

# CESM1.2 tutorial: WACCM and CAM-Chem

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- 
- CESM-WACCM component configurations
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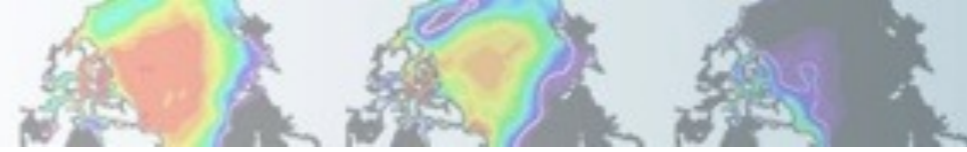
NCAR



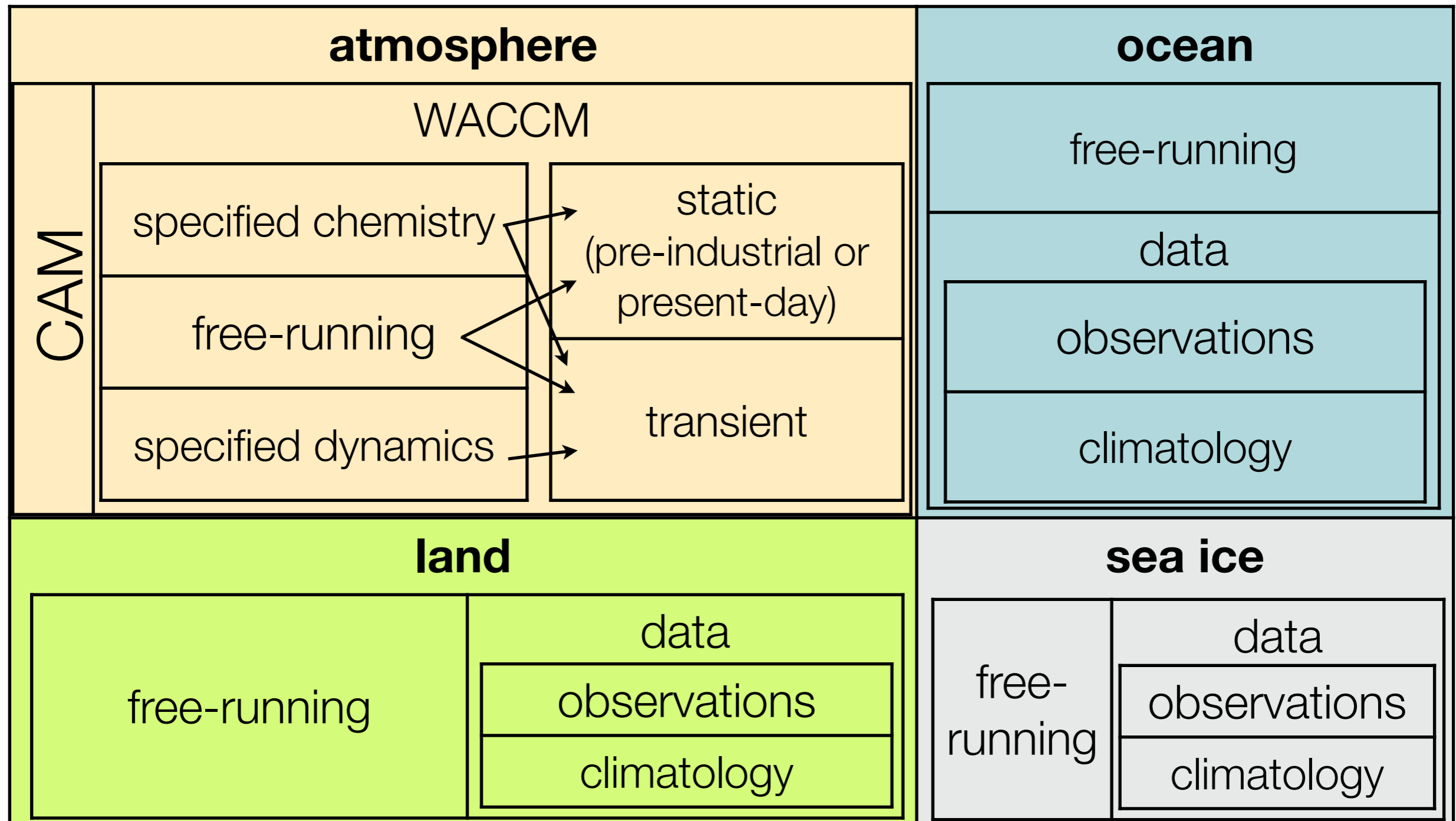
# WACCM

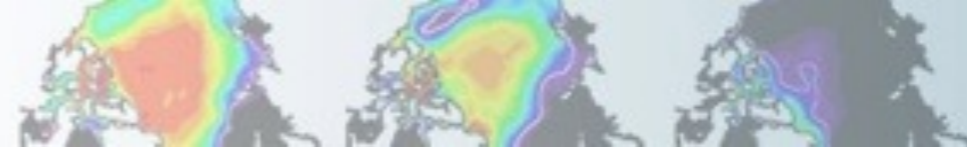
Whole Atmosphere  
Community Climate Model





# CESM-WACCM component configurations





# Quickstart guide for present-day WACCM compset

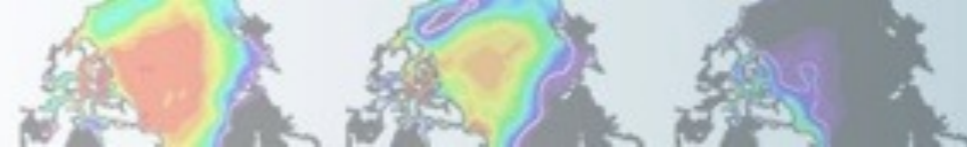
- Go to the scripts directory in your source code:

```
> cd /glade/p/cesm/tutorial/cesm1_2_2/tutorial/scripts
```

- Review options for create\_newcase command:

```
>create_newcase -list grids | less
Model Grids:  name          (alias) (compset)
...
model grid:   a%1.9x2.5_l%1.9x2.5_oi%1.9x2.5_r%r05_m%gx1v6_g%null_w%null
(alias: f19_f19) ← used with data ocean (F-compsets)
model grid:   a%1.9x2.5_l%1.9x2.5_oi%gx1v6_r%r05_m%gx1v6_g%null_w%null
(alias: f19_g16) ← used with full ocean (B-compsets)
...
>create_newcase -list compsets | less
...
alias: FW                shortname: F_2000_WACCM
                        longname: 2000_CAM4%WCCM_CLM40%SP_CICE
                                %PRES_DOCN%DOM_RTM_SGLC_SWAV
```





# 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  
yellowstone -case ~/f.e12.FW.f19_f19.001
```

case naming conventions: [http://www.cgd.ucar.edu/cseg/run\\_case\\_naming\\_convention.html](http://www.cgd.ucar.edu/cseg/run_case_naming_convention.html)

- go to your new case directory:

```
▶ cd ~/f.e12.FW.f19_f19.001
```

- set up the case

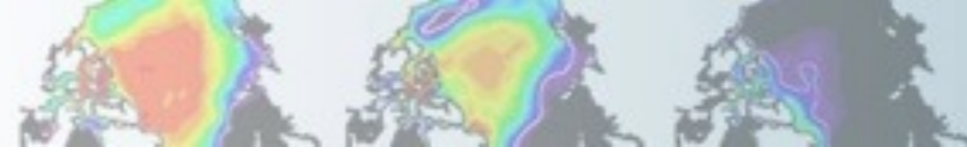
```
▶ ./cesm_setup
```

- 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:

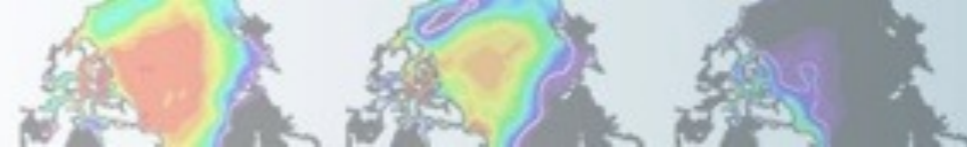
```

▶ less CaseDocs/atm_in
&aerosol_nl
 aer_drydep_list      = 'bc_a1', 'dst_a1', 'dst_a3', 'ncl_a1', 'ncl_a2', 'ncl_a3', 'num_a1', 'num_a2', 'num_a3',
 'pom_a1', 'so4_a1',
   'so4_a2', 'so4_a3', 'soa_a1', 'soa_a2'
 aer_wetdep_list      = 'bc_a1', 'dst_a1', 'dst_a3', 'ncl_a1', 'ncl_a2', 'ncl_a3', 'num_a1', 'num_a2', 'num_a3',
 'pom_a1', 'so4_a1',
   'so4_a2', 'so4_a3', 'soa_a1', 'soa_a2'
 sol_factb_interstitial = 0.1D0
 sol_facti_cloud_borne  = 1.0D0
 sol_factic_interstitial = 0.4D0
/
&aoa_tracers_nl
 aoa_read_from_ic_file = .true.
 aoa_tracers_flag      = .true.
/
&cam_inparm
 avgflag_pertape      = 'A', 'I', 'I', 'A', 'A', 'A', 'I', 'I'
 bnd_topo              = '/glade/p/cesmdata/cseg/inputdata/atm/cam/topo/USGS-gtopo30_1.9x2.5_remap_c050602.nc'
 dtime                 = 1800
 fincl1               = 'SZA', 'PHIS', 'PS', 'Z3', 'T', 'OMEGA', 'U', 'V',
 'RELHUM', 'PSL', 'TROP_Z', 'TROP_T', 'TROP_P', 'LNO_COL_PROD', 'LNO_PROD', 'NO2_XFRC',
 'AOA1', 'AOA2', 'N2O', 'CO2', 'CH4', 'O', 'O1D', 'O2',
 'O2_1D', 'O2_1S', 'O3', 'H', 'OH', 'HO2', 'H2', 'H2O2',
 'H2O', 'H2O_GAS', 'Q', 'TOTH', 'N', 'NO', 'NO2', 'NO3',
 'N2O5', 'HO2NO2', 'HNO3', 'HNO3_TOTAL', 'HNO3_STS', 'HNO3_NAT', 'HNO3_GAS', 'NOX',
 'NOY', 'CL', 'CL2', 'CLO', 'OCLO', 'CL2O2', 'HOCL', 'CLONO2',
 'HCL', 'HCL_TOTAL', 'HCL_GAS', 'HCL_STS', 'CLOX', 'CLOY', 'TCLY', 'BR',
 'BRCL', 'BRO', 'BRONO2', 'HOBR', 'HBR', 'BROX', 'BROY', 'TBRY',
 'COF2', 'COFCL', 'HF', 'F', 'FOY', 'TFY', 'CH3CL', 'CCL4',

```

See <http://www.cesm.ucar.edu/models/cesm1.2/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
#BSUB -n 180
#BSUB -R "span[ptile=15]"
#BSUB -q small
#BSUB -B ← send email when job begins
#BSUB -N ← send email when job ends
#BSUB -a poe
#BSUB -x
#BSUB -o cesm.stdout.%J
#BSUB -e cesm.stderr.%J
#BSUB -J f.e12.FW.f19_f19.001 ← maximum wall time for job
#BSUB -W 2:00 ←
#BSUB -P UESM0002 ← charge account number
```

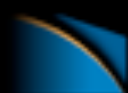
**Tip:** You can set your default charge account by creating a text file called `.ccsm_proj` in your home directory, with the account ID.

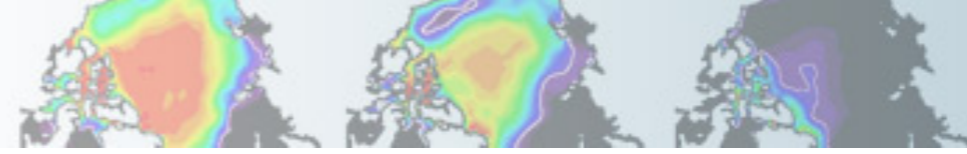
- submit the job to the batch queue (default 5-day run):

```
▶ *.submit
```

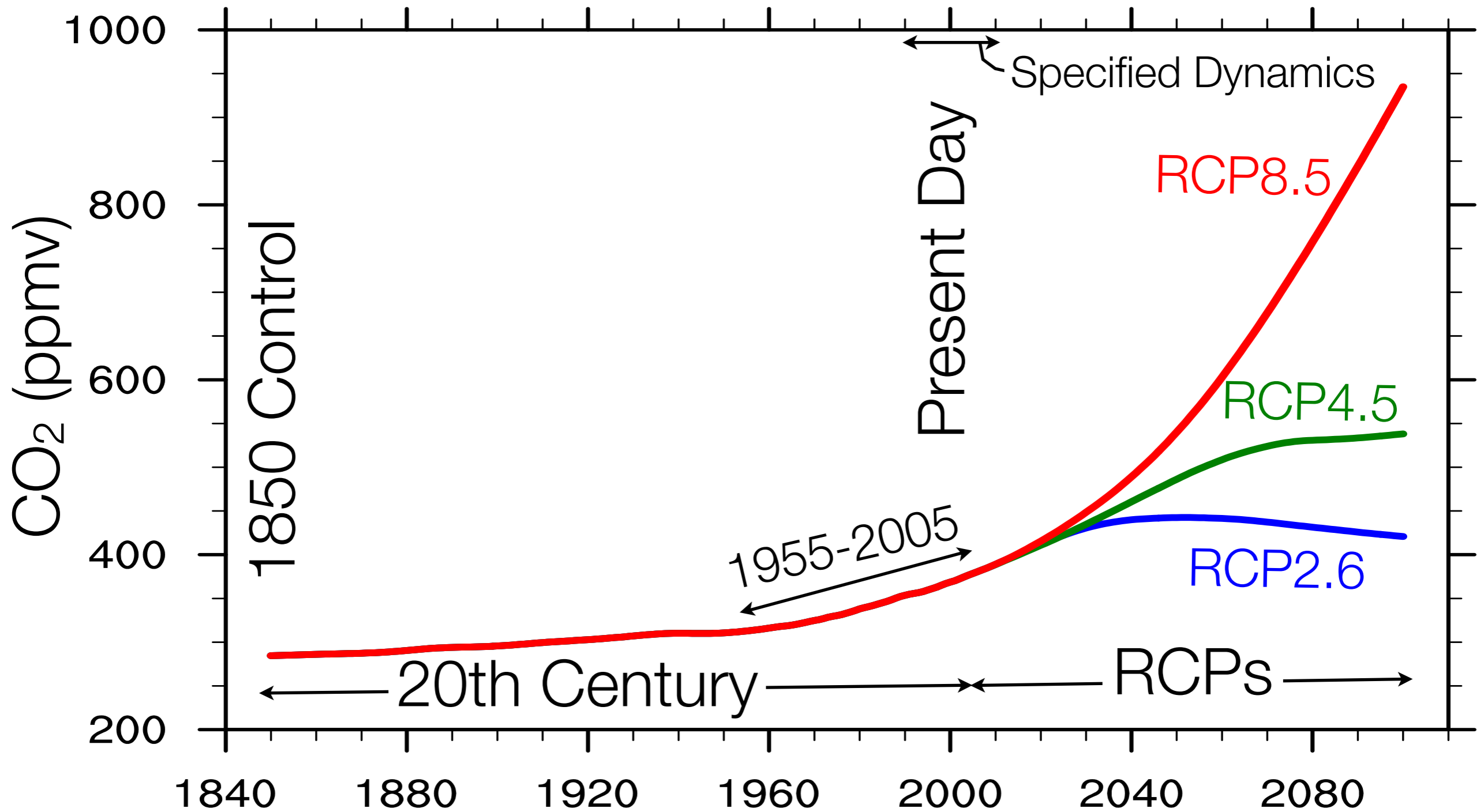
- Check job status:

```
▶ bjobs
```





# Transient and static WACCM & CAM-Chem configurations

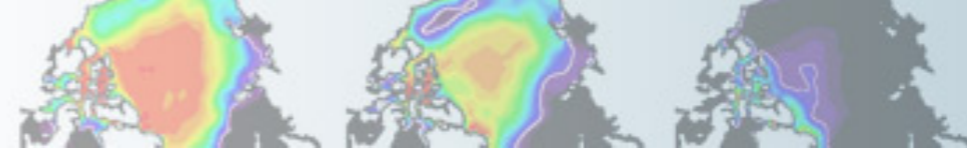


# CESM1.2.2(WACCM) component configurations

Find scientifically validated compsets here: <http://www2.cesm.ucar.edu/models/scientifically-supported>

Compsets	Component Description	Supported Grids
<p><b>Full ocean, static:</b>            B_1850_WACCM_CN (B1850WCN)            B_2000_WACCM_CN (BWCN)</p>	<p><b>CLM4.0/CN</b>            pre-industrial            present day</p>	<p><b>f19_g16</b></p>
<p><b>Full ocean, transient:</b>            B_1850-2005_WACCM_CN (B20TRWCN)            B_1955-2005_WACCM_CN (B55TRWCN)            B_RCP2.6_WACCM_CN (BRCP26WCN)            B_RCP4.5_WACCM_CN (BRCP45WCN)            B_RCP8.5_WACCM_CN (BRCP85WCN)</p>	<p><b>CLM4.0/CN</b>            annual solar variability, historical            daily solar variability, historical            daily solar variability, 2005-2100            daily solar variability, 2005-2100            daily solar variability, 2005-2100</p>	<p><b>f19_g16</b></p>
<p><b>Data ocean, static:</b>            F_1850_WACCM (F1850W)            F_2000_WACCM (FW)            F_2000_WACCMX (FWX)            F_1996_WACCMX (FWX1996)</p>	<p><b>CLM4.0/CN</b>            pre-industrial            present day            thermosphere extension, solar max            thermosphere extension, solar min</p>	<p><b>f19_f19, f45_f45</b></p>
<p><b>Data ocean, transient:</b>            F_1955-2005_WACCM_CN (F55WCN)            FGEOS_C4WCM_L40CN (FSDW)            F_1955-2005_WACCM_SC (B55TRWSCCN)            B_RCP2.6_WACCM_SC_CN            (BRCP26WSCCN)            B_RCP4.5_WACCM_SC_CN</p>	<p><b>CLM4.0/CN, daily solar variability</b>            historical            nudged by specified dynamics            specified chemistry, historical            specified chemistry, 2005-2100            specified chemistry, 2005-2100            specified chemistry, 2005-2100</p>	<p><b>f19_f19, f45_f45</b></p>





# CAM-chem component configurations

Compsets CESM1.2.2. for res: 1.9x2.5	Model (phys)/ radiation	Chemistry	Components / Meteorology
B_2000_TROP_MOZART (BMOZ) B_2000_MOZSOA_CN B_2000_MOZMAM_CN (BMOZMAM)	CAM4, active	trop_mozart +soa chemistry trop_mozart mam	All active + CLM/CN All active, CLM/CN
F_2000_MOZMAM_CN (FMOZMAM) F_SD_BAM_CN	CAM4 passive	trop_mozart  trop_bam	Prescr. ocn/ice, CLM/CN
B_2000_CN_CHEM (B2000CNCHM) B_1850_CN_CHEM (B1850CNCHM) B_1850-2000_CN_CHEM (B20TRCNCHM)	CAM4, active	super_fast_llnl	MEGAN VOC emis, all active CLM/CN
F_1850_CN_CHEM (F1850CNCHM)	CAM4, passive		Prescr. ocn/ice, CLM/CN
F_2000_C4SSOA_L40 (FSOA) FGEOS_C4SSOA_L40 F2000_STRATMAM3_CN FGEOS_STRATMAM3_CN	CAM4, passive  CAM5, passive	trop_strat +soa chemistry trop_strat mam+soa chemistry	Prescr. ocn/ice, MEGAN GEOS5 met. Prescr. ocn/ice, CLM/ CN GEOS5 met.
F_2000_STRATMAM7_CN	CAM5 passive	trop_strat mam +soa chemistry	Prescr. ocn/ice, CLM/CN



## 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.



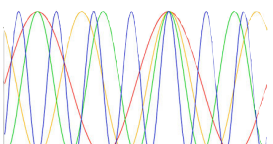
 fexcl1, fexcl2, etc: list of variables excluded from default output on h0, h1, etc.

# 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 history variables?

---

- Put fincl and other namelist modifications in the user\_nl\_cam file in your \$casedir

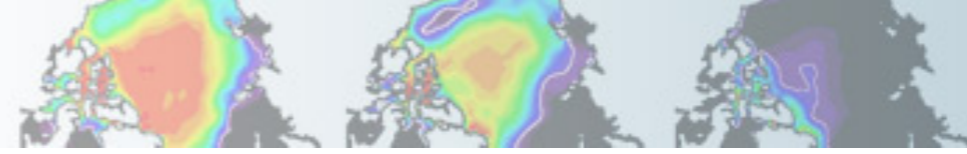
```
fincl1 = 'AOA1', 'AOA2', 'BR', 'BRCL', 'O3', ...
```

- Generate a new namelist:

```
> cd $CASEROOT
> ./preview_namelists
```

- 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

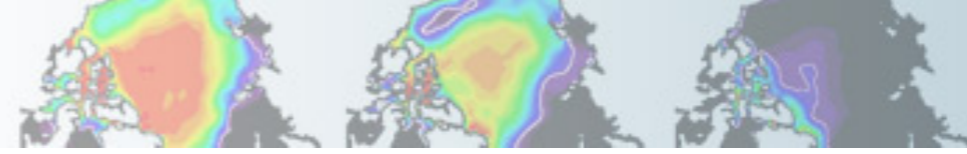
  Fixed
M, N2
  End Fixed
End SPECIES

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

```

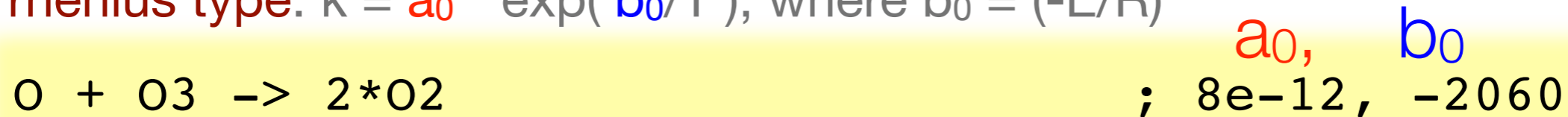


# Modifying the chemical preprocessor input file

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



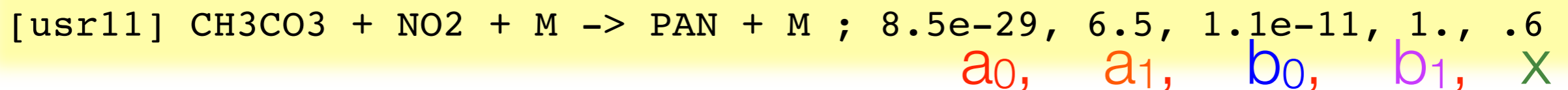
- **Arrhenius type:**  $k = a_0 * \exp(b_0/T)$ , where  $b_0 = (-E/R)$



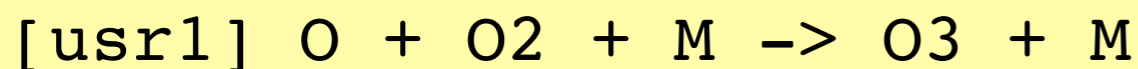
- **Troe rate constant:**  $k = \alpha^x / (1 - \beta^2)$ , where:

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

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

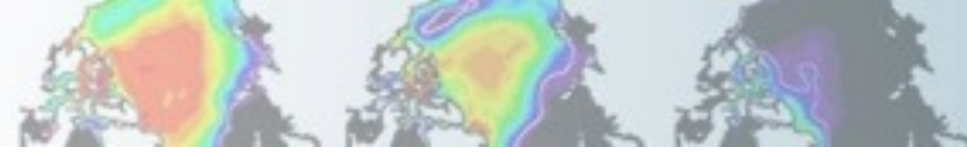


- **User-specified reaction rate:**



rate defined in routine mo\_usrxrt.F90





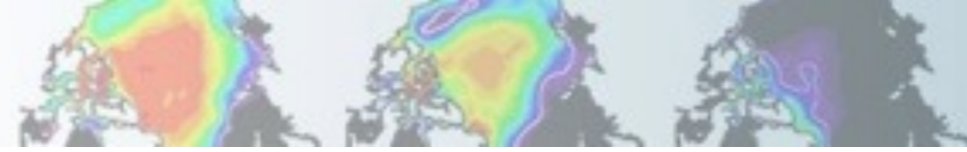
# User-specified reaction rates

```
[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:

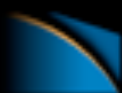
```
[cph1,cph] O + O3 -> 2*O2 ; 8e-12, -2050
```

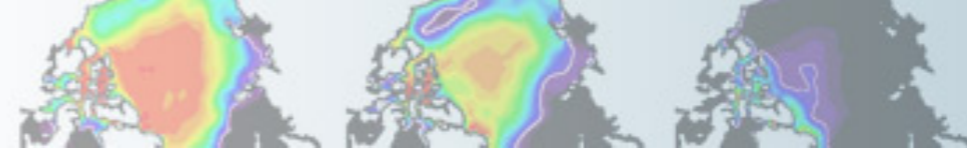
- Edit the file `env_build.xml` in the case directory to add the CAM configure option `-usr_mech_infile` pointing to the new preprocessor input file:

```
<!--"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:

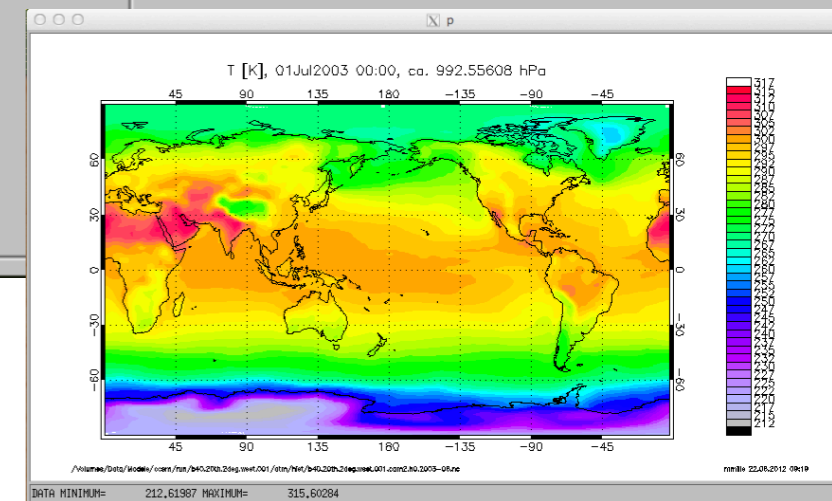
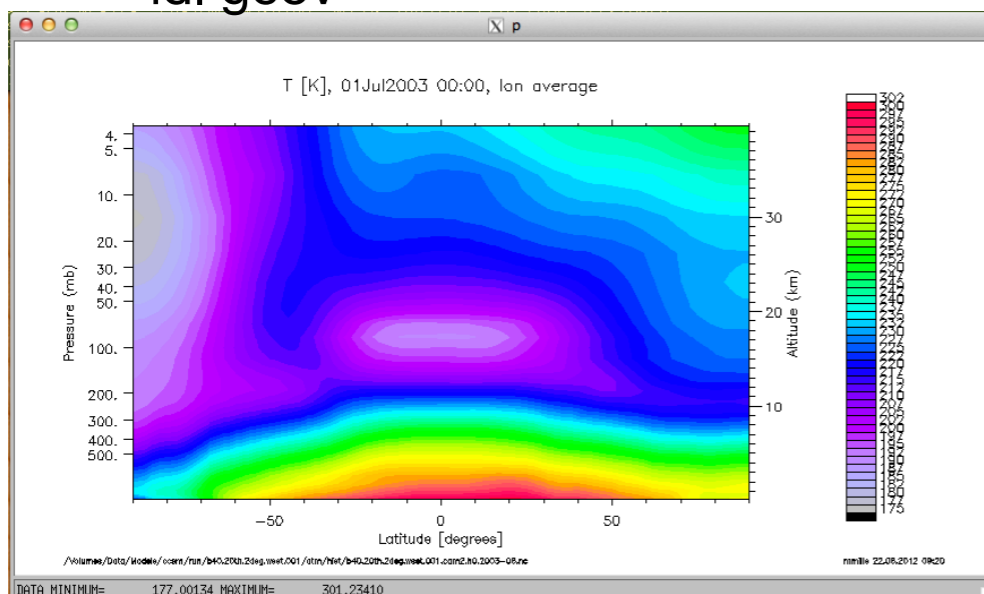
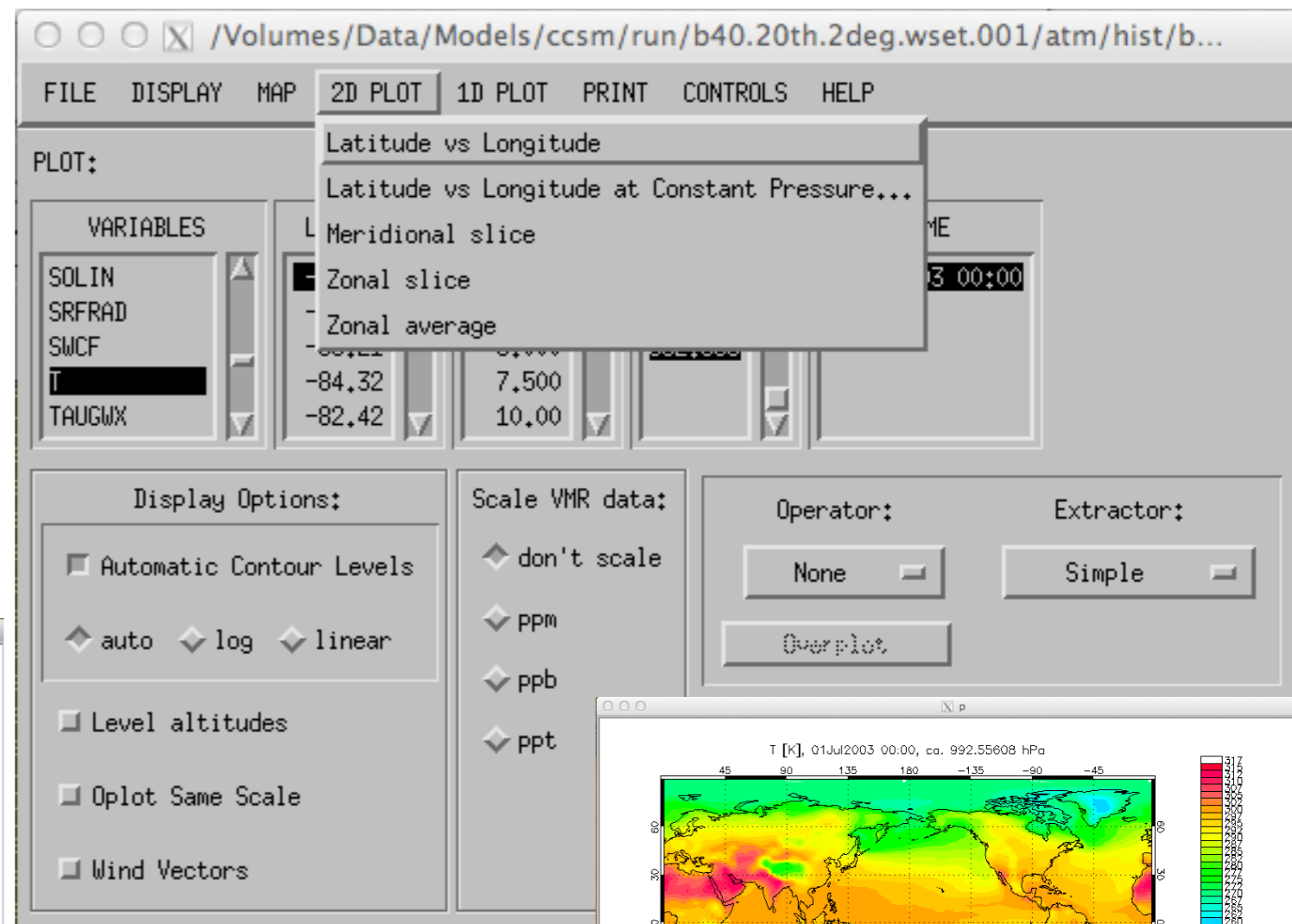
```
> configure -cleanall
> configure -case
> *.build
```

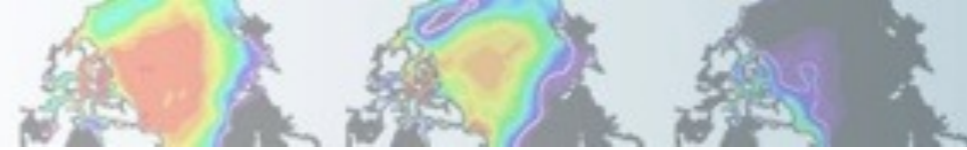




# Post-processing data analysis

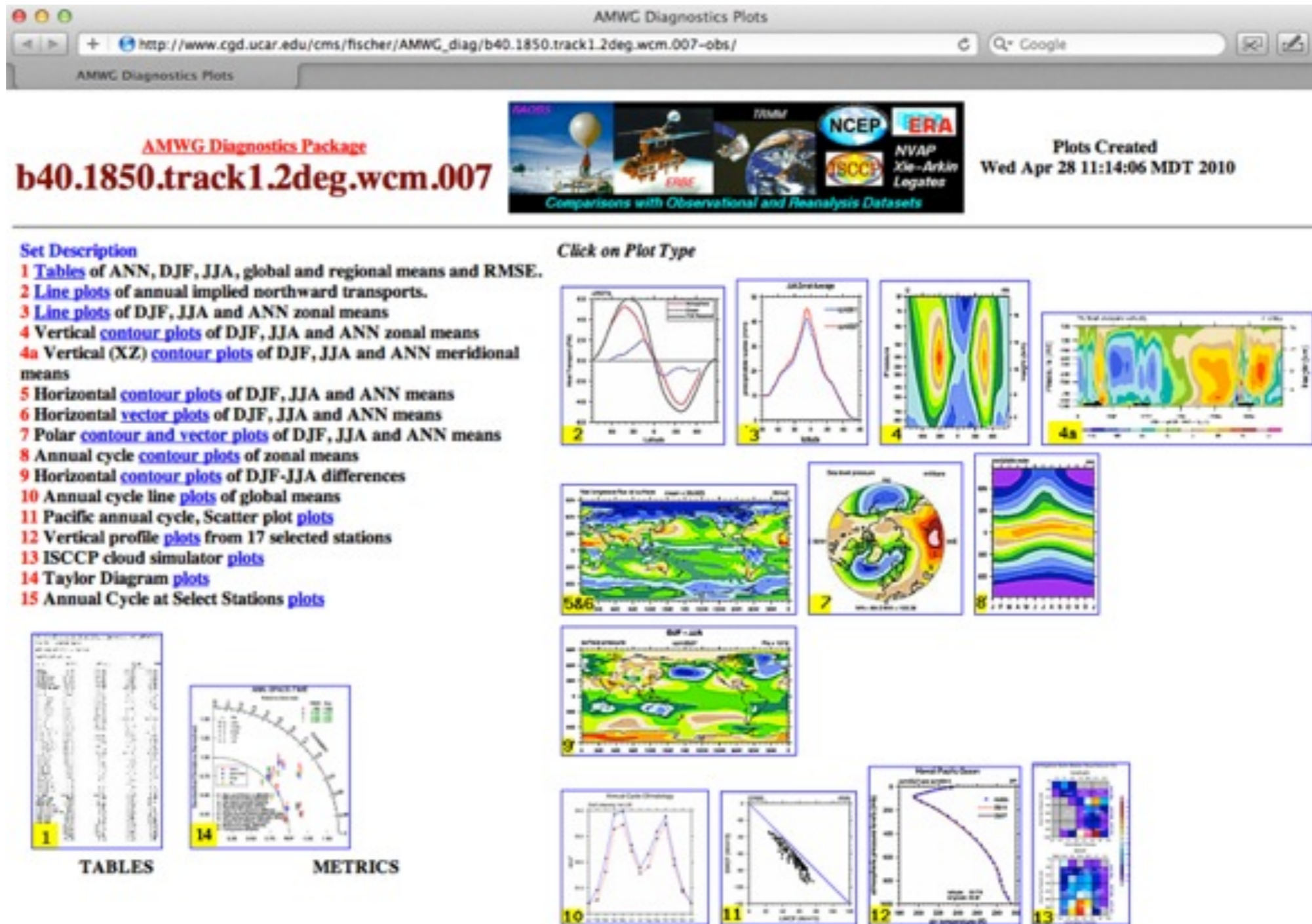
- CESM history files are in standard netCDF format, and may be analyzed with standard analysis tools, including Matlab, IDL, NCL, and NCO.
- GEOV is an IDL-based viewer for geophysical history files created by NCAR's CAM, WACCM and MOZART models. GEOV can be downloaded from the WACCM webpage ([http://www.cesm.ucar.edu/working\\_groups/WACCM/](http://www.cesm.ucar.edu/working_groups/WACCM/)).
  - Install GEOV on yellowstone by editing your `~/.cshrc` file to include:  
`setenv IDL_STARTUP ~fvitt/idl_startup`  
 This sets the idl path to include GEOV:
    - `source ~/.cshrc`
  - View model output on yellowstone:
    - `cd /glade/scratch/$USER/archive`
    - `idl geov`





# Post-processing data analysis

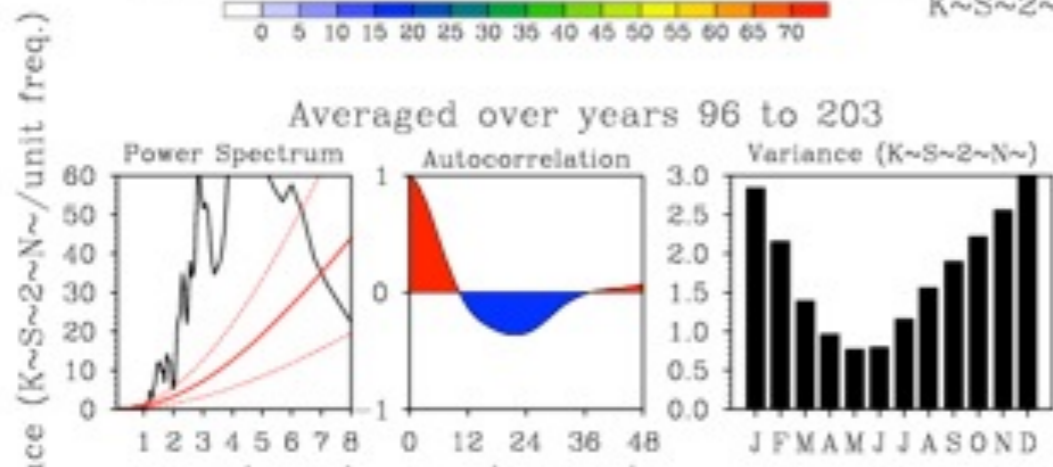
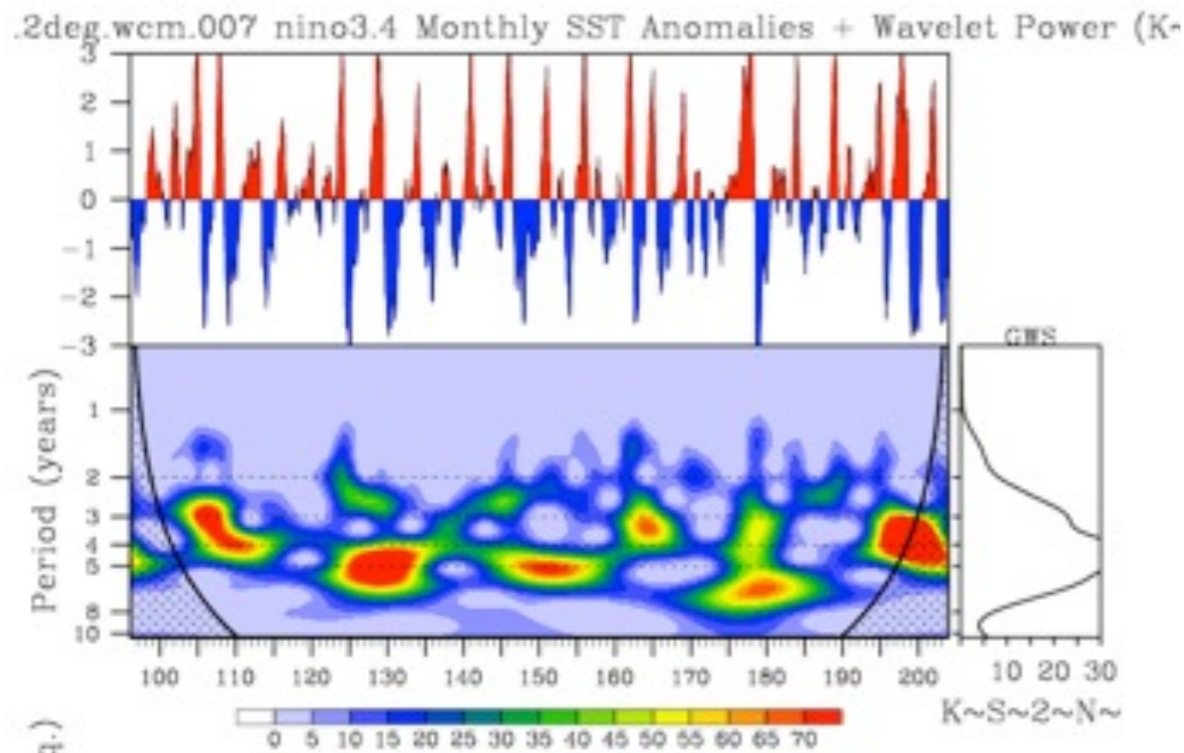
CAM diagnostic packages are described under CAM Post-Processing Utilities on the **CAM documentation page** at <http://www.cgd.ucar.edu/amp/amwg/diagnostics/>



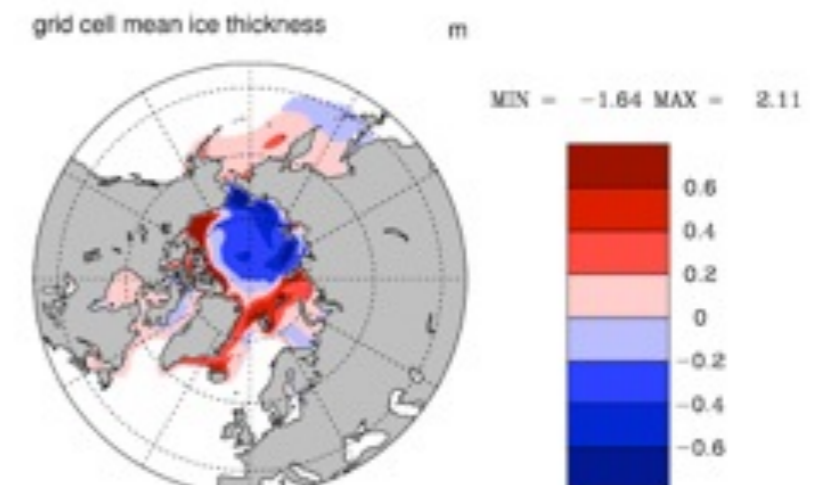
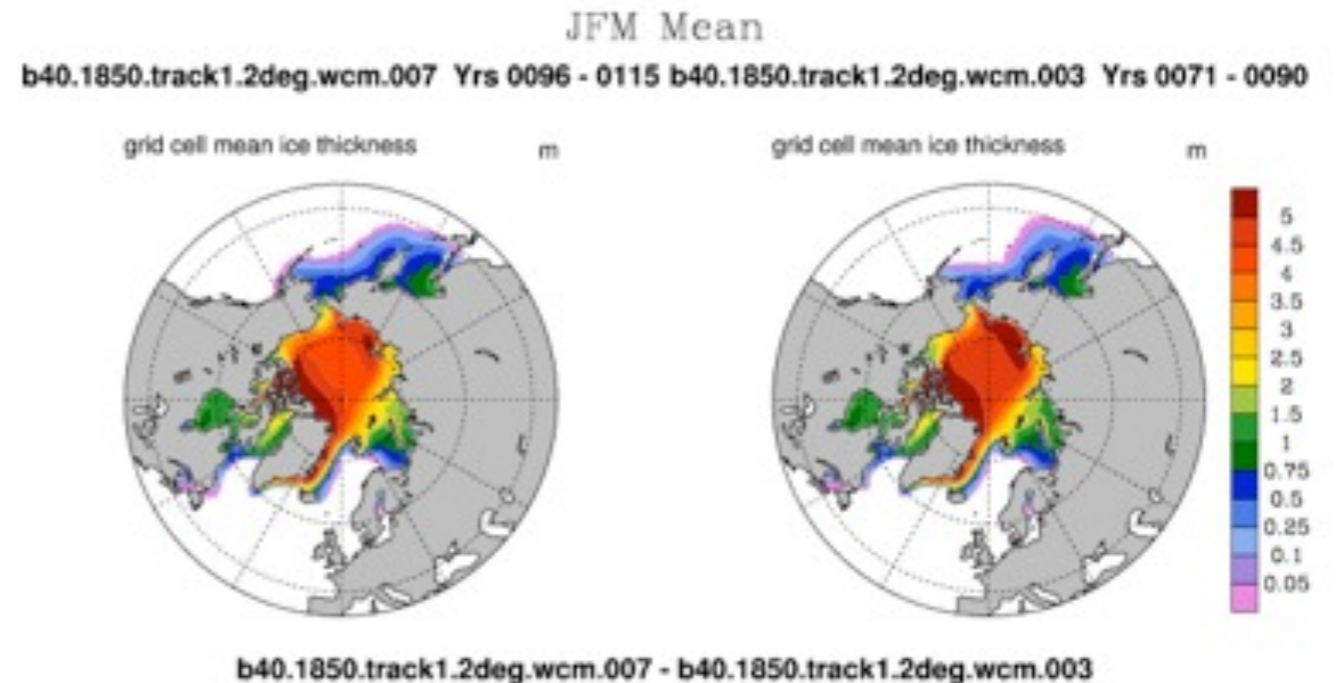
# Post-processing data analysis

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/cesm1.2/model\\_diagnostics/](http://www.cesm.ucar.edu/models/cesm1.2/model_diagnostics/)).

## Ocean ENSO



## Sea Ice Thickness



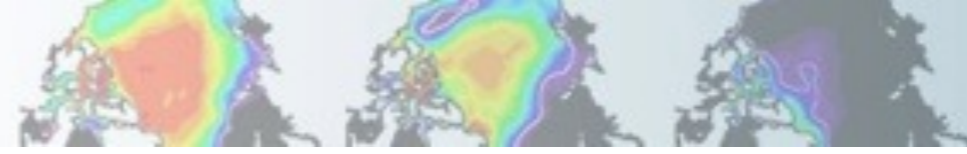
# Validating CESM/WACCM

- 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.

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

**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

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