

Decadal Prediction with CCSM4

Update on ocean data assimilation efforts and the latest coupled results

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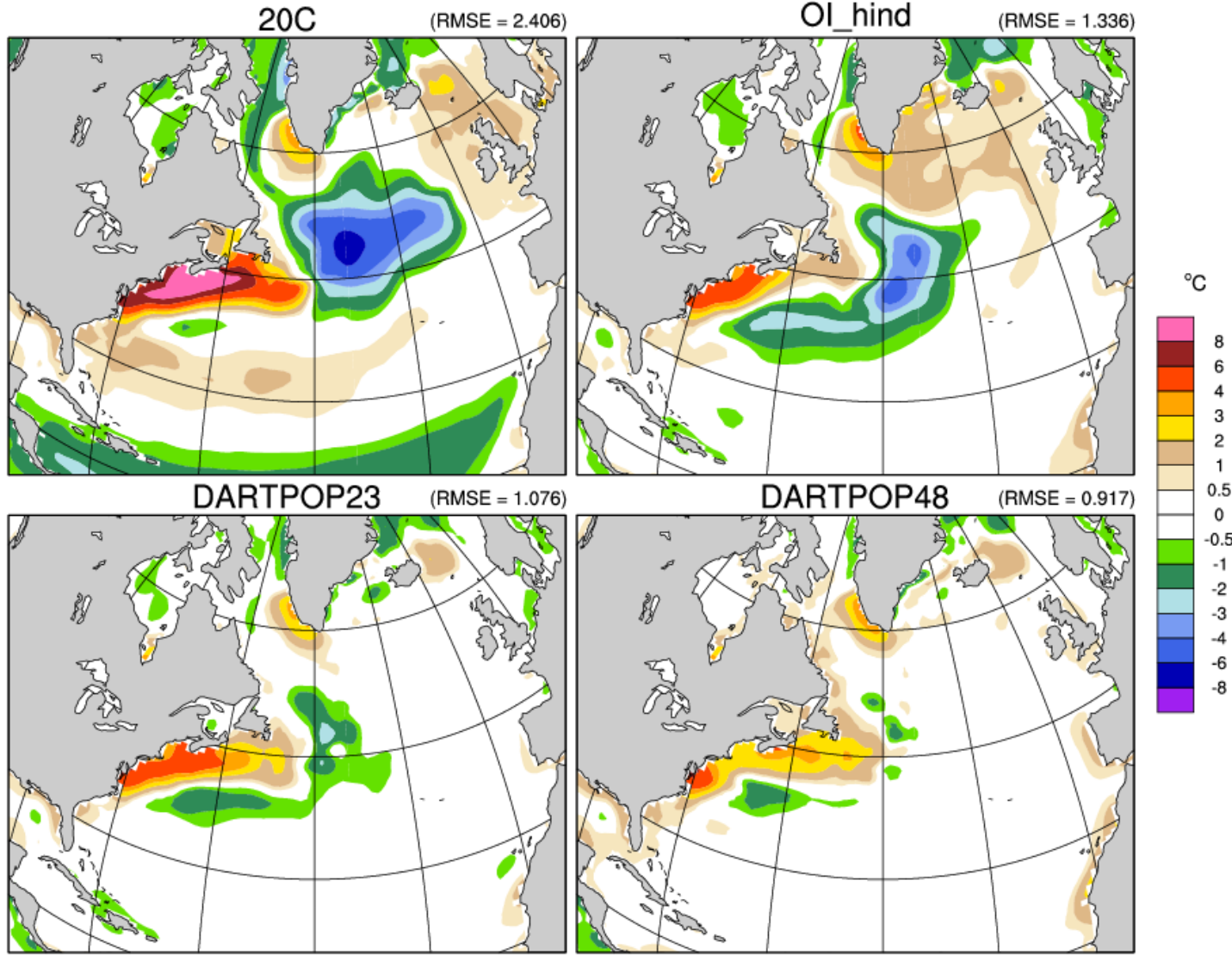
CCSM Workshop 2010, Breckenridge



I. Data Assimilation in CCSM

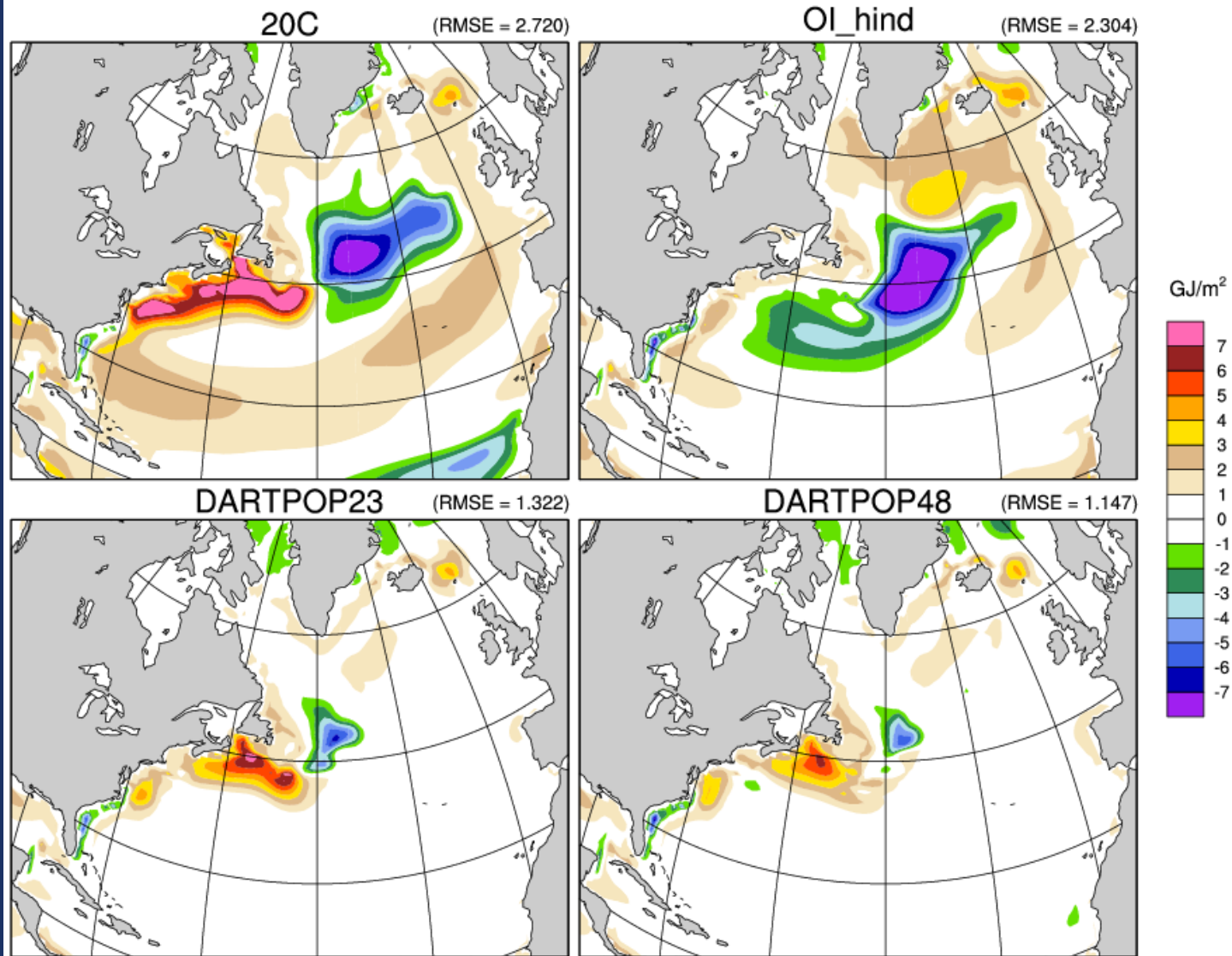
- **Data Assimilation Research Testbed (DART) tools can be run with interactive ensemble of POP ocean models within CCSM framework (thanks to Jeff Anderson, Tim Hoar, Nancy Collins, Kevin Raeder, Mariana Vertenstein, & Nathan Hearn)**
- **All World Ocean Database T & S observations are assimilated once per simulation day; DART modifies POP restart files (inefficient! but works...)**
- **Two production runs to-date (intended to provide decadal prediction IC's for 2000):**
 1. **DARTPOP23: 23-member assimilation from 1998-01-01 to 2000-01-01, COREv2 atmospheric fields.**
 - ⇒ **Problems with low ensemble spread & incorrect data archiving**
 2. **DARTPOP48: 48-member assimilation from 1998-01-01 to 2000-01-01*, each member forced by a unique atm stream from a prior CAM-assimilation ensemble.**
 - ⇒ **Improved ensemble spread**
 - ⇒ **≈45 minutes per simday on 7 bluefire nodes (62% CCSM, 38% DART)**

1998 SST Bias



20C : CCSM4 20th Century simulation
 OI_hind: 1948-2007 ocean-ice hindcast simulation

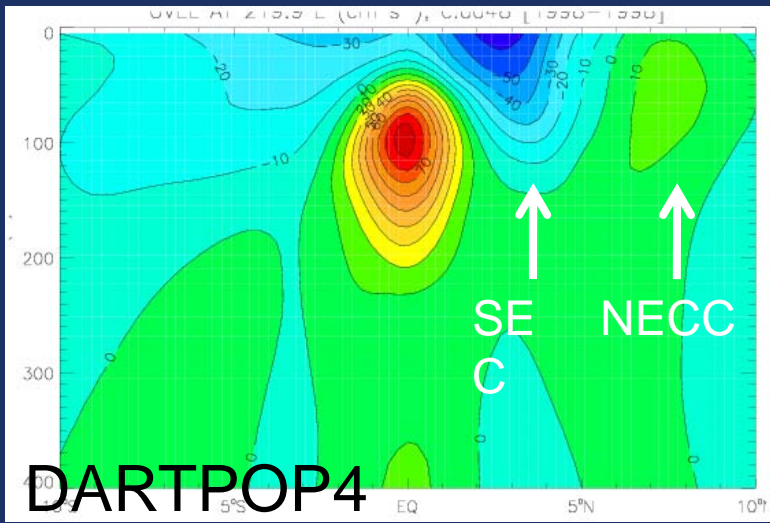
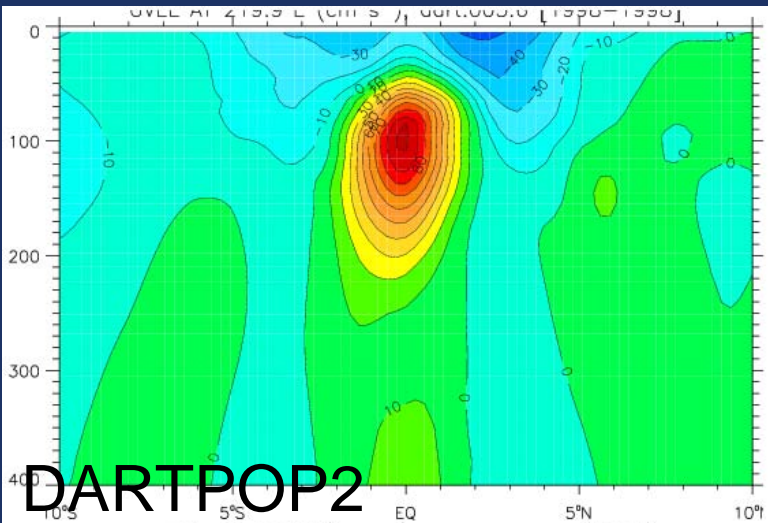
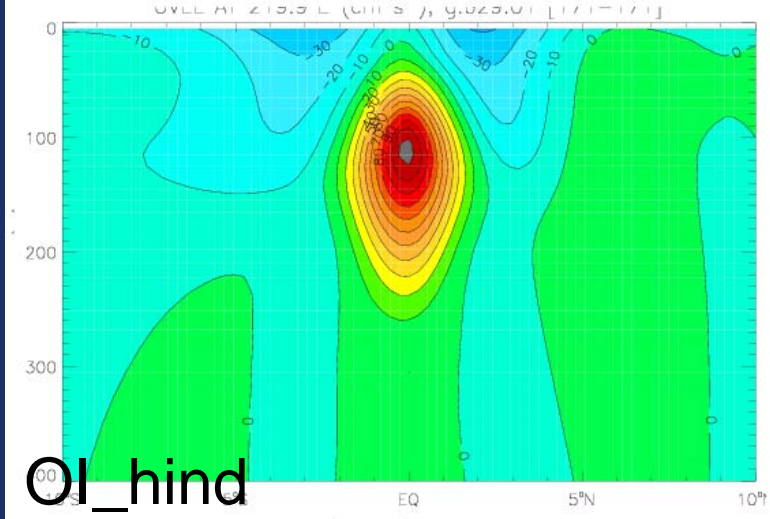
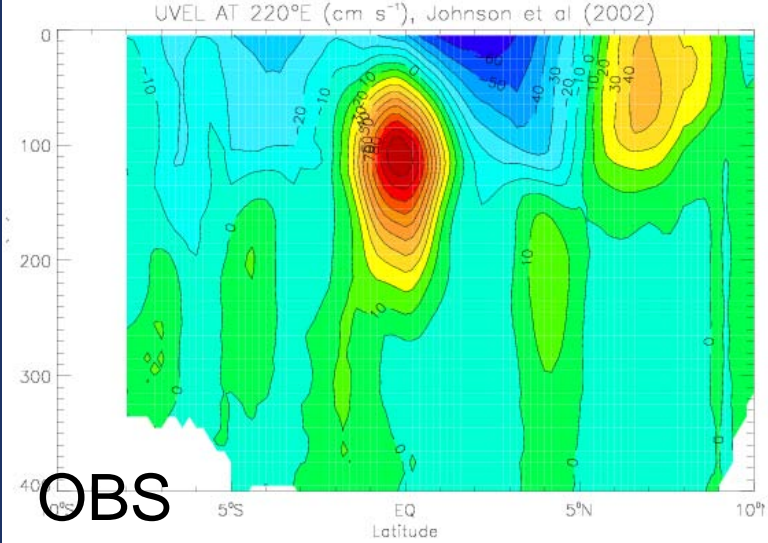
1998 300m Heat Content Bias



20C : CCSM4 20th Century simulation

OI_hind: 1948-2007 ocean-ice hindcast simulation

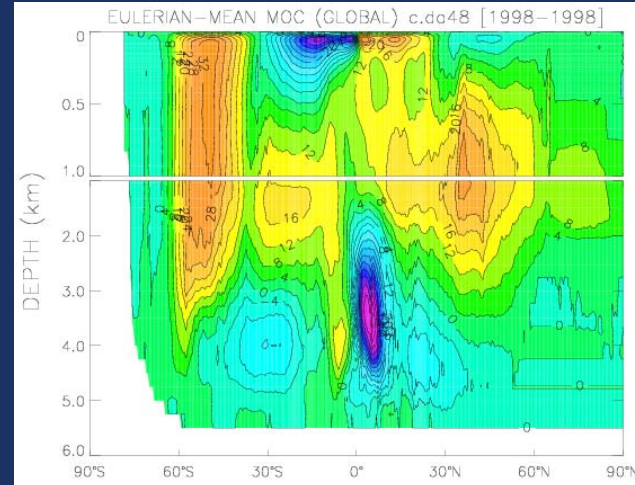
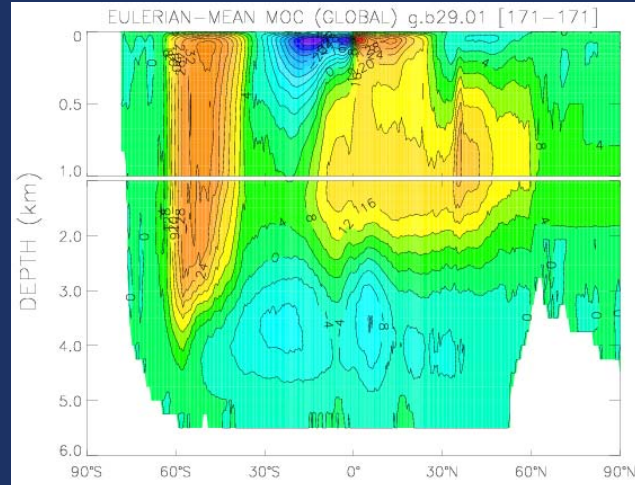
1998 Equatorial Zonal Velocity at 220°E



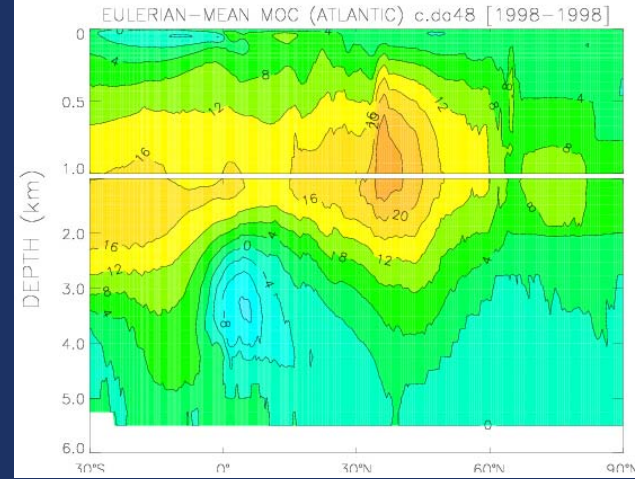
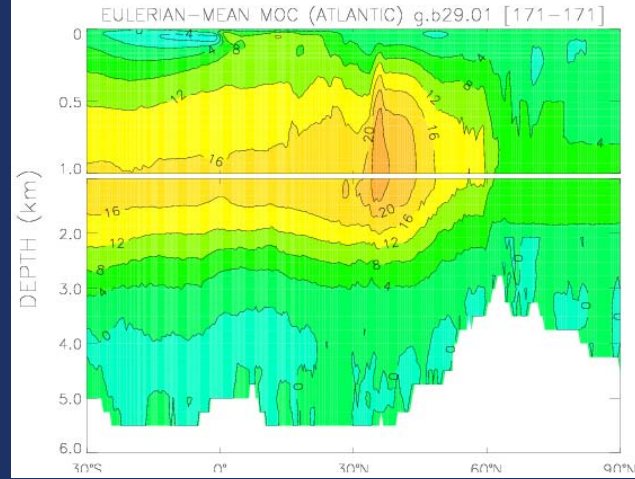
OI_hind

DARTPOP48

MOC

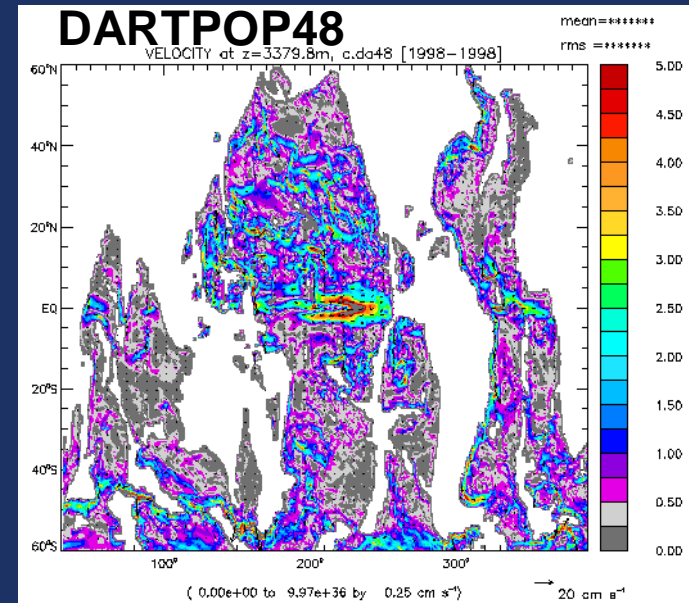
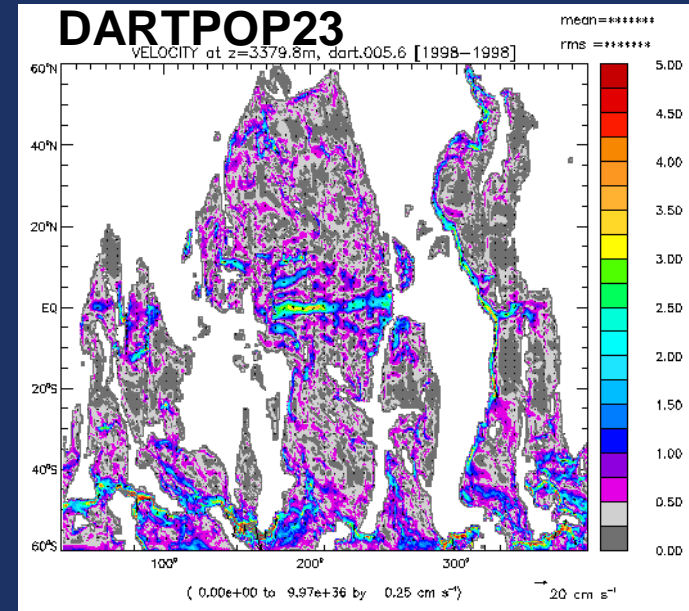
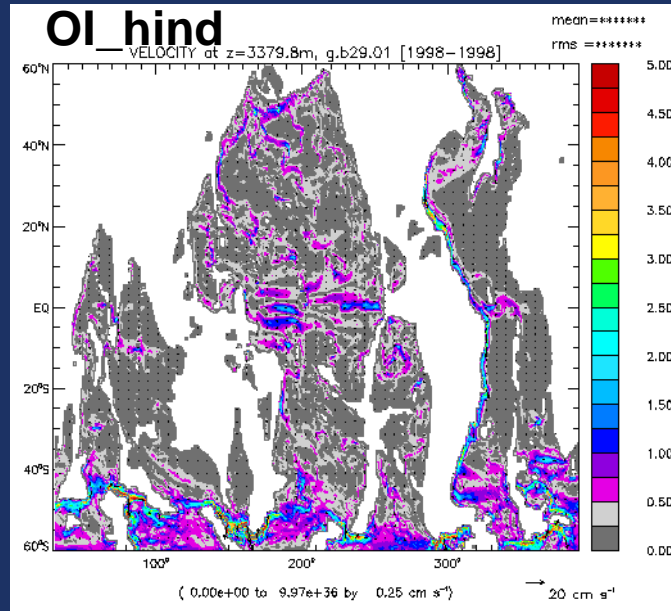


AMOC

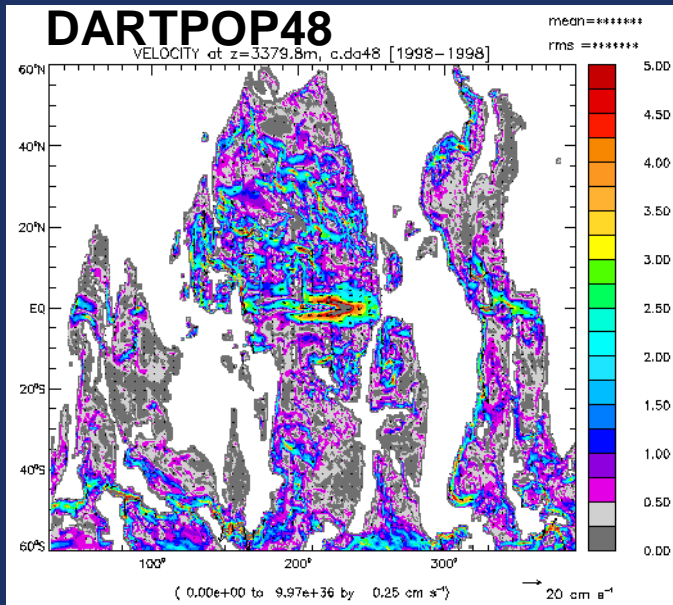
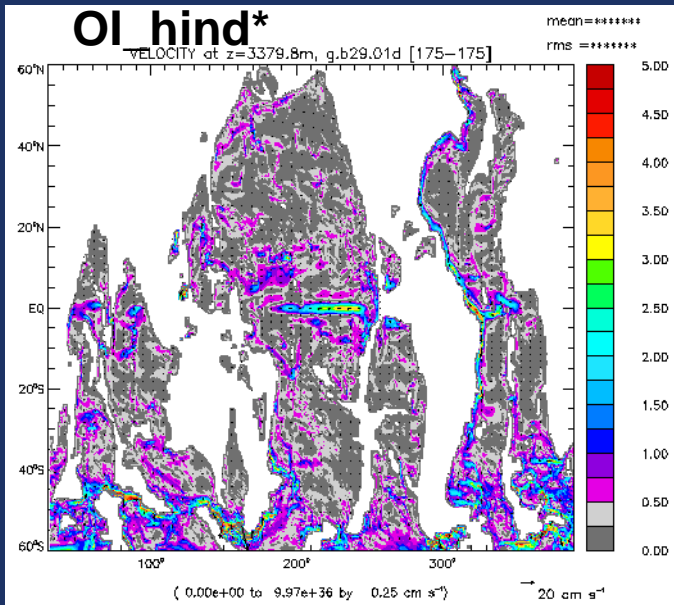
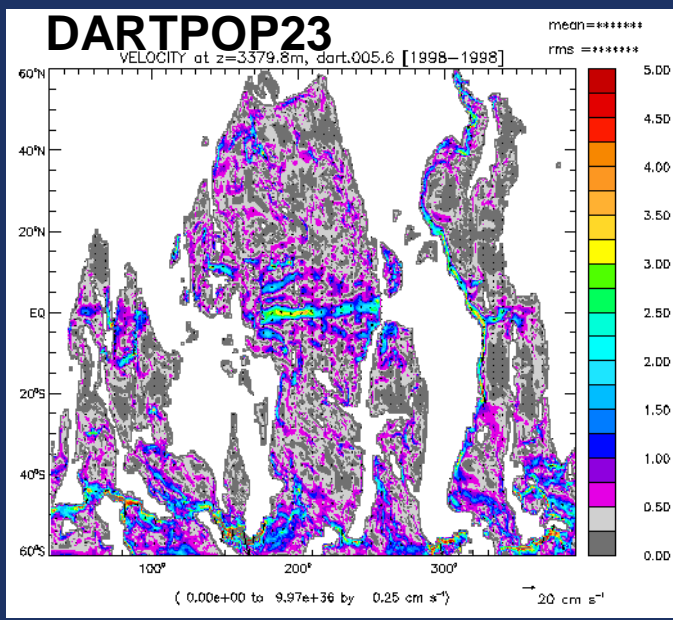
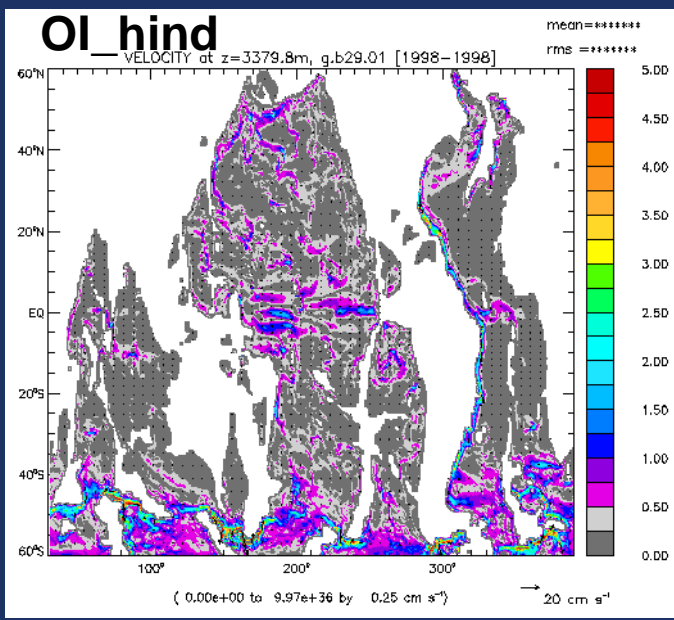


Assimilation results in strong overturning circulation at depth— is this real?

Mean 3400m Velocity

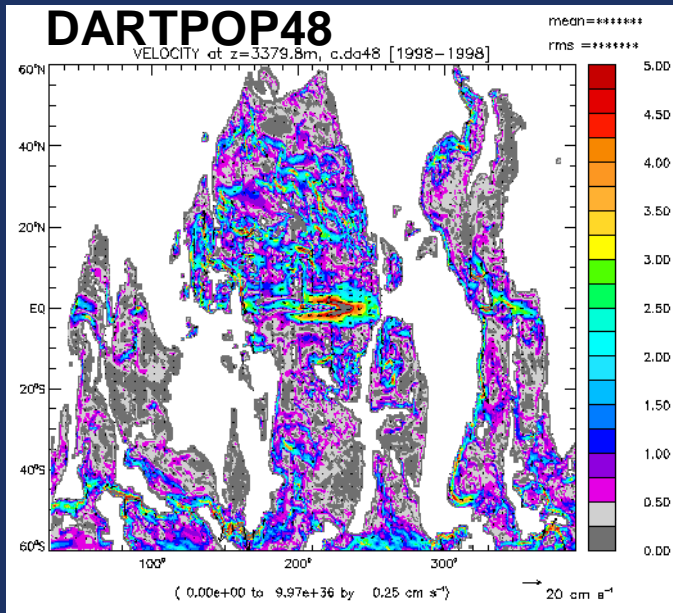
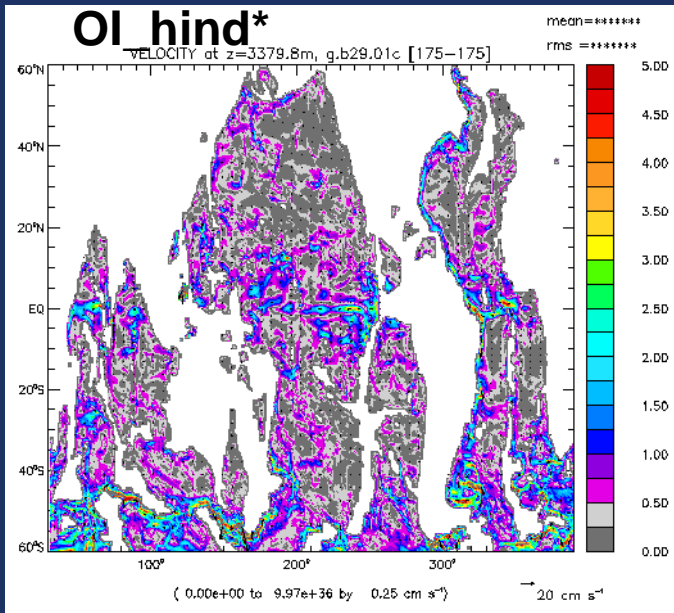
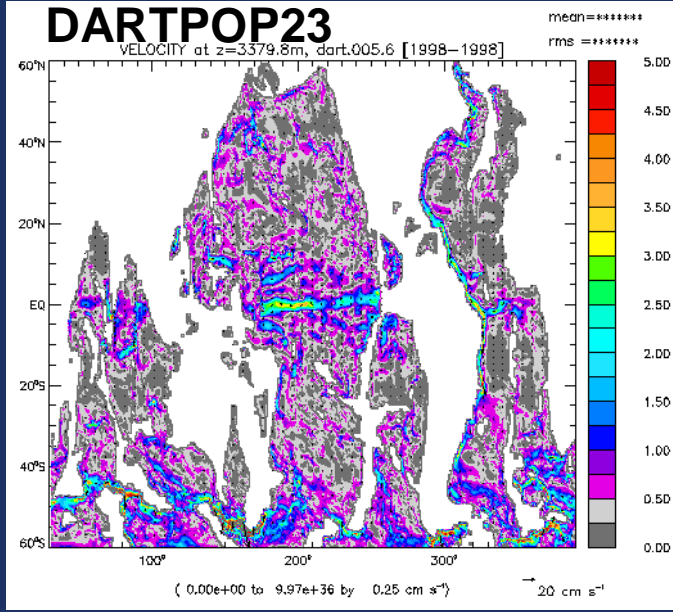
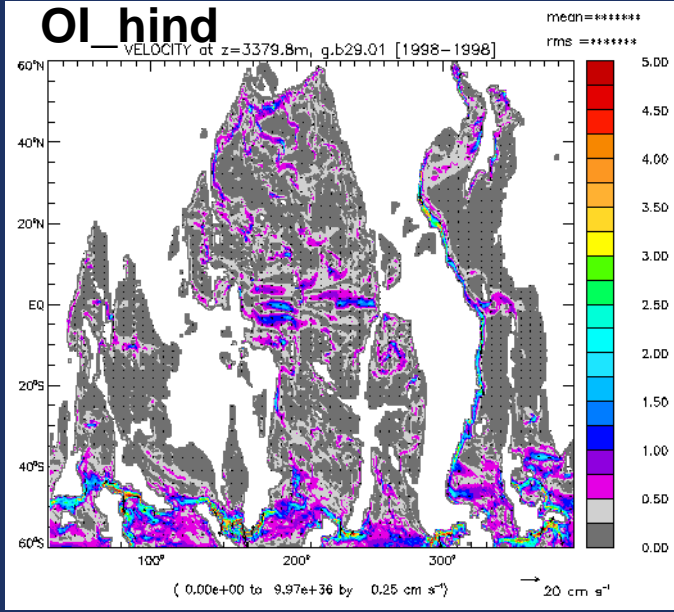


Mean 3400m Velocity



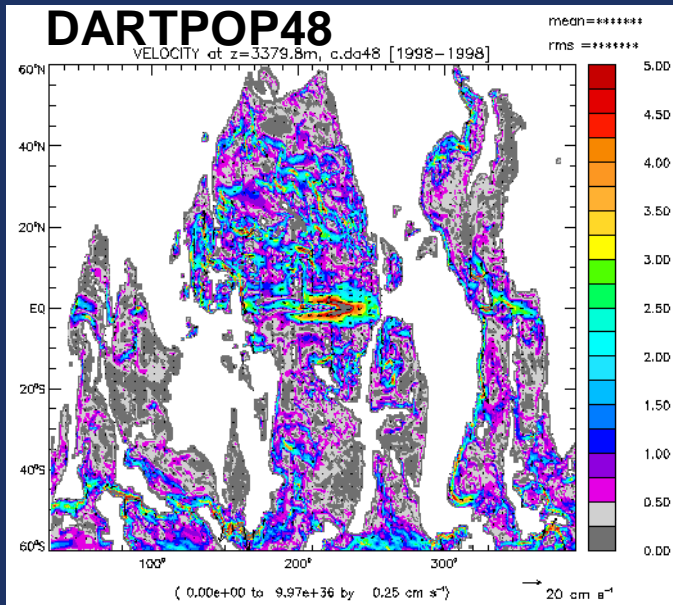
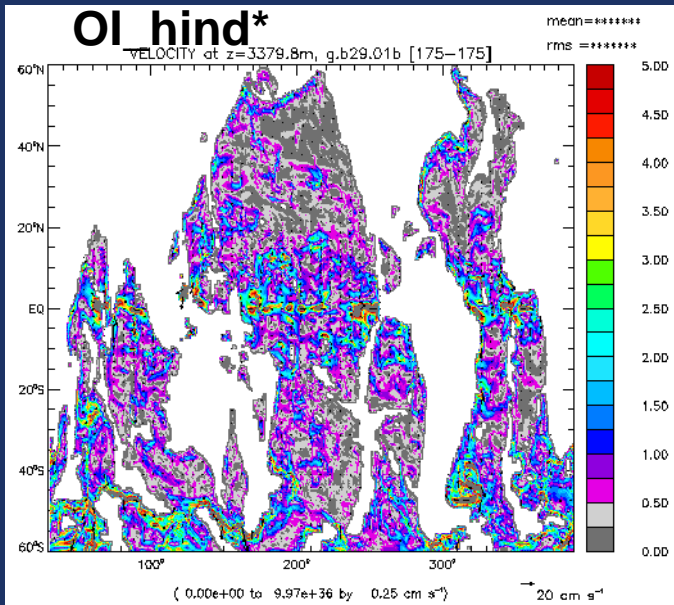
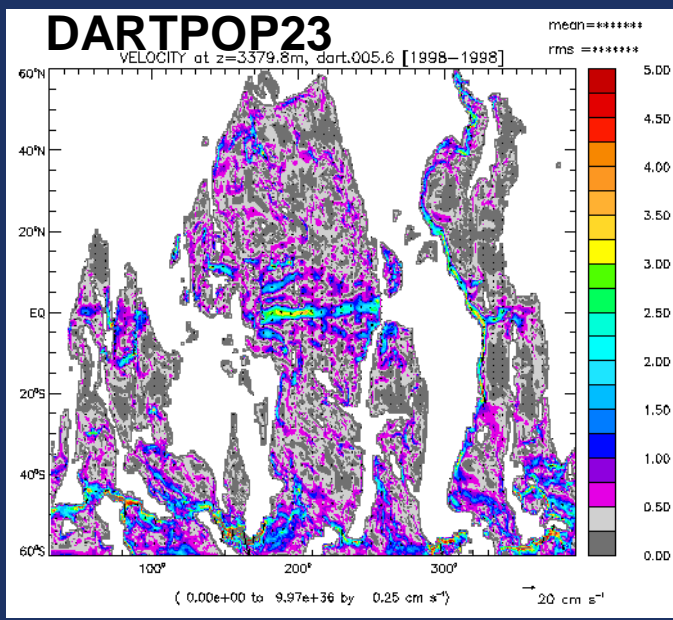
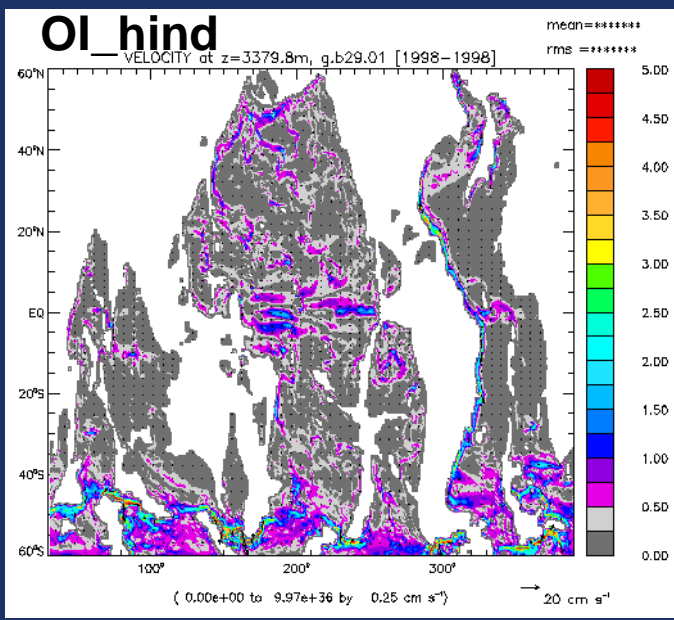
* 3D restoring to Levitus T/S, $\tau=365$ days

Mean 3400m Velocity



* 3D restoring to Levitus T/S, $\tau=100$ days

Mean 3400m Velocity

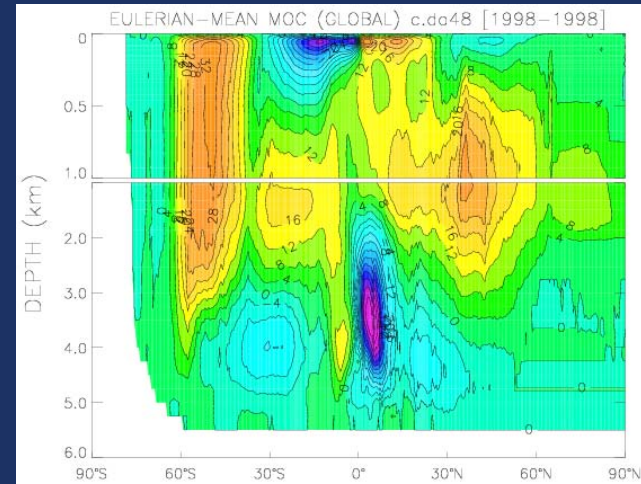
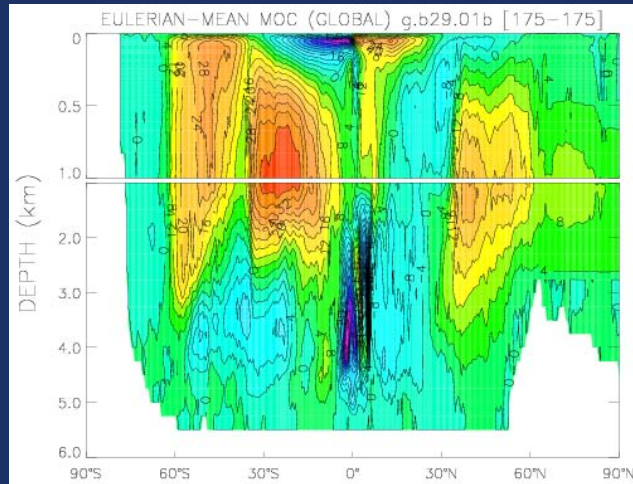


* 3D restoring to Levitus T/S, $\tau=10$ days

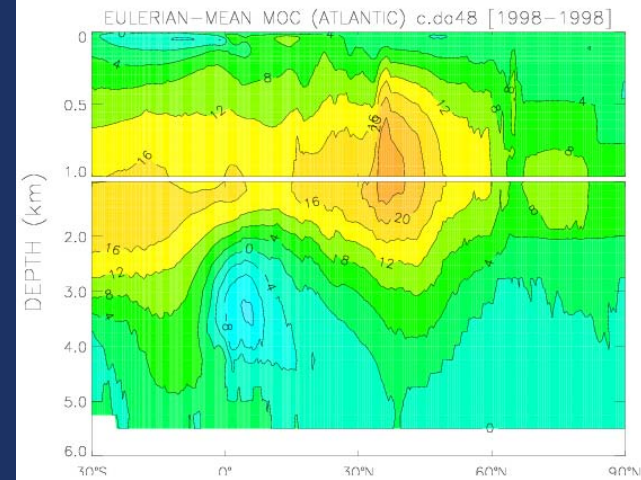
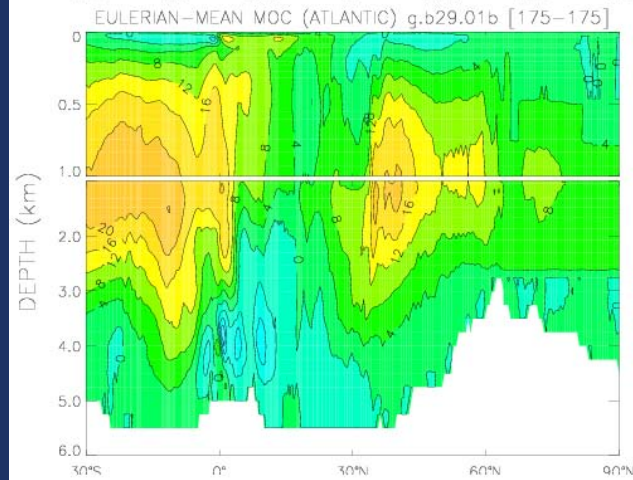
OI_hind*

DARTPOP48

MOC



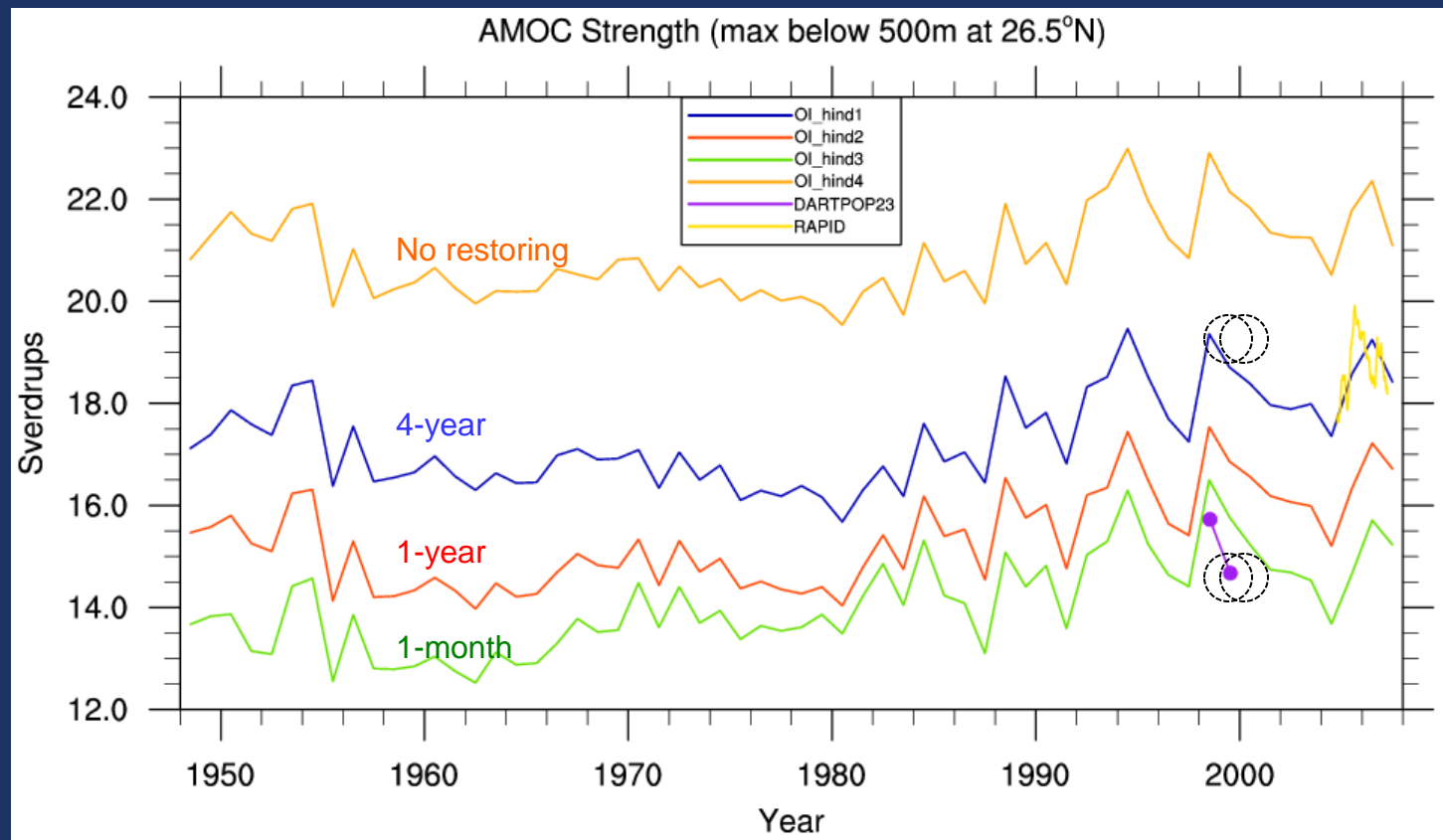
AMOC



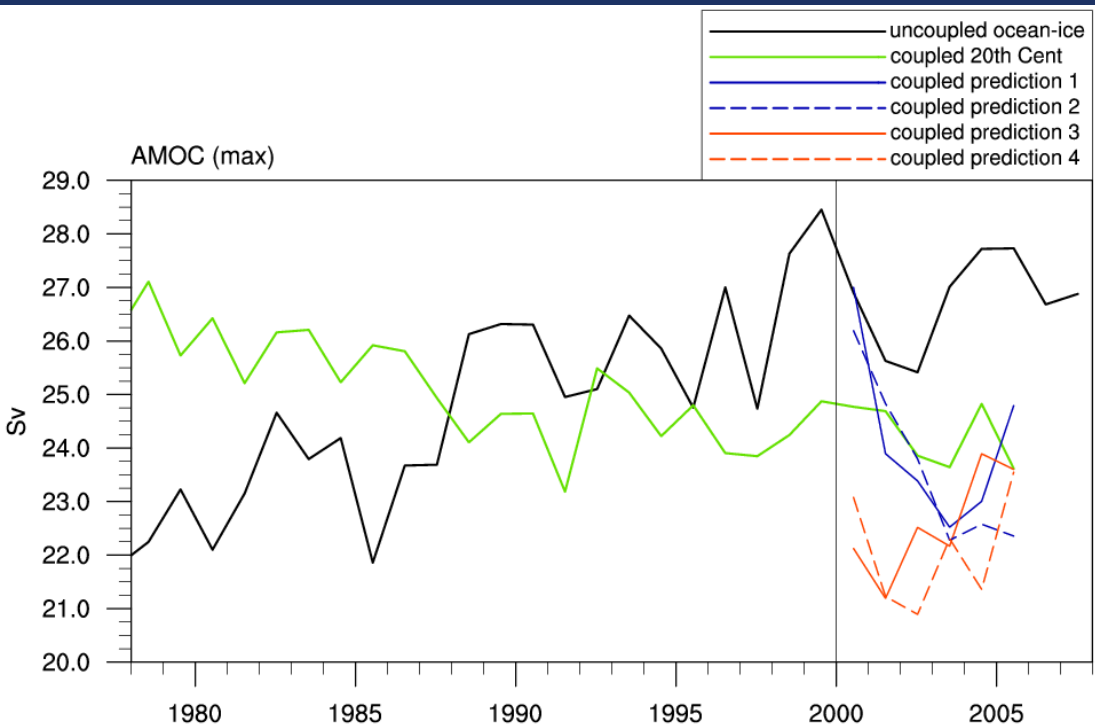
AMOC from DART resembles that seen when we run hindcast simulations with strong restoring to 3D WOA temperature and salinity fields*.

II. CMIP5 decadal prediction (DP) experiments

1. December 2009: Completed 4 DP test experiments. 2 initialized from best ocean-ice hindcast (4-year salinity restoring timescale), 2 from DARTPOP23. Integrated 6 years starting at 2000-01-01.

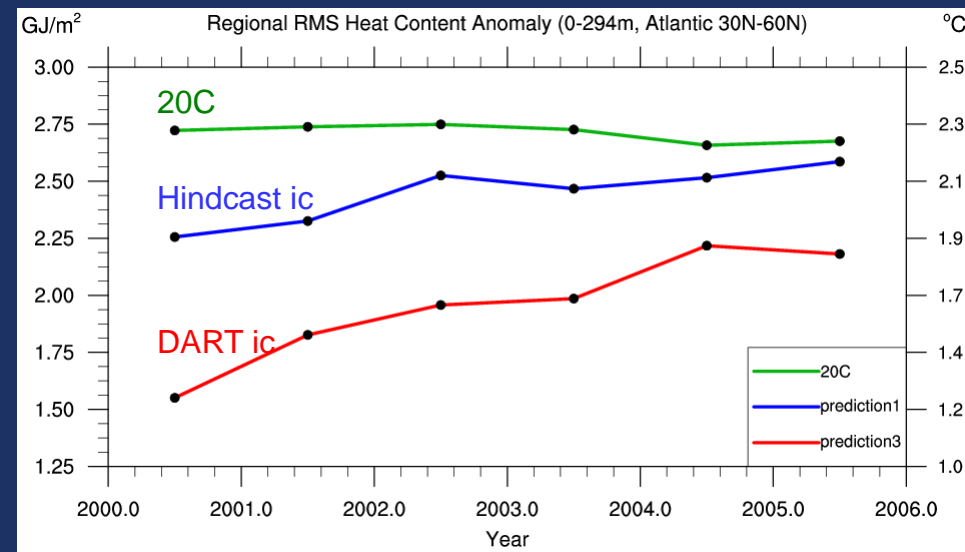


AMOC



These first 4 DP tests showed low skill at AMOC prediction...

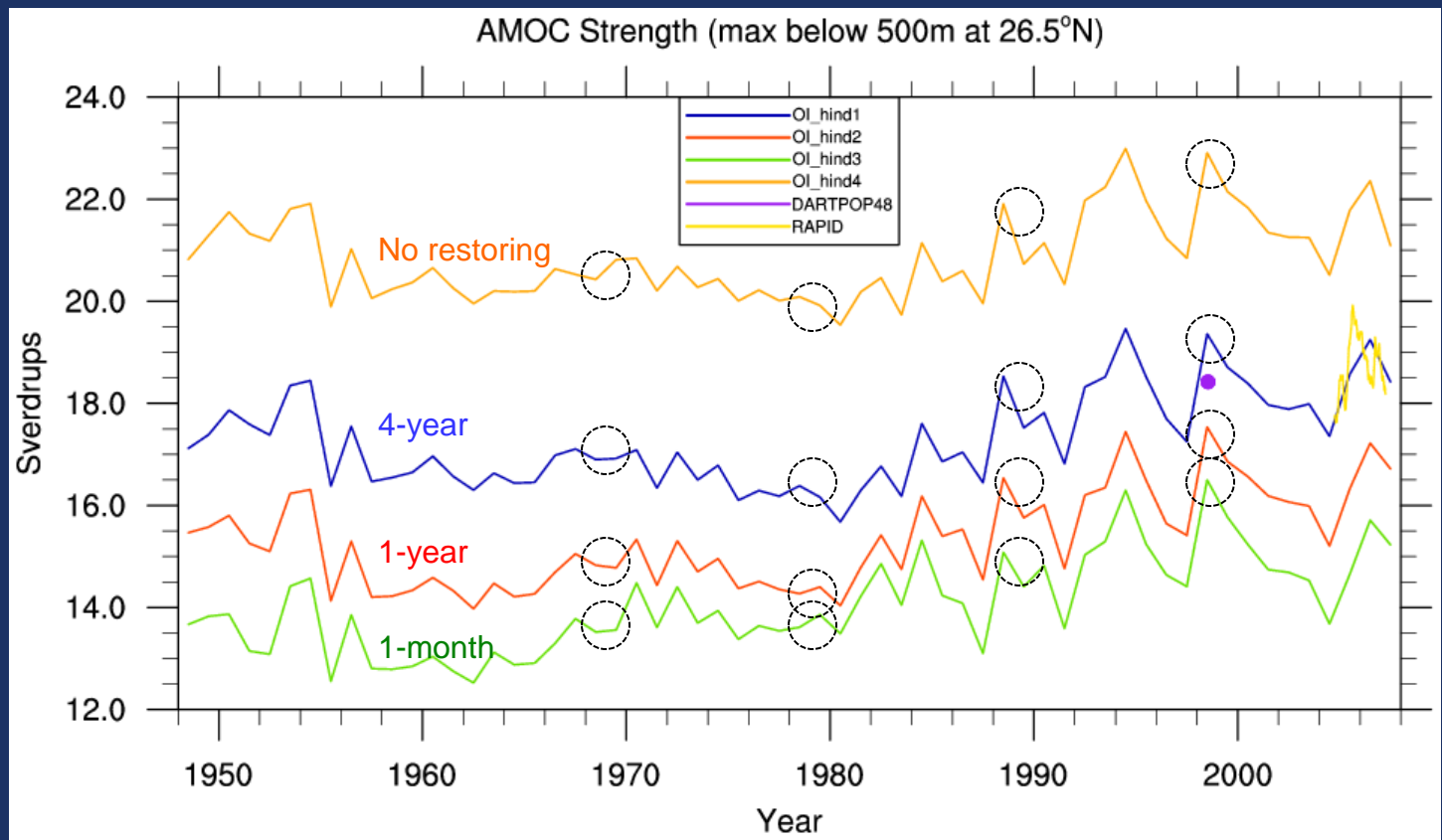
N Atl Heat Content Bias



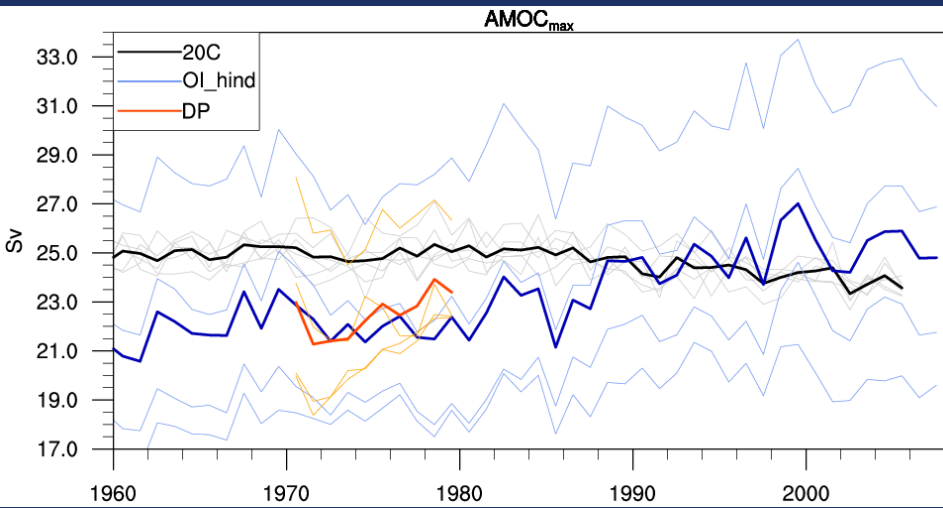
...but persistent bias reduction associated with ocean initialization.

II. CMIP5 decadal prediction (DP) experiments

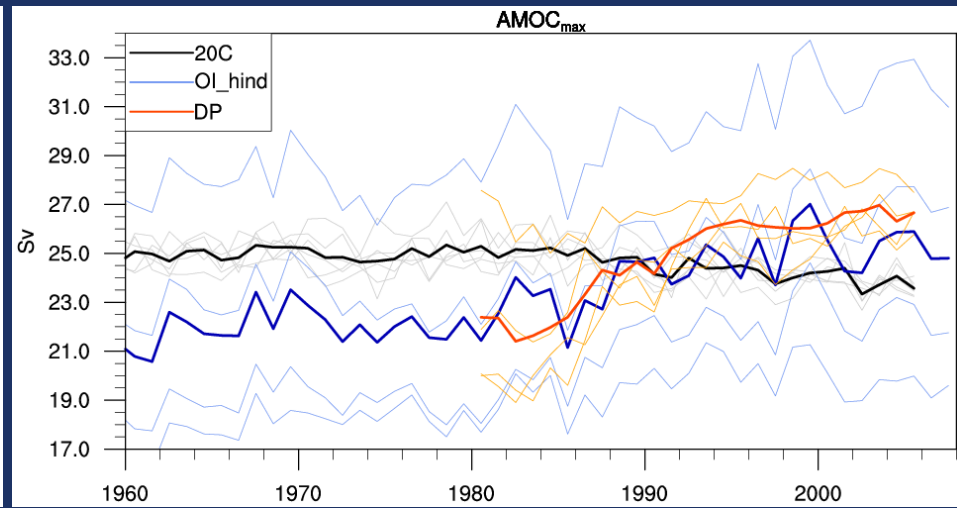
- June 2010: 16 CCSM4 DP experiments completed. All initialized from ocean-ice hindcasts (4 restoring timescales X 4 start dates). New DART-initialized (DARTPOP48) runs are forthcoming. 1980 DP runs integrated 26 years, all others 10 years.



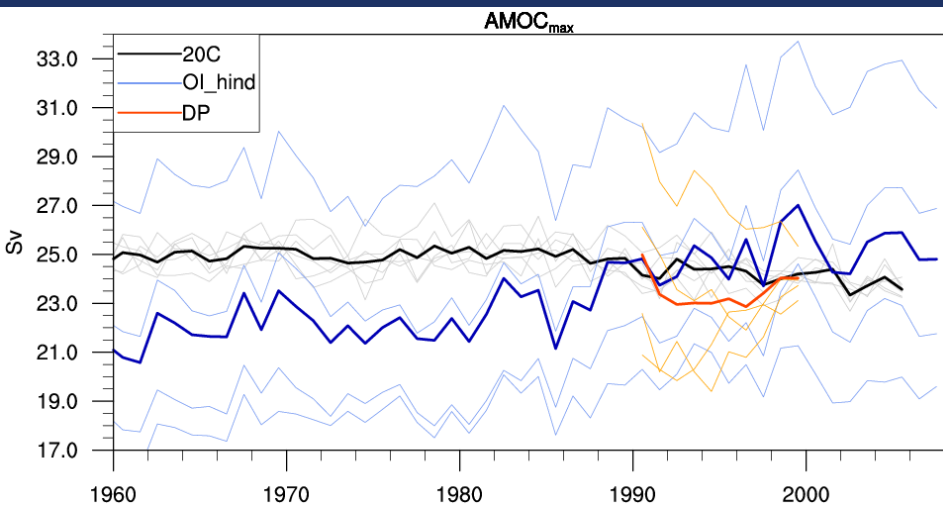
AMOC (max north of 28°N)



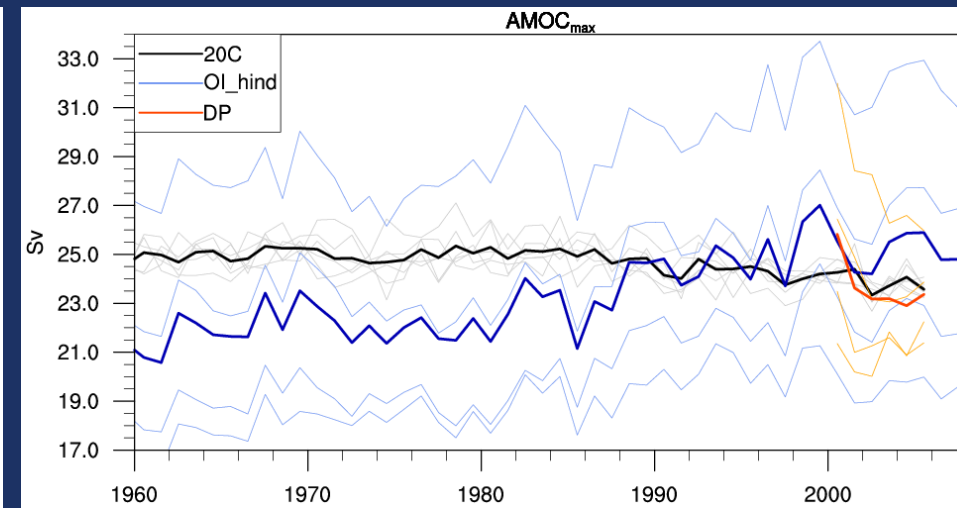
1970 initialization



1980 initialization

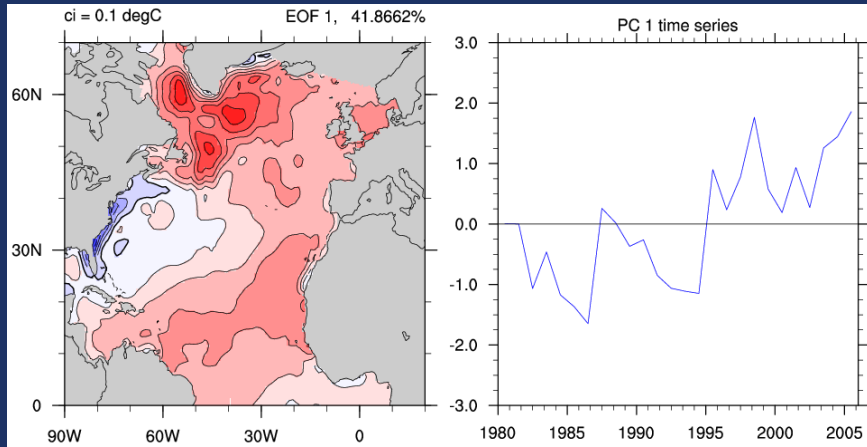


1990 initialization

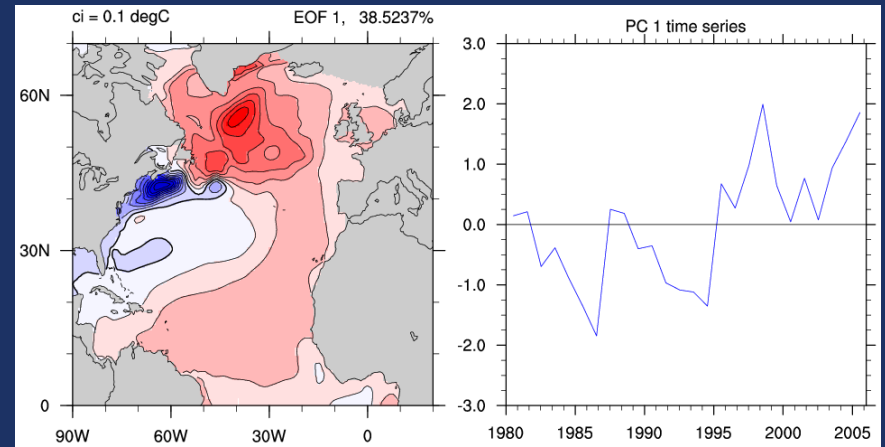


2000 initialization

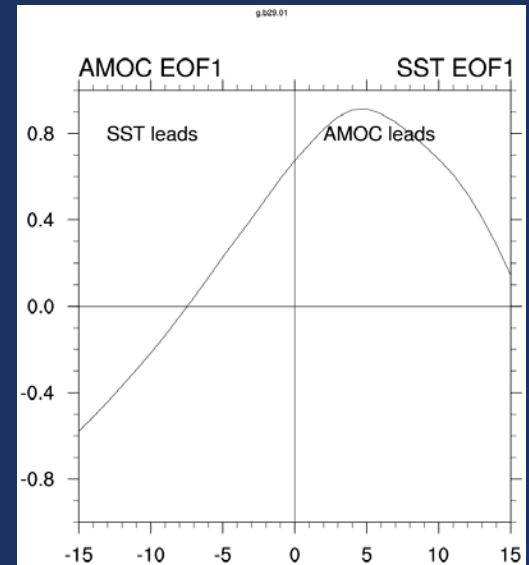
N. Atlantic SST EOF 1



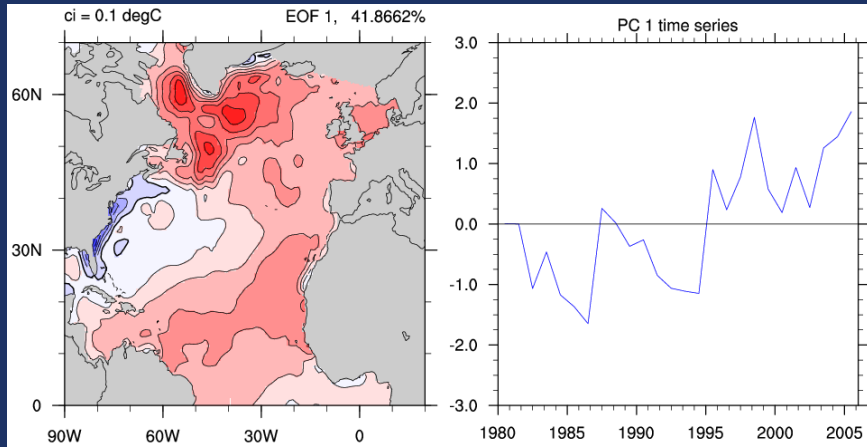
HADOI-SST
obs



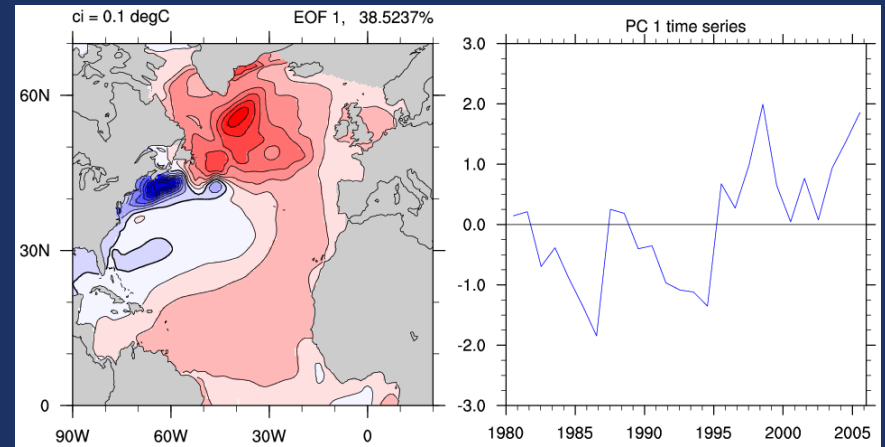
OI_hind1



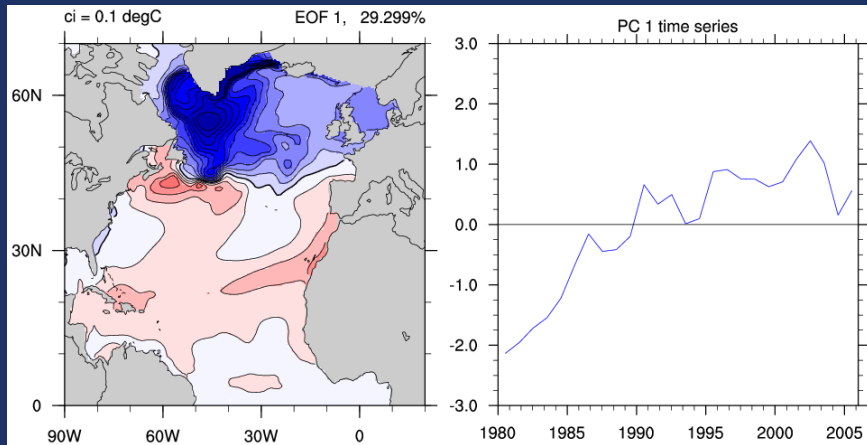
N. Atlantic SST EOF 1



HADOI-SST
obs

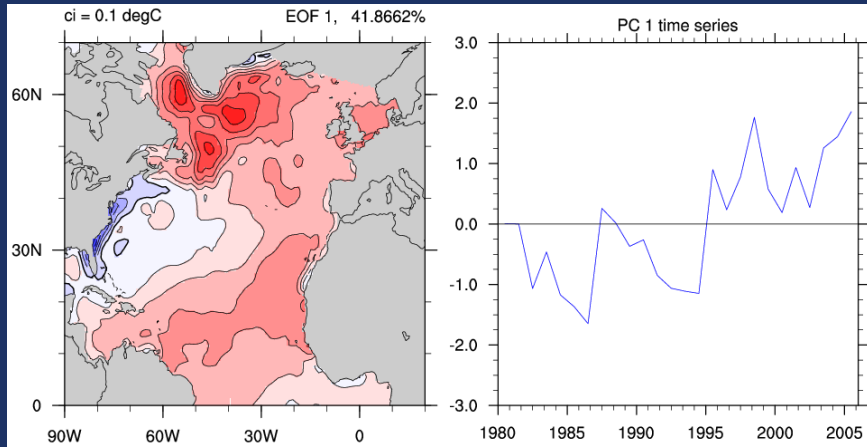


OI_hind1

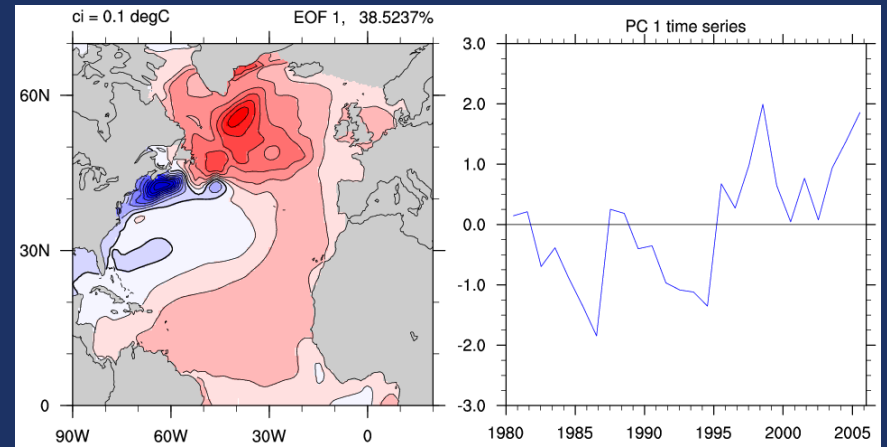


DP1

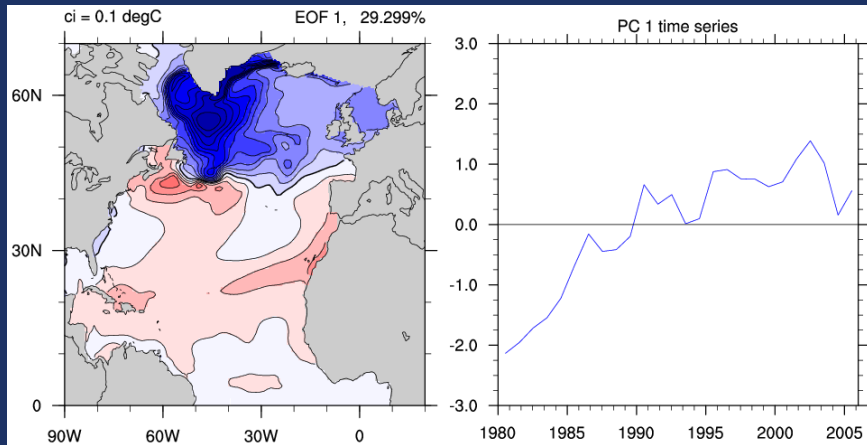
N. Atlantic SST EOF 1



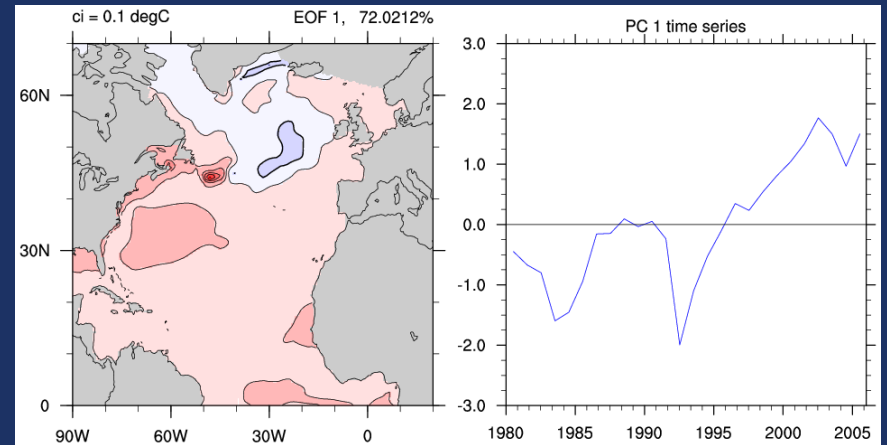
HADOI-SST
obs



OI_hind1



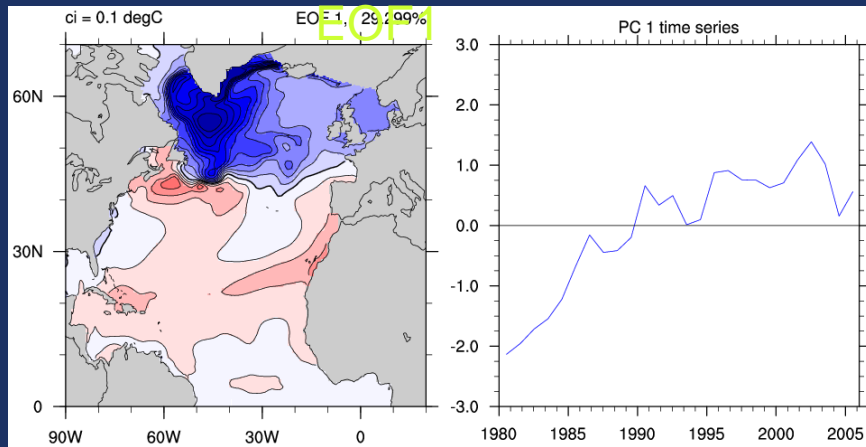
DP1



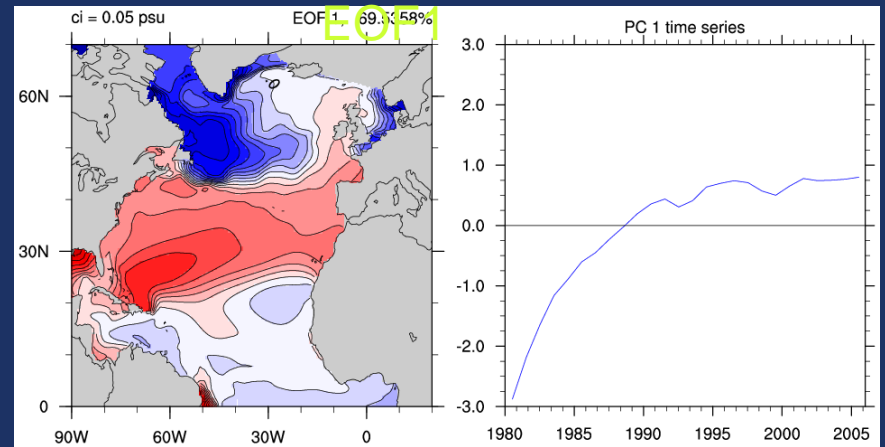
20C, ensavg

DP1

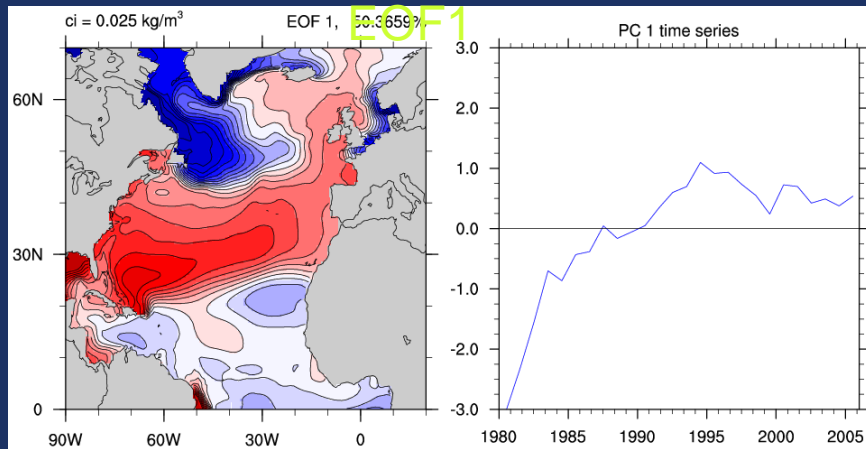
SST



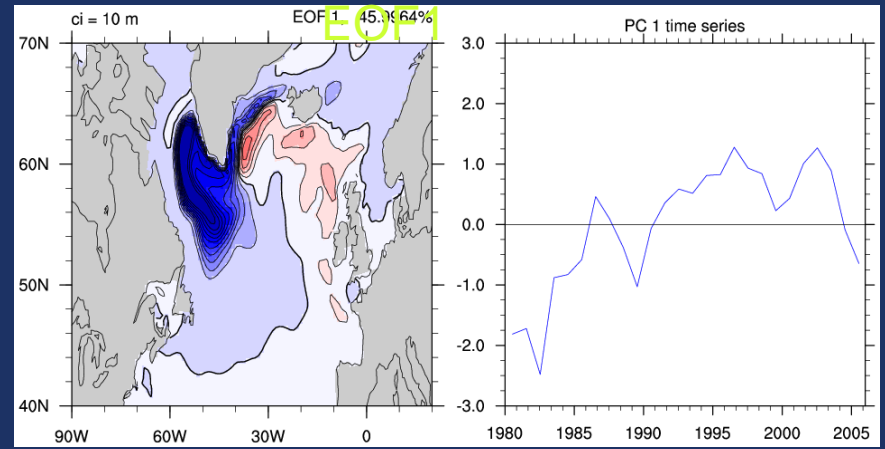
SSS



SSD



MLD



=> Saw similar evolution in early DP attempts using CCSM3.5

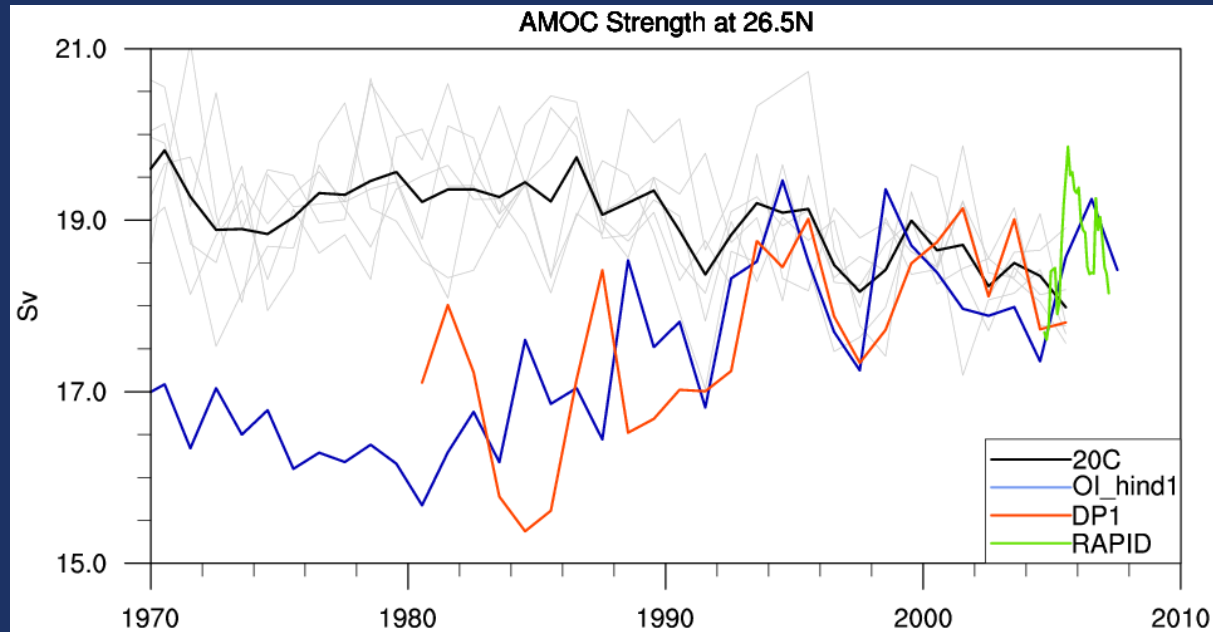
- Apart from overall bias reduction early on, we have no indication so far that initializing CCSM leads to more realistic decadal climate evolution in the Atlantic.
- To really assess DP quality/viability, we need multidecadal runs over the observed record. Is it possible to use data assimilation to generate initial conditions from 1980 or earlier?

to be continued...

Thank You

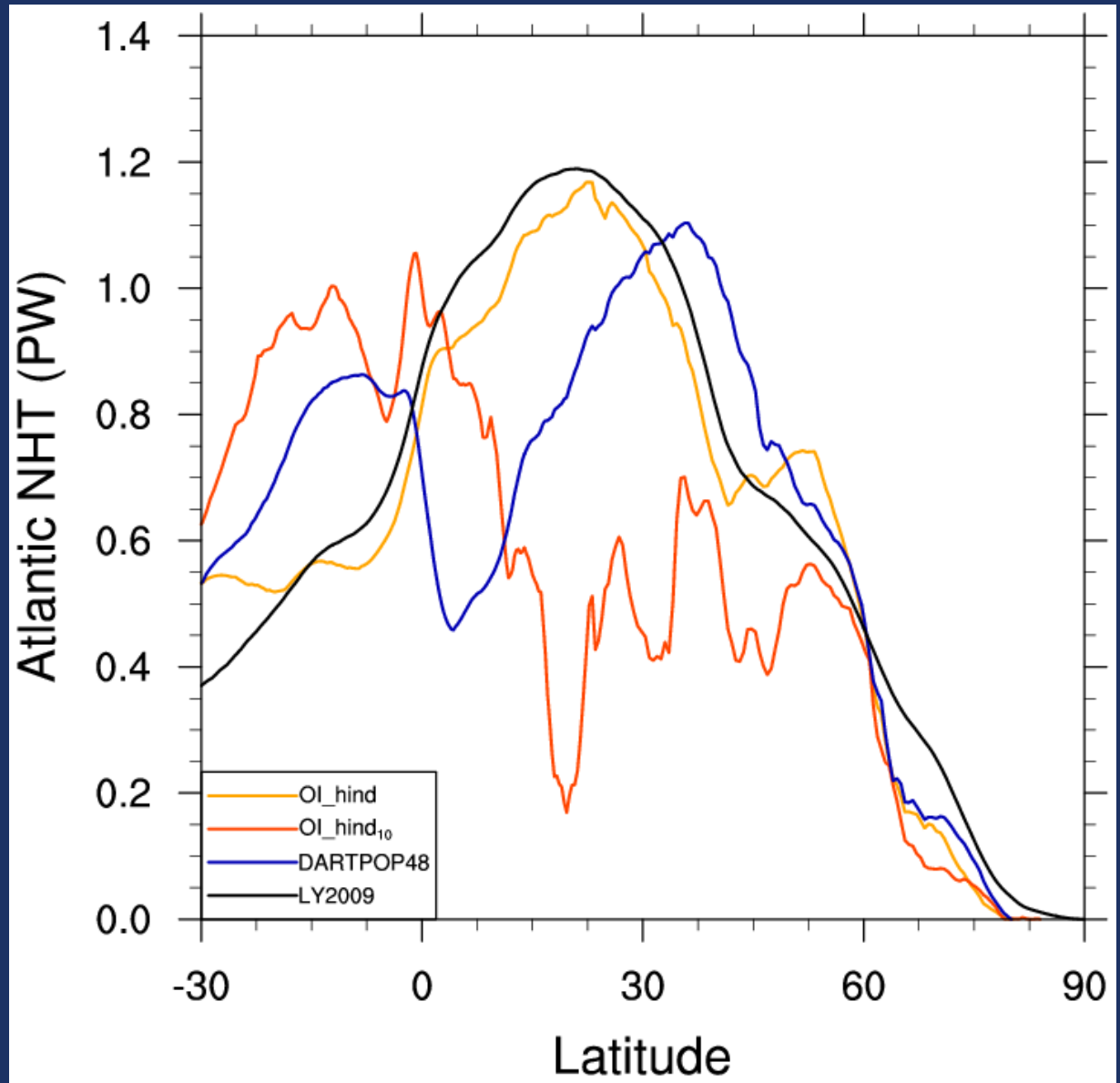
AMOC at 26.5°N

1980 initialization

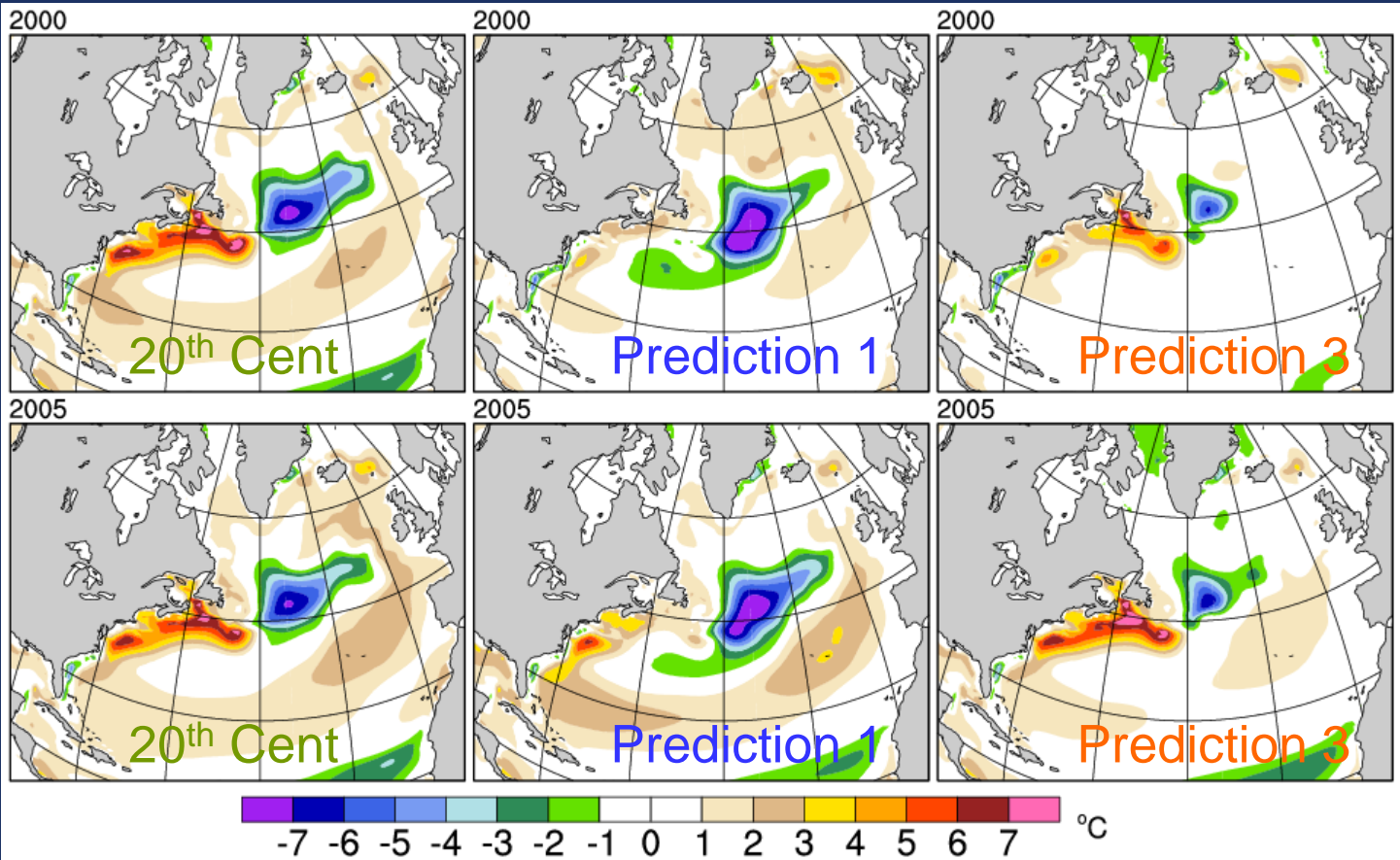


	1980-2000 Trend (Sv/decade)
20C ensemble	-0.4
OI_hind1	1.3
DP1	1.0

Atlantic Meridional Heat Transport



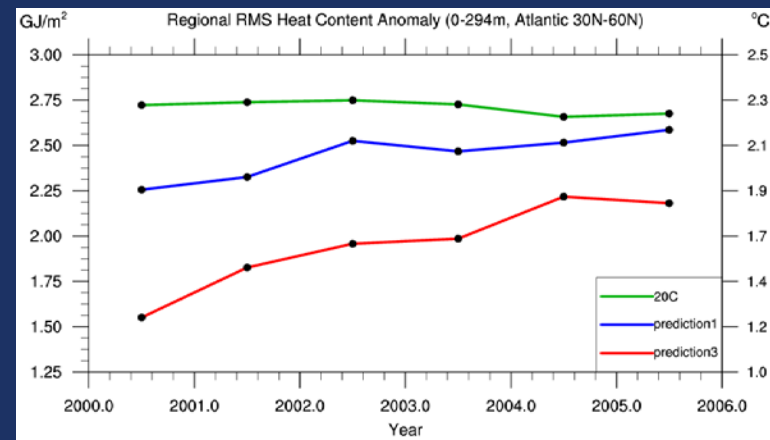
Mean Temperature Bias (0-294m)

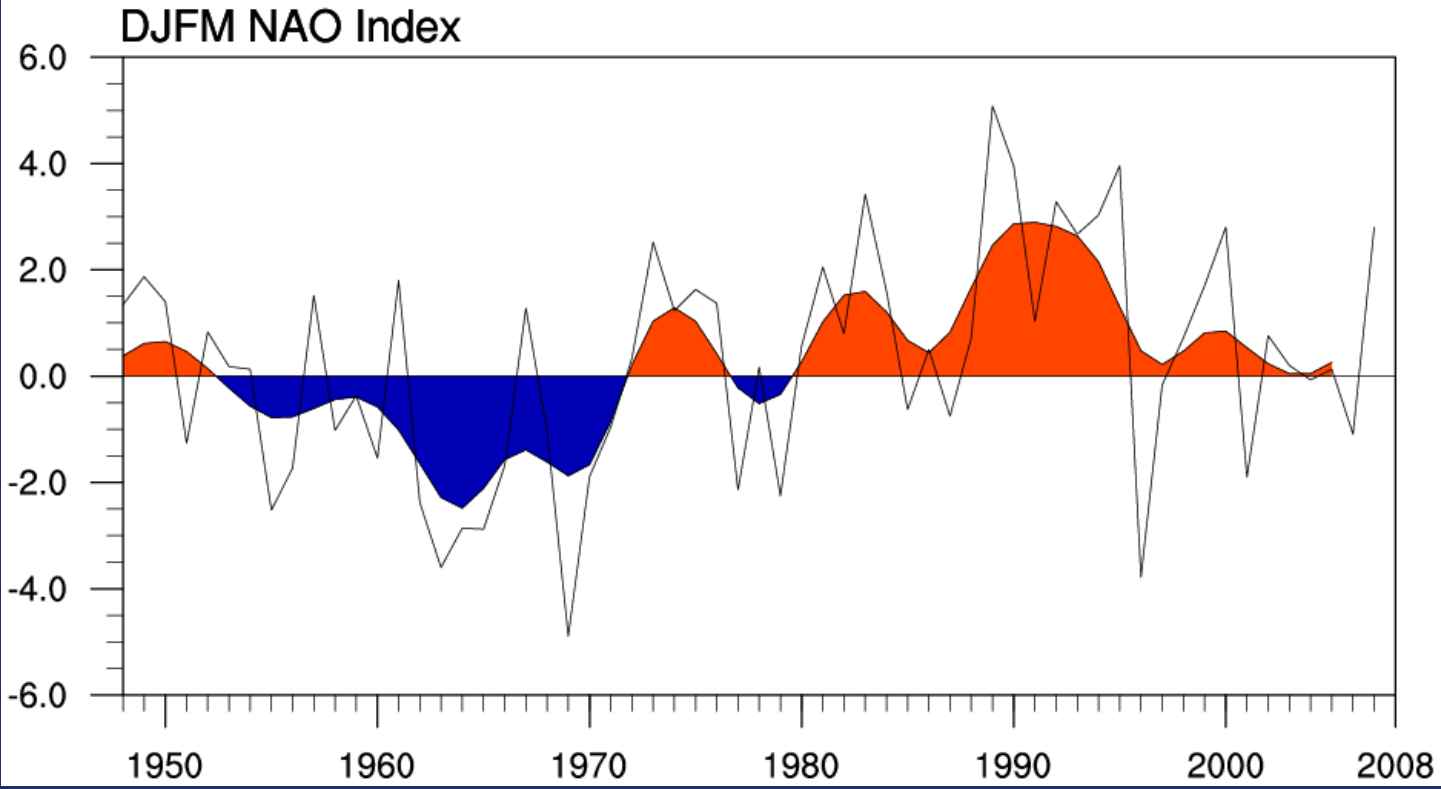


2000

2005

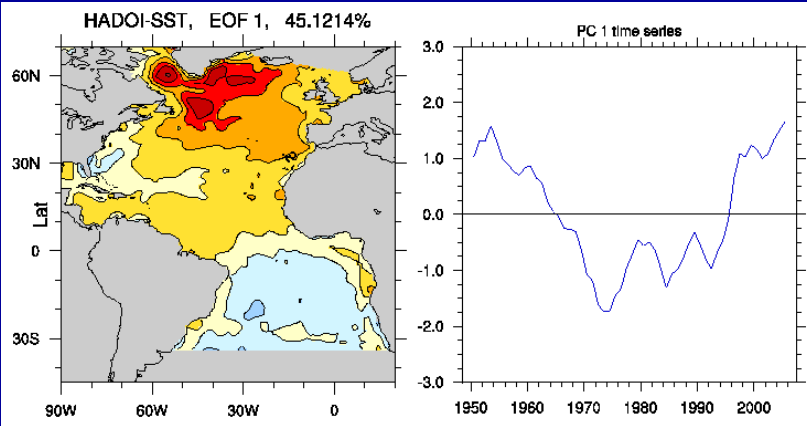
However, prediction tests show that upper ocean bias reduction persists for 5+ years, especially with data assimilation initialization (red).





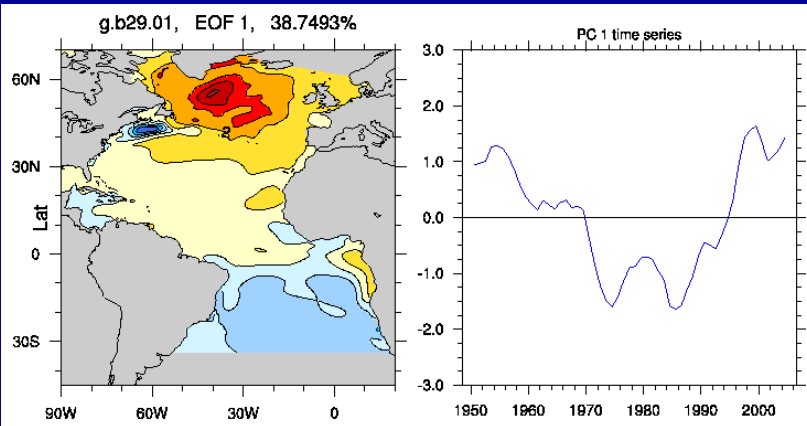
Observations:

SST
"AMO"

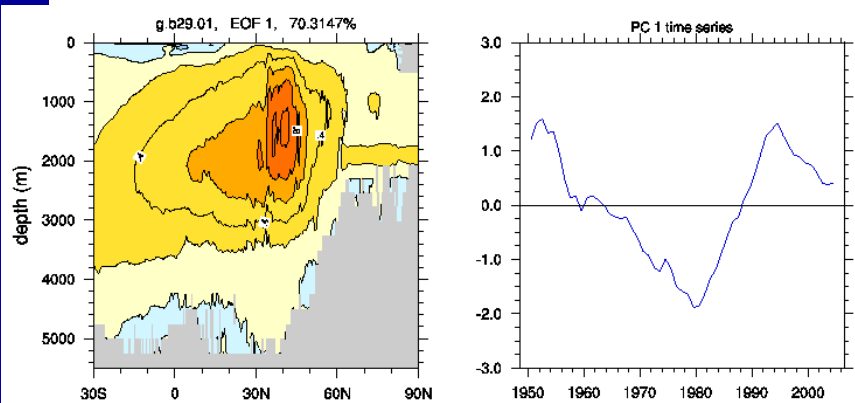


Ocean-ice hindcast simulation:

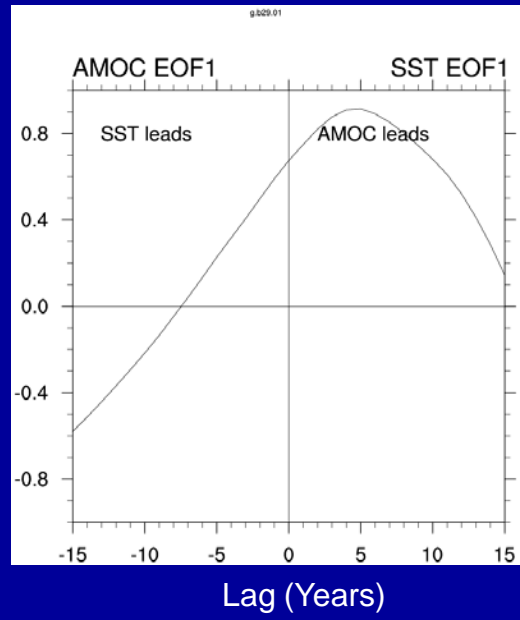
SST



AMOC



Correlation of PC1 of AMOC and SST



AMOC at 26.5N (Sv)

