

THE E3SM DIAGNOSTICS PACKAGE FOR EARTH SYSTEM MODEL EVALUATION

In the development cycle of an earth system model, like the Energy Exascale Earth System Model (E3SM), an important step is performing diagnostics by comparing the model to observational or reanalysis data or by comparing it to another model. E3SM_diags is a diagnostics software package that can be used alone or embedded into the E3SM workflow to enable seamless transition between model runs and diagnostics. The package includes a group of the most up-to-date analysis datasets to facilitate model validation. Example diagnostics include the global precipitation contour plot in Figure 1, the Taylor diagram in Figure 2 and the cloud 2D histogram plot from simulator output in Figure 4.

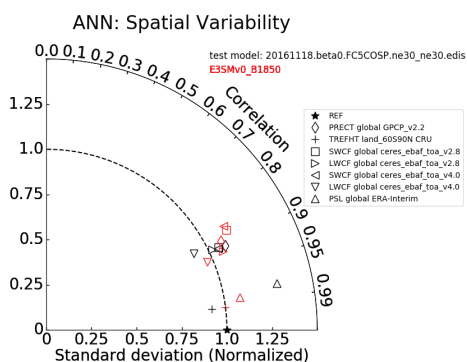


Figure 2. A Taylor diagram provides a way of graphically summarizing how closely a pattern matches observations. The similarity between two patterns is quantified in terms of their correlation, their root-mean-square difference (RMS) and the amplitude of their variations, represented by their standard deviations.

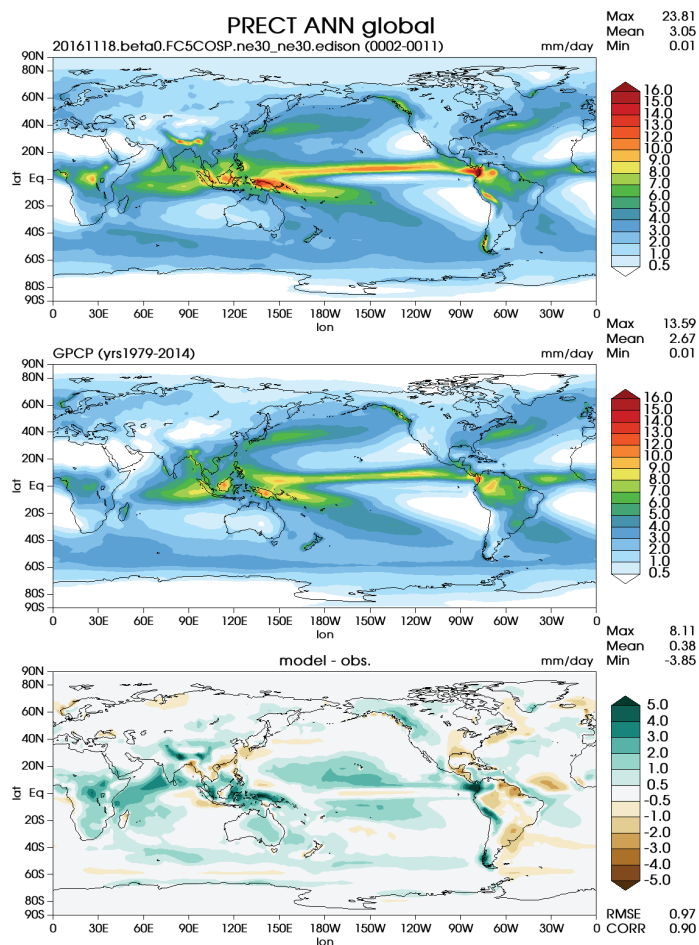


Figure 1. Example of a diagnostic latitude-longitude contour plot of global precipitation. Top panel shows E3SM model data, middle shows observational data, and bottom shows the difference.

FLEXIBLE SOFTWARE

E3SM Diagnostics is designed to be adjustable and modular, enabling users to manipulate different aspects of the diagnostics workflow. Numerous configuration options exist to customize data processing and metric computation as well as data visualization. Users can select pre-defined geographic

Get E3SM Diagnostics

- Code – https://github.com/E3SM-Project/e3sm_diags
- Code DOI – <http://doi.org/10.5281/zenodo.1009156>
- Docs – <https://e3sm.org/resources/tools/diagnostic-tools/e3sm-diagnostics/>

regions and generate derived variables. Though designed for E3SM, the package can be easily expanded to accommodate output from other earth system models. Written with parallel computing in mind, the package can manage a multiprocessing pool to speed up diagnostics processes (see Fig. 3).

DIAGNOSTIC PLOTS

The software supports diagnostics based on seasonal or annual climatology data, including:

- Latitude-Longitude contour maps (Fig. 1)
- Polar contour maps
- Zonal mean line plots
- Pressure-Latitude zonal mean contour plots
- Cloud Top Height - Optical Thickness (Tau) joint histograms (Fig. 4)
- Tables summarizing metrics
- Taylor Diagrams for spatial variability (Fig. 2)

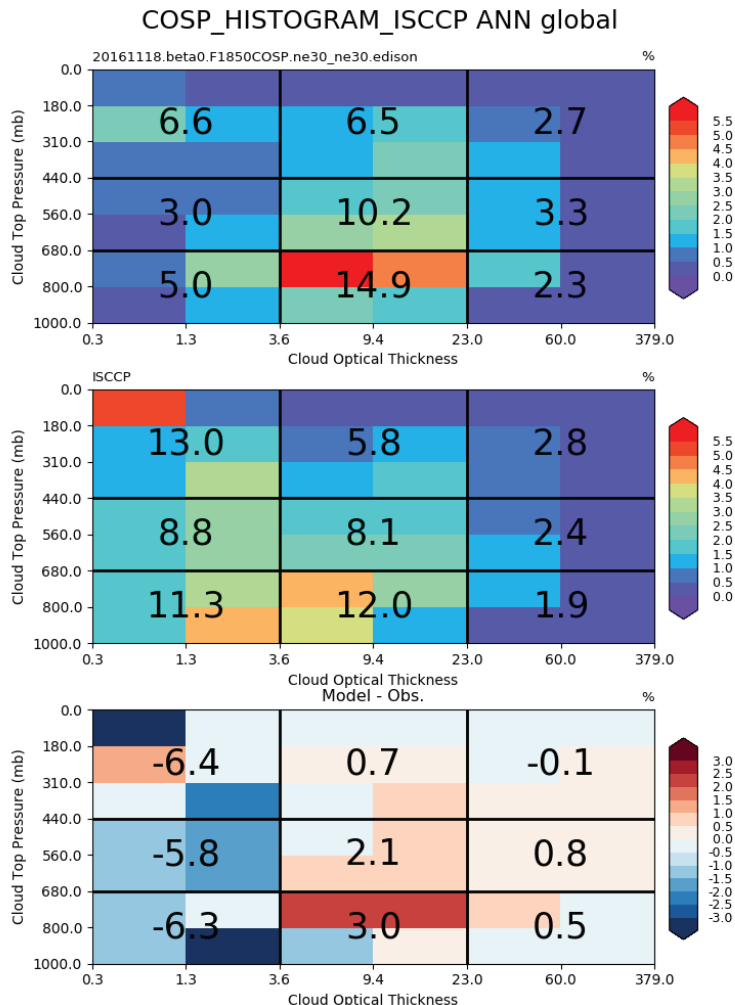


Figure 4. Example of a 2D joint histogram plot using **COSP** simulator output. COSP stands for the Cloud Feedback Model Intercomparison Project (CFMIP) Observation Simulator Package. Top panel shows E3SM model data, middle shows observational data, and bottom shows the difference.

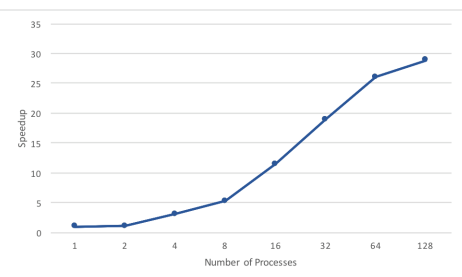


TABLE I
 STRONG SCALABILITY TIMING DATA

Number of Processes	Time (min)	Speedup	Efficiency
1	71.18	1.00	1.00
2	69.83	1.02	0.51
4	23.18	3.07	0.77
8	13.58	5.24	0.66
16	6.23	11.43	0.71
32	3.75	18.96	0.59
64	2.73	26.04	0.41
128	2.47	28.86	0.23

Timing data for 215 diagnostics runs, which produce over 1330 different figures for the diagnostics.

Figure 3. Performance data collected over 200+ runs showing speedup vs. process count.

AVAILABLE DATASETS

The E3SM Diagnostics Package includes up-to-date analysis datasets for earth system variables:

- [GPCP](#) for precipitation
- [CERES_EBAF](#) for radiation
- [Hadley Center data](#) for sea surface temperature
- [WHOI-OAFlux](#) for ocean surface latent and sensible heat fluxes
- [ERA-Interim](#) and [MERRA2](#) for reanalysis datasets
- [ISCCP](#), [MISR](#) and [MODIS](#) for satellite simulator datasets

SUPPORT

DOE Office of Science, Biological and Environmental Research (BER)

CONTACTS

Chengzhu (Jill) Zhang, Ph.D.
 Lawrence Livermore National Laboratory
zhang40@llnl.gov

Sally McFarlane, Ph.D.
 DOE Program Manager
 Office of Biological and Environmental Research
Sally.McFarlane@science.doe.gov