CESM1 for Deep Time Paleoclimate

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NCAR

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A word about how to use this presentation…

This presentation covers fully COUPLED runs only.

This presentation is designed for users familiar with running CCSM3 for paleoclimate applications.

This presentation highlights differences from CCSM3.

Formal and complete CCSM3 documentation for paleoclimate can be found at: http://www.cgd.ucar.edu/ccr/paleo/Notes/PaleoCCSM3.pdf

Or by contacting a paleoclimate liaison:

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To obtain new tools discussed in this presentation, contact Christine Shields.

OUTLINE: Deep Time Paleo CESM1

"What do I need to change in the default CESM1 to run with a different geography"?

"How is this different from CCSM3"?

1. What is in CESM1?

2. Model Initial/Forcing Files (Differences from CCSM3)

    a. Ocean (POP2)
    b. Ice (CICE4)
    b. Coupler (CPL7)
    c. Land (CLM4)
    d. Atmosphere (CAM4)

3. Summary Flow Chart

4. Additional Model Namelist and Code Changes

What is in CESM1?

http://www.ccsm.ucar.edu/models/cesm1.0/

Atmosphere: CAM4 (CAM4 default, CAM5 available but not applied to paleo yet).
http://www.ccsm.ucar.edu/models/cesm1.0/cam/

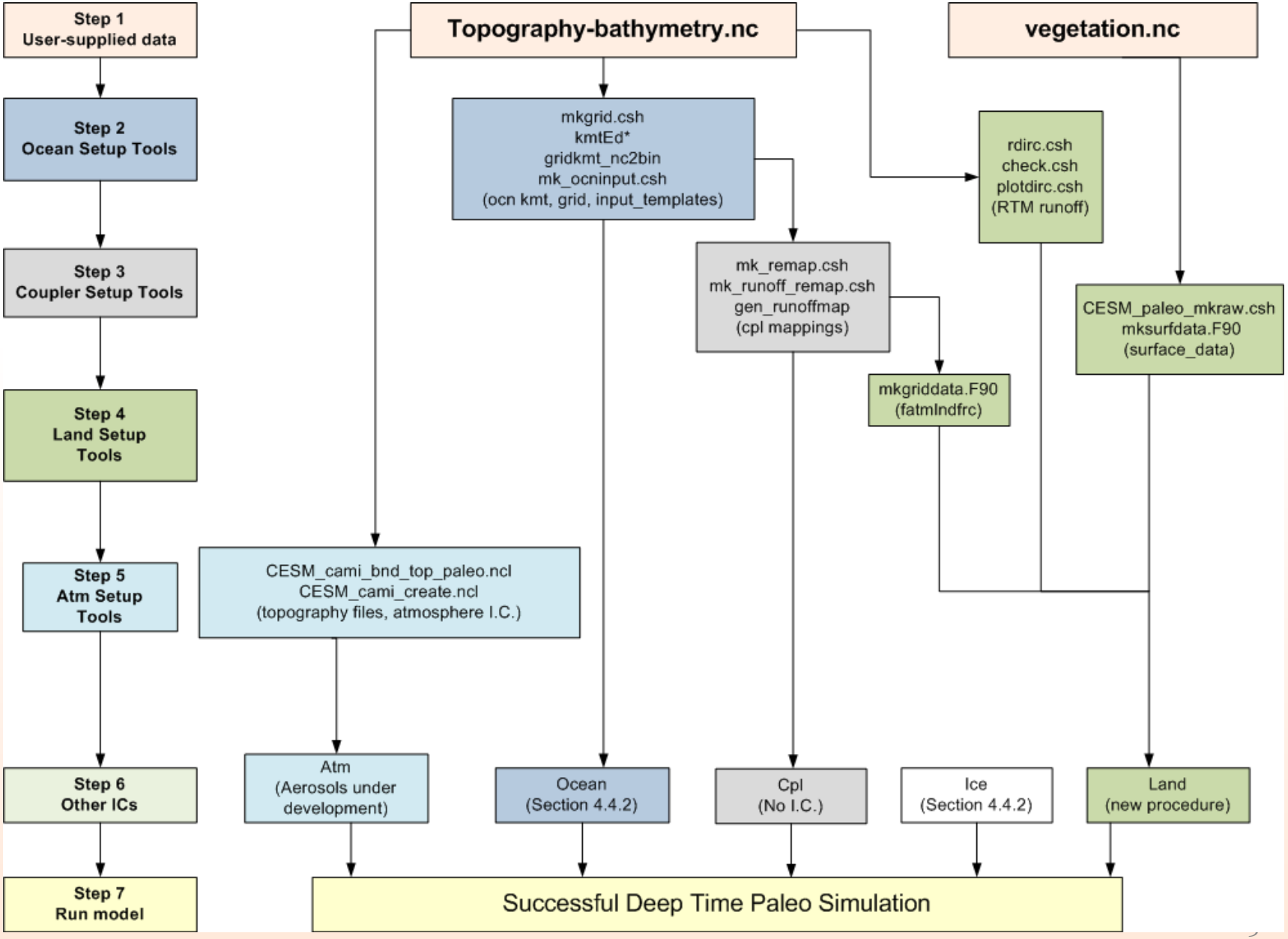
Land: CLM4 (CN "on" by default, new initialization spin up procedure, surface_data computed offline, surface_data only on atm/lnd grid, surface_data includes new fields).
http://www.ccsm.ucar.edu/models/cesm1.0/clm/

Ocean: POP2 (60 vertical level ocean).
http://www.ccsm.ucar.edu/models/cesm1.0/pop2/

Ice: CICE4 (No model setup changes, model component name change).
http://www.ccsm.ucar.edu/models/cesm1.0/cice/

Coupler: CPL7 (No changes to scripts creating mapping files; model runs as single executable).
http://www.ccsm.ucar.edu/models/cesm1.0/cpl7/

Summary Flow Chart



OCEAN Initial/Forcing Files

(differences from CCSM3)

User supplied Topography/Bathymetry Netcdf File : No changes to file format

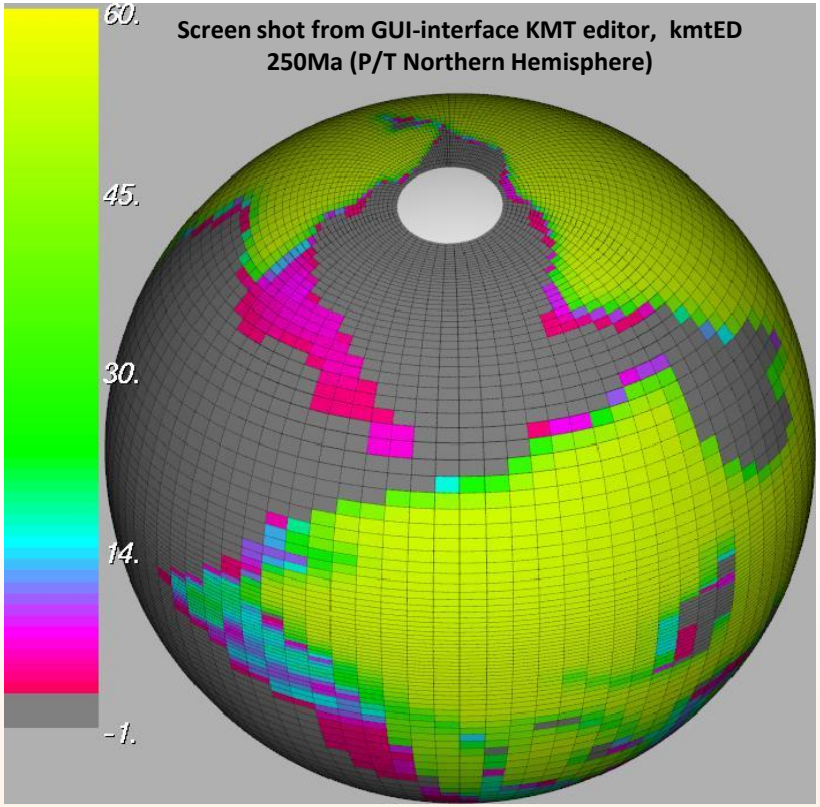
Grid file: no changes to scripts

KMT file: use new 60 level vertical grid

If converting from CCSM3 to CESM1, you will need to re-run paleotopo.f90 and kmtED (or kmt editing tool) to create a new binary KMT file.

Region Mask file: update if land/ocean mask has changed.

WARNING: Region Mask and KMT have to match EXACTLY!! If you add/subtract land points in kmtED (or your kmt editing tool), you WILL need to re-run the region mask tool.



NEW forcing file: tidal_mixing

This file is geography dependent. A tool for deep time is under consideration. Alternatively, you can turn this feature to "**false**" in the pop namelist.

Ocean IC: no changes

NEW input_template file:gx3v7_overflow

WARNING: This file controls a new feature in POP2 called ocean overflows. It is dependent on bathymetry. We recommend setting overflows to "**false**" in the pop namelist. If you are familiar with this feature, and wish to develop your own overflows, see POP2 doc for details.

ICE Initial/Forcing Files

(differences from CCSM3)

NEW FORCING FILES

The ice model requires aerosol deposition information. CICE simply uses the atmosphere aerosol deposition file (i.e. on the atmosphere grid).

A tool for creating aerosols for deep time periods is pending.

INITIAL CONDITIONS

There are no notable differences in how CICE handles ice initialization for deep time paleoclimate.

It is recommended that the user start with the zero ice initial state and allow the model to spin up the ice.

Zero ice is now specified in the ice namelist. Set the "***ice_in***" option to "none".

Coupler Forcing Files

(differences from CCSM3)

There are no notable differences in the scripts to create coupler mapping files.

We still use ***scrip*** and we still generate both bilinear and conservative mappings.

We still apply conservative mapping to BOTH flux and state ocn->atm variables.

We still apply the bilinear mapping to the atm->ocn state variables.

We still apply the conservative mapping to the atm->ocn flux variables.

We still create RTM (runoff) to ocean mappings with **gen_runoffmap**.

Mapping files are now specified in the **env_conf.xml** file (and not the coupler namelist).

LAND Forcing Files

(differences from CCSM3)

FRACDATA (ATMLNDFRC)

(defines landfrac/ocnfrac)

1. Run gen_domain

This tool requires the conservative ocn-to-atm coupler mapping files generated by ***scrip***.
The output is a *domain* file used in **mkgriddata**.

2. Run mkgriddata

Fortran tool found in the models/lnd/clm/tools directory. Required input includes your paleo *domain* file generated by **gen_domain** and a default CESM atm griddata file (ex T31), (found in the default inputdata location). A *fracdata* file is output and set in the clm namelist using the *fatmlndfrc* namelist variable.

SURFACE_DATA

(used only by land model)

1. Run CESM_paleo_mkraw Tool:

Creates standard paleo_mkraw datasets with some additions to the pft file.
CESM1/CCSM3 seven standard "raw" files:

previously "pft"->

mksrf_soicol_paleo.nc.
mksrf_soitex_paleo.nc
mksrf_lai_paleo.nc
mksrf_lanwat_paleo.nc
mksrf_landuse_paleo.nc
mksrf_glacier_paleo.nc
mksrf_urban_paleo.nc

Creates 4 new surface data types:

mksrf_fmax_paleo.nc
mksrf_organic_paleo.nc
mksrf_topo_paleo.nc
mksrf_vocef_paleo.nc

2. Run mksurfdata Tool:

Fortan tool found in the models/lnd/clm/tools directory. We now compute the surface_data file **OFFLINE**. Another major difference is the surface_data is computed from the atm/land grid. No information needs to be passed through the coupler. The **ffrac** file required for mksurfdata can be created by the ncl tool **mk_ffrac.ncl** and is only defined on the atm/lnd grid, (ex. T31).

REMEMBER: The landfrac /ocnfrac are determined by the **atmlndfrac** file created by the **mkgriddata** tool and read into the coupled system via the clm namelist. Ffrac used to create the surface_data file is NOT used by the clm namelist or mkgriddata.

LAND Forcing Files Continued

(differences from CCSM3)

Other New FORCING FILES:

The land namelist requires specification of a number of new forcing fields related to aerosols, nitrogen deposition, and snow properties.

The snow property forcing files are NOT geography dependent and therefore can be used for deep time paleoclimate.

The aerosol and nitrogen deposition tools are pending.

LAND Initial File

(CN new spinup procedure, from Sam Levis)

The standard way to run CESM1 is with the CN model turned ON.

CN variables require a very long spin up. The safest strategy is to run an "I" case (land only) to spin up the CN variables. Next, initialize CLM with the equilibriated data. The next two slides explain your options for the CLM initialization procedure.

Option 1: ***Spin up carbon/nitrogen (CN) from scratch for 650+ year***

Step 1: B-case with high frequency compset and run for 30 years

Step 2: I-case with "**-ad_spinup on**" in CLM_CONFIG_OPTS and run for 600 years with finidat=' '

Step 3: I-case with "**-exit_spinup on**" in CLM_CONFIG_OPTS and run for 1 year with finidat from step 2

Step 4: I-case with neither of the above options and run for >50 years with finidat from Step 3.

Comments:

1. Look for long-term average NEE near zero for successful spin-up
2. Initial file from Step 4 may be used to start a CNDV (dynamic veg.) run

LAND Initial File continued

(CN new spinup procedure, from Sam Levis)

***Option 2*: Run without the nitrogen for a < 500-year spin-up**

Step 1: B-case with high frequency compset and run for 30 years

Step 2: I-case with "**-supln on**" to CLM_CONFIG_OPTS and start with finidat=‘ ‘

Comments:

1. Again, look for NEE near zero
2. Current implementation results in over-productive veg. from unlimited nitrogen

***Option 3*: Use spun up data from some existing run with similar climate**

If running on a different grid or different continental outline, need to run the clm tool, ***interpinic.***

***Option 4*: Run B-case *WITHOUT* CN for a < 100-year spin-up (same as CCSM3)**

Atmosphere Initial/Forcing Files

(differences from CCSM3)

NEW FORCING FILES

1. **bnd_topo:** PHIS, SGH SGH30, LANDFRAC*,LANDM_COSLAT* are now initialized in a separate topography file and specified by the *bnd_topo* namelist parameter. SGH30 is a new field. Run new tool **CESM_cami_bnd_topo_paleo.nc** to create this file.

   **LANDFRAC/LANDM_COSLAT are atm grid only (ex. T31). Topography and landfrac_pft from the surface_data file are suggested input for the new tool. Therefore, it is best to create the land forcing files before the atmosphere files.*

2. **prescribed_aero_file:** A tool to create prescribed aerosols is under development.
3. **tropopause_climo_file:** This is **NOT REQUIRED** for standard **EQUILIBRIUM** runs (i.e. you don't need to change the default namelist values). This file is only used in conjuction with volcanoes in transient runs
4. **rad_climate_for_*:** Radiation physical property files are NOT geography dependent and therefore can be used for deep time paleoclimate.

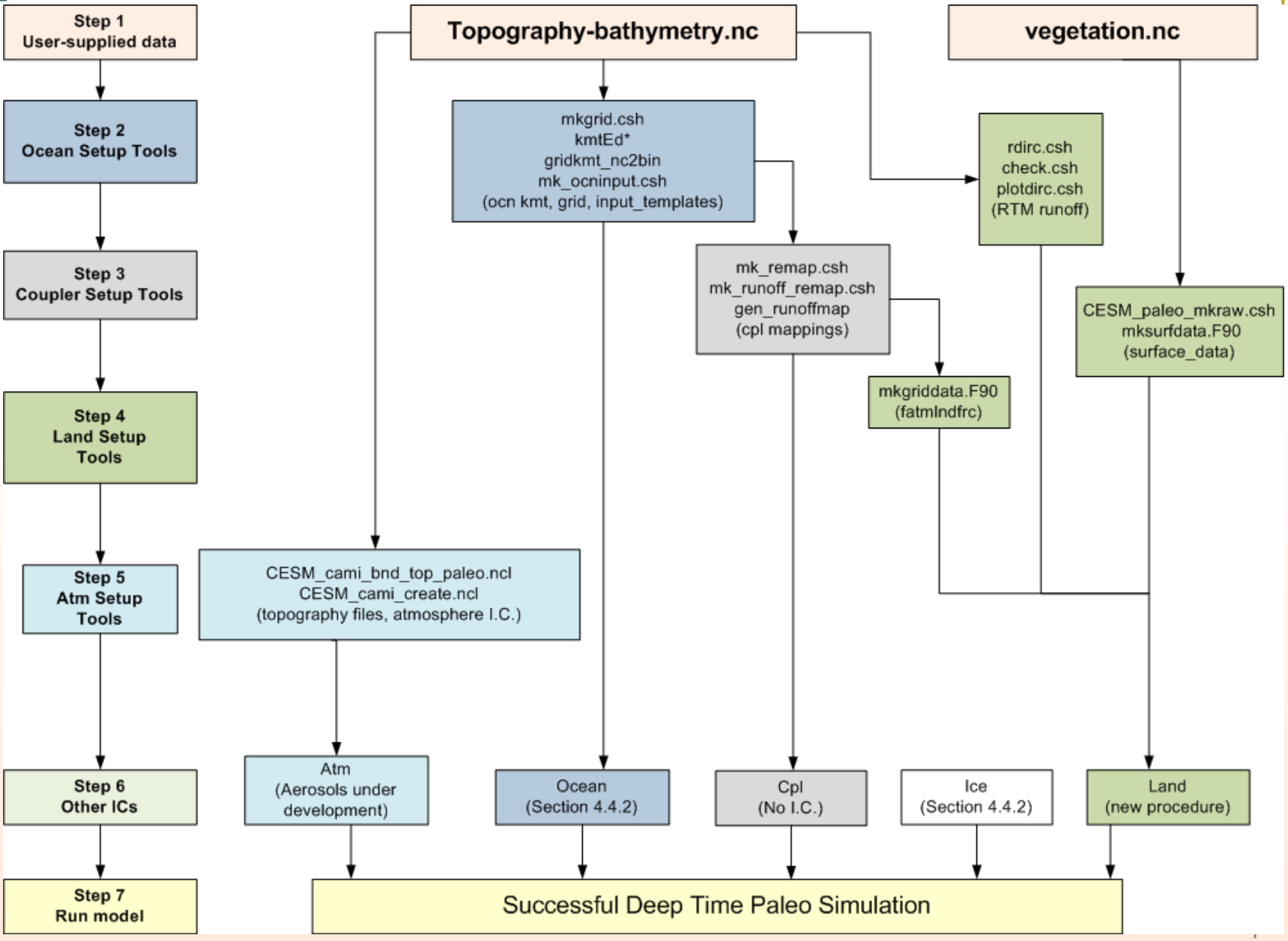
INITIAL CONDITIONS: CAMI File

The initial condition file looks slightly different in CESM1 compared to CCSM3. Most notablaly, the 3-D variables are now arrayed as VAR(time,lev,lat,lon) instead of VAR(time,lat,lev,lon).

A new tool, **CESM_cami_create.ncl,** is available

a. to create basic initial conditions if you are starting from scratch (similar to the old ccsm3 tool).
b. to be used as a template to swap out your initial conditions from an older run and replace in exact CESM1 /CAM4 format.

Summary Flow Chart



Additional Model Namelist and Code Changes

OCEAN

1. In pop namelist, you will need to set **lhoriz_varying_bckgrnd** to “false”.

2. In pop namelist, you may need to set **ldiag_velocity** to “false”.

3. In pop namelist, you may want to change the backround vertical mixing parameters **bckgrnd_vdc1** to 0.524 and **bckgrnd_vdc2** to 0.313, (see POP2 doc for further details).

4. In pop namelist, remember to set **overflows** and **tidal mixing** to false if desired.

ICE

Remember to set **ice_ic** = “none” if initializing with a zero ice state.

COUPLER

1. Mapping files are now specified in **env_config.xml**
2. Orbital parameters are still set in the coupler namelist. There are no changes to variable names.

Additional Model Namelist and Code Changes Continued

ATMOSPHERE

1. CO2 values can be set via the **env_conf.xml** file using variable name **CCSM_CO2_PPMV.** This values will be propagated to the land model, so if you change CO2 *after* your run the "configure" command, be sure you change it across models. (see CESM documentation).
2. The total solar irradiance is now called "**solar_const**" but is still specified in the cam namelist. The units for "solar_const" are W/m2.
3. All other traces gases continue to be set in the cam namelist.

LAND

1. Source code mods are still required in **clm_varpar.F90** if you are using an RTM grid other than half degree.
2. Source code mods may be required in **clm_varctl.F90** if the CO2 value you choose is >3000 ppmv. (search on co2_ppvm string).
3. In the clm namelist, turn **urban_hac = 'OFF'**.

A Word about Time Steps….

Time steps are still modified in the respective namelists,

CAM: dtime
CLM: dtime, rtm_steps
POP: dt_count (now set in the namelist directly)
CICE: (see CICE doc), note: ice dynamics sub-cycling now called xndt_dyn

Changing the Atmospheric Time Step:

1. Be sure land time step = atmosphere time step.

2. The atmosphere and land are now coupled at every time step. Therefore, if you change the time step, you need to modify the coupling interval variable to be consistent with the new time step. **ATM_NCPL** is set in **env_run.xml**. Units are coupling intervals per day.

Have Fun with the Deep Time CESM Simulations!