A compact CESM Large Ensemble

CESM LENS (Kay et al., 2015)

Ensemble simulations are performed with a fully coupled earth system model, CESM1, from 1920 to 2100. Each member is forced by identical historical and RCP8.5 radiative forcing, but is initialized by slightly different atmospheric initial condition. 34 ensemble members include the ocean biogeochemistry component. At the basin resolution, monthly output of a single ocean variable (3D) takes 37GB of data from 1920 to 2100, and the full output is on the order of 25TB.

Re-gridding

Bilinear interpolation is performed using cdo (climate data operators) to reduce the re-gridding.

For the basin-scale means, the mean statistics of the original data well. Its spatial patterns can closely follow the original data. Generally, errors tend to occur near the coastlines. For the basin-scale averages, it is expected that smaller basins have larger errors.

The square of correlation coefficient (R2) are greater than 0.99 for all basins and for all variables. Generally, errors affected by the re-gridding?

Benchmark: single member

How is a single member affected by the re-gridding?

Ensemble mean and standard deviation are calculated for a few selected variables and compared to the original CESM-LENS output. They closely follow the original data. Here, we examined area-weighted averages of (left) SST, (middle) O2 at 200m, and (right) air-sea CO2 flux. Black lines reflect the values directly calculated from the original data, and the red lines are based on the re-gridded (2° x 2°) data.

The square of correlation coefficient (R2) are greater than 0.99 for all basins and for all variables. Generally, errors affected by the re-gridding?

Benchmark: ensemble statistics

Standard deviation of SST

Standard deviation among ensemble members can quantifying the magnitude of natural variability. Its spatial pattern is generally well captured.

ToE of global hypoxic depth

ToE of global hypoxic depth is plotted on the right with (blue) each members and (white) ensemble mean. The baseline period is set to 1970-1990 with a mean of 328m and the standard deviation of 2.9m. ToE is detected when hypoxic depth remains outside of two times the standard deviation of the baseline value. Excluding one outlier, the ToE covers the range of 2021 to 2059 with the natural variability (1STD) of hypoxic depth.

World Ocean Atlas 2013v2

Analysis of global mean hypoxic depth

To determine the spatial map of ToE, the natural variability (noise) is first estimated from all ensemble members using 1970-1990 (upper left). For each grid cells, ToE is detected when hypoxic depth remains outside of two times the STD below the baseline value (lower right). ToE does not occur in most of tropics because the hypoxic depth does not have a significant shoaling trend.

This data product is freely available from https://doi.org/10.5065/5YK4-D48.

We welcome collaborations/suggestions for scientific applications, inter-comparison with other ESM-LENS dataset(s), or selection of variables for future refinement of this data set.

Example: The Time of Emergence (ToE) for hypoxic depth

Hypoxic depth is defined as the depth at which the O2 level goes below a threshold. Low-O2 water can be harmful to marine organisms, and the hypoxic depth is expected to rise under global warming.

It is publicly available (registration required) at http://rda.ucar.edu/datasets/ds645.0

Contact: taka.ito@eas.gatech.edu