Ocean Climate Simulations with Uncoupled HYCOM and Fully Coupled CCSM3/HYCOM

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Outline

• Simulations with Uncoupled HYCOM under CORE forcing
  • Brief review about the CORE
  • Description of HYCOM and POP and salinity forcing
  • The simulation of the Atlantic Meridional Overturning Circulation and closely related fields.

• Simulations with Fully Coupled CCSM3/HYCOM
  • Default simulations
  • Parameter tuning and sensitivity experiments

• Conclusion
The Coordinated Ocean-ice Reference Experiment (CORE)

• Protocol to examine the simulations of ocean-ice models with a consistent forcing (Griffies et al., 2009)

• The atmospheric state is prescribed

  Climatology of Large and Yeager (2004)

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

• CCSM bulk formula
Salinity Forcing

(1) P-E+R

(2) P-E+R + weak restoring \( V_{piston} = 50m/4\text{year} \)

(3) P-E+R + strong restoring \( V_{piston} = 50m/360\text{day} \)

\[
F(x, y, t) = V_{piston} \left[ SSS_{data} (x, y, t') - SSS_{model} (x, y, t) \right] - \langle F \rangle(t)
\]

\( t' = 1, 2, \ldots 12\text{month} \)

HYCOM: \( \langle F \rangle = 0 \)  
  global mean restoring flux is not compensated

POP: \( \langle F \rangle \neq 0 \); additional restoring under sea ice
  (Bill Large, personal communication)

So one should be cautious when comparing the salinity restoring cases
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
MOC

Collapses

Active but weak

Vigorous

Unit: Sv
The MOC index is defined as the maximum streamfunction value at 45°N. A notable difference is the variability of the MOC.
SST Biases

Cooling at high-latitude NA

Reduces
SSS Biases

Large freshening at high-latitude NA

Reduces
Meridional Velocity at 30°N

No deep western boundary current

Strong deep current

Unit: m/s
Two versions of fully coupled CCSM3/HYCOM have been configured: 1 degree HYCOM coupled to T42 and T85 CAM.

Long-term integrations have been obtained with both versions. The simulation results have been compared to observations and those from CCSM3/POP.
SST Biases (°C) with the Default Setting - years 91-100
SSS Biases (psu) with the Default Setting - years 91-100
## Parameter Tuning and Sensitivity Experiments

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<th>Smagorinsky viscosity parameter</th>
<th>Along-isopycnal diffusivity parameter</th>
<th>Background vertical diffusivity parameter</th>
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<td>Exp (3)</td>
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</table>
SST Biases (°C) years 26-30
SSS Biases (psu) years 26-30

Default

Exp (1) Smagorinsky viscosity

Exp (2) Along-isopycnal diffusivity

Exp (3) Background verticle diffusivity
Pacific Equatorial Undercurrent (m/s) years 26-30
Atlantic Meridional Overturning Circulation (Sv)
The AMOC index is the maximum overturning streamfunction in 500-3000 m at 30°N.
Conclusions and Future Work

• Both uncoupled HYCOM and POP cannot simulate an active AMOC under CORE forcing without the application of salinity restoring.

• Once salinity restoring is applied, the AMOC is active in both models. The stronger the restoring, the more vigorous of the AMOC.

• The AMOC shows differences in HYCOM and POP such as its variability. Not clear why this is the case.

• The fully coupled CCSM3/HYCOM shows a cold bias in the northern North Atlantic. This cold bias is can be reduced by varying the Smagorinsky coefficient, along-isopycnal diffusivity and background vertical diffusivity.

• Future studies: Impact of the coordinate distribution, GM mixing and different atmosphere (CAM 4.0)