ESA Climate Change Initiative – Fire_cci

Option 2 - Extending Fire Disturbance Time Series using AVHRR-LTDR

O2.D1 - User Requirement Document (URD) and Product Specification Document (PSD) for AVHRR

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Summary

This document is the version 1.1 of the User Requirements Document and Product Specification Document for the Option 2 of the Fire_cci project, corresponding to the extension of the fire disturbance time series using AVHRR-LTDR data. It refers to Work Package 210. It complements the burned area requirements described in the User Requirements Document of the main project (Heil et al. 2016), and provides the specifications for the development of the AVHRR-LTDR BA product based on those requirements, complementing the Product Specification Document of the main project (Chuvieco et al. 2016).

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1.1	15/05/2017	ESA	Section 3	Added clarification regarding the researchers invited to answer que survey.
1.1	15/05/2017	ESA	Section 4	Added clarification to the term “compatible”.
1.1	15/05/2017	ESA	Section 4.4	Change in land cover reference in Table 4.

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1. Executive Summary

This document is the User Requirements Document (URD) and Product Specification Document (PSD) of the AVHRR-LTDR Option 2 of the Fire_cci project. It describes the results of the User requirement survey as well as the specifications of the burned area product to be generated within this option.

1.1. Applicable Documents

[AD-1]	ESA Climate Change Initiative (CCI) Phase 2 Statement of Work, prepared by ESA Climate Office, Reference CCI-PRGM-EOPS-SW-12-0012, Issue 1.3, date of issue 24 March 2015, available at http://www.esa-fire-cci.org/webfm_send/828
[AD-2]	ECV Fire Disturbance Proposal for Option 2: Extending Fire Disturbance Time Series using AVHRR-LTDR.
[AD-3]	Heil A., Yue C., Mouillot F. and Kaiser J.W. (2016) ESA CCI ECV Fire Disturbance: D1.1 User requirement document, version 5.1. Available from: http://www.esa-fire-cci.org/documents
[AD-4]	Chuvieco E., Pettinari M.L., Heil A. and Storm T. (2016) ESA CCI ECV Fire Disturbance: D1.2 Product Specification Report, version 6.1. Available from: http://www.esa-fire-cci.org/documents.

2. Burned area estimations prior to the MODIS era

Wildland fires are one of the most relevant processes impacting human and natural ecosystems (Flannigan et al. 2006; GCOS 2011). They also affect atmospheric composition, through direct gas emissions derived from the combustion process (CO2, CH4, CO, N2O y NOX) as well as by the removal of vegetation which acts as a carbon sink (GCOS 2011; Granier et al. 2011; Urbanski et al. 2008; Ward et al. 2012). For these reasons, wildland fires affect climate change and are simultaneously affected by climate oscillations, particularly when heat waves and severe droughts occur (Chen et al. 2016; Hantson et al. 2015; Preisler et al. 2009). These reasons explain that fire disturbance is considered by GCOS as an Essential Climate Variable (GCOS 2011) and it has been recently included in the IPCC assessment report (Ciais et al. 2014).

Climate modellers require input data to parametrize and validate their models. In the case of wildland fires, the timing, size, intensity and spatial distribution of fires are critical variables to better understand the role of fire in carbon and atmospheric emission models (Hantson et al. 2016). Accurate and updated data of burned area is therefore becoming widely recognized as a relevant parameter for carbon and climate models. Satellite burned area products have been generated in the last years based on existing global observation sensors (Mouillot et al. 2014), such as MODIS (MCD45), VEGETATION (Copernicus) and MERIS (Fire_cci) data. These products only cover from 2000 and all show inconsistencies and omission and commission errors (Granier et al. 2011; Padilla et al. 2015). On the other hand, this short period precludes the intensive use of these datasets for climate modelling, which requires long periods of time. Most papers dealing with fire models emphasize the need to extend the existing time series of burned area information backwards. Previous estimations of burned area for the pre-2000 period are based on fire ignition and propagation models. They estimated burned

area from meteorological moisture codes provided by climate models (Thonicke et al. 2001) or they were based on fire occurrence reports provided by some national fire services (Mouillot and Field 2005). These data were complemented with auxiliary sources, such as journalist news, literature sources or charcoal deposits in lakes (Power et al. 2010).

Most papers dealing with fire modelling emphasize the need to have long periods of time to better understand the interactions between vegetation, atmosphere and fire (Granier et al. 2011; Le Page et al. 2007; Mouillot et al. 2014). For this reason, the temporal extension of existing burned area products to the AVHRR legacy (>1981) would be really appreciated by researches involved in fire models.

3. User requirements

This section analyses and summarises the feedback obtained from researchers that participated in the user requirement questionnaire survey designed specifically for the AVHRR-LTDR BA extension.

26 researchers of different nationalities answered the questionnaire, which was promoted by UAH and the CRG of the Fire_cci project, apart from being sent to all the researchers who have downloaded the Fire_cci products and published in the Fire_cci website. The survey was active during December 2016 (see Annex 1 for the survey questions). The respondents belong mostly to University and Research Institutes (78.13%), but there were also researchers for both governmental and non-governmental organizations, as well as representatives of the commercial sector. These researchers represented mainly Europe (65.38%), followed by America (19.23%), Asia (11.54%) and Africa (3.85%). The most important applications of burned area information mentioned were dynamic vegetation modelling and statistical modelling of fire patterns and fire drivers, with more than 50% in each case. Other applications cited, in order of relevance, were biogeochemical modelling, forest and fire management planning, atmospheric chemistry modelling, land use change modelling, fire emissions and environmental law.

These users have previously worked with the GFED BA product (69.2%), Fire_cci BA product (57.7%), MODIS MCD45 (11.5%), Landsat (7.7%) and Radar sensors (3.8%). 11.5% have not used BA products in the past. The next section summarizes the requirements identified by the respondents of the survey.

3.1. Temporal coverage

More than 60% of the respondents requested a temporal coverage extending back to 1980, or as far back in time as possible. This option emphasizes the relevance of the information potentially generated by this option for climate users. Figure 1 summarizes the answers to this question.

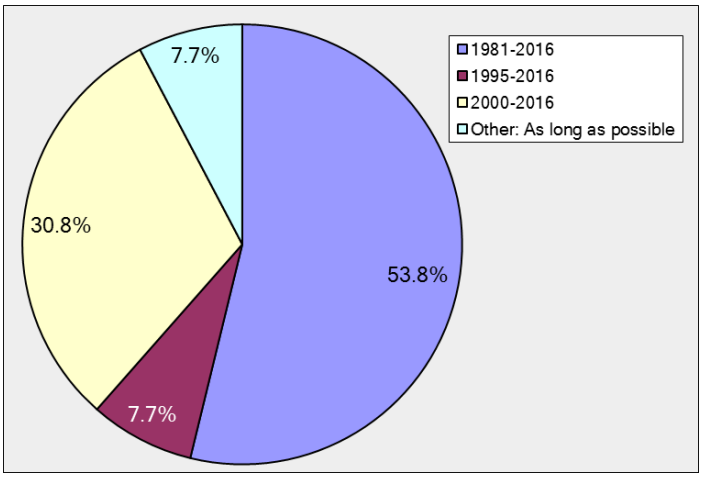

Figure 1: Period of time of interest for burned area products

3.2. Spatial and temporal resolution of the BA product

The spatial resolution requested by the users varied in range from 0.2 km (which is smaller than the spatial resolution of the AVHRR-LTDR product, and hence impracticable), to 1 degree. Table 1 summarizes the answers given by the respondents.

Table 1: Preferred spatial resolution stated by the users

Spatial resolution requested	Percentage
< 1km	8
1 km	20
5 km (0.05 deg)	24
10 km	8
25 km (0.25 deg)	8
50 km (~ 0.5 deg)	20
100 km (~ 1 deg)	12

Regarding the temporal resolution, 36% of the respondents stated that the minimum temporal resolution should be daily products, 8% suggested having BA information every 2 or 3 days, 12% considered that weekly information should be the selected temporal resolution, and 44% stated that monthly information would be sufficient.

3.3. Accuracy requirements

Users were asked to estimate their required product accuracy in terms of maximum permissible omission and commission errors as a percentage of the BA. Values obtained varied between 5 and 50%, grouped as follows:

Table 2: Percentage of users that required the following maximum errors

Commission and omission error	Percentage of users
≤ 10%	27.8
≤ 20%	33.3
≤ 30%	27.8
> 30%	11.1

It is important to note that no existing BA product currently achieve error values lower than 30%, as showed by Padilla et al. (2015).

3.4. Ancillary data layers

Respondents to the survey stated that the affected land cover, followed by the uncertainty characterization, were the ancillary variables most important to have included in the burned area product. Table 3 summarizes the answers provided.

Table 3: Ancillary variables and their importance as evaluated by the respondents (in number of selected responses)

Ancillary data layers	Not important	Somehow important	Important	Very important
Uncertainty characterization (as % of BA)	0	7	10	9
Affected land cover (Area burned in land cover XX)	1	4	9	11
Fraction of observed area (0-100)	0	7	11	7
Fraction of burnable area (0-100)	2	6	9	8
Other (open question): Sensor ID	0	0	0	1

In other words the majority of respondents were in favour of including uncertainty characterization, affected burned area, fraction of observed area and fraction of burnable area.

3.5. Data formats

The data format mainly selected by the users was NetCDF-CF format (50%), which coincides with the format required by ESA for all the CCI projects (ESA Climate Office 2015). Other selected options were GeoTIFF (26.9%), HDF (11.5%), ASCII files (7.7%) and PDF files (3.8%).

3.6. Data access

Regarding the disseminations channels for the AVHRR-LTDR product, most of the respondents (57.7%) considered that the ESA CCI Data Portal should be the preferred site for providing the data to the users. Other selected access methods included the GFED website (23.1%) and a dedicated FTP site (19.2%).

4. Product Specifications

Product specifications should, on the one hand, be compatible (same format and same variables) with the products generated by the Fire_cci main project and, on the other, try to comply with the requirements expressed by the users, considering the limitations of the AVHRR-LTDR data.

Following the PSD of the main project, two products are generated: one at full spatial resolution of the input sensor (pixel product, 300 m for MERIS, 250 for MODIS) and one at a coarser resolution (grid product: 0.25 degrees), mainly intended for climate

users. Since the minimum resolution of AVHRR-LTDR is 0.05 degrees (approximately 5 x5 km), this option will only generate a grid product. The following section describes the product specifications of the BA product to be derived in this option. We recommend referring to the PSD of the Fire_cci main project (Chuvieco et al. 2016) for further details.

4.1. Product description

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

4.2. Temporal compositing

The modellers answering the URD were mostly in favour of daily or weekly products, but the current temporal resolution of input satellite data used to generate the BA pixel products would imply high risk to obtain inconsistent data at daily intervals, especially in tropical cloudy areas. For this reason, the BA product will be produced in 15-day grid products (or their equivalent when months are 31, 29 or 28 days long).

4.3. Spatial Resolution

The AVHRR-LTDR product will keep the main project resolution of 0.25 x 0.25 degrees.

4.4. Grid attributes

Since the respondents to the user questionnaire were in favour of those variables already generated by the Fire_cci main project, the same attributes will be kept (Table 4).

Table 4: Layers of the BA grid product

Layer	Attribute	Units	Data Type	Notes
1	Sum of BA	Square metres	Float	Sum of area of all pixels detected as burned within each grid cell.
2	Standard Error	Square metres	Float	This value is the standard error of the estimation of BA in each grid cell.
3	Fraction of observed area	0 to 100	Float	The fraction of area in the grid that was observed for the whole 15-day period (without cloud cover / haze or low quality pixels)
4	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.
5	Number of patches	99999	Float	This variable will not be generated as the input pixel is too coarse for estimating burn patches, but the layer will be kept for consistency with the main project, with a Non Available value.
6-NN	Sum of BA of LC XX	Square metres	Float	Sum of all burned pixels of each land cover XX as defined by the LandCover_cci maps*.

* Reference land cover will be LandCover_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 will be used.

4.5. Product projection system

This product will be 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°.

4.6. File formats

The product will be delivered in raster format, on a regular geographical grid. The product format is NetCDF-CF (see http://www.unidata.ucar.edu/software/netcdf/docs for detailed information about this format and section). This format was selected by most modellers, and it is the one required in the ESA CCI Guidelines (ESA Climate Office 2015).

4.7. Product file naming conventions

The grid files are named as following:

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

<Indicative Date>

The identifying date for this data set:

Format is YYYYMMDD, where YYYY is the four digit year, MM is the two digit month from 01 to 12 and DD is the two digit day of the month from 01 to 31. For 15-day products, the first half of the month have date = 07 and the second half date = 22, which are approximately the average dates of each biweekly period.

<Additional Segregator>

This should be left empty.

v<GDS version>

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

fv<File Version>

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

Example:

20051207-ESACCI-L4_FIRE-BA-AVHRR-LTDR-fv01.0.nc

4.8. File metadata

The grid files follow the NetCDF Climate and Forecast (CF) Metadata Convention (http://cf-pcmdi.llnl.gov/). Refer to Annex 2 of the Product Specification Document (Chuvieco et al. 2016) for a detailed description.

5. References

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Annex 1: User survey questionnaire

The following questions were included in the user survey:

1. Please indicate what kind of institution you belong to:
    a. University/Research Institute
    b. Governmental organization
    c. Non-governmental/Non-profit organization
    d. Commercial sector
    e. Other (please specify):

2. Please indicate the country in which you are working:

3. For what general application(s) do you require burned area information:
    a. Atmospheric chemistry(-climate) modelling
    b. Biogeochemical modelling
    c. Dynamic vegetation modelling
    d. Statistical modelling of fire patterns and fire drivers
    e. Forest and fire management planning (e.g. fire prevention, early response, post fire measures)
    f. Other (please specify):

4. What satellite-derived burned area products have you used in the past?
    a. Fire_cci burned area products
    b. GFED burned area
    c. So far, none
    d. Other (please specify):

5. Which period are you mainly interested to obtain BA products for?
    a. 1981-2016
    b. 1995-2016
    c. 2000-2016
    d. Other (please specify):

6. Define which minimum characteristics the AVHRR-LTDR BA product should have for your application. Please take into account the coarse resolution of the input data: daily images at 0.05 degree resolution (approx. 5x5 km).
    a. Spatial resolution (size of the grid cell, in km):
    b. Temporal resolution (time accumulation of BA, in days):
    c. Maximum commission and omission errors (in percentage of BA):

7. Define preferred file format for the AVHRR-LTDR BA product
    a. NetCDF-CF
    b. HDF
    c. GeoTIFF
    d. TXT (ASCII files)
    e. Other (please specify):

8. Define the relevance of these auxiliary variables to be included in the AVHRR-LTDR BA product (to be selected between Not important, Somehow important, Important, Very important)
    a. Uncertainty characterization (as % of BA)
    b. Affected land cover (Area burned in land cover XX)
    c. Fraction of observed area (0-100)
    d. Fraction of burnable area (0-100)
    e. Other (please specify):

9. Which dissemination channels do you consider more important for the AVHRR-LTDR BA product
    a. ESA CCI Data Portal
    b. Dedicated FTP site
    c. GFED web page
    d. Other (Please specify):

10. Do you have any other comments, questions, or suggestions related to the AVHRR-LTDR BA product?

Annex 2: Acronyms and abbreviations

ASCII	American Standard Code for Information Interchange
AVHRR	Advanced Very High Resolution Radiometer
BA	Burned Area
CCI	Climate Change Initiative
ECV	Essential Climate Variables
FTP	File Transfer Protocol
GCOS	Global Climate Observing System
GFED	Global Fire Emissions Database
GHG	Greenhouse Gases
HDF	Hierarchical Data Format
LC	Land Cover
LTDR	Long Term Data Record
MERIS	Medium Resolution Imaging Spectrometer
MODIS	Moderate Resolution Imaging Spectroradiometer
NetCDF	NETwork Common Data Format
PDF	Portable Document Format
PSD	Product Specification Document
TIFF	Tagged Image File Format
URD	User Requirements Document