ESA Climate Change Initiative – FireCCI
D1.2 Product Specification Document (PSD)

Project Name	ECV Fire Disturbance: FireCCI
Contract Nº	4000126706/19/I-NB
Issue Date	20/12/2022
Version	7.1
Author	M. Lucrecia Pettinari
Document Ref.	Fire_cci_D1.2_PSD_v7.1
Document type	Public

To be cited as: M.L. Pettinari (2022) ESA CCI ECV Fire Disturbance: D1.2 Product Specification Document, version 7.1. Available at: https://climate.esa.int/en/projects/fire/key-documents/

Project Partners

Prime Contractor/ Scientific Lead & Project Management	UAH – University of Alcala (Spain)
Earth Observation Team	UAH – University of Alcala (Spain) UPM – Universidad Politécnica de Madrid (Spain) CNR-IREA - National Research Council of Italy – Institute for Electromagnetic Sensing of the Environment (Italy)
System Engineering	BC – Brockmann Consult (Germany)
Climate Modelling Group	CNRS - Laboratory for Sciences of Climate and Environment (France) VU – Vrije Universiteit Amsterdam (Netherlands)

Distribution

Affiliation	Name	Address	Copies
ESA	Clément Albergel (ESA)	clement.albergel@esa.int	electronic copy
Project Team	Emilio Chuvieco (UAH)	emilio.chuvieco@uah.es	electronic copy
	M. Lucrecia Pettinari (UAH)	mlucrecia.pettinari@uah.es	
	Amin Khaïroun (UAH)	amin.khairoun@uah.es	
	Magí Franquesa (UAH)	magin.franquesa@uah.es	
	Consuelo Gonzalo (UPM)	consuelo.gonzalo@upm.es	
	Ángel Mario García Pedrero (UPM)	angelmario.garcia@upm.es	
	Dionisio Rodríguez Esparragón (UPM)	dionisio.rodriguez@ulpgc.es	
	Daniela Stroppiana (CNR)	stroppiana.d@irea.cnr.it	
	Matteo Sali (CNR)	sali.m@irea.cnr.it	
	Thomas Storm (BC)	thomas.storm@brockmann-consult.de	
	Florent Mouillot (CNRS)	florent.mouillot@ird.fr	
	Philippe Ciais (CNRS)	philippe.ciais@lsce.ipsl.fr	
	Guido van der Werf (VU)	g.r.vander.werf@vu.nl	

Summary

This document is version 7.1 of the Product Specification Document for the FireCCI project. It refers to the product specifications of burned area products, and it is an update of the previous version 6.3, including the modifications implemented during Phase 1 of CCI+, previously included in the Algorithm Development Plan v2.1, and that will continue to guide the BA production during Phase 2.

	Affiliation/Function	Name	Date
Prepared	UAH – Project Manager	M. Lucrecia Pettinari	20/12/2022
Reviewed	UAH - Science Leader	Emilio Chuvieco	20/12/2022
Authorized	UAH - Science Leader	Emilio Chuvieco	20/12/2022
Accepted	ESA - Technical Officer	Clément Albergel	27/12/2022

This document is not signed. It is provided as an electronic copy.

Document Status Sheet

Issue	Date	Details
1.0	14/12/2010	First Document Issue (Draft)
1.4	27/01/2011	Second version
1.5	24/02/2011	Third major revision
1.6	21/03/2011	Adaption to ESA comments
1.7	10/05/2011	Minor adaption
2.0	20/06/2011	Minor adaption and changes
2.1	08/06/2012	Adaption and synchronisation to LC_cci specifications
3.0	13/03/2013	Updating pixel and grid product specifications and metadata
4.0	26/06/2013	Final updates with agreements derived from the Hamburg PM
4.1	13/08/2013	Addressing comments according to CCI-FIRE-EOPS-MM-13-0024.pdf
4.2	10/09/2014	Updating according to modifications implemented in output products
4.3	27/10/2014	Updating references
5.0	01/11/2015	Fifth version, first corresponding to Phase 2 of FireCCI
5.1	15/01/2016	Minor changes
6.0	20/09/2016	Changes to address the new URD, and include information for the small fire dataset
6.1	30/12/2016	Addressing comments according to CCI-FIRE-EOPS-MM-16-0129.
6.2	30/09/2017	Inclusion of layers in the pixel and grid product
6.3	05/12/2017	Addressing comments according to CCI-FIRE-EOPS-MM-17-0097.
7.0	05/12/2022	Revision of the whole document.
7.1	20/12/2022	Addressing comments according to Fire_cci D1.2 PSD v7.0 RID.

Document Change Record

Issue	Date	Request	Location	Details
1.4	27/01/2011	UAH	Whole Document	Partner Input included
1.5	24/02/2011	UAH	Whole Document	Comments from partners included after Progress Meeting 2
1.6	21/03/2011	UAH	Whole Document	Revision following receipt of review comments from Stephen Plummer (ESA) and FireCCI team members
1.7	10/05/2011	UAH	Whole Document Section 2.3 Section 5.1.6, page 7	Revision following comments from Stephen Plummer (ESA) Applicable Documents recompiled Batch conversion utilities added

Issue	Date	Request	Location	Details
			Section 5.1.9 Page 10, table 3 Page 11, table 4	File metadata for pixel product introduced Additional information for BA pixel product introduced Footnote added
2.0	20/06/2011	UAH /GAF	Page 7, table 1 Page 12, table 6 Section 5.6, page 14 Page 13 Whole document	Confidence level of pre-processing excluded Graduation of dominant vegetation introduced GOFC-GOLD comments addressed Auxiliary file including permanent fields Typo and formatting corrections
2.1	08/06/2012	UAH	Section 5.1 Figure 1/Table 2 Sections 5.1.8 and 5.2.8	Introducing GeoTIFF output format for pixel product Update of BA geographical tiles (in compliance with LC_cci) Adaptation of product file name convention according to ESA DS-WG
3.0	13/03/2013	UAH	Section 2.4 Section 3.4 Section 5 Section 5.1.4, Table 1 Section 5.1.6 Section 5.1.9, Table 3 Section 5.2.4, Table 5 Section. 5.2.5 Section 5.3 Section 5.7 Section 5.8 Annex 3 Whole document	Adaptation of title of chapters Fixing 15-day composites, weekly discarded Introducing cross-indices to sub-sections Upgrade, introducing “Data Type” column; deleting footnotes Change format to GeoTIFF Listing Globcover land cover classes; deleting Table 3 in v2.0 “Additional information for BA pixel product” Upgrading information layers of grid product Including links to GFEDv3.1 and GFAS v1.0 Introducing URL link to host BA products Introducing modifications from LC_cci agreements Introducing changes from v2.0 to v3.0 Enclosing NetCDF metadata structure Typo corrections, layout update
4.0	26/06/2013	UAH	Section 1 Section 5.1.3 Section 5.2.4, Table 4	Update and further remarks Spatial resolution of pixel product modified Modifying values and definitions of layers
4.1	13/08/2013	UAH	Whole document Section 3.1	Renaming CUG to CRG Including references to ATBD I/III v2
4.2	10/09/2014	UAH	Section 5.1.1 Section 5.1.4 Section 5.1.8 Section 5.2.2 Section 5.2.4 Section 5.2.8 Section 5.6 Whole document	Indicating on individual layers Indicating on separate GeoTIFF files; Table 1 updated Naming convention updated Amendment on temporal composition Table 2 updated Naming convention updated Amendment on patch numbers (point 4) Updating references
4.3	27/10/2014	GAF	Whole document	Updating references
5.0	01/11/2015	UAH	Name Whole document Page 2 Sections 2.1, 2.2, 2.3, 3.2, 5, 5.1.4, Section 3.3 Table 1	New naming convention for the document New format and layout, updated references Inclusion of team members of Phase 2 Updated Eliminated Minimum Spatial Unit reference Layer 2 of the pixel product (input sensor) was removed.

Issue	Date	Request	Location	Details
			Section 5.1.5 and 5.1.6 Section 5.1.7, Figure 1 and Table 2. Sections 5.1.8 and 5.2.8 Section 5.1.9 Sections 5.2.3, 5.2.5 and 5.2.6 Table 4	Changed order Changed to reflect new non-overlapping tiles Modified naming conventions Added processing version to metadata The spatial resolution was changed to 0.25 deg., and other information accordingly Variables changed to include new LC_cci reference product
5.1	15/01/2016	ESA	Summary and text Sections 1, 2.1, 3.1, 4, 5.1, 5.1.2, 5.1.3, 5.1.9, 5.2 Sections 5.1.1. and 5.1.4 Section 5.1.5 Tables 1 and 4 Annexes	Changed reference to new version of URD v4.1. Minor changes in the text. Added missing identifier. New section added to the document Information added to the notes. Annex 2 has been deleted, and the following annexes were renumbered. The references to the annexes were updated in the text.
6.0	20/09/2016	UAH	Whole document Summary and executive summary Sections 2.2, 3.2, 5.2.2, 5.2.3, 5.2.5, 5.3, 5.6 Section 2.4 Section 3.1 Sections 5.1, 5.1.2, 5.2.6, Section 5.1.3 Table 1 Section 5.1.5 Section 5.1.8 Section 5.1.9 Section 5.1.10 Table 4 Section 5.2.8 Section 5.2.10 Section 5.4 Section 5.5 Section 6 Annex 2 Acronyms	Replaced the acronym CCI_LC with LC_cci to be consistent with other deliverables. The references to the URD and ATBD documents were updated. Updated text. Minor changes in the text. Section deleted. Changes in the text to include other sensors and continental products. Updated text. Updated text to include other sensors Updated text. Inclusion of a new layer to account for different sensors. Inclusion of the LC_cci 2010 dataset. Updated text. Added Figure 2. Information on indicative sensor and additional segregator updated. Updated metadata information. Updated text in layers 1to 4. New layer included to account for fraction of burnable area. Information on indicative sensor updated Section deleted. This topic is addressed in the new Section 5.3. The rest of the section numbers were changed accordingly. Updated text to reference to the new downloading method. Updated link. New references included. Updated text. New acronyms added.
6.1	30/12/2016	ESA	Front Page	Authors added to author list. Small changes in the text.

Issue	Date	Request	Location	Details
			Sections 1, 2.1, 3.1, 3.4, 4, 5.1, 5.1.9, 5.2.1, 5.2.4, Table 1 Sections 5, 5.2.6, 5.2.1. Section 5.1.8 Section 5.2.6 References Annex 2 Annex 4	Text expanded. Subset size of the medium-resolution products has been changed to 5x5 degrees. Last sentences deleted. Updated references. Metadata updated. Acronym added and acronyms re-ordered.
	30/09/2017	UAH	All document Sections 2.2, 3.1, 5.1.9 Section 5.1.4 Section 5.1.5, 5.2.2, 5.6 Section 5.2.4 References Annex 2	GCOS reference updated Minor changes in the text Notes on confidence level updated Text updated Table 3 updated Updated references Updated metadata
6.3	05/12/2017	UAH CCI UAH CCI UAH	Section 5.1.3 Table 1 Section 5.1.9 Section 5.2.8 Section 5.6	Deleted reference to Proba-V 300m. Complemented the notes in layer 2. Inclusion of information detailing that the pixel layers can be provided in individual files. Inclusion of AVHRR in the indicative sensor Information updated
7.0	05/12/2022	UAH	Summary, Sections 1.1, 2.1, 2.2, 4, 4.1, 4.1.2, 4.1.3, 4.1.5, 4.2.2, 4.3, 4.4, 4.5, Annex 2, Annex 3 Sections 2.3, 4, 5.6 Sections 3.1, 3.2, 3.3, 4.1.4, 4.1.7, 4.1.8, 4.1.9, 4.1.10, 4.2.2, 4.2.4, 4.2.7, 4.2.8, Annex 1	Sections updated Section removed (section number refers to previous version of the document) Small changes in the text
7.1	20/12/2022	ESA	Sections 2.2, 3.1 Section 2.2 Annex 4	Small changes in the text Table 1 added. New acronyms added

Table of Contents

1. Executive Summary 8
2. Introduction 8
2.1. Background 8
2.2. Purpose of the document 8
3. Terms of Reference 9
3.1. Burned Area 9
3.2. Spatial resolution 10
3.3. Temporal resolution 10
3.4. File formats 10
3.5. File name conventions 10
4. Product Specifications 10

4.1. Pixel BA product 10
4.1.1. Product description 10
4.1.2. Temporal compositing 11
4.1.3. Spatial Resolution 11
4.1.4. Pixel attributes 11
4.1.5. Land Cover information 12
4.1.6. File formats 12
4.1.7. Product projection system 12
4.1.8. Subsets 12
4.1.9. Product file naming conventions 14
4.1.10. File metadata 15
4.2. Grid BA product 15
4.2.1. Product description 15
4.2.2. Temporal compositing 15
4.2.3. Spatial Resolution 16
4.2.4. Grid attributes 16
4.2.5. Product projection system 17
4.2.6. Subsets 17
4.2.7. File formats 17
4.2.8. Product file naming conventions 18
4.2.9. File metadata 18
4.3. Product Accuracy 18
4.4. Data dissemination for all products 18
4.5. Data Documentation 19
5. References 19
Annex 1: Description of the Plate Carrée Projection 21
Annex 2: Dimensions, variables and metadata of the gridded BA product (NetCDF file) 22
Annex 3: Land cover categories 26
Annex 4: Acronyms and abbreviations 28

List of Tables

Table 1: Summary of products characteristics 9
Table 2: Layers of the Target BA pixel based product 11
Table 3: Geographical distribution of BA tiles for the pixel product 13
Table 4: Layers of the BA grid products 16

List of Figures

Figure 1: Geographical distribution of subsets for the global BA product 13
Figure 2: Geographical distribution of tiles for medium-resolution products 13
Figure 3: Deformations introduced by the Plate Carrée projection (Gaba 2008) 21

1. Executive Summary

Fires emit greenhouse gases (GHGs) and aerosols, important climate forcing factors that need to be estimated and modelled to better understand climate and carbon cycling. Fires are also a major factor in land cover change, and hence affect fluxes of energy and water to the atmosphere. In this context, spatial and temporal monitoring of trace gas emissions from fires is of primary importance. The Fire Disturbance Essential Climate Variable provides baseline products for the land-surface to allow this.

Burned area (BA), as derived from satellites, is considered the primary variable that requires climate-standard continuity. It can be combined with information on burn efficiency and available fuel load to estimate emissions of trace gases and aerosols. Measurements of BA may be used as direct input (driver) to climate and carbon cycle models or, when long time series of data are available, to parameterise climate-driven models for BA (GCOS 2022a).

This document is the FireCCI Product Specification Document (PSD) corresponding to Phase 2 of the FireCCI+ project. It describes the product specifications that will lead to the generation of the BA products. The product specifications address the main requirements expressed by the users during user requirements collection, and the experience of the consortium in de development of the BA datasets. Due to the limited time of Phase 2, and the Algorithm Development Plan (ADP) agreed for this Phase, no major changes are foreseen compared to the specifications stablished during Phase 1 of CCI+, except in the case of the Small Fire Dataset (SFD).

2. Introduction

2.1. Background

The ESA CCI initiative stresses the importance of providing a higher scientific visibility to data acquired by ESA sensors, especially in the context of the IPCC reports. This implies producing consistent time series of accurate Essential Climate Variables (ECV) products, which can be used by the climate, atmospheric and ecosystem scientists for their modelling efforts. The importance of keeping long-term observations and the international links with other agencies currently generating ECV data is also stressed.

The fire disturbance ECV identifies burned area (BA) as the primary fire variable. Accordingly, the FireCCI project shall focus on developing and validating algorithms to meet GCOS ECV requirements for (consistent, stable, uncertainty-characterised) global satellite data products from multi-sensor data archives (GCOS 2022a).

In order to generate a long and consistent time series of BA products, which can be used by scientists for their modelling efforts, it is necessary to understand in detail their needs. For this reason, this document is based on the inputs of our climate research group (CRG) and external comments from scientists using BA products, which were received in different forms such as user surveys (see Heil and Pettinari, 2021), direct feedback from product users, etc. Hence, the PSD is built based on the requirements expressed by the actual and potential users, balancing between potentially contradictory demands (but emphasizing those of the climate-vegetation modellers community) and technical capabilities.

2.2. Purpose of the document

This document describes in detail the product specifications in order to obtain BA products that are consistent, stable and error-characterised and to ensure the longest possible

temporal record, derived from multi-sensor data. The purpose of this document is to present the structure, syntax and file naming conventions used to describe the different BA products. During the different phases of the CCI programme, this document has evolved to address the different products being processed. The current version is the baseline for the prototyping and production of the global and small fire dataset BA over regional test sites (RTS) products based on Sentinel-3, Landsat, and Sentinel-2 surface reflectance, respectively, plus the Merged product, but it is also applicable to other existing global products, such as those derived from MODIS.

Table 1: Summary of products characteristics

BA product	Input data	Resolution	Time Series	Geographical Extent
FireCCIS311	Surface Reflectance: Sentinel-3 SYN Active fires: S-NPP VIIRS	Pixel: 300 m Grid: 0.25 degrees	2019-2022	Global
FireCCI51	Surface Reflectance: Terra MODIS Active fires: Terra/Aqua MODIS	Pixel: 250 m Grid: 0.25 degrees	2001-2021	Global
FireCCIM10	BA datasets: FireCCI51 FireCCILT10 MCD64A1	Grid: 0.25 degrees	1982-2019	Global
FireCCISFDSA	Surface reflectance: Landsat TM//ETM+/OLI Sentinel-2 MSI	Pixel: 20/30m	1990-2019	RTS in South America
FireCCISFDAF				RTS in Africa
FireCCISFDSI				RTS in Siberia

3. Terms of Reference

3.1. Burned Area

Burned Area (BA) is defined in this document as any vegetated area that has been completely or partially consumed by a fire, regardless of whether that fire was human or naturally caused, or whether that fire affected wildland areas or human managed territories (agricultural or pastures).

The BA products only comprise a discrimination of burned and unburned areas (information on radiated energy or biomass consumed is not included). Biomass burning implies a partial or total loss of dead and/or live green vegetation, which results in a substitution of vegetation by char, ash or scorched leaves, especially just after the fire (this signal will last longer or shorter depending on the ecosystem's adaptation to fire, particularly to vegetation recovery). The spectral signature of burned surfaces is very diverse, depending on the type and amount of vegetation consumed, the post fire evolution, and whether the fuel was burned by a ground or a crown fire. For this reason, generating an accurate algorithm able to detect surface changes caused by fires is a very challenging task.

The current version of the PSD includes both global and regional test sites BA products. The former are derived from MODIS and Sentinel-3 (S-3) sensors, while the latter are based on Landsat and Sentinel-2 (S-2). The global Merged product is a combination of different existing BA products. The different BA products are obtained with the spatial and temporal resolution defined in the next sections.

3.2. Spatial resolution

Spatial resolution identifies the size in metres or degrees of the minimum unit included in the image. In satellite remote sensing, spatial resolution is commonly defined by the pixel or cell area (in hectares or m^2: i.e. for Sentinel-3 Synergy (SYN) ~9 ha), but the length of the pixel is also frequently used (the square root of the area: i.e. for Sentinel-3 SYN ~300 m). This latter definition is used throughout this document.

3.3. Temporal resolution

This term is defined as follows: on the one hand, it is the temporal frequency of the product, and on the other, it is the period of temporal compositing. The former refers to how often an area is observed and therefore what the temporal span between two consequent BA pixels is. The latter refers to what will be the minimum temporal period of the product to be delivered to the users, for instance in bi-weekly, monthly or yearly composites. All FireCCI products include the date when the pixel is detected. Temporal resolution depends on the observing cycle of the sensor used. The temporal compositing is described in Sections 4.1.2 and 4.2.2.

3.4. File formats

The different products that are proposed in this document include a description of file format that follows suggestions from the users and technical constraints, mostly related to support open standards and avoid proprietary formats. The products follow standards published by ESA for all CCI products (ESA 2021).

3.5. File name conventions

The naming of the products stated in Sections 4.1.9 and 4.2.8 follows the ECV naming convention.

4. Product Specifications

The following sections include the specifications of the two products that will be produced within the FireCCI project: pixel and grid based.

While the BA products based on coarse resolution sensors (MODIS, SYN, Merged) have a global coverage, the products based on medium resolution sensors (Landsat, S-2), corresponding to the small fire datasets, will only cover certain regions of Africa, Russia, and South America, as indicated in the project proposal.

4.1. Pixel BA product

Pixel-based products were demanded in the URD (Heil and Pettinari 2021), particularly in regards to the increasing need in fire patch characterisation (Yue et al. 2014), and analysis performed at local and regional scales (Barbero et al. 2019, Mansuy et al. 2014, Mitsopoulos et al. 2020).

4.1.1. Product description

The pixel product is a raster dataset consisting of individual layers that together describe the attributes of the BA product. Attributes are described in Section 4.1.4.

4.1.2. Temporal compositing

The global pixel product of the FireCCI project generates monthly composites, including all pixels detected as burned during that period. Monthly products allow discriminating pixels that might be burned more than once in a calendar year (which may occur, for instance, in tropical regions that have the dry season between December and February).

In the case of the SFD, since the Landsat return interval is of 16 days, there are not enough monthly observations to create a monthly product (two at the most), which is further reduced due to the presence of cloud coverage in certain areas and periods of the year. For this reason, for this product a yearly composite will be provided, starting in April and finishing in March of each year, to minimize the risk of having double burnings in the same calendar year, particularly in Northern tropical regions when fires occur at the end or beginning of the calendar year.

4.1.3. Spatial Resolution

The Spatial resolution of the BA product will be linked to the best available resolution of the input sensor: MODIS 250 m, SYN 300 m, Landsat 30 m, Sentinel-2 (S-2) 20 m. For the later sensors, this resolution meets the 100 m breakthrough target resolution suggested by the GCOS requirements (GCOS 2022b).

4.1.4. Pixel attributes

Each pixel of the monthly files will have the fields described in Table 2.

Table 2: Layers of the Target BA pixel based product

Layer	Attribute	Units	Data Type	Notes
1	Date of the first detection	Day of the year	Integer	Possible values: • 0 (zero): when the pixel is not burned. • 1 to 366: day of the first detection when the pixel is burned. • -1: when the pixel is not observed in the composite period. • -2: used for pixels that are not burnable: continuous water, bare land, urban, permanent ice-snow. Further description on the methodology to obtain the date of detection is available in the Algorithm Theoretical Basis Document of each BA product (see https://climate.esa.int/en/projects/fire/key-documents/).
2	Confidence level	%	Byte	Probability of detecting a pixel as burned. Possible values: • 0 (zero): when the pixel is not observed in the composite period, or it is not burnable. • 1 to 100: Probability values. The closer to 100, the higher the confidence that the pixel is actually burned. This applies to all pixels in the map except the ones classified as 0, independently of being classified as burned or not in layer 1. This value expresses the uncertainty of the detection. Further description of the methodology to obtain the confidence level is available in the Algorithm Theoretical Basis Document of each BA product (see https://climate.esa.int/en/projects/fire/key-documents/).
3	Land cover of burned pixels	Land cover code	Byte	Possible values: • 0 (zero): when the pixel is not burned in the composite period. • 10 to 180: land cover code when the pixel is burned (codes listed in Annex 3).

				Land cover of the pixel detected as burned, extracted from the Land Cover CCI (LC_cci) and High Resolution Land Cover CCI (HRLC_cci) maps. See Section 4.1.5 for further information.

4.1.5. Land Cover information

The land cover information was selected to provide information about the pre-fire land cover category, and for this reason the reference land cover used is the closest available product prior to the year being processed.

In the case of global BA products, the land cover assigned to the pixel detected as burned is extracted from the LC_cci product (Defourny et al. 2017), to assure consistency with other variables within the CCI programme. This product includes annual land cover maps from 1992 to 2015. For years following 2015, the C3S land cover product v2.1.1 (Defourny et al. 2021), which is the continuation of the moderate-resolution LC_cci product, is used instead.

The pixel product of the SFD will use the HRLC_cci product legend (ESA 2020), as it has a similar spatial resolution as the BA, and is therefore more appropriate to characterize the land cover that has been burned.

The land cover categories included in the different BA pixel products are listed in Annex 3.

4.1.6. File formats

The product is delivered in GeoTIFF format. Files are compressed using standard algorithms (i.e. tar.gz) to reduce downloading file sizes.

4.1.7. Product projection system

The Coordinate Reference System (CRS) used for the global BA products is a geographic coordinate system (GCS) based on the World Geodetic System 84 (WGS84) reference ellipsoid and using a Plate Carrée projection (see Annex 1) with geographical coordinates of equal pixel size. 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. Information on product projection, ellipsoid and pixel size are included in the GeoTIFF file header, so every pixel in the file can be geographically referenced without the need of adding specific pixel indicators of geographical position.

4.1.8. Subsets

The global BA products will be distributed in continental tiles, following a similar approach to other international projects. Producing global mosaics of BA products at the finest resolution of the input images would create huge file sizes, with many oceanic areas that are not relevant for fire information. For this reason, geographical subsets have been defined. All subsets are non-overlapping regions. They cover mostly continental tiles, excluding areas that do not burn or are very small and surrounded by large proportions of water. Figure 1 shows the extent of these tiles, which are referenced in Table 3.

.

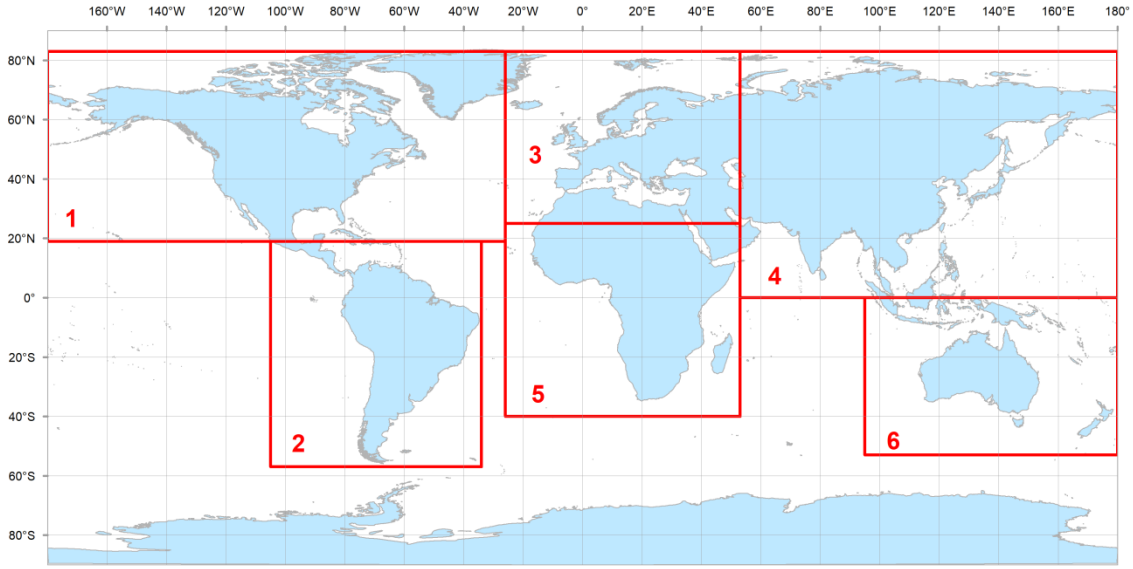

Figure 1: Geographical distribution of subsets for the global BA product

Table 3: Geographical distribution of BA tiles for the pixel product

Areas	Name	Upper left		Lower right	
1	North America	180°W	83°N	26°W*	19°N
2	South America	105°W	19°N	34°W	57°S
3	Europe & Northern Africa	26°W	83°N	53°E	25°N
4	Asia	53°E	83°N	180°E	0°N
5	Sub-Saharan Africa	26°W	25°N	53°E	40°S
6	Australia & New Zealand	95°E	0°N	180°E	53°S

*The FireCCI51 product, based on MODIS 250m, has its limit on 50ºW.

The BA products generated from medium-resolution sensors (Landsat, S-2), will be delivered in geographical tiles of 5x5 degrees (see Figure 2).

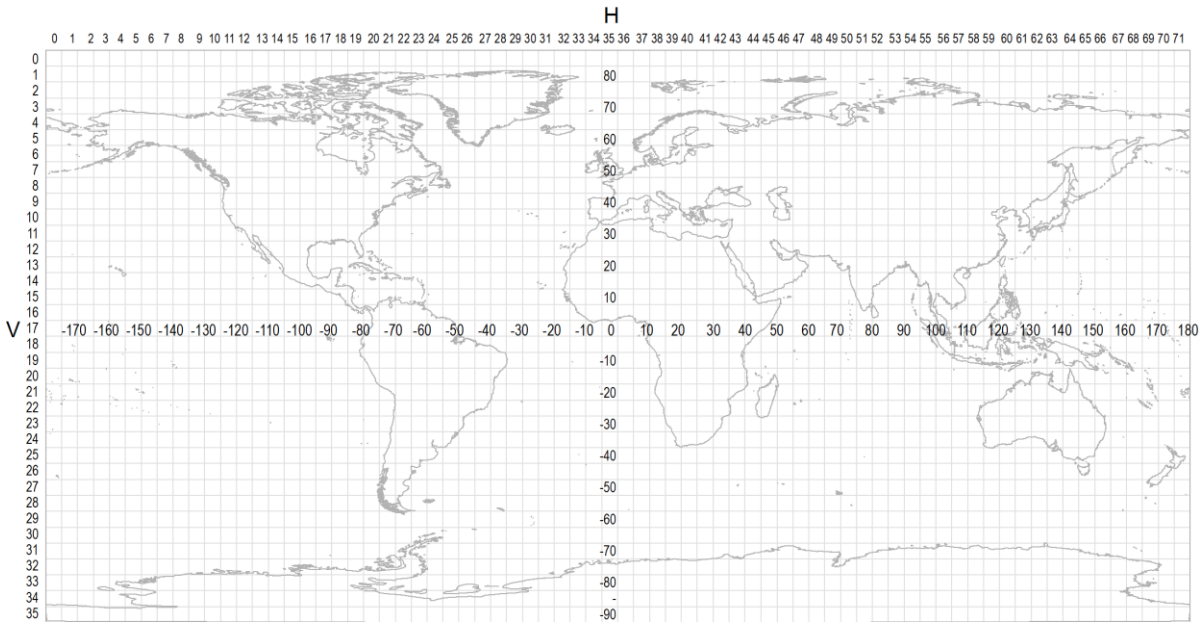

Figure 2: Geographical distribution of tiles for medium-resolution products

4.1.9. Product file naming conventions

The files for each sensor and month will be named as follows:

<Indicative Date> -ESACCI-L3S_FIRE-BA- <Indicative sensor> [-<Additional Segregator>] - [-v<GDS version>] - fv<xx.x>[-<Layer>].tiff

<Indicative Date>

The identifying date for this data set:

Format is YYYYMMDD, where YYYY is the four-digit year, MM is the two digit month from 01 to 12 and DD is the two digit day of the month from 01 to 31. For monthly products DD=01. For yearly products, the format will be that of the first day of the compositing period; for example for a file corresponding to April 1992 to March 1993, the indicative date will be 19920401.

<Indicative sensor>

MODIS when outputs come from MODIS 250 m channels; SYN for the Sentinel-3 Synergy product. For the small fire dataset, MSI will be used for Sentinel-2 MSI outputs, and TM, ETM+ or OLI will be used for Landsat products.

<Additional Segregator>

This should be AREA_<TILE_NUMBER> being the tile number the subset index described in 4.1.8. (see Table 3 for more information).

For the small fire dataset the tile number will correspond to the column and row of the global 5x5 degree grid (see Figure 2).

v<GDS version>

Including the version number of the GHRSST Data Specification is optional for the CCI file naming convention. If used it should be 02.0.

fv<File Version>

File version number in the form n{1,}[.n{1,}] (That is 1 or more digits followed by optional . and another 1 or more digits). The most recent version of the MODIS-based BA product is fv5.1 (released in November 2018).

<Layer>

The individual layers of the pixel product are provided as different GeoTIFF files. The code of each layer is:

- JD: layer 1, corresponding to the Julian day, or day of the year of detection of the BA.
- CL: layer 2, corresponding to the confidence level
- LC: layer 3, corresponding to the land cover

Example:

20190301-ESACCI-L3S_FIRE-BA-MODIS-AREA_3-fv5.1-JD.tif

20190301-ESACCI-L3S_FIRE-BA- MODIS -AREA_3-fv5.1-JD.xml

4.1.10. File metadata

For each BA file product, an additional xml file with the same name is created. This file holds the metadata information following the ISO 19115 standard. The following fields are populated:

- Universal Unique Identifier
- Language
- Contact
- Date stamp
- Metadata Standard Name
- Reference System
- Citation
  - Title
  - Creation date
  - Publication date
  - DOI
  - Abstract (contains information about each layer)
- Point of Contact
  - Resource provider
  - Distributor
  - Principal investigator
  - Processor
- Keywords
- Resource constraints
- Spatial resolution
- Extent
  - Geographical extent
  - Temporal extent

4.2. Grid BA product

Grid-based products were demanded in the URD, especially by those modellers working with climate-vegetation-atmospheric emission models and were confirmed in internal discussions in the FireCCI consortium. Therefore, the grid product is of greater interest for climate-vegetation-atmospheric modellers, as they commonly work with global grids on input weather data, and many of the current models have grids as the main input factors.

4.2.1. Product description

The grid product is a raster file that integrates the pixel BA information at a set of geographical cells that cover the whole globe. Each file includes the total BA affecting each cell area and for a certain time period. The raster file includes different auxiliary layers, described in section 4.2.4, which can help climate modellers to better characterize the burning conditions in each grid cell.

Only the global products will be produced at grid level. In the case of the Merged product, it will only be produced at grid level.

4.2.2. Temporal compositing

The grid products are offered as monthly files, which implies a good compromise between temporal resolution and repeating coverage of the input datasets.

4.2.3. Spatial Resolution

Following the recommendations of the URD and in line with other global BA products, the spatial resolution of the grid product is 0.25 x 0.25 degrees. Grid attributes are computed from all pixels included in each cell of that size within the time period previously indicated. To assure consistency, the grid product will have the same spatial and temporal resolution regardless of which input sensor has been used to generate the BA information.

4.2.4. Grid attributes

Table 4 shows the attributes that are stored for each grid cell. These variables have been based on the requirements provided by the users, and further discussed within the Climate Research Group (CRG) and the fire researchers of the CMUG.

Table 4: Layers of the BA grid products

Layer	Attribute	Units	Data Type	Notes
1	Sum of BA	Square metres	Float	Sum of area of all pixels detected as burned within each grid cell and period. Further description on the methodology to obtain the burned area from the BA detections is included in the Algorithm Theoretical Basis Document (formatting tool) of each product (see https://climate.esa.int/en/projects/fire/key-documents/).
2	Standard Error	Square metres	Float	This value is the standard error of the estimation of BA in each grid cell, based on the aggregation of the confidence level of the pixel product. Further description on the methodology to obtain this value is available in the Algorithm Theoretical Basis Document (formatting tool) of each product (see https://climate.esa.int/en/projects/fire/key-documents/).
3	Fraction of burnable area	0 to 1	Float	The fraction of area in the grid that corresponds to land covers that could be affected by fire.
4	Fraction of observed area	0 to 1	Float	The fraction of the total burnable area in the grid that was observed during the month (without cloud cover / haze or low quality pixels)
5	Sum of BA of Cropland, rainfed	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
6	Sum of BA of Cropland, irrigated or post-flooding	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
7	Sum of BA of Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
8	Sum of BA of Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
9	Sum of BA of Tree cover, broadleaved, evergreen, closed to open (>15%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.

Layer	Attribute	Units	Data Type	Notes
10	Sum of BA of Tree cover, broadleaved, deciduous, closed to open (>15%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
11	Sum of BA of Tree cover, needleleaved, evergreen, closed to open (>15%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
12	Sum of BA of Tree cover, needleleaved, deciduous, closed to open (>15%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
13	Sum of BA of Tree cover, mixed leaf type (broadleaved and needleleaved)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
14	Sum of BA of Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
15	Sum of BA of Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
16	Sum of BA of Shrubland	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
17	Sum of BA of Grassland	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
18	Sum of BA of Lichens and mosses	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
19	Sum of BA of Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
20	Sum of BA of Tree cover, flooded, fresh or brackish water	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
21	Sum of BA of Tree cover, flooded, saline water	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.
22	Sum of BA of Shrub or herbaceous cover, flooded, fresh/saline/brackish water	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the LC_cci *.

* See Section 4.1.5 for further information.

4.2.5. Product projection system

This product is stored in geographical coordinates. Each cell has a latitude and longitude assignment that is tied to the centre of the grid cell. For example, a series of adjacent grid cells have longitude references of -67.625°, -67.375°, -67.125° and -66.875°. Similarly, a series of latitude references are 0.125°, -0.125°, -0.375° and -0.625°.

4.2.6. Subsets

No subsetting takes place. A global coverage of the referred grid resolution (0.25 x 0.25 degrees) is stored in a single file for each month.

4.2.7. File formats

The product is delivered in raster format, on a regular geographical grid. The product format is NetCDF-CF (see https://www.unidata.ucar.edu/software/netcdf/ for detailed information about this format and section). This format is the CCI standard for ECV datasets (ESA 2021), and was also selected by most modellers.

4.2.8. Product file naming conventions

The grid files are named as following:

<Indicative Date> -ESACCI-L4_FIRE-BA- <Indicative sensor> [-<Additional Segregator>][-v<GDS version>] -fv<xx.x>.nc

<Indicative Date>

The identifying date for this data set:

Format is YYYYMMDD, where YYYY is the four-digit year, MM is the two-digit month from 01 to 12 and DD is the two digit day of the month from 01 to 31. For monthly products DD=01.

<Indicative sensor>

MODIS when outputs come from MODIS 250 m channels; SYN for the Sentinel-3 SYN product; MERGED for the Merged product.

<Additional Segregator>

This should be left empty.

v<GDS version>

Including the version number of the GHRSST Data Specification is optional for the CCI file naming convention. If used it should be 02.0.

fv<File Version>

Version number of the FireCCI BA algorithm. It should be in the form n{1,}[.n{1,}] (That is 1 or more digits followed by optional . and another 1 or more digits). The most recent version of the MODIS-based BA product is fv5.1 (released in November 2018).

Example:

20190301-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc

4.2.9. File metadata

The grid files follow the NetCDF Climate and Forecast (CF) Metadata Convention (http://cfconventions.org/cf-conventions/cf-conventions.html). Annex 2 describes the fields included in the .nc files.

4.3. Product Accuracy

Following the recommendations of GCOS and the CCI Climate Modellers User Group (CMUG), compiled and reviewed in Heil and Pettinari (2021), all BA products to be generated within the FireCCI project will be validated using internationally agreed validation protocols. More specifically, the CEOS Cal-Val guidelines to generate reference fire perimeters will be used (Stroppiana et al. 2022).

In addition, all BA products contain traceable uncertainty characterization and quality flags (e.g. for missing detections due to clouds). The pixel product includes the confidence level (see 4.1.4) and the grid product the standard error (see 4.2.4) to account for uncertainties of the different phases of the product generation.

4.4. Data dissemination for all products

The pixel products are compressed with standard algorithms (.tar.gz files) to reduce download volumes, while for grid products the standard NetCDF format is kept.

The products are served through the CCI Open Data Portal (https://climate.esa.int/en/odp/#/project/fire), and are also available at the Centre for Environmental Data Analysis (CEDA) archive (https://catalogue.ceda.ac.uk/uuid/6c3584d985bd484e8beb23ff0df91292).

4.5. Data Documentation

The Product User Guide and Algorithm Theoretical Basis Document of each product is available in the FireCCI web (https://climate.esa.int/en/projects/fire/key-documents/), which includes a detailed explanation of the burned area algorithm, product characteristics, fields and formats.

5. References

Barbero, R., Curt, T., Ganteaume, A., Maillé, E., Jappiot, M. and Bellet, A.: Simulating the effects of weather and climate on large wildfires in France, Nat. Hazards Earth Syst. Sci. https://doi.org/10.5194/nhess-19-441-2019, 2019.

Defourny, P., Lamarche, C., Bontemps, S., De Maet, T., Van Bogaert, E., Moreau, I., Brockmann, C., Boettcher, M., Kirches, G., Wevers, J., Santoro, M., Ramoino, F., & Arino, O. (2017). Land Cover Climate Change Initiative - Product User Guide v2. Issue 2.0. [online] Available at: http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf.

Defourny, P., Lamarche, C., Marissiaux, Q., Brockmann, C., Boettcher, M., Kirches, G. (2021). Product User Guide and Specification - ICDR Land Cover 2016 to 2020, version 1.1. Available at: https://datastore.copernicus-climate.eu/documents/satellite-land-cover/D5.3.1_PUGS_ICDR_LC_v2.1.x_PRODUCTS_v1.1.pdf

ESA (2020). High Resolution Land Cover ECV Product User Guide v1.1. Available at: https://climate.esa.int/media/documents/CCI_HRLC_Ph1-D4.3_PUG_v1.1.pdf

ESA Climate Office (2021). CCI Data Standards, Issue 2, Rev. 3. Ref. CCI-PRGM-EOPS-TN-13-0009.

Gaba, E. (2008) Map of the world in an equirectangular projection with Tissot's Indicatrix of deformation. Available at: https://en.wikipedia.org/wiki/File:Tissot_indicatrix_world_map_equirectangular_proj.svg

GCOS (2022a). The 2022 GCOS Implementation Plan. (GCOS-244, GOOS-272). Geneva, Switzerland: World Meteorological Organization.

GCOS (2022b). The 2022 GCOS ECVs Requirements. (GCOS-245). Geneva, Switzerland: World Meteorological Organization.

Heil, A., Pettinari, M. L. (2021). ESA CCI ECV Fire Disturbance D1.1 User Requirement Document v7.2. Available at https://climate.esa.int/en/projects/fire/key-documents/.

Mansuy, N., Boulanger, Y., Terrier, A., Gauthier, S., Robitaille, A., & Bergeron, Y. (2014). Spatial attributes of fire regime in eastern Canada: influences of regional landscape physiography and climate. Landscape Ecology, 29, 1157-1170.

Mitsopoulos, I., Mallinis, G., Dimitrakopoulos, A., Xanthopoulos, G., Eftychidis, G. and Goldammer, J. G.: Vulnerability of peri urban and residential areas to landscape fires in Greece: Evidence by wildland-urban interface data, Data in Brief, 31, 106025, https://doi.org/10.1016/j.dib.2020.106025, 2020.

Stroppiana D., Franquesa M., Sali M., Gatti A. (2022) ESA CCI ECV Fire Disturbance: D5.1 Product Validation Plan , version 3.0. Available at: https://climate.esa.int/en/projects/fire/key-documents/

Yue, C., Ciais, P., Cadule, P., Thonicke, K., Archibald, S., Poulter, B., Hao, W., Hantson, S., Mouillot, F., & Friedlingstein, P. (2014). Modelling the role of fires in the terrestrial carbon balance by incorporating SPITFIRE into the global vegetation model ORCHIDEE–Part 1: simulating historical global burned area and fire regimes. Geoscientific Model Development, 7, 2747-2767.

Annex 1: Description of the Plate Carrée Projection

It is an equirectangular projection (also named equidirectional projection, equidistant cylindrical projection, geographic projection). It has become a standard in computer applications to process global maps because of the relationship between pixels and its geographical position.

The projection maps meridians to equally spaced vertical straight lines, and circles of latitude to evenly spread horizontal straight lines. The projection is neither equal area nor conformal, but because if its simplicity is commonly used in thematic mapping.

It is defined by the equation:

$$x = \lambda \cos(\phi_1)$$

$$y = \phi$$

Where:

λ is the length of the central meridian of the projection. ϕ is the latitude and ϕ_1 are the standard parallels (north and south of the equator), where the scale of the projection is real. The coordinates λ and ϕ are linear measurements, not angular. The point (0.0) is in the centre of the projection.

There is a horizontal section that increases with distance from the equator.

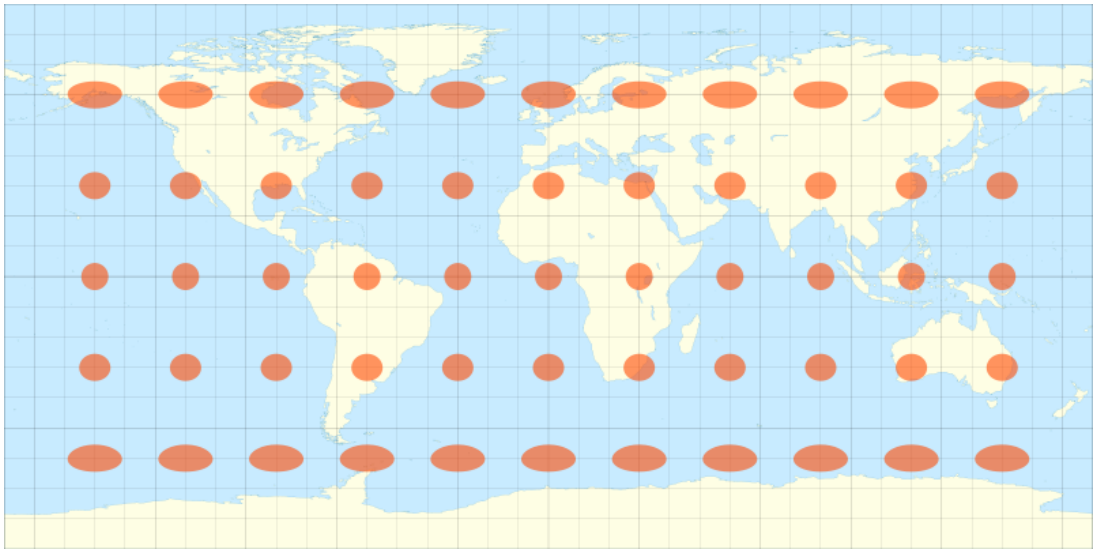

Figure 3: Deformations introduced by the Plate Carrée projection (Gaba 2008)

Annex 2: Dimensions, variables and metadata of the gridded BA product (NetCDF file)

This is an example of the metadata of the file 20190101-ESACCI-L4_FIRE-BA-SYN-fv1.0.nc, as extracted using Python's netCDF4 library.

<class 'netCDF4._netCDF4.Dataset'>
root group (NETCDF4_CLASSIC data model, file format HDF5):
title: Sentinel-3 SYN Burned Area Grid product, version 1.0
institution: University of Alcala
source: Sentinel-3 Synergy (SYN) product, derived from OLCI+SLSTR Surface Reflectance, VIIRS VNP14IMGML thermal anomalies, C3S Land Cover dataset v2.1.1
history: Created on 2022-03-01 18:04:32
references: See https://climate.esa.int/en/projects/fire/
tracking_id: 6b5321cb-081f-4a6a-8476-b42a1ea71447
Conventions: CF-1.7
product_version: v1.0
format_version: CCI Data Standards v2.3
summary: The grid product is the result of summing burned area pixels and their attributes within each cell of 0.25x0.25 degrees in a regular grid covering the whole Earth in monthly composites. The attributes stored are sum of burned area, standard error, fraction of burnable area, fraction of observed area, and the burned area for 18 land cover classes of C3S Land Cover.
keywords: Burned Area, Fire Disturbance, Climate Change, ESA, GCOS
id: 20190801-ESACCI-L4_FIRE-BA-SYN-fv1.0.nc
naming_authority: int.esa.climate
doi: 10.5285/3aaaaf94813e48f18f2b83242a8dacbe
keywords_vocabulary: none
cdm_data_type: Grid
comment: These data were produced as part of the Climate Change Initiative Programme, Fire Disturbance ECV.
date_created: 20220301T180432Z
creator_name: University of Alcala
creator_url: https://geogra.uah.es/gita/en/
creator_email: emilio.chuvieco@uah.es
contact: mlucrecia.pettinari@uah.es
project: Climate Change Initiative - European Space Agency
geospatial_lat_min: -90
geospatial_lat_max: 90
geospatial_lon_min: -180
geospatial_lon_max: 180
geospatial_vertical_min: 0
geospatial_vertical_max: 0
time_coverage_start: 20190801T000000Z
time_coverage_end: 20190831T235959Z
time_coverage_duration: P1M
time_coverage_resolution: P1M
standard_name_vocabulary: NetCDF Climate and Forecast (CF) Metadata Convention
license: ESA CCI Data Policy: free and open access
platform: Sentinel-3A, Sentinel-3B
sensor: OLCI, SLSTR
spatial_resolution: 0.25 degrees
key_variables: burned_area
geospatial_lon_units: degrees_east
geospatial_lat_units: degrees_north
geospatial_lon_resolution: 0.25
geospatial_lat_resolution: 0.25
dimensions(sizes): vegetation_class(18), lat(720), lon(1440), bounds(2), strlen(150), time(1)
variables(dimensions): float64 lat(lat), float64 lat_bounds(lat, bounds), float64 lon(lon), float64 lon_bounds(lon, bounds), float64 time(time), float32 time_bounds(time, bounds), int32 vegetation_class(vegetation_class), |S1 vegetation_class_name(vegetation_class, strlen), float32

burned_area(time, lat, lon), float32 standard_error(time, lat, lon), float32 fraction_of_burnable_area(time, lat, lon), float32 fraction_of_observed_area(time, lat, lon), float32 burned_area_in_vegetation_class(time, vegetation_class, lat, lon), int32 crs()
    groups:
OrderedDict([('lat', <class 'netCDF4._netCDF4.Variable'>
float64 lat(lat)
    units: degree_north
    standard_name: latitude
    long_name: latitude
    bounds: lat_bounds
unlimited dimensions:
current shape = (720,)
filling on, default _FillValue of 9.969209968386869e+36 used), ('lat_bounds', <class
'netCDF4._netCDF4.Variable'>
float64 lat_bounds(lat, bounds)
unlimited dimensions:
current shape = (720, 2)
filling on, default _FillValue of 9.969209968386869e+36 used), ('lon', <class
'netCDF4._netCDF4.Variable'>
float64 lon(lon)
    units: degree_east
    standard_name: longitude
    long_name: longitude
    bounds: lon_bounds
unlimited dimensions:
current shape = (1440,)
filling on, default _FillValue of 9.969209968386869e+36 used), ('lon_bounds', <class
'netCDF4._netCDF4.Variable'>
float64 lon_bounds(lon, bounds)
unlimited dimensions:
current shape = (1440, 2)
filling on, default _FillValue of 9.969209968386869e+36 used), ('time', <class
'netCDF4._netCDF4.Variable'>
float64 time(time)
    units: days since 1970-01-01 00:00:00
    standard_name: time
    long_name: time
    bounds: time_bounds
    calendar: standard
unlimited dimensions: time
current shape = (1,)
filling on, default _FillValue of 9.969209968386869e+36 used), ('time_bounds', <class
'netCDF4._netCDF4.Variable'>
float32 time_bounds(time, bounds)
unlimited dimensions: time
current shape = (1, 2)
filling on, default _FillValue of 9.969209968386869e+36 used), ('vegetation_class', <class
'netCDF4._netCDF4.Variable'>
int32 vegetation_class(vegetation_class)
    units: 1
    long_name: vegetation class number
unlimited dimensions:
current shape = (18,)
filling on, default _FillValue of -2147483647 used), ('vegetation_class_name', <class
'netCDF4._netCDF4.Variable'>
|S1 vegetation_class_name(vegetation_class, strlen)
    units: 1
    long_name: vegetation class name
unlimited dimensions:
current shape = (18, 150)

filling on, default _FillValue of used), ('burned_area', <class 'netCDF4._netCDF4.Variable'>
float32 burned_area(time, lat, lon)
    units: m2
    standard_name: burned_area
    long_name: total burned_area
    valid_range: [0.000000e+00 7.693146e+08]
    cell_methods: time: sum
unlimited dimensions: time
current shape = (1, 720, 1440)
filling on, default _FillValue of 9.969209968386869e+36 used), ('standard_error', <class
'netCDF4._netCDF4.Variable'>
float32 standard_error(time, lat, lon)
    units: m2
    long_name: standard error of the estimation of burned area
    valid_range: [0.000000e+00 7.693146e+08]
unlimited dimensions: time
current shape = (1, 720, 1440)
filling on, default _FillValue of 9.969209968386869e+36 used), ('fraction_of_burnable_area', <class
'netCDF4._netCDF4.Variable'>
float32 fraction_of_burnable_area(time, lat, lon)
    units: 1
    long_name: fraction of burnable area
    comment: The fraction of burnable area is the fraction of the cell that corresponds to vegetated land
covers that could burn. The land cover classes are those from C3S Land Cover,
https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-land-cover?tab=overview
    valid_range: [0. 1.]
unlimited dimensions: time
current shape = (1, 720, 1440)
filling on, default _FillValue of 9.969209968386869e+36 used), ('fraction_of_observed_area', <class
'netCDF4._netCDF4.Variable'>
float32 fraction_of_observed_area(time, lat, lon)
    units: 1
    long_name: fraction of observed area
    comment: The fraction of observed area is the fraction of the total burnable area in the cell
(fraction_of_burnable_area variable of this file) that was observed during the time interval, and was not
marked as unsuitable/not observable. The latter refers to the area where it was not possible to obtain
observational burned area information for the whole time interval because of the lack of input data (non-
existing data for that location and period).
    valid_range: [0. 1.]
unlimited dimensions: time
current shape = (1, 720, 1440)
filling on, default _FillValue of 9.969209968386869e+36 used), ('burned_area_in_vegetation_class', <class
'netCDF4._netCDF4.Variable'>
float32 burned_area_in_vegetation_class(time, vegetation_class, lat, lon)
    units: m2
    long_name: burned area in vegetation class
    cell_methods: time: sum
    comment: Burned area by land cover classes; land cover classes are from C3S Land Cover,
https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-land-cover?tab=overview
    valid_range: [0.000000e+00 7.693146e+08]
unlimited dimensions: time
current shape = (1, 18, 720, 1440)
filling on, default _FillValue of 9.969209968386869e+36 used), ('crs', <class
'netCDF4._netCDF4.Variable'>
int32 crs()
    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: 0.25,0.0,0.0,-0.25,-180.0,90.0
unlimited dimensions:
current shape = ()
filling on, default _FillValue of -2147483647 used)])

Annex 3: Land cover categories

Global products:

LC number	Class name	FireCCI number
0	No data	0
10	Cropland, rainfed	10
11	*Herbaceous cover*	*10*
12	*Tree or shrub cover*	*10*
20	Cropland, irrigated or post-flooding	20
30	Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous cover) (<50%)	30
40	Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) / cropland (<50%)	40
50	Tree cover, broadleaved, evergreen, closed to open (>15%)	50
60	Tree cover, broadleaved, deciduous, closed to open (>15%)	60
61	*Tree cover, broadleaved, deciduous, closed (>40%)*	60
62	*Tree cover, broadleaved, deciduous, open (15-40%)*	60
70	Tree cover, needleleaved, evergreen, closed to open (>15%)	70
71	*Tree cover, needleleaved, evergreen, closed (>40%)*	*70*
72	*Tree cover, needleleaved, evergreen, open (15-40%)*	*70*
80	Tree cover, needleleaved, deciduous, closed to open (>15%)	80
81	*Tree cover, needleleaved, deciduous, closed (>40%)*	*80*
82	*Tree cover, needleleaved, deciduous, open (15-40%)*	*80*
90	Tree cover, mixed leaf type (broadleaved and needleleaved)	90
100	Mosaic tree and shrub (>50%) / herbaceous cover (<50%)	100
110	Mosaic herbaceous cover (>50%) / tree and shrub (<50%)	110
120	Shrubland	120
121	*Evergreen shrubland*	*120*
122	*Deciduous shrubland*	*120*
130	Grassland	130
140	Lichens and mosses	140
150	Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	150
151	*Sparse tree (<15%)*	*150*
152	*Sparse shrub (<15%)*	*150*
153	*Sparse herbaceous cover (<15%)*	*150*
160	Tree cover, flooded, fresh or brackish water	160
170	Tree cover, flooded, saline water	170
180	Shrub or herbaceous cover, flooded, fresh/saline/brackish water	180

Note: Only the level 1 classes are considered, so the subdivisions have the number of broader categories. Only vegetated LC classes have been considered.

Small Fire Dataset in the period 1990-2019:

LC number	Class name	FireCCI number
10	Tree cover evergreen broadleaf	10
20	Tree cover evergreen needleleaf	20
30	Tree cover deciduous broadleaf	30
40	Tree cover deciduous needleleaf	40
50	Shrub cover evergreen	50
51	Shrub cover evergreen broadleaf	51
52	Shrub cover evergreen needleleaf	52
60	Shrub cover deciduous	60
61	Shrub cover deciduous broadleaf	61
62	Shrub cover deciduous needleleaf	62
70	Grassland	70
71	Grassland, natural	71
72	Grassland, managed	72
80	Croplands	80
81 (811, 812, 8121, 8122)	Croplands, winter (rainfed, irrigated sparkling, irrigated flooding)	81
82 (821, 822, 8221, 8222)	Croplands, summer (rainfed, irrigated sparkling, irrigated flooding)	82
83 (831, 832, 8321, 8322)	Croplands, multicropping (rainfed, irrigated sparkling, irrigated flooding)	83
90	Woody vegetation aquatic or regularly flooded	90
100	Grassland vegetation aquatic or regularly flooded	100
110	Lichens and Mosses	110

Note: Only the level 1 and 2 classes of the land cover classification are considered. In the case of cropland classes with more detailed (level 3 and 4) categories, the classes are reclassified to the coarser category. Only vegetated LC classes have been considered.

Annex 4: Acronyms and abbreviations

ADP	Algorithm Development Plan
ATBD	Algorithm Theoretical Basis Document
AVHRR	Advanced Very High Resolution Radiometer
BA	Burned Area
C3S	Copernicus Climate Change Service
CCI	Climate Change Initiative
CEDA	Centre for Environmental Data Analysis
CMUG	Climate Modellers User Group
CRG	Climate Research Group
CRS	Coordinate Reference System
ECV	Essential Climate Variable
EO	Earth Observation
ESA	European Space Agency
ETM+	Enhanced Thematic Mapper +
FireCCI51	
GCOS	Global Climate Observing System
GCS	Geographic Coordinate System
GHG	Green House Gases
GHRSST	Group for High Resolution Sea Surface Temperature
HDF	Hierarchical Data Format
HRLC_cci	High Resolution Land Cover CCI project
IPCC	Intergovernmental Panel on Climate Change
LC	Land Cover
LC_cci	CCI Land Cover project
MCD64A1	NASA's burned area product
MODIS	Moderate Resolution Imaging Spectroradiometer
MSI	MultiSpectral Instrument
NetCDF	NETwork Common Data Format
OLCI	Ocean and Land Colour Instrument on board Sentinel-3
PSD	Product Specification Document
RTS	Regional Test Site/s
S-2	Sentinel-2
S-3	Sentinel-3
S-NPP	Suomi National Polar-orbiting Partnership
SFD	Small Fire Dataset
SLSTR	Sea and Land Surface Temperature Radiometer
SYN	Synergy product based on Sentinel-3 OLCI and SLSTR
TM	Thematic Mapper
URD	User Requirements Document
VIIRS	Visible Infrared Imaging Radiometer Suite