Large Scale Wetland Inventorying based on Sentinel-1 and Sentinel-2 Time-Series Data

Michael Riffler[1], Björn Dulleck[1], Christian Gruber[1], Christian Tottrup[2], Marc Paganini[3], Andreas Walli[1]

[1]GeoVille Information Systems, Innsbruck, Austria

[2]DHI GRAS, Hørsholm, Denmark

[3]European Space Agency, Frascati, Italy

Wetland Inventorying using EO Data

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

Highly dynamic environments → time-series analysis

Focus on physical properties → measurable

Heritage of developments

Water Observation Information System for African authorities

2012

Wetland Information and toolbox for Ramsar contratcing parties+

2015

Mainstreaming EO for IWRM and international development projects

2016

National demonstrator on wetland inventorying

2017

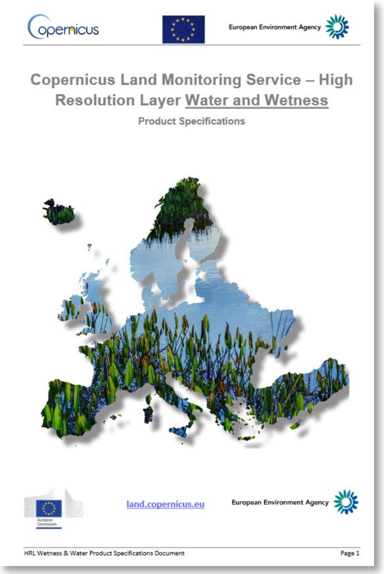
2018

Extension on Wetland inventorying

2019

Surface water dynamics from space

2022


opernicus
European Environment Agency
Copernicus Land Monitoring Service – High Resolution Layer Water and Wetness
Product Specifications
land.copernicus.eu
European Environment Agency
HRL Wetness & Water Product Specifications Document
Page 1


User Manual
Copernicus Land Monitoring Service
High Resolution land cover characteristics
Lot4: Water & Wetness 2018
opernicus
European Environment Agency

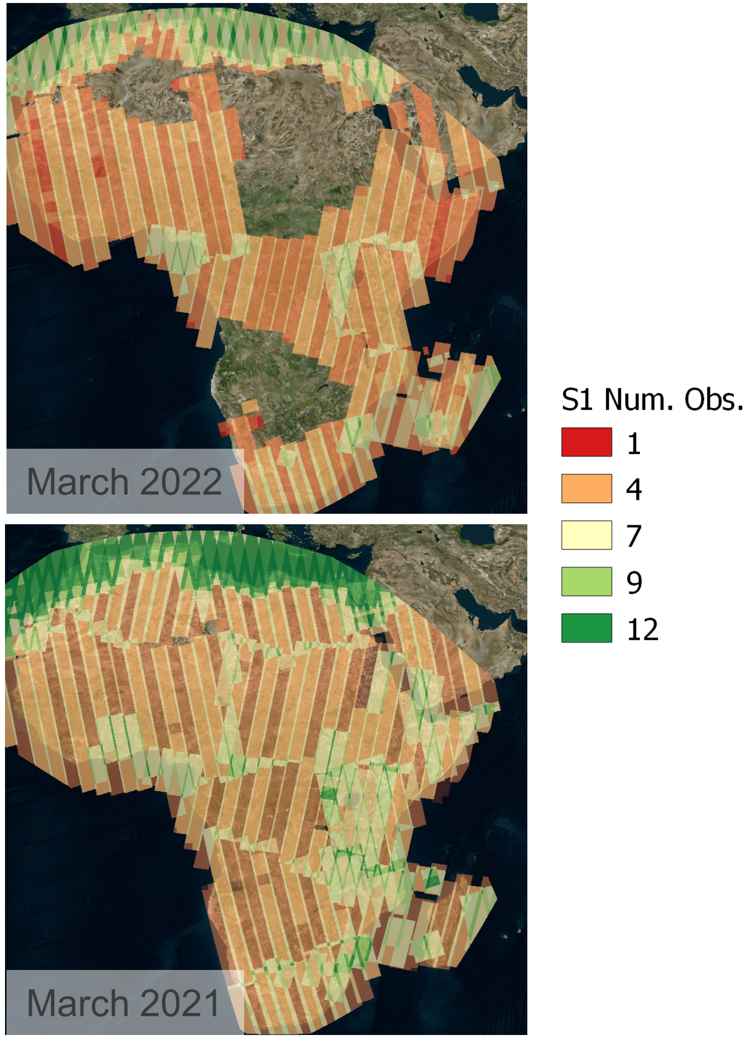
Copernicus HRL Water & Wetness
2015 / 2018

Data

Input data requirements and usage of the data

Sensor	Product	Resolution	Method / Usage
Sentinel-1 **(10-2016 to 09-2020)**	GRDH	20m (10m pixel size)	Water detection, Soil moisture
Sentinel-2 **(10-2016 to 09-2020)**	L1C and L2A	10m/20m	Water & wetness detection, Soil moisture
DEM	CopDEM / SRTM v4	30 / 90m	TWI, HAND for water & wetness detection
SMAP soil moisture	SMAP_L3_SM_P_E	9km	Soil moisture
MODIS NDVI	MYD13A3, MYD13A1	500m / 250m	Soil moisture
IMERG	3B-HHR-L.MS.MRG.3IMERG	10km	Soil moisture post-processing

Sentinel-1 coverages



Methodology – hybrid approach

Optical-based (Sentinel-2, Landsat)

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A highly automated algorithm for wetland detection using multi-temporal optical satellite data

Christina Ludwig, Andreas Walli, Christian Schleicher, Jürgen Weichselbaum, Michael Riffler*

GeoVille Information Systems and Data Processing GmbH, Sparkassenplatz 2, 6020 Innsbruck, Austria

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Water frequency
Wetness frequency
WWPI

ABSTRACT

Wetlands are valuable ecosystems providing a variety of important ecosystem services such as food supply and flood control. Due to increasing anthropogenic influences and the impact of climate change, wetlands are increasingly threatened and degraded. An effective monitoring of wetlands is therefore necessary to preserve and restore these endangered ecosystems. Earth Observation (EO) data offer a great potential to support cost-effective and large-scale monitoring of wetlands. Current state-of-the-art methods for wetland mapping, however, require large training data and manual effort and can therefore only be locally applied. The focus of this study is to evaluate a methodology for large-scale and highly automated wetland mapping based on current EO data streams. For this purpose, an algorithm for water and wetness detection based on multi-temporal optical imagery and topographic data is presented. Suitable spectral indices sensitive to water and wetness were identified using feature selection methods based on mutual information between optical indices and occurrence of water and wetness. In combination with the Topographic Wetness Index (TWI), these were used to derive monthly water and wetness masks using a dynamic thresholding approach. Aggregating all observations corrected for seasonal bias yielded flooding and wetness frequencies and the Water Wetness Presence (or Probability) Index (WWPI) as an indicator for wetland occurrence or a pre-inventory. To demonstrate the applicability of the proposed method, the algorithm is demonstrated at three study sites with different wetland types in Kenya/Uganda, Algeria, and Austria using Sentinel-2 MultiSpectral Instrument (MSI) imagery. For all sites, the overall accuracy was above 92%. User's and producer's accuracies were higher for water (> 96%) than for wetness (> 75%). Due to the high degree of automation and low processing time, the proposed method is applicable on a large scale and has already been applied during the production of the Copernicus High Resolution Water-Wetness Layer and within the European Space Agency (ESA) project GlobWetland Africa.

1. Introduction

Wetlands are very important ecosystems providing habitat for a variety of flora and fauna as well as many valuable ecosystem services such as flood control, water purification, and food supply. However, with increasing human water demand for agriculture, livestock, and settlements, wetlands are becoming increasingly threatened and degraded especially in water scarce regions (Ramsar Convention, 2016). Effects of climate change such as temperature increases and changes in precipitation patterns, are expected to have a significant impact on the occurrence, structure and functions of wetlands (Erwin, 2009), especially in their role as an organic carbon sink (Junk et al., 2013).

Thus, for preservation and restoration of wetlands, a cost-effective and efficient monitoring of these ecosystems is necessary. Satellite data offers great potential for wetland monitoring and has been the subject of many studies (Tiner et al., 2015). Yet, a large-scale monitoring system that captures the seasonal dynamics and long-term trends of wetlands has not yet been implemented. Pekel et al. (2016) produced a global surface water map based on the Landsat archive. Although being a first step towards large-scale monitoring of water-related ecosystems, it is not sufficient for wetland monitoring, since only the spatio-temporal distribution of open surface water is covered and the mapping of wet soils is missing.

Due to their high spatial heterogeneity and temporal dynamics, wetlands are very difficult to map using remote sensing imagery (Ozesmi and Bauer, 2002). Seasonal or daily water level changes make the extent and spectral signature of wetlands highly dynamic. Therefore, mono-temporal classification approaches are not sufficient to fully

* Corresponding author.
E-mail addresses: ludwig@geoville.com (C. Ludwig), walli@geoville.com (A. Walli), schleicher@geoville.com (C. Schleicher), weichselbaum@geoville.com (J. Weichselbaum), riffler@geoville.com (M. Riffler).

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Article

Surface Water Dynamics from Space: A Round Robin Intercomparison of Using Optical and SAR High-Resolution Satellite Observations for Regional Surface Water Detection

Christian Tottrup [1,*], Daniel Druce [1], Rasmus Probst Meyer [1], Mads Christensen [1], Michael Riffler [2], Bjoern Dulleck [2], Philipp Rastner [2], Katerina Jupova [3], Tomas Sokoup [3], Arjen Haag [4], Mauricio C. R. Cordeiro [5], Jean-Michel Martinez [5], Jonas Franke [6], Maximilian Schwarz [7], Victoria Vanthof [8], Suxia Liu [9], Haowei Zhou [10], David Marzi [11], Rudiyanto Rudiyanto [12], Mark Thompson [13], Jens Hiestermann [13], Hamed Alemohammad [14], Antoine Masse [15], Christophe Sannier [15], Sonam Wangchuk [16], Guy Schumann [17], Laura Giustarini [17], Jason Hallowes [18], Kel Markert [19] and Marc Paganini [20]

1 DHI A/S, 2970 Hørsholm, Denmark; dadr@dhigroup.com (D.D.); rame@dhigroup.com (R.P.M.); madc@dhigroup.com (M.C.)
2 GeoVille GmbH, 6020 Innsbruck, Austria; riffler@geoville.com (M.R.); dulleck@geoville.com (B.D.); rastner@geoville.com (P.R.)
3 Gisat s.r.o., 170 00 Praha, Czech Republic; katerina.jupova@gisat.cz (K.J.); tomas.soukup@gisat.cz (T.S.)
4 Deltares, 2629 HV Delft, The Netherlands; arjen.haag@deltares.nl
5 Géosciences Environnement Toulouse (GET), Unité Mixte de Recherche 5563, IRD/CNRS/Université, 31400 Toulouse, France; mauricio@ana.gov.br (M.C.R.C.); jean-michel.martinez@ird.fr (J.-M.M.)
6 Remote Sensing Solutions GmbH, 81673 München, Germany; franke@rssgmbh.de
7 Department of Biology, Ludwig-Maximilians-University Munich, 82152 Planegg-Martinsried, Germany; schwarz@rssgmbh.de
8 Faculty of Environment, University of Waterloo, Waterloo, ON N2L 3G1, Canada; vrvantho@uwaterloo.ca
9 Key Laboratory of Water Cycle and Related Land Surface Processes, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China; liusx@igsnrr.ac.cn
10 College of Resources and Environment, Sino-Danish Center, University of Chinese Academy of Sciences, Beijing 100049, China; zhouhw.18b@igsnrr.ac.cn
11 Department of Electrical, Computer and Biomedical Engineering, University of Pavia, 27100 Pavia, Italy; david.marzi01@universitadipavia.it
12 Program of Crop Science, Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu, Kuala Nerus 21030, Terengganu, Malaysia; rudiyanto@umt.edu.my
13 GeoTerraImage (Pty) Ltd., Pretoria 0184, South Africa; mark.thompson@geoterraimage.com (M.T.); jens.hiestermann@geoterraimage.com (J.H.)
14 Radiant Earth Foundation, Washington, DC 20005, USA; hamed@radiant.earth
15 Group CLS, 31400 Toulouse, France; amasse@groupcls.com (A.M.); csannier@groupcls.com (C.S.)
16 Faculty of Science, Vrije Universiteit Amsterdam, 1081 HV Amsterdam, The Netherlands; s.wangchuk@vu.nl
17 RSS-Hydro SARLS, 3593 Dudelange, Luxembourg; gschumann@rss-hydro.lu (G.S.); lgiustarini@rss-hydro.lu (L.G.)
18 EkoSource Insight (Pty) Ltd., Johannesburg 2196, South Africa; jhallowes@ekosource.co.za
19 SERVIR-Mekong, Bangkok 10400, Thailand; kel.markert@nasa.gov
20 European Space Agency, ESRIN, 00044 Frascati, Italy; marc.paganini@esa.int
* Correspondence: cto@dhigroup.com

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Abstract: Climate change, increasing population and changes in land use are all rapidly driving the need to be able to better understand surface water dynamics. The targets set by the United Nations under Sustainable Development Goal 6 in relation to freshwater ecosystems also make accurate surface water monitoring increasingly vital. However, the last decades have seen a steady decline in in situ hydrological monitoring and the availability of the growing volume of environmental data from free and open satellite systems is increasingly being recognized as an essential tool for largescale monitoring of water resources. The scientific literature holds many promising studies on satellite-based surface-water mapping, but a systematic evaluation has been lacking. Therefore, a round robin exercise was organized to conduct an intercomparison of 14 different satellite-based

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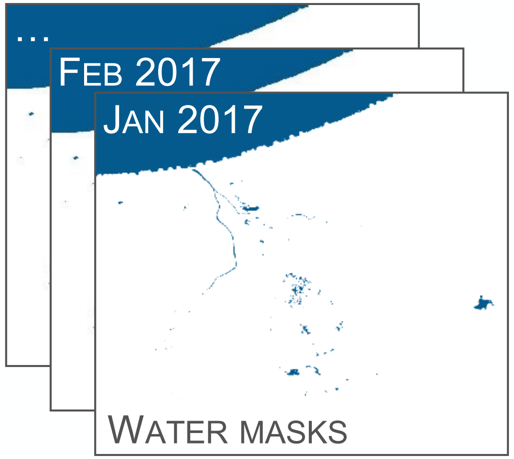
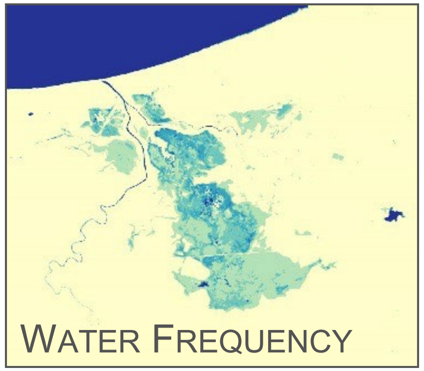
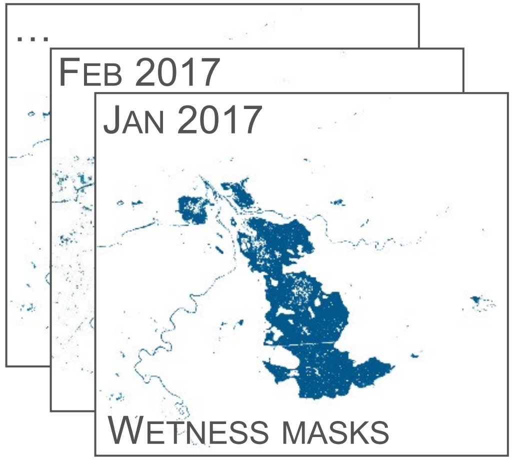
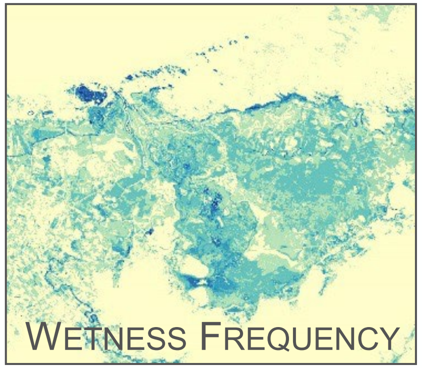
Methodology

Optical/SAR fusion
at monthly mask level



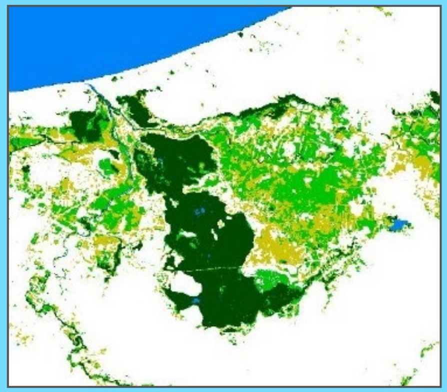






Classification

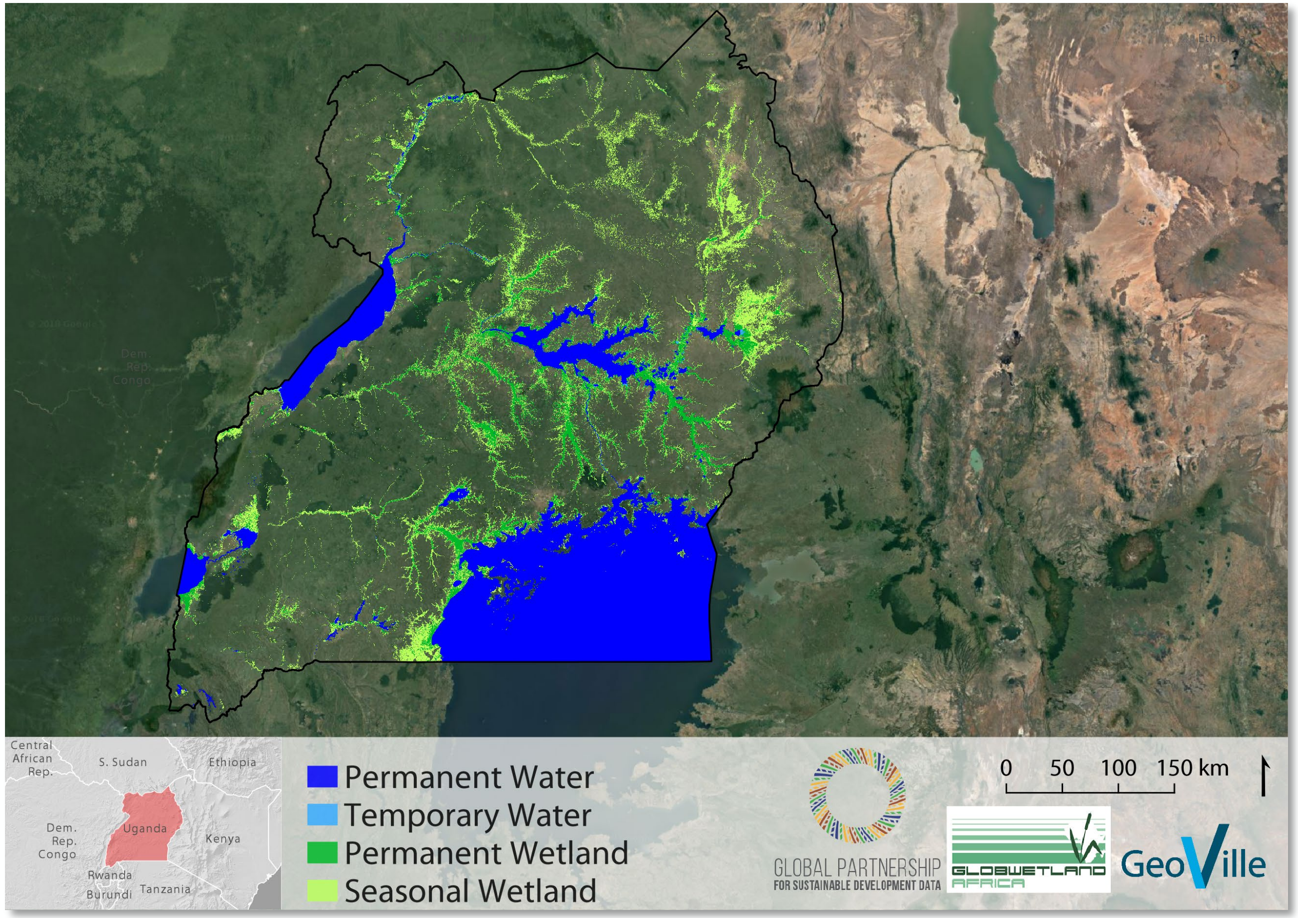
Water and Wetness Presence Index (WWPI)



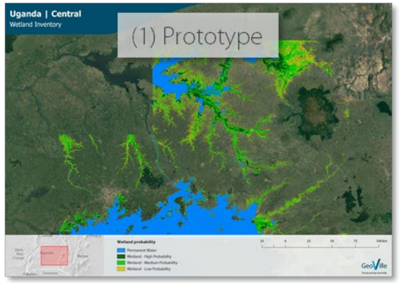
Rule-Based Classification

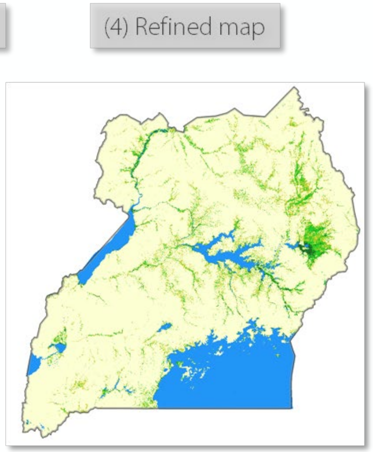
+ post-processing using various additional datasets (GHSL, OSM, CCI Land Cover, national information)

Method improvement – user iteration



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

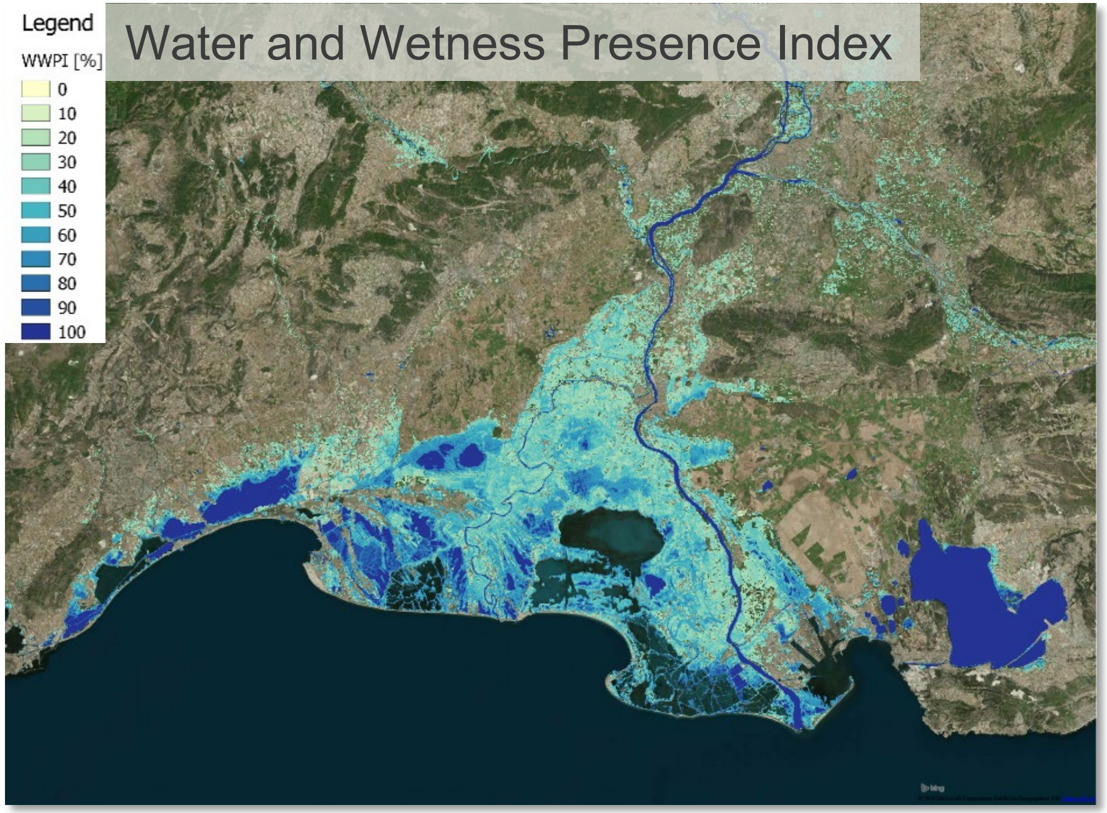


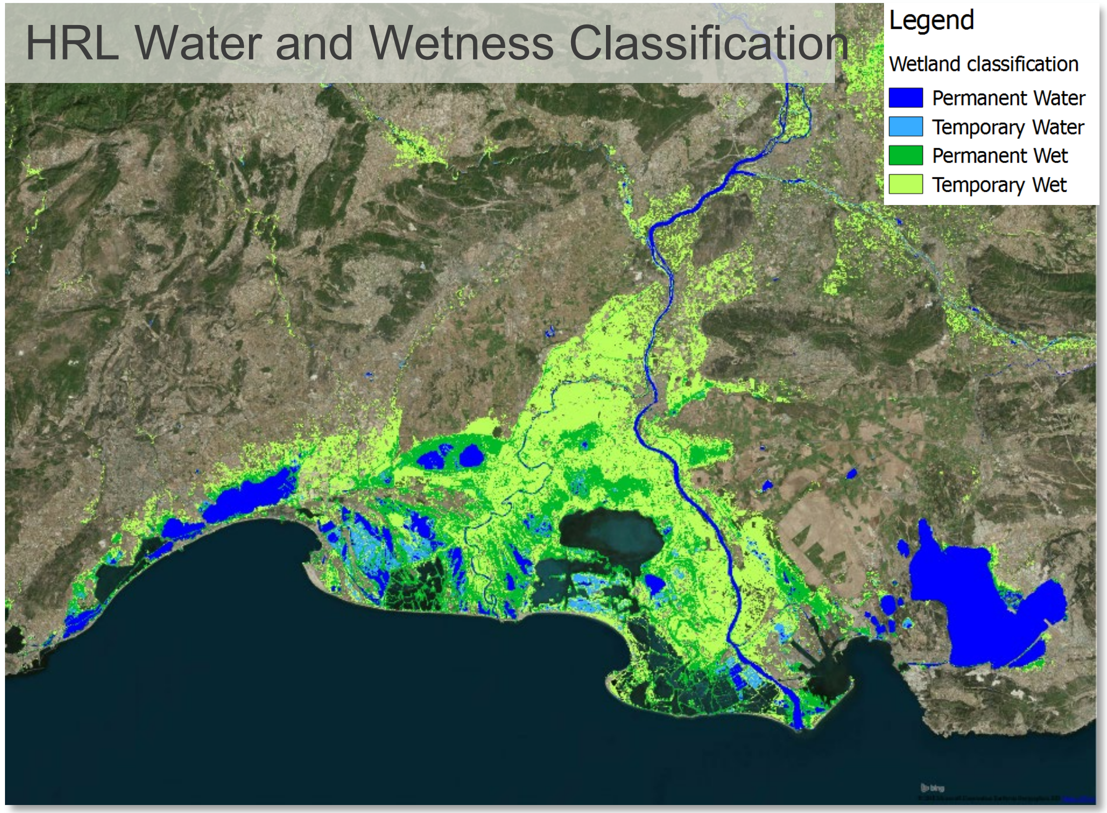


Input: Sentinel-1 and Sentinel-2, 2016–2017

Results

Copernicus Land Monitoring Service – Pan-European HRL Water & Wetness 2015 / 2018





Results

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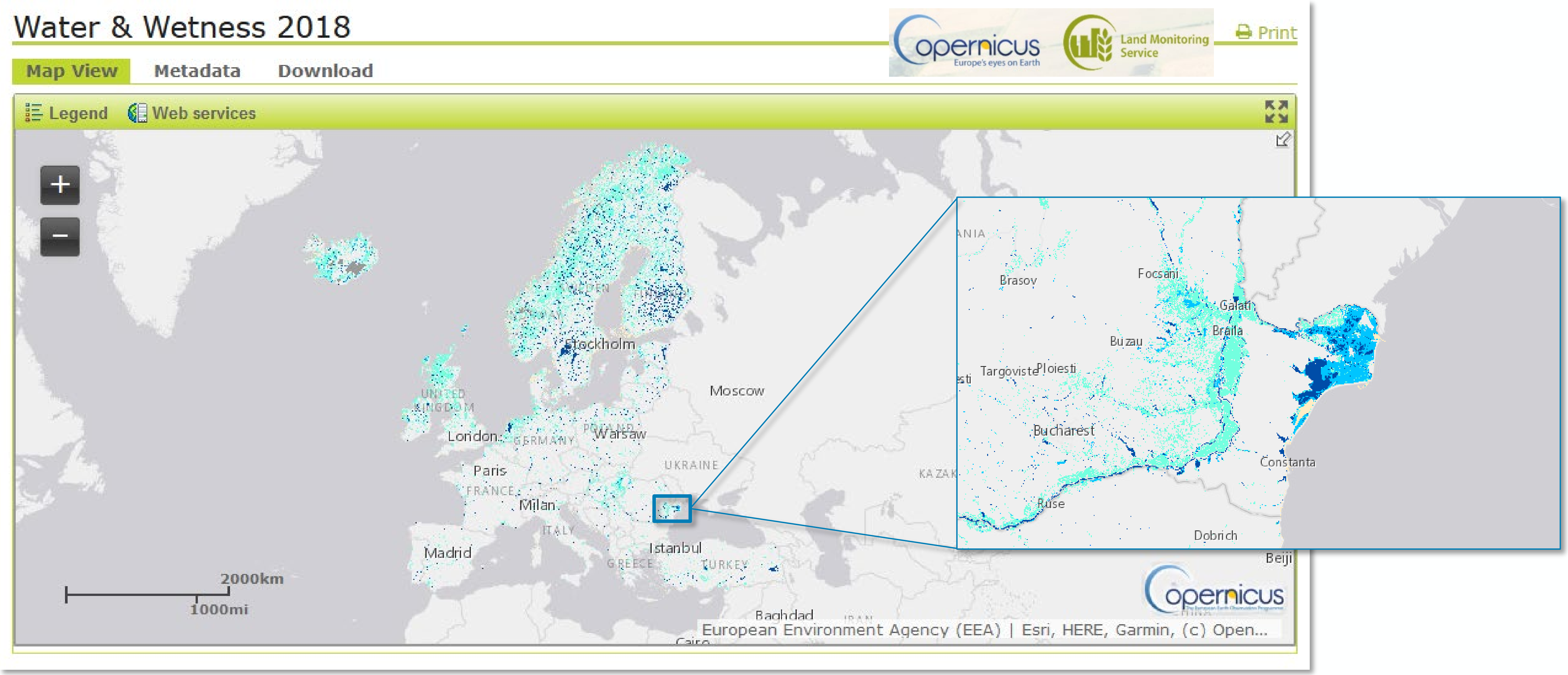
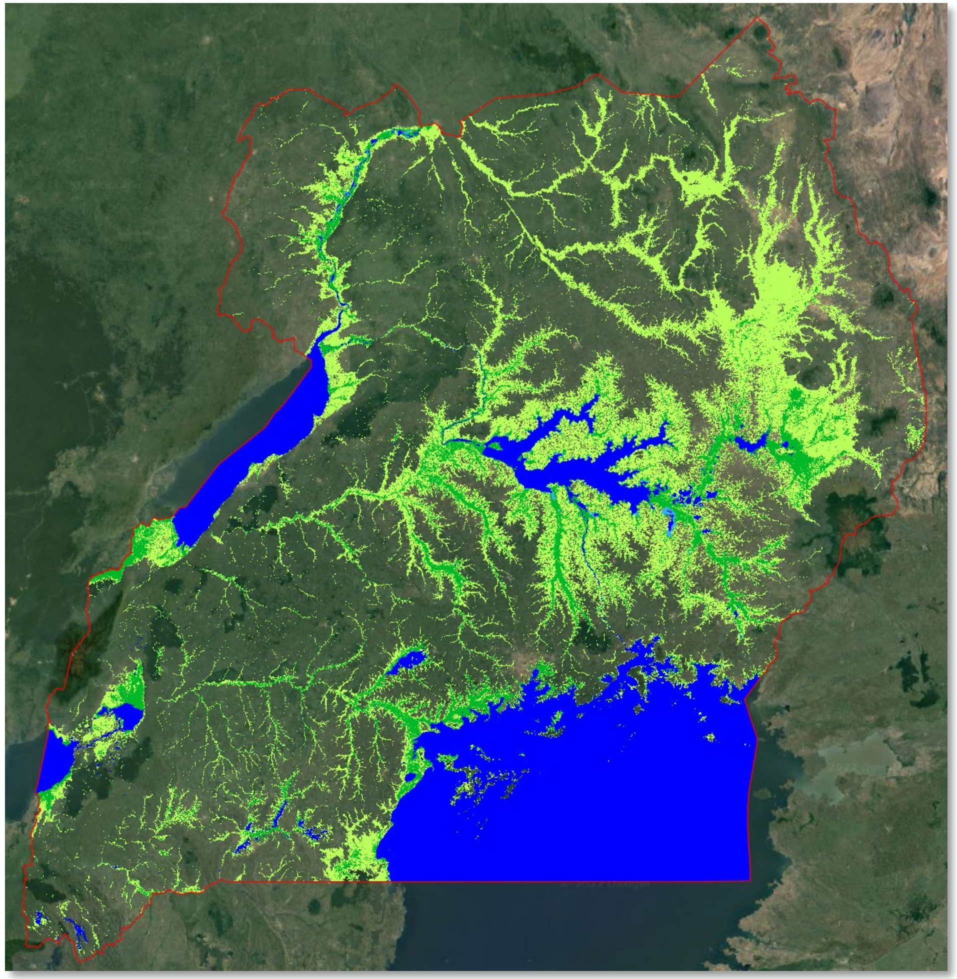
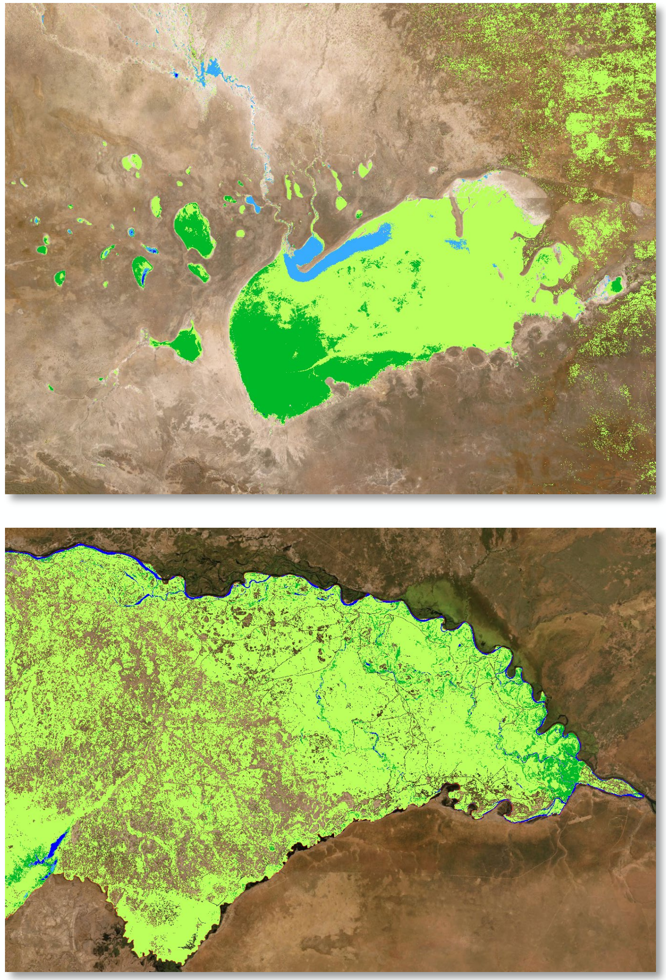


Results

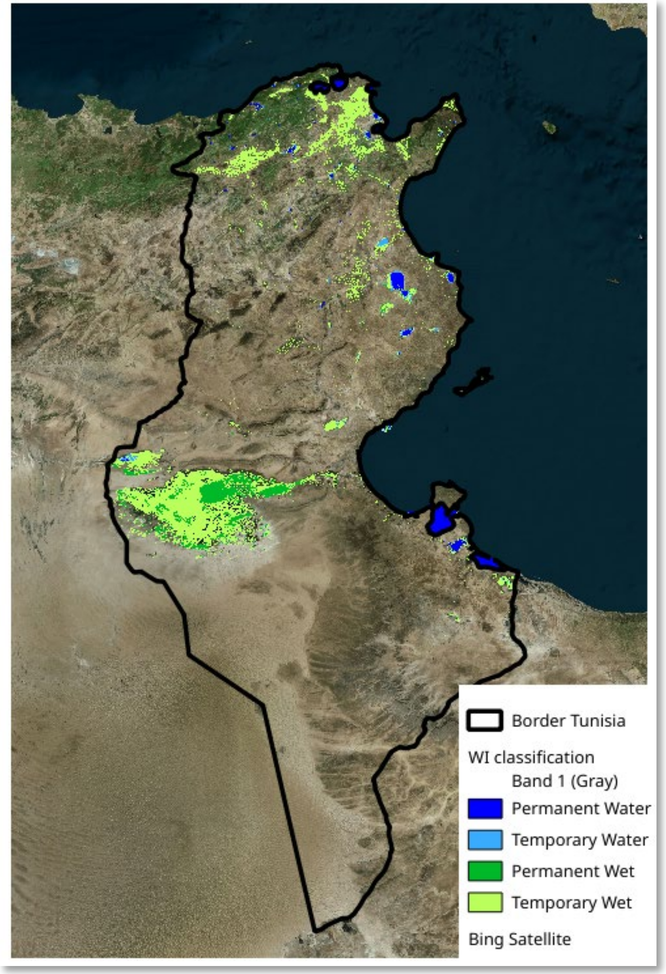
National products produced within GlobWetland Africa



Uganda (Version 2)



Namibia



Tunisia

Validation

External validation performed for Europe

- **Sampling method**

  Stratified random sampling

- **Reference sata**

  VHR imagery analyzed by visual interpretation (multiple interpretation)

  Geolocated photographs of wetland area

  Production imagery

- **Error measures**

  Weighted error matrix, overall accuracy, derived measures for each classes, commission and omission errors, 95% confidence interval

- **Qualitative user feedback**

  Collected through questionnaires and direct user feed back

Class	User accuracy	Com. Error (S-Europe)	Com. Error (N-Europe)
Permanent Water	98%	3%	1%
Temporary Water	92%	9%	10%
Permantent Wet	94%	6%	6%
Temporary Wet	92%	12%	5%

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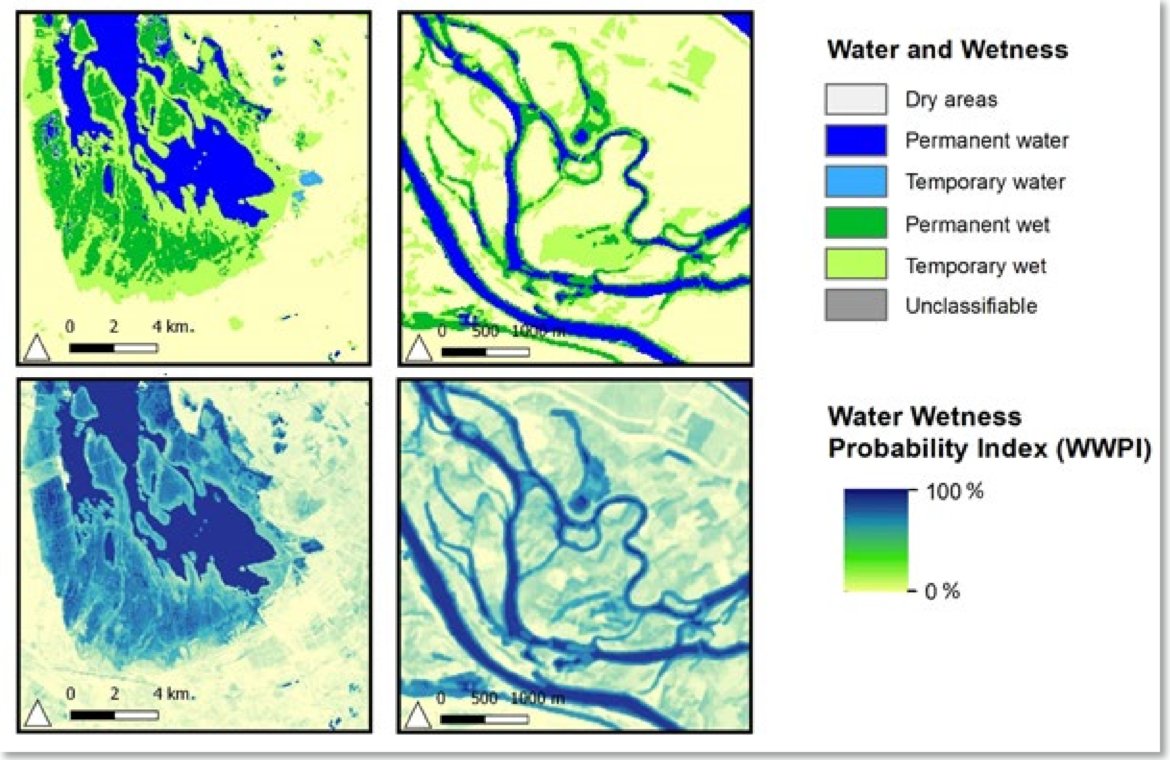
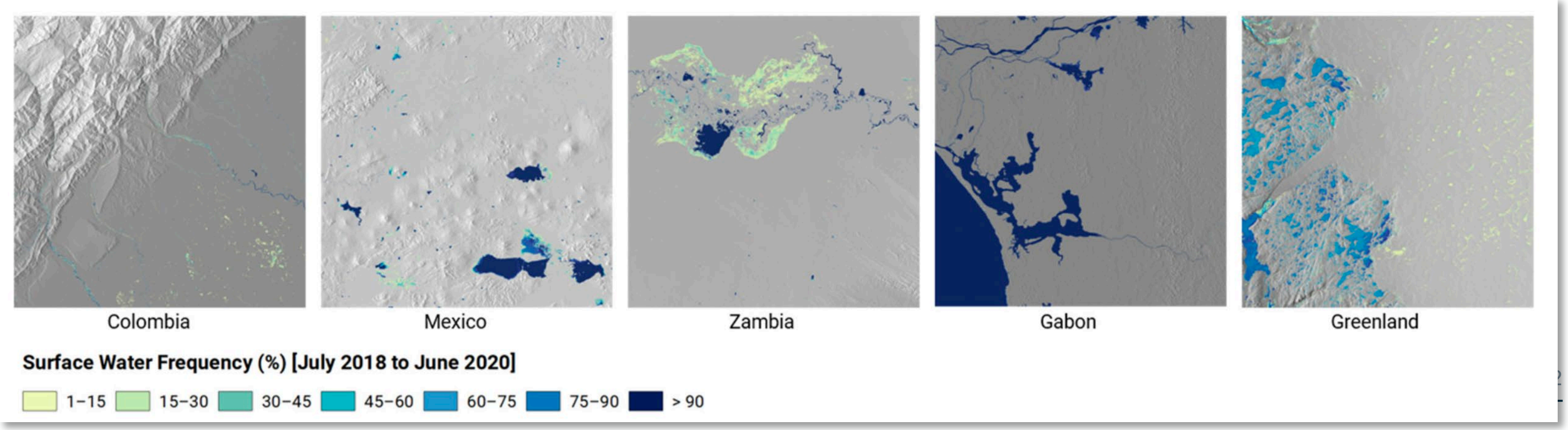
Discussion

- **Validation is difficult,** due to the multi-temporal approach and inappropriate reference data → **requires feedback from users**
- Detection of **agricultural/irrigated areas** → keep or exclude?
- Detection of water/wet soil underneath **dense vegetation challenging**
- **Qualitative feedback** from GlobWetland Africa users **positive**
- Partly **challenging data situation**
- Availability of **historical data**





Summary and Outlook

- **Optical- and radar-based product** to detect water and wet surfaces as a Wetland pre-Inventory product
  - **Water and Wetness Frequencies** and **Water and Wetness Presence Index**

    → Delimitation of water-related surfaces/ecosystems
  - Flexible system allowing application of **use-case-specific classification**
- **Fully automated production via Sentinel-1 and Sentinel-2** data streams processed at Earth Observation Data Centre (EODC), easily deployable to other cloud infrastructures
- **Implemented into online processing system,** allowing users to test the value of the product
- **Validated in Europe (externally) and Africa (internally)** with good overall accuracies for water and wet soil classes
- **GlobWetland Africa Toolbox** can be used to transfer products into full national wetland inventory product

THANK YOU FOR YOUR ATTENTION!

For Further information please contact:

Dr. Michael Riffler
riffler@geoville.com