

Towards a New CESM Port-Validation Tool

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- 1 Disclaimer
- 2 Basic Overview
 - How Will this Tool Work?
 - Building the Ensemble
 - Comparing User Output to the Ensemble
- 3 Ongoing Work

This is a work in progress, with many details still up in the air. Throughout this talk, I'll differentiate between what we have decided is “best” and what we are still investigating. Comments and suggestions are certainly welcome (see email in bottom left corner).

CSEG: Generate an Ensemble on a Trusted Machine*

Create ensemble of 101 B1850C5CN runs that differ only in the CAM pertlim parameter (101 values used are $\{-5.9, -5.8, \dots, -1.1, -1, 0, 1, 1.1, \dots, 5.8, 5.9\} \cdot 10^{-14}$). These are one-year runs and we look only at annual averages of the output.

User: Run on the Machine to be Validated

Run three B1850C5CN runs with that differ only in the CAM pertlim parameter (the three values should be chosen randomly from the 101 used above). These are also one-year runs with annually averaged output.

*Note: We'll provide ensembles from latest CESM 1.0.X, CESM 1.1.X, and CESM 1.2.X

What Happens to the Ensemble Output

Statistics Calculated

For each member of the ensemble, consider the sub-ensemble containing the other 100 members.

- 1 For every variable (x), compute the 100-member ensemble mean (\bar{x}) and standard deviation (σ) at every (i, j, k) point.
- 2 Compute the root-mean-square Z-score of the omitted member

$$RMSZ_x = \sqrt{\frac{1}{n_x} \sum_{i,j,k} \left(\frac{x_{i,j,k} - \bar{x}_{i,j,k}}{\sigma_{i,j,k}} \right)^2}$$

Also compute the 101-member ensemble mean and standard deviation.

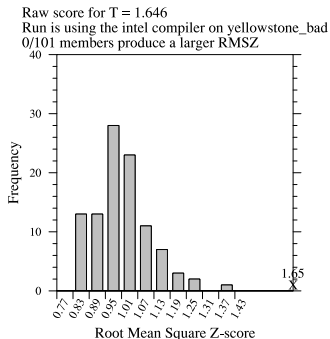
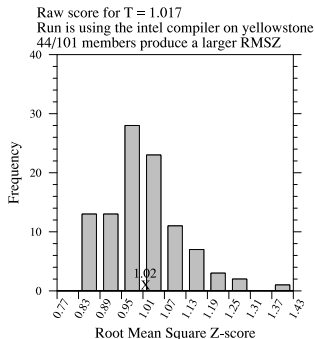
End Result

A netCDF file containing the mean and standard deviation of each variable as well as the 101 RMSZ scores for each variable.

A Sample Ensemble Output File

```
$ ncdump -h cesm1_1.B1850C5CN.ne30_g16.yellowstone.nc
netcdf cesm1_1.B1850C5CN.ne30_g16.yellowstone {
dimensions:
    ncol = 48602 ;
    lev = 30 ;
    ens_size = 101 ;
    nvars = 189 ;
    nvars3d = 88 ;
    nvars2d = 101 ;
variables:
    float ens_avg3d(ncvars3d, nlev, ncol) ;
    float ens_stddev3d(ncvars3d, nlev, ncol) ;
    float ens_avg2d(ncvars2d, ncol) ;
    float ens_stddev2d(ncvars2d, ncol) ;
    float RMSZ(nvars, ens_size) ;
}
```

Comparing a Run to the Ensemble



Two-Step Process

- 1 Compute the RMSZ score for each variable using the 101-member ensemble mean and standard deviation
- 2 See how the run compares to the 101 RMSZ computed based on the other 100 members
 - Good: RMSZ for all variables falls within the ensemble RMSZ values

What Variables Should We Be Looking At?

- Started by just looking at 4 CAM variables:
 - 1 Q (specific humidity)
 - 2 T (temperature)
 - 3 TS (surface temperature)
 - 4 U (zonal wind)
- Have also generated an FC5 ensemble with all the default CAM and CLM output

Plan Forward

- 1 Look at correlation of RMSZ scores between all variable pairs, do some PCA to determine how many / which variables to keep
- 2 Once we have decided on variable count, work backwards design test criteria (number of runs / number of allowable “failures”)

How Can We Simulate a Test That Should Fail?

Want to be confident that the test flags climate-changing modifications, which we think we can get from the following:

- 1 Changing compiler optimization
- 2 Using non-spun-up land initial condition
- 3 Introducing an error in boundary flux calculation
- 4 Changing CAM's physics or dynamics timestep (or both)
- 5 Changing convergence criteria in the iterative solvers
- 6 Changing the way vectors are mapped between the atmosphere grid and the ocean grid
- 7 Disabling reproducible sums (or changing some other global reduction)
- 8 Changing physical parameters (what if $g = 10 \text{ m/s}^2$?)

Updating the CESM Mapping Tools

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- 1 Mapping Tools in CESM
 - About
 - Directory Structure
- 2 Ongoing Work

A Little Background

- Organizing the mapping directory was my first task after being hired (Mar 2012), middle of CESM 1.1 development.
- Goals
 - ① Add a utility to check the quality of the maps used in CESM
 - ② Make it easy to generate new mapping files (CAM-SE in the model currently, MPAS-O in development, more regional refinement, etc)
 - ③ Remove dependence on NCAR machines for tools (I came in as we transitioned from bluefire to yellowstone)

Where to Find the Mapping Tools

CESM 1.1.X – `$CESMROOT/mapping`

CESM 1.2.X – `$CESMROOT/tools/mapping`

Directories under Mapping

`check_maps` – Maps several analytic functions from source grid to destination grid, compares to function computed on destination grid. (In CESM 1.2, output includes netCDF file with before and after maps.)

- `examples` – goal is to populate with many examples, currently just has directions for creating a new regional grid for WRF-CLM
- `gen_domain_files` – generate domain files needed for non-coupled runs
- `map_field` – new for CESM 1.2.0 (thanks Tony!), this tool takes model output, a mapping file, and a variable name as input and generates the field on a new grid as output.

Directories under Mapping

- [gen_mapping_files](#) – A wrapper for the tool in `gen_ESMF_mapping_file`, you list input all the grids (ATM, OCN, LND, etc) and it generates all necessary maps
- [gen_mapping_files/gen_ESMF_mapping_file](#) – A wrapper for the ESMF mapping generator, requires the ESMF binaries to be installed.
- [gen_mapping_files/runoff_to_ocn](#) – A tool designed to generate the runoff-to-ocean mapping file. Works in 3 stages
 - 1 Creates a nearest-neighbor runoff to ocean map (eventually handled by ESMF)
 - 2 Creates a smooth ocean-to-ocean map (don't want all runoff in single cell)
 - 3 Multiply (1) and (2) to get runoff-to-smooth-oceanCurrently yellowstone-only, but that's changing!

- Improved support for machines beyond yellowstone
- CLM is updating their toolkit to use `gen_ESMF_mapping_file` utility instead of calling ESMF directly
- Working to improve documentation.