Earth Observation for Ecosystem Accounting

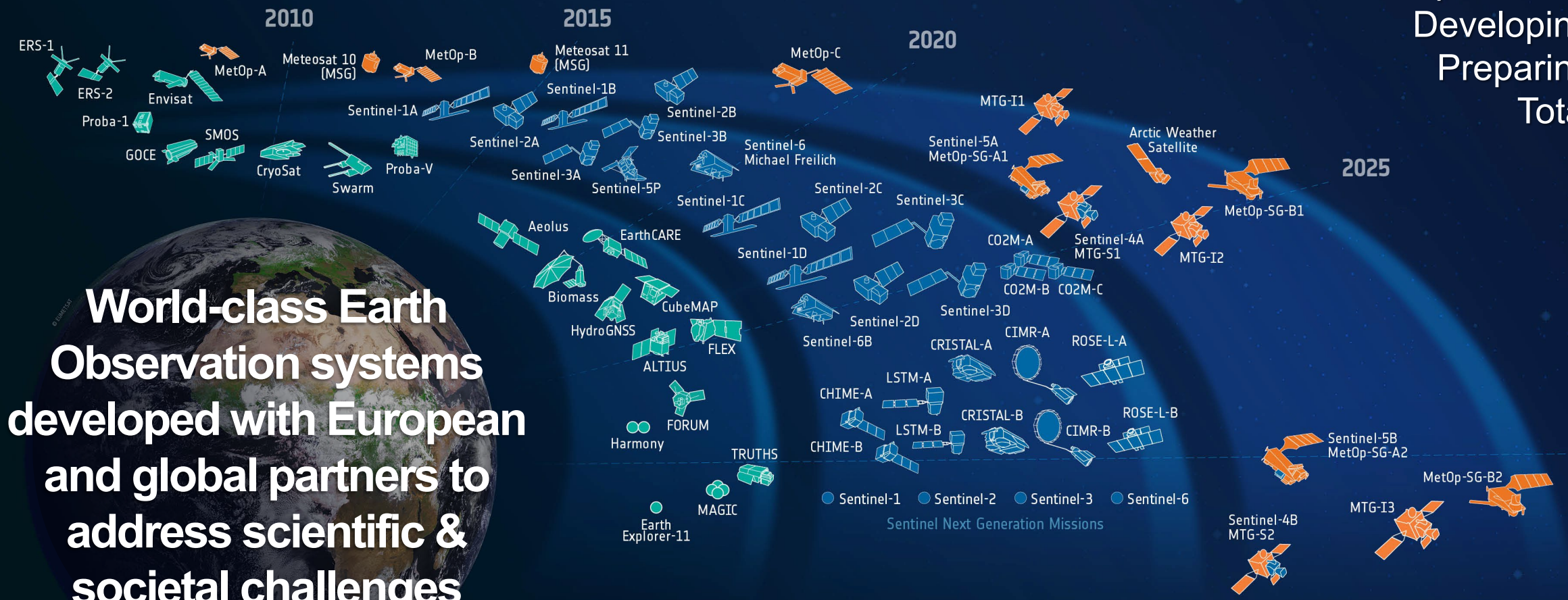
Giuseppe Ottavianelli, European Space Agency

ACES, 12-15 December 2022, Washington DC

ESA's Earth Observation Missions

Satellites

Heritage **04**
Operational **14**
Developing **41**
Preparing **22**
Total **81**



World-class Earth Observation systems developed with European and global partners to address scientific & societal challenges

Science | Copernicus | Meteorology

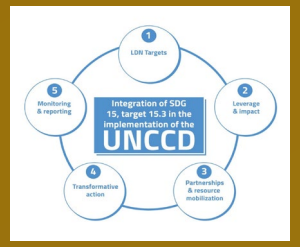
EO Supports Major International and European Policy Frameworks

Ecosystem Accounting underpins the Multilateral Environmental Agreements

UN Convention to Combat Desertification (UNCCD)

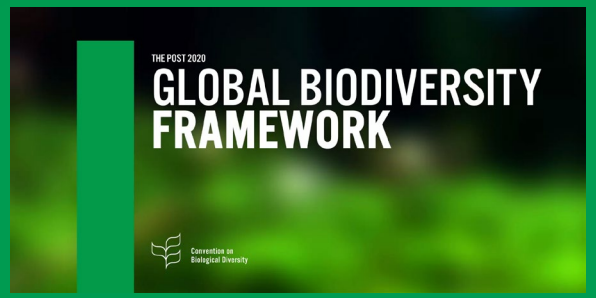
UNCCD 2018-2030 Strategic Framework

Strategic Objective 1: to improve the conditions of ecosystems



Convention on Biological Diversity (CBD)

Post 2020 Global Biodiversity Framework (GBF) and its monitoring framework



UN Framework Convention on Climate Change (UNFCCC)

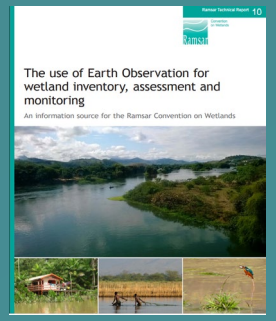
UNFCCC Paris Agreement

Glasgow Climate Pact

Ramsar Convention on Wetlands

Ramsar Strategic Plan (2016 – 2024)

Conservation and wise use of all wetlands



UN SEEA Ecosystem Accounting and EU EA

International standard on Ecosystem Accounting that regulates the production of statistical accounts on ecosystem extent, condition and services, underpinning the development of monitoring frameworks of other MEAs.

Sustainable Development Goals (SDGs)

SDG Target 6.6
Protect and restore water-related ecosystems

SDG Target 14.2
Sustainably manage and protect marine and coastal ecosystems

SDG Target 15.1
Ensure conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems.

The great value of Earth Observation

- Science-based and traceable
- Transparent and reproduceable
- Open approach with free data
- Future long-term provision
- Clear uncertainty levels and consistency
- Cross-boundary

- Quantitative analytics with multi-data integration
- Global to local perspective
- Across decades to rapid actions
- Multi-ecosystems approach
- Multi-stressors/drivers monitoring

The emergence of **EO data streams at appropriate scales** combined with **advances in digital technologies** offer **unprecedented opportunities for countries** to efficiently monitor the **extent** and **conditions** of their ecosystems, determine **ecosystem services** and implement their **national ecosystem accounting**.

GEO EO4EA initiative

GEO EO4EA (secr.: Conservation International)

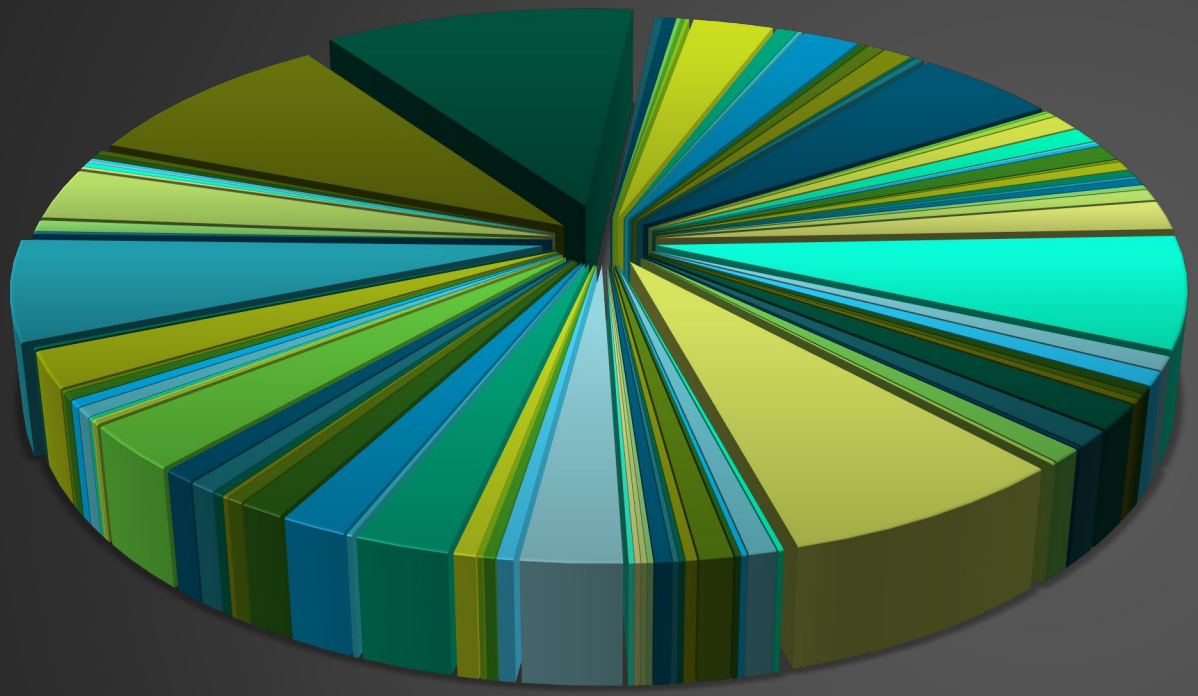
PURPOSE
further the development and use of Earth Observations for natural capital accounting (NCA) consistent with the set of standards and guidelines put forth by the UN-SEEA, and specifically the Ecosystem Accounts (EA).

MISSION
document, pioneer, develop, and test the methods and tools that will allow earth observation technology to more effectively enable the widespread adoption of ecosystem accounting.

GEO EARTH OBSERVATIONS FOR ECOSYSTEM ACCOUNTING


esa
https://eo4ea-2022.esa.int/
EO 4
ecosystem
accounting
EO 4 Ecosystem Accounting
Virtual event | 28 Nov–1 Dec 2022
EARTH OBSERVATIONS FOR
ECOSYSTEM ACCOUNTING
United
Nations
System of
Environmental
Economic
Accounting

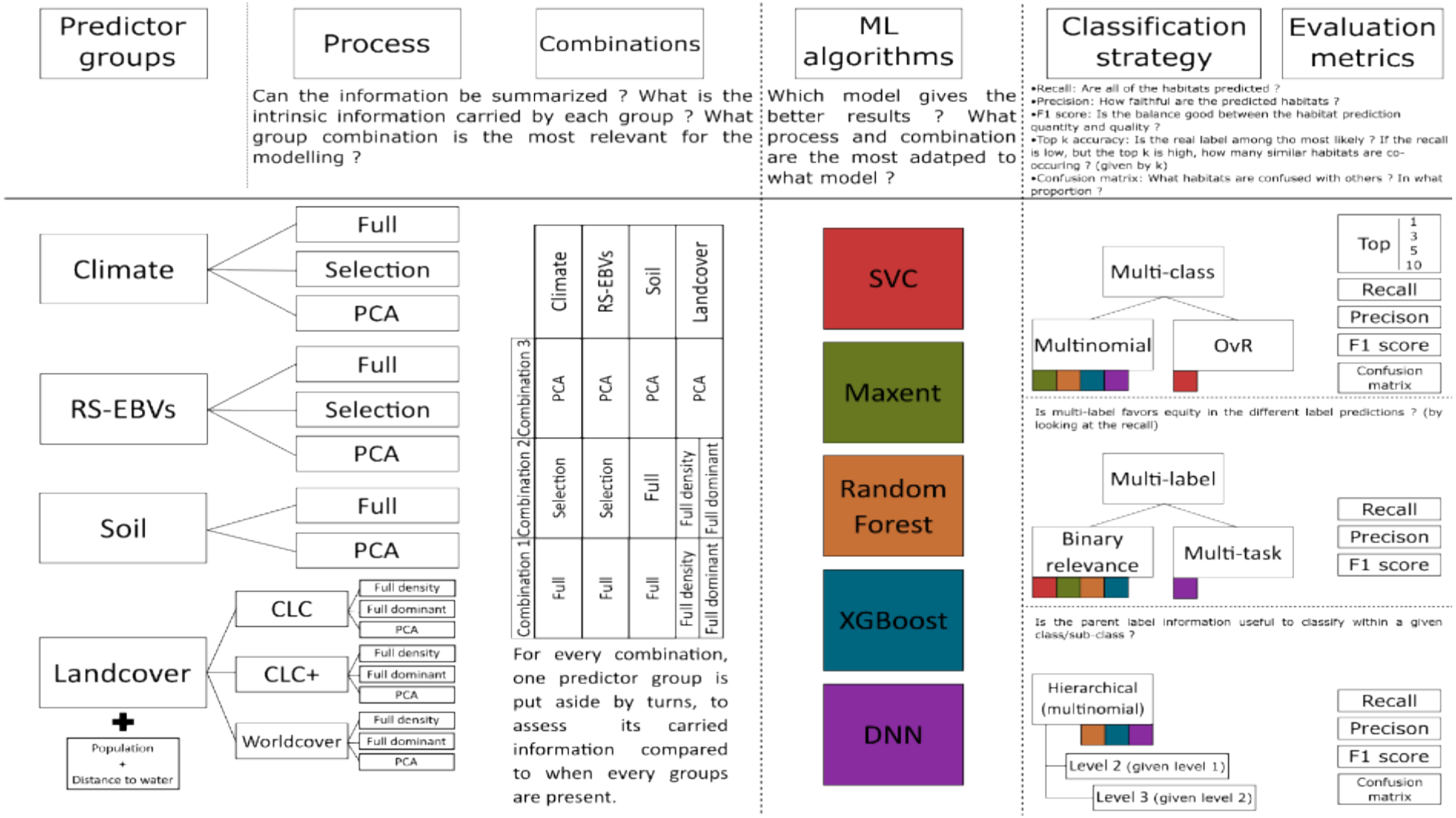
691 Participants from 91 Counties



- Angola
- Argentina
- Australia
- Austria
- Bangladesh
- Belgium
- Bolivia
- Botswana
- Brazil
- Bulgaria
- Cameroon
- Canada
- Cape Verde
- Chile
- China
- Colombia
- Congo
- Costa Rica
- Croatia
- Cyprus
- Czech Republic
- Denmark
- Djibouti
- Egypt
- Ethiopia
- Finland
- France
- Germany
- Ghana
- Greece
- Guatemala
- Hong Kong
- Hungary
- India
- Indonesia
- Iran
- Ireland
- Israel
- Italy
- Jamaica
- Japan
- Jordan
- Kazakhstan
- Kenya
- Latvia
- Lebanon
- Liberia
- Luxembourg
- Madagascar
- Malaysia
- Maldives
- Mauritius
- Mexico
- Morocco
- Mozambique
- Namibia
- Nepal
- Netherlands
- New Zealand
- Nigeria
- Norway
- Pakistan
- Panama
- Peru
- Philippines
- Poland
- Portugal
- Qatar
- Romania
- Rwanda
- Senegal
- Singapore
- Slovakia
- Slovenia
- South Africa
- South Korea
- Spain
- Sudan
- Sweden
- Switzerland
- Taiwan
- Thailand
- Timor-Leste
- Togo
- Turkey
- Uganda
- United Kingdom
- United States
- Uruguay
- Vietnam
- Zambia
- (blank)

ECOSYSTEM EXTENT

Complex algorithms – External Models – ML solutions

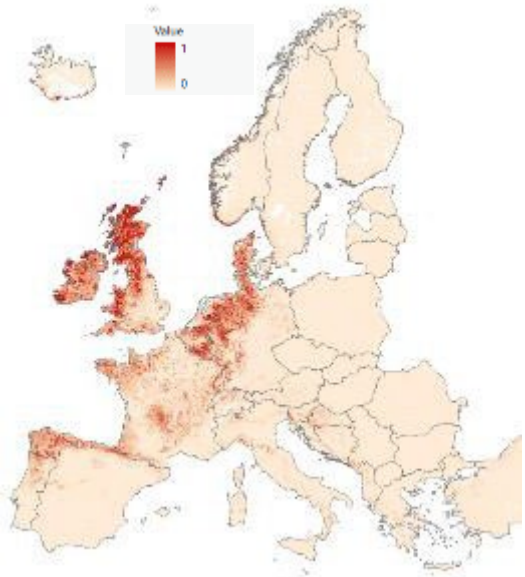


Example European EUNIS habitat modelling: S41 Wet heath

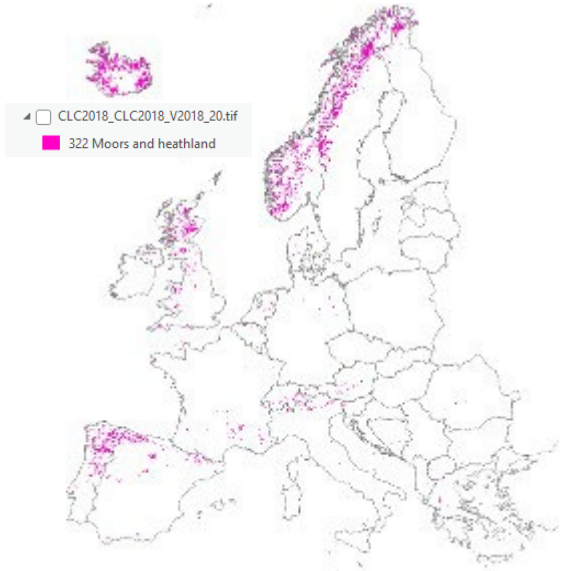
Distribution data

from European Vegetation Archive (EVA)

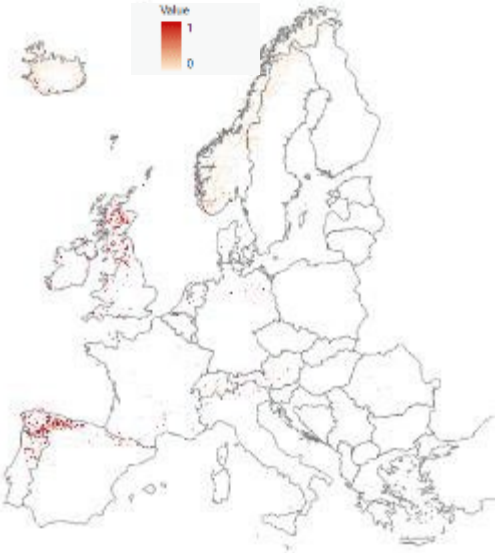
Habitat suitability map

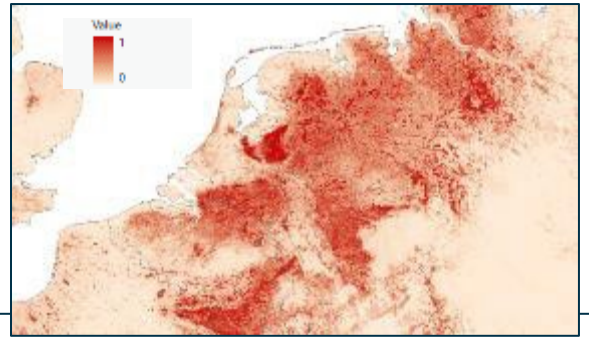


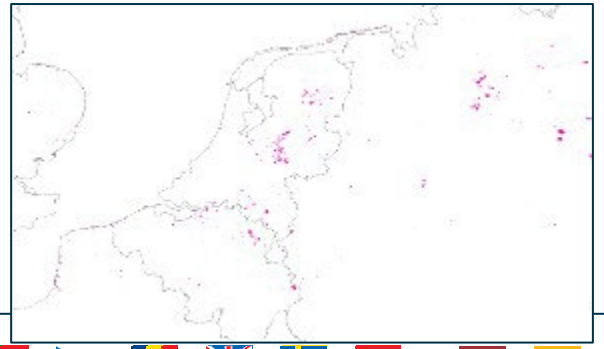
Land cover

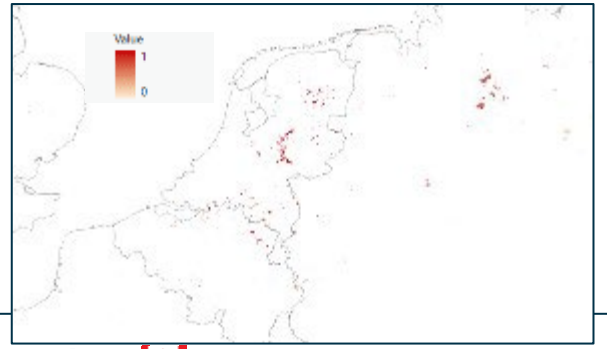


Habitat probability map





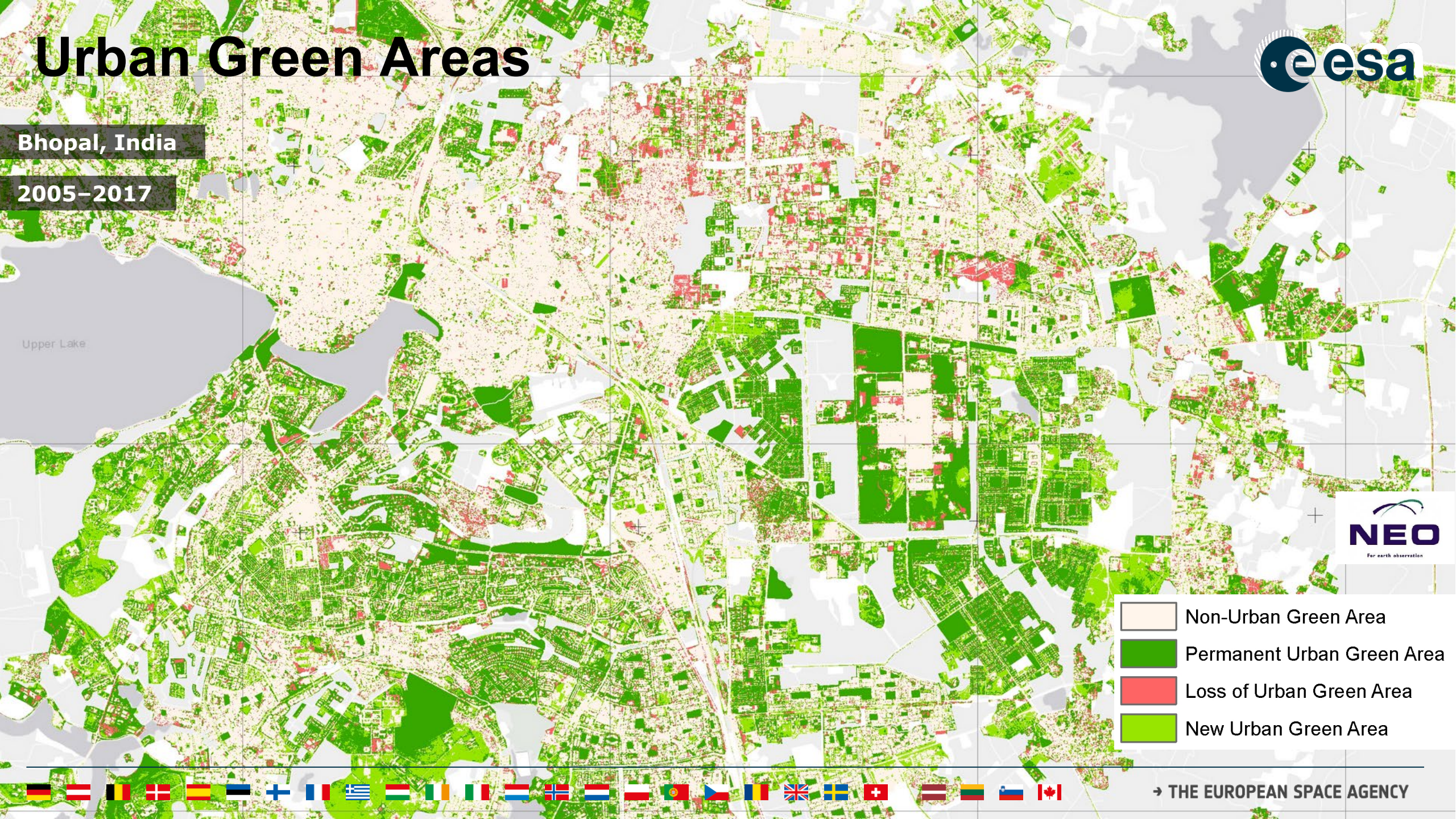




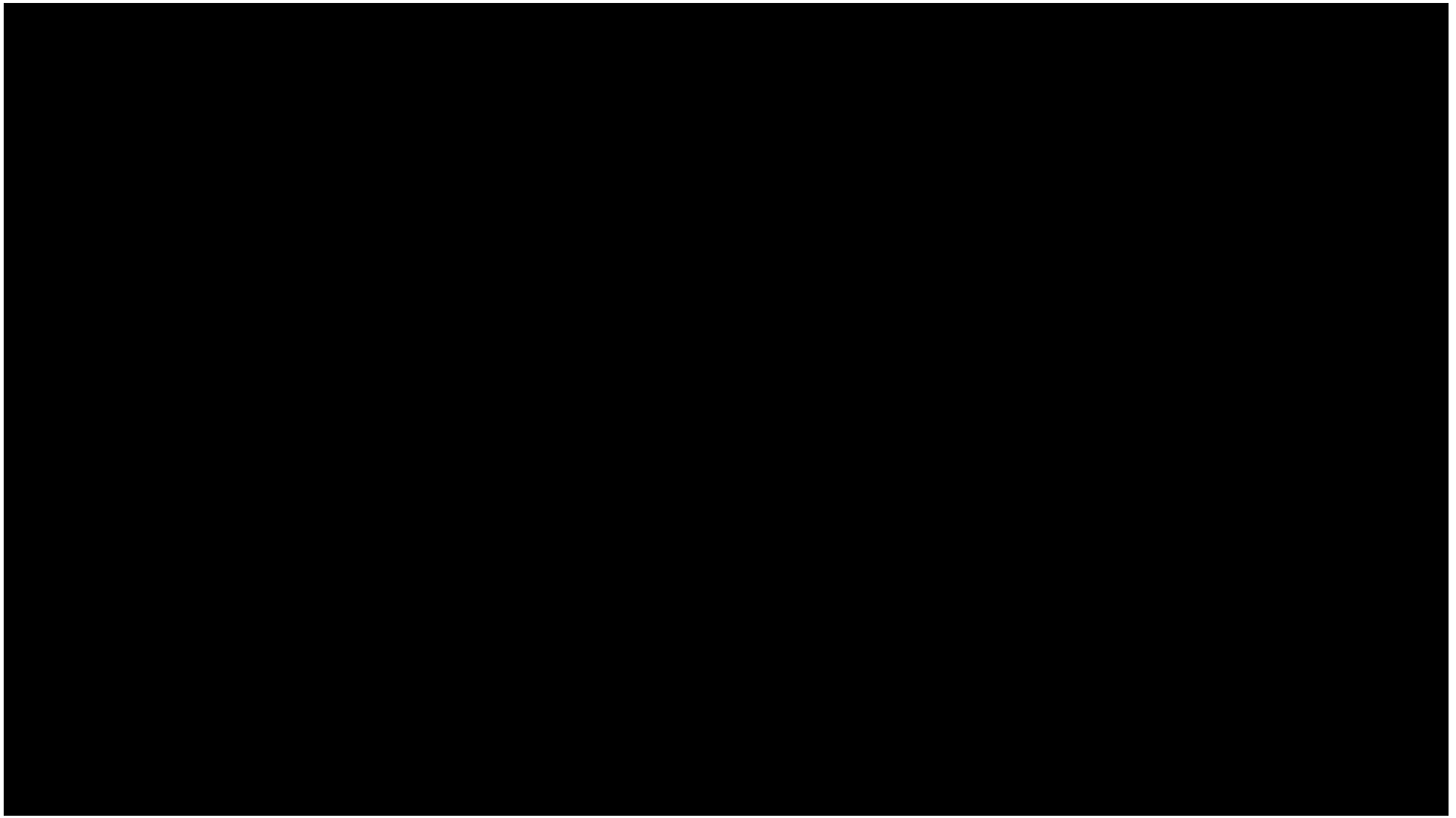
Urban Green Areas

Bhopal, India

2005–2017



Dynamic World Settlement Footprint (WSF) products



UN HABITAT
FOR A BETTER URBAN FUTURE

World Settlement footprint and its dynamic evolution in time, with Landsat and Copernicus Sentinel-1 and Sentinel-2.

Advance the **understanding of urbanization** at planetary scales.

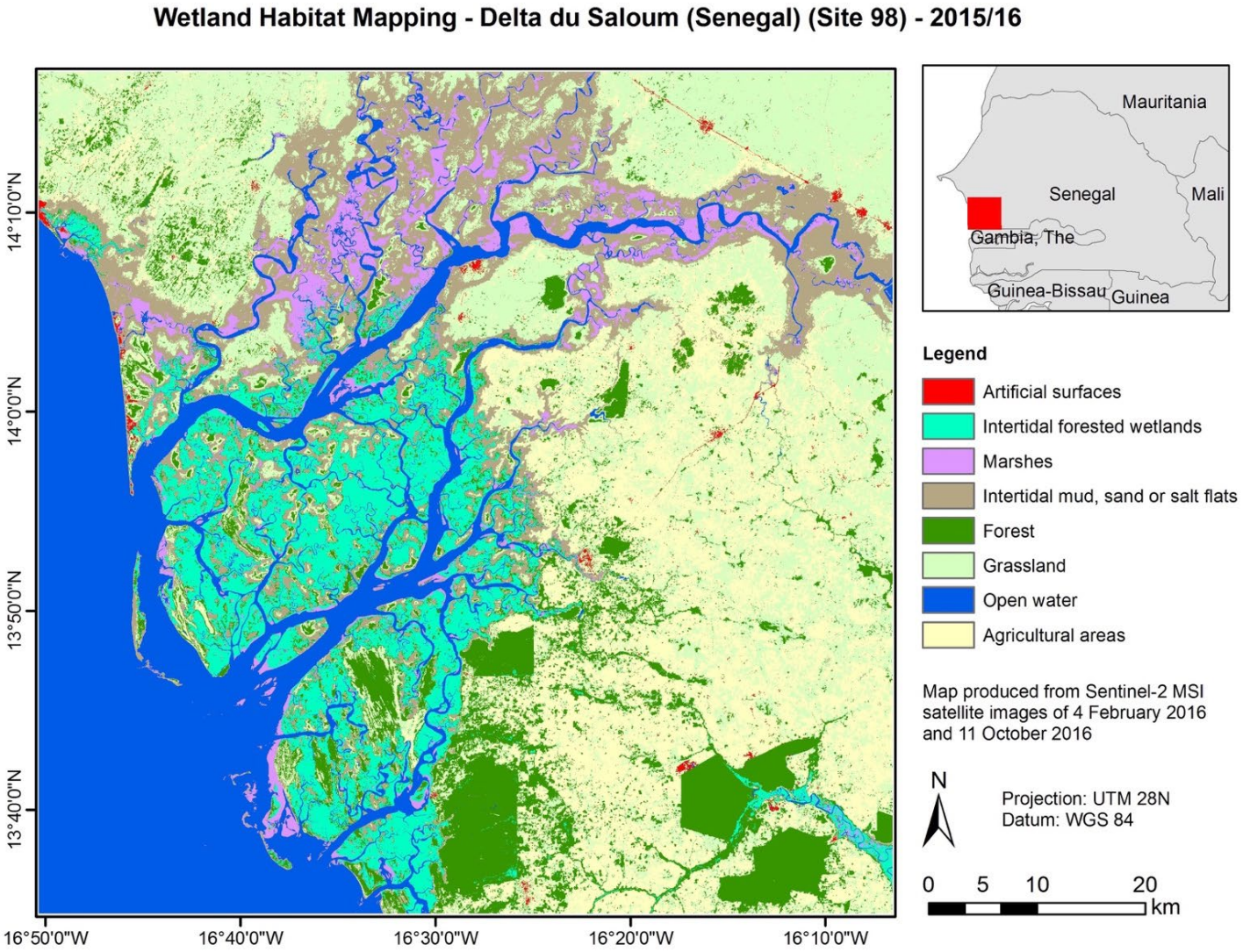
Stakeholders: UN Habitat, National Statistical Offices (NSOs), National Mapping Agencies, Cities councils.

Urban effective planning for sustainable solutions and direct contribution to the **SDGs**.

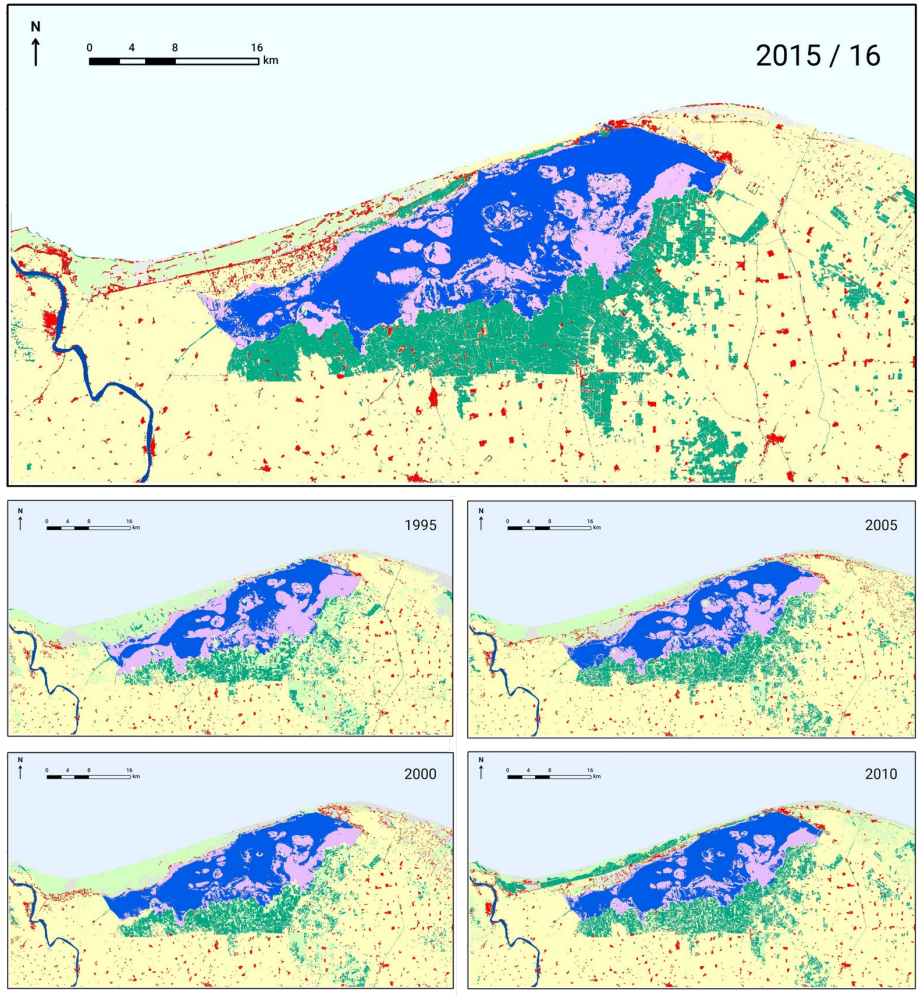
DLR urban tep

Wetland ecosystems: Wetland Habitat Mapping

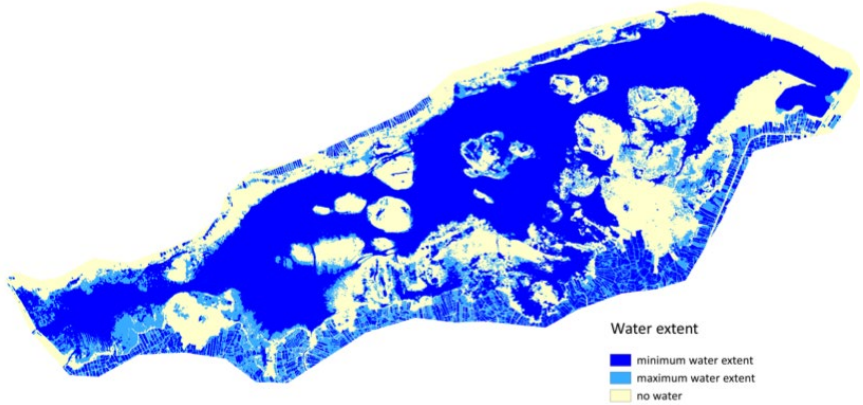
- Supervised **classification of the land cover and land use** inside and around the wetland site.
- Exploit **time series of HR optical satellite images** to capture the variety of wetland habitats.
- Detect **changes in wetland habitats**, derive **trends**, **assess threats and estimate impacts.**
- **Standardized** Land Cover / habitat **classification scheme** with Ramsar wetlands typologies

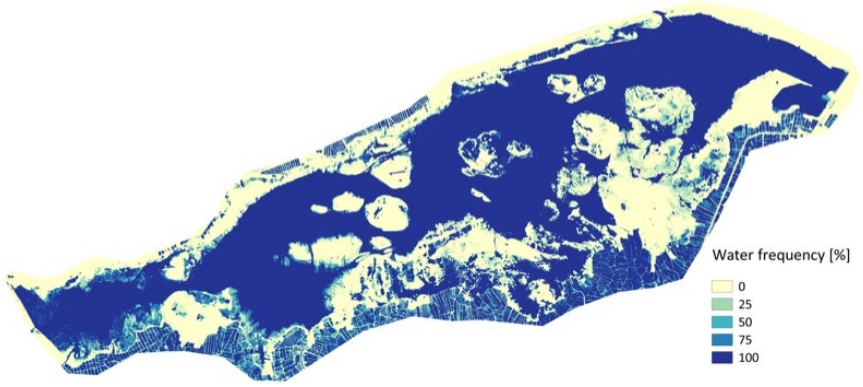


Wetland ecosystems: Wetland Habitat Monitoring



Lake Burullus, Egypt

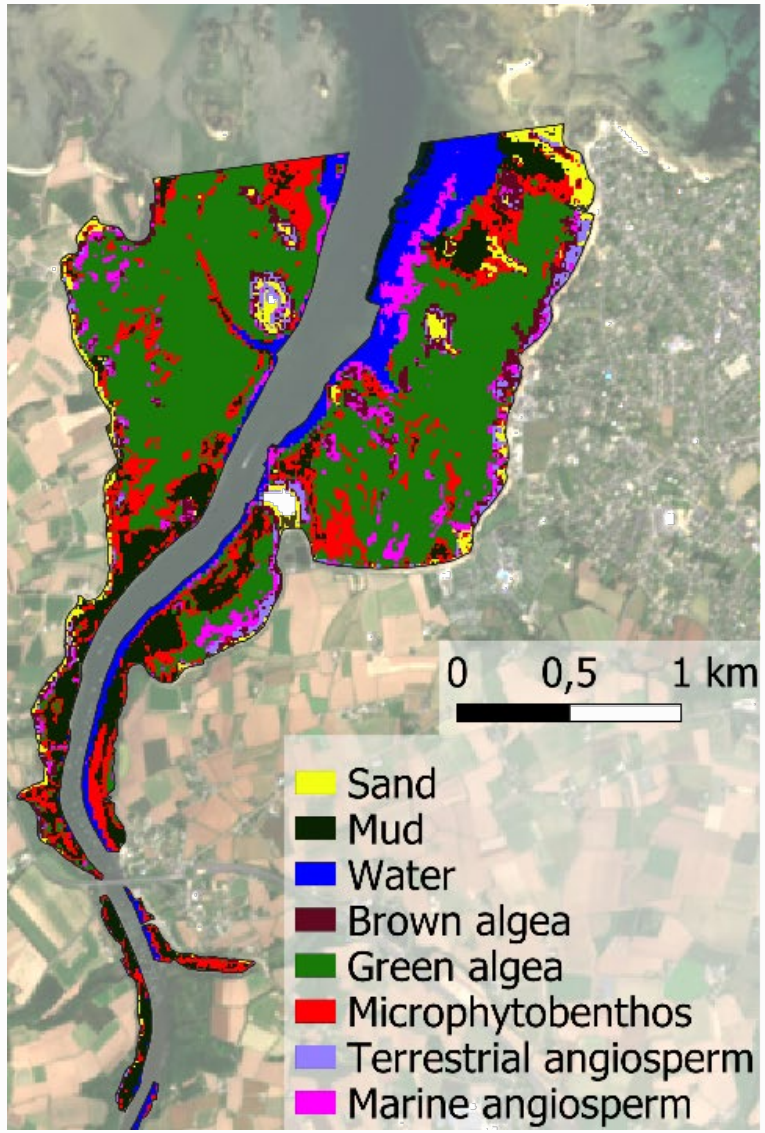




- Artificial surfaces
- Agricultural areas
- Sand shores
- Sparse vegetation
- Aquaculture ponds
- Salt marshes
- Rivers
- Sea
- Brackish lakes

Intertidal ecosystems

- Intertidal habitat mapping (seagrass, microphytobenthos , macroalgae, oyster reefs, and polychaetes reef)
- Impact of anthropogenic pressures
- Case study: Atlantic coast, France and Portugal



SCALABLE SPATIAL SEAGRASS ECOSYSTEM EXTENT ACCOUNTS

esa

GLOBAL SEAGRASS WATCH
serverless is more

22
Mediterranean countries

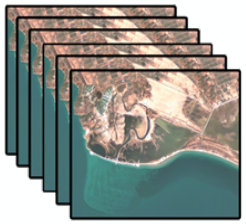
56,783 km²
Mapped seabed area

>19,000 km²
Mapped seagrass area

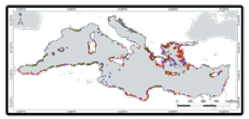
72 %
Overall accuracy

DLR

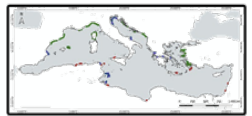
279,186
10-m Sentinel-2 image tiles (2015-2019)

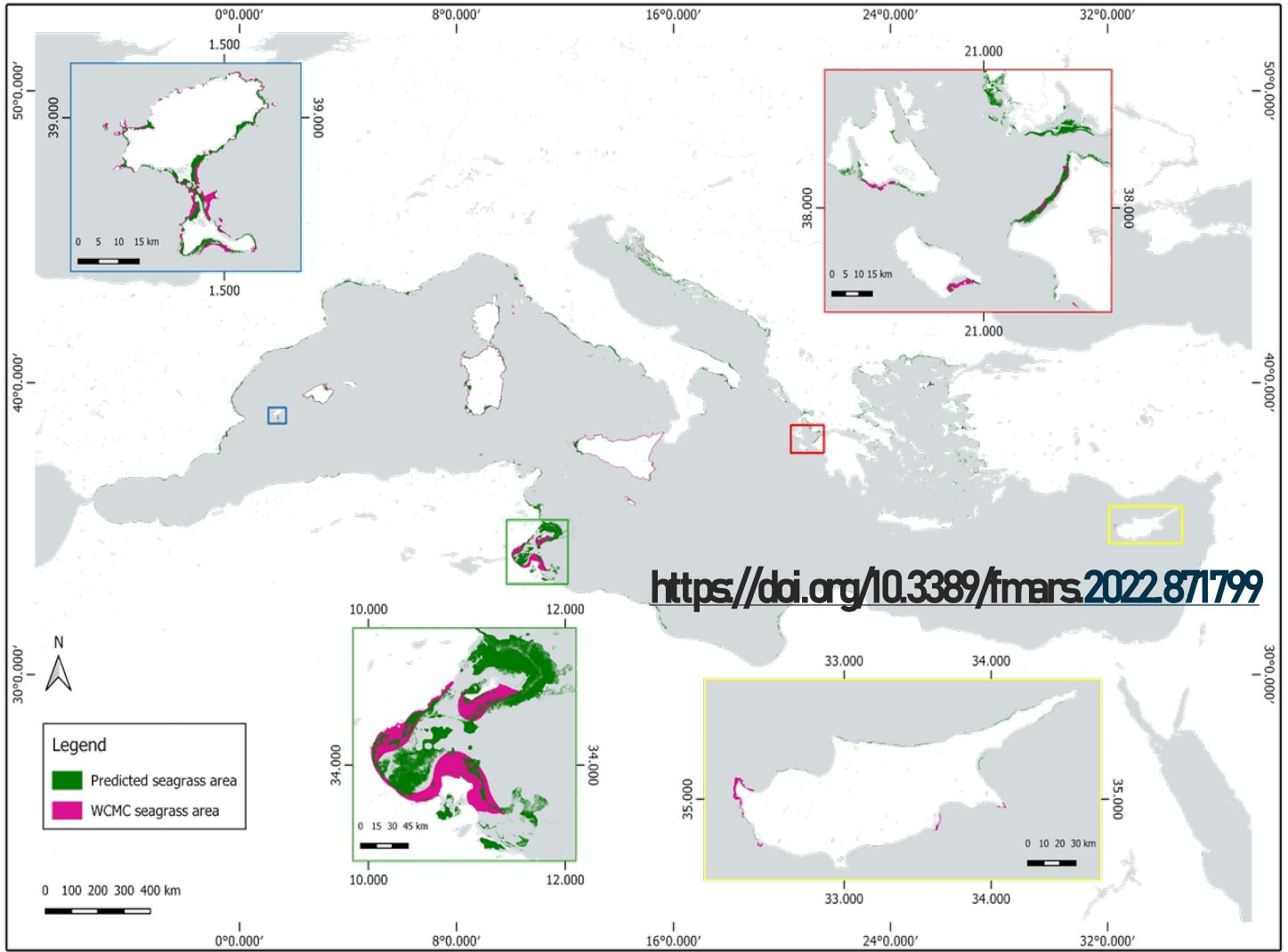


62,928
Human-labelled training pixels



2,480
Field-collected validation points



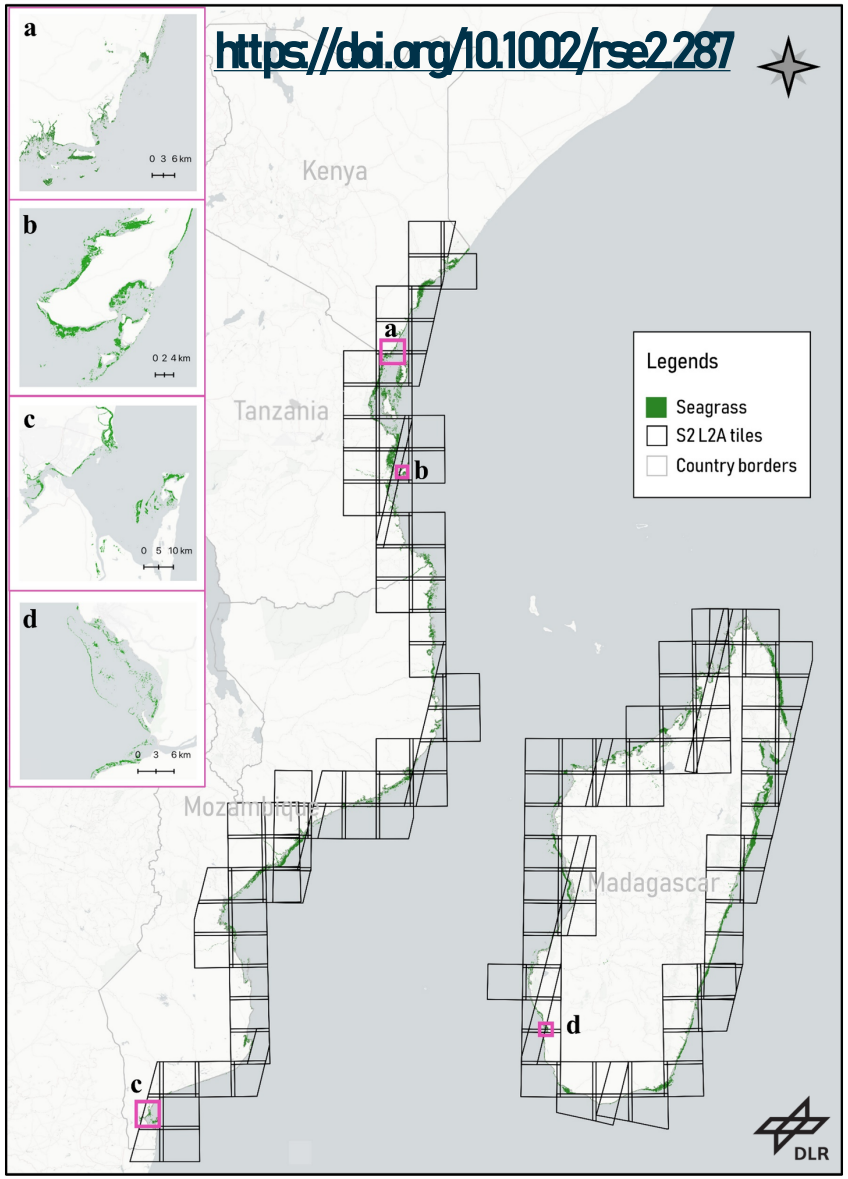


GLOBAL SEAGRASS WATCH
serverless is more

11,560
10-m Sentinel-2 L2A image tiles (2018-2020)

128,000 km²
Mapped seabed area

84.3%
Overall accuracy



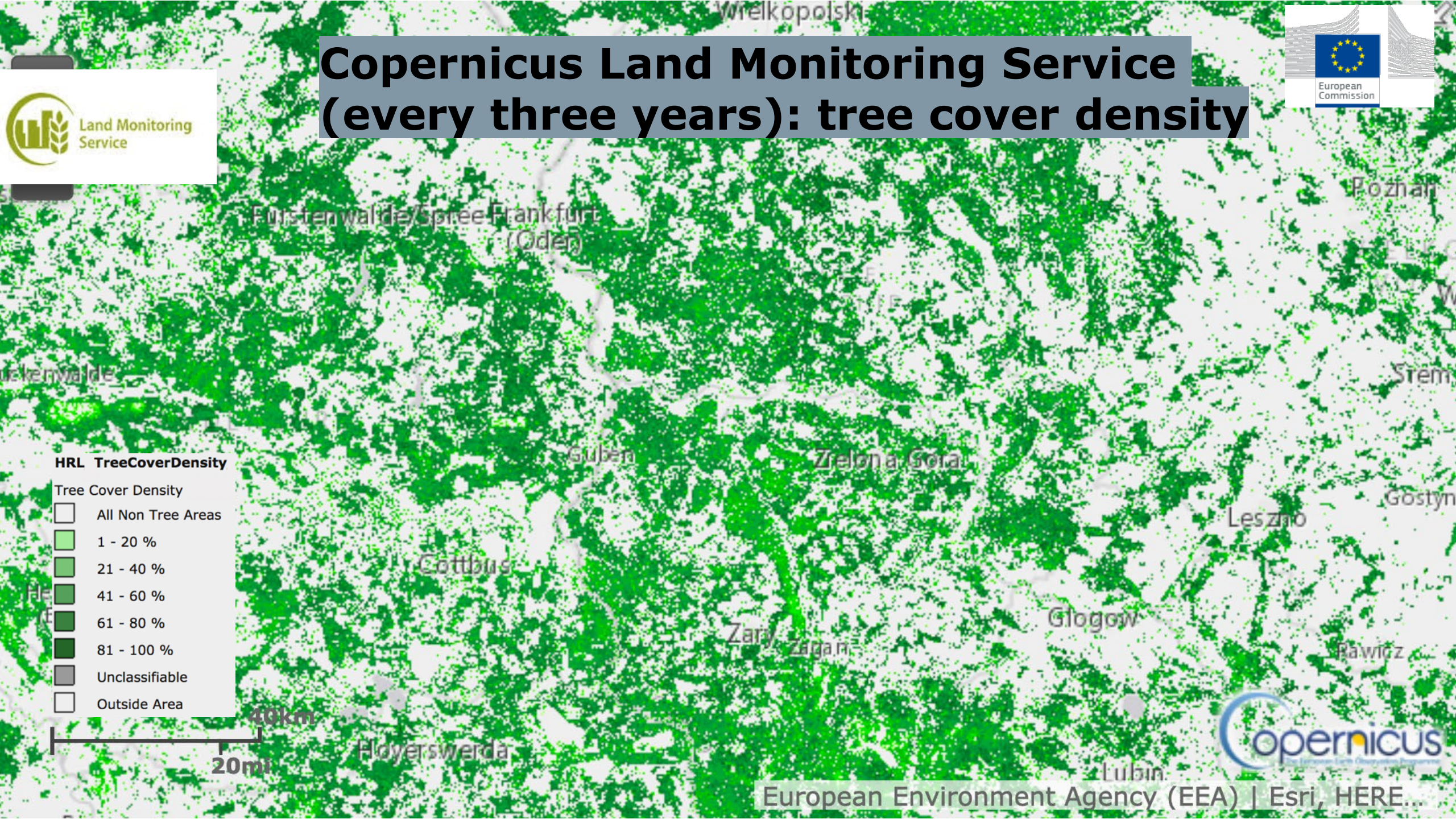
4,316 km²
Mapped seagrass area

147.5 Megatons CO_2
Stored carbon dioxide in regional seagrass soils

20,820
reference data points

ECOSYSTEM CONDITIONS

Copernicus Land Monitoring Service (every three years): tree cover density



Bark Beetle Infestation

Bark beetle infestation progression (14-day) and infestation probability over the beetle season 2018

RADD (RAdar for Detecting Deforestation) Alerts - based on dense Sentinel-1 time series

http://radd-alert.wur.nl

Central African Republic
RADD Alerts 2019 –2021
Selective logging

Credit: Pieter Moonen

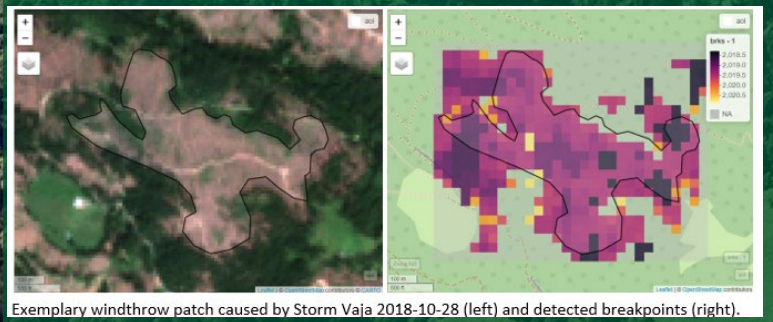
WAGENINGEN UNIVERSITY & RESEARCH

Reiche et al.(2021), ERL

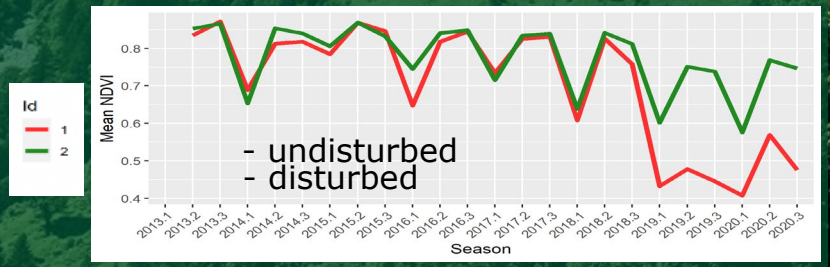
Alpine ecosystems conditions: Forests

Forest disturbance:

- Spatial information on forest cover changes
- Temporal information on the timing of the change event

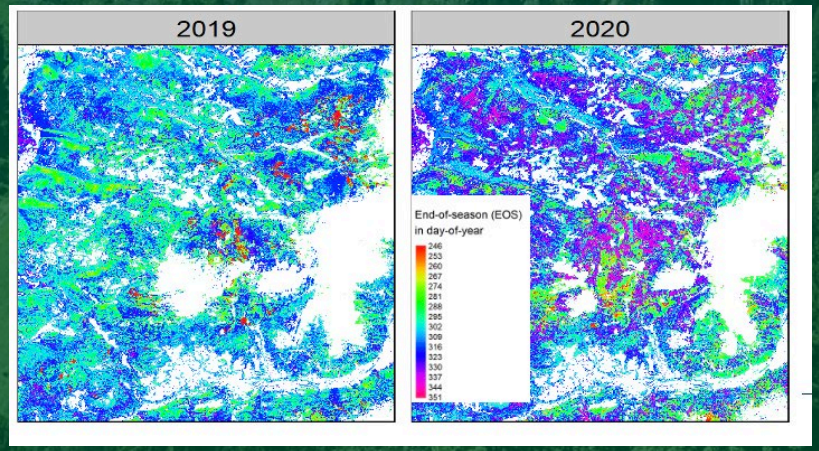


Exemplary windthrow patch caused by Storm Vaja 2018-10-28 (left) and detected breakpoints (right).



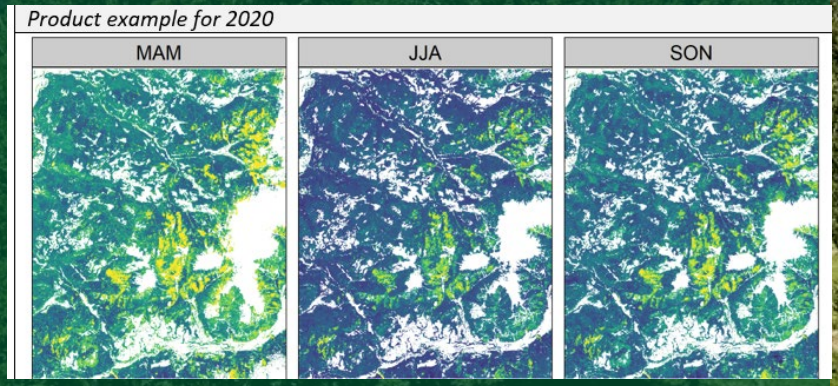
Forest phenology:

- Spatial information on End of Season
- Trends on End of Season



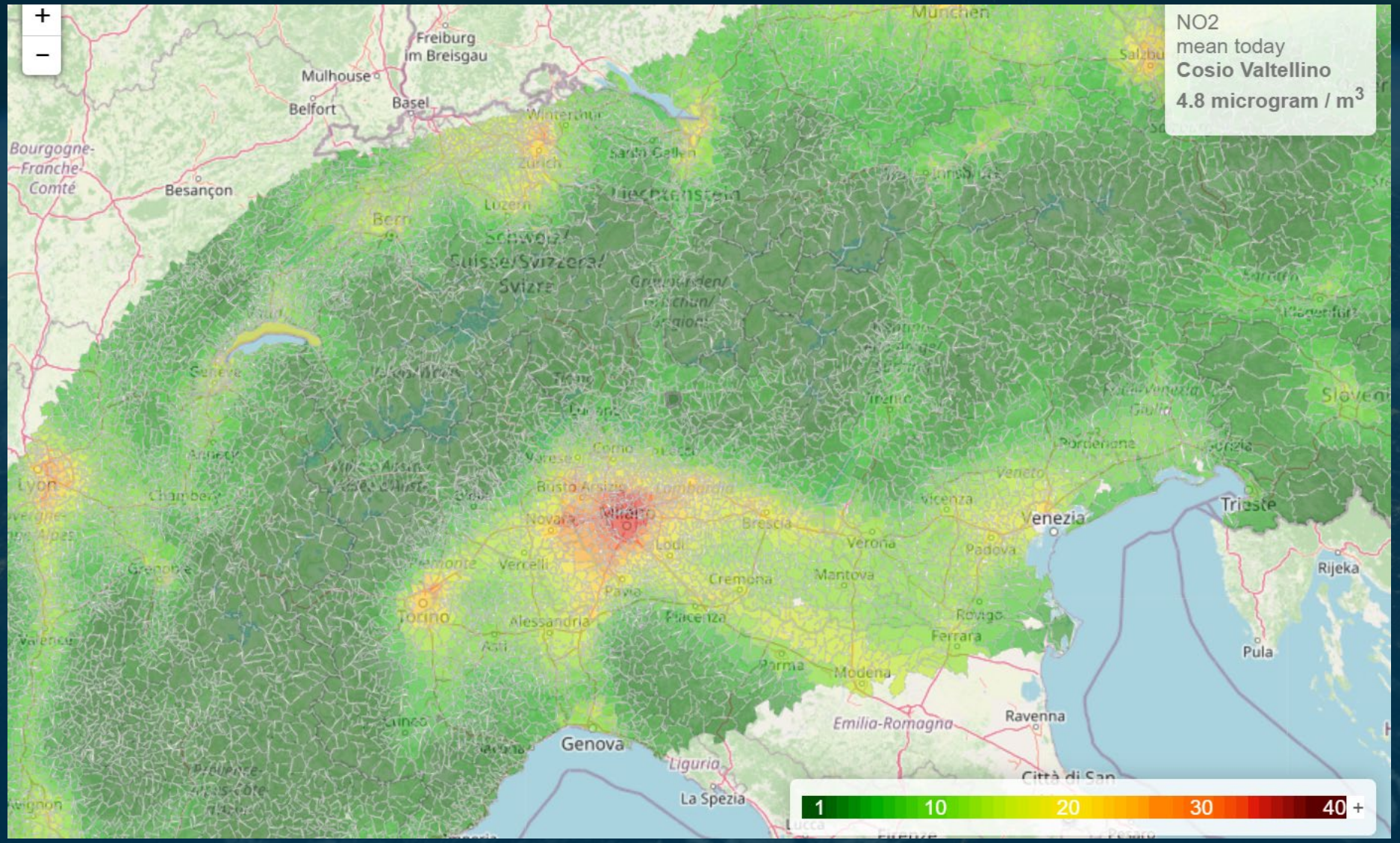
Fire recovery:

- Forest recovery seasonal trajectory
- Forest recovery annual trajectory



SOLENIX eurac research BOKU

AlpAirEO



Air Quality Mapping over the Alps

Ozone

NO2

PM

SO2

AQ Index

wdc.dlr.de/AlpAirEO/

ESA World Emission

World Emission

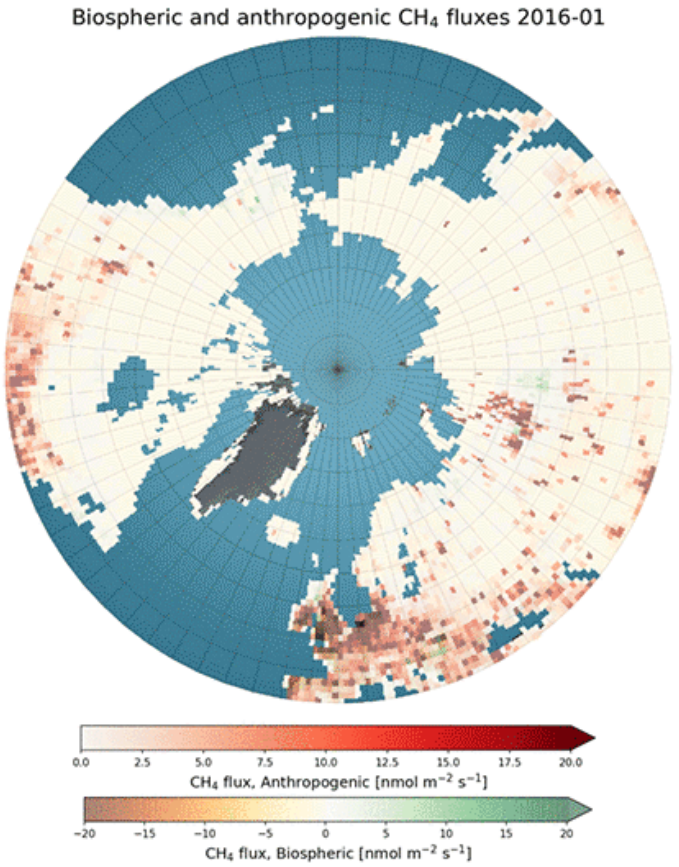
Pollutant and greenhouse gas emission inventories

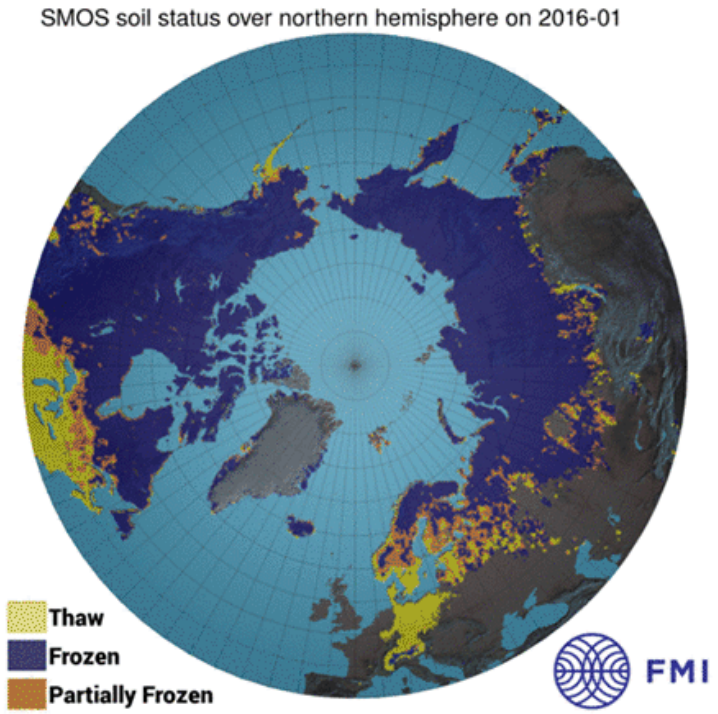
world-emission.com

	Local	Regional	Global
CO2	X	X	X
CH4	X	X	X
NH3	X	X	X
SO2	X		X
NOx	X	X	X
PM		X	
CO		X	X
CH3OH	X		X
VOC			X
CHOCHO			X
HCHO			X
Isoprene			X

Methane Emissions in the Arctic region

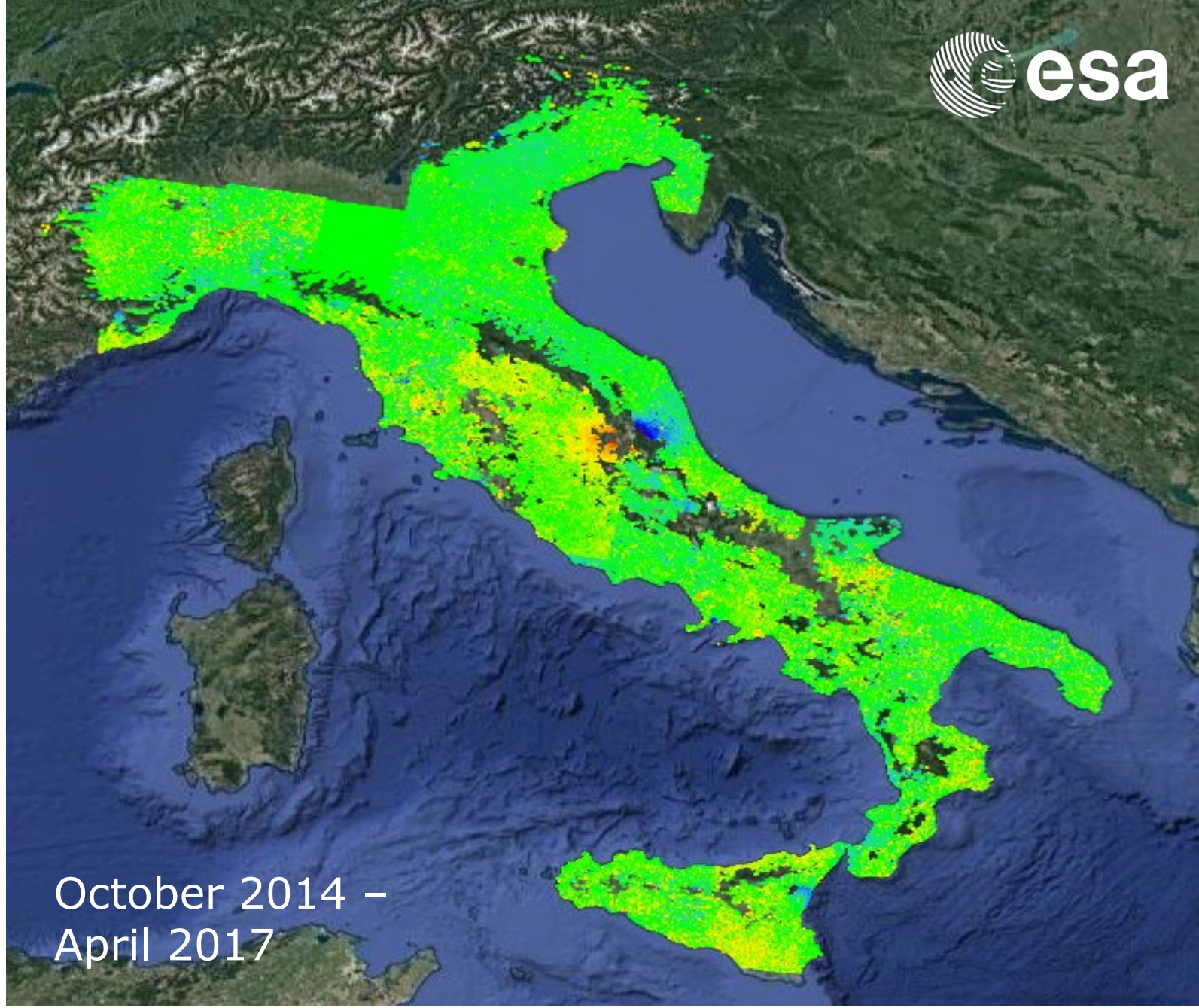
MethEO - Methane emissions in the Northern Hemisphere by applying both data from Earth Observing (EO) satellites and global atmospheric methane inversion model estimates - eo science for society



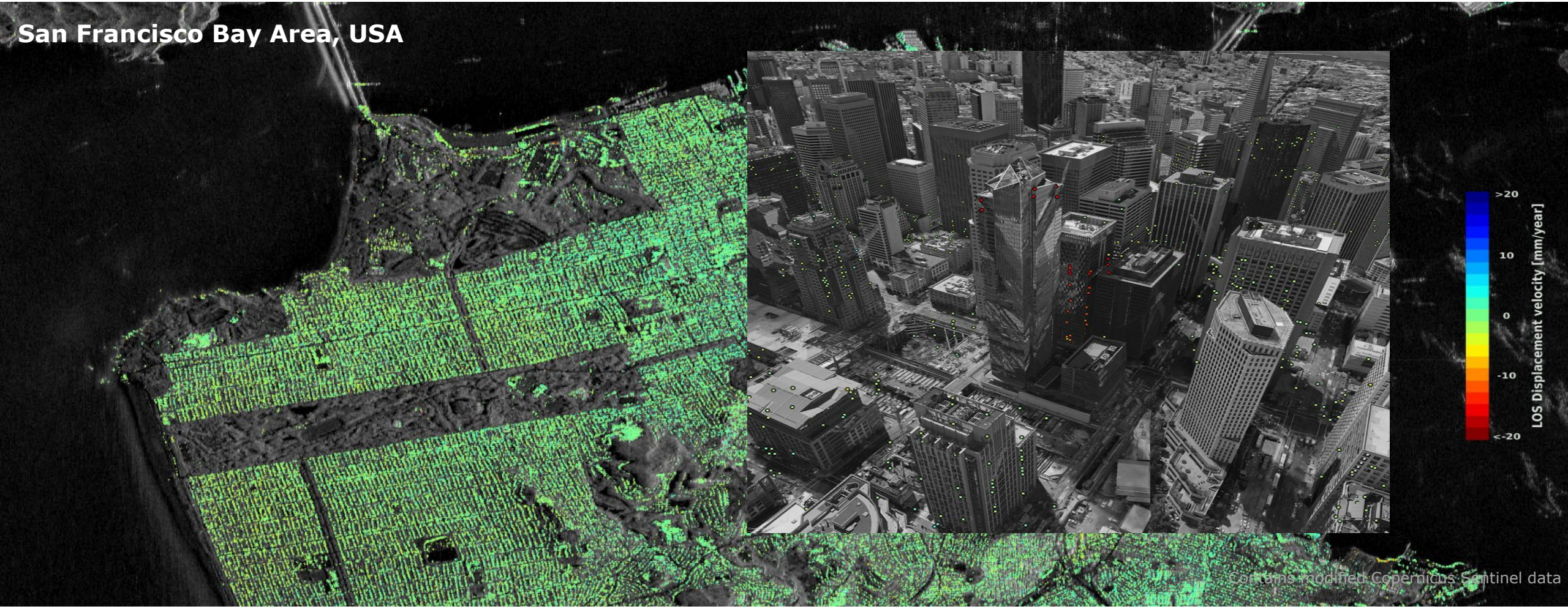


Country-Level Land Motion Products

Towards national- and regional-scale disaster risk management information with Interferometric SAR



Subsidence Risk at Building Level



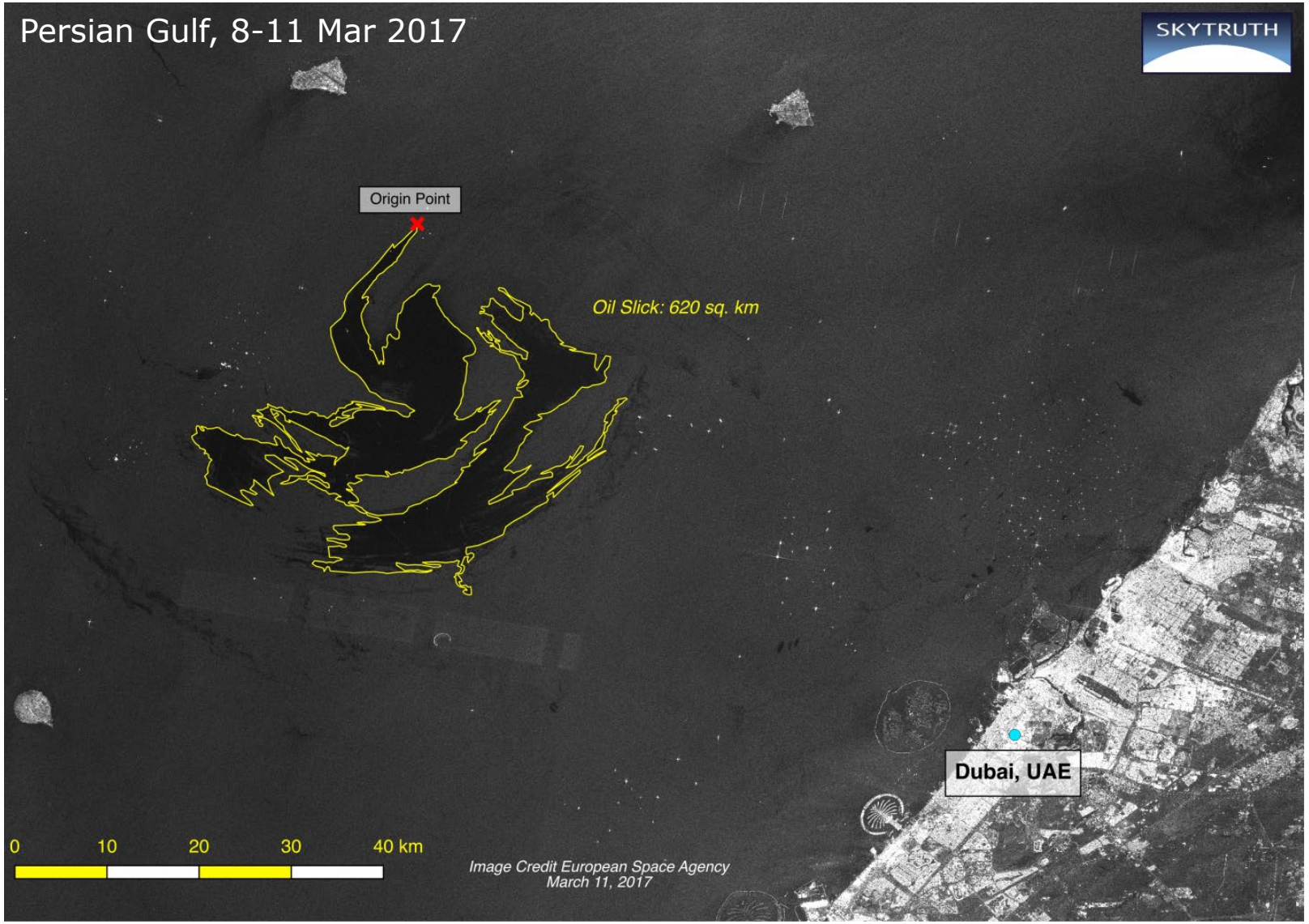
http://insarap.org

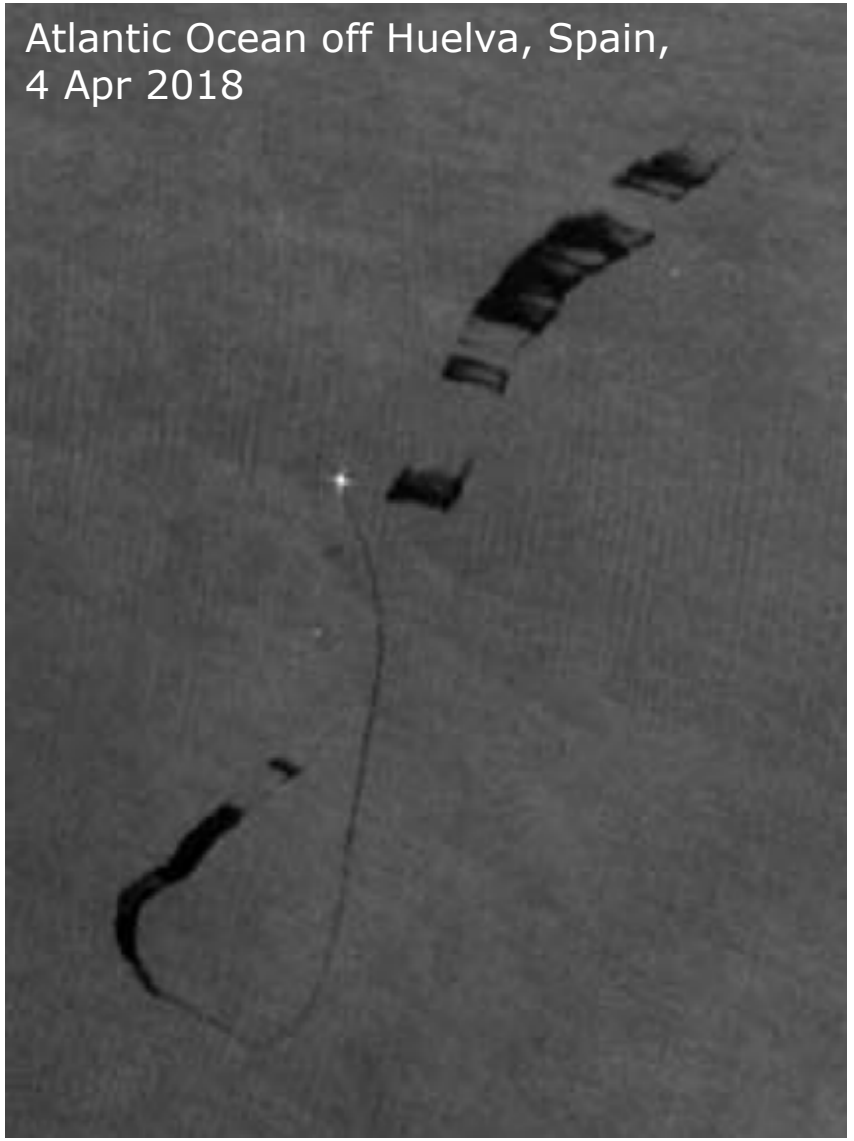
PPO.LABS

norut
NORTHERN RESEARCH INSTITUTE

→ THE EUROPEAN SPACE AGENCY

Oil Spill Detection and Monitoring



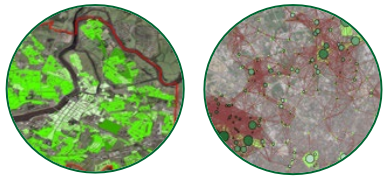


Ocean Acidification from Space

ECOSYSTEM SERVICES

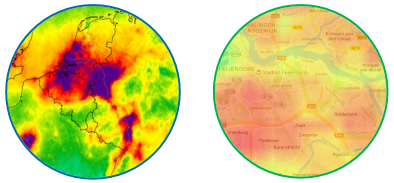
EO for sustainable and resilient cities

Green Areas/Networks



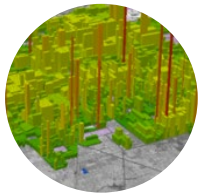
Urban Extent and Change

Urban Climate

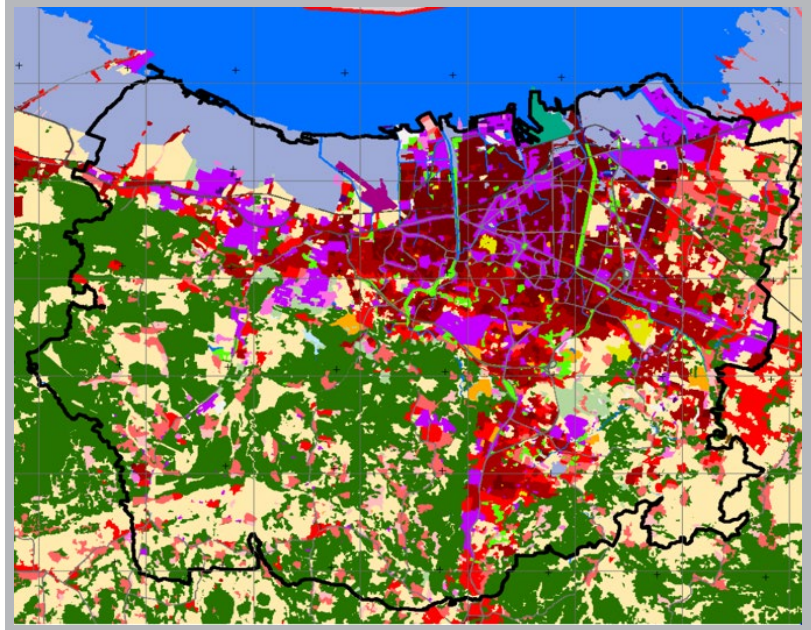


Building Footprint

Population Density

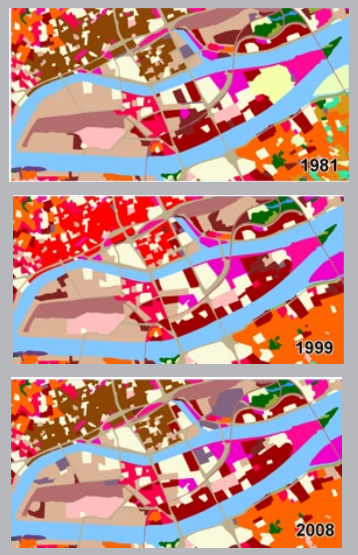


Baseline Products: Urban and Peri-Urban LU /LC



Detailed

Change

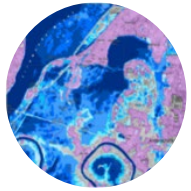


Transport Infrastructure

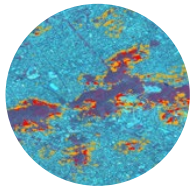
Informal Settlements

Waste Sites

Flood Risk



Landslide Risk



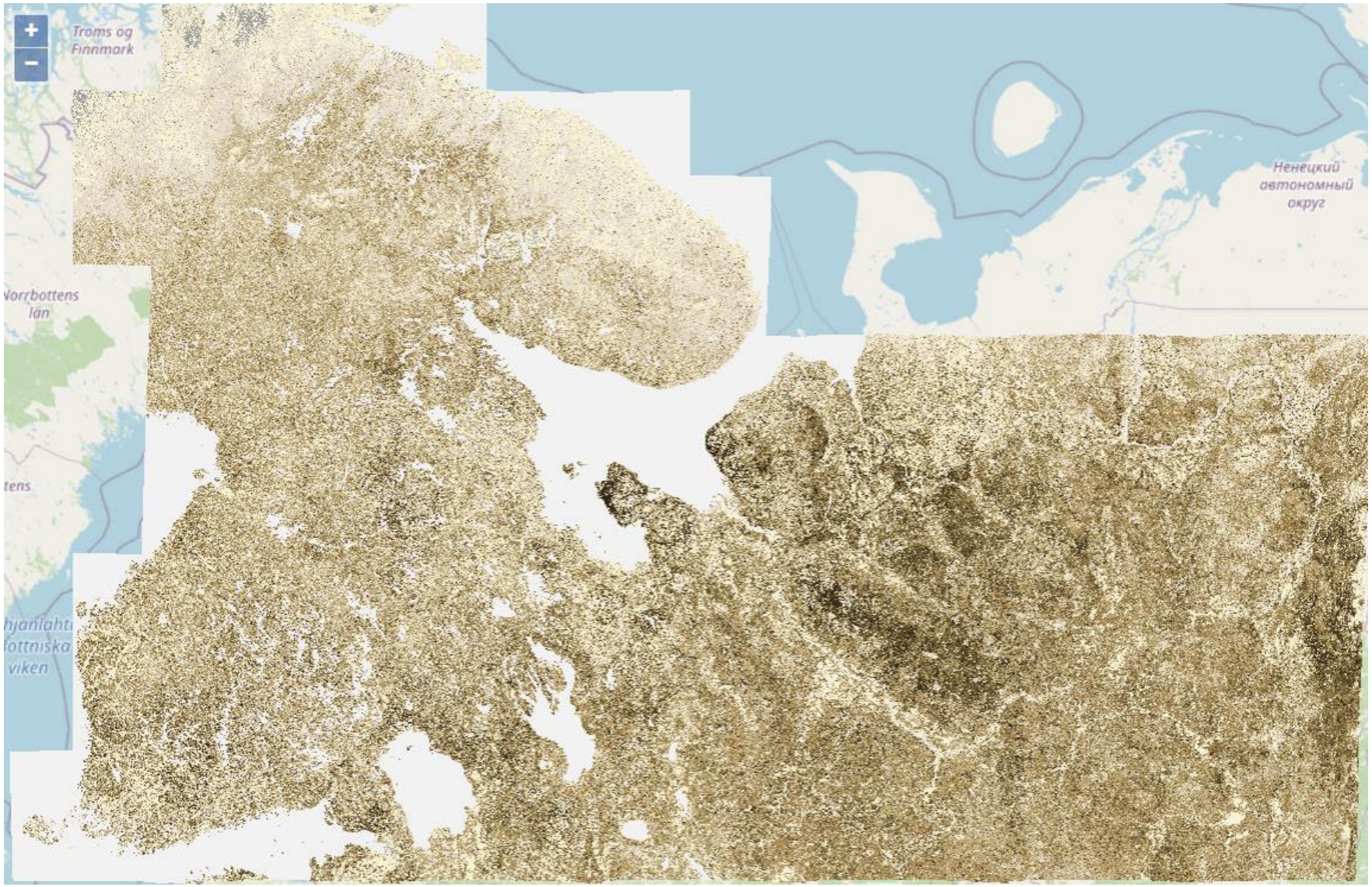
Terrain Motion

Forest Carbon Monitoring

Carbon Assessment – Growing Stock Volume

esa

VTT

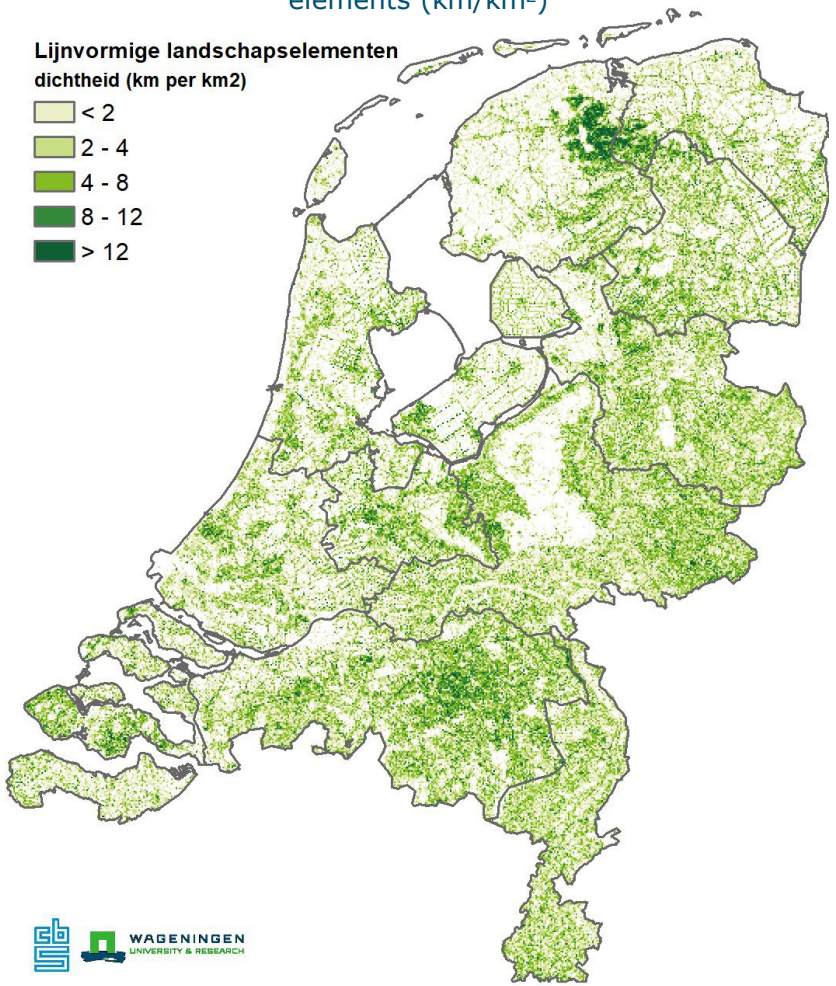


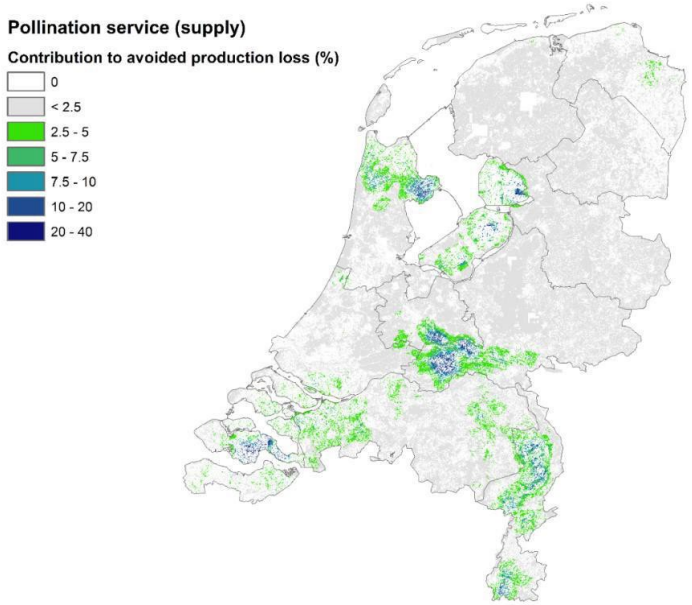
Legend

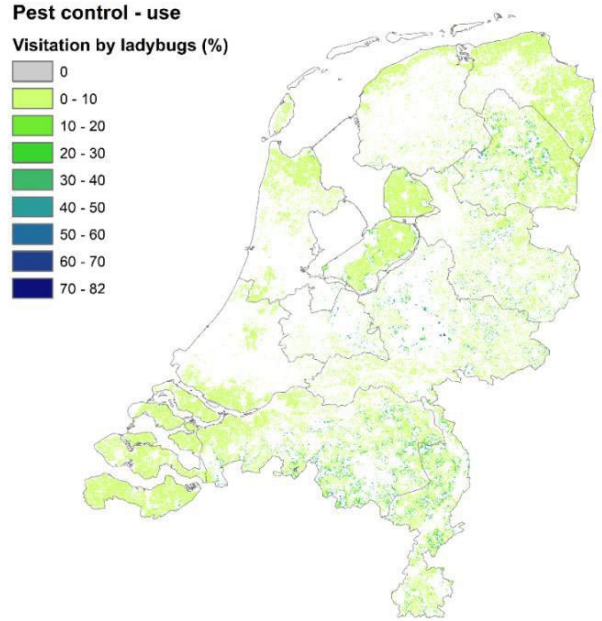
No data (*e.g.* clouds)	
Water	
Non-tree cover	
≤ 50 m³/ha	
51-100 m³/ha	
101-150 m³/ha	
151-200 m³/ha	
201-250 m³/ha	
251-300 m³/ha	
> 300 m³/ha	

Condition and ecosystem services

Linear landscape elements (km/km²)



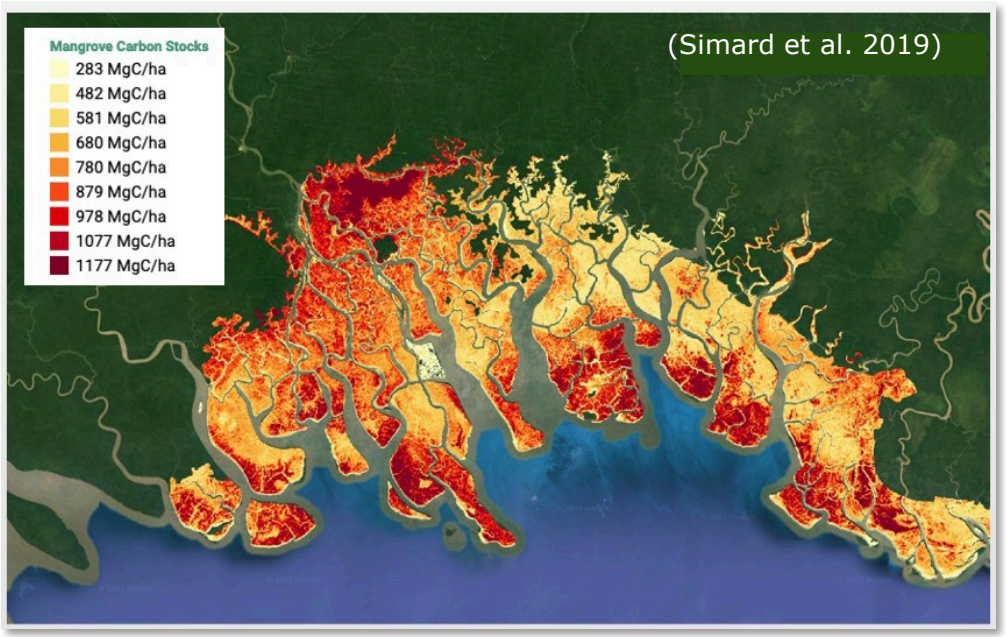


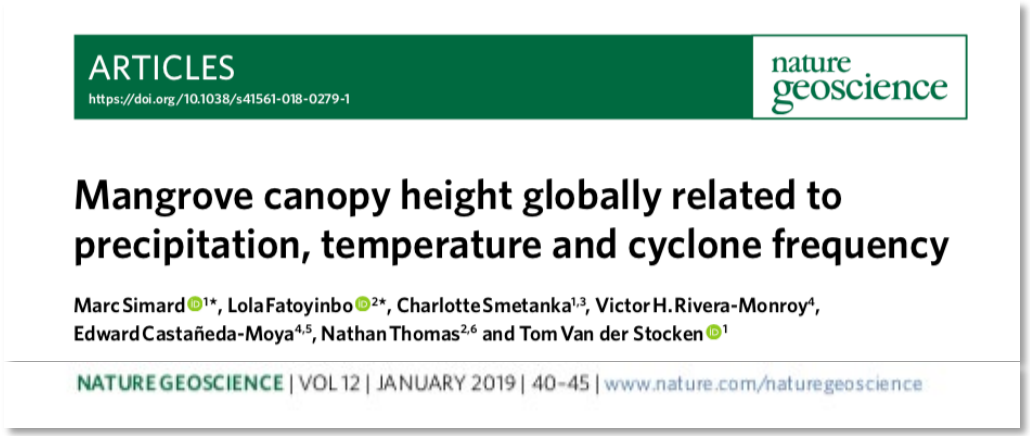


GLOBAL MANGROVE WATCH

Mangrove Above Ground Biomass

- Derived from NASA JPL/GSFC (Simard et al. 2019)
- 30 m geospatial dataset. Baseline year 2000. Overlayed on GMW 2016 extent maps (Bunting et al 2018). Gaps filled by regional averages.
- Mangrove AGB closely related to tree height. Mangrove height derived from SRTM DEM (2000) and ICESat GLAS (2003-2009).
- Region specific allometric model correlated with in situ (height & basal area).
- Key AGB factors: annual precipitation, mean temperature and cyclone frequency + local factors (typology, nutrients, salinity)




ARTICLES
https://doi.org/10.1038/s41561-018-0279-1
nature geoscience

Mangrove canopy height globally related to precipitation, temperature and cyclone frequency

Marc Simard[1*], Lola Fatoyinbo[2*], Charlotte Smetanka[1,3], Victor H. Rivera-Monroy[4], Edward Castañeda-Moya[4,5], Nathan Thomas[2,6] and Tom Van der Stocken[1]

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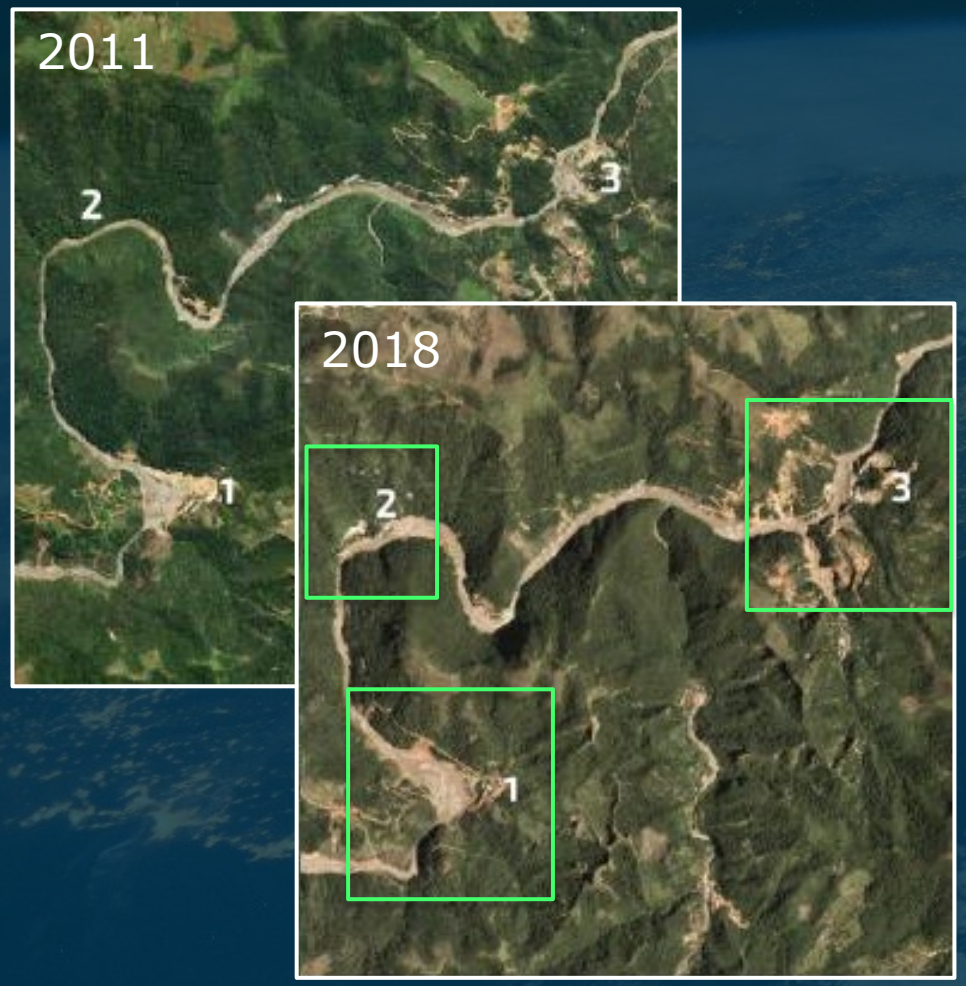
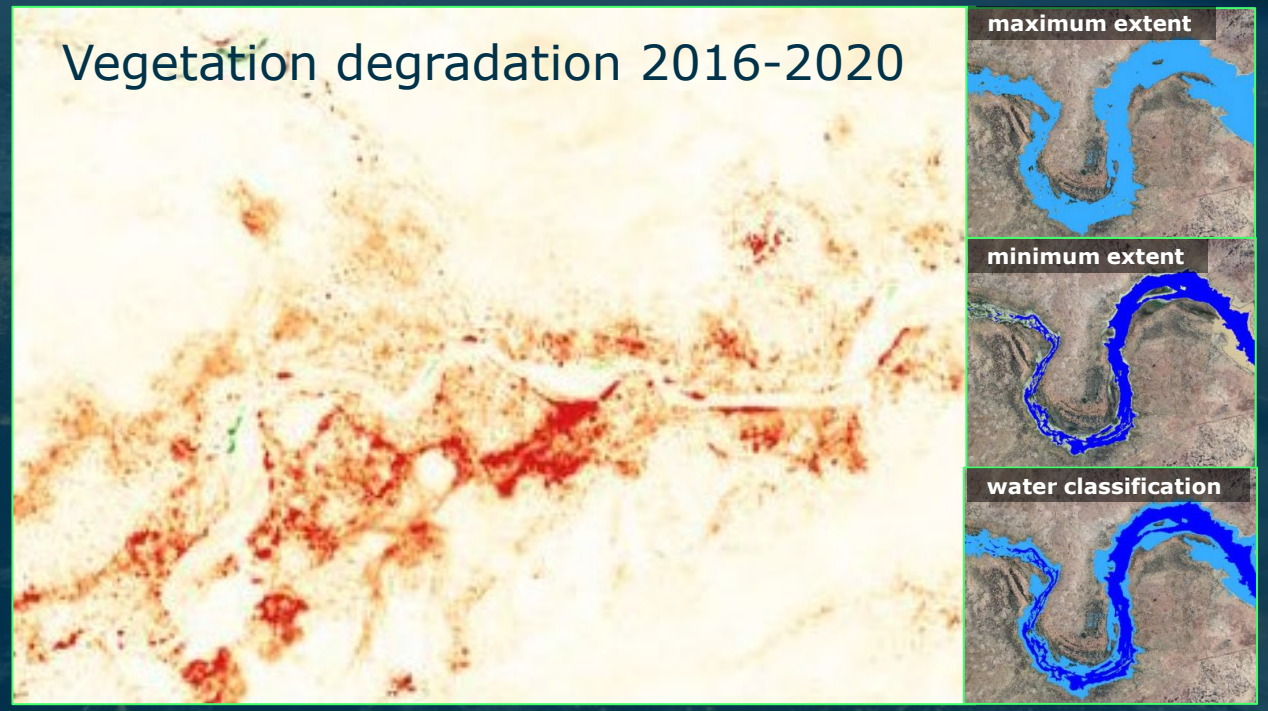
Example analyses – Danube/Black Sea environmental risk



Detection and monitoring of illegal/illicit extraction of sand/gravel



Monitoring impact of discharges into Danube Catchment

Opportunities and Challenges

EO opportunies & challenges in SEEA-compliant Ecosystem Accounting

- Requires a **change of mindset in NSOs** to use Earth Observation and Big Data more widely.
- Requires integration of **many strands of expertise (and data)** including statisticians, ecologists, national mapping agencies, geo-spatial and EO experts, and financial / economic institutions.
- Importance to have a **precise estimation of the uncertainties** for officially statistics.
- Need to have **regularly updated accounts** that allows to track the “intrinsic” variations of the subject accounts.
- Need for **practical methodological guidelines** (datasets, tools and models) **with operational examples** to help countries integrating EO within their national systems on ecosystem accounting.


THANK YOU