U.S. AMOC Program

www.atlanticmoc.org

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 in JSOST ORPP
- October 2007: US AMOC Implementation Plan released
- March 2008: US AMOC Science Team formed
- May 2009: 1st Annual meeting (Annapolis, MD)
- June 2010: 2nd Annual meeting (Miami, FL)
- July 2011: Joint US/UK AMOC Science Conference (Bristol, UK)
- August 2012: 3rd Annual meeting (Boulder, CO)
- Summer 2013: Joint US/UK AMOC Science Conference (US host)

Recent Developments

- DOE added as sponsoring agency in 2012 (11 new projects added)
- Over 50 funded projects now linked to the program
- 4th Annual Progress Report published March 2012
- External program review in progress

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: B. Johns (prev. S. Lozier)

Task Teams:

1. AMOC Observing System Implementation and Evaluation
(Chair: Susan Lozier; Vice-chair: Patrick Heimbach)

2. AMOC State, Variability, and Change
(Chair: Josh Willis; Vice-chair: Rong Zhang)

3. AMOC Mechanisms and Predictability
(Chair: Gokhan Danabasoglu; Vice-chair: Young-Oh Kwon)

4. Climate Sensitivity to AMOC: Climate/Ecosystem Impacts
(Chair: Ping Chang; Vice-chair: Yochanon Kushnir)

Executive Committee:

Science Chair + Task Team chairs/vice-chairs

Meeting Objectives

- Present new results; keep abreast of each others research
- Assess progress toward main program goals
- Define challenges and potential approaches
- Set priorities for near-term *collaborative* research

Near-term Research Priorities

Observing system implementation and evaluation

1. Assessing the meridional coherence of AMOC changes should be a continued focus of prognostic models, state estimation models, and enhancement of the AMOC observing system. The design of monitoring systems for the time varying strength of the AMOC in the subpolar North Atlantic and subtropical South Atlantic should be completed this year and implemented during 2012. The importance of deep temperature and salinity measurements (i.e., deep Argo) in monitoring AMOC variability should also be assessed.

Near-term Research Priorities

AMOC State, variability, and change

2. Assimilation modeling efforts should focus on reaching a consensus on the variability of the AMOC over the past few decades, and on placing realistic uncertainty bounds on these estimates. It is important that we understand the uncertainties of existing estimates and the accuracies required to detect climatically important AMOC-related changes.

3. Studies aiming to develop fingerprinting techniques to better characterize AMOC variability by combining model simulations with observations should be further encouraged and supported. Particular focus should be on understanding the linkage between AMOC variability and SST variability, both from a diagnostic and mechanistic viewpoint.

4. The meridional heat transport (MHT) carried by the AMOC provides the main connection to the climate system. Therefore it is important to explore AMOC and MHT relationships in various models (forward, assimilation, non-eddy-resolving, eddy-resolving) in comparison with observational data being generated by the program, to understand the reasons for differences, or biases, in the relationship between model AMOC intensity and MHT in available models.

Near-term Research Priorities

AMOC mechanisms and predictability

5. Further effort needs to be directed toward understanding AMOC variability mechanisms and the model dependencies of these variability mechanisms. To address this issue, a detailed comparison study for the AMOC mechanisms should be coordinated among modeling groups. A focused effort is also needed to develop a synthesis of existing observations, including synthesis of proxy data, to discriminate various model-based proposed mechanisms against the observational data.

6. In coordination with the near-term prediction experiments being conducted by modeling centers for the IPCC AR5, an inter-comparison study should be performed to investigate the robustness of AMOC predictions among simulations using various models. These efforts should seek collaboration with the U.S. CLIVAR Decadal Predictability Working Group as well as the International CLIVAR Working Group on Ocean Model Development and Global Synthesis and Observational Panel.

Near-term Research Priorities

Climate sensitivity to AMOC: climate/ecosystem impacts

7. Further study is required to understand the teleconnections between AMOC/North Atlantic SST and climate variability elsewhere, and the physical mechanisms of these teleconnections. Targeted studies of 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 are also needed.

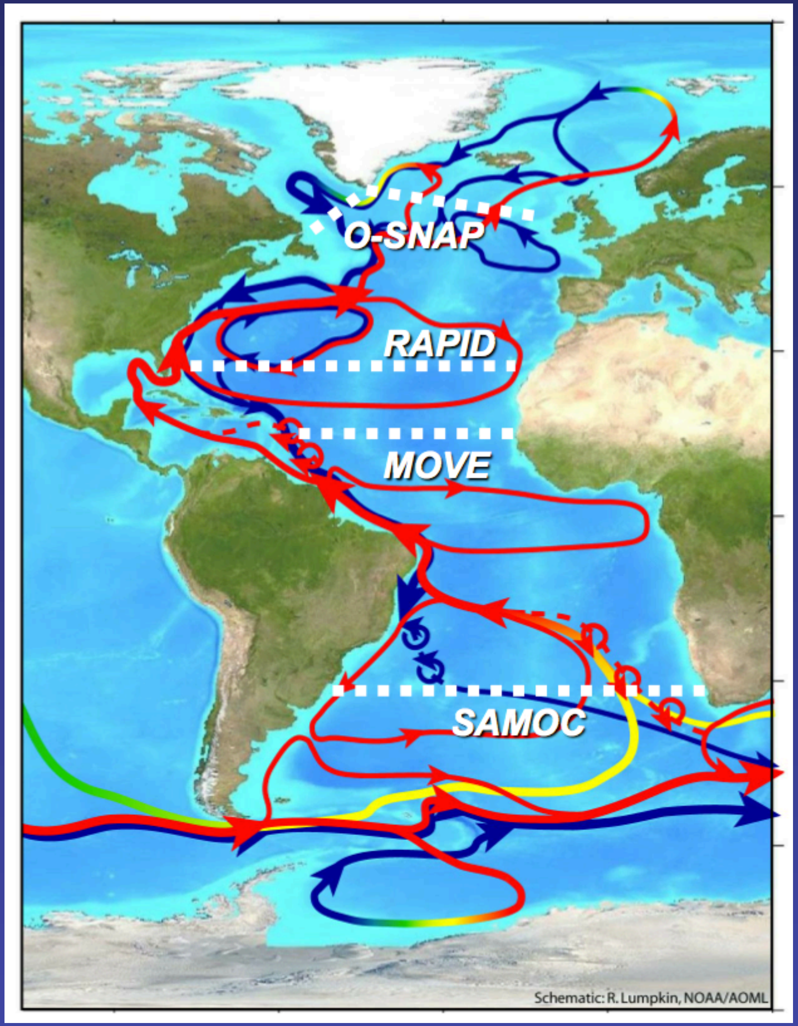
AMOC Observing System

<u>**Strategy**</u>:

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

<u>Value</u>:

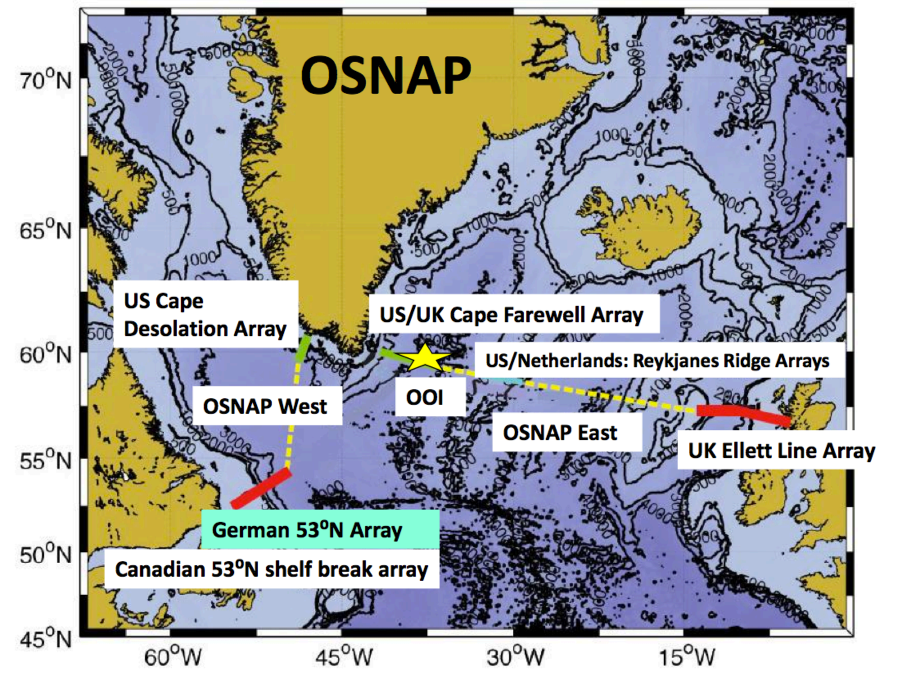
- ***Accurate*** multi-year mean AMOC estimates, for comparison with future (and past) AMOC states
- ***Understanding*** of processes underlying short-term (intraseasonal to annual) variability
- ***Benchmarks*** for evaluation of modeled AMOC variability (GCMs, data synthesis models)



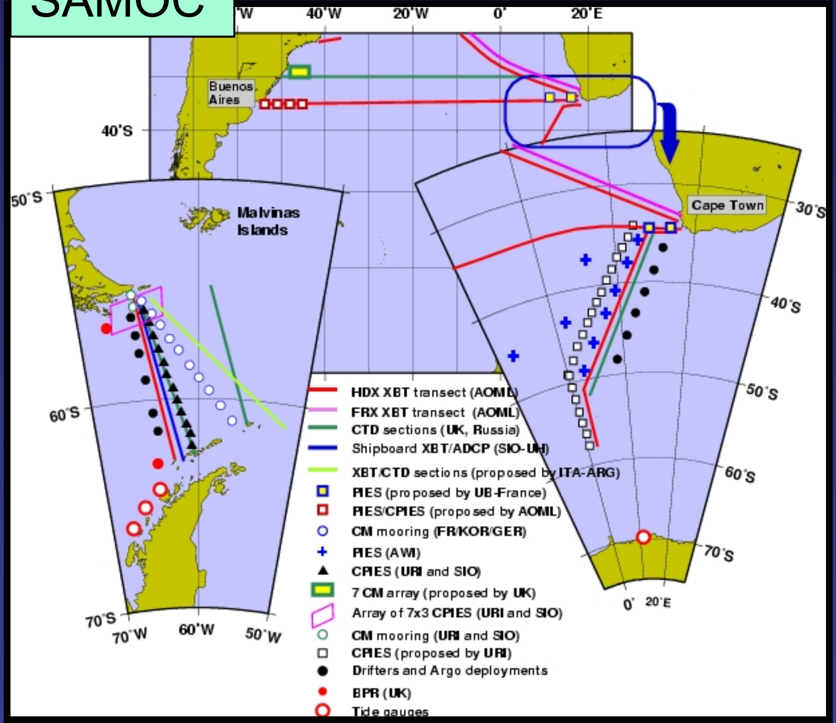
Subpolar North Atlantic

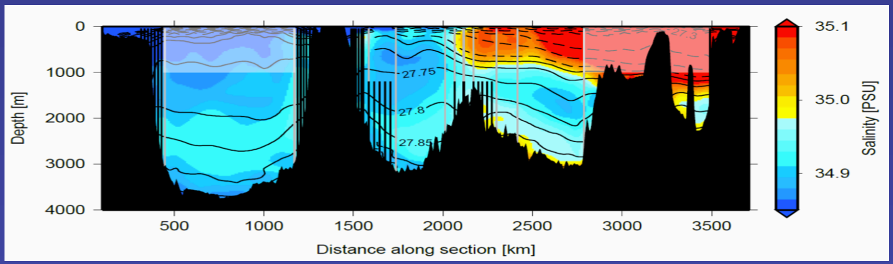
South Atlantic

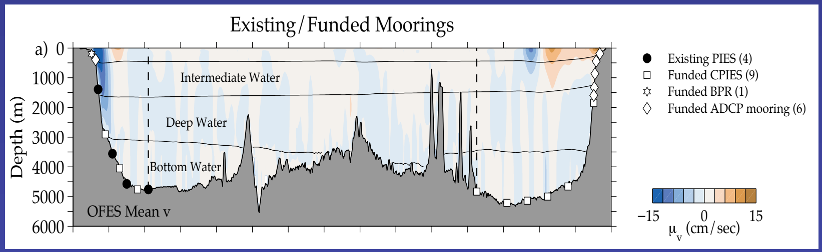
OSNAP



SAMOC





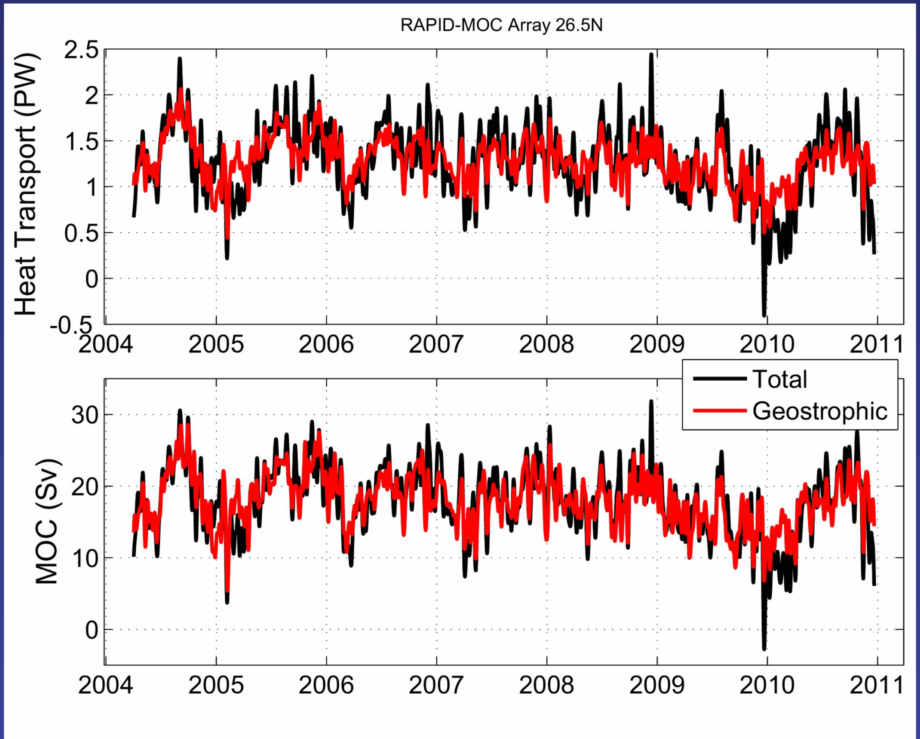


(U.S., U.K., Germany, Netherlands, Canada)

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

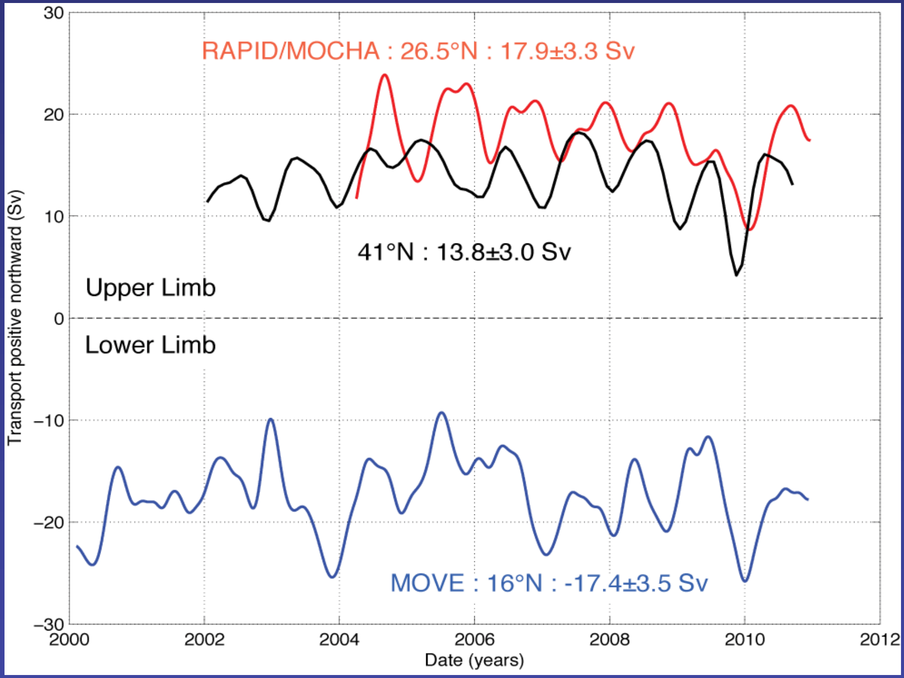
AMOC Variability from Observations

RAPID-MOCHA Array (26.5°N)



McCarthy et al. (2012)

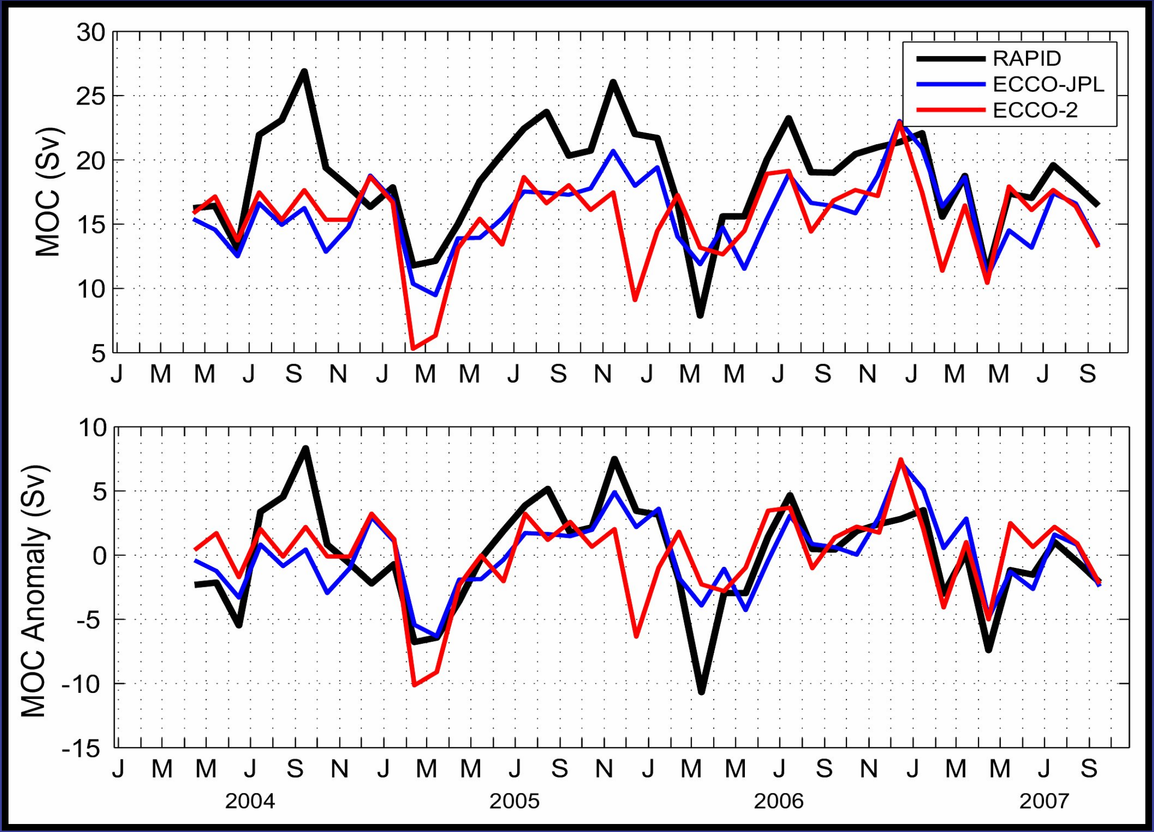
RAPID, MOVE, and 41°N (Willis)

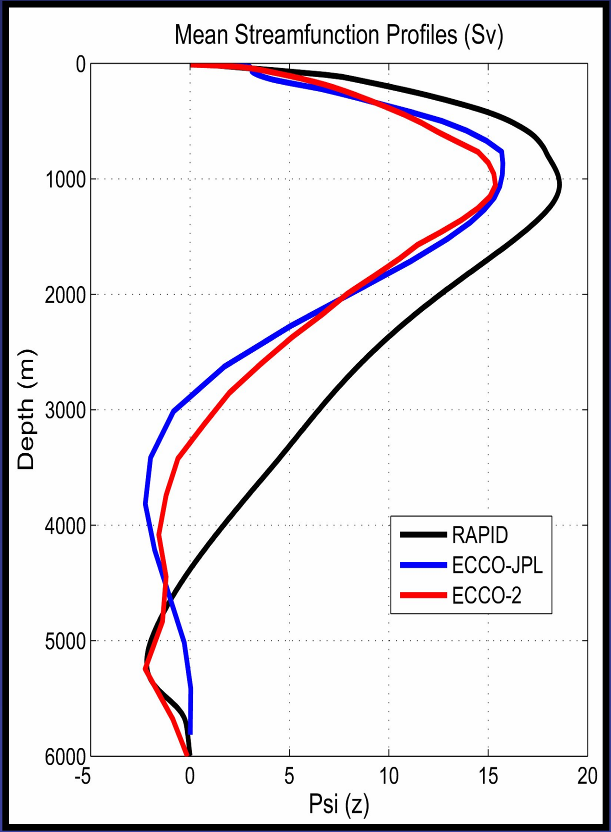


Baringer et al. (2012)
State of the Climate in 2011 (BAMS Suppl.)

Synthesis Models

RAPID vs. ECCO products

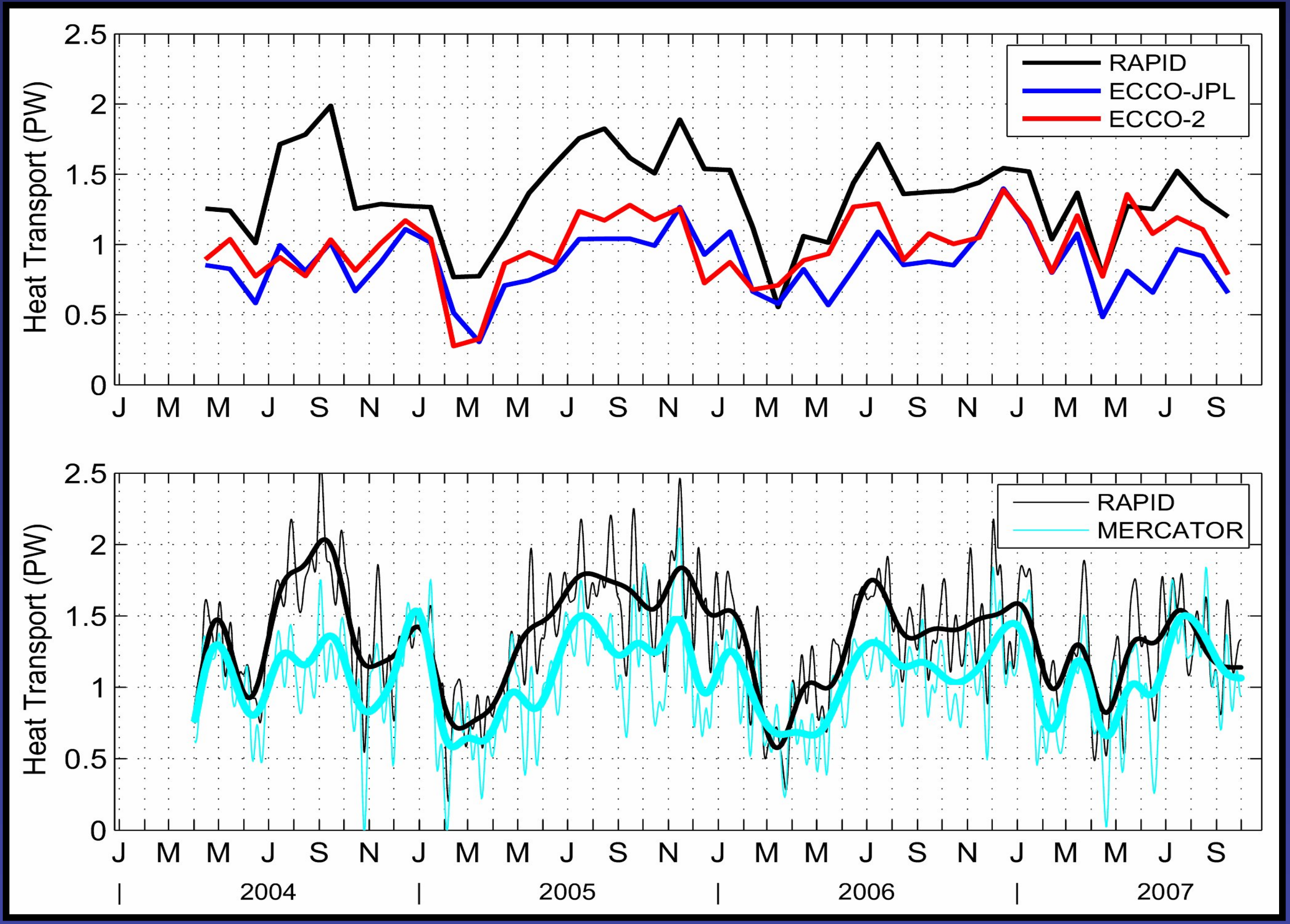




➔ *Anomaly agreement is encouraging; biases still exist*

Synthesis Models: Heat Transport

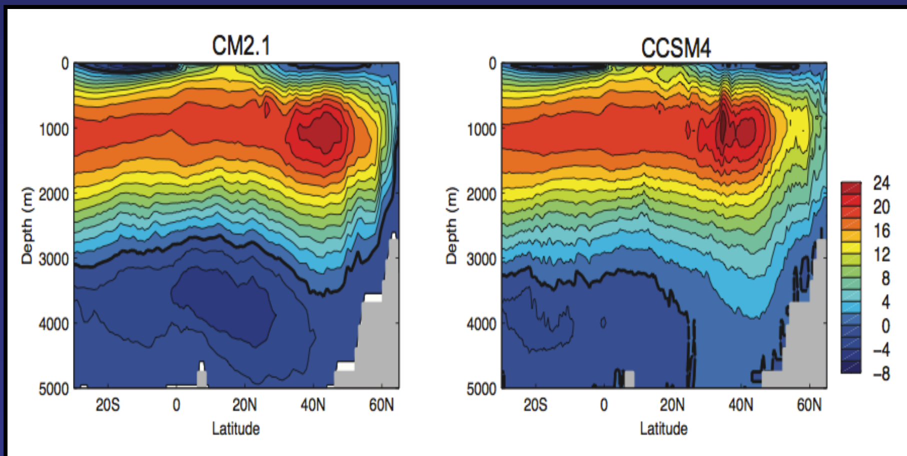
RAPID vs. ECCO products

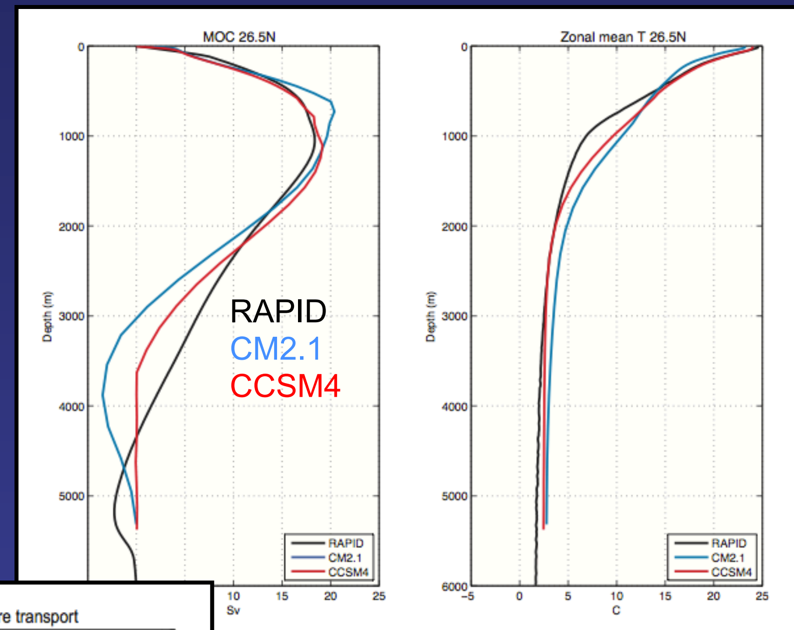


➔ Heat transport tends to be biased to a greater degree than MOC strength

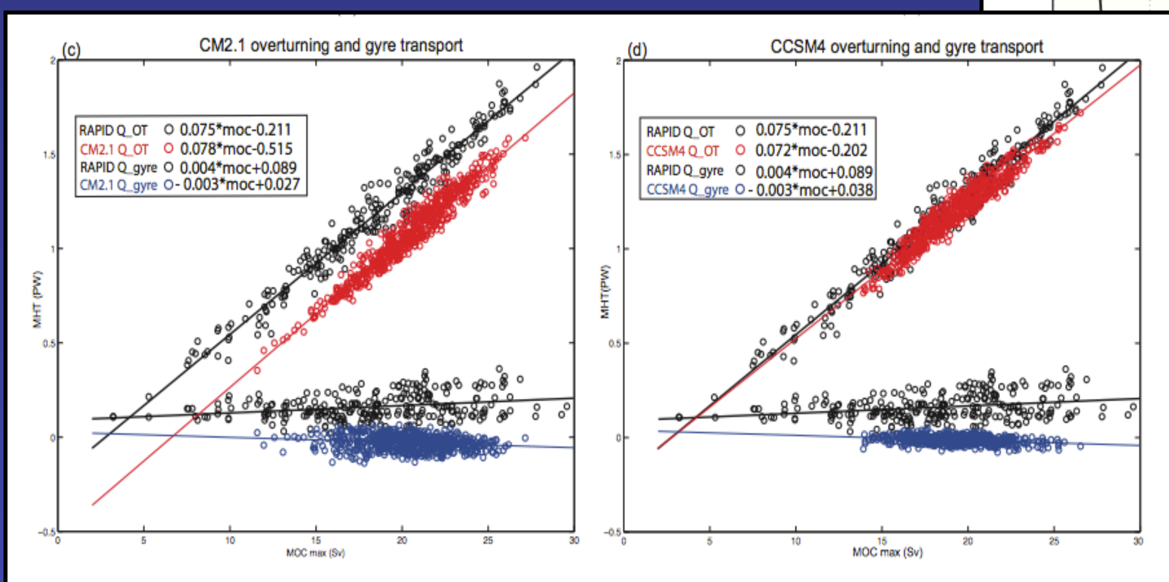
AMOC Representation in Coupled Models

Model Overturning Streamfunctions





MOC profiles at 26.5°N vs. RAPID

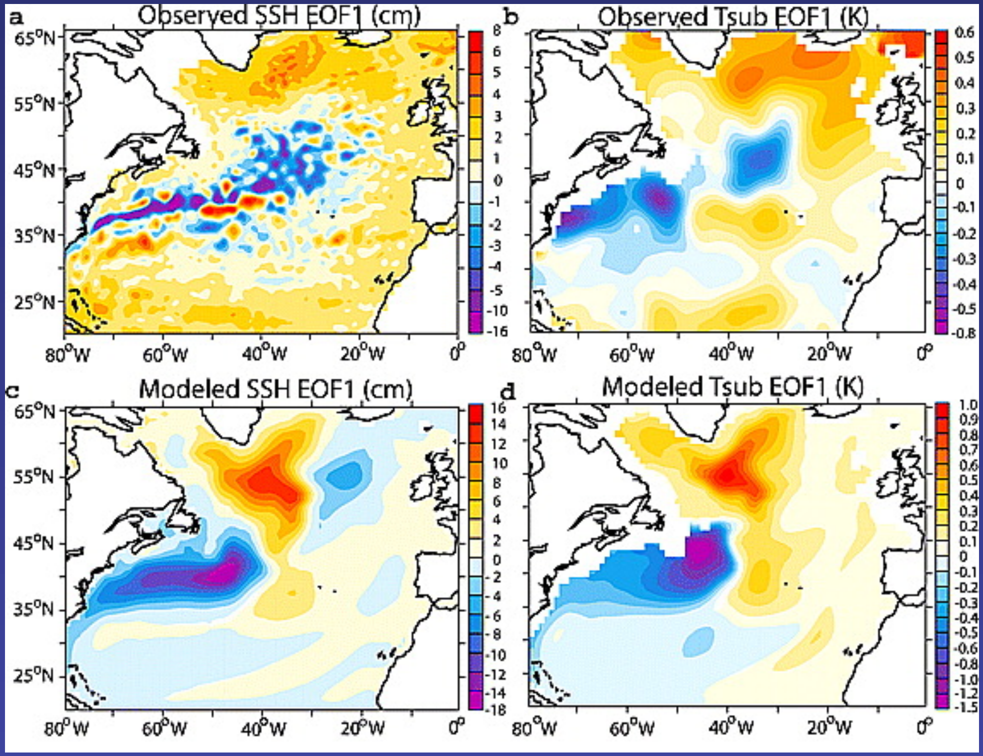


Overturning and gyre heat transport regressed against the MOC strength

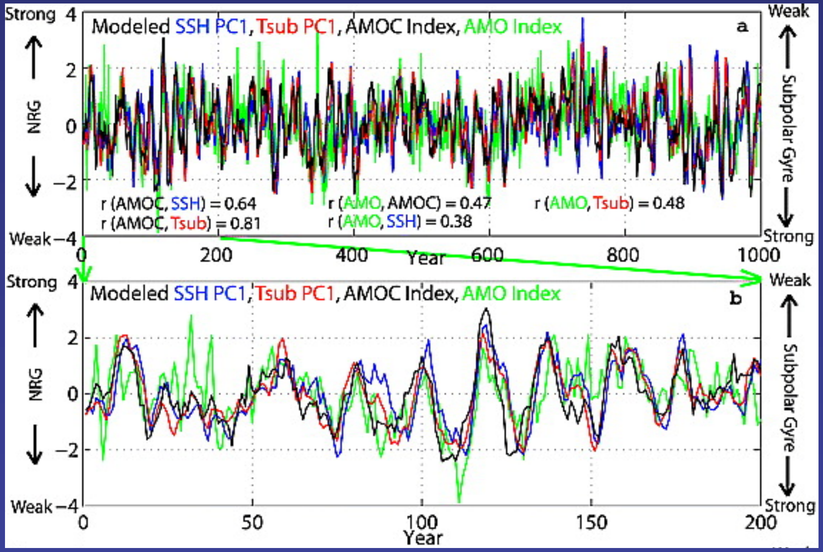
Msadek et al. (2012)

AMOC "Fingerprinting"

Observed and modeled 1st EOFs of sea surface height (SSH) and subsurface temperature (Tsub)



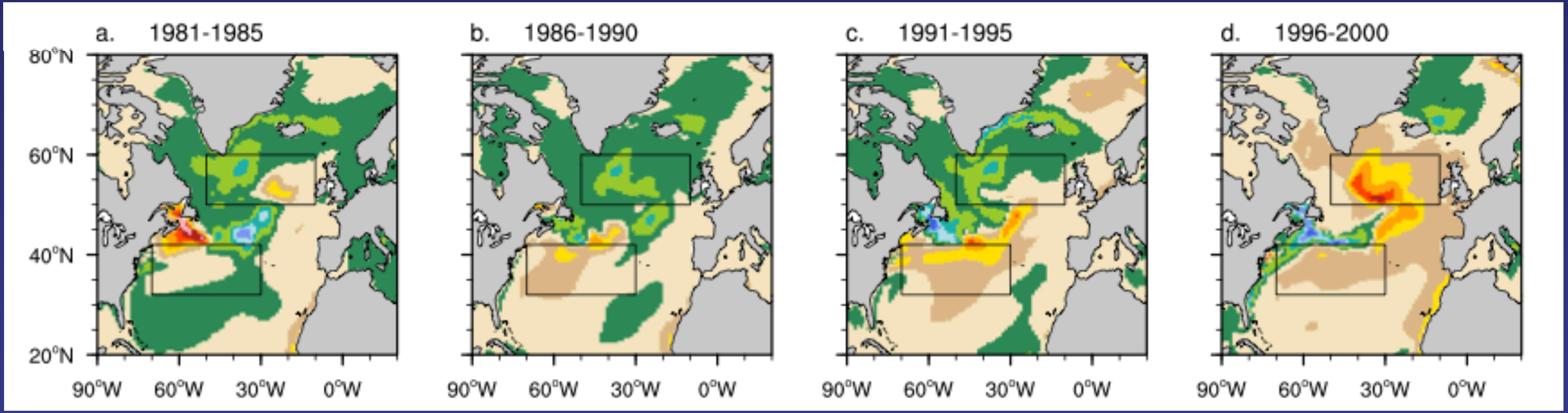
Time series of SSH, Tsub, and AMO index vs. AMOC strength



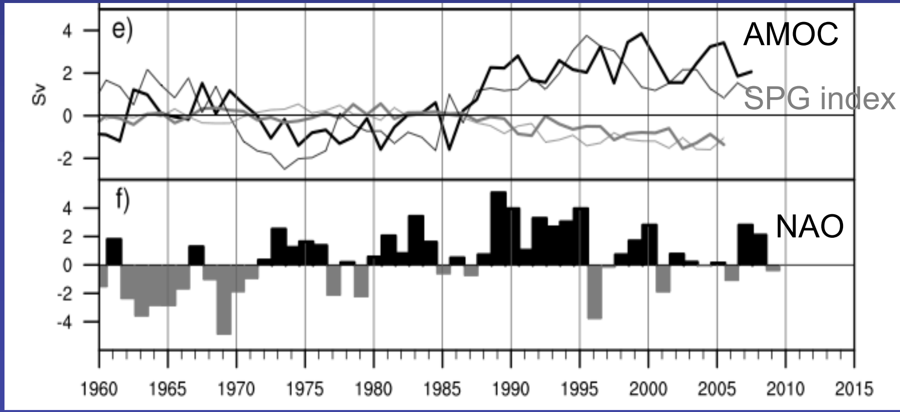
Zhang et al. (2008), Mahajan et al. (2011)
GFDL CM2.1

AMOC Mechanisms and Predictability

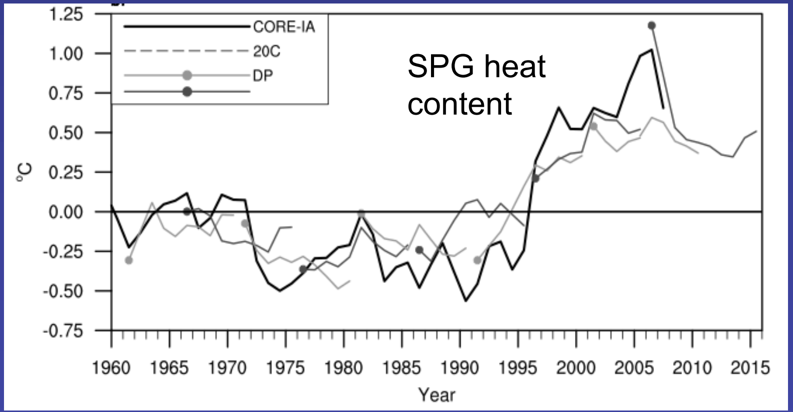
Predictability of the subpolar gyre warming in the late 1990's:



CCSM4 hindcast with CORE-IA forcing

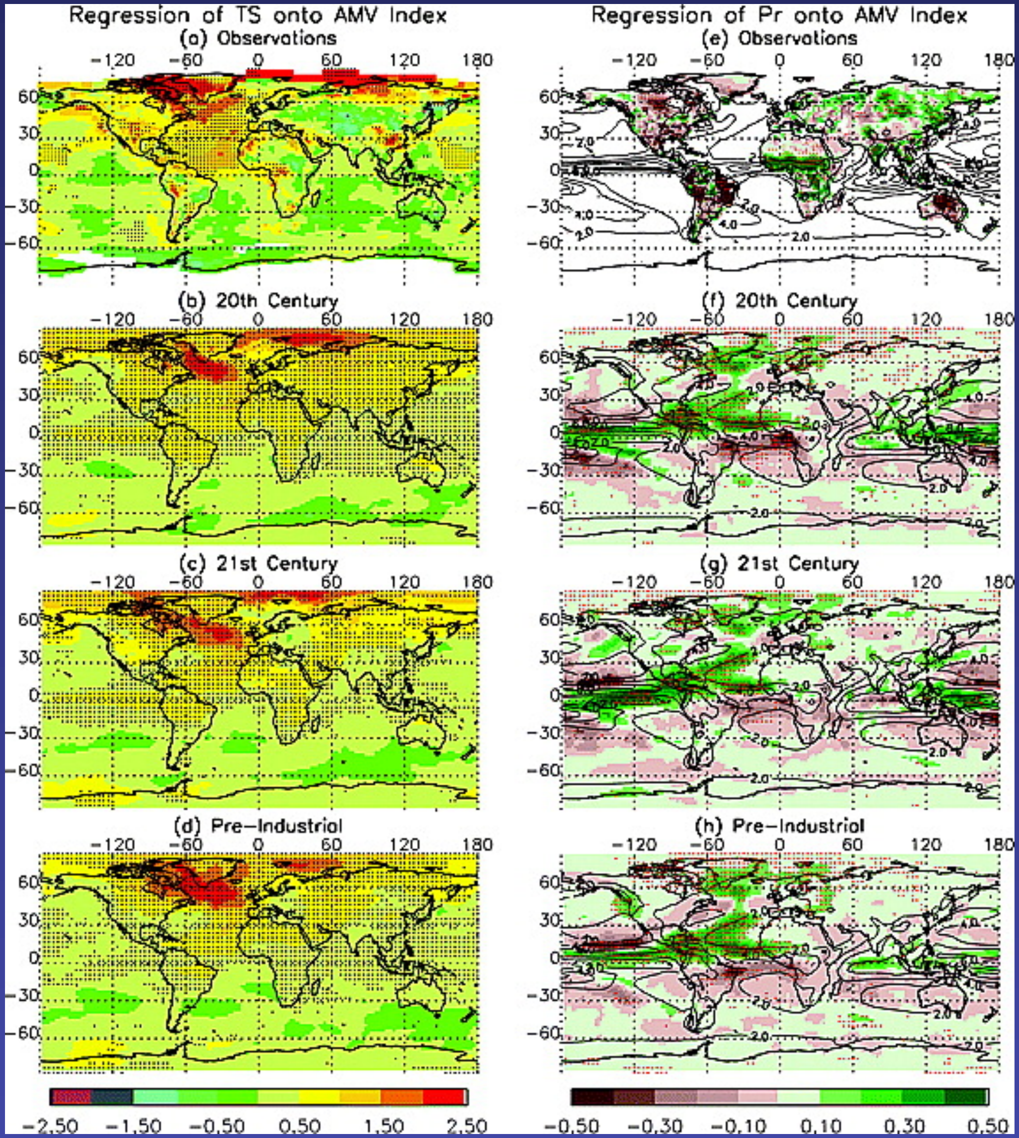


Decadal predictions init. w/ hindcast

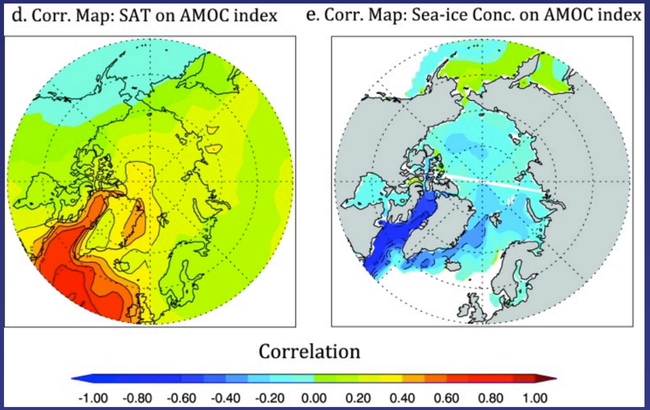


Yeager et al. (2012)

AMOC/AMV Climate Impacts



AMOC impacts on sea ice



Mahajan et al (2011), CM2.1

Global precipitation variability linked to AMV

Ting et al (2011)

2012 USAMOC Annual Meeting

Aug. 15-17, NCAR, Boulder, CO

Agenda:

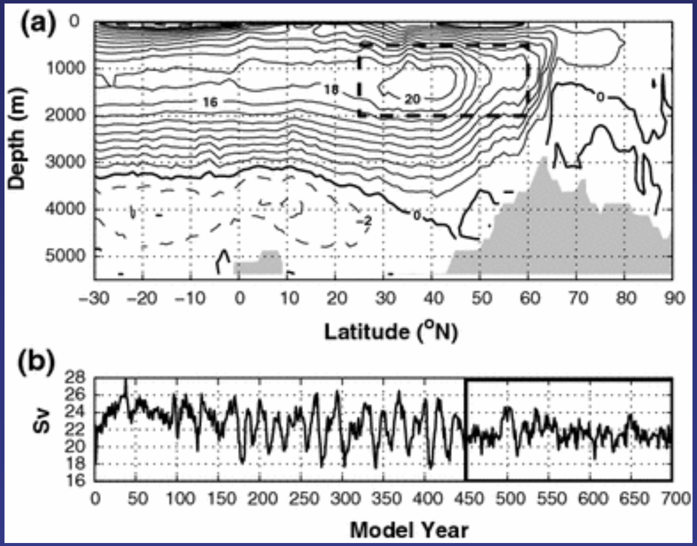
- **1 day for presentations**
- **1 day for "mini-workshops"**
- **½ day for mini-workshop reports and discussion on future directions/ priorities**

Mini-workshops:

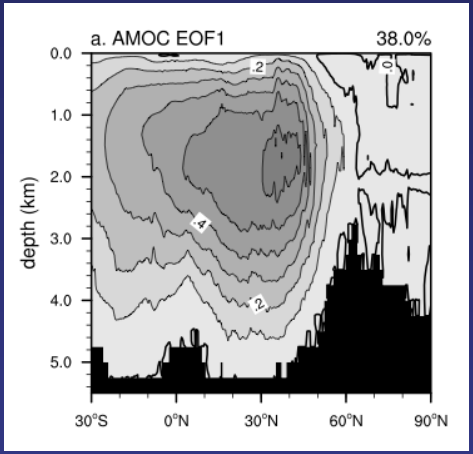
1. AMOC fingerprinting from historical and proxy data
   Speakers: Ben Horton, Casey Saenger
2. AMOC's impact on the carbon cycle
   Speakers: Galen McKinley, Scott Doney
3. The AMOC observing system
   Speakers: Johanna Baehr, Rui Ponte
4. AMOC Mechanisms and Predictability
   Speakers: Tom Delworth, Grant Branstator

AMOC Variability Mechanisms

AMOC variability in CCSM3 and CCSM4

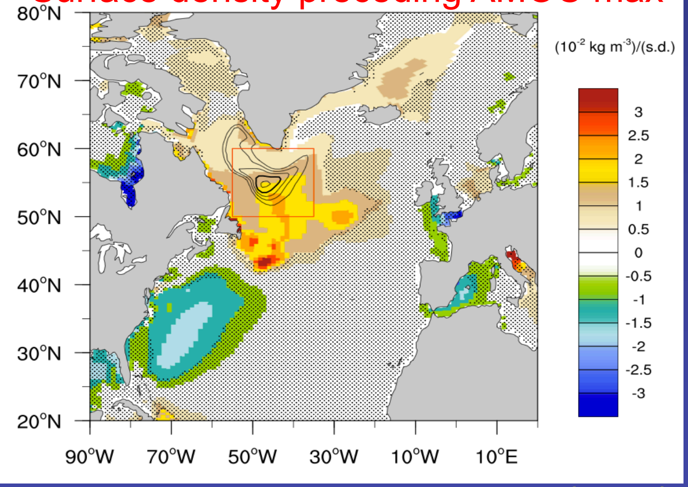


Kwon and Frankignoul (2012)

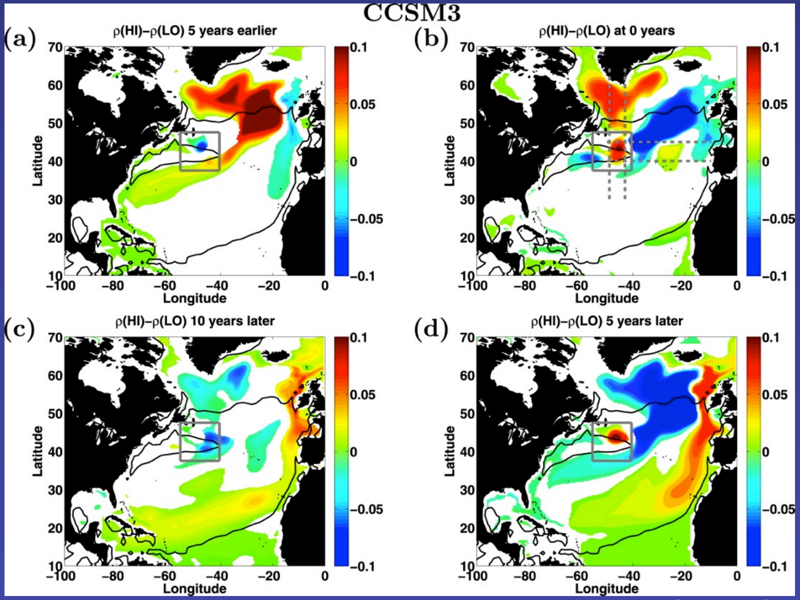


Danabasoglu et al. (2012)

Surface density preceding AMOC max



Danabasoglu et al. (2012)



Tulloch and Marshall (2012)