Simulating the Atlantic Meridional Overturning Circulation with HYCOM and POP

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Eric Chassignet, William Large, Nancy Norton, Stephen Yeager,
Alan Wallcraft and Sumner Dean

CCSM workshop, 2008

The Coordinated Ocean-ice Reference Experiment (CORE)

- An experimental protocol to examine the simulations of ocean-ice models with a consistent forcing

  (Griffies et al., 2008)

- The atmospheric state is prescribed

  Dataset of Large and Yeager, 2004

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

- Thermal Forcing is based on bulk formulae

Salinity Forcing

(1) P-E+R

(2) P-E+R + weak restoring $V_{piston} = 50m/4years$

(3) P-E+R + strong restoring $V_{piston} = 50m/360days$

$$F_{restore}(x,y,t) = V_{piston}\left[SSS^{data}(x,y,t') - SSS^{\text{model}}(x,y,t)\right]$$
$$t' = 1,2,\ldots 12month$$

POP: $F_{norm} \neq 0$ Global net salt flux is compensated
(Bill Large, personal communication)

HYCOM: $F_{norm} = 0$ Global net salt flux is not compensated

The salinity forcing between HYCOM and POP is not perfectly identical

HYCOM and POP

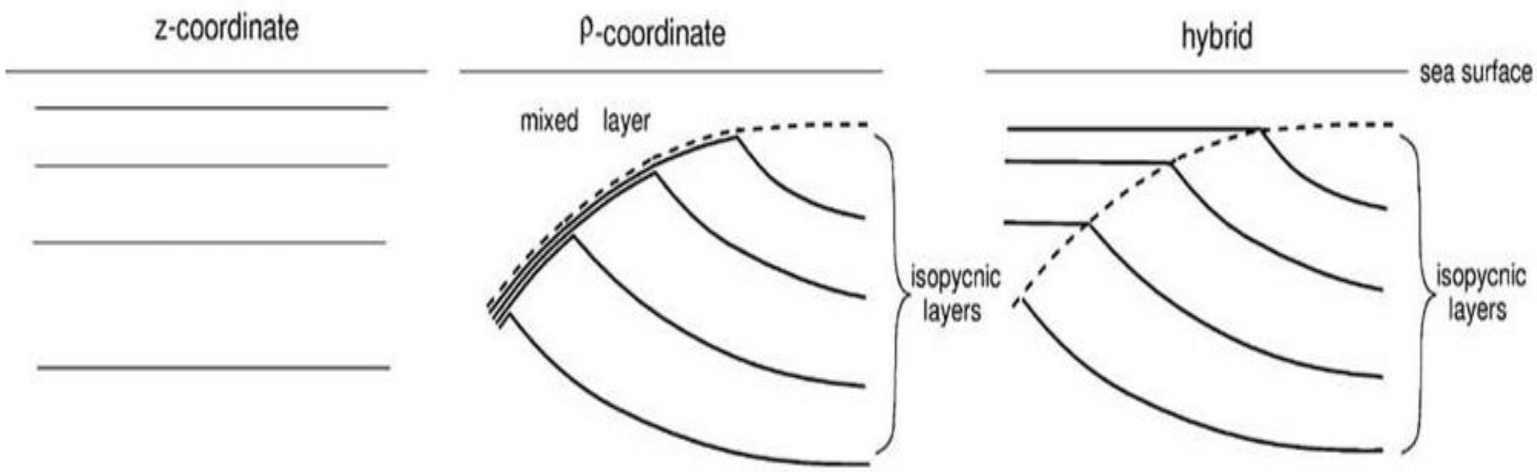
Grid: NCAR's gx1v3 grid; HYCOM: Arakawa-C; POP: Arakawa-B

Vertical resolution: HYCOM: 32 hybrid layers; POP: 40 levels

Initialization: January of the Poles Hydrographic Climatology, resting

Duration: 150 years for three salinity boundary conditions

POP



HYCOM

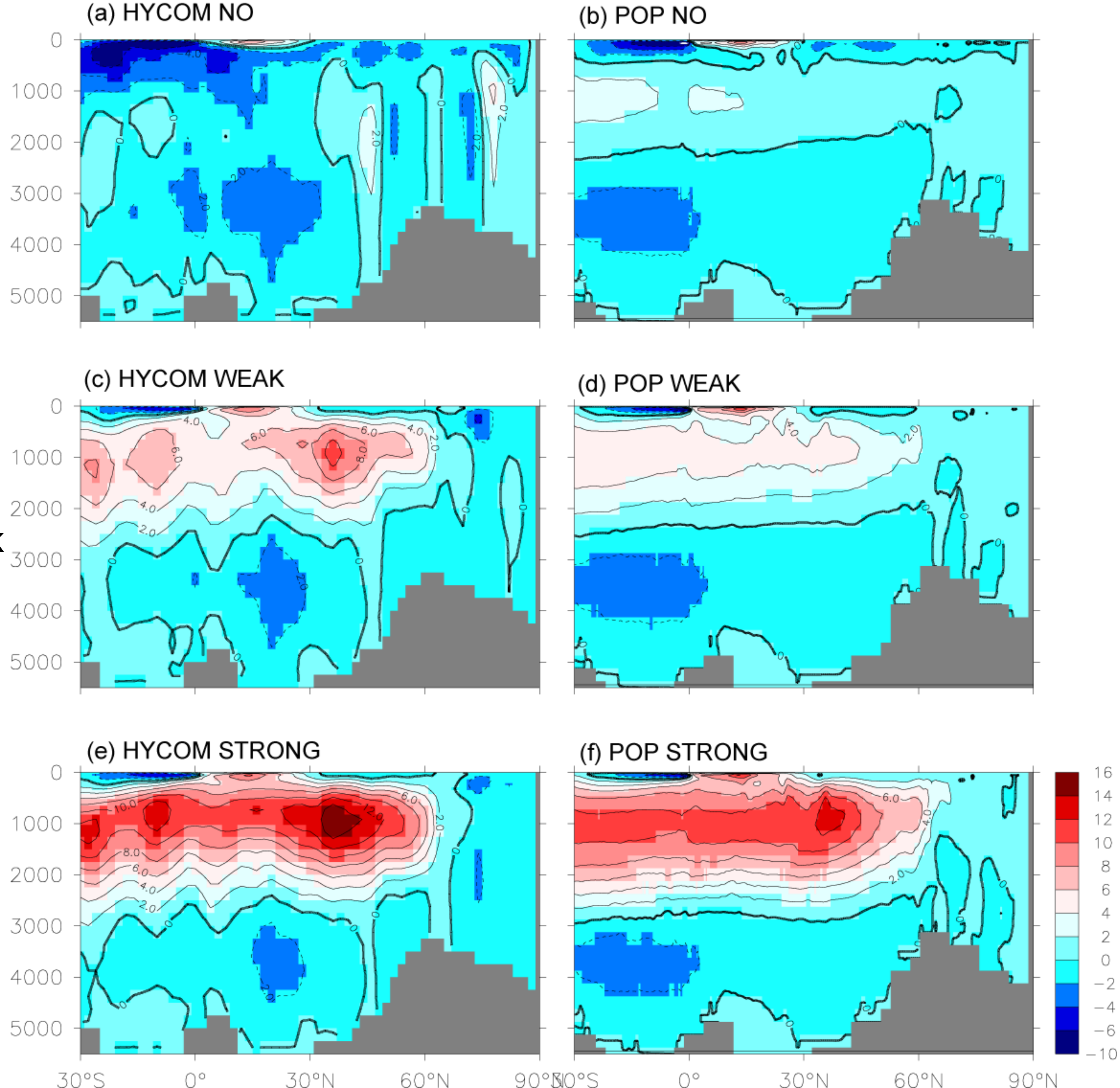
MOC

Collapses

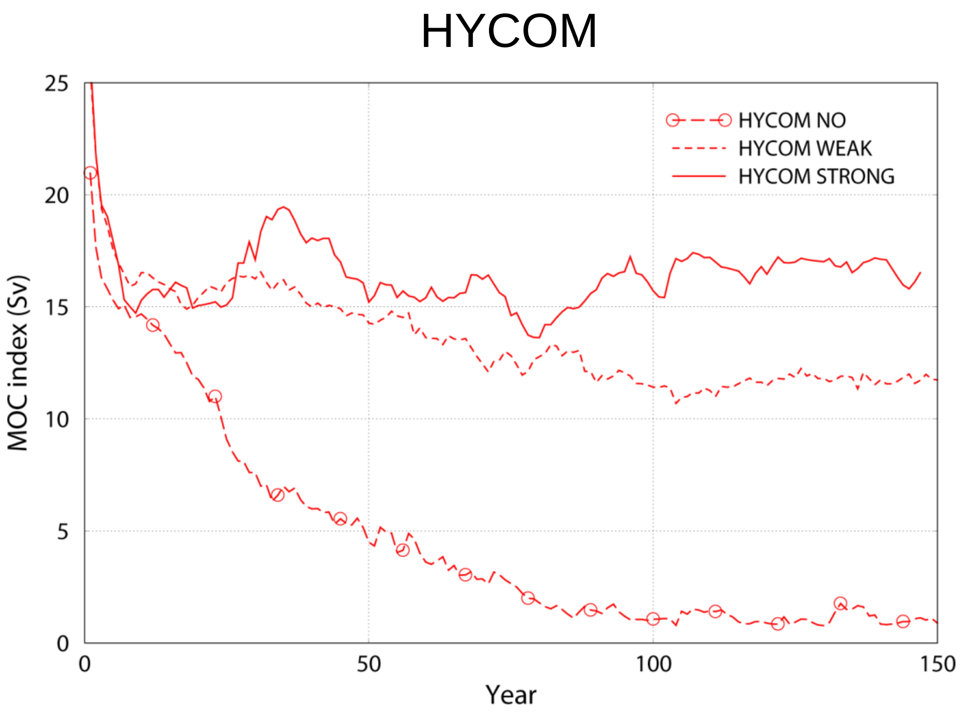
Active but weak

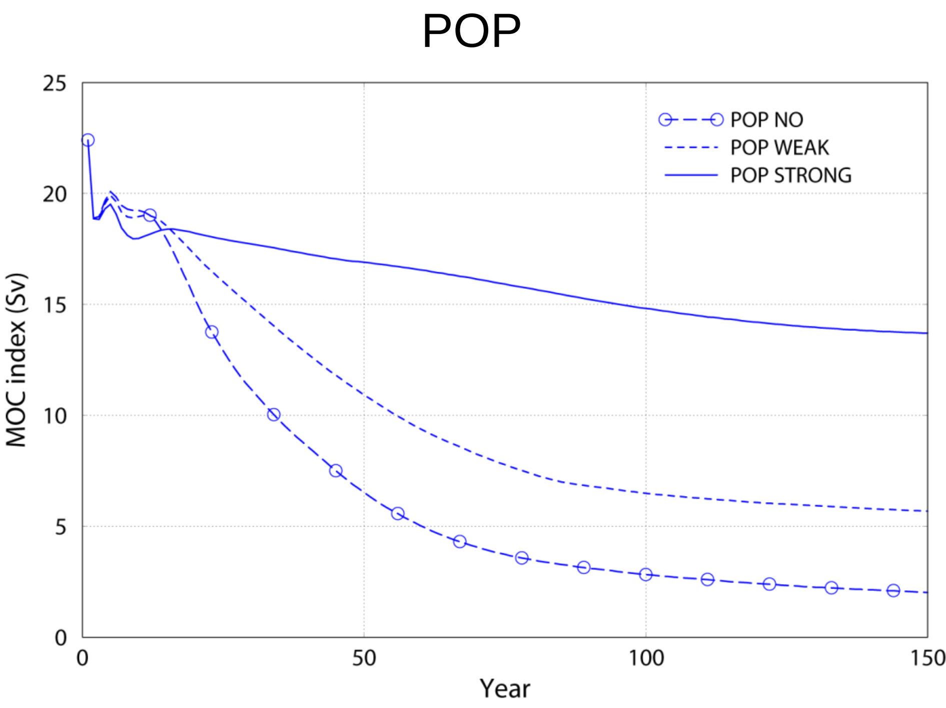
Vigorous

Unit: Sv



Time Evolution





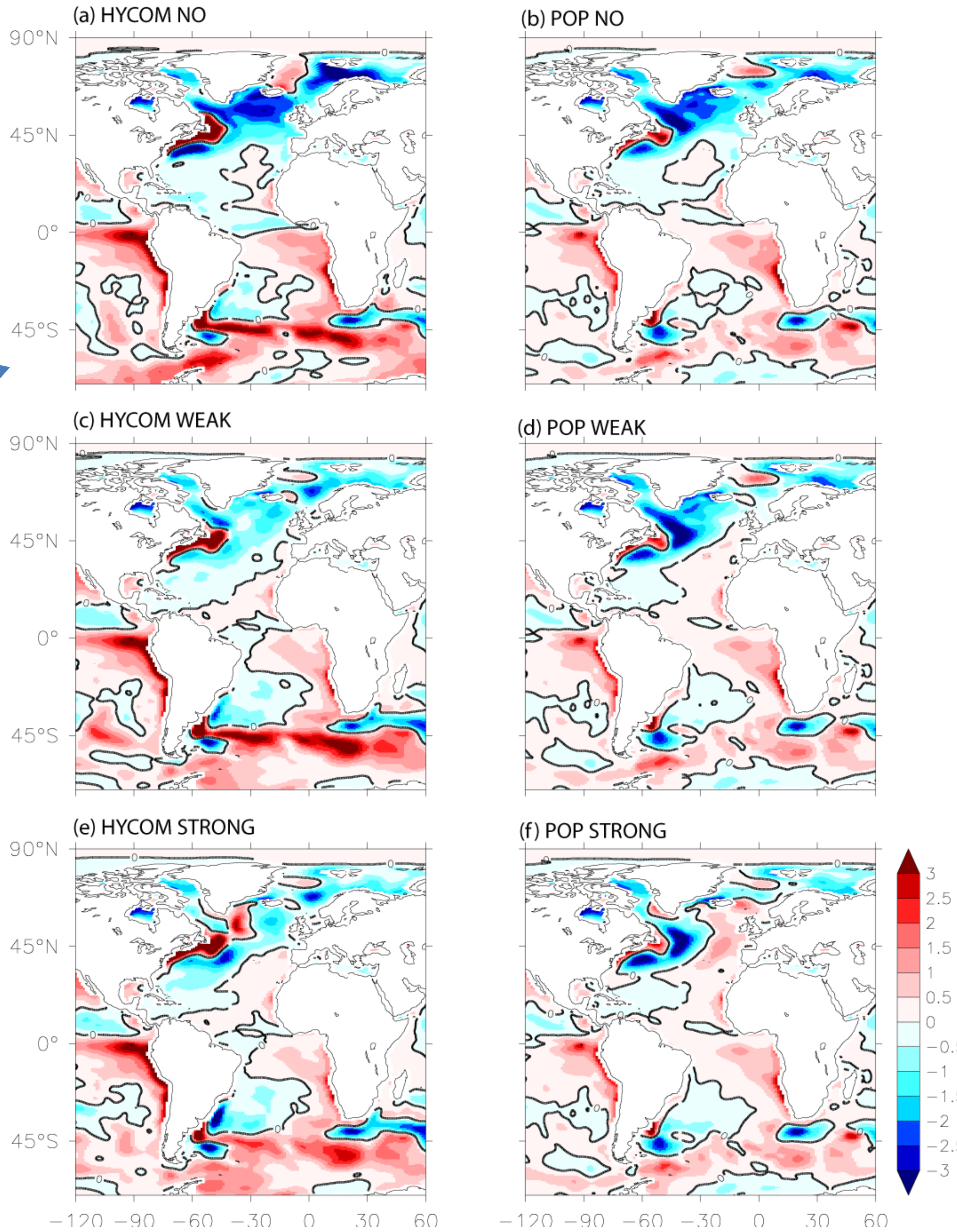
The MOC index is defined as the maximum streamfunction value at 45^{o}N

A notable difference is the variability of the MOC

SST Biases

Cooling at high-latitude NA

Cold bias is reduced

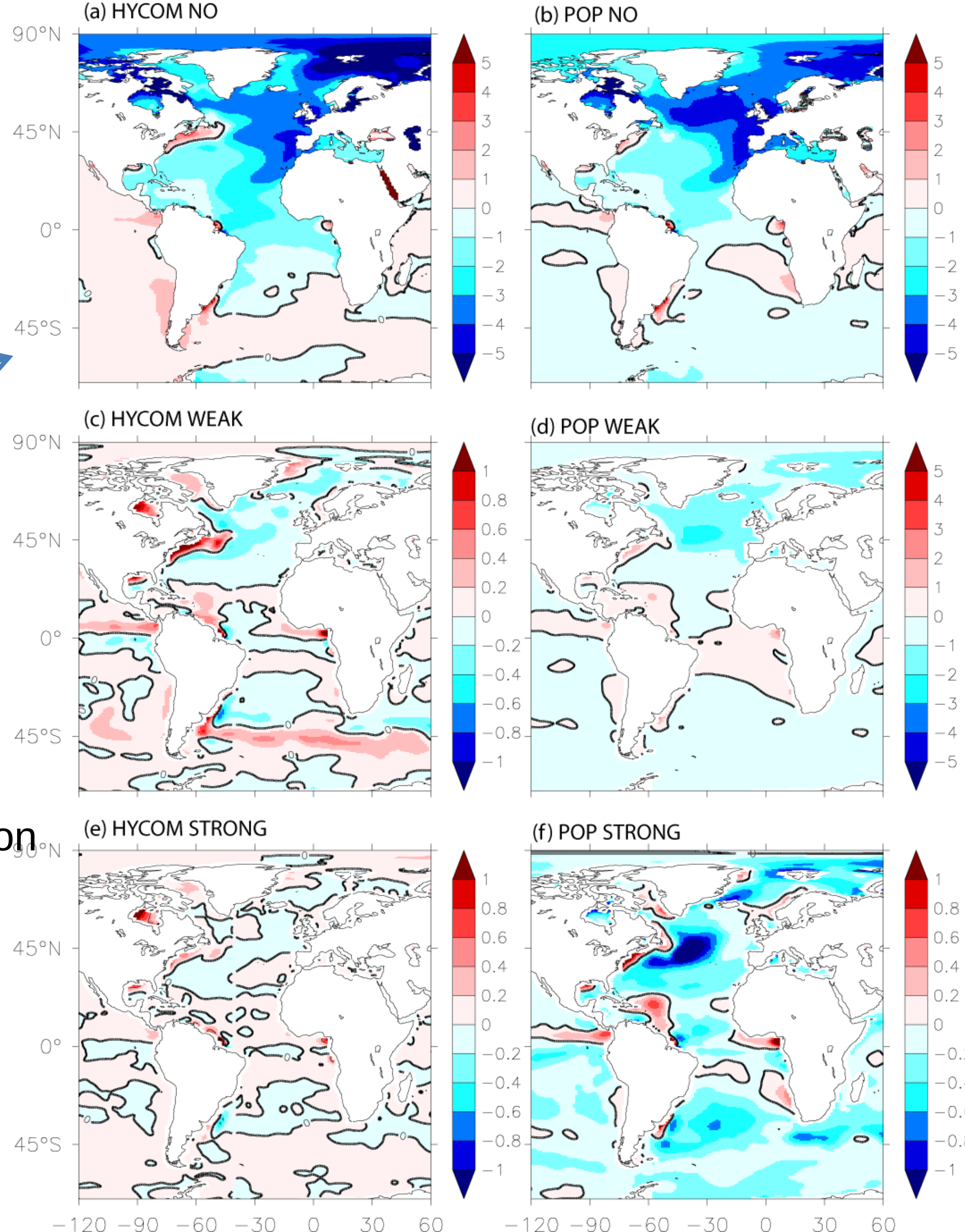


SSS Biases

Large freshening at high-latitude NA

Reduced freshening

Impact of the differing salinity boundary condition



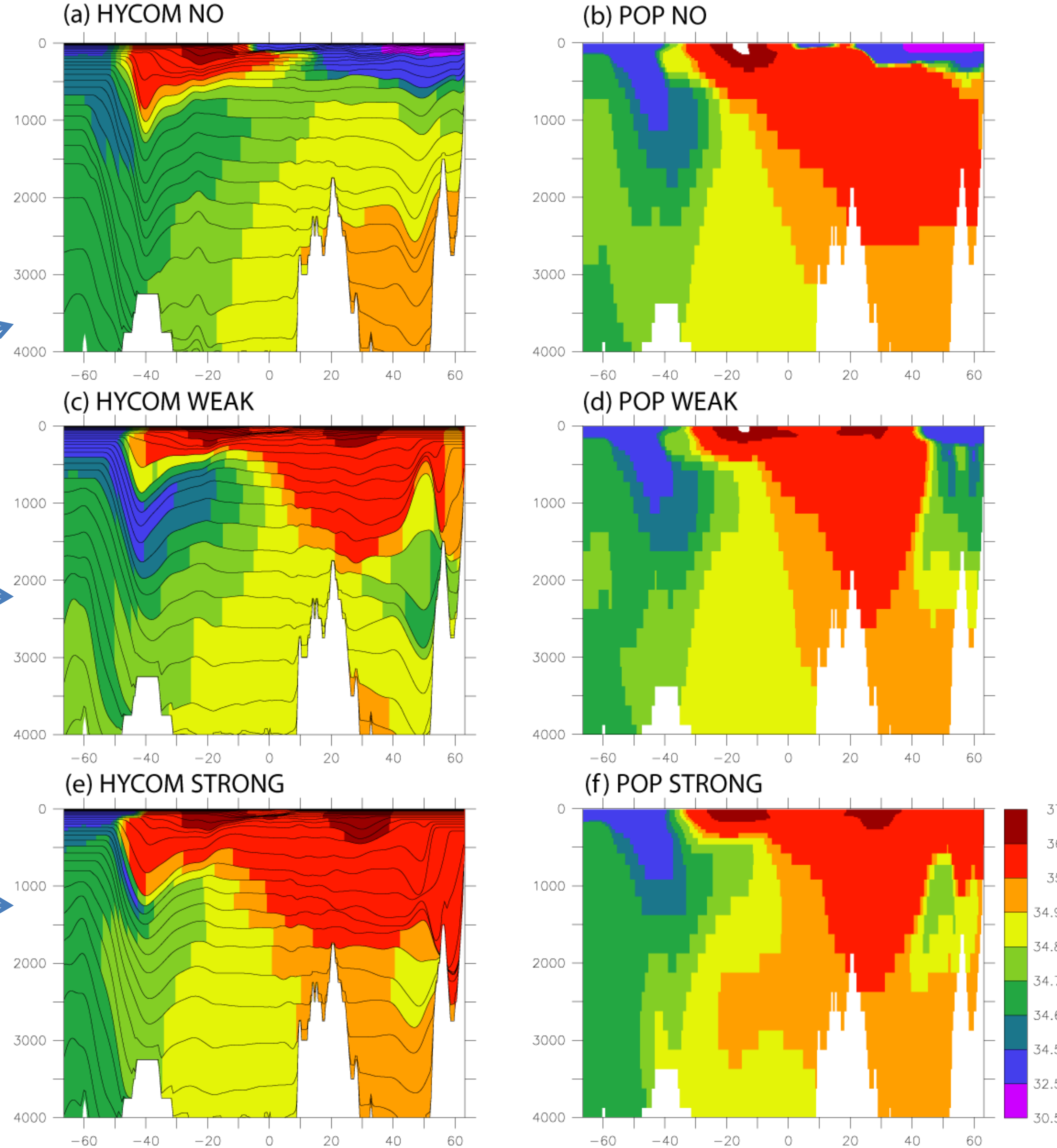
Salinity at 25°W

Large freshening at high-latitude NA →

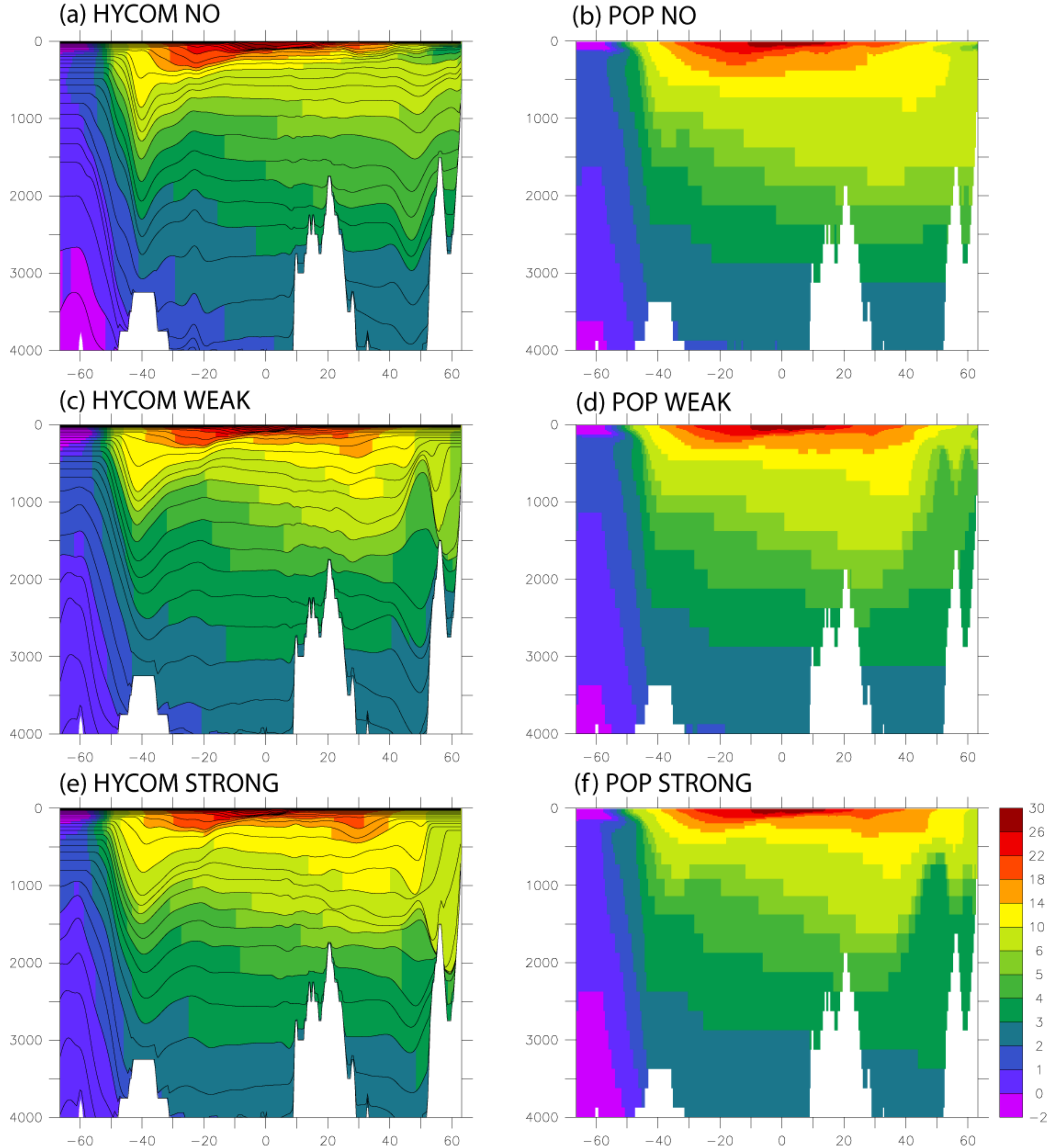
AAIW and overflow →

High salinity in NA →

Unit: psu

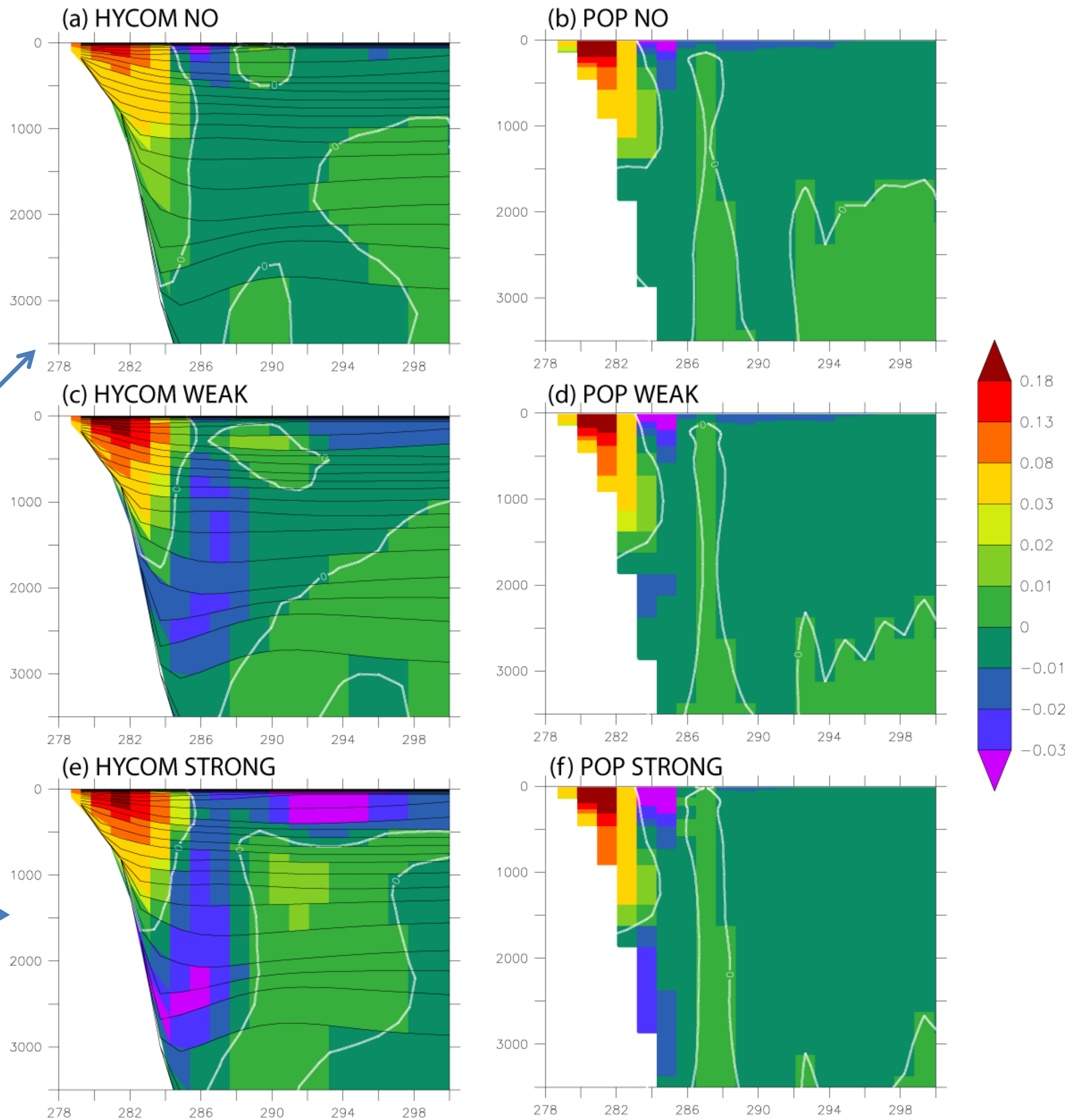


Temp at 25°W


(a) HYCOM NO
(b) POP NO
(c) HYCOM WEAK
(d) POP WEAK
(e) HYCOM STRONG
(f) POP STRONG
0
1000
2000
3000
4000
−60
−40
−20
0
20
40
60
30
26
22
18
14
10
6
5
4
3
2
1
0
−2

Meridional Velocity at 30°N

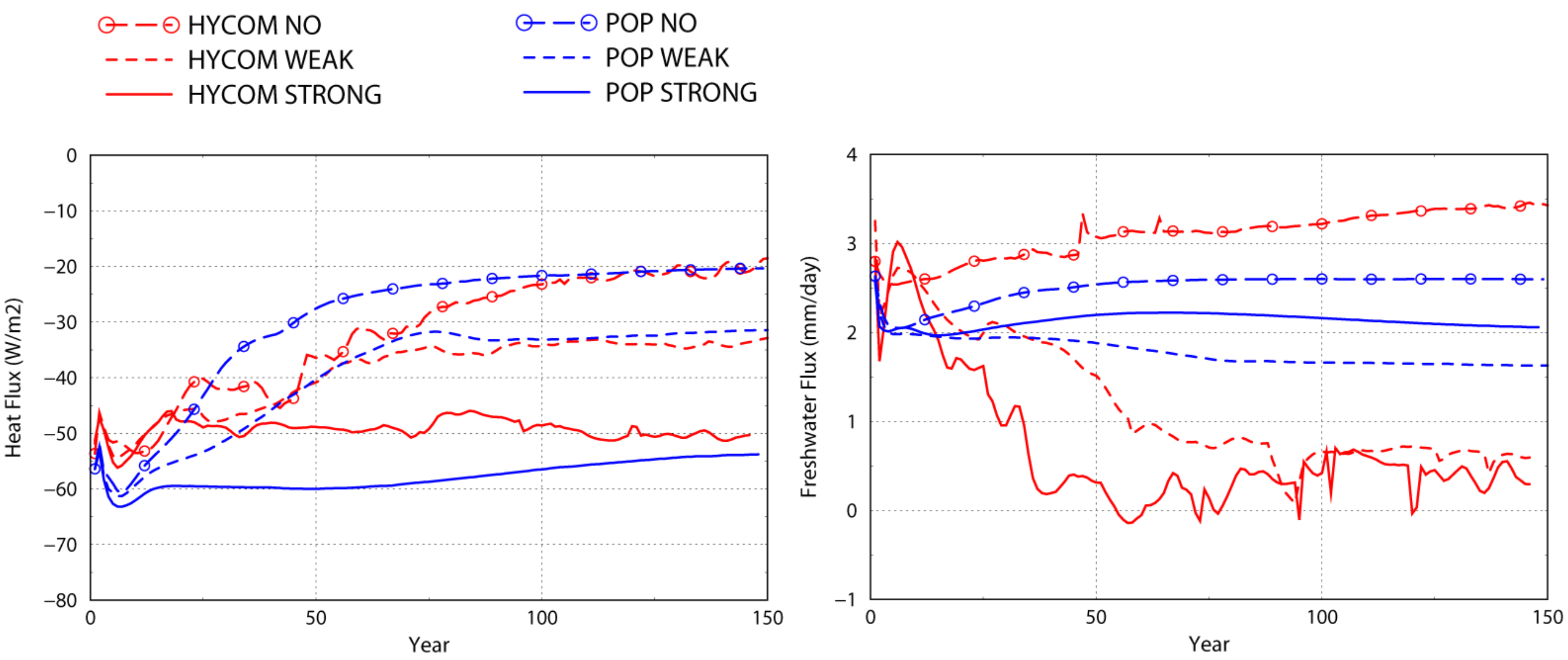
No deep western boundary current



Strong deep current

Unit: m/s

Thermohaline Fluxes at Deep Convection Region (50°-80°N, 60°W-30°E)

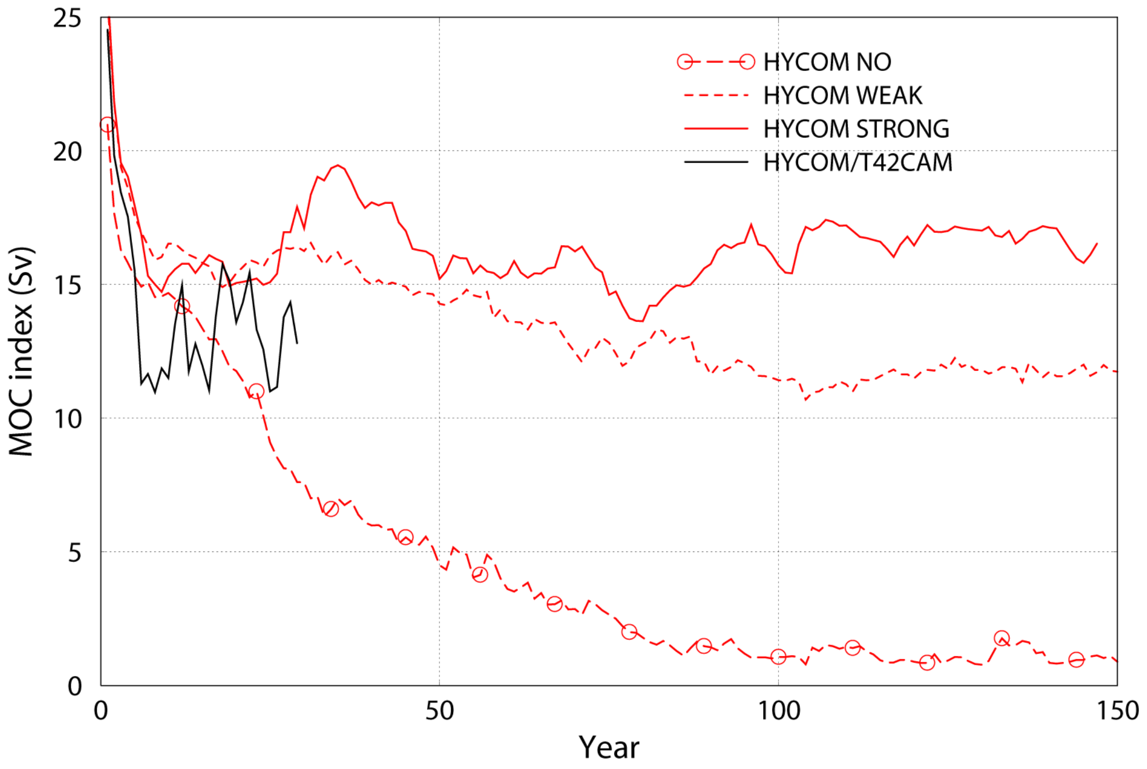


Freshwater flux shows most significant difference between HYCOM and POP

Conclusion and Future Work

- HYCOM and POP show both similarity and difference in terms of the MOC simulation.
- Both HYCOM and POP cannot simulates an active MOC under CORE forcing without the application of salinity restoring.
- Once salinity restoring is applied, the MOC is active in both models. The stronger the restoring, the more vigorous of the MOC.
- The MOC shows differences in HYCOM and POP such as its variability. It is important to understand these differences.
- Comparison of the characteristics of the MOC between the uncoupled and coupled models, and between the coupled CCSM3/HYCOM and CCSM3/POP.

HYCOM/T42CAM



HYCOM/T42CAM