

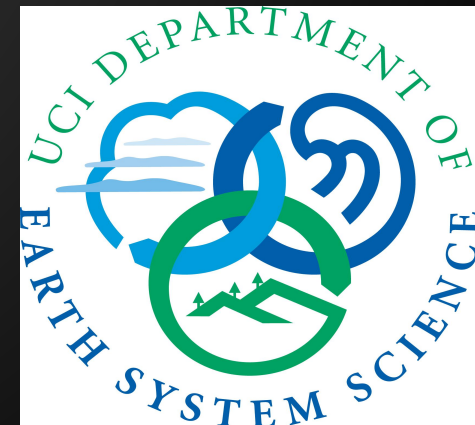
How to Generate Climatologies

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Departments of Earth System Science and
Computer Science, UC Irvine

ACME PI Meeting
Albuquerque, NM
November 2-4, 2015

[Seminar on Web](#)



Add N numbers, then divide by N

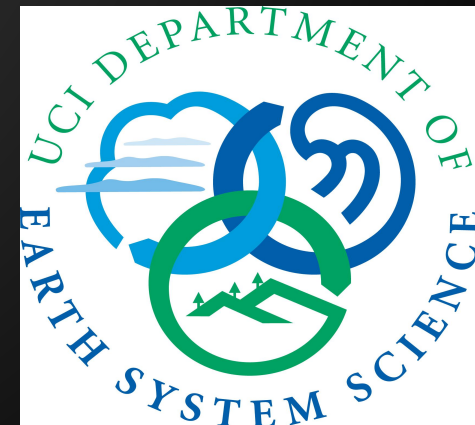
Optimizing Intrinsic Parallelism to generate climatologies with netCDF Operators (NCO)

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Climatologies

1. Prerequisites

2. Monthly, Seasonal, Annual "Climos"

3. Regridding

4. Parallelism Strategies

5. Examples for Cooley, Edison, Rhea

Find/Obtain/Install "climo_nco.sh"

```
> git clone git@github.com:ACME-Climate/ \  
PreAndPostProcessingScripts  
> ln -s ~/PreAndPostProcessingScripts/generate_  
climatologies/climo_nco.sh ~/bin/climo_nco.sh
```

Confluence "climo_nco.sh" docs

The image shows a browser window displaying a Confluence page. The browser's address bar shows the URL: https://acme-climate.atlassian.net/wiki/display/ATM/Generating+Climatologies+%28climo+files%29+with+climo_nco.sh. The Confluence navigation bar includes the ACME logo, 'Confluence', 'Spaces', 'People', 'Calendars', and a 'Create' button. The page breadcrumb is 'Pages / Atmosphere Group / How-to articles'. The main heading is 'Generating Climatologies (climo files) with climo_nco.sh', with subtext 'Created by Peter Caldwell, last modified by Charlie Zender just a moment ago'. The page content is divided into sections: 'Overview:', 'Prerequisites:', and 'Using climo_nco.sh:'. The 'Overview' section states that NCO is the most correct and fastest tool for generating climatologies. The 'Prerequisites' section details the required NCO version and installation paths. The 'Using climo_nco.sh' section provides instructions on how to obtain and clone the script from GitHub.

Pages / Atmosphere Group / How-to articles

Generating Climatologies (climo files) with climo_nco.sh

Created by Peter Caldwell, last modified by Charlie Zender just a moment ago

Overview:

Based on extensive evaluation of AMWG, UV-CDAT, and NCO codes for generating climatology files (see [here](#)), we have determined that NCO provides the most correct answers, has the best metadata, and is fastest. Until UV-CDAT bests NCO in these measures we advocate using the NCO tool for creating climatologies.

NCO is actually a package of simple tools that operate on netCDF files; there is no single NCO command for making climo files. Instead, we have created a shell script called **climo_nco.sh** which uses NCO commands to generate all climatology files.

Prerequisites:

climo_nco.sh requires NCO version 4.5.2-alpha8 or later to compute seasonal averages (because it requires the ability to pass different weights for each month to the averager function and this capability was introduced to **ncra** just for **climo_nco.sh**). Appropriate versions of NCO have been installed for you on rhea.ccs.ornl.gov (Titan's analysis cluster), pileus.ornl.gov (CADES at ORNL), cooley.alcf.anl.gov (Mira's analysis cluster), and edison/hopper (NERSC machines). **climo_nco.sh** is hard-coded to find these versions automatically, and does not require any module or path changes on the LCFs. For other machines (e.g., yellowstone), check that the default NCO is recent enough (try "module load nco", then "ncks --version") or use developers' executables/libraries (in ~zender/[bin,lib] on all machines). Or follow [these directions](#) (on the NCO homepage) to install on your own machines/directories.

You also need **climo_nco.sh**. Grab it at https://github.com/ACME-Climate/PreAndPostProcessingScripts/blob/master/generate_climatologies/climo_nco.sh or check-out the entire PreAndPostProcessingScripts git repo (a better option for keeping up-to-date with changes to this script) by typing "git clone <https://github.com/ACME-Climate/PreAndPostProcessingScripts.git>". Sometimes that doesn't work and this works better: "git clone git@github.com:ACME-Climate/PreAndPostProcessingScripts.git". Here's the ACME [Git Tutorial](#). If you have permissions problems, try this: <https://help.github.com/articles/generating-ssh-keys/>.

Using climo_nco.sh:

Find/Obtain/Install NCO

Cooley, Edison, Pileus, Rhea, Yellowstone:

```
> export PATH='~zender/bin':${PATH}
> export LD_LIBRARY_PATH='~zender/lib': \
${LD_LIBRARY_PATH}
```

Local clusters, workstations, laptops:

```
> sudo aptitude install nco # Debian
> sudo dnf install nco # Fedora
> sudo port install nco # Mac Ports
> git clone git@github.com:nco/nco.git # DIY
> ./configure; sudo make install
```

GitHub NCO homepage



README.md

NCO NetCDF Operators



netCDF Operators (NCO) Software Stack

The NCO toolkit manipulates and analyzes data stored in [netCDF](#)-accessible formats, including [DAP](#), [HDF4](#), and [HDF5](#). It exploits the geophysical expressivity of many [CF](#) (Climate & Forecast) metadata conventions, the flexible description of physical dimensions translated by [UDUnits](#), the network transparency of [OPeNDAP](#), the storage features (e.g., compression, chunking, groups) of [HDF](#) (the Hierarchical Data Format), and many powerful mathematical and statistical algorithms of [GSL](#) (the GNU Scientific Library). NCO is [fast](#), [powerful](#), and [free](#).

What is NCO?

Climatologies

1. Prerequisites
2. Monthly, Seasonal, Annual "Climos"
3. Regridding
4. Parallelism Strategies
5. Examples for Cooley, Edison, Rhea

Run "climo_nco.sh"

```
> climo_nco.sh -c name -s 1980 -e 1985 -i in -o out  
> climo_nco.sh # Prints help
```

climo_nco.sh Help Screen

```
zender@aerosol:~$ climo_nco.sh

Quick documentation for climo_nco.sh (read script for more thorough explanations)

Basic usage: climo_nco.sh -c caseid -s yyyy_srt -e yyyy_end -i drc_in -o drc_out

Command-line options:
-a clm_md Annual climatology mode (default scd)
-b bnd_nm Bounds dimension name (default nbnd)
-c caseid Case ID string (default famipc5_ne30_v0.3_00003)
-d dbg_lvl Debugging level (default 0)
-e yyyy_end Ending year in YYYY format (default 1983)
-f fml_nm Family name (empty means none) (default )
-h hst_nm History volume name (default h0)
-i drc_in Input directory (default /Users/zender/data/ne30/raw)
-l lnk_flg Link ACME to AMWG climo filename (default Yes)
-m mdl_nm Model name (default cam)
-n nco_opt NCO options (empty means none) (default --no_tmp_fl)
-o drc_rgr Regridded directory (default /Users/zender/data/ne30/clm)
-o drc_out Output directory (default /Users/zender/data/ne30/clm)
-p par_typ Parallelism type (default bck)
-r rgr_map Regridding map (empty means none) (default )
-R rgr_opt Regridding options (empty means none) (default )
-t thr_nbr Thread number for regridded (default 2)
-s yyyy_srt Starting year in YYYY format (default 1980)
-v var_lst Variable list (empty means all) (default )
-x cf_flg Xperimental switch (for developers) (default No)

Examples: climo_nco.sh -c famipc5_ne30_v0.3_00003 -s 1980 -e 1983 -i /Users/zender/data/ne30/raw -o /Users/zender/data/ne30/clm
          climo_nco.sh -c famipc5_ne30_v0.3_00003 -s 1980 -e 1983 -i /Users/zender/data/ne30/raw -o /Users/zender/data/ne30/clm -r ~/zender/data/maps/map_ne30np4_to_fv129x256_aave.20150901.nc
          climo_nco.sh -m clm2 -b tbnd -c famipc5_ne30_v0.3_00003 -s 1980 -e 1983 -i /Users/zender/data/ne30/raw -o /Users/zender/data/ne30/clm

Interactive batch queue (cooley): qsub -I -A HiRes_EarthSys --nodecount=1 --time=03:00:00 --jobname=climo_nco
Interactive batch queue (edison): qsub -I -A acme -V -l mppwidth=24 -l walltime=03:00:00 -q debug -N climo_nco
Interactive batch queue (rhea): qsub -I -A CLI115 -V -l nodes=1 -l walltime=03:00:00 -N climo_nco
3-yrs ne30: climo_nco.sh -c famipc5_ne30_v0.3_00003 -s 1980 -e 1982 -i /lustre/atlas1/cli115/world-shared/mbranst/famipc5_ne30_v0.3_00003-wget-test -o /Users/zender/data/ne30/clm -r ~/zender/data/maps/map_ne30np4_to_fv129x256_aave.20150901.nc > ~/climo_nco.out 2>&1 &
3-yrs ne120: climo_nco.sh -p mpi -c famipc5_ne120_v0.3_00003 -s 1980 -e 1982 -i /lustre/atlas1/cli115/world-shared/mbranst/famipc5_ne120_v0.3_00003-wget-test -o /Users/zender/data/ne120/clm -r ~/zender/data/maps/map_ne120np4_to_fv257x512_aave.20150901.nc > ~/climo_nco.out 2>&1 &

zender@aerosol:~$
```

Command

Options

Examples

Queues

Generate Climatology

> `climo_nco.sh -c name -s 1980 -e 1985 -i in -o out`

```
zender@aerosol:~$ ls $DATA/ne30/raw
AMIP_ACMEv02ce_FC5_ne30_ne30_COSP.cam.h0.2008-01.nc
Proc0rdering_FC5_ne30_g16-Switch0rd2.cam.h0.0001-01-01-00000.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-01.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-02.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-03.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-04.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-05.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-06.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-07.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-08.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-09.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-10.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-11.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-12.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-01.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-02.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-03.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-04.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-05.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-06.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-07.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-08.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-09.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-10.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-11.nc
famipc5_ne30_v0.3_00003.cam.h0.1980-12.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-01.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-02.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-03.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-04.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-05.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-06.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-07.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-08.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-09.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-10.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-11.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-12.nc
zender@aerosol:~$
```

*Native
grid
input*

Standard Output

```
> climo_nco.sh -c name -s 1980 -e 1985 -i in -o out
```

```
zender@aerosol:~$ climo_nco.sh -v FSNT -c famipc5_ne30_v0.3_00003 -s 1980 -e 1983 -i ${DATA}/ne30/raw -o ${DATA}/ne30/clm
Started climatology generation for model-run famipc5_ne30_v0.3_00003 at Tue Nov 3 13:47:27 PST 2015.
Climatology from 4 years of contiguous data crossing 5 calendar years from YYYYMM = 197912 to 198311.
Winter statistics based on seasonally contiguous December (scd-mode): DJF sequences are consecutive months that cross calendar-year boundaries.
Annotation for the CF climatology attribute and climatology_bnds variable will not be performed.
This climatology will not be regridded.
NCO version is 4.5.4-alpha01
Generating climatology...
Climatological monthly mean for month 1 ...
Climatological monthly mean for month 2 ...
Climatological monthly mean for month 3 ...
Climatological monthly mean for month 4 ...
Climatological monthly mean for month 5 ...
Climatological monthly mean for month 6 ...
Climatological monthly mean for month 7 ...
Climatological monthly mean for month 8 ...
Climatological monthly mean for month 9 ...
Climatological monthly mean for month 10 ...
Climatological monthly mean for month 11 ...
Climatological monthly mean for month 12 ...
Climatological seasonal means...
Climatological annual mean...
Link ACME to AMWG climo filenames...
Completed climatology generation for model-run famipc5_ne30_v0.3_00003 at Tue Nov 3 13:47:27 PST 2015.
Quick plots of climatological annual mean: ncview /Users/zender/data/ne30/clm/famipc5_ne30_v0.3_00003_ANN_197912_198311_climo.nc &
Elapsed time 0m0s
zender@aerosol:~$
```

Status

Preamble

Summary

Climatology Files

> climo_nco.sh -c name -s 1980 -e 1985 -i in -o out

```
zender@aerosol:~$ ls $DATA/ne30/raw
AMIP_ACMEv02ce_FC5_ne30_ne30_COSP.cam.h0.2008-01.nc
ProcOrdering_FC5_ne30_g16-Switch0rd2.cam.h0.0001-01-01-00000.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-01.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-02.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-03.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-04.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-05.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-06.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-07.nc
famipc5_ne30_v0.3_00003.cam.h0.1979-08.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-06.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-07.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-08.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-09.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-10.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-11.nc
famipc5_ne30_v0.3_00003.cam.h0.1981-12.nc
famipc5_ne30_v0.3_00003.cam.h0.1982-01.nc
famipc5_ne30_v0.3_00003.cam.h0.1982-02.nc
famipc5_ne30_v0.3_00003.cam.h0.1982-03.nc
```

*Climo
output*

```
zender@aerosol:~$ ls $DATA/ne30/clm
famipc5_ne30_v0.3_00003_01_198001_198301_climo.nc
famipc5_ne30_v0.3_00003_01_climo.nc@
famipc5_ne30_v0.3_00003_02_198002_198302_climo.nc
famipc5_ne30_v0.3_00003_02_climo.nc@
famipc5_ne30_v0.3_00003_03_198003_198303_climo.nc
famipc5_ne30_v0.3_00003_03_climo.nc@
famipc5_ne30_v0.3_00003_04_198004_198304_climo.nc
famipc5_ne30_v0.3_00003_04_climo.nc@
famipc5_ne30_v0.3_00003_05_198005_198305_climo.nc
famipc5_ne30_v0.3_00003_05_climo.nc@
famipc5_ne30_v0.3_00003_06_198006_198306_climo.nc
famipc5_ne30_v0.3_00003_06_climo.nc@
famipc5_ne30_v0.3_00003_07_198007_198307_climo.nc
famipc5_ne30_v0.3_00003_07_climo.nc@
famipc5_ne30_v0.3_00003_08_198008_198308_climo.nc
famipc5_ne30_v0.3_00003_08_climo.nc@
famipc5_ne30_v0.3_00003_09_198009_198309_climo.nc
famipc5_ne30_v0.3_00003_09_climo.nc@
famipc5_ne30_v0.3_00003_ANN_197912_198311_climo.nc
famipc5_ne30_v0.3_00003_ANN_climo.nc@
famipc5_ne30_v0.3_00003_DJF_197912_198302_climo.nc
famipc5_ne30_v0.3_00003_DJF_climo.nc@
famipc5_ne30_v0.3_00003_JJA_198006_198308_climo.nc
famipc5_ne30_v0.3_00003_JJA_climo.nc@
famipc5_ne30_v0.3_00003_MAM_198003_198305_climo.nc
famipc5_ne30_v0.3_00003_MAM_climo.nc@
famipc5_ne30_v0.3_00003_SON_198009_198311_climo.nc
famipc5_ne30_v0.3_00003_SON_climo.nc@
zender@aerosol:~$
```

*AMWG
symlink*

climo_nco.sh Options

- > climo_nco.sh -c name -s 1980 -e 1985 -i in -o out
- > climo_nco.sh ... -v FSNT,Q ... # Subset
- > climo_nco.sh ... > climo_nco.out 2>&1 & # top
- > climo_nco.sh ... -m clm2 -b tbnd ... # CLM2
- > climo_nco.sh ... -m cism -h h ... # CISM
- > climo_nco.sh ... -m pop -h h ... # POP
- > climo_nco.sh ... -R 'col_nm=nCells' ... # MPAS-O
- > climo_nco.sh ... -d 1 ... # Debug
- > climo_nco.sh ... -f Experiment ... # Nickname
- > climo_nco.sh ... -p mpi ... # Parallel

Climatologies

1. Prerequisites
2. Monthly, Seasonal, Annual "Climos"
3. **Regridding**
4. Parallelism Strategies
5. Examples for Cooley, Edison, Rhea

Simultaneous Regridding & "Loose Coupling"

```
> climo_nco.sh -c name -s 1980 -e 1985 -i in -o out
> climo_nco.sh ... -r map.nc ... # Mapfile
> climo_nco.sh ... -r ~zender/data/maps/ \
map_ne30np4_to_fv129x256_aave.20150901.nc
```

Regridding (1): Combined Destination

```
> climo_nco.sh -c name -s 1980 -e 1985 -i in -o out \
-r map_ne30np4_to_fv257x512_bilin.20150901.nc
```

```
zender@aerosol:~$ ls ${DATA}/ne30/clm
famipc5_ne30_v0.3_00003_01_198001_198301_climo.nc
famipc5_ne30_v0.3_00003_01_198001_198301_climo_fv257x512_bilin.nc
famipc5_ne30_v0.3_00003_01_climo.nc@
famipc5_ne30_v0.3_00003_02_198002_198302_climo.nc
famipc5_ne30_v0.3_00003_02_198002_198302_climo_fv257x512_bilin.nc
famipc5_ne30_v0.3_00003_02_climo.nc@
famipc5_ne30_v0.3_00003_03_198003_198303_climo.nc
famipc5_ne30_v0.3_00003_03_198003_198303_climo_fv257x512_bilin.nc
famipc5_ne30_v0.3_00003_03_climo.nc@
famipc5_ne30_v0.3_00003_04_198004_198304_climo.nc
famipc5_ne30_v0.3_00003_04_198004_198304_climo_fv257x512_bilin.nc
famipc5_ne30_v0.3_00003_04_climo.nc@
famipc5_ne30_v0.3_00003_05_198005_198305_climo.nc
famipc5_ne30_v0.3_00003_05_198005_198305_climo_fv257x512_bilin.nc
famipc5_ne30_v0.3_00003_05_climo.nc@
famipc5_ne30_v0.3_00003_06_198006_198306_climo.nc
famipc5_ne30_v0.3_00003_06_198006_198306_climo_fv257x512_bilin.nc
famipc5_ne30_v0.3_00003_06_climo.nc@
famipc5_ne30_v0.3_00003_07_198007_198307_climo.nc
famipc5_ne30_v0.3_00003_07_198007_198307_climo_fv257x512_bilin.nc
famipc5_ne30_v0.3_00003_07_climo.nc@
famipc5_ne30_v0.3_00003_08_198008_198308_climo.nc
famipc5_ne30_v0.3_00003_08_198008_198308_climo_fv257x512_bilin.nc
famipc5_ne30_v0.3_00003_08_climo.nc@
famipc5_ne30_v0.3_00003_09_198009_198309_climo.nc
famipc5_ne30_v0.3_00003_09_198009_198309_climo_fv257x512_bilin.nc
zender@aerosol:~$
```

Native climo

Regridded climo

Regrid symlink to AMWG

Regridding (2): Separate Destinations

```
> climo_nco.sh -c name -s 1980 -e 1985 -i in -o out \  
-r map_ne30np4_to_fv257x512_bilin.20150901.nc \  
-O rgr # rgr = regrid directory
```

The terminal window shows a directory listing of files in the 'rgr' directory. The files are organized into two columns. The left column contains files with dates from 198001 to 198305. The right column contains files with dates from 09 to 12, and seasonal files (ANN, DJF, JJA, MAM, SON). A callout box on the left points to the first file in the left column and contains the text 'Regridded climo'. A callout box on the right points to the first file in the right column and contains the text 'Regrid link to AMWG'.

```
zender@aerosol:~$ ls rgr  
famipc5_ne30_v0.3_00003_01_198001_198301_climo.nc  famipc5_ne30_v0.3_00003_09_climo.nc@  
famipc5_ne30_v0.3_00003_01_climo.nc@             famipc5_ne30_v0.3_00003_10_198010_198310_climo.nc  
famipc5_ne30_v0.3_00003_02_198002_198302_climo.nc  famipc5_ne30_v0.3_00003_10_climo.nc@  
famipc5_ne30_v0.3_00003_02_climo.nc@              famipc5_ne30_v0.3_00003_11_198011_198311_climo.nc  
famipc5_ne30_v0.3_00003_03_198003_198303_climo.nc  famipc5_ne30_v0.3_00003_11_climo.nc@  
famipc5_ne30_v0.3_00003_03_climo.nc@              famipc5_ne30_v0.3_00003_12_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_04_198004_198304_climo.nc  famipc5_ne30_v0.3_00003_12_climo.nc@  
famipc5_ne30_v0.3_00003_04_climo.nc@              famipc5_ne30_v0.3_00003_ANN_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_05_198005_198305_climo.nc  famipc5_ne30_v0.3_00003_ANN_1979_198212_climo.nc@  
famipc5_ne30_v0.3_00003_05_climo.nc@              famipc5_ne30_v0.3_00003_DJF_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_06_198006_198306_climo.nc  famipc5_ne30_v0.3_00003_DJF_1979_198212_climo.nc@  
famipc5_ne30_v0.3_00003_06_climo.nc@              famipc5_ne30_v0.3_00003_JJA_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_07_198007_198307_climo.nc  famipc5_ne30_v0.3_00003_JJA_1979_198212_climo.nc@  
famipc5_ne30_v0.3_00003_07_climo.nc@              famipc5_ne30_v0.3_00003_MAM_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_08_198008_198308_climo.nc  famipc5_ne30_v0.3_00003_MAM_1979_198212_climo.nc@  
famipc5_ne30_v0.3_00003_08_climo.nc@              famipc5_ne30_v0.3_00003_MAM_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_09_198009_198309_climo.nc  famipc5_ne30_v0.3_00003_SON_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_09_climo.nc@              famipc5_ne30_v0.3_00003_SON_1979_198212_climo.nc@  
famipc5_ne30_v0.3_00003_10_198010_198310_climo.nc  
famipc5_ne30_v0.3_00003_11_198011_198311_climo.nc  
famipc5_ne30_v0.3_00003_12_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_ANN_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_ANN_1979_198212_climo.nc@  
famipc5_ne30_v0.3_00003_DJF_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_DJF_1979_198212_climo.nc@  
famipc5_ne30_v0.3_00003_JJA_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_JJA_1979_198212_climo.nc@  
famipc5_ne30_v0.3_00003_MAM_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_MAM_1979_198212_climo.nc@  
famipc5_ne30_v0.3_00003_SON_1979_198212_climo.nc  
famipc5_ne30_v0.3_00003_SON_1979_198212_climo.nc@  
zender@aerosol:~$
```

Regridded climo

Regrid link to AMWG

Nicknames simplify names

> climo_nco.sh -c famipc5_ne30_v0.3_00003 ... \
-f Control # nickname replaces CASEID name

```
zender@aerosol:~$ ls $DATA/ne30/clm
Control_01_198001_198301_climo.nc
Control_01_198001_198301_climo_fv129x256_aave.nc
Control_01_198001_198301_climo_fv257x512_bilin.nc
Control_01_climo.nc@
Control_02_198002_198302_climo.nc
Control_02_198002_198302_climo_fv129x256_aave.nc
Control_02_198002_198302_climo_fv257x512_bilin.nc
Control_02_climo.nc@
Control_03_198003_198303_climo.nc
Control_03_198003_198303_climo_fv129x256_aave.nc
Control_03_198003_198303_climo_fv257x512_bilin.nc
Control_03_climo.nc@
Control_04_198004_198304_climo.nc
Control_04_198004_198304_climo_fv129x256_aave.nc
Control_04_198004_198304_climo_fv257x512_bilin.nc
Control_04_climo.nc@
Control_05_198005_198305_climo.nc
Control_05_198005_198305_climo_fv129x256_aave.nc
Control_05_198005_198305_climo_fv257x512_bilin.nc
Control_05_climo.nc@
Control_06_198006_198306_climo.nc
Control_06_198006_198306_climo_fv129x256_aave.nc
Control_06_198006_198306_climo_fv257x512_bilin.nc
Control_06_climo.nc@
Control_07_198007_198307_climo.nc
Control_07_198007_198307_climo_fv129x256_aave.nc
Control_07_198007_198307_climo_fv257x512_bilin.nc
Control_07_climo.nc@
Control_08_198008_198308_climo.nc
Control_08_198008_198308_climo_fv129x256_aave.nc
Control_08_198008_198308_climo_fv257x512_bilin.nc
Control_08_climo.nc@
Control_09_198009_198309_climo_fv257x512_bilin.nc
Control_09_climo.nc@
Control_10_198010_198310_climo.nc
Control_10_198010_198310_climo_fv129x256_aave.nc
Control_10_198010_198310_climo_fv257x512_bilin.nc
Control_10_climo.nc@
Control_11_198011_198311_climo.nc
Control_11_198011_198311_climo_fv129x256_aave.nc
Control_11_198011_198311_climo_fv257x512_bilin.nc
Control_11_climo.nc@
Control_12_197912_198212_climo.nc
Control_12_197912_198212_climo_fv129x256_aave.nc
Control_12_197912_198212_climo_fv257x512_bilin.nc
Control_12_climo.nc@
Control_ANN_197912_198311_climo.nc
Control_ANN_197912_198311_climo_fv129x256_aave.nc
Control_ANN_197912_198311_climo_fv257x512_bilin.nc
Control_ANN_climo.nc@
Control_DJF_197912_198302_climo.nc
Control_DJF_197912_198302_climo_fv129x256_aave.nc
Control_DJF_197912_198302_climo_fv257x512_bilin.nc
Control_DJF_climo.nc@
Control_JJA_198006_198308_climo.nc
Control_JJA_198006_198308_climo_fv129x256_aave.nc
Control_JJA_198006_198308_climo_fv257x512_bilin.nc
Control_JJA_climo.nc@
Control_MAM_198003_198305_climo.nc
Control_MAM_198003_198305_climo_fv129x256_aave.nc
Control_MAM_198003_198305_climo_fv257x512_bilin.nc
Control_MAM_climo.nc@
Control_SON_198009_198311_climo.nc
Control_SON_198009_198311_climo_fv129x256_aave.nc
```

Climatologies

1. Prerequisites
2. Monthly, Seasonal, Annual "Climos"
3. Regridding
4. Parallelism Strategies
5. Examples for Cooley, Edison, Rhea

Three Parallelism Modes

```
> climo_nco.sh -c name -s 1980 -e 1985 -i in -o out
> climo_nco.sh ... -p nil ... # Serial
> climo_nco.sh ... -p bck ... # Background (default)
> climo_nco.sh ... -p mpi ... # MPI
```

- **Serial:** Execute sequentially on single node
- **Background:** Fork process for each month, then each season, all on single node. Optimal w/ 12 cores.
- **MPI:** Spawn MPI process to new node for each month, then each season. Optimal w/ 12 nodes.

Background Parallelism &

core1

core2

...

core12

jan1, jan2,
... janN

feb1, feb2,
... febN

dec1, dec2
, ... decN

- Stage 1: 1 month per core (12 cores)
- Stage 2: 1 season per core (4 cores)
+ load-balanced regridding (8 cores)
- Stage 3: 1 annual (1 core) + load-balanced regridding (4 cores)

MPI Parallelism

node1

node2

...

node12

jan1, jan2,
... janN

feb1, feb2,
... febN

dec1, dec2
, ... decN

- Stage 1: 1 month per node (12 nodes)
- Stage 2: 1 season per node (4 nodes)
+ load-balanced regridding (8 nodes)
- Stage 3: 1 annual (1 node)
+ load-balanced regridding (4 nodes)

Threaded Regridding

- Regridding automatically invokes 2 (default) to 8 threads
- `> climo_nco.sh...-t 8... # Threads`

node1
core1

var1, var4,
... varN-2

core2

var2, var5,
... varN-1

core3

var3, var6,
... varN

node1
core1

var1, var4,
... varN-2

core2

var2, var5,
... varN-1

core3

var3, var6,
... varN

node2
core1

var1, var4,
... varN-2

core2

var2, var5,
... varN-1

core3

var3, var6,
... varN

node3
core1

var1, var4,
... varN-2

core2

var2, var5,
... varN-1

core3

var3, var6,
... varN

Choose Parallel Mode to Optimize Throughput

RAM required: $\sim 4x$ sizeof(monthly file) per process

- **Serial:** Safest, slowest. Ideal for laptops, desktops. Alternative to MPI-mode for small RAM systems.
- **Background:** Default mode. Works on login nodes, compute nodes, and beefy (≥ 12 cores) workstations for ne30. Can work for ne120 on large memory compute nodes (e.g., Cooley = 384 GB/node).
- **MPI:** Necessary for fast ne120 on small-moderate (64-192 GB RAM/node) systems

Climatologies

1. Prerequisites
2. Monthly, Seasonal, Annual "Climos"
3. Regridding
4. Parallelism Strategies
5. Examples for Rhea, Cooley, Edison, (Yellowstone)

Rhea Example

```
> climo_nco.sh -p nil -v FSNT -c name -s 1980 -e 1985  
-i in -o out -r map.nc # Fast initial serial to debug  
> qsub -I -A CLI115 -V -l nodes=1 -l walltime=00:10:00  
-N climo_nco # ne30, grab one interactive node  
> climo_nco.sh -c name -s 1980 -e 1985 -i in -o out -r  
map.nc # ne30 production, background (ne120 dies!)  
> qsub -I -A CLI115 -V -l nodes=12 -l walltime=00:30:  
00 -N climo_nco # ne120, grab twelve nodes  
> climo_nco.sh -p mpi -c name -s 1980 -e 1985 -i in -o  
out -r map.nc # ne120 production, MPI
```

Cooley Example

```
> climo_nco.sh -p nil -v FSNT -c name -s 1980 -e 1985  
-i in -o out -r map.nc # Fast initial serial to debug  
> qsub -I -A HiRes_EarthSys --nodecount=1 --time= \\\n00:10:00 --jobname=climo_nco # ne30, one node  
> climo_nco.sh -c name -s 1980 -e 1985 -i in -o out -r  
map.nc # ne30 production, background (ne120 works!)
```

Edison Example

```
> climo_nco.sh -p nil -v FSNT -c name -s 1980 -e 1985  
-i in -o out -r map.nc # Fast initial serial to debug  
> qsub -l -A acme -V -l mppwidth=24 -l walltime= \ 00:  
10:00 -q debug -N climo_nco # ne30, one node  
> climo_nco.sh -c name -s 1980 -e 1985 -i in -o out -r  
map.nc # ne30 production, background (ne120 dies!)
```

Other

1. Low frequency climos (from, e.g., annual mean output)
2. High frequency (daily/hourly $h[1-N]$) climos/regridding
3. Regridding unstructured data when horizontal dimension (i.e., cell/column) varies more slowly than others (e.g., vertical, species)
4. Extensive variables (e.g., numbers, counts) climos/regridding

<http://dust.ess.uci.edu/hire>

Supplementary Slides