Run WRF-GHG

Dra. Noelia Rojas Benavente

registry.chem

```
# GHG emission variables
state   real     -              ivjf     eghg_bio       -       -       -        -              "All biospheric GHG fluxes "                 ""
state   real     ebio_gee       ivjf     eghg_bio       1       Z       hr       "EBIO_GEE"     "biospheric VPRM CO2 uptake"                 "mol km^-2 hr^-1"
state   real     ebio_res       ivjf     eghg_bio       1       Z       hr       "EBIO_RES"     "biospheric VPRM CO2 release"                "mol km^-2 hr^-1"
state   real     ebio_ch4wet    ivjf     eghg_bio       1       Z       hr       "EBIO_CH4WET"  "Biogenic CH4 wetland emissions"          "mol km^-2 hr^-1"
state   real     ebio_ch4soil   ivjf     eghg_bio       1       Z       hr       "EBIO_CH4SOIL" "CH4 soil uptake fluxes"                     "mol km^-2 hr^-1"
state   real     ebio_ch4term   ivjf     eghg_bio       1       Z       hr       "EBIO_CH4TERM" "CH4 termite emissions"                      "mol km^-2 hr^-1"
```

fluxes

```
# GHG chem packages, passive tracers
package   co2_tracer        chem_opt==16            -            chem:co2_ant,co2_bio,co2_bio_gee,co2_bio_res,co2_oce,co2_bck,co2_tst,co_ant,co_bck
package   ghg_tracer        chem_opt==17            -            chem:co2_ant,co2_bio,co2_bio_gee,co2_bio_res,co2_oce,co2_bck,co2_tst,co2_bbu,co_ant,co_bck,co_bbu,co_ts
ch4_tst,co2tst_nonsilesia,ch4tst_nonsilesia,co2tst1,ch4tst1,co2tst2,ch4tst2,co2tst3,ch4tst3,co2tst4,ch4tst4,co2tst5,ch4tst5,co2tst6,ch4tst6,co2tst7,ch4tst7,co2tst8,ch4tst
0
```

```
state   real    tr18_9     ikjftb  tracer        1         -     i8rhusdf=(bdy_interp:dt)    "tr18_9"         "tr18_9"          -

# GHG chem arrays, Chem Scalars for CO2 used in the GHG options
state   real  co2_bio_gee  ikjftb   chem         1         -     i0{12}rhusdf=(bdy_interp:dt)  "CO2_BIO_GEE"   "mixing ratio of VPRM CO2, GEE-only"          "ppmv"
state   real  co2_bio_res  ikjftb   chem         1         -     i0{12}rhusdf=(bdy_interp:dt)  "CO2_BIO_RES"   "mixing ratio of VPRM CO2, RES-only"        "ppmv"
state   real    co2_bio    ikjftb   chem         1         -     i0{12}rhusdf=(bdy_interp:dt)  "CO2_BIO"       "mixing ratio of VPRM CO2"                  "ppmv"
state   real    co2_ant    ikjftb   chem         1         -     i0{12}rhusdf=(bdy_interp:dt)  "CO2_ANT"       "mixing ratio of anthropogenic CO2"         "ppmv"
state   real    co2_oce    ikjftb   chem         1         -     i0{12}rhusdf=(bdy_interp:dt)  "CO2_OCE"       "mixing ratio of ocean CO2"                 "ppmv"
state   real    co2_bck    ikjftb   chem         1         -     i0{12}rhusdf=(bdy_interp:dt)  "CO2_BCK"       "mixing ratio of background CO2"            "ppmv"
state   real    co2_bbu    ikjftb   chem         1         -     i0{12}rhusdf=(bdy_interp:dt)  "CO2_BBU"       "mixing ratio of biomass burning CO2"       "ppmv"
state   real    co2_tst    ikjftb   chem         1         -     i0{12}rhusdf=(bdy_interp:dt)  "CO2_TST"      "mixing ratio of CO2, anthropogenic test fluxes"    "ppmv"
```

module_ghg_fluxes.F

```
   ! 2D biospheric fluxes:
   if (k==1) then
      ! Modification:
      ! Divide co2_bio into 3 different tracers
      chem(i,1,j,p_co2_bio)= chem(i,1,j,p_co2_bio) + conv_rho* (eghg_bio(i,1,j,p_ebio_gee) + eghg_bio(i,1,j,p_ebio_res))
      chem(i,1,j,p_co2_oce)= chem(i,1,j,p_co2_oce) + conv_rho* ebio_co2oce(i,j)
      chem(i,1,j,p_co2_bio_gee)= chem(i,1,j,p_co2_bio_gee) + conv_rho* eghg_bio(i,1,j,p_ebio_gee) !uptake
      chem(i,1,j,p_co2_bio_res)= chem(i,1,j,p_co2_bio_res) + conv_rho* eghg_bio(i,1,j,p_ebio_res) ! release
   end if
```

```
! 2D biospheric fluxes:
if (k==1) then
   ! Modification:
   ! Divide ch4_bio into 3 different tracers
   chem(i,1,j,p_ch4_bio)= chem(i,1,j,p_ch4_bio) + conv_rho* (eghg_bio(i,1,j,p_ebio_ch4wet) + eghg_bio(i,1,j,p_ebio_ch4soil) &
                                                           + eghg_bio(i,1,j,p_ebio_ch4term))
   chem(i,1,j,p_ch4_bio_wet)= chem(i,1,j,p_ch4_bio_wet) + conv_rho* eghg_bio(i,1,j,p_ebio_ch4wet)
   chem(i,1,j,p_ch4_bio_soil)= chem(i,1,j,p_ch4_bio_soil) + conv_rho* eghg_bio(i,1,j,p_ebio_ch4soil)
   chem(i,1,j,p_ch4_bio_term)= chem(i,1,j,p_ch4_bio_term) + conv_rho* eghg_bio(i,1,j,p_ebio_ch4term)
end if
```

```
DO j=jts,jte
   DO i=its,ite
      !  3D anthropogenic fluxes
      DO k=kts,min(config_flags%kemit,kte)
         conv_rho=8.0461e-6/rho_phy(i,k,j)*dtstep/dz8w(i,k,j)  ! 8.0461e-6=molar_mass(air)/3600, [g/mol/s]
         chem(i,k,j,p_ch4_ant)= chem(i,k,j,p_ch4_ant) + conv_rho* emis_ant(i,k,j,p_e_ch4)
         chem(i,k,j,p_ch4_tst)= chem(i,k,j,p_ch4_tst) + conv_rho* emis_ant(i,k,j,p_e_ch4tst)
         chem(i,k,j,p_co_tst) = chem(i,k,j,p_co_tst)  + conv_rho* emis_ant(i,k,j,p_e_cotst)

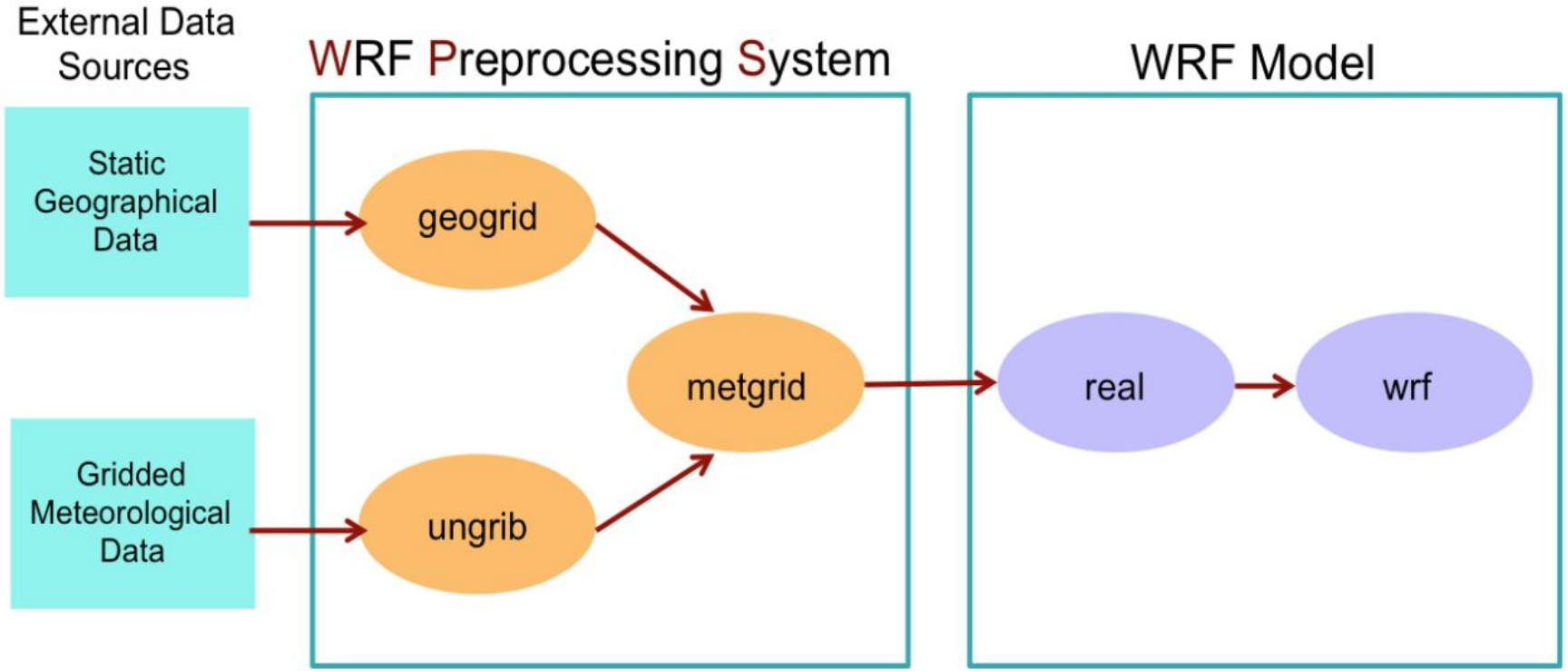
         ! Additional tagged tracers for CoMet Reanalysis_2
         chem(i,k,j,p_co2tst_nonsilesia) = chem(i,k,j,p_co2tst_nonsilesia) + conv_rho* emis_ant(i,k,j,p_e_co2tst_nonsilesia)
         chem(i,k,j,p_ch4tst_nonsilesia) = chem(i,k,j,p_ch4tst_nonsilesia) + conv_rho* emis_ant(i,k,j,p_e_ch4tst_nonsilesia)
         chem(i,k,j,p_co2tst1) = chem(i,k,j,p_co2tst1) + conv_rho* emis_ant(i,k,j,p_e_co2tst1)
         chem(i,k,j,p_ch4tst1) = chem(i,k,j,p_ch4tst1) + conv_rho* emis_ant(i,k,j,p_e_ch4tst1)
         chem(i,k,j,p_co2tst2) = chem(i,k,j,p_co2tst2) + conv_rho* emis_ant(i,k,j,p_e_co2tst2)
         chem(i,k,j,p_ch4tst2) = chem(i,k,j,p_ch4tst2) + conv_rho* emis_ant(i,k,j,p_e_ch4tst2)
         chem(i,k,j,p_co2tst3) = chem(i,k,j,p_co2tst3) + conv_rho* emis_ant(i,k,j,p_e_co2tst3)
         chem(i,k,j,p_ch4tst3) = chem(i,k,j,p_ch4tst3) + conv_rho* emis_ant(i,k,j,p_e_ch4tst3)
         chem(i,k,j,p_co2tst4) = chem(i,k,j,p_co2tst4) + conv_rho* emis_ant(i,k,j,p_e_co2tst4)
         chem(i,k,j,p_ch4tst4) = chem(i,k,j,p_ch4tst4) + conv_rho* emis_ant(i,k,j,p_e_ch4tst4)
         chem(i,k,j,p_co2tst5) = chem(i,k,j,p_co2tst5) + conv_rho* emis_ant(i,k,j,p_e_co2tst5)
         chem(i,k,j,p_ch4tst5) = chem(i,k,j,p_ch4tst5) + conv_rho* emis_ant(i,k,j,p_e_ch4tst5)
```

chemics_init.F

```
! Tropics are still preliminary, too strong SWDOWN might cause too high uptake
!DATA vprm_table_tropics &
!     / 501.0, 324.0, 206.0, 303.0, 682.0, 646.0, 157.0, 0.0, &
!      -0.2101, -0.1729, -0.2555, -0.0874, -0.1141, -0.1209, -0.1334, 0.0000, &
!       0.1601, 0.3258, 0.3422, 0.0239, 0.0049, 0.0043, 0.0269, 0.0000, &
!       0., 0., 0., 0., 0., 0., 0., 0. /

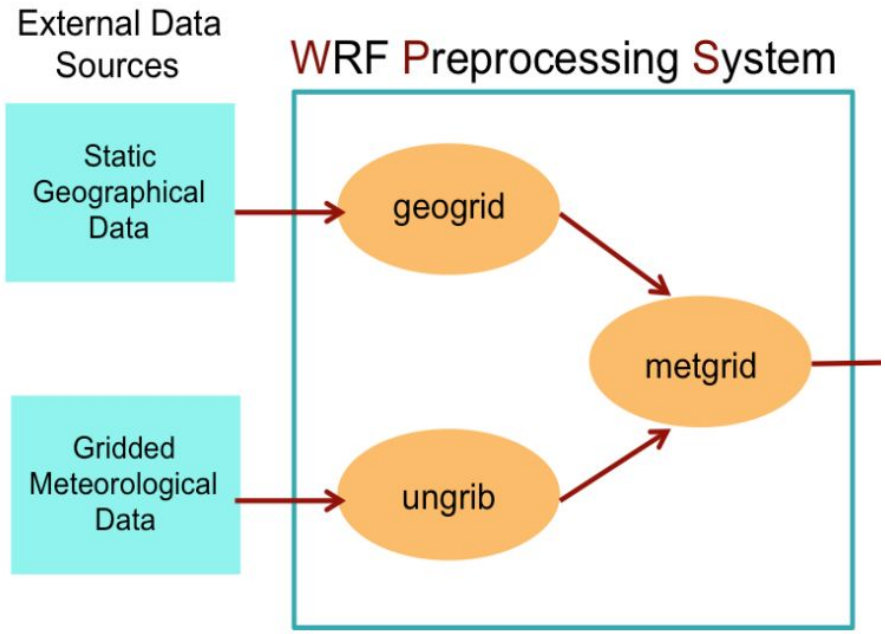
! Update of vprm_table_tropics following e-mail exchange by C. Gerbig and Samtiago Botia
! Implemented by in Jan 2019
! Original comment:
! "Tropics version from Jan 2013, optimized using LBA flux data 2001-2010"
DATA vprm_table_tropics &
      / 993.9, 324.0, 206.0, 303.0, 6860.7, 2329.0, 15475.5, 0.0, &
       -0.1096, -0.1729, -0.2555, -0.0874, -0.0277, -0.0417, -0.0568, 0.0000, &
        0.2114, 0.3258, 0.3422, 0.0239, -0.2535, -0.0814, -0.3122, 0.0000, &
        1.8187, 0., 0., 0., 7.1125, 3.6716, 7.3377, 0. /
```


```
DATA vprm_table_tropics &
      / 993.9, 324.0, 206.0, 303.0, 6860.7, 2329.0, 15475.5, 0.0, &
       -0.1096, -0.1729, -0.2555, -0.0874, -0.0277, -0.0417, -0.0568, 0.0000, &
        0.2114, 0.3258, 0.3422, 0.0239, -0.2535, -0.0814, -0.3122, 0.0000, &
        1.8187, 0., 0., 0., 7.1125, 3.6716, 7.3377, 0. /
```


External Data Sources
WRF Preprocessing System
WRF Model
Static Geographical Data
Gridded Meteorological Data
geogrid
ungrib
metgrid
real
wrf

MapBiomas

ERA 5 ~25km



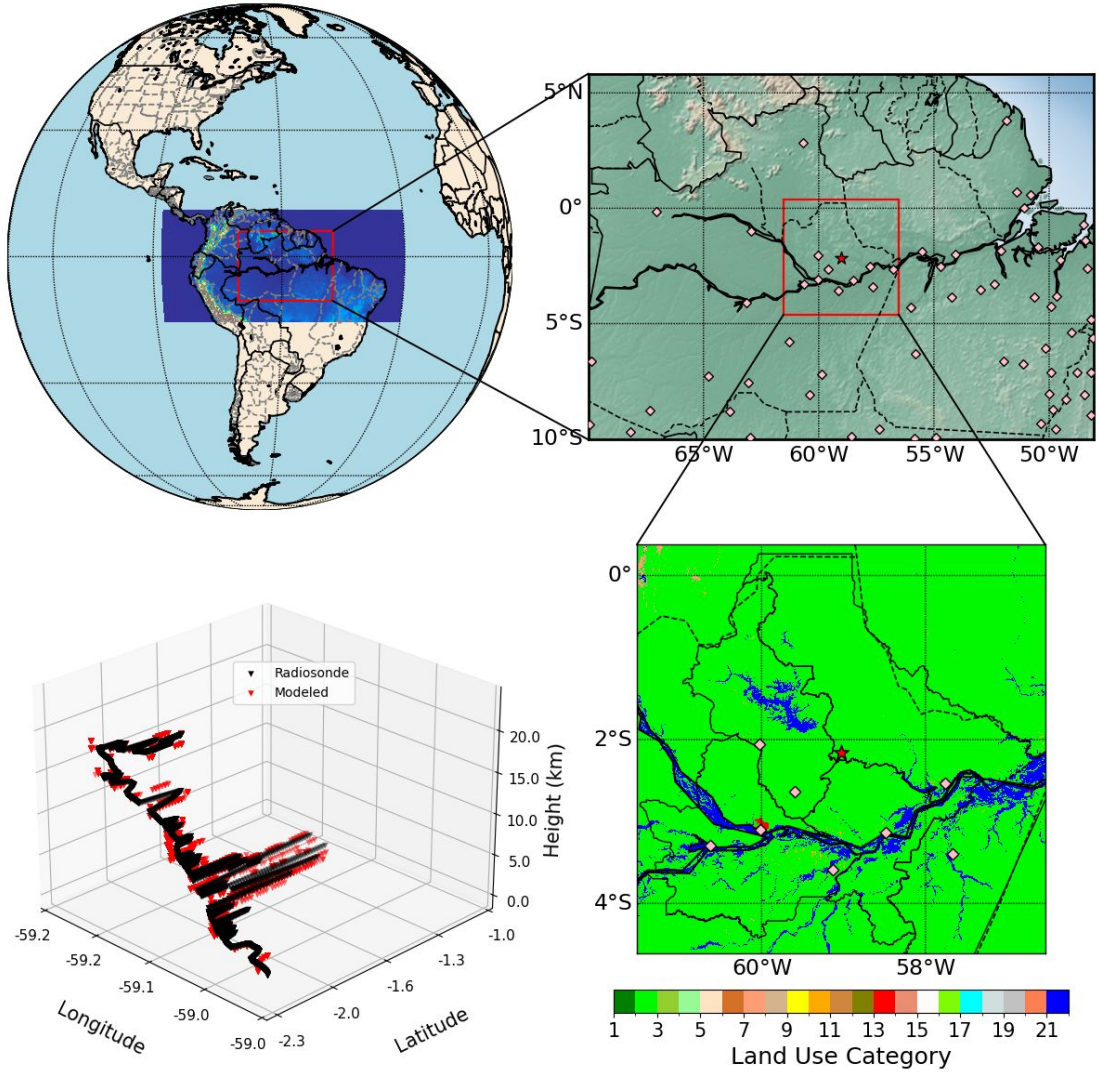
namelist.wps

Study Area

ATTO Tower: (-59.02972,-2.15764)

- 3 domains (18km, 6km e 2km)
- 281 x 281 points
- centered ATTO tower

ncl util/plotgrids_new.ncl



WRF-GHG model setup

namelist.input

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met_em.d02.2023-01-23_00:00:00.nc
met_em.d02.2023-01-23_06:00:00.nc
met_em.d02.2023-01-23_12:00:00.nc
met_em.d02.2023-01-23_18:00:00.nc
met_em.d02.2023-01-24_00:00:00.nc
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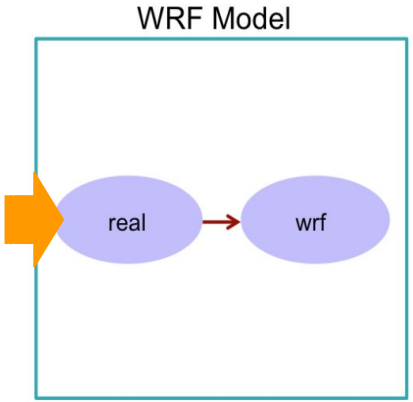

WRF

physics → **Table**

	D1	D2	D3
mp_physics	Morrison-2- moment	Morrison-2- moment	Morrison-2- moment
cu_physics	Grell 3D Ensemble	Grell 3D Ensemble	Grell 3D Ensemble
ra_lw_physics	RRTMG	RRTMG	RRTMG
ra_sw_physics	RRTMG	RRTMG	RRTMG
sf_sfclay_physics	Revised MM5	Revised MM5	Revised MM5
sf_surface_physics	Unified Noah Land Surface	Unified Noah Land Surface	Unified Noah Land Surface
bl_pbl_physics	Yonsei University	Yonsei University	Yonsei University

WRF-GHG model setup

met_em.d02.2023-01-22_00:00:00.nc
met_em.d02.2023-01-22_06:00:00.nc
met_em.d02.2023-01-22_12:00:00.nc
met_em.d02.2023-01-22_18:00:00.nc
met_em.d02.2023-01-23_00:00:00.nc
met_em.d02.2023-01-23_06:00:00.nc
met_em.d02.2023-01-23_12:00:00.nc
met_em.d02.2023-01-23_18:00:00.nc
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met_em.d02.2023-01-25_00:00:00.nc
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met_em.d02.2023-01-26_12:00:00.nc
met_em.d02.2023-01-26_18:00:00.nc
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met_em.d02.2023-01-27_06:00:00.nc
met_em.d02.2023-01-27_12:00:00.nc
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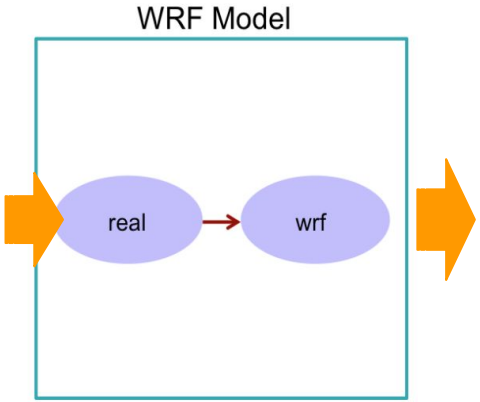

namelist.input

```
&physics
progn                               = 1,     1,     1,    1,
naer                                = 1e9
mp_physics                          = 10,    10,    10,   10,
cu_physics                          = 5,     5,     5,    5,
ra_lw_physics                       = 4,     4,     4,    3,
ra_sw_physics                       = 4,     4,     4,    3,
sf_sfclay_physics                   = 1,     1,     1,    1,
sf_surface_physics                  = 2,     2,     2,    2,
bl_pbl_physics                      = 1,     1,     1,    5,
radt                                = 18,    6,     2,   27,
bldt                                = 0,     0,     0,    0,
cudt                                = 0,     0,     0,    5,
cu_diag                             = 1,     1,     1,    1,
isfflx                              = 1,                  ! or
ifsnow                              = 0,
icloud                              = 1,
cugd_avedx                          = 1,
topo_wind                           = 2,                  ! 1:
surface_input_source                = 1,
num_soil_layers                     = 4,
num_land_cat                        = 21,
sf_urban_physics                    = 0,     0,    0,    0,
mp_zero_out_thresh                  = 1.e-8,
ishallow                            = 0,                  ! Shal
shcu_physics                        = 0,
maxiens                             = 1,
maxens                              = 3,
maxens2                             = 3,
maxens3                             = 16,
ensdim                              = 144,
cu_rad_feedback                     = .true., .true., .true.,
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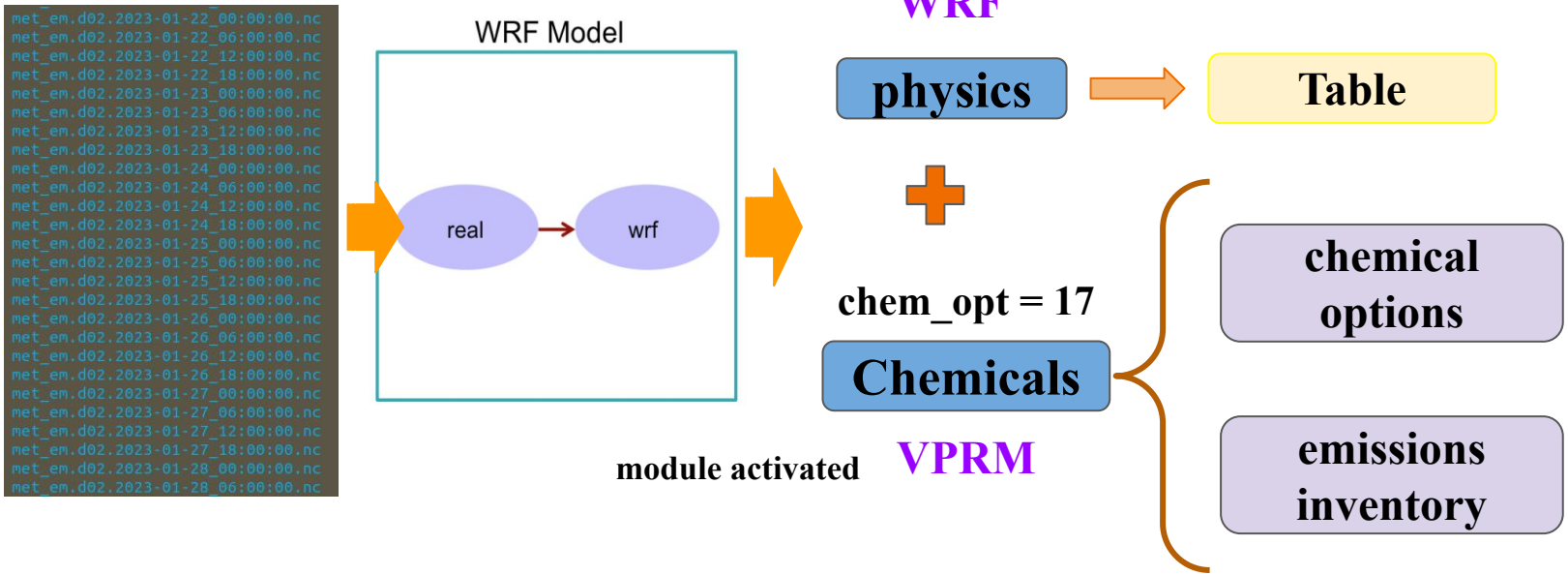
WRF-GHG model setup

namelist.input



WRF-GHG model setup

chemical options

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met_em.d02.2023-01-22_18:00:00.nc
met_em.d02.2023-01-23_00:00:00.nc
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met_em.d02.2023-01-23_18:00:00.nc
met_em.d02.2023-01-24_00:00:00.nc
met_em.d02.2023-01-24_06:00:00.nc
met_em.d02.2023-01-24_12:00:00.nc
met_em.d02.2023-01-24_18:00:00.nc
met_em.d02.2023-01-25_00:00:00.nc
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met_em.d02.2023-01-26_06:00:00.nc
met_em.d02.2023-01-26_12:00:00.nc
met_em.d02.2023-01-26_18:00:00.nc
met_em.d02.2023-01-27_00:00:00.nc
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met_em.d02.2023-01-27_12:00:00.nc
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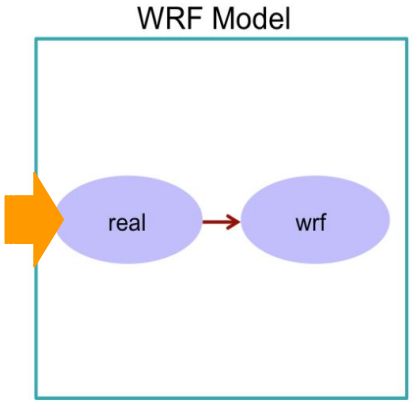
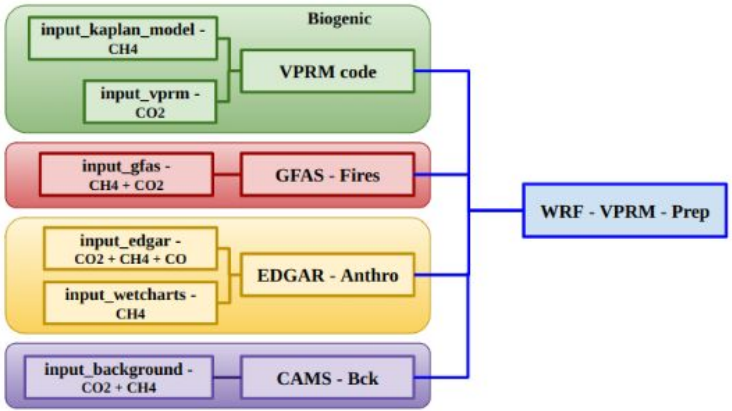



```
&chem
kemit                               = 8,
chem_opt                            = 17,     17,  17,    0,
bioemdt                             = 18,      6,   2,    1,
photdt                              = 30,     30,  30,   30,
chemdt                              = 1.,     1.,  1.,   1.,
!frames_per_emissfile               = 36,
io_style_emissions                  = 2,
emiss_inpt_opt                      = 16,     16,   16,   16,
emiss_opt                           = 17,     17,   17,   17,
chem_in_opt                         = 0,       0,    0,   0,
phot_opt                            = 0,       0,    0,   0,
gas_drydep_opt                      = 0,       0,    0,   0,
aer_drydep_opt                      = 0,       0,    0,   0,
bio_emiss_opt                       = 17,     17,   17,  17,
dust_opt                            = 0,
dmsemis_opt                         = 0,
seas_opt                            = 0,
gas_bc_opt                          = 0,       0,    0,    0,
gas_ic_opt                          = 0,       0,    0,    0,
aer_bc_opt                          = 0,       0,    0,    0,
aer_ic_opt                          = 0,       0,    0,    0,
gaschem_onoff                       = 0,       0,    0,    0,
aerchem_onoff                       = 0,       0,    0,    0,
wetscav_onoff                       = 0,       0,    0,    0,
cldchem_onoff                       = 0,       0,    0,    0,
vertmix_onoff                       = 1,       1,    1,    1,
! As per suggestion by Ravan Ahmadov from 07.06.2018
conv_tr_wetscav                     = 0,
chem_conv_tr                        = 1,       1,    1,    1,
biomass_burn_opt                    = 5,       5,    5,    5,
plumerisefire_frq                   = 0,       0,    0,    0,
aer_ra_feedback                     = 0,       0,    0,    0,
have_bcs_chem                       = .true., .false., .flase.,  .false.,
have_bcs_tracer                     = .true., .false., .false.,  .false.,
vprm_opt                            = "VPRM_table_TROPICS", "VPRM_table_TROPICS","VPRM_table_TROPICS","VPRM_table_TROPICS",
! wpeat                              = 0.05,
! wflood                             = 0.19,
! term_opt                           = "CH4_termite_OW",
/
```

Emissions inventory

WRF-VPRM-PrepPy

The Weather Research and Forecasting (WRF) Model is a state of the art mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications. The model serves a wide range of meteorological applications across scales from tens of meters to thousands of kilometers. Furthermore, a coupled with the Vegetation Photosynthesis and Respiration Model (VPRM) (referred to as WRF-VPRM), has used to better understand the effects that mesoscale transport has on atmospheric CO2 distributions.



https://github.com/rnoeliab/WRF-VPRM-Prepy?tab=readme-ov-file

Emissions inventory

Biogenic

Preparation of biogenic emissions

First part

Wetland map
annual soil temperature
CPOOL

EVI
LSWI
vegetation fraction

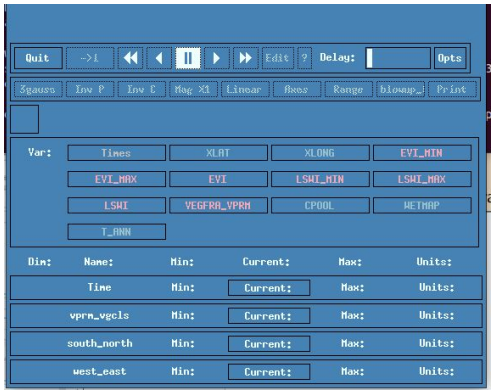
input Kaplan model
(biogenic emissions for CH_4)

VPRM pre-processor
(biogenic emissions for CO_2)

Biogenic emissions

input VPRM

WRF-GHG model
opt = 17



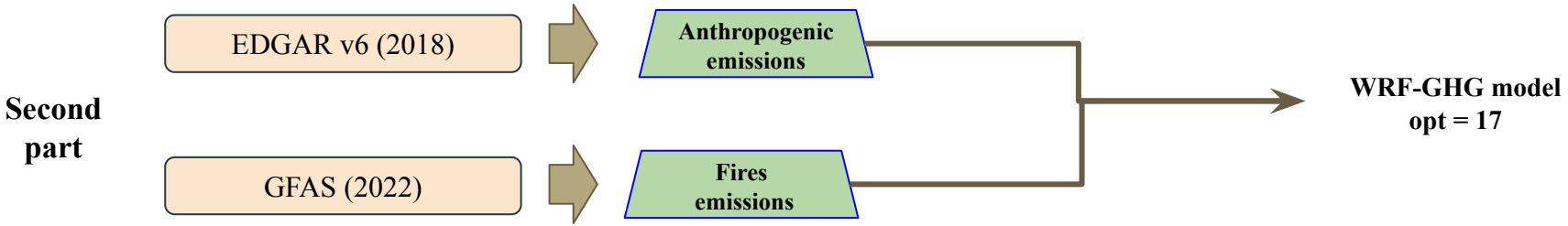
https://github.com/tglauch/pyVPRM_examples/tree/main

with python

Emissions inventory

Anthro | **Biogenic** | **Fires**

Preparation of anthropogenic and fires emissions



B. Anthropogenic Emissions

Preparing the Anthropogenic emissions (EDGAR + Wetchart):

EDGAR -- GHG emissions

- Firstly - check if the "download_edgar_ghg.sh" script is ready to be executed:

```
$ chmod +x download_edgar_ghg.sh
$ ./download_edgar_ghg.sh
```

C. Fire Emissions

Preparing the Fire emissions:

- Firstly - to obtain fire emissions data from GFAS website, it is necessary to perform some previous steps:

```
1. Create ".cdsapirc" in the $HOME/ directory
   gedit .cdsapirc &
2. to type:
   # To GFAS
   url: https://ads.atmosphere.copernicus.eu/api/v2
   key: <UID>:<APIKEY>
```

Emissions inventory

Anthro | Biogenic | Fires | Background

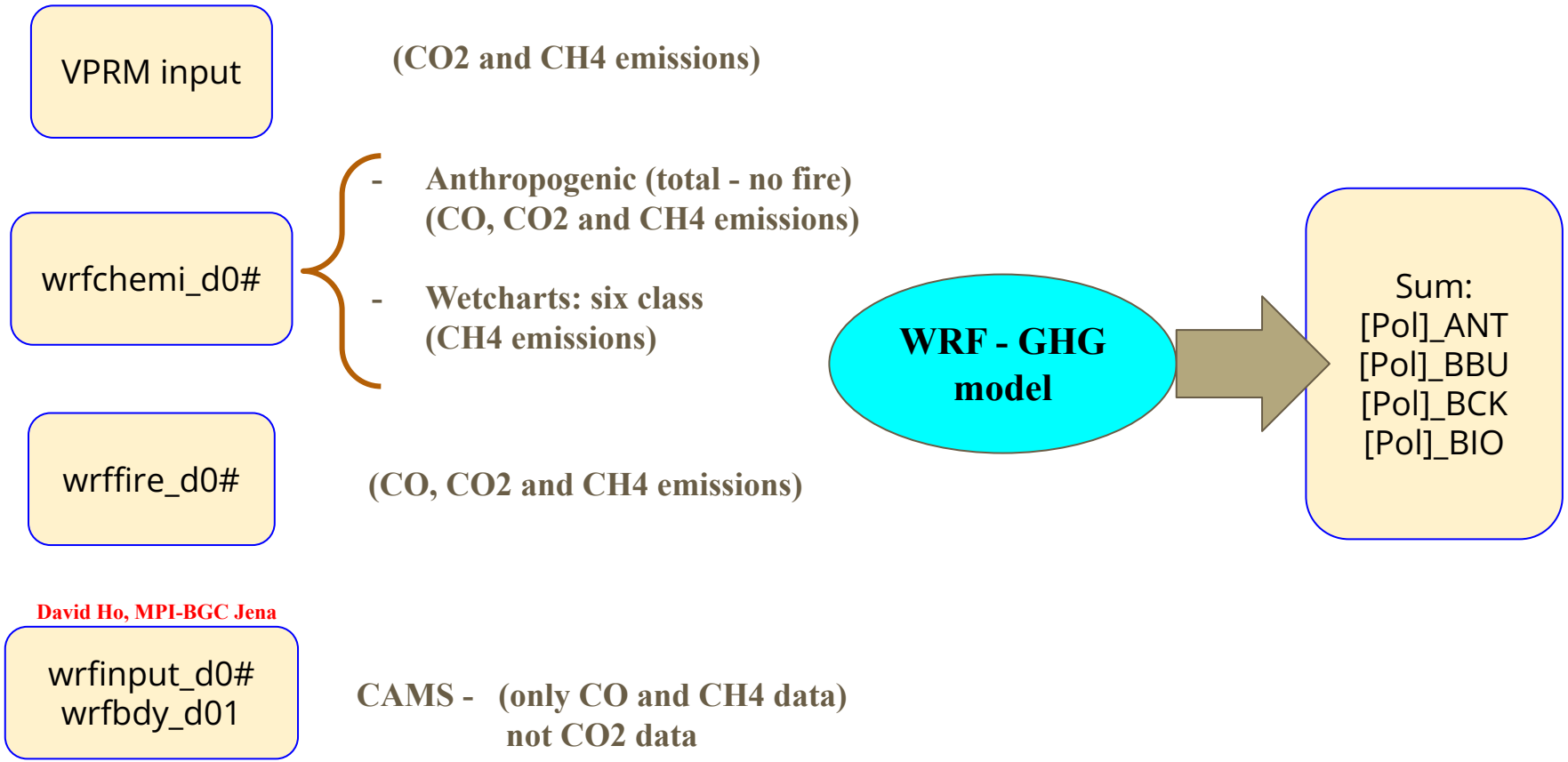
Preparation of background emissions

third part — CAMS

Initial and Boundary conditions

WRF-GHG model
opt = 17

First tests using VPRM processor in the WRF-GHG model



in-situ vs model

$CO2_{ATTO}$ VS $CO2_{model}$

$$CO2_{model} = CO2_{BIO} + CO2_{BBU} + CO2_{ANT} + CO2_{BCK}$$

$CH4_{ATTO}$ VS $CH4_{model}$

$$CH4_{model} = CH4_{BIO\text{-}KAPLAN} + CH4_{BBU} + CH4_{ANT} + CH4_{BCK}$$

$$CH4_{BIO\text{-}KAPLAN} = CH4_{kaplan} + CH4_{SOIL} + CH4_{TERM}$$

is calculated by the VPRM module

$$CH4_{models} = CH4_{WETCHTS} + CH4_{SOIL} + CH4_{TERM} + CH4_{BBU} + CH4_{ANT} + CH4_{BCK}$$

SIX MODELS

Thanks