

## Report to 44<sup>th</sup> Session of the WCRP Joint Scientific Committee

### Climate and Ocean: Variability, Predictability and Change (CLIVAR)

8-11 May 2023

#### 1. Highlights achieved since JSC-43

- The [CLIVAR Research Focus on Marine Heatwaves in the Global Ocean \(MHW RF\)](#) was approved by CLIVAR SSG in December 2022, with the goal to achieve a better understanding of MHWs globally, including detection, surface and subsurface characteristics, mechanisms, connection with climate change and biogeochemical extremes, in order to increase preparedness and promote efficient adaptation planning, while contributing to the training of the next generation of scientists and providing input to observational programs. The MHW RF was jointly proposed by IORP, PRP and ARP. The MHW RF was kicked off via a telecon organized on 28 February 2023, and the 1<sup>st</sup> MHW RF in-person meeting will be scheduled for 23 July 2023 at Trieste, Italy, before the ICTP/CLIVAR MHW Summer School.
- The Skill Development, Awareness, and Application ([SDA<sup>2</sup>](#)) framework for ECR capacity building was developed by IORP, and will be applied to the upcoming ICTP/CLIVAR MHW summer school. The framework is to provide training on basic knowledge and skills, opportunities for ECS to interact with senior scientists, and apply the knowledge and skills they have learned in their future research. Meanwhile, the '[Indian Ocean Youth Ambassador](#)' initiative was proposed by IORP, by bringing together the ECS networks working in the IO (e.g., IIOE-2 ECSN, WIOMSA ECSN, YESS, and etc.), to share resources and information, co-organize capacity building activities and co-author papers.
- The [Tropical Pacific Decadal Variability \(TPDV\) working group](#) has been active since it was launched in May 2021; a review paper summarizing the body of knowledge collected during the telecons and associated discussions has been submitted in March 2023 to Nature Review Earth & Environment as a major outcome of the TPDV WG.
- The [ENSO Conceptual Model Working Group](#). A review paper on 'ENSO Recharge Oscillator (RO) Conceptual Model: past achievements, future prospects' will be submitted to Reviews of Geophysics in Summer of 2023. The RO-based courses on ENSO (undergraduate/master level 1/MOOC) are being proposed. The [ICTP/CLIVAR joint ENSO summer school](#) was organized in July 2022, with the [ENSO Metrics](#) coordinated by PRP as one of the important components.
- The 2<sup>nd</sup> [CLIVAR-FIO Summer School on 'Ocean Macroturbulence and Its Role in Earth's Climate'](#) was successfully organised from 15<sup>th</sup> to 20<sup>th</sup> August 2022 in Qingdao, China and online. 19 onsite trainees and over 100 online trainees from 33 countries attended the school. The school addressed the topics of observations, dynamics, modelling of the ocean meso- and sub-mesoscale motions, and their role in the earth's climate. Activities comprised of lectures, problem-solving, discussions of recent journal articles, practical exercises as well as group work on research proposal development ([report](#)).
- The [CLIVAR AMOC Task Team](#) is scheduling a [workshop](#) to review and assess the AMOC observations, with the goal to inform the design of a future-focused AMOC observing system that can provide continuous measurements of key variables while also remaining sustainable over multiple decades. [Monthly AMOC webinar series](#) will be organized prior to the workshop. The [Atlantic Ocean Blog \(AOB\)](#) was established by ARP.
- CLIVAR continues its effort in guiding and supporting the global and regional **ocean observing system** design and implementation. Key activities include:
  - [CLIVAR/GOOS/ICTP workshop: 'From global to coastal: Cultivating new solutions and partnerships for an enhanced Ocean Observing System in a decade of accelerating change'](#) was organised in August 2022 in Trieste, Italy and online. This workshop brought members across different CLIVAR panels, observing system scientists and leaders together with invited speakers from de-

veloping rim nations to discuss priorities and cross-cutting strategies as well as explore new partnerships for the expansion of the regional ocean observing systems. The discussions were organised around three thematic topics: 1) oceanographers' connection; 2) new technologies and 3) co-design stakeholders, with key outcomes of: improved science communication between ocean observing scientists with instrument developers, end-users, policy makers and stakeholders to better understand their needs, as well as a mentee-mentor programme with web/App interface to facilitate new and productive relationships that build understanding, capacity and equity in ocean observing, ocean science and technology and ocean forecasting ([see news](#)).

- [Regional Training Workshop on Observing Coastal and Marginal Seas in the Western Indian Ocean](#) was organized by IORP on 7-9 June 2022 at Maputo, Mozambique and online, with the support of Partnership for Observation of the Global Ocean (POGO) and ReMoTURB Project (RE-cruitment in Mozambique fisheries in a highly turbulent shelf ocean ecosystem) implemented by Mozambican Oceanographic Institute (InOM, former IIP) and Nelson Mandela University. During the workshop, participants listened to the voices from WIO rim countries about their observational needs and gaps, in particular in the coastal and marginal seas; understood the best practices on fit-to-purpose and easy-to-use observation instruments and innovative platforms; found out where to find the data and how to use the data to solve societal needs, and discussed how to leverage support from national and international opportunities ([workshop report](#)).
- The [7<sup>th</sup> Argo Science Workshop](#) was endorsed by CLIVAR, and supported by GSOP members.
- CLIVAR Exchanges special issue on Tropical Atlantic Ocean Observing System (TAOS) (<http://doi.org/10.36071/clivar.82.2022>) was published in December 2022, summarizing the important findings from the [TAOS review report](#) and highlighting the societal relevance of TAOS.
- A review paper to assess the COVID impacts on IndOOS-2 is being prepared by IORP, and will be submitted to BAMS in 2023.
- WG3 (Observations) of TBI RF is compiling a list of major recommendations from the tropical Pacific (TPOS), Atlantic (TAOS), and Indian Ocean observing system (IndOOS) reviews, which will be used to determine those that are most important for TBI, identify gaps, and make recommendations for integration across individual basins.
- Active interaction with GOOS and OOPC (See section 4).
- [2023 CLIVAR workshop on the tropical Pacific and its interbasin interactions](#) was organized on 14-17 February 2023 at Monash University, Australia and online, by PRP, its two WGs and the TBI RF. The workshop provided opportunities to connect within and across the four research groups represented at this meeting, share the latest research with each other, and identify synergies for current and future collaborations. Several test runs for the TBI coordinated experiments (CoEx) have been completed, and two critical aspects of the experiment design (i.e., the SST restoring time scale and the latitudinal width of the restoring region) were discussed and a consensus was reached. The full-scale experiments will start in the second part of 2023.
- The activities of the [Climate Dynamics Panel \(CDP\)](#) cover a wide range of topics, including: weather-climate interaction across different spatio-temporal scales; ocean basin to ocean basin and tropical-extratropical teleconnections; development of predictive theories of climate dynamics, involving non-linear interactions between the dynamics and physics of the atmosphere and ocean. The [1<sup>st</sup> CDP Annual Workshop](#) themed 'External versus internal variability on decadal and longer time scales' was organized online using a series -webinar format, which lasted for 6 weeks with a 2-hour session per week from 14 September to 21 October 2022. The workshop enhanced the CLIVAR capacity building by setting up a lightning talk session and best ECS poster award especially for the Early Career Scientists (ECS). This workshop has been recognized by the CLIVAR SSG as a flagship activity of CDP. [A summer school and workshop on Atlantic Variability and Tropical Basins Interaction](#) is going to be organized by CDP and TBI RF at ICTP, Trieste, Italy and online.
- **Polar research:** SORP is closely tied to other panels/groups via its members (e.g., NORP, SCAR, SOOS, FRISP, UN Ocean Decade and etc.). The key topics covered by SORP are: 1) to constrain the role of the Southern Ocean in the planet's heat and freshwater balance Issues; 2) to constrain the Southern

Ocean's role in global carbon cycling. A CLIVAR Exchanges special issue on highlighting small and developing Antarctic Programmes is being prepared by SORP. After two years' preparation, the [SORP Task Team: Southern Ocean Freshwater release model experiments Initiative \(SOFIA\)](#) was officially launched, to reconcile the growing number of Southern Ocean model studies on meltwater impacts. The Arctic Processes in CMIP6 Bootcamp was successfully organized by NORP in October 2022, involving 84 (58%) early career researchers. The NORP-SORP joint workshop on polar fresh water: Sources, Pathways and Impacts of fresh water in northern and southern Polar oceans and seas ([SPICE UP](#)) was organized online on 19-21 September 2022. As a legacy, a meeting summary paper "[Polar Fresh Water in a Changing Global Climate: Linking Arctic and Southern Ocean Processes](#)" has been under preprint by Bulletin of the American Meteorological Society (BAMS).

- The ongoing activities of GSOP focus on two questions: 1) How does data assimilation of observations impact dynamical balance of models? 2) What metrics are most suitable for assessing data assimilating systems? The panel also contributed to the best practices on the use of observations; Deep Argo Mission; Argo trajectories: under ice
- The [FilaChange workshop](#) was organized by SWOT-AdAC and CLIVAR-OMDP, from 29 August to 2 September 2022, at 4 hubs in Paris, Providence, Qingdao, Hobart; a cloud-based model comparison was published, and dataset was established.
- CLIVAR/GEWEX Monsoons Panel (MP) has established a sub-structure of working groups (WGs) dedicated to three monsoon regions, namely the Asian-Australian (WG-AAM), African (WG-AFM) and American (WG-AMM) Monsoons. The three regional monsoons WGs are working towards enhancing understanding of the monsoons in those regions through various process studies with an emphasis on improving prediction skills in those respective areas.

## 2. Planned science initiatives and major events (next 3 to 5 years)

- A CLIVAR/CFMIP [Joint Working Group on TROPical PacIc SST warming patternS \(TROPICS\)](#) was proposed by CDP, by inviting also interested representatives from PRP. Three components will be included in this joint WG: air-sea interaction, global dynamics; cloud and radiation.
- OMDP will continue its active role in contributing to CMIP7, particularly through OMIP. Moreover, as some of the OMIP members are also coupled modelers, in the future, OMDP may start a conversation for an activity connecting more to coupled CMIPs. Meanwhile, there is a plan of OMDP to develop a new ocean forcing dataset based on ERA-5, which will replace the soon-to-be-discontinued JRA55-do forcing dataset. The use of machine learning in ocean models will be further discussed within OMDP.
- [ICTP-CLIVAR Summer School on Marine Heatwaves: Global Phenomena with Regional Impacts](#) (24-29 July 2023, Trieste, Italy and online).
- [4<sup>th</sup> Summer School on Theory, Mechanisms and Hierarchical Modeling of Climate Dynamics: Atlantic Variability and Tropical Basin Interactions at Interannual to Multi-Decadal Time Scales](#) (31 July – 11 August 2023, Trieste, Italy and online).
- [Workshop on Meeting AMOC Observation Needs in a Changing Climate](#) (18-20 July 2023, Hamburg, Germany and online) and [Pre-workshop webinar series](#).
- The bi-polar effort will be continued by a SORP-NORP joint summer school on polar freshwater, which is being tentatively scheduled for 2024.
- NORP is also planning to activate national representatives to secure support for Arctic Ocean-Sea ice state estimates.
- The SOFIA experiment protocol paper has been submitted to GMD. A link to the preprint will be posted soon. It will start the tier 2 experiment soon.
- CLIVAR will continue to organize annual summer schools, with hosts alternating between ICTP and FIO. Proposals for the 2024 summer school will be invited from the CLIVAR community in summer 2023.
- CLIVAR will plan to maintain 2 active Research Foci, to concentrate attention on scientific issues of current importance for a period of 3-5 years. Proposals for the next RF will be invited at the end of 2023.

### 3. Active or planned collaborations with other Core Projects, Lighthouse Activities etc.

- OMDP has close connections to the **ESMO project**, via long-term communication with GSOP, DAO, WGNE. OMDP is collaborating with **WGNE and DAO** on how to initialize OMIP and coupled forecast systems. OMDP members (Fox-Kemper, Danabasoglu, Marsland) have been participants in the ESMO Transition team.
- CLIVAR collaborated in the development of the Ocean Risk Hub, which is under **My Climate Risk LHA**: Jenifer Veitch (SAEON) and Roxy Koll (IITM) from CLIVAR community are involved. They will work on risks from ocean extremes for coastal communities (Indian and Atlantic oceans). Another one in the Pacific Ocean is still being developed. The Ocean Risk Hubs will bridge the science CLIVAR develops to society, and they are a cross-panel and cross CLIVAR-LHA activity.
- ICPO supported the organisation of the [WCRP 2022 Sea Level Conference](#) and the [7<sup>th</sup> SPARC General Assembly Asia Hub](#) in Qingdao, China.
- CLIVAR SSG will be organized alongside the WCRP Open Science Conference in Kigali, Rwanda, and some poster clusters are coordinated by CLIVAR members, e.g., [PC12: Changing in Sea Surface temperature patterns in the Tropics](#); [PC14: Ocean Mixing and climate](#); [PC16: Marine Heatwave in the world oceans](#), and etc.
- MP coordinates the formation and function of regional working groups and collaborates with the WCRP and WWRP substructures relevant to monsoon research regarding the organization of scientific meetings and regional working groups, as well as on relevant issues for advancing monsoon research.
- CLIVAR's interaction with CliC is coordinated via NORP and SORP.

#### 3a. Requests for the WCRP Academy to support your training activities?

- WCRP Academy may help advertise the CLIVAR capacity building activities through their network, and include the archived training materials into the WCRP training repository. The upcoming training activities of CLIVAR in 2023 can be referred to section 2. Organizers of CLIVAR capacity building activities are encouraged to coordinate with WCRP academy before and after events.
- WCRP Academy can help recommend lecturers through the WCRP expertise pool.
- One big issue the training activities are facing is funding sources. It would be great if WCRP can support such activities both in-kind or financially

### 4. Partnerships with projects outside WCRP

- **OOPC**: Online discussions between CLIVAR and OOPC representatives took place in October 2022 (during [OOPC-25](#)) and [March 2023](#), with a few specific topics identified: MHW, pan-tropical ocean observations, water-carbon-energy cycles and budgets; connection to the UN Ocean Decade endorsed programmes implemented by GOOS; and etc identified in a [mind map](#). Benjamin Rabe will participate in-person in the OOPC-26 on behalf of CLIVAR in June 2023, and other members from CLIVAR region panels and GSOP will attend online. A formal representative from CLIVAR will be identified to serve as an ex officio in OOPC.
- **PICES**: CLIVAR and PICES have had demonstrated long-time successful interdisciplinary cooperation, through participating each other's meetings, and establishing joint WGs. The CLIVAR-PICES Joint working group on Ocean Extremes and coastal impacts in the North Pacific (WG-49) has been established. [Antonietta Capotondi](#) was invited to be co-chair and ex-officio in WG-49 representing CLIVAR. There are potential linkages with CLIVAR MHW RF and upcoming ICTP-CLIVAR Summer School on MHW.
- **SOLAS**: CLIVAR and SOLAS have demonstrated collaborations through the integrated ocean carbon research, Indian Ocean research and capacity building, and etc. One of CLIVAR's experts Dr Lisan YU

serves in the newly elected SOLAS Scientific Steering Committee as a WCRP- appointed SOLAS SSC member. Dr Yu, with her expertise in marine carbon cycle, marine CO<sub>2</sub> removal, plankton ecology & physiology, will work towards increasing further collaborations between CLIVAR and SOLAS. She will also participate in-person in the SOLAS SSC meeting on behalf of CLIVAR and WCRP in May 2023.

- **UN Ocean Decade:** CLIVAR has been involved in several UN Ocean Decade Actions. It is a partner of Digital Twin of the Ocean (DITTO) Programme and helped coordinate the 1<sup>st</sup> DITTO Summit at G7 meeting G7 (4-5 May 2022, London) and virtual satellite activities organized alongside the Summit. CLIVAR is also closely connected to the three UN Ocean Decade Programmes implemented by GOOS, i.e., Ocean observing Co-Design; CoastPredict and Observing Together. SORP has contributed to the Southern Ocean Action Plan development. ICPO also supported the application and implementation of the Decade Coordination Center (DCC) and Ocean Seamless Forecasting (OSF) and Ocean Negative Carbon Emissions (ONCE) programmes implemented by China. In addition, several CLIVAR activities were endorsed by the UN Ocean Decade, e.g., the CLIVAR/GOOS Workshop, FilaChange Workshop, and etc.
- **US CLIVAR:** US CLIVAR provided great level of financial support to the CLIVAR activities, through its bi-annual open call for proposals, and also through funding of US participants at CLIVAR events. Meanwhile, topics of common interests of CLIVAR and US CLIVAR are being coordinated, e.g., the CLIVAR AMOC Task Team.

## 5. Issues and challenges:

- With the new LHAs and core projects being formulated, the internal communication within WCRP should be strengthened, in order to make sure that the whole community is aware of the activities and initiatives implemented by different components of the WCRP.
- With increasing demands from society for climate information, CLIVAR is anticipated to provide information of strong societal relevance and to have more interaction with other communities (e.g., the biogeochemical community) to better understand the ocean's role in the earth's climate system.
- The global observing system has been established (GOOS), but there is no integrated Arctic observation system, for example, no NOOS (Northern Ocean Observing System), because of the complex geopolitics of the Arctic. NORP is making efforts on this, but the process could be promoted if WCRP can support it.
- In terms of support to CLIVAR activities, since April 2023, the International CLIVAR Project Office (ICPO) is no longer hosted by the First Institute of Oceanography, the new host is the Ocean University of China; furthermore 3 of the 4 ICPO staff (including the executive director) left the ICPO at the end of March. Until the new office is fully implemented at OUC, strong support and coordination from the WCRP Secretariat is needed.
- With the restart of in-person activities, and a wish to renew connections with other groups at WCRP and elsewhere, there is a demand for travel funds for CLIVAR representatives to attend other meetings which is stretching the CLIVAR budget. If other meetings can at least provide hybrid access for observers, that helps to alleviate some of the pressure.