

# A new Climate Variability Diagnostics Package with application to CESM and CMIP5

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# Reasoning behind the CVDP

- The CESM-SSC has recently requested a stronger focus on coupled model behavior.
- A model's coupled climate variability is not adequately documented by any of the 5 existing CESM diagnostic packages.
- There is not an automated way to compare modes of climate variability in CESM to that of other models or to observations.
- To assist the community in evaluating climate model behavior.

[Methodology](#) | [Metrics Table](#)

Climatological Period Used: Full

Input Namelists: [OBS](#) | [Models](#)

Derived Namelists: [PR](#) | [PSL](#) | [SND](#) | [TAS](#) | [TS](#)

Created: Tue Feb 25 16:33:08 MST 2014

CVDP Version 3.0.7

## CESM Comparison

### Means and Standard Deviation Maps

<b>SST</b>	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>
<b>TAS</b>	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>
<b>PSL</b>	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>
<b>PR</b>	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>

### Coupled Modes of Variability

<b>AMO</b>	<a href="#">Pattern</a>	<a href="#">Timeseries</a>	<a href="#">Power Spectra</a>
<b>PDO</b>	<a href="#">Pattern</a>	<a href="#">Timeseries</a>	<a href="#">Power Spectra</a>
<b>ENSO</b>	Spatial Composites	<a href="#">JJA<sup>0</sup></a>	<a href="#">SON<sup>0</sup></a>
		<a href="#">DJF<sup>+1</sup></a>	<a href="#">MAM<sup>+1</sup></a>
		<a href="#">El Niño Hovmöller</a>	<a href="#">La Niña Hovmöller</a>
	Niño3.4	<a href="#">Timeseries</a>	<a href="#">Power Spectra</a>
		<a href="#">Monthly Std. Dev.</a>	<a href="#">Running Std. Dev.</a>

## Global Trend Maps

SST	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>	<a href="#">Monthly</a>
TAS	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>	<a href="#">Monthly</a>
PSL	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>	<a href="#">Monthly</a>
PR	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>	<a href="#">Monthly</a>
SND	DJF	MAM	JJA	SON	Annual	Monthly

## Global Timeseries

SST	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>	<a href="#">Monthly</a>
TAS	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>	<a href="#">Monthly</a>
PR	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>	<a href="#">Monthly</a>

## Global Timeseries Running Trends (Monthly)

SST	<a href="#">8yr</a>	<a href="#">10yr</a>	<a href="#">12yr</a>	<a href="#">14yr</a>	<a href="#">16yr</a>
TAS	<a href="#">8yr</a>	<a href="#">10yr</a>	<a href="#">12yr</a>	<a href="#">14yr</a>	<a href="#">16yr</a>

## Zonal Averages

PR	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>
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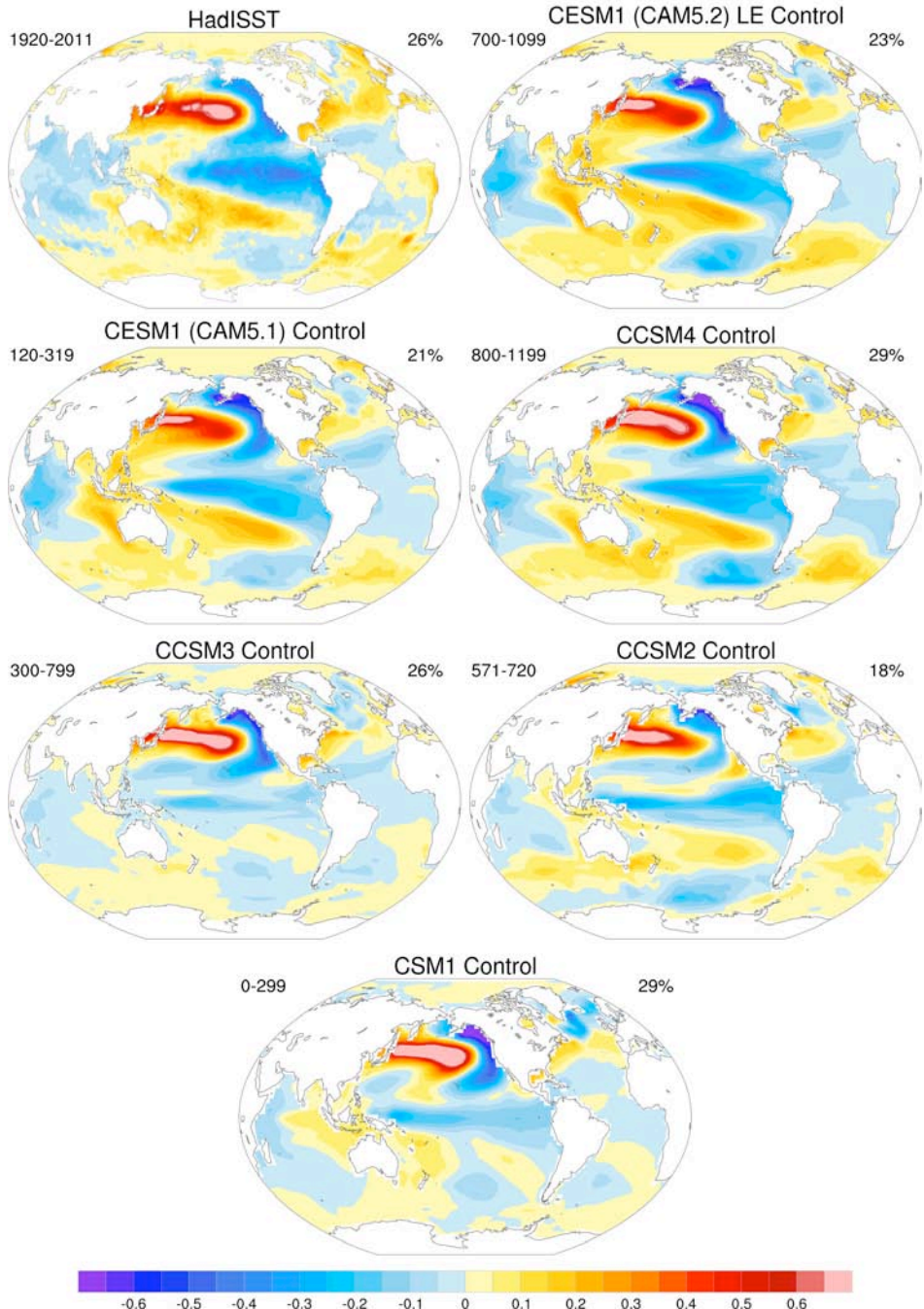
## Additional Indices

<a href="#">North Pacific Index</a>	<a href="#">Tropical North Atlantic SST</a>	<a href="#">Tropical South Atlantic SST</a>	<a href="#">Tropical Indian Ocean SST</a>				
<a href="#">niño1+2 Timeseries</a>	<a href="#">niño3 Timeseries</a>	<a href="#">niño4 Timeseries</a>	<a href="#">Indian Ocean Dipole</a>				
<b>PSAZ</b>	Timeseries	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>	<a href="#">Monthly</a>
	SST Regressions	<a href="#">DJF</a>	<a href="#">MAM</a>	<a href="#">JJA</a>	<a href="#">SON</a>	<a href="#">Annual</a>	<a href="#">Monthly</a>

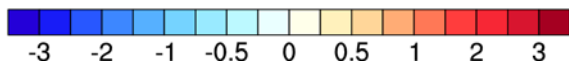
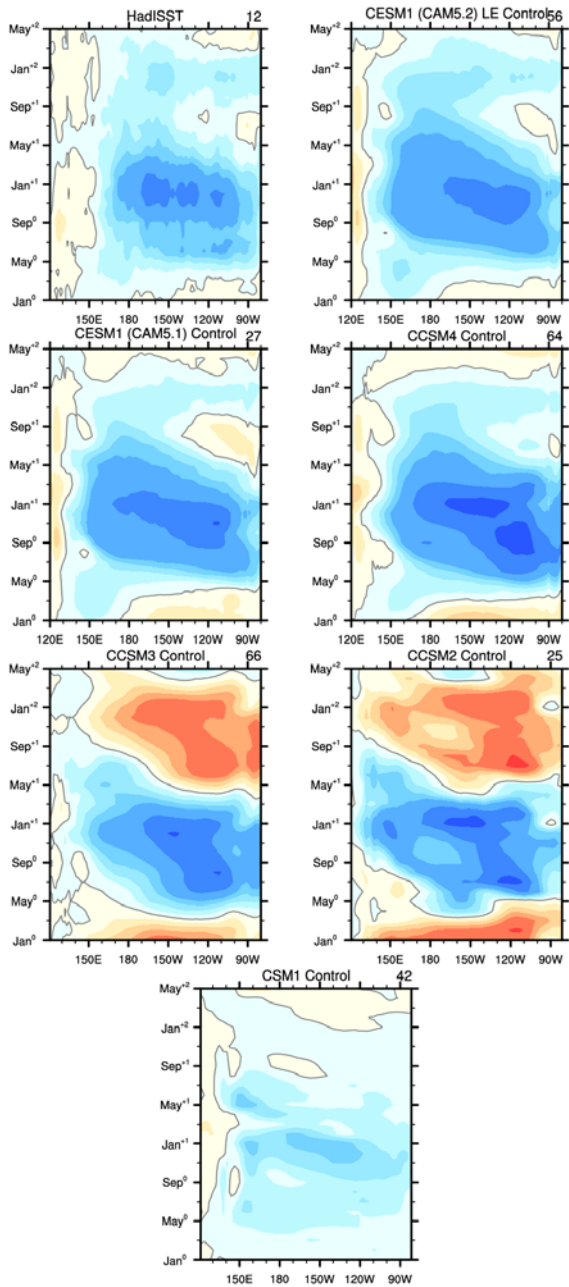
# PDO (Monthly)

# CESM Evolution 1998-present

## Pacific Decadal Oscillation 1<sup>st</sup> EOF of North Pacific SST (20°:90°N, 110:160°E)

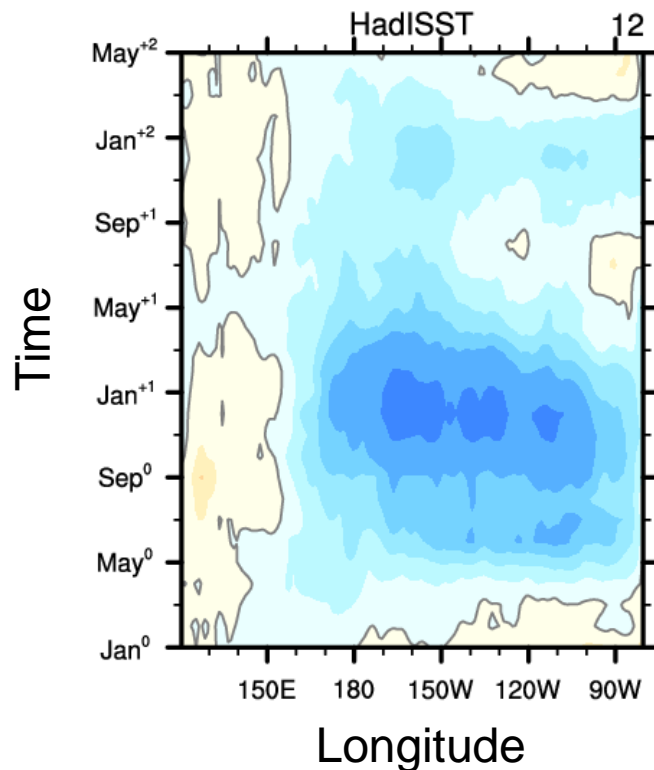


# La Niña Composite (3°S:3°N)



# CESM Evolution 1998-present

La Niña Hovmöller  
 SST averaged from 3°S-3°N, and  
 composited for all nino3.4 events < -1  
 standard deviation

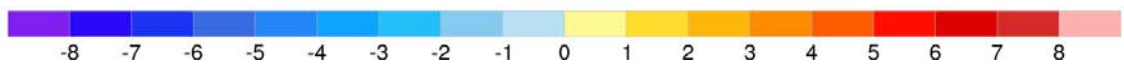
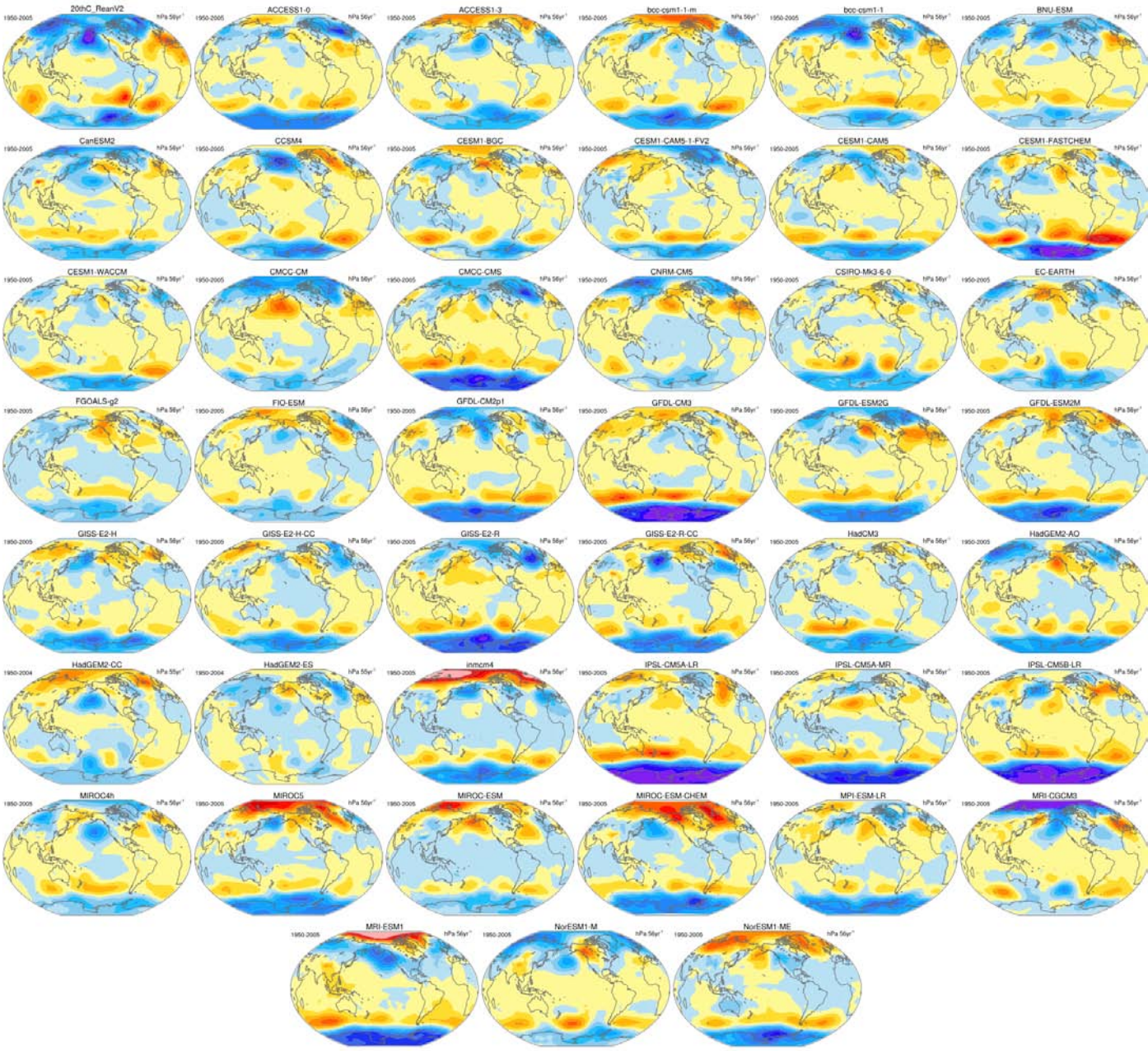


OBS

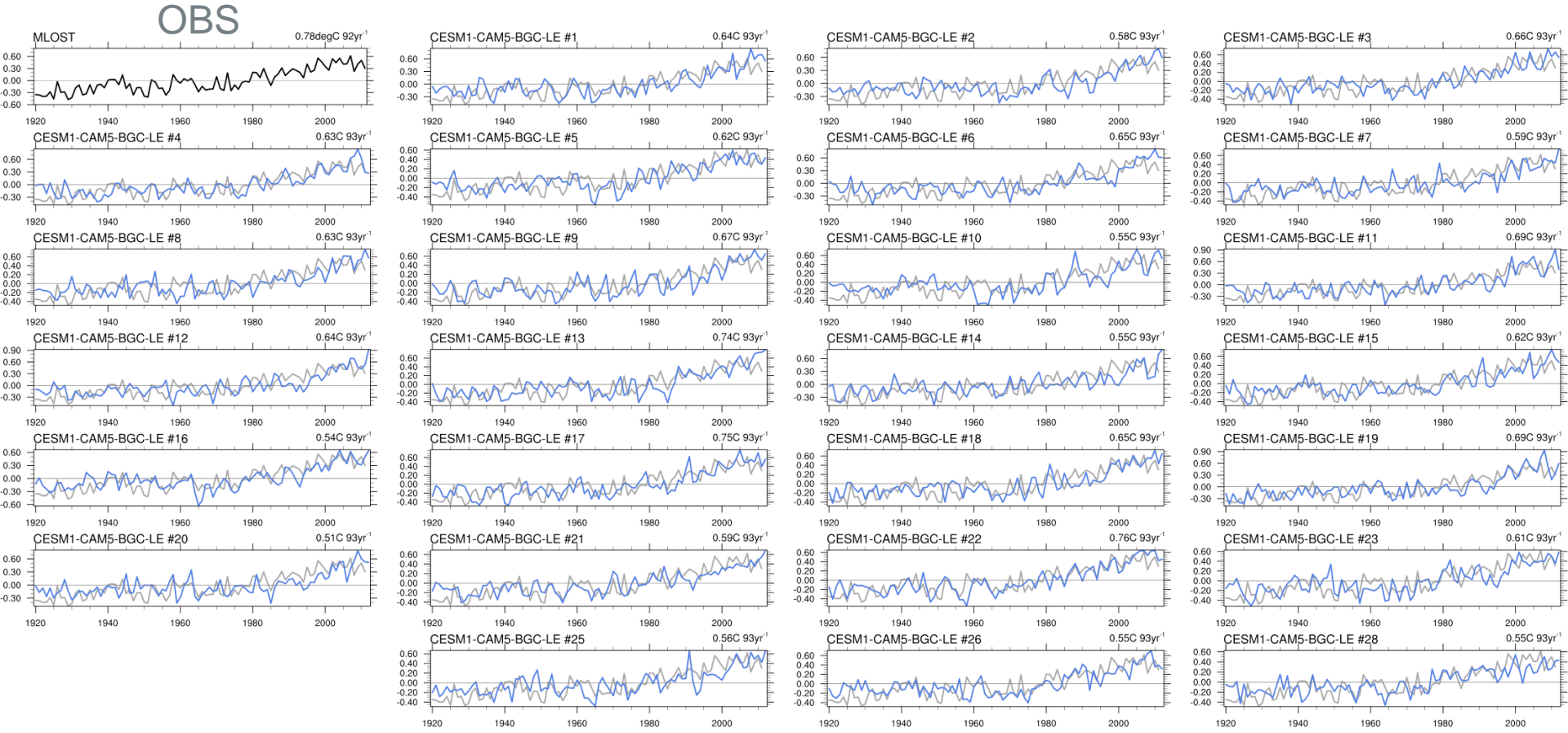
PSL Trends (DJF)

CMIP5  
Historical  
1950-2005

PSL Trends  
1950-2005  
(DJF)

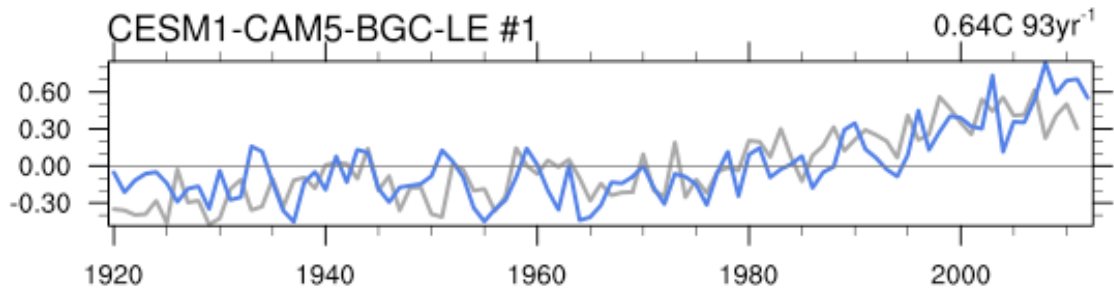


# TAS Global Average (DJF)



CEM1  
Large Ensemble  
1920-2012

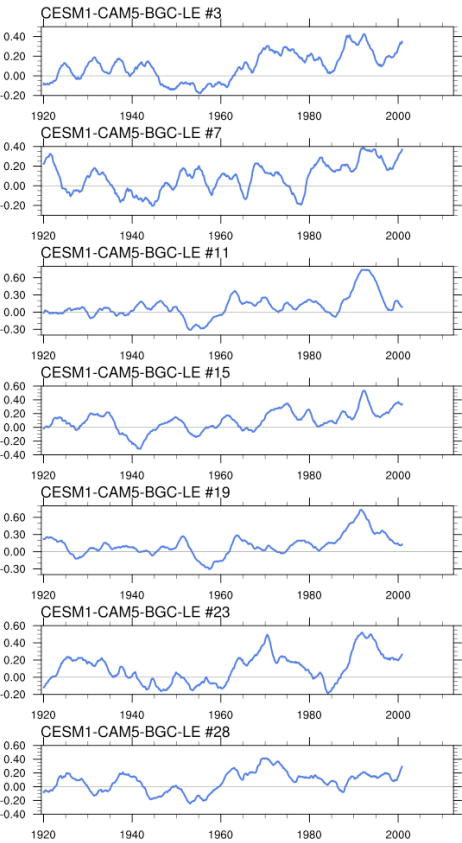
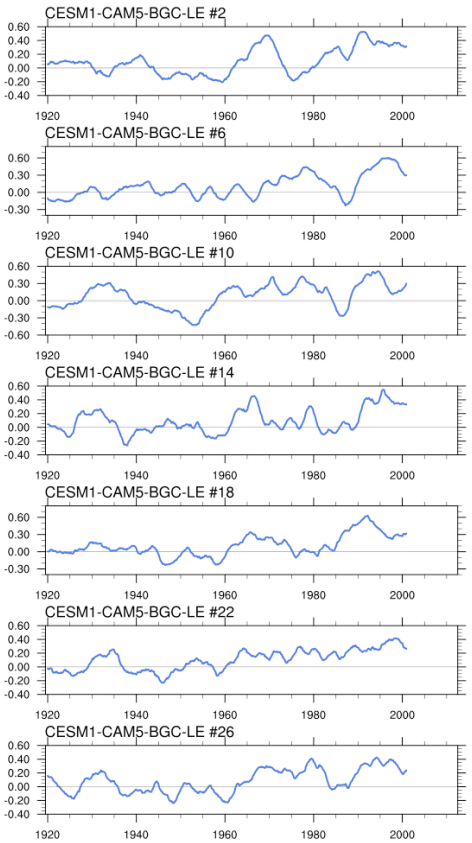
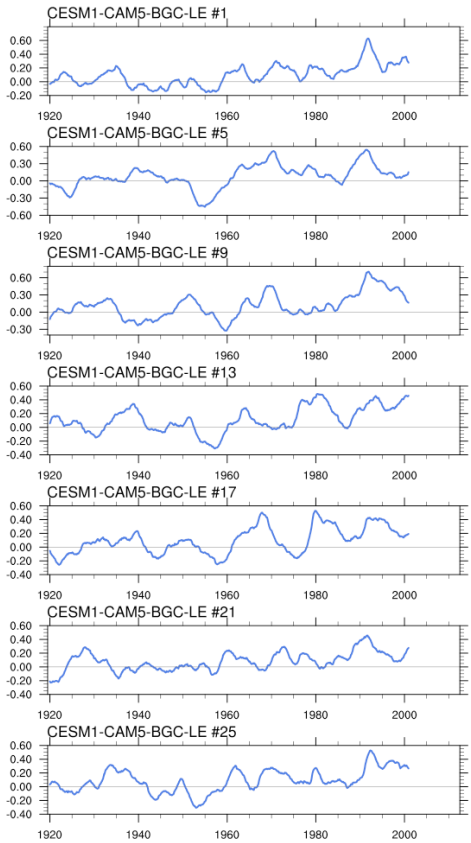
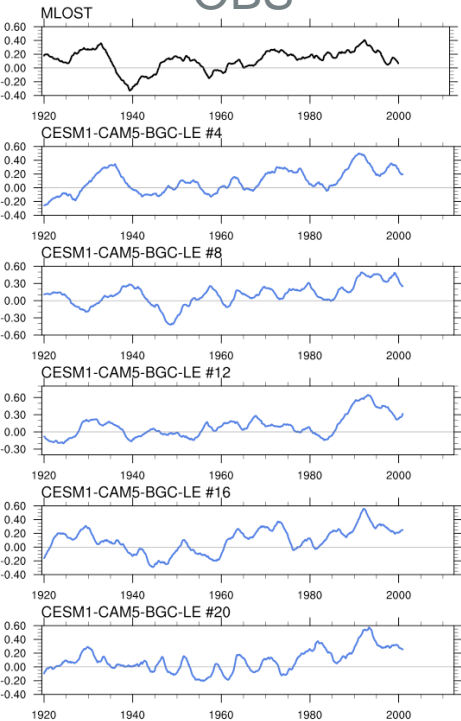
2m Air T Global Average





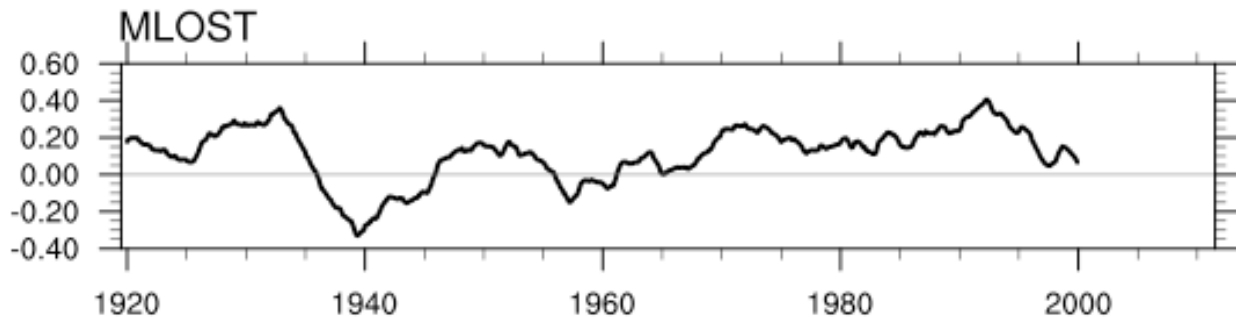
# TAS Running 12yr Trend (Monthly)

OBS



CESM1  
Large Ensemble  
1920-2012

2m Air T Global  
Running Trends



NCAR  
UCAR

CGD's Climate An  
Climate Var

[Methodology](#) | [Metrics Table](#)

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## Methodology

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- TS is surface ("skin") temperature and is used in lieu of SSTs, TAS is 2m air temperature and is equivalent to TREFHT.
- PR is total precipitation and is equivalent to CESM variables PRECC+PRECL, PSL is sea level pressure, and SNOWDP is snow depth.
- The annual cycle is removed prior to every calculation.
- Area-averages are always based on cosine of the latitude weighting.
- All calculations are detrended with the exception of trend maps, global area-average timeseries, and all atmospheric modes and their associated timeseries.

**AMO** (Atlantic  
Multidecadal  
Oscillation)

Timeseries defined as North Atlantic SST (0:60°N, 80°W:0°E) minus global SST (60°S:60°N). Pattern created by regressing SST anomalies onto timeseries. Smoothed timeseries (black line) created by running timeseries through 61 month running average. Based on Trenberth, K. E., and D. J. Shea (2006), Atlantic hurricanes and natural variability in 2005, *Geophys. Res. Lett.*, 33, L12704, doi:10.1029/2006GL026894.

**PDO** (Pacific Decadal  
Oscillation)

Global mean (60°S:70°N) SST removed at each timestep, square root of the cosine of the latitude weighting applied, and leading EOF and associated principal component (PC) timeseries computed over 20:70°N, 110:160°E. Pattern created by regressing SST anomalies onto normalized PC timeseries. See Deser, C., M. A. Alexander, S. -P. Xie, and A. S. Phillips, 2010: Sea surface temperature variability: patterns and mechanisms. *Ann. Rev. Mar. Sci.*, 2010.2, 115-143, doi:10.1146/annurev-marine-120408-151453.

Seasonal/annual PSL averages are formed, the square root of the cosine of the latitude weighting is applied, and then the leading

# Metrics Table: An objective way to assess performance.



## CGD's Climate Analysis Section Climate Variability Diagnostics Package

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### CESM Comparison

Metrics Table

Pattern Correlations/RMS Differences	ENSO				Decadal Modes		Annular Modes		Variance Maps			Total Score
	ENSO TAS (DJF+1)	ENSO PSL (DJF+1)	El Nino Hov	La Nina Hov	AMO (Monthly)	PDO (Monthly)	NAM (DJF)	SAM (DJF)	SST sigma (Ann)	PSL sigma (Ann)	PR sigma (Ann)	
CESM1 (CAM5.2) LE Control	0.67/0.48	0.80/0.82	0.88/0.32	0.87/0.26	0.73/0.34	0.85/0.07	0.94/0.34	0.93/0.31	0.63/0.09	0.95/0.12	0.79/0.18	0.85/0.30
CESM1 (CAM5.1) Control	0.61/0.51	0.74/0.90	0.89/0.27	0.84/0.30	0.77/0.36	0.84/0.06	0.91/0.41	0.93/0.30	0.63/0.09	0.95/0.12	0.79/0.18	0.84/0.32
CCSM4 Control	0.69/0.52	0.72/1.17	0.90/0.44	0.91/0.39	0.71/0.35	0.83/0.07	0.91/0.53	0.91/0.35	0.69/0.10	0.93/0.16	0.80/0.17	0.84/0.39
CCSM3 Control	0.77/0.36	0.77/0.76	0.47/0.57	0.43/0.59	0.73/0.29	0.73/0.08	0.97/0.33	0.91/0.39	0.64/0.10	0.94/0.15	0.74/0.22	0.80/0.35
CCSM2 Control	0.60/0.47	0.50/1.13	0.54/0.51	0.37/0.65	0.76/0.29	0.74/0.08	0.93/0.39	0.97/0.58	0.59/0.09	0.94/0.17	0.72/0.21	0.77/0.42
CSM1 Control	0.58/0.45	0.72/0.77	0.73/0.30	0.68/0.33	0.56/0.43	0.76/0.08	0.91/0.39	0.93/0.46	0.43/0.16	0.94/0.13	0.71/0.20	0.77/0.34

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### Patter Corr / RMS (wrt OBS)

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	Total Score
CESM1 (CAM5.2) LE Control	0.85/0.30
CESM1 (CAM5.1) Control	0.84/0.32
CCSM4 Control	0.84/0.39
CCSM3 Control	0.80/0.35
CCSM2 Control	0.77/0.42
CSM1 Control	0.77/0.34

File Edit Search Preferences Shell Macro Windows

```

load "$NCARG_ROOT/lib/ncarg/nclscripts/csm/gsn_code.ncl"
load "$NCARG_ROOT/lib/ncarg/nclscripts/csm/gsn_csm.ncl"

outdir          = "/project/cas/asphilli/CVDP/LE_1920-2012/" ; location of output files (must end in a "/")
                                                         ; It is recommended that a new or empty directory be pointed to here
                                                         ; as existing files in outdir can get removed.

namelists_only  = "False" ; Set to True to only create the variable namelists. Useful
                                                         ; upon running the package for the first time to verify that the correct
                                                         ; files are being selected by the package. (See files in namelist_byvar/ directory)
                                                         ; Set to False to run the entire package.

obs             = "True" ; True = plot OBS (specified in namelist_obs), False = do not
scale_timeseries = "True" ; True = scale timeseries so that x-axis length is comparable across timeseries, k
output_data     = "True" ; True = output selected calculated data to a netCDF file. Make sure .nc files from
                                                         ; runs are in outdir or they will get added to/modified.

compute_modes_mon = "True" ; True = compute DJF, MAM, JJA, SON, Annual and Monthly Atmospheric Modes of Variability
                                                         ; False = do not compute the Monthly Atmospheric Modes of Variability (saves comp

;-----
opt_climo       = "Full" ; "Full" = remove climatology based on full record of each simulation,
                                                         ; "Custom" = use start and end year of climatological period specified by climo_syear and climo_eyear

if (opt_climo.eq."Custom") then
  climo_syear   = 1920 ; remove the climatology/annual cycle based on these years when opt_climo = "Custom"
  climo_eyear   = 2010 ; note: climo_syear and climo_eyear should be within the range of years of all analyses
end if ; and specified observational datasets.

;-----
output_type     = "png" ; "ps" or "png". Note that for output_type = "ps", png's are created from the .ps files
png_scale       = 1.5 ; Will be used if output type = "png". Value between .1->5. Any value > 1 (< 1) increase
webpage_title   = "CESM Large Ensemble Comparison 1920-2012" ; Default = 1, which = 1500 (W) x 1500 (H) before automatic cropping of white space
                                                         ; Default title

tar_output      = "True" ; tar up all output in outdir and remove individual files?
                                                         ; When tar files in outdir will be created, any files that are not tarred will be removed from the outdir directory

;=====END USER MODIFICATIONS=====
version = "3.9.7"

```

## Requirements

- Input file names must end in "YYYYMM-YYYYMM.nc", and those specified dates are what is actually in the file.
- Users must look at their data. (Ha. Ha.)

- Reads in timeseries as opposed to history files.

# Package Highlights

- Calculates the major modes of variability along with trends and provides quantifiable metric tables.
- Can run on non-CESM (ex. CMIP3/5) data, allowing intercomparisons between CESM and other models.
- Compares numerous model simulations at once, and can choose a unique period of study for each.
- Can output calculations to netCDF files.
- Runs on centuries of data, and is relatively fast.
- If a variable is missing for a simulation the package runs with what it has.

# Future Plans

- All input welcome (asphilli@ucar.edu); future additions/modifications likely.
- Currently being run by friendly users (=those who ask).
- Package will be released to all when NCL v6.2.0 is released in mid-late March.
- Will send out an email to the CVCWG email-list when package is released.

<http://www2.cesm.ucar.edu/working-groups/cvcwg>