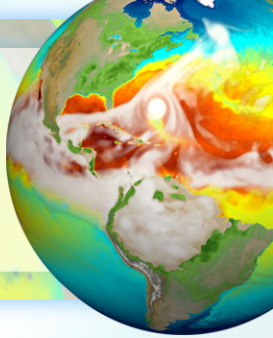


Introduction to E3SM Diagnostics Package (e3sm_diags v2)

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

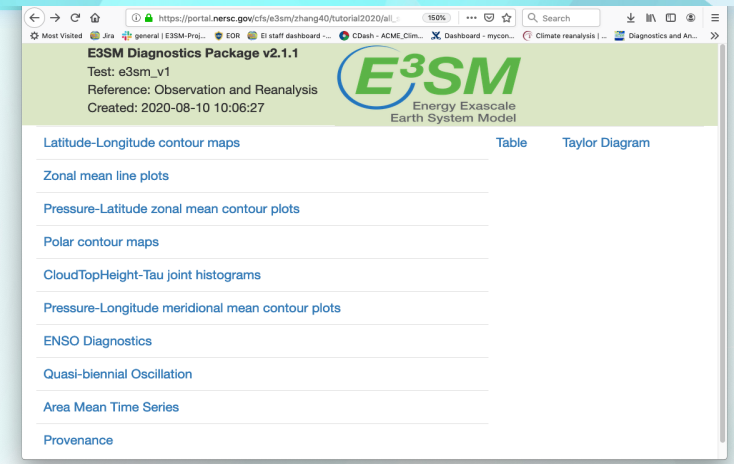
E3SM Energy Exascale Earth System Model

August 2020

U.S. DEPARTMENT OF ENERGY

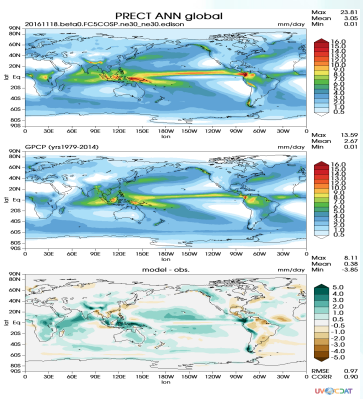
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344. LLNL PRES-813617

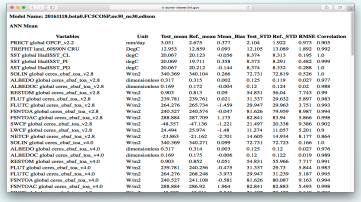
Introduction

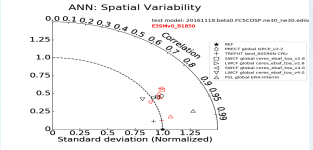


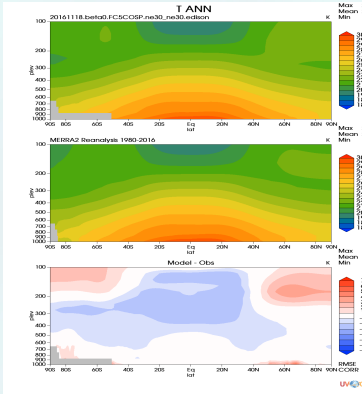
- A **modern, Python-based** diagnostics package developed for supporting E3SM model development.
- Modeled after NCAR's atmosphere diagnostics package with key sets implemented.
- Focuses on atmospheric variables. Support for land/river variables is ongoing.
- Features:
  - ✓ Flexible to add new observational 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.

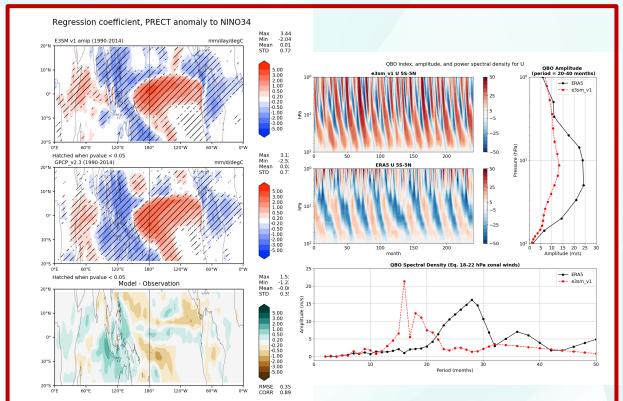
Current Available Sets

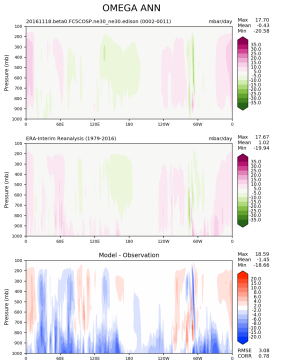


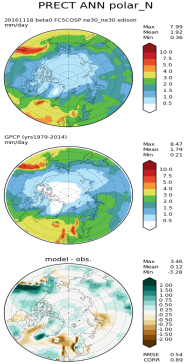


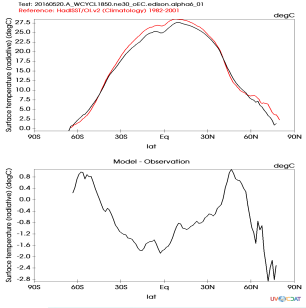


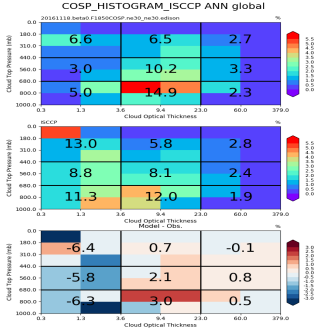




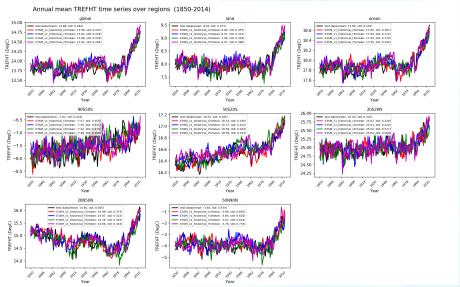








Core Sets



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 regrided 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]

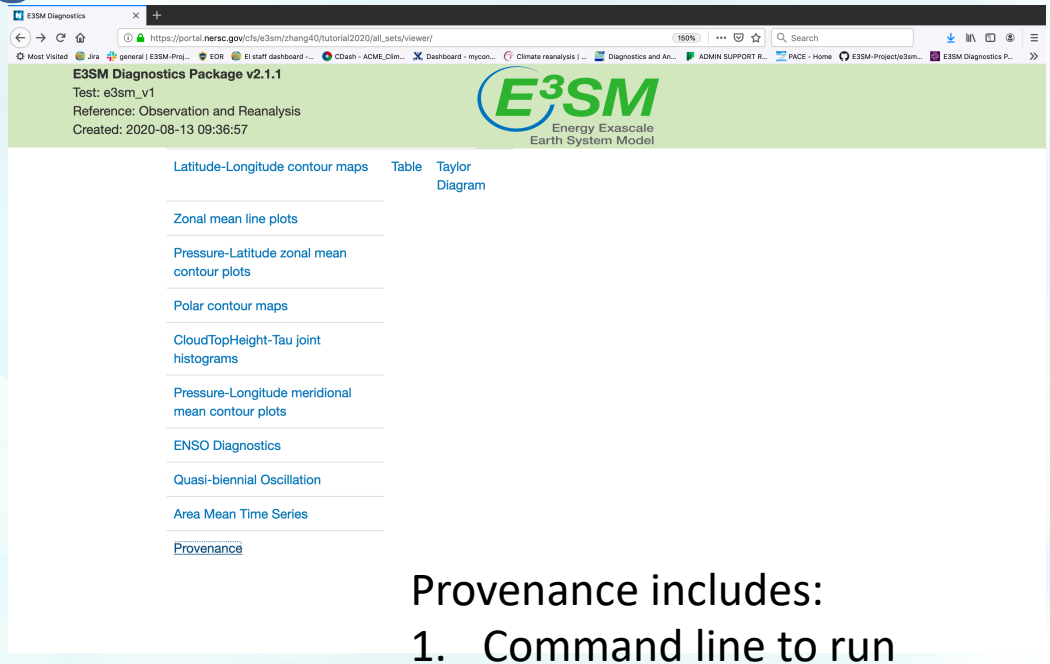
Quick Guide on Cori NERSC

- 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)

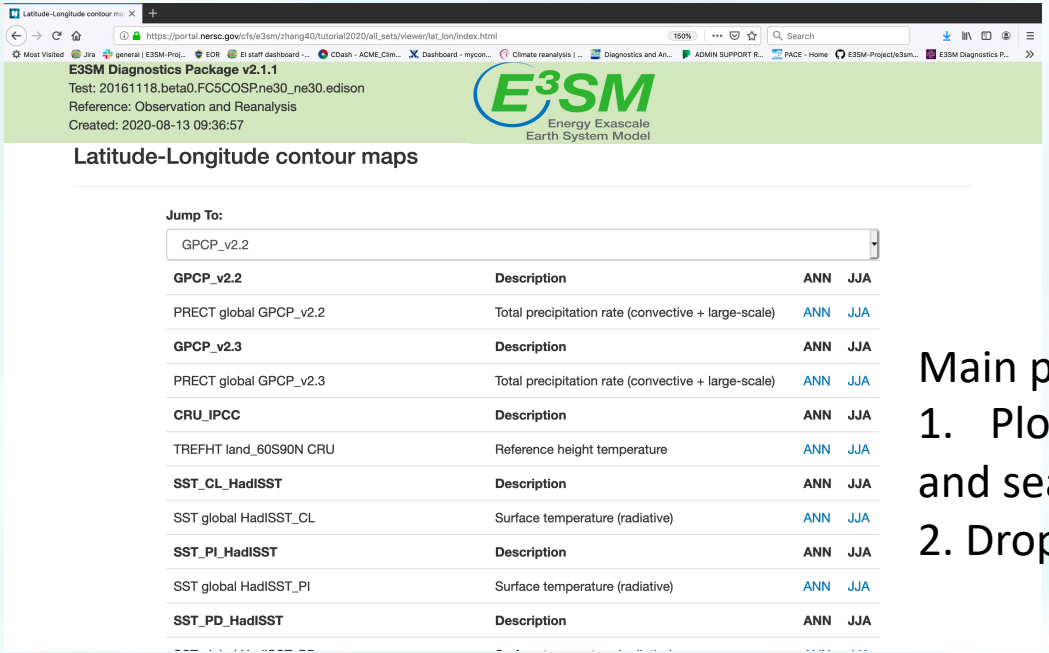
- python tutorial_2020_climo_sets.py
- Go through output at https://portal.nersc.gov/cfs/e3sm/zhang40/tutorial2020/all_sets/viewer/

e3sm_diags viewer:



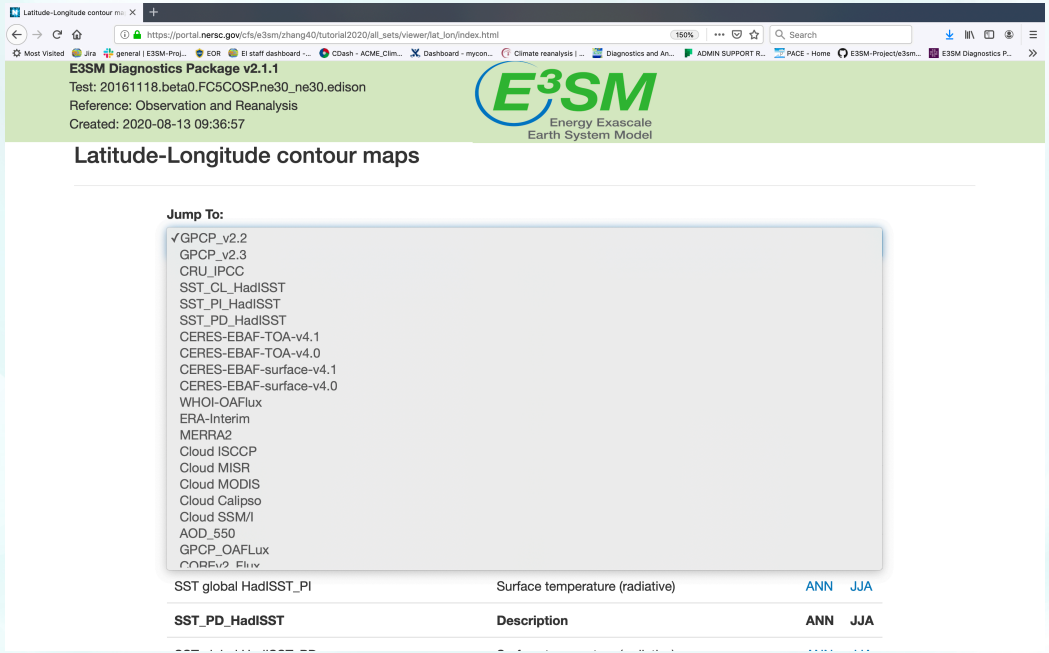
Provenance includes:

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



Main page for lat-lon:

1. Plots grouped by obs sets and seasons
2. Drop-down menu


Latitude-Longitude contour ma
https://portal.nersc.gov/cfs/e3sm/zhang40/tutorial2020/all_sets/viewer/lat_lon/index.html
150%
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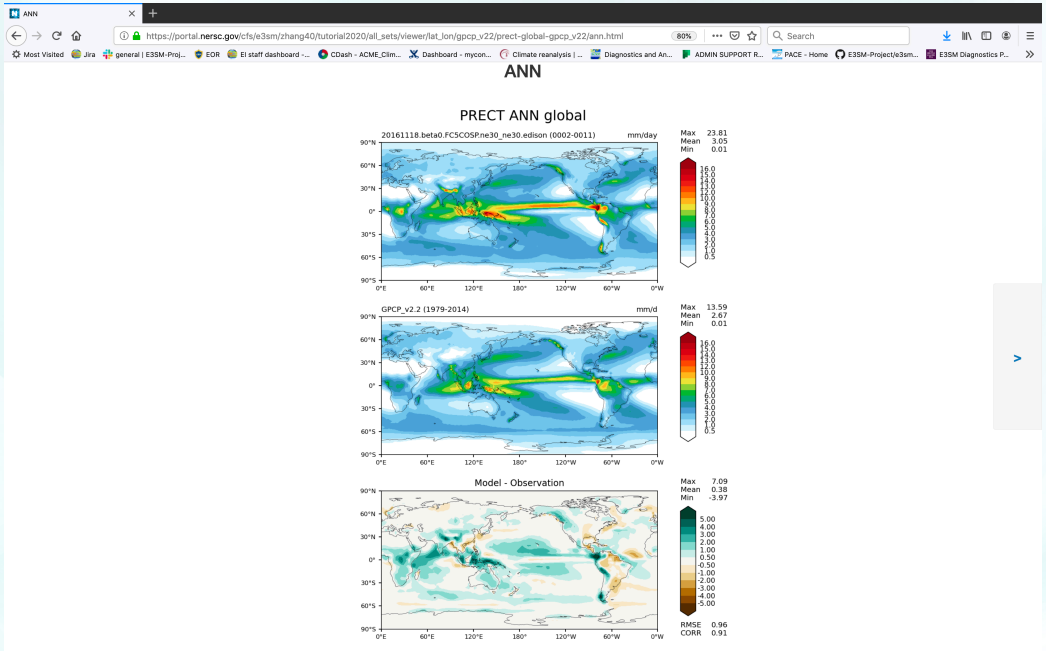
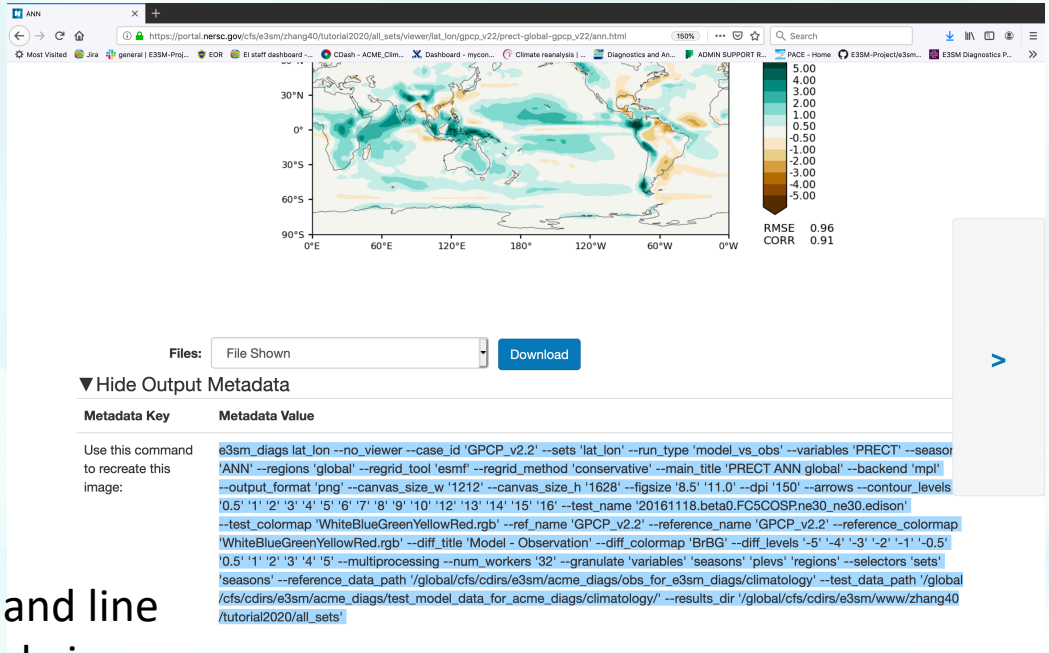
CDash - ACME_Clim...
Dashboard - mycon...
Climate reanalysis | ...
Diagnostics and An...
ADMIN SUPPORT R...
PACE - Home
E3SM-Project/e3sm...
E3SM Diagnostics P...
E3SM Diagnostics Package v2.1.1
Test: 20161118.beta0.FC5COSP.ne30_ne30.edison
Reference: Observation and Reanalysis
Created: 2020-08-13 09:36:57
E3SM
Energy Exascale
Earth System Model
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
AOD_550
GPCP_OAFLux
SST global HadISST_PI
Surface temperature (radiative)
ANN
JJA
SST_PD_HadISST
Description
ANN
JJA


ANN
https://portal.nersc.gov/cfs/e3sm/zhang40/tutorial2020/all_sets/viewer/lat_lon/gpcp_v22/prect-global-gpcp_v22/ann.html
Search
ANN
PRECT ANN global
20161118.beta0.FC5COSP.ne30_ne30.edison (0002-0011)
mm/day
Max 23.81
Mean 3.05
Min 0.01
GPCP_v2.2 (1979-2014)
mm/d
Max 13.59
Mean 2.67
Min 0.01
Model - Observation
Max 7.09
Mean 0.38
Min -3.97
RMSE 0.96
CORR 0.91

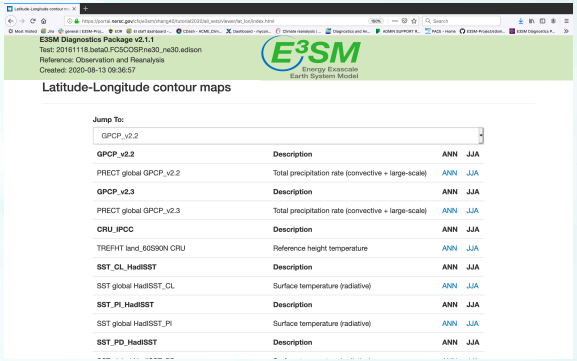


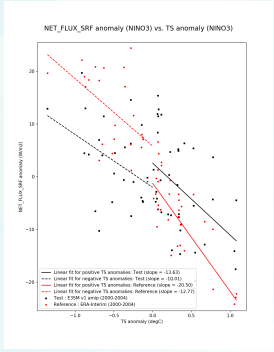
- Run using a command line
- Reproduce the single image
- Edit the line to refine the image, i.g., change ‘contour levels’ etc.

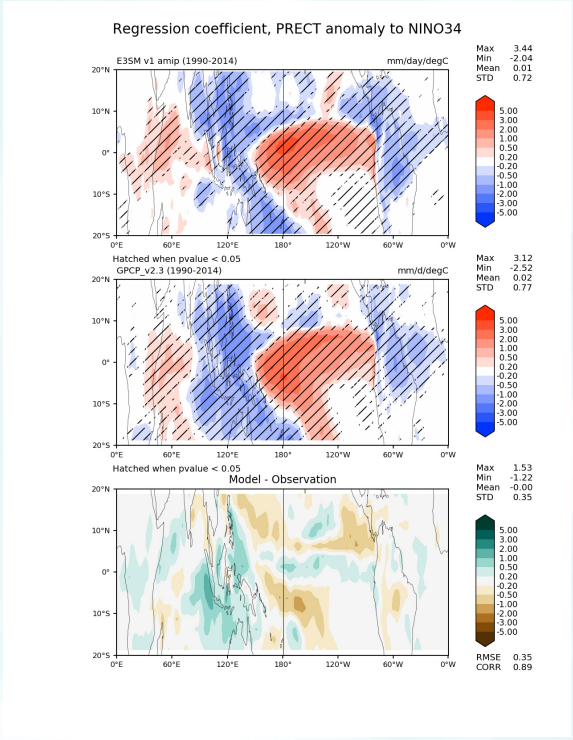
*make sure to change ‘results_dir’

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



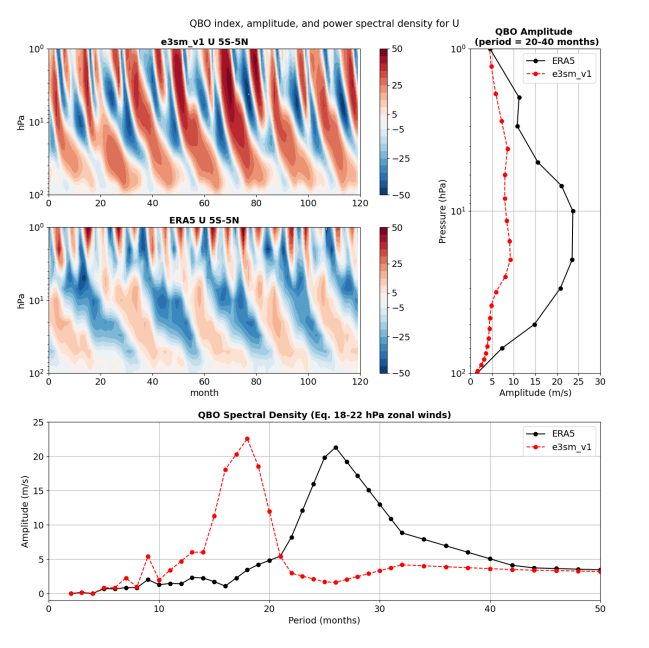




(ENSO diags from Aprime)

Newly Implemented: Quasi-biennial Oscillation

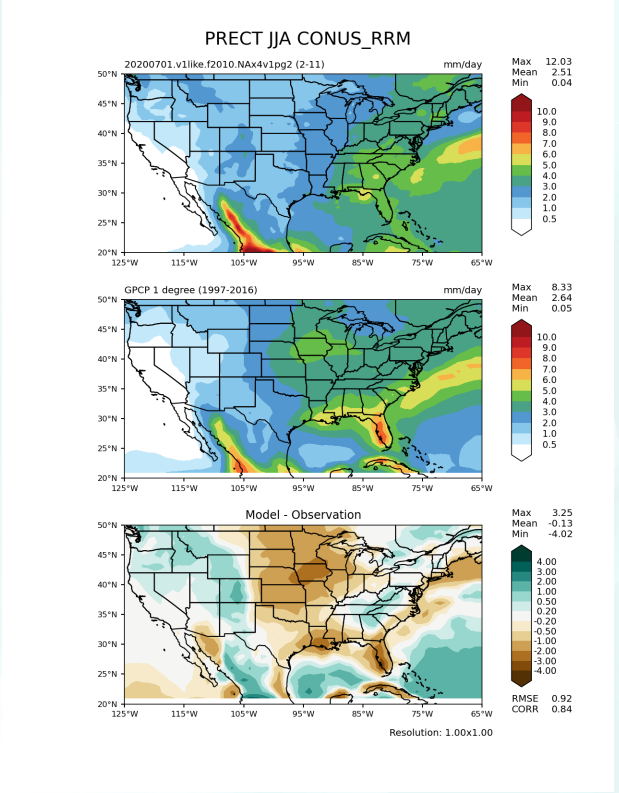
- QBO diags over 5S-5N
- QBO index, amplitude and spectral intensity of U
- 0.25 deg ERA5 data with 37 vertical levels
- First direct community contribution
  (Thanks to Chris Terai)



(Richter et al. 2019 JAMES)

Newly Implemented: Initial RRM Support

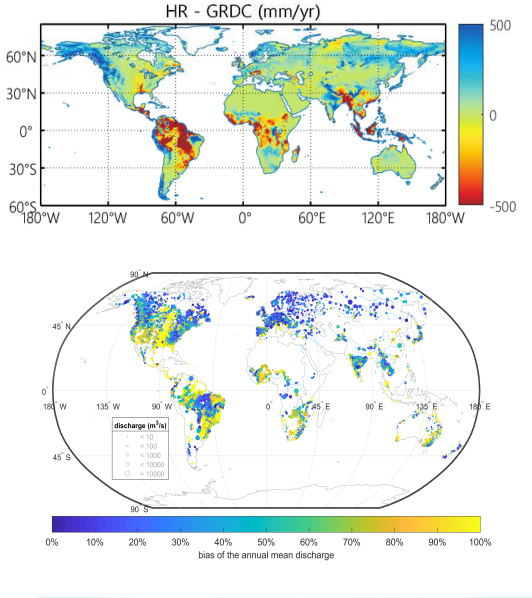
- Lat-lon plots to zoom in on a region.
- CONUS_RRM domain
- New analysis data: 0.25 deg ERA5 and 1 deg GPCP
- python **run_lat_lon.py -d lat_lon_rrm.cfg**
- **Example output**



(Qi Tang et al. 2019 GMD)

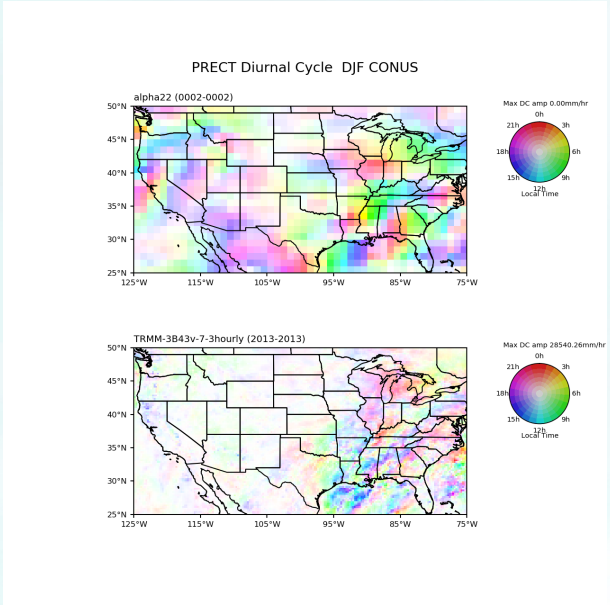
Ongoing Development

Runoff and streamflow diagnostics (Tian Zhou)



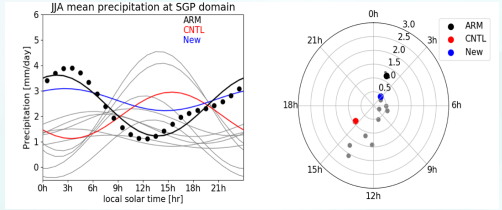
(Golaz et al. 2019 JAMES)
(Caldwell et al. 2019 JAMES)

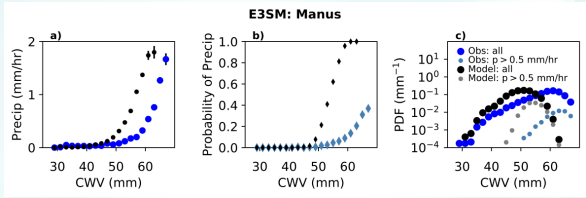
Diurnal cycle of precipitation (Charlie Zender, Wuyin Lin)



(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