

Introduction to E3SM Diagnostics Package (e3sm_diags v2)

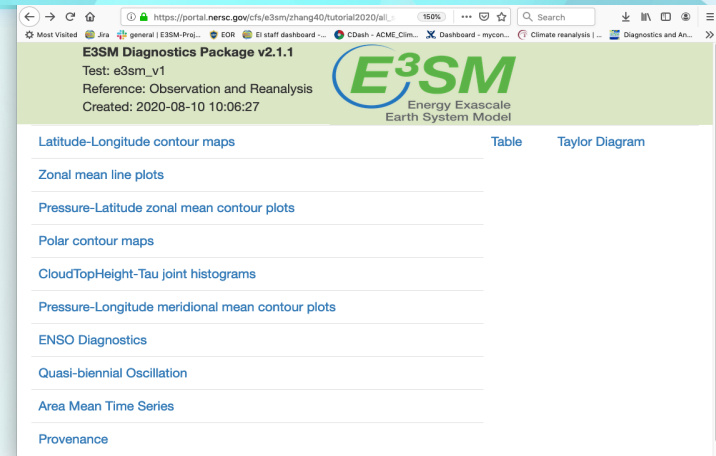
Core Development Team: Jill Chengzhu Zhang, Ryan Forsyth, Chris Golaz and Zeshawn Shaheen
Lawrence Livermore National Lab

Contributors: Xylar Asay-Davis, Charlie Zender, Sterling Baldwin

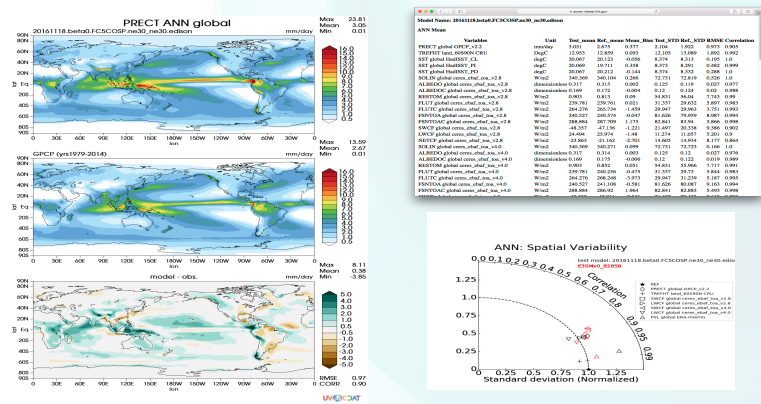
Chris Terai, Salil Mahajan, Tian Zhou, Wuyin Lin, Karthik Balaguru, Qi Tang and many others from E3SM

Introduction

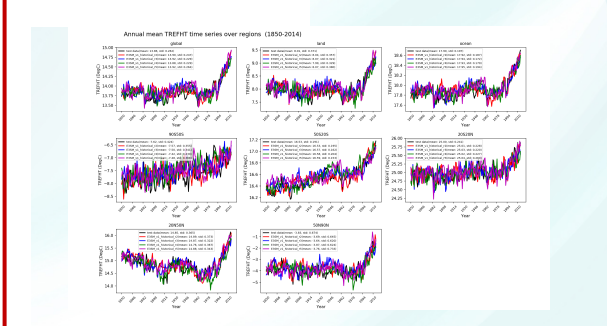
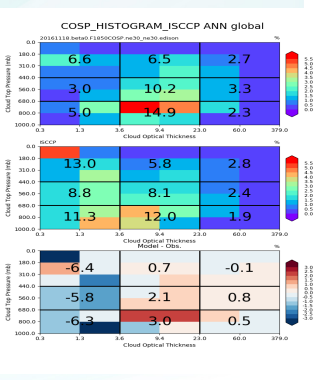
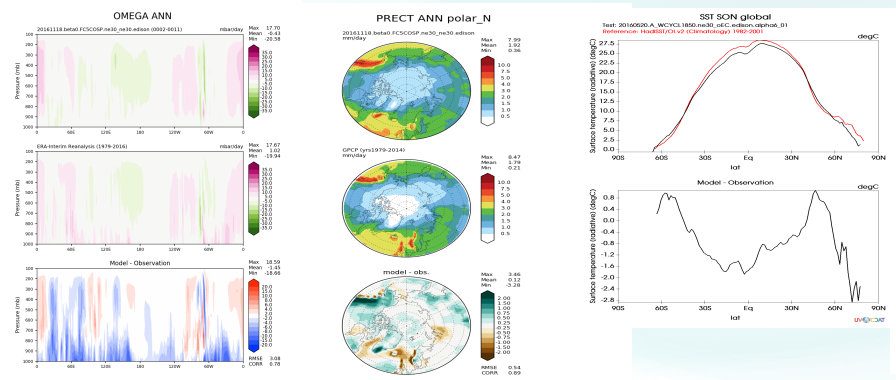
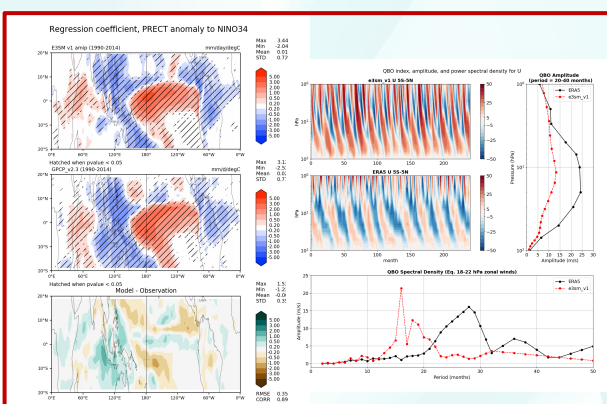
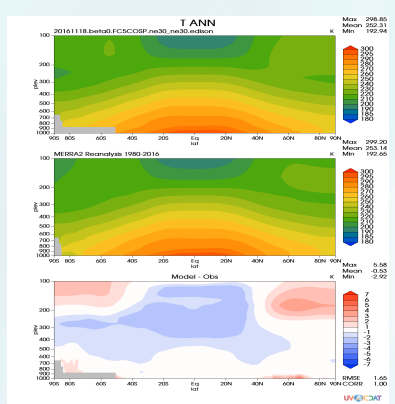
- A **modern, Python-based** diagnostics package developed for supporting E3SM model development.
- Modeled after NCAR's atmosphere diagnostics package with key sets implemented.
- Focuses on atmospheric variables. Support for land/river variables is ongoing.
- Features:
 - ✓ Flexible to add new observational datasets/diagnostics, modify figures.
 - ✓ Easy installation, configuration, and execution.
 - ✓ Runs fast using multi-processing.
 - ✓ Provenance saved for reproducing diags figures.
- Maintain an **updated** observational data repository.
- A **community tool** that accommodates CMIP convention.



Current Available Sets



Model Name	20181118 beta01.FCSC-FSP.nc30_3x30_e000000						
ANN Name							
Variables							
PRECT global_CPCT_v2.0	mm/day	Unit	mm/day	Max	100.0	Min	0.0
TRITRTF01_1000	mm/day	Unit	mm/day	Max	200.0	Min	0.0
SST ANNA IASOSI02_01	K	Unit	K	Max	3.0	Min	-3.0
SST ANNA IASOSI01_01	K	Unit	K	Max	3.0	Min	-3.0
SST ANNA IASOSI03_01	K	Unit	K	Max	3.0	Min	-3.0
SST ANNA IASOSI04_01	K	Unit	K	Max	3.0	Min	-3.0
SST ANNA IASOSI05_01	K	Unit	K	Max	3.0	Min	-3.0
SST ANNA IASOSI06_01	K	Unit	K	Max	3.0	Min	-3.0
SST ANNA IASOSI07_01	K	Unit	K	Max	3.0	Min	-3.0
SST ANNA IASOSI08_01	K	Unit	K	Max	3.0	Min	-3.0
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SST ANNA IASOSI10_01	K	Unit	K	Max	3.0	Min	-3.0
SST ANNA IASOSI11_01	K	Unit	K	Max	3.0	Min	-3.0
SST ANNA IASOSI12_01	K	Unit	K	Max	3.0	Min	-3.0
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Core Sets

ENSO diags and QBO diags
Annual mean time series

Input Data Requirement

- Support data on regular latitude-longitude grids (not support raw EAM output)
 - [Preprocessing through NCO](#) to generate regridded climo and time series files
- Use seasonal climatology data as input for core set
 - `ncclimo -s start_yr -e end_yr -c run_id -i drc_in -o drc_out -r map_fl -O drc_rgr \`
 - `-a sdd --no_amwg_links`
 - Filename: 20180215.DECKv1b_H1.ne30_oEC.edison_ANN_200001_200112_climo.nc
- Use monthly time series data as input for both core and new sets
 - # Pipe list to stdin
 - `cd $drc_in;ls *cam*200[1-9]*.nc | ncclimo -v TREFHT -s 1 -e 9 -o drc_out -r map_fl -O drc_rgr`
 - Filename: TREFHT_185001_201312.nc or tas_185001_201312.nc or tas_185001_201312.xml
- [Example data](#)

Installation

- Run on Linux or MacOS machines/ or use the latest version
 1. Install [Miniconda](#) and initialize conda.
 2. Create conda env from an environment.yml file
 - Download the [e3sm_diags_env.yml file](#) from e3sm_diags Github repo
 - `conda env create -f e3sm_diags_env.yml`Alternatively:
 - `conda create -n e3sm_diags_env e3sm_diags=2.1.1 python=3 mesalib \`
`-c conda-forge -c cdat/label/v82 -c e3sm`
 3. Activate conda env
 - `conda activate e3sm_diags_env`
- Download obs and sample model data for testing available from E3SM data server
 - Obs: [climatology](#) and [time-series](#)
 - [Example testing data](#)

Installation

- On E3SM supported machines (Cori, Compy, Acme1, Anvil, Cooley, Rhea)
 - e3sm_unified: A conda environment pulls together python and other E3SM analysis tools such as E3SM_diags, MPAS-Analysis, NCO, zstash, CDAT and processflow.
 - **source <activation_path>/load_latest_e3sm_unified.sh**
 - **(on Cori haswell/knl: source /global/cfs/cdirs/e3sm/software/anaconda_envs/load_latest_e3sm_unified_mpich.sh)**
 - [Paths to activation scripts of different machines](#)
- Observation data and example data for testing are available on these machines ([data path for each machine](#)).

Configuration and Run: Core Sets

- **Run: Python `tutorial_2020_climo_sets.py`**

```
import os
from acme_diags.run import runner
from acme_diags.parameter.core_parameter import CoreParameter

param = CoreParameter()

param.reference_data_path = '/global/cfs/cdirs/e3sm/acme_diags/obs_for_e3sm_diags/climatology'
param.test_data_path = '/global/cfs/cdirs/e3sm/acme_diags/test_model_data_for_acme_diags/climatology/'
param.test_name = '20161118.beta0.FC5COSP.ne30_ne30.edison'
param.seasons = ["ANN", "JJA"]
prefix = '/global/cfs/cdirs/e3sm/www/zhang40/tutorial2020'
param.results_dir = os.path.join(prefix, 'climo_sets')
param.multiprocessing = True
param.num_workers = 30

#Additional parameters:
#param.short_test_name = 'e3sm_v1'
#param.run_type = 'model_vs_model'
#param.diff_title = 'Difference'
#param.output_format = ['png']
#param.output_format_subplot = ['pdf']
#param.save_netcdf = True

runner.sets_to_run = ['lat_lon', 'zonal_mean_xy', 'zonal_mean_2d', 'polar', 'cosp_histogram', 'meridional_mean_2d']
runner.run_diags([param])
```

[All available parameters](#)

[See output results](#)

Configuration and Run: All Sets

- **Run: Python tutorial_2020_all_sets.py**

```
import os
from acme_diags.run import runner
from acme_diags.parameter.core_parameter import CoreParameter
from acme_diags.parameter.area_mean_time_series_parameter import AreaMeanTimeSeriesParameter
from acme_diags.parameter.enso_diags_parameter import EnsoDiagsParameter
from acme_diags.parameter.qbo_parameter import QboParameter

param = CoreParameter()

param.reference_data_path = '/global/cfs/cdirs/e3sm/acme_diags/obs_for_e3sm_diags/climatology'
param.test_data_path = '/global/cfs/cdirs/e3sm/acme_diags/test_model_data_for_acme_diags/climatology/'
param.test_name = '20161118.beta0.FC5COSP.ne30_ne30.edison'
param.seasons = ["ANN", "JJA"]

prefix = '/global/cfs/cdirs/e3sm/www/zhang40/tutorial2020'
param.results_dir = os.path.join(prefix, 'all_sets_10yr')
param.multiprocessing = True
param.num_workers = 30
```


Continue

Configuration and Run: all sets

- **Run: Python tutorial_2020_all_sets.py**

```
#Set specific parameters for new sets
enso_param = EnsoDiagsParameter()
enso_param.reference_data_path = '/global/cfs/cdirs/e3sm/acme_diags/obs_for_e3sm_diags/time-series/'
enso_param.test_data_path = '/global/cfs/cdirs/e3sm/acme_diags/test_model_data_for_acme_diags/time-series/E3SM_v1/'
enso_param.test_name = 'e3sm_v1'
enso_param.start_yr = '1990'
enso_param.end_yr = '1999'

qbo_param = QboParameter()
qbo_param.reference_data_path = '/global/cfs/cdirs/e3sm/acme_diags/obs_for_e3sm_diags/time-series/'
qbo_param.test_data_path = '/global/cfs/cdirs/e3sm/acme_diags/test_model_data_for_acme_diags/time-series/E3SM_v1/'
qbo_param.test_name = 'e3sm_v1'
qbo_param.start_yr = '1990'
qbo_param.end_yr = '1999'

ts_param = AreaMeanTimeSeriesParameter()
ts_param.reference_data_path = '/global/cfs/cdirs/e3sm/acme_diags/obs_for_e3sm_diags/time-series/'
ts_param.test_data_path = '/global/cfs/cdirs/e3sm/acme_diags/test_model_data_for_acme_diags/time-series/E3SM_v1/'
ts_param.test_name = 'e3sm_v1'
ts_param.start_yr = '1990'
ts_param.end_yr = '1999'

runner.sets_to_run = ['lat_lon', 'zonal_mean_xy', 'zonal_mean_2d', 'polar', 'cosp_histogram', 'meridional_mean_2d', 'enso_diags', 'qbo', 'area_mean_time_series']
runner.run_diags([param, enso_param, qbo_param, ts_param])
```

[See output results](#)

Quick Guide on Cori NERSC

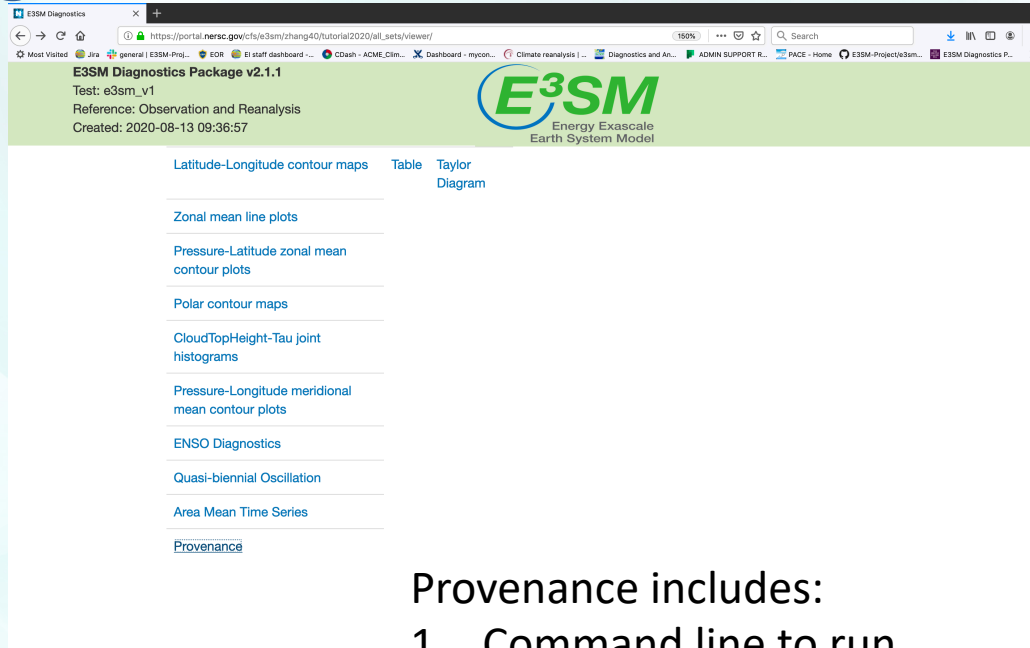
- SSH to cori
- Download tutorial examples: `wget https://raw.githubusercontent.com/E3SM-Project/e3sm_diags/master/examples/tutorials/tutorial_2020_all_sets.py`
- Edit script: `tutorial_2020_climo_sets.py`
 - Change `results_dir`
- `salloc --nodes=1 --partition=debug --time=00:30:00 -C haswell`
- `conda activate e3sm_diags_env`

(Alternatively, source

`/global/cfs/cdirs/e3sm/software/anaconda_envs/load_latest_e3sm_unified_mpich.sh`)

- `python tutorial_2020_climo_sets.py`
- Go through output at https://portal.nersc.gov/cfs/e3sm/zhang40/tutorial2020/all_sets/viewer/

e3sm_diags viewer:



The screenshot shows a web browser window displaying the E3SM Diagnostics viewer. The browser's address bar shows the URL: https://portal.nersc.gov/cfs/e3sm/zhang40/tutorial2020/all_sets/viewer/. The page header includes the E3SM logo and the text "Energy Exascale Earth System Model". Below the header, the page displays the following information:

E3SM Diagnostics Package v2.1.1
Test: e3sm_v1
Reference: Observation and Reanalysis
Created: 2020-08-13 09:36:57

The main content area features a list of diagnostic options, each with a horizontal line below it:

- [Latitude-Longitude contour maps](#)
- [Zonal mean line plots](#)
- [Pressure-Latitude zonal mean contour plots](#)
- [Polar contour maps](#)
- [CloudTopHeight-Tau joint histograms](#)
- [Pressure-Longitude meridional mean contour plots](#)
- [ENSO Diagnostics](#)
- [Quasi-biennial Oscillation](#)
- [Area Mean Time Series](#)
- [Provenance](#)


Navigation links for "Table" and "Taylor Diagram" are also visible.

Provenance includes:

1. Command line to run
2. Environment.yml
3. Configuration script to run

Latitude-Longitude contour maps

E3SM Diagnostics Package v2.1.1
 Test: 20161118.beta0.FC5COSP.ne30_ne30.edison
 Reference: Observation and Reanalysis
 Created: 2020-08-13 09:36:57



Jump To:

GPCP_v2.2

GPCP_v2.2	Description	ANN	JJA
PRECT global GPCP_v2.2	Total precipitation rate (convective + large-scale)	ANN	JJA
GPCP_v2.3	Description	ANN	JJA
PRECT global GPCP_v2.3	Total precipitation rate (convective + large-scale)	ANN	JJA
CRU_IPCC	Description	ANN	JJA
TREFHT land_60S90N CRU	Reference height temperature	ANN	JJA
SST_CL_HadISST	Description	ANN	JJA
SST global HadISST_CL	Surface temperature (radiative)	ANN	JJA
SST_PI_HadISST	Description	ANN	JJA
SST global HadISST_PI	Surface temperature (radiative)	ANN	JJA
SST_PD_HadISST	Description	ANN	JJA

- Main page for lat-lon:
1. Plots grouped by obs sets and seasons
 2. Drop-down menu

E3SM Diagnostics Package v2.1.1

Test: 20161118.beta0.FC5COSP:ne30_ne30.edison

Reference: Observation and Reanalysis

Created: 2020-08-13 09:36:57



Latitude-Longitude contour maps

Jump To:

- ✓ GPCP_v2.2
- GPCP_v2.3
- CRU_IPCC
- SST_CL_HadISST
- SST_PI_HadISST
- SST_PD_HadISST
- CERES-EBAF-TOA-v4.1
- CERES-EBAF-TOA-v4.0
- CERES-EBAF-surface-v4.1
- CERES-EBAF-surface-v4.0
- WHOI-OAFlux
- ERA-Interim
- MERRA2
- Cloud ISCCP
- Cloud MISR
- Cloud MODIS
- Cloud Calipso
- Cloud SSM/I
- AD5_550
- GPCP_OAFlux
- CO2Fv2_Elivv

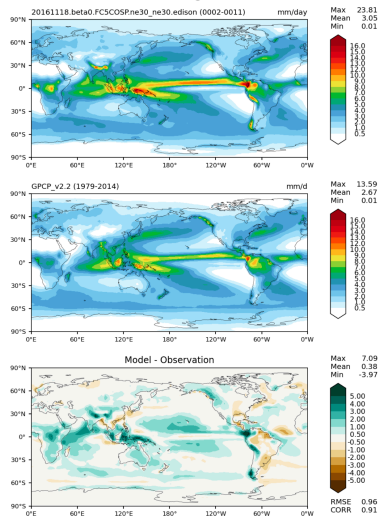
SST global HadISST_PI Surface temperature (radiative) ANN JJA

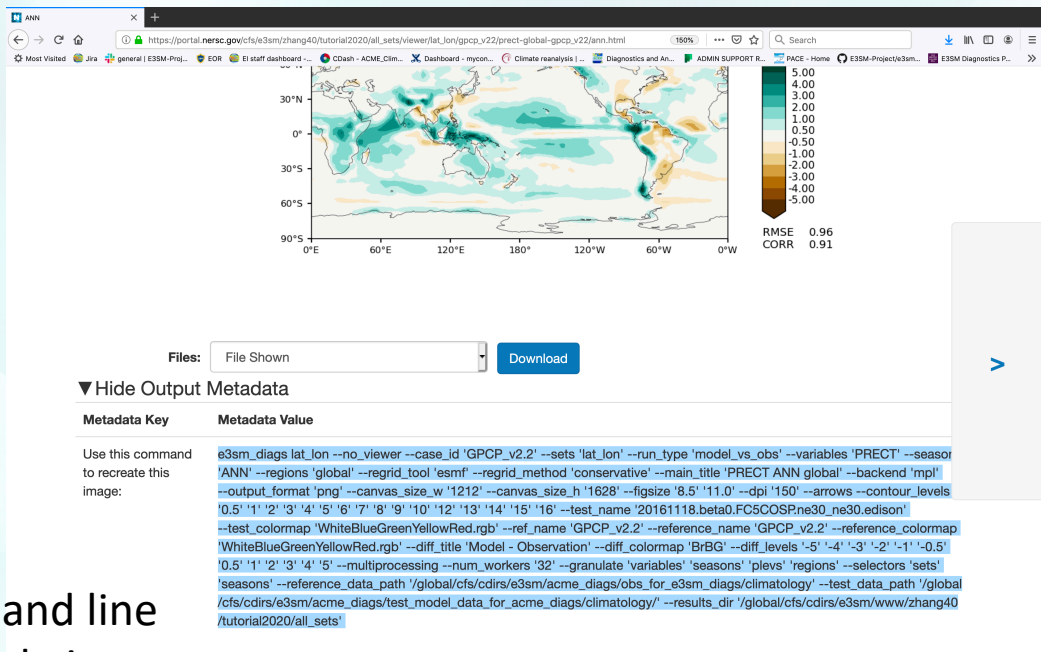
SST_PD_HadISST Description ANN JJA

...

ANN

PRECIP ANN global





- Run using a command line
 - Reproduce the single image
 - Edit the line to refine the image, i.g., change 'contour levels' etc.
- *make sure to change 'results_dir'

Newly Implemented: ENSO Diags

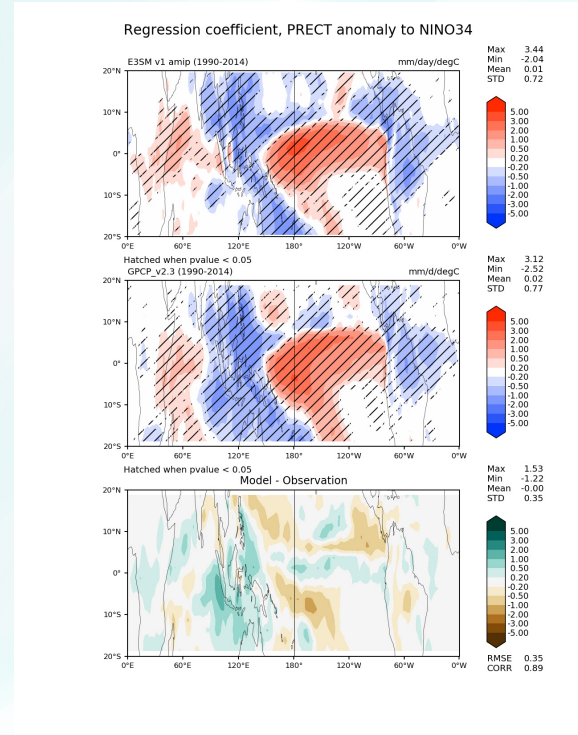
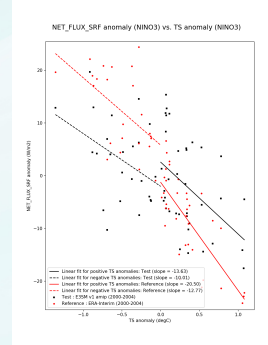
- Two components of ENSO-diagnostics
 - Maps on regression coefficient of atmospheric fields over SST anomaly
 - Scatter plots of atmospheric feedback on SST anomaly

E3SM Diagnostics Package v2.1.1
 Title: 20181118.118.118.118.GCOSIP(NINO3)_JASO.action
 Reference: Observation and Reanalysis
 Created: 2020-08-13 09:36:57

Latitude-Longitude contour maps

Jump To:

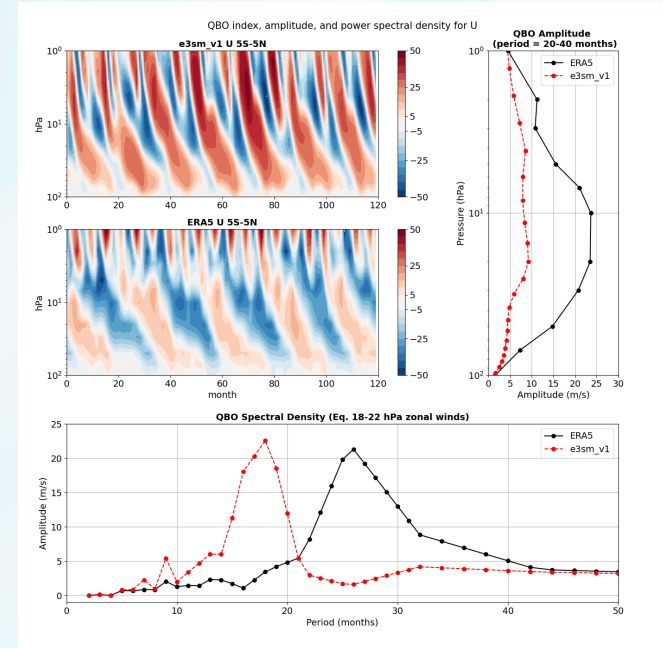
Variable	Description	ANN	JJA
GPCP_v2.2			
GPCP_v2.2	Description	ANN	JJA
PRECCT global GPCP_v2.2	Total precipitation rate (convective + large-scale)	ANN	JJA
GPCP_v2.3	Description	ANN	JJA
PRECCT global GPCP_v2.3	Total precipitation rate (convective + large-scale)	ANN	JJA
CRU_IPCC	Description	ANN	JJA
TREHT_land_BOSSON CRU	Reference height temperature	ANN	JJA
SST_CL_HadISST	Description	ANN	JJA
SST global HadISST_CL	Surface temperature (radiative)	ANN	JJA
SST_PI_HadISST	Description	ANN	JJA
SST global HadISST_PI	Surface temperature (radiative)	ANN	JJA
SST_PD_HadISST	Description	ANN	JJA



(ENSO diags from Aprime)

Newly Implemented: Quasi-biennial Oscillation

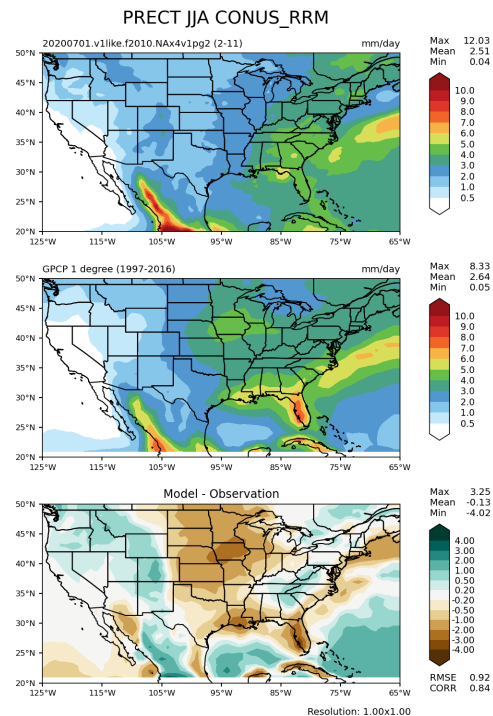
- QBO diags over 5S-5N
- QBO index, amplitude and spectral intensity of U
- 0.25 deg ERA5 data with 37 vertical levels
- First direct community contribution
(Thanks to Chris Terai)



(Richter et al. 2019 JAMES)

Newly Implemented: Initial RRM Support

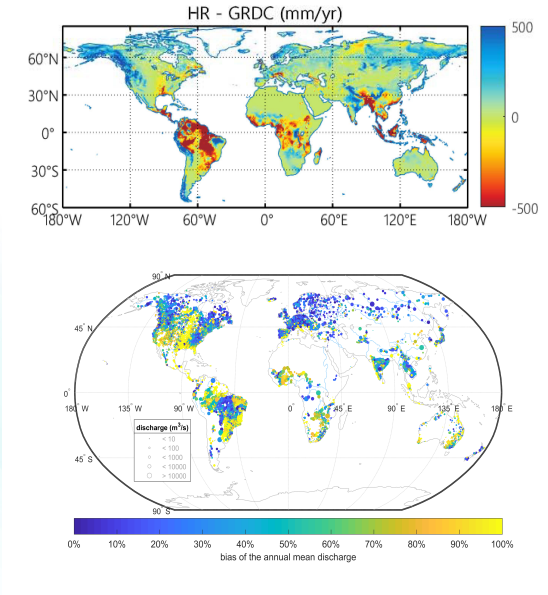
- Lat-lon plots to zoom in on a region.
- CONUS_RRM domain
- New analysis data: 0.25 deg ERA5 and 1 deg GPCP
- `python run_lat_lon.py -d lat_lon_rrm.cfg`
- Example output



(Qi Tang et al. 2019 GMD)

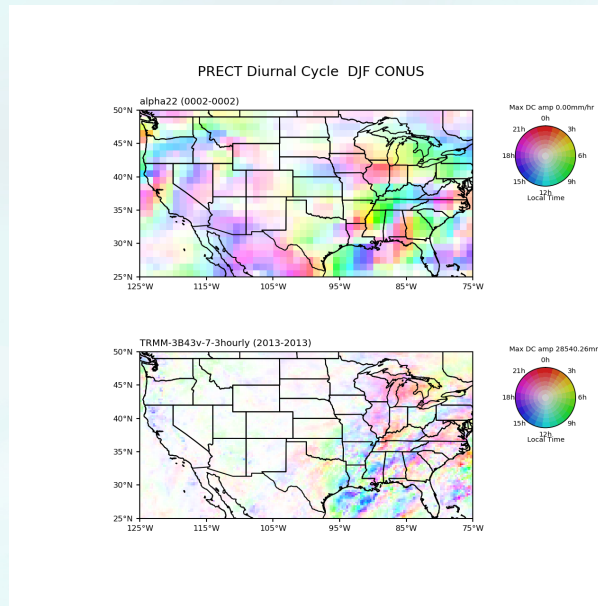
Ongoing Development

Runoff and streamflow diagnostics (Tian Zhou)



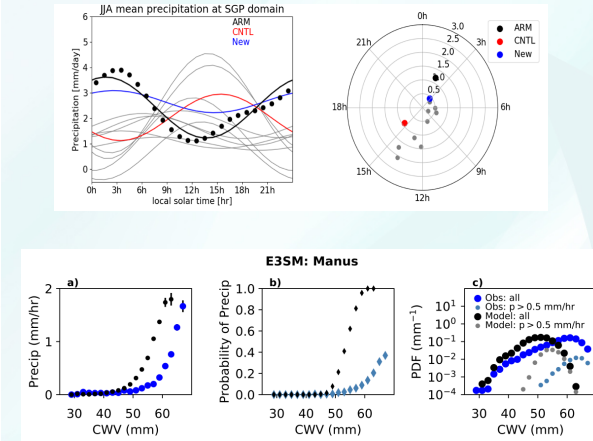
(Golaz et al. 2019 JAMES)
(Caldwell et al. 2019 JAMES)

Diurnal cycle of precipitation (Charlie Zender, Wuyin Lin)



(Xie et al. 2019 JAMES)

ARM data-oriented diags (Jill Zhang)



(Zhang et al. 2020 BAMS)

Planned/Requested New Sets

- TC analysis (Karthik Balaguru)
- Stratospheric ozone diags (Qi Tang)
- Dust aerosol (Yan Feng)
- Precipitation intensity (NGD Atmospheric Physics)
- Atmospheric CO₂ diagnostics /metrics (BGC)

How to Contribute

- Feature requests
- Share the data sets and Python-based script (including instructions on data pre-processing)
- [Developer's guide](#) on how to add new diagnostics set.
- We will help with providing skeleton codes and provide infrastructure help.
- Final touch-up: linking viewers, code structure re-org, testing etc.

Thank you!

Please try it out and give us your feedback 😊

GitHub: https://github.com/E3SM-Project/e3sm_diags

Documentation on quick guide and more examples:

https://e3sm-project.github.io/e3sm_diags/docs/html/index.html