

# SoilSuite Europe

## EO basierte Bodeninformation

Uta Heiden, Pablo d'Angelo, Paul Karlshöfer, Peter Schwind,  
Jonas Eberle, André Twele, Torsten Heinen  
(Deutsches Zentrum für Luft und Raumfahrt e.V.)

Laura Poggio, Fenny van Egmond  
(ISRIC - World Data Centre for Soil)

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11.-12. November 2025  
Berlin



**ISRIC**  
World Soil Information

Knowledge for Tomorrow



# EU Bodenrichtlinie (23. Oktober 2025)

23. Oktober 2025 - Europäische „Richtlinie zur Bodenüberwachung und -resilienz“ verabschiedet

## Ziel

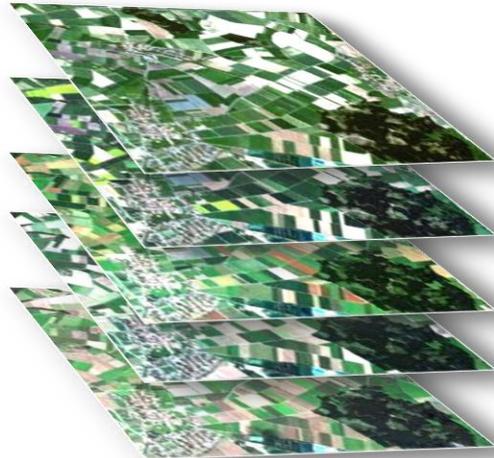
- alle Böden in der Europäischen Union bis 2050 sind in einem gesunden Zustand, derzeit ca. 60-70% degradiert
- Eines der Kernelemente: Systematisches Monitoring des Bodens mit Bewertung seines Zustandes
- Monitoring sogenannter „Soil descriptors“:
  - Organischer Kohlenstoffgehalt
  - Lagerungsdichte
  - Bodenart (als Input für weitere Bodenkennwerte)
  - Wasserrückhaltevermögen
  - Elektrische Leitfähigkeit (Versalzung)
  - ...



Foto: U. Heiden

# Basic idea – temporal compositing of bare soils

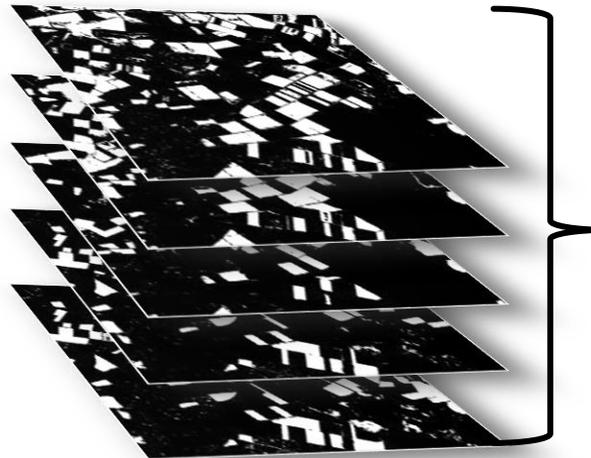
Temporal stack  
Reflectance images



Spectral index  
threshold

Temporal stack  
Bare soil masks

April 20.5%  
May 17.5%  
July 13.8%  
Aug 26.8%  
Sept 25.8%



Temporal Composite  
Bare soil mask



Expanding data base  
Bare Soil Exposure = 47.9 %

**Soil Composite Mapping Processor (SCMAP)**

References (selection)

- Diek, S. et al. (2017). Barest Pixel Composite for Agricultural Areas Using Landsat Time Series. Remote Sens. 2017, 9, 1245.
- Rogge, D. et al. (2018). Building an exposed soil composite processor (SCMaP) for mapping spatial and temporal characteristics of soils with Landsat imagery (1984–2014), RSE, 205, 1-17.
- Demattê, J.A.M. et al. (2018). Geospatial Soil Sensing System (GEOS3): A powerful data mining procedure to retrieve soil spectral reflectance from satellite images. RSE, 212, 161–175.
- Vadour, E., et al. (2021). Temporal mosaicking approaches of Sentinel-2 images for extending topsoil organic carbon content mapping in croplands, International Journal of Applied Earth Observation and Geoinformation, 96, 2021, 102277, DOI: 10.1016/j.jag.2020.102277.
- Dvorakova, K. et al. (2021). Sentinel-2 Exposed Soil Composite for Soil Organic Carbon Prediction. RS, 13 (9), 1-21. doi: 10.3390/rs13091791
- Heiden, U. et al. (2022). Soil Reflectance Composites - Improved Thresholding and Performance Evaluation. Remote Sensing, 14 (18), Seiten 1-26. doi: 10.3390/rs14184526.

# SoilSuite 2018 – 2022

- Sentinel-2
- 2018 – 2022
- < 80 % cloud cover
- > 20° sun elevation
- 20 m pixel size
- 3 bands

## Bare Surface Mask

	Bare surface occurrence
	Permanent vegetation
	Other surfaces

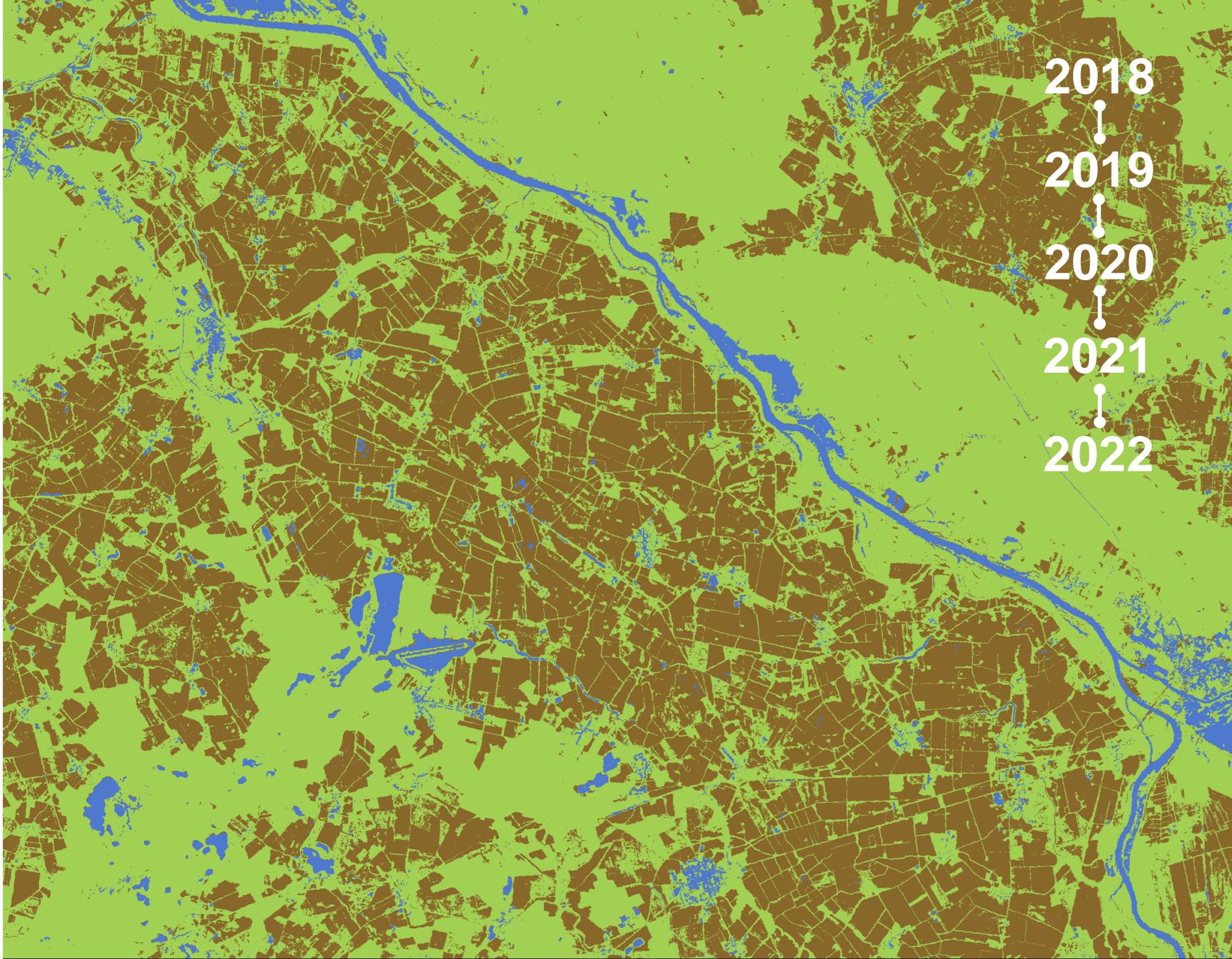


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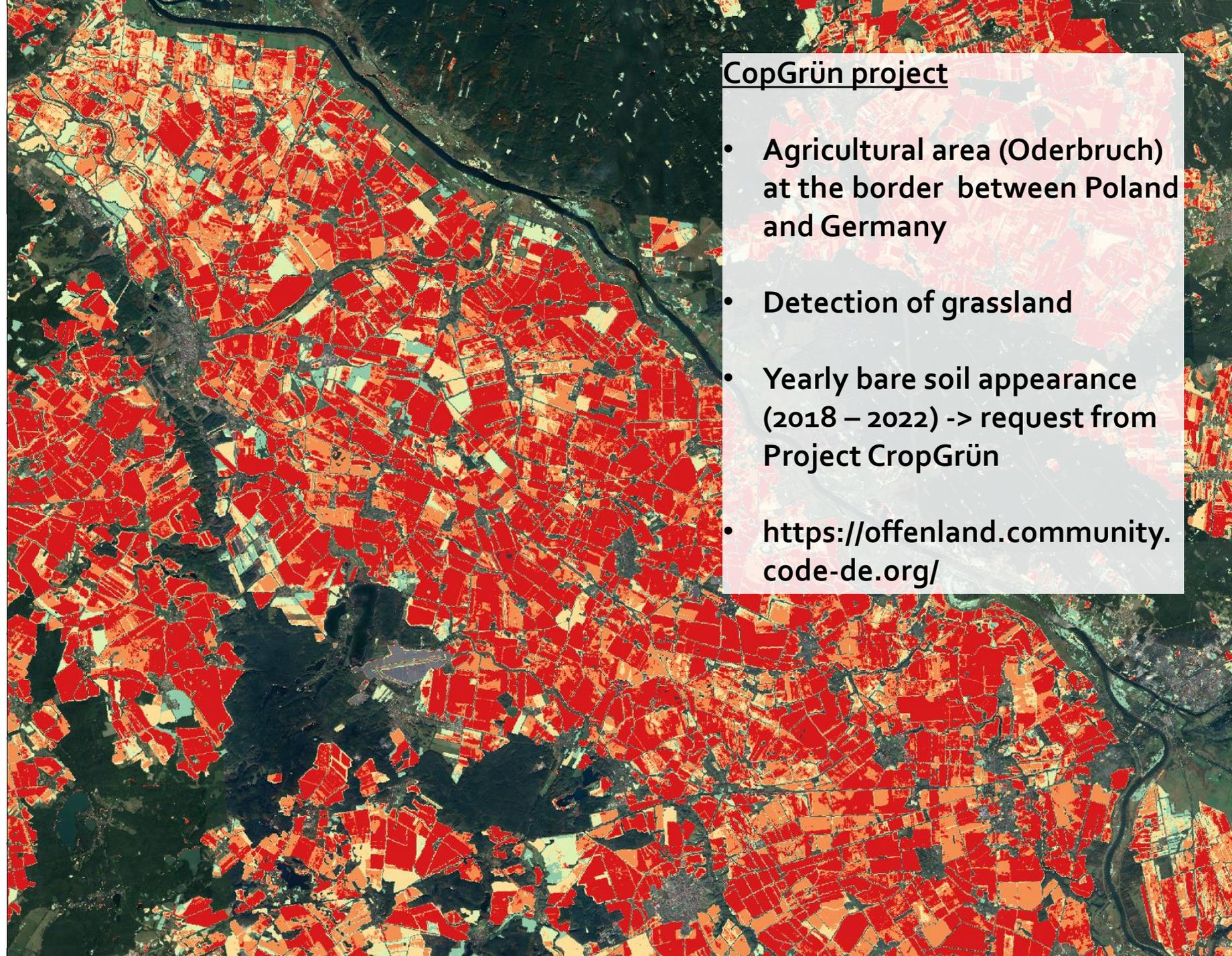
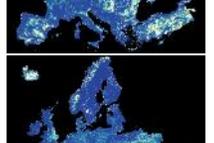
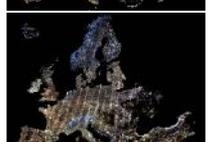
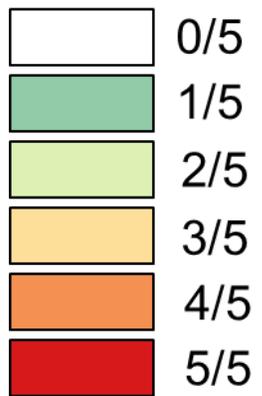
	Bare surface occurrence
	Permanent vegetation
	Other surfaces



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Bare Surface Mask  
used to detect  
grassland (0/5)



## CopGrün project

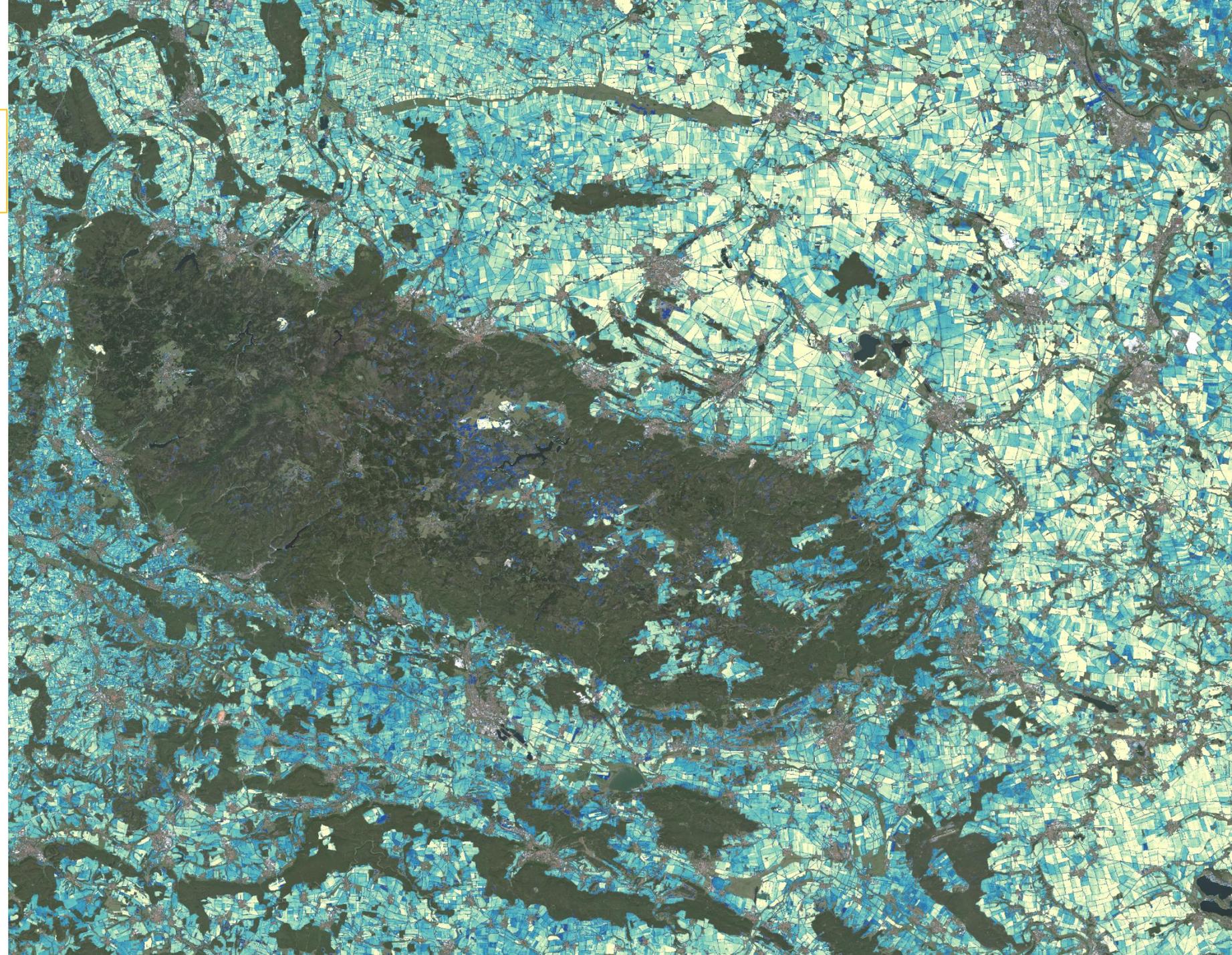
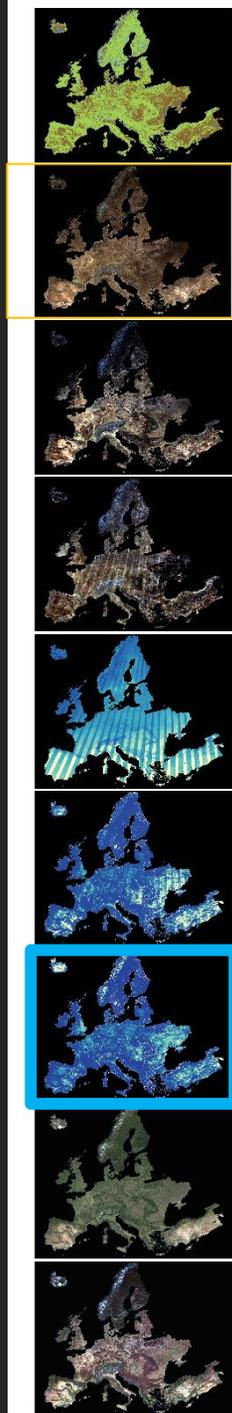
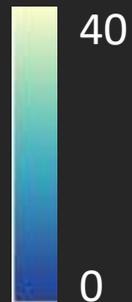
- Agricultural area (Oderbruch) at the border between Poland and Germany
- Detection of grassland
- Yearly bare soil appearance (2018 – 2022) -> request from Project CropGrün
- <https://offenland.community.code-de.org/>

# SoilSuite 2018 – 2022

- Sentinel-2
- 2018 – 2022
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- > 20° sun elevation
- 20 m pixel size
- 1 band

## Bare Surface Statistics

- Bare Surface  
Frequency [%]

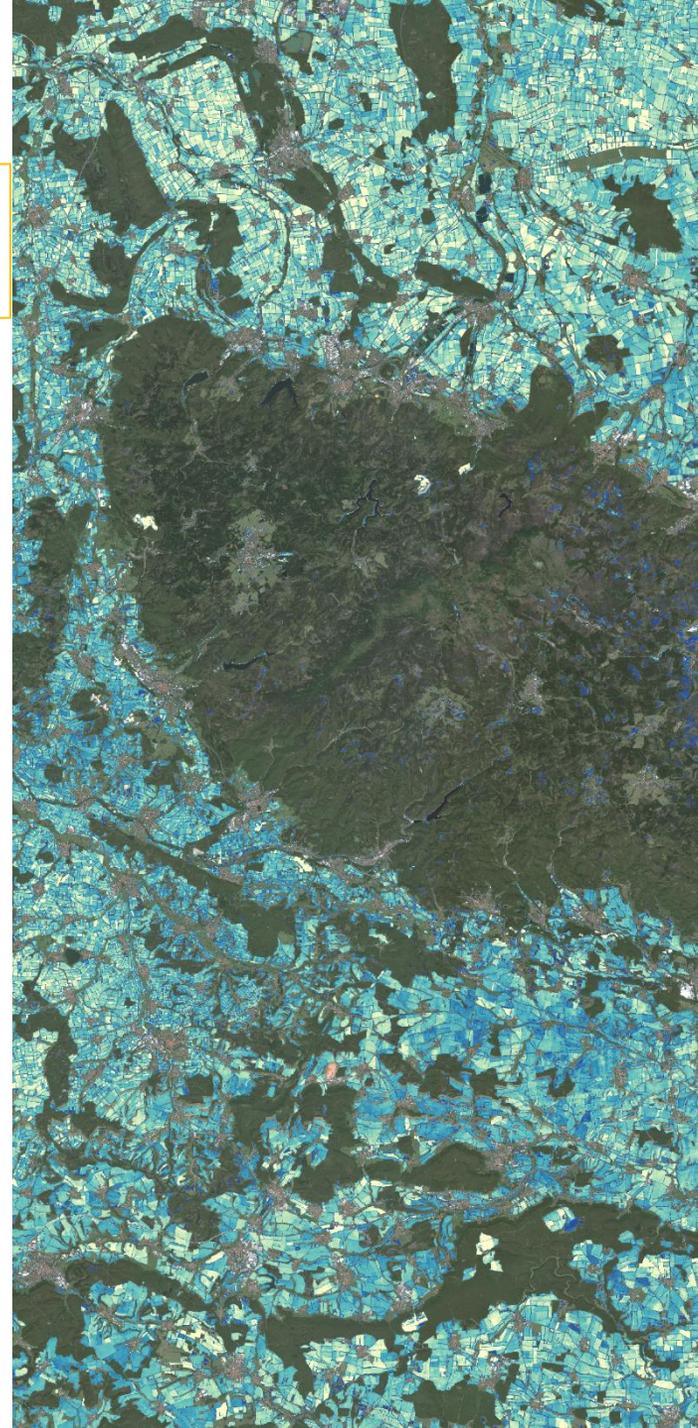
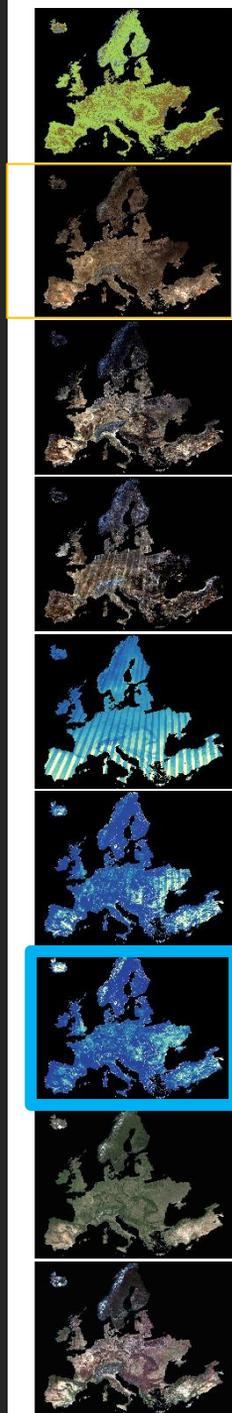


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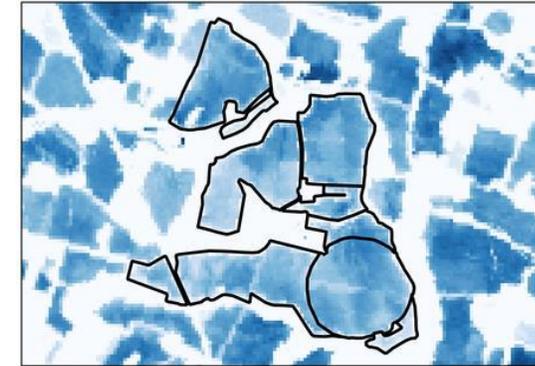
## Bare Surface Statistics

- Bare Surface  
Frequency [%]



First tests for supporting the monitoring of regenerative agriculture practice

Conventional farmer



Long-time regenerative farmer



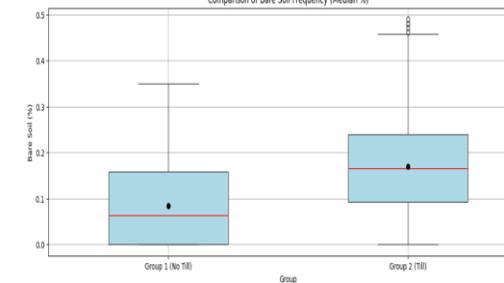
Farmer's parcels

SoilSuite

Bare soils frequency  
0 meaning no bare soil in 5 years  
0,5 meaning 50% of bare soils in 5 years



Comparison of Bare Soil Frequency (Median %)

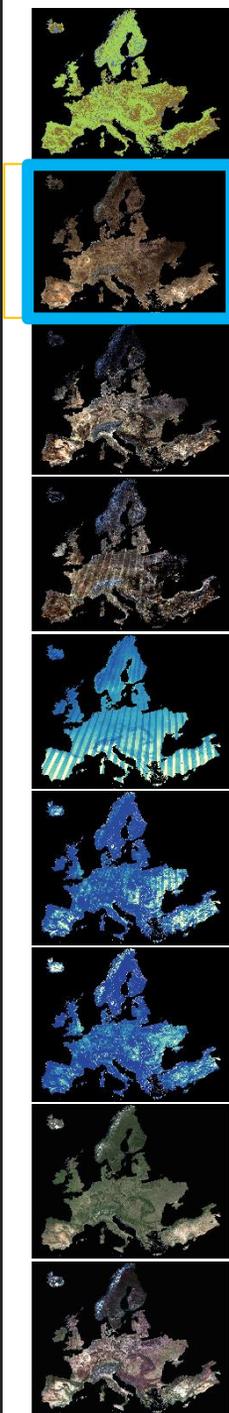


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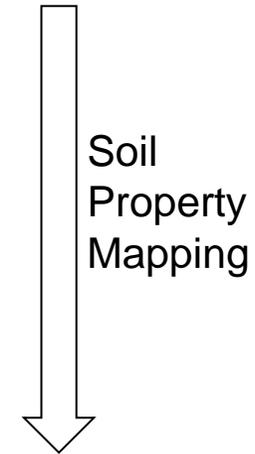
Bare Surface  
Reflectance  
Composite

– Mean



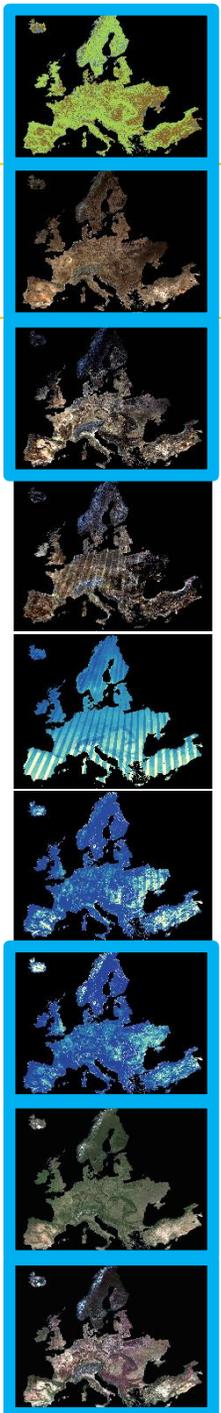
## Projects

- EU CUP4SOIL
- EU MRV4SOC
- ESA WorldSoils – SOC



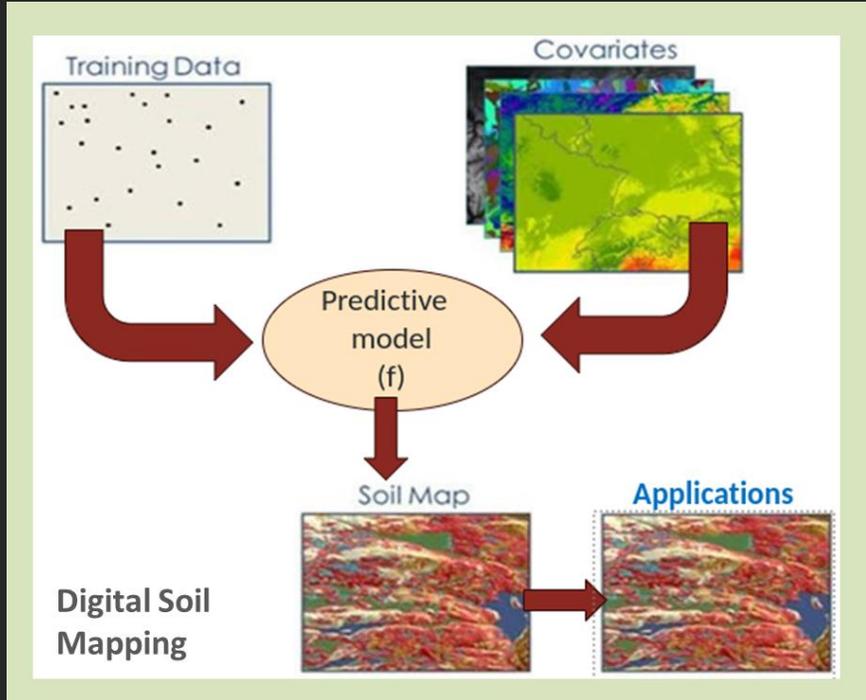
## Publications

- doi: 10.1016/j.geoderma.2025.117340
- doi: 10.1016/j.jag.2025.104504
- doi: 10.1111/ejss.70071
- doi: 10.1016/j.geoderma.2024.117113
- doi: 10.3390/rs17010089
- doi: 10.1016/j.geoderma.2024.116867
- doi: 10.1109/IGARSS53475.2024.10642714
- doi: 10.1016/j.geoderma.2022.116128
- doi: 10.3390/rs13091791



## Digital Soil Mapping

- Input:
  - Soil core data from LUCAS (and other sources in WoSIS if relevant)
- Covariates:
  - SoilSuite prepared by DLR
  - Data available from Copernicus (DEM, land cover)
  - Geology/parent material (JRC)
  - Simple radar products from S-1
- Model:
  - Quantile random forest (robust approach allowing pixel-based uncertainty assessment)
- Outputs:
  - Primary soil properties
  - Uncertainty index
  - Spatial pattern evaluation



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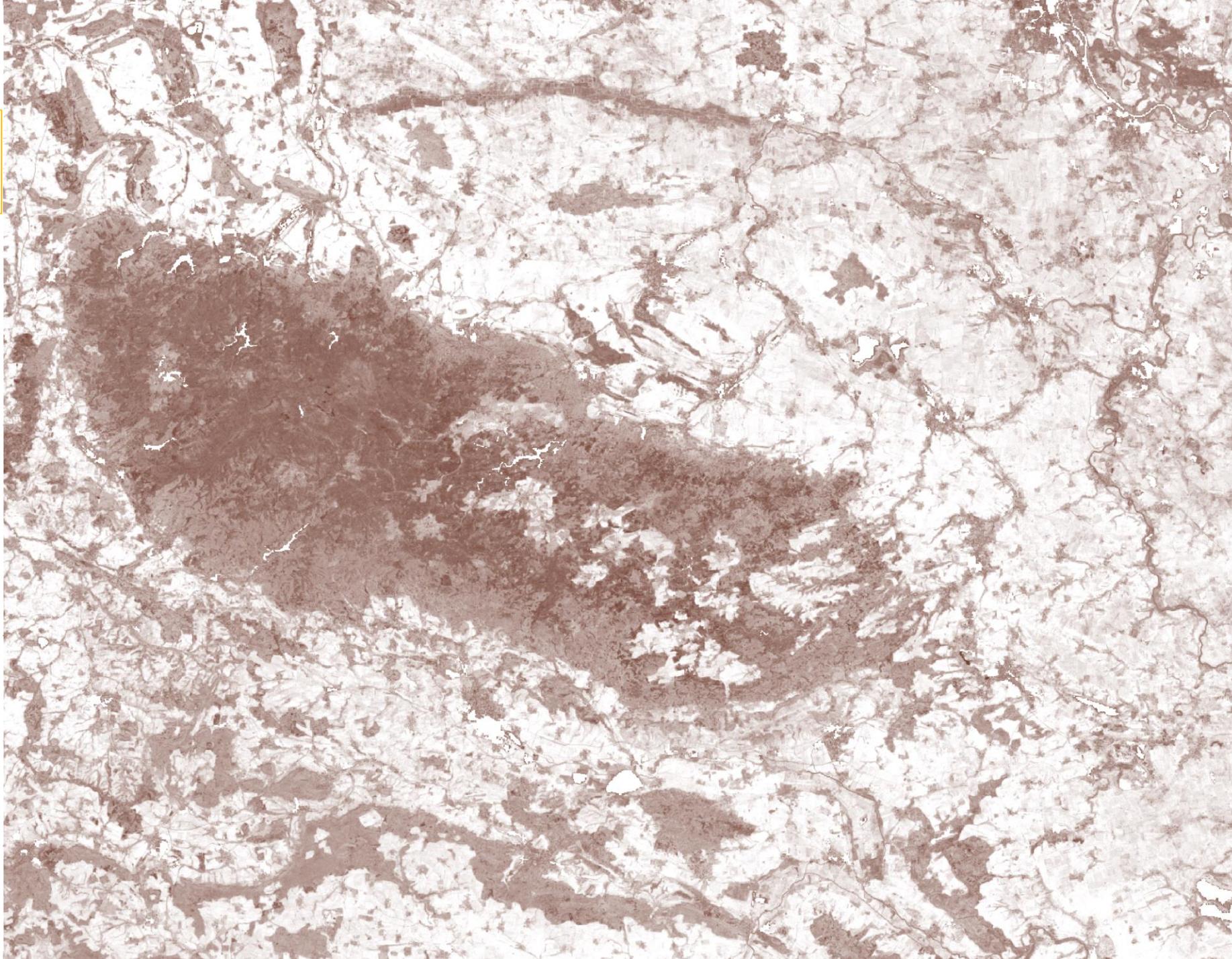
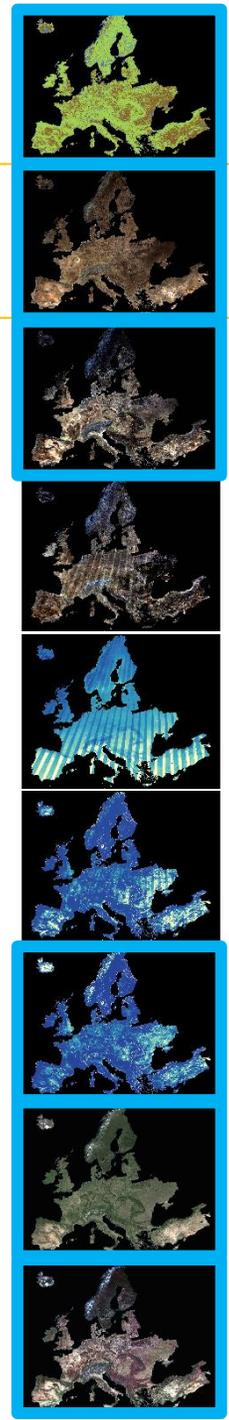
Bare Surface  
Reflectance  
Composite

– Mean



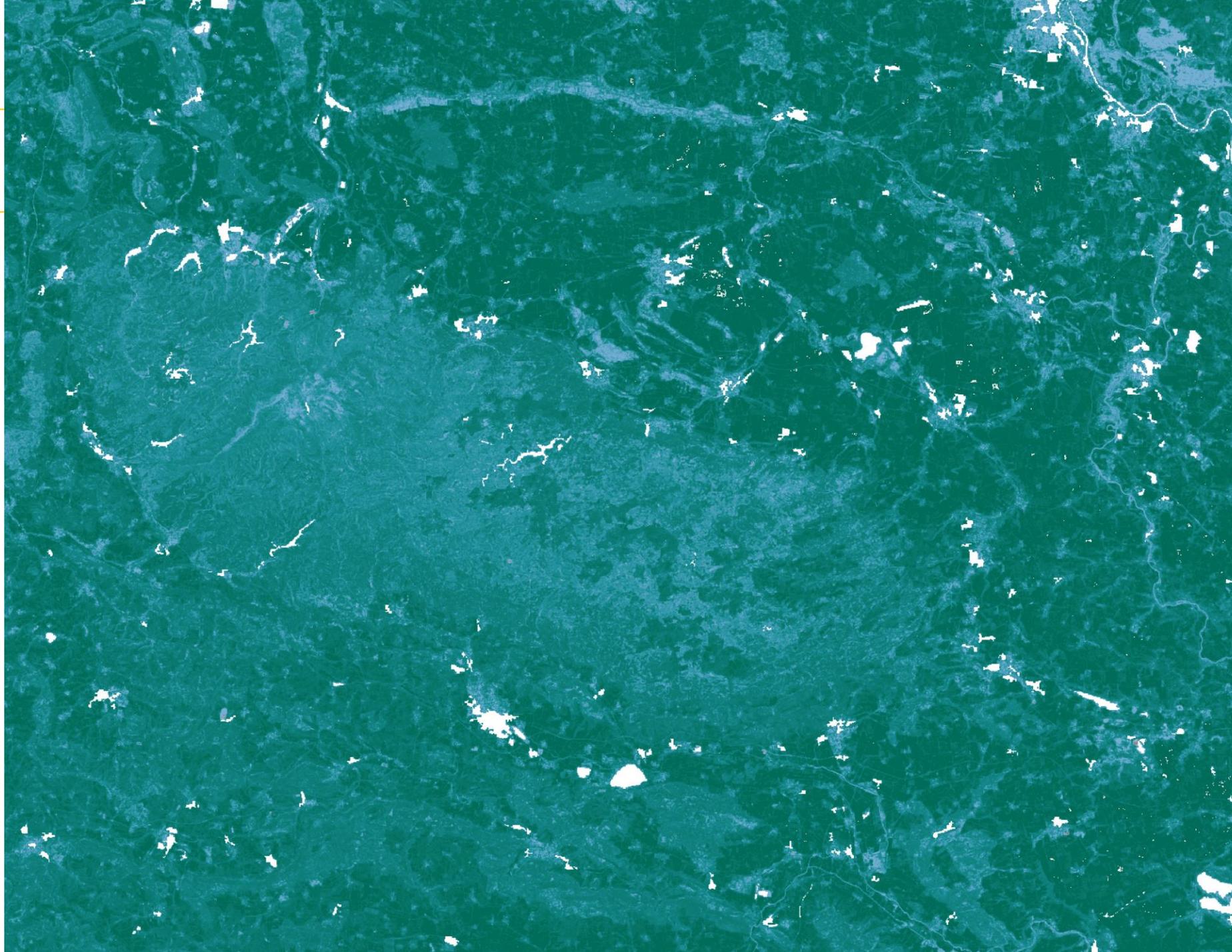
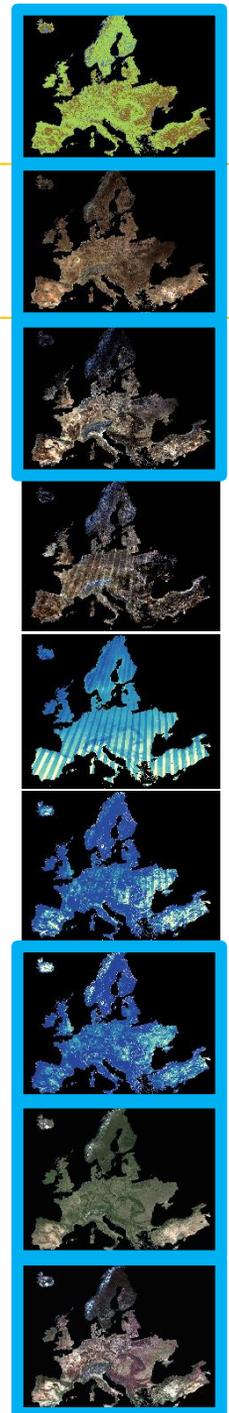
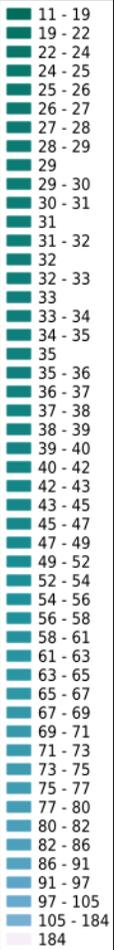
# SoilProperties 2018 – 2022

- Soil organic carbon content
- 30cm mean
- dg/kg



# SoilProperties 2018 – 2022

- Soil organic uncertainty
- 30cm mean
- [%]



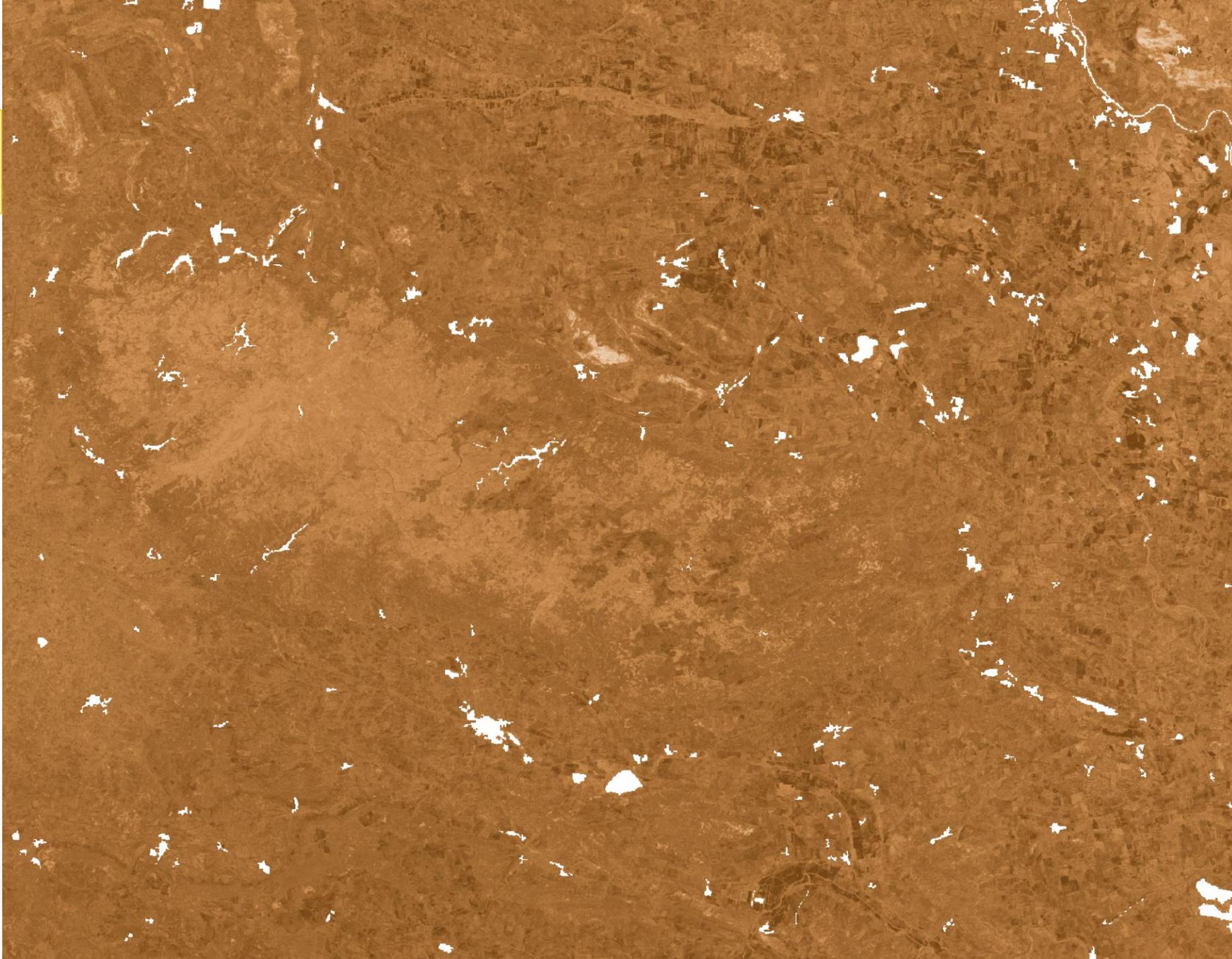
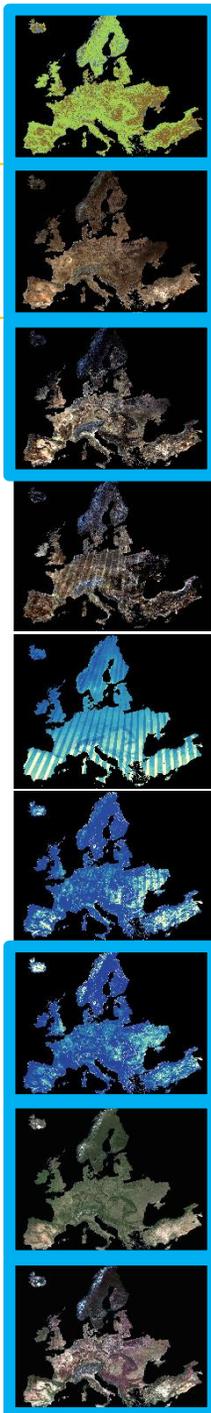
# SoilProperties 2018 – 2022

- Clay content
- 30cm mean
- g/kg

40

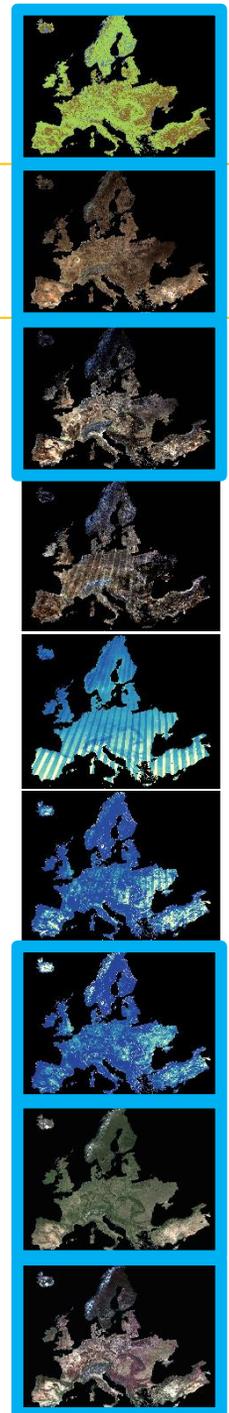
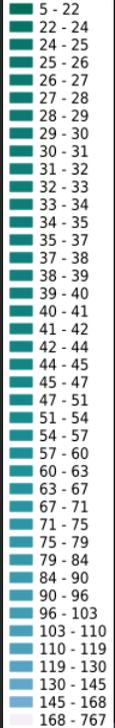


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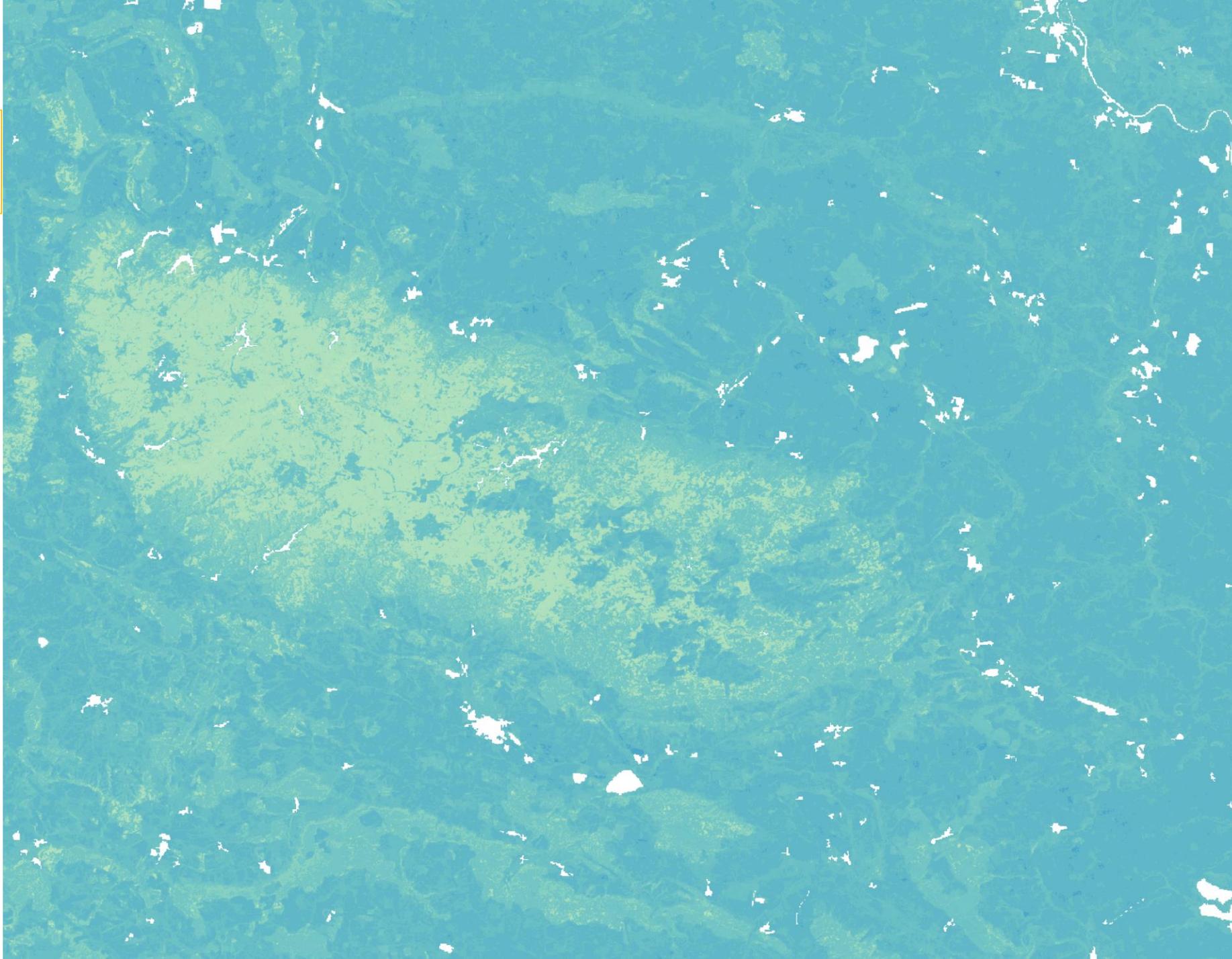
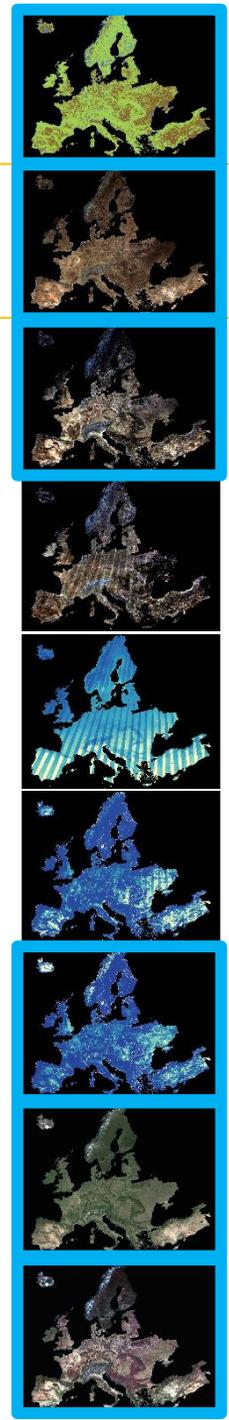
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- Clay content uncertainty
- 30cm mean
- [%]



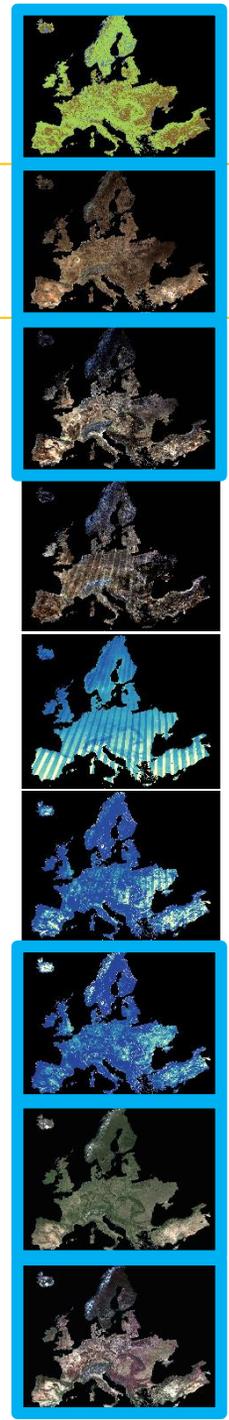
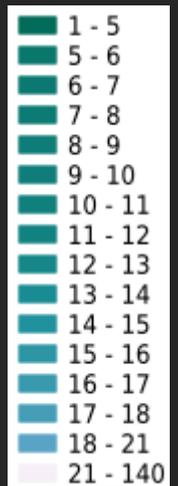
# SoilProperties 2018 – 2022

- Bulk density
- 30cm mean
- $\text{cg}/\text{cm}^3$



# SoilProperties 2018 – 2022

- Bulk density uncertainty
- 30cm mean
- [%]

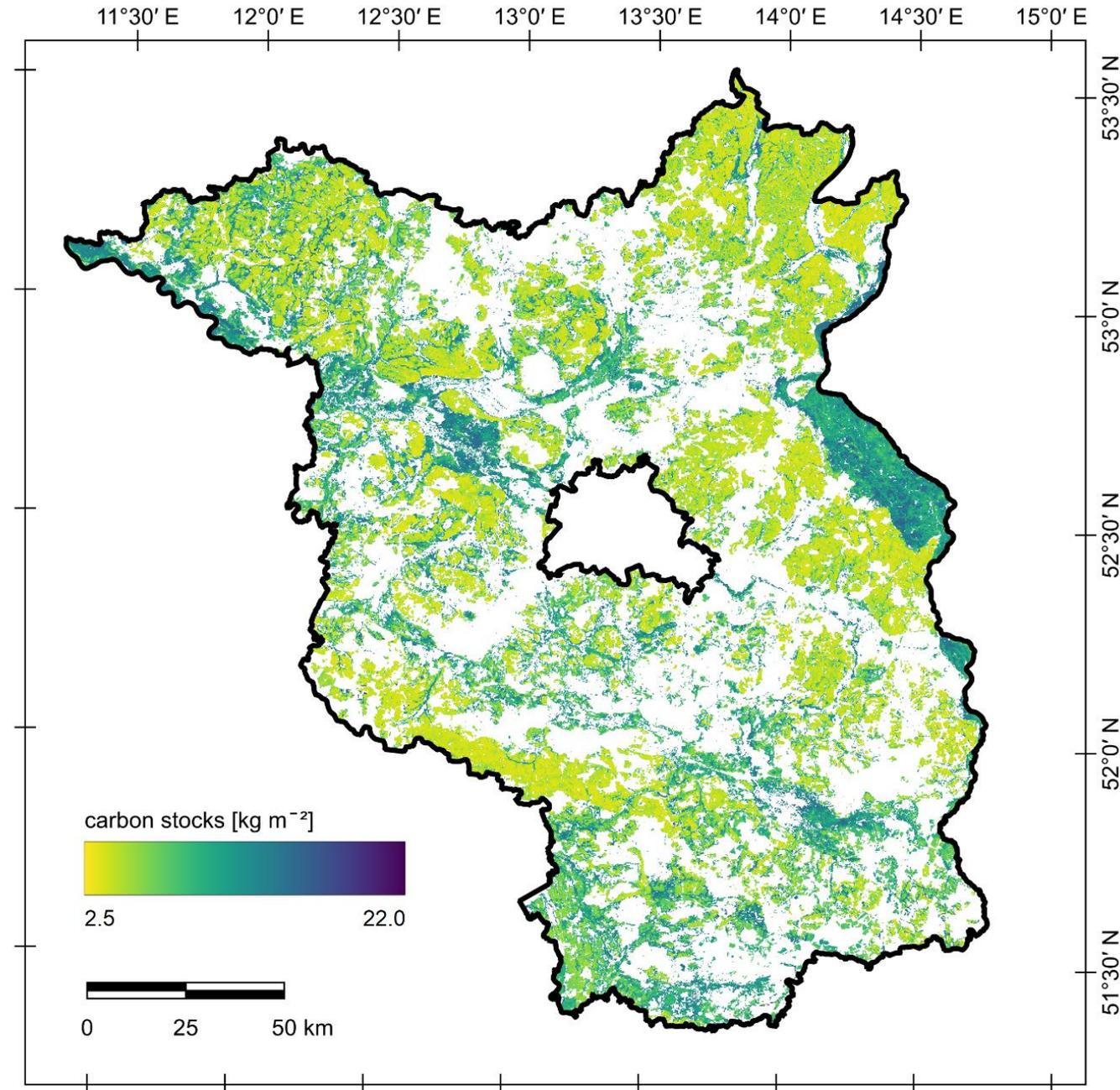
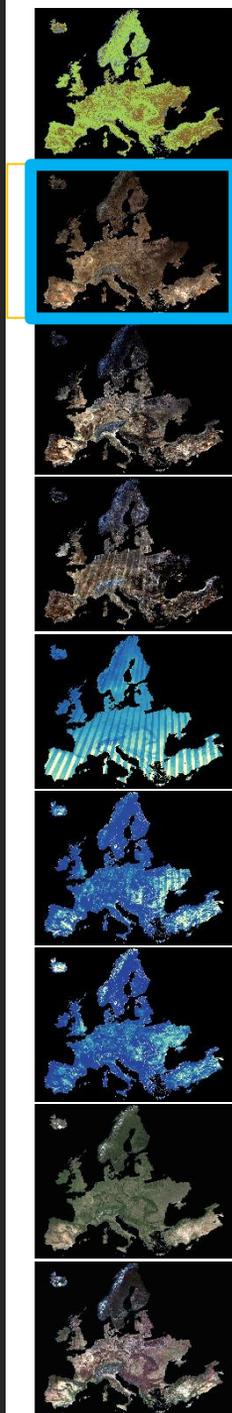


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Bare Surface  
Reflectance  
Composite

– Mean



## Showcase



Federal ministry of  
mining, geology and  
raw materials  
Brandenburg  
(Germany)

Soil carbon stocks

Model validation:

Depth 0 – 10 cm:  
RMSE =  $0.7 \text{ kg m}^{-2}$   
Pseudo  $R^2 = 0.69$

Depth 0 – 100 cm:  
RMSE =  $3.7 \text{ kg m}^{-2}$   
Pseudo  $R^2 = 0.53$

# SCMaP can be configured project-specific

## Fully automated and operational processor

- Spectral and statistical information products for soils
- deployed e.g. at terrabyte – DLR's HPDA platform and OTC
- Tested for Europe, in Brazil, Westafrica, Canada, China

## Publication:

- Karlshöfer et al. 2025, Geoderma, [10.1016/j.geoderma.2025.117340](https://doi.org/10.1016/j.geoderma.2025.117340).
- Heiden et al., 2025: Tech report, [10.15489/qkud8cudg596](https://doi.org/10.15489/qkud8cudg596)
- Heiden, U. et al., 2022: RS, [10.3390/rs14184526](https://doi.org/10.3390/rs14184526)
- Rogge et al., 2018: RSE, [10.1016/j.rse.2017.11.004](https://doi.org/10.1016/j.rse.2017.11.004)

## Selection of optical sensors

- Landsat: 1984 – today (max. 1 valid obs./month)
- Sentinel-2: 2015 – today (2-4 valid obs./month)

## Temporal settings:

- Year/s, month, seasons

## Min. sun elevation

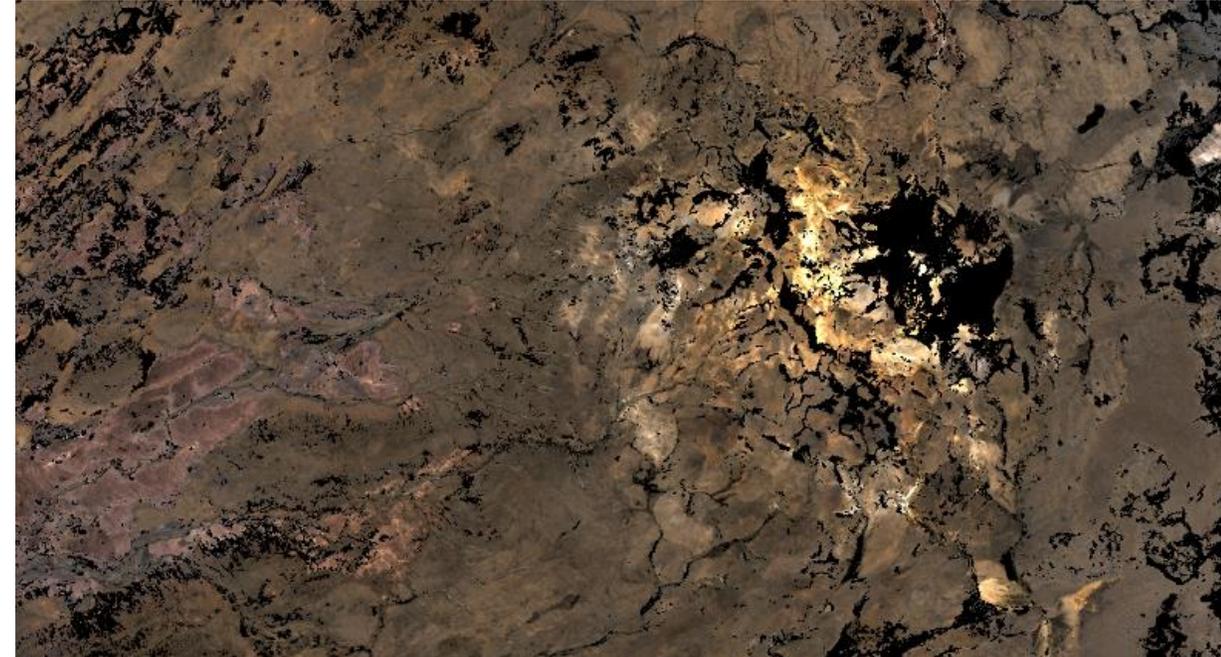
- for better spectral reliability – can filter out images with low sun elevations (spectral images with low quality)

## Soil-specific cloud screening:

- $(B11-B8A)/(B11+B8A) > 0.02$
- $b \leq \text{median}(B) + 3\sigma; \sigma = 1.48 \text{ median}(|B - \text{median}(B)|)$

## Various spectral indices for selection of bare soil pixels

- E.g. Combination of the NDVI + NBR  $\frac{B8 - B4}{B8 + B4} + \frac{B8 - B12}{B8 + B12}$



**SOILSUITE EUROPE**



## SoilSuite for Europe

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## SoilSuite – Sentinel-2 – Europe, 5 year composite (2018-2022)

[Map](#) [Download](#) [STAC Collection](#) [CSW Record](#)

[All Themes](#) [Pedosphere](#) DOI: 10.15489/qkud8cudg596

[DLR](#) [EOC](#) [Land](#) [SCMaP](#) [Soil](#) [Sentinel-2](#) [Temporal Composites](#) [Soil Coverage](#)  
[Soil Composite Mapping Processor](#) [Reflectance Composite](#) [Surface Reflectance Composite](#)  
[Bare Soil Coverage](#) [Bare Soil Frequency](#)

The SoilSuite contains a collection of different image data products that provide information about the spectral and statistical properties of European soils and other bare surfaces such as rocks. It is created using DLR's Soil Composite Mapping Processor (ScMAP), which utilises the Sentinel-2 data archive.

SCMaP is a specialised processing chain for detecting and analysing bare soils/surfaces on a large (continental) scale. Bare surface and soil pixels are selected using a combined NDVI and NBR index (PVIR2) that optimises the exclusion of photosynthetically active and non-active vegetation. The index is calculated and applied for each individual pixel. All SoilSuite products are calculated based on the available Sentinel-2 scenes recorded between January 2018 and December 2022 in Europe. The data package excludes all scenes with a cloud cover of > 80 % and a sun elevation of < 20 degrees. The spectral composite products are calculated from the mean value after extensive removal of clouds, haze and snow effects at both scene and pixel level. The spectral data products are available at a pixel size of 20 m and contain 10 Sentinel-2 bands (B02, B03, B04, B05, B06, B07, B08, B08a, B11, B12).

## SoilProperties for Europe

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**Vielen Dank für Ihre Aufmerksamkeit**

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

