CAM Breakout Session Exercises

CESM Tutorial
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Exercises

- First run the control case
- Then choose one (or more) modifications to try

1. Turn off 'freeze-drying' approximation
   (*namelist change, Arctic*)
2. Increase orographic height over the western US by 50%
   (*dataset change, mid-latitude)*

2a. Modify sea surface temperature
   (*dataset change, tropical)*

3. Increase the triggering threshold for deep convection just over land (*code change--simple, tropical*)
4. Modify emissivity of ice clouds (*code change--advanced*)

All exercises are based on CAM4; you can use CAM5 with Ex. 1-3 by running control AND modified case with correct compset (slide 3)

Control Case: creating an F-case

F-case refers to a specific model configuration with prescribed (observed data) ocean and prescribed sea-ice (thickness, area)

Compset Type	Atmosphere	Land	Ocean	Ice
F *(these exercises)*	*Interactive*	*Interactive*	Data	Thermodynamic
B *(previous exercises)*	*Interactive*	*Interactive*	*Interactive*	*Interactive*

Create a new F-case for your control *(Do this now)*

```
cd /glade/p/cesm/tutorial/cesm1_2_0.tutorial/scripts
```

The casename is your choice; I like it to tell me as much as possible about the case.

```
./create_newcase -case ~/cases/cesm1_2_0.cntl -res T31_T31 -compset F_2000
    -mach yellowstone
```

Note the difference with the B-case we've been running *(DON'T do this now)*

```
./create_newcase -case $CASEROOT -res T31_gx3v7 -compset B_1850 -mach alps
```

To use cam5 instead of cam4:
–compset F_2000_CAM5

This is an example of how I like to name my cases. Feel free to use the tutorial standard (f.day5.0 or f2000.day5.0) but start thinking about what information you want in your case names as you work.

Control Case (cont.)

Optional: set shell variables so you don't have to type the long names all the time

```
setenv CASENAME cesm1_2_0.cntl; setenv CASEROOT ~/cases/$CASENAME
```

Or `source Tools/ccsm_getenv`

- **Run length options (suggested run time: 2 months)**

```
cd $CASEROOT
./xmlchange -file env_run.xml -id STOP_N -val 2
./xmlchange -file env_run.xml -id STOP_OPTION -val nmonths
```

- **Configure**

```
./cesm_setup
```

- **Required namelist variables (for this atm resolution to use data ice model)**

Add two variables to $CASEROOT/user_nl_cice with an editor.

```
grid_file = '/glade/p/cesm/cseg/inputdata/share/domains/domain.ocn.48x96_gx3v7_100114.nc'
kmt_file = '/glade/p/cesm/cseg/inputdata/share/domains/domain.ocn.48x96_gx3v7_100114.nc'
```

Note that the file names are the same; do a mouse-copy 'ls' to double check the complicated names.

The 'single quotes' are absolutely necessary.

- **Build**

```
./cesm1_2_0.cntl.build
```

***** The rest of the exercises are configured the same up to this point, come back to this page every time and do all of the above!*****

Control Case: continued

- **Check completion of build**

`cat CaseStatus` (should show 'build complete')

`ls /glade/scratch/$LOGNAME/$CASENAME/bld/cesm.exe` (should exist)

- **Submit**

```
bsub < cesm1_2_0.cntl.run
```

- **Checking jobs**

```
bjobs
```

Shows output similar to:

```
JOBID   USER    STAT QUEUE FROM_HOST   EXEC_HOST    JOB_NAME   SUBMIT_TIME
992612 bundy    PEND small yslogin1-ib               *2_0_cntl Aug 16 11:10
```

This should take about 10 minutes once it's in the queue.

Meanwhile, continue to the following pages to choose and set up your next exercise.

You may want to read through the descriptions of all the exercises to find one that will both interest and challenge you. The namelist change is similar to the day2 practical. The dataset exercises shows tools of interest for modifying netcdf files. The code changes are important if you'll be modifying code, and the second provides hints and tools to help you find the relevent code to change intead of just telling you what to do.

Comparing results to control case

Once you have completed an exercise, come back to this page for a guide to a quick comparison

You might need to load modules: `module load ncview; module load netcdf`

- **A quick comparison:** create an ncfile containing the diffs between two cases

(both runs need to be finished for this to work!)

```
cd /glade/scratch/$LOGNAME/archive/$CASENAME/atm/hist
setenv CNTL cesm1_2_0.cntl    (optional: use your case names in these env vars so you can copy and use the ncdiff lines)
setenv CASE1 cesm1_2_0.nofrzdry
ncdiff $CASE1/atm/hist/$CASE1.cam.h0.0001-01.nc
       $CNTL/atm/hist/$CNTL.cam.h0.0001-01.nc
        diff_${CASE1}_${CNTL}.nc
```

Use ncview to browse variables in this file that contains only the diffs

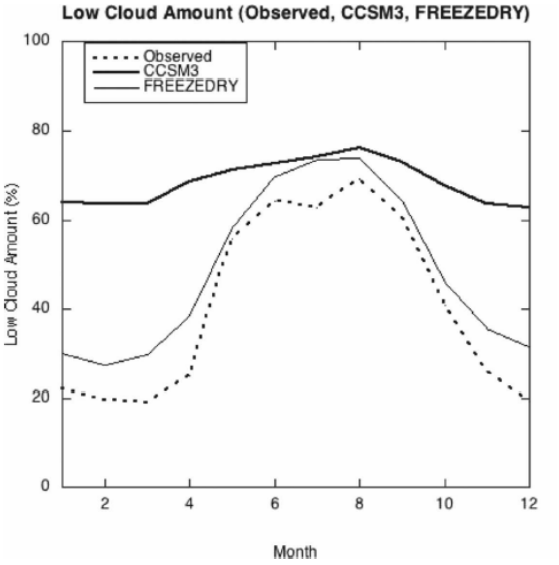
```
ncview diff_${CASE1}_${CNTL}.nc
```

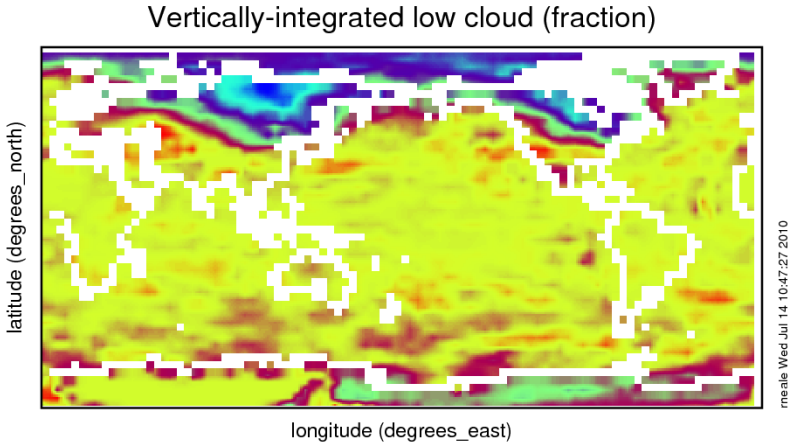
- **Use ncl scripts from the diagnostics tutorial to compare single fields**
- **Run the AMWG mean diagnostics for a more comprehensive comparison (not time to do this today)**
- **Is two months enough model run time to see changes? To see meaningful changes? Is T31 good enough resolution to start with?**

Exercise 1: *Namelist Change*

(a review from previous day)

- **ACTION**: Switch off an approximation that reduces the cloud fraction in very dry atmospheric conditions (Vavrus and Walliser, 2008), which improved results from CCSM3.





if (cldfrc_freeze_dry) then
f = f x max(0.15,min(1.0,q/0.003))
endif

Recall from day2: for a complete list of namelist, please see the on-line documentation for each component model.
CAM4: http://www.cesm.ucar.edu/cgi-bin/eaton/namelist/nldef2html-pub
CAM5: http://www.cesm.ucar.edu/cgi-bin/eaton/namelist/nldef2html-cam5_2

Example 1: *Namelist Change*

- Follow **control case** example (slide 4) through the build, but with a new casename
- **Set namelist variable that controls 'freeze drying'** `cldfrc_freeze_dry= .false.`

Recall from day 2 you can choose one of two methods to change the namelist:

1. **env_run.xml** using xmlchange (do *before* ./cesm_setup)

```
xmlchange -file env_run.xml -id CAM_NAMELIST_OPTS -val "cldfrc_freeze_dry=.false."
```

2. (Or) add setting to **user_nl_cam** file (do *after* ./cesm_setup) using emacs/vi:

```
! Users should add all user specific namelist changes below in the form of
! namelist_var = new_namelist_value
 cldfrc_freeze_dry                = .false.
```

- Check that it worked: is the namelist really changed?

if using method (2), call `./preview_namelist` first

```
grep freeze /glade/scratch/$LOGNAME/$CASENAME/run/atm_in
```

or compare to control namelist:

```
diff /glade/scratch/$LOGNAME/$CASENAME/run/atm_in /glade/scratch/$LOGNAME/cesm1_2_0.cntl/run/atm_in
```

You should see the difference

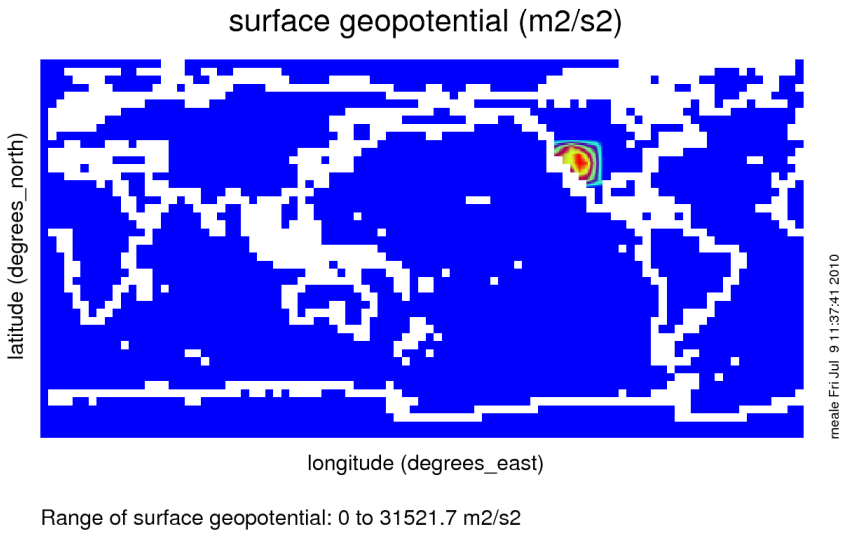
If so, submit run. While waiting, you might want to start another exercise.

What effects to look for? (Comparing to Control:slide 6)

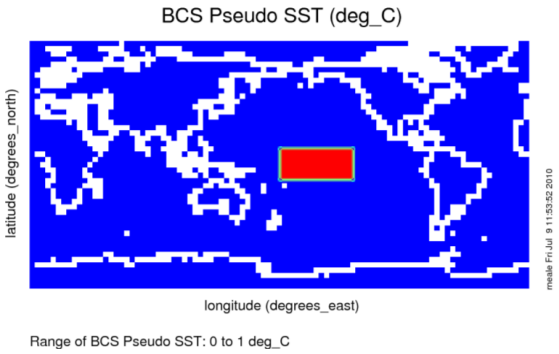
✓ *cloud (CLDLOW) ,Surface temperature (TS), surface energy budget (FSDS,FLNS), surface pressure (PS),...*

Example 2: *Dataset change*

- Change input boundary datasets (orography) by increasing surface geopotential height by 50% in the western USA



See alternative case 2a to add a Sea Surface Temperature (SST) anomaly instead



Example 2 (cont): *Dataset change*

1) Follow **control case** example (slide 4) through the build but with a new casename

Now we want to modify Orography surface boundary dataset

Orography file (specifies surface geopotential height **PHIS; `ncview`** if you want to look)

2) Make a local copy of the orography file in your $CASEROOT

```
cd $CASEROOT
cp /glade/p/cesm/cseg/inputdata/atm/cam/topo/USGS-gtopo30_48x96_c050520.nc .
```

Example 2 (cont): *Dataset change*

Change orography surface boundary data

3) Use nco utilities to edit values on the file (http://nco.sourgeforce.net)

We will use a function called **ncap2 – (netCDF Arithmetic Averager)** single line command below

```
ncap2 -O -s 'lat2d[lat,lon]=lat ; lon2d[lat,lon]=lon' 1

-s 'omask=(lat2d >= 30. && lat2d <= 50.) && (lon2d >= 235. && lon2d <= 260.)' 2

-s 'PHIS=(PHIS*(1.+omask*0.5))' 3

USGS-gtopo30_48x96_c050520.nc USGS-gtopo30_48x96_us_oro_x50.nc
```

1. Define 2D latitude and longitude arrays

2. Create a mask – setting = 1 for the desired lat/lon range; elsewhere = 0

3. Apply mask to 2D field (PHIS = surface geopotential = gZ) – 1.5x PHIS in region of interest

Quickly check data by making a netcdf file containing the difference (new – old)

```
ncdiff -v PHIS USGS-gtopo30_48x96_us_oro_x50.nc
   USGS-gtopo30_48x96_c050520.nc PHIS_diff.nc
ncview PHIS_diff.nc
```

Example 2 (cont): *Dataset change*

Edit namelist to point to modified dataset

```
echo "bnd_topo = './USGS-gtopo30_48x96_us_oro_x50.nc'" >>& user_nl_cam
```

Check

```
./preview_namelist
grep topo /glade/scratch/$LOGNAME/$CASENAME/run/atm_in
```

Copy changed orography boundary data to run directory

```
cp USGS-gtopo30_48x96_us_oro_x50.nc /glade/scratch/$LOGNAME/$CASENAME/run
```

Build and run.

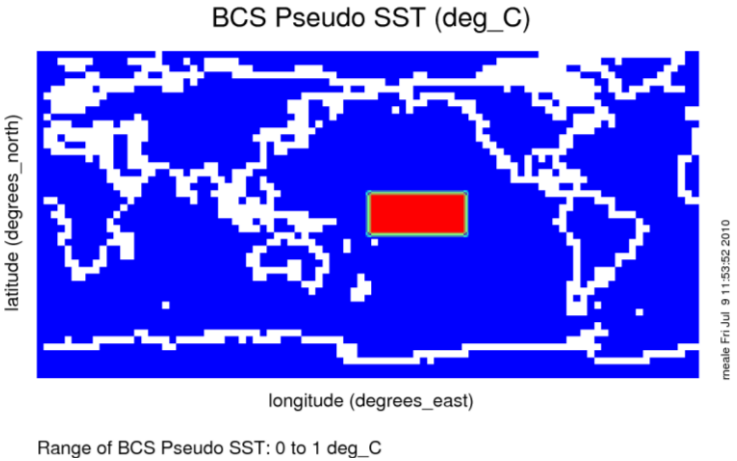
Once it starts running, check that the correct file is being used.

What to look for when experiment is complete? (Comparing to Control:slide 6)

- ✓ *Surface temperature (TS), surface pressure (PS), cloud (CLDLOW), rainfall (PRECT), winds (OMEGA,U,W)*

Example 2a: *Dataset change*

- ACTION: Change input boundary datasets (Sea Surface Temperature) by increasing it's value by 2K in the tropical Central Pacific



Follow **control case** example (slide 4) through build.

While building: you need to modify the SST file. This file is located in the 'inputdata' location:
`/glade/p/cesm/cseg//inputdata/atm/cam/sst/sst_HadOIBl_bc_48x96_clim_c050526.nc`

Copy SST file to your case directory and follow instructions on the next page

```
cd $CASEROOT
cp /glade/p/cesm/cseg//inputdata/atm/cam/sst/sst_HadOIBl_bc_48x96_clim_c050526.nc .
```

Example 2a (cont): *Dataset change*

Change SST surface boundary data

Use nco utilities to edit values on the file (**http://nco.sourgeforce.net**)

We will use a function called **ncap2 – (netCDF Arithmetic Averager)** single line command below

1
```
ncap2 -O -s 'lat2d[lat,lon]=lat ; lon2d[lat,lon]=lon'
```
1. Define 2D latitude and longitude arrays

2
```
-s 'omask=(lat2d >= -10. && lat2d <= 10.) && (lon2d >= 180. && lon2d <= 240.)'
```
2. Create a mask – setting = 1 for the desired lat/lon range; elsewhere = 0

3
```
-s 'SST_cpl=(SST_cpl+omask*2.)'
```
3. Apply mask to 2D field (SST_cpl): +2K in region of interest (equatorial Pacific)

```
sst_HadOIBl_bc_48x96_clim_c050526.nc
```
infile

```
sst_HadOIBl_bc_48x96_clim_warmtcp.nc
```
outfile

Quickly check data by making a netcdf file containing the difference (new – old)

```
ncdiff -v SST_cpl sst_HadOIBl_bc_48x96_clim_warmtcp.nc
   sst_HadOIBl_bc_48x96_clim_c050526.nc SST_cpl_diff.nc
ncview SST_cpl_diff.nc
```

You should see a difference!

Example 2a (cont): *Dataset change*

Apply changed SST (before cesm_setup; for 'after' method see Exercise 2)

- ***figure out which namelist variable to change*** ***('grep' is how you would have found the sst file to change)***

```
cd $CASEROOT
grep sst *.xml
    env_run.xml:<entry id="SSTICE_DATA_FILENAME"
     value="$DIN_LOC_ROOT/atm/cam/sst/sst_HadOIBl_bc_48x96_clim_c050526.nc"  />
```

- ***change it in env_run.xml***

```
./xmlchange -file env_run.xml -id SSTICE_DATA_FILENAME \
  -val "./sst_HadOIBl_bc_48x96_clim_warmtcp.nc"
```

- ***Process env_run.xml to make namelist files***

```
./preview_namelists
```

Check your changes went into namelists *Hint:* grep sst $CASEROOT/CaseDocs/*_in

- ***Copy changed SST data to run directory***

```
cp sst_HadOIBl_bc_48x96_clim_warmtcp.nc /glade/scratch/$LOGNAME/$CASENAME/run
```

- ***Submit your run***

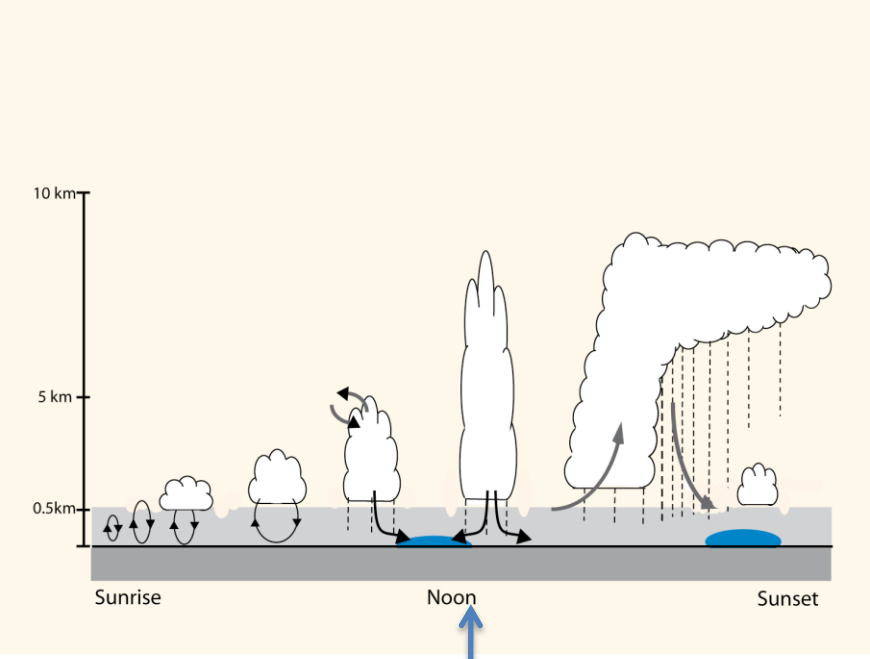
(While running, *check it's really using the file.* *Hint*: cd $RUNDIR; grep sst_Had cesm.log.*

What to look for in results? (Comparing to Control:slide 6)

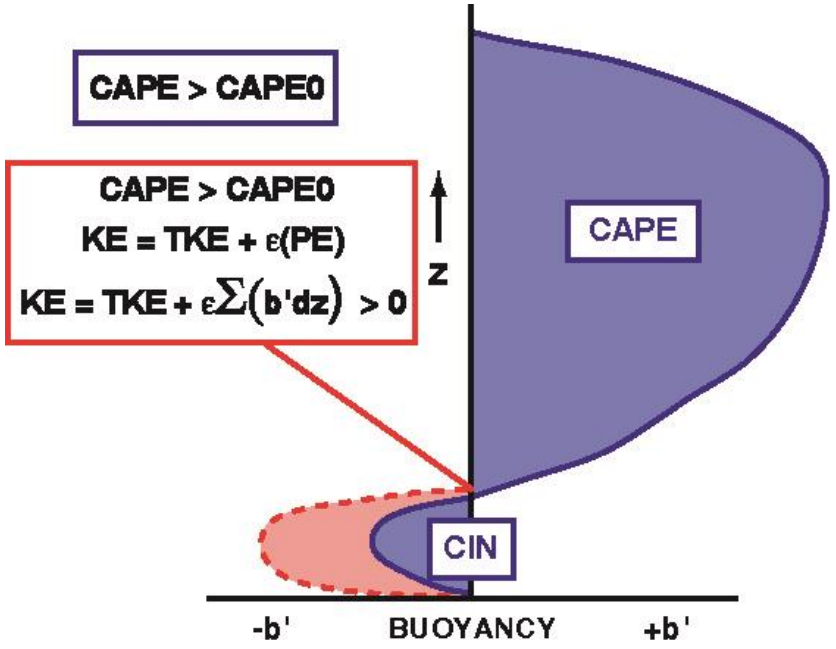
✓ *Surface temperature (TS), surface pressure (PS), cloud (CLDLOW), rainfall (PRECT), winds (OMEGA,U,W)*

Example 3: *Code Change CAPE*

- Examine the mean effects of delaying the initiation of convection by increasing the minimum required convective available potential energy (CAPE) to initiate convection over land;



Models peak around noon
Too early



Example 3 (cont): *Code Change CAPE*

- **Follow guide for control example before build *then***
- **Copy fortran code file that controls deep convection calculation (Zhang and McFarlane, 1995) to local code modification directory for the atmosphere**

```
cd $CASEROOT/SourceMods/src.cam
cp /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/physics/cam/zm_conv.F90 .
```

- **Edit** `zm_conv.F90:`

Search for the following lines

```
if (cape(i) > capelmt) then
 lengath = lengath + 1
 index(lengath) = i
end if
```

The minimum CAPE (capelmt) for triggering convection is = 70 J/kg everywhere.

Let's increase the value over land (x10 to 700 K/kg) to hopefully get a big singal in order to analyze what the mean effect of delaying convection is.

Example 3 (cont): *Code Change CAPE*

Change the following in sub-routine ***zm_convr***

```
if (cape(i) > capelmt) then
 lengath = lengath + 1
 index(lengath) = i
end if
```

To

```
if (landfrac(i) > 0.5_r8) then
 capelmt_mask = 10._r8*capelmt
else
 capelmt_mask = capelmt
end if

if (cape(i) > capelmt_mask) then
 lengath = lengath + 1
 index(lengath) = i
end if
```

And, near the top of subroutine zm_convr, right after:

```
 real(r8) pblt(pcols)
```

Add `real(r8) :: capelmt_mask`

Where land fraction is >50%,

Scale the existing trigger value by 10x

Create a local variable called capelmt_mask to use as the convection trigger

Declare the capelmt_mask variable

Diff your new and old file, Build (check if successful!) and run.

Example 3 (cont): *Code Change CAPE*

To check if build was succesful:

- stdout/err from build command
- CaseStatus file in CASEROOT should show 'build complete'

To check that **new code was incorporated into build**, check time stamp on object files. The one you modified (and those affected by it) should be newer than most of the object files *and* the executable should show the newest time stamp, too.

```
ls -ltr /glade/scratch/$LOGNAME/$CASENAME/bld/atm/obj
... [more files above] ...
-rw-r--r-- 1 bundy ncar  10504 Jul 25 14:47 clubb_intr.o
-rw-r--r-- 1 bundy ncar 269592 Jul 25 14:47 micro_mg_cam.o
-rw-r--r-- 1 bundy ncar 107487 Jul 25 14:47 microp_driver.mod
-rw-r--r-- 1 bundy ncar  10416 Jul 25 14:47 microp_driver.o
-rw-r--r-- 1 bundy ncar    883 Jul 25 16:08 tmp_filepath
-rw-r--r-- 1 bundy ncar  31004 Jul 25 16:08 zm_conv.mod
-rw-r--r-- 1 bundy ncar 230648 Jul 25 16:08 zm_conv.o
-rw-r--r-- 1 bundy ncar  47994 Jul 25 16:08 convect_shallow.mod
-rw-r--r-- 1 bundy ncar  84350 Jul 25 16:08 zm_conv_intr.mod
-rw-r--r-- 1 bundy ncar 141424 Jul 25 16:08 zm_conv_intr.o
... [a few files below] ...

ls -l /glade/scratch/$LOGNAME/$CASENAME/bld/cesm.exe
-rwxr-xr-x 1 bundy ncar 84383206 Jul 25 16:09 cesm.exe
```

timestamp on files shows that zm_conv are newer than most of the other files.

executable is newer than zm_conv files

Never assume that it's working– always find a way to check!

Example 3 (cont): *Code Change CAPE (cont.)*

- **Submit job. When done:**

What to look for ? (Comparing to control, slide 6)

- ✓ *Surface temperature (TS), surface fluxes (LHFLX,SHFLX), cloud (CLDLOW), rainfall (PRECT) over land*
- ✓ *How does it affect the diurnal cycle? (if feeling brave output hourly rainfall (PRECT) and surface temperature (TS) over a limited land region*
- ✓ *Is 2 months long enough to get a good signal?*

Example 4: *Code Change- Ice Clouds*

Ice clouds are a strong regulator of infrared radiation; for an exercise we're going to make "ice" clouds in CAM4 transparent to this longwave radiation.

This exercise will guide you through the process, including

1. reading the scientific documentation of the model
2. introducing some tools that can make it easier to navigate the source code
3. deciding which files and fields to modify
4. using the variables present in CAM
5. building, running and examining output

Example 4 (cont): *Code Change- Ice Clouds*

Reading documentation to learn where to look in the code

- Search in CAM4 Scientific Description for "longwave radiation"

  http://www.cesm.ucar.edu/models/ccsm4.0/cam/docs/description/cam4_desc.pdf

  4.9 Parameterization of Longwave Radiation

  The method employed in the CAM4 to represent longwave radiative transfer is based on an absorptivity/emissivity formulation

- This gives us a clue of what to look for in the code. If we find where the emissivity is calculated and/or used, we can modify it to make ice clouds transparent to longwave radiation.

- Create, setup and build a new case following the control case instructions(we will re-build the modified code, meanwhile using some files created by the build to navigate through the source code)

Example 4 (cont): *Code Change- Ice Clouds*

Tools to search CAM code

- UNIX commands `find` and `grep` can do the job
- However, CAM source code is
  - in a complicated directory structure and
  - any particular model build uses only a subset of the directories (for example, different dynamical cores)

  So we have tools that use find and grep within this directory structure
- These tools are available with this tutorial although their use is optional; if you want to use them in the future, copy them to your home machine before you go

  `grepccm string` searches for string in all files in the directories used by this particular model build

  `findccm filename` searches for a file named filename in all the directories used by this model build
- Copy from `/glade/u/home/bundy/bin/grepccm` and make executable

```
cp ~bundy/bin/grepccm ~; chmod 755 ~/grepccm
cp ~bundy/bin/findccm ~; chmod 755 ~/findccm
```

Example 4 (cont.): *Code Change- Ice Clouds*

Tools to search CAM code (grepccm)

- Part of the CAM (the atm component of CESM) build is the creation of a file called **Filepath** in the build directory. Filepath is a text file listing all the directories containing source code that are used in the model build.

For example: `cat /glade/scratch/$LOGNAME/$CASENAME/bld/atm/obj/Filepath`

```
/glade/u/home/bundy/cam/case/tutorial/cesm1_2_0.cntl/SourceMods/src.cam
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/chemistry/pp_none
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/chemistry/mozart
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/chemistry/bulk_aero
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/chemistry/utils
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/physics/cam
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/dynamics/eul
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/advection/slt
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/cpl_mct
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/cpl_share
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/control
/glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/utils
```

- `grepccm` searches for the string in each file in each directory listed in Filepath
- You must be in a directory containing Filepath to use this tool

```
cd /glade/scratch/$LOGNAME/$CASENAME/bld/atm/obj/
~/grepccm "cloud emissivity"
```

Example 4 (cont.): *Code Change- Ice Clouds*

Deciding which files to modify (using grepccm)

examining output

- addfld/outfld refers to writing field to history file
- pointer is likely to be used to store field in the physics buffer
- **intent(out)** variable declaration implies the field is calculated in this file; have to view it to see!
- **intent(in)** variable declaration means it can't be modified in this subroutine so this is NOT the place to change it

```
>  ~/grepccm "cloud emissivity"
---- searching /glade/scratch/bundy/cesm1_2_0.cntl/bld/atm/obj
grep: No match.
12 other directories
---- searching /glade/u/home/bundy/cam/case/tutorial/cesm1_2_0.cntl/SourceMo
grep: No match.
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
cloud_diagnostics.F90:       call addfld ('EMIS', '1', pver, 'A','cloud emis
cloud_diagnostics.F90:       call addfld ('EMISCLD', '1', pver, 'A','cloud e
cloud_diagnostics.F90:    real(r8), pointer :: cldemis(:,:)   ! cloud emissi
cloud_diagnostics.F90:       ! Cloud emissivity.
pkg_cldoptics.F90:! Compute cloud emissivity using cloud liquid water path (
pkg_cldoptics.F90:    real(r8), intent(out) :: emis(pcols,pver)       ! clou
radlw.F90:! assumes randomly overlapped clouds with variable cloud emissivit
radlw.F90:    real(r8), intent(in) :: emis(pcols,pver)    ! Cloud emissivity
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/
```

Example 4 (cont): *Code Change- Ice Clouds*

Deciding which files to modify (cont.)

```
> less /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/physics/cam/pkg_cldoptics.F90 [excerpts]
subroutine cldems(lchnk   ,ncol    ,clwp    ,fice    ,rei     ,emis    ,cldtau)
real(r8), intent(out) :: emis(pcols,pver)        ! cloud emissivity (fraction)
emis(i,k) = 1._r8 - exp(-1.66_r8*kabs*clwp(i,k))
```

We don't necessarily want to change the emis calculation; we want to change how it's used by the longwave radiation.

So keep looking, first idea is to find what calls this subroutine

```
> cd /glade/scratch/$LOGNAME/$CASENAME/bld/atm/obj/Filepath
> grepccm "call cldems"
---- searching /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/physics/cam
cloud_diagnostics.F90:       call cldems(lchnk, ncol, cwp, ficemr, rei, cldemis, cldtau)
> less /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/physics/cam/cloud_diagnostics.F90
[excerpts]
! Cloud emissivity.
      call cldems(lchnk, ncol, cwp, ficemr, rei, cldemis, cldtau)

      ! Effective cloud cover
      do k=1,pver
         do i=1,ncol
            effcld(i,k) = cld(i,k)*cldemis(i,k)
         end do
      end do
```

- *It looks like **`emis`** is calculated in the call to **`cldems`** and is then used to calculate the effective cloud*
- *One possibility is to make our change right before the effective cloud calculation (note, try something else if you want!)*

Example 4 (cont): *Code Change- Ice Clouds modifying source code: Set* emis=0 *where* `t.lt.0`

- Copy the file to $CASEROOT/SourceMods/src.cam

```
cp /glade/p/cesm/tutorial/cesm1_2_0.tutorial/models/atm/cam/src/physics/cam/cloud_diagnostics.F90 \
    $CASEROOT/SourceMods/src.cam/
```

- Open the file in an editor and go to "call cldems" (near line 373)
- Make the cloud transparent to the radiation by setting emissivity = 0 where the temperature is below freezing (a first attempt to find 'ice clouds'). ***Code in red is new***

```
! Cloud emissivity.
    call cldems(lchnk, ncol, cwp, ficemr, rei, emis)

! Effective cloud cover
    do k=1,pver
       do i=1,ncol
          if ( state%t(i,k) .lt. 273._r8 ) then
             emis(i,k) = 0._r8
          endif
          effcld(i,k) = cldn(i,k)*cldemis(i,k)
       end do
    end do
```

More info on syntax, variables and structures at beginning of presentation about 'CAM physics'

- *k=1,pver loops over the vertical coordinate*
- *i = 1,ncol loops over the horizontal (lat/lon) coordinate*
- *state%t means the t (temperature) variable that is part of the state variable*
- *_r8 is a floating point number with a precision particular to the CAM build. You should declare all floating point variables as real(r8) and use _r8 after all decimal points; real(dblkind) is available for double precision.*

Example 4 (cont): *Code Change- Ice Clouds*

add new output field to check change

- To check that our modification behaves as we expect it to, write out the **emis** field before and after we change it.
- We know the emissivity is already available on the history files because there is a call to **outfld** in this subroutine. This occurs after the modification we added.

```
call outfld('EMIS'    ,cldemis    , pcols,lchnk)
```

- To write out emissivity before we change it, copy the 'outfld' line to a location above the change and modify the field name that will appear on the history file. The **outfld** subroutine works on the entire array, so make the call before the do-loops.

```
! Cloud emissivity.
    call cldems(lchnk, ncol, cwp, ficemr, rei, emis)
    call outfld('EMISorig'    ,cldemis    , pcols,lchnk)
! Effective cloud cover
    do k=1,pver
...
```

• Did you wonder about the outfld call for EMISCLD*? Or notice that all of this is surrounded by logic for camrt_rad?*

•CAMRT is the radiation parameterization used in CAM4; CAM5 uses RRTMG.

• You also may have noticed rk_clouds and mg_clouds; those are micro-physics parameterizations that are used in CAM4 and CAM5 respectively.

• There are a lot of options in the code and you must be cafeful to know what is being used–

making these changes in CAM5 instead of CAM4 should result in NO effect.

Example 4 (cont): *Code Change- Ice Clouds*

add new output field to check change (cont.)

We need to tell the model a little more about the field we are writing.

- During initialization, add a call to the subroutine **`addfld`**. Look for the **`addfld`** call for **`EMIS`** earlier in this file (subroutine cloud_diagnostics_init)
- Copy and paste the **`addfld`** call. Modify the name of the field from **`EMIS`** to **`EMISorig`** and change the long name to describe the new field.

```
call addfld ('EMISorig', '1', pver, 'A','cloud emissivity zeroed where t lt
  0',phys_decomp, sampling_seq=sampling_seq)
```

- (To understand the arguments to outfld and addfld, you could use grepccm to find "subroutine outfld" or "subroutine addfld")
- Add both EMIS fields to the atmosphere namelist output; neither are written by default. The :A means average (also available: I= instant, M=min, X =max)

fincl1 = 'EMIS:A','EMISorig:A' (recall from day2: edit $CASEROOT/user_nl_cam)

For a complete list of namelist variables and their options, see the on-line documentation for each component model.

CAM4: http://www.cesm.ucar.edu/cgi-bin/eaton/namelist/nldef2html-pub

CAM5: http://www.cesm.ucar.edu/cgi-bin/eaton/namelist/nldef2html-cam5_2

Example 4 (cont): *Code Change- Ice Clouds*

Re-build with code mod and solve problems

1) Build the model *(check for errors)*

Uh oh! stdout/err from build command shows ERROR and non-zero exit code

ERROR: cam.buildexe.csh failed, see /glade/scratch/bundy/f.day5.4/bld/atm.bldlog.130806-124840

[3] Exit 99 f.day5.4.build

Sorry! This tutorial has ***a built-in error*** to give you practice in finding problems, so it **should fail** like this. Look at the `bldlog` (yours will have different trailing numbers) and see if you can figure it out.

The answer is on the last page of the tutorial but please try by yourself before looking!

2. Once you've fixed the error, build the model again *(and again check for errors)*

- CaseStatus file in CASEROOT should show 'build complete' with a new time stamp
- check that **new code was incorporated into build.** The executable and the file you modified (and those affected by it) should be newer than most of the object files.

```
ls -ltr /glade/scratch/$LOGNAME/$CASENAME/bld/atm/obj
... [more files above] ...
-rw-r--r-- 1 bundy ncar   1596 Aug  6 12:32 inital.mod
-rw-r--r-- 1 bundy ncar   2640 Aug  6 12:32 inital.o
-rw-r--r-- 1 bundy ncar    867 Aug  6 13:13 tmp_filepath
-rw-r--r-- 1 bundy ncar  32506 Aug  6 13:13 cloud_diagnostics.mod
-rw-r--r-- 1 bundy ncar  67840 Aug  6 13:13 cloud_diagnostics.o
-rw-r--r-- 1 bundy ncar  70449 Aug  6 13:13 physpkg.mod
-rw-r--r-- 1 bundy ncar 261912 Aug  6 13:13 physpkg.o
ls -l /glade/scratch/$LOGNAME/$CASENAME/bld/cesm.exe
-rwxr-xr-x 1 bundy ncar 84386555 Aug  6 13:13 /glade/scratch/bundy/f.day5.4/bld/cesm.exe
```

timestamp on .o, .mod files shows modified ones are newer

executable is newer than modified files

Never assume that it's working– always find a way to check!

Example 4 (cont): *Code Change- Ice Clouds*

Run and examine results

- Run the model.
  - look at the cam or cesm log files while it's running to see if you can find evidence of your new outfld variable
  - watch for history files as soon as they're made
  - Record notes! Now is a great time to recall exactly what you did for this run.

    In a week, a year or even 10 years, you will want to be able to find the case name, model configuration, initialization details, source code modifications and data location. Ideally you will be able to re-create the case exactly
- Check for success (CaseStatus file, 0001-02 history file in archive dir)
- Examine results
  - compare EMIS and EMISorig. Are the differences what you expected? (Make sure to look at higher altitudes than just the surface)
  - compare this run to the control. Look for longwave cloud fields in the longnames on the history files (ncdump -h file.nc). How about surface temperature? Sea–surface temperature? (that's a trick question– why?)
- Start another exercise? *Try 2 or 2a for something different.*

Answers

Basic commands for all cases (using my casename cesm1_2_0.cntl)

```
cd /glade/p/cesm/tutorial/cesm1_2_0.tutorial/scripts
./create_newcase -case ~/cases/cesm1_2_0.cntl
        -mach yellowstone -res T31_T31 -compset F_2000

cd ~/cases/cesm1_2_0.cntl
./cesm_setup
./cesm1_2_0.cntl.build  >& ! out.build

./xmlchange -file env_run.xml -id STOP_N -val 2
./xmlchange -file env_run.xml -id STOP_OPTION -val nmonths

echo "grid_file = '/glade/p/cesm/cseg//inputdata/share/domains/domain.ocn.48x96_gx3v7_100114.nc'" >>&user_nl_cice
echo "kmt_file = '/glade/p/cesm/cseg//inputdata/share/domains/domain.ocn.48x96_gx3v7_100114.nc'" >>&user_nl_cice
```

Make any dataset changes or code changes here.

```
./cesm1_2_0.cntl.submit
```

Likely run-time errors

- No hist files in archive directory and only 5 days in rundir ->**stop_n , stop_option not changed**
- Run quit with an error relating to ice model grid -> **forget to set grid_file, kmt_file in user_nl_cice**

Exercise 4 built-in error

We set emis(i,k) = 0._r8 instead of cldemis(i,k) = 0._r8. Fix in cloud_diagnostics.F90 and build again.

Fields to look at: LWCF (long wave cloud forcing), QRL (longwave heating rate), TS (surface temperature)

SST is a trick question on the comparison because this is an F-case with a data-ocean; SST shouldn't change.

Potential Exercise 4 error: no effect because using CAM5 and change is to CAMRT radiation, not RRTMG