Connection between T/S decadal variations in the Subpolar North Atlantic and the tropical Atlantic AMOC

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NOAA/GFDL

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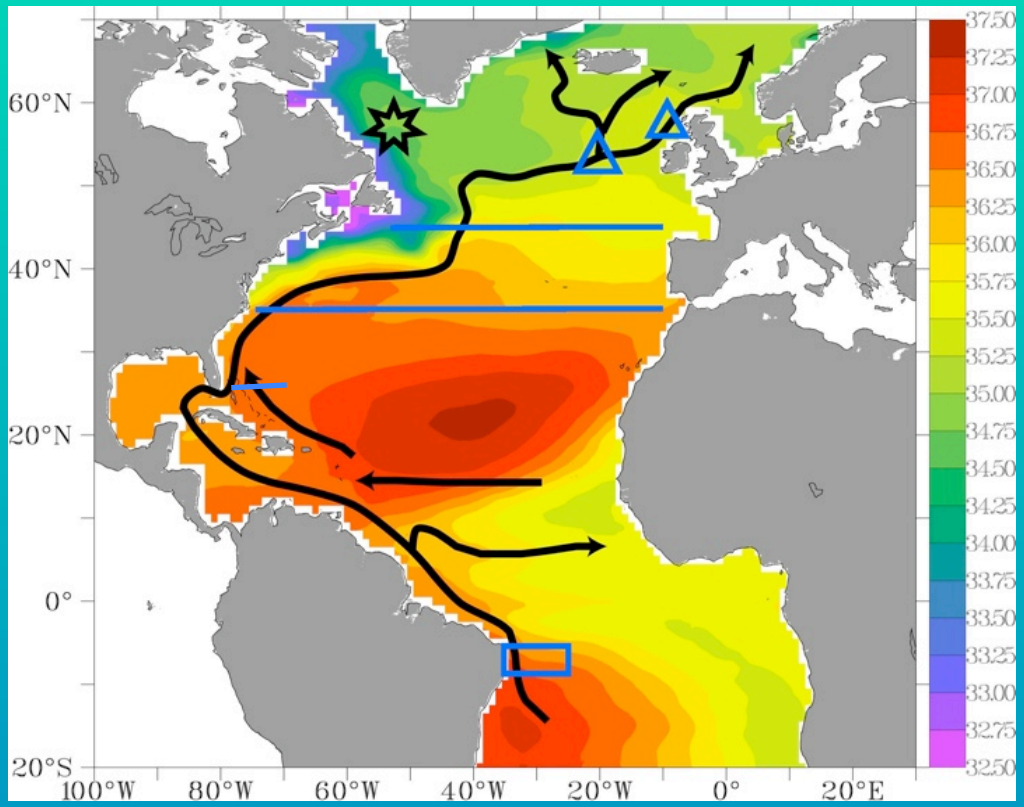
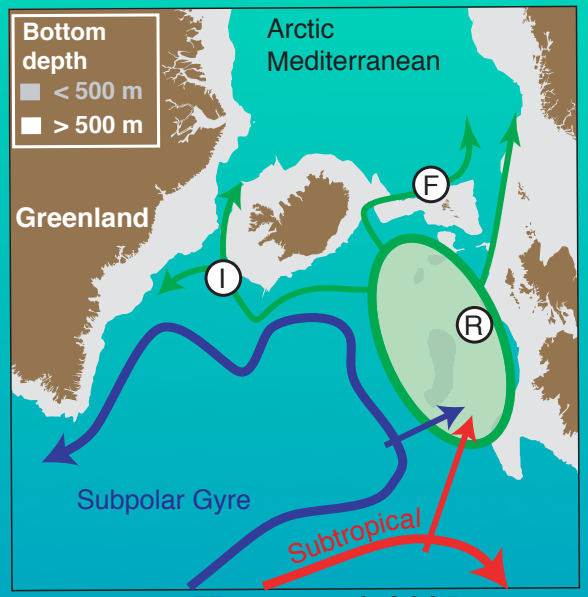
Upper Limb of AMOC and Salinity at 100 m





Hatun et al. 2005

Motivation:

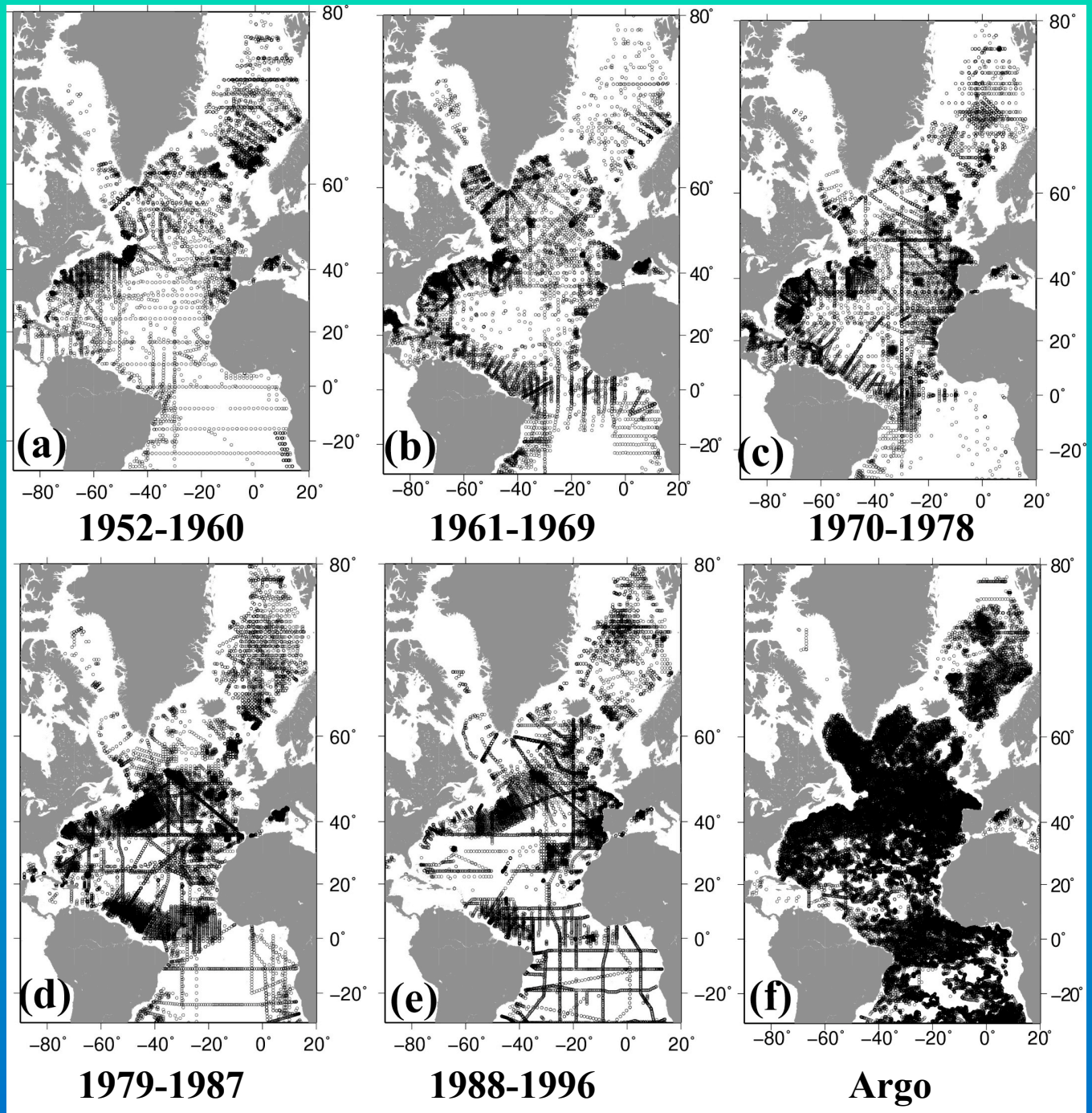
Salinity anomalies from subtropical/tropical Atlantic to the subpolar region as one of the mechanisms to make AMOC oscillate (e.g. Persechino et al. 2012 Hadley CHIME 20 yr cycle vs. Vellinga and Wu 2004 HadCM3 90 yr cycle)

Purpose:

Observational evidence of poleward propagation of subtropical T/S anomalies and its relation to AMOC (time scale)

Data and Model Outputs

- Historical hydrography and Argo profiles, 1950-2011
- Coupled climate models, mid-1800s~2000s (GFDL2.1, CCSM3, GFDL ESM2M, CCSM4)
- Data Assimilations, mid-1900~2000s (GECCO, SODA, GFDL Coupled Data Assimilation)
- NCAR Ocean-Ice Model forced by CORE forcing (1948-2007), GFDL ESM 500-yr control

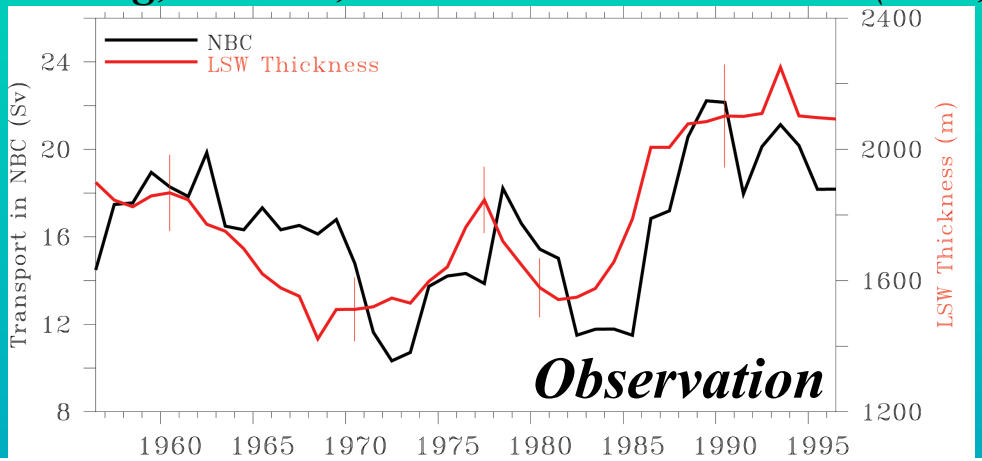


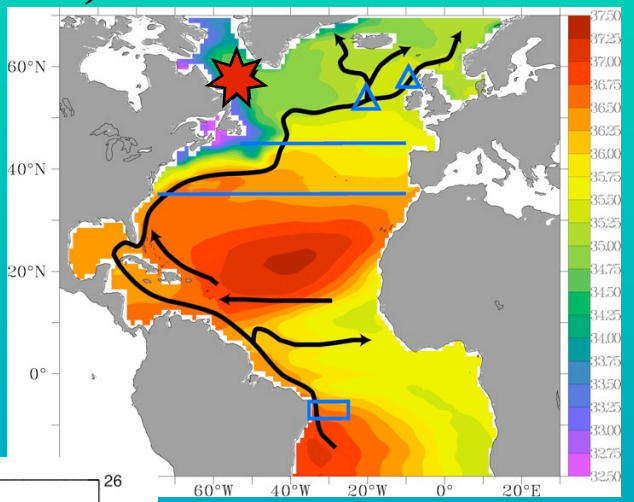
Before 2003, total of 138,584 profiles that have both T and S measurements, reaching 1200m or deeper

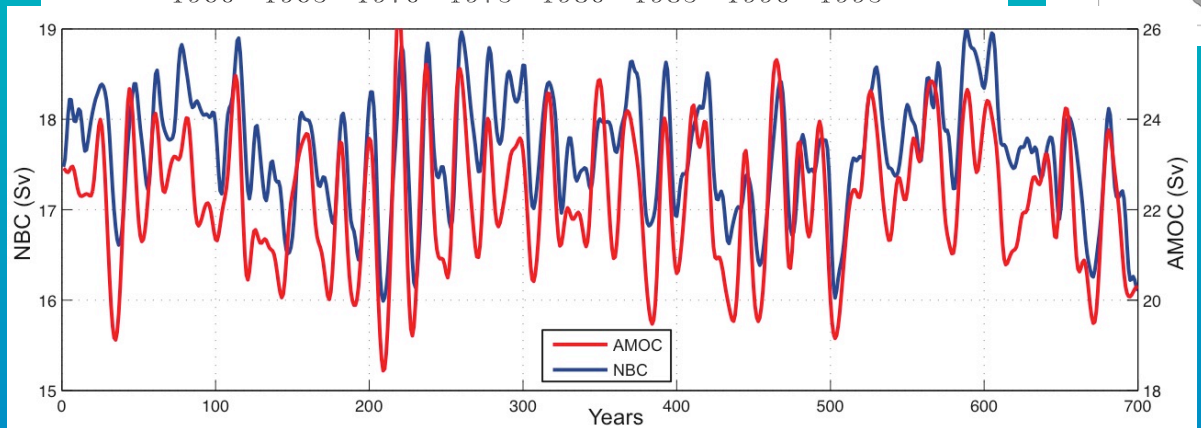
Argo profiles with possible salinity drift are removed from our archive using T-S relation revealed in shipboard data

Multi-Decadal Variation of NBC and Labrador Sea Deep Convection

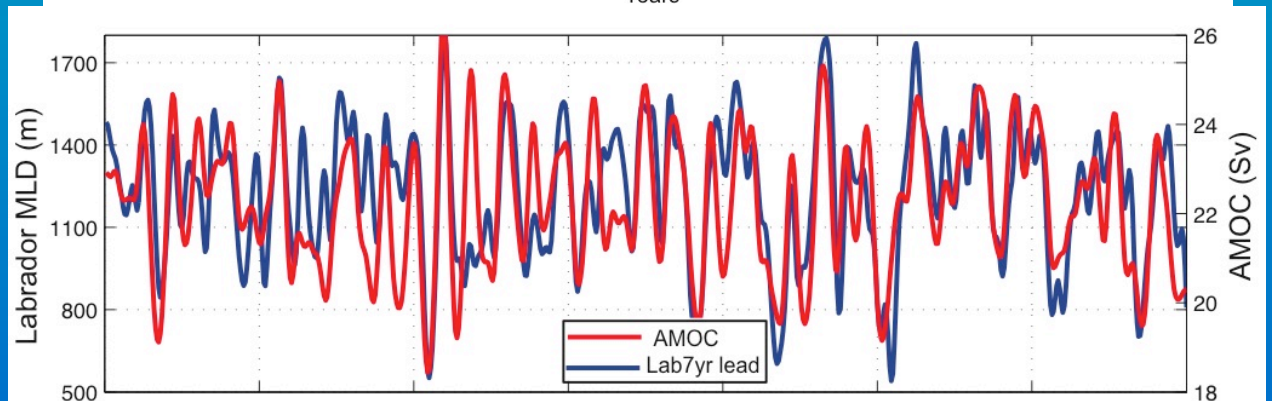
Zhang, Msadek, McPhaden and Delworth (JGR, 2011)







700-year GFDL2.1 (GFDL ESM)

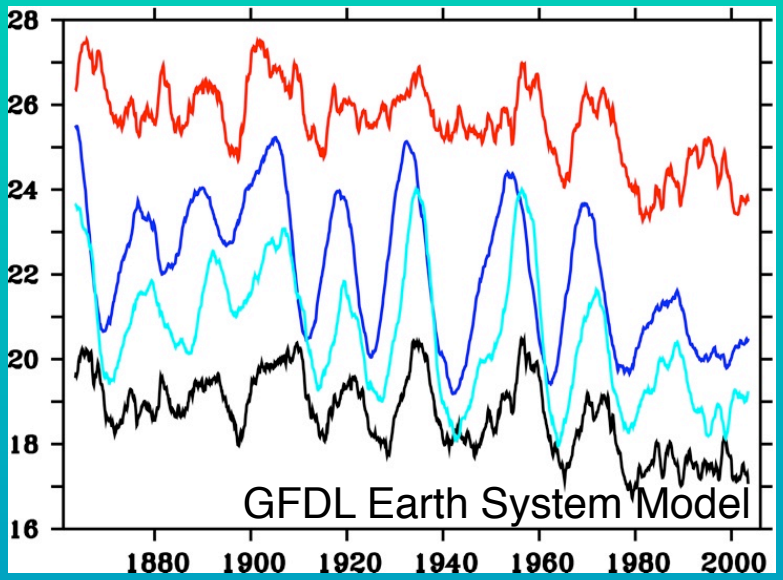


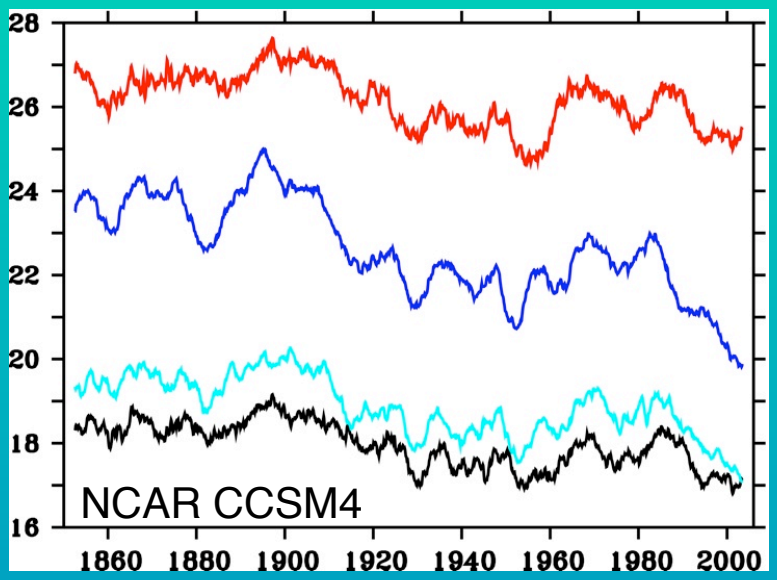
AMOC 6°S

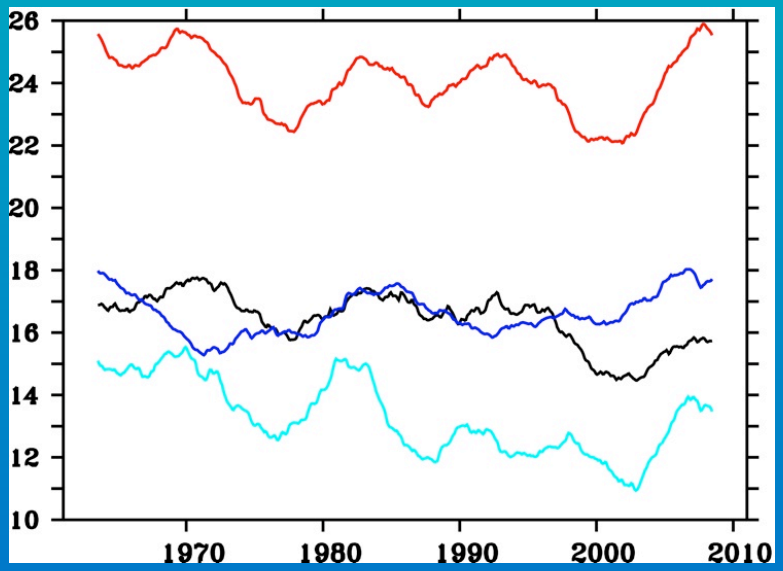
NBC 6°S

AMOC 40°N

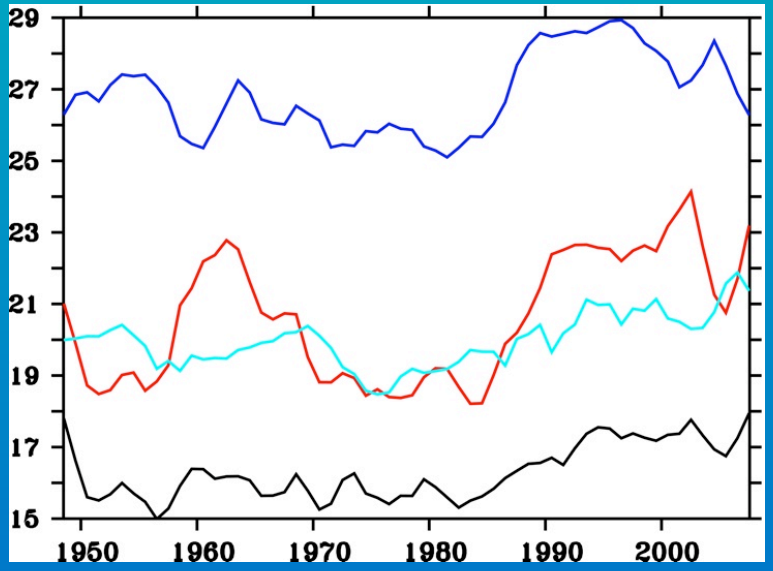
AMOC 26°N





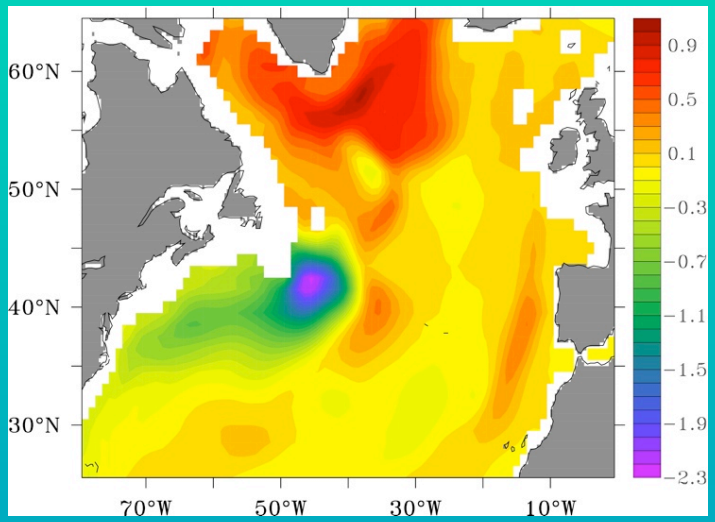


GFDL Coupled Data Assimilation

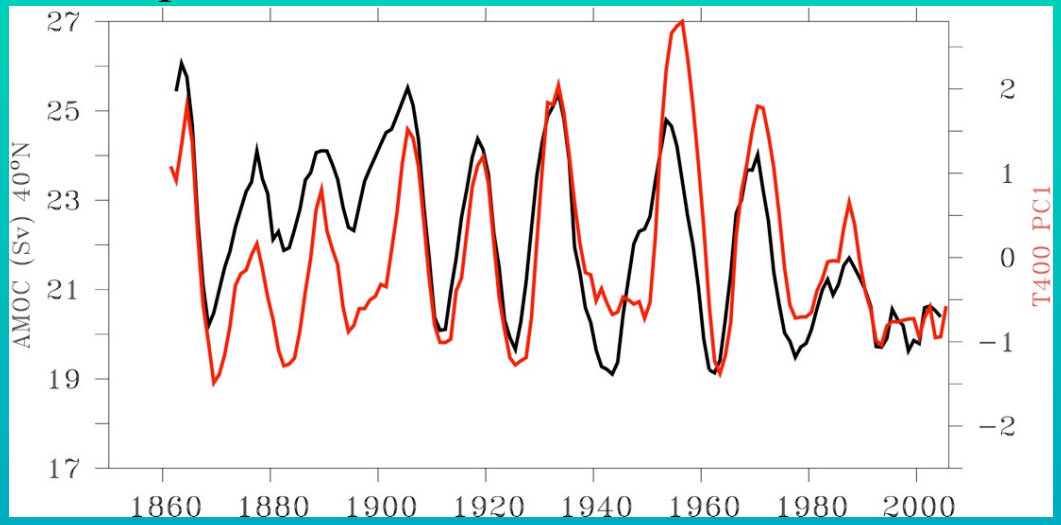


NCAR Ocean-Ice CORE

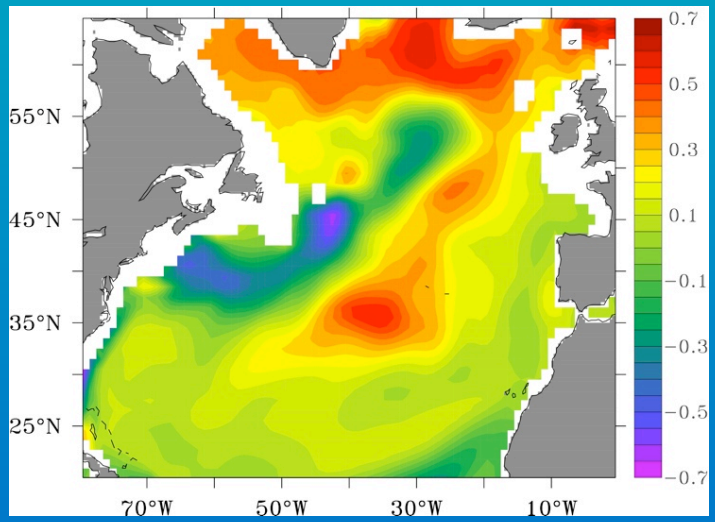
GFDL Earth System Coupled Model



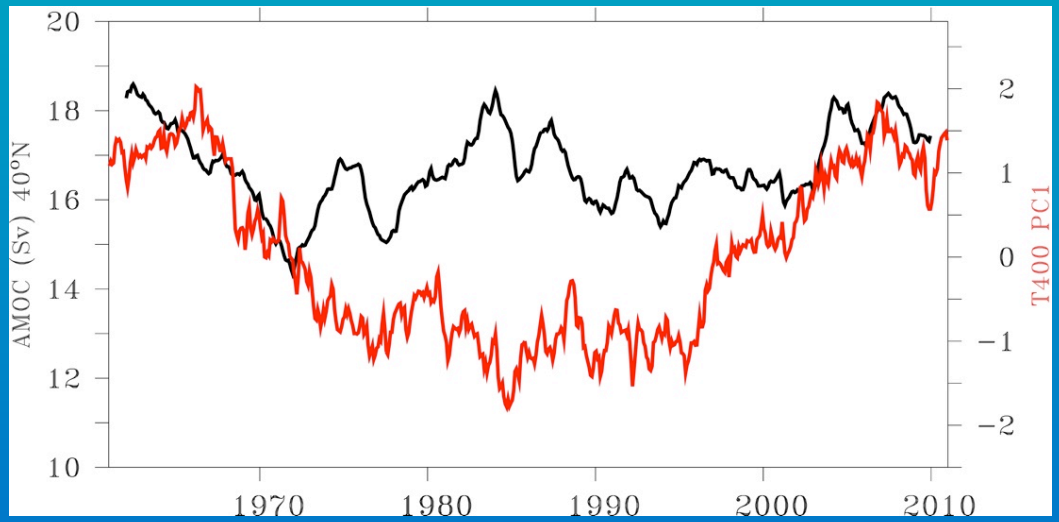
T400 EOF1



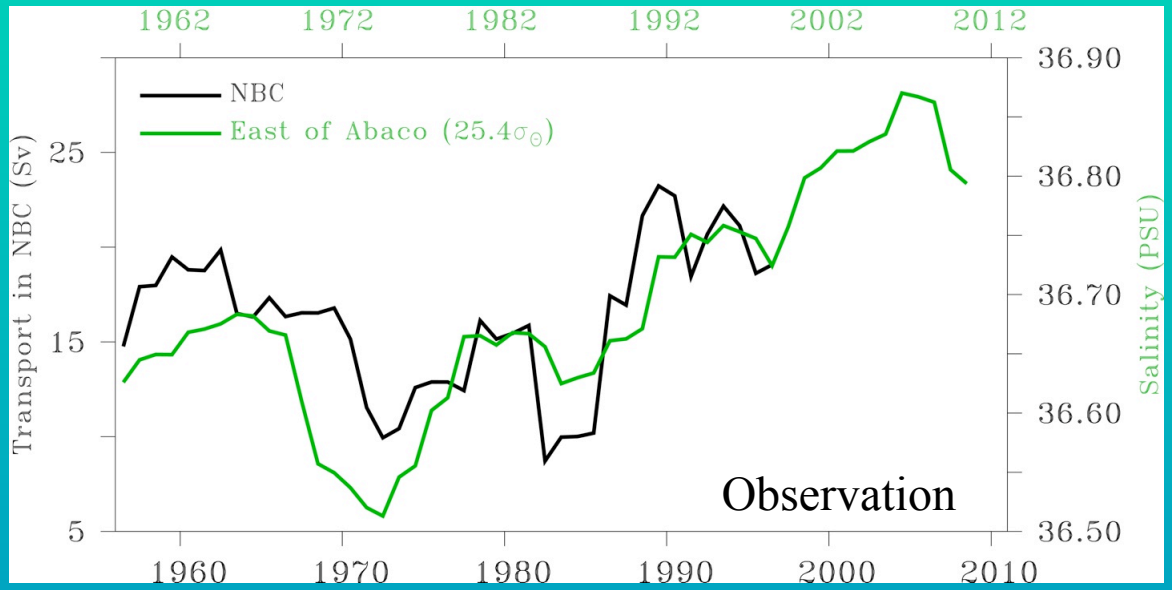
GFDL Coupled Data Assimilation

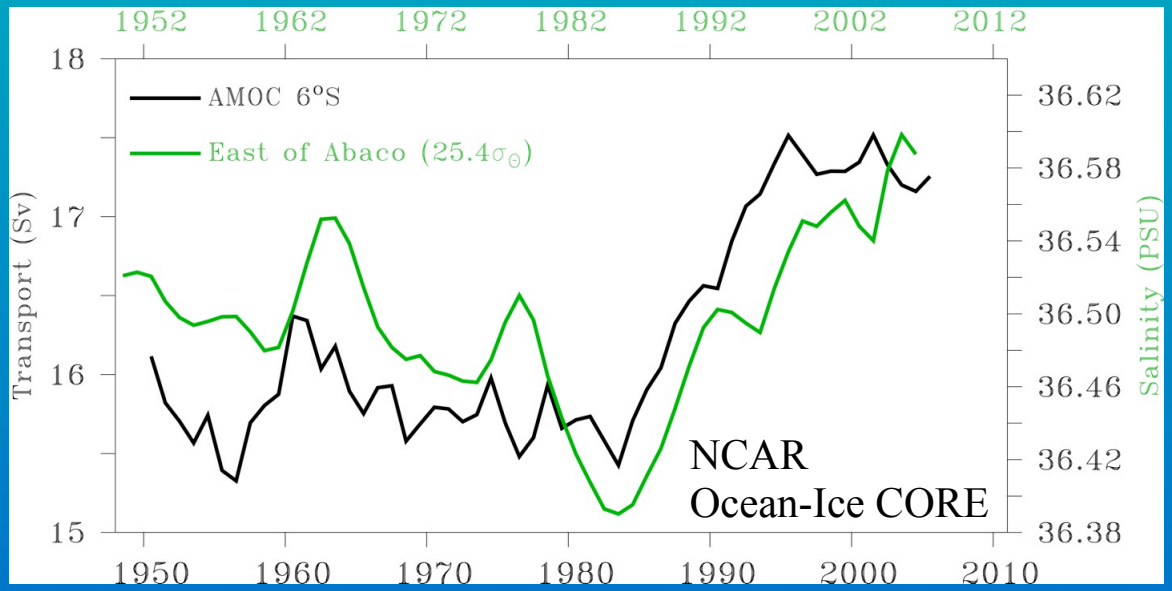


T400 EOF1

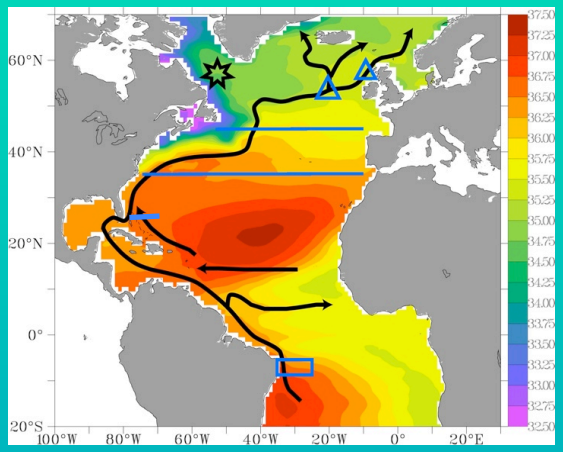


AMOC (6°S) and Western Subtropical Atlantic Salinity (east of Abaco)

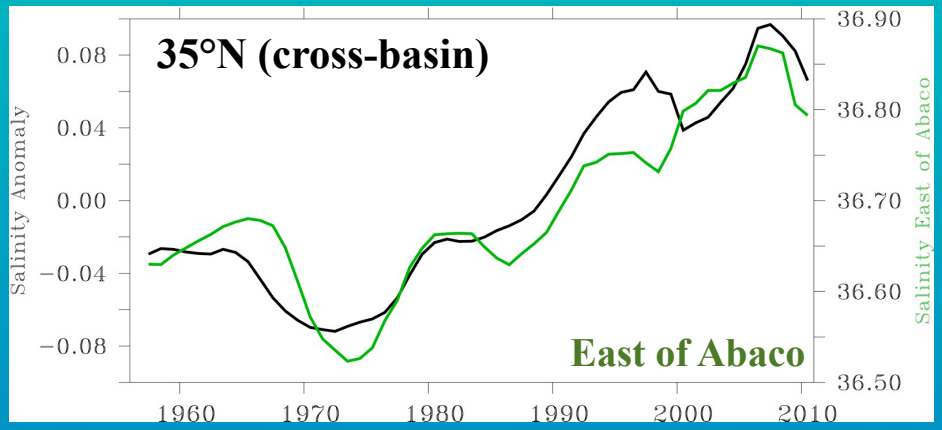


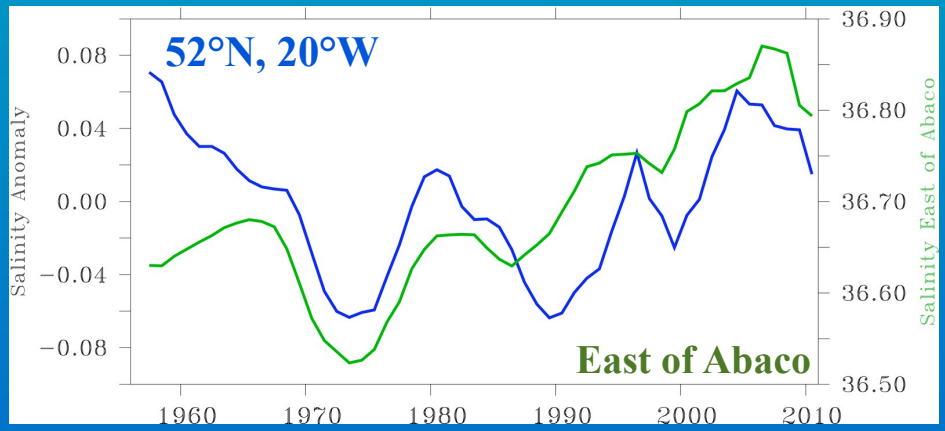


Salinity east of Abaco vs.
35°N (cross-basin average) and
52°N (near Station J) at 100m

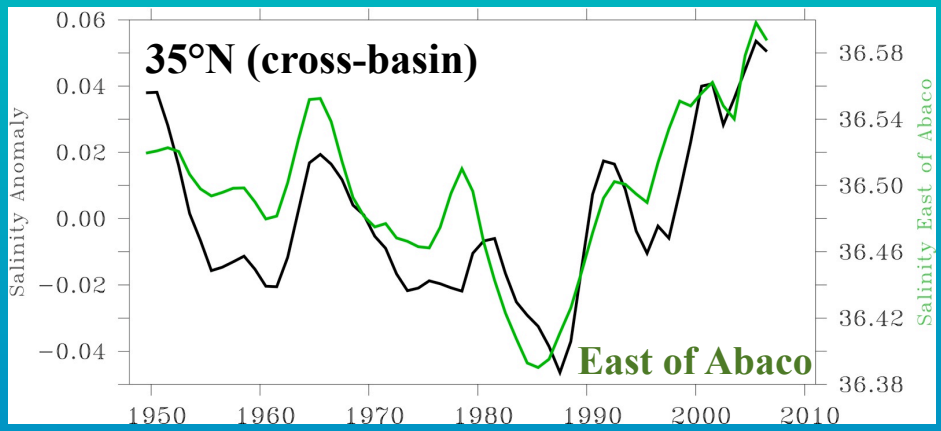


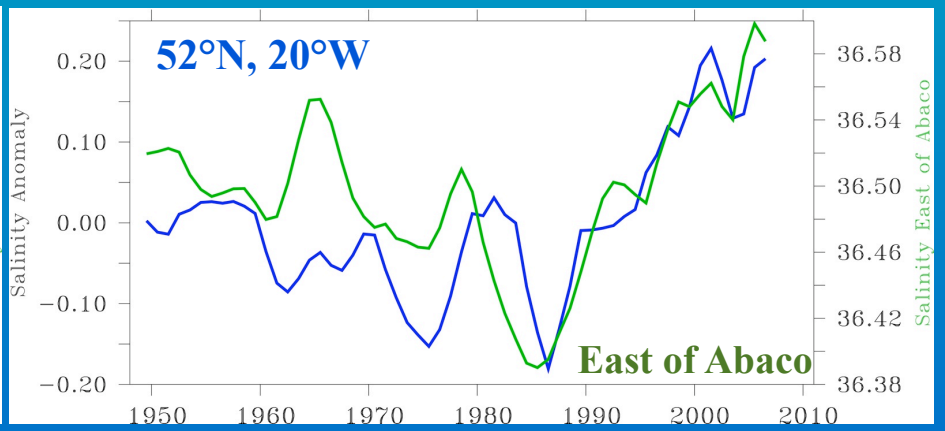
Observation



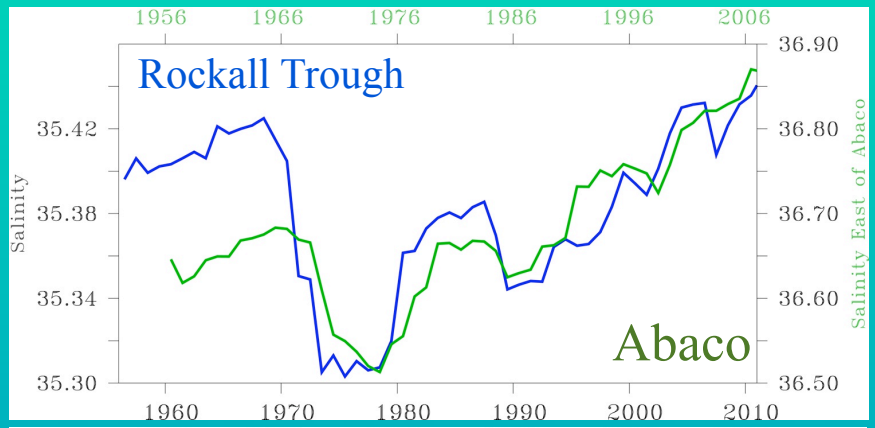


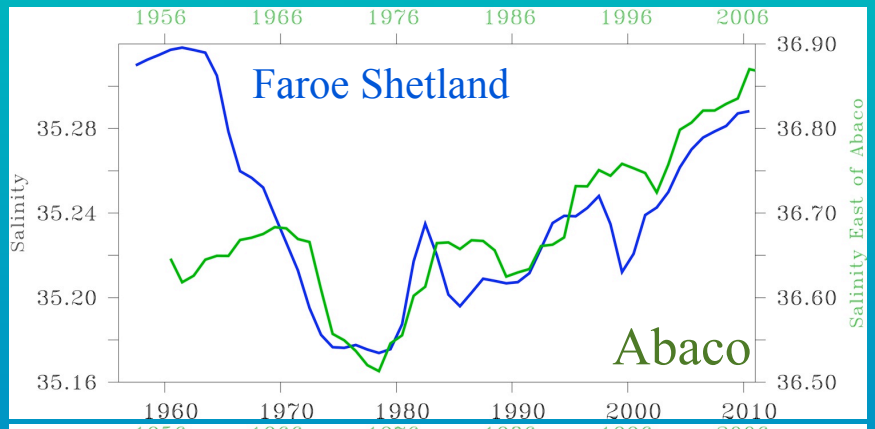
NCAR Ocean-Ice CORE

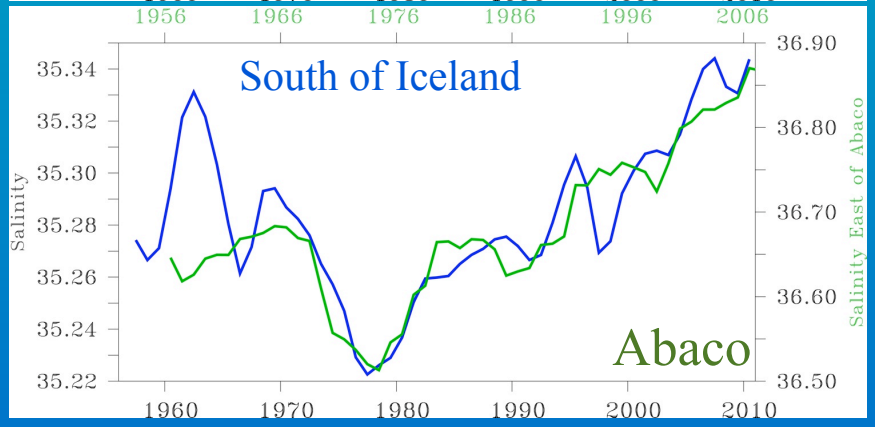




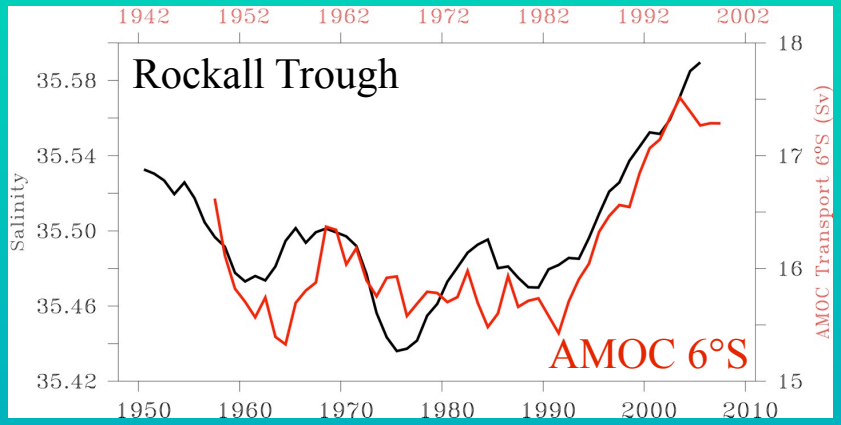
Observation

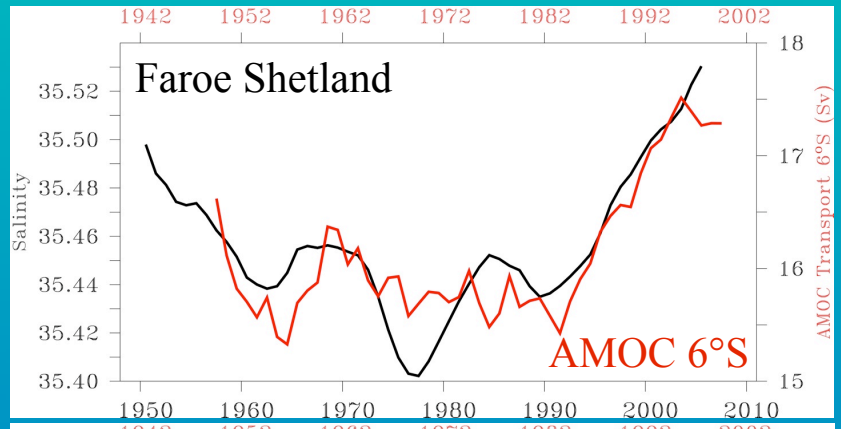


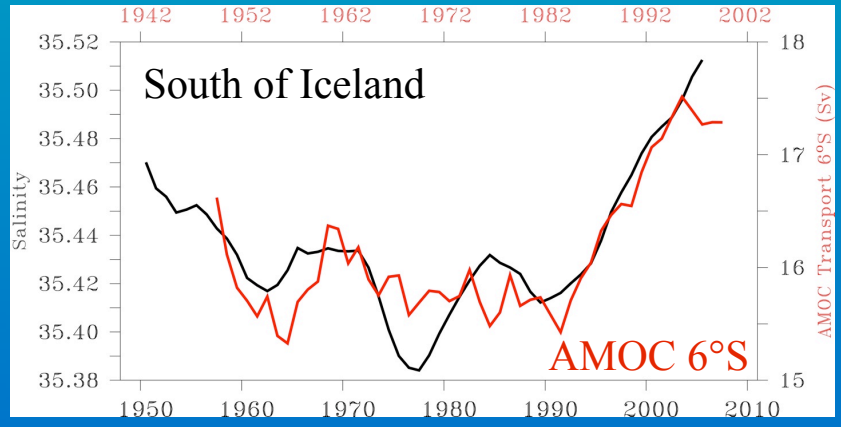




NCAR Ocean-Ice CORE

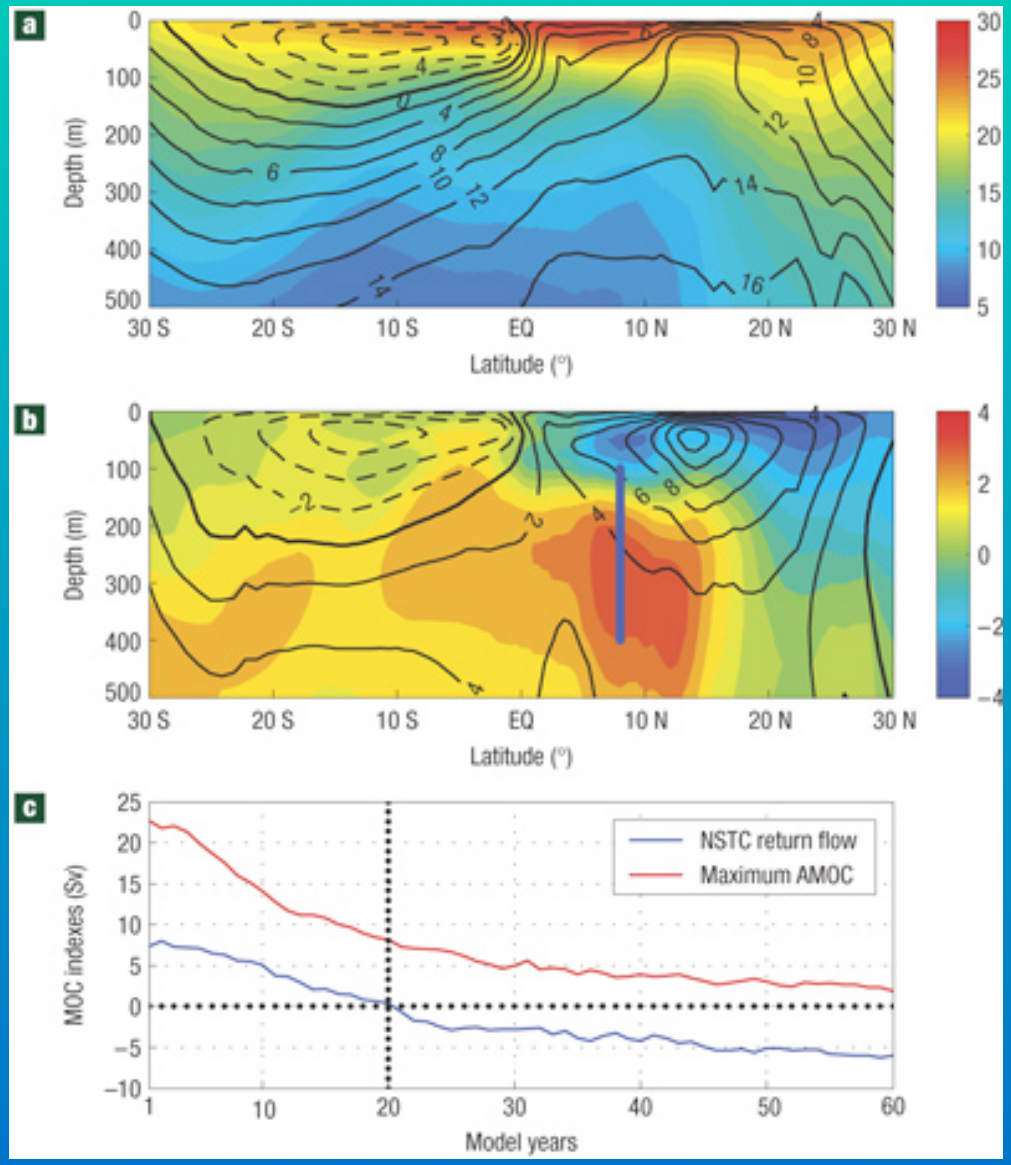




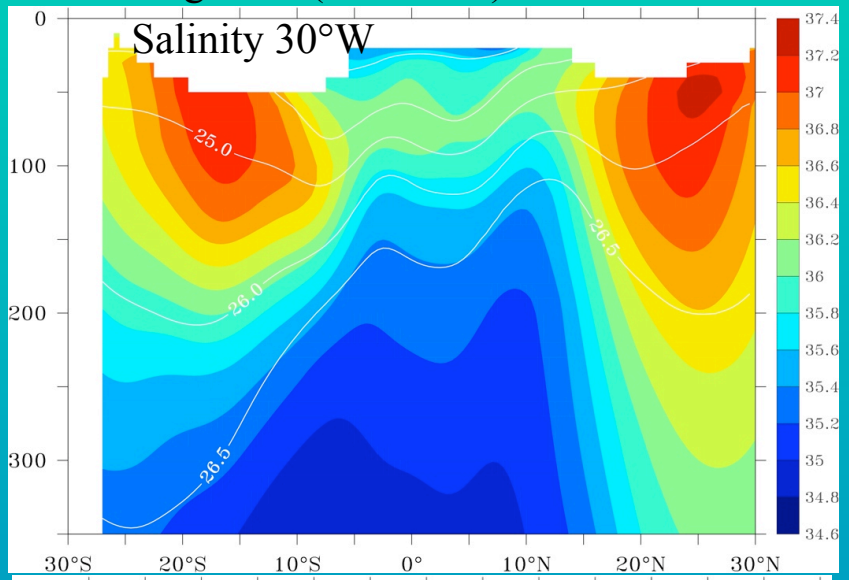


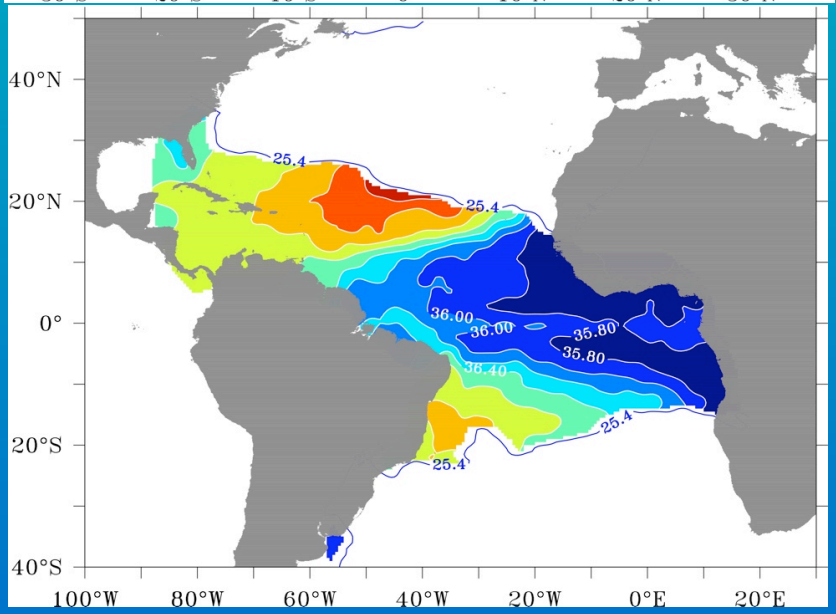
Change of AMOC vs. Subtropical Cell in the North Atlantic

Chang et al. (Nature GeoSci. 2008)

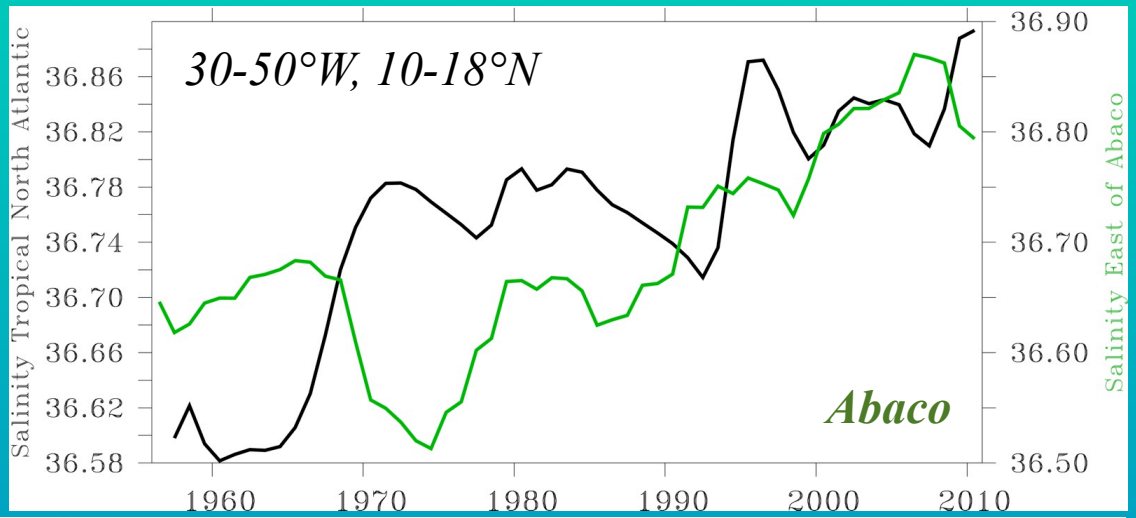


Zhang et al. (JPO 2003)

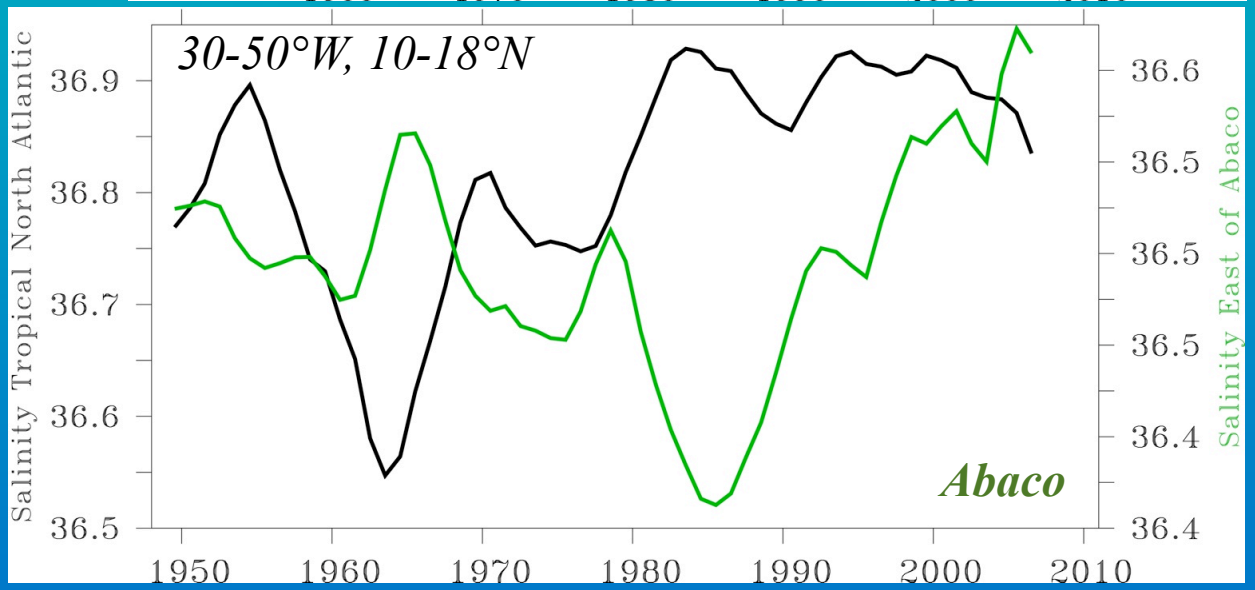




Salinity: east of Abaco vs. tropical North Atlantic (25.4 σ_θ)

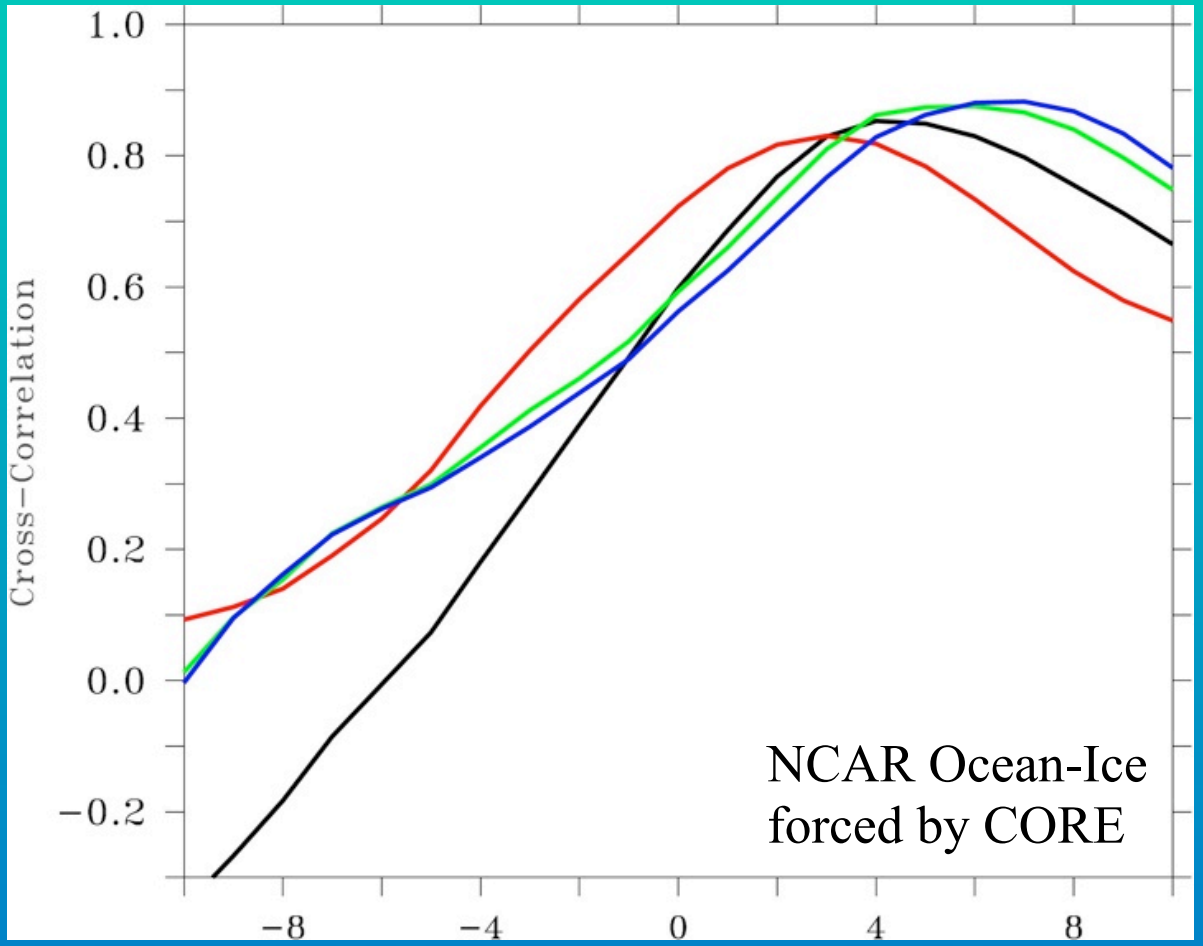


Observation

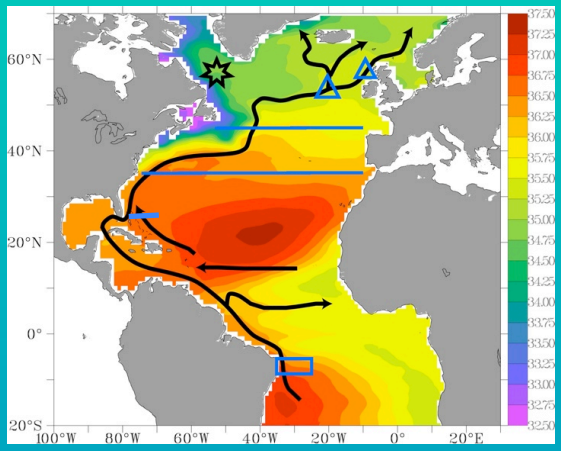


NCAR Ocean-Ice forced by CORE

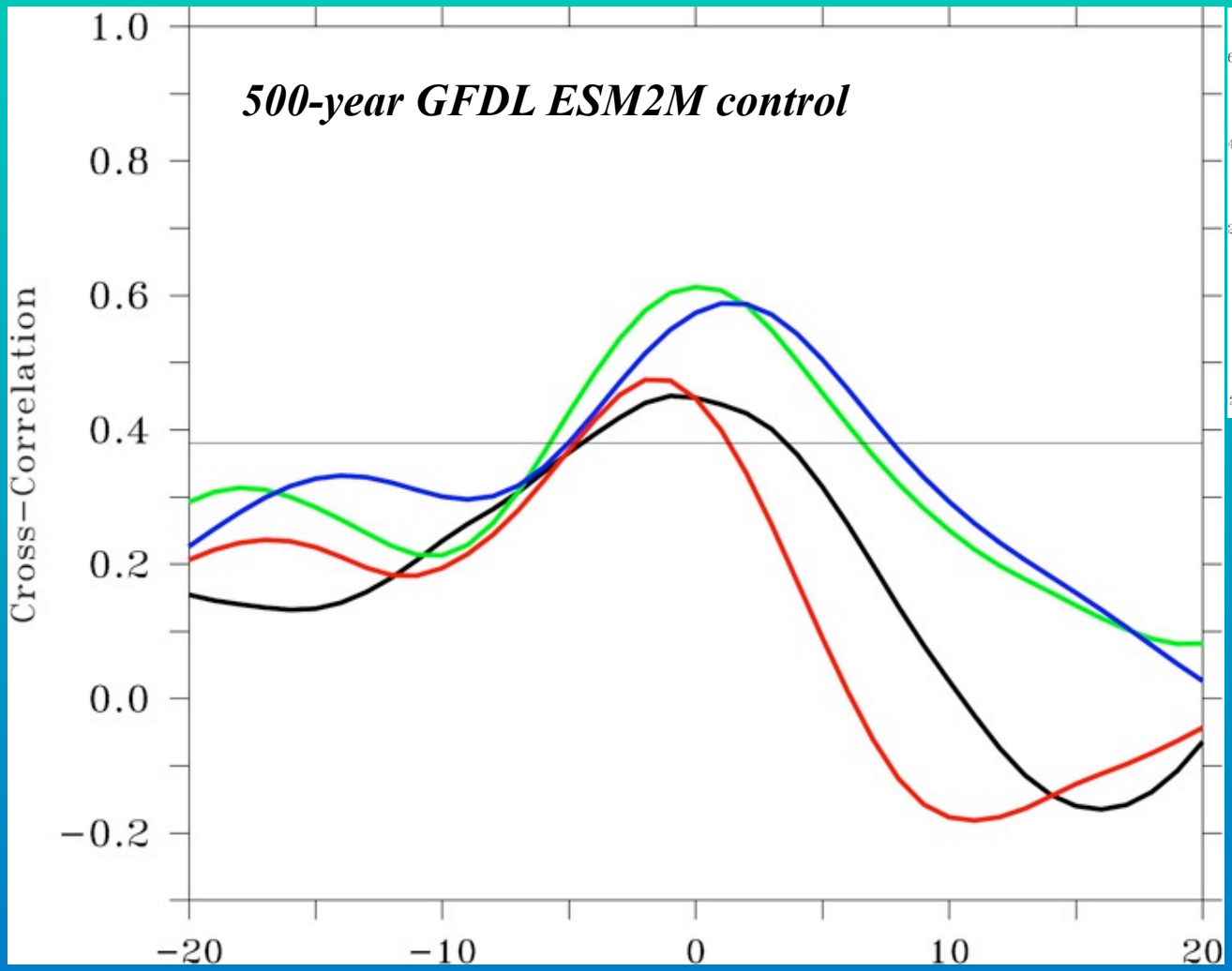
Cross-Correlation of AMOC 6°S and salinity at Abaco, 35°N, and eastern subpolar gyre at 52°N and 58°N

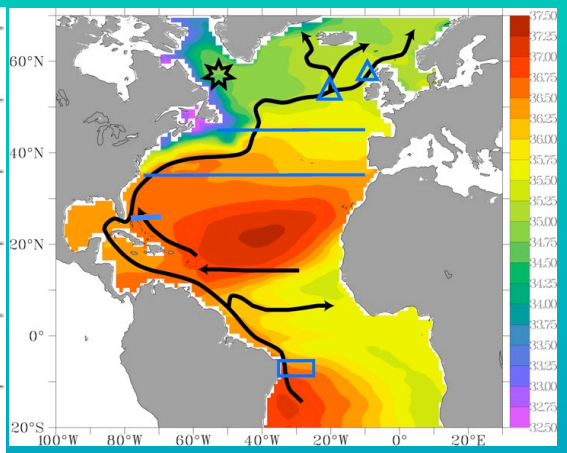


AMOC lagging **AMOC leading**

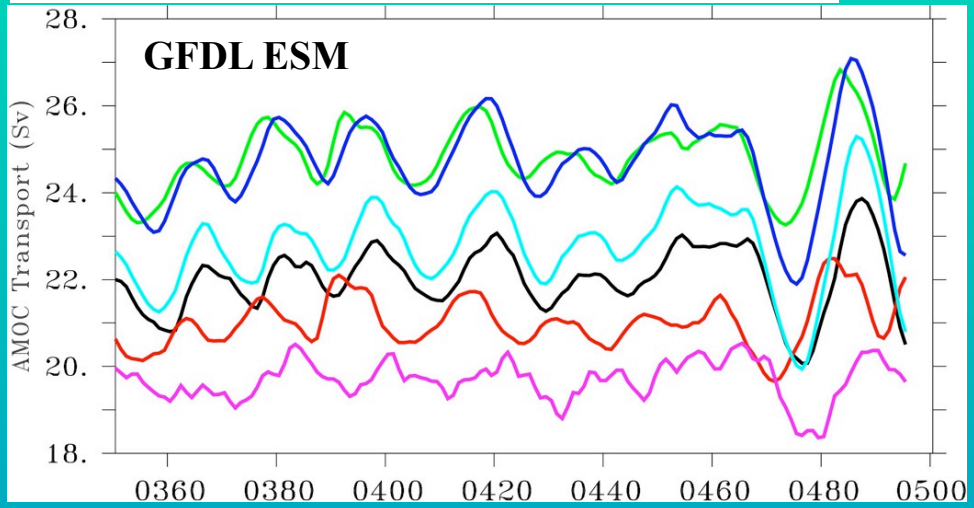


Cross-Correlation of AMOC 6ºS and salinity at Abaco, 35ºN, and eastern subpolar gyre at 52ºN and 58ºN

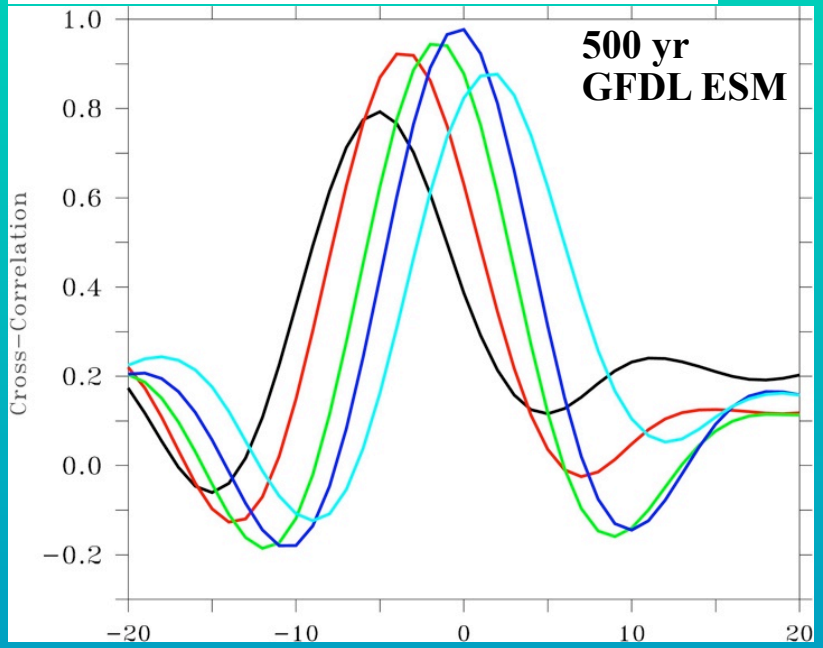




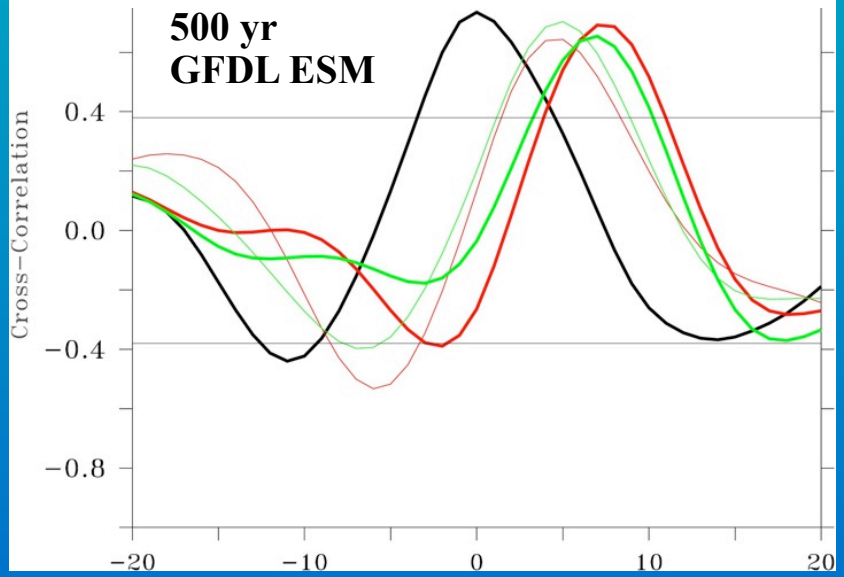
AMOC at 50°N, 45°N, 40°N, 35°N, 26°N, 6°S



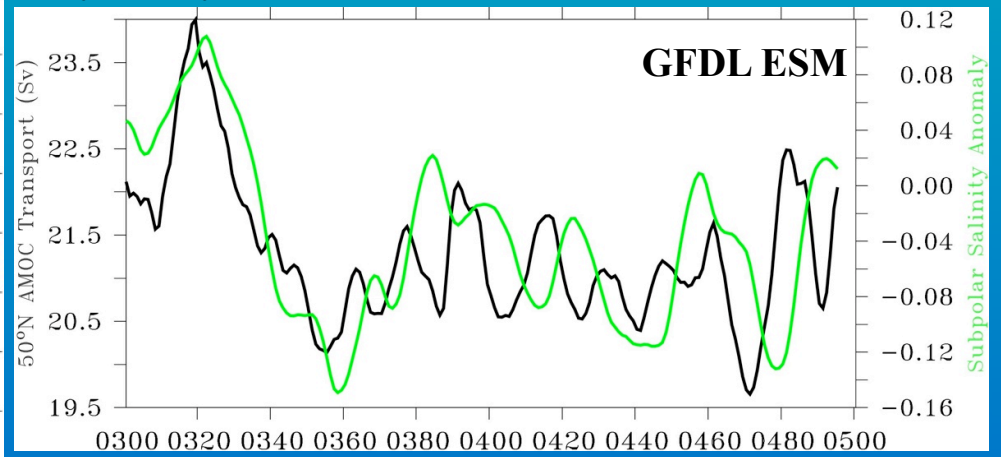
Cross-Correlation of **AMOC 26°N** *and* **AMOC at 50°N, 45°N, 40°N, 35°N, 6°S**



Cross-correlation between **AMOC 50°N** *and* **upper ocean density at Lab Sea, temperature and salinity** *in* Eastern and **Western** *subpolar gyre*



AMOC at 50°N leads the subpolar gyre salinity by 8-10 yrs



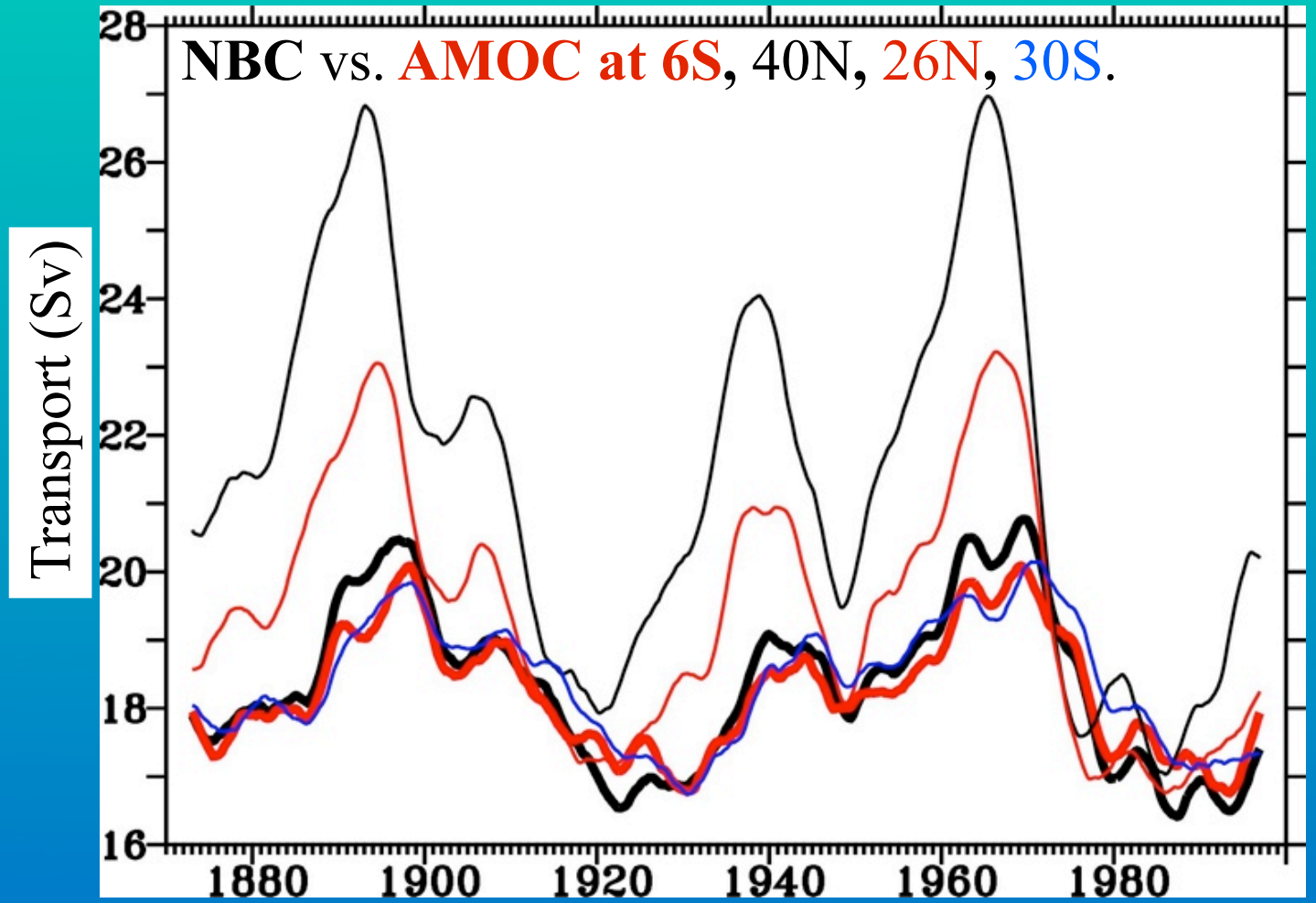
Summary

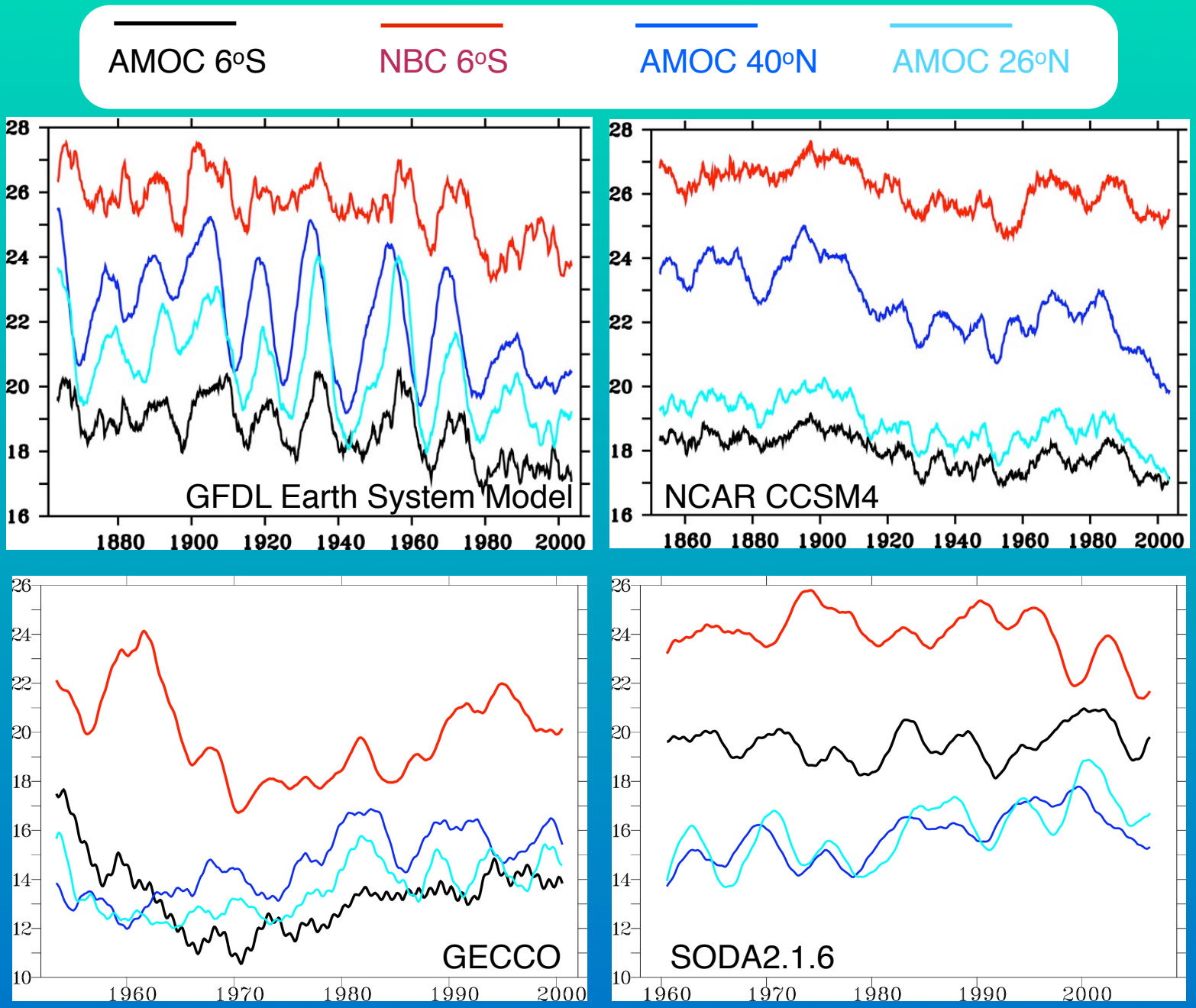
- ***Observation and forced NCAR ocean model reveal that decadal variations of upper ocean salinity (and temperature) in subtropical North Atlantic lead those in the eastern subpolar North Atlantic by 6-8 years.***
- ***While other processes such as the expansion of subpolar gyre and fresh water export from the Arctic have been suggested to regulate the subpolar North Atlantic salinity, we show that at least part of the observed variability can be traced back to the western subtropical Atlantic, along the pathway of AMOC surface return flow.***
- ***Sources of the subtropical salinity variability in the western Atlantic are linked to the tropical Atlantic AMOC and its interaction with the northern STC.***
- ***The time delay of poleward propagation of T/S anomalies from subtropical/ tropical latitudes might lead to a preferred 20 yr time scale of AMOC variability, as in the GFDL ESM2M. But the time delay of T/S anomalies in the GFDL model is more controlled by the delay of lower latitude AMOC in response to forcing in the subpolar region.***

Acknowledgment:

- ***Thanks to modeling centers to share their model results***

NCAR CCSM3


NBC vs. AMOC at 6S, 40N, 26N, 30S.
Transport (Sv)
28
26
24
22
20
18
16
1880
1900
1920
1940
1960
1980


AMOC 6°S
NBC 6°S
AMOC 40°N
AMOC 26°N
GFDL Earth System Model
NCAR CCSM4
GECCO
SODA2.1.6