ESA Climate Change Initiative – Fire_cci
D3.3.2 Product User Guide – Small Fire Database (PUG-SFD)

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Summary

This document is the version 1.2 of the Product User Guide for the Small Fire Database of the Fire_cci project. It provides practical information about the use of this product, which is currently available for Sub-Saharan Africa, and it is based on the Sentinel-2 MSI sensor.

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Document Status Sheet

Issue	Date	Details
1.0	23/03/2017	First Issue of the document
1.1	01/10/2018	Addressing comments on CCI-FIRE-EOPS-MM-17-0042
1.2	12/02/2019	New sections added to include the grid product

Document Change Record

Issue	Date	Request	Location	Details
1.1	01/10/2018	ESA	List of figures	Deleted.
		ESA	Section 1	Reduced.
		ESA	Sections 1.1, 1.2, 2.1, 2.3	Small changes in the text
		ESA	Section 1.3	Text reduced
		UL	Sections 2, 2.4	Text and figure updated
		UAH	Section 2.5	Naming convention updated
		UL	Section 2.6.1	Figure updated
		UAH	Section 2.6.2	Text and table updated
		UAH, UL	Sections 2.6.3, 3, 4, 5	Sections updated
1.2	12/02/2019	UAH	Sections 1.1, 1.3, 2.6.3	Small changes in the text
			Section 2	Change in the name of the section
			Section 2.6.1	Table updated
			Section 3	New section and sub-sections describing the grid product have been added
			Sections 4, 6	Text expanded
			Section 7	New references added
			Annex 2	New annex added

Table of Contents

1. General overview

This document contains practical information on how to use the Small Fire Database (SFD) product of the Fire_cci project, which in the current version is based on the Multi Spectral Instrument (MSI) on board the ESA Sentinel-2 (S2) satellite. This product is called the SFD Fire_cci v1.1 product, FireCCISFD11 for short.

1.1. Introduction

The SFD Fire_cci v1.1 product comprises maps of burned area from Sub-Saharan Africa (Figure 1). It was developed and tailored for its use by climate, vegetation and atmospheric modellers, as well as by fire researchers or fire managers interested in spatially detailed burned patterns.

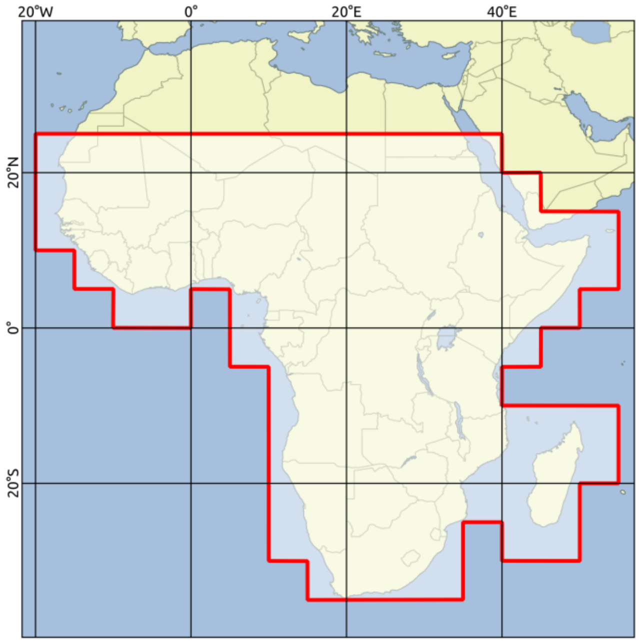

Figure 1: Sub-Saharan Africa, where the FireCCISFD11 product was generated.

The Fire_cci project produces two burned area products that are available at different spatial resolutions: the PIXEL product (L3S) and the GRID product (L4), which is derived from the pixel one (see Chuvieco et al. 2017).

1.2. Available data and key features of the MSI-L1C images

The input images for the FireCCISFD11 product were MSI Level-1C images (MSI-L1C), acquired by the Sentinel-2A satellite. Images were acquired every 10 days (revisit of the S2A satellite). However, the archived images at the ESA Sentinel server have less temporal frequency for same areas, either due to acquisition programming or archiving problems. Nevertheless, overlapping areas of two contiguous orbits can be observed twice in 10 days. Bands 8A (Near Infrared), 11 (Short SWIR) and 12 (Long SWIR) at their original 20m resolution were used to generate the BA product. The time series covers the period from January to December 2016 to produce the final BA product. The dataset does not include information from the beginning of the time series of S2 (June 2015) because data availability before January 2016 was not consistent. MSI images (MSI-L1C product) were downloaded at Brockmann Consult (http://www.brockmann-consult.de/, last accessed September 2018) from the ESA S2 server (https://scihub.copernicus.eu/dhus, last accessed September 2018).

The BA product was based on pre-processed MSI Level-2A product, generated by the Sen2Cor software, which is part of the Sentinel-2 ToolBox. The code performs the following tasks: atmospheric-correction, cirrus-correction and a classification of the scene of Level-1C input data. The original tiling system (100x100km tiles) was maintained throughout the processing chain of the BA algorithm; original tiles were reprojected and aggregated into 5x5 degrees tiles after detecting burned areas.

1.3. BA algorithm

The BA algorithm used for producing the final Fire_cci BA product is described in the Algorithm Theoretical Basis Document (Bastarrika and Roteta, 2018) and in Roteta et al. (2019).

2. Pixel BA product

The FireCCISFD11 product is a GeoTIFF file with three layers indicating the date of detection (Figure 2), the confidence level and the land cover in the pixel detected as burned (see Section 2.6 for further detail).

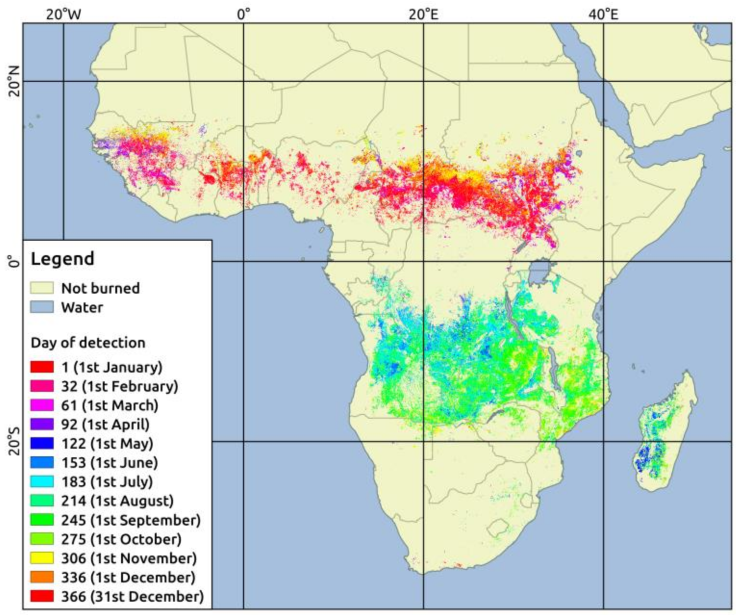

Figure 2: Day of detection or of burn for all the subsets in 2016, derived from the pixel product.

2.1. Temporal compositing

The pixel products are released as monthly composites so they can encompass those pixels that burn more than once during a calendar year. This may occur in the Northern Tropical areas, where the dry season (and hence the burn season) and the fire period commonly occur between December and February.

2.2. Spatial Resolution

The Spatial resolution of this BA product is 0.000179663 degrees (approximately 20 m at the Equator), the original resolution of both SWIR bands in the MSI images.

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. Subsets

The BA product is distributed in 5x5 degree tiles, each one a non-overlapping region. They cover Sub-Saharan Africa from the southernmost point of the continent (latitude 35ºS) to beyond the Tropic of Cancer (latitude 25ºN), between longitudes 20ºW and 55ºE. Figure 3 shows the extent of these tiles.

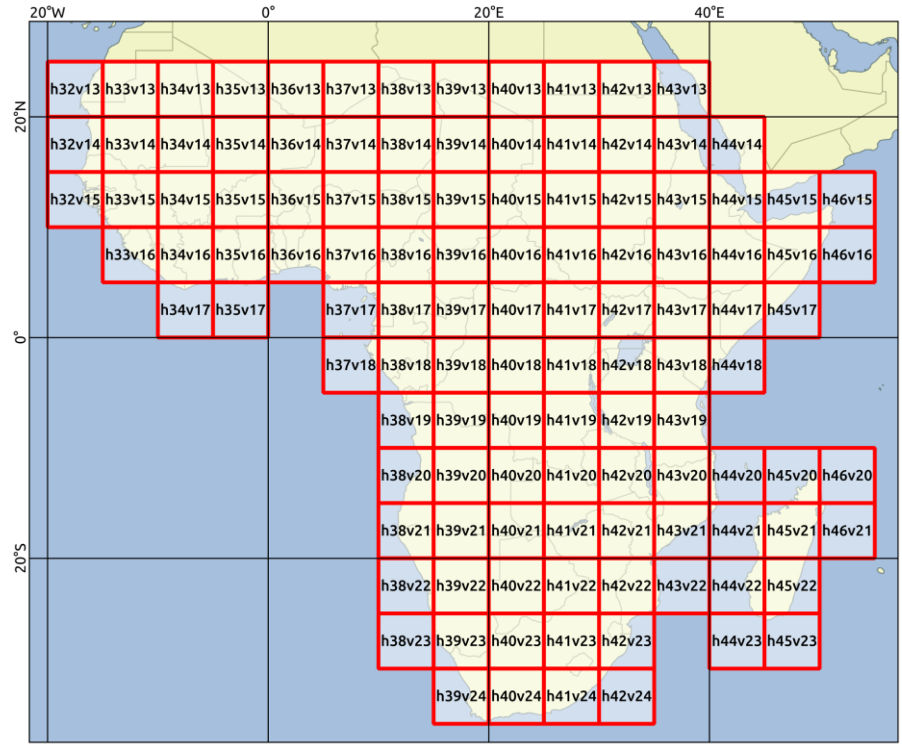

Figure 3: Geographical distribution of subsets of the FireCCISFD11 product.

2.5. 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<File_Version>-<Layer>.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 monthly products DD=01.

< **Indicative Sensor**>
For version 1.1 of the product, the sensor is MSI.

<Additional_Segregator>

This is AREA_<TILE_NUMBER> being the tile number the subset index described in Section 2.4.

<**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 fv1.1.

<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:

20160101-ESACCI-L3S_FIRE-BA-MSI-AREA_h38v16-fv1.1-JD.tif

2.6. Pixel attributes

The following sub-sections describe each of the layers of the pixel product (Annex 1), 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.

2.6.1. Layer 1: Date of the first detection

Layer	Attribute	Units	Data Type	Notes
1 (JD)	Date of the first detection	Day of the year, from 1 to 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.

When the pixel is characterized as burned, it is assumed that the complete pixel was burned, as for all BA products. All pixels with confidence level higher than 50 (Layer 2, section 2.6.2) have a day of detection.

The date of the burned pixel (usually also called day of the year or Julian day) may not be coincident with the actual burning date, and it could correspond 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 equatorial latitudes or those with high cloud coverage the date might be up to weeks after the fire is over.

An example of this layer corresponding to the month of June for Area h42v16 is shown in Figure 4.

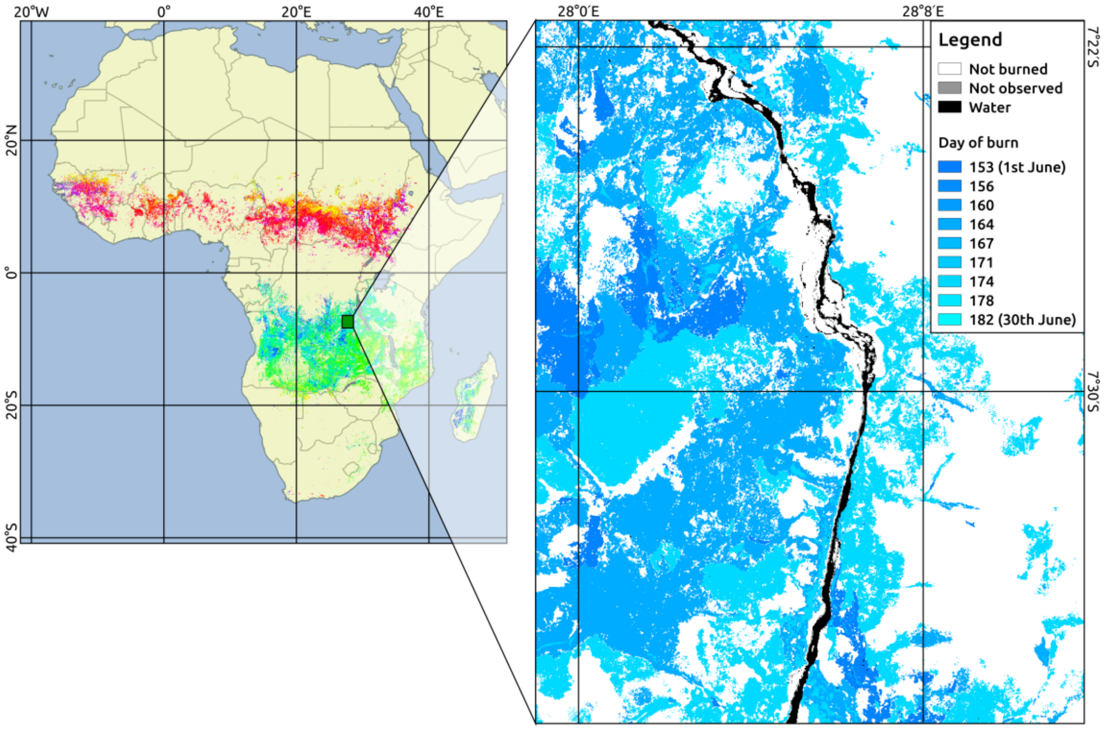

Figure 4: Example of the Date of the first detection layer for the h41v19 tile on June 2016

2.6.2. Layer 2: Confidence level

Layer	Attribute	Units	Data Type	Notes
2 (CL)	Confidence level	0 to 100	Integer	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. - 1: value assigned when the pixel was observed, but the probability of burn was lower than 50. - 50 to 100: Probability values. The closer to 100, the higher the confidence that the pixel is actually burned.

The confidence level was based on spectral properties of initial burned areas, which were detected near thermal anomalies hotspots from the MCD14ML C6 product. The original probability values were rescaled, in order to provide values easier to understand by users. The technical details are explained in Bastarrika and Roteta 2018.

An example of this layer corresponding to the month of June for Area h42v16 is shown in Figure 5.

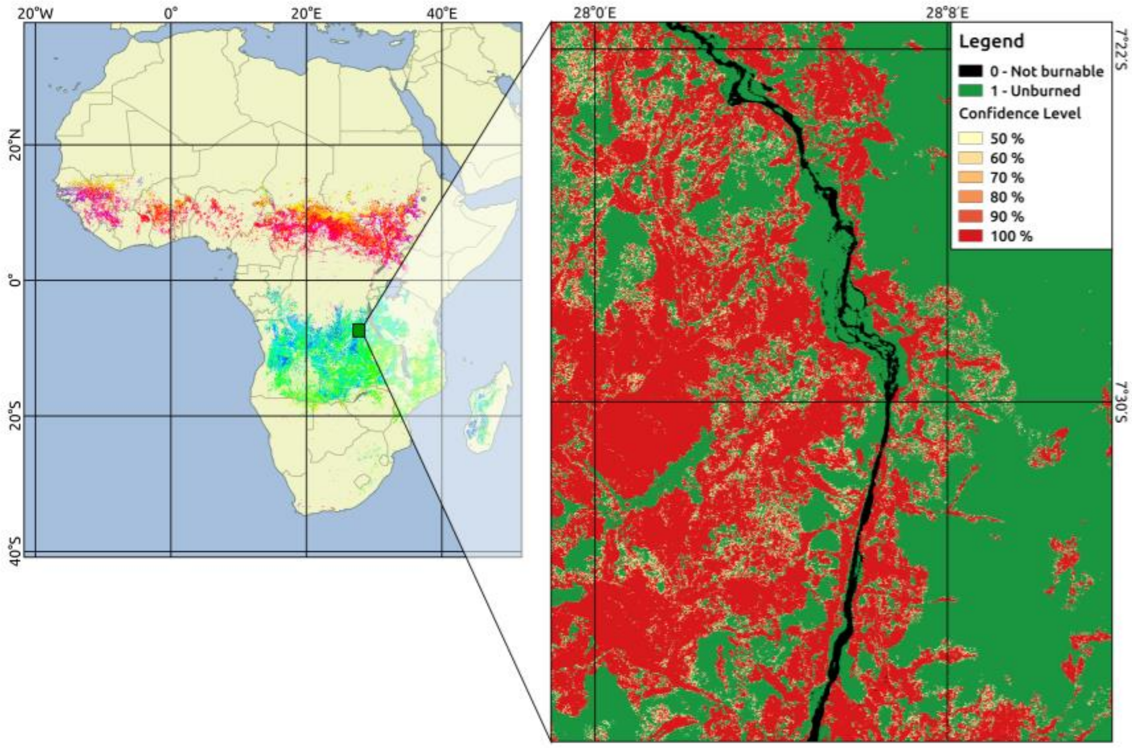

Figure 5: Example of the Confidence Level layer for the h41v19 tile on June 2016

2.6.3. Layer 3: Land cover of burned pixels

Layer	Attribute	Units	Data Type	Notes
3 (LC)	Land cover of burned pixels	0 to N	Byte	Land cover of the pixel detected as burned, extracted from the CCI Land Cover maps. N is the number of land cover categories in the reference map. It is only valid when layer 1 > 0. A pixel value of 0 is allocated to pixels that are not taken into account in the BA processing (continuous water, bare areas).

The land cover assigned to the pixel detected as burned was extracted from the CCI S2 prototype Land Cover map at 20m of Africa 2016 (downloadable in http://2016africalandcover20m.esrin.esa.int/, last accessed September 2018); unburned pixels are assigned the value 0. The land cover categories included in the BA product are listed in Table 1.

Table 1: Land cover categories in Layer 3.

LC number	Class name
1	Trees cover area
2	Shrubs cover area
3	Grassland
4	Cropland
5	Vegetation aquatic or regularly flooded
6	Lichen and mosses / sparse vegetation

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. Obviously, errors included in this land cover map also affect the information contained in the BA product, and hence the calculation of emissions using land-cover-based emissions factors would be affected.

An example of this layer corresponding to the month of June for Area h42v16 is shown in Figure 6.

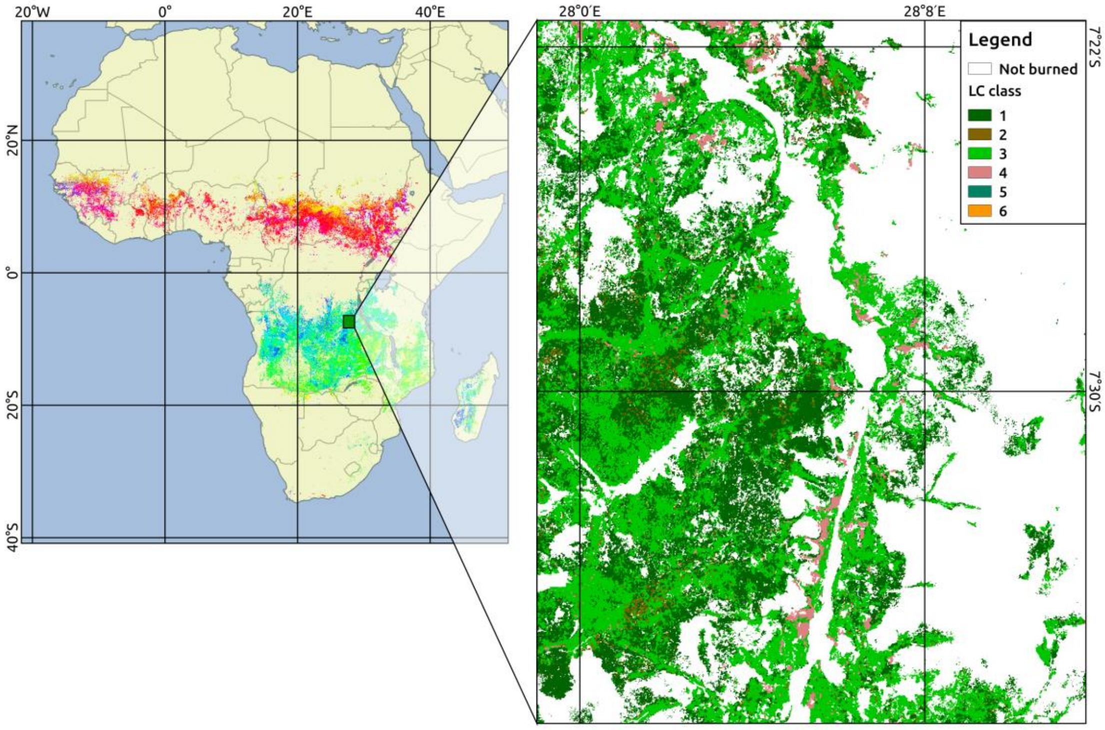

Figure 6: Example of the Land Cover layer for the h41v19 tile on June 2016

2.7. File metadata

For each BA file product, an additional xml file with the same name is created. This file holds the metadata information following the ISO 19115 standard. The description of the populated fields is included in Annex 1.

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. Since FireCCISFD11 only covers sub-Saharan Africa, only the cells in that area have BA information, and the rest of the world has a value of 0.

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 the six land cover classes described in Section 2.6.3. Figure 7 shows the total BA from this product for 2016.

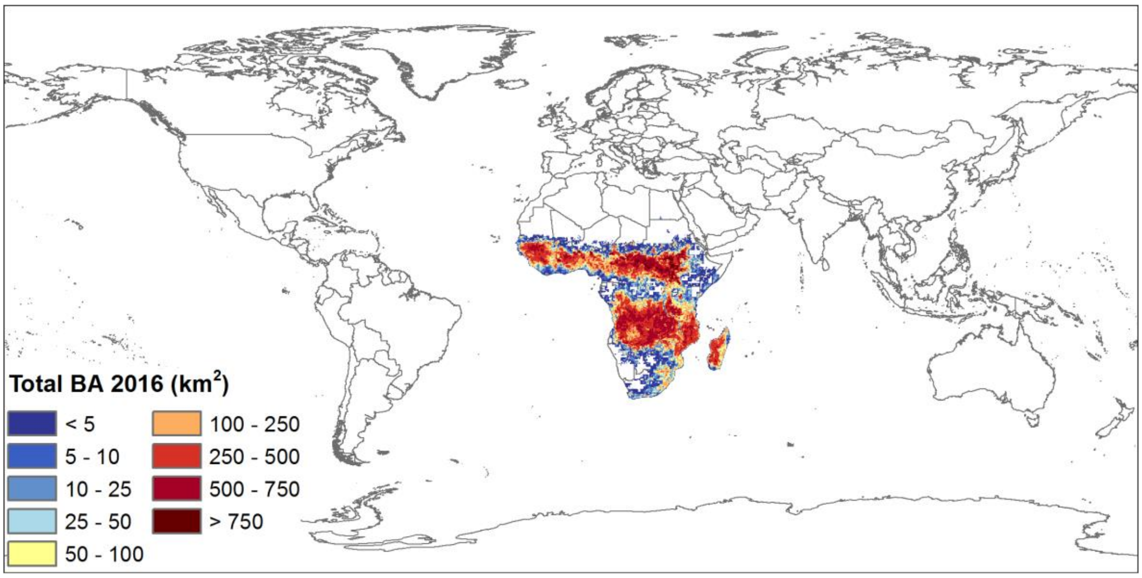

Figure 7: Total burned area for the year 2016.

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 3.4).

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. As the product only covers sub-Saharan Africa, the other areas of the world have a value of 0 in all layers.

3.3. Product projection system

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

The product format is NetCDF-CF (see http://www.unidata.ucar.edu/software/netcdf/docs for detailed information about this format).

3.4. 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 MSI.

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 fv1.1.

Example:

20161201-ESACCI-L4_FIRE-BA-MSI-fv1.1.nc

3.5. 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.

3.5.1. 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. The value in this layer indicates the sum of all the burned area within each 0.25-degree cell. Further description on the methodology to obtain the burned area from the BA detections is included in the Algorithm Theoretical Basis Document (Bastarrika and Roteta 2018).

An example of this layer corresponding to November 2016 is shown in Figure 8.

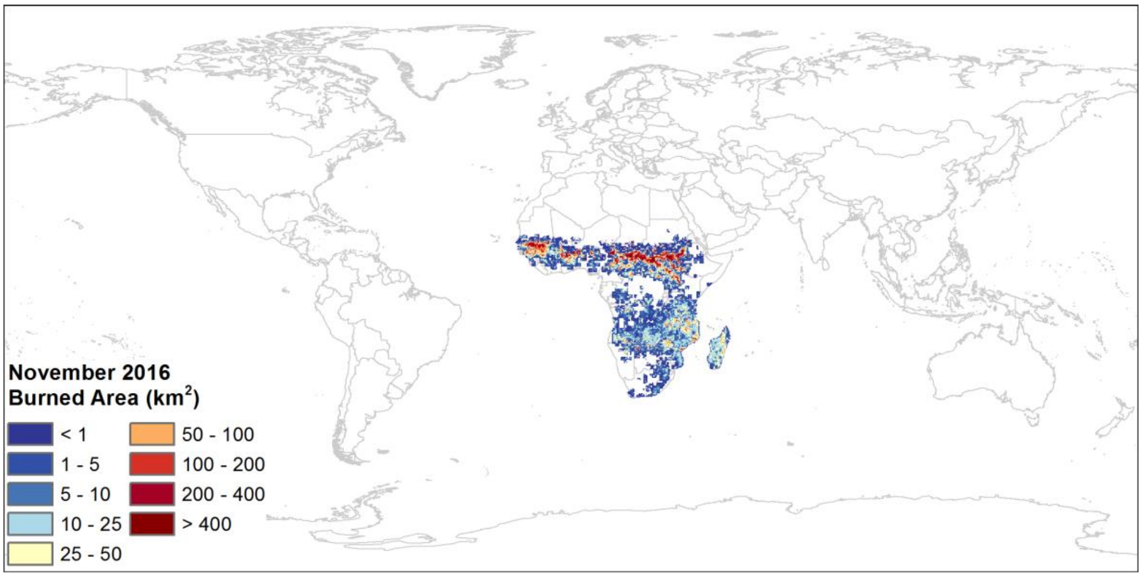

Figure 8: Example of the Burned Area attribute of the 20161101-ESACCI-L4_FIRE-BA-MSI-fv1.1.nc file

3.5.2. 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. Therefore, 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 November 2016 is shown in Figure 9.

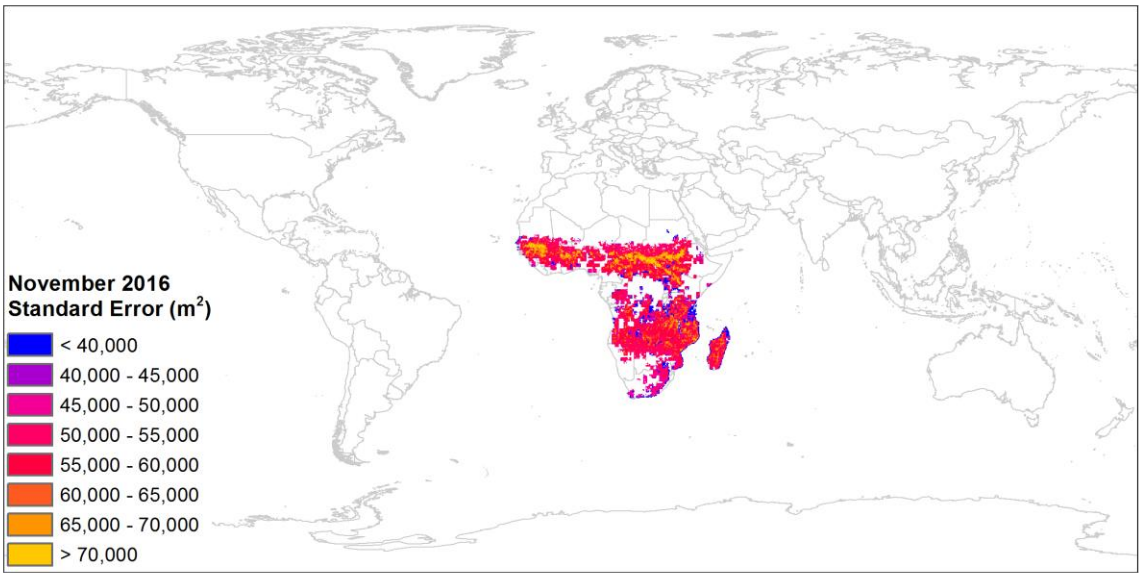

Figure 9: Example of the Standard Error attribute of the 20161101-ESACCI-L4_FIRE-BA-MSI-fv1.1.nc file

3.5.3. 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 land covers that could be affected by fire.

Includes all land cover categories that can be burned. Land cover information was extracted from the LC_cci project (see Section 2.6.3).

An example of this layer corresponding to November 2016 is shown in Figure 10.

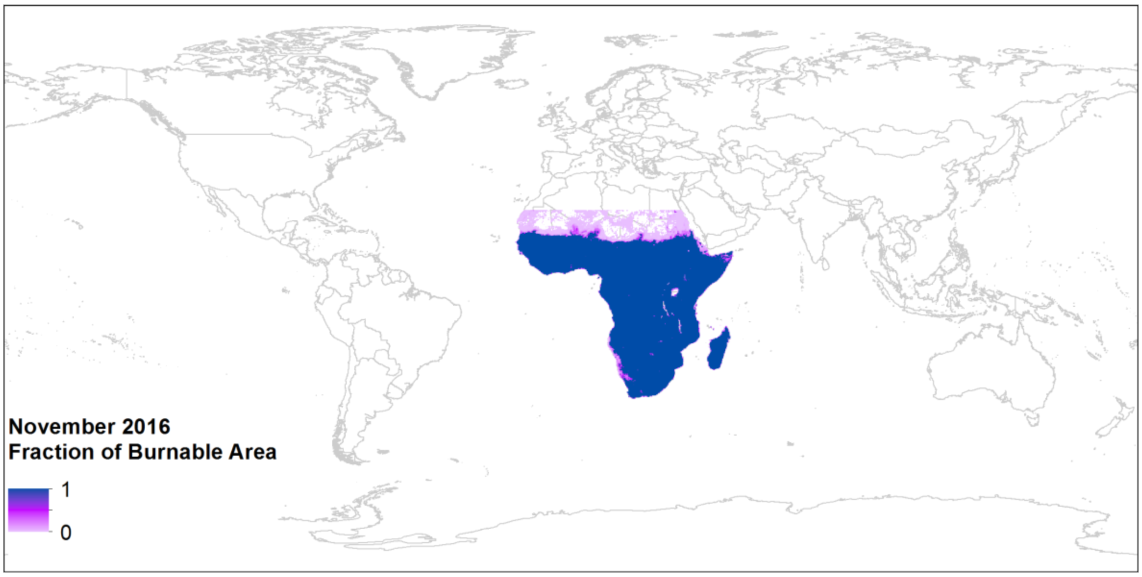

Figure 10: Example of the Fraction of Burnable area of 20161101-ESACCI-L4_FIRE-BA-MSI-fv1.1.nc file

3.5.4. Attribute 4: Fraction of observed area

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

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 November 2016 is shown in Figure 11.

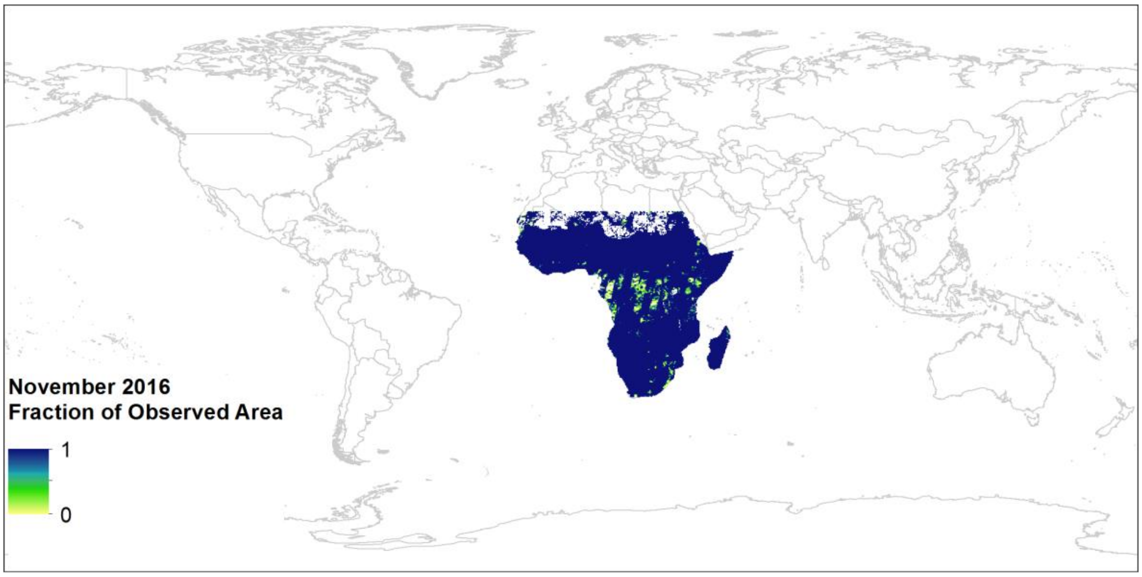

Figure 11: Example of the Observed Area Fraction attribute of the 20161101-ESACCI-L4_FIRE-BA-MSI-fv1.1.nc file

3.5.5. 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.

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 form together a single-continuous patch.

An example of this layer corresponding to November 2016 is shown in Figure 12.

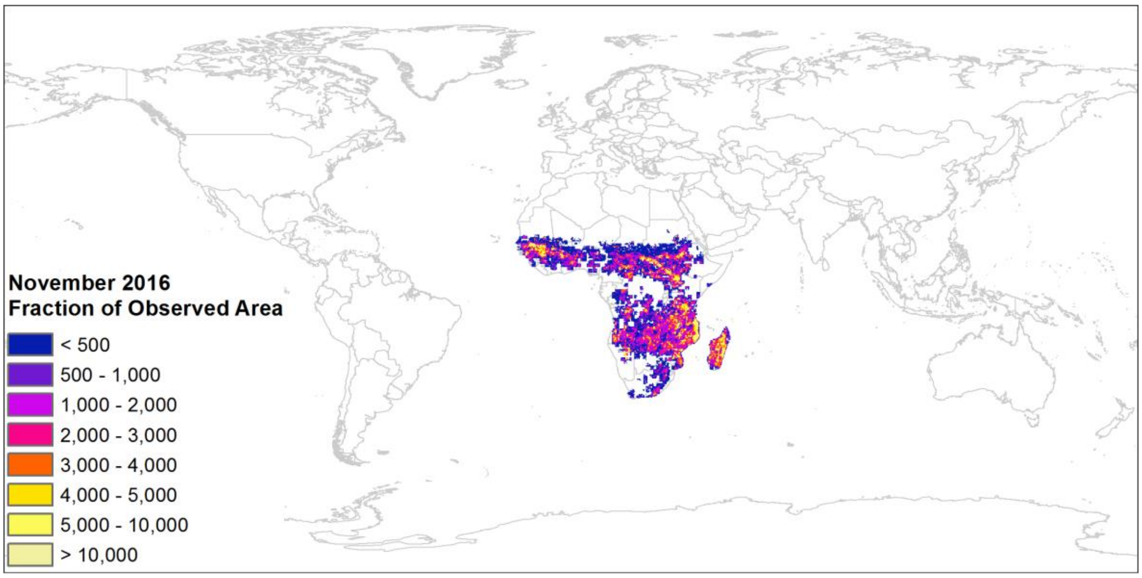

Figure 12: Example of the Number of Patches attribute of the 20161101-ESACCI-L4_FIRE-BA-MSI-fv1.1.nc file

3.5.6. Attributes 6-11: Sum of burned area for each land cover category

	Attribute	Units	Data Type	Notes
6 to 11	burned_area_in_vegetation_class*	Square metres	Float	Sum of all burned pixels of each land cover as defined by the African LC_cci.

*The vegetation_class categories are those described in Section 2.6.3.

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 for Africa 2016 (see Section 2.6.3). 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 November 2016 are shown in the following figures. Figure 13 shows the sum of the burned area of tree cover areas (LC_cci class 1), while Figure 14 shows the sum of BA in croplands (LC_cci class 4) for the same time period.

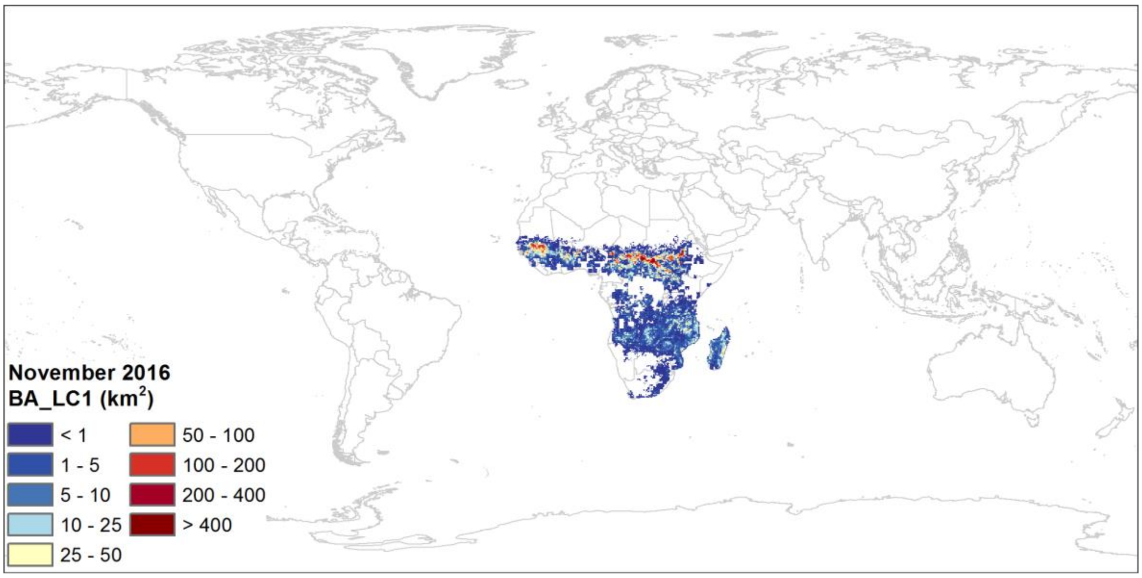

Figure 13: Example of the Burned Area in Vegetation Class attribute, for land cover class 1, corresponding to tree cover area, of the 20161101-ESACCI-L4_FIRE-BA-MSI-fv1.1.nc file

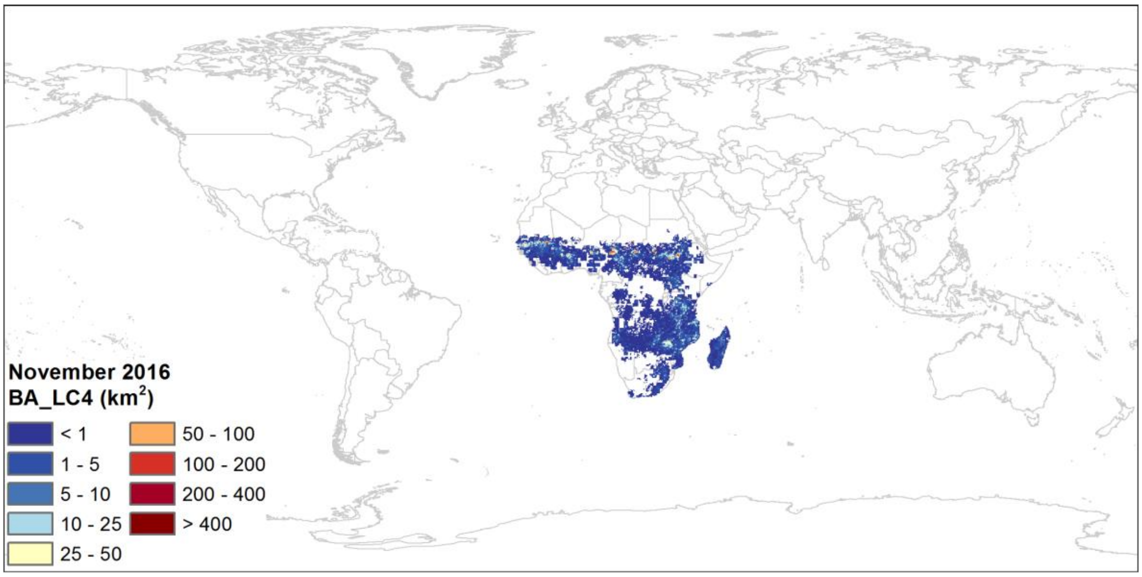

Figure 14: Example of the Burned Area in Vegetation Class attribute, for land cover class 4, corresponding to croplands, of the 20161101-ESACCI-L4_FIRE-BA-MSI-fv1.1.nc file

3.6. 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.

4. Product assessment

The algorithm used to generate this pixel product was preliminary assessed using a sample set of 52 areas selected in different biomes of Africa, in a similar way as in Padilla et al., 2014. The overall omission and commission errors (OE and CE) were 24.5% and 8.1% respectively, with a Kappa value of 0.809 (methods and results explained in Bastarrika and Roteta, 2018). High commission errors correspond to cloud borders not masked adequately and to agricultural fields with spectral signal similar to that of burned areas.

Omission errors are due to low severity burned fires that the algorithm gets confused with the unburned background.

Complementary, a preliminary comparison with MCD64 Collection 6 product shows that a considerably high number of small burned areas were being omitted in the second product because of the low spatial resolution (Figure 15), though this still requires further research.

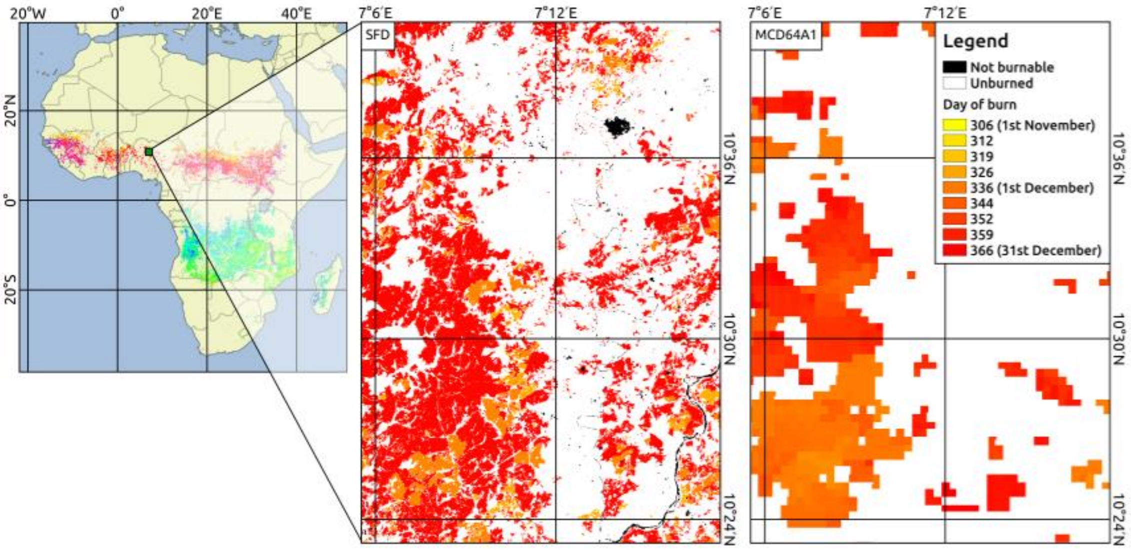

Figure 15: Intercomparison of FireCCISFD11 BA and MCD64A1 Collection 6 products

The formal validation exercise performed to the product is described in Padilla et al. (2018). The results obtained for the product were:

- Dice Coefficient: 0.77
- Relative bias: -0.0896
- Commission error: 19.3%
- Omission error: 26.5%

5. Data limitations and constraints

5.1. Missing data

Two main problems have been found when analysing the results of the BA product. The first is caused by the availability of the imagery. At the moment of processing, there was a lack of images corresponding to the year 2015. Since the algorithm requires a pre-fire cloud-free image to compute the difference between different dates, the data of January 2016 might be affected due to the reduced availability of December 2015 images.

5.2. Pre-processing errors

Related to the Scene Classification (SCL) created by the Sen2Cor tool from the Sentinel-2 ToolBox when generating the Level-2A product of MSI images, two false detections have been found in this classification, both causing an increase in the commission error:

- BA classified as cloud shadows or dark pixels in Sen2Cor (categories 2 and 3). This false detection was found in the early development of the algorithm, so both categories were removed from the mask and a new condition was introduced in place of the Sen2Cor mask: pixels with reflectance below 0.07 in band 12 (Long SWIR band) were considered to be cloud shadows and masked. This prevented most cloud shadows from being detected as burned, but some pixels were not masked and so were detected as BA. In Figure 16, some shadows are not masked on 1st January 2016 and appear as burned in the BA product, even if they were not burned either in the previous date (22th December 2015) nor in the next (11th January 2016).

- Very thin clouds not detected and classified as ground, and later detected as BA. This misinterpretation was not detected in the study areas where the algorithm was tested, so it is present in some places the product. The error is represented in Figure 17, where most of the cloud in the centre was not masked and was later classified as burned area.

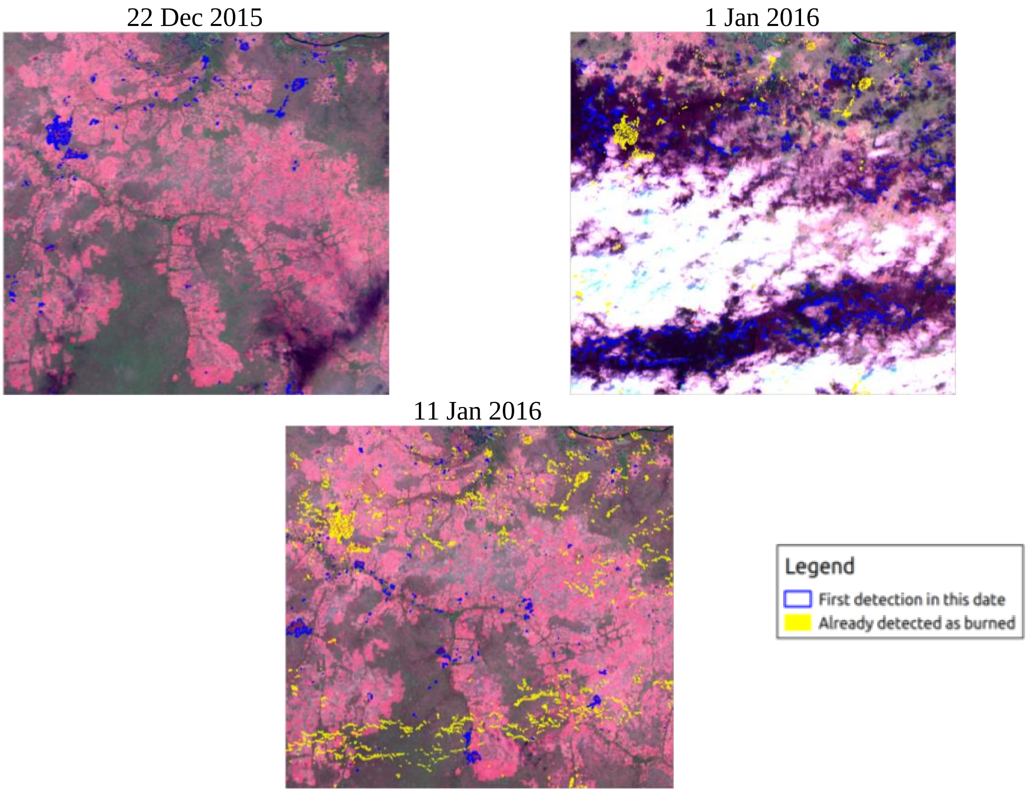

Figure 16: Extract from a temporal series showing how cloud shadows can be detected as BA by the algorithm.

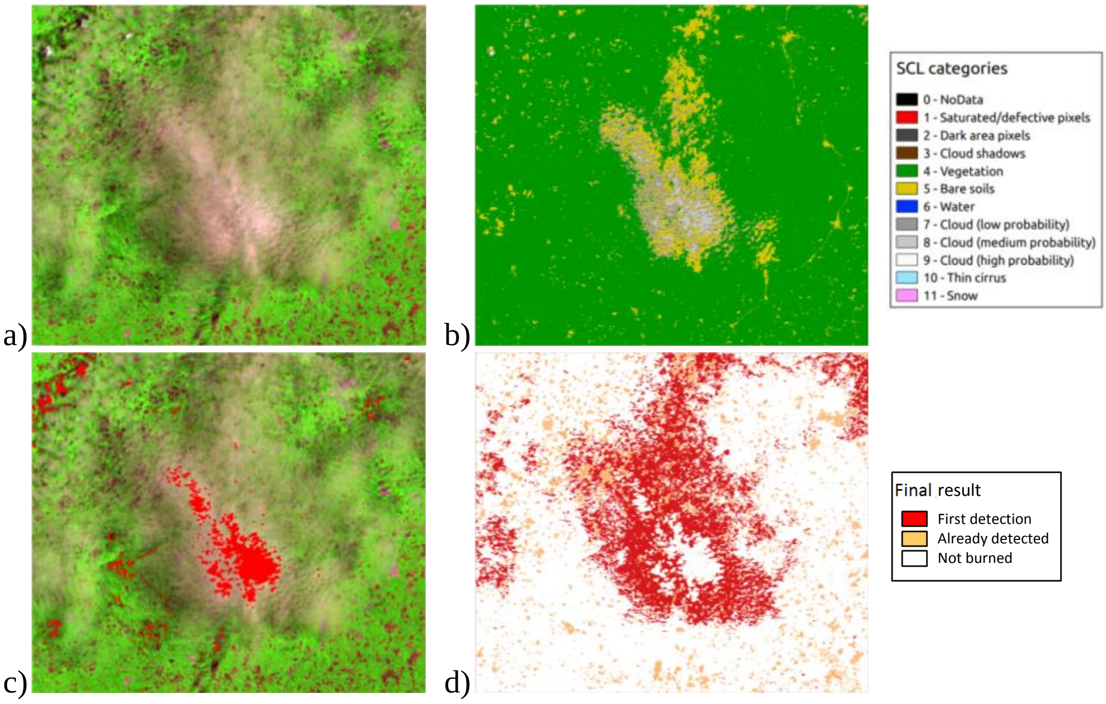

Figure 17: a) false colour composition (B12-B8A-B04 in MSI bands), b) classification of the scene (SCL), c) mask generated from the SCL (red pixels), d) false detection of thin clouds as burned areas.

6. Data dissemination

The SFD Fire_cci v1.1 BA product is freely available from the Fire_cci website: https://www.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/sfd.php (or at least sending us an e-mail to mlucrecia.pettinari[at]uah.es with your contact information), for us to be able to contact users when new versions of the products become available.

7. References

Bastarrika A., Roteta E. (2018) ESA CCI ECV Fire Disturbance: D2.1.2 Algorithm Theoretical Basis Document-SFD, version 1.0. Available at: https://www.esa-fire-cci.org/documents

Chuvieco E., Pettinari M. L., Heil A., Storm T. (2017) ESA CCI ECV Fire Disturbance: D1.2 Product Specification Document, version 6.3. Available at: https://www.esa-fire-cci.org/documents

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.

Padilla M., Chuvieco E. (2014) ESA CCI ECV Fire Disturbance: Product Validation Report I, version 2.0.

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

Roteta, E., Bastarrika, A., Padilla, M., Storm, T., Chuvieco, E. (2019) Development of a Sentinel-2 burned area algorithm: Generation of a small fire database for sub-Saharan Africa. Remote Sensing of Environment 222, 1-17, doi: https://doi.org/10.1016/j.rse.2018.12.011

Annex 1: 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
  - 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 2: Metadata of the grid product

Here is an example of the dimensions and variables of the gridded product for the 20160101-ESACCI-L4_FIRE-BA-MSI-fv1.1.nc file:

<u>Global Attributes</u>:
title = 'Fire_cci Gridded MSI Burned Area product'
institution = 'University of Alcala'
source = ' MSI L1C, MODIS MCD14ML Collection 6, ESA CCI S2 prototype land cover 20m map of Africa '
history = 'Created on 2018-12-04 20:30:40'
references = 'See www.esa-fire-cci.org'
tracking_id = 'ea737f0c-aff6-47b1-b877-a216c529dde4'
Conventions = 'CF-1.6'
product_version = 'v1.1'
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 6 land cover classes of land cover.'
keywords = 'Burned Area, Fire Disturbance, Climate Change, ESA, GCOS'
id = '20160101-ESACCI-L4_FIRE-BA-MSI-fv1.1.nc'
naming_authority = 'org.esa-fire-cci'
doi = '10.5285/4b0773a84e8142c688a628c9ce62d4ec'
keywords_vocabulary = 'none'
cdm_data_type = 'Grid'
comment = 'These data were produced as part of the ESA Fire_cci programme.'
date_created = '20181204T203040Z'
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 = '20160101T000000Z'
time_coverage_end = '20160131T235959Z'
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 = ' Sentinel-2'
sensor = 'MSI'
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 = 6
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: 6x1
    Dimensions: vegetation_class
    Datatype: int32
    Attributes:
        units = '1'
        long_name = 'vegetation class number'
vegetation_class_name
    Size: 150x6
    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 ESA CCI S2 prototype land cover 20m map of Africa, http://2016africalandcover20m.esrin.esa.int/'
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 images for that location and period), cloud cover, haze or pixels that fell below the quality thresholds of the algorithm.'

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: 1440x720x6x1
  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 ESA CCI S2 prototype land cover 20m map of Africa, http://2016africalandcover20m.esrin.esa.int/'

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 ESA CCI S2 prototype land cover 20m map of Africa, http://2016africalandcover20m.esrin.esa.int/'

Annex 3: Acronyms and abbreviations

BA	Burned Area
CCI	Climate Change Initiative
CE	Commission Error
CRS	Coordinate Reference System
ECV	Essential Climate Variables
ESA	European Space Agency
GCS	Geographic Coordinate System
LC	Land Cover
MCD64	MODIS Burned Area product
MCD14	MODIS Active Fire Product
MODIS	MODerate resolution Imaging Spectrometer
MSI	Multi Spectral Instrument
MSI-L1C	MSI Level-1C product
OE	Omission Error
PSD	Product Specification Document
S2	Sentinel 2
S2A	Sentinel-2A satellite
SCL	Scene Classification
SFD	Small Fire Dataset
SWIR	Short-Wave Infrared
WGS84	World Geodetic System 84