ESA Climate Change Initiative – Fire_cci
D4.2.1 Product User Guide - MODIS (PUG)

Project Name	ECV Fire Disturbance: Fire_cci
Contract Nº	4000126706/19/I-NB
Issue Date	21/04/2020
Version	1.0
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Document Ref.	Fire_cci_D4.2.1_PUG-MODIS_v1.0
Document type	Public

To be cited as: M.L. Pettinari, J. Lizundia-Loiola, E. Chuvieco (2020) ESA CCI ECV Fire Disturbance: D4.2.1 Product User Guide - MODIS, version 1.0. Available at: https://climate.esa.int/en/projects/fire/key-documents/

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Climate Modelling Group	MPIM – Max Planck Institute for Meteorology (Germany) CNRS - National Centre for Scientific (France)

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Summary

This document is the version 1.0 of the deliverable 4.2.1 corresponding to the Product User Guide for the MODIS Fire_cci v5.1 product (FireCCI51). It provides practical information about the use of the Fire_cci global burned area products based on the MODIS sensor, which have been updated to include the year 2019.

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Document Status Sheet

Issue	Date	Details
1.0	30/01/2018	First Issue
1.1	16/05/2018	Addressing comments of ESA-CCI-FIRE-EOPS-MEM-18-0011
1.2	22/10/2018	Revised issue updated for FireCCI51
1.3	14/12/2018	Addressing comments of ESA-CCI-FIRE-EOPS-MEM-18-0199 and inclusion of the grid product
1.4	20/06/2019	Update to include the 2018 information, and fixing some errors in the previous version
1.5	31/03/2020	Update to include the 2019 information
D4.2 v1.0	21/04/2020	Addressing comments of ESA on Fire_cci+_D3.3.3_PUG_V1.5_RID.doc

Document Change Record

Issue	Date	Request	Location	Details
1.1	16/05/2018	UAH ESA ESA UAH ESA	All document Section 1.2 Section 2.4.2 Section 2.4.3 Section 2.6 Section 2.8 Section 3.4.4	Inclusion of product acronym Added explanation on how the 1000 m data was resampled Added clarification. Added clarification of “not burned” meaning in the table. Added table foot to Table 1. Fixed an error in the years assigned to the different LC_cci epochs. Minor modifications in the recommendation on product use.
1.2	22/10/2018	UAH	All document Section 1.1 Section 1.2 Section 2 Sections 2.4.1, 2.4.2, 2.4.3 Section 2.8 Previous Sections 3 and 4 Section 3 Section 4 Annex 3	Included the FireCCI51 product Small changes in the text Previous sections 1.2 and 1.3 merged and reduced Text updated Figures updated Section updated. Sections temporarily removed. New section added. Text updated. Annex removed.
1.3	14/12/2018	ESA ESA	Section 2.1	Small changes in the text. Caption of Figures updated.

Issue	Date	Request	Location	Details
		ESA UAH UAH ESA, UAH UAH	Sections 2.4.1, 2.4.2, 2.4.3 Sections 2.4.2, 6 Sections 3 and 4 Section 5 Section 6 Annex 1	New reference added. Sections referring to the grid product and the validation results were re-incorporated. Text expanded Text expanded Table updated
1.4	20/06/2019	UAH	Contractual data Sections 1.1, 2.8, 3.2.6 Section 2 Section 2.8 Sections 3.4.5, 5 Annex 3	Updated contractual information and partners Updated temporal coverage to include 2018 BA Text expanded Updated reference of the land cover product Text updated Included annex that was missing from last version
1.5	31/03/2020	UAH	Summary, Sections 1.1, 2, 2.4.1, 2.4.2, 2.4.3, 2.8, 3, 3.4.1, 3.4.2, 3.4.3, 3.4.4, 3.4.5, 3.4.6, 5 Section 1.2 References Annex 3	Updated temporal coverage to include 2019 BA information and figures Added reference to publication Added reference Metadata updated
D4.2 v1.0	21/04/2020	ESA	Document number Section 2.4.2	Changed the deliverable number from D3.3.3 to D4.2 (going back to v1.0) to address the changes in the deliverable list in the CCI+ Programme. Clarified the meaning of not burnable

Table of Contents

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 MODIS Fire_cci BA v5.1 products (FireCCI51), which are based on the Moderate Resolution Imaging Spectroradiometer (MODIS) on board the Terra satellite.

1.1. Introduction

The MODIS Fire_cci version 5.1 products (FireCCI51) 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 cover the period 2001-2019, and complement and extend the temporal range of the previous BA products developed by the Fire_cci project: MERIS Fire_cci v4.1 (FireCCI41, Chuvieco et al. 2016), which comprised the 2005-2011 period, and MODIS Fire_cci v5.0 (FireCCI50, Chuvieco et al. 2018), which comprised the 2001-2016 period.

The Fire_cci project produces two burned area products available at different spatial resolutions, the PIXEL product and the GRID product, both derived from the original algorithm pixel outputs.

1.2. Input data and BA algorithm

The main input for this BA Fire_cci product are the MOD09GQ Collection 6 images, acquired by the Terra satellite, which offer daily surface reflectance information in the RED and near infrared (NIR) bands of the MODIS sensor at 250 m spatial resolution. Complementary to the surface reflectance product, the daily MOD09GA Collection 6 product was also used to extract information on the quality of the data (quality flags), as well as the MCD14ML Collection 6 product to extract thermal information. Land cover information from the Land Cover CCI project (see section 2.8) has also been used. The description of the algorithm can be found in the Algorithm Theoretical Basis Document (Lizundia-Loiola et al., 2018) and in Lizundia-Loiola et al. (2020).

2. Pixel BA product

The pixel BA product is a GeoTIFF file with three layers indicating the date of detection (Figure 2.1), the confidence level and the land cover in the pixel detected as burned (see Section 2.3 for further detail). This product is derived from the algorithm’s pixel outputs distributed in MODIS standard tiles in sinusoidal coordinates.

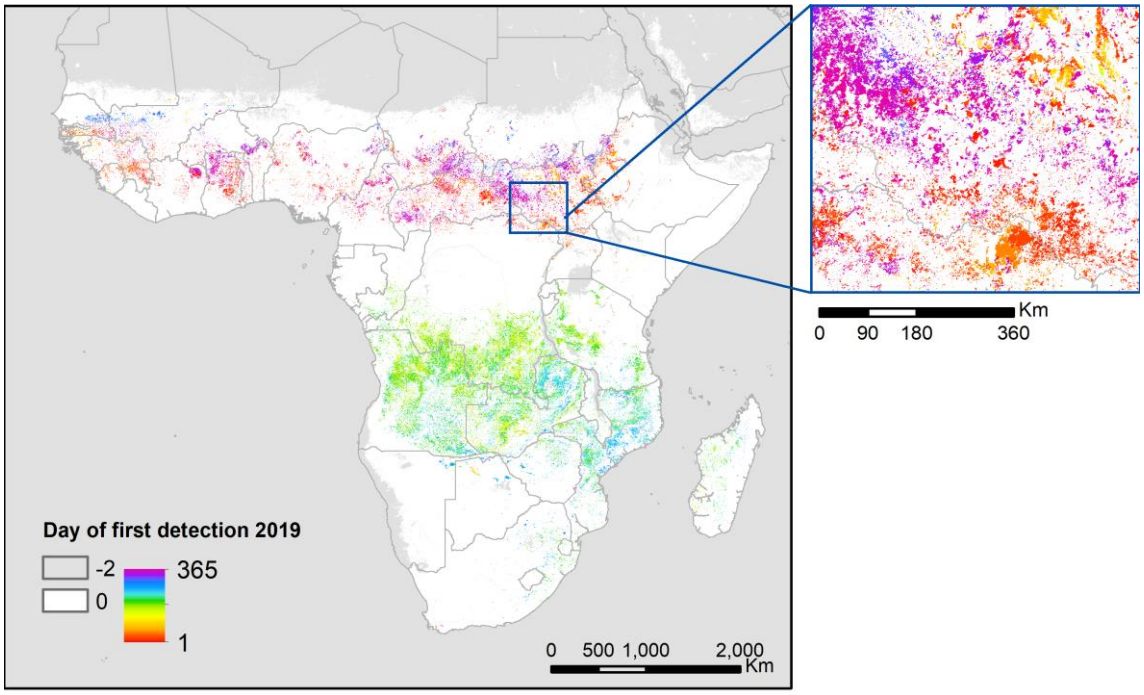

Figure 2.1: Day of detection for Area 5 (Sub-Saharan Africa) for the year 2019, derived from the pixel product.

2.1. Temporal compositing

The pixel products are released as monthly composites such that those pixels that burn more than once during a calendar year can be encompassed. This may occur in the Northern Tropical areas, where the dry season commonly occurs between December and February.

2.2. Spatial Resolution

The Spatial resolution of this BA product is 0.0022457331 degrees (approximately 250 m at the Equator), which is the original resolution of MODIS RED and NIR bands.

2.3. 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.

2.4. Pixel attributes

The following sub-sections describe each of the layers of the pixel product, including the name of the attributes in the GeoTIFF file, the units of the attributes and the data type, and some information useful for the correct use of the product.

They also include examples of the pixel product layers.

2.4.1. Layer 1: Date of the first detection

Layer	Attribute	Units	Data Type	Notes
1	Date of the first detection (JD)	Day of the year, from 1 to 365 (or 366)	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 month. • -2: used for pixels that are not burnable: water bodies, bare areas, urban areas, permanent snow and ice.

This layer corresponds to the day in which the fire was first detected, also commonly called Julian Day. 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 image availability and cloud coverage. For areas with low cloud coverage, the detected date of burn should be very close to the actual date of burn, while for areas with high cloud coverage the date may be from several days or even weeks after the fire is over.

An example of this layer corresponding to December 2019 for Area 5 is shown in Figure 2.2.

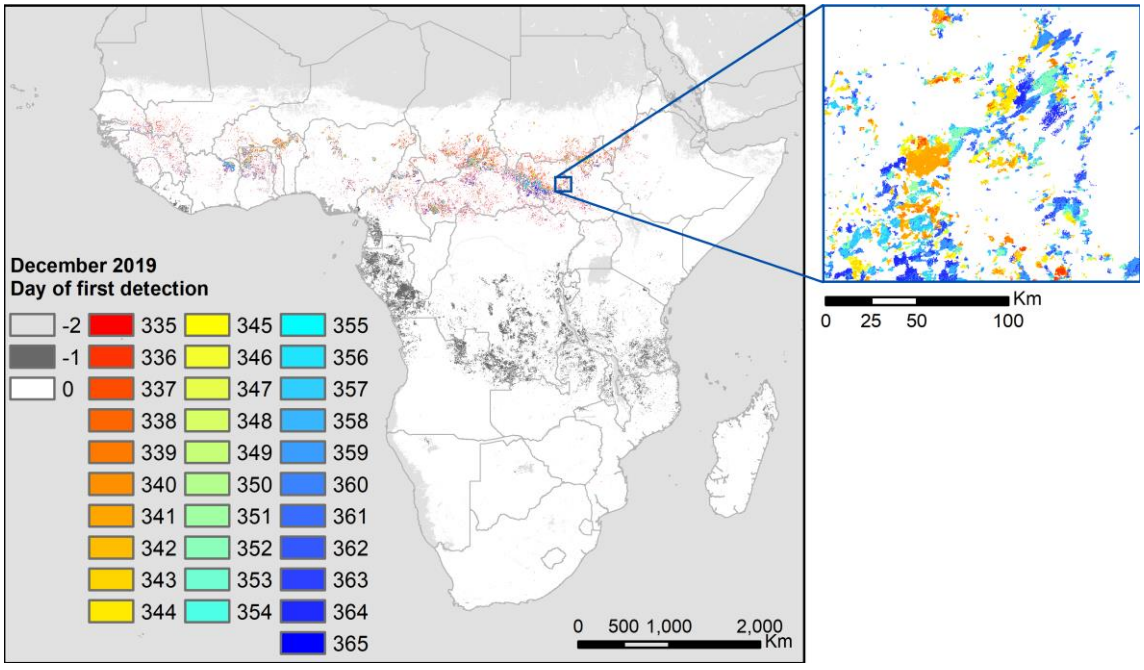

Figure 2.2: Example of the Date of the first detection layer for Africa December 2019 (20191201-ESACCI-L3S_FIRE-BA-MODIS-AREA_5-fv5.1.tif file). Values: -2: not burnable, -1: not observed, 0: not burned, 335 to 365: Julian day of first detection.

2.4.2. Layer 2: Confidence level

Layer	Attribute	Units	Data Type	Notes
2	Confidence level (CL)	0 to 100	Byte	Probability of detecting a pixel as burned. Possible values: - 0 (zero): when the pixel is not observed in the month, or it is not burnable (not vegetated). - 1 to 100: Probability values. The closer to 100, the higher the confidence that the pixel is actually burned. This value expresses the uncertainty of the detection for all pixels, even if they are classified as unburned.

The confidence level is the probability that the pixel is actually burned. A pixel with a confidence level of 80 means that it is burned with a probability of 80%, which implies that the input data and the algorithm result in a fairly high belief of the pixel being burned. A low value (for instance, 5) would indicate a strong belief of the pixel not being burned. These values can also be called "per pixel" uncertainty (p_b). p_b was modelled from the uncertainty of the different input variables used in the MODIS BA algorithm (Lizundia-Loiola et al. 2018). It should be noted that this uncertainty is just a description of how much one can trust the interpretation of the burned/unburned state of a pixel given the uncertainty of the data, the choices done in modelling, etc. It does not give an indication about whether the estimates of BA are close to the truth, as that is really the role of validation (Padilla et al. 2018).

An example of this layer corresponding to December 2019 for Area 5 is shown in Figure 2.3. All pixels with a burnable land cover include a confidence level, both if they are classified as burned or as not burned.

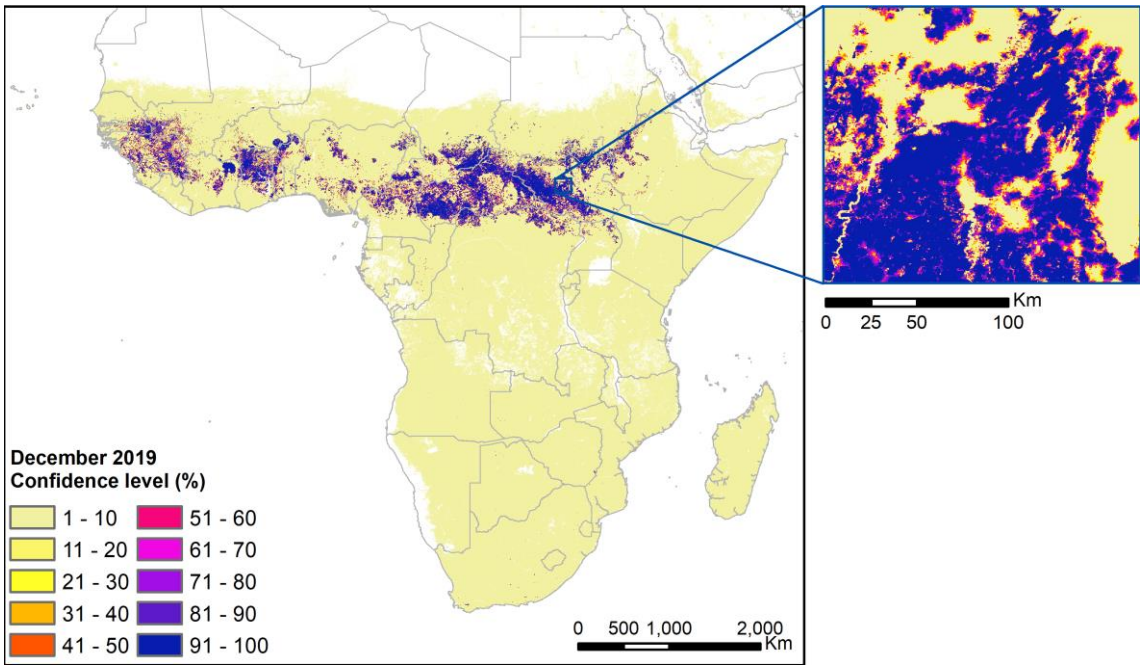

Figure 2.3: Example of the Confidence Level layer for Africa December 2019 (20191201-ESACCI-L3S_FIRE-BA-MODIS-AREA_5-fv5.1.tif file). Values: 0: not observed or not burnable, 1 to 100: confidence level.

2.4.3. Layer 3: Land cover of burned pixels

Layer	Attribute	Units	Data Type	Notes
3	Land cover of burned pixels (LC)	0 to N	Byte	Possible values: • 0 (zero): when the pixel is not burned in the month, either because it was observed and not classified as burned, or because it is non burnable or was not observed. • 10 to 180: land cover code when the pixel is burned (codes listed in Annex 1). Land cover of the pixel detected as burned, extracted from the Land Cover CCI maps (see Section 2.8).

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 is the CCI Land Cover map (see Section 2.8). Errors included in this map will also affect the information contained in the BA product and hence the calculation of emissions using land-cover-based emissions factors would be affected. The resolution of the land cover and BA products is the same, as the land cover was resampled from its original spatial resolution (approx. 300 m at the Equator) to the resolution of the pixel product.

An example of this layer corresponding to December 2019 for Area 5 is shown in Figure 2.4.

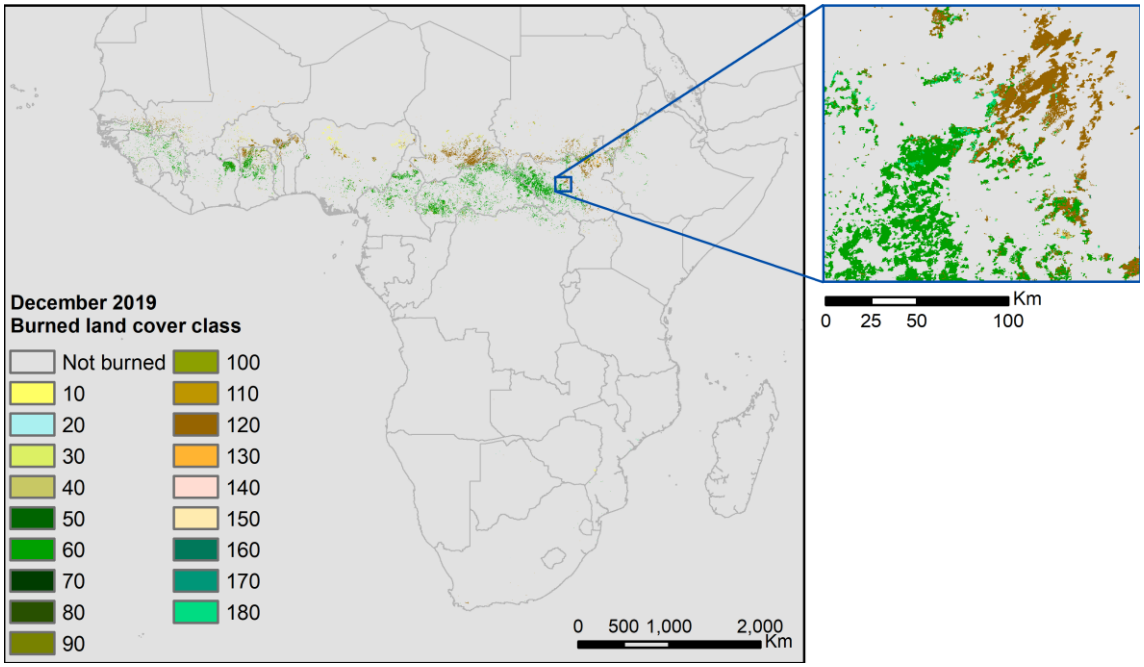

Figure 2.4: Example of the Land Cover of burned pixels layer for Africa December 2019 (20191201-ESACCI-L3S_FIRE-BA-MODIS-AREA_5-fv5.1.tif file). The description of the land cover categories is in Annex 1. Main classes in the zoomed map: 60: Tree cover, broadleaved, deciduous, closed to open (>15%), 120: Shrubland.

2.5. File formats

The product is delivered in GeoTIFF format, with each layer as an individual file, and together compressed into tar.gz files to reduce downloading file sizes.

2.6. Geographical subsets

The BA product is distributed in continental tiles. 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 2.5 shows the extent of these tiles, which are referenced in Table 1.

Table 1: Geographical distribution of BA tiles for the pixel product

Areas	Name	Upper left		Lower right	
1	North America	180°W	83°N	50°W	19°N
2	South America	105°W	19°N	34°W	57°S
3	Europe –North 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

Coordinates correspond to the centres of the border pixels.

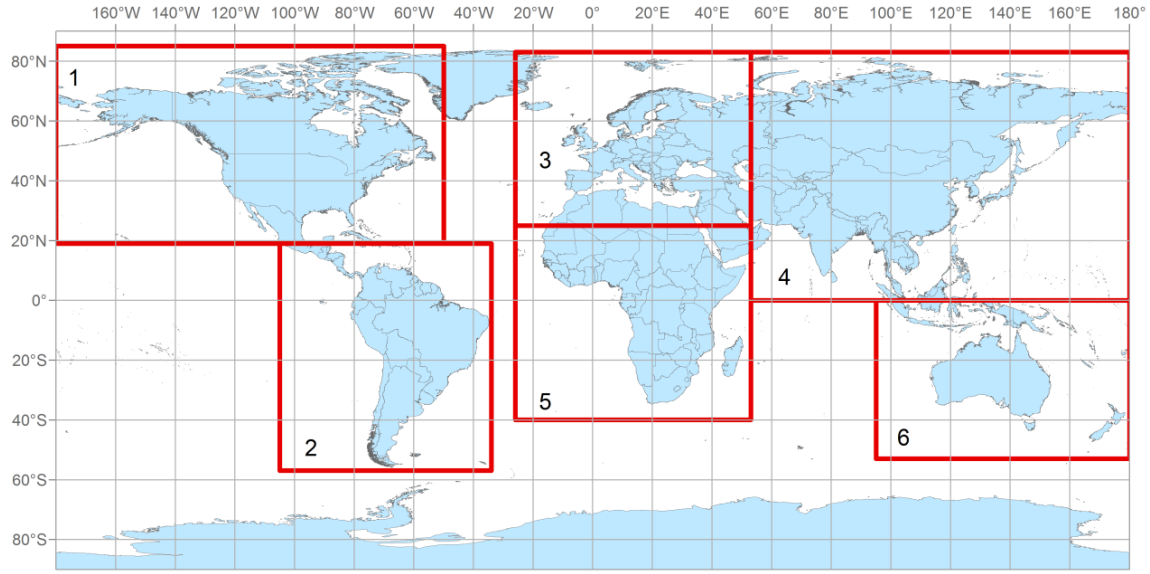

Figure 2.5: Geographical distribution of subsets for the global pixel BA product

2.7. Product file naming conventions

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

<Indicative_Date>-ESACCI-L3S_FIRE-BA-<Indicative_sensor>-<Additional_Segregator>-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.

<Indicative_sensor>

In this version of the product it is MODIS.

<Additional_Segregator>

This is AREA_<TILE_NUMBER> being the tile number the subset index described in 2.6. (see Table 1 for more information).

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). This version is fv5.1.

<Layer>

As each layer is provided as an individual GeoTIFF file, 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.xml

2.8. 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. The land cover assigned to the pixel detected as burned was extracted from the LC_cci product (ESA 2017) to assure consistency with other variables within the CCI programme.

For the FireCCI51 products, the LC_cci v2.0.7 was used (ESA 2017). This product offers annual land cover files that cover the period 1992 – 2015. For each processed year, previous year information was used, except 2017 to 2019 for which the last available year (2015) was used.

The land cover categories included in the BA product are listed in Annex 1.

2.9. File metadata

For each BA product, an additional xml file with the same name is created. This file holds the metadata information following the ISO 19115 standard. The description of the populated fields is included in Annex 2.

3. Grid BA product

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. In addition to this variable, other attributes are stored in the NetCDF file: standard error of the estimations, fraction of burnable area, fraction of observed area, number of patches and the burned area for 18 land cover classes of LC_cci. Figure 3.1 shows the total BA from this product for 2019. This product is derived from the MODIS standard tiles in sinusoidal coordinates, which are reprojected to geographical cells of 0.25-degrees resolution. The

impact of this reprojection explains that minor differences may be found when comparing the grid and pixel product, particularly in total burned area or number of patches per grid cell.

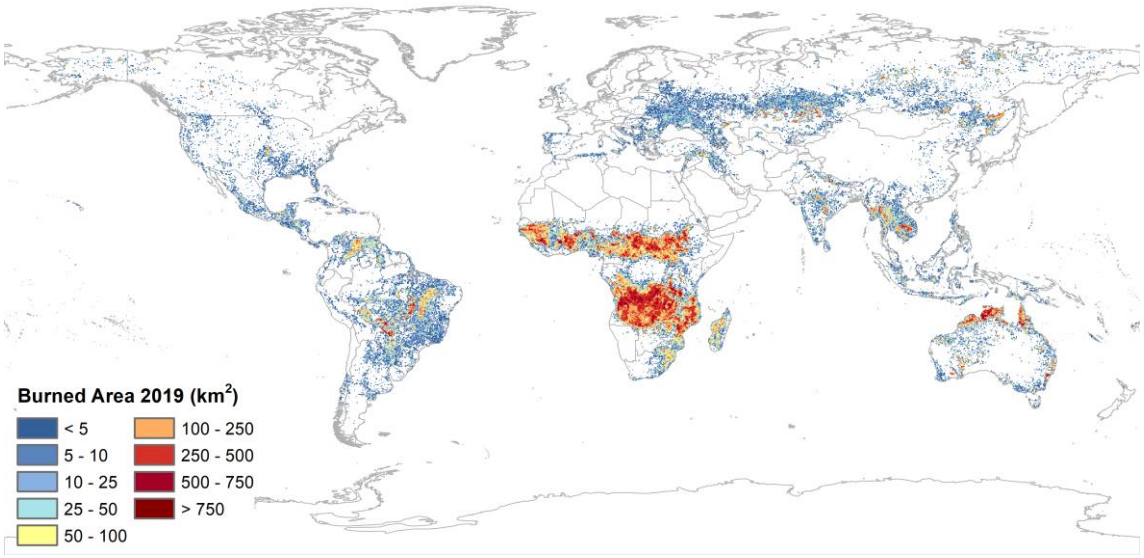

Figure 3.1: Total burned area for the year 2019.

3.1. 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 3.6).

3.2. 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.

3.3. 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°.

3.4. 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.

3.4.1. Attribute 1: Sum of burned area

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

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. Any burn smaller than the spatial resolution of the input sensor (for this BA product, this implies approximately 6 hectares) is unlikely to be detected. It can only be detected when the char signal is sufficiently different from the surroundings to alter the reflectance used in the BA detection system to a degree that triggers the detection. Further description on the methodology to obtain the burned area from the BA detections is included in the Algorithm Theoretical Basis Document (Lizundia et al. 2018) and in Lizundia-Loiola et al. (2020).

An example of this layer corresponding to August 2019 is shown in Figure 3.2.

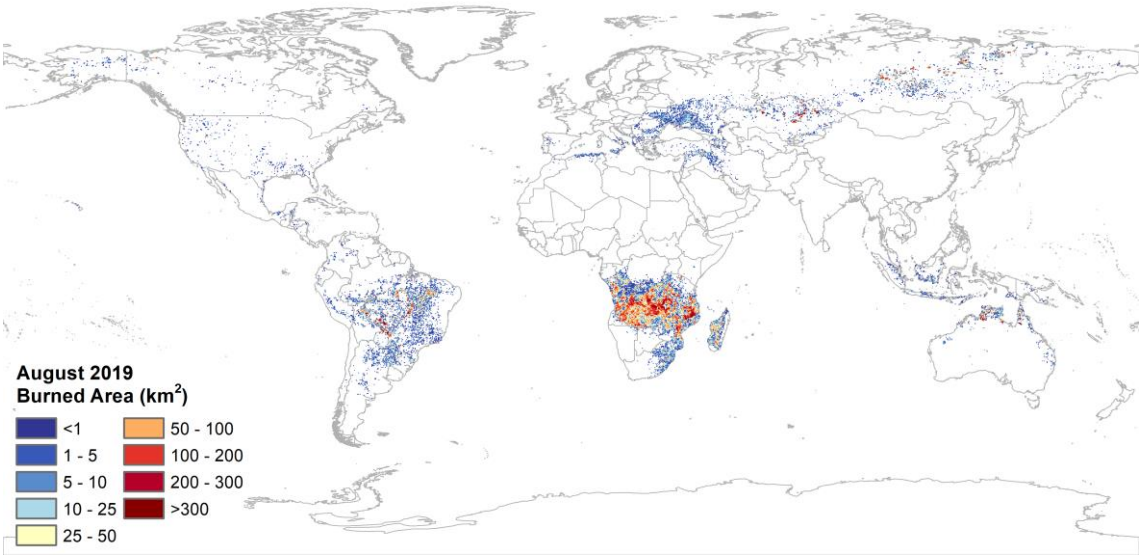

Figure 3.2: Example of the Burned Area attribute of the 20190801-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc file.

3.4.2. 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, based on the aggregation of the confidence level of the pixel product.

The standard error is modelled from the confidence level (p_b) of the pixel product. The rationale of the calculation is the following: the aggregation of the burned pixels into the grid cells implies adding up the area of each pixel. But that does not take into account that some pixels appear very clearly burned (high p_b), whereas others have lower p_b values. Some pixels have intermediate values which, in case a certain p_b threshold was used to determine a pixel being burned or not, could imply its belonging to either class if only e.g. the noise in the observations was marginally different, so the sum of burned pixels would be variable if only the input data had slightly different noise added to it.

Clearly, if all pixels are either burned or unburned with very strong evidence (p_b equal to 1 or 0, respectively), then small changes in the data would not really change the aggregation, but if there are a lot of "not sure pixels" (where the data is insufficient to make a very clear distinction), this could have a major impact.

This spread of possible values is what is quantified by the uncertainty. If BAr was defined as a random variable of the number of burned pixels within a grid cell, and for simplicity it could be assumed that BAr is normal with a mean and standard deviation, an epistemic view on probability suggests that the distribution of BAr describes the strength of belief in the value of BAr lying in a particular "bin". So the belief would be maximum at the mean of the distribution of BAr, but will be very weak say 3 standard deviations away from the mean. So in this case, the standard deviation of the distribution gives a way to calculate the interval where the true mean might be based on the observed data and choice of algorithm. Note that in this case the standard deviation is saying nothing about how precisely the mean can be estimated, as the information is really contained in the shape of the distribution. Uncertainty in the case described earlier informs the user about the sensitivity of the data to the observed fire phenomenon, the ability of the algorithm and the quality of the observations that have been used to label pixels (Lewis et al. 2017).

Since the Attribute 1 was calculated as the sum of the individual burned pixel areas and not directly as BAr, the p_b was rescaled so that the mean was made equal to the sum of burned area of Attribute 1. The standard error was then computed as the standard deviation of the distribution times the pixel area in m^2 (which was a fixed size as the calculation was performed in the native sinusoidal projection). More detail on the statistical models can be found in the ATBD (Lizundia et al. 2018).

An example of this layer corresponding to August 2019 is shown in Figure 3.3.

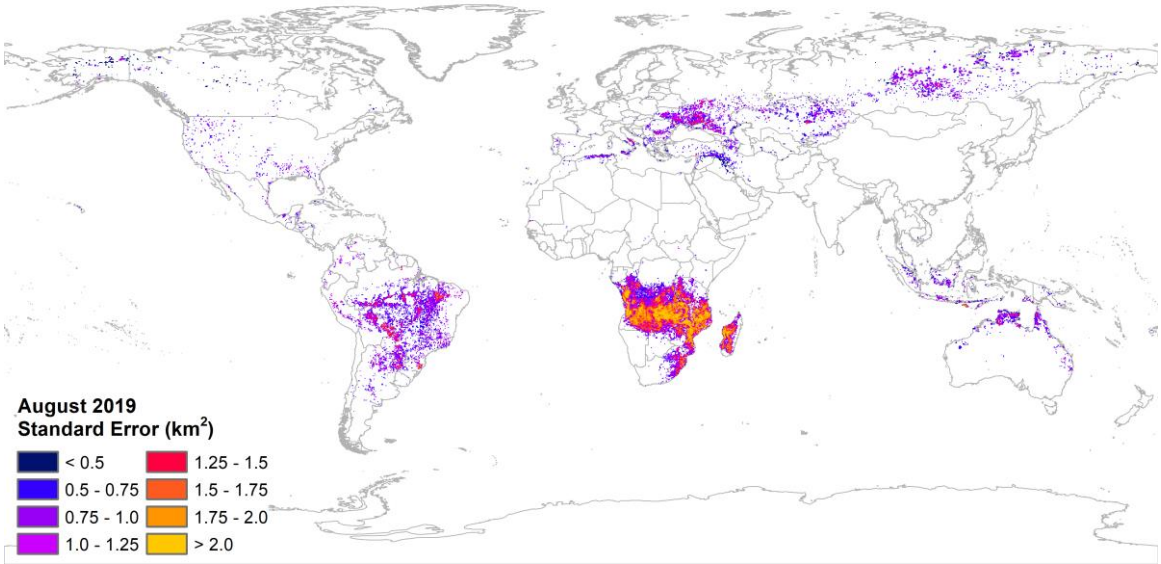

Figure 3.3: Example of the Standard Error attribute of the 20190801-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc file

3.4.3. Attribute 3: Fraction of burnable area

	Attribute	Units	Data Type	Notes
3	Fraction of burnable area	0 to 100	Float	Fraction of area in the grid that corresponds to 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 project (see section 2.8).

An example of this layer corresponding to August 2019 is shown in Figure 3.4. This layer does not change monthly, but only when a new land cover year is considered (see section 2.8).

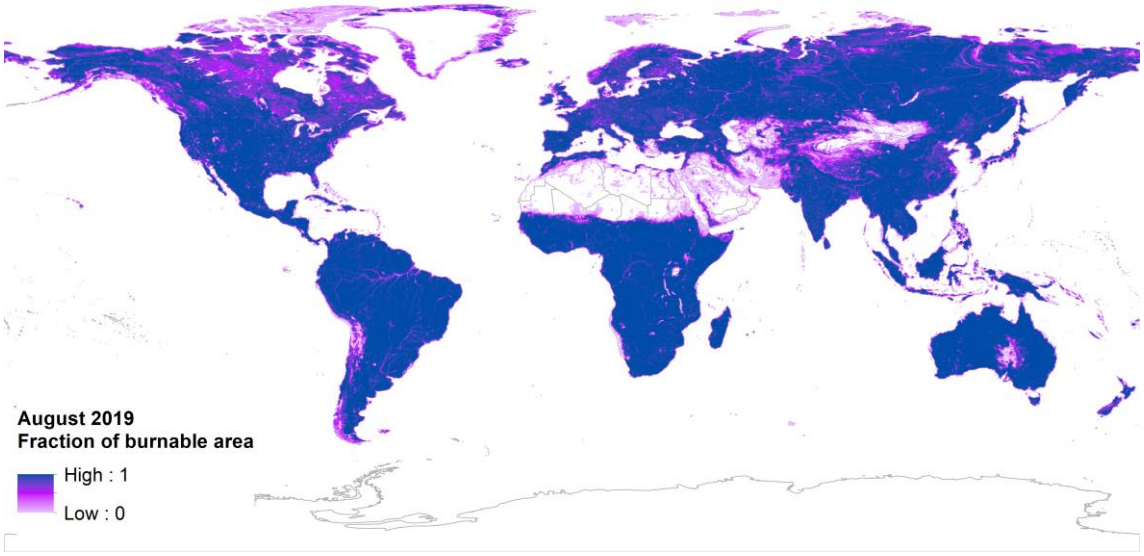

Figure 3.4: Example of the Fraction of Burnable Area attribute of the 20190801-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc file

3.4.4. Attribute 4: Fraction of observed area

	Attribute	Units	Data Type	Notes
4	Fraction of observed area	0 to 100	Float	Fraction of the total burnable area in the grid that was observed during the month (without cloud cover / haze or low quality pixels)

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 the input sensor. This may be caused by a sensor failure or by persistent cloud coverage.

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 month and therefore it identifies the regions where the product may miss burned pixels. All grid cells with fraction of observed area lower than 80% should be used with care.

An example of this layer corresponding to August 2019 is shown in Figure 3.5. Please note the absence of input data for various tiles in the tropics, for example.

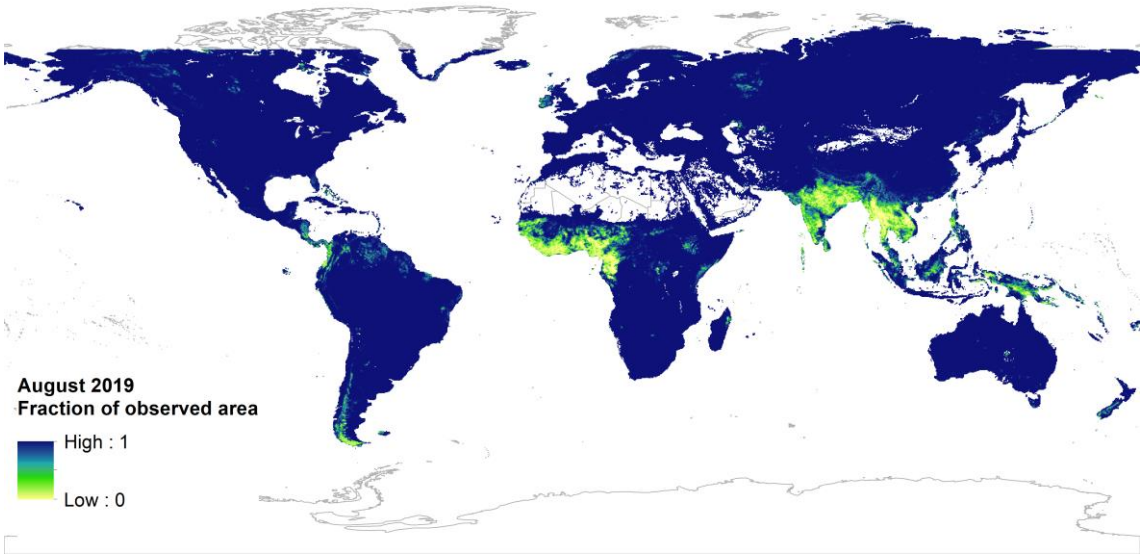

Figure 3.5: Example of the Fraction of Observed Area attribute of the 20190801-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc file.

3.4.5. Attribute 5: Number of patches

	Attribute	Units	Data Type	Notes
5	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 month.

The patches were calculated in the native sinusoidal projection of the burned area product. Individual patches only contain contiguous pixels. However, when a single burn patch covers two adjacent 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. In spite of these limitations (common to most other global BA products), this information can still be useful to obtain standard indicators of fire activity.

An example of this layer corresponding to August 2019 is shown in Figure 3.6.

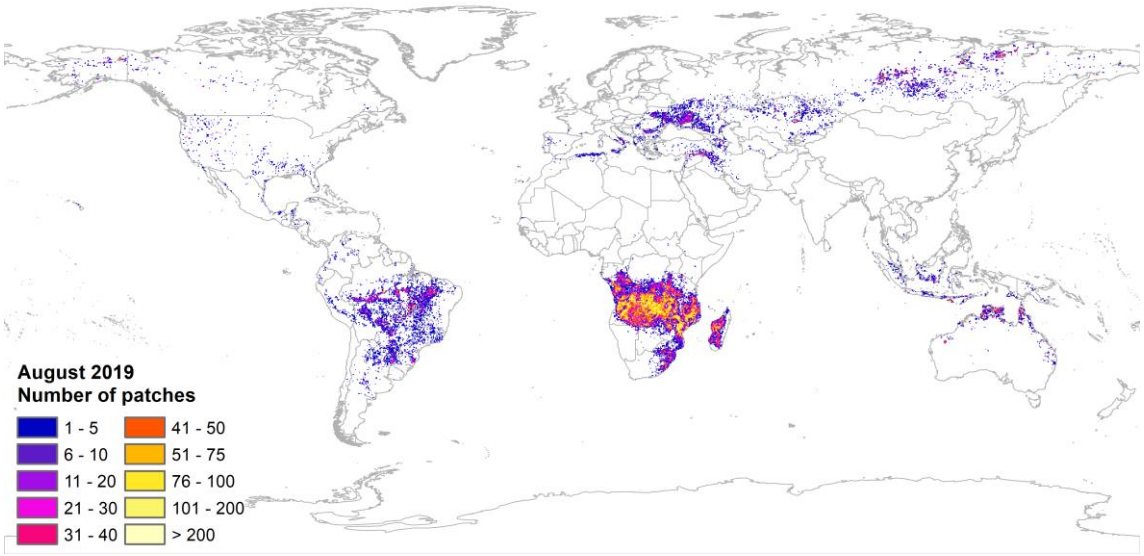

Figure 3.6: Example of the Number of Patches attribute of the 20190801-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc file

3.4.6. 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**.

*The vegetation_class categories are those described in Annex 1.

** Reference land cover is the one corresponding to the previous year of the product, except for 2017 to 2019, where it corresponds to the latest LC product, i.e. 2015. See Section 2.8 for further information.

As in the case of the pixel product, 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 Land Cover CCI (see Section 2.8). 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 due to 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 2019 are shown in the following figures. Figure 3.7 shows the sum of the burned area of croplands (LC_cci class 10), while Figure 3.8 shows the sum of BA in broadleaf deciduous trees (LC_cci class 60) for the same time period.

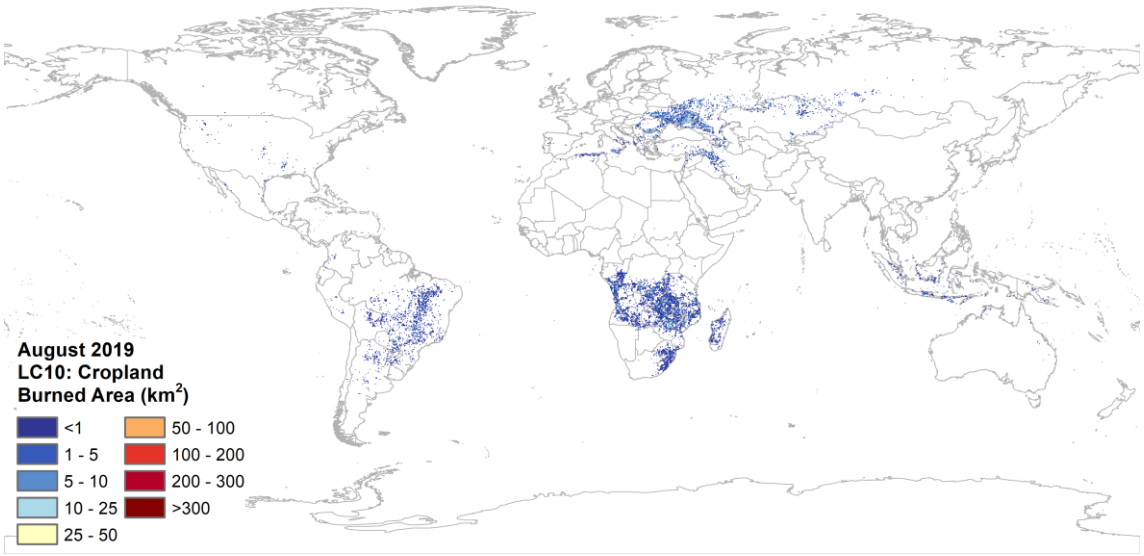

Figure 3.7: Example of the Burned Area in Vegetation Class attribute, for land cover class 10, corresponding to croplands, of the 20190801-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc file

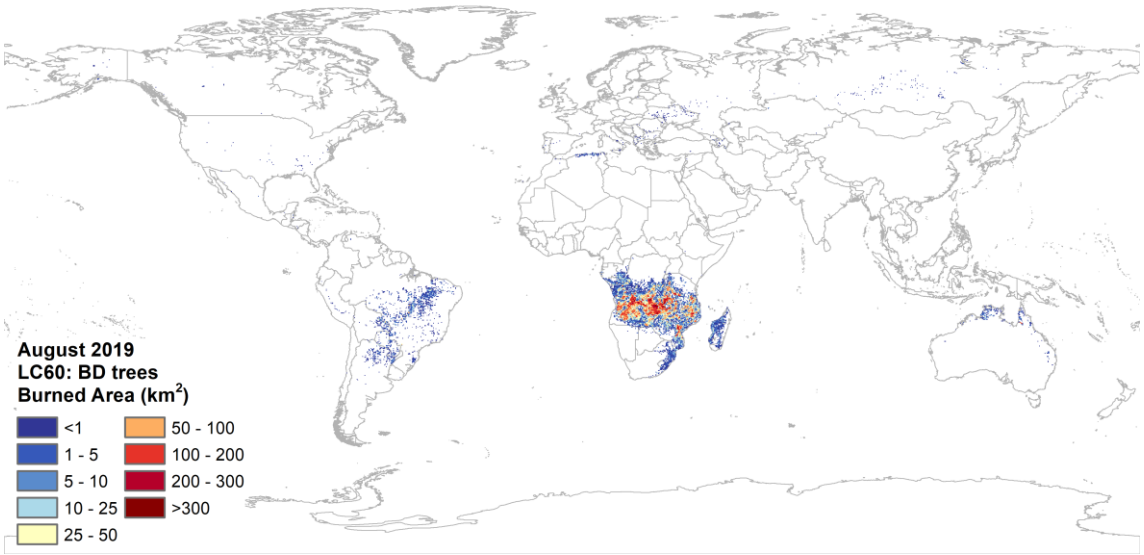

Figure 3.8: Example of the Burned Area in Vegetation Class attribute, for land cover class 60, corresponding to broadleaf deciduous tree cover, of the 20190801-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc file

3.5. File format

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).

3.6. Product file naming conventions

The grid files are named as following:

<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 MODIS.

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 fv5.1.

Example:

20191201-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc

3.7. File metadata

The grid files follow the NetCDF Climate and Forecast (CF) Metadata Convention (http://cfconventions.org/). Annex 3 describes the fields included in the .nc files.

4. 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, using multi-temporal pairs of Landsat TM-ETM-OLI images selected from 2003 to 2014. The validation results are detailed in the Product Validation Report (Padilla et al. 2018).

5. Changes and improvements since last version

The FireCCI51 product introduced several changes from the previous FireCCI50 product. The most important are:

- The improvement of the BA detection algorithm has allowed detecting much more burned area compared to FireCCI50 (see Lizundia-Loiola et al. 2018 for more information).
- Three more years of data (2017 to 2019) have been processed.
- An error in the pixel product corresponding to Area 2 (South America) where the northern part of the continent was cut has been fixed.
- The grid product is now delivered in monthly files, as requested by the users of the product.
- The land cover information has been updated, and now uses LC_cci v2.0.7 yearly files.
- The method for calculating the uncertainty has been improved.

6. Known issues

Due to the availability of a single satellite (Terra) between 2001-01 and 2002-07 underestimation of burned area pixels is expected in year 2001 and the first half of 2002, as a consequence of fewer hotspots available during that period. We kindly recommend the users to use data since 2003 if studies involve the derivation of temporal trends.

In the pixel product, users might occasionally notice that the same pixel could be labelled as burned in consecutive months. Although this issue was effectively handled in the original algorithm, the re-projection of the sinusoidal output to geographic coordinates could lead to this situation in burned patches that were adjacent to each other but burned in consecutive months, especially in high latitudes.

In the pixel product the land cover categories were not aggregated to the first level of classification (as shown in Annex 1), and some pixels have land cover values corresponding to second level classes.

7. Data dissemination

The MODIS Fire_cci BA products are available to the public through the Fire_cci website https://esa-fire-cci.org/, or the CCI Open Data Portal: http://cci.esa.int/data.

We strongly recommend registering before downloading the products using the link https://geogra.uah.es/fire_cci/ (or at least sending us an e-mail to mlucrecia.pettinari[at]uah.es with your contact information), to contact users when new versions of the products become available.

8. References

Chuvieco E., Yue C., Heil A., Mouillot F., Alonso-Canas I., Padilla M., Pereira J. M., Oom D. and Tansey K. (2016). "A new global burned area product for climate assessment of fire impacts." Global Ecology and Biogeography **25**(5): 619-629, https://doi.org/10.1111/geb.12440.

Chuvieco E., Lizundia-Loiola J., Pettinari M.L. Ramo R., Padilla M., Tansey K., Mouillot F., Laurent P., Storm T., Heil A., Plummer S. (2018) "Generation and analysis of a new global burned area product based on MODIS 250m reflectance bands and thermal anomalies". Earth System Science Data **10:** 2015-2031, https://doi.org/10.5194/essd-10-2015-2018.

ESA. Land Cover CCI Product User Guide Version 2. Tech. Rep. (2017). Available at: http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf.

Lewis P., Gómez-Dans J., Brennan J. and Chernetskiy M. (2017). "Uncertainty tracking when aggregating from fine to coarse resolution in the ESA CCI Fire Product." Fire_cci. 36 pp.

Lizundia-Loiola J., Pettinari M. L., Chuvieco E., Storm T., Gómez-Dans J. (2018). "ESA CCI ECV Fire Disturbance: Algorithm Theoretical Basis Document-MODIS, version 2.0." Fire_cci_D2.1.3_ATBD-MODIS_v2.0. Available at https://esa-fire-cci.org/documents.

Lizundia-Loiola, J., Otón, G., Ramo, R., Chuvieco, E. (2020) A spatio-temporal active-fire clustering approach for global burned area mapping at 250 m from MODIS data. Remote Sensing of Environment **236**: 111493, https://doi.org/10.1016/j.rse.2019.111493.

Padilla M., Wheeler J., Tansey K. (2018). "ESA CCI ECV Fire Disturbance: D4.1.1 Product Validation Report, Version 2.1". Available at https://esa-fire-cci.org/documents.

Annex 1: Land cover categories (extracted from LC_cci)

LC number		Class name	Fire_cci number
1st level	2nd level		
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 (Please refer to Section 6: Known issues). Only vegetated LC classes have been considered.

Annex 2: Metadata of the pixel product (XML file)

In each XML file corresponding to the pixel product, 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

Annex 3: Metadata of the grid product

This is an example of the metadata of the file 20190101-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc, as extracted using Python's netCDF4 library.

<type 'netCDF4._netCDF4.Dataset'>
root group (NETCDF3_CLASSIC data model, file format NETCDF3):
title: Fire_cci Gridded MODIS Burned Area product
institution: University of Alcala
source: MODIS MOD09GQ Collection 6, MODIS MOD09GA Collection 6, MODIS MCD14ML Collection 6, ESA CCI Land Cover dataset v2.0.7
history: Created on 2020-03-30 22:19:02
references: See www.esa-fire-cci.org
tracking_id: 122c81a0-715f-47f2-bfd3-7b871e8064cf
Conventions: CF-1.6
product_version: v5.1
summary: The grid product is the result of summing up burned area pixels and their attributes, as extracted from their original sinusoidal projection, 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 Land Cover CCI.
keywords: Burned Area, Fire Disturbance, Climate Change, ESA, GCOS
id: 20190101-ESACCI-L4_FIRE-BA-MODIS-fv5.1.nc
naming_authority: org.esa-fire-cci
doi: 10.5285/3628cb2fdba443588155e15dee8e5352
keywords_vocabulary: burned area, fire
cdm_data_type: Grid
comment: These data were produced as part of the ESA Fire_cci programme.
date_created: 20200330T221902Z
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: 20190101T000000Z
time_coverage_end: 20190131T235959Z
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: Terra
sensor: MODIS
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(sizes): vegetation_class(18), lat(720), lon(1440), nv(2), strlen(150), time(1)
variables(dimensions): float32 [4mlat[0m(lat), float32 [4mlat_bnds[0m(lat,nv), float32 [4mlon[0m(lon), float32 [4mlon_bnds[0m(lon,nv), float64 [4mtime[0m(time), float32 [4mtime_bnds[0m(time,nv), int32 [4mvegetation_class[0m(vegetation_class), |S1 [4mvegetation_class_name[0m(vegetation_class,strlen), float32 [4mburned_area[0m(time,lat,lon), float32 [4mstandard_error[0m(time,lat,lon), float32 [4mfraction_of_burnable_area[0m(time,lat,lon), float32 [4mfraction_of_observed_area[0m(time,lat,lon), float32 [4mnumber_of_patches[0m(time,lat,lon), float32 [4mburned_area_in_vegetation_class[0m(time,vegetation_class,lat,lon)
groups:

```
OrderedDict([(u'lat', <type 'netCDF4._netCDF4.Variable'>
float32 lat(lat)
    units: degree_north
    standard_name: latitude
    long_name: latitude
    bounds: lat_bnds
unlimited dimensions:
current shape = (720,)
filling off
), (u'lat_bnds', <type 'netCDF4._netCDF4.Variable'>
float32 lat_bnds(lat, nv)
unlimited dimensions:
current shape = (720, 2)
filling off
), (u'lon', <type 'netCDF4._netCDF4.Variable'>
float32 lon(lon)
    units: degree_east
    standard_name: longitude
    long_name: longitude
    bounds: lon_bnds
unlimited dimensions:
current shape = (1440,)
filling off
), (u'lon_bnds', <type 'netCDF4._netCDF4.Variable'>
float32 lon_bnds(lon, nv)
unlimited dimensions:
current shape = (1440, 2)
filling off
), (u'time', <type 'netCDF4._netCDF4.Variable'>
float64 time(time)
    units: days since 1970-01-01 00:00:00
    standard_name: time
    long_name: time
    bounds: time_bnds
    calendar: standard
unlimited dimensions: time
current shape = (1,)
filling off
), (u'time_bnds', <type 'netCDF4._netCDF4.Variable'>
float32 time_bnds(time, nv)
unlimited dimensions: time
current shape = (1, 2)
filling off
), (u'vegetation_class', <type 'netCDF4._netCDF4.Variable'>
int32 vegetation_class(vegetation_class)
    units: 1
    long_name: vegetation class number
unlimited dimensions:
current shape = (18,)
filling off
), (u'vegetation_class_name', <type 'netCDF4._netCDF4.Variable'>
|S1 vegetation_class_name(vegetation_class, strlen)
    units: 1
    long_name: vegetation class name
unlimited dimensions:
current shape = (18, 150)
filling off
), (u'burned_area', <type 'netCDF4._netCDF4.Variable'>
float32 burned_area(time, lat, lon)
    units: m2
```

standard_name: burned_area
long_name: total burned_area
cell_methods: time: sum
unlimited dimensions: time
current shape = (1, 720, 1440)
filling off
), (u'standard_error', <type 'netCDF4._netCDF4.Variable'>
float32 standard_error(time, lat, lon)
units: m2
long_name: standard error of the estimation of burned area
unlimited dimensions: time
current shape = (1, 720, 1440)
filling off
), (u'fraction_of_burnable_area', <type '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 CCI Land Cover, http://www.esa-landcover-cci.org/
unlimited dimensions: time
current shape = (1, 720, 1440)
filling off
), (u'fraction_of_observed_area', <type 'netCDF4._netCDF4.Variable'>
float32 fraction_of_observed_area(time, lat, lon)
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 the lack of input data (non-existing data for that location and period).
unlimited dimensions: time
current shape = (1, 720, 1440)
filling off
), (u'number_of_patches', <type 'netCDF4._netCDF4.Variable'>
float32 number_of_patches(time, lat, lon)
units: 1
long_name: number of burn patches
comment: Number of contiguous groups of burned pixels.
unlimited dimensions: time
current shape = (1, 720, 1440)
filling off
), (u'burned_area_in_vegetation_class', <type '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 CCI Land Cover, http://www.esa-landcover-cci.org/
unlimited dimensions: time
current shape = (1, 18, 720, 1440)
filling off
)])

Annex 4: Acronyms and abbreviations

BA	Burned Area
CCI	Climate Change Initiative
LC_cci	CCI Land Cover project
CRS	Coordinate Reference System
ECV	Essential Climate Variables
ESA	European Space Agency
FireCCI41	MERIS Fire_cci v4.1
FireCCI50	MODIS Fire_cci v5.0
FireCCI51	MODIS Fire_cci v5.1
GCS	Geographic Coordinate System
LC	Land Cover
MERIS	Medium Resolution Imaging Spectrometer
MODIS	Moderate Resolution Imaging Spectrometer
NIR	Near Infrared
p_b	Per pixel uncertainty
WGS84	World Geodetic System 84