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

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PREP-CHEM-SRC
(emiss_opt=5: GOCART RACM_KPP)

Emissions Methodology
    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° x 0.5°, monthly, 1960-2000)

**EDGAR v4.2** (0.1° x 0.1°, annual, 1970-2008)
- CO₂, CH₄, N₂O, HFCs, PFCs, SF₆

**GOCART**
- OC, BC and SO₂ (1° x 1°, annual, 2006)
- DMS (1° x 1.25°, monthly)
- NO₃, H₂O₂ and OH (3D, 1° x 1.25°, monthly, 2006)
Anthropogenic emissions

Diurnal cycle is applied inside WRF

\[
\int_{0}^{86400} r(t) \, dt = 1,
\]

\[
\bar{E}_\eta(k, t) = \left\{ \begin{array}{ll}
\frac{F_\eta}{\bar{\rho}(k_1) \Delta z_1} r(t), & k = 1 \text{ (surface)} \\
0, & k > 1 \text{ (above)}
\end{array} \right.
\]

Alonso et al. (2010)
Anthropogenic emissions

Example for Alaska
Anthropogenic emissions

AREA DELIMITTER 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 (bio_emiss_opt=0)

1) GEIA
   $10^\circ \times 10^\circ$, 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
   $0.5^\circ \times 0.5^\circ$, 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 $0.2^\circ$ grid
Alonso et al. (2010)
Biofuel burning in the developing world

Emissions_Yevich_Logan

$10^0 \times 10^0$, 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)
$1^\circ \times 1^\circ$, 8-day or monthly, 1997 - 2004

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

Freitas et al. (2011)
Biomass burning emissions inventory
Regional scale – daily basis

6 types of biomes
110 chemical species
Near real time fire product

Andreae and Merlet, 2001
Emission & combustion factors

<table>
<thead>
<tr>
<th>Biome category</th>
<th>Emission Factor for CO (g/kg)</th>
<th>Emission Factor for PM2.5 (g/kg)</th>
<th>Aboveground biomass density (kg/ha)</th>
<th>Combustion factor (β, fraction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical forest¹</td>
<td>110</td>
<td>8.3</td>
<td>20.7</td>
<td>0.48</td>
</tr>
<tr>
<td>South America savanna²</td>
<td>63.</td>
<td>4.4</td>
<td>0.9</td>
<td>0.78</td>
</tr>
<tr>
<td>Pasture</td>
<td>49.</td>
<td>2.1</td>
<td>0.7</td>
<td>1.00</td>
</tr>
</tbody>
</table>

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

\[ M[\eta] = \alpha_{\text{veg}} \cdot \beta_{\text{veg}} \cdot E_{\text{fr}}^{[\eta]} \cdot a_{\text{fire}}, \]

Freitas et al., 2005; Longo et al., 2007
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: \( E_\eta = \frac{\lambda F_\eta}{\rho_{\text{air}} \Delta z_{\text{first phys. model layer}}} \)

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

Example in the model:

Flaming emission

Smoldering emission

Injection layer

diurnal cycle of the burning for S. America:

\[ E_\eta(t) = r(t) E_\eta \]

Freitas et al. (2011)
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

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

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

\[ \delta_{\text{entr}} = \frac{2}{\pi R} \left( u_e - u \right) \]

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

Freitas et al. (2010)
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° rectangular projection grid: (A) Diehl (2009), (B) 3BEM, (C) EDGAR

Freitas et al. (2011)
Compiling PREP-SRC-CHEM

Install libraries: netCDF, Zlib, HDF5
Set library paths in:
PREP-CHEM-SRC-1.x/bin/build/include.mk.<compiler>
make OPT=<compiler>.wrf CHEM=RADM_WRF_FIM

Executable: prep_chem_sources_RADM_WRF_FIM.exe
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,
---- 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

렌더링된 이미지는 단일 페이지의 문서를 나타내며, 일부 previous extracted text가 포함되어 있습니다. 다음은 naturallly의 plain text representation입니다.

```
./prep_chem_sources_RADM_WRF_FIM.exe

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

wrfinput_d01

../chem/convert_emiss.exe

netCDF emissions (wrfchemi*, wrffirechemi*, wrfchemi_gocart_bg_*)

./real.exe (chem_opt=0)
```


Thank you!

Questions?

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