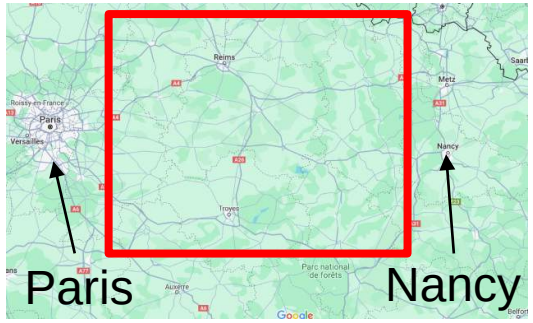


Example France

SCMaP products

Mean Surface Reflectance

- Sentinel-2
- L2A reflectance (MAJA processed)
- 2018 – 2022

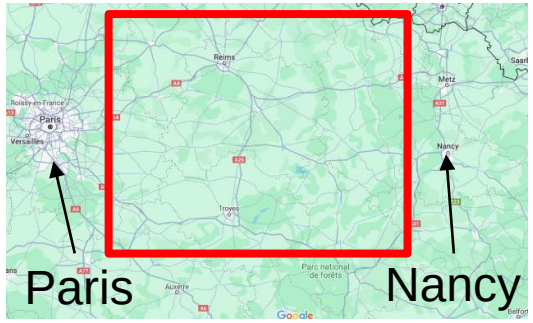


Example France

SCMaP products

Mean Surface Reflectance – Standard deviation

- Sentinel-2
- L2A reflectance (MAJA processed)
- 2018 – 2022

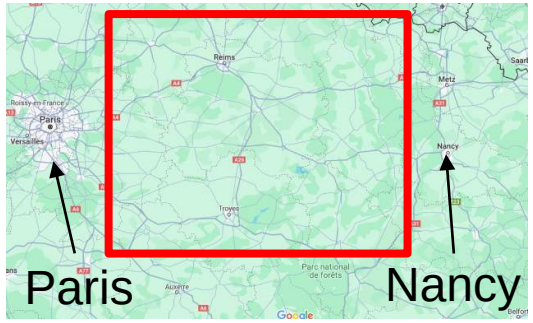


Example France

SCMaP products

Bare Soil/Surface Reflectance –

- Sentinel-2
- L2A reflectance (MAJA processed)
- 2018 – 2022
- PV+IR2
- Regionalised thresholds



Example France

SCMaP products

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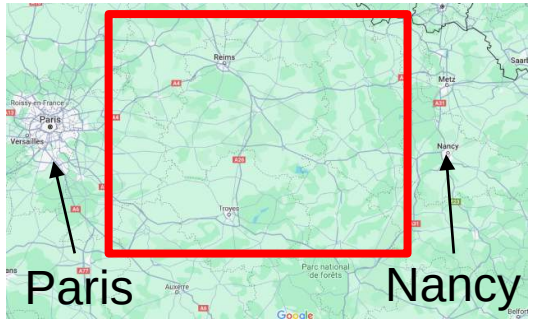
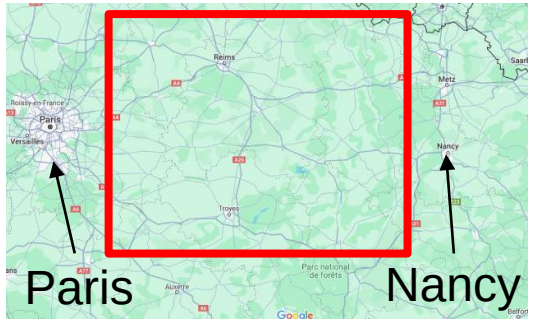


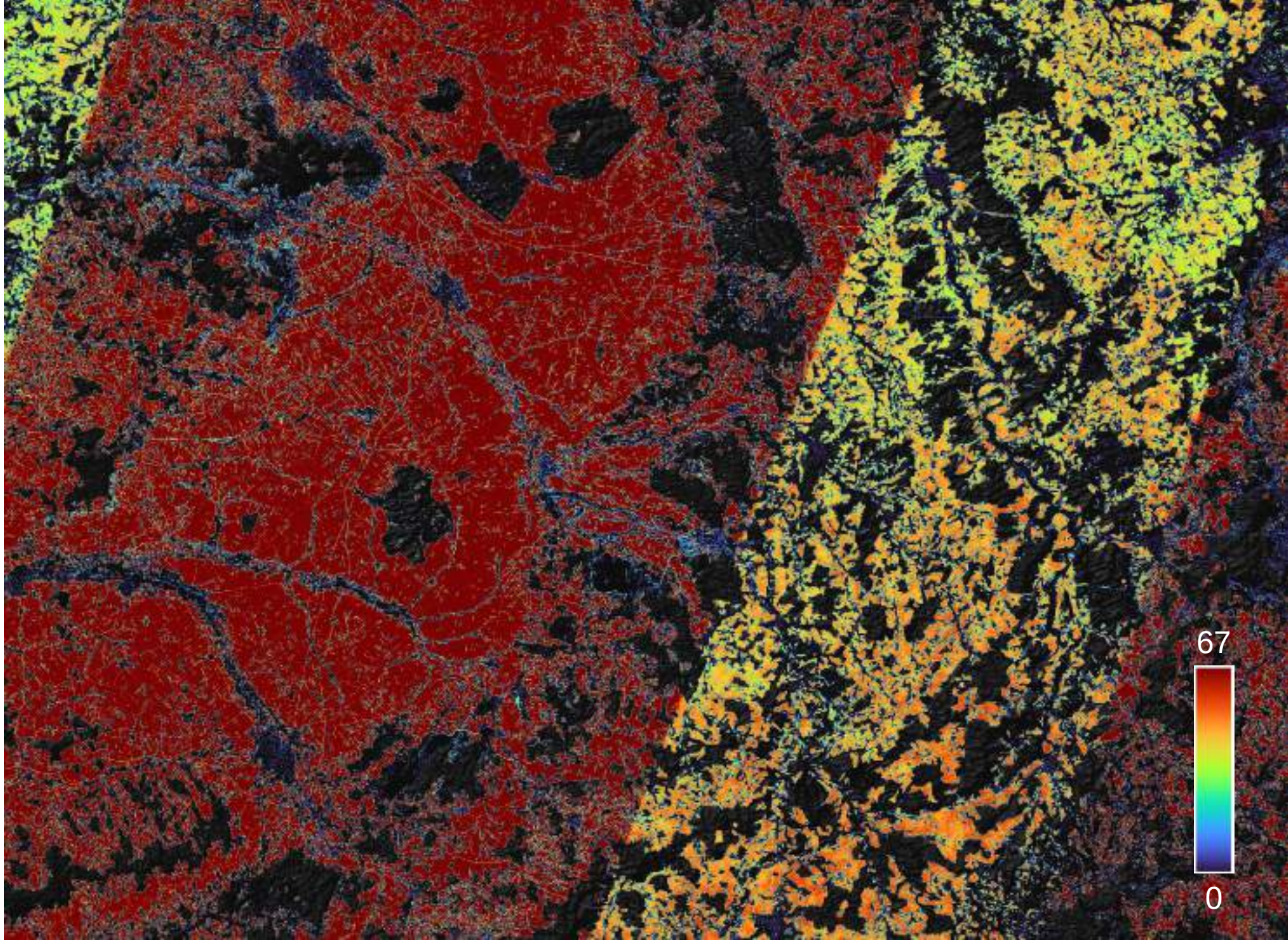
Example France

SCMaP products

Valid Pixel Count

- Sentinel-2
- 2018 – 2022



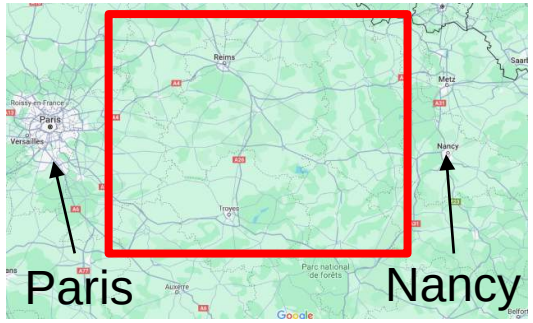


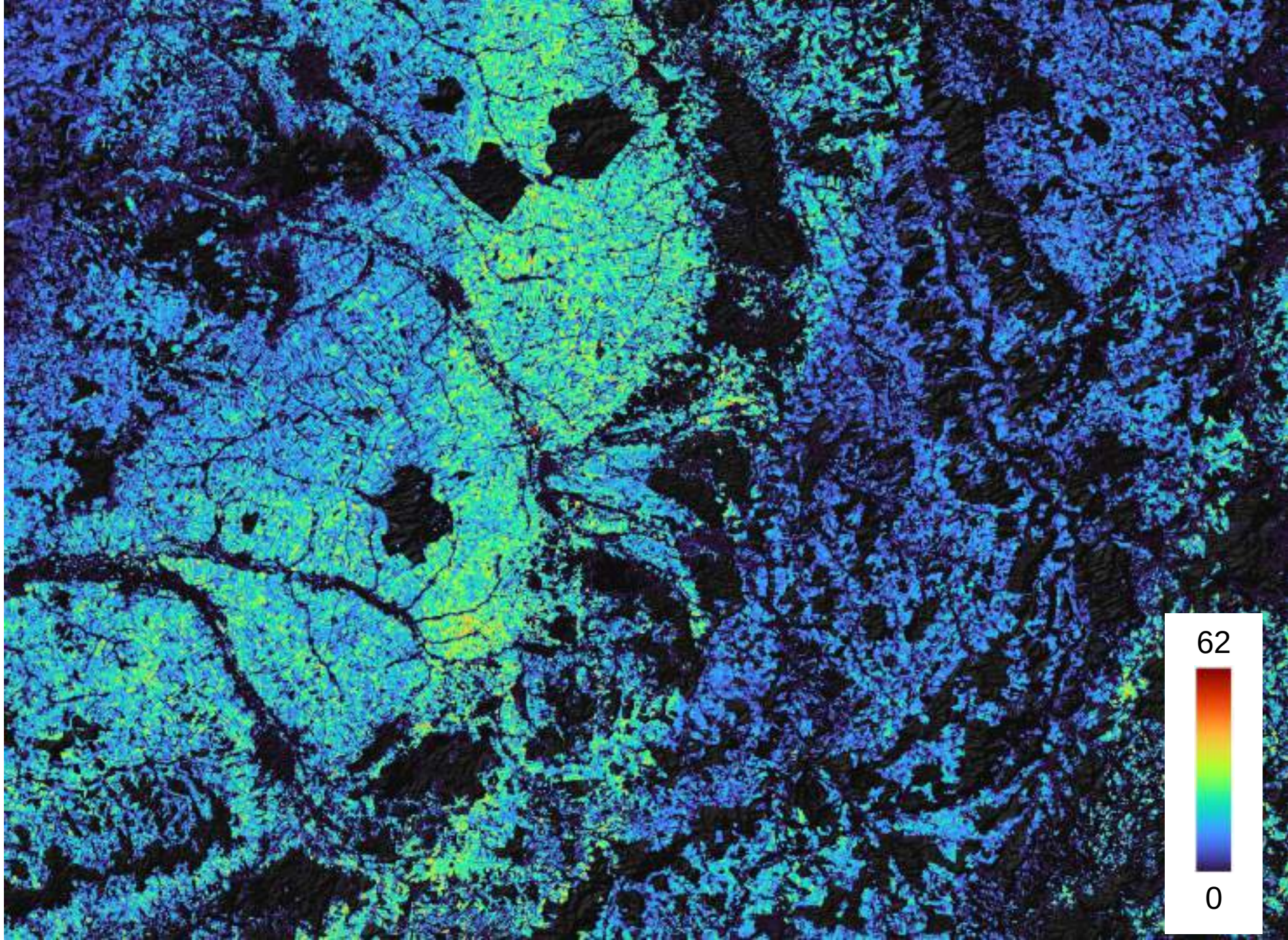
Example France

SCMaP products

Bare Soil
Pixel Count

- Sentinel-2
- 2018 – 2022
- PV+IR2
- Regionalised thresholds



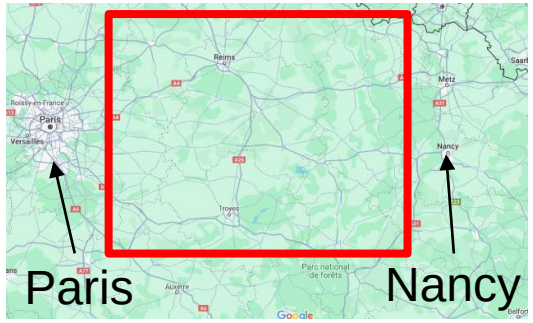


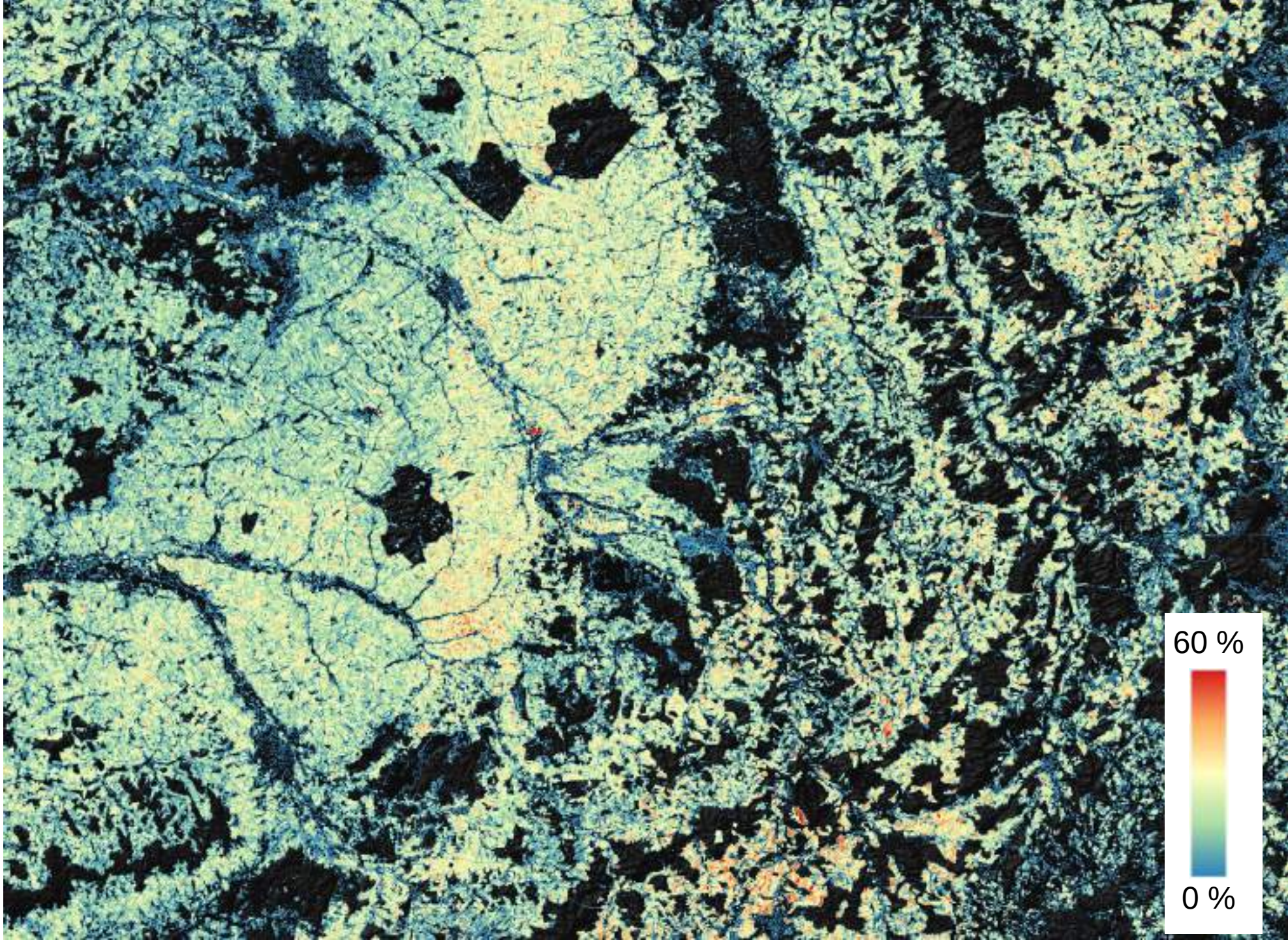
Example France

SCMaP products

Bare Soil Frequency [%]

- Sentinel-2
- 2018 – 2022
- PV+IR2
- Regionalised thresholds



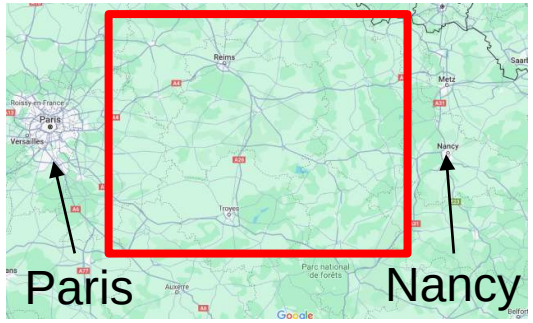


Example France

Soil parameter

Soil Organic Carbon Content

- Topsoil - 0-30cm
- g/kg*10



SOC [g/kg*10]

2500

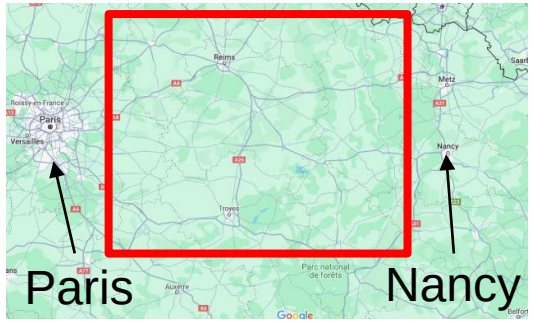
0

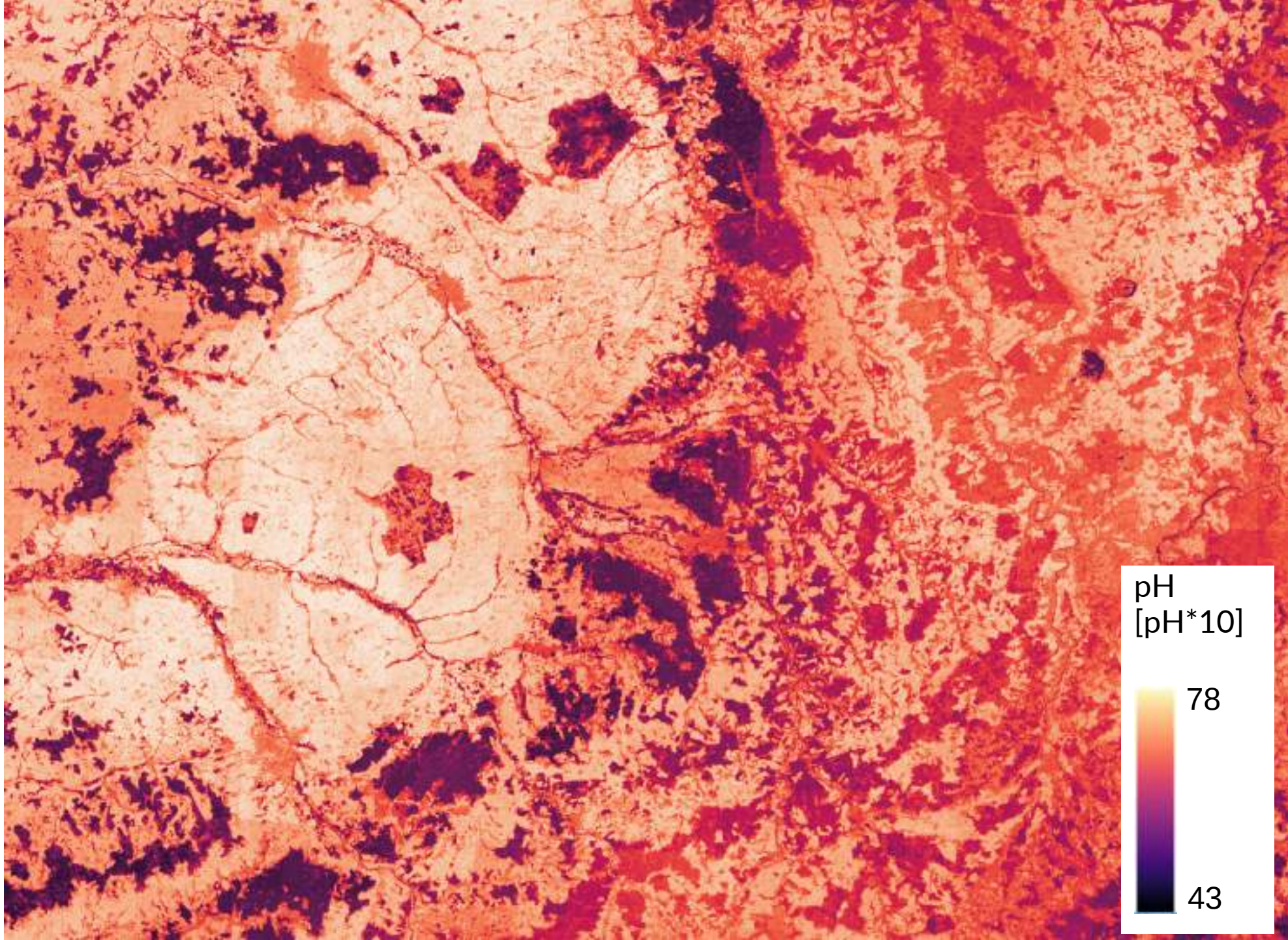
Example France

Soil parameter

pH in water

- Topsoil - 0-30cm
- pH*10



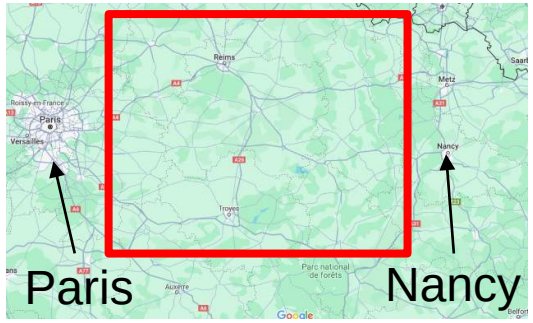


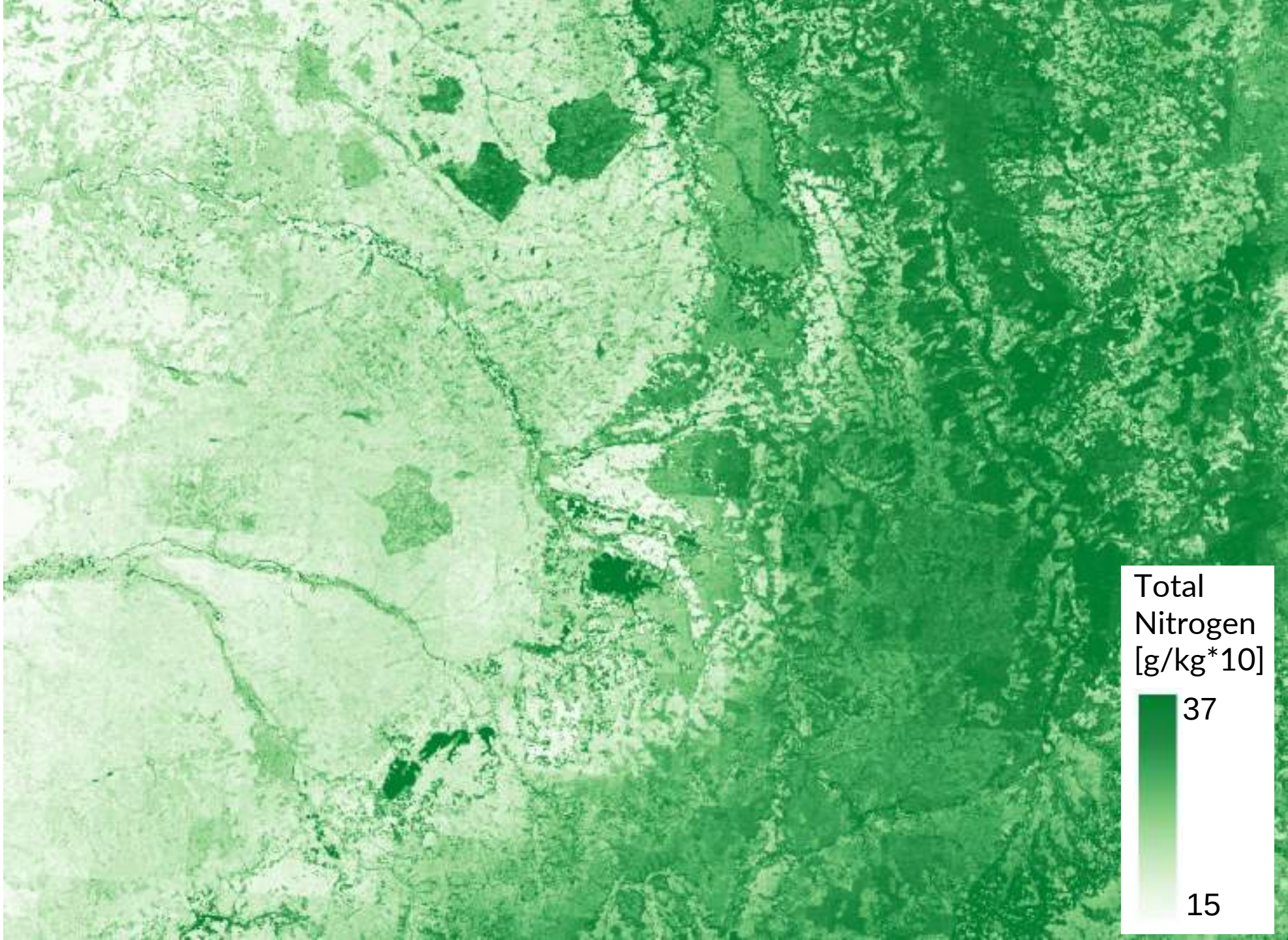
Example France

Soil parameter

Total Nitrogen

- Topsoil - 0-30cm
- [g/kg*10]



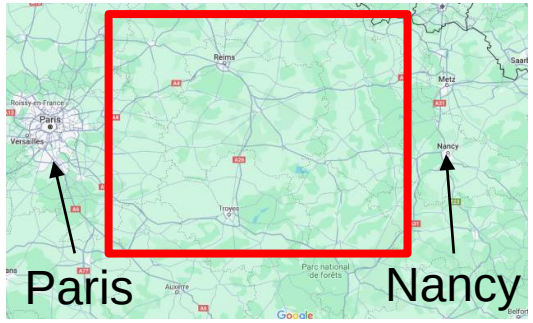


Example France

Soil parameter

Bulk density, oven dry

- Topsoil - 0-30cm
- [kg/dm^3]



Bulk Density [kg/dm^3]

140

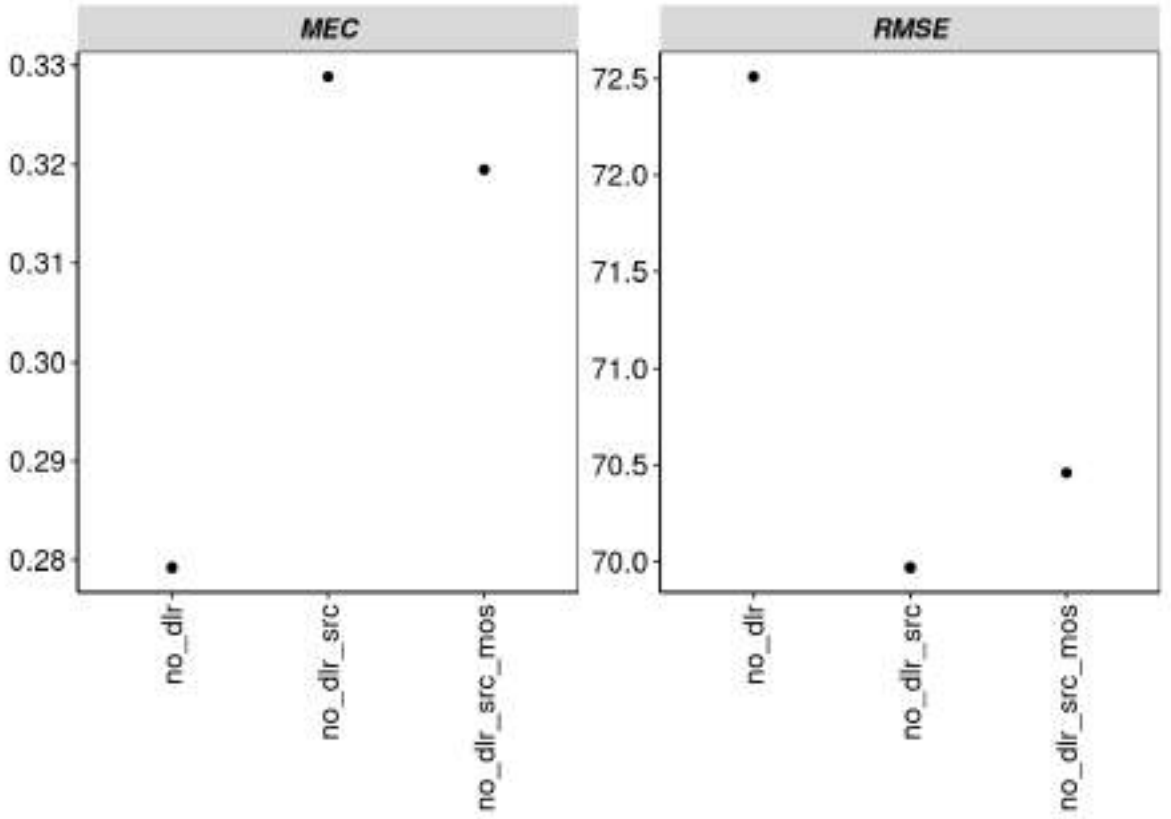
80

Intermediate products

Cross-validation - SOC

Used covariates at the X-Axes:

Groups (x-axes)	Description
no_dlr	All covariates excluding DLR/SCMaP products
no_dlr_src	All covariates excluding DLR/SCMaP covariate: Soil Reflectance Composite
no_dlr_src_mos	All covariates excluding DL/SCMaP covariates using the mosaic of MREF and SRC and SRC itself



Intermediate products

Cross-validation – pH (water)

Used covariates at the X-Axes:

Groups (x-axes)	Description
no_dlr	All covariates excluding DLR/SCMaP products
no_dlr_src	All covariates excluding DLR/SCMaP covariate: Soil Reflectance Composite
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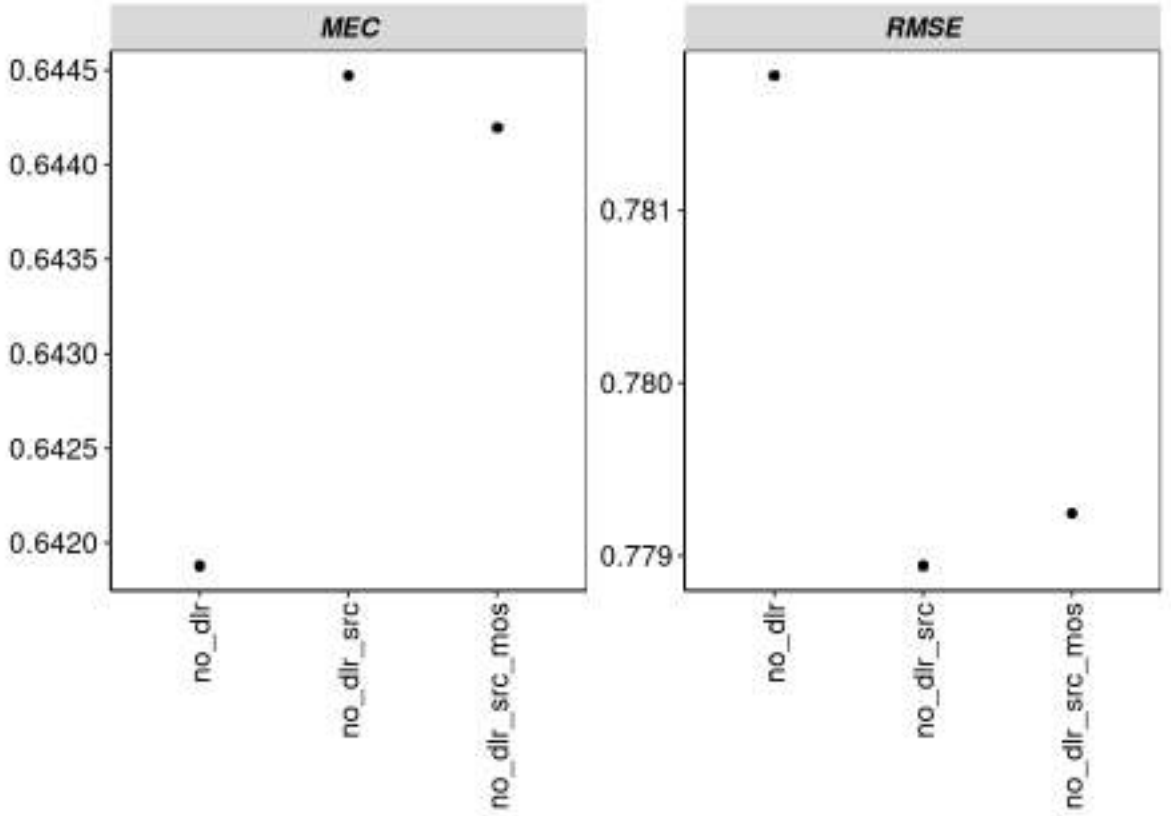

Intermediate products

Cross-validation – bulk density (oven dry)

Used covariates at the X-Axes:

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no_dlr	All covariates excluding DLR/SCMaP products
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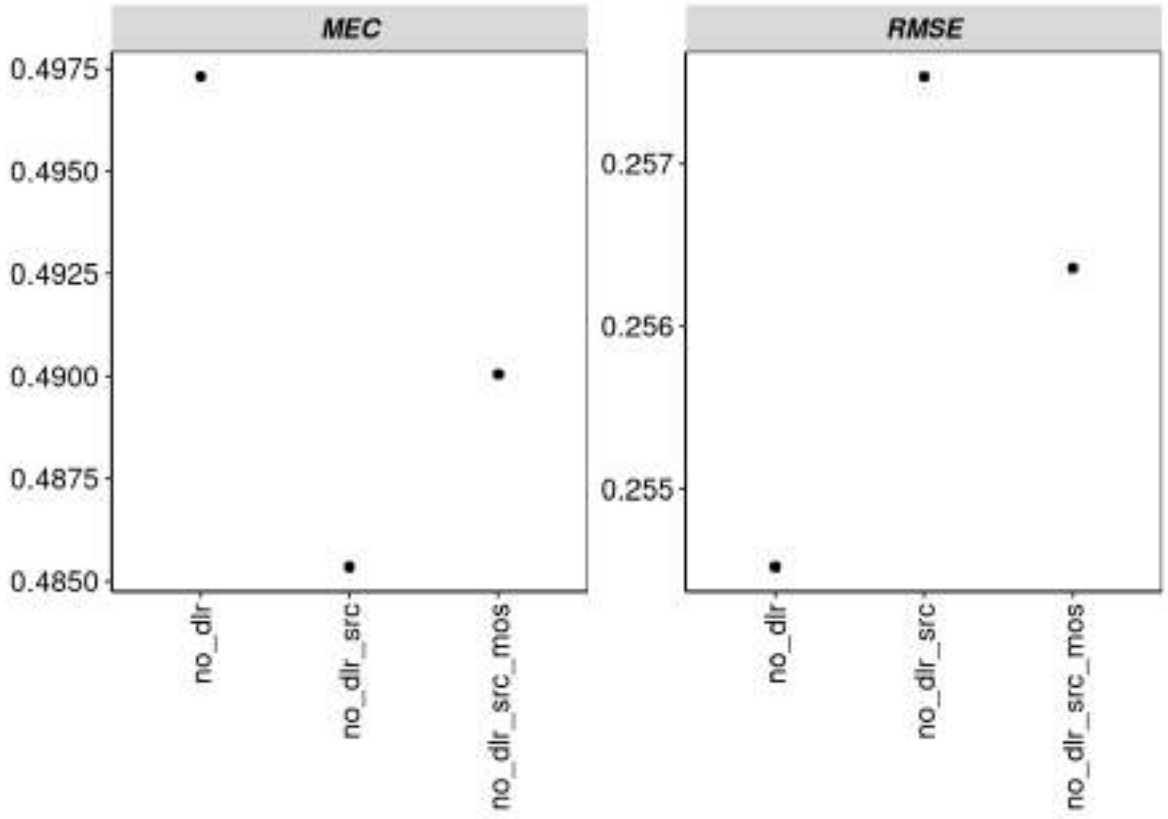

Data policy and web portals

	CUP4SOIL (EU - FPCUP)
License	CC BY 4.0
Products	5 Years SCMaP and Soil products (2018 – 2022) • Mean + Soil reflectance composites • Statistic-Products (Frequency, Valid pixels, etc.) • Bare soil mask Yearly SCMaP products Soil frequency, Soil count, Valid pixels, Soil mask Soil parameters: • SOC, texture, pH, bulk density, etc • Associated accuracy / uncertainty
Format	Cloud Optimized GeoTiff (COG) 20 m (Europe)
Web Platform	DLR Geoservice (Browsing, Webservices, Download, STAC) ISRIC Webportal (Browsing, Webservices, Download)

Purpose:

- Provide a set of data products for stakeholders to „play around" and get first experiences
- Development of show cases
- Special emphasis on validation / accuracy / uncertainty of the products (more products in progress)
- Explore the pros and cons of SOC maps from WorldSoils and CUP4SOIL and other sources (SoilGrids, Holisoils, …)

Summary and future developments

- Summary:
  - DLR and ISRIC partnered to produce:
    - SCMaP intermediate products
    - Soil parameter
  - Test about the beste choise of covariates – direct spectral covariates could improve the modelling
  - Data will be published and available

- Future developments:
  - Preparing the webserver
  - Comparison of WorldSoils SOC with CUP4SOIL SOC
  - Validation / Uncertainty by „spatial pattern agreement“ („How well does digital soil mapping represent soil geography “)

- Further CUP4SOIL presentation on:
  - IUSS Centennial – May 2024 Heiden et al - **High resolution soil quality indicators maps for Europe**
  - EGU 14–19 April, 2024, Vienna, Austria: **Laura Poggio et al.: European high resolution soil quality products**
  - IGARSS 7 - 12 July, 2024, Athens, Greece: **Uta Heiden et al.: „High resolution soil products at European scale integrating remote sensing information”**

CUP4SOIL - Thank you very much!

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DLR

ISRIC World Soil Information