Future air quality simulations using WRF-Chem

Annually varying GHG concentrations

- Compile WRF in climate mode: Look at Section 4.1 of this link (http://www.meteo.unican.es/wiki/cordexwrf/SoftwareTools/ClWrf). This page has a lot of information but you only need to include the switch -DCLWRFGHG in configure.wrf file. This will enable the long-wave radiation routines to read in annually varying GHG concentrations.

```
#ifdef CLWRFGHG

   CALL read_CAMgases(yr,julian,"RRTMG",co2,n2o,ch4,cfc11,cfc12)

   IF ( wrf_dm_on_monitor() ) THEN
     WRITE(message,*)'CAM-CLWRF interpolated values______ year:',yr,' julian day:',julian
     call wrf_debug( 100, message)
     WRITE(message,*)'  CAM-CLWRF co2vmr: ',co2,' n2ovmr:',n2o,' ch4vmr:',ch4,' cfc11vmr:',cfc11,' cfc12vmr:',cfc12
     call wrf_debug( 100, message)
   ENDIF

#endif
```

“CAMtr_volume_mixing_ratio” is the file read by read_CAMgases. By default, it is linked to RCP8.5 scenario file. Make sure you link it to the correct scenario file before running your case.

Drive WPS/WRF with CESM output files

- CESM output is already converted to the intermediate file format required by WPS and is available from NCAR Research Data Archive (http://rda.ucar.edu/datasets/ds316.1) . See section 6 of NCAR technical note for details: https://opensky.ucar.edu/islandora/object/technotes%3A527
- No need to run ungrib for these files.
- No leap years included in CESM simulations.
- Make sure sst_update is on
- Increase bdy_width to 10.
- Recommended model top is 10 hPa.
- Use buckets for energy and precipitation collections but be careful while analyzing because the bucket is emptied as soon as it reaches the threshold. For example, if the precipitation threshold is 100 mm, the values of RAINC and RAINNC will be set to zero as soon as their total becomes 100. So, it will require some post-processing to calculate annual/seasonal total precipitation.

Chemistry challenges

- Future anthropogenic emissions may not be available at your target resolution. May need to develop your emissions at the target resolution.
- Daily varying future fire emissions as expected by WRF-Chem are not be available.
- We did not consider future land use changes in our studies.
- Inconsistent CO2 values defined in chemistry part of the code. It is set from 350-380 in various parts of the code (module_mosaic_cloudchem.F, module_sorgam_aqchem.F, module_sorgam_vbs_cloudchem.F, module_ctrans_grell.F, and chemics_init.F etc.). Ensure that your CO2 value in chemistry part is consistent with the RCP scenario you are using for that year.
- Recommend using the upper boundary conditions for multi-year simulations to keep key species (e.g., ozone, NOx, N2O, HNO3, N2O5, H2O, CO, and methane) to values representative of stratospheric levels. Simone Tilmes has the tools to convert CAM-Chem output to WRF format for future simulations.

Storage challenges

- Storage can be an issue depending on how many years and scenarios you want to simulate.
- Think about what is your interest and what variables you will need to answer the questions you have.
- We saved key meteorological and chemical variables at the surface and 3-d distributions of selected variables (e.g., CO, ozone, NO2, and extinction coefficient) every hour. Full 3-D output was saved only every hour. This requires some modifications to the code but is really simple.