CLIVAR REPORT

Climate and Ocean: Variability, Predictability, and Change

Project Report

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Action 1: *Approach the Nansen Program (Noel Keenlyside), PIRATA (Moacyr Araujo & Renellys Perez) and St. Helena (Paquita Zuidema) about the possibility of enhancing observations of the atmosphere and ocean in this region.*

Action 2: *Review and identify the location and availability of existing atmospheric sounding data (Paquita Zuidema)*

Action 3: *To discuss with Marcus Dengler for ocean buoys around Cape Verde (There are currently 5 moorings, two with a surface buoy that includes meteorologic parameters positioned off Mauritania and 3 subsurface moorings in the tropical Atlantic that have sediment traps attached. The PI of this project (ERC grant) is Jan-Berend Stuut (Jan-Berend.Stuut@nioz.nl) from NIOZ. There is some information about the project at www.nioz.nl/dust).*

Action 4. *Identify gaps in coupled modeling of the Southeast Atlantic climate system (Paquita Zuidema, Noel Keenlyside, and Jeff Knight)*

Action 5: *Draft the request for CLIVAR to endorse EUREC4A/ATOMIC (Chris Fairall & Sabrina Speich). The request will be circulated to ARP members for (prompt) comments before it is submitted.*

Action 6: *Explore potential additional sources of data in the Southeast Atlantic (Moacyr Araujo), including ARGO floats and the possibility of coordinated observations with Namibia.*

Action 7: *Preparation of a paper or report for a wide audience (e.g. the Bulletin of the American Meteorological Society or Eos) on these results and the potential for progress (Jeff Knight).*

Action 8: *Scope a possible workshop focused on the causes of climate model biases in the North & tropical Atlantic (Noel Keenlyside, Jeff Knight, Eric Chassignet).*

Action 9: *Organize the 2nd TAOS (Tropical Atlantic Observing System) Review Workshop, back-to-back with PIRATA-23 in Marseille, France October 22-26, 2018 (Moacyr Araujo & Sabrina Speich).*

Action 10: *Identify paleo AMOC variability and forced changes through engagement with PaleoAMOC Task Team of the US AMOC Science Team, PAGES and the PMIP project, ongoing through 2018-2021 (Ruža Ivanović)*

Action 11: *Strengthening international involvement in AMOC science. The ARP will have representation as the upcoming AMOC meeting – July 2018 in Miami (Sabrina Speich, María Paz Chidichimo, Mike Patterson and Renellys Perez)*

Action 12: *Making the case for the value of sustaining the AMOC observing system in terms of impacts (Brad De Young, Ruža Ivanović, Eric Chassignet, Sabrina Speich, and María Paz Chidichimo)*

Action 13: *Explore EBUS as a joint interest of the Atlantic and Pacific Regional Panels (Walter Robinson).*

Action 14*: ARP members are encouraged to nominate candidates to apply during open call for nominations, which will take place in second half of 2018.*

Action 15: *Update the ARP webpage to reflect current panel activities, and with a new graphics. (Jing Li, in collaboration with Sabrina and Walter).*

1. Welcome

Sabrina Speich and Walter Robinson, co-chairs of the Atlantic Region Panel (ARP) welcomed all panel members and invited guests (Appendix 2). The meeting opened with introductions, followed by brief discussion of meeting goals, intended outcomes, and how to solicit community input. Apologies were received from Bjorn Backberg, Maria Paz Chidichimo, Benoît Meyssignac, and Young-Oh Kwon, for unable to attend the meeting.

2. Topic 1: Ocean-Atmosphere interaction in the Atlantic Ocean

Paquita Zuidema provided an update on observations in the Southeast Atlantic, with a focus on aerosols produced by biomass burning, their interactions with the stratocumulus cloud deck, and their potential interactions with the underlying ocean. The Southeast Atlantic is a key region for such studies, because of the extensive and climatologically important stratocumulus cloud layer and because Africa produces 1/3 of the global inventory of aerosols from biomass burning. She described three ongoing activities

- AEROCOM comparing aerosols in observations and in 12 global models. Among these models, the aerosol radiative forcing ranges from strongly negative to positive (through cloud interactions)
- COLOCATE: the Clarify-Oracles-Lasic-aerOClo-seAls Team Experiment which is providing 4-8 radiosondes launches per day)
- AEROCLO: AErosol RadiatiOn and CLOuds in Southern Africa

Identified observational and science needs include better connections between observational and modeling activities in the ocean and the atmosphere, better constrained fluxes of heat, water, and momentum at the sea surface, more extensive and frequent radiosonde observations of the atmosphere, accounting for variability in the cloud deck, including cloud-clearing events. Opportunities that were discussed include possible radiosonde launches from St. Helena, from platforms of opportunity (container ships & oil drilling platforms), radiosonde launches (up to 4 per day) from vessels servicing the PIRATA array, and the possible use of individual requestable instrument from the U.S. Department of Energy.

The action items emerging from this discussion (responsible person/people) are:

Action 1. *Approach the Nansen Program (Noel Keenlyside), PIRATA (Moacyr Araujo & Renellys Perez) and St. Helena (Paquita Zuidema) about the possibility of enhancing observations of the atmosphere and ocean in this region.*

Action 2. *Review and identify the location and availability of existing atmospheric sounding data (Paquita Zuidema)*

Action *3. To discuss with Marcus Dengler for ocean buoys around Cape Verde (There are currently 5 moorings, two with a surface buoy that includes meteorologic parameters positioned off Mauritania and 3 subsurface moorings in the tropical Atlantic that have sediment traps attached. The PI of this project (ERC grant) is Jan-Berend Stuut (Jan-Berend.Stuut@nioz.nl) from NIOZ. There is some information about the project at www.nioz.nl/dust).*

Action *4. Identify gaps in coupled modeling of the Southeast Atlantic climate system (Paquita Zuidema, Noel Keenlyside, and Jeff Knight)*

Chris Fairall described plans for the Atlantic Tradewinds Ocean Atmosphere Mesoscale Campaign (ATOMIC). This is a project that will build on the already approved EUREC^{4}A project, which is focused on studying the dynamics and organization of trade-wind cumulus, with a field project to be conducted near Barbados, initially during the winter (January & February 2020). While EUREC^{4}A primarily addresses atmospheric processes relevant to Earth's radiation budget and climate, there are opportunities to consider broader implications, such as the initiation of deep convection, the availability and forecasting

of solar energy, and potential interactions between shallow atmospheric convection and with ocean eddies. Concerning the latter, there are in Europe a related EUREC^{4}A project focusing on the impact of ocean mesoscale eddies on the atmosphere. Indeed, this region, is characterized by a rich ocean eddy field (see Bony et al., 2017 for reference). A U.S. science team for ATOMIC is forming, with the intent of requesting NOAA observational assets to collaborate with European nations.

The action item stemming from this presentation:

Action 5: *Draft the request for CLIVAR to endorse EUREC^{4}A/ATOMIC (Chris Fairall & Sabrina Speich). The request will be circulated to ARP members for (prompt) comments before it is submitted.*

Moacyr Araujo presented results showing a strong precursor signal in Southeast Atlantic sea-surface temperatures for extreme rainfall in Northeast Brazil, a region characterized by high variability in rainfall. A challenge to developing and exploiting this source of predictability is the paucity of data in the Southeast Atlantic region.

The action item arising from this presentation:

Action 6: *Explore potential additional sources of data in the Southeast Atlantic (Moacyr Araujo), including Argo floats and the possibility of coordinated observations with Namibia.*

Jeff Knight presented results, principally arising from the UKMO operational seasonal forecasting system and follow-on modeling experiments and diagnoses demonstrating that the tropical Atlantic offers is a source of seasonal predictability for the extratropical atmosphere – for example the North Atlantic Oscillation (NAO. A specific example is the successful simulation of the extreme winter of 2013/2014 when tropical Atlantic anomalous atmospheric heating is relaxed to observations. Similar results are obtained for the extreme wet conditions in December 2015 in the United Kingdom. Moreover, across many CMIP5 models, it is found that changes, with climate change, in the tropical Atlantic Rossby wave source correspond to changes in the NAO> From atmospheric dynamical considerations, namely the concept of the Rossby wave source, it can be understood why the tropical Atlantic is strongly coupled to the Northern extratropics. Beyond greater attention to this problem in the community, enhanced ocean and lower-atmosphere observations could elucidate the connection between ocean heat content in the tropical Atlantic and moist convection in the overlying atmosphere.

The action arising from this presentation:

Action 7: *Preparation of a paper or report for a wide audience (e.g. the Bulletin of the American Meteorological Society<BAMS> or Eos) on these results and the potential for progress (Jeff Knight).*

Noel Keenlyside presented model results showing a strong influence of western boundary currents on the atmospheric circulation, with the implication that the poor representation of these features in CMIP-class models may explain strong SST biases in such models, especially in the North Atlantic, presumably leading to biases in their atmospheric circulations. The hope is that some of this bias may be reduced in models with finer ocean resolutions.

The action item emerging from this presentation:

Action 8: *scope a possible workshop focused on the causes of climate model biases in the North & tropical Atlantic (Noel Keenlyside, Jeff Knight, Eric Chassignet).*

3. Topic 2: Modelling and Prediction Studies

Moacyr Araujo reported on the PIRATA 22 meeting in Fortaleza, Brazil that celebrated the 20th anniversary of PIRATA (Prediction & Research Moored Array in the Tropical Atlantic). Foci of this well-

attended meeting included the mechanisms of tropical Atlantic variability, its connections to biogeochemistry, its predictability, and plans and prospects for the future of PIRATA.

The action item emerging from this presentation:

Action 9: Organize the 2nd TAOS (Tropical Atlantic Observing System) Review Workshop, back-to-back with PIRATA-23 in Marseille, France, *October 22-26, 2018* (Moacyr Araujo & Sabrina Speich).

Renellys Perez & ***Mike Patterson*** reported on the outcomes of the 2018 International AMOC (Atlantic Meridional Overturning Circulation) Meeting. The meeting has 3 themes: AMOC as a 4-dimensional process, proxies and fingerprints for AMOC variability, and AMOC in a changing climate. These will be featured at the Ocean Sciences Meeting immediately following ARP16. Mike described the process that will lead to the sunset of the US AMOC science team in 2020, while US support for AMOC science will continue. Among the considerations for this sunset is the need to transition the observing system from a research project to a sustained observing system. It was noted that the case for sustained observations will have to be made in terms of their value in addressing societal impacts. New foci for AMOC science include the development of an Atlantic basin wide AMOC observing system and the lack of coherence among AMOC signals from different observing arrays. An AMOC AGU journals special collection is being developed. And there is a new paleo-AMOC task team. It was agreed that the ARP can contribute to engaging with the paleo community (PAGES) and to strengthening international involvement in AMOC science beyond the US and the UK. Discussions will continue at ARP17.

The action items emerging from this presentation:

Action 10: Identify paleo AMOC variability and forced changes through engagement with PaleoAMOC Task Team of the US AMOC Science Team, PAGES and the PMIP project, ongoing through 2018-2021 (Ruža Ivanović)

Action 11: Strengthening international involvement in AMOC science. The ARP will have representation as the upcoming AMOC meeting – July 2018 in Miami (Sabrina Speich, María Paz Chidichimo, Mike Patterson and Renellys Perez)

Action 12: Making the case for the value of sustaining the AMOC observing system in terms of impacts (Brad De Young, Ruža Ivanović, Eric Chassignet, Sabrina Speich and María Paz Chidichimo)

Brad De Young described the LabSea2020 project, which primarily serves to coordinate interest and existing activities focused on the Labrador Sea. The project has a strong emphasis on carbon dioxide, because the Labrador Sea accounts for a large portion of the anthropogenic CO_2 uptake by the Atlantic. Key science questions to be addressed include the connections between Labrador Sea convection and the AMOC, the influence of a possible AMOC slowdown on CO_2 uptake, the observed decline in nutrients, and links to the biosphere. Beyond oceanography, LabSea2020 is engaged with marine meteorology, coastal communities, sea ice, and coastal terrestrial science. The designation of a Labrador Sea marine protected area is under discussion. LabSea2020 seeks "friendship" with CLIVAR (as opposed to a formal endorsement) as well as the assistance of the ARP in increasing awareness of LabSea2020.

Siqi Gruber (European Commission) addressed the European Union (EU) interest in scientific collaboration in the Atlantic basin, as manifest in the Galway Statement (May 2013) and the Belem Statement (July 2017). The former addresses collaboration among the EU, the US and Canada, whereas the latter is focused on the South Atlantic and particular attention paid to ecosystems, aquaculture, ocean literacy, seafloor mapping, and, in the case of Belem, emerging pollutants, food security, and fisheries management. Resources will be available, including some to researchers outside the EU. Calls for proposals are developed several years ahead. Upcoming calls will emphasize ocean observations, cloud computing services for ocean research, and ocean technology. There are in particular two calls for the

H2020 2018 and 2019 programs related with the Atlantic Ocean (BG08) and the G7 observing strategy (BG07).

4. Topic 3: Ocean Dynamics and gaps in observations

Ryan Rykaczewski (University of South Carolina) described programs that address the Eastern boundary Upwelling System (EBUS). These are regions of large and persistent biases in models. They are of great economic importance (e.g. for their productive fisheries) and they are sensitive to climate variability and change. Outstanding science issues include the dynamical processes that operate in these regions, their representation in numerical models, how they are coupled to large scale patterns of variability, their influence on local, regional, and global, temperatures and precipitation, and biogeochemical questions concerning the controls on local primary productivity, and its contribution to the primary productivity of basins, carbon cycling, and the processes controlling the oxygen minimum.

EBUS is a research focus (RF) of CLIVAR, and is also an interest of Integrated Marine Biosphere Research project (IMBeR) and Scientific Committee on Oceanic Research (SCOR). This year new high-resolution ocean model simulations will be carried out using the JRA-55 reanalysis by CLIVAR EBUS RF and a 2019 International Center for Theoretical Physics (ICTP) summer school on EBUS is proposed for 2019.

Paquita Zuidema pointed out the values of comparing and contrasting EBUS across ocean basins, given the differences in the overlying atmospheric conditions. She noted the apparent existence of synchronized oscillations in fishery yields across different EBUS regions, that are subject to forcing by different large-scale modes of variability. EBUS offers CLIVAR a connection to IMBeR, SCOR and PICES (The North Pacific Marine Science Organization).

The action item from these presentations:

Action 13: *Explore EBUS as a joint interest of the Atlantic and Pacific Regional Panels (Walter Robinson).*

5. Topic 4: Panel Business

Sabrina Speich briefly discussed the Tropical Atlantic Observing System (TAOS) review that is being coordinated by the ARP, its connection to other panel activities, and the need for an observing system review focused on the tropical Atlantic. This review should be achieved as a test-case for the Atlantic Observing system based on the Framework of Ocean Observing (FOO) as developed within the H2020 AtlantOS Project.

Sabrina Speich noted that OceanObs'19 is seeking submission of proposals for white papers. It was agreed to defer a decision to pursue this pending the outcome(s) of the upcoming (February 17-18, 2018) Workshop on Ocean Mesoscale Eddy Interactions with the Atmosphere.

It was noted that Moacyr Araujo and Young Oh Kwon are rotating off the ARP and that their membership cannot be further extended. Therefore, nominations must be sought for two more panel members.

Action 14*: ARP members are encouraged to nominate candidates to apply during open call for nominations, which will take place in second half of 2018.*

It was discussed that the ARP website needs to be updated to reflect current panel activities, and that new graphics should be provided.

Action 15*:Update the ARP webpage to reflect current panel activities, and with a new graphics. (Jing in collaboration with Sabrina and Walter).*

It was agreed to hold ARP17 in Vienna in relation with the EGU that will take place 7–12 April 2019 (as it is preceding the OceanObs'19 meeting).

Jing briefed the meeting with two upcoming CLVIAR events, and encouraged people to distribute the news via their own network:

- CLIVAR-FIO Summer School on “Past, present and Future Sea Level changes (25-30 June 2018, Qingdao China)
- IV International Conference on El Niño Southern Oscillation: ENSO in a warmer Climate (16-18 October 2018, Guayaquil, Ecuador)

Group photo of the 16th Session of CLIVAR Atlantic Region Panel Meeting

Appendix 1: Agenda

Time	Agenda items
09:00	**Opening: Review of the panel activities after ARP-15** ***(Sabrina and Walter)***
09:30	**Topic 1: Ocean-Atmosphere interaction in the Atlantic Ocean (Walter)**
09:30	1.1 Atmospheric fieldwork going on in the Atlantic - On-going fieldwork in the southeast Atlantic (*Paquita Zuidema)* - EUREC^{4}A (*Chris Fairall*)
09:50	1.2 Oceanic contributions to strong rainfall variability/extreme events along the southwestern tropical Atlantic *(Moacyr Araujo)*
10:10	***Break***
10:30	1.3 Impact of Tropical Atlantic biases in climate predictions/projections *(Noel Keenlyside)*
10:50	1.4 The tropical Atlantic as a global climate driver *(Jeff Knight)*
11:20	**Discussion**
12:30	***Working Lunch (to discuss the time, venue, preferred organization/format and possible topics for ARP-17)***
14:00	**Topic 2: Ocean Dynamics and gaps in observations (Sabrina)**
14:00	2.1 Key role of the Ocean Western Boundary Currents in shaping the Northern Hemisphere climate *(Noel Keenlyside)*
14:20	2.3 Eastern Upwelling Zone (Paquita Zuidema/Ryan Rykaczewski)
14:40	**Discussion**
15:30	***Break***
16:00	**Topic 3: Information from ARP related programmes**
16:00	3.1 Galway and Belem Accords and the Blue Growth (Atlantic) EC H2020 call (*Sieglinde Gruber, EC DG Research)*
16:20	3.2 Update from 2017 OOPC meeting, AtlantOS, and OceanObs'19 *(Sabrina Speich)*
16:35	3.3 PIRATA-22 *(Moacyr)*
16:50	3.4 LabSea2020 (*Brad de Young*)
17:05	2.2 AMOC Workshop (*Mike Patterson)*
17:15	**Discussion**
17:40	**Topic 4: Panel Business**
	1.TAOS review (*Sabrina*)
	2. CLIVAR Exchanges on 'Ocean Mesoscale Eddy Interaction with the Atmosphere'
	3. Membership issue
	4. Update on CLIVAR website
18:00	***Adjourn***

Appendix 2: Participants to ARP Panel Meeting

Name	Affiliation	Role	Country
Sabrina Speich	Laboratoire of Météorologie Dynamique, IPSL	Co-chair	France
Walter Robinson	North Carolina State University	Co-chair	USA
Eric Chassignet	Florida State University	Member	USA
Jeff Knight	Met Office Hadley Centre	Member	UK
Moacyr Araujo	Universidade Federal de Pernambuco	Member	Brazil
Noel Keenlyside	University of Bergen	Member	Norway
Ruza Ivanovic	University of Leeds	Member	UK
Brad De Young	Department of Physics and Physical Oceanography, Memorial University of Newfoundland	Member	Canada
Paquita Zuidema	UNIVERSITY OF MIAMI	Member	USA
Renellys Perez	NOAA-AOML	Invited speaker	USA
Chris Fairall	NOAA/EUREC4A	Invited speaker	USA
Ryan Rykaczewski	University of South Carolina	Invited speaker	USA
Mike Patterson	US CLIVAR	Invited speaker	USA
Sieglinde Gruber	EC DG Research	Invited speaker	Europe (Italy)
Jing Li	International CLIVAR Project Office (ICPO)	ICPO	China