NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

Adam Phillips and Clara Deser

John Fasullo, Isla Simpson, Dave Schneider

Climate Analysis Section, NCAR

CGD Seminar

17 November 2020

NCAR

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

Adam Phillips and Clara Deser

John Fasullo, Isla Simpson, Dave Schneider

Climate Analysis Section, NCAR

CGD Seminar

17 November 2020

NCAR

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

An automated analysis tool and data repository for exploring forced and internal components of climate variability and change.

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

ed analysis tool and
tory for **exploring**
ternal components
iability and change.

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

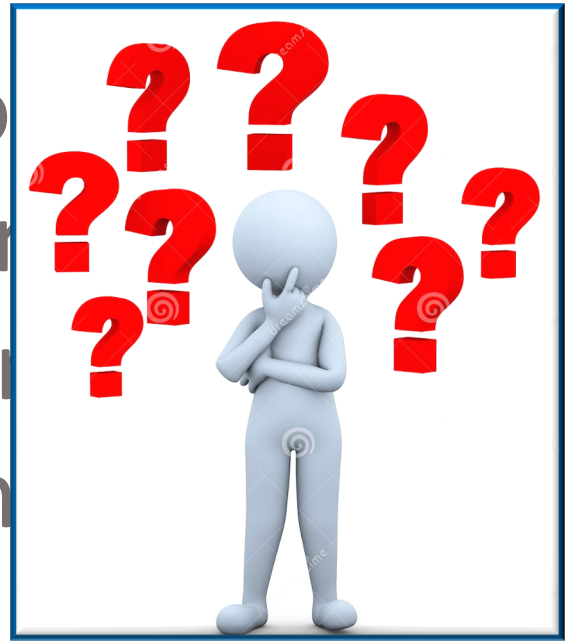
https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

ed analysis too

tory for explor

ternal compon

iability and ch



NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

- How well does my model simulate: ENSO? AMV? PDV? AMOC? NAO? Variability in general?

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

- How well does my model simulate: ENSO? AMV? PDV? AMOC? NAO? Variability in general?
- How does my model compare with other models (and are there true structural differences)?

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

- How well does my model simulate: ENSO? AMV? PDV? AMOC? NAO? Variability in general?
- How does my model compare with other models (and are there true structural differences)?
- Does climate change affect internal variability?

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

- How well does my model simulate: ENSO? AMV? PDV? AMOC? NAO? Variability in general?
- How does my model compare with other models (and are there true structural differences)?
- Does climate change affect internal variability?
- What are the relative contributions of internal variability and forced climate change to long-term trends?

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

- How well does my model simulate: ENSO? AMV? PDV? AMOC? NAO? Variability in general?
- How does my model compare with other models (and are there true structural differences)?
- Does climate change affect internal variability?
- What are the relative contributions of internal variability and forced climate change to long-term trends?

➢ *Initial-condition Large Ensembles*

Initial-condition Large Ensembles

Initial-condition Large Ensembles

nature climate change

30 March 2020
Deser et al.

PERSPECTIVE
https://doi.org/10.1038/s41558-020-0731-2

US CLIVAR Working Group on Large Ensembles

Insights from Earth system model initial-condition large ensembles and future prospects

C. Deser[1,2]✉, F. Lehner[1,2], K. B. Rodgers[2,3,4], T. Ault[2,5], T. L. Delworth[2,6], P. N. DiNezio[2,7], A. Fiore[2,8], C. Frankignoul[2,9], J. C. Fyfe[2,10], D. E. Horton[2,11], J. E. Kay[2,12,13], R. Knutti[2,14], N. S. Lovenduski[2,12,15], J. Marotzke[2,16], K. A. McKinnon[2,17], S. Minobe[2,18], J. Randerson[2,19], J. A. Screen[2,20], I. R. Simpson[1,2] and M. Ting[2,8]

What are they? Why are they useful?

How large do they need to be?

How are they best designed?

Emerging applications and future directions?

The CESM1 Large Ensemble Project

Historical & RCP8.5
radiative forcing

Year 401

simulation #1

1850 control

2100

The CESM1 Large Ensemble Project

Historical & RCP8.5
radiative forcing

Year 401

1850 control

1920

2100

40 simulations
(parallel worlds)

Different atmospheric initial states ***Perturbed by order 10^{-14} K***
Same ocean, ice & land initial states *(1 Jan 1920)*

The CESM1 Large Ensemble Project

+

Internal climate variability

Historical & RCP8.5 radiative forcing

Year 401

1850 control

1920

2100

40 simulations (parallel worlds)

Different atmospheric initial states ***Perturbed by order 10^{-14} K***

Same ocean, ice & land initial states *(1 Jan 1920)*

The CESM1 Large Ensemble Project

+

Internal climate variability

Historical & RCP8.5 radiative forcing

Year 401

1850 control

1920

2100

40 simulations (parallel worlds)

spread is not predictable! ***(beyond ~ 10 years)***

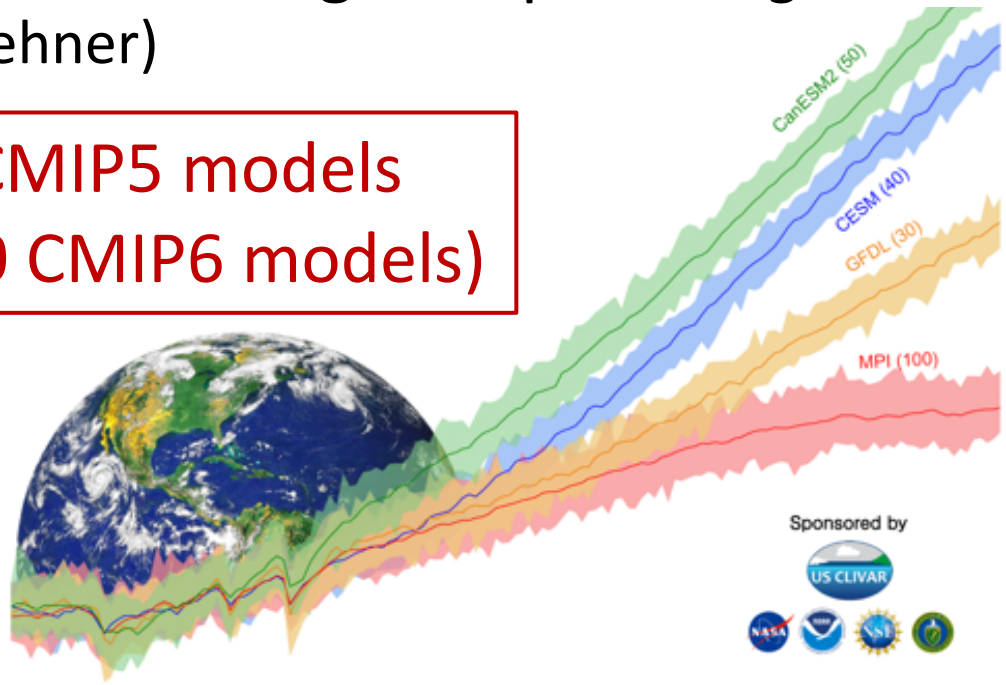
Different atmospheric initial states ***Perturbed by order 10^{-14} K***

Same ocean, ice & land initial states *(1 Jan 1920)*

MULTI-MODEL LARGE ENSEMBLE ARCHIVE (MMLEA)

US CLIVAR Working Group on *Large Ensembles*
(Flavio Lehner)

7 CMIP5 models
(10 CMIP6 models)



https://www.cesm.ucar.edu/projects/community-projects/MMLEA/

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

Like the original CVDP

- Computes modes of variability, trends, and climate indices.
- All output saved to a data repository for later use.
- User specifies the data sets (models & observations).

New for the CVDP-LE

- Computes ensemble mean and ensemble spread.
- Quantitative comparison to observations (rank metrics).
- Comprehensive User's Guide.

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

Tutorial and teaching resource

User's Guide (35 pages)

- Background on internal climate variability
- Utility of Large Ensembles
- Diagnostics and metrics (fully referenced)
- Treatment of observational uncertainty
- Two views: *Ensemble Summary* vs. *Individual Members*
- Interpretation of plots and metrics
- Best practices and tips for applying the package

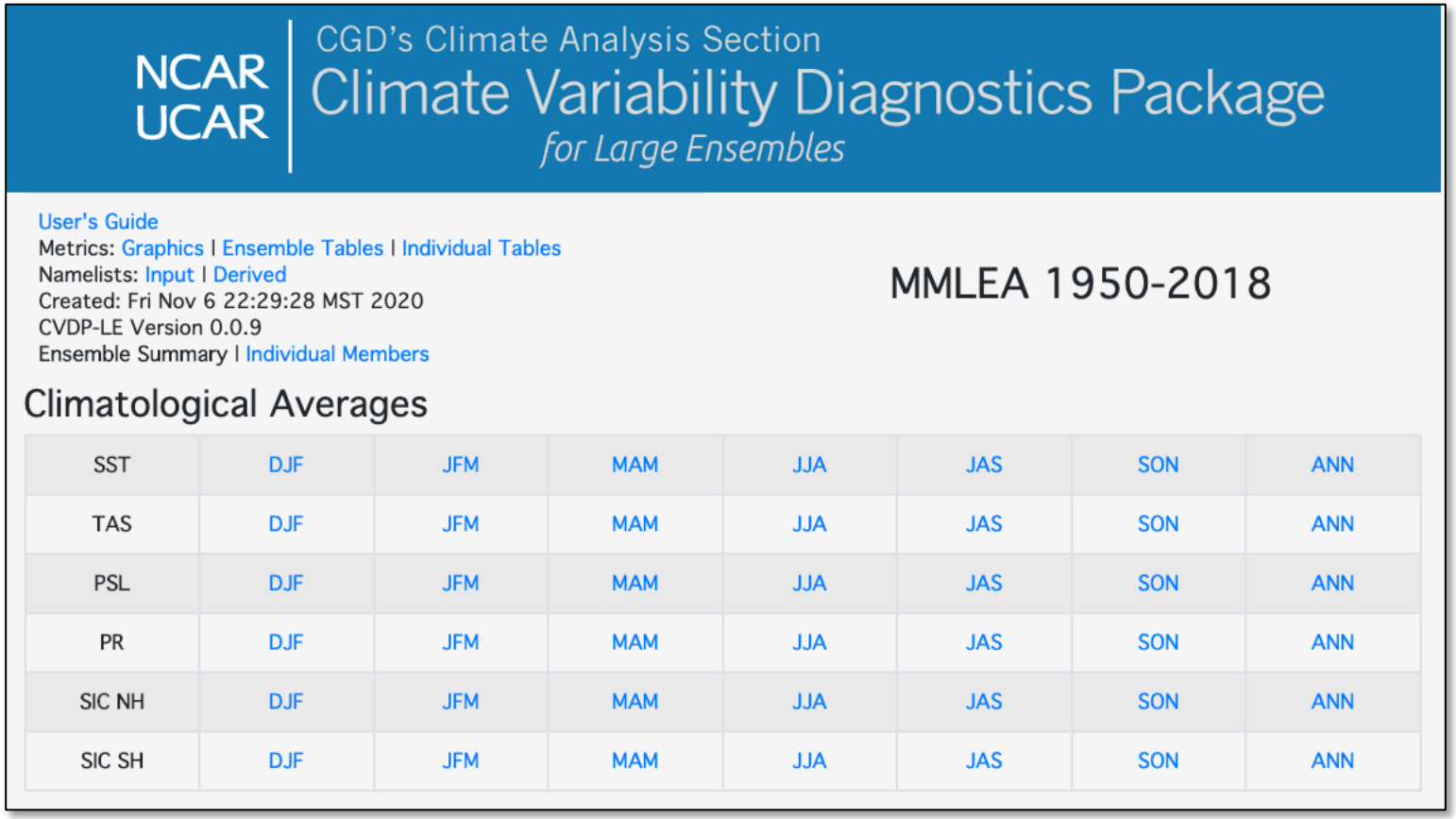
Phillips, A. S., C. Deser, J Fasullo, D. P. Schneider and I. R. Simpson, 2020: Assessing Climate Variability and Change in Model Large Ensembles: A User's Guide to the "Climate Variability Diagnostics Package for Large Ensembles", doi:10.5065/h7c7-f961

Tutorial and teaching resource

User's Guide (35 pages)

- Background on internal climate variability
- Utility of Large Ensembles
- Diagnostics and metrics (fully referenced)
- Treatment of observational uncertainty
- Two views: *Ensemble Summary* vs. *Individual Members*
- Interpretation of plots and metrics
- Best practices and tips for applying the package

Diagnostics Overview



NCAR UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

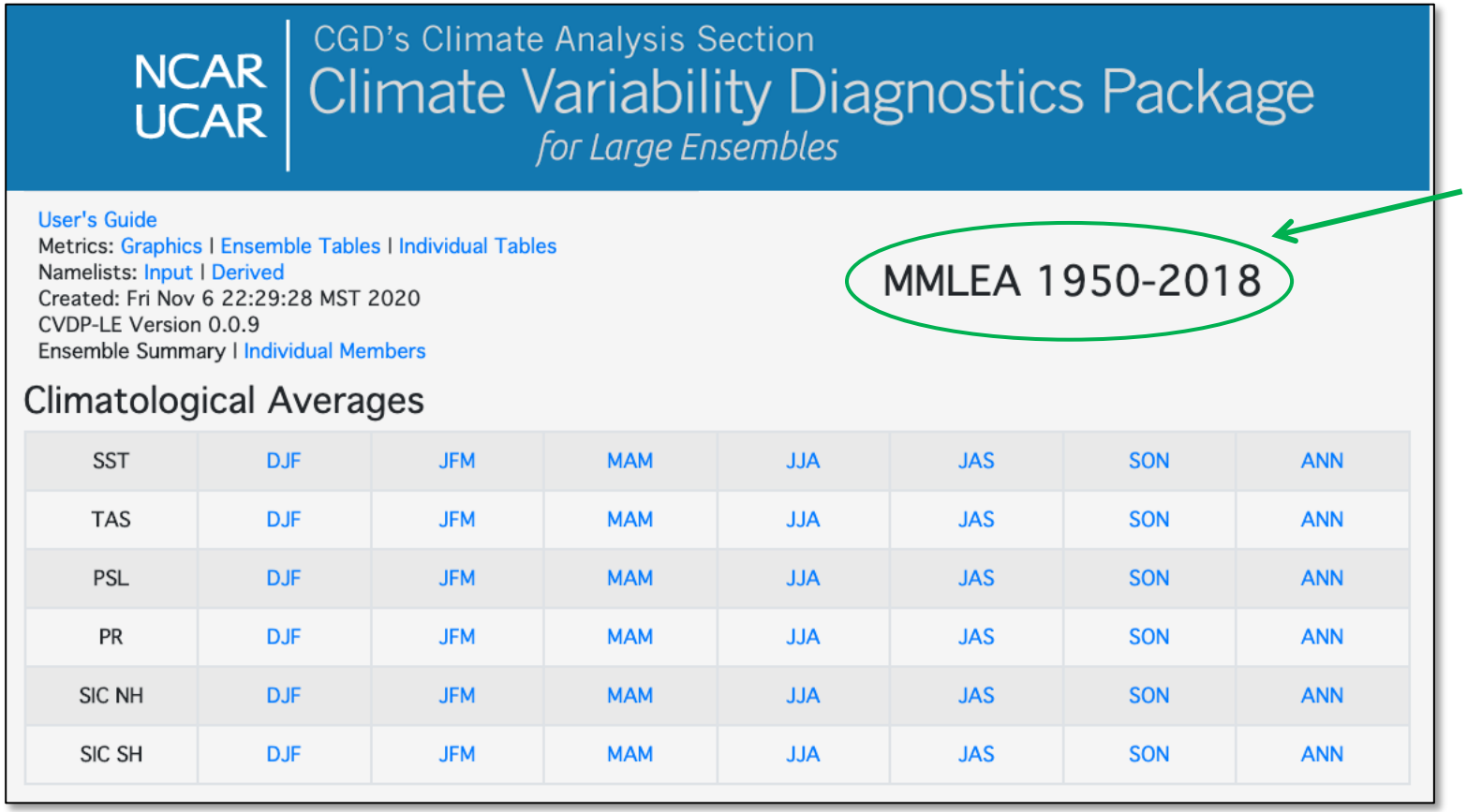
User's Guide
Metrics: Graphics | Ensemble Tables | Individual Tables
Namelists: Input | Derived
Created: Fri Nov 6 22:29:28 MST 2020
CVDP-LE Version 0.0.9
Ensemble Summary | Individual Members

MMLEA 1950-2018

Climatological Averages

SST	DJF	JFM	MAM	JJA	JAS	SON	ANN
TAS	DJF	JFM	MAM	JJA	JAS	SON	ANN
PSL	DJF	JFM	MAM	JJA	JAS	SON	ANN
PR	DJF	JFM	MAM	JJA	JAS	SON	ANN
SIC NH	DJF	JFM	MAM	JJA	JAS	SON	ANN
SIC SH	DJF	JFM	MAM	JJA	JAS	SON	ANN

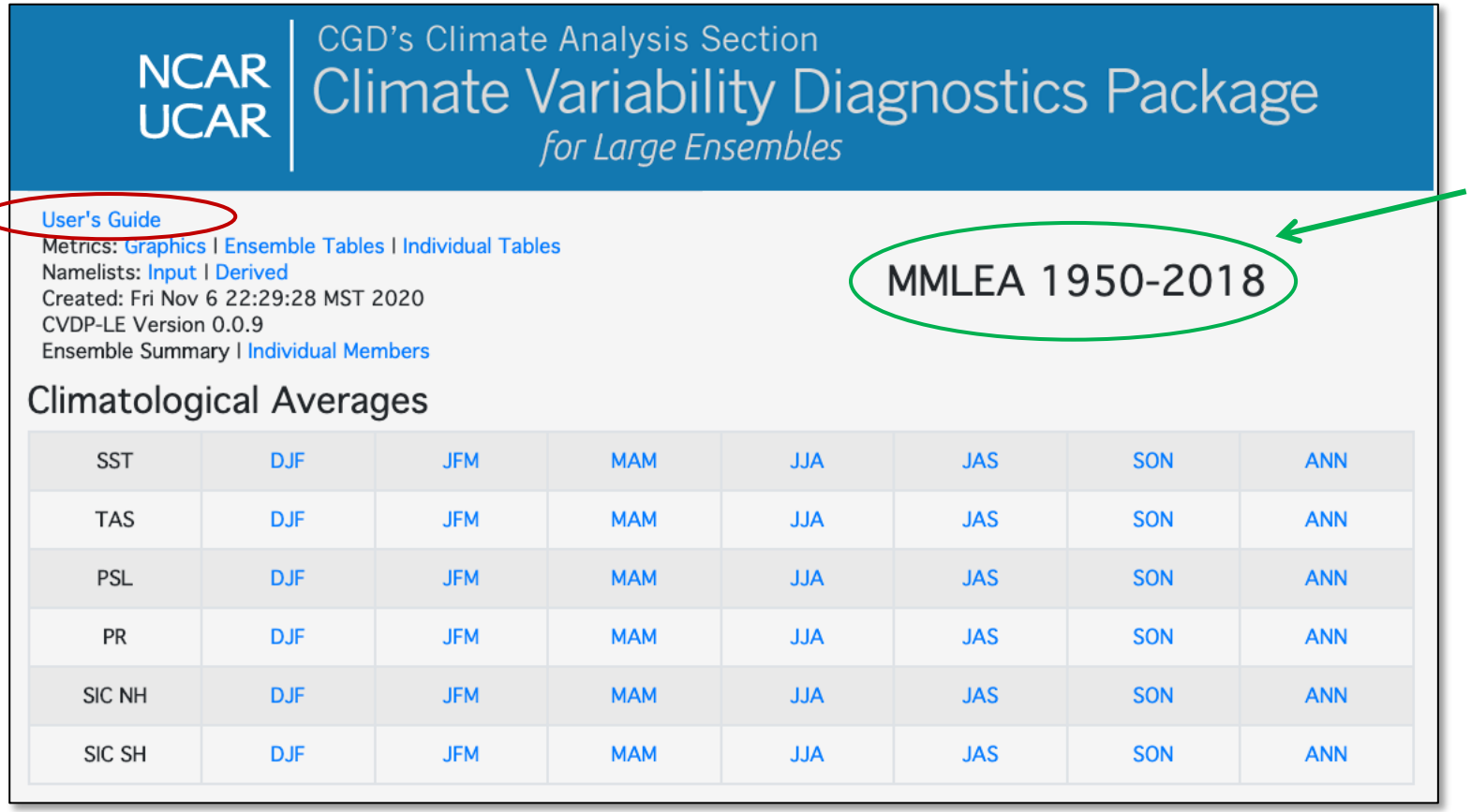
Diagnostics Overview



User-specified title

Diagnostics Overview

Link to User's Guide



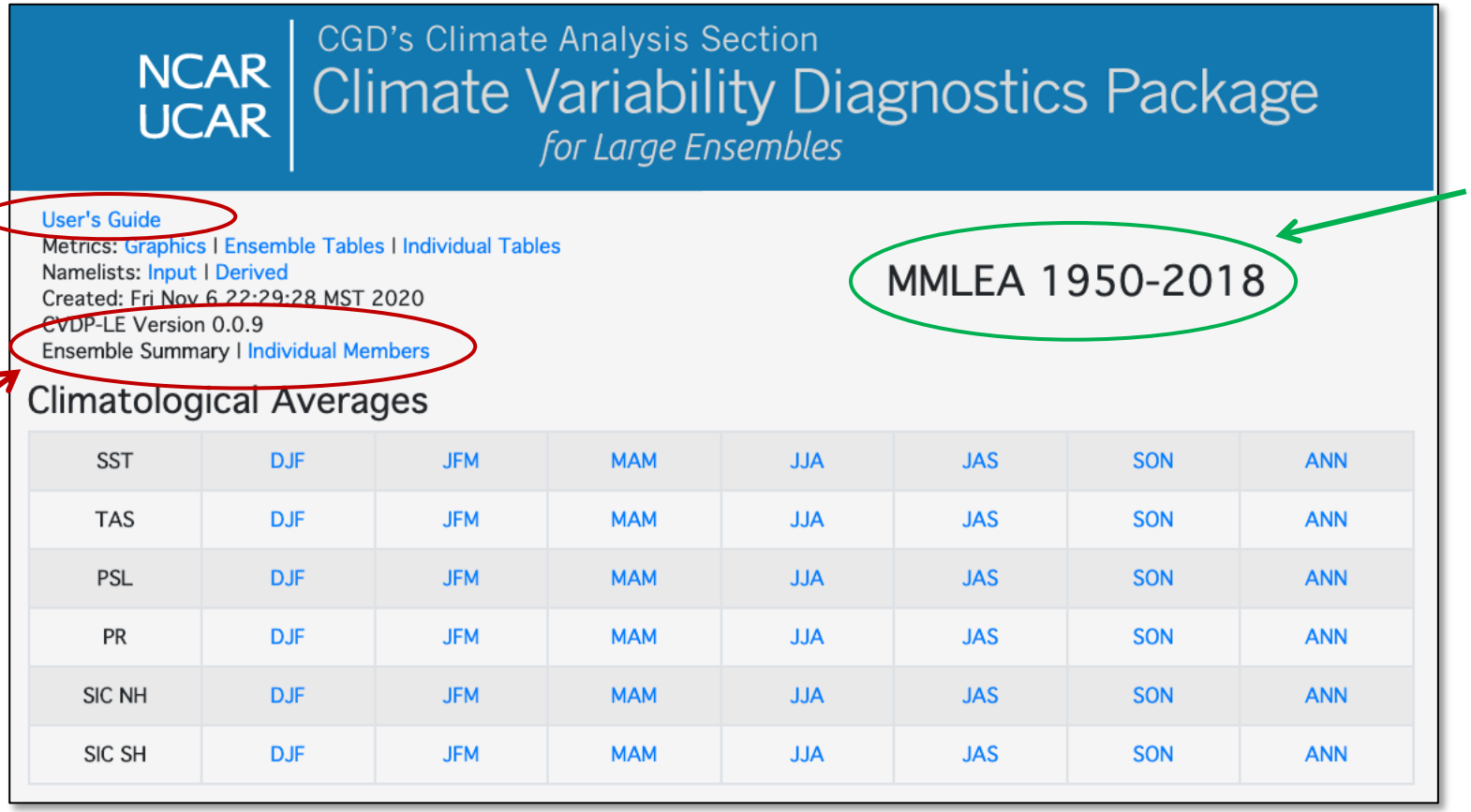
User-specified title

Diagnostics Overview

Link to User's Guide

Two ways of viewing the output

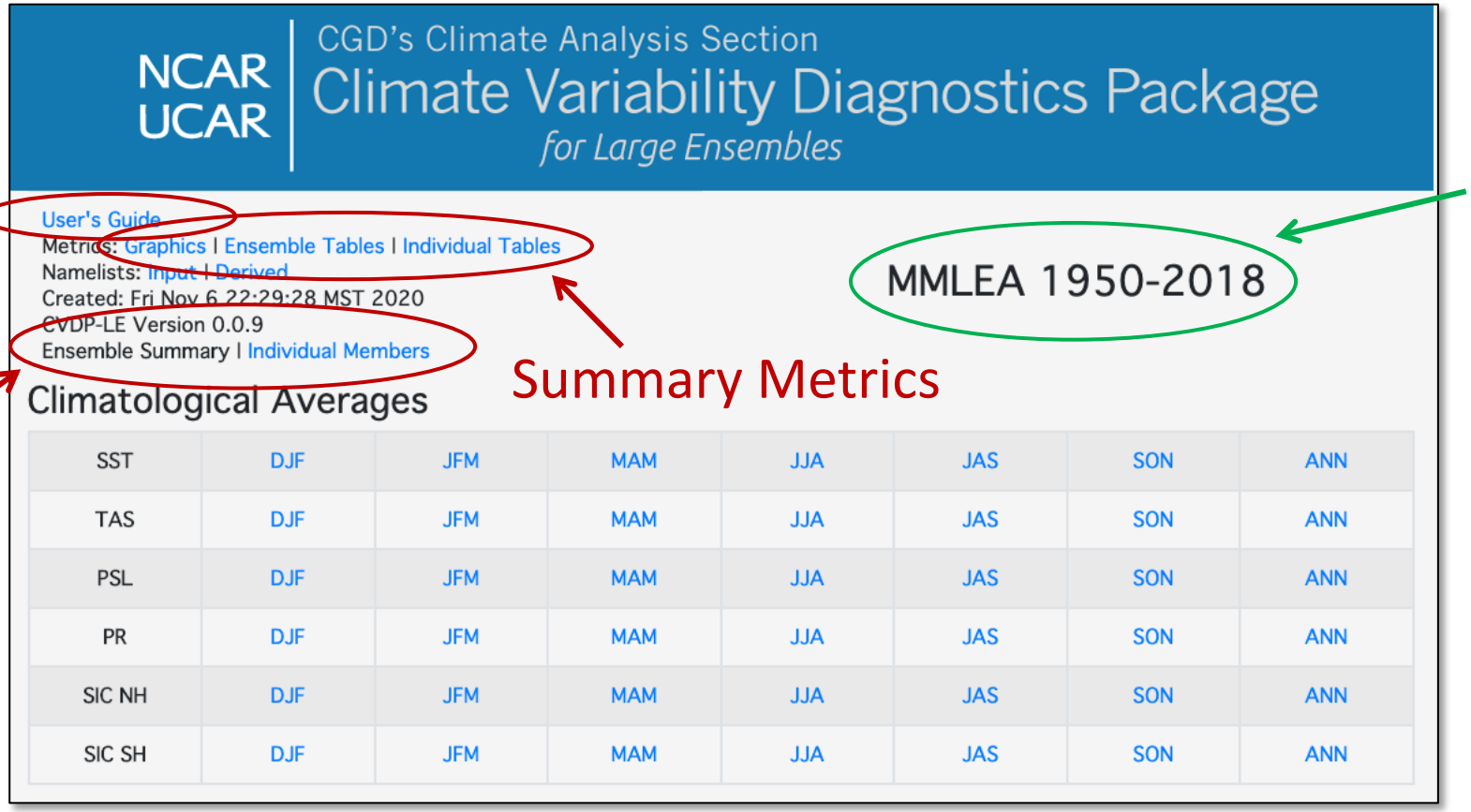
User-specified title



Diagnostics Overview

Link to User's Guide

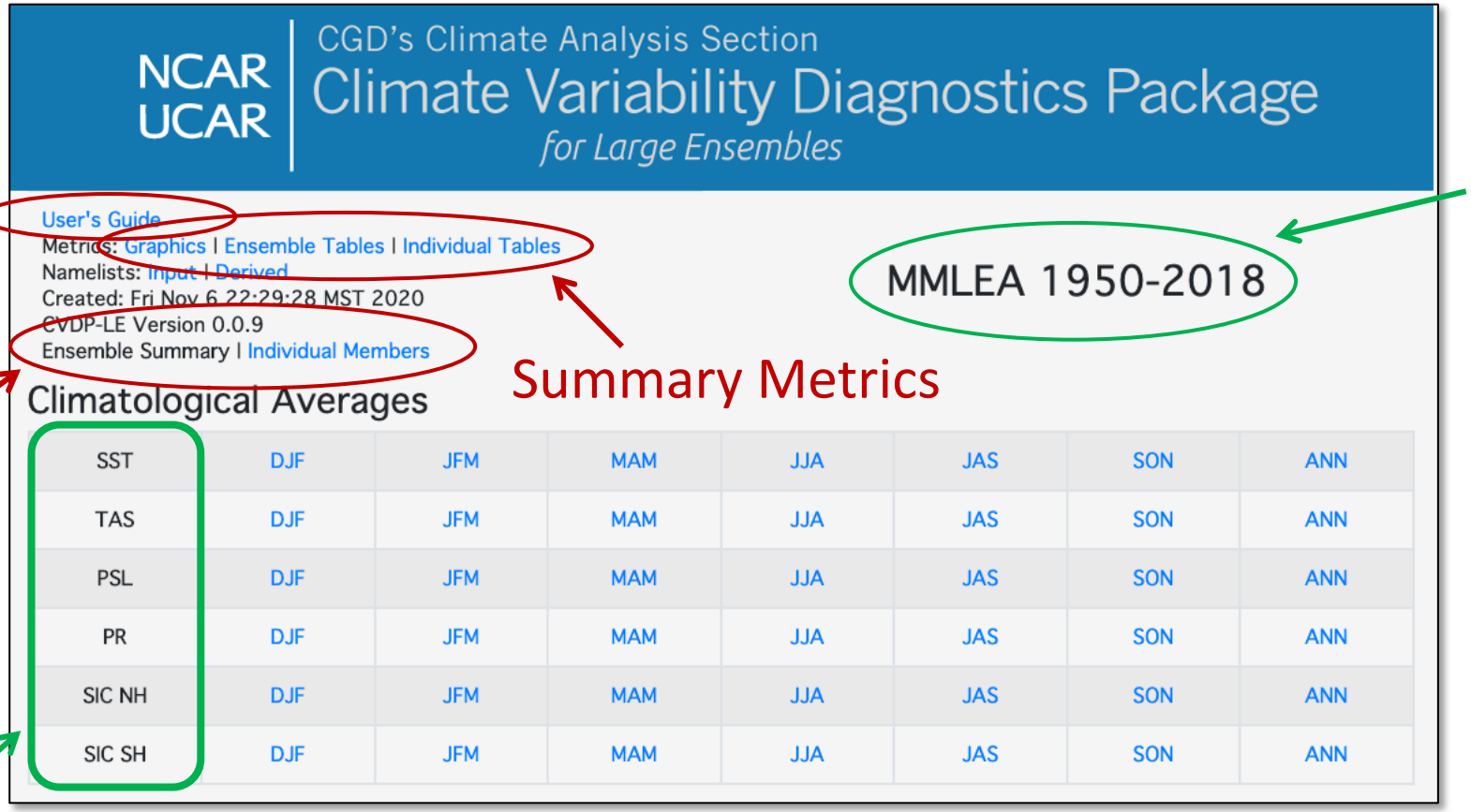
Two ways of viewing the output



Summary Metrics

User-specified title

Diagnostics Overview



Link to User's Guide

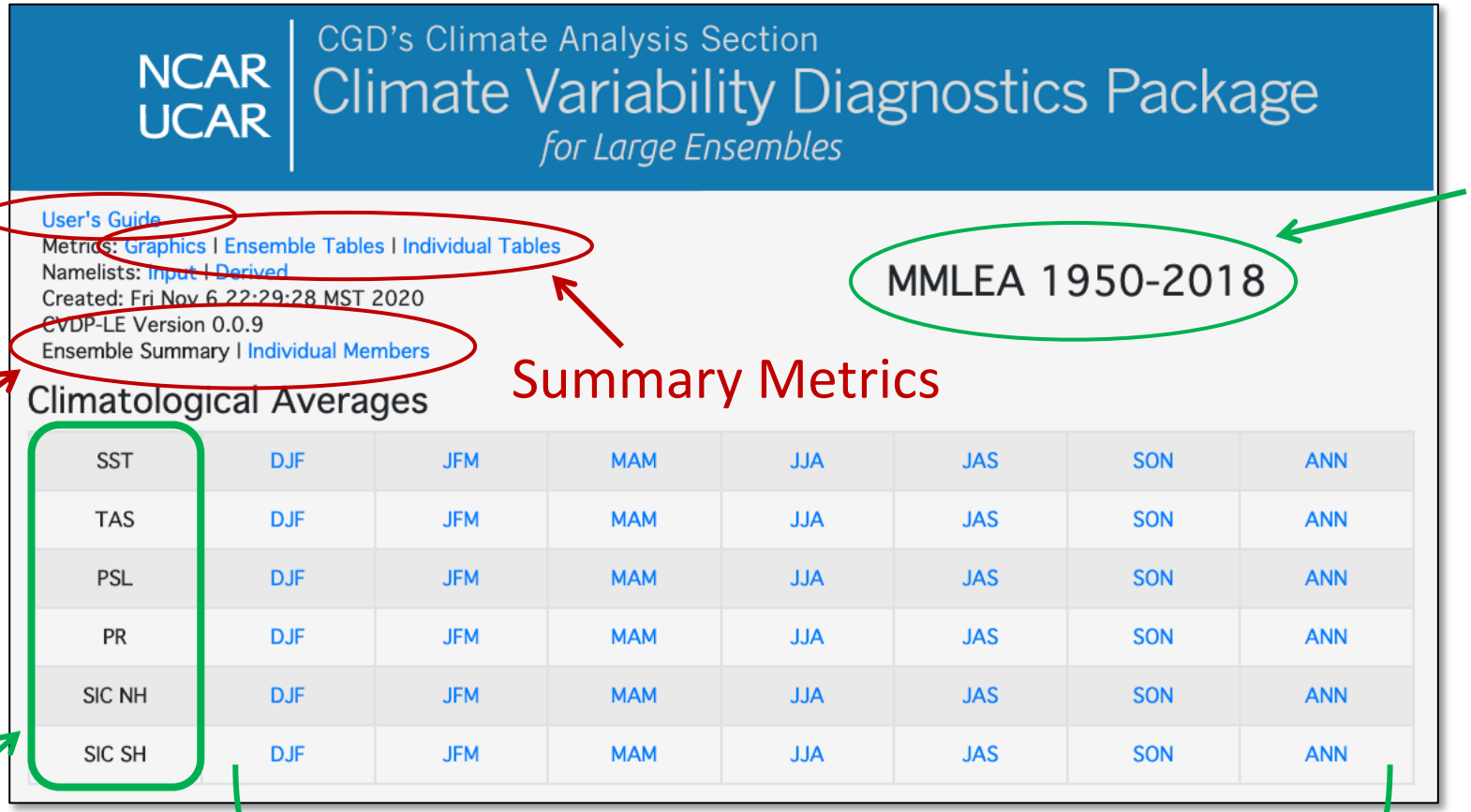
User-specified title

Summary Metrics

Two ways of viewing the output

Variables

Diagnostics Overview



Link to User's Guide

User-specified title

Summary Metrics

Two ways of viewing the output

Variables

Seasons

NCAR UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

User's Guide
Metrics: Graphics | Ensemble Tables | Individual Tables
Namelists: Input | Derived
Created: Mon Nov 9 14:29:53 MST 2020
CVDP-LE Version 0.0.9
Ensemble Summary | Individual Members

MMLEA 1950-2018

Climatological Averages

SST	DJF	JFM	MAM	JJA	JAS	SON	ANN
TAS	DJF	JFM	MAM	JJA	JAS	SON	ANN
PSL	DJF	JFM	MAM	JJA	JAS	SON	ANN
PR	DJF	JFM	MAM	JJA	JAS	SON	ANN
SIC NH	DJF	JFM	MAM	JJA	JAS	SON	ANN
SIC SH	DJF	JFM	MAM	JJA	JAS	SON	ANN

Standard Deviations

SST	DJF	JFM	MAM	JJA	JAS	SON	ANN
TAS	DJF	JFM	MAM	JJA	JAS	SON	ANN
PSL	DJF	JFM	MAM	JJA	JAS	SON	ANN
PR	DJF	JFM	MAM	JJA	JAS	SON	ANN
SIC NH	DJF	JFM	MAM	JJA	JAS	SON	ANN
SIC SH	DJF	JFM	MAM	JJA	JAS	SON	ANN

Global Trend Maps

SST	DJF	JFM	MAM	JJA	JAS	SON	ANN
TAS	DJF	JFM	MAM	JJA	JAS	SON	ANN
PSL	DJF	JFM	MAM	JJA	JAS	SON	ANN
PR	DJF	JFM	MAM	JJA	JAS	SON	ANN
SIC NH	DJF	JFM	MAM	JJA	JAS	SON	ANN
SIC SH	DJF	JFM	MAM	JJA	JAS	SON	ANN

NCAR UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

User's Guide
Metrics: Graphics | Ensemble Tables | Individual Tables
Namelists: Input | Derived
Created: Mon Nov 9 14:29:53 MST 2020
CVDP-LE Version 0.0.9
Ensemble Summary | Individual Members

MMLEA 1950-2018

Climatological Averages

SST	DJF	JFM
TAS	DJF	JFM
PSL	DJF	JFM
PR	DJF	JFM
SIC NH	DJF	JFM
SIC SH	DJF	JFM

Standard Deviations

SST	DJF	JFM
TAS	DJF	JFM
PSL	DJF	JFM
PR	DJF	JFM
SIC NH	DJF	JFM
SIC SH	DJF	JFM

Global Trend Maps

SST	DJF	JFM
TAS	DJF	JFM
PSL	DJF	JFM
PR	DJF	JFM
SIC NH	DJF	JFM
SIC SH	DJF	JFM

Coupled Modes of Variability

ENSO	Spatial Composites	El Niño - La Niña SST/TAS/PSL JJA^0 SON^0 DJF^1 MAM^1	El Niño - La Niña PR JJA^0 SON^0 DJF^1 MAM^1
		El Niño SST/TAS/PSL JJA^0 SON^0 DJF^1 MAM^1	El Niño PR JJA^0 SON^0 DJF^1 MAM^1
		La Niña SST/TAS/PSL JJA^0 SON^0 DJF^1 MAM^1	La Niña PR JJA^0 SON^0 DJF^1 MAM^1
		El Niño Hovmöller	La Niña Hovmöller
	Niño3.4	Timeseries	Monthly Std. Dev.
		Power Spectra	Wavelet
		Autocorrelation	Running Standard Deviation
AMV	Regr: SST TAS PR	Timeseries	Power Spectra
	Regr LP: SST TAS PR	Timeseries	
AMV'	Regr: SST TAS PR	Timeseries	Power Spectra
	Regr LP: SST TAS PR	Timeseries	
PDV	Regr: SST TAS PR	Timeseries	Power Spectra
PDV'	Regr: SST TAS PR	Timeseries	Power Spectra
AMOC	Means	Standard Deviations	Patterns
	Timeseries	SST/TAS Regressions	
	Spectra	AMV/AMOC Lag Correlations	

NCAR UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

User's Guide
Metrics: Graphics | Ensemble Tables | Individual Tables
Namelists: Input | Derived
Created: Mon Nov 9 14:29:53 MST 2020
CVDP-LE Version 0.0.9
Ensemble Summary | Individual Members

MMLEA 1950-2018

Climatological Averages

SST	DJF	JFM
TAS	DJF	JFM
PSL	DJF	JFM
PR	DJF	JFM
SIC NH	DJF	JFM
SIC SH	DJF	JFM

Standard Deviations

SST	DJF	JFM
TAS	DJF	JFM
PSL	DJF	JFM
PR	DJF	JFM
SIC NH	DJF	JFM
SIC SH	DJF	JFM

Global Trend Maps

SST	DJF	JFM
TAS	DJF	JFM
PSL	DJF	JFM
PR	DJF	JFM
SIC NH	DJF	JFM
SIC SH	DJF	JFM

Coupled Modes of Variability

ENSO									
AMV									
AMV'									
PDV									
PDV'									
AMOC									

Atmospheric Modes of Variability

SO	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
NAM	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
NAO	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
SAM	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
PNA	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
NPO	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
PSA1	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
PSA2	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN

NCAR UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

User's Guide
Metrics: Graphics | Ensemble Tables | Individual Tables
Namelists: Input | Derived
Created: Mon Nov 9 14:29:53 MST 2020
CVDP-LE Version 0.0.9
Ensemble Summary | Individual Members

MMLEA 1950-2018

Climatological Averages

SST	DJF	JFM
TAS	DJF	JFM
PSL	DJF	JFM
PR	DJF	JFM
SIC NH	DJF	JFM
SIC SH	DJF	JFM

Standard Deviations

SST	DJF	JFM
TAS	DJF	JFM
PSL	DJF	JFM
PR	DJF	JFM
SIC NH	DJF	JFM
SIC SH	DJF	JFM

Global Trend Maps

SST	DJF	JFM
TAS	DJF	JFM
PSL	DJF	JFM
PR	DJF	JFM
SIC NH	DJF	JFM
SIC SH	DJF	JFM

Coupled Modes of Variability

ENSO	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
AMV	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
AMV'	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
PDV	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
PDV'	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
AMOC	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN

Atmospheric Modes of Variability

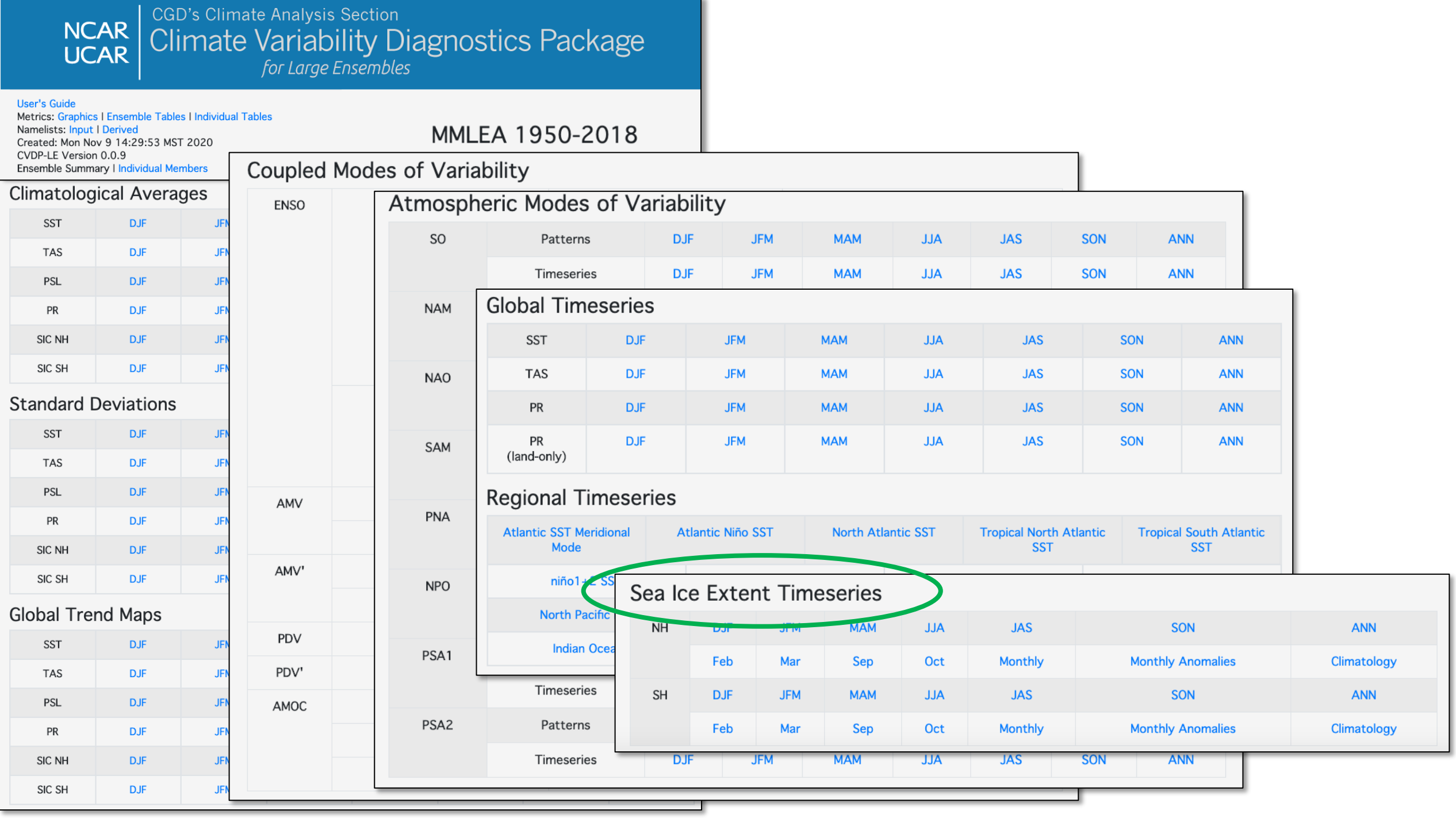
SO	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
NAM	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
NAO	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
SAM	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
PNA	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
NPO	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
PSA1	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN
PSA2	Patterns	DJF	JFM	MAM	JJA	JAS	SON	ANN
	Timeseries	DJF	JFM	MAM	JJA	JAS	SON	ANN

Global Timeseries

SST	DJF	JFM	MAM	JJA	JAS	SON	ANN
TAS	DJF	JFM	MAM	JJA	JAS	SON	ANN
PR	DJF	JFM	MAM	JJA	JAS	SON	ANN
PR (land-only)	DJF	JFM	MAM	JJA	JAS	SON	ANN

Regional Timeseries

Atlantic SST Meridional Mode	Atlantic Niño SST	North Atlantic SST	Tropical North Atlantic SST	Tropical South Atlantic SST
niño1+2 SST	niño3 SST	niño3.4 SST	niño4 SST	
North Pacific PSL Index (NPI)	North Pacific SST Meridional Mode	South Pacific SST Meridional Mode		
Indian Ocean SST Dipole	Tropical Indian Ocean SST	Southern Ocean SST		


NCAR
UCAR
CGD's Climate Analysis Section
Climate Variability Diagnostics Package
for Large Ensembles
User's Guide
Metrics: Graphics | Ensemble Tables | Individual Tables
Namelists: Input | Derived
Created: Mon Nov 9 14:29:53 MST 2020
CVDP-LE Version 0.0.9
Ensemble Summary | Individual Members
MMLEA 1950-2018
Climatological Averages
SST DJF JFM
TAS DJF JFM
PSL DJF JFM
PR DJF JFM
SIC NH DJF JFM
SIC SH DJF JFM
Standard Deviations
SST DJF JFM
TAS DJF JFM
PSL DJF JFM
PR DJF JFM
SIC NH DJF JFM
SIC SH DJF JFM
Global Trend Maps
SST DJF JFM
TAS DJF JFM
PSL DJF JFM
PR DJF JFM
SIC NH DJF JFM
SIC SH DJF JFM
Coupled Modes of Variability
ENSO
AMV
AMV'
PDV
PDV'
AMOC
Atmospheric Modes of Variability
SO Patterns DJF JFM MAM JJA JAS SON ANN
Timeseries DJF JFM MAM JJA JAS SON ANN
NAM
NAO
SAM
PNA
NPO
PSA1
PSA2
Timeseries
Patterns
Timeseries DJF JFM MAM JJA JAS SON ANN
Global Timeseries
SST DJF JFM MAM JJA JAS SON ANN
TAS DJF JFM MAM JJA JAS SON ANN
PR DJF JFM MAM JJA JAS SON ANN
PR (land-only) DJF JFM MAM JJA JAS SON ANN
Regional Timeseries
Atlantic SST Meridional Mode
Atlantic Niño SST
North Atlantic SST
Tropical North Atlantic SST
Tropical South Atlantic SST
niño1+2 SS
North Pacific
Indian Ocea
Sea Ice Extent Timeseries
NH DJF JFM MAM JJA JAS SON ANN
Feb Mar Sep Oct Monthly Monthly Anomalies Climatology
SH DJF JFM MAM JJA JAS SON ANN
Feb Mar Sep Oct Monthly Monthly Anomalies Climatology

NCAR
UCAR

CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

Adam

- Overview of the development process
- Technical guidance
- Webpage and data repository

Clara

- Interpretation of plots and metrics
- Application to the CMIP5 and CMIP6 archives

CVDP-LE Development Path

- Feb 2019-present, started w/CVDP codebase
- Overriding development requirement*:*

Ease of use

- Implemented feature requests (subset):
  - Allow user to specify unlimited number of observations/simulations
  - Allow different time periods for each input dataset
  - Allow missing model data
  - Compute pattern correlations
  - **Allow different units, grids and variable names**
  - Compute the % of time observations falls within model spread
  - Allow no observations
  - Allow different number of ensemble members
  - **Form differences, no matter the grid**
  - Display number of valid members per ensemble
  - Provide clear error messages
  - Package should avoid erroring out
  - Titles/statistics should rarely overlap one another
  - **Modularize as much as it makes sense to do so**

- Comment the code extensively
- Provide documentation and written directions on adding a metric
- Output graphics should be publication quality
- Add consistent titles and statistics to each plot
- **Calculate ensemble metrics, and show via graphics**
- **Output all calculations (including ensemble means) to netCDF files**

Metrics & Coding details

Metrics

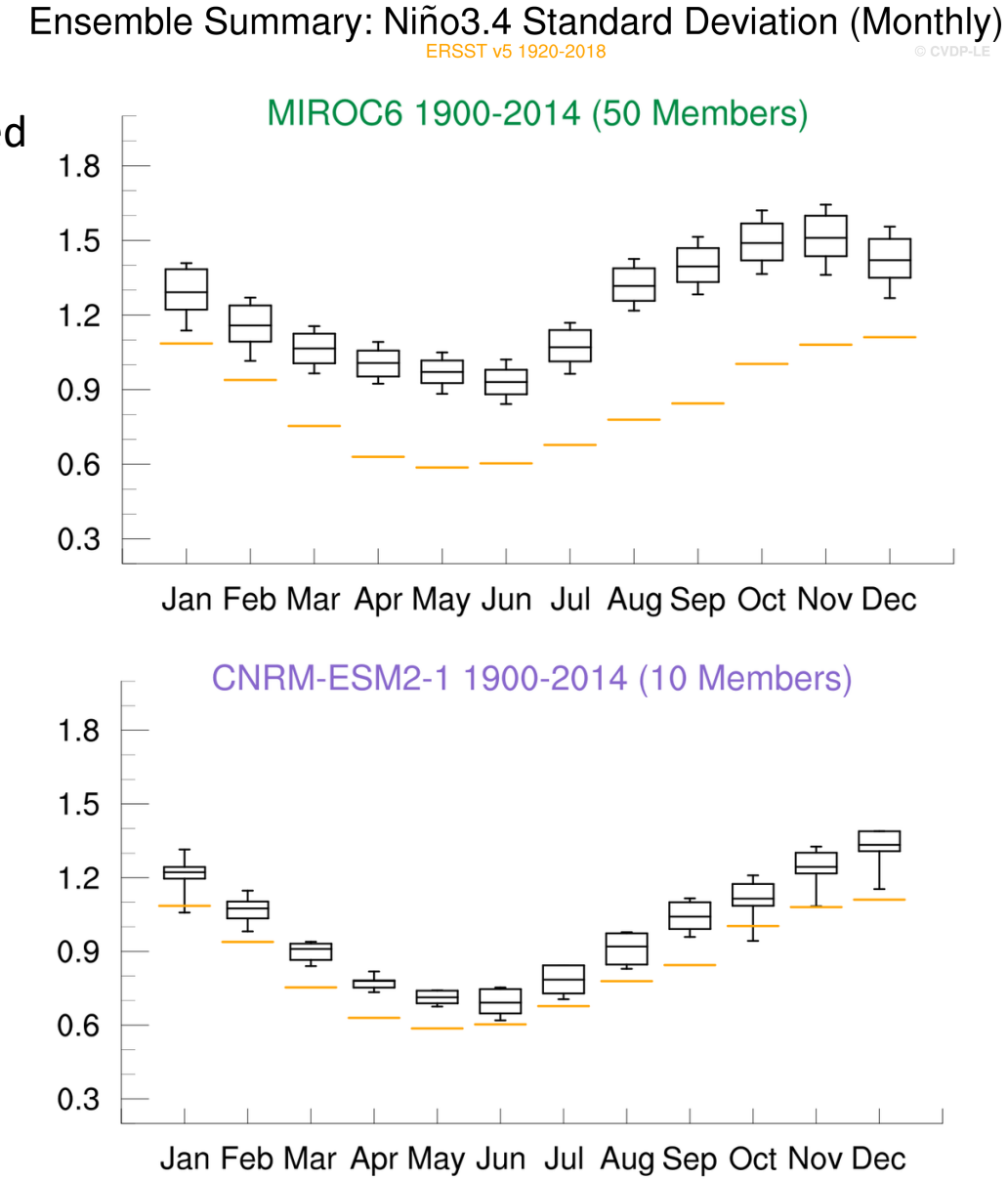
- 28,000 lines of code, 26 scripts, ~30 new functions, ~1000 plots produced
- New website, new User's Guide, new readme file
- 250 run MMLEA 1950-2018 comparison took 12 hours w/parallelization
  384 run CMIP6 Historical 1900-2014 comparison took 18 hours
  38 member CESM Control Comparison (100yr each) took 9 hours

Coded in NCL

- Why on earth was NCL used; wasn't NCL developed in the 90's?

Highlighted Coding Improvements/Additions

- Model file identification coding script completely rewritten.
- Ensemble graphics/metrics + biases from observations are calculated.
- Data only mode.
- Code is highly modularized; calculations separated from graphics. Modularity makes it easier to strip code out for outside applications.
- Package will read in previously created metrics to save time.



Running the CVDP-LE

- Similar to the CVDP, 3 text files need to be set up for CVDP-LE to run:
  - driver.ncl script (sets options)
  - namelist (set paths of simulations)
  - namelist_obs (sets specific observations to be used)

- Software requirements: NCL, python and Image Magick.

- Analyzes monthly CESM/CMIP timeseries files.

Running the CVDP-LE

driver.ncl

```
;================================================================================================
  outdir            = "/project/diagnostics/external/Multi-Case/CVDP-LE/Benchmark/"   ; 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 = analyze and plot observations (specified in namelist_obs), False = do not.
  create_graphics      = "True"             ; True = create graphics from calculation results, False = only perform calculations and create netCDF files.
;- - - - - - - - - - - - - - - - - - - -
  colormap          = 0                     ; 0 = default colormaps, 1 = colormaps better for color blindness

  output_type       = "png"                 ; png = create png files, ps = create ps files as well as png files (for web viewing).

  png_scale         = 3.0                   ; Set the output .png size. Value between .1->5.  Any value > 1 (< 1) increases (decreases) png size.
                                            ; When output_type = "png" a value of 1 will result in a png sized 1500 (H) x 1500 (W) before automatic cropping of white space
                                            ; When output_type = "ps"  a value of 1 will result in a png density setting of 144 before automatic cropping of white space
  webpage_title     = "MMLEA 1950-2099"     ; Set webpage title

  tar_output        = "False"               ; True = tar up all output in outdir and remove individual files, False = do not
                                            ; Note: ALL files in outdir will be tarred up and then removed from the outdir directory.
;---Advanced Options-----------------------------------------------------------
  zp = "ncl_scripts/"    ; directory path of CVDP NCL scripts. (must end in a "/")
                         ; Examples: "ncl_scripts/" if all code is local, or on CGD or CISL systems: "~asphilli/CESM-diagnostics/CVDP-LE/Release/v1.0.0/ncl_scripts/"
                         ; Regardless of this setting the following files should be in one directory: namelist, driver.ncl, and namelist_obs.
                         ; If pointing to code in ~asphilli make sure the driver script version #s match between this script and the script in ~asphilli.
```

new entry required: Identify the ensemble

namelist

```
ACCESS-ESM1-5 r1i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/ACCESS-ESM1-5/r1i1p1f1/gn/ | 1900 | 2014 | 1-ACCESS-ESM1-5
ACCESS-ESM1-5 r2i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/ACCESS-ESM1-5/r2i1p1f1/gn/ | 1900 | 2014 | 1-ACCESS-ESM1-5
ACCESS-ESM1-5 r3i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/ACCESS-ESM1-5/r3i1p1f1/gn/ | 1900 | 2014 | 1-ACCESS-ESM1-5
ACCESS-ESM1-5 r4i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/ACCESS-ESM1-5/r4i1p1f1/gn/ | 1900 | 2014 | 1-ACCESS-ESM1-5
ACCESS-ESM1-5 r5i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/ACCESS-ESM1-5/r5i1p1f1/gn/ | 1900 | 2014 | 1-ACCESS-ESM1-5
ACCESS-ESM1-5 r6i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/ACCESS-ESM1-5/r6i1p1f1/gn/ | 1900 | 2014 | 1-ACCESS-ESM1-5
ACCESS-ESM1-5 r7i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/ACCESS-ESM1-5/r7i1p1f1/gn/ | 1900 | 2014 | 1-ACCESS-ESM1-5
ACCESS-ESM1-5 r8i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/ACCESS-ESM1-5/r8i1p1f1/gn/ | 1900 | 2014 | 1-ACCESS-ESM1-5
ACCESS-ESM1-5 r9i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/ACCESS-ESM1-5/r9i1p1f1/gn/ | 1900 | 2014 | 1-ACCESS-ESM1-5
ACCESS-ESM1-5 r10i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/ACCESS-ESM1-5/r10i1p1f1/gn/ | 1900 | 2014 | 1-ACCESS-ESM1-5
CanESM5 r10i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/CanESM5/r10i1p1f1/gn/ | 1900 | 2014 | 2-CanESM5
CanESM5 r10i1p2f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/CanESM5/r10i1p2f1/gn/ | 1900 | 2014 | 2-CanESM5
CanESM5 r11i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/CanESM5/r11i1p1f1/gn/ | 1900 | 2014 | 2-CanESM5
CanESM5 r11i1p2f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/CanESM5/r11i1p2f1/gn/ | 1900 | 2014 | 2-CanESM5
CanESM5 r12i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/CanESM5/r12i1p1f1/gn/ | 1900 | 2014 | 2-CanESM5
CanESM5 r12i1p2f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/CanESM5/r12i1p2f1/gn/ | 1900 | 2014 | 2-CanESM5
CanESM5 r13i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/CanESM5/r13i1p1f1/gn/ | 1900 | 2014 | 2-CanESM5
CanESM5 r13i1p2f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/CanESM5/r13i1p2f1/gn/ | 1900 | 2014 | 2-CanESM5
CanESM5 r14i1p1f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/CanESM5/r14i1p1f1/gn/ | 1900 | 2014 | 2-CanESM5
CanESM5 r14i1p2f1 | /project/data/cmip6/historical/{Amon,SImon,Omon}/*/CanESM5/r14i1p2f1/gn/ | 1900 | 2014 | 2-CanESM5
```

There are no restrictions on the number of models listed.
Ensemble sizes can be different, as can the analyzed years.

Running the CVDP-LE

namelist

```
CESM2.1 piControl 1201-1300 | /project/mojave/cesm2/b.e21.B1850.f09_g17.CMIP6-piControl.001/{atm,ice,ocn}/month_1/*/ | 1201 | 1300 | 1-CESM2
CESM2.1 piControl 1301-1400 | /project/mojave/cesm2/b.e21.B1850.f09_g17.CMIP6-piControl.001/{atm,ice,ocn}/month_1/*/ | 1301 | 1400 | 1-CESM2
CESM2.1 piControl 1401-1500 | /project/mojave/cesm2/b.e21.B1850.f09_g17.CMIP6-piControl.001/{atm,ice,ocn}/month_1/*/ | 1401 | 1500 | 1-CESM2
CESM2.1 piControl 1501-1600 | /project/mojave/cesm2/b.e21.B1850.f09_g17.CMIP6-piControl.001/{atm,ice,ocn}/month_1/*/ | 1501 | 1600 | 1-CESM2
CESM2.1 piControl 1601-1700 | /project/mojave/cesm2/b.e21.B1850.f09_g17.CMIP6-piControl.001/{atm,ice,ocn}/month_1/*/ | 1601 | 1700 | 1-CESM2
CESM2.1 piControl 1701-1800 | /project/mojave/cesm2/b.e21.B1850.f09_g17.CMIP6-piControl.001/{atm,ice,ocn}/month_1/*/ | 1701 | 1800 | 1-CESM2
CESM2.1 piControl 1801-1900 | /project/mojave/cesm2/b.e21.B1850.f09_g17.CMIP6-piControl.001/{atm,ice,ocn}/month_1/*/ | 1801 | 1900 | 1-CESM2
CESM2.1 piControl 1901-2000 | /project/mojave/cesm2/b.e21.B1850.f09_g17.CMIP6-piControl.001/{atm,ice,ocn}/month_1/*/ | 1901 | 2000 | 1-CESM2

CESM1-LENS piControl 1101-1200 | /project/mojave/cesm1/LENS/{atm,ice,ocn}/month_1/*/b.e11.B1850C5CN.f09_g16.005* | 1101 | 1200 | 2-CESM1
CESM1-LENS piControl 1201-1300 | /project/mojave/cesm1/LENS/{atm,ice,ocn}/month_1/*/b.e11.B1850C5CN.f09_g16.005* | 1201 | 1300 | 2-CESM1
CESM1-LENS piControl 1301-1500 | /project/mojave/cesm1/LENS/{atm,ice,ocn}/month_1/*/b.e11.B1850C5CN.f09_g16.005* | 1301 | 1400 | 2-CESM1
CESM1-LENS piControl 1401-1500 | /project/mojave/cesm1/LENS/{atm,ice,ocn}/month_1/*/b.e11.B1850C5CN.f09_g16.005* | 1401 | 1500 | 2-CESM1
CESM1-LENS piControl 1501-1600 | /project/mojave/cesm1/LENS/{atm,ice,ocn}/month_1/*/b.e11.B1850C5CN.f09_g16.005* | 1501 | 1600 | 2-CESM1
CESM1-LENS piControl 1601-1700 | /project/mojave/cesm1/LENS/{atm,ice,ocn}/month_1/*/b.e11.B1850C5CN.f09_g16.005* | 1601 | 1700 | 2-CESM1
CESM1-LENS piControl 1701-1800 | /project/mojave/cesm1/LENS/{atm,ice,ocn}/month_1/*/b.e11.B1850C5CN.f09_g16.005* | 1701 | 1800 | 2-CESM1
```

The same simulation can be specified multiple times.

namelist_obs

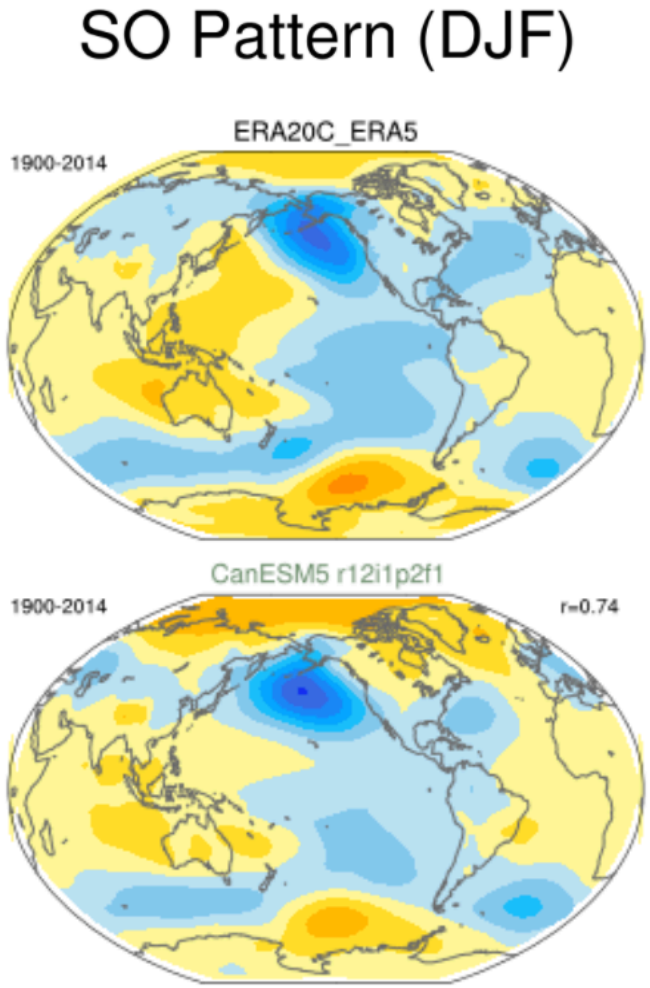
```
TS | ERSST v5 | /project/cas/asphilli/DSets/ersstv5.185401-202012.nc | 1920 | 2019
PSL | ERA20C_ERA5 | /project/cas/asphilli/ECMWF_reanalysis_comb/era20c_era5.mon.mean.msl.190001-201912.nc | 1920 | 2019
TREFHT | BEST | /project/cas/asphilli/DSets/best.tas.185001-202003.nc | 1920 | 2019
PRECT | GPCC | /project/mojave/observations/OBS-PR/GPCC/gpcc.pr.10.comb_v2018v6mon.189101-201912.nc | 1920 | 2019
aice_nh | NASA CDR NH | /project/cas/asphilli/NSIDC/seaice_conc_monthly_nh_NOAA_NSIDC_CDR.v03r01.197811-201702.nc | 1979 | 2016
aice_sh | NASA Bootstrap SH | /project/cas/asphilli/NSIDC/seaice_conc_monthly_sh_NASA_Bootstrap.nsidc.v03r01.197811-201702.nc | 1979 | 2016
MOC | CESM1 Forced Ocean Simulation | /project/yampa02/asphilli/cesm1/CESM1.1_DPlgens/g.e11_LENS.GECOIAF.T62_g16.009.pop.h.MOC.194801-201512.nc | 1950 | 2015

TS | HadISST | /project/mojave/observations/OBS-SST/hadisst.187001-201912.nc | 1920 | 2019
PSL | CERA20C_ERA5 | /project/cas/asphilli/ECMWF_reanalysis_comb/cera20c_era5.mon.mean.msl.190101-201912.nc | 1920 | 2019
TREFHT | GISTEMP | /project/mojave/observations/OBS-TAS/gistemp.tas.188001-202012.nc | 1920 | 2019
PRECT | GPCC | /project/mojave/observations/OBS-PR/GPCC/gpcc.pr.10.comb_v2018v6mon.189101-201912.nc | 1920 | 2019
aice_nh | NASA CDR NH | /project/cas/asphilli/NSIDC/seaice_conc_monthly_nh_NOAA_NSIDC_CDR.v03r01.197811-201702.nc | 1979 | 2016
aice_sh | NASA Bootstrap SH | /project/cas/asphilli/NSIDC/seaice_conc_monthly_sh_NASA_Bootstrap.nsidc.v03r01.197811-201702.nc | 1979 | 2016
MOC | CESM1 Forced Ocean Simulation | /project/yampa02/asphilli/cesm1/CESM1.1_DPlgens/g.e11_LENS.GECOIAF.T62_g16.009.pop.h.MOC.194801-201512.nc | 1950 | 2015

TS | ERSST v5 | /project/cas/asphilli/DSets/ersstv5.185401-202012.nc | 1979 | 2019
PSL | ERA20C_ERA5 | /project/cas/asphilli/ECMWF_reanalysis_comb/era20c_era5.mon.mean.msl.190001-201912.nc | 1979 | 2019
TREFHT | BEST | /project/cas/asphilli/DSets/best.tas.185001-202003.nc | 1979 | 2019
```

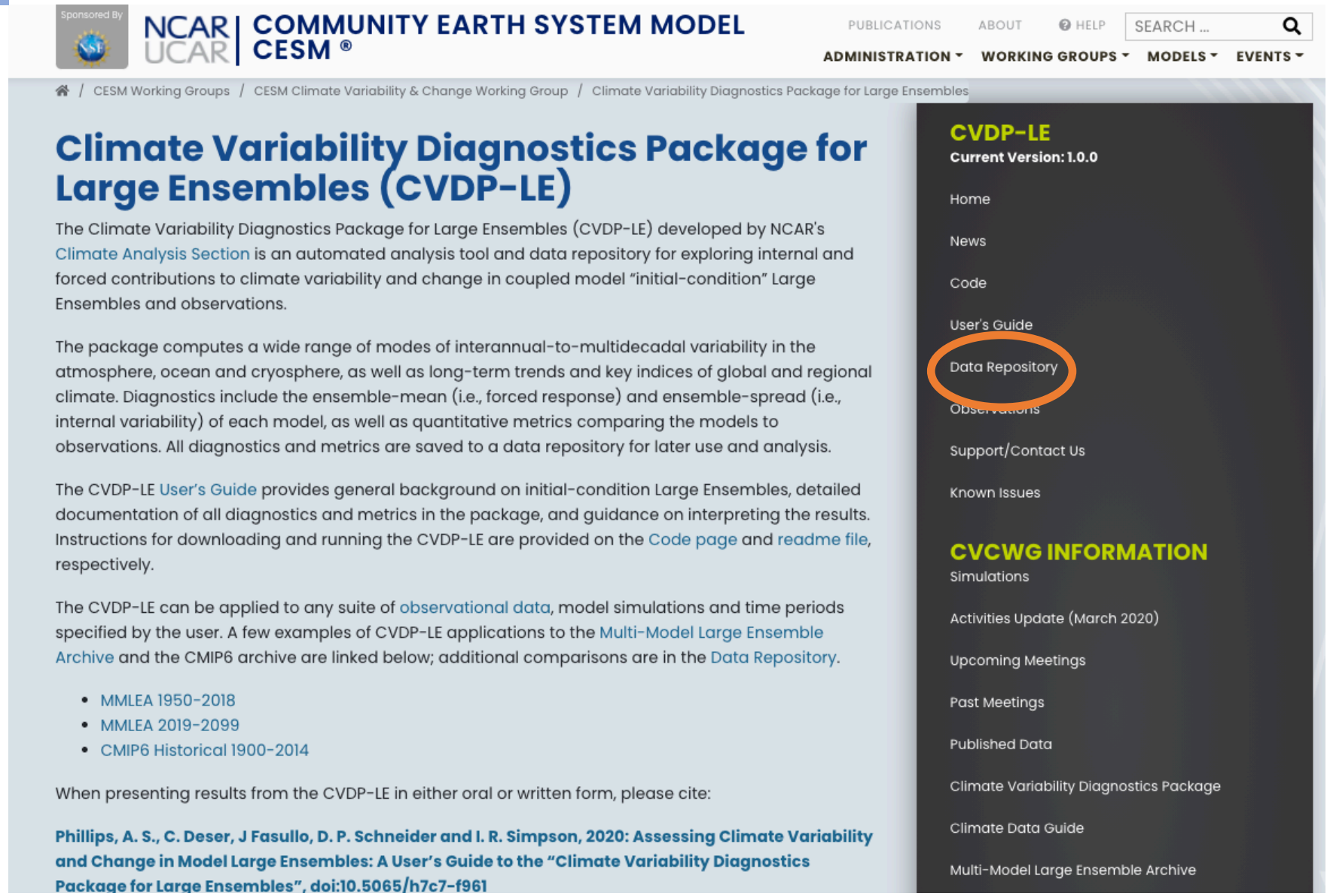
There are no restrictions on the number of observations listed

- To submit the package: “ncl driver.ncl”
- Can be run on any machine that has NCL, Image Magick and python installed. Regularly run on NCAR-CGD/CISL processing machines.



Using CVDP-LE Outputs

Even if you do not wish to run the package, you can download comparison results via the website.

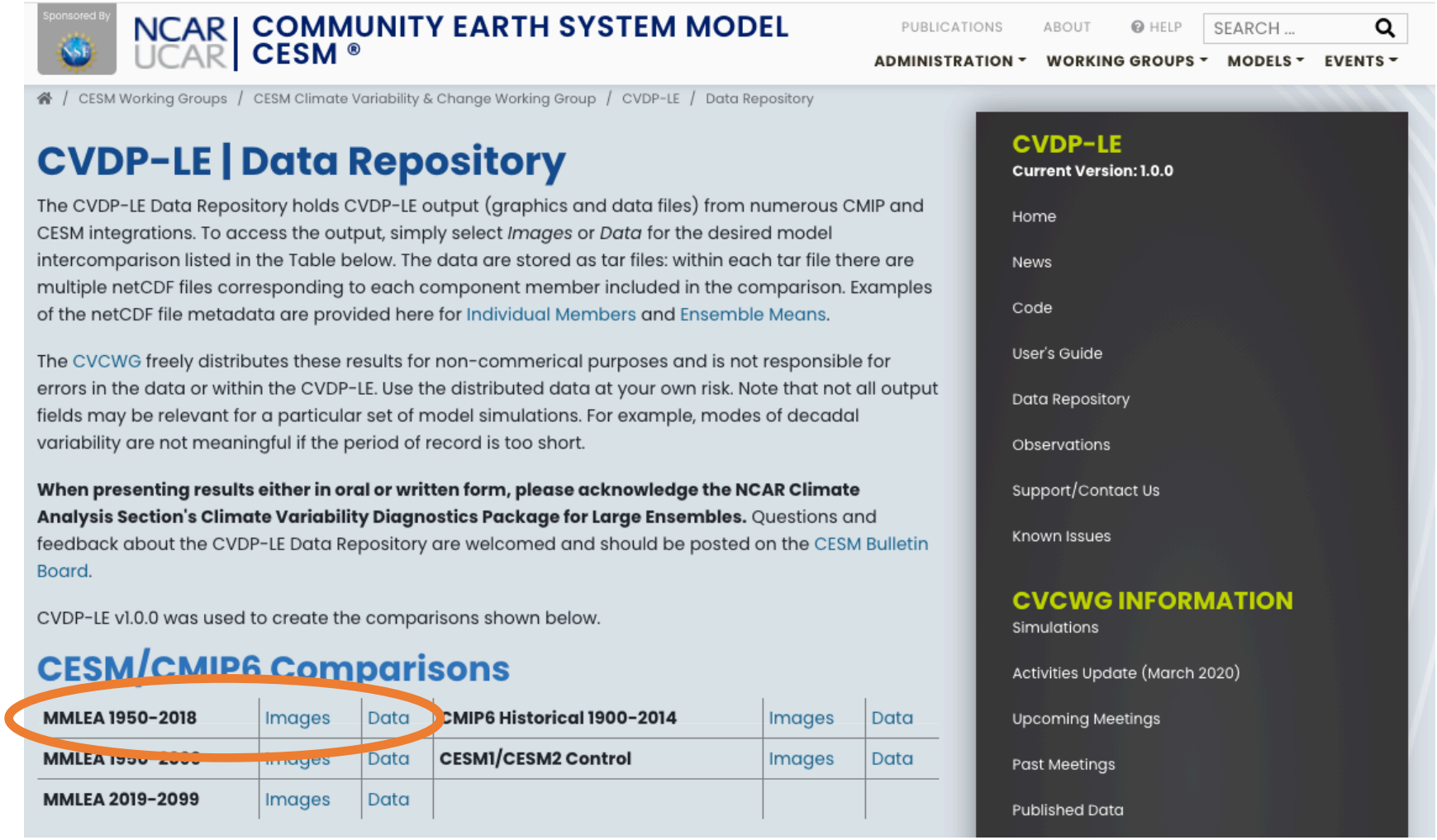


https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

Using CVDP-LE Outputs

Even if you do not wish to run the package, you can download comparison results via the website.

Every model run has its own netCDF file containing all the calculated metrics.

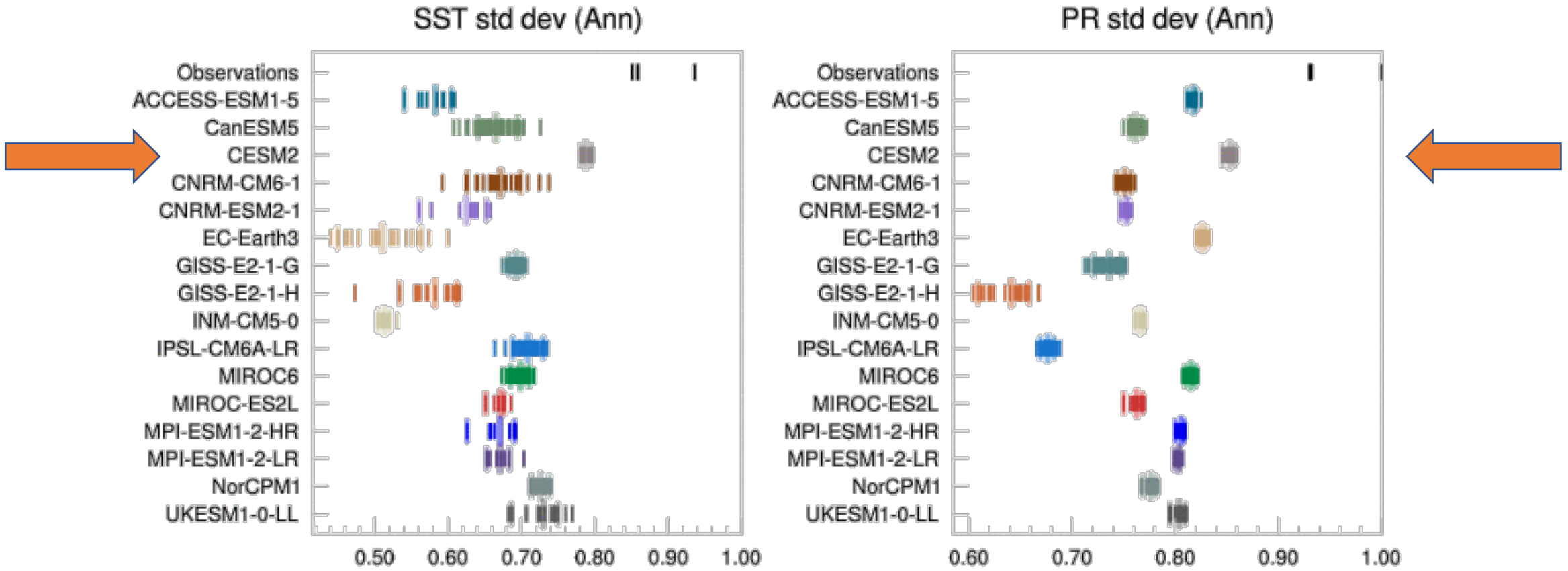


https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

CMIP6 Historical Comparison, 1900-2014

Ensemble Metrics (subset)

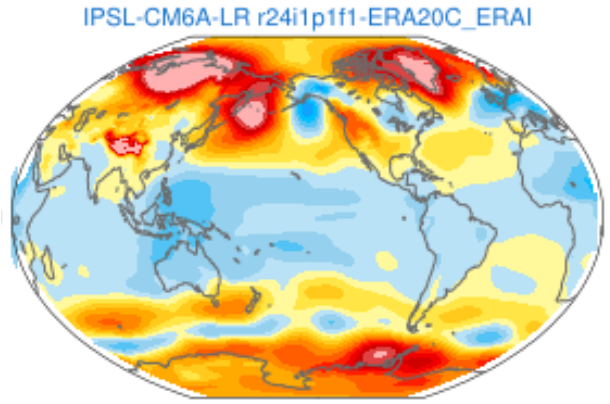
Pattern Correlation with Reference Observations



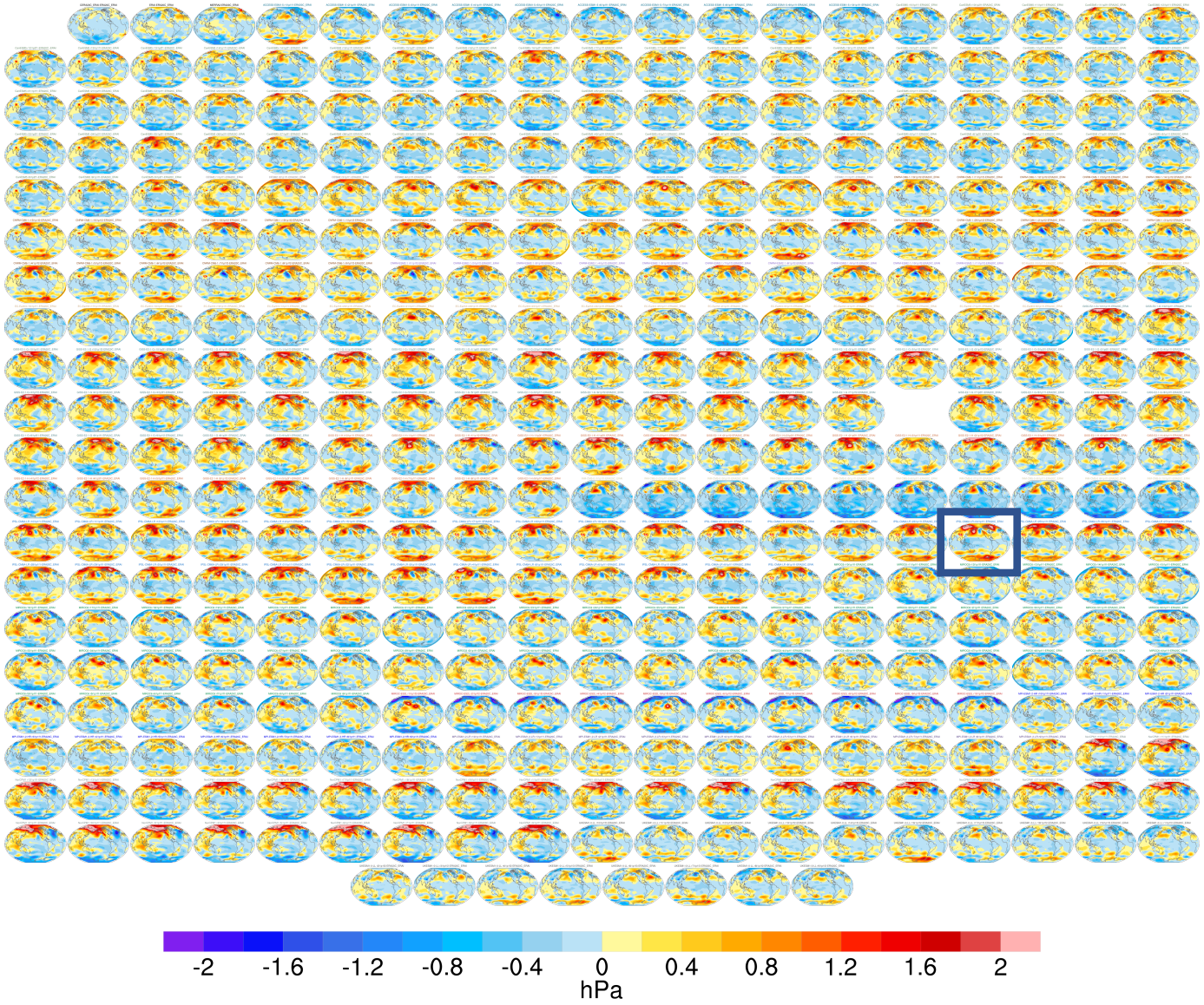
Selected Graphics

CMIP6 Historical Comparison, 1900-2014

Individual Members View

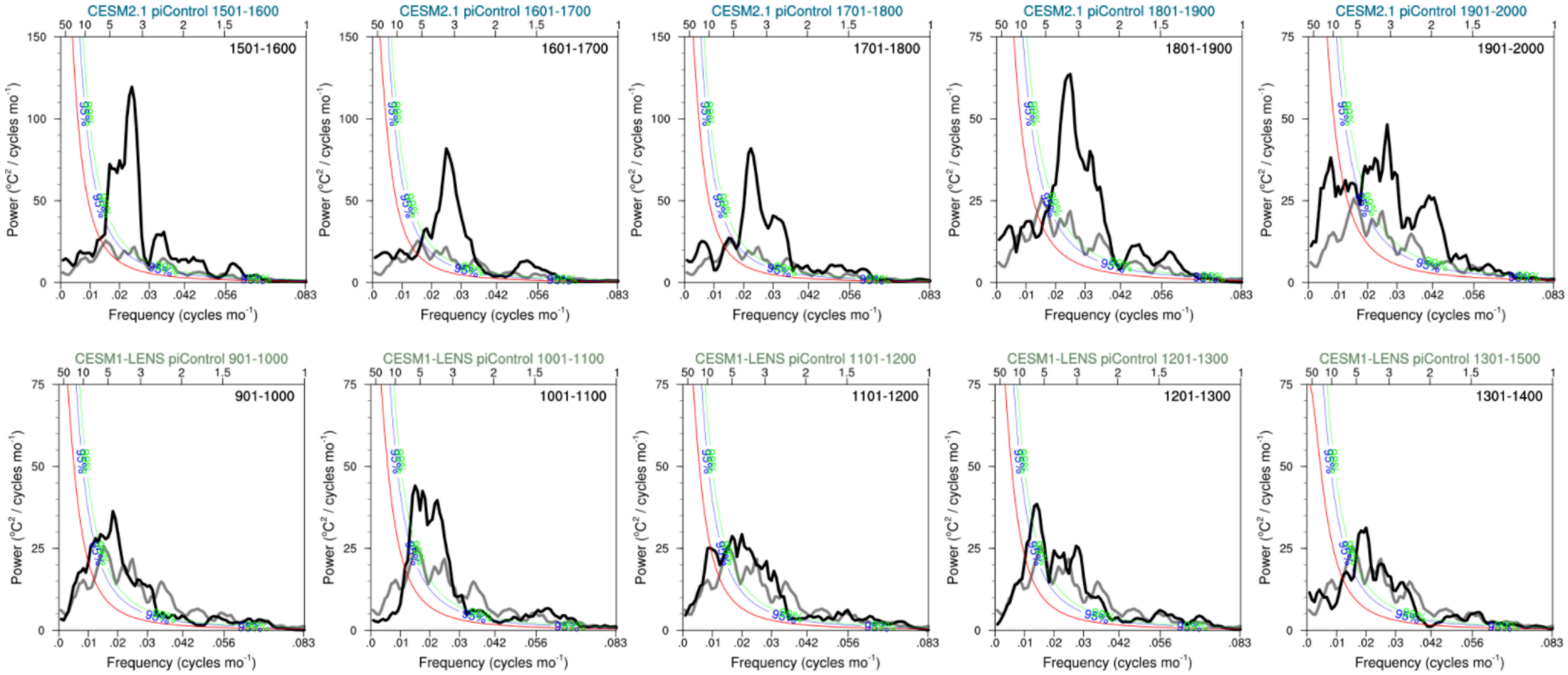


PSL Standard Deviations Differences (DJF)



Ensemble Summary: Niño3.4 SST Power Spectra (Monthly)

ERSST v5 1900-2019

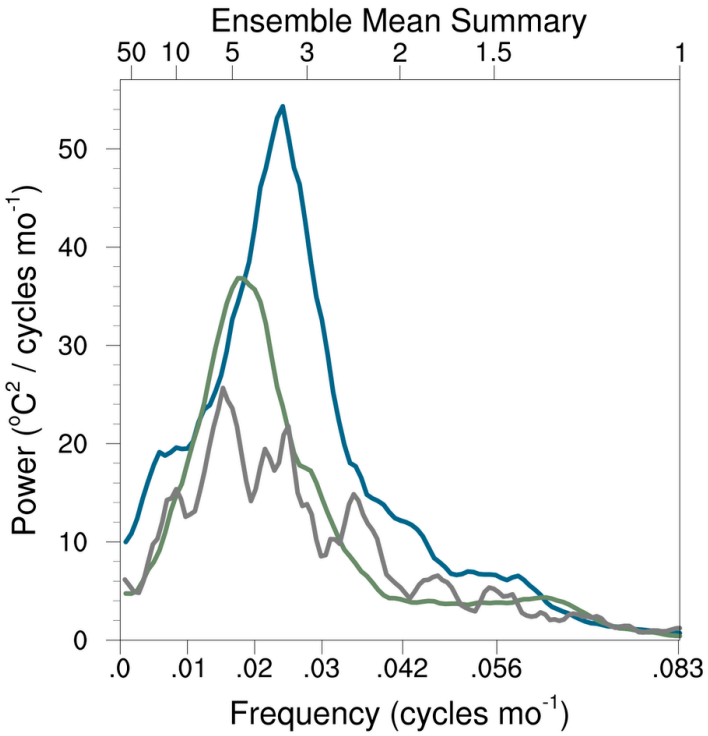


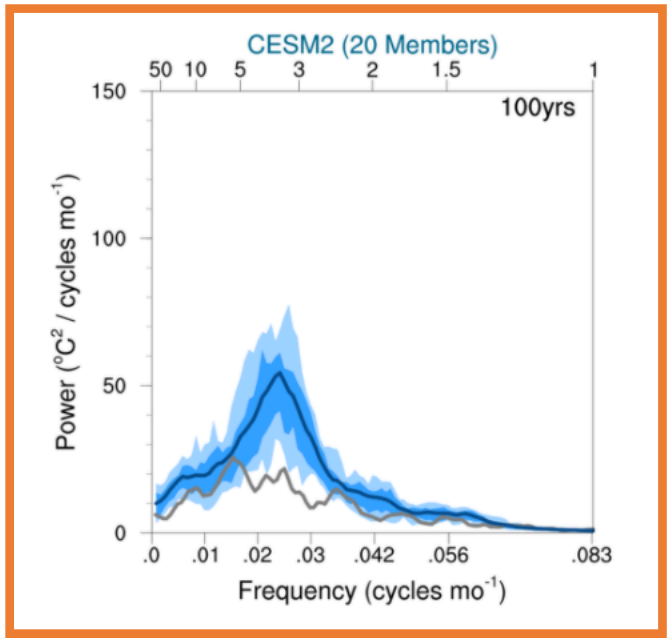
CESM2/CESM1 piControl
100yr Slice Comparison
Individual Members View

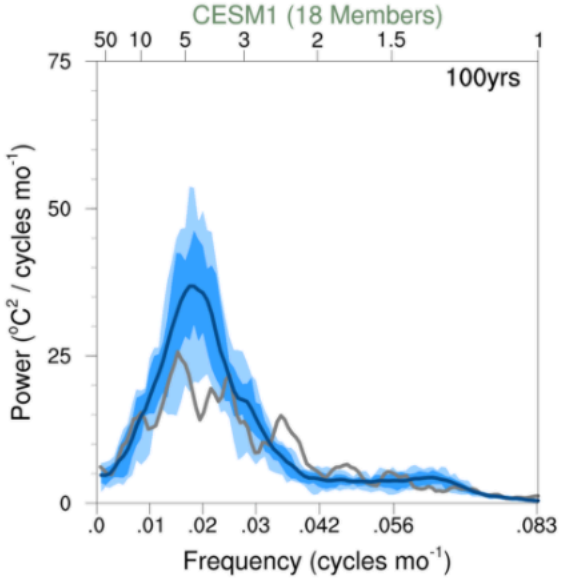
Ensemble Summary: Niño3.4 SST Power Spectra (Monthly)

ERSST v5 1900-2019

CESM2/CESM1 piControl
100yr Slice Comparison
Ensemble Summary View







Available Now

CVDP-LE now available for use on NCAR CGD or CISL machines

CGD: /home/asphilli/CESM-diagnostics/CVDP-LE/Release/v1.0.0

CISL: /glade/u/home/asphilli/CESM-diagnostics/CVDP-LE/Release/v1.0.0

Code will be available on github by the end of this week.

https://github.com/NCAR/CVDP-LE

Diagnostics Overview

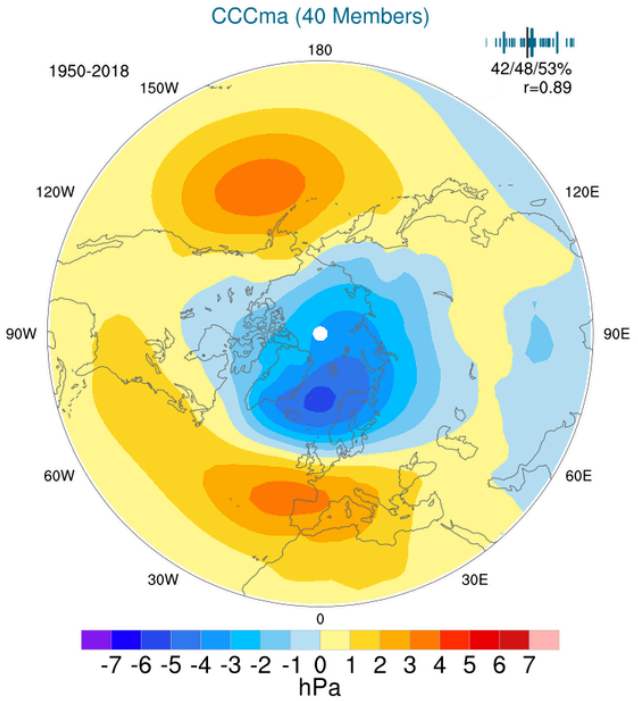
Diagnostics Overview

Diagnostics Overview

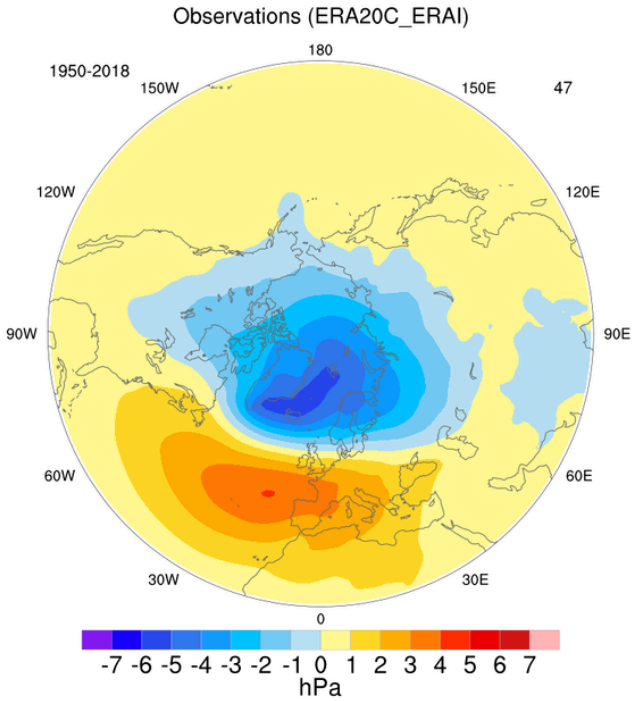
Ensemble Summary: NAO Pattern (DJF)

Ensemble Summary: NAO Pattern (DJF)

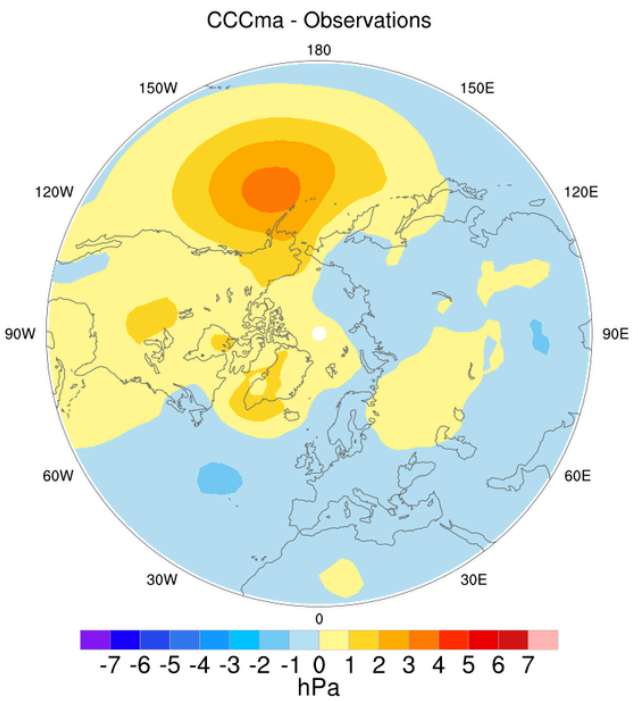
Model



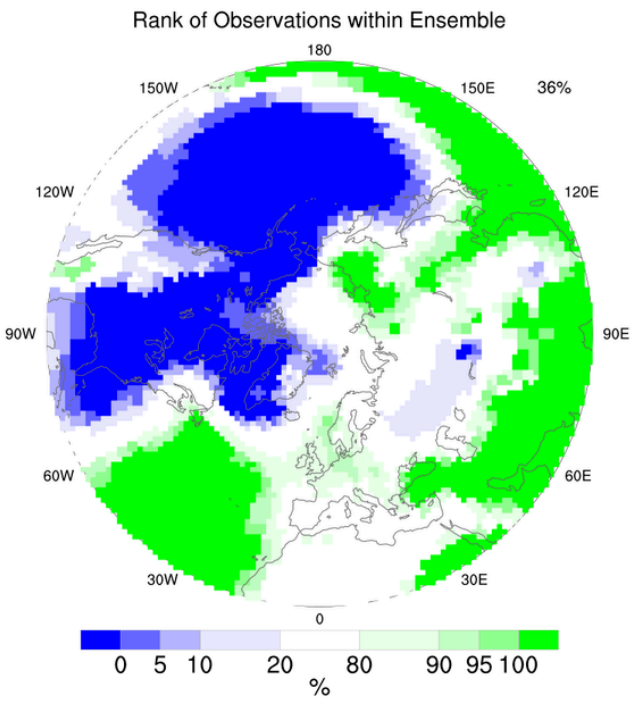
Observations



Difference

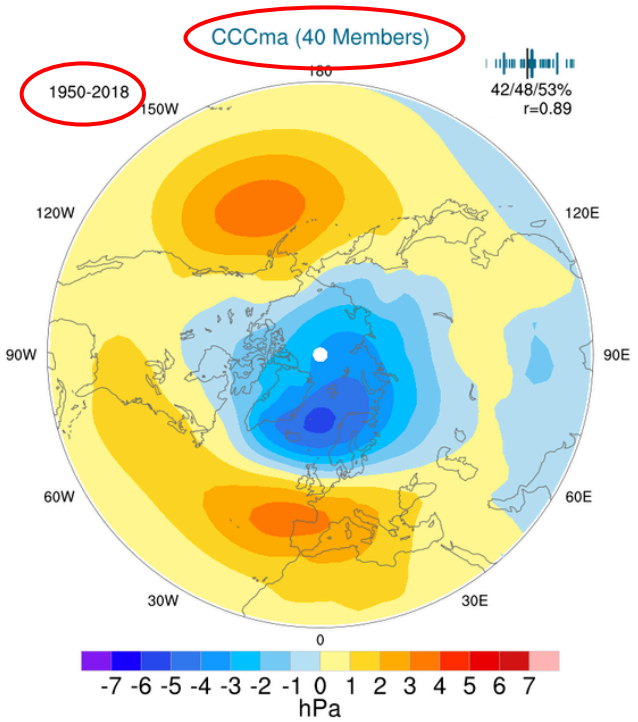


Rank

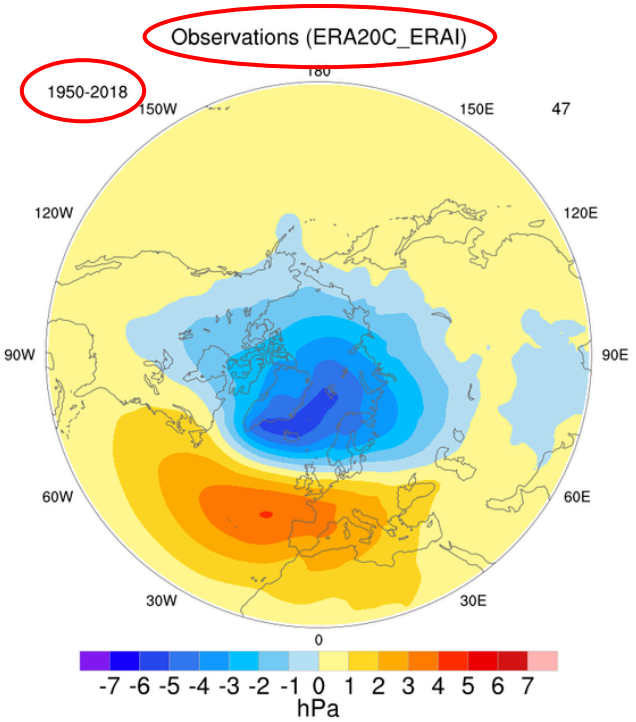


Ensemble Summary: NAO Pattern (DJF)

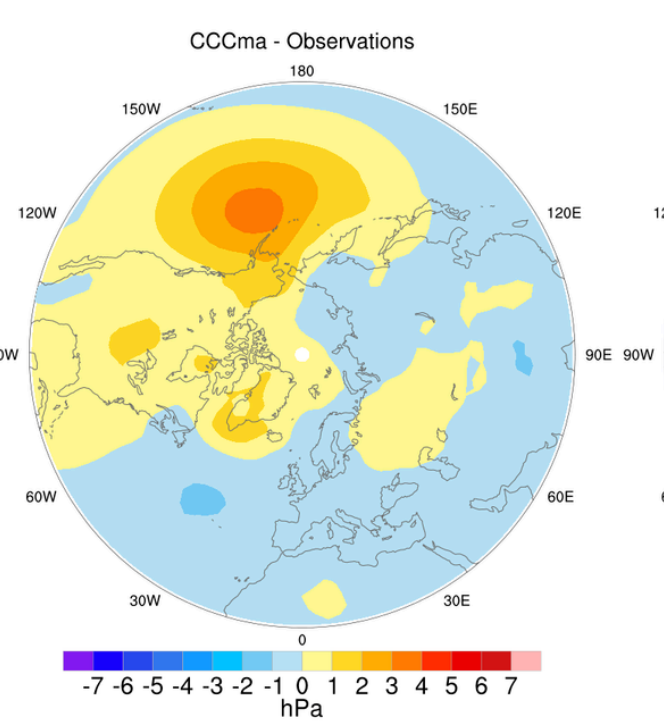
Model



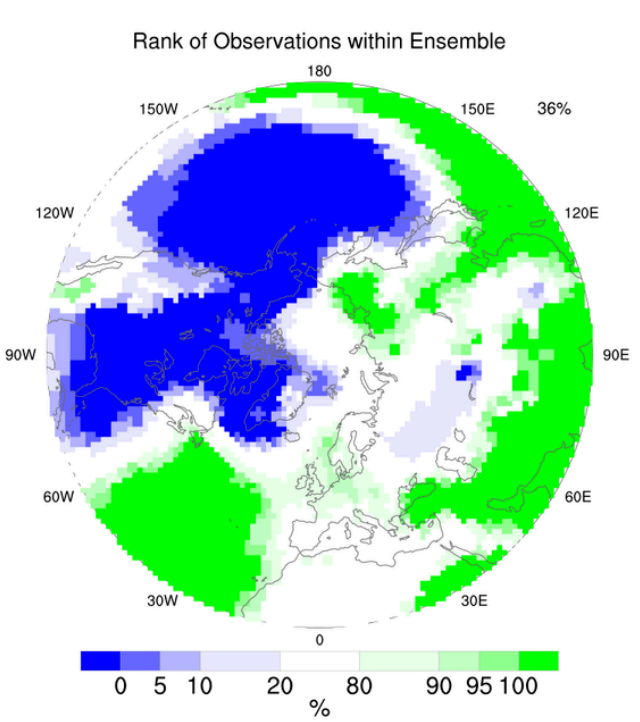
Observations



Difference

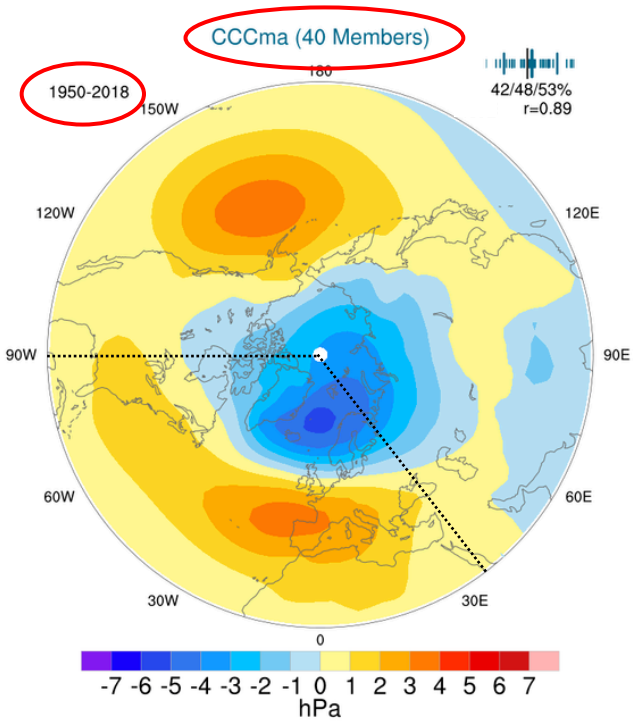


Rank

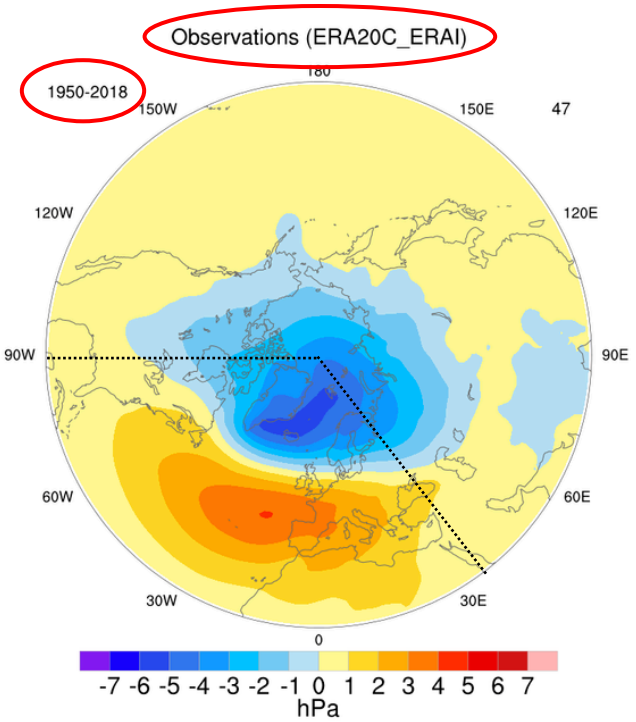


Ensemble Summary: NAO Pattern (DJF)

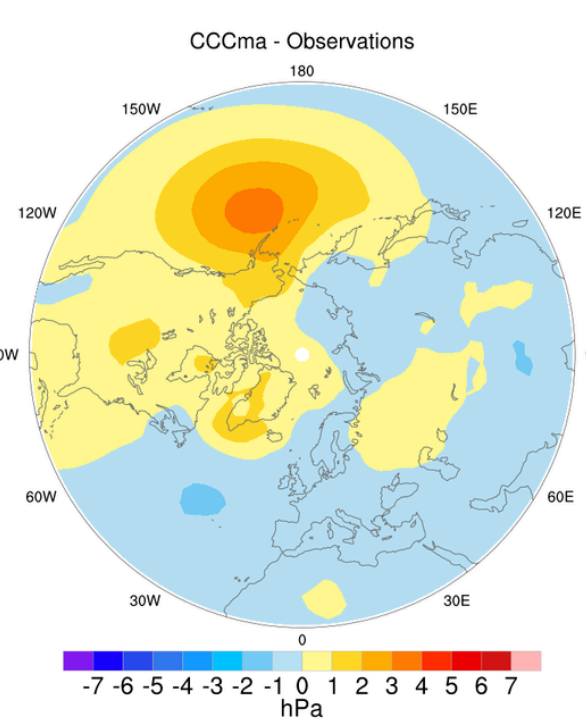
Model



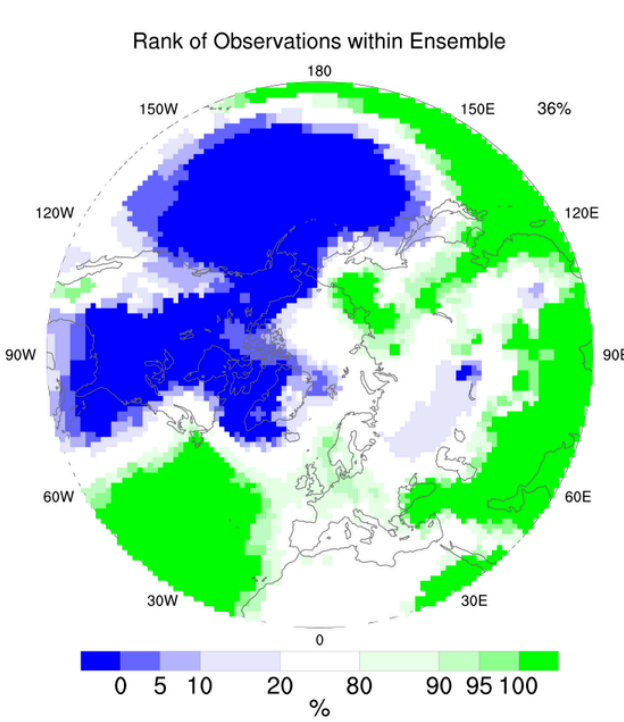
Observations



Difference



Rank



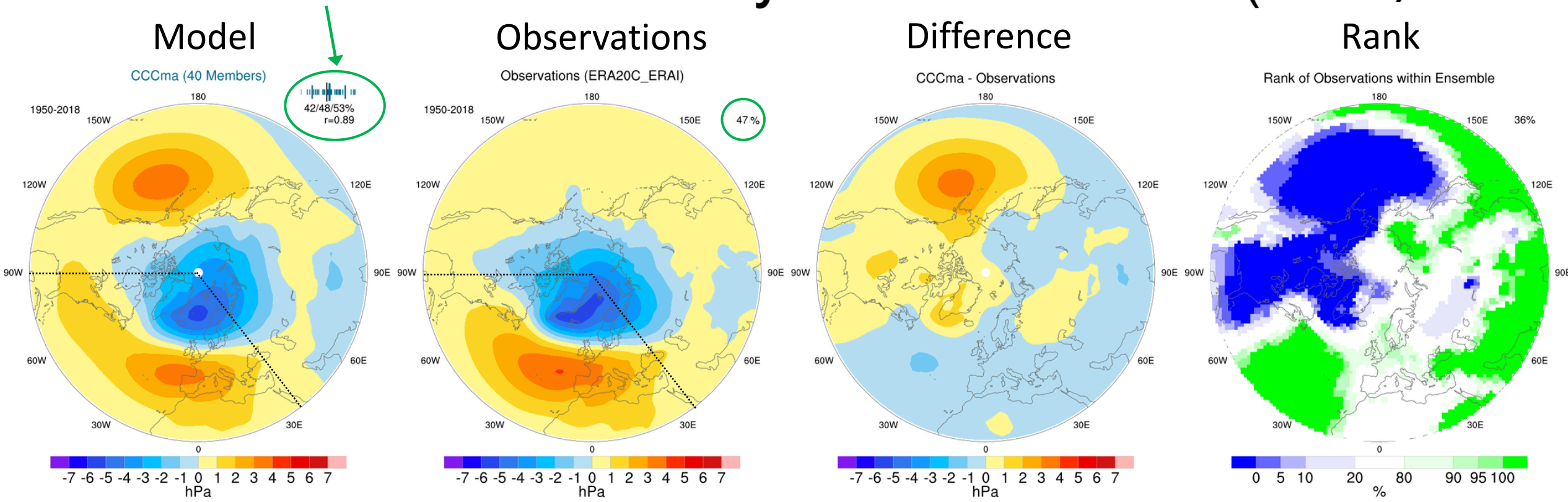
NAO = EOF1 SLP (20-80N, 90W-40E) *Hurrell and Deser (2009)*

Calculated for each ensemble member, then averaged.

All graphics, data and metrics saved to a repository.

ummary: NAO Pattern (DJF)

Distribution of % variance explained (10th/50th/90th percentiles)



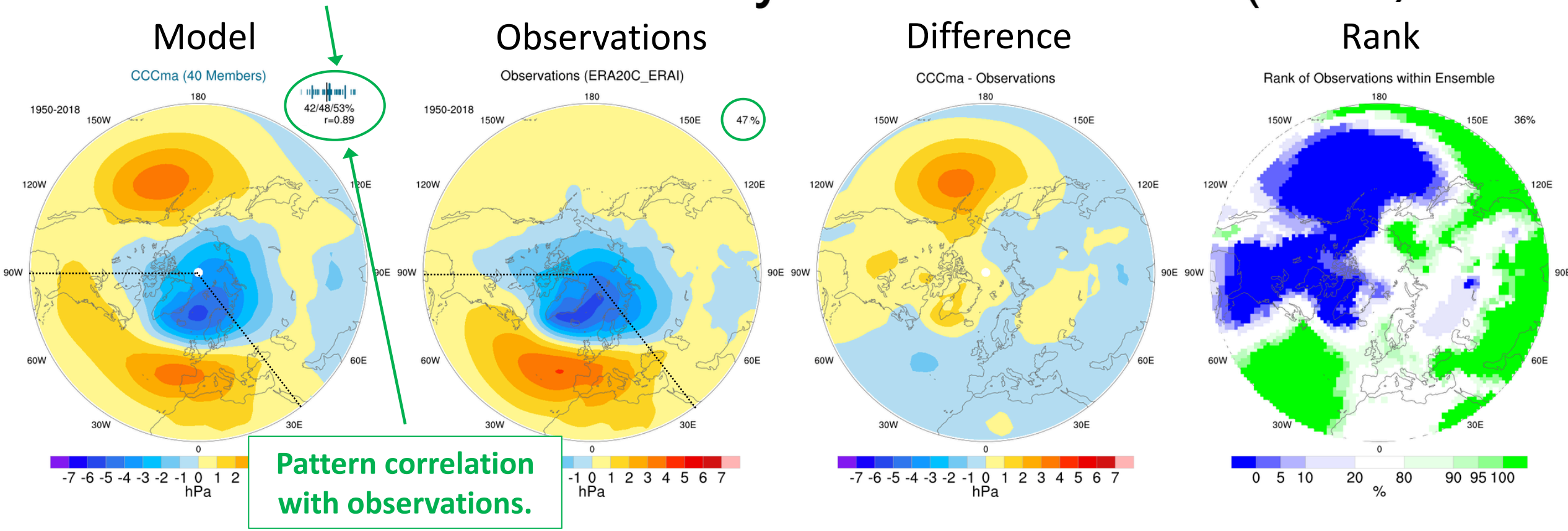
NAO = EOF1 SLP (20-80N, 90W-40E) *Hurrell and Deser (2009)*

Calculated for each ensemble member, then averaged.

All graphics, data and metrics saved to a repository.

ummary: NAO Pattern (DJF)

Distribution of % variance explained (10th/50th/90th percentiles)



Pattern correlation with observations.

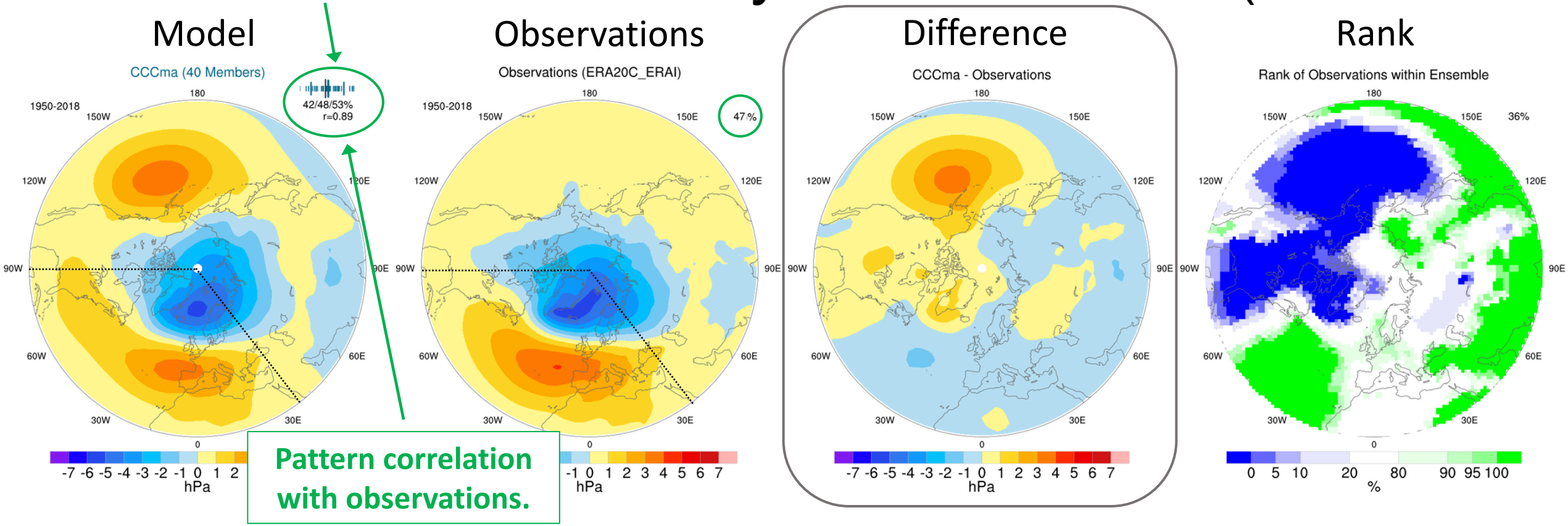
NAO = EOF1 SLP (20-80N, 90W-40E) *Hurrell and Deser (2009)*

Calculated for each ensemble member, then averaged.

All graphics, data and metrics saved to a repository.

ummary: NAO Pattern (DJF)

Distribution of % variance explained (10th/50th/90th percentiles)



Pattern correlation with observations.

NAO = EOF1 SLP (20-80N, 90W-40E) *Hurrell and Deser (2009)*

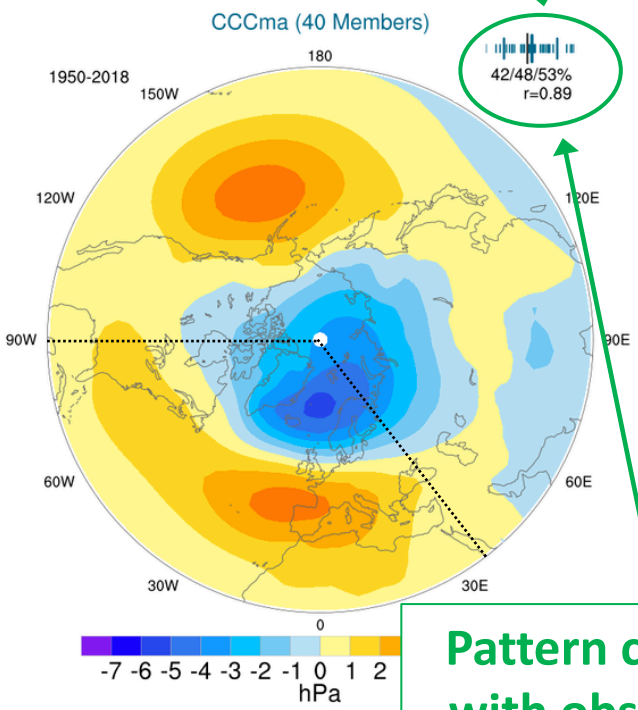
Calculated for each ensemble member, then averaged.

All graphics, data and metrics saved to a repository.

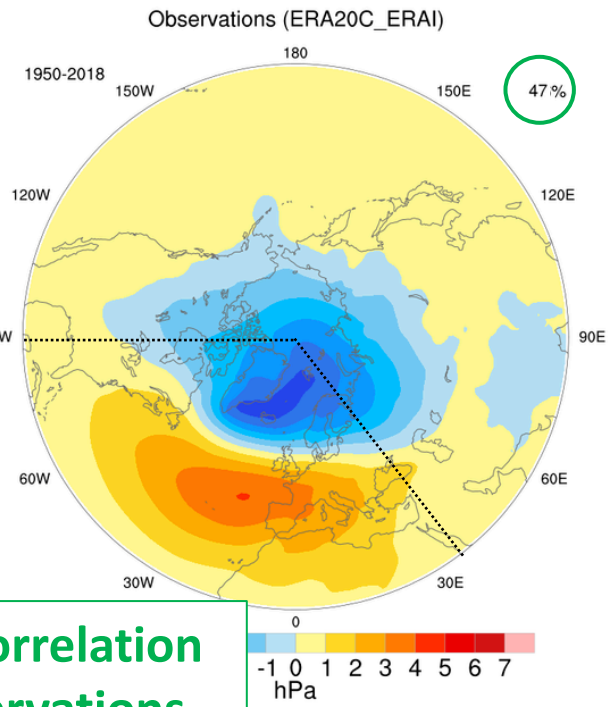
ummary: NAO Pattern (DJF)

Distribution of % variance explained (10th/50th/90th percentiles)

Model

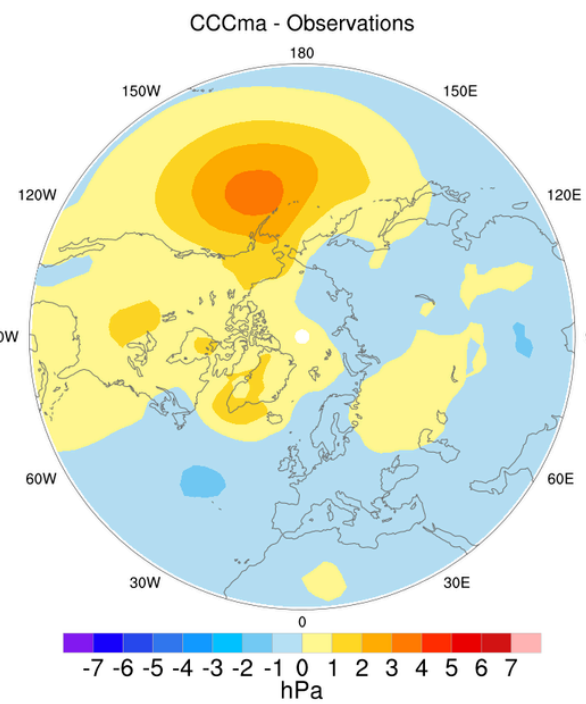


Observations

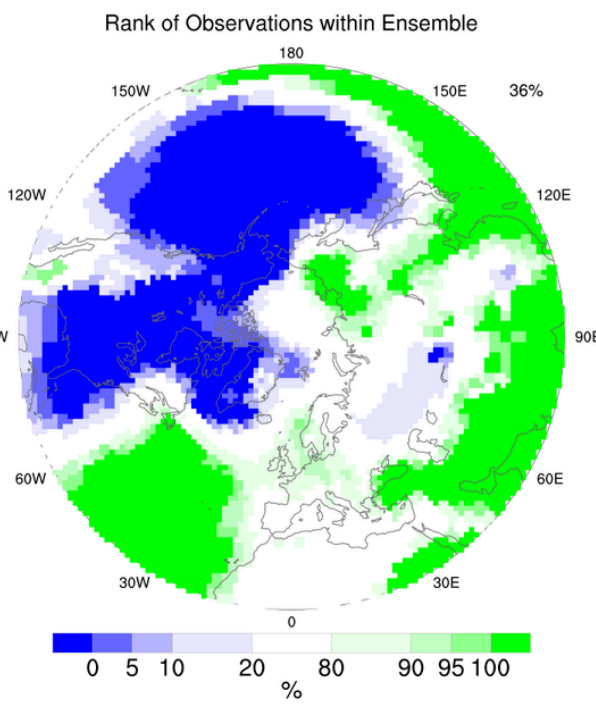


Pattern correlation with observations.

Difference



Rank



White areas: **Observations lie within 20-80th % of model ensemble spread.**

Obs < any member

Obs > any member

NAO = EOF1 SLP (20-80N, 90W-40E) *Hurrell and Deser (2009)*

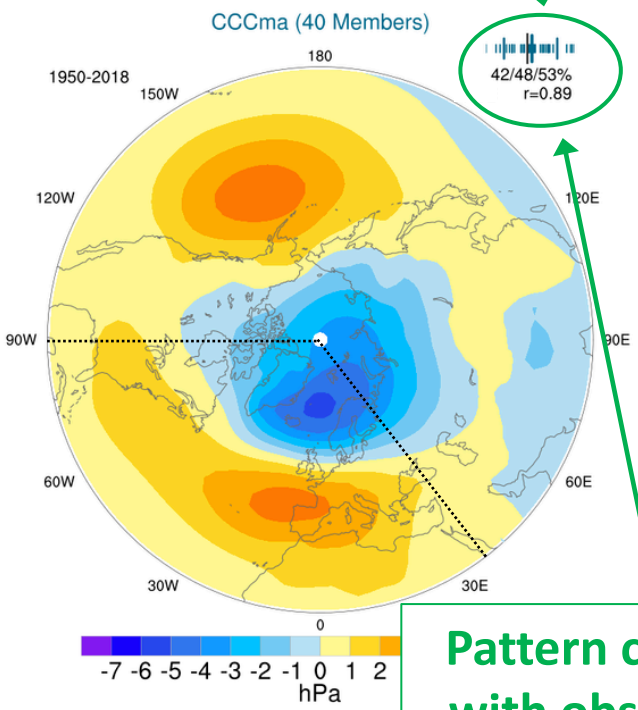
Calculated for each ensemble member, then averaged.

All graphics, data and metrics saved to a repository.

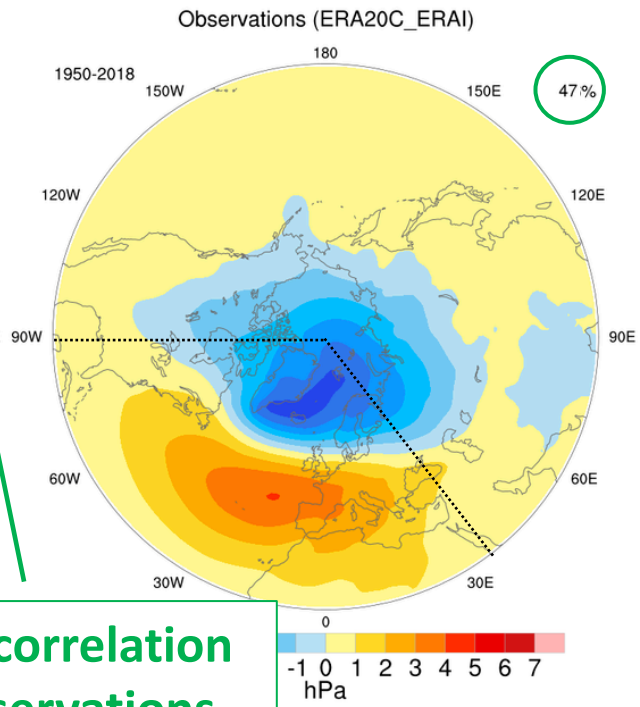
ummary: NAO Pattern (DJF)

Distribution of % variance explained (10th/50th/90th percentiles)

Model

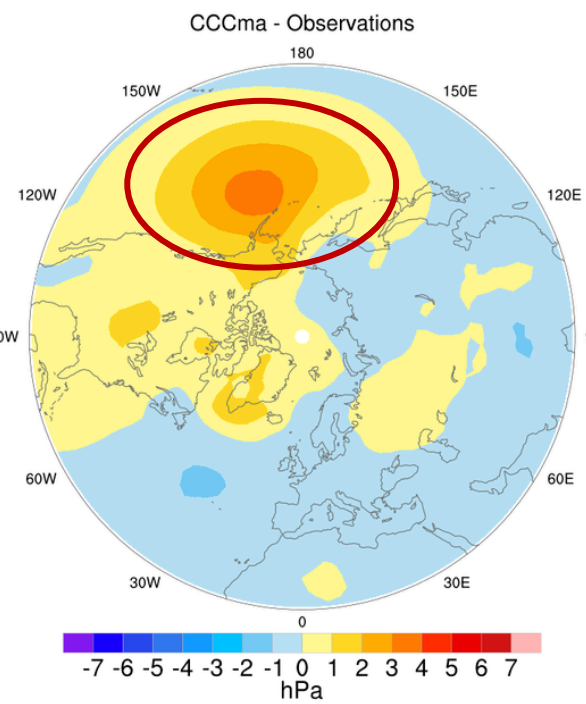


Observations

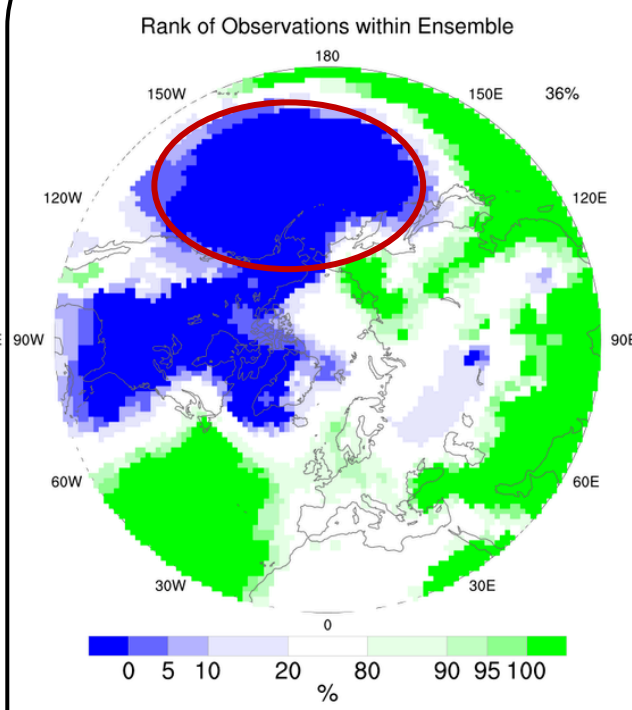


Pattern correlation with observations.

Difference



Rank



White areas: **Observations lie within 20-80th % of model ensemble spread.**

Obs < any member

Obs > any member

NAO = EOF1 SLP (20-80N, 90W-40E) *Hurrell and Deser (2009)*

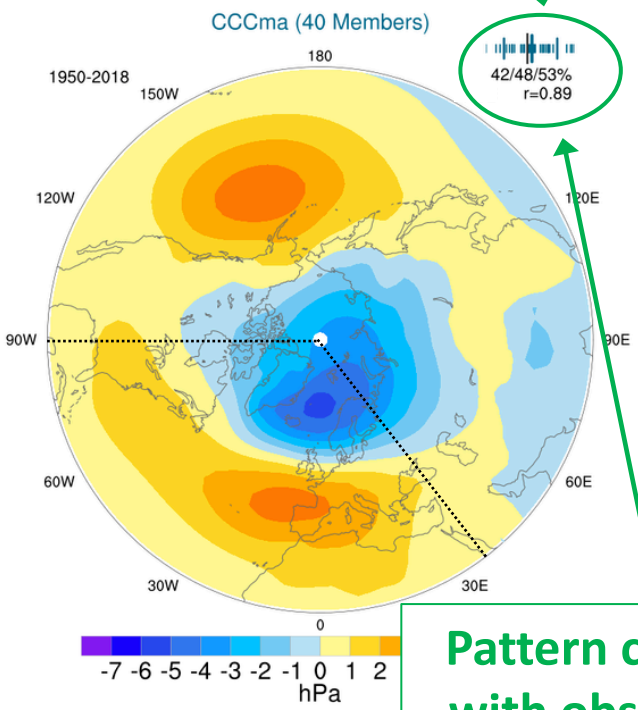
Calculated for each ensemble member, then averaged.

All graphics, data and metrics saved to a repository.

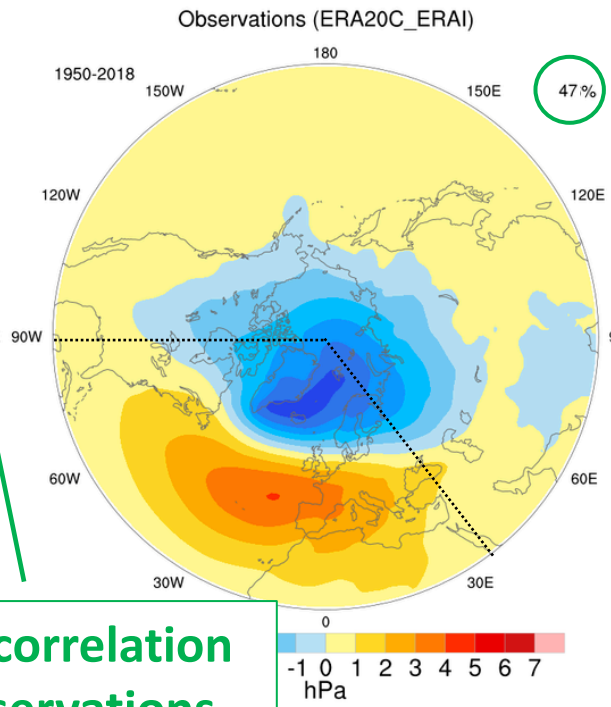
ummary: NAO Pattern (DJF)

Distribution of % variance explained (10th/50th/90th percentiles)

Model

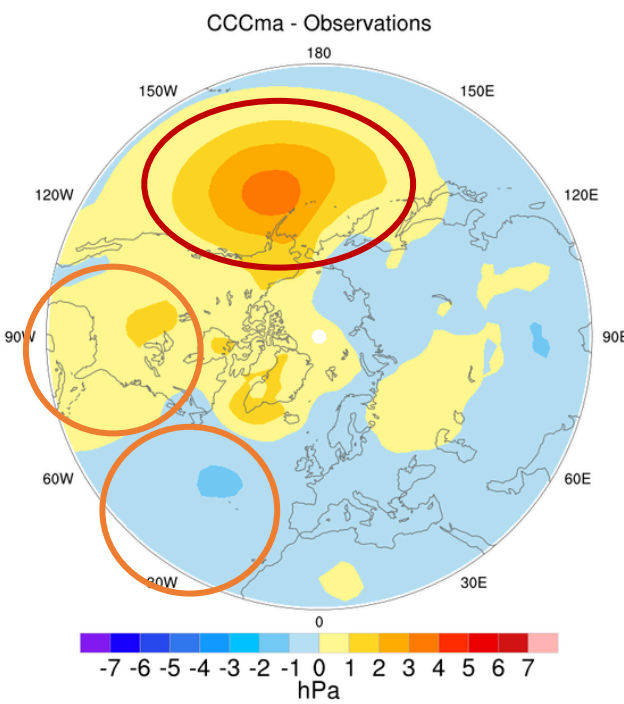


Observations

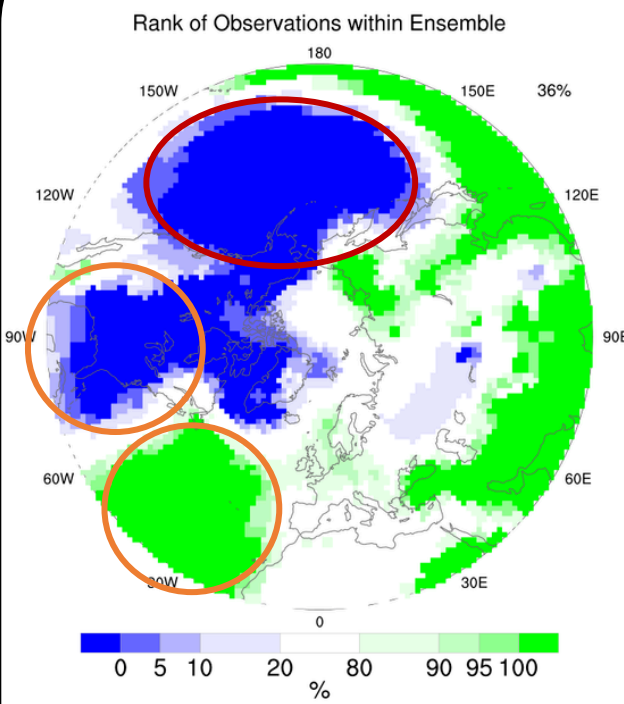


Pattern correlation with observations.

Difference



Rank



White areas: **Observations lie within 20-80th % of model ensemble spread.**

Obs < any member

Obs > any member

NAO = EOF1 SLP (20-80N, 90W-40E) *Hurrell and Deser (2009)*

Calculated for each ensemble member, then averaged.

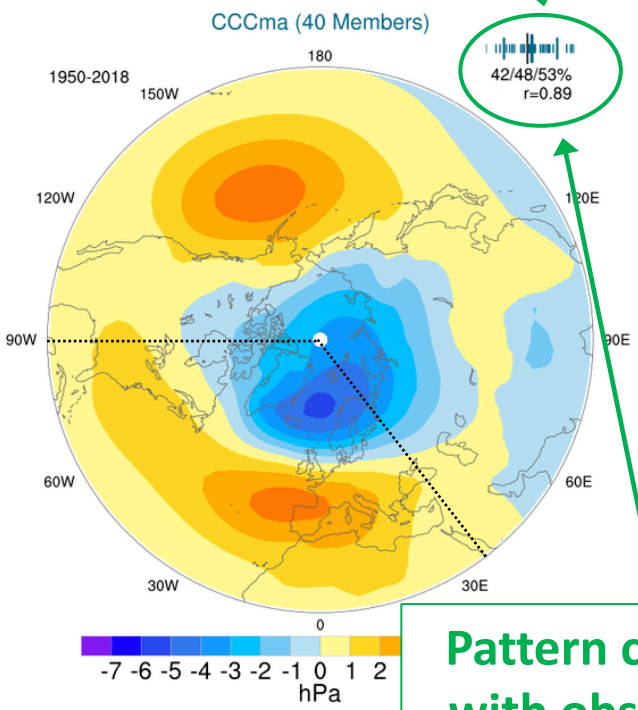
All graphics, data and metrics saved to a repository.

ummary: NAO Pattern (D

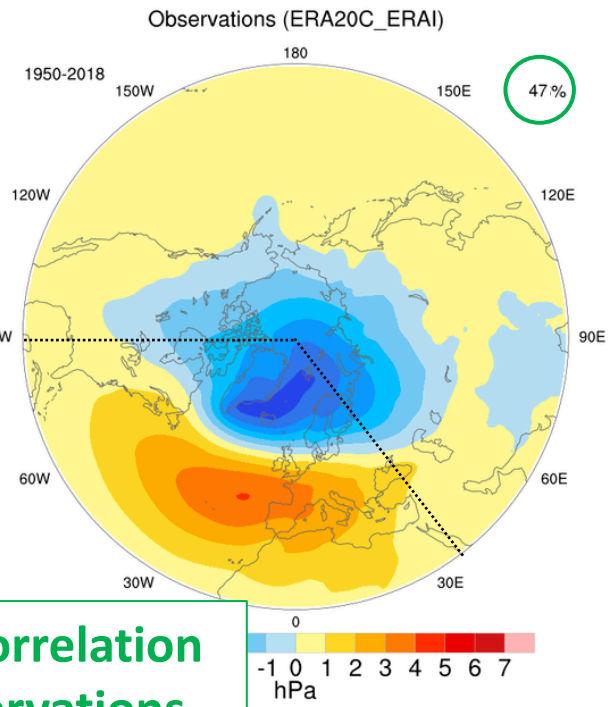
Distribution of % variance explained (10th/50th/90th percentiles)

10-90th % Fractional Area

Model

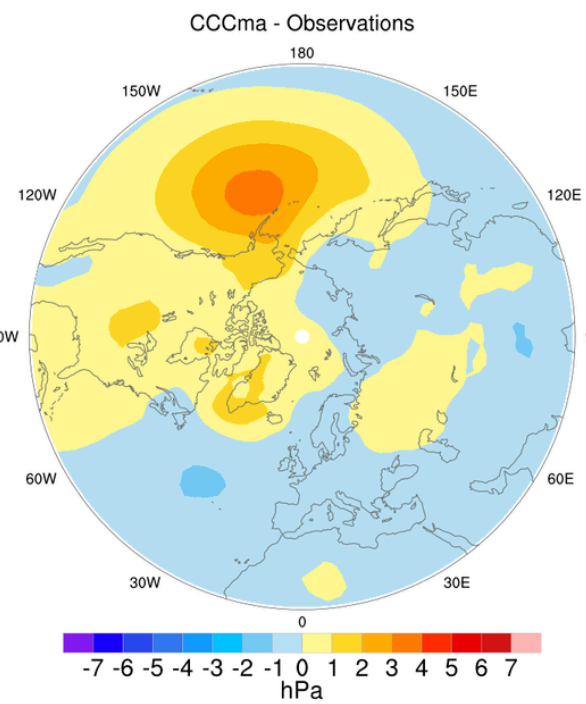


Observations

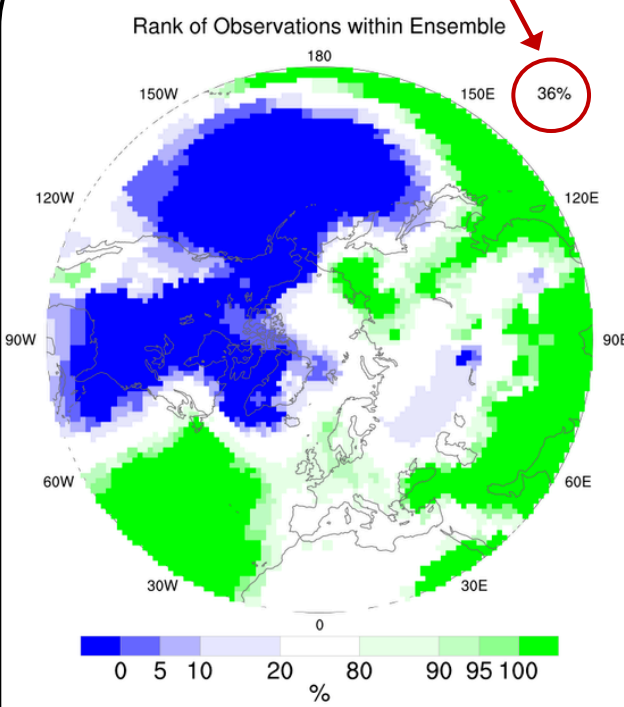


Pattern correlation with observations.

Difference



Rank



White areas: **Observations lie within 20-80th % of model ensemble spread.**

Obs < any member

Obs > any member

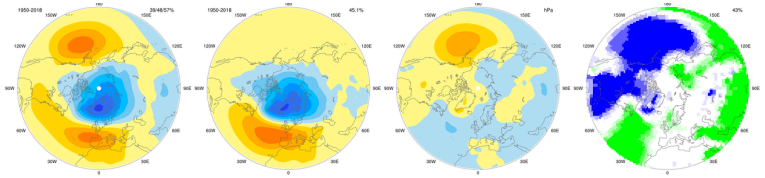
NAO = EOF1 SLP (20-80N, 90W-40E) *Hurrell and Deser (2009)*

Calculated for each ensemble member, then averaged.

All graphics, data and metrics saved to a repository.

Ensemble Summary: NAO Pattern (DJF)

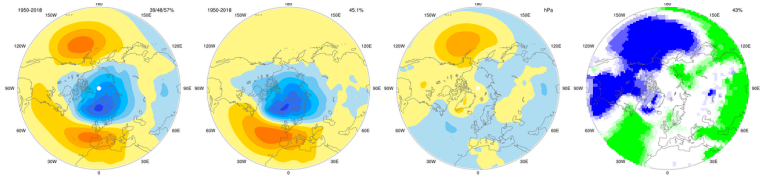
CCMA
(40 members)



CMIP5 Multi-Model
Large Ensemble Archive

Ensemble Summary: NAO Pattern (DJF)

CCMA
(40 members)



CSIRO
(30 members)

GFDL-CM3
(20 members)

GFDL-ESM2M
(30 members)

MPI
(70 members)

NCAR CESM1
(40 members)

SMHI_KNMI
(16 members)

CMIP5 Multi-Model
Large Ensemble Archive

Ensemble Summary: NAO Pattern (DJF)

CCMA
(40 members)

CSIRO
(30 members)

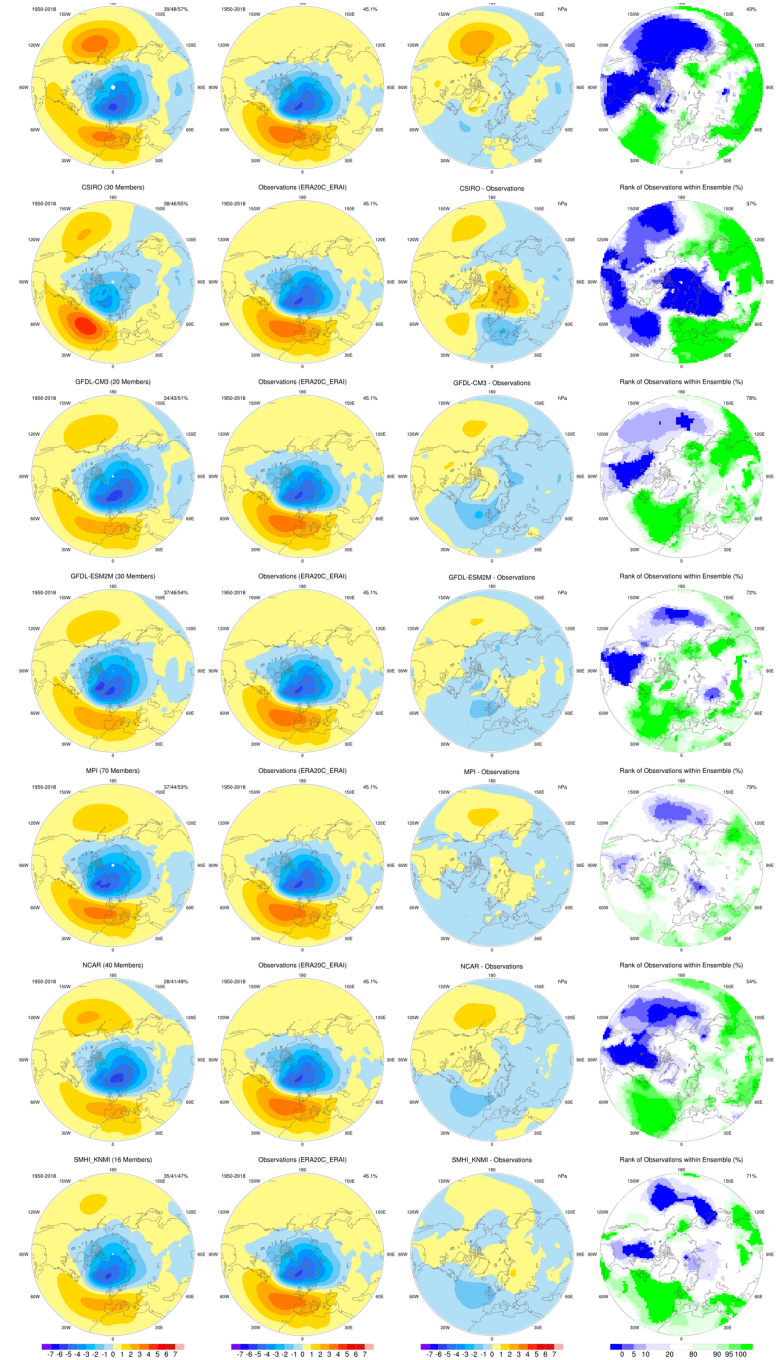
GFDL-CM3
(20 members)

GFDL-ESM2M
(30 members)

MPI
(70 members)

NCAR CESM1
(40 members)

SMHI_KNMI
(16 members)



CMIP5 Multi-Model
Large Ensemble Archive

Ensemble Summary: NAO Pattern (DJF)

CCMA
(40 members)

CSIRO
(30 members)

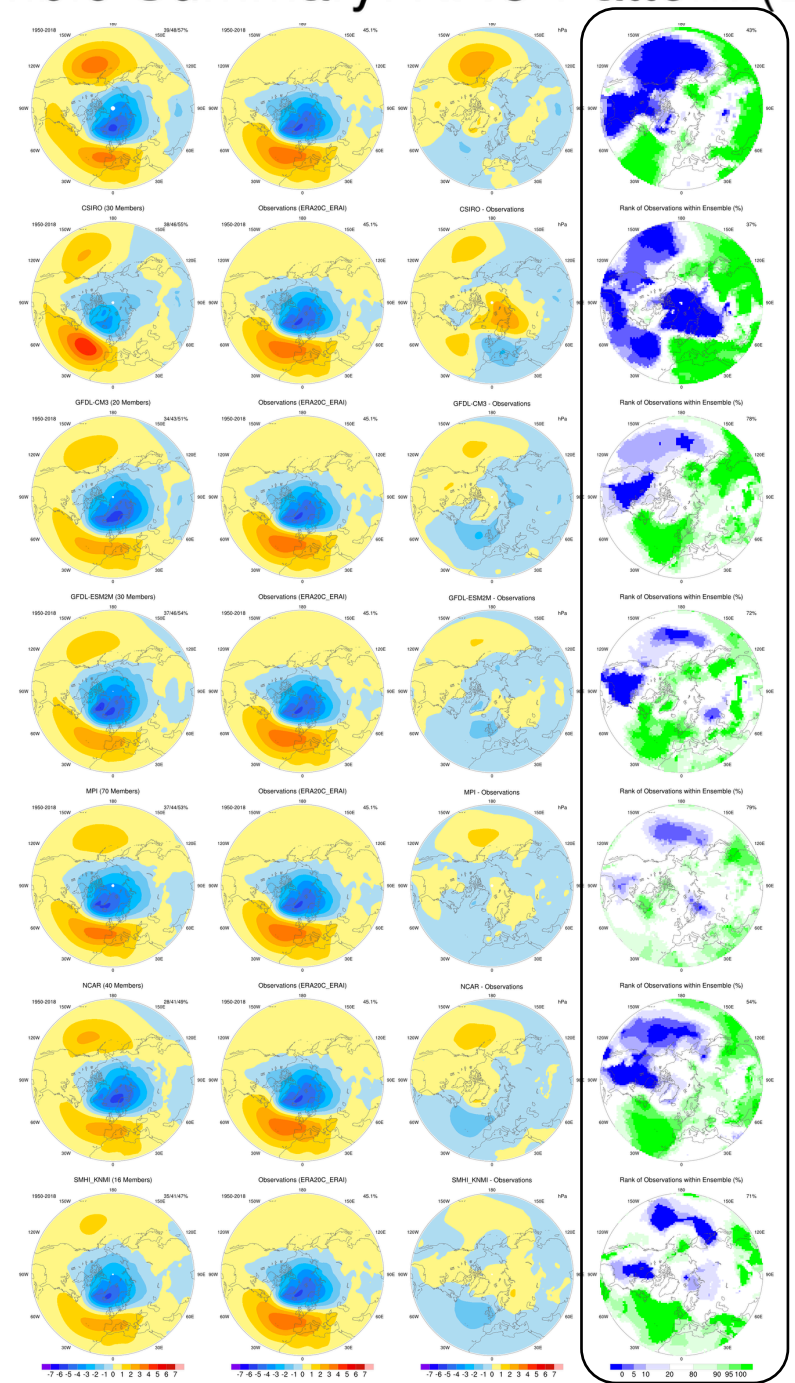
GFDL-CM3
(20 members)

GFDL-ESM2M
(30 members)

MPI
(70 members)

NCAR CESM1
(40 members)

SMHI_KNMI
(16 members)



CMIP5 Multi-Model
Large Ensemble Archive

Ensemble Summary: NAO Pattern (DJF)

CCMA
(40 members)

CSIRO
(30 members)

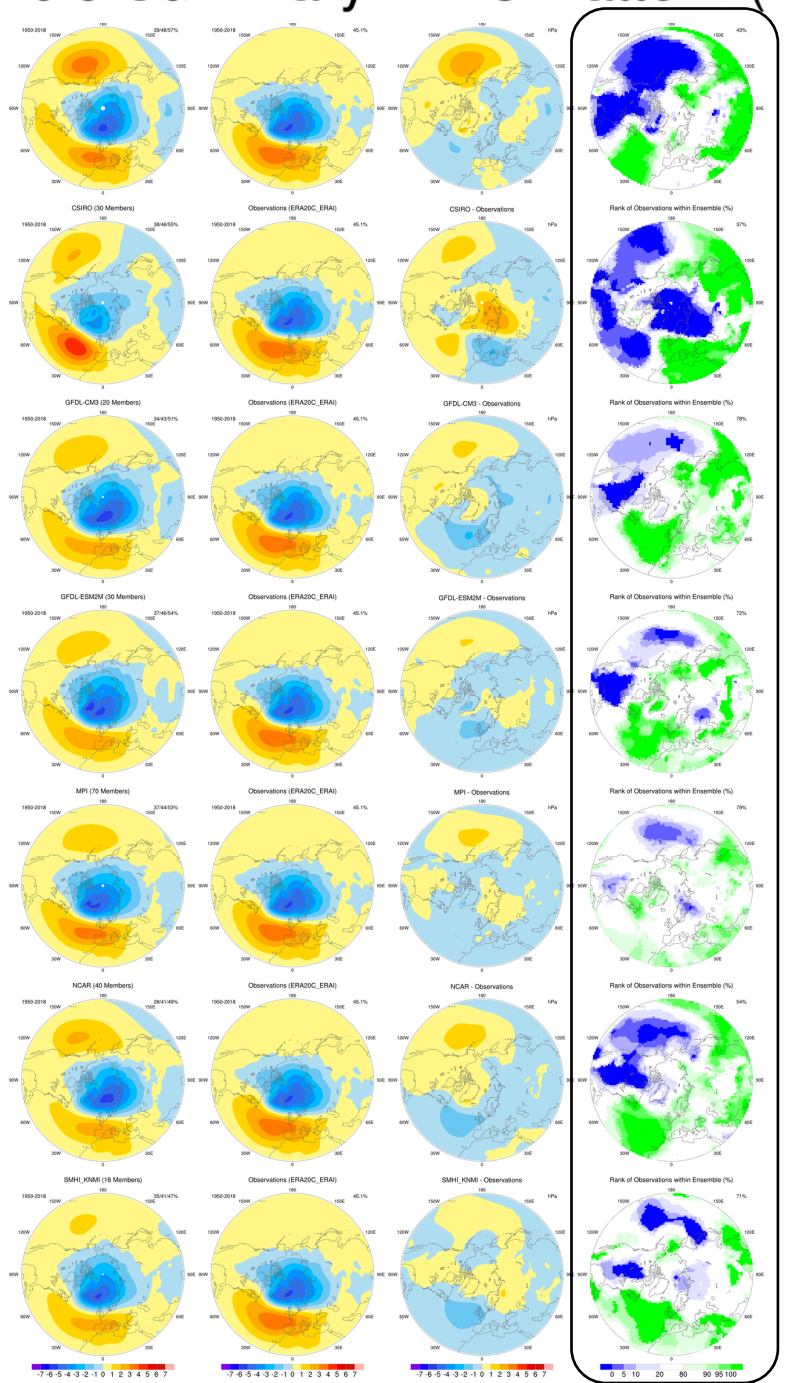
GFDL-CM3
(20 members)

GFDL-ESM2M
(30 members)

MPI
(70 members)

NCAR CESM1
(40 members)

SMHI_KNMI
(16 members)



CMIP5 Multi-Model
Large Ensemble Archive

← MPI is the most realistic: largest (60%) areal coverage of observations falling within 10^{th} – 90^{th} % of model spread.

Ensemble Summary: NAO Pattern (DJF)

CCMA
(40 members)

CSIRO
(30 members)

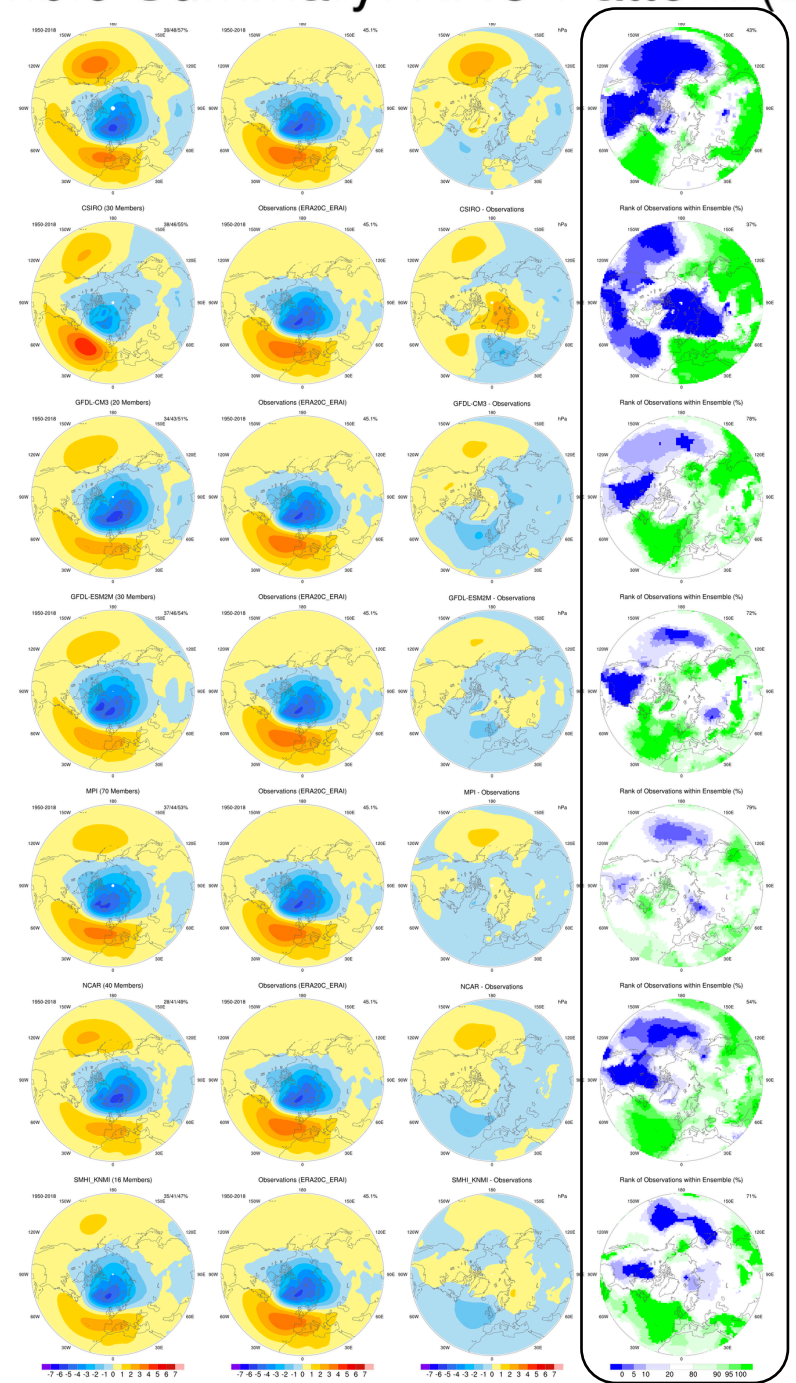
GFDL-CM3
(20 members)

GFDL-ESM2M
(30 members)

MPI
(70 members)

NCAR CESM1
(40 members)

SMHI_KNMI
(16 members)

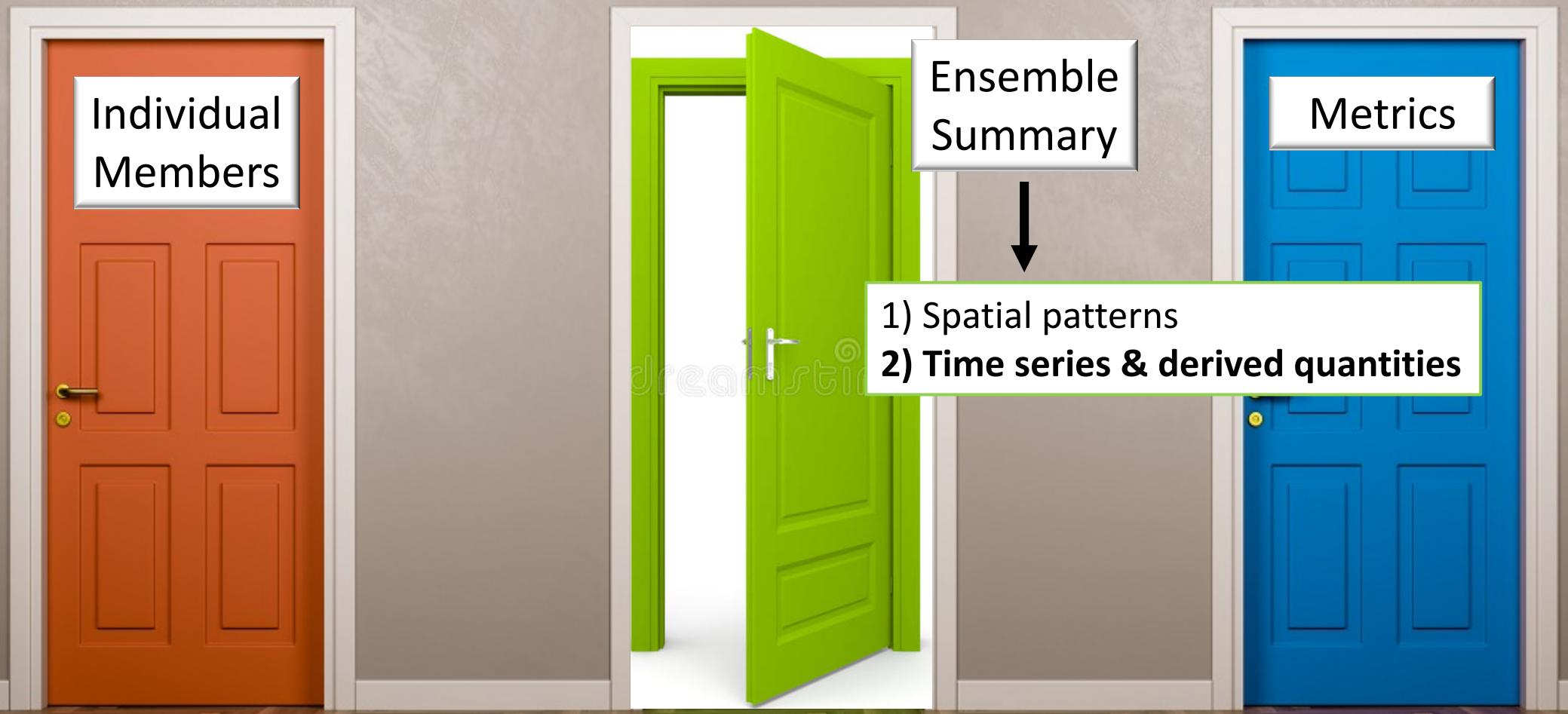


CMIP5 Multi-Model
Large Ensemble Archive

← MPI is the most realistic: largest (60%) areal coverage of observations falling within 10th – 90th % of model spread.

But need to check that amplitude of internal variability is realistic (compare σ maps).

Diagnostics Overview



CMIP5 Multi-Model Large Ensemble Archive

Global mean Air Temperature

Ensemble Summary: TAS Global Average (ANN)

Observations (BEST) 1950-2018, Linear trend = 0.9C 69yr^{-1}

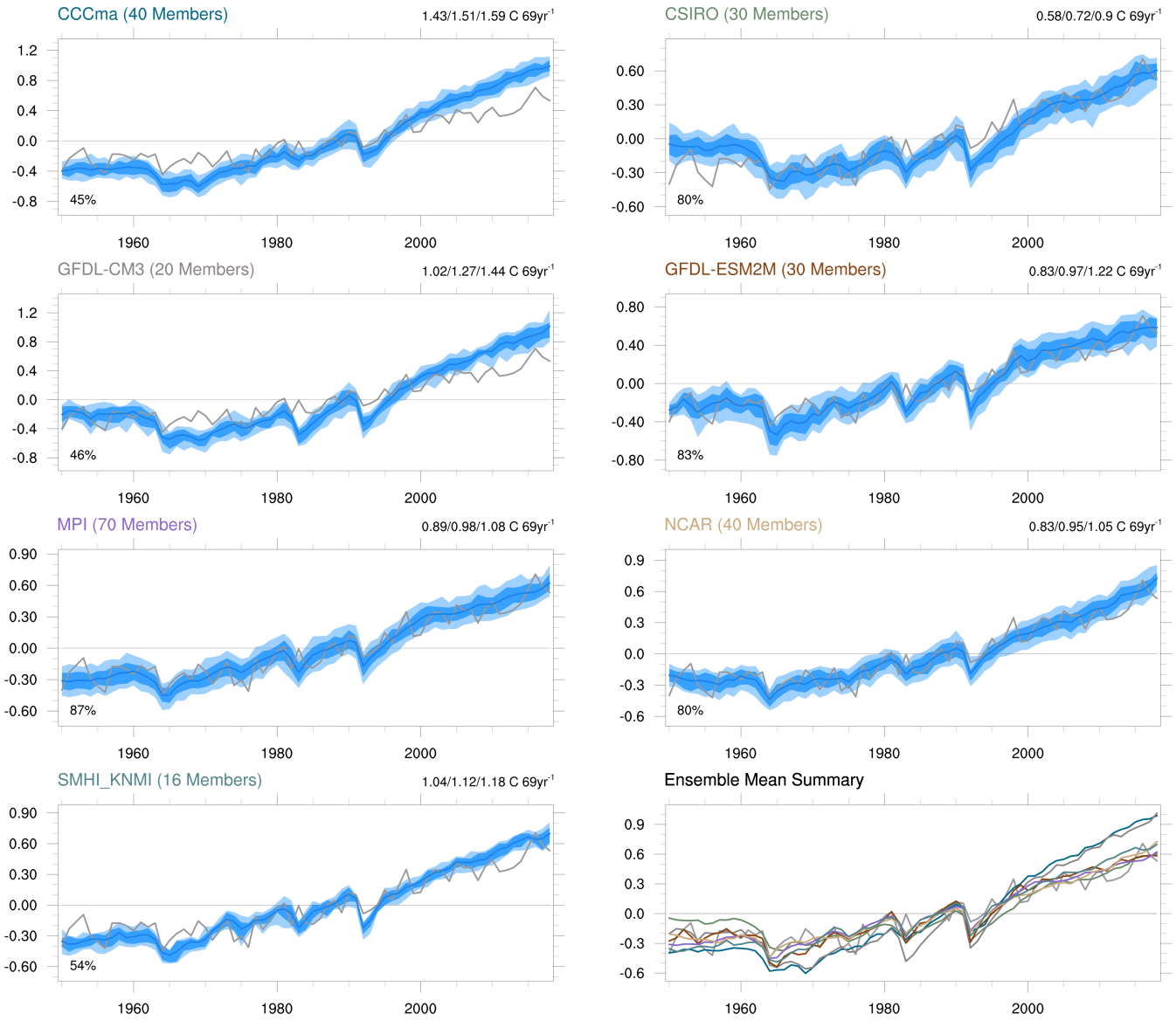
Observations

Model
Ensemble Mean

Ensemble Spread

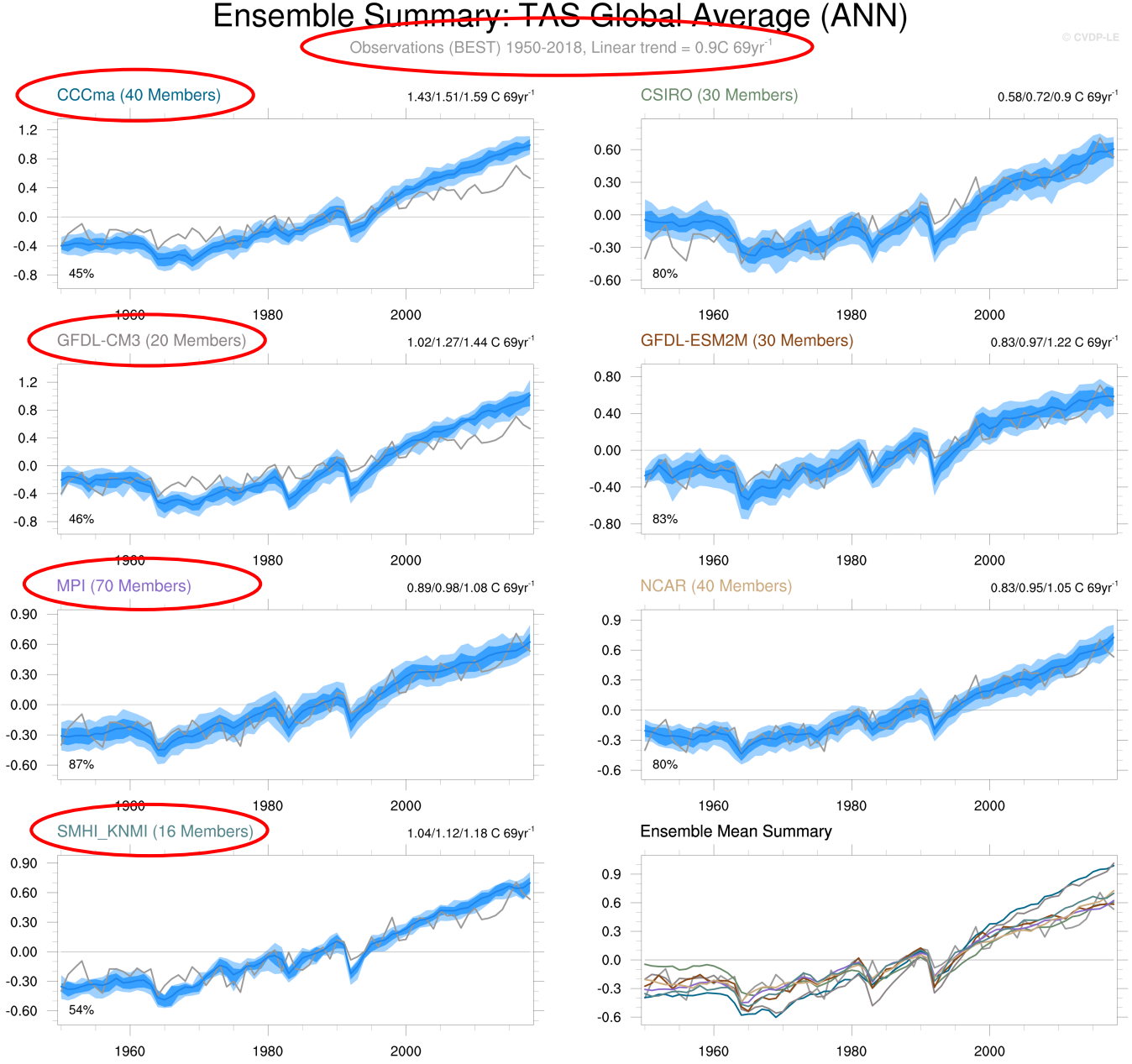
25-75%

10-90%



CMIP5 Multi-Model Large Ensemble Archive

Global mean Air Temperature



Observations

Model
Ensemble Mean

Ensemble Spread

25-75%

10-90%

CMIP5 Multi-Model Large Ensemble Archive

Observations

Model Ensemble Mean

Ensemble Spread

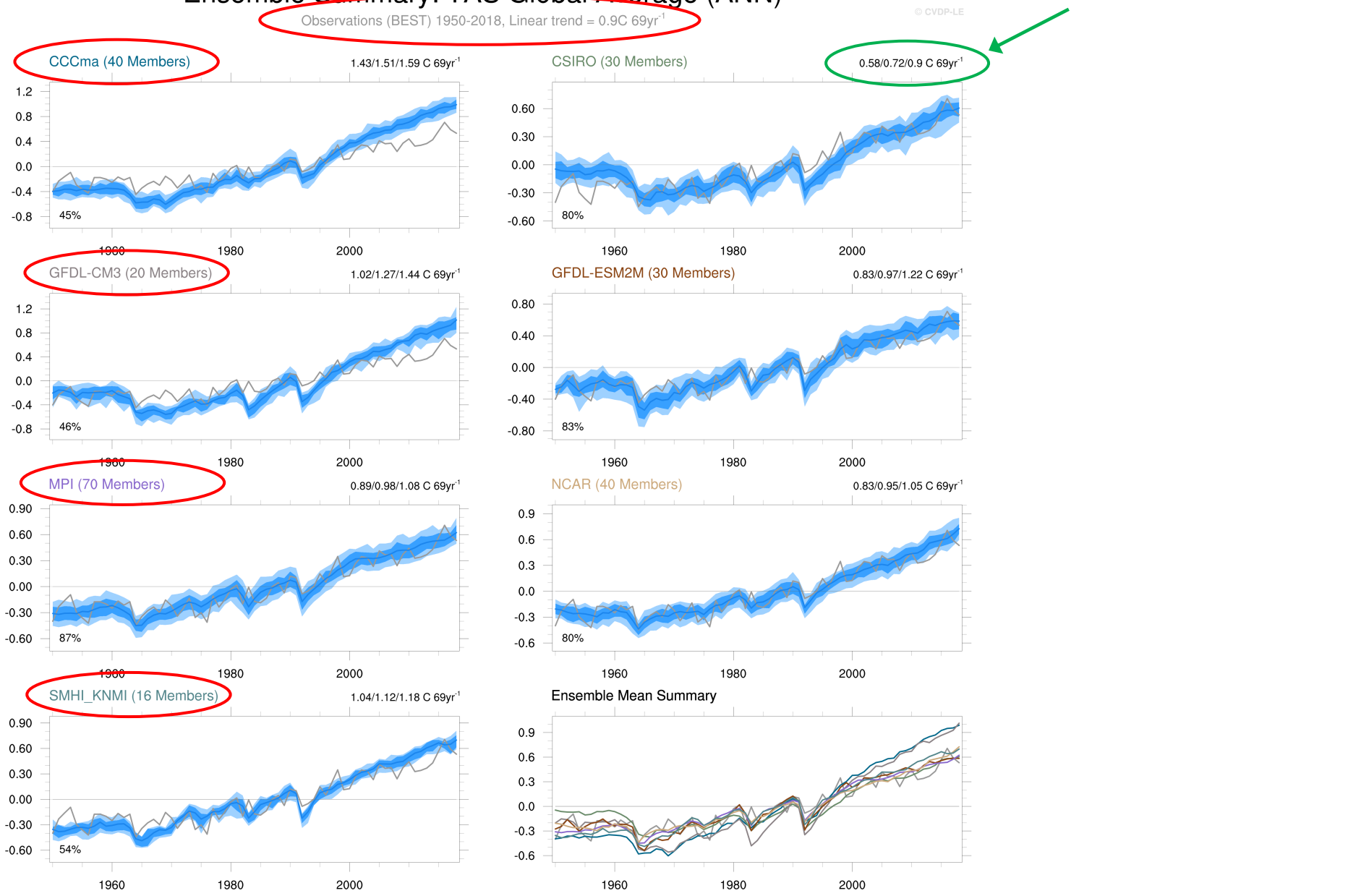
25-75%

10-90%

Global mean Air Temperature

Ensemble Summary: TAS Global Average (ANN)

Distribution of trend values (10th/50th/90th percentiles).



CMIP5 Multi-Model Large Ensemble Archive

Global mean Air Temperature

Distribution of trend values (10^{th}/50^{th}/90^{th} percentiles).

Percentage of time that Obs falls within 10-90% of model spread.

Ensemble Spread

25-75%

10-90%

CMIP5 Multi-Model Large Ensemble Archive

Global mean Air Temperature

Distribution of trend values ($10^{th}/50^{th}/90^{th}$ percentiles).

Percentage of time that Obs falls within 10-90% of model spread.

Ensemble Spread

25-75%

10-90%

Color-coded by model

CMIP5 Multi-Model Large Ensemble Archive

Global mean Air Temperature

Distribution of trend values ($10^{th}/50^{th}/90^{th}$ percentiles).

Percentage of time that Obs falls within 10-90% of model spread.

Ensemble Spread

25-75%

10-90%

All graphics, data and metrics saved to a repository.

Color-coded by model

CMIP6
Large Ensembles

Observations

Model
Ensemble Mean

Ensemble Spread

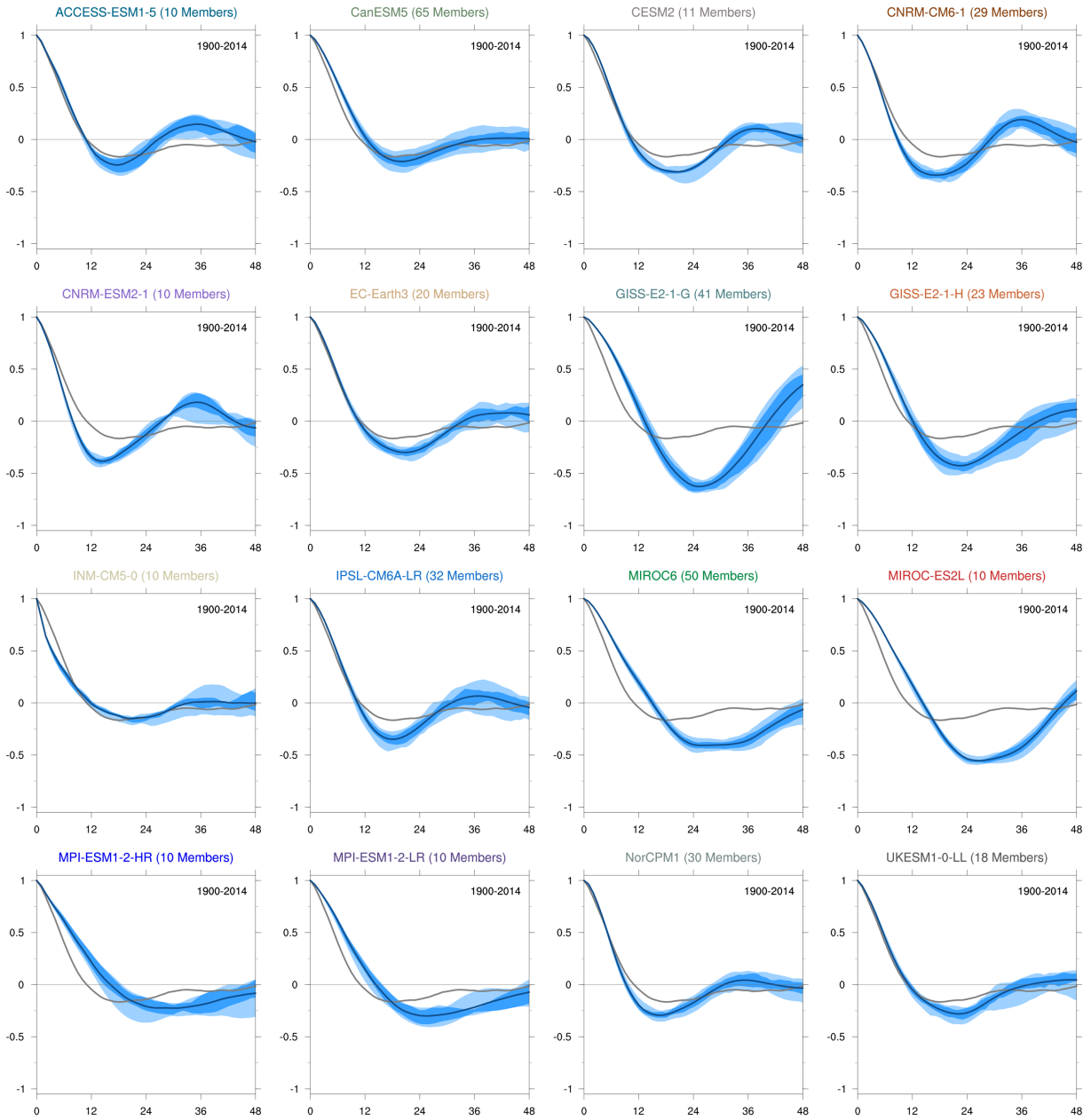
25-75%

10-90%

All graphics, data and metrics saved to a repository.

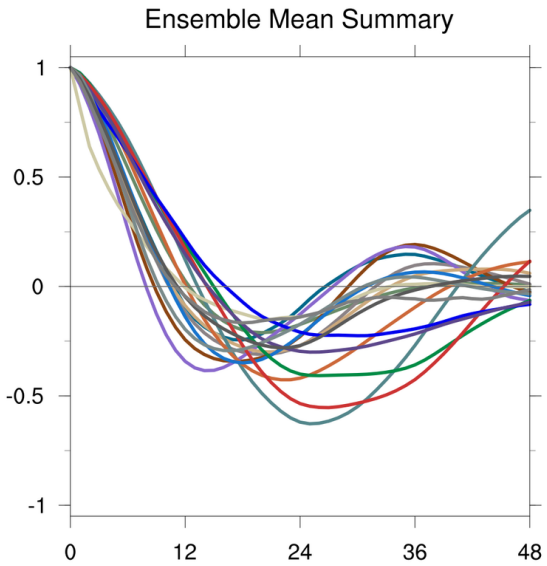
Ensemble Summary: Niño3.4 Autocorrelation (Monthly)

ERSST v5 1900-2014



Lag Autocorrelations
(0 - 48 months)

Niño3.4 SST Index
(detrended)



CMIP6
Large Ensembles

Observations

Model
Ensemble Mean

Ensemble Spread

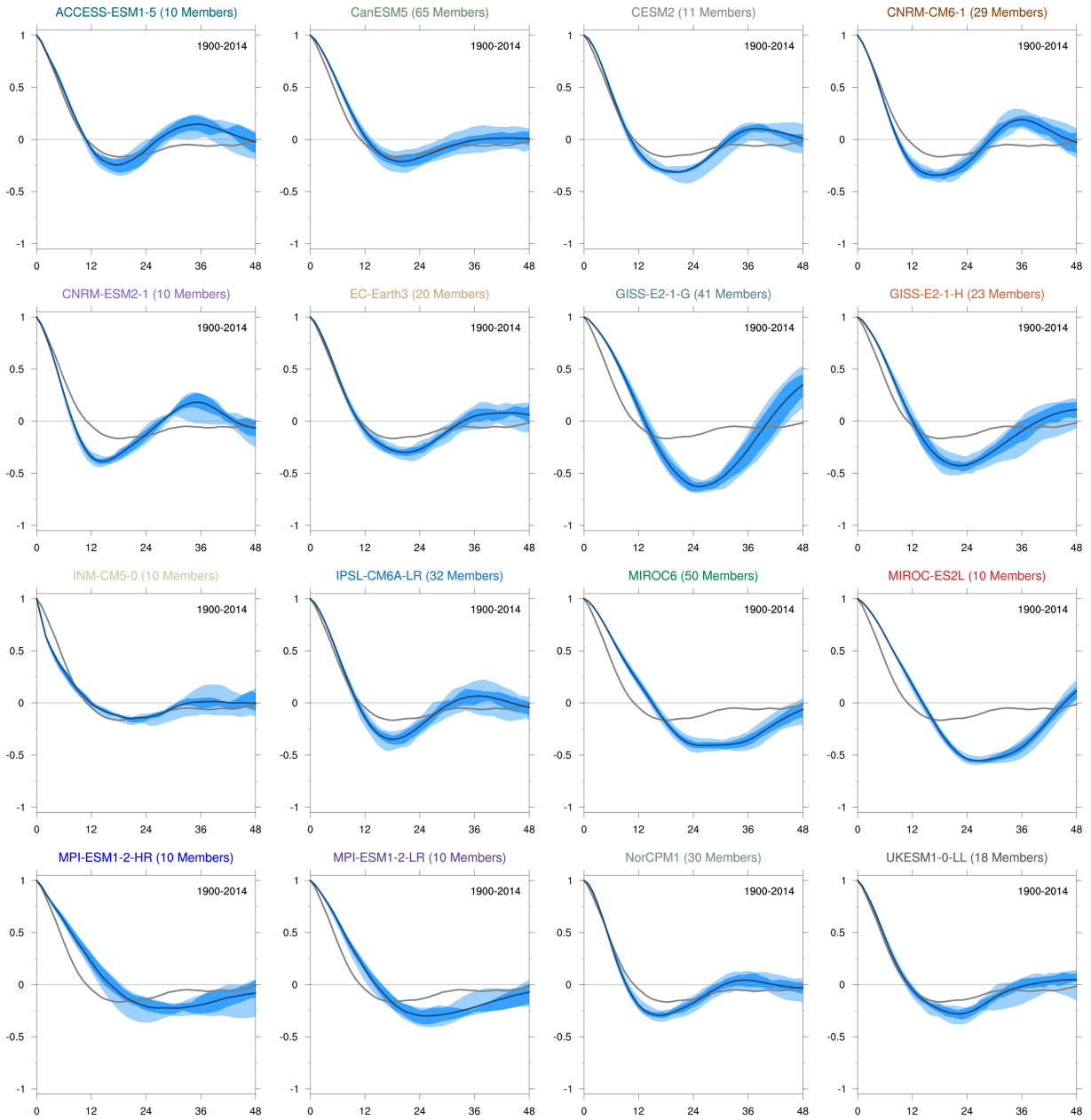
25-75%

10-90%

All graphics, data and metrics saved to a repository.

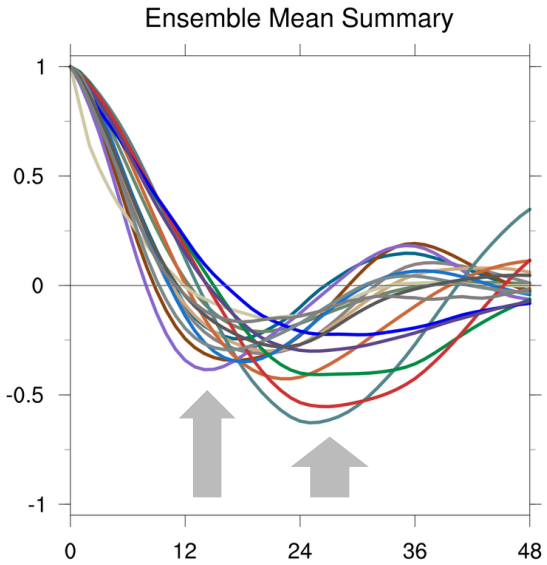
Ensemble Summary: Niño3.4 Autocorrelation (Monthly)

ERSST v5 1900-2014



Lag Autocorrelations
(0 - 48 months)

Niño3.4 SST Index
(detrended)



CMIP6
Large Ensembles

Observations

Model
Ensemble Mean

Ensemble Spread

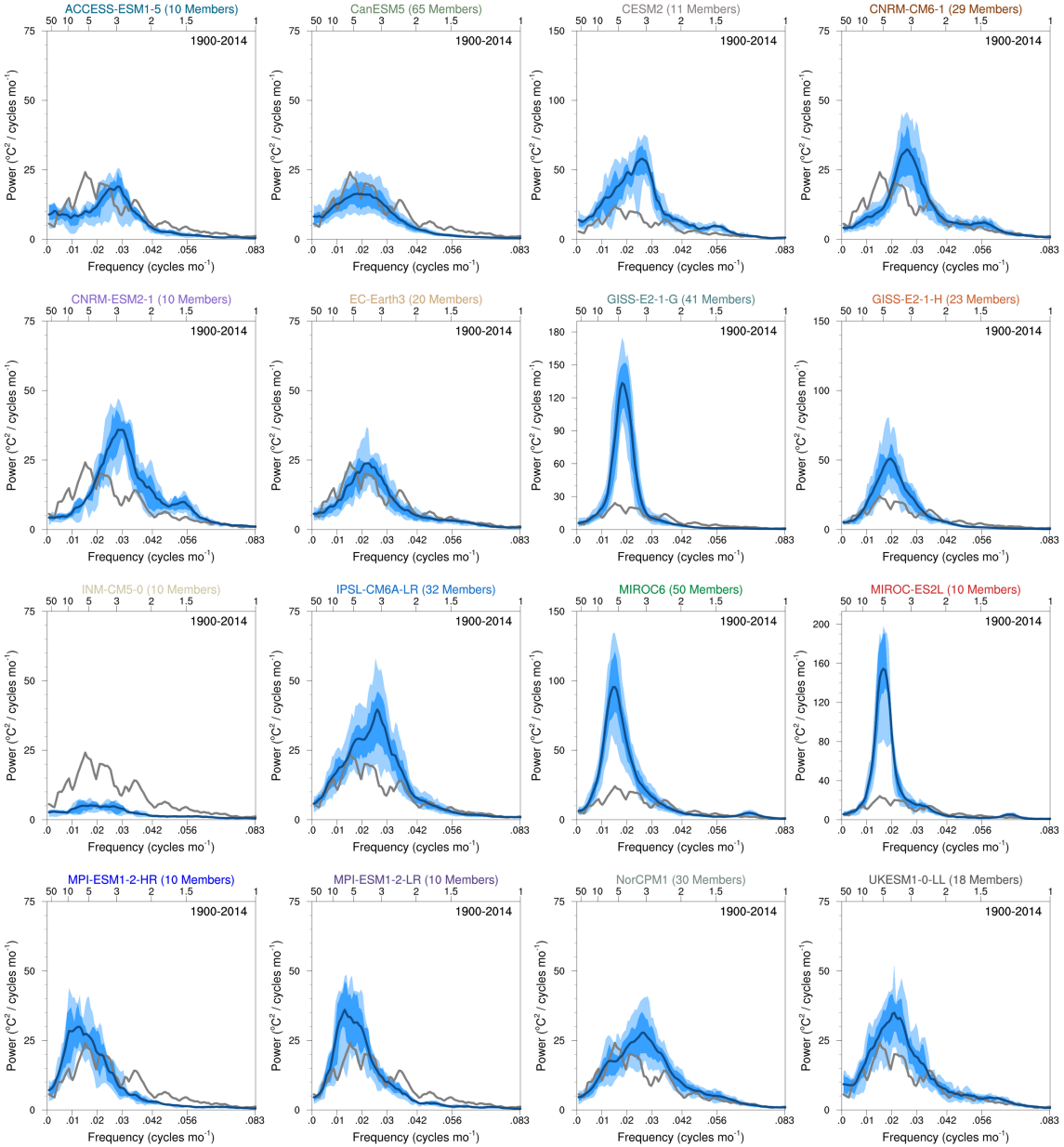
25-75%

10-90%

All graphics, data and metrics saved to a repository.

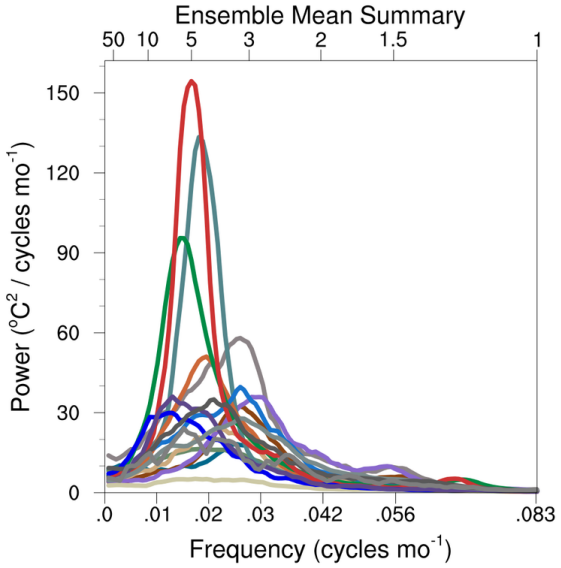
Ensemble Summary: Niño3.4 SST Power Spectra (Monthly)

ERSST v5 1900-2014



Power Spectra

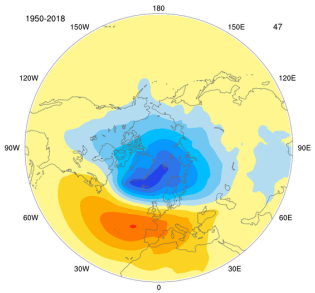
Niño3.4 SST Index (detrended)



Diagnostics Overview

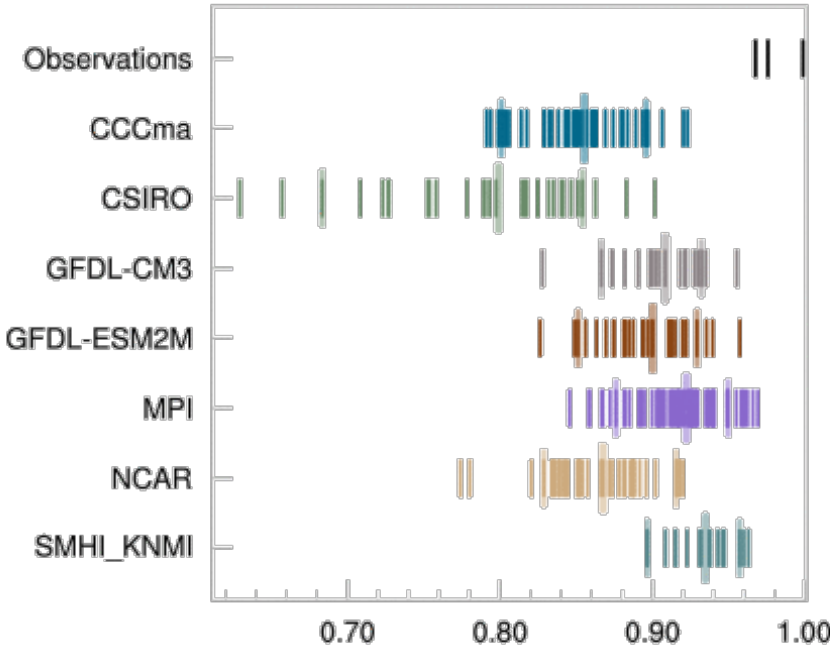
Diagnostics Overview

CMIP5 Multi-Model Large Ensemble Archive

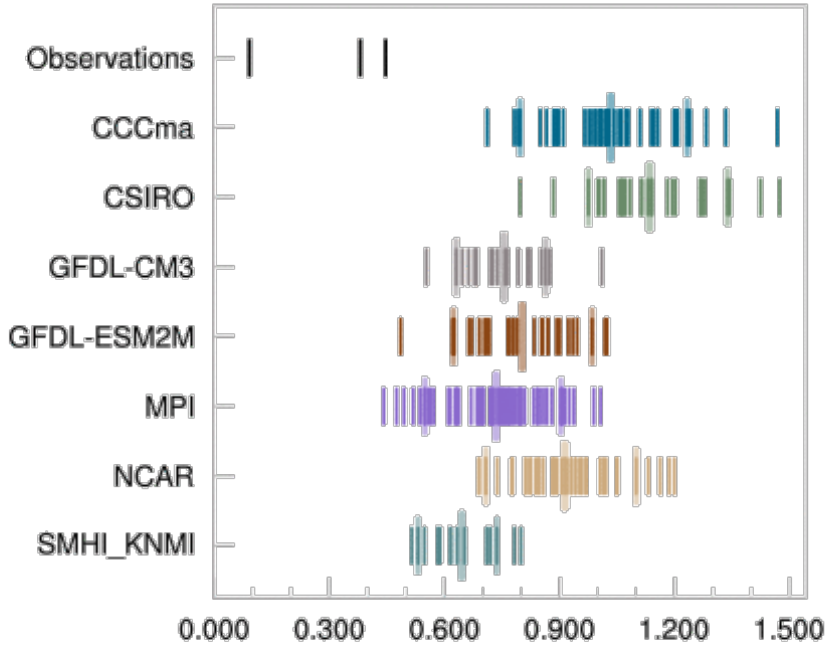


Winter NAO (Model *vs.* ERA-20C 1950-2018)

Pattern Correlations



Spatial RMS Differences



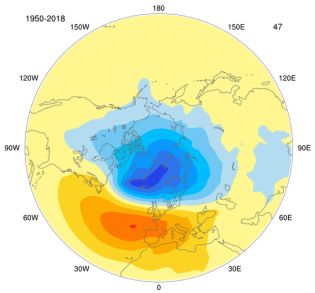
Longer bars: 10th / 50th / 90th percentiles

All graphics, data and metrics saved to a repository.

Observational Uncertainty

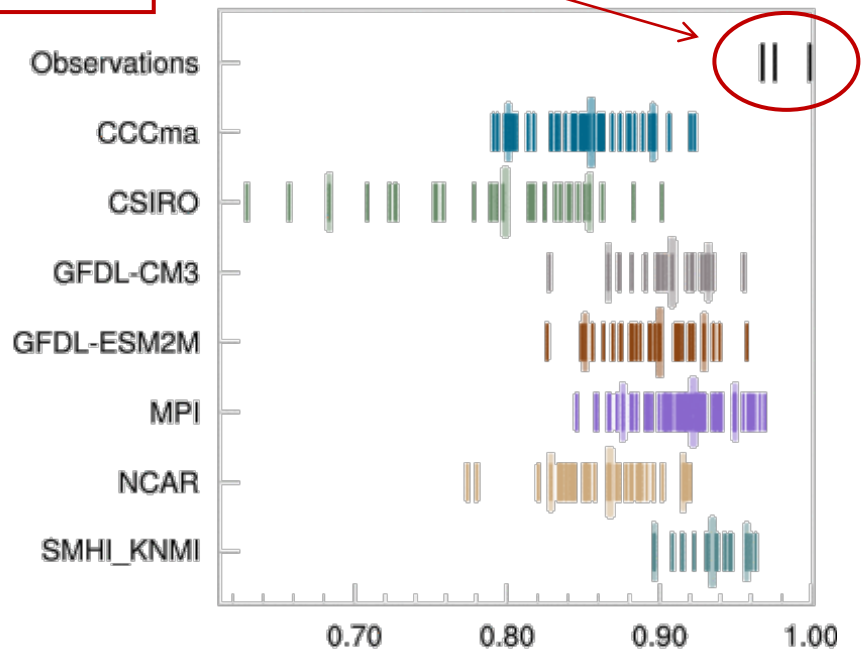
CERA20C (1950-2018)
ERA-I (1979-2018)
MERRA2 (1980-2017)

CMIP5 Multi-Model Large Ensemble Archive

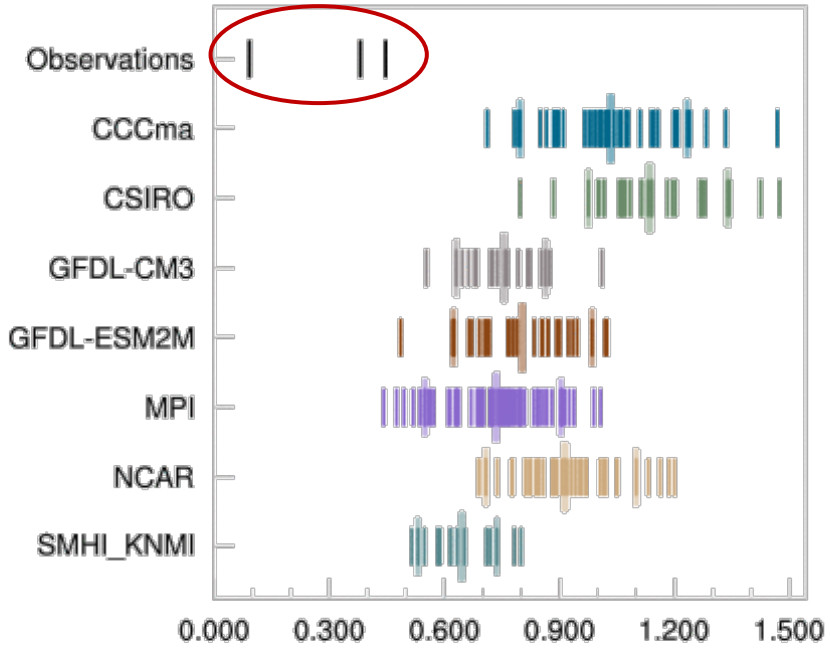


Winter NAO (Model *vs.* ERA-20C 1950-2018)

Pattern Correlations



Spatial RMS Differences



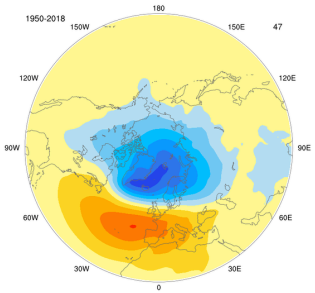
Longer bars: 10th / 50th / 90th percentiles

All graphics, data and metrics saved to a repository.

Observational Uncertainty

CERA20C (1950-2018)
ERA-I (1979-2018)
MERRA2 (1980-2017)

CMIP5 Multi-Model Large Ensemble Archive



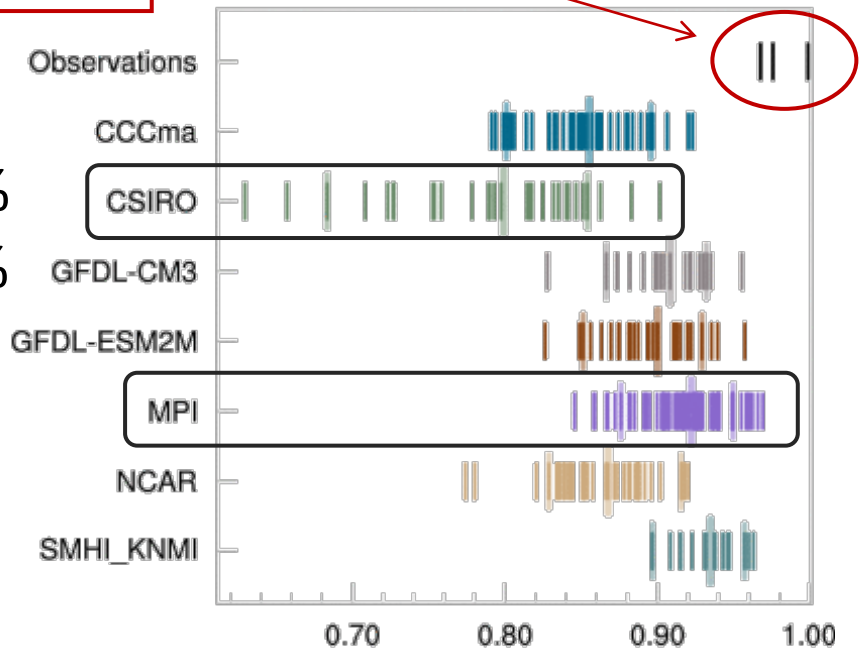
Winter NAO (Model *vs.* ERA-20C 1950-2018)

CSIRO 90th % < MPI 10th %

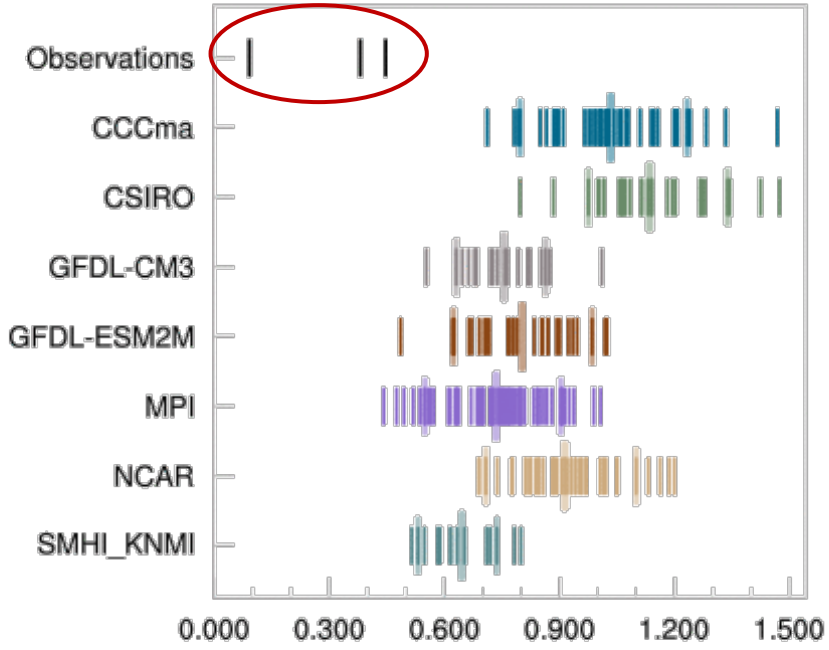
Models are structurally different.

See also Fasullo et al. (2020)

Pattern Correlations



Spatial RMS Differences



Longer bars: 10th / 50th / 90th percentiles

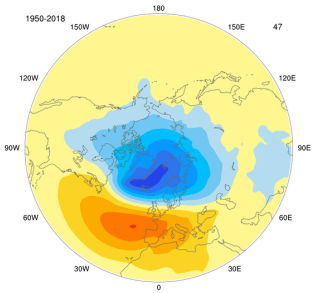
All graphics, data and metrics saved to a repository.

Observational Uncertainty

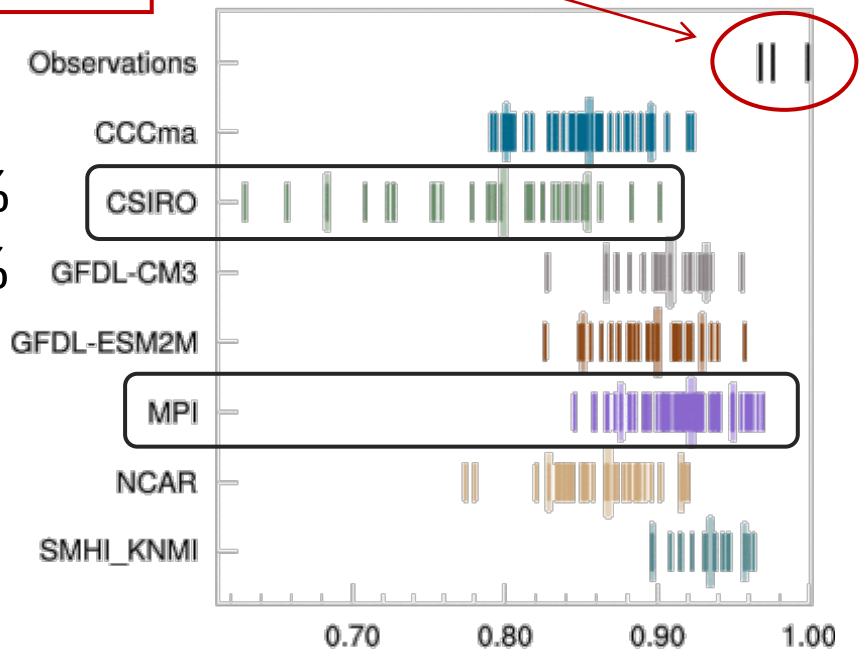
CERA20C (1950-2018)
ERA-I (1979-2018)
MERRA2 (1980-2017)

CMIP5 Multi-Model Large Ensemble Archive

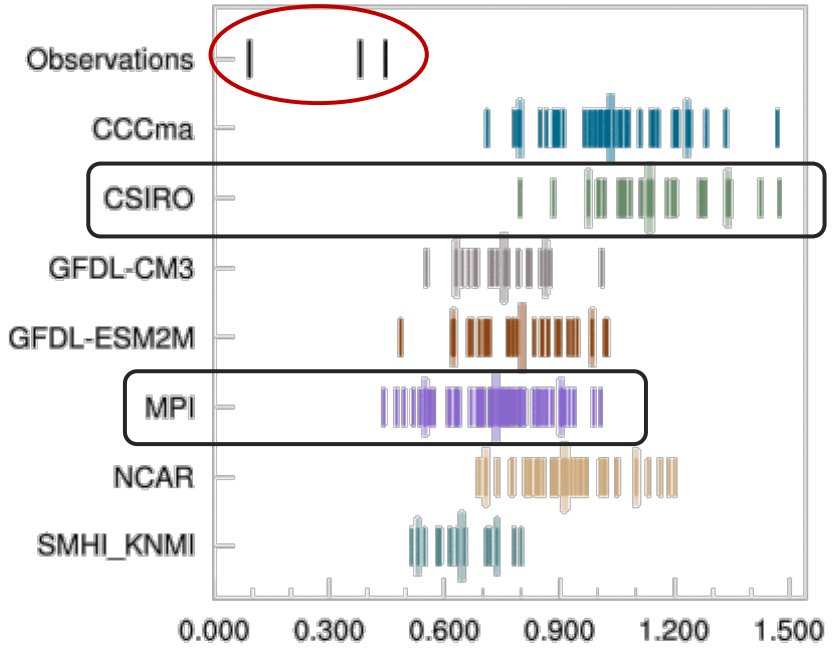
Winter NAO (Model *vs.* ERA-20C 1950-2018)



Pattern Correlations



Spatial RMS Differences



CSIRO 90th % < MPI 10th %

↓

Models are structurally different.

CSIRO 10th % > MPI 90th %

↓

Models are structurally different.

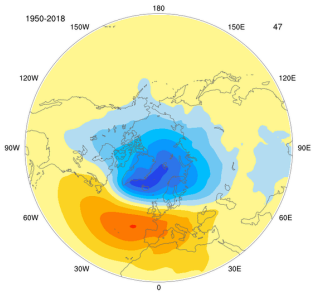
See also Fasullo et al. (2020)

Longer bars: 10th / 50th / 90th percentiles

All graphics, data and metrics saved to a repository.

CMIP6 Large Ensembles

Winter NAO (Model *vs.* ERA-20C 1900-2014)

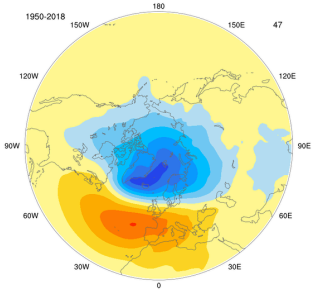


Observational Uncertainty

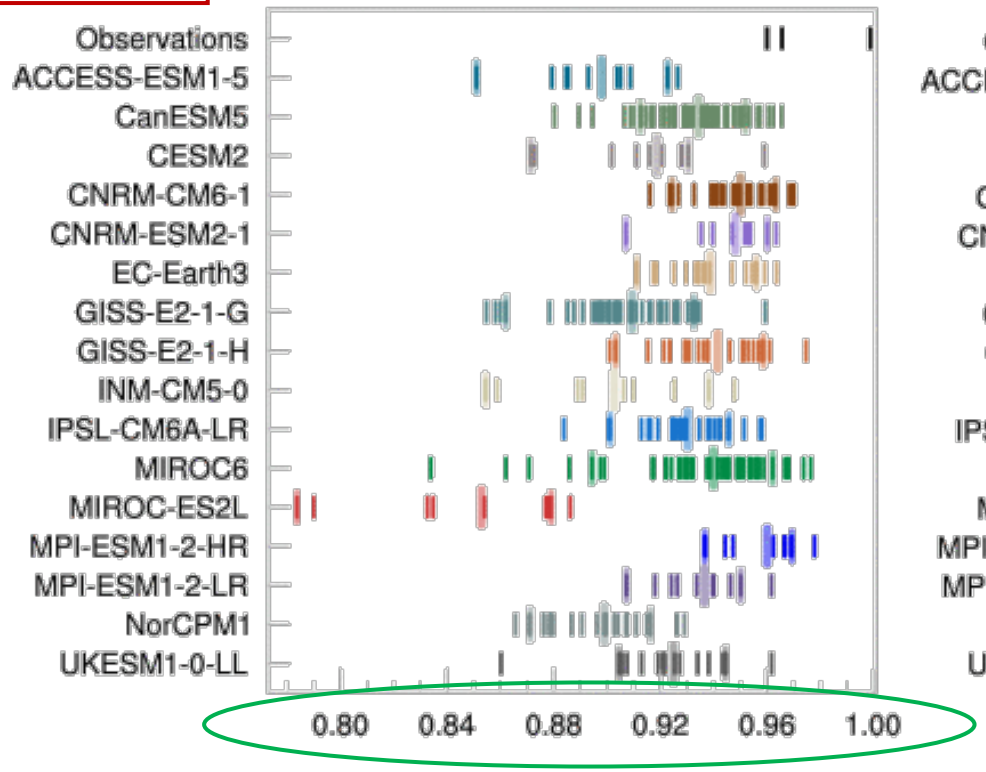
CERA20C (1901-2014)
ERA-I (1979-2014)
MERRA2 (1980-2014)

CMIP6 Large Ensembles

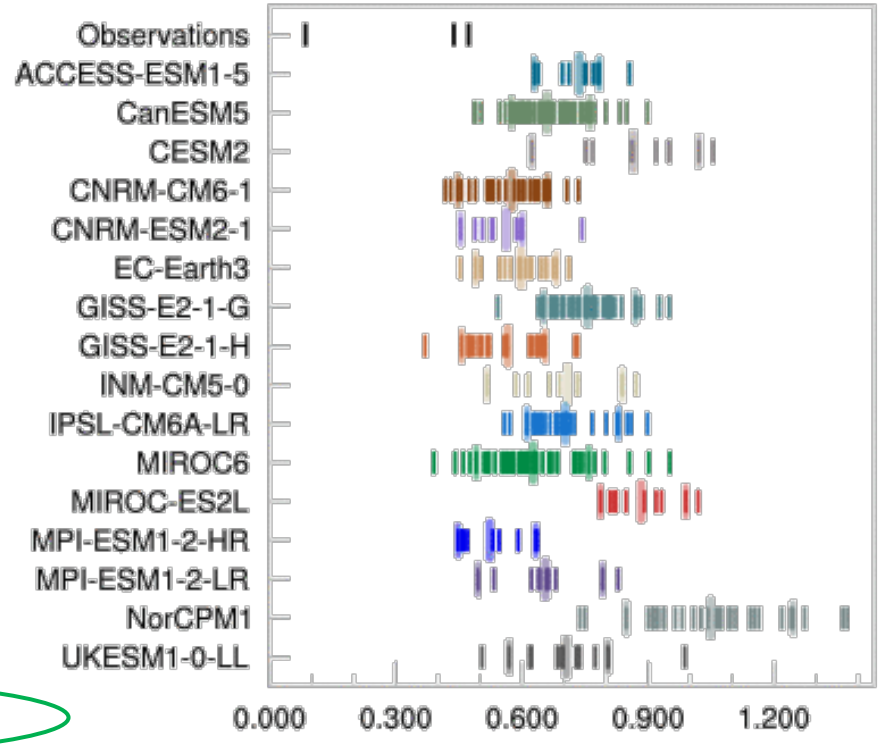
Winter NAO (Model *vs.* ERA-20C 1900-2014)



Pattern Correlations



Spatial RMS Differences



Longer bars: 10th - 50th - 90th percentiles

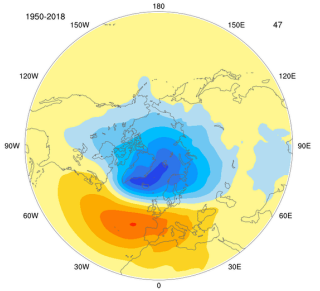
All graphics, data and metrics saved to a repository.

Observational Uncertainty

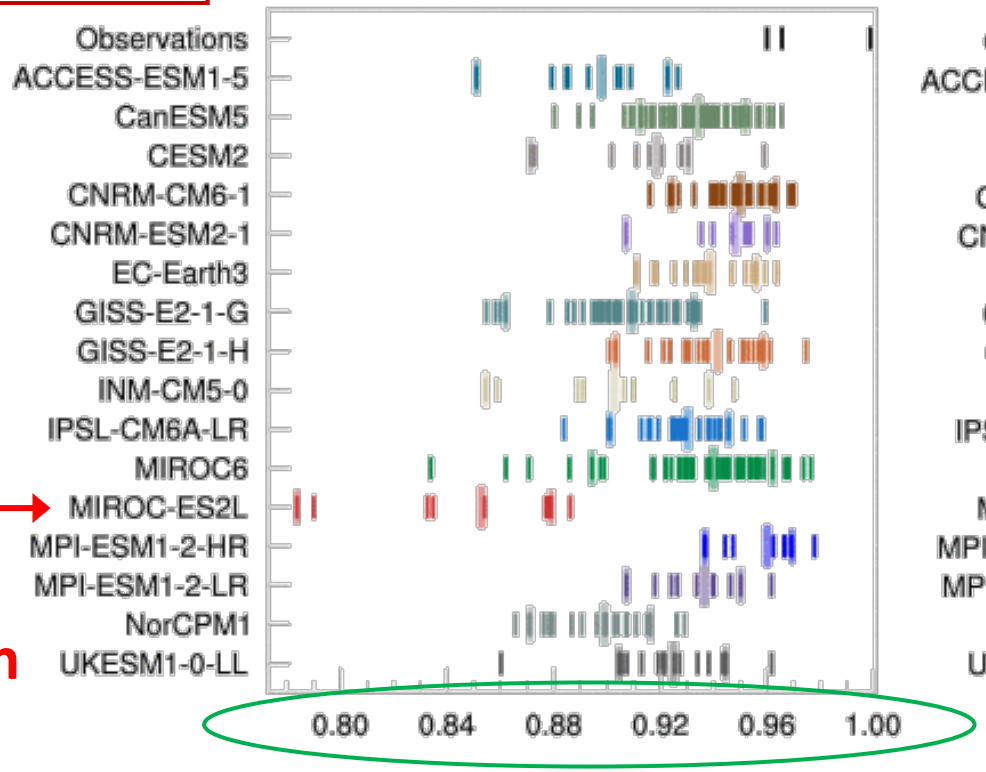
CERA20C (1901-2014)
ERA-I (1979-2014)
MERRA2 (1980-2014)

CMIP6 Large Ensembles

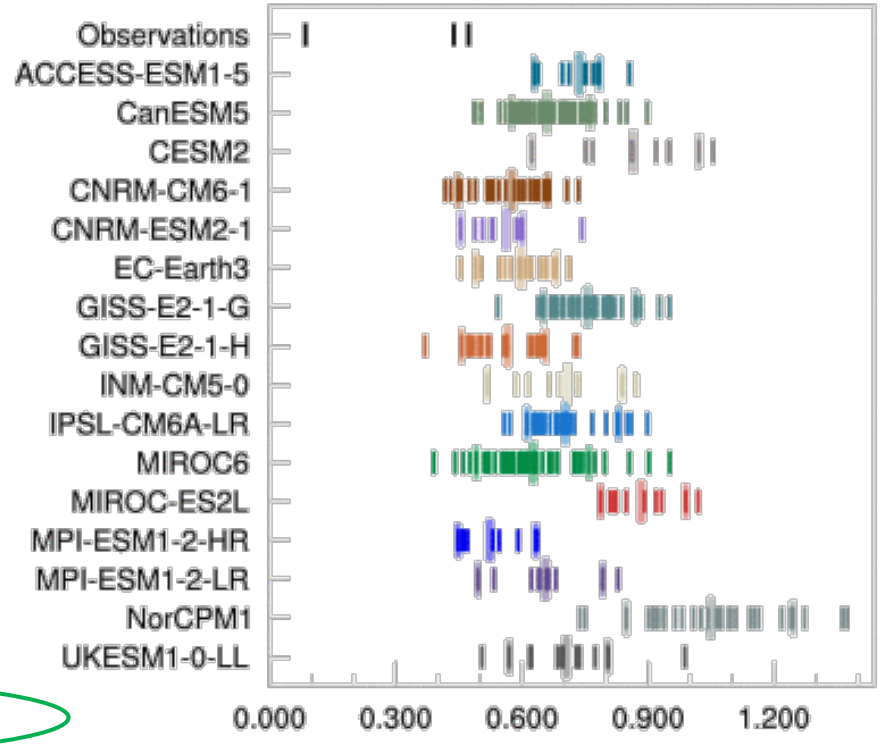
Winter NAO (Model *vs.* ERA-20C 1900-2014)



Pattern Correlations



Spatial RMS Differences



Lowest pattern correlation → MIROC-ES2L

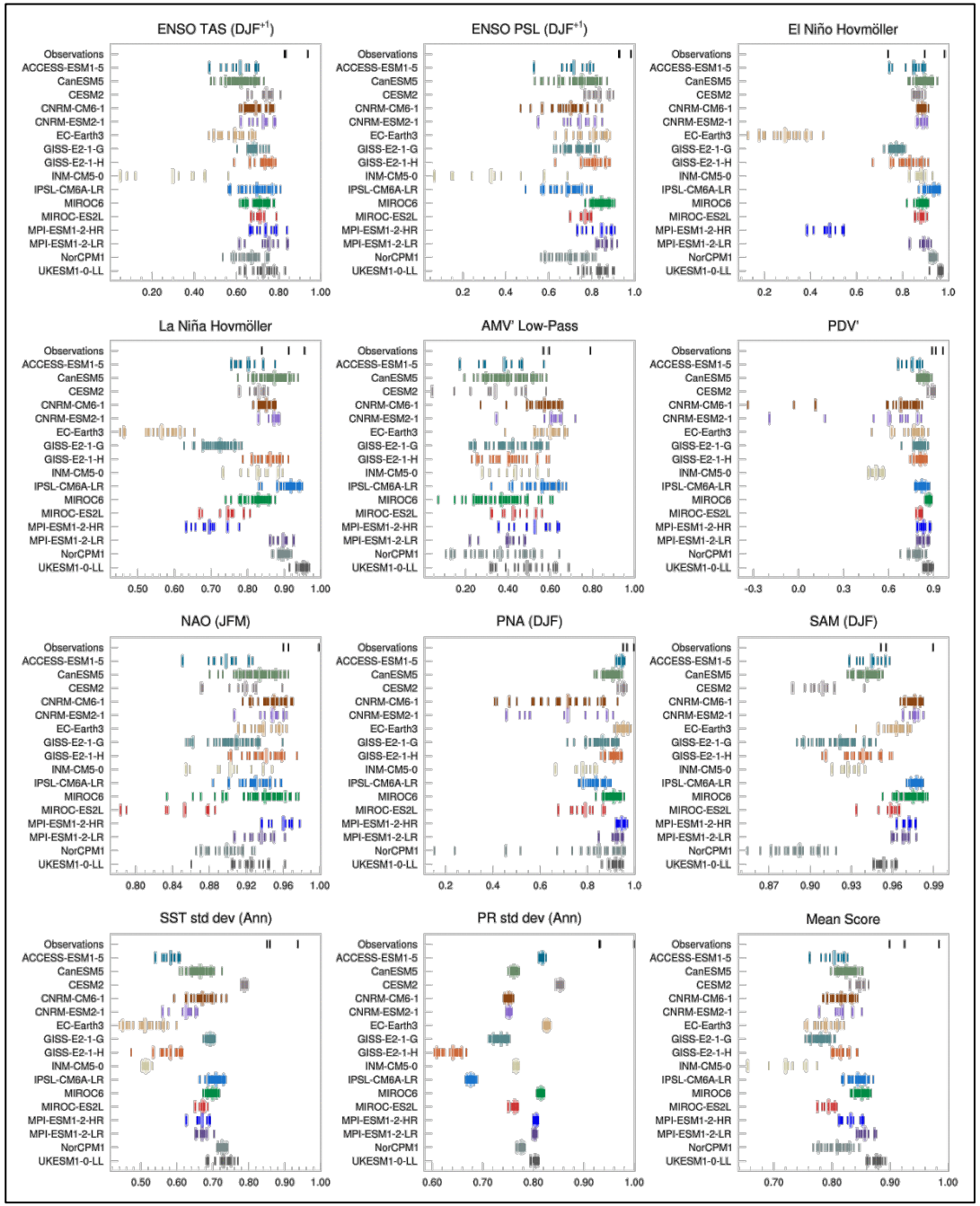
← **Highest spatial rmse**

Longer bars: 10th - 50th - 90th percentiles

All graphics, data and metrics saved to a repository.

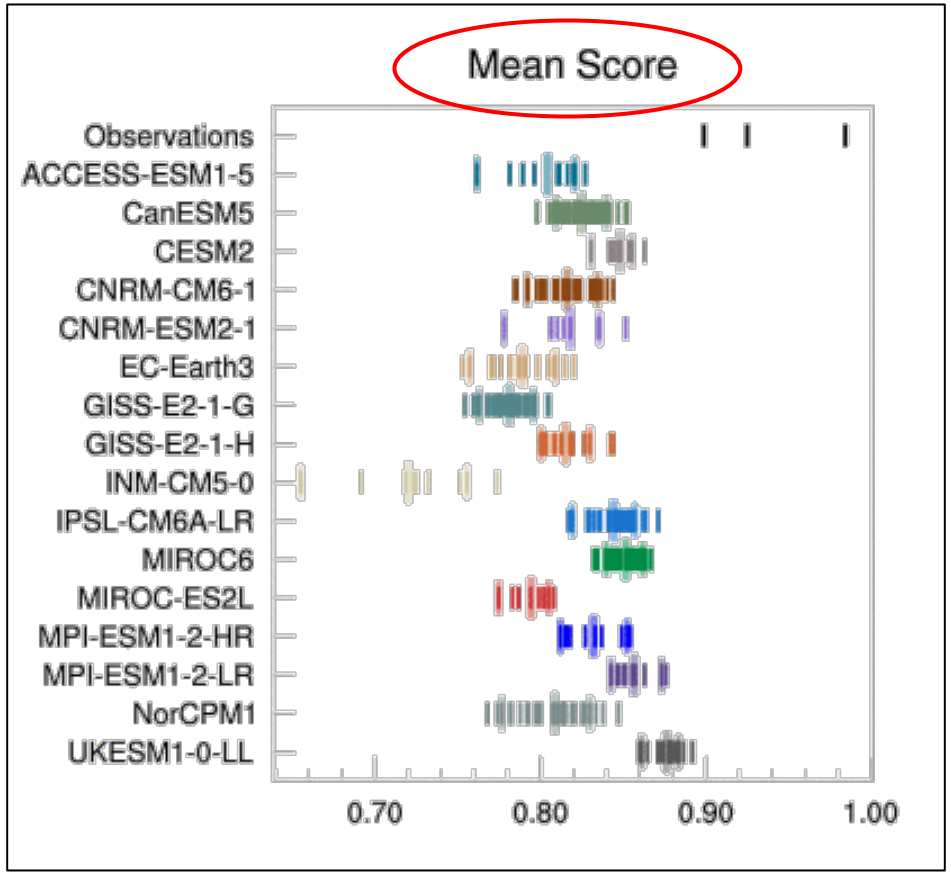
11 Metrics

(4 ENSO, AMV, PDV, NAO, PNA, SAM, σ SST, σ Land Precip)

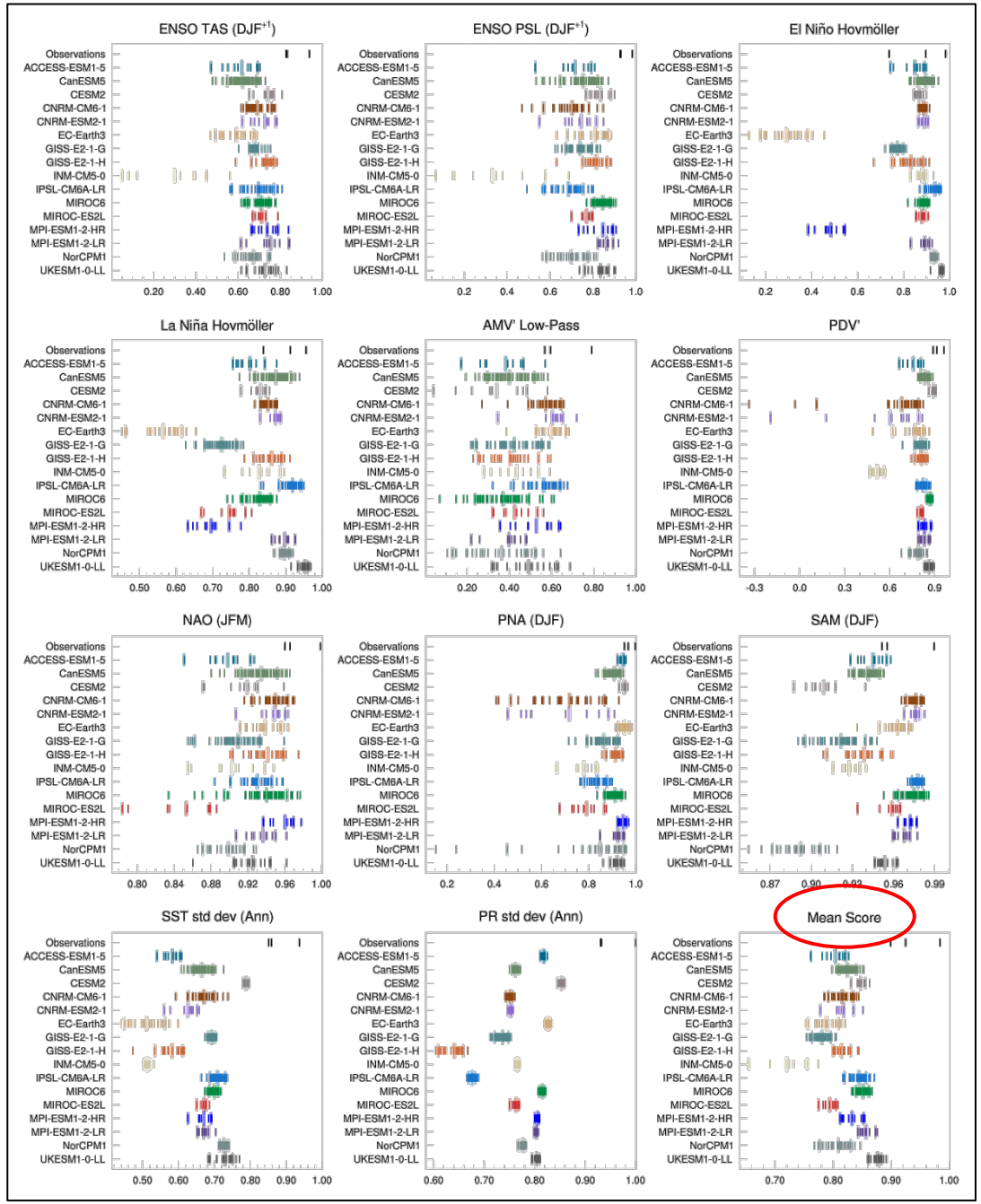


11 Metrics

(4 ENSO, AMV, PDV, NAO, PNA, SAM, σ SST, σ Land Precip)

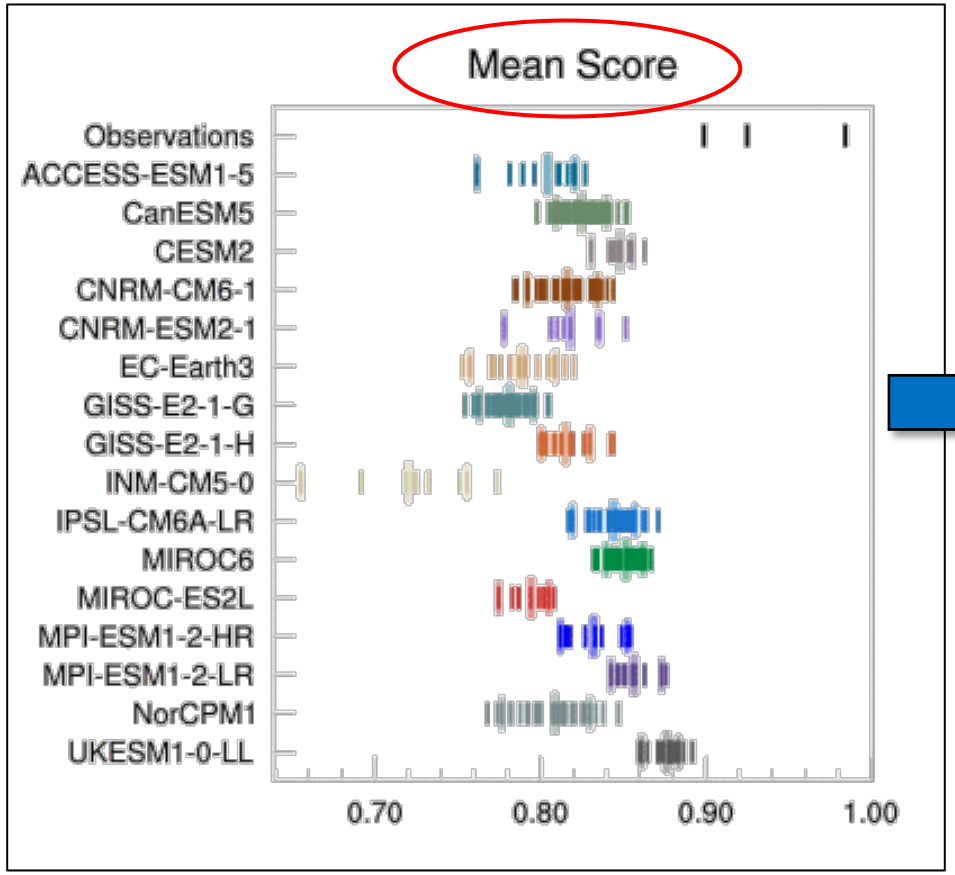


Longer bars: 10th - 50th - 90th percentiles

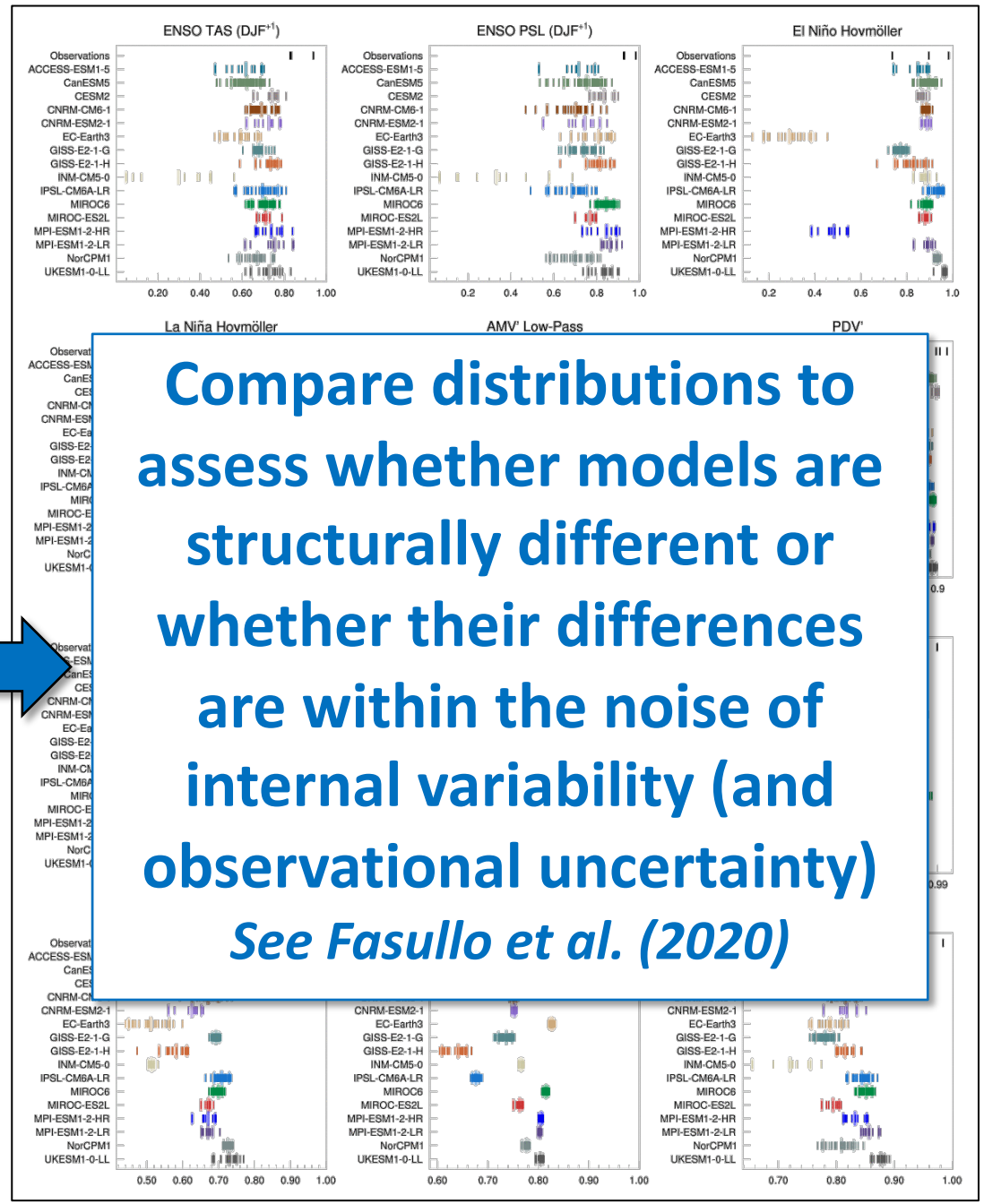


11 Metrics

(4 ENSO, AMV, PDV, NAO, PNA, SAM, σ SST, σ Land Precip)



Longer bars: 10th - 50th - 90th percentiles

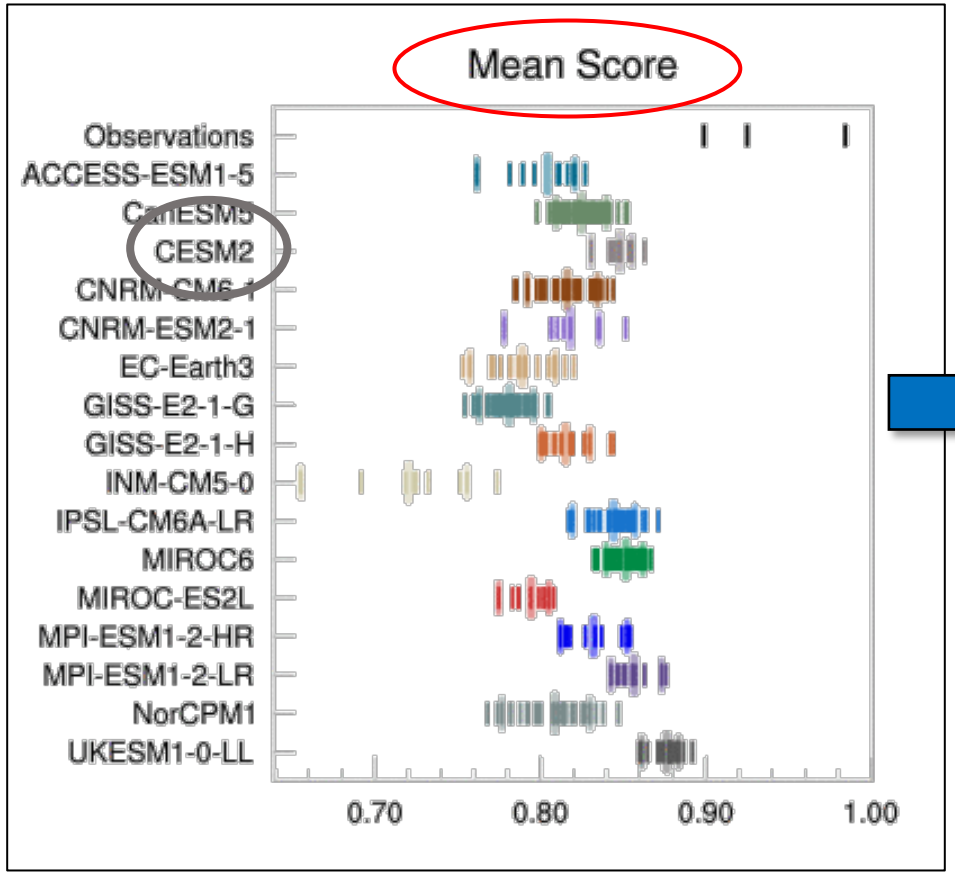


Compare distributions to assess whether models are structurally different or whether their differences are within the noise of internal variability (and observational uncertainty)

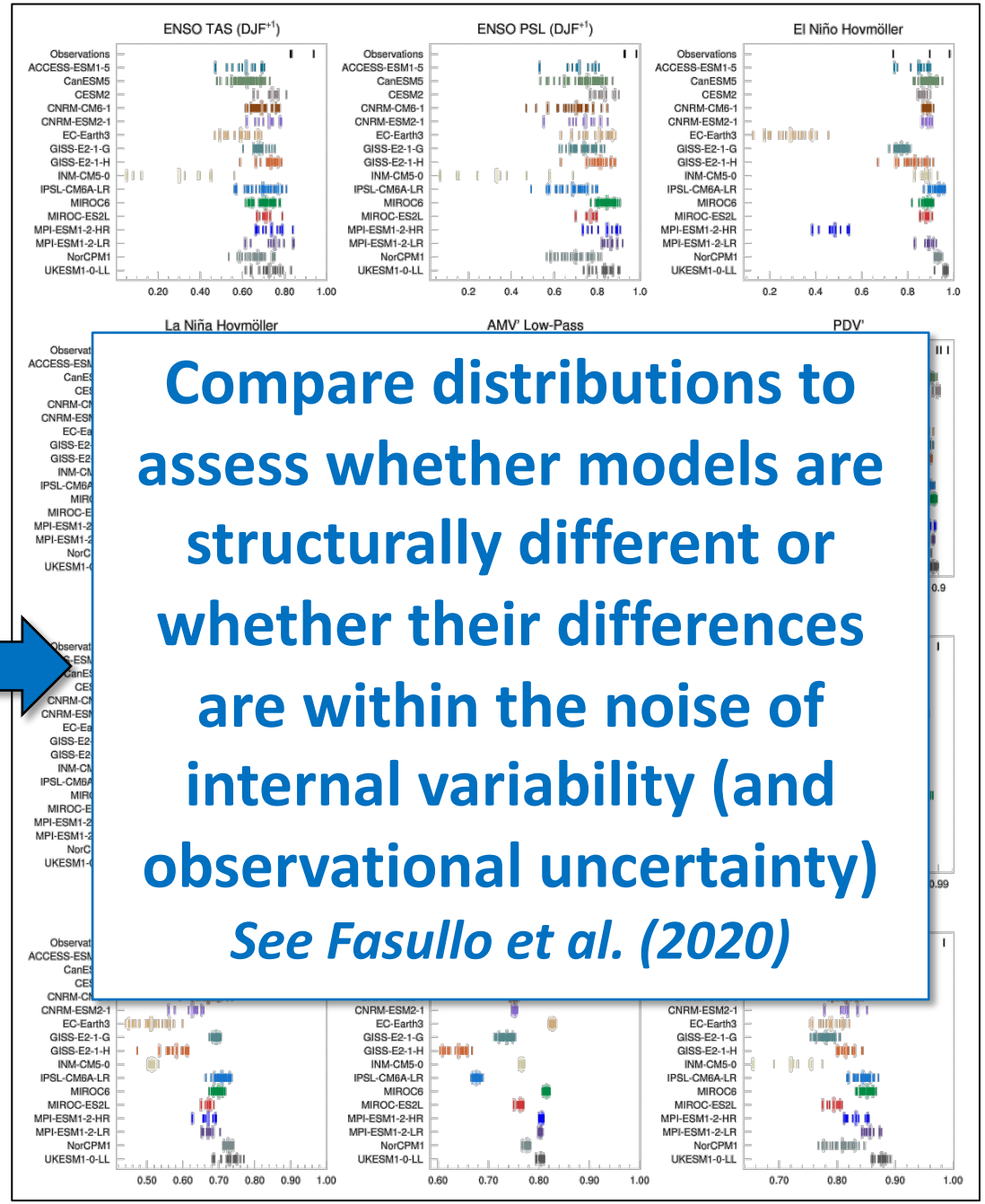
See Fasullo et al. (2020)

11 Metrics

(4 ENSO, AMV, PDV, NAO, PNA, SAM, σ SST, σ Land Precip)



Longer bars: 10th - 50th - 90th percentiles



Compare distributions to assess whether models are structurally different or whether their differences are within the noise of internal variability (and observational uncertainty)

See Fasullo et al. (2020)

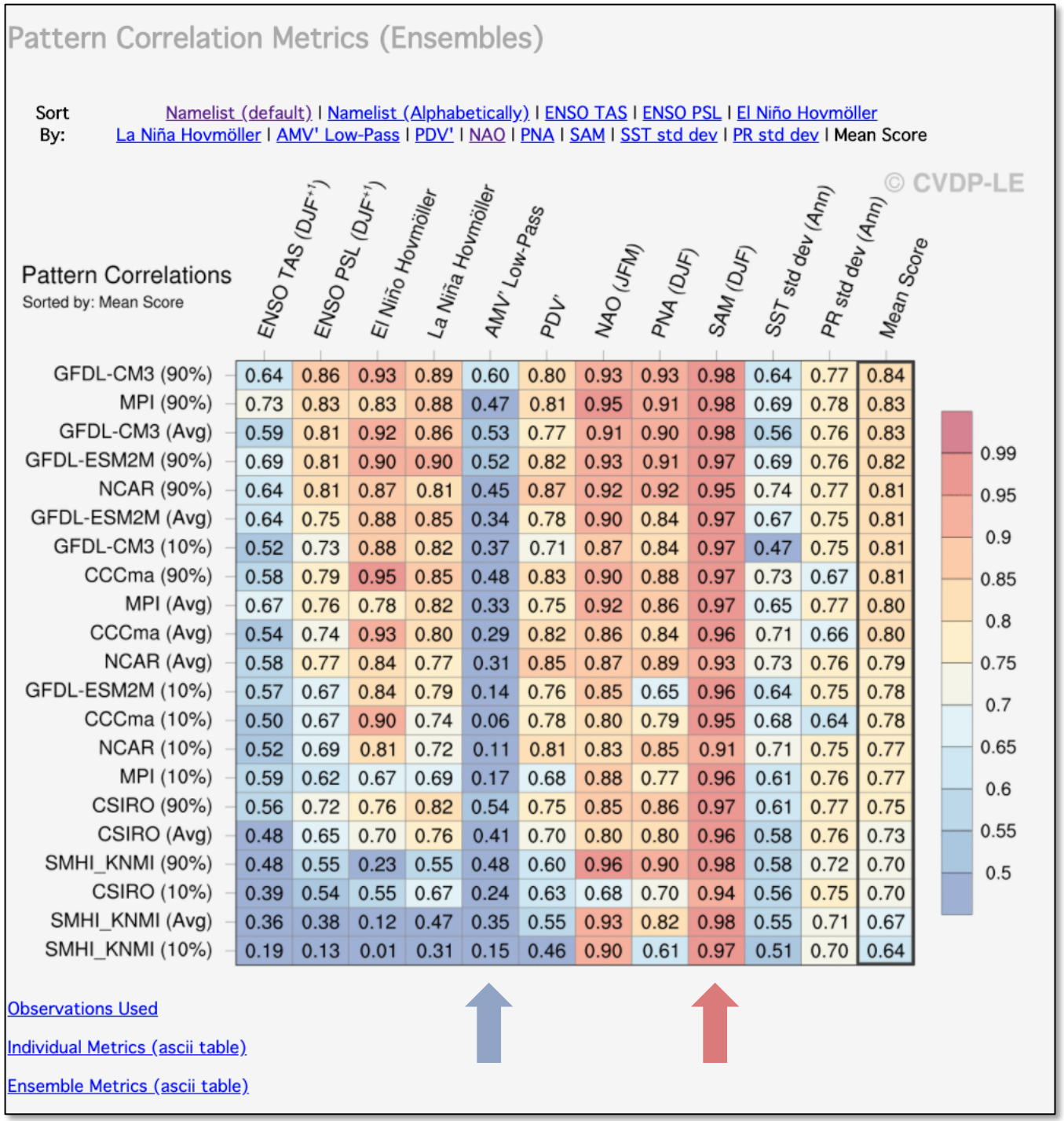
Diagnostics Overview

Metrics Tables

Pattern Correlations and Spatial RMSE

10th / 50th / 90th percentiles for each model.

Color coded for ease-of-use.



Metrics Tables

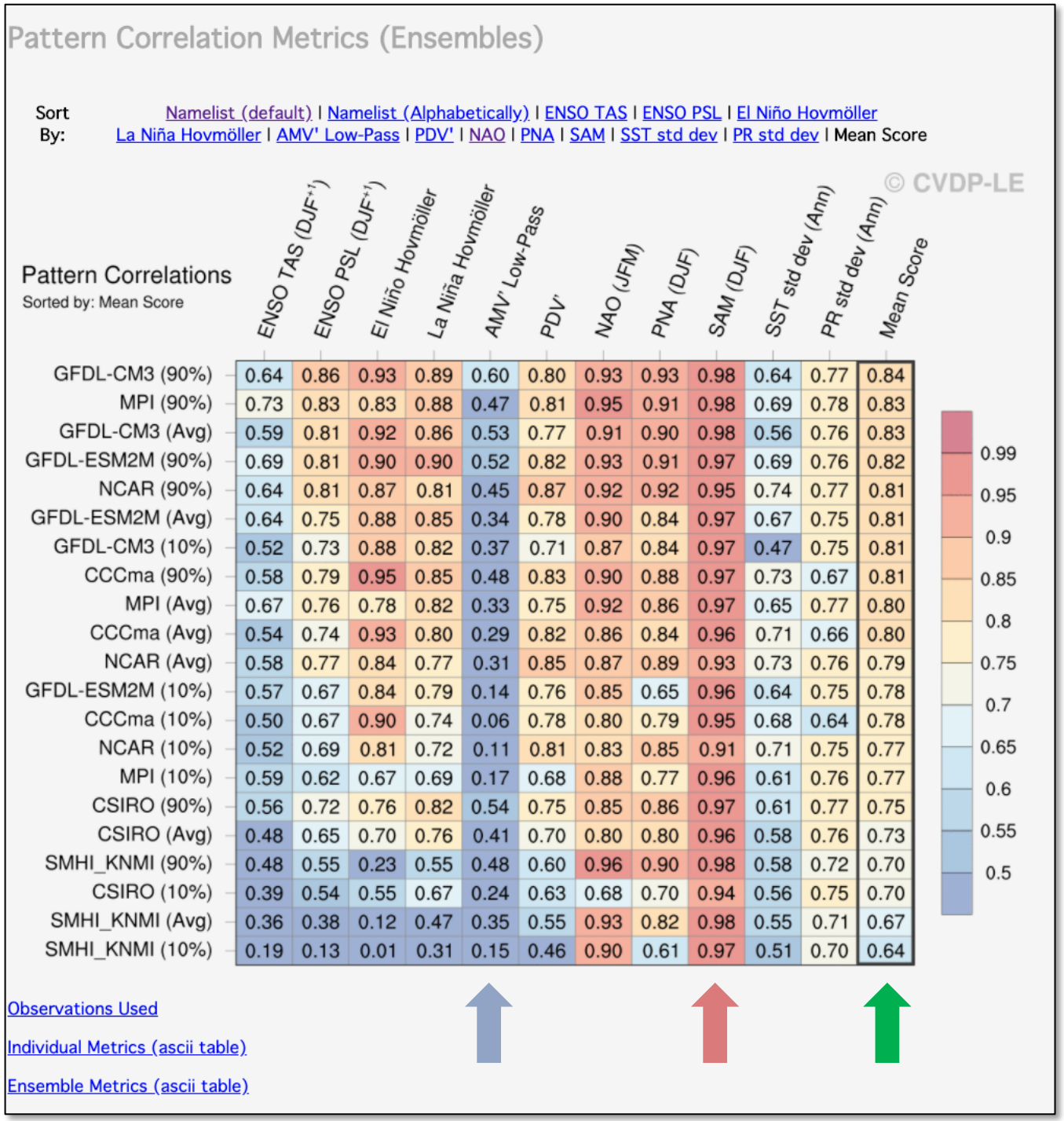
Pattern Correlations and Spatial RMSE

10^{th} / 50^{th} / 90^{th} percentiles for each model.

Color coded for ease-of-use.

Sortable

(here *Mean Score* is used).



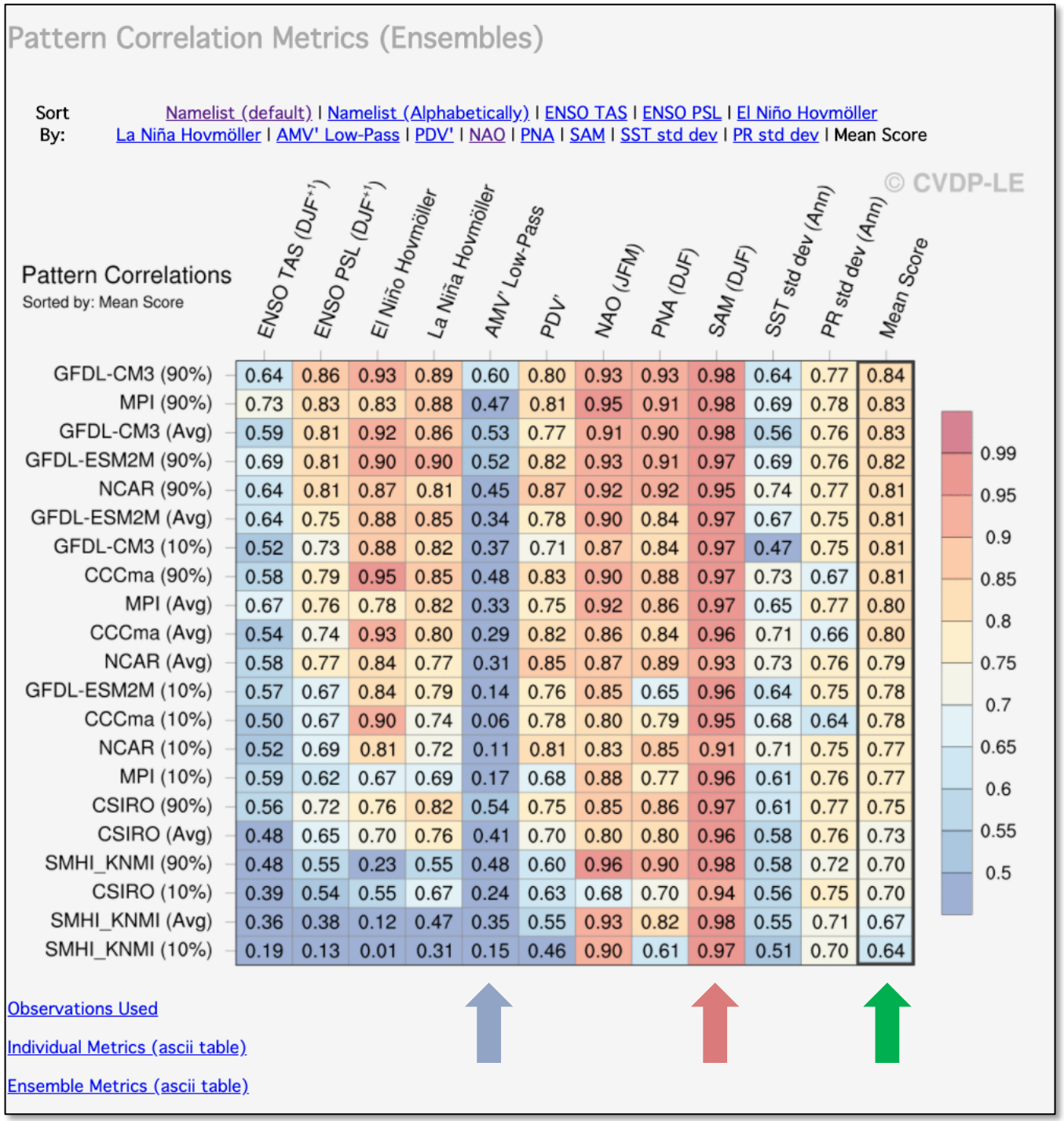
Metrics Tables

Pattern Correlations and Spatial RMSE

10^{th} / 50^{th} / 90^{th} percentiles for each model.
Color coded for ease-of-use.

Sortable
(here *Mean Score* is used).

All graphics, data and metrics saved to a repository.



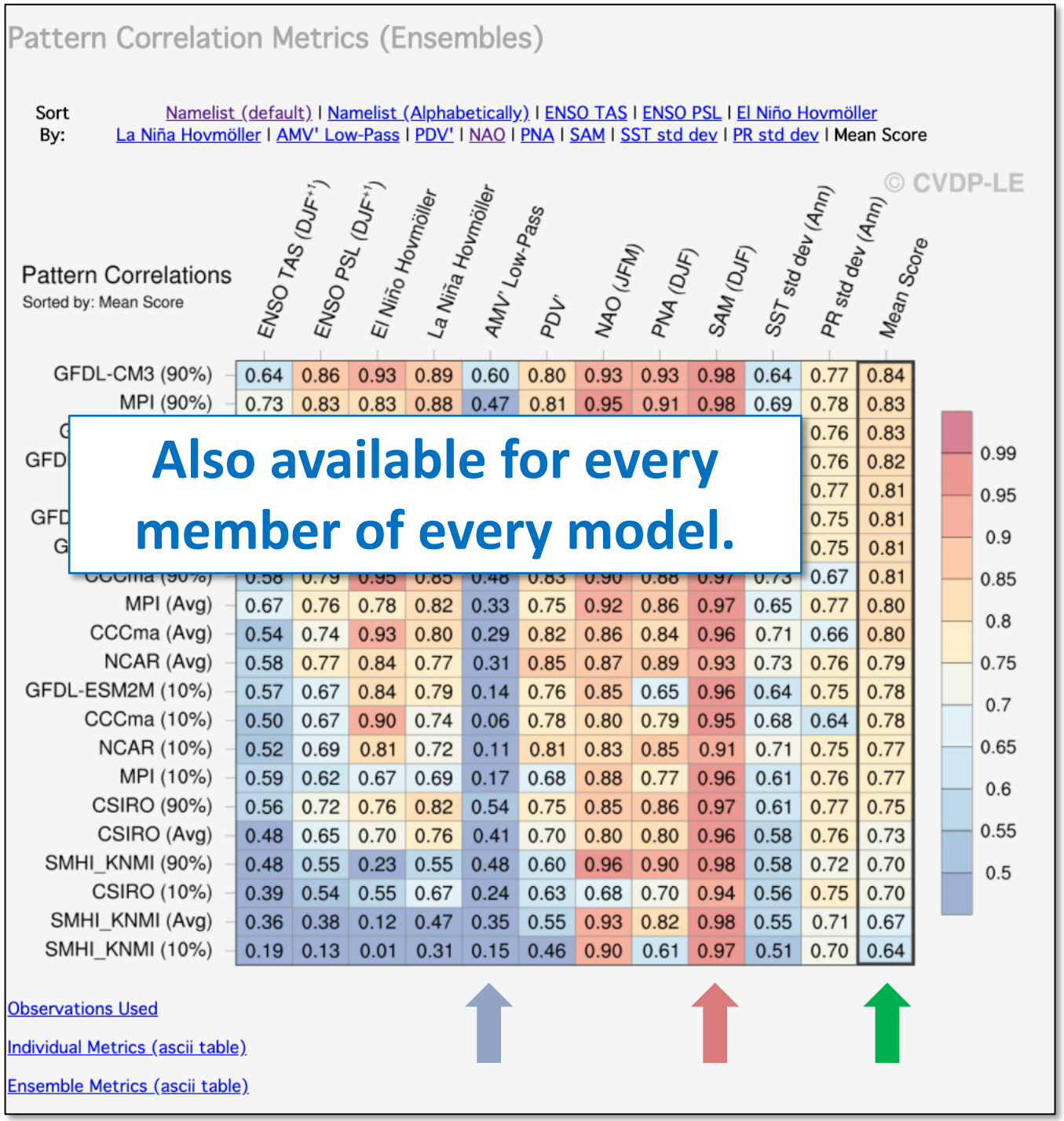
Metrics Tables

Pattern Correlations and Spatial RMSE

10^{th} / 50^{th} / 90^{th} percentiles for each model.
Color coded for ease-of-use.

Sortable
(here *Mean Score* is used).

All graphics, data and metrics saved to a repository.



NCAR UCAR | CGD's Climate Analysis Section

Climate Variability Diagnostics Package

for Large Ensembles

https://www.cesm.ucar.edu/working_groups/CVC/cvdp-le/

CESM Working Groups / CESM Climate Variability & Change Working Group / Climate Variability Diagnostics Package for Large Ensembles

Climate Variability Diagnostics Package for Large Ensembles (CVDP-LE)

The Climate Variability Diagnostics Package for Large Ensembles (CVDP-LE) developed by NCAR's Climate Analysis Section is an automated analysis tool and data repository for exploring internal and forced contributions to climate variability and change in coupled model "initial-condition" Large Ensembles and observations.

The package computes a wide range of modes of interannual-to-multidecadal variability in the atmosphere, ocean and cryosphere, as well as long-term trends and key indices of global and regional climate. Diagnostics include the ensemble-mean (i.e., forced response) and ensemble-spread (i.e., internal variability) of each model, as well as quantitative metrics comparing the models to observations. All diagnostics and metrics are saved to a data repository for later use and analysis.

The CVDP-LE User's Guide provides general background on initial-condition Large Ensembles, detailed documentation of all diagnostics and metrics in the package, and guidance on interpreting the results. Instructions for downloading and running the CVDP-LE are provided on the Code page and readme file, respectively.

The CVDP-LE can be applied to any suite of observational data, model simulations and time periods specified by the user. A few examples of CVDP-LE applications to the Multi-Model Large Ensemble Archive and the CMIP6 archive are linked below; additional comparisons are in the Data Repository.

- MMLEA 1950-2018
- MMLEA 2019-2099
- CMIP6 Historical 1900-2014

When presenting results from the CVDP-LE in either oral or written form, please cite:

Phillips, A. S., C. Deser, J Fasullo, D. P. Schneider and I. R. Simpson, 2020: Assessing Climate Variability and Change in Model Large Ensembles: A User's Guide to the "Climate Variability Diagnostics Package for Large Ensembles", doi:10.5065/h7c7-f961

We welcome your feedback and suggestions on any aspect of the CVDP-LE.

CVDP collaborators: Adam Phillips (software lead), Clara Deser (science lead), John Fasullo, Isla Simpson, and Dave Schneider, as well as other members of NCAR's Climate Analysis Section.

CVDP-LE
Current Version: 1.0.0

Home
News
Code
User's Guide
Data Repository
Observations
Support/Contact Us
Known Issues

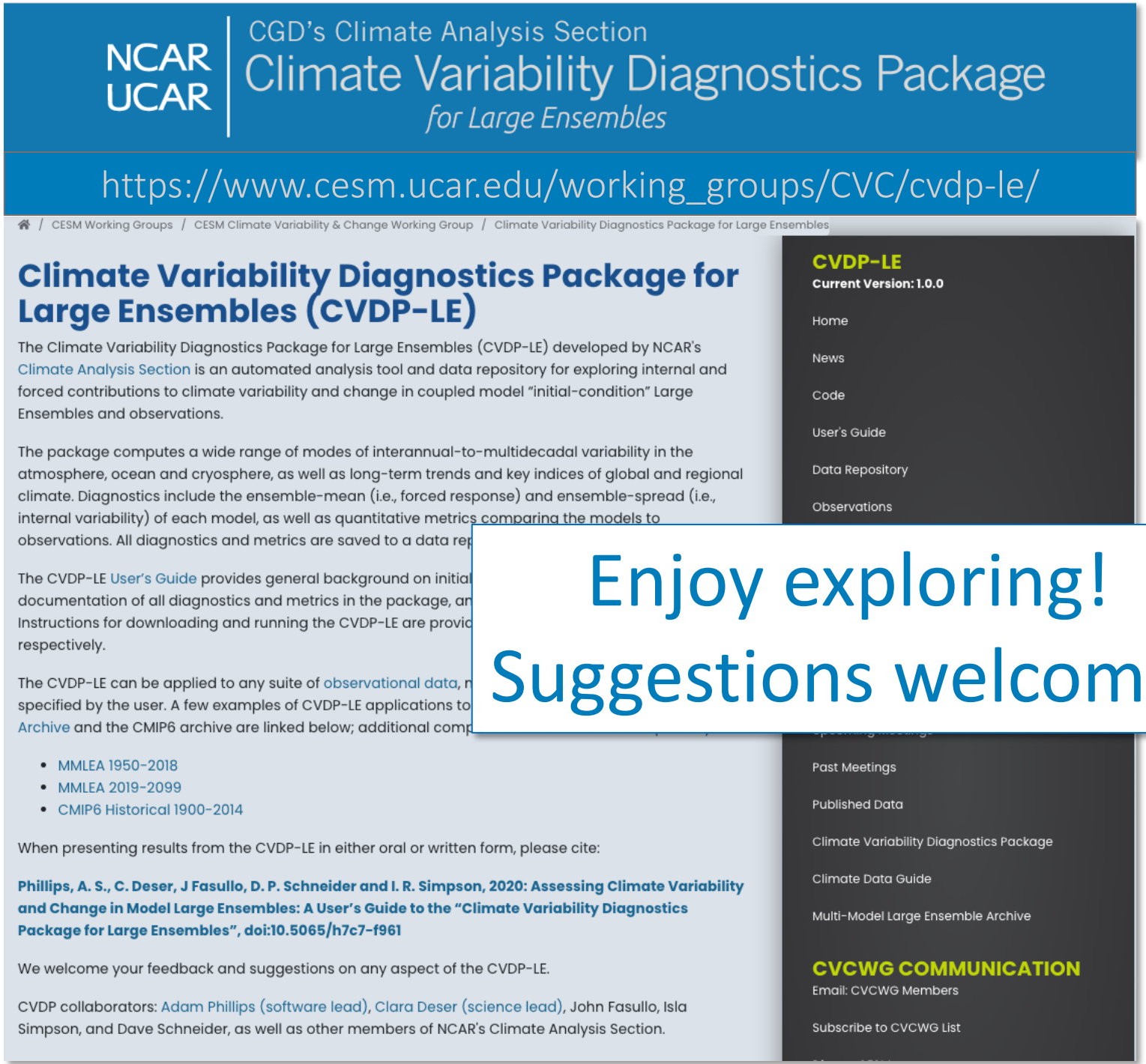
CVCWG INFORMATION
Simulations
Activities Update (March 2020)
Upcoming Meetings
Past Meetings
Published Data
Climate Variability Diagnostics Package
Climate Data Guide
Multi-Model Large Ensemble Archive

CVCWG COMMUNICATION
Email: CVCWG Members
Subscribe to CVCWG List

Some Application Ideas

(User's Guide)

- Multiple time periods to see if modes of variability change with time.
- Subsets of ensemble members to assess robustness.
- Filter the data to investigate dependence on time scale.
- Use an "ensemble" of shorter segments from a control simulation.



Some Application Ideas
(User's Guide)

- Multiple time periods to see if modes of variability change with time.
- Subsets of ensemble members to assess robustness.

Filter the data to investigate dependence on time scale.

- Use an "ensemble" of shorter segments from a control simulation.