Comparing AMOC trends in a set of ocean reanalysis products at 41N

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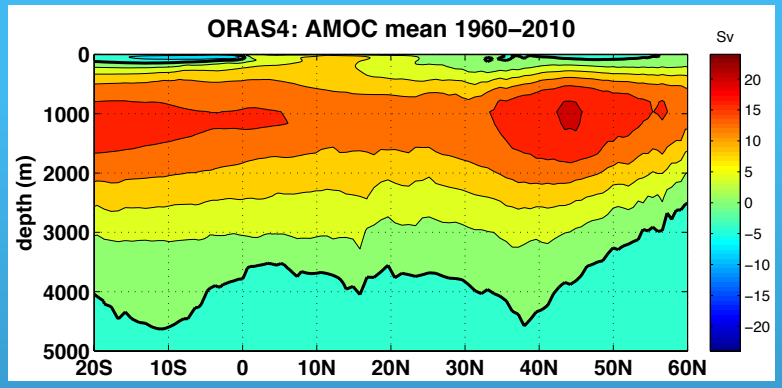
Why do we care about low-frequency AMOC variability in ocean reanalysis products?

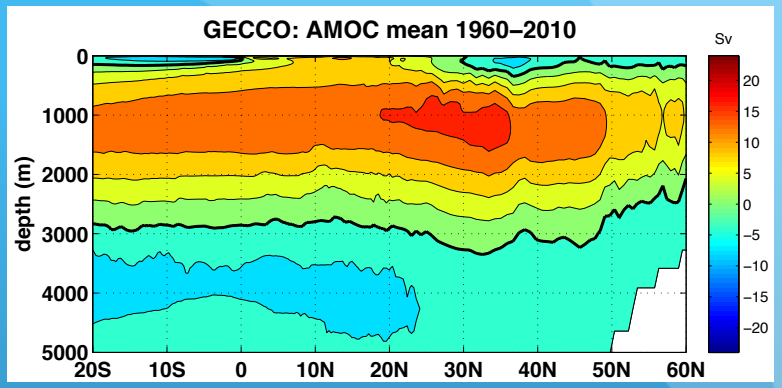
- **Process understanding**
- AMOC state upon initialization is thought to play an important role in **decadal-scale climate prediction** in the North Atlantic. (Robson et al 2012; Yeager et al 2012, etc)
  - Retrospective prediction experiments are used to evaluate the performance of prediction systems.
  - Ocean reanalysis products are used to initialize those retrospective predictions, *commonly from start-dates starting in the 1960's*

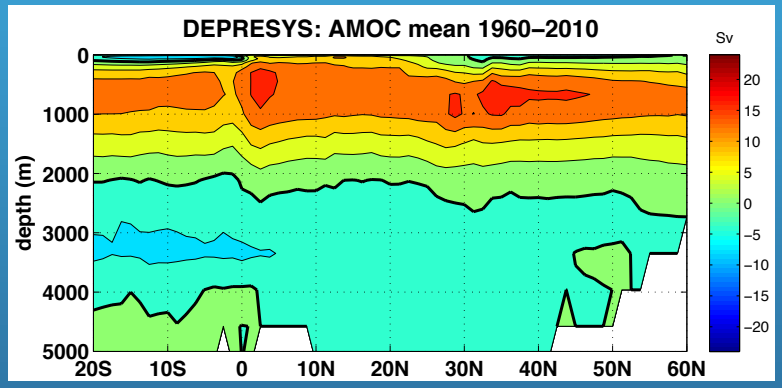
Groups that have given us AMOC data and state variable reconstructions

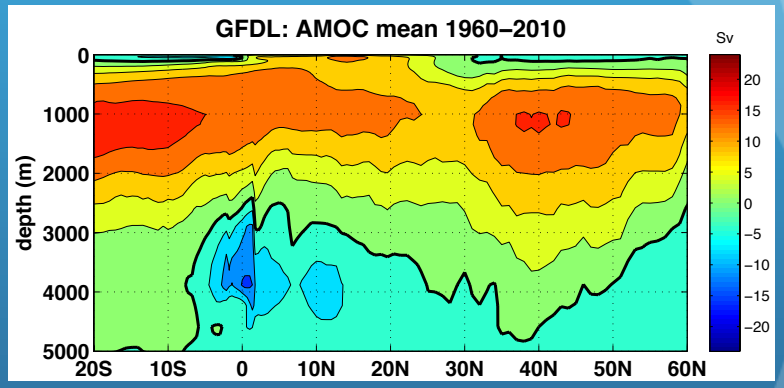
GROUP	METHOD	DP INIT?	INSITU TEMP/ SALINITY	ALTIMETRY	SST
ECDA3.2(GFDL)	EKF	yes	yes	no	yes
ORAS4(ECMWF)	NEMOVAR 3DVar	yes	yes	yes	yes
SODA	OI	yes	yes	no	yes
GECCO2	4DVAR	yes	yes	yes	yes
DePreSys (Smith and Murphy 2007)	OI	yes	yes	no	yes
UR025.4 (1989-	OI	?	yes	yes	yes

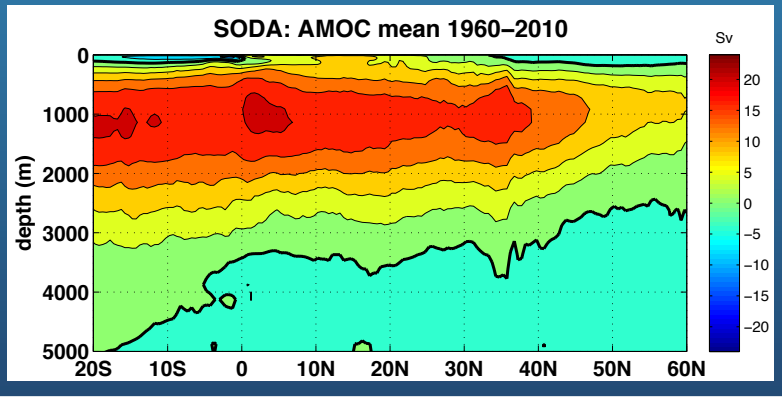
Time-mean AMOC (1960-2010)



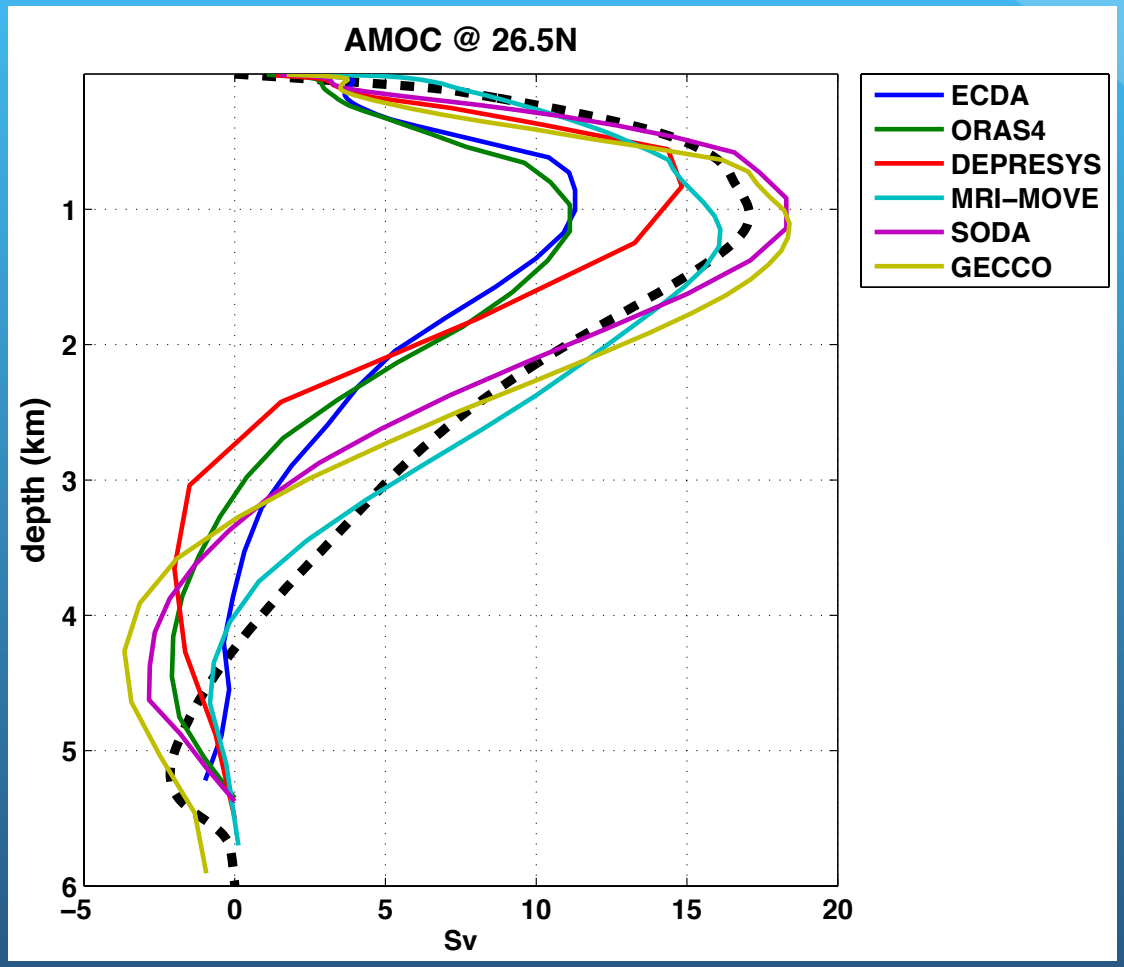




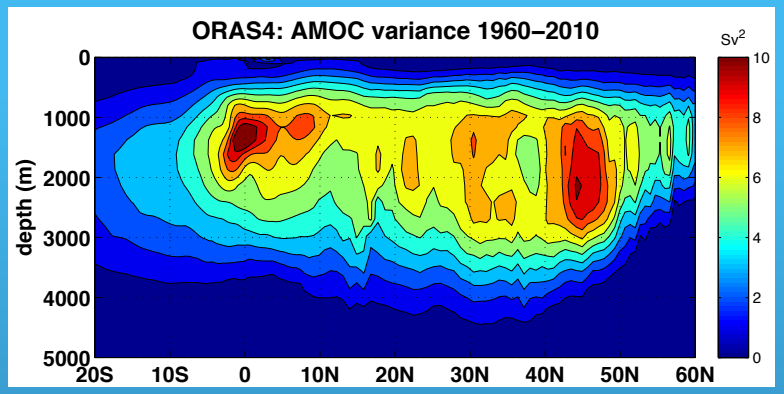


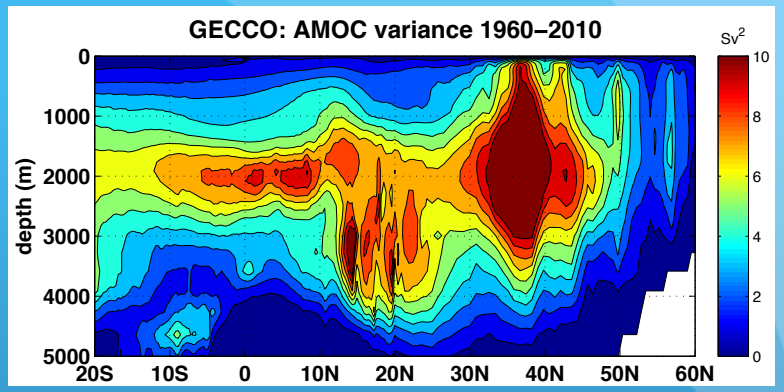


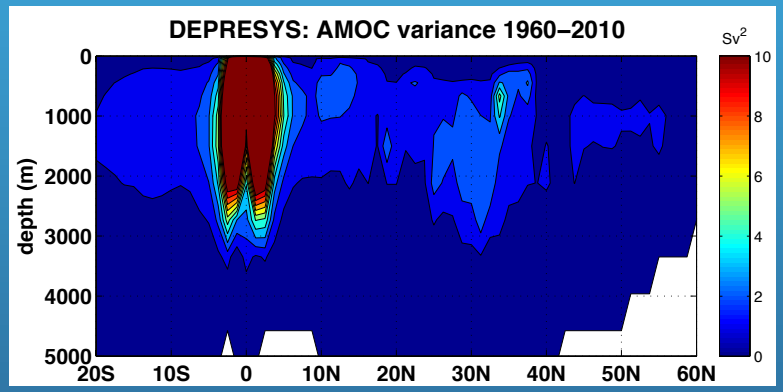
Comparison to RAPID estimates @ 26.5N

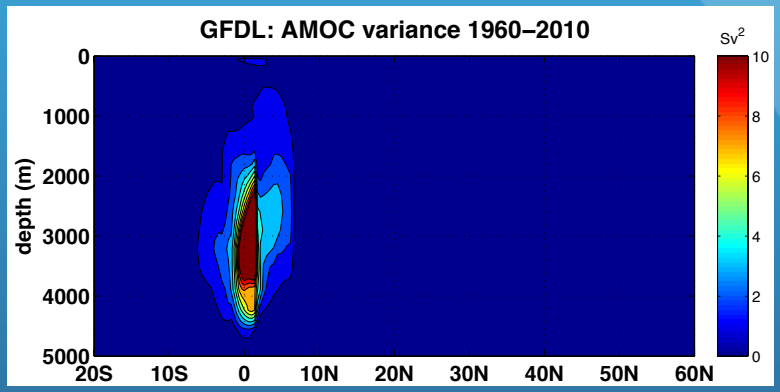


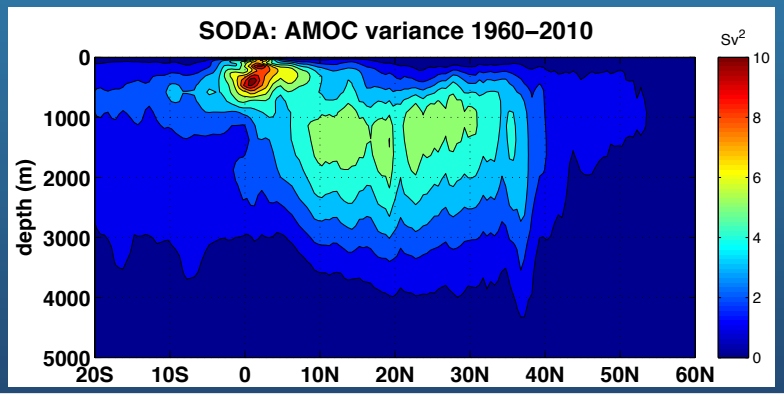
Variance of AMOC (1960-2010)



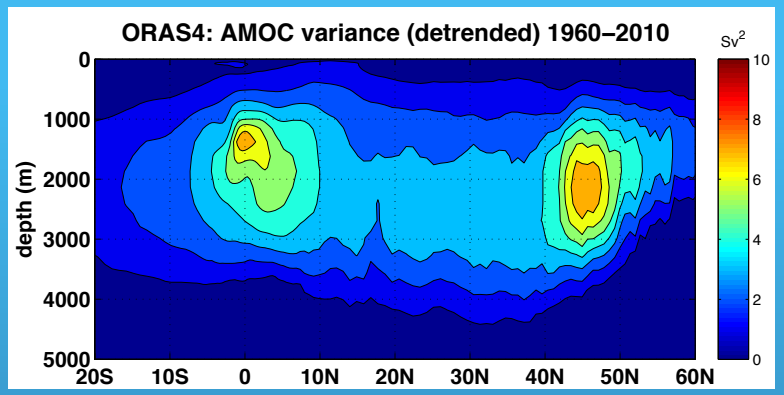


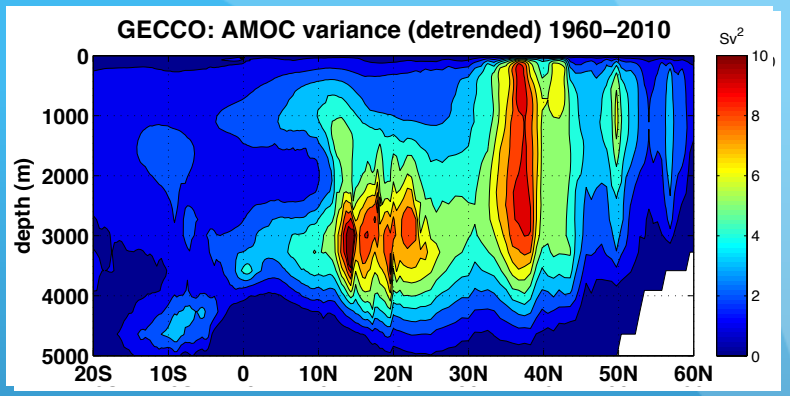


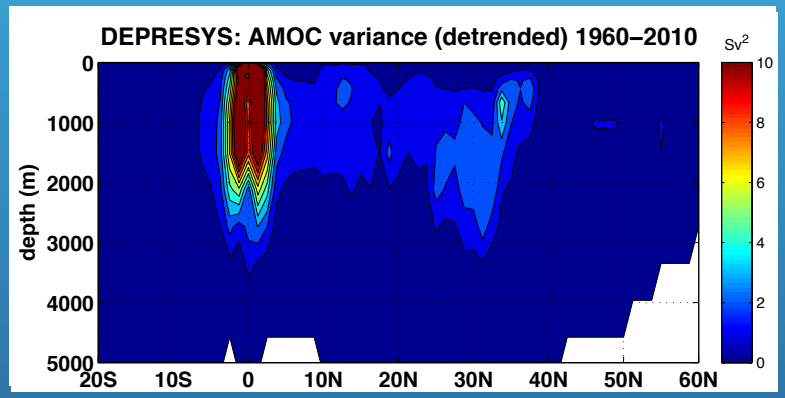


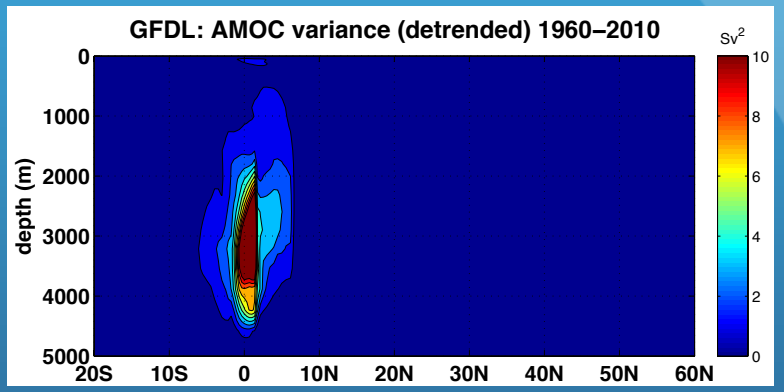


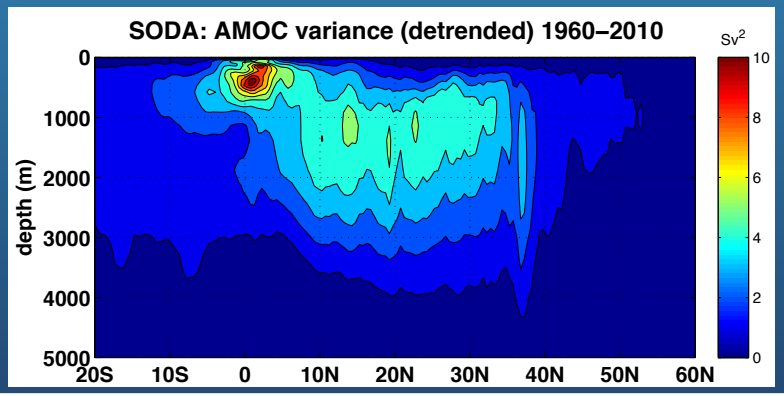
Variance of AMOC (detrend) (1960-2010)



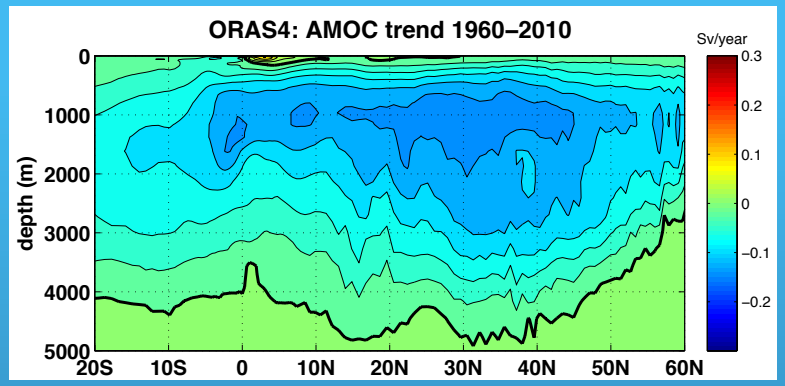


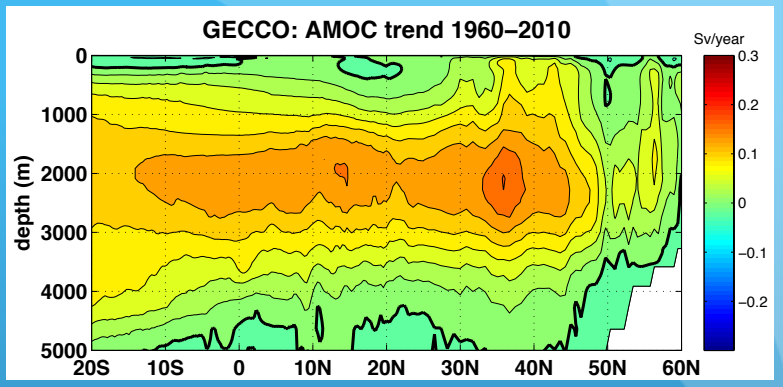


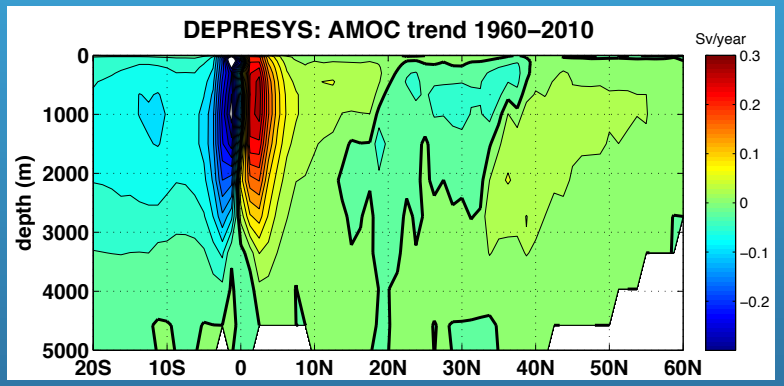


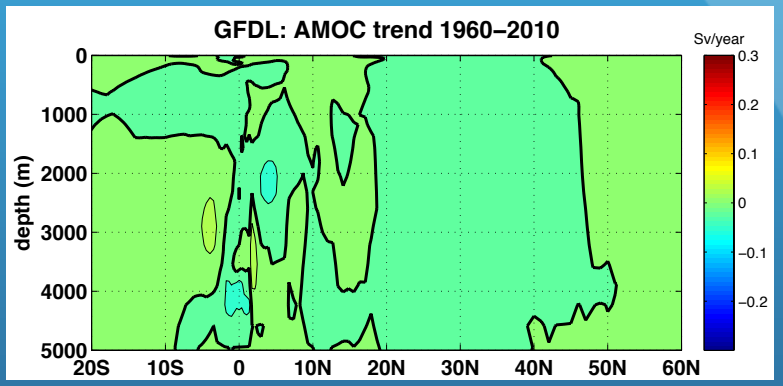


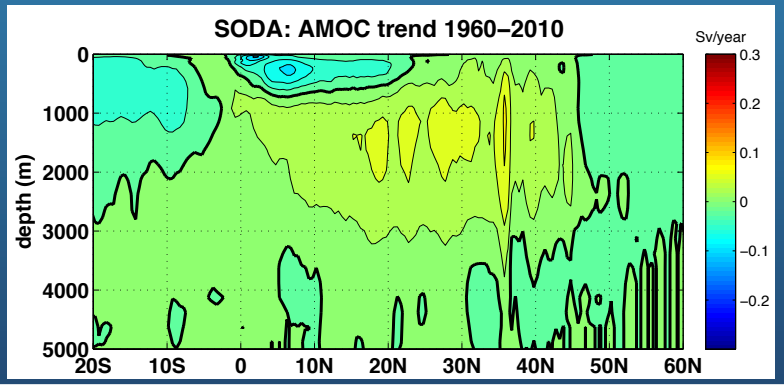
AMOC Trend (1960-2010)



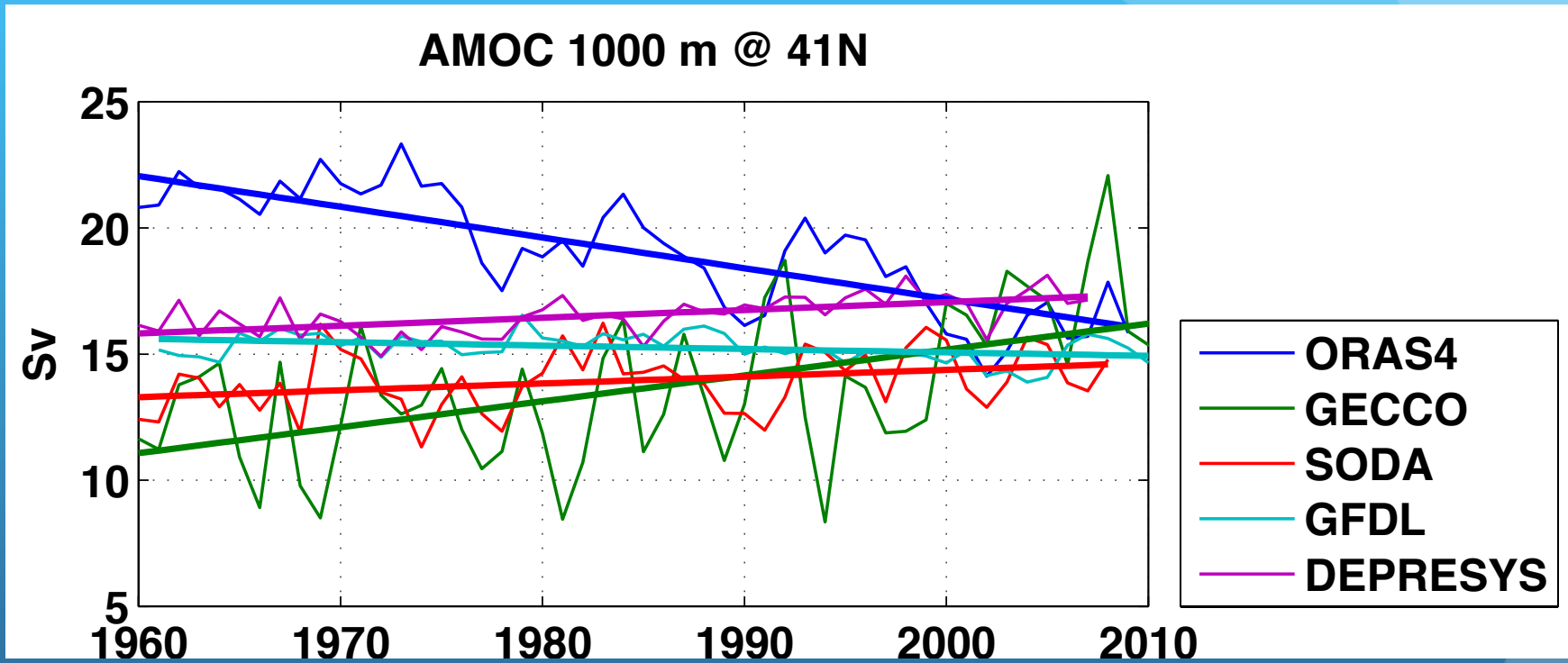






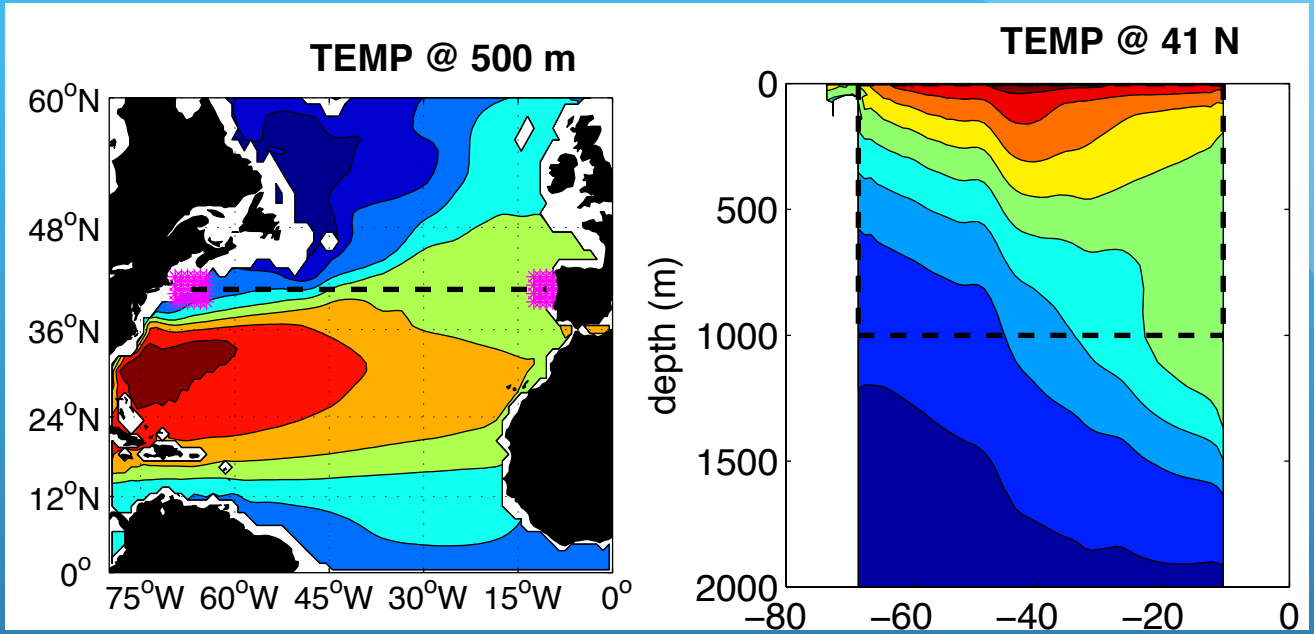


AMOC time-series @ 41N (1960-2010)



Trends in the AMOC are inconsistent

The geostrophic shear @ 41N



$$\Psi_{total} \approx \Psi_{Ekman} + \Psi_{shelf} + \Psi_{geostrophic}$$

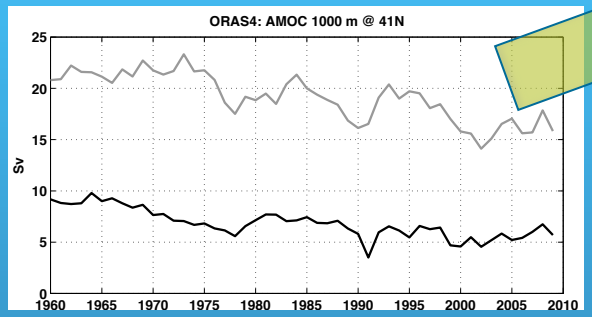
$$\Psi_{geostrophic} = \int_{-H}^{0} \overline{v}_g^{\,x} dz$$

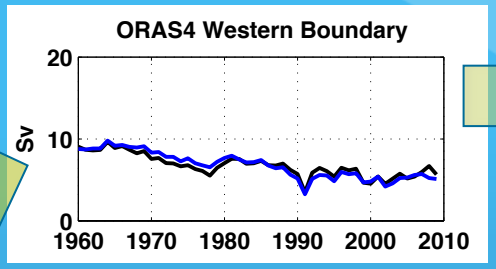
$$= \int_{-H}^{0} \frac{g}{f\rho_o} \int_{-H}^{z} \rho_w(z') - \rho_e(z') dz' dz \quad + \quad H\overline{v}_{-H}^{\,x}$$

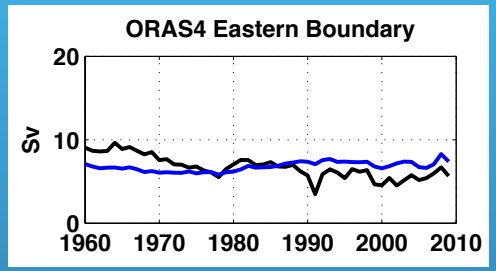
$$\rho_w = f(T_w, S_w)$$
$$= f(\overline{T_w} + T_w', \overline{S_w} + S_w')$$

$$\rho_e = f(T_e, S_e)$$
$$= f(\overline{T_e} + T_e', \overline{S_e} + S_e')$$

ORAS4


ORAS4: AMOC 1000 m @ 41N
Sv
25
20
15
10
5
0
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010


ORAS4 Western Boundary
Sv
20
10
0
1960 1970 1980 1990 2000 2010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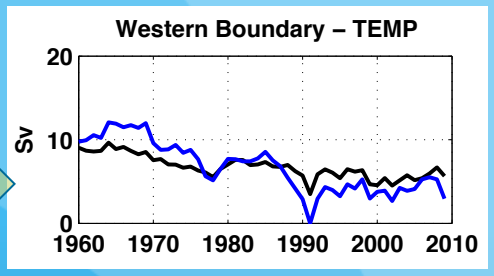
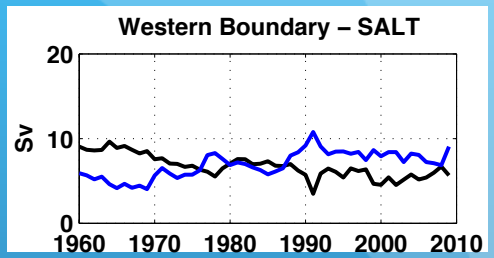
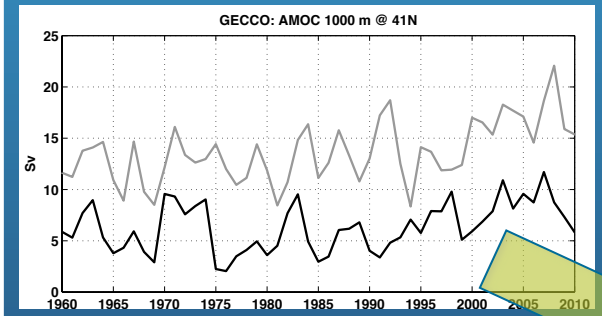

Western Boundary – TEMP
Sv
20
10
0
1960 1970 1980 1990 2000 2010


Western Boundary – SALT
Sv
20
10
0
1960 1970 1980 1990 2000 2010

GECCO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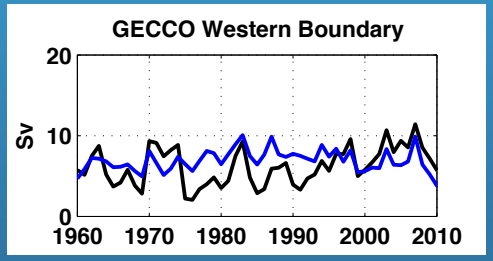
GECCO Western Boundary
Sv
20
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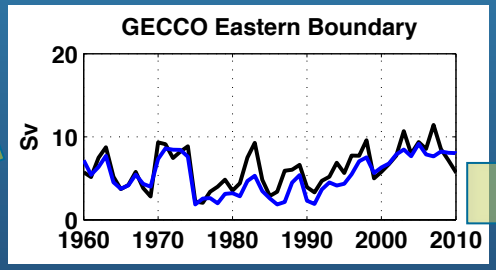
1960 1970 1980 1990 2000 2010


GECCO Eastern Boundary
Sv
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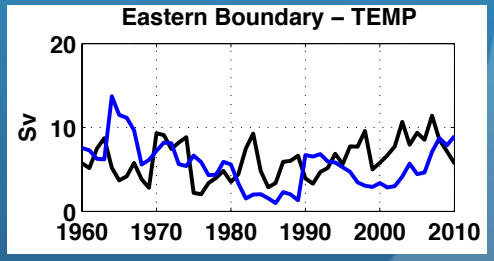
Eastern Boundary – TEMP
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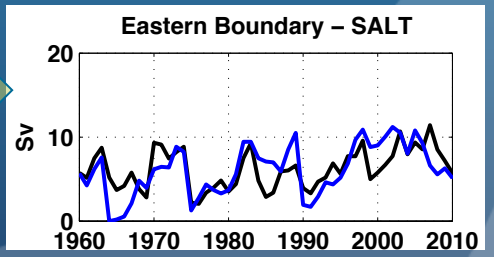
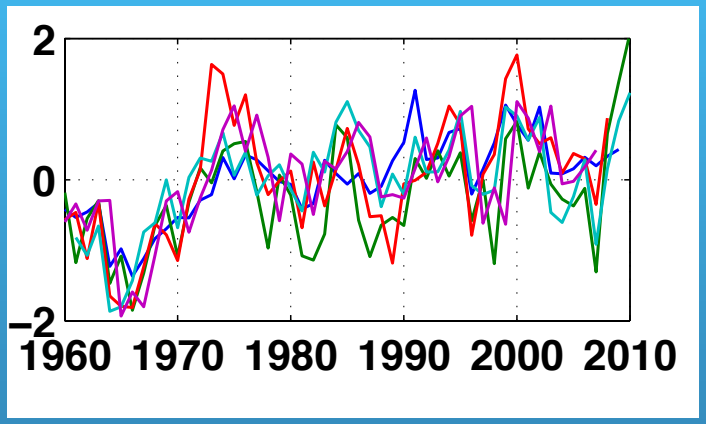
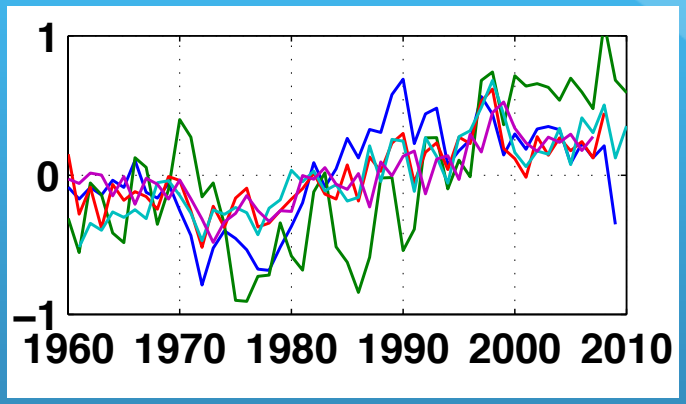

Eastern Boundary – SALT
Sv
20
10
0
1960 1970 1980 1990 2000 2010

Is the temperature at the eastern/western boundary in agreement?

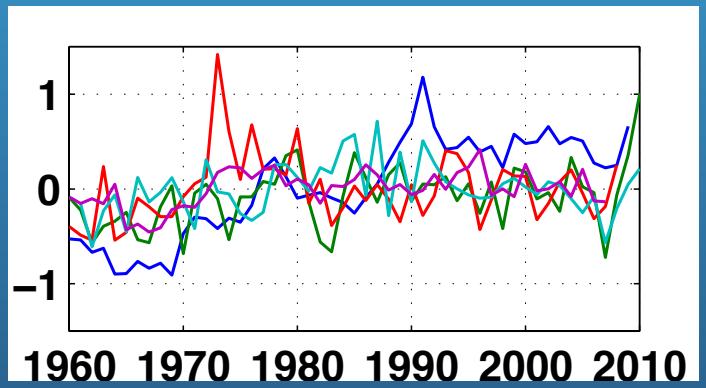
WESTERN BOUNDARY

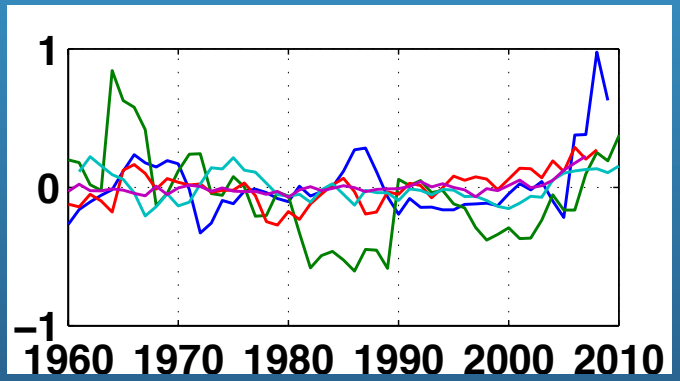


EASTERN BOUNDARY

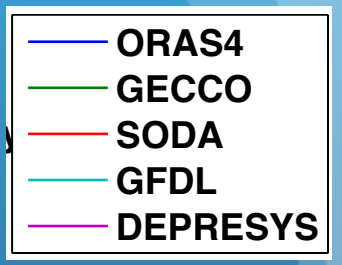


0-250 m





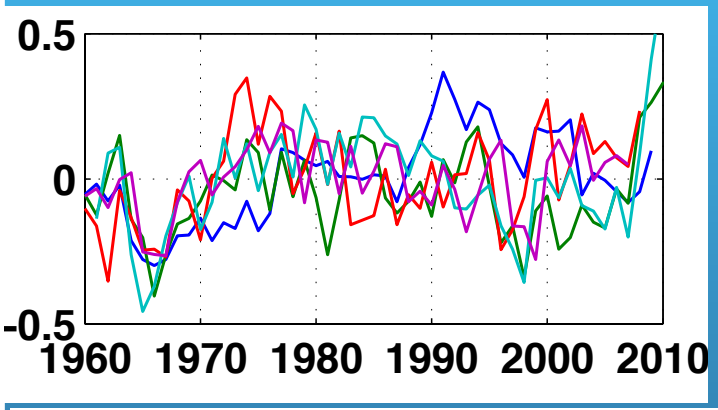
250-1000 m

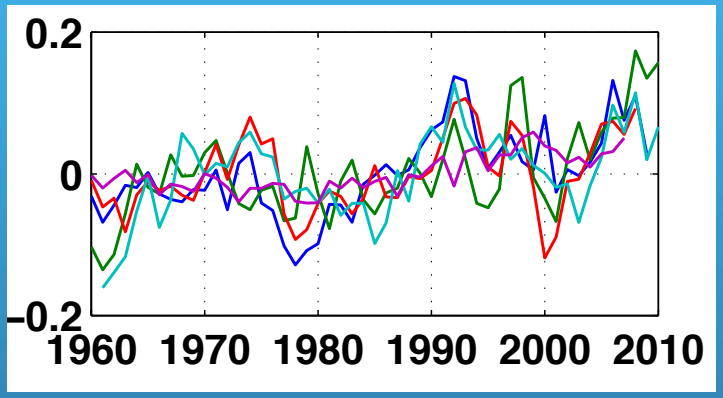


Is the salinity at the eastern/western boundary in agreement?

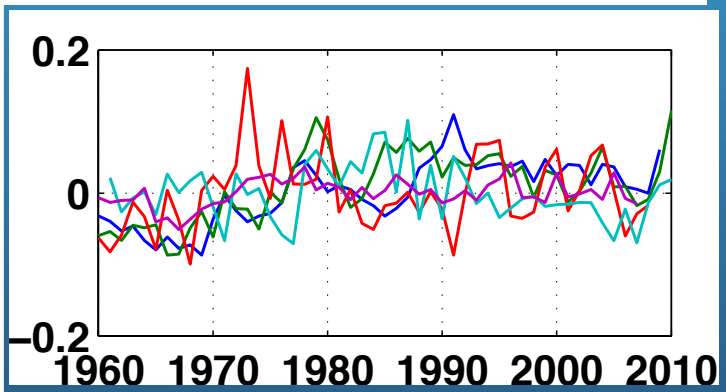
WESTERN BOUNDARY

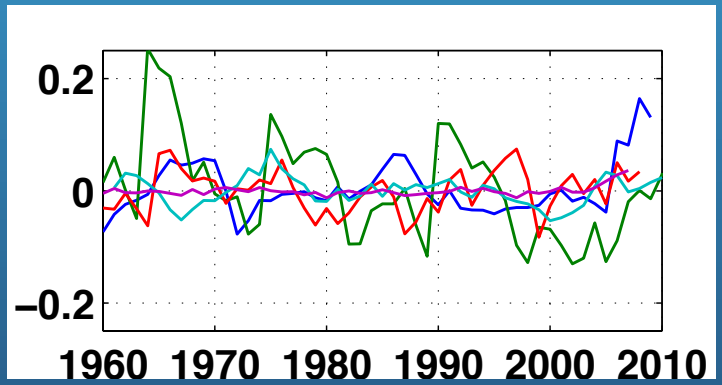
EASTERN BOUNDARY



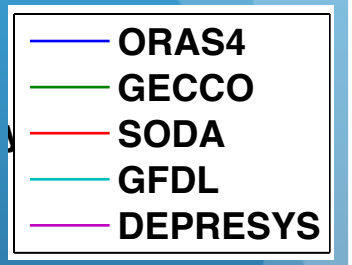


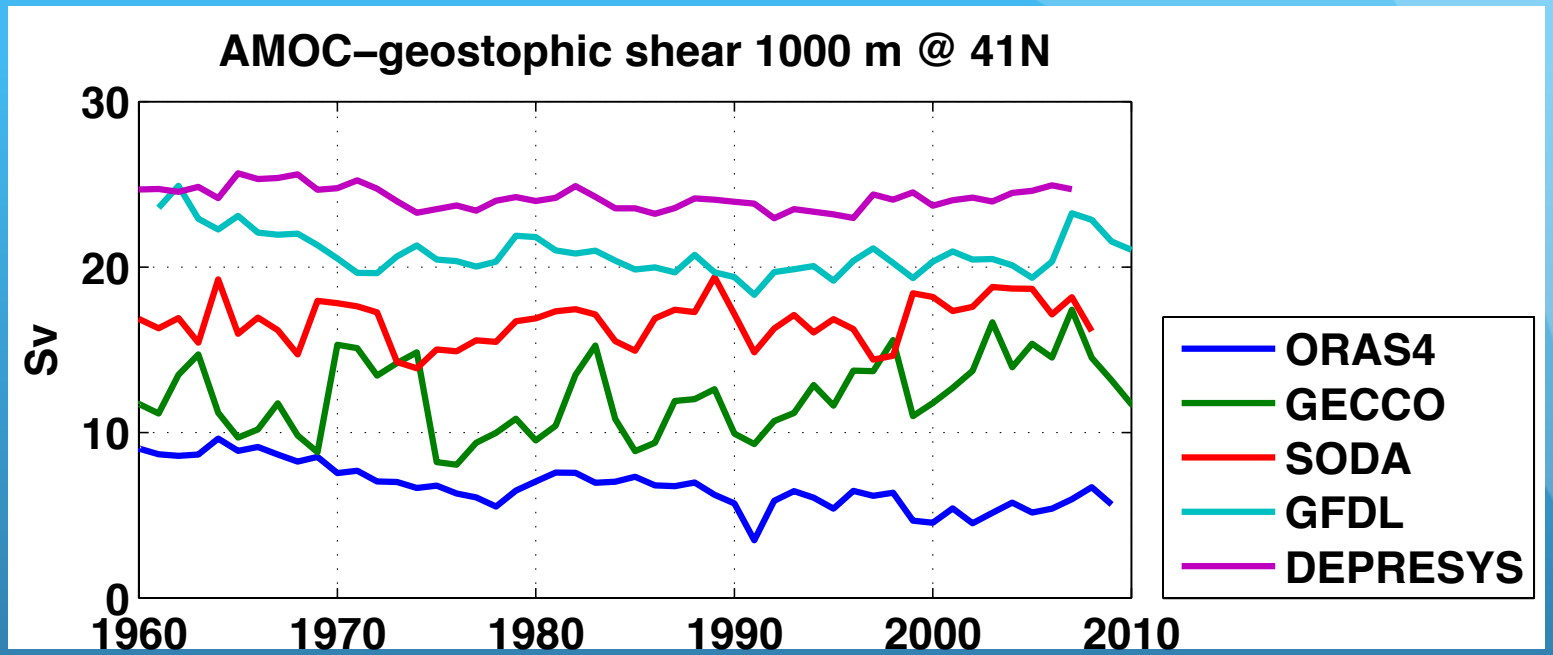
0-250 m





250-1000 m





Trends in the
geostrophic shear component of AMOC
in the upper ocean are inconsistent

Summary

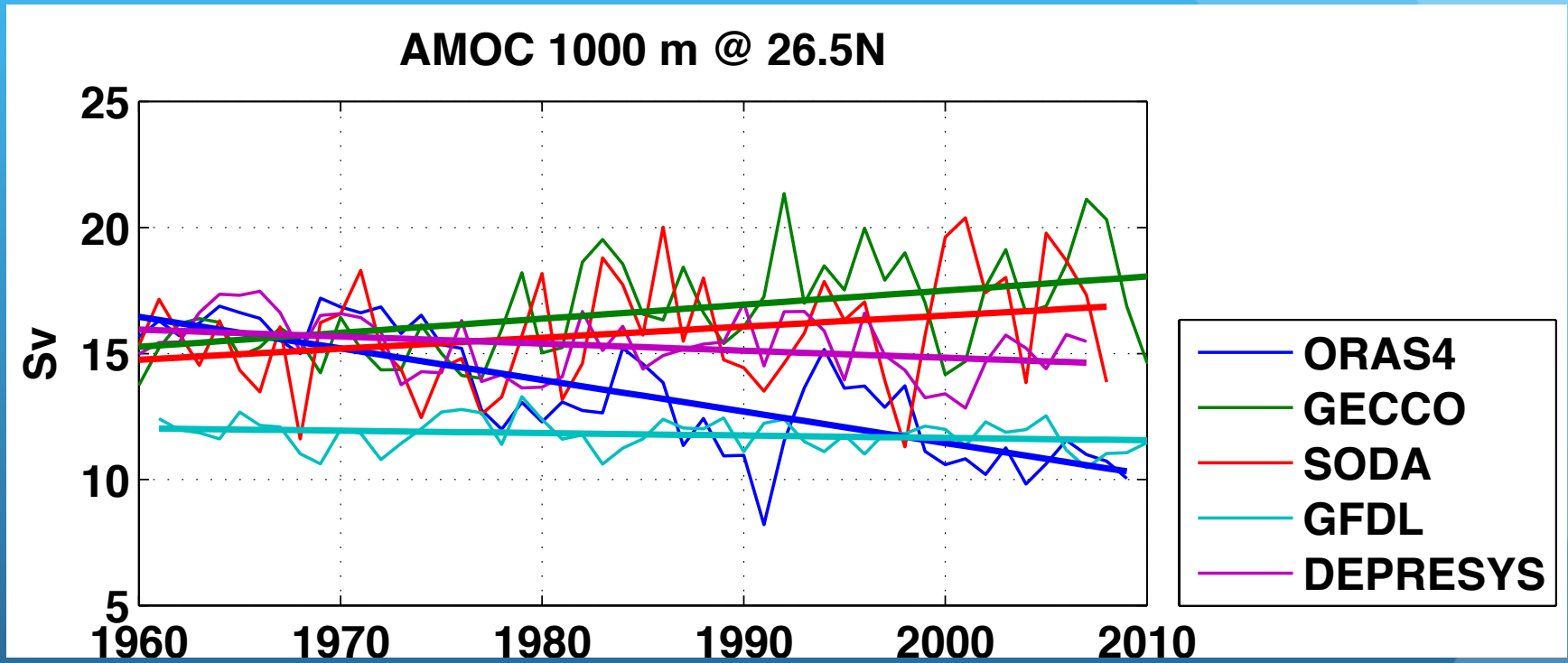
- AMOC variabilty/trends are not consistent between ocean reanalysis products.
- In a preliminary analysis at 41N we found disagreement about
  - 1) whether density variations on the east or west boundary were dominated the trend
  - 2) whether density variations were primarily driven by temperature or salinity.
  - 3) temp/salinity trends on the boundaries, especially below 250m

Some questions raised by this:

- Are the current generation of reanalysis products useful to inform our understanding of low-frequency AMOC?

- If AMOC is key to decadal prediction, are retrospective forecasts made from reanalysis products useful for anticipating future decadal prediction performance?

AMOC time-series @ 26.5N (1960-2010)



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