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

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Grupo de Modelagem da Atmosfera e Interfaces
Modeling of the Atmosphere and its Interfaces Group

CENTRO DE PREVISÃO DE TEMPO E ESTUDOS CLIMATICOS

WRF-Chem Tutorial, 16 Oct. 2012
Sao Paulo, Brazil

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

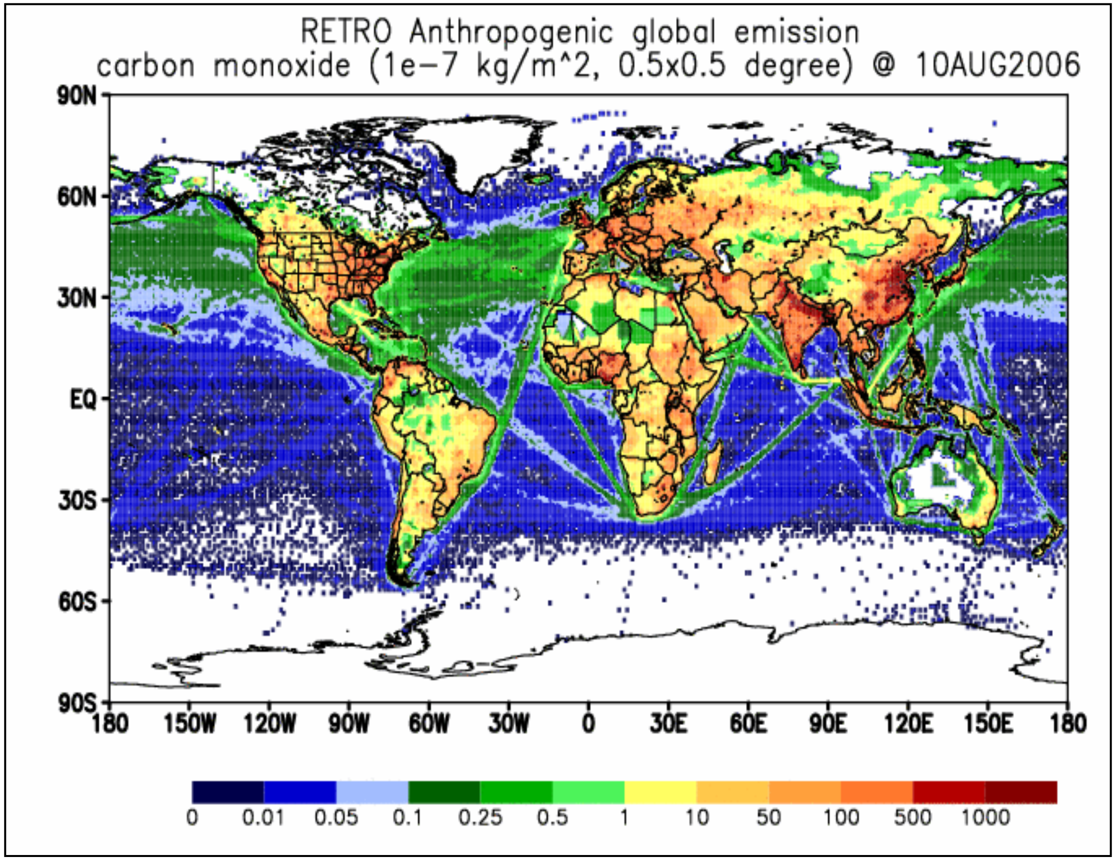
Anthropogenic emissions

Global Inventories

RETRO (0.5^0 x 0.5^0, monthly, 1960-2000)

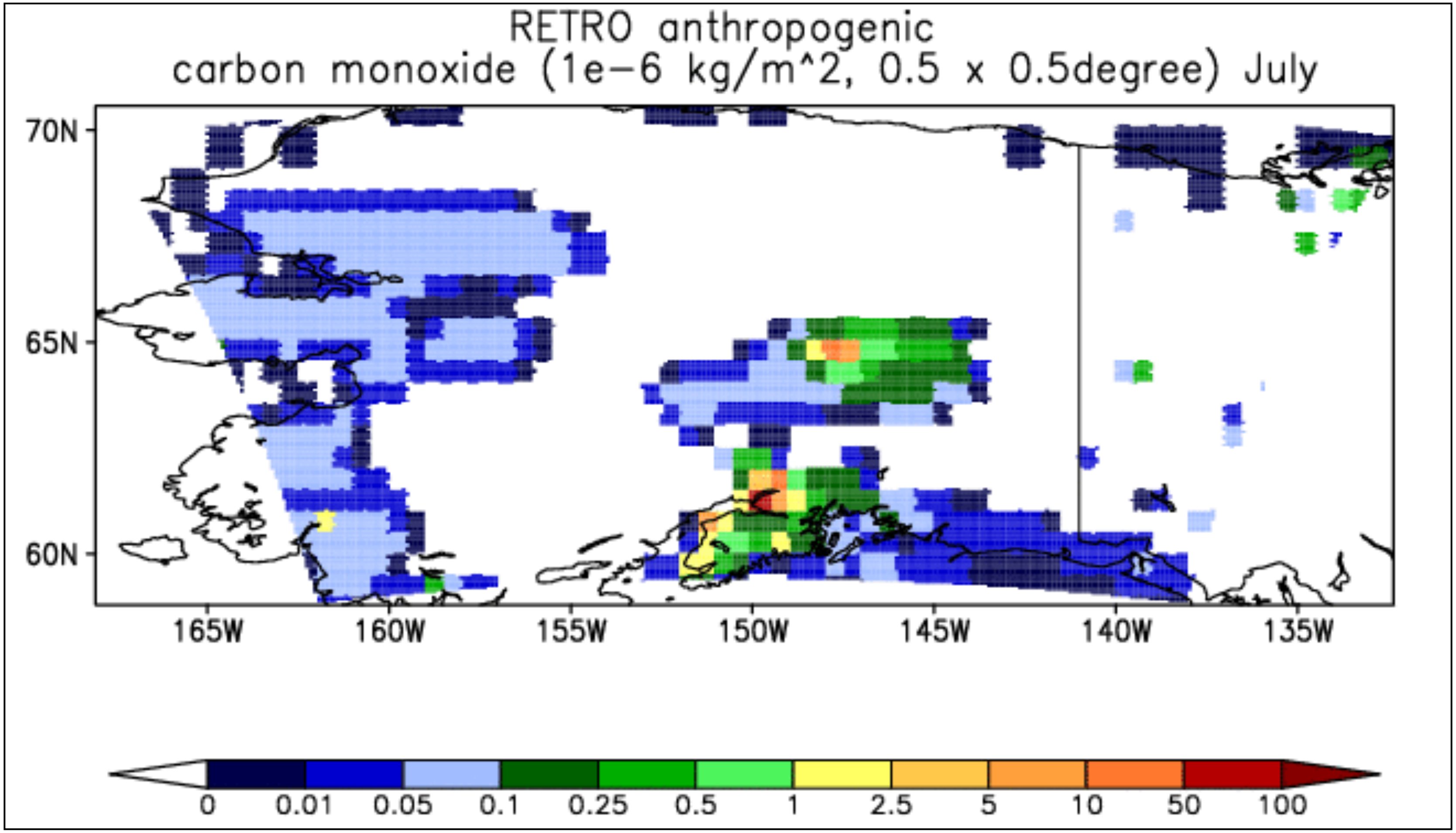
EDGAR v4.2 (0.1^0 x 0.1^0, annual,1970-2008)
CO_2, CH_4, N_2O, HFCs, PFCs, SF_6

GOCART
OC, BC and SO_2 (1^0 x 1^0, annual, 2006)
DMS (1^0 x 1.25^0, monthly)
NO_3, H_2O_2 and OH (3D, 1^0 x 1.25^0 monthly, 2006)



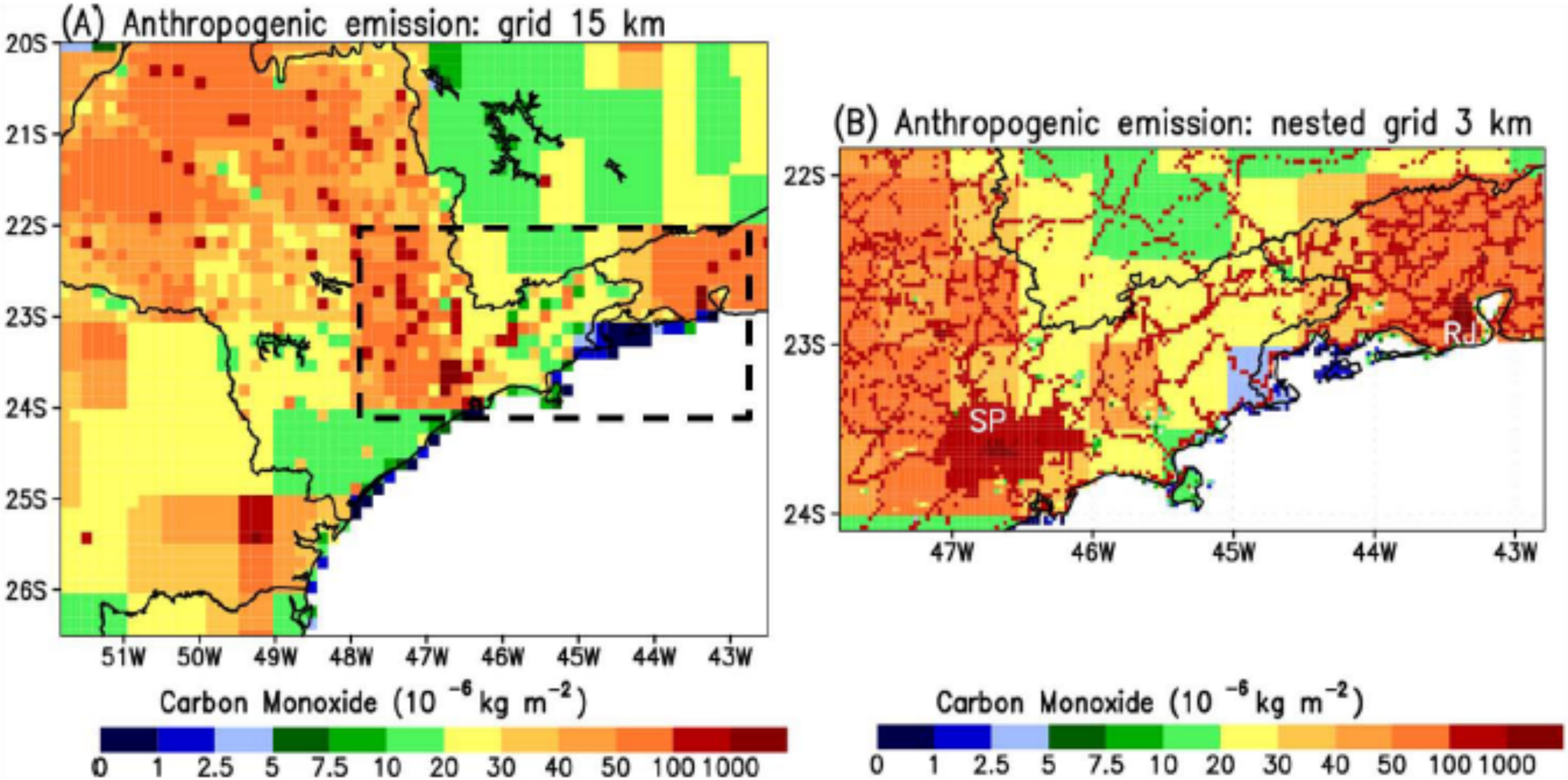
Anthropogenic emissions

Example for Alaska



Anthropogenic emissions

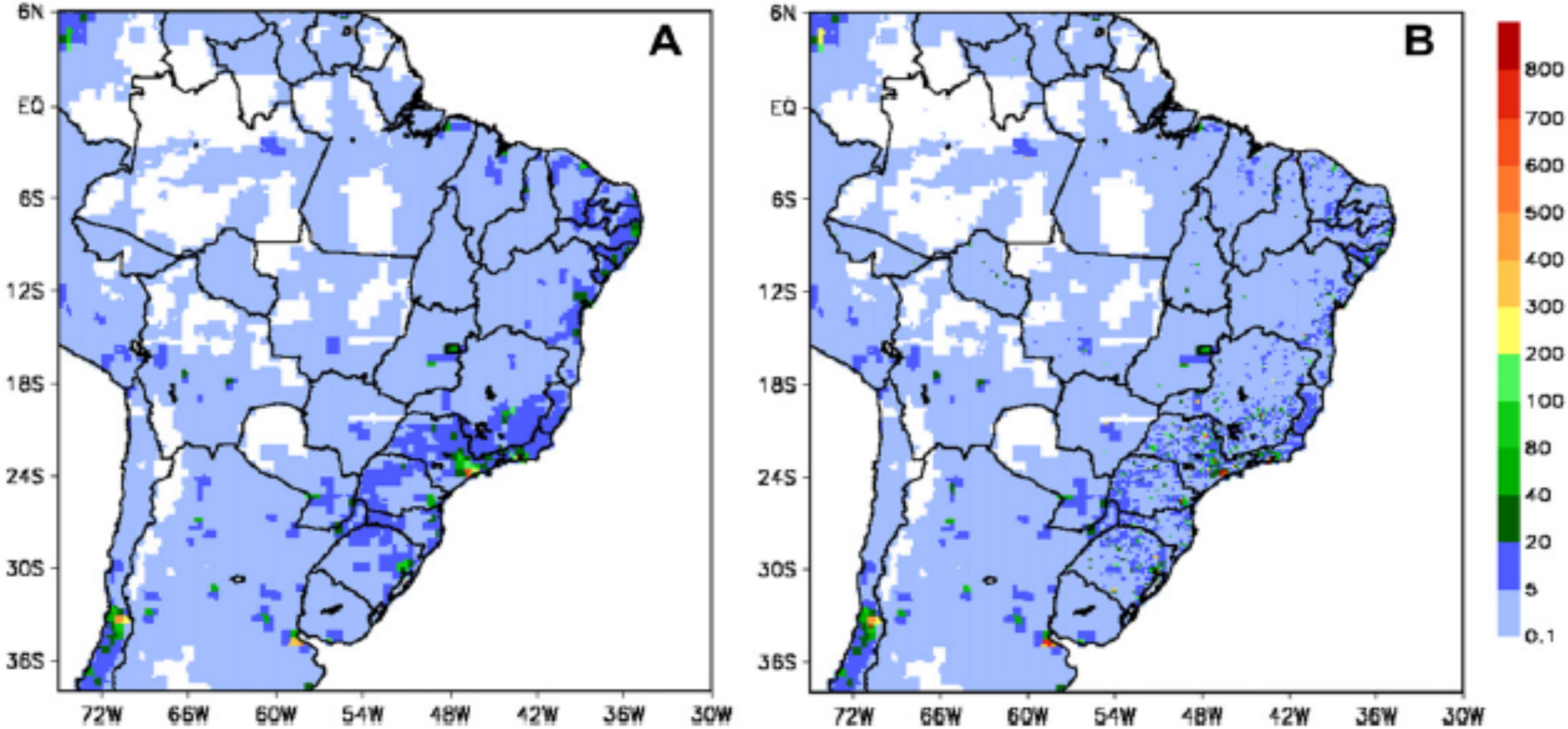
AREA DELIMITER algorithm distributes emissions on high resolution grids



Alonso et al. (2010)

Anthropogenic emissions

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



CO emissions (x10^6 kg m^2 day^{-1})) on a 20 km grid covering South America without (A) and with (B) updated inventories

Alonso et al. (2010)

Biogenic emissions (if bio_emiss_opt=0)

1) GEIA

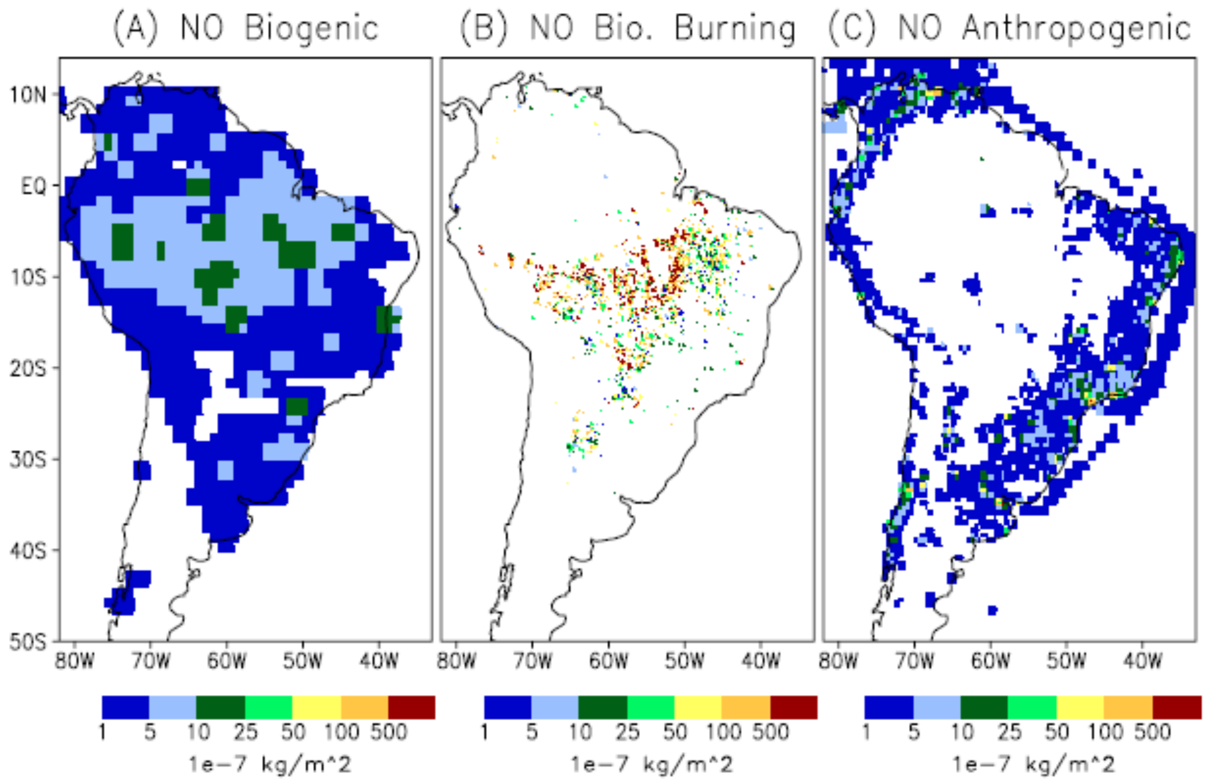
1^0 x 1^0, monthly, 2002

Acetone, C_2H_4, C_2H_6, C_3H_6, C_3H_8, CO, CH_3OH, DMS, NO, Isoprene, Terpenes and NVOC

2) MEGAN 2000 climatology

0.5^0 x 0.5^0, monthly, 2000

CO, CH_4, C_2H_4, C_2H_6, C_3H_6, C_3H_8, CH_3OH, 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 0.2^0 grid

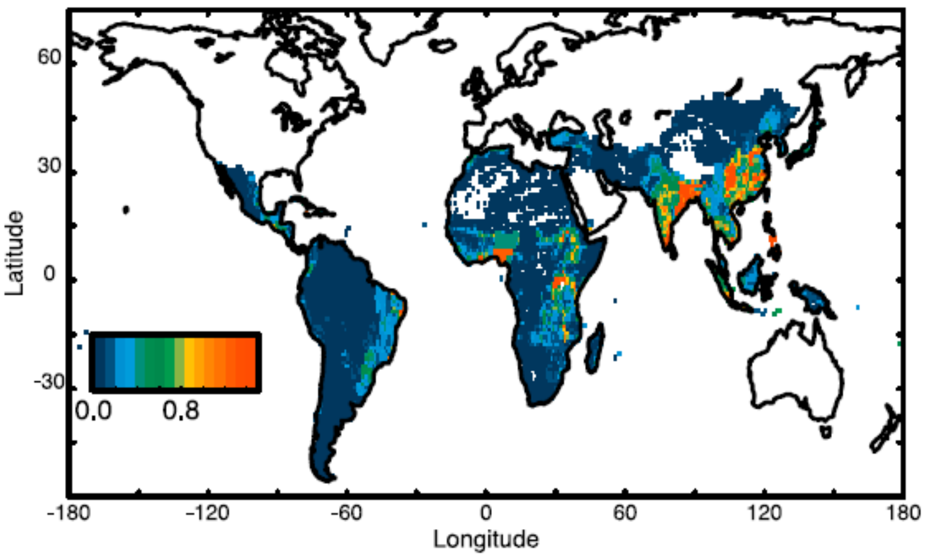
Alonso et al. (2010)

Biofuel burning in the developing world

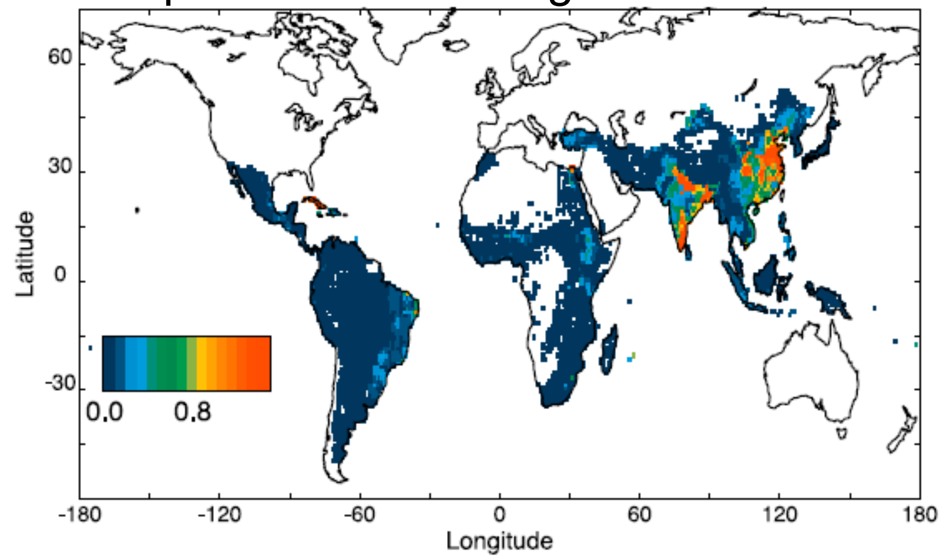
Emissions_Yevich_Logan

$1^0 \times 1^0$, Tg dry matter yr^{-1}

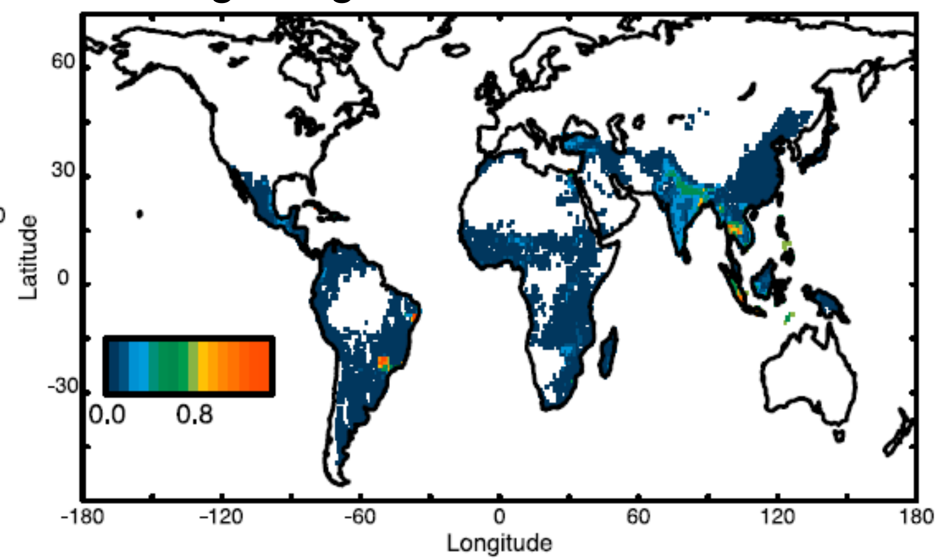
Woodfuel (fuelwood and charcoal) use



Crop residue and dung use



Burning of agricultural residue in the fields

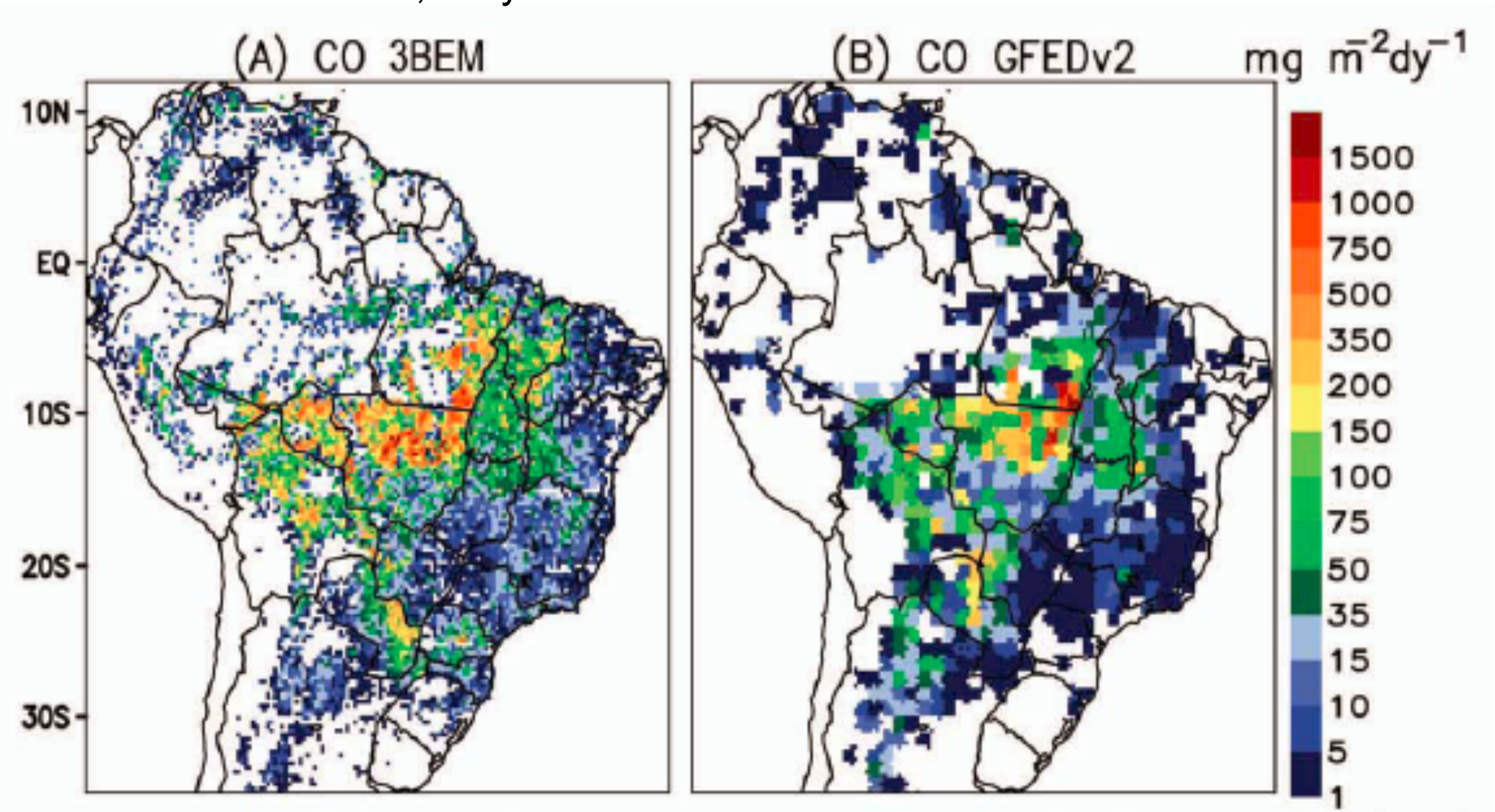


Yevich and Logan, 2003

Biomass burning emissions

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

Global Fire Emissions Database (**GFEDv2**)
$1^0 \times 1^0$, 8-day or monthly, 1997 - 2004



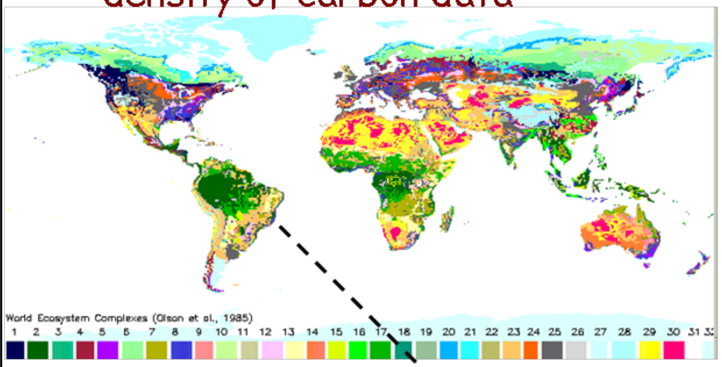
Average daily CO emissions, Aug.-Oct. 2002, 35 km

Freitas et al. (2011)

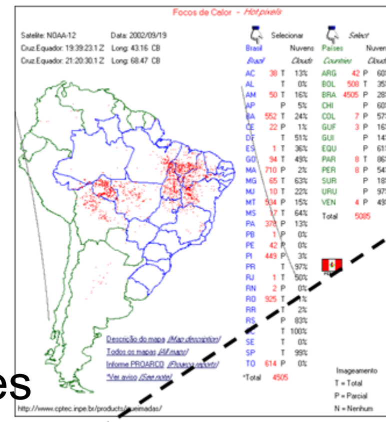
3BEM

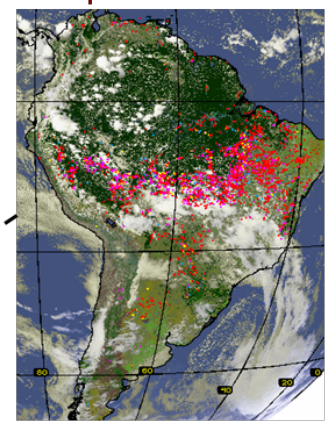
Biomass burning emissions inventory
Regional scale – daily basis

density of carbon data



near real time fire product

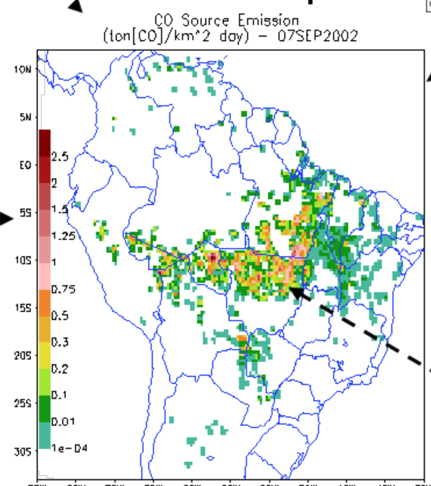




6 types of biomes

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/m²)	Combustion factor (β, fraction)
Tropical forest[1]	110.	8.3	20.7	0.48
South America savanna[2]	63.	4.4	0.9	0.78
Pasture[3]	49.	2.1	0.7	1.00

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

mass estimation

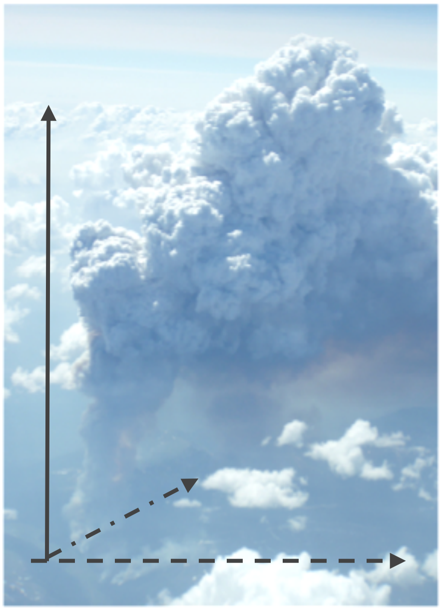
$$M_{[\eta]} = \alpha_{veg} . \beta_{veg} . Ef_{veg}^{[\eta]} . a_{fire} ,$$

CO source emission (kg m^{-2}day^{-1})

Freitas et al., 2005; Longo et al., 2007

3BEM Plume Rise

Biomass burning and wildfires
- Smoldering : mostly surface emission.
- Flaming: mostly direct injection in the PBL, free troposphere or stratosphere.

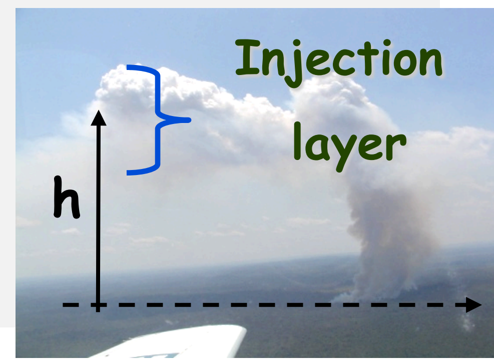


Plume rise model

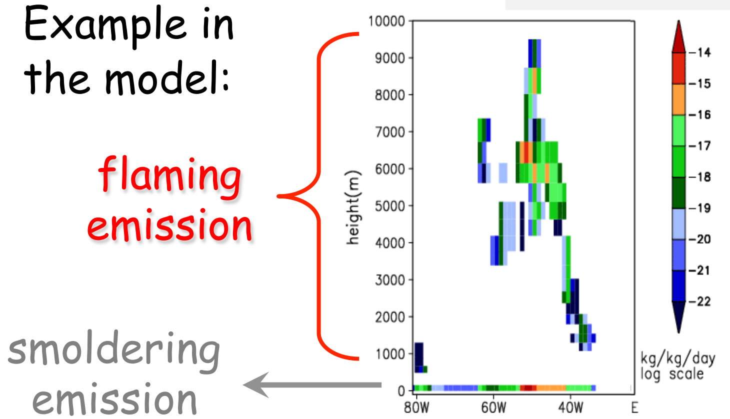
total emission flux: F_η being λ the smoldering fraction

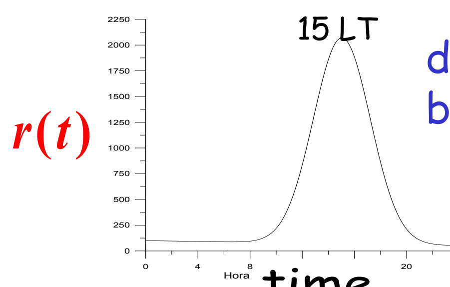
smoldering term : $E_\eta = \dfrac{\lambda F_\eta}{\rho_{air} \Delta z_{\text{first phys. model layer}}}$

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



Example in the model:





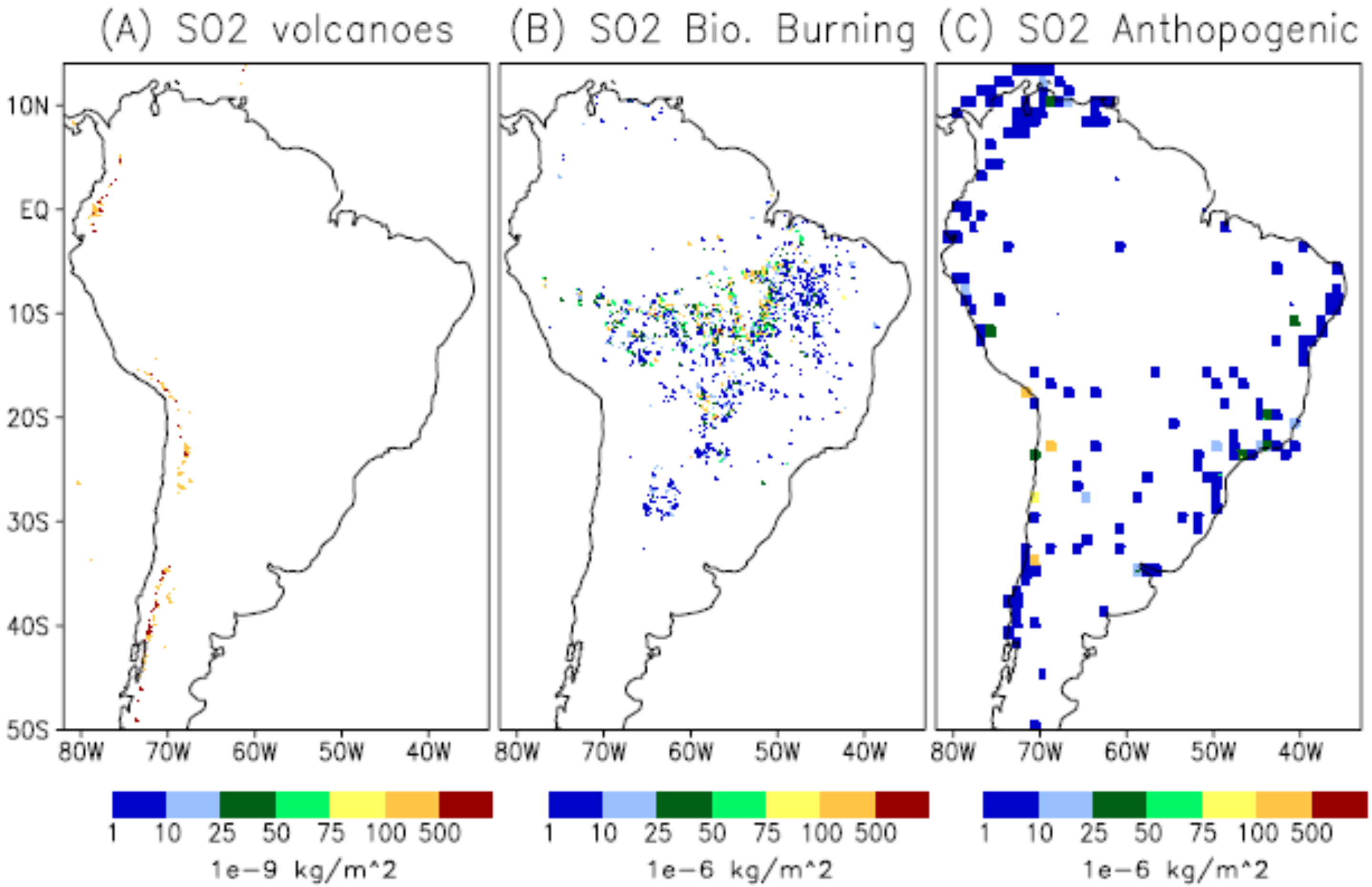
diurnal cycle of the burning for S. America:

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

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_2 from AEROCOM program, 1979 – 2007 (Diehl, 2009)



SO_2 emissions on 27 August 2002 on a 0.2^0 rectangular projection grid: (A) Diehl (2009), (B) 3BEM, (C) EDGAR

Freitas et al. (2011)

Compiling PREP-SRC-CHEM

- Required libraries: HDF4/HDF5, zlib, jpeg, netCDF
- cd to:

  PREP-CHEM-SRC-1.x/bin/build
- Set library paths in:

  include.mk.<compiler>
- cd to:

  PREP-CHEM-SRC-1.x/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,
```

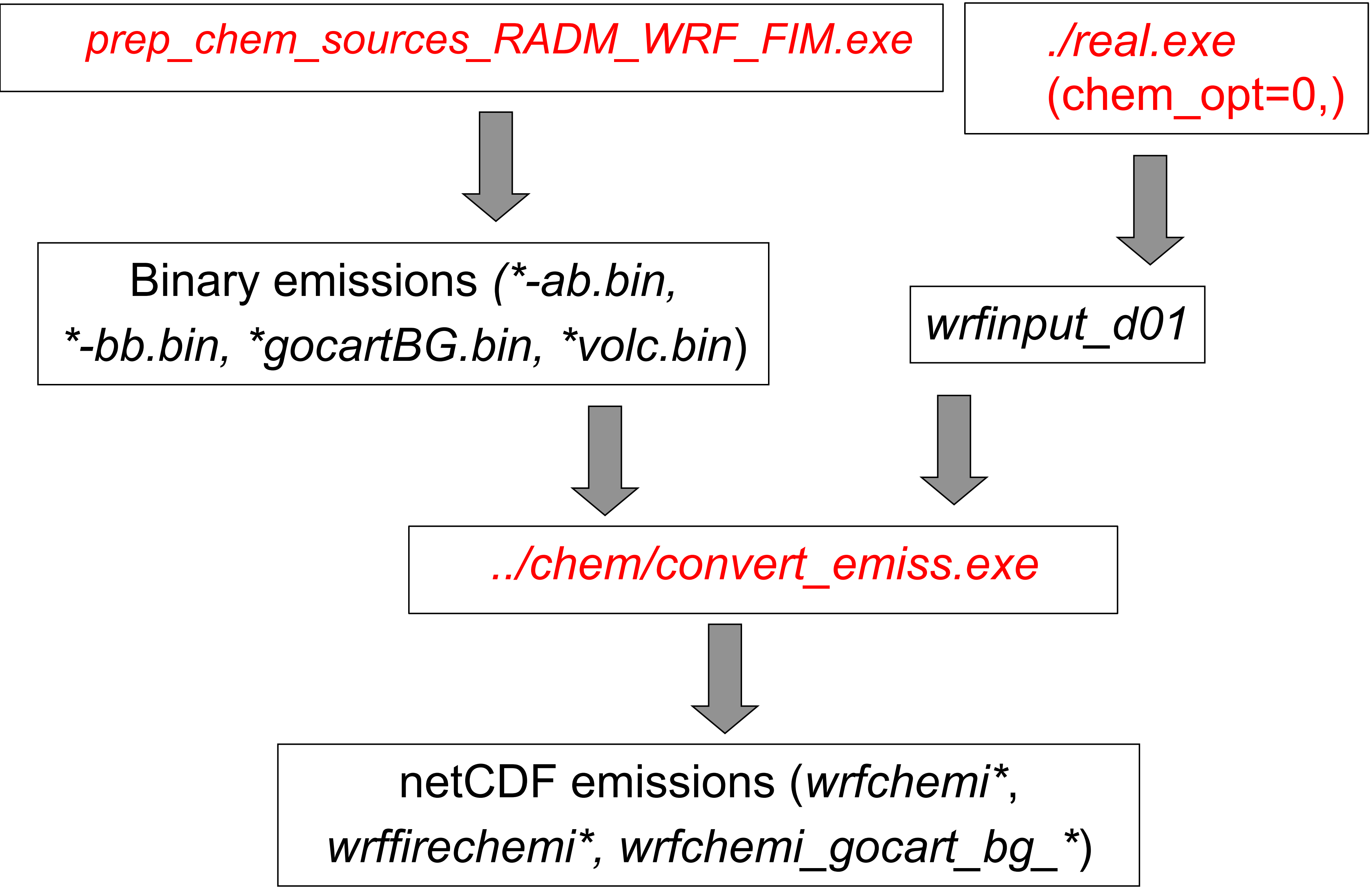
Input file (namelist): prep_chem_sources.inp

```
!---------------- 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

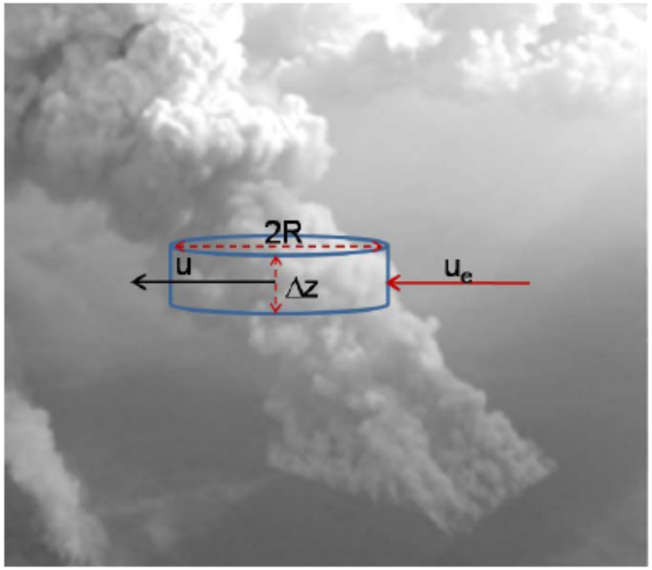


Future improvements: Environmental Wind Effects on Plume Rise

Biomass burning plumes in the Amazon region
without (left) and with (right) environmental wind shear
Photos: M.O. Andreae, M. Welling

Freitas et al. (2010)

Environmental Wind Effects on Plume Rise

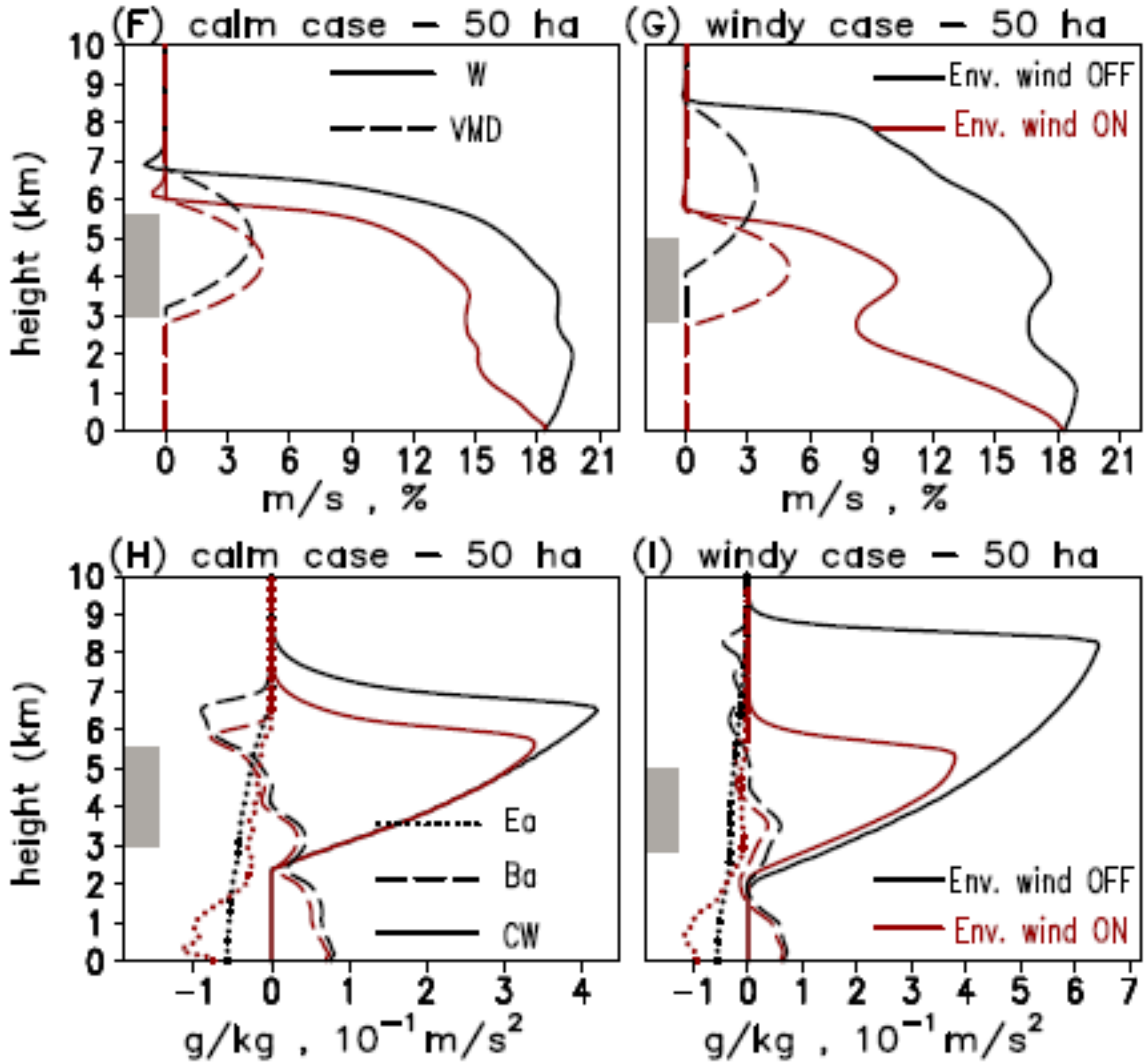


$$\lambda_{\text{entr}} = \frac{2\alpha}{R}|w|$$

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

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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Thank you!

Questions?

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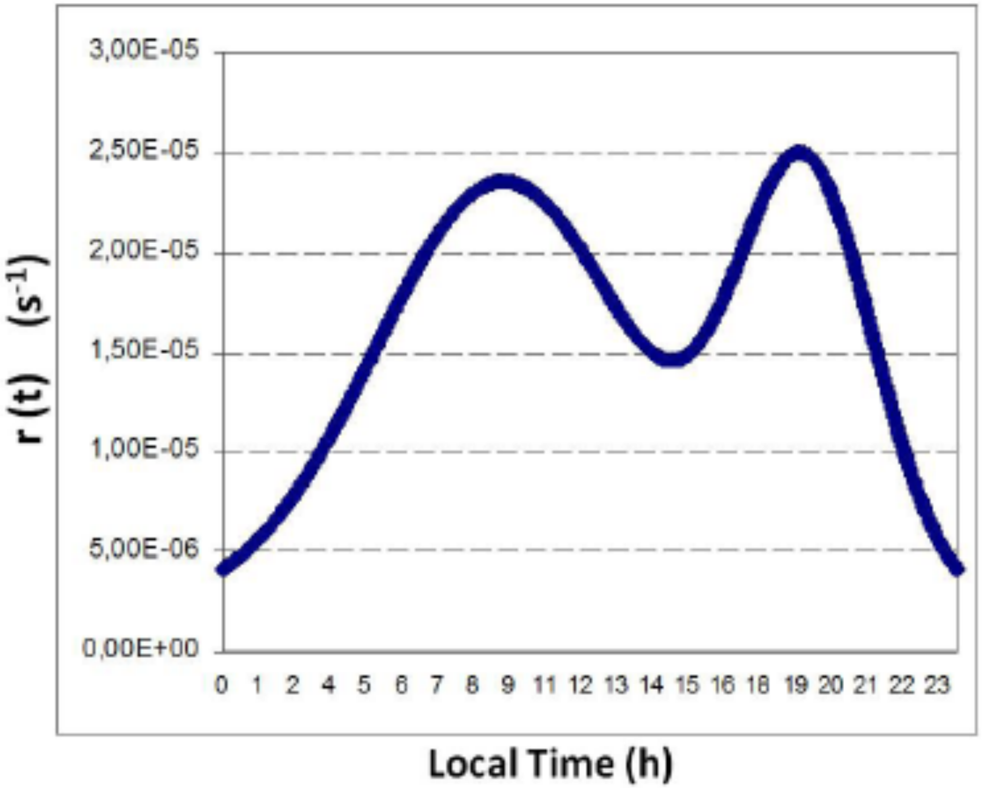
Anthropogenic emissions

Diurnal cycle is applied inside WRF



$$\int_0^{86400} r(t)dt = 1,$$

$$\bar{E}_\eta(k,t) = \begin{cases} \frac{F_\eta}{\bar{\rho}(k_1)\ \Delta z_1} r(t),\ k = 1 \text{ (surface)} \\ 0,\ k > 1 \text{ (above)} \end{cases},$$

Alonso et al. (2010)