Coupled Simulations with CCSM3/HYCOM: Model Tuning and Sensitivity Experiments

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Overview

Goals:

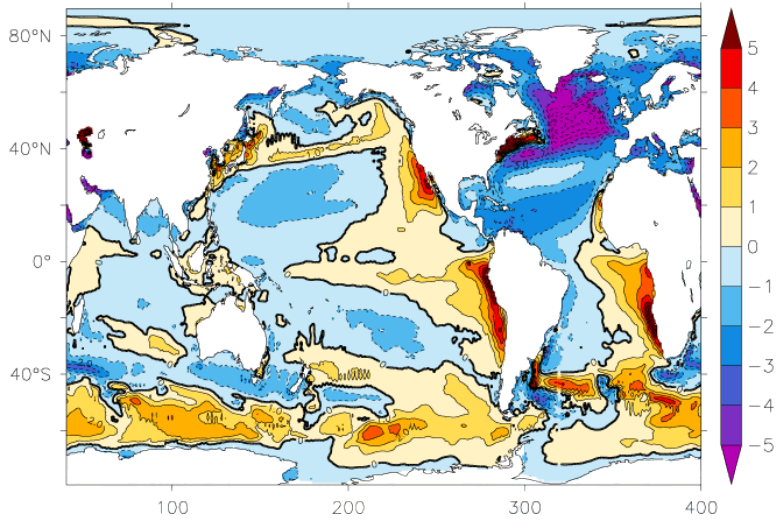
- To assess the impact of the primarily isopycnic versus depth coordinates in ocean and climate modeling;
- To use CCSM with the layered ocean model HYCOM as a research tool for studies on past, present and future climates

Status

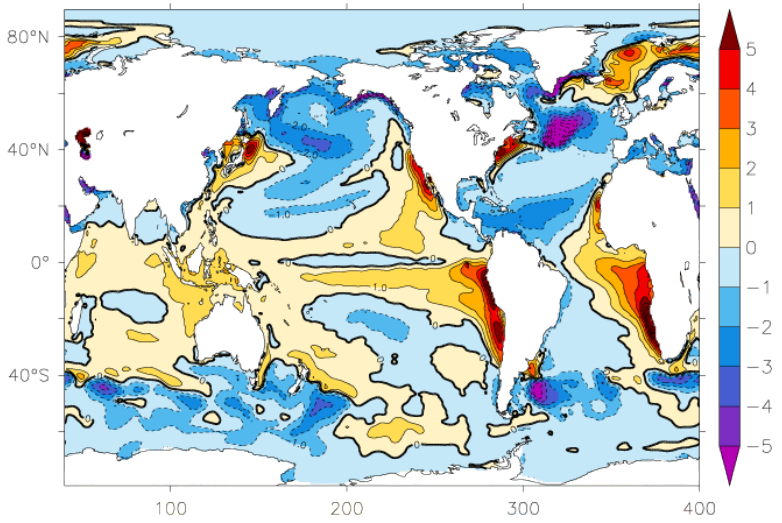
- The performance of the uncoupled HYCOM has been compared to the uncoupled POP and other leading ocean models by prescribing the atmospheric forcing (CORE, Large and Yeager, 2004) => Griffies et al. (2009), Yin et al. (2009).
- Long-term fully coupled CCSM3/HYCOM (T42x1 and T85x1) simulations have been performed.
- CCSM3/HYCOM shows similar biases to those of CCSM3/POP in most places. However, CCSM3/HYCOM has an additional cold bias (>5^{o}C) in the high-latitude North Atlantic induced by a weak meridional overturning circulation (MOC) and a warm bias in the Southern Ocean.
- A systematic study on the sensitivity of the simulation results to critical model parameters (viscosity, isopycnal and diapycnal diffusivity) have been carried out and the model simulations have been improved, especially the SST in the North Atlantic.

SST Biases (°C) with the Default Setting - years 91-100

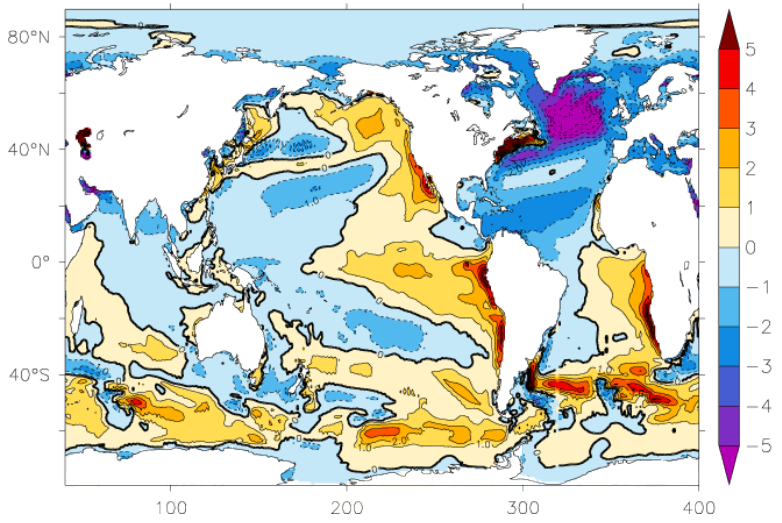
CCSM3/HYCOM T42x1



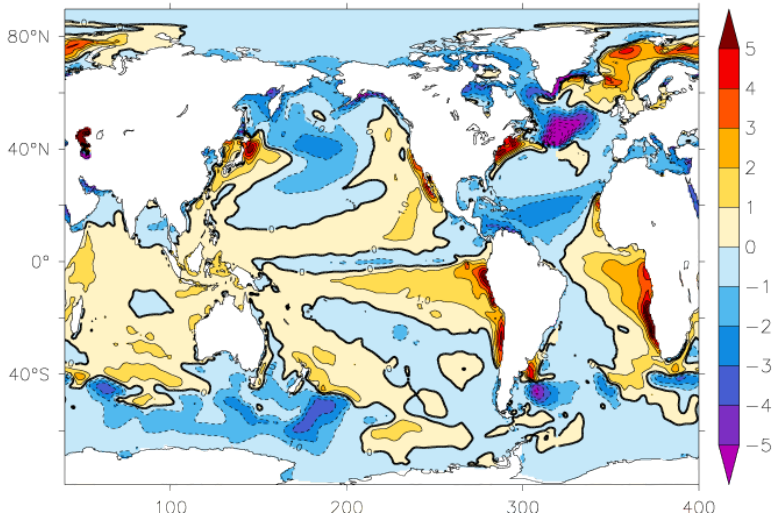
CCSM3/POP T42x1



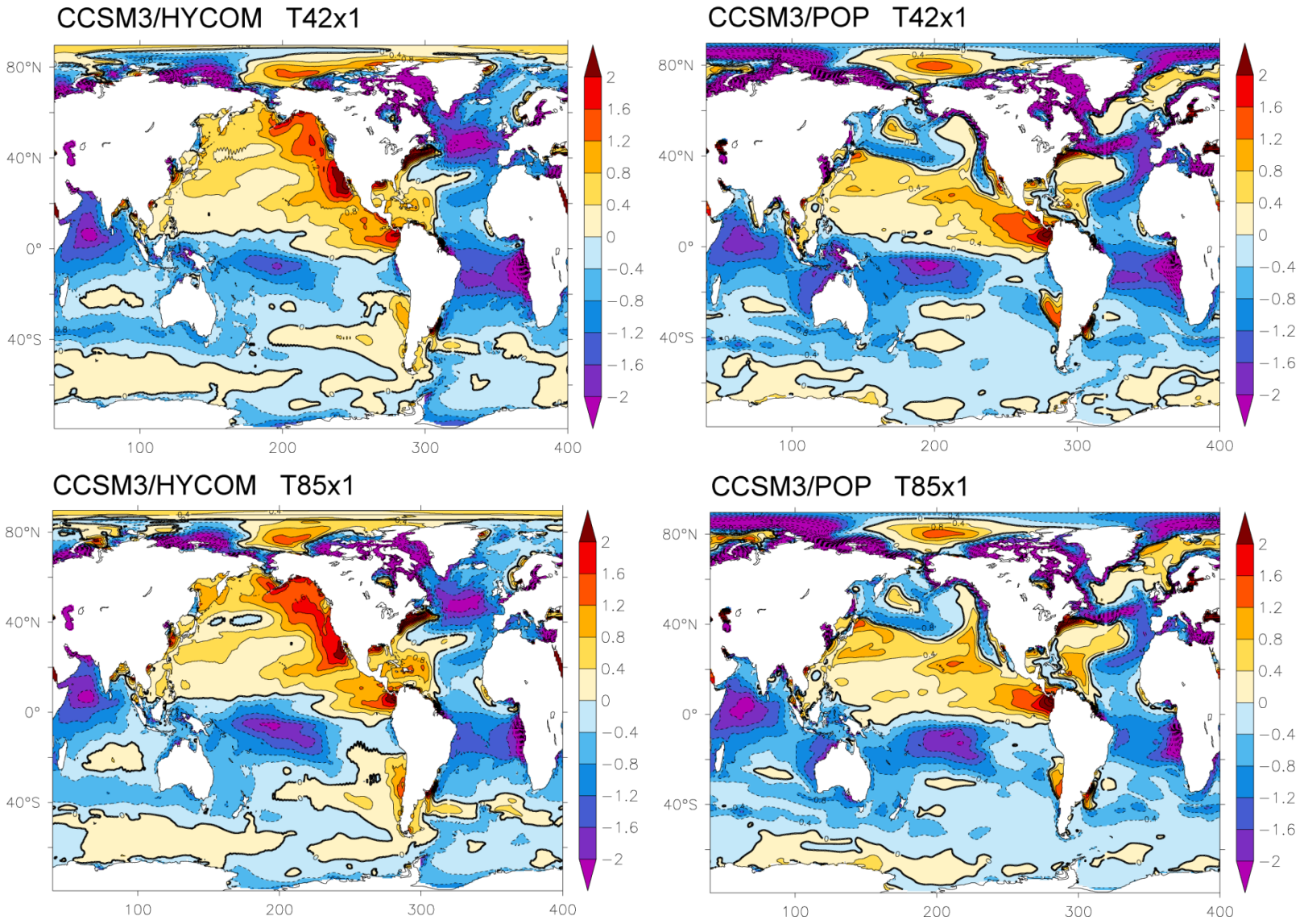
CCSM3/HYCOM T85x1



CCSM3/POP T85x1

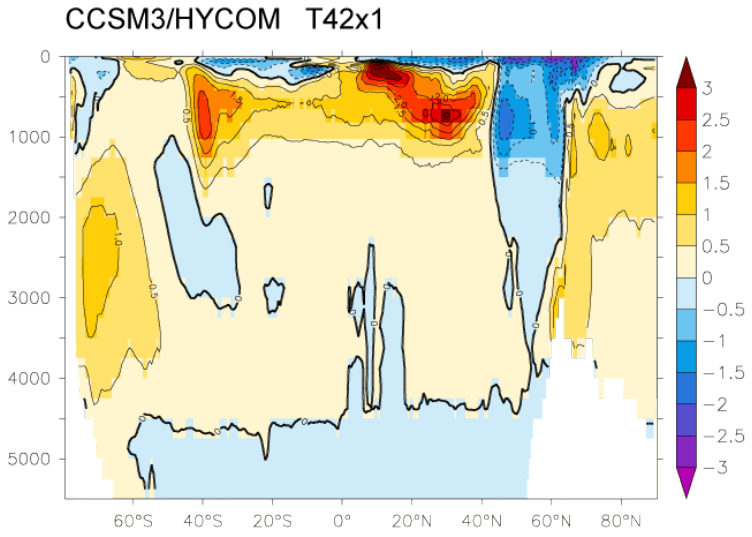


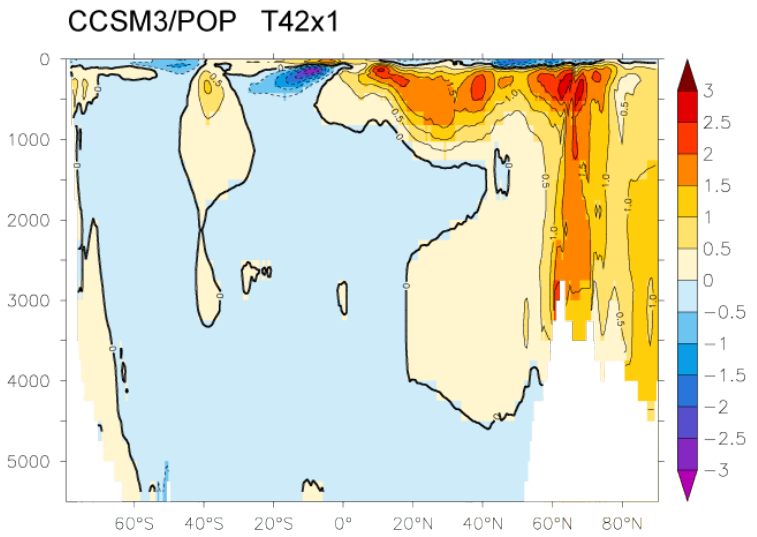
SSS Biases (*psu*) with the Default Setting - years 91-100



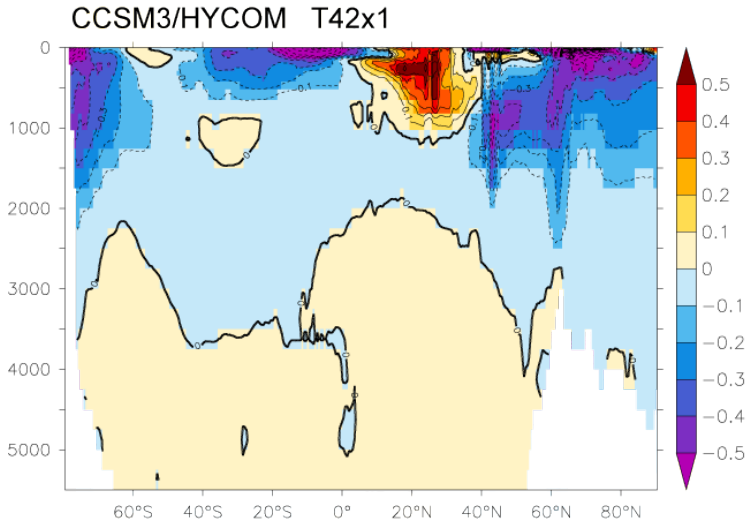
Zonal Mean Temperature and Salinity Biases with the Default Setting - years 91-100

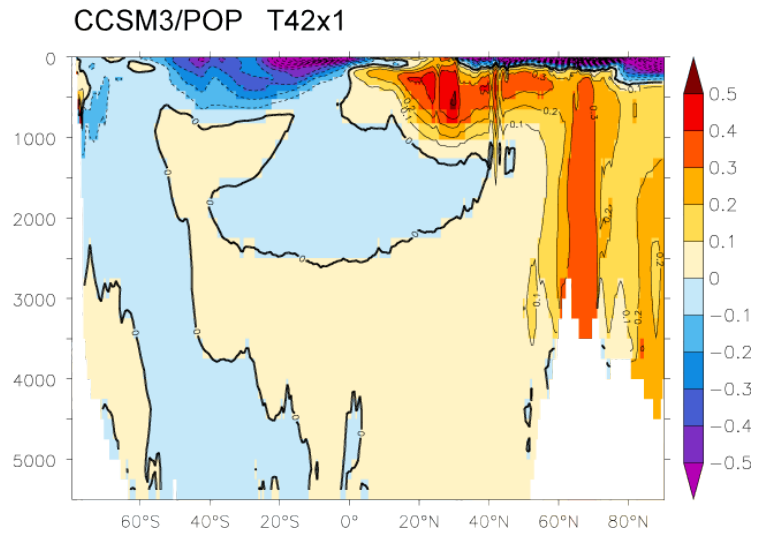
T (°C)





S (psu)

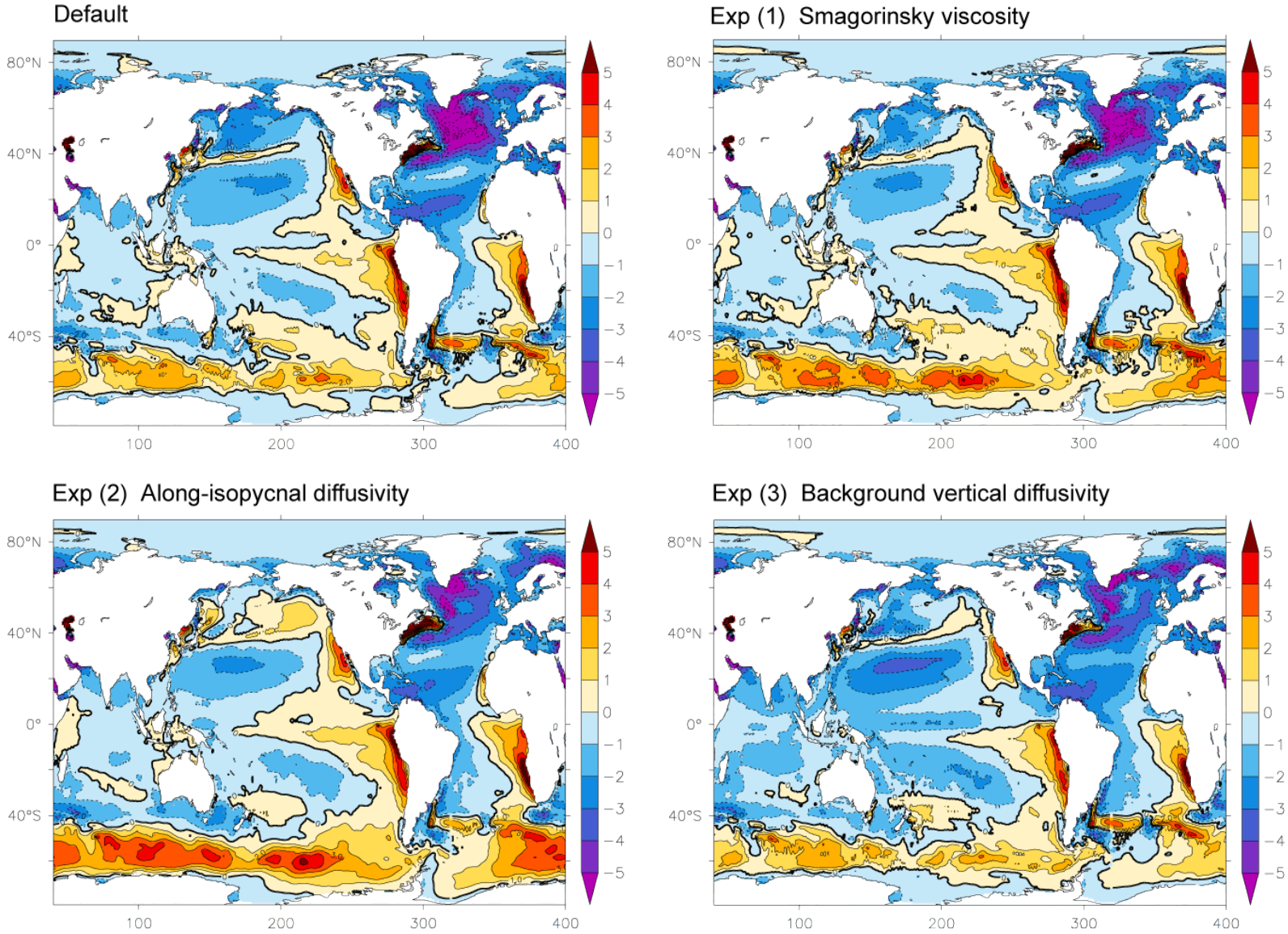




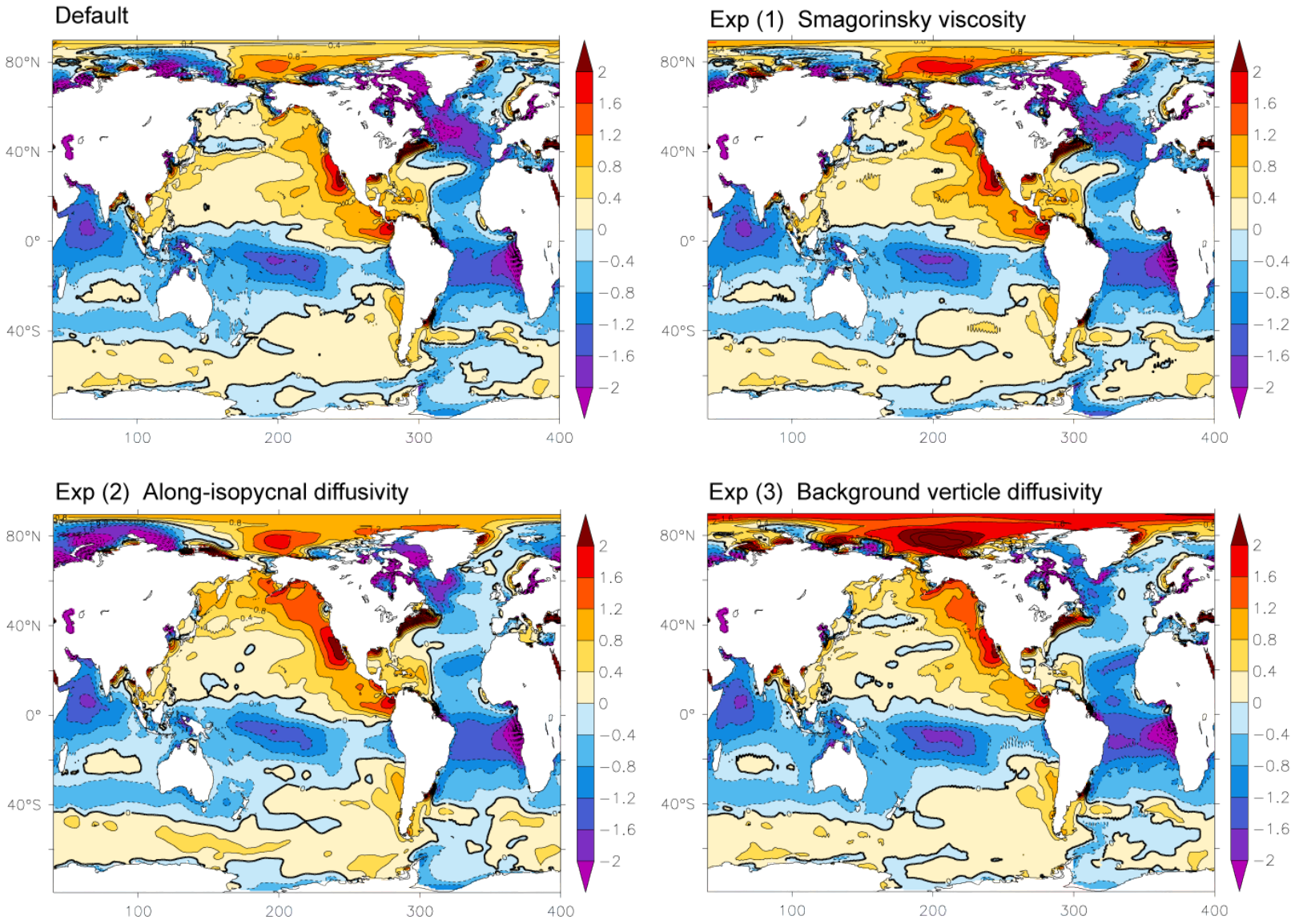
Model Tuning and Sensitivity Experiments

	Smagorinsky viscosity parameter	Along-isopycnal diffusivity parameter	Background vertical diffusivity
Default	0.2	0.005	10^{-5}
Exp (1)	0.1	0.005	10^{-5}
Exp (2)	0.2	0.03	10^{-5}
Exp (3)	0.2	0.005	$5x10^{-5}$

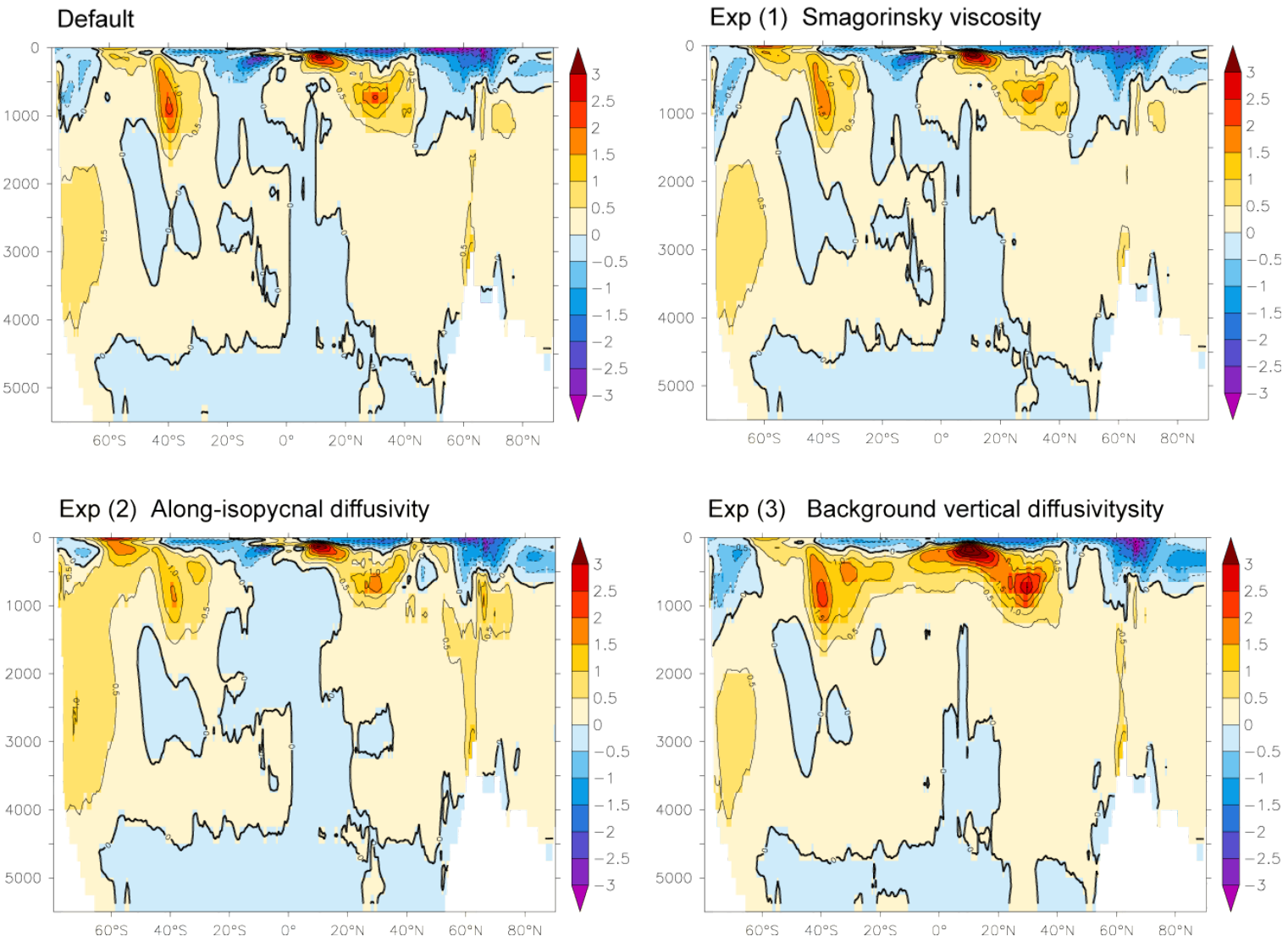
SST Biases (°C) years 26-30



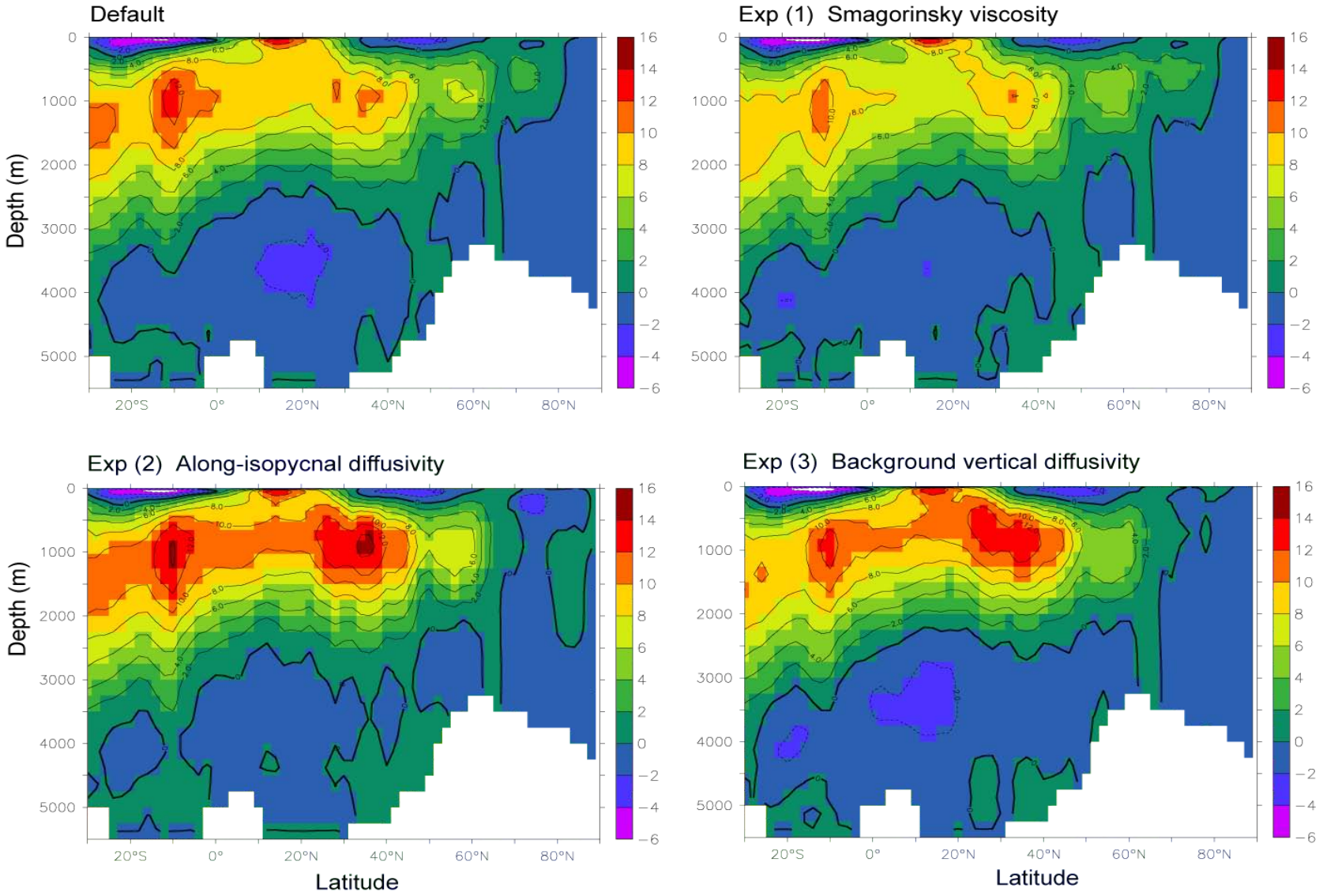
SSS Biases (*psu*) years 26-30



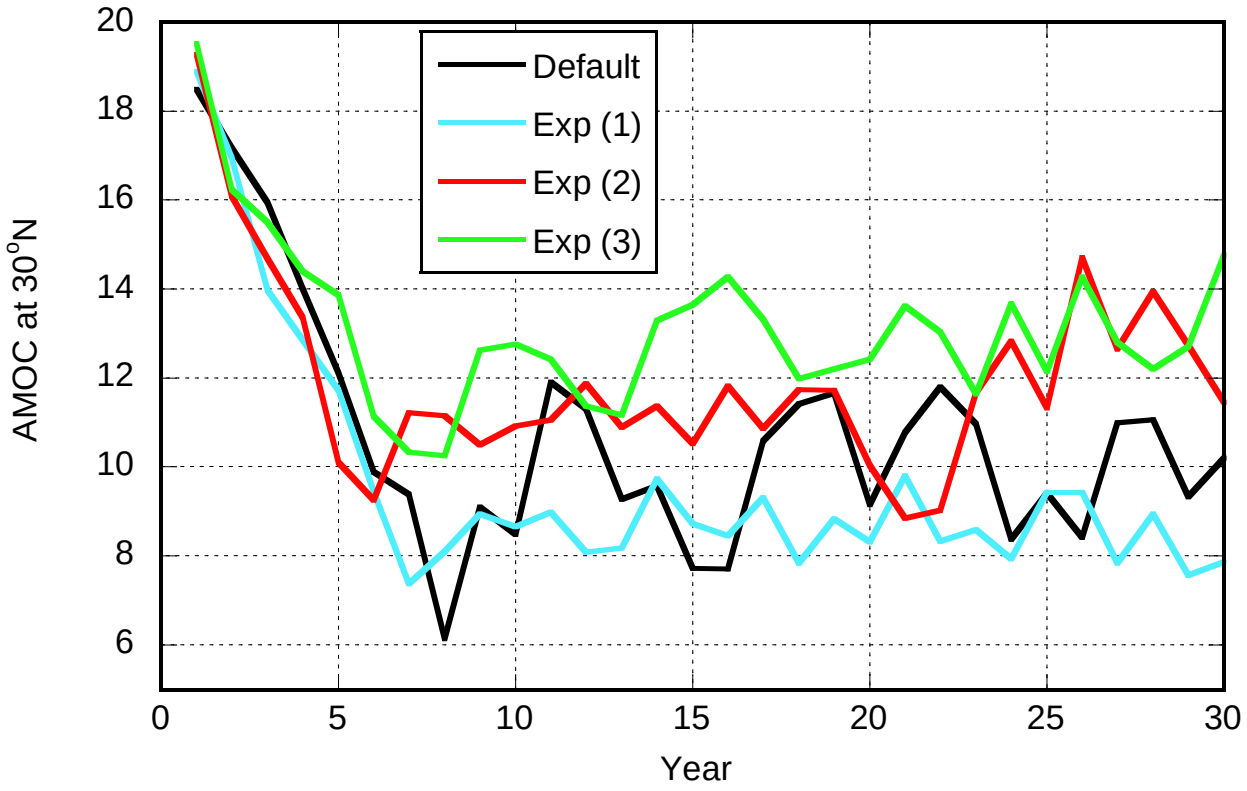
Zonal Mean Temperature Biases (°C)



Atlantic Meridional Overturning Circulation (Sv)

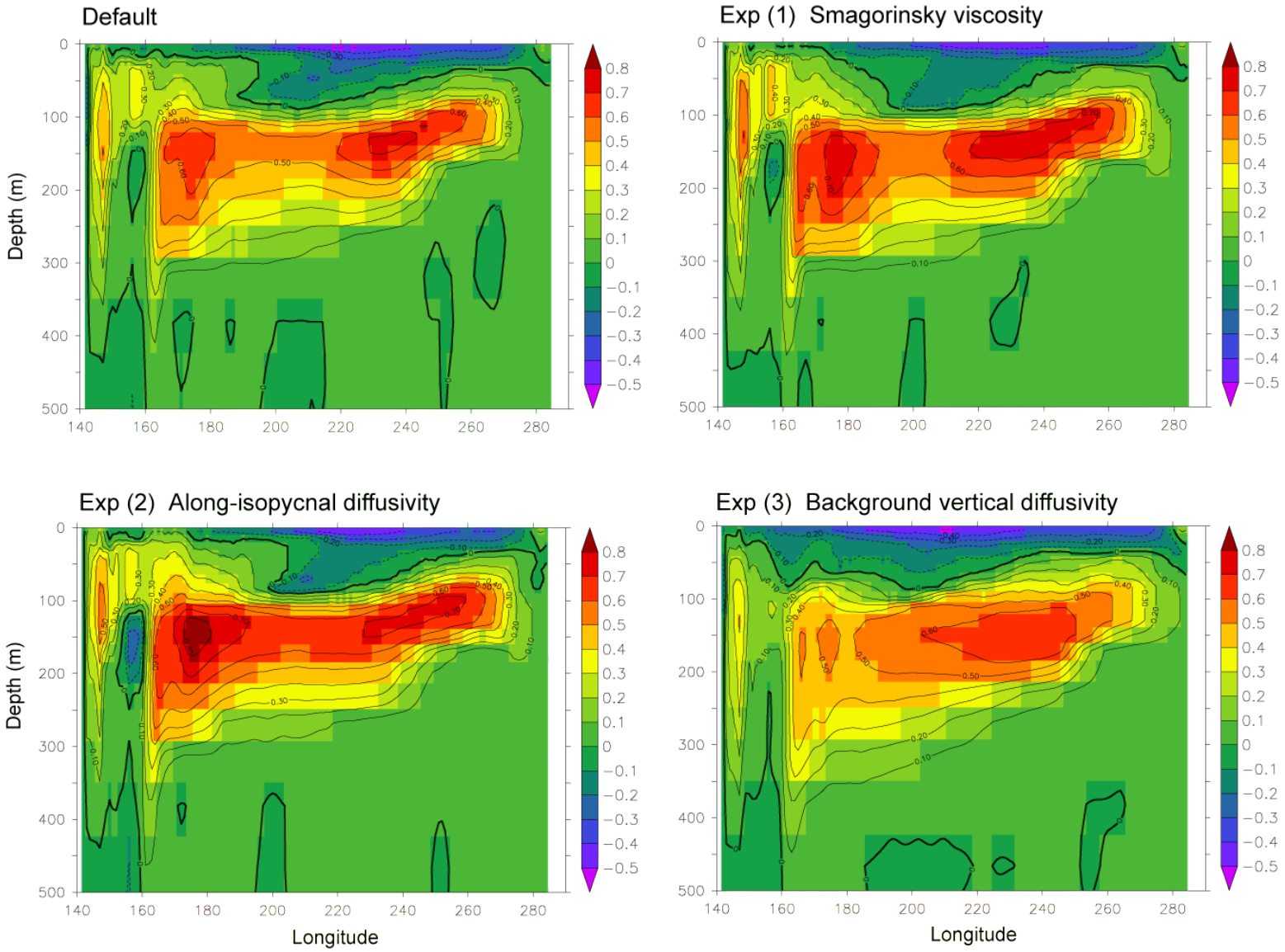


Atlantic Meridional Overturning Circulation (Sv)



The AMOC index is the maximum overturning streamfunction in 500-3000 m at 30°N.

Pacific Equatorial Undercurrent (m/s) years 26-30



Conclusions and Future Work

- The fully coupled CCSM3/HYCOM can realistically simulate many ocean climate features.
- The cold bias in the North Atlantic can be greatly reduced by tuning viscosity and diffusivity.
- The deep convection in the Labrador Sea remains weak in all integrations. We plan to do the following to further improve the model simulation:

  (1) Increase the number of layers from 32 to 50.

  (2) Implement Visbeck variable thickness diffusivity scheme (1997).

  (3) Introduce depth-dependent background vertical diffusivity to mimic topography-induced mixing.

Mixed Layer Depth (m)