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# CESM 1.0.5 near past initial conditions user guide: prescribing ice sheets

**By Florence Colleoni**

Centro Euro-Mediterraneo sui  
Cambiamenti Climatici, Bologna  
(Italy)  
[fcolleoni@gmail.com](mailto:fcolleoni@gmail.com)

**Nan Rosenbloom**

National Center for  
Atmospheric Research (USA)  
[nanr@ucar.edu](mailto:nanr@ucar.edu)

**SUMMARY** The Community Earth System Model, developed and maintained by NCAR, is the first completely open-source Earth System Model. In this document, I will refer to CESM 1.0.5, which corresponds to the last official release of CESM 1.0 (the more recent version is now CESM 1.2). CESM 1.0.5 includes atmosphere, land, ocean, sea-ice and a partially coupled ice-sheet model. Several grid resolutions have been developed for each component of CEMS and for present-day Earth's topography/bathymetry. One of the major advantage of this model is that the procedure to run it is straightforward in its present-day configuration. However, the CESM is not flexible when changes in the topography and bathymetry have to be introduced in order to simulate near and deep past climates. To implement a different land-sea mask, as well as different surface conditions, such as vegetation cover, ice sheets etc..., each component of CESM requires substantial changes in its initial conditions files, which require an advanced knowledge of the model structure. In order to make those kind of changes accessible to new users, the following document aims at detailing a relatively simple procedure to modify the initial conditions files for the coupled atmosphere-land-ocean-sea-ice configuration of the CESM 1.0.5 (B compset). This procedure was developed at NCAR and is based on the script released by the Paleo-working Group. This procedure has been successfully tested on CMCC IBM supercomputing facilities. In this user guide, the procedure is applied to a glaciation case, i.e. when large ice sheets covered the Northern Hemisphere repeatedly in the past and when sea level drop of about 120 meters. This procedure is by far non automatic and requires substantial manual work at each stage described in the document. Finally, following this procedure does not provide any guarantees that the simulations will be successful.

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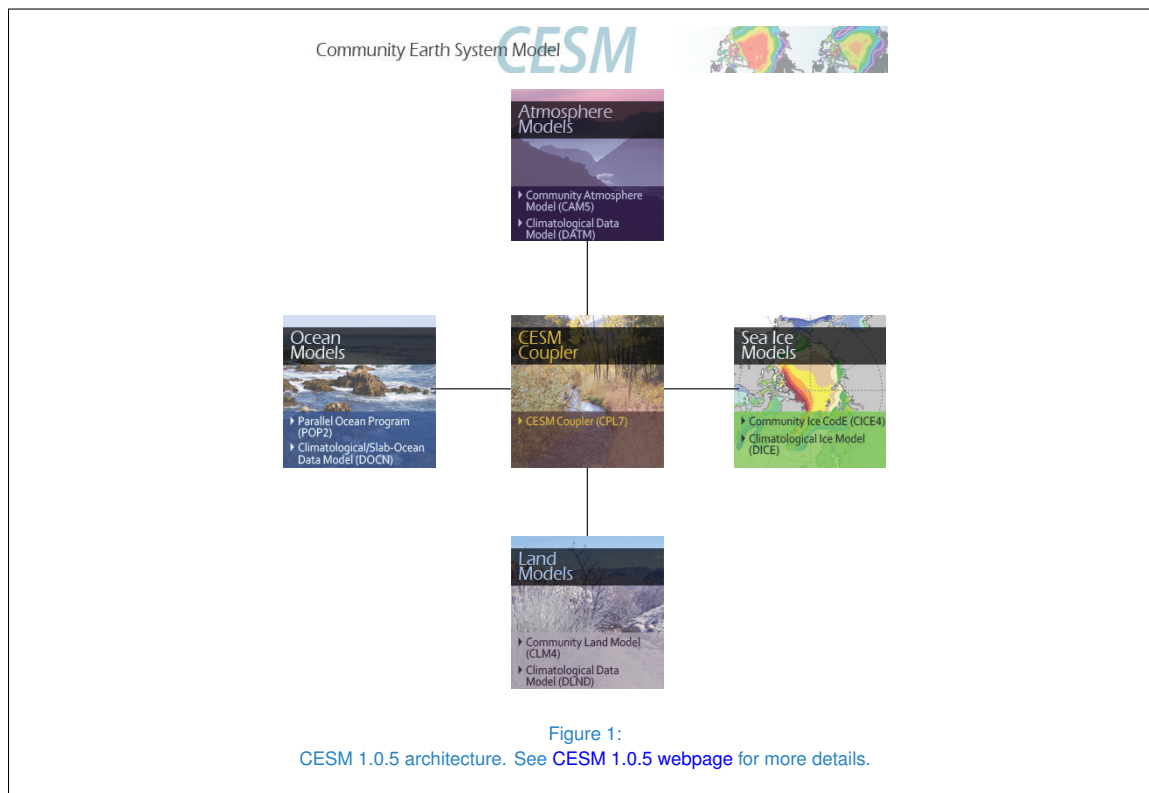
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## Introduction

### 1 The Community Earth System Model

The Community Earth System Model (CESM) 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 1.0.5 is developed jointly by NCAR and LANL (POP, CICE, CISM) and is maintained by NCAR. The code and its documentation are available on the CESM 1.0.5 website: <http://www.cesm.ucar.edu/models/cesm1.0/>. The CESM 1.0.5 fully coupled 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 against present-day climate observations. One of the major advantage of this model is that it is straightforward to run in its present-day configuration.



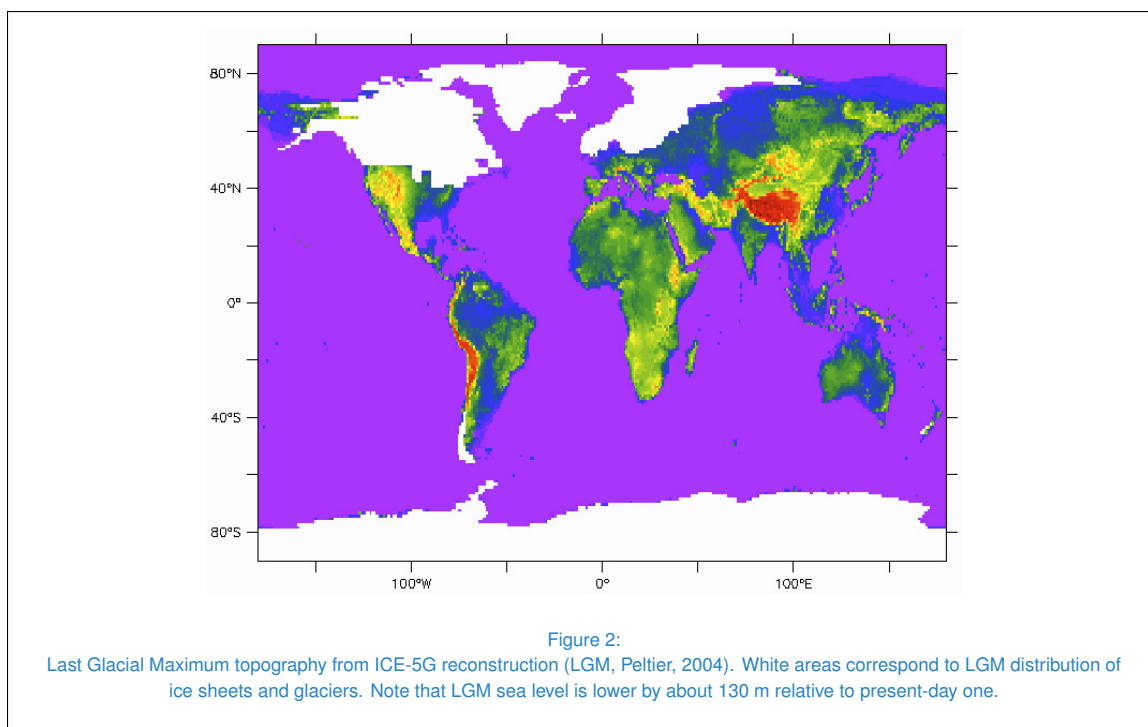
The CESM 1.0.5 has been successfully tested for paleoclimate simulations, however its climate components are not flexible to simulate near or deep past climates requiring different topographies and or bathymetries relative to present-day. To use a continental distribution or a sea level departing from present-day ones, each component of CESM needs substantial changes in its initial conditions, which requires an advanced knowledge of the model. The procedure is not simple but has been however tested successfully by NCAR Paleo Working Group for various time periods (Last Glaciation



and deglaciation, Pliocene, Miocene, Permian, Cretaceous etc...). In order to make those kind of changes more accessible to new users, the following document aims at describing this procedure to introduce large changes in the land-sea mask and surface conditions in a the coupled atmosphere-land-ocean-sea-ice configuration of the CESM 1.0.5 (B case). The user may note that this procedure is by far non automatic and requires substantial manual work at each stages. Finally, following this procedure does not provide any guarantees that the simulations will be successful.

## 2 Modelling near past climates

Simulating past climates implicates various changes in the Earth's topography. Fifty million years ago (Myrs), the continental distribution highly differed from present-day one and the modern configuration emerged about 10 Myrs ago. "Near past climate" refers more or less to the last 10 Myrs, during which, **only sea-level and surface elevation** changed as a result of the alternation of glacial/interglacial cycles (Figure 2). On the contrary "Deep past climate" refers to periods older than 10 Myrs, more specifically when the continental distribution was totally different than the modern one.



Creating initial conditions for "Near Past" or "Deep Past" has different implications:

- **Deep past:** changes in the surface topography, land cover, but also of the ocean bathymetry and ocean basins decomposition require a large amount of work both to create the initial files and to modify some specific default files into the model itself, which are set-up with present-day characteristics.
- **Near past:** the ocean bathymetry is kept at its modern state, only some of the oceanic basins



are removed from the default modern decomposition due to sea level drops. 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. This also limits the inconsistencies between the various components of the CESM.

In this user guide, we focus on how to generate the initial 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 1.0.5 fully coupled configuration (B case). Those changes implicate substantial modifications at all levels for all components. Beside, the model itself is particularly sensitive to inconsistencies between the land-sea mask of the various component. In CESM, some of the components are decomposed on the same grid:

- atmosphere (CAM) and land (CLM) share the same grid
- ocean (POP) and sea-ice (CICE) share the same grid.

Once the user has compiled the CESM and submit the job, the coupler checks that the land-sea masks computed for CAM and CLM matches the one computed for POP and CICE. If this first stage is successful, the user can hope that the new initial conditions are fine. Bellow, the end of the coupler log file is shown as an example:

```
(seq_mct_drv) : Performing domain checking
(domain_check_mct) --- checking ocn/ice domains ---
(domain_check_grid_mct) the domain size is = 140
(domain_check_grid_mct) maximum difference for mask 0.0000000000000000
(domain_check_grid_mct) maximum allowable difference for mask 0.1000000000000000E-01
(domain_check_grid_mct) the domain size is = 140
(domain_check_grid_mct) maximum difference for lat 0.568434188608080E-13
(domain_check_grid_mct) maximum allowable difference for lat 0.1000000000000000E-01
(domain_check_grid_mct) the domain size is = 140
(domain_check_grid_mct) maximum difference for lon 0.568434188608080E-13
(domain_check_grid_mct) maximum allowable difference for lon 0.1000000000000000E-01
(domain_check_grid_mct) the domain size is = 140
(domain_check_grid_mct) maximum difference for area 0.130104260698261E-17
(domain_check_grid_mct) maximum allowable difference for area 0.1000000000000000E+00
(domain_check_mct) --- checking atm/land domains ---
(domain_check_grid_mct) the domain size is = 48
(domain_check_grid_mct) maximum difference for lat 0.142108547152020E-13
(domain_check_grid_mct) maximum allowable difference for lat 0.1000000000000000E-11
(domain_check_grid_mct) the domain size is = 48
(domain_check_grid_mct) maximum difference for lon 0.568434188608080E-13
(domain_check_grid_mct) maximum allowable difference for lon 0.1000000000000000E-11
(domain_check_grid_mct) the domain size is = 48
(domain_check_grid_mct) maximum difference for area 0.476528601300874E-09
(domain_check_grid_mct) maximum allowable difference for area 0.9000000000000000E-06
(domain_check_mct) --- checking fractions in domains ---
(domain_check_mct) maximum difference for ofrac sum 0.0000000000000000
(domain_check_mct) maximum difference for ifrac sum 0.0000000000000000
(domain_check_mct) maximum allowable difference for frac sum 0.1000000000000000E-01
(domain_check_mct) maximum allowable tolerance for valid frac 0.1000000000000000E-01
(domain_check_mct) (domain_check_mct) : min/max ascale 0.0000000000000000 1.0000000000000004 atmdom_a
(domain_check_mct) (domain_check_mct) : min/max ascale 0.9999999999999841 1.0000000000000004 lnddom_l
(domain_areafactinit_mct) : min/max mdl2drv 0.999718744540964 1.00061729371141 areafact_a
(domain_areafactinit_mct) : min/max drv2mdl 0.999383087105043 1.00028133458592 areafact_a
(domain_areafactinit_mct) : min/max mdl2drv 0.979340530542676 1.01536195556158 areafact_i
(domain_areafactinit_mct) : min/max drv2mdl 0.984870463702687 1.02109528689257 areafact_i
(seq_mct_drv) : Initializing fractions
(map_atm2ocn_mct) :calling1 npfix
```

```

(seq_frac_check) [lnd init] afrac min/max = 1.000000000000000000 1.000000000000000000
(seq_frac_check) [lnd init] lfrac min/max = 1.000000000000000000 1.000000000000000000
(seq_frac_check) [lnd init] lfrin min/max = 1.000000000000000000 1.000000000000000000
(seq_frac_check) [ice init] afrac min/max = 0.000000000000000000 1.00000000000000622
(seq_frac_check) [ice init] ofrac min/max = 0.000000000000000000 1.000000000000000000
(seq_frac_check) [ice init] ifrac min/max = 0.000000000000000000 0.000000000000000000
(seq_frac_check) [ocn init] afrac min/max = 0.000000000000000000 1.00000000000000622
(seq_frac_check) [ocn init] ofrac min/max = 0.000000000000000000 1.000000000000000000
(seq_frac_check) [ocn init] ifrac min/max = 0.000000000000000000 0.000000000000000000
(seq_frac_check) [atm init] afrac min/max = 1.000000000000000000 1.000000000000000000
(seq_frac_check) [atm init] lfrac min/max = 1.000000000000000000 1.000000000000000000
(seq_frac_check) [atm init] ofrac min/max = 0.000000000000000000 0.000000000000000000
(seq_frac_check) [atm init] ifrac min/max = 0.000000000000000000 0.000000000000000000
(seq_frac_check) [atm init] lfrin min/max = 1.000000000000000000 1.000000000000000000
(seq_frac_check) [atm init] sum min/max = 1.000000000000000000 1.000000000000000000
(seq_frac_check) [atm init] sum ncnt/maxerr = 0 0.000000000000000000
(seq_mct_drv) : Setting fractions
(seq_mct_drv) : Initializing atm/ocn flux component
(seq_mct_drv) : Calling map_lnd2atm_mct
(seq_mct_drv) : Calling map_ocn2atm_mct for mapping o2x_ox to o2x_ax
(seq_mct_drv) : Calling map_ocn2atm_mct for mapping xao_ox to xao_ax
(seq_mct_drv) : Calling map_ice2atm_mct for mapping i2x_ix to i2x_ax
(seq_mct_drv) : Calling mrg_x2a_run_mct
(seq_mct_drv) : Calling atm_init_mct

(seq_mct_drv) : Model initialization complete
  
```

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



## Before Starting

First of all, to change the initial conditions, it is important to understand what are the steps of the procedure and why the user must strictly follow the order of the various steps. It is important to understand that the procedure starts with the computation of **ocean and coupler** initial conditions on which most of the surface datasets are based. The user can have an overview of the whole procedure in Figure 4.

The entire procedure begins with the computation of **ocean new bathymetry and basins distribution**. In POP, the World Ocean is divided in 10 basins and 4 marginal seas (Figure 3):

- Southern Ocean; Pacific Ocean; Indian Ocean; Atlantic Ocean; Arctic Ocean; Persian Gulf; Mediterranean; Labrador Sea; Hudson Bay; GIN Sea
- Red Sea; Baltic Sea; Black Sea; Caspian Sea

Changes in sea level sometimes imply a reorganization of the World Ocean basins and occasionally, some marginal Seas or small peripheral basins may be removed by the procedure.

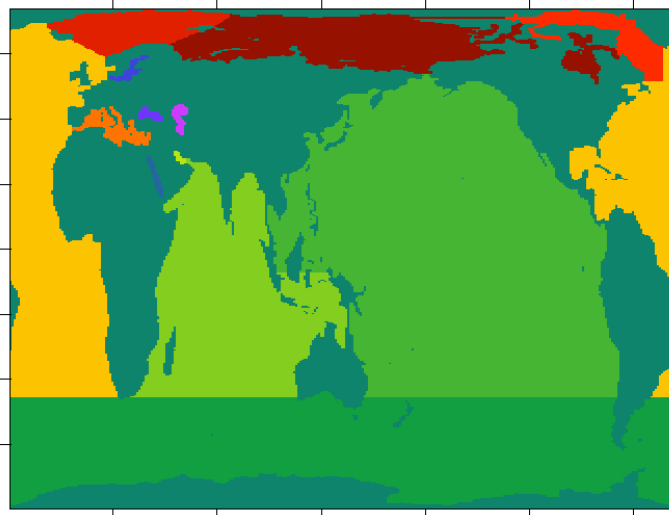
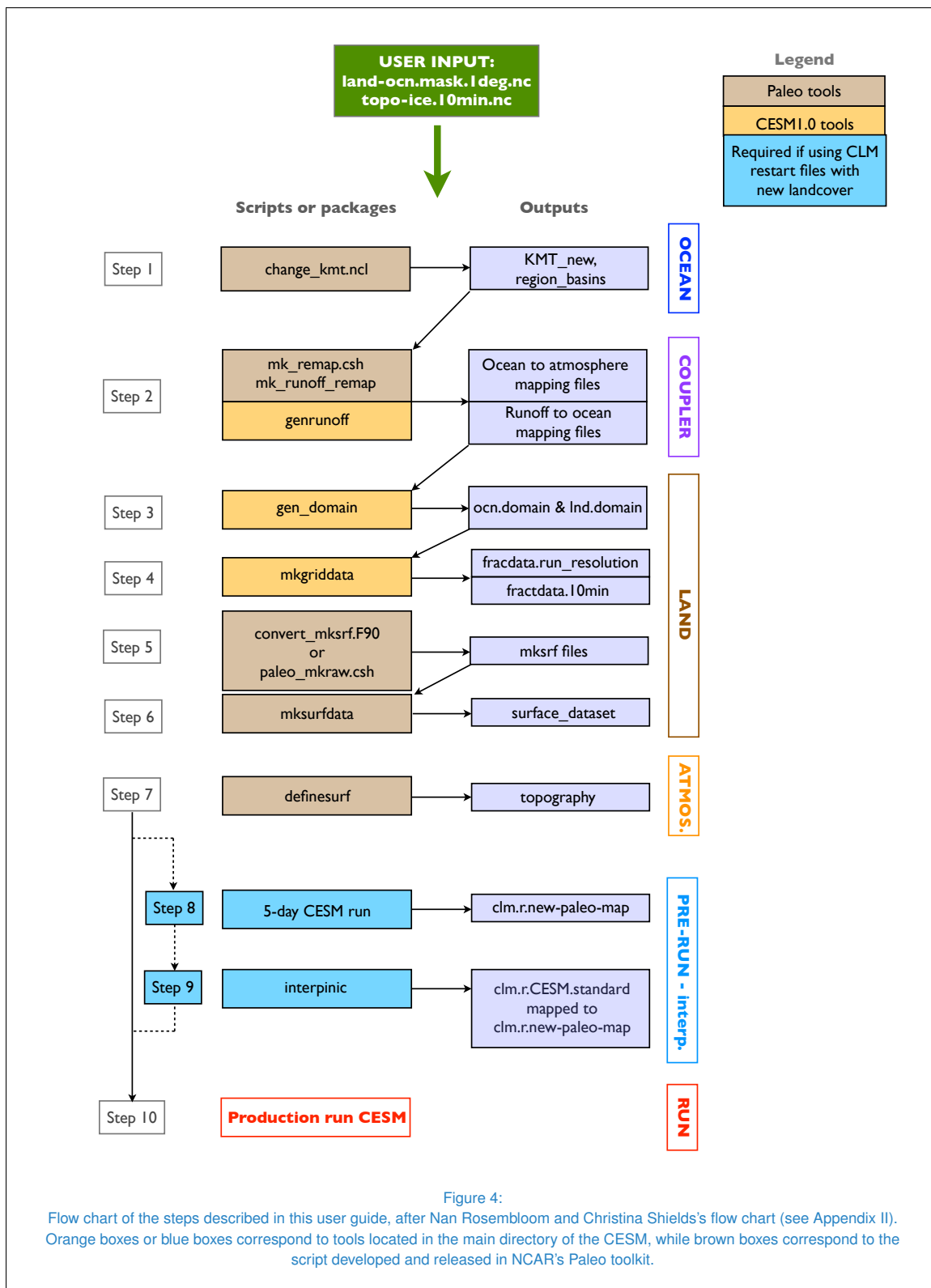


Figure 3:  
Distribution of ocean basins and marginal seas within POP for present-day topography.

Once the ocean land-sea mask and basins have been created, it is then possible to compute the **coupler mapping files**. The mapping files contain the interpolation weights needed to interpolate from POP to CAM and vice versa. In this step, a mapping file to interpolate the **runoff from land to ocean** is also computed. The next step is to compute the **CLM surface conditions**, which account for the newly created land-sea mask and the new ice sheets and vegetation distribution. The final step is to compute the **initial conditions for CAM**, which accounts for changes in surface topography and land-sea mask.







## 1 Software requirements

- Fortran 90
- NetCDF Fortran libraries
- NCAR Command Language: download at <http://www.ncl.ucar.edu/>)
- Ncview
- Spherical Coordinates Remapping and Interpolation Package (**SCRIP**): needed to create mapping files for CESM 1.0 and earlier versions of CCSM. Download the package and documentation on LANL [SCRIP page](#).

## 2 NCAR's Paleo Toolkit

In 2012, NCAR Paleo Working Group released a [Paleo Toolkit](#) containing all the necessary scripts to modify the initial conditions as described in this user guide. The Paleo Toolkit is available for download here: <https://www2.cesm.ucar.edu/working-groups/pwg/documentation/cesm1-paleo-toolkit>.

Furthermore, the Paleo Working Group wiki page contains a lots of informations to properly set-up the paleoclimate simulations and some of the scripts of the Paleo Toolkit. This toolkit contains two tar files, one dedicated to the old version of CCSM3 and one dedicated to CCSM4 version. For CESM 1.0.5, the user has to consider the CCSM4 tar file, which corresponds to the fully coupled configuration B1850 using CAM4 (CAM5 presents large improvements about the chemistry of atmosphere which are not of direct interest in our case). Therefore, simulations performed using the early versions of CESM with CAM4 are similar to simulations performed with the last release of CCSM4. However, some of the packages from CCSM3 may also be useful.

In the directory [ccsm4\\_extra\\_pub.2012mar16.nr/](#), the scripts are ordered such as:

- **atmlndfrac/** : scripts for steps 3 and steps 4
- **cam\_tools/** : for deep past or CAM stand alone run (docn/mk\_docn.domain.ncl)
- **cn\_nitdep/** : for cases using Carbon-Nitrogen pools
- **convert\_mkstrf/** : scripts for step 5
- **cpl\_mapping/** : scripts for step 2
- **lnd/** : for deep past
- **mkstrfdata/** : empty. package located under CESM1.0.5/models/lnd/clm/tools
- **modify\_kmt/** : scripts for step 1



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- **paleo\_ccsm4\_aerosol/** : to prescribe a different aerosol distribution for paleo time period (not used in this procedure, but could be included if the user needs to prescribe a new aerosol distribution.)
- **paleo\_mkraw/** : for deep past (for near past, use `convert_mkrsrf/` scripts)
- **rtm/** : for deep past only. For near past use the tool **gen\_runoff/**, located in the Paleo Toolkit for CCSM3. This tool aims at providing a new file of river flow directions used by the RTM model coupled to CLM. However, for near past simulations using almost present-day topography, the user may use the default CESM `rdir05.nc` already prescribed in the namelist. But, the user will have to produce the runoff mapping file using the **gen\_runoff** tool to account for the new land sea mask if needed. In alternative, a more recent version of this tool, **runoff\_to\_ocn/** is available in CESM 1.1 and more recent versions under [CESM1.1/mapping/gen\\_mapping\\_files/](#). The user may also find it in this [CESM forum post](#).

In the directory [ccsm3\\_setup\\_tools\\_110319-NR-120316/](#), the user can find:

- **atm/** : scripts for step 7. The only tool that will be used from this directory is the **definesurf tool**. There are two versions present in the directory: **definesurf-svn100709/** is the most recent version of this tool accounting for the changes between CCSM3 and CESM1.0. The other version, **definsurf-paleo-queternary/** contains a directory **landmcoslat/** in which the user can find the script **fix\_landm\_coslat.ncl** used at step 7.
- **cpl/** : the user can find the **gen\_runoff/** package which is used to compute the runoff mapping files needed by the coupler.

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. All the scripts ported on CMCC supercomputing platforms were initially developed by Nan Rosebloom and Christina Shield (NCAR).

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 1.0.5 by using the following color code:

**blue**: default CESM 1.0.5 present-day raw data files

**red**: user provided files

**orange**: files computed during the procedure

### 3 Building a new CESM 1.0.5 B\_ca

Most of the scripts that will be used in this procedure introduce changes based on default present-day CESM 1.0 initial conditions files that the user can get [building the CESM default case](#) and for which new boundary conditions will be created. In this manual, the procedure is described for:

- **B\_case** (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 user guide](#) for more details on the supported resolutions).

The instructions to build the case are provided in the [CESM 1.0 User Guide](#). This process will automatically download all the files required by all the components of the B1850 compset to run with the default configurations already implemented in CESM 1.0. Once the user has built the case, he can proceed with the steps described in the forthcoming sections. Do not clean-up the case directory since it will be used to create the 5-days CLM restart file accounting for the new land sea mask and needed to run a proper case using the new initial conditions (**see section 7 and Figure 4, step 7**).



## Creating initial conditions files

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### 1 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 interpolation 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 1.0.5 case resolution (e.g. f09\_g16, T31\_gx3v7, see the [CESM 1.0 user guide](#) for more details on the supported resolutions).

**Table 1**  
Pre-processing initial topography script and associated files

Numerical tool	Scripts	Inputs / Outputs
User based	User based	<b>Input:</b> <a href="#">USGS_gtopo30_10min.nc</a> <a href="#">Relief_user_10min.nc</a> (topography at 10min res.) <a href="#">landice_user.nc</a> (ice mask)  <b>Output:</b> <a href="#">topo_user_10min.nc</a> (htopo, ice, landfract, landsmask,variance)

Most of the scripts that will be used in the following steps are based on **default present-day CESM 1.0.5 initial conditions files** to which the differences provided by the user new input conditions are added.

To create the initial topography file, the **user must create his own script**. The purpose of this step is to add the topographic difference, between the topography provided by the user and present-day topography, on top of the CESM USGS present-day 10 min topography file. The input and output files are reported in Table 1. The new topographic file should contain the following variables:

- **htopo**: already in USGS topo file. Changes in topography have to be added on this variable
- **landfract**: already in USGS topo file. Changes in land-sea mask have to be added on this variable. Make sure that the values range between 0-1.
- **variance**: already in USGS topo file. This variable does not have to be modified. The user may copy and paste the USGS variance variable in his own topographic file
- **ice**: ice-sheets and glaciers mask provided by the user. This variable may equals 100 where ice sheets are present and 0 elsewhere. This also includes Greenland and Antarctica.



- **landmask**: this variable is a simple land-sea mask with 1 for land and 0 for ocean.

**WARNING:** the longitudes and latitudes have to be equals to USGS topo file. The user must therefore interpolate his own topography and land-ice mask to USGS topography grid. Check also that the coordinates are written in the same order than in USGS file.

The user file should look like the following:

```
netcdf topo_mis6_10min.111021 {
dimensions:
  lat = 1080 ;
  lon = 2160 ;
variables:
  float htopo(lat, lon) ;
    htopo:_FillValue = -1.e+34f ;
    htopo:units = "meter" ;
    htopo:long_name = "10-min elevation from USGS 30-sec dataset" ;
  double lat(lat) ;
    lat:units = "cell center locations" ;
    lat:long_name = "latitude" ;
  double lon(lon) ;
    lon:units = "cell center locations" ;
    lon:long_name = "longitude" ;
  float ice(lat, lon) ;
    ice:missing_value = -1.e+34f ;
    ice:_FillValue = -1.e+34f ;
    ice:long_name = "landice" ;
    ice:history = "From landlandice_MIS6_10min" ;
    ice:lonFlip = "longitude coordinate variable has been reordered via lonFlip" ;
  float landfract(lat, lon) ;
    landfract:_FillVal = -1.e+34f ;
    landfract:long_name = "RELIEF[D=Relief_140_aveclacs_casp0,GX=RELIEF[D=Relief],GY=RELIEF[D=Relief]]" ;
    landfract:missing_value = -1.e+34f ;
    landfract:lonFlip = "longitude coordinate variable has been reordered via lonFlip" ;
    landfract:_FillValue = -1.e+34f ;
    landfract:units = "meter" ;
  int landmask(lat, lon) ;
    landmask:longname = "landmask" ;
    landmask:_FillValue = -9999 ;
  float variance(lat, lon) ;
    variance:long_name = "variance of 30-sec elevations" ;
    variance:units = "meter**2" ;

// global attributes:
  :infile3 = "USGS-gtopo30_10min_c050419.nc" ;
  :infile2 = "landice_MIS6_10min" ;
  :infile1 = "Relief_140_aveclacs_casp0" ;
  :srcCode = " " ;
  :author = " " ;
  :create_date = " " ;
```

In this example, NCL was used to generate this new topographic file, but any kind of tool can be used to do it.



## 2 Ocean and coupler initial conditions files

This part is dedicated to the computation of the initial conditions for POP (ocean) and CPL (coupler). The whole procedure is described below and illustrated by the flow chart in Figure 4. In this section, seven files are generated:

- **a new land-sea mask**
- **a region mask:** distribution of the various oceanic basins and marginal seas (Figure 3).
- **the coupler mapping files (x4):** handle the interpolation from/to the oceanic grid to/from the atmospheric grid.
- **a new runoff to ocean map:** to handle the interpolation from land to ocean.
- **the land and oceanic domains:** land-sea masks used to create surface conditions

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

### 2.1- Ocean topography and region mask

First of all, the initial pre-processed topography at **10 min** resolution has to be interpolated at **1°x1°**. Similarly to the previous section, **the script must be created by the user**. The new topography interpolated at 1° should contain the same variables than in the original user provided topography at 10 min: htopo, landfract, landmask, variance, ice.

**WARNING:** be sure that the following variables are computed in the indicated ranges:

**ICE: 0 - 100**

**LANDFRACT: 0 - 1**

**LANDMASK: 0 - 1**

This new topography is used to generate the new land-sea mask and the ocean region mask (Figure 3). This step is based on the CESM present-day bathymetry KMT file located in `csm/inputdata/ocn/pop2/grid/` (the present-day land-sea mask and region mask are binary files `.ieee4`).

The script `change_kmt.ncl` from the Paleo Toolkit is able to open those files and modify 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 is preserved over the unchanged areas**.

To generate the new KMT and region mask, the user has to point to the `new_topography_1x1.nc` file. As reported in Table 2, `change_kmt.ncl` also needs the original present-day POP bathymetry, regions and horizontal grid files provided directly for the resolution of interest in the `csm/inputdata/ocn/pop2/grid` directory.



Execute the script:

```
> ncl change_kmt.ncl
```

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

Numerical tool	Scripts	Inputs / Outputs
User provided	User provided	<b>Input:</b> topo_user_10min.nc  <b>Output:</b> new_topo_user_1x1.nc
NCL	change_kmt.ncl	<b>Input:</b> new_topo_user_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.ieeei8 (POP present-day horizontal grid)  <b>Output:</b> kmt_gx1v6_user.ieeei4 region_mask_gx1v6_user.ieeei4 USER_kmt.nc (file to check for disturbing pixels)

A NetCDF file, **USER\_kmt.nc**, containing the main variables modified by **change\_kmt.ncl** is also created to help the user to check whether the new land-sea mask and region mask are correct.

It is important to check the number of basins contained in the new oceanic region mask. Indeed, when changing the ocean bathymetry, changes occur in the region mask since some basins may disappear. 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 1.0.5 model ([CESM 1.0.5/models/ocn/pop2/input\\_templates/gx1v6\\_region\\_ids](#)). The original **gx1v6\_region\_ids** file provided in the CESM 1.0.5 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 values assigned to the basins have to be re-assigned. An example is given in Table 3, illustrating our glaciation case. The Baltic Sea as well as the Hudson Bay have been removed and filled with land. The basins no longer exist in the new ocean bathymetry 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 the **gx1v6\_region\_ids** and takes the absolute value of the maximum number written in this file. In our case, 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 1.0.5 (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				

The second feature that may change, due to the new land-sea mask, is the location of the **overflows areas**. In POP, the location of the overflows for present-day bathymetry are prescribed in an initial input file that the user may find in [CESM 1.0.5/models/ocn/pop2/input\\_templates/gx1v6\\_overflow](#)). In this file, there are several regions where overflows occur due to ocean bathymetry as for example: the Denmark Strait, the Faroe Bank Channel, the Ross Sea and the Weddell Sea. Typically, for a glaciation case, only the overflow located in the Denmark Strait is preserved.

## 2.2- Coupler mapping files

The mapping files contain informations (weights etc...) used by the coupler to interpolate the fields from ocean grid onto the atmospheric grid and vice versa. The runoff to ocean map is also part of this process since to be computed, it uses one of the ocean 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 (See Software requirements). To perform the interpolation between ocean and atmosphere, `mk_remap_gx1v6.csh` needs the original ocean and atmosphere grid files, and the new ocean KMT file generated at the previous step. All the input and output 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 comment them successively to get the four mapping files:





**Table 4**  
New coupler mapping, runoff and domain files

Numerical tool	Scripts	Inputs / Outputs
shell + SCRIP	mk_remap_gx1v6.csh	<p><b>Input:</b></p> <p>kmt_gx1v6.user.ieeei4</p> <p>fv0.9x1.25.070727.nc (CAM grid at 0.9x1.25 res.)</p> <p>horiz_grid_20010402.ieeer8 (POP present-day horizontal grid)</p> <p><b>Output:</b></p> <p>map_ocn_to_atm.user.aave.nc</p> <p>map_atm_to_ocn.user.aave.nc</p> <p>map_ocn_to_atm.user.bilin.nc</p> <p>map_atm_to_ocn.user.bilin.nc</p> <p>gx1v6.user.nc (new ocean grid, only used for runoff map)</p>
Fortran 90	gen_runoff/ build.calypso.csh runoff.calypso.run	<p><b>Input:</b></p> <p>gx1v6.user.nc</p> <p>rdirc.05.061026</p> <p><b>Output:</b></p> <p>map_r05_to_gx1v6.user.nc</p>
Fortran 90	gen_domain/	<p><b>Input:</b></p> <p>map_ocn_to_atm.aave.nc</p> <p><b>Output:</b></p> <p>domain.ocn.gx1v6.user.nc</p> <p>domain.lnd.fv09_1.25.gx1v6.user.nc</p>

one time for **conservative** interpolation:

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

one time for **bilinear** interpolation:

```
!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 Figure 4).

Once the mapping files have been generated, the user may compute the runoff mapping file. This file is generated at  $0.5^\circ$  horizontal resolution and is based on the new ocean grid file computed at the previous step (Table 4). The runoff package `gen_runoff/` has to be compiled first using the script `build.machine.csh`. In alternative, the user can download the new package `runoff_to_ocn`, available in the latest version of CESM 1.2 and similar to the `gen_runoff` package (See NCAR's Paleo Toolkit section). The user can thus follow the instructions below using the most recent version of this runoff tool.

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_user.nc'
file_nn = 'map_nn_gx1v6.nc'
file_smooth = 'map_smoother_gx1v6.nc'
file_new = 'map_r05_to_gx1v6_user.nc'
title = 'runoffmap: r05- > gx1v6 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.run
```

### 2.3- Domain and fraction files

The penultimate step of this section is the computation of the land and oceanic domain files using the `gen_domain` package provided with the Paleo Toolkit and located in `atmlndfrac/`. First, edit 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, the land fraction file, both at the run resolution (here fv  $0.9 \times 1.25$ ) and at 10 min resolution can be created. Those files are generated through the `mkgriddata` package (CESM 1.0.5/`models/lnd/clm/tools`). The package produces three files containing land fraction, topography and a new grid file. The two latter are not further used 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.

The mkgriddata has to be run two times:

- 10 min resolution: uses the topographic file at 10 min resolution. The fraction file produced at 10 min will be used in the next section to compute the land surface conditions.
- fv\_0.9x1.25 (or other) resolution: uses the land domain file `domain.lnd.fv09_1.25.gx1v6.nc` from previous step. The fraction file produced at run resolution will be prescribed in the CLM namelist.

Compile the package and then execute it:

```
> mkgriddata < mkgriddata.namelist > mkgriddata.out
```

**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 has to insert the default 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 [mkgriddata package](#). **This is not necessary when generating the land fraction at 10 min resolution.**



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## 3 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 I, Figure 8 illustrates the various steps of this section.

### 3.1 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°**. As for the interpolation at 1°, the user has to create its own script to interpolate the 10 min topography. The coordinates have to match those of the default `mkglacier.nc` file, for example.

Be sure that the following variables are computed in the indicated ranges:

**ICE: 0 - 100**

**LANDFRACT: 0 - 1**

**LANDMASK: 0 - 1**

For step 3.4, 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` provided in the Paleo Toolkit in `convert_mksrf/`. This script also needs the original present-day CESM `mk-srf_topo_10min.nc` file downloaded from the NCAR repositories (Table 5). To execute the script, the user has to point to the topo files and:

```
> 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 1.0.5 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`.

### 3.2 Adding glaciers to the list of PFTs

The ice sheets distribution is extracted from the 0.5° resolution topography interpolated at the previous step and transformed into a PFT type and landunit file. CLM initial conditions file considers 15 PFTs by default (Figure 5). As the user can note, the type “glaciers” is not included into this



**Table 5**  
Pre-processing topography for surface dataset

Numerical tool	Scripts	Inputs / Outputs
User based	User based	<b>Input:</b> topo_user_10min.nc  <b>Output:</b> topo_user_05deg.nc
NCL	create_mkstrf_topo.ncl	<b>Input:</b> topo_user_10min.nc mkstrf_topo_10min.c080912.nc  <b>Output:</b> mkstrf_topo_10min.user.nc
Fortran NetCDF	mkgriddata package	<b>Input:</b> topo_user_10min.nc domain.lnd.fv09_1.25_gx1v6_user.nc  <b>Output:</b> fracdata_10min.nc griddata_10min.nc (not used) topodata_10min.nc (not used) fracdata_fv09_1.25.nc (CLM namelist) griddata_fv09_1.25.nc (not used) topodata_fv09_1.25.nc (not used)

default 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_mkstrf.F90` and uses three default present-day files from CESM 1.0.5 containing the present-day glaciers mask, the present-day landunit distribution and present-day landuse map (in our case the default distribution corresponds to that of pre-industrial).

Indeed, in CLM, a type of landunit is attributed to each pixel (Figure 5). 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 has to declare how much of each pixel will be “Glacier” and/or vegetated. This is exactly what `convert_mkstrf.F90` does.

The routine is based on a template routine in which the user has to point to the default CESM 1.0.5 files listed in Table 6:

To edit the script:



Table 6

New PFTs distribution - adding glaciers to the landcover

Numerical tool	Scripts	Inputs / Outputs
NCL	convert_mksrf.F90	<b>Input:</b> topo_user_05deg.nc mksrf_topo.10min.c080912.nc  <b>Output:</b> mksrf_glacier_user.nc mksrf_pft_user.nc mksrf_landwat_user.nc
NCL	add_harvest.ncl	<b>Input:</b> mksrf_pft_user.nc mksrf_landuse.rc1850.c090630.nc  <b>Output:</b> mksrf_pft_user_harvest.nc
NCL	nn_fill.ncl	<b>Input:</b> mksrf_glacier_user.111021.nc mksrf_landwat_user.111021.nc mksrf_pft_user.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  <b>Output:</b> mksrf_glacier_user.nn.nc mksrf_landwat_user.nn.nc mksrf_pft_user.harvest.nn.nc mksrf_soitex.10level.user.nn.nc mksrf_organic.10level.0.5deg.user.nn.nc mksrf_fmax_user.nn.nc mksrf_soilcol_user.nn.nc mksrf_lai_global_user.nn.nc
NCL	create_urban.ncl	<b>Input:</b> mksrf_urban_3den.0.5x0.5_simyr2000.c090223.v1.nc mksrf_pft_mis6.harvest.nn.111021.nc  <b>Output:</b> mksrf_urban_user.nc



```
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
```

### 3.3 Finalising the new PFTs distribution

After creating the new glaciers PFT type, 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 PFT “Glacier” computed at the previous step. This step is done using the script `add_harvest.ncl` provided in the Paleo Toolkit and located in `convert_mksrf/`. This script that uses the new PFTs distribution `mksrf_pft_user.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-neighbor algorithm filling the empty pixels by using their nearest PFTs and soil properties and computes all the soil properties. This step uses all the default CESM 1.0.5 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. This script is not provided in the Paleo Toolkit and has to be required to Nan Rosembloom. In alternative, the user may use any kind of tool to do this step

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 5) 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:

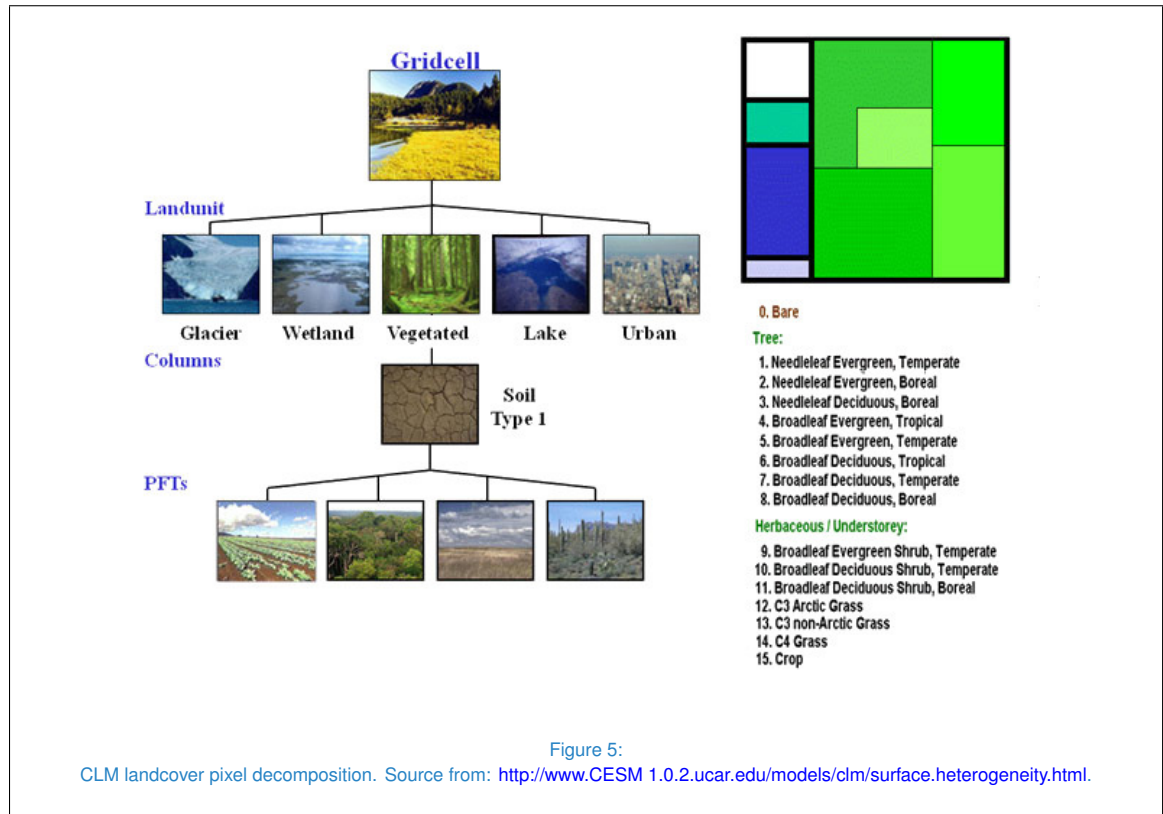
```
pct_urban = 0
```

As for `nn_fill.ncl`, `create_urban.ncl` is not provided along with the Paleo Toolkit.

### 3.4 Creating CLM initial conditions file



The files obtained in the previous steps 4.1 to 4.3 are combined together to create the new surface dataset that will constitute the input file to initialize CLM. The path to those files will be set in the namelists before compiling and running the B case (see section 6).



To create new surface initial conditions, a special package, `mksurfdata`, has been released and is located in the CESM 1.0.5 directory `CESM 1.0.5/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 = 'csm/inputdata/lnd/clm2/griddata/griddata_0.9x1.25_070212.nc'
mksrf_fsoitex = 'mksrf_soitex.10level.c010119.nc'
mksrf_forganic = 'mksrf_organic.10level.0.5deg_mis6.nn.nc'
mksrf_flanwat = 'mksrf_lanwat_mis6.nn.111021.nc'
mksrf_fmax = 'mksrf_fmax_mis6.nn.111021.nc'
mksrf_fglacier = 'mksrf_glacier_mis6.nn.111021.nc'
mksrf_furban = 'mksrf_urban_mis6.111021.nc'
mksrf_fvegtyp = 'mksrf_pft_mis6.harvest.nn.111021.nc'
mksrf_fsoicol = 'mksrf_soicol_mis6.nn.111021.nc'
mksrf_flai = 'mksrf_lai_global_mis6.nn.111021.nc'
mksrf_ftopo = 'mksrf_topo.10min.mis6.111021.nc'
mksrf_ffrac = 'fracdata_1080x2160.nc'
mksrf_fvocef = 'mksrf_vocef.c060502.nc'
mksrf_firrig = ''
mksrf_fdynuse = 'pftdyn_hist_simyr1850.txt'
```





```
outnc_double = .true.
/
```

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 **steady-state** conditions. The corresponding file to compute dynamic vegetation is called `pftdyn_hist_simyr1850-2005.txt` and contains the name of the raw vegetation files for each year from 1850 to 2005 included. In this guide, we compute steady-state vegetation conditions.

A crucial aspect of this file is its format since the `mksurfddata` 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.

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 CMCC supercomputing platform, the batch script is `mksurfddata.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
```



**Table 7**  
Computing CLM initial conditions file

Numerical tool	Scripts	Inputs / Outputs
Fortran NetCDF	mksurdata package	<b>Input:</b> griddata_0.9x1.25_070212.nc mksrf_soitex.10level.c010119.nc mksrf_vocef.c060502.nc fracdata_1080x2160.nc mksrf_glacier_user.nn.111021.nc mksrf_lanwat_user.nn.111021.nc mksrf_urban_mis6.111021.nc mksrf_organic.10level.0.5deg_user.nn.111021.nc mksrf_fmax_user.nn.111021.nc mksrf_pft_user.harvest.nn.111021.nc mksrf_soilcol_user.nn.111021.nc mksrf_lai_global_user.nn.111021.nc mksrf_topo.10min.use.111021.nc pftdyn_hist_simyr1850.txt  <b>Output:</b> surfdata.pftdyn_0192x0288_user.nc surfdata_0192x0288_user.nc (CLM namelist)

```
set SRCDIR = /users/home/ans021/BC/surface_bc/mksurdata
echo "start computing surface dataset" `date`
time $SRCDIR/mksurdata < mksurdata.namelist >& mksurdat.out!
echo "finished computing surface dataset " `date`

tail -200 out.$LID
```



## 4 Atmosphere initial conditions

The last CESM 1.0.5 component for which the user has to create new initial conditions is CAM. The procedure uses the [definesurf package](#) (Paleo Toolkit for CCSM3 - definesurf-svn100709). 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 topography at 10 min resolution obtained from section 2. To keep consistent with the gradual land fraction, the script [fix\\_landm\\_coslat.ncl](#) (Paleo Toolkit for CCSM3 in definesurf-paleo-quadernary/landmcoslat/) 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 I, Figure 9.

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	<b>Input:</b> <a href="#">fv_0.9x1.25.nc</a> <a href="#">landm_coslat.nc</a> <a href="#">topo_user_10min.nc</a>  <b>Output:</b> <a href="#">topo_user_0.9x1.25_remap.nc</a>
NCL	fix_landm_coslat.ncl	<b>Input:</b> <a href="#">topo_user_0.9x1.25_remap.nc</a>  <b>Output:</b> <a href="#">topo_user_0.9x1.25_remap.mod.nc</a>

## 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 `fix_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:

```
> ncl fix_landm_coslat.ncl
```

The final output is the new topography file that will be directly read by the CESM 1.0.5 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.



## Setting the namelists: B case

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 1.0.5, where are located the new files. Since all the default input files for the CESM 1.0.5 runs are located in `esm/inputdata`, I used to put them there as well, because it limits the changes introduced into the namelists.

Once the B case directory is created, the first script to be modified is `env.conf.xml`. Then the case is configured and the user may edit the namelists located in `$USER_case/Buildconf` (see [CESM 1.0 user guide](#)).

### 5.1 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_user_aave_da.nc" />

<!--atm to ocn state mapping file for states (char) -->
<entry id="MAP_A2OS_FILE" value="map_fv09_1.25_to_gx1v6_user_bilin_da.nc" />

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

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

.
.
<!--runoff (.5 degree) to ocn mapping file (char) -->
<entry id="MAP_R2O_FILE_R05" value="map_r05_to_gx1v6_user.nc" />
```

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

```
> ./configure -case
```

### 5.2 Orbital parameters: `env_run.xml`

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:

```
> vi env_run.xml/
ORBITAL_MODE = fixed_year
ORBITAL_YEAR = -138050
```



# 30

For past time, the value is **negative**.

### 5.3 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<sub>2</sub>, CH<sub>4</sub> and NO<sub>2</sub> 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_user.mod.nc'
.
.
/
&chem_surfvals_nl
ch4vmr           = 791.6e-9
co2vmr           = 284.7e-6
f11vmr           = 12.48e-12
f12vmr           = 0.0
n2ovmr           = 275.68e-9
/
```

### 5.4 CLM namelist: `clm.buildnml.csh`

The user has to change the value of CO<sub>2</sub> 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 the urban landunits from the surface dataset in section 4.3).

```
&clm_inparm
co2_ppmv         = 284.7
fatmldnfrfc     = '$DIN_LOC_ROOT/lnd/clm2/griddata/fracdata_0.9x1.25_gx1v6_user.nc'
fsurdat         = '$DIN_LOC_ROOT/lnd/clm2/surfddata/surfddata_192x288_user.nc'
urban_hac       = 'OFF'
```

### 5.5 POP namelist: `pop2.buildnml.csh`

As for CAM namelist, the user has to indicate the new bathymetry and ocean basins distribution 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_user.ieeei4  
set topography_filename = $DIN_LOC_ROOT/ocn/pop/gx3v7/grid/kmt_gx1v6_user.ieeei4
```

## 5.6 CICE namelist: cice.buildnml.csh

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

```
&grid_nml  
.br/>.br/>kmt_file = '$DIN_LOC_ROOT/ocn/pop/gx3v7/grid/kmt_gx1v6_user.ieeei4'  
/
```



## GENERATING THE NEW INITIAL CLM INITIAL CONDITIONS RESTART FILE: THE 5-DAYS CESM 1.0.5 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 I.

To do so, the user has to configure all the namelists, 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 make a cold restart, i.e. create a new restart file containing the CLM initial conditions adapted to the platform.

After this modification, the user can run the B case 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 1.0.5 repository [CESM 1.0.5/models/Ind/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](#).

## Production run

Finally, the user can run the final paleo experiment by:





1. recreate or reuse the B case directory
2. set the namelists and scripts XML as in Section ??
3. point at the new interpolated CLM file in the `finidat` field of the CLM namelist.
4. compile and run the case

## Useful links related to CESM 1.0.5 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 1.0.5.

[Paleo Documentation](#): 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 latest 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
change.kmt.ncl	< 5 min
mk_remap_gx1v6.csh	< 5 min
gen_domain.aix	< 5 min
runoff.run	< 20 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
mksurldata	20 min - several hours
definesurf	< 5 min
fix_landm_coslat.ncl	< 5 min



## Appendix I: 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

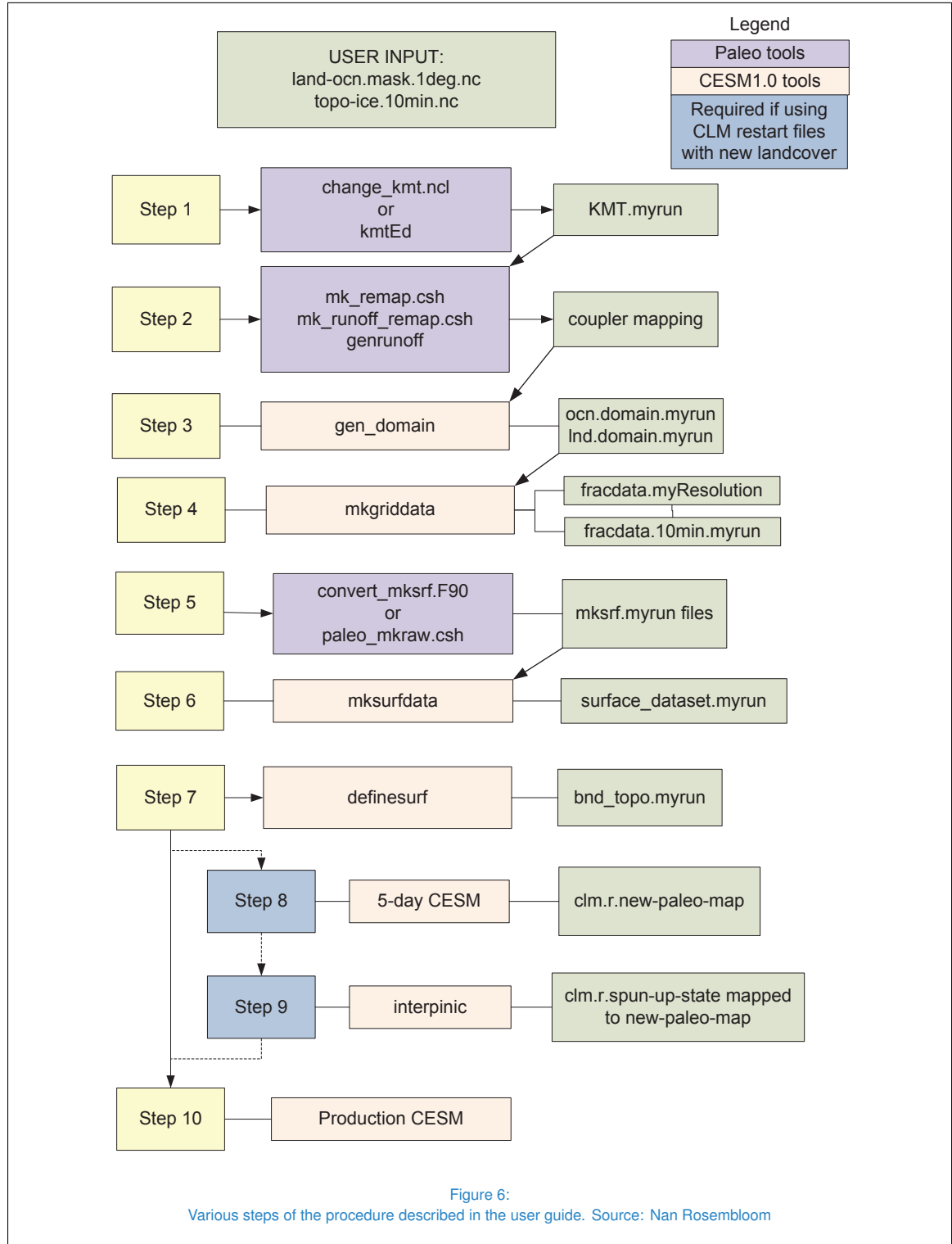


Figure 6: Various steps of the procedure described in the user guide. Source: Nan Rosembloom

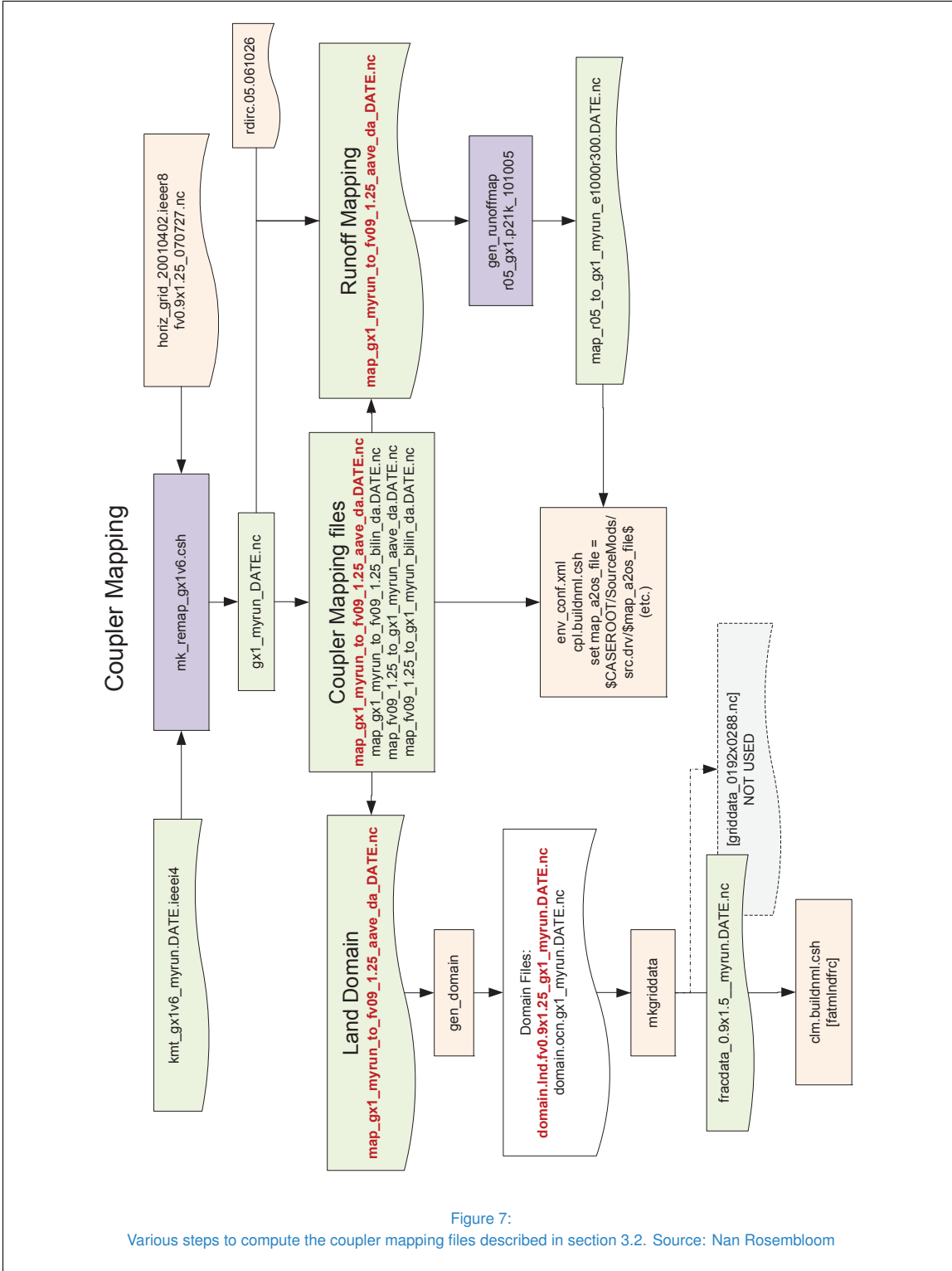


Figure 7: Various steps to compute the coupler mapping files described in section 3.2. Source: Nan Rosembloom

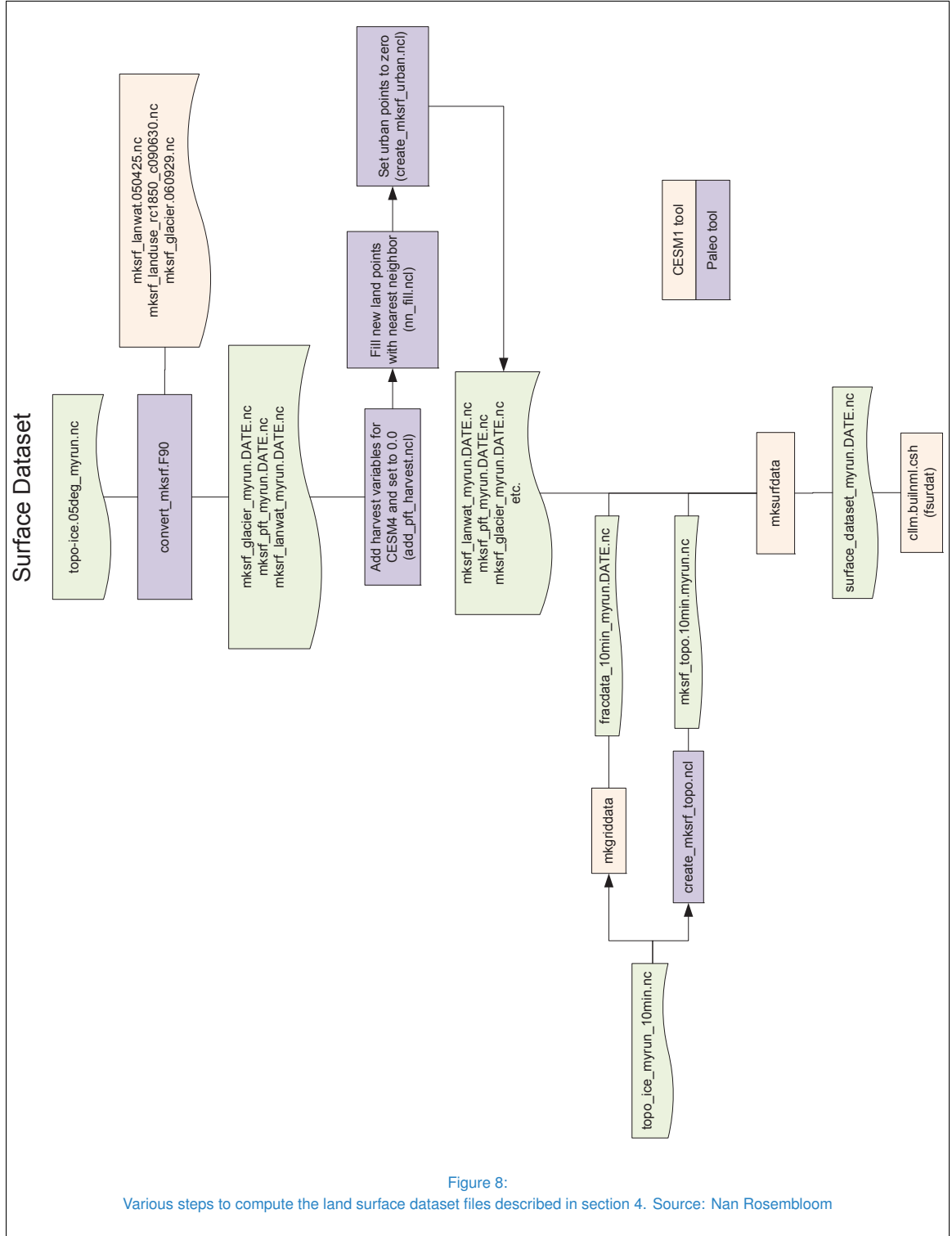


Figure 8:

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

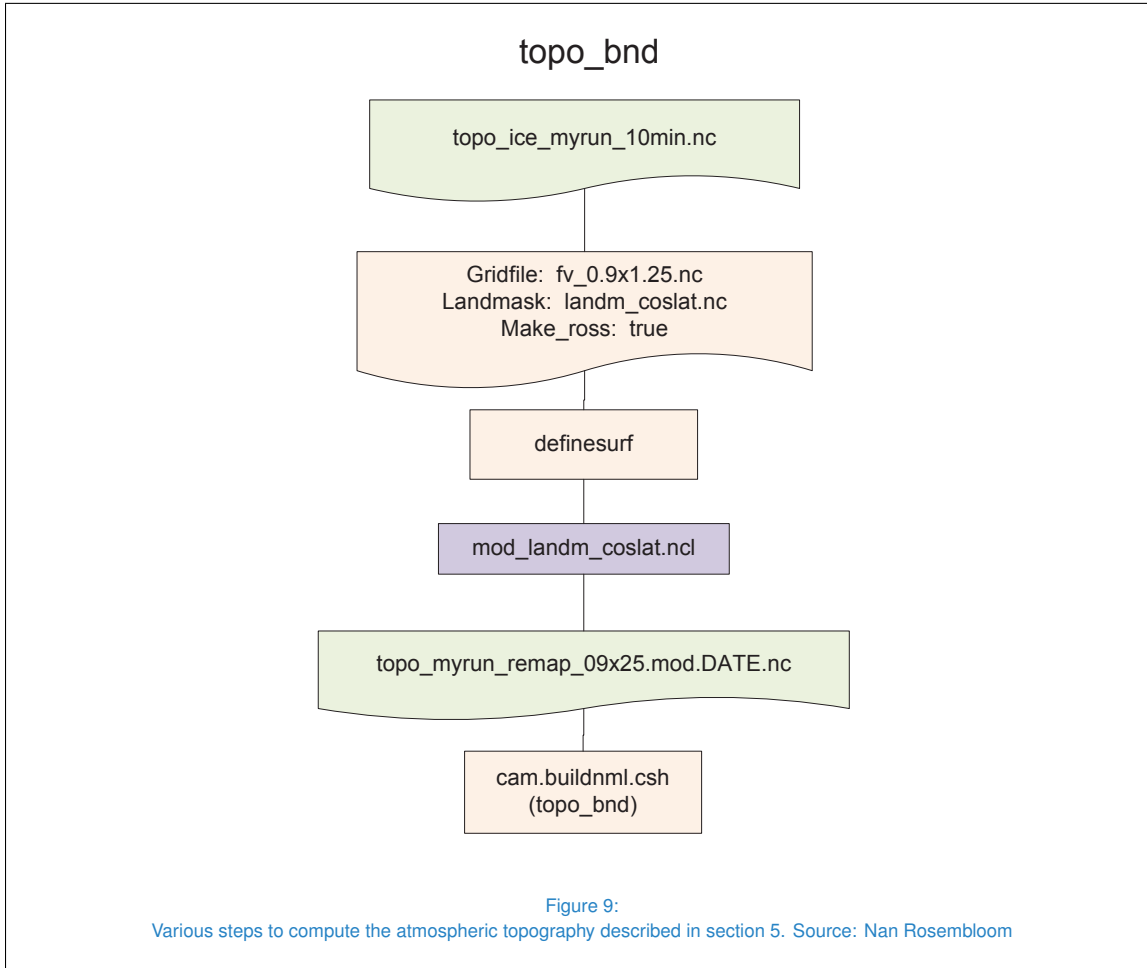


Figure 9:  
Various steps to compute the atmospheric topography described in section 5. Source: Nan Rosembloom