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Advances in burned area detection from remote sensing: The FireCCI products

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Abstract

The FireCCI project has developed, during the last decade, a suite of burned area (BA) products based on remote sensing tailored to the climate researchers and also useful for different fire applications. The different products span from 1982 to 2020, and include global products at coarse spatial resolution (FireCCILT11, at 0.05-degrees) and medium resolution (FireCCI51 and FireCCIS310, at 250 m and 300 m respectively), with derived grid products at 0.25-degree resolution. An additional burned area product at 20 m spatial resolution is also available for Sub-Saharan Africa for the years 2016 and 2019, with an accompanying grid product at 0.05-degrees. All products include ancillary information related to the uncertainty of the detection, the observational limitations, and the land cover burned.

The grid products, in NetCDF format, are specifically developed for climate researchers and those studying global vegetation dynamics, which usually use coarse resolution datasets as input for their models. The pixel products, on the other hand, provide the best possible spatial resolution based on the inputs of the BA algorithms, and are intended for researchers working on fire dynamics, land cover change, or focused on regional study areas, among other applications.

The latest product developed, FireCCIS310, represents the next generation of medium-resolution global burned area products. With an improved algorithm and taking advantage of the SWIR bands of the Sentinel-3 SYN product and the VIIRS active fires, it detected almost 5 Mkm2 of BA during the year 2019. This is expected to result in changes in the global estimation of fire emissions.

1. Remote sensing for burned area detection: FireCCI

Remote sensing data is a widely used and very advantageous source of information for burned area (BA) detection, as it provides global information in a systematic way (Chuvieco et al., 2019). The available sensors deliver images at diverse spatial and temporal resolutions, and in different spectral regions. This makes them suitable for the detection of burned scars with the use of infrared data at different wavelengths (near (NIR), short-wave (SWIR) and thermal).

Within the European Space Agency (ESA) Climate Change Initiative (CCI), the FireCCI project has the objective to develop and validate burned area algorithms to meet, as far as possible, GCOS (Global Climate Observing System) Essential Climate Variable (ECV) requirements for consistent, stable, and error-characterized global satellite data products from multi-sensor data archives. Since the start of the CCI Programme, FireCCI has developed different BA products based on surface reflectance and active fire information from a variety of ESA and NASA sensors.

2. The FireCCI burned area products

The current suite of products obtained from the FireCCI algorithms spans from 1982 to 2020, with plans to expand it to the present and future. These products, apart from providing information on burned area, also include ancillary information related to the uncertainty of the detection, the land cover affected (extracted from the CCI Land Cover product), and the observational limitations of the input data. All products supply information in monthly files, and are delivered at two spatial resolutions: pixel (at the original resolution of the surface reflectance input data) and grid (at a coarser resolution and specifically tailored for climate researchers). Figure 1 shows the total burned area obtained from the aggregation of the monthly grid files of FireCCIS310 for the year 2019.

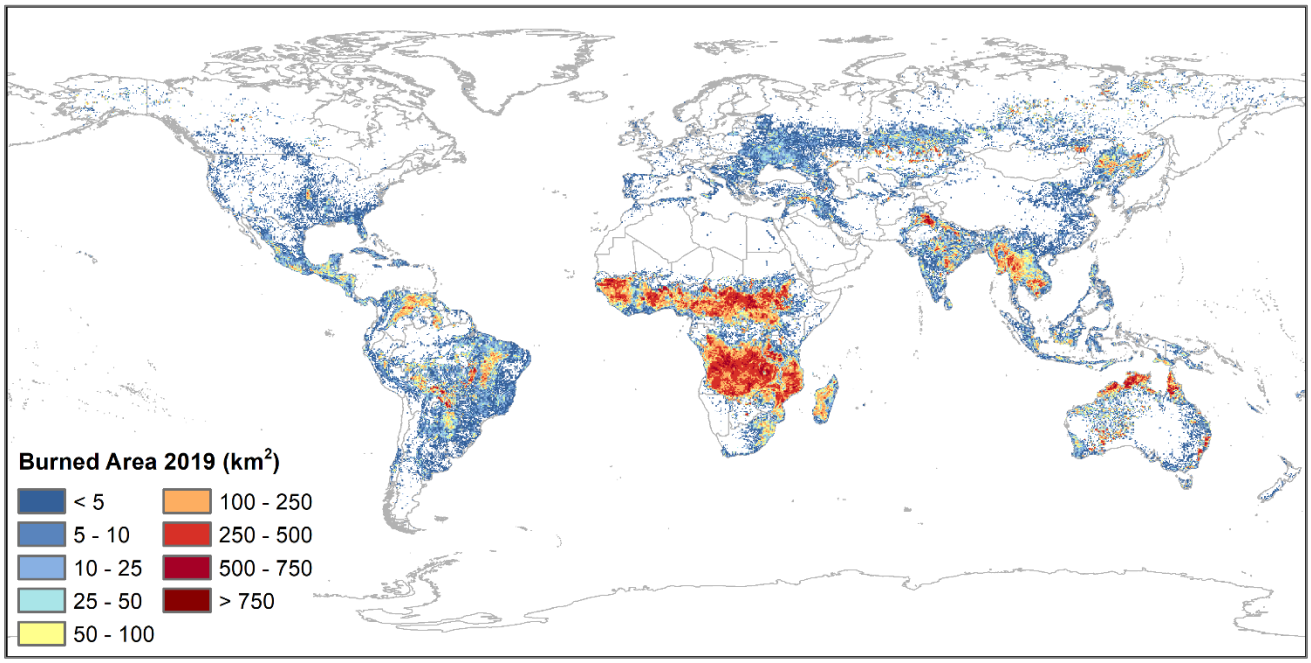

Figure 1- Total burned area of the year 2019 obtained from the FireCCIS310 grid product.

The current products include:

2.1. FireCCILT11

The dataset with the longest time series is the FireCCILT11 product, based on AVHRR information obtained from the Land Long-Term Data Record (LTDR) version 5 (https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/applications/ltdr/#project-documentation, accessed on March 2022), and spanning from 1982 to 2018 at a global scale (Otón et al. 2021). The pixel product has a spatial resolution of 0.05 degrees (approx. 5 km at the Equator), and provides information on the date of the fire detection, the confidence level of that detection, the burned area in each pixel, and an ancillary layer with the number of observations available for the detection. The grid product, at a resolution of 0.25 degrees, summarizes the data of the pixel product for each grid cell, and includes layers corresponding to the sum of burned area, the standard error, and the fraction of burnable area and observed area in each cell. FireCCILT11 is the global BA product with the longest time-series to date, although it presents high uncertainties related to the coarse resolution of input images (0.05 degrees) and stability of the LTDR series. It is especially intended for climate researchers working at global or continental scales and needing long BA time series.

2.2. FireCCI51

Another global product, but with a higher spatial resolution than FireCCILT11, is FireCCI51, whose algorithm uses as input MODIS NIR surface reflectance at 250 m and 1 km-resolution active fires (Lizundia-Loiola et al. 2020). This product covers a 20-year time series (2001 to 2020). It is the product providing global monthly BA information with the highest resolution currently available. The pixel product includes layers corresponding to the date of detection, the confidence level and the land cover burned, while the grid product, at 0.25-degree resolution, contains the same information as FireCCILT11, and also includes layers with the amount of BA for each land cover class.

2.3. FireCCIS310

As part of our effort to extend the BA information into the coming years, the FireCCI project has recently developed a new algorithm to detect BA using the 300 m-resolution SWIR bands of the Sentinel-3 SLSTR (Sea and Land Surface Temperature Radiometer) sensor, extracted from the Synergy (SYN) products developed by ESA (https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-3-synergy, accessed on March 2022). This input is complemented by VIIRS (Visible Infrared Imaging Radiometer Suite) active fire information at 375 m resolution, obtained from the S-NPP (Suomi National Polar-Orbiting Partnership) satellite. The resulting BA product, called FireCCIS310, takes advantage of the improved BA detection capacity of the SWIR bands and the higher resolution of the VIIRS thermal information, apart from including improvements in the detection algorithm. The first assessment of the product for 2019 data shows that it detects more BA than previous global BA datasets (4.99 Mkm^2, 28% more than FireCCI51), and with an increased spatial and temporal accuracy (Lizundia-Loiola et al. 2022). FireCCIS310 supplies the same layers as FireCCI51, but at a spatial resolution of 300 m for the pixel product. This product will continue to be processed for subsequent years.

Figure 2 shows the comparison between the BA detected by FireCCI51, FireCCIS310 and FireCCISFD20 (see section 2.4) in a small region in the border between Tanzania and Mozambique.

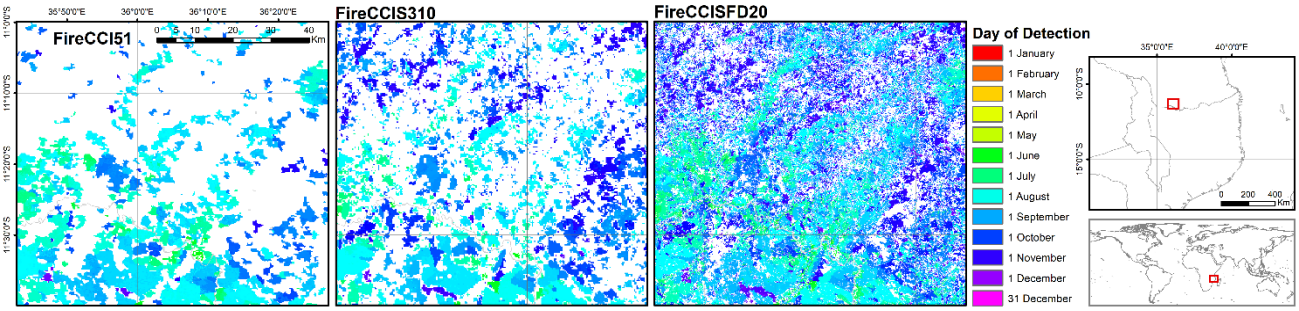

***Figure 2*- Comparison of burned area detection between FireCCI51, FireCCIS310 and FireCCISFD20 during 2019 for a region in Southern Tanzania.**

2.4. FireCCISFD

Finally, a specific dataset has been created for sub-Saharan Africa, where more than 70% of the total global burned area occurs (Chuvieco et al., 2019). This product, called FireCCISFD (SFD comes from Small Fire Dataset), uses surface reflectance from the Sentinel-2 MSI (MultiSpectral Instrument) sensor at 20 m spatial resolution, complemented with active fire information (Roteta et al. 2019). Version 1.1 of this dataset (FireCCISFD11) covers the year 2016 and is based on Sentinel-2A data + MODIS active fires, while the newer version (FireCCISFD20) has been processed for the year 2019, and takes advantage of the additional data provided by Sentinel-2B, duplicating the input data amount and temporal resolution, and the improved spatial resolution of the VIIRS active fire detection (Chuvieco et al. 2022). The grid version of this product has a spatial resolution of 0.05 degrees, as requested by climate researchers. Due to the much higher spatial resolution of the input data (Sentinel-2 MSI versus MODIS or Sentinel-3 SYN), this product detected 58% more BA than FireCCI51 for 2016, and 82% in 2019. The vast majority of this additional BA is due to the improved detection of small burned patches, not detectable with moderate resolution sensors (Ramo et al. 2021, and see also Figure 2). This dataset is especially useful for researchers working at regional level in Africa, and for studies dealing with greenhouse gasses emissions estimations.

2.5. Access to the products

All FireCCI products are available from the CCI Open Data Portal (https://climate.esa.int/en/odp/#/dashboard) and in the CEDA Catalogue (https://catalogue.ceda.ac.uk/uuid/6c3584d985bd484e8beb23ff0df91292), and the documentation of the products can be downloaded from the FireCCI website (https://climate.esa.int/en/projects/fire/about/).

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