

# Generating Emissions Fields for WRF-Chem with PREP-CHEM-SRC

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# **PREP-CHEM-SRC**

## **Emissions Utility for:**

Anthropogenic

Biogenic

Biomass burning and plume rise

Volcanoes

## **How to generate emissions**

Compiling

Namelist

Running PREP-CHEM-SRC and `convert_emiss`

# Anthropogenic emissions

## Global Inventories

**RETRO** ( $0.5^\circ \times 0.5^\circ$ , monthly, 1960-2000)

**EDGAR** v4.2 ( $0.1^\circ \times 0.1^\circ$ , annual, 1970-2008)

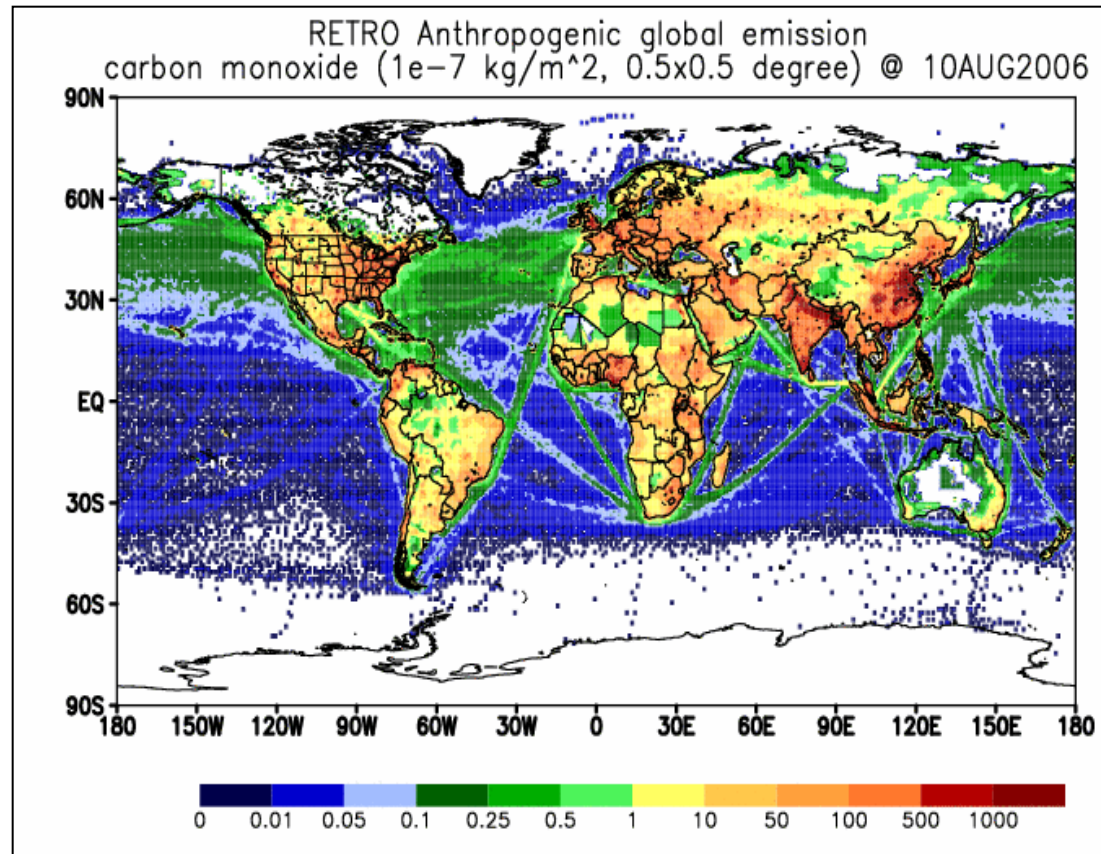
$\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2\text{O}$ , HFCs, PFCs,  $\text{SF}_6$

**GOCART**

OC, BC and  $\text{SO}_2$  ( $1^\circ \times 1^\circ$ , annual, 2006)

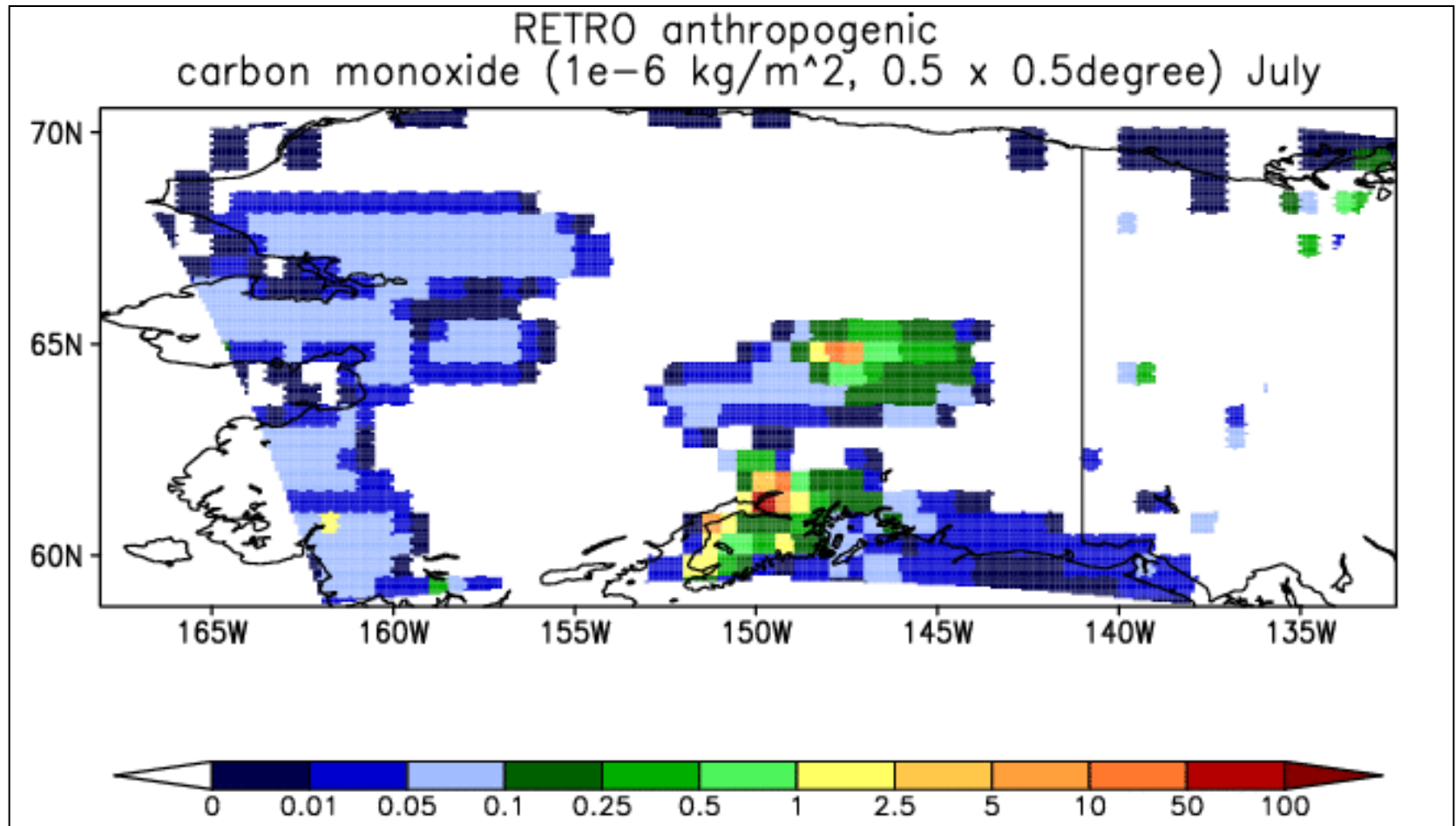
DMS ( $1^\circ \times 1.25^\circ$ , monthly)

$\text{NO}_3$ ,  $\text{H}_2\text{O}_2$  and OH (3D,  $1^\circ \times 1.25^\circ$   
monthly, 2006)



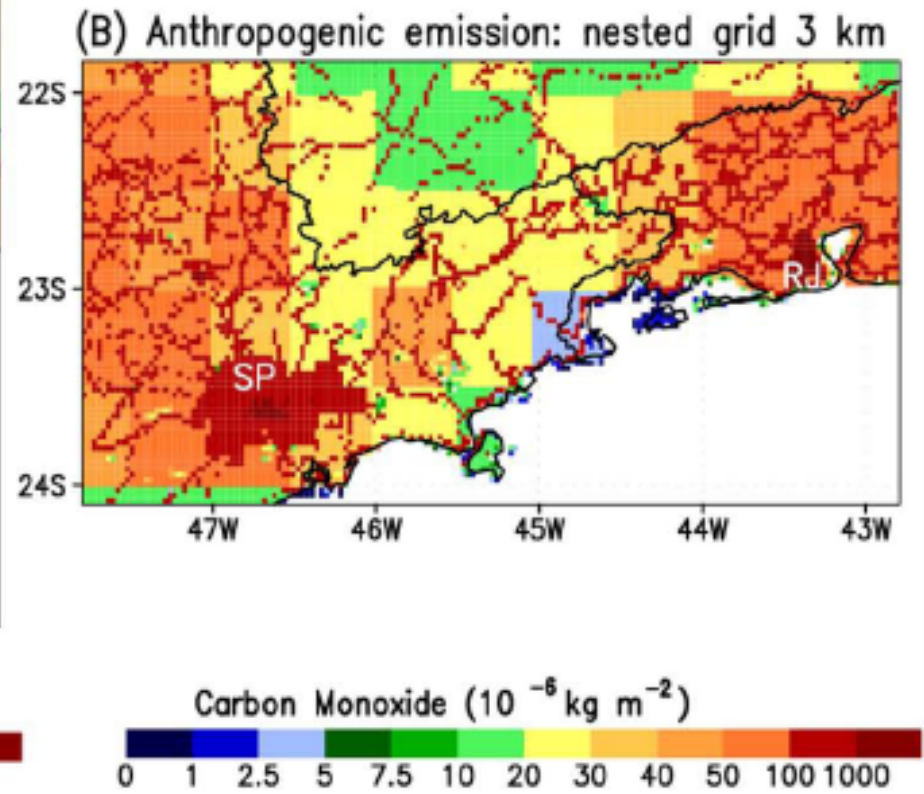
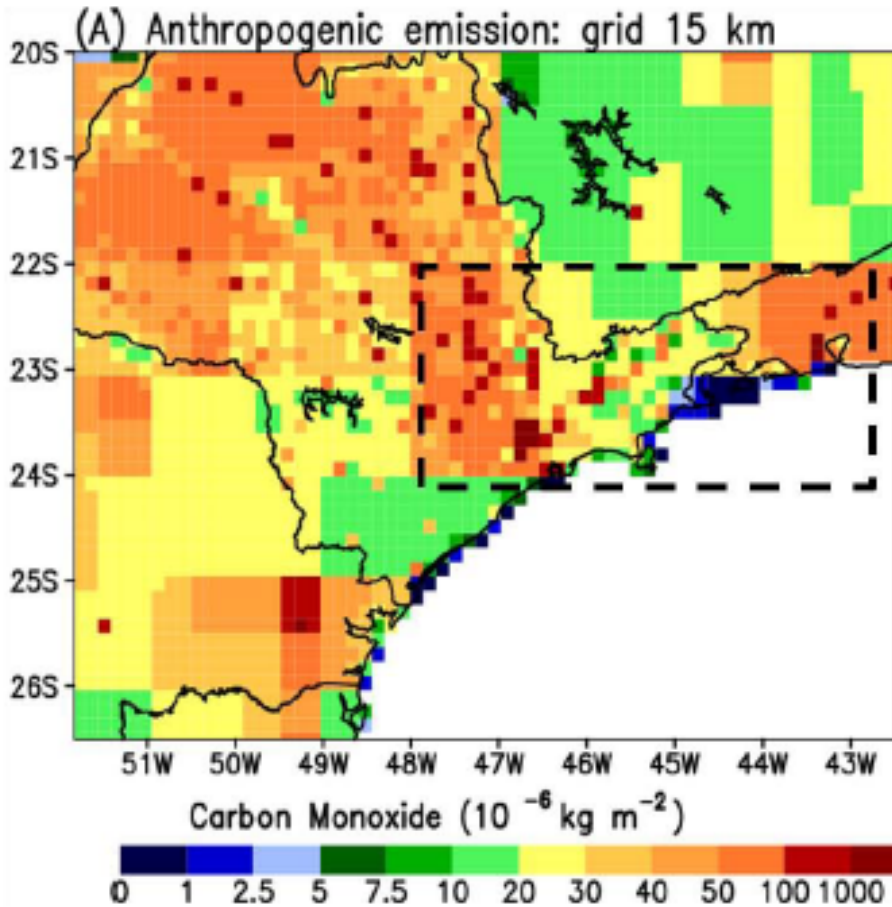
# Anthropogenic emissions

## Example for Alaska



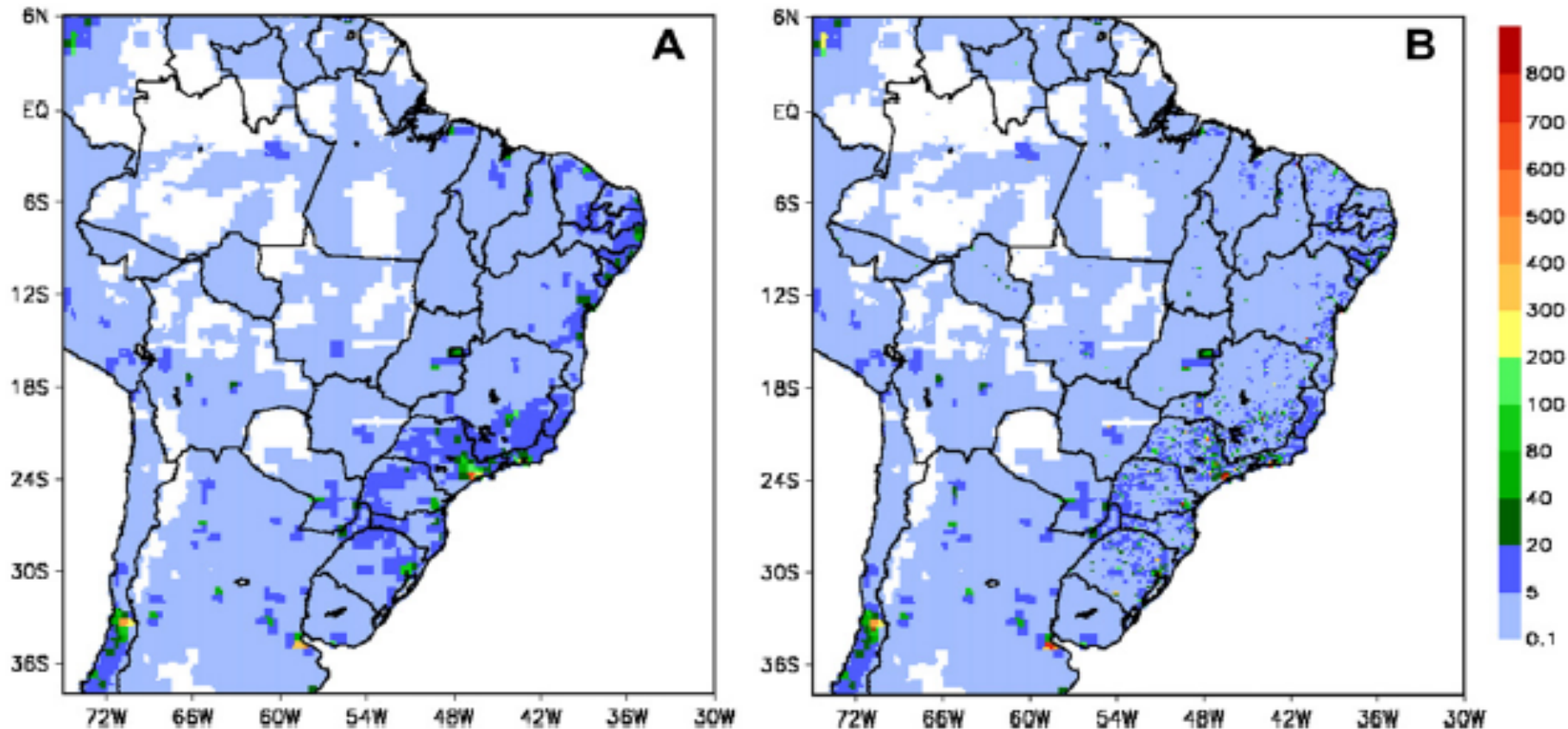
# Anthropogenic emissions

AREA DELIMITER algorithm distributes emissions on high resolution grids



# Anthropogenic emissions

South America: Updated local inventories and extrapolation to cities without inventories based on socioeconomic data



CO emissions ( $\times 10^6 \text{ kg m}^2 \text{ day}^{-1}$ ) on a 20 km grid covering South America without (A) and with (B) updated inventories

# Biogenic emissions (if bio\_emiss\_opt=0)

## 1) GEIA

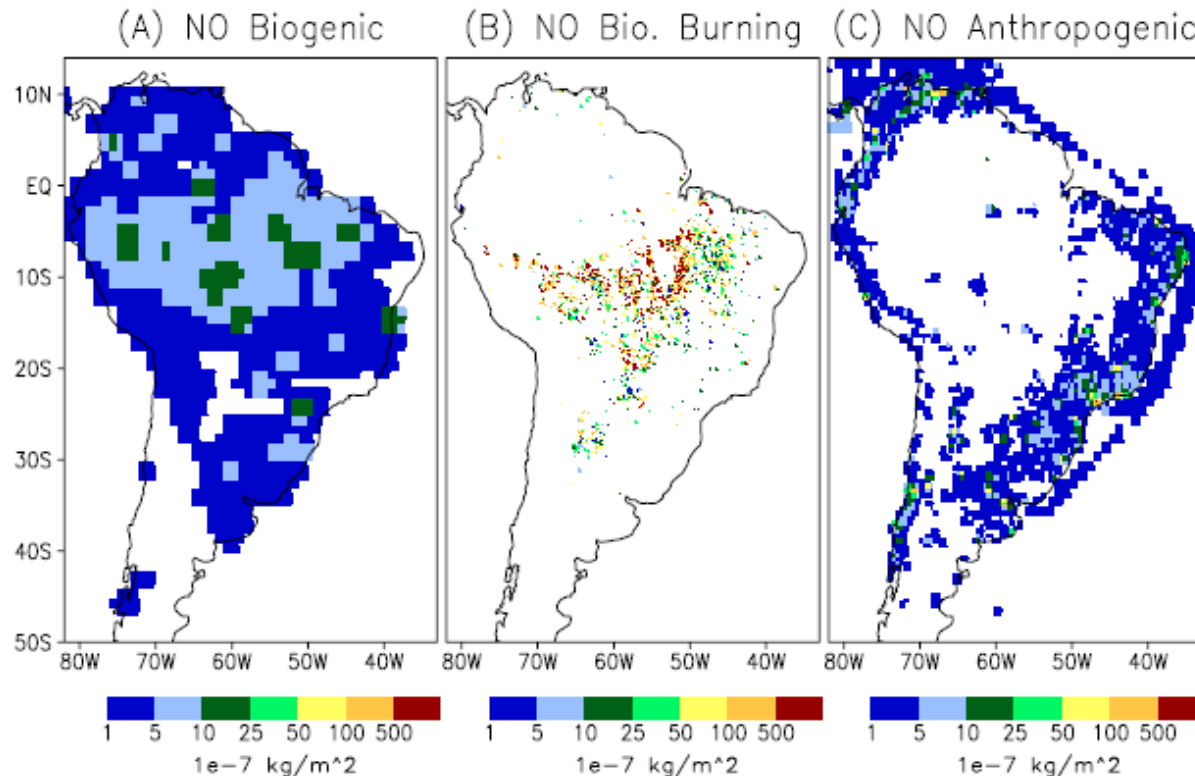
1° x 1°, monthly, 2002

Acetone, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, C<sub>3</sub>H<sub>6</sub>,  
C<sub>3</sub>H<sub>8</sub>, CO, CH<sub>3</sub>OH, DMS, NO,  
Isoprene, Terpenes and NVOC

## 2) MEGAN 2000 climatology

0.5° x 0.5°, monthly, 2000

CO, CH<sub>4</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, C<sub>3</sub>H<sub>6</sub>, C<sub>3</sub>H<sub>8</sub>,  
CH<sub>3</sub>OH, Formaldehyde, Acetaldehyde,  
Acetone, other Ketones, Toluene,  
Isoprene, Monoterpenes and  
Sesquiterpenes



Daily emissions from (A) GEIA (B) 3BEM (C) RETRO for 27 August 2002 on a 0.2° grid

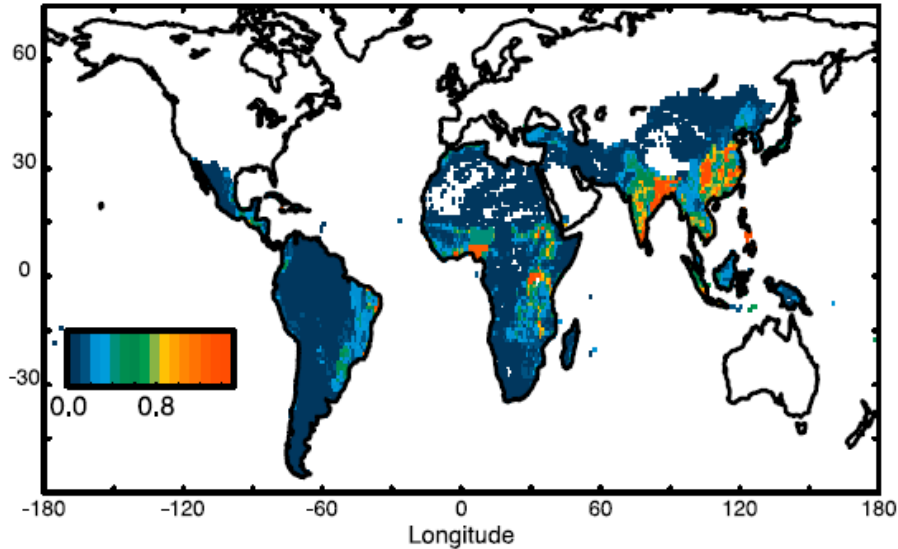
Alonso et al. (2010)

# Biofuel burning in the developing world

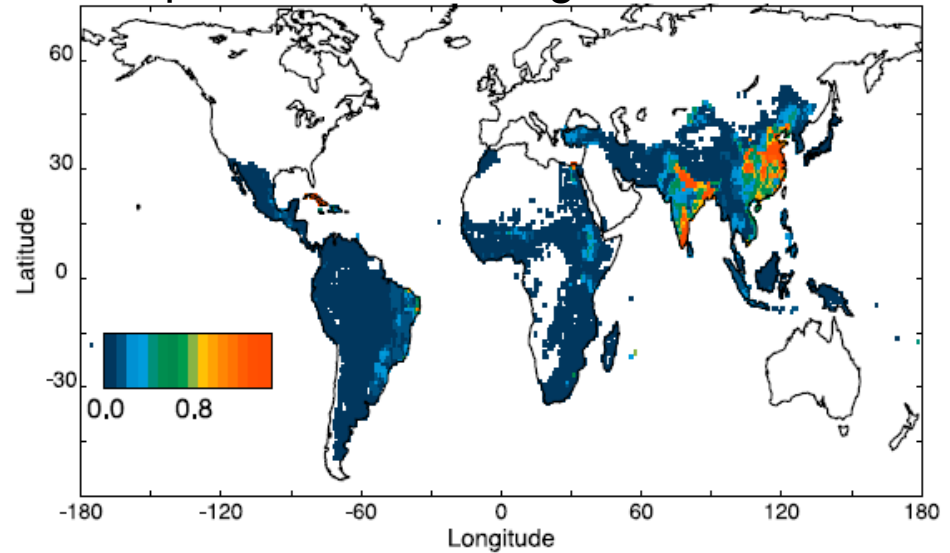
Emissions\_Yevich\_Logan

$10^0 \times 10^0$ , Tg dry matter yr<sup>-1</sup>

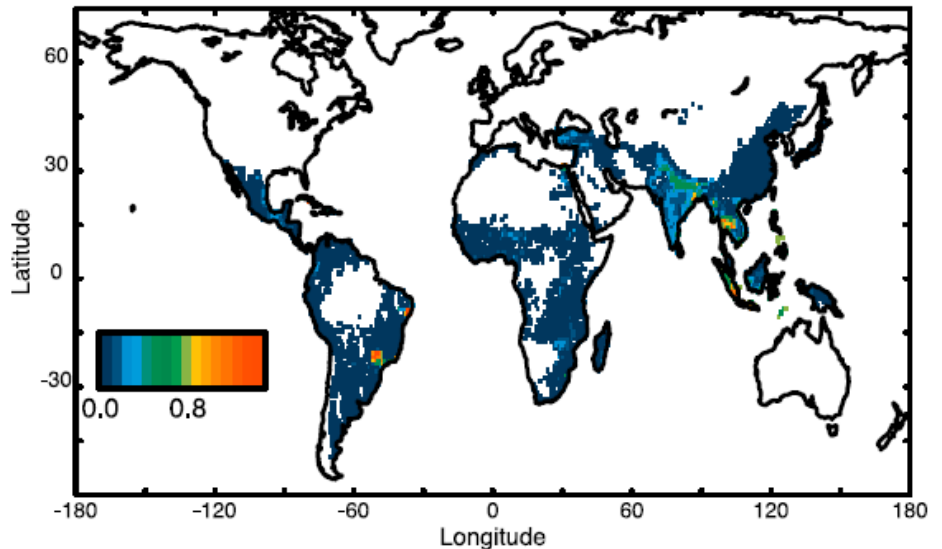
Woodfuel (fuelwood and charcoal) use



Crop residue and dung use



Burning of agricultural residue in the fields

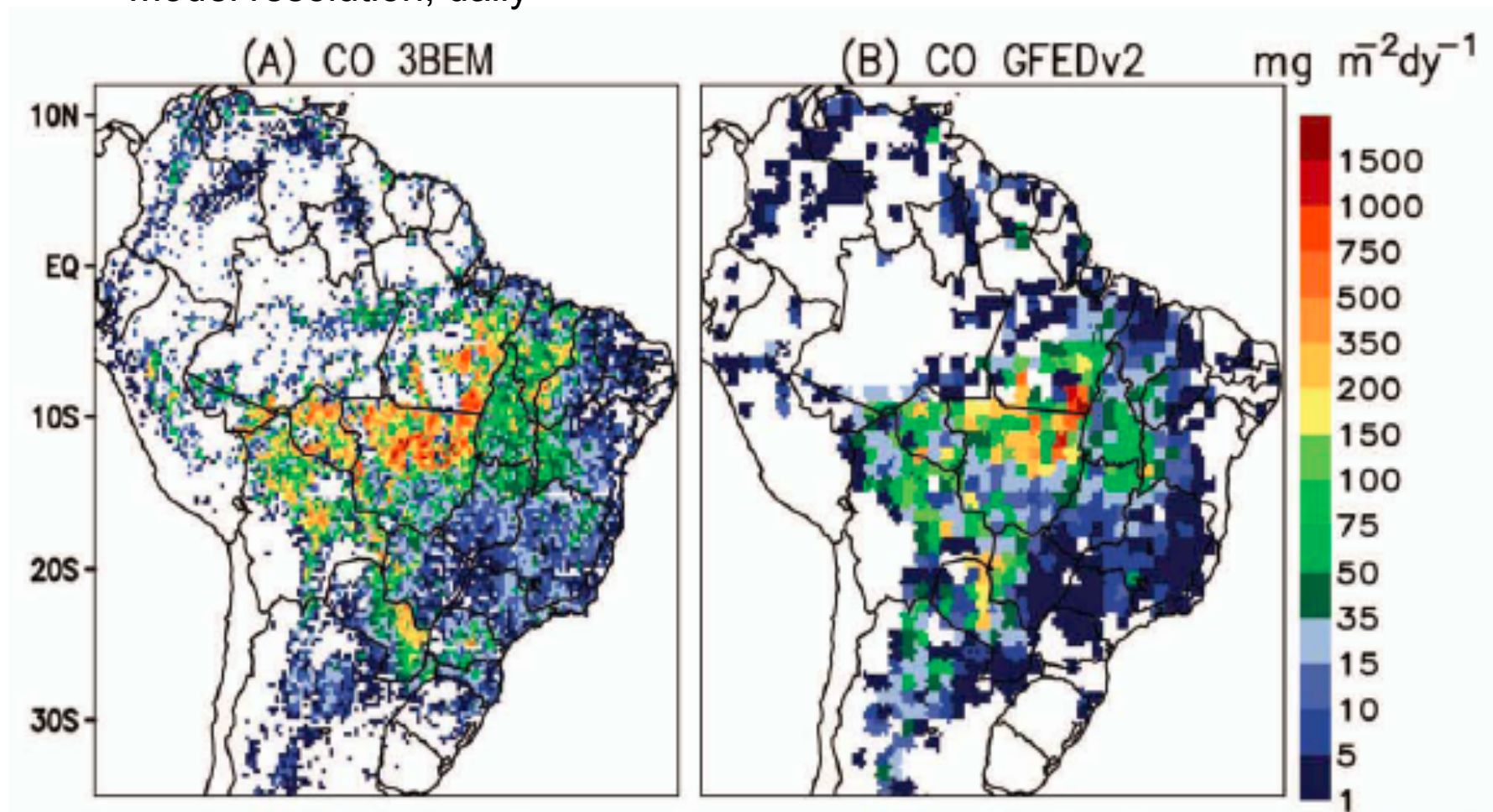




# Biomass burning emissions

Brazilian Biomass Burning  
Emission Model (**3BEM**)  
Model resolution, daily

Global Fire Emissions Database (**GFEDv2**)  
 $1^\circ \times 1^\circ$ , 8-day or monthly, 1997 - 2004



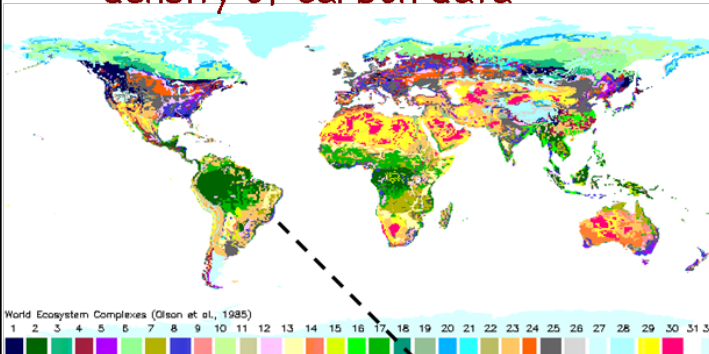
Average daily CO emissions, Aug.-Oct. 2002, 35 km

Freitas et al. (2011)

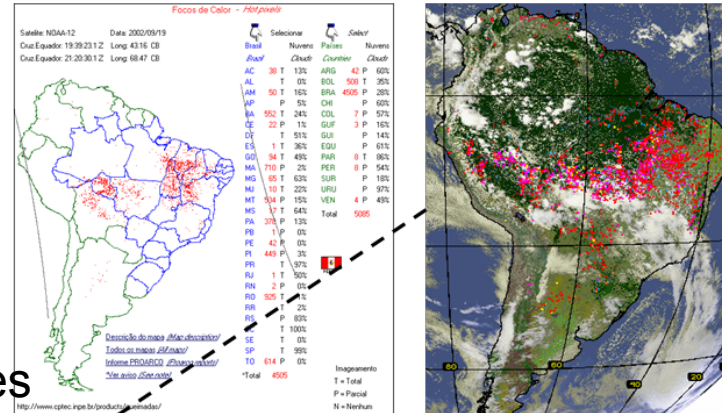
# 3BEM

## Biomass burning emissions inventory Regional scale – daily basis

density of carbon data

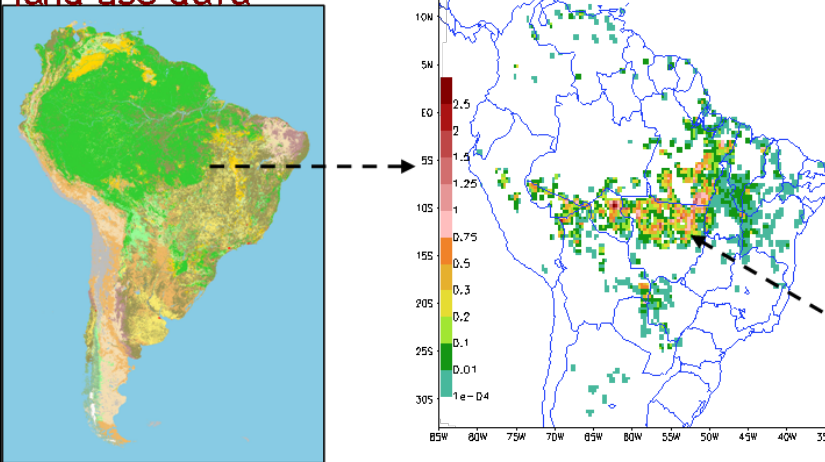


near real time fire product



6 types of biomes  
110 chemical species

land use data



Andreae and Merlet, 2001  
emission & combustion factors

Biome category	Emission Factor for CO (g/kg)	Emission Factor for PM2.5 (g/kg)	Aboveground biomass density (α, kg/m <sup>2</sup> )	Combustion factor (β, fraction)
Tropical forest <sup>1</sup>	110.	8.3	20.7	0.48
South America savanna <sup>2</sup>	63.	4.4	0.9	0.78
Pasture <sup>3</sup>	49.	2.1	0.7	1.00

<sup>1</sup> Average values for primary and second-growth tropical forests, <sup>2</sup> Average values for campo cerrado (C3) and cerrado sensu stricto (C4), <sup>3</sup> value for campo limpo (C1). All numbers are from Ward et al.,

mass estimation

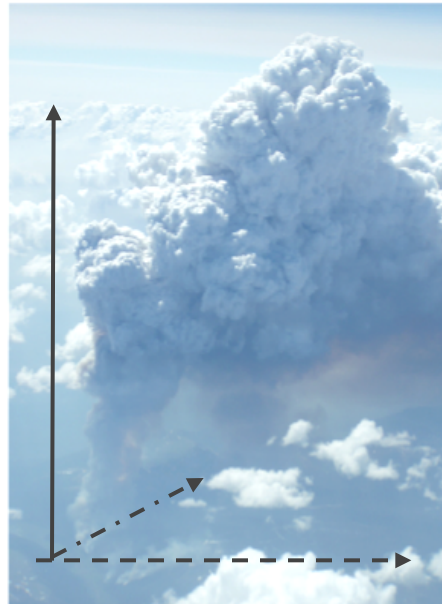
$$M_{[\eta]} = \alpha_{veg} \cdot \beta_{veg} \cdot E_{f_{veg}}^{[\eta]} \cdot a_{fire}$$

CO source emission (kg m<sup>-2</sup>day<sup>-1</sup>)

# 3BEM Plume Rise

Biomass burning  
and wildfires

Smoldering : mostly surface emission.  
Flaming: mostly direct injection in the PBL,  
free troposphere or stratosphere.

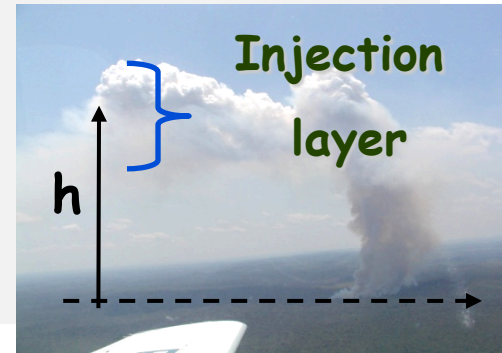


## Plume rise model

total emission flux:  $F_\eta$  being  $\lambda$  the smoldering fraction

smoldering term :  $E_\eta = \frac{\lambda F_\eta}{\rho_{air} \Delta z_{\text{first phys. model layer}}}$

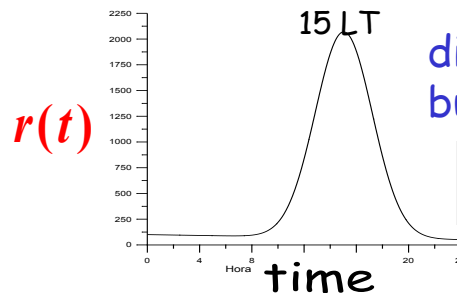
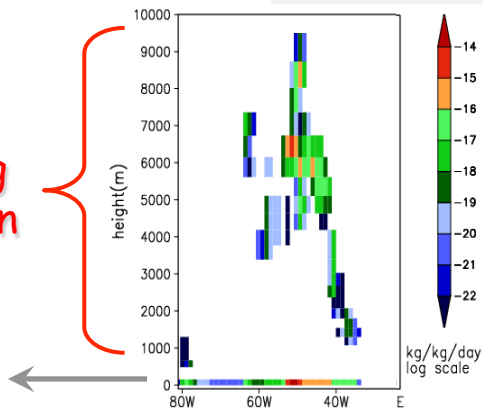
flaming term :  $E_\eta = \frac{(1 - \lambda) F_\eta}{\rho_{air} \Delta z_{\text{injection layer}}}$



Example in  
the model:

flaming  
emission

smoldering  
emission



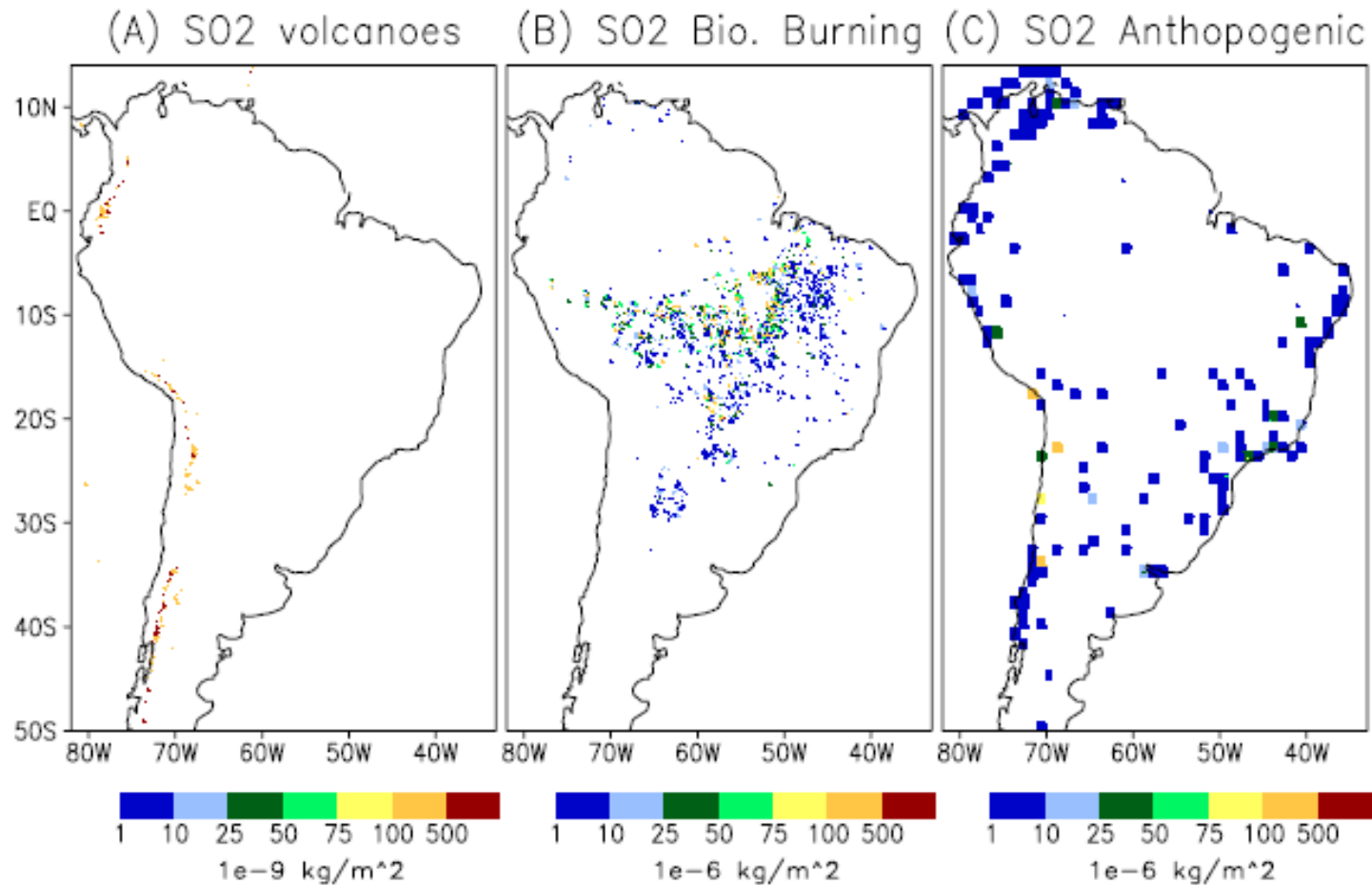
diurnal cycle of the  
burning for S. America:

$$E_\eta(t) = r(t) E_\eta$$

Freitas et al. (2011)

# Volcano emissions

Based on Mastin et al. (2009) database of 1535 volcanoes  
Mass eruption rate, plume height and time duration  
SO<sub>2</sub> from AEROCOM program, 1979 – 2007 (Diehl, 2009)



# Compiling PREP-SRC-CHEM

- Required libraries: HDF4/HDF5, zlib, jpeg, netCDF
- cd to:  
PREP-CHEM-SRC-1.3/bin/build
- Set library paths in:  
include.mk.<compiler>
- cd to:  
PREP-CHEM-SRC-1.3/bin
- Compile  
make OPT=<compiler> CHEM=RADM\_WRF\_FIM

Executable : *prep\_chem\_sources\_RADM\_WRF\_FIM.exe*

Input file (namelist): *prep\_chem\_sources.inp*

# Input file (namelist): prep\_chem\_sources.inp

\$RP\_INPUT

!----- **grid\_type**

grid\_type= 'lambert',           ! 'polar' = polar stereo. grid output  
                                  ! 'll' = lat/lon grid output  
                                  ! 'lambert' = lambert grid output  
                                  ! 'mercator' = mercator grid output

!----- **date of emission**

ihour=0,  
iday=12,  
imon=7,  
iyear=2004,

!----- **select the sources datasets to be used: 1 = yes, 0 = not**

use\_retro=1,  
retro\_data\_dir='/import/archive/u1/uaf/freitas/Emission\_data/RETRO/anthro',  
use\_edgar =1, ! 0 - not, 1 - Version 3, 2 - Version 4 for some species  
use\_gocart=1,  
user\_data\_dir='/home/poluicao/EMISSION\_DATA/SouthAmerica\_Megacities',  
  
use\_bioge =2, ! 1 - GEIA, 2 - MEGAN  
use\_fwbawb=1,  
fwbawb\_data\_dir='/import/archive/u1/uaf/freitas/Emission\_data/Emissions\_Yevich\_Logan',  
use\_gfedv2=0,  
use\_bbem=1,  
use\_bbem\_plumerise=1,

# Input file (namelist): prep\_chem\_sources.inp

!----- **if the merging of gfedv2 with bbem is desired (=1, yes, 0 = no)**  
merge\_GFEDv2\_bbem =0,

!----- **Fire product for 3BEM/3BEM-plumerise emission models**

bbem\_wfabba\_data\_dir='/import/archive/u1/uaf/freitas/Emission\_data/fires\_data/WF\_ABBA/filt/f,  
bbem\_modis\_data\_dir ='/import/archive/u1/uaf/freitas/Emission\_data/fires\_data/MODIS/Fires.',  
bbem\_inpe\_data\_dir ='/import/archive/u1/uaf/freitas/Emission\_data/fires\_data/DSA/Focos',  
bbem\_extra\_data\_dir ='/import/archive/u1/uaf/freitas/Emission\_data/fires\_data/xxxxx,

!----- **gocart background**

use\_gocart\_bg=1,

!----- **volcanoes emissions**

use\_volcanoes=0,

volcano\_index=0, !REDOUBT

use\_these\_values='NONE',

! define a text file for using external values for INJ\_HEIGHT, DURATION,

! MASS ASH (units are meters - seconds - kilograms) and the format for

! a file 'values.txt' is like this: 11000. 10800. 1.5e10

! use\_these\_values='values.txt',

begin\_eruption='198912141930', !begin time UTC of eruption YYYYMMDDhhmm

!----- degassing volcanoes emissions

use\_degass\_volcanoes=0,

degass\_volc\_data\_dir='/home/poluicao/EMISSION\_DATA/VOLC\_SO2',

# Input file (namelist): prep\_chem\_sources.inp

!----- **For regional grids (polar, Lambert, Mercator)**

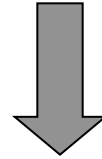
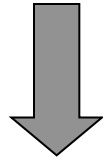
```
NGRIDS = 3,          ! Number of grids to run
NNXP   = 391,463,499, ! Number of x gridpoints
NNYP   = 271,454,478, ! Number of y gridpoints
NXTNEST = 0, 1, 2,    ! Grid number which is the next coarser grid
DELTAX  = 18000,
DELTAY  = 18000,      ! X and Y grid spacing
! Nest ratios between this grid and the next coarser grid.
NSTRATX = 1, 3, 3,    ! x-direction
NSTRATY = 1, 3, 3,    ! y-direction
NINEST  = 1, 78, 128, ! Grid point on the next coarser
NJNEST  = 1, 30, 153, ! nest where the lower southwest
! NKNEST = 1, 1, 1,    ! nest where the lower southwest
! corner of this nest will start.
! If NINEST or NJNEST = 0, use CENTLAT/LON
POLELAT = 15.,        ! If polar, latitude/longitude of pole point
POLELON = 10.,        ! If lambert, lat/lon of grid origin (x=y=0.)
STDLAT1 = 0.,         ! If polar, unused
STDLAT2 = 15.,        ! If lambert, standard latitudes of projection (truelat2/truelat1 from
namelist.wps, STDLAT1 < STDLAT2)
CENTLAT  = 15.0,
CENTLON  = 10.0,
```



# Running PREP-CHEM-SRC and convert\_emiss

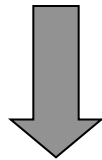
*prep\_chem\_sources\_RADM\_WRF\_FIM.exe*

*./real.exe*  
(chem\_opt=0,)

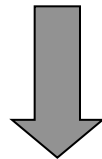


Binary emissions (*\*-ab.bin,*  
*\*-bb.bin, \*gocartBG.bin, \*volc.bin*)

*wrfinput\_d01*



*../chem/convert\_emiss.exe*



netCDF emissions (*wrfchemi\*,*  
*wrffirechemi\*, wrfchemi\_gocart\_bg\_\**)

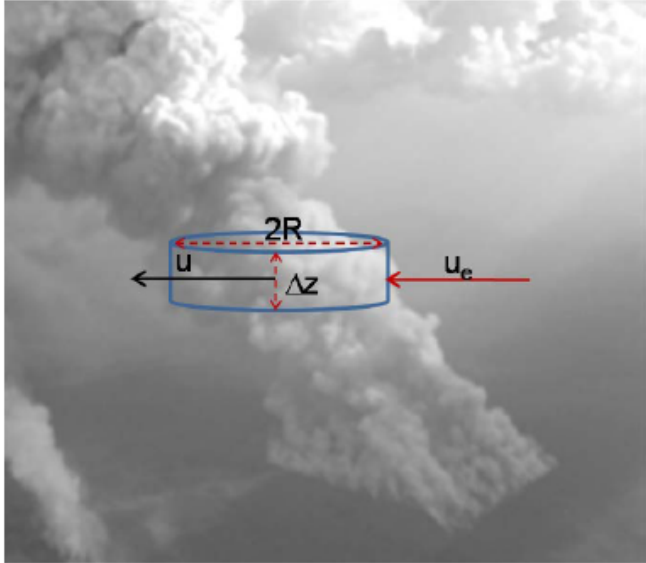
# Future improvements: Environmental Wind Effects on Plume Rise



Biomass burning plumes in the Amazon region  
without (left) and with (right) environmental wind shear

Photos: M.O. Andreae, M. Welling

# Environmental Wind Effects on Plume Rise

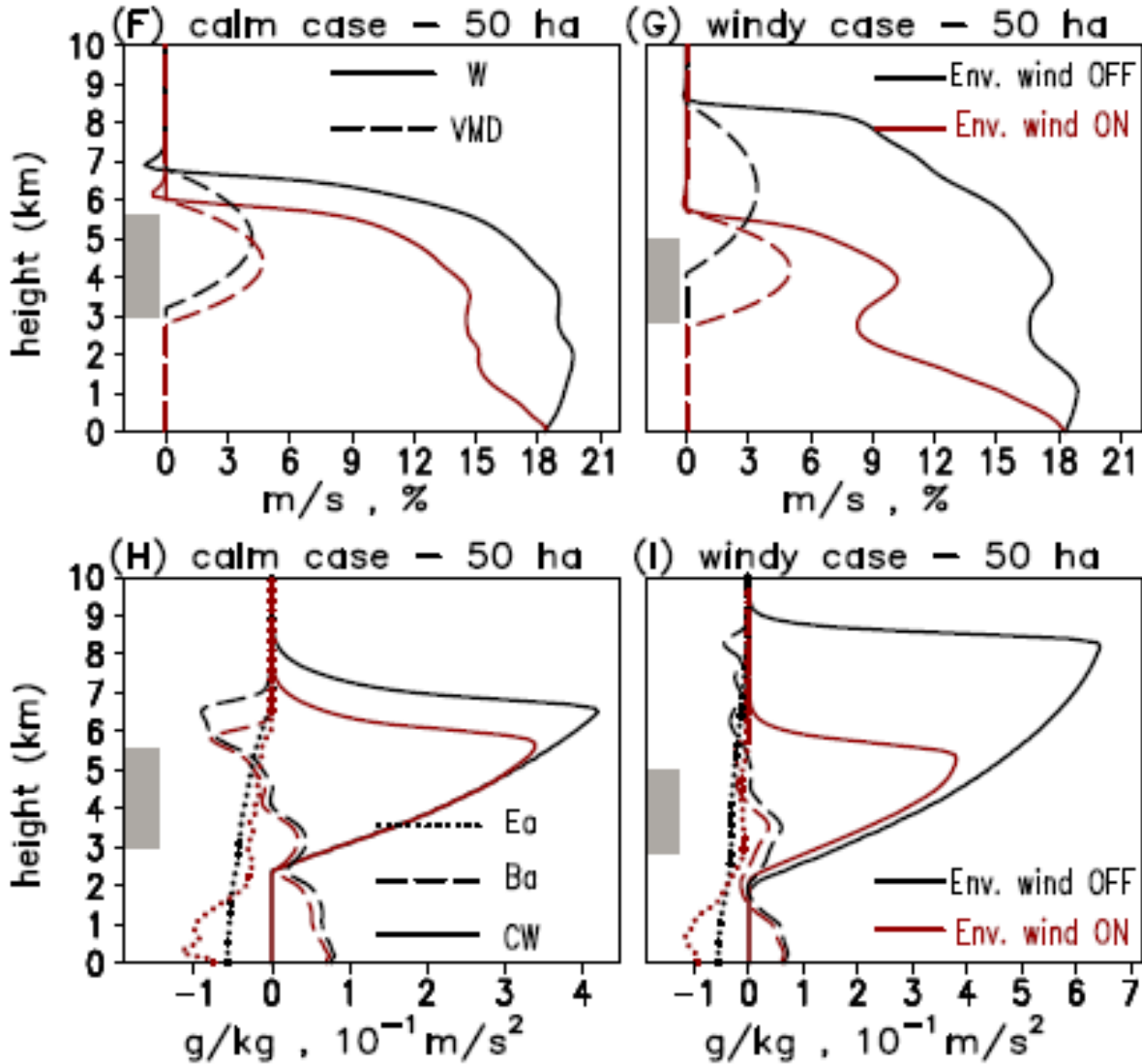


$$\lambda_{\text{entr}} = \frac{2\alpha}{R} |w|$$

$$\delta_{\text{entr}} = \frac{2}{\pi R} (u_e - u)$$

$W$ : vertical velocity  
 $VMD$ : vertical mass distribution  
 $Ea$ : Entrainment acceleration  
 $Ba$ : buoyancy acceleration  
 $CW$ : total condensate water

1-D PRM results for a 50 ha fire, calm and windy conditions



Freitas et al. (2010)

# References

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Freitas, S. R. ; Longo, K. M. ; Alonso, M. F. ; Pirre, M. ; Marecal, V. ; Grell, G. ; Stockler, R. ; Mello, R. F. ; Sánchez Gácita, M. . PREP-CHEM-SRC 1.0: a preprocessor of trace gas and aerosol emission fields for regional and global atmospheric chemistry models. *Geoscientific Model Development*, v. 4, p. 419-433, 2011.

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Freitas, S. R., K. M. Longo, R. Chatfield, D. Latham, M. A. F. Silva Dias, M. O. Andreae, E. Prins, J. C. Santos, R. Gielow and J. A. Carvalho Jr.: Including the sub-grid scale plume rise of vegetation fires in low resolution atmospheric transport models. *Atmospheric Chemistry and Physics*, v. 7, p. 3385-3398, 2007.

Freitas, S. R.; Longo, K. M.; M. Andreae. The impact of including the plume rise of vegetation fires in numerical simulations of associated atmospheric pollutants. *Geophys. Res. Lett.*, 33, L17808, doi:10.1029/2006GL026608, 2006.

Yevich, R. and J.A. Logan, An assessment of biofuel use and burning of agricultural waste in the developing world, *Global Biogeochemical Cycles*, 2003



**Thank you!**

**Questions?**

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