Climate Simulations Using the GISS/HYCOM Coupled Model

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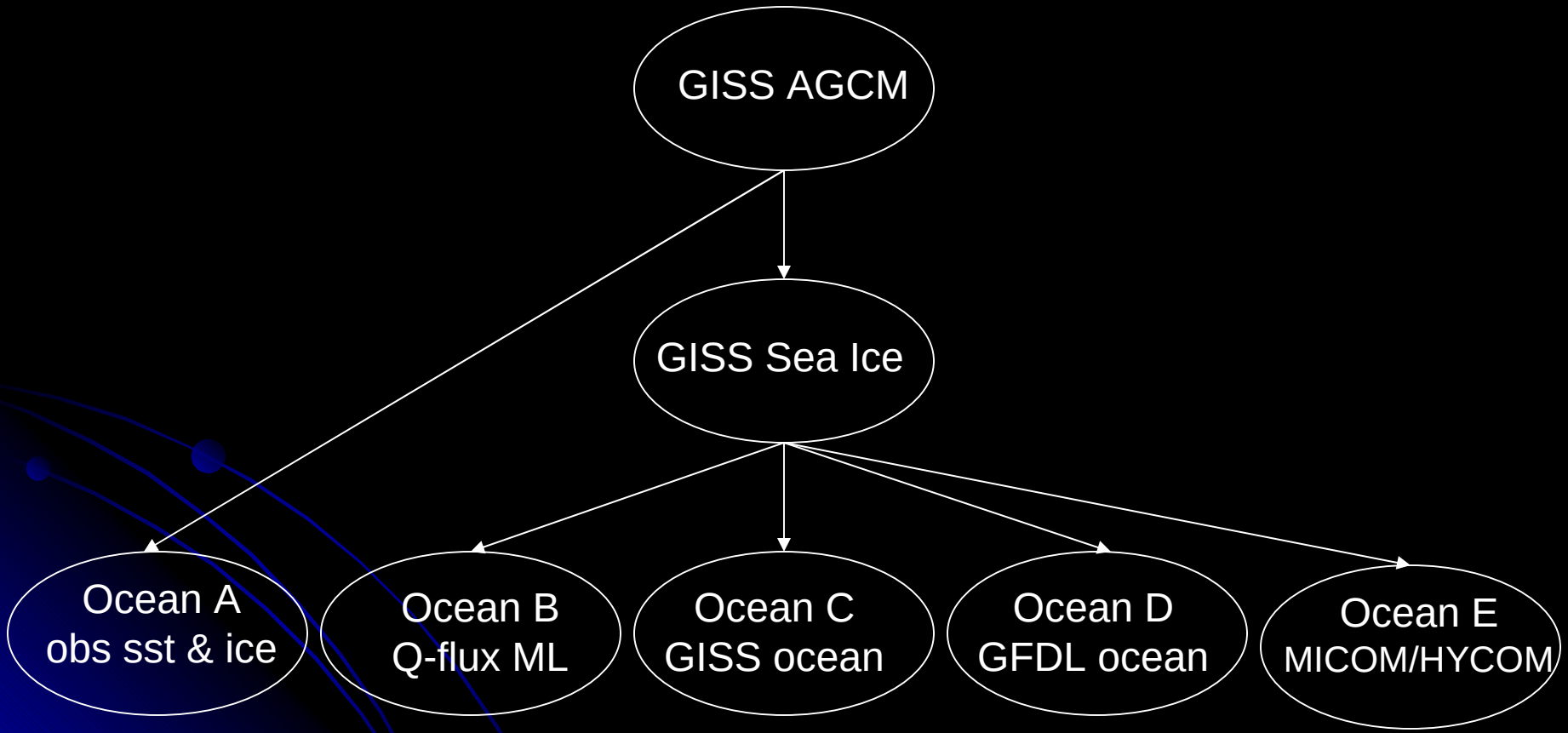
Sun & Bleck 2001; Bleck & Sun 2003; Sun & Hansen 2003

Coupled Model Activities at GISS



Model Setup

- AGCM: GISS SI2000 atmospheric model (*Hansen et al.* 1997; 2002)

  12 layers, 4^{o}x5^{o} resolution
- OGCM: Hybrid version of Miami Isopycnal Coordinate Ocean Model (HYCOM, *Bleck et al*. 1992, *Bleck* 2002)

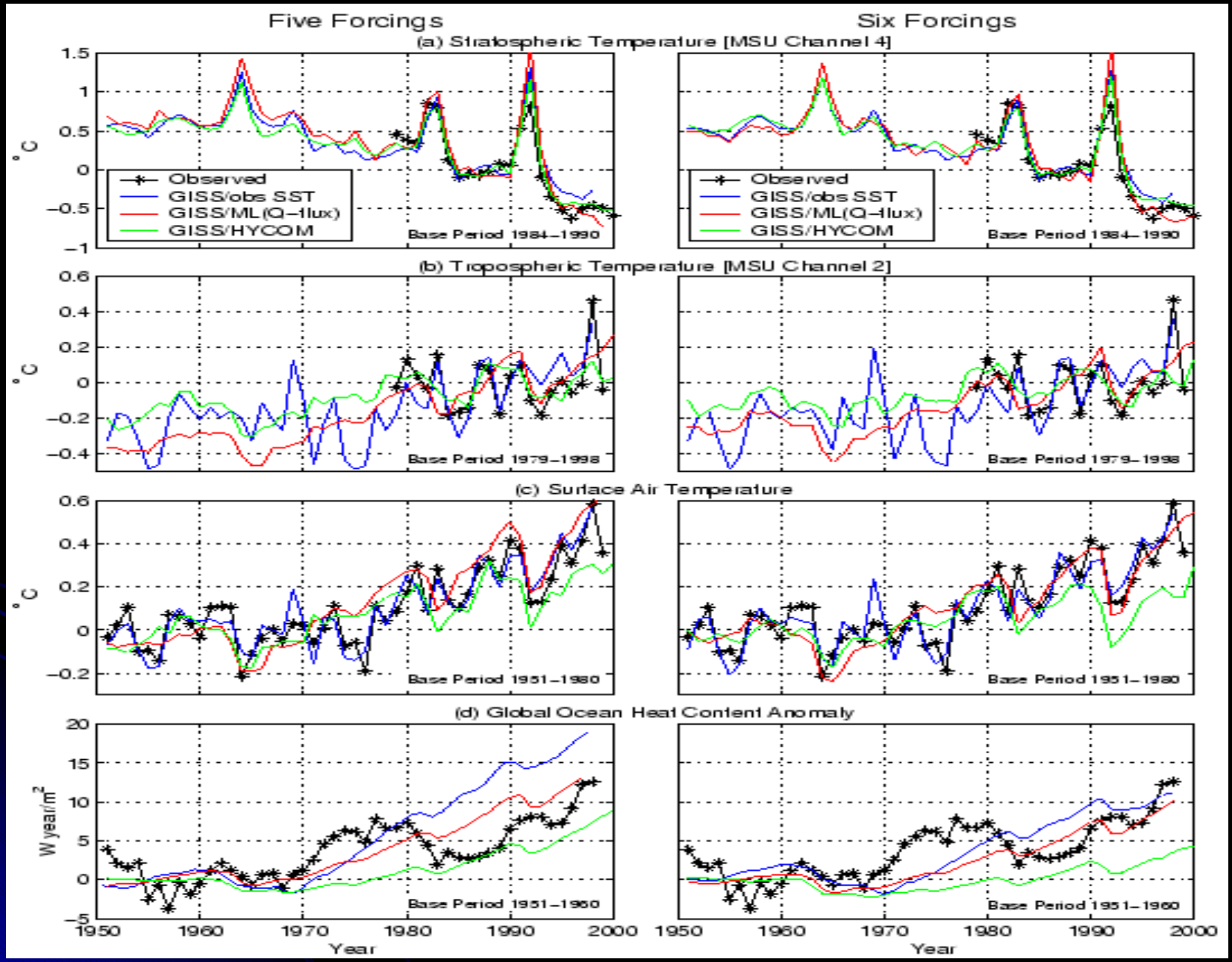
  16 σ_2 layers in the vertical, 2^{o} at Equator
- Sea ice: thermodynamic ice only (*Russell et al*. 2000)

Flux Coupler

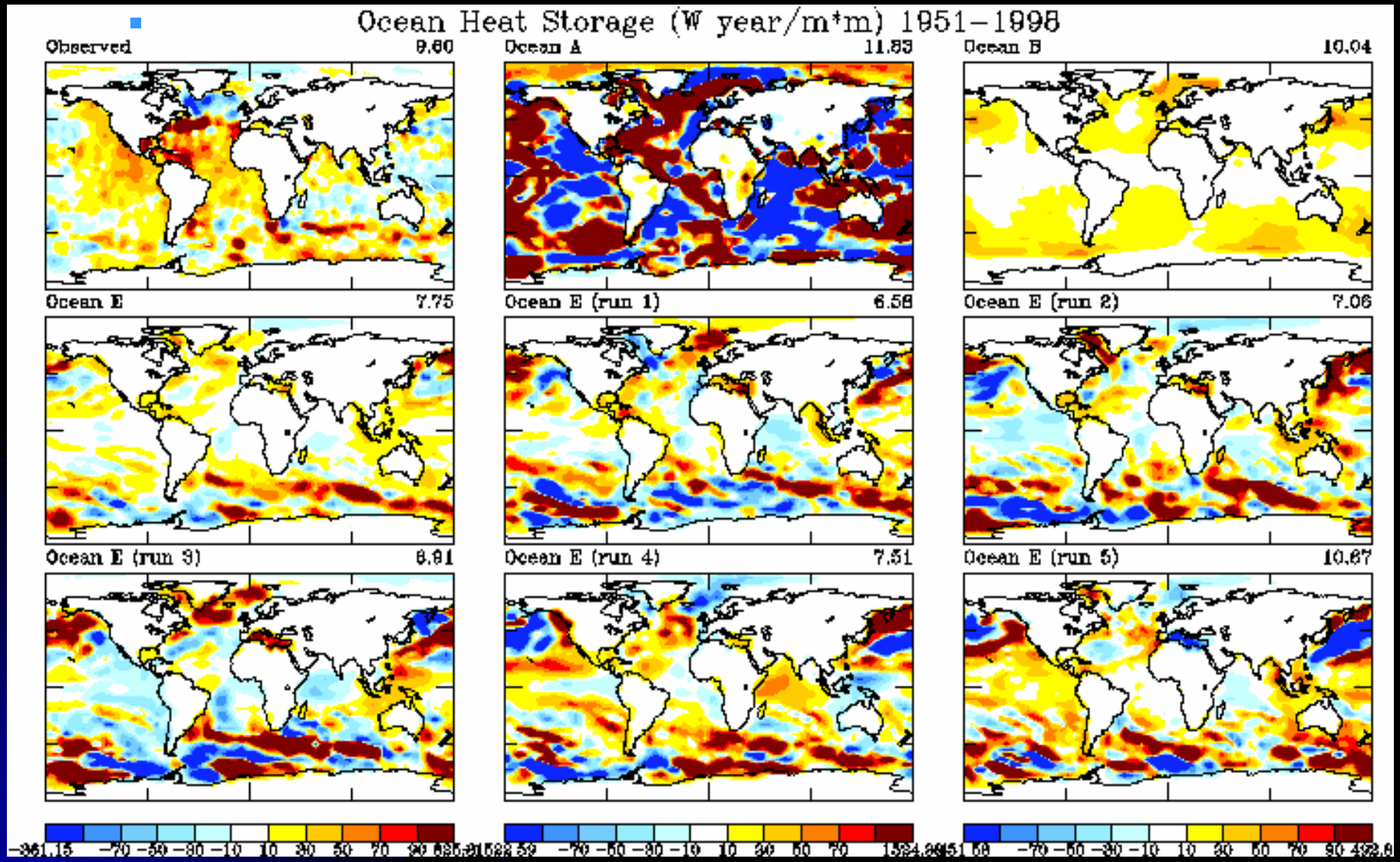
- AGCM passes heat flux, freshwater flux and momentum flux to OGCM
- OGCM (include sea ice) passes sea and ice surface temperature and ice coverage
- Flux integral is conserved during coupling
- No flux correction applied

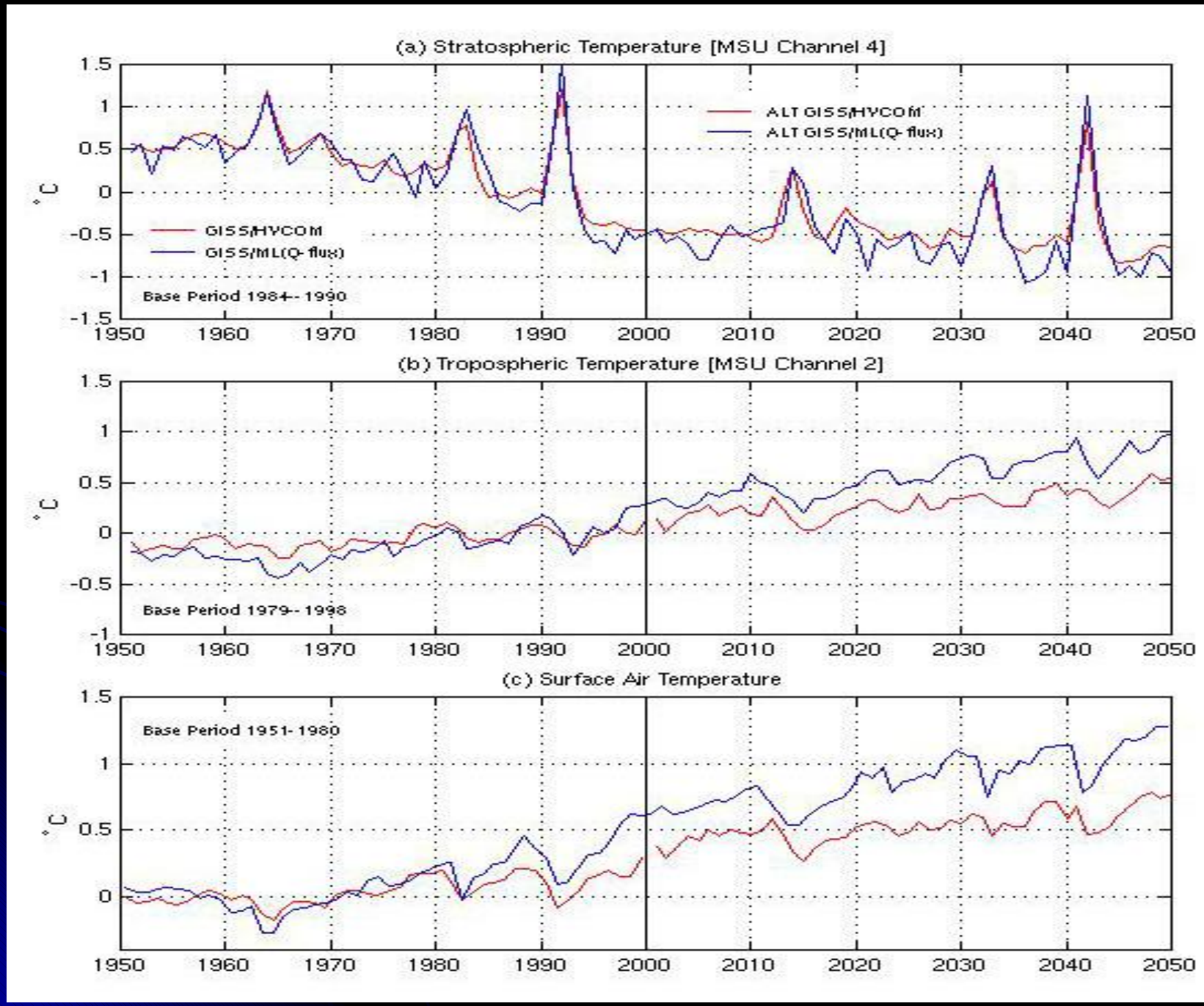
Initial Conditions for the Coupled Model

- AGCM: observed 1950 atmospheric composition
- OGCM: temperature and salinity from observed climatology (Levitus, 1994)
- No spin up

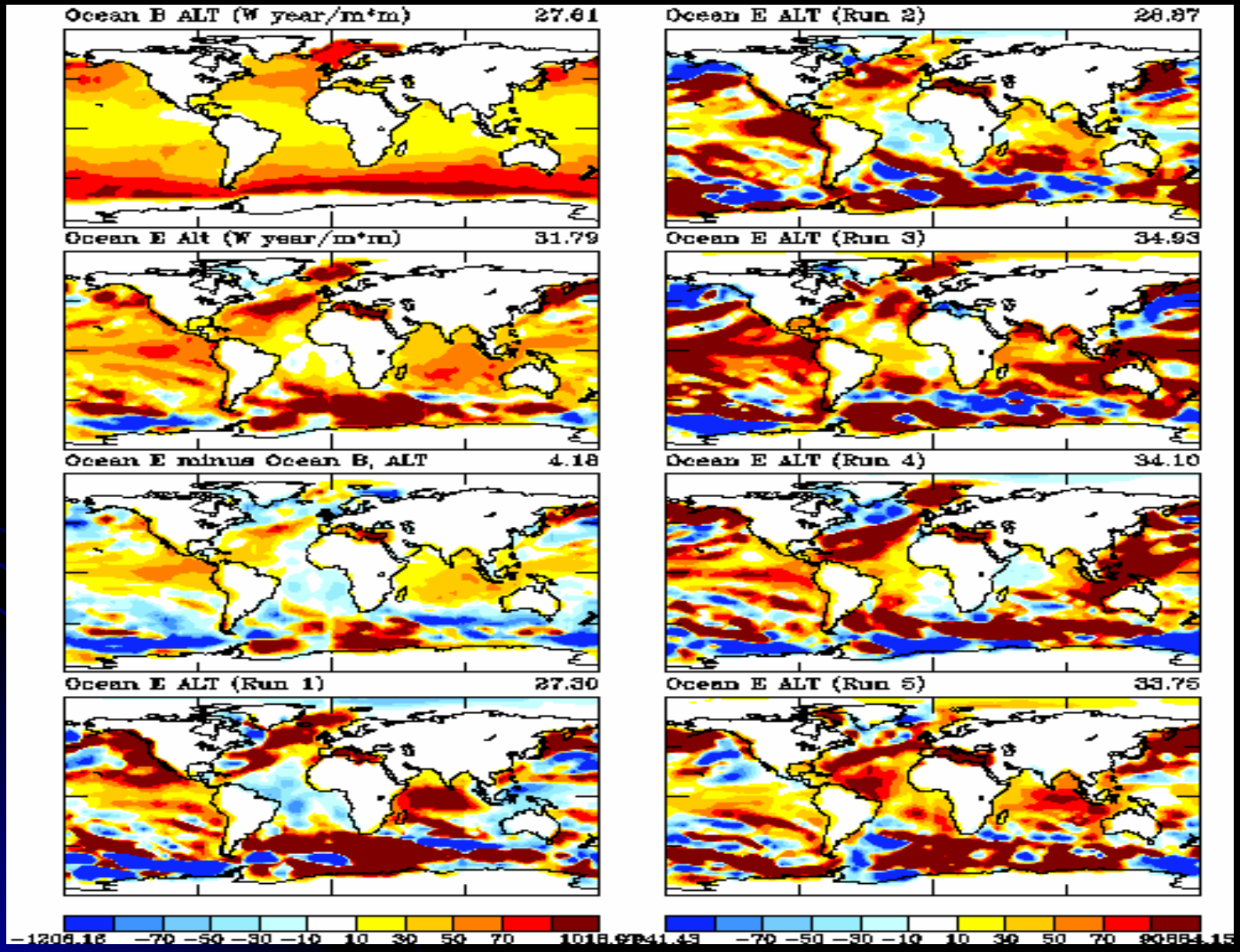

Five Forcings
Six Forcings
(a) Stratospheric Temperature [MSU Channel 4]
(b) Tropospheric Temperature [MSU Channel 2]
(c) Surface Air Temperature
(d) Global Ocean Heat Content Anomaly
°C
W year/m²
Observed
GISS/obs SST
GISS/ML(Q-flux)
GISS/HYCOM
Base Period 1984–1990
Base Period 1979–1998
Base Period 1951–1980
Base Period 1951–1960
Year

Ocean Heat Storage 1951-1998



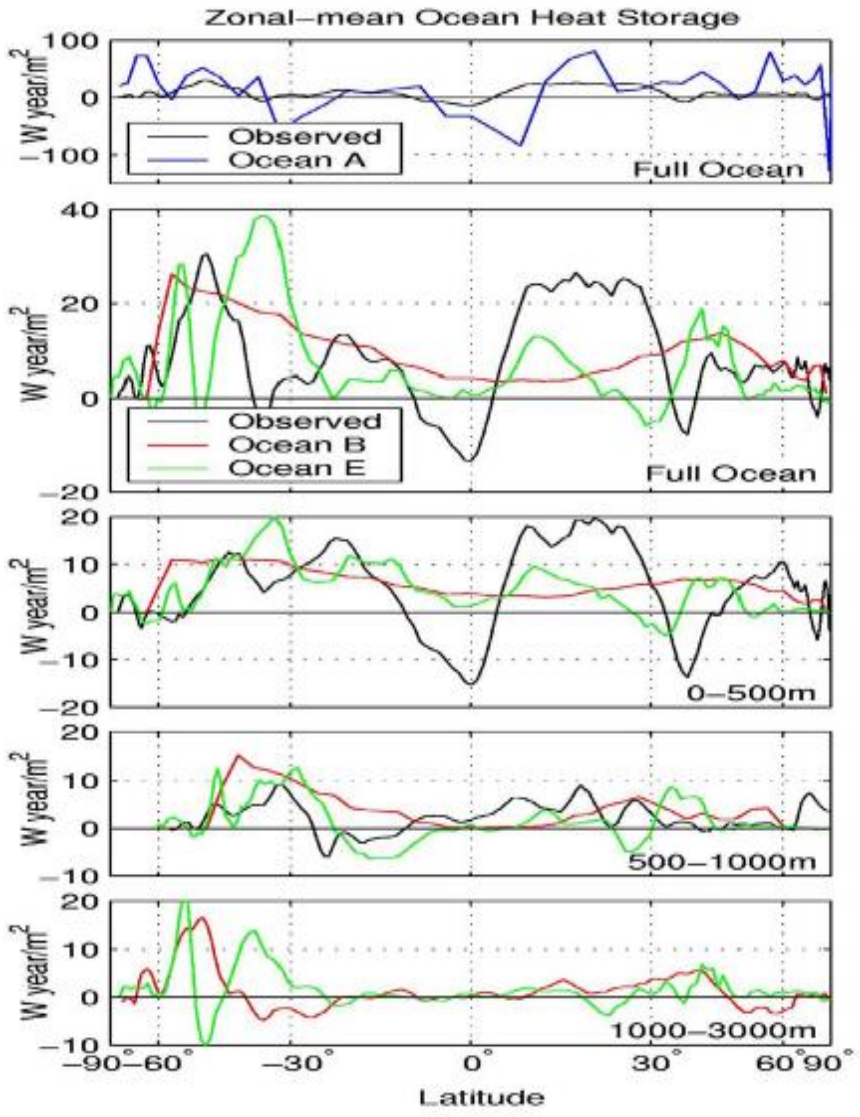

(a) Stratospheric Temperature [MSU Channel 4]
ALT GISS/HYCOM
ALT GISS/ML(Q-flux)
GISS/HYCOM
GISS/ML(Q-flux)
Base Period 1984--1990
°C
(b) Tropospheric Temperature [MSU Channel 2]
Base Period 1979--1998
°C
(c) Surface Air Temperature
Base Period 1951-1980
°C
1.5
1
0.5
0
-0.5
-1
-1.5
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050

Ocean Heat Storage 2000-2050 (ALT)

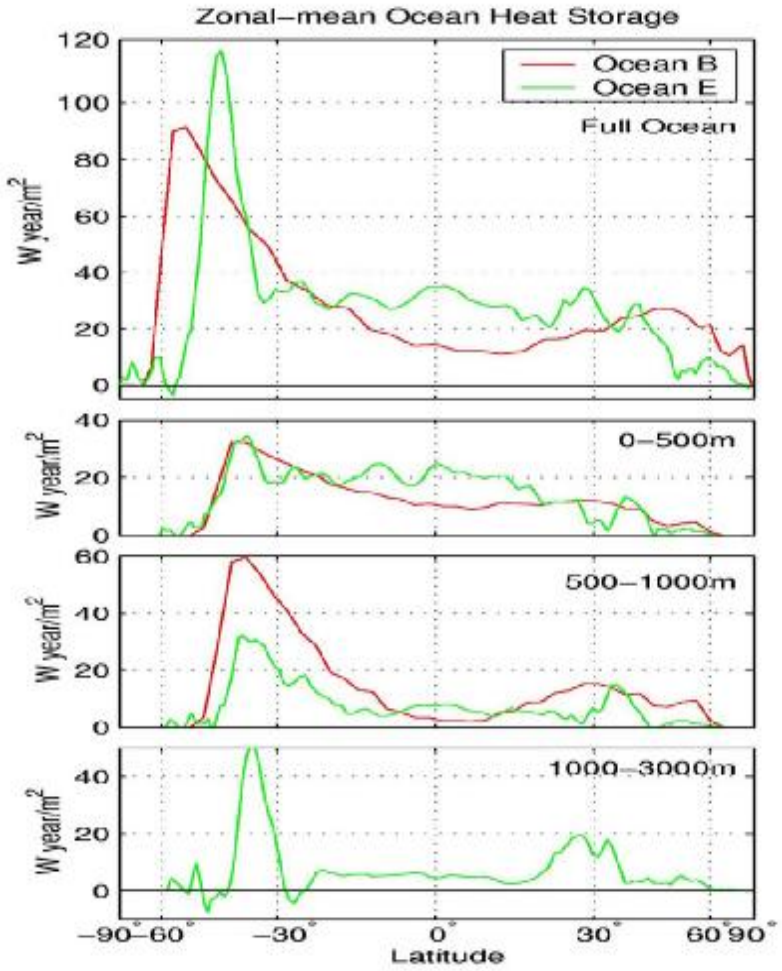


Zonal-mean Ocean Heat Storage

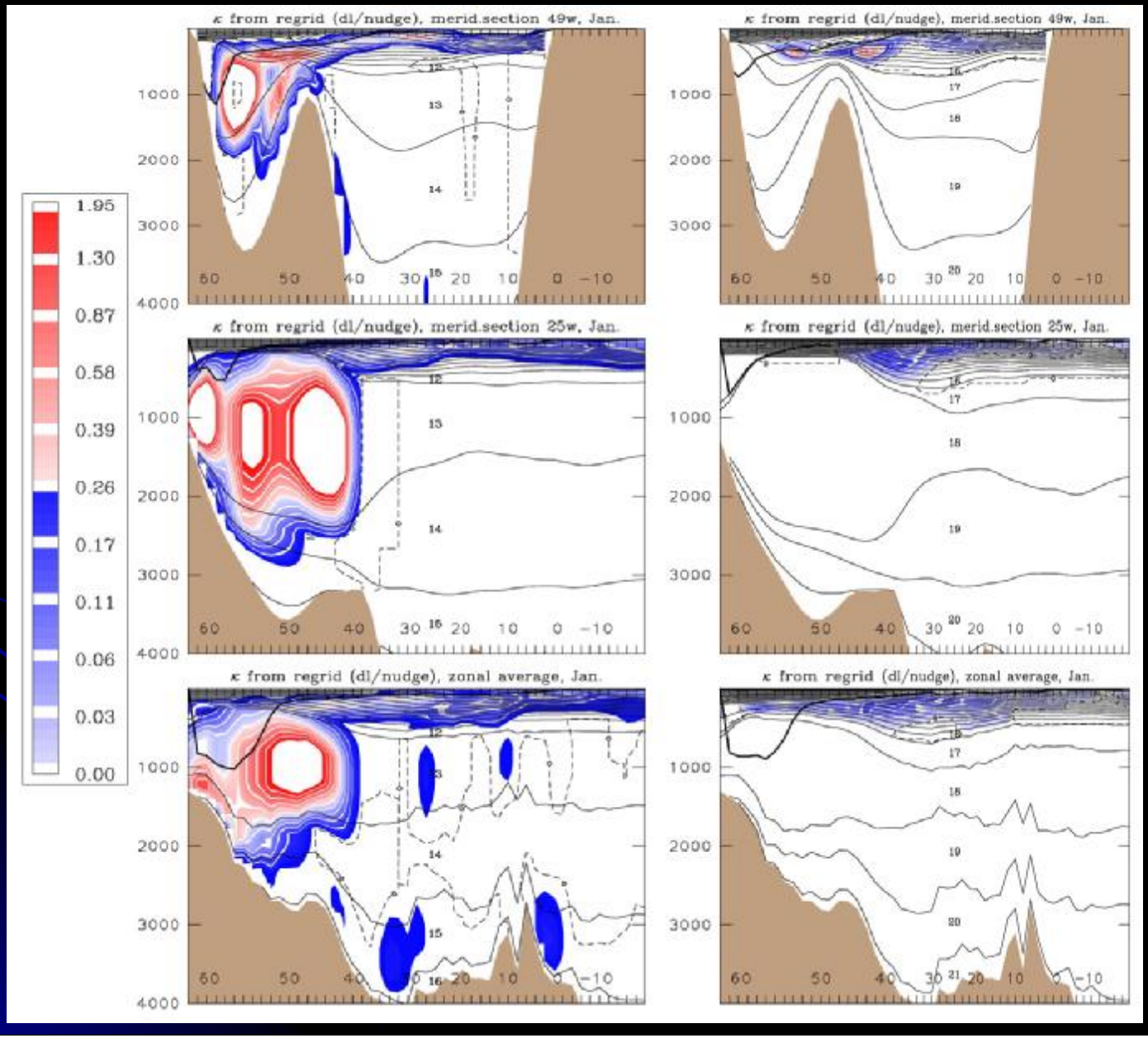
1951 - 1998



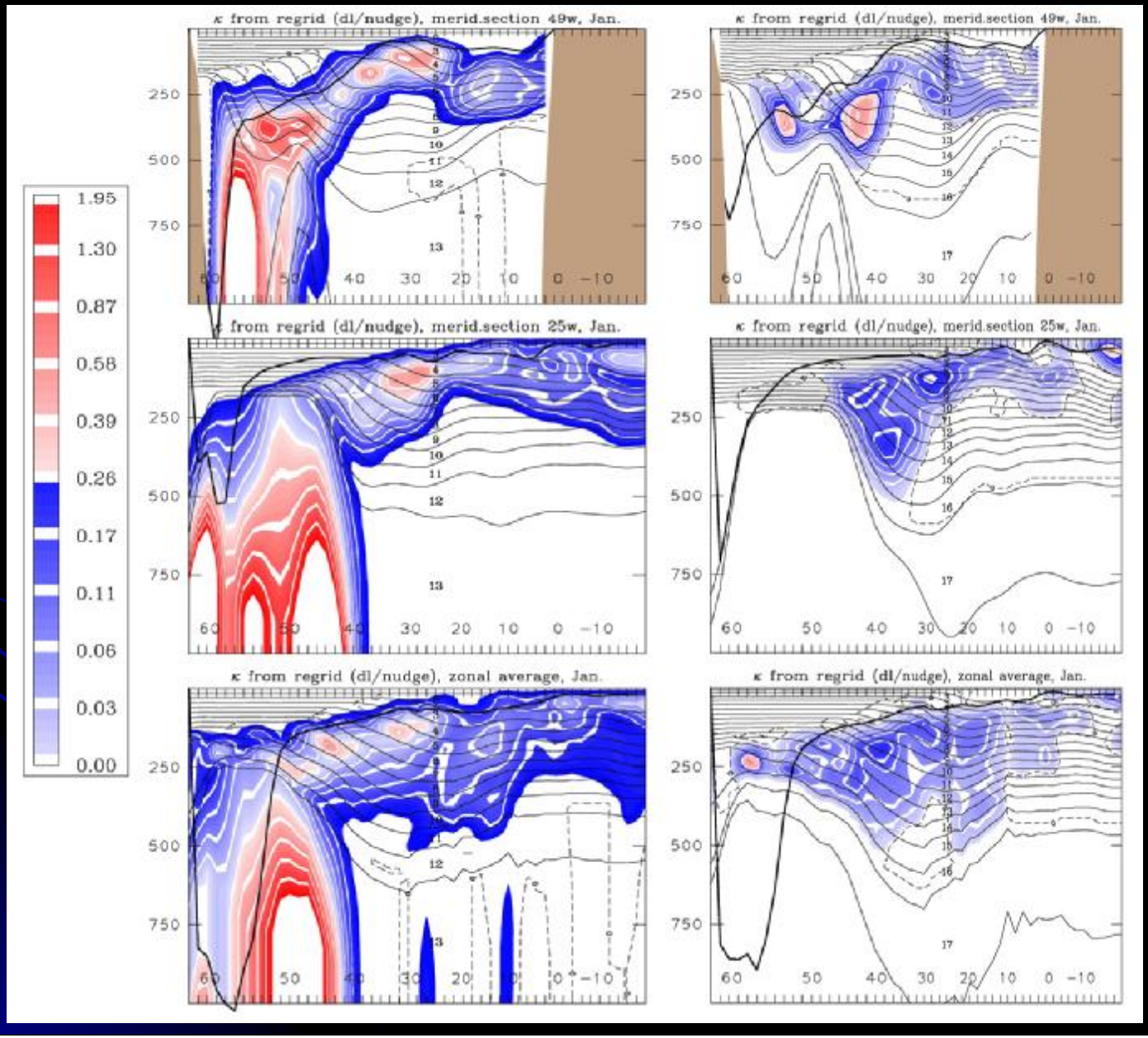
2000 - 2050



Spurious Diapycnal Mixing in HYCOM



Spurious Diapycnal Mixing in HYCOM



Summary

- Coupled GISS/HYCOM model is able to reproduce many observed features, including deep water formation
- Atlantic thermohaline circulation appears to be stable during global warming
- There is more ocean heat storage and less surface warming in ocean E than in ocean B
- Spurious diapycnal diffusion in HYCOM is small with increased vertical resolution