Clivar Atlantic Regional Panel

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Panel overview

The CLIVAR Atlantic Regional Panel (ARP) is a part of the CLIVAR organization. The panel is in charge of implementing the CLIVAR science plan in the Atlantic sector. During the last 12 years, the primary function of the panel has been to promote, recommend and oversee the implementation of observational systems in the Atlantic Ocean sector and major research initiatives on Atlantic climate variability and predictability. The ARP works in close collaborations with other CLIVAR panels, regional and global programs. Important achievements have been made over the last two years in development of the Atlantic observing system, ocean and climate modeling systems and interdisciplinary multinational climate research programs. In the following we highlight some of the major scientific and implementation accomplishments made by the CLIVAR international community within the Atlantic Ocean.

Achievements for 2016-17

Scientific results from activities

Atlantic Ocean Observations developments

North Atlantic Atlantic Meridional Overturning Circulation (AMOC) observations

The RAPID/MOCHA array (Cunningham et al., 2007; http://www.rapid.ac.uk, http://www.aoml.noaa.gov/phod/mocha/index.php) has been observing the AMOC at 26.5°N for more than ten years and has revealed much greater variability than had been expected, and in particular a decrease in the AMOC strength since the mid of the 2000s. the RAPID/MOCHA array is still in place and observing efforts are continuing and funded by UK and NOAA.

The Overturning in the Subpolar North Atlantic Program (OSNAP, http://www.o-snap.org) international initiative aims to observe the AMOC north of the RAPID/MOCHA array. It is a partnership among oceanographers from the US, UK, Germany, France, the Netherlands, Canada and China. With high-resolution mooring arrays from the Labrador coast to the Scottish shelf, OSNAP provides a continuous record of the full water column, trans-basin fluxes of heat, mass and freshwater in the subpolar North Atlantic and has been operational since 2014. The moorings are turned over every two years and there is limited real-time data so the results only appear every second year. The first results of the data collection from the first 21 months of the full OSNAP observing system will be presented at international conferences in the winter of 2017/2018 and a publication will be released. It is intended that OSNAP will continue as a long-term North Atlantic monitoring program but has begun with funding as a research program. Funding for the first phase will wind-down in 2018. Proposals for renewal of the program were submitted in late summer of 2017.

Since 2002, the French-Spanish OVIDE project (https://wwz.ifremer.fr/lpo/La-recherche/Projets-en-cours/OVIDE) contributes to the observation of both the circulation and the water mass properties along a section from Greenland to Portugal. Additional measurements are also conducted in the Irminger Sea and Iceland Sea (current meter mooring array, Argo float deployments, and surface measurements on voluntary observing ships). OVIDE occupies biennally the A25 Greenland to Portugal OVIDE section since 2002. It is a contribution to the GO‐SHIP (high frequency line) program. Last occupation was June‐July 2016 on the Spanish RV Sarmiento de Gambo (PI: F. Pérez). Next Occupation will be in June‐July 2018 (PI : H. Mercier, Planned). The data time-series is now 15 years long.

With these North Atlantic observing initiatives it will be possible to determine the AMOC connectivity between the North Atlantic Sub-Polar and Sub-Tropical Gyres.

South Atlantic AMOC related observations

With the main objective of quantifying and understanding the MOC and its associated Meridional Heat Transport (MHT), the CLIVAR-endorsed South Atlantic MOC (SAMOC) observational network has expanded dramatically over the past few years (see also http://www.aoml.noaa.gov/phod/SAMOC_international/).

Meinen et al. (2017) estimated the Deep Western Boundary Current (DWBC) variability at 34.5°S from the PIES/CPIES array near the western boundary between 2009 and 2014. The time-mean DWBC transport was -15 Sv (negative indicates southward flow) with a peak-to-peak range of -89 to +50 Sv and a large temporal standard deviation of 23 Sv.

At the northern edge of the SAMOC observing system, the trans-basin Tropical South Atlantic Array (TSAA) at 11°S was deployed by Germany in 2013 including four tall current meter moorings off Brazil, bottom pressure sensors on both sides of the basin and repeated ship-based observations. This array will allow to investigate the seasonal to interannual variability of the North Brazil Undercurrent (NBUC) and the DWBC, as well as the tropical MOC. Between 2013-1016, the observed NBUC transport was 25.6 ± 1.0 Sv and the DWBC transport was -19 ± 2.2 Sv (update from Hummels et al. 2015). The DWBC had a spectral peak around 60 days associated with deep eddies.

Since 2008, 38 South Atlantic SAMOC-related cruises have been conducted. A first GO-SHIP SAMBA cruise along 34.5°S took place in January 2017 lead by GEOMAR and partially funded by the AtlantOS H2020 project, with participants from eight countries.

PIRATA and the Tropical Atlantic Observing System

The Prediction and Research moored Array in the Tropical Atlantic (PIRATA, https://www.pmel.noaa.gov/gtmba/pirata) project has benefited from recent observing capability expansion. Once T- Flex testing period is aready completed, T-Flex implementation has begun. For 2017, the deployment of 7 T-Flex moorings is underway at: 8°E-6°S (FR cruise), 23°W-21°N, 23°W-4°N (US cruise), 35°W-0°N, 38°W-20°N, 38°W-15°N and 38°W-4°N (BR cruise). Ocean Tracking Network (OTN, acoustic receivers) have been also installed on all buoys and Xpods (turbulence) sensors have been deployed at 23°W-0°N and 10°W-0°N since 2014 for five years within an NSF funded project. One new Acoustic Doppler Current Profiler (ADCP) mooring has been deployed at 0°E-0°N in 2016 (within the European PREFACE project). Moreover, new enhancements of PIRATA observing network are planned through the Brazilian contribution (+54 T/C sensors) for three buoys located in the western Tropical Atlantic (38°W-8°N, 38°W-4°N, and 35°W-0°N) with the aim to observe barrier-layers and heat content variability induced by the spreading of Amazon river plume as well as ocean-atmosphere interaction and hurricanes tracks. The further development of the tropical and South Atlantic observing system particularly including regions off Africa connected with capacity building and development should be a main focus of the ARP work aimed to enhance observing system in regions not well covered by observations so far.

New funding has been made available from the EU AtlantOS program to enhance T/C and velocity on moorings, to deploy a new CO2 system at 8°E-6°S, and some new real-time O2 sensors on 3 sites along 23°W. The Quality Control of the PIRATA-BR cruises CTD and CO2 data was ensured and all 16 PIRATA-BR cruises (from 1998 to 2016) are now available. The implementation of the new GTMBA (Global Tropical Moored Buoys Array, www.pmel.noaa.gov/gtmba/) website has been achieved, grouping the three tropical networks (TAO, RAMA and PIRATA). GTMBA site was developed to replace the existing PMEL TAO web pages that have not been substantially updated in over 10 years. The new website will improve integration with other PMEL and NOAA websites to improve content, visualization, and user-experience.

German/GEOMAR cruises (TAMOC-RACE) have been continuously conducted (since 2013) along 11°S in order to investigate the mean meridional transports of the warm and cold water route as well as their variability. Next cruise (M145) is scheduled to early 2018 in cooperation with institutions from Brazil and Angola. In addition, from 2017 on PIRATA-BR cruises will repeat 11°S and 5°S transects off Brazil keeping the same sites/protocol of CTD-LADCP measurements performed by GEOMAR cruises.

PIRATA will be evaluated again in 2017-2018, 20 years after its early steps, and 10 years after the international review by OOPC and CLIVAR. In spite of its enhancements and important evolution, the review of PIRATA should be considered by taking into account other observing systems, and thus with the whole Tropical Atlantic Observing System (TAOS, also considering Argo, satellite missions, drifters, etc.). PREFACE and AtlantOS deliverables will concern suggestions for a sustainable long term monitoring system in the tropical Atlantic and the organization & sustainability of PIRATA network in about the same time frame. An AtlantOS task is also dedicated to how to quantify the value of observing efforts (datasets, etc.). IndOOS (Indian Ocean Observing System) and TPOS2020 (Pacific Observing System) will also be evaluated and exchanges with these communities would be relevant and helpful. The CLIVAR Atlantic Region Panel is fully involved in such a process, that will start during the next TAV-PREFACE-PIRATA-22 meeting that will be held at Fortaleza, Brazil, early November 2017. Furthermore, an internationally developed Blueprint of Integrated Atlantic Ocean Observing Systems will be developed for the OceanObs19 conference.

Developments on the European H2020 project AtlantOS

The AtlantOS H2020 EU research and innovation project (https://www.atlantos-h2020.eu) pools the effort of 57 European and 5 non-European partners from 18 countries to collaborate on optimising and enhancing Atlantic Ocean observing. The overarching target of the AtlantOS initiative is to deliver an advanced framework for the development of an integrated Atlantic Ocean. The project has a budget of about € 21 Million for 4 years (April 2015 – June 2019) and is coordinated by GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany (Prof. Dr. Martin Visbeck).

AtlantOS has been very active this year with many actions as in PIRATA, SAMOC, and OSNAP. AtlantOS actions cover many more objectives and achievements. Information is regularly updated from the AtlantOS web page and Newsletters. AtlantOS has also very active in the organization of international meetings for specific objectives as well as it has been deeply involved in high-level international ecents as the Ocean Conference in New York early this year or the Belem Statement signature in Lisbon, last July 2017.

AtlantOS has initiated many capacity building efforts and processes to open the Atlantic Observing System integration to countries bordering the basin. In particular, it has initiated the process of developing an Atlantic Ocean Observation System BluePrint. The BluePrint will present best practice to integrate existing ocean observing activities into a more sustainable, more e cient, and more t-for- purpose Integrated Atlantic Ocean Observing System, with the ambition to be integrative, user- responsive, multi-national, multi-sectoral and purposeful. The team started its work in February 2017. By now, a draft outline is developed. The overall goal is to present the BluePrint at the OceanObs 2019.

BluePrint towards an Integrated Atlantic Ocean Observation System

The BluePrint for Ocean Observing in the Atlantic is a strategic effort undertaken by the Atlantic observing and stakeholders community aiming to provide a document that outlines the elements necessary for a more sustainable, coordinated and comprehensive ocean observing system delivering relevant ocean information for a wide range of societal benefit areas spanning ocean change, near-real-time ocean state estimation. Such an observing system should support sustainable ocean use in the North and South Atlantic. The BluePrint team developed from an open nomination process and expansion to ensure adequate disciplinary and geographic representation. The team is led by Brad deYoung (Canada) and Martin Visbeck (Germany). It includes representation from Belgium, Brazil, Canada, France, Germany, Ireland, Portugal, South Africa, the United Kingdom, the United States, South Africa and Spain. The first full the meeting of the BluePrint Team took place in New York following the Ocean Conference at the UN in June 2017 and the meeting on the New era of Blue Enlightenment in Lisbon in July 2017, the BluePrint Outline was finalized and the writing process of the BluePrint started. The Lisbon meeting was a good opportunity to enhance the links between partners from the North and South Atlantic. The Team has agreed to develop two related documents that will be written at the same time: A shorter version (~ 20 pages), covering the key points and highlighting key steps for success as well as a longer, more detailed document (~ 100 pages), pointing to successful examples and offering more background information. The BluePrint documents will be shared with the AtlantOS community in November 2017 and made available to other interested reviewers upon request. The BluePrint will benefit from active engagement from all interested parties and partners. Information on the BluePrint will be available on the web site atlanticblueprint.net

Sea-level

Sea-level updates from the global perspectives outcomes and perspectives from the CLIVAR Sea Level conference

The closure of the sea level budget after correcting for an instrumental drift in the early satellite altimetry record (TOPEX record) has been improved. The improved sea-level record shows a significant acceleration over the last decade due to an increased Greenland contribution. However, challenges remain in the sea level budget closure, such as accurately estimating ocean heat uptake in the deep ocean and under the ice as well as in reducing errors in particular at regional scale.

Recent increases in ice flow from ice sheets are due to local wind-driven oceanic circulation changes around Antarctica. These local circulation changes that may involve natural variability have global consequences for sea level.

The 3D Earth structures are now particularly needed to accurately model sea level and ice sheet feedbacks, and the recent (last millennia) ice history is vital for making accurate predictions of ice sheet evolution.

Extreme sea level events amplitude show temporal variability at interannual and multidecadal timescales driven mostly by regional sea level related to large-scale climate modes such as the North Atlantic Oscillation.

With a flexible model mesh, it is now possible to make accurate global projections on extreme sea levels (surges and tides) except for areas under tropical cyclones thread.

Sea level: Focus on the Atlantic

Recent studies suggest that North Atlantic Intra-annual variability is dominated by westward propagating eddy signals, boundary trapped waves and inter-tropical Kelvin and Rossby waves. Interannual and longer timescale variations present mainly propagating Rossby waves and large scale gyre oscillations dominated by advection.

The increased Greenland meltwater flux induces sea-level rise in the North Atlantic in the two major regions of deep-water formation, the Labrador Sea and the Nordic Seas. This increase seems to correlate with the decline of the AMOC. However, while in the Labrador Sea the warming forcing from the atmosphere and Greenland meltwater input lead to sea level rise, in the Nordic Seas these two forcings have an opposite influence on the convective mixing and basin-mean SSH (relative to the global mean). The warming leads to less sea-ice cover in the Nordic Seas, which favors stronger surface heat loss and deep mixing, lowering the SSH.

There have been significant efforts this year on understanding sea level changes along the Eastern coast of US. Glacial isostatic adjustment (and present day ice loss from ice sheets to a smaller extent) explain most of the observed trends in sea level on the eastern coast of US while the decadal variability and the large acceleration is predominantly caused by the ocean dynamic contribution. The ocean dynamic contribution is linked to both changes in the large-scale ocean circulation (associated with NAO and the AMOC) and in local wind and sea level pressure changes.

Paleoceanography in the Atlantic basin

Efforts are being made across the community to align palaeoceanography with modern oceanography, in particular with regard to the way physical circulation is considered and to extend observations of AMOC back through time (e.g. see US-CLIVAR palaeo AMOC meeting report, published in May 2017: https://indd.adobe.com/view/b6e3e493-7c88-4bb5-bf13-3e8b4a1ff01b). In this regard, there is currently no clear solution to obtaining high [temporal] resolution paleo data to constrain AMOC variability on [sub-] decadal timescales. However, high-resolution work relating to surface climate (e.g. from the coral community), in particular from the past-2k PAGES project (PAGES Open Science Meeting, May 2017), presents a possible way forward, although reconstructing AMOC variability from [incomplete] surface climate remains challenging.

One possible way forward is to link the past and present through transient modelling (e.g. the last Millennium and the new last deglaciation PMIP working groups). Increased efforts to produce a 4D reanalysis product of the last 21 ka, combining models and geological archives using innovative statistical methods, may provide a tool for assessing past AMOC variability (UK EPSRC Past Earth Network). However, such research is in its infancy and will require significant investment from palaeoclimate modellers to simulate the period (PMIP4 last deglaciation working group). Geochemical paleo-data compilation projects (e.g. PAGES OC3 and INQUA iPODS) are reaching the end of the their initial funded period, and will yield useful products for reconstructing and understanding past AMOC and carbon-cycle dynamics (including surface reservoir changes, ocean productivity, sources of atmospheric greenhouse gases). Our wider understanding of how many of these tracers operate, and thus how to interpret the data, continues to improve, especially with the increasing data produced by GEOTRACES (Goldschmidt conference, August 2017). However, without greater uptake of isotope-enabled modelling by model developers, direct comparison between physical simulations and geochemical data (and hence reanalysis) remains difficult. It is anticipated that this will limit progress in the use of palaeo-archives and palaeoclimate modelling to extend the instrumental record of AMOC.

Of relevance, but not only relating to the Atlantic, the PMIP4 [including CMIP6] experiment protocols have been or are in the process of being finalised for the last Millennium, mid-Holocene (6 ka), Last Glacial Maximum (21 ka), last deglaciation (26-0 ka), last interglacial (127 ka), mid-Pliocene (~3 Ma) and Eocene (~50 Ma): experiment designs are already published or are under review.

Ocean and Climate Modeling developments

High resolution modeling of the Atlantic

The impact of horizontal resolution on North Atlantic dynamics, especially the Gulf Stream separation and penetration, is seeing renewed interest with the upcoming SWOT mission. Among other things, Chassignet and Xu (2017) showed that the representation of Gulf Stream penetration and associated recirculating gyres shifts from unrealistic to realistic when the resolution is increased to 1/50 and when the nonlinear e ects of the submesoscale eddies intensifies the midlatitude jet and increases its penetration eastward. The eddy kinetic energy penetration into the deep ocean also drastically increases with resolution and more closely resembles the observations. Because of their computational cost, there are a only a few simulations at that resolution have been performed and only for a short time (JPL: Global 1/50 degree for 2 years, LGGE: North Atlantic 1/60 4 years, and FSU: North Atlantic 1/50 degree 20 years). Given the integration length of these simulations, it is premature to investigate climate variability at that resolution. There is however a synthesis paper in the work on the AMOC variability using high resolution models (~1/10 degree), with regional studies of key components such a the Southern Ocean, Gulf Stream, Agulhas leakage, and high latitude convection regions.

Atlantic variability and predictability

The community is reassessing the relative importance of dynamic versus thermodynamic ocean-atmosphere interaction in driving Atlantic climate variability, and on decadal timescales, the role of external versus internally generated variability is also being actively investigated. The limits and nature of climate predictability depend on these four factors. The global climatic impacts of the Atlantic interannual to decadal variability are also becoming more recognized.

Thermodynamic ocean-atmosphere interaction is able to explain the first order properties of south tropical Atlantic variability: its amplitude, pattern, timing, and red-spectral character. This type of variability appears to be dominant in current climate models, because of large climatological biases that inhibit the thermocline feedback. Nevertheless, some current climate prediction systems exhibit skill in predicting equatorial Atlantic sea surface temperature (SST) in summer. Analysis is required to see if this is because of reduced climatological biases and an improved representation of dynamical ocean-atmosphere interaction. Further observational and modeling studies are required to address this issue.

Thermodynamic ocean-atmosphere interaction can also explain the spatial structure of observed Atlantic multi-decadal variability (AMV). However, the shortness of the instrumental record makes it difficult to assess whether observed AMV is consistent with the Hasselmann stochastic null hypothesis. Reconstructed turbulent heat flux, ocean model experiments and reanalysis, and decadal prediction experiments all provide strong evidence that ocean dynamics play an important role in driving observed SST in the subpolar North Atlantic. External climate forcing – greenhouse gases, and natural and anthropogenic aerosols – were also implicated in observed AMV. As all of these factors likely play a role, it is important to have a more mechanistic understanding of the various components AMV, and to identify appropriate metrics. This will help to understand and improve climate models and to advance decadal prediction.

The tropical Atlantic is now recognized to influence the tropical Pacific interannual and decadal variability. In particular, the recent warming of the tropical Atlantic appears to have driven a strengthening of the Pacific trade winds, cooling of eastern tropical Pacific SST, and the global warming hiatus. Furthermore, a trans Atlantic-Pacific basin mode of variability could provide predictability of tropical Pacific climate on decadal timescales. Planned CMIP6 DCPP pacemaker experiments will be important to understand the role of the Atlantic on global climate.

The tropical Atlantic has exhibited pronounced long-term climate change that provides predictability on decadal timescales. The extra-tropical North Atlantic is characterised by pronounced multi-decadal variability, but a long-term weak cooling is observed in the subpolar north Atlantic. This pattern is consistent with the warming hole found in climate projections, and understanding its atmospheric impact could help constrain future projections of regional climate.

North Atlantic-European climate variability and its global drivers on seasonal to decadal timescales

Recent developments in understanding the climate variability of the North Atlantic-European region have had several foci. One area is the greater attention that is now being paid to variability in the summer season, which has led to the launch of some new coordinated projects. Over the past 3 decades, research priority has been placed on the winter season due to its greater tendency to produce impacts. This lengthy effort has borne fruit, but perhaps at the expense of the summer, in which some very important European climate impacts can occur (floods, droughts and heatwaves). Many aspects of the summer climate and its variability are rather different to the winter, and there is optimism that the increased attention will lead to better understanding in the 3-4 years over which current projects will run.

A key trend that has continued in 2017 is a drive for a greater dynamical understanding of regional climate variability and change. It is now recognised that progress in prediction below the global scale depends crucially on the understanding of dynamical interactions and their proper representation in climate models. These processes link the North Atlantic-European region with many remote regions of the globe, and there are leading-order uncertainties in seemingly basic questions, like what effect Atlantic Ocean temperatures have on the position of the jet stream. While the challenges remain large, new work has been produced which tackles the question of what the dynamical influences are. For example, there has been increased appreciation of dynamical connections with the tropics, and in particular the Tropical Atlantic, which are important for affecting the mid-latitude Atlantic and Europe. This viewpoint has helped in attributing the causes of certain seasons with extreme weather. It has also been shown that understanding the regional response of the atmosphere to changes in sea ice, such as the sharp decline seen in the last decade, is likely to be a fundamentally dynamical issue that needs to be carefully picked apart.

Another area where strides have been made is in understanding the response of variability like the winter North Atlantic Oscillation (NAO) to the solar cycle. It is now apparent that, at least on average in long-term records, the NAO’s response to the solar cycle is lagged by several years. Previous understanding of atmospheric mechanisms linking the altered solar cycle heating with the NAO have now been complemented by a recognition of the role of the North Atlantic Ocean in producing the lag. Increasingly, studies are recognising the importance of viewing the solar response as coupled, rather than solely an atmospheric response.

Many climate modelling centres are now gearing up to produce the wide range of simulations required for CMIP6. Looking forward, therefore, there will be new opportunities to study climate variability in the North Atlantic region using the latest versions of coupled climate models. As well as control (simulating of internal variability without forcing) and historical simulations, there will also be a number of process-based sensitivity experiments in some of the intercomparison sub-projects that make up CMIP6. An example is the ‘pacemaker’ experiments in the CMIP6 Decadal Climate Prediction Project which will allow variability to be studied in simulations where conditions in the North Atlantic or Pacific Oceans are constrained to vary as in observations.

Update on engaging CLIVAR with HighResMIP and PRIMAVERA

This is a joint activity between the Climate Dynamics Panel (Shoshiro Minobe) and the Atlantic Regional Panel (WR). Note that PRIMAVERA is a European Union activity. PRIMAVERA simulations will be the first contributions to an anticipated larger HighResMIP set of simulations.

- In Qingdao (22 September, 2016) a process was developed to facilitate participation of CLIVAR investigators in PRIMAVERA & HighResMIP: Short proposals were solicited from CLIVAR researchers, submitted in advance of the HighResMIP workshop at the end of October 2016
- 18 proposals were submitted
- With initial PRIMAVERA simulations are largely complete, coordination to accomplish the proposed research will be initiated by discussions at the PRIMAVERA 3rd General Assembly (GA3, Bologna, week of 20 November, 2017). A specific goal is to identify a PRIMAVERA contact/collaborator for each CLIVAR proposal. With this in mind, CLIVAR investigators will (in person or remotely) provide short presentations at GA3.

Enhancement in International Collaborations

One of the main goals of ARP was to improve the pan-Atlantic collaboration. This goes beyond collaborations between the US and Europe and indeed concrete actions have been undertaken to initiate or strengthen northern and southern hemisphere collaborations. The development of the pan-Atlantic AMOC program described above or actions under TAOS and AtlantOS are excellent example of great collaborations between scientists and funding agencies from many countries that ensures the best use of available resources. Multinational efforts like SAMOC, RAPID-MOCHA, TAOS, OSNAP or AtlantOS require a distinct international coordination and ARP strongly aims to contribute to such efforts. Within this framework, ARP will be in charge of the TAOS Review starting next year. Also, great progresses have been made at high-political level to enforce collaborations all across the Atlantic with the signature, on July 12 2017, of the Bélem Statement on Atlantic Ocean Research between EU, South Africa and Brazil (https://ec.europa.eu/research/iscp/pdf/belem_statement_2017_en.pdf).

Plans for 2018 and beyond

We propose that the sixteen meeting of ARP be held on the 10th of February 2018 in Portland, OR, in conjunction (just before) with the Ocean Sciences 2018 meeting (OS18). Room bookings for ARP-16 are in place. On February 8-9 2018, always in Portland, OR, in conjunction with OS18, ARP will organize the first TAOS Review Workshop, intended to initiate the one-year review process. Finally, at the end of OS18 and in conjunction with an OS18 session, ARP is co-organizing, with US CLIVAR, a 1.5-day workshop (on February 17-18 2018) focusing on “Ocean Mesoscale Eddy Interactions with the Atmosphere” (https://usclivar.org/meetings/ocean-mesoscale-eddy-workshop). The aim of the workshop is to create a shared understanding of how ocean-atmosphere interactions at the ocean-eddy scale should be represented in climate models to improve climate prediction and projection in both the atmosphere and the ocean.

In parallel, the ocean community is starting the organization of the OceanObs'19 Conference that will be held in Honolulu, Hawaii, September 2019 (http://www.oceanobs19.net). Sabrina Speich is one of the four OO19 Program Co-chairs and will insure strong interactions with ARP in building OO19 program and goals.

Budget and other needs for 2018

Please keep in mind that the overall budget of CLIVAR is limited and this needs to be distributed between all activities and the SSG meeting.

Annex A

Proforma for CLIVAR Panel Requests

for SSG approval for meetings

1. **Panel or Working Group:** Atlantic Region Panel (ARP)
2. **Title of meeting or workshop:** The 16th Session of CLIVAR Atlantic Region Panel
3. **Proposed venue:** Portland, Oregon, US
4. **Proposed dates:** 10 February 2018
5. **Proposed attendees, including likely number:** ARP panel members and ICPO staff, 14 participants
6. **Rationale, motivation and justification, including: relevance to CLIVAR science & WCRP Grand Challenges, and any cross-panel/research foci links and interactions involved:**

To bring the Atlantic Panel together, 16 months after our previous meeting in Qingdao to address two major current activities of the panel, a comprehensive review of the Tropical Atlantic Observing System and the *Workshop on Ocean Mesoscale Interactions with the Atmosphere*, and to plan and discuss initiatives for the coming years in the broad areas of ocean dynamics, gaps in ocean observations, and ocean-atmosphere interaction.

7. **Specific objectives and key agenda items:** please refer to annex
8. **Anticipated outcomes (deliverables):** Report of the 16th Session of the CLIVAR Atlantic Region Panel with actions items
9. **Format:** one-day round table meeting
10. **Science Organizing Committee (if relevant):** N/A
11. **Local Organizing Committee (if relevant):** N/A
12. **Proposed funding sources and anticipated funding requested from WCRP**

No funding request from **WCRP** in 2018.

Additional support is anticipated from **US CLIVAR** to support the catering and logistics and/or the travel cost of US-based members in CLIVAR ARP.

Annex:

Agenda for the 16th Session of Atlantic Region Panel Meeting (Draft)

Time: 9:00 – 18:00, 10 February 2018
Venue: TBD, Portland, US

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 *(Paquita Zuidema)*
09:50	1.2 Oceanic contributions to strong rainfall variability/extreme events along the western tropical Atlantic *(Moacyr Araujor)*
10:10	***Break***
10:30	1.3 Constraining models in the tropical Atlantic *(Jeff Knight)*
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 Boundary Currents and shelf-deep ocean interactions *(Maria Paz Chidichimo)*
14:20	2.2 Eastern Upwelling Zone (Paquita Zuidema)
14:40	**Discussion**
15:30	***Break***
16:00	**Topic 3: Information from ARP related programmes**
16:00	3.1 Atlantic-Arctic connection in the framework of Horizon2020 effort *(Young-Oh Kwon)*
16:20	3.2 Update from 2017 OOPC meeting and AtlantOS *(Sabrina Speich)*
16:40	3.3 PIRATA-22 *(TBC)*
17:00	**Discussion**
17:30	**Topic 4: Panel Business**
	1.TAOS review
	2. CLIVAR Exchanges on ‘Ocean Mesoscale Eddy Interaction with the Atmosphere’
	3. Update on CLIVAR website
18:00	***Adjourn***

Annex B

Proforma for CLIVAR Panel Requests

for SSG approval for meetings

1. **Panel or Working Group:** Atlantic Region Panel (ARP)

2. **Title of meeting or workshop:** Workshop on Ocean Mesoscale Eddy Interactions with the Atmosphere

3. **Proposed venue:** Portland, Oregon, US

4. **Proposed dates:** 17-18 February 2018 (1.5 day)

5. **Proposed attendees, including likely number:** Approximately 50 attendees.

   Attendance will be by application, with participation sought from the following communities:

- Observationalists (*in situ* and remote) who are focused on air-sea fluxes on the ocean-eddy scale.
- Modelers from the major modeling and prediction centers who develop and run IPCC-class, climate prediction, as well as eddy-permitting models.
- Investigators and early-career scientists with interest in exploring the role of air-sea coupling on the ocean mesoscale in the dynamics of climate variability and change within both media.

6. **Rationale, motivation and justification, including: relevance to CLIVAR science & WCRP Grand Challenges, and any cross-panel/research foci links and interactions involved:**

To the extent that the ocean eddy field and its variability is communicated to the atmosphere, ocean eddy-atmosphere interactions are important for the role played by the ocean in the coupled variability of the climate system. These interactions are a potentially important process, that, in its absence or poor representation may contribute to the uncertainty in climate predictions and projections. Finally, a critical question for model development and application is the extent to which it is necessary to fully resolve ocean eddies and their interactions with the atmosphere.

The workshop will meet the objective of CLIVAR as ‘to describe and understand the dynamics of the coupled ocean-atmosphere system and to identify processes responsible for climate variability, change and predictability on seasonal, interannual, decadal, and centennial time-scales, through the collection and analysis of observations and the development and application of models of the coupled climate system, in cooperation with other relevant climate-research and observing activities’.

Given the general topics of the workshop, SORP should also be involved as eddies are extremely important in the Southern Ocean, as the main source of heat transport across the Antarctic Circumpolar Current (ACC). Also, the topics will be of the interest to IORP, since the Agulhas System is full of eddies, that will also feed to the Atlantic Ocean. Moreover, it might be of the interest of EBUS as well, as there is always strong eddies in upwelling regions.

7. Specific objectives and key agenda items:

Day 1: morning – invited review/summary presentations

- Observations of air-sea fluxes on the ocean mesoscale
- Implications of ocean mesoscale air-sea interactions for ocean dynamics in observations and models
- Implications of ocean mesoscale air-sea interactions for atmospheric climate dynamics in observations and models
- Progress in modeling air-sea mesoscale coupling

Day 1: afternoon – working group meetings

Participants will be encouraged to move among WGs. Each group will have an assigned facilitator and a rapporteur (early-career scientist assisted by a student). WG notes and proposals will be recorded on a shared Google doc.

Working group 1: Observational requirements for addressing open questions about eddy-scale air-sea fluxes.

Outcomes: Shared approaches for diagnosing fluxes from observational data (*in situ* and remote), possible development of virtual field campaigns

Working group 2: Representation of eddy-scale air-sea fluxes for ocean only models.

Outcomes: Protocols for a common modeling activity applying a set of common treatments of fluxes on the mesoscale in different ocean models

Working group 3: Atmospheric weather/climate impacts of the ocean eddy field and its variability.

Outcomes: Protocols for two common sets of experiments:

1) Applying representations of the ocean eddy field to atmosphere-only models

2) Filtering versus retaining ocean eddies in eddy-permitting coupled models

Day 2: morning - plenary

Reconvene in plenary for breakout reports and synthesis discussion of research needs and recommendations.

8. Anticipated outcomes (deliverables):

Beyond plans for coordinated science activities described as working group outcomes in item 7, the organizing committee, in coordination with the working group chairs will share results with the broader community through a workshop report and articles for EOS, Bulletin of the American Meteorological Society, CLIVAR Exchanges, and/or US CLIVAR Variations.

9. Format:

A 1.5-day workshop that will address two distinct challenges. The first and final ½ days will be in plenary session comprised of invited overview summary talks covering the four topics. These will draw upon presentations in sessions during the preceding Ocean Sciences Meeting (the associated session at OSM has been approved, entitled *"A1001: Advances in understanding ocean eddies and their interactions with the atmosphere.*). In the afternoon of Day 1, working groups will convene for discussions and the preparation of deliverables. The final morning will again be a plenary session at which the working groups report to all the participants.

10. Science Organizing Committee (if relevant)

- Ping Chang, Texas A&M University
- Eric Chassignet, Florida State University
- Walt Robinson, North Carolina State University
- Sabrina Speich, Ecole Normale Supérieure

11. Local Organizing Committee (if relevant)

- Jing Li (International CLIVAR)
- Mike Patterson (US CLIVAR)
- Jill Reisdorf (UCAR)
- Kristan Uhlenbrock (US CLIVAR)

12. Proposed funding sources and anticipated funding requested from WCRP

$5K: Modest registration fee ($50 for ECS, $125 for General, and free for Organizing Committee and Invited Speakers)

$18K: Funds from US agencies (NSF, NOAA, & NASA) have been secured through US CLIVAR resulting from a successful proposal under 2017 US CLIVAR Spring Workshop Call. These funds will be used for the venue and A/V rental and supplies, as well as coffee breaks and a working lunch on the first day of the workshop. If funds remain, they will be used to support travel costs for early career scientists and students.

No funding request from WCRP in 2018.

Annex C

Proforma for CLIVAR Panel requests

for SSG approval for meetings

1. **Panel or Working Group:** Atlantic Region Panel (ARP)
2. **Title of meeting or workshop:** Tropical Atlantic Observing System (TAOS) Review Workshop
3. **Proposed venue:** Portland, Oregon, USA
4. **Proposed dates:** 8-9 February 2018 (before the 2018 Ocean Science Meeting)
5. **Proposed attendees, including likely number:** ARP panel members, invited speakers, and representatives from TAOS programmes, 50 participants
6. **Rationale, motivation and justification, including: relevance to CLIVAR science and WCRP Grand Challenges, and any cross-panel/research foci links and interactions involved**

The tropical Atlantic observing system was last reviewed in 2006 by **CLIVAR** (Climate and Ocean: Variability, predictability and Change) and **OOPC** (Ocean Observations Panel for Climate) with a primary focus on **PIRATA** (Prediction and Research Moored Array in the Tropical Atlantic). Since then, the international Tropical Atlantic Climate Experiment **(TACE)** has been completed and more recently EU program Enhancing Prediction of Tropical Atlantic Climate and its Impacts (**PREFACE**), scheduled for 2013-2017, is nearing completion. Scientific priorities and observational technologies have evolved since 2006 and in parallel the observing system has evolved. For example, Argo is now fully developed and has been operating successfully for ten years. PIRATA has also expanded to new sites and enhanced its measurement suite with new CO_2, O_2, and turbulence microstructure measurements. So it would be timely to systematically review the design of the sustained observing system in the tropical Atlantic in order to take advantage of what has been learned in the past decade, to collectively identify new opportunities to build on past accomplishments, and to explore the possibility for expanded interdisciplinary initiatives with other communities, e.g. in biogeochemistry.
The goal of the Tropical Atlantic Observing System (**TAOS**) Review should be the provision of sustained high-quality oceanographic and marine meteorological measurements to support knowledge based decision-making through improved scientific understanding, weather and climate forecasts, and environmental assessments for the benefit of society.
The proposed TAOS Review will be organised by CLIVAR **Atlantic Region Panel (ARP)** and with close cooperation with **PIRATA and the Ocean Observing Panel for Climate (OOPC).** CLIVAR ARP will take the lead and coordinate the review, evaluate scientific progress since the last review, and recommend actions to advance sustained observing efforts in the tropical Atlantic. ARP will seek OOPC's endorsement for the review, and will try to involve the International Ocean Carbon Coordination Project (**IOCCP**) and/or the Integrated Marine Biosphere Research Program (**IMBER**) and Surface Ocean -

Lower Atmosphere Study (**SOLAS**) as key partners as well. The review would complement other reviews focusing on different elements of the Atlantic observing system that will take place in the next couple of years (for example**, RAPID-AMOC** and **OSNAP**). It would benefit from parallel efforts being carried out in the Pacific Ocean, namely **TPOS2020**, and in the Indian Ocean for the Indian Ocean Observing System (**IndOOS**). Results of the review could also feed into the **AtlantOS** design strategy that is being formulated in advance of the OceanObs'19 conference.

The review will be forward learning and strategic, and focus on possible changes to the observing system in the next decade. The changes imply to look beyond PIRATA, and look forward to recently developed tropical Atlantic research programmes and projects, new observing technologies, observing system requirements from user community (e.g. weather and climate forecast), and observational products that will be delivered. The review will be comprehensive across all observing system components, and with the focus primarily on the in situ observing system. It is important to include meteorological, air-sea fluxes, aerosols, biogeochemistry and biology observations as elements in a single integrated observing system. Also, the representation of data assimilation, coupled modelling and satellite observation are critical in the TAOS Review.

The Review should be initiated with a dedicated two-day workshop to learn, discuss gaps, opportunities and requirements on the status of observations, modelling and integrations and the way forward. For this, CLIVAR ARP proposes to organize the two-day workshop with the following agenda items.

7. Specific objectives and key agenda items:

a. Operational drivers - Requirement from User Communities and donors

- OOPC (**Bernadette Sloyan**, <CSIR, Australia>, **Katy Hill** <GCOS-GOOS, WMO>, **John Wilkin** <Rutgers University>)
- NOAA (**David Legler**)
- Climate in America **(Ana Maria Duran Quesada** <ANA.DURANQUESADA@ucr.ac.cr, University of Costa Rica in San Jose>; **Paola Arias** (paola.arias@udea.edu.co) <University of Antioquia, Medellin, Argentina>)
- Tropical cyclones**: Scott Stripling** < scott.stripling@noaa.gov, US National Hurricane Center >; **Joanne Camp** (joanne.camp@metoffice.gov.uk) <Met Office, UK>
- User community in Africa: **Matthieu Rouault** (UCT, South Africa) or **Chris Reason** (UCT, South Africa)
- IOCCP (**Toste Tanhua**)
- IMBeR (**Carol Robinson**)
- SOLAS (**Veronique Garcon** or **Rick Wanninkhof**)

b. Science Drivers and technologies

- Ocean variability and changes <**Sunke Schmidtko**, GEOMAR, Germany>
- Coupled Modeling (**Jeff Knight**, MetOffice, UK & ARP)
- Physical and biogeochemical processes in the Atlantic Ocean<**Alberto Piola**, Argentina or **Peter Brand**, GEOMAR, Germany>

- Ocean Data Assimilation (**Pierre-Yves Le Traon** <FR, EU GODAE>, **Pierre Brasseur** <LEGI/LGGE/OSUG>, **Magdalena Balmaseda** <ECMWF>)
- Remote Sensing (**Dudley Chelton** & **Bertrand Chapron**)
- Satellite (**Tony Lee**)
- Argo (**Claudia Schmid**< co-PI of the US Argo Project, NOAA >, **Molly Baringer** <NOAA/AOML>, **Pierre-Yves Le Traon** <FR, EU GODAE>, **Dean Roemmich** <USA, ARGO co-chair>)
- GO-SHIP (**Bernadette Sloyan** and **Toste Tanhua**)
- New technologies (**Mat Mowlem**, NOC, UK)
- Biogeochemical measurement and instruments (**Peter Brandt**< O_2 sensors >, **Libby Jewett** <Ocean acidification, GOA-ON>, **Frederick Woriskey** < OTN >, **Toste Tanhua** <IOCCP>)

c. Review of Topical Atlantic Observing and Research Programmes

- TACE (**Wilco** & **Bill Johns**)
- PREFACE (**Noel Keenlisyde** & **Peter Brandt**)
- PIRATA (**Moacyr Araujo**, **Bernard Bourles, Mike McPhaden**<SSG>)
- RAPID-AMOC (**Ute Schuster** <Ocean Interior Carbon observations and modelling, Uni-Exeter, UK>)
- OSNAP (**Bill Johns** and **Johannes Karstensen**)
- SAMOC (**Maria-Paz Chidichimo**, ARP)
- AtlantOS (**Martin Visbeck** <PI>, **Johannes Karstensen** <Deputy PI>)

d. To identify the observational needs in 2025 and beyond

8. **Anticipated outcomes (deliverables):**

A **white paper** that could document the main findings of the tropical Atlantic observing system review will be prepared before OceanObs'19. The white paper is supposed to provide the scientific guidelines on future development of tropical Atlantic Ocean observing system, by setting priorities as well as mindful resource trade-offs.
Besides the white paper, **synthetic reports** specified for AtlantOS or other potential contributors to tropical Atlantic Ocean observing system could also be provided upon request.
Articles to highlight the major outcome of the review could be prepared for *Eos, Bulletin of the American Meteorological Society, CLIVAR Exchanges, and/or US CLIVAR Variations*, etc.

9. **Format:** two-day workshop (plenary + group discussion)

10. **Science Organizing Committee (if relevant):**

- **Bill Johns,** University of Miami, US (member of the PREFACE "External Scientific Advisory Panel", and also involved in TACE and OSNAP) **– Chair**
- **Sabrina Speich,** LMD-IPSL, Ecole Normale Supérieure, France (Co-Chair of CLIVAR ARP)
- **Jeff Knight,** Met Office, UK (member of CLIVAR ARP, atmosphere perspective)

- **Bernard Bourles,** IRD, France, (PIRATA SSG Co-chair)
- **Moacyr Araujo,** UFPE, Brazil (PIRATA SSG co-chair)
- **Katy Hill (or John Wilkin),** GCOS-GOOS, WMO, Switzerland (OOPC)
- **Martin Visbeck (or Johannes Karstensen),** (AtlantOS)
- **Pierre-Yves Le Traon,** EU GODAE, France (Operational Oceanography)
- **Dean Römmich,** Scripps Institution of Oceanography, USA (Argo)
- **Dudley Chelton (or Bertrand Chapron),** (Remote Sensing)
- **Yochanan Kushnir**, LDEO, (Atmosphere perspective)
- **Magdalena Balmaseda ?,** (Seasonal Forecast, ECMWF)
- **TBC,** NOAA-National Hurricane Center

11. **Local Organizing Committee (if relevant):** TBC

12. Proposed funding sources and anticipated funding requested from WCRP

No funding request from **WCRP** in 2018.

Additional Funding supports are anticipated from **OOPC, AtlantOS, NOAA, NASA**, etc.