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CESM 1.0.2 near past initial conditions user guide: prescribing ice sheets

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SUMMARY The Community Earth System Model has been developed and is maintained by NCAR. At this stage of the report, the CESM 1.0.2 includes atmosphere, land, ocean, sea-ice and a partially coupled ice sheets model. Several grid resolutions have been developed for each component and for present-day Earth's topography/bathymetry and one of the big advantage of this model is that the running procedure is straightforward in its present-day configuration for any new user. However, the CESM 1.0.2 components are not flexible to simulate near or deep past climates which require a different topography/bathymetry relative to present-day. Indeed, to simulate a different continental distribution and a different sea level, each component needs substantial changes in its initial conditions files which require an advanced knowledge of the model. In order to make those kind of changes accessible for new users, the following document aims at proposing a relatively simple procedure to modify the initial conditions files for the coupled atmosphere-land-ocean-sea-ice compset of the CESM 1.0.2 (B compset). This procedure was mainly developed at NCAR but never tested before on the different super-computing platforms and outside of NCAR. The guide presented here have been successfully tested on CMCC IBM Power 6 platform taking as example a glaciation configuration. However, this process is by far non automatic and requires some substantial manual work at each stage of the procedure. Finally, following this procedure does not provide any guarantees that the simulations will be successful.

We thank Nan Rosembloom and Bette Otto-Bliesner for their technical and scientific support to learn the procedure described in this guide. The research leading to these results has received funding from the Italian Ministry of Education, University and Research and the Italian Ministry of Environment, Land and Sea under the GEMINA project.

INTRODUCTION

1 The Community Earth System Model

The Community Earth System Model (CESM 1.0.2) is an Earth System Model composed of an AGCM (CAM), an OGCM (POP), a land model (CLM), a sea-ice model (CICE) and a dynamical ice sheets model (CISM). The CESM 1.0.2 has been developed between NCAR and LANL and is maintained by NCAR. The code and its documentation are available on the CESM 1.0.2 website: http://www.CESM 1.0.2.ucar.edu. At this stage of the report, the CESM 1.0.2 fully couple compset (B compset) includes atmosphere (CAM), land (CLM), ocean (POP), sea-ice (CICE) which are managed by the coupler (Figure 1). Several spectral and finite-volume grids resolutions have been developed for each component. The model has been calibrated for present-day Earth's topography/bathymetry and extensively validated on present-day climate observations. One of the big advantage of this model is that the running procedure is straightforward in its present-day configuration for any new user.

Figure 1:
CESM 1.0.2 architecture. See CESM 1.0.2 webpage for more details.

While the latest version of CESM 1.0.2 has also been successfully tested for paleoclimate simulations recently, its climate components are not flexible to simulate near or deep past climates requiring different topographies/bathymetries relative to present-day. Indeed, to use a different continental distribution and a different sea level, each component needs substantial changes in its initial conditions files, which requires an advanced knowledge of the model. The procedure is highly time consuming and has been, up to now, only tested on NCAR Bluefire by NCAR Paleo working group for various time periods, using the local numerical tools developed in-situ. In order to make those kind of changes more accessible for new users, the following document aims at describing this procedure to modify the initial conditions files for the coupled atmosphere-land-ocean-sea-ice compset of the CESM 1.0.2 (B compset). The various scripts presented here have been ported and successfully tested on CMCC IBM Power 6 platform to simulate a glacial maximum.

However, this process is by far non automatic and requires some substantial manual work at each stage of the procedure. Finally, following this procedure does not provide any guarantees that the simulations will be successful. The user may find the scripts on CMCC wiki, or directly request them to one of the authors of this User Guide.

2 Modelling near past climates

Simulating past climates implicates various changes in the Earth's topography. Fifty million years (Mys) ago, the continental distribution was completely different and reached its present-day configuration about 10 Mys ago. "Near past climates" refers more or less to the last 10 Mys, during which, only sea-level and surface elevation were different due to the alternation of glacial/interglacial cycles (Figure 2). On the contrary "Deep past climate" refers to time periods older than 10 Mys, more specifically when the continental distribution was totally different than the modern one.

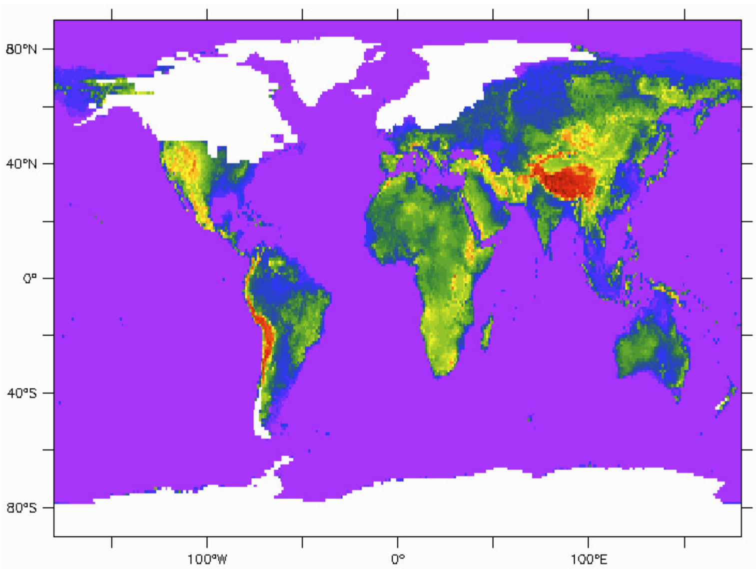

Figure 2:
Last Glacial Maximum topography from ICE-5G reconstruction (Peltier, 2004). White areas correspond to the distribution of ice sheets and glaciers at this time. Note that sea-level is also lower by about 130 m SLE relative to present-day.

Creating initial conditions for "Near Past" or "Deep Past" has different implications. For "Deep Past", changes in the surface topography, land cover, but also of the ocean bathymetry and basins decomposition require a large amount of work both to create the initial files and to modify some specific pre-existing files into the model itself, set-up with present-day characteristics. For "Near Past", the ocean bathymetry is kept at its modern state, only some of the oceanic basins are removed from the pre-existing modern decomposition due to sea level drops and of course the land-sea mask and surface topography are modified depending on whether or not the user introduces some ice sheets or topographic features. The concept is to add some slight differences relative to present-day global topography in order to reduce the number of changes introduced in the model and probable inconsistencies between the various components of the CESM 1.0.2.

In this user guide, we focus on how generating the initial boundary conditions for near past climates and in particular, how to change sea-level and prescribe ice sheets over North America and Eurasia in the CESM 1.0.2 fully coupled compset (B compset). Those changes implicate substantial modifications at all levels for all components. Beside, the model itself is particularly sensitive to inconsistencies between the grids of the various climatic component and new land-sea masks.

Indeed, CAM and CLM share the same grid, CICE and POP share the same grid. During the first stage of the initialization process, the coupler checks that the land-sea masks computed for CAM and CLM matches the one computed for POP and CICE. While this first stage is successful, the user can hope that his initial conditions are not too unstable and that the model will not crash immediately.

NOTA BENE: when everything get successful, the user is in total state of happiness and can eventually enjoy and party!, most of his problems are solved... - *Florence Colleoni*

NEW INITIAL CONDITIONS FILES

The user can have an overview of the whole procedure in Appendix II, Figure 4. For each step of this guide, the scripts, the input and output files are listed in the different Tables and the settings and execution are extensively detailed. Finally, some of the Makefiles adapted to the IBM computing platform "CALYPSO" (CMCC, Italy)are attached in Appendix I. The user may be aware that only few changes in the Makefiles have been necessary since CALYPSO is almost similar to NCAR's BlueFire platform.

All the scripts ported on CALYPSO were initially developed by Nan Rosembloom (NCAR) for the Last Glacial Maximum. Some of them have then been cleaned and adjusted to a more general goal and to test a different glacial topography (140 kyrs ago). All those scripts have been ported on the IBM CALYPSO supercomputer (AIX operative system) and partly run in interactive mode or in queue mode.

It is important to understand that the procedure starts with the computation of ocean and coupler initials conditions on which most of the surface datasets are based.

In **all the tables** of this document, the files generated from the scripts or provided by the user are distinguished from the original raw grid files or others directly coming from CESM 1.0.2 by using the following color code:

blue: pre-existing CESM 1.0.2 raw data files
red: user provided files
orange: computed files during the procedure

0 Software requirements

- Fortran 90
- NetCDF Fortran libraries
- NCAR Command Language: download at http://www.ncl.ucar.edu/)
- Ncview

1 Building a new CESM 1.0.2 B_compset

Since most of the scripts that will be used in this procedure are generated on top of pre-existing present-day CESM 1.0.2 files for the various compsets at various resolutions, it is necessary to download them from NCAR servers, to first build a compset for which he will create new boundary conditions. In this manual, the explanations are given for:

- B_compset (atm-lnd-ocn-sic)
- using pre-industrial period files (B1850 compset)

- finite volume 0.9x1.25 atmospheric resolution and displaced pole 1° ocean resolution (f09_g16, see the CESM 1.0.2 user guide for more details on the supported resolutions).

The instructions to build the compset are provided in the CESM 1.0.2 User Guide. This process will automatically download all the files required by all the components of the compset to run with the pre-defined configurations already implemented in CESM 1.0.2. Once the user has built the compset, he can proceed with the steps described in the forthcoming sections. Do not clean-up the compset directory since it will be used to create the 5-days initial conditions land file at run time **(see section 7 Appendix II, Figure 4, step 7)**.

2 Pre-processing the topography

Using a very clean topography from the beginning is particularly important for the rest of the procedure, especially for the ocean and for the coupler. For that reason, the user should spend as much time as necessary to obtain a satisfying initial topography. What does it mean? It means removing all the small islands that might create problems during the various interpolations steps required during the entire procedure described in this guide. Indeed, the initial topography file should be at **10 min** horizontal resolution. During the various steps, this file will be interpolated at **0.5**°, at **1**° and finally at the CESM 1.0.2 compset resolution (e.g. f09_g16, T31_gx3v7, see the CESM 1.0.2 user guide for more details on the supported resolutions).

Table 1
Pre-processing initial topography script and associated files

Numerical tool	Scripts	Inputs / Outputs
NCL	mk140kTopo.ncl	**Input:** USGS_gtopo30_10min.nc Relief_140k_10min.nc (topography at 10min res.) landice_mis6.nc (ice mask) **Output:** topo_mis6_10min.nc (htopo, ice, landfract, landsmask,variance)

Most of the scripts that will be used in the following steps are based on **pre-existing CESM 1.0.2 initial conditions files** to which the differences provided by the user new input conditions are added. This is the compset for the initial topography file.

To create this file, we use the script mk140kTopo.ncl. This script needs the USGS present-day 10 min topography file, the user new topography (with a different sea level for example) and the new land ice distribution (ice sheets and glaciers) if different from present-day one. The input and output files are reported in Table 1 and the execution time of the script is reported in Table 9.

To execute the script: > `ncl mk140kTopo.ncl`

3 Ocean and coupler initial conditions files

This part is dedicated to the computation of the initial conditions for POP2 (ocean) and CPL6 (coupler). The whole procedure is described bellow and illustrated by the flow chart in Appendix II, Figure 5. In this section, seven files are generated:

- a new land-sea mask
- a region mask: distribution of the various oceanic basins and marginal seas
- the coupler mapping files (x4): handle the interpolation from/to the oceanic grid to/from the atmospheric grid.
- a new oceanic runoff distribution
- the land and oceanic domains

The execution time of the all the scripts used in this section is detailed in Table 9.

3.1- Ocean topography and region mask

First of all, the initial pre-processed topography at **10 min** resolution has to be interpolated at **1°x1°**. This is done by using the script 10min2_1x1deg.ncl.

To execute the script:
> ncl 10min2_1x1deg.ncl

Be sure that the following variables are computed in the indicated ranges:
ICE: 0 - 100
LANDFRACT: 0 - 1
LANDMASK: 0 - 1

The new land-sea mask and the ocean region mask are created by the script change_kmt_new.ncl. This script is based on the pre-existing present-day topography kmt file (the user may start from a different one as well kmt file) provided by the CESM 1.0.2 in the csm/inputdata/ocn/pop2/grid directory (the present-day land-sea mask and region mask are binary files .ieee4). The script change_kmt_new.ncl is able to open those files and change only the areas where the new topography is different from present-day. POP is particularly sensitive to new continental points inserted in the new topography. That is why, for practical issue, when simulating **near past climates, in the script, present-day bathymetry and topography are preserved over the unchanged areas**.

Then edit the script change_kmt_new.ncl to point to the new_topography_1x1.nc file and execute it:

> ncl change_kmt_new.ncl

As reported in Table 2, change_kmt_new.ncl also needs the original present-day POP topography, regions and horizontal grid files provided directly for the resolution of interest to the user in the csm/inputdata/ocn/pop2/grid directory.

The execution time of the scripts is detailed in Table 9.

Table 2
New ocean topography and region mask files

Numerical tool	Scripts	Inputs / Outputs
NCL	10min2_1x1deg.ncl	**Input:** topo_mis6_10min.nc **Output:** topo_mis6_1x1.nc
NCL	change_kmt_new.ncl	**Input:** topo_mis6_1x1.nc (topography at 1° res.) topography_20090204.ieeei4 (POP present-day topo) region_mask_20090205.ieeei4 (POP present-day ocean basins) horiz_grid_20010402.ieeer8 (POP present-day horizontal grid) **Output:** kmt_gx1v6_mis6.ieeei4 region_mask_gx1v6_mis6.ieeei4 MIS6kmt.nc (file to check for disturbing pixels)

A NetCDF file containing the main variables generated by change_kmt_new.ncl is also created to check whether the new land-sea mask and region mask are correct. Moreover it is important to check also the number of basins contained in the new oceanic region mask. Indeed, when changing the ocean topography file, changes occur in the region mask and in the overflow locations as well (in POP, the locations of the overflows for present-day bathymetry are prescribed as initial input in CESM 1.0.2/models/ocn/pop2/input_templates). In the present-day region mask file, each basin and marginal sea is assigned a value between 1 to -14. You can find the present-day configuration in the main directory of the CESM 1.0.2 model (CESM 1.0.2/models/ocn/pop2/input_templates). The original gx1v6_region_ids file provided in the CESM 1.0.2 for present-day is shown in Table 3.

If the topo provided by the user induces modifications in the present-day basins distribution (no Baltic Sea, no Hudson Bay for example), the previous value assigned to the basins has to be re-assigned. An example is given in Table 3, illustrating our glaciation compset. The Baltic Sea as well as the Hudson Bay have been removed and filled with ice. The basins no longer exist in the new ocean topography file and as a consequence, the user has to modify the list and re-assign values to the Black Sea and the Caspian Sea. Note that a **negative value** is indicative of a **marginal sea**. Those modifications are necessary because the POP ocean model checks for the total number of ocean basins prescribed and takes the absolute value of the maximum number indicated in the gx1v6_region_ids file. In our compset, this number is $abs(-12) = 12$, for present-day it would be $abs(-14) = 14$. Those changes have to be done before building the compset.

Table 3
Present-day gx1v6_region_ids file provided in CESM 1.0.2 (left) and an example of gx1v6_region_ids file provided by users (right)

1	'Southern Ocean '	0.0	0.0	0.0	1	'Southern Ocean '	0.0	0.0	0.0
2	'Pacific Ocean '	0.0	0.0	0.0	2	'Pacific Ocean '	0.0	0.0	0.0
3	'Indian Ocean '	0.0	0.0	0.0	3	'Indian Ocean '	0.0	0.0	0.0
4	'Persian Gulf '	22.0	60.0	0.0	4	'Persian Gulf '	22.0	60.0	0.0
-5	'Red Sea '	14.0	47.0	3.0e15	-5	'Red Sea '	14.0	47.0	3.0e15
6	'Atlantic Ocean '	0.0	0.0	0.0	6	'Atlantic Ocean '	0.0	0.0	0.0
7	'Mediterranean Sea '	36.0	354.0	0.0	7	'Mediterranean Sea '	36.0	354.0	0.0
8	'Labrador Sea '	0.0	0.0	0.0	8	'Labrador Sea '	0.0	0.0	0.0
9	'GIN Sea '	0.0	0.0	0.0	9	'GIN Sea '	0.0	0.0	0.0
10	'Arctic Ocean '	0.0	0.0	0.0	10	Arctic Ocean '	0.0	0.0	0.0
11	'Hudson Bay '	61.0	295.0	0.0	-11	' Black Sea '	40.0	25.0	3.0e15
-12	'Baltic Sea '	56.0	8.0	3.0e15	-12	'Caspian Sea '	82.0	72.0	3.0e15
-13	'Black Sea '	40.0	25.0	3.0e15					
-14	'Caspian Sea '	70.0	65.0	3.0e15					

3.2- Coupler mapping files

The mapping files contains informations (weights etc...) which are used by the coupler to interpolate the ocean grid onto the atmospheric grid and vice versa. The runoff map is also part of this process since to be computed, it uses one of the mapping file generated.

The script that computes the four mapping files is the shell script mk_remap_gx1v6.csh. This script needs the `SCRIP` software, which handles the interpolation of the various grids (SCRIP webpage). Once downloaded, the user has to compile `SCRIP` editing some of the paths in the `Makefile`. To perform the interpolation between ocean and atmosphere, mk_remap_gx1v6.csh needs the original ocean and atmosphere grid files, and the new ocean topography (kmt_mis6.nc) generated at the previous step. All the inputs and outputs files are reported in Table 4.

BE AWARE: mk_remap_gx1v6.csh has to be executed two times. This is because, two of the mapping files are computed using a conservative interpolation method while the two others are generated using a bilinear interpolation method. In the script, one of the two methods is commented and the user has to switch them on/off to get the four mapping files:

one time for **conservative** interpolation:

```
!mv scrip_ina scrip_in
!$scriptdir/scrip
```

one time for **bilinear** interpolation:

Table 4
New coupler mapping, runoff and domain files

Numerical tool	Scripts	Inputs / Outputs
shell + SCRIP	mk_remap_gx1v6.csh	**Input:** topo_mis6_10min.nc fv0.9x1.25_070727.nc (CAM grid at 0.9x1.25 res.) horiz_grid_20010402.ieeer8 (POP present-day horizontal grid) **Output:** map_ocn_to_atm_aave.nc map_atm_to_ocn_aave.nc map_ocn_to_atm_bilin.nc map_atm_to_ocn_bilin.nc gx1v6_mis6.nc (new ocean grid, only used for runoff map)
Fortran 90	build.calypso.csh runoff.calypso.run	**Input:** gx1v6_mis6.nc rdirc.05.061026 **Output:** map_r05_to_gx1v6_mis6.nc
Fortran 90	make.AIX.csh gen_domain.aix	**Input:** map_ocn_to_atm_aave.nc **Output:** domain.ocn.gx1v6.mis6.nc domain.lnd.fv09_1.25_gx1v6_mis6.nc

```
!mv scrip_inb scrip_in
!$scripdir/scrip
```

Do not forget to set the path for the SCRIP executable in mk_remap_gx1v6.csh. To check the consistency of the mapping files, the user may use `scrip_test` executable and namelists, which are designed to produce readable NetCDF outputs from the mapping files generated.

NOTES AND ADVICE: producing the mapping files for the coupler is not an easy task and the user should pay attention to it since if it fails for some reasons, and for only one pixel, the model will not be able to run with the new conditions. Then given the structure of this procedure, the user may have to start again from almost the beginning of the procedure (see all the flow charts in Appendix II).

Once the mapping files have been generated, the user may compute the runoff map. This file is generated at **0.5**° horizontal resolution and is based on the new ocean grid file computed at the previous step (Table 4). The runoff package has to be compiled first using the script build.calypso.csh.

The namelist runoff_map_gx1.nml has to be set-up properly as following:

```
&input_nml
gridtype = "rtm"
file_roff = 'rdirc.05.061026'
file_ocn = '../gx1v6_mis6.nc'
file_nn = 'map_nn_gx3v7.nc'
file_smooth = 'map_smoother_gx3v7.nc'
file_new = 'map_r05_to_gx3v7_mis6 - comb21k_120618.nc'
title = 'runoffmap : r05- > gx1v6 140k full ice coverage in NH'
eFold = 1000000.0
rMax = 300000.0
/
```

The runoff is then computed executing the batch script runoff.calypso.run. The computation time is larger than 5 min, that is why it is recommended to avoid running interactively:

```
> bsub < runoff.calypso.run
```

The penultimate step of this section is the computation of the land and oceanic domain files using the gen_domain package. First, the namelist gen_domain.nml with the new mapping files. The user may also edit the `Makefile` to specify the NetCDF library and the Fortran compiler. To compile and execute the package do:

```
> ./make.AIX.csh
> gen_domain.aix < gen_domain.nml > gen_domain.out
```

Finally, from the land domain file domain.lnd.fv09_1.25_gx1v6.nc, the land fraction file, at the run resolution (here fv 0.9x1.25) can be created. This file is generated through the mkgriddata package (CESM 1.0.2/models/lnd/clm/tools). The package produces three files containing land fraction, topography and a new grid file. The two latter are not used at all by the procedure neither during the run time. To use the package, the user has to set-up the namelist and compile the package. Some modifications of the NetCDF library path and compiler name in the Makefile are necessary. See the section 4.1 and Table 5 for more details.

BE AWARE that, the mkgriddata package produces coordinates that sometimes do not completely match with the coordinates of the surfdata.nc file. To avoid this problem, the user just has to insert the CLM grid file in the namelist. The routines will force the land fraction to be calculated on the CLM grid. Some instructions are detailed in the README file included into the mkgridata package. This is not necessary when generating the land fraction at 10 min resolution, as detailed in Section 4.1.

4 Land initial conditions

In this section, the final CLM initial surface data file will be computed at **0.5°** resolution. For that reason, the initial 10 min topography will be interpolated at 0.5° resolution. However, to create the final CLM initial surface data file, an additional topographic file at **10 min** resolution, including some bedrock informations has to be created. The flow chart in Appendix II, Figure 6 illustrates the various steps of this section.

4.1 Pre-processing topography

For steps 4.2 to 4.3, the initial pre-processed topography at **10 min** resolution used in step 2 has to be interpolated at **0.5°x0.5°**. This is done by using the script 10min2_05deg.ncl.

To execute the script in a Terminal, write:

```
> ncl 10min2_05deg.ncl
```

Be sure that the following variables are computed in the indicated ranges:
ICE: 0 - 100
LANDFRACT: 0 - 1
LANDMASK: 0 - 1

For step 4.4, the user also needs an additional topographic file at **10 min** resolution which contains a variable named TOPO_BEDROCK. This is done using the script create_mksrf_topo.ncl. This script also needs the original mksrf_topo_10min.nc file downloaded from the NCAR Bluefire repositories (Table 5). To execute the script do:

```
> ncl create_mksrf_topo.ncl
```

NOTE: the bedrock topography corresponds to an ice free topography. Those informations are available for present-day (e.g. ETOPO2 and ETOPO1) but, for example, in the compset of glaciations, if the user only knows about the surface elevation and the landice distribution but does not have any information about the ice thickness, the bedrock topography cannot be retrieved. However this information is only necessary in the compset of running a dynamical ice sheets model which requires both ice thickness and bedrock topography as input fields. Since no ice sheet model has been implemented yet in CESM 1.0.2 at the time of this user guide, the bedrock topography is not necessary to run the simulations. Consequently, TOPO_BEDROCK is set equal to TOPO_ICE in create_mksrf_topo.ncl.

Finally, a new land fraction file at **10 min** resolution has to be created using the package mkgriddata located in CESM 1.0.2/models/lnd/clm/tools. The package produces three files containing the land fraction, the topography and a new grid file respectively. The two latter are not used at all by the procedure. To use the package, the user has to set-up the namelist and compile the routines. Some modifications of the NetCDF library path and compiler name in the Makefile are necessary.

Table 5
Pre-processing topography for surface dataset

Numerical tool	Scripts	Inputs / Outputs
NCL	10min2_05deg.ncl	**Input:** topo_mis6_10min.nc **Output:** topo_mis6_05deg.nc
NCL	create_mksrf_topo.ncl	**Input:** topo_mis6_10min.nc mksrf_topo.10min.c080912.nc **Output:** mksrf_topo.10min.mis6.nc
Fortran NetCDF	mkgriddata package	**Input:** topo_mis6_10min.nc **Output:** fracdata_10min.nc griddata_10min.nc (not used) topodata_10min.nc (not used)

Compile the package and then execute it:

```
> mkgriddata < mkgriddata.namelist > &! mkgriddata.out
```

4.2 Adding glaciers to the list of PFTs

The ice sheets distribution is extracted form the 0.5° resolution topography interpolated at the previou step and transformed into a PFT type and landunit. CLM initial conditions file considers 15 PFTs by default (Figure 3). As the user can notice, the type "glaciers" is not included into this distribution. Consequently, this step aims at introducing the 16th PFT in the new initial boundary conditions file. All the scripts and input/output files are reported in Table 6. Three files are created: the land ice distribution, the glaciers PFT type and the new landuse distribution. The Fortran 90 routine is called convert_mksrf.F90 and uses three pre-existing files from CESM 1.0.2 containing the present-day glaciers mask, the present-day landunit distribution and present-day landuse map (in our compset the default distribution corresponds to that of pre-industrial).

Indeed, in CLM, a type of landunit is attributed to each pixel (Figure 3). In total, there are five declared landunits: Urban, Lake, Wetland, Glacier and Vegetated. The "Vegetated" type is further divided into PFTs. To add some ice sheets over the ground, the user have to declare how much of each pixel will be "Glacier" and/or vegetated. This is exactly what convert_mksrf.F90 does.

The routine is based on a template routine in which the user has to point at the original CESM 1.0.2

Table 6
New PFTs distribution - adding glaciers to the landcover

Numerical tool	Scripts	Inputs / Outputs
NCL	convert_mksrf.F90	**Input:** topo_mis6_05deg.nc mksrf_topo.10min.c080912.nc **Output:** mksrf_glacier_mis6.nc mksrf_pft_mis6.nc mksrf_landwat_mis6.nc
NCL	add_harvest.ncl	**Input:** mksrf_pft_mis6.nc mksrf_landuse_rc1850_c090630.nc **Output:** mksrf_pft_mis6_harvest.nc
NCL	nn_fill.ncl	**Input:** mksrf_glacier_mis6.111021.nc mksrf_lanwat_mis6.111021.nc mksrf_pft_mis6.harvest.111021.nc mksrf_soitex.10level.c010119.nc mksrf_organic.10level.0.5deg.081112.nc mksrf_fmax.070406.nc mksrf_soilcol_global_c090324.nc mksrf_lai_global_c090506.nc **Output:** mksrf_glacier_mis6.nn.nc mksrf_lanwat_mis6.nn.nc mksrf_pft_mis6.harvest.nn.nc mksrf_soitex.10level_mis6.nn.nc mksrf_organic.10level.0.5deg_mis6.nn.nc mksrf_fmax_mis6.nn.nc mksrf_soilcol_mis6.nn.nc mksrf_lai_global_mis6.nn.nc
NCL	create_urban.ncl	**Input:** mksrf_urban_3den_0.5x0.5_simyr2000.c090223_v1.nc mksrf_pft_mis6.harvest.nn.111021.nc **Output:** mksrf_urban_mis6.nc

files listed in Table 6:
To edit the script:
0) cp convert_mksrf.template convert_mksrf.template.myrun
1) edit convert_mksrf.template.myrun

and then to compile and execute:

```
> cp convert_mksrf.template.myrun convert_mksrf.F90
> gmake
> ./convert_mksrf
```

4.3 Finalising the new PFTs distribution

After creating the new glaciers and ice sheets PFTs, the user has to add those modifications to the landunits and the PFTs of pre-industrial or present-day pre-existing default distribution.

First, the crop areas are modified and substituted by the new glaciers PFT computed at the previous step. This step is done using the script add_harvest.ncl that uses the new PFTs distribution mksrf_pft_mis6.nc created at the previous step.

Due to the new distribution of the glaciers and harvest PFTs, some of the pixels could have remained empty. To fill them, the user has to execute the script nn_fill.nc which corresponds to a near-neighbour algorithm filling the empty pixels by using their nearest PFTs and soil properties and computes all the soil properties. This step uses all the pre-existing CESM 1.0.2 soil properties files, as for example, the vertical distribution of organic matter, the soil texture, the LAI, etc...Those files are listed in Table 6.

Finally, since for the near past and deep past simulations there are no urban areas, the user has to remove the "**urban**" landunit (see Figure 3) and substitute it by vegetated areas to allow CLM to recreate some consistent hydrological conditions during the run. This final step is performed by the script create_urban.ncl which uses the modern urban areas distribution and the combined new PFTs distribution, including the harvest areas (crop) computed at the first step of this section.

IMPORTANT: in the script "create_urban.ncl", the user have to set:

```
pct_urban = 0
```

4.4 Creating CLM initial conditions file

The files obtained in the previous step 4.1 to 4.3 are all combined to create the new surface dataset that will constitute the input file to initialise CLM. Those files will be pointed in the namelists before

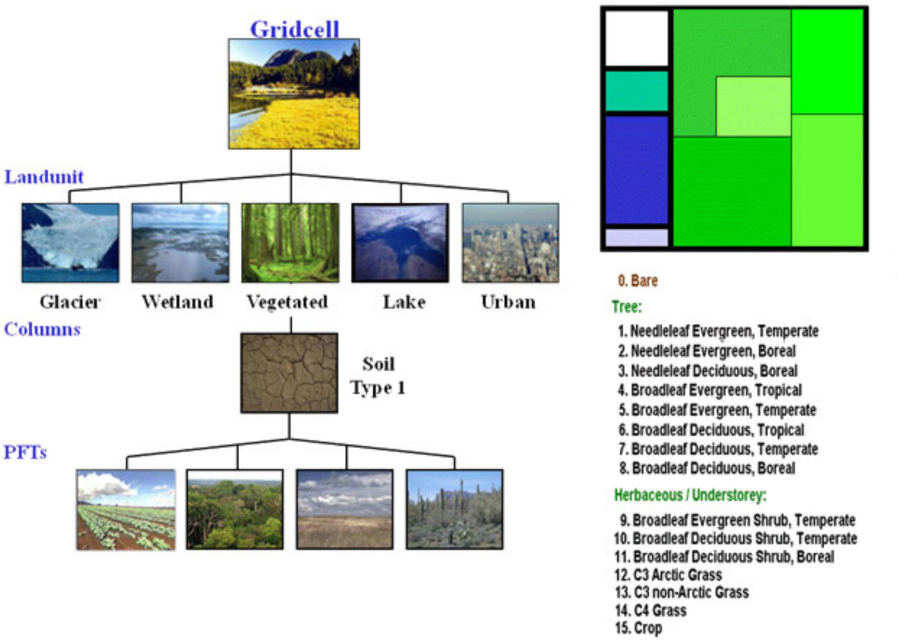

Figure 3:
CLM landcover pixel decomposition. Source from: http://www.CESM 1.0.2.ucar.edu/models/clm/surface.heterogeneity.html.

compiling and running the B compset (see section 6).

To create new surface initial conditions, a special package, mksurfdata, has been released and is located in the CESM 1.0.2 directory CESM 1.0.2/models/land/clm/tools. This package combines all the files created in the previous steps into a unique file that will be given as input to CLM.

First of all, the user has to set-up the namelist mksurfdata.namelist according to the input files listed in Table 7:

```
&clmexp
mksrf_fgrid = '/users/home/ans021/csm/inputdata/lnd/clm2/griddata/griddata_0.9x1.25_070212.nc'
mksrf_fsoitex = '/users/home/ans021/mksurf_rawdata/mksrf_soitex.10level.c010119.nc'
mksrf_forganic = '/users/home/ans021BC/mksrf_organic.10level.0.5deg_mis6.nn.nc'
mksrf_flanwat = '/users/home/ans021/BC/surface_bc/surf_ncl/mksrf_lanwat_mis6.nn.111021.nc'
mksrf_fmax = '/users/home/ans021/BC/surface_bc/surf_ncl/mksrf_fmax_mis6.nn.111021.nc'
mksrf_fglacier = '/users/home/ans021/BC/surface_bc/surf_ncl/mksrf_glacier_mis6.nn.111021.nc'
mksrf_furban = '/users/home/ans021/BC/surface_bc/surf_ncl/mksrf_urban_mis6.111021.nc'
mksrf_fvegtyp = '/users/home/ans021/BC/surface_bc/surf_ncl/mksrf_pft_mis6.harvest.nn.111021.nc'
mksrf_fsoicol = '/users/home/ans021/BC/surface_bc/surf_ncl/mksrf_soilcol_mis6.nn.111021.nc'
mksrf_flai = '/users/home/ans021/BC/surface_bc/surf_ncl/mksrf_lai_global_mis6.nn.111021.nc'
mksrf_ftopo = '/users/home/ans021/BC/surface_bc/surf_ncl/mksrf_topo.10min.mis6.111021.nc'
```

```
mksrf_ffrac = '/users/home/ans021/BC/mkgriddata/fracdata_1080x2160.nc'
mksrf_fvocef = '/users/home/ans021/mksurf_rawdata/mksrf_vocef.c060502.nc'
mksrf_firrig = ' '
mksrf_fdynuse = 'pftdyn_hist_simyr1850.txt'
outnc_double = .true.
/
```

After some modifications in the Makefile, the user must compile the package following those options:

in the Makefile:

```
SMP = TRUE
```

then to compile:

```
> gmake SMP = TRUE -j 64
```

It is critical to follow those recommendations to run the executable in a reasonable time. Without those optimisations, the run could last for hours and/or days. The executable is optimised and can be submitted to a queue. On the CALYPSO platform, the batch script is mksurfdata.calypso.run:

```
# /bin/csh -f!
#==============================================================================
# SVN $Id$
# SVN $URL$
#==============================================================================
# This is an LSF batch job script for runoff computation
#==============================================================================
#BSUB -n 64
#BSUB -R "span[ptile=64]"
#BSUB -q poe_medium
#BSUB -N
#BSUB -a poe
#BSUB -o poe.stdout.%J
#BSUB -e poe.stderr.%J
#BSUB -J maprunoff
#BSUB -W 2:00

setenv LID "`date +%y%m%d-%H%M%S`"

setenv OMP_NUM_THREADS 64

# cd /fis01/cgd/cseg/csm/mapping/makemaps/r05_??? <- your working dir
set SRCDIR = /users/home/ans021/BC/surface_bc/mksurfdata

echo "start computing surface dataset" `date`
time $SRCDIR/mksurfdata < mksurfdata.namelist >& mksurfdat.out!
echo "finished computing surface dataset " `date`

tail -200 out.$LID
```

In this package, one of the input files, pftdyn_hist_simyr1850.txt is particularly important and determines if the user will compute a surface dataset for **dynamical** vegetation use or for **stationary** conditions. A corresponding file to compute dynamic vegetation is called pftdyn_hist_simyr1850-2005.txt and contains the name of the vegetation distribution for each year from 1850 to 2005 included. In this guide, we compute static vegetation conditions.

A crucial aspect of this file is its format since the CLM Fortran code reads it with a specific format statement (A125, 1x, I4):

```
/users/home/ans021/BC/surface_bc/surf_ncl/mksrf_pft_mis6.harvest.nn.111021.nc
                                1850
```

BE SURE when modifying the absolute path of this file that the format is respected.

Table 7
Computing CLM initial conditions file

Numerical tool	Scripts	Inputs / Outputs
Fortran	mksurfdata package	**Input:**
NetCDF		griddata_0.9x1.25_070212.nc
		mksrf_soitex.10level.c010119.nc
		mksrf_vocef.c060502.nc
		fracdata_1080x2160.nc
		mksrf_glacier_mis6.nn.111021.nc
		mksrf_lanwat_mis6.nn.111021.nc
		mksrf_urban_mis6.111021.nc
		mksrf_organic.10level.0.5deg_mis6.nn.111021.nc
		mksrf_fmax_mis6.nn.111021.nc
		mksrf_pft_mis6.harvest.nn.111021.nc
		mksrf_soilcol_mis6.nn.111021.nc
		mksrf_lai_global_mis6.nn.111021.nc
		mksrf_topo.10min.mis6.111021.nc
		pftdyn_hist_simyr1850.txt
		Output:
		surfdata.pftdyn_0192x0288.nc
		surfdata_0192x0288.nc

5 Atmosphere initial conditions

The last CESM 1.0.2 component for which the user has to create new initial conditions is CAM. The procedure uses the definesurf package. This package is based on, a pre-existing master T42 file landm_coslat.nc containing the present-day topography land fractions to the coastlines, on the atmospheric grid on which the user wants to interpolate his new topography, here fv_0.9x1.25.nc, and the user's input land fraction topography at 10 min resolution obtained from section 2. To keep consistent with the gradual land fraction, the script mod_landm_coslat.ncl further modifies the new topography interpolated on the final atmospheric grid. All those files are reported in Table 8 and the procedure is described in Appendix II, Figure 7.

To execute the package, first, the user may compile it and then:

```
> ./definesurf -t topo_mis6_10min.nc -g fv_0.9x1.25.nc -l landm_coslat.nc newtopo.nc
```

Table 8
Creating CAM initial conditions

Numerical tool	Scripts	Inputs / Outputs
Fortran NetCDF	definesurf package	**Input:** fv_0.9x1.25.nc landm_coslat.nc topo_mis6_10min.111021.nc **Output:** topo_mis6_0.9x1.25_remap.111101.nc
NCL	mod_landm_coslat.ncl	**Input:** topo_mis6_0.9x1.25_remap.111101.nc **Output:** topo_mis6_0.9x1.25_remap.111101.mod.nc

BUGS

A syntax bug was fixed in the routine map2f.f90. This bug might have been corrected in the latest version of the code. The user may contact NCAR directly to get a more recent version:

```
-----------------------------------------------------------------------
Line 926:
sc(j) = jc + min(1., tmp) --> old version
sc(j) = jc + min(1.0d0 , tmp)  --> new version, fixed bug
```

```
Line 951:
se(j) = jc + min(1., tmp) -->  old version
se(j) = jc + min(1.0d0 , tmp) --> new version, fixed bug
-----------------------------------------------------------------
```

Finally, to correct the gradual land fraction, the user has to edit the script mod_landm_coslat.ncl to correct the areas where some new land have been added or removed in the new topography (for example, the Bering Strait). To execute:

```
> nclmod_landm_coslat.ncl
```

The final output is the new topography file that will be directly red by the CESM 1.0.2 during the initialisation of the run. The initialisation is performed from whatever cami_ic.nc file (the default CAM initial condition file). The atmosphere will quickly adjust to the new topography.

6 Setting the namelists: B compset

In this final section are indicated the namelists' fields where the user has to prescribed the new initial conditions files computed along the entire procedure. First of all, the user has to indicate to the CESM 1.0.2, where are located the new files. Since all the default input files for the CESM 1.0.2 runs are located in csm/inputdata, I used to put them there as well, because it limits the changes introduced into the namelists.

When the B compset is created, the first script to be modified is env_conf.xml. Then the compset is configured and the user may edit the namelists located in $USERcompset/Buildconf (see CESM 1.0.2 user guide).

6.1 Coupler mapping files: env_conf.xml

The user has to substitute the default mapping files by the ones computed in section 3.2:

```
<!--atm to ocn flux mapping file for fluxes (char)  -->
<entry id="MAP_A2OF_FILE"   value="map_fv09_1.25_to_gx1v6_aave_da.nc"  />

<!--atm to ocn state mapping file for states (char)  -->
<entry id="MAP_A2OS_FILE"   value="map_fv09_1.25_to_gx1v6_bilin_da.nc"  />

<!--ocn to atm mapping file for fluxes (char)  -->
<entry id="MAP_O2AF_FILE"   value="map_gx1v6_to_fv09_1.25_aave_da.nc"  />

<!--ocn to atm mapping file for states (char)  -->
<entry id="MAP_O2AS_FILE"   value="map_gx1v6_to_fv09_1.25_aave_da.nc"  />

.
.
<!--runoff (.5 degree) to ocn mapping file (char)  -->
<entry id="MAP_R2O_FILE_R05"   value="map_r05_to_gx1v6_mis6.nc"  />
```

Once the mapping files have been pointed by the user, configure the compset:

```
> ./configure -compset
```

6.2 Coupler namelist: cpl.buildnml.csh

To set-up the orbital forcing, the epoch of the simulation is specified in time A.D. (1950 + time). For example, for the penultimate glaciation that occurred 140 kyrs BP, the time will be:

```
orb_iyear_ad = -138050
```

For past time, the value is negative.

6.3 CAM namelist: cam.buildnml.csh

To initialise the atmospheric component, the user needs to set the new topography from section 5. The user may also changes the values of the GHGs according to the epoch considered. Here the values are taken from CO_2, CH_4 and NO_2 ice cores records retrieved from EPICA Dome C, East Antarctica and corresponds to 140 kyrs BP.

```
&cam_inparm
bnd_topo                = '$DIN_LOC_ROOT/atm/cam/topo/topo_mis6_0.9x1.25_remap.mod.nc'
.
.
/
&chem_surfvals_nl
ch4vmr         = 791.6e-9
co2vmr         = 284.7e-6
f11vmr         = 12.48e-12
f12vmr         = 0.0
n2ovmr         = 275.68e-9
/
```

6.4 CLM namelist: clm.buildnml.csh

The user has to change the value of CO_2 in agreement with that set-up in CAM namelist above. Since in this example, we are modelling a past glaciation, the option "**urban_hac**" is switched off (we removed all the urban landunit from the surface dataset in section 4.3).

```
&clm_inparm
co2_ppmv     = 284.7
fatmlndfrc      = '$DIN_LOC_ROOT/lnd/clm2/griddata/fracdata_0.9x1.25_gx1v6_mis6.nc'
fsurdat            = '$DIN_LOC_ROOT/lnd/clm2/surfdata/surfdata_192x288_mis6.nc'
urban_hac      = 'OFF'
```

6.5 POP namelist: pop2.buildnml.csh

As for CAM namelist, the user has to indicate the new topographic and ocean basins computed in section 3.1.

```
.
.
#------------------------------------------------------------------------------
#  identify all gx1v6 datasets residing in $DIN_LOC_ROOT/ocn/pop
```

```
#-----------------------------------------------------------------------------

set regionmask_filename    = $DIN_LOC_ROOT/ocn/pop/gx3v7/grid/region_mask_mis6.ieeei4
set topography_filename    = $DIN_LOC_ROOT/ocn/pop/gx3v7/grid/kmt_gx1v6_mis6.ieeei4
```

6.6 CICE namelist: cice.buildnml.csh

Since CICE shares the same grid with POP, the topography has to be consistent:

```
&grid_nml
.
.
kmt_file                = '$DIN_LOC_ROOT/ocn/pop/gx3v7/grid/kmt_gx1v6_mis6.ieeei4'
/
```

7 Generating the new initial CLM initial conditions file: the 5-days CESM 1.0.2 run

When running on a new platform, outside of NCAR, it might be necessary to regenerate the initial boundary conditions file for CLM. This is due to some differences in the allocation of the processors and memory during the compilation of the model. This part corresponds step 8 and step 9 on Figure 4 showing the whole procedure in Appendix II.

To do so, the user has to configure the namelist, as shown in section 6, except for the CLM namelist in which the original option pointing at the initial boundary conditions file is modified:

```
&clm_inparm
finidat    = '$USER_REPOSITORY/b40.1850.track1.1deg.006.clm2.r.0863-01-01-00000.nc'
```

into

```
&clm_inparm
finidat   = '  '
```

This will allow the model to create a new restart file containing the CLM initial conditions adapted to the platform.

After this modification, the user can run the B compset for 5 days only. The default configuration of env_run.xml is already set-up for a 5-day run. At the end of this run, the user gets a CLM restart file clm.r.new-paleo which is used to interpolate the original CLM initial conditions file b40.1850.track1.1deg.006.clm2.r.0863-01-01-00000.nc.

The interpolation is performed using the interpinic package located in the CESM 1.0.2 repository CESM 1.0.2/models/lnd/clm/tools/interpinic. The user will have to edit the Makefile to change the path of the NetCDF libraries and will have to compile the routines. To execute interpinic:

```
> ./interpinic -i b40.1850.track1.1deg.006.clm2.r.0863-01-01-00000.nc          -o
clm.r.new-paleo
```

The file clm.r.new-paleo will be then overwritten with the variables contained in b40.1850.track1.1deg.006.clm2.r.0863-01-01-00000.nc, that is why, we recommend to re-name it, for example: b40.1850.track1.1deg.006.clm2.r.0863-01-01-00000_interp-paleo.nc.

Finally, the user can run the true paleo experiment pointing at the new interpolated CLM file in the `finidat` field of the CLM namelist.

USEFUL LINKS RELATED TO CESM 1.0.2 PALEOCLIMATE MODELLING

During the entire procedure and for the first paleo runs, I found the following Wiki pages very useful for the various crashes of the components of CESM 1.0.2.

Paleo Documentation: on the CESM 1.0.2 dedicated website, the user can find some further documentation and advices when configuring the run for paleo times. The Paleo working group, have created a wiki page which accessible to anybody.

The following websites are dedicated to paleo datasets and ice sheet configurations used to create paleo topographies:

- PMIP3: Paleoclimate Models Intercomparison Phase 3
- ICE-5G: W. R. Peltier Last glacial deglaciation (21k - 0k) ice sheets reconstructions (Peltier, 2004).
- Ice Cores Gateway: to get the lastest GHGs records available for various parts of the world.

APPENDIX 0: EXECUTION TIME OF THE SCRIPTS USED IN THIS USER GUIDE

Table 9
Computational time estimates on CALYPSO IBM power 6 platform

Scripts	Execution time
mk140kTopo.ncl	$<$ 5 min
10min2_1deg.ncl	$<$ 5 min
change_kmt_new.ncl	$<$ 5 min
mk_remap_gx1v6.csh	$<$ 5 min
gen_domain.aix	$<$ 5 min
runoff.calypso.run	$<$ 20 min
10min2_05deg.ncl	$<$ 5 min
mkgridata	$<$ 5 min
create_mksrf_topo.nc	$<$ 5 min
convert_mksrf	$<$ 5 min
add_harvest.ncl	$<$ 5 min
nn_fill.ncl	$<$ 5 min
create_urban.ncl	$<$ 5 min
mksurfdata	20 min - several hours
definesurf	$<$ 5 min
mod_landm_coslat.ncl	$<$ 5 min

APPENDIX I: MAKEFILES

AIX specific options common to all Makefiles: extracts

```
# Architecture-specific flags and rules
#----------------------------------------------------------------------
# AIX
#----------------------------------------------------------------------
ifeq ($(UNAMES),AIX)
CPPDEF += -DAIX -DFORTRAN_SAME
cpre = $(null)-WF,-D$(null)
FPPFLAGS := $(patsubst -D%,$(cpre)%,$(CPPDEF))
#LIB_NETCDF := /usr/local/lib64/r4i4
LIB_NETCDF := /usr/local/netcdf-3.6.3/lib
FFLAGS = -c -I$(INC_NETCDF) -q64 -qsuffix=f=f90 -qsuffix=f=f90:cpp=F90 \
$(FPPFLAGS) -g -qfullpath
LDFLAGS = -L$(LIB_NETCDF) -lnetcdf -q64
ifneq ($(OPT),TRUE)
FFLAGS += -qinitauto=FF911299 -qflttrap=ov:zero:inv:en -C
else
FFLAGS += -O2 -qmaxmem=-1 -Q
LDFLAGS += -Q
endif
CFLAGS := -q64 -g $(CPPDEF) -O2
FFLAGS += $(cpp_path)
CFLAGS += $(cpp_path)
ifeq ($(SMP),TRUE)
FC = xlf90_r
FFLAGS += -qsmp=omp
LDFLAGS += -qsmp=omp
else
FC = xlf90
endif
endif
```

SCRIP Makefile: extracts

```
#/bin/csh!
#
# Makefile for interpolation code
#
# CVS:$Id: makefile,v 1.7 2000/04/19 21:46:44 pwjones Exp $
#
COMPILE = xlf90
#COMPILE = f90
FLAGS = -O3
#FLAGS = -O3 -r10000 -q64 -I/usr/local/include
#FLAGS = -g -DEBUG:div_check=3:subscript_check=ON:trap_uninitialized=ON:verbose_runtime=ON -r10000 -64 -I/usr/lo
LIB = -L/usr/local/netcdf-3.6.3/lib -lnetcdf
INCLUDE = /usr/local/netcdf-3.6.3/include
SRCDIR = .
EXEDIR = ..
```

Gen_domain Makefile: extracts

```
#/bin/csh -fv!
#===============================================================================
# SVN $Id: make.AIX.csh 6670 2007-09-28 21:55:15Z kauff $
# SVN $URL: https://svn-ccsm-models.cgd.ucar.edu/tools/mapping/gen_domain/trunk/make.AIX.csh $
#===============================================================================
set SRCDIR = .
xlf90 -O2 -qstrict -qmaxmem=-1 -qrealsize=8 -qarch=auto -q64 -qsuffix=f=F90 -o gen_domain.aix $SRCDIR/
gen_domain.F90 -I /usr/local/include -L/usr/local/netcdf-3.6.3/lib -lnetcdf
```

mkgridata Makefile: extracts

```
#-----------------------------------------------------------------------
# This Makefile is for building clm tools on AIX, Linux (with pgf90 or!
# lf95 compiler), Darwin or IRIX platforms.
```

```
#
# These macros can be changed by setting environment variables:
#
# LIB_NETCDF --- Library directory location of netcdf. (defaults to /usr/local/lib)
# INC_NETCDF --- Include directory location of netcdf. (defaults to /usr/local/include)
# MOD_NETCDF --- Module directory location of netcdf. (defaults to $LIB_NETCDF)
# USER_FC ------ Allow user to override the default Fortran compiler specified in Makefile.
# USER_FCTYP --- Allow user to override the default type of Fortran compiler (linux and USER_FC=ftn
only).
# USER_CC ------ Allow user to override the default C compiler specified in Makefile (linux only).
# USER_LINKER -- Allow user to override the default linker specified in Makefile.
# USER_CPPDEFS - Additional CPP defines.
# USER_CFLAGS -- Additional C compiler flags that the user wishes to set.
# USER_FFLAGS -- Additional Fortran compiler flags that the user wishes to set.
# USER_LDLAGS -- Additional load flags that the user wishes to set.
# SMP ---------- Shared memory Multi-processing (TRUE or FALSE) [default is FALSE]
# OPT ---------- Use optimized options.
#
#------------------------------------------------------------------------
# Set up special characters
null :=
EXENAME = mkgriddata
RM = rm
# Check for the netcdf library and include directories
ifeq ($(LIB_NETCDF),$(null))
LIB_NETCDF := /usr/local/netcdf-3.6.3/lib
endif
ifeq ($(INC_NETCDF),$(null))
LIB_NETCDF := /usr/local/netcdf-3.6.3/include
endif
.
.
.
.
# Newer makes set the CURDIR variable.
CURDIR := $(shell pwd)
ifeq ($(CLM_ROOT),$(null))
# ROOTDIR := $(CURDIR)/../../
ROOTDIR := /users/home/ans021/BC/mkgriddata
else
ROOTDIR := $(shell ls -1d $(CLM_ROOT)/models/lnd/clm*)
endif
$(CURDIR)/Depends: $(CURDIR)/Srcfiles $(CURDIR)/Filepath
```

```
/users/home/ans021/CESM 1.0.21_0_2/scripts/ccsm_utils/Build/mkDepends Filepath Srcfiles > $@
.
.
.
```

mksurfdata Makefile: extracts

```
#------------------------------------------------------------------------
# This Makefile is for building clm tools on AIX, Linux (with pgf90 or
# lf95 compiler), Darwin or IRIX platforms.
#
# These macros can be changed by setting environment variables:
#
# LIB_NETCDF --- Library directory location of netcdf. (defaults to /usr/local/lib)
# INC_NETCDF --- Include directory location of netcdf. (defaults to /usr/local/include)
# MOD_NETCDF --- Module directory location of netcdf. (defaults to $LIB_NETCDF)
# USER_FC ------ Allow user to override the default Fortran compiler specified in Makefile.
# USER_FCTYP --- Allow user to override the default type of Fortran compiler (linux and USER_FC=ftn only).
# USER_CC ------ Allow user to override the default C compiler specified in Makefile (linux only).
# USER_LINKER -- Allow user to override the default linker specified in Makefile.
# USER_CPPDEFS - Additional CPP defines.
# USER_CFLAGS -- Additional C compiler flags that the user wishes to set.
# USER_FFLAGS -- Additional Fortran compiler flags that the user wishes to set.
# USER_LDLAGS -- Additional load flags that the user wishes to set.
# SMP ---------- Shared memory Multi-processing (TRUE or FALSE) [default is FALSE]
# OPT ---------- Use optimized options.
#
#------------------------------------------------------------------------
# Set up special characters
null :=
EXENAME = mksurfdata
RM = rm
# Check for the netcdf library and include directories
ifeq ($(LIB_NETCDF),$(null))
#LIB_NETCDF := /usr/local/lib
LIB_NETCDF := /usr/local/netcdf-3.6.3/lib
endif
ifeq ($(INC_NETCDF),$(null))
#INC_NETCDF := /usr/local/include
INC_NETCDF := /usr/local/netcdf-3.6.3/include
```

```
endif
.
.
.
# Set if Shared memory multi-processing will be used
ifneq ($(strip $(SMP)),)
SMP := TRUE
endif
.
.
.
# Newer makes set the CURDIR variable.
CURDIR := $(shell pwd)
ifeq ($(CLM_ROOT),$(null))
ROOTDIR := $(CURDIR)/../../
else
ROOTDIR := $(shell ls -1d $(CLM_ROOT)/models/lnd/clm*)
endif
$(CURDIR)/Depends: $(CURDIR)/Srcfiles $(CURDIR)/Filepath
/users/home/ans021/CESM 1.0.21_0_2/scripts/ccsm_utils/Build/mkDepends Filepath Srcfiles > $@
#$(ROOTDIR)/../../../scripts/ccsm_utils/Build/mkDepends Filepath Srcfiles > $@
```

APPENDIX II: FLOW CHARTS SUMMARIZING THE PROCEDURE DESCRIBED IN THIS USER GUIDE

- Flow chart showing the various steps of the procedure described in the user guide
  Source: Nan Rosembloom

- Various steps to compute the coupler mapping files described in section 3.2
  Source: Nan Rosembloom

- Various steps to compute the land surface dataset files described in section 4
  Source: Nan Rosembloom

- Various steps to compute the atmospheric topography described in section 5
  Source: Nan Rosembloom

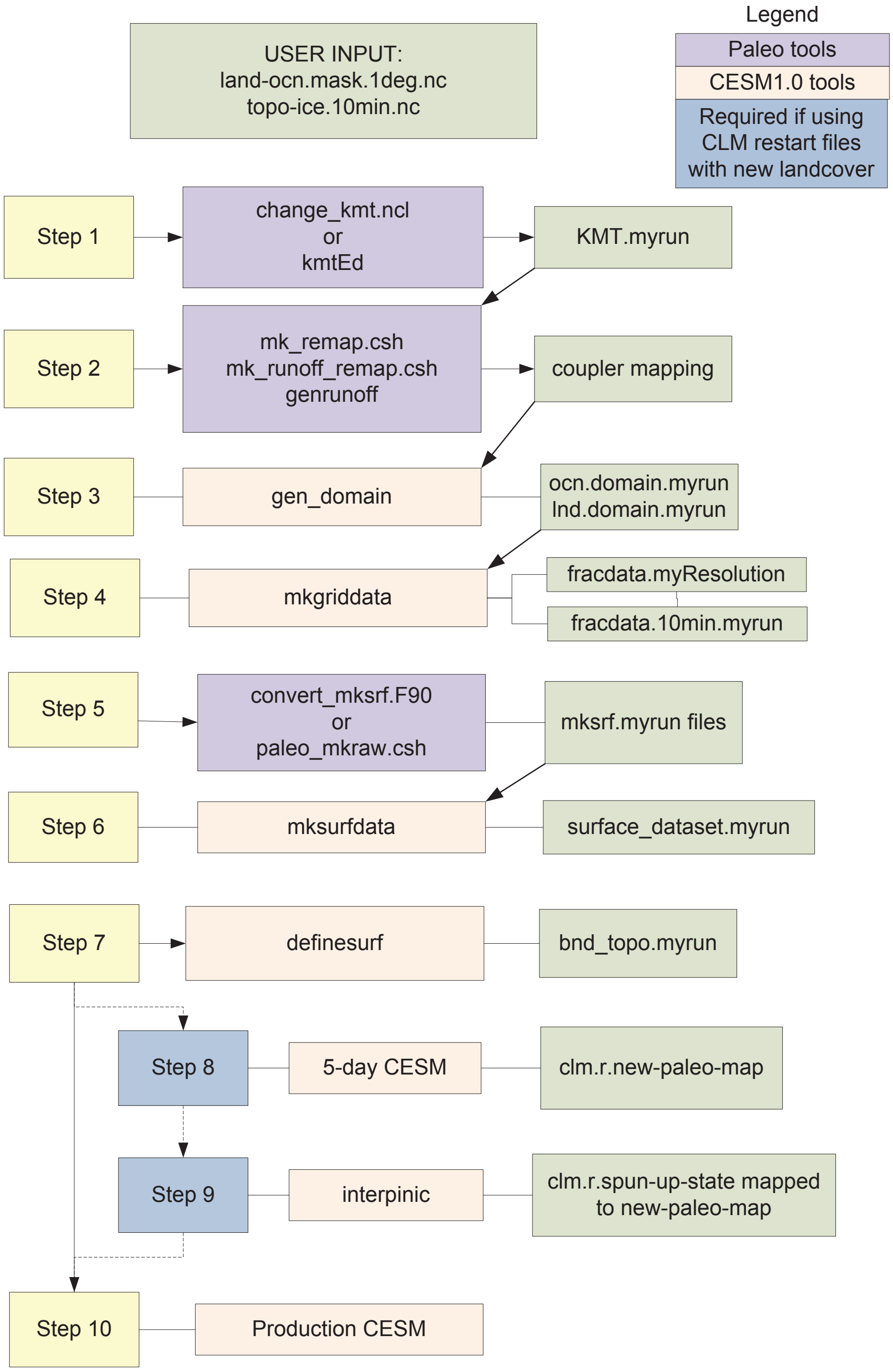

Figure 4:
Various steps of the procedure described in the user guide. Source: Nan Rosembloom

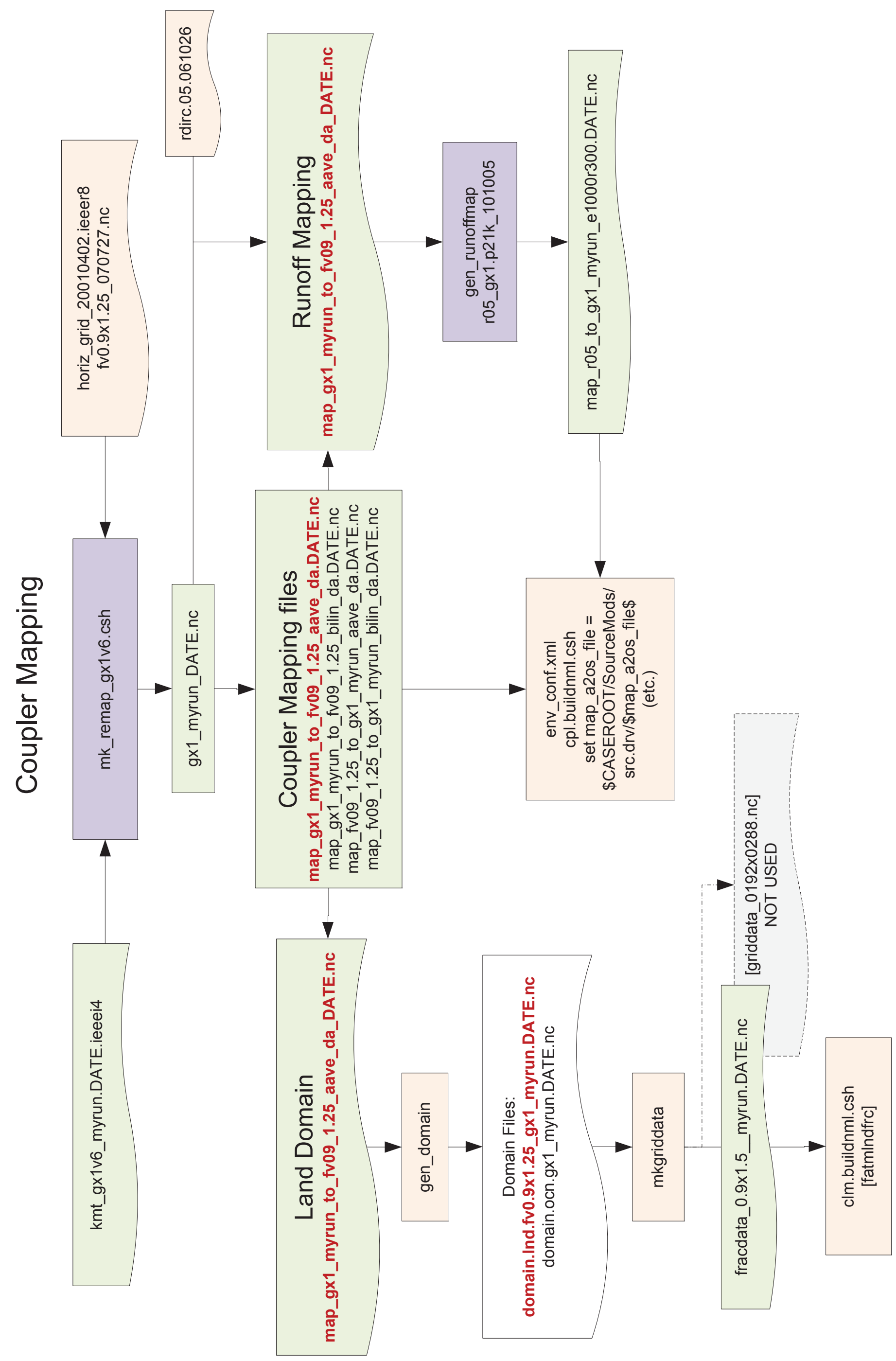

Figure 5:
Various steps to compute the coupler mapping files described in section 3.2. Source: Nan Rosembloom

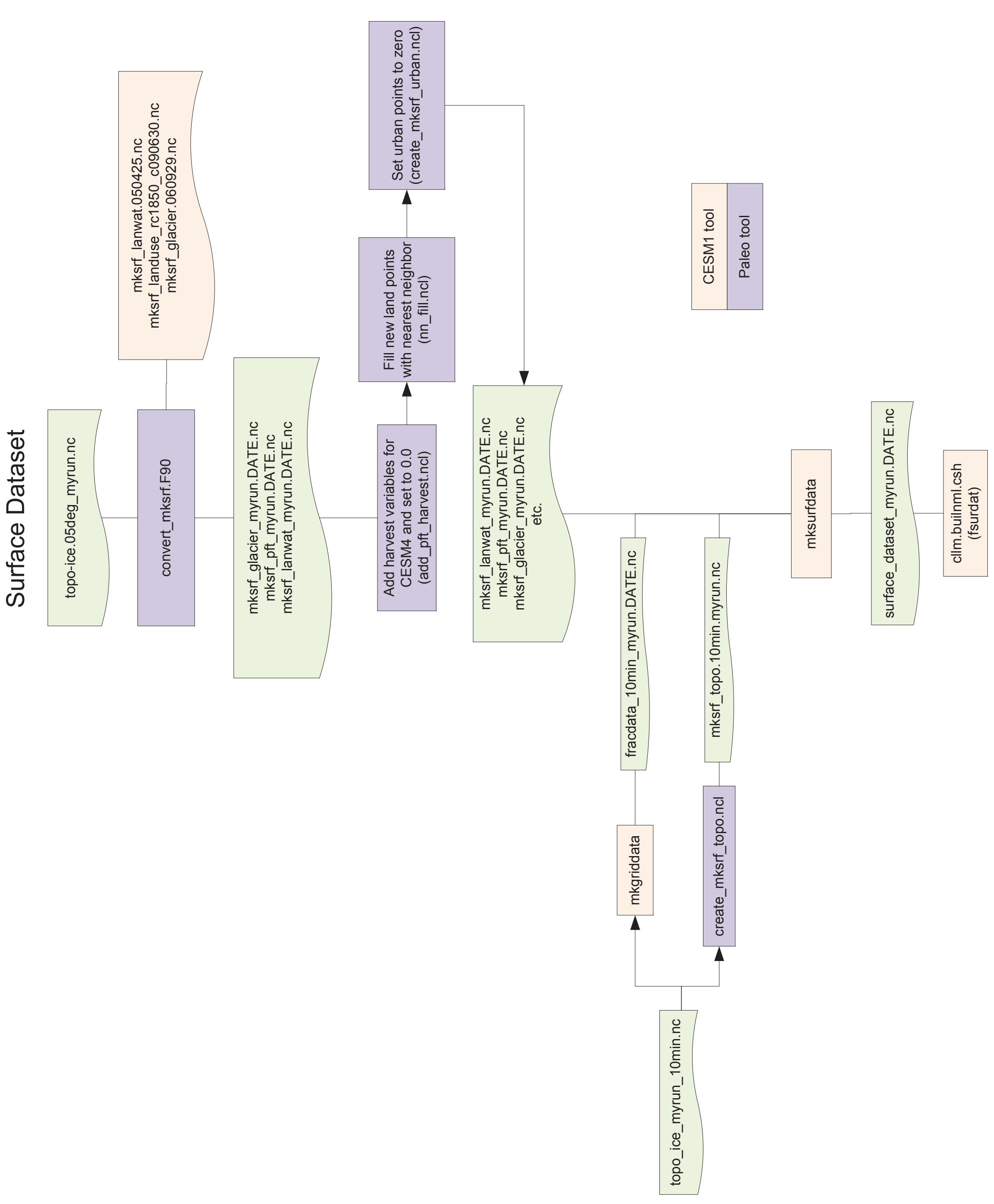

Figure 6:
Various steps to compute the land surface dataset files described in section 4. Source: Nan Rosembloom

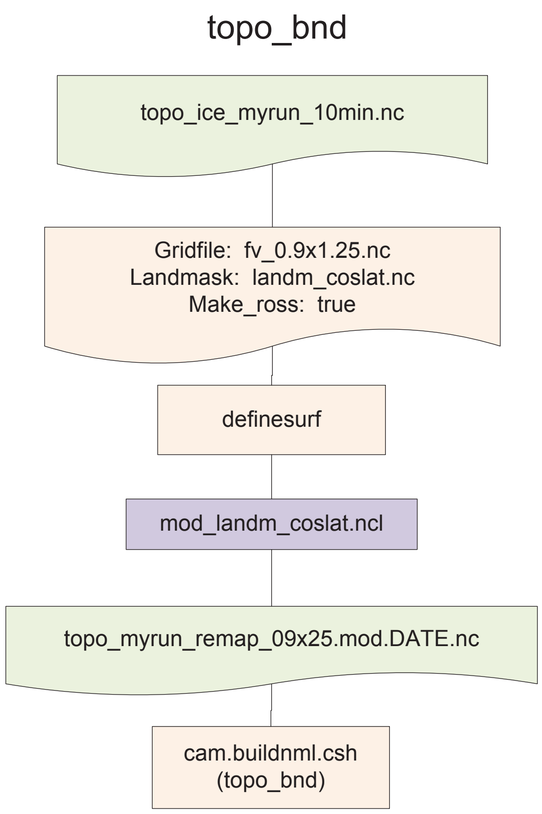

Figure 7:
Various steps to compute the atmospheric topography described in section 5. Source: Nan Rosembloom