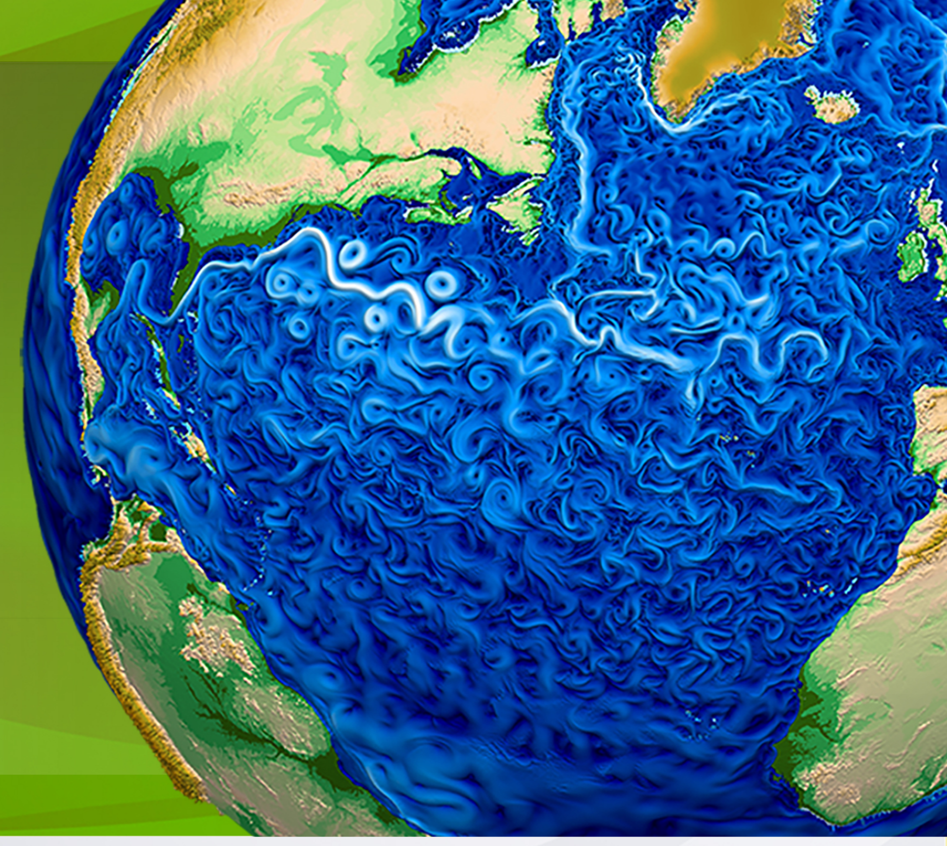

Testing an Alternative Initialization Strategy for Present-Day Transient Climate Simulations.

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Objective

To explore the viability of initializing present day coupled climate transient simulations using atmospheric reanalysis-forced ocean/sea rather than carrying out a long 20th Century simulation.

The standard practice of initializing an ensemble of present day (PD) transient climate simulations by branching off a multi-century preindustrial control (PICNTRL), and then running each of the ensemble members from 1850 through to present day, is not feasible for next-generation coupled climate models. These models will largely resolve oceanic mesoscale eddies and weather-scale atmospheric phenomena, so will be much more computationally expensive than standard climate models. Rather than initialize PD transients from the PICNTRL, we use global ocean and sea-ice realizations, taken from an atmospheric reanalysis-forced global coupled ocean/sea-ice model in the latter half of the 20th Century. We expect that by initializing the ensemble of transients using ocean and ice states of minimal spread, selected just prior to the strong warming of the late 20th century, from a reanalysis forced coupled ocean/ice simulation, very low frequency variability will be precluded from our PD ensemble and we will only resolve variability associated with the latter half of the 20th and early 21st Century. Since our eventual goal is to produce near-term climate projections (up to 40 years), we hypothesize that our limited-variability PD transients will be appropriate as initial states for these projections. This approach is unlike that of long term climate prediction that aims to capture as much spread as possible in the transient ensemble, together with very low-frequency trends.

Approach

Coupled CESM 1.0 was configured using:

- CAM4: Eulerian spectral dynamical core using triangular spectral truncation at 85 wavenumbers (T85)
- CLM4: Initialized from year 863 of CCSM4 1850 control.
- POP2.0: Nominal 1°, 60-level grid - NP rotated into Greenland at 80°N, 40°W. Initialized from PHC2.
- CICE4.0: Configured on POP grid, initialized from a spun-up ice state from a coupled climate run (standard release).

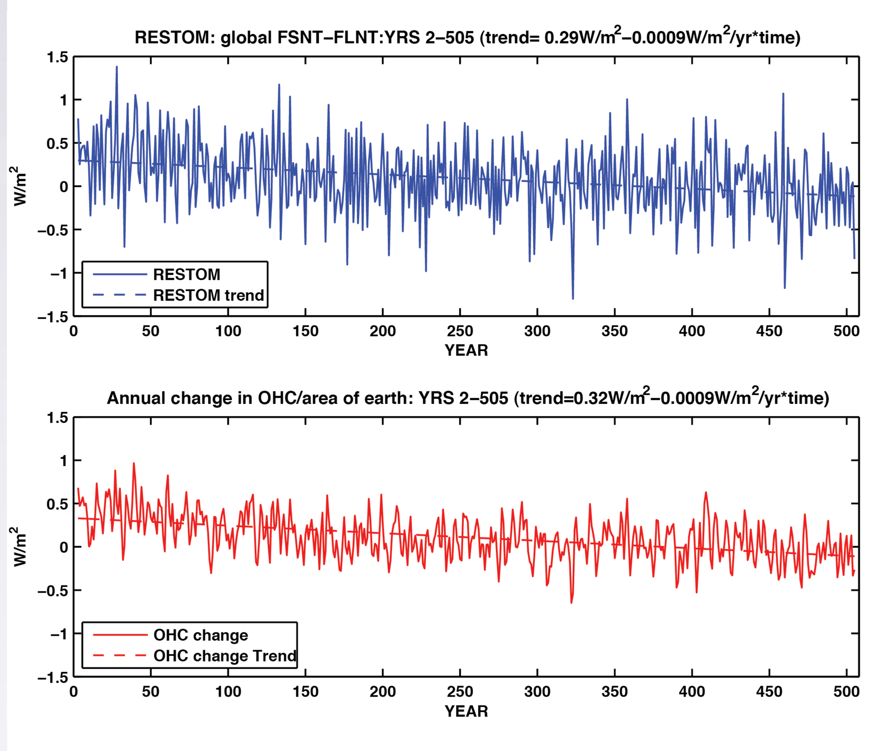
Forced CESM 1.0 uses

- Data atmosphere: Coordinated Ocean Reference Experiment 2 (CORE2) interannually varying forcing (IAF).
- POP2.0: Nominal 1°, 60-level grid (gx1v6) with the North Pole rotated into Greenland at 80°N, 40°W.
- CICE4.0: Configured on the same grid as POP.
- POP was initialized from PHC2 potential temperature & salinity; POP/CICE started in 1970.

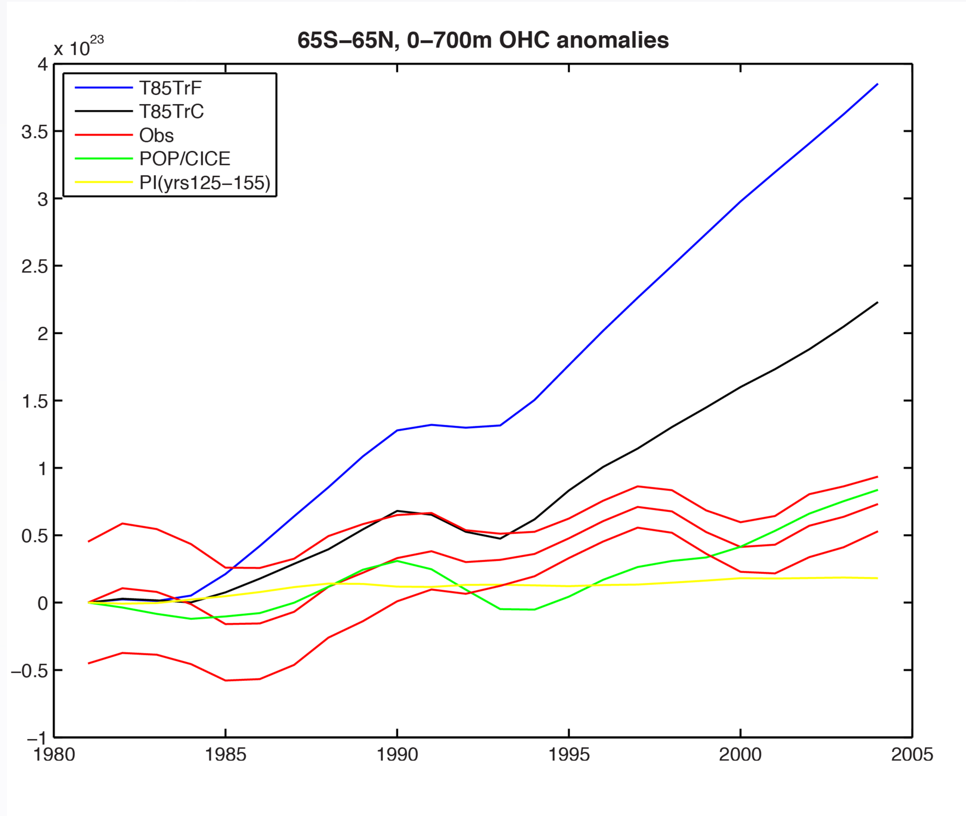
500-year PICNTRL: Optimized physics parameterization values obtained by Evans et al. (2014) from a forced preindustrial configuration of stand-alone CESM 1.0/CAM4 (T85).
T85TrF: Five-member ensemble of PD transients initialized from forced POP/CICE on 1 [Jan-May] 1980 and run from 1975-2005. "Tuning" parameters as in the PICNTRL.
T85TrC: Three-member ensemble PD transients initialized from PICNTRL at years 200, 250, and 300, and run from 1850-2005. "Tuning" parameters as in the PICNTRL.

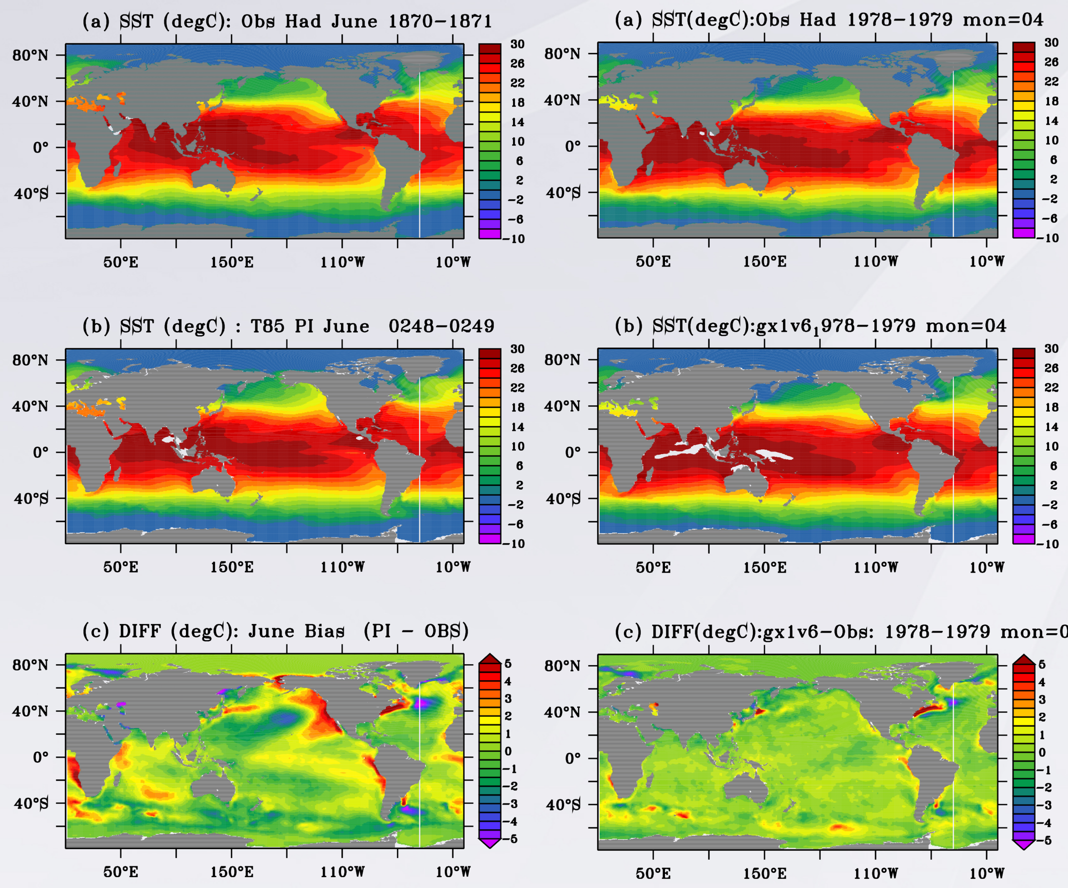
The two sets of PD ensembles: their climatologies, trends, and variability, were compared with each other and late 20th and early 21st Century observations. We also examined these quantities in the PICNTRL for years 380-400, 430-450, and 480-500. Standard horizontal resolution was used in the first instance so we could compare PD transients simulated using the two protocols.

T85x1 PICNTRL top of the atmosphere (TOA) net downward radiation (upper) & change in ocean heat content (OHC)/area of Earth (lower).



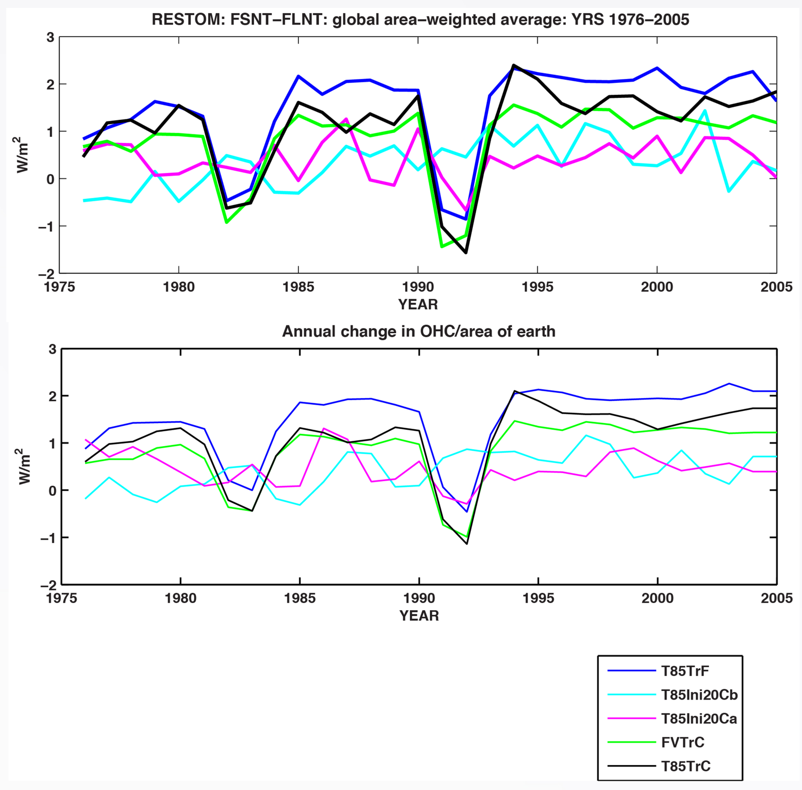
Ocean Heat Content (OHC) Anomaly (J): top 700 m of water column, 65°S-65°N from observations (Domingues et al. 2008, Version 3.1), from T85TrF & T85TrC ensemble means, & POP/CICE. PICNTRL is included for reference. OHC' are all set to zero in 1980.





Examples of SST from T85 PICNTRL (left) and POP/CICE (right) just before their full fields were taken to initialize T85TrC and T85TrF, respectively (top panel). Middle panel shows SSTs from observations for the same periods; their biases (model-observations) are in the lower panels. POP/CICE SST shows less bias than that from the T85 PICNTRL.

TOA net downward radiation (upper) & change in OHC/area of Earth (lower): T85TrF, T85TrC, & two T85x1 runs with constant PI forcing: one initialized from POP/CICE (cyan) and other from PHC2 (magenta).



Impact

In all, comparisons of trends (i.e. globally averaged SST) and climatologies (i.e. mixed layer depth) from the two sets of PD transients did not show differences to observational quantities that were markedly unrealistic. The OHC' trend in T85TrF was greater than that of T85TrC, with both being larger than that from the observations. The stronger drift in T85TrF OHC' is to be expected in the light of the TOA imbalances of the respective PD transients.

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