# POET inventory documentation

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**Available at : http://www.aero.jussieu.fr/projet/ACCENT/POET.php**

## 1. Introduction

The dataset consists of 1° x 1° gridded anthropogenic, fire, and natural emission data, for the time period January 1990-December 2000. Anthropogenic emissions are annual data, while fire and natural emissions are monthly data.

This emission inventory was developed within the POET FP5 European project.
It is a result of collaboration between:


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## 2. Reference

The reference document is :
**" Olivier J., J. Peters, C. Granier, G. Petron, J.F. Müller, and S. Wallens: Present and future surface emissions of atmospheric compounds, POET report #2, EU project EVK2-1999-00011, 2003 ".**

The reference requested when used in any study is :
**"Granier, C., A. Guenther, J.F. Lamarque, A. Mieville, J.F. Muller, J. Olivier, J. Orlando, J. Peters, G. Petron, G. Tyndall, S. Wallens, POET, a database of surface emissions of ozone precursors, available on the internet at : http://www.aero.jussieu.fr/projet/ACCENT/POET.php , 2005."**

## 3. Abstract


Global emissions of gases (ozone precursors) from anthropogenic, natural, and biomass burning sources have been estimated for the period 1990-2000.
Anthropogenic emissions (including 15 sectors) are based on national activity data (fuel or matter combustion per year), emission factors (kg species/ kg matter combusted par activity), and grid maps (e.g. population maps) for spatial distribution of the emissions within a country.
Biomass burning emissions are derived from ATSR data and the climatology from Hao (1994). The spatial and temporal distribution of biomass burning emissions is estimated using active fires observed by ATSR satellite experiment, which are scaled to the climatology from Hao (1994).
Biogenic emissions are adapted from the GEIA inventories and from Müller and Brasseur, 1995.

## 4. Data sources

For anthropogenic emissions : statistics from the UN (United Nations) and the IEA (International Energy Agency)
For biomass burning emissions : ATSR (on board ERS-2 satellite) data, for the period 1997-2003

## 5. Unit

The UNIT used for all POET data is : **molecules. cm-2 . s-1**

## 6. List of species

The list of species available in the POET inventory is based on the chemical species used in the MOZART-4 model (Emmons et al., in preparation, 2006)

| Name in inventory | Long name- definition |
|---|---|
| CO | Carbon Monoxide |
| NOx | Nitrogen oxides |
| C2H6 | Ethane |
| C2H4 | Ethene |
| C3H8 | Propane |
| C3H6 | Propene |
| Butane | Butane and higher alkanes |
| Butene | Butene and higher alkenes |
| CH2O | Formaldehyde |
| CH3CHO | All non-CH2O aldehydes |
| CH3OH | Methanol |
| C2H5OH | Ethanol and higher alcohols |
| Acet | Acetone |
| Mek | Methyl-ethyl-ketone and all non-acetone ketones |
| Toluene | Toluene and all aromatic species |
| Isoprene | Isoprene |
| Terpenes | Terpenes |

## 7. Spatial and temporal information

- Geographical Coverage :
  Global LONG : -180° : 180°
  LAT : -90° : 90°

- Spatial Resolution : 1° x 1°

- Temporal Coverage of the Data
  Start : 01/1990
  End : 12/2000

- Temporal Resolution
  1 year (anthropogenic)
  1 month (biomass burning, oceans and biogenic data)

## 8. Data Formats

Emission data are provided in 2 formats : **ASCII and NetCDF ,**
1 file corresponding to 1 year and 1 species.

Ex. of file names :
***ASCII files*** :
anthro.2000.co (for anthropogenic data)
bb.season.1990.co (for biomass burning ; "season" indicates that the data are monthly data)
bio.co (biogenic emission data)
oceans.co (oceans emission data)

***NetCDF files*** *:* the suffix '.nc' is added to the file name:
anthro.2000.co.nc
bb.season.1990.co.nc
…

Anthropogenic data are annual data: they give the mean emissions per month over the year (same emissions values for the 12 months).
Biomass burning data are monthly seasonal data.
Biogenic and oceans emissions are monthly seasonal data, and are assumed to have no interannual variability, so the file name doesn't indicate any year.

## 9. ASCII files : description of files

- Annual data files (anthropogenic data) :

The header gives indications on the file : source of data, spatial resolution, year, unit, and the number of columns.
- 1st column gives the longitude of the left border of the 1° x 1° cell
- 2nd column gives the longitude of the right border of the 1° x 1° cell
- 3rd column gives the latitude of the southern border of the 1° x 1° cell
- 4th column gives the latitude of the northern border of the 1° x 1° cell
- 5th column gives the emissions values (total anthropogenic emissions)

- Monthly data files (for biomass burning, biogenic and oceans emissions data) :

Monthly data contain 16 columns:
- 1st column gives the longitude of the left border of the 1° x 1° cell
- 2nd column gives the longitude of the right border of the 1° x 1° cell
- 3rd column gives the latitude of the southern border of the 1° x 1° cell
- 4th column gives the latitude of the northern border of the 1° x 1° cell
- 5th to 16th columns (12 columns) give the total biomass burning emissions values for the 12 months

## 10. NetCDF files : description of files

You can find a documentation on the NetCDF format and how to read NetCDF format at the following internet adresses :
http://www.unidata.ucar.edu/software/netcdf/index.html
and here : http://www.unidata.ucar.edu/software/netcdf/docs/faq.html#whatisit

NetCDF format can be read either in FORTRAN, C language, or with a software like Matlab or IDL.

The containt of a NetCDF file can be viewed with the command 'ncdump' in a UNIX shell:
**ncdump anthro.1990.co.nc**

This will give you the information on :
- the dimensions (longitude, latitude, time), 'dimensions' along which the variables (emission data here) are given.
- the variables contained in the file (total, findus, fpower, …), and a brief definition of each of these variables ( 'long name').
Ex :
findus : long_name = "Industry (excluding coke ovens, refineries) "
fpower : long_name = "Power generation"
total : long_name = "Total anthropogenic emissions"

- ***Anthropogenic data*** :

Contrary to ASCII files, POET NetCDF anthropogenic data files contain not only the total anthropogenic emission data, but also the emission data by sources for several sectors (industry, power generation, road traffic, …).

Thus, the NetCDF files contain between 3 and 15 variables, depending on the species ;
*Exemple* : for NOx, there are 14 different sectors (14 sectors + total = 15 variables), while for C2H4, there are only 2 (2 + total = 3 variables).

Here are the variables names for all the activity sectors of anthropogenic emissions, which correspond to the sectors used in the EDGAR inventory :

| *Variable name :* | *Long name (definition)* |
|---|---|
| findus | : Industry (excluding coke oven, refineries, etc.) |
| fpower | : Power generation |
| fother | : Other transformation sectors (refineries, coke ovens, gas works) |
| fresid | : Residentials, commercials and other sectors |
| froad | : Transport road |
| frail | : Transport land non-road (rail +inland water +pipeline +non-specified) |
| fship | : Transport international shipping |
| foil | : Oil production, transmission and handling |
| fcoal | : Coal production |
| iiron | : Iron industry |
| ialu | : Aluminium industry |
| ipaper | : Pulp and Paper industry |
| ichem | : Chemistry industry |
| icement | : Cement |
| waste | : Waste incineration |
| bindus | : Biofuel industry: Iron & Steel (excluding coke ovens) |
| bpower | : Biofuel Power generation |
| bother | : Biofuel Other transformation sectors (refineries, coke ovens,..) |
| bresid | : Biofuel Residentials, commercials and other sectors |
| broad | : Biofuel road transport |
| agrwb | : Agricultural waste burning |
| total | : Total anthropogenic sources of emissions |

- ***Biomass burning data*** :

Contrary to ASCII files, POET NetCDF biomass burning data files contain not only the total biomass burning emissions data, but also the detailed emission data for forest and savanna burning.

Thus, the NetCDF files contain 3 variables ('forest', 'savanna', and 'bb') :

| | |
|---|---|
| forest | : forest burning emissions |
| savanna | : savanna burning emissions |
| bb | : total biomass burning emissions |

## 11. Methodology for deriving emissions

### *11.1. Anthropogenic emissions*

POET anthropogenic data are based on version 3 of the EDGAR inventory. Version 3 of the EDGAR inventory for anthropogenic emissions has been developed at RIVM, which are typical of years 1990 and 1995. The methodology has been described in Olivier et al. (2001).

Basically, national activity data from international statistics (United Nations, IEA) are used for 1990 and 1995; data gaps are filled by interpolation and extrapolation. Then, emission factors for various source categories are used to calculate the total annual emissions on a per country or per region basis. Next, national total emissions are, per source category, distributed on a 1x1 degree grid using grid maps appropriate for these sources. The EDGAR information system enables to extract the data at various aggregation levels.

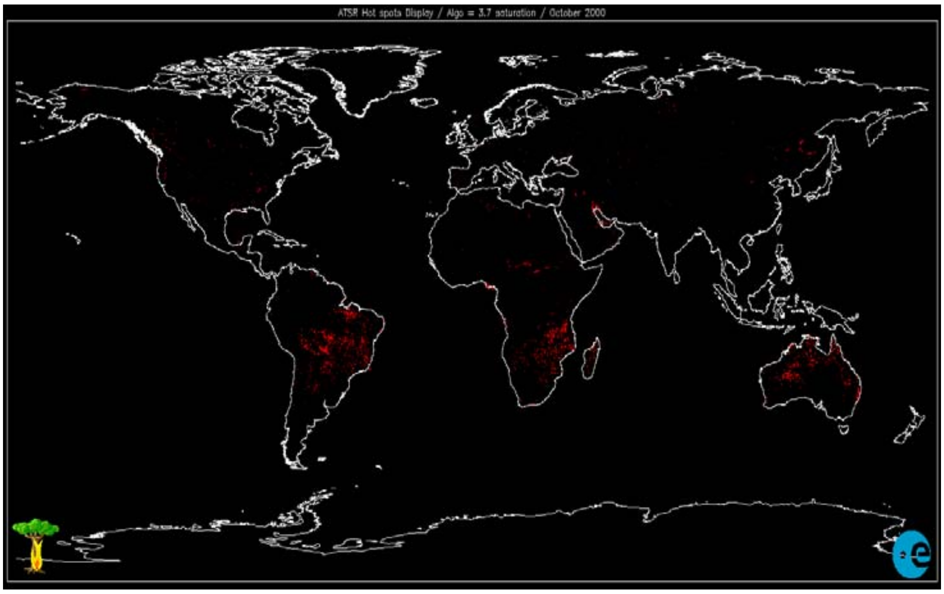
The inventories for 1990 and 1995 have been developed first by world regions, and gridded inventories have been completed next, based on previous spatial distributions. The 1997 inventory has been compiled by combining the inventory for 1995 with regional trend data for various sources for the 1995-1997 period, based on either activity data or reporting emission trends. Details on this approach are provided in Peters and Olivier (2003). Compared to the previous version 2 of the EDGAR inventory, the amounts of agricultural waste burning have been revised substantially, based on updated data.

### *11.2. Biomass burning emissions*

**The data used to derive the emissions are :**

- ✓ Fire pixels data from ATSR instrument on board ERS-2 satellite, from 1997 to 2003
- ✓ CLM 3.0 vegetation map (P.J. Lawrence, University of Colorado, USA) derived from MODIS data and CLM 2.0 map (Bonan et al, 2002) : map at 0.5°x0.5° consisting in percentages of 17 PFTs (Plant Functional Types) for each cell.
- ✓ Climatological amounts of $CO_2$ emitted from forest and savanna burning for the period 1985-1990, from Hao et al. (1994)

***Fire counts detected by ATSR in October 2000 :***




**The methodology for deriving $CO_2$ emissions is the following :**

***1. Integration of fire pixels by month on a 0.5x0.5° map:***
Compute the number of fire pixels (*nfire_pixels*) in each 0.5°x0.5° cell and for each month, from the ATSR fire pixels data.

***2. Spatial integration of fires by vegetation type:***
Calculate the total number of fire pixels in forests and in savannas (by using the vegetation map), for every month from 1997 to 2003 :

$$\text{sum\_fire\_pixels}_{forest} = \sum_{lat}\sum_{long} nfire\_pixels \times percent\_forest$$

$$\text{sum\_fire\_pixels}_{savanna} = \sum_{lat}\sum_{long} nfire\_pixels \times percent\_savanna$$

### 3. *Temporal integration of fires by vegetation type :*

Integrate the total number of fire pixels in forests and savannas over the 5 years period (1997-2003)

$$N_{\text{fires-forest(1997-2003)}} = \sum_{y=1997}^{2003} \sum_{m=1}^{12} sum\_fire\_pixels_{forest}$$

$$N_{\text{fires-savanna(1997-2003)}} = \sum_{y=1997}^{2003} \sum_{m=1}^{12} sum\_fire\_pixels_{savanna}$$

### 4. *Assumption and use of Hao climatology*

We assume the total CO2 emissions over the 1997-2003 period is equal to the Hao climatology for the 1985-1990 period (Hao et al., 1994)

$$E(CO2)_{1997\text{-}2003} = E(CO2)_{Hao}$$

### 5. *Deducing CO2 emissions per fire pixel*

Calculate the "average" CO2 quantity emitted for one fire pixel occurring in forest cover ($E(CO2)_{\text{firepixel(forest)}}$) and for one fire pixel occurring in savanna cover ($E(CO2)_{\text{firepixel(savanna)}}$):

$$E(CO2)_{\text{/firepixel(forest)}} = E(CO2)_{\text{Hao-forest}} / N_{\text{fires-forest(1997-2003)}}$$

$$E(CO2)_{\text{/firepixel(savanna)}} = E(CO2)_{\text{Hao-savanna}} / N_{\text{fires-savanna(1997-2003)}}$$

### 6. *Deriving gridded CO2 emissions*

The gridded CO2 emissions are then derived with the ATSR fire pixel maps for each month ,

for each grid point ,

if percent_forest > percent_savanna, then

$E(CO2) = nfire\_pixels \times E(CO2)_{\text{/firepixel(forest)}}$

if percent_ savanna > percent_ forest, then

$E(CO2) = nfire\_pixels \times E(CO2)_{\text{/firepixel(savanna)}}$

### 7. *Deriving emissions for other gases*

Calculate other gas emissions from CO2 emissions using Emissions Ratios (ER) from Andreae and Merlet, 2001.

$$E(gas) = E(CO2) \times ER_{gas}$$

The emissions ratios to CO2 applied for different types of vegetation burning are presented in the table below.

Table : Emission ratios to $CO_2$ for different types of vegetation burning (expressed as molecule per molecule of $CO_2$).

| | Tropical forests | Boreal and mid latitude forests | Savanna | Agricultural waste |
|---|---|---|---|---|
| | **molec./molec(C)** | **molec./molec(C)** | **molec./molec(C)** | **molec./molec(C)** |
| $CH_4$ | 1.13E-2 | 7.8E-3 | 3.82E-3 | 4.5E-3 |
| CO | 0.099 | 0.102 | 0.0619 | 0.088 |
| $NO_x$ (as $NO_2$) | 1.41E-3 | 2.66E-3 | 3.47E-3 | 2.22E-3 |
| $C_2H_6$ | 1.07E-3 | 5.32E-4 | 2.84E-4 | 8.64E-4 |
| $C_3H_8$ | 9.0E-5 | 1.15E-4 | 5.45E-5 | 3.16E-4 |
| $C_2H_4$ | 1.86E-3 | 1.07E-3 | 7.54E-4 | 1.33E-3 |
| $C_3H_6$ | 3.49E-4 | 3.74E-4 | 1.66E-4 | 6.34E-4 |
| $C_4H_{10}$ | 1.32E-4 | 1.74E-4 | 8.28E-5 | 1.51E-4 |
| $C_4H_8$ | 3.21E-4 | 2.94E-4 | 1.75E-5 | 2.18E-4 |
| Toluene | 2.01E-4 | 3.68E-4 | 1.28E-4 | 6.83E-5 |
| Methanol | 1.67E-3 | 1.67E-3 | 1.08E-3 | 1.67E-3 |
| Ethanol | 6.03E-5 | 6.60E-5 | 4.59E-5 | 5.11E-5 |
| $CH_2O$ | 8.89E-4 | 1.4E-3 | 2.23E-4 | 8.39E-4 |
| Acetaldehyde | 8.56E-4 | 9.76E-4 | 5.56E-4 | 5.07E-4 |
| Acetone | 2.85E-4 | 2.52E-4 | 2.03E-4 | 2.9E-4 |
| MEK[(1)] | 5.18E-4 | 5.50E-4 | 3.21E-4 | 4.5E-3 |
| $NH_3$ | 2.04E-3 | 2.19E-3 | 1.64E-3 | 2.04E-3 |
| $SO_2$ | 2.38E-4 | 4.16E-4 | 1.46E-4 | 1.67E-4 |

[(1)] methyl-ethyl-ketone species (all non-acetones ketones)
[a] Obtained by assuming that TNMVOC = the sum of all NMVOCs listed in Table 1 of Andreae and Merlet (2001).

### *10.3. Biogenic emissions*

The geographical distribution and seasonal variation of the biogenic emissions are adapted from the GEIA inventories (for NOx, isoprene, terpenes, and methanol) and from Müller and Brasseur, 1995 (for CO).