

CESM1.0.4 tutorial: WACCM and CAM-Chem

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 - Quickstart guide for present-day WACCM compset
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 - WACCM & CAM-Chem customer support



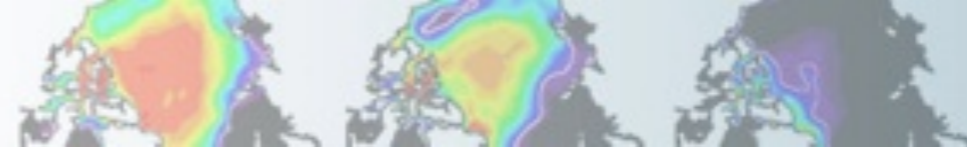
NCAR



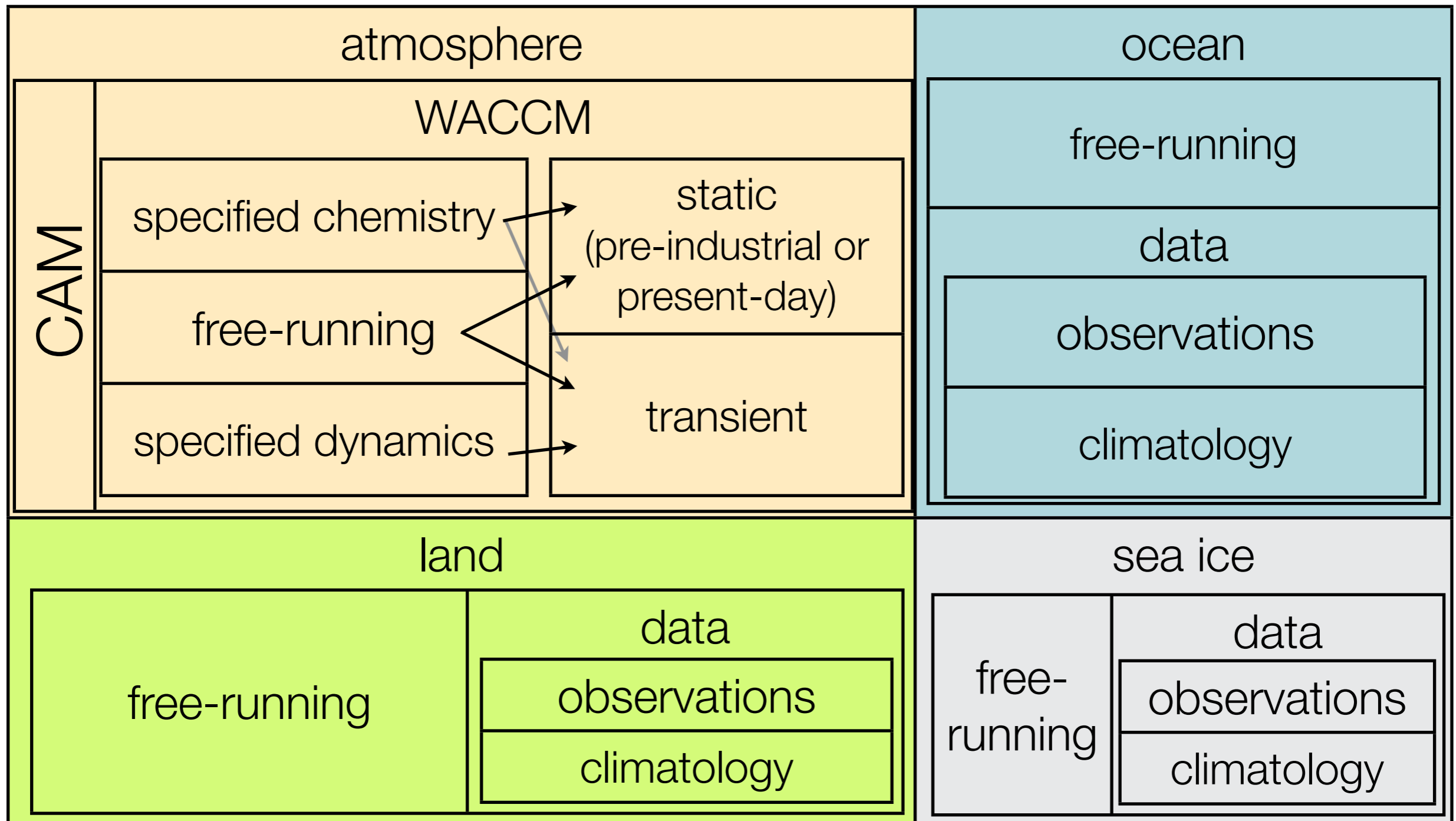
WACCM

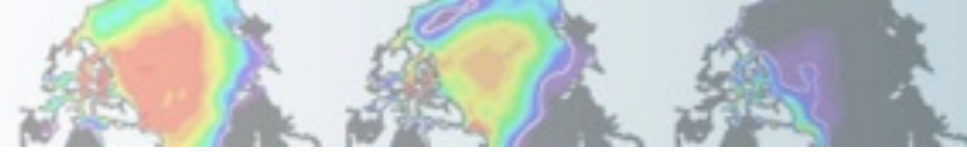
Whole Atmosphere
Community Climate Model





CESM-WACCM component configurations





Quickstart guide for present-day WACCM compset

- Go to the scripts directory in your source code:

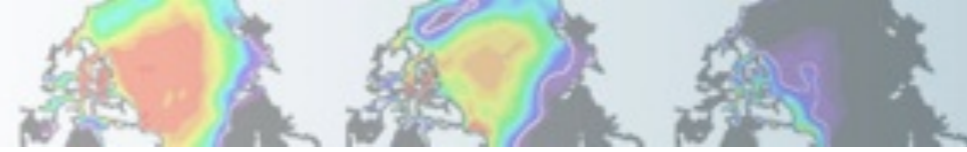
```
> cd /CESM/cseg/collections/cesm1_0_4_tutorial/scripts
```

- Review options for create_newcase command:

```
>create_newcase -list | less
RESOLUTIONS:  name (shortname)
...
  1.9x2.5_1.9x2.5 (f19_f19) ← used with data ocean (F-compsets)
  1.9x2.5_gx1v6 (f19_g16) ← used with full ocean (B-compsets)
...
COMPSETS:  name (shortname): description
...
  F_2000_WACCM (FW)
    Description: present-day cam/clm with prescribed ice/ocn
...
MACHINES:  name (description)
  bluefire (NCAR IBM p6, os is AIX, 32 pes/node, batch system is LSF)
...

```





Quickstart guide for present-day WACCM compset

- create a new F_2000_WACCM case called “f.e10.FW.f19_f19.001” from the existing F_2000_WACCM compset :

```
▶ create_newcase -res f19_f19 -compset F_2000_WACCM -mach  
bluefire -case ~/f.e10.FW.f19_f19.001
```

case naming conventions: http://www.cgd.ucar.edu/cseg/run_case_naming_convention.html

- go to your new case directory:

```
▶ cd ~/f.e10.FW.f19_f19.001
```

- configure the case

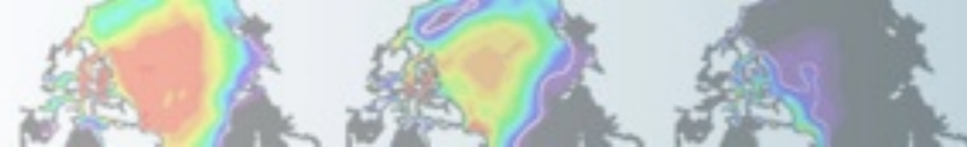
```
▶ configure -case
```

- build the model:

```
▶ *.build
```

- namelists (atm_in, ice_in, Ind_in, docn_in) will appear in the CaseDocs subdirectory, as well as in your \$rundir





Quickstart guide for present-day WACCM compset

- Check the newly generated namelist prior to run:

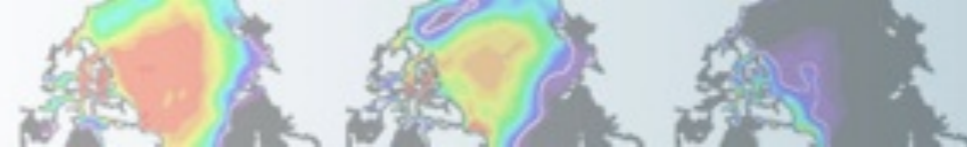
```

▶ less CaseDocs/atm_in
&aerodep_flx_nl
 aerodep_flx_cycle_yr           = 2000
 aerodep_flx_datapath          = '/glade/proj3/cseg/inputdata/atm/cam/chem/trop_mozart_aero/aero'
 aerodep_flx_file              = 'aerosoldep_monthly_1849-2006_1.9x2.5_c090803.nc'
 aerodep_flx_specifier         = 'BCDEPWET', 'BCPHODRY', 'BCPHIDRY', 'OCDEPWET', 'OCPHODRY', 'OCPHIDRY', 'DSTX01DD',
 'DSTX02DD',
 'DSTX03DD', 'DSTX04DD', 'DSTX01WD', 'DSTX02WD', 'DSTX03WD', 'DSTX04WD'
 aerodep_flx_type              = 'CYCLICAL'
/
&aerosol_nl
 soil_erod                     = '/glade/proj3/cseg/inputdata/atm/cam/dst/dst_1.9x2.5_c090203.nc'
/
&aoa_tracers_nl
 aoa_tracers_flag              = .true.
/
&cam_inparm
 absems_data                   = '/glade/proj3/cseg/inputdata/atm/cam/rad/abs_ems_factors_fastvx.c030508.nc'
 avgflag_pertape               = 'A'
 bnd_topo                      = '/glade/proj3/cseg/inputdata/atm/cam/topo/USGS-gtopo30_1.9x2.5_remap_c050602.nc'
 dtime                         = 1800
 efield_hflux_file             = '/glade/proj3/cseg/inputdata/atm/waccm/efld/coeff_hflux.dat'
 efield_lflux_file             = '/glade/proj3/cseg/inputdata/atm/waccm/efld/coeff_lflux.dat'
 efield_wei96_file             = '/glade/proj3/cseg/inputdata/atm/waccm/efld/wei96.cofcnts'
 fincl1                        = 'AOA1', 'AOA2', 'BR', 'BRCL', 'BRO', 'BRONO2', 'CCL4', 'CF2CLBR', 'CF3BR', 'CFC11', 'CFC113', 'CFC12',
 'CH2O',
 'CH3BR', 'CH3CCL3', 'CH3CL', 'CH3O2', 'CH3OOH', 'CH4', 'CL', 'CL2', 'CL2O2', 'CLDHGH', 'CLDLOW', 'CLDMED',
 'CLDTOT', 'CLO', 'CLONO2', 'CLOUD', 'CO', 'CO2', 'DTCOND', 'DTV', 'DUV', 'DVV', 'EKGWSPEC', 'FLNS', 'FLNSC', 'FLNT',
 'FLNTC', 'FSDS', 'FSNS', 'FSNSC', 'FSNT', 'FSNTC', 'H', 'H2', 'H2O', 'H2O2', 'HBR', 'HCFC22', 'HCL', 'HNO3', 'HO2',
 'HO2NO2', 'HOBR', 'HOCL', 'HORZ', 'LANDFRAC', 'LHFLX', 'N', 'N2O', 'N2O5', 'NO', 'NO2', 'NO3', 'O', 'O1D', 'O2', 'O3

```

See <http://www.cesm.ucar.edu/models/cesm1.0/cam/> for links to CAM namelist definition page





Quickstart guide for present-day WACCM compset

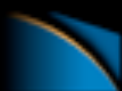
- check the charge accounts and wall time in your run script:

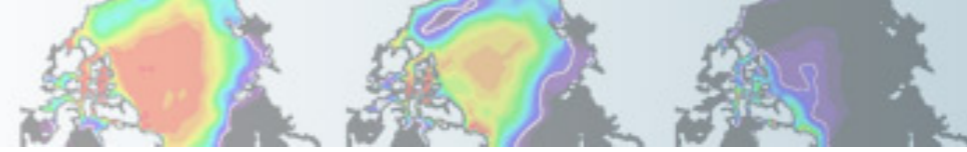
```
▶ less *.run
#! /bin/tcsh -f
#BSUB -n 256
#BSUB -R "span[ptile=64]"
#BSUB -q regular
#BSUB -B ← send email when job begins
#BSUB -N ← send email when job ends
#BSUB -x
#BSUB -a poe
#BSUB -o poe.stdout.%J
#BSUB -e poe.stderr.%J
#BSUB -J f.e11.FW.f19_f19.001 ← maximum wall time for job
#BSUB -W 0:19 ←
#BSUB -P 12345678 ← charge account number
```

Tip: You can set your default charge account by creating a text file called `.ccsm_proj` in your home directory, with the account ID.

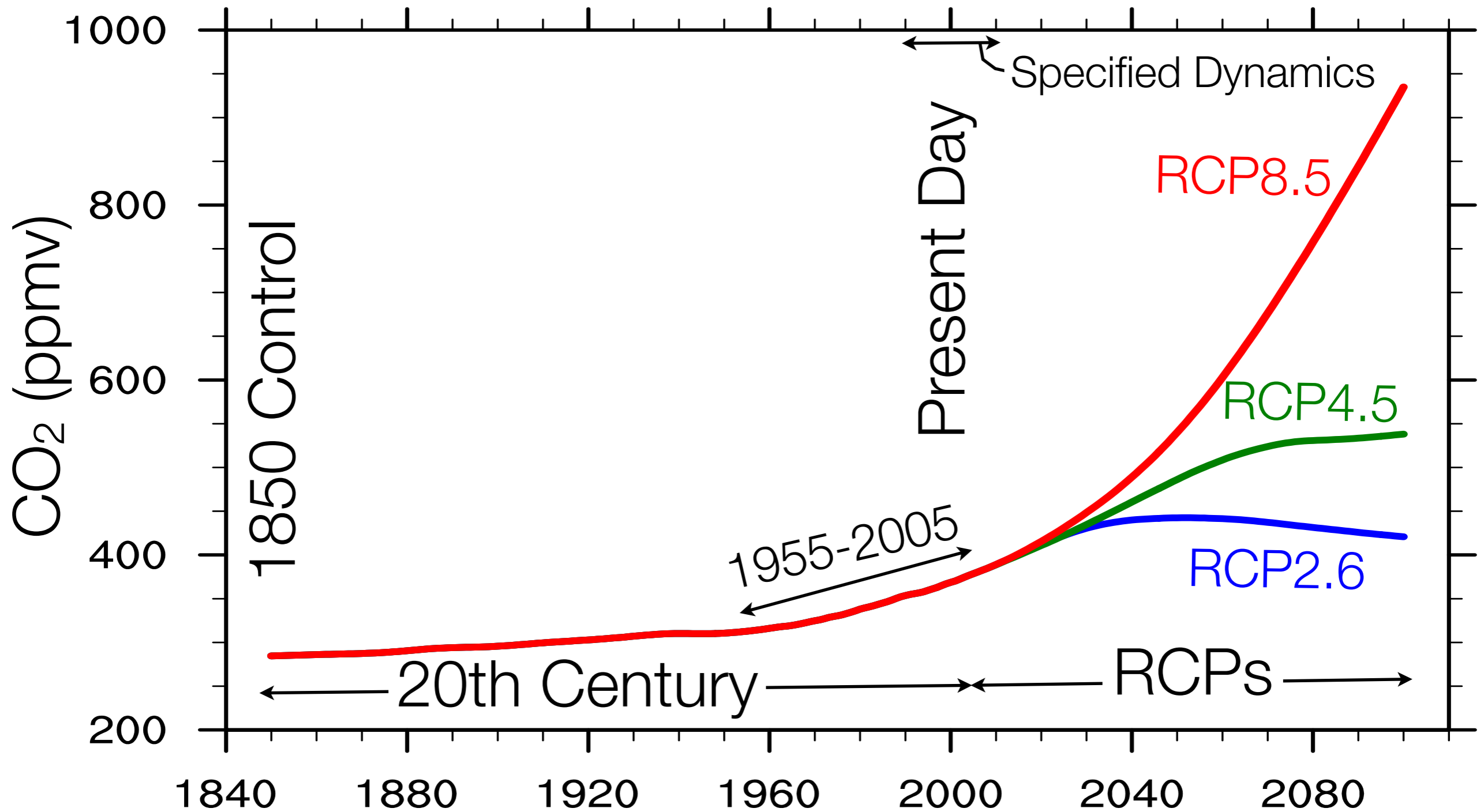
- submit the job to the batch queue (default 5-day run):

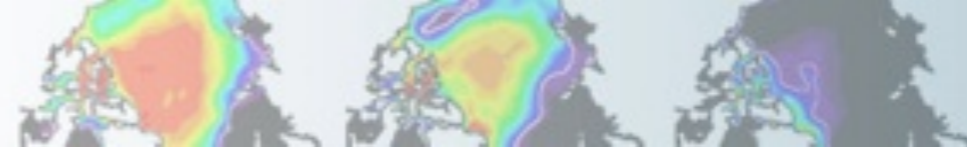
```
▶ *.submit
```





Transient and static WACCM & CAM-Chem configurations



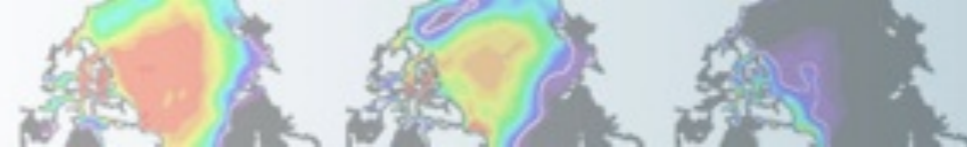


WACCM compsets with data ocean

- **F_1850_WACCM (F1850W)**: Pre-industrial (perpetual year 1850AD)
- **F_1955-2005_WACCM_CN (F55WCN)**: 1955 to 2005 transient, with daily solar data and SPEs.
- **F_2000_WACCM (FW)**: Present-day (perpetual year 2000AD). **Scientifically validated at 1.9x2.5_1.9x2.5.**
- **F_2000_WACCM_SC (FWSC)**: Specified chemistry, perpetual year 2000
- **F_SD_WACCM (FSDW)**: Specified dynamics
- **F_2000_WACCMX (FWX)**: Present-day WACCM-X (thermosphere extension), constant solar max

Resolution: Run F-compsets at 1.9x2.5_ 1.9x2.5 (f19_f19).



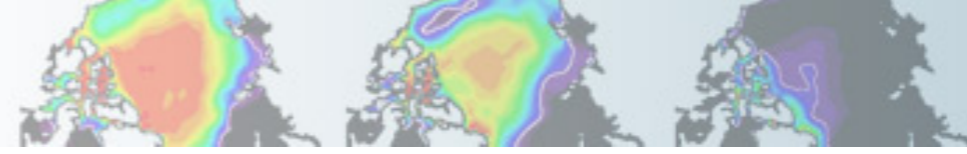


WACCM compsets with fully coupled ocean

- **B_1850_WACCM** (short name **B1850W**): Pre-industrial (perpetual year 1850AD)
- **B_1850_WACCM_CN (B1850WCN)**: Pre-industrial with carbon-nitrogen cycle in CLM. **Scientifically validated at 1.9x2.5_gx1v6.**
- **B_1850-2005_WACCM_CN (B20TRWCN)**: 20th Century (1850-2005 transient) with carbon-nitrogen cycle in CLM. **Scientifically validated at 1.9x2.5_gx1v6.**
- **B_2000_WACCM_CN (BWCN)**: Present-day (perpetual year 2000AD)
- **B_1955-2005_WACCM_CN (B55TRWCN)**: 1955 to 2005 transient, with daily solar data and SPEs. **Scientifically validated at 1.9x2.5_gx1v6.**
- **RCP future scenarios**: 2005 to 2100 transient, with daily solar data and SPEs. **Scientifically validated at 1.9x2.5_gx1v6.**
 - **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).





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





How do I change model output?

- Review list of current CAM history variables
 - Currently >2300 existing CAM history variables
 - Complete list is printed in atm.log.* file generated during each run in \$rundir/run.
 - Search log file for “MASTER FIELD LIST” to review.

```


***** MASTER FIELD LIST *****
 1 US                m/s
 2 VS                m/s
 3 US&IC             m/s
 4 VS&IC             m/s
 5 PS&IC             Pa
 6 T&IC              K
 7 Q&IC              kg/kg
 8 CLDLIQ&IC         kg/kg
 9 CLDICE&IC         kg/kg
10 O3&IC             kg/kg
11 O&IC              kg/kg
12 O1D&IC           kg/kg
13 O2&IC             kg/kg
14 O2_1S&IC         kg/kg
15 O2_1D&IC         kg/kg
16 N2O&IC           kg/kg
17 N&IC              kg/kg
18 NO&IC             kg/kg
19 NO2&IC           kg/kg
20 NO3&IC           kg/kg
21 HNO3&IC          kg/kg
22 HO2NO2&IC        kg/kg
23 N2O5&IC          kg/kg
24 CH4&IC           kg/kg
25 CH3O2&IC         kg/kg
26 CH3OOH&IC        kg/kg
27 CH2O&IC          kg/kg
28 CO&IC            kg/kg
29 H2&IC            kg/kg
30 H&IC             kg/kg
31 OH&IC            kg/kg
32 HO2&IC           kg/kg
33 H2O2&IC          kg/kg
34 CLY&IC           kg/kg
35 BRY&IC           kg/kg
36 CL&IC            kg/kg
37 CL2&IC           kg/kg
38 CLO&IC           kg/kg
39 OCLO&IC          kg/kg
40 CL2O2&IC         kg/kg
41 HCL&IC           kg/kg
42 HOCL&IC          kg/kg
43 CLONO2&IC        kg/kg
44 BRCL&IC          kg/kg
45 BR&IC            kg/kg
46 BRO&IC           kg/kg
47 HBR&IC           kg/kg
48 HOBR&IC          kg/kg
49 BRONO2&IC        kg/kg
50 CH3CL&IC         kg/kg
51 CH3BR&IC         kg/kg
52 CFC11&IC         kg/kg
53 CFC12&IC         kg/kg
54 CFC113&IC        kg/kg
55 HCFC22&IC        kg/kg
56 CCL4&IC          kg/kg
57 CH3CCL3&IC       kg/kg
58 CF3BR&IC         kg/kg
59 CF2CLBR&IC       kg/kg
60 CO2&IC           kg/kg
61 N2p&IC           kg/kg
62 O2p&IC           kg/kg
63 Np&IC            kg/kg


```

How do I change output of existing namelist variables?

- Create a user_nl_cam file in your \$casedir:

```
avgflag_pertape      = 'A', 'I', 'I', 'A', 'A'
fincl1               = 'AOA1', 'AOA2', 'BR', 'BRCL', ...
fincl2               = 'PS', 'Z3', 'T', 'U', 'V', ...
fincl3               = 'PS:B', 'T:B', 'Z3:B', 'U:B', 'V:B', ...
fincl4               = 'PS', 'PSL', 'U', 'V', 'T', ...
fincl5               = 'MSKtem', 'PS', 'PSL', 'VTH2d', ...
fincl4lonlat         = 10e_20n
fincl5lonlat         = 10e:20e_15n:20n
mfilt                = 1,365,30,120,240
nhtfrq              = 0,-24,-24,-6,-3
```

-  avgflag_pertape: averaging flag for all variables on history files (h0, h1, h2, etc.). Valid values are “A” (Average), “I” (Instantaneous), “X” (Maximum), “M” (Minimum), “B” (GMT 00:00:00 average), and “L” for local time history averaging.



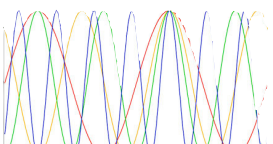
-  fincl1, fincl2, etc: list of variables added to default output on h0, h1, etc. Appended ":" sets averaging flag for the field.

-  fexcl1, fexcl2, etc: list of variables excluded from default output on h0, h1, etc.

How do I change output of existing namelist variables?

- Create a user_nl_cam file in your \$casedir:

```
avgflag_pertape      = 'A', 'I', 'I', 'A', 'A'
fincl1              = 'AOA1', 'AOA2', 'BR', 'BRCL', ...
fincl2              = 'PS', 'Z3', 'T', 'U', 'V', ...
fincl3              = 'PS:B', 'T:B', 'Z3:B', 'U:B', 'V:B', ...
fincl4              = 'PS', 'PSL', 'U', 'V', 'T', ...
fincl5              = 'MSKtem', 'PS', 'PSL', 'VTH2d', ...
fincl4lonlat        = 10e_20n
fincl5lonlat        = 10e:20e_15n:20n
mfilt               = 1,365,30,120,240
nhtfrq              = 0,-24,-24,-6,-3
```

- 
 • **fincl[12345]lonlat:** List of columns or contiguous columns at which the fincl[12345] fields will be output. '10e_20n' would pick the model column closest to 10°E longitude by 20°N latitude. '10e:20e_15n:20n' would select the model columns which fall within the longitude range from 10-20°E and the latitude range from 15-20°N.
- 
 • **mfilt:** maximum number of time samples written to h0, h1, etc.
- 
 • **nhtfrq:** write frequencies for history files in timesteps (if positive) or hours (if negative). The h0 files may be monthly averages if nhtfrq(1) = 0.

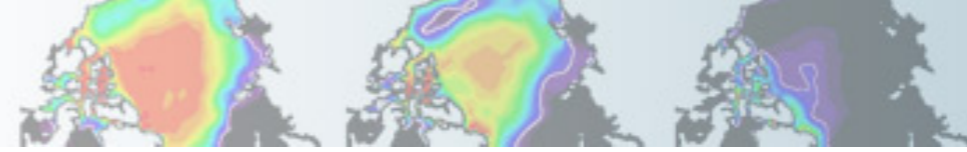
How do I change output of existing namelist variables?

- Create a user_nl_cam file in your \$casedir
- Generate a new namelist:

```
> cd $CASEROOT
> configure -cleannamelist
> configure -case
```

- Resubmit your job

```
> *.submit
```



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 chemistry preprocessor input file used in your previous run is in your `$CASEROOT/CaseDocs/chem_mech.in`
- Additional input files for default chemical mechanisms are in each source code subdirectory for mechanisms under `$CCSMROOT/models/atm/cam/src/chemistry/pp_*` (i.e. `pp_waccm_mozart`)

```

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

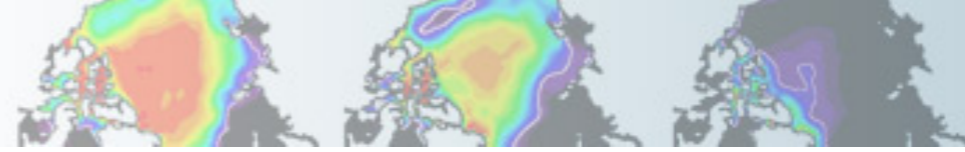
  Fixed
M, N2
  End Fixed
End SPECIES

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

```

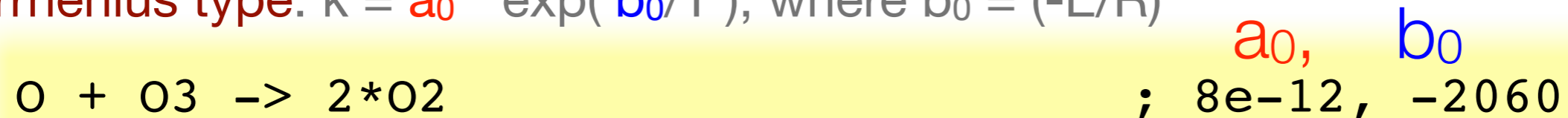


Modifying the chemical preprocessor input file

- **Temperature-independent rates:** k [$\text{cm}^3 \text{ molec}^{-1} \text{ s}^{-1}$] = a_0



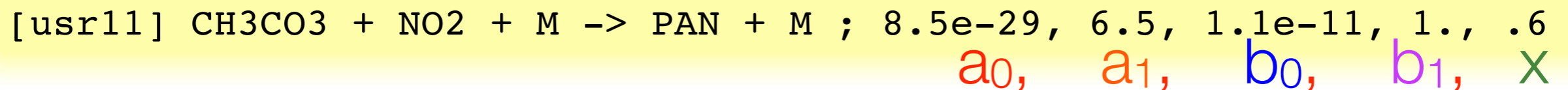
- **Arrhenius type:** $k = a_0 * \exp(b_0/T)$, where $b_0 = (-E/R)$



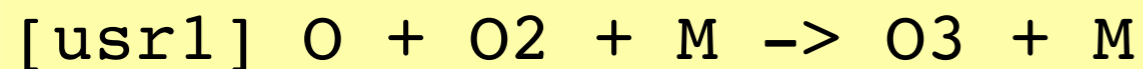
- **Troe rate constant:** $k = \alpha^x / (1 - \beta^2)$, where:

$$\alpha = k_0 * M / k_\infty, \quad \beta = \log_{10}(\alpha), \quad M = \text{air density (molec cm}^{-3}\text{)}, \quad T = \text{temperature (K)}$$

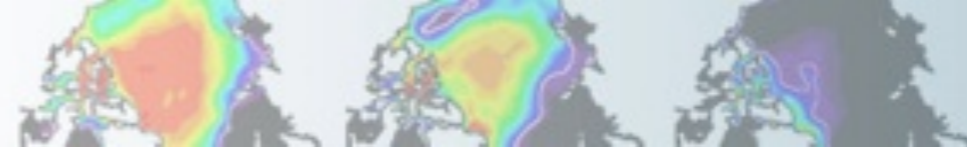
$$k_0 = a_0 * (300/T)^{a_1}, \quad k_\infty = b_0 * (300/T)^{b_1}, \quad x = \text{“exponential factor”}$$



- **User-specified reaction rate:**



rate defined in routine `mo_usrxrt.F90`

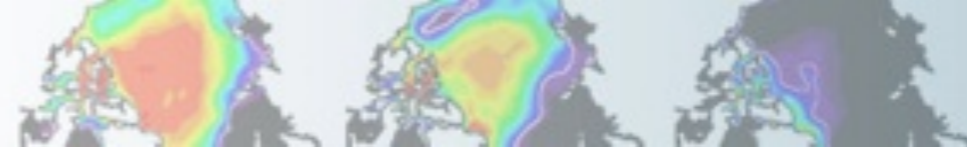


User-specified reaction rates

```
[usr_0_02] O + O2 + M -> O3 + M
```

rate defined in routine mo_usrrxt.F90:

```
!-----  
!      ... o + o2 + m --> o3 + m  
!-----  
level_loop : do k = 1,pver  
  tinv(:)      = 1._r8 / temp(:ncol,k)  
  tp(:)       = 300._r8 * tinv(:)  
  sqrt_t(:)   = sqrt( temp(:ncol,k) )  
  if( usr_0_02_ndx > 0 ) then  
    rxt(:,k,usr_0_02_ndx) = 6.e-34_r8 * tp(:)**2.4_r8  
  end if  
  if( usr_OA_02_ndx > 0 ) then  
    rxt(:,k,usr_OA_02_ndx) = 6.e-34_r8 * tp(:)**2.4_r8  
  end if
```



Building the model with new chemistry

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

```
> cd $CASEROOT
> cp CaseDocs/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
```

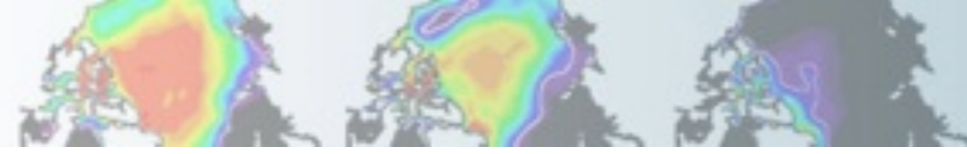
- Edit the file `env_conf.xml` in the case directory to add the CAM configure option `-usr_mech_infile` pointing to the new preprocessor input file:

```
<!--"CAM configure options, see CAM configure utility for details (char)" -->
<entry id="CAM_CONFIG_OPTS" value="-phys cam4 -chem waccm_mozart
-usr_mech_infile $CASEROOT/my_waccm_mech.in" />
```

- Reconfigure & rebuild:

```
> configure -cleanall
> configure -case
> *.build
```





Post-processing data analysis

- CESM history files are in standard netCDF format, and may be analyzed with standard analysis tools, including Matlab, IDL, NCL, and NCO.
- GEOV is an IDL-based viewer for geophysical history files created by NCAR's CAM, WACCM and MOZART models. GEOV can be downloaded from the WACCM webpage (http://www.cesm.ucar.edu/working_groups/WACCM/).

Window title: /Volumes/Data/Models/ccsm/run/b40.20th.2deg.wset.001/atm/hist/b...

FILE DISPLAY MAP 2D PLOT 1D PLOT PRINT CONTROLS HELP

PLOT:

VARIABLES	LATITUDE	LONGITUDE	LEVELS	TIME
SOLIN	-90.00	0.000	929.649	01Jul2003 00:00
SRFRAD	-88.11	2.500	970.555	
SWCF	-86.21	5.000	992.556	
T	-84.32	7.500		
TAUGWX	-82.42	10.00		

Display Options:

Automatic Contour Levels

auto log linear

Level altitudes

Oplot Same Scale

Wind Vectors

Scale VMR data:

don't scale

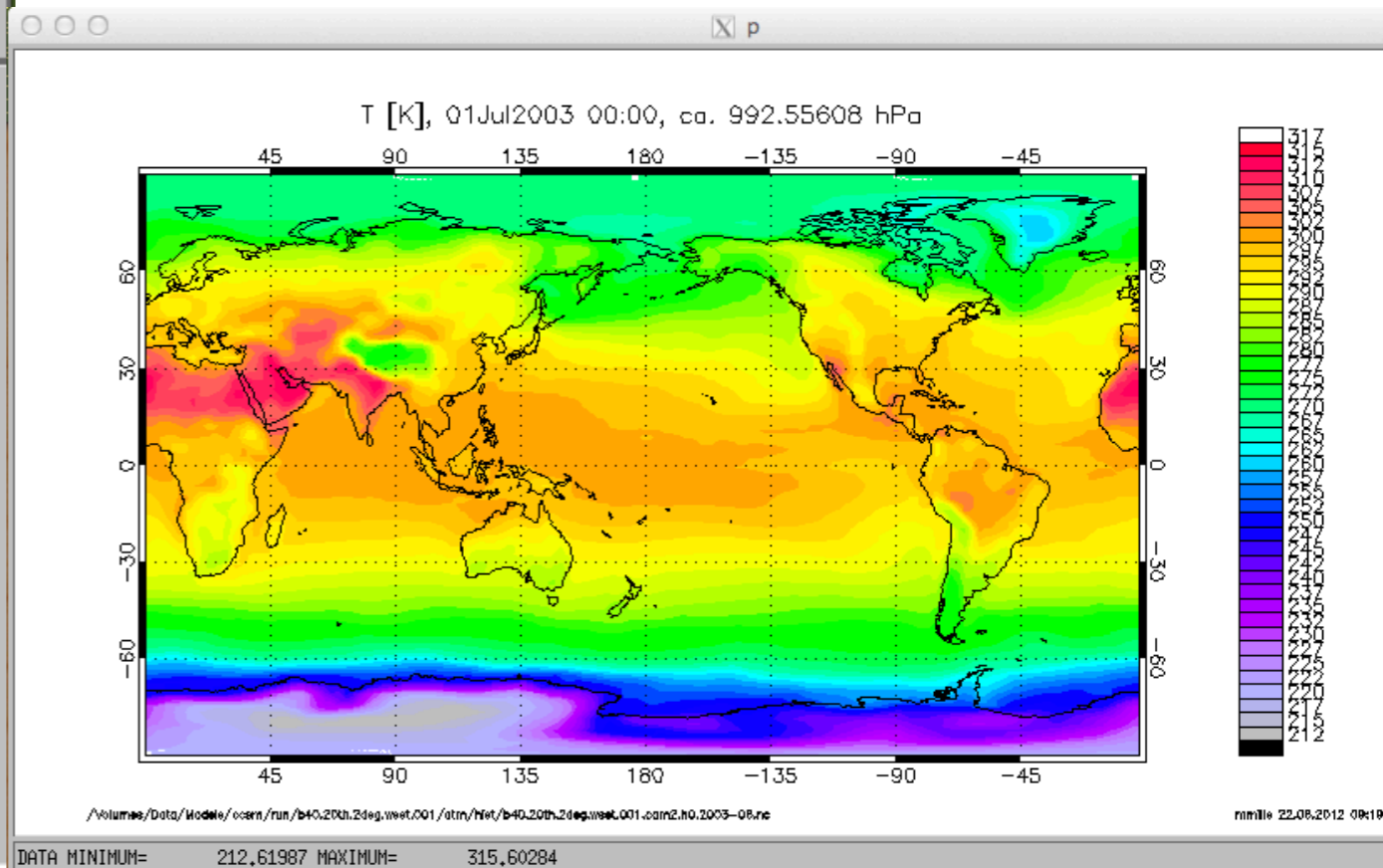
ppm

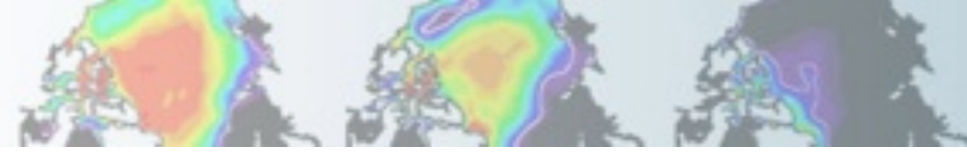
ppb

ppt

Operator:

Extractor:





Post-processing data analysis

- CESM history files are in standard netCDF format, and may be analyzed with standard analysis tools, including Matlab, IDL, NCL, and NCO.
- GEOV is an IDL-based viewer for geophysical history files created by NCAR's CAM, WACCM and MOZART models. GEOV can be downloaded from the WACCM webpage (http://www.cesm.ucar.edu/working_groups/WACCM/).

FILE DISPLAY MAP 2D PLOT 1D PLOT PRINT CONTROLS HELP

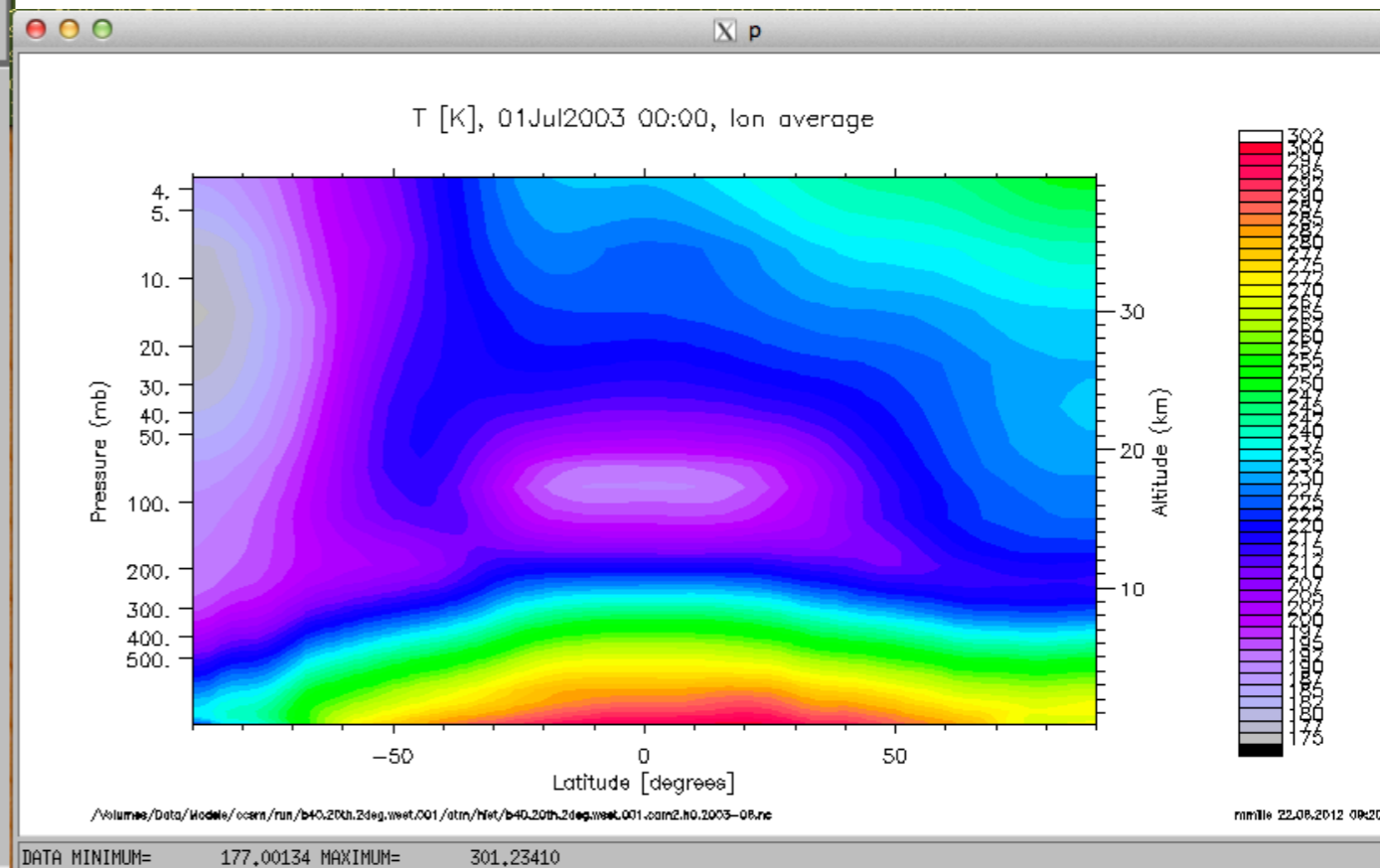
PLOT: Latitude vs Longitude
Latitude vs Longitude at Constant Pressure...
Meridional slice
Zonal slice
Zonal average

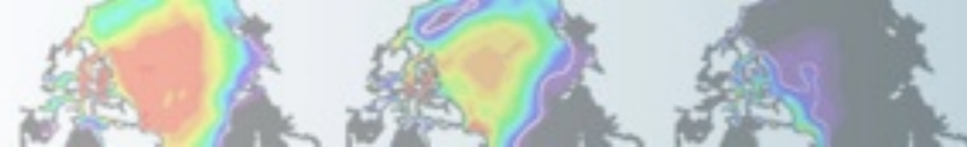
VARIABLES
SOLIN
SRFRAD
SMCF
T
TAUGWX

Display Options:
 Automatic Contour Levels
 auto log linear
 Level altitudes
 Oplot Same Scale
 Wind Vectors

Scale VMR data:
 don't scale
 ppm
 ppb
 ppt

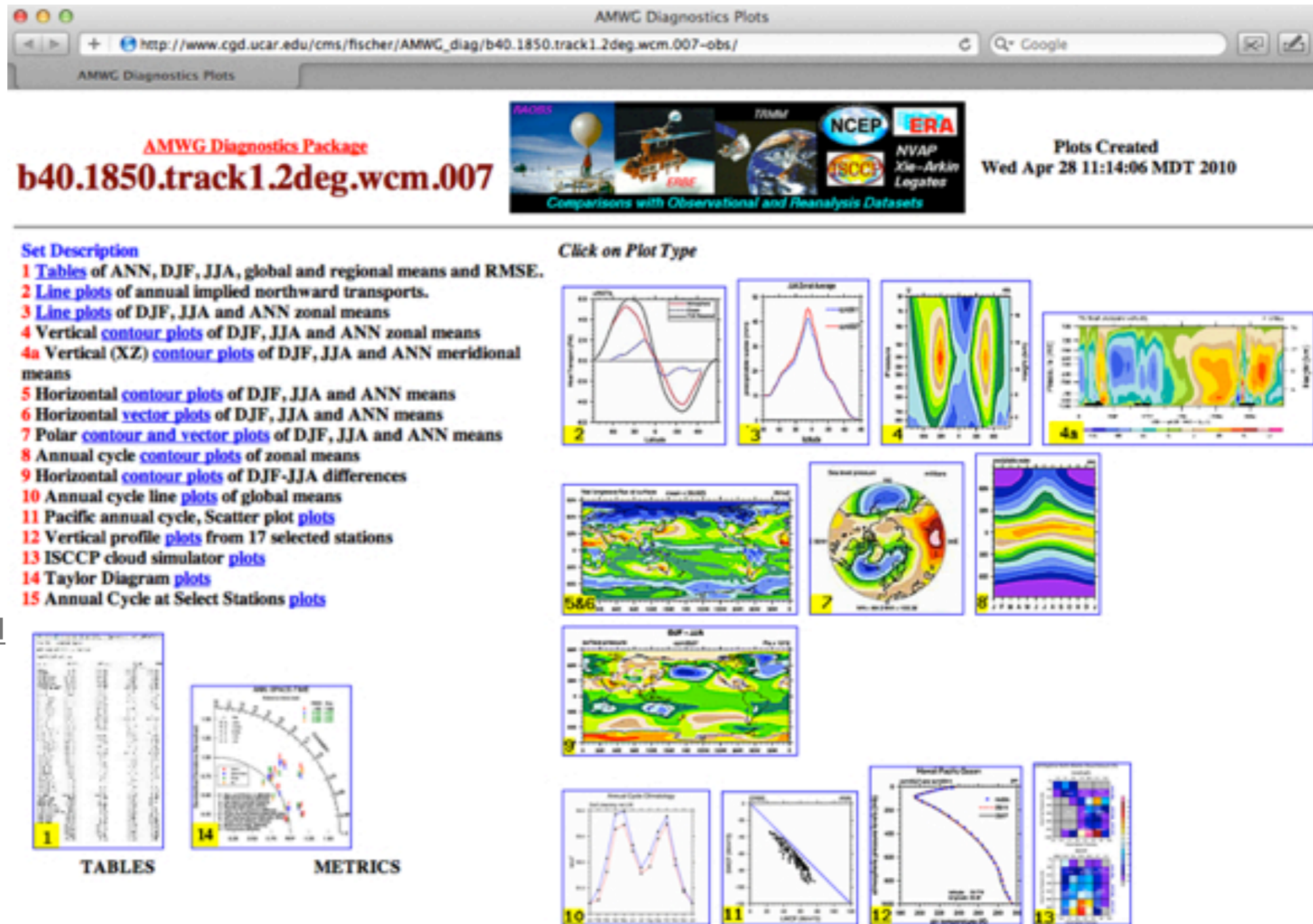
Operator: None
Extractor: Simple
Overplot





Post-processing data analysis

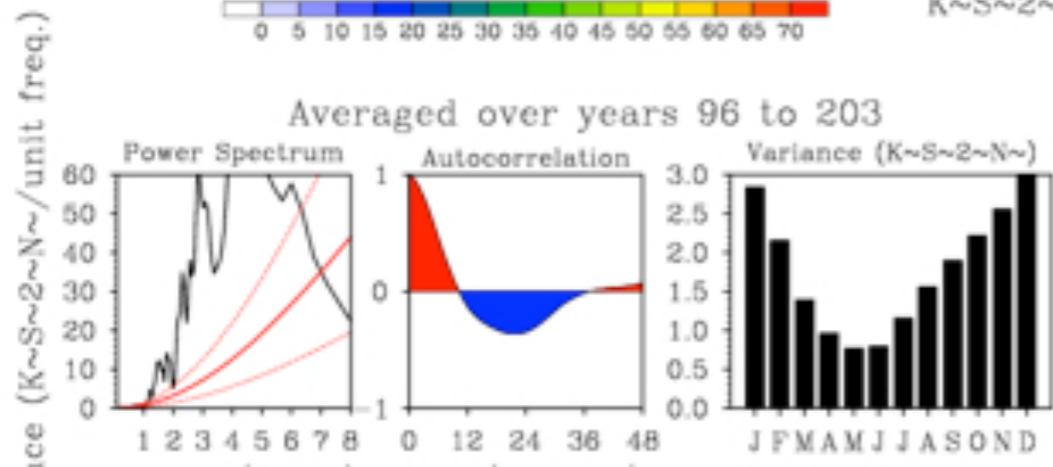
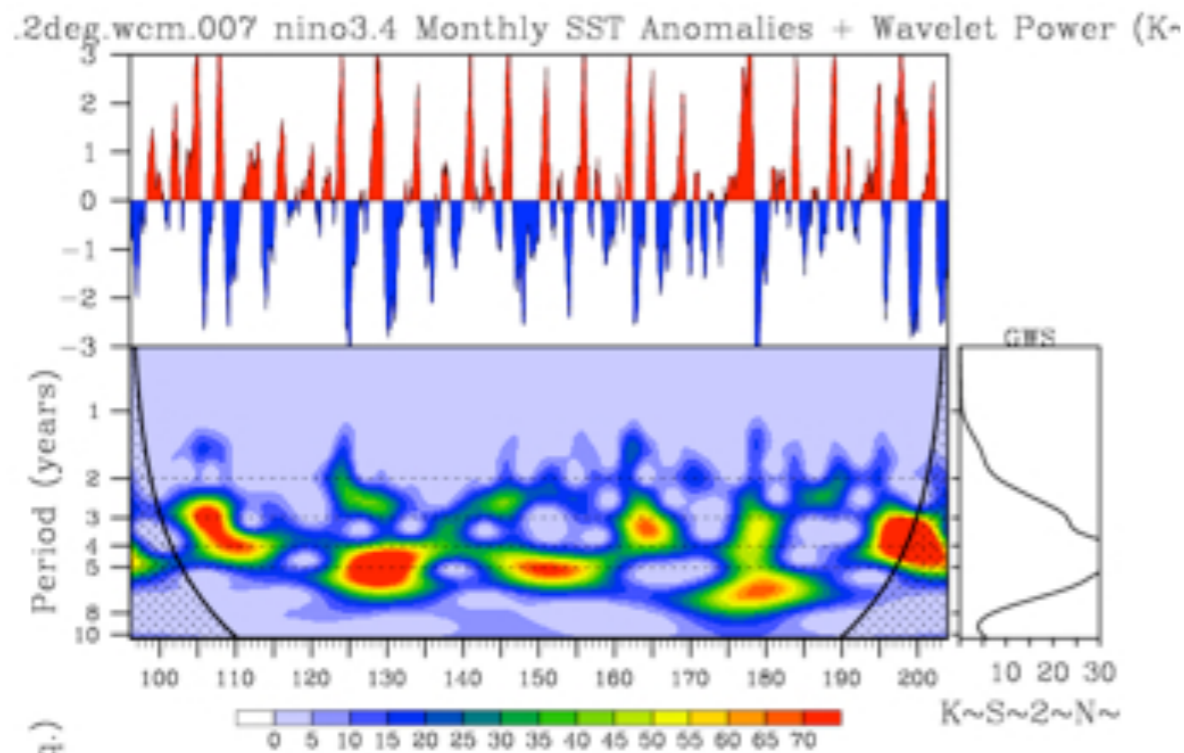
CAM diagnostic packages are described under CAM Post-Processing Utilities on the [CAM documentation page](http://www.cesm.ucar.edu/models/cesm1.0/cam/) at <http://www.cesm.ucar.edu/models/cesm1.0/cam/>.



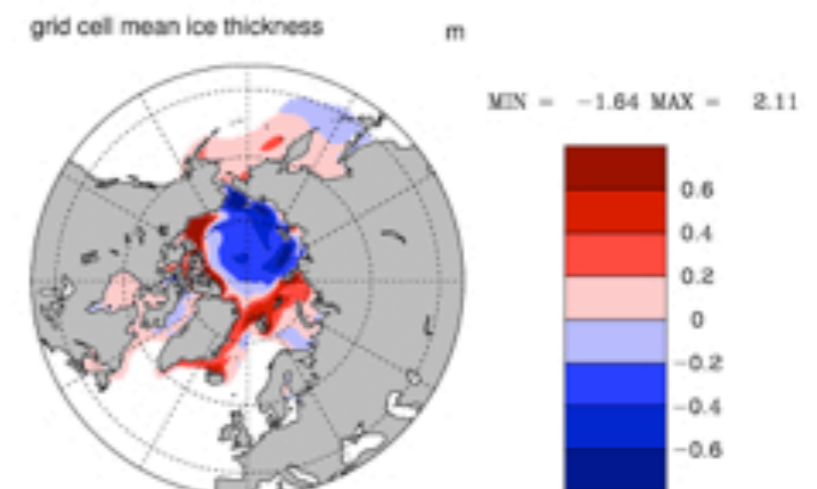
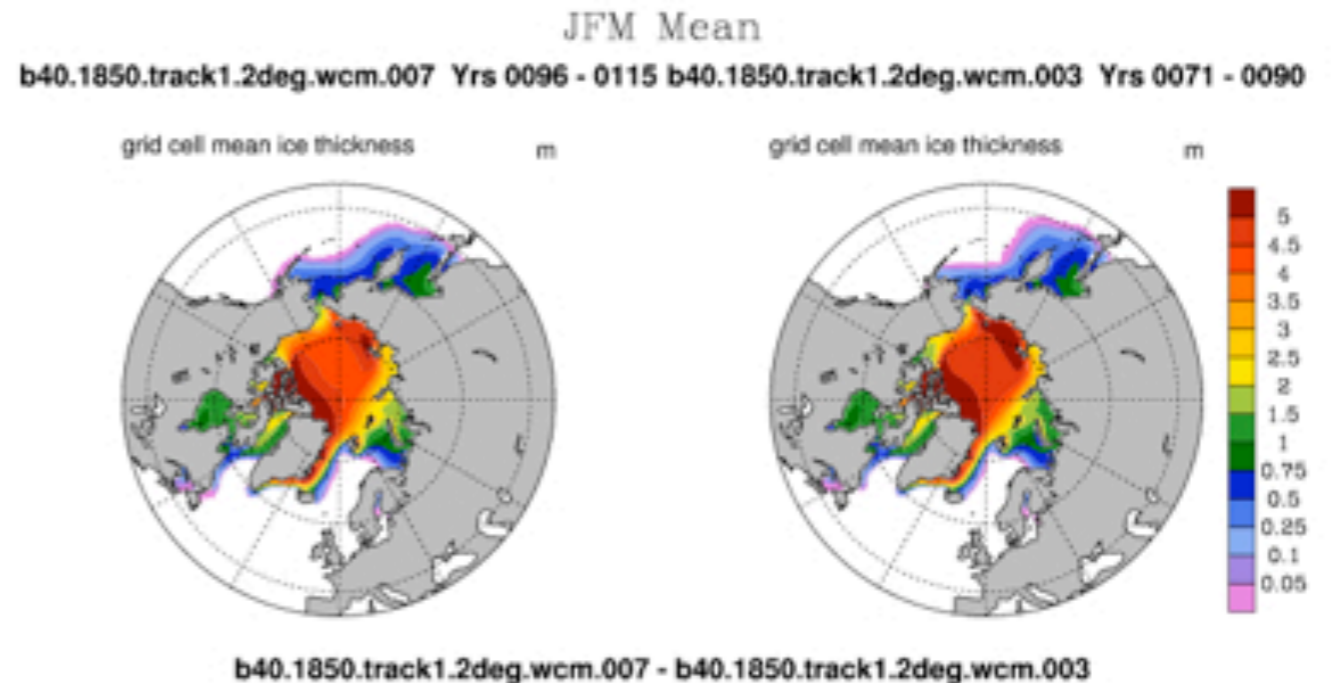
Post-processing data analysis

Diagnostic packages for all model components (atmosphere, land, ice, and ocean) can be found from the [component post-processing utilities page](http://www.cesm.ucar.edu/models/cesm1.0/model_diagnostics/) (http://www.cesm.ucar.edu/models/cesm1.0/model_diagnostics/).

Ocean ENSO



Sea Ice Thickness



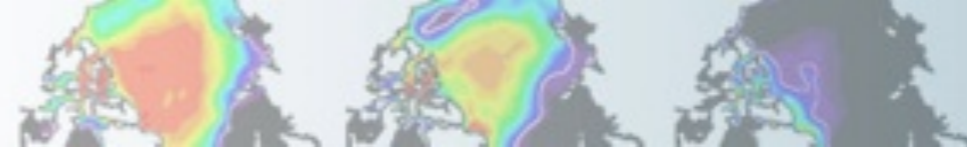
Validating CESM/WACCM

- Users may validate their implementation of CESM/WACCM by repeating experiments we have done at NCAR, and using the component post-processing utilities to compare the climate generated to output we have made available publicly on the Earth System Grid (<http://www.earthsystemgrid.org>).
- Please visit our CESM 1.0 experiments and diagnostics page (<http://www.cesm.ucar.edu/experiments/cesm1.0/>) for an updated list of experiments with links to output data locations.
- Output from additional experiments will be made available on a timeline in accordance with the CMIP5 data policy.

CESM1 (WACCM) 2° Pre-Industrial Control Case Name: b40.1850.track1.2deg.wcm.007 Data Availability: ESG (years 156-185)	156-185 w/observations	Atm	Ice	Land	Ocean	CCR	Ocean Timeseries
CESM1 (WACCM-X) 2° Present Day Control Case Name: f.e10.FWX.f19_f19.control.001 Data Availability: CESM	2001 w/observations	Atm	Ice	Land	---	---	---

Case Name: [b40.1850.track1.2deg.wcm.007](#)
Machine: [NCAR:bluefire](#)
CMIP5 ID: ----
Compset: [B 1850 WACCM CN](#)
Resolution: [1.9x2.5 qx1v6](#)
Years: [96-295](#)
Time Frequencies Saved: [Monthly, Daily, Subdaily](#)
Initialization: [year 156](#)
Start/End Dates: [4/16/10, at year 260 as of 3/1/11](#)
Data Release Date (Full): [11/1/11](#)

Case Name: [f.e10.FWX.f19_f19.control.001](#)
Machine: [NCAR:bluefire](#)
CMIP5 ID: ----
Compset: [F 2000 WACCMX \(publicly available 2/21/12\)](#)
Resolution: [1.9x2.5 1.9x2.5](#)
Years: [1/2001-2/2002](#)
Time Frequencies Saved: [Monthly, Daily, Subdaily](#)
Initialization: [startup run type](#)
Start/End Dates: [2/8/12, ongoing](#)
Data Release Date (Full): [2/17/12](#)



WACCM and CAM-Chem Customer Support

CGD Forum: <http://bb.cgd.ucar.edu/>

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