



CHES land surface modeling course

Practical steps for setting up site simulations in CLM/NorESM

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Before start

Read User's Guide Documentation for CLM4.5 in CESM1.2.0

CLM4.5 guide is currently only available online:

<http://www.cesm.ucar.edu/models/cesm1.2/clm/models/lnd/clm/doc/UsersGuide/book1.html>

Key steps:

- Choosing a compset using CLM
- Customizing the CLM setup
- Customizing the CLM namelist
- Customizing the DATM Namelist and Streams files
- Using the CLM tools to create your own input datasets (e.g. make surface data)



Model installation and porting

- Download NorESM (incl. CLM) source code from NCAR or Hexagon
svn co --username guestuser --password friendly
https://svn-ccsm-models.cgd.ucar.edu/cesm1/release_tags/cesm1_2_2 cesm1_2_2

rsync -arv /work/shared/noresm/point_inputdata/NorESM/ /home/kurs/course15/NorESM/ --exclude cases --exclude archive --exclude exeroot --exclude infrastructure
- Install necessary libraries: zlib, HDF5, NetCDF, LAPACK (all available at hexagon)
- Modify machine settings for cluster “hexagon” (already done for you)
Edit config_machines.xml, config_compilers.xml, config_batch.xml



1. Model testing (global simulation)

- **Test CLM4.5 I compset**

```
CESMDIR=/home/kurs/$USER/NorESM
cd $CESMDIR/scripts
./create_newcase -case
$CESMDIR/cases/I2000CLM45BGC.f09_g16 \
-res f09_g16 \
-compset ICRUCLM45 \
-mach hexagon

cd $CESMDIR/cases/I2000CLM45BGC.f09_g16
./case.setup
./case.build
```

#Congratulations, if build successful (most errors occur at this step)

```
./preview.namelist
```

#Finally one can submit the job by:

```
./case.submit
```

- **Key points:**

- Choose the compset: refers to pre-selected component models and their specific settings

```
./create_newcase -list compsets
./create_newcase -list grids
```
- “I” compsets contain active CLM model with a data atmosphere model (datm) and a stub ocean, and stub sea-ice models



CLM updates

- CLM4.0CN -> CLM4.5CN
- – Updated physics: photosynthesis, hydrology, fire, and many others
- CLM4.5CN -> CLM4.5BGC
- – Updated soil biogeochemistry (Century): changed soil/litter decomposition rates; vertical resolution to soil C and N cycling; revised mineral N dynamics
- 3 major groups of compsets for CLM “I”
 - CLM4.5SP: new biogeophys + satellite phenology (CN off)
 - CLM4.5CN: new biogeophys + CN soil BGC + nitrogen
 - CLM4.5BGC: new biogeophys + CENTURY-like vertically resolved soil BGC + CH₄ emissions + nitrogen updates



2. Model testing (site simulation)

- **Run a pre-built case**

```
CESMDIR=/home/kurs/$USER/NorESM  
cd $CESMDIR/cases/1x1_Jambi_ICLM45BGC
```

- Customize the model run period
Open the runtime configuration file

```
vi env_run.xml
```

Change the value of following variables: RUN_STARTDATE, STOP_N, STOP_OPTION, STOP_DATE

Can also be done with xmlchange commands

```
./xmlchange RUN_STARTDATE=2014-01-01  
./xmlchange STOP_N=1,STOP_OPTION=nyears,STOP_DATE=20150101
```

Submit the job:

```
./case.submit
```

Check the output:

```
ls /work/$USER/exeroot/1x1_Jambi_ICLM45BGC/run
```



3. Set up your own model case

- **Create the case**

```
cd $CESMDIR/scripts  
./create_newcase -case $CESMDIR/cases/1x1_Jambi_ICLM45BGC \  
-res CLM_USRDAT -compset ICRUCLM45BGC -mach hexagon
```

- **Setup the case**

```
cd $CESMDIR/cases/1x1_Jambi_ICLM45BGC  
./case.setup
```

- **Setup user namelists and env_run.xml for input setting**

```
edit user_nl_clm, user_nl_datm, env_run.xml (see next slides)
```

- **Build the case**

```
./case.build
```

- **Submit the job**

```
./case.submit
```

- **Check the output**

```
ls /work/$USER/exeroot/1x1_Jambi_ICLM45BGC or  
ls /work/$USER/archive/1x1_Jambi_ICLM45BGC/
```



4. Modify the model settings

- **Customizing the CLM namelist**

```
cd $CESMDIR/cases/1x1_Jambi_ICLM45BGC
```

```
#update user_nl_clm
```

```
echo " fsurdat = '/work/shared/noresm/point_inputdata/ln/clm2/surfddata_map/surfddata_1x1pt_Iskoras_16pfts_simyr2000.nc'
```

```
paramfile = '/work/shared/noresm/point_inputdata/ln/clm2/pftdata/clm5_params.c160225.nc'
```

```
hist_fincl2 = 'GPP', 'NEE', 'NPP', 'TOTPFTC', 'TOTVEGC', 'TOTCOLC', 'TOTLITC', 'LEAFC', 'LIVSTEMC', 'DEADSTEMC',  
'FROOTC', 'TLAI', 'FSH', 'EFLX_LH_TOT', 'FSA', 'FSR', 'QFLX_EVAP_TOT', 'FPSN', 'ALBD'
```

```
hist_fincl3 = 'GPP', 'NEE', 'NPP', 'TLAI', 'FSH', 'EFLX_LH_TOT', 'FSA', 'FSR', 'QFLX_EVAP_TOT', 'FPSN', 'ALBD'
```

```
hist_nhtfrq = 0, -24, 1
```

```
hist_mfilt = 12, 365, 17520
```

```
" > user_nl_clm
```

#Options hist_nhtfrq, hist_mfilt decide the frequency and length of model output, e.g. 0 and 12 indicate monthly output, -24 and 365 indicate yearly output with daily mean value, 1 and 17520 indicate yearly output with per time step (30min) value

- **These namelist variables are not locked and can be modified without rebuilding the model**



4. Modify the model settings

- **Customizing the DATM Namelist and Streams files**

```
cd $CESMDIR/cases/1x1_Jambi_ICLM45BGC
```

```
#update user_nl_datm
```

```
echo " dtlimit = 1.5,1.5,1.5
fillalgo = 'nn','nn','nn'
fillmask = 'nomask','nomask','nomask'
mapalgo = 'nn','nn','nn'
mapmask = 'nomask','nomask','nomask'
streams = 'datm.streams.txt.CLM1PT.CLM_USRDAT 2014 2014 2014', 'datm.streams.txt.presaero.trans_1850-
2000 1849 1849 2006', 'datm.streams.txt.co2tseries 1860 1860 2015 '
taxmode = 'cycle','extend','extend'
tintalgo = 'nearest','linear','linear' " > user_nl_datm
```

- Copy the CO2 stream file to run directory and template meteorological stream file to case directory

```
cp $INPUTDIR/./site_setting_files/datm.streams.txt.co2tseries $RUNDIR
cp $INPUTDIR/./site_setting_files/user_datm.streams.txt.CLM1PT.CLM_USRDAT $CASEHOME/$CASE
```

- **These namelist variables are not locked and can be modified without rebuilding the model**



4. Modify the model settings

- **Customizing the CLM setup**

```
cd $CESMDIR/cases/1x1_Jambi_ICLM45BGC
```

```
./xmlchange CLM_BLDNML_OPTS="-mask navy -bgc bgc"  
./xmlchange CLM_USRDAT_NAME=1x1pt_Jambi,DATM_MODE=CLM1PT_3S  
./xmlchange CCSM_BGC=CO2A,CLM_CO2_TYPE=diagnostic,DATM_PRESAERO=trans_1850-  
2000  
./xmlchange  
STOP_N=1,STOP_OPTION=nyears,STOP_DATE=20150101,RUN_STARTDATE=2014-01-01  
./xmlchange  
RUN_TYPE=hybrid,RUN_REFCASE=1x1_Jambi_I1850CLM45BGC_spinup,RUN_REFDATE=100  
1-01-01,GET_REFCASE=TRUE
```

- **These env settings are not locked and can be modified without rebuilding the model**

- **Re-submit the job**

```
./case.submit
```

- **Check the output**

```
ls ../../exeroot/1x1_Jambi_ICLM45BGC/
```



4. Modify the model settings

- **More about DATM Namelist: if the meteorological variables have different temporal resolutions (therefore different interpolation algorithms), one has to use separate stream files, e.g. 3 streams for solar, precipitation, and other variables, respectively**
#e.g. the NCEP or ERA forcing data use three streams for meteo variables

```
echo " dtlimit = 1.5,1.5,1.5,1.5,1.5
fillalgo = 'nn','nn','nn','nn','nn'
fillmask = 'nomask','nomask','nomask','nomask','nomask'
mapalgo = 'nn','nn','nn','nn','nn'
mapmask = 'nomask','nomask','nomask','nomask','nomask'
streams = 'datm.streams.txt.NCEP_Jambi.Solar 1990 1990 2010', 'datm.streams.txt.NCEP_Jambi.Precip 1990
1990 2010', 'datm.streams.txt.NCEP_Jambi.TPQW 1990 1990 2010', 'datm.streams.txt.presaero.trans_1850-2000
1849 1849 2006', 'datm.streams.txt.co2tseries 1860 1860 2015'
taxmode = 'cycle','cycle','cycle','extend','extend'
tinalgo = 'coszen','nearest','linear','linear','linear' " > user_nl_datm
```

- Copy the corresponding stream files to run directory

```
cp $INPUTDIR/./site_setting_files/datm.streams.txt.co2tseries $RUNDIR
cp $INPUTDIR/./site_setting_files/datm.streams.txt.NCEP_Jambi.Solar $RUNDIR
cp $INPUTDIR/./site_setting_files/datm.streams.txt.NCEP_Jambi.Precip $RUNDIR
cp $INPUTDIR/./site_setting_files/datm.streams.txt.NCEP_Jambi.TPQW $RUNDIR
```



5. Using R scripts to create your own meteo forcing data

- **Extract forcing data from global dataset to a site**
extract ERA data to point.R
extract NCEP data to point.R
- **Create your own forcing data files with site observation data**
atm_forcing_ncdf_Jambi.R



6. Using the CLM tools to create your own input datasets

- **Steps for create surface input data for a specific site**

1. Create SCRIP grid datasets (if NOT already done): use `mkmapgrids` or `mkscripgrid.ncl` or `mknoocnmap.pl`
2. Create domain dataset (if NOT already done): use `gen_domain`
3. Create mapping files for `mksurfd_data_map` (if NOT already done): use `mkmapdata.sh`
4. Create surface datasets: use `mksurfd_data_map` with customized `namelist-yfan`
(there are some bugs in the above tools, happy debugging!)
5. Create some sort of initial condition dataset, e.g.
 - a) Use spinup procedures to create initial condition datasets
 - b) Use interpinic to interpolate existing initial condition datasets
6. Enter the new datasets into the build-namelist XML database
Add new site names “1x1pt_Bariri, 1x1pt_Jambi” into the default build-namelist XML database
“~/models/lnd/clm/bld/namelist_files/namelist_definition_clm4_5.xml” (entry id="res"; lines 826-829) so that make surface tools can find the map for Jambi site.



6. Spin-up initial conditions

- **INITIAL spinup: set up a point simulation and spinup from cold condition**

```
CESMDIR="/home/kurs/$USER/NorESM"
```

```
cd $CESMDIR/scripts
```

```
./create_newcase -case $CESMDIR/cases/1x1_Jambi_I1850CLM45BGC_spinup -res  
CLM_USRDAT -compset I1850CRUCLM45BGC -mach gwdu102
```

- **Set env options for user data name, model mode, simulation length, etc.**

```
cd $CESMDIR/cases/1x1_Jambi_I1850CLM45BGC_spinup
```

```
./xmlchange CLM_USRDAT_NAME=1x1pt_Jambi,DATM_MODE=CLM1PT
```

```
./xmlchange CLM_BLDNML_OPTS='--mask navy -bgc bgc'
```

```
./xmlchange CLM_BLDNML_OPTS="--bgc_spinup on" -append
```

```
./xmlchange CLM_FORCE_COLDSTART='on'
```

```
./xmlchange RESUBMIT=9,STOP_N=100,STOP_OPTION=nyears,STOP_DATE=10010101
```

```
./xmlchange DATM_PRESAERO=clim_1850,CLM_NML_USE_CASE=1850_control
```

```
./xmlchange RUN_STARTDATE=0001-01-01
```

```
./xmlchange
```

```
DATM_CLMNCEP_YR_ALIGN=1,DATM_CLMNCEP_YR_START=1948,DATM_CLMNCEP_YR_END=1972
```

#NOTE do not use `--crop` option when spin-up, otherwise history output files will be too large and model will stop due to timeout



6. Spin-up initial conditions

- **Set user namelist options for input dataset (surface and forcing data)**

```
cat << EOF > user_nl_clm
fsurdat =
'/work/shared/noresm/point_inputdata/lnd/clm2/surfddata_map/surfddata_1x1pt_Jambi_for
est_17pft_simyr2000_c160912.nc'
paramfile =
'/work/shared/noresm/point_inputdata/lnd/clm2/pftdata/clm_params78_repPFT.c150912-
Jambi.nc'
hist_mfilt = 100
hist_nhtfrq = -8760
EOF
```

```
cat << EOF > user_nl_datm
dtlimit = 1.5,1.5,1.5
fillalgo = 'nn','nn','nn'
fillmask = 'nomask','nomask','nomask'
mapalgo = 'nn','nn','nn'
mapmask = 'nomask','nomask','nomask'
streams = 'datm.streams.txt.NCEP_Jambi.Solar 1 1901 1920',
'datm.streams.txt.NCEP_Jambi.Precip 1 1901 1920',
'datm.streams.txt.NCEP_Jambi.TPQW 1 1901 1920',
taxmode = 'cycle','cycle','cycle'
tintalgo = 'coszen','nearest','linear'
```

```
EOF
```



6. Spin-up initial conditions

- **FINAL Spinup: use the initial spin-up as initial condition for one more run at least 200+ years in normal mode.**

```
cd $CESMDIR/scripts
./create_newcase -case $CESMDIR/cases/1x1_Jambi_ICLM45BGC_finalspinup -res
CLM_USRDAT -compset I1850CRUCLM45BGC -mach gwdu102

cd $CESMDIR/cases/1x1_Jambi_ICLM45BGC_finalspinup
./xmlchange CLM_BLDNML_OPTS="-mask navy -bgc bgc -bgc_spinup off"
./xmlchange CLM_USRDAT_NAME=1x1pt_Jambi,DATM_MODE=CLM1PT
./xmlchange RESUBMIT=1,STOP_N=100,STOP_OPTION=nyears,STOP_DATE=2010101
./xmlchange
DATM_CLMNCEP_YR_ALIGN=1,DATM_CLMNCEP_YR_START=1948,DATM_CLMNCEP_YR_END=1972
./xmlchange
RUN_TYPE=hybrid,RUN_REFCASE=1x1_Jambi_I1850CLM45BGC_spinup,RUN_REFDATE=1001-01-
01,GET_REFCASE=TRUE
```




7. Advanced settings

- Take a closer look at files `$CASE/env_build.xml` and `$CASE/env_run.xml`

CONTINUE_RUN,RESUBMIT
RUN_TYPE,RUN_REFCASE,RUN_REFDATE,GET_REFCASE

DATM_MODE,DATM_PRESAERO,DATM_CLMNCEP_YR_ALIGN/_START/_END
CLM_CO2_TYPE

CLM_FORCE_COLDSTART

CLM_USRDAT_NAME

CLM_CONFIG_OPTS
CLM_BLDNML_OPTS

- Take a look at locked final configuration files

`$CASE/CaseDocs/Ind_in`
`$CASE/CaseDocs/datm_atm_in`



CLM options for biogeophysics and biogeochemistry

- CLM4.0-CN : -phys clm4_0 -bgc cn (clm4.0 physics, clm4.0 cn)
- CLM4.5-CN : -phys clm4_5 -bgc cn (clm4.5 physics: clm4.5 cn)
- CLM4.5-BGC : -phys clm4_5 -bgc bgc -vsoilc_centbgc on -clm4me on (clm4.5 physics, clm4.5 bgc with nitrogen and methane and century decomposition)

CLM4.5 has options to select different biogeophysics and biogeochemistry options and switch on/off different decomposition models, vertically resolved soil C profile.



CLM options for biogeophysics and biogeochemistry

This is done through CLM configure script option `CLM_CONFIG_OPTS` in `env_build.xml` or `CLM_BLDNML_OPTS` in `env_run.xml`, or by script “`user_nl_clm`”

`CLM_CONFIG_OPTS`, `CLM_BLDNML_OPTS` and “`user_nl_clm`” are all used by “`$(CODEROOT)/lnd/clm/bld/build-namelist`” to generate the full list of user namelist options as in the input file “`$(CASE)/CaseDocs/lnd_in`”

#Note: `CLM_CONFIG_OPTS` is locked after the `$(CASE).build` script is run. If you want to change something in `CLM_CONFIG_OPTS` you'll need to clean the build and rerun `$(CASE).build`

The other env variables set in `env_run.xml` can be changed at run-time without rebuild the case



CLM Script configuration items

- phys "value" Value of clm4_0 or clm4_5 (default is clm4_0) set by CLM_CONFIG_OPTS
- bgc "value" Build CLM with BGC package [sp | cn | bgc] (default is sp).
 - sp = Satellite Phenology (only phys=clm4_5)
 - cn = Carbon Nitrogen model (for compset CLM45CN if phys=clm4_5, use_cn=true)
 - bgc = Carbon Nitrogen with methane, nitrification, vertical soilc, Century decomposition
(for compset CLM45BGC if phys=clm4_5, use_cn=true,
vsoilc_centbgc='on', and clm4me=true)
- #The -bgc bgc option toggles on the namelist variables: use_cn, use_lch4,
use_nitrif_denitrif, use_vertsoilc, use_century_decomp
- clm4me "value" Turn Methane model: [on | off]
- vsoilc_centbgc "value" [on, off or colon delimited list of no options] (default off)
 - no-vert Turn vertical soil Carbon profile off
 - no-cent Turn CENTURY off
 - no-nitrif Turn the Nitrification/denitrification off
 - [no-vert,no-cent,no-nitrif,no-vert:no-cent]



CLM options for biogeophysics and biogeochemistry

The pros and cons of alternative decomposition structures

- CLM-CN: fewer vertical layers and no methane, but more stable estimates of C&N pools
- Century: better vertical resolution to soil C&N cycling; but overestimation of soil C for the tropics

Given the pros and cons, a special case can be set as:

```
./xmlchange CLM_CONFIG_OPTS="-phys clm4_5 -bgc cn  
-vsoilc_centbgc no-cent -clm4me on"
```

CLM Model Development

Thou shalt never modify CESM root

Thou shalt put your mods in SourceMods

Copy the subroutine code file you want to modify from “\$CESMROOT/model/lnd” or your new code file to “\$CASEROOT/SourceMods/src.clm/” and edit. When build the case, these files will be compiled first. This can avoid affect the model base codes of future cases.

- For example, if want to modify soil roughness length parameter zlnd:

First go to CLM4.5 source code folder “\$CESMROOT/models/lnd/clm/src/clm4_5” and find zlnd in the code files:

```
grep zlnd */*      #which will locate the code file that you want modify:
```

```
main/clm_varcon.F90:  real(r8)  :: zlnd = 0.01_r8    #Roughness length for soil [m]
```

Create a new case and then copy the file clm_varcon.F90 to “case_root/SourceMods/src.clm/” and start editing the parameter zlnd in the file.

Clean_build and rebuild the case