Global Fire Emissions Database version 2 (GFEDv2)

Released 21 December 2005

Keywords: biomass burning, fire, emissions, burned area, global, gridded, ascii, carbon, CO2, CO, CH4, NMHC, aerosols

available online at: http://ess1.ess.uci.edu/%7Ejranders/data/GFED2/

1. Introduction

The dataset consists of 1° x 1° gridded monthly burned area, fuel loads, combustion completeness, and fire emissions (Carbon, CO_2, CO, CH4, NMHC, H_2, NO_x, N_2O, PM2.5, TPM, TC, OC, BC) for the time period January 1997 – December 2006. Emission estimates for the 2001 – 2006 period are also available with an 8-day time step. We intend to keep the database updated when recent satellite data becomes available. The dataset also includes monthly estimates of the C4 fraction of carbon emissions that can be used to construct the 13C isotope ratio. The dataset was intended to be used for large-scale modeling studies.
The dataset is a result of collaboration between:

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Louis Giglio	Science Systems and Applications, Inc., Maryland
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2. Data format

Each data file contains 360 columns and 180 rows (and has a 1 degree latitude by 1 degree longitude spatial resolution, with a monthly or 8-day temporal resolution). The upper left corner of each file is centered at 179.5W, 89.5N and the lower right corner at 179.5E, 89.5S. The data files are in ascii format and were compressed using the Matlab program to the general .zip format. Values are separated by blank spaces. Naming is as follows:

<SUBJECT>_<YEAR><TIME>.txt

where SUBJECT is:

BF	Burned fraction (Burned area equals the product of BF and grid cell area)
FL	Fuel loads (g C / m^2). This is not identical to total biomass!
CC	Combustion completeness, the fraction of the fuel load actually combusted (unitless, 0-1)
C4	Fraction of emissions stemming from the combustion of C4 plants (unitless, 0-1)
VEG	Vegetation map used to convert C to trace gas emissions. 1 = non forest, 2 = tropical forest, 3 = extratropical forest
C	Carbon emissions (g C / m^2 / month or g C / m^2 / 8 days). DM equals C / 0.45.
CO2	CO2 emissions (g CO2 / m^2 / month or g CO2 / m^2 / 8 days)
CO	CO emissions (g CO / m^2 / month or g CO / m^2 / 8 days)

Etc, also for CH4, NMHC, H2, NOx, N2O, PM2p5 (PM2.5), TPM, TC, OC, BC.

Units used on trace gas and aerosol species follow the conventions used in Andreae and Merlet (2001).

TIME (2 digits) is 01 for January, 02 for February, etc.
TIME (3 digits) is JD001 for Julian day 1-8, JD009 for Julian Day 9-16, etc.

for example: CO2_199701.txt is the CO2 emissions file for January 1997, CH4_199702.txt is the CH4 file for February 1997 etc. For each SUBJECT, all monthly files for the 8 year period are combined in one zipped file named GFEDv2_SUBJECT for monthly files and GFEDv2_8day_SUBJECT for the 8 day files.

Table 1. Global annual emissions for carbon, dry matter, and trace gas emissions, in Tg species year^{-1}.

Species	Year												
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Mean	SD	SD / Mean
C	2991	3183	2284	2038	2224	2386	2251	2320	2367	2196	2424	366	0.15
DM	6646	7074	5077	4529	4942	5303	5002	5156	5261	4879	5387	813	0.15
CO2	10760	11454	8291	7423	8108	8640	8143	8406	8581	7935	8774	1287	0.15
CO	557	591	392	337	365	418	397	405	411	392	427	82	0.19
CH4	30.4	29.8	18.8	15.1	16.6	20.1	18.5	20.1	20.5	19.8	21.0	5.1	0.24
NMHC	38.7	38.2	24.9	20.5	22.6	26.4	24.4	26.4	26.9	25.7	27.5	6.1	0.22
H2	16.1	14.8	9.4	7.3	8.2	9.9	8.9	10.3	10.5	10.1	10.5	2.8	0.26
NOx	14.1	16.2	11.5	10.4	11.2	12.1	11.7	11.4	11.6	10.8	12.1	1.7	0.14
N2O	1.37	1.52	1.07	0.96	1.04	1.13	1.08	1.08	1.10	1.03	1.14	0.17	0.15
PM2.5	48.2	54.4	34.0	29.0	30.9	37.2	36.4	34.8	35.1	34.4	37.4	7.8	0.21
TPM	58.4	70.9	46.6	41.9	44.3	50.8	50.5	46.1	46.6	45.0	50.1	8.6	0.17
TC	33.2	37.2	23.8	20.6	22.0	25.9	25.2	24.3	24.6	23.9	26.1	5.1	0.20
OC	29.1	34.5	21.4	18.5	19.5	23.6	23.5	21.5	21.7	21.4	23.5	4.8	0.21
BC	3.64	3.78	2.62	2.27	2.49	2.75	2.58	2.70	2.75	2.58	2.82	0.49	0.18

Table 2. Biomass burning emission estimates (Tg carbon $year^{-1}$) for different regions (see Figure 1) and years.

Region	**Year**												
	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Mean**	**SD**	**SD / Mean**
BONA	16	93	37	11	7	45	55	90	46	26	42	30	0.71
TENA	8	19	25	24	14	20	12	10	13	16	16	6	0.36
CEAM	15	212	25	98	20	31	81	17	37	28	56	62	1.09
NHSA	32	83	11	29	38	27	80	33	23	22	38	24	0.64
SHSA	272	314	360	160	241	264	216	443	453	226	295	97	0.33
EURO	9	14	8	25	14	13	15	10	15	12	14	5	0.34
MIDE	0	0	1	0	1	1	1	1	1	1	1	0	0.41
NHAF	740	565	606	665	720	615	541	562	627	521	616	74	0.12
SHAF	465	721	535	567	606	568	581	565	619	517	574	68	0.12
BOAS	71	438	134	140	107	221	330	66	67	125	170	124	0.73
CEAS	60	45	26	37	49	72	44	45	43	50	47	12	0.26
SEAS	102	265	314	73	159	97	77	182	106	83	146	84	0.58
EQAS	1089	317	66	51	50	257	86	170	242	429	276	313	1.13
AUST	111	96	136	157	199	156	131	127	75	141	133	35	0.26
Global	2991	3183	2284	2038	2224	2386	2251	2320	2367	2196	2424	366	0.15

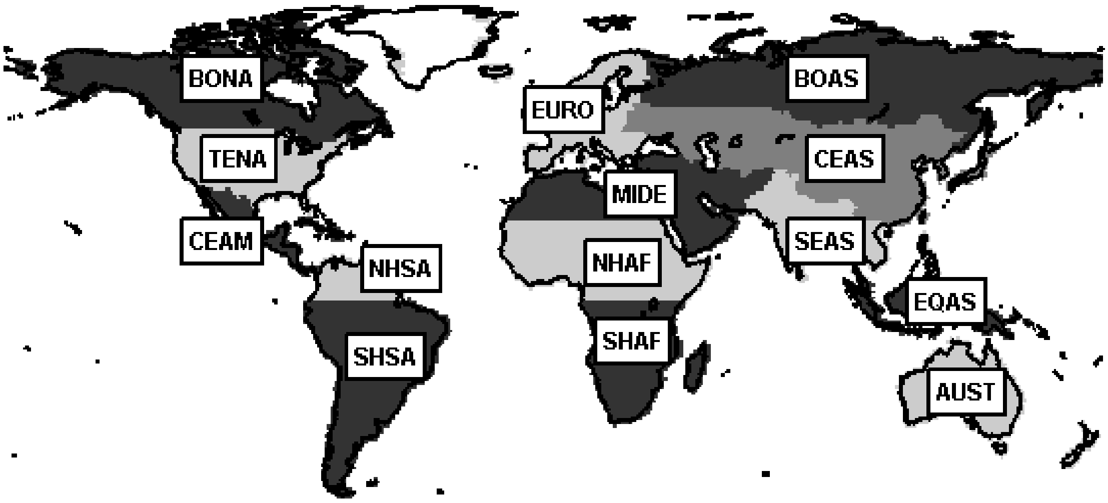

Figure 1. Map of the 14 regions used in Table 1.

3. Methodology

The approach used to calculate burned area for the 2001-2004 period is described in:
Giglio, L., G.R. van der Werf, J.T. Randerson, G.J. Collatz, and P.S. Kasibhatla (2006), Global Estimation of Burned Area using MODIS Active Fire Observations, *Atmospheric Chemistry and Physics*, 6, 957-974. SRef-ID: 1680-7324/acp/2006-6-957. Available online from:
http://www.atmos-chem-phys.net/6/957/2006/acp-6-957-2006.html

Emission estimates, as well as burned area for the 1997-2000 period, are described in:
Van der Werf, G.R., J.T. Randerson, L.Giglio, G.J. Collatz, and P.S. Kasibhatla (2006), Interannual variability in global biomass burning emission from 1997 to 2004, *Atmospheric Chemistry and Physics*, 6, 3423-3441. SRef-ID: 1680-7324/acp/2006-6-3423. Available online from:
http://www.atmos-chem-phys.net/6/3423/2006/acp-6-3423-2006.html

The method to derive the C4 fraction of the emissions is described in:
Randerson, J. T., G. R. van der Werf, G. J. Collatz, L. Giglio, C. J. Still, P. Kasibhatla, J. B. Miller, J. W. C. White, R. S. DeFries, and E. S. Kasischke (2005), Fire emissions from C3 and C4 vegetation and their influence on interannual variability of atmospheric CO2 and d13CO2, Global Biogeochemical. Cycles, 19, GB2019, doi:10.1029/2004GB002366. Available online from:
http://www.ess.uci.edu/~jranders/Paperpdfs/2005GBCRandersonC3C4.pdf

Our modelling framework calculates carbon emissions. Emission factors from Andreae and Merlet (2001) and Andreae (personal comm.) were used to derive trace gas emissions from the carbon emissions, see Table 2. Emissions for other species than the ones provided can be calculated using the carbon emissions: divide carbon emissions in each grid cell by 0.45 to estimate dry matter (DM) emissions, and then use your own emission factors in combination with the land cover classification (into savanna / herbaceous vegetation, tropical forest, and extratropical forest) that is also provided. This also allows for using your own emission factors for species already provided.

Citation:
If you use this data, please mention that you have used data from the Global Fire Emissions Database version 2 (GFEDv2). Depending on the data used, please use the most appropriate reference of the ones mentioned above. When using the 8 day data, please also acknowledge the MODIS 8 day fire hot spots that were used to construct these, for example: "….. we used fire emissions from the Global Fire Emissions Database version 2 (van der Werf et al., 2006) resampled to an 8 day time step using MODIS fire hot spots (Giglio et al., 2003) ….." using the following reference:

Giglio L, J. Descloitres J, C.O. Justice, Y.J. Kaufman (2003), An enhanced contextual fire detection algorithm for MODIS, *Remote Sensing of Environment* 87 (2-3): 273-282

Table 2. Emission factors used (Andreae and Merlet, 2001; Andreae, pers. comm.)

Specie	Savanna	Tropical Forest	Extratropical Forest
CO2	1664	1580	1568
CO	63	102	106
CH4	2.2	6.8	4.8
NHMC	3.4	8.1	5.7
H2	0.99	3.80	1.81
NOx	2.35	1.85	3.00
N2O	0.21	0.20	0.26
PM2.5	4.9	9.1	13.0
TPM	8.5	8.5	17.6
TC	3.7	6.0	8.3
OC	3.2	5.2	9.1
BC	0.46	0.63	0.56

4. Uncertainties

Despite recent improvements offered by new satellite products to determine the timing and location of fires, quantifying fire emissions across large spatial scales still suffers from large uncertainties, mainly due to uncertainties in fuel loads, combustion completeness, and burned area. We will continue improving and updating this dataset and would appreciate any feedback from data users.

5. Updates and known data issues

December 21, 2005	Release 1
June 23, 2006	Updated the burned fraction (BF), combustion completeness (CC), and fuel load (FL) files
November 27, 2006	Added files for the year 2005 and added emission files with an 8 day time step for the 2001 – 2005 period
June 22, 2007	2006 added, both with monthly and 8-day temporal resolution

Fires in Alaska: based on the vegetation map, most fires in Alaska were assigned the emission factor of savanna and grassland which does not resemble the majority of the fires that burn in forests. Hence the emissions of reduced gases may be underestimated.

8 day fire emissions: for several 8 day periods, especially in 2001, no data was available. For these periods the average of the 8 day period before and after was taken, and when consecutive 8 day periods were missing the data before and after that period was used. It concerns the following time periods:

Year	JD	Calendar days
2001	169	June 18 – June 25, 2001
2001	177	June 26 – July 3, 2001
2001	265	September 22 – September 29, 2001
2001	273	September 30 – October 7, 2001
2001	281	October 8 – October 15, 2001
2002	81	March 22 – March 29, 2002
2003	145	May 25 – June 1, 2003
2006	361	December 27 – December 31, 2006

6. Acronyms and Satellite Data Set Availability

TRMM: Tropical Rainfall Measuring Mission
VIRS: Visible and Infrared Spectrometer
ATSR: Along Track Scanning Radiometer
MODIS: MODerate resolution Imaging Spectrometer
AVHRR: Advanced Very High Resolution Radiometer

TRMM-VIRS fire counts available online at:
http://daac.gsfc.nasa.gov/precipitation/trmmVirsFire.shtml

ATSR fire counts available online at:
http://dup.esrin.esa.int/ionia/wfa/index.asp