

# Global Fire Emissions Database, Version 4 (GFED4s) Monthly and daily fire emissions 1997 – 2014

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*This readme file accompanies version 4.1 of the emissions. Changes to version 4.0 are marginal but we would encourage you to use this latest version.*

## **Introduction**

This fourth version of the Global Fire Emissions Database (GFED4s) provides monthly burned area, fire carbon (C) and dry matter (DM) emissions, and the contribution of different fire types to these emissions in order to calculate trace gas and aerosol emissions using emission factors. All these datasets are based on burned area boosted by small fire burned area, hence the “s” in the GFED4.1s name.

## **Naming convention**

The files are distributed via <http://www.falw.vu/~gwerf/GFED/GFED4/> as annual files named GFED4.1s\_YYYY.hdf5 where YYYY is the year (1997 – 2014). The “s” denotes that these emissions are based on both the standard GFED4 burned area (Giglio et al., 2013) AND burned area derived from active fire information seen outside the burned area maps, see Randerson et al. (2012).

Files are in the hdf5 (sometimes denoted with the extension .h5) format.

## **Resolution**

The spatial resolution of the global files is 0.25 degree, so the different fields have 720 rows and 1440 columns. The center of the upper left grid cell is located at longitude -179.875° and latitude 89.875°. The temporal resolution of the emissions files is monthly, and we provide data to distribute these over the month as well as a diurnal cycle based on Mu et al. (2011). This is only available from 2003 onwards.

## Layers

Each hdf5 file contains 4 different groups: burned area, emissions, biosphere fluxes, and ancillary data (see next page for a schematic overview).

- Within the *burned\_area* group, there are two datasets available for each month (01, 02, .. , 12): *burned\_fraction* and *burned\_area\_source*. The former is the fraction of each grid cell that burned in that month according to the GFED4s burned area data, the latter indicates what data was used to construct the burned area maps excluding small fires. In general, ATSR and VIRS data was used before 2001, MODIS after 2001. This solely concerns the GFED4 burned area dataset.
- The emissions group contains, for 12 months (01, 02, .. , 12), 5 datasets: *emissions* (carbon [C] with units of  $\text{g C m}^{-2} \text{ month}^{-1}$  and dry matter [DM] with units of  $\text{kg DM m}^{-2} \text{ month}^{-1}$ ), *small\_fire\_fraction* (unitless), *daily\_fraction* (unitless), *diurnal\_cycle* (unitless), as well as a group *partitioning* which contains, for both C and DM, the datasets that partition total emissions into different source categories which can be used to estimate trace gas and aerosol emissions (all unitless):
  - SAVA (Savanna, grassland, and shrubland fires)
  - BORF (Boreal forest fires)
  - TEMF (Temperature forest fires)
  - DEFO (Tropical forest fires [deforestation and degradation])
  - PEAT (Peat fires)
  - AGRI (Agricultural waste burning)
- The *small fire fraction* indicates what fraction of total emissions stemmed from the small fire burned area. GFED4 emissions can be calculated by subtracting this fraction from GFED4s emissions. However, we recommend using GFED4s emissions. Note that GFED4 burned area **cannot** be calculated this was (GFED4s burned area minus the small fire fraction) for various reasons, please use the original GFED4 burned area datasets for this.
- The *daily fraction* indicates what fraction of total emissions was emitted in the different days of that month
- The *diurnal cycle* gives the partitioning of the daily emissions over 8 three-hour windows (UTC), this field is uniform over the month.
- The biosphere fluxes contain monthly net primary production (NPP), heterotrophic respiration ( $R_h$ ), and fire emissions. All are in  $\text{g C m}^{-2} \text{ month}^{-1}$ .
- The ancillary group contains the datasets *grid\_cell\_area* and *basis\_regions*, with the former indicating how many  $\text{m}^2$  each grid cell contains and the latter are the 14 basis regions we use to summarize the results throughout our papers.

The file structure schematically where <month> is 01, 02, 03, .., 12 and <source> is SAVA, BORF, TEMF, DEFO, PEAT, AGRI:

```
/burned_area
    /<month>
        /burned_fraction
        /source

/emissions
    /<month>
        /DM
        /C
        /small_fire_fraction
        /daily fraction*
            /day_1
            /day_2
            /etc. (total of n days in month)
        diurnal_cycle*
            /UTC_0-3
            /UTC_3-6
            /etc. (total of 8)
        /partitioning
            /C_<source>
            /DM__<source>

/biosphere
    /<month>
        /NPP
        /Rh
        /fire_emissions

/ancill
    /basis_regions
    /grid_cell_area
```

\* Only for 2003 onwards

## Converting DM emissions to trace gas and aerosol emissions

To convert the DM to trace gas or aerosol emissions the DM fields (kg DM m<sup>-2</sup> month<sup>-1</sup>) have to be multiplied with emission factors. These are reported as g species emitted per kilogram dry matter burned and vary between fire types. We have compiled a set of recommended emission factors based mostly on the work of Akagi et al. (2011) but also using other publications. Details can be found in the MS Excel file on <http://www.falw.vu/~gwerf/GFED/GFED4/ancill/>. This directory also contains a txt file with emission factors. As an example, we can calculate carbon monoxide (CO) emissions using:

$$E_{CO}(x, y, time) = \sum^{sources} EF_{CO_{source}} \times DM(x, y, time) \times contr_{source}(x, y, time)$$

Where E is emissions and EF is the emission factor, in this case for CO. Contr is the contribution of the various sources. (savanna fires etc.). This should then be summed over those sources of interest. An example script (Python) that can be used to do these calculations can be found on <http://www.falw.vu/~gwerf/GFED/GFED4/ancill/code/> and tables with regional and annual totals for various species are on [globalfiredata.org](http://globalfiredata.org). Wolfgang Knorr (Lund University) kindly provided Matlab code to read the data as well, these are also on <http://www.falw.vu/~gwerf/GFED/GFED4/ancill/code/>

- *The conversion of carbon to dry matter is based on the emission factors of CO<sub>2</sub>, CO, and CH<sub>4</sub>. If you change any of these emission factors please also adjust the dry matter emissions to remain consistent.*
- *When computing total regional emissions do not forget that units are per m<sup>2</sup>, so for total emissions these have to be multiplied with the area of the region of interest, included in the emissions files.*

## Peculiarities

Some remote islands including Hawaii and Fiji have burned area but no emissions because these are not covered by the NDVI datasets we used.

## Citation

A manuscript detailing the changes made compared to version 3 is in preparation. We kindly ask you to cite the GFED work in one of the following ways:

1. When not focusing on fires but using it as model input please mention you used fire emissions from the Global Fire Emissions Database version 4 (GFED4.1s) based on an updated version of van der Werf et al. (2010).
2. When focusing on fires in your publication please mention you used fire emissions from the Global Fire Emissions Database version 4 (GFED4s) based on an updated version of van der Werf et al. (2010) with burned area from Giglio et al. (2013) boosted by small fire burned area (Randerson et al., 2012). If you also use the higher temporal resolution please include a citation of Mu et al. (2011).

*When using GFED4 burned area instead of emissions, please do not cite the emissions work but cite Giglio et al. (2013) when using the 0.25° GFED4 burned area data or Giglio et al. (2009) when using the MCD64A1 burned area maps.*

## **References**

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