

A stylized graphic of a satellite or space probe, rendered in shades of green and white, positioned on the left side of the slide. It features a central body with two rectangular solar panels and a curved antenna-like structure.

# *EO for Wetland Inventory, Assessment and Monitoring: Opportunities and challenges*

## **Earth Observation Day**

| Ramsar STRP 27 | Gland | 6 December 2024 |

**Marc Paganini**

European Space Agency, Directorate of Earth Observation Programmes  
Climate Action, Sustainability and Science Department



# ESA history of collaboration on wetlands with Ramsar



2000



TESEO Wetlands  
Treaty Enforcement Services using Earth Observation  
2000-2002



GLOBWETLAND  
2003-2008



GlobWetland II  
2009-2014

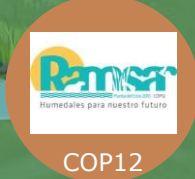


GLOBWETLAND AFRICA  
2016-2019

**TIGER INITIATIVE**

- TIGER programme (since 2002)
- TIGER-NET project (2012-2015)
- TIGER Capacity Building Facility (2008-2015)

MAPPING WATER BODIES FROM SPACE  
CONFERENCE  
MWBS 2015



TIGER WORKSHOP 2016  
Supporting Water for Sustainable Development  
1-2 February 2016 | Addis Ababa, Ethiopia



GLOBWETLAND AFRICA extension  
2020-2022



MAPPING WATER BODIES FROM SPACE  
2nd CONFERENCE  
MWBS 2018

2020-2024  
WorldWater



E04WI WETLAND INVENTORIES  
2023-2025

2025



# Stringent EO requirements for monitoring wetlands globally

- ***Global and systematic observation scenarios with multiple satellite sensors (radar/optical)***  
to map the large variety of wetland ecosystems around the globe.
- ***Multi-temporal and multi-spectral optical bands with high radiometric performances***  
to better discriminate wetland habitats, better delineate wetland areas, and better assess threats from agriculture, urbanisation and climate change.
- ***High spatial resolution***  
to have more spatial details for capturing the variety of small habitats in wetlands and for detecting small water bodies.
- ***Short revisiting times***  
to capture the seasonality of dynamic wetland ecosystems such as inundation regimes (permanent and seasonal waters) that are important indicators of healthy conditions of wetlands.



## The use of Earth Observation for wetland inventory, assessment and monitoring

An information source for the Ramsar Convention on Wetlands

Provide wetland practitioners with an overview and illustration, through case studies, on the use of EO for implementation of the Convention and the wise use of wetlands.





ELSEVIER

Advances in Ecological Research

Volume 58, 2018, Pages 243-277



## Chapter Six - Mapping Mediterranean Wetlands With Remote Sensing: A Good-Looking Map Is Not Always a Good Map

[Christian Perennou](#) <sup>\*</sup>  , [Anis Guelmami](#) <sup>\*</sup>, [Marc Paganini](#) <sup>†</sup>, [Petra Philipson](#) <sup>‡</sup>, [Brigitte Poulin](#) <sup>\*</sup>, [Adrian Strauch](#) <sup>§</sup>, [Christian Tottrup](#) <sup>¶</sup>, [John Truckenbrodt](#) <sup>||</sup>, [Ilse R. Geijzendorffer](#) <sup>\*</sup>

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<https://doi.org/10.1016/bs.aecr.2017.12.002> 

[Get rights and content](#) 





# Commonly stated obstacles to the operational use of EO in wetland inventory, monitoring and assessment

Restrictive data access policies (including cost)

Not enough “fit for purpose” products

Frequency of observations insufficient to track changes at appropriate scales

Needs for continuity of observations and long-term EO satellite missions

Lack of standardisation of EO data processing methodologies

Lack of analysis ready data

Lack of clear and solid user-oriented methods and guidelines

Capacity building and training

Difficulties to discover and access EO data

Insufficient solid track records of successful case studies

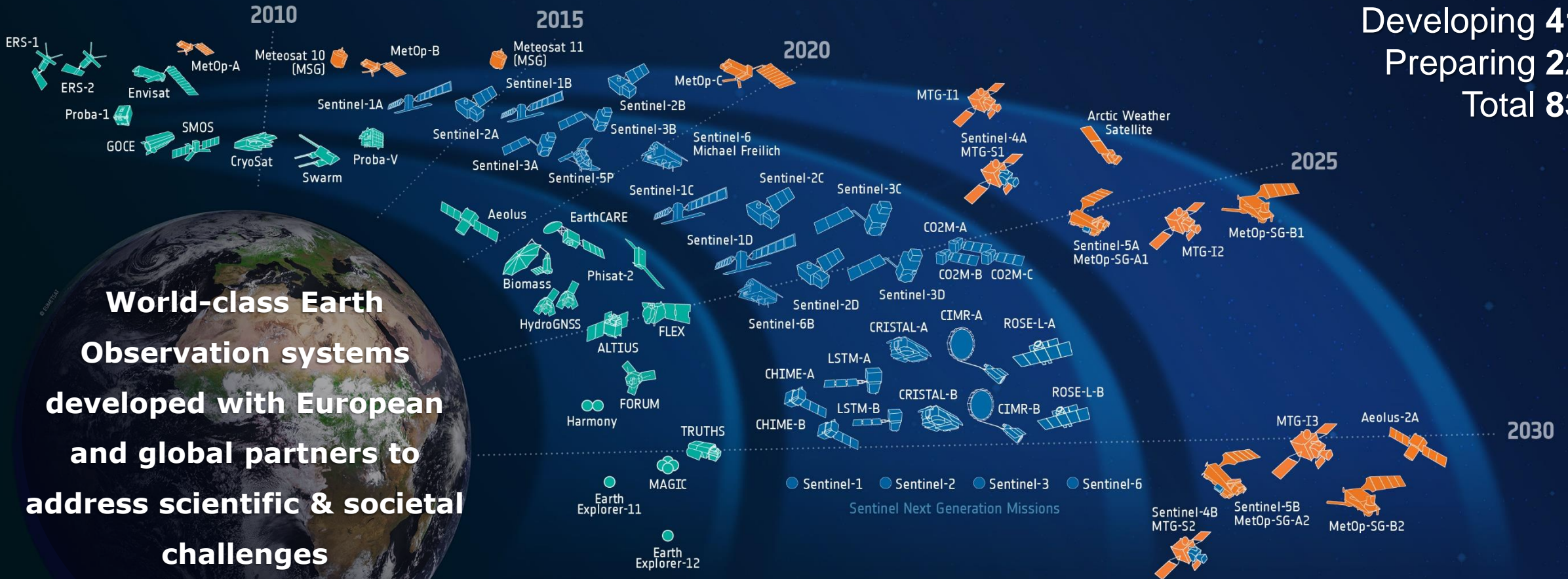


# ESA's Earth Observation Missions



## Satellites

Heritage 06  
Operational 14  
Developing 41  
Preparing 22  
Total 83



Science



Copernicus



Meteorology

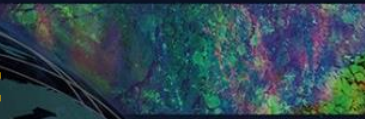




# The European Copernicus Programme



**State-of-the-art observations with unprecedented coverage**



**sentinel-1**

→ RADAR VISION



**sentinel-2**

→ COLOUR VISION

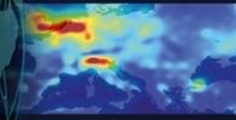


**sentinel-3**

→ A BIGGER PICTURE



**Systematic data availability**

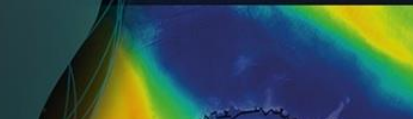


**sentinel-4**

→ EUROPEAN AIR MONITORING



**Full, free and open data policy**

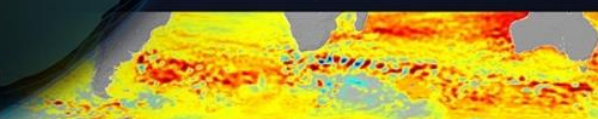


**sentinel-sp | sentinel-5**

→ GLOBAL AIR MONITORING



**Long-term availability**



**sentinel-6**

→ SURFING THE SEAS



→ Know more: <https://copernicus.eu> and <https://sentinels.copernicus.eu>

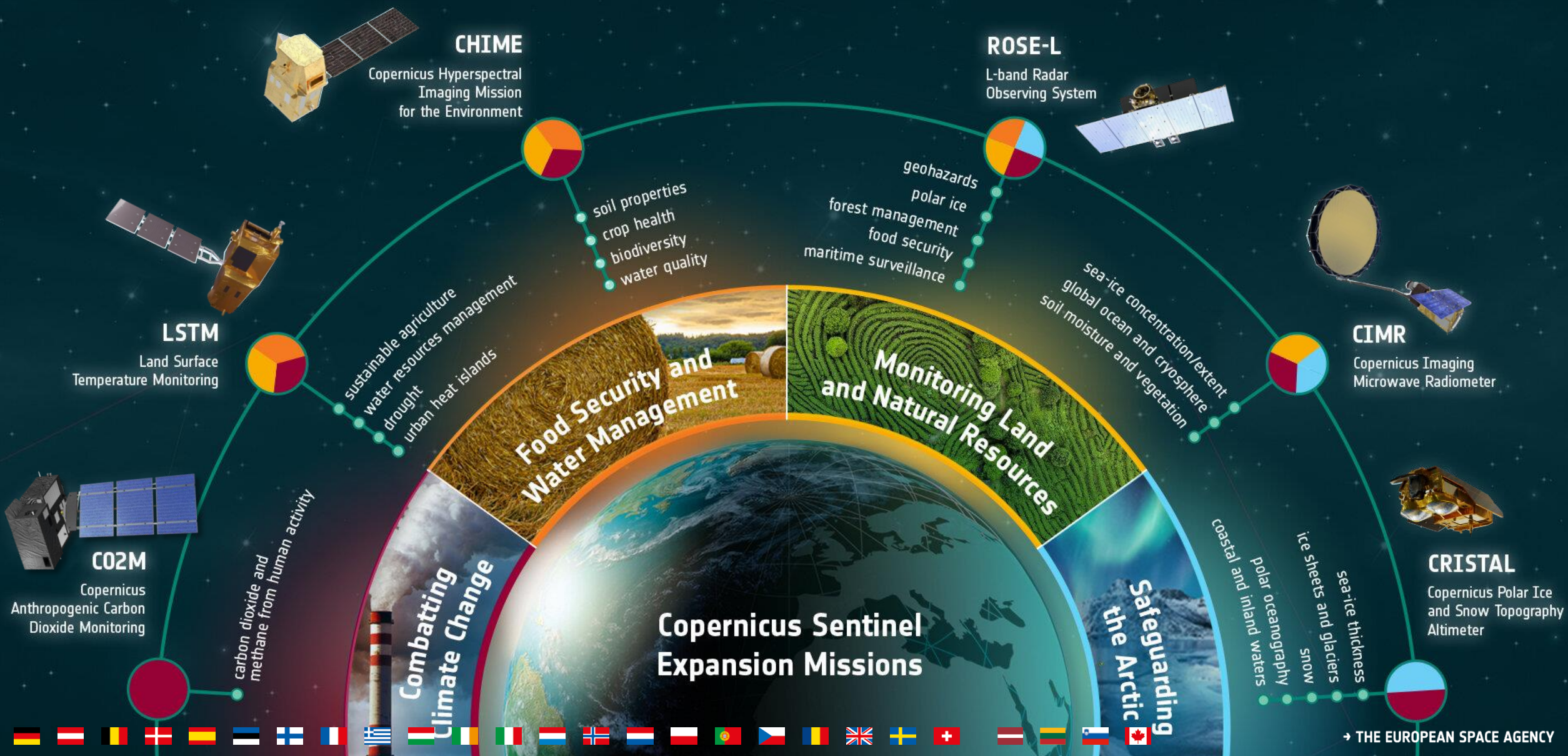




PROGRAMME OF THE EUROPEAN UNION



co-funded with





# Building on steady satellite data streams



Mobilise the EO data revolution  
for the benefits of all  
Ramsar Contracting  
Parties  
leaving no country  
behind

## High Performance Computing Infrastructures



# Building on advances in information technology (AI)



# data exploitation platforms

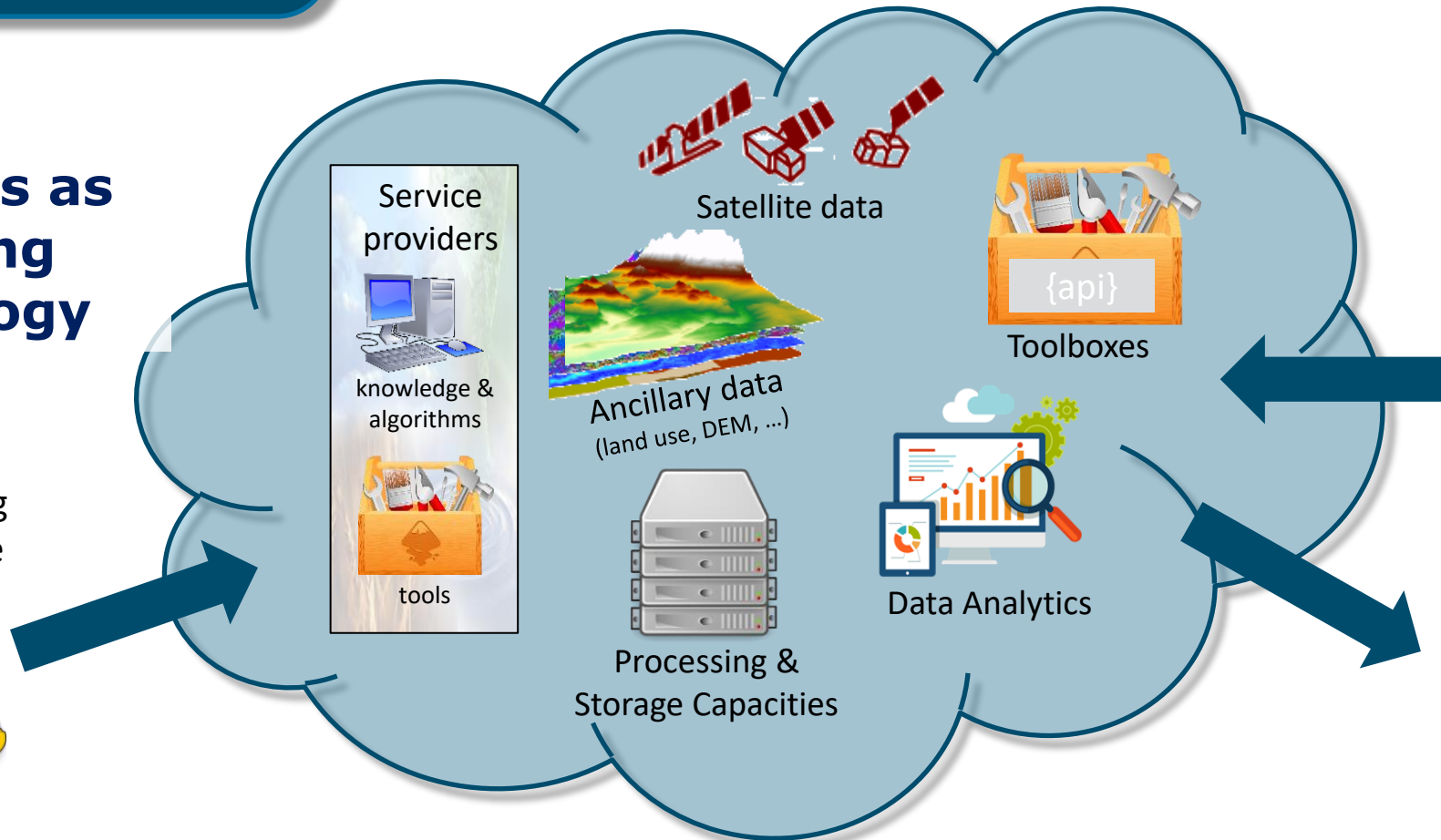
The power of the  
Cloud  
The power of  
Partnerships

***"Bringing the users to the data"***

**Simplify the extraction of information** from EO data  
**Enable large scale exploitation** of EO data  
**Stimulate innovation** with EO data

## Platforms as enabling technology

Mobile data  
Crowdsourcing  
citizen science



Remote access for users

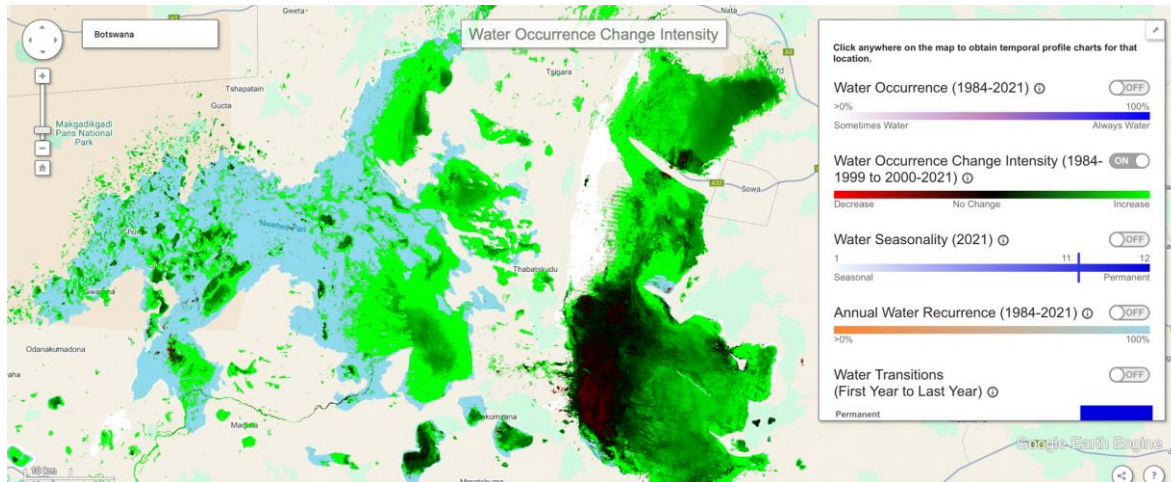


User generated results

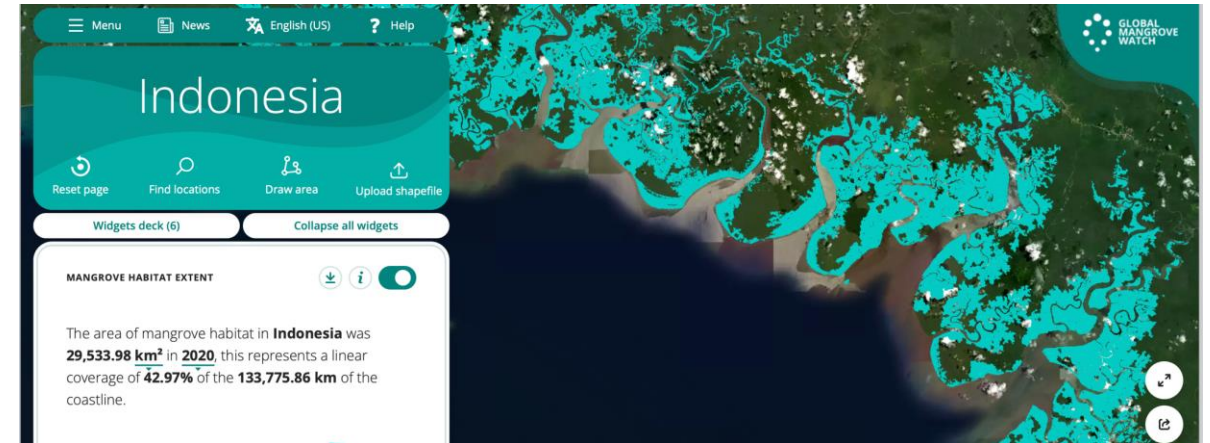


# Global Data Sets

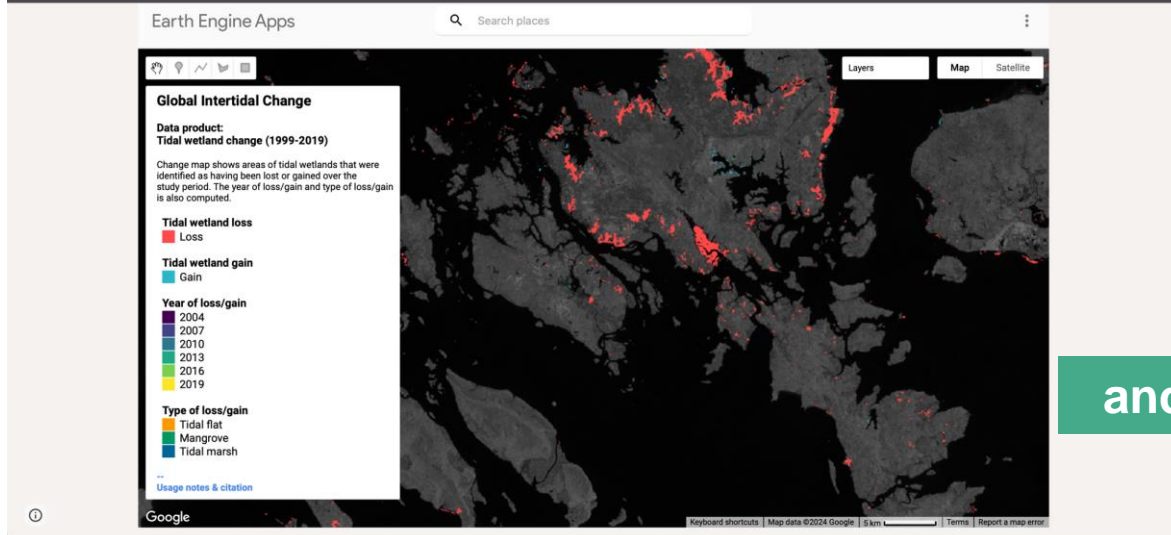
<https://global-surface-water.appspot.com>



<https://www.globalmangrovetwatch.org>



<https://www.globalintertidalchange.org>



<https://land.copernicus.eu/en/products/water-bodies/>



Home > CLMS portfolio > Water Bodies > Lake Water Quality 2019-present (raster 100 m), global, 10-daily - version 1

## Lake Water Quality 2019-present (raster 100 m), global, 10-daily - version 1

General info

Download

Provides semi-continuous observations for a large number of medium and large-sized lakes, according to the Global Lakes and Wetlands Database (GLWD) or otherwise of specific environmental monitoring interest. 10-daily observations are available in near real time in the spatial resolution of 100 m and with the temporal extent from 2019 to present.

and soon ....





# Global Data Sets: *sdg6.6.1 Freshwater Ecosystem Explorer*

Freshwater Ecosystems Explorer



About

Partners

FAQ

Feedback

Search for a country

Uganda

Select basin level

Hydro Basin Level 6

## Current SDG 6.6.1 indicator status



Off-track Neutral On-track

The current status is an accumulation of recent data for all SDG 6.6.1 sub-indicators. For an in-depth explanation of this component [read the methods](#)

## Water Quality of Large Lakes: Trophic State

The data show the total percentage deviation, from a baseline, for turbidity and... [Read Full Definition](#)

### Progression of subindicator data:

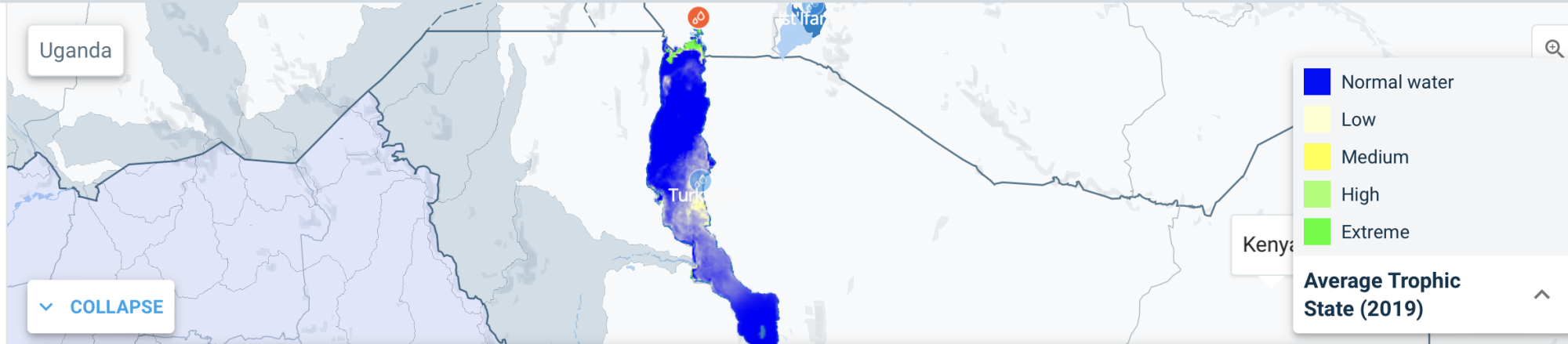


## Water Quality of Large Lakes: Turbidity

## Inland Wetland Extent

NATIONAL SDG DATA

Uganda



- Normal water
- Low
- Medium
- High
- Extreme

Average Trophic State (2019)

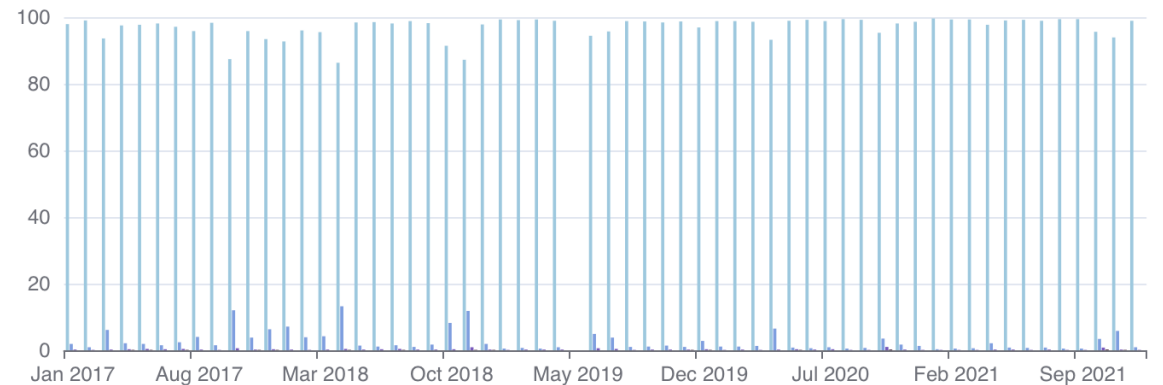
## Water Quality of Large Lakes: Trophic State

Data: Year 2021 relative to a five-year baseline (2006-2010)

Trophic State 2 out of 15 lakes affected 13.33%

### MONTHLY TIMESERIES

Download



Low Trophic Medium Trophic High Trophic Extreme Trophic

<https://www.sdg661.app>



# Global Data Sets: *GEO Global Ecosystems Atlas*

**BETA**

**SEARCH** ←

🔍 South Africa ×

**CURRENT STATUS** ⓘ

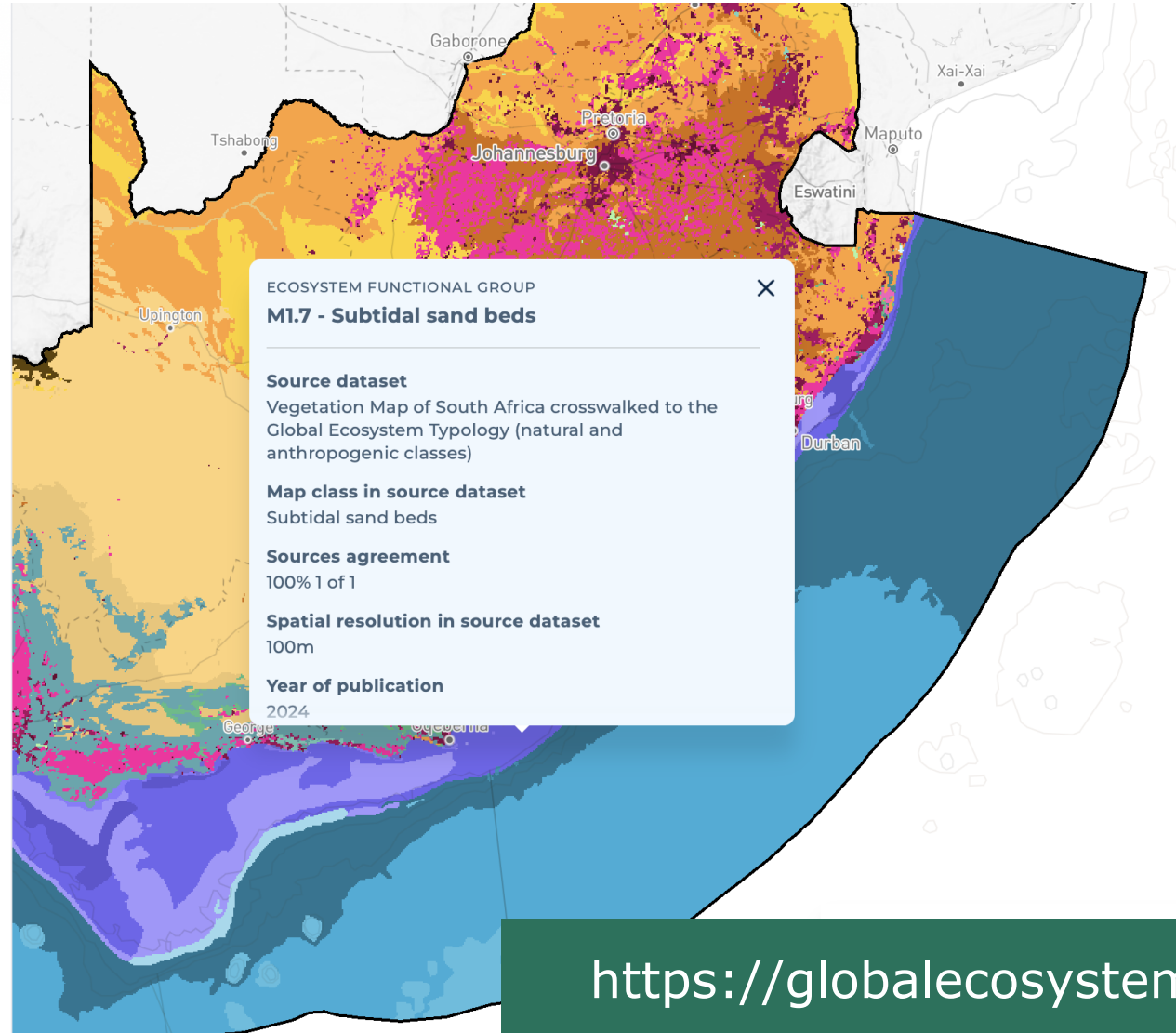
**99.93%** coverage

**7** realms    **16** biomes    **38** ecosystem functional groups

**REALMS** ⓘ

**58.45%** Marine

- Terrestrial (41.26%)
- Terrestrial-Freshwater (<0.01%)
- Freshwater (0.11%)
- Freshwater-Marine (0.03%)
- Marine (58.45%)
- Marine-Terrestrial (0.15%)
- Marine-Freshwater-Terrestrial (<0.01%)



☰

🔍

🔍

⚙️

🔗

💬



# EO integration in SEEA Ecosystem Accounting



## Stock Accounts and Changes in Stocks (in physical terms)

Ecosystem  
Extent

Ecosystem  
Condition

## Flow Accounts (in physical terms)

Ecosystem  
Services  
(flow and use)

## Natural Capital Valuation (in monetary terms)

Ecosystem  
Asset Account

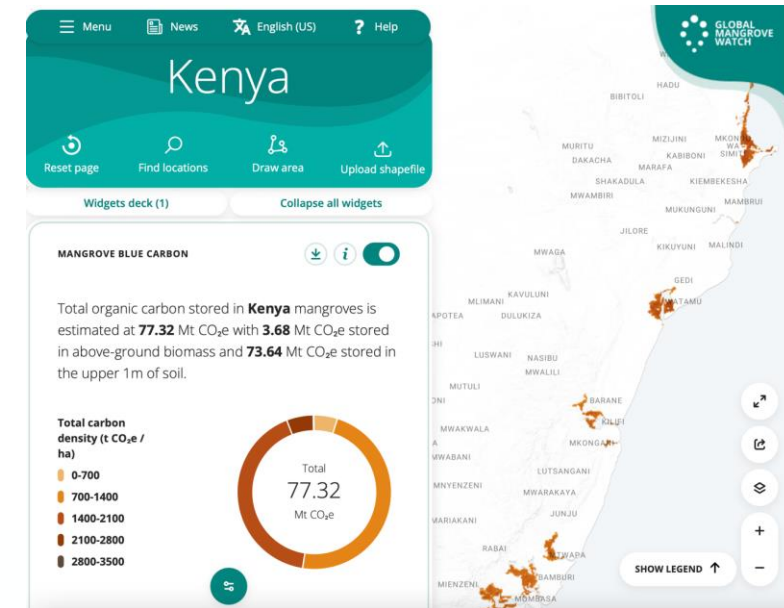
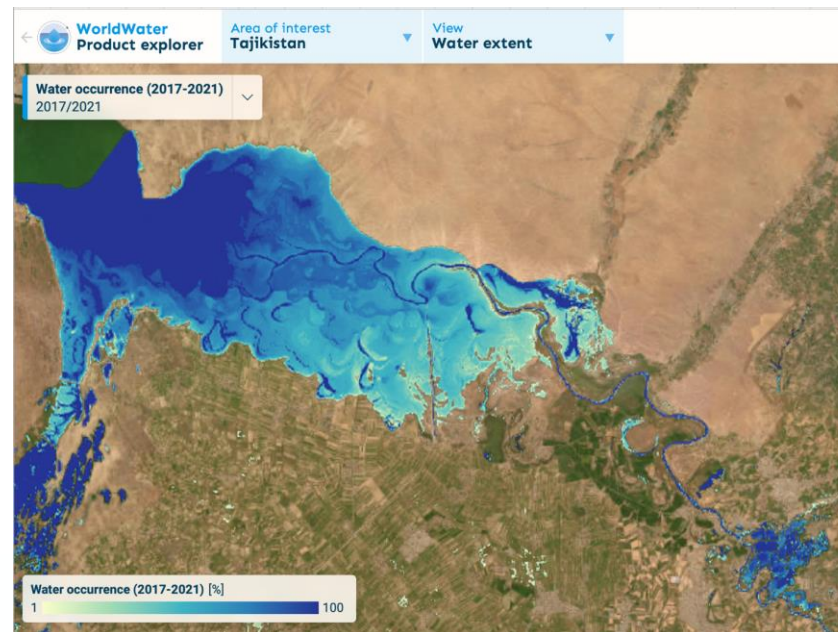
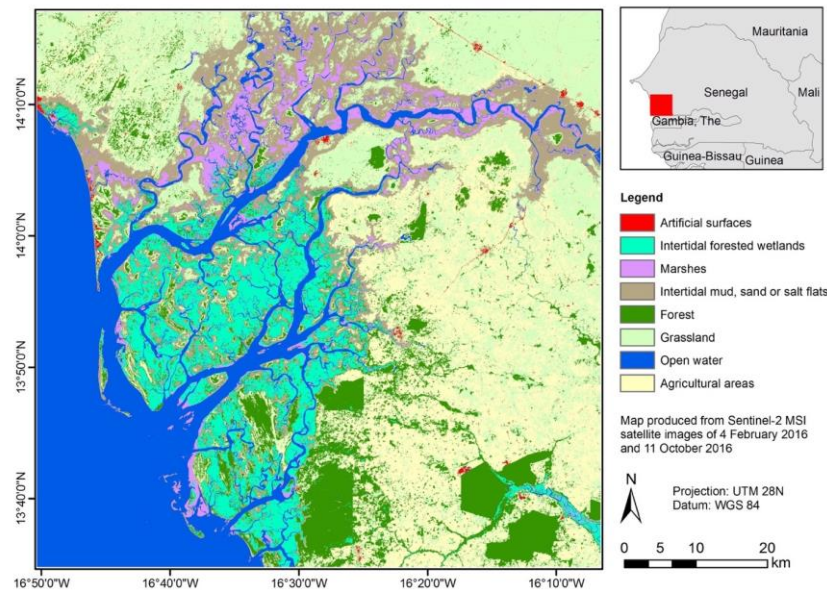
Ecosystem  
Services  
Account

## Wetland Ecosystem **Extent** e.g., Habitats Mapping

## Wetland Ecosystem **Condition** e.g., hydrological regimes

## Wetland Ecosystem **Services** e.g., blue carbon

Wetland Habitat Mapping - Delta du Saloum (Senegal) (Site 98) - 2015/16





# Wetland Inventory, Monitoring and Assessment

## Multiple EO Applications



### Wetland Delineation

Delineation of wetland areas across large river catchments, in support to national wetland inventorying.



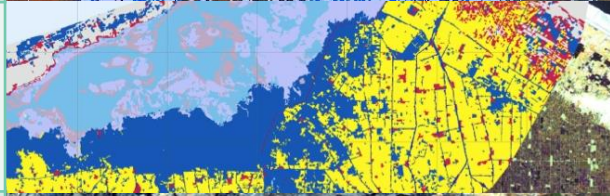
### Wetland Carbon Dynamics

Quantifying carbon storage and fluxes in wetlands, including peatlands and mangroves.



### Wetland Habitats and Pressure

for the assessment of the wetland status, inside and around wetland areas.



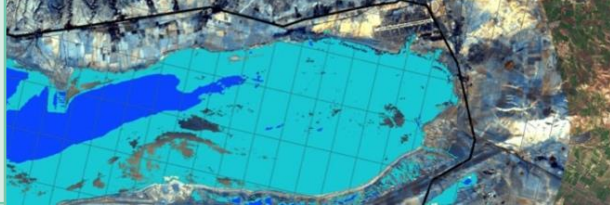
### Wetland Conservation

Supporting the design and monitoring of wetland conservation.



### Hydrological Regimes

analysis of the intra- and inter-annual variations of the water tables, inside and around Ramsar/wetland areas.



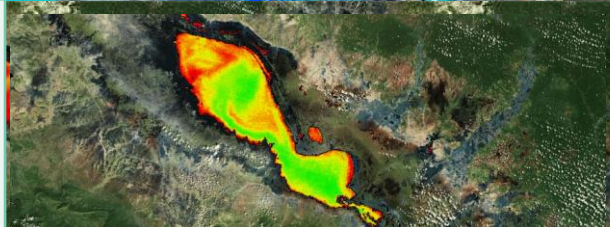
### Wetland Restoration

measuring the effectiveness of restoration efforts over time



### Water Quality Monitoring

monitoring of the aquatic contamination and physical disturbances of the wetland ecosystem.



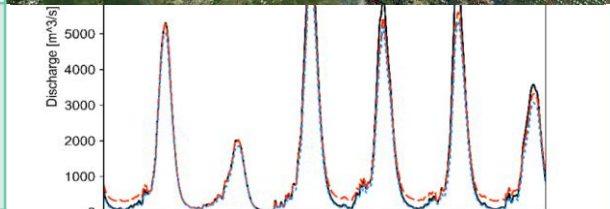
### Climate Change Impacts

Assessing wetland vulnerability and resilience to climate-induced changes (sea level rise, droughts, and extremes).



### River Basin Hydrology

Modelling hydrological dynamics within river catchments to evaluate wetland connectivity and impacts of infrastructure



### Peatland Monitoring

Monitoring peatland extent, degradation, and restoration efforts, including peat loss from drainage and fire.



### Mangroves Monitoring

for the assessment of the status and trends of tropical mangroves.



### Sedimentation and Erosion

Monitoring sediment transport and deposition patterns to understand their impact on wetland habitats



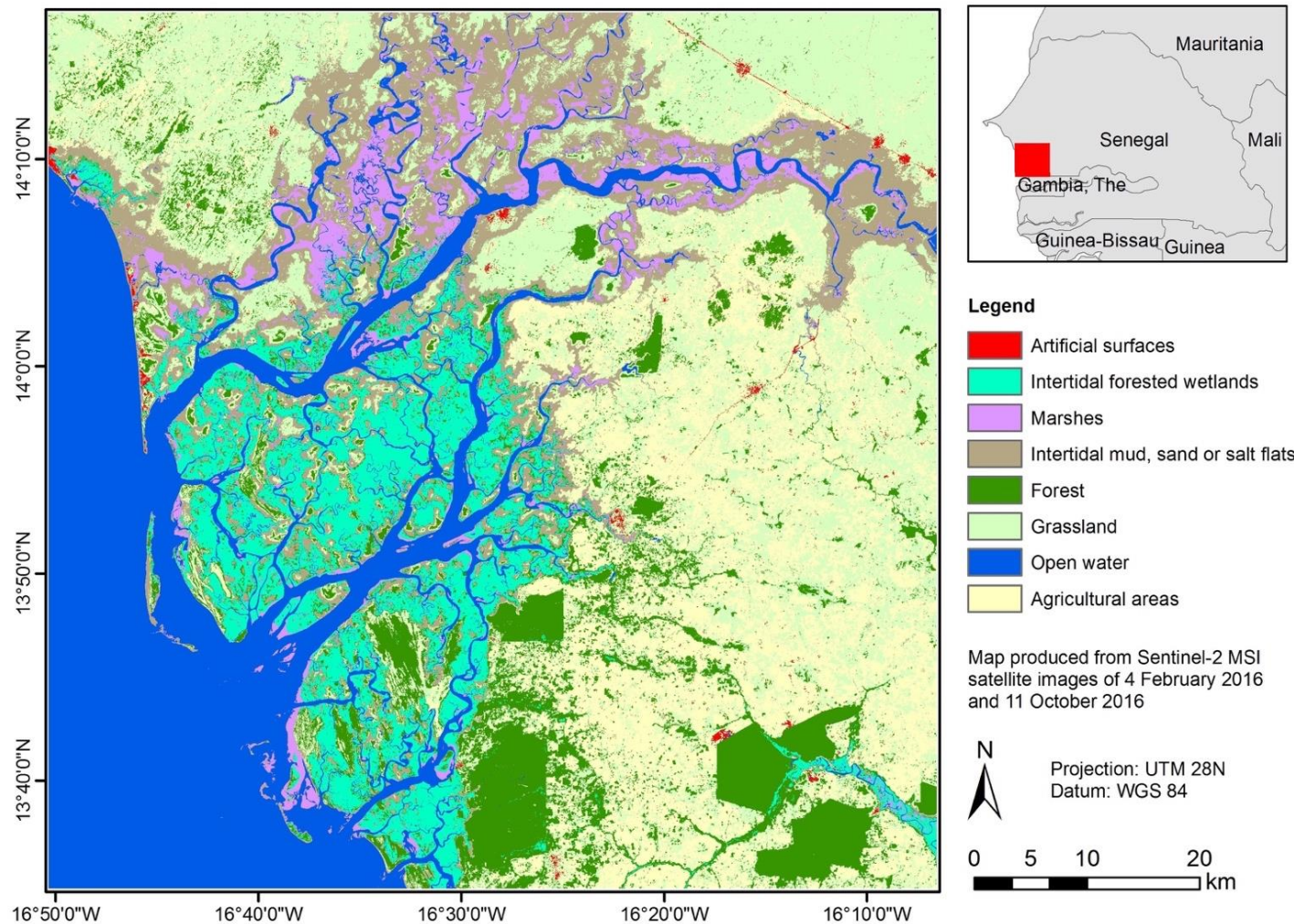


# Wetland Habitat Mapping: Monitoring changes in Ramsar Sites

Wetland Habitat Mapping - Delta du Saloum (Senegal) (Site 98) - 2015/16

- 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

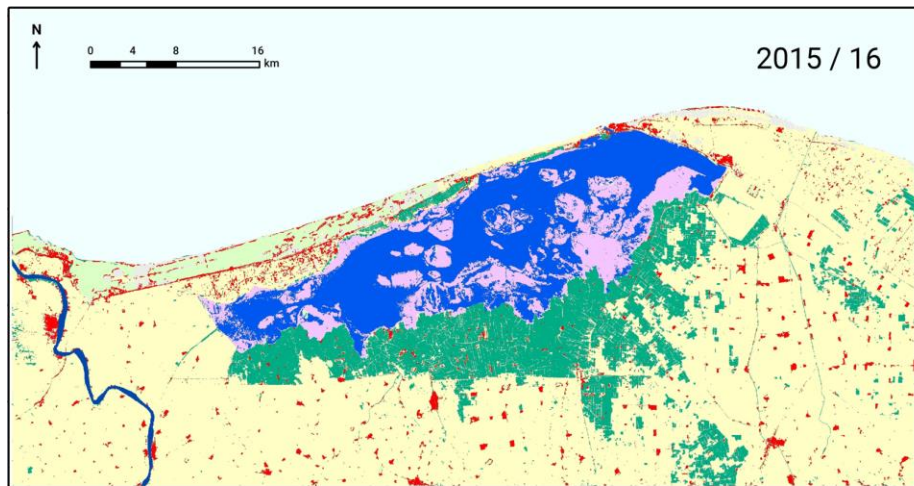
<http://globwetland-africa.org>



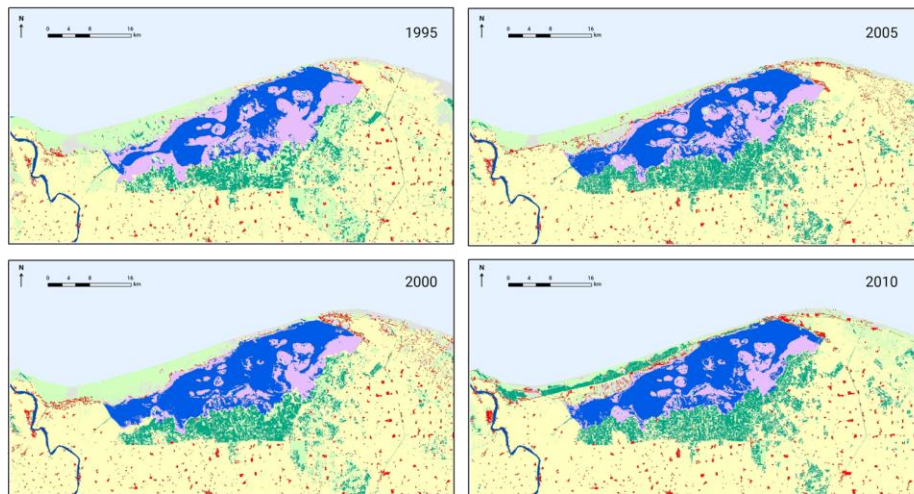


# Wetland Habitat Monitoring

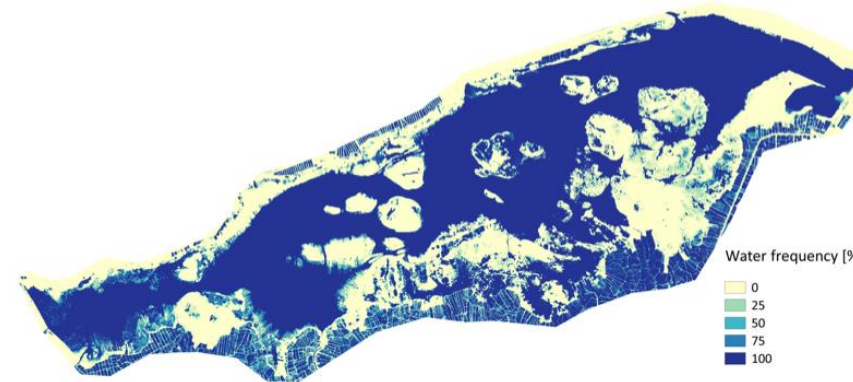
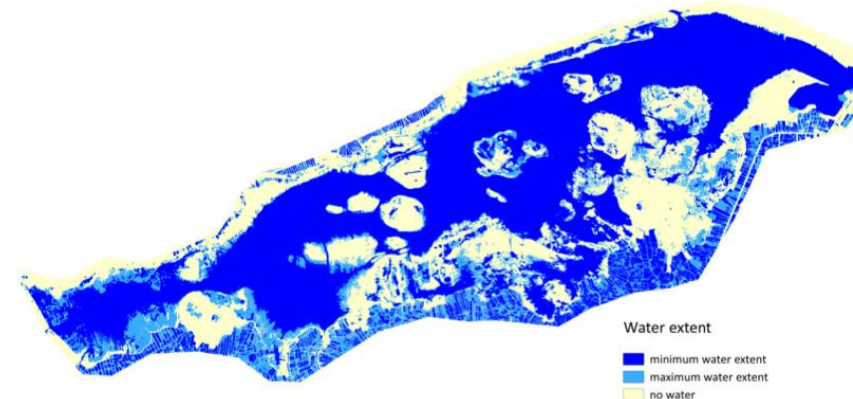
*Harnessing the rich legacy of Landsat imagery*



*Lake Burullus, Egypt*

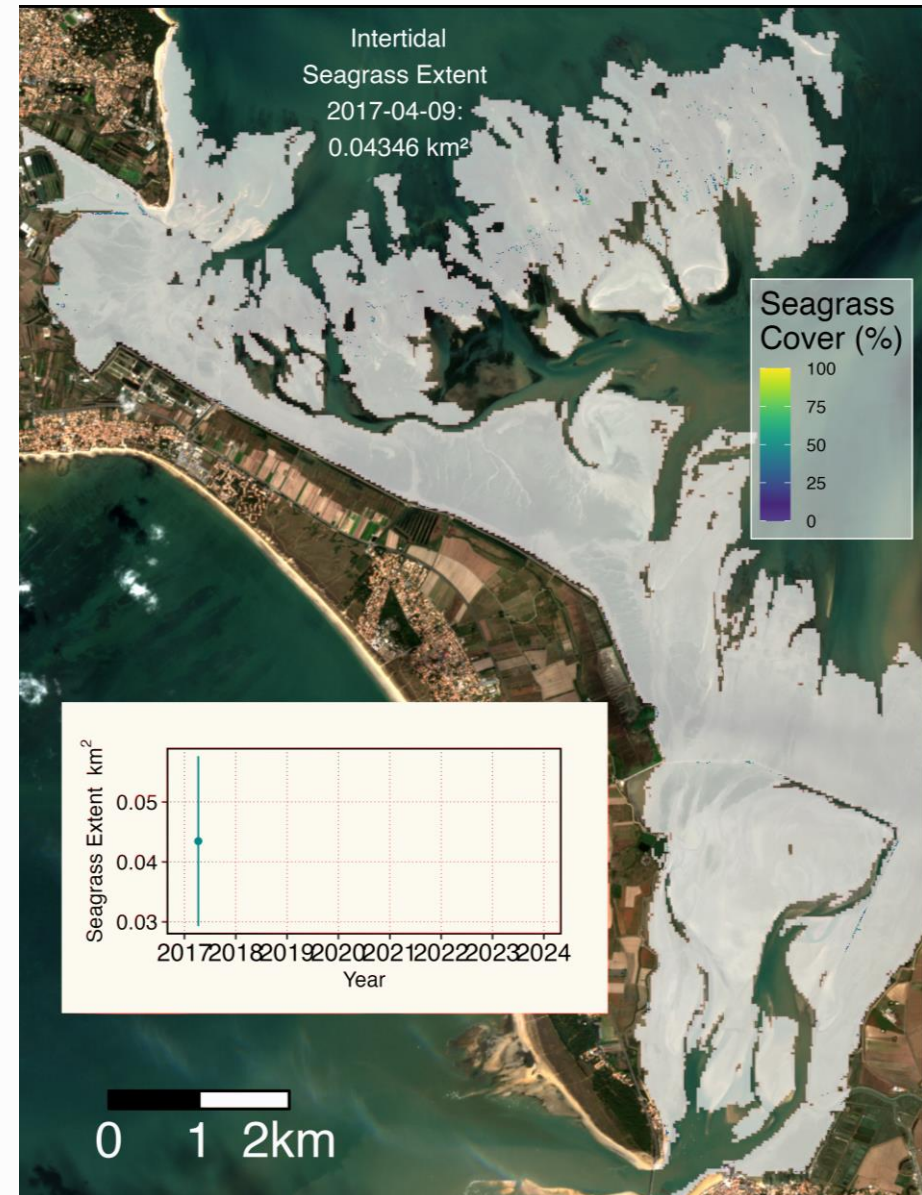
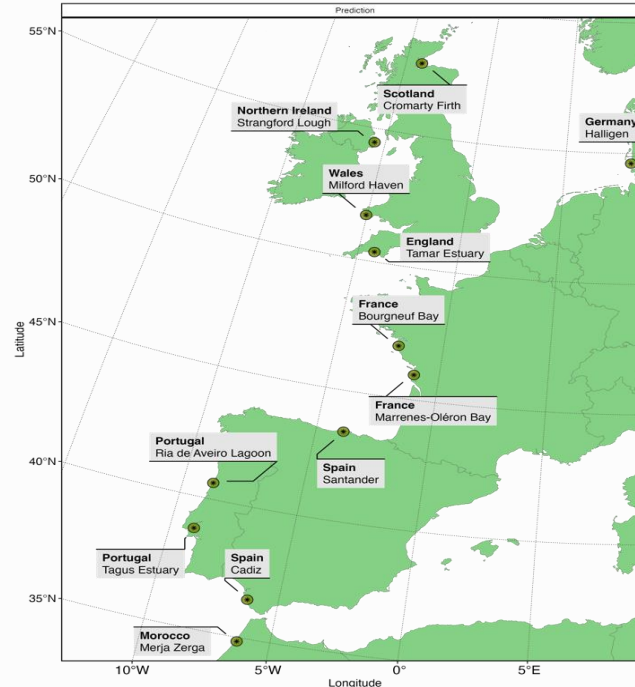
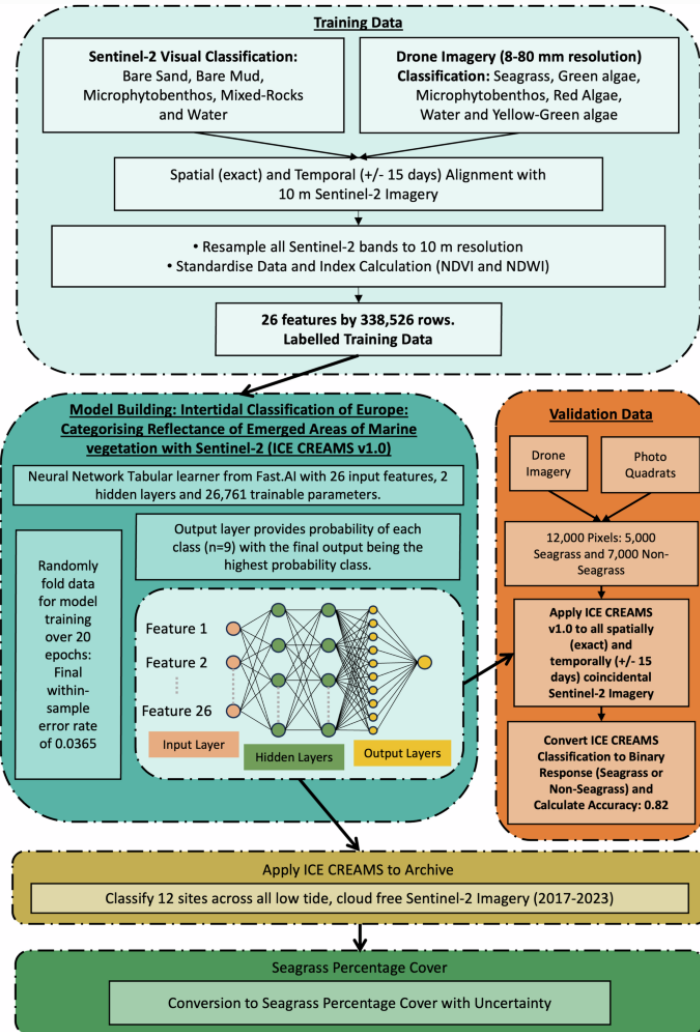


- Artificial surfaces
- Agricultural areas
- Sand shores
- Sparse vegetation
- Aquaculture ponds
- Salt marshes
- Rivers
- Sea
- Brackish lakes





## First assessment of **Intertidal Seagrass** across whole of Europe from the whole S2 record (2016/2017-2022)



- Davies et al, 2024: A sentinel watching over inter-tidal seagrass phenology across Western Europe and North Africa Nature - Communications Earth and Environment
- Davies et al, 2024: Intertidal seagrass extent from Sentinel-2 time-series show distinct trajectories in Western Europe, Remote Sensing of Environment



# EO for Wetland Inventory (EO4WI)



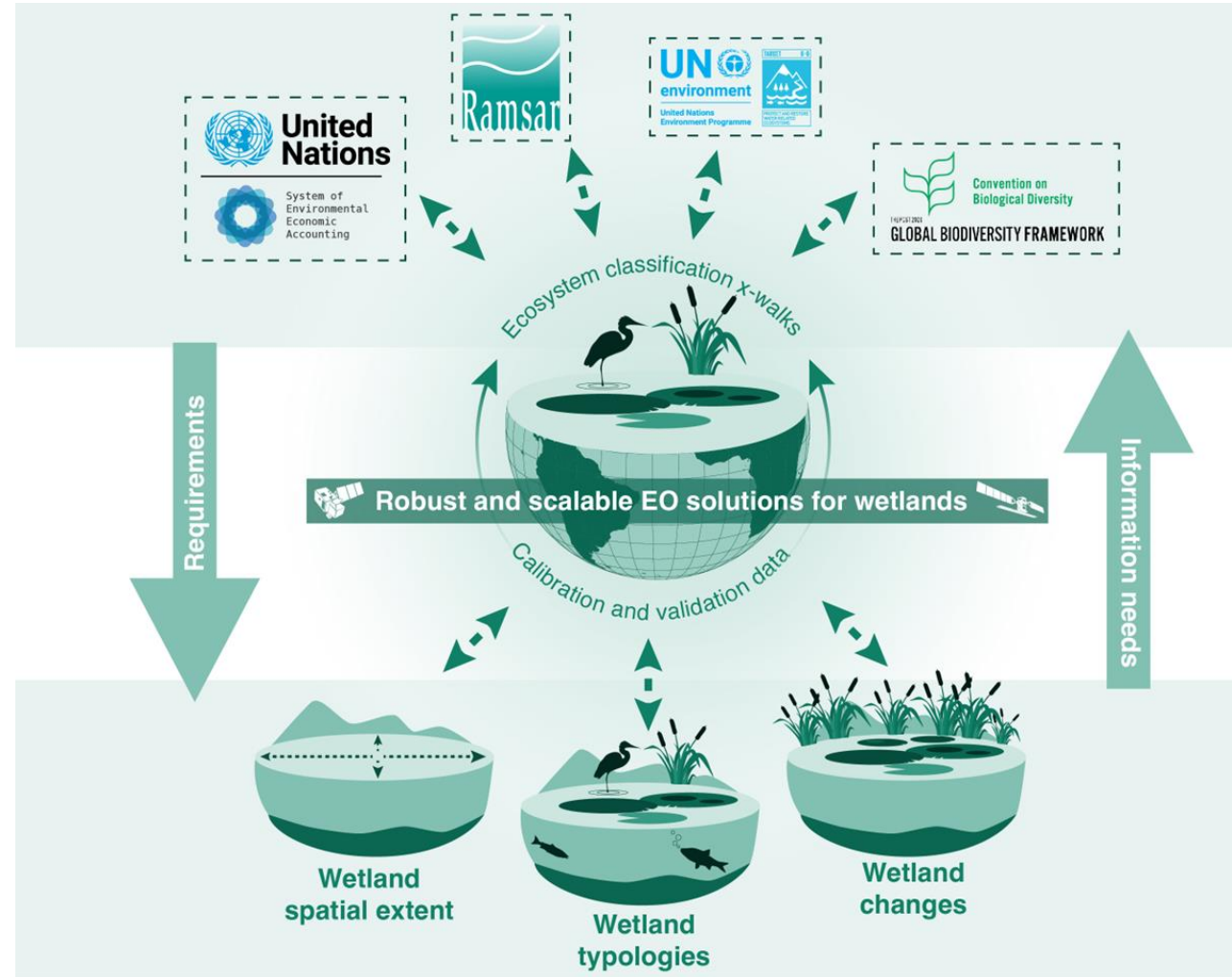
EO4WI

WETLAND INVENTORIES



Develop scalable EO solutions to automatically identify, delineate, classify the spatial extent of wetlands ecosystems (i.e., wetland spatial extent disaggregated by wetland types), and their changes, and derive indicators on wetland extent and changes, at different spatial aggregation levels (e.g., by administrative units and river basins).

Free and open source tools will be made available on the ESA OpenEO platform







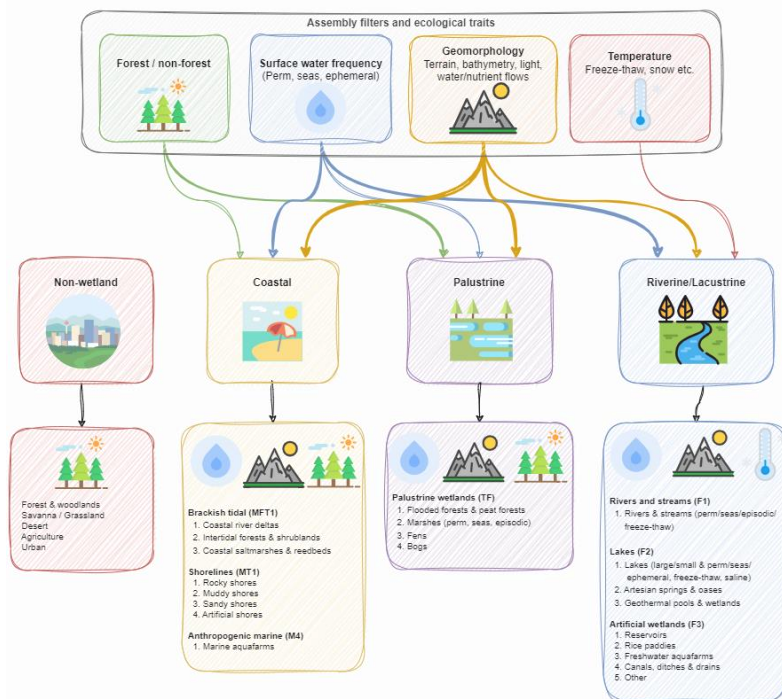
**EO4WI**  
WETLAND INVENTORIES

# EO for Wetland Inventory (EO4WI)



Classification typology  
compatible with IUCN  
GET and Ramsar  
Classification System

Stratification / classification framework



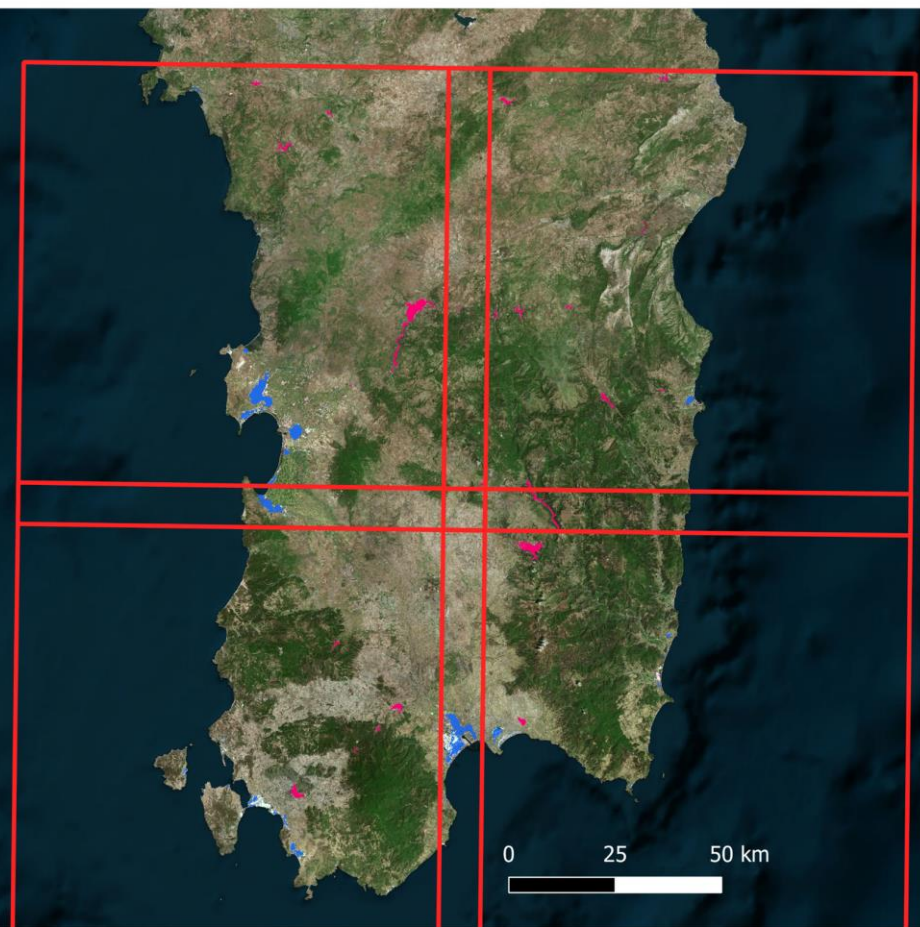
Legend

Proof of Concept Sentinel-2 tiles

EO4WI - GWW Wetland Types  
Band 1: remapped (Gray)

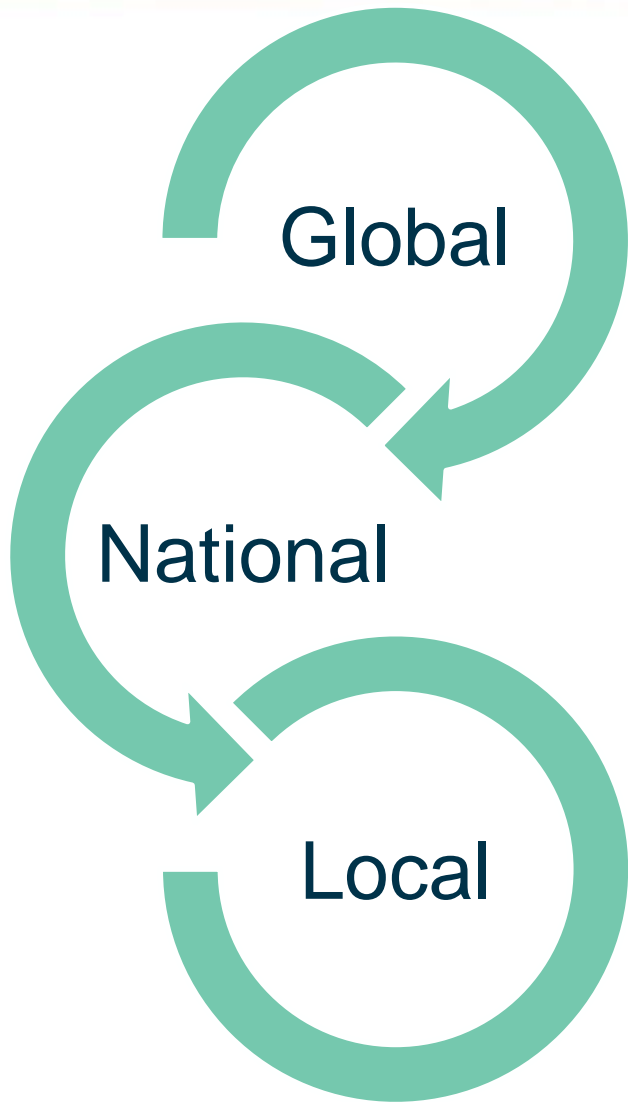
- Sandy shorelines
- Muddy shorelines
- Rocky shoreline
- Salt marsh
- Intertidal forests and shrubs
- Salt pans (coastal)
- Seasonal marsh
- Permanent marsh
- Forested wetlands
- Aquaculture
- Bog
- Rice
- Reservoirs
- Canals
- Saline Lakes
- Salt pans (inland)
- Lakes
- Tidal Rivers (brackish)
- River
- Stream
- Stream (bigger)
- Unclassified open water
- Lagoons
- Estuaries

Bing Aerial Basemap





# Wetland Inventory with EO, a 3-tier approach



Global wetland datasets  
from global models

National wetland  
inventories

Ramsar site monitoring

**GLOBAL WETLAND WATCH**  
A new system for globally mapping and monitoring changes to wetland ecosystems



**Land Monitoring Service**

**GLOBAL ECOSYSTEMS ATLAS**

## EO4WI Toolbox

- pre-trained AI models with GWW
- Physical based models (water and wetness) + ML/DL models
- Flexible to different wetland typologies
- Training labels from national datasets
  
- pre-trained AI models compatible with GWW and National Wetland Inventory
- Site level classification
- Training labels from field data surveys
- Post-processing for manual adjustments





# BIOSPACE25

Biodiversity Insight from Space

10–14 February 2025 | ESA-ESRIN | Frascati (Rome), Italy

<https://biospace25.esa.int>



# Take home messages

- The uptake of Earth Observation in wetland monitoring can benefit from the availability of a **steadily increasing flow of satellite data of suitable characteristics** and from the **emergence of affordable digital solutions** to address the size and complexity of satellite observations.
- Within many national governments, **there is a recognition of the importance of Earth Observation for wetland inventory, monitoring, assessment and conservation.**
- Despite the growing awareness among Ramsar Contracting Parties that traditional wetland monitoring must be complemented with satellite observations to meet the ambition of the new Ramsar Strategic Plan, **the uptake of Earth Observation is still slow and unevenly adopted by countries.**
- **A number of challenges still need to be adequately tackled for countries to fully embrace EO technologies in their national wetland processes.**
- There is a need for a **stronger collaboration between countries and EO experts, to enable the potential of Earth Observation to be fully realised within Ramsar.**