GIS and Earth Observations for national wetland inventories

Ramsar NWI training webinars | 19-22 October 2020

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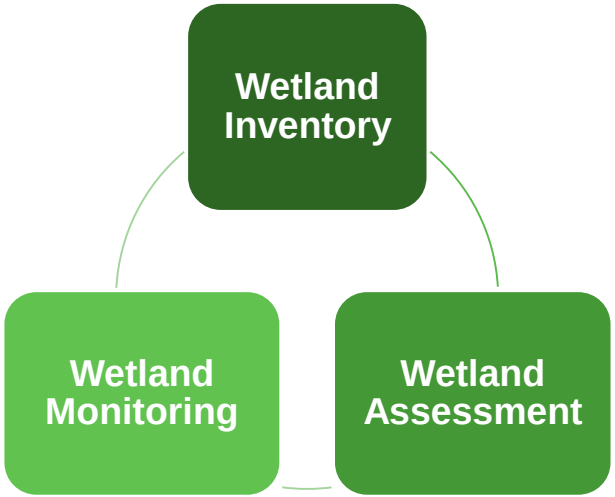
Wetland monitoring from Space

- **Continuous data acquisition**: Earth Observation satellites allows continuous observation of the Earth surface and its changes on a regular basis.
- **Historical archive**: The existing archives of Earth Observation data allows an historical view of environmental issues (40+ years).
- **Multi-scale capabilities**: The different Earth Observation satellite allows the observation of the Earth at global, regional, national and local scales.
- **Multi-sensor information**: The synergic use of optical and radar systems allows different types of environmental parameters and processes to be observed and monitored.



Stringent EO requirements for monitoring wetlands globally

- ***Global and systematic observation scenarios with multi-sensor (radar/optical) approaches***
  to improve wetland inventories globally, which are still largely lacking.
- ***Multi-temporal and multi-spectral optical bands with high radiometric performances***
  to better distinguish 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.

Commonly stated obstacles to the scaling-up and operational use of EO in wetland Inventory, Monitoring & 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 analysis ready data

Capacity building and training

Lack of standardisation of EO data processing methodologies

Lack of clear and solid user-oriented methods and guidelines

Difficulties to discover and access EO data

Insufficient solid track records of successful case studies

The European Copernicus Program

S-1

Radar

A	3 Apr. 2014
B	25 Apr. 2016
C	2022/23
D	> 2022/23

S-2

High Res. Optical

A	23 Jun. 2015
B	6 Mar. 2017
C	2022/23
D	> 2022/23

S-3

Medium Res. Optical & Altimetry

A	16 Feb. 2016
B	25 Apr. 2018
C	2023
D	> 2023

S-4

Atmospheric Chemistry (GEO)

A	2022
B	2027

S-5P

Atmospheric Chemistry (LEO)

A	13 Oct. 2017

S-5

Atmospheric Chemistry (LEO)

A	2021
B	2027
C	> 2027

S-6

Altimetry

A	2020
B	2025

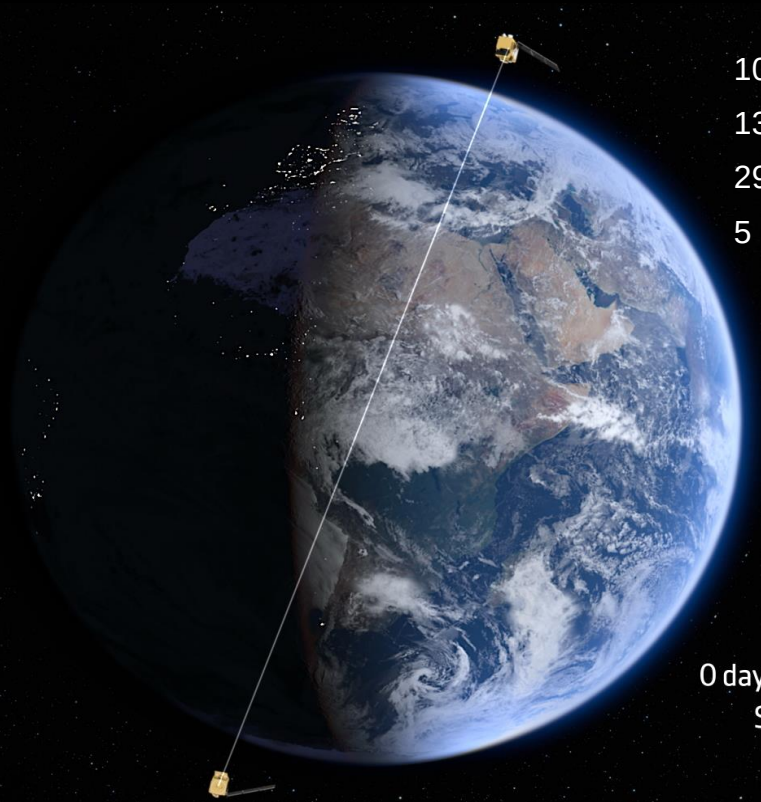
Long term data continuity for sustained monitoring

Universal access to satellite data globally

Copernicus Sentinel 2 mission

Systematic observations of

- **All land surfaces** between 56° South latitude and 84 North latitude
- **Major islands and coral reefs** (greater than 100 km2 size),
- EU islands and all other small islands located at less than **20 km from the coastline**
- The **whole Mediterranean Sea** as well as all inland water bodies and close seas
- S2A launch on 23 June 2015
  S2B launch on 7 March 2017



10m/20m/60m

13 spectral bands

290km swath

5 days revisiting

0 days 00 hours 00 minutes
Sentinel-2 constellation:
summer solstice

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

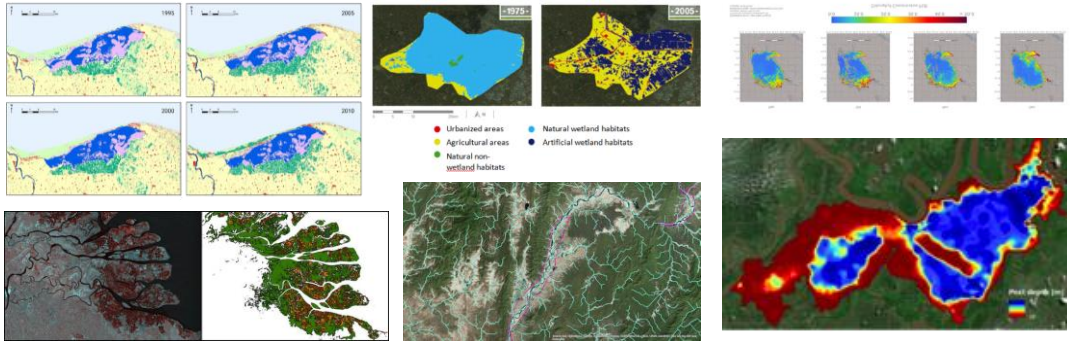
Objective of the report is to:

- Review and report on the **role and use of EO** for inventorying, mapping, and assessment of wetlands, including Ramsar Sites.
- Highlight **existing projects and EO efforts.**
- Present a series of **case studies** which highlight current practices: with an emphasis on practical applications.

https://www.ramsar.org/sites/default/files/documents/library/rtr10_earth_observation_e.pdf

6 Case Studies on the use of EO for wetland inventory, assessment and monitoring

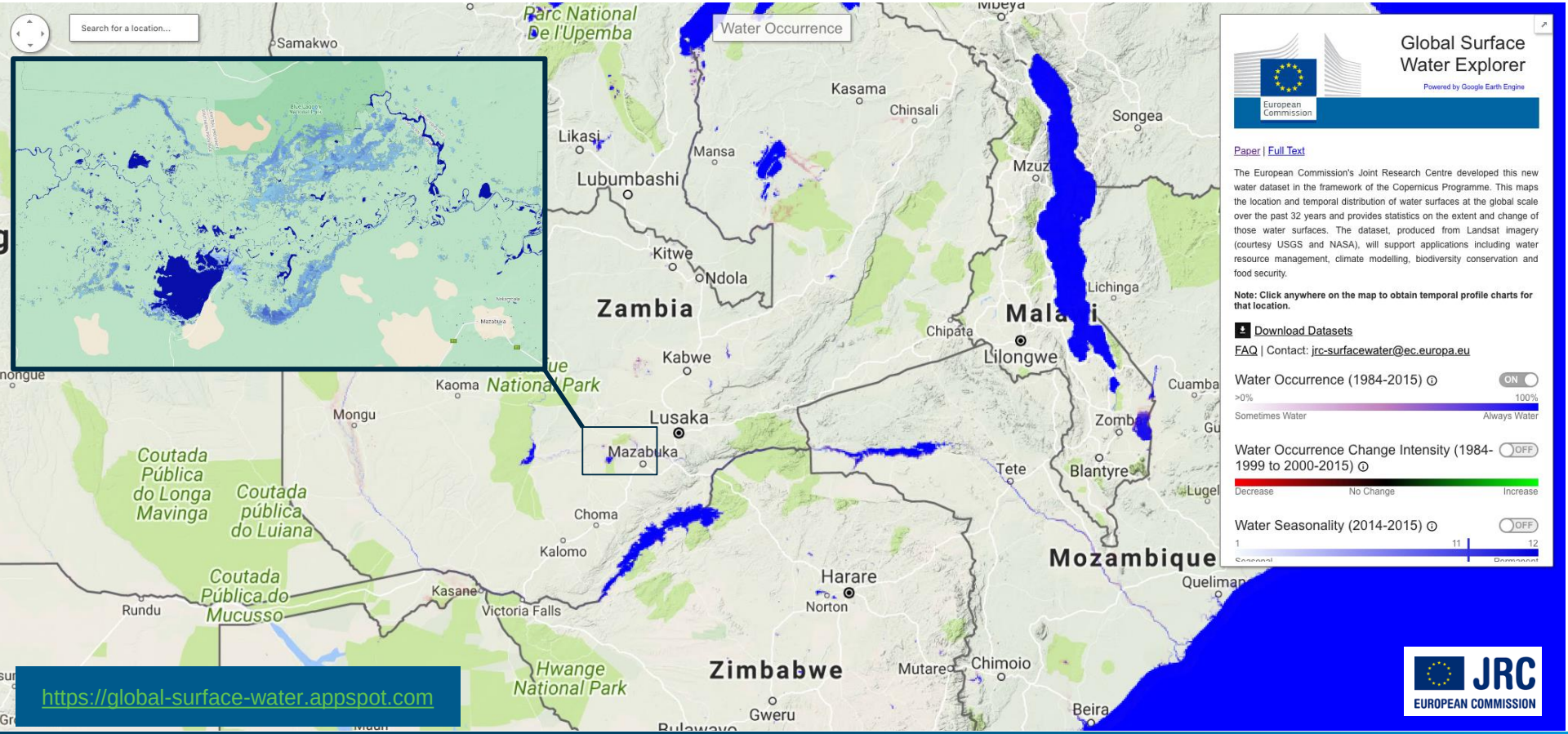
- Updating information on an existing Ramsar Site: the case of Lake Burullus, Egypt
- EO for regional or national assessments: Mediterranean coastal wetlands.
- EO for monitoring lakes and reservoirs - Lake Victoria and Lake Volta.
- EO for mangrove mapping and change assessment.
- EO for national wetland inventory.
- EO for tropical peatland mapping.



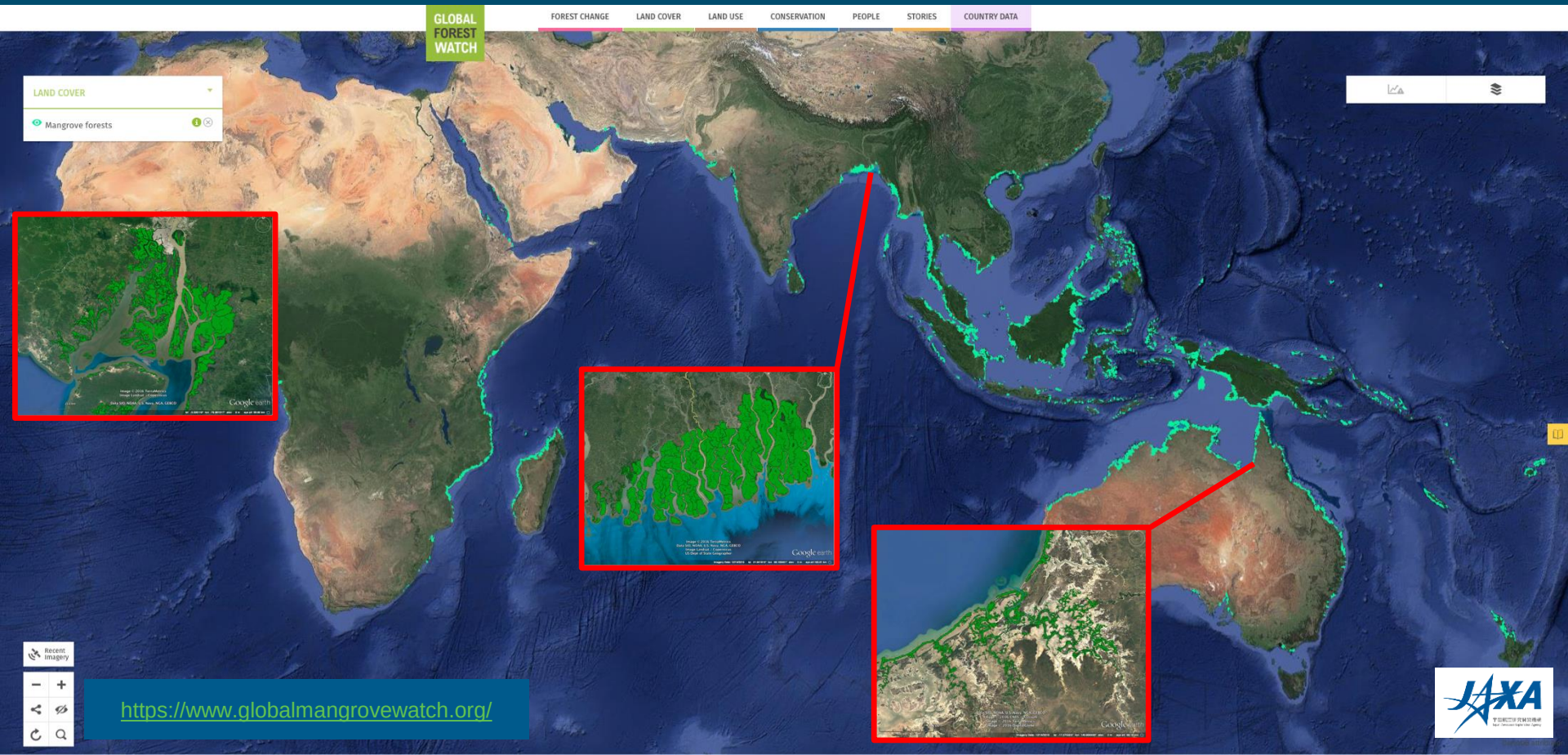
International collaboration to scale up EO innovation in the implementation of the Ramsar Convention on Wetlands and other MEAs

International collaboration to scale up EO innovation in the implementation of the Ramsar Convention on Wetlands and other MEAs

Global Surface Water Explorer

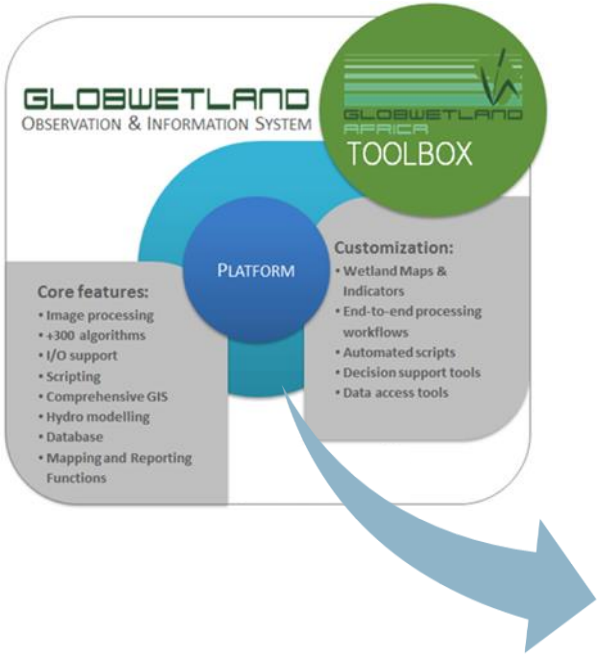


Global Mangrove Watch

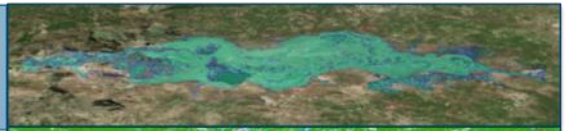


International collaboration to scale up EO innovation in the implementation of the Ramsar Convention on Wetlands and other MEAs

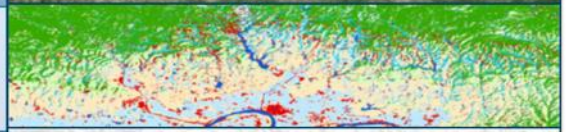
GlobWetland Africa, a free of charge and open-source EO toolbox for wetland inventory and monitoring



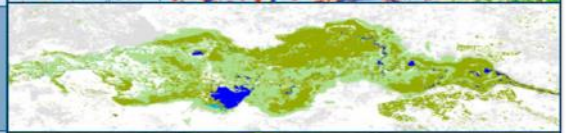
Wetland inventory
identification and delineation of wetland areas over large river catchments, in support to national wetland inventorying campaigns;



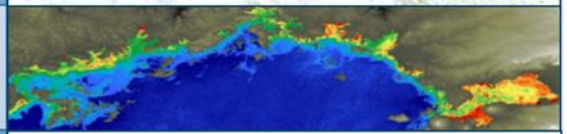
Wetland habitats maps
for the assessment of the wetland status and for long-term change and trend analysis, inside and around Ramsar/wetland areas;



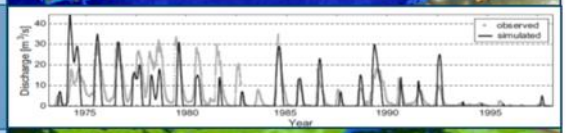
Water cycle regimes,
for the analysis of the intra- and inter-annual variations of the water tables, inside and around Ramsar/wetland areas;



Water quality parameters
such as turbidity, suspended solids and chlorophyll concentration, for the monitoring of the aquatic contamination and physical disturbances of the wetland ecosystem;



River basin hydrology
for the modelling of the water balance and the impact of/on wetlands within river catchments;



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

http://globwetland-africa.org/

GW-A products vs Ramsar strategic objectives and SDG targets

GW-A main products	Contribution to Ramsar Strategic Plan	Ramsar 2016-2024 Targets	SDG Targets
Wetland Inventory	**Wetland distribution** and status data and information available.	Targets 5, 8, 9, 13	SDG Target 6.6
Wetland Habitat Mapping	Wetland observing system(s) reporting on **changes in wetland status**.	Targets 1,5,7,11	SDG Target 6.6 SDG Target 15.1
Inundation Regimes	Managing wetlands as natural water infrastructure integral to **water resource managemen**t at the scale of river basins.	Targets 6,12	SDG Target 6.3 SDG Target 6.6 SDG Target 12.2
Water Quality	By 2020, **pollution, including excess nutrients**, has been brought to levels that are not detrimental to ecosystem function and biodiversity.	Targets 2,4	SDG Target 6.3 SDG Target 12.4
River Basin Hydrology	Effectiveness of **cooperative management** in place **for shared wetland systems** (for example, in shared river basins and coastal zones).	Targets 2, 9, 14, 17	SDG Target 6.5
Mangrove Mapping	National Wetland Policy and instruments fully in place alongside and integrated with … **coastal and marine resource management** plans.	Targets 8, 11, 14	SDG Target 6.6 SDG Target 14.2 SDG Target 15.1

A Ramsar framework for wetland inventory and ecological character description

- The Framework provides **guidance on a standard approach** to designing a **wetland inventory program**.
- It includes **information on determining appropriate remote sensing techniques** to apply, wetland classifications and existing standardised inventory methods, and recommends standards for core data fields and data and metadata recording.

Ramsar handbooks for the wise use of wetlands, 4th edition

Appendix II

Determining the most appropriate remotely sensed data for a wetland inventory

1. The following steps provide an outline procedure for assessing which is the most appropriate remote sensing technique for a particular inventory. The

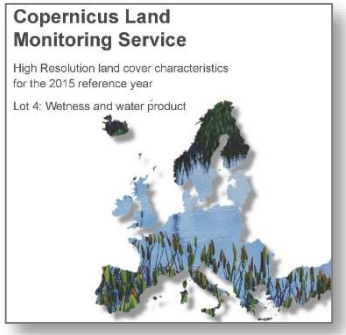
Wetland Inventorying using EO Data

Source: www.rainharvest.co.za

Source: http://www.wetlands.org

Wetland identification and delineation with the aim to support national and regional agencies to monitor wetlands in a cost-effective and sustainable way → large-scale mapping

Implementation status



Copernicus Water & Wetness HR Layer 2015/2018

Production of the Pan-European coverage

GlobWetland Africa

Developing EO tools and products to effectively monitor the status and trends of wetlands in Africa for the Ramsar Convention on Wetlands

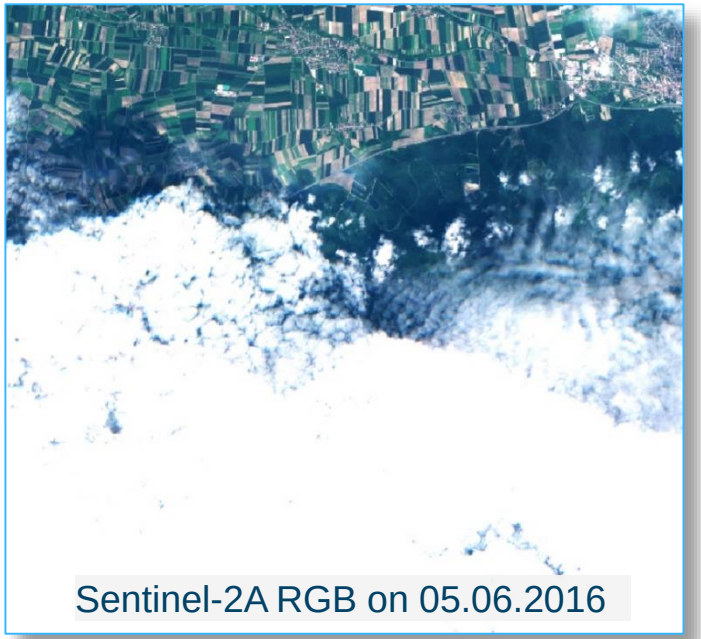
EO4SD Water Resource Management

Large-scale exploitation of EO data in support of international development

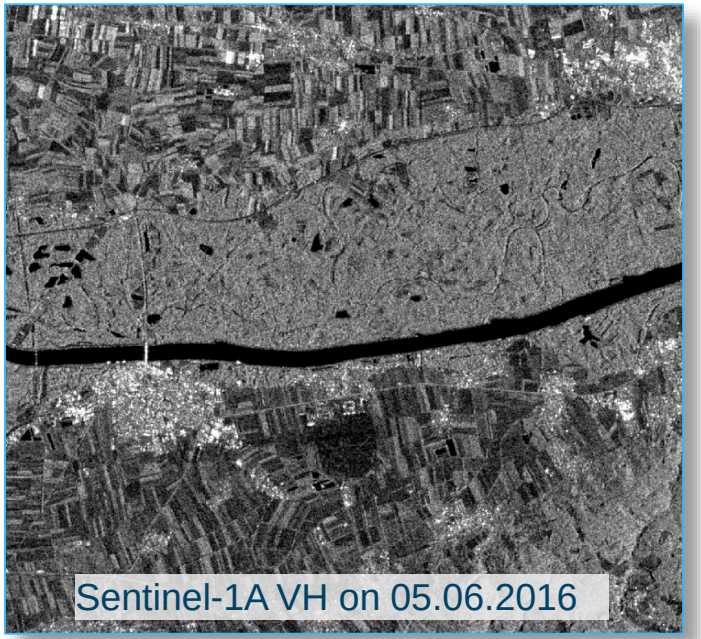
Wetland Inventory of Uganda

Earth Observation support for monitoring and reporting on wetlands, SDG 6.6

Data



Sentinel-2A RGB on 05.06.2016



Sentinel-1A VH on 05.06.2016

Other data used: Landsat 5, 7, 8 and SRTM 30m DEM

Methodology

Optical-based (Sentinel-2, Landsat)

- Combining **multi-spectral** information
- Enhancing spectral signatures making use of **water absorption in NIR/SWIR**
- Unsupervised and **supervised classification** or **thresholding** approaches

Challenges:

- Clouds
- Confusion with shadows
- Dense vegetation

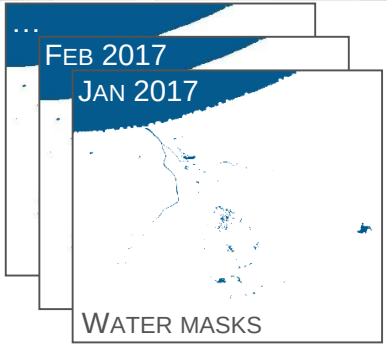
Radar-based (Sentinel-1)

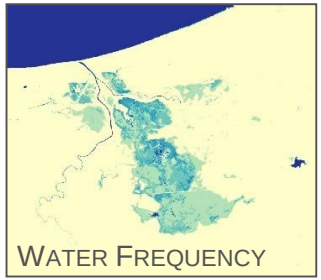
- Different methods depending on type of radar and type of data (imaging radar, interferometric methods)
- SAR sensors **sensitive to dielectric properties** (moisture content) and **geometric attributes** (roughness)

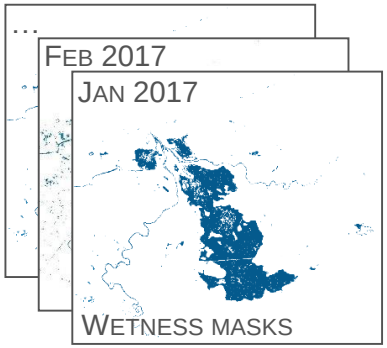
Challenges:

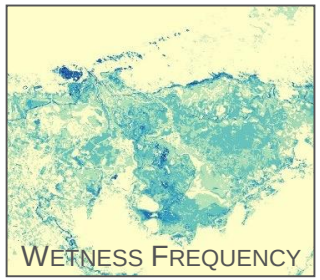
- Sandy/arid regions
- Confusion with other flat surfaces
- Dense vegetation

Methodology



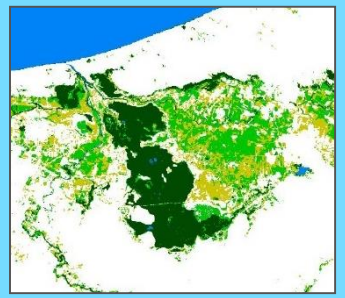






CLASSIFICATION

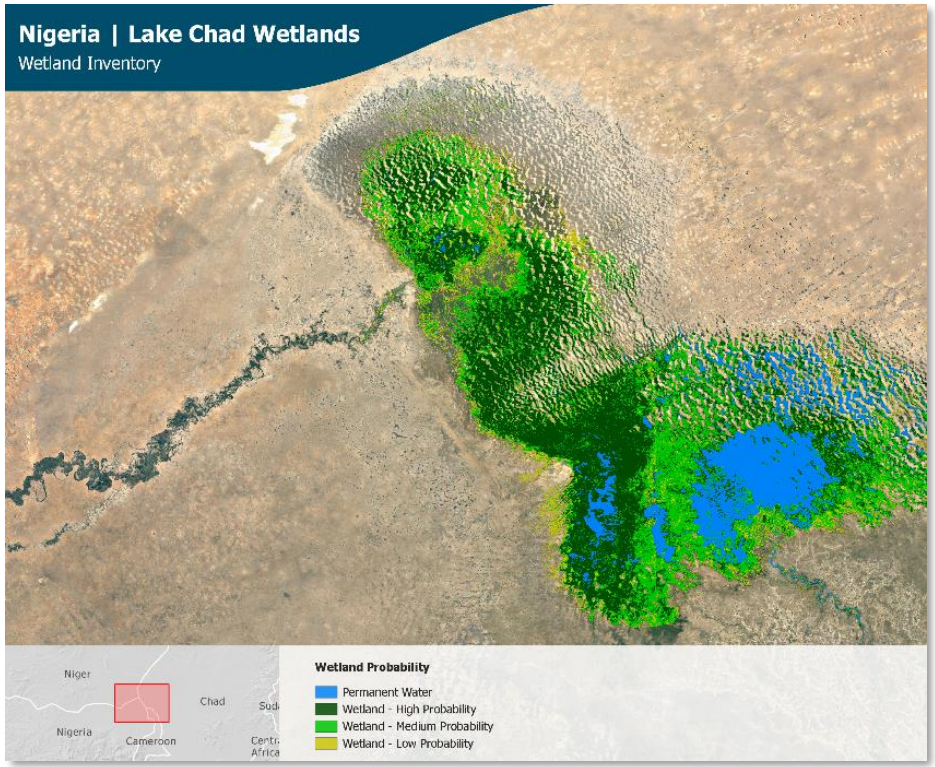
WATER AND WETNESS PRESENCE INDEX (WWPI)

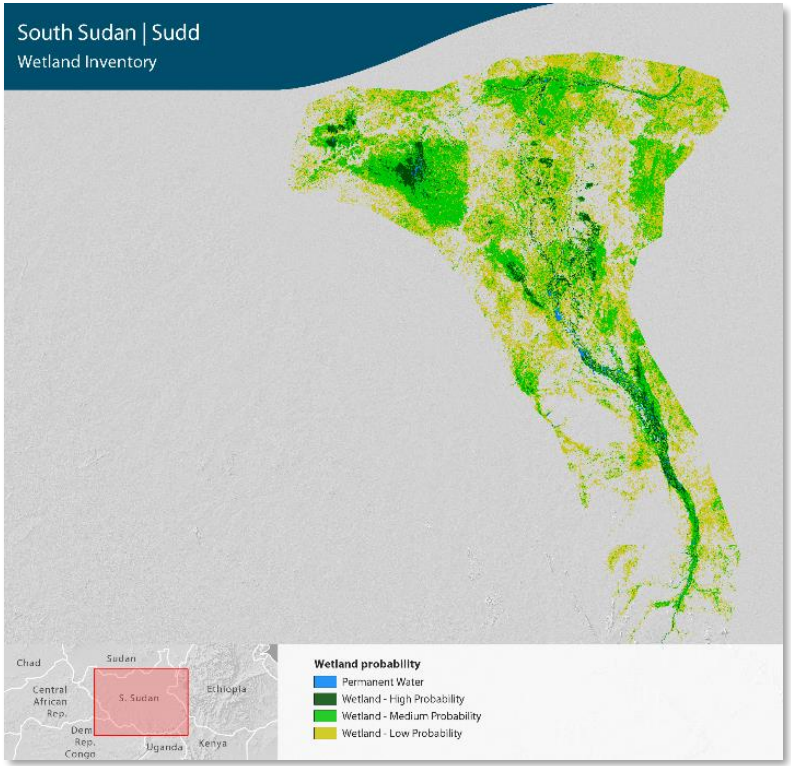


RULE-BASED CLASSIFICATION

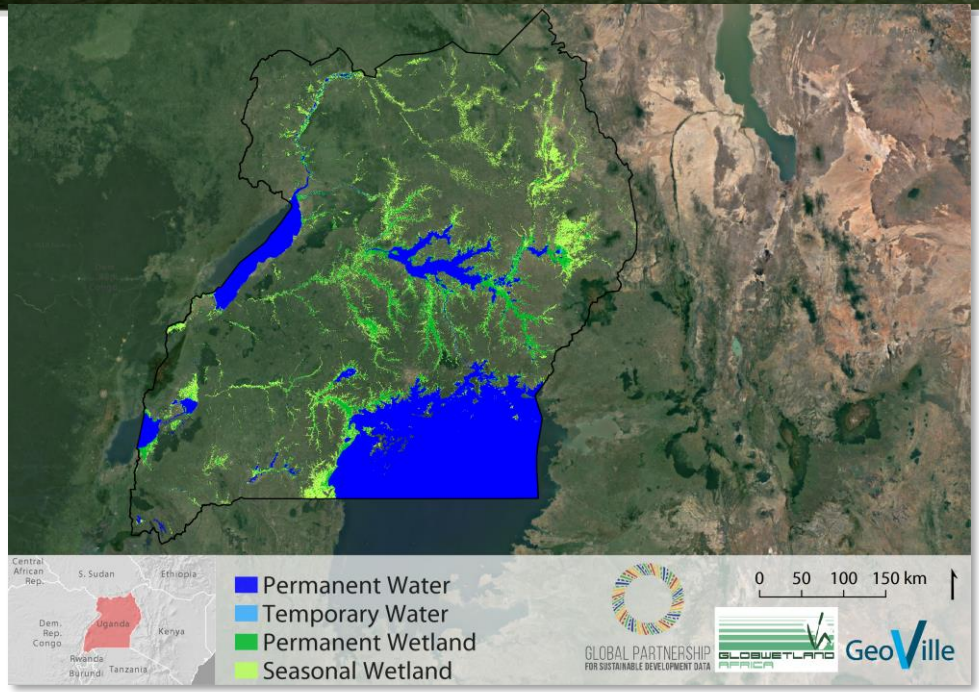
Highly dynamic environments →Time series analysis!

Results

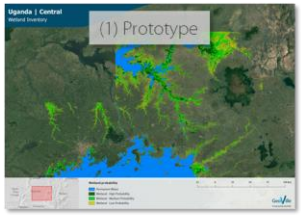

Nigeria | Lake Chad Wetlands
Wetland Inventory
Niger
Nigeria
Chad
Cameroon
Wetland Probability
Permanent Water
Wetland - High Probability
Wetland - Medium Probability
Wetland - Low Probability


South Sudan | Sudd
Wetland Inventory
Chad
Sudan
Central African Rep.
S. Sudan
Ethiopia
Dem. Rep. Congo
Uganda
Kenya
Wetland probability
Permanent Water
Wetland - High Probability
Wetland - Medium Probability
Wetland - Low Probability

Results



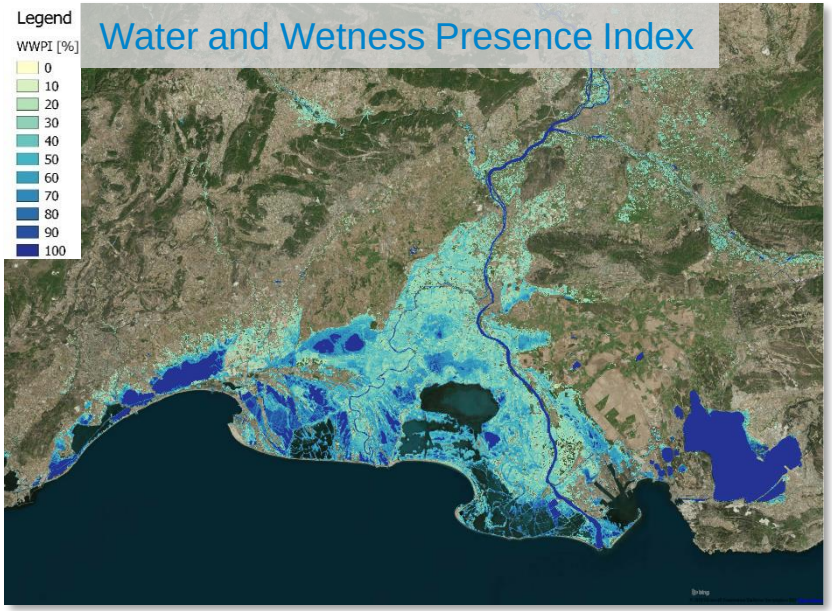
Country-case Uganda (Global Partnership for Sustainable Development Data)



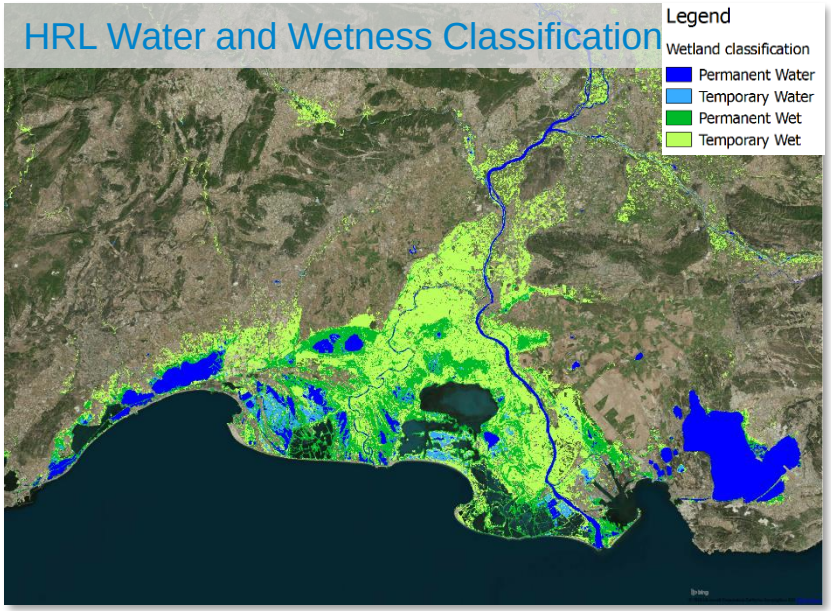
Input: Sentinel-1 and Sentinel-2, 2016–2017

Results

Water and Wetness Presence Index



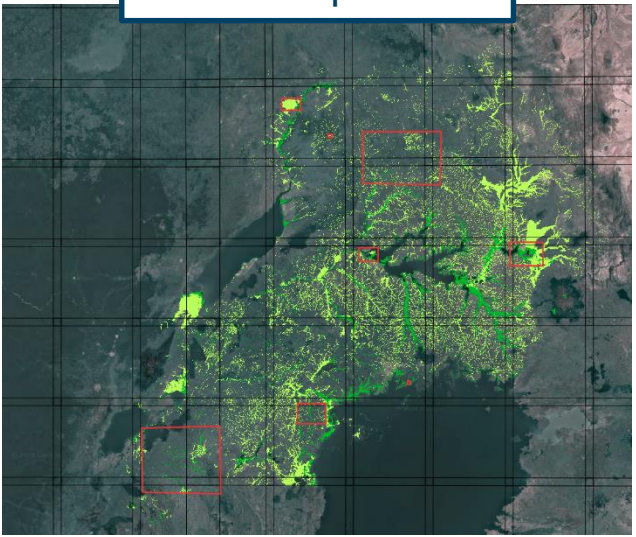
HRL Water and Wetness Classification



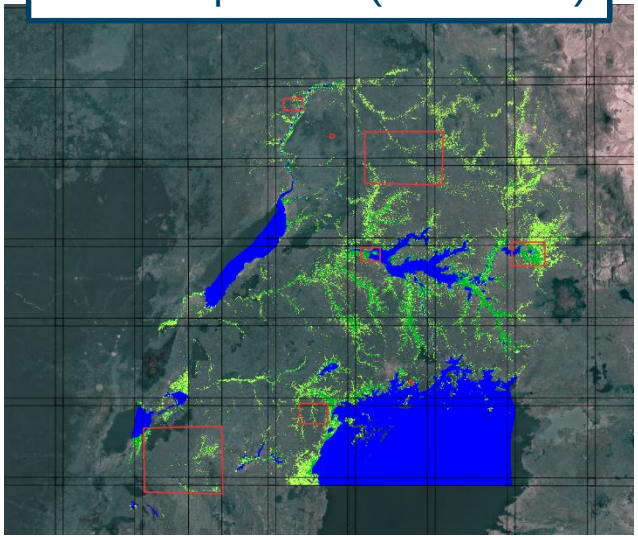
Discussion

Product comparisons and analyses

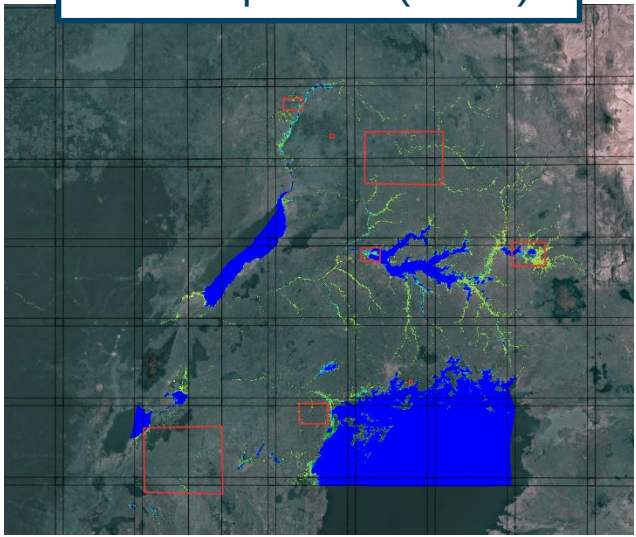
National product



GPSDD product (EO-based)



Global product (250m)

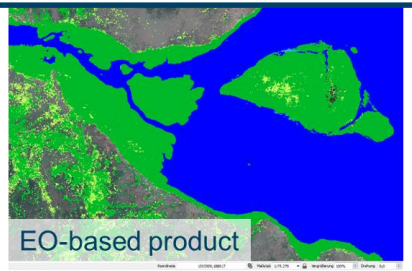


Discussion

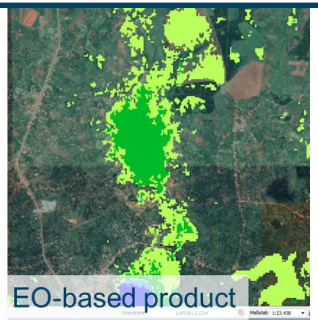
Working on hot-spot regions

National better than EO

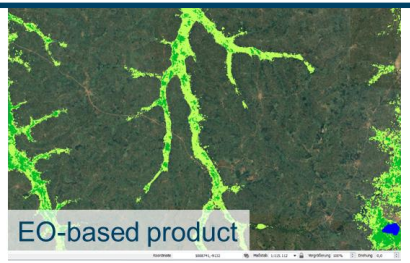
EO better than national

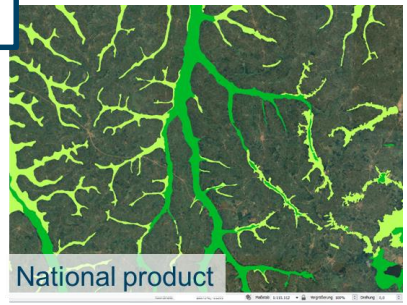


EO better than national



National still valid?





Summary & Outlook - Methodology

- **Optical- and radar-based product** to detect water and wet surfaces
- **Water and Wetness Frequencies** and **Water and Wetness Presence Index** → Delimitation water-related surfaces/ecosystems
- Application of **use case specific classification**
- Highly automated production via **Sentinel-1** and **Sentinel-2** data streams processed at Earth Observation Data Centre (EODC) which is part of WEkEO-DIAS **accessible via API-based service**
- **Validated in Europe (externally)** and **Africa (internally)** with good overall accuracies for water and wetness classes

Finalising the NWI

Automatic Wetland Inventory

Pre-inventory

Import/ Download QGIS

Inspect and update

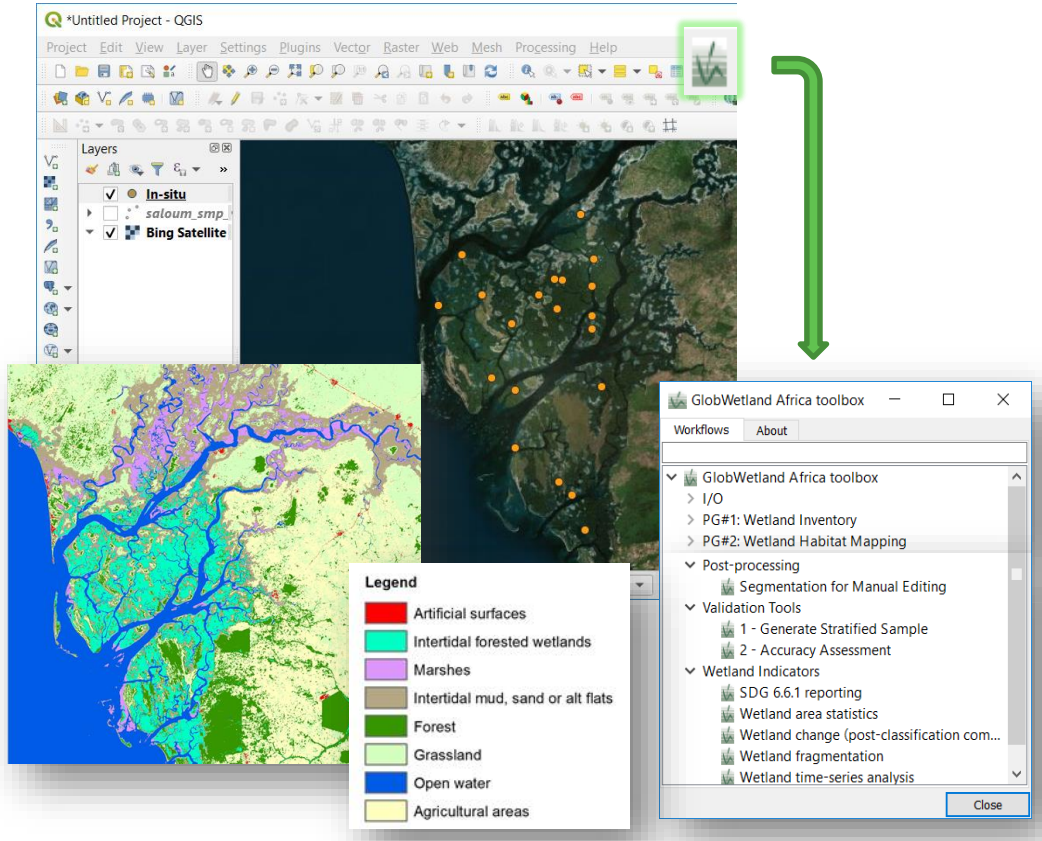
Validate

Indicators

Publish

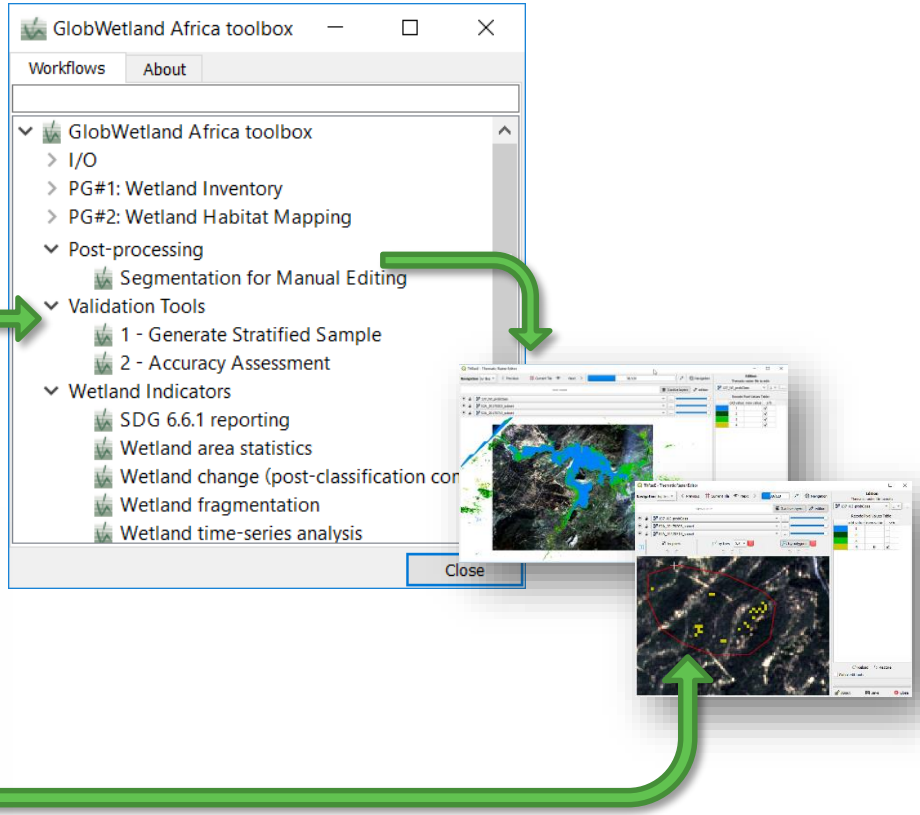
The GlobWetland Africa Toolbox

- **Key capabilities**
  - Seamless interface with cloud processing environment for operational large-scale processing and application
  - Retrieve, manage and process NWI data as well as integrate in-situ data -> map updating and validation
  - Produce wetland information products (incl. wetland habitat mapping) and indicators



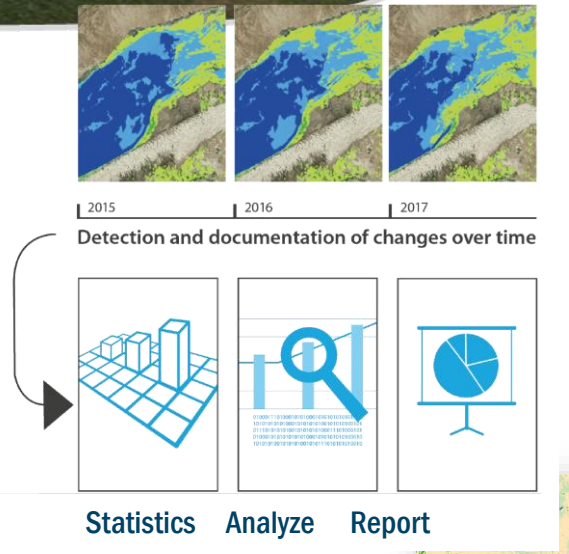
Inspection and updating

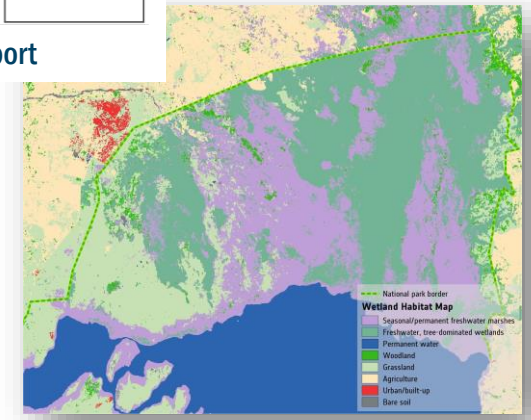
- Import map in GIS and review by panning and zooming
- Interactive dialogue for editing
- Update and validate with independent reference data (e.g. in-situ)



Indicators

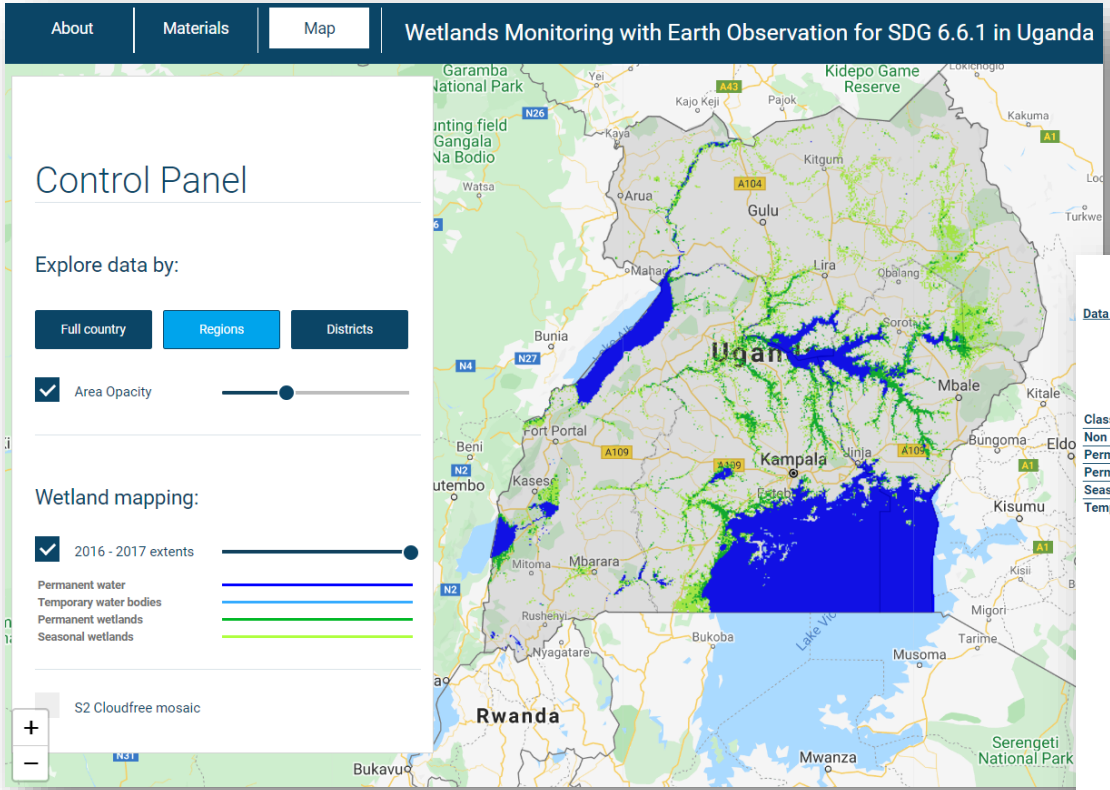
- Apply statistics and perform detailed mapping and analytics to support reporting, planning and decision making:
  - What is the wetland extent and how has it changed over time?
    - $(\gamma - \beta)/\beta \times 100$
  - Is the wetland under threat from urbanization, agricultural encroachment and/or aquaculture development?

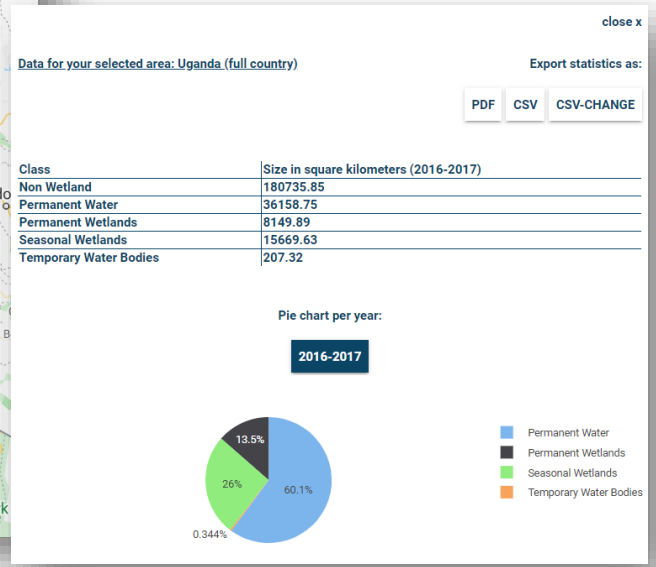




Wetland habitat mapping provides a detailed map of individual wetland sites. Example from the Lake George wetlands (Uganda) showing signs of agricultural encroachment into the Ramsar site along the northern boundary.

Publish

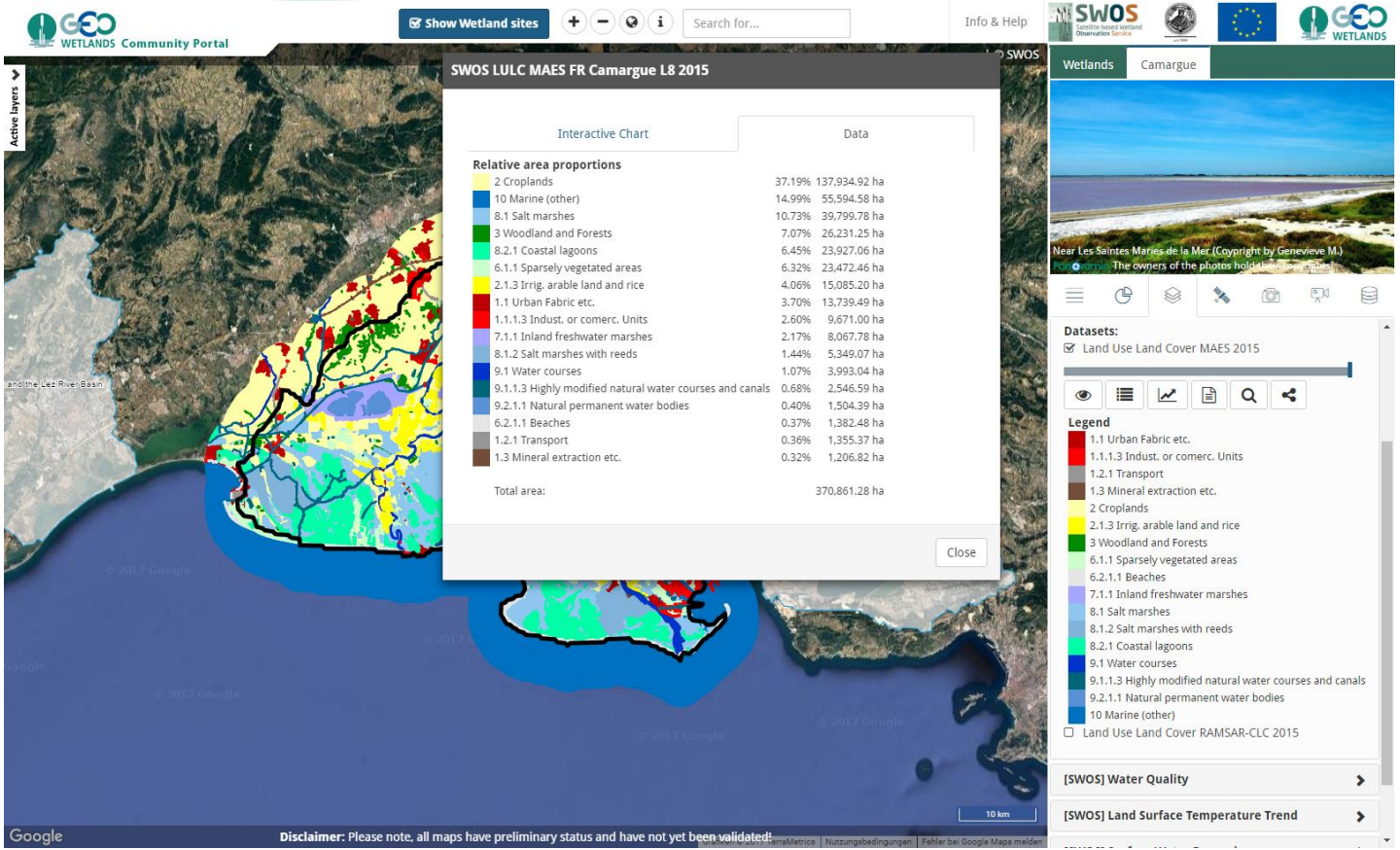




http://uganda-wetlands.dhigroup.com/

International collaboration to scale up EO innovation in the implementation of the Ramsar Convention on Wetlands and other MEAs

The GEO Wetlands Community Portal, an EO knowledge sharing hub for wetland practitioners



- User-friendly **satellite data discovery and access**
- **visualization tools** to explore available wetland-related datasets (e.g. GSW)
- Continuous **upload of thematic products**
- **Products download**
- On-demand Map / Indicator **production** *(on-line processing in the future)*
- **EO best practices**
- **Inter-operable with** with other GEO portals (OGC compliant)
- Access to **s/w toolboxes**

Take home message (1/2)

- Previously expressed **limitations in the use of Earth Observation** for deriving wetland information have become less of a constraint.
- The Sentinels of the European Copernicus program (together with freely available data from other space agencies) bring **unprecedented observation capacity** for wetland monitoring.
- The **open and free data policies of government-funded satellite data,** along with **assurance of long-term continuity of observations**, are important incentives for CPs to routinely integrate EO into their work.
- With the increasing availability of "**analysis ready" datasets**, the level of expertise required for basic wetland applications has decreased

Take home message (2/2)

- An **increasing number of thematic products** are also being made available (at regional to global levels) which can be used to assess and monitor wetlands directly.
- The development of **new EO platforms for big data exploitation** and the availability of **open source and open access toolboxes** reduces cost for IT, processing and software licensing.
- **Knowledge of the local context** and **collection of in situ data** remains critical for ensuring locally relevant outputs.
- Earth Observation has the potentials to become an important and **integral component of national Wetland Inventories**.