Report of the 25th Session of the CLIVAR Scientific Steering Group

San Diego CA, USA, 15-16 February 2020

April 2020

WCRP Publication No.: 3/2020
CLIVAR Report No.: 202003

Table of Contents

EXECUTIVE SUMMARY

The 25th Session of the CLIVAR Scientific Steering Group was held at the Carte Hotel San Diego Downtown in San Diego CA, USA from 15th to 16th February 2020. The meeting was hosted by US CLIVAR and brought together the members of the Scientific Steering Group (SSG), the WCRP Joint Scientific Committee (JSC), representatives from US CLIVAR, invited US agency program leaders/managers, co-chairs of the Panels, Research Foci, other WCRP core projects, other partnership projects/organizations, and invited speakers to review progress, identify opportunities for enhanced collaboration, and develop strategies to achieve CLIVAR's objectives, and to prepare the input from CLIVAR to the WCRP's high-level science questions and flagships workshops. Over forty participants gathered (in San Diego or remotely) over two days of plenary, breakout presentations and discussion, and a closed business session of the SSG.

The first session was a presentation to reflect on the new WCRP Strategic Plan and its future implementation. Then, a representative of each Panel and Research Foci presented highlights of the activities implemented during 2019, plans for the next year and proposals for membership changes. Comments and suggestions to panel/RF business were given by the SSG and will be compiled and distributed to each panel/RF soon after the meeting by the International CLIVAR Project Office (ICPO).

Participants also heard about overall program direction, updated international program goals, and other agencies' interests and opportunities. Further details on the meeting are available at the SSG meeting website (http://clivar.org/events/25th-session-clivar-scientific-steering-group).

The CLIVAR Scientific Steering Group met on the last day of the meeting to discuss the outcomes, make recommendations, and decide on the next steps.

1. INTRODUCTORY SESSION

1.1. Welcome and Meeting Objectives.

The CLIVAR Scientific Steering Group (SSG) co-chair, Annalisa Bracco, welcomed all participants (see Appendix A), presented the detailed agenda (included in Appendix B), and explained the meeting objectives:

- To review CLIVAR's developments related to the WCRP strategic plan and its implementation, and the role that CLIVAR can play.
- To discuss how CLIVAR can advance climate science through large-scale, internationally coordinated projects.
- To discuss CLIVAR's contribution to UN Ocean Decade
- Review progress, steer activities within panels and within Research Foci (RF);
- Planning of meetings, workshops and summer schools;
- Budget requirements and allocation of resources; and
- Membership and other internal SSG business.

Since there are several participants who were attending their first SSG meeting, the session finished with a self-introduction of participants.

1.2. WCRP Presentation (Detlef Stammer)

Detlef gave a presentation on WCRP, beginning with a historical context, discussed the structure and achievements, and presented the WCRP Strategic Plan 2019-2028 which was developed as an outcome of the WCRP Review and included a new Vision and Mission. Detlef outlined the Roadmap for the implementation process - including upcoming workshops - as well as the Conceptual Framework. Since its inception there have been two main overarching questions for WCRP around Predictability and Human influence. WCRP remains focused on research: understanding and prediction (near-term, longer-term), WCRP is looking for high level overarching questions: human impacts on climate change and the associated manifestations including changes in oceans, monsoons, and climate extremes. In association with implementation of the new vison and mission, there will be a 2-year transition phase to the new structure, which should be built on a dynamic evolution platform.

Questions and comments from the participants:

Detlef emphasizes high level questions (pushing processes out of primary consideration) while Annalisa focuses on specific process (digging deeper to the details).

- *It's not the opposite, but two different levels. All endeavors serve for one final goal.*

Are we not reinventing the wheel looking at science questions bearing in mind WCRP Strategic Plan?

- *The WCRP Strategic Plan is very lean. We need to think a lot more about what we need to do and what we need to focus on.*

If we take all of the world's supercomputing effort together, this would be a linear combination, but the need for increasing resolution is an exponential problem.

- *It's on two levels. For example, providing regional climate information can be goals…. We need multiscale computer modeling efforts to reach this.*

What is the impact of human activities in climate? – This continues to be an overriding question. But in physical terms it's more about what we need to represent the response of climate system to human forcing, which is being investigated in the scenario experiments. What are the elements that models need to represent in order to reduce uncertainty? Should we continue with the same CMIP6 process? Links to *Future Earth*, links science to services to society as a stepwise process should be further emphasized.

- *Now more about what will the impact be, rather than if humans have an influence in climate. CLIVAR is already working with Future Earth, for example IMBeR.*

In the CLIVAR science plan there is a whole chapter on open questions, are these the kind of questions that we are looking for?

- *WCRP aims at high level goals, looking for specific items that all core activities need to talk to and mainly contribute to a large joint activity or experiment. So, there is a need to consider how CLIVAR science questions can map onto the core goals of WCRP.*

There is a need to come back to the fundamental questions, climate sensitivities for example. The role of the oceans in this, we need to look at ocean-atmosphere coupling for example.

Clouds and sensitivity, focus on improved modeling, observations (e.g. How much energy is going into system and where is it going? We don't have the observations in place to answer this).

We need to get WCRP targets into national targets. International Ocean Observation System (IOOS) regional information and society need to develop new partnerships. How do we map our global perspective with the priorities of nations? Should it be mapped into as operations or research?

We need to cultivate synergy between observational and modeling groups, and this effort should be strengthened.

2. PANEL REPORTS

2.1. CLIVAR/CliC Northern Ocean Region Panel (NORP) (Ruth Mottram by telecon)

The presentation gave an overview and aims of the panel. Six tasks teams have been set up but are likely to be revised at the next NORP meeting at the Artic Science Summit Week (ASSW)

meeting in March. Main achievements have been around papers, meetings and workshops. Future activities are focused on a new review paper on Arctic freshwater storage and fluxes, and a NORP 2021 summer school in Helgoland. The panel would like some additional financial support for this latter activity.

Questions and Comments:

What are the connections with CliC and the Atlantic Region Panel?

- *Panel is jointed supported by CliC. They need to explore more collaboration with the Atlantic Region Panel.*

The proposed Boot Camp seems to be very general; it is important to keep it Arctic focused.

- *The panel really wants to have Arctic focus and is hoping to look at the Sea-Ice Model Intercomparison Project (SIMIP), and the Ice Sheet Model Intercomparison Project (ISMIP), which are very much centered around the panel's focus.*

The panel progress is going well. Regarding the Greenland Ice Sheet-Ocean Observing System (GrlOOS), what has the panel involved in this system? Since Greenland ice sheet-ocean interaction is one of the task teams of the panel, how can the task team be more involved in this activity?

- *There are research infrastructures in Greenland, but they are not very well-connected, and there are some obvious gaps. We've been involved in some of the projects such as the QGreenland project. But there is room for more involvement of NORP.*

2.2. CLIVAR/CliC/SCAR Southern Ocean Region Panel (SORP) (Elisabeth Sikes)

SORP is co-sponsored by CLIVAR, the Climate and Cryosphere (CliC), and the Scientific Committee on Antarctic Research (SCAR). The panel acts as a forum for discussion and communication of scientific advances in the understanding of climate variability and change in the Southern Ocean, and provides suggestions for its sponsors on progress, achievements, new opportunities, and impediments in internationally coordinated Southern Ocean research.

Regarding coordination with SCAR, CliC, OOPC, seven Task Teams have been formed. The panel has identified key science challenges being identified, will interact more with the Southern Ocean Observing System (SOOS) and actively engage with early career scientists particularly in the area of national activities. Regarding SSG request for major WCRP activities, the panel will focus on

1. the role of Southern Ocean in global carbon cycling
2. the role of Southern Ocean in the planet's heat and freshwater balance

The panel is proposing a workshop "From global to local: cultivating new solutions and partnerships for an enhanced Ocean Observing System in a decade of accelerating Change."

Questions and comments:

The panel listed three questions for the key science challenges, but two of them need to be undertaken by WCRP. What are the one or two actionable items that the panel is focusing that will bring all the members together as a coordinated activity? Does the panel need to have one or two topics which the majority of the members are focusing on which you can deliver to CLIVAR?

- *Such activities certainly will help answer these questions*

S2S from WCRP has an activity on mixed layer. Can SORP make a recommendation on which data sets are useful to validate?

- *SOOS coordinates Southern Ocean observations, and Argo float and bio-Argo float are possibilities; but the panel would need to discuss.*

The panel has a lot of good work, particularly the national reports, which are collected annually, but how will the report be used?

- *So far, they just end up on a database. We can go to the SORP webpage and access them, but no efforts are made to synthesize them. It's still in the data-gathering phase.*

There are synergies between SORP and SOOS. How is the science flowing to SOOS?

- *Panels are working on a joint paper; this would be a focus next year.*

2.3. Pacific Region Panel (PRP) (Antonietta Capotondi)

During the last year the panel has been very busy with several activities.

- Western Boundary Currents and Indonesian Throughflow: new initiative on Pacific Lower Latitude Western Boundary Currents (LLWBC); North Pacific Ocean Circulation Experiment (NPOCE); this is a link to TPOS2020.
- ENSO metrics: support to model developers and users.
- Tropical Pacific Decadal Variability (TPDV): motivated by understanding decadal variability under climate change and poor simulation by climate models. Paper submitted to *Science.*
- AGU Monograph: *ENSO in a Changing Climate* to be published.
- ENSO Summer School in Trieste, Italy: Tropical Oceans, ENSO and their interaction (3-14 August 2020).

Activities for next year:

- ENSO conceptual models.
- More on TPDV: the paper Submitted to Science identifies the key gaps in TPDV.
- Ecosystem Prediction: ocean biogeochemistry (BGC): 2020 focus on marine heatwaves (MHW).
- Expand panel activities from Tropical to whole basin.
- Interactions with other groups and programmes e.g. TOPS2020, US CLIVAR group on ocean isotopes, ANDEX, NORP and SORP, and RF on Tropical Basin Interactions.

Input to WCRP implementation process:

Most critical impacts on society will come from the ability to predict and project climate variations on a variety of timescales, thus the panel will focus on: 1) decadal prediction; 2) ecosystem change.

Questions and comments:

Panel is focused on ENSO, but what about sub-tropical/high latitudes e.g. Kuroshio and other sources of variability?

- *Good idea. The western boundary current is important to think about.*

Should the panel strengthen its connections (e.g. metrics) with CMIP6 and predictability of heatwaves?

- *Yes, good ideas. Need to look at prediction systems.*

The panel provided input to TPOS2020. How was it received?

- *Not clear, e.g. mooring removal, though in the second report they did try to address these concerns.*

To integrate ENSO metrics into CMIP6.

2.4. Atlantic Region Panel (ARP) (Walter Robinson)

The membership covers both ocean and ocean-atmosphere interactions. In terms of 2019 interactions, the Tropical Atlantic Observing System (TAOS) review was a major activity, as was the interaction with the Atlantic Tradewinds Ocean-Atmosphere Mesoscale Interaction (ATOMIC) and the Ocean-Atmosphere component of EUREC^{4}A field campaign and associated modelling; contribution to OceanObs'19; and interaction with US CLIVAR AMOC Science Team. One of the emerging themes is on ocean macroturbulence (a summer school will be held in Qingdao on this topic). Given that the Tropical Basin Interactions was selected as a new CLIVAR Research focus, the panel expects to have many interactions with the new group.

Questions and comments:

How much involvement of the other panels is there in the summer school?

- *Probably not as much as should have been, though many are global scientists.*

Will the PIRATA array be continued in some sense?

- *The drafts have shown a PIRATA array, so it is a stronger case than it has been.*

Is the data from PIRATA used by operational centers?

- *Usually it is, but I agree that its important!*

To strengthen the engagement with other panels (e.g. to involve SORP in the summer school); to consider how to advocate and implement the *TAOS Review* outcomes.

2.5. CLIVAR/IOC-GOOS Indian Ocean Region Panel (IORP) (Roxy M. Koll)

The panel has focused on the IndOOS-2 report, though including many interactions with other CLIVAR groups as well as external activities. IORP had membership changes with additional expertise on biogeochemistry and biology and the linkage with SIBER. The membership has already been approved by the SSG before this meeting due to the time constraints for its upcoming panel meeting in Goa, in March 2020. The advocacy and implementation strategy for IndOOS-2 has also been introduced, by highlighting the recent progress on regional partnership on Indian Ocean observation, e.g. RAMA-OMNI (India) Framework and China-Kenya and China-Australia cooperation in mooring deployment. The panel has also been involved in UN Decade Consultation Workshop for the Indian Ocean and a strong advocate for IndOOS-2 in terms of support for the 'Predictable Ocean.' In the future, the panel will increase the representation of east Africa and small island countries in the membership and strengthen the cooperation with other panels, (e.g. multi-region workshop on ocean observation and the joint workshop with the Monsoons Panel) and other international programmes and projects (e.g. IIOE-2, IRF, IMBeR, IOGOOS and IOCINIO).

Questions and comments:

Both ARP and PRP need to expand their members in Africa.

Multi-region Workshop on Ocean Observations

Lisa Beal presented the workshop: 'From Global to Local: Cultivating new solutions and partnerships for an enhanced Ocean Observing System in a decade of accelerating change', which will be organized in May 2021. The proposal to the International Centre for Theoretical Physics (ICTP) is being developed by Lisa Beal (IORP) and Riccardo (SORP) with support from all CLIVAR regional panels and GSOP. The motivation of the workshop is to resolve similar challenges that face the ocean observation in all regions, sharing experience and lessons learnt. The workshop will focus on the current most important societal and scientific drivers for the ocean observations; how to transit to more multidisciplinary ocean observing system; the needs for regional scale forecasting; the expansion into Exclusive Economic Zone (EEZ) and coastal zones; resource mobilization and linkage to UN Ocean Decade and Sustainable Development Goals (SDGs). The workshop will emphasize the participation from developing countries. IOC, GOOS and other partners showed interests in this workshop. But there is a concern that the involvement of other programmes may dilute the original focus of the workshop on the discussion of the practical issues.

Questions and comments:

There were some issues on how this activity was approved by the SSG.

Emphasis is placed on the need to include the modeling community, connect observation-modeling-prediction.

Are we duplicating efforts? We have TPOS, IndOOS, maybe wait for TAOS to be completed? Is it premature to do this?

Participation of Africans? New African SSG members can assist here.

Is the human influence aspect missing? Modeling would help? Which are human driven?

- *Apologies if not done in the right way. Ideas came from the panels and are thought as a good way forward. I would agree with the modelling aspect, though we have to be careful about what we can achieve.*

This could be the only large meeting of CLIVAR in 2021, so a lot budget of 2020 will be mobilized to 2021, and this should be only meeting for most of the panels.

2.6. Monsoons Panel (Francois Guichard, by telecon)

The presentation gave some context to the monsoon panel activities, including the current panel structure. Enhanced emphasis has been placed on linkages across scales and physical processes. Recent activities include meetings, workshops, and regular teleconferences. The three WGs focused on regional activities such as assembling a website on regional monsoons, looking for sources of error in GCMs for monsoon simulation, exploitation of S2S database for monsoons, the *Future Climate for Africa* program, and capacity building and connections to climate services.

A new Global Monsoons MIP was initiated by the Monsoons Panel. There are improved interactions with the World Weather Research Programme (WWRP) monsoons panel, GEWEX, CLIVAR and SPARC, e.g. in the area of how the stratosphere modulates monsoon teleconnections. Several future activities have been outlined such as continued interactions with IPCC AR6, S2S diagnostics, and engaging more closely with the Young Earth System Scientists (YESS), among others.

Questions and comments

About the regional working groups, some activities by the regional WGs don't seem necessary be specific to a particular region. How do you decide whether an activity should be the focus of a regional WG?

- *Main focus of regional WGs is on the regional component of particular activities.*

GMMIP contributes to CMIP6 (workshop in IOCAS).

Interaction with WMO/WWRP MP should be enhanced.

Look for interactions with SPARC: focus on Monsoon teleconnection.

2.7. Global Synthesis and Observation Panel (GSOP) (Steven Jayne)

GSOP is responsible for the definition and promotion of CLIVAR's overall global needs for sustained ocean observations, and the evaluation of model-based synthesis of ocean observations. Several new members have been brought onto the panel, to include topics of air-sea interactions and coupled assimilation. Some recent activities include new articles and TPOS2020 input. Ocean reanalysis is an important topic for GSOP, particularly deep ocean reanalysis where parameters poorly constrained. Other fields such as SST and sea ice extent are well constrained.

Questions and comments:

GSOP invited SSG to suggest qualified names of co-chairs. The two co-chairs will both rotate-off by 2020, the co-chairs should carefully think about this.

Gap analysis in reanalysis should be carried out?

There has been joint work between GSOP and OMDP, and this should focus on data assimilation frameworks, so the they are aligned with improvement cycles of climate models and data assimilation models, maximizing the value of observations. This might be an example of the type of intensive effort and high-level project WCRP is aiming for.

2.8. Ocean Model Development Panel (OMDP) (Baylor Fox Kemper)

The mission of OMDP in CLIVAR and WCRP is to: (i) collaborate with and to advise other CLIVAR panels and Research Foci Teams on issues related to ocean modelling; (ii) coordinate activities aimed at addressing modeling needs and (iii) address other modeling-related issues impeding progress of CLIVAR research. Baylor presented on OMDP. Several key meetings: e.g. joint meeting with CLIVAR/US CLIVAR. Several papers have been published and others are in process. Google scholar page for OMDP. The panel is proposing 8 female and 5 new male members.

Questions and Comments:

Need to revisit emeritus people and see if they should stay on…!

- *Lots of these people are still contributing!*

Topics of key papers?

- *Comparison between different models.*

The panel should send a representative to attend the pan-CLIVAR meeting in 2021

2.9. Climate Dynamics Panel (CDP) (Shoshiro Minobe)

The panel has been focusing on three key areas: organizations of storm-tracks, blocking, and jet streams. Several workshops and meetings in 2019 were held, and science outcomes include DCVP pacemaker experiment and contribution to the IPCC special report. Plans for 2020

include several meetings and collaboration with PRIMAVERA (Process-based sIMulation: AdVances in high-resolution modelling and European climate Risk Assessment), US CLIVAR air-sea interactions, *Japanese Hotspot2* project and the new RF on Tropical Basin Interactions. The panel recognizes a need for better understanding of role of forced versus natural variability on regional scales. Some of the prediction targets the panel is focusing include marine heatwaves, sea-level especially for vulnerable island countries, upwelling and marine ecosystems. Another focus is interactive eddy resolving ocean – important for simulating air-sea interaction.

WCRP Questions:

How to create a basis of timely regional predictions with uncertainty estimation from sub-seasonal to decadal timescales.

Proposal: To establish a group to conduct regional prediction experiments for a set of selected targets as a showcase. E.g. marine heatwaves, regional sea level, upwelling.

Questions and comments:

Membership of multiple panels? There may be cases when multiple membership is a good thing, but other cases not… Perhaps not co-chairs of more than one activity.

Human influences and rising GHGs are being considered?

- *Already have this in predictions. Need a good forecast and then deconstruct it. Important to connect such activities across panels.*

Comments: send representative to attend the pan-CLIVAR meeting in 2021.

3. RESEARCH FOCI/GRAND CHALLENGE REPORTS

3.1. Eastern boundary upwelling systems Research Foci (EBUS RF) (Ryan Rykaczewski)

Overview the EBUS RF progress until 2019 was provided with emphasis on interaction with PICES WG-40 and ICTP-CLIVAR Summer School on Oceanic Eastern Boundary Upwelling System (Trieste Italy, July 2019). The EBUS RF will be sunset in 2020 after completing the final work on a Perspective manuscript on priorities in EBUS Sciences, which is now being drafted, covering the five basic questions. Though the ideas and contributions have been received across the EBUS RF, some substantial effort is needed in narrowing the focus of the paper and attempting to remove the 'review-type' portion of the current draft. The RF also works closely with SCOR WG-155 on EBUE. Some points highlighted:

- Structure of models is a bigger issue than forcing.
- Uncertainty in variability of EBUS on BGC and fish;
- Bio-physical interaction – to be answered in Question 5 of the perspective paper
- What process and resolution are needed to improve the model performance in EBUS region are yet to be answered.
- Connection between tropical/Equatorial to EBUS is not clear.

Questions and comments:

Will you consider ocean acidification as well?

- *Will be included, e.g. we know it will change but impacts are not resolved.*

How would this work continue within CLIVAR?

- *We will have to discuss this within this group.*

Questions around lack of fishery related questions…

- *Paper focused on expertise of those involved.*

More on biophysical interactions

3.2. Sea Level GC (Roderik van de Wal)

Ongoing global sea level rise is projected to accelerate in the future. IPCC SROCC is more focused on risks rather than projections. Roderik highlighted several achievements and key papers. There is request for a third co-chair David Behar. Plans include workshop on user interaction in the Arctic autumn 2020, follow up of a high-end paper, workshop on sea level and subsidence (2021), new sea level budget community paper (2021) and a sea level conference in 2022.

Questions and comments:

Regarding post-2022 plans and lack of gender balance in co-chairs, do we need a sea level scientist for co-chair?

- *Membership is more gender balanced. David needed to connect to user community. Members warmly welcome Behar to join the GC. Broader topics are going to be covered, broader expertise is needed (one new co-chair, and new leads and members for six working packages).*

Sea level projection should include risk analysis.

Regional diversity needs to increase. We have co-chairs (2 European + 1 USA), but none from Asia.

- *We need also to consider the expertise needed for the group; the panel is counting on the 2022 Singapore conference to recruit more expertise from Asia.*

It is necessary to strengthen collaboration and interactions with other panels/RFs.

- *Several joint papers have been published by OMDP, which demonstrated a good inter-panel cooperation.*

What about constraints on uncertainty of sea level projection? How much can we believe?

- *Ice sheet is the major contribution to sea level rise, thus need to include ice sheet into climate system models.*

3.3. Decadal climate variability and predictability (DCVP) Research Foci (Yochanan Kushnir)

This was the DCVP RF final report, and started with a brief historical perspective. The group started in the fall of 2014. Models tend to underestimate decadal variability, and key teleconnections between basins. Summarized DCVP main objectives were explained. In 2017 the group laid out the following plan for 2018-2019:

1. Complete DCVP contribution to CLIVAR Science Plan.
2. Participate in analysis of Decadal Climate Prediction Project (DCPP) experiments, particularly the results from component C and contribute to publications of the results.
3. Continue participation in the planning of the WCRP international workshop on Subseasonal to Decadal variability planned for September 2018 and represent DCVP work in that meeting.
4. Present DCVP science in the 2019 Ocean Observations Conference.
5. Plan and execute a final DCVP Science Symposium and Summer School and publish outcome.

Most of the tasks have been completed. Much of pending tasks will be handed over to the Climate Dynamics Panel. Several challenges remain. For example, understanding mechanisms and predictability of decadal variability, overcoming modelling impediments to simulating, and predicting decadal variability.

Questions and comments:

We have to be careful of interpretations. We tend to identify climate modes with eigenvalues. Is this a problem if such modes are changing over time?

- *People are identifying variability with e.g. cluster analysis. Techniques of looking at data are changing.*

3.4. Tropical Basin Interactions (Ingo Richter)

The motivation for the RF group was introduced. In the 1970s and 1980s there was an ENSO centric view, for example, ENSO influences other ocean basins through the atmospheric bridge. Evidence for Atlantic and Indian Oceans influencing the Pacific emerged in the 2000s. Open questions include: how important is TBI for variability and seasonal prediction, what are the detailed mechanisms, what observations would be helpful? How do decadal variability and trends modulate the TBI? What is the influence of model biases and what is the role of TBI in climate change?

Activities of TBI would include holding workshops, meetings, promoting analysis of existing multi-model data bases such as CMIP6, coordinate multi-model experiments and archive of proxy data.

Questions and comments:

Seasonal forecasts – do you have operational centres focused on this?

Why releasing experiments after two years and not sooner?

- *Have to ensure we have consistent experiments.*

Discussion, moving forward in the new WCRP, WCRP High-level Science Questions Workshop, regional activities (Part 1)

Participants then engaged in a preliminary discussion about how CLIVAR should contribute to the upcoming WCRP high level workshops, some comments included:

- All GCs will be sunset by 2022. It is not clear if the current structure of core projects will remain or not.
- Magdalena from SSG will represent CLIVAR at the WCRP High-level Science Questions and Flagship Workshop in February 2020 in Hamburg, Germany;
- Implementation strategy of WCRP SP will be released in JSC-41 in May;
- Three Flagship ideas: Greenland Ice Sheet; Third Pole Environment (TPE) and ANDEX
    - Understanding the climate system, its predictability and response to external forcing;
    - Guiding the design of reliable climate information system.
- Input from SORP:
    - The role of the Southern Ocean in the global carbon cycle
    - The role of the Southern Ocean in heat and freshwater balance
- Input from PRP:
    - Understand the nature of climate variability on different time scales, how different timescales interact, and how interaction is modified by climate change
- Input from CDP
    - Create a basis of timely regional predictions with uncertainty estimation from sub-seasonal to decadal time scales
    - Lighthouse activity: coordinated regional prediction experiments for a set of selected targets
- Input from SSG
    - Combine physical constraints with machine learning to
        - Reduce biases in current climate simulation;
        - Reduce uncertainty in climate projection;
        - Downscale projections and prediction to provide actionable information to users.
- Some CLIVAR specific high-level questions
    - Decadal Predictability
    - When does the ocean play a role?

- Cooperate with IOCCP, IMBeR, SOLAS on Carbon research

- More observation is needed. Based on the societal requirement. (e.g. to enhance the understanding of oxygen changes in the ocean requires more observations)
- Identify the big question with societal relevance/irrelevance
- CMIP is a good example of coordinated international effort on climate research, but need to pay more attention to the development of new generation of models.

4. ICPO ACTIVITIES

4.1. ICPO (Jose Santos, by teleconference)

Jose apologized for not being able to attend the meeting because of the novel coronavirus problem; he appreciated the support of Mike Sparrow from WCRP and Jennie from US CLIVAR on this SSG.

There have been some staff changes in the two offices: From ICMPO side, Rupa Kumar K. became the New Director; Sandeep D Sukhdeve became the new Assistant Engineer. From the ICPO side, Qian Zhao replaced Lina as the new administrative assistant.

Current Coordination of groups at ICPO:

Jing Li: ARP, EBUS, IORP, PRP, SL

Liping Yin: OMDP, SORP, NORP, CDP

Jose Santos: GSOP, TBI

Rupa Kumar: Monsoons panel.

Activities both of ICGPO and ICMPO were reported in this presentation, mainly including the data statistics of all activities, workshops, panel meetings, summer schools, publications, new RF, and budget mobilizations. Jose will be working from Ecuador and will replace staff scientists to attend panel meetings until the novel coronavirus emergency ends.

Questions and Comments

The SSG is concerned about when a decision will be made about a postponement of the summer school if the coronavirus emergency continues. This will be discussed in Qingdao and the ICPO will inform the SSG.

ICMPO evolution: Mike Sparrow said the ICMPO will extend the current agreement for one year, during which time the possible reform of the office to be a global Monsoons Office that combines all the Monsoon activities from WWRP, CLIVAR and WCRP will be discussed. The SSG thought it is not something the SSG should decide on in isolation but that WCRP (GEWEX and CLIVAR) and WWRP need to do jointly.

5. CLIVAR ACTIVITIES

5.1. ***Summer schools (A. Bracco)***

The multi-panel meeting focused on Observations is going ahead, this has been set out as a training activity. Lisa informed attendees that a proposal has just been sent to ICTP. Needs to include participants from developing countries. Focus on observing systems and benefits to all countries. Plan for a 2-day workshop and 1-day for panel meetings. It is suggested that in order to have time for the panel meetings, the format changes to (3-day workshop and 2-day panel meeting). OOPC is included on the organizing committee. IOC are also interested.

ICTP wants to only support the travel expenses of scientists from developing countries. It is important to have the scientists from developing countries to be present in the workshop and bring them into conversation. Encourage these scientists or institutions to involve in the ocean observation systems.

There is a suggestion to achieve expansion of sustained observing systems into continental shelf seas. GOOS and IOC UN decade also want to be involved, hoping to focus on specific issues overcoming societal problems.

Funding: The pan-CLIVAR meeting in 2021 may cost a lot so the budget of this year will be cut to save money for 2021.

All the regional panels and GSOP will attend the pan-panel meeting and have their individual panel meeting alongside. CDP and OMDP will just send representatives for the pan meeting. All regional panels were suggested not to meet in 2020.

6. INTERACTION WITH OTHER PROJECTS

6.1. ***US CLIVAR (Carol Anne Clayson)***

The context of US CLIVAR was summarized, including its goals, activities, which are based on Research Challenges, and structure, including panels, working groups, and science teams. The US AMOC Science Team is sunsetting and transitioning, as a coordinating activity, with the help of the CLIVAR Atlantic Region Panel. Current working groups include Large Ensembles, Water Isotopes, Air-Sea Interactions, Emerging Data Science Tools, and Uncertainty Quantification. Several workshops are planned with connections to CLIVAR internationally. Future challenges and opportunities include sustaining and growing the ocean observing system, scoping new research challenge on climate at the coasts, informing directions for future US modelling investments, and engaging producers and users of climate information to inform research directions.

Questions and comments:

Dynamics between US and International CLIVAR continue to be strong. All US CLIVAR workshops are open to the international community. All US working groups, each with up to 18 members, include participation of international scientists.

If one considers that in the Indian Ocean more than 50% of observations are from US agencies, do you have insight for the future?

- *No, but it's a challenge we must discuss. It is important to note that the US supports approximately 50% of all GOOS component systems. How to sustain currently supported observing systems while attempting to evolve and expand the next-generation GOOS is a challenge being addressed within the US, taking advantage of community inputs to OceanObs'19, the upcoming National Academy of Sciences workshop on sustaining ocean observations, and the launch next year of the Decade of Ocean Sciences for Sustainable Development.*

US has more end to end (research to operations) and engagement with satellite agencies, and use of e.g., hackathon and new technologies.

CLIVAR does not exclude satellites. GSOP is meant to include satellites, although this has not been a recent emphasis.

- *GEWEX does seem to have a stronger satellite component.*

Does US CLIVAR have any insight of how to impact the US agencies on their decision of funding for planning/operation of the observation system?

- *The US CLIVAR SSC and its panels do not advise US agencies on their funding. Our role is to identify the ocean and climate observing system needs to advance the understanding, monitoring, and prediction of the climate system and, in particular, the ocean's role. US agencies have historically been responsive to the identification of such science-driven needs, and we anticipate that they will continue to be.*

6.2. ***CliC (Mike Sparrow)***

The CliC project is being supported temporarily in Geneva, with Gwen providing half-time secretarial support. A proposal from Massachusetts University to NSF and NASA is currently under review. CliC activities include workshops, input to major conferences, sponsors, telecon, social media.

The CliC science plan is currently being updated: general science themes; overhang research needs and themes; structure of main activities; 5-year timescale.

There are several interactions with CLIVAR: co-sponsored panels, overlapping science themes.

Possibility of further CliC-CLIVAR interaction: TPE; connect TPE with Arctic or Antarctic.

The panels that associate with both CLIVAR and CliC can request funding from both projects, but the two projects will check with each other before allocating the money. For CliC itself, 90% of the funding will go to a few core activities.

6.3. ***GEWEX (Graene Stephens)***

The GEWEX Science plan was highlighted. GEWEX has four core panels. These consist of several working groups, most of which are process centric in focus. Several cross-cutting activities include monsoons panel, GC on Extremes. A GEWEX 'science and applications traceability matrix' makes the traceability from WCRP strategies, to core science plan, to defined metrics to applications/programs. Cross GEWEX-CLIVAR EEI has formed WG with experts from AGRO, ER, Gravimetry. GEWEX hopes CLIVAR experts can involve.

GEWEX's attitude toward the revolution of the ICMPO office: A project office could have little contribution to broad climate sciences of WCRP. It appears to be of very insular, national focus. If a broader 'coordinating office' is to be formed it should not be independent of the actual activities within WCRP but would use these as basic integrative frameworks of the office.

Questions:

How the sea level budget been assessed?

- There is a picture showing the sea level budget and times series of global energy budget in the GEWEX presentation. Changing energy balance along time would have related to other aspects of changes over time.

Connection between GSOP and the GEWEX earth energy balance?

- *1) Need to bring in experts to fill the knowledge gap. 2) There had been a CLIVAR CONCEPT-HEAT (sunset) RF which has a lot discussion about this. This will be moving forward and included in the WCRP perspective.*

6.4. ***IndOOS-2 (Lisa Beal)***

Some justifications for Indian Ocean Observing System (IndOOS)-2 were provided, which include the increased vulnerability around India Ocean (extreme events, regional sea level rise, fishing) and remaining gaps (low prediction skills S2S, large discrepancies in climatologies of heat exchanges; lack of observation in western IO due to piracy). The IndOOS Review has identified the observation coverage with specified equipmentation based on different scientific, social, environmental purposes and requested for more cooperation with broad communities for the achievement of the goals for IndOOS-2. Core findings include the need to complete coverage of western equatorial ocean, the lack of biogeochemical measurements, the need for enhanced vertical and temporal resolution of upper ocean measurements, the lack of observations in the western boundary currents, the need for more observations of the deep ocean and more land motion sites alongside tide gauges and additional island sites. Additional core findings beyond the observing system include, e.g. satellite measurements, data assemblage and coupled data assimilation; partnership, data sharing and best practices. We need to expand the observation in EEZ through new partnerships; to strengthen Capacity building; to catalyze new investment from global community, and to increase the investment in governance and scientific

leadership. IndOOS Review is co-sponsored by several agencies. Review, IndOOS-2 Roadmap, CLIVAR Exchanges special issue has been finished.

Questions:

Will cutting the array from 40 to 31 have some impacts?

- *Some of those kinds of discussions mentioned that there was probably less contravention than Pacific. The reasons are: 1) A lot of the cutbacks of these moorings were from pragmatic considerations. It is a 'cleaning up the house' exercise; 2) The Cutting of one repeating line to be replaced by new technologies. So, there is a small sacrifice from the scientific point of view. Refer to RAMA Chapter in the IndOOS-2 full report.*

How to make interaction with the operational seasonal forecast centers?

- *In terms of having them involved in the review, there is one chapter for sub-seasonal to seasonal forecasting, and some scientists from the forecast centers have involved.*

6.5. IOC– Discussion on the UN Decade (Salvatore Arico)

The UN Decade was presented; which has the vision "The Ocean we need for the Future we want". It stresses acting for societal outcomes, and its composed of six themes. The UN Decade adopts a bottom-up approach, which is emerging from new ocean science action projects (both global and regional) and the contribution of existing science plans/organizations, the science action priorities of the Decade have been identified, and scientific and societal outcomes will be generated by implementing the Science Action Plan (SAP) of the Decade, which will finally contribute to SDGs. The SAP for the Decade is inclusive, inter-and trans-disciplinarily, transformative in nature and contributing to global sustainable development. The Decade will have its second Global Meeting on 18-20 March 2020 in Paris and the 2nd UN Ocean Conference will be organized 2-6 June 2020 in Lisbon, Portugal. The Implementation Plan of the Decade will be finalized including the Science Action Plan; Capacity Development Plan; Governance, monitoring and reporting; and Communication. The official start of the Decade will be in 2021.

Discussion part: How CLIVAR and WCRP can contribute to the UN Decade science plan?

- CLIVAR and WCRP want to know what the UN Decade actually needs at this point to bring them into the discussion, then find a mutual interest such like societal relevance, prediction, etc.
- UN is open for comments and additional inputs, would like WCRP to participate or contribute through CLIVAR or other projects, one possible contribution is through output from the two WCRP workshops on high level science.
- Considering the many existing science plans, UN would like to find things in common to find opportunities of collaboration, avoid duplication of efforts & provide an interface with society.
- CLIVAR is confused about what IOC really needs: From a previous email from UN Decade, CLIVAR is asked to provide grand ideas in guidelines in ocean modeling & ocean data synthesis. Will WCRP be expected to contribute a paragraph or contribute high resolution modeling effort assuming there would be funding for it? CLIVAR was also asked to

contribute to the carbon component of the Decade, and the requirement from IOC is very specific and needs the response very soon.

- Communication with other disciplines: it's better to learn what the other side needs. Everyone thinks what they can contribute and collect the ideas together, discuss together, consider what the other disciplines need, and make the ideas into science action.
- CLIVAR is very active and has many experiences on the specific activities especially on cultivating ECS, disseminating knowledge and connecting to stakeholders. It would be good to collect the ongoing CLIVAR activities that are relevant to UN Decade.
- Focus a little bit on what we can specifically say that connects to society; e.g. CLIVAR activities would feed into sustainable use of the ocean.
- WCRP Lighthouse activities (e.g. the climate system prediction) could be the same for WCRP and UN Ocean Decade. We can take CLIVAR science goals and think about how we can translate that into a benefit for society.
- What should be discussed on WCRP level? Determine who actually do the work of translating into societal benefits. Three or four disciplines collaborate together tocontribute; this will need scientific support.
- WCRP community with other stakeholders can do their translation to societal benefits using the Decade process.

6.6. Discussion, moving forward in the new WCRP, WCRP High-level Science Questions Workshop, regional activities (Part 2).

Wenju Cai Chaired the discussion focusing on the instructions for preparing input to the first workshop.

Discussion and Questions

We must make real progress in climate science. WCRP needs to think about what its contribution is, bearing in mind there are other programs, etc. Need to demonstrate its relevance and justify its focus. One of our big problems of climate change science is whether climate sensitivity changes under a changing climate? Do we need a WOCE-2 or a set high-resolution climate experiment? What is our lighthouse idea?

So, is our equivalent an improved Argo float system?

- *Could be, for Earth Energy Imbalance, Argo would be part of it, including satellite missions.*

Securing Earth's climate, the Special Report on the Ocean and Cryosphere (SROCC) mentions unprecedented new states, also there is clear oxygen decline for the ocean. When will those changes detectable? What do we need to do to stop these? Thresholds, etc.?

We need to define where CLIVAR strengths are. Where do input from CLIVAR panels come in?

- *Workshop next week is about CLIVAR at large. Structure is at next workshop.*

We seem to have more and more CMIP models, and this is a huge investment. Is there a diminishing return? Where is the limit? Can we divert some of this focus elsewhere? There are other activities such as data rescue, assimilation, and earth system models

The Working Group on Numerical Experimentation (WGNE) Perspective: will have a further focus on earth system modelling…need to become regional earth system models. Need to build partnerships with ocean modelling groups. AI is being widely discussed. Global tipping points are crucial, regional tipping points should be considered.

We keep coming back to the issue that we are not capturing observations where people meet the ocean. Need for observations in the boundary current systems.

A small idea can become big. e.g. it would no sense going to high resolution, unless we have evidence that such high resolution is needed. We need eddy-resolving models. For the atmosphere it is less clear that 4km will be better than 9 km models.

The goal of the first workshop is to refine the overarching research objectives of WCRP, and to think about activities/experiments required to reach them. Specifically, the workshop will discuss:

- What are the top three overarching developments that can revolutionize our insight into the climate system and solve many societal challenges ahead of us?
  - Improved and reliable earth system models: resolution and complexity (Machine Learning)
  - Seamless prediction
  - Better exploitation of observations for initialization, modeling, verification and calibration/downscaling
- Is there one experiment that needs to be performed jointly by the international community that cannot be done by individuals because it is too big but that needs to be performed to make progress? Which question(s) would it solve?
  - Risky to focus on a single experiment or single model
- Is there a single big infrastructure item required to make this progress?
  - Data basis for sharing experimentation and observations
  - Modelling infrastructure to exchange/share model modules (efficient exchange of ideas)
  - Observation handling infrastructure to confront (and combine) model with observations
  - One experiment is risky, but we agree on a large experimental campaign targeting the flagship objectives.

Session 2: Big Questions and Knowledge Gaps
Session sets the scene regarding "thinking big", focusing on core WCRP science and providing a thought- and discussion-provoking stimulus for the remaining workshop.

- **Big societally relevant questions/needs:**
  - Support adaptation and mitigation actions
  - Predicting climate risks and emergencies
  - Securing ocean climate for ecosystem and humans, securing our shores
  - New and novel research required to address these needs?
- **Knowledge gaps**
  - Regional impacts of climate change
  - Are there limits to adaptation? (e.g. Tipping points)

Session 3: Proposals for WCRP Flagship Objectives
Session brings in proposals for flagship objectives defining WCRP's highest level aspiration. They should be equivalent to the WCRP's initial overarching objectives:

- to determine the predictability of climate; and
- to determine the effect of human activities on climate

Suggestion for Flagships
To establish the scientific basis for adaptation and mitigation action for a climate resilient society by:

- Understanding the climate system, its predictability and its response to human activities.
- Enabling the generation of actionable climate information on global to local scales.
- Need enhancements on models, observations (especially biochemistry), assimilation methods, Databases, and computer capabilities.

Light House/Beacon
To complement the existing CMIP protocol with initialized ensemble seamless predictions, we needs to have

- True ESM operating at all time scales: leveraging efforts among modelling centers
- Efforts on ESM re-analyses back in time (data rescue, initialization methods)
- Innovative Machine Learning solution for
  - Modelling complex components
  - Enhance the information content of model output (downscaling, calibration, filtering, conditional probability)
  - Identify signals and errors, causality

7. SSG CLOSED MEETING.

During this closed meeting, the SSG discussed the budget allocated by WCRP for 2020, the membership and activities proposed by panels and RFs, and plans for new SSG membership. *Next SSG meeting? In association with pan CLIVAR meeting? Need to revisit this. SSG will discuss by email.*

The co-chairs closed the meeting, thanking all SSG members for their participation, and the local hosts for all the logistics arrangements.

APPENDIX A. Participants

Group	Name	Organization
CLIVAR SSG	Soon-il An	Yonsei University, Korea
CLIVAR SSG	Magdalena Balmaseda	ECMWF
CLIVAR SSG	Nathan Bindoff	University of Tasmania, Australia
CLIVAR SSG	Annalisa Bracco	Georgia Institute of Technology
CLIVAR SSG	Wenju Cai	CSIRO
CLIVAR SSG	Mat Collins	University of Exeter, UK
CLIVAR SSG	Gokhan Danabasoglu	NCAR
CLIVAR SSG	Francois Engelbrecht	CSIR
CLIVAR SSG	Masa Kageyama	LSCE, France
CLIVAR SSG	Sonya Legg	Princeton University
CLIVAR SSG	Mauricio Mata	Federal University of Rio Grande
CLIVAR SSG	M Ravichandran	NCPOR, India
OMDP	Baylor Fox Kemper	Brown University
CDP	Shoshiro Minobe	Hokkaido University
SORP	Elisabeth Sikes	Rutgers University
ARP	Walter Robinson	North Carolina State University
IORP	Roxy Mathew Koll	Indian Institute of Tropical Meteorology
IORP	Lisa Beal	University of Miami
PRP	Antonietta Capotondi	University of Colorado
EBUS	Ryan Rykaczewski	South Carolina University
SL	Roderik van de Wal	Utrecht University
GSOP	Steven Jayne	Woods Hole Oceanographic Institution
DCVP	Yochanan Kushnir	LDEO Columbia University
TBI	Ingo Richter	Japan Agency for Marine-Earth Science and Technology
TBI	Noel Keenlyside	Bjerknes Centre for Climate Research, University of Bergen
Sponsor & Partner	Detlef Stammer	WCRP Joint Scientific Committee
Sponsor & Partner	Mike Sparrow	Officer in charge, WCRP

Sponsor & Partner	Graeme Stephens	GEWEX
Sponsor & Partner	Salvatore Arico	IOC
Sponsor & Partner	Mike Patterson	US CLIVAR Project Office
Sponsor & Partner	Jennie Zhu	US CLIVAR Project Office
Sponsor & Partner	Carol Anne Clayson	US CLIVAR SSC Chair
US Agency Representatives	James Todd	NOAA Global Ocean Monitoring and Observing Program
US Agency Representatives	Sandy Lucas	NOAA Climate Variability and Predictability Program
US Agency Representatives	Virginia Selz	NOAA Climate Observations and Modeling Program
US Agency Representatives	Xujing Jia Davis	NSF Arctic Natural Sciences

Remote Participants

Group	Name	Organization
MONSOONS	Francoise Guichard	CNRM-GAME
NORP	Ruth Mottram	Danish Meteorological Institute
ICPO	Jose Santos	Executive Director ICPO, First Institute of Oceanography, China
ICPO	Liping Yin	Staff Scientist ICPO, First Institute of Oceanography, China
ICPO	Jing Li	Staff Scientist ICPO, First Institute of Oceanography, China
ICPO	Qian Zhao	Administrative Assistant ICPO, First Institute of Oceanography, China
ICMPO	Rupa Kumar Kolli	Director ICMPO

APPENDIX B. Agenda

Agenda: 25th Session of the CLIVAR Scientific Steering Group
15-16 February 2020. San Diego, CA
Carte Hotel San Diego Downtown.

Participants: CLIVAR SSG members, CLIVAR Panel/RF representatives, Observers					
Sat. 15/02			**Session**	**Presenter/Discussion lead**	**Time**
	1		**Opening**		
09:00		1.1	Welcome and meeting objectives	A. Bracco/W. Cai	15
09:15		1.2	WCRP presentation	Detlef Stammer	45
10:00			***Break***		***30***
	2		**Panel Reports**		
10:30		2.1	CLIVAR/CliC Northern Ocean Region P.	Ruth Mottram (videoconference)	20
10:50		2.2	CLIVAR/CliC/SCAR Southern Ocean R. P.	Elisabeth Sikes	20
11:10		2.3	Pacific Region Panel	Antonietta Capotondi	20
11:30		2.4	Atlantic Region Panel	Walter Robinson	20
11:50		2.5	CLIVAR/IOC-GOOS Indian Ocean Region P.	Roxy Koll/Lisa Beal	20
12:10			***Lunch***		***60***
13:10		2.6	Monsoons Panel	Francoise Guichard (videoconference)	20
13:30		2.7	Global Synthesis & Observations P.	Steven Jayne	20
13:50		2.8	Ocean Model Development Panel	Baylor Fox Kemper	20
14:10		2.9	Climate Dynamics Panel	Shoshiro Minobe	20
14:30			***Break***		***30***
	3		**Research Foci Reports**		
15:00		3.1	Eastern Boundary Upwelling Systems	Ryan Rykaczewski	20
15:20		3.2	Regional Sea Level Change and Coastal Impacts Grand Challenge	Roderik van de Wal	20
15:40		3.3	Decadal Climate Variability and Predictability	Yochanan Kushnir	20
16:00		3.4	Tropical basin interaction	Ingo Richter	20
16:20			Discussion, moving forward in the new WCRP, WCRP High-level Science Questions Workshop, regional activities (Part 1)	A. Bracco/W. Cai	60
17:20			***Adjourn for day***		
Sun. 16/02			**Session**	**Presenter / Discussion lead**	**Time**
	4		**ICPO Activities**		
09:00		4.1	ICPO report	J. Santos (videoconference)	20
	5		**CLIVAR activities**		
09:20		5.1	CLIVAR Summer School 2020	A. Bracco/W. Cai	10
	6		***Interactions with Other Projects***		
09:40		6.1	US CLIVAR	Carol Anne Clayson	15

9:55			***Break***		***20***
10:15		6.2	CliC	Mike Sparrow	15
10:30		6.3	GEWEX	Graeme Stephens	15
10:45		6.4	IndOOS-2	Lisa Beal	10
11:00		6.5	IOC – Discussion on the UN Decade	Salvatore Arico	30
11:30		6.6	Discussion, moving forward in the new WCRP, WCRP High-level Science Questions Workshop, regional activities (Part 2). Closing of public part of SSG	A. Bracco/W. Cai	75
12:45			***Lunch***		***60***
			***In camera* – SSG and ICPO only**		
13:45	**7**		**Review of 2019 Meeting proposals and budget**	ICPO staff/SSG	45
14:30	**8**		**Membership issues**	SSG	60
		8.1	Discussions on New RF	A. Bracco/W. Cai	
		8.2	Discussion on every panel	A. Bracco/W. Cai	
15:30			***Break***		***20***
15:50	**9**		**Preparations for next JSC**	A. Bracco/W. Cai	60
16:50	**10**		**Any Other Business/Next SSG**	A. Bracco/W. Cai	30

The
World Climate Research Programme (WCRP)
facilitates analysis and prediction of Earth system change for use in a range of practical applications of direct relevance, benefit and value to society.