



# CUP<sub>4</sub>SOIL

## High-resolution product presentation and data access



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ESA SYMPOSIUM ON EARTH OBSERVATION FOR SOIL  
PROTECTION AND RESTORATION

07.02.2024



**ISRIC**  
World Soil Information

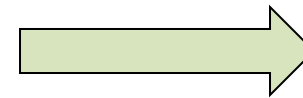
Knowledge for Tomorrow



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

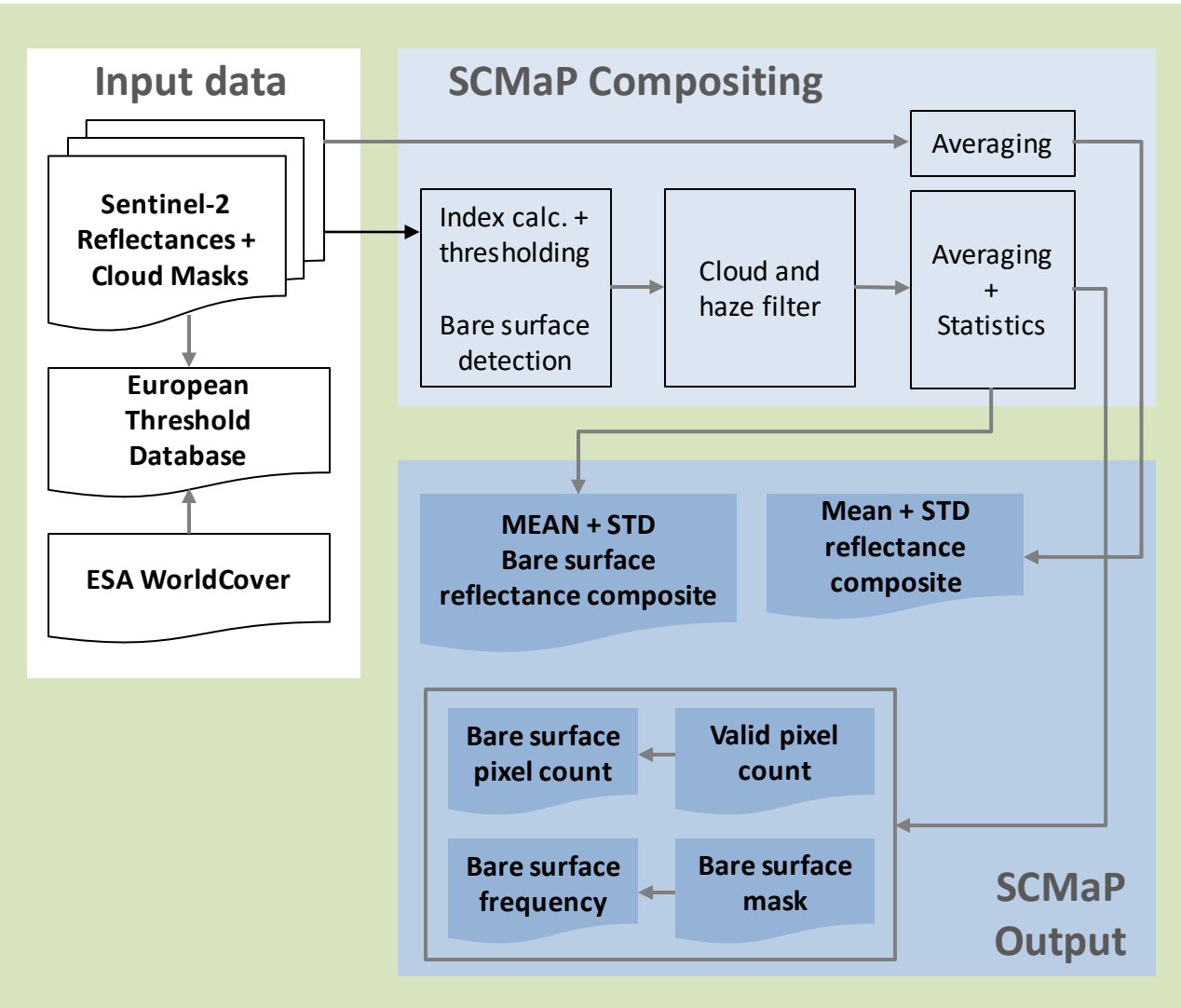


- Intermediate SCMaP soil products
  - Current possibility of EO-based soil parameter
  - Deviations from user requirements
- 
- Data package to “play around”
  - Develop show cases

# CUP<sub>4</sub>SOIL and WorldSoils

	WorldSoils (ESA)	CUP <sub>4</sub> SOIL (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

# General overview

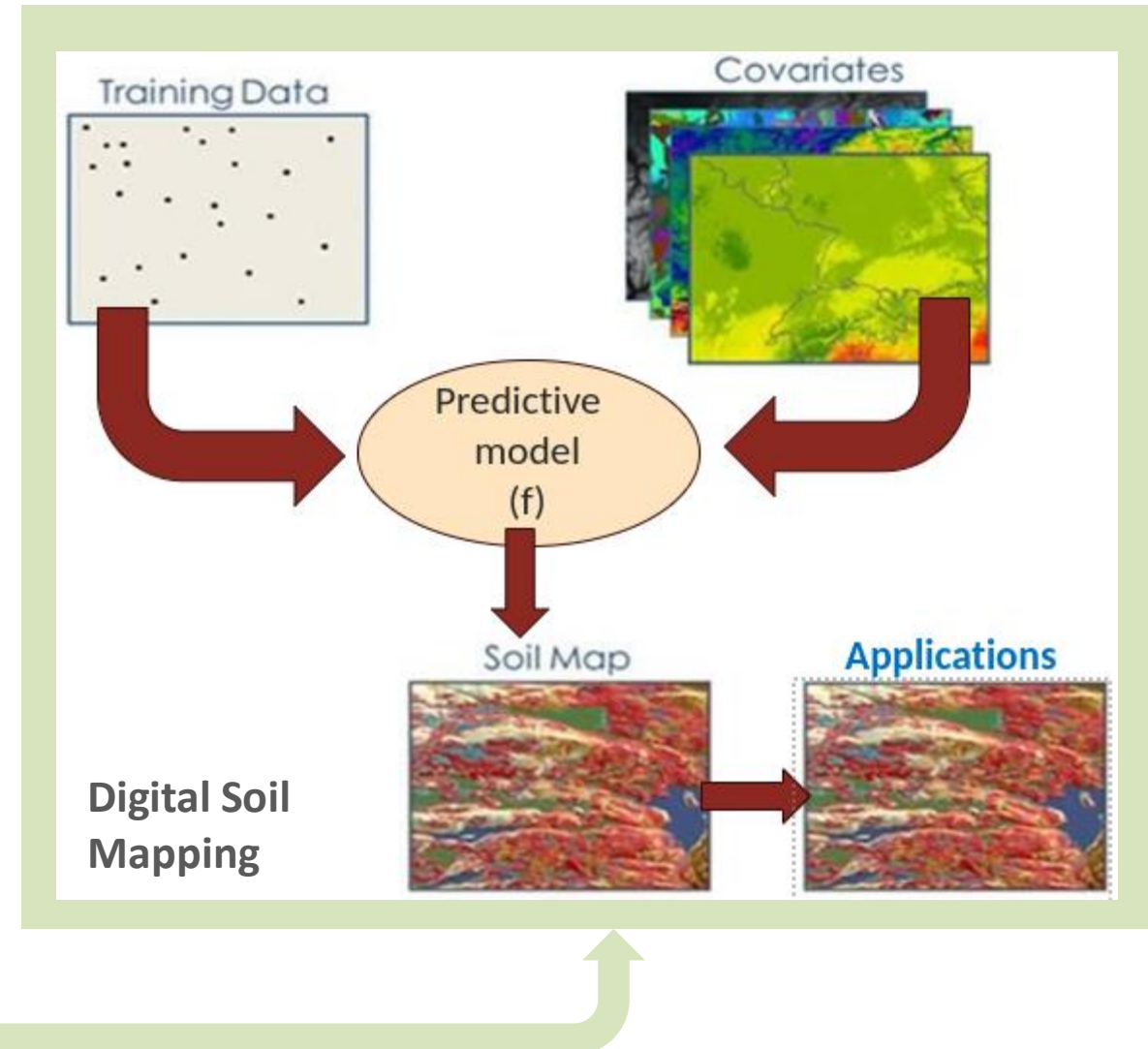
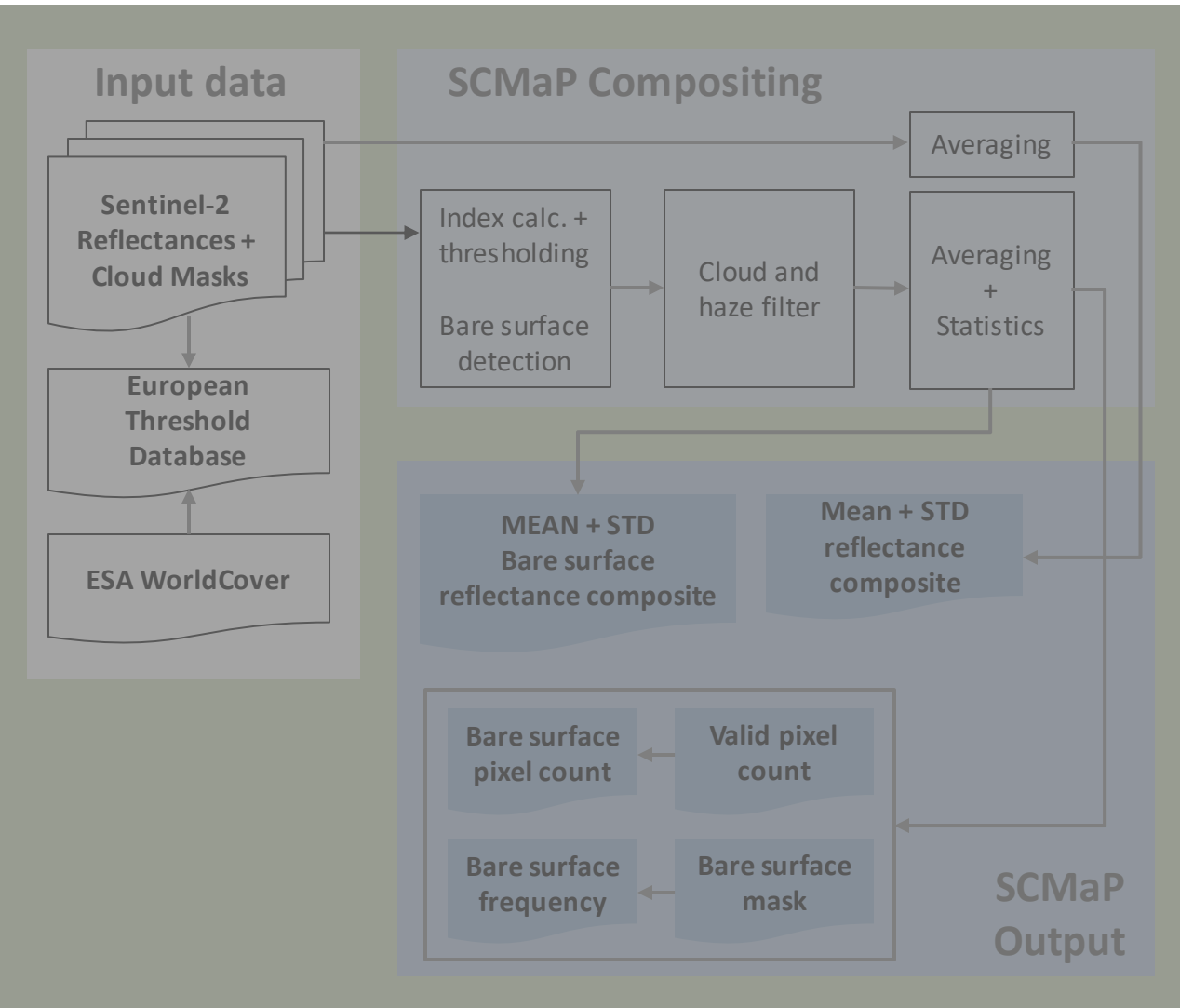


- All Sentinel-2 images in L2A format -> processed with MAJA from 2018 – 2022
- Larger Europe including Ukraine
- Spectral Index based (e.g. Diek et al. 2017, Rogge et al. 2018, Demattê et al., 2018)
- Used index: PV+IR2 (Heiden et al. 2022, Möller, M. et al. 2022, Dvorakova, K., et al., 2023)

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

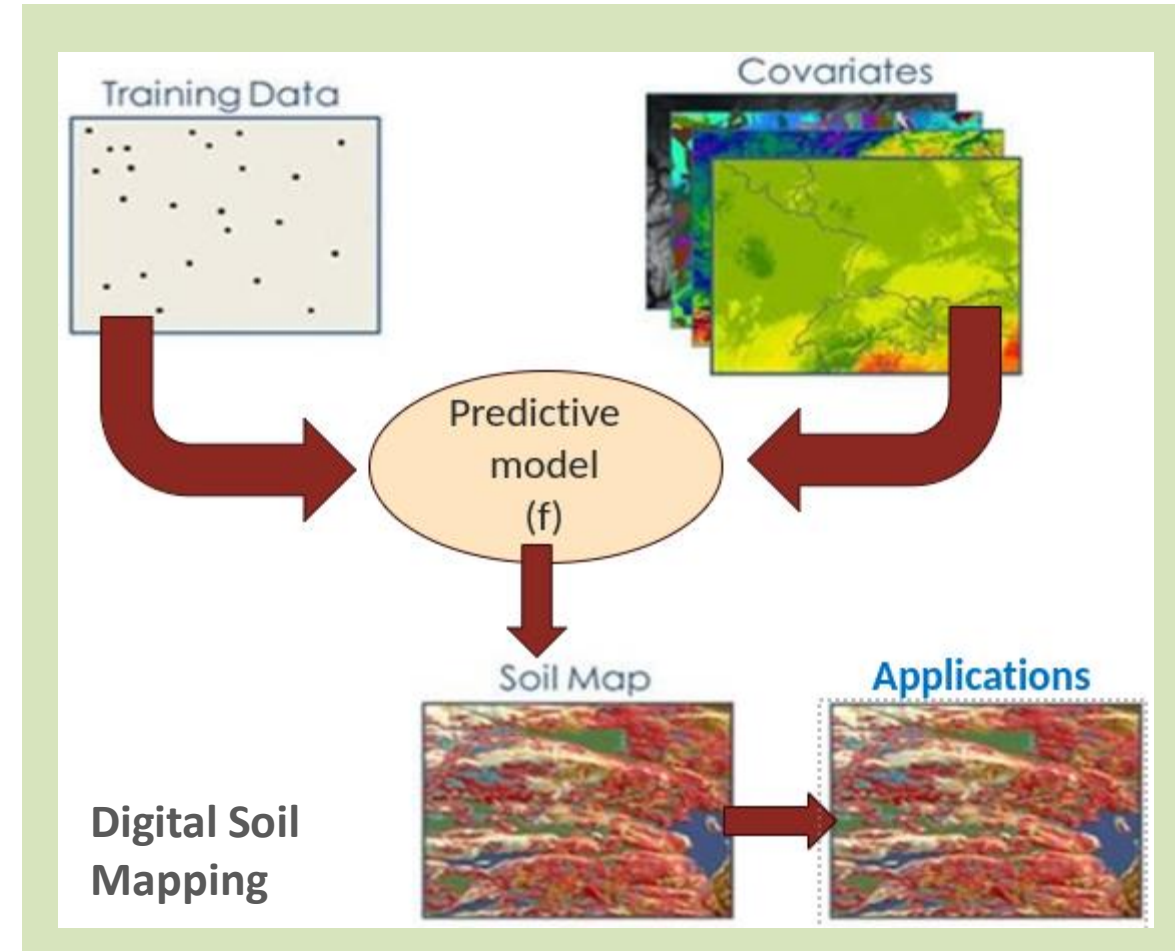
- Regionalised thresholds (Karlshöfer et al., in preparation)
- 5-years composite products

# General overview

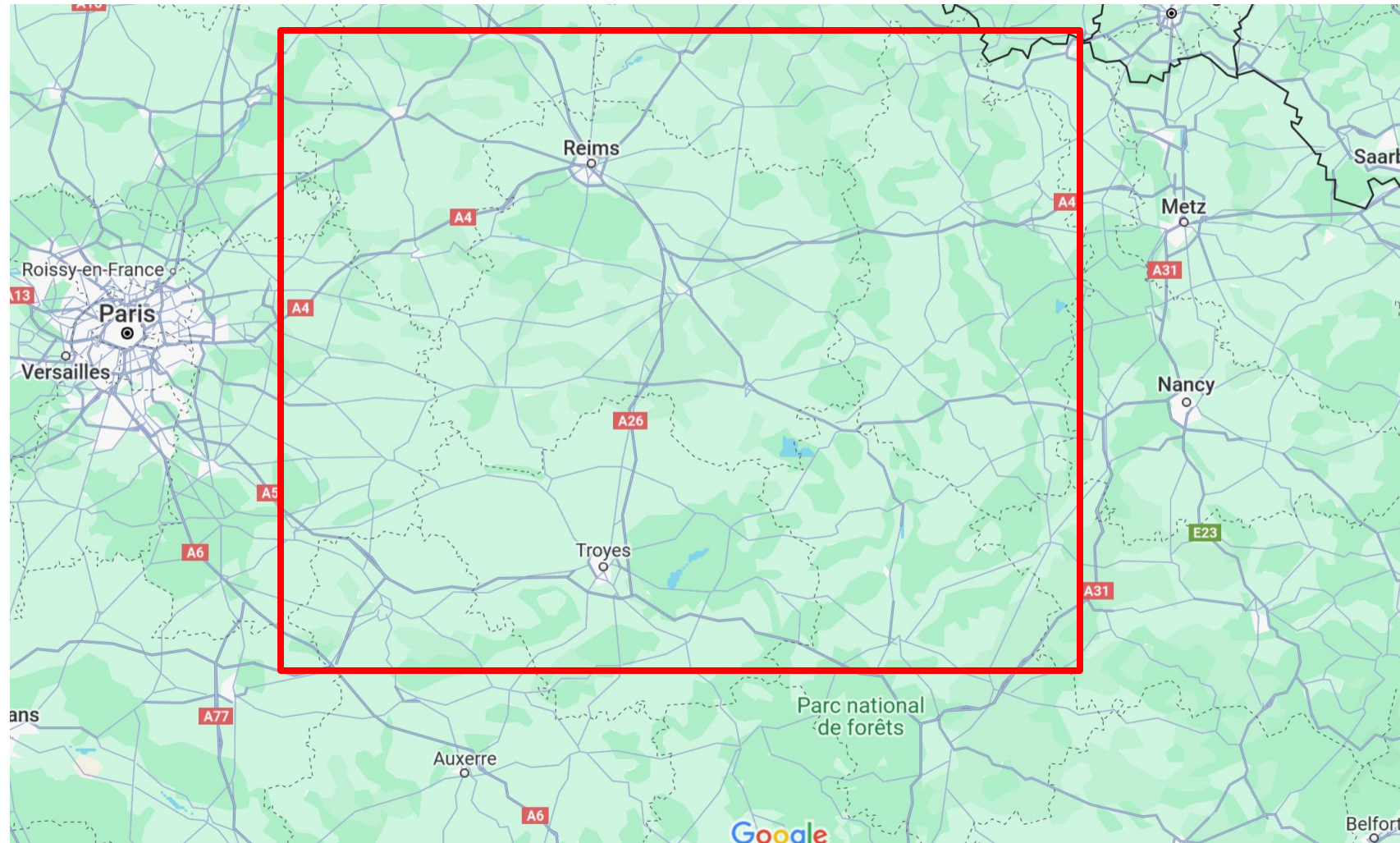


# Digital Soil Mapping – some notes

- 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

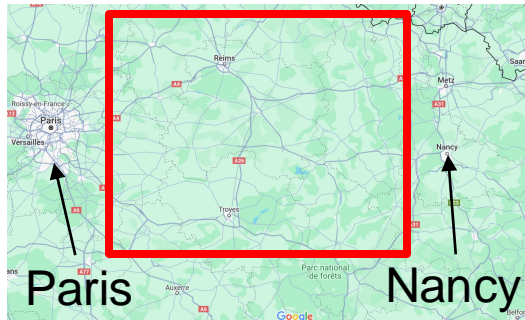


Source: Google maps (<https://www.google.de/maps>)

# Example France SCMaP products

## Mean Surface Reflectance

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

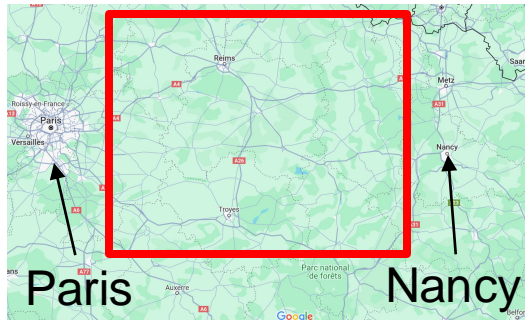




# Example France SCMaP products

Mean Surface  
Reflectance –  
Standard deviation

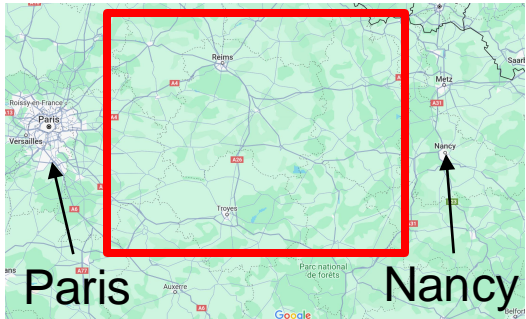
- Sentinel-2
- L2A reflectance  
(MAJA processed)
- 2018 – 2022



# Example France SCMaP products

## Bare Soil/Surface Reflectance –

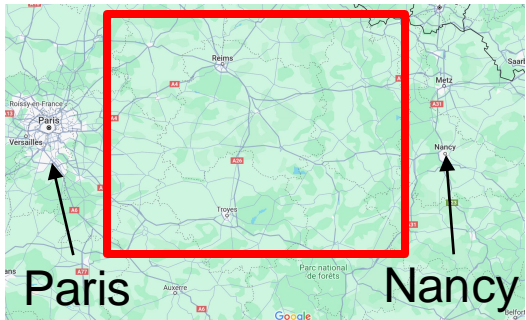
- Sentinel-2
- L2A reflectance (MAJA processed)
- 2018 – 2022
- PV+IR2
- Regionalised thresholds



# Example France SCMaP products

**Bare Soil/Surface  
Reflectance –  
Standard deviation**

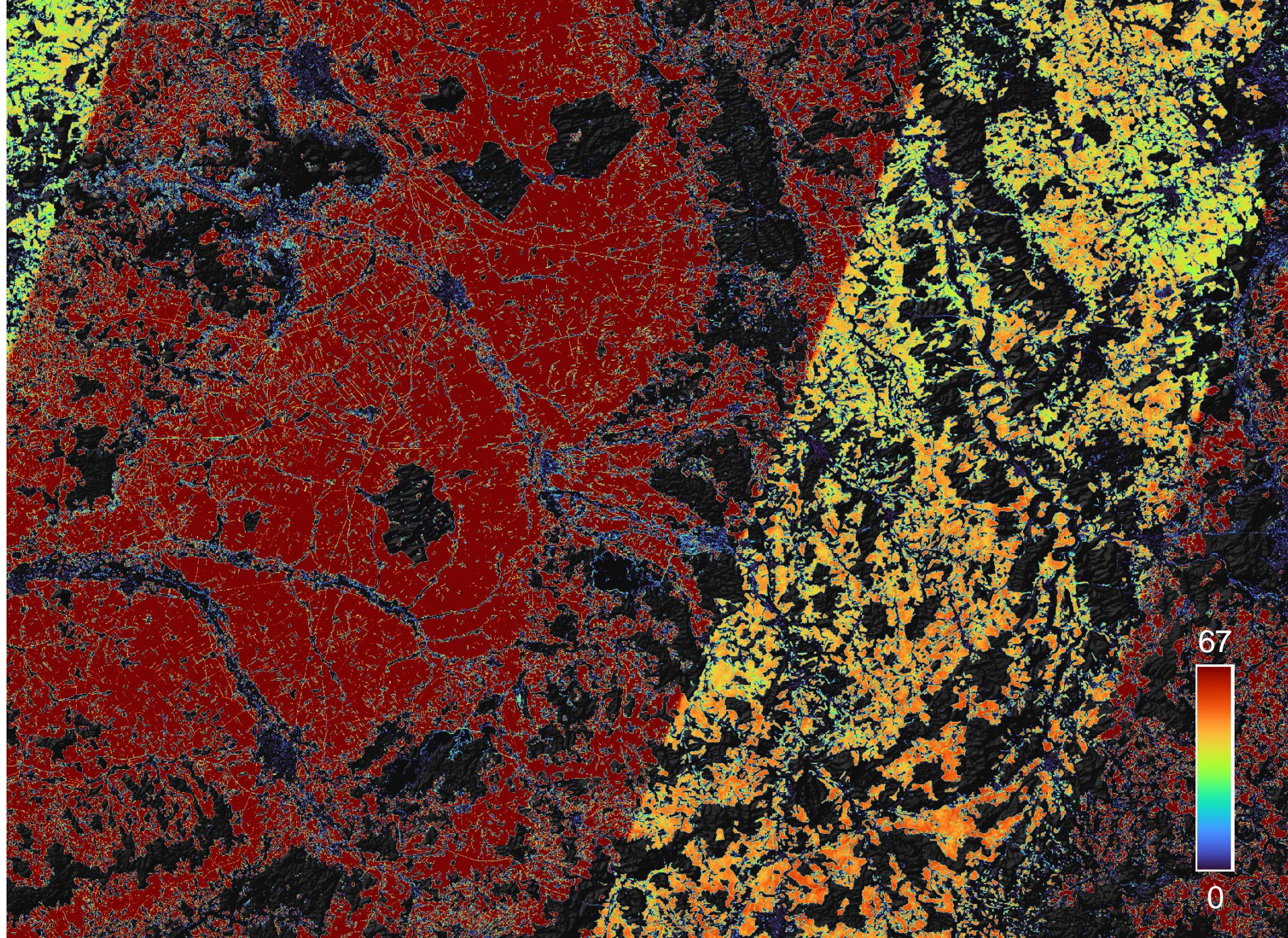
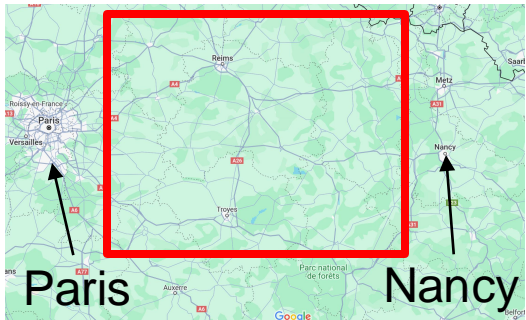
- Sentinel-2
- L2A reflectance (MAJA processed)
- 2018 – 2022
- PV+IR2
- Regionalised thresholds



# Example France SCMaP products

## Valid Pixel Count

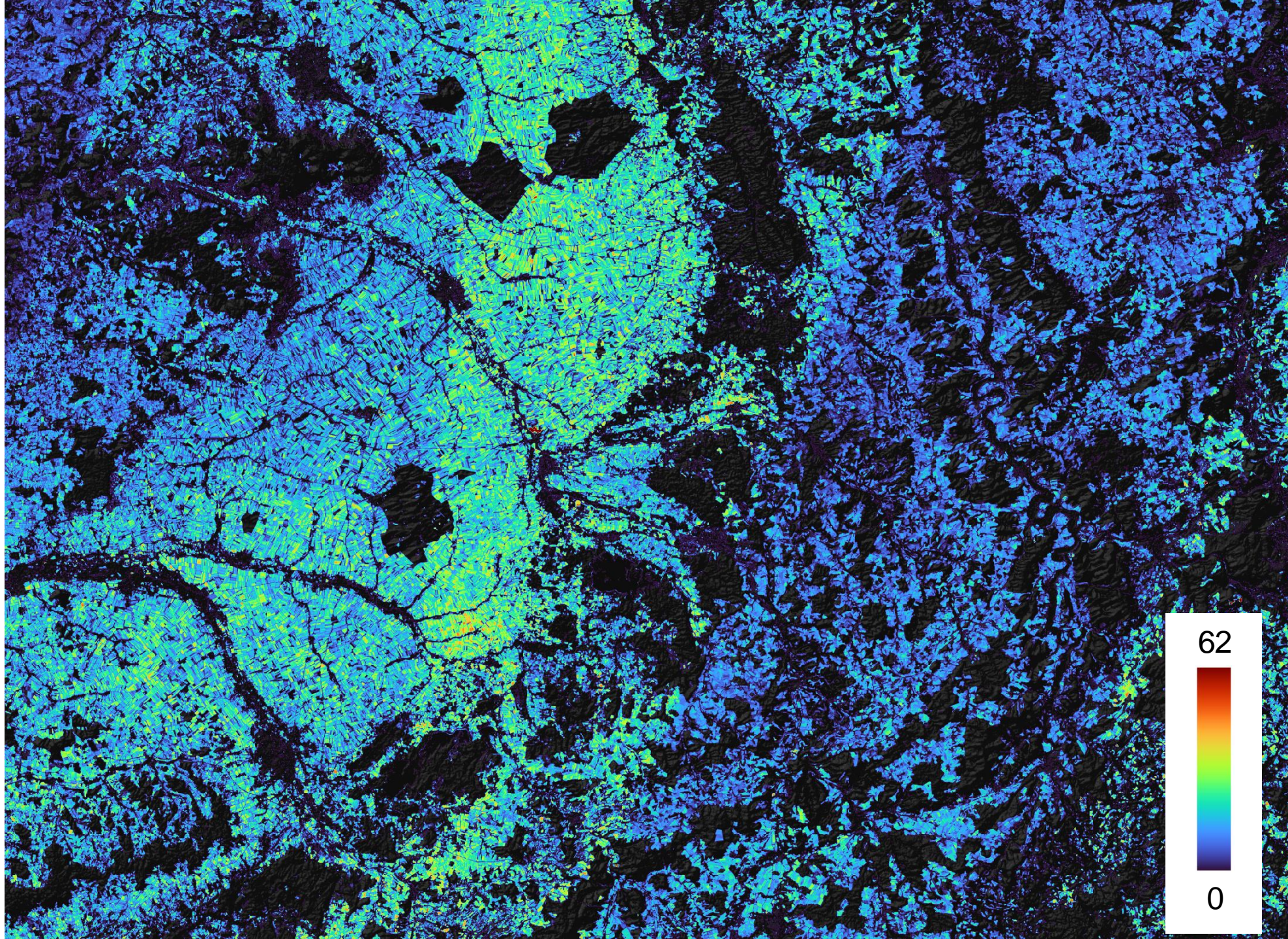
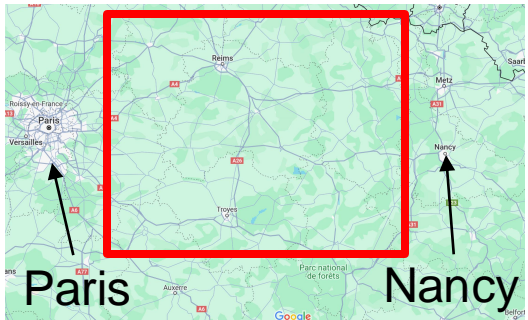
- Sentinel-2
- 2018 – 2022



# Example France SCMaP products

## Bare Soil Pixel Count

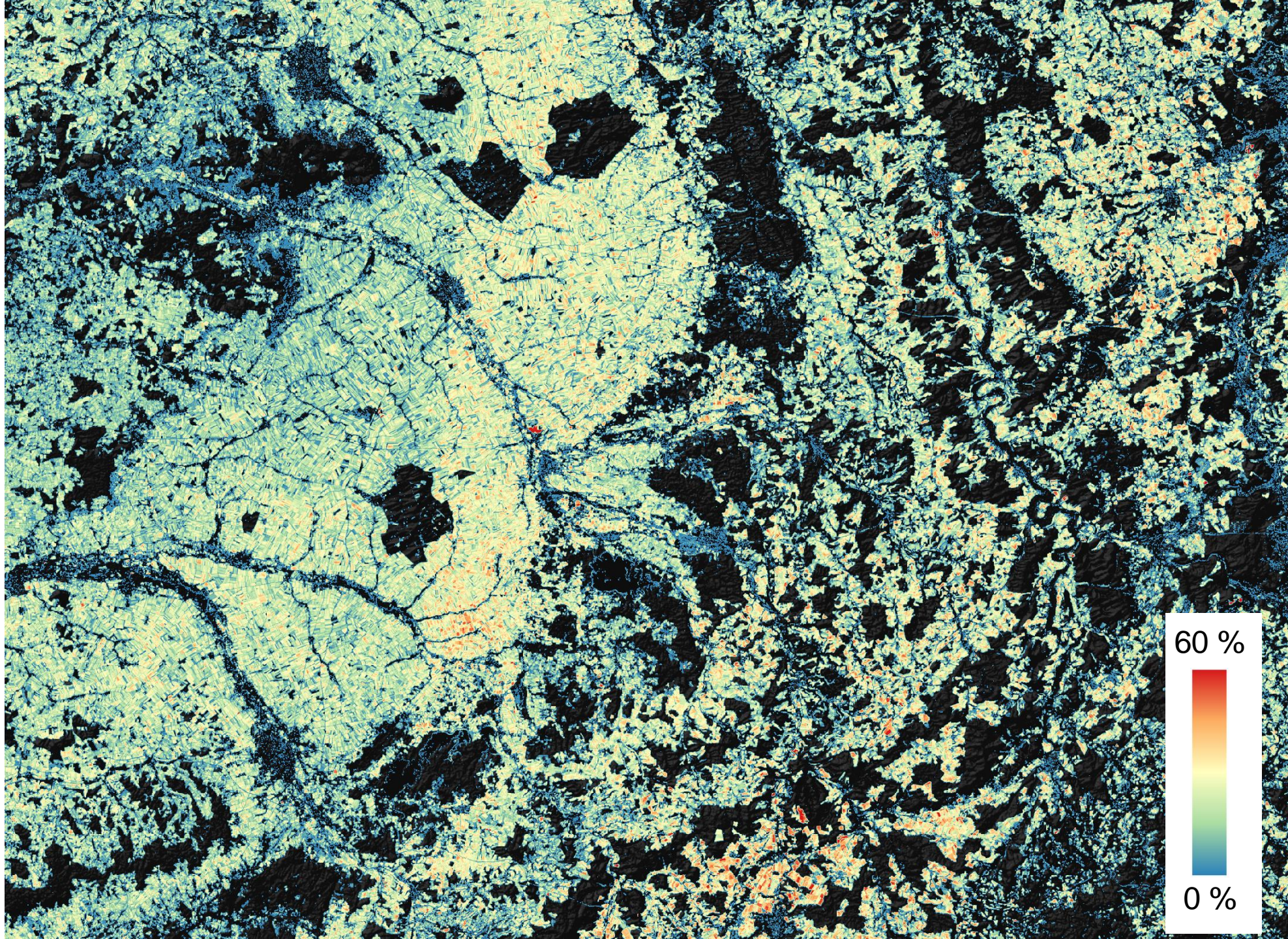
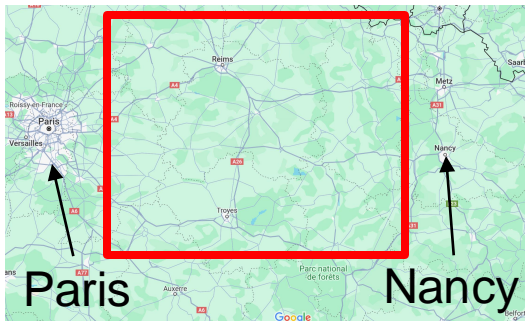
- Sentinel-2
- 2018 – 2022
- PV+IR2
- Regionalised thresholds



# Example France SCMaP products

Bare Soil  
Frequency [%]

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

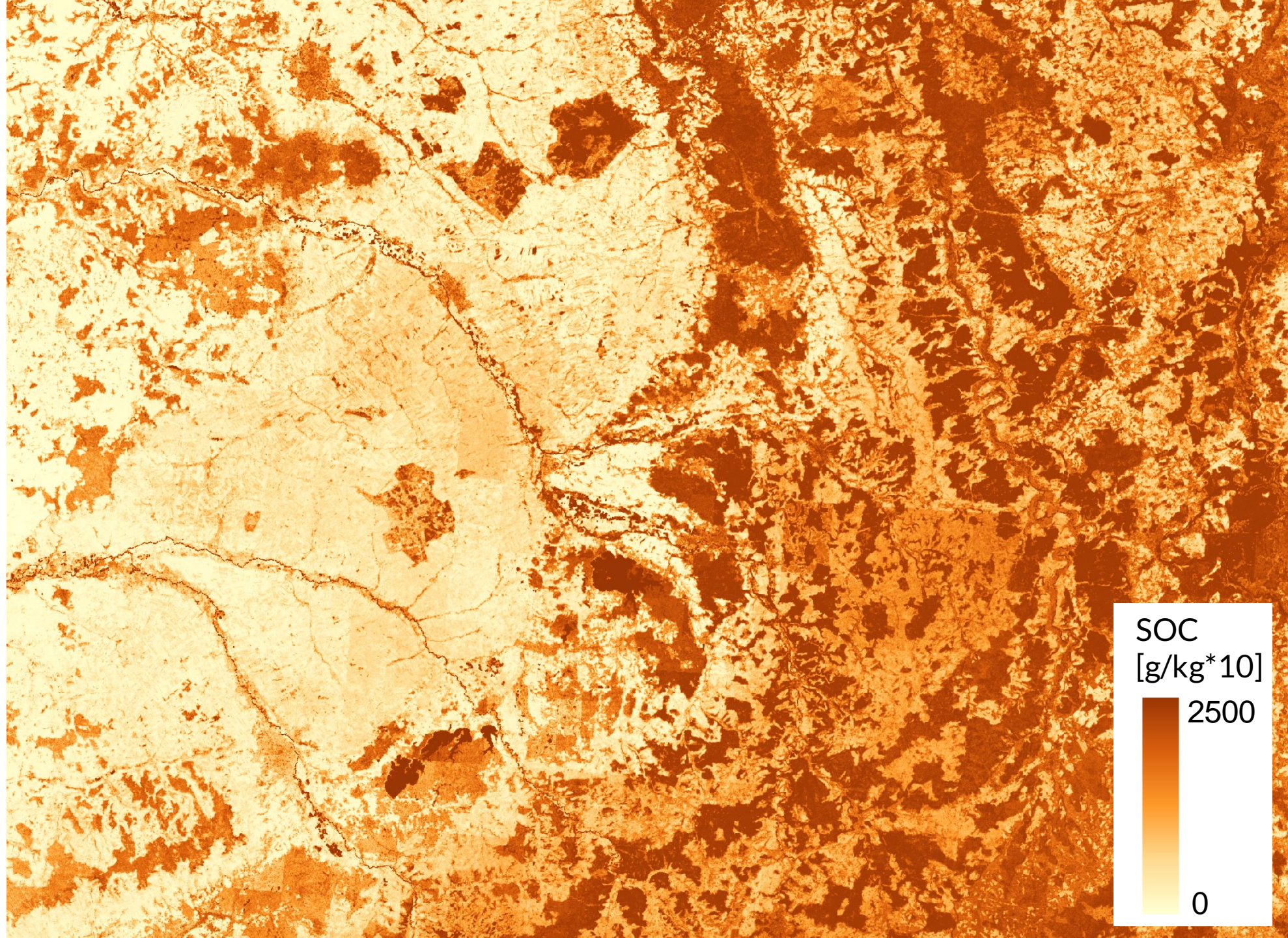
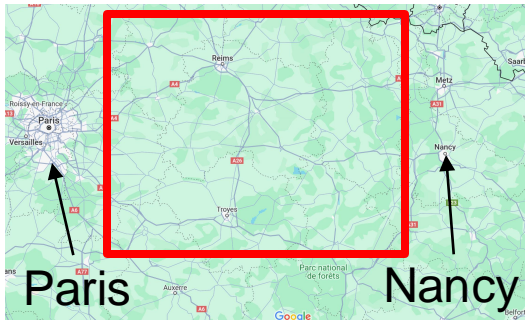


Example France

# Soil parameter

Soil Organic Carbon  
Content

- Topsoil - 0-30cm
- $\text{g/kg} \cdot 10$



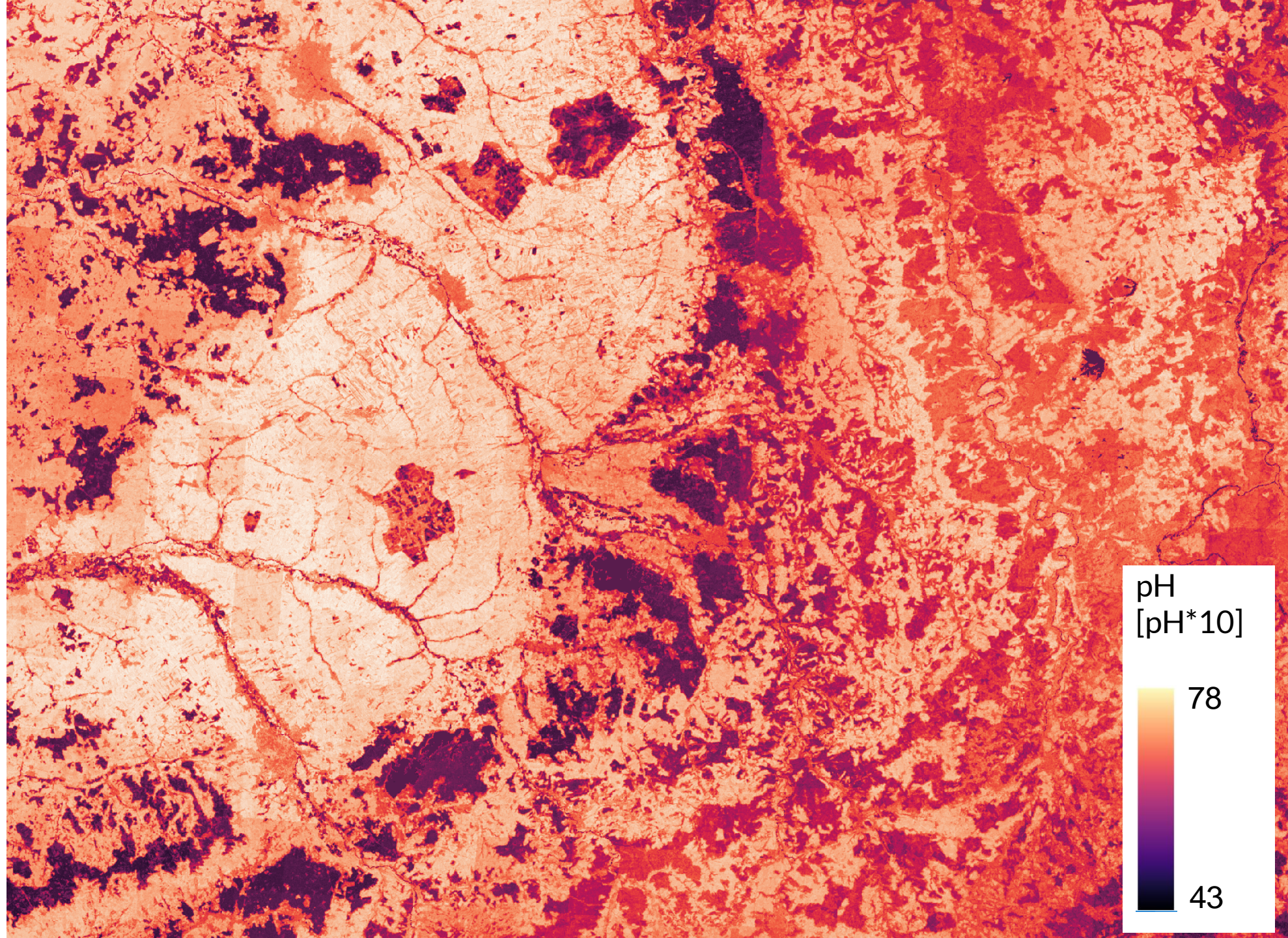
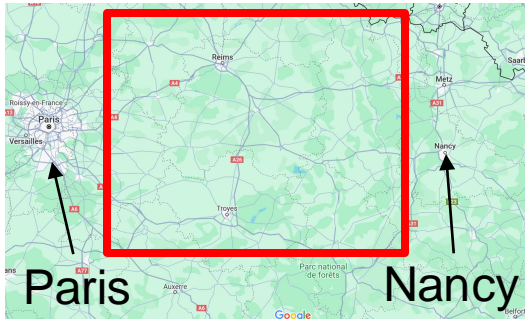
Example France

# Soil

## parameter

pH in water

- Topsoil - 0-30cm
- pH\*10



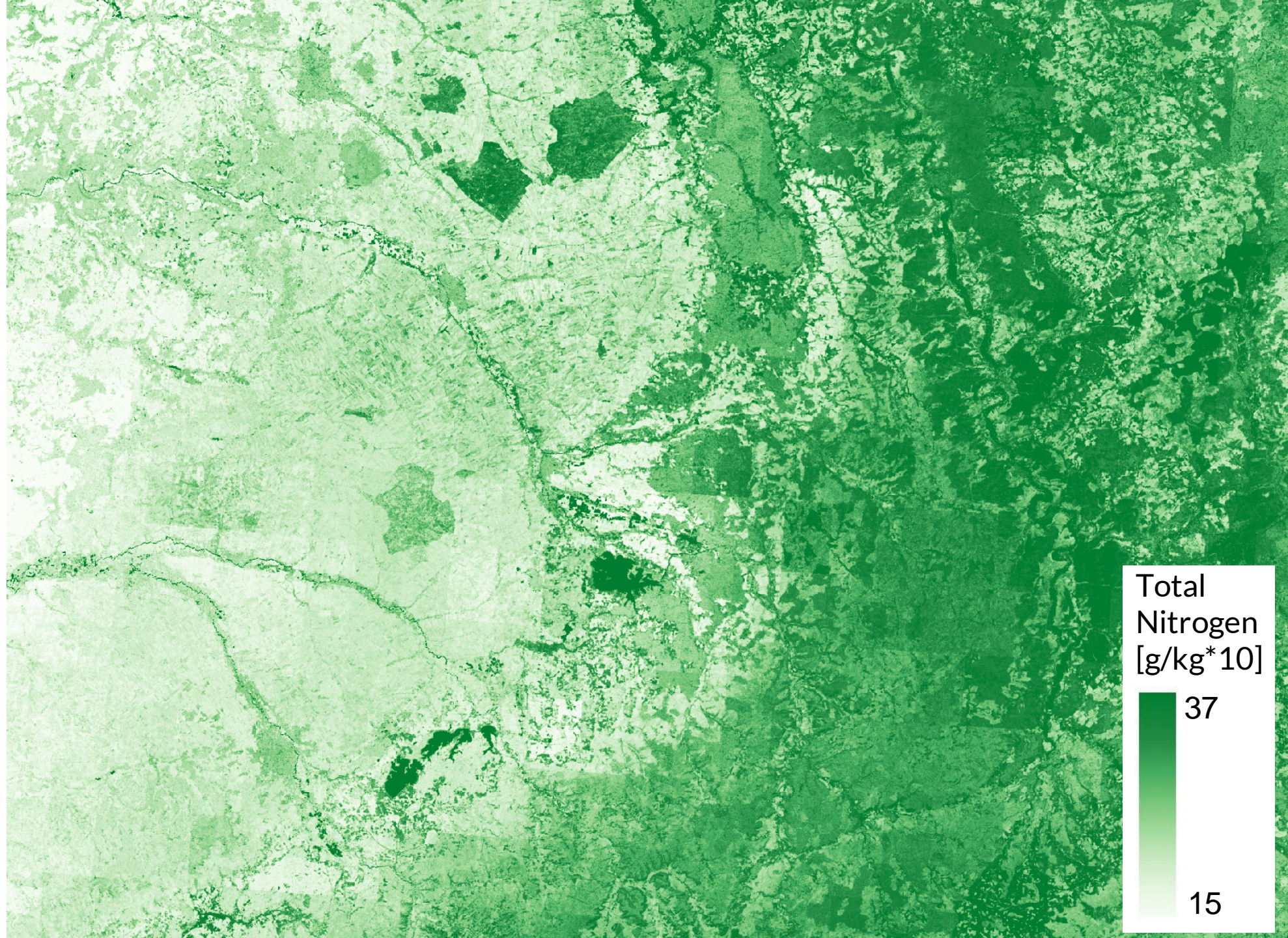
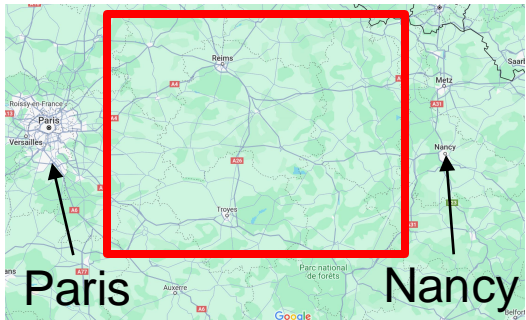


Example France

# Soil parameter

**Total Nitrogen**

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



Total  
Nitrogen  
[g/kg\*10]

37

15

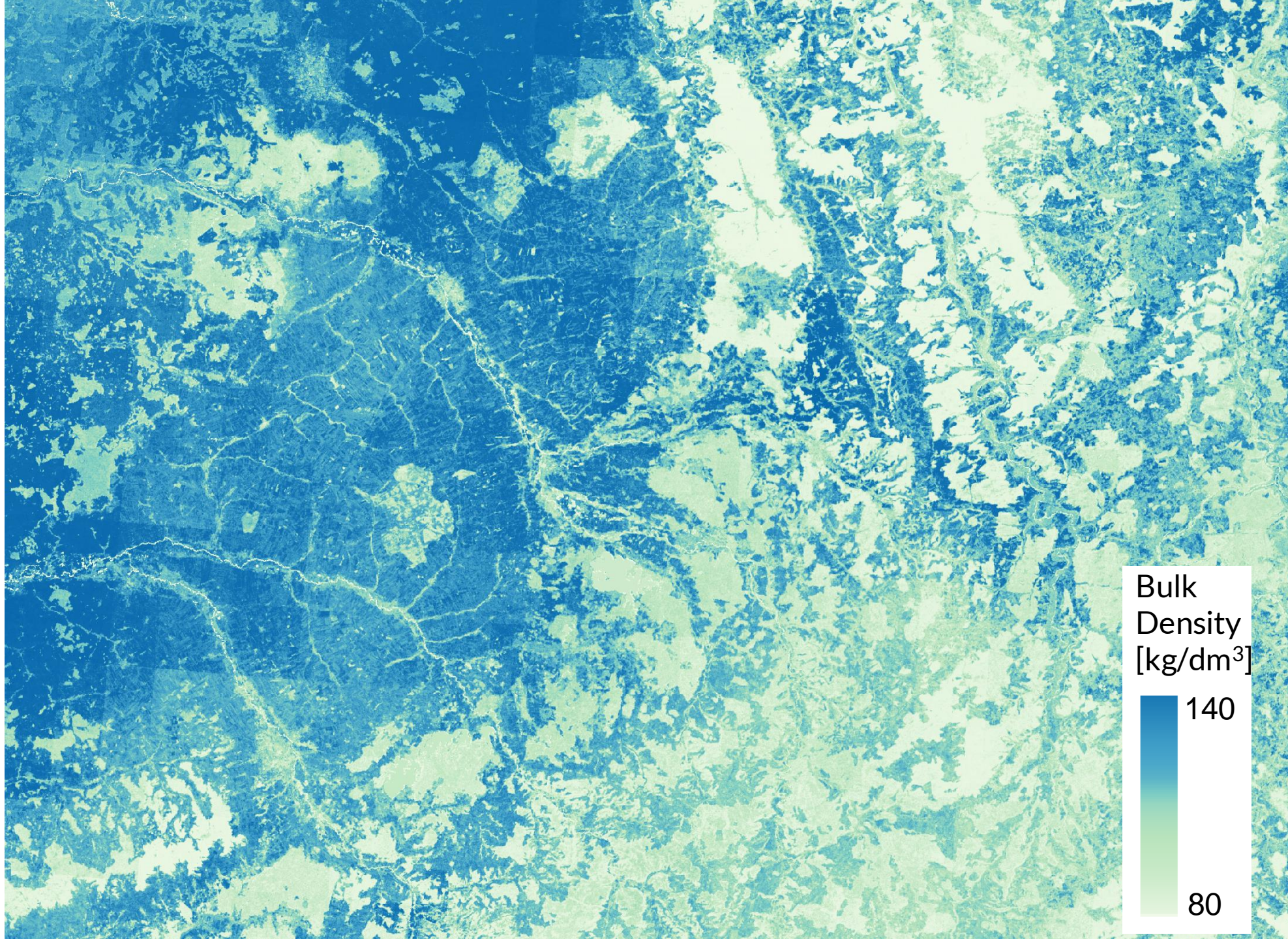
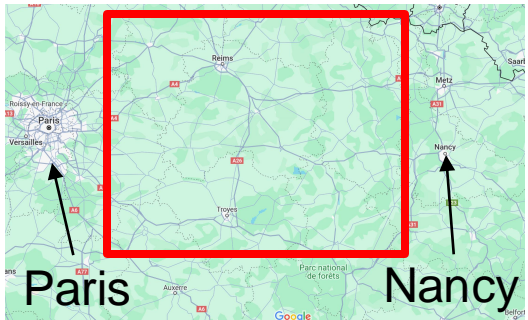
Example France

# Soil

## parameter

**Bulk density, oven dry**

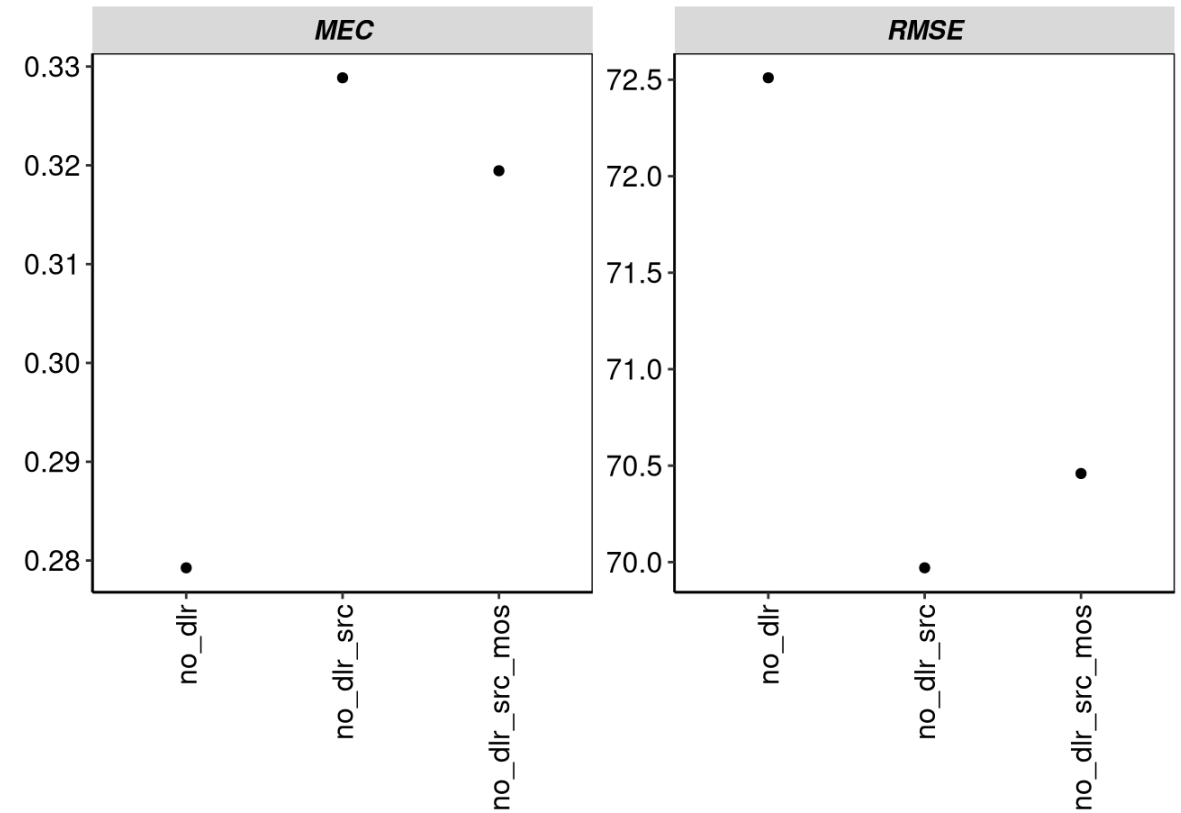
- Topsoil - 0-30cm
- [kg/dm<sup>3</sup>]



# Cross-validation - SOC

Used covariates at the X-Axes:

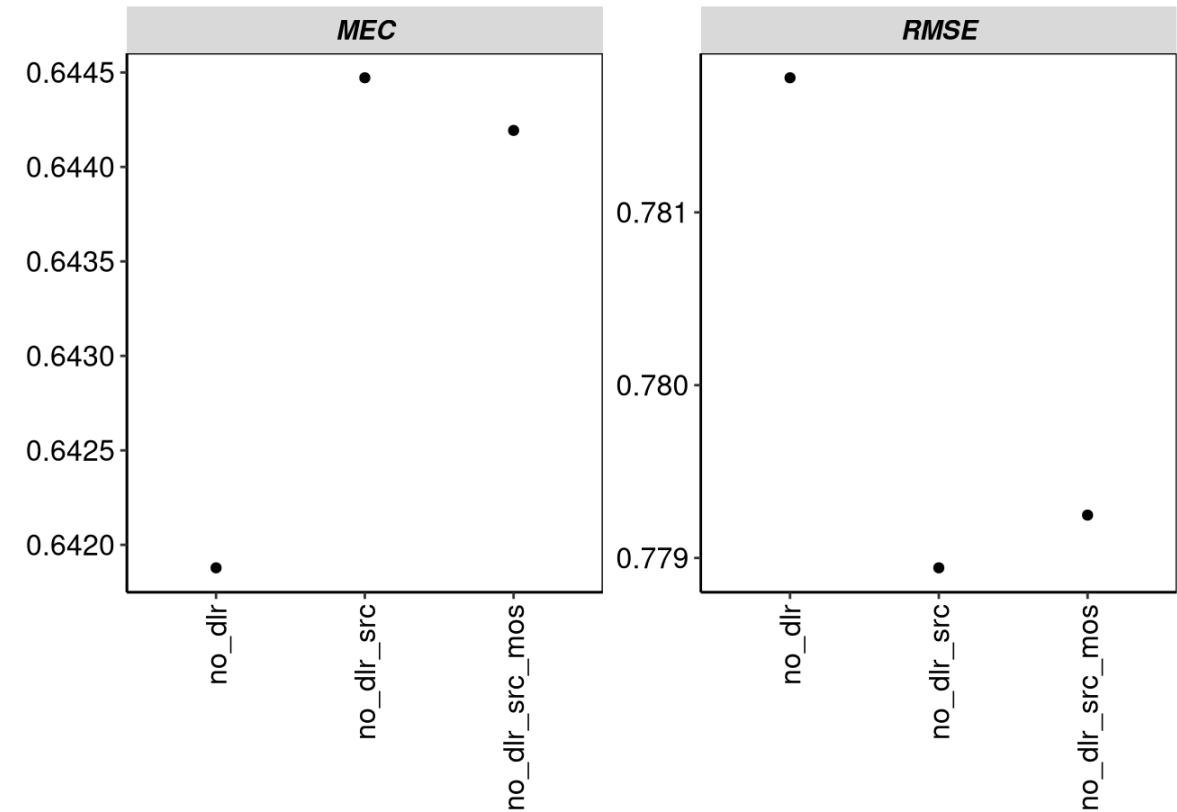
Groups (x-axes)	Description
no_dlr	All covariates excluding DLR/SCMaP products
no_dlr_src	All covariates excluding DLR/SCMaP covariate: Soil Reflectance Composite
no_dlr_src_mos	All covariates excluding DL/SCMaP covariates using the mosaic of MREF and SRC and SRC itself



# Cross-validation – pH (water)

Used covariates at the X-Axes:

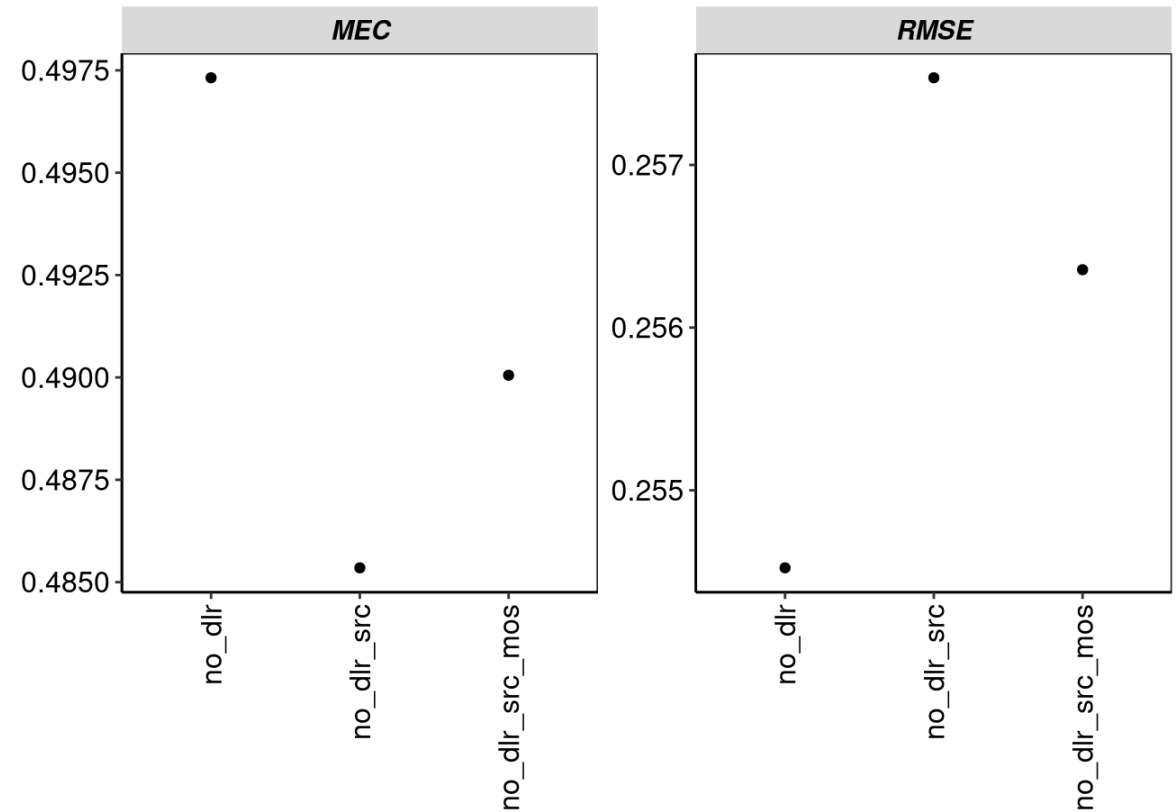
Groups (x-axes)	Description
no_dlr	All covariates excluding DLR/SCMaP products
no_dlr_src	All covariates excluding DLR/SCMaP covariate: Soil Reflectance Composite
no_dlr_src_mos	All covariates excluding DL/SCMaP covariates using the mosaic of MREF and SRC and SRC itself



# Cross-validation – bulk density (oven dry)

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



# Data policy and web portals

	CUP <sub>4</sub> SOIL (EU - FPCUP)
License	CC BY 4.0
Products	<p><u>5 Years SCMaP and Soil products (2018 – 2022)</u></p> <ul style="list-style-type: none"> <li>• Mean + Soil reflectance composites</li> <li>• Statistic-Products (Frequency, Valid pixels, etc.)</li> <li>• Bare soil mask</li> </ul> <p><u>Yearly SCMaP products</u> Soil frequency, Soil count, Valid pixels, Soil mask</p> <p><u>Soil parameters:</u></p> <ul style="list-style-type: none"> <li>• SOC, texture, pH, bulk density, etc</li> <li>• Associated accuracy / uncertainty</li> </ul>
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 CUP<sub>4</sub>SOIL and other sources (SoilGrids, Holisoils, ...)

# Summary and future developments

- Summary:
  - DLR and ISRIC partnered to produce:
    - SCMaP intermediate products
    - Soil parameter
  - Test about the best choice 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 CUP<sub>4</sub>SOIL SOC
  - Validation / Uncertainty by „spatial pattern agreement“ („How well does digital soil mapping represent soil geography“)
- Further CUP<sub>4</sub>SOIL 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“**



# CUP<sub>4</sub>SOIL - Thank you very much!

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[uta.heiden@dlr.de](mailto:uta.heiden@dlr.de)



DLR



**ISRIC**  
World Soil Information



Framework Partnership Agreement  
for Copernicus User Uptake

Photo: Uta Heiden