Exploration of new POP grids for CESM2

Steve Yeager

thanks to Fred Castruccio and Mike Levy

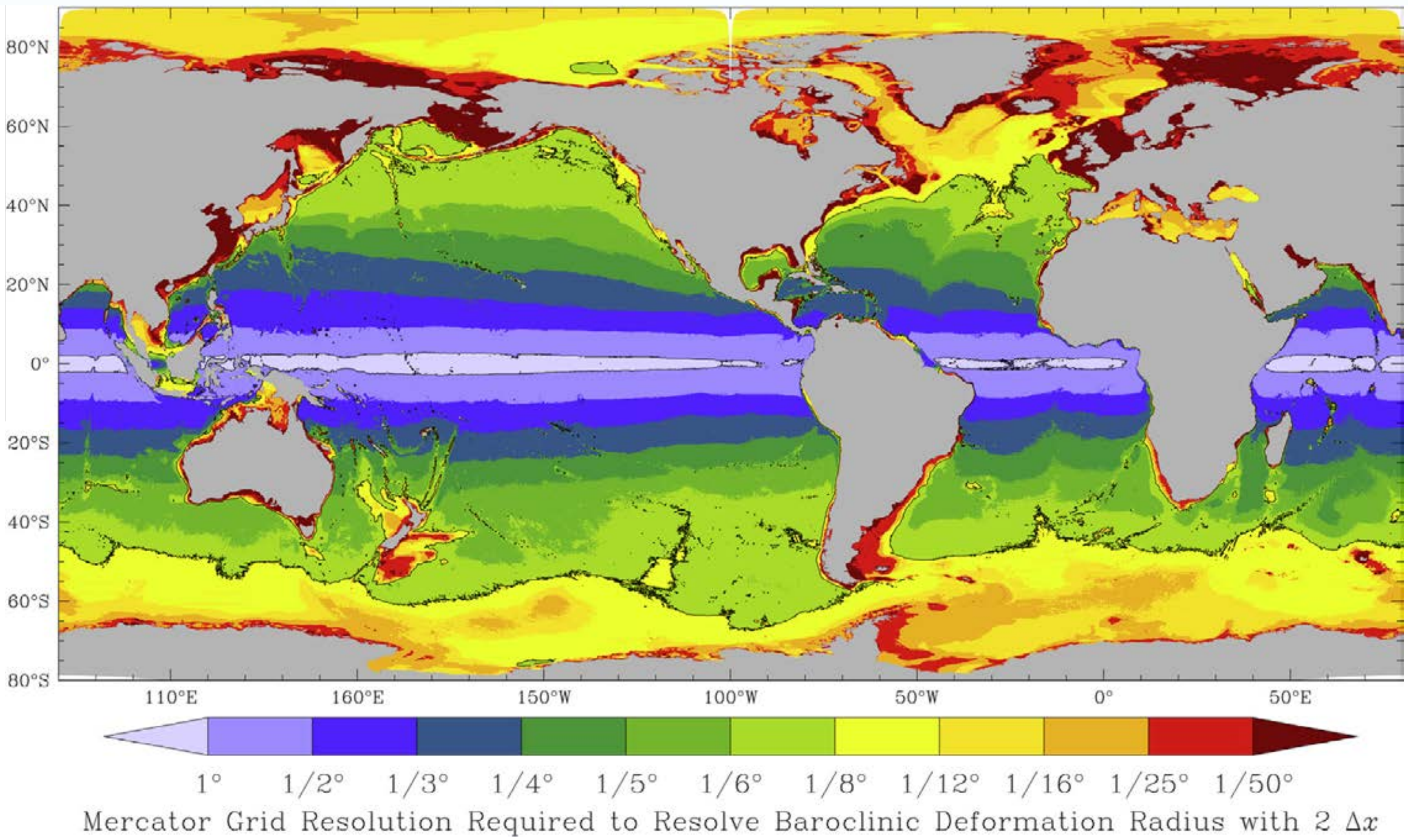
Intro

- Last year's OMWG & Breckenridge meetings:

  Can we improve upon O(1^{o}) POP ocean solutions with a modest/affordable increase in horizontal and/or vertical resolution?

- gx1 has been the CCSM workhorse for 10+ years-- is cheap enough that it is now routinely used in "paleo" applications (e.g. coupled ensembles of Last Millenium)

- Assess potential benefits of extra resolution while avoiding eddy-permitting regime ➔ nominal ½-degree resolution



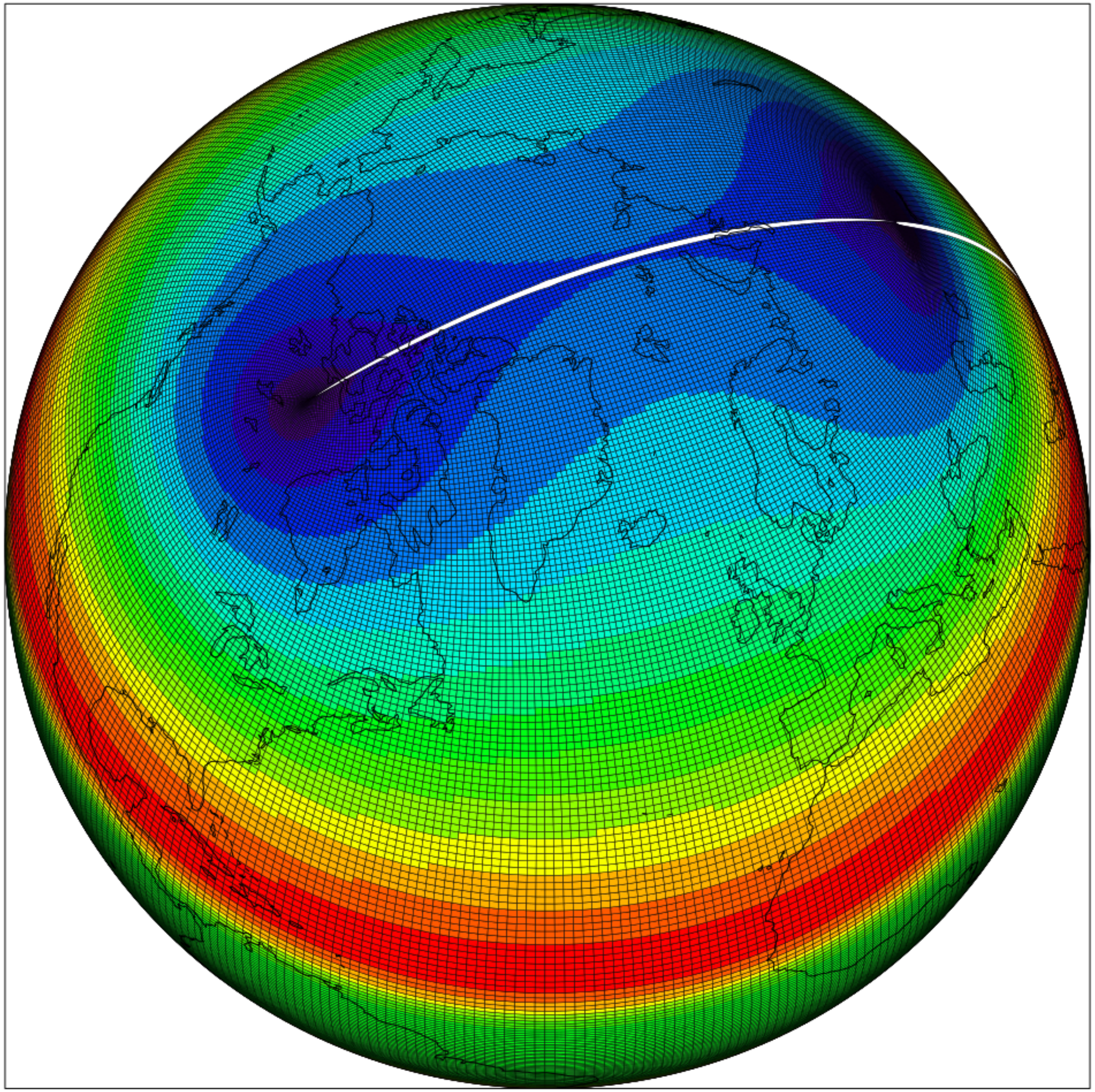
"…one should ask *where*, not *whether,* a global ocean model can explicitly represent eddies." Hallberg (2013)

New 0.5° tripole grid for POP

★ tx0.5v1:
nlon=720, nlat=572
nz=60

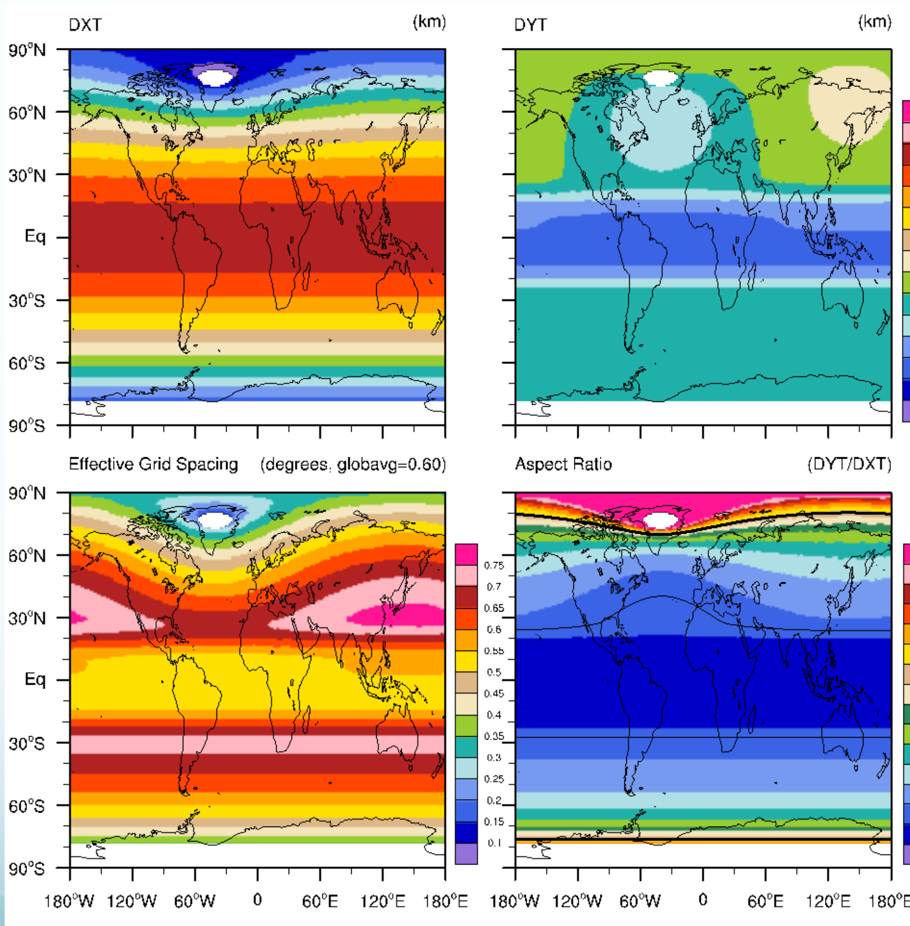
- gx1v6:
nlon=320, nlat=384
nz=60

➔ 3.4x more grid points than gx1v6

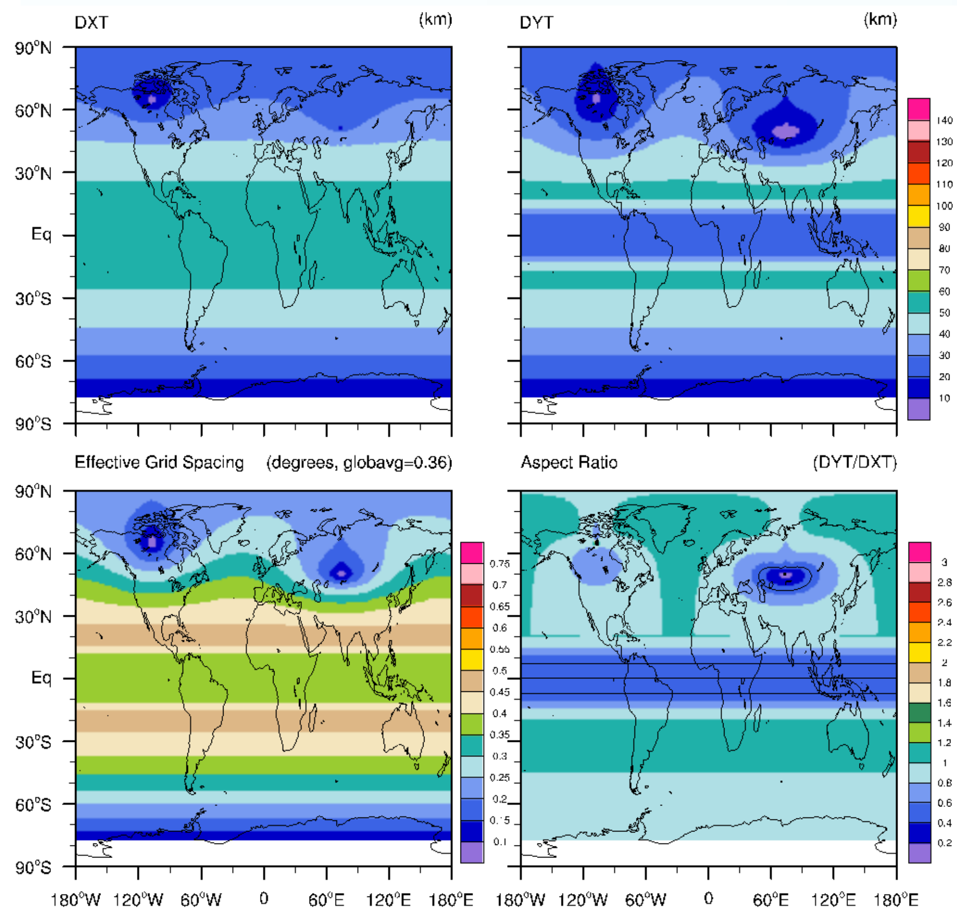


Horizontal mesh

gx1v6

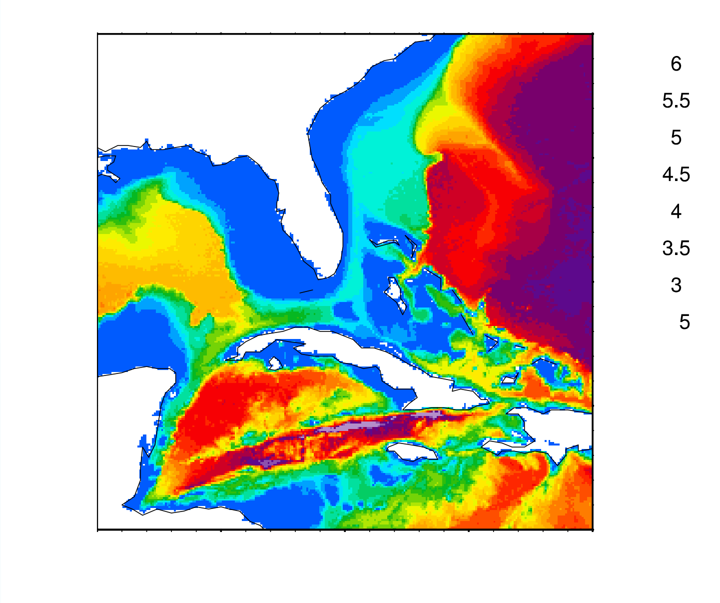


tx0.5v1

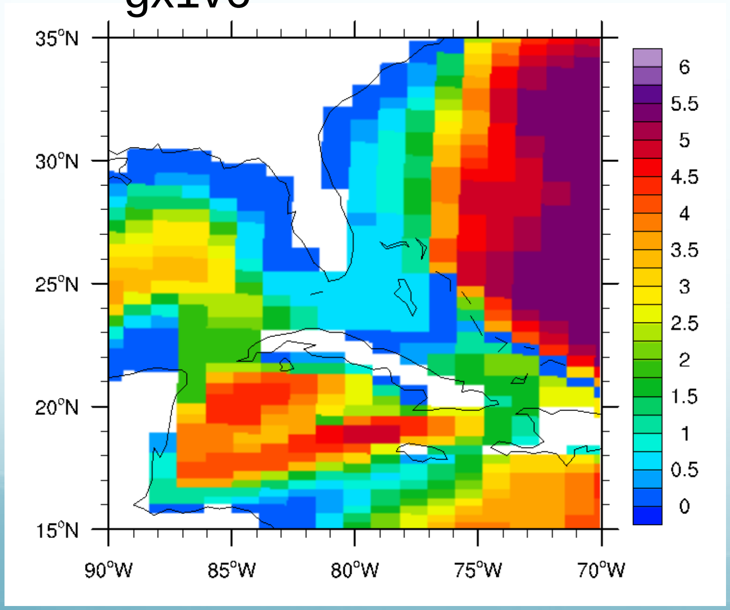


Ocean Bathymetry (km)

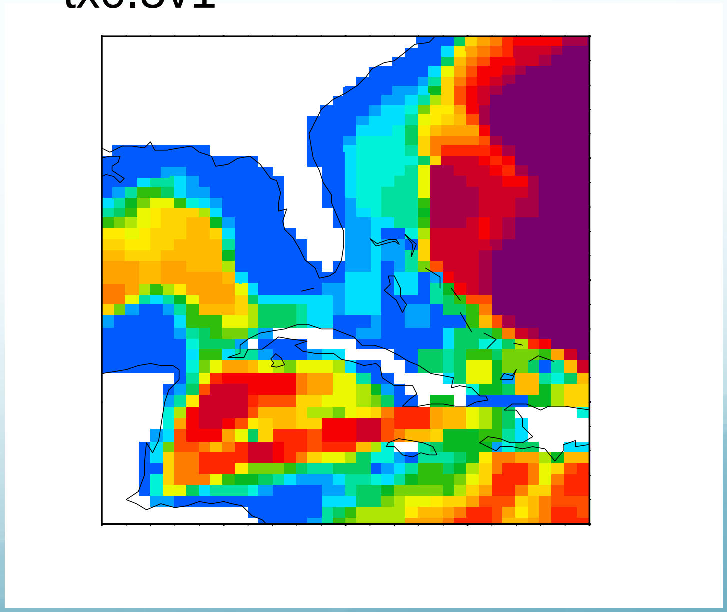
1/30º ETOPO2



gx1v6



tx0.5v1



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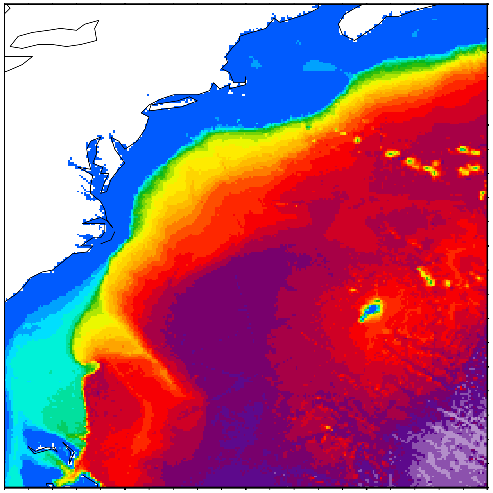

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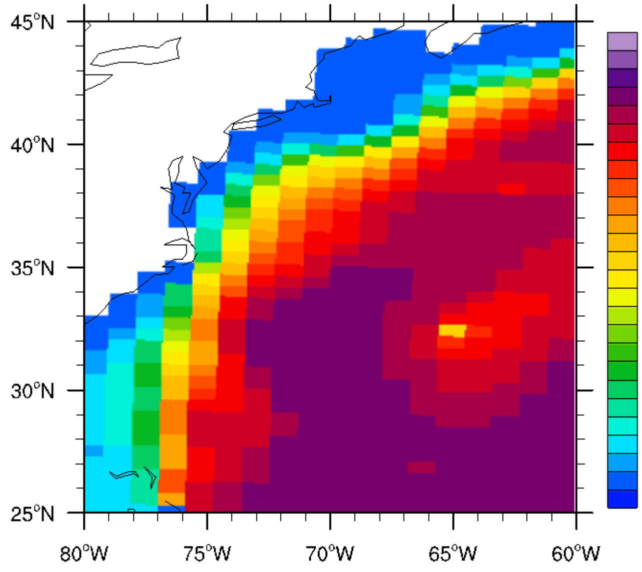

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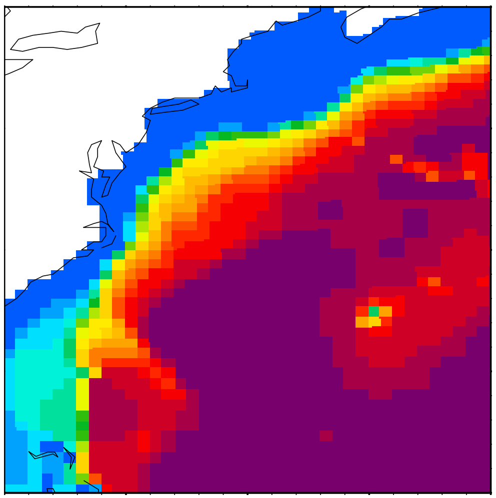

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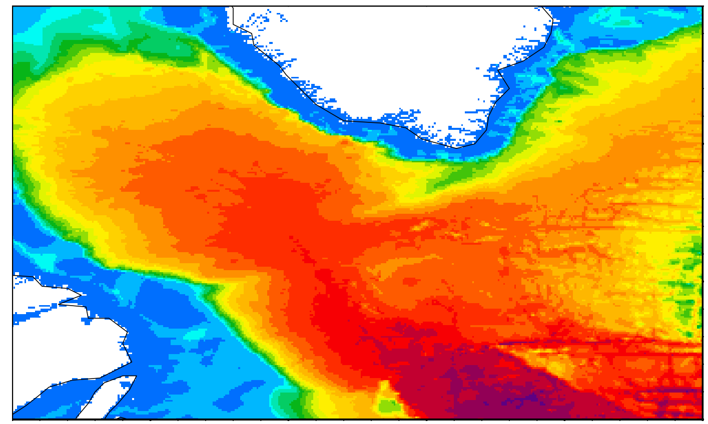
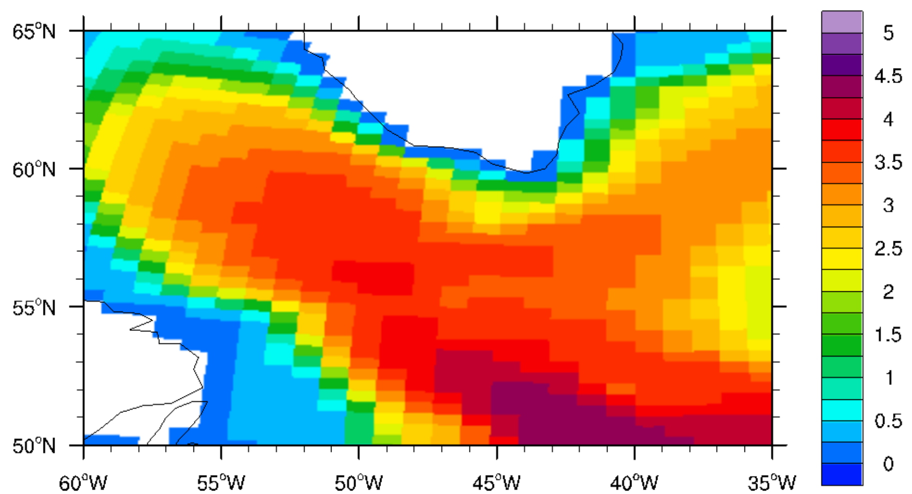


gx1v6



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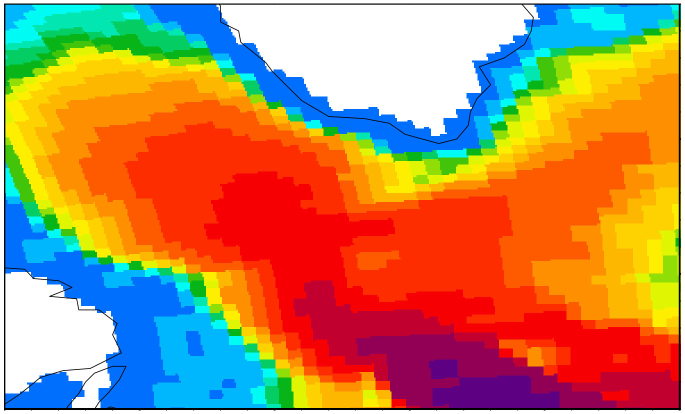

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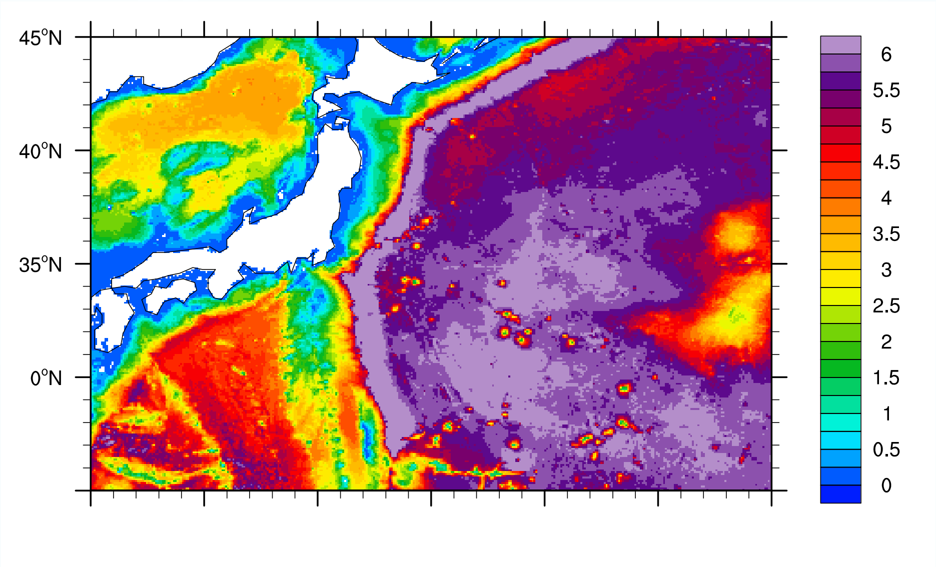
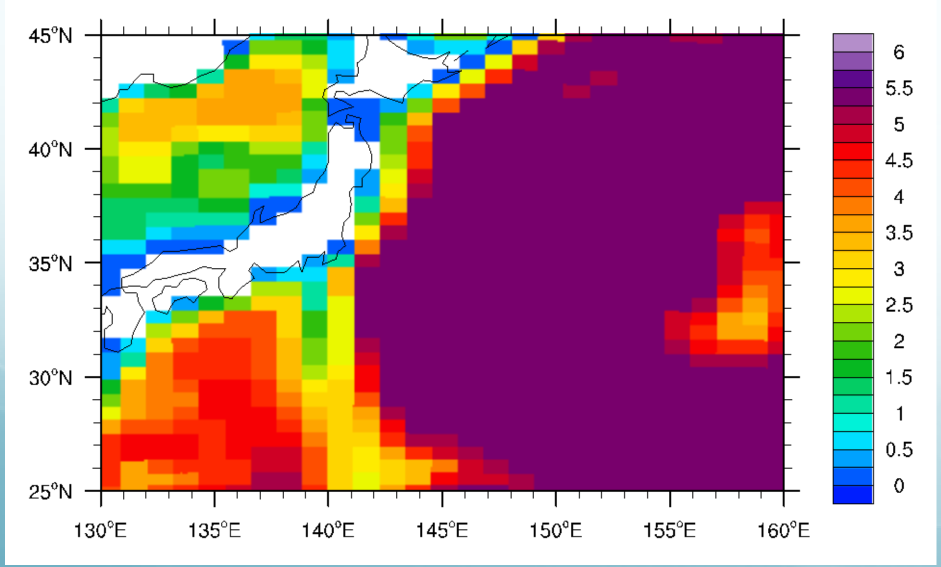


gx1v6



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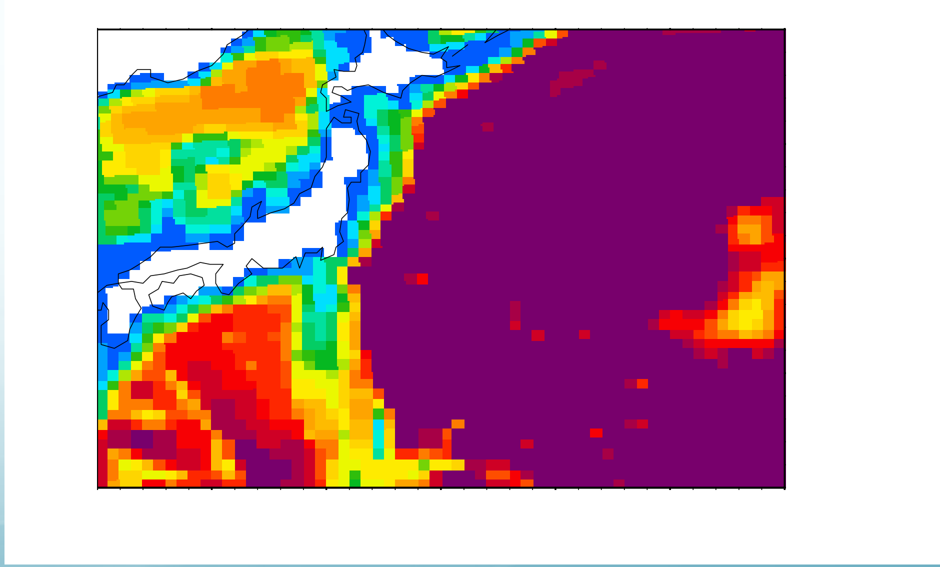


Experiments

“gx1v6” vs. “tx0.5v1”

- G compset (coupled ocean/ice)
- CORE-II interannual forcing (1948-2011)
- Started from state-of-rest, PHC/Levitus TEMP/SALT
- Ice ic’s from spun-up gx1v6 CORE-II hindcast
- 1st cycle analyzed*
- tx0.5v1 has not been tuned*
- Overflow parameterization turned OFF*
- No BGC*
- Very preliminary results*

* caveats

Cost

“gx1v6” vs. “tx0.5v1”

- G compset (gx1v6):
  - POP Δt ~ 63 min   (dt_count=23)
  - ~ 0.8 wall clock hours/sim.yr.*
  - ~ 153 CPU-hours/sim.yr.

5.4x

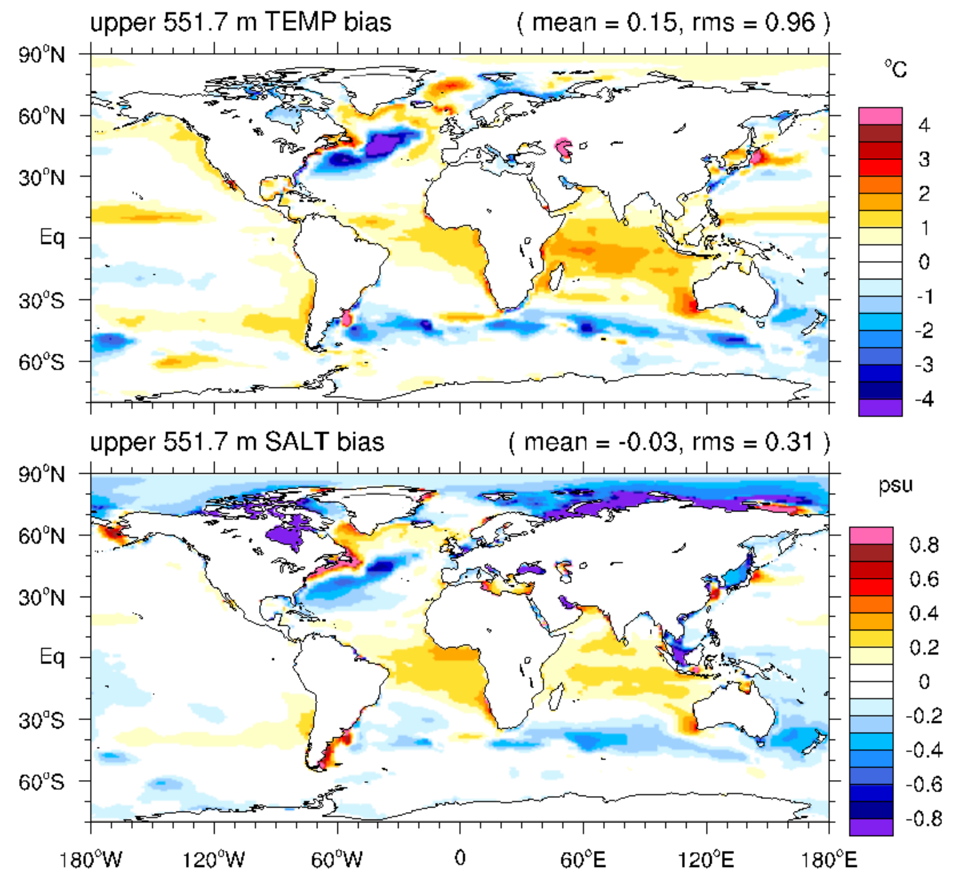
- G compset (tx0.5v1):
  - POP Δt ~ 45 min   (dt_count=32)
  - ~ 4.5 wall clock hours/sim.yr*
  - ~ 830 CPU-hours/sim.yr.

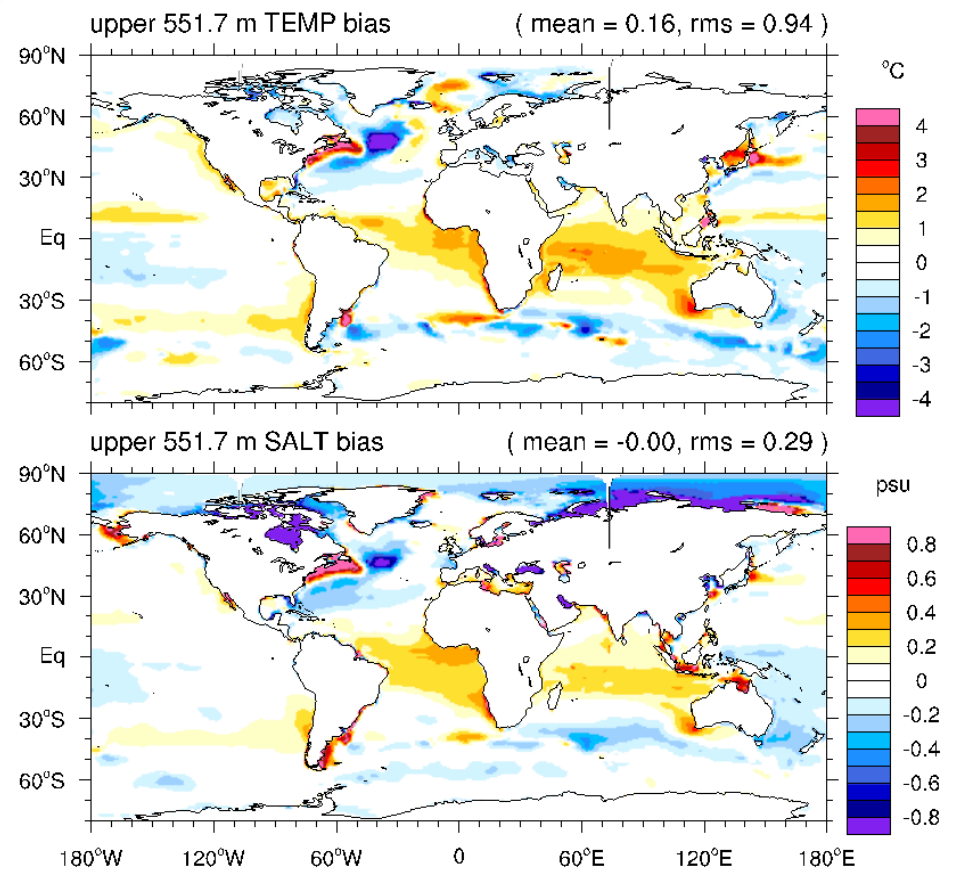
* 6 yellowstone nodes; tx0.5v1 layouts have not been optimized

Mean (1979-1998) upper 552m T,S bias

gx1v
6

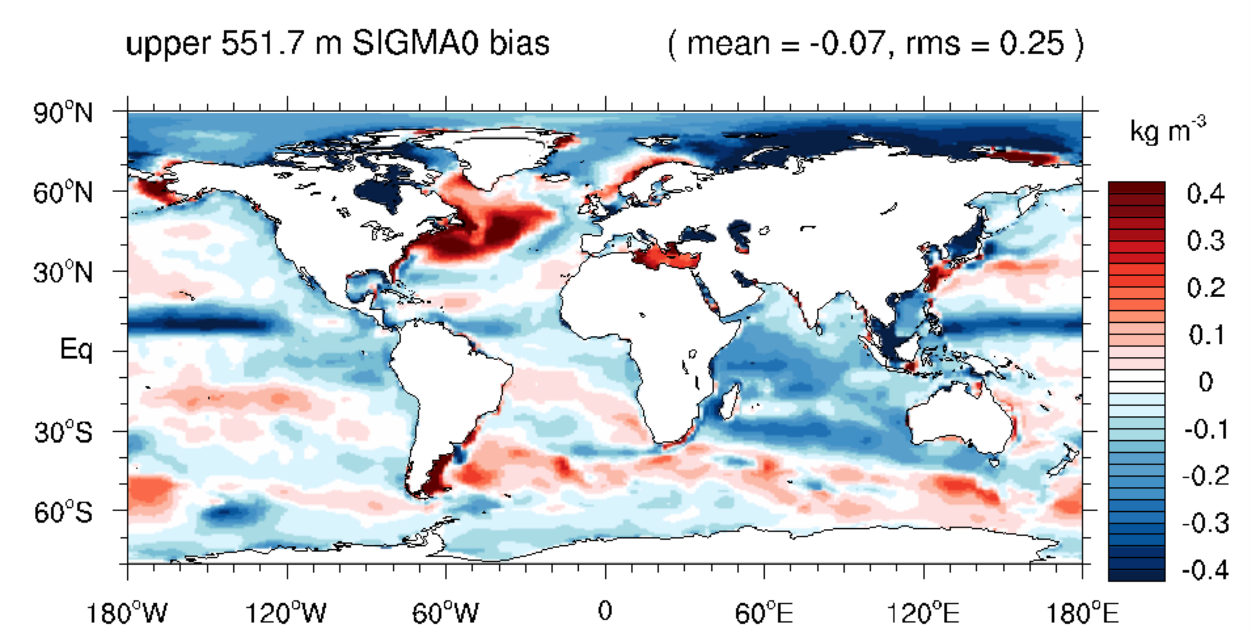
tx0.5v1



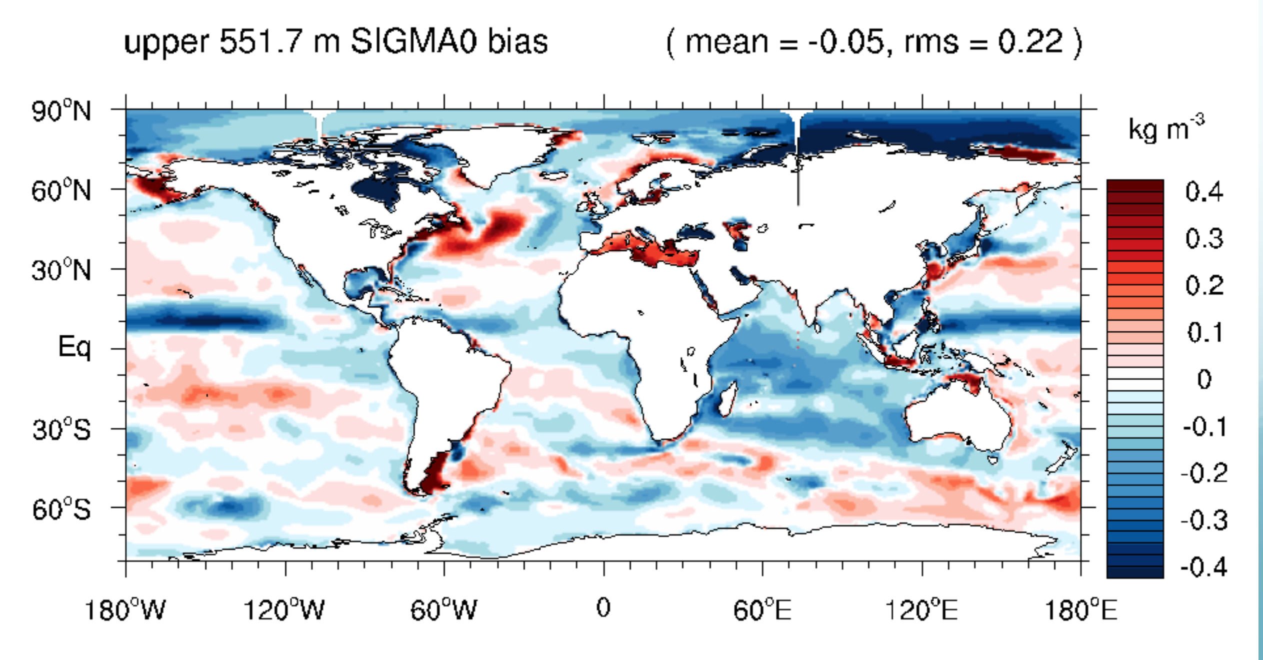


Mean (1979-1998) upper 552m σ_o bias

gx1v
6



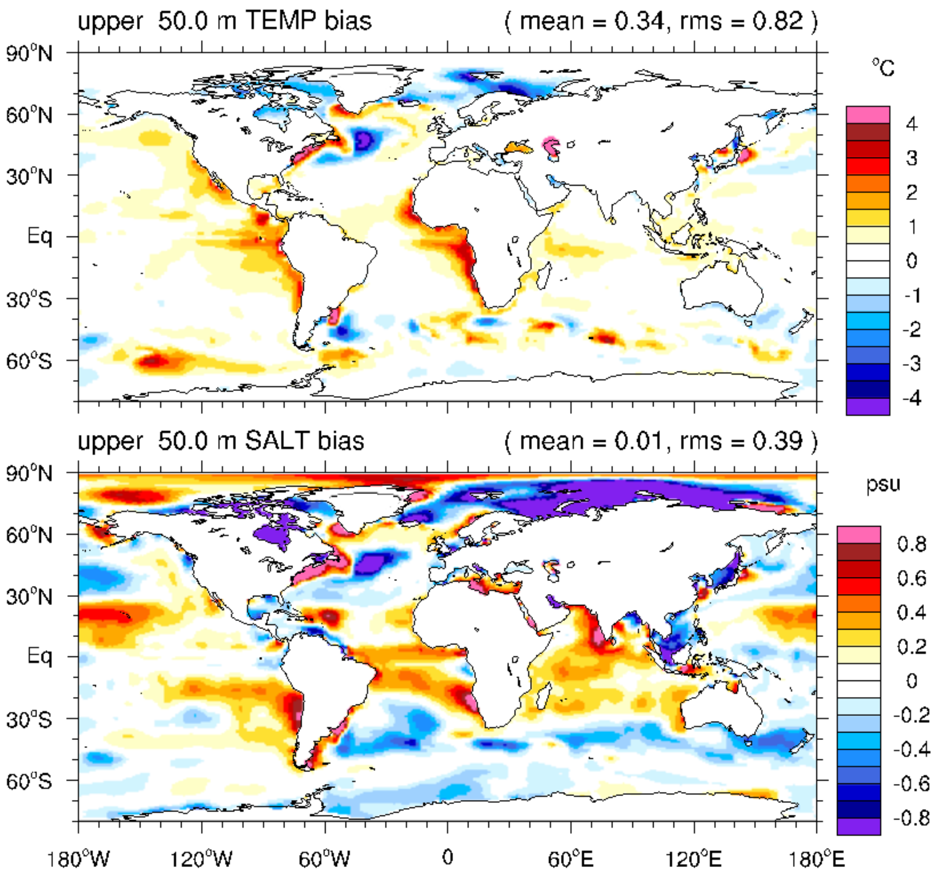
tx0.5v1

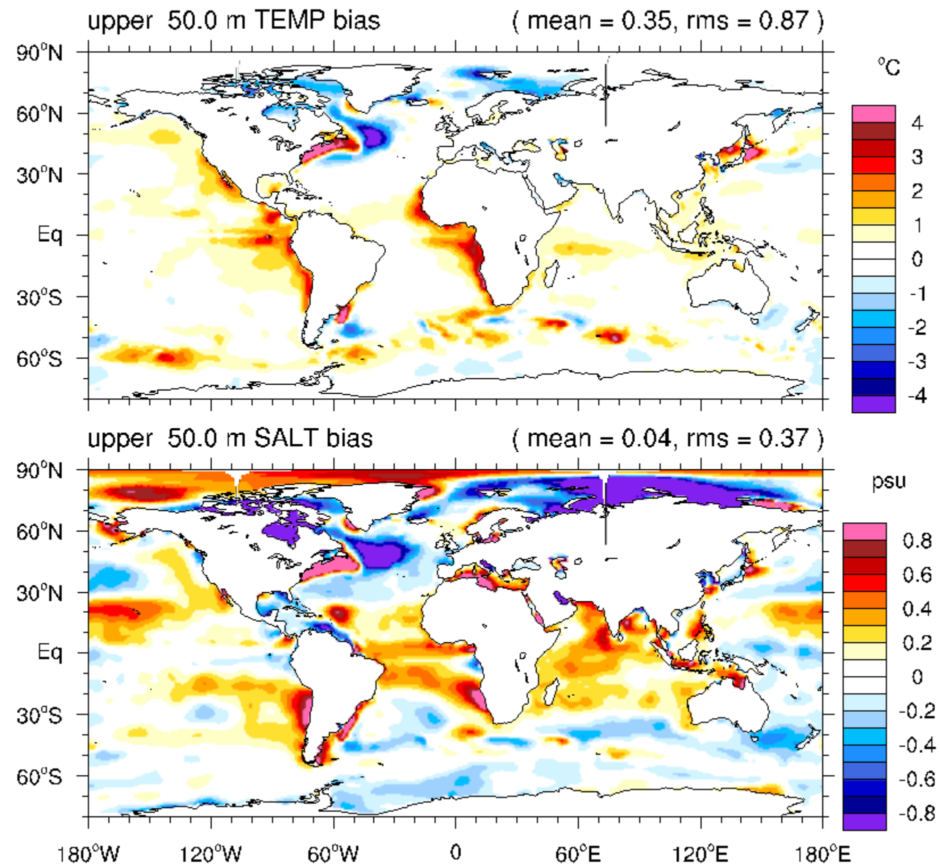


Mean (1979-1998) upper 50m T,S bias

gx1v
6

tx0.5v1



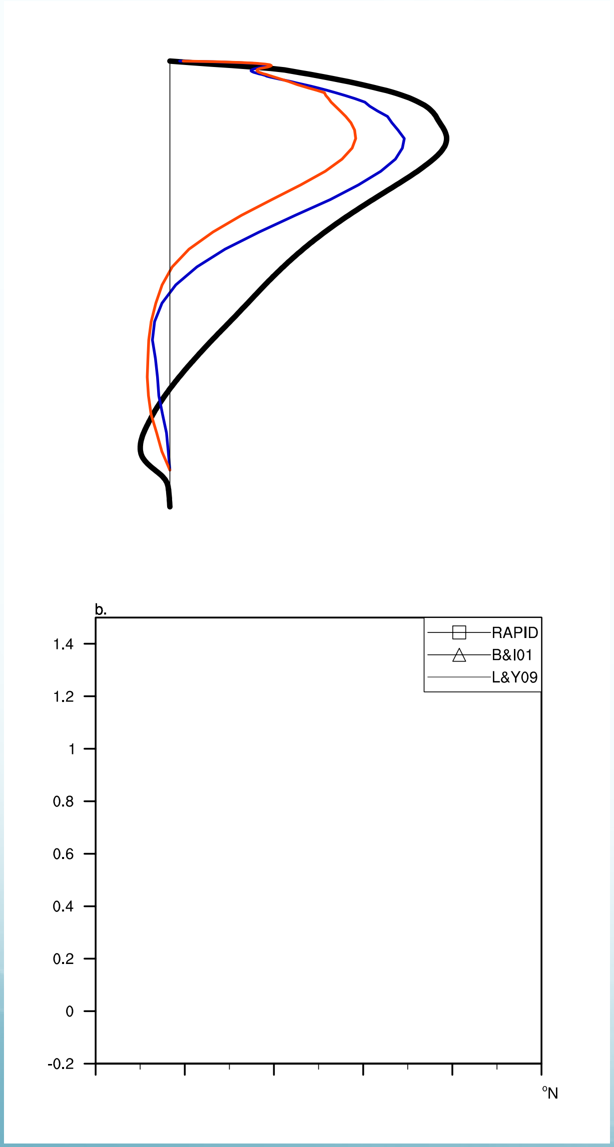


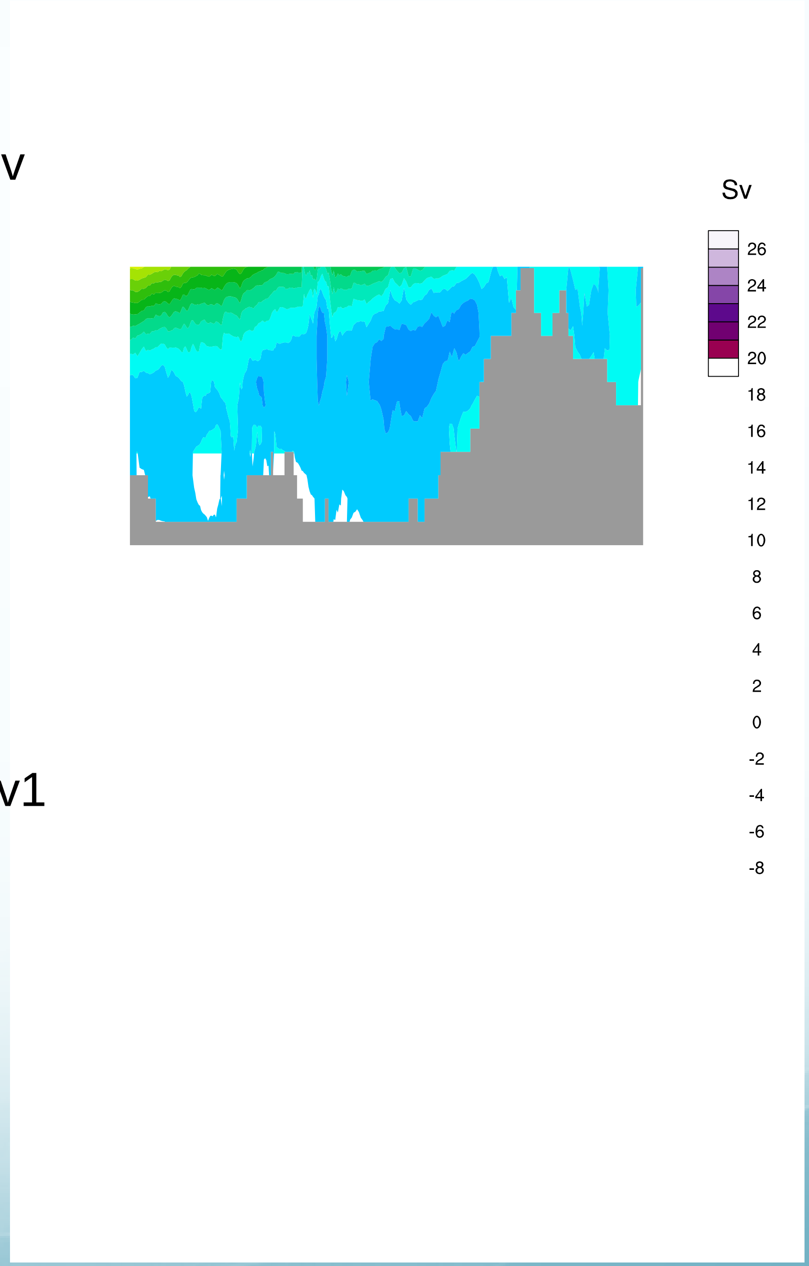
Mean Atlantic Overturning

AMOC

gx1v6

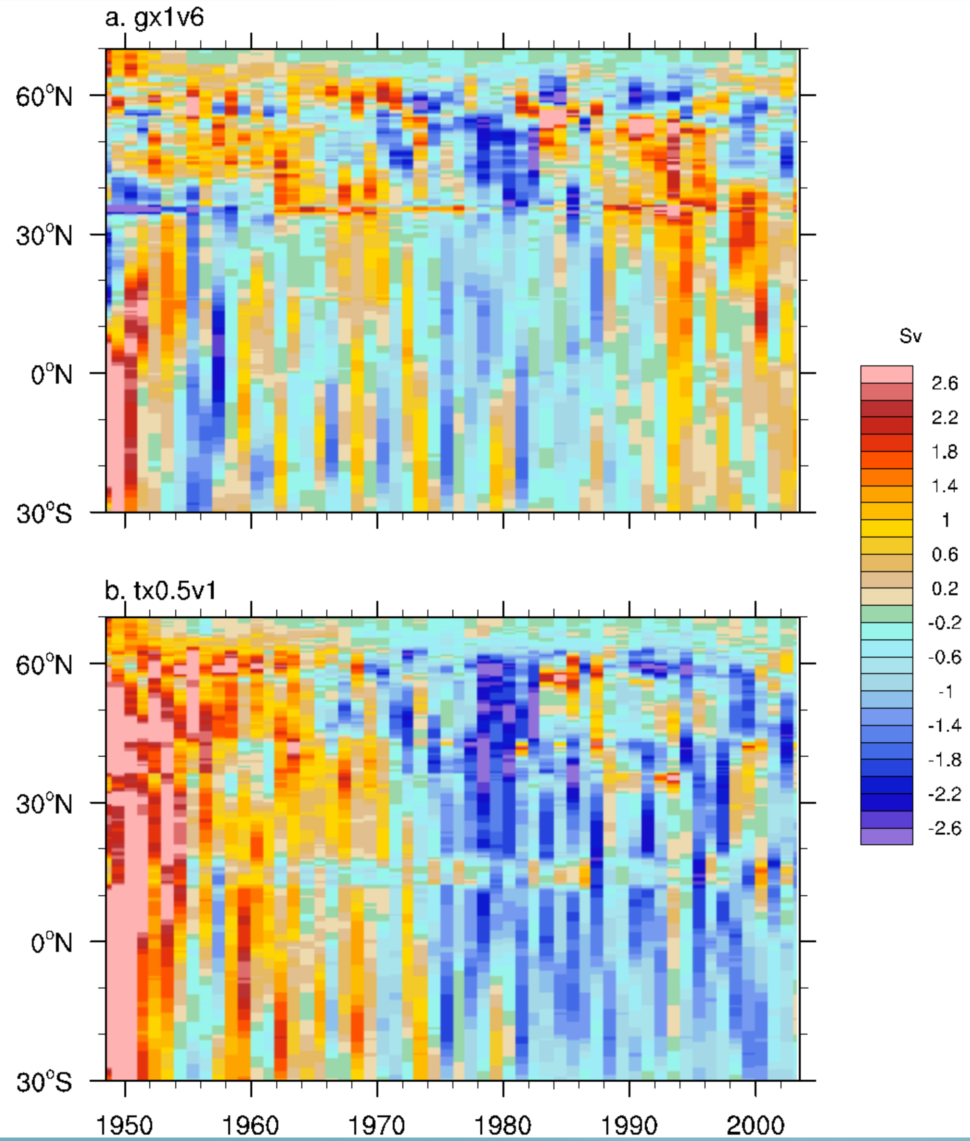
tx0.5v1





AMOC variability

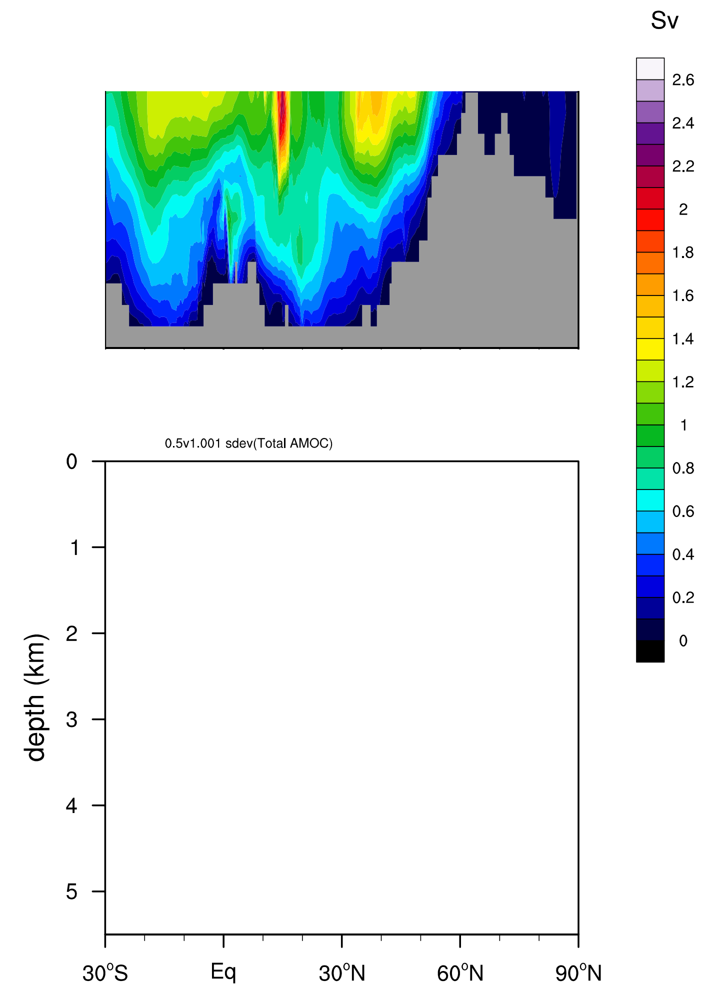
AMOC max



gx1v6

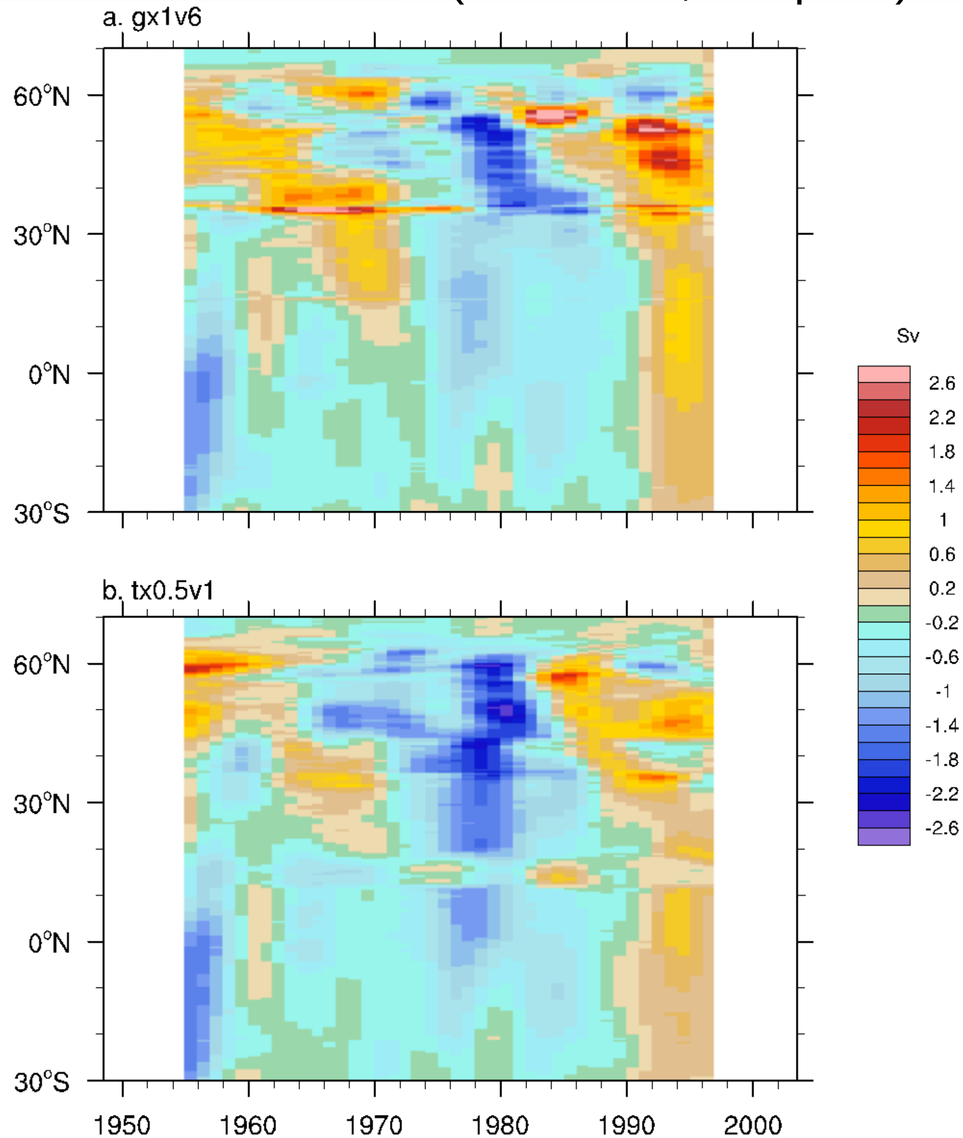
tx0.5v1

std dev



AMOC variability

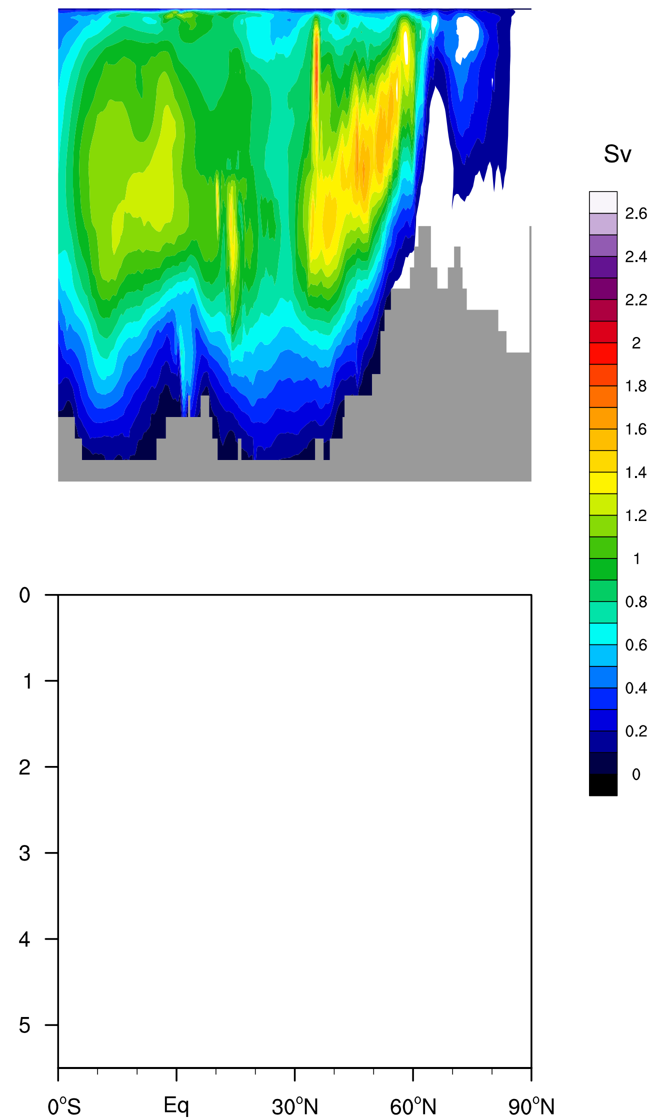
AMOC max (detrended, low-pass)



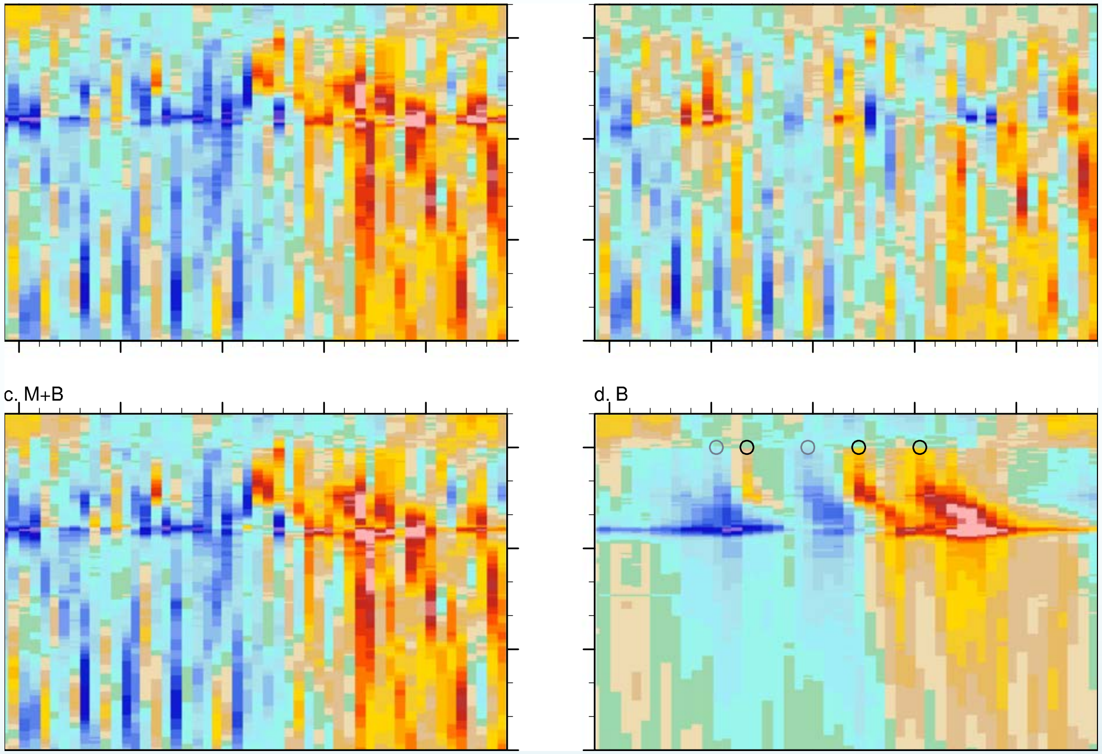
gx1v
6

tx0.5v1

std dev (detrended)



AMOC variability



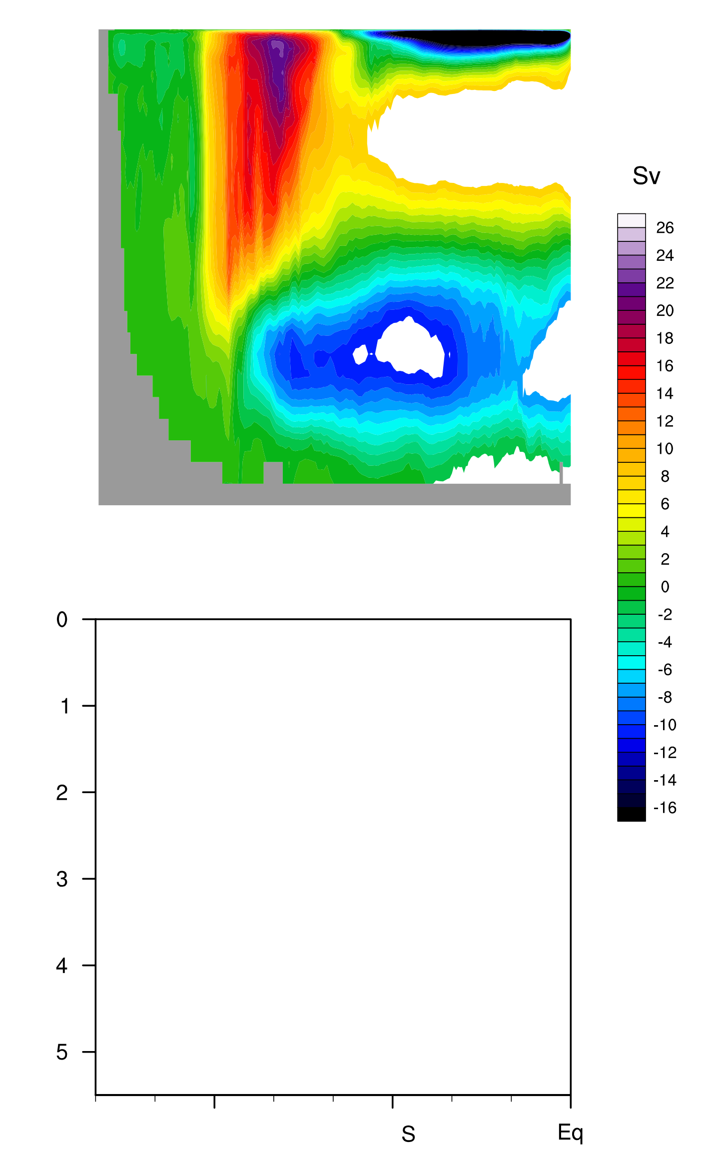
Yeager & Danabasoglu (2014)

Mean Global Overturning

MOC

gx1v
6

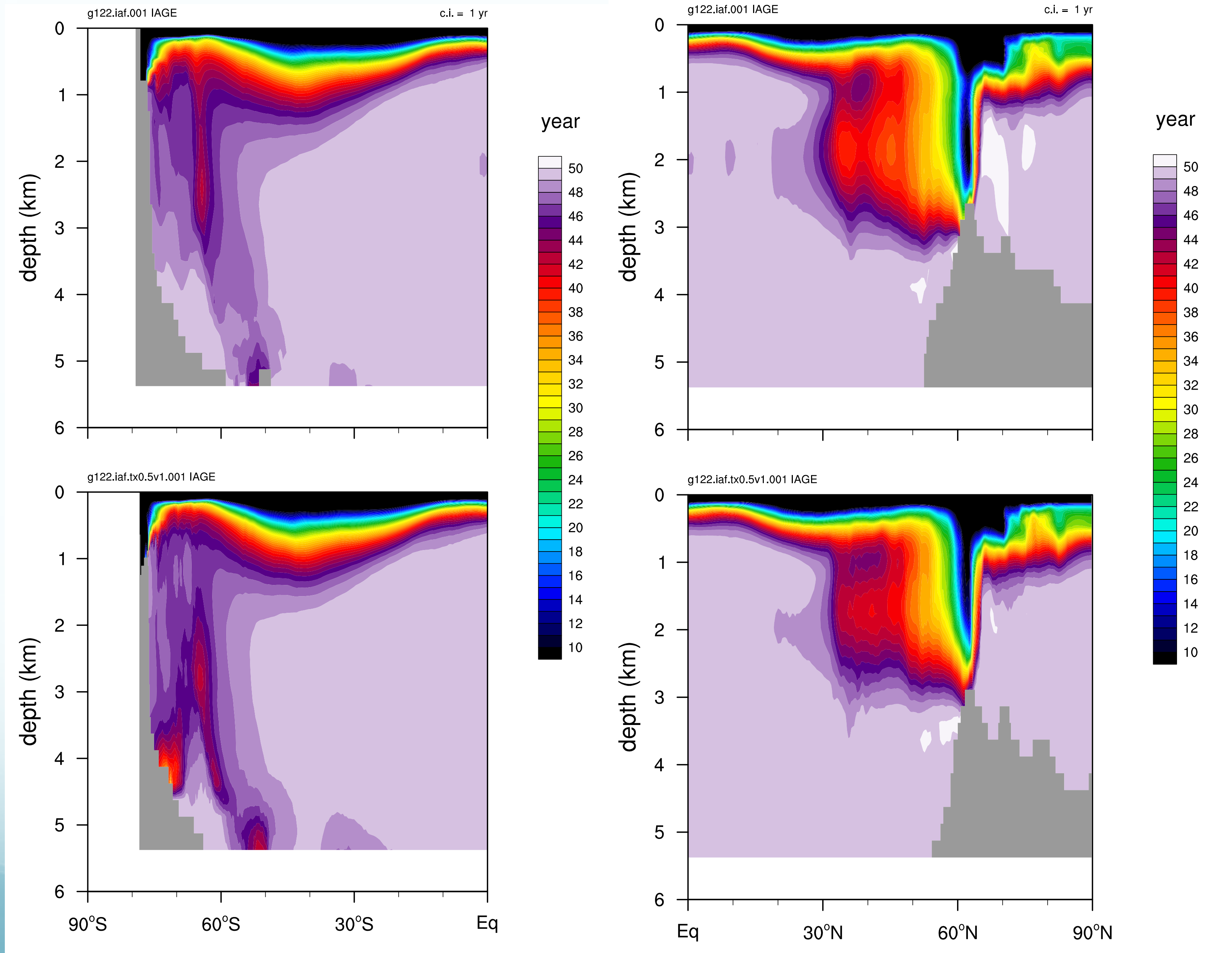
tx0.5v1



Deep Ventilation

gx1v6

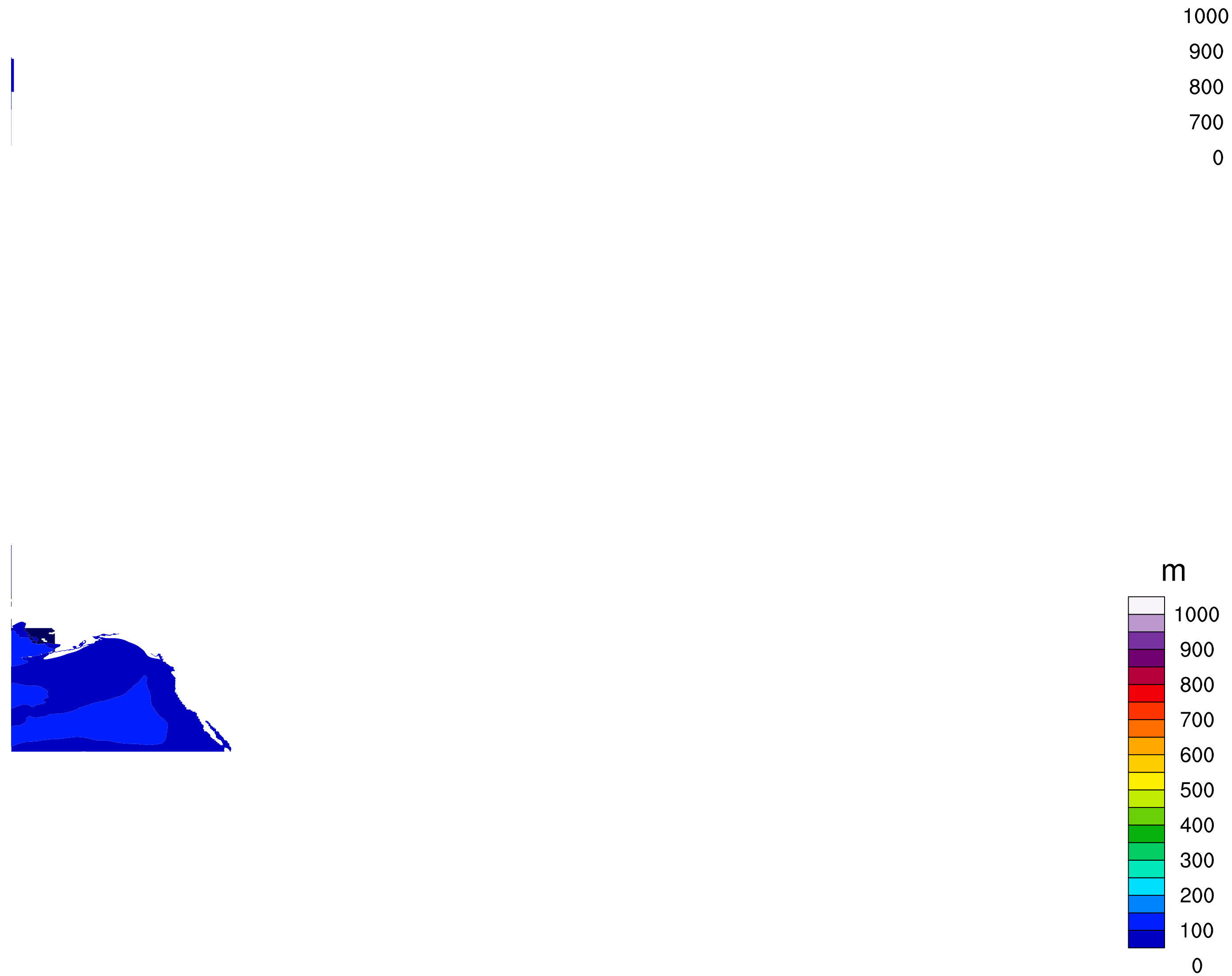
tx0.5v1



Winter MLD

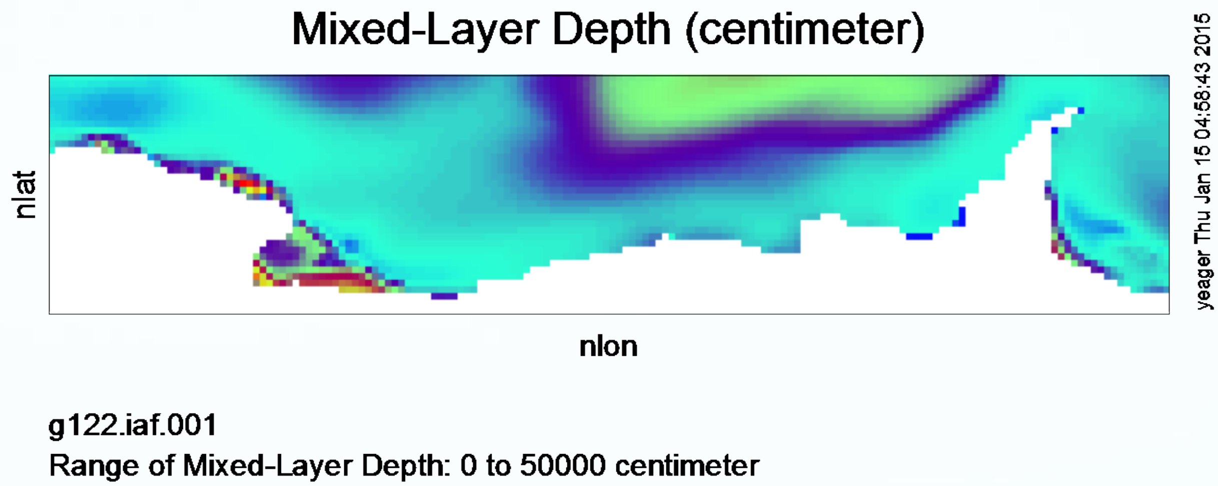
gx1v6

tx0.5v1

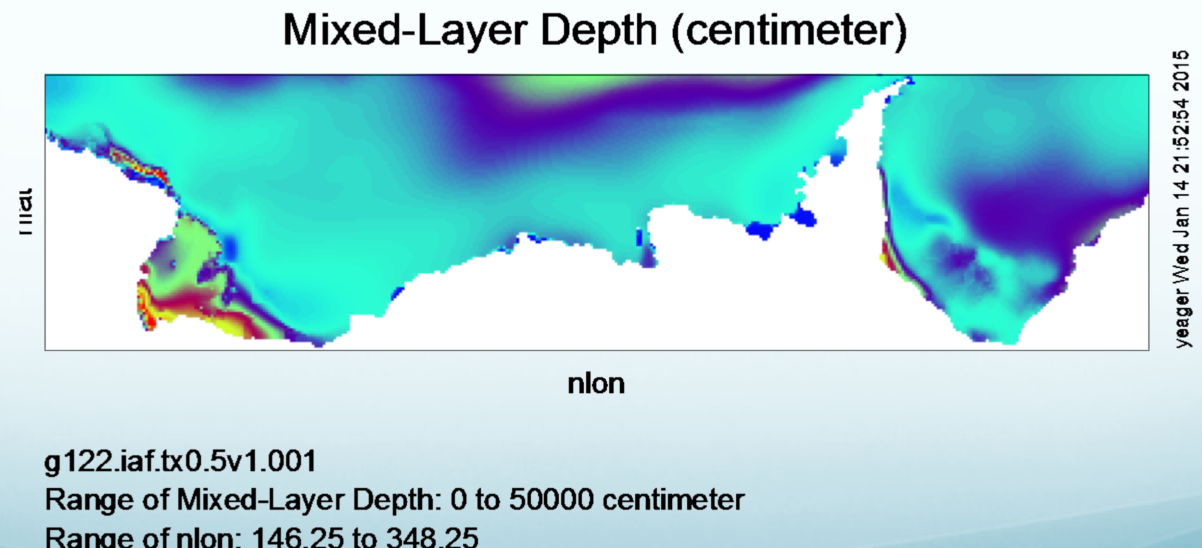


Winter MLD

gx1v6



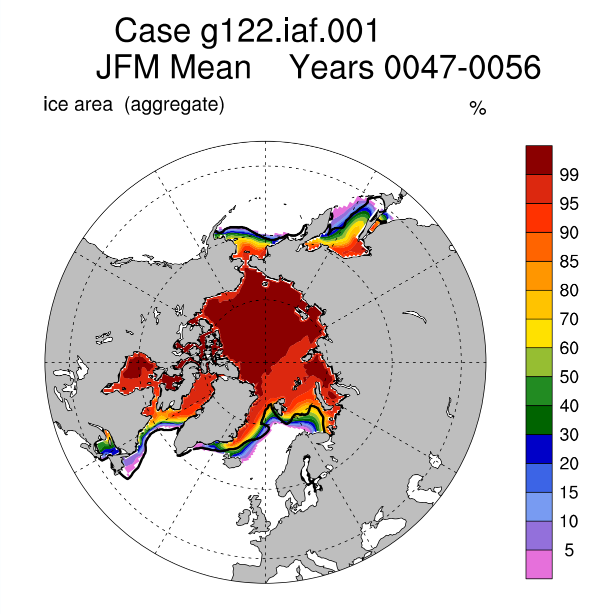
tx0.5v1

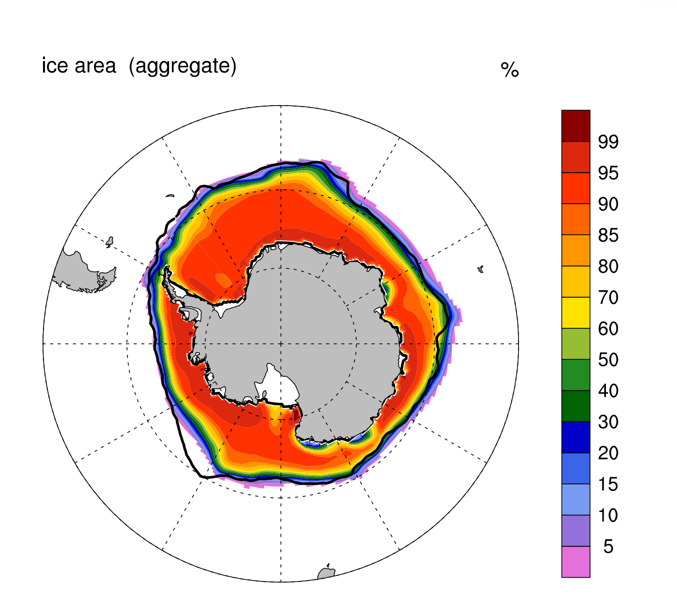


Winter Sea Ice Extent

JAS Mean

gx1v6





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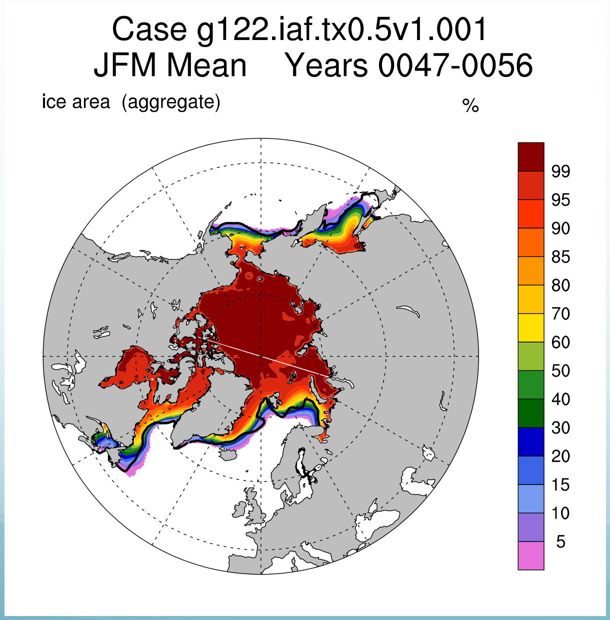

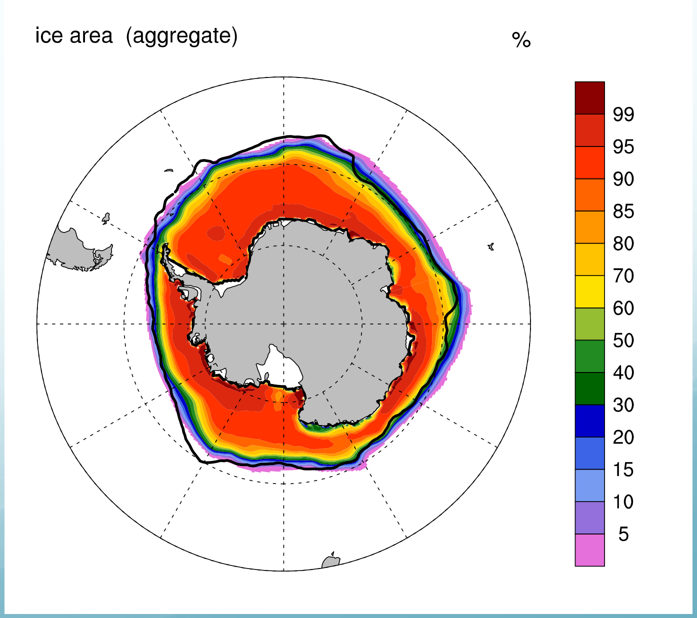

Conclusions

- Full assessment of tx0.5v1 will require multiple CORE-II cycles, coupled runs, inclusion of BGC, & more extensive analysis (more eyes needed!)

- Preliminary results do not suggest a significant improvement in climatological model biases, BUT…

- Impacts on model simulation of observed variability will require closer examination

AMOC variability