Fully Coupled High-Resolution ACME v0.1 Approximate Present Day Transients
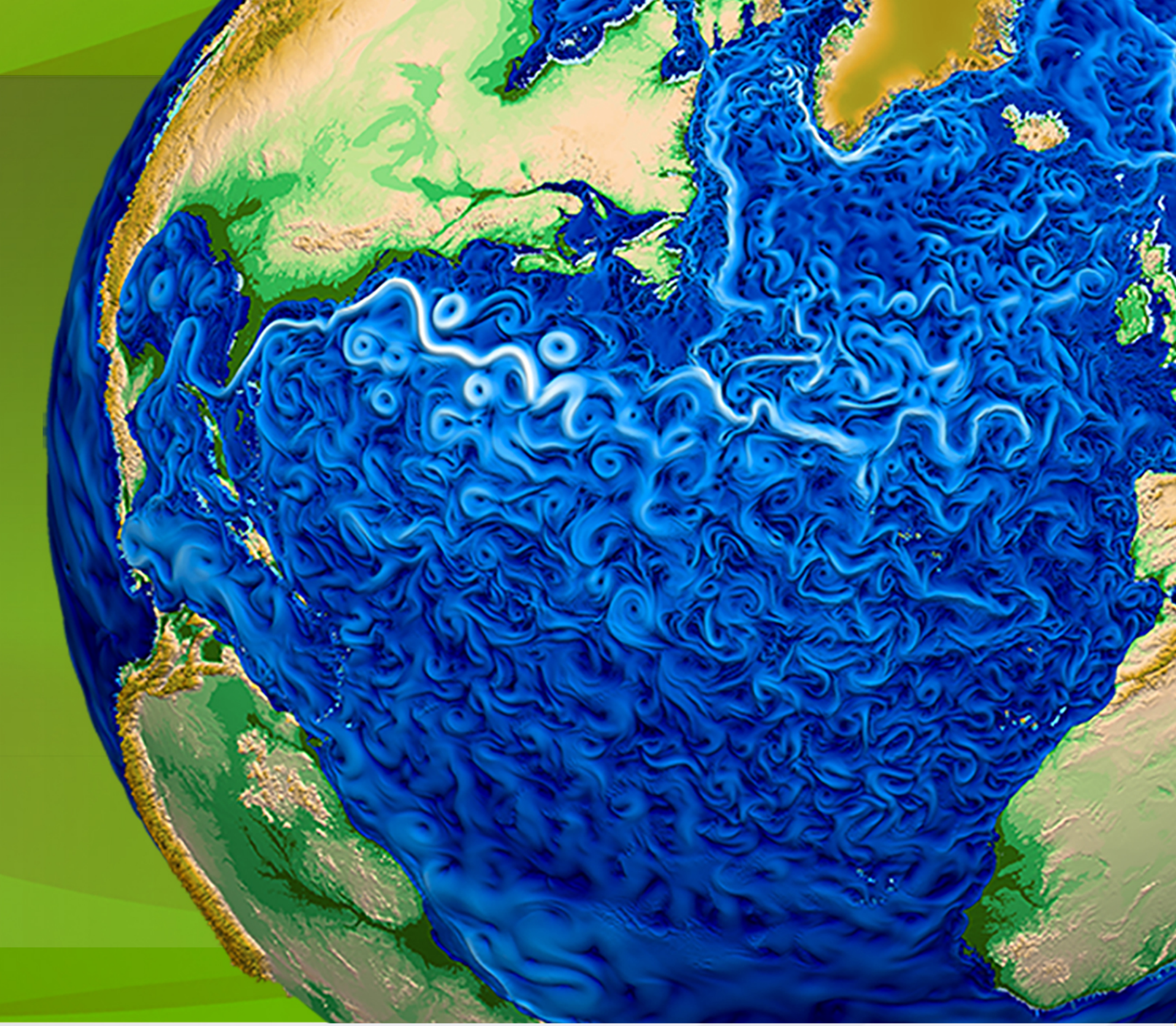
Julie L. McClean, David C. Bader, Mark Taylor, Qi Tang, Mathew E. Maltrud, Milena Veneziani, Jack Ritchie, Detelina Ivanova, Marcia Branstetter, Kate Evans, Salil Mahajan

Objectives

- Examine the veracity of an ensemble of approximate present day transients initialized from either a forced global ocean/sea simulation or a preindustrial fully coupled simulation using high resolution ACME v0.1.
- Use these results to provide a baseline for comparisons with subsequent ACME simulations

Approach

To provide this baseline, a 130-year 1850 pre-industrial control simulation and a 6-member ensemble of idealized present day (PD) transient simulations approximating 1970-2010 climate change, were carried out using fully coupled high-resolution ACMEv0.1.

Model Descriptions:

Coupled ACME v0.1 was configured using:
- 0.25° CAM5-se and CLM4
- 0.1°, 42-level POP2 and CICE4

Global 0.1°, 42-level POP2/CICE4:
- Forced with Coordinated Ocean Reference Experiment 2 (CORE2) corrected interannual forcing (CIAF).
- POP was initialized from PHC2 potential temperature & salinity.
- POP/CICE simulation: 1948-2009.
- Consistent configuration with ACME v0.1

Simulations:

130+ year 1850 Preindustrial Control (PICNTRL):
- Initialized from a two-year (1970-1971) spun up state of 0.1° POP/CICE
- "Tuned" in coupled mode to achieve an acceptable top of the atmosphere (TOA) radiation balance.

Approximate Present Day (APD) Forcing:
- Repeating 2000 forcing for GHG concentrations, SO_2 & stratospheric aerosols (no volcanoes).
- Termed "APD" as the integrated net energy uptake of the global system over the length of the transient runs was consistent with observations summarized in the IPCC AR4 report for the late 20th century.

APD Transients (APDTs):
- APDT 1-3 (1970-2015) initialized from 0.1° POP2/CICE4. Initial conditions represent a spread in climate mode variability from the late 1960s to the late 1970s.
- APDT 4 (1970-2003) was branched off the PICNTRL at year 90; the PICNTRL had reached a roughly quasi-steady state (not equilibrium).
- APDT 5 (1970-2003) was initialized from the same initial condition as the PICNTRL.
- APDT 6 (1970-2000) was initialized from year 20 of the PICNTRL to understand differences when initializing from the PICNTRL after it had 2 decades to adjust versus 90 years to adjust to its initial state.

Results:

Ocean Heat Content (OHC, left) and OHC Anomaly (right) in Joule for APDTs: top 700 m of water column, 65°S-65°N. OHCA from observations (Domingues et al. 2008, Version 3.1). PICNTRL OHCA (years 90-135-dashed thin blue line) included for reference. OHC' are all set to zero in 1970.
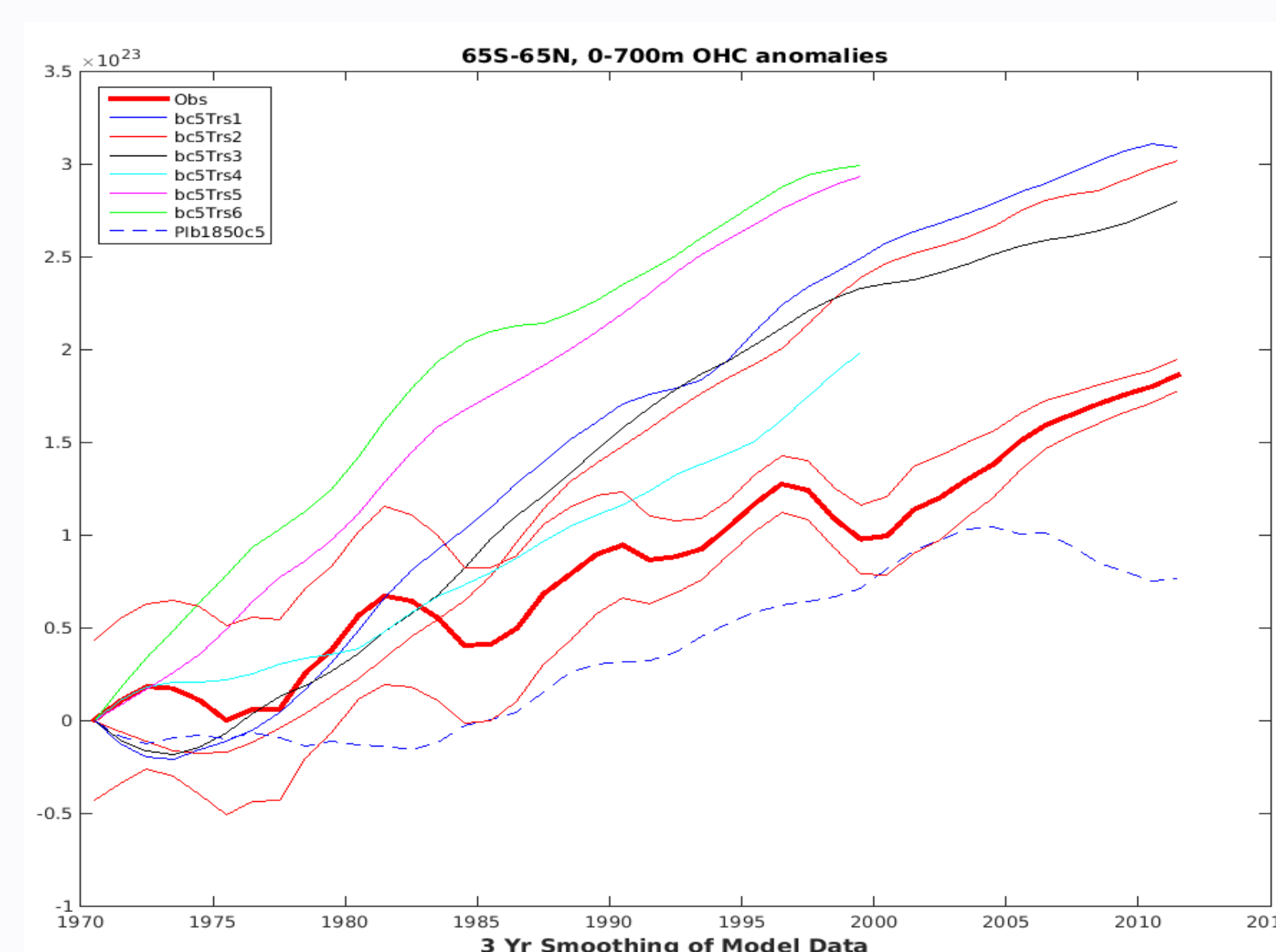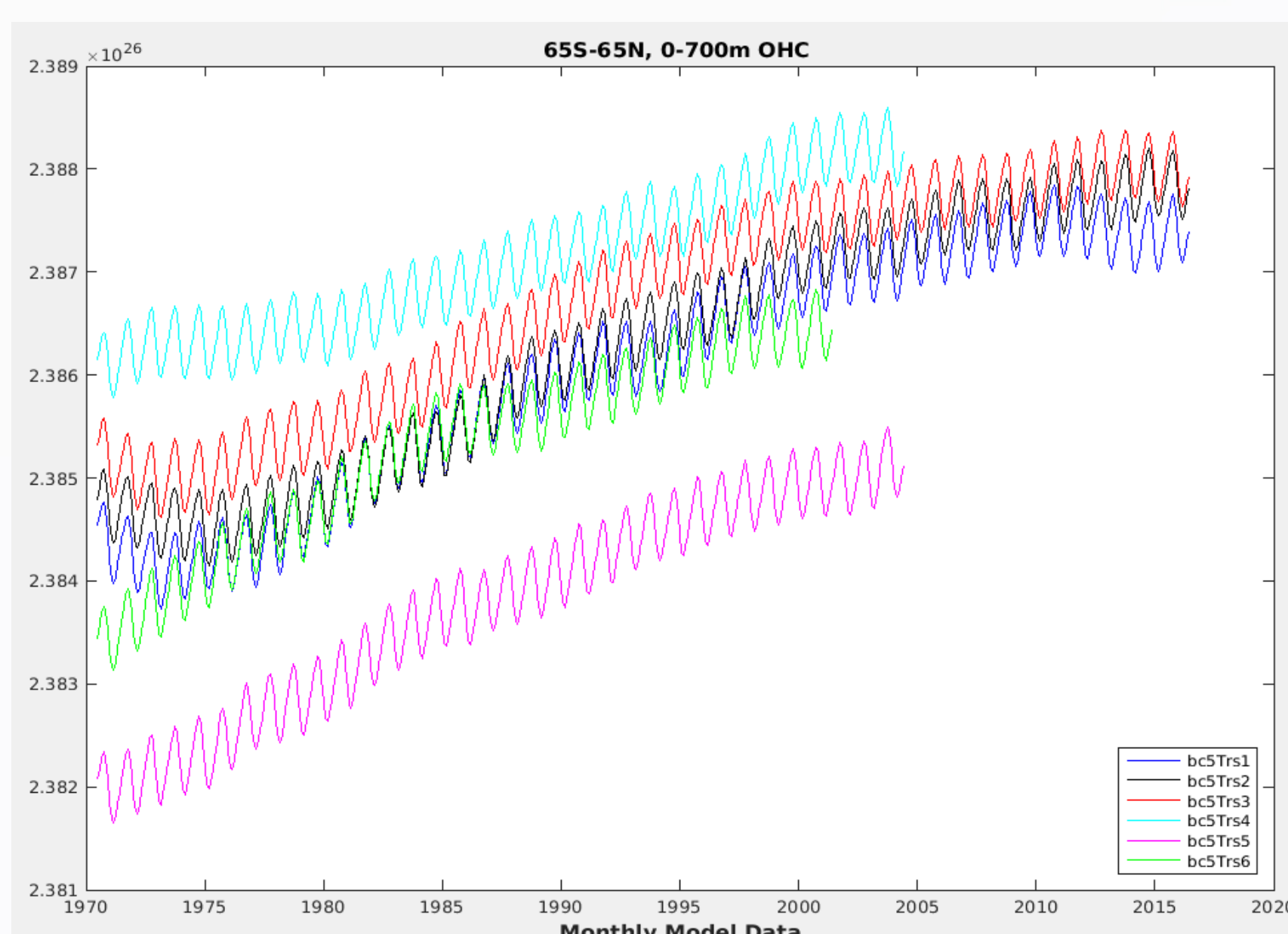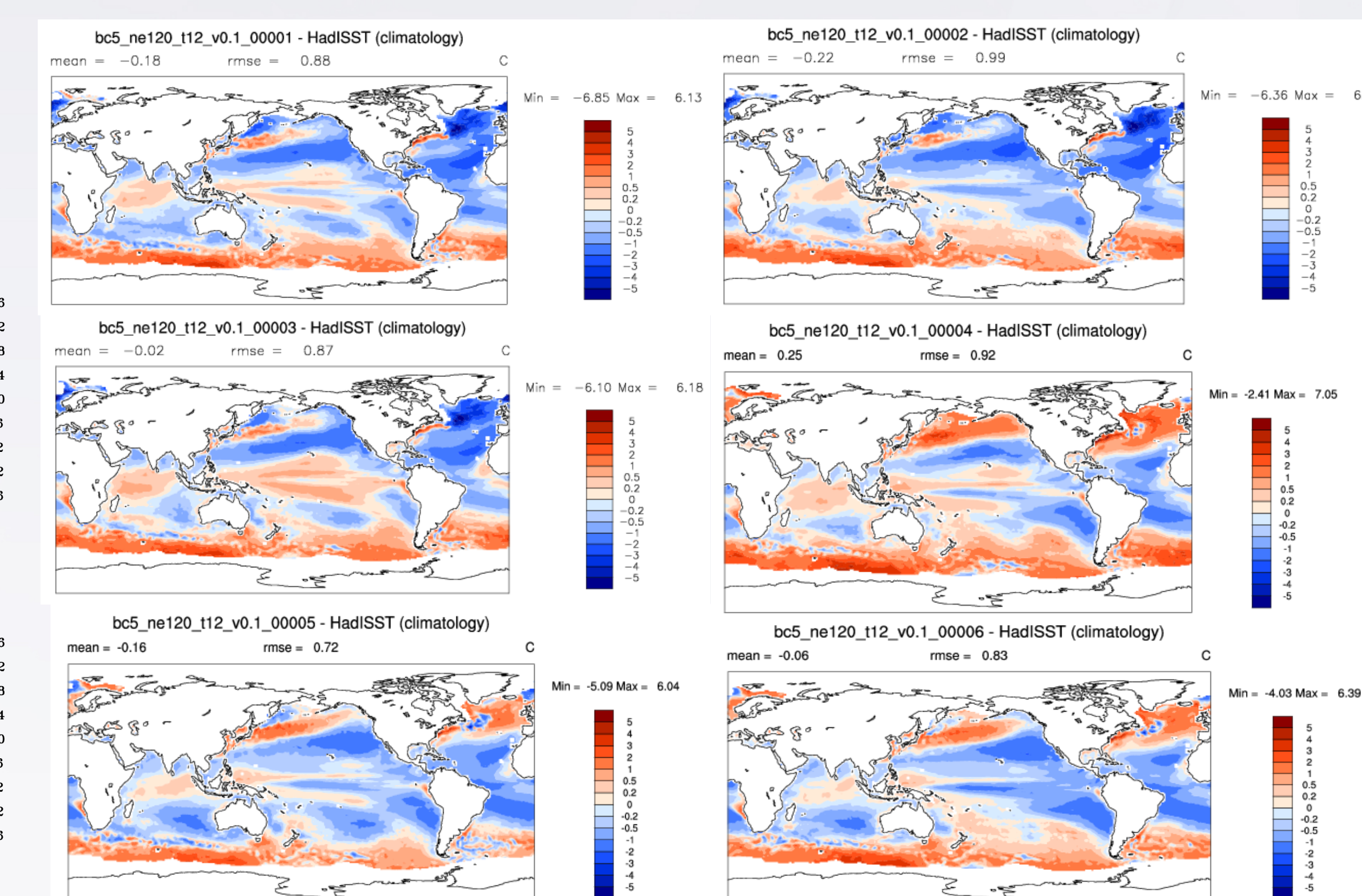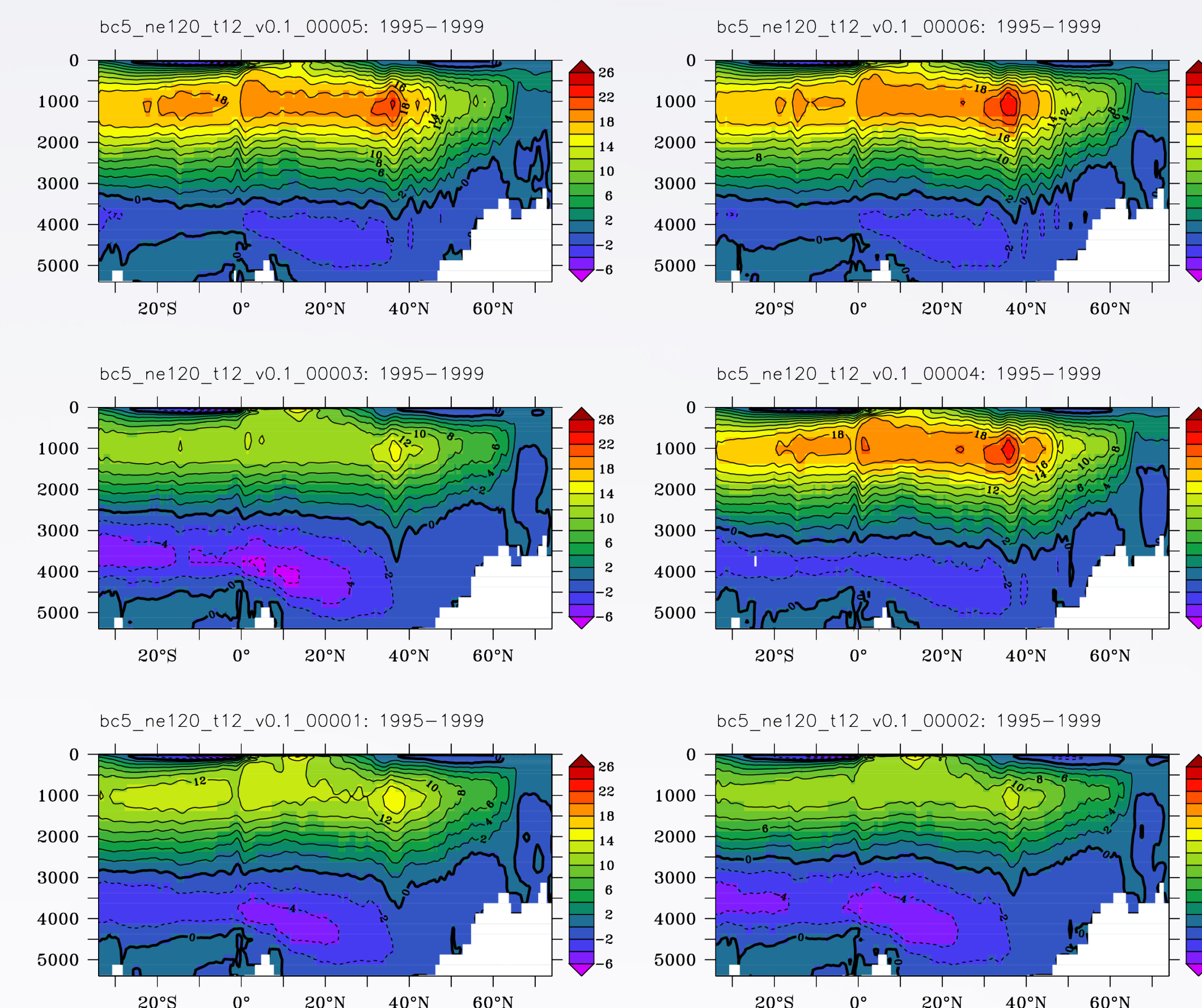
APD Transients

TOA Net Radiation (Wm⁻²) (top) & Change in Globally-Averaged Ocean Heat Content (OHC)/Area of Earth (lower) for APDTs.
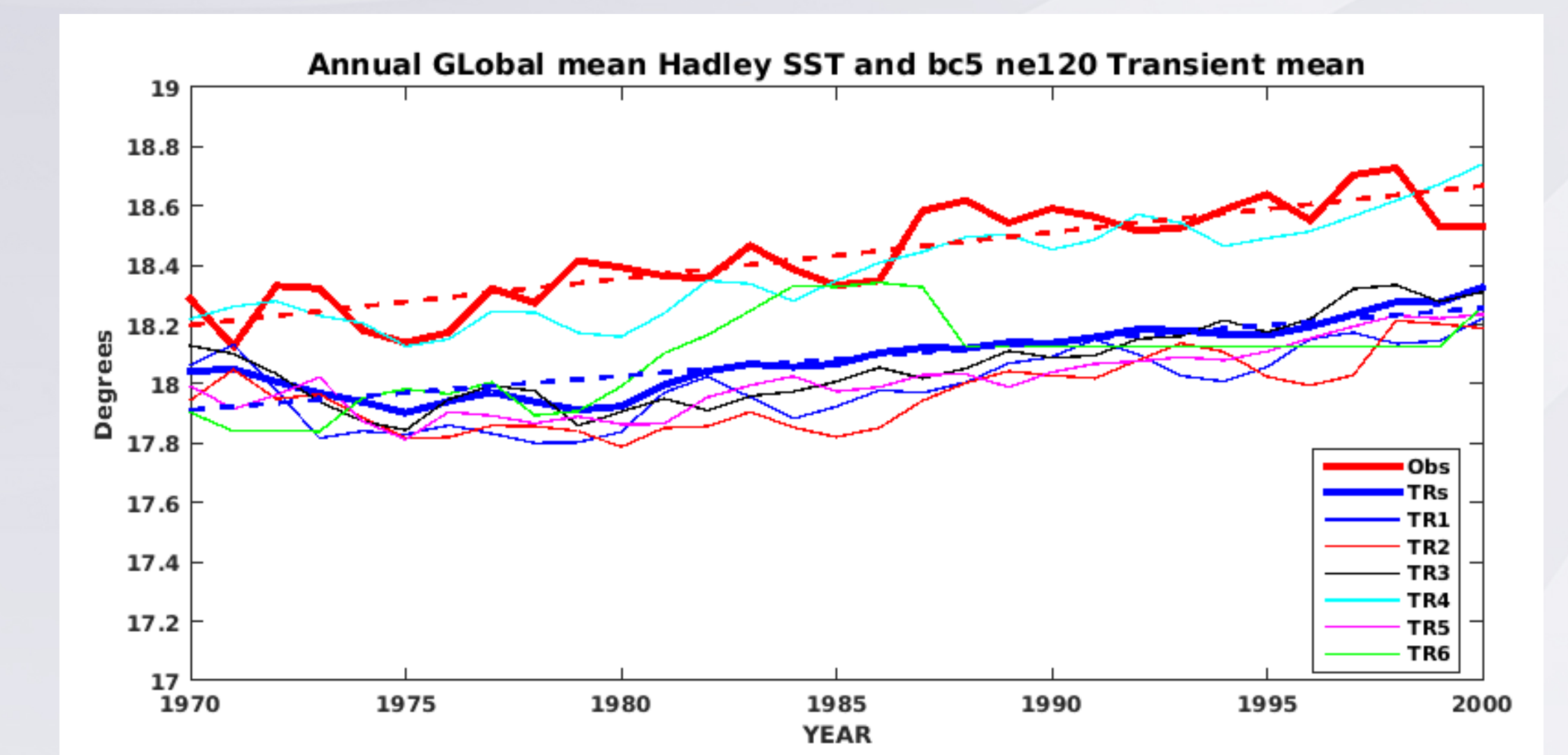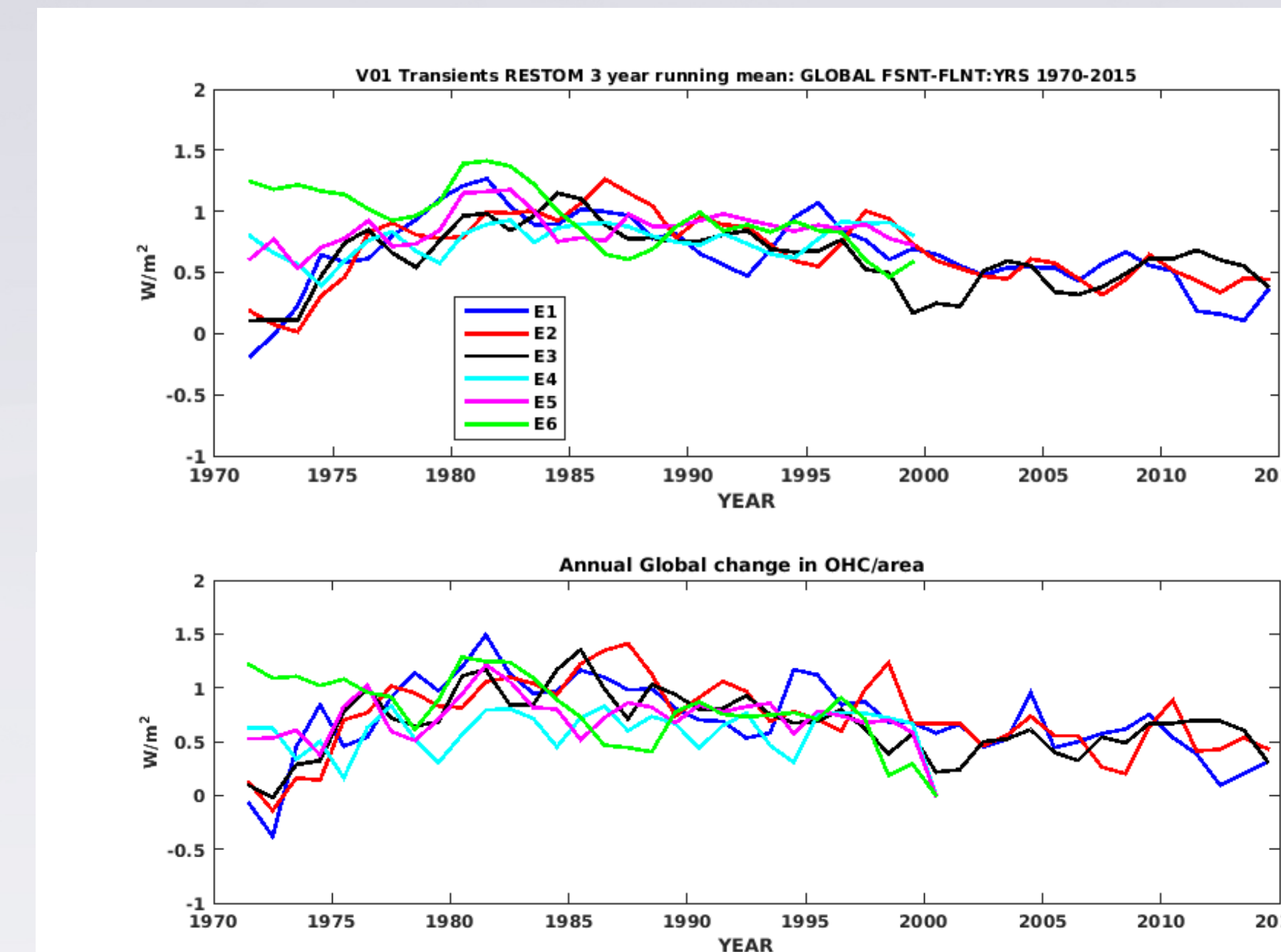
Global Area-Averaged Sea Surface Temperature (SST) (°C) Trends. Observations: thick red line, APDT Ensemble Average: thick blue line.
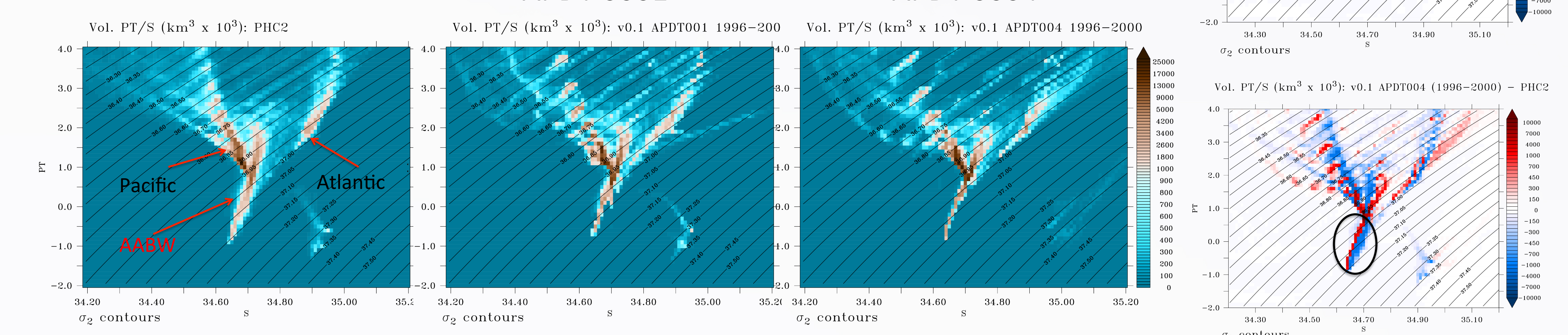
SST Biases (°C): 1996-2000

Atlantic Meridional Overturning Circulation (SV): 1995-1999

Antarctic Bottom Water (AABW) and Deep Water biases

Observations — APDT 0001 — APDT 0004

Impact

The standard initialization protocol of branching present day transients (PDTs) off a multi-century PICNTRL and running from 1850 to present day is precluded at enhanced horizontal resolution by lack of computer power. We find that initializing PTDs from multi-decadal high-resolution forced ocean/sea ice states as well as from a high-resolution 100 year PICNTRL produce simulations that realistically depict change in the late 20th Century. Biases are inherent in both approaches; the use of one above the other may be driven by regional interests.