U.S. AMOC Science Team

www.usclivar.org/amoc

An U.S. inter-agency program

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

Outline

- Background on Science Team objectives and organization;
- A few examples of ongoing projects;
- Near- and long-term priorities;
- Thoughts / discussions about the future of the Science Team.

U.S. AMOC Program Scientific Objectives

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

48 funded projects supported by 4 agencies at the start of FY15

U.S. AMOC Program Organization

Science Team: Comprised of PIs and co-PIs, performing AMOC-relevant research designated by the funding agencies

Task Teams (TTs):

1. AMOC Observing System Implementation and Evaluation
   (Chair: Chris Meinen; Vice-chair: Renellys Perez)
2. AMOC State, Variability, and Change
   (Chair: LuAnne Thompson; Vice-chair: Alicia Karspeck)
3. AMOC Mechanisms and Predictability
   (Chair: Rym Msadek; Vice-chair: Steve Yeager)
4. Climate Sensitivity to AMOC: Climate/Ecosystem Impacts
   (Chair: Ruth Curry; Vice-chair: Andreas Schmittner)

Executive Committee:

Science Team chair: Gokhan Danabasoglu

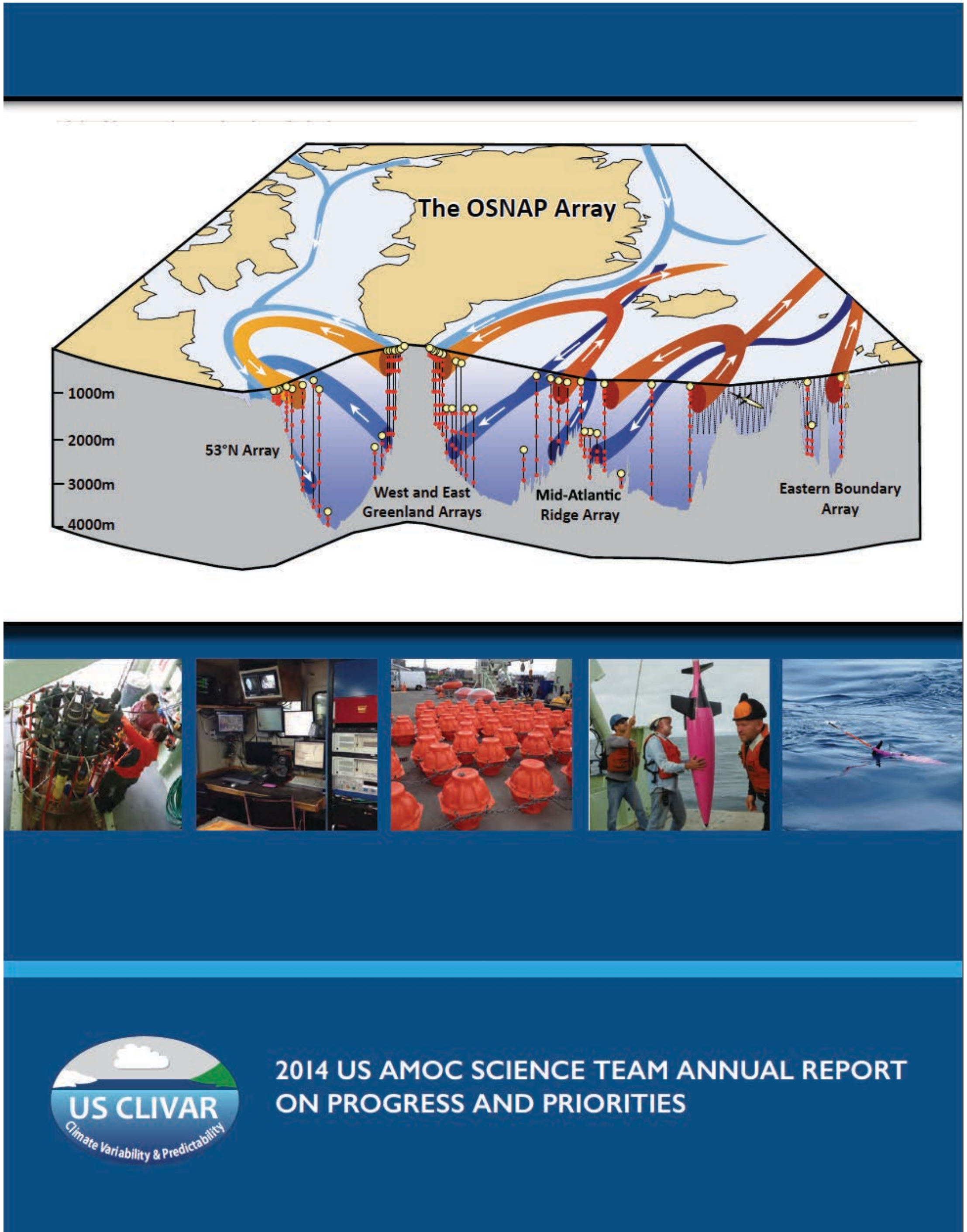
+ TT chairs and vice-chairs

The U.S. AMOC Executive Committee is charged with:

- Identifying research needs to achieve the program objectives;
- Encouraging and developing research activities to address these needs;
- Coordinating ongoing U.S., and whenever possible international, research activities to address the program objectives;
- Summarizing the state of the science and program progress;
- Developing input to AMOC program reports as necessary.

U.S. AMOC Program History

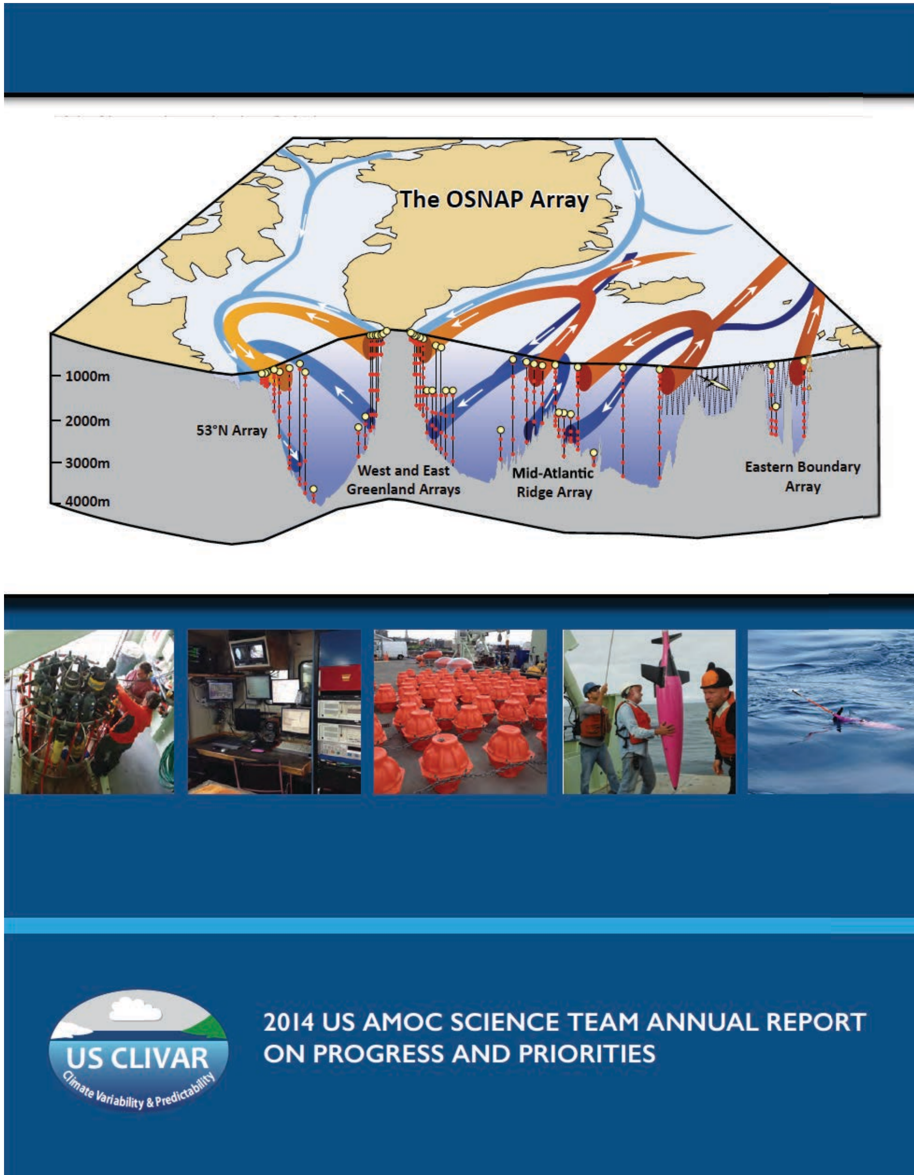
- January 2007: AMOC identified as near-term priority by JSOST
- October 2007: U.S. AMOC Implementation Plan released
- March 2008: U.S. AMOC Science Team formed
- May 2009: 1st Annual PI Meeting (Annapolis, MD)
- June 2010: 2nd Annual PI Meeting (Miami, FL)
- July 2011: Joint U.S./U.K. AMOC Science Conference (Bristol, U.K.)
- August 2012: 3rd U.S. AMOC Meeting (Boulder, CO)
- 2012-2013: External Review of the Program
- July 2013: Joint U.S./U.K. International AMOC Science Meeting (Baltimore, MD)
- 09-11 September 2014: 4th U.S. AMOC Meeting (Seattle, WA)
- 20-24 July 2015: Joint U.S./U.K. International AMOC Science Meeting (Bristol, U.K.)

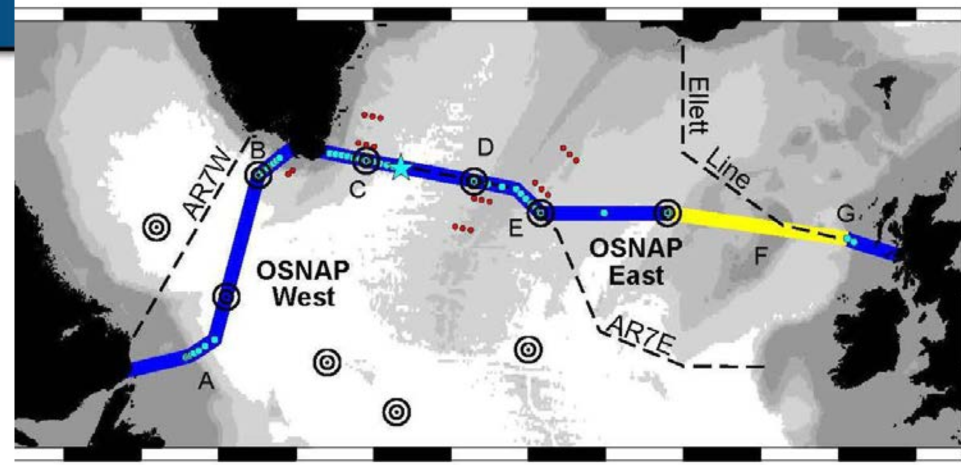


COVER IMAGE: OSNAP array schematic by Penny Holiday, National Environmental Research Council, UK; OSNAP deployment cruise images from summer 2014 by Amy Bower, Clare Johnson, Karen Wilson, Sijia Zou.

Many thanks to Mike Patterson and Kristan Uhlenbrock for their support of the US AMOC Science Team

OSNAP: Overturning in the Subpolar North Atlantic



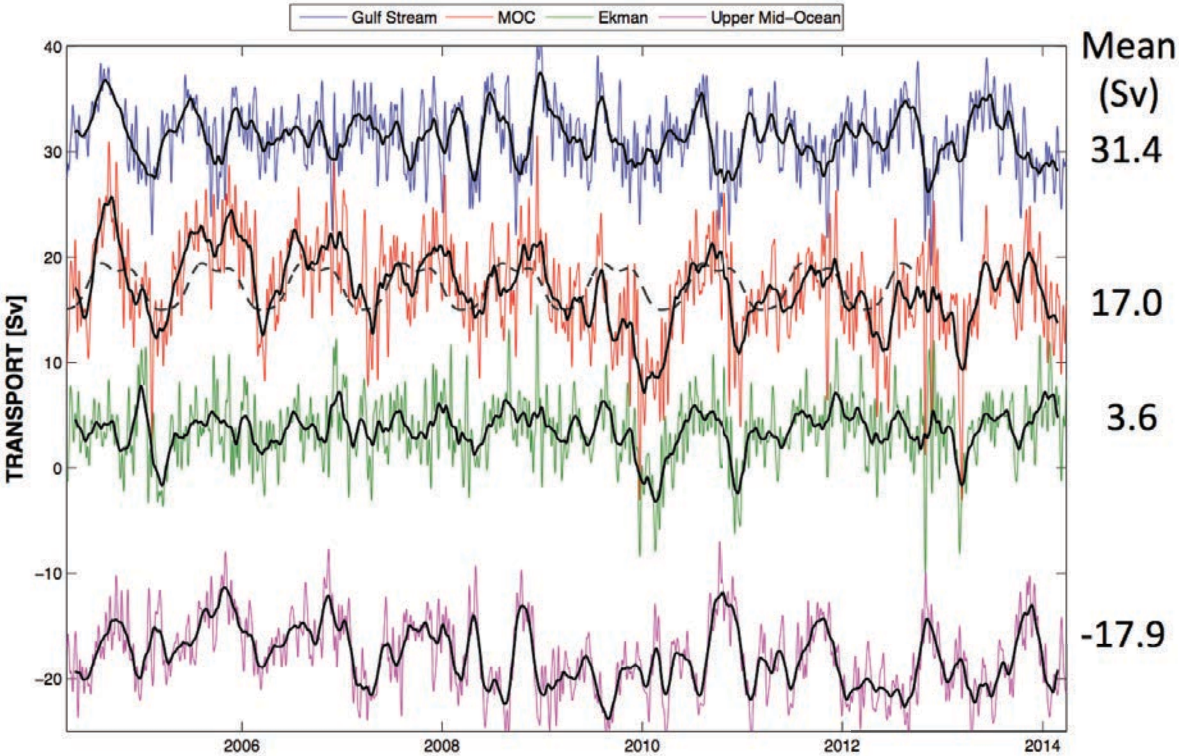


Lozier et al.

The specific OSNAP objectives are:

- Quantify the subpolar AMOC and its intra-seasonal to interannual variability via overturning metrics, including associated fluxes of heat and freshwater.
- Determine the pathways of overflow waters in the NASPG to investigate the connectivity of the deep boundary current system.
- Relate AMOC variability to deepwater mass variability and basin-scale wind forcing.
- Determine the nature and degree of the subpolar-subtropical AMOC connectivity.
- Determine from new OSNAP measurements the configuration of an optimally efficient long-term AMOC monitoring system in the NASPG.

The entire OSNAP observing system was deployed in summer 2014. The first data returns from the moored instrumentation are expected in summer 2015, although the data from the full array will not be recovered till summer 2016.

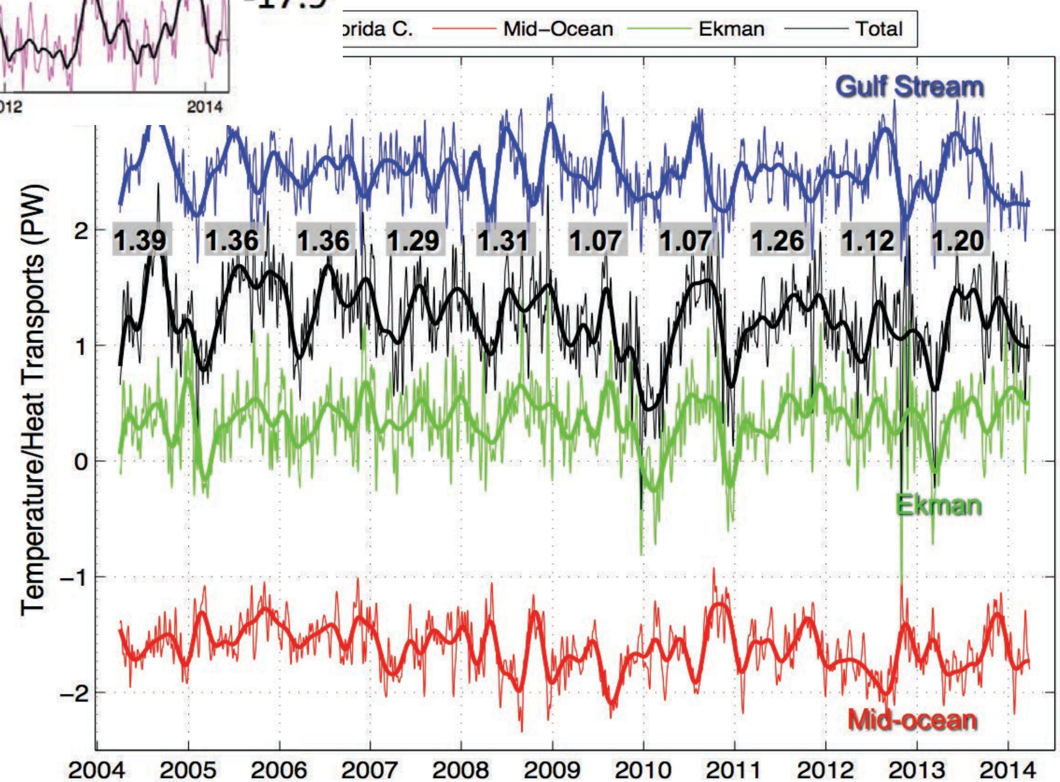


Smeed et al.

RAPID – MOCHA
Array at 26.5°N

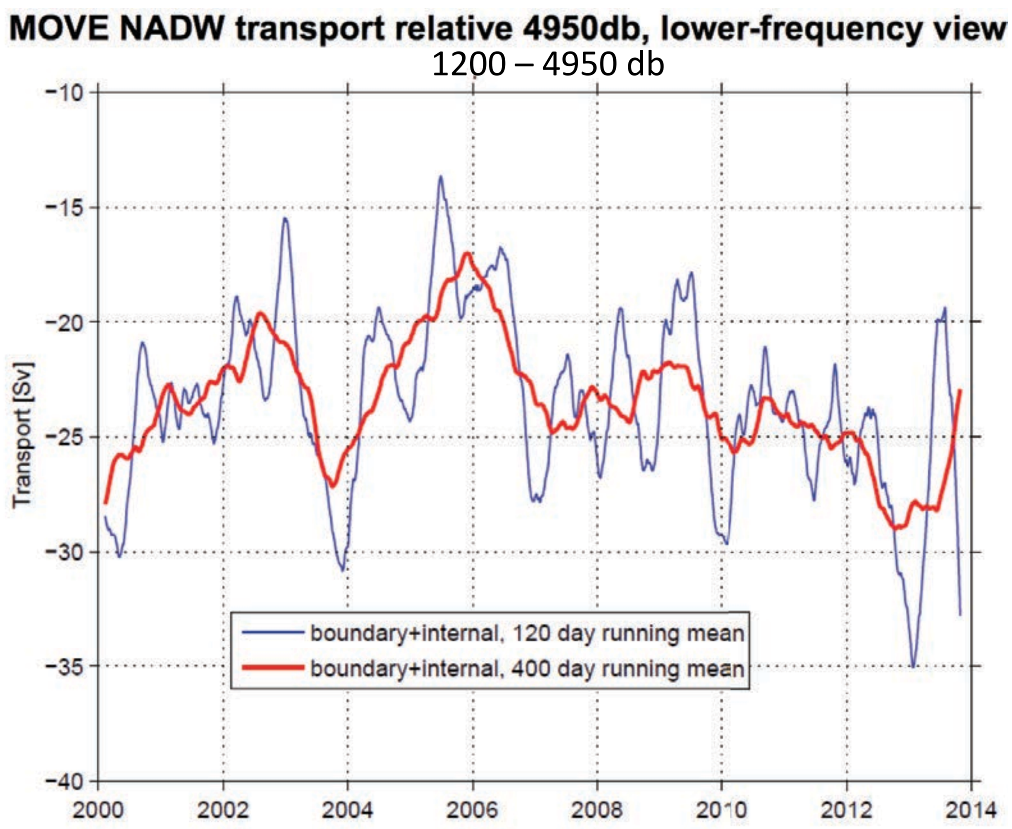
AMOC declines from 18.7 Sv (2004-2008) to 15.6 Sv (2009-2013). There is a corresponding reduction in the heat transport from 1.34 PW to 1.14 PW.

RAPID will continue at least through 2020.



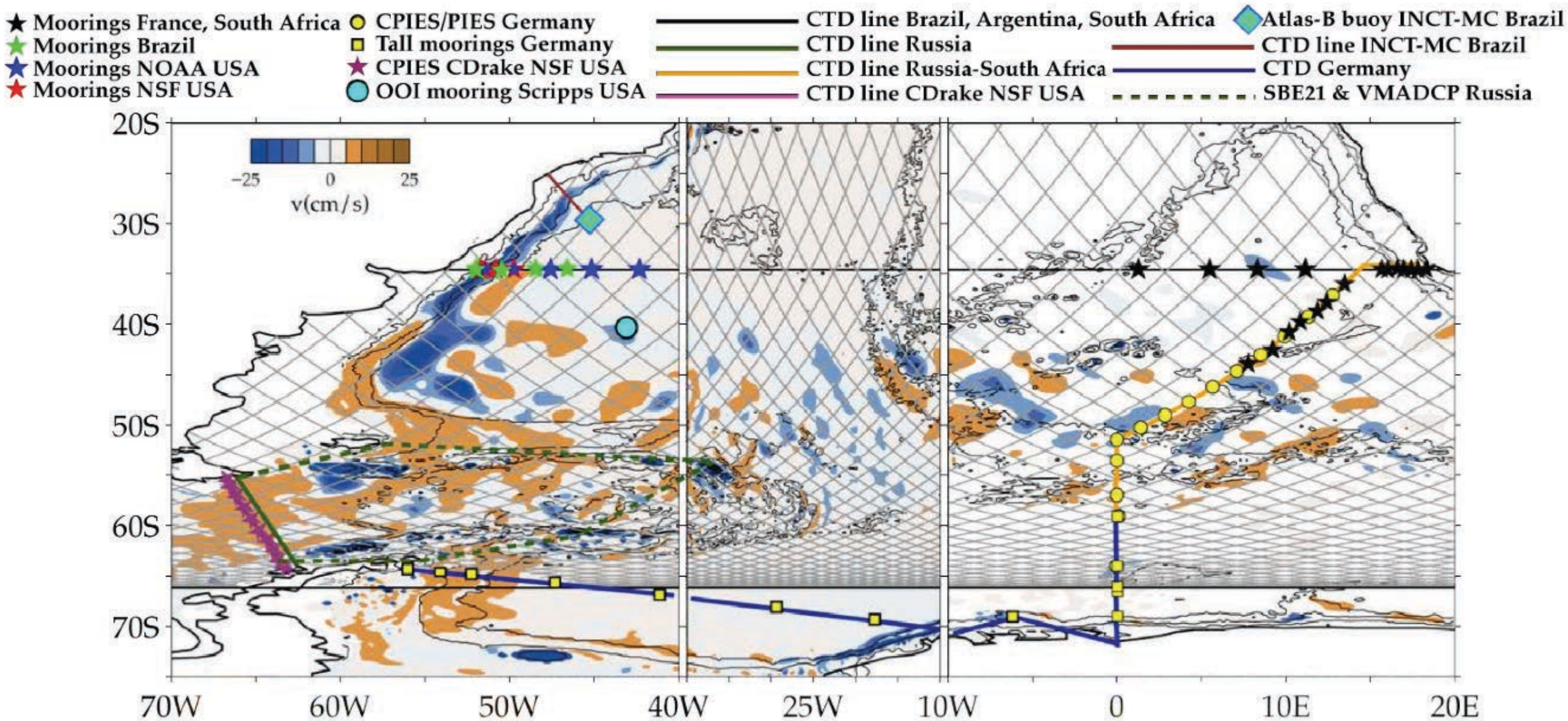
Johns et al.

MOVE: Meridional Overturning Variability Experiment (16°N)



Send et al.

SAMOC observational network "vision"



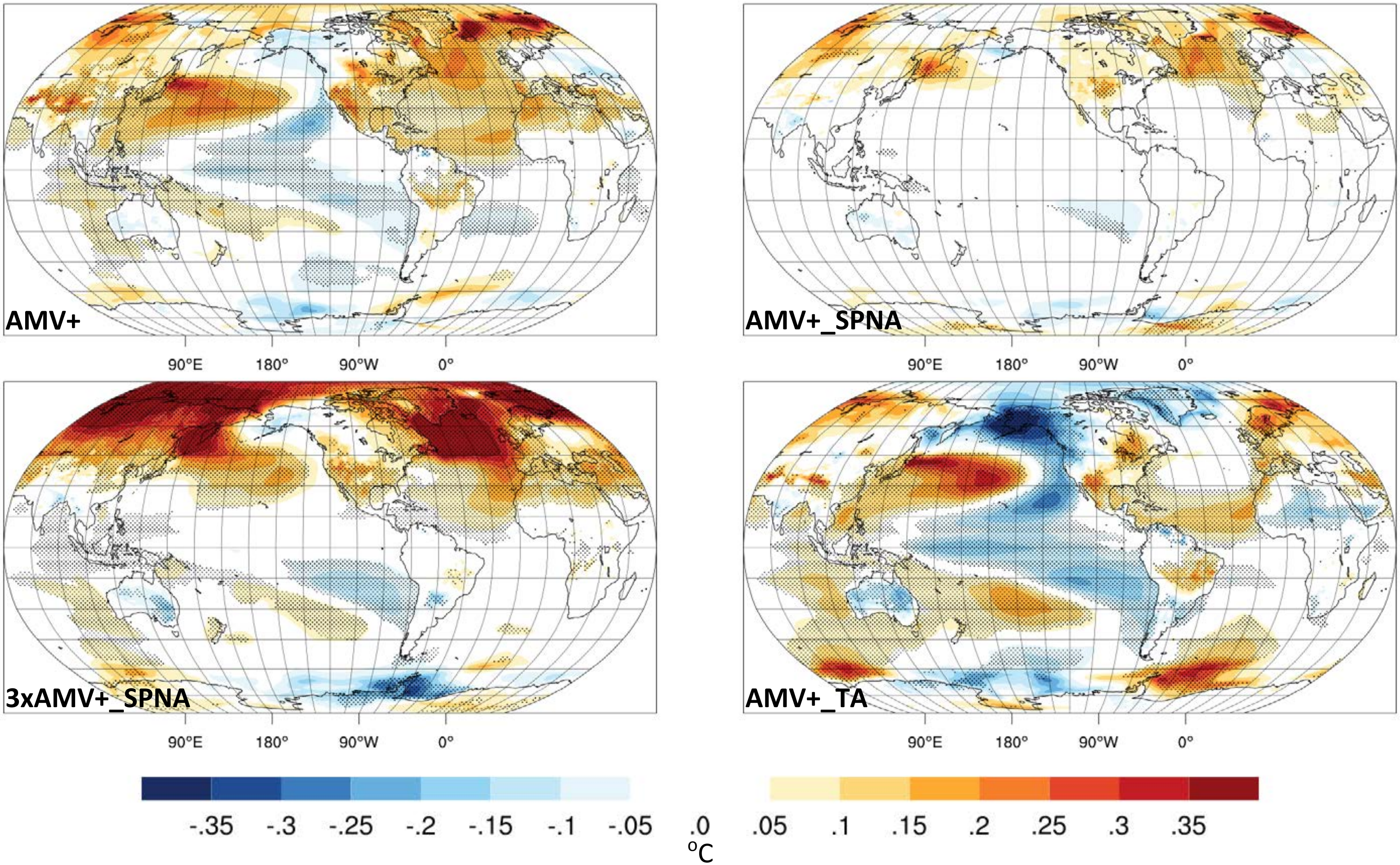
- SAMoc Basin-wide Array (**SAMBA**), **Oblique Goodhope transect**, **Drake Passage**
- Oct 2014: **Western boundary SAMBA** hydrography, PIES/CPIES telemetry cruise
- Oct 2014: **Eastern boundary SAMBA** tall mooring deployment,CPIES telemetry cruise
- Dec 2014: **Oblique Goodhope transect** PIES deployment cruise

Perez et al.

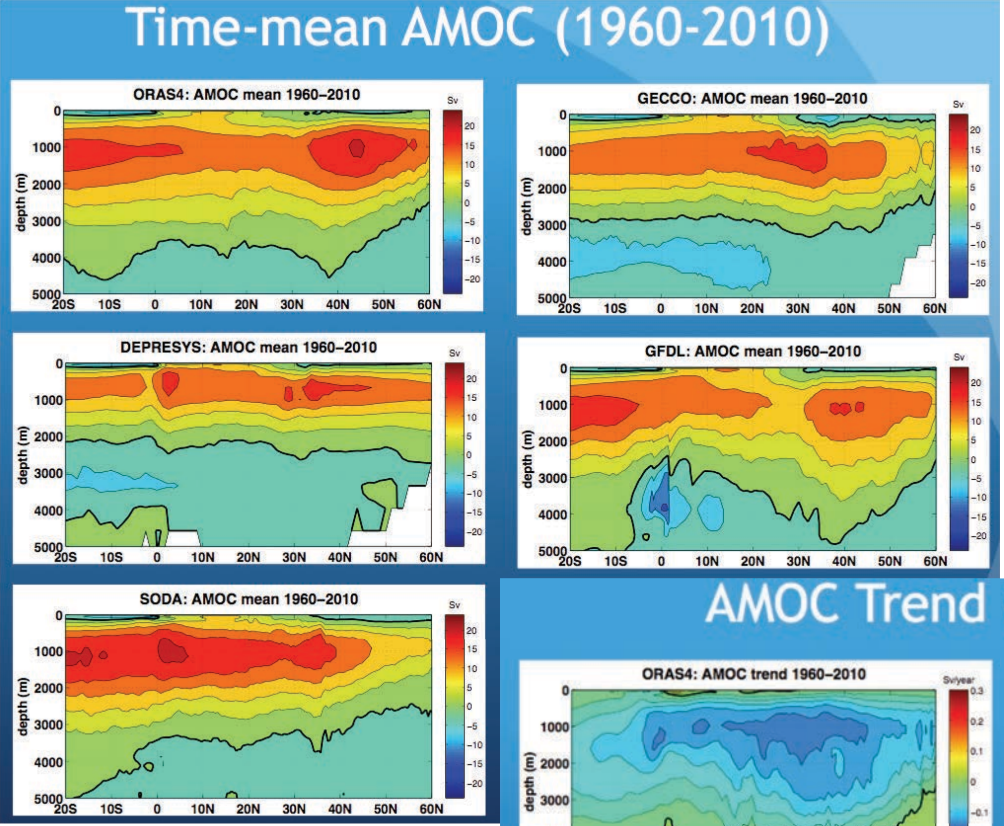
GFDL and NCAR Coordinated AMV Climate Impacts Experiments
Surface Air Temperature

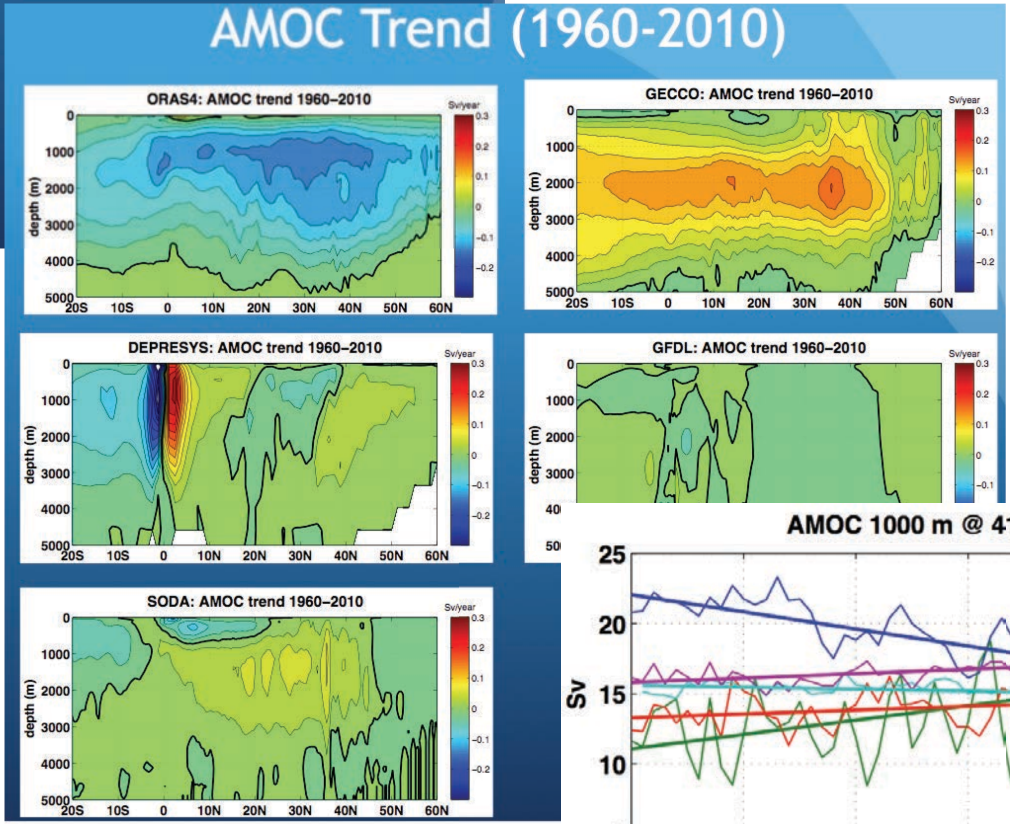
Frederic Castruccio, Yohan Ruprich-Robert, et al.

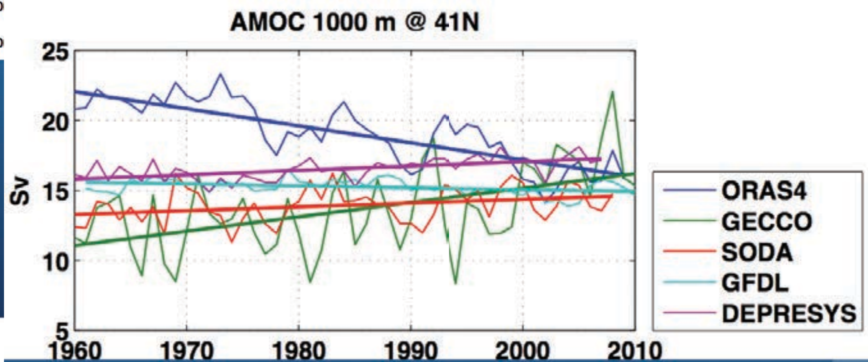
10-year climatological composite (30 members)



Representation of AMOC in Reanalysis Products







Karspeck et al.

TT1: Observing System Implementation and Evaluation

Near-term priorities

- Improving understanding of the meridional coherence of the AMOC and the mechanisms that control AMOC changes continues to be a high near-term priority. The newly deployed OSNAP array and the augmented elements of the SAMBA array will play key roles in this.

- Expansion of the existing observing system to better capture the deep ocean and to better quantify the role of deep temperature and salinity signals in contributing to AMOC variability continues to be a priority.

- Ensuring that AMOC estimates (and the key underlying measurements collected as part of the AMOC estimates) are made available in widely recognized locations such as the World Ocean Database, OceanSITES, etc.

- Making sure that error estimates are produced and provided alongside AMOC estimates (and the constituent components).

TT2: Evaluation of AMOC State, Variability, and Change

Near-term priorities

- Use new and existing observations in combination with modeling experiments to refine our understanding of the present and historical circulation (and related transports of heat and freshwater) in the North and South Atlantic. An emerging priority is to provide a more detailed characterization of AMOC flow pathways and their impact on variability.
- Continue development and investigation of AMOC "fingerprints".
- Investigate connections between surface forcing and historical AMOC variability.
- Develop a more comprehensive understanding of the strengths and weaknesses of existing global ocean reanalysis products and hindcasts.

TT3: AMOC Mechanisms and Predictability

Near-term priorities

- Investigate how surface exchanges of buoyancy and momentum between the ocean and the atmosphere/cryosphere drive the AMOC circulation across a broad range of timescales from monthly to millennial.
- Clarify the apparent disagreement between models of different complexity regarding: i) the role of Southern Ocean winds and ii) the role of Nordic Seas overflows in maintaining and modulating the AMOC.
- Quantify the magnitude, location, and physical mechanisms associated with interior diapycnal mixing which contribute to the diabatic AMOC.
- Investigate the role of freshwater forcing, and south Atlantic freshwater transports, in determining the variability and stability of AMOC.
- Expand the use of eddy-resolving models, particularly in regional/process studies.
- Quantify the predictability properties of AMOC in idealized and comprehensive models and identify mechanisms that affect these properties.

TT4: Climate Sensitivity to AMOC: Climate-Ecosystem Impacts

Near-term priorities

- Identify the mechanisms by which AMOC variability, imprinted on SST and/or the cryosphere, affects local and remote atmospheric patterns and phenomena.
- Assess AMOC impacts on the cryosphere, particularly Arctic sea ice and the Greenland ice sheet.
- Assess AMOC impacts on global and regional sea level.
- Improve understanding of how AMOC variability affects ocean-atmosphere exchanges of carbon, biogeochemical cycles, and marine ecosystems.

Long Term Priorities*

Task Team 1

Find and/or develop new technologies and methods for studying the AMOC and its key components to address the overall observing goals for AMOC in a world of finite resources.

Develop plans to observe and study the shallow and deep pathways of the AMOC through the basin at locations away from the places of the few trans-basin arrays.

Test data assimilation schemes to better understand how the systems are using the data collected, and improve communication between the US AMOC community and the data assimilation community.

Task Team 2

Synthesize modeling and observational evidence, including data assimilation, to build scientific consensus on the variability and change of the AMOC over the last 50 years.

Task Team 3

Explore the mechanisms associated with AMOC variability on centennial-to-millennial timescales, and evaluate the realism of GCMs on these timescales relative to available paleo proxy data.

Translate the knowledge developed about AMOC variability and predictability mechanisms into reliable decadal climate forecasts.

Incorporate mesoscale eddy-resolving ocean models more fully into the toolkit used for AMOC mechanisms/prediction work, including long coupled GCM simulations.

Synthesize results from theoretical, idealized models, and complex GCM investigations into a common conceptual framework regarding key AMOC variability mechanisms and identify the resulting predictability of the AMOC.

Task Team 4

Understand how AMOC variability affects other components of the Earth system – its climate, hydrologic cycle, atmospheric circulation, coupled phenomena (e.g., ENSO, monsoons), cryosphere, sea level, marine and terrestrial ecosystems, biogeochemical cycles, and carbon budgets – both locally and remotely.

* Long-term reflects program priorities and goals that will be achieved by additional resources and / or technological advancements over the next 5+ years. Developments in observational technologies that enable more observational coverage at reduced costs and in computational technologies that empower more extensive use of high-resolution models represent two examples of advancements. As such, the long-term priories do not reflect lower priority areas, but currently are limited by resources.

Tentative Science Team Meetings Schedule

(considering the move to a new 18-month meeting cycle)

Already scheduled

UK RAPID – US AMOC International Science Meeting

Towards a holistic picture of the Atlantic Meridional Overturning Circulation via observation, modelling, and synthesis

21-24 July 2015, Bristol, UK

2016: NO US AMOC Science Team Meeting ... Instead take advantage of

Connecting paleo and modern oceanographic data to understand AMOC over decades to centuries

23-25 May 2016, Boulder, CO

Hali Kilbourne (chair), A. Schmittner, D. Oppo, R. Zhang, and P. Heimbach

2017: Spring / Early Summer

US AMOC ST Meeting

2018: Summer / Early Fall

US AMOC / UK RAPID International Science Meeting

Somewhere, USA

EC Discussions Regarding Sunsetting of the US AMOC Science Team

US AMOC ST is expected to end in the next 2-3 years, e.g., within the 2017-2018 time frame.

EC Discussion topics include general plans / views for sunsetting the ST ….

- What should be an end product and how should it be developed?
- What is the target audience for this end product?
- What end products would be helpful to US CLIVAR and IAG and their interests?
- What are the expectations of the US CLIVAR and IAG regarding end products?
- How do we proceed?
- Do the EC terms stay the same to complete what is expected?

EC Discussions Regarding Sunsetting of the US AMOC Science Team

Benefits of extending the life time of the ST to, for example, match that of the UK RAPID Program (2019-2020 time frame) ….. To make sure that ST members take full advantage of new observational data from OSNAP, SAMOC, RAPID, etc. and that collaborations continue.

A report that presents accomplishments of the ST over its life time and provides guidance for future AMOC funded research. Accomplishments would be presented in the context of the the original objectives and evolving priorities, and that the document would identify remaining research needs and questions to be addressed beyond the lifetime of the ST by including identified gaps / unfinished near- and long-term priorities.

Compiling a special journal issue.

A journal article on what was achieved as a ST and what still needs to be pursued, maybe for BAMS.

A combination of the above.

Form a writing team, building upon past leaders and new contributors, to develop and coordinate planned documents / papers.

RAPID - US AMOC International Science Meeting
21-24 July 2015, Bristol, U.K.

Towards a holistic picture of the Atlantic Meridional Overturning Circulation via observation, modelling and synthesis

This meeting is the 3rd in a series of international science meetings jointly organised by the UK Natural Environment Research Council's RAPID Climate Change Programme and the US Atlantic Meridional Overturning Circulation (AMOC) Program. Its goal is a holistic understanding of the AMOC and its impacts on weather, climate and ecosystems, in the past, present and future.

Such an understanding can only be achieved by comprehensive observations (both present day and paleo), by the use of climate and earth system models, and by synthesizing observations and models.

KEY DATES

15 Jan 2015:
Abstract submission opens

15 Feb 2015:
Meeting registration opens

27 Apr 2015:
Abstract submission closes

15 May 2015:
Preliminary programme

Therefore the meeting will seek to address the following four themes:

1. Characterising the AMOC: structure, variability, mechanisms and ocean response

To characterise the AMOC structure and variability holistically requires continuous observations, supported by modelling to provide insights into the mechanism involved. To understand the AMOC's role in weather, climate and ecosystems, it is necessary to know how variations in the AMOC are related to variations in the ocean's transport and storage of heat, freshwater, carbon and nutrients. The theme will address these issues.

2. Impacts of the AMOC on the atmosphere, cryosphere, and land

Changes in the AMOC have potential impacts on many aspects of the global climate. Most recently it has been implicated in the so-called warming hiatus. Therefore, this theme seeks to examine the links between past and present changes in the AMOC and changes in the atmosphere, in the cryosphere and on land.

3. AMOC state estimation, predictability and prediction

One of the major challenges is to describe the complete, pan-Atlantic, state of the AMOC accurately, and to use this as a basis for making predictions of its future state and climate impacts on timescales of years to decades. This theme will examine progress towards determining the state of the AMOC, assessing its predictability, and delivering actual predictions of its future state and wider impacts.

4. Novel approaches to pan-Atlantic observations, modelling, analysis and synthesis

This theme seeks to explore new developments in observational techniques (e.g. autonomous platforms) and data security (e.g. data transmission), new approaches to modelling, analysing, and predicting the AMOC, new methods for synthesizing observations and models, and how these can contribute to achieving a better holistic picture of the Atlantic in the future.

SCIENTIFIC STEERING COMMITTEE

Chair: Meric Srokosz (RAPID Science Coordinator)
RAPID: Rowan Sutton, NCAS, University of Reading; David Smeed, NOC.
OSNAP: Penny Holliday, NOC;
US AMOC: Renellys Perez, UM CIMAS; Rong Zhang, NOAA GFDL; Steve Yeager, NCAR

More information on the science meeting website:

www.rapid.ac.uk/ic15

VENUE

@Bristol Science and Discovery Centre (below) lies in the heart of Bristol's historic Harbourside.