

5 Fun Things To Do With WACCM



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- How do I change model output?
- How do I change a reaction rate?
- How is the solar spectrum specified?
- How do I change a boundary condition?
- How do I change an initial condition?



How do I change model output?

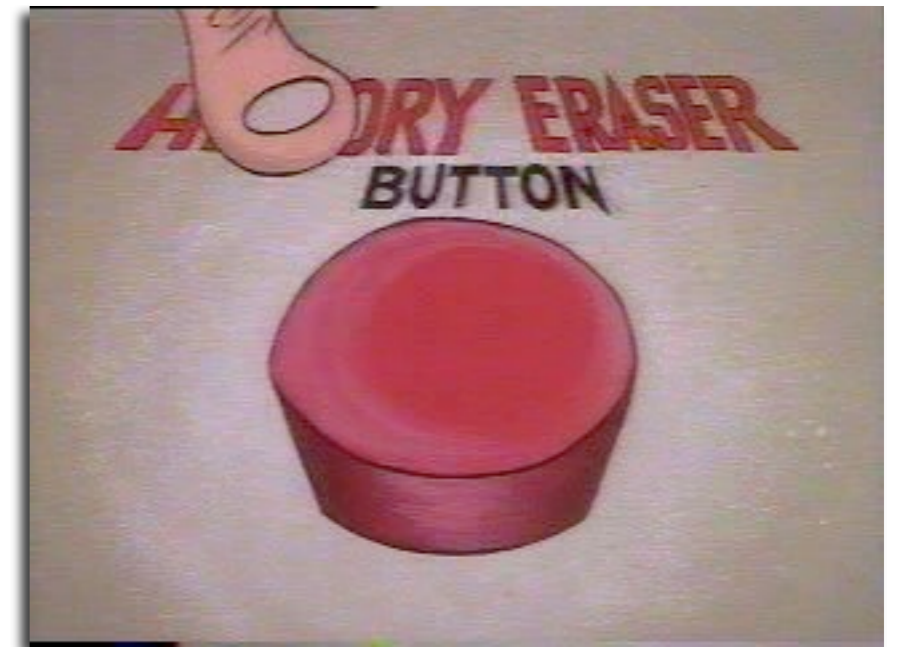
- Review list of current CAM history variables
 - Currently >2300 existing CAM history variables
 - Complete list is printed in atm.log.* file generated during each run in \$rundir/run.
 - Search log file for “**MASTER FIELD LIST**” to review.

***** MASTER FIELD LIST *****

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

How do I change model output?

- Case 1: Existing history variable
 - Adding/deleting history variables to output
 - Changing frequency or averaging of output
- Case 2: Create new history
 - Modifying source code
 - Call routines `addfld` & `outfld`
 - compiling with modified source code





`finc1` and `fexc1`: 2 cool cats controlling history

`finc1`



- Lists history variables that you want to **include** in model output, in addition to default history variables.



`fexc1`

- Lists default history variables that you want to **exclude** from model output

History file series

CAM output can be sent to numerous history file series, each of which may have independent output variables, frequency and averaging characteristics.


- The **first** history file series is monthly averaged output by default, producing files named `$case.cam2.h0.YYYY-MM.nc`
- Additional history file series may be of arbitrary frequency, averaged or instantaneous.
 - Series 2 : `$case.cam2.h1.*`
 - Series 3 : `$case.cam2.h2.*`
 - etc.
- Each series has its own fincl and fexcl, BUT...




How do I change output of existing namelist variables?

- After you configure a case, edit \$casedir/Buildconf/cpl.buildnml.csh:

```
&cam_inparm
    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', ...
    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), and “B” (GMT 00:00:00 average).

-  **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?

```
&cam_inparm
  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', ...
  mfilt    = 1,365,30,120,240
  nhtfrq   = 0,-24,-24,-6,-3
```

- **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`.
- To change output in a run that has already started, see CAM user guide FAQ.

Running with a new namelist

- For durable namelist changes, create a `user_nl_cam` file

- contains modified cam namelist settings

- place in `$CASEROOT`

- Reconfigure the case to generate a new namelist:

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

- Check the newly generated namelist prior to build:

```
> cd $CASEROOT/CaseDocs
> less atm_in
```

```
&chem_inparm
airpl_emis_file           = '/fis/cgd/cseg/csm/inputdata/atm/cam/chem/trop_mozart/emis/emiss
clim_soilw_file           = '/fis/cgd/cseg/csm/inputdata/atm/cam/chem/trop_mozart/dvel/clim
depvel_lnd_file           = '/fis/cgd/cseg/csm/inputdata/atm/cam/chem/trop_mozart/dvel/regri
electron_file             = '/fis/cgd/cseg/csm/inputdata/atm/waccm/phot/electron.dat '
euvac_file                = '/fis/cgd/cseg/csm/inputdata/atm/waccm/phot/euvac.nc '
euvacdat_file            = '/fis/cgd/cseg/csm/inputdata/atm/waccm/phot/euvac.dat '
flbc_date                 = 20000101
```


How do I create a new history variable?

- Modify source code to add calls to 2 routines governing history variables:
 - `addfld`: Add a field to the master field list. Called once at setup.
 - `outfld`: Accumulate (or take min, max, etc. as appropriate) input field into its history buffer for appropriate tapes. Called each timestep.
 - All modified routines go in `$CASEROOT/SourceMods/src.cam`
- Compile with modified source code:

```
> cd $CASEROOT  
> $CASE.$MACH.build
```



How do I change a reaction rate?

- The **chemistry preprocessor**: generates CAM Fortran source code to solve chemistry.
- Input: a simple ASCII file listing chemical reactions and rates.
- Sample input files are in `$CCSMROOT/models/atm/cam/chem_proc/inputs`



```

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

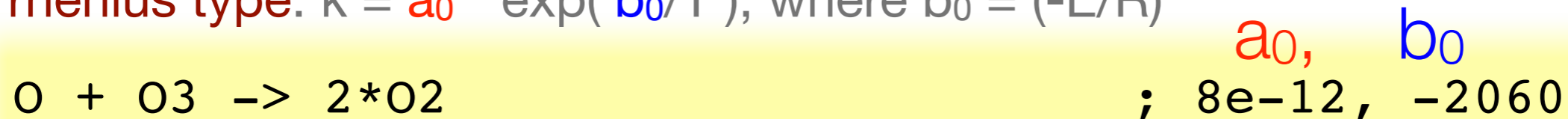
```

Modifying the chemical preprocessor input file

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



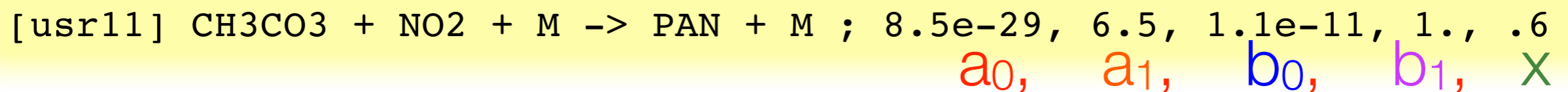
- **Arrhenius type:** $k = a_0 * \exp(b_0/T)$, where $b_0 = (-E/R)$



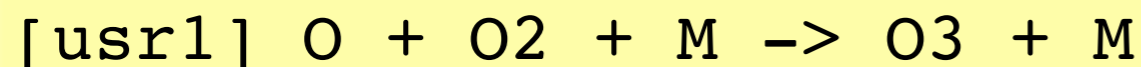
- **Troe rate constant:** $k = \alpha^x / (1 - \beta^2)$, where:

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

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



- **User-specified reaction rate:**



rate defined in routine mo_usrrxt.F90

Building the model with new chemistry

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

```
> cd $CASEROOT
> cp $CCSMROOT/models/atm/cam/chem_proc/inputs/waccm_mozart_mech.in my_waccm_mech.in"
> nedit my_waccm_mech.in &
```

- 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:

```
> configure -cleanall
> configure -case
```

How is the solar spectrum specified?

- Namelist variables point to 2 files specifying solar forcing
 - `solar_parms_file`: F10.7, K_p , A_p
 - solar and geomagnetic parameters used for aurora, UBCs, and wavelengths shorter than Lyman- α

```
> grep solar_parms_file CaseDocs/atm_in
solar_parms_file = '/fis/cgd/cseg/csm/inputdata/atm/waccm/phot/wa_smax_c100517.nc'
```

- `solar_data_file`: tsi, ssi, tsi_ref, ssi_ref
 - Covers wavelengths longer than Lyman- α
 - Time-variation of total solar irradiance, as well as variability with λ

```
> grep solar_data_file CaseDocs/atm_in
solar_data_file = '/fis/cgd/cseg/csm/inputdata/atm/cam/solar/
spectral_irradiance_Lean_1610-2009_ann_c100405.nc'
```

- solar_parms_file: F10.7, K_p, A_p

```

> ncdump /fis/cgd/cseg/csm/inputdata/atm/waccm/phot/wa_smax_c100517.nc
netcdf wa_smax_c100517 {
dimensions:
    time = UNLIMITED ; // (2 currently)
variables:
    float f107(time) ;
        f107:long_name = "10.7 cm solar radio flux (F10.7)" ;
        f107:units = "10^-22 W m^-2 Hz^-1" ;
    float f107a(time) ;
        f107a:long_name = "81-day centered mean of 10.7 cm solar radio flux (F10.7)" ;
    float kp(time) ;
        kp:long_name = "Daily planetary K index" ;
    short ap(time) ;
        ap:long_name = "Daily planetary a index" ;
        ap:units = "nanoTeslas" ;
    short isn(time) ;
        isn:long_name = "International Sunspot Number" ;
    int date(time) ;
        date:long_name = "current date (YYYYMMDD)" ;

data:
    f107 = 210, 210 ;
    f107a = 210, 210 ;
    kp = 4, 4 ;
    ap = 27, 27 ;
    isn = 0, 0 ;
    date = 101, 22000101 ;
}
  
```

List of dates between which other data are interpolated

- `solar_data_file`: tsi, ssi, tsi_ref, ssi_ref

- Data are given as a function of time (i.e. annually or daily) and wavelength
- tsi (time): total solar irradiance (W m^{-2})
- ssi (time, wavelength): solar spectral irradiance ($\text{mW m}^{-2} \text{nm}^{-1}$)
- tsi_ref, ssi_ref: values for tsi and ssi averaged over the reference time period of years 1834-1867 (solar cycles 8-10).

```
netcdf spectral_irradiance_Lean_1610-2009_ann_c100405 {
dimensions:
    time = UNLIMITED ; // (400 currently)
    ref_time_bound = 2 ;
    wavelength = 3780 ;
variables:
    double tsi_ref ;
        tsi_ref:time_op = "average" ;
        tsi_ref:bounds = "ref_time_bound" ;
        tsi_ref:long_name = "average of tsi over ref_time_bound" ;
        tsi_ref:units = "W/m^2" ;
        tsi_ref:average_op_ncl = "dim_avg over dimension: time" ;
    double ref_time_bound(ref_time_bound) ;
        ref_time_bound:units = "days since 0000-01-01 00:00:00" ;
        ref_time_bound:long_name = "reference time interval bound" ;
    int date(time) ;
        date:format = "YYYYMMDD" ;
    double time(time) ;
        time:calendar = "noleap" ;
        time:axis = "T" ;
        time:time_origin = "01-JAN-0000" ;
        time:units = "days since 0000-01-01 00:00:00" ;
    double wavelength(wavelength) ;
        wavelength:units = "nm" ;
        wavelength:long_name = "Wavelength of band center" ;
    double band_width(wavelength) ;
        band_width:units = "nm" ;
        band_width:long_name = "Wavelength width of band" ;
    double ssi_ref(wavelength) ;
        ssi_ref:time_op = "average" ;
        ssi_ref:bounds = "ref_time_bound" ;
        ssi_ref:long_name = "average of ssi over ref_time_bound" ;
        ssi_ref:units = "mW/m^2/nm" ;
        ssi_ref:average_op_ncl = "dim_avg over dimension: time" ;
    double tsi(time) ;
        tsi:units = "W/m^2" ;
        tsi:long_name = "Total Solar Irradiance at 1 a.u." ;
    double ssi(time, wavelength) ;
        ssi:units = "mW/m^2/nm" ;
        ssi:long_name = "Solar Spectral Irradiance at 1 a.u." ;
```

How do I change a boundary condition?

- Find an existing boundary condition file (LBC or UBC):

```
> grep lbc CaseDocs/atm_in
flbc_date = 20000101
flbc_file = '/path/to/inputdata/atm/waccm/lb/LBC_1765-2005_1.9x2.5.nc'
flbc_list = 'N2O', 'HCFC22', 'H2', 'CO2', 'CH4', 'CH3CL', 'CH3CCL3', ...
flbc_type = 'CYCLICAL'
> cd /path/to/inputdata/atm/waccm/lb
```

- Modify the existing netCDF BC data file (via NCL, NCO, IDL) to produce a new one:

```
> ncap -O -s "CO2=CO2*0.833" $infile $outfile
> ncatted -a units,CO2,o,c,"kg/kg" $outfile
```

- Change `flbc_file` or the appropriate `ubc_file` in your namelist to point your new file

How do I change an initial condition?

- Copy an existing initial condition file:

```
> grep ncdata CaseDocs/atm_in
ncdata=' /path/to/inputdata/atm/waccm/ic/icfile.cam2.i.2000-01-01-00000.nc '
```

```
> cd /path/to/inputdata/atm/waccm/ic
```

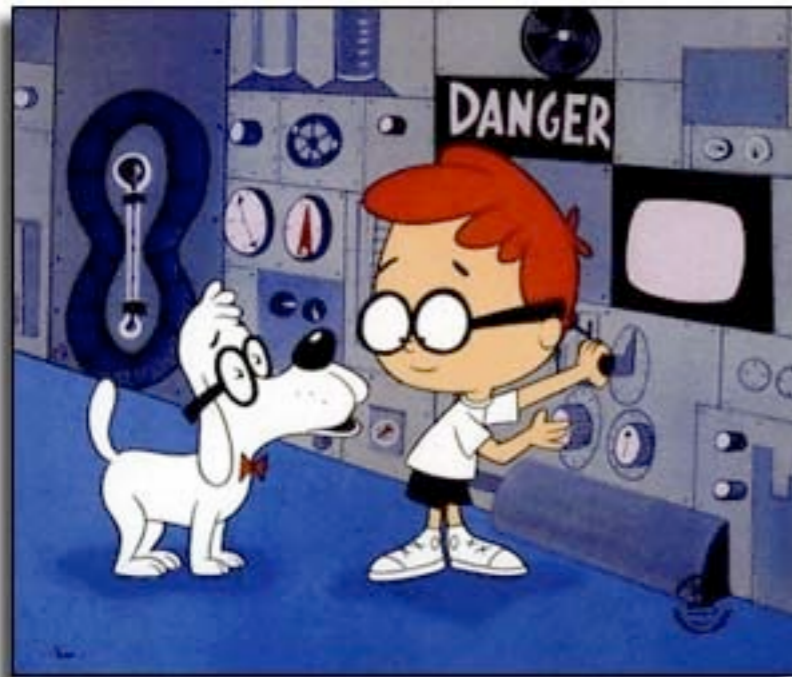
- Modify the existing netCDF input data file (via NCL, NCO, IDL) to produce a new one:

```
> ncap -O -s "CO2=CO2*0.833" $infile $outfile
```

```
> ncatted -a units,CO2,o,c,"kg/kg" $outfile
```

- Change `nc_data` in your namelist to point your new file
- Run as an initial run

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