Product Specification Document (PSD)

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lakes cci

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1. Introduction

The purpose of this product specification document (PSD) for the lakes climate change initiative project (lakes CCI) is to translate a set of product requirements into a specification for the data sets to be generated. Starting from the *a priori* requirement to produce a consistent data set for all thematic variables included in lakes CCI (those variables that were specified in response to GCOS ECV definitions), this document takes input from user consultation as well as product specifications of existing cci projects (notably ocean colour, OC, and sea surface temperature, SST) as well as products included in the Copernicus Land Monitoring Service, to ensure consistency.

CCI lakes will produce two versions of the Lakes climate data record:

- Version 1: The lakes products are generated using existing algorithms. This dataset corresponds to the state of the art at the beginning of the project. The focus is on homogenization of the five products that comprise the lakes ECV (except Ice Thickness). It will be made available to users in February 2020 (Climate Research Data Package CRDP delivery V1)

- Version 2: The lake products are generated using algorithm and wider product improvements in the first phase of the project. This version, with improved algorithms and geographical coverage, will be delivered in May 2021(Climate Research Data Package CRDP delivery V2)

1.1. Summary of requirements

One consistent data format containing all lakes thematic variables. While the different sensing strategies that underpin each thematic variable require optimised processing environments, data sources and expert teams, the final product of lakes CCI will be singular and harmonized. Users will have access to all variables collected within a single aggregation period, from a single file source. (Section 2.2).

Retaining the finest granularity of information available for the longest time period. A generational increase in sensing capability between satellite sensors means that some variables have been recorded at increasingly fine temporal and spatial scales. The data set should balance consistency of the product over time and between variables against potential loss of information. (Section XX).

Follow CCI data Standards v2.0 (17/0/2018). The dataset will be stored in NetCDF format using common vocabularies to ensure consistency with other CCI datasets and the CCI data analysis toolbox.

2. Description

The Lakes ECV dataset is composed of the following thematic variables:

- Lake Water Level (LWL)
- Lake Water Extent (LWE)
- Lase Surface Water Temperature (LSWT)
- Lake Ice Cover (LIC)
- Lake Water Leaving Reflectance (LWLR)

These thematic variables will be combined to provide users access to any combination of variables available within each aggregation interval.

2.1. Sources of satellite data

Data generated in the Lakes CCI project is derived from data from multiple instruments and multiple satellites. The satellites and instruments for each product that forms the ECV lakes are provided in Table 1.

Table 1. Satellites and instruments used to generate the ECV Lake

Product	Satellite	Instrument
LWL	TOPEX/Poseidon (T/P)	Poseidon-1
	Jason-1	Poseidon-2
	Jason-2	Poseidon-3
	Jason-3	Poseidon-3B
	ENVISAT	Radar Altimeter (RA-2)
	SARAL	AltiKa
	Sentinel-3A	SAR Altimeter
LWE	Landsat-4	MSS (Multispectral Scanner) TM (Thematic Mapper)
	Landsat-5	MSS (Multispectral Scanner) TM (Thematic Mapper)
	Landsat-7	ETM+
	Landsat-8	OLI
	Sentinel-2	MSI (Multi-Spectral Instrument)
	Sentinel-1	SAR
	ENVISAT	ASAR
	ERS 1-2	SAR
LIC	Terra/Aqua	MODIS
	Suomi NPP	VIIRS
	Sentinel-3	OLCI-SLSTR A/B
	Sentinel-1	C-band SAR
LSWT	ERS-2	ATSR-2
	Envisat	AATSR
	Metop-A/B	AVHRR
	Terra	MODIS
LWLR	Envisat	Meris
	Sentinel-3	OLCI A/B
	Aqua	MODIS A
	Suomi NPP	VIIRS
	Orbview-2	SeaWIFS

A consequence of this diversity of products is that temporal and spatial resolutions as well as data availably of each component are not the same (Table 2). Two of these products are not in a grid format (LWL and LWE).

For LWE in addition of the described optical HR imagery, HR SAR data could/would be exploited mainly SENTINEL 1 ENVISAT

Table 2. Spatial and temporal resolution for each product

Product	Spatial Resolution	Temporal Resolution	Temporal Coverage
LWL	N/A	1 to 10 days	1993 – present
LWE	10-30 m	1 to 10 days	1993 – present
LIC	250 m	Daily	2000 - present
LSWT	0.05 deg	Daily	1995 - present

LWLR	300m – 1100 m	1-3 days	1997 - present

2.2. Harmonization

A central issue in the Lakes CCI project is the harmonization of the different thematic variables. Each thematic variable relies on different sensing concepts and therefore sensors and missions, which are not necessarily synchronous nor do these provide consistent spatiotemporal coverage. First-order harmonization of the thematic variables will ensure that each NetCDF file contains all information available for each product, identifying missing values as such. The harmonized product will have the following characteristics:

• Daily aggregation interval pinned to 12:00:00 UTC. Thematic variables that do not exist for a given date will be set to the netCDF fill value.
• Grid format with spatial resolution of 1/120 degrees (near 1 km at the equator). Variables not produced in grid format (LWL and LWE) will be duplicated in the grid for the area given under the nominal spatial delineation of that lake, derived from its maximum water extent as used for LWLR.
• Datum: WGS84
• Extent: -180 to 180 degrees longitude, -90 to 90 degrees latitude, where positive signs point north and east. The pixel coordinate will be the centre of the pixel.
• The number of grid rows will be 21600, the number of grid columns will be 43200.

Further detail on product dimensions is provided in the sections below

3. File naming convention

As recommended in the CCI data standards document, the name of the files in the Lakes CCI will be:

ESACCI-<CCI Project>-<Processing Level>-<Data Type>-<Product String>-<Indicative Date>-fv<version>.nc

Where:

CCI Project: LAKES

Processing Level: L3S. The lakes cci product will be Super-collated: observations combined from multiple instruments and observation times into a common spatiotemporal grid.

Data type: LK_PRODUCTS

Product String: MERGED. It means data from more than one platform and/or sensor

Indicative Date: in YYYYMMDD format

Version: V1.0

Thus, an example file name in the first data release would be:

ESACCI-LAKES-L3S-LK_PRODUCTS-MERGED-20080808-fv1.0.nc

4. Global Attributes

To ensure consistency where the same global attributes apply to several ECVs, and to avoid ambiguity, relevant terms have been gathered in an ontology, defining the CCI entities and the relationship between those entities, including:

- project
- platform
- sensor
- institution

The CCI Ontology is available online on the ESA CCI website at cci.esa.int/working-groups.

http://vocab.ceda.ac.uk/ontology/cci/cci-content/index.html

The following table contains the global attributes that will be included in the output files following the CCI standards. Some of them are already defined other will be set at the data package generation.

Attribute	Value
title	ESA CCI lakes product
institution	LWL: LEGOS/CLS
	LWE: LEGOS/CLS
	LSWT: University of Reading
	LIC: H2O Geomatics
	LWLR: PML
source	LWL: European Space Agency (ESA), National Aeronautics and Space Administration (NASA), European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), National Oceanic and Atmospheric Administration (NOAA), Indian Space Research Organisation (ISRO)
	LWE: European Space Agency (ESA), National Aeronautics and Space Administration (NASA)
	LSWT: European Space Agency (ESA), European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), European Centre for Medium-Range Weather Forecasts (ECMWF)
	LIC: European Space Agency (ESA), National Aeronautics and Space Administration (NASA)
	LSLR: European Space Agency (ESA), National Aeronautics and Space Administration (NASA)
history processing history of the dataset	LWL
	LWE
	LSWT
	LIC: Lake ice cover processor by H2O Geomatics
	LWLR: Calimnos processor by Plymouth Marine Laboratory, including calls to Idepix (SNAP) and POLYMER (Hygeos) algorithms

Attribute	Value
references	http://cci.esa.int/lakes
tracking_id	Universal Unique Identifier
conventions	CF-1.7
product_version	V 1.0
Summary	This dataset contains L3S daily ECV Lakes products: Water Level (LWL), Water Extent (LWE), Ice cover (LIC), Surface Water Temperature (LSWT) and Water Leaving Reflectance (LWLR). L3S data are observations combined from multiple instruments into a common spatiotemporal grid
keywords	Satellite, Lake, Climate Change, Lake Water Level, Lake Water Extent, Lake Surface Water Temperature, Lake Ice Cover, Lake Water Leaving Reflectance
id	To be completed when the data package will be generated
naming_authority	To be completed when the data package will be generated
keywords_vocabulary	LWL
	LWE
	LSWT: LAKES/RESERVOIRS
	LIC: lake, reservoir, freshwater, inland water, ice, remote sensing, climate
	LWLR: inspire_theme: Orthoimagery gcmd_keywords: EARTH_SCIENCE-OCEANS-OCEAN_OPTICS-WATER-LEAVING RADIANCE; EARTH_SCIENCE-TERRESTRIAL_HYDROSPHERE-WATER_QUALITY_WATER_CHEMISTRY-CHLOROPHYLL, SUSPENDED_SOLIDS, TURBIDITY gemet_keywords: water; algal bloom; aquatic environment; freshwater; freshwater quality; inland water; lagoon; lake; dam; phytoplankton; turbidity; water monitoring; water quality; water reservoir; climate; seasonal variation; environmental data; environmental monitoring; monitoring; remote sensing
cdm_data_type	Grid
comment	These data were produced at ESACCI as part of the ESA Lakes CCI project
date_created	YYYYMMDD
creator_name	ESA SST CCI
creator_url	http://cci.esa.int/lakes
creator_email	to be defined
project	Climate Change Initiative - European Space Agency
geospatial_lat_min	-90.0
geospatial_lat_max	90.0

Attribute	Value
geospatial_lon_min	-180.0
geospatial_lon_max	180.0
geospatial_vertical_min	NA
geospatial_vertical_max	NA
time_coverage_start	yyyymmddThhmmssZ
time_coverage_end	yyyymmddThhmmssZ
time_coveragae_duration	ISO8601
time_coverage_resolution	P1D
standard_name_vocabulary	NetCDF Climate and Forecast (CF) Metadata Convention version 1.7
license	ESA CCI Data Policy: free and open access
platform	LWL: TOPEX/Poseidon, Jason-1, Jason-2, Jason-3, Envisat, SARAL GFO, Sentinel-3a
	LWE: Landsat 4, 5, 7, 8, Sentinel 1
	LSWT: ERS2, Envisat, MetOpA, MetOpB
	LIC: Aqua, Terra
	LWLR: Orbview-2, Aqua, Envisat, Suomi NPP, Sentinel-3a, Sentinel-3b
sensor	LWL: Poseidon-1, Poseidon-2, Poseidon-3, Radar Altimeter (RA and RA-2), AltiKa, SRAL
	LWE: MSS, TM, OLI
	LSWT: ATSR2, AATSR, AVHRR
	LIC: MODIS
	LWLR: SeaWifs, MODIS, MERIS, VIIRS, OLCI
spatial_resolution	1 km at Equator
key_variables	water_surface_height_above_reference_datum, lake_water_extent, lake_ice_cover lake_surface_water_temperature, lake_water_leaving_reflectance (and derived variables)
geospatial_lat_units	degrees_north
geospatial_lon_units	degrees_east
geospatial_lat_resolution	1/120 degrees (0.008333)
geospatial_lon_resolution	1/120 degrees (0.008333)

5. Dimensions

Following the CCI data standards, the gridded products have the dimensions time, latitude and longitude.

Dimension Name	Attribute	Type	Value
time	units	c	seconds since 01/01/1970
time	standard_name	c	time
time	long_name	c	time
time	calendar	c	gregorian
lat	units	c	degrees_north
lat	standard_name	c	latitude
lat	long_name	c	latitude
lat	valid_min	f	-90
lat	valid_max	f	90
lat	axis	c	Y
lat	reference_datum	c	WGS84 datum
lon	units	c	degrees_east
lon	standard_name	c	longitude
lon	long_name	c	longitude
lon	valid_min	f	-180
lon	valid_max	f	180
lon	axis	c	X
lon	reference_datum	c	WGS84 datum

6. Products

6.1. Lake Water Level (LWL) variables

Variable Name	Attribute	Type	Value
water_surface_height_above_reference_datum	standard_name	c	water_surface_height_above_reference_datum
water_surface_height_above_reference_datum	long_name	c	water surface height above geoid
water_surface_height_above_reference_datum	units	c	m
water_surface_height_above_reference_datum	valid_min	d	
water_surface_height_above_reference_datum	valid_max	d	
water_surface_height_above_reference_datum	_FillValue	d	-32768
water_surface_height_uncertainty	standard_name	c	water_surface_height_uncertainty
water_surface_height_uncertainty	long_name	c	water surface height uncertainty
water_surface_height_uncertainty	units	c	m
water_surface_height_uncertainty	valid_min	d	0
water_surface_height_uncertainty	valid_max	d	
water_surface_height_uncertainty	_FillValue	d	-32768

6.2. Lake Water Extent (LWE) variables

Variable Name	Attribute	Type	Value
lake_surface_water_extent	standard_name	c	lake_water_extent
lake_surface_water_extent	long_name	c	Lake Water Extent
lake_surface_water_extent	units	c	km2
lake_surface_water_extent	valid_min	s	0
lake_surface_water_extent	valid_max	s	
lake_surface_water_extent	_FillValue	s	-32768
Lake_surface_water_extent_uncertainty	standard_name	c	water_extent_uncertainty
Lake_surface_water_extent_uncertainty	long_name	c	Water extent uncertainty
Lake_surface_water_extent_uncertainty	units	c	km2
Lake_surface_water_extent_uncertainty	valid_min	s	0
Lake_surface_water_extent_uncertainty	valid_max	s	
Lake_surface_water_extent_uncertainty	_FillValue	s	-32768

6.3. Lake Surface Water Temperature (LSWT) variables

Variable Name	Attribute	Type	Value
lake_surface_water_temperature	standard_name	c	lake_surface_water_temperature
lake_surface_water_temperature	long_name	c	lake surface skin temperature
lake_surface_water_temperature	units	c	kelvin
lake_surface_water_temperature	valid_min	s	-200

Variable Name	Attribute	Type	Value
lake_surface_water_temperature	valid_max	s	5000
lake_surface_water_temperature	scale_factor	f	0.01
lake_surface_water_temperature	add_offset	f	273.15
lake_surface_water_temperature	_FillValue	s	-32768
lake_surface_water_temperature	comment	c	The observations from different instruments have been combined.
lswt_uncertainty	standard_name	c	lake_surface_water_temperature_uncertainty
lswt_uncertainty	long_name	c	total uncertainty in lake surface water temperature
lswt_uncertainty	units	c	kelvin
lswt_uncertainty	valid_min	s	0
lswt_uncertainty	valid_max	s	10000
lswt_uncertainty	scale_factor	f	0.001
lswt_uncertainty	add_offset	f	0.0
lswt_uncertainty	_FillValue	s	-32768
lswt_uncertainty	comment	c	Total uncertainty was computed with LSWT uncertainties from the Optimal Estimation and bias correction uncertainty.
quality_level	standard_name	c	lake_surface_water_temperature_quality_level
quality_level	long_name	c	quality level of LSWT pixel
quality_level	valid_min	b	0
quality_level	valid_max	b	5
quality_level	flag_meaning	c	no_data bad_data worst_quality low_quality acceptable_quality best_quality
quality_level	flag_value	c	0,1,2,3,4,5
quality_level	_FillValue	b	0

Variable Name	Attribute	Type	Value
quality_level	comment	c	These are quality indicators and they are important to properly use the data.

6.4. Lake Ice Cover (LIC) variables

Variable Name	Attribute	Type	Value
lake_ice_cover	standard_name	c	lake_ice_cover
lake_ice_cover	long_name	c	Lake ice cover
lake_ice_cover	units	c	Category (ice: 128, water: 85, cloud: 42)
lake_ice_cover	valid_min	s	42
lake_ice_cover	valid_max	s	128
lake_ice_cover	_FillValue	s	-32768
lake_ice_cover_uncertainty	standard_name	c	lake_ice_cover_uncertainty
lake_ice_cover_uncertainty	long_name	c	lake ice cover uncertainty
lake_ice_cover_uncertainty	units	c	percentage
lake_ice_cover_uncertainty	valid_min	s	0
lake_ice_cover_uncertainty	valid_max	s	10000
lake_ice_cover_uncertainty	scale_factor	f	0.01
lake_ice_cover_uncertainty	_FillValue	s	-32768

6.5. Lake Water Leaving Reflectance (LWLR) variables

Variable Name	Attribute	Type	Value
Rw[xxx]	_FillValue	f	9.96921e+36
Rw[xxx]	units	c	1 [dimensionless]
Rw[xxx]	standard_name	c	fully_normalized_water_leaving_reflectance_at_[xxx]nm [where xxx is one of 400, 412, 442, 490, 510, 560, 620, 665, 674, 681, 709, 754, 779, 885, 900, 1020]
Rw[xxx]	long_name	c	Fully normalized water-leaving reflectance at [xxx] nm
Rw[xxx]	valid_min	s	0
Rw[xxx]	valid_max	s	1
Rw[xxx]_uncertainty	_FillValue	f	9.96921e+36
Rw[xxx]_uncertainty	units	c	1 [dimensionless]
Rw[xxx]_uncertainty	standard_name	c	fully_normalized_water_leaving_reflectance_at_[xxx]nm_uncertainty
Rw[xxx]_uncertainty	long_name	c	Uncertainty in fully normalized water-leaving reflectance at [xxx] nm
Rw[xxx]_uncertainty	valid_min	s	0
Rw[xxx]_uncertainty	valid_max	s	Inf
chla	_FillValue	f	9.96921e+36
chla	units	c	mg m^{-3}
chla	standard_name	c	mass_concentration_of_chlorophyll_a_in_water_body
chla	long_name	c	concentration of chlorophyll-a
chla	valid_min	s	0
chla	valid_max	s	1000

Variable Name	Attribute	Type	Value
chla_uncertainty	_FillValue	f	9.96921e+36
chla_uncertainty	units	c	mg m^{-3}
chla_uncertainty	standard_name	c	mass_concentration_of_chlorophyll_a_in_water_body_uncertainty
chla_uncertainty	long_name	c	Uncertainty in concentration of chlorophyll-a
chla_uncertainty	valid_min	s	0
chla_uncertainty	valid_max	s	Inf
turbidity	_FillValue	f	9.96921e+36
turbidity	units	c	NTU
turbidity	standard_name	c	turbidity_in_water_body
turbidity	long_name	c	turbidity
turbidity	valid_min	s	0
turbidity	valid_max	s	10000
turbidity_uncertainty	_FillValue	f	9.96921e+36
turbidity_uncertainty	units	c	NTU
turbidity_uncertainty	standard_name	c	turbidity_in_water_body_uncertainty
turbidity_uncertainty	long_name	c	Uncertainty in turbidity
turbidity_uncertainty	valid_min	s	0
turbidity_uncertainty	valid_max	s	Inf

Annex A. Project Acronyms

AATSR	Advanced Along Track Scanning Radiometer
AATSR	Advanced Along Track Scanning Radiometer
AERONET-OC	AErosol RObotic NETwork - Ocean Color
AMI	Active Microwave Instrument
AMSR-E	Advanced Microwave Scanning Radiometer for EOS
APP	Alternating Polarization mode Precision
ASAR	Advanced Synthetic Aperture Radar
ASLO	Association for the Sciences of Limnology and Oceanography
ATBD	Algorithm Theoretical Basis Document
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced very-high-resolution radiometer
BAMS	Bulletin of the American Meteorological Society
BC	Brockman Consult
C3S	Copernicus Climate Change Service
CCI	Climate Change Initiative
CDR	Climate Data Record
CEDA	Centre for Environmental Data Archival
CEMS	Centre for Environmental Monitoring from Space
CEOS	Commitee on Earth Observation Satellites
CGLOPS	Copernicus Global Land Operation Service
CIS	Canadian Ice Service
CLS	Collecte Localisation Satellite
CMEMS	Copernicus Marine Environment Monitoring Service
CMUG	Climate Modelling User Group
CNES	Centre national d'études spatiales
CNR	Compagnie Nationale du Rhône
CORALS	Climate Oriented Record of Altimetry and Sea-Level
CPD	Communiation Plan Document
CR	Cardinal Requirement
CRG	Climate Research Group
CSWG	Climate Science Working Group
CTOH	Center for Topographic studies of the Ocean and Hydrosphere
DUE	Data User Element
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential Climate Variable
ELLS-IAGRL	European Large Lakes Symposium-International Association for Great Lakes Research
ENVISAT	Environmental Satellite
EO	Earth Observation
EOMORES	Earth Observation-based Services for Monitoring and Reporting of Ecological Status
ERS	European Remote-Sensing Satellite
ESA	European Space Agency
ESRIN	European Space Research Institute
ETM+	Enhanced Thematic Mapper Plus
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAQ	Frequently Asqued Questions
FCDR	Fundamental Climate Data Record
FIDUCEO	Fidelity and Uncertainty in Climate data records from Earth Observations
FP7	Seventh Framework Programme

GAC	Global Area Coverage
GCOS	Global Climate Observing System
GEMS/Water	Global Enfonment Monitoring System for freshwater
GEO	Group on Earth Observations
GEWEX	Global Energy and Water Exchanges
GloboLakes	Global Observatory of Lake Responses to Environmental Change
GLOPS	Copernicus Global Land Service
GTN-H	Global Terrestrial Network – Hydrology
GTN-L	Global Terrestrial Network – Lakes
H2020	Horizon 2020
HYDROLARE	International Data Centre on Hydrology of Lakes and Reservoirs
ILEC	International Lake Environment Commettee
INFORM	Index for Risk Management
IPCC	Intergovernmental Panel on Climate Change
ISC	International Science Council
ISO	International Organization for Standardization
ISRO	Indian Space Research Organisation
JRC	Joint Research Centre
KPI	Key Performance Indicateurs
LEGOS	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales
LIC	Lake Ice Cover
LSWT	Lake Surface Water Temperature
LWE	Lake Water Extent
LWL	Lake Water Level
LWLR	Lake Water Leaving Reflectance
MERIS	MEdium Resolution Imaging Spectrometer
MGDR	Merged Geophysical Data Record
MODIS	Moderate Resolution Imaging Spectroradiometer
MSI	MultiSpectral Instrument
MSS	MultiSpectral Scanner
NASA	National Aeronautics and Space Administration
NERC	Natural Environment Research Council
NetCDF	Network Common Data Form
NOAA	National Oceanic and Atmospheric Administration
NSERC	Natural Sciences and Engineering Research Council
NSIDC	National Snow & Ice Data Center
NWP	Numerical Weather Prediction
OLCI	Ocean and Land Colour Instrument
OLI	Operational Land Imager
OSTST	Ocean Surface Topography Science Team
PML	Plymouth Marine Laboratory
PRISMA	PRecursore IperSpettrale della Missione Applicativa
Proba	Project for On-Board Autonomy
R	Linear Correlation Coefficient
RA	Radar Altimeter
RMSE	Root Mean Square Error
SAF	Satellite Application Facility
SAR	Synthetic Aperture Radar
SeaWIFS	Sea-viewing Wide Field-of-view Sensor
SIL	International Society of Limnology
SLSTR	Sea and Land Surface Temperature Radiometer
SoW	Statement of Work
SPONGE	SPaceborne Observations to Nourish the GEMS
SRD	System Requirements Document

SSD	System Specification Document
SST	Sea Surface Temperature
STSE	Support To Science Element
SWOT	Surface Water and Ocean Topography
TAPAS	Tools for Assessment and Planning of Aquaculture Sustainability
TB	Brightness Temperature
TM	Thematic Mapper
TOA	Top Of Atmosphere
TR	Technical Requirement
UNEP	United Nations Environment Programme
UoR	University of Reading
US	United States
VIIRS	Visible Infrared Imaging Radiometer Suite
WCRP	World Climate Research Program
WHYCOS	World Hydrological Cycle Observing Systems
WMO	World Meteorological Organization
WP	Work Package