North Atlantic water mass transformation in OMIP models

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Introduction

Simulations in the Ocean Model Intercomparison Project (OMIP) are all driven by the same atmospheric forcing, yet have a variety of responses

Goal: Evaluate biases in OMIP simulations using surface water mass transformation (WMT)

Objective1:
Compare OMIP1 and OMIP2 WMT to observational WMT benchmarks

Objective 2:
Compare OMIP1 and OMIP2 WMT to AMOC 45 °N

Methods

AMOC streamfunction $\Psi(\sigma) = -\int_{\sigma_b}^{\sigma}\int_{x_w}^{x_e} v\, dx d\sigma$

WMT = The transformation of water from one density class to another

$$WMT_{sfc}(\sigma) = \frac{1}{\Delta\sigma}\iint \boldsymbol{f}\, dA_\sigma$$

Density flux

$$\boldsymbol{f(x,y,t)} = -\frac{\alpha}{c_p} f_{heat} + \beta f_{salt}$$

Relationship between AMOC and WMT

$$\Psi(\sigma) = WMT_{sfc}(\sigma) + WMT_{mix}(\sigma) - \frac{\partial V}{\partial t}$$

$$\Psi(\sigma) \approx WMT_{sfc}(\sigma)$$

Acknowledgements

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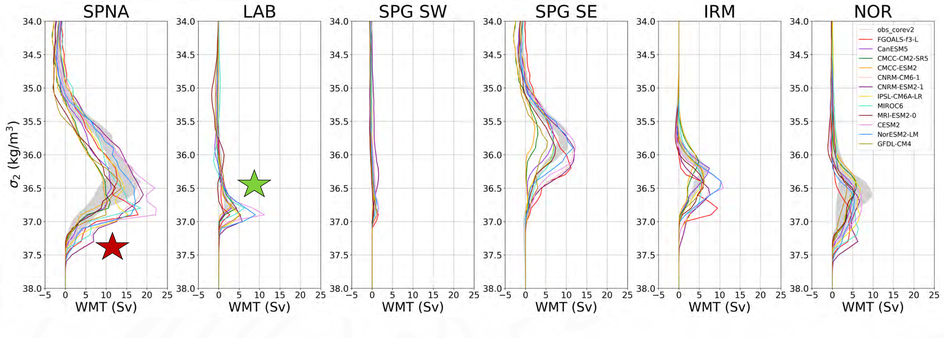
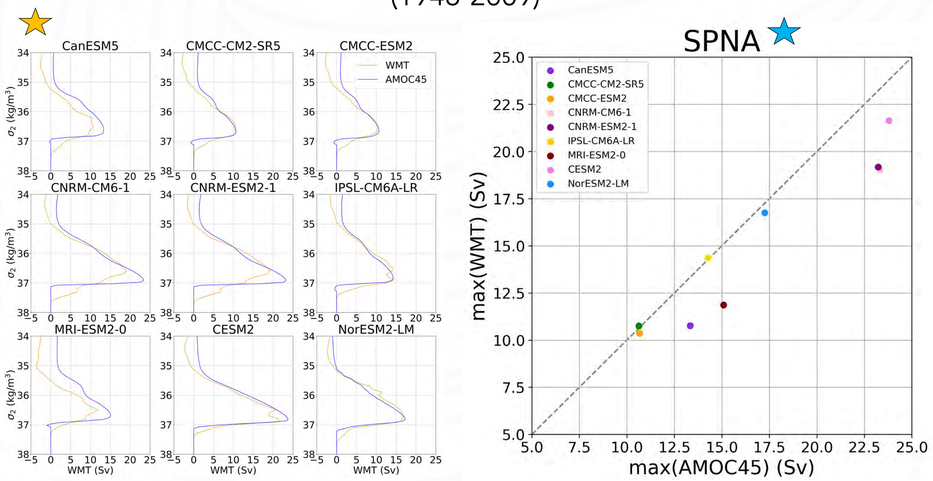
OMIP1 (5th cycle)

COREv2 Forced ocean-sea-ice models

Model vs Observation-based WMT (1992-2009)



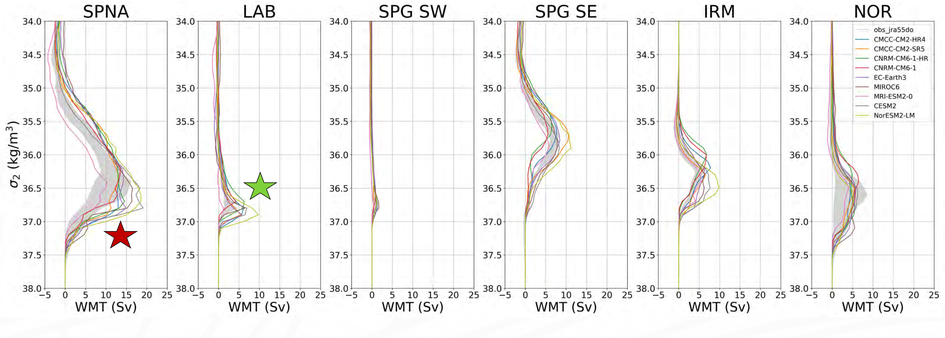
WMT vs AMOC 45 °N (1948-2009)



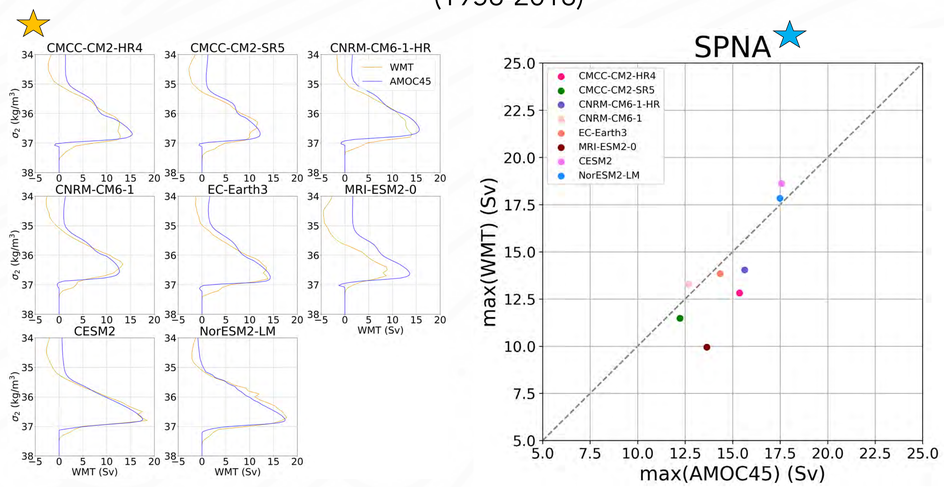
OMIP2 (6th cycle)

JRA55-do Forced ocean-sea-ice models

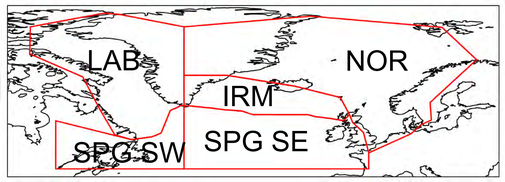
Model vs Observation-based WMT (1992-2009)



WMT vs AMOC45 °N (1958-2018)

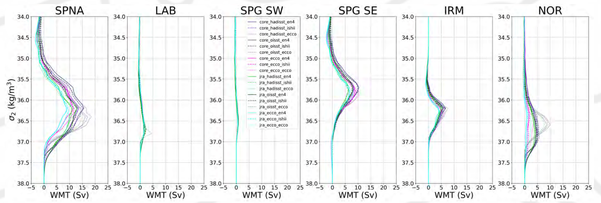


Regions



SPNA = LAB + SPG SW + SPG SE +IRM +NOR

Observation-based WMT



Key Takeaways

- OMIP WMT has a higher magnitude and is shifted towards denser density classes in the SPNA relative to the observation-based estimates. The shift can be attributed to the LAB, IRM, and NOR regions
- AMOC at 45°N and WMT from 45°N to the Nordic seas agrees well in both OMIP simulations with discrepancies likely due to internal mixing
- Most OMIP simulations have too much WMT in the Labrador Sea
- The spread in max WMT and max AMOC 45°N is reduced in OMIP2