
Regridding E3SM Data

Release 1.6

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REGRIDDING GUIDE

This guide will cover regridding native E3SM model output from each of its components native grids, to any regular grid. These regridding examples are specific for the E3SMv1.x model, and may not work with later versions. For detailed up-to-date information on the E3SM model activities, refer to the [E3SM organizational website](#).

1.1 Environment Setup

You will need to first create an anaconda environment with the dependencies and install the netCDF Operators (NCO). Follow [this link](#) for the full set of NCO documentation. Although there are several ways to install nco, the recommended method is to use the [conda](#) package manager.

1.1.1 Conda

```
conda install -c conda-forge nco
```

To create a new conda environment named “regrid” with just nco use:

```
conda create --name regrid -c conda-forge nco
```

1.1.2 Pre-build Executable

Pre-build executables are available on a variety of platforms.

1.2 Map files

All of these methods assume you have a mapping file on hand to convert between the relevant grids. This is a partial list of mapping files for commonly used E3SM resolutions.

- High resolution MPAS ocean (18km to 6km) to 1/4 degree lon lat
- High resolution atmos/land (ne120) to 1/4 degree lon lat
- Standard resolution MPAS ocean (60km to 30km) to 1x1 degree lon lat
- Standard resolution atmos/land (ne30) to 1x1 degree lon lat

A set of commonly used mapfiles can be found [here](#). The mapfiles follow the naming convention of “map_<source-grid>_to_<destination-grid>_<regridding-algorithm>”. This allows you to mix-and-match whichever raw grid was

used to whichever destination grid is desired. The “ne30” raw grid corresponds to roughly 1 by 1 degree longitude/latitude, and is the “standard” resolution for the E3SM model. Higher resolutions are ne120 which corresponds to roughly 0.25 degree by 0.25 degree lon/lat.

The two most common regridding algorithms are bi-linear (“bilin”/“blin”) and Area Averaged (“aave”). For bi-linear each of the grid points in the dest grid contains the average of the nearest four grid points in the source grid, weighted by their distance from the destination grid point. If any of the four surrounding input grid points contain missing data, the interpolated value will be flagged as missing. Bilin is a good default regridding method.

The aave method is the area average with latitude weighting, and gives better results when going from a high resolution grid to a lower resolution. A spatial average of the source data is calculated in the area outlined by each grid box in the destination grid. If a grid box in the source grid partially overlaps the area of a destination grid cell, its contribution to the spatial average is weighted by the fraction of area within the destination grid cell domain. See [here](#) for additional information.

1.3 Data files

1.3.1 EAM/CAM

Raw E3SM model output can be obtained from [ESGF here](#). The ESGF search interface allows faceted search of the published E3SM model data. On the left side of the interface, each of the E3SM search facets is represented by a drop down menu. For example, the “Campaign” facet allows for the selection of data from a specific simulation campaign. Selecting the “DECK-v1” option and pressing “search” will narrow down the datasets displayed to only those experiments that participated in the [DECK experimental campaign](#). Similarly, the “experiment” facet can be used to display all datasets belonging to a single simulation. The facets can be added together in an AND relationship, for example selecting the `experiment=1pctCO2 AND realm=atmos` will display all datasets that have both belong to the 1pctCO2 experiment, and are atmospheric data files.

The atmospheric files take the form of `<experiment_case_name>.cam.h0.<year>-<month>.nc`, for example `20180215.DECKv1b_1pctCO2.ne30_oEC.edison.cam.h0.0001-01.nc`. The E3SM atmospheric model is a heavily modified descendent of the UCAR [Community Atmospheric Model](#), and so include “cam” in their name. Note that future versions of the E3SM model will include a name change to the “E3SM Atmosphere Model” or eam. The EAM/CAM data files come in 4 temporal frequencies, monthly (cam.h0), daily (cam.h1), 6 hourly (cam.h3), and 3hr (cam.h4).

1.3.2 ELM/CLM

Similarly, the E3SM Land Model descends from the [Community Land Model](#), and so contain the substring “clm2”. Future versions of the E3SM output will replace this with “elm” for the E3SM Land Model. All land model data are monthly averages.

1.3.3 MPAS

The Ocean/Ice components of E3SM come from the [Model for Prediction Across Scales \(MPAS\)](#), a modern state-of-the-art ocean model developed specifically for the E3SM project. All MPAS data are monthly averages.

ATMOSPHERIC REGRIDDING

2.1 Regridding EAM/CAM atmospheric data files

2.1.1 Simple example

This example will regrid all files in a directory of ne30 cam.h0 files. This assumes that the mapfile is already in place in the current directory and that a set of cam.h0 files are in place under a directory named “cam.h0”. All the variables inside the file will be regridded.

```
#!/bin/bash
mapfile=map_ne30np4_to_cmip6_180x360_aave.20181001.nc # path to appropriate mapfile
input_dir=cam.h0 # input directory path
output_dir=180x360 # output directory path

ncremap -m ${mapfile} -I ${input_dir} -O ${output_dir}
```

2.1.2 Medium Complexity

In this example, the same regridding operation as above is performed, but only on the CLD_CAL and FSDDS variables. Running with specific variables selected significantly speeds up the regridding process, as the rest of the variables are ignored. Output file size will also be reduced, as only the selected variables will be present.

```
#!/bin/bash
mapfile=map_ne30np4_to_cmip6_180x360_aave.20181001.nc # path to mapfile
input_dir=cam.h0 # input directory path
output_dir=180x360 # output directory path
vars=CLD_CAL,FSDDS # variables to regrid

ncremap -v ${vars} -m ${mapfile} -I ${input_dir} -O ${output_dir}
```

2.2 RegridDED Climatology

In this example, the CLD_CAL and FSDDS variables will be regridded and averaged over the seasons to create both seasonal and annual climatologies. The output will be compressed and deflated. The model data starts at 1850-01 and ends at 2014-12. For high temporal frequency files (i.e. higher frequency than monthly), add the `-clm_md=hgh_frq` argument to the `ncclimo` command. The `ncclimo` tool needs the caseid of the experiment data supplied to it with the “-c” flag.

```
#!/bin/bash

input_dir=cam.h0
output_dir=native_ts           # path to output directory_
↪for native timeseries
regrid_dir=180x360ts           # path to output directory_
↪for regridded timeseries
mapfile=map_ne30np4_to_cmip6_180x360_aave.20181001.nc # path to mapfile
vars=CLD_CAL,FSDS              # comma separated variable_
↪list
start=1850                      # the first year of data
end=2014                        # the last year of data
flags="-7 --dfl_lvl=1"         # format and deflation flags
caseid=20180129.DECKv1b_piControl.ne30_oEC.edison    # the caseid for the data_
↪being processed

ncclimo \
  ${flags} \
  --var=${vars} \
  -c ${caseid} \
  --yr_srt=${start} \
  --yr_end=${end} \
  --input=${input_dir} \
  --output=${output_dir} \
  --regrid=${regrid_dir} \
  --map=${mapfile}
```

2.3 Regridded Timeseries

In this example, the CLD_CAL and FSDS variables will be regridded and extracted into single variable per file time-series. The command is identical to the above climatology example, except that the additional year-per-file flag (`-ypf`) is added.

When choosing variables to extract into time-series, its only possible to use variables with both a time and space dimension. In the E3SM model the spacial dimension is denoted by the ncol axis (column number).

```
#!/bin/bash

input_dir=cam.h0
output_dir=180x360
mapfile=map_ne30np4_to_cmip6_180x360_aave.20181001.nc # path to mapfile
vars=CLD_CAL,FSDS              # comma separated variable_
↪list
start=1850                      # the first year of data
end=2014                        # the last year of data
flags="-7 --dfl_lvl=1 --ypf=50" # format and deflation flags,_
↪create a new output file for each 50 year chunk
caseid=20180129.DECKv1b_piControl.ne30_oEC.edison    # the caseid for the data_
↪being processed

ncclimo \
  ${flags} \
  --var=${vars} \
  -c ${caseid} \
  --yr_srt=${start} \
```

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```
--yr_end=${end} \  
--input=${input_dir} \  
--output=${output_dir} \  
--map=${mapfile}
```


LAND REGRIDDING

3.1 Regridding ELM/CLM land data files

3.1.1 Low Complexity

In this example, a directory of ne30 clm2.h0 files will be regridded. This will regrid all variables in the input files, using sub-grid-scale regridding, which uses the land fraction around coastal areas to better represent the values around complex coastal geometry.

```
#!/bin/bash
mapfile=map_ne30np4_to_cmip6_180x360_aave.20181001.nc # path to mapfile
input_dir=clm2.h0 # path to input directory
output_dir=180x360 # path to output directory
land_file=<input file path> # this is the path to a
↳single land file to pull the landfrac variable from

ncremap -m ${mapfile} -I ${input_dir} -O ${output_dir} --sgs_frc=${land_file}/landfrac
```

3.1.2 Medium Complexity

In this example, the same regridding operation as above is performed, but only on the DEADSTEMC and CDWC variables. Running with specific variables significantly speeds up the run and reduces output files size, as the rest of the variables are ignored.

```
#!/bin/bash
mapfile=map_ne30np4_to_cmip6_180x360_aave.20181001.nc # path to mapfile
input_dir=clm2.h0 # path to input directory
output_dir=180x360 # path to output directory
vars=DEADSTEMC,CDWC # the variables must be in a
↳comma separated list with no spaces
land_file=<input file path> # this is the path to a
↳single land file to pull the landfrac variable from

ncremap -v ${vars} -m ${mapfile} -I ${input_dir} -O ${output_dir} --sgs_frc=${land_
↳file}/landfrac
```

3.1.3 High Complexity

In example, the regridding operation is performed and the selected variables are output in single-variable-per-file time-series files. The output will be compressed and deflated. The model data starts at 1850-01 and ends at 2014-12.

This example produces time-series files, to produce monthly and annual climatologies remove the “-ypr N” (years-per-file) flag, and optionally add the “-a sdd” (seasonally discontinuous december) flag if you don’t want to include the n-1th december from the climo.

When choosing variables to extract into time-series, its only possible to use variables with both a time and space dimension.

```
#!/bin/bash
mapfile=map_ne30np4_to_cmip6_180x360_aave.20181001.nc # path to mapfile
input_dir=clm2.h0 # path to input directory
output_dir=180x360 # path to output directory
vars=DEADSTEMC,CDWC # the variables must be in a_
↪comma separated list with no spaces
start=1850 # the first year of model data
end=2014 # the last year of model data
land_file=<input file path> # this is the path to a single_
↪land file to pull the landfrac variable from
flags="-7 --dfl_lvl=1" # format and deflation

ncclimo \
  ${flags} \
  --var=${vars} \
  --yr_srt=${start} \
  --yr_end=${end} \
  --ypr=50 \
  --input=${input_dir} \
  --output=${output_dir} \
  --map=${mapfile} \
  --sgs_frc=${land_file}/landfrac
```

MPAS REGRIDDING

4.1 Regridding MPAS ocean/sea-ice data files

4.1.1 Low Complexity

In this example, a directory of `mpaso.hist.am.timeSeriesStatsMonthly` files will be regridded. For `mpassi` files, add the flag `--sgs_frc=timeMonthly_avg_iceAreaCell` to turn on sub-grid-cell regridding, or use the `-prc_typ=mpasseaice` to change the procedure type to `mpas-sea-ice`.

```
#!/bin/bash
mapfile=map_oEC60to30v3_to_cmip6_180x360_aave.20181001.nc # map from the MPAS 60km-
↳to-30km mesh to the 1x1 degree grid
input_dir=mpaso # path to input directory
output_dir=180x360 # path to output directory
flags="--prc_typ=mpas --d2f" # This invokes the mpas_
↳regridder, and converts output from double precision to single

ncremap -m ${mapfile} -I ${input_dir} -O ${output_dir} {flags}
```

4.1.2 High Complexity

In this example, two variables will be extracted into single-variable-per-file time-series files. These will be compressed and deflated, and the data will be converted from double to single precision. For `mpas` sea-ice files, add the flag `--sgs_frc=timeMonthly_avg_iceAreaCell` to turn on sub-grid-cell regridding, or use the `-prc_typ=mpasseaice` to change the procedure type to `mpas-sea-ice`

```
#!/bin/bash
mapfile=map_oEC60to30v3_to_cmip6_180x360_aave.20181001.nc # map_
↳from the MPAS 60km-to-30km mesh to the 1x1 degree grid
input_dir=mpaso #_
↳path to input directory
output_dir=180x360 #_
↳path to output directory
vars=timeMonthly_avg_seaSurfaceSalinity,timeMonthly_avg_seaSurfaceTemperature #_
↳variables to extract in a comma separated list
start=1850 #_
↳first year of model data
end=2014 #_
↳last year of model data
flags="-7 --dfl_lvl=1 -m mpas --d2f" #_
↳format and deflation flags
```

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```
ncclimo \  
  ${flags} \  
  --var=${vars} \  
  --yr_srt=${start} \  
  --yr_end=${end} \  
  --input=${input_dir} \  
  --output=${dir_out} \  
  --map=${mapfile}
```