Day 3: Diagnostics and Output

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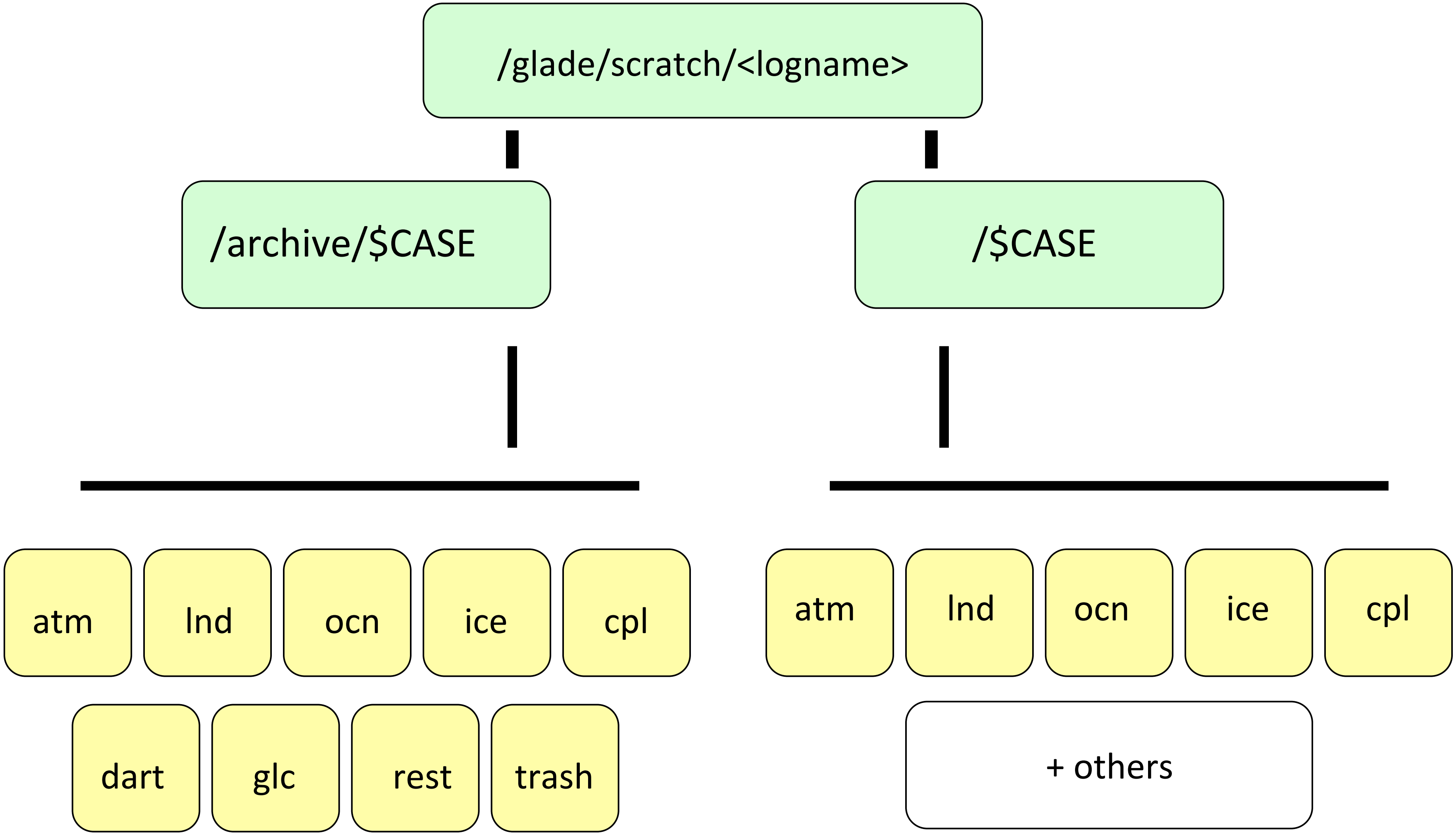
Day 3: Diagnostics and Output

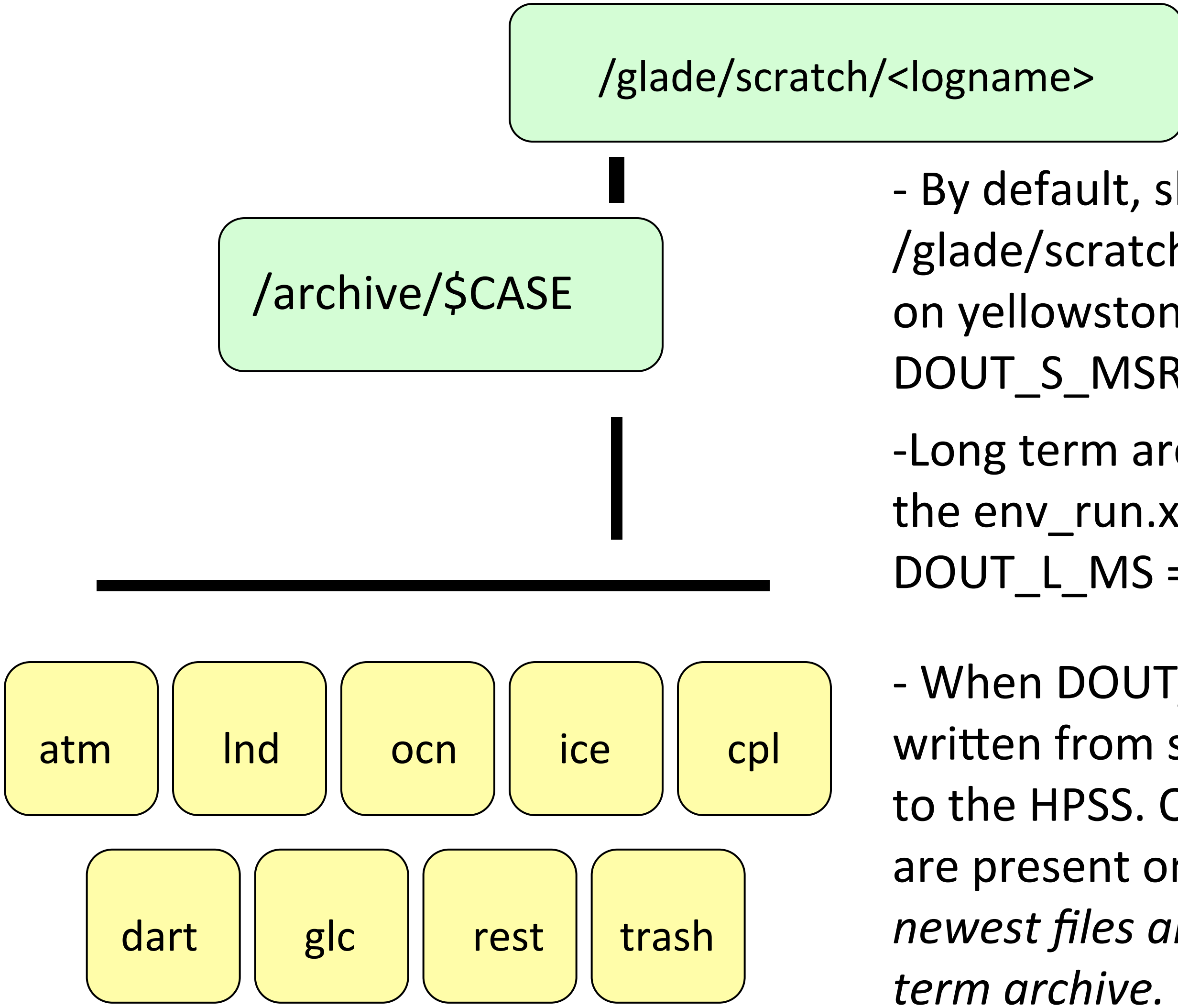
Outline

I. CESM1 output data and experiments
II. Introduction to the netCDF format, ncdump
III. netCDF Operators (NCO) and Climate Data Operators (CDO)
IV. Quick-use tools: ncview, panoply, ImageMagick, ghostview, xxdiff
V. Introduction to NCL
VI. Practical Lab #3
   A. Diagnostics packages
   B. NCL post-processing scripts
   C. NCL graphics scripts
   D. Additional Exercises
   E. Challenges
VII. Appendix (NCAR Archival System: The HPSS)

Short-Term Archive and Runtime Directories



Short-Term Archive



- By default, short term archiver writes to /glade/scratch/<logname>/archive/$CASE on yellowstone. (Can modify by setting DOUT_S_MSROOT in env_run.xml)

-Long term archiver is activated when the env_run.xml parameter DOUT_L_MS = “TRUE”.

- When DOUT_L_MS = “TRUE”, all files are written from short-term archive directory to the HPSS. Once confirmed that the files are present on the HPSS, *all but the newest files are removed from the short-term archive.*

CESM History File Naming Conventions

All history output files are in “netCDF” format

Location of history files in short-term archive directory:
/glade/scratch/<logname>/archive/$case/<component>/hist
component = atm, ocn, etc.

CESM distinguishes between different time sampling frequencies by creating distinct history files for each frequency. *Sampling frequencies are set by the user within the namelist.*

Example history file names:

f40_test.cam.h0.1993-11.nc
f40_test.clm2.h0.1993-11.nc
f40_test.pop.h.1993-11.nc
f40_test.cice.h.1993-11.nc

By default, h0/h denotes that the time sampling frequency is monthly.

Other frequencies are saved under the h1, h2, etc file names:
f40_test.cam2.h1.1993-11-02-00000.nc

CESM1 Monthly History Files + time

The time coordinate variable in **monthly** CESM history files represents *the end* of the averaging period for variables that are averages. This is different from the time expressed in the file name. *The time given in the file name is correct.*

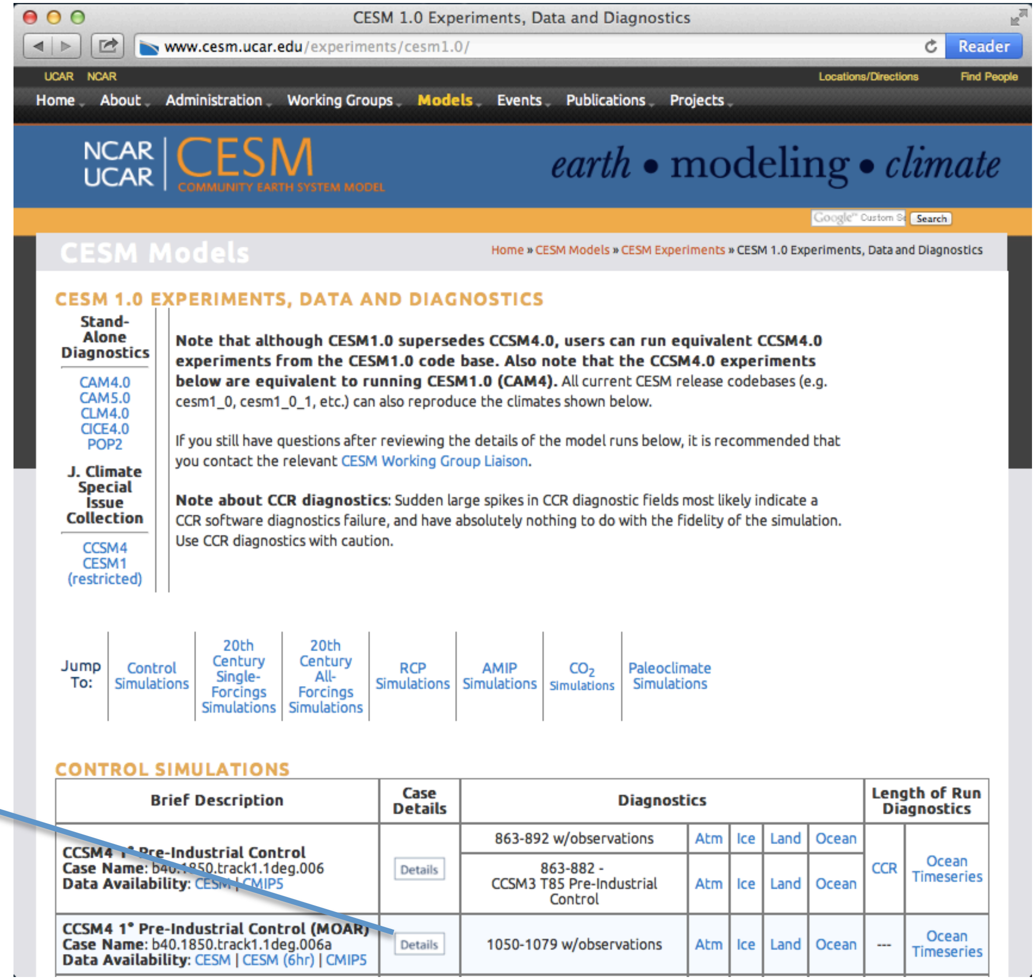
Example: If you open a file named f40_test.cam.h0.1993-11.nc, read in the time coordinate variable and translate it from units of "days since YYYY-MM-DD 00:00:00", the translated time/date will be 00Z December 1st, 1993 even though the file holds averaged variables for November 1993.

One can always consult the time_bnds array in the file for verification of the averaging period. In the above example the translated times of time_bnds are: 00Z Nov 1st 1993 and 00Z Dec 1st 1993.

Note that this does not apply to CCSM/CESM CMIP data.

CESM Experiments Pages

Case Name: b40.1850.track1.1deg.006a
Machine: NCAR:bluefire
CMIP5 ID: ---
Compset: B_1850_CN
Resolution: 0.9x1.25_gx1v6
Years: 953-1108
Initialization: 0953-01-01 of b40.1850.track1.1deg.006
HPSS Location: /CCSM/csm /b40.1850.track1.1deg.006a
Case Details: MOAR control simulation. Extra output saved.
Start/End Dates: 12/29/10, 2/2/11
Data Release Date (Full): 7/15/11



CESM 1.0 Experiments, Data and Diagnostics

www.cesm.ucar.edu/experiments/cesm1.0/

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CESM Models

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CESM 1.0 EXPERIMENTS, DATA AND DIAGNOSTICS

Stand-Alone Diagnostics

CAM4.0
CAM5.0
CLM4.0
CICE4.0
POP2

J. Climate Special Issue Collection

CCSM4
CESM1 (restricted)

Note that although CESM1.0 supersedes CCSM4.0, users can run equivalent CCSM4.0 experiments from the CESM1.0 code base. Also note that the CCSM4.0 experiments below are equivalent to running CESM1.0 (CAM4). All current CESM release codebases (e.g. cesm1_0, cesm1_0_1, etc.) can also reproduce the climates shown below.

If you still have questions after reviewing the details of the model runs below, it is recommended that you contact the relevant CESM Working Group Liaison.

Note about CCR diagnostics: Sudden large spikes in CCR diagnostic fields most likely indicate a CCR software diagnostics failure, and have absolutely nothing to do with the fidelity of the simulation. Use CCR diagnostics with caution.

Jump To: Control Simulations | 20th Century Single-Forcings Simulations | 20th Century All-Forcings Simulations | RCP Simulations | AMIP Simulations | CO_2 Simulations | Paleoclimate Simulations

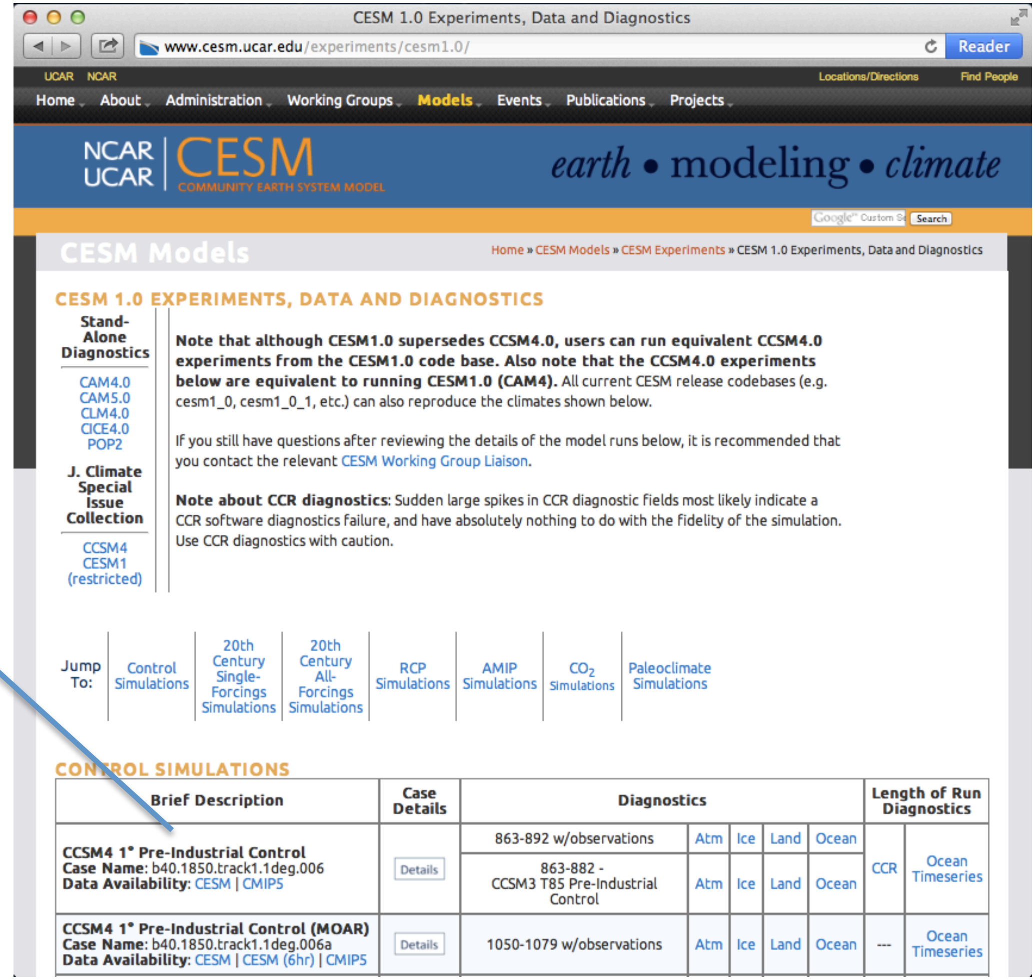
CONTROL SIMULATIONS

Brief Description	Case Details	Diagnostics					Length of Run Diagnostics	
CCSM4 1° Pre-Industrial Control **Case Name**: b40.1850.track1.1deg.006 **Data Availability**: CESM | CMIP5	Details	863-892 w/observations	Atm	Ice	Land	Ocean	CCR	Ocean Timeseries
		863-882 - CCSM3 T85 Pre-Industrial Control	Atm	Ice	Land	Ocean		
CCSM4 1° Pre-Industrial Control (MOAR) **Case Name**: b40.1850.track1.1deg.006a **Data Availability**: CESM | CESM (6hr) | CMIP5	Details	1050-1079 w/observations	Atm	Ice	Land	Ocean	---	Ocean Timeseries

http://www.cesm.ucar.edu/experiments/cesm1.0/
http://www.cesm.ucar.edu/experiments/cesm1.1/

CESM Experiments Pages

Links to the Earth System Grid



http://www.cesm.ucar.edu/experiments/cesm1.0/

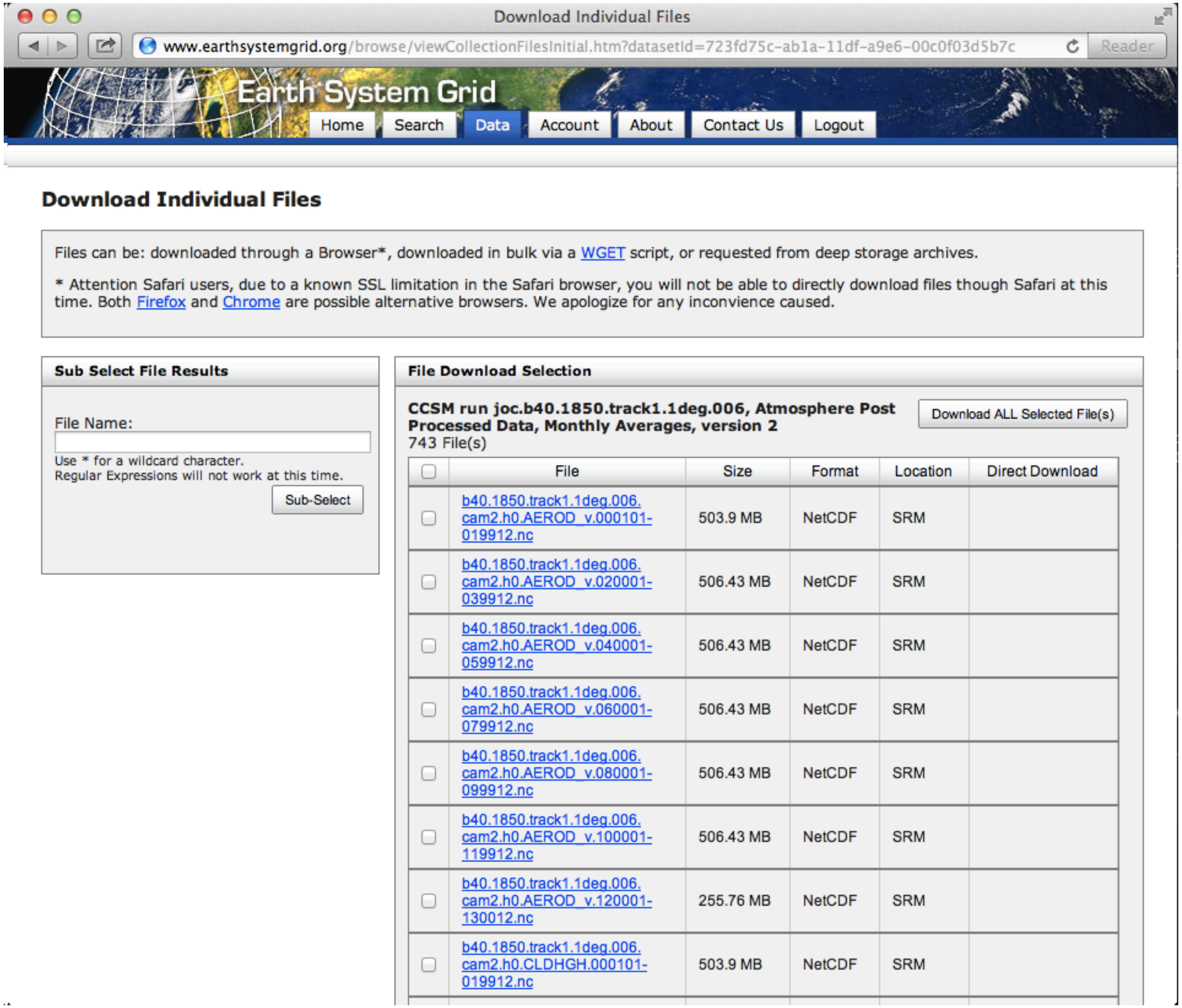
http://www.cesm.ucar.edu/experiments/cesm1.1/

Earth System Grid

Publicly released CESM data is available via the ESG.

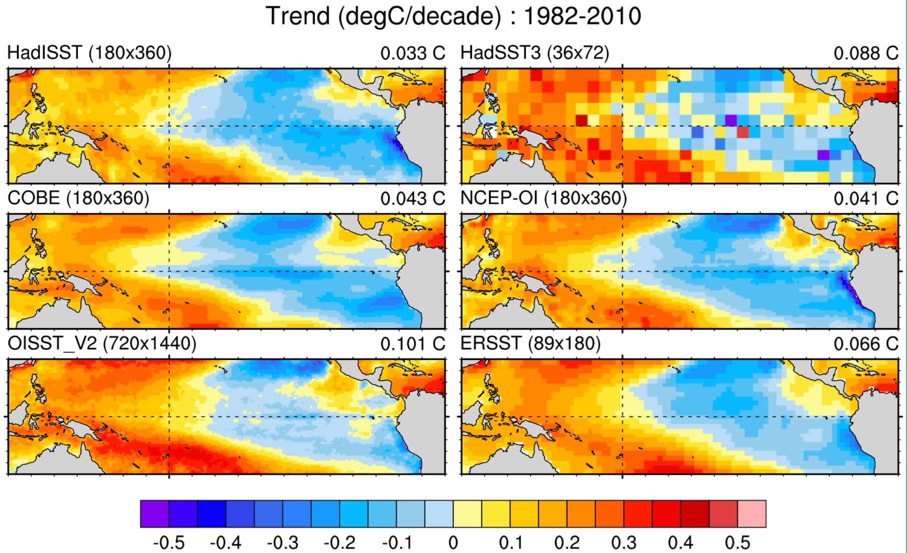
Registration is quick and easy. NCAR accounts are not required.

Post-processed data in CESM and CMIP formats along with raw history files are provided.



http://www.earthsystemgrid.org

Concise and reliable expert guidance on the strengths, limitations and applications of climate data…



Comparison of SST data sets and their recent trends in the tropical Pacific

http://climatedataguide.ucar.edu

Describe observations used for Earth System Model evaluation; **150+ data sets** profiled

Data set pros and cons evaluated by **nearly 4 Dozen Experts** ('expert-user guidance')

Comparisons of many common variables: SST, precipitation, sea ice concentration, atmospheric reanalysis, etc.

140,000 unique visitors in 2014 (up from 41,000 in 2012)

For more info contact David P. Schneider, NCAR, Climate Analysis Section. dschneid@ucar.edu

Introduction to netCDF

netCDF stands for “network Common Data Form”

PROS: self-describing, portable, metadata friendly, supported by many languages including fortran, C/C++, Matlab, ferret, GrADS, NCL, IDL; viewing tools like ncview / ncdump; and tool suites of file operators (NCO, CDO).

CONS: compression not available until netCDF4, oftentimes requires users to explicitly access information (not true in NCL)

http://www.unidata.ucar.edu/software/netcdf

http://www.unidata.ucar.edu/software/netcdf/docs/BestPractices.html

Introduction to ncdump

ncdump is a netCDF utility that allows one to dump the contents of the netCDF file to screen or file.

To view the header of a netCDF file:

ncdump –h slp.mon.mean.nc

To view the contents of a variable:

ncdump –v slp slp.mon.mean.nc | less

```
netcdf slp.mon.mean {
dimensions:
        lon = 144 ;
        lat = 73 ;
        time = UNLIMITED ; // (744 currently)
variables:
        float lat(lat) ;
                lat:units = "degrees_north" ;
                lat:actual_range = 90.f, -90.f ;
                lat:long_name = "Latitude" ;
        float lon(lon) ;
                lon:units = "degrees_east" ;
                lon:long_name = "Longitude" ;
                lon:actual_range = 0.f, 357.5f ;
        double time(time) ;
                time:units = "hours since 1-1-1 00:00:0.0" ;
                time:long_name = "Time" ;
                time:actual_range = 17067072., 17609832. ;
        float slp(time, lat, lon) ;
                slp:long_name = "Sea Level Pressure" ;
                slp:valid_range = 870.f, 1150.f ;
                slp:actual_range = 960.1486f, 1082.558f ;
                slp:units = "millibars" ;
                slp:missing_value = -9.96921e+36f ;,
// global attributes:
                :title = “Monthly mean slp from the NCEP Reanalysis" ;
                :description = "Data is from NMC initialized reanalysis\n",
                "(4x/day).  These are the 0.9950 sigma level values." ;
                :Conventions = "COARDS" ; }
```

Introduction to netCDF operators (NCO)

NCO is a suite of programs designed to perform certain "operations" on netCDF files, i.e., things like averaging, concatenating, subsetting, or metadata manipulation.

Command-line operations are extremely useful for processing model data given that modellers often work in a UNIX-type environment. The NCO's do much of the "heavy lifting" behind the scenes in the diagnostics packages.

UNIX wildcards are accepted for many of the operators.

The NCO's recognize missing data by the _FillValue attribute.
(missing_value is ignored.)

The NCO Homepage and Reference Manual can be found at http://nco.sourceforge.net

Note: There are many other netCDF operators beyond what will be described here.

Introduction to netCDF operators

NCRA (netCDF record averager)

Example: ncra file1.nc file2.nc avgfile.nc

file1.nc = input model history file, for jan year 1
file2.nc = input model history file, for feb year 1
avgfile.nc = new file consisting of jan/feb averaged data for all fields found in the input model history file.

NCRCAT (netCDF record concatenator)

Examples: ncrcat file1.nc file2.nc out12.nc

out12.nc = new model history time series file consisting of the months of jan and feb, year 1. Each time-varying field in this file now has 2 time steps.

Introduction to netCDF operators

NCEA (netCDF ensemble averager)

Example: ncea amip_r01.nc amip_r02.nc amip_r03.nc amip_ENS.nc

amip_r01.nc = input file from ensemble member #1
containing monthly Jan-Dec year 1 data
amip_r02.nc = same as above but contains data from ensemble member #2
amip_r03.nc = same as above but contains data from ensemble member #3
amip_ENS.nc = new file consisting of monthly Jan-Dec year 1 data
averaged across the 3 ensemble members.

NCDIFF (netCDF differencer)

Example: ncdiff amip_r01.nc amip_r02.nc diff.nc

diff.nc = contains the differences between amip_r01.nc and amip_r02.nc.

Note: Useful for debugging purposes.

Introduction to netCDF operators

NCATTED (attribute editor)

Example: ncatted –a units,lat,c,c,"degrees_north" in.nc

Add a units attribute to the lat variable called degrees_north in file in.nc.

NCRENAME (rename variables, dimensions, attributes)

Example: ncrename –v TREFHT,TAS -a missing_value,_FillValue in.nc

Rename the variable TREFHT to TAS, and rename all missing_value attributes to _FillValue in file in.nc.

Introduction to netCDF operators

NCKS (netCDF "Kitchen Sink" = does just about anything)

Combines various netCDF utilities that allow one to cut and paste subsets of data into a new file.

Example: ncks –v TEMP f40_test.pop.h.1993-11.nc f40_test.TEMP.199311.nc

f40_test.pop.h.1993-11.nc	= input model history file (monthly)
-v TEMP	= only grab the TEMP variable
f40_test.TEMP.1993-11.nc	= output file containing TEMP + associated coordinate variables

Note #1: Only those variables specified by –v and their associated coordinate variables are included in the output file. As the variables date, TLAT, and TLONG are not coordinate variables of TEMP, they won't be copied to the output file unless one does this:

ncks –v TEMP,date,TLAT,TLONG f40_test.pop.h.1993-11.nc f40_test.T.1993-11.nc

Note #2: Wildcards not accepted.

Introduction to netCDF operators

netCDF operator options

-v Operates only on those variables listed.

ncks –v T,U,PS in.nc out.nc

-x –v Operates on all variables except those listed.

ncrcat –x –v CHI,CLDTOT 1999-01.nc 1999-02.nc out.nc

-d Operates on a subset of data.

ncks -d lon,0.,180. -d lat,0,63 in.nc out.nc

Real numbers indicate actual coordinate values, while integers indicate actual array indexes. In the above example, all longitudes will be grabbed from 0:180E, and the first 64 latitudes indexes will be grabbed.

-h Override automatic appending of the global history attribute with the NCO command issued (which can be very long)

More options exist beyond what was discussed here.

Introduction to Climate Data Operators (CDO)

CDO are very similar to the NCO. Within the CDO library there are over 600 command line operators that do a variety of tasks including: detrending, EOF analysis, meta data modification, statistical analysis and similar calculations.

CDO are not currently used in the diagnostics packages, so we will not go into specifics here. We mention the CDO to make you aware of their existence.

The CDO Homepage can be found at:

https://code.zmaw.de/projects/cdo/

CDO documentation can be found at:

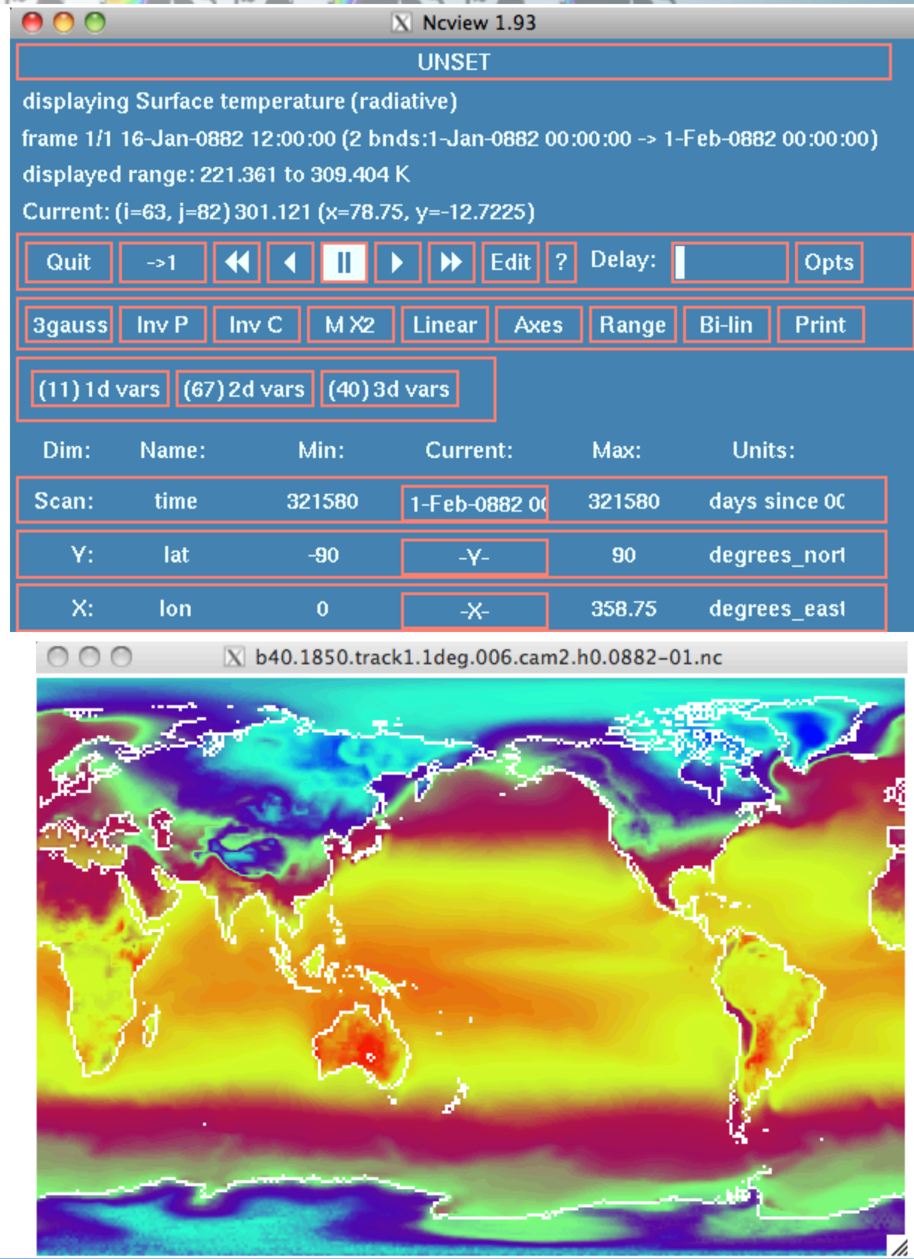
https://code.zmaw.de/projects/cdo/wiki/Cdo#Documentation

Introduction to ncview

ncview is a graphical interface which allows one to quickly view the variables inside a netCDF file.

Example: ncview file1.nc

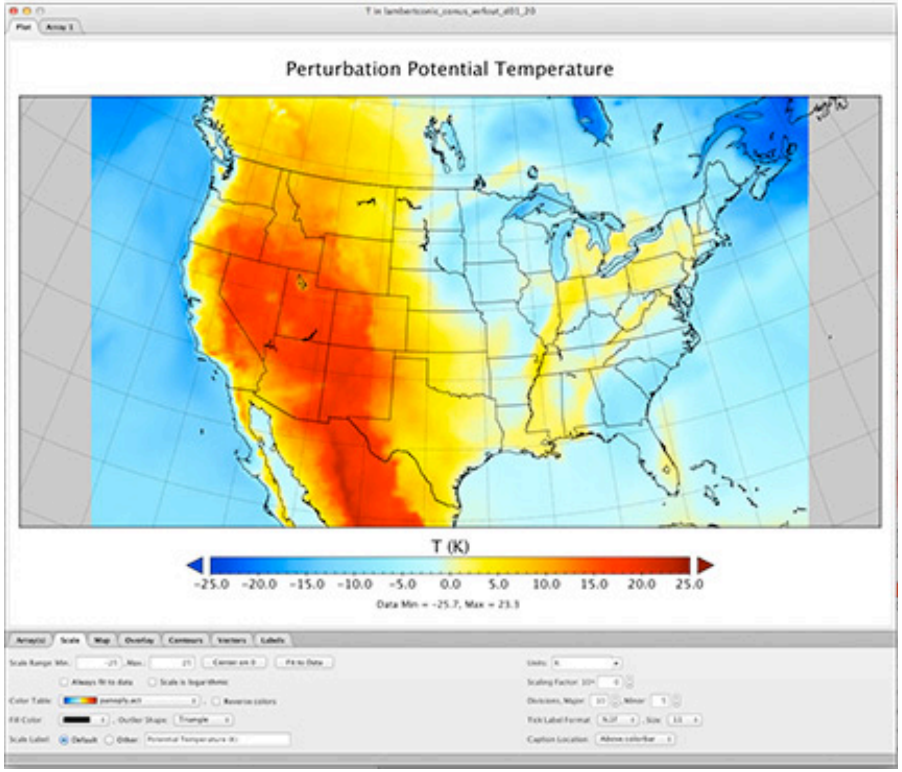
ncview allows you to interactively visualize a selected variable across a selected range (time, spatial).



Panoply

panoply is another GUI application that allows one to quickly view data in a netCDF, HDF, or GRIB format (amongst others). Similar to ncview, but more powerful, panoply allows the user to perform simple calculations, apply masks, and to quickly create spatial or line plots.

Note: Requires Java SE 7 runtime environment or newer. No documentation yet.



The Panoply homepage can be found at:

http://www.giss.nasa.gov/tools/panoply/

ImageMagick

ImageMagick is a free suite of software that that can be used to display, manipulate, compare or convert images. It can also be used to create movies.

There are two ways to use ImageMagick. One way is to simply display the image and alter it using pop-up menus visible after clicking on the image:

display plot1.png

A second way is to alter an image at the command line, which is usually the faster and cleaner way to do it:

convert –density 144 –rotate 270 plot2.ps plot2.jpg

(set the resolution to 2x default, rotate the image 270 degrees, and convert to a jpg.)

There are many options available when using convert, some of which you may need to use depending on your version of ImageMagick:

convert -trim +repage –background white –flatten plot2.ps plot2.png

(crop out all the possible white space, reset various settings, set the background to white, create a canvas based on white background and merge layers, and convert to a png.)

ImageMagick

ImageMagick is a free suite of software that that can be used to display, manipulate, compare or convert images. It can also be used to create movies.

To compare two images (ps, pdf, png, gif, jpg, etc):

compare image1.png image2.png diff.png

(diff.png will have red outlines showing what is different between image1 and image2, while the rest of diff.png is faded out. This works for a number of formats, including ps, pdf, png, gif and jpg.)

To create a movie from the command line:

convert –loop 0 –adjoin –delay 35 *.gif movie.mp4

(loop through the movie once, create the movie (-adjoin),
and increase the time between slides (-delay 0 is the default))

http://www.imagemagick.org

gv (Ghostview)

gv and Gnome Ghostview are simple programs that allow one to view postscript files:

gv plot4.ps (gv) or ggv plot4.ps (gnome ghostview)

(gv is installed on caldera)

Once displayed, one can alter the orientation of the image, or change its' size, or print specific pages amongst a group of pages. For viewing postscript (or encapsulated postscripts), gv should be used.

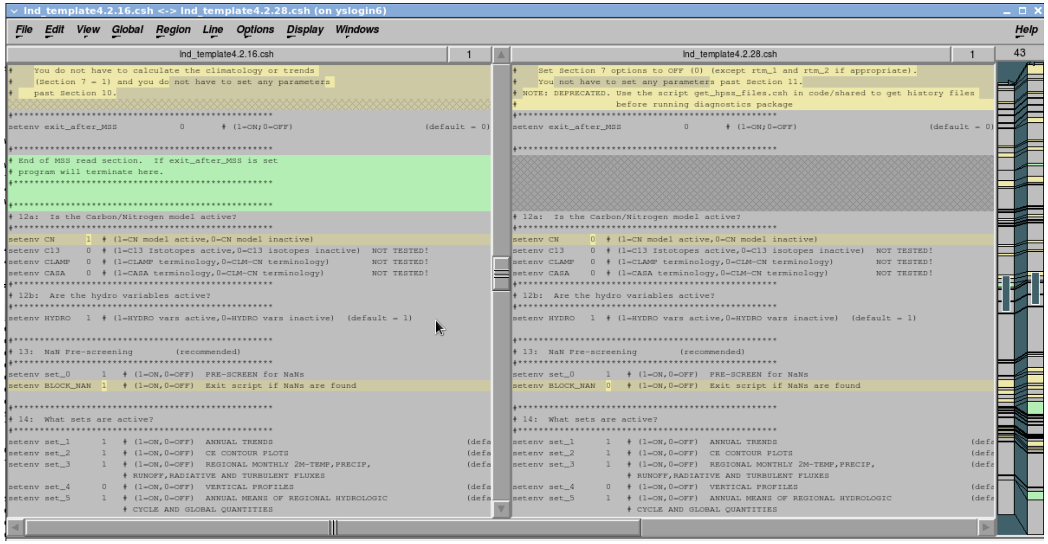
http://pages.cs.wisc.edu/~ghost/gv/index.htm

xxdiff

xxdiff allows one to quickly compare two or three scripts and highlights differences:

xxdiff script1.f script2.f

http://furius.ca/xxdiff/



NCL

NCL is an interpreted language designed for data processing and visualization. NCL is free, portable, allows for the creation of excellent graphics, can input/output multiple file formats, and contains numerous functions and procedures that make data processing easier.

http://www.ncl.ucar.edu

Support: Postings to the
ncl-talk email list concerning the NCL language are often answered within 24 hours by the NCL developers or by other NCL users.

Many downloadable examples are provided.

NCL is the official CESM processing language.

NCL

NCL easily reads in netCDF files:

```
a = addfile("b40.1850.track1.1deg.006.0100-01.nc","r")
z3 = a->Z3                    ; all metadata imported
```

NCL specializes in regridding, whether from one grid to another:

```
lat = ispan(-89,89,2)
lon = ispan(0,358,2)
z3_rg = linint2(z3&lon,z3&lat,z3,True,lon,lat,0) ; regrid to 2x2
```

or from CAM's hybrid sigma levels to pressure levels.

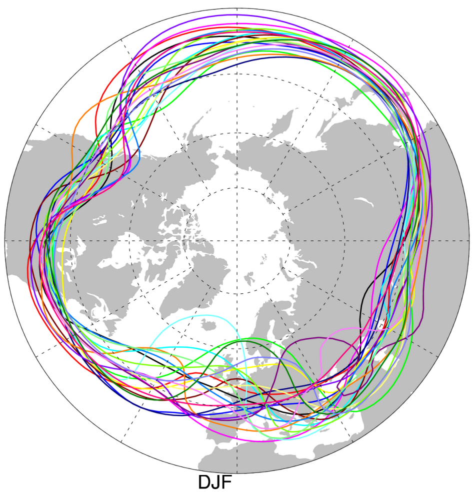
```
lev_p = (/ 850., 700., 500., 300., 200. /)
P0mb = 0.01*a->P0
tbot = T(klev-1,:,:)
Z3_p =vinth2p_ecmwf(z3,hyam,hybm,lev_p, \
               PS,1,P0mb,1,True,-1,tbot,PHIS)
```

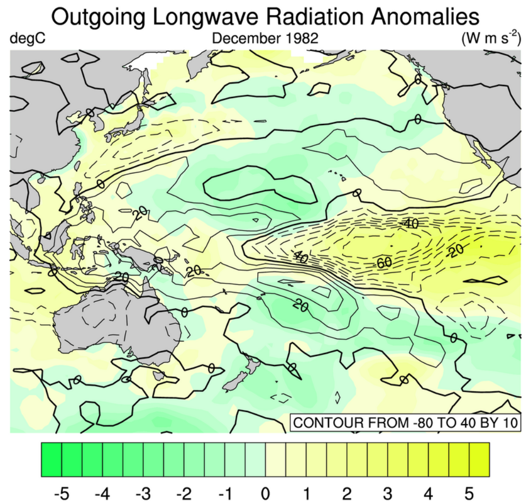
NCL

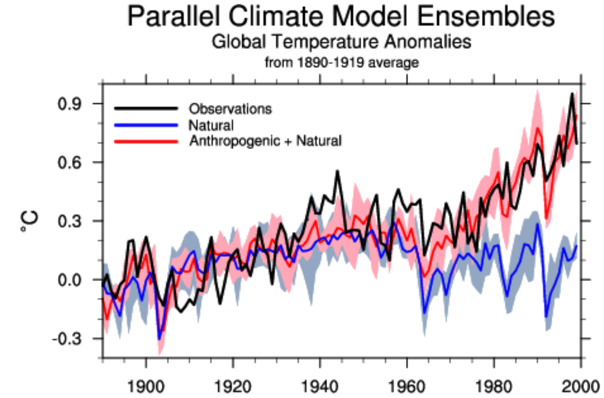
NCL's graphics package is exceptionally flexible. There are thousands of plot options (called resources) available that allow one to customize plots:

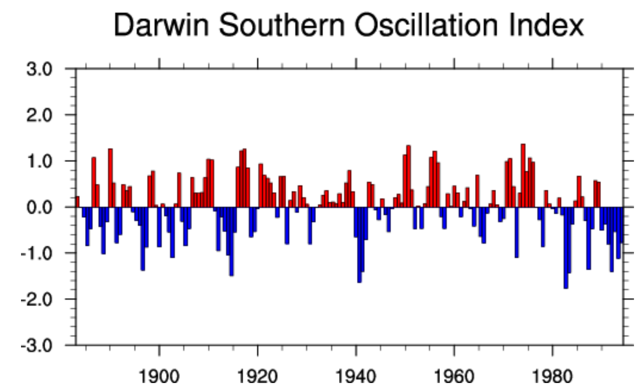
```
a = addfile("b40.1850.track1.1deg.006.0100-01.nc","r")
ts = a->TS(0,:,:)
wks = gsn_open_wks("ps","test")
gsn_define_colormap(wks,"amwg")
res = True
res@mpCenterLonF = 180.
res@mpProjection = "WinkelTripel"
res@mpOutlineOn = True
res@mpGeophysicalLineColor = "gray70"
res@cnFillOn = True
res@gsnSpreadColors = True
plot = gsn_csm_contour_map(wks,ts,res)
```

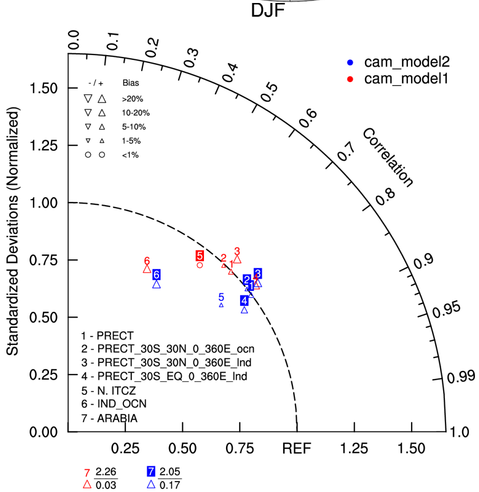
NCL Example Graphics

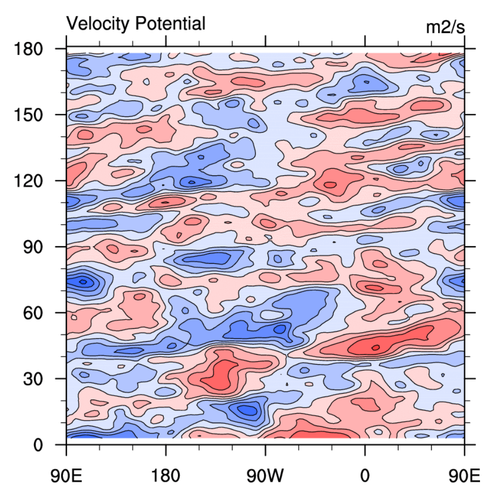




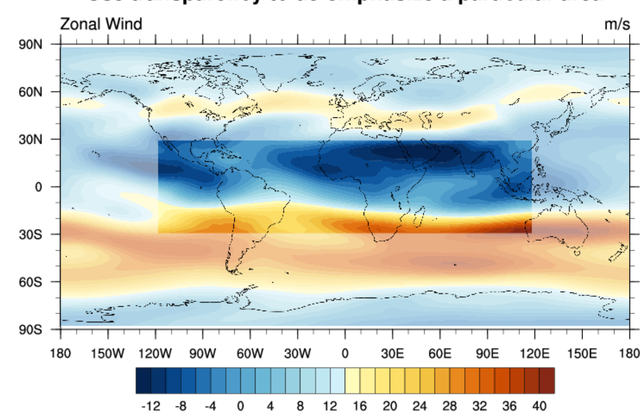




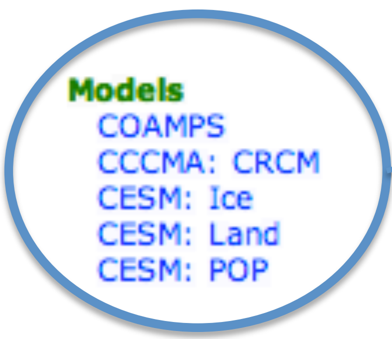


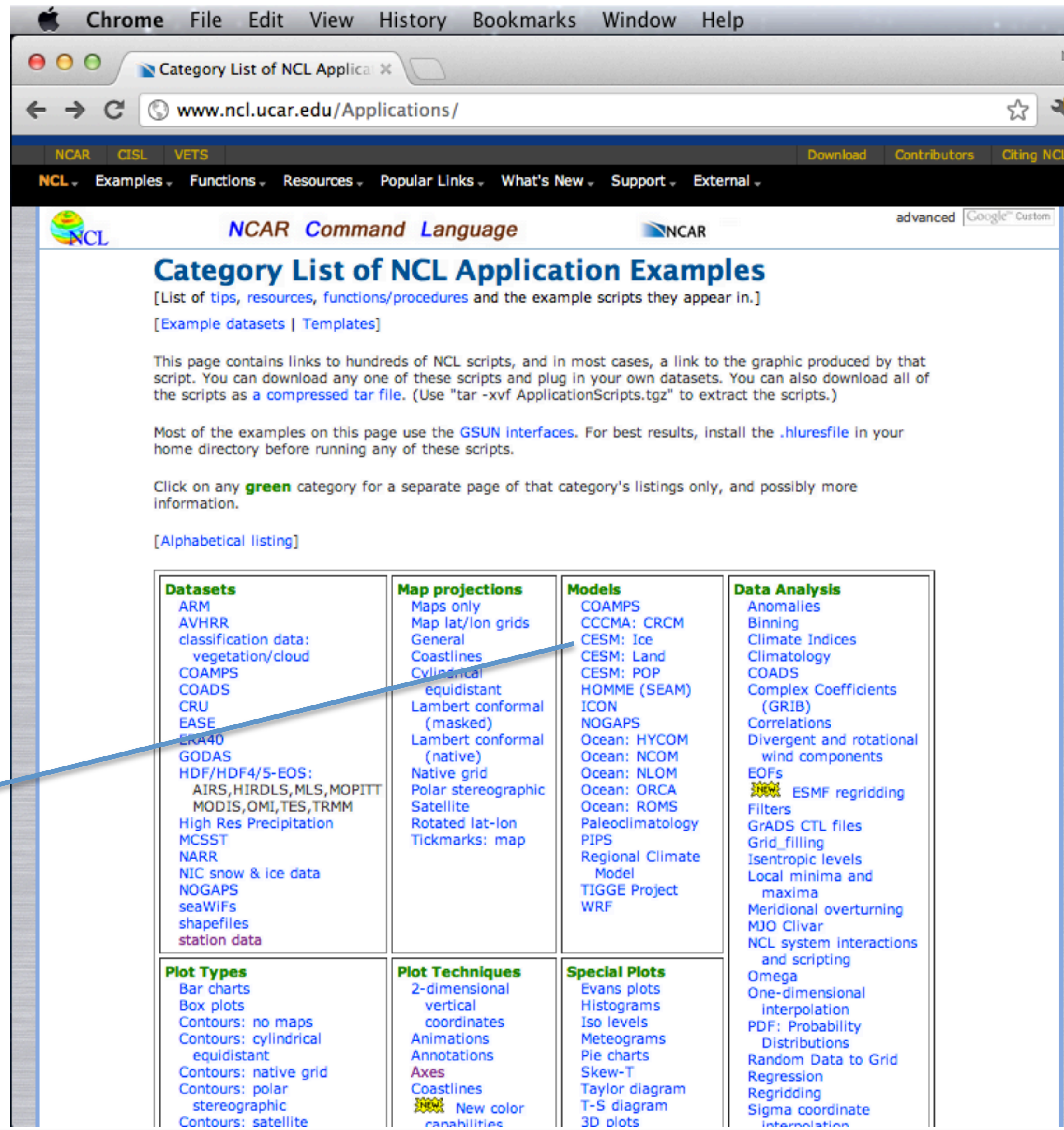


Use transparency to de-emphasize a particular area

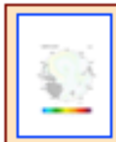


The NCL website: Examples





The NCL website: Examples



1D coordinate variables

ice_2.ncl: A polar vector plot of ice velocity.

gsn_csm_vector_map_polar is the plot interface that draws vectors on a polar stereographic map.

vcMonoLineArrowColor = False, Turns on color vectors.

To turn on curly vectors, set the resource *vcGlyphStyle* = "CurlyVector"

NCL

For more information, or to get started learning NCL:

- http://www.ncl.ucar.edu/get_started.shtml
- Take the NCL class (information available on NCL website)
- Watch some of the NCL webinars:
  http://www.ncl.ucar.edu/Training/Webinars/
- Page through the NCL mini-language and processing manuals
  http://www.ncl.ucar.edu/Document/Manuals/

Using NCL in Practical Lab #3

Within the lab, you are going to be provided NCL scripts that post-process the monthly model data that you created and draw simple graphics.

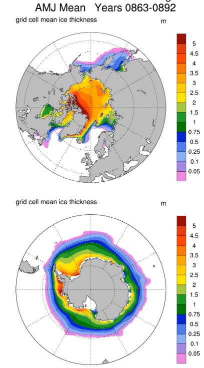
What is meant by post-processing: Convert the model history data from one time step all variables on one file to all time steps, one variable per file. (Also convert CAM 3D data from hybrid-sigma levels to selected pressure levels.)

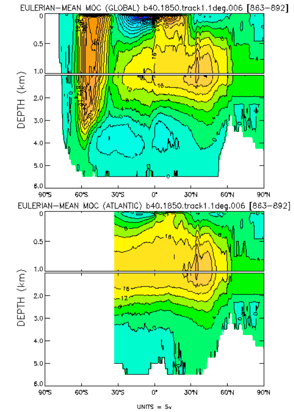
The diagnostic script suites all use NCL, and you will have the opportunity to run these as well.

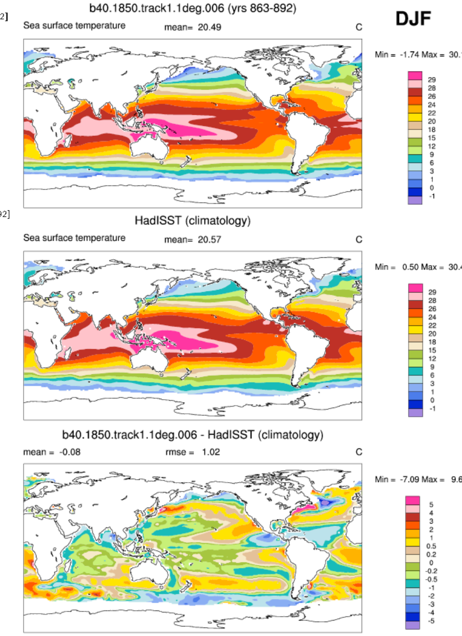
Diagnostics Packages

What are they?

A set of C-shell scripts that automatically generate a variety of different plots from model output files that are used to evaluate a simulation.

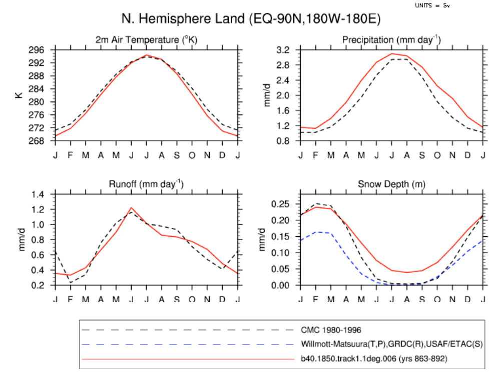






How many packages are there?

4 Comp: Atmosphere, Ice, Land, Ocean
3 Climate: CVDP, CCR, AMWG Variability



Why are they used?

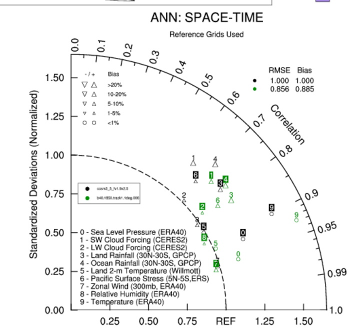
The diagnostics are the easiest and fastest way to get a picture of the mean climate of your simulation. They can also show if something is wrong.

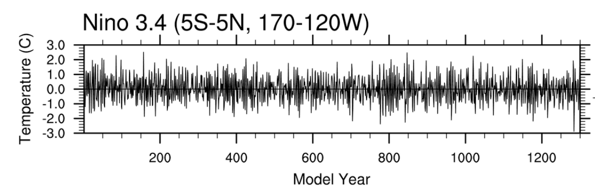
```
+++++++++++++++++++++++++++++
CPL7 Surface Energy Budget for Years:  1 1300
  (+ ==> model gains heat, - ==> model loses heat)
            FREEZE     MELT   RUNOFF        SW        LW       LAT       SEN       NET  (W/m^2)
          -------- -------- -------- --------- --------- --------- --------- ---------
  ATM:      0.000    0.000    0.000  -167.337    64.023    85.696    17.776     0.157
  OCN:      0.128   -0.992   -0.062   124.207   -41.138   -71.886   -10.366    -0.109
ICE_N:     -0.062    0.365    0.000     0.495    -0.862    -0.101     0.159    -0.005
ICE_S:     -0.066    0.627    0.000     0.609    -1.313    -0.265     0.399    -0.009
  LND:      0.000    0.000    0.062    42.027   -20.710   -13.444    -7.969    -0.034

O+I+L:     -0.000    0.000    0.000   167.338   -64.023   -85.696   -17.777    -0.158

  OCN NET renormalized:   -0.15341

   Mean ATM frac:    1.00000
   Mean OCN frac:    0.65350
 Mean ICE_N frac:    0.02278
 Mean ICE_S frac:    0.03198
   Mean LND frac:    0.29174
+++++++++++++++++++++++++++++
```



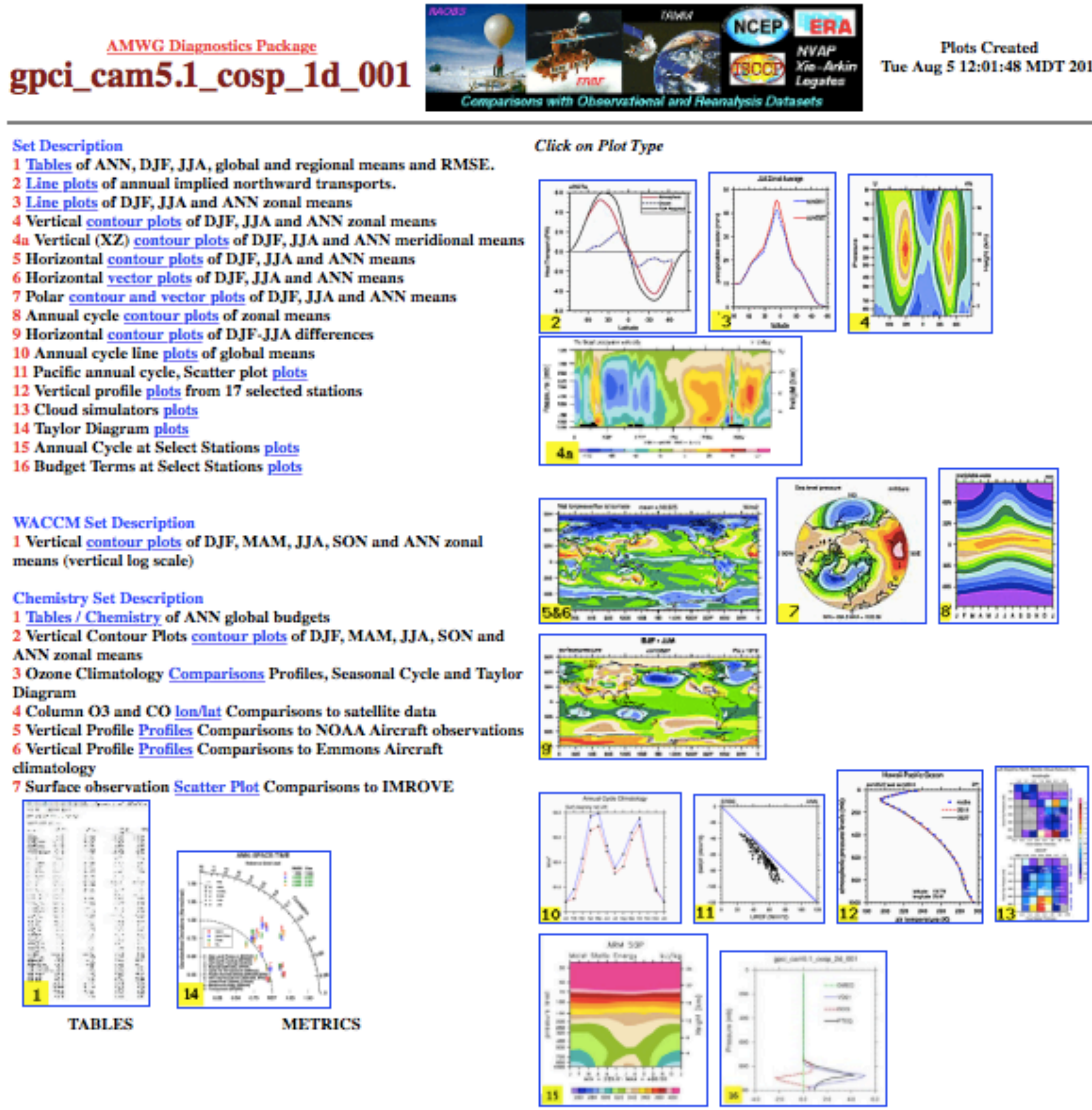


Note: The component diagnostics packages can be used as the first step in the research process, but the general nature of the calculations does not lend itself to in-depth investigation.

http://www.cesm.ucar.edu/models/cesm1.2/model_diagnostics/

Diagnostics Packages

AMWG Diagnostics Package Output


AMWG Diagnostics Package

gpci_cam5.1_cosp_1d_001

Comparisons with Observational and Reanalysis Datasets

Plots Created
Tue Aug 5 12:01:48 MDT 2014

Set Description
1 Tables of ANN, DJF, JJA, global and regional means and RMSE.
2 Line plots of annual implied northward transports.
3 Line plots of DJF, JJA and ANN zonal means
4 Vertical contour plots of DJF, JJA and ANN zonal means
4a Vertical (XZ) contour plots of DJF, JJA and ANN meridional means
5 Horizontal contour plots of DJF, JJA and ANN means
6 Horizontal vector plots of DJF, JJA and ANN means
7 Polar contour and vector plots of DJF, JJA and ANN means
8 Annual cycle contour plots of zonal means
9 Horizontal contour plots of DJF-JJA differences
10 Annual cycle line plots of global means
11 Pacific annual cycle, Scatter plot plots
12 Vertical profile plots from 17 selected stations
13 Cloud simulators plots
14 Taylor Diagram plots
15 Annual Cycle at Select Stations plots
16 Budget Terms at Select Stations plots

WACCM Set Description
1 Vertical contour plots of DJF, MAM, JJA, SON and ANN zonal means (vertical log scale)

Chemistry Set Description
1 Tables / Chemistry of ANN global budgets
2 Vertical Contour Plots contour plots of DJF, MAM, JJA, SON and ANN zonal means
3 Ozone Climatology Comparisons Profiles, Seasonal Cycle and Taylor Diagram
4 Column O3 and CO lon/lat Comparisons to satellite data
5 Vertical Profile Profiles Comparisons to NOAA Aircraft observations
6 Vertical Profile Profiles Comparisons to Emmons Aircraft climatology
7 Surface observation Scatter Plot Comparisons to IMROVE

TABLES METRICS

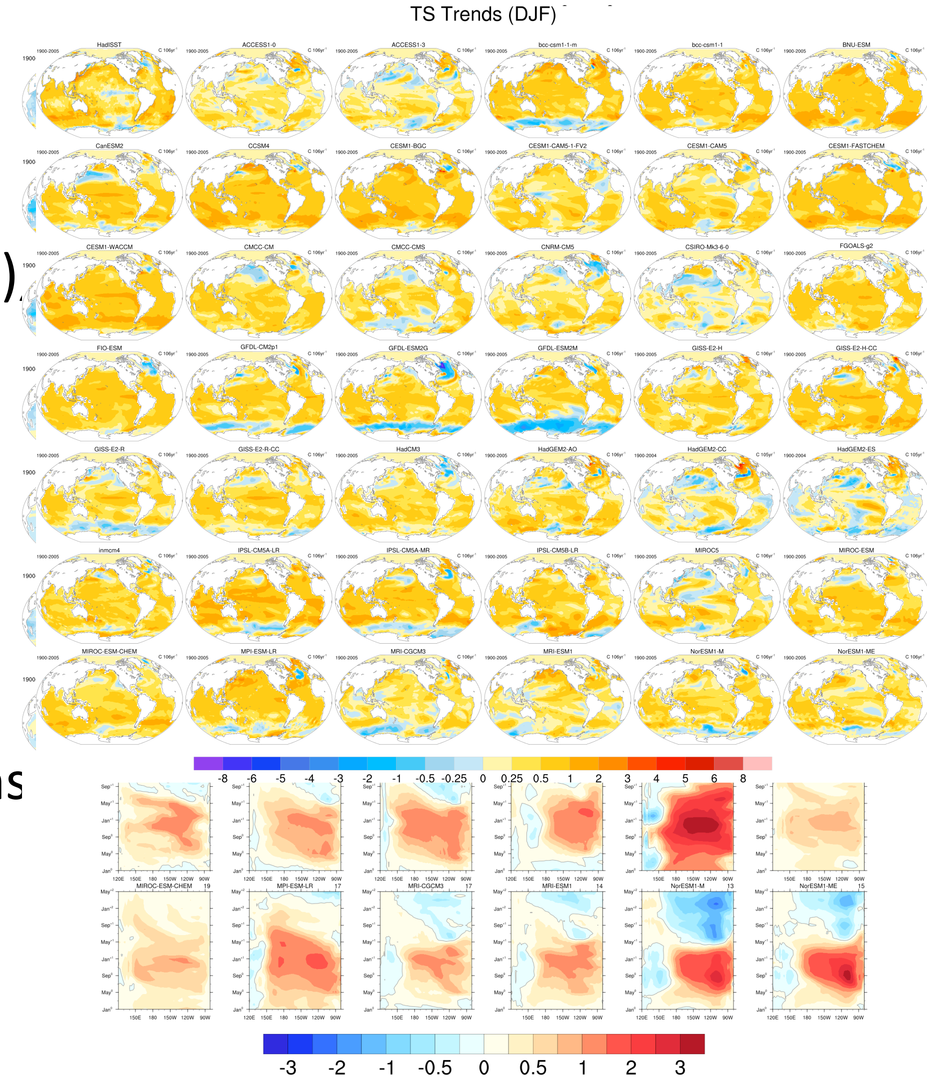
Click on Plot Type

Climate Variability Diagnostic Package

The Climate Variability Diagnostics Package (CVDP) is the newest of the diagnostics packages. The CVDP calculates the major modes of variability (AMO, PDO, NAM, SAM, etc.), AMOC metrics, and trends amongst other calculations.

Unlike the other diagnostics packages, this package is run over decades/ centuries and allows multiple simulations to be input at once. Data from the CMIP3 or CMIP5 archives are also allowed, allowing intercomparisons between CESM and other models. Calculations can be output to netCDF files for future use.

The CVDP is a component of the Earth System Model Validation Tool (ESMValTool).



For more information: http://www2.cesm.ucar.edu/working-groups/cvcwg/cvdp

Recent Updates to Diagnostics Packages

- Component diagnostics packages are all in the process of getting updated to use python averaging tools that result in much faster turn-around times. The component diagnostics packages are being wrapped into the model workflow so that running all of them will be easier/faster upon the CESM2 release.
- CVDP: Sea ice metrics have been added, unlimited numbers of observational datasets can be run at once and task parallelism has been implemented that can decrease runtime by ~80%.

Diagnostics Packages

The diagnostics packages are all available off of the SVN repository. (The exceptions are the CCR and AMWG Variability diagnostics which are only run in-house.)

The diagnostics packages were built to be flexible. Many comparisons are possible using the options provided. Here, we have you set a few options to compare observations to your model run. You can also use the diagnostics to compare model runs to one another, regardless of model version.

The atmospheric, land, and ice packages each have one script that can do comparisons vs. observations or vs. another model run. The ocean diagnostics have three main scripts: popdiag (for comparison to observations), popdiagdiff (for comparison to another model run), and popdiagts (calculates various ocean time series).

Typically, 20 or 30 year time slices of data are analyzed using the component diagnostics. (Exception: the popdiagts script is usually run on the entire run.) Here, you only have ~2 years of data, so that's what we will use.

Diagnostics Packages

Each component diagnostics package has different requirements in terms of the minimum amount of data required for them to run. (Ocean: 12 months, Atmosphere, Land: 14 months, Ice: 24 months) If you do not have the amount of data needed to run a specific diagnostics package, there is a directory set up with years 2110-2112 of CESM1-LE pre-industrial control data here: /glade/scratch/asphilli/archive/b.e11.B1850C5CN.f09_g16.005

(Path also given in test_data_location.txt file found in scripts/ directory.)

Note #1: Each diagnostics package will take around a 1/2hr to run. It is suggested that you start one of these packages first, and then move on to the post-processing or NCL graphics scripts.

Note #2: If you wish to take these diagnostics packages back with you to your home institution, you will need to have the netCDF operators and NCL installed, as well as Image Magick.

Note #3: When submitting the diagnostics scripts, the syntax ">&!" is used. What this means: > = pass the on-screen output to a file, & = run in background mode, and ! = overwrite the existing output file if necessary.

Note #4: **Do not enter leading 0's**. example: 0012

Note #5: Only complete years can be analyzed by the packages.

Practical Lab #3

Within the lab, you will have the opportunity to play with the CESM history files that you created. There are 5 sets of diagnostics scripts, 4 NCL post-processing scripts, and 7 NCL graphics creating scripts. You will also be able to try out the various software packages discussed earlier (ncview, ImageMagick, etc.).

The following slides contain information about how to run the various scripts on CISL's caldera system, along with exercises that you can try. It is suggested that you first focus on running those scripts written for the model component that you're most interested in. For instance, if you're an oceanographer, try running the ocean diagnostics script, along with the ocean post-processing script and ocean graphics NCL scripts.

Once you've completed running one of the diagnostics packages, take a run at one of the other packages, or try the exercises or challenges on the last slide.

You are not expected to run every diagnostics package and exercise.

Getting Started

There are a number of scripts that you will need to copy to your own directory. Here's what you will need to do to get set up:

1) The diagnostics packages, post-processing scripts, and plotting scripts will all be run on the CISL machine caldera. Logon to yellowstone and then onto caldera or geyser (you choose) as you've previously done:

    ssh –Y user@yellowstone.ucar.edu

    Run caldera.csh or geyser.csh that is in your home directory or:

    bsub –XF –Is –P UESM0004 –W 02:00 –n 1 –q caldera /bin/tcsh

2) From the caldera or geyser window, create a new directory in your home called scripts, and cd into it:

    mkdir scripts
    cd scripts

3) Copy all the necessary files over to your scripts directory, and move the hluresfile (sets NCL defaults) to your home directory and rename in .hluresfile:

    cp –R /glade/u/home/asphilli/CESM_tutorial/* .
    mv hluresfile ../.hluresfile

Getting Started

4) Within your .cshrc or .tcshrc files make sure that you are loading the NCL/ncview/nco modules:

    cd
    gedit .tcshrc (or use xemacs, vi, etc.)

   add the following (if these lines are not there):

    module load ncview
    module load cdo
    module load nco
    module load ncl

   (If you did need to add the above four lines, make sure you source the file after modifying and saving it: source .tcshrc)

   If you do not have a .tchsrc or .cshrc file, copy the tcshrc file from your scripts directory to your home directory:

    cd
    mv scripts/tcshrc .tcshrc
    source .tcshrc

5) Reminder: Your model output will be under:
   /glade/scratch/<logname>/archive/<run>

AMWG Diagnostics Package

To run the atmospheric diagnostics script:

(Note that setting a 0/1 option to 0 turns that option ON.)

1) cd to your scripts directory, then into atm_diag:

```
cd                    (changes to your home directory)
cd scripts/atm_diag
```

2) Open up the file diag140804.csh using your favorite text editor:

```
gedit diag140804.csh    (or use xemacs, vi, etc.)
```

3) Modify the following lines and save the file:

line 107 Enter your run name
line 111 Change "user" to your logname
line 112 Set atmospheric history file path
line 171 Enter the model year you wish to start the diagnostics on
line 172 Enter the # of years you wish to analyze

4) Make the necessary atmospheric diagnostics directories:

```
mkdir /glade/scratch/<logname>/amwg
mkdir /glade/scratch/<logname>/amwg/climo
mkdir /glade/scratch/<logname>/amwg/diag
```

AMWG Diagnostics Package

5) Submit the job, let it run in background mode, and write the output to a file named atm.out:

    ./diag140804.csh >&! atm.out &

6) If the diagnostics package errors out, check the output file atm.out, and correct the script.

7) Once the diagnostics script has successfully completed, a tar file should have been created here:
/glade/scratch/<logname>/amwg/diag/<run>

8) cd to your diag directory, create a new directory called html, move the tar file to the html directory, and untar it:

```
cd /glade/scratch/<logname>/amwg/diag/<run>
mkdir html
mv *.tar html/
cd html
tar –xf *.tar
```

AMWG Diagnostics Package

8) cd into the new directory, fire up a firefox window, and open up the index.html file:

```
cd <run>-obs
firefox index.html &
```

For reference: Your atmospheric diagnostics web files are located here:
/glade/scratch/<logname>/amwg/diag/<run>/html/<run>-obs/

For more information about the AMWG Diagnostics Package:

http://www2.cesm.ucar.edu/working-groups/amwg/amwg-diagnostics-package

LMWG Diagnostics Package

To run the land diagnostics script:

(Note that setting a 0/1 option to 1 turns that option ON.)

1) There is a bug in the current version of the NCO's that can cause the land diagnostics package to crash. It is recommended that when running the land diagnostics package you revert to using NCO v4.2.0. To revert to v4.2.0:

   module load nco/4.2.0

2) cd to your scripts directory, then into lnd_diag:

   cd (changes to your home directory)

   cd scripts/lnd_diag

3) Open up the file lnd_template4.2.28.csh using your favorite text editor:

   gedit lnd_template4.2.28.csh (or use xemacs, vi, etc.)

LMWG Diagnostics Package

4) Modify the following lines:
   lines 92,93,94 Enter your run name
   line 124 Set land history file path
   line 126 Set atmospheric history file path
   line 193 Enter the model year you wish to start the diagnostics on
   line 194 Enter the # of years you wish to analyze
   line 203 Set to same value as line 193 (can be different though)
   line 204 Set to same value as line 194 (again, can be different)

5) Submit the job, let it run in background mode, and write the output to a file named lnd.out:

   ./lnd_template4.2.28.csh >&! lnd.out &

6) If the diagnostics package errors out, check the output file lnd.out, and correct the script.

7) Once the diagnostics script has successfully completed, a tar file should have been created in the following directory:
   /glade/scratch/<logname>/lnd_diag/<run>

LMWG Diagnostics Package

8) cd to the new directory in /glade/scratch, create a new directory called html, move the tar file to the html directory, and untar it:

```
cd /glade/scratch/<logname>/lnd_diag/<run>
mkdir html
mv *.tar html/
cd html
tar –xf *.tar
```

9) cd into the new directory, fire up a firefox window, and open up the setsIndex.html file:

```
cd <run>-obs
firefox setsIndex.html &
```

For reference: Your land diagnostics web files are located here:
/glade/scratch/<logname>/lnd_diag/<run>/html/<run>-obs/

For more information about the LMWG Diagnostics Package:
http://www.cesm.ucar.edu/models/cesm1.2/clm/clm_diagpackage.html

PCWG Diagnostics Package

To run the polar diagnostics script:

(Note that setting a 0/1 option to 1 turns that option ON.)

1) Copy your ice history files to a specified location on /glade/scratch:

```
cd /glade/scratch/<logname>
mkdir diags
mkdir diags/<run>
cd diags/<run>
cp ../../archive/<run>/ice/hist/*.h.* .
```

(The above cp command copies your ice history files to a set diagnostics directory. If you need to use the sample data you will need to modify the cp command accordingly. Note: Technically this step can be skipped if you are using your own simulation by modifying lines 110 and 111 of ice_diag.csh.)

2) cd to your scripts directory, then into ice_diag:

```
cd                        (changes to your home directory)
cd scripts/ice_diag
```

3) Open up the file ice_diag.csh using your favorite text editor:

```
gedit ice_diag.csh    (or use xemacs, vi, etc.)
```

PCWG Diagnostics Package

4) Modify the following lines:
   line 22 Enter your run name
   line 34 Change to gx3v7 if analyzing your run. If analyzing b.e11.B1850C5CN.f09_g16.005 leave set to gx1v6
   line 37 Alter the first number to the start model year
   line 38 Alter the first number to the end model year
   line 40 Enter the # of years you wish to analyze (usually = line27(0)-line26(0)+1)

5) Submit the job, let it run in background mode, and write the output to a file named ice.out:

```
./ice_diag.csh  >&! ice.out &
```

6) Once the diagnostics script has successfully completed, a tar file should have been created in your scratch directory:
   /glade/scratch/<logname>/web_plots/<run>/<run>.tar

PCWG Diagnostics Package

7) cd to the new directory in /glade/scratch, create a html directory, move the tar file into the html directory, and cd into html:

```
cd /glade/scratch/<logname>/web_plots/<run>
mkdir html
mv <run>.tar html
cd html
```

8) Untar the file, and cd to the directory containing the index.html file:

```
tar –xf <run>.tar
```

9) cd to the appropriate directory, fire up a firefox window, and open up the index.html file:

```
cd /glade/scratch/<logname>/   (path continued below)
    web_plots/<run>/html/ice/yrs<startyr>-<endyr>
firefox index.html &
```

OMWG Diagnostics Package

There are multiple oceanic diagnostics scripts. Here we will got through the steps to run the popdiag script, which compares your run to observations. (If you are interested in running popdiagdiff or popdiagts, see the Challenges slide.) (Note that setting a 0/1 option to 1 turns that option ON.)

1) cd to your scripts directory, then into ocn_diag:

```
cd                    (changes to your home directory)
cd scripts/ocn_diag
```

2) Open up the file popdiag.csh using your favorite text editor:

```
gedit popdiag.csh    (or use xemacs, vi, etc.)
```

3) Modify the following lines:

line 48 — Enter your run name
line 49 — Change to gx3v7 if analyzing your run. If analyzing b.e11.B1850C5CN.f09_g16.005 leave set to gx1v6
line 52 — Alter the first number to the start model year (Do not enter
line 53 — Alter the first number to the end model year leading 0's.)
line 95 — Set local oceanic history file path
line 113 — replace user with your logname

OMWG Diagnostics Package

4) Submit the job, let it run in background mode, and write the output to a file named ocn.out:

```
./popdiag.csh  >&! ocn.out &
```

5) cd to the popdiag scratch directory, start firefox, and look at popdiag.html:

```
cd /glade/scratch/<logname>/popdiag/<run>
firefox popdiag.html &
```

For reference: Your ocean diagnostics web files are located here:
/glade/scratch/<logname>/popdiag/<run>

Note: In the future if you wish to turn Swift on, make sure you read the README-SWIFT.pdf file before setting Swift = 1 in any of the popdiag*.csh scripts.

Climate Variability Diagnostics Package

The CVDP is different from the component diagnostic packages. The CVDP is run on timeseries/post-processed data (only), and can be run on non-CESM data. The CVDP can also be run on 2+ simulations at once. Entire simulations (spanning 100's of years) can be passed into the package, but note that your ~5yr tutorial simulations are too short to put in the CVDP.

All input file names must end with the standard CMIP5 file naming syntax "YYYYMM-YYYYMM.nc". Soft links can be used to meet this requirement.

The CVDP reads in 8 variables: aice, MOC, PRECC, PRECL, PSL, SNOWDP, TREFHT, and TS. (CMIP names: sic, stfmmc/msftmyz, pr, psl, snd, tas,ts)

Three scripts need to be set up to run the CVDP:
namelist (lists the location of model run data to be analyzed)
namelist_obs (specified which observational datasets to use)
driver.ncl (sets CVDP options)

For the lab session, you will have the chance to run the CVDP on three simulations from the CESM1 Large Ensemble Project.
https://www2.cesm.ucar.edu/models/experiments/LENS

Climate Variability Diagnostics Package

1) cd to your scripts directory, then into CVDP:

    cd ~/scripts/CVDP

2) Open up the **namelist** using your favorite text editor:

    gedit namelist (or use xemacs, vi, etc.)

    The format of each row in **namelist** is as follows:
    Run Name | Path to all data for a simulation | Analysis start year | Analysis end year

    Modify each of the three rows so that the analysis start and end years are specified as 1979 and 2012. Note that " | " serves as the delimiter.

3) Open up the **namelist_obs**:

    gedit namelist_obs (or use xemacs, vi, etc.)

    The format of each row in **namelist_obs** is as follows:
    Variable | Obs Name | Path to obs dataset | Analysis start year | Analysis end year

    namelist_obs is already set appropriately, so no changes need to be made. These datasets are not distributed with the CVDP, but can be downloaded online. Note that MOC, SNOWDP, aice_nh and aice_sh do not have observational datasets and are not listed.

Climate Variability Diagnostics Package

4) Open up the **driver.ncl**:

    gedit driver.ncl (or use xemacs, vi, etc.)

    Modify:

    line 7 replace user with your logname

    line 18 change "False" to "True" to output calculations to netCDF

5) Run the CVDP by submitting **driver.ncl**, let it run in background mode, and write the output to a file named cvdp.out:

    ncl driver.ncl >&! cvdp.out &

6) Once the CVDP is complete (~25 mins), cd to the outdir specified in driver.ncl, fire up a firefox window, and open up the index.html file:

    cd /glade/scratch/<logname>/CVDP

    firefox index.html &

NCL post-processing scripts

All 4 post-processing scripts are quite similar, and are located in your scripts directory. To list them, type: ls *create* . If these scripts are used for runs other than the tutorial runs, note that the created netCDF files may get quite large (especially pop files). This can be mitigated by setting concat and concat_rm = False.

To set up the post-processing scripts, alter lines 7-15 (7-17 for atm). There are comments to the right of each line explaining what each line does.

To run the atm script (for example), type the following:

ncl atm.create_timeseries.ncl

All 4 scripts will write the post-processed data to work_dir (set at top of each script)/processed/<run>. Once the post-processing is complete, we can use the new files in our NCL graphics scripts, or view them via ncview.

NCL Graphics Scripts

These scripts are set up so that they can read either raw history files from your archive directory (lnd,ice,ocn history files) or the post-processed files after they've been created by the NCL post-processing scripts.

You will need to modify the user defined file inputs at the top to point to your data files, either your raw history files or your newly created post-processed files. Once the files are modified, to execute the scripts, simply type (for example): ncl atm_latlon.ncl . To see the script output use gv: gv atm_latlon.ps

There are 7 NCL graphics scripts available for you to run:

atm_latlon.ncl	atm_nino34_ts.ncl	ice_south.ncl
ice_north.ncl	lnd_latlon.ncl	ocn_latlon.ncl
ocn_vectors.ncl		

The ocn_vectors.ncl allows you to compare one ocean history file to another, and is more complicated (you can modify the first 50 lines) than the other 6 scripts. To run them, simply set the options at the top of the script.

Exercises

1) Use ncdump to examine one of the model history files. Find a variable you've never heard of, then open up the same file using ncview, and plot that variable.

2) Modify one of the NCL scripts to plot a different variable.

3) Use the netCDF operators to difference two files. Plot various fields from the difference netCDF file using ncview.

4) Convert the output from one of the NCL scripts from .ps to .jpg, and crop out the white space. Import the image into Powerpoint.

5) Use the netCDF operators to concatenate sea level pressure and the variable date from all the monthly atmospheric history files (.h0.) into one file.

6) Same as 5), but only do this for the Northern Hemisphere.

7) Same as 6), but don't append the global history file attribute.

Challenges

1) Modify one of the NCL scripts to alter the look of the plot. Use the NCL website's Examples page to assist.

2) Add a variable or 3 to one of the post-processing scripts, then modify one of the NCL scripts to plot one of the new variables.

3) Use the atmospheric diagnostics package to compare your simulation against the simulation here: /glade/scratch/asphilli/archive/b.e11.B1850C5CN.f09_g16.005 Make sure you compare the same number of years.

4) Use the popdiagdiff.csh script to compare year 1 of your model run against year 2. *Note that when running popdiagdiff one can only compare two runs against each another when they are on the same POP grid.*

Challenges

5) Run popdiagts on your model simulation. modify lines 51-54 and 92 accordingly. (Do not run this on the b40.1850.track1.2deg.003 data as popdiagts will pull over files from every year of the simulation from the HPSS.)

Introduction to the NCAR Archival System

The High Performance Storage System (HPSS)

- Tape-based archival system (same back end as MSS)
- FTP-like interface
- Connected to most CISL/CGD systems
- Reading and writing methods [*]nix-like: cp, mv, put, get,…
- Files do not expire, and can be as large as 1TB
- By default, 1 tape copy of each file is created.

http://www2.cisl.ucar.edu/docs/hpss-guide

HPSS Commands

Key commands:

ls –l	<full pathname for file>	: shows to screen specified file
get	<source file>	: copies file(s) from HPSS
put	<source file> <destination>	: copies file(s) to HPSS
lcd	<local directory>	: changes your local directory
prompt		: do not prompt for input

HPSS Access

There are two ways to access data on the HPSS. One way is to interactively enter the HPSS from the command line by using HSI, and then using various ftp commands:

hsi (You may be prompted for your UCAR UCAS password)
cd /CCSM/csm/b40.1850.track1.1deg.006/atm/hist
ls –l *.h0.1000*
prompt (To turn off prompting)
get *.h0.1000* (All files will be written from the HPSS to whichever local directory you were in when you started your hsi session)

The other way to access the HPSS is from the command line:

hsi –q 'lcd /glade/scratch/user; prompt; get /CCSM/csm/b40.1850.track1.1deg.006/atm/hist/*.h0.1000*'

(Put the files on the local directory /glade/scratch/user, don't prompt, and grab all atmospheric history files that have ".h0.1000" in their name.)

hsi –q 'lcd /glade/scratch/user; cd /USER; put atm.nc'

(write /glade/scratch/user/atm.nc to the HPSS directory /USER; lcd unneeded if already in /glade/scratch/user)