

CESM1.0.3 tutorial: WACCM and CAM-Chem

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- Transient and static configurations
 - WACCM compsets
 - WACCM driven by specified dynamics (SD-WACCM)
 - WACCM with specified chemistry (SC-WACCM)
 - CAM-Chem compsets
 - Exercise: Change a reaction rate
 - create a case, configure, build and run
 - Satellite and aircraft tracking
 - Local time history averaging



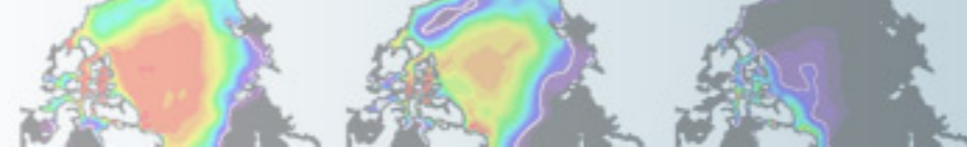
NCAR



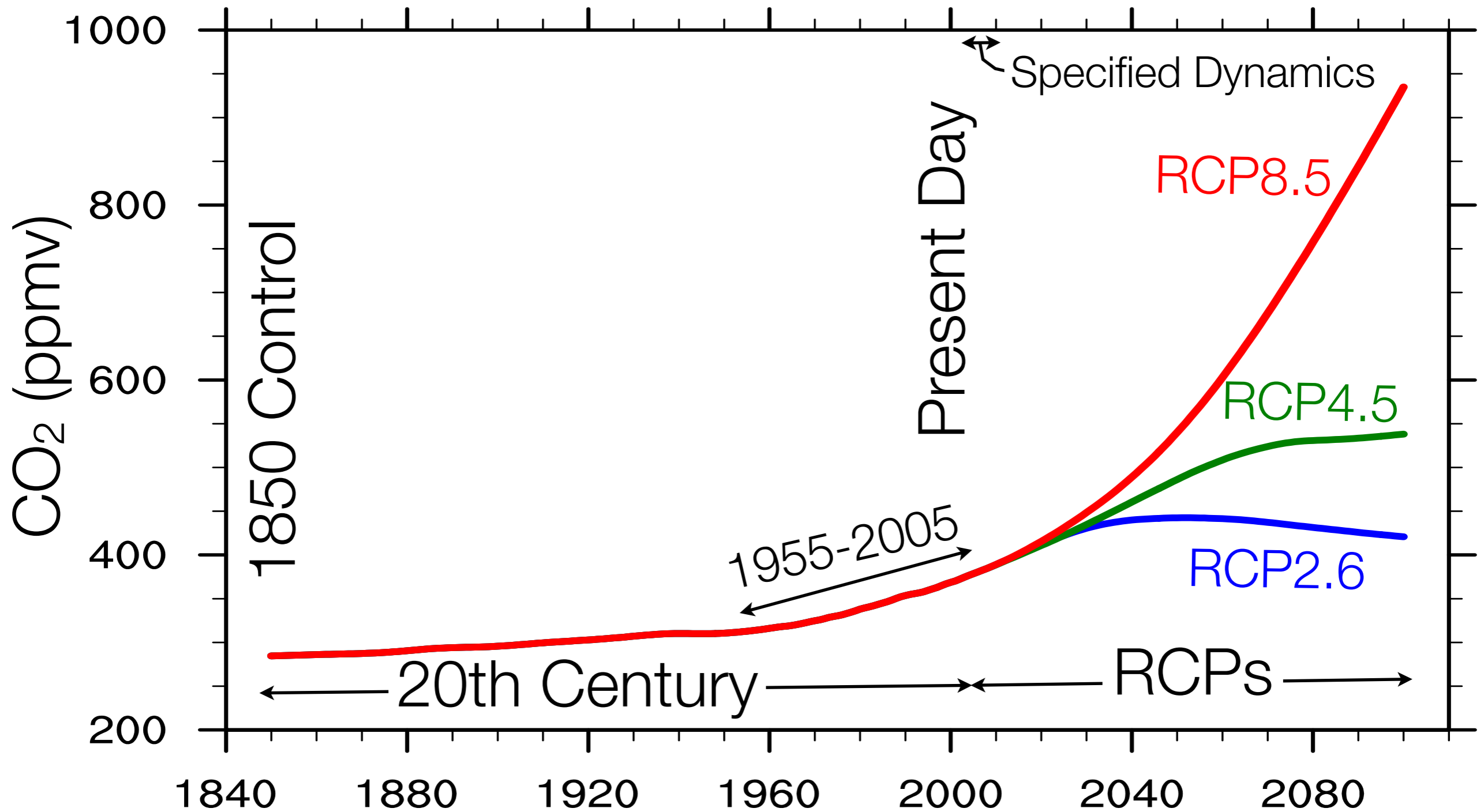
WACCM

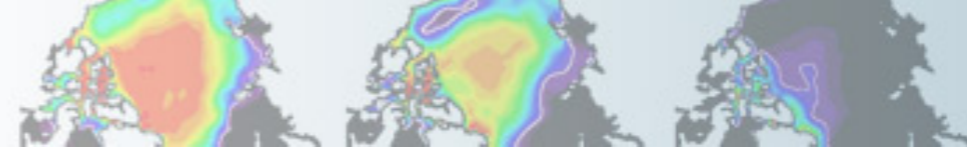
Whole Atmosphere
Community Climate Model





Transient and static WACCM & CAM-Chem configurations

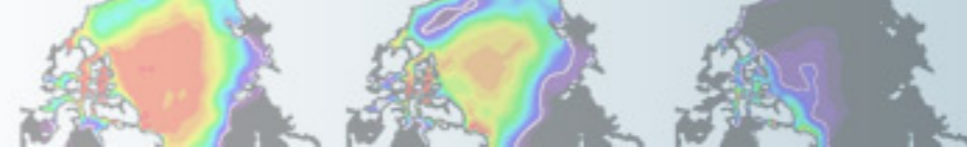




WACCM full ocean/ice model (B-) compsets

- **B_1850_WACCM_CN (B1850WCN)**: Pre-industrial with carbon-nitrogen cycle in CLM, constant solar, no quasi-biennial oscillation (QBO).
- **B_1850-2005_WACCM_CN (B20TRWCN)**: 20th Century (1850-2005 transient) with carbon-nitrogen cycle in CLM, annually varying solar, prescribed QBO.
- **B_2000_WACCM_CN (BWCN)**: Present-day (perpetual year 2000AD).
- **B_1955-2005_WACCM_CN (B55TRWCN)**: 1955 to 2005 transient, with daily varying solar data, solar proton events (SPEs), prescribed QBO.
- **RCP future scenarios**: 2005-2100 transient, with daily varying solar data, SPEs, prescribed QBO.
 - **B_RCP2.6_WACCM_CN (BRCP26WCN)**
 - **B_RCP4.5_WACCM_CN (BRCP45WCN)**
 - **B_RCP8.5_WACCM_CN (BRCP85WCN)**
- **Resolution**: Run B-compsets at 1.9x2.5_gx1v6 (f19_g16).

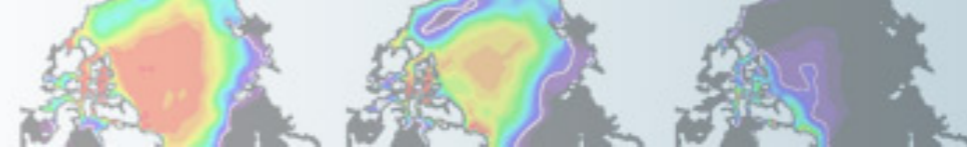




WACCM prescribed sea ice, data ocean (F-) compsets

- **F_1850_WACCM (F1850W)**: Pre-industrial (perpetual year 1850AD)
- **F_2000_WACCM (FW)**: Present-day (perpetual year 2000AD).
- **F_1955-2005_WACCM_CN (F55WCN)**: 1955 to 2005 transient, with daily solar data and SPEs.
- **F_2000_WACCM_SC (FWSC)**: Specified chemistry, perpetual year 2000
- **F_SD_WACCM (FSDW)**: Specified dynamics
- **Resolution**: Run F-compsets at 1.9x2.5_ 1.9x2.5 (f19_f19).



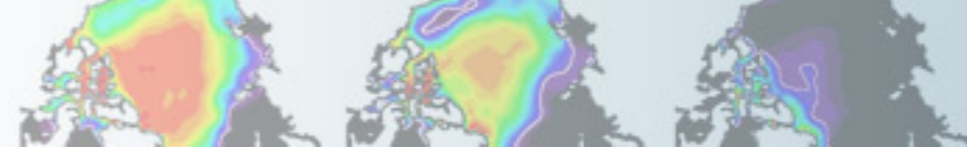


Specified Chemistry: SC-WACCM

- Significantly faster throughput for dynamical studies.
- Run WACCM using limited chemistry, specified from zonally averaged output of a previous WACCM run: CO₂, H, NO, O, O₂, O₃, QRS_TOT (merged SW heating)
- Namelist variables:

```
ghg_chem           = 'true'  
cam_chempkg       = 'waccm_ghg'  
waccm_forcing_datapath= '/path/do/forcing/file'  
waccm_forcing_file  = 'ghg_forcing_2000_c110321.nc'
```
- **F_2000_WACCM_SC** compset repeats year 2000 out of the box. May be modified for transient runs.
- Runs ~2.5 times faster than WACCM with full middle atmosphere chemistry

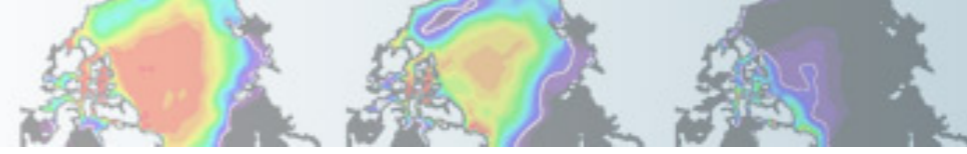




Specified Dynamics: SD-WACCM

- Reproduce winds and temperatures from specific periods in analyses.
- Meteorological fields from NASA GMAO [GEOS5.1] available for 1 Jan 2004 - 1 Oct 2010. **F_SD_WACCM** compset starts on 1 Jan 2005 out of the box.
- GEOS5.1 resolution: $0.5^\circ \times 0.66^\circ$, 72 levels ($\leq 80\text{km}$)
- SD-WACCM resolution: $1.9^\circ \times 2.5^\circ$, 88 levels ($\leq 140\text{km}$)
- Nudge T, U, V, PS by 1% at every dynamics timestep below $\sim 50\text{ km}$, fully interactive dynamics aloft.
- Chemistry: standard **wacm_mozart** middle atmosphere mechanism (57 species, 230 photochemical reactions)
- Ongoing developments for future release:
 - MERRA meteorological fields to cover 1979-2010.
 - MOZART4 troposphere mechanism (122 species, 380 reactions)

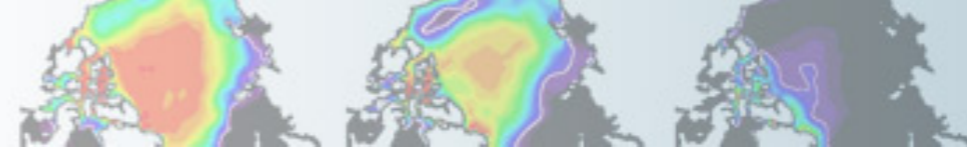




CAM-Chem compsets

- **B_2000_TROP_MOZART (BMOZ)**: CAM4 with trop_mozart (103 species) chemistry, full ocean, present day (perpetual year 2000AD)
- **F_2000_TROP_MOZART (FMOZ)**: CAM4 with trop_mozart, data ocean, present day (perpetual year 2000AD)
- **F_SD_CAMCHEM (FSDCHM)**: CAM4 with specified dynamics, trop_mozart, data ocean
- **F_TROP_STRAT_CHEM (FTSC)**: CAM4 with strat_mozart (trop_mozart + about 20 more species and reactions in the stratosphere), data ocean, present day
- **B_2000_CN_CHEM (B2000CNCHM)**: CAM4 with super_fast_llnl chemistry, full ocean, present day
- **B_1850_CN_CHEM (B1850CNCHM)**: CAM4 with super_fast_llnl, full ocean, pre-industrial
- **F_1850_CN_CHEM (F1850CNCHM)**: CAM4 with super_fast_llnl, data ocean, pre-industrial
- **B_1850-2000_CN_CHEM (B20TRCNCHM)**: CAM4 with super_fast_llnl, full ocean, transient 1850-2000





Setting up a simulation

Run the model out of the box (using an existing compset)

- Create a new case called “f1955-2005.2deg.wcm.001”:

- CESM_ROOT = (/glade/proj3/cseg/collections/cesm1_0_3)

Go to your model directory CESM_ROOT, then cd scripts and invoke:

```
▶ create_newcase -case ~/f1955-2005.2deg.wcm.001
                 -res f19_f19
                 -compset F55WCN
                 -mach bluefire
```

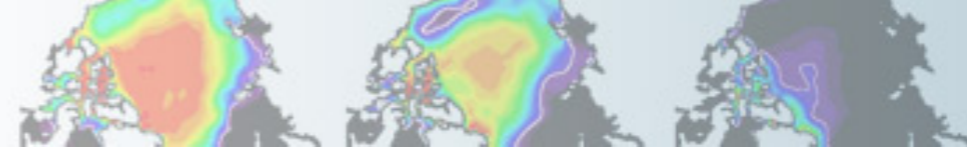
➔ A new directory called “f1955-2005.2deg.wcm.001” is created in your home directory

- cd ~/f1955-2005.2deg.wcm.001

- ls

```
CaseStatus          README.case        check_input_data  env_case.xml      env_run.xml
LockedFiles         SourceMods        configure          env_conf.xml      xmlchange
Macros.bluefire     Tools             create_production_test env_mach_pes.xml
README              check_case        env_build.xml     env_mach_specific
```





Changing a reaction rate

- The **chemistry preprocessor**: generates CAM Fortran source code to solve chemistry.
- Input: a simple ASCII file listing chemical reactions and rates.
- The waccm_mozart input file is in `$CCSMROOT/models/atm/cam/src/chemistry/pp_waccm_mozart/chem_mech.in`

```

SPECIES
  Solution
O3, O, O1D -> O, O2, O2_1S -> O2, O2_1D -> O2
  End Solution

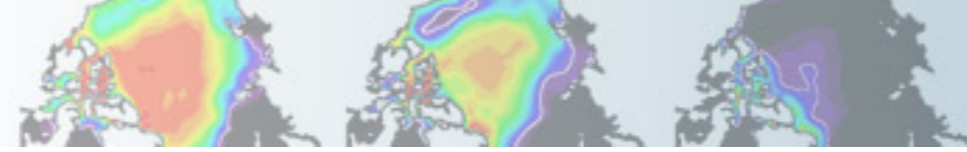
  Fixed
M, N2
  End Fixed
End SPECIES

Solution Classes
  Explicit
  CH4, N2O, CO, H2, CH3CL, CH3BR, CFC11, CFC12
  End explicit
  Implicit
  O3, O, O1D, O2, O2_1S, O2_1D
  End implicit
End Solution Classes

CHEMISTRY
  Photolysis
[jo2_a] O2 + hv -> O + O1D
  End Photolysis

  Reactions
[cph1,cph] O + O3 -> 2*O2 ; 8e-12, -2060
  End Reactions
END CHEMISTRY

```

Configuring the model with new chemistry

- Copy a sample preprocessor input file to the case directory and edit it:

```
> cd $CASEROOT
```

```
> source Tools/ccsm_getenv
```

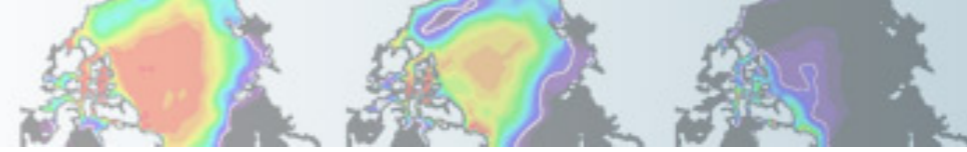
```
> cp $CCSMROOT/models/atm/cam/src/chemistry/pp_waccm_mozart/  
chem_mech.in my_waccm_mech.in"
```

```
> nedit my_waccm_mech.in &
```

- Modify the temperature-dependence of the reaction $O + O_3 \rightarrow 2*O_2$, changing the exponent term from -2060 to -2050:

```
[cph1,cph] O + O3 -> 2*O2 ; 8e-12, -2050
```





Configuring the model with new chemistry

- Edit the file `env_conf.xml` in the case directory to add the CAM configure option `-usr_mech_infile` pointing to the new preprocessor input file:

```
> grep CAM_CONFIG_OPTS env_conf.xml
```

```
<entry id="CAM_CONFIG_OPTS" value="-phys cam4 -chem  
waccm_mozart" /
```

```
> xmlchange -file env_conf.xml -id CAM_CONFIG_OPTS -val  
"-phys cam4 -chem waccm_mozart -usr_mech_infile  
$CASEROOT/my_waccm_mech.in"
```

- IF you had previously configured this case, you would need to clean up via:

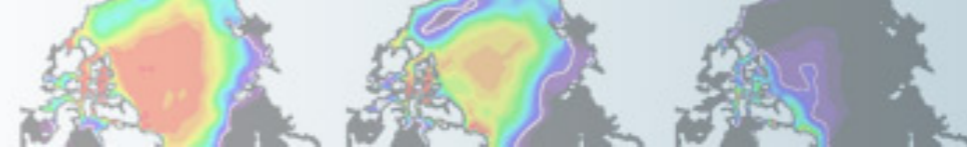
```
> configure -cleanall
```

- Now configure the case:

```
> configure -case
```

- These same steps may be used to change chemistry in CAM-Chem compsets as well.





Building and running the model

- Build the model:

```
> ./*.build
```

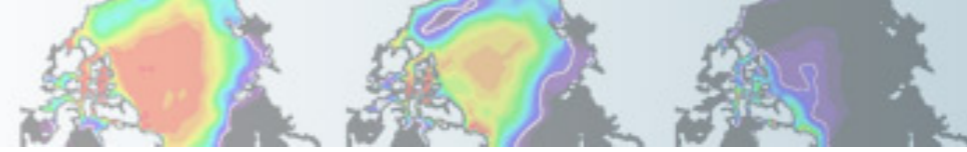
- Edit `env_run.xml` to change the length of the run, number of resubmits, frequency of restart saves, and long-term archiving.
- Edit your `*.run` script to set the maximum wall time, queue, and account number.
- Submit to the batch queue with:

```
> ./*.submit
```

- Check submitted batch jobs:

```
> bjobs
```

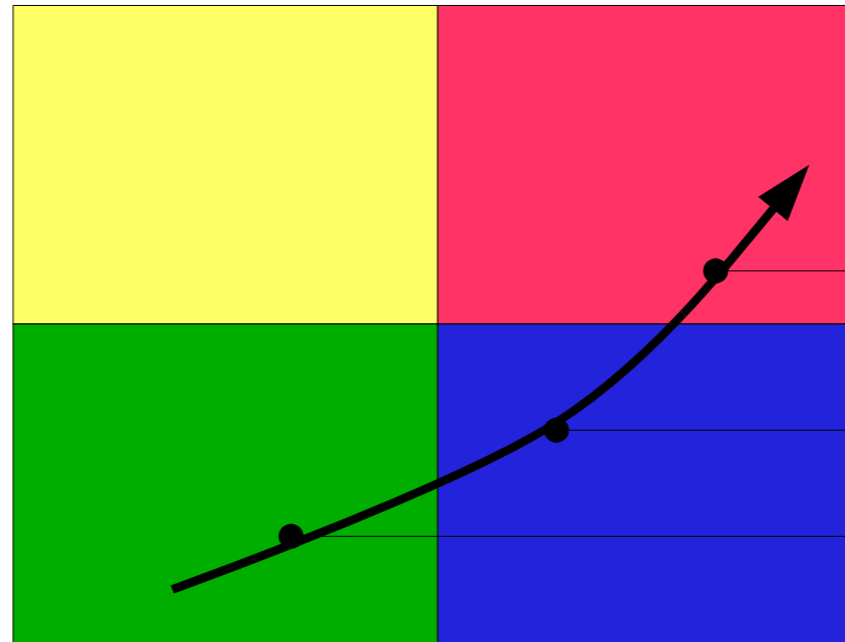




History Column Sampling

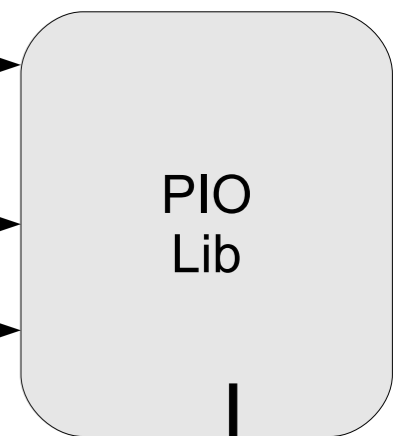
- Sample the CAM history buffer along a specified path (satellite, aircraft)
- All history variables can be sampled
- At each timestep, output stream of model columns nearest to specified coordinates for +/- half a timestep in a sequence specified via a tracking file

Horizontal grid distributed across MPI tasks

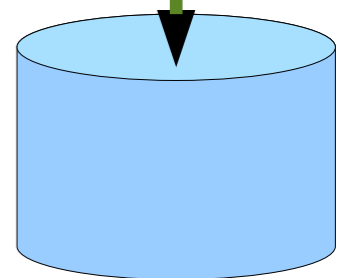


Output individual columns along the flight path

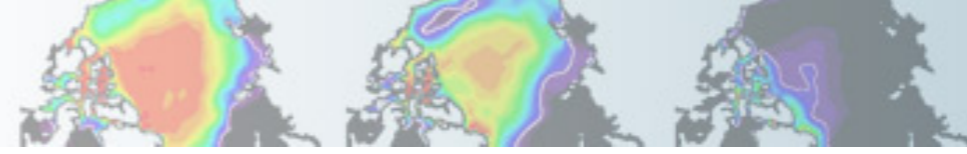
The corresponding model columns along the flight path are extracted and output in the same sequence as the input tracking file



Stream columns to Netcdf file



Courtesy Francis Vitt



History Column Sampling

Namelist options:

```
sathist_fincl      = 'PS','Q','T','U','V','O3',...
sathist_track_infile = '../satellite_profilelist.nc'
sathist_mfilt      = 500000
sathist_hfilename_spec = '%c.cam2.sat.%y-%m-%d-%s.nc'
```

input file

output file format

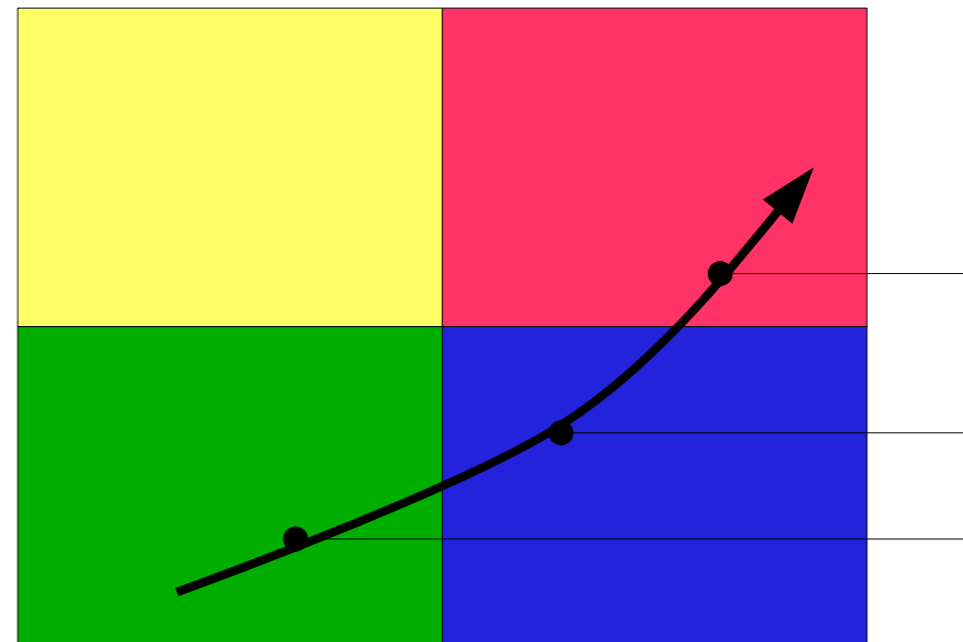
Tracking file:

Required variables:

```
int time(profs) ;
   time:long_name = "time of day" ;
   time:units = "s" ;
int date(profs) ;
   date:long_name = "date[yyyymmdd]" ;
   date:units = "yyyymmdd" ;
float lat(profs) ;
   lat:long_name = "latitude" ;
   lat:units = "degrees" ;
float lon(profs) ;
   lon:long_name = "longititude" ;
   lon:units = "degrees" ;
```

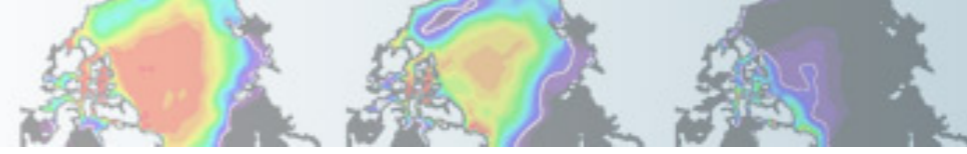
profiles

Horizontal grid distributed across MPI tasks



Courtesy Francis Vitt





Local time history averaging

Namelist settings:

```
avgflag_pertape = 'A', 'L'  
fincl2          = 'Q', 'T', 'PS'  
lcltod_start    = 0, 0  
lcltod_stop     = 0, 7200
```

