U.S. AMOC Science Team

http://www.usclivar.org/amoc

A U.S. interagency program with a focus on AMOC monitoring and prediction capability

NASA Earth Science Division

Satellite data analyses, modeling and space-based observations

NOAA Climate Program Office

Observing systems, monitoring, climate modeling

NSF Geosciences program

Process studies, models, and observations

U.S. Department of Energy

Climate and process modeling, climate impacts

U.S. AMOC Program History

- January 2007: AMOC identified as near-term priority by JSOST
- October 2007: U.S. AMOC Implementation Plan released
- March 2008: U.S. AMOC Science Team formed
- May 2009: 1st Annual PI meeting (Annapolis, MD)
- June 2010: 2nd Annual PI meeting (Miami, FL)
- July 2011: Joint U.S./U.K. AMOC Science Conference (Bristol, UK)
- August 2012: 3rd U.S. AMOC meeting (Boulder, CO)
- July 2013: Joint U.S./U.K. International AMOC Science Meeting (Baltimore, MD)

Recent Developments:

- Over 50 funded projects supported by 4 agencies; New 2013 awards by NOAA, NSF and NASA
- 5-year period as SOST priority completed; Science Team continues as U.S. CLIVAR priority
- 5th Annual Progress Report published June 2013
- External Review Committee Report issued June 2013 *(discussed by Executive Committee on Wednesday)*

U.S. AMOC Scientific Objectives

- AMOC observing system implementation and evaluation
- Assessment of AMOC state, variability, and change
- Assessment of AMOC variability mechanisms and predictability
- Assessment of the AMOC's role in global climate and ecosystems

Program Organization:

Science Team Chair: Gokhan Danabosoglu (previously Bill Johns)

Task Teams:

1. *AMOC Observing System Implementation and Evaluation*
   (Outgoing Chair: Susan Lozier; New Chair: Patrick Heimbach)
2. *AMOC State, Variability, and Change*
   (Outgoing Chair: Josh Willis; New Chair: Rong Zhang)
3. *AMOC Mechanisms and Predictability*
   (Outgoing Chair: Gokhan Danabasoglu; Outgoing Vice-chair: Young-Oh Kwon)
4. *Climate Sensitivity to AMOC: Climate/Ecosystem Impacts*
   (Outgoing Chair: Ping Chang; New Chair: Yochanon Kushnir)

Executive Committee:

Science Chair + Task Team chairs/vice-chairs

Whither US AMOC Science Team?

- Very successful to date given the difficult global financial conditions
- We are only part way through the initial US plan (i.e. plan, observe, model, synthesis, repeat as needed to sustain and demonstrate value)
- Others have aspirations to work in the same manner. So, progress and evolution are ESSENTIAL. AMOC should aim to be a pathfinder, not just a great example.
- Agency program managers suggest that the Science Team consolidate and sustain gains in observing, plan synthesis, and highlight results from this (Science Team) operational model.
- Is there a next-generation model for AMOC research community?

Back-up Slides

Research Priorities

1. Enhance observing system to provide estimates of overturning variability in the subpolar North Atlantic as well as in the South Atlantic.

2. Assess the importance of deep temperature and salinity measurements (i.e., deep Argo) in monitoring AMOC variability.

3. Synthesize observations from existing elements of the observing system, including comparing the transport and transport variability of the flow field at Line W, RAPID-MOCHA and the MOVE array in the broader context of satellite and Argo float observations across the North Atlantic.

4. Develop fingerprinting techniques to better characterize AMOC variability by combining model simulations with observations should be further encouraged and supported.

5. Develop a set of metrics for the AMOC, in both depth and density spaces, in order to understand how AMOC variability relates to, is impacted by, and impacts oceanic and atmospheric processes and properties.

Research Priorities (cont.)

6. Coordinate assimilation modeling efforts to reach a consensus on the variability of the AMOC over the past few decades, and on placing realistic uncertainty bounds on these estimates.

7. Explore AMOC and MHT relationships in various models (forward, assimilation, non-eddy-resolving, eddy-resolving) in comparison with observational data to understand the reasons for differences, or biases, in the relationship between model AMOC intensity and MHT in available models.

8. Contribute to ongoing near-term AMOC prediction and predictability efforts through coordinated and focused analysis and inter-comparison of the CMIP5 decadal prediction simulations, including verification of notable AMOC-related climate events.

9. Understand the connections between AMOC/North Atlantic SST and climate variability elsewhere, the physical mechanisms of these teleconnections, and the related impacts on humans and ecosystems. Explore the impact of AMOC variability on sea ice, ocean ecosystems, sea level changes around the Atlantic Basin, and the exchange of carbon between the atmosphere and ocean.

U.S. AMOC Science Highlight Slides

(from 2012 Meeting and Report)

2012 U.S. AMOC PI Meeting
August 15-17, 2012, Boulder

Mini-Workshops

1. AMOC Fingerprinting from Historic and Proxy Records
2. AMOC's Impact on the Carbon Cycle
3. AMOC Observing System
4. AMOC Mechanisms and Predictability

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Mini-Workshops

1. **AMOC Fingerprinting from Historic and Proxy Records**
2. **AMOC's Impact on the Carbon Cycle**
3. **AMOC Observing System**
4. **AMOC Mechanisms and Predictability**

Key Recommendations

- Develop a more robust definition of AMOC
- Develop robust fingerprints using selected models with proxy and instrumental records
- Enhance deep ocean and carbon/biogeochemical observations in the North Atlantic (Argo-type floats with biogeochemical sensors)
- Improve model simulations (CORE-type ocean model simulations with carbon cycle combined with careful diagnostic studies)
- Examine ocean heat content & meridional heat transport using model-observation comparisons
- Provide common metrics and diagnostics for assessment of CORE-II experiments focused on AMOC mean and variability as well as assessment of its predictability and prediction

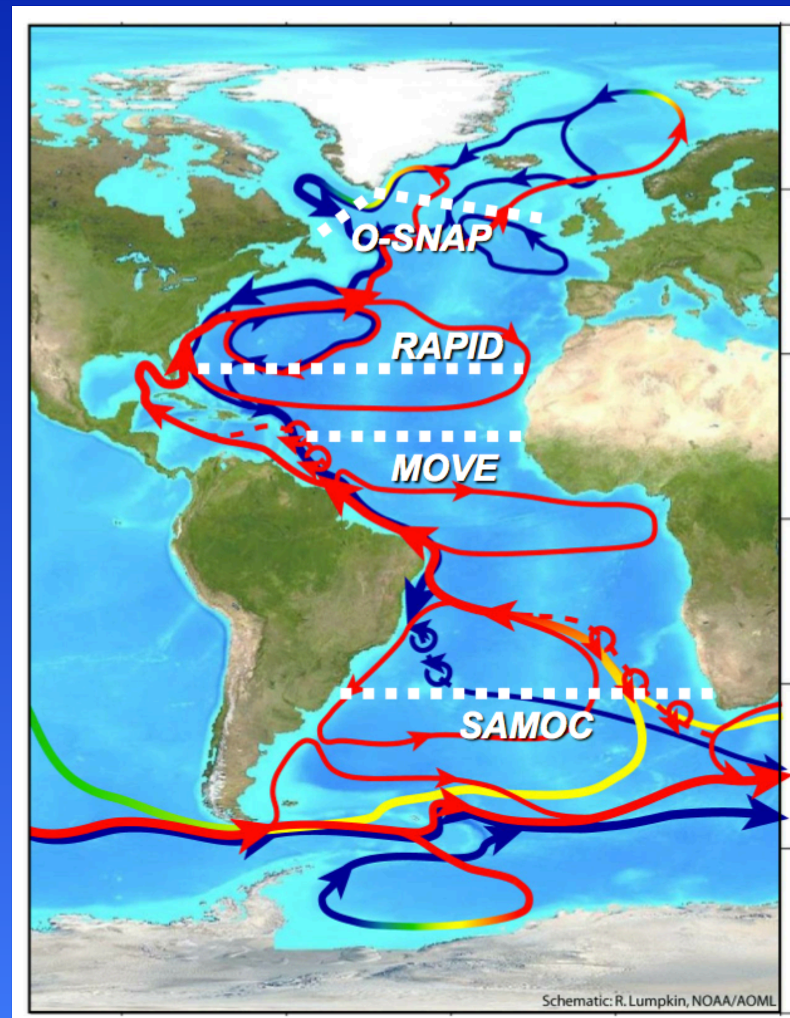
AMOC Observing System

Strategy:

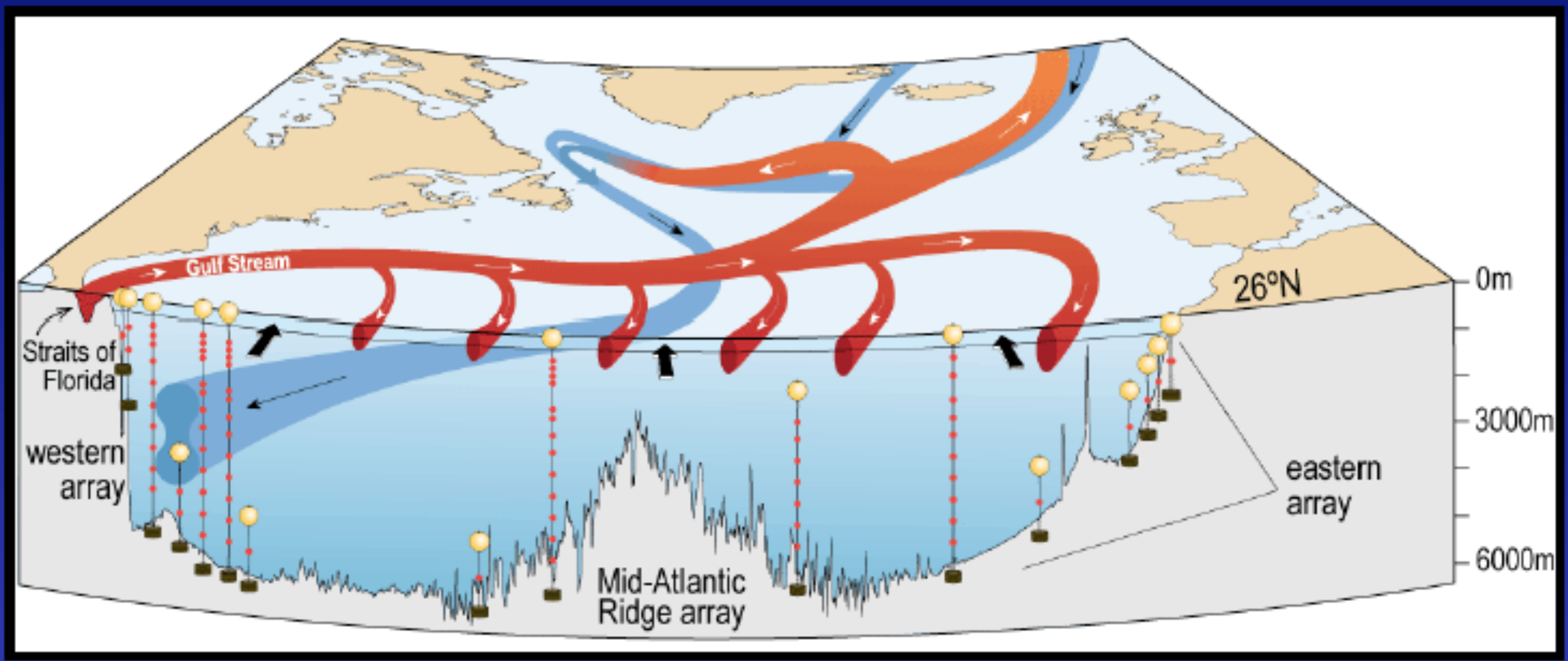
Establish discrete set of trans-basin arrays (moorings + autonomous profiling) for continuous AMOC estimates

Value:

- ***Accurate*** multi-year mean AMOC estimates, for comparison with future (and past) AMOC states
- ***Understanding*** of processes underlying short-term (intraseasonal to annual) variability
- ***Benchmarks*** for evaluation of modeled AMOC variability (GCMs, data synthesis models)



The RAPID / MOCHA* Array



How it works:
- Gulf Stream : telephone cable
- Ekman : scatterometer
- Mid-ocean : density, current meters

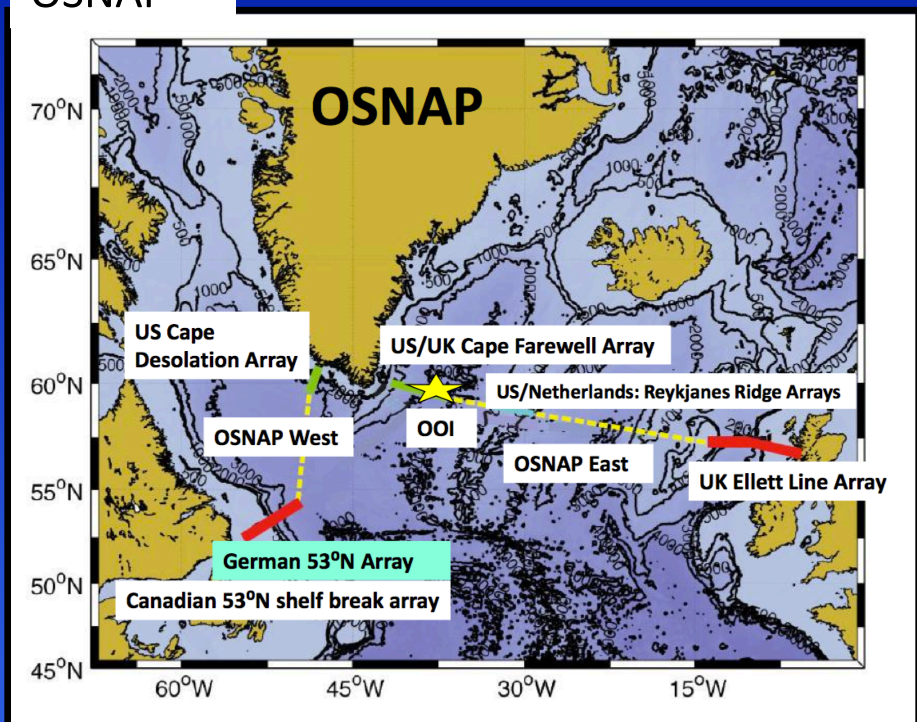
Why 26.5°N?
- Maximum heat transport
- History of measurements:
  - Florida Current
  - repeat hydro-sections

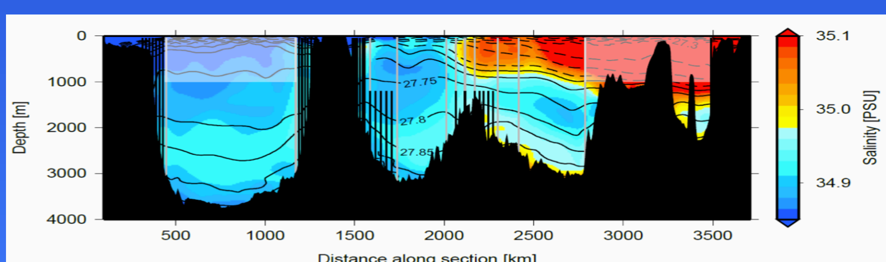
→ **Funded through 2014 - will provide a 10 year time series (2004-2014)**

* NERC / UK RAPID Climate Change Programme
NSF / US Meridional Overturning Circulation and HeatFlux Array

Subpolar North Atlantic

OSNAP

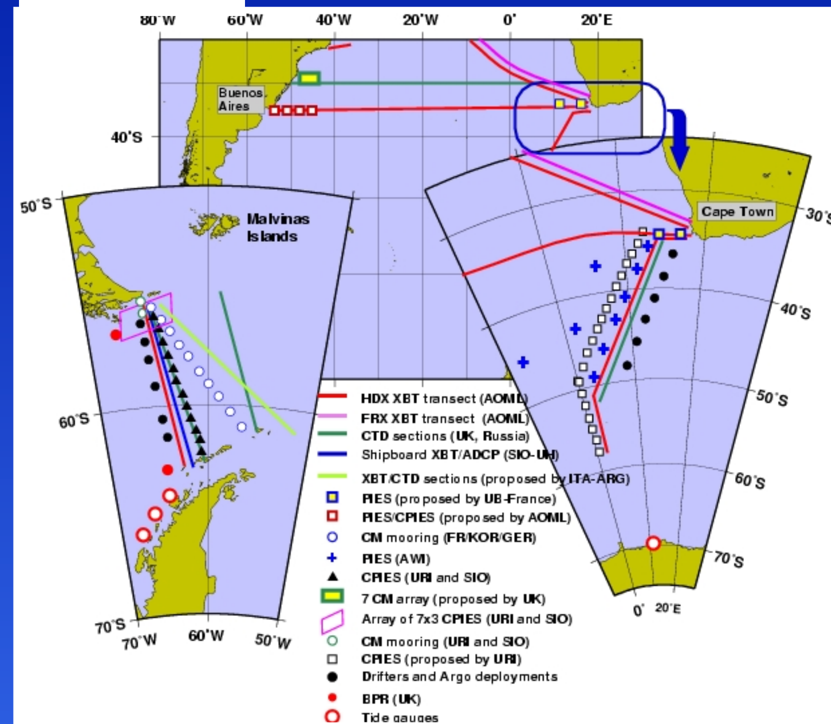


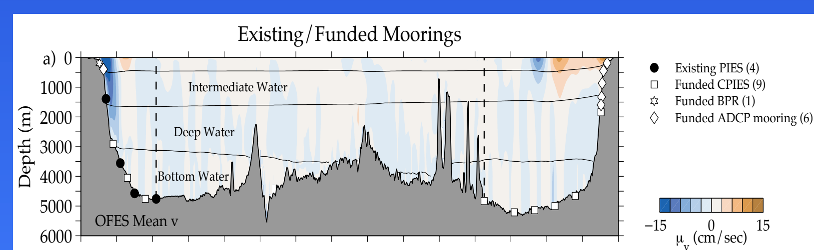


(U.S., U.K., Germany, Netherlands, Canada)

South Atlantic

SAMOC

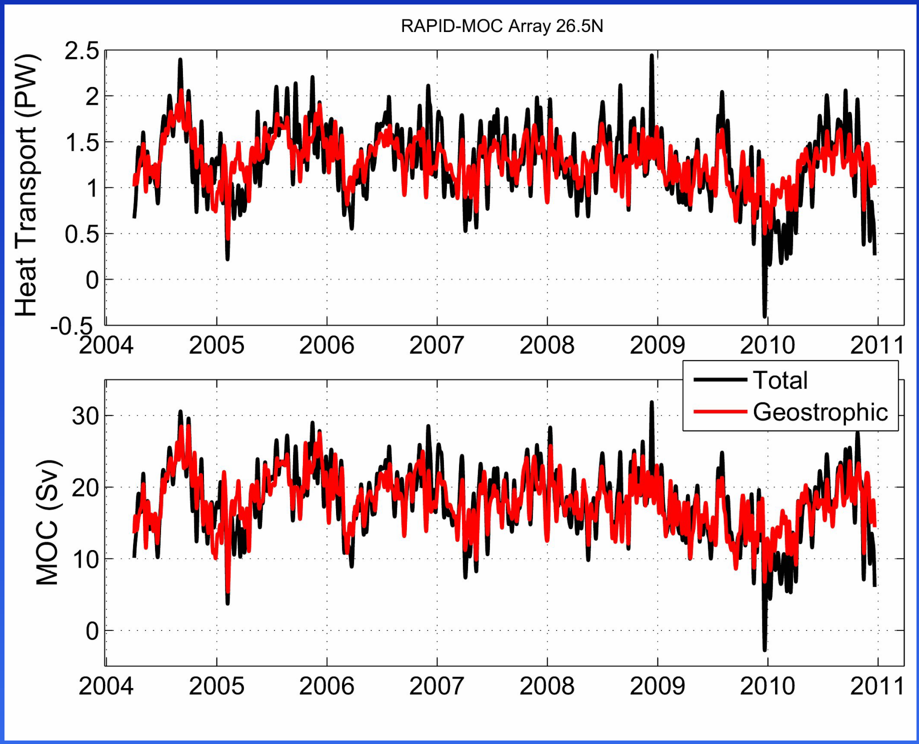




(U.S., Brazil, Argentina, France, S. Africa)

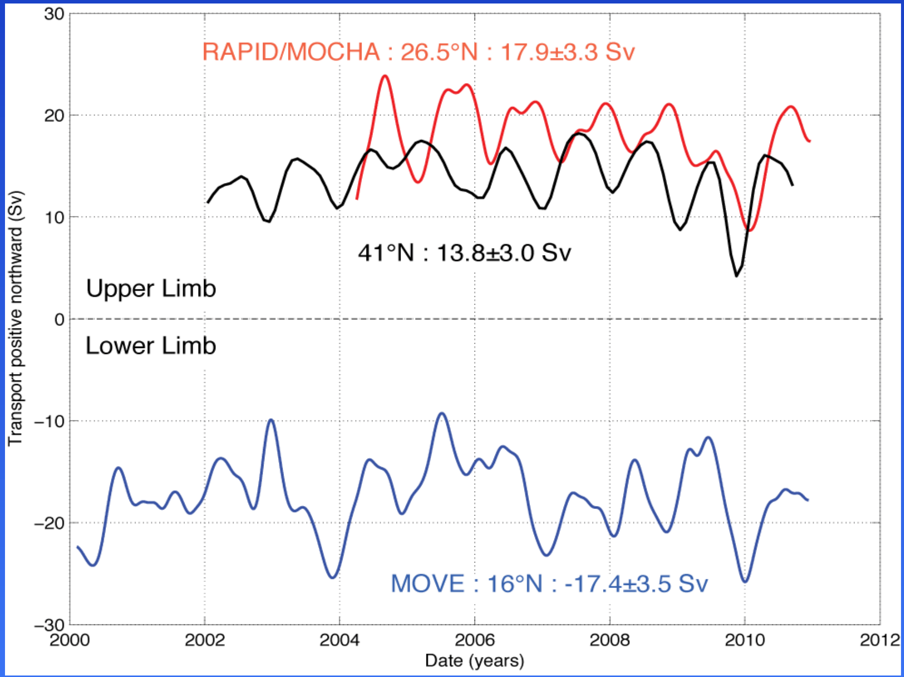
AMOC Variability from Observations

RAPID-MOCHA Array (26.5°N)



McCarthy et al. (2012)

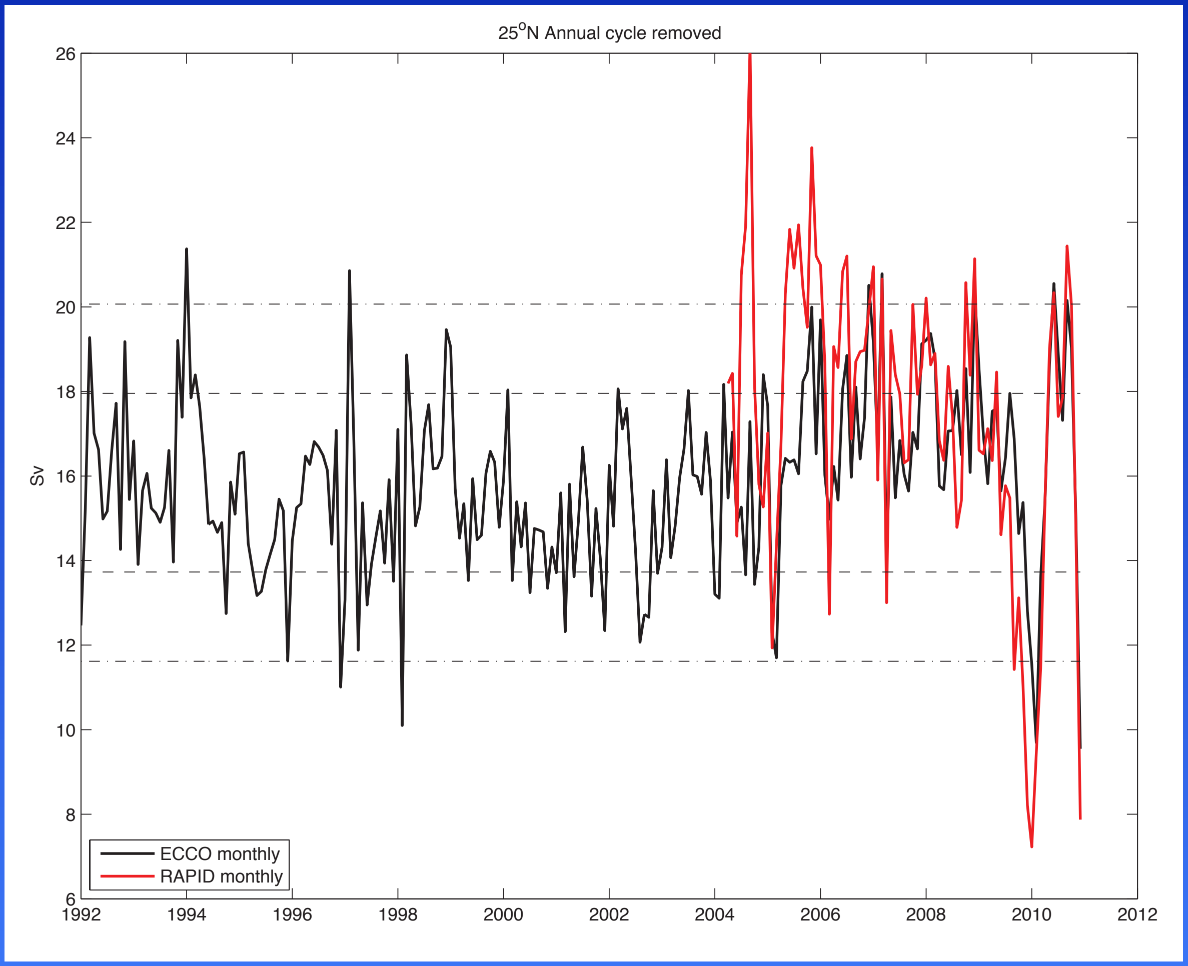
RAPID, MOVE, and 41°N (Willis)



Baringer et al. (2012)
State of the Climate in 2011 (BAMS Suppl.)

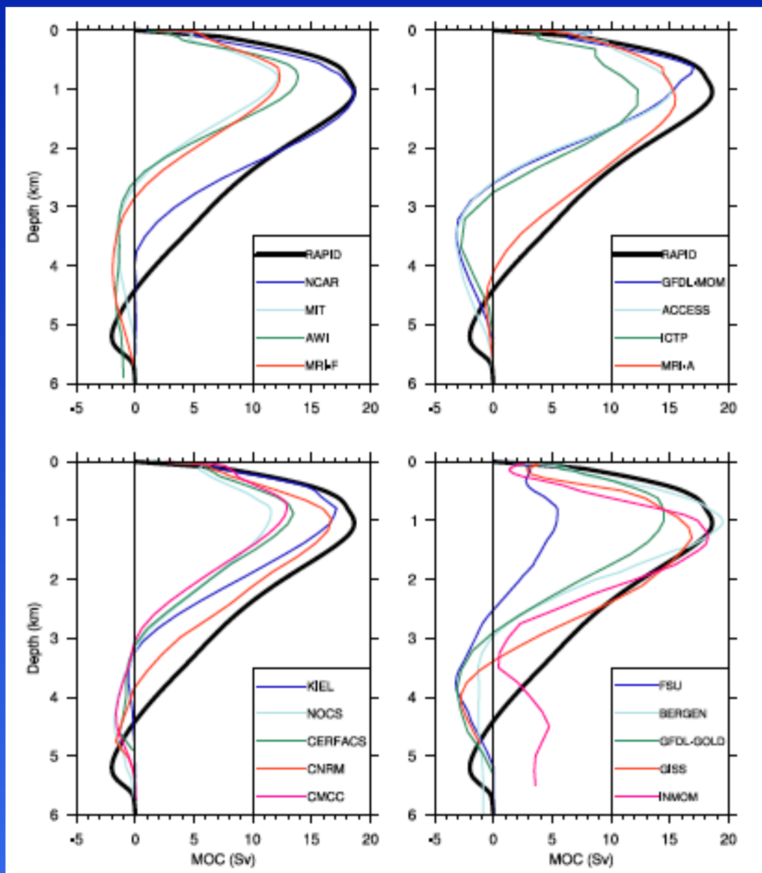
Synthesis Models

RAPID vs. ECCO products

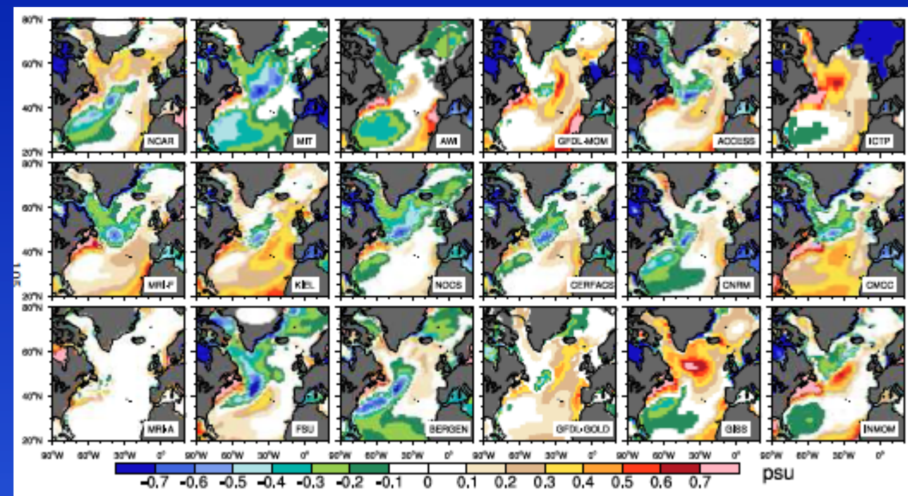


Courtesy of Patrick Heimbach

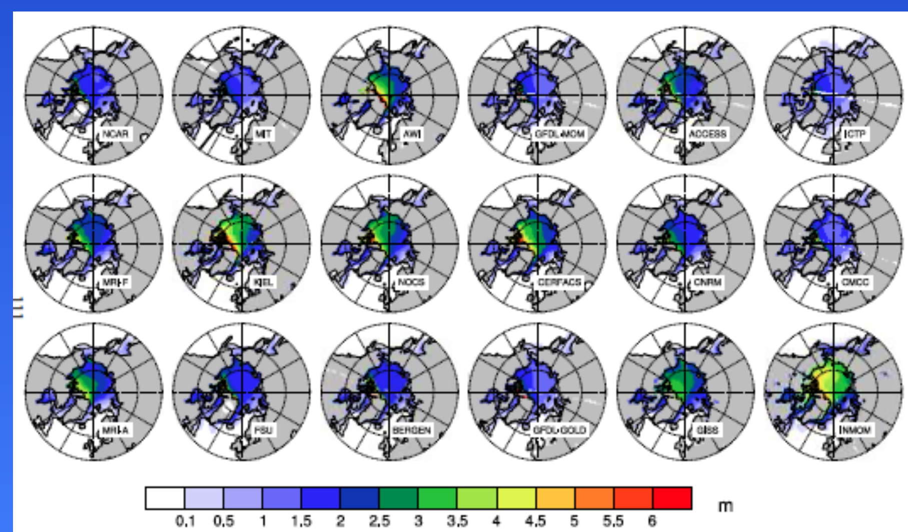
AMOC Representation in CORE-II Simulations



2004-2007 mean MOC profiles at 26.5°N for 18 global ocean- sea ice models vs RAPID



0-700 m average salinity model minus observations

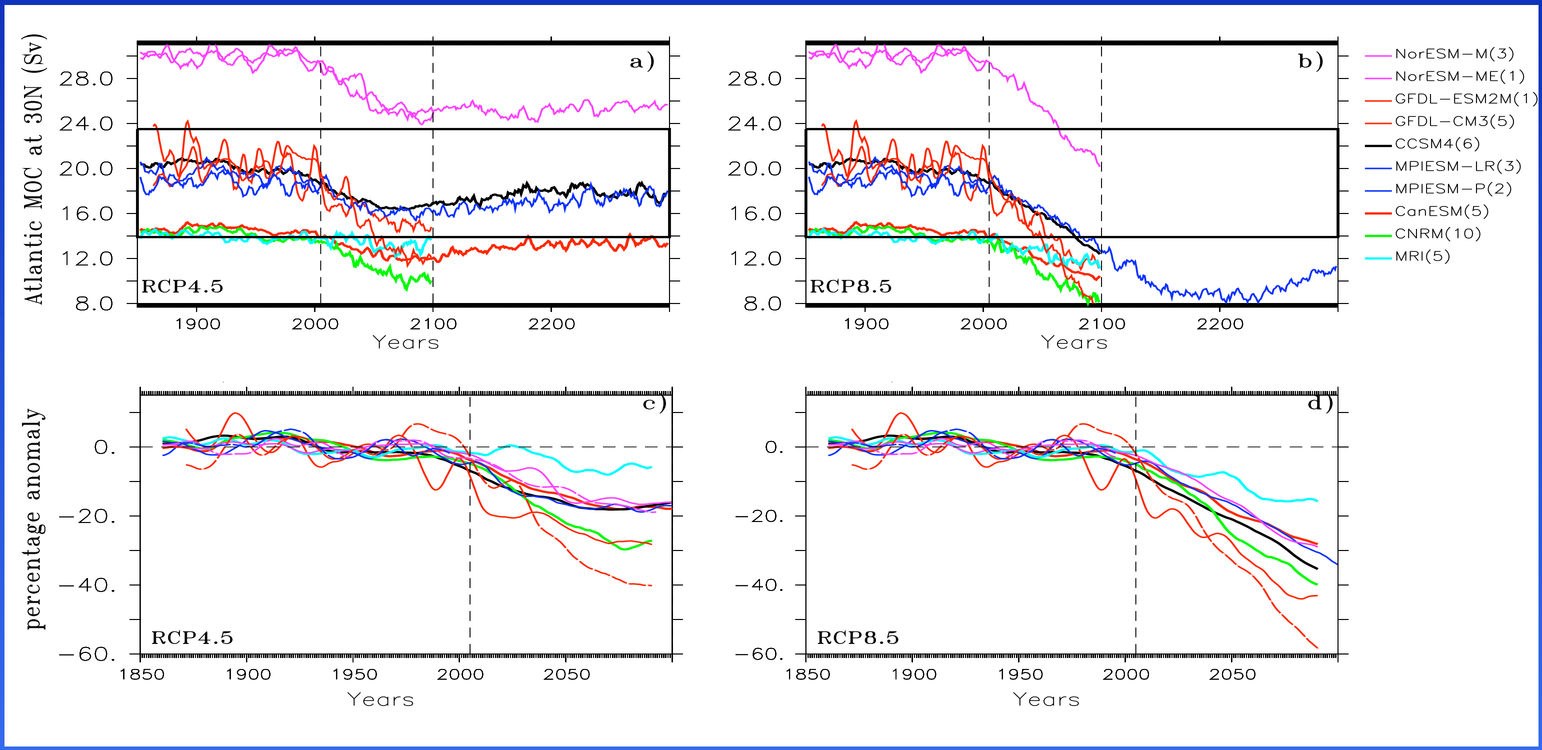


March mean sea ice thickness

Danabasoglu et al. (2013)

AMOC Representation in Coupled Models

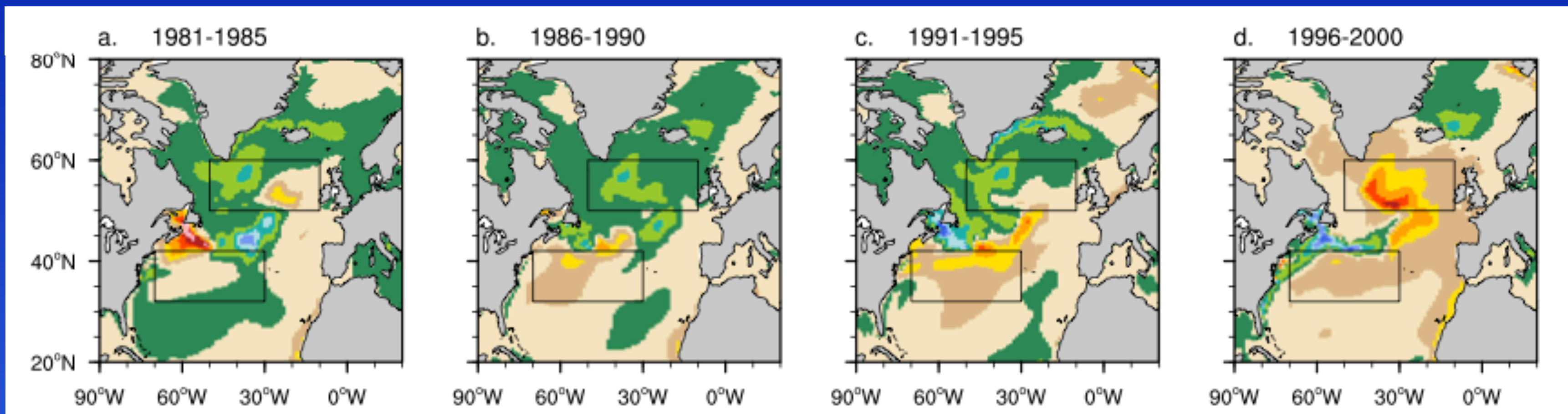
AMOC time series simulated by 10 CMIP5 models



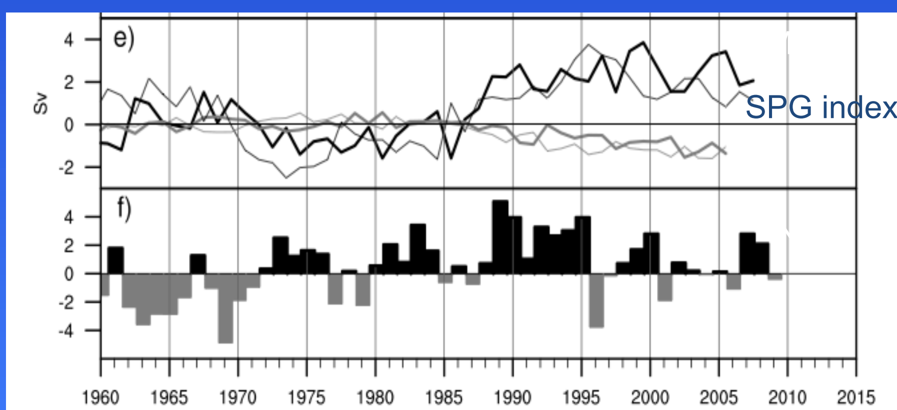
Cheng et al. (2013)

AMOC Mechanisms and Predictability

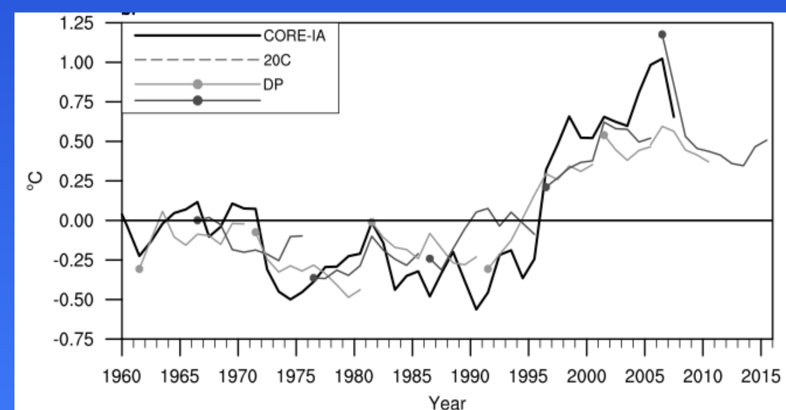
Predictability of the subpolar gyre warming in the late 1990's:



CCSM4 hindcast with CORE-IA forcing

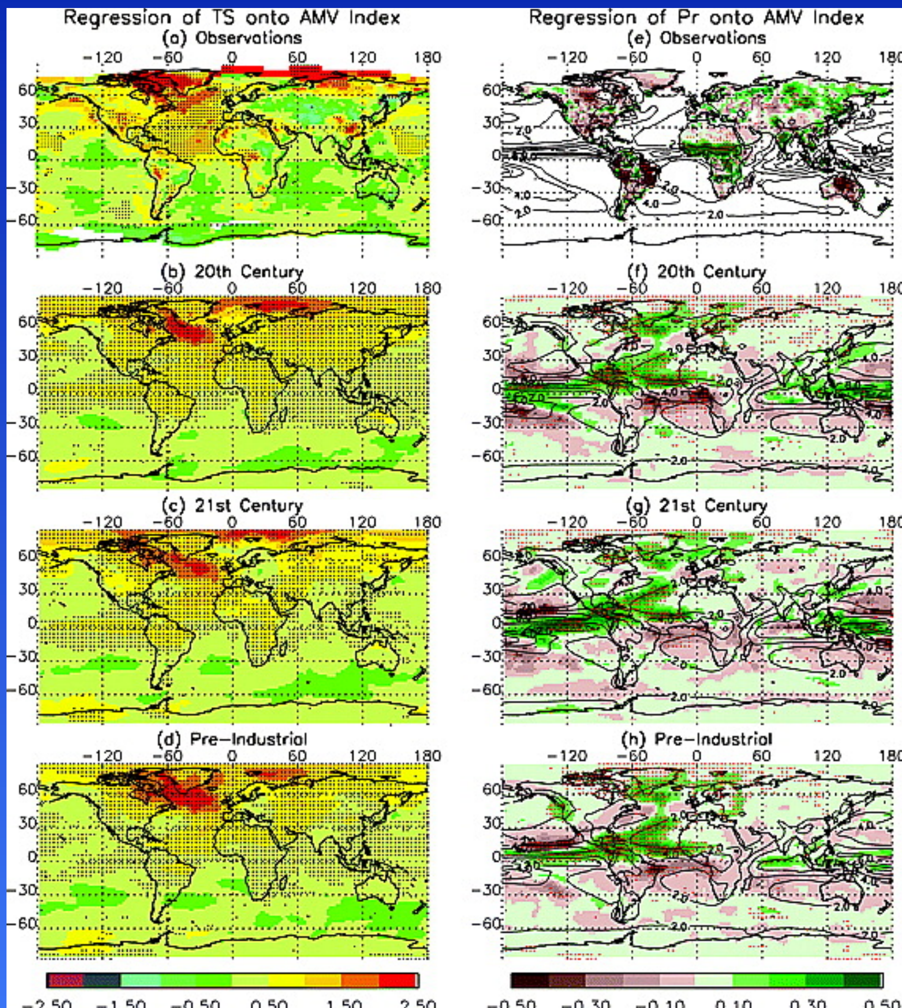


Decadal predictions init. w/ hindcast

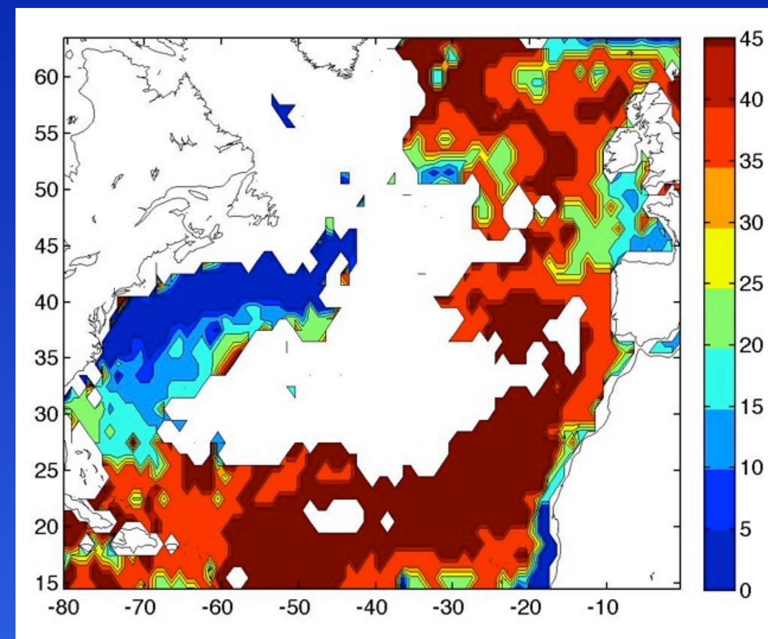


Yeager et al. (2012)

AMOC/AMV Climate Impacts



Ting et al (2011)



Courtesy of Katherine Kelly

Global precipitation variability linked to AMV

Locations where ocean processes are dominant contributor to SST anomalies