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.

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Climate Variability Diagnostics Package

Methodology | Metrics Table
Climatological Period Used: Full
Input Namelists: OBS | Models
Derived Namelists: PR | PSL | SND | TAS | TS
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CVDP Version 3.0.7

CESM Comparison

Means and Standard Deviation Maps

SST	DJF	MAM	JJA	SON	Annual
TAS	DJF	MAM	JJA	SON	Annual
PSL	DJF	MAM	JJA	SON	Annual
PR	DJF	MAM	JJA	SON	Annual

Coupled Modes of Variability

AMO	Pattern	Timeseries	Power Spectra
PDO	Pattern	Timeseries	Power Spectra
ENSO	Spatial Composites	JJA^{0}	SON^{0}
		DJF^{+1}	MAM^{+1}
		El Niño Hovmöller	La Niña Hovmöller
	Niño3.4	Timeseries	Power Spectra
		Monthly Std. Dev.	Running Std. Dev.

Global Trend Maps

SST	DJF	MAM	JJA	SON	Annual	Monthly
TAS	DJF	MAM	JJA	SON	Annual	Monthly
PSL	DJF	MAM	JJA	SON	Annual	Monthly
PR	DJF	MAM	JJA	SON	Annual	Monthly
SND	DJF	MAM	JJA	SON	Annual	Monthly

Global Timeseries

SST	DJF	MAM	JJA	SON	Annual	Monthly
TAS	DJF	MAM	JJA	SON	Annual	Monthly
PR	DJF	MAM	JJA	SON	Annual	Monthly

Global Timeseries Running Trends (Monthly)

SST	8yr	10yr	12yr	14yr	16yr
TAS	8yr	10yr	12yr	14yr	16yr

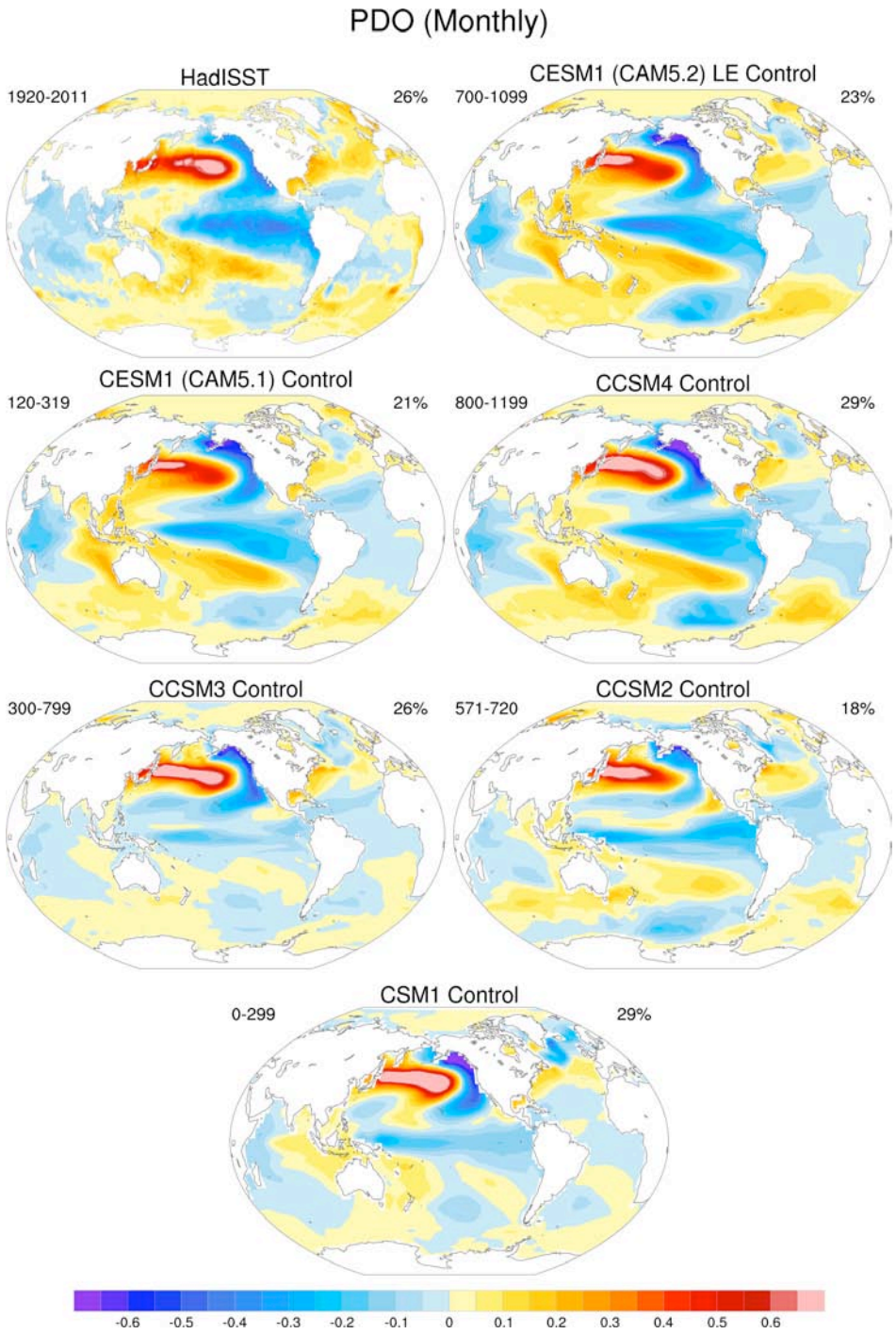
Zonal Averages

PR	DJF	MAM	JJA	SON	Annual

Additional Indices

North Pacific Index	Tropical North Atlantic SST	Tropical South Atlantic SST	Tropical Indian Ocean SST
niño1+2 Timeseries	niño3 Timeseries	niño4 Timeseries	Indian Ocean Dipole

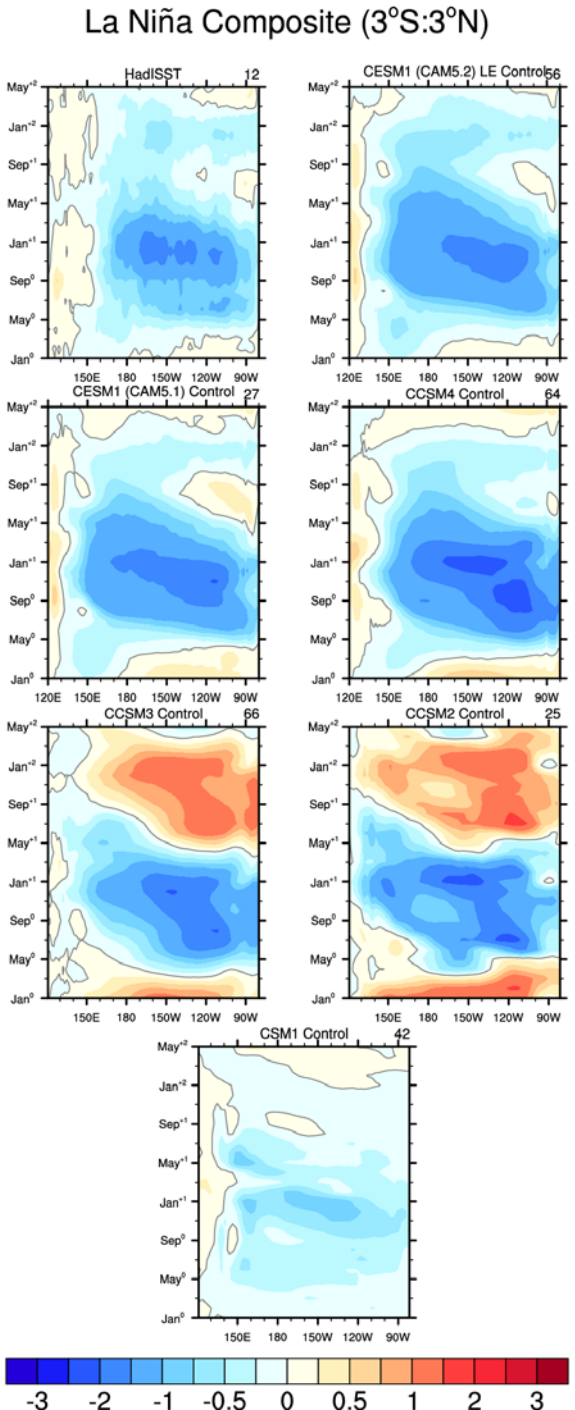
PSA2	Timeseries	DJF	MAM	JJA	SON	Annual	Monthly
	SST Regressions	DJF	MAM	JJA	SON	Annual	Monthly



CESM Evolution 1998-present

Pacific Decadal Oscillation

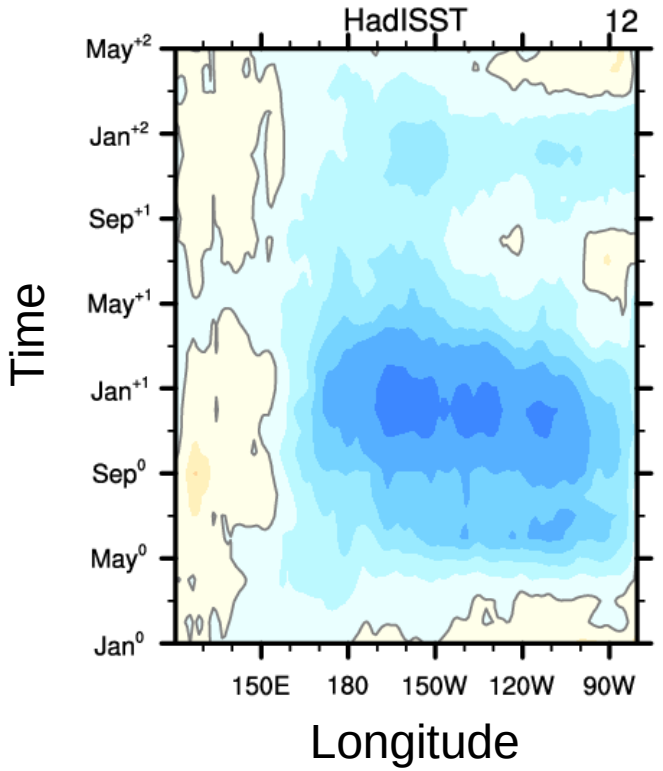
1st EOF of North Pacific SST (20°:90°N, 110:160°E)

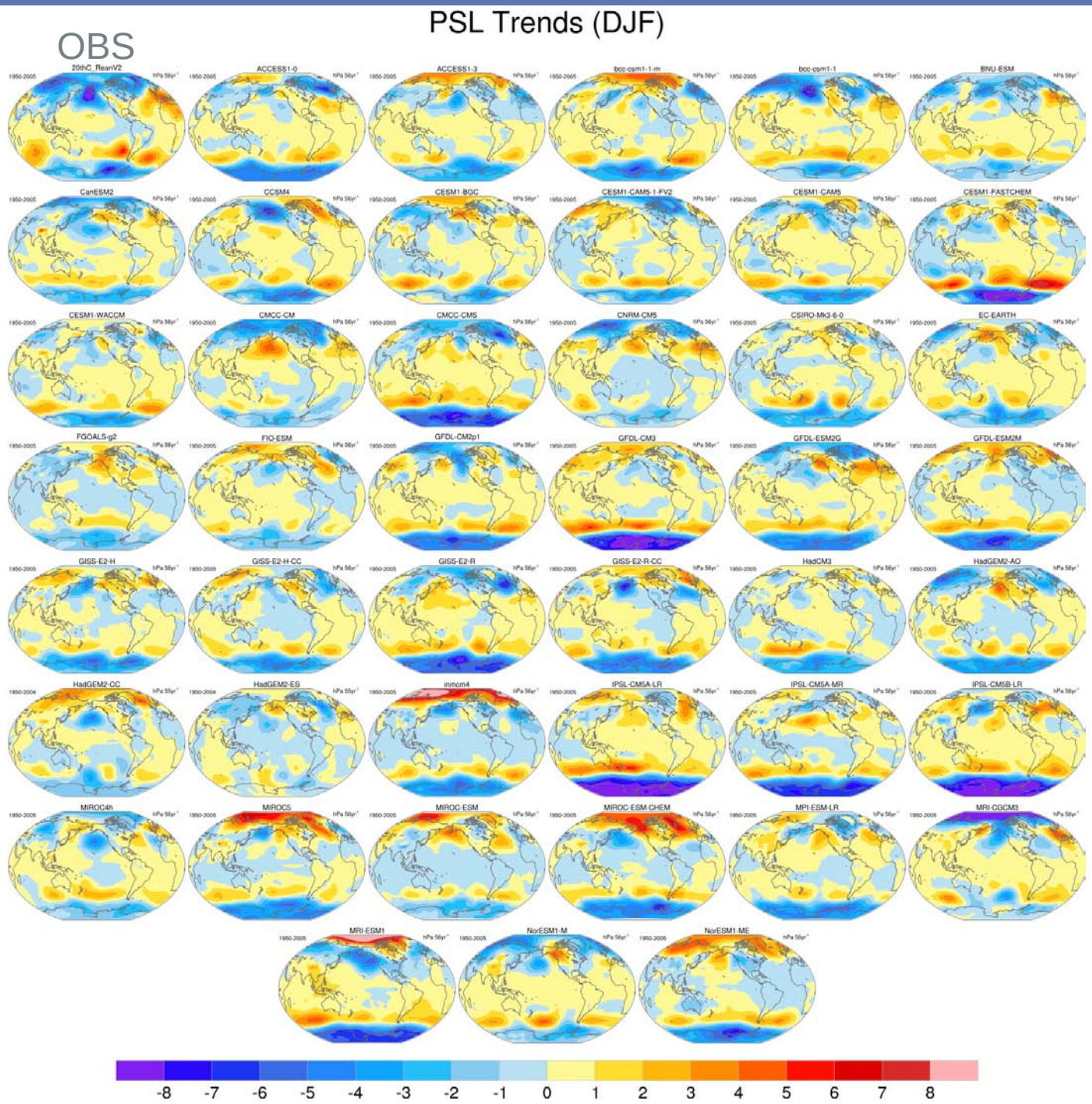


CESM Evolution 1998-present

La Niña Hovmöller

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

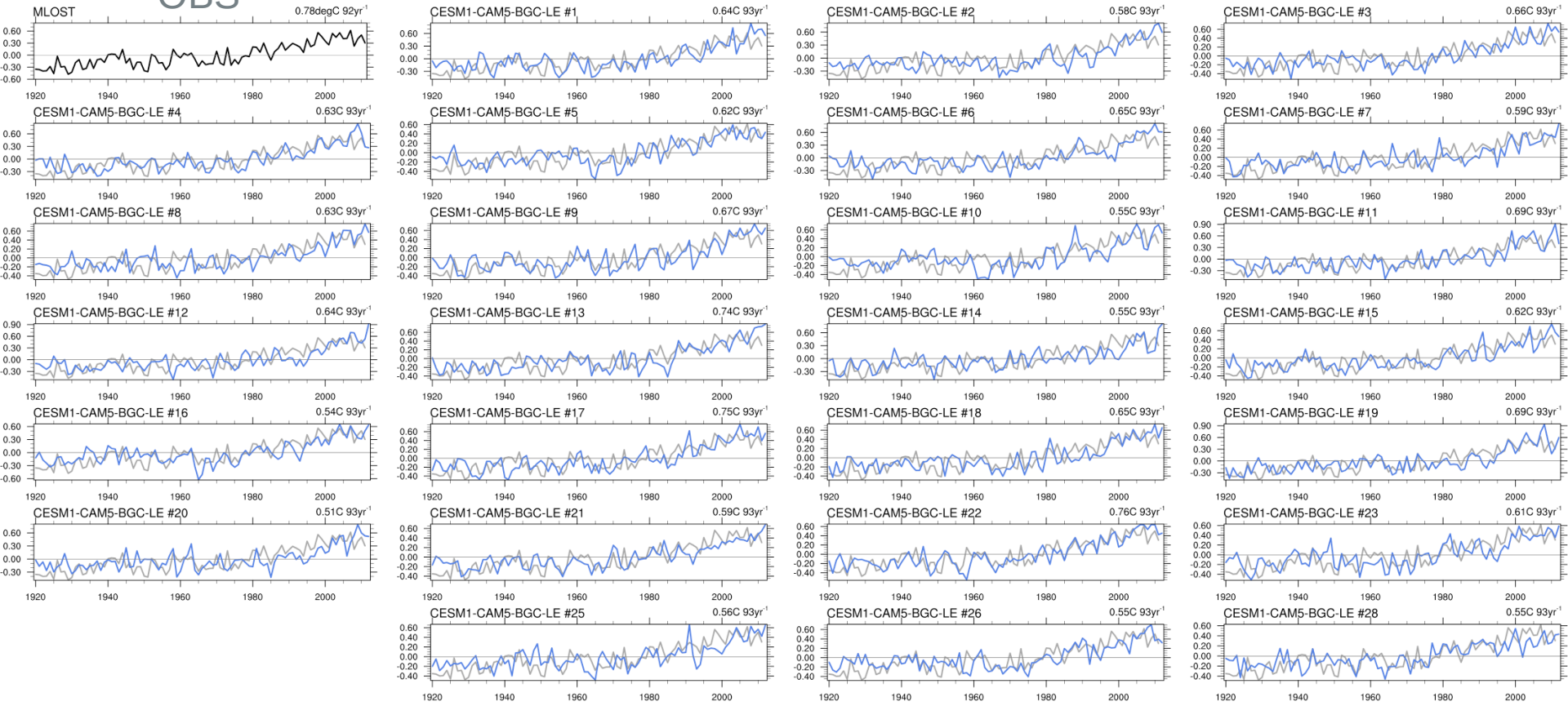




CMIP5
Historical
1950-2005

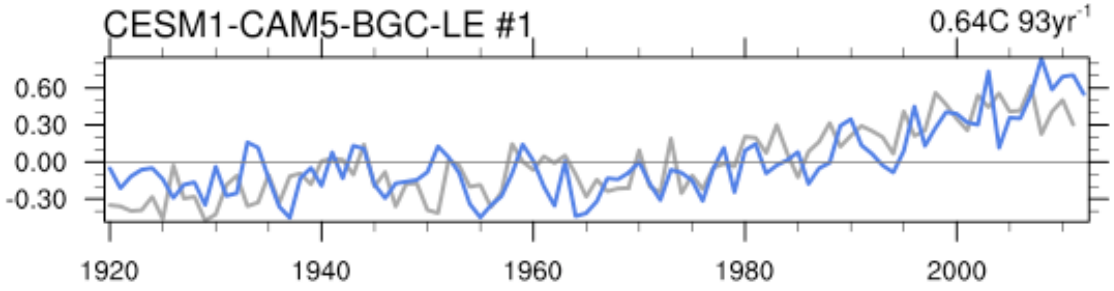
PSL Trends
1950-2005
(DJF)

TAS Global Average (DJF)



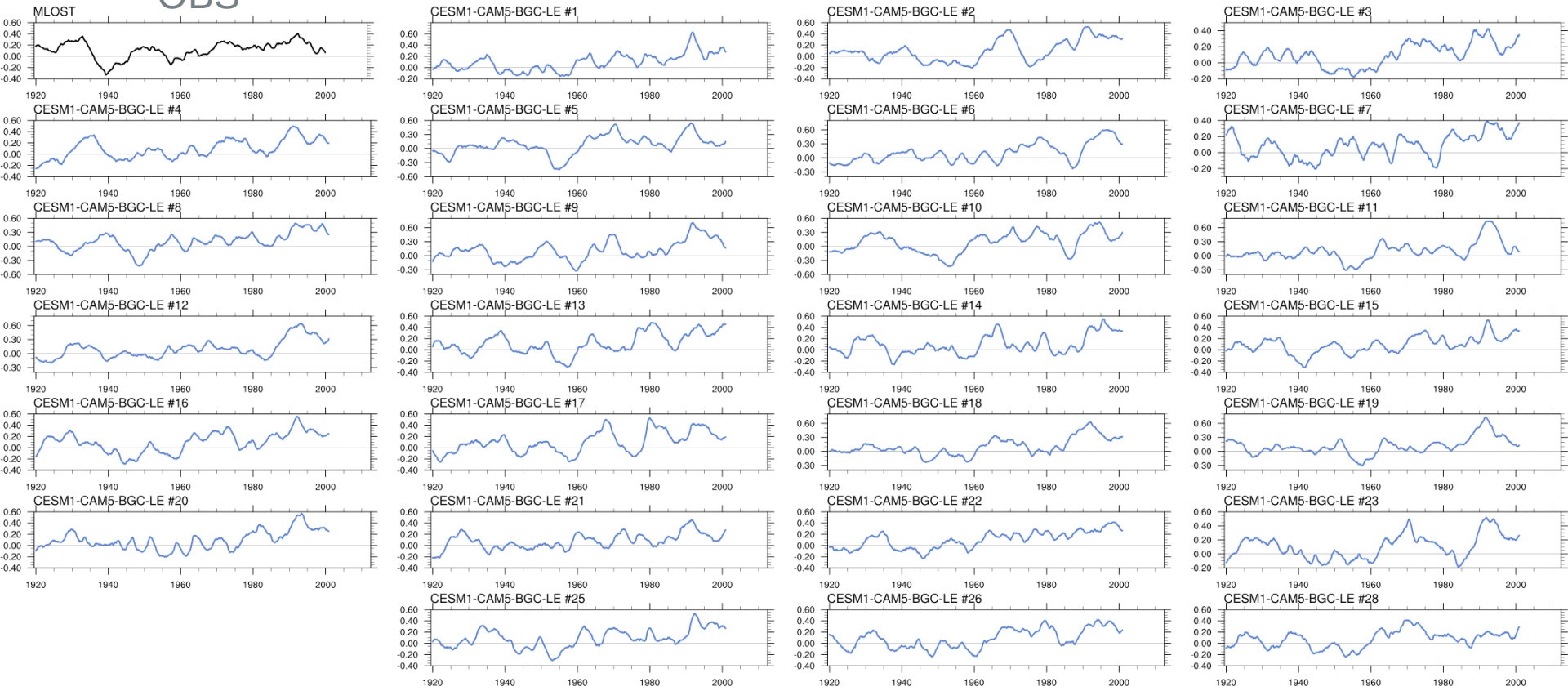
CESM1 Large Ensemble 1920-2012

2m Air T Global Average



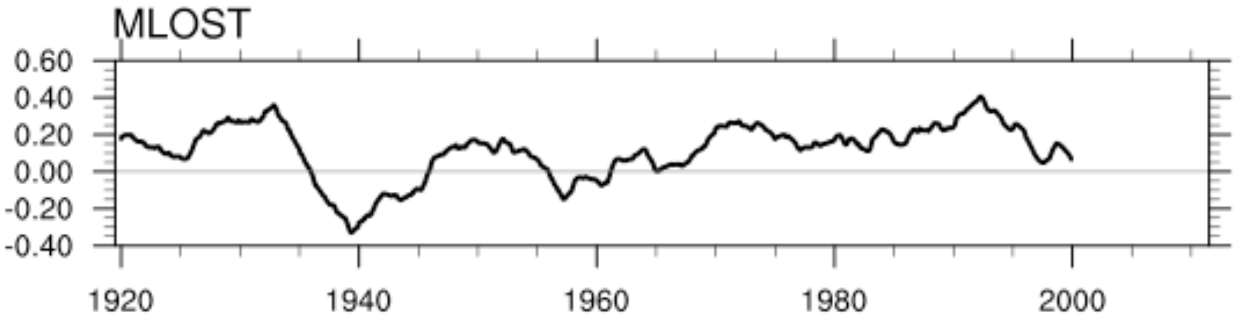
TAS Running 12yr Trend (Monthly)

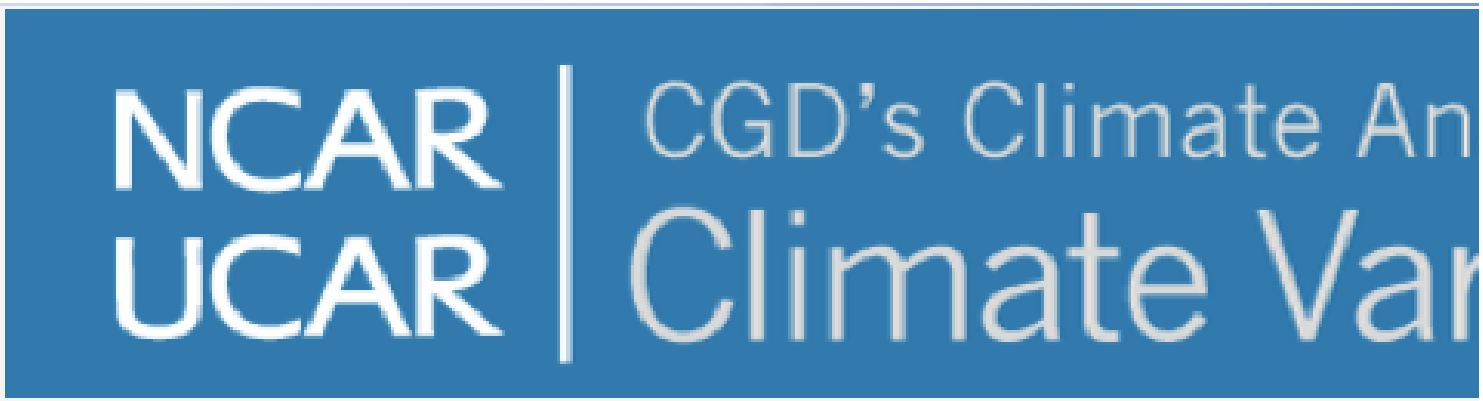
OBS



CESM1 Large Ensemble 1920-2012

2m Air T Global Running Trends





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Methodology

Back to Diagnostics Plots

- 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 timerseries. 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.

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Climate Variability Diagnostics Package

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CESM Comparison

Metrics Table

ENSO | Decadal Modes | Annular Modes | Variance Maps

Pattern Correlations/RMS Differences Observations vs. Model(s)

	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)	Total Score
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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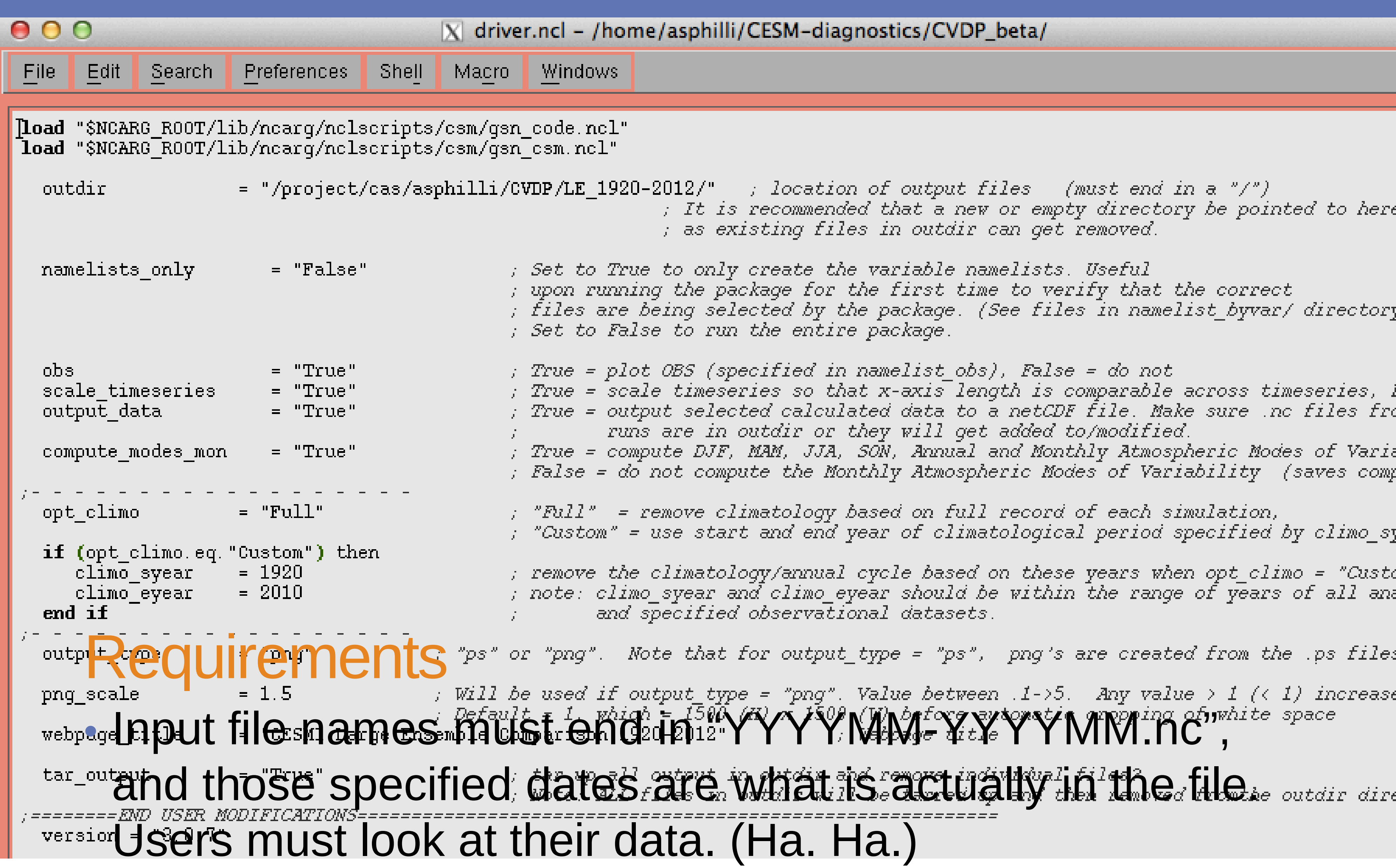
Patter Corr / RMS (wrt OBS)

	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



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