On the robustness of the evaluation of ENSO in climate models: How many ensemble members are needed?

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Abstract

This work examines the multi-decadal variability of both the tropical Pacific mean state and El Niño-Southern Oscillation (ENSO), as represented by the spread of the ensemble members in climate simulations. Considering the large ensembles of climate models require considerable resources to generate, defining an appropriate ensemble size for a particular application is an important experimental design criterion. We estimate the ensemble size (N) needed to assess a model's ability to capture observed ENSO behavior by utilizing the recently developed CLIVAR ENSO Metrics Package (Planton et al., 2021, BAMS). Using the large ensembles (N: 20_~65) available from CMIP6 and the Single-Model Initial condition Large Ensembles (SMILEs) Project, we find that larger ensembles are needed to robustly capture baseline ENSO characteristics (N > 65) and physical processes (N > 50) than the background climatology (N \geq 12) and remote ENSO teleconnections (N \geq 6). While these results vary somewhat across metrics and models, our study highlights that ensembles are required to robustly evaluate simulated historical ENSO behavior, and provide initial guidance for designing model ensembles to reliably evaluate and compare ENSO simulations.

Keywords: ENSO, CMIP6, Large Ensemble, CLIVAR ENSO Metrics, PCMDI Metrics Package (PMP), Monte, Carlo Sampling

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