Land Cover CCI

PRODUCT USER GUIDE - YEAR 1

VERSION 1.1

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SYMBOLS AND ACRONYMS

(A)ATSR : (Advanced) Along Track Scanning Radiometer

API : Application Programming Interface

ASAR : Advanced Synthetic Aperture Radar

ATBD : Algorithm Theoretical Basis Document

AVHRR : Advanced Very High Resolution Radiometer

BC : Brockmann-Consult

CCI : Climate Change Initiative

CCI-LC : Climate Change Initiative Land Cover

CEOS : Committee on Earth Observation Satellites

CEOS-WGCV : CEOS Working Group on Calibration and Validation

CMC : Climate Modelling Community

CMIP : Coupled Model Intercomparison Project

CMUG : Climate Modelling User Group

CRS : Coordinate Reference System

ECV : Essential Climate Variable

ERS : European Remote Sensing Satellite

Envisat : Environmental Satellite

EO : Earth Observation

ESA : European Space Agency

ET : Evapotranspiration

fAPAR : Fraction-Absorbed Photosynthetically Active Radiation

FR : Full Resolution

Gamma-RS : Gamma Remote Sensing

GCOS : Global Climate Observing System

GCS : Global Coordinate System

GDAL : Geospatial Data Abstraction Library

GFED : Global Fire Emissions Database

GIMMS : Global Inventory Monitoring and Modelling System

GIS : Geographic Information System

GMM : Global Monitoring Mode

GRASS	: Geographic Resources Analysis Support System
IMM	: Image Mode Medium
IPCC	: Intergovernmental Panel on Climate Change
ISSI	: International Space Science Institute
LAI	: Leaf Area Index
Landsat	: Land remote sensing Satellite
LC	: Land Cover
LCCS	: Land Cover Classification System
LS	: Land Surface
MERIS	: Medium Resolution Imaging Spectrometer
MODIS	: Moderate Resolution Imaging Spectroradiometer
NDVI	: Normalized Difference Vegetation Index
NIR	: Near InfraRed
NLCD	: National Land Cover Database
OLCI	: Ocean and Land Colour Instrument
PFT	: Plant Functional Types
PROBA-V	: Project for On-Board Autonomy, with the V standing for Vegetation
PUG	: Product User Guide
RR	: Reduced Resolution
SAR	: Synthetic Aperture Radar
SLSTR	: Sea and Land Surface Temperature Radiometer
SPOT	: Satellite Pour l'Observation de la Terrre
SPOT-VGT	: SPOT- Vegetation
SR	: Surface Reflectance
SRTM	: Shuttle Radar Topography Mission
SWBD	: SRTM Water Body Database
UCL	: Université catholique de Louvain
UN	: United Nations
UNFCCC	: United Nations Framework Convention on Climate Change
WB	: Water Body
WGS84	: World Geodetic System 84
WSM	: Wide Swath Mode

REFERENCE DOCUMENTS

Applicable documents

ID	TITLE	ISSUE	DATE
AD.1	Statement of Work for ESA Climate Change Initiative Phase II - CCI-PRGM-EOPS-SW-12-0012	1.2	07.06.2013
AD.2	ESA Climate Change Initiative Phase II - Land Cover ECV Technical baseline for the project (update of the technical proposal with clarification and negotiation items)	1.0	13.03.2014
AD.3	CCI System Requirements v1, CCI-PRGM-EOPS-TN-12-0031 Available on line at: http://46.137.76.174/?q=webfm_send/72.	1.0	13.06.2013
AD.4	CCI-LC URD Phase II. Land Cover Climate Change Initiative - User Requirements Document	1.1	30.11.2014
AD.5	CCI-LC PSD Phase II. Land Cover Climate Change Initiative - Product Specification Document	1.1	01.12.2014
AD.6	CCI-LC DARD Phase II. Land Cover Climate Change Initiative - Data Access Requirement Document	1.1	30.11.2014
AD.7	CCI-LC ATBD Phase II. Land Cover Climate Change Initiative - Algorithm Specification Document - Part I: Overview	1.1	03.12.2014
AD.8	CCI-LC ATBD Phase II. Land Cover Climate Change Initiative - Algorithm Specification Document - Part II: Pre-processing	1.1	03.12.2014
AD.9	CCI-LC ATBD Phase II. Land Cover Climate Change Initiative - Algorithm Specification Document - Part III: LC classification	1.1	03.12.2014
AD.10	CCI-LC ATBD Phase II. Land Cover Climate Change Initiative - Algorithm Specification Document - Part IV: LS seasonality	1.1	03.12.2014
AD.11	CCI-LC ATBD Phase II. Land Cover Climate Change Initiative - Algorithm Specification Document - Part V: WB classification	1.1	03.12.2014

Reference documents

ID	TITLE	ISSUE	DATE
RD.1	CCI-LC URD Phase I. Land Cover Climate Change Initiative - User Requirements Document	2.2	23.02.2011
RD.2	CCI-LC PSD Phase I. Land Cover Climate Change Initiative - Product Specification Document	1.11	03.07.2014

ID	TITLE	ISSUE	DATE
RD.3	CCI-LC PVP Phase I. Land Cover Climate Change Initiative - Product Validation Plan	1.3	04.07.2011
RD.4	CCI-LC ATBD Phase I. Land Cover Climate Change Initiative - Algorithm Theoretical Basis Document	2.3	28.11.2013
RD.5	CCI-LC PVASR Phase I. Land Cover Climate Change Initiative - Product Validation and Algorithms Selection Report	2.2	03.07.2012
RD.6	CCI-LC PUG Phase I. Land Cover Climate Change Initiative - Product User Guide	2.4	02.09.2014
RD.7	CCI-LC project Phase I - Production of a reference dataset for the validation of the Water bodies product (D3 of CCN4)	1.0	07.08.2013
RD.8	Di Gregorio A., 2005, UN Land Cover Classification System (LCCS) – Classification concepts and user manual for Software version 2. Available at: www.glcn-lccs.org		
RD.9	Bicheron, P., Defourny, P., Brockmann, C., Schouten, L., Vancutsem, C., Huc, M., Bontemps, S., Leroy, M., Achard, F., Herold, M., Ranera, F., Arino, O. GlobCover: products description and validation report, ESA GlobCover project. Available at: http://due.esrin.esa.int/globcover/	2.0	05.09.2008
RD.10	Bontemps, S., Herold, M., Kooistra, L., van Groenestijn, A., Hartley, A., Arino, O., Moreau, I., and Defourny, P. (2012). Revisiting land cover observations to address the needs of the climate modelling community. Biogeosciences, 9, 2145-2157, doi:10.5194/bgd-9-2145-2012		2012
RD.11	Global Mangrove Atlas. Available at: http://geodata.grid.unep.ch/results.php		
RD.12	Randolph Inventory Glaciers. Available at: http://www.glims.org/RGI/		
RD.13	Bontemps, S., Defourny, P., Van Bogaert, E., Kalogirou, V. and Arino, O., GlobCover 2009 - Products Description and Validation Report (2010). Available at: http://due.esrin.esa.int/globcover/		2010
RD.14	Committee on Earth Observation Satellites, 2008, Working Group on Information Systems and Services - Interoperability Handbook, February 2008 Issue 1.1. Available at: http://www.eohandbook.com/	1.1	2008
RD.15	Verhegghen A., Bontemps S. and Defourny, P., 2014. Global land-surface phenology reference dataset from 13 years NDVI and EVI SPOT VEGETATION time series analysis. International Journal of Remote Sensing, 35, 7, 2440-2471.		2014
RD.16	NetCDF Climate and Forecast (CF) Metadata Conventions,	1.5	25.10.2010
RD.17	Bennett, V, Guidelines for Data Producers - Climate Change Initiative Phase I, CCI-PRGM-EOPS-TN-11-0003	2.1	20.03.2012
RD.18	The Geospatial Data Abstraction Library website : http://www.gdal.org/		
RD.19	The Geographic Resources Analysis Support System (GRASS GIS) website : http://grass.osgeo.org/		

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1 INTRODUCTION

1.1 Scope

The Product User Guide (PUG) is the reference product description, which describes the products' data format, filenames, metadata, as well as their contents, with the aim to enable users to work with the products.

During the 1st phase of the Climate Change Initiative (CCI), a set of products were generated, consisting in a set of 3 consistent global Land Cover (LC) products corresponding to the 1998-2002, 2003-2007 and 2008-2012 periods, climatological 7-day time series representing seasonal dynamics of the land surface, the Medium Resolution Imaging Spectrometer (MERIS) Surface Reflectance (SR) time series which served as input for generating the global land cover maps and a global Water Body (WB) product derived from the Envisat Advanced Synthetic Aperture Radar (ASAR) archives. These products were described in a PUG [RD.6], which was made available to the users along with the products (http://maps.elie.ucl.ac.be/CCI/viewer/index.php).

In March 2014, a 2nd phase of project started and a new set of products will be generated, that will be described in this document. This document reflects the current state of the project and will thus evolve throughout the project.

1.2 Background of the project

The European Space Agency (ESA) CCI projects will deliver the next generation of satellite derived geophysical parameters, with quantified uncertainties that will allow each parameter to be assessed against requirements from the Global Climate Observing System (GCOS) for Essential Climate Variables (ECV) and the Climate Modelling Community (CMC), represented within the CCI program by the Climate Modelling User Group (CMUG).

The objective of the CCI is to realize the full potential of the long-term global Earth Observation (EO) archives that ESA together with its Member states have established over the last thirty years, as a significant and timely contribution to the ECV databases required by United Nations Framework Convention on Climate Change (UNFCCC). The programme is organized in 2 phases.

The CCI Phase I provided a unique opportunity for the European EO science community to define and validate innovative approaches for continuously generating and updating a comprehensive and consistent set of ECV global satellite based data products in the long term – i.e. decades hence. The focus was on a major sustained, and coordinated scientific effort to review and improve underlying processing, retrieval and validation methods.

The CCI Phase II focuses on the generation of long-term, consistent, global data records for each ECV, exploiting the full range of available data sets from ESA and relevant European missions with the aim to issue extended and improved globally consistent ECV data sets from all CCI projects. Each

project must make significant, further progress towards meeting the GCOS and related user requirements, exceeding the achievements of the Phase I CCI projects with quantifiable validated measure of performance.

This means the prototype ECV production systems implemented in CCI Phase I, must be developed to a sustainable level, based on complete requirements specified and thoroughly validated by the competent science communities during Phase I [AD.3] These system requirements must be updated to take account of the availability of new and upcoming missions (e.g. Landsat-8, Sentinels, PROBA-V) and evolution to meet industry level standards for operations, maintenance, evolution and configuration control. Phase II projects should follow an iterative life-cycle, of concurrent development and operations. Project activities must continue to be driven by climate science, traceable to documented user needs and CCI projects must engage the relevant science communities, working side-by-side with industry and data centres in Europe.

1.3 Structure of the document

After this introduction, the document is divided into 7 sections that are shortly described below:

- Section 2 briefly presents the CCI Land Cover (CCI-LC) project;
- Sections 3 to 6 describes the different products: land cover maps, land surface seasonality product, open water bodies product and surface reflectance time series;
- Section 7 presents the various tools that can be used to visualize and aggregate the products;
- Section 8 explains how to access the CCI-LC products and give their terms of use.

This document also contains various appendices to provide additional detailed information.

2 CCI LAND COVER PROJECT

2.1 Revisited land cover concept

Considering the importance of land cover as an input in climate modelling, the development of a new global LC database was initiated during the 1st phase of the project. The specifications of this new database relied on an in-depth user requirement analysis conducted during the 6 first months of the Phase I project [RD.1].

This analysis revealed first the need to consider LC data under 2 aspects: ***stable*** in the form of land cover map and and ***dynamic*** in the form of time series. In addition, the LC products should provide ***flexibility*** to serve different scales and purposes in terms of spatial and temporal resolutions. Their quality should also be transparent by using ***quality flags*** and controls.

From a remote sensing point of view, these requirements – and the first one in particular – led in rethinking the whole LC concept into ***LC state*** and ***LS seasonality*** components [RD.2]. The ***LC state*** concept refers to the set of LC features remaining stable over time which define the LC independently of any sources of temporary or natural variability. It is agreed that the LC state is well described using the United Nations (UN) Land Cover Classification System (LCCS) [RD.8], which is also quite compatible with the Plant Function Types (PFT) concept of many models [RD.1]. The ***LS seasonality*** concept relates directly to the temporary or natural variability of LC features that can induce some variation in land surface over time without changing the LC in its essence. This LS seasonality is typically driven by biogeophysical processes. It encompasses different observable variables such as the green vegetation phenology, snow coverage, open water presence, and burned areas occurrence, etc.

Furthermore, the need to generate successive LC state products consistent over time resulted in the development of a new original classification approach. Most often, LC maps were generated from few instantaneous observations of the land cover state. As a result, classification outputs are sensitive to the date(s) of observation and can reflect temporary conditions (e.g. map savannahs as burnt scars, boreal forest as snow, croplands as bare soils, etc.). The developed alternative consisted in describing the LC state ***from multi-year observation dataset***. In this case, assuming that no LC change – even temporary – has occurred over this multi-year period, the LC is expected to be mapped in a consistent way over time. This approach was successfully implemented in the 1st phase and will be continued in this 2nd phase.

2.2 Users' requirements

At the beginning of the 2nd phase of the project, a new user survey was conducted among the climate modelling partners of the CCI-LC project to analyze the fulfillment of the requirements defined in Phase I and to identify target requirements for future LC products. The comprehensive user survey

results of Phase I were reanalyzed (excepted future modeling requirements) and consolidated through synthesizing new user needs from the scientific community from initiatives such as Terrabytes and International Space Science Institute (ISSI) special group, from Coupled Model Intercomparison Project (CMIP) 6 process and from the outcomes of the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC). The GCOS process has started to specify new ambitions for ECVs to meet the needs of the climate mitigation community – this also posed new requirements for the CCI-LC project. This activity is documented in details in [AD.4]. It resulted in a series of new requirements, which were organized into higher or lower priority categories:

1) Higher priority

a) Better description of LC characteristics in the context of PFT model requirements. As a follow up of the Phase I work, the new requirement is to formulate LC – PFT conversion tables separately for different climatic regions. These regions are to be defined by the climate modeler users of the consortium, with PFT fractions per region identified using the land cover validation dataset.
b) In particular, the percentage ranges for LC – PFT conversion in the case of mixed classes, for example the class 'mosaic tree and shrub (>50%) / herbaceous (<50%)', should be better defined in order to provide the proportion (%) of tree, shrub, and herbaceous.
c) Longer temporal extent for LC maps (30 years and more) including datasets for the 1990's and the 1980's.
d) Higher temporal resolution: annual time steps in LC change.
e) More specific information of land cover/use change is required, at least in the context of the IPCC land categories (forests, agriculture, grassland, settlement, wetland, other land).
f) Additional attributes of the LC classes are demanded including vegetation height, minimum and maximum Leaf Area Index (LAI), clumping index and the distinction between C3 and C4 plants.

2) Lower priority

a) Move to 30 m (or better) scale LC and change assessments, at least for selected regions.
b) Seek options for including land management (forestry, agriculture, livestock) with land cover datasets.
c) Provide additional LS seasonality such as Fraction-Absorbed Photosynthetically Active Radiation (fAPAR), surface albedo for vegetation and soil LC classes.
d) Provide additional relevant attributes of LC classes such as aboveground tree biomass, vegetation density, and permafrost fraction.
e) Improve the description of the results and products. Besides the detailed technical reports, short technical summaries highlighting important points should be provided.

The requirements are summarized in Figure 2-1.

	Threshold requirement Phase I	Target requirement Phase I	Threshold requirement Phase II	Target requirement Phase II
	Coverage and sampling			
Geographic Coverage	*Global* ✓	*Global with regional and local specific products* ✗	*Global with regional specific products*	*Global with regional specific products*
Temporal sampling	*Best/stable map and regular updates* ✓	*Monthly data on vegetation dynamics and change* ✓	*5-10 year epoch maps with monthly vegetation dynamics(NDVI)*	*1-year epoch maps. Monthly data on vegetation dynamics (NDVI)*
Temporal extent	*1-2 years, most recent* ✓	*1990 (or earlier)-present* ✗	*1990 (or earlier) - present*	*1980 (or earlier) - present*
	Resolution			
Horizontal Resolution	*1000 m* ✓	*30 m* ✗	*300 m with regional 30 m products*	*30 m*
Vertical Resolution	–	–		
	Error/Uncertainty			
Precision	*Thematic land cover detail sufficient to meet current modelling user needs* ✗	*Thematic land cover detail sufficient to meet future model needs* ✗	*Thematic land cover detail (incl. conversion tables to PFT for climatic regions) sufficient to meet current and future model needs, incl. key land IPCC changes*	*Thematic land cover detail (incl. conversion tables to PFT for climatic regions) and traits) sufficient to meet current and future model needs, incl. land changes and land management*
Accuracy	*Higher accuracy than existing datasets* ✓	*Errors of 5-10% either per class or as overall accuracy* ✗	*Higher accuracy than existing datasets*	*Errors of 5-10% either per class or as overall accuracy*
Stability	*Higher stability than existing datasets* ✓	*Errors of 5-10% either per class or as overall accuracy* ✗	*Higher stability than existing datasets*	*Errors of 5-10% either per class or as overall accuracy*
Error Characteristics	*Independent onetime accuracy assessment* ✓	*Operational and independent multi-date validation* ✗	*Independent multi-date validation*	*Operational and independent multi-date validation*

Figure 2-1: Threshold (minimum) and target (optimal) requirements identified for LC products in the User Requirements Survey carried out in the CCI – LC project Phases I and II. Check–marks indicate fulfilled requirements (from [AD.4])

2.3 Project outputs

The outputs of the CCI-LC Phase II project concern global SR time series, global LC maps, global LS seasonality products and a global WB product, all of them being delivered along with metadata. The outputs also include software systems, products documentation and validation reports.

At the end of the 3-year long Phase II, the key global datasets for the end-users will be:

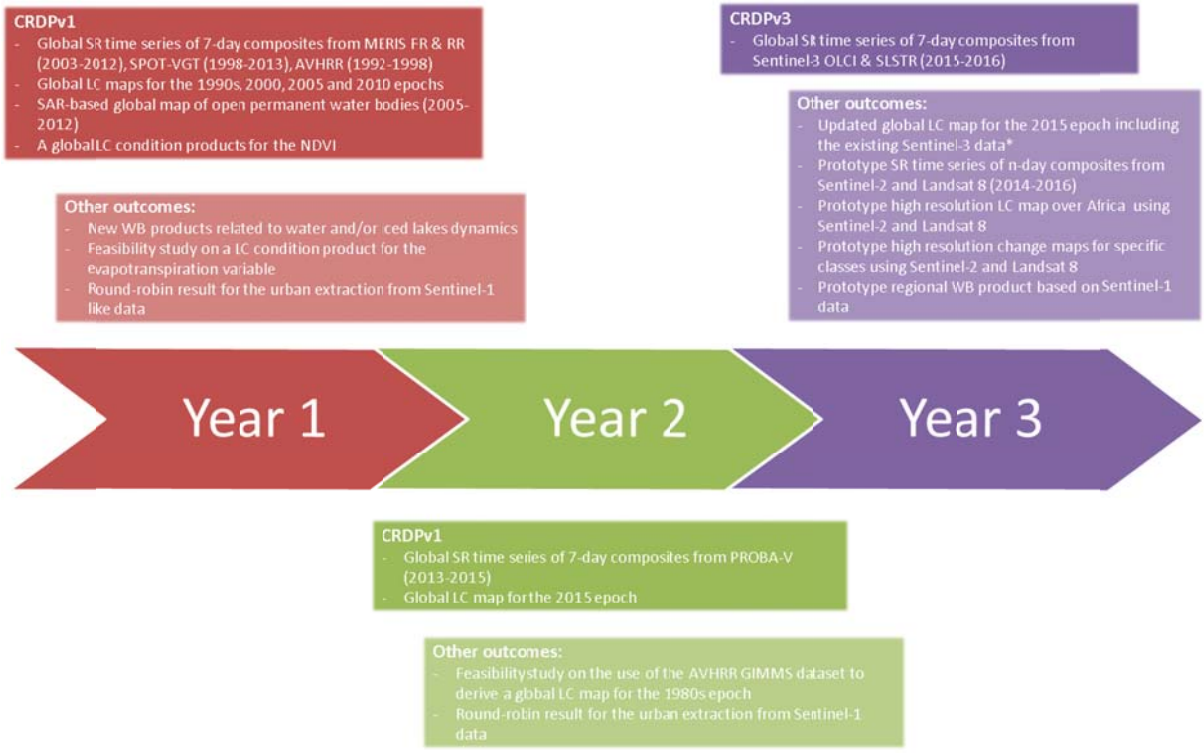
1) Global SR time series and associated metadata over different epochs and from different sensors:
    a. Time series of Advanced Very High Resolution Radiometer (AVHRR) 7-day composites[1] from 1992 through 1999;
    b. Time series of SPOT-Vegetation (SPOT-VGT) 7-day composites from 1998 through 2014;
    c. Time series of Envisat MERIS Full Resolution (FR) 7-day composites from 2003 through 2012;
    d. Time series of Envisat MERIS Reduced Resolution (RR) 7-day composites from 2003 through 2012;
    e. Time series of PROBA-V 7-day composites from 2013 through 2015 (and beyond);
    f. Time series of Sentinel-3 Ocean and Land Colour Instrument (OLCI) and Sea and Land Surface Temperature Radiometer (SLSTR) 7-day composites from 2015 (and beyond).
2) Global LC maps for the 1990s, 2000, 2005, 2010 and 2015 epochs based on the above AVHRR, SPOT-VGT, MERIS FR and RR, PROBA-V, Moderate Resolution Imaging Spectroradiometer (MODIS) composites and associated metadata;
3) An updated global LC map for 2015 including the above Sentinel-3 OLCI and SLSTR composites and associated metadata[2];
4) Global LS seasonality products and associated metadata for the Normalized Difference Vegetation Index (NDVI);
5) Global map of permanent open WB for the 2010 epoch based on Envisat ASAR time series.

In addition, prototypes products are foreseen, which will demonstrate the pre-processing and classification algorithms developed for the Sentinel-1 and -2 missions and to expand historical time series. They include:

[1] A7-day compositing period is foreseen to be consistent with the other sensors, but this has to be confirmed according to the data coverage
[2] According to the availability of Sentinel-3 data in terms of quantity and timing with respect to the overall project planning

1) Sentinel-2 and Landsat 8 time series of regional SR composites from 2014 (and beyond) and associated metadata;
2) Regional LC maps based on the above Sentinel-2 and Landsat 8 composites and associated metadata;
3) Change maps dedicated to critical LC classes and/or regions according to users' priorities based on the above Sentinel-2 and Landsat 8 composites and associated metadata;
4) Prototype WB and urban products based on Sentinel-1 SAR data, tuned geographically to the regional LC maps obtained with Sentinel-2 data;
5) A consistent coarse spatial resolution LC map for continental or sub-continental regions for the 1980s based on the AVHRR Global Inventory Monitoring and Modelling System (GIMMS) dataset;
6) An EvapoTranspiration (ET) Feasibility study will be performed during the first year of this 2nd phase. Encouraging results may lead to the production of an ET seasonality product.

Those products will be generated throughout the project, following the planning illustrated in Figure 2-2.



* The reason why this update is not included in the CRDPv3 is that it will be delivered at the end of the year 3, thus not available for climate assessment

Figure 2-2: Planning of datasets to be produced in the CCI-LC Phase II (from [AD.5])

This version of the PUG focuses on the products generated during the 1st year of the project. Their main specifications are summarized in Table 2-1.

Table 2-1: Summary of the CCI-LC Phase I outputs.

Product	Coverage		Resolution		Sensor	Projection	Format
	Spatial	Temporal	Spatial	Temporal			
MERIS SR time series	Global	2003-2012	300m 1000m	7-day	MERIS FR MERIS RR	WGS 84	NetCDF
AVHRR SR time series	Global	1992-1999	1000m	7-day	AVHRR	WGS 84	NetCDF
LC map 2010 epoch	Global	2008-2012	300m	5-year	MERIS FR/RR	WGS 84	NetCDF & GeoTiff
LC map 2005 epoch	Global	2003-2007	300m	5-year	MERIS FR/RR	WGS 84	NetCDF & GeoTiff
LC map 2000 epoch	Global	1998-2002	300m	5-year	MERIS FR/RR; SPOT-VGT	WGS 84	NetCDF & GeoTiff
LC map 1990s epoch	Global	1992-1998	300m	6-year	MERIS FR/RR; AVHRR	WGS 84	NetCDF & GeoTiff
NDVI LS seasonality	Global	1999-2012	1000m	7-day	SPOT-VGT	WGS 84	NetCDF & GeoTiff
Snow LS seasonality	Global	2000-2012	500m	7-day	MOD10A2	WGS 84	NetCDF & GeoTiff
Burned Areas LS seasonality	Global	2000-2012	500m	7-day	MCD64A1	WGS 84	NetCDF & GeoTiff
Water Bodies product	Global	2005-2010	300m	5-year	ASAR WSM	WGS 84	NetCDF & GeoTiff

At the moment of writing this report, these products have not been generated yet. For the products already generated in Phase I, improved accuracy is expected but there will be no significant difference in terms of specifications. Their description is thus included and will be updated if needed when the products will be ready. For the new products (AVHRR time series and global LC map for the 1990s), their description will be added as soon as possible. Three climatological variables were produced in Phase I (the NDVI, burned areas and snow seasonality products). A dataset limited to the NDVI seasonality only will be available in Phase II.

3 LAND COVER MAPS

3.1 Products description

The CCI-LC project delivers consistent global LC maps at 300m spatial resolution for four epochs: the 1990s, 2000, 2005 and 2010, corresponding to the 1992-1998, 1998-2002, 2003-2007 and 2008-2012 periods.

These maps are derived from a unique baseline LC map which is generated thanks to the entire MERIS FR and RR archive from 2003 to 2012. This 10-year baseline LC map is then back- or up-dated using (i) SPOT-VGT time series from 1998 to 2012 for the 2000, 2005 and 2010 epochs and (ii) AVHRR time series from 1992 to 1998 for the 1990s epoch. This process is illustrated in Figure 3-1.

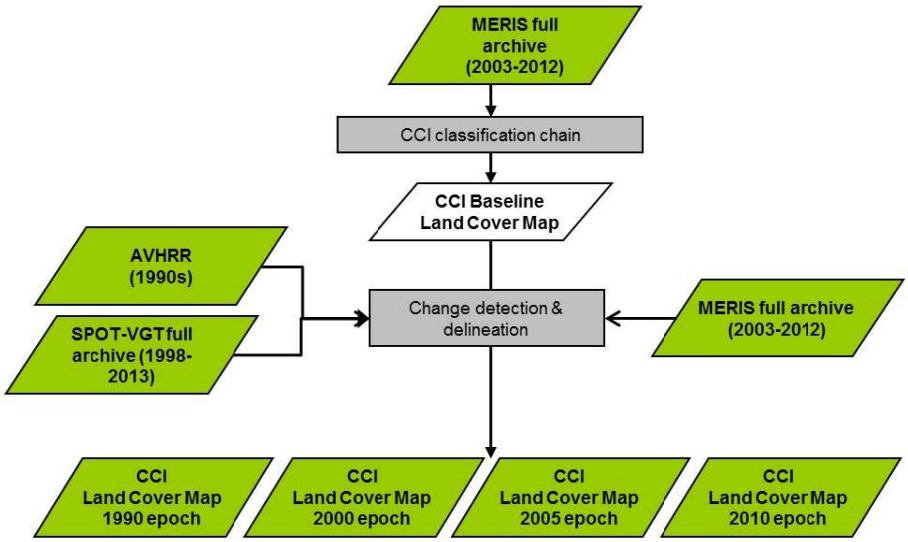


Figure 3-1: Schematic representation of the CCI-LC classification chain made of 2 main processes to generate global LC maps representative of 5-year epochs using the entire archives of Envisat MERIS and SPOT-VGT data

The 2000, 2005 and 2010 epochs were already produced in Phase I. Improved versions will be generated during this Phase II. The current PUG still describes the Phase I products and will be updated as soon as the Phase II products will be available.

The project also delivers a user tool along with the land cover product, which allows users to aggregate the LC map to the spatial resolution which is suitable for their models. This tool is described in detail in Section 7.3.

3.1.1 Processing chain

The four global LC maps over the 1990s, 2000, 2005 and 2010 epochs rely on EO datasets coming from three different sensors: MERIS, SPOT-VGT and AVHRR 2. Table 3-1 details the way these satellite data are used.

Table 3-1: Satellite data sources that are planned to be used to generate the global LC maps

GLOBAL LC DATABASE	REFERENCE PERIOD	SATELLITE DATA SOURCE
Baseline 10-year global LC map	2003-2012	MERIS FR/RR global SR composites between 2003 and 2012
Global LC database for the 1990 epoch	1992-1998	Baseline 10-year global LC map AVHRR global SR composites between 1992 and 1998 for back-dating the baseline
Global LC database for the 2000 epoch	1998-2002	Baseline 10-year global LC map SPOT-VGT global SR composites between 1998 and 2002 for back-dating the baseline
Global LC map for the 2005 epoch	2003-2007	Baseline 10-year global LC map SPOT-VGT and MERIS FR global SR composites between 2003 and 2007 for back- and up-dating the baseline
Global LC map for the 2010 epoch	2008-2012	Baseline 10-year global LC map SPOT-VGT and MERIS FR global SR composites between 2008 and 2012 for up-dating the baseline

The classification module that generates the baseline map was developed by the Université catholique de Louvain (UCL). It was designed to be globally consistent while regionally-tuned. It capitalized on the GlobCover unsupervised classification chain [RD.9] while also relying on a machine learning algorithm and on a multiple-year strategy [RD.10]. In this way, it combined both the spectral and temporal richness of the MERIS FR time series.

Figure 3-2 presents the global LC map from the 2010 epoch and Figure 3-3 shows the classification obtained over the 3 epochs in the Amazon region.

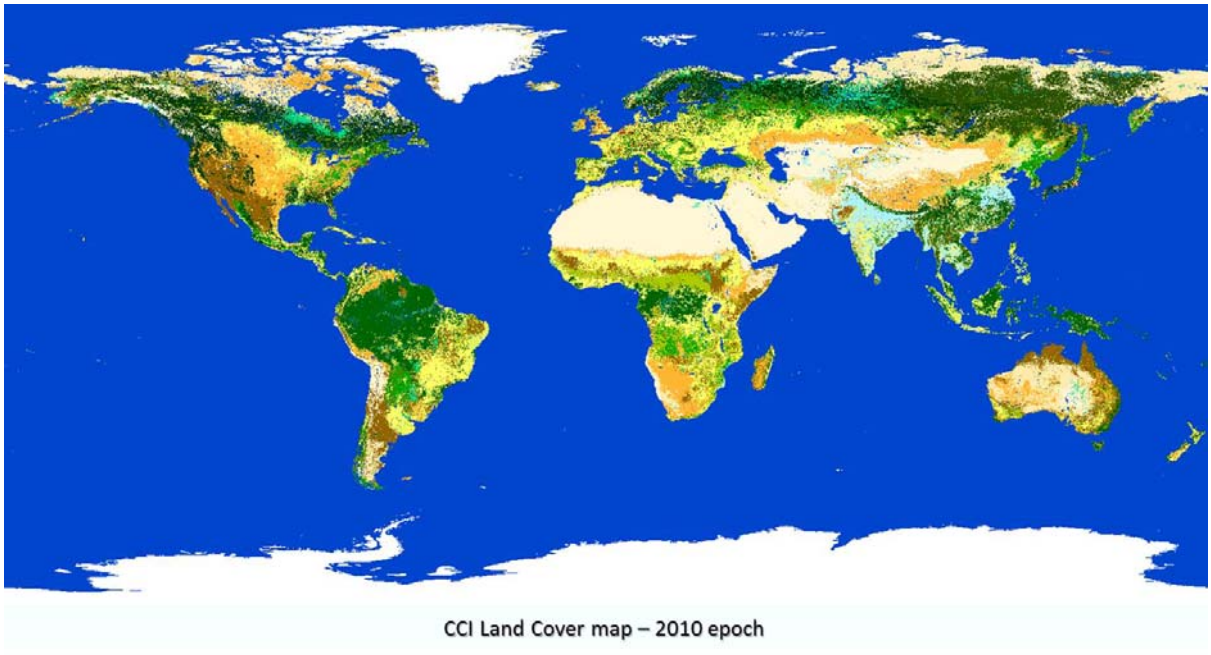


Figure 3-2: The CCI global LC map from the 2010 epoch (2008-2012), at 300m spatial resolution.

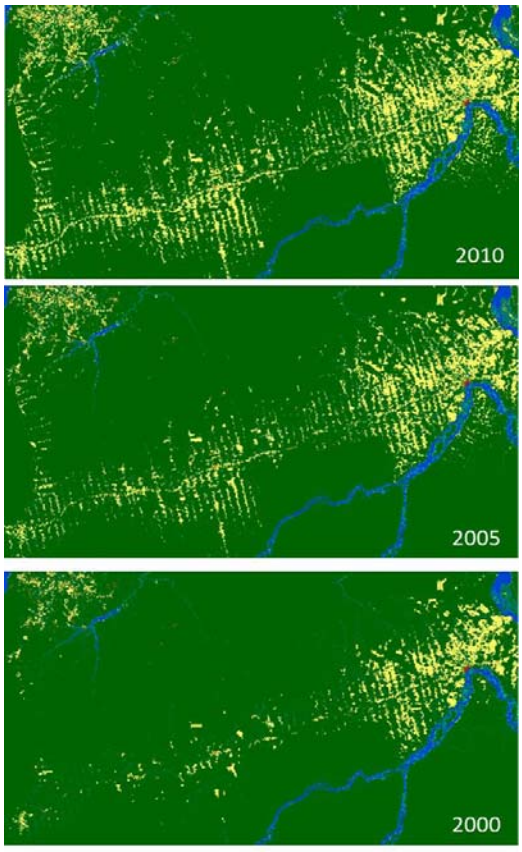


Figure 3-3: The CCI global land cover map from the 2010 epoch (2008-2012) on the top, from the 2005 epoch (2003-2007) at center and from the 2000 epoch (1998-2002) on the bottom, over the Amazon.

3.1.2 Legend

The typology has been defined using the UN-LCCS with the view to be as much as possible compatible with the GLC2000, GlobCover 2005 and 2009 products. In addition, the UN-LCCS has been found quite compatible with the PFTs by the climate modellers involved in the user requirements analysis [RD.1]. The UN-LCCS defines LC classes using a set of classifiers. The system was designed as a hierarchical classification, which allows adjusting the thematic detail of the legend to the amount of information available to describe each land cover class, whilst following a standardised classification approach.

The CCI maps are designed to be globally consistent. Therefore, its legend is determined by the level of information that is available and that makes sense at the scale of the entire world. The "level 1" legend – also called "global" legend" – meets this requirement. It is presented in in Table 3-2. This legend counts 22 classes and each class is associated with a ten values code (i.e. class codes of 10, 20, 30, etc.).

The CCI maps are also described by a more detailed legend, called "level 2" or "regional". This level 2 legend makes use of more accurate and regional information – where available – to define more LCCS classifiers and so to reach a higher level of detail in the legend. This regional legend has therefore more classes which are listed in Appendix I. The regional classes are associated with non-ten values (i.e. class codes such as 11, 12, etc.). They are not present all over the world since they were not properly discriminated at the global scale and the level of detail in the reference land cover database was not available everywhere. As a result, only regional products are delivered with this extended legend.

The explicit LCCS definition of each CCI-LC global and regional class is provided in Appendix II.

Table 3-2: Global (or level 1) legend of the global CCI-LC maps, based on LCCS.

VALUE	LABEL	COLOR
0	No Data	
10	Cropland, rainfed	
20	Cropland, irrigated or post-flooding	
30	Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	
40	Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	
50	Tree cover, broadleaved, evergreen, closed to open (>15%)	
60	Tree cover, broadleaved, deciduous, closed to open (>15%)	
70	Tree cover, needleleaved, evergreen, closed to open (>15%)	
80	Tree cover, needleleaved, deciduous, closed to open (>15%)	
90	Tree cover, mixed leaf type (broadleaved and needleleaved)	
100	Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	
110	Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	
120	Shrubland	
130	Grassland	
140	Lichens and mosses	
150	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	
160	Tree cover, flooded, fresh or brakish water	

170	Tree cover, flooded, saline water	
180	Shrub or herbaceous cover, flooded, fresh/saline/brakish water	
190	Urban areas	
200	Bare areas	
210	Water bodies	
220	Permanent snow and ice	

Among these LC classes, four were largely identified thanks to external dataset: the “tree cover, flooded, saline water” (class value 170) class which is based on the global mangrove atlas [RD.11], the “urban areas” (class value 190) which have been extracted from the reference dataset [AD.6], the “water bodies” (class value 210) which have been inherited from the CCI-LC WB product (see Section 4) and the “snow and ice” (class value 220) class which comes from the Randolf Glaciers Inventory [RD.12] (to which the CCI-Glaciers project is a main contributor).

3.2 Qualitative assessment

The following figures present the products (mainly the 2010 as it is the most recent one and as only the forest classes may differ in the other epochs), through snapshots and visual comparison with reference datasets in various regions of the world. The GlobCover 2005 and 2009 products ([RD.9] and [RD.13]) were particularly used in this comparison, in order to show the accomplished progress.

The high level of thematic detail is illustrated in Figure 3-4, Figure 3-5 and Figure 3-6. In addition, Figure 3-4 and Figure 3-5 show the good agreement between the CCI-LC map and the reference made of high spatial resolution dataset (20 m in Europe with the Corine map and 30 m in US with the National Land Cover Dataset (NLCD)). It can also be noted that the amount of mosaic classes (which was a critical issue of the GlobCover products) has significantly been limited.

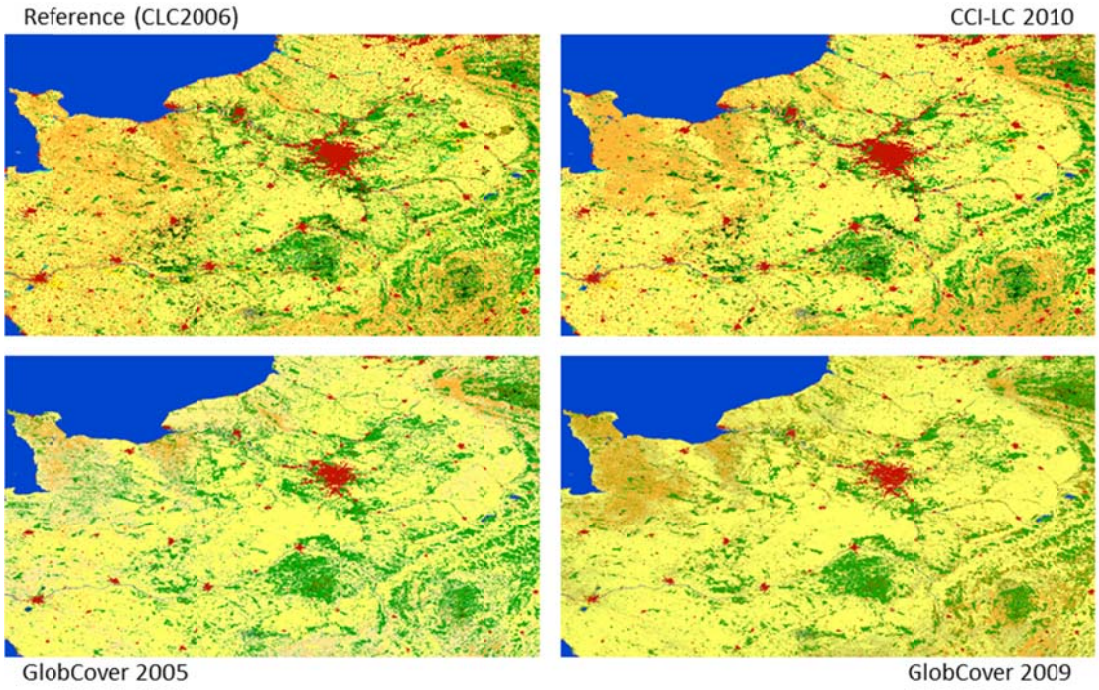


Figure 3-4: Comparison, over Europe, of the CCI-LC for the 2010 epoch (top right) with the reference dataset used in the classification made of Corine 2006 (top left) and the GlobCover 2005 and 2009 products (bottom left and right respectively).

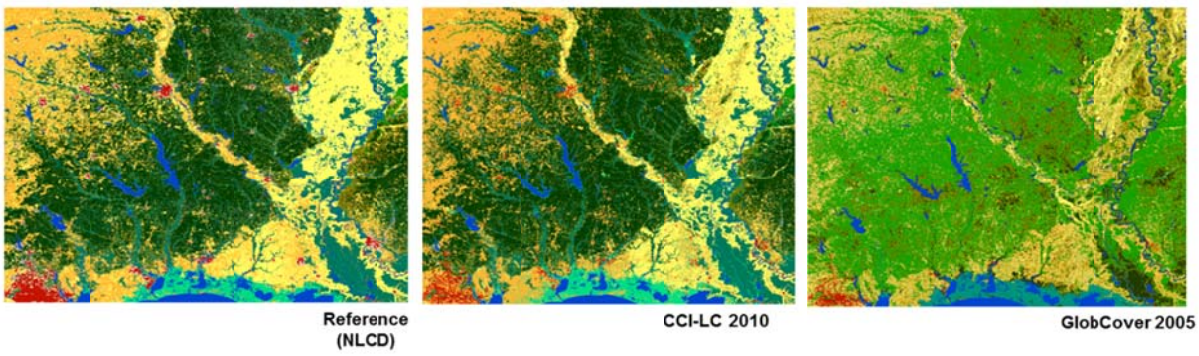


Figure 3-5: Comparison, in Florida (US), of the CCI-LC for the 2010 epoch (center) with the reference dataset used in the classification made of the US-NLCD (left) and the GlobCover 2005 product (right).

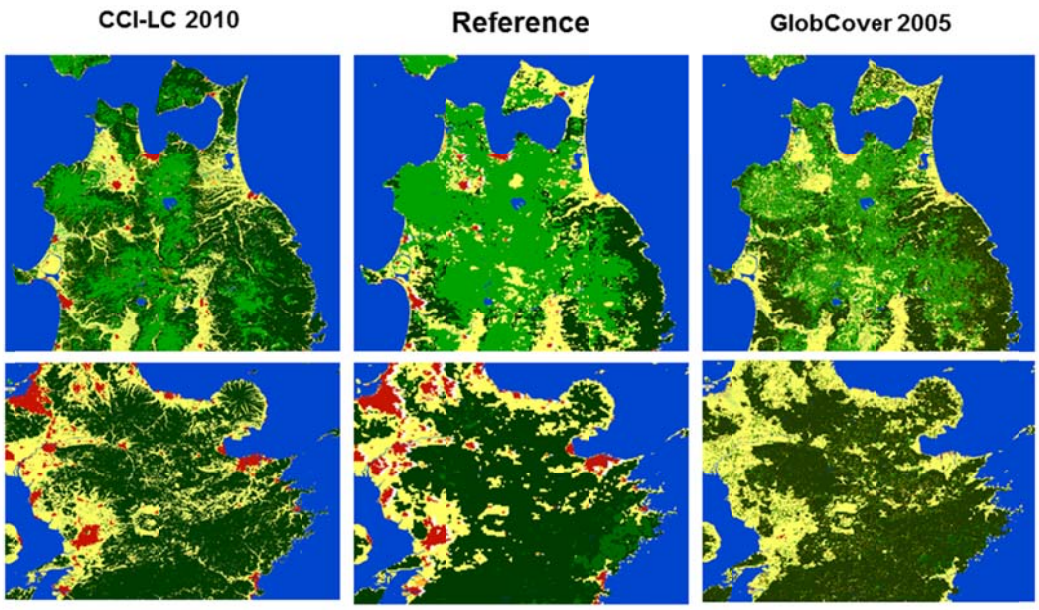


Figure 3-6: Comparison, in Japan, of the CCI-LC for the 2010 epoch (left) with the reference dataset used in the classification made of GLC2000 (center) and the GlobCover 2005 product (right).

The mapping of the deforestation in tropical basins looks quite good when overlying the map with Google Earth (Figure 3-7).

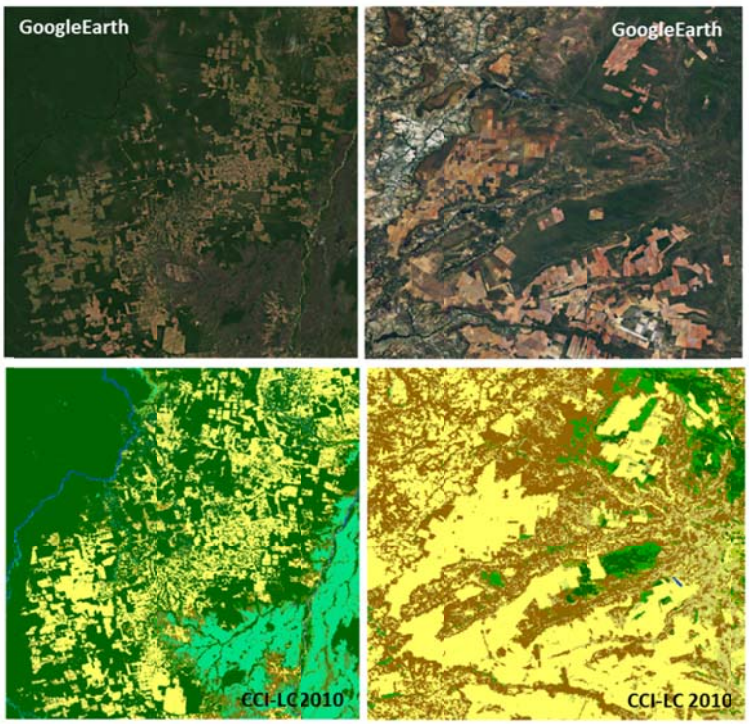


Figure 3-7: Illustration of the deforestation mapping in the CCI-LC 2010 map, with zooms in Central America.

3.3 Products validation

A critical step in the acceptance of the LC maps by the user communities is providing confidence in their quality through validation against independent data such as ground-based reference measurements or alternate estimates from other projects and sensors.

The main objective of the validation is to allow a potential user determining the "map's fitness for use" for his / her application. There are several definitions of validation available from various agencies, and it was agreed that the Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (CEOS-WGCV) definition would be adopted within the CCI program:

> *"The process of assessing, by independent means, the quality of the data products derived from the system outputs".*

The validation process independence has been ensured (i) using validation datasets that were not used during the production of the LC maps and (ii) being carried out by external parties, i.e. by staff not involved in the production of the LC maps.

Validation methodologies and results will be added in the next version.

3.4 Products format

- **Naming Convention**

The file name convention of the global LC maps delivered by the CCI-LC project is the following:

File name = <id>-v<version>.nc/tif

where <id> = <project>-<level>-<var>-<code>-<spatres>-<tempres>-<epoch>-<area>

The dash "-" is the separator between name components. The filename convention obeys NetCDF CF by using the postfix ".nc" and can be written as a GeoTiff file using the extension ".tif". The different name components are defined in Table 3-3.

Table 3-3. Components that make the name of the LC maps delivered by the CCI-LC project.

FIELD	SIGNIFICATION	VALUE
project	Project acronym	ESACCI-LC (constant)
level	Processing level	L4 (constant)
var	Unit of the LC product	LCCS (constant)
code	Product code identifier for CCI-LC products	Map (constant)
spatres	Spatial resolution	300m (constant but could be updated if other sensors are used to generate SR products)
tempres	Temporal resolution	P5Y (constant but could updated if shorter or longer intervals are processed)
epoch	Centre year of the epoch of the product	2000, 2005 or 2010
area	Text (max 8 digits) describing the regional subset (see Appendix 3)	"NorthAm" for North America "CenAm" for Central America

		"SouthAm" for South America "WestEur" for Western Europe "EastEur" for Easter Europe "NorthAfr" for North Africa & Middle-East "Afr" for Africa "CenAsia" for Central Asia "SEAsia" for South East Asia "AusNZ" for Australia & New Zealand "GrnIce" for Greenland & Iceland In case of global products, this field does not exist.
version	Incremental that follows the successive revisions of the CCI-LC Processing lines	Version of product revision, preferably major.minor, optionally with processing centre [a-zA-Z0-9._]*

An example file name of the global LC map from 2010 would be: "ESACCI-LC-L4-LCCS-Map-300m-P5Y-2010-v1.0.nc/tif ».

- **Processing Level**

Level 4 (i.e. "variables that are not directly measured by the instruments, but are derived from these measurements" [RD.14])

- **Units**

Each pixel value corresponds to the label of a land cover class defined using UN-LCCS classifiers (see Table 3-2 in Section 3.1.2 and Appendix 1 in Section 9).

- **Spatial Extent**

All terrestrial zones of the Earth between the parallels 90°N and 90°S.

- **Spatial Resolution**

300m

- **Temporal resolution**

1 product over a 5-year epoch

- **Product layers**

The land cover map is delivered along with 4 quality flags which document the reliability of the classification (Table 3-4).

Table 3-4: Quality flags of the LC maps.

NAME IN PRODUCT	DATA TYPE	DESCRIPTION
ESACCI-LC-L4-LCCS-Map-300m-P5Y-YYYY-vx.x.nc/tif	8-bit unsigned	LC classification in LCCS (22 global classes + NoData coded as 0)
ESACCI-LC-L4-LCCS-Map-300m-P5Y-YYYY-v1.0_qualityflag1.nc/tif	byte	Indicates if the pixel has been processed (1) or not (0) 0 - pixel not processed 1 - pixel processed
ESACCI-LC-L4-LCCS-Map-300m-P5Y-YYYY-	byte	Indicates the pixel status as defined by the pre-

NAME IN PRODUCT	DATA TYPE	DESCRIPTION
v1.0_qualityflag2.nc/tif		processing: 1 - Pixel flagged as “clear land” 2 - Pixel flagged as “clear water” 3 - Pixel flagged as “clear snow and ice” 4 - Pixel flagged as “cloud” 5 - Pixel flagged as “cloud shadow” 6 - Pixel flagged as “filled”
ESACCI-LC-L4-LCCS-Map-300m-P5Y-YYYY-v1.0_qualityflag3.nc/tif	short	Indicates the number of valid observations available to derive the classification
ESACCI-LC-L4-LCCS-Map-300m-P5Y-YYYY-v1.0_qualityflag4.nc/tif	byte	Provides a level of confidence in the product (ranging from 0 to 100)

- **Projection**

The projection is a Plate Carree with a geographic Lat/Long representation based on the WGS84 ellipsoid. The Coordinate Reference System (CRS) used for the global LC products is a geographic coordinate system (GCS) based on the World Geodetic System 84 (WGS84) reference ellipsoid and using a Plate Carree projection.

The projection makes use of an equatorial radius (also called semi-major axis) of 6378.14 km and of a polar radius (also called semi-minor axis) of 6356.76 km. The inverse flattening parameter is of 298.26 m. The coordinates are specified in decimal degrees. A complete description of the CRS is given in Figure 3-8 as an ISO 19111 WKT representation.

```
GEOGCS["GCS_WGS_1984",
    DATUM["D_WGS_1984",
        SPHEROID["WGS_1984",6378137.0,298.257223563]],
    PRIMEM["Greenwich",0.0],
    UNIT["Degree",0.0174532925199433],
AUTHORITY["EPSG",4326]]
```

Figure 3-8: Description of the coordinate reference system defining the global LC products.

- **Format**

The three LC maps are delivered in NetCDF-4 and GeoTiff format. The NetCDF files specification follows CF conventions [RD.16].

- **Metadata**

The metadata for the LC maps are provided as global attributes in the NetCDF file and are included in the GeoTiff raster. It follows the CCI guidelines [RD.17].

- **Estimated size**

The size of the global land cover maps is around 260 MB. The size of the quality flags varies between 80MB and 2GB. These estimations take an internal LZW compression into account.

4 LAND SURFACE SEASONALITY PRODUCTS

4.1 Products description

To meet the climate modeling community needs and describe the natural variability of the land surface, one climatological variable, also named "LS seasonality", is been produced: the NDVI, representative of the vegetation greenness.

On a per pixel basis, the climatological variable reflects, along the year, the average trajectory and the inter-annual variability of a land surface feature over the 1999-2012 period. It is built from existing long-term global datasets with high temporal frequency and moderate spatial resolution (1km). It is a result from a compilation of 13 years of 7-day instantaneous observations into 1 temporarily aggregated profile depicting, along the year, the reference behaviour for the vegetation greenness. The methodology underlying the generation of these products was developed by the Université catholique de Louvain (UCL).

The climatological dataset include various series of measurements, delivered in time series of 52 files (1file per 7-day time interval). The NDVI climatological variable includes the mean, standard deviation, the number of valid and cloud-free weekly composites and the pixel status (e.g. land, water, etc.). Table 4-1 summarizes its main characteristics.

Table 4-1: Main characteristics of the LS seasonality product.

CLIMATOLOGICAL DATASET	MEASUREMENTS	DATA SOURCES	SPATIAL COVERAGE AND RESOLUTION	TEMPORAL COVERAGE	TEMPORAL RESOLUTION	TOTAL DATA VOLUME
NDVI	- Mean - Standard deviation - Number of valid weekly composites - Status	14 years of daily S1 SPOT-VGT surface reflectance time series	Global 1000m	1999-2012	Weekly	~ 30GB

Three climatological variables were produced in Phase I (the NDVI, burned areas and snow seasonality products). A dataset limited to the NDVI seasonality only will be available in Phase II.

4.1.1 NDVI seasonality product

The NDVI seasonality product describes globally the yearly reference dynamic of the vegetation greenness characterizing the 1999-2012 period. It is therefore a valuable reference dataset for

phenology studies and phenological metrics extraction at global scale [RD.15]. It is built from 14 years of SPOT-VGT daily top of canopy SR syntheses (S1 products) and of related quality flags.

It comprises 4 measurements in total. The annual behaviour of the vegetation is characterised by two time series of 7-day composites, corresponding first to the NDVI smoothed average and second to the inter-annual variability over the aggregation period (14 years). In addition, 2 quality flags are provided at the pixel-level: the number of valid and cloud-free weekly composites used to generate the NDVI average and the status qualifying the pixel. These items are described thoroughly in Section 4.3.1.

The average component of the resulting NDVI seasonality is illustrated for the 4 seasons of the year in Figure 4-1. As it can be seen, the product clearly captures the spatial pattern of many land features, including the ones situated in the cloudiest regions of the world like the equatorial areas.

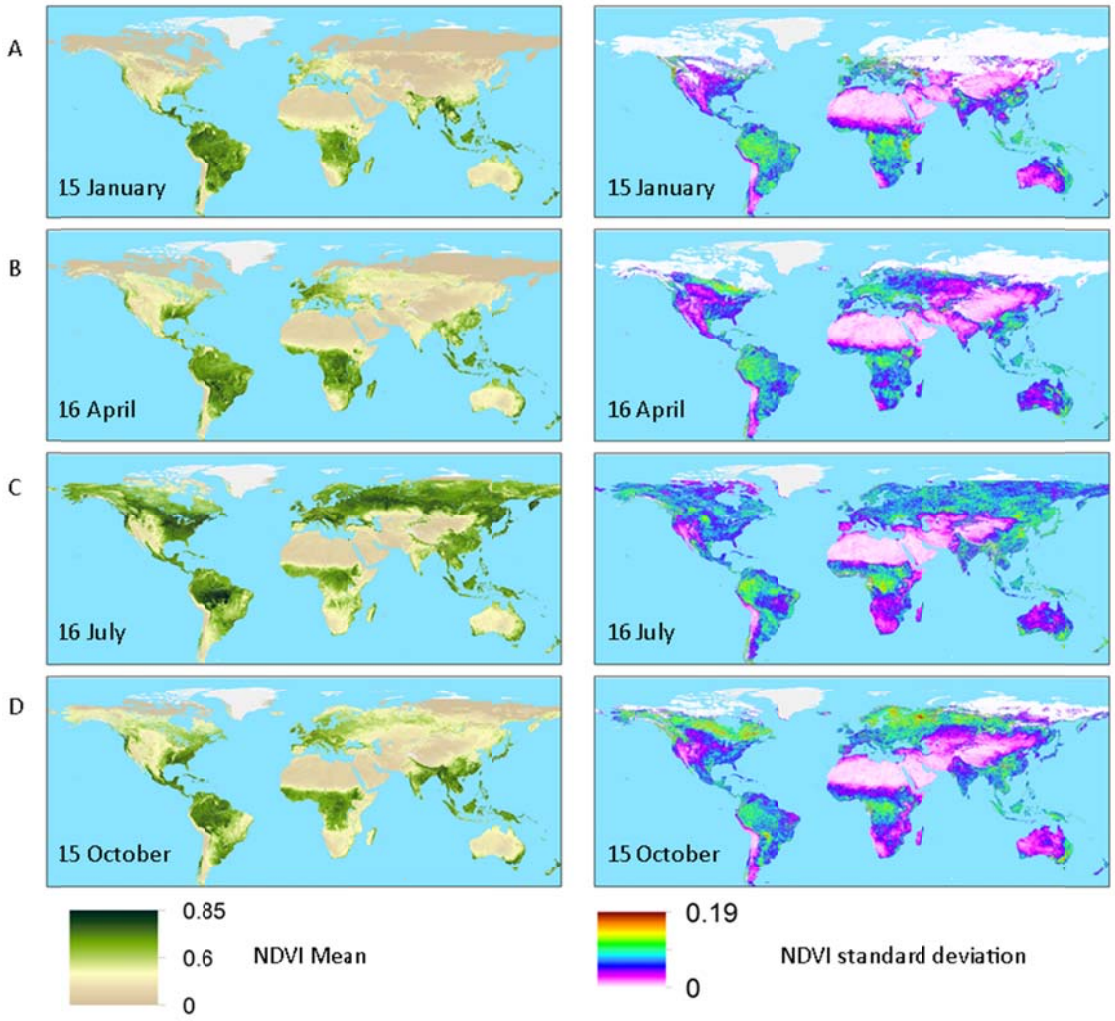


Figure 4-1: Average (left) and standard deviation (right) components of the NDVI Seasonality Product at 4 weeks of the year. The dates indicated in Figure A, B, C and D correspond to starting day of the 7-day composite period. White colour situated in high latitudes corresponds to NaN values [RD.15]

The SPOT-VGT 1-km spatial resolution associated with a high geometric accuracy allows producing meaningful profiles, even in highly fragmented areas such as in Africa (Figure 4-2). The 3 NDVI profiles, extracted on (i) a mosaic class of different cropland areas, (ii) a mosaic class of tree and shrub cover types and (iii) a land cover class made of broadleaved deciduous trees, demonstrate the spatial consistency of the product and its capacity to depict the intra-annual variability of the vegetation greenness.

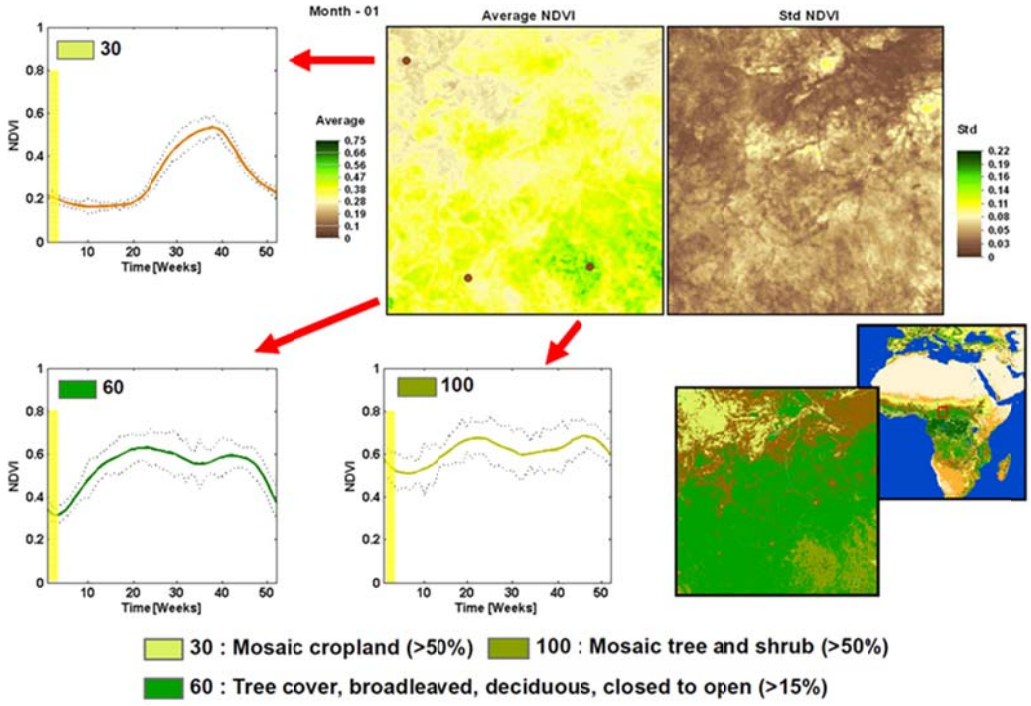


Figure 4-2: Detailed spatial example of NDVI seasonality profiles - average (plain line) and standard deviation (dotted line) - extracted in the region of Central Africa. The profiles are extracted from 3 pixels belonging to 3 classes of the 2010 LC state map product. The variety of the dynamic of vegetation is clearly captured.

4.2 Products evaluation

The potentialities for the NDVI seasonality were highlighted in the contexts of cropland diversity (intensity of agricultural practices, crop cycles), thematically close land cover classes diversity (bare areas, grassland and shrubland), vegetation seasonalities and leaf types.

Yet, it shall be mentioned that the reliability of the products is spatially variable and dependant on the number of valid and cloud-free weekly composites which is to be used as a quality indicator. The lowest numbers of valid and cloud-free observations are found over the western coast of central Africa and extreme latitudes.

One of the drawbacks with using optical time series for global mapping is the inconsistency of the valid coverage along the year. Data are missing over high latitudes during winter time when there is no solar illumination.

The lack of validation and uncertainty estimates is also a limitation.

4.3 Products format

4.3.1 NDVI seasonality

The global NDVI seasonality characterizing the 1999-2012 epoch includes 4 series of measurements distributed in the form of 52* 7-day layers for a total compressed data volume of 30 GB. Two of the series represent variables describing the yearly reference dynamic of the vegetation greenness and its inter-annual variation: the smoothed averaged NDVI and the standard deviation. The other two layers are the number of valid and cloud-free weekly composites and the status of the pixel.

Each layer has a spatial resolution of 1km and a geographic Lat/Long WGS84 projection (see Section 3.4 for a complete description).

The layers are delivered in NetCDF-4 and GeoTiff format. The NetCDF files specification follows CF conventions [RD.16].

- **Science dataset**

Table 4-2 summarizes the description of each 52* 7-day layers in terms of variable description, valid values range, scaling factor, NaN value and pixel depth.

Table 4-2: The description of the 4 series layers included in the global NDVI seasonality product.

NDVI Seasonality Series	Description	Valid values Range	Scaling Factor	NaN value	Pixel depth
AggMean	Smoothed NDVI values corresponding to the averaged NDVI over the 1999-2012 period. It gives the yearly reference dynamic of the vegetation greenness at a 7-day frequency.	[-10000 to 10000]	0.0001	32767	Int16
Std	Standard deviation of the averaged NDVI over the 1999-2012 period. It represents the inter-annual variability of the average NDVI for each 7-day period.	[0 to 10000]	0.0001	32767	Int16
NYearObs	Number of valid and cloud-free weekly composites contributing to each 7-day period of the AggMean and Std series. It is a quality indicator of the average and std estimates.	[0 to 14]	None	None	Int16
Status	Status of the pixel; 0: invalid, 1 : land , 2 : water , 3 : snow, 4 : cloud , 5 : filled ice	[0 to 5]	None	0	Int16

- **Naming convention**

The file name convention of the global LS seasonality products is as generic as possible. All seasonality products follow this structure:

File name = <id>-v<version>.nc/tif

where <id> = <project>-<level>-<var>-<prod>-<spatres>-<tempres>-<epoch>-<date>

The dash "-" is the separator between name components. They are defined in Table 4-3.

Table 4-3: Naming convention in the NDVI seasonality filenames.

FIELD	SIGNIFICATION	VALUE
project	Project Acronym	ESACCI-LC (constant)
level	Processing level	L4 (constant)
var	Variable identifier for the LS seasonality	NDVI-Cond (constant)
prod	Product identifier for LS seasonality	AggMean, Std, Status, NYearObs
spatres	Spatial resolution	1000m (constant)
tempres	Multi-year period of the product defined by the number of years + Temporal resolution of the product	P14Y7D (constant)
epoch	Multi-year epoch of the product, defined by the start and end years	[YYYY-YYYY] where the two "YYYY" are the first year and the last year of the period. This field is 1999-2012 for the NDVI Seasonality product.
date	Start date of the compositing period	[yyyymmdd] where "yyyy" is the starting year of the epoch, "mm" is the month and "dd" is the day
version	Incremental that follows the successive revisions of the CCI-LC Processing lines	Version of product, major-minor

An example file name of the global LS seasonality product related to the 1999-2012 NDVI standard deviation variable between the 1st to 7th January would be: "ESACCI-LC-L4-NDVI-Cond-Std-1000m-P14Y7D-1999-2012-19990101-v2.0.tif".

5 OPEN WATER BODIES PRODUCT

5.1 Product description

The CCI-LC WB gives the repartition of open and permanent water bodies (inland water and oceans) at 300m spatial resolution and at global scale. It is the result of a land/water classification based on Synthetic Aperture Radar (SAR) data, combined with the Shuttle Radar Topography Mission (SRTM) Water Body data (SWBD) and MERIS data.

This product was already produced in Phase I and an improved map will be generated during this Phase II. The current PUG still describes the Phase I product and will be updated as soon as the new version will be available.

The land/water classification was derived from multi-temporal metrics based on time series of the backscattered intensity recorded by the ASAR instrument onboard the ENVISAT satellite between 2005 and 2010 (occasionally up to 2012 to avoid data voids). The main source of ASAR imagery was the Wide Swath Mode (WSM) at 150m spatial resolution. As the quantity of WSM was insufficient in some places, imagery in Image Mode Medium (IMM) at 75m and Global Monitoring Mode (GMM) at 500m was used in complement. The methodology to build the CCI-LC WB is fully described in [AD.11]. The SAR data classification module was developed by Gamma Remote Sensing (GAMMA-RS).

Figure 5-1 and Figure 5-2 illustrate the CCI-LC WB product at global and regional scales, respectively.

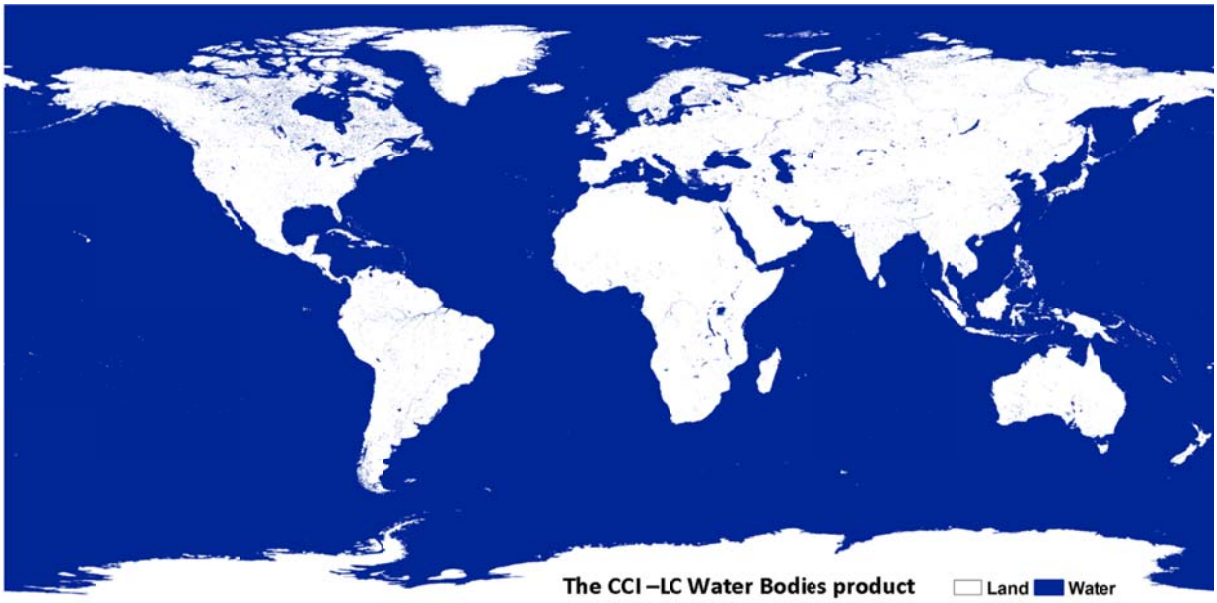


Figure 5-1: Illustration of the CCI-LC Water Bodies product.

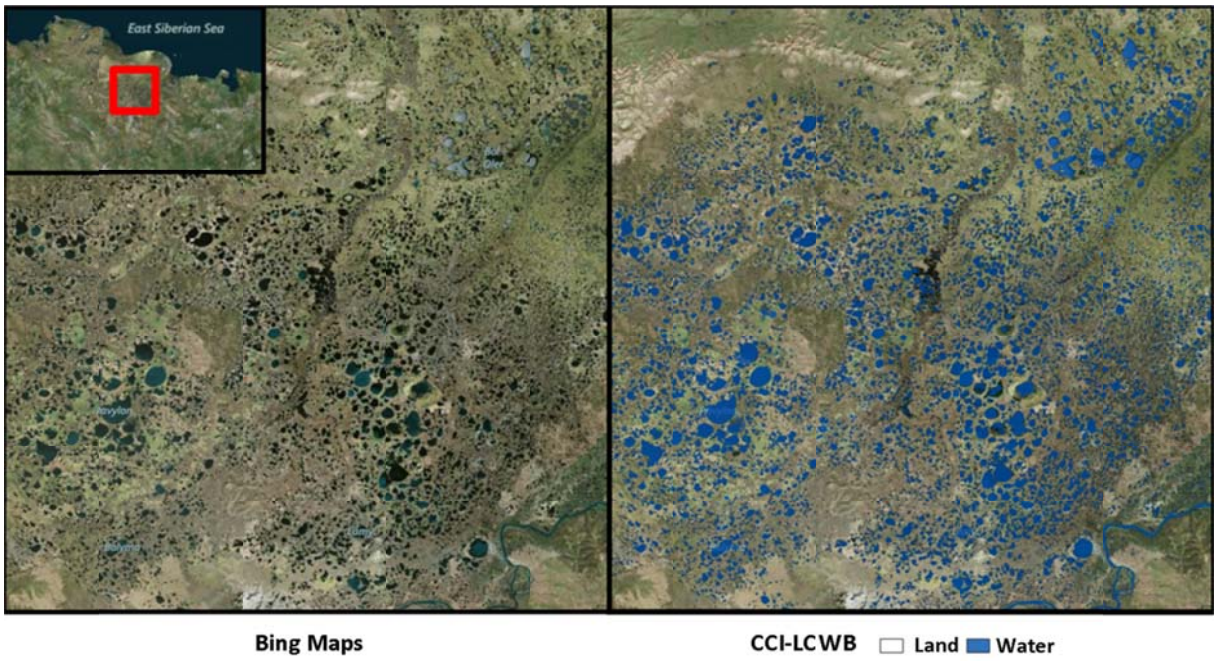


Figure 5-2: The high density of SAR data (> 60°N) used in the CCI-LC Water Bodies allows classifying water bodies with high quality as shown by this example over a regional subset in Russia.

5.2 Algorithm and product evaluation

5.2.1 Methodology

A specific analysis has been carried out to evaluate the performance of the developed classification algorithm and hence, the quality of the product. Yet, this analysis cannot be considered as a validation stricto sensus since it gave more emphasis on areas that are known to be difficult to map.

The methodology includes three different steps: elaborating the sampling strategy, building a reference database and assessing the product accuracy.

- **Sampling strategy**

Large parts of the Earth's surface are either large permanent water bodies (oceans, large lakes) or land areas where water bodies are absent. The water classification algorithm gives correct and unambiguous results in those areas, which would therefore lead to a very high overall accuracy. As the objective of this validation scheme was to evaluate the performances of the water bodies product in areas where errors are most expected (shorelines, sand dunes, ice-covered regions, etc.), a stratified random sampling is used.

2300 points were randomly selected according to 3 criteria: (i) vicinity of land/water borders according to the GlobCover 2009 [RD.13] and MODIS Water Mask product (MOD44W) [**Erreur !**

Source du renvoi introuvable.], (ii) equal intervals of 45 degrees of latitude and (iii) desert or inland ice-covered regions. Figure 5-3 illustrates the spatial repartition of the 2300 points resulting from this stratified random sampling. The detailed description of the sampling methodology is described in [RD.7].

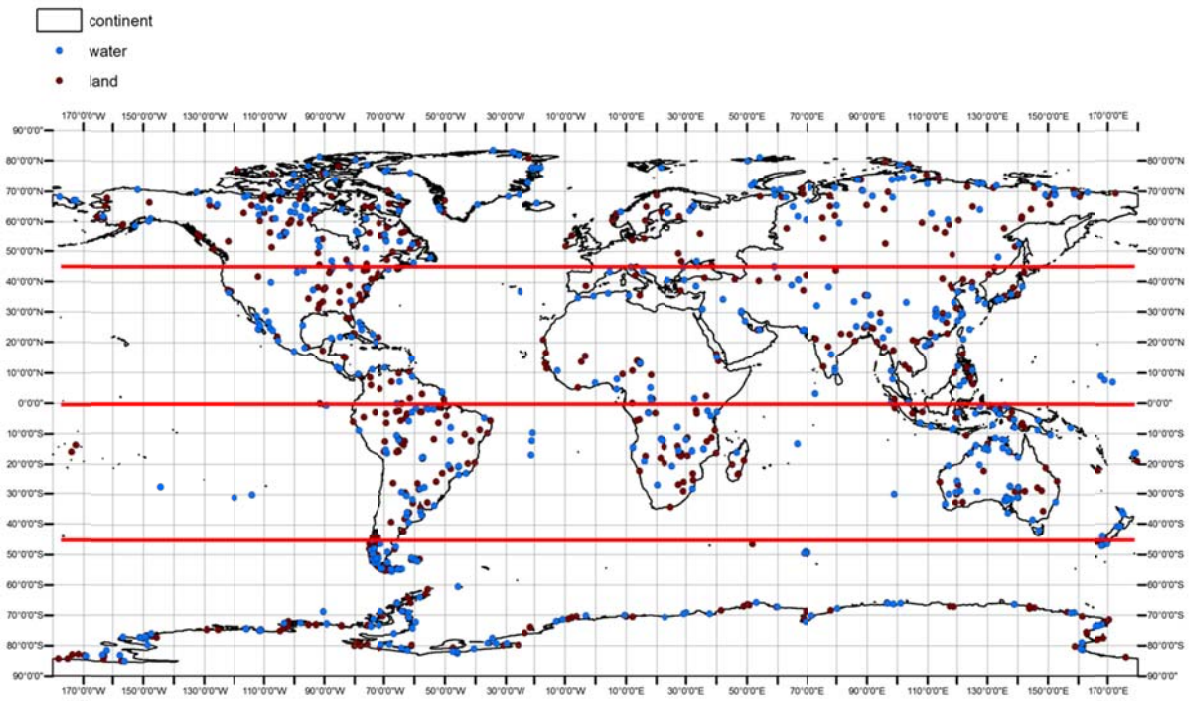


Figure 5-3: Final set of point locations: the red lines indicate the subdivision in 4 zones according to latitude.

- **Reference dataset collection**

Based on the location of the selected sampling points, polygons corresponding to the 300m footprint of the CCI-LC WB product were generated. These polygons footprints were overlaid over the high resolution satellite data of Google Earth and labelled as “land”, “water” or “unknown” after interpretation of the imagery. Google Earth allowed a rapid access to recent remote sensing images with high zooming capabilities. In addition, the expert could also support his work using any additional sources of information such as the historic toolbar, pictures or so. The timescale option permitted reinforcing the capacity to evaluate the permanency of the observed water bodies. Indications on the permanency and the date of detection were also recorded in the database. Figure 5-4 shows an example of the interface used to evaluate the footprint label.

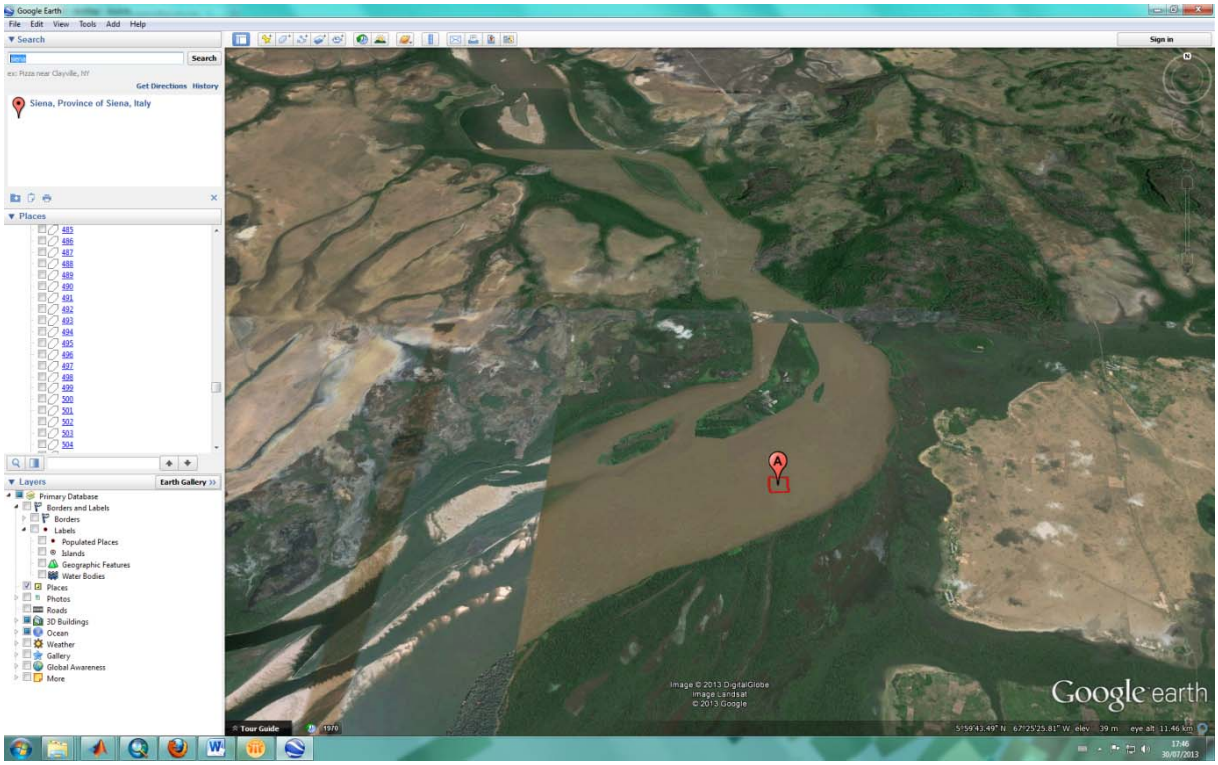


Figure 5-4: Example of the construction of the reference dataset collection. Polygons corresponding to footprints of the CCI-LC WB product are overlaid in Google Earth and labelled as "land", "water" or "unknown" according to visual interpretation of the high resolution imagery.

5.2.2 Results

From the 2300 footprints of the reference database, 811 were removed for the following reasons: the footprints location fell in unprocessed areas of the WB product or in areas were manual refinements were applied; when the footprints could not been interpreted in Google Earth. The reference data set, including the remaining 1844 footprints, was then compared to the CCI-LC WB product in order to build a confusion matrix.

The overall, the producer's and user's accuracies are presented in Table 5-1. All figures show high accuracies and the overall accuracy reaches 96%. Under-detection of water is more frequent than over-detection.

Table 5-1: Contingency matrix built on the comparison between the reference dataset of 1844 footprints and the CCI-LC WB product.

		REFERENCE DATASET			
		NO WATER	WATER	SUM	USER ACCURACY
CCI-LC WB PRODUCT	NO WATER	1089	66	1155	94%
	WATER	12	677	689	98%
	SUM	1101	743	1844	
	PRODUCER ACCURACY	99%	91 %		96 %

5.3 Product format

The product consists of 3 layers: the classification between permanent water and land, the number of WSM + IMM observations and the number of GMM.

Each layer has a geographic Lat/Long WGS84 projection (see Section 3.4 for a complete description).

The layers are delivered in GeoTiff format.

- **Science dataset**

Table 5-2 gives a summary of the layers currently included in the CCI-LC WB product in terms of variable description, valid values range, units, fill value and pixel depth.

Table 5-2: The description of the layers included in the CCI-LC WB product.

LAYER NAMES	DESCRIPTION	VALID VALUES RANGE	UNITS	FILL VALUE	PIXEL DEPTH
Map	Land/permanent water classification at 300m spatial resolution. Legend : 1-Land, 2-Water	[1 to 2]	None	None	Byte
NObsImsWS	Number of observations originating from the ASAR WSM + IMM imagery	[0 to 65535]	None	65535	Int16
NObsImsGM	Number of observations originating from the ASAR global monitoring mode imagery	[0 to 65535]	None	65535	Int16

- **Naming convention**

The file name convention is as generic as possible and follows this structure:

File name = <id>-v<version>.nc/tif

where <id> = <project>-<level>-<code>-<var>--<spatres>-<tempres>-<epoch>

The dash "-" is the separator between name components. They are defined in Table 5-3.

Table 5-3: Naming convention in the CCI-LC WB dataset.

FIELD	SIGNIFICATION	VALUE
project	Project Acronym	ESACCI-LC (constant)
level	Processing level	L4 (constant)
code	Product code identifier for CCI-LC products	WB (constant)
var	Variable code identifier for the WB product	Variable name of the product. It could be: Map or NObsImsWS or NObsImsGM
spatres	Spatial resolution	300m (constant)
tempres	Multi-year period of the product defined by the number of years	P6Y (constant)
epoch	Multi-year epoch of the product, defined by the start and end years	[YYYY-YYYY] where the two "YYYY" are the first year and the last year of the period. This field is 2005-2010 for this product.
version	Incremental that follows the successive revisions of the CCI-LC Processing lines	Version of product, preferably major-minor , optionally with processing centre [a-zA-Z0-9._]*

An example file name of the number of valid observations in global monitoring mode is: ESACCI-LC-L4-WB-NObsImsGM-300m-P6Y-2005-2010-v2.0.tif

6 SURFACE REFLECTANCE PRODUCTS

6.1 Products description

The SR products delivered by the CCI-LC project consist in:

1) Time series of AVHRR 7-day composites from 1992 through 1999;
2) Time series of SPOT-VGT 7-day composites from 1998 through 2013;
3) Time series of Envisat MERIS FR 7-day composites from 2003 through 2012;
4) Time series of Envisat MERIS RR 7-day composites from 2003 through 2012.

Table 6-1 details the satellite dataset that are planned to be used in order to generate the global SR composite time series.

Table 6-1: Satellite data that are planned to be used to generate the CCI-LC SR time series

GLOBAL SR COMPOSITE TIME SERIES	REFERENCE PERIOD	SATELLITE DATA SOURCE	TECHNICAL SPECIFICATIONS OF THE SATELLITE DATA SOURCE
AVHRR global SR composite time series	1992-1998	AVHRR 2	• 1km spatial resolution • 5 spectral bands in visible and infrared • Global coverage
SPOT-VGT global SR composite time series	1998-2012	SPOT-VGT P	• 1km spatial resolution • 4 spectral bands in visible and infrared • Global coverage
MERIS global SR composite time series	2003-2012	Envisat MERIS FR & RR	• 300-m or 1000- m resolution full swath • 15 spectral bands in visible and near infrared (NIR) • Global coverage

The pre-processing module was developed by Brockmann-Consult (BC), capitalizing on the GlobCover and GlobAlbedo projects.

The MERIS FR and RR SR time series were already produced in Phase I. Improved versions will be generated during this Phase II. The current PUG still describes the Phase I products and will be updated as soon as the Phase II products will be available. As for the new SPOT-VGT and AVHRR time series, they will be described in this document as soon as they are available.

6.1.1 MERIS SR time series

The spectral content encompasses 13 of 15 MERIS spectral channels – bands 11 and 15 being removed – (Table 6-2) and the spatial resolution is of 300m for the FR and 1000m for the RR.

Table 6-2: MERIS spectral channels.

BAND NUMBER	BAND CENTRE (NM)	BAND WIDTH (NM)	USE
1	412.5	10	Yellow substance and detrital pigments
2	442.5	10	Chlorophyll absorption maximum
3	490	10	Chlorophyll and other pigments
4	510	10	Suspended sediment, red tides
5	560	10	Chlorophyll absorption minimum
6	620	10	Suspended sediment
7	665	10	Chlorophyll absorption and fluorescence reference
8	681.25	7.5	Chlorophyll fluorescence peak
9	705	10	Fluorescence reference, atmospheric corrections
11	760.625	3.75	O2 R-branch absorption band
10	753.75	7.5	Vegetation, cloud
12	775	15	Atmosphere corrections
13	865	20	Vegetation, water vapour reference
14	885	10	Atmosphere corrections
15	900	10	Water vapour, land

The time series are made of temporal syntheses obtained over a 7-day compositing period. The exact schema for the 7-day periods is to start at January 1 and go on 7-day by 7-day periods until the end of the year. In this way, it should be noted that the last period of December comprises 8 days. As for leap years, the 7-day period including February 29 comprises 8 days. There are separate time series for MERIS FR and MERIS RR.

In order to simplify the handling and analysis of 300m spatial resolution global datasets, the MERIS SR time series are being delivered in tiles. Global products are subdivided into 72 x 36 tiles (Figure 6-1) following the tiling system already used in the GlobCover project ([RD.9] and [RD.13]). Tiles are 5 degrees by 5 degrees. The tile coordinate system starts at (0,0) (85N180W) (horizontal tile number, vertical tile number) in the upper left corner and proceeds right (horizontal) and downward (vertical). The tile in the bottom right corner is (71, 35) (90S175E). A tile is physically represented by a single file whose file name also indicates the tile south-west corner (see Section 6.2 for a complete description of the naming convention). In addition, tiles having no land contribution are not delivered.

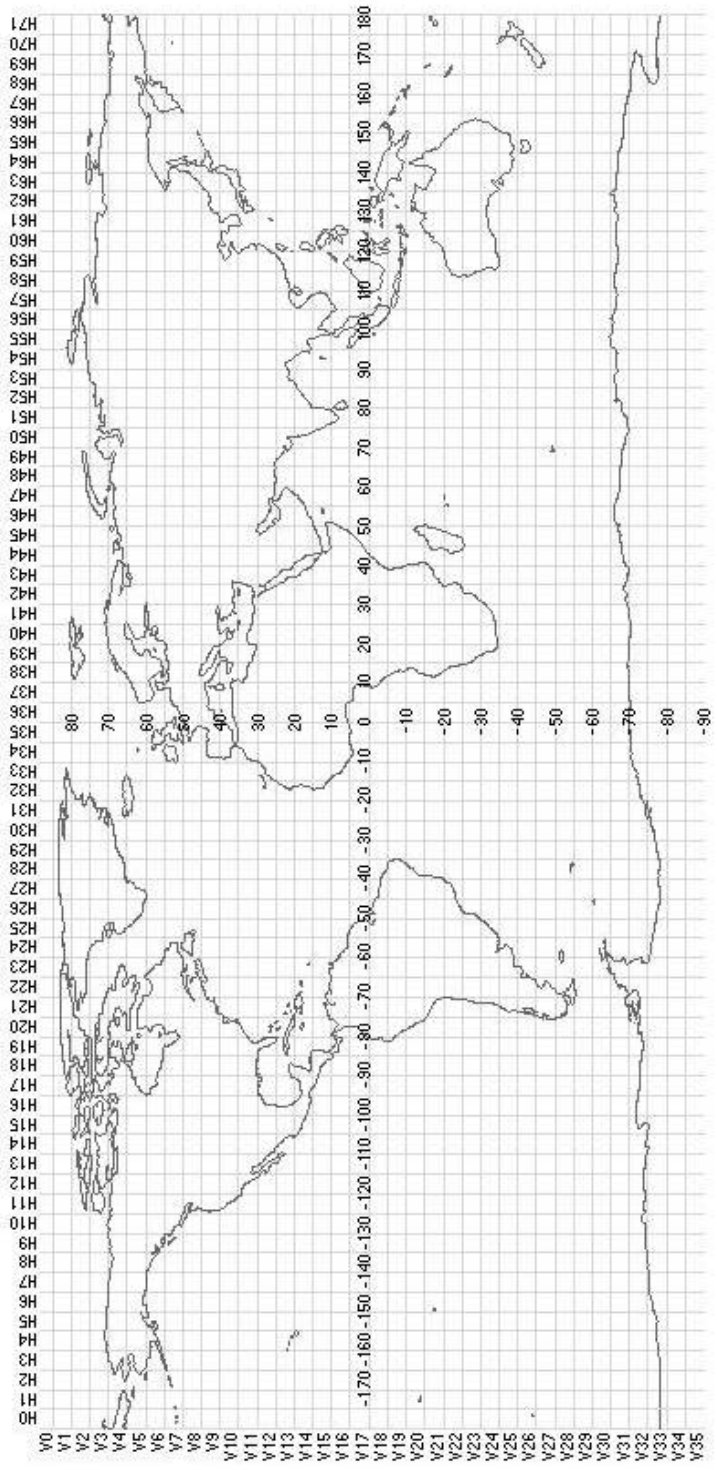


Figure 6-1: Description of the tiling system used for the SR products (from [RD.9] and [RD.13])

The following figure (Figure 6-2) shows the individual RGB image of tile h37v12 of CCI-LC MERIS FR SR 7-day composite from 2005-07-02 at 300m spatial resolution.

Figure 6-2: Example of CCI-LC SR 7-day composite, at 300m spatial resolution and tile v12h37 - ESACCI-LC-L3-SR-MERIS-300m-P7D-h37v12-20050702-v1.0.nc (RGB with channels 7, 5, 2).

Two examples of the global RGB image of CCI-LC MERIS FR SR 7-day composite are illustrated in Figure 6-3 (2009-04-02) and Figure 6-4 (2003-01-15). The different coverage of the Earth is clearly visible and is mainly influenced by the different number of available input daily data.

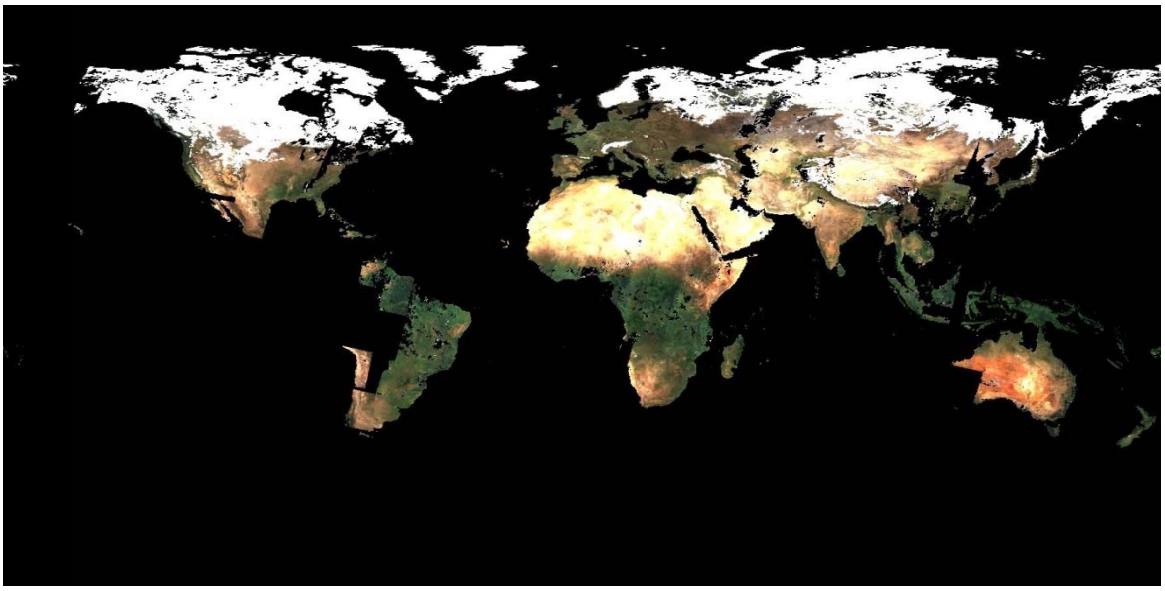


Figure 6-3: The CCI-LC Global Surface reflectance FR 7-day composite from the 2009-04-02 through 2009-04-08 at 300m spatial resolution (RGB with channels 7, 5, 3).

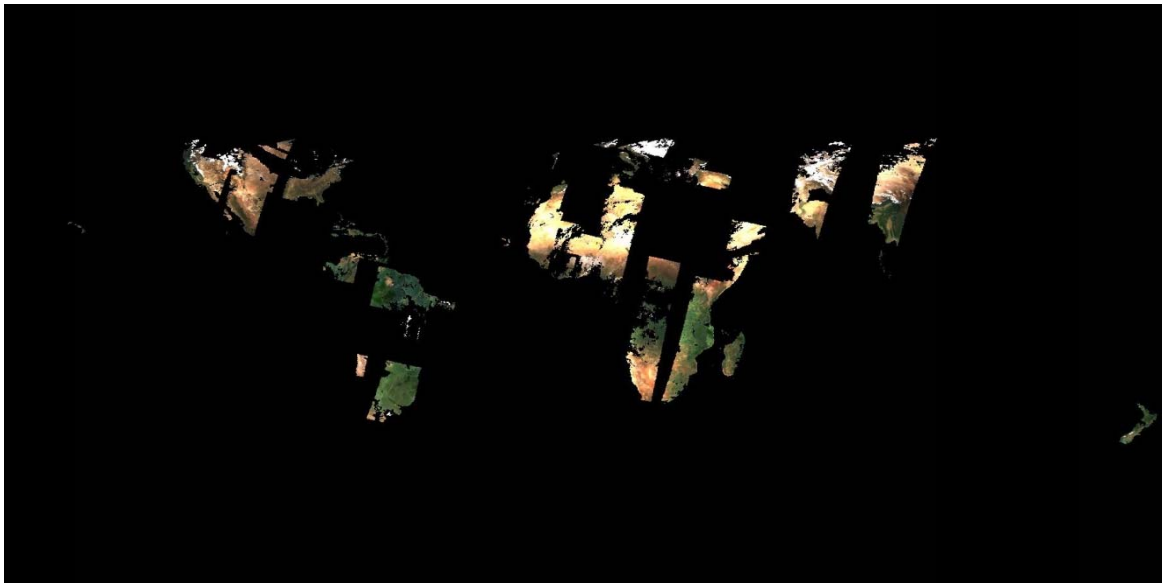


Figure 6-4: The CCI-LC Global Surface reflectance FR 7-day composite from the 2003-01-15 through 2003-01-21 at 300m spatial resolution (RGB with channels 7, 5, 3).

The Figure 6-5 shows the average of all FR 7-day composites related to the 2010 epoch (i.e. the 5 years from 2008 to 2012) at 300m spatial resolution.

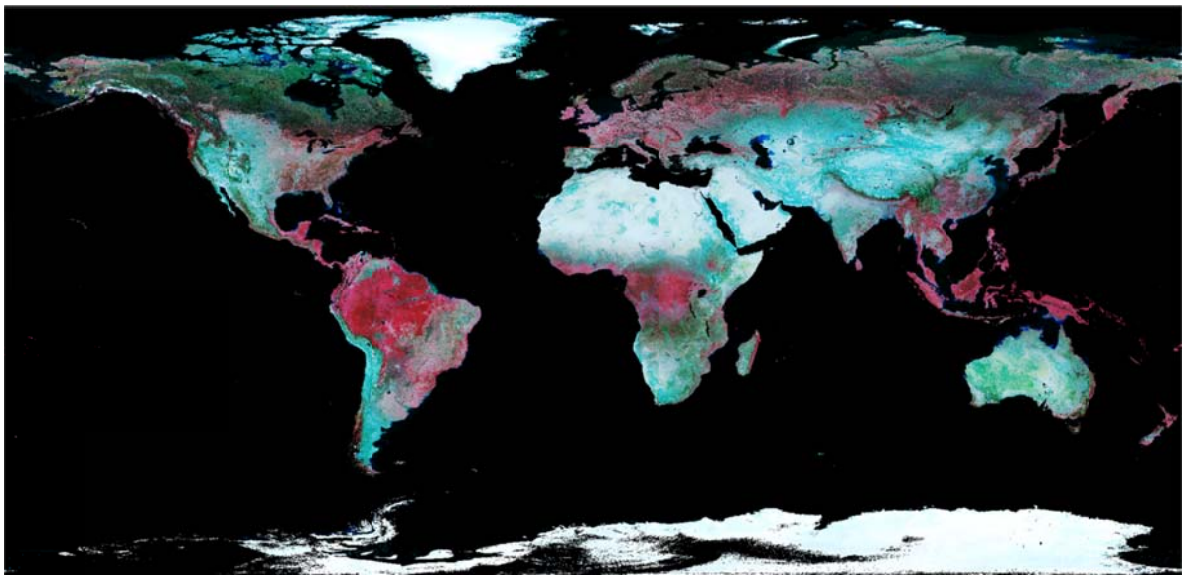


Figure 6-5: The CCI-LC Global Surface reflectance FR composite from all SR 7-day composite from the 2010 epoch (2008-2012), at 300m spatial resolution (RGB with channels 14, 7, 5).

6.2 Products format

- **Naming convention**

The file name convention of the global SR composite time series delivered by the CCI-LC project is the following:

File name = <id>-v<version>.nc

where <id> = <type>-<tile>-<start time>

where <type> = <project>[-<level>]-<code>-<sensor>-<spatres>-<tempres>

The dash "-" is the separator between name components. The filename convention obeys NetCDF CF by using the postfix ".nc". The different name components are defined in Table 6-3.

Table 6-3: Components that make the name of the SR products delivered by the CCI-LC project.

FIELD	SIGNIFICATION	VALUE
project	Project Acronym	ESACCI-LC (constant)
level	Processing level	L3 (constant)
code	Product code identifier for CCI-LC products	SR (constant)
sensor	Mission, platform and sensor identifier	MERIS (constant but could be updated if other sensors are used to generate SR products)
spatres	Spatial resolution	300m (or 1000m)
tempres	Compositing period	P7D (constant)
tile	Tile of the Plate Carree grid (see Figure 6-1)	Tile name in format hXXvYY where XX is the column and YY is the row e.g. " h71v27" - tile in column 71 and row 27 of the Plate Carree grid (see Figure 6-1)
start time	Start time of the interval mentioned in the field “period”	“yyyyMMdd” where: “yyyy” is the start year of the composite “MM” is the start month of the composite “dd” is the start day of the composite
version	Incremental that follows the successive revisions of the CCI-LC Processing lines	Version of product, preferably major.minor , optionally with processing centre [a-zA-Z0-9._]

An example file name of the first 7-day SR composite for the year 2008 located at the tile h40v13 would be: “ESACCI-LC-L3-SR-MERIS-300m-P7D-h40v13-20080326-v1.0.nc”

- **Processing Level**

Level 3 (i.e. “data or retrieved environmental variables which have been derived from level 1 or 2 products and which have been spatially and/or temporally resampled” [RD.14])

- **Units**

Top of Canopy Reflectance values (no unit, provided as a fraction) coded in 16-bits

- **Spatial Extent**

All the terrestrial zones of the earth between the parallels 90°N and 60°S. The SR products are provided in tiles as defined in Section 6.1.

- **Spatial resolution**

300m

- **Temporal resolution**

7 day

- **Product layers**

The CCI-LC global 7-day SR products description is based on the structure of the NetCDF files. The global attributes of the composites are described in the Appendix C.

- **Projection**

The projection is a Plate Carree with a geographic Lat/Long representation based on the WGS84 ellipsoid (see Section 3.4 for a complete description).

- **Format**

All the SR time series are delivered in NetCDF-4 format using the "classic model" of NetCDF with compression. The file specification follows CF conventions [RD.16].

- **Metadata**

The metadata for the SR products is provided as global attributes in the NetCDF file. It follows the CCI guidelines [RD.17].

- **Estimated size**

The size of a global 7-day 300-m MERIS FR SR composite is estimated at ~70 GB (compressed) and the size of the one tile is estimated at ~0.3 GB (compressed).

7 SOFTWARE TOOLS

A set of tools to browse and view the content of the CCI-LC products are available.

7.1 Software tools for viewing and using the CCI-LC SR 7-day composite products

7.1.1 BEAM

Since the CCI-LC SR 7-day products are in NetCDF format, these products can be opened with all NetCDF compatible software packages. We particularly recommend using the BEAM toolbox, which is specifically developed by ESA for the exploitation of EO data products. BEAM, for example, features the interpretation of flag-codings, provides image interpretation information, handles missing data gracefully and allows band arithmetic using a fast expression language.

BEAM is the Basic European Remote Sensing Satellite (ERS) & Envisat (Advanced) Along Track Scanning Radiometer ((A)ATSR) and MERIS Toolbox and is a collection of executable tools and an Application Programming Interface (API) which have been developed to facilitate the use, viewing and processing of data of various sensors. Furthermore, BEAM is open source and freely available from http://earth.esa.int/beam.

Regarding the CCI-LC products, BEAM could for example be used to:

- view the images and metadata;
- create regional subsets;
- investigate the products by creating statistics, histograms, and scatter plots;
- perform image analysis (e.g. clustering);
- validate data by comparison with in-situ or any other kind of reference data.

The components of the BEAM software are the following ones:

- VISAT - An intuitive desktop application to be used for visualization, analysis and processing of remote sensing raster data. Figure 7-1 gives an impression of how VISAT looks and feels like;
- A set of scientific tools running either from the command line or invoked by VISAT, also entirely written in Java;
- A rich Java API for the development of new remote sensing applications and BEAM extension plug-ins.

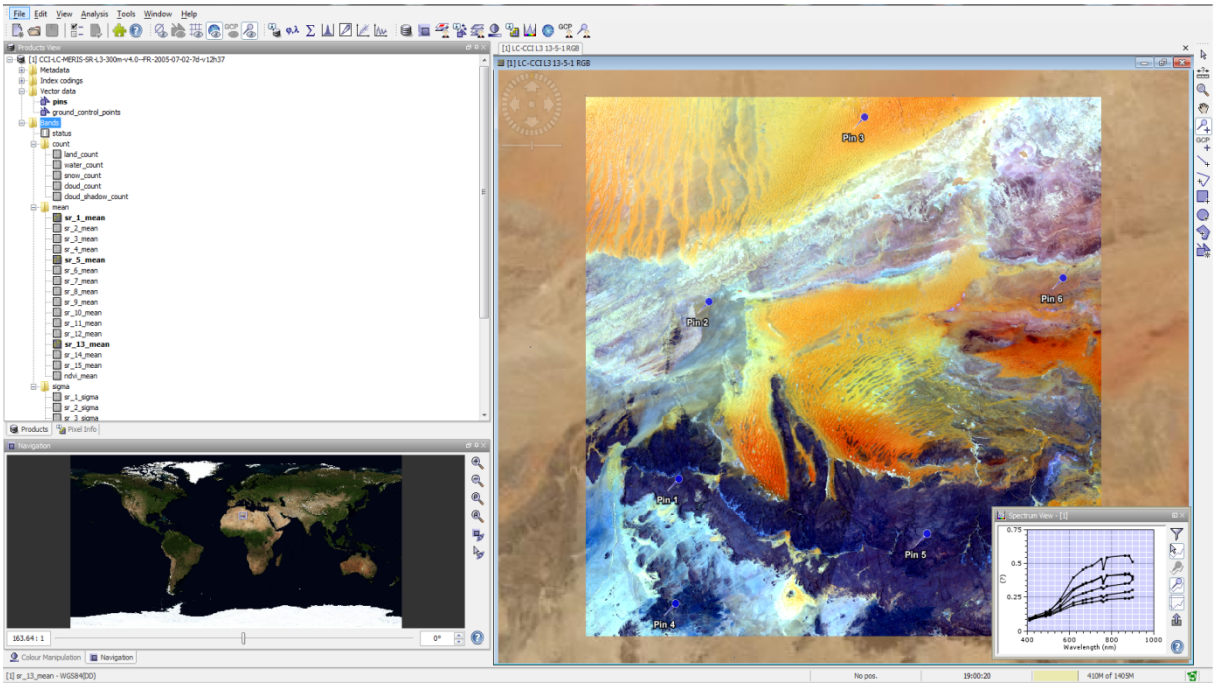


Figure 7-1: Screenshot of VISAT

7.1.2 Panoply

The Panoply data viewer provided by for free (available at http://www.giss.nasa.gov/tools/panoply/) can also be used. It is illustrated at Figure 7-2.

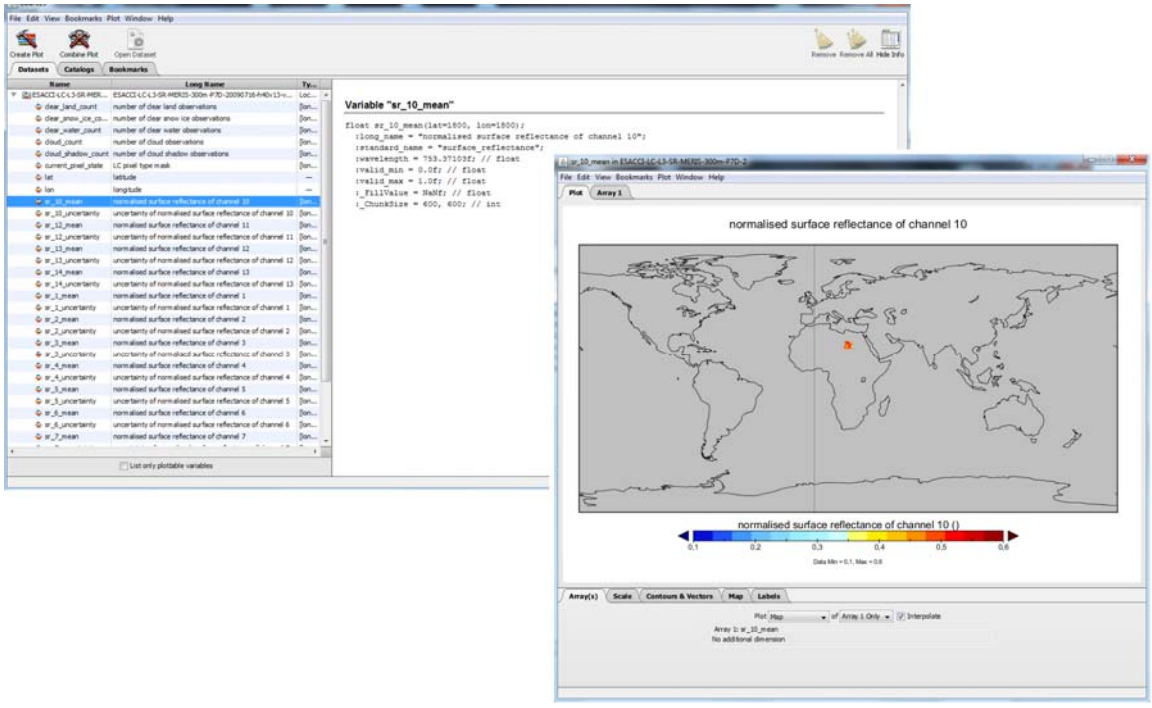


Figure 7-2: Screenshot of Panoply

7.2 Software tools for the CCI-LC map and seasonality products

The CCI-LC map and seasonality product are delivered both in the NetCDF and GeoTiff formats.

The GeoTiff format is supported by many softwares such as ArcGIS, Erdas and ENVI. These softwares can be used simply to visualize the data or to cross LC information with other spatial sources (vector or raster layers), extract temporal series on the seasonality products, compute statistics, etc.

Several Open Source softwares also support the GeoTiff format, such as the Geospatial Data Abstraction Library (GDAL [RD.18]) and the Geographic Resources Analysis Support System (GRASS GIS [RD.19]).

GDAL is a library for reading and writing raster geospatial data formats. It is built with a variety of useful command-line utilities for data translation and processing. This software allows easy access to the metadata and statistics of the files via the gdalinfo command. Regional subsets can also be created with the gdal_translate function.

GRASS GIS is a free Geographic Information System (GIS) software used for geospatial data management and analysis, image processing, graphics/maps production, spatial modeling, and visualization.

7.3 CCI-LC user tool

The LC map and seasonality products are delivered at spatial resolution of 300m (LC maps), 1km (NDVI seasonality product). All products are delivered in a Plate Carree projection as global files and regional subsets are also delivered for LC maps (see Appendix 3 in Section 11). However, climate models may need products associated with a coarser spatial resolution, over specific areas (e.g. for regional climate models) and/or in another projection. In order to face the variety of requirements, the CCI-LC project has developed a tool that allows users to adjust these three parameters of the LC products in a way which is suitable to their model.

The climate users of the CCI-LC project have established a minimum list of possibilities in terms of spatial resolution and projection that the tool shall - and does - offer. They are presented in Table 7-1.

Table 7-1: Minimum set of projections and spatial resolutions that need to be included in the re-projection, aggregation and subset tool developed by the CCI-LC project

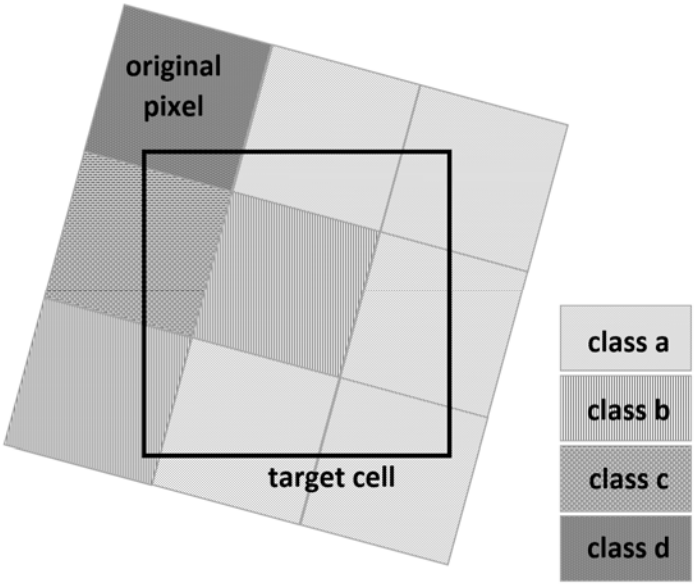
PARAMETER THAT CAN BE ADJUSTED	POSSIBILITIES OFFERED BY THE TOOL
Regional subset ID	Predefined regional subset
	Free specification of regional subset (4 corner coordinates)
Spatial resolution	Original resolution
	0.25 degree
	0.5 degree
	1 degree
	1.875 degree
Projection	Original projection (Plate-Carree)

PARAMETER THAT CAN BE ADJUSTED	POSSIBILITIES OFFERED BY THE TOOL
	Gaussian grid
Conversion of CCI-LC classes to PFT	CCI-LC standard cross table
	User defined cross table

In case of re-projection and aggregation of the CCI-LC products the applied resampling algorithms are different depending on the type of product and on the included bands and are described in the following.

- **Re-sampling algorithm for the CCI-LC MAP products**

The aggregated CCI-LC map product includes following bands: the fractional area of each CCI-LC class, the majority classes and the fractional area of each PFT as well as the accuracy. The majority class n is defined as the CCI-LC class which has the rank n of sorted list of CCI-LC class by fractional area in the target cell (see also Figure 7-3). The number of majority classes is a parameter which can be defined by user. The rules for the resampling are specified in consultation with the users. So each original pixel contributes to the target cell according to its area percentage but the value of a pixel will only consider if the flag -processed flag- has the status processed and the flag -current_pixel_state- has the status clear land, water or snow and ice. Then the accuracy is calculated by the median of the values of the band -algorithmic_confidence_level-.



	Area	Majority class
class a	~ 8/16	1
class b	~ 5/16	2
class c	~ 2/16	3
class d	~ 1/16	4

Figure 7-3: Visualization of the pixel aggregation from the spatial resolution of original LC-CCI Map product into the user defined spatial resolution of the aggregated LC-CCI Map product

- **Re-sampling algorithm for the CCI LS seasonality product**

In case of the aggregation of the NDVI CCI LS seasonality product, the mean of NDVI and the sum over all valid NDVI observations are included in the aggregated product. The rules for the resampling are also specified in consultation with the users. As well as for the CCI-LC map products, each original pixel contributes to the target cell according to its area percentage but the value of a pixel will only consider if the flag -current_pixel_state- has a dedicated status w.r.t. the type of seasonality product.

- **LCCS to PFT conversion**

Furthermore, it is very important that the modellers can use the aggregation tool to apply the conversion from the LC legend to their user-specific PFT list in order to deliver an appropriate PFT product. The conversion of CCI-LC classes to PFT is based on a look-up table, which has been confirmed by the climate modellers and is shown in Table 7-2. The users have the possibility to define their own look-up tables.

ID	CCI LC map description	Tree					Shrub				Grass		Non-vegetated			Total %
		Broadleaf Evergreen	Broadleaf Deciduous	Needleleaf Evergreen	Needleleaf Deciduous	Broadleaf Evergreen	Broadleaf Deciduous	Needleleaf Evergreen	Needleleaf Deciduous	Natural Grass	Managed Grass	Bare soil	Water	Snow/Ice	No data	
0	No data														100	100
10	Cropland, rainfed										100					100
11	Herbaceous cover										100					100
12	Tree or shrub cover						50				50					100
20	Cropland, irrigated or post-flooding										100					100
30	Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	5	5			5	5	5		15	60					100
40	Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	5	5			7.5	10	7.5		25	40					100
50	Tree cover, broadleaved, evergreen, closed to open (>15%)	90				5	5									100
60	Tree cover, broadleaved, deciduous, closed to open (>15%)		70				15			15						100
61	Tree cover, broadleaved, deciduous, closed (>40%)		70				15			15						100
62	Tree cover, broadleaved, deciduous, open (15-40%)		30				25			35		10				100
70	Tree cover, needleleaved, evergreen, closed to open (>15%)			70		5	5	5		15						100
71	Tree cover, needleleaved, evergreen, closed (>40%)			70		5	5	5		15						100
72	Tree cover, needleleaved, evergreen, open (15-40%)			30			5	5		30		30				100
80	Tree cover, needleleaved, deciduous, closed to open (>15%)				70	5	5	5		15						100
81	Tree cover, needleleaved, deciduous, closed (>40%)				70	5	5	5		15						100
82	Tree cover, needleleaved, deciduous, open (15-40%)				30		5	5		30		30				100
90	Tree cover, mixed leaf type (broadleaved and needleleaved)		30	20	10	5	5	5		15		10				100
100	Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	10	20	5	5	5	10	5		40						100
110	Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	5	10	5		5	10	5		60						100
120	Shrubland					20	20	20		20		20				100
121	Evergreen shrubland					30		30		20		20				100
122	Deciduous shrubland						60			20		20				100
130	Grassland									60		40				100
140	Lichens and mosses									60		40				100
150	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	1	3	1		1	3	1		5		85				100
152	Sparse shrub (<15%)					2	6	2		5		85				100
153	Sparse herbaceous cover (<15%)									15		85				100
160	Tree cover, flooded, fresh or brakish water	30	30							20			20			100
170	Tree cover, flooded, saline water	60				20							20			100
180	Shrub or herbaceous cover, flooded, fresh/saline/brakish water		5	10			10	5		40			30			100
190	Urban areas		2.5	2.5						15		75	5			100
200	Bare areas											100				100
201	Consolidated bare areas											100				100
202	Unconsolidated bare areas											100				100
210	Water bodies												100			100
220	Permanent snow and ice													100		100

Table 7-2: Look-up table - conversion of CCI-LC classes to PFT

- **Examples**

Figure 7-4 gives an example of the global land cover map aggregated at a cell size of 9.8km and the pixel value represents the majority class 1 w.r.t. the LC class, according to Table 3-2.

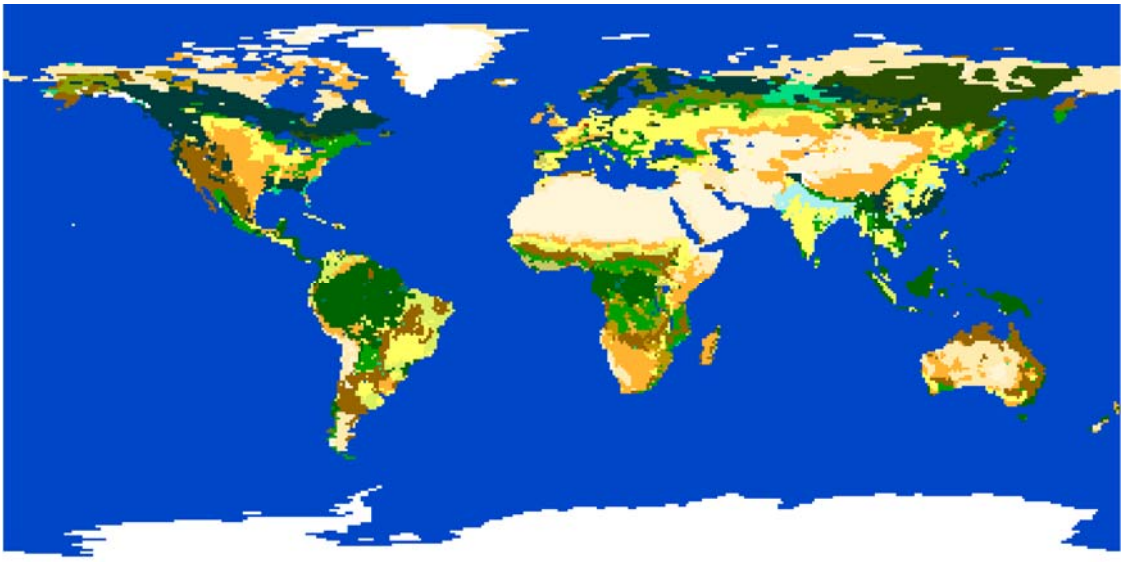


Figure 7-4: Example of an aggregated global land cover map V1 obtained with the aggregation tool. Its pixel size is 9.8 km, the majority class is 1, the pixel value represents the LC class according to Table 7-2

Figure 7-5 shows an example of the global land cover map aggregated at a cell size of 9.8km and the pixel value represents the area of the LC class 130 - grassland. Figure 7-6 gives an example of the global land cover map aggregated at a cell size of 9.8km and the pixel value represents the area of the PFT – natural grass.

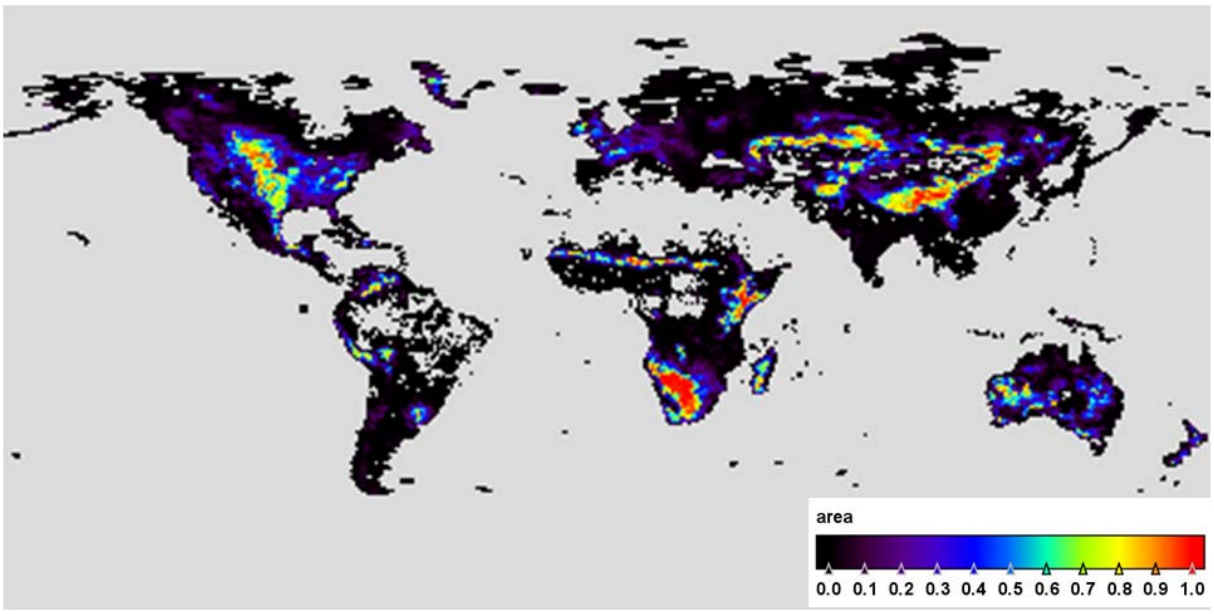


Figure 7-5: Example of an aggregated CCI Global Land Cover Map V1 obtained with the aggregation tool. Its pixel size is 9.8 km, area of CCI-LC class – 130 – grassland

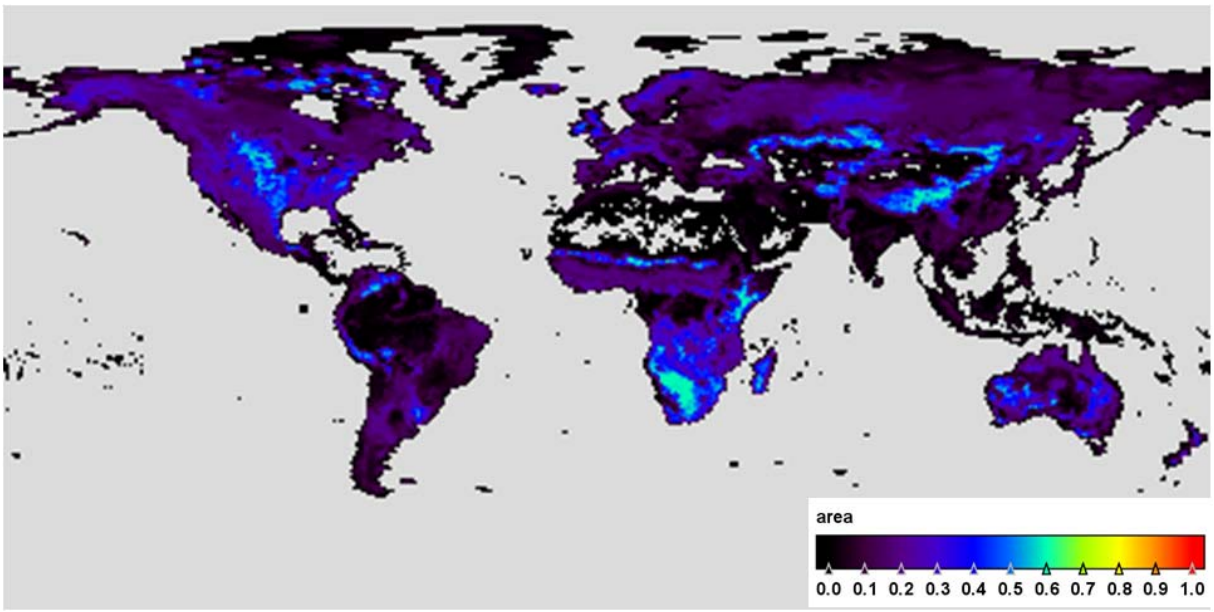


Figure 7-6: Example of an aggregated CCI Global Land Cover Map V1 obtained with the aggregation tool. Its pixel size is 9.8 km, area of CCI-LC PFT – natural grass

The instruction manual of the aggregation tool can be found in the Appendix D of this document.

7.4 Software tools for CCI-LC dataset visualisation

Considering the heavy download related to the full CCI-LC products dataset, a web interface was developed to mainly visualise data. It is accessible at the following address: http://maps.elie.ucl.ac.be/CCI/viewer/index.html. Figure 7-7 illustrates the home page of the visualisation interface.

It includes two main compartments: the map environment (right) and the information panel (left). The information panel includes the description of the LC-Map legend (1) and the functionality to download pdf documents describing the products: this actual product user guide, summary user guides for the CCI-LC Maps and seasonality products and the CCI-LC Maps legend (2).

The "+ O -" button (3) can be used to adapt the zoom, such as the mouse wheel and to set the visualization extent to global. By default, the base layer displayed in the map environment corresponds to the CCI-LC Map 2010 but it can be changed by selecting one of the products available in (4): a 10-year global MERIS surface reflectance product composite, the CCI-LC Maps from the 1998-2002, 2003-2008 or 2009-20012 epochs and the water bodies product.

The base layer is interactive (5). A left click, anywhere on the layer, highlights the LC-Map label of the selected pixel in the legend description of the left panel. A right click activates the display of the CCI LS NDVI seasonality profiles reference behaviours.

Finally, the download data button (6) redirects the user to a new web page where some of the products are available for download:

- The CCI-LC maps for three epochs and their corresponding quality flags (see Table 3-4);
- The SAR WB layer from the WB product (see Table 5-2);
- The profiles of the NDVI, product can be extracted according to LAT/LONG coordinates or simply downloaded;
- The user tool.

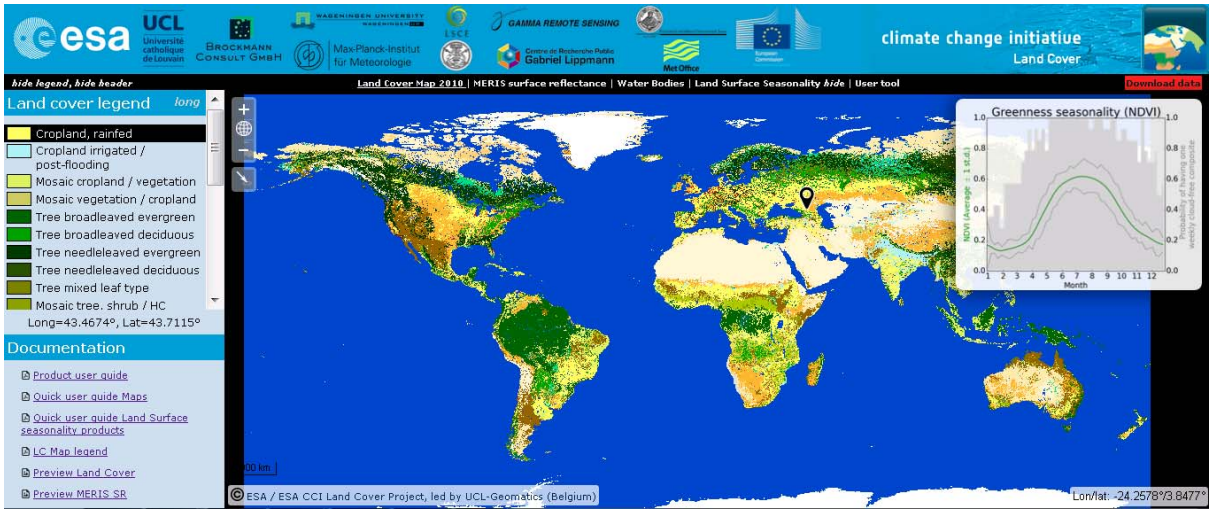


Figure 7-7: Main page of the CCI-LC products visualisation tool, with the following functionalities: top-left) LC-Maps legend description; bottom-left) download of documents describing the CCI-LC products; top-left) tools box to control the zooms (+ and -), to set the view to the global extent (O) and to reach particular coordinates; top) products available for visualization; centre) visualisation panel. A right click on the map activates the apparition of the LS seasonality profiles (NDVI) and highlights the LC-Map label on the left panel; top right) redirection to data download web page;

8 DATA ACCESS AND POLICY

The CCI-LC products are made available through the viewer presented in Section 7.4:

CCI-LC visualization interface (http://maps.elie.ucl.ac.be/CCI/viewer/index.html)

For the time being, the data delivered in the CCI-LC database are the following ones:

- MERIS FR and RR time series version 1.0;
- LC map 2010 version 1.4;
- LC maps 2005 and 2000 version 1.3
- NDVI seasonality products version 2.0;
- WB product version 2.0.

This CCI-LC database has been processed by the CCI-LC consortium led by UCL-Geomatics (Belgium). They are made available to the public by ESA and the consortium. You may use one or several CCI-LC products land cover map for educational and/or scientific purposes, without any fee on the condition that you credit the ESA Climate Change Initiative and in particular its Land Cover project as the source of the CCI-LC database:

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9 APPENDIX 1 – GLOBAL AND REGIONAL CCI-LC LEGENDS

LABEL		VALUE		COLOR
GLOBAL LABEL	REGIONAL LABEL	GLOBAL VALUE	REGIONAL VALUE	
No Data		0		
Cropland, rainfed		10		
	Cropland, rainfed, herbaceous cover		11	
	Cropland, rainfed, tree or shrub cover		12	
Cropland, irrigated or post-flooding		20		
Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)		30		
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)		40		
Tree cover, broadleaved, evergreen, closed to open (>15%)		50		
Tree cover, broadleaved, deciduous, closed to open (>15%)		60		
	Tree cover, broadleaved, deciduous, closed (>40%)		61	
	Tree cover, broadleaved, deciduous, open (15-40%)		62	
Tree cover, needleleaved, evergreen, closed to open (>15%)		70		
	Tree cover, needleleaved, evergreen, closed (>40%)		71	
	Tree cover, needleleaved, evergreen, open (15-40%)		72	
Tree cover, needleleaved, deciduous, closed to open (>15%)		80		
	Tree cover, needleleaved, deciduous, closed (>40%)		81	
	Tree cover, needleleaved, deciduous, open (15-40%)		82	

Tree cover, mixed leaf type (broadleaved and needleleaved)		90		
Mosaic tree and shrub (>50%) / herbaceous cover (<50%)		100		
Mosaic herbaceous cover (>50%) / tree and shrub (<50%)		110		
Shrubland		120		
	Evergreen shrubland		121	
	Deciduous shrubland		122	
Grassland		130		
Lichens and mosses		140		
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)		150		
			151	
			152	
			153	
Tree cover, flooded, fresh or brakish water		160		
Tree cover, flooded, saline water		170		
Shrub or herbaceous cover, flooded, fresh/saline/brakish water		180		
Urban areas		190		
Bare areas		200		
	Consolidated bare areas	201		
	Unconsolidated bare areas	202		
Water bodies		210		
Permanent snow and ice		220		

10 APPENDIX 2 – LCCS & THE CCI-LC LEGEND

VALUE	CCI LAND COVER LEGEND (LEVEL 1)	LCCS LABEL	LCCS ENTRY
10	Cropland, rainfed	Rainfed shrub crops // Rainfed tree crops // Rainfed herbaceous crops	A11 Cultivated Terrestrial Areas and Managed Lands
20	Cropland, irrigated or post-flooding	Irrigated tree crops // Irrigated shrub crops // Irrigated herbaceous crops // Post- flooding cultivation of herbaceous crops	
30	Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	Cultivated and managed terrestrial areas / Natural and semi-natural primarily terrestrial vegetation	
40	Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	Natural and semi-natural primarily terrestrial vegetation / Cultivated and managed terrestrial areas	
50	Tree cover, broadleaved, evergreen, closed to open (>15%)	Broadleaved evergreen closed to open trees // Broadleaved semi-deciduous closed to open trees	A12 Natural and Semi-natural Terrestrial Vegetation – Woody / Trees
60	Tree cover, broadleaved, deciduous, closed to open (>15%)	Broadleaved deciduous closed to open (100-40%) trees	
70	Tree cover, needleleaved, evergreen, closed to open (>15%)	Needleleaved evergreen closed to open (100-40%) trees	
80	Tree cover, needleleaved, deciduous, closed to open (>15%)	Needleleaved deciduous closed to open (100-40%) trees	
90	Tree cover, mixed leaf type (broadleaved and needleleaved)	Broadleaved closed to open trees / Needleleaved closed to open trees	
100	Mosaic forest or shrubland (50-70%) / grassland (20-50%)	Closed to open trees / Closed to open shrubland (thicket) // Herbaceous closed to open vegetation	A12 Natural and Semi-natural Terrestrial Vegetation
110	Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	Herbaceous closed to open vegetation // Closed to open trees / Closed to open shrubland (thicket)	
120	Shrubland	Broadleaved closed to open shrubland (thicket)	Natural and Semi-natural Terrestrial Vegetation
130	Grassland	Herbaceous closed to very open vegetation	Natural and Semi-natural Terrestrial Vegetation –

140	Lichens and mosses	Closed to open lichens/mosses	
150	Sparse (<15%) vegetation	Sparse trees // Herbaceous sparse vegetation // Sparse shrubs	A12 Natural and Semi-natural Terrestrial Vegetation
160	Tree cover, flooded, fresh or brakish water	Closed to open (100-40%) broadleaved trees on temporarily flooded land, water quality: fresh water // Closed to open (100-40%) broadleaved trees on permanently flooded land, water quality: fresh water	A24 Natural and Seminatural Aquatic Vegetation
170	Tree cover, flooded, saline water	Closed to open (100-40%) broadleaved trees on permanently flooded land (with daily variations), water quality: saline water // Closed to open (100-40%) broadleaved trees on permanently flooded land (with daily variations), water quality: brackish water // Closed to open (100-40%) semi-deciduous shrubland on permanently flooded land (with daily variations), water quality: saline water // Closed to open (100-40%) semi-deciduous shrubland on permanently flooded land (with daily variations), water quality: brackish water	
180	Shrub or herbaceous cover, flooded, fresh/saline/brakish water	Closed to open shrubs on permanently flooded land // Closed to open herbaceous vegetation on permanently flooded land // Closed to open shrubs on temporarily flooded land // Closed to open herbaceous vegetation on temporarily flooded land // Closed to open shrubs on waterlogged soil // Closed to open herbaceous vegetation on waterlogged soil Water quality: fresh, brackish or saline waterl	
190	Urban areas	Artificial surfaces and associated areas	B15 Artificial Surfaces

200	Bare areas	Bare areas	B16 Bare Areas
210	Water bodies	Natural water bodies // Artificial water bodies	B28 Inland Waterbodies, snow and ice
220	Permanent snow and ice	Artificial perennial snow // Artificial perennial ice // Perennial snow // Perennial ice	

11 APPENDIX 3 – REGIONAL WINDOWS OF THE GLOBAL LAND COVER MAPS

The CCI-LC project delivers the LC maps both as global files and regional subsets (in order to make easier their reading and analysis). Nine regional subsets are foreseen. They are presented in Figure and their precise delineation is provided in Table.

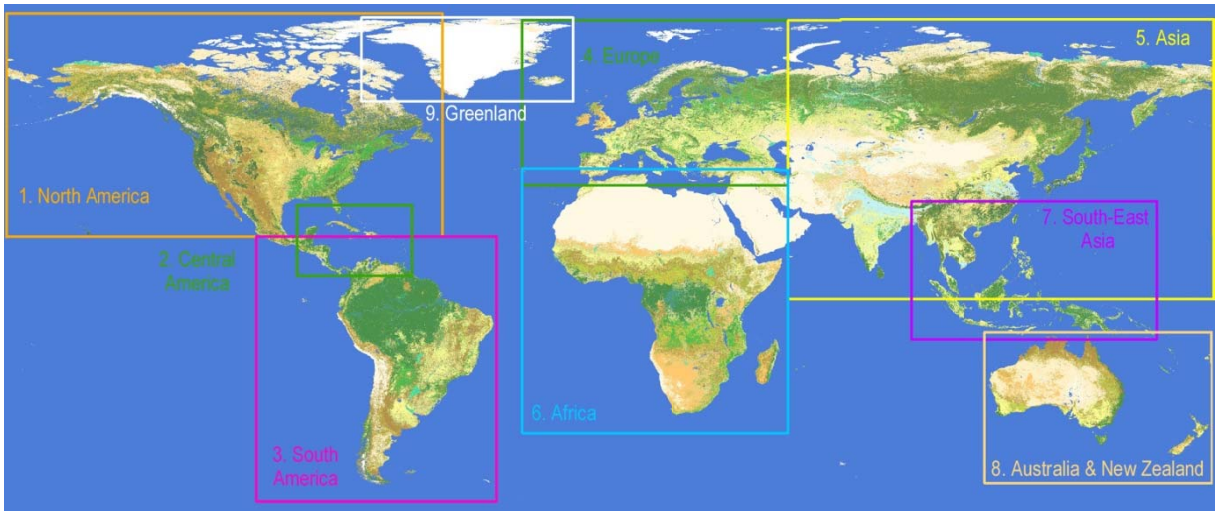

Figure 11-1: Regional windows of the world, underlying the LC products distribution

Table 11-1: Coordinates of the regional windows of the world, underlying the LC products

REGIONAL SUBSET ID	REGIONAL SUBSET NAME	UPPER LEFT COORDINATES	LOWER RIGHT COORDINATES
1	North America	180°W, 85°N	50°W, 19°N
2	Central America	93°W, 28°N	59°W, 7°N
3	South America	105°W, 19°N	34°W, 60°S
4	Western Europe	26°W, 83°N	53°E, 34°N
5	Asia	53°E, 83°N	180°E, 0°N
6	Africa	26°W, 40°N	53°E, 40°S
7	South East Asia	90°E, 29°N	163°E, 12°S
8	Australia & New Zealand	112°E, 10°S	180°E, 55°S
9	Greenland	74°W, 84°N	11°W, 59°N

12 APPENDIX 4 – NETCDF ATTRIBUTES

- **Surface reflectance product**

The CCI-LC global 7-day SR products description is based on the structure of the NetCDF files. The global attributes of the composites are described in Table 12-1.

Table 12-1: Global attributes of the global 7-day SR products delivered by the CCI-LC project, according to the structure of the NetCDF files.

Attribute Name	Format	Value	Description
title		ESACCI-LC-L3-SR-MERIS-300m-P7D-h40v13-20080326-v1.0	Product identifier (see "naming convention" here above)
summary		This dataset contains a tile of a Level-3 7-day global surface reflectance composite from satellite observations placed onto a regular grid.	
project		Climate Change Initiative - European Space Agency	
references		http://www.esa-landcover-cci.org/	References that describe the data or methods used to produce it.
institution		Brockmann Consult GmbH	Where the data has been produced
contact		info@brockmann-consult.de	
source		MERIS FR L1b	Method of production of the original data
history		amorgos-4.0 lc-sdr-2.0 lc-sr-2.0	List of applications that have modified the original data, with time stamp, processor and parameters
comment			Miscellaneous information about the data or method used to produce it
Conventions		CF-1.6	Name of the conventions followed
standard_name_ vocabulary		NetCDF Climate and Forecast (CF) Standard Names version 18	

Attribute Name	Format	Value	Description
keywords		satellite,observation,reflectance	
keywords_ vocabulary		NASA Global Change Master Directory (GCMD) Science Keywords	
license		ESA CCI Data Policy: free and open access	
naming_authority		org.esa-cci	
cdm_data_type		grid	
platform		e.g "ENVISAT"	
sensor		e.g "MERIS"	
type		sr- 300m-7d	Product type
id		e.g "ESACCI-LC-L3-SR-MERIS-300m-P7D-h40v13-20080326-v1.0"	
tracking_id		e.g "2521cb70-348f-4676-9d7c-c0311a8118ac"	
tile	hXXvYY	e.g. " h71v27"	Example for the tile in row 27 and column 71 of the Plate Carree grid (see Figure 6-1)
product_version	major.minor	e.g " 1.0"	Product revision (see here above)
date_created	yyyy-MM-dd'T'HH:mm:ss'Z'	e.g " 20130424T124732Z"	Creation time of product
creator_name		Brockmann Consult	
creator_url		http://www.brockmann-consult.de/	
creator_email		info@brockmann-consult.de	
time_coverage_start	yyyy-MM-dd'T'HH:mm:ss'Z'	e.g" 20080326T000000Z"	Start of aggregation period e.g. 2009-01-01T00:00:00Z
time_coverage_end	yyyy-MM-dd'T'HH:mm:ss'Z'	e.g" 20080402T000000Z"	End of aggregation period e.g. 2009-01-11T00:00:00Z
time_coverage_duration	0 ... 1382400	P7D	aggregation period
time_coverage_resolution		P7D	
geospatial_lat_min	-90.0 ... 90.0		South border of the bounding box
geospatial_lat_max	-90.0 ... 90.0		North border of the bounding box
geospatial_lon_min	-180.0 ... 180.0		West border of the bounding box
geospatial_lon_max	-180.0 ... 180.0		East border of the bounding box
spatial_resolution		300	Resolution of the product in meters
geospatial_lat_units		degrees_north	

Attribute Name	Format	Value	Description
geospatial_lat_ resolution		e.g " 0.002778 "	
geospatial_lon_units		degrees_east	
geospatial_lon_ resolution		e.g " 0.002778 "	
TileSize		600:600	

The global 7-day SR NetCDF file for a tile has two dimensions that define the spatial raster, as described in Table 12-2.

Table 12-2: Information related to the spatial dimension of the global SR products delivered by the CCI-LC project

Dimension	Value	Description
lat	1800	Dimension that distinguishes different lines
lon	1800	Dimension that distinguishes different columns

The variables and variables' attributes of the global 7-day SR NetCDF file are presented in Table 12-3.

Table 12-3: Variables and variables' attributes of the global 7-day SR products delivered by the CCI-LC project, according to the structure of the NetCDF files.

Variable	Attribute	Format	Value	Description
crs		int	0	Coordinate reference system attribute container
	wkt		GEOGCS["WGS84(DD)" DATUM["WGS84", SPHEROID["WGS84", 6378137.0, 298.257223563]], PRIMEM["Greenwich", 0.0], UNIT["degree", 0.017453292519943295], AXIS["Geodetic longitude", EAST], AXIS["Geodetic latitude", NORTH]]	
	i2m		0.0027777777777777778,0.0,0.0,-0.0027777777777777778,20.0,25.0	
lon		float (lon)	-180.0 .. 180.0	Longitude coordinate of pixel column
	standard_name		longitude	
	long_name		longitude coordinate	
	units		degrees east	
	valid_min		-180.0	
	valid_max		180.0	

Variable	Attribute	Format	Value	Description
lat		float (lat)	-90.0 .. 90.0	Latitude coordinate of pixel row
	standard_name		latitude	
	long_name		latitude coordinate	
	units		degrees north	
	valid_min		-90.0	
	valid_max		90.0	
sr_<n>_mean n = 1 .. 10, 12 .. 14 (MERIS) n=B0,B2, B3, MIR (SPOT-VGT)		float (lat,lon)		Mean of SR values of channel <n>[3]
	long_name		normalised (averaged) surface reflectance of channel n	
	standard_name		surface_bidirec-tional_reflectance	
	wavelength_nm		MERIS: 412.5, 442.5, 490, 510, 560, 620, 665, 681.25, 708.75, 753.75, 778.75, 865, 885, SPOT-VGT: 450, 645, 835, 1665	Centre wavelength of channel
	valid_min		0	
	valid_max		1	
	_FillValue		NaN	
	ancillary_variab-les		sr_n_uncertainty current_pixel_state clear_land_count clear_water_count clear_snow_ice_count cloud_count cloud_shadow_count	
sr_<n>_uncertainity n = 1 .. 10, 12 .. 14 (MERIS) n=B0,B2, B3, MIR (SPOT-VGT)		float (lat,lon)		uncertainity of normalized surface reflectance values of channel <n>[4]
	long_name		uncertainity of normalized surface reflectance values of channel n	
	standard_name		surface_bidirec-tional_reflectance standard_error	
	wavelength_nm		see above	Centre wavelength of channel
	valid_min		0.0	
	valid_max		0.5	

[3] valid for current pixel_state 1 or 3

[4] The uncertainity values of the SR values are to less due to a calculation failure regarding the error propagation of the uncertainty of the SDR values.

Variable	Attribute	Format	Value	Description
	_FillValue		NaN	
vegetation index_mean		float (lat,lon)		Mean of vegetation index, e.g. NDVI
	long_name		mean of vegetation index	
	standard_name		normalized_difference_ vegetation_index	
	valid_min		-1	
	valid_max		+1	
	_FillValue		NaN	
	ancillary_variab-les		current_pixel_state clear_land_count clear_water_count clear_snow_ice_count cloud_count cloud_shadow_count	
clear_land_ count		short (lat,lon)		Number of contributing observations over clear sky land in aggregation period
	long_name		Number of contributing of observations over clear sky land	
	standard_name		surface_bidirectional_ reflectance number_of_observations	
	valid_min		0	
	valid_max		150	
	_FillValue		-1	
clear_water_ count		short (lat,lon)		Number of observations with water coverage in aggregation period
	long_name		number of clear_water observations	
	standard_name		surface_bidirectional_ reflectance number_of_observations	
	valid_min		0	
	valid_max		150	
	_FillValue		-1	
clear_snow_ ice_count		short (lat,lon)		Number of contributing observations with snow and ice coverage in aggregation period
	long_name		number of clear_snow_ice observations	

Variable	Attribute	Format	Value	Description
	standard_name		surface_bidirectional_ reflectance number_of_observations	
	valid_min		0	
	valid_max		150	
	_FillValue		-1	
cloud_count		short (lat,lon)		Number of observations with cloud coverage in aggregation period
	long_name		number of cloud observations	
	standard_name		surface_bidirectional_ reflectance number_of_observations	
	valid_min		0	
	valid_max		150	
	_FillValue		-1	
cloud_shadow_count		short (lat,lon)		Number of observations with cloud shadow coverage in aggregation period
	long_name		number of cloud_shadow observations	
	standard_name		surface_bidirectional_ reflectance number_of_observations	
	valid_min		0	
	valid_max		150	
	_FillValue		-1	
current_pixel_state		byte (lat,lon)		Status of surface associated with the surface reflectance in the aggregation period: "invalid" = 0 "clear_land " = 1 "clear_water" = 2 "clear_snow_ice" = 3 "cloud" = 4 "cloud_shadow"=5
	long_name		LC pixel type mask	
	standard_name		surface_bidirectional_ reflectance status_flag	
	flag_values		0 ... 5	

Variable	Attribute	Format	Value	Description
	flag_meanings		invalid clear_land clear_water clear_snow_ice cloud cloud_shadow	
	valid_min		0	
	valid_max		5	
	_FillValue		-1	

- **Land cover products**

The CCI-LC global land cover products description is based on the structure of the NetCDF files. The global attributes of the land cover maps are described in Table 12-4.

Table 12-4 : Global attributes of the global LC maps delivered by the CCI-LC project, according to the structure of the NetCDF files

Attribute Name	Format	Value	Description
title		ESACCI-LC-L4-LCCS-Map-300m-P5Y-01-2010-v1.0.nc/tif	Product identifier (see "naming convention" above)
summary		This dataset contains a global land cover map obtained from surface reflectance composites, placed onto a regular grid.	
project		Climate Change Initiative - European Space Agency	
references		http://www.esa-landcover-cci.org/	References that describe the data or methods used to produce it.
institution		UCL	Where the data has been produced
contact		Pierre.Defourny@uclouvain.be	
source		MERIS FR L1B, MERIS RR L1B, SPOT-VGT S1	Source of the original data
history		lc-mosaic-1.1 lc-compositing-1.0 lc-stratification-1.0 lc-classification-1.0 lc-labeling-1.0	List of applications that have modified the surface reflectance composites, with time stamp, processor and parameters
comment			Miscellaneous information about the data or method used to produce it
Conventions		CF-1.6	Name of the conventions followed
type		LCMap-300m	Product type

Attribute Name	Format	Value	Description
date_created	yyyy-MM-dd'T'HH:mm:ss'Z'	e.g " 20130424T124732Z"	Creation time of product
creator_name		UCL-Geomatics	
creator_url		http://www.uclouvain.be/elie.html	
creator_email		Pierre.Defourny@uclouvain.be	
epoch	YYYY	[YYYY] where the two "YYYY" are the middle year of the epoch	Multi-year epoch of the product, defined by the middle year
geospatial_lat_min	-90.0 ... 90.0		South border of the bounding box
geospatial_lat_max	-90.0 ... 90.0		North border of the bounding box
geospatial_lon_min	-180.0 ... 180.0		West border of the bounding box
geospatial_lon_max	-180.0 ... 180.0		East border of the bounding box
geospatial_lat_min	-90.0 ... 90.0		South border of the bounding box
geospatial_lat_units		degrees_north	
geospatial_lat_ resolution		e.g " 0.002778 "	
geospatial_lon_units		degrees_east	

The variables and variables' attributes of the global 7-day SR NetCDF file are presented in Table 12-5.

Table 12-5: Variables and variables' attributes of the global LC maps delivered by the CCI-LC project, according to the structure of the NetCDF files

Variable	Attribute	Format	Value	Description
crs		int		Coordinate reference system attribute container
	grid_mapping_name		Plate Carree	
	semi_major_axis		6378137.0	
	inverse_flattening		298.257223563	
	false_easting		0.0	
	false_northing		0.0	
	longitude_of_central_meridian		0.0	
	scale_factor_at_central_meridian		1.0	
time		double(time)		Start time of the multi-year period
	standard_name		time	

Variable	Attribute	Format	Value	Description
	long_name		multi-year period	
	units		year	
lon		double (lon)	-180.0 .. 180.0	Longitude coordinate of image column
	standard_name		longitude	
	long_name		WGS84 longitude coordinate	
	units		degrees east	
	valid_min		-180.0	
	valid_max		180.0	
lat		double (lat)	-90.0 .. 90.0	Latitude coordinate of image row
	standard_name		latitude	
	long_name		WGS84 latitude coordinate	
	units		degrees north	
	valid_min		-90.0	
	valid_max		90.0	
lc_classif_lcss		byte (lat,lon)		LC classificatio n in LCCS
	standard_name		land cover	
	long_name		LC class defined in LCCS	
	vocabulary		UN-LCCS 2005	
	valid_min		1	
	valid_max		240	
	_FillValue		0b	
lc_quality_flag_ 1		byte (lat,lon)		LC map quality flag 1: pixel processed or not
	standard_name		land_cover status_flag	
	long_name		LC map processed area flag	
	valid_min		0	
	valid_max		1	
	_FillValue		-1b	
lc_quality_flag_ 2		byte (lat,lon)		LC map quality flag 2: pixel status
	standard_name		land_cover status_flag	

Variable	Attribute	Format	Value	Description
	long_name		LC map area type mask	
	valid_min		0	
	valid_max		6	
	_FillValue		-1b	
lc_quality_flag_3		short(lat,long)		LC map quality flag 3: number of valid observations
	standard_name		land_cover number_of_observations	
	long_name		number of valid observations	
	valid_min		0	
	valid_max		32767	
	_FillValue		-1s	
	_FillValue		-1b	
	scale_factor		0.01f	
lc_quality_flag_4		byte(lat,long)		LC map quality flag 4: LC map confidence level
	standard_name		land_cover confidence_level	
	long_name		LC map confidence level based on product validation	
	valid_min		0	
	valid_max		100	
	_FillValue		-1b	

13 APPENDIX 5 – METADATA

- **NDVI seasonality product**

The following attributes are included in all **4** series of products (AggOcc, Std, NYearObs and Status). Fields named “Files”, “Data set”, “Description”, “Scaling factor” and “Valid values range” vary according to the layer of interest. It follows the CCI guidelines [RD.17].

The following metadata concerning the NDVI status layer is proposed as an example.

```
Driver: GTiff/GeoTIFF
Files: ESACCI-LC-L4-NDVI-Cond-Status-1000m-P14Y7D-1999-2012-19990709-v2.0.tif
Size is 40320, 20160
Coordinate System is:
GEOGCS["WGS 84",
    DATUM["WGS_1984",
        SPHEROID["WGS 84",6378137,298.257223563,
            AUTHORITY["EPSG","7030"]],
        AUTHORITY["EPSG","6326"]],
    PRIMEM["Greenwich",0],
    UNIT["degree",0.0174532925199433],
    AUTHORITY["EPSG","4326"]]
Origin = (-180.000000000000000,90.000000000000000)
Pixel Size = (0.008928571400000,-0.008928571400000)
Metadata:
   Compositing period =7 days
   Copyright =ESA / ESA CCI Land Cover Project, led by UCL-Geomatics (Belgium)
   Data Set =Normalized Vegetation Index (NDVI) - Status
   Description =Status of the pixel; 1 : land , 2 : water , 3 : snow, 4 : cloud , 5
: filled ice
   NaN value =0
   Scaling Factor       =none
   Sensor =SPOT-VEGETATION
   Temporal coverage =1999 - 2012
   Valid values range =1 to 5
```

```
  AREA_OR_POINT=Area
Image Structure Metadata:
  COMPRESSION=LZW
  INTERLEAVE=BAND
Corner Coordinates:
Upper Left  (-180.0000000,  90.0000000) (180d 0' 0.00"W, 90d 0' 0.00"N)
Lower Left  (-180.0000000, -89.9999994) (180d 0' 0.00"W, 90d 0' 0.00"S)
Upper Right ( 179.9999988,  90.0000000) (180d 0' 0.00"E, 90d 0' 0.00"N)
Lower Right ( 179.9999988, -89.9999994) (180d 0' 0.00"E, 90d 0' 0.00"S)
Center      (  -0.0000006,   0.0000003) (  0d 0' 0.00"W,  0d 0' 0.00"N)
Band 1 Block=256x256 Type=Int16, ColorInterp=Gray
```

- **Open water bodies product**

The following attributes are included in the layers of the product. It follows the CCI guidelines [RD.17].

The metadata of the WB-Map layer is proposed as an example.

```
Driver: GTiff/GeoTIFF
Size is 129600, 64800
Coordinate System is:
GEOGCS["WGS 84",
    DATUM["WGS_1984",
        SPHEROID["WGS 84",6378137,298.257223563,
            AUTHORITY["EPSG","7030"]],
        AUTHORITY["EPSG","6326"]],
    PRIMEM["Greenwich",0],
    UNIT["degree",0.0174532925199433],
    AUTHORITY["EPSG","4326"]]
Origin = (-180.000000000000000,90.000000000000000)
Pixel Size = (0.002777777700000,-0.002777777700000)
Metadata:
  AREA_OR_POINT=Area
  Copyright =ESA / ESA CCI Land Cover Project, led by UCL-Geomatics (Belgium)
  Dataset =Global Water Body Data Set from ENVISAT ASAR Data
  Description =Water classification; 1: Other , 2: Water
```

```
  Scaling Factor =none
Image Structure Metadata:
  COMPRESSION=LZW
  INTERLEAVE=BAND
Corner Coordinates:
Upper Left  (-180.0000000,  90.0000000) (180d 0' 0.00"W, 90d 0' 0.00"N)
Lower Left  (-180.0000000, -89.9999950) (180d 0' 0.00"W, 89d59'59.98"S)
Upper Right ( 179.9999899,  90.0000000) (179d59'59.96"E, 90d 0' 0.00"N)
Lower Right ( 179.9999899, -89.9999950) (179d59'59.96"E, 89d59'59.98"S)
Center      (  -0.0000050,   0.0000025) (  0d 0' 0.02"W,  0d 0' 0.01"N)
Band 1 Block=256x256 Type=Byte, ColorInterp=Gray
```

14 APPENDIX 6 – INSTRUCTION MANUAL OF THE AGGREGATION TOOL

CCI-LC User Tools

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Version: 3.6

Release: 2014/11/28

Summary

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This set of tools (conversion tool, aggregation tool, subset tool) prepares data for model computation.

General Note

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The target files are always written in NetCDF-4 (enhanced model) file format.

If the NetCDF-4 Classic file format is needed the standard nccopy tool can be used for conversion.

Installation

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As a prerequisite the CCI-LC User Tools require an installed Java SE JRE version 7 or higher

on the system. It can be obtained from the web page at

http://www.oracle.com/technetwork/java/javase/downloads/index.html.

1) Unzip the zip-file in a directory of your choice.

2) Inside the unzipped directory you can find a folder which is named 'bin'.

Inside you can find the windows and unix start scripts for the CCI-LC tools.

Execution

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All start scripts are available in windows and unix versions.

Use the scripts in the same manner.

Conversion Tool Usage (converts Tiff to NetCDF-4 files)

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convert.sh -PtargetDir=<dirPath> <pathToMapTifFile|pathToSeasonalityTifFile>

In case of a CCI-LC Map file the corresponding flag files must be in the same directory as the Map file.
They are automatically detected and added to the output NetCDF-4 file.
If a seasonality product shall be converted the AggMean tif file must be provided as source. All the associated variables (AggMean, Std, Status and NYearObs) are considered and integrated into the output NetCDF-4 file if they reside in the same folder as the source tif file.

Parameter Description:

-PtargetDir=<dirPath>

Specifies the directory where the target will be written. If this parameter is omitted the directory of the source file is used. The target is written as NetCDF-4 file.
If already a file with the same name/path exists, it will be overwritten.
(see "Output File Naming Convention")

Aggregation Tool Usage

CCI LS Seasonality Products

aggregate-cond.sh -PgridName=<name> -PnumRows=<integer> -PtargetDir=<dirPath> <sourceFilePath>

Parameter Description:

-PgridName=<name>

Specifies the target grid of the resulting product. For example a regular gaussian grid.
Valid Parameters are: GEOGRAPHIC_LAT_LON and REGULAR_GAUSSIAN_GRID
This is a mandatory parameter.

-PnumRows=<integer>

Specifies the number of rows for the specified grid.
Default ist 2160 rows. A grid with the default number of rows leads to a resolution of ~9.8km/pixel in the target product.
For a REGULAR_GAUSSIAN_GRID only the following values are valid:
32, 48, 80, 128, 160, 200, 256, 320, 400, 512, 640

-PpredefinedRegion=<regionName>

Specifies one of the available predefined regions. This is an optional value.
If a predefined region is given it has precedence over the user defined region (north, east, ...)
Valid Values are: NORTH_AMERICA, CENTRAL_AMERICA, SOUTH_AMERICA, WESTERN_EUROPE_AND_MEDITERRANEAN, ASIA, AFRICA, SOUTH_EAST_ASIA, AUSTRALIA_AND_NEW_ZEALAND, GREENLAND

-Pnorth=<degree>

Specifies north bound of the regional subset. This is an optional value

-Peast=<degree>

Specifies east bound of the regional subset. This is an optional value

-Psouth=<degree>

Specifies south bound of the regional subset. This is an optional value

-Pwest=<degree>

Specifies west bound of the regional subset. This is an optional value

-PtargetDir=<dirPath>

Specifies the directory where the target will be written. If this parameter is omitted the directory of the source file is used. It is written as NetCDF-4 file.

If already a file with the same name/path exists, it will be overwritten.

(see "Output File Naming Convention")

<sourceFilePath>

Is the path to the source NetCDF-4 file.

CCI-LC Map Products

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aggregate-map.sh -PgridName=<name> -PnumRows=<integer>
-PoutputLCCSClasses=<boolean> -PnumMajorityClasses=<integer>
-PoutputPFTClasses=<boolean> -PuserPFTConversionTable=<filePath>
-PtargetDir=<dirPath> <sourceFilePath>

Parameter Description:

For a description of the common aggregation parameters please have a look into the above section for the CCI LS Seasonality Products. In addition for the aggregation of the CCI-LC Map Products the following parameters exist:

-PoutputLCCSClasses=<boolean>

Specifies whether the LCCS classes shall be added to the output. This parameter can be omitted. The default is true.

-PnumMajorityClasses=<integer>

Specifies the number of majority classes in the output. This parameter can be omitted, in this case the default (5) is used. A value of 1 will produce an output with just the majority class.

-PoutputPFTClasses=<boolean>

Specifies if a conversion to PFT classes shall be performed and the result added to the output. This parameter can be omitted. The default is true.

-PuserPFTConversionTable=<filePath>

Specifies the path to a user defined PFT conversion table. If not given the default
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CCI-LC conversion table will be used. For a description of the file format see further down.

-PoutputAccuracy=<boolean>

Specifies the computation of the accuracy shall be performed and the result added to the output. This parameter can be omitted. The default is true.

A real example might look like the following:

```
aggregation-map.sh -PgridName=REGULAR_GAUSSIAN_GRID -PnumRows=320
        -PoutputLCCSClasses=false -PnumMajorityClasses=3
        -PpredefinedRegion=AUSTRALIA_AND_NEW_ZEALAND
        -PtargetDir="/data/CCI-LC/output/" "/data/CCI-LC/ESACCI-LC-L4-LCCS-Map-300m-P5Y-2010-v2.nc"
```

The PFT (Plant Functional Type) conversion table

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The file can start with an optional comment. If the comment is used the first line must start with '#' in order to indicate the comment. Multiple lines are not supported. The comment ('pft_table_comment') is included as an attribute into the NetCDF output file.

The PFT table with a table header. Each column of the header defines one PFT except the first. The first column must contain the value of each LCCS class index. The subsequent rows, one for each LCCS class, define the conversion from corresponding class to the PFTs. Columns are separated with the pipe ('|') symbol and the column header names are used as band names.

Subset Tool Usage

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```
subset.sh -PpredefinedRegion=<regionName> -PtargetDir=<dirPath> <sourceFilePath>
```

or

```
subset.sh -Pnorth=<degree> -Peast=<degree> -Psouth=<degree> -Pwest=<degree> -PtargetDir=<dirPath> <sourceFilePath>
```

-PpredefinedRegion=<regionName>

Specifies one of the available predefined regions.

Valid Values are: NORTH_AMERICA, CENTRAL_AMERICA, SOUTH_AMERICA, WESTERN_EUROPE_AND_MEDITERRANEAN, ASIA, AFRICA, SOUTH_EAST_ASIA, AUSTRALIA_AND_NEW_ZEALAND, GREENLAND

-Pnorth=<degree>

Specifies north bound of the regional subset.

-Peast=<degree>

Specifies east bound of the regional subset.

-Psouth=<degree>

Specifies south bound of the regional subset.

-Pwest=<degree>

Specifies west bound of the regional subset.

-PtargetDir=<dirPath>

Specifies the directory where the target will be written. It is written as NetCDF-4 file.

If already a file with the same name/path exists, it will be overwritten.

(see "Output File Naming Convention")

<sourceFilePath>

The source file to create a regional subset from.

In order to create a regional subset of a map, seasonality or aggregated product the subset tool can be used. As parameter either one of the predefined regions can be selected or the outer bounds of the desired region can be specified. The target file is written into the directory of the source file.

Classes Remapping Tool Usage

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remap.sh <map-netcdf-file> [classes_LUT]

This tool splits up the information found in the band "lccs_class" into the classes given via a CSV file.

Either such a file is provided as second parameter, or a default classification will be used.

The input CSV needs to adhere to the following format:

<Source Name>|<target band name 1>|<target band name 2>| ...

120|20|30| ...

150|10|| ...

Such a file would be interpreted as follows: It applies to each pixel that if the source band has the value 120, the target band 1 is assigned the value 20 and the target band 2 the value 30. If the source band has the value 150, the target band 1 is assigned the value 10 and the target band 2 the no-data-value.

Note that the separator character is expected to be '|'.

Parameter Description:

<map-netcdf-file>

Specifies the input file.

[classes_LUT] (optional)

Points to the LUT file that will be used for remapping.
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Output File Naming Convention

"""

Conversion Tool Output:

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Map Product: ESACCI-LC-L4-LCCS-Map-{sRes}m-P{tRes}Y-{epoch}-v{versNr}.nc

Seasonality Product: ESACCI-LC-L4-{seasonality}-Cond-{sRes}m-P{tRes}D-{startY}{MonthDay}-v{versNr}.nc

Split Points:

~~~~~~~~~~~~~~

Map Product: ESACCI-LC-L4-LCCS-Map-{sRes}m-P{tRes}Y-{epoch}-v{versNr}.nc

^

|--- Split Position

Seasonality Product: ESACCI-LC-L4-{seasonality}-Cond-{sRes}m-P{tRes}D-{startY}{MonthDay}-v{versNr}.nc

^

|--- Split Position

Examples Map Result:

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Aggregation:

Input : ESACCI-LC-L4-LCCS-Map-300m-P5Y-2006-v2.nc

Output : ESACCI-LC-L4-LCCS-Map-300m-P5Y-aggregated-0.083333Deg-2006-v2.nc

Subset:

Input : ESACCI-LC-L4-LCCS-Map-300m-P5Y-aggregated-0.083333Deg-2006-v2.nc

Output : ESACCI-LC-L4-LCCS-Map-300m-P5Y-aggregated-0.083333Deg-EUROPE-2006-v2.nc

Output : ESACCI-LC-L4-LCCS-Map-300m-P5Y-aggregated-0.083333Deg-ASIA-2006-v2.nc

Output : ESACCI-LC-L4-LCCS-Map-300m-P5Y-aggregated-0.083333Deg-USER_REGION-2006-v2.nc

Examples Seasonality Result:

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Subset:

Input : ESACCI-LC-L4-NDVI-Cond-300m-P9Y7D-20010101-v2.nc

Output : ESACCI-LC-L4-NDVI-Cond-300m-P9Y7D-EUROPE-20010101-v2.nc

Output : ESACCI-LC-L4-NDVI-Cond-300m-P9Y7D-ASIA-20010101-v2.nc

Output : ESACCI-LC-L4-NDVI-Cond-300m-P9Y7D-USER_REGION-20010101-v2.nc