ESA Climate Change Initiative – Fire_cci
D3.3.4 Product User Guide – AVHRR- Long Term Data Record (PUG-LTDR)

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Summary

This document is the version 1.1 of the Product User Guide for the LTDR Fire_cci v1.0 product (FireCCILT10). It provides practical information about the use of the Fire_cci global burned area products based on the AVHRR-LTDR product.

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1.1	15/04/2020	UAH	Section 3 Section 4 Section 6 Section 7	Text expanded to include validation results. Text updated. New section added to include recommendations on data use. Additional reference added.

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1. General overview

The ESA CCI Programme comprises the generation and provision of Essential Climate Variables (ECV) on global scale based on long-term satellite data time series. "Fire Disturbance" is deemed as one of these ECVs and is tackled through the Fire_cci project. Burned area (BA) is considered as the primary variable for the Fire Disturbance ECV.

This document contains practical information on how to use the LTDR Fire_cci BA v1.0 products (also called FireCCILT10 for short), which are based on the Land Long-Term Data Record (LTDR, Pedelty et al. 2007) product based on images acquired by the Advanced Very High Resolution Radiometer (AVHRR 2-3) sensor on board the National Oceanic and Atmospheric Administration (NOAA 7-19) satellites.

1.1. Introduction

The LTDR Fire_cci version 1.0 products (FireCCILT10) comprise maps of global burned area developed and tailored for use by climate, vegetation and atmospheric modellers, as well as by fire researchers or fire managers interested in historical burned patterns. These products double the time series of the previous BA product developed by the Fire_cci product: MERIS Fire_cci v4.1 (Chuvieco et al. 2016), MODIS Fire_cci v5.0 (Chuvieco et al. 2018) and MODIS Fire_cci v5.1 (Lizundia et al. 2019), which comprised the 2005-2011, 2001-2016 and 2001-2017 period, respectively.

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 pixel one. Nevertheless, the low spatial resolution of the LTDR dataset ($0.05^{\circ} \approx 5$ km) only permits to produce a GRID product.

1.2. Available data and key features of the LTDR images

The main input for this BA Fire_cci product are the AVH09 Version 5 images, acquired the Advanced Very High Resolution Radiometer (AVHRR) sensor on board the National Oceanic and Atmospheric Administration (NOAA) satellites, which offer daily surface reflectance information in the RED, near infrared (NIR) and Mid-wave infrared (MWIR) bands and top-of-atmosphere brightness temperature in the MWIR and two thermal channels in the Long-wave infrared (LWIR) of the AVHRR sensor at 0.05° spatial resolution. Furthermore, the daily product offers information on the quality of the data (Quality Assessment Field), solar zenith angle, view zenith angle and relative azimuth.

The unit of analysis of the LTDR products is global in geographic coordinates (GCS_Unknown_datum_based_upon_the_Clarke_1866_ellipsoid) in which they are delivered (Pedelty et al. 2007). All other input data has been re-projected to this coordinate system, if necessary, prior to processing. However, the final products have been re-projected to geographical coordinates (WGS84) to keep consistency with other CCI products.

1.3. BA algorithm

The FireCCILT10 algorithm uses the LTDR product as input. The algorithm begins with the creation of monthly composites using the maximum temperature criterion. This criterion deletes noise and artifacts. The unburnable areas are masked out using the CCI Land Cover product (Version 1.6.1., Kirches et al. 2013). A synthetic index is then created to detect BA with the introduction of different bands (Red, NIR and Thermal), spectral indices (BAI, GEMI) and temporal differences. Multiannual monthly models are

generated within Random Forest (RF, Breiman 2001) and are trained with MCD64A1 dataset (Collection 6, Giglio et al. 2009). The probability obtained from the RF output is then used to classify between burned and unburned pixels, based on a sensivity analysis. The percentage of burned in each pixel is obtained by a statistical analysis of the BA per pixel compared to the time series of MCD64A1. The details of the algorithm are described in the Algorithm Theoretical Basis Document ATBD (Otón and Chuvieco 2018).

2. Grid BA product

The grid product is the result of summing up burned area pixels (0.05 degrees), multiplied by their burned fraction, within each cell of 0.25 degrees in a regular grid covering the whole Earth in monthly composites. In addition to this variable, other attributes are stored: standard error of the estimations, fraction of burnable area, fraction of observed area, and the burned area for 18 land cover classes of CCI Land Cover product (Version 2.0.7., Santoro et al. 2017). Figure 1 shows the total BA from this product for 2016.

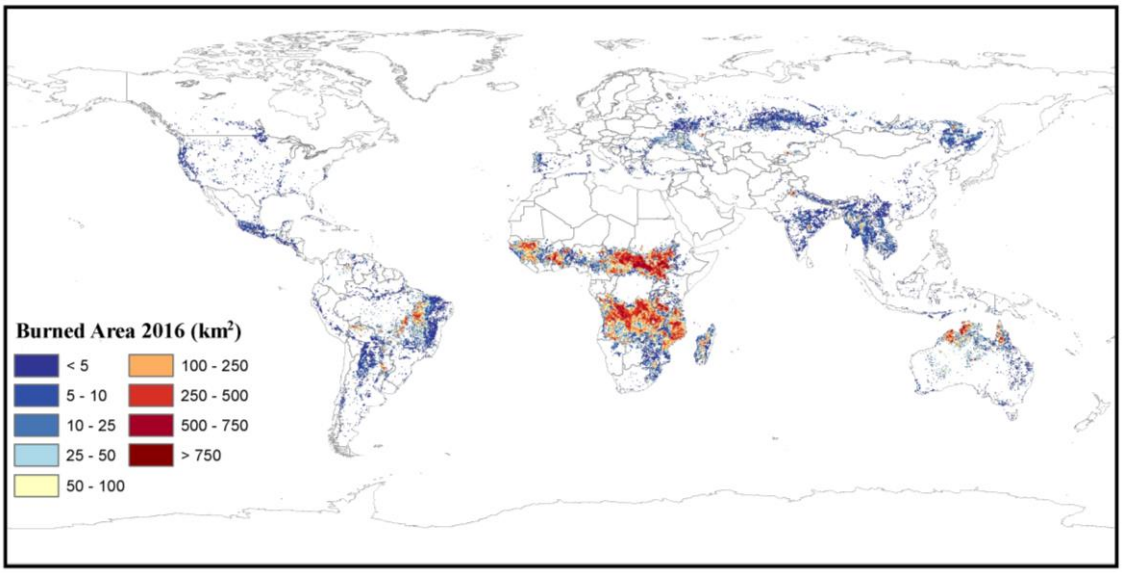

Figure 1: Total burned area for the year 2016

2.1. Temporal compositing

Grid products are released in monthly files, covering from the start to the end of the month. They are named assigning the day 1 of the month in the naming convention (see Section 2.6).

2.2. Spatial Resolution

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.

2.3. Product projection system

The grid product is stored in geographical coordinates. Each cell has a latitude and longitude assignment which 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°.

2.4. Grid attributes

The following sub-sections describe each of the grid attributes, including the name of the variables (attributes) in the NetCDF file, the unit of the attributes and the data type, and some information useful for the correct use of the product.

They also include an example of the grid product attributes.

2.4.1. Attribute 1: Sum of burned area

	Attribute	Units	Data Type	Notes
1	Burned_area	Square metres	Float	Sum of burned area of all pixels detected as burned within each grid cell.

In most global BA products, it is assumed that a pixel at the native spatial resolution of the detecting instrument is totally burned when detected as burned. In the case of the FireCCILT10 product, since the LTDR pixels are quite large, a complementary step is taken to calculate how much of each pixel was burned. As a result, the LTDR pixels can be partially or totally burned. Further description on the methodology to obtain the burned area from the BA detections is included in the Algorithm Theoretical Basis Document (Otón and Chuvieco 2018).

An example of this layer corresponding to August 2016 is shown in Figure 2.

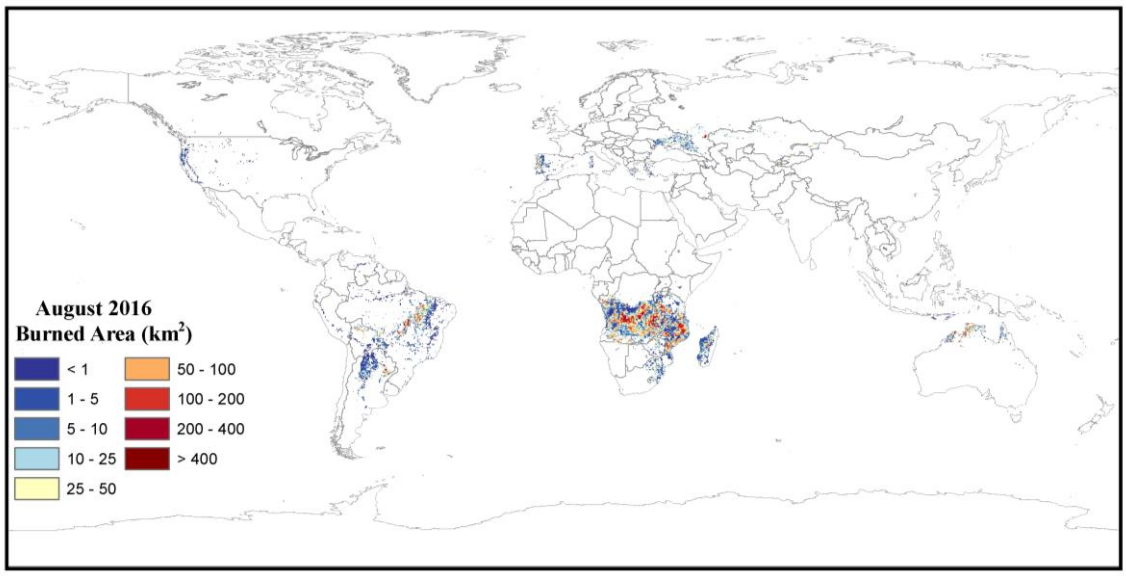

Figure 2: Example of the Burned Area attribute of the 20160801-ESACCI-L4_FIRE-BA-AVHRR-LTDR-fv01.0.nc file.

2.4.2. Attribute 2: Standard error

	Attribute	Units	Data Type	Notes
2	Standard Error	Square metres	Float	This value is the standard error of the estimation of BA in each grid cell.

The standard error is modelled from the estimation of the probability (p_b) of each pixel being burned. The calculation is then aggregated from the spatial resolution of 0.05º to 0.25º.

An example of this layer corresponding to August 2016 is shown in Figure 3.

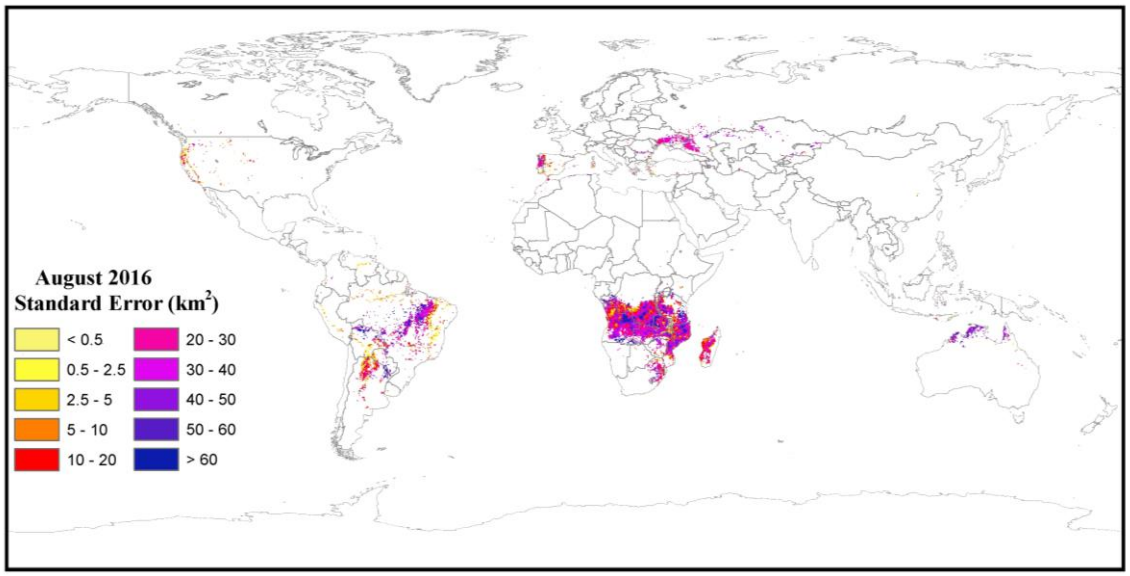

Figure 3: Example of the Standard Error attribute of the 20160801-ESACCI-L4_FIRE-BA-AVHRR-LTDR-fv01.0.nc file

2.4.3. Attribute 3: Fraction of burnable area

	Attribute	Units	Data Type	Notes
3	Fraction of burnable area	0 to 100	Float	The fraction of area in the grid that corresponds to vegetated land covers that could be affected by fire.

Includes all land cover categories that can be burned. That means that it excludes water bodies, permanent snow and ice, urban areas and bare areas. Land cover information was extracted from the LC_cci v2.0.7.

An example of this layer corresponding to August 2016 is shown in Figure 4.

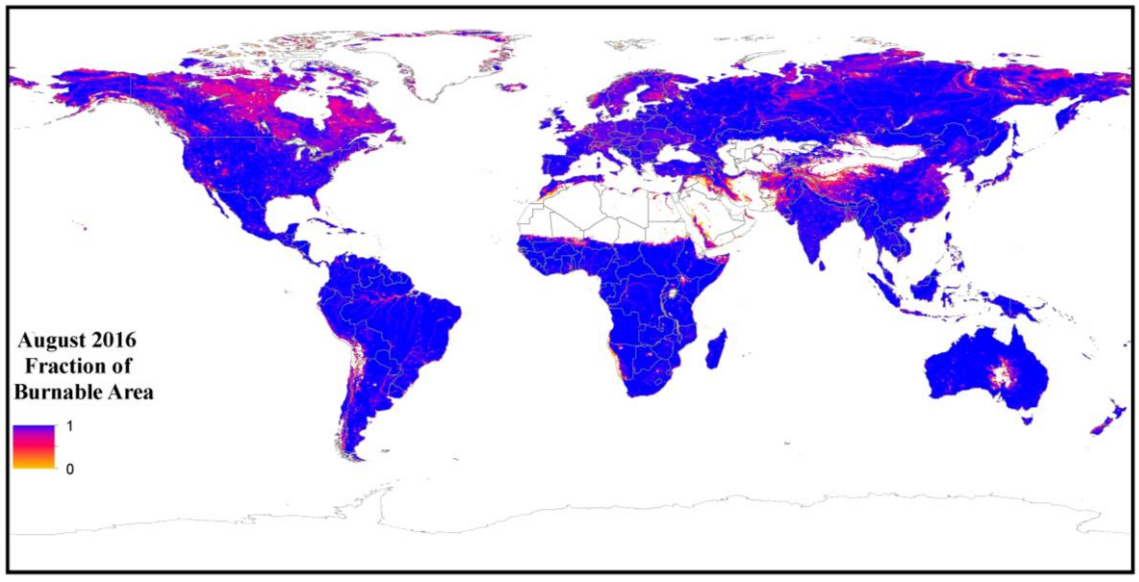

Figure 4: Example of the Fraction of Burnable area of the 20160801-ESACCI-L4_FIRE-BA-AVHRR-LTDR-fv01.0.nc file

2.4.4. Attribute 4: Fraction of observed area

	Attribute	Units	Data Type	Notes
4	Fraction of observed area	0 to 100	Float	The fraction of area in the grid that was observed for the whole monthly period.

The observed area fraction 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 the input sensor. This may be caused by a sensor failure or because the sensor did not get data from that area, like it occurs some months at high latitudes.

Recommendation on product use: this is a very important attribute to consider, as it shows the proportion of each cell that was not observed in a particular monthly product and therefore it identifies the regions where the product may miss burned pixels. Due to the poor performance of the Quality Assessment Field layer, it is not possible detect and delete pixels with clouds, shadows or noise.

An example of this layer corresponding to August 2016 is shown in Figure 5.

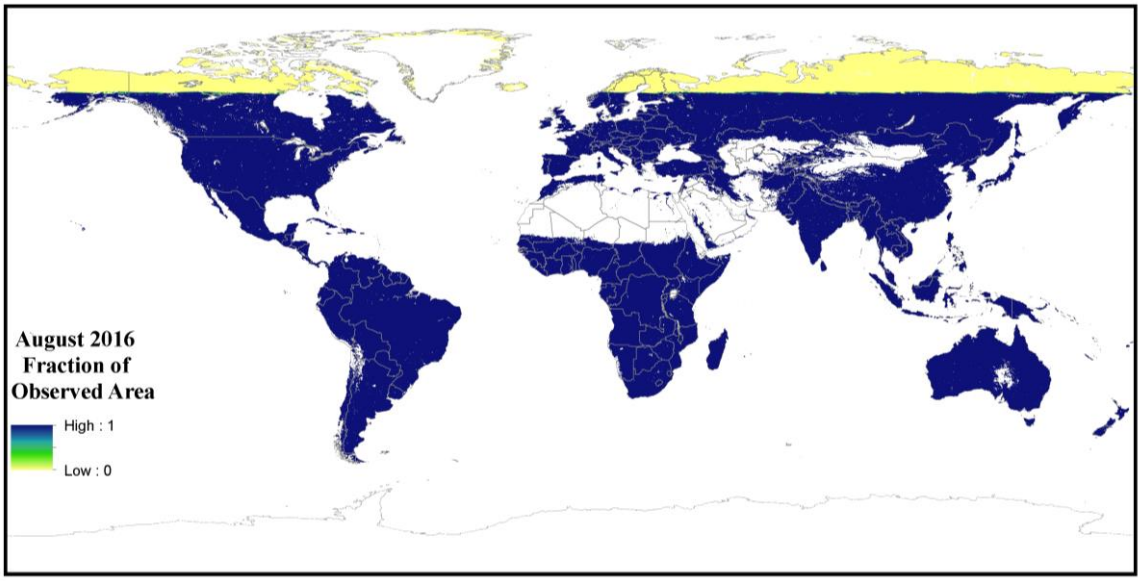

Figure 5: Example of the Observed Area Fraction attribute of the 20160801-ESACCI-L4_FIRE-BA-AVHRR-LTDR-fv01.0.nc file.

2.4.5. Attribute 5: Number of patches

	Attribute	Units	Data Type	Notes
5	Number of patches	-	Float	-1: Non Available

This variable is not generated as the input pixel is too coarse for estimating burn patches, but the layer is kept for consistency with the other Fire_cci grid products, with a Non Available value (-1).

2.4.6. Attributes 6-23: Sum of burned area for each land cover category

	Attribute	Units	Data Type	Notes
6 to 23	burned_area_in_vegetation_class	Square metres	Float	Sum of all burned pixels of each land cover as defined by the LC_cci*.

* Reference land cover is LC_cci version 2.0.7, with yearly land cover information between the periods 1992-2015. For years with no land cover data, the closest available data is used.

It is assumed that each burned pixel that adds to the total burned area in a grid cell corresponds to only one land cover, 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 is the LC_cci v2.0.7 (Santoro et al. 2017). Obviously, the errors of this map affect the estimation provided by the 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 climate modelling research.

Two examples of these types of layers corresponding to August 2016 are shown in the following figures. Figure 6 shows the sum of the burned area of croplands (LC_cci class 10), while Figure 7 shows the sum of BA in broadleaf deciduous trees (LC_cci class 60) for the same time period.

Important note: The LTDR algorithm uses the CCI Land Cover product Version 1.6.1. (Kirches et al. 2013) of the year 2000 as a mask to indicate if a pixel is burnable or not prior to BA detection. But the FireCCILT10 grid product uses the CCI Land Cover yearly product Version 2.0.7. (Santoro et al. 2017) in the "Burned Area in vegetation class" layer. This causes some inconsistencies in a few grid cells when the two land cover datasets vary in their classification of a pixel being burnable or not.

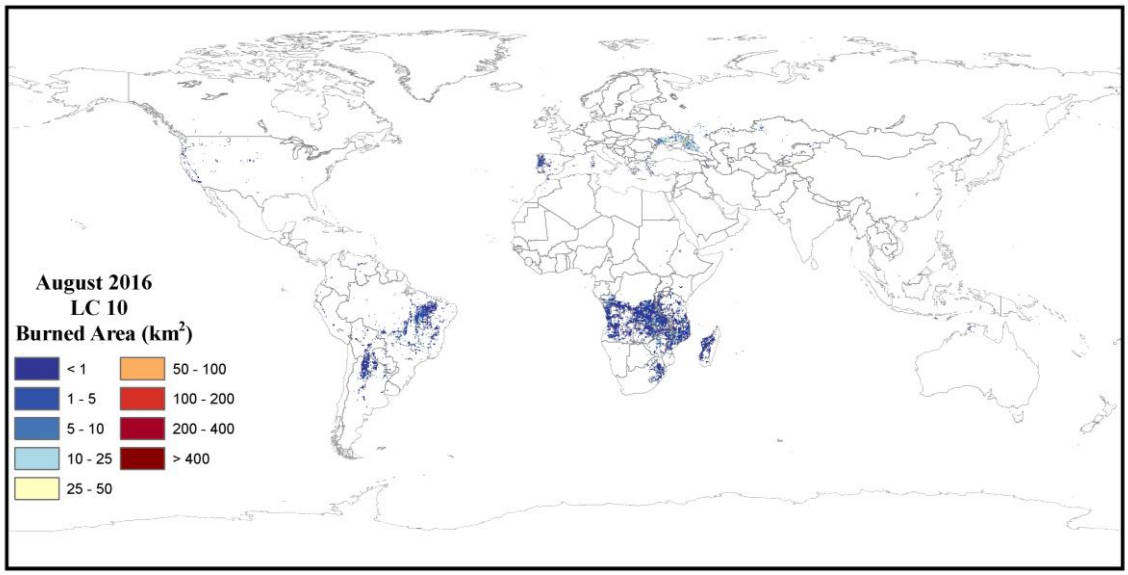

Figure 6: Example of the Burned Area in Vegetation Class attribute, for land cover class 10, corresponding to croplands, of the 20160801-ESACCI-L4_FIRE-BA-AVHRR-LTDR-fv01.0.nc file

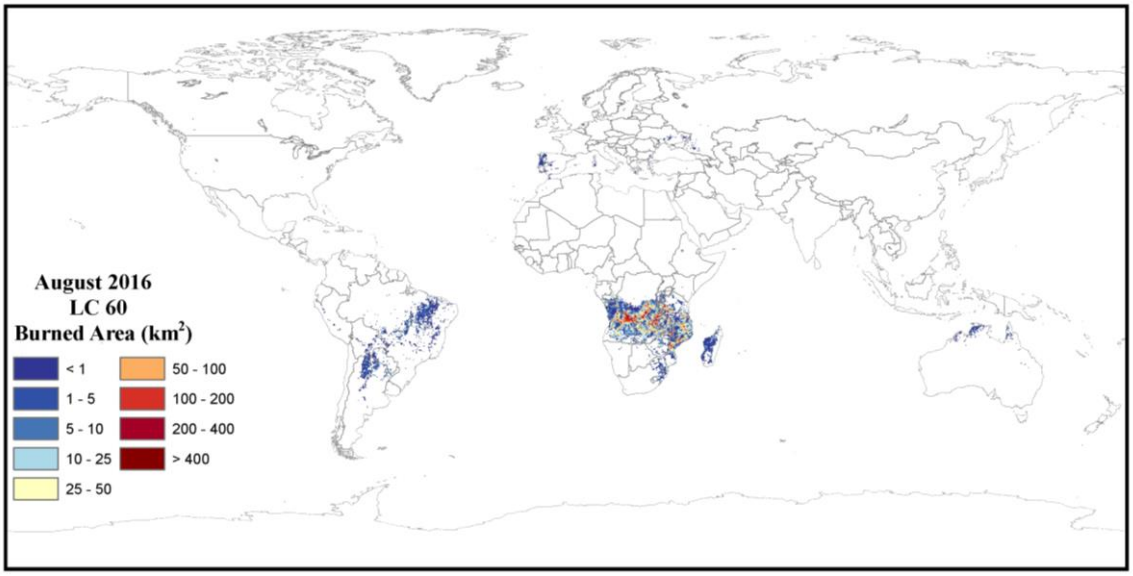

Figure 7: Example of the Burned Area in Vegetation Class attribute, for land cover class 60, corresponding to broadleaved deciduous tree cover, of the 20160801-ESACCI-L4_FIRE-BA-AVHRR-LTDR-fv01.0.nc file

2.5. File formats

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).

2.6. Product file naming conventions

The files for each sensor and month are named as follows:

<Indicative_Date>-ESACCI-L4_FIRE-BA-<Indicative_sensor>-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 files the day is set to 01.

<Indicative_sensor>

In this version of the product it is AVHRR-LTDR.

fv<File_version>

Version number of the Fire_cci BA algorithm. It is in the form n{1,}[.n{1,}] (That is 1 or more digits followed by optional . and another 1 or more digits.). Current version is fv1.0.

Example:

20051201-ESACCI-L4_FIRE-BA-AVHRR-LTDR-fv1.0.nc

2.7. File metadata

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

3. Product validation

The final products generated in the Fire_cci project have been validated at global scale using a probability sampling design that takes into account both the spatial and temporal dimension (Padilla et al. 2017). The validation dataset was derived from multitemporal pairs of Landsat TM-ETM-OLI images selected from 2003 to 2014, as well as a longer temporal period in Africa for 2016. The validation was based on cross tabulated error matrices, from which accuracy measures were computed to satisfy criteria specified by end-users of BA products. Accuracy differences with Fire_cci v4.1, Fire_cci v5.1 and the NASA MCD64A1 c6 products were evaluated between each pair of products, following the theory of the stratified combined ratio estimator (Padilla et al. 2015; Padilla et al. 2018).

Validation results for the FireCCILT10 product were (standard errors are shown in parenthesis):

- Short units Dice Coefficient (DC): 0.116 (0.013), relative bias (relB): 1.966 (0.506); omission errors: 0.922 (0.011) and commission error: 0.769 (0.025)
- Long unit DC: 0.362 (0.043), relB: -0.216 (0.171); omission errors: 0.588 (0.058) and commission error: 0.677 (0.057).

As expected, errors are much lower in the long-unit sample, both because the temporal sampling of the FireCCILT10 is one month (burned pixels may likely be outside the validation period when short periods are considered), and because the long-unit period covers Africa, and Tropical regions have shown better agreement than Boreal and temperature regions.

The full results of the validation are described in the Product Validation Report (Padilla et al. 2018). Further comparisons with national fire perimeters are provided by Oton et al. (2019).

4. Data dissemination

The LTDR Fire_cci BA products are available to the public through the Fire_cci website https://esa-fire-cci.org. Please, note that this is a beta product, and therefore not part of the official release of the Fire_cci project.

5. Known issues

The LTDR product (AVH09) has some problems in 1994:

- from day 1 to 71 the bands of the images have gaps but they are useful;
- from day 72 to 256 the bands of the images have gaps but they are useless;
- from day 257 to 365 there is no information inside the files (days 271, 272, 274 to 279 and 281 to 365 inclusive) or there is noise (days 257 to 270 inclusive, 273 and 280).

Since the 1994 product is not consistent, it is not provided to the public.

6. Data use

This is a first version of a long-term BA product, originally intended to improve the time series of existing BA products at global scale. The current version shows the influence of AVHRR Global Area Coverage (GAC) data quality (mostly spatial resolution), sensor degradation and availability of input images, and therefore is unstable, particularly in Boreal and Temperate regions. The temporal trends in Tropical regions have been

observed more accurate, particularly since 2001. This is the period that was used for training, so impacts of oversampling may also be present. The paper by Oton et al. (2019) includes a further description of the developing phases and known problems the FireCCILT10 data.

Please, use this product with proper consideration of its current limitations and report whatever findings you consider relevant to improve the product. The Fire_cci team is working in updating this dataset, increasing the stability of the BA time series and solving its low sensitivity to detect BA in Boreal latitudes.

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Annex 1: Land cover categories (extracted from LC_cci)

LC number	Class name	Fire_cci 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	*Shrubland evergreen*	***120***
122	*Shrubland deciduous*	***120***
130	Grassland	**130**
140	Lichens and mosses	**140**
150	Sparse vegetation (tree, shrub, herbaceous cover) (<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.

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

Here is an example of the dimensions and variables of the gridded product for the 2000-02-01 12:00:00 file:

Global Attributes:
title = 'Fire_cci Gridded LTDR Burned Area product'
institution = 'University of Alcala'
source = 'AVH09 Surface Reflectance Product (Version 5), ESA CCI Land Cover dataset v2.0.7.'
history = 'Created on 2019-01-21 11:32:21'
references = 'See www.esa-fire-cci.org'
tracking_id = '20c9aabc-df32-4ee6-9756-cc8e445d472a'
Conventions = 'CF-1.6'
product_version = '1.0'
summary = 'The grid product is the result of summing up burned area pixels within each cell of 0.25 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, number of patches and the burned area for 18 land cover classes of LC_cci.'
keywords = 'Burned Area, Fire Disturbance, Climate Change, ESA, GCOS'
id = '20000201-ESACCI-L4_FIRE-BA-AVHRR-LTDR-fv1.0.nc'
naming_authority = 'org.esa-fire-cci'
doi = '10.5285/4f377defc2454db9b2a6d032abfd0cbd '
keywords_vocabulary = ‘burned area, fire’
cdm_data_type = 'Grid'
comment = 'These data were produced as part of the ESA Fire_cci programme.'
date_created = '20190121T113221Z'
creator_name = 'University of Alcala'
creator_url = 'www.esa-fire-cci.org'
creator_email = 'emilio.chuvieco@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 = '20000201T000000Z'
time_coverage_end = '20000229T235959Z'
time_coverage_duration = 'P1M'
time_coverage_resolution = 'P1M'
standard_name_vocabulary = 'NetCDF Climate and Forecast (CF) Metadata Convention'
licence = 'ESA CCI Data Policy: free and open access'
platform = ' NOAA-7, 9, 11, 14, 16, 18 and 19'
sensor = 'AVHRR'
spatial_resolution = '0.25 degrees'
geospatial_lon_units = 'degrees_east'
geospatial_lat_units = 'degrees_north'
geospatial_lon_resolution = '0.25'

geospatial_lat_resolution = '0.25'

Dimensions:
vegetation_class = 18
lat = 720
lon = 1440
nv = 2
strlen = 150
time = 1 (UNLIMITED)

Variables:
lat
Size: 720x1
Dimensions: lat
Datatype: single
Attributes:
units = 'degree_north'
standard_name = 'latitude'
long_name = 'latitude'
bounds = 'lat_bnds'
lat_bnds
Size: 2x720
Dimensions: nv,lat
Datatype: single
lon
Size: 1440x1
Dimensions: lon
Datatype: single
Attributes:
units = 'degree_east'
standard_name = 'longitude'
long_name = 'longitude'
bounds = 'lon_bnds'
lon_bnds
Size: 2x1440
Dimensions: nv,lon
Datatype: single
time
Size: 1x1
Dimensions: time
Datatype: double
Attributes:
units = 'days since 1970-01-01 00:00:00'
standard_name = 'time'
long_name = 'time'
bounds = 'time_bnds'
calendar = 'standard'
time_bnds
Size: 2x1
Dimensions: nv,time
Datatype: single

vegetation_class
Size: 18x1
Dimensions: vegetation_class
Datatype: int32
Attributes:
units = '1'
long_name = 'vegetation class number'
vegetation_class_name
Size: 150x18
Dimensions: strlen,vegetation_class
Datatype: char
Attributes:
units = '1'
long_name = 'vegetation class name'
burned_area
Size: 1440x720x1
Dimensions: lon,lat,time
Datatype: single
Attributes:
units = 'm2'
standard_name = 'burned_area'
long_name = 'total burned_area'
cell_methods = 'time: sum'
standard_error
Size: 1440x720x1
Dimensions: lon,lat,time
Datatype: single
Attributes:
units = 'm2'
long_name = 'standard error of the estimation of burned area'
fraction_of_burnable_area
Size: 1440x720x1
Dimensions: lon,lat,time
Datatype: single
Attributes:
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 CCI Land Cover, http://www.esa-landcover-cci.org/'
fraction_of_observed_area
Size: 1440x720x1
Dimensions: lon,lat,time
Datatype: single
Attributes:
units = '1'
long_name = 'fraction of observed area'
comment = '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 lack of input data (non-existing data for that location and period).'

number_of_patches

Size: 1440x720x1

Dimensions: lon,lat,time

Datatype: single

Attributes:

units = '1'

long_name = 'number of burn patches'

comment = 'Number of contiguous groups of burned pixels.'

burned_area_in_vegetation_class

Size: 1440x720x18x1

Dimensions: lon,lat,vegetation_class,time

Datatype: single

Attributes:

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 CCI Land Cover, http://www.esa-landcover-cci.org/'

burnable_area_fraction

Size: 1440x720x1

Dimensions: lon,lat,time

Datatype: single

Attributes:

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 CCI Land Cover, http://www.esa-landcover-cci.org/'

Annex 3: Acronyms and abbreviations

ATBD	Algorithm Theoretical Basis Document
AVHRR	Advanced Very High Resolution Radiometer
BA	Burned Area
BAI	Burn Area Index
CCI	Climate Change Initiative
LC_cci	CCI Land Cover project
CF	Climate and Forecast Metadata Convention
DC	Dice Coefficient
ECV	Essential Climate Variables
ESA	European Space Agency
ETM	Enhanced Thematic Mapper
fv	File version
GAC	Global Area Coverage
GCS	Geographic Coordinate System
GEMI	Global Environmental Monitoring Index
LC	Land Cover
LTDR	Land Long-Term Data Record
LWIR	Long-wave infrared
MCD64	MODIS Burned Area product
MERIS	Medium Resolution Imaging Spectrometer
MODIS	Moderate Resolution Imaging Spectrometer
MWIR	Mid-wave infrared
NASA	National Aeronautics and Space Administration
NetCDF	NETwork Common Data Format
NIR	Near Infrared
NOAA	National Oceanic and Atmospheric Administration
OLI	Operational Land Imager
pb	Per pixel uncertainty
PUG	Product User Guide
relB	Relative Bias
RF	Random Forest
TM	Thematic Mapper
WGS84	World Geodetic System 1984