


Climate Change Initiative Extension (CCI+) Phase 1
New Essential Climate Variables (NEW ECVS)
High Resolution Land Cover ECV (HR_LandCover_cci)

Product User Guide
(PUG)

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Changelog

Issue	Changes	Date
1.0	First version.	21/04/2019
1.1	Revision according to "CCI_HRLC_Ph1_Milestone5_RID-ESA.v1.xlsx"	04/05/2020



Detailed Change Record



Issue	RID	Description of discrepancy	Sections	Change
1.1	FR-01	Suggested to report the reference year 2019 in the title, even if there are fields related to the time coverage.	2.3 Global Attributes (Metadata)	Reference year included in the title metadata.
1.1	FR-02	The LC class legend reported in the Table 2 is the one generated by the climate group and as per AI#41 Climate group to circulate changed legend to the users to have feedback?	2.6 Legend for classification products	The legend related to AI#41 is the LCC legend (as coming from the Users survey). The legend has been updated with latest version and a clarification on the mapping between pixels value and legend codes has been added (see Sections 3.1.1, 4.1.1, 5.1.1).

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1 Introduction

1.1 Executive summary

Following the activities of user requirements updating according to Climate User Community and other users' consultations, the Consortium worked on defining HRLC products requirements accounting for technical constraints such as main data sources available, spatial and temporal coverage, software and tools for quality control. The PUG start from the description of Product Specification and details some of the information that are together with the products (Climate Research Data Package, CRDP). The CRDP v0 is delivered on the basis of the Round Robin activity and will be updated on the basis of the finalization of the processing pipelines and generation of the first version of the products (v1).

The PUG contains the description of the following products that will be part of the Data Package:

- Static High Resolution Land Cover Map for year 2019
- Historical High Resolution Land Cover Map every 5 years since 1990 until 2015
- Historical High Resolution Land Cover Change Detection Map every year since 1990 until 2015
- NDVI/EVI indexes every 4 months since 1990 until 2015

1.2 Purpose and scope

The purpose is to present the product to users having access to the repository of products and to the delivery system. Practically speaking, the document is normally stored in the same directory as the product repository root directory to allow the users to understand the content of the repository and the content of the files without downloading huge amount of data.

The first part of the document presents the summary of the products that will be delivered as specified in the PSD together with introduction to the general product features that applies to all products: Area of Interest, Metadata, Format general considerations and Legend (which applies to classification products).

The second part presents a chapter for each of the product with information on Format, Metadata, Projection and Naming (according to CCI Data Standards).

In the future versions of this document, it will provide more details on the products, some example images screenshots and a detailed user manual for the Delivery System.



1.3 Applicable documents

Ref. Title, Issue/Rev, Date, ID

- [AD1] CCI HR Technical Proposal, v1.1, 16/03/2018
- [AD2] CCI Extension (CCI+) Phase 1 – New ECVs – Statement of Work, v1.3, 22/08/2017, ESA-CCI-PRGM-EOPS-SW-17-0032
- [AD3] Data Standards Requirements for CCI Data Producers, v2.1, 02/08/2019, CCI-PRGM-EOPS-TN-13-0009
- [AD4] Product Specification Document, v2.0, 03/01/2020, CCI_HRLC_Ph1-D2.0_PSD
- [AD5] Product Validation Plan, v2.0, 06/01/2020, CCI_HRLC_Ph1-D2.5_PVP
- [AD6] Algorithm Theoretical Basis Document, v2.0, 03/01/2020, CCI_HRLC_Ph1-D2.2_ATBD
- [AD7] Product Validation and Algorithm Selection Report, v1.0, 29/10/2019, CCI_HRLC_Ph1-D2.1_PVASR
- [AD8] User Requirement Document, v2.1, 22/01/2020, CCI_HRLC_Ph1-D1.1_URD



1.4 Reference documents

N/A

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1.5 Acronyms and abbreviations

API	Application Programming Interface
CCI	Climate Change Initiative
CRC	Climate Research Community
CMUG	Climate Modelling User Group
CREAF	Centre de Recerca Ecològica i Aplicacions Forestals
ECV	Essential Climate Variables
ESM	Earth System Models
EVI	Enhanced Vegetation Index
FTP	File Transfer Protocol
GCOS	Global Climate Observing System
GDPR	General Data Protection Regulation
GIS	Geodata Information System
HR	High Resolution
LAI	Leaf Area Index
LC	Land Cover
LCC	Land Cover Change
LCCS	Land Cover Coverage Classification System
LCML	Land Cover Meta Language
LCZ	Local Climate Zone
LSCE	Laboratoire des Sciences du Climat et de l'Environnement
MR	Medium Resolution
NDVI	Normalized Difference Vegetation Index
PFT	Plant Functional Type
RS	Remote Sensing
SFT	Surface Functional Type
SoW	Statement of Work
URD	User Requirements Document
VM	Virtual meeting
WFS	Web Feature Service
WMS	Web Map Service
WP	Work Package

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2 General Product Description

The user requirements concerning the products generated and the metadata associated are presented in the following sub-sections. Further details can be found in URD [AD8].

2.1 Products summary

In the Product Specification Document (PSD) the climate user requirements described in the User Requirement Document (URD) are turned into a set of products specifications. All requirements, needs and suggestions coming from users' community consultations and other sources have been carefully analysed and considered. The result is a trade-off between user requirements and technical requirements is described in detail in [AD4].

The main output described in the PSD consist of:

- A HRLC map at subcontinental level at spatial resolution 10m as reference static input to the climate models.
- A long-term record of regional HRLC maps at spatial resolution 30m in sub-regions of the static input for historical analysis every 5 years.
- The change information at 30 m and yearly scale for HRLC map update
- NDVI/EVI seasonal composites

The table below summarizes the product to be delivered after the processor/pipeline integration phase. The products are described in detail in the sections

	Static Map	Historical Maps - Classification	Historical Maps - Change Detection	Historical Maps - NDVI/EVI
Products	Classification Map	Classification Map	Change Detection Map	Raster Map
Resolution (meters)	10	30	30	30
Source Data	Sentinel 1, Sentinel 2	Landsat 5-7-8	Landsat 5-7-8	Landsat 5-7-8
Years	2019	1990-1995, 1996-2000, 2001-2005, 2006-2010, 2011-2015	Every year from 1990 to 2015	Every 4 months from 1990 to 2015 (selecting the three less cloudy images in the year)
Projection	UTM WGS84	Latitude Longitude WGS84	Latitude Longitude WGS84	Latitude Longitude WGS84
Encoding	Multiple files (both NetCDF and GeoTIFF) organised in tiles	Multiple files (both NetCDF and GeoTIFF)	Multiple files (both NetCDF and GeoTIFF)	Multiple files (both NetCDF and GeoTIFF)

2.2 Key areas location

The geographical coordinates of the three regions are the following:

Amazonia:

- Static map: (24°S -9°N; 34°W - 62°W)

- Historical LC and LCC map: (24°S - 12°S; 47°W - 62°W)

Sahel:

- Static map: (0°N - 18.5°N; 18°W - 43.5°E),
- Historical LC and LCC map: (4°N - 16°N; 27°E - 43.5°E)

Siberia:

- Static map: (52°N - 79°N; 65°E - 142°E),
- Historical LC and LCC map: (60°N - 74°N; 65°E - 86°E).

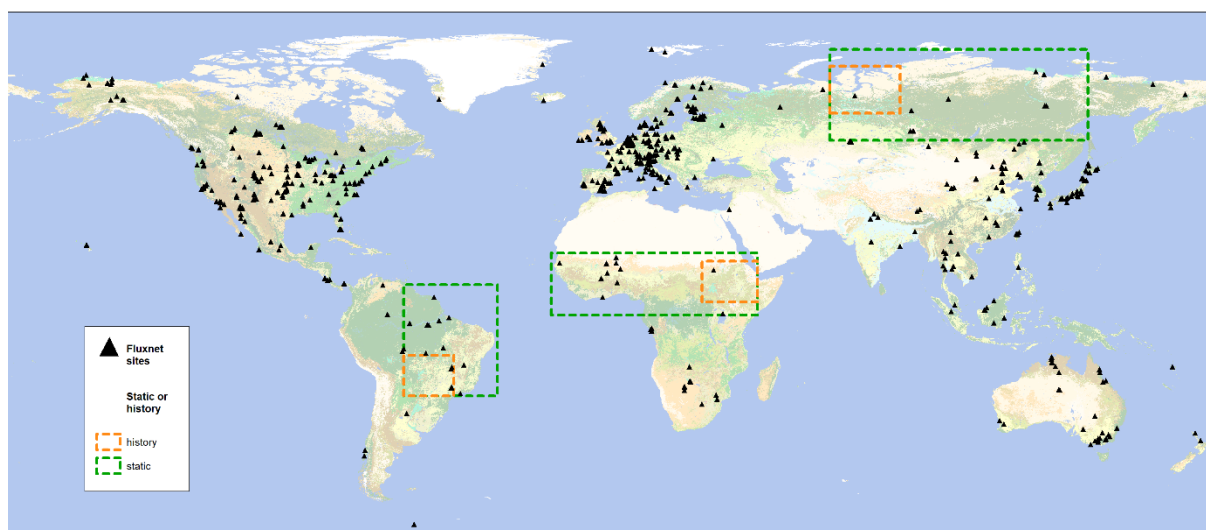




Figure 1. Final requirements for the location of the 3 study areas and Fluxnet sites.



2.3 Global Attributes (Metadata)

The table below contains the description of the global attributes as defined in Data Standards with an example reported in the table.

Global Attribute	Example
title	ESA CCI High Resolution Land Cover 2019 L3P derived from Sentinel 2 L2A and Sentinel 1 L1GRD
Institution	Università degli Studi di Trento Fondazione Bruno Kessler Université Catholique de Louvain Università degli Studi di Pavia Università degli Studi di Genova Politecnico di Milano Université de Versailles Saint Quentin CREA e-GEOS s.p.a. Planetek Italia

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	GeoVille
institution_abbreviation	
source	CCI High Resolution Land Cover Static Map Processing Chain 1.0
history	2020-09-01T14:17:10 UTC -- Creation from processor version v1.0
references	http://cci.esa.int/hrlandcover
Conventions	CF-1.6, ACDD-1.3, ISO 8601
product_version	1.0
summary	Classification product derived from processing of Sentinel 1 and Sentinel 2 with resolution of 10 m over specific Area of Interest with Legend based on a derivation of LCCS
keywords	satellite,observation,ocean
Id	ESACCI-HRLC-L4-MERGED-SAHEL-29PPL-00010m-P1Y-2019-fv01.0.nc
naming authority	Egeos
keywords_vocabulary	NASA Global Change Master Directory (GCMD) Science
keywords	land cover classification
cdm_data_type	Grid
comment	The products are generated as part of ESA CCI HRLC project
date_created	20200901T120000Z
date_modified	20200901T120000Z
creator_name	e-GEOS
creator_url	https://www.e-geos.it
creator_email	cci-hrlc@e-geos.it
creator_institution	e-GEOS
project	Climate Change Initiative - European Space Agency
geospatial_lat_min	4
geospatial_lat_max	16
	degrees_north
geospatial_lon_min	27
geospatial_lon_max	43.5

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geospatial_lon_units	degrees_east
geospatial_vertical_min	0
geospatial_vertical_max	1180
time_coverage_start	20190101T000000Z
time_coverage_end	20191231T000000Z
time_coverage_duration	PT1Y
time_coverage_resolution	PT1Y
geospatial_bounds	POLYGON ((27. 4., 27. 16., 43.5 16., 43.5 4., 27. 4.))
standard_name_vocabulary	NetCDF Climate and Forecast (CF) Metadata Convention version 1.6
license	ESA CCI Data Policy: free and open access
platform	Sentinel 2, Sentinel 1
sensor	sensor
spatial_resolution	10 m
netcdf_version_id	4.3.0 of Jul 8 2013 12:17:12 \$
acknowledgement	Please acknowledge the use of these data with the following statement: these data were obtained from the ESA CCI High Resolution Land Cover project
format_version processing_level	Data Standards Requirements for CCI Data Producers, v2.1, 2 August 2019
processing_software	CCI High Resolution Land Cover Static Map Processing Chain 1.0 deployed on e-GEOS Processing System
processing_level	L3P
key_variables	class
geospatial_lat_units	meters
geospatial_lon_units	meters
geospatial_lon_resolution	10
geospatial_lat_resolution	10



Table 1: Attribute metadata and example content for HRLC products

2.4 Format considerations

Regarding the format of the products, it has been natural to consider both GeoTIFF and NetCDF as encoding of the final output. There are important consideration on this regarding the two encoding as:

NetCDF:

- Is a portable format meant to include metadata internally and to be very generic about scientific data
- Include the coordinates as variables for various purposes (e.g. it allows non rectangular grid)

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- It is meant to store multi-dimensional data
- Has the concept of subdataset which is extremely wide

GeoTIFF:

- Is portable but has not a strict way of storing metadata and there is not a common convention. Anyway, metadata can be added.
- Coordinates are derived by the context (top left pixel position, resolution in x and y)
- Has the concept band which is less general than a subdataset as it inherits from the file encoding (e.g. it does not support different types)

For this reason, as a general behaviour, NetCDF tend to be bigger in dimension (it must store all coordinate values in float) and less compressible. On the other side, the GeoTIFF cannot store different datatypes (e.g. int and float together) so it is impossible to store in the same file both a classification (e.g. integer 8 bit) and a posterior probability (e.g. float 32 bit) or at least a transformation has to be performed like converting the probability in an integer value from 0 to 100 discarding some of the precision.

In general, the choices made in the “format” paragraphs for each product has the objectives to ease the use of the product for different audiences like climate modellers (e.g. NetCDF) or geoinformation experts.

For data types, please consider the following references:

- “Band types of Byte, UInt16, Int16, UInt32, Int32, Float32, Float64, CInt16, CInt32, CFloat32 and CFloat64 are supported for reading and writing. Paletted images will return palette information associated with the band” from <https://gdal.org/drivers/raster/gtiff.html>
- Data Type page from NetCDF official documentation: https://www.unidata.ucar.edu/software/netcdf/documentation/NUG/data_type.html

In the case of GeoTIFF, palette information will be reported whenever possible with information about legend (see paragraph 2.6).

In case of multiple file delivery, for the need of a unique access to a mosaic-like file, a VRT file (GDAL VRT Format, <https://gdal.org/drivers/raster/vrt.html>) will be delivered containing the merge of all the tile for a global view of the area. The use of large files is discouraged due to the poor performance and the need to move large amount of data on the network.

2.5 Archive Directory

The common directory structure for the product repository is based on suggestions and existing conventions used by CCI teams (as requested by the Data Standard document [AD3]) and is arranged as follows:

`/<archive_root>/<type>/<version>/<time>/`

where each <...> may itself be complex, e.g.



- **<time>** may be <year>/<month> or <year>/<day-in-year> or <year>/<month>/<day>
- **<archive-root>** is /esacci/<cci_project>/
- **<cci_project>** is e.g. <hrlc> or <aerosol>
- **<type>** will be different for each ECV, but needs to be defined, and consistent within an ECV
- **<version>** uniquely identifies the version

2.6 Legend for classification products

Here follows the FAO LCCS description of land cover classes selected for the CCI HRLC product. This is used both for classification of the static map and for historical map.

LC CLASS							
CODE	1 st LEVEL	CODE	2 nd LEVEL	CODE	3 rd LEVEL	CODE	4 th LEVEL
10	Tree cover evergreen broadleaf						
20	Tree cover evergreen needleleaf						
30	Tree cover deciduous broadleaf						
40	Tree cover deciduous needleleaf						
50	Shrub cover evergreen	51	Broadleaf				
		52	Needleleaf				
60	Shrub cover deciduous	61	Broadleaf				
		62	Needleleaf				
70	Grasslands	71	Natural				
		72	Managed				
80	Croplands	81	Winter	811	Rainfed		
				812	Irrigated	8121	Sparkling
						8122	Flooding
		82	Summer	821	Rainfed		
				822	Irrigated	8221	Sparkling
						8222	Flooding
		83	Multicropping	831	Rainfed		
				832	Irrigated	8321	Sparkling
						8322	Flooding
90	Woody vegetation aquatic or regularly flooded						
100	Grassland vegetation aquatic or regularly flooded						
110	Lichens and Mosses						
120	Bare areas	121	Unconsolidated	1211	Sands		
				1212	Bare soils		
		122	Consolidated				
130	Built-up	131	Buildings				
		132	Artificial Roads				
140	Open Water seasonal						
150	Open Water permanent						
160	Permanent snow and/or ice	161	Snow				
		162	Ice				

Table 2: Legend for the CCI HRLC

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3 Static High Resolution Land Cover Map Product

3.1 Product Description

The static map at spatial resolution of 10m is one of the main products of the project. Such map will represent the LC of the three sub-continental areas that have been identified in Section 2.1. The static map will refer to the year 2019.

The main sources of information will be Sentinel-2 and Sentinel-1 for the case of optical and radar data, respectively. This focus is explained by the desired spatial resolution of 10m of the product.

The static map will also be associated with a pixelwise measure of uncertainty. Spatial and temporal resolution



The Static Map will be released for year 2019. The production of such product includes analysis and processing of a large quantity of data from Sentinel-1 and Sentinel-2 missions for the full year 2019. We recall that temporal resolution of Sentinel optical data can reach 5 days and even less for overlapping orbits. This revisit time is lowered to up to three days in case of SAR data (less at high latitudes). The processing chain is organised in two parallel stream of processing (Multispectral and SAR) that are combined after the pre-processing step to perform an alignment (coregistration between Multispectral and SAR image) and at the end of separate classification steps where the data fusion is applied to generate the final product. Additional information on the processing chain are given in [AD7] for what concerns the final selection of the algorithm and in [AD6] for what concern the algorithms behind the chain.

The legend of the final classification product is defined in 2.6 according to the analysis made by the Scientific Team together with Climate Modellers.

3.1.1 Format, metadata and projection

Product specifications will be compliant with last update of CCI Data Standards Requirements [AD3]. In particular, this will ensure complete interoperability of HRLC products with other products delivered in the framework of CCI. In particular the metadata will be stored in the NetCDF/GeoTIFF as specified in 2.3 and the format as specified in 2.4. Here we present the table with the list of different information in the dataset (the final data type is specified both for NetCDF and for GeoTIFF versions):

Layer	Description	NetCDF DataType	GeoTIFF DataType	Range
class	Class identified by a number from 1 to 43 and 0 as no data. Classes are identified with the legend described in table 2. Association is done in the metadata.	NC_BYTE	Byte	0 - 43
probability	Probability from 0 to 100	NC_BYTE	Byte	0 - 100
clear_sky	The number of observations with clear sky land coverage, for each pixel	NC_BYTE	Byte	0 - 255
Cloudy	The number of observations of cloudy coverage, for each pixel	NC_BYTE	Byte	0 - 255

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Shadow	The number of observations of cloud shadow coverage, for each pixel	NC_BYTE	Byte	0 - 255
Scenes	The number of images per pixel	NC_BYTE	Byte	0 - 255

Table 3: descriptions of the information content of the product in terms of pixel content (layer, data type, range of values)

The pixel value from 0 – 43 is mapped to the legend values described in paragraph 2.6 and the mapping is reported in metadata (e.g. as attribute in the NetCDF or GeoTIFF) so that any Land Cover class code is mapped uniquely to a pixel value.

The reference projection of the product will be based on the original projection coming from Sentinel 2 data in order to allow the overlay with original Sentinel 2 images without warping. The final delivery will be thus done in tiles (as specified in the naming) following the Sentinel 2 MGRS tiling scheme.

Additional delivery projection and data organisation (WGS84 Lat Lon, Single Mosaic File, Different Tiling) will be discussed at the time of the first delivery taking into account of the size of products and of requirements coming from Climate Modellers.

3.1.2 Naming

The files for each product type are named according to the CCI Data Standards defined

ESACCI-<CCI Project>-<Processing Level>-<Data Type>-<Product String>-<Additional Segregator>] <IndicativeDate>[<Indicative Time>]-fv<File version>.nc

Where:

<CCI Project>

ESACCI- HRLC

<Processing Level>

L4

<Data Type>

Map

<Product String>

MERGED



<Additional Segregator Tile>

Tile code for the area of interest: SAHEL, SIBERIA, AMAZONIA

<Additional Segregator Tile>

Tile code following Sentinel 2 tiling system based on MGRS: 5 total chars

<Additional Segregator Resolution>

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Resolution of the product using 5 digits and unit of measure (m for meters and d for degree)

<Start Date> and <End Date>

The identifying date for this data set is YYYY, where YYYY is the four digit year. As prefix, the indication of the period is given as specified in Data Standard document with ISO notation

<File Version>

File version number in the form n{1,}[.n{1,}] (That is 1 or more digits followed by optional . and another 1 or more digits).

Example:

- ESACCI-HRLC-L4-MERGED-SAHEL-29PPL-00010m-P1Y-2019-fv01.0.nc
- ESACCI-HRLC-L4-MERGED-SAHEL-29PPL-00010m-P1Y-2019-fv01.0.tif

3.1.3 Delivery

The delivery will be managed in two ways:

- FTP or HTTP service with data organised in a folder structure as specified in 2.5
- Delivery system with possibility to use WMS/WCS services and a user interface

Here is an example of the Web Interfaces showing a classification product:

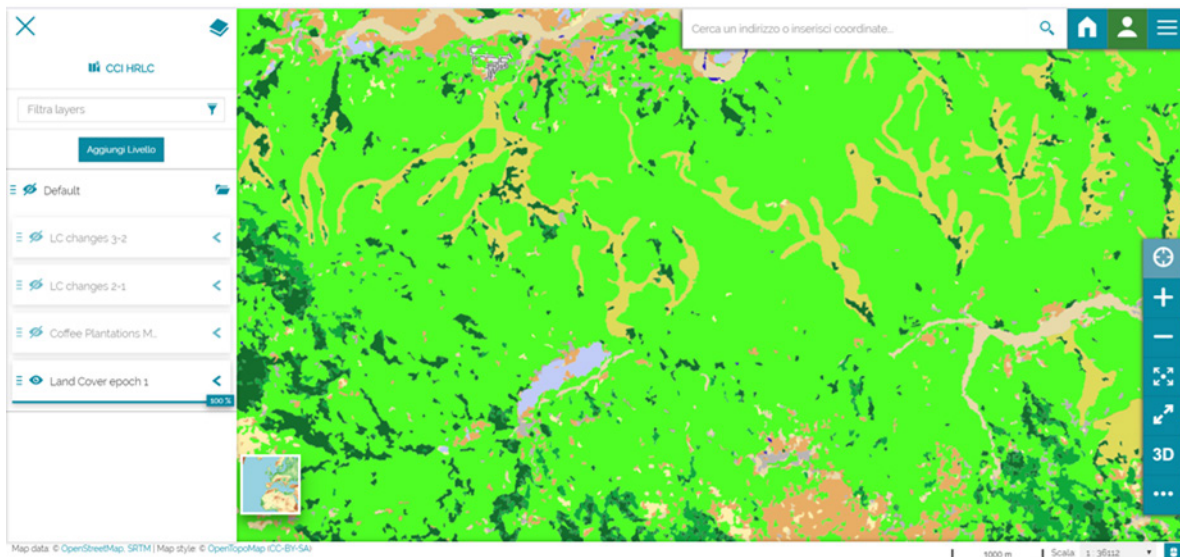




Figure 2: Example visualization of classification product through a Web-GIS interface accessing a WMS service

4 Historical High Resolution Land Cover Map Product

4.1 Product Description

The historical map at spatial resolution of 30m is one of the main products of the project. Such map will represent the LC of the three sub-continental areas that have been identified in Section 2.1. The static map will be produced

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on the basis of Landsat acquisitions of 5 years (to allow to have enough scenes to be used) and in particular for the following 5-years periods: 1990-1995, 1996-2000, 2001-2005, 2006-2010, 2011-2015

The main sources of information will be Landsat 5, Landsat 7 and Landsat 8 and also ERS-1, ERS-2, ENVISAT-ASAR will also be considered. The land cover map will also be associated with a pixelwise measure of uncertainty.

The Land Cover Map Change product is part of the Historical high resolution land cover chain and is based on the following steps: i) production of a LC change map for each year; and ii) production of the 5-year LC maps after the analysis of the related yearly LC change maps. Additional information on the processing chain are given in [AD7] for what concerns the final selection of the algorithm and in [AD6] for what concern the algorithms behind the chain.

The Land Cover Change Detection product is described in chapter 5.

Spatial and temporal resolution of the historical HRLC map products of the CCI HRLC are summarized in **Error! Reference source not found.**



4.1.1 Format, metadata and projection

Product specifications will be compliant with last update of CCI Data Standards Requirements [AD3]. In particular, this will ensure complete interoperability of HRLC products with other products delivered in the framework of CCI. In particular the metadata will be stored in the NetCDF/GeoTIFF as specified in 2.3 and the format as specified in 2.4. Here we present the table with the list of different information in the dataset (the final data type is specified both for NetCDF and for GeoTIFF versions):

Layer	Description	NetCDF DataType	GeoTIFF DataType	Range
class	Class identified by a number from 1 to 43 and 0 as no data. Classes are identified with the legend described in table 2. Association is done in the metadata.	NC_BYTE	Byte	0 - 43
probability	Probability from 0 to 100	NC_BYTE	Byte	0 - 100
clear_sky	The number of observations with clear sky land coverage, for each pixel	NC_BYTE	Byte	0 - 255
cloudy	The number of observations of cloudy coverage, for each pixel	NC_BYTE	Byte	0 - 255
shadow	The number of observations of cloud shadow coverage, for each pixel	NC_BYTE	Byte	0 - 255
scenes	The number of images per pixel	NC_BYTE	Byte	0 - 255

Table 4: descriptions of the information content of the product in terms of pixel content (layer, data type, range of values)

The pixel value from 0 – 43 is mapped to the legend values described in paragraph 2.6 and the mapping is reported in metadata (e.g. as attribute in the NetCDF or GeoTIFF) so that any Land Cover class code is mapped uniquely to a pixel value.

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The reference projection of the product will be based on the original projection coming from Sentinel 2 data in order to allow the overlay with original Landsat images without warping. The final delivery will be thus done in tiles (as specified in the naming) following the Landsat Path/Row tiling scheme.

Additional delivery projection and data organisation (WGS84 Lat Lon, Single Mosaic File, Different Tiling) will be discussed at the time of the first delivery taking into account of the size of products and of requirements coming from Climate Modellers.

4.1.2 Naming

The files for each product type are named according to the CCI Data Standards defined

ESACCI-<CCI Project>-<Processing Level>-<Data Type>-<Product String>-<Additional Segregator> <IndicativeDate>[<Indicative Time>]-fv<File version>.nc

Where:

<CCI Project>

ESACCI- HRLC

<Processing Level>

L4

<Data Type>

Map

<Product String>

MERGED

<Additional Segregator Tile>

Tile code for the area of interest: SAHEL, SIBERIA, AMAZONIA

<Additional Segregator Tile>

Tile code following Landsat Path/Row using 3 chars for Path and 3 chars for Row: PPPRRR

<Additional Segregator Resolution>

Resolution of the product using 5 digits and unit of measure (m for meters and d for degree)



<Additional Segregator Tile>

Specific to Change Maps: LandCover

<Start Date> and <End Date>

The identifying date for this data set is YYYY, where YYYY is the four digit year of the last year

<File Version>

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File version number in the form n{1,}[.n{1,}] (That is 1 or more digits followed by optional . and another 1 or more digits).

Example:

- ESACCI-HRLC-L4-MERGED-SAHEL-171051-00030m-LandCover-P5Y-2015-fv01.0.nc
- ESACCI-HRLC-L4-MERGED-SAHEL-171051-00030m-LandCover-P5Y-2015-fv01.0.tif

4.1.3 Delivery

The delivery will be managed in two ways:

- FTP or HTTP service with data organised in a folder structure as specified in 2.5
- Delivery system with possibility to use WMS/WCS services and a user interface

5 Historical High Resolution Land Cover Change Detection

5.1 Product Description

The historical map change detection at spatial resolution of 30m is one of the main products of the project. Such map will represent the change in the land cover (the value in the pixel is the class to which the pixel has changed) of the three sub-continental areas that have been identified in Section 2.1. The change map will be produced on the basis of Landsat acquisitions of 1 year from 1990-2019.

The main sources of information will be Landsat 5, Landsat 7 and Landsat 8.

The Land Cover Map Change product is part of the Historical high resolution land cover chain and is based on the following steps: i) production of a LC change map for each year; and ii) production of the 5-year LC maps after the analysis of the related yearly LC change maps. Additional information on the processing chain are given in [AD7] for what concerns the final selection of the algorithm and in [AD6] for what concern the algorithms behind the chain.



The Land Cover Map product is described in chapter 5.

Spatial and temporal resolution of the historical HRLC map products of the CCI HRLC are summarized in **Error! Reference source not found.**

5.1.1 Format, metadata and projection

Product specifications will be compliant with last update of CCI Data Standards Requirements [AD3]. In particular, this will ensure complete interoperability of HRLC products with other products delivered in the framework of CCI. In particular the metadata will be stored in the NetCDF/GeoTIFF as specified in 2.3 and the format as specified in 2.4. Here we present the table with the list of different information in the dataset (the final data type is specified both for NetCDF and for GeoTIFF versions):

Layer	Description	NetCDF DataType	GeoTIFF DataType	Range
class	Class identified by a number from 1 to 16 and 0 as no data. Classes are identified with the legend described in Table 2. The value is the class to which the pixel has	NC_BYTE	Byte	0 - 16

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	changed (considering only level 1 of the LC legend). Association is done in the metadata.			
probability	Probability from 0 to 100	NC_BYTE	Byte	0 - 100

Table 5: descriptions of the information content of the product in terms of pixel content (layer, data type, range of values)

The pixel value from 0 – 16 is mapped to the legend values described in paragraph 2.6 (only Level 1 in the case of change detection) and the mapping is reported in metadata (e.g. as attribute in the NetCDF or GeoTIFF) so that any Land Cover class code is mapped uniquely to a pixel value.

The reference projection of the product will be based on the original projection coming from Sentinel 2 data in order to allow the overlay with original Landsat images without warping. The final delivery will be thus done in tiles (as specified in the naming) following the Landsat Path/Row tiling scheme.

This additional delivery projection and data organisation (WGS84 Lat Lon, Single Mosaic File, Different Tiling) will be discussed at the time of the first delivery taking into account of the size of products and of requirements coming from Climate Modellers.

5.1.2 Naming

The files for each product type are named according to the CCI Data Standards defined

ESACCI-<CCI Project>-<Processing Level>-<Data Type>-<Product String>[-<Additional Segregator>] <IndicativeDate>[<Indicative Time>]-fv<File version>.nc

Where:

<CCI Project>

ESACCI- HRLC

<Processing Level>

L4

<Data Type>

Map

<Product String>

MERGED



<Additional Segregator Tile>

Tile code for the area of interest: SAHEL, SIBERIA, AMAZONIA

<Additional Segregator Tile>

Tile code following Landsat Path/Row using 3 chars for Path and 3 chars for Row: PPPRRR

<Additional Segregator Resolution>

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Resolution of the product using 5 digits and unit of measure (m for meters and d for degree)

<Additional Segregator Tile>

Specific to Change Maps: ChangeDetection

<Start Date> and <End Date>

The identifying date for this data set is YYYY, where YYYY is the four digit year

<File Version>

File version number in the form n{1,}[.n{1,}] (That is 1 or more digits followed by optional . and another 1 or more digits).

Example:

- ESACCI-HRLC-L4-MERGED-SAHEL-171051-00030m-ChangeDetection-P1Y-2015-fv01.0.nc
- ESACCI-HRLC-L4-MERGED-SAHEL-171051-00030m-ChangeDetection-P1Y-2015-fv01.0.tif

5.1.3 Delivery

The delivery will be managed in two ways:

- FTP or HTTP service with data organised in a folder structure as specified in 2.5
- Delivery system with possibility to use WMS/WCS services and a user interface

Here is an example of the Web Interfaces showing a change detection product with the possibility to show “transitions” among different land cover or only those of interest:

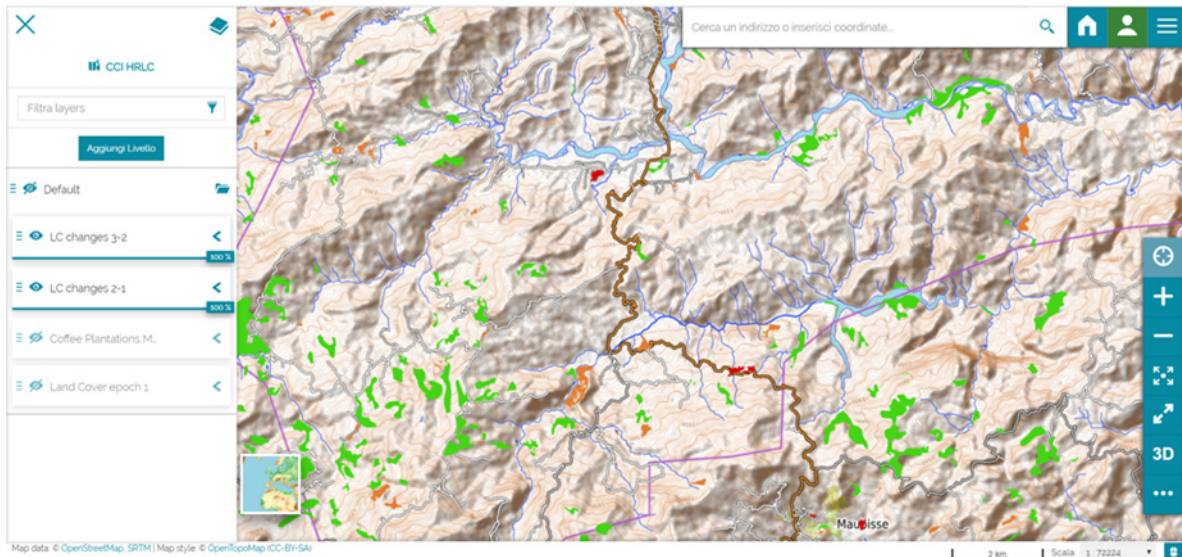




Figure 3: Example visualization of change detection product through a Web-GIS interface accessing a WMS service

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6 Historical High Resolution Land Cover NDVI/EVI

6.1 Product Description

The NDVI products are derived from internal steps of the historical map land cover processing chain. During the processing, an additional step will be added to derive 3 files per analyzed year (1990-2019) that corresponds to, alternatively:

- One image per season (not including winter one for obvious reasons)
- Less cloudy images per year (which are not necessarily equally distributed in time).

The product is made of one single band and there is no confidence information, since it is a simple mathematical product that does not depend on any further process from our side.

6.1.1 Format, metadata and projection

Product specifications will be compliant with last update of CCI Data Standards Requirements [AD3]. In particular, this will ensure complete interoperability of HRLC products with other products delivered in the framework of CCI. In particular the metadata will be stored in the NetCDF/GeoTIFF as specified in 2.3 and the format as specified in 2.4. Here we present the table with the list of different information in the dataset (the final data type is specified both for NetCDF and for GeoTIFF versions):

Layer	Description	NetCDF DataType	GeoTIFF DataType	Range
index	NDVI/EVI value for each pixel with values ranging from [-1,1], representing areas with no vegetation (NDVI<0) and areas with vegetation (NDVI>0).	NC_FLOAT	Float32	continuous values from -1 to 1

Table 6: descriptions of the information content of the product in terms of pixel content (layer, data type, range of values)

The reference projection of the product will be based on the original projection coming from Sentinel 2 data in order to allow the overlay with original Landsat images without warping. The final delivery will be thus done in tiles (as specified in the naming) following the Landsat Path/Row tiling scheme.

This additional delivery projection and data organisation (WGS84 Lat Lon, Single Mosaic File, Different Tiling) will be discussed at the time of the first delivery taking into account of the size of products and of requirements coming from Climate Modellers.

6.1.2 Naming



The files for each product type are named according to the CCI Data Standards defined

ESACCI-<CCI Project>-<Processing Level>-<Data Type>-<Product String>-<Additional Segregator>[<IndicativeDate>[<Indicative Time>]-fv<File version>.nc

Where:

<CCI Project>

ESACCI- HRLC

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<Processing Level>

L3

<Data Type>

NDVI or EVI

<Product String>

MERGED

<Additional Segregator Tile>

Tile code for the area of interest: SAHEL, SIBERIA, AMAZONIA

<Additional Segregator Tile>

Tile code following Landsat Path/Row using 3 chars for Path and 3 chars for Row: PPPRRR

<Additional Segregator Resolution>

Resolution of the product using 5 digits and unit of measure (m for meters and d for degree)

<Start Date> and <End Date>

The identifying date for this data set is MM-YYYY, where MM is the month YYYY is the four digit for the year of the last acquisition used to calculate the NDVI composite

<File Version>

File version number in the form n{1,}[.n{1,}] (That is 1 or more digits followed by optional . and another 1 or more digits).

Example:

- ESACCI-HRLC-L3-NDVI-SAHEL-171051-00030m-P4M-032015-fv01.0.nc
- ESACCI-HRLC-L3-NDVI-SAHEL-171051-00030m-P4M-032015-fv01.0.tif

6.1.3 Delivery

The delivery will be managed in two ways:



- FTP or HTTP service with data organised in a folder structure as specified in 2.5
- Delivery system with possibility to use WMS/WCS services and a user interface

7 Quality documentation

7.1 Quality Flags

The quality of both the static and historical HR LC maps generated in this project is first documented using a set of quality flags and values, determined on a per-pixel basis. These are:

1. The status of the pixel, being produced during the pre-processing, through the pixel identification step.

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Six statuses are proposed: “Cloud”, “Shadow”, “Clear land”, “Invalid” and “Filled”.

2. If the pixel has a status different from “Invalid” and “Filled”, an indicator describing the overall quality of the reflectance value (derived from the pre-processing)
3. The number of valid and cloud-free observations used for the classification
4. If the pixel has a status different from “Invalid” and “Filled”, an indicator describing the uncertainty associated with the land cover class.
5. For the HR historical maps, an indicator describing if the pixel has changed with regards to the previous period.

These information on the pre-processing are then made available in the final product as specified in 3.1.1, in 4.1.1 and in 5.1.1 with availability of posteriors probability for all the L4 products and the addition of the specific information on “Cloud”, “Shadow” and “Clear Land” of the scenes concurring to the generation of the map (only for Land Cover maps, not available for Change Detection map).

7.2 Independent validation

A statistical validation framework was established in the context of the GlobCover and CCI Moderate Resolution (MR) LC projects. This statistical validation framework is organized in four steps as described in Figure 4. These steps are adjusted to the CCI+ HRLC mapping activities: RR, static maps and change detection.

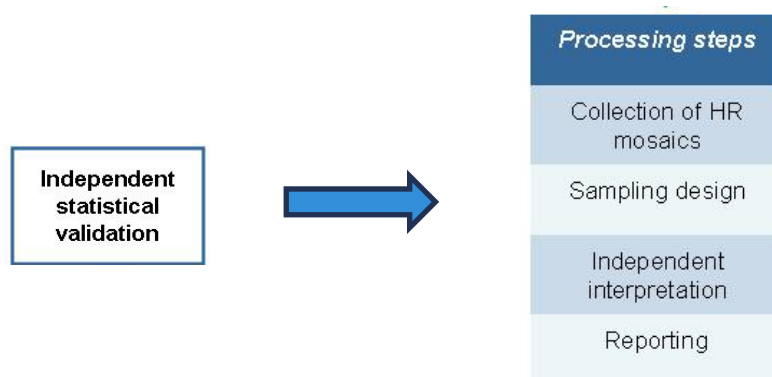




Figure 4. Different components of the independent statistical validation component.

LC product accuracy is assessed by comparison with independent data sources such as, ground based in-situ measurements or higher resolution satellite data. The collection of higher resolution satellite as “ground truth” is considered as the best option to support the validation of remote sensing products in general and of the HR LC maps in particular.

Reference data samples are collected on specific areas designed to be statistically valid for accuracy assessment of the HR LC products, to address the issues of rare classes with a strong impact on the climate system (urban areas, wetlands, etc.) and to bias a specific sampling for the LC change validation.

The reference data sources are then intended to be interpreted over each validation samples through an international network of experts in a standardized manner.

Then, the classification is compared to the reference data, and the extent to which these two classifications agree is defined as map accuracy. The full methodology and the accuracy figures are documented in the Product Validation Plan [AD5].

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8 User Tool

All the High Resolution Land Cover products will be available through the CCI Climate Open Data portal and accessible with different methods like:

- FTP
- WMS/WCS

The link to the Delivery System will be made available to the Users as soon as the products are available. The User Manual will be also added to this section.

The Delivery System is meant to be interfaced by the CCI Toolbox in order to provide easy functionalities for retrieving.

Appropriate color mapping will be provided in different formats such as SLD (Styled Layer Descriptor) usable in QGIS and in the CCI Toolbox format to be included directly as information retrieved from the CCI Open Data Portal.