Observing the Meridional Overturning Circulation (MOC), continued



Chris Meinen

OSNAP

- In place during September 2014 to present
- More detail in talk by Feili Li & posters

NOAC

 In place during April 2016 to present (Western basin since June 2009)

RAPID-MOC/MOCHA/WBTS

- In place during April 2004 to present
- More detail in talks by David Smeed, Elaine McDonagh & posters

MOVE

- In place during February 2000 to present
- More detail in poster by M. Lankhorst

TSAA

• In place during July 2013 to present

SAMBA

- In place during March 2009-December 2010 and September 2013 to present
- More detail in posters by C. Meinen, M. Kersale

Paleo community interest in AMOC Task Team 5: Hali Kilbourne Telecon: 07 September 2018



An Emerging Puzzle!

Sunrise US AMOC Science Team Sunrise Sunrise Sunset Plans Transition



Maintaining momentum until 2020 and beyond Sunset Date: 31 December 2020

Planned Activities	COLLABORATION	Convene science meetings (2018, 2020) and coordinate conference sessions Organize a Paleo AMOC Task Team Transition current program-to-program collaborations (e.g., with UK RAPID-AMOC, EU AtlantOS) to US and International CLIVAR		
	PRIORITIES	Revise near- and long-term priorities to reflect ongoing research needs extending beyond the Science Team Distill a set of programmatic action items to be completed through 2020 Establish the pathway for transitioning components of the AMOC observing system from research to sustained		
	LEGACY PRODUCTS + Accomplishments Report	Produce capstone special journal collection, including review/ synthesis and science papers Produce white paper(s) regarding AMOC observing requirements for Ocean Obs '19 Produce metrics for bridging the evaluation of model simulations, reanalyses, and observations Produce analyses of CMIP6 and CORE simulations of AMOC Issue final US AMOC Science Team report Complete bibliometrics of US AMOC Science Team research		
	COMMUNICATION	Inform the community of the sunset plans, including a town hall at 2020 Ocean Sciences Meeting Include discussion of Science Team wrap-up in final two reports Prepare timeline graphic showing activities for 2018-2020 with indication of ongoing activities beyond Prepare graphics highlighting Science Team accomplishments Develop an AMOC website structure to showcase accomplishments/legacy using the above content Create a general AMOC listserv for the community		

Future Challenges and Opportunities

- Ensuring continuity / funding of AMOC-related research efforts
- Ensuring continuity of established / on-going observational efforts, e.g., establishing a pathway from research to sustained observations
- Ensuring continuity of existing (program-to-program) collaborations, e.g., transitioning to US and International CLIVAR panels and activities
- Ensuring coordination of science across such panels and activities

Proposed papers for an AMOC virtual special collection in AGU journals

Submission time frame: 01 May – 31 October 2018

	Paper Topic	Lead Author	Co-Lead	Journal
1	Observing the Atlantic Meridional Overturning Circulation: Pathways, Fluxes, and Transformation	Stuart Cunningham		Review of Geophysics
2	Linkage between the AMOC variability and the AMV and associated climate impacts, including both modern and paleo observational linkages	Rong Zhang		Review of Geophysics
3	Technological advances and novel approaches to existing and emerging data (and technologies) for sustainable AMOC observations	Gerard McCarthy		JGR-Oceans
4	Pathways of the Atlantic Meridional Overturning Circulation	Susan Lozier	Amy Bower	JGR-Oceans
5	AMOC stability, particularly focusing on the role of freshwater transport across 30°S	Wilbert Weijer	Sybren Drijfhout	JGR-Oceans
6	High-resolution models of the AMOC, including regional studies of key components such as the Southern Ocean, Gulf Stream, Agulhas Leakage, and high-latitude convection regions	LuAnne Thompson	Xiaobiao Xu	JGR-Oceans
7	Reexamining linkages between the Atlantic Meridional Overturning Circulation and Eastern North American sea level	Chris Little	Chris Piecuch	JGR-Oceans
8	Impact of the AMOC on ocean tracers	Anand Gnanadesikan		JGR-Oceans
9	Intercomparison of reanalysis products	Laura Jackson		JGR-Oceans
10	Recent advances in theoretical modeling of the AMOC	Helen Johnson	David Marshall	JGR-Oceans
11	North Atlantic variability across the last millennium: A review	Paolo Moffa Sanchez	David Reynolds	Paleoceanography/ Climatology

A Review of the Role of the Atlantic Meridional Overturning Circulation in Atlantic Multidecadal Variability and Associated Climate Impacts

Rong Zhang, Rowan Sutton, Gokhan Danabasoglu, Young-Oh Kwon, Robert Marsh, Stephen G. Yeager, Danial E. Amrhein, Christopher M. Little

Reviews of Geophysics (submitted)

By synthesizing recent studies employing a wide range of approaches (modern observations, paleo reconstructions, and climate model simulations), the paper provides a comprehensive review of the linkage between multidecadal AMOC variability and Atlantic Multidecadal Variability (AMV) and associated climate impacts.

The role of the AMOC in AMV and associated climate impacts has been underestimated in most state-of-the-art climate models, posing significant challenges but also great opportunities for substantial future improvements in understanding and predicting AMV and associated climate impacts.

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2020 US AMOC Science Team Meeting East Coast, USA





Organizing Committee



Renellys Perez (NOAA AOML) (chair)

Martha Buckley (GMU); Gokhan Danabasoglu (NCAR); Helen Johnson (Oxford); Elaine McDonagh (NOC); Mike Patterson (US CLIVAR); Michael Spall (WHOI); Meric Srokosz (NOC); Kristan Uhlenbrock (US CLIVAR); Richard Wood (UKMO)











Observing the Atlantic Meridional Overturning Circulation: Pathways, Fluxes, and Transformation

Stuart Cunningham et al.

This review focuses on in situ observations. Specifically: purposefully designed transatlantic AMOC arrays providing basin wide integrated estimates of circulation and heat and fresh-water fluxes; observations of the Deep Western Boundary Current; Pacific-Arctic-Nordic-Atlantic Exchanges; and deep convection in the Labrador Sea.

Goals are to provide for the first time a comprehensive description of these observing systems (how the observations are made, why they are being made and what part of the AMOC they address and their limitations); to show and describe the fundamental data from them, and where possible or known, to identify commonality in the variability and fluxes.

The paper will also show how the observations are able (or not) to quantify or constrain key mechanisms and dynamics of AMOC variability: the goal is to understand the role of observations in understanding the changing AMOC in the 21st Century. Do observations now and in the future constrain predictions of 21st C slowing? What are the gaps in the observing system?

Sustainable Observations of the AMOC: Methodology and Technology

G. D. McCarthy, D. A. Smeed, R. Hummels, K. Jochumsen, M. Rhein,C. Schmid, C. Hughes, C. Flagg, C. Meinen, D. Rayner, L. Houpert, P.Brown, M. Inall, K. M. Larsen and et al.

The first half of the paper describes existing methods and observation systems for estimating the AMOC.

The second half of the paper looks at technology that is emerging or not utilised in observing the AMOC. Also looks at gaps, future outlook, and sustainability.

Lagrangian Views of the Pathways of the Atlantic Meridional Overturning Circulation

Susan Lozier, Amy Bower, M. Baringer, A. Biastoch, K. Drouin, N. Foukal, M. Lankhorts, S. Rühs, Xiaobiao Xu and S. Zou

The overall topic is AMOC pathways from the Lagrangian viewpoint only —both observational and within numerical models.

The goal is to present a review of published literature on pathways of the upper and lower limbs of the AMOC by region, moving from region to region along the general path of the 'conveyor', starting at the upper limb in the South Atlantic and ending at the lower limb in the South Atlantic.

Stability of the Atlantic Meridional Overturning Circulation: A Review and Synthesis

W. Weijer, W. Cheng, G. Danabasoglu, S. Drijfhout, A. Fedorov, A. Hu, L. Jackson, W. Liu, E. McDonagh, J. Mecking, and J. Zhang

High Resolution Models of the AMOC

LuAnne Thompson, Xiaobiao Xu, et al.

Reexamining Linkages Between Eastern North American Sealevel and the Atlantic Meridional Overturning Circulation

Christopher Little, Aixue Hu, Gerard McCarthy, Christopher Piecuch, Rui Ponte, Matthew Thomas

A better understanding of the relationship between AMOC and coastal sea level will inform: i) future coastal flooding risks along the North Atlantic coastline and ii) reconstructions of the North Atlantic circulation.

The literature remains ambiguous with respect to the following two key questions:

- Is there a well-defined, robust, and stationary "AMOC signature" in coastal sea level?
- Are current generation models reliable for the purpose of: 1) coastal sea level projections and/or 2) assessing relationships between the large-scale ocean circulation and coastal sea level?

The manuscript highlights the role of ongoing and future research, revealing: i) the spatio-temporal coherence of AMOC and AMOCassociated currents and ii) the applicability of geostrophic balance (and its utility as an explanatory tool) over different spatial and temporal scales.

Impact of the AMOC on Ocean Tracers

Anand Gnanadesikan, et al.

North Atlantic Variability in Global Ocean Reanalyses (An Intercomparison)

Laura Jackson et al.

Analysis of results is ongoing. The intercomparison also includes: mixed layer depths; water mass properties; gyres; ocean transports; heat and freshwater changes.

There are some coherent changes in AMOC across reanalyses products. In particular, an increase from 2001-2006 followed by a decrease at 26°N, and at 50°N there is a weakening since the mid 90s along with interannual Ekman-driven variability.

The AMOC across the OSNAP section shows some correspondence with the observations over the last couple of years.

Recent Advances in the Theoretical Modeling of the AMOC

Helen Johnson, David Marshall, Mike Spall, et al.

The paper will focus on the contributions that theoretical models have made over the last decade or so to changing our view of the AMOC and to providing a dynamical framework for understanding recent observations and modelled complexity.

Key advances/contributions of theoretical models over the last decade have been:

- An understanding of the role of the wind (both hemispheres) in determining the mean AMOC and its variability.
- Providing a dynamical framework to think about the roles of diabatic versus adiabatic processes in returning deep water to the surface.
- A shift from largely 2D theoretical models to 3D and multiple basin, reflecting our increased understanding of the essential physics.

A section on updated paradigms of marginal sea downwelling / convection.

North Atlantic Variability Across the Last Millennium

Paola Moffa Sanchez, David Reynolds, P. Ortega, E. Moreno-Chamarro, et al.

Ongoing work on creating a database / compilation of all published paleooceanographic records from the North Atlantic spanning the last 2000 years and putting them together to extract some conclusions on the centennial scale ocean changes.

A team of modellers is working on extracting common features across the CMIP5 last millennium model outputs.