fire_cci

D3.4 – Product User Guide (PUG)

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Summary

This document is the Product User Guide for the ECV Fire Disturbance (fire_cci). It provides practical information to user of the Fire_cci Global Burned Area products.

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1.4	15/09/2014	Updating to version 3 of the algorithm and product
1.5	8/10/2014	Updating to final products of fire_cci

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List of Abbreviations

AATSR	Advanced Along-Track Scanning Radiometer
ATBD	Algorithmic Theoretical Basis Document
ATSR	Along-Track Scanning Radiometer
BA	Burned Area
BEAM	Open Source Toolbox for Remote Sensing raster data
CCI	Climate Change Initiative
CF	Climate and Forecast Conventions
CRS	Coordinate Reference System
CMUG	Climate Modelling User Group
DLR	German Aerospace Centre
ECV	Essential Climate Variable
ENVISAT	ENVIronmental SATellite
ESA	European Space Agency
FR	Full Resolution
FRS	Full Resolution, full Swath
GAF	Name of a German company
GCS	Geographic Coordinate System
GeoTIFF	Standard
GDS	GHRSST Data Specification
GCOS	Global Climate Observing System
GHG	GreenHouse Gases
GMV	Name of a Spanish company
GHRSST	Group for High Resolution Sea Surface Temperature
HDF5	Hierarchical Data Format, version 5
INIA	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria
IPCC	Intergovernmental Panel on Climate Change
IRD	L'Institut de recherche pour le développement
ISA	Instituto Superior de Agronomia
LSCE	Laboratoire des Sciences du Climat et l'Environnement
MERIS	Medium Resolution Imaging Spectrometer, on board of ENVISAT
MODIS	MODerate Resolution Imaging Spectrometer (on board of TERRA and AQUA)
NASA	National Aeronautics and Space Administration (USA)
MPI	Max-Planck-Institute
NetCDF	Network Common Data Form
PSD	Product Specification Document
SPOT	Système Probatoire d'Observation de la Terre

UAH	University of Alcalá de Henares
UL	University of Leicester
VEGETATION	CNES Earth observation sensor onboard SPOT-4/5 (VGT)

1 General Overview

The ESA CCI Programme comprises the generation and provision of 13 Essential Climate Variables (ECV) on global scale based on long-term satellite data time series. “Fire Disturbance” is deemed as one of these Essential Climate Variables and is tackled through the fire_cci project. Burned area (BA) is considered as the primary variable for the Fire Disturbance ECV. It can be combined with information of combustion completeness and available fuel load to estimate emissions of trace gases and aerosols.

This document contains practical information on how to use the fire_cci Global BA products. It also provides information on tools for the application and further use of the products.

1.1 Introduction

The fire_cci merged product comprises maps of global burned area developed and tailored for use by climate, vegetation and atmospheric modelers, as well as by fire researchers or fire managers interested in historical burned patterns.

The fire_cci project produces two burned area products available at different spatial resolutions, the PIXEL product and the GRID product, which is derived from the first one.. The project aimed to provide a consistent BA time series.

The source data for the fire_cci BA products were the Advanced Along-Track Scanning Radiometer (AATSR) sensor and the Medium Resolution Imaging Spectrometer (MERIS), both on board the Envisat ESA satellite, and the VEGETATION instrument on board of SPOT (Système Probatoire d’Observation de la Terre) satellite. Following extensive pre-processing and quality screening of satellite images, burned area detection algorithms were applied to AATSR, VGT and MERIS-FRS data and the results were merged to generate synthetic BA products. However, after validation and intercomparison analysis, the final BA product to be publicly release in Phase 1 is based only on MERIS data.

1.2 Available data and key features of the MERIS-FRS images

The input images for the final BA fire_cci product are MERIS-FRS images, acquired by the ENVISAT satellite. Images are collected every 3 days (depending on latitude), at 300 m spatial resolution. The time series covers from December 2005 to January 2009 to produce the 2006-2008 BA final product. Corrected MERIS reflectances were received from Brockman Consult (http://www.brockmann-consult.de/). The pre-processing chain was based on the one developed for the Landcover CCI project with modifications to obtain daily reflectances instead of weekly composites (as it was required by that project: http://www.esa-landcover-cci.org/?q=webfm_send/59). The surface directional reflectances were delivered as floats between 0 and 1. In order to improve the performance of the BA algorithm, the corrected reflectances were gridded into 10x10 degrees tiles (3600x3600 pixels at MERIS spatial resolution). These tiles were the input files for all processes of our BA algorithm.

1.3 BA algorithm

The BA algorithm used for producing the final fire_cci BA product was based on a hybrid approach, combining information on active fires from the MODIS sensor and temporal changes in reflectance from MERIS time series. The algorithm is divided in two phases: in the first one the most clearly burned pixels are discriminated as “seed” pixels, while in the second one, a contextual procedure is run to improve the detection of the whole burned patch. In both phases, 10x10 degree tile statistics and statistics are computed for each monthly period, to adapt the discrimination thresholds to spatial and temporal variations of burning conditions. Additional information is provided in the ATBD II document (http://www.esa-fire-cci.org/webfm_send/756) and in a technical paper recently submitted (Alonso-Canas y Chuvieco, in review).

2 Pixel BA product

2.1 Product description

The BA product is a raster format with four layers indicating the date of detection (figure 1), sensors used to detect the BA (in the final product, only MERIS, but merging of different sensors was also tested), the confidence level and the land cover in the pixel detected as burned (Table 1).

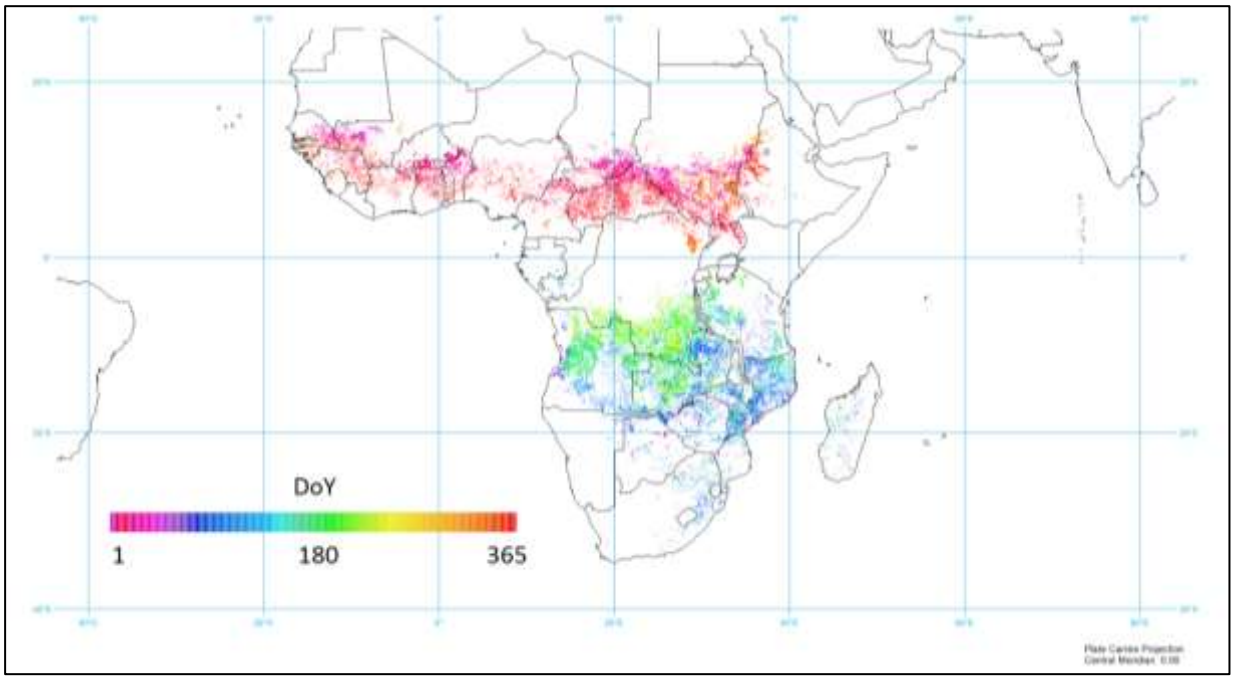

Figure 1: Day of Detection for the African continent (2008) derived from the pixel product

2.2 Pixel attributes

Each pixel of this product has a set of four fields or layers. Each of these fields is stored in a separate GeoTIFF raster file. The contents are described in Table 1. They follow the Product Specification Document (PSD) with the exception of SC, which was defined as a field to store the specific sensor detecting each pixel, since the fire_cci product was expected to include a fusion of different sensors. However, after the validation and intercomparison analysis, it has been finally decided to derive the final BA product of fire_cci phase 1 after the detections derived from MERIS FRS. Therefore, the SC field of the pixel product would always be 3. To avoid including redundant information, this field has not been finally included in the downloadable package.

Table 1to store the specific sensor detecting each pixel, since the fire_cci product was expected to include a fusion of different sensors. However, after the validation and intercomparison analysis, it has been finally decided to derive the final BA product of fire_cci phase 1 after the detections derived from MERIS FRS. Therefore, the SC field of the pixel product would always be 3. To avoid including redundant information, this field has not been finally included in the downloadable package.

Table 1 - Layers of the BA pixel product

Layer	Attribute	Units	Data Type	Notes
1 <JD>	Date of the first detection –	Day of the year, from 1 to	Integer	A zero (0) will be included in this field when the pixel is not burned in the month or it is not observed. A pixel value of 999 is allocated to

	Julian Day	365 (or 366)		tiles that are not taken into account in the burned area processing (continuous water, ocean).
2 <SC>	Sensor detecting the BA[1]	0 to S	Integer	S is a numerical code that identifies which sensor was used to detect that pixel as burned: 0 = none; 1= ATSR; 2 = VGT; 3 = MERIS FR; 4 = AATSR+SPOT; 5 = AATSR+MERIS FR; 6 = VGT + MERIS FR; 7 = AATSR+VGT+MERIS FR; 8 = ATS2; 9 = ATSR2+AATSR; 10 = ATSR2+VGT; 11 = ATSR2+MERIS FR; 12 = ATSR2+AATSR+VGT; 13 = ATSR2+AATSR+MERIS FR; 14 = ATSR2+VGT+MERIS FR; 15 = ATSR2+VGT+AATSR+MERIS FR; For future sensors, additional numbers may be generated. A pixel value of 999 is allocated to tiles that are not taken into account in the burned area processing (continuous water, ocean).
3 <UNC_LC>	Confidence level	0 to 100	Integer	This value is a probability value that estimates the confidence that a pixel is actually burned, as a result of both the pre-processing and the actual burned area classification. The higher the value, the higher the confidence that the pixel is actually burned. A pixel value of 999 is allocated to tiles that are not taken into account in the burned area processing (continuous water, ocean).
4 <LC>	Land cover of burned pixels	0 to N	Integer	Land cover of that pixel, extracted from the Globcover2005 or landcover_cci if available. N is the number of land cover categories in the reference map. It is only valid when layer 1 > 0. A pixel value of 999 is allocated to tiles that are not taken into account in the burned area processing (continuous water, ocean).

[1] For this version of the fire_cci BA product, all burned pixels come from MERIS detections, and therefore the SC field has not been included in the final product.

2.3 Product tiles

The BA product is distributed as continental tiles (Figure 2 and table 2), following a common practice in other global BA products, which reduces as well the file size of a global mosaic by avoiding storing data over the oceans. The definition of these tiles was coordinated with the landcover_cci project, to offer the final user the same geographical partitions. Following the recommendations of the GOFC-GOLD Fire Implementation Team, most subsets are non-overlapping regions. They cover continental tiles, following suggestions from the User Requirements Document (Schultz et al. 2011: http://www.esa-fire-cci.org/webfm_send/264) excluding areas that do not burn or are very small and surrounded by large proportions of water. However, as a result of the coordination with the landcover_cci, we have accepted an overlapping region to cover the African continent in a single tile. Most GIS programs include mosaic functions, which would make it simple to create a global mosaic from these continental tiles. In case of tiles 4 and 6, attention should be paid to avoid duplicating pixels in the overlapping region between 40º and 25º N.

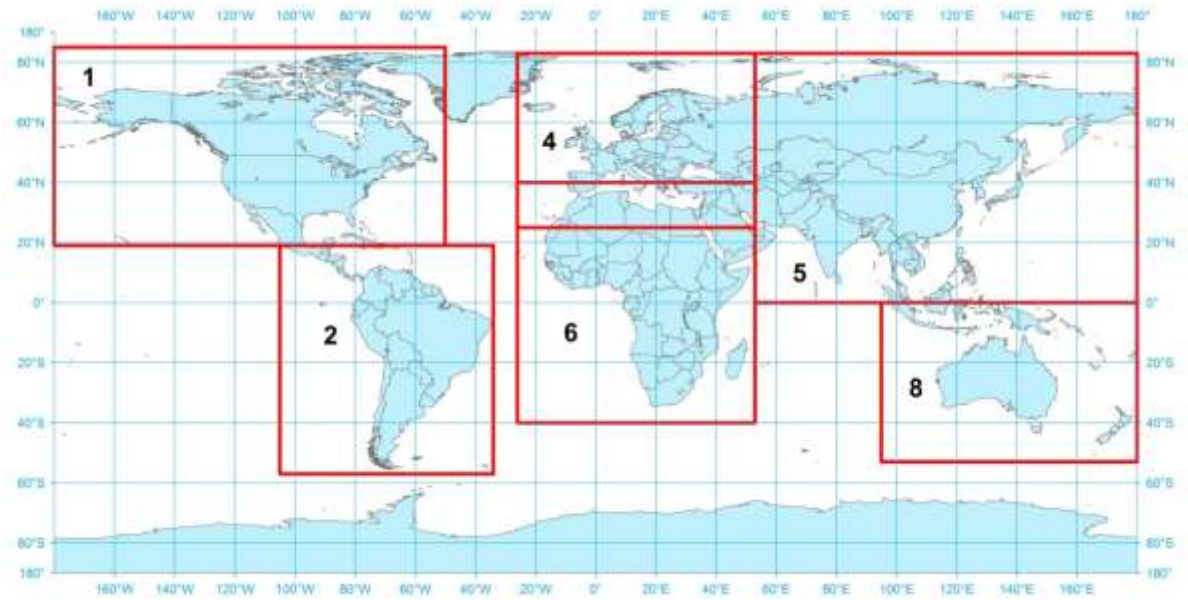

Figure 2 - Geographical distribution of subsets for the global BA product

Table 2 – Geographical distribution of BA tiles for the pixel product[2]

Zones	Name	Upper left		Lower right	
1	North America	180°W	85°N	50°W	19°N
2	South America	105°W	19°N	34°W	57°S
4	Europe	26°W	83°N	53°E	25°N
5	Asia	53°E	83°N	180°E	0°N
6	Africa	26°W	40°N	53°E	40°S
8	Australia & New Zealand	95°E	0°N	180°E	53°S

[2] Numbers of the zones keep the convention of the landcover_cci. The numbers not included refer to zones that overlap the current tiles (such as 2: Central America and 7: South-East Asia) or are not relevant for fire (9: Greenland).

2.4 Temporal compositing

The pixel products are released as monthly composites as they can account for circumstances when burning has taken place more than once within a pixel during a calendar year (for instance, the North Tropical regions that have the dry season around December-February). When merging of sensors takes place, then the first date of detection is recorded in the product. This occurs even if detections between sensors occurs in the overlap between calendar months.

2.5 Spatial resolution

The spatial resolution of the merged pixel product is the best available for each sensor, 300m when MERIS FRS are available and 1000m otherwise. After screening during the merging process all pixels assigned as burned are represented, whether they are single isolated cases or large contiguous pixels. In the current release of the product, all products are available at 300m resolution.

2.6 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 with geographical coordinates of equal pixel size. The coordinates are specified in decimal degrees. Information on product projection, ellipsoid and pixel size is 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.

2.7 Product format and file naming conventions

The product is delivered in GeoTIFF format. Files are compressed using ZIP or RAR to reduce downloading file sizes.

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

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

<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 15-day products, the first half of the month have date = 07 and the second half date = 22, which are approximately the average dates of each biweekly period.

<Indicative sensor> MERGED when the product comes from a combination of different sensors. MERIS, when data coming from MERIS sensor. VGT when outputs come from SPOT VEGETATION.

<Additional Segregator> This should be AREA_<TILE_NUMBER> being the tile number the id of the tile (see Table 2).

<Layer Name> This is the Layer name (see Table 1 for more information).

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 is fv03.1.

Example:

20050301000000-ESACCI-L3S_FIRE-BA-MERGED-AREA_3-JD-fv03.1.tif

20050301000000-ESACCI-L3S_FIRE-BA-MERGED-AREA_3-JD-fv03.1.xml (this is the file metadata. See section below)

2.8 File metadata

The standard ISO 19115 metadata with extension to raster format is provided for each subset tile. The fields included in the metadata are described in Annex 1. The metadata are available in two formats, .xml and .rtf.

2.9 Uncertainty characterization

The uncertainty of the burned area estimates is expressed as the probability that a pixel is actually burned, and it is reported in the "Confidence level" attribute. The probability of a pixel being really burned is modelled and predicted with a logistic regression model, which accounts for the confidence level of each sensor product, as well as with the density of burned areas. This model is calibrated with reference data. The probability of a pixel being really burned is positively related with the fuzzy confidence level and with the number of pixels mapped as burned in a 9x9 window (pixels labelled as burned within a large burned patch are usually well mapped). For technical details see ATBD III v2 (Tansey and Bradley 2014).

2.10 Product recommendations

Layer 1: Date of the first detection (JD)

When the pixel is characterized as burned, it is assumed that the complete pixel was burned, as for all burned area products.

The date of the burned pixel may not be coincident with the actual burning date, but most probably taken from one to several days afterwards, depending on the temporal resolution of the sensor, image availability and the cloud coverage. For areas with low cloud coverage and for sensors with daily revisiting period (at medium to high latitudes for VGT or high latitudes for AATSR and MERIS), the detected date of burn should be very close to the actual date of burn, while for equatorial latitudes or those with high cloud coverage the date may be from several days or even weeks after the fire is over.

Layer 3: Confidence level

This confidence is an estimation of how confident it is that the BA product identifies a pixel as true burned or true unburned. It provides a statistical estimation which should be useful for modellers, but it is based on a sample of fire reference information (Tansey and Bradley 2014) that may be not fully representative of regional fire conditions.

Layer 4: Land cover burned

It is assumed that there is only one land cover within the pixel, as in most land cover maps. This is a reasonable estimation for homogenous land cover areas, but it may imply errors for heterogeneous landscapes. The basic land cover map selected for this version of the product is GlobCover2005. Obviously, the errors included in this map also affect the analysis of BA covers. The resolution of land cover and BA products is the same when MERIS data are available. The base Globcover 2005 map was derived from MERIS data acquired between 2004 and 2006. When the landcover_cci product is available, the land cover will be extracted from this product selecting the closest epoch to the time series being processed in the fire_cci product.

3 Grid BA product

3.1 Product description

The grid product is a result of summarizing burned area information in the pixel product into a regular grid covering the Earth for 15-day periods on a global coverage with 0.5 degree spatial resolution. There are 22 attributes stored in NetCDF file format: sum of burned area, standard error, fraction of observed area, number of patches and the burned area for 18 land cover classes of Globcover 2005. Figure 3 shows the total BA from this product for 2008.

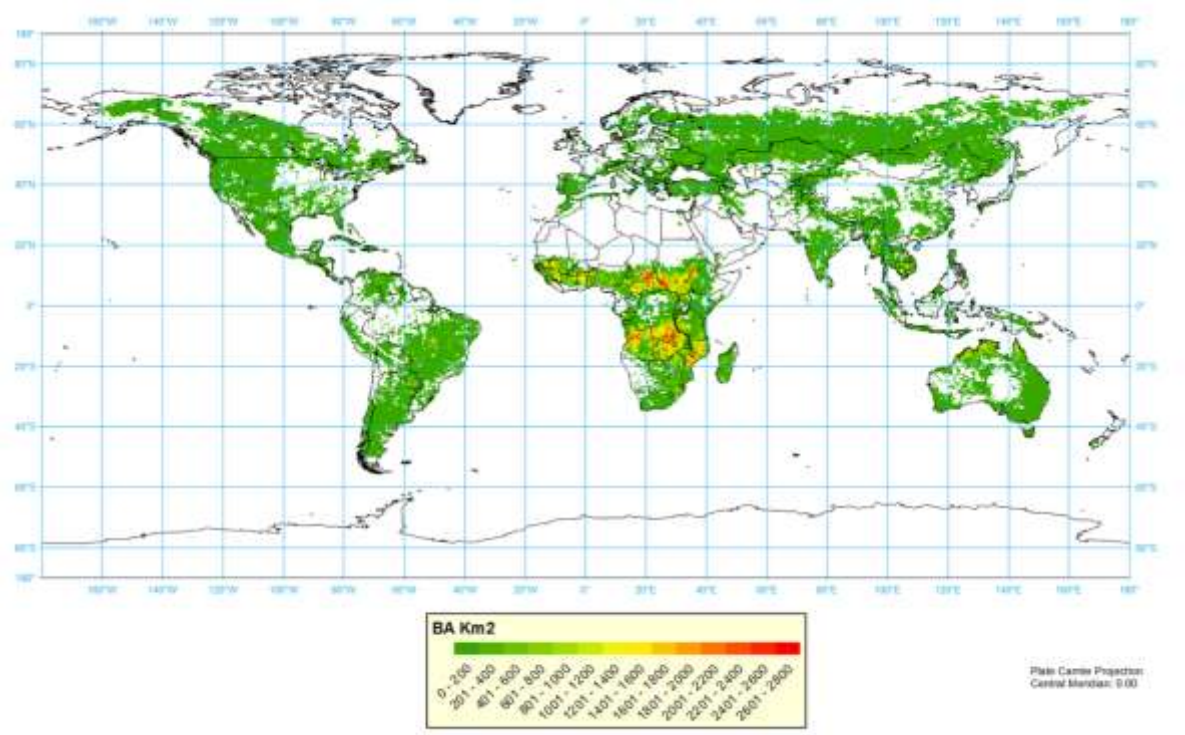

Figure 3: Total BA for 2008 derived from the grid product

3.2 Temporal compositing

Grid products are released at half-monthly time periods beginning at the start of each calendar month with each half being 15 days each for a 30-day month, and 15 days (the first half) and 16 days (the second half) for a 31-day month. The second half of February is either 13 days (no-leap year) or 14 days (leap year). This maintains 24 time periods with time divisions set to the convention of the calendar year.

3.3 Spatial resolution

The spatial resolution of the target grid product is 0.5 x 0.5 degrees.

3.4 Grid attributes

Table 3 shows the fields that are stored for each grid cell. This information has been based on the requirements described in the User Requirements Document (Schultz et al. 2011) and expressed in the Product Specification Document (Chuvieco et al. 2013).

Table 3 Layers of the BA grid products

	Layer	Units	Data Type	Notes
1	Sum of burned area	Square metres	Float	
2	Standard Error	Square metres	Float	This value is the standard error of the estimation of burned area in each grid cell.
3	Fraction of observed area	0 to 1	Float	The fraction of area in the grid that was observed for the whole 15-day period (without cloud cover / haze or low quality pixels)
4	Number of patches	0 to N	Float	Number of contiguous groups of burned pixels. Contiguity is defined as any burned pixel that has contact with the side of another burned pixel during the whole 15 day period.
5	Sum of burned area of Post-flooding or irrigated croplands	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
6	Sum of burned area of Rainfed croplands	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
7	Sum of burned area of Mosaic Cropland (50-70%) / Vegetation (grassland, shrubland, forest) (20-50%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
8	Sum of burned area of Mosaic Vegetation (grassland, shrubland, forest) (50-70%) / Cropland (20-50%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
9	Sum of burned area of Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
10	Sum of burned area of Closed (>40%) broadleaved deciduous forest (>5m)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
11	Sum of burned area of Open (15-40%) broad-leaved deciduous forest/woodland (>5m)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
12	Sum of burned area of Closed (>40%) needle-leaved	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the

	Layer	Units	Data Type	Notes
	evergreen forest (>5m)			Globcover2005 product (or landcover_cci if available).
13	Sum of burned area of Open (15-40%) needle-leaved deciduous or evergreen forest (>5m)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
14	Sum of burned area of Closed to open (>15%) mixed broadleaved and needle-leaved forest (>5m)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
15	Sum of burned area of Mosaic Forest/Shrubland (50-70%) / Grassland (20-50%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
16	Sum of burned area of Mosaic Grassland (50-70%) / Forest/Shrubland (20-50%)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
17	Sum of burned area of Closed to open (>15%) (broadleaved or needle-leaved, evergreen or deciduous) shrubland (<5m)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
18	Sum of burned area of Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
19	Sum of burned area of Sparse (<15%) vegetation	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
20	Sum of burned area of Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
21	Sum of burned area of Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).
22	Sum of burned area of Closed to open (>15%) vegetation (grassland, shrubland, woody vegetation) on regularly flooded or waterlogged soil - Fresh, brackish or saline water	Square metres	Float	Sum of all burned pixels of this Land cover as defined by the Globcover2005 product (or landcover_cci if available).

3.5 Product projection system

This product is stored in geographical coordinates. Each cell has a latitude and longitude assignment which is tied to centre of the grid cell.

3.6 Product format and file naming conventions

The product is delivered in raster format, on a regular geographical grid. The product format is NetCDF-CF (see http://www.unidata.ucar.edu/software/netcdf/docs for detailed information about this format and section). This format was selected by most modellers as well as by consensus within the guidelines of the first CCI co-location Meeting.

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 15-day products, the first half of the month have date = 07 and the second half date = 22, which are approximately the average dates of each biweekly period.

<Indicative sensor>

MERGED when the product comes from a combination of different sensors. MERIS, when data coming from MERIS sensor. VGT when outputs come from SPOT VEGETATION.

<Additional Segregator>

This should be left empty.

v<GDS version>

Including the version number of the GHRSST Data Specification is optional for the CCI filenaming 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.)

Example: 19991201000000-ESACCI-L4_FIRE-BA-MERGED-fv03.1.nc

3.7 File metadata

The grid files follow the NetCDF Climate and Forecast (CF) Metadata Convention (http://cf-pcmdi.llnl.gov/). Annex 2 describes the metadata fields included in the product.

3.8 Uncertainty characterization

The uncertainty is expressed as the standard error of the estimation of burned area in each grid cell, and it is reported in the “Standard Error” attribute. The standard error is modelled and predicted with a linear regression model, calibrated with reference data. The response variable is the absolute observed error and the explicative variable is the burned area extent estimated for the grid cell. The standard error is positively related with the estimated extent of burned area in each grid cell.

3.9 Product recommendations

Attribute 1: Sum of burned area

This is the sum of all pixels detected as burned. In common with other global BA products it is assumed that a pixel at the native spatial resolution of the detecting instrument was totally burned. Fire size distribution is related to the spatial resolution of the input sensors. These vary from 1.15 km to 300 m thus any burn smaller than these is unlikely to be detected unless it is sufficiently different from the surroundings to alter the reflectance used in the BA detection system to a degree that triggers the detection.

Attribute 2: Standard error

This value provides an estimation of true burned area in the whole cell based on statistical models fitted with fire reference data as described in the ATBD III (Tansey and Bradley 2014). Even though those reference datasets were chosen to represent different fire regimes, they may be not fully representative of some regional fire conditions.

Attribute 3: Fraction of observed area

It is assumed that cloud detection and all pre-processing masks operate with the same efficiency for each contributing sensor. The fraction of observed area is included as a layer in the grid product with the particular aim of providing information on the incomplete observation of the Earth surface by satellites (or due to intrinsic failure of the detection algorithms).

Attribute 4: Number of patches

It is assumed that individual patches only contain contiguous pixels. However, when a single burn patch is present in two grid cells it is considered as two separate burns. This should only marginally affect the analysis of burn patch sizes. On the opposite side, different burned areas may be considered as a single patch when they occurred around the same dates and form together a single-continuous patch. This temporal window has been fixed to a 15 day period for the fire_cci product.

In spite of these limitations (common to most other global BA products), this information is still very useful to obtain standard indicators of fire activity. To our knowledge, this information on the number of fire patches is not currently available in other gridded fire products.

Attribute 5-22: Sum of burned area for <land cover>

As in the case of the fire_cci pixel product, it is assumed that there is only one land cover within the pixel, as in most land cover maps. This is a reasonable estimation for homogenous land cover areas, but it may imply errors for heterogeneous landscapes. The basic land cover map selected for this version of the product is Globcover2005. Obviously, the errors of this map affect the estimation provided by the pixel fire_cci product.

It is assumed, that the land cover source has accurately described the land cover type and is spatially consistent. We aim to provide readily available information for users on the type of vegetation that has burned. This information could be used, for example, with the vegetation type dependent fuel load data for calculation of the carbon emissions and other trace gas emissions in fires, or could be used to apply vegetation type relevant combustion completeness and emission factor information in the climate modelling practice.

It is not recommended, that the users pick up other arbitrary land cover data in order to generate similar information by themselves, because all CCI products are developed to be internally consistent across the programme. Since the land cover is static and refers to 2005 any change subsequent to this as a result of fire is not included in these data. .

4 Product uncertainty

4.1 Product validation

The final and intermediate products generated in the ESA Fire Disturbance (fire_cci) project were validated at global scale using a probability sampling design (Padilla & Chuvieco, 2014). Stratified random sampling was used to select 105 non-overlapping Thiessen scene areas (TSA) and reference fire perimeters were determined from two multi-temporal Landsat TM/ETM+ images for each

sampled TSA (Padilla et al., 2014). The validation was based on cross tabulated error matrices, from which accuracy measures were computed to satisfy criteria specified by end-users of burned area products. Accuracy differences were evaluated between each pair of products, following the theory of the stratified combined ratio estimator. Statistical tests identified the MERIS based BA product as the most accurate product of those developed within the fire_cci project, with a Dice of Coefficient (DC) for the burned area of 28% and commission (Ce) and Omission (Oe) errors of 64% and 77% respectively, with an overall accuracy of 99.6%.

4.2 Comparison with existing BA products validation

Comparison of fire_cci global BA product with existing global BA products (MCD45, GFEDv3, Geoland) was carried out for the three year period (2006 to 2008) when fire_cci is available. The fire_cci product based on MERIS-FRS data estimated the total BA in the range of 3.5 to 3.7 million km². Trends of this product were found very similar to the Global Fire Emission Datase (GFED) BA estimation. The GFED BA is based on MCD64 BA detections, and it is currently considered the most accurate global BA product.

Both considering the accuracy reported and the good comparison with well-accepted BA products, we decided to release the MERIS BA product as the final output of the fire_cci project phase 1..

4.3 Evaluation by the CMUG

This document has been reviewed by Dr. Silvia Kloster, from the MPI, as part of the required external evaluation from the CMUG, a dedicated forum for the Earth Observation Data Community and Climate Modelling Community to work closely together. Comments and questions were answered and some modifications of the preliminary version to clarify contents were introduced. Her comments have been also introduced in the strengths and limitations of the product.

4.4 References

All documents are made public and freely accessible on www.esa-fire-cci.org:

Alonso-Canas, I and Chuvieco, E. (in review): Global burned area mapping from ENVISAT-MERIS data, submitted to Remote Sensing of Environment.

Bachmann, M. Borg, E., Fichtelmann, B., Günther, K., Krauß, T., Müller, A.,Müller, R., Richter, R., Wurm, W. (2013), ESA CCI ECV Fire Disturbance - Algorithm Theoretical Basis Document – Volume I – Version 2 - Pre-processing, Fire_cci_Ph2_DLR_D3_6_1_ATBD_I_v2_2.pdf.

Chuvieco, E., Calado T., Oliva P., (2014), ESA CCI ECV Fire Disturbance - Product Specification Document: Fire_cci_Ph2_UAH_D1_2_PSD_v4_1.pdf.

Padilla M., Oliva, P., Chuvieco E. (2012) ESA CCI ECV Fire Disturbance - Product Validation and Algorithm Selection Report: Fire_cci_Ph2_UAH_D2_1_PVASR_v2_0.pdf, https://www.esa-fire-cci.org/webfm_send/581

Padilla, M., & Chuvieco, E. (2014). Product validation report II (PVR II): Results from the global sample. Alcala de Henares: ESA CCI ECV Fire Disturbance (fire_cci).

Padilla, M., Stehman, S.V., & Chuvieco, E. (2014). Validation of the 2008 MODIS-MCD45 global burned area product using stratified random sampling. Remote Sensing of Environment, 144, 187-196.

Pereira, J.M.C., Mota, B., Calado, T., Itziar, A., Oliva, P., González-Alonso, F. (2013), ESA CCI ECV Fire Disturbance- Algorithm Theoretical Basis Documents Volume II: Fire_cci_Ph3_ISA_D3_6_2_ATBD_II_v2_1.pdf.

Schultz, M., Mouillot, F. Yue, C., Cadule, P. and Ciais, P. (2011), ESA CCI ECVFire Disturbance - User Requirements Document: Fire_cci_Ph1_JUELICH_D1_1_URD_v3_5.pdf, http://www.esa-fire-cci.org/webfm_send/264

Tansey, K. and Bradley, A. (2014), ESA CCI ECV Fire Disturbance - Algorithm Theoretical Basis Document Volume III: Fire_cci_Ph3_UL_D3_6_3_ATBD_III_v2_2.pdf, https://www.esa-fire-cci.org/webfm_send/726

5 Annex 1

5.1 Metadata fields for the pixel product (as described in the PSD).

They are available in both .xml and .rtf (Rich Text Format) for each of the pixel products.

The standard ISO 19115 metadata with extension to raster format is provided for each subset tile. The following fields are populated:

- Universal Unique Identifier
- Language
- Contact
- Date stamp
- Metadata Standard Name
- Reference System
- Citation

o Title

o Date

o Publication date

o Abstract (contains information about each layer)

o Associated documentation

- Point of Contact

o Resource provider

o Custodian

o Owner

o User

o Distributor

o Originator

o Point of Contact

o Principal Investigator

o Processor

o Publisher

o Author

o Collaborator

- Keywords
- Resource constraints
- Spatial resolution
- Extent

5.2 NetCDF-CF metadata layers (attributes) of the gridded BA product

Here is an example of the dimensions, variables, and fully CF compliant metadata of a netCDF file for the test site SS07 for the 2003-01-07 12:00:00 having 1 timestep with a relative time axis starting 1970-01-01 00:00:00.

dimensions:

lat = 14 ;

lon = 6 ;

time = UNLIMITED ; // (1 currently)

nv = 2 ;

vegetation_class = 18 ;

strlen = 150 ;

variables:

float lat(lat) ;

lat:units = "degree_north" ;

lat:standard_name = "latitude" ;

lat:long_name= "latitude" ;

lat:bounds = "lat_bnds" ;

float lat_bnds(lat, nv) ;

float lon(lon) ;

lon:units = "degree_east" ;

lon:standard_name = "longitude" ;

lon:long_name="longitude" ;

lon:bounds = "lon_bnds" ;

float lon_bnds(lon, nv) ;

double time(time) ;

time:units = "days since 1970-01-01 00:00:00" ;

time:calendar = "gregorian" ;

time:standard_name = "time" ;

time:long_name= "time" ;

time:bounds = "time_bnds";

double time_bnds(time,nv);

int vegetation_class(vegetation_class) ;

vegetation_class:long_name = "vegetation class" ;

float burned_area(time, lat, lon) ;

burned_area:units = "m2" ;

burned_area:standard_name = "burned_area" ;

burned_area:long_name = "total burned area" ;

burned_area:cell_methods = "time: sum";

float standard_error(time, lat, lon) ;

standard_error:units = "m2" ;

standard_error:standard_name = "burned_area_standard_error" ; // **

standard_error:long_name = "standard error of the estimation of burned area" ;

float observed_area_fraction(time, lat, lon,) ;

observed_area_fraction:units = "1" ;

observed_area_fraction:standard_name = "burned_area_observed_area_fraction" // **

observed_area_fraction:long_name = "fraction of observed area" ;

observed_area_fraction:comment = "The fraction of observed area is 1 minus the area fraction of unsuitable/not observable pixels in a given grid. The latter refers to the area where it was not possible to obtain observational burned area information for the whole time interval because of cloud cover, haze or pixels that fell below the quality thresholds of the algorithm." ;

int patch_number(time, lat, lon) ;

patch_number:units = "1" ;

patch_number:standard_name = "burned_area_ patch_number" // **

patch_number:long_name = " number of patches" ;

patch_number:comment = "Number of contiguous groups of burned pixels." ;

float burned_area_in_vegetation_class(time, vegetation_class, lat, lon,) ;

burned_area_in_vegetation_class:units = "m2" ;

burned_area_in_vegetation_class:standard_name = "burned_area_in_vegetation_class" ; // **

burned_area_in_vegetation_class:long_name = "burned area in vegetation class" ;

burned_area_in_vegetation_class:cell_methods = "time: sum";

burned_area_in_vegetation_class:comment = "Burned area by land cover classes; land cover classes are from Globcover2005; http://due.esrin.esa.int/globcover/." ;

char vegetation_class_name(vegetation_class, strlen);

vegetation_class_name:long_name = “vegetation class name”

// global attributes:

:Conventions = "CF-1.6" ; // Latest value CF version.

:title = "" ; // Provide a useful title for the data in the file.

:source = "" ; // The method of production of the original data. If it is observational, source should characterize it (e.g., "surface observation" or "radiosonde").

:institution = "" ; // Institution of the person or group that produced the data.

:project = "" ; // Project the data was collected under.

:references = "" ; // Published or web-based references that describe the data or methods used to produce it.

:acknowledgment = "" ; // Text to use to properly acknowledge use of the data (optionally).

:comment = "" ; // Provide useful additional information here.

:contact = "" ; // Name and contact information (e.g., email, address, phone number) of person who should be contacted for more information about the data (optionally).

:history = "" ; // Tracks all modifications to the original data. It is recommend that each line begin with a timestamp indicating the date and time of day that the programme was executed.

data:

vegetation_class_name = "post-flooding or irrigated croplands (or aquatic)", "rainfed croplands", "mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)", "mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%) ", "closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)", "closed (>40%) broadleaved deciduous forest (>5m)", "open (15-40%) broadleaved deciduous forest/woodland (>5m)", "closed (>40%) needleleaved evergreen forest (>5m)", "open (15-40%) needleleaved deciduous or evergreen forest (>5m)", "closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)", "mosaic forest or shrubland (50-70%) / grassland (20-50%)", "mosaic grassland (50-70%) / forest or shrubland (20-50%) ", "closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)", "closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)", "sparse (<15%) vegetation", "closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - fresh or brackish water", "closed (>40%) broadleaved forest or shrubland permanently flooded - saline or brackish water", "closed to open (>15%) grassland or woody vegetation on regularly flooded or waterlogged soil - fresh, brackish or saline water";

lat = 47, 47.5, 48, 48.5, 49, 49.5, 50, 50.5, 51, 51.5, 52, 52.5, 53,53.5 ;

lon = 53, 53.5, 54, 54.5, 55, 55.5 ;

lat_bnds = 46.75,47.25, 47.25,47.75, 47.75,48.25, 48.25,48.75, 48.75,49.25, 49.25,49.75, 49.75,50.25, 50.25,50.75, 50.75,51.25, 51.25,51.75, 51.75,52.25, 52.25,52.75, 52.75,53.25, 53.25,53.75;

lon_bnds= 52.75, 53.25, 53.25,53.75, 53.75,54.25, 54.25,54.75, 54.75,55.25, 55.25,55.75;

time = 12059.5 ;

time_bnds = 12053, 12068;

Notes:

(1) standard_names marked with *** will be proposed to the CF committee soon.

(2) compared to the original data set, a long_name attribute has been added to all variables to facilitate plotting

(3) the dimension variables were extended to include dimension_bounds variables in order to avoid ambiguities concerning the grid (and time) definition