

SAMOC

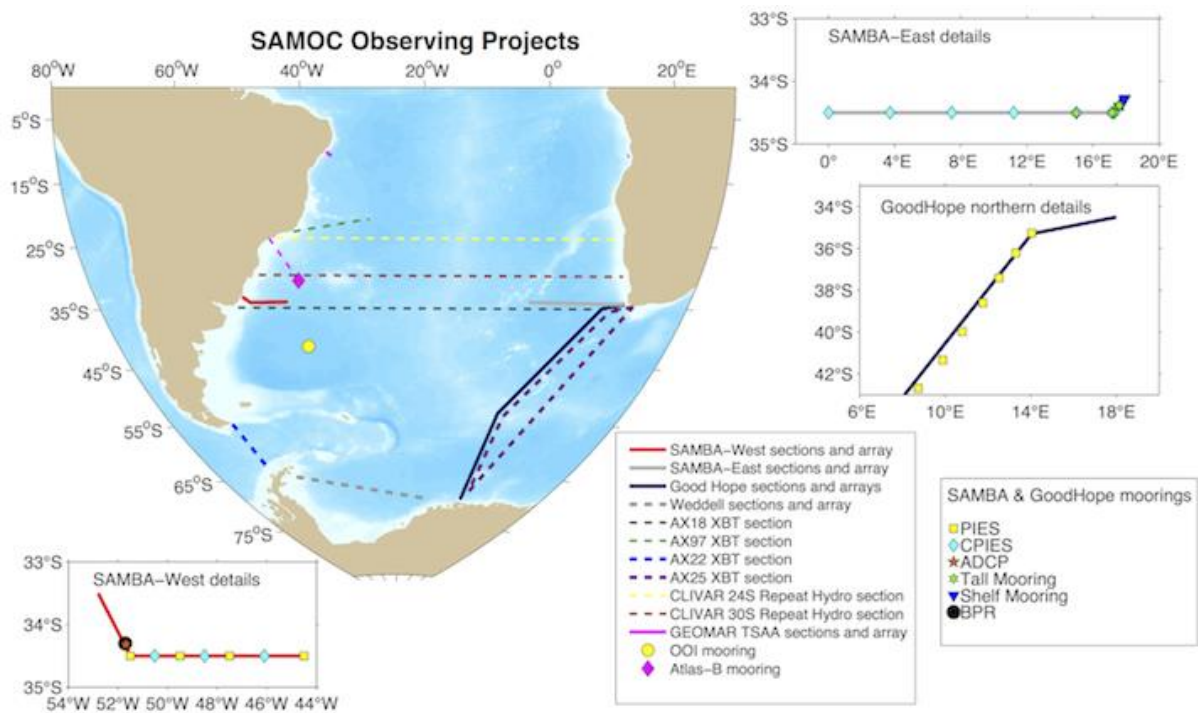
South Atlantic Meridional Overturning Circulation

SAMOC VIII Workshop Report

Workshop date: Monday, 15 July 2019, 9:00-3:30pm

Workshop venue: Palais des Congr s, Montr al, Qu bec, Canada

Report prepared by: Tarron Lamont, Chris Meinen, Renellys Perez, and Edmo Campos



Executive Summary

South Atlantic Meridional Overturning Circulation (SAMOC) Workshop VIII

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The Atlantic Meridional Overturning Circulation (AMOC) extends from the Southern Ocean to the northern part of the North Atlantic, transporting heat northwards through the South and North Atlantic Oceans. Climate studies have shown that changes in the AMOC lead to longer-term slower climatic shifts, and can also have a much shorter-term impacts on weather, through atmospheric feedback mechanisms. Recognition of the importance of the contribution and influence of the South Atlantic Ocean to this larger-scale circulation (e.g. CLIVAR, 2003), resulted in an international focus and priority to improve the global understanding of the South Atlantic Meridional Overturning Circulation (SAMOC). The first international SAMOC workshop was held in 2007 to discuss existing observations and future implementation plans for new observations. In 2012, the International CLIVAR organisation endorsed the SAMOC Initiative as an important science activity (<http://www.clivar.org/the-science/endorsed-projects/endorsed-projects>). Data collected by the AMOC observing systems in the South Atlantic have, over the past decade, resulted in significant improvements in our understanding of AMOC mean state, variability, structure, and meridional coherence, and have also informed numerical modelling studies which show striking differences between AMOC mean state and variability (Danabasoglu et al., 2014, 2016). These model discrepancies, as well as the importance of the AMOC to global climate and weather, highlight the need for sustained observations of the large-scale circulation, and call for improved numerical model and climate simulations.

On 15 July 2019, a group of 21 international scientists gathered at the Palais des Congr s in Montr al, Qu bec, Canada, for the SAMOC VIII Workshop. Prior to the workshop, most of the participants had attended the 27th International Union of Geodesy and Geophysics (IUGG) General Assembly, during which there were numerous presentations and discussions addressing recent progress on the science of SAMOC. Thus, the focus of the SAMOC VIII Workshop was on logistical progress and constraints within each of the projects contributing to the international SAMOC initiative. The discussions also included plans and opportunities for collaboration, as well as student and postdoctoral fellowship projects, and updates to the SAMOC NOAA-hosted website and the Data Sharing Policy, among other important topics.



Participants in the SAMOC VIII workshop. Photo courtesy Manuel Gutierrez-Villanueva.

Introduction

Analyses of numerical models of the climate system have found that variations in the Atlantic Meridional Overturning Circulation (AMOC) are connected with changes in precipitation patterns, extreme weather phenomenon (e.g. droughts, heat waves, hurricane intensification), and sea level changes (e.g., Broecker, 1995; Enfield et al., 2001; Vellinga and Wood, 2002; Stouffer et al., 2006; Zhang and Delworth, 2006; IPCC, 2013; McCarthy et al., 2015; Buckley and Marshall, 2016; Delworth and Zeng, 2016; Lopez et al., 2016). The international science community has been researching the structure and variability of the AMOC for several decades now (e.g. Stommel, 1958; and many papers since), but observational and modeling studies of the AMOC have experienced a quantum leap in the new millennium as the aforementioned connections to critical climate quantities like sea level came into focus. Improving understanding of AMOC was designated a key near-term science priority for several countries in the Atlantic region – and new and/or improved AMOC observation programs began being put in place in the North Atlantic in the early 2000s (e.g. Cunningham et al., 2007; Send et al., 2011).

In the South Atlantic, the development of similar observing systems has lagged somewhat behind the North Atlantic, mainly as a result of logistical and funding issues as opposed to being a question of scientific importance. The need for better AMOC observations in the South Atlantic has been widely acknowledged, however, and in 2012 the international CLIVAR organization endorsed a broad framework for AMOC observation and study in the South Atlantic (the “SAMOC initiative”). The measurement program for SAMOC is also one of the two Atlantic regional observing systems being assessed as part of the European AtlantOS effort to integrate the Atlantic observing system under WP5: Integrated Regional Observing Systems. Initial efforts for trans-basin in situ AMOC observing arrays have been initiated at 34.5°S (e.g. Meinen et al., 2013; Ansorge et al., 2014; Meinen et al., 2018) and at 11°S (e.g., Hummels et al., 2015).

A series of workshops aimed at improving scientific understanding of the SAMOC have been ongoing for several years, dating back to the first workshop in 2007 in Buenos Aires, Argentina (www.aoml.noaa.gov/phod/SAMOC/index_SAMOC1.html). Workshops have been held roughly every 18 months to provide opportunities to review the scientific advances in SAMOC research, identify significant observational gaps, and to develop plans for collaborations for joint research cruises, observing arrays, publications, and student and postdoctoral researcher opportunities. For the last few meetings, the SAMOC workshops have been held adjacent to major international science meetings to reduce travel expenses for the participants.

On 15 July 2019, a group of 21 international scientists gathered at the Palais des Congrès in Montréal, Québec, Canada, for the SAMOC VIII Workshop. Prior to the workshop, most of the participants had attended the 27th International Union of Geodesy and Geophysics (IUGG) General Assembly, during which there were numerous presentations and discussions addressing recent progress on the science of SAMOC. Thus, the focus of the SAMOC VIII Workshop was on logistical progress and constraints within each of the projects contributing to the international SAMOC initiative. The discussions also included plans and opportunities for collaboration, as well as student and postdoctoral fellowship projects, and updates to the SAMOC NOAA-hosted website and the Data Sharing Policy, among other important topics.

Summary of Presentations

The Workshop welcome, overview and goals, as well as a brief overview of the SAMOC initiative, were presented by Prof. Edmo Campos. This was followed by several presentations providing updates on the observing systems forming part of the international SAMOC initiative. Dr. Christopher Meinen presented an update on the status of the SAMBA-West array, as well as updates on the repeat CTD and XBT sections and on the satellite-Argo products, on behalf of Drs. Shenfu Dong and Claudia Schmid and Prof. Sabrina Speich. Mr. Manuel Gutierrez-Villanueva presented updates on the Drake Passage array and shipboard datasets, on behalf of Drs. Janet Sprintall and Teresa Chereskin. Dr. Lamont presented updates on the status and plans for the SAMBA-East array, and also presented updates on the 11°S array, on behalf of Dr. Rebecca Hummels. These updates are briefly described in the bulleted list below.

- Update on SAMBA-West (Dr. Christopher Meinen): The initial moorings, provided by NOAA and supported with ship's time from Argentina and Brazil, have been recovered and redeployed several times since March 2009. The same four sites, the 'Southwest Atlantic MOC' (SAM) Array, have been continuously occupied since 2009. Beginning in 2012, several additional sites have been instrumented within the array with funding from Brazil, and more deployments are planned in future. Two cruises are conducted per year: March-May on a Brazilian vessel (N. Oc. Alpha-Crucis) and September-October on an Argentine vessel (ARA Puerto Deseado). The cruises include CTD/LADCP casts from the continental shelf, along the array, out to Site D (44.5°W), as well as maintenance of the mooring array (e.g. telemetry, recovery, deployment). Additional cruises are done for special occasions, such as the January 2019 cruise (N. Oc. Alpha-Crucis) to deploy new CRIES at Sites E and F. Two new tall mooring deployments are planned along the array, with funding from the European Union, Argentina, and Brazil. A tall dynamic height mooring with additional biogeochemical sensors, current meters, and an upward-looking ADCP at 200m, is planned to be deployed near the 700m isobath. The initial deployment is planned for one year, beginning in September-October 2020, through the iAtlantic project. A tall dynamic height mooring with additional current meters (exact number and deployment depths to be determined) will be deployed near the 3500m isobath. This initial deployment is also planned for one year, beginning in September-October 2020, through the TRIATLAS project.
- Update on CTD/XBT sections and satellite-Argo products (Dr. Christopher Meinen): The high-density XBT transect (AX18) along 34.5°S has been occupied since 2002, with the overall objective of monitoring the upper limb of the South Atlantic MOC. A total of 52 transects provide MOC/MHT estimates on a quarterly basis, and the data have been used to evaluate performance of numerical models simulating the South Atlantic MOC/MHT. Dr. Shenfu Dong has shown that there is a good correspondence between MOC and MHT in these data (a one Sv increase in MOC gives a 0.04 PW increase in MHT along the AX18 transect), and that there has been no statistically significant trend in the MHT at this latitude over the observation period. The AX18 XBT data has been combined with satellite altimetry to create a proxy record that extends back to 1993 at multiple latitudes. The XBT data have also been combined with historical satellite SST records to create a proxy record that extends back to 1870. This century-long time series can be used to advance our understanding of the impact of the AMOC on global extreme weather events and future climate changes. Further estimates of the MOC and MHT (both raw and filtered time series) for several locations across

the North and South Atlantic Ocean, are also routinely being derived from interpolated/gridded daily Argo and altimetry data by Dr. Claudia Schmid. These MOC and MHT time series are available at https://www.aoml.noaa.gov/phod/samoc_argo_altimetry/index.php. Finally, the first trans-basin hydrographic survey along the entire SAMBA transect (34.5°S) has been conducted in January 2017, on board the RV Maria S. Merian (cruise MSM60). The cruise, which was conducted through the GO-SHIP program, was led by Dr. Johannes Karstensen and involved scientists from Argentina, Brazil, France, Germany, and South Africa. A report and summary of data collected during the cruise is available at https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/16717/. Prof. Sabrina Speich is currently supervising a PhD student (Gaston Manta, LMB, ENS Paris) who is examining the hydrography collected during MSM60, and is looking at the transport per water mass along the transect, as well as at differences between the eastern and western components, and the impacts of mesoscale eddies.

- Update on SAMBA-East (Dr. Tarron Lamont): The SAMBA-East time series commenced in September 2013, with the deployment of eight CRIES and two bottom-mounted ADCPs, from IFREMER, along the South African continental slope. An earlier pilot study, involving two CRIES from IFREMER, was previously deployed in this area during February 2008 through December 2010. The new 2013 was augmented, in September 2014, by deployment of four tall moorings (including upward-looking ADCPs at 500m, and several microCATs) from DEA. In addition, two bottom-mounted ADCPs were deployed by DEA, as a test case in a high trawling region, across the South African shelf in September 2014, to measure the Benguela Jet Current. One of these moorings was redeployed in September 2015 and has been serviced annually since. The two IFREMER bottom-mounted ADCPs were recovered (and not redeployed) in July 2017 and the data is currently being re-processed and examined to determine their utility for inclusion into the larger SAMOC dataset. The tall moorings were last serviced in September-October 2018, when an additional down-ward looking ADCP was added to the mooring at the 1000m isobath to better measure flow throughout the water column. Furthermore, during the September-October 2018 servicing, the tall mooring deployments reverted back to using coated steel cable, since too many problems were encountered with the use of Dynema rope during the previous deployment. The next CRIES servicing cruise is scheduled for September-October 2019. Letters of continued support were received from IFREMER for the use of the CRIES, and from NOAA and LMD ENS for the use of data collected along the SAMBA. The current cycle of South African funding for the array will cease at the end of 2020, and it is anticipated that these letters will provide some impetus for continued funding in the next application. A new collaboration (since 2019) between DEA and MIT/University of Maryland (Prof. Glenn Flierl and Dr. Sheekela Baker-Yeboah) will add a total of eleven PIES to the equipment available for the SAMBA-East array. It is anticipated that these PIES will be deployed in between the existing CRIES deployments to improve the resolution of measurements across the Agulhas leakage corridor. There is also funding being made available through Prof. Sabrina Speich (from TRIATLAS) for an additional PIES/CRIES (exact details still to be determined). It is also planned to extend the SAMBA array up onto the continental shelf, but this requires substantial amounts of new funding to obtain the required equipment and consumables. Additional shelf deployments will also require considerable amounts of lobbying with the South African pelagic and demersal trawling industries, as these moorings will be located within a high-density trawling area. Dr. Lamont has been invited to join the

AtlantOS implementation team, which seeks to redevelop and expand the former AtlantOS project into the new AtlantOS programme. This programme is currently seeking to develop demonstration/pilot projects around which to build the programme. The projects forming part of the SAMOC Initiative could potentially be a good demonstration project for the new AtlantOS programme.

- Update on 11°S array (Dr. Tarron Lamont, on behalf of Dr. Rebecca Hummels): The relevant observations at 11°S includes the moorings and bottom pressure recorders on the western and eastern boundaries (deployed within the German CLIVAR, RACE, and SACUS projects), as well as the PIRATA buoy at 10°S, 10°W. Ship-based measurements of the western and eastern boundary currents have been conducted along the transect since the 1990s through numerous programmes (Meteor/PIRATA/Brazilian Navy/EAF-Nansen), and a single full-depth trans-basin section along the array was completed in 2018. Bottom pressure recorder data is currently being de-tided and de-drifted and combined with satellite altimetry to calculate upper ocean geostrophic transport variations. The next cruise is planned for November 2019, to service four full depth moorings monitoring the North Brazil Undercurrent and Deep Western Boundary Current transports.
- Updates on Drake Passage (Mr. Manuel Gutierrez-Villanueva): Drs. Teresa Chereskin and Janet Sprintall have been maintaining XBT and underway ADCP sections across the Drake Passage since 1996. The total of 142 XBT sections collected thus far have a horizontal resolution of 5-10km and a depth range of 0-850m. The underway ADCP measurements comprise 399 transects since 1999 using a 150kHz instrument, measuring the upper 300m, and 272 transects since 2004 using a 38kHz instrument, measuring between 0-1000m. A new proposal to continue these observations will be submitted to the NSF in boreal summer 2019. Since 2002, underway and discrete measurements of pCO₂, DIC, nutrients, and other meteorological variables have also been made across the Drake Passage by Drs. David Munro, Colm Sweeney, and Nicole Lovenduski. A proposal was submitted to the NSF in boreal spring 2019 to continue these observations.
- The South Atlantic Gateway - SAGA (Prof. Pedro Vélez-Belchí): This is a newly-funded project which aims to measure the zonal flows in the mid-latitude central South Atlantic Ocean. The project aims to deploy four PIES and three tall moorings along 9°W, just east of the Mid-Atlantic Ridge. The moorings will focus on sampling deep waters (2000-4000m). The instruments are set to be deployed in April/May 2020. As part of this project, two hydrographic cruises will be undertaken. The first is a full-depth trans-basin hydrographic section (119 stations) along 34.5°S, set to take place between 15 October 2020 (sailing from Cape Town, South Africa) and 21 November 2020 (arriving in Punta Arenas, Chile). The second hydrographic cruise (119 stations) will sample two transects; first along 9°W (between 34.5-11°S), and then the western half of the 11°S transect. This cruise is set to take place between 12 January 2021 (sailing from Punta Arenas, Chile) to 21 February 2021 (arriving in Recife, Brazil).

Afternoon logistics discussions

Discussions during the workshop included issues and opportunities on existing and future proposal and cruise plans, student and Post-Doc project plans, data analysis and publication plans, as well as data sharing policies. The discussions also included updates on the SAMOC webpage, and new technology ideas for implementation as part of the monitoring arrays. The following action items were identified by the community as part of these discussions:

1. Given that Dr. Elaine McDonagh will be leaving NOC at the end of this month and moving to Norway, plans need to be put in place to try and extend the deployments of the TRIATLAS moorings for SAMBA-West beyond the current period of one year. The iAtlantic mooring is similarly funded only for one year, so further funding must be sought for it also.
2. Funding for a post-doctoral researcher to work on the new TRIATLAS SAMBA-West data, is available via Dr. Elaine McDonagh, but it needs to be determined what exactly the research will focus on.
3. The South African research grant for SAMBA-East mooring work ceases at the end of 2020, and new plans need to be made for application to continue funds. This may prove complicated because the South African National Research Foundation does not have a priority to fund long-term monitoring/research.
4. The new AtlantOS programme will be presented to the community at OceanObs19, and could possibly be used as a vehicle to obtain additional funding, with potentially more longevity, for SAMOC, by using the SAMOC Initiative as a demonstration project under the AtlantOS programme.
5. New proposals for the continuation of the Drake Passage work have been/will be submitted in boreal Spring and Summer 2019.
6. Funding for only three of the four PIES for the upcoming SAGA deployment has been secured thus far. Further discussions with the SAMOC community are required to try and secure funding for and/or the use of a 4th PIES.
7. All involved in the SAMOC Initiative are to examine the publication list on the SAMOC website and provide an updated list of publications using any SAMOC data to Dr. Renellys Perez.
8. A host site is to be investigated for housing all SAMOC data – it was suggested that the South African Marine Information Management System (MIMS) would be a good candidate. This will be further investigated over the next six months to determine the best course of action for hosting the SAMOC datasets.
9. The SAMOC mailing list needs to be updated, with addresses of new members added, and some “broken” addresses removed. Please provide updates to Dr. Christopher Meinen and/or any member of the SAMOC Executive Committee.

Acknowledgements

The organisers of the SAMOC VIII Workshop would like to thank the organising committee of the 27th IUGG General Assembly for making the meeting room available. We also wish to thank Prof. Edmo Campos for providing refreshments, as well as all international funding agencies around the world that fund the researchers studying the SAMOC.

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Appendix 1

South Atlantic Meridional Overturning Circulation (SAMOC) VIII Workshop

Montreal, Canada – 15 July 2019

Date: Monday, 15 July, 9:00am-5:00pm

Venue: Room 518C

Organizers: Edmo Campos and the rest of the SAMOC Executive Committee

Agenda

<i>9:00am-9:10am</i>	Welcome and overview of workshop goals	Edmo Campos
<i>9:10am-9:30am</i>	Brief overview of SAMOC	Edmo Campos
<i>9:30am-10:30am</i>	Updates on Observing System status	Chair: Renellys Perez
	<ul style="list-style-type: none">• SAMBA-west (Chris Meinen)• SAMBA-east (Tarron Lamont)• 11□S array (Tarron Lamont, on behalf of Rebecca Hummels)• Drake Passage (Manuel Gutierrez-Villanueva)• CTD & XBT sections, & satellite-Argo products (Chris Meinen, on behalf of Shenfu Dong & Claudia Schmid)	
<i>10:30am-11:00am</i>	Coffee break	
<i>11:00am-Noon</i>	Updates on Observing System status continued	
<i>Noon-1:30pm</i>	Lunch break	
<i>1:30pm-3:30pm</i>	Discussion of Logistics issues	Chair: Chris Meinen
	<ul style="list-style-type: none">• Future proposal plans and opportunities• Future cruise plans and opportunities• Existing and future publication plans• Student and postdoc project plans• Data analysis issues: Are there bottlenecks?• Data sharing: Policy, issues and future plans• SAMOC webpage, data serving, email list, etc.• New Technology ideas?• Memorandum of Understanding (MOU)?	
<i>3:30pm-4:00pm</i>	Coffee break	
<i>4:00pm-4:50pm</i>	Discussion of Logistics issues continued	
<i>4:50pm-5:00pm</i>	Closing	Tarron Lamont

Appendix 2

Workshop participant list

1. Edmo Campos (Oceanographic Institute of the University of São Paulo, Brazil)
2. Renellys Perez (Atlantic Oceanographic and Meteorological Laboratory, NOAA, USA)
3. Marion Kersale (Atlantic Oceanographic and Meteorological Laboratory, NOAA, USA)
4. María Casanova Masjoan (IOCAG, University of Las Palmas de Gran Canaria, Spain)
5. María Dolores Pérez-Hernández (IOCAG, University of Las Palmas de Gran Canaria, Spain)
6. Pedro Vélez-Belchí (Insituto Español de Oceanografía, Spain)
7. Alonso Hernández-Guerra (IOCAG, University of Las Palmas de Gran Canaria, Spain)
8. Gerard McCarthy (Maynooth University, Ireland)
9. Denis Volkov (CIMAS/University of Miami & Atlantic Oceanographic and Meteorological Laboratory, NOAA, USA)
10. Jim Todd (Climate Program Office, NOAA, USA)
11. Damian Arevalo-Martinez (GEOMAR/Helmholtz Center for Ocean Research Kiel, Germany)
12. Siren Ruehs (GEOMAR/Helmholtz Center for Ocean Research Kiel, Germany)
13. Alison Macdonald (Woods Hole Oceanographic Institution, USA)
14. Ana Breatriz Leite Cavalcante (Oceanographic Institute of the University of São Paulo, Brazil)
15. Chris Meinen (Atlantic Oceanographic and Meteorological Laboratory, NOAA, USA)
16. Tarron Lamont (Oceans & Coasts Research, DEA, South Africa)
17. Manuel Gutierrez Villanueva (Scripps Institution of Oceanography, USA)
18. Harry Bryden (National Oceanography Centre, United Kingdom)
19. Elaine McDonagh (National Oceanography Centre, United Kingdom)
20. Guillermina Paniagua (Centro de Investigaciones del Mar y la Atmósfera, University of Buenos Aires, Argentina)
21. Elena Tel (Insituto Español de Oceanografía, Spain)