

User Manual

Copernicus Land Monitoring Service

High Resolution land cover characteristics

Lot4: Water & Wetness 2018



European Environment Agency



Consortium Partners:

Consortium Composition of the Copernicus HRL Lot 4 2018			
No.	Organisation name	Organisation short name	Country
Consortium Partners			
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ABBREVIATIONS

AD	Applicable Document
AOI	Area of Interest
CLMS	Copernicus Land Monitoring Service
CRS	Coordinate Reference Sheet
CSCDA	Copernicus Space Component Data Access
DOM	Départements d'outre-mer
EBM	EuroBoundaryMap
ECoLaSS	Evolution of Copernicus Land Services based on Sentinel data
EEA	European Environment Agency
EEA-39	39 member and cooperating countries of the European Environment Agency
EO	Earth Observation
EPSG	European Petroleum Survey Group
ESA	European Space Agency
ESRI	Environmental Systems Research Institute
ETRS89	European Terrestrial Reference System 1989
EU	European Union
GISCO	Geographic Information System of the European Commission
HAND	Height Above Nearest Drainage index
HR	High Resolution
HRL	High Resolution Layer
INSPIRE	INfrastructure for SPatial InfoRmation in Europe
JR	Joanneum Research
JRC	European Commission DG Joint Research Centre
LAEA	Lambert Azimuthal Equal Area projection
LC	Land Cover
LU	Land Use
LUCAS	Land Use/Cover Area Frame Statistical Survey
LZW	Lempel-Ziv-Welch-Algorithm (compression)
MMU	Minimum Mapping Unit
NDVI	Normalized Difference Vegetation Index (NIR-R)/(NIR+R)
NDWI	Normalised Difference Water Index
NMDI	Normalised Multiband Drought Index
OA	Overall Accuracy
PA	Producer's Accuracy
QA	Quality Assurance
QC	Quality Check
SAR	Synthetic Aperture Radar

S-1	Sentinel-1, space mission carried out by ESA within Copernicus Programme, C-band SAR satellites (S-1A + S-1B)
S-2	Sentinel-2, space mission carried out by ESA within Copernicus Programme, EO satellites (S-2A + S-2B, L1C)
SWIR	Short Wavelength Infrared
TCBI	Tasselled Cap Brightness Index
TWI	Topographic Wetness Index
UA	User's Accuracy
VHR	Very High Resolution
WAW	Water and Wetness
WWPI	Water and Wetness Probability Index
XML	Extensible Markup Language

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I. Executive summary

Copernicus is the European Union's Earth Observation Programme. It offers information services based on satellite Earth observation and in situ (non-space) data. These information services are **freely** and **openly** accessible to its users through six thematic Copernicus services (atmosphere monitoring, marine environment monitoring, land monitoring, climate change, emergency management and security).

The Copernicus Land Monitoring Service (CLMS) provides geographical information on land cover and its changes, land use, vegetation state, water cycle and earth surface energy variables to a broad range of users in Europe and across the world in the field of environmental terrestrial applications. In the framework of the High-Resolution Layers, four thematic High-Resolution Layers (HRL) on land cover characteristics for all of Europe at 10m spatial resolution, covering 39 countries with more than 6 mio. km² were created. Based on High-Resolution (HR) to Very-High-Resolution (VHR) satellite imagery, including ESA's Sentinel-1 and Sentinel-2 satellites an update and change mapping of the High-Resolution Layers "Imperviousness" and "Forest", as well as a mapping of "Grassland and Grassland Change", and "Water and Wetness" for the EEA-39 countries has been done. A fifth thematic HRL on Small Woody Features (SWF) for the reference year 2018 is being procured by EEA and will provide raster products at 5m spatial resolution, derived from VHR satellite data.

The CLMS is jointly implemented by the European Environment Agency and the European Commission DG Joint Research Centre (JRC).

This document captures detailed definitions and product specifications for the High-Resolution Layer (HRL) Water and Wetness for the 2018 reference year, which is the update of the Water and Wetness status layer for the reference year 2015. The HRL Water and Wetness with reference year 2018 has been fully produced in the European Terrestrial Reference System 1989 (ETRS89) and in Lambert Azimuthal Equal Area (LAEA) projection by a consortium of well-established European service providers. It comprises the WAW product for 2018 in full spatial resolution of 10m x 10m (instead of the original 20m x 20m resolution of the WAW 2015 production). The main product is a classified layer, which contains defined classes of permanent water, temporary water, permanent wet, temporary wet, and dry areas, derived from water and wetness occurrences in the period 2012-2018. It will be complemented by the Water and Wetness Probability Index (WWPI), a product mainly dedicated to expert users.

All thematic layers for 2018 are derived from multi-temporal Sentinel-2 satellite data from the European Space Agency (ESA) and provide dedicated information on current environmental conditions and change trends in 10m, 20m and 100m spatial resolution.

The High-Resolution Layers are designed for use by a broad user community as basis for environmental and regional analyses and for supporting political decision-making. Specifically, they are supporting (amongst others) the reporting on Land Use, Land Use Change and Forestry (LULUCF).

II. Background of the document

Scope of the document

The Product User Manual is the primary document that users are recommended to consult before using the product. It provides an overview of the product characteristics, production methodology and workflows, user requirements and example/potential use cases, information about the quality assessment checks and their results as well as product technical support.

Content and structure

The document is structured as follows:

- Chapter III recalls the user requirements
- Chapter IV presents potential application areas and/or example use cases
- Chapter V presents product description (product file naming convention and format(s), product content and characteristics)
- Chapter VI provides a description of the production methodology and workflows
- Chapter VII summarizes the quality assessment and/or validation procedure and the results
- Chapter VIII provides information about product access and use conditions as well as the technical product support
- Chapter IX lists references to the cited literature
- Chapter X provides annexes

Applicable documents

Ref.	Document Name
AD01	Tender specifications: EEA/IDM/R0/18/009
AD02	H2020 EcoLasSS User Requirement Analysis: Deliverable D3.2 - Service Evolution Requirements Report Vol. 2
AD03	Nextspace User Study: Nextspace database for user requirements

III. Review of user requirements

The Copernicus High-Resolution Layers provide information based on space data and address a wide range of policies such as environment, regional development, transport and energy at EU level. In this context, frequently updated reliable data about land cover and land cover changes in Europe is mandatory. Specifically, with the more frequent and higher quality EO data of ESA's Sentinel satellites this information can be provided even faster and in a higher spatial resolution. Higher resolution of the input data (10m instead of 20m) and additional layers (e.g. confidence layers) improve the information content, quality and quantity for users.

The HRL Water and Wetness fulfils the requirements set up in the open call for tenders EEA/IDM/R0/18/009 (AD01): "Service contracts for the Copernicus Land monitoring services – High Resolution land cover characteristics for the 2018 reference year".

In frame of the Horizon 2020 (H2020) project ECoLaSS a survey (AD02) of key stakeholders has been performed in order to evaluate the user requirements towards the evolution of existing and future Copernicus products. This survey made also use of the results from the Nextspace User Study (AD03) and revealed that HRL users like European institutions, service industry, research and academia, national agencies, regional administrations, NGS or private users would in general appreciate:

- High accuracy of the products
- No data gaps - due to enhanced cloud gap mitigation
- Extensive coverage of the product
- Sufficient spatial and timely resolution concerning both, status layer and change layer
- Short update cycles
- Change monitoring
- Free and open access
- High technical quality
- High thematic quality/meaningful and application-oriented product definitions
- Standardized and comparable nomenclature
- Transparent and scientific workflows and state-of-the-art methodology
- Detailed documentation of these workflow and the respective methodology
- Consistency of the Pan-European products enabling synergistic use of all products
- Streamlining the pan-European product with global ones
- Availability of historic data and compatibility of time series
- Open access to the original Copernicus Sentinel data
- Sophisticated product presentation and visualisation possibilities in an online viewer on the Copernicus platform
- IPCC conformity

It is the strength of the HRL products that many of the mentioned requirements are already satisfied or at least taken into account in the current implementation. The increased spatial resolution compared to the HRL 2015 ultimately helps to reduce the confusion between water, wet and dry areas and provides more detailed outlines of water/wetness areas compared to the previous

implementation of the 2015 HRL. In addition, the new confidence layer provides uncertainty and probability estimates for the main products at pixel level which is a requirement for modelling studies. This makes the new HRL Water and Wetness even more useful for a wide range of additional applications.

IV. Product application areas and/or examples of use cases

The Copernicus Land Monitoring Services (CLMS) provides the basis for integrated analysis of the main drivers of land use change to inform about Europe's natural resources and their changes.

Use case: HRL WAW 2018 data to respond to EU reporting obligations

The HRL WAW addresses a wide range of policies such as environment, agriculture, regional development, transport and energy at EU level. In this context, frequently updated reliable data about water and wet surfaces in Europe is mandatory for efficient water management. Specifically, with the more frequent and higher quality EO data of the European Sentinel satellites this information can be provided even in a higher spatial resolution of 10m for the reference year 2018 as compared to 2015 (20m spatial resolution). Higher resolution of the input data and additional layers improve the information quality and quantity to feed the increasing reporting obligations of EEA and other European organisations as well as Member State local authorities.

Other application examples

The HRL product series represents a high-quality, homogenous 'rolling archive' inventory of the status and dynamics of water surfaces as well as the occurrence of surface wetness, it forms the basis for political decision making on water management not only within the individual EEA-39 member states but due to its homogeneity also on a full European scale to aid environmental and political initiatives on an intergovernmental and supra-national level.

V. Product description

Overview

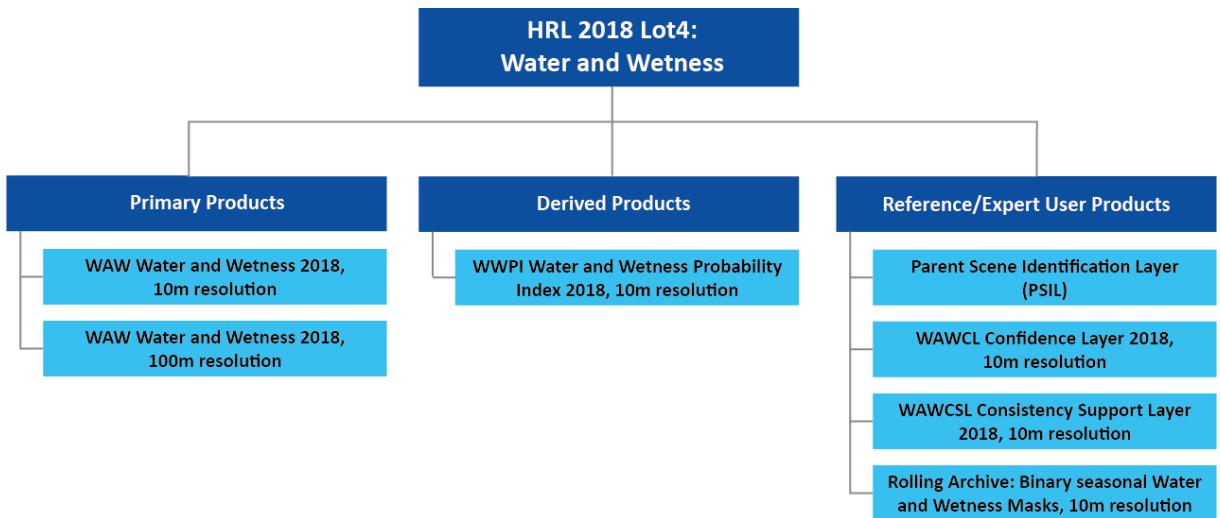


Figure 1: The HRL Water and Wetness 2018 product portfolio.

The HRL Water and Wetness 2018 portfolio, as visualized in *Figure 1*, covers primary, additional, and reference / expert user products that are of further interest for expert users. Products are based on imagery covering the period 2012-2018. All products are produced in European ETRS89 LAEA projection, and the following products are further made available in national projections:

- Water and Wetness 2018 (10m and 100m resolution)
- Water and Wetness Probability Index (10m resolution)

For detailed characterization of all products see the section ‘Product Specifications’.

The main WAW 2018 layer is complemented by the Water and Wetness Probability Index (WWPI), a product mainly dedicated to expert users.

Derived products are established from the primary products by means of standardized GIS processes (re-projection and aggregation). For the HRL Water and Wetness these are the re-projected (to national projection) and aggregated (from 10m to 100m) Water and Wetness primary products. They are delivered in European cartographic projection (LAEA) as well as national projections.

Furthermore, supplementary layers meant for expert users and/or as support for future HRL updates were established in the frame of the HRL WAW production 2018. This covers a rolling archive of intermediate production layers, such as the binary seasonal water and wet layers, and additional layers as the Parent Scene Identification Layer (PSIL) and, as a new element in the 2018 production, a confidence layer that identifies the likelihood of (in)correctness on pixel level based on information gained during production.

The Rolling Archive database is a new product, consisting of water and wetness masks showing the seasonal water / wet / dry occurrences. Due to the nature of the main HRL Water and Wetness product covering a prolonged time of 7 years, with regular updated of the layer every three years, it is especially important to be consistent throughout the time period. To guarantee re-producibility and future continuation of the baseline product, these masks are provided within a database consisting of all seasonal masks starting from 2009.

Thematic characteristics and definition of the HRL Water and Wetness 2018

The HRL Water and Wetness 2018 provides primary products in full spatial resolution of 10m x 10m (as compared to 20m x 20m resolution in 2015). The main product is a classified layer, differentiating the classes of permanent water, temporary water, permanent wet, temporary wet, and dry areas, derived from water and wetness occurrences in the period 2012-2018. Table 1 below summarizes the detailed definitions for these classes.

Table 1: Definition of water and wetness classes.

CLASS	EXPLANATION	EXAMPLES
Dry	<i>Always dry or mostly dry with minor instances of wet or water (i.e. <25%)</i>	<ul style="list-style-type: none"> • Sand • Bedrock • Sealed surfaces
Permanent water	<i>Always water. The highest ratio of the water / total instances (>85%) are classified as permanent water surfaces.</i>	<ul style="list-style-type: none"> • Permanent inland lakes (natural) • Artificial ponds (permanent fishponds, reservoir) • Natural ponds (permanent open water surfaces of inland or coastal wetlands) • Rivers • Channels (permanently with water) • Coastal water surfaces: lagoons, estuaries • Liquid dump sites (permanent)
Temporary water	<i>Temporary water surfaces. Alteration of dry and water or alteration of wet and water. Temporary water surfaces will have a ratio between >25% to 85% (water / total instances) with varying degrees of wetness*</i>	<ul style="list-style-type: none"> • Temporary water surfaces associated to permanent water bodies • Temporary natural (e.g. steppe) lakes and temporary artificial lakes (e.g. cassettes of fishponds) • Intermittent rivers • Flood areas • Water-logged areas • Wet agricultural fields, including rice fields • Intertidal areas
Permanent wet	<i>Always wet surfaces. Areas with >75% wet / total instances</i>	<ul style="list-style-type: none"> • Reeds • Peat land • Inland wetlands and coastal wetlands (incl. salt marshes)
Temporary wet	<i>Temporary wet surfaces. Alteration of dry and wet. Areas with 25% to 75% wet / total instances and minor instances of water*</i>	<ul style="list-style-type: none"> • Including areas of changing soil moisture • Inland saline marshes • Intermittent wetlands
Sea water		

<i>Unclassifiable</i>		<ul style="list-style-type: none"> • No satellite image available, or clouds, shadows, or snow
<i>Outside area</i>		<ul style="list-style-type: none"> • Area not included in EEA39

*In cases where the classes temporary water and temporary wetness overlap, the class will be determined by the dominating number of instances.

Elements included and excluded from the production of the main HRL Water and Wetness product are listed in Table 2 as follows:

Table 2: Elements to be included and excluded in the Water and Wetness layer.

ELEMENTS TO BE INCLUDED IN THE HRL WATER AND WETNESS 2018	ELEMENTS TO BE EXCLUDED FROM THE HRL WATER AND WETNESS 2018
<ul style="list-style-type: none"> ▪ Open water bodies (including floating or emergent vegetation) <ul style="list-style-type: none"> ○ Permanent lakes, reservoirs, ponds ○ Rivers ▪ Temporary open water bodies (intermittent rivers, changing lake/reservoir levels) ▪ Temporarily inundated areas (due to snow melt, floods, or rain) ▪ Wet agricultural fields, including rice fields and water-logged areas ▪ Transitional coastal water bodies (lagoons, estuaries) 	<ul style="list-style-type: none"> ▪ Sea and ocean (sea water beyond a boundary provided by the EEA) ▪ Permanent snow and glaciers

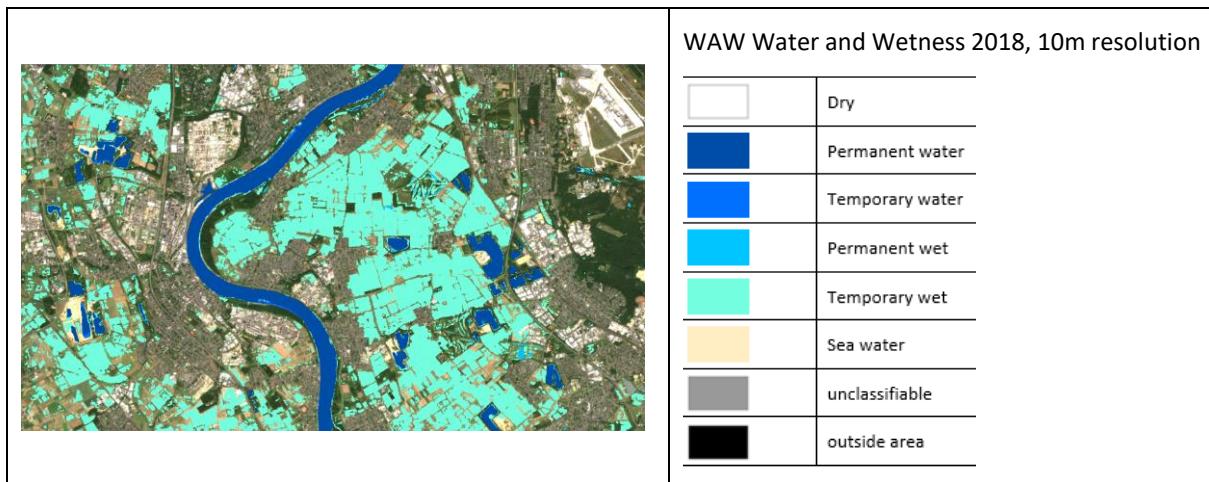
Product specifications

WAW Water and Wetness 2018, 10m resolution

The WAW Water and Wetness is a raster displaying water and wetness classes based on 2012-2018 imagery for the reference year 2018 in 10m spatial resolution.

HRL WAW 2018	Water and Wetness layer	Primary product
File name	WAW_2018_010m_eu_03035_v2_0	
Reference year	2018 (based on 2012-2018 imagery)	
Geometric resolution	Pixel resolution 10m x 10m, fully conform with the EEA reference grid	
Coordinate Reference System	European ETRS89 LAEA projection / national projections	
Geometric accuracy (positioning scale)	Less than half a pixel. According to ortho-rectified satellite image base provided through CSCDA	

Thematic accuracy
Quantitative (stratified random points sample compared to external datasets)
The thematic accuracy expected depends on the class:
<ul style="list-style-type: none"> • Permanent water: target accuracy 85% • Temporary water: target accuracy 80% • Permanent wet areas: target accuracy 80% • Temporary wet areas: target accuracy 80% • Dry areas: target accuracy 85%
Data type
8-bit unsigned Raster, compressed with LZW
Minimum Mapping Unit (MMU)
One pixel (10 m)
Necessary attributes
Raster value, count, class name, area (in km ²), percentage (taking outside area not into account)
Raster coding (thematic pixel values)
 Dry
 Permanent water
 Temporary water
 Permanent wet
 Temporary wet
 Sea water
 unclassifiable (no satellite image available, or clouds, shadows, or snow)
 outside area
Metadata
XML metadata files according to INSPIRE metadata standards
Delivery format
GeoTIFF (*.tif)



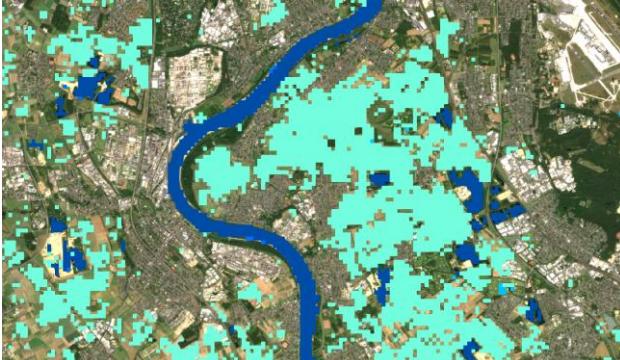
WAW Water and Wetness 2018, 100m resolution

The WAW Water and Wetness is a raster displaying water and wetness classes based on 2012-2018 imagery for the reference year 2018 in an aggregated version of 100m spatial resolution.

HRL WAW 2018	Water and Wetness layer	Primary product
File name		
WAW_2018_100m_eu_03035_v1_0		
Reference year		
2018 (based on 2012-2018 imagery)		
Geometric resolution		
Pixel resolution 100m x 100m, fully conform with the EEA reference grid		
Coordinate Reference System		
European ETRS89 LAEA projection / national projections		
Geometric accuracy (positioning scale)		
Less than half a pixel. According to ortho-rectified satellite image base provided through CSCDA		
Thematic accuracy		
The thematic accuracy assessment is made on the main water & wetness product.		
Data type		
8-bit unsigned Raster, compressed with LZW		
Minimum Mapping Unit (MMU)		
N/A		
Necessary attributes		
Raster value, count, class name, area (in km ²), percentage (taking outside area not into account)		
Raster coding (thematic pixel values)		

	Dry
	Permanent water
	Temporary water
	Permanent wet
	Temporary wet
	Sea water
	unclassifiable (no satellite image available, or clouds, shadows, or snow)
	outside area

Metadata	
XML metadata files according to INSPIRE metadata standards	
Delivery format	
GeoTIFF (*.tif)	



WAW Water and Wetness 2018, 100m resolution

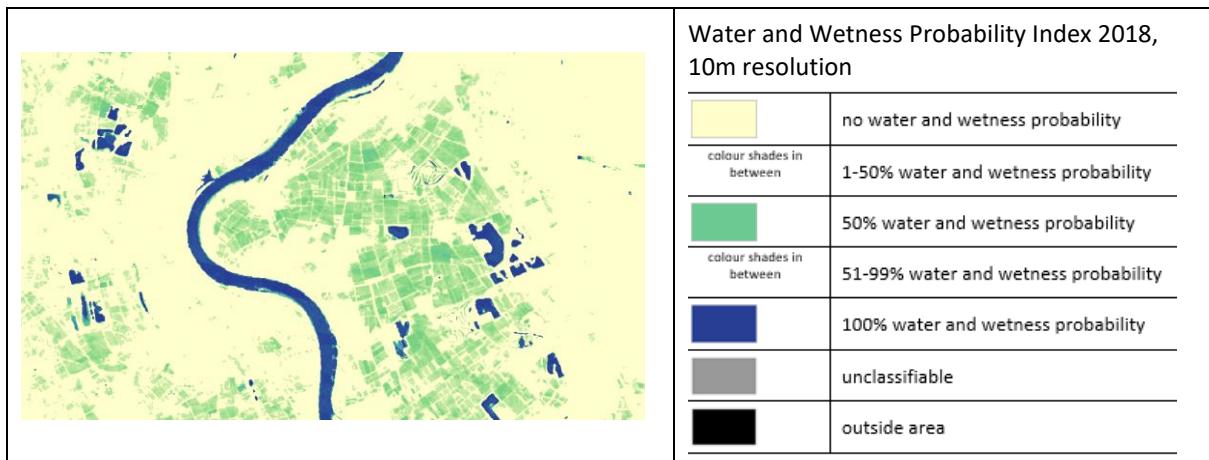
	Dry
	Permanent water
	Temporary water
	Permanent wet
	Temporary wet
	Sea water
	unclassifiable
	outside area

WWPI Water and Wetness Probability Index 2018, 10m resolution

The WWPI Water and Wetness Probability Index is a raster displaying a combined index of water and wetness based on 2012-2018 imagery for the reference year 2018 in 10m spatial resolution.

HRL WWPI 2018	Water and Wetness Probability Index	Additional product
File name WWPI_2018_010m_eu_03035_v2_0		
Reference year 2018 (based on 2012-2018 imagery)		

Geometric resolution
Pixel resolution 10m x 10m, fully conform with the EEA reference grid
Coordinate Reference System
European ETRS89 LAEA projection / national projections
Geometric accuracy (positioning scale)
Less than half a pixel.
According to ortho-rectified satellite image base provided through CSCDA
Thematic accuracy
The thematic accuracy assessment is made on the main water & wetness product, while the WWPI is only an additional product for expert users.
Data type
8-bit unsigned Raster, compressed with LZW
Minimum Mapping Unit (MMU)
N/A
Necessary attributes
Raster value, count, class name, area (in km ²), percentage (taking outside area not into account)
Raster coding (thematic pixel values)
 no water and wetness probability
 colour shades in between 1-50% water and wetness probability
 50% water and wetness probability
 colour shades in between 51-99% water and wetness probability
 100% water and wetness probability
 unclassifiable
 outside area
Metadata
XML metadata files according to INSPIRE metadata standards
Delivery format
GeoTIFF (*.tif)



WAWCL Confidence Layer 2018, 10m resolution

The WAWCL Confidence Layer is a raster displaying a measure of confidence for the WAW 10m 2018 reference product in 10m spatial resolution.

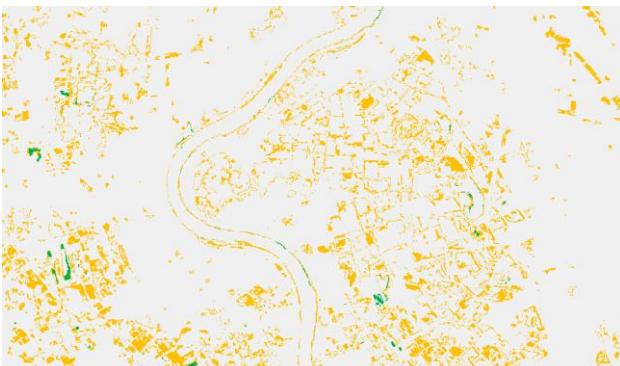
HRL WAWCL 2018	Water and Wetness Confidence Layer	Expert / reference product
File name	WAWCL_2018_010m_eu_03035_v1_0	
Reference year	2018	
Geometric resolution	Pixel resolution 10m x 10m, fully conform with the EEA reference grid	
Coordinate Reference System	European ETRS89 LAEA projection	
Geometric accuracy (positioning scale)	Less than half a pixel. According to ortho-rectified satellite image base provided through CSCDA	
Thematic accuracy	The thematic accuracy assessment is made on the main water & wetness product, while the WAWCL is only an additional product for expert users.	
Data type	8-bit unsigned Raster, compressed with LZW	
Minimum Mapping Unit (MMU)	N/A	
Necessary attributes	Raster value	

Raster coding (thematic pixel values)															
	0% percent of confidence														
colour shades in between	1-49% percent of confidence														
	50% percent of confidence														
colour shades in between	51-99% percent of confidence														
	100% percent of confidence														
	unclassifiable (no satellite image available, or clouds, shadows, or snow)														
	outside area														
Metadata															
XML metadata files according to INSPIRE metadata standards															
Delivery format															
GeoTIFF (*.tif)															
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	0% percent of confidence														
colour shades in between	1-49% percent of confidence														
	50% percent of confidence														
colour shades in between	51-99% percent of confidence														
	100% percent of confidence														
	unclassifiable														
	outside area														

WAWCSL Consistency Support Layer 2018, 10m resolution

The WAWCSL Consistency Support Layer is a raster displaying a measure of difference between the 2015 and 2018 reference layers in 10m spatial resolution.

HRL WAWCSL 2018	Water and Wetness Consistency Support Layer	Expert / reference product
File name		
WAWCSL_2018_010m_eu_03035_v1_0		
Reference year		
2018 (based on 2012-2018 imagery)		
Geometric resolution		
Pixel resolution 10m x 10m, fully conform with the EEA reference grid		

Coordinate Reference System																														
European ETRS89 LAEA projection																														
Geometric accuracy (positioning scale)																														
Less than half a pixel.																														
According to ortho-rectified satellite image base provided through CSCDA																														
Thematic accuracy																														
The thematic accuracy assessment is made on the main water & wetness product, while the WAWCSL is only an additional product for expert users.																														
Data type																														
8-bit unsigned Raster, compressed with LZW																														
Minimum Mapping Unit (MMU)																														
N/A																														
Necessary attributes																														
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	unclassifiable (no satellite image available, or clouds, shadows, or snow)																													
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XML metadata files according to INSPIRE metadata standards																														
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VI. Production methodology and workflow

The methodologies and workflows of the delivered products are described in the following sections in more detail.

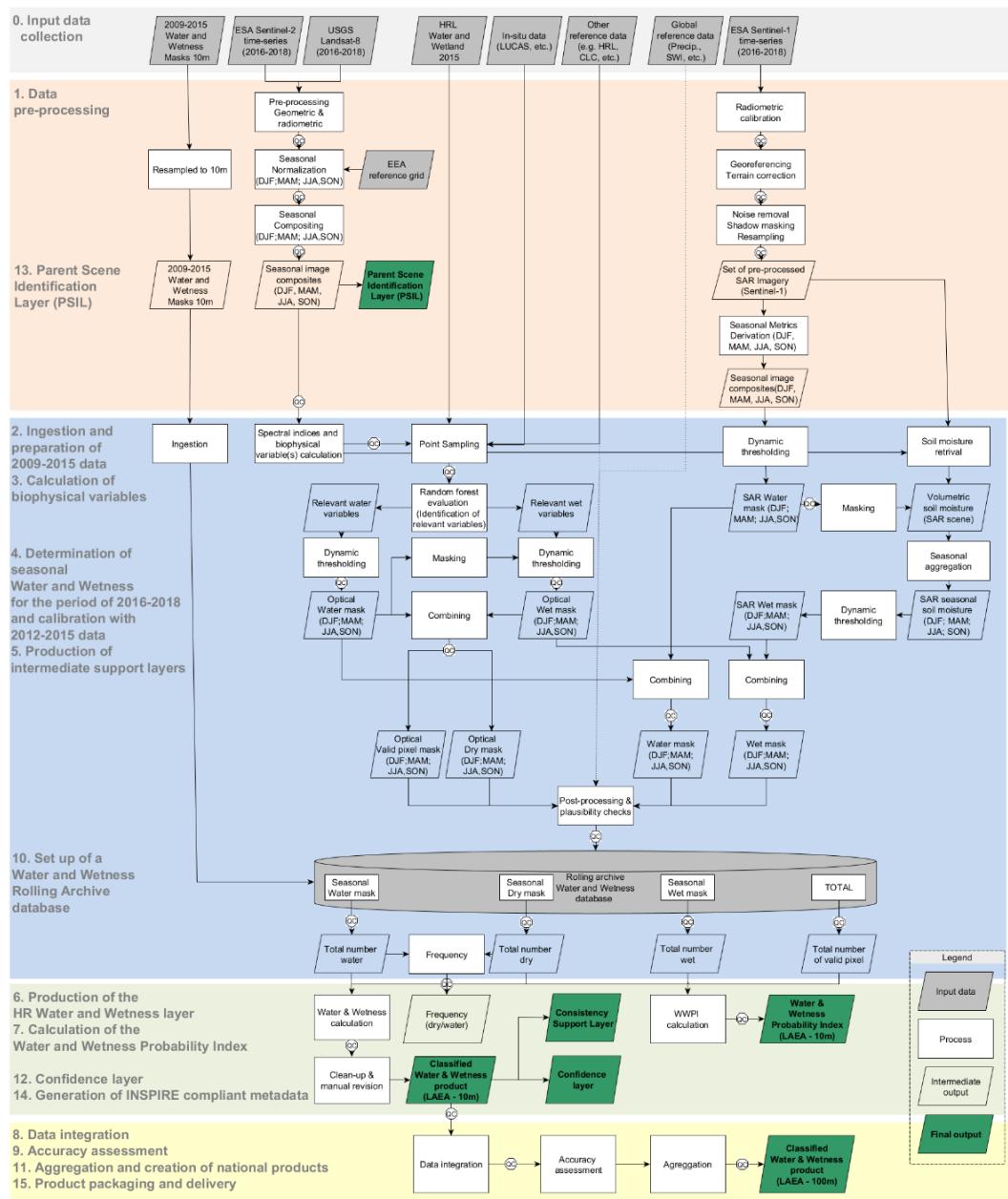


Figure 2: Workflow diagram for the production of the HRL Water and Wetness Layer

HRL Water and Wetness 2018

The methodology applied for the production of the HRL Water and Wetness allows to derive water and wetness in a robust, reliable and reproducible way out of high resolution optical and SAR satellite

images. It is based on data from Landsat-5/-7/-8 for the period from 2012 to 2015 which was produced for HRL 2015 and subsequently on the fully pre-processed Sentinel-2 and Sentinel-1 time series from 2016 to 2018. The classification is performed for a time period of seven years from 2012 to 2018.

The production is based on an unsupervised dynamic thresholding approach supported by a supervised machine learning classifier with subsequent visual improvement of classification results and derivation of water frequencies based on seasonal spectral composites and different biophysical indices such as NDVI, NDWI, and NMDI. In addition, Sentinel-1 based soil moisture estimations are included to the seasonal wetness masks. The result is a raster dataset of permanent and temporary water as well as permanent and temporary wet surfaces with a spatial resolution of 10 x 10m.

Optical HR Data

Initially all Sentinel-2 scenes were L2A corrected using the Sen2Cor processor. Cloud and shadow masks were derived from the Sen2Cor cloud detection and scene classification results. For each Sentinel-2 tile, a total of three-monthly cloud-free composite materials were calculated for the period from 2016-2018 using a combination of approaches, such as maximum NDVI (Gutman et al., 1994¹). Geometric median compositing is an appropriate approach, because it is “using a high-dimensional summary statistic that applies to all bands at once to guarantee that the biophysical relationships among all spectral bands are maintained” (Roberts et al., 2017²).

The optical classification was applied on the composites for each EEA tile using a dynamical threshold-based classifier. Therefore, several spectral indices were computed and stacked for each composite. For water detection, spectral indices such as the Normalised Difference Water Index (NDWI) and its modified version mNDWI, as well as the Normalised Difference Vegetation Index (NDVI) were used. For wetness extraction, individual indices and thresholds were chosen dynamically from the classifier for each site.

From the achieved water-, wetness- and dry frequencies the classification into water and wetness classes were processed by thresholding water and wet occurrences as described in the Tender specifications (AD01) and listed in Table 3.

Table 3: Classification criteria for the primary HRL Water and Wetness product [AD01].

Code	Class	Frequency layers		
		Water relative frequency	Wet relative frequency	Dry relative frequency
1	Permanent water • always water	> 85% Water	<=15% Wet	<=15%

¹ Gutman, G.G., Ignatov, A.M., Olson, S., 1994. Towards better quality of AVHRR composite images over land: reduction of cloud contamination. *Remote Sens. Environ.* 50 (2), 134–148.

² Roberts, D., Mueller, N., McIntyre, A., 2017. High-dimensional pixel composites from earth observation time series. *IEEE transactions on geoscience and remote sensing* 55 (11).

2	Temporary water <ul style="list-style-type: none"> alteration of dry and water alteration of wet and water with varying degrees of wetness water instances dominate over wet 	>25 - 85% Water	15 - 75% Wet Water > Wet	<=75%
3	Permanent wet <ul style="list-style-type: none"> always wet 	<=25%	> 75% Wet	<=25%
4	Temporary wet <ul style="list-style-type: none"> alteration of dry and wet with minor instances of water wet instances dominate over water 	25 - 75%	25 - 75% Wet > Water	<=75%
0	Dry <ul style="list-style-type: none"> always / mostly dry with minor instances of water or wet always / mostly dry with minor instances of water or wet 	<=25%	<=25%	> 75%

Water and wetness thresholding

Water and wetness were determined by dynamic thresholding dependent on the regions for which the dedicated threshold was applied. Particular attention was paid to the threshold to ensure a plausible value in the range of spectral index that indicates water or wetness.

SAR water detection (Sentinel-1)

Seasonal water detection was carried out using an adaptive thresholding approach applied on seasonal backscatter statistics. A dynamic variable backscatter threshold for each pixel was applied based on statistical information from the adjacent pixels. The resulting water mask is masked by the Height Above Nearest Drainage (HAND) index (Rennó et al. 2008³).

³ Rennó, C. D., Nobre, A. D., Cuartas, L. A., Soares, J. V., Hodnett, M. G., Tomasella, J., & Waterloo, M. J. (2008), HAND, a new terrain descriptor using SRTM-DEM: Mapping terra-firme rainforest environments in Amazonia. *Remote Sensing of Environment*, 112(9), 3469–3481.

Estimation of soil moisture (Sentinel-1)

Soil moisture was estimated based on Sentinel-1 backscatter values and incidence angles as well as relevant biophysical variables from the optical and SAR data using the Water Cloud Model (Attema & Ulaby, 1978⁴).

Fusion factor of SAR and optical EO data.

After performing separate classifications from optical and SAR data the results were fused to obtain the main water and wetness product. The fusion was applied on seasonal basis to avoid over-classification from SAR frequencies. Since the Sentinel-1 water and wet frequencies are based on more observations (~6 S-1 images/season) than the seasonal optical composites (~3 images/season), the fusions are applied with different weights. Therefore, masks are only fused at areas where a certain probability of water and wetness occurrence derived from optical imagery is given. The final classification of permanent water (1), permanent wet areas (3) and dry areas (0) have a clear definition with no overlaps. Overlaps may occur, however, between the temporary water (2) and the temporary wet (4) classes.

Water and Wetness Probability Index

The Water Wetness Probability Index (WWPI) is an additional product meant for expert users. It indicates the occurrence of water and/or wet areas throughout the entire observation period 2012-2018 for the 2018 product and is derived from frequencies of WATER, WET and DRY. The WWPI is finally calculated according to the number of WATER and WET occurrences, the latter with a predefined weighting factor of 0.75, divided by the total number of valid observations (sum of WATER, WET and DRY occurrences). The resulting product assembles the water and wet occurrence as an index on a scale between 0 (only dry observations) to 100 (only water observations). The HRL Water and Wetness Probability Index is provided in a pixel resolution of 10m.

Aggregated Water and Wetness 2018

The 10m classified Water and Wetness layer is aggregated to 100m for the complete European LAEA layer according to the procedure described in the following.

For the aggregation of the 10m classified product to a 100m raster in a concise way, all underlying 10m cells are considered. A majority rule is applied to ensure that the most appropriate class value is given to the 100m cell, considering all underlying 100 pixels that are covered by the 100m raster cell. The 100m cell receives the code of the majority of 10m pixels, under consideration of the fraction of valid and un-valid pixels and equality.

Case 1: Majority of one pixel value:

The 100m cell receives the value of the 10m pixels that occurs most within a 100m cell. For example:

- 15 pixels have the value 3 (permanent wet)

⁴ Attema E. P. W. & Ulaby F. T. (1978). Vegetation modeled as a water cloud. Radio Science, vol. 13, no. 2, pp. 357-364, March-April 1978.

- 7 pixels have the value 2 (temporary water)
- 3 pixels have the value 254 (unclassifiable)

The aggregated 100m cell is assigned the value 3 (permanent wet).

Case 2: Equality of pixels values:

It is possible that the same amount of different pixel values occurs within one 100m cell. This may be true for two or more values concurrently. In case of equality (i.e. the same amount of 10m pixel values) the following rules shall be applied:

- In case of equality, the permanent water and wetness classes (class 1 and 3) shall be preferred over the temporary classes (class 2 and 4).
- In case of equality between permanent classes (class 1 and 3) or equality between temporary classes (class 2 and 4) water shall be preferred over wetness.
- In case of equality all water and wetness classes (class 1-4) are preferred over dry (class 0).
- In case of equality all water and wetness classes shall be preferred over classes 253 (sea water), 254 (unclassifiable) and 255 (no data).
- In case of equality class 0 (dry) shall be preferred over 253 (sea water), 254 (unclassifiable) and 255 (no data).

These rules also apply in case of equality of 3 or 4 classes (e.g. 30 pixels of class 1, 30 pixels of class 2, 30 pixels of class 4 and 10 pixel of class 255).

Justification for these rules in case of equality of pixel values:

- According to the ETC quality checks, the most reliable classifications (i.e. the classes with the highest user accuracy = lowest commission errors) are preferred.
- To avoid that omissions in the 10m layer, which are a known limitation of the layer, are reproduced or multiplied in the aggregated layers, all water and wetness classifications are preferred over dry (class 0) or the classes 253 (sea water), 254 (unclassifiable) and 255 (no data).

The following matrix (Table 4) shows the rules defined in case of equality of 10m pixel values within a 100m cell in a structured way.

		class							
		0	1	2	3	4	253	254	255
class	0		1	2	3	4	0	0	0
	1			1	1	1	1	1	1
	2				3	2	2	2	2
	3					3	3	3	3
	4						4	4	4
	253								255
	254								255
	255								

Table 4: Matrix of aggregation rules in case of equality of 10m pixel values within a 100m cell

In case of equality, the two class codes of equal number of pixels, one from the vertical and one from the horizontal row/column are to be selected. The cell where the row/column lines cross each other indicates the class code (pixel value) of the corresponding 100m cell.

Binary Seasonal Water and Wet Masks & Seasonal Water and Wetness Rolling Archive Database

As input for the Rolling Archive, binary seasonal water and wet masks covering the period 2009–2018 are provided. To achieve full geometric consistency with the new 2018 production, the historic masks (2009–2015) from the first WAW production were re-processed with the current (2018) methodology and resampled to 10m. The archive includes the following layers:

- Re-processed historic seasonal masks: (i.e. 16 seasons) time-stamped seasonal binary water and wet masks for the period 2009–2015.
- Seasonal masks: (i.e. 13 seasons) time-stamped seasonal binary water, wet and dry masks for the period 2015–2018.

The tiling of the layers is corresponding to the EEA tiling grid.

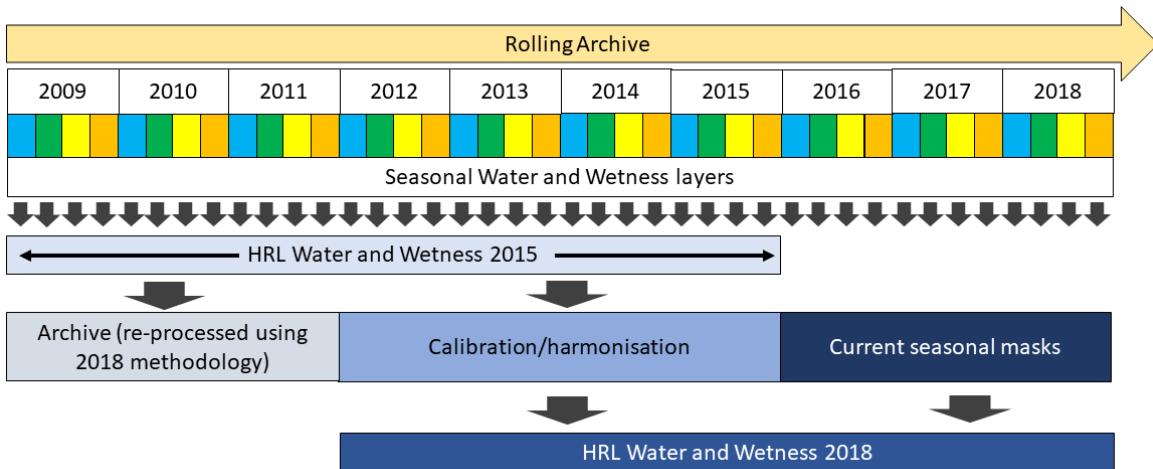


Figure 3: Overview of the Water and Wetness rolling archive database and seasonal layers for the Water and Wetness production

The Rolling Archive database is set up as a PostgreSQL/PostGIS geospatial database to store all binary seasonal water and wet masks for the full 2009–2018 period in a structured and easily accessible manner. The format of the database is a compressed database dump of a PostgreSQL/ PostGIS geospatial database for ease of exchange and storage (tar.gz). The Rolling Archive database will not only enable the structured storage and access of already existing individual time steps (e.g. water detection spring 2014, or wet detection summer 2017), but will also provide an added value through query of the content.

The Rolling archive including the seasonal water and wetness masks are specified as ‘Expert products’ and therefore not directly available on the CLMS land monitoring homepage. Users could for example create new frequencies for shorter periods of time with this information or look when or where there is water or wetness, as this information cannot be extracted directly from the WAW classification or the WWPI.

Consistency Support Layer

This layer was not requested in the ITT, but provided by the Service Providers as an additional support layer to inform users where the differences between the two status layers of 2015 and 2018 are influenced by the increased quality and resolution of input data. Thus, a dedicated workflow has been developed that separates ‘technical differences’ (due to the shift in spatial resolution from 20m to 10m) between the primary HRL Water and Wetness products 2015 and 2018 and actual changes in water and wetness. In this context, a consistency support layer was provided as an additional deliverable in support of harmonized reference products facilitating the further derivation of reliable change statistics.

The Consistency Support Layer is based on the full Sentinel-2 time series. Therefore, a linear regression was performed on the Modified Normalized Difference Water Index (mNDWI) composites 2018 and

2015, which indicate on pixel-level whether the phenology curves at a particular location are stable or imply any trend, thereby providing an indication (threshold) if an observed difference is likely to be real or due to the resolution change. For the decision if the trend is positive or negative, the WAW classification from 2015 and 2018 was taken into account.

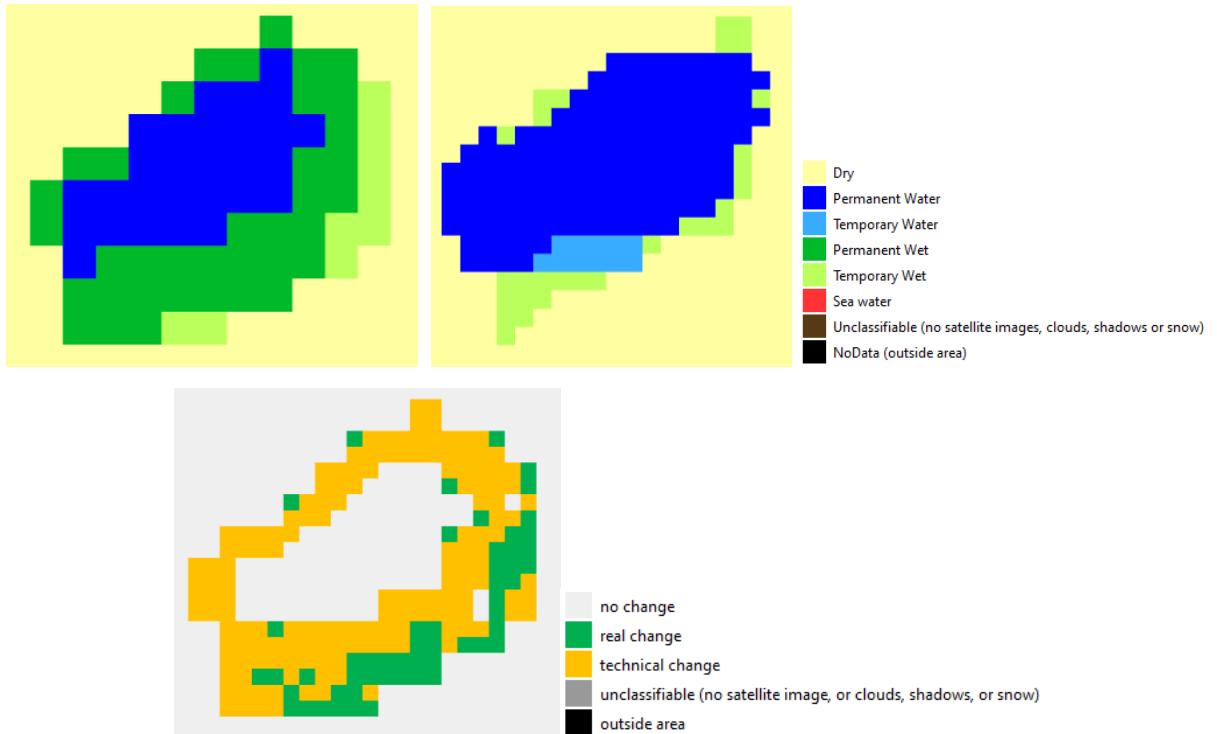


Figure 4: Upper left – WAW 2015, upper right – WAW 2018, down – consistency support layer. The pixels, considered the same class in both layers, are classified as no change. Changes between the five classes are indicated as real or technical changes. The decision, whether classified as real or technical change, is a threshold-based approach based on a linear regression performed on mNDWI composites and the WAW 2015 and 2018.

Confidence layer

As an integral part of production, a confidence layer is provided as an additional layer with the full delivery of the HRLs providing information regarding the spatial variability of the product quality. This is a very useful supplementary information compared to the conventional map-based accuracy assessment (e.g., Foody, 2002) which are based on a comparison of a limited number of reference points (ground-truth) with the mapped product and which are susceptible to regional biases. The confidence layer informs the user at pixel level about the reliability of the product enabling, for instance, potential users to include the product in modelling studies or to exclude parts of the maps with enhanced uncertainty from further analyses.

The uncertainty associated with thematic classification is generally due to (1) the sources of uncertainties from the input data, (2) the propagation of these uncertainties through the pre-processing chain, and (3) the uncertainties introduced within the classification module (Lunetta et al,

1991). The main influencing factors to impact LC classifications on a pixel level are the sensor precision and calibration, geolocation accuracy, atmospheric disturbances, similar spectral signatures of different objects, quality of the reference data and the algorithm performance in general (Huang et al., 2002). Any LC product is a function of these imprecisions and how they are propagated along the processing chain finally impacting the reliability of the resulting classification. The uncertainties arising from the input data and how these imprecisions affect the classification result is usually difficult and costly to assess, since this would require tracing the detector error through all procedures applied to the data. We therefore neglect these from the further estimation of uncertainties.

The confidence layer provided with the product combines multiple quality and processing-based parameters and contain information showing the per-pixel confidence index at 10m pixel resolution. For the calculation, the confidence layer uses the water (1) and wetness (minimum of 3) probabilities from December 2015 to December 2018. Depending on the class of the HRL, the water or wetness probability is used. This results in merged probabilities for 13 seasons depending on the class. From each of these seasons the logarithm to base 2 is calculated. In the case of permanent classes (0,1,3), the final result has the 75th percentile of seasonal logarithms and in the case of temporary classes (2, 4) the arithmetic mean. The sense behind it is entropy as Measure for the information content. It has to be noted that each probability (water/wet/dry) is calculated separately.

Parent Scene Identification Layer (PSIL ESRI Geo-DB)

The parent scene identification layer (PSIL) of the Water and Wetness products is an additional layer in form of a Geodatabase. The layer comprises information on the HR EO image data integrated into the seasonal image composites and used for the production of the HRL. For each EEA tile, the layer gives information about the intersecting Sentinel-2 tile id's and all filtered Sentinel-1 and Sentinel-2 scenes that were used for the production of the HRL product. Moreover, the earliest and latest date of all those scenes were saved for each EEA tile. The PSIL product is meant to increase transparency of the layer production, to provide a valuable aid in the validation process and quality control of the Water and Wetness layers, and to provide a basis for further analyses and investigations.

Limitations of the products

The HRL portfolio comes with a sound and state of the art methodology and provides users with highly accurate information on water and wetness layer and its water and wetness masks at pan-European level. Even if the used method handles outliers to a certain extent, intensive preparation of the input data and a dedicated post-processing (including automatic and semi-automatic steps) were necessary in order to ensure a valid thematic classification.

It should be noted that the WAW 2018 product still includes coarse Landsat and ERS data in addition to the Sentinel data for the initial period from 2012 to 2015. This also influences the quality of the product. Hence, the period from 2012 to 2015 provides a lower level of detail and it might be that some wet or water areas are not detected because of the limited spatial and spectral resolution of the

input data, even if re-processed using the 2018 methodology to harmonize the input masks. The quality of the products is also affected by the lower density of the time series from 2012 to 2015 as well as the presence of Landsat 7 stripes⁵, resulting in artefacts that might also appear in the final product. However, these negative effects could be widely eliminated through consecutive error elimination.

Multiple factors influence the extent of (temporary) wet areas, like the type of soil and yearly number of precipitation events that need to be considered for a realistic mapping of those areas. Due to the inconsistency in the temporary wet class between the 2015 and 2018 WAW products, the historical water and wet masks were re-processed using the 2018 methodology. In the 2018 workflow, a significant improvement in wetness detection could be achieved. In a next step, the classification of both, 2015 and 2018 was updated based on the re-processed input masks. As the inconsistencies were only related to class 4 of the WAW products, only this class was replaced by the new classification to guarantee a harmonized product line starting in 2015.

Differences from the previous version(s)

HRL Water and Wetness 2018 compared to 2015

The “High Resolution Water and Wetness” layer was first produced for the reference year 2015 with a spatial resolution of 20m. The current layer provides a first update of this product for the reference year 2018. With this update, there have been technical modifications – mainly related to the increase of the spatial and temporal resolution of the input data.

In 2015, the production was mainly based on Landsat time-series with 30m resolution, to which a scene selection approach was applied in order to handle the huge data amounts combined with Sentinel-1 data. In 2018, instead of applying resampled 20m Landsat data, Sentinel-1 and Sentinel-2 images with a higher spatial resolution of 10m were used as the main input datasets for updating the WAW layer to the period 2015 to 2018. This time it was possible to consider all available input data as processing was performed on a highly efficient cloud processing system to which input data streams were directly connected. Furthermore, the input datasets and processing chains were improved. Those improvements are described in detail in chapter VI. Basically, the HRL 2018 water and wetness detection processing chain includes several input data sets as moisture sensitive optical indices, SAR-based soil moisture estimations and the topographic wetness index (TWI) that are combined to derive wetness frequencies from 2012 to 2018.

Both, the improved processing chain as well as the use of high-quality Sentinel-1 and Sentinel-2 data with its high spatial and temporal resolution enables for a significant improvement of the quality compared to the 2015 product. The WAW 2018 shows that smaller structures such as small water bodies could be detected due to the higher resolution of the input data. Also, smaller rivers could be captured more reliably and accurately (see *Figure 5* and *Figure 6*).

In an additional task, the temporary wet class of both, the 2015 and the 2018 WAW product, were re-classified based on the re-processed water and wetness masks to overcome the large differences in

⁵ <https://www.esriuk.com/~media/Files/Pdfs/library/whitepapers/pdfs/landsat-anomaly.pdf>,

https://www.usgs.gov/land-resources/nli/landsat/landsat-7?qt-science_support_page_related_con=0#qt-science_support_page_related_con

class 4 due to a significant improvement of the methodology detecting wetness (see *Figure 7* and *Figure 8*).

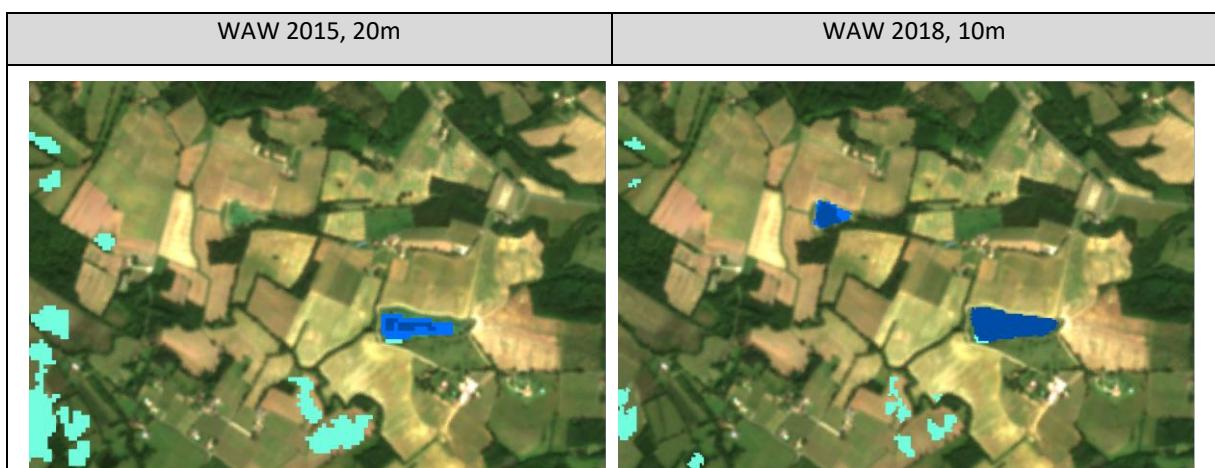


Figure 5: WAW 2015 compared to WAW 2018; Coord.: 3520208,2360506

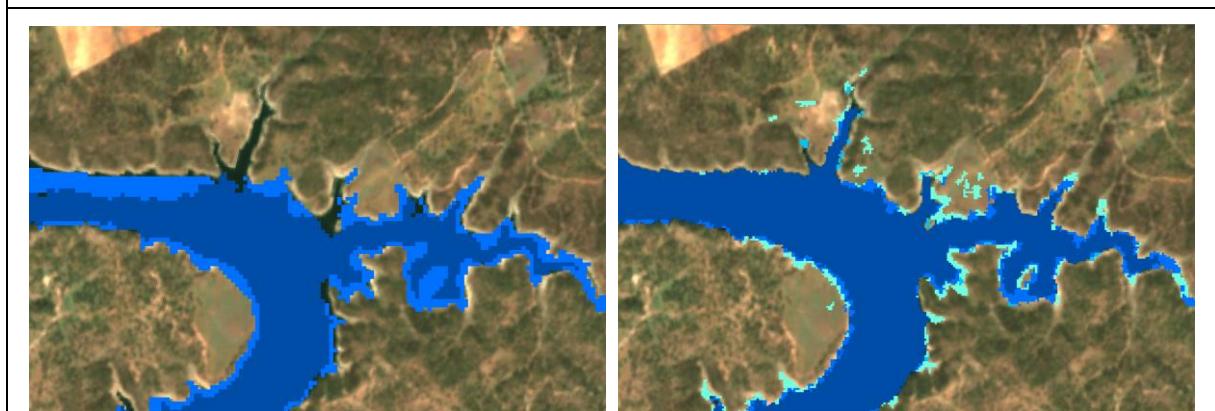
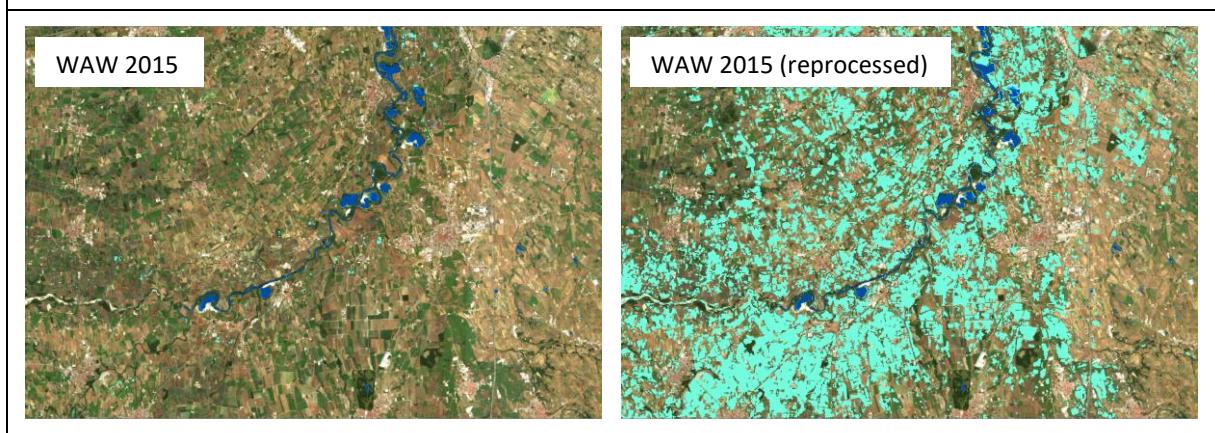


Figure 6: WAW 2015 compared to WAW 2018; Coord.: 2823253,1896813



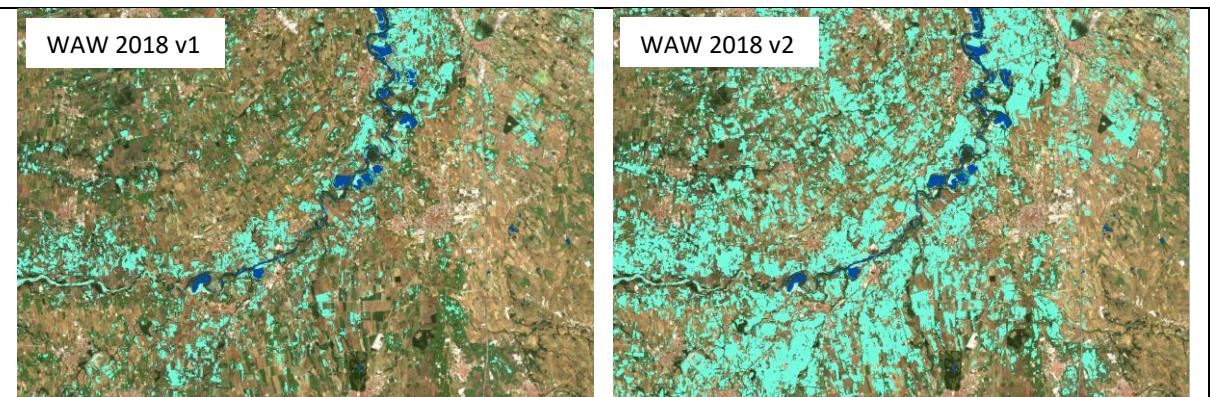


Figure 7: Original version of the WAW 2015 and WAW 2018 (left) compared to the corresponding products (right) which were reprocessed with the new methodology; Coord.: 4132260,2408998

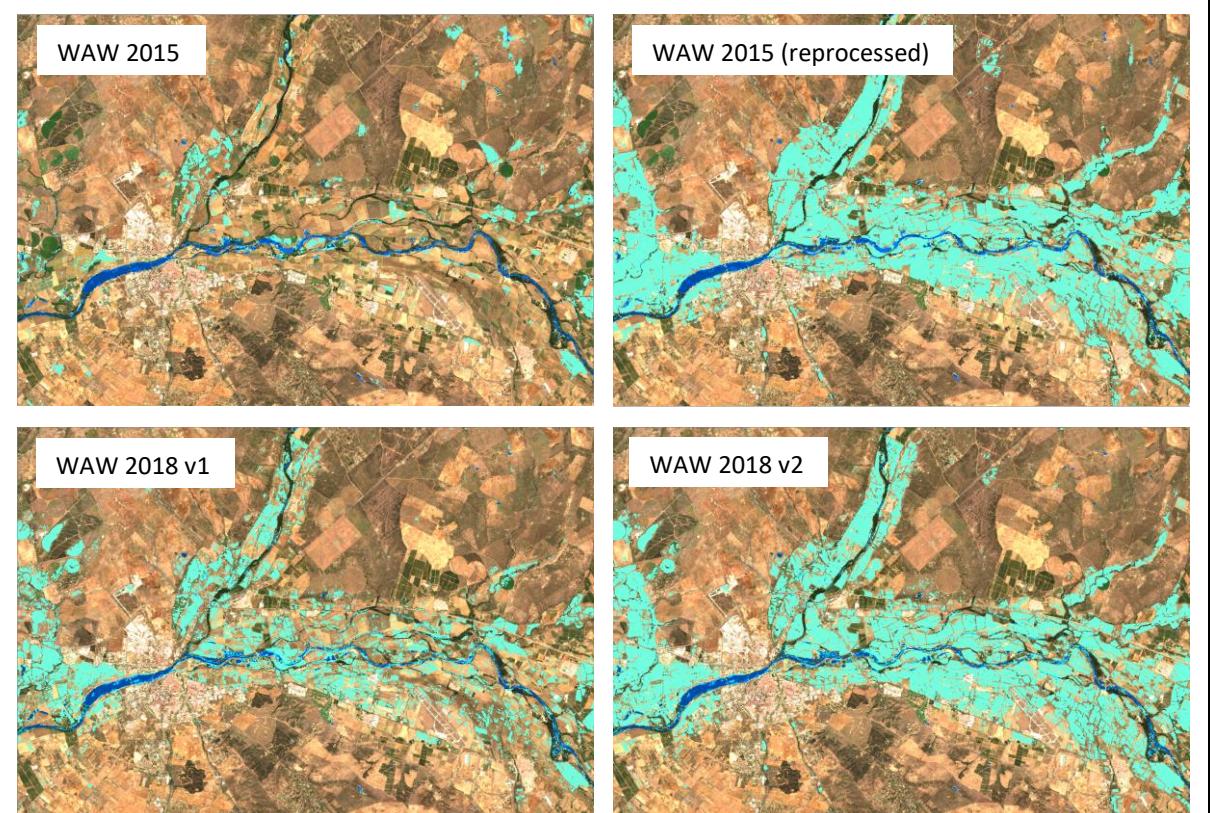


Figure 8: Original version of the WAW 2015 and WAW 2018 (left) compared to the corresponding products (right) which were reprocessed with the new methodology; Coord.: 2858691,1912613

VII. Quality assessment

Internal validation

Each HRL product is subject to internal validation (by the service providers). This section provides guidance on how the product was validated by defining suitable indicators or metrics. Although the validation was consortium-internal, independency was ensured through a validation by the consortium partners who did not perform the actual production. A quantitative assessment of the thematic accuracy is performed based on selected point samples compared to external datasets. The thematic accuracy expected depends on the specific class:

- Permanent water: target accuracy 85%
- Temporary water: target accuracy 80%
- Permanent wet areas: target accuracy 80%
- Temporary wet areas: target accuracy 80%
- Dry areas: target accuracy 85%

The accuracy assessment represents the bulk of the work described as part of this section. Classification correctness should be evaluated using a misclassification rate and/or misclassification matrix. Contrary to logical consistency or completeness, thematic accuracy cannot be subjected to an exhaustive check. A thorough thematic assessment would imply a very time-consuming work and therefore high costs. Misclassification rate is estimated by sampling and product information is compared to reference data. Thus, thematic accuracy assessment has three components: (i) the sampling design, (ii) the response design and (iii) the estimation and analysis procedures.

The stratification and the sampling design consist primarily in selecting an appropriate sampling frame and sampling unit. A probability sampling design is preferred for its objectivity. For the internal validation procedure, a stratified approach was chosen which consists in allocating a pre-defined number of samples per land-cover class. It is based on the LUCAS (Land Use/Cover Area frame statistical Survey) sampling approach. LUCAS corresponds to a grid of approximately 1,100,000 points throughout the European Union where land cover or land use type is observed. Using LUCAS points ensures traceability and coherence between the different layers. For the WAW layer, a stratification is applied for the whole analysed area based on a series of omission/commission strata.

The response design is the photointerpretation of each sample unit and is based on the independent assessment at the unit level. The reference data are the images used in the production, the VHR_IMAGE_2018 dataset. The last step, the analysis procedure, consists in analysing the samples in order to draw conclusions for the thematic accuracy of the product. Thematic accuracy is presented in the form of an error matrix resulting from samples interpretation.

Table 5: Confusion matrix of the internal validation of the unweighted 100% WAW 2018 delivery for EEA-39

WAW layer 2018	Reference Data							User	CI95%
	Dry	Permanent water	Temporary water	Permanent wet	Temporary wet	Total			

Map Data	Dry	9095	5	6	10	15	9131	99.6%	0.13%
	Permanent water	3	220	9	1	1	234	94.0%	4.02%
	Temporary water	11	13	176	9	9	218	80.7%	7.12%
	Permanent wet	12	1	2	267	7	289	92.4%	3.78%
	Temporary wet	7	3	3	1	336	350	96.0%	2.34%
	Total	9128	242	196	288	368	10222		
	Prod.	99.6%	90.9%	89.8%	92.7%	91.3%		98.8%	
	CI95%	0.12%	4.73%	6.06%	3.72%	3.37%		2.29%	

The full delivery validation results, presented by the confusion matrix in Table 5, shows an overall accuracy of 98.75%, which is slightly lower than the internal validation for HRL WAW 2015 (99.0%). However, please note that the WAW 2015 overall accuracy was obtained with a higher occurrence frequency of the ‘dry’ class that turned out to be underestimated temporary wet areas, which has now been adapted with the current delivery of the re-processed WAW 2015. Further, the population of ‘temporary water’ and ‘wet’ classes (temporary and permanent) is higher in the WAW 2018.

In terms of UA, all classes comply with the accuracy targets, although ‘temporary water’ is only slightly above this target (by 0.7%). However, significant improvements were achieved for this class in the 100% delivery (80.7%) by applying the improvements of the methodology. The overall UA results for the ‘permanent wet’ class show a significant improvement with respect to WAW 2015 (92.4% vs 73.3%). The overall PA shows values well above the respective class accuracy thresholds.

Compared to the first 100% percent delivery, the UA of class 4 could be significantly improved (87.5 vs. 96%) with the re-processed layer which also matches with the look and feel of this updated product. Further the PA of classes 2,3 and 4 were improved by the re-processing of the temporary wet class.

QA/QC Procedures

All procedures of technical Quality Assurance (QA) and Quality Control (QC) are implemented consistently and under the coordination and supervision of the project’s Quality Manager. Within the overall QA scheme dedicated technical QC was performed throughout the entire HRL production chain, including

- ✓ Continuous monitoring and maintenance of the processing infrastructure

- ✓ Quality Assurance within the production process, applying planned and systematic checks at various stages between data collection and the final product, as well as
- ✓ Final Quality Control after the main production of the HRLs (but still before making final data aggregation and re-projection), where the accuracy and precision of the products is being assessed

The introduction of a centralised cloud processing environment is a key improvement to previous implementations as a **more systematic and objective QA mechanism** is ensured.

Quality assurance follows the ISO9001 standards for Quality Management⁶ and the INSPIRE data quality elements and comprises of dedicated procedures of ongoing quality checks (QC breakpoints) during implementation of the production chain, in order to keep persistent control over the various stages of production, assure fitness-for-purpose of the end-products and that all quality requirements are fulfilled, including

- ✓ Thematic accuracy & consistency
- ✓ Geometric accuracy & consistency
- ✓ Logical / topologic consistency
- ✓ Thematic coding / attributes
- ✓ Metadata completeness and compliance to INSPIRE.

Priority will be given to the target thematic accuracies to be achieved by each product, as well as to the issues of product consistency (spatial and temporal) and homogeneity.

VIII. Terms of use and product technical support

Terms of use

The product(s) described in this document is/are created in the frame of the Copernicus programme of the European Union by the European Environment Agency (product custodian) and is/are owned by the European Union. The product(s) can be used following Copernicus full free and open data policy, which allows the use of the product(s) also for any commercial purpose. Derived products created by end users from the product(s) described in this document are owned by the end users, who have all intellectual rights to the derived products.

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IX. References

Documents of the EU

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Links:

https://europa.eu/european-union/documents-publications/official-documents_en

X. Annexes

Annex 1: Naming convention of HRL 2018 products

File naming for HRL products (raster and vector)

The proposed file naming convention will be applied both to raster and vector (no difference in file name), HRLs and associated reports throughout the processing chain.

Neither points (“.”) nor minus (“-“) are allowed within file names. The file naming is based on the following descriptors:

THEME	YEAR	RESOLUTION	EXTENT	EPSG	VERSION
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THEME:

- Abbreviation for status products (green colour in Table 6)
- Abbreviation for change products (blue colour in Table 6)
- Abbreviation for additional, derived and expert products (orange colour in Table 6)
- Abbreviation for main products followed by abbreviation for reference products (example: WWPI) (orange colour in Table 6)
- PSIL: Abbreviation for main products followed by PSIL (example: IMDPSIL) (orange colour in Table 6)
- Confidence Layer: Abbreviation for main products followed by CL (example: WAWCL) (orange colour in Table 6)

REFERENCE YEAR

- 2015 or 2018 in four digits

RESOLUTION

- Four-digit (i.e. 010m and 100m)

EXTENT

- 2-digit country code for country deliveries in national projection
- “eu” for all deliveries in European Projection (partial and full lot mosaics)
- 6-letter coordinate-orientated cell code ID for the tiles according to the following examples:
 - CellCode: 100kmE0N7 → File naming EXTENT: E00N07
 - CellCode: 100kmE2N65 → File naming EXTENT: E02N65
 - CellCode: 100kmE37N35 → File naming EXTENT: E37N35

EPSG

- 5-digit EPSG code (geodetic parameter dataset code by the European Petroleum Survey Group, <http://www.epsg-registry.org/>)
- i.e. “03035” for the European LAEA projection

VERSION (only for final deliveries)

- 4-digit qualifier of the version number, starting with “V1_0” for a first full final version, and allowing to capture re-processing/calculation of small changes as (“V1_1”, “V1_2” etc.). In case of major changes, a second version should be used (“V2_0”).

Examples and meaning of full product names for final products:

WAW_2018_010m_eu_03035_V1_0.tif

Water wetness layer, 2018 reference year, 10m spatial resolution, European product in European projection (EPSG: 3035), first final version.

WAW_2018_010m_eu_03035_V1_1.tif

Water wetness layer, 2018 reference year, 10m spatial resolution, European product in European projection (EPSG: 3035), first final version, second delivery after small changes.

Annex 2: File naming nomenclature of HRL WAW 2018 products

Table 6: File naming nomenclature

Descriptor	To be written as	Meaning	Comments
	WAW	Water and wetness product	Abbreviation to be used for main Lot 4 product
	WWPI	Water and wetness Probability Index	Additional Lot 4 product
	WaM	Water mask (seasonal)	Intermediate Lot 4 layer; Tile-based result
	WeM	Wetness mask (seasonal)	
	WAWCL	Confidence Layer	Additional Lot 4 products; Tile-based result
	WAWCSL	Consistency Support Layer	
	WAWPSIL	Parent Scene Identification Layer	
REFERENCE YEAR	WAWRA	Rolling Archive	Geospatial Database of Lot 4 intermediate layers
	2012	Reference year 2012 (+/- 1 year)	
	2015	Reference year 2015 (+/- 1 year)	

Descriptor	To be written as	Meaning	Comments
	2018	Reference year 2018 (+/- 1 year)	Only for change products
	0609	Change 2006-2009	
	0912	Change 2009-2012	
	1215	Change 2012-2015	
	1518	Change 2015-2018	
	0612	Change 2006-2012	
REFERENCE SEASON	2016_1	Dec 2015-Feb. 2016	For the seasonal water and wet masks in Lot 4
	2016_2	Mar. 2016-May 2016	
	2016_3	Jun. 2016-Aug. 2016	
	2016_4	Sept.-Nov. 2016	
RESOLUTION	010m	10m spatial (pixel) resolution	
	020m	20m spatial (pixel) resolution	
	100m	100m spatial (pixel) resolution	
EXTENT	al	Albania	2-letter abbreviation for the country (in national projections), "eu" for deliveries in European projection and additional EEA cell grid code for tile-based delivery (e.g. eu_E02N65)
	at	Austria	
	ba	Bosnia and Herzegovina	
	be	Belgium	
	bg	Bulgaria	
	ch	Switzerland	
	cy	Cyprus	
	cz	Czech Republic	
	de	Germany	
	dk	Denmark	
	ee	Estonia	
	es	Spain (including Andorra)	
	eu	European Projection	
	euExxNxx	European Projection (tile-based delivery)	
	fi	Finland	
	fr	France	
	gb	United Kingdom	
	gf	French Guiana	
	gp	Guadeloupe	
	gr	Greece	
	hr	Croatia	

Descriptor	To be written as	Meaning	Comments
	hu	Hungary	
	ie	Ireland	
	im	Isle of Man	
	is	Iceland	
	it	Italy	
	li	Liechtenstein	
	lt	Lithuania	
	lu	Luxembourg	
	lv	Latvia	
	me	Montenegro	
	mk	Macedonia, FYR of	
	mq	Martinique	
	mt	Malta	
	nl	Netherlands	
	no	Norway	
	pl	Poland	
	pt	Portugal	
	re	Réunion	
	ro	Romania	
	rs	Serbia	
	se	Sweden	
	si	Slovenia	
	sk	Slovakia	
	tr	Turkey	
	xk	Kosovo	
	yt	Mayotte	
EPSG	e.g. 03035	LAEA (European Projection)	5-digit EPSG code (geodetic parameter dataset code by the European Petroleum Survey Group) http://www.epsg-registry.org/
VERSION	V0_1	First interim version	4-digit qualifier of the version number, starting with "V1_0" for a first full final version, and allowing to capture re-processing/calculation of small changes as ("V1_1", "V1_2" etc.). In case of major changes, a second
	V1_0	First full final version	
	V1_1	Re-delivery of first full final version with small changes	
	V2_0	Second full final version	
	etc.	etc.	

Descriptor	To be written as	Meaning	Comments
			version should be used (“V2_0”).

Annex 3: Download Content

All HRL products can be downloaded from the CLMS website under <https://land.copernicus.eu/pan-european/high-resolution-layers>. Please note, that an account needs to be created in order to login and to download the products. Products can be downloaded as full pan-European mosaic or as tiles with a side length of 1000 km x 1000 km.

Raster products are delivered as GeoTIFF (*.tif) (8bit unsigned / 16bit signed) in LZW compression with world file (*.tfw), pyramids (*.ovr), attribute table (*.dbf) and statistics (*.aux.xml). Each product is accompanied with product-specific color tables (*.clr & *.txt) and INSPIRE-compliant metadata in XML format and an INSPIRE Mapping Table.

In addition, a Coordinate Reference Sheet (CRS) is provided in PDF format, listing the characteristics of the European Terrestrial Reference System 1989.

Vector products are provided in shapefile (*.shp) format or as ESRI File Geodatabase.

Annex 4: Coordinate Reference System Sheet

Each product is delivered with a PDF providing Coordinate Reference System (CRS) information, including details of parameters used to transform to ETRS89 LAEA projection as in the following example from Hungary. The pdf is named as follows:

CRS_Information_Sheet_<country 2-letter ISO code>, e.g. CRS_Information_Sheet_HU.pdf.

Table 7: CRS information sheet for Hungary (example)

National		
Datum		HD72 / EOV
	type	geodetic
	valid area	Hungary
Prime meridian		Greenwich
	longitude	0
Ellipsoid		GRS 1967
	semi major axis	6378160
	inverse flattening	298.247167427
Projection		Hotine Oblique Mercator (variant B)
	latitude of origin	47.1443937222222
	longitude of origin	19.04857177777778
	latitude of 1 st standard parallel	
	latitude of 2 nd standard parallel	
	scale factor at origin	
	false easting	650000
	false northing	200000
EPSG-Code	23700	
European		
Datum		ETRS89 (European Terrestrial Reference System 1989)
	type	geodetic
	valid area	Europe / EUREF
Prime meridian		Greenwich
	longitude	0°
Ellipsoid		GRS 1980
	semi major axis	6 378 137 m
	inverse flattening	298.257222101
Projection	Geographic (Ellipsoidal Coordinate System)	
Datum shift parameters used		
Operation method		Coordinate Frame
	geocentric X translation	52.684
	geocentric Y translation	-71.194
	geocentric Z translation	-13.975
	rotation X-axis	0.312
	rotation Y-axis	0.1063
	rotation Z-axis	0.3729
	correction of scale	1.0191
EPSG-Code	1449	

Annex 5: Colour Palettes and Attribute Fields

All HRL products are delivered with an embedded raster colormap including the following attribute fields in the *.tif.dbf file: ["value", "count", "area_km2", "area_perc", "class_name"].

To all product deliveries, both the GIS file specifying the colour palette, and a table listing the RGB values is provided in the following formats:

- *.clr for GIS colour palettes
- *.txt for other purposes

Table 8: Colour palette and attributes of WAW layer

Class Code	Class Name	Red	Green	Blue	
0	Dry	255	255	255	
1	Permanent water	0	77	168	
2	Temporary water	0	112	255	
3	Permanent wet	0	197	255	
4	Temporary wet	115	255	223	
253	Sea water	255	237	195	
254	unclassifiable	153	153	153	
255	outside area	0	0	0	

Table 9: Colour palette and attributes of WWPI layer

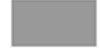
Class Code	Class Name	Red	Green	Blue	
0	no water and wetness probability	255	255	204	
1-49	1-50% water and wetness probability	colour shades in between			
50	50% water and wetness probability	109	201	146	
51-99	51-99% water and wetness probability	colour shades in between			
100	100% water and wetness probability	40	62	148	
254	unclassifiable (no satellite image available, or clouds, shadows, or snow)	153	153	153	
255	outside area	0	0	0	

Table 10: Colour palette and attributes of WAW confidence layer

Class Code	Class Name	Red	Green	Blue	
0	0% percent of confidence	255	0	0	
1-49	1-49% percent of confidence	colour shades in between			
50	50% percent of confidence	255	255	0	
51-99	51-99% percent of confidence	colour shades in between			
100	100% percent of confidence	8	99	0	
254	unclassifiable (no satellite image available, or clouds, shadows, or snow)	153	153	153	
255	outside area	0	0	0	

Table 11: Colour palette and attributes of WAW Consistency Support Layer

Class Code	Class Name	Red	Green	Blue	
0	no change	240	240	240	
1	real change	0	176	80	
2	technical change	255	192	0	
254	unclassifiable (no satellite image available, or clouds, shadows, or snow)	153	153	153	

255	outside area	0	0	0	
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Annex V: Technical Topics for all Lots

Aggregation Rules

Table 12: Aggregation rules for status layers

Aggregation rules for status layers	
Valid pixels (inside AOI)	<p>If the majority ($>=50$) of 10m pixels within a 100m cell has a valid value (other than 255) the following rules apply:</p> <p>If one or more underlying pixels are unclassifiable (pixel value 254) within the valid pixel mask than unclassifiable (254) is assigned.</p> <p>If no pixel is unclassifiable (pixel value 254):</p> <ul style="list-style-type: none"> - The average value of the 100m cell is calculated taking into account the valid pixel only.
Invalid pixels (outside area)	If the majority of 10m pixels within a 100m cell is outside area (pixel value 255).