# ***The World Climate Research Programme (WCRP): a short update to SCOR-2022***

## *The World Climate Research Programme*

*"The World Climate Research Programme (WCRP) coordinates and facilitates international climate research to develop, share and apply the climate knowledge that contributes to societal well-being."*

WCRP leads the way in addressing frontier scientific questions related to the coupled climate system — questions that are too large and too complex to be tackled by a single nation, agency or scientific discipline. Through international science coordination and partnerships, WCRP contributes to advancing our understanding of the multi-scale dynamic interactions between natural and social systems that affect climate. WCRP engages productively through these partnerships to inform the development of policies and services and to promote science education.

Like SCOR, WCRP does not fund science directly, but provides coordination and a platform for the exchange of ideas on specific high-priority research topics related to the climate system. Funds for WCRP activities come from its co-sponsors[1] as well as voluntary contributions from various countries and agencies. Since the start of the COVID-19 pandemic, all WCRP activities have been organised virtually, including meetings of the Joint Scientific Committee (JSC), the body responsible for providing scientific guidance to the Programme.

Currently, WCRP is in the process of implementing its new research strategy (WCRP Strategic Plan 2019-2028[2]). Major elements of the Science and Implementation Plan are to strengthen support for core research, ensure engagement of the next generation of scientists and improve the diversity of WCRP leaders (across nations, regions, and disciplines), deepen our interaction with partners at national and international levels, and ensure that society has the climate knowledge that it needs for decision-making. The new WCRP structure was approved in 2021 and is currently being made fully operational.

The end result is that WCRP has reoriented itself to ensure that there is the science, knowledge and understanding needed to target frontier problems, such as disaster risk reduction, climate adaptation, mitigation, and intervention strategies, that need to be solved together with partners for which WCRP's core research continues to be essential for developing answers. The integral role of WCRP in developing knowledge of the climate system will result in an increased understanding of the Earth system, including of the complex interactions between the physical environment and society.

These efforts will culminate in the WCRP Open Science Conference (https://www.wcrp-climate.org/wcrp-osc23), 23-27 October 2023 in Kigali, Rwanda, which will bring together diverse research communities, programmes and partners to discuss the latest developments in climate science, with an emphasis on science-based information for decision making.

## *The WCRP Lighthouse Activities*

As a part of its new structure, WCRP has developed five new 'Lighthouse Activities' (LHAs) that aim to make critical near-term progress towards meeting WCRP's Vision, Mission, and four Scientific Objectives, as outlined in the WCRP Strategic Plan 2019–2028. The WCRP Lighthouse Activities

[1] World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) and the International Council for Science (ISC)

[2] https://www.wcrp-climate.org/wcrp-sp-overview

are designed to be ambitious and transdisciplinary (integrating across WCRP and collaborating with partners) so that they can rapidly advance some of the new science and technologies, and institutional frameworks, that are needed to manage climate risk and meet society's urgent need for robust and actionable climate information more effectively. WCRP's five LHAs are Digital Earths, Explaining and Predicting Earth System Change, My Climate Risk, Safe Landing Climates and WCRP Academy. The draft Science Plans of the activities were approved in 2021 and they are working on developing their first activities, aimed at building wider collaboration in the community. Though still in the early stages, there are several connections to ocean research. For example, one theme of the Safe Landing Climates' Lighthouse Activity is sea level rise, which aims to quantify an "acceptable" rate of sea level rise and its irreversibility from multiple decades to millennia and study the impact of storm surges and cyclones on coastal communities to assess the potential for adaptation. Digital Earths will push the co-development of ultra-high-resolution modelling of the Earth-system and its components, including the ocean, as well aspects of data assimilation for a comprehensive and consistent description of the state of the system at any given time. These LHAs will partner with Future Earth (Risk KAN, Ocean KAN, Coasts, Surface Ocean – Lower Atmosphere Study (SOLAS)), Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS), and others.

### *The WCRP Regional Sea-Level Change and Coastal Impacts Grand Challenge*

The Grand Challenge (GC) on Regional Sea-Level Change and Coastal Impacts is of most relevant to SCOR, though many others (e.g., decadal climate, carbon feedbacks) have a significant ocean component. The Sea Level GC represents an integrated interdisciplinary program on sea level research reaching from the global to the regional and local scales. A specific research topic on 'Climate Services for Adaptation to Sea-Level Rise' in Frontiers in Marine Science , which was coordinated by the SL GC is now available online. Two Practitioner-led Workshops to Advance Resilience to Sea Level Rise: Leading Practices and Current Challenges, was organised on 14-16 February 2022 (for Africa, Caribbean, Central America, Europe, Middle East, North America, South America) and 22-24 February 2022 (for Asia, Oceania, Pacific Islands).The WCRP Sea Level Conference 2022 was successfully organised on 12-16 July 2022 in Singapore and online, with a large representation from vulnerable Asian coastal areas, and including top world stakeholders, city planners, coastal developers and managers and other relevant stakeholders to focus on the flow of knowledge from sea-level science to strengthen climate change adaptation and disaster resilience in coastal zones.

The SL GC has sunset with this conference, and it is expected that some of the activities/topics of the SLGC will be continued by other CLIVAR panels, other WCRP core project (e.g., RIfS) and WCRP Lighthouse Activities (e.g. 'Safe Landing Climate').

### *The WCRP task teams*

Following the WCRP JSC's decision In November 2021, and further discussions with the WCRP leadership group, a limited duration task teams have been created to address three thematic: (1) Global Precipitation Experiment (GPEX), (2) Climate Intervention and (3) water-energy and carbon cycles and budgets. The GPEX tiger team was formed and charged with working out a strategy for how WCRP will address major science gaps in the field of precipitation in collaboration with the entire WCRP community as well as with other activities happening internationally. The Climate Intervention task team that also includes a SOLAS representative will come up with recommendations on how WCRP and the wider community should address/engage. The task team on water, energy and carbon cycles and budgets will work to establish a strategy as to how research into the coupled

energy, water and carbon cycles, across all time scales and across the land, atmosphere and ocean domains of the Earth system, can be best coordinated and facilitated as a cross-cutting theme across the WCRP.

***The WCRP Core Projects***

Until 2021 WCRP had four Core Projects (Research Communities), CLIVAR (Climate and Ocean Variability, Predictability and Change - www.clivar.org), CliC (Climate and Cryosphere- www.climate-cryosphere.org), GEWEX (Global Energy and Water Exchanges- www.gewex.org) and SPARC (Stratosphere-troposphere Processes And their Role in Climate - http://www.sparc-climate.org). Two new Core Projects have been established: Earth System Modelling and Observations (ESMO) and Regional Information for Society (RifS). ESMO will work on advancing predictions and projections of the Earth system on time scales from weeks to centuries via a model-observation integrating framework, as well as improving monitoring, understanding, and attribution of climate system changes and impacts. RIfS will facilitate and catalyze new targeted research related to the provision of actionable information about climate variability and change in support of adaptation and mitigation. Both CLIVAR and CliC endorse of the SCAR/SCOR Southern Ocean Observing System (SOOS). Of these Core Projects, the work of CLIVAR is of particular relevance to SCOR.

***The CLIVAR Core Project of WCRP***

CLIVAR aims to understand the dynamics, the interaction, and the predictability of the climate system with emphasis on ocean-atmosphere interactions. Many scientific activities carried out by CLIVAR panels and Research Foci groups are of strong relevance to other WCRP core projects, Lighthouse Activities, and other emerging initiatives (e.g., Global Precipitation Experiment- GPEX). CLIVAR also helps identify ocean hubs for My Climate Risk Lighthouse Activity.

In the era of post-COVID, many CLIVAR meetings have been shifted from completely online to hybrid, to address the strong desire of in-person meetings, but at the same time, also to facilitate the participation of people from the global south and/or with strict travel limitations. The first hybrid meeting organised by CLIVAR was the Regional Training Workshop on Observing the Coastal and Marginal Seas in the Western Indian Ocean (7-9 June 2022, Maputo, Mozambique). More hybrid activities are being prepared and expected to be organised in the second semester of 2022.

The panels/RFs are requested by the CLIVAR Scientific Steering Group (SSG) to devise specific plans for capacity building, by involving early career scientists (ECS) and researchers from the Global South. CLIVAR SSG also encouraged the panels/RFs to develop ideas/proposals for cross-panel interactions and share information with other panels on their successful activities for capability building. Many capacity building activities are being organised by CLIVAR, such as: 3rd Summer School on Theory, Mechanisms and Hierarchical Modelling of Climate Dynamics: Tropical Oceans, ENSO and their Teleconnections (18-29 July 2022, Trieste, Italy), CLIVAR-FIO Summer School on Ocean Macroturbulence and Its Role in Earth's Climate (15-20 August 2022, Qingdao, China), Arctic Processes in CMIP6 bootcamp (11-21 October 2022, Søminestationen, Denmark).

CLIVAR has strong connection and contribution to the UN Decade of Ocean Science for Sustainable Development (2021-2030), in particular with the Digital Twins of the Ocean (DITTO) programme; Ocean Observing Co-design programme, Ocean to Climate Seamless Forecasting System (OSF). In addition, the CLIVAR-GOOS Workshop entitled 'From global to coastal: Cultivating new solutions and partnerships for an enhanced Ocean Observing System in a decade of accelerating change' (15-17 August 2022, Trieste, Italy), was endorsed as an UN Ocean Decade Activity.

A call for New CLIVAR Research Foci is expected to be launch in the next months to start activities in the upcoming year.

## Appendix: Relevant CLIVAR activities, by Panels and RF

### Eastern Boundary Upwelling System Research Foci (EBUS RF)

The CLIVAR EBUS RF used to have close cooperation with the SCOR WG-155 on Eastern Boundary Upwelling Ecosystem (EBUE) in the past. A session titled 'PL11 Key uncertainties challenging our understanding of the responses of Eastern Boundary Upwelling Systems to climate variability and change' was organised by EBUS members in the 2022 Ocean Science Meeting. Two sessions will be organized by EBUS RF members in the EBUS Conference in Lima (S26-Climate change impacts and adaptation strategies in EBUS; S3-Natural and forced variability of the $CO_2$ fluxes in EBUS). A small pelagic fish symposium in Lisbon organized in November. An EBUS Perspective paper is being prepared and to be published in 2022, and the recommendations offered in the manuscript draft may have relevance to WCRP LHAs on My Climate Risk, Digital Earths, and Explaining and Predicting Earth System Change. Although the EBUS Rf has already sunset, past members are still involved in activities that are relevant to SCOR.

### Indian Ocean Region Panel (IORP)

IORP is devoted to promoting the sustained Indian Ocean Observing System (IndOOS). A progress report on IndOOS-2 implementation is being prepared by a working group led by IORP with the cooperation of IndOOS Resource Forum (IRF), the 2nd International Indian Ocean Expedition (IIOE-2) and IOGOOS. IORP also closely links with biogeochemical groups (SIBER and SOLAS) and try to expand science to policy and society. A pilot project on CoLaB (Coastal Lab in a Box) is under development, with the aim to promote sustainable low-cost coastal observing systems in under resourced countries. The panel is also proposing an 'Indian Ocean ECS Ambassador' initiative to enhance the connections between ECS groups working in the Indian Ocean, e.g. WIOMSA, IIOE-2 ECSN, YESS. IORP members supported the organisation of the WCRP Climate Research Forum in the Southern Asian Region. Capacity building is also a central component of IORP, e.g. the WIO Workshop with the support from POGO.

### Pacific Region Panel (PRP)

The ENSO Conceptual Model Working Group of PRP continued to synthesize existing knowledge on several fundamental properties of ENSO and their representation in conceptual models, and a review paper is being prepared. A review paper on Tropical Pacific Decadal Variability promoted by the PRP and led by Scott Power was published in *Science* in 2021 (https://doi.org/10.1126/science.aay9165). Monthly telecons were organised by the TPDV WG of PRP since May 2021, to review the current state of knowledge on oceanic and atmospheric processes forcing Pacific decadal Variability. A synthesis paper on the state of knowledge on TPDV is being prepared. Continue interactions with PICES through involvement in the development of the new PICES working group (WG-49) on "Climate Extremes and Coastal Impacts in the Pacific". 3rd Summer School on Theory, Mechanisms and Hierarchical Modelling of Climate Dynamics: Tropical Oceans, ENSO and their Teleconnections (18-29 July 2022, Trieste, Italy) was organised by PRP.

### Atlantic Region Panel (ARP)

A special issue on Tropical Atlantic Observing System (TAOS) is being coordinated by ARP. Atlantic Meridional Ocean Circulation (AMOC) is a main focus of ARP, with a CLIVAR AMOC WG established

in 2021 and several AMOC-related workshops and projects are led/coordinated by AMOC WG members. ARP works closely with the TBI RF, especially on the role of the Tropical Atlantic and the observation requirement for TBI. With the shared leadership of ARP and WCRP My Climate Risk LHA, the panel members are also interested in ocean extremes and impacts as well as the coastal resilience. In addition, the CLIVAR-FIO Summer School on Ocean Macroturbulence and Its Role in Earth's Climate (15-20 August 2022, Qingdao, China) is initiated and supported by ARP. The Atlantic Blog is being prepared by the panel.

**Global Synthesis and Observations Panel (GSOP)**

GSOP was established to:

1. Develop, promote, and seek to implement strategies for the synthesis of global ocean, atmosphere and coupled climate information. Methods will include observation-based syntheses and model-based syntheses e.g. Reanalyses.
2. Define CLIVAR's requirement for globally sustained observations and promote the use of resulting data sets in global synthesis efforts. Provide strategic advice and supporting evidence in collaboration with WMO and IOC bodies, to help sustain, evolve, and optimise the global ocean observing system based on new science and reanalysis insights.
3. Develop metrics to evaluate ocean and coupled syntheses, to promote the utility of synthesis products for climate applications, including initialisation of coupled forecasts, detection/attribution of climate change and variability, and determining the ocean'srole in the global heat, water and biogeochemical cycles.
4. Provide strategic advice and direction to CLIVAR/WCRP data management and processing activities within the Framework for Ocean Observing, related to production of climate quality global ocean synthesis products.
5. Liaise and collaborate with WCRP Councils, Panels and Working Groups in identifying the requirements for, and coordinating the development of, a sustainable Earth system monitoring and prediction system.

During the recent meetings, members have discussed the activities for the panel during 2022, concentrated along these main topics:

- The Deep Argo role in the observing system: The group discussed how to proceed with further multi-perspective studies, encompassing idealized and real observing scenarios, data assimilation and objective analysis multi-year studies. A google doc will be shared soon with tentative topics, to be populated by the group with details and relevant literature on the implementation of deep Argo and related studies.
- SynObs: SynObs is a Project under the UN Ocean Decade, led by one of our panel members (Yosuke Fujii). The main goals of SynObs are to contribute to design of an optimal, integrated, global ocean observing system; and to explore the synergy among different ocean observation platforms in the coastal and open ocean
- GSOP aims also to participate actively in the definition of two WCRP LHA ("Explaining and Predicting Earth System Change", "Digital Earths") and the new WCRP core project "Earth System Modelling and Data Capabilities"

**Tropical Basin Interactions Research Foci (TBI)**

The interactions among the tropical Pacific, Atlantic, and Indian Ocean basins are increasingly recognized as a key factor in understanding climate variability on interannual to decadal timescales. While recent years have seen progress toward understanding tropical basin interactions, much

remains to be learned. This includes a deeper understanding of the mechanisms, the preferred pathways, and the potential benefits for seasonal-to-decadal prediction. The RF TBI aims to make progress in these areas by fostering research activities and holding workshops and summer schools. Two specific outcomes are the coordination of new climate model experiments and the compilation of a paleo proxy archive.

- Workshops
  The "WCRP-CLIVAR Workshop on Climate Interactions among the Tropical Basins" was held online from February 24-26, 2021 (https://www.clivar.org/events/wcrp-clivar-workshop-climate-interactions-among-tropical-basins-online).

- Scientific results from activities
  Many RF members have participated in TBI-related research activities. The Special Issue of CLIVAR Exchanges, guest-edited by Ingo Ritcher, has been published. It contains several research papers presented at the TBI Workshop (https://www.clivar.org/documents/exchanges-80). The overview article co-authored by Ingo and Noel summarises the current status of TBI research and the way forward.

- Scientific capacity building and career support
  Ingo Richter has submitted a JSPS (Japanese equivalent of NSF) proposal with Reik Donner (PIK, Germany) and Giorgia DiCapua (PIK; Early Career Scientist) as collaborators (pending). This collaboration was initiated through the TBI Workshop. Additionally, Reik's Master's Student, Luisa Alves, is applying for the JSPS Summer Program, which would allow a two-month stay at JAMSTEC in the summer of 2022, to be hosted by Ingo (to be submitted by the end of November).

- Belén Rodríguez has submitted a proposal to the National Research Council of Spain (CSIC) to organize a meeting in Madrid in 2023 on multidecadal modulations of TBI (pending).

- Knowledge exchange
  The RF TBI is linked to other CLIVAR activities through co-memberships of the following members: Andrea (Pacific Region Panel), Ingo and Regina (Atlantic Region Panel), Noel (Climate Dynamics Panel), Malte, Mike, and Chunzai (ENSO Conceptual Model group), Roxy and Mike (Indian Ocean Region Panel), and Malte (Tropical Pacific Decadal Variability group). Furthermore, Regina is co-chairing one of the WCRP lighthouse activity (LHA) teams. Ingo has presented RF TBI activities on a number of occasions, including the Japan CLIVAR Committee Meeting, the JICore Workshop (a JAMSTEC-IPRC collaboration), and in personal communications to Rowan Sutton and Shoshiro Minobe (members of LHA EPESC). Belen Rodriguez-Fonseca has been a member of the CLIVAR-Spain panel and has presented RF TBI activities in this capacity.

**Ocean Model Development Panel (OMDP)**

The OMDP is engaged in the following activities:

1. To stimulate the development of ocean models for research in climate and related fields.
2. To encourage investigations of the effects of model formulation on the results of ocean models, making use of sensitivity studies and intercomparisons.
3. To promote interaction amongst the ocean modelling community and between this and other communities through workshops and other activities.
4. To stimulate the validation of ocean models when used in stand-alone mode and as part of a coupled ocean-atmosphere model, using oceanographic data and other methods, and to advise on the observational requirements of such studies.
5. To publicize developments in ocean models amongst the climate modelling community.
6. To collaborate with other activities in areas of overlapping responsibility.

7. To advise on ocean modelling and related issues and to report on its activities to the CLIVAR Scientific Steering Group and the CLIVAR co-chair of WGCM.

Since the last SCOR annual meeting, OMDP has organized one panel meeting and several workshops. From 29 Sep - 1 Oct 2021, the workshop on Future Directions in High-resolution Ocean Modelling was successfully held in Kiel, Germany and online when a low-resolution design of the virtual conference center formed a nice contrast to the high-resolution models discussed at the conference. Just after the workshop, the OMDP held the sixth panel meeting. One major outcome of the panel meeting is on the cooperation of the SWOT-AdAC. After some efforts, the Joint SWOT-AdAC/OMDP meeting, Filachange conference will take place in four sites (Campus Pierre et Marie Curie, Sorbonne University, Paris, France; Brown University, Providence, Rhode Island, USA; Ocean University of China, Qingdao, China; CSIRO, Hobart, Australia) and online. Another achievement of the cooperation between OMDP and SWOT-AdAC, a paper on cloud-based analysis framework proposed by the Pangeo Project that aims to tackle the transfer of data deluge and analysis challenges will be officially published soon.

**CLIVAR/CliC Northern Oceans Region Panel (NORP)**

2022 is a challenge year of NORP. By the end of this year, 10 members need to rotate off the panel. To solve this, in 2021, the panel organized several meetings to discuss the member issue. The outcome is NORP invited three scientists to serve as ex-officio members until current members start rotating off the panel. The panel focus on the gender and geographic balance when invited the ex-officio members. The 2nd Session of the CLIVAR/CliC Northern Oceans Region Panel was held on September 15 and 22, 2021. This year, NORP started the two events that the panel has planned long before but postponed due to the COVID-19: The joint NORP-SORP workshop on polar fresh water: Sources, Pathways and ImpaCts of frEsh water in northern and soUthern Polar oceans and seas (SPICE UP) will take place online on 19/20/21 Sep, 2022, and the NORP Arctic processes CMIP6 Bootcamp will be held during 11-20 on October in Søminestationen, Denmark. The bootcamp is intended for early-career scientists with research interests in climate and ocean, especially in the Arctic process study which will include scientific lectures, introduction to CMIP data, and applying the CMIP data. Co-sponsor for the Aspen Global Change Institute workshop on “Arctic Climate and Weather Extremes: Detection, Attribution, and Future Projection" 15-20 May 2022

**Climate Dynamics Panel**

The CDP organized the 5th Session of CLIVAR Climate Dynamic Panel during late May to late June, 2022. During the meeting, the panel thought that it has the responsibility to help form consensus on current disputed issues through community discussion, so the panel decided to organize annual CDP workshops in the following years. So in 2022, the first CDP annual workshop: External versus internal variability on decadal and longer time scales has been organized and will take place from 14th September to 21th October online. In 2021, CDP members organized a hybrid International workshop for mid-latitude air-sea interaction: Advancing Predictive Understanding of Regional Climate Variability and Change across Timescales in June with 100-200 participants, the workshop has been endorsed by CLIVAR. Other outcomes of CDP from the second half of 2021 to the recent include: the virtual conference sessions during the AGU fall meeting, the online workshop on “towards providing more reliable regional climate change projections” during June to July 2021 and the CFMIP 2021 Virtual Meeting in September 2021.

**CLIVAR/CliC/SCAR Southern Ocean Region Panel (SORP)**

SORP is classified as a CLIVAR “Region Panel” and CliC “Activity” as one of the “Working Groups, and Panels”, and SCAR “Expert Group” within Physical Sciences Group. SORP is to serve as a forum for the discussion and communication of scientific advances in the understanding of climate

variability and change in the Southern Ocean, and to advise CLIVAR, CliC, and SCAR on progress, achievements, new opportunities and impediments in internationally coordinated Southern Ocean research. In 2021, SORP organized the 14th panel meeting (online) on 6-7 and 13-14 October. SORP also organized the SO UN decade town hall meeting and the SO freshwater synthesis session during the 2022 Ocean Science Meting. SORP also contributed to the SOOS science plan, the UN decade of ocean science and sustainable development. Two new task teams were formed after the SORP-14, the freshwater-release model experiments which has appealed several institutes to join in and the highlighting small and developing Antarctic programs which will issue a special issue of CLIVAR Exchanges. SORP will make efforts to form networks to better serve WCRP's new Lighthouse Activities.

WCRP and CLIVAR look forward to further exploring collaborations in ocean related activities with SCOR in the future. Please contact Hindumathi Palanisamy (WCRP - hpalanisamy@wmo.int) or Jose Santos (CLIVAR - jose.santos@clivar.org) to discuss further.