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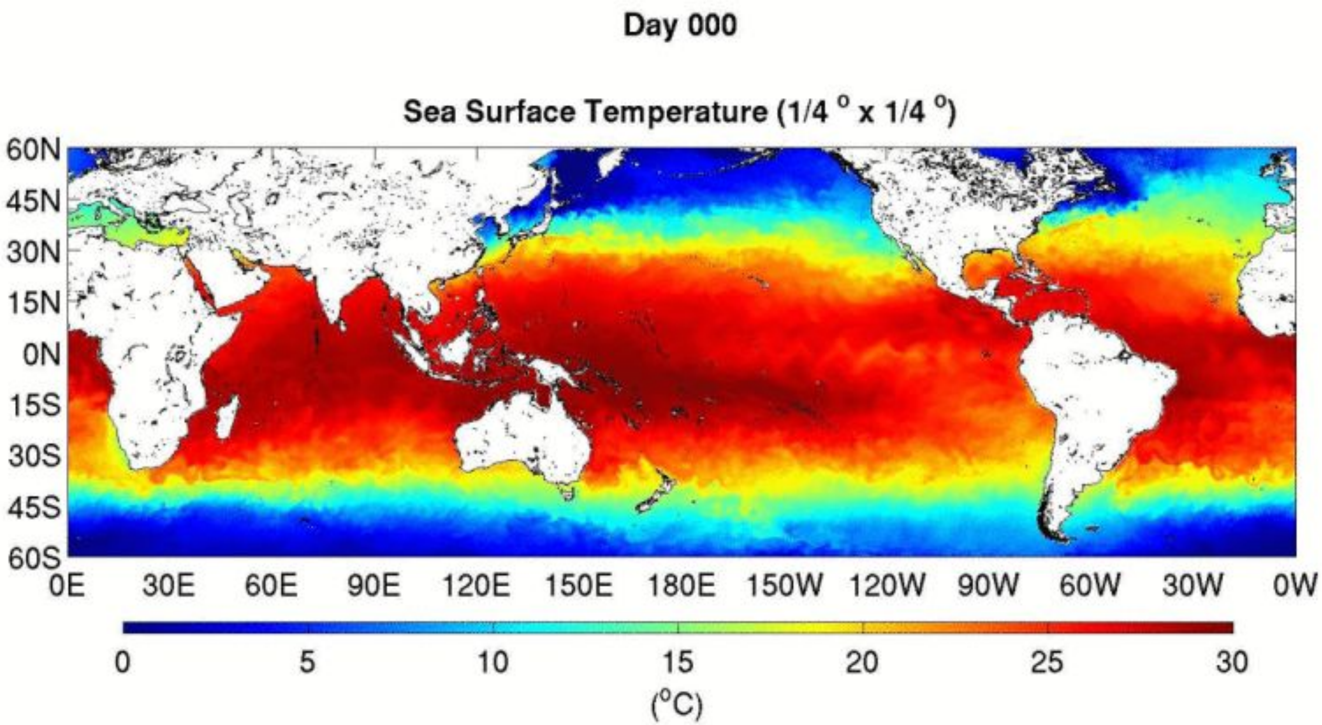
Simulating Recent AMOC Recovery after 2010 in OMIP2 experiments



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CMIP6-Endorsed MIPs

Tsujino et al. (2020)


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Geos
Model Devel

Evaluation of global ocean–sea-ice model simulations bas experimental protocols of the Ocean Model Intercomparis phase 2 (OMIP-2)

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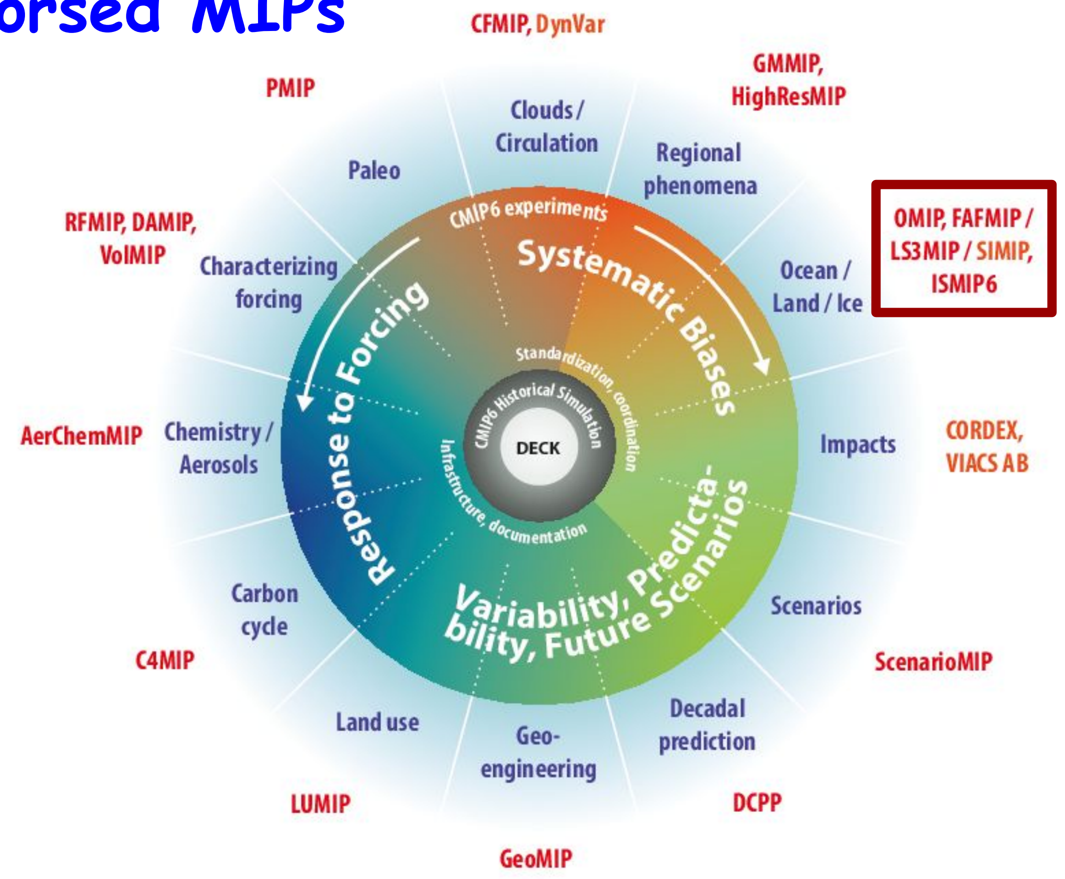
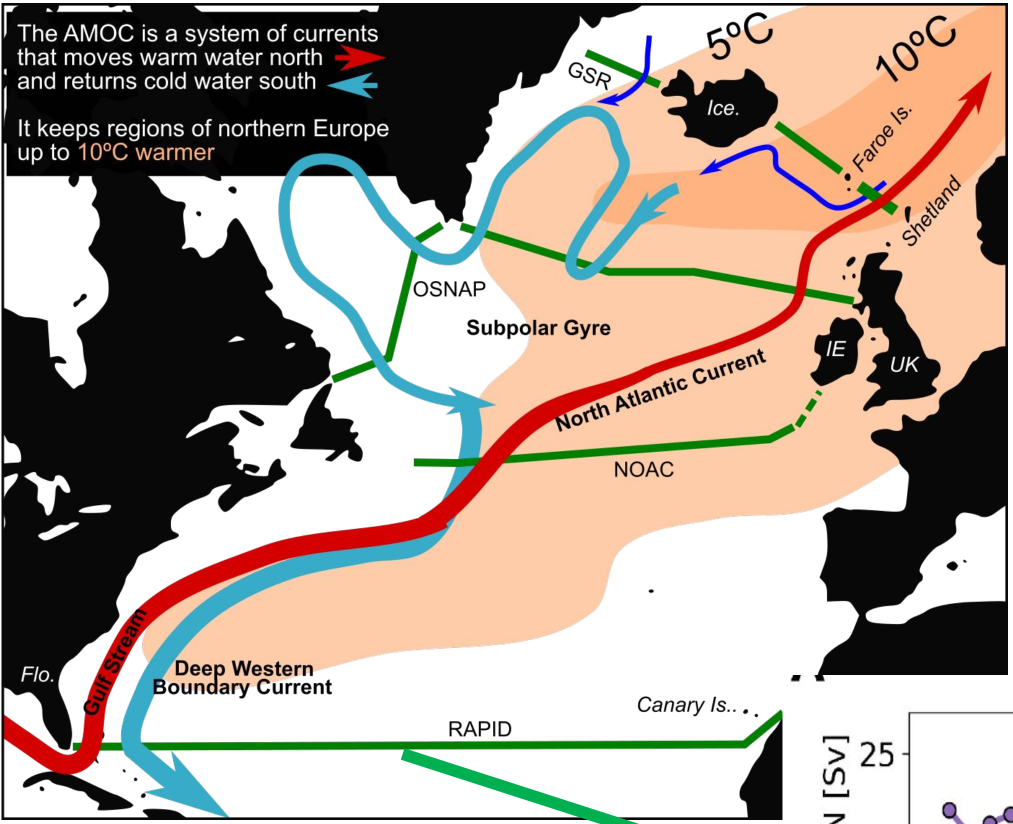


OMIP1 (CORE-IAF)/OMIP2 (JRA55-do)

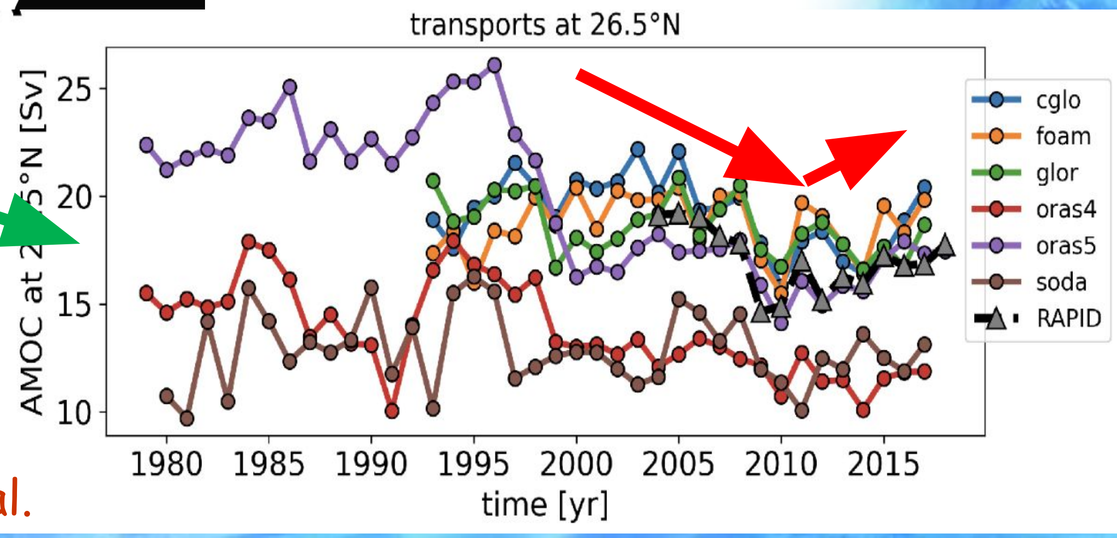
JRA55-do: higher resolution, self-consistent, and near real-time

366 years (1958~2018 x 6 cycles)

AMOC and AMOC transport in ocean reanalysis



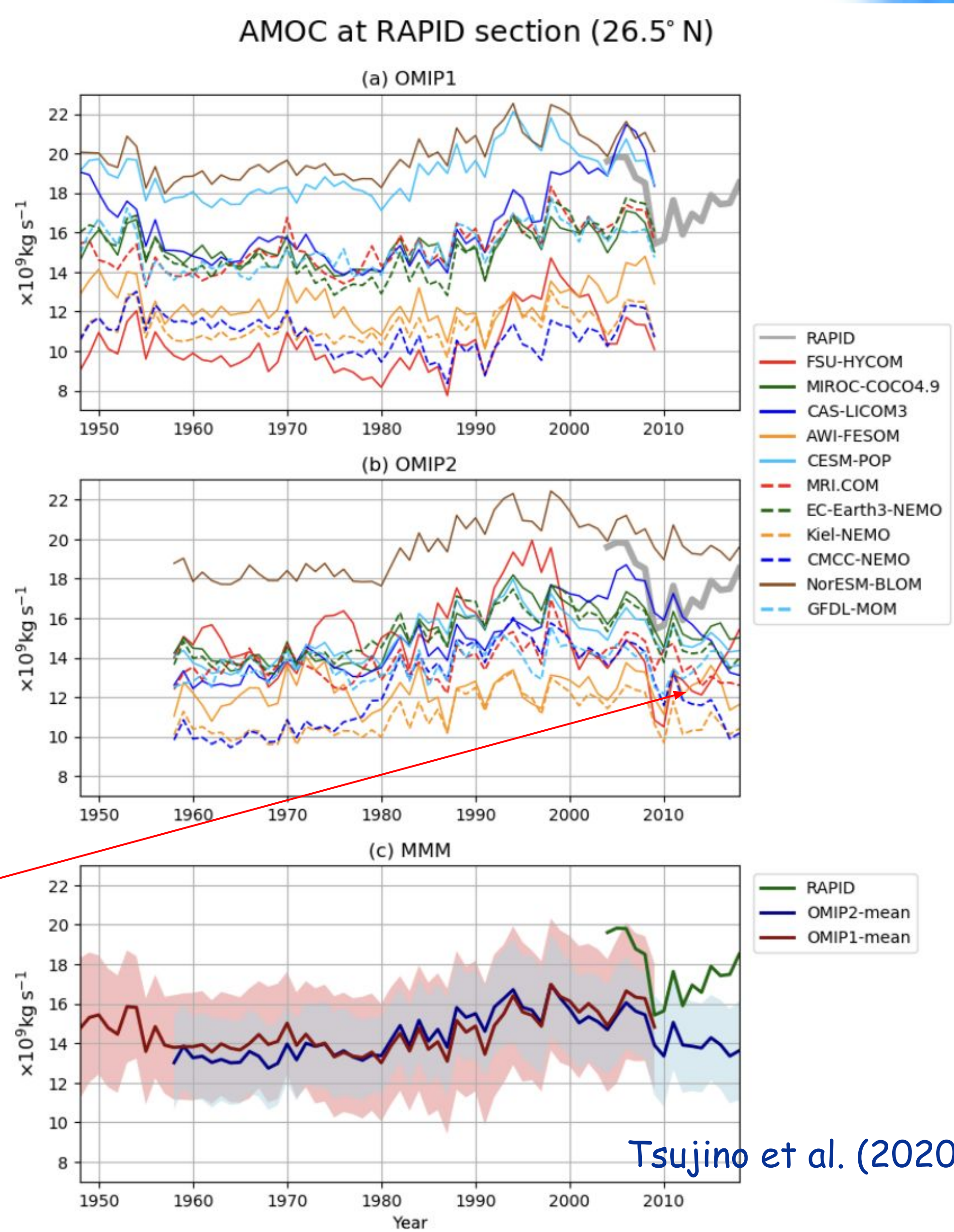
- Most reanalysis data show reasonable transport (except SODA/ORAS4)
- Increasing trends after 2010



De Toma et al.

Comparison of AMOC transport in OMIP2

Most models show non-increasing trends after 2010.



Tsujino et al. (2020)

Model name	Configuration	Ocean model and version	Sea-ice model and version	Horizontal grid (arrangement)	Orientation	Nominal horizontal resolution
AWI-FESOM		FESOM v1.4	FESIM v2	unstructured	displaced	1°*
CAS-LICOM3		LICOM3	CICE4	structured (B)	tripolar	1°*
CESM-POP		POP2	CICE 5.1.2	structured (B)	displaced	1°*
CMCC-NEMO		NEMO v3.6	CICE 4.1	structured (C)	tripolar	1°*
EC-Earth3-NEMO	ORCA1	NEMO v3.6	LIM 3	structured (C)	tripolar	1°*
FSU-HYCOM		HYCOM	CICE 4.1	structured (C)	tripolar	0.72°*
GFDL-MOM	OM4	MOM6	SIS2	structured (C)	tripolar	1/4 °
Kiel-NEMO	ORCA05	NEMO v3.6	LIM 2	structured (C)	tripolar	0.5°
MIROC-COCO4.9		COCO4.9	COCO4.9	structured (B)	tripolar	1°*
MRI.COM	GONDOLA100	MRI.COMv4	CICE3, Mellor and Kantha (1989)	structured (B)	tripolar	100 km*
NorESM-BLOM		BLOM	CICE 5.1.2	structured (C)	tripolar	1°*

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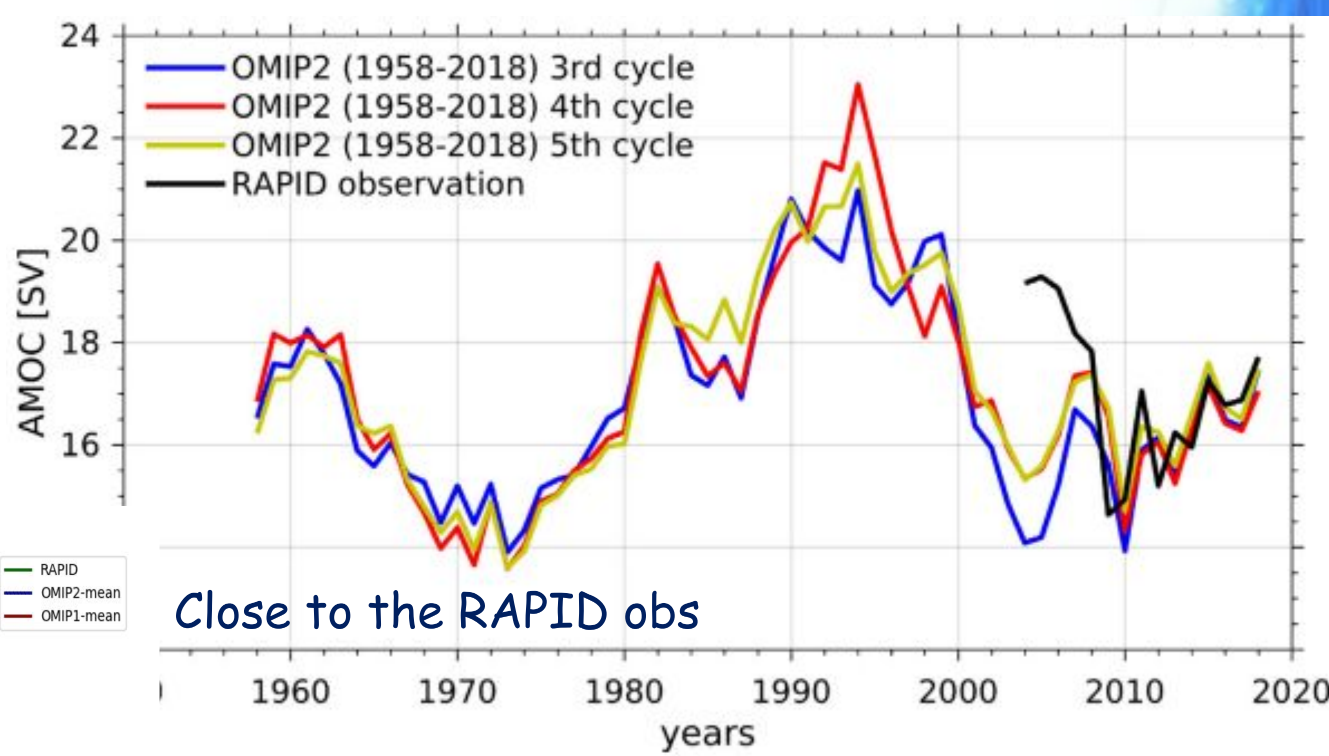
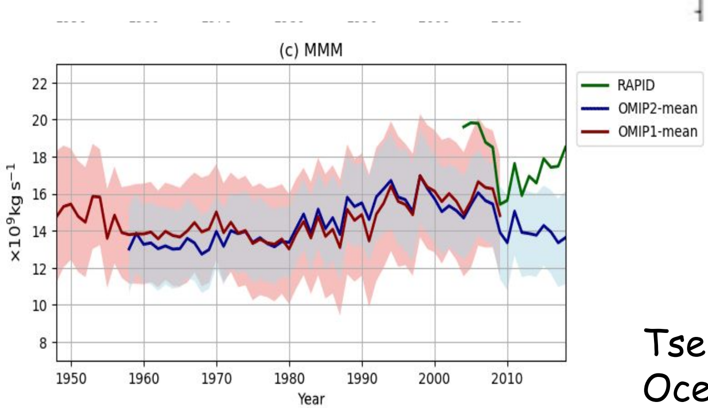
Taiwan Multiscale Community Ocean Model

Model	Ocean model	Sea Ice model	Horizontal grid	Orientation	Nominal resolution	Vertical grid
TaiESM1-TIMCOM	TIMCOMv1.8	CICE4.1	Structure (A+C)	Gaussian (symmetric bc at north pole)	1.125° (320x288)	Z(45)

- *Primitive*, hydrostatic equation
- Fourth-order combined Arakawa A and C-grid
- Free surface
- KPP vertical mixing
- GM parameterization



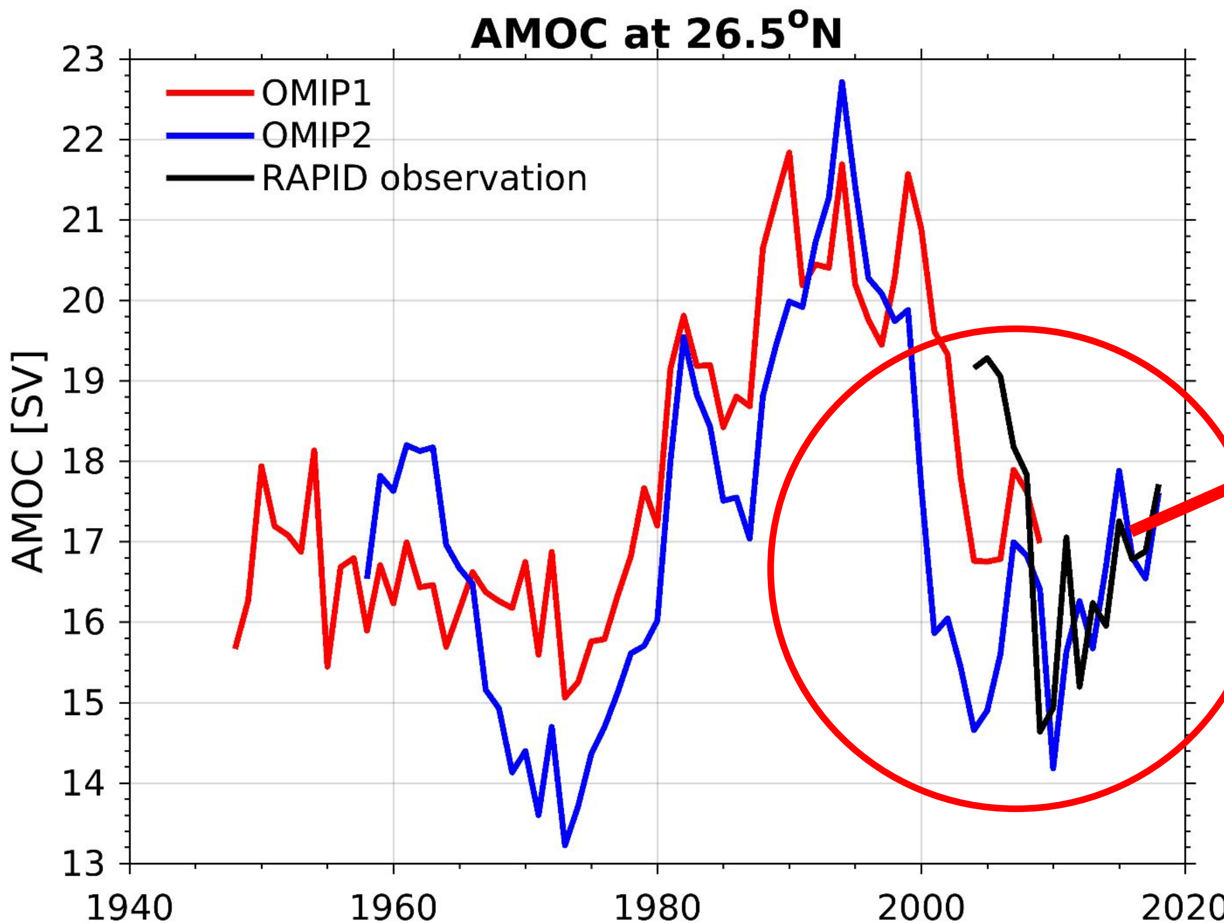
Close to the RAPID obs

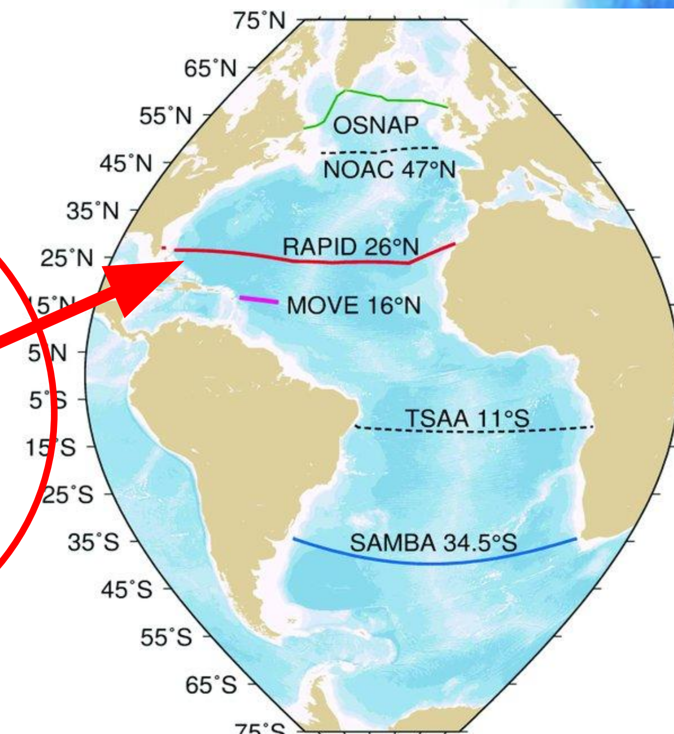


Tseng et al. (2022), "TIMCOM model datasets for the CMIP6 Ocean Model Intercomparison Project," Ocean Modell., 179, 102109

AMOC time series (26.5°N)

TIMCOM successfully resolve a recent AMOC increase since 2010, matching observation from the RAPID array.

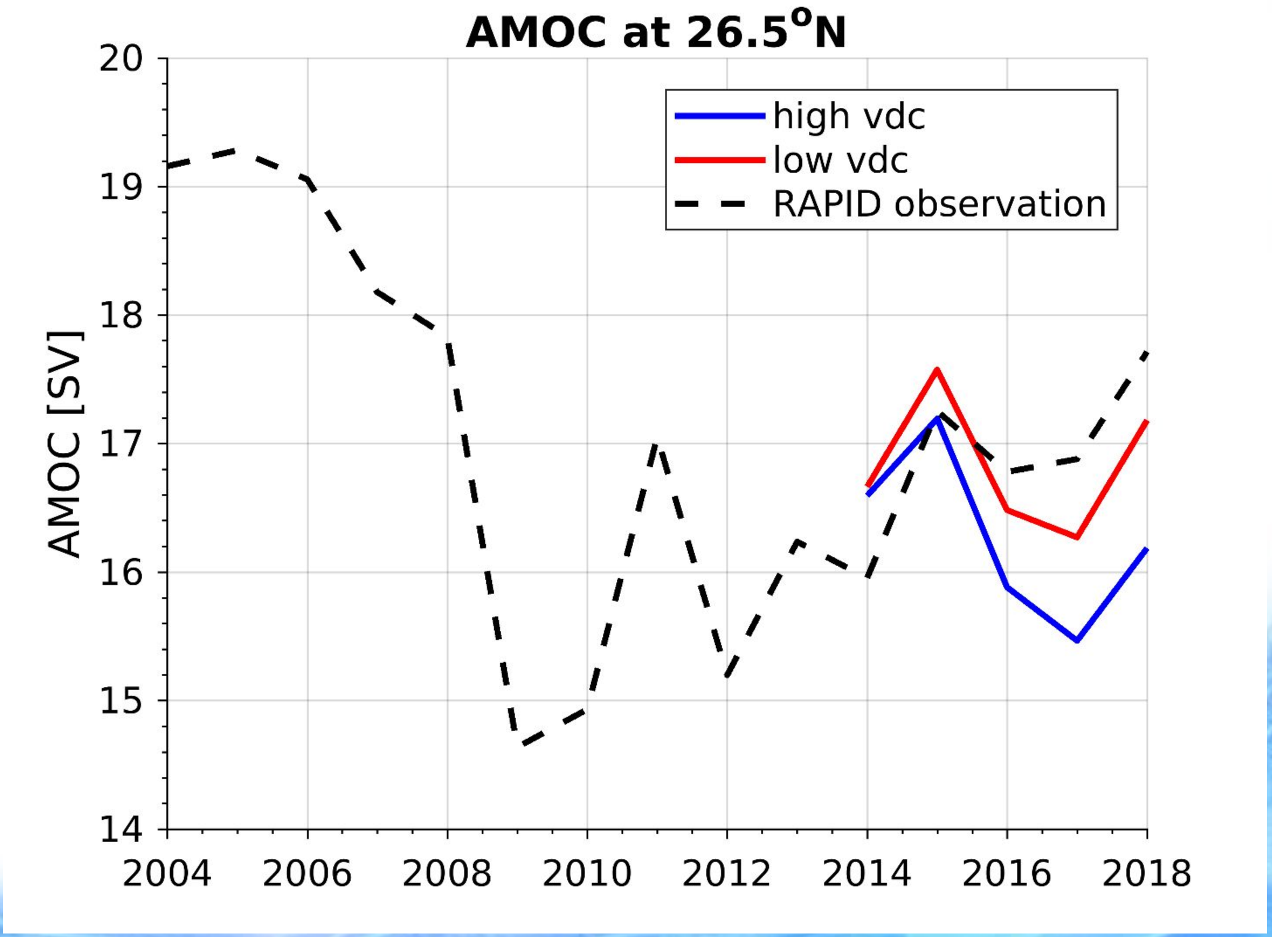




Key to simulate AMOC variability

- A lower surface vertical mixing (VDC) for salinity is the key to reproduce the AMOC increase in the recent years

- Comparison between High VDC (10 times larger) and Low VDC



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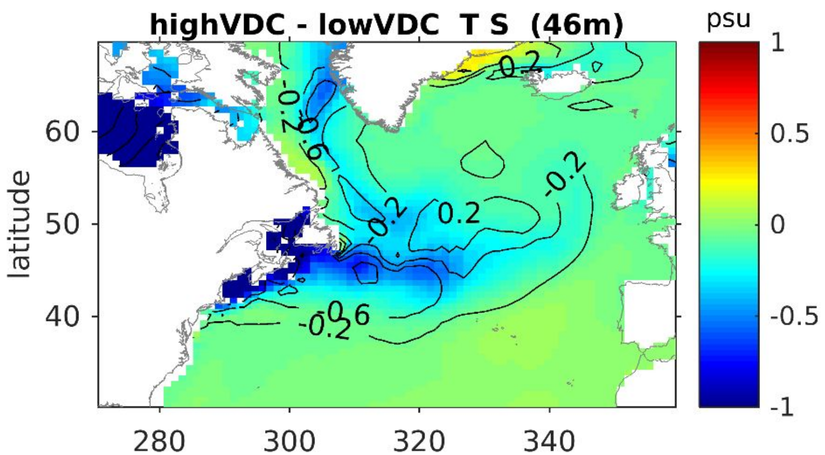
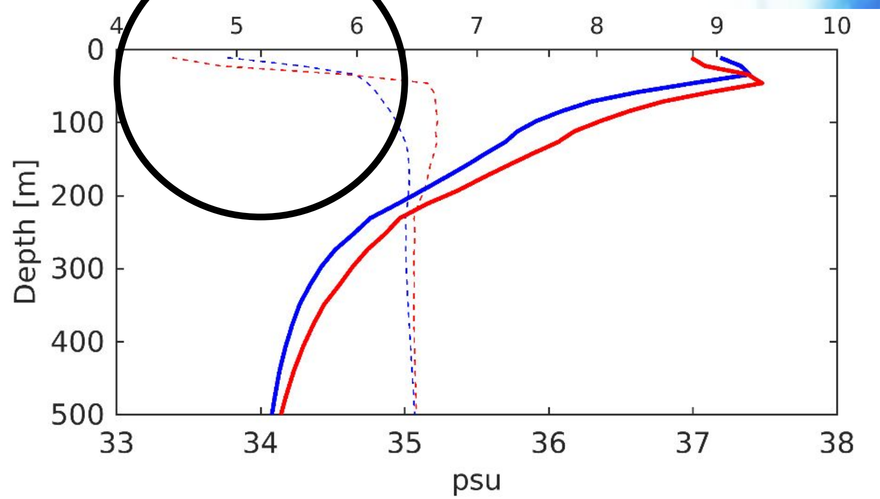
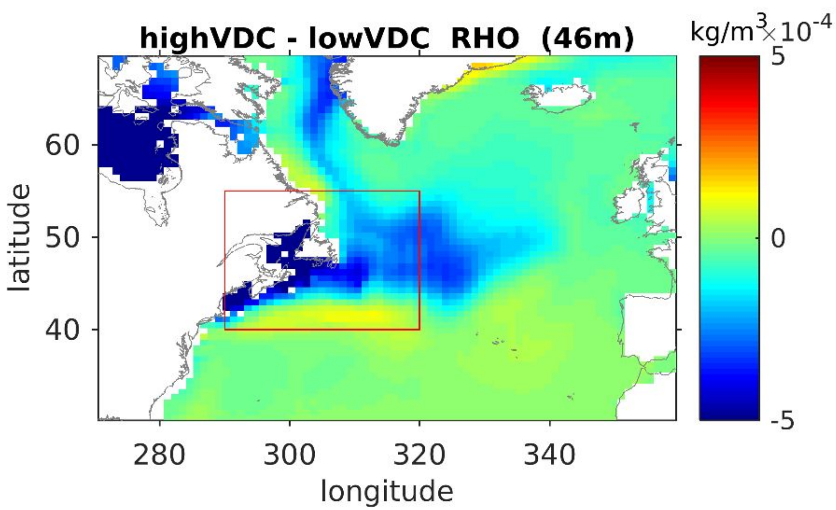
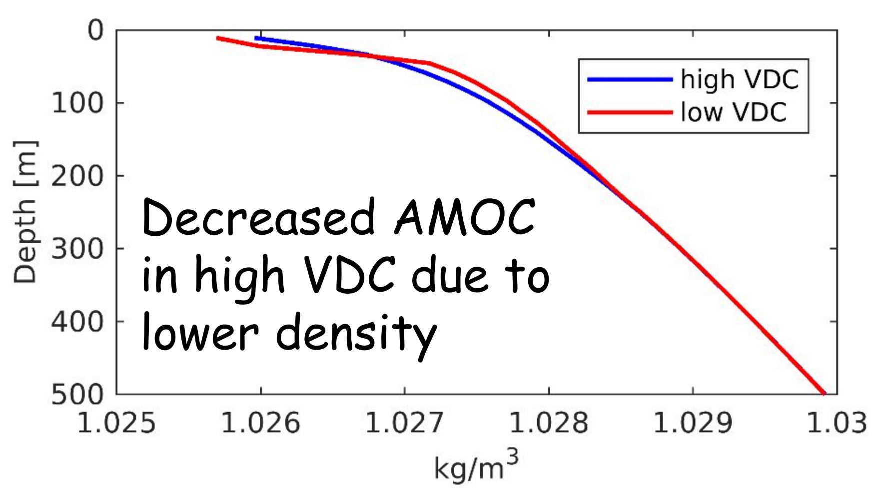
Key to simulate AMOC variability

- Weaker VDC for salinity isolates surface from mixing with subsurface layers, to keep the signals of temperature variability during the cold event in the recent five years.









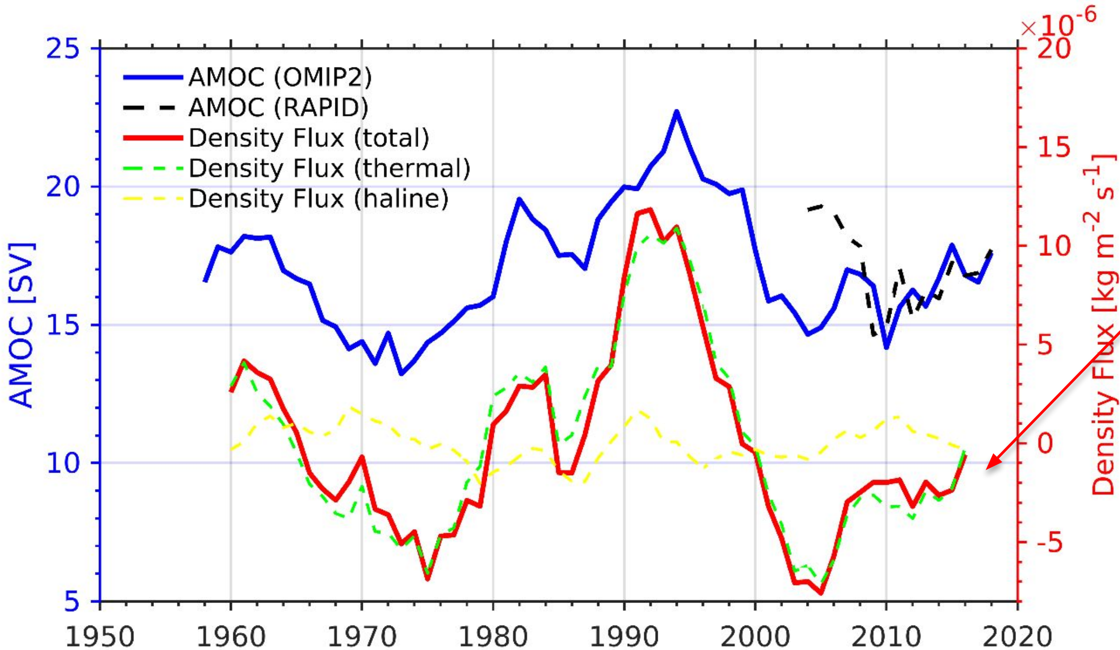
Recent driver of AMOC increase

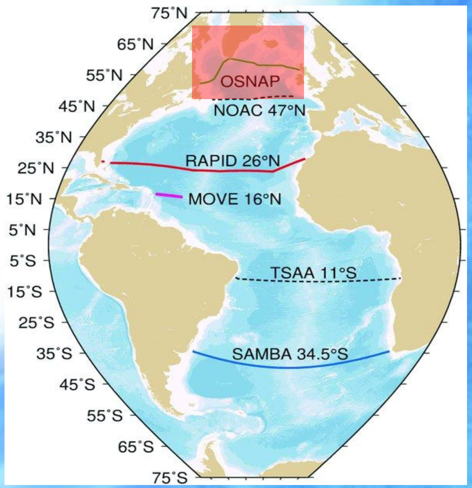
Strength of AMOC primarily driven by density anomalies in deep water formation sites (Danabasoglu et al., 2012).

$$D = \frac{\alpha(T,S)}{C_p Q} + \rho_0 \beta(T,S) \frac{S}{(1-S)}(E-P)$$

(thermal effect) (salinity effect)

The recent increase in AMOC is primarily controlled thermally by the surface cooling in the high latitude of North Atlantic (Josey et al., 2018)





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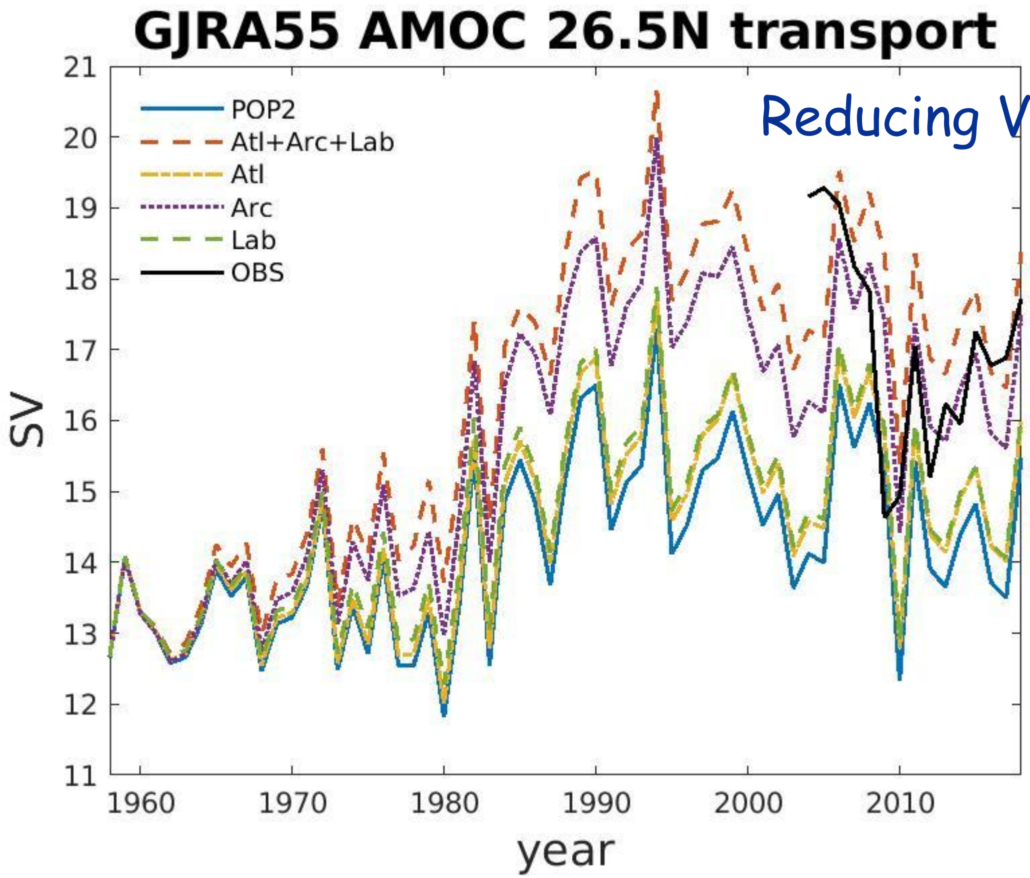
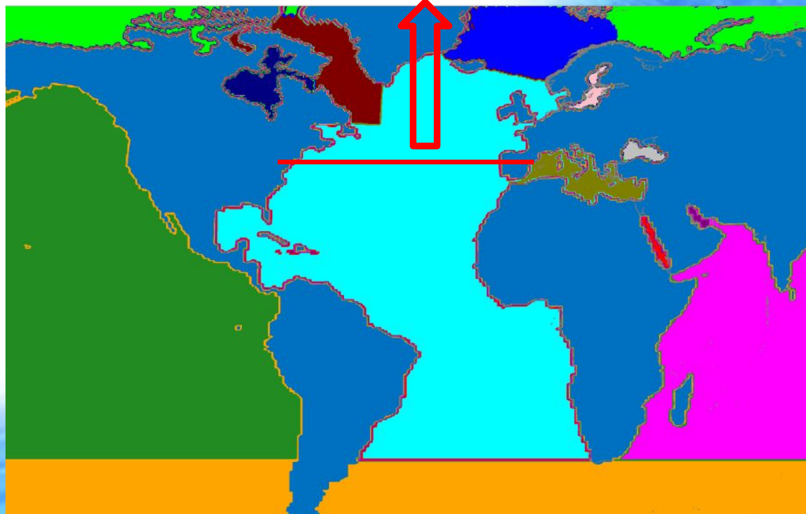
AMOC time series (26.5°N) in POP

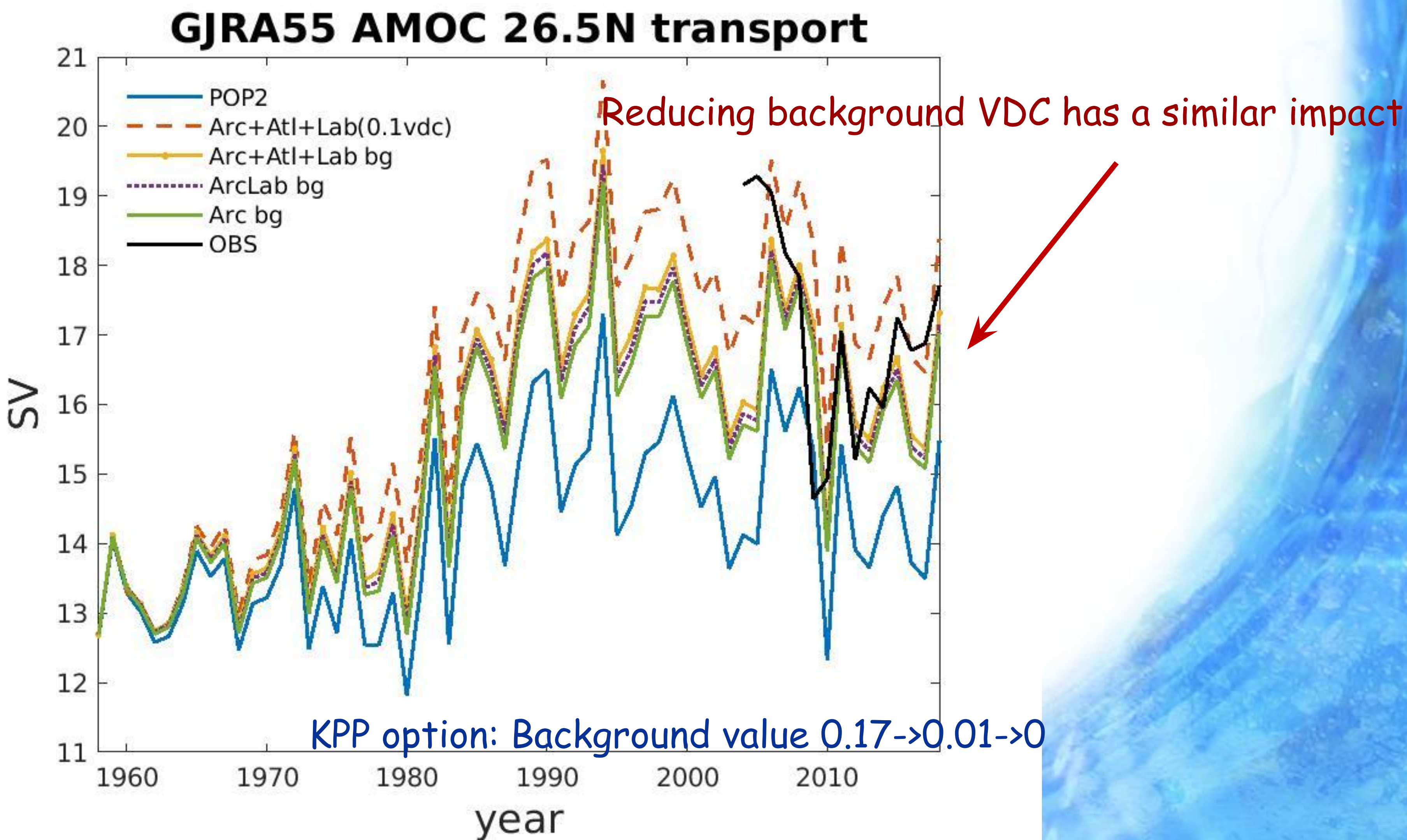


Reducing VDC to 1/10 VDC (top 30m salinity)

Arctic region dominates



AMOC time series (26.5°N) in POP

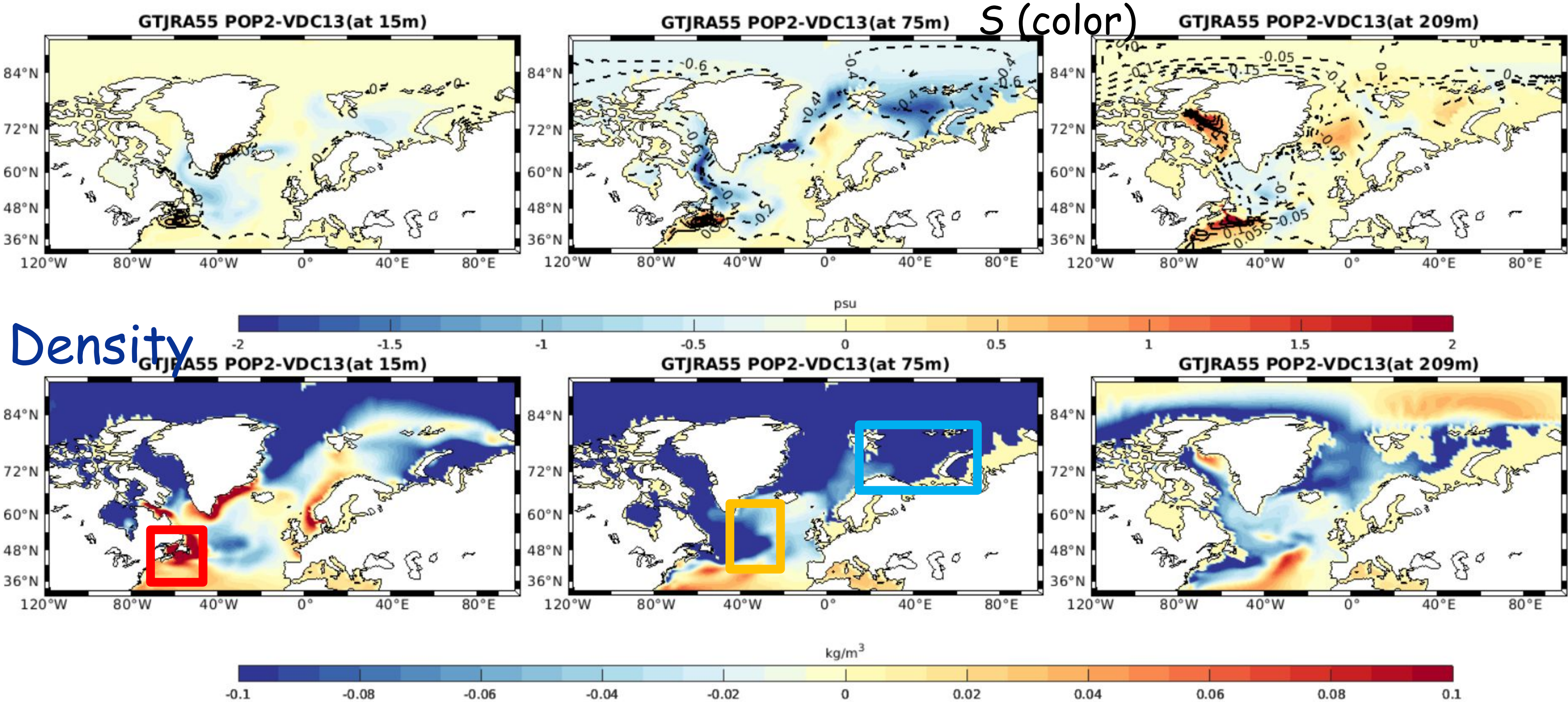


POP2-0.1VDC

15m 75m 209m

T (contour)
S (color)

Density



Overall saltier and heavier in the 0.1VDC simulation

Conclusion

- Both TIMCOM and POP2 may show reasonable AMOC transport after 2010
- Better AMOC variability requires small eddy diffusivity within KPP for Arctic salinity
- Recent increase in AMOC primarily controlled thermally by the surface cooling in the high latitude of North Atlantic
- Can small eddy diffusivity generate accurate Arctic stratification?

Thank you!

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