Ocean Climate Simulations with CCSM3/HYCOM

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Outline

1. *Background*

2. *Model configuration and CORE forcing*

3. *Results and model intercomparison*

4. *Conclusion and future work*

Background

1. Systematically investigate the performance of the ocean model with hybrid vertical coordinate (HYCOM) in the climate model (CCSM)

2. As the first step, test the ocean-only or coupled ocean-ice model in the CCSM modeling system using the atmospheric forcing from the Coordinated Ocean-ice Reference Experiment (CORE)

3. Compare CCSM3/HYCOM with CCSM3/POP and other ocean/climate models

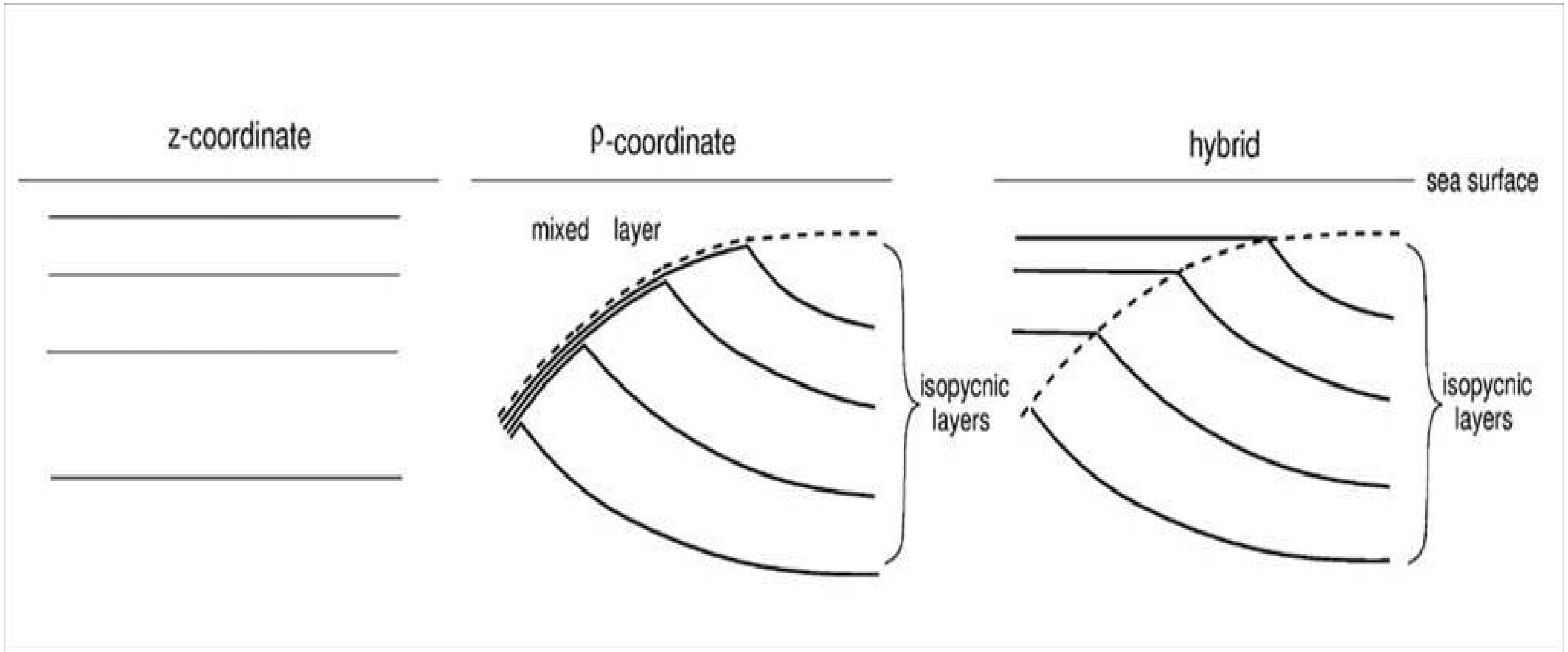
HYCOM Configuration

Configuration: NCAR's gx1v3 grid; 32 hybrid layers, sigma-2; integrated with the CCSM3 coupler version 6, http://www.hycom.org for details

Parallelization: MPI, scale well up to 120 PEs

Initialization: January of the Poles Hydrographic Climatology, resting

Model speed: with 90 PEs of Blueice, 8-10 years/day



Coordinated Ocean-ice Reference Experiment

Atmospheric data: Large and Yeager, 2004

short-wave radiation, long-wave radiation, wind stress, wind speed, surface air temperature, relative humidity, precipitation, runoff

Thermal Forcing: bulk formula

Salinity Forcing:

(1) P-E+R

(2) P-E+R + weak relaxation to climatological SSS (50m/4year)

(3) P-E+R + strong relaxation to climatological SSS (50m/300 days)

Model Integrations

Sponsored by the Breakthrough Science Computation

Model Runs	CCSM/HYCOM	CCSM/POP
Ocean-only without salinity restoring	√ 150	√
Ocean-only with weak salinity restoring (50 m/4 years)	√ 150	
Ocean-only with strong salinity restoring (50 m/300 days)	√ 150	
Coupled ocean-ice without salinity restoring	√ 150	√
Coupled ocean-ice with weak salinity restoring (50 m/4 years)	√ 500	√
Coupled ocean-ice with strong salinity restoring (50 m/300 days)	√ 150	

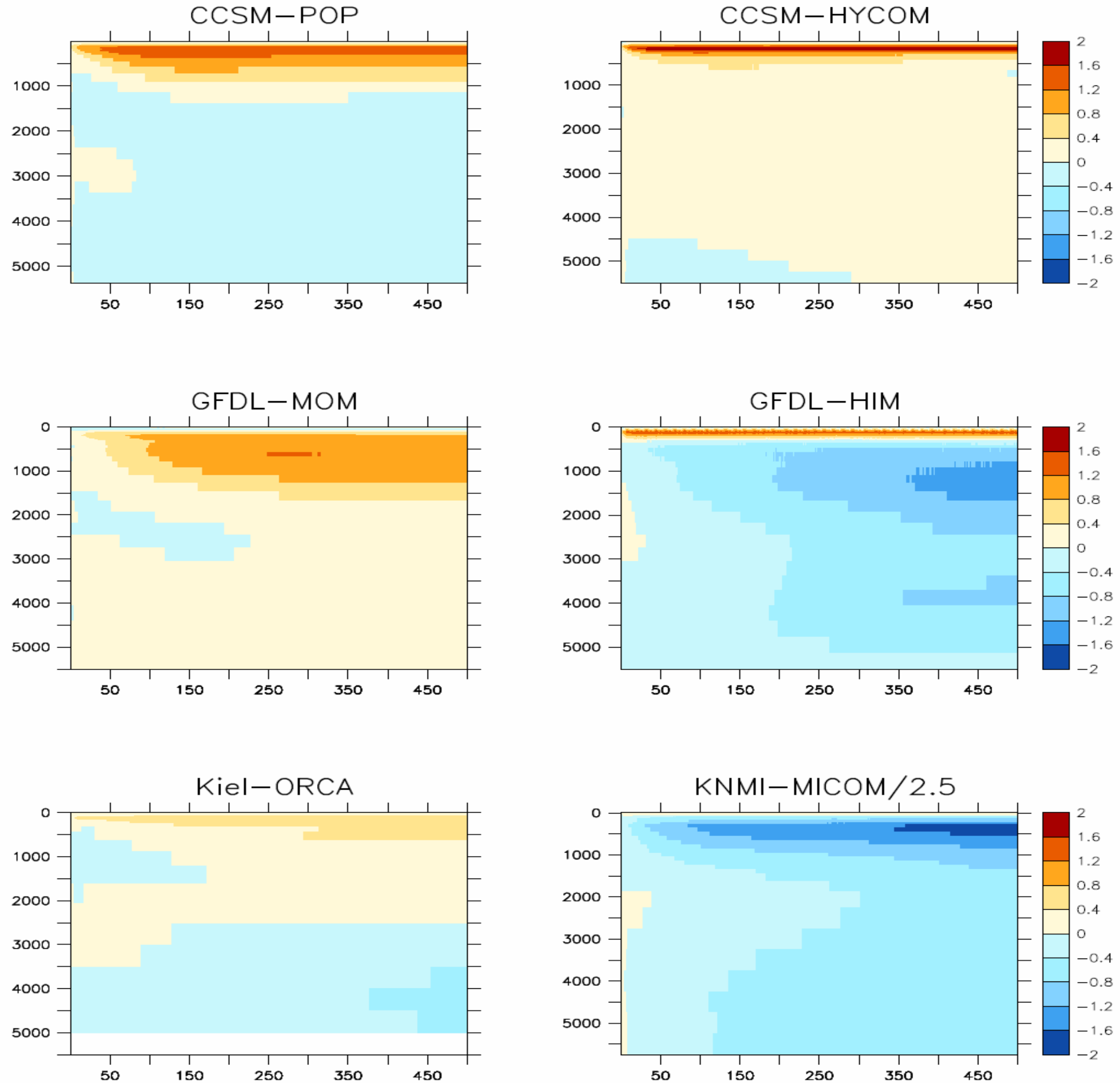
Evolution of Global Mean Ocean Temperature

CCSM/HYCOM

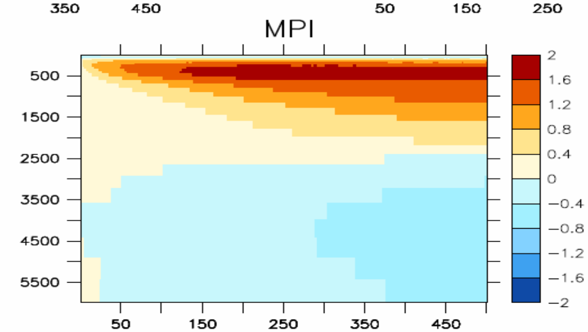
2 ^oC bias at subsurface layer

The mixed layer is too deep in equatorial Pacific

The bias in the ocean interior is small



Courtesy Stephen Griffies

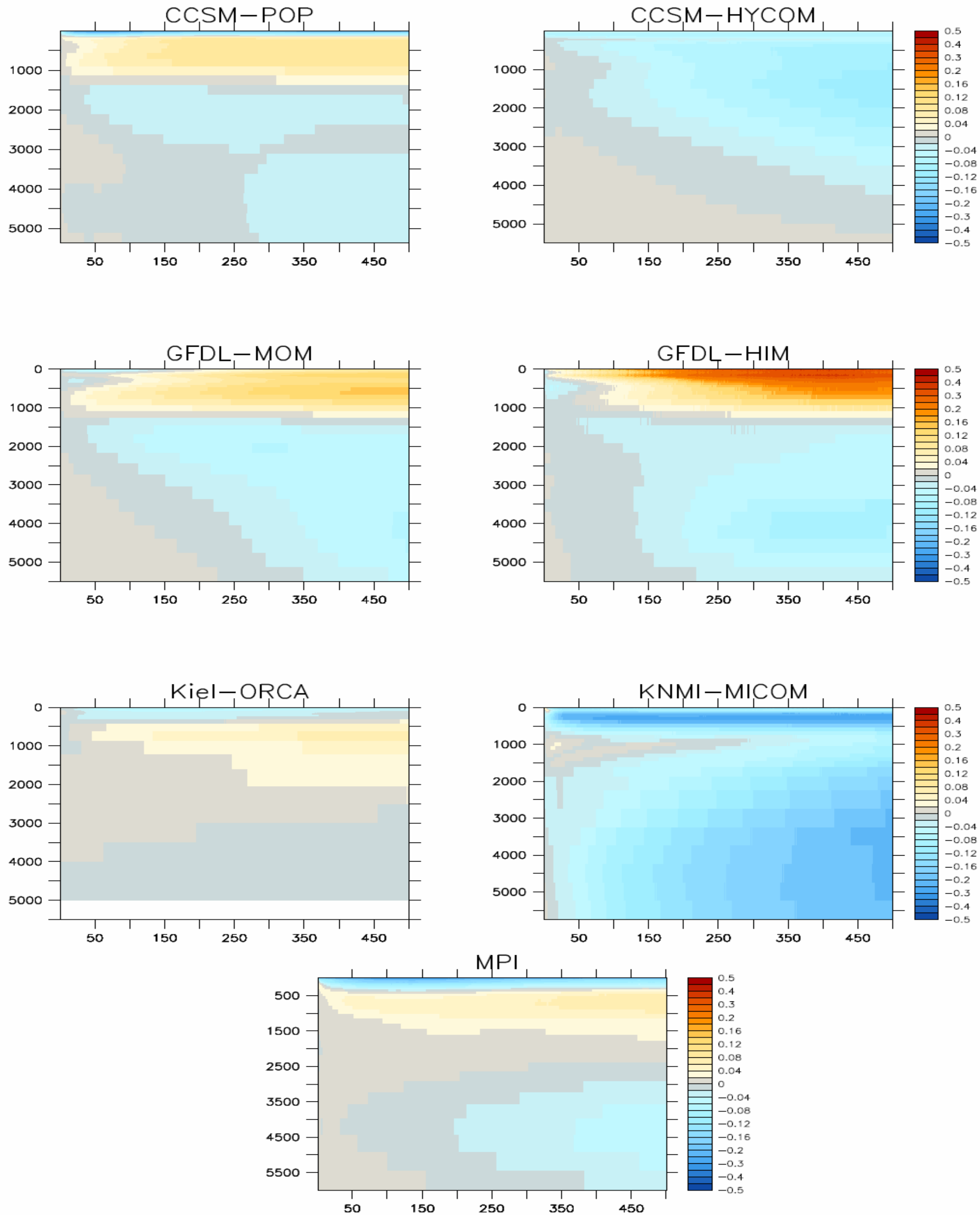


Evolution of Global Mean Ocean Salinity

CCSM/HYCOM

The ocean salinity drift is quite small due to the salinity restoring

An overall freshening trend



The SST Biases at Year 491-500

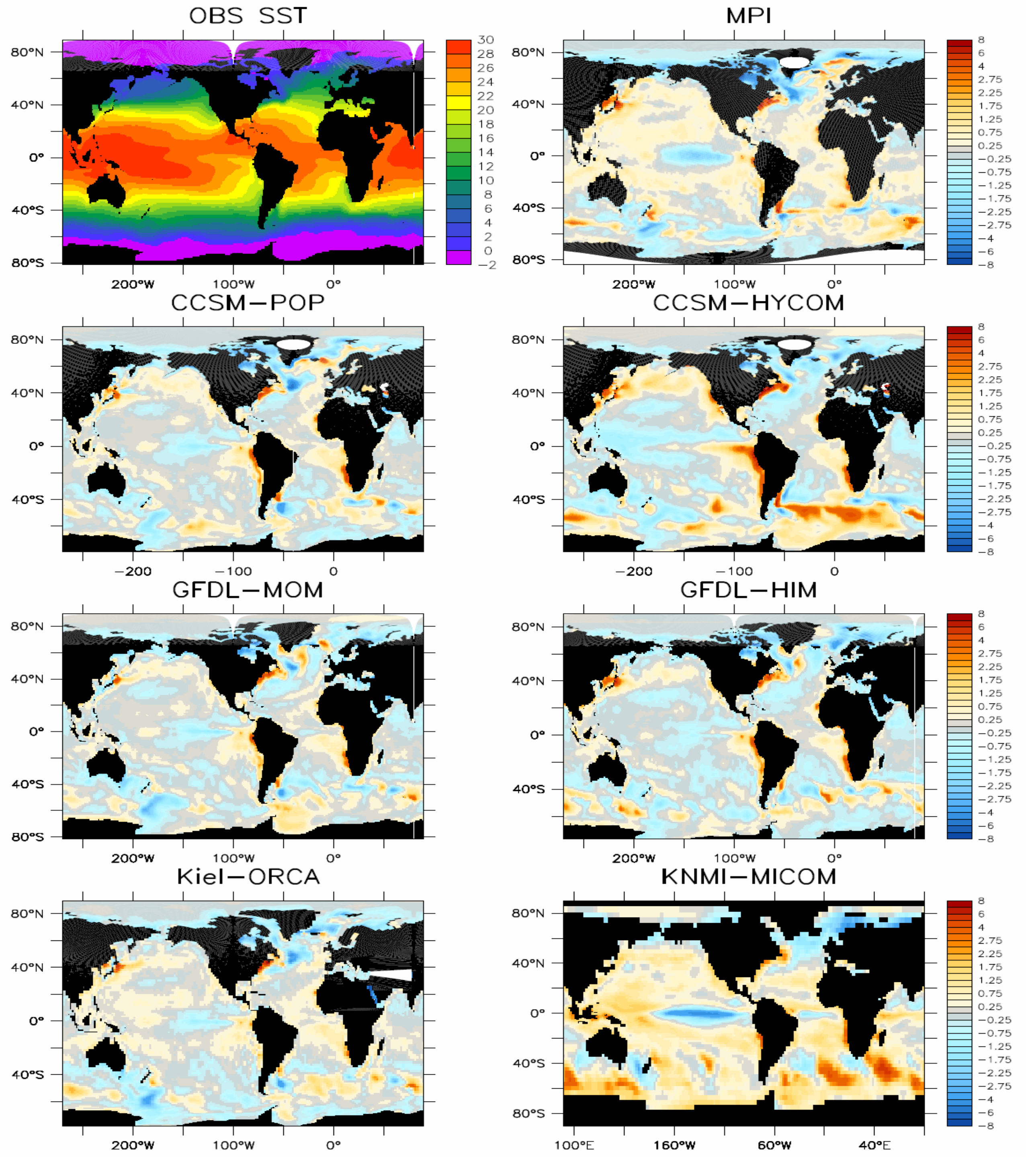
CCSM/HYCOM

Relatively large biases at

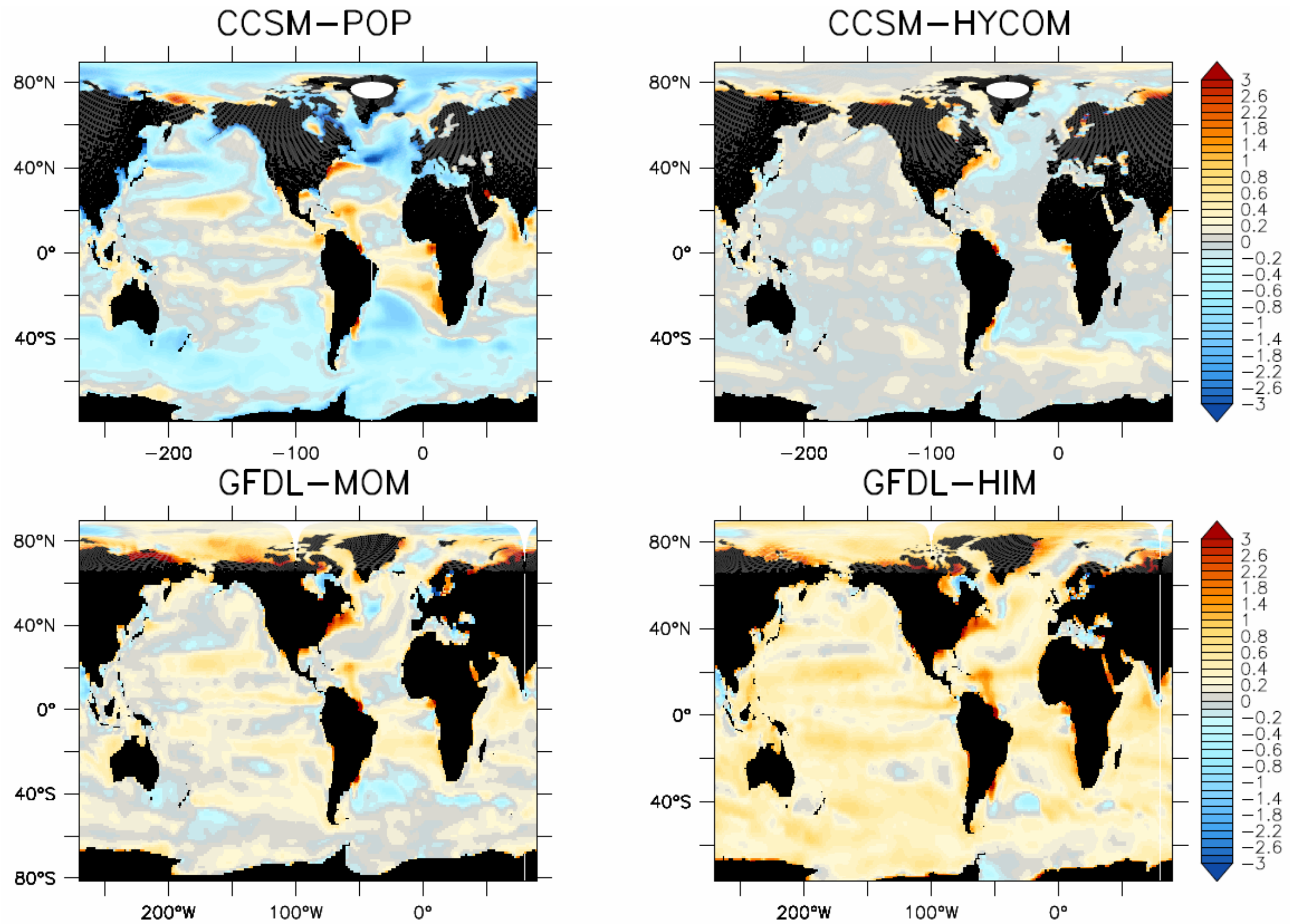
(1) the coastal regions

(2) eastern equatorial Pacific

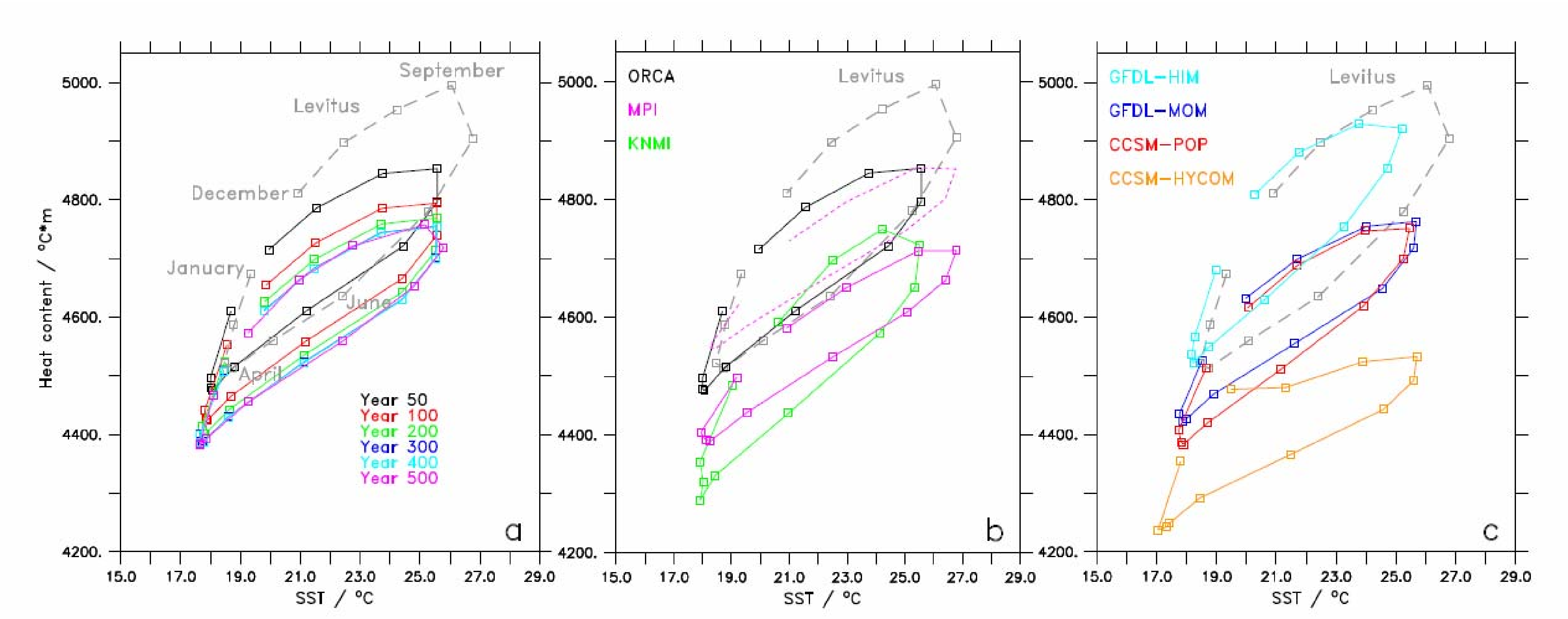
(3) Gulf Stream region



The SSS Biases at Year 491-500



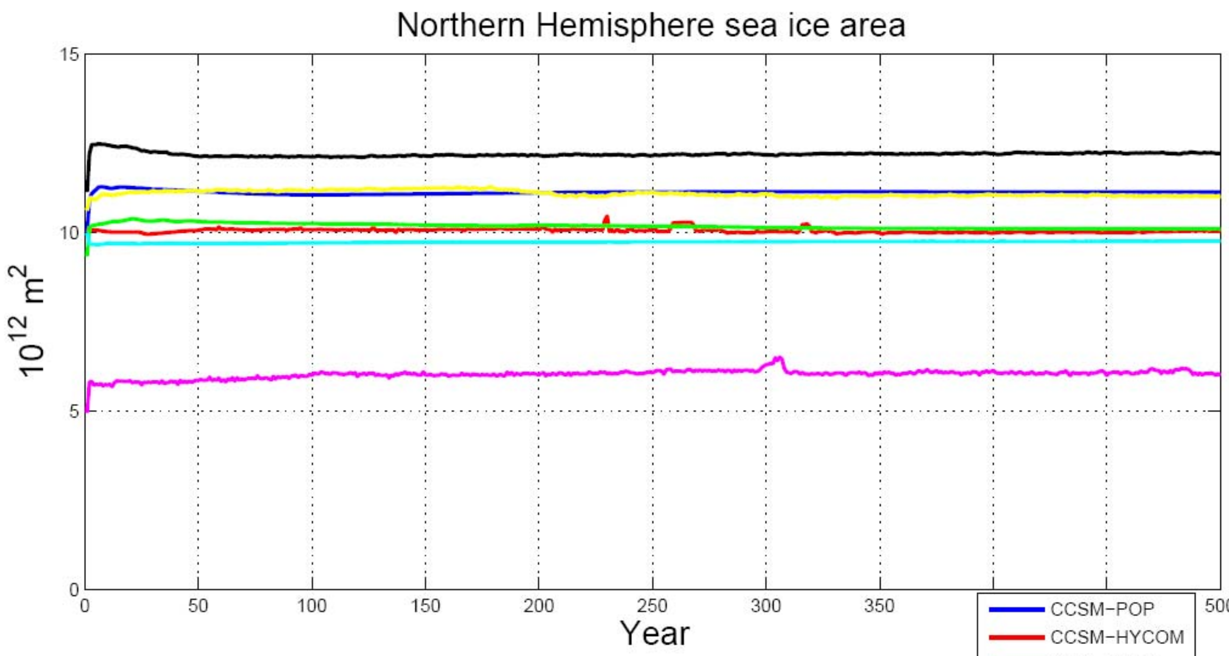
The SST vs Heat Content over the upper 250 m (48W, 35N)



CCSM/HYCOM

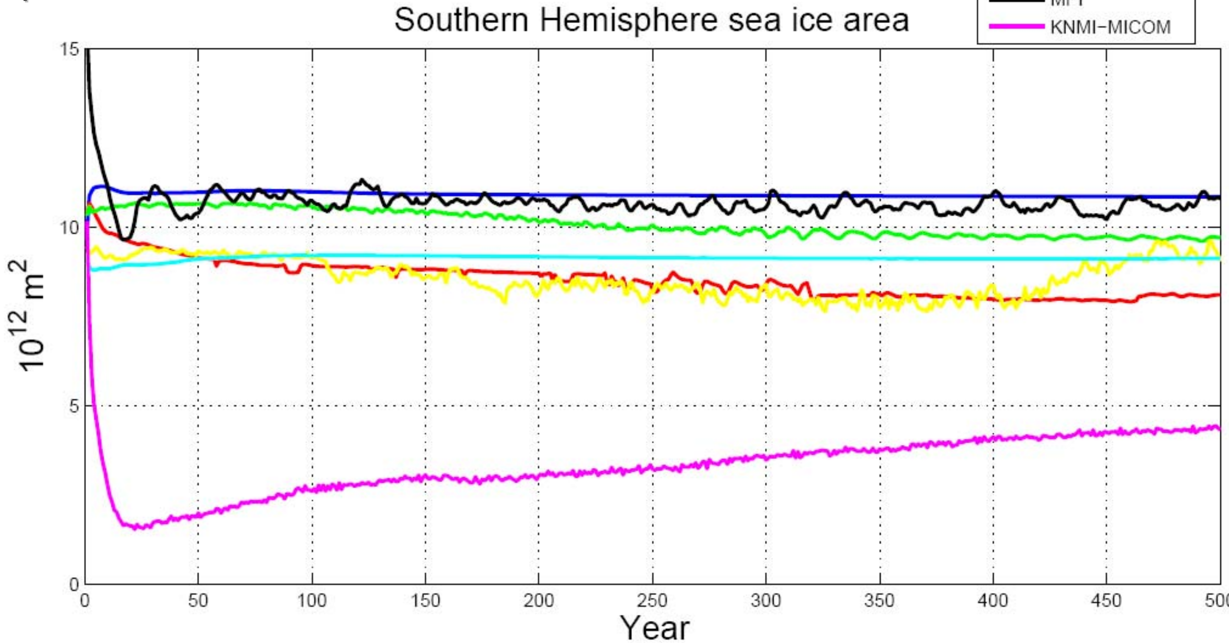
The heat content has not equilibrated yet at Year 50 and shows an increase trend with time

Annual Mean Sea Ice Area

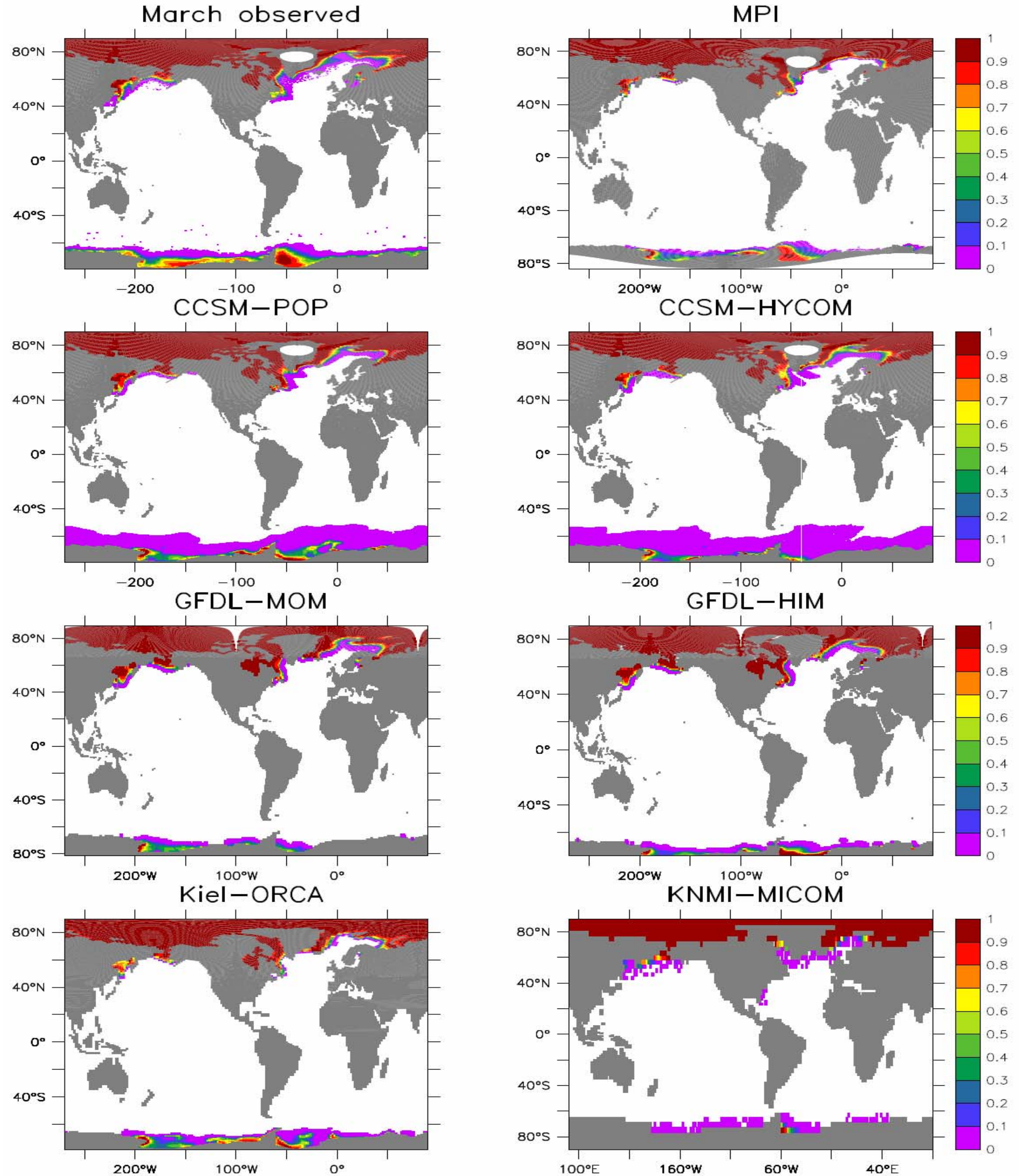


Stable in Northern Hemisphere

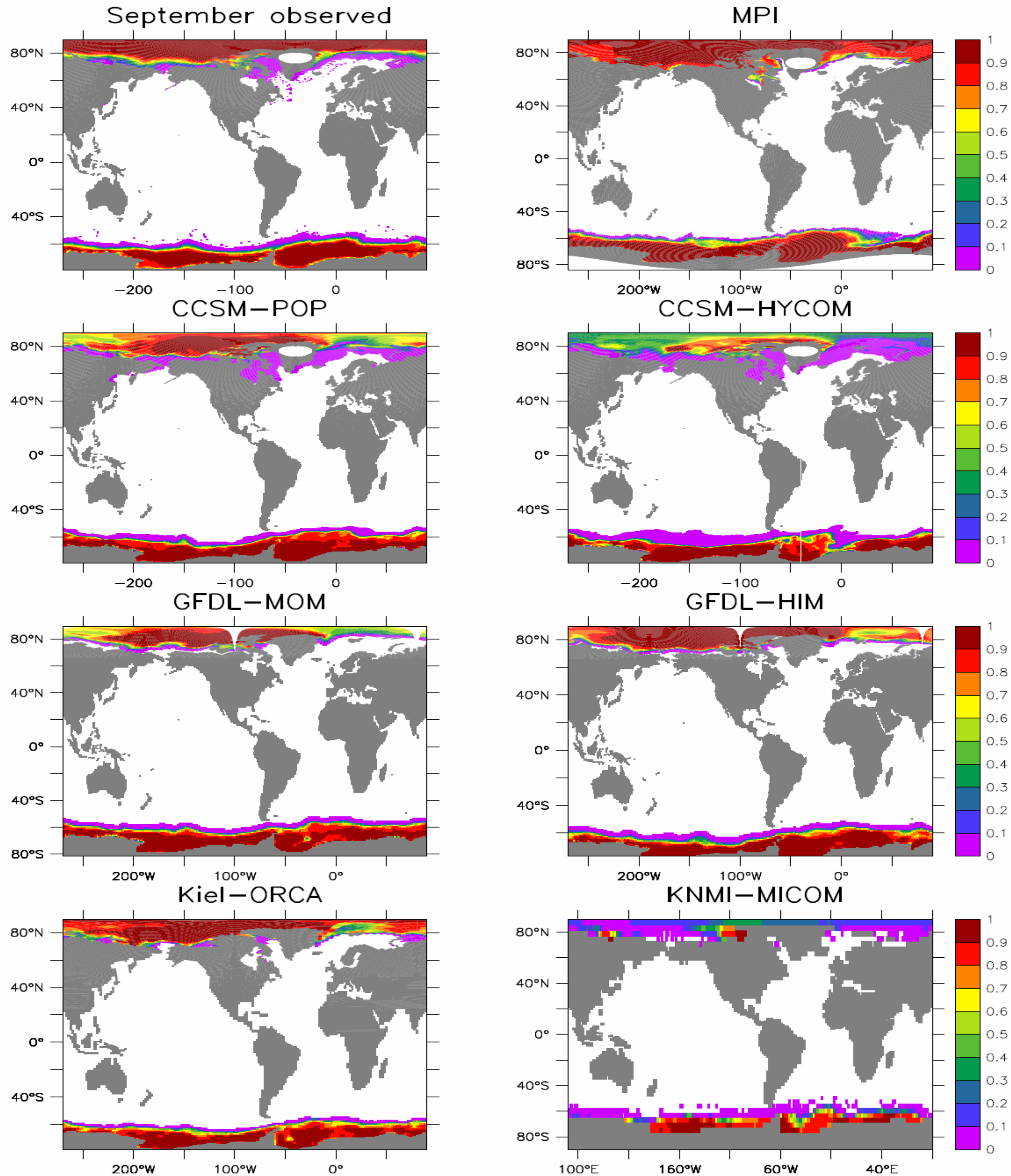
Decrease trend in Southern Hemisphere



March Sea Ice Area Y491-500



September Sea Ice Area Y491-500

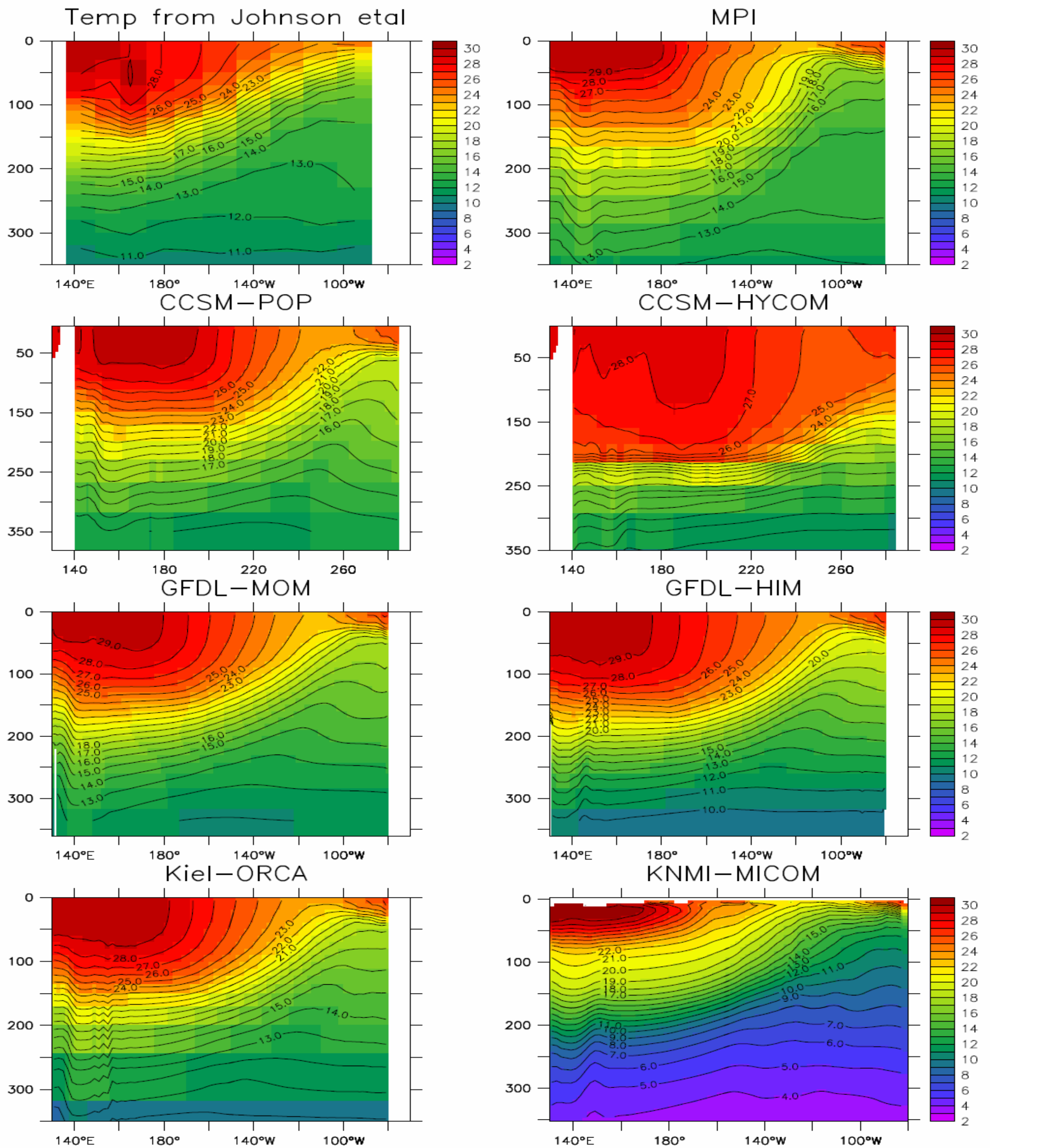


Ocean Temp at Equator Y491-500

CCSM/HYCOM

The mixed layer and thermocline is too deep

The investigation of the reason is under way

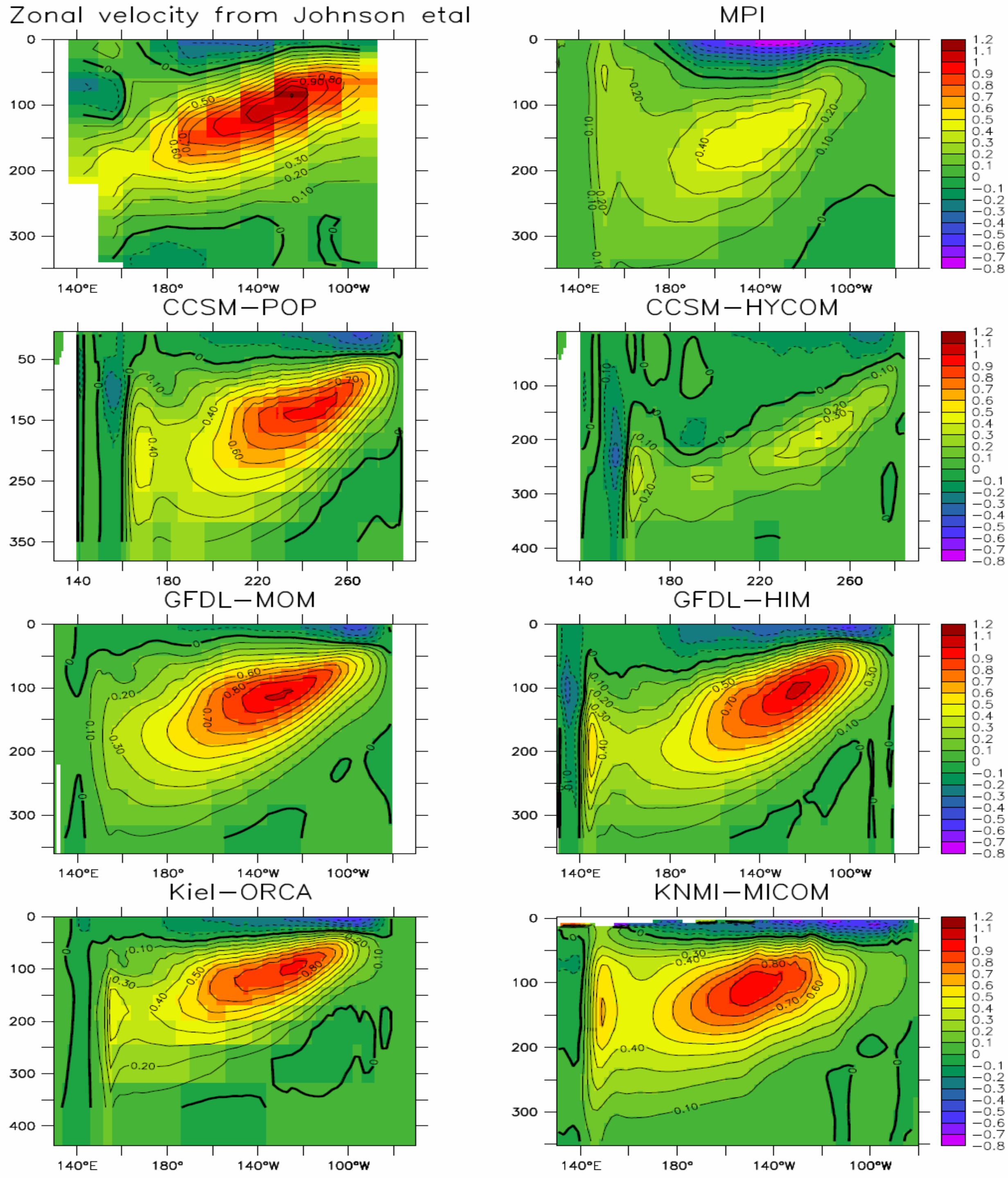


Zonal Velocity at Equator Y491-500

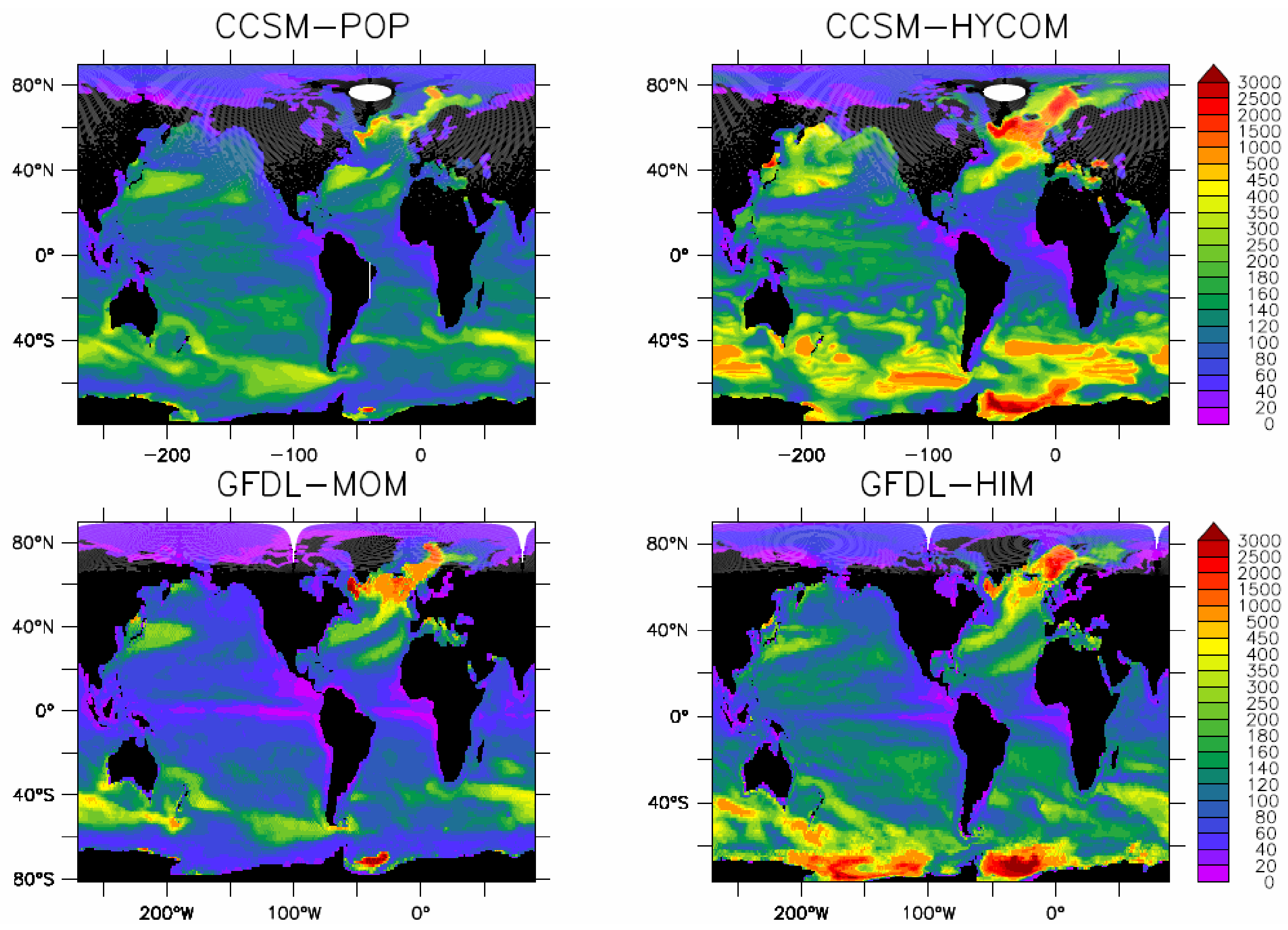
CCSM/HYCOM

The EUC is too weak

The investigation of the reason is under way



Maximum Mixed Layer Depth (Y491-500)



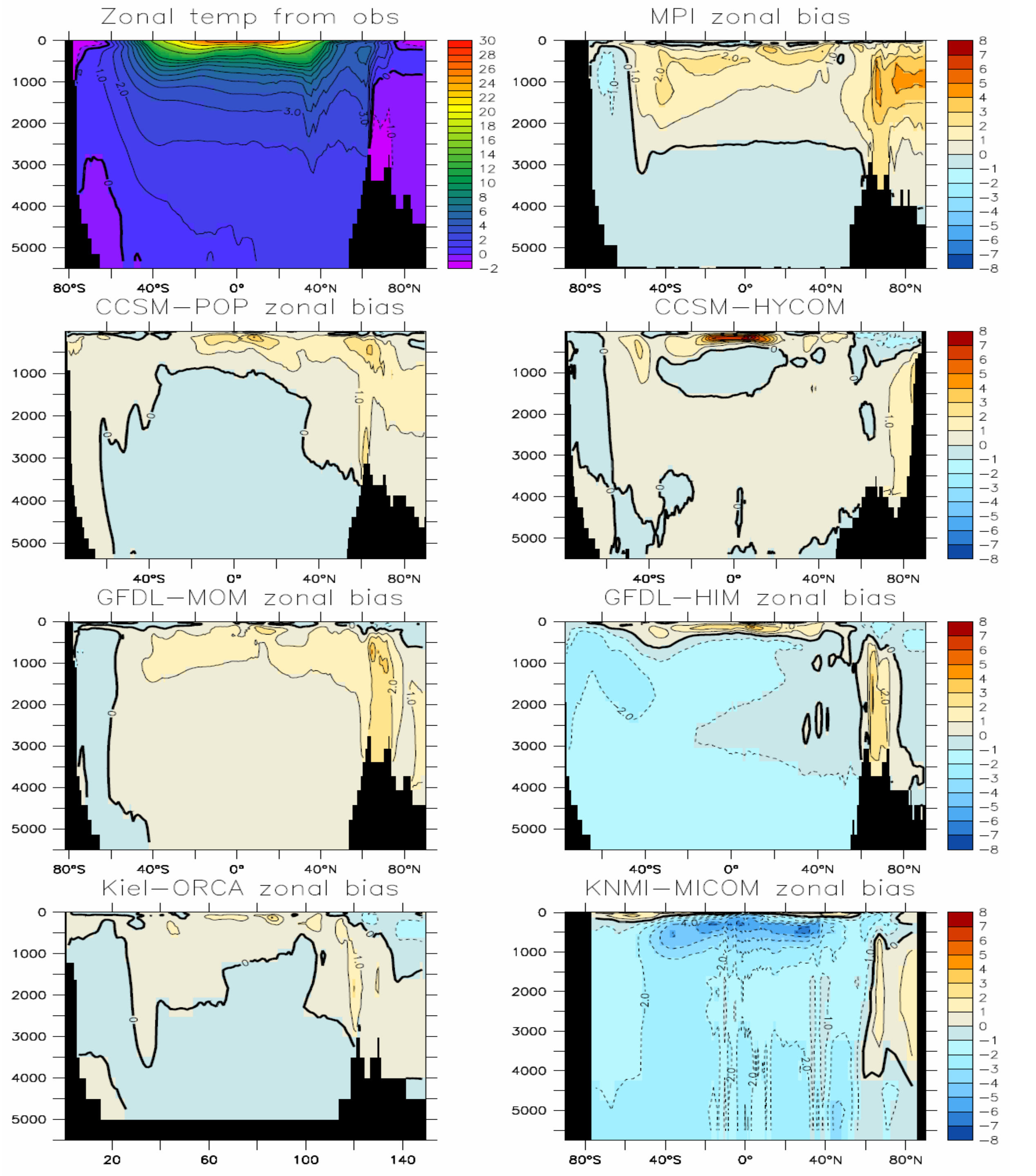
The Biases of the Zonal Mean Temperature Y491-500

CCSM/HYCOM

Large at subsurface layer in tropics

Associated with the weak EUC and deep thermocline in Pacific

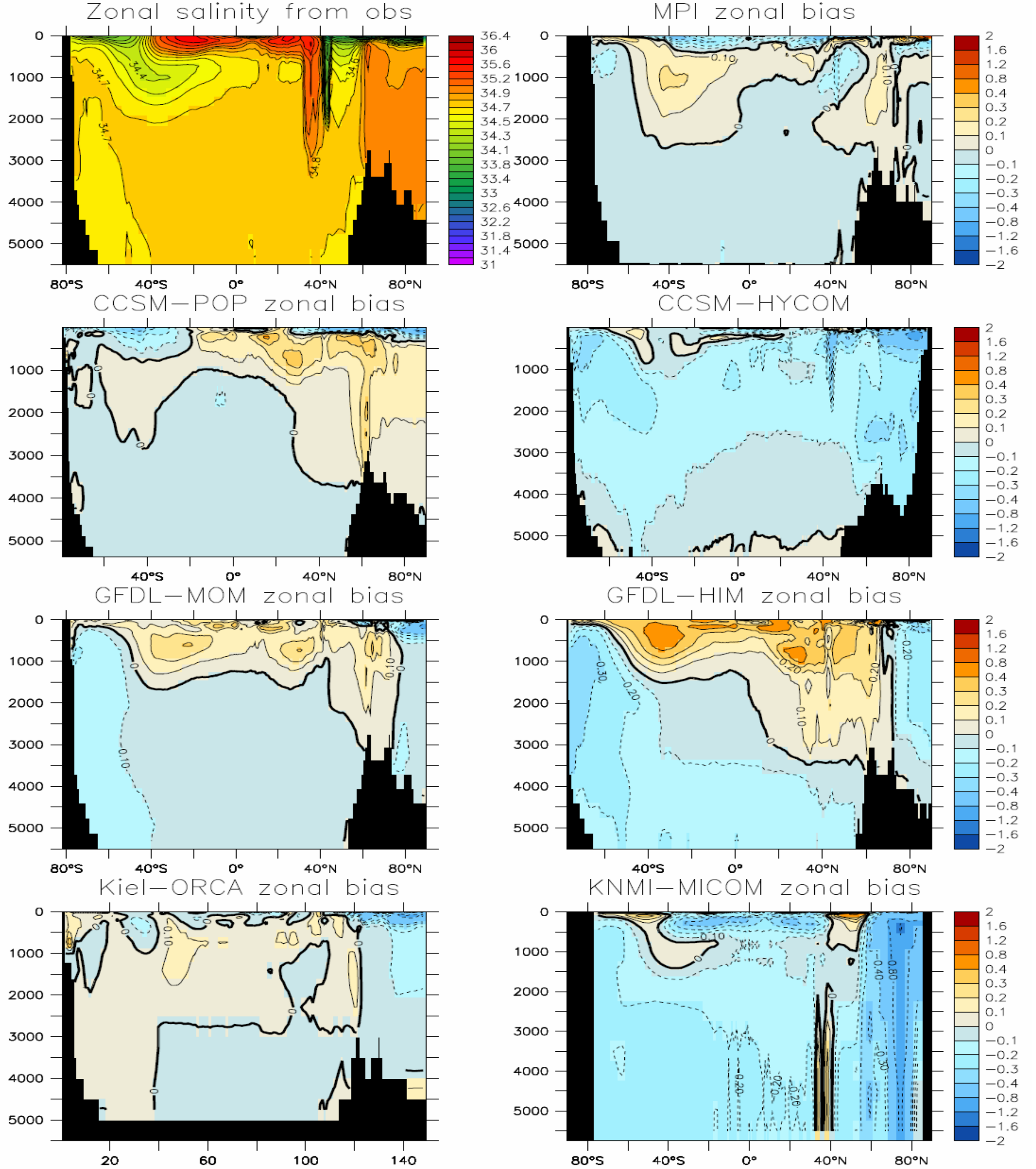
Small in ocean interior



The Biases of the Zonal Mean Salinity Y491-500

CCSM/HYCOM

Relatively small in comparison with other models

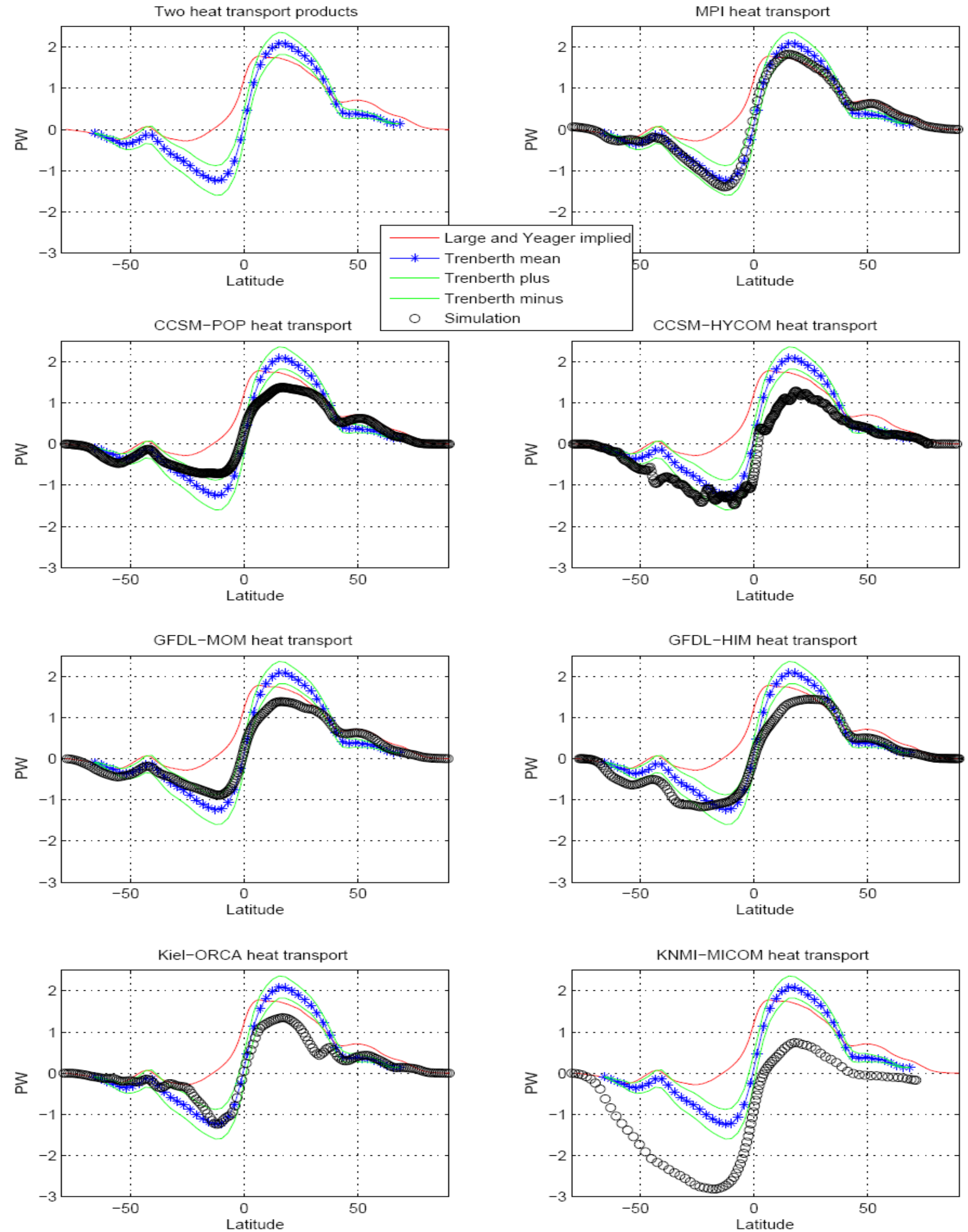


Poleward Heat Transport Y491-500

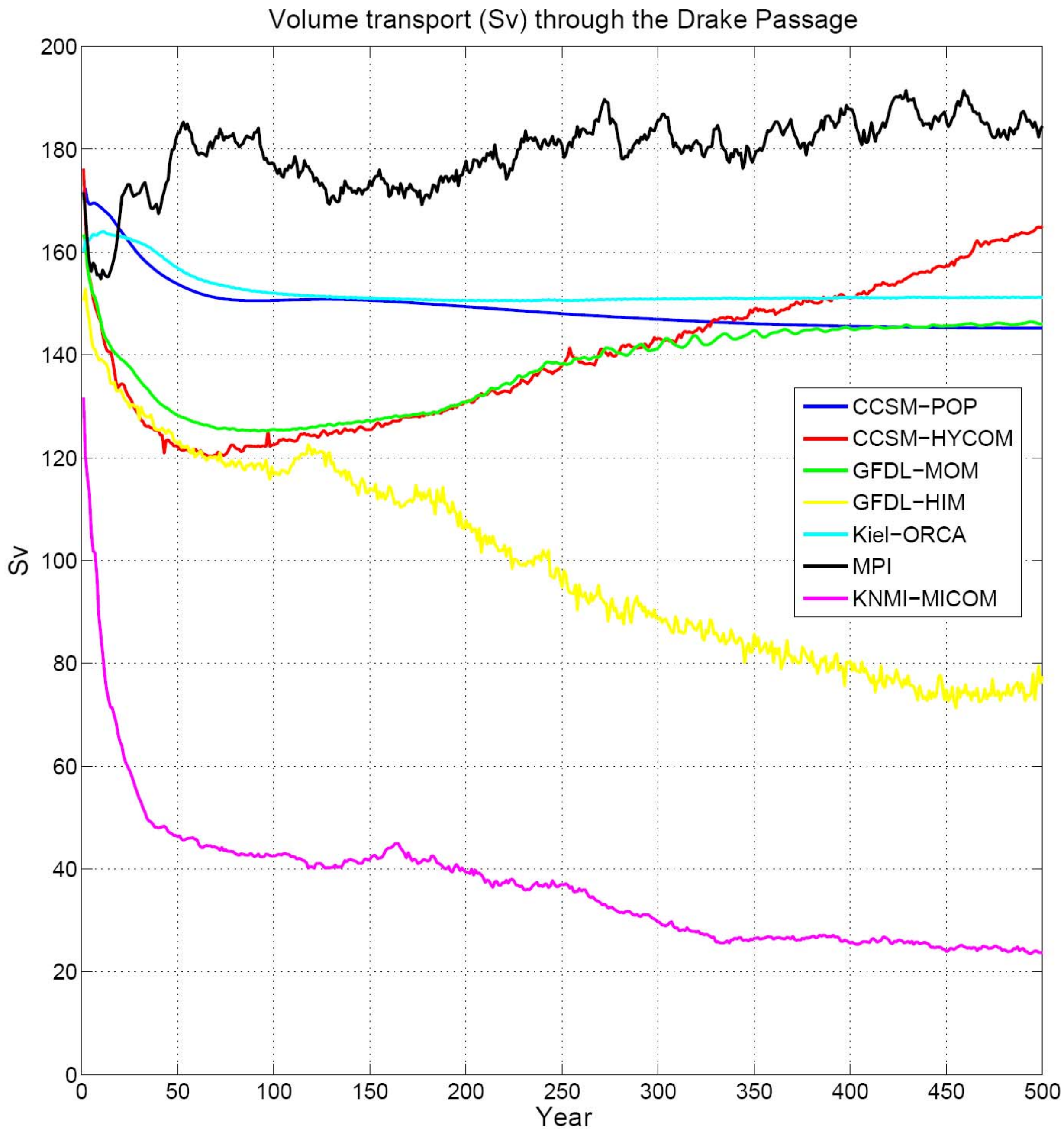
CCSM/HYCOM

Weaker than the estimate based on the reanalysis

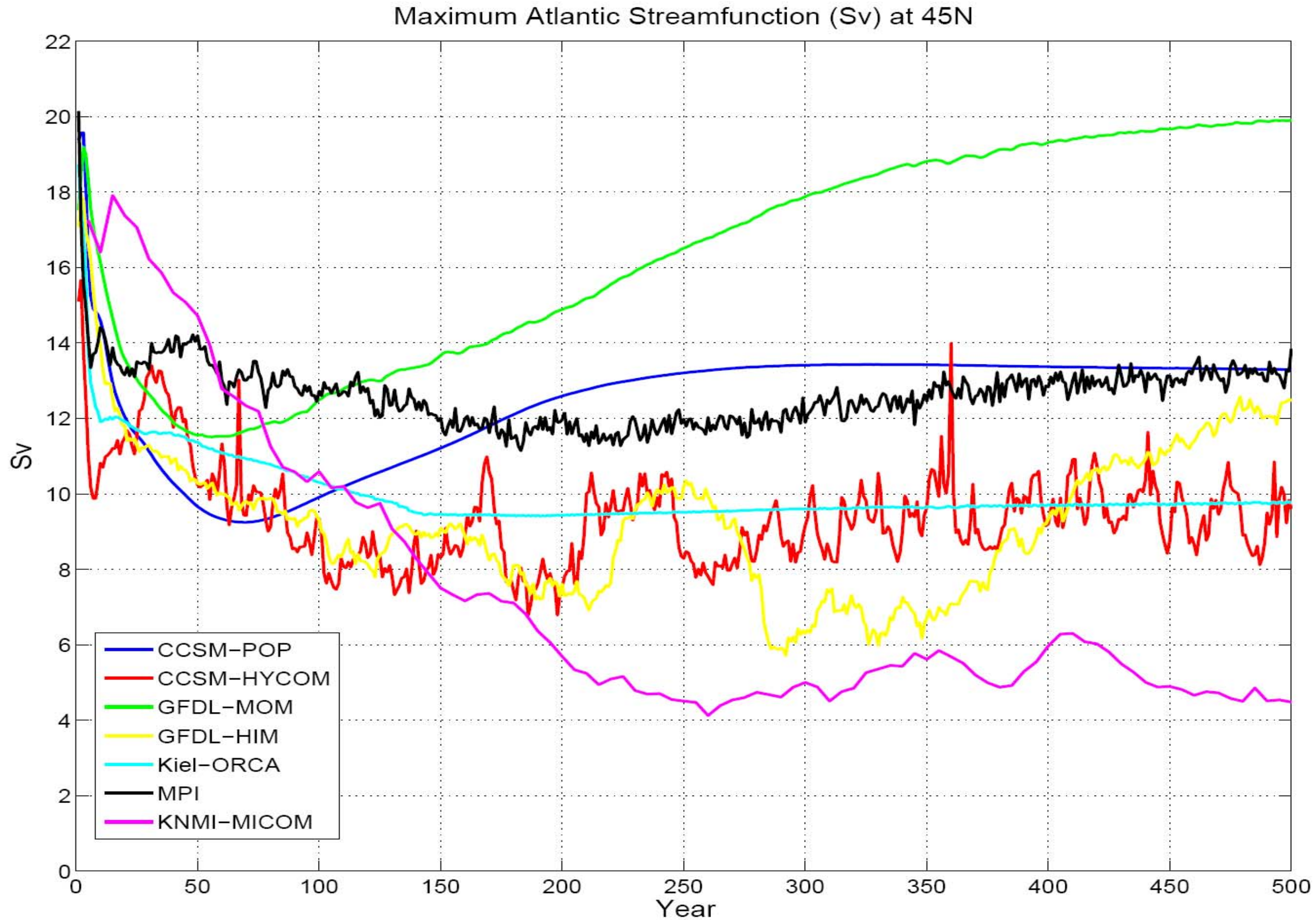
But comparable to other models



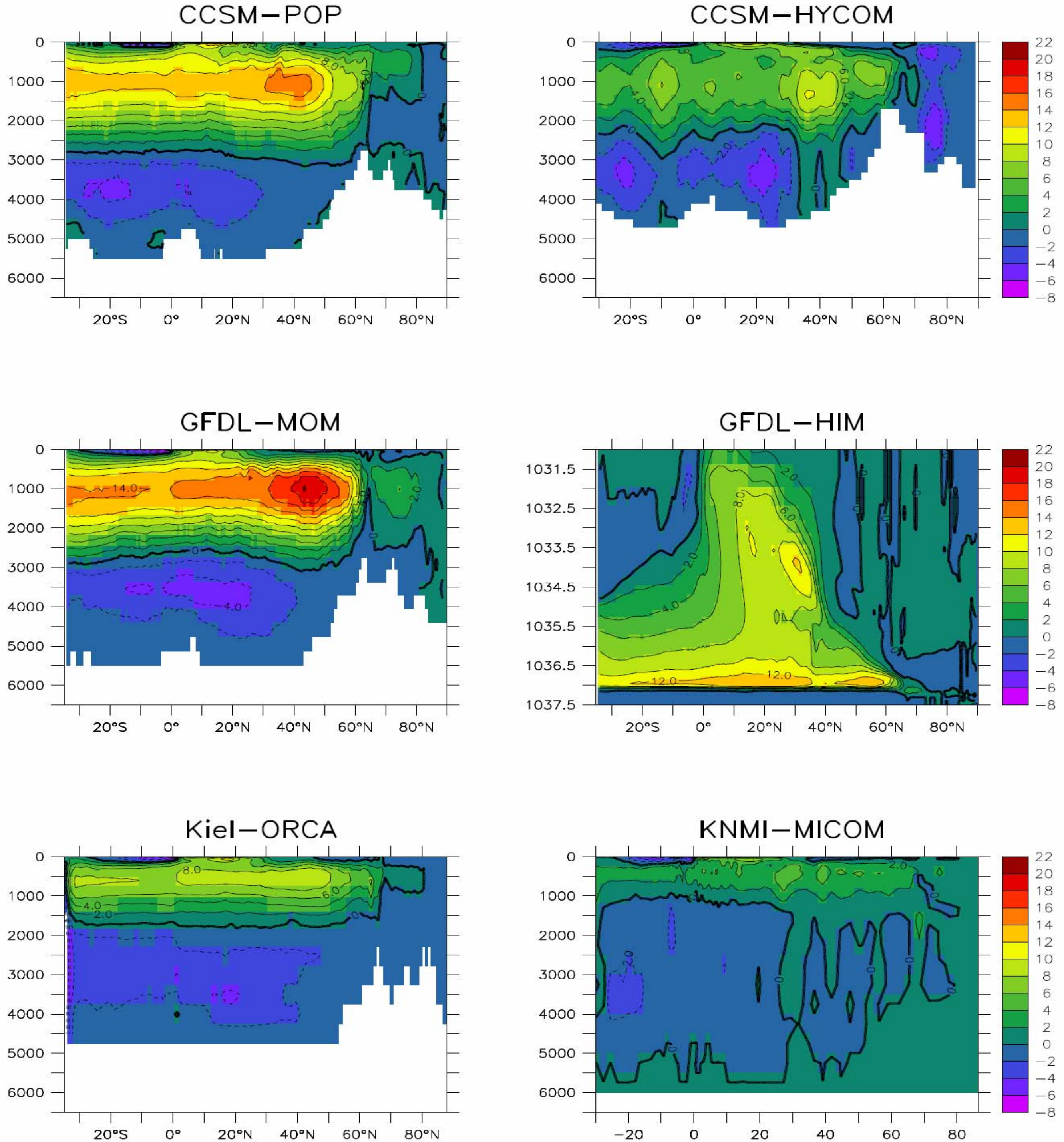
The Drake Passage Transport Y491-500



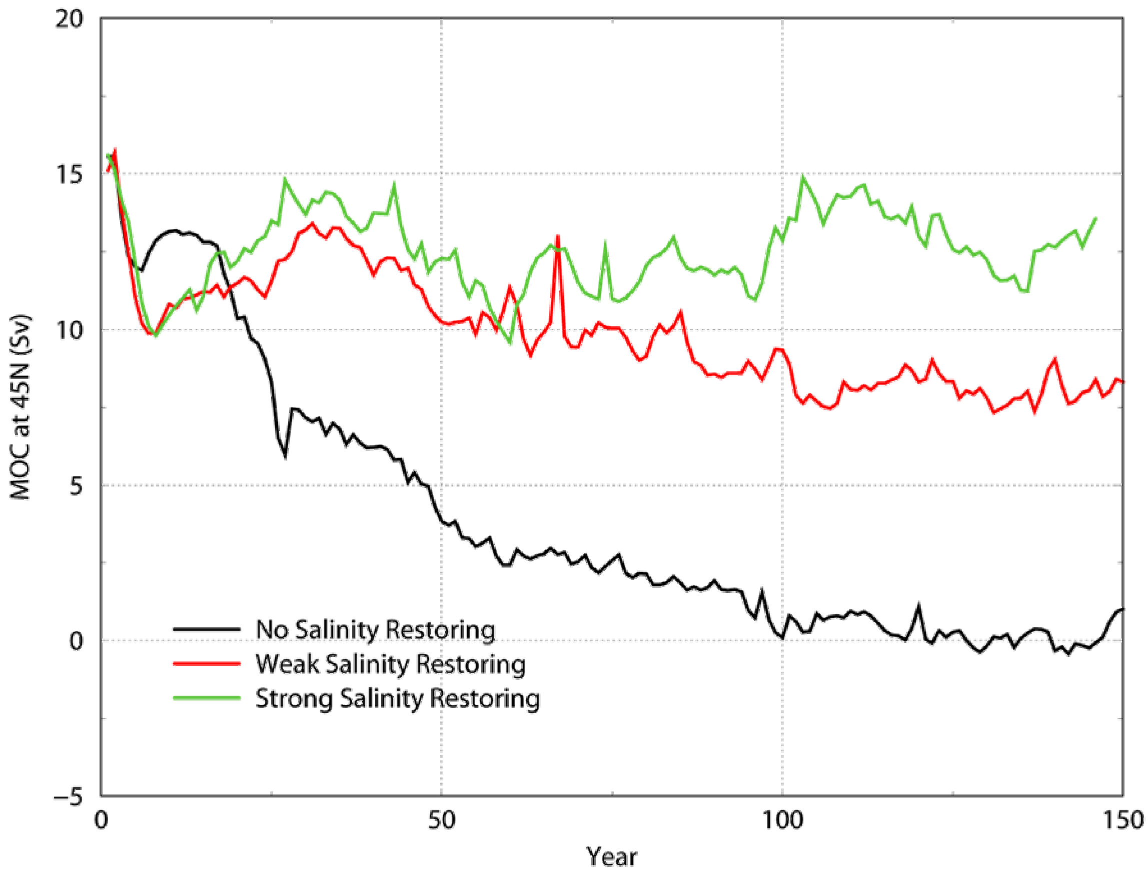
The Evolution of the Atlantic Meridional Overturning Circulation



The Streamfunction Pattern of the Atlantic MOC

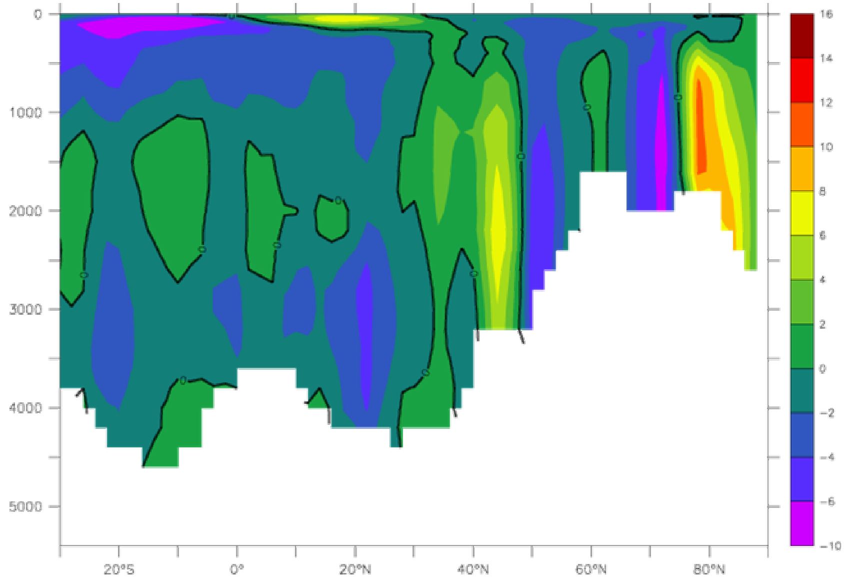


The impact of the Salinity Boundary Condition on Atlantic MOC in CCSM/HYCOM Coupled ocean-ice model

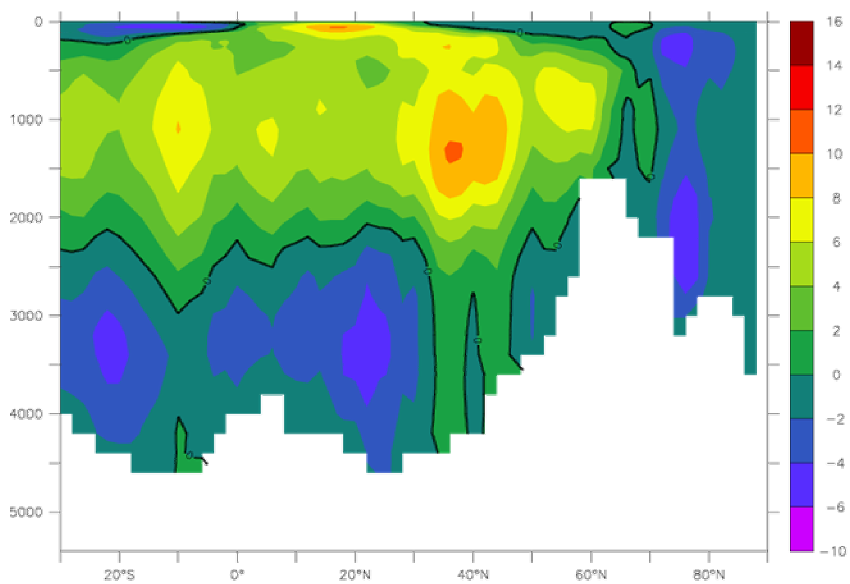


Atlantic MOC collapses in the run without salinity restoring

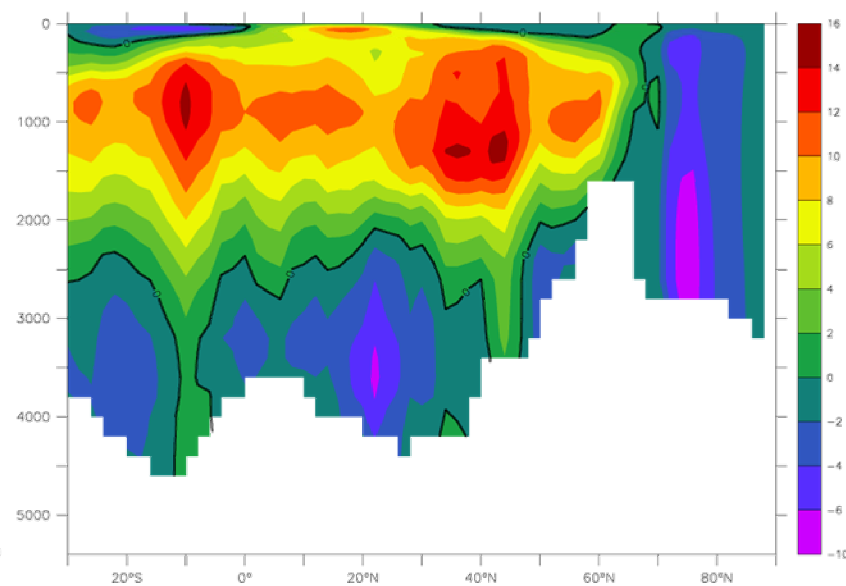
The Atlantic MOC Streamfunction in 3 CCSM/HYCOM runs Year 141-150



No salinity restoring

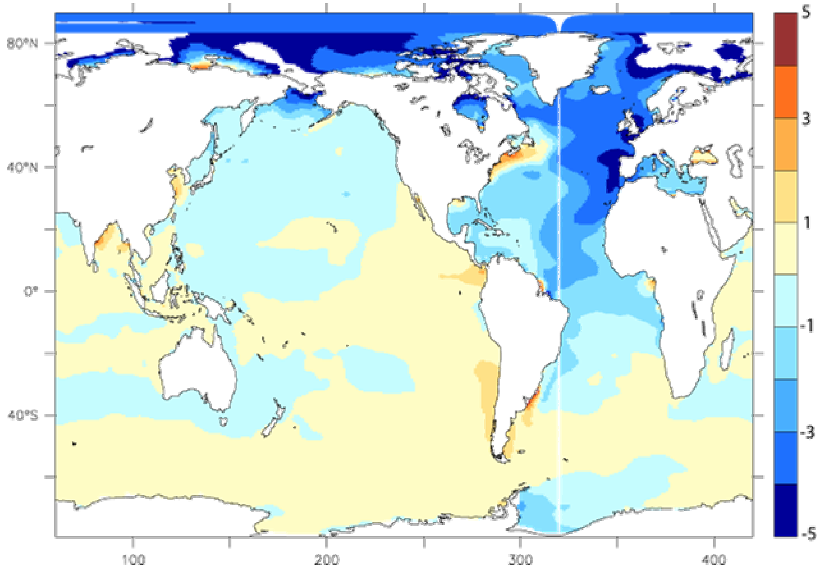


Weak salinity restoring

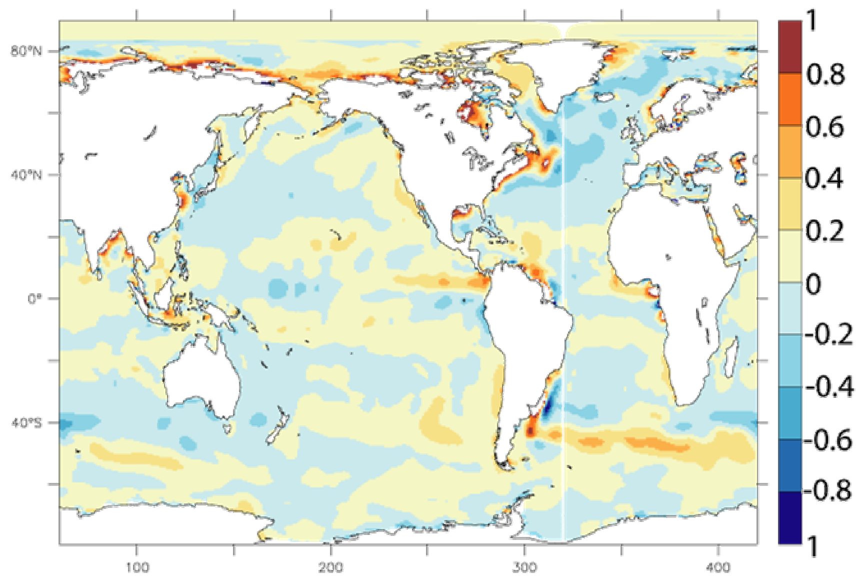


Strong salinity restoring

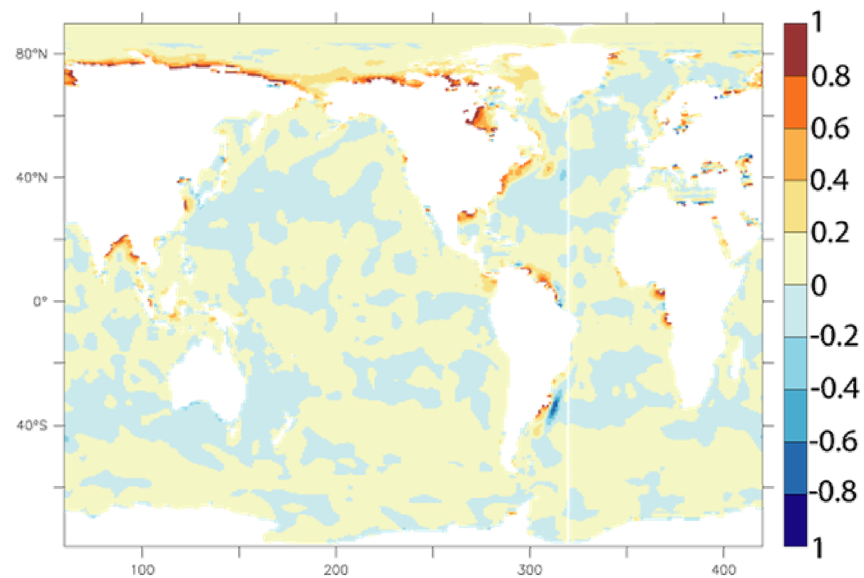
The SSS Drifts in 3 CCSM/HYCOM runs Year 141-150



No salinity restoring



Weak salinity restoring



Strong salinity restoring

Conclusion and Future work

1. As the first set of long-term integrations, many ocean simulations with CCSM3/HYCOM are reasonably well.

2. An apparent problem is at the equatorial Pacific.

3. Some tuning work is necessary for HYCOM.

4. The integration with the fully coupled CCSM3/HYCOM has started.