CLIVAR REPORT

Climate and Ocean: Variability, Predictability, and Change

Meeting Report

The 15th Session of CLIVAR Pacific Region Panel

13th February, 2023, Melbourne Australia and online

June 2023

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Executive Summary

The 15th Session of CLIVAR Pacific Region Panel (PRP) was successfully organized on 13th February 2023 at Monash University, Melbourne, Australia and online. The panel has not met in person in a long time since COVID. The PRP-15 was organized in conjunction with the 2023 CLIVAR joint workshop on the tropical Pacific and its interbasin interactions, which is co-organized by PRP and its two working groups as well as CLIVAR Tropical Basin Interaction Research Focus (TBI RF).

In the opening session, the PRP co-chairs (Shayne and Sophie) welcomed the participants, briefly introduced the membership updates, and communicated the SSG feedback to the PRP 2022 Annual Report. In session one of the meeting, updates on PRP activities were presented by the respective focal members. The updates on the two PRP working groups, i.e., the Tropical Pacific Decadal Variability Working Group (TPDV WG) and ENSO Conceptual Model Working Group, were presented by the coordinators. Both WGs are at the stage to finalize their review papers, which is the main task for the WGs during the workshop following the PRP-15. The outcomes of the ENSO Summer School, status and next steps of ENSO metrics, and the updates on ocean isotopes were also briefly presented.

Session two of the meeting was dedicated to the observations and TPOS funded process studies. Dr. Hui Zhou presented the progress of NPOCE on behalf of Dr. Fan Wang. Dr. Sophie Cravatte briefly introduced the TPOS updates, as well as ODYSEA future satellite mission. The updates from two NOAA CVP TPOS Pre-Field process studies: 'Understanding Equatorial Pacific Climate Processes via Hierarchical Coupled Modelling' and 'Improved Understanding of air-sea interaction processes and biases in the Tropical Western Pacific using observation sensitivity experiments and global forecast models' were presented by Dr. Andrew Wittenberg and Dr. Kristopher Karnauskas respectively.

In the third session, the PRP work plan for 2023 and onward were fully discussed. PRP members in turn introduced themselves and the possible linkage and contributions to the panel. Round table discussion on the future PRP research topics were conducted. A few interesting topics were brought by PRP members from brainstorming, e.g., marine heatwave, observed and projected warming pattern across the Pacific, model biases examination (e.g., equatorial cold tongue biases) and application of Artificial Intelligence (AI) in model bias reduction, patterns of atmospheric teleconnections in a changing climate, sea level rise (pattern) in the Pacific, and etc. In particular, a proposal on TROpical Pacific SST warming patternS (TROPICS) Working Group was introduced to the panel. Possible membership from PRP is to be identified to the new WG.

1. Updates on panel activities

1.1 Opening (Shayne/ Sophie/Antonietta)
- Welcome everyone who spent quite a long journey to Australia to attend the meeting.
- Membership:
  - Thanks to members leaving the panel: Jerome, Yukiko and Yu, and Antonietta (stepped down as co-chair, but remains a member for one year).

- o Welcome new members: Tsubasa Koyama, Dhrubajyoti Samanta, Sayaka Yasunaka, and welcome new co-chair: Sophie Cravatte.
- SSG meeting feedback to PRP:
  - o Appreciated the broad scope and comprehensive progress that the PRP has achieved.
  - o Comment to link to WCRP Academy for sharing the ENSO summer school material.
  - o Connection with PICES: through CLIVAR-PICES joint WGs (WG-40, WG-49).
  - o To be involved in TPOS pilot studies.
  - o To engage more with 2023 WCRP Open Science Conference (Kigali, Rwanda). It is hard to organize another PRP panel meeting alongside the WCRP OSC. Deadline for abstracts submission: 28 February 2023 (extended to 14 March 2023).

Action 1: Everyone to think about what is missing for PRP activities.

1.2 ENSO conceptual model working group (Jerome Vialard)
- Start in 2020. Membership: 8 PRP members, 9 other ENSO experts, and 7 ECSs. 16 will present this week.
- Review the Terms of References: 8 out of 10 have been addressed. Two pending:
  - o 'Community Conceptual Model' for ENSO;
  - o Summarize and publish our findings (in progress);
- Focus on recharge oscillators (RO).
- Previous WG activities:
  - o 13 telecons between June 2020 to September 2022: talks on related themes, syntheses by WG members, review the paper frame.
  - o Online conference sessions (AGU 2020, OSM 2022)
- Ongoing activities:
  - o Related to ENSO monograph chapter by Jin et al.
    - More systematic review of the past RO achievements;
    - More outlook on RO usefulness/necessary extension to study.
  - o ENSO diversity; ENSO-related TBI; ENSO response to climate change, ENSO sensitivity to mean state (natural climate variability, model biases) – overlaps with TBI RF and TPDV WG.
  - o 1st draft and figure list are ready.
  - o Objective for the week: Finalize figure list and provide detailed review to lead authors.
  - o Agenda for the week: Prepare common discussion for cross-group interactions (ENSO-TBI, ENSO-TPDV).
- Future of the WG:
  - o Finalize the review paper (submission in summer 2023);
  - o Last conference session with RO focus in 2023/2024 (AGU? OSM? AMS?);
  - o Community RO code & tools;
  - o ENSO for dummies:
    - RO-based course on ENSO
    - Hands-on with the RO
    - Test on French students in Fall 2023
    - To be proposed to a small subset of the WG**: 'CLIVAR MOOC':** Online YouTube video, code package; report the whole initiative.

● Could also connect CLIVAR MOOC to WCRP Academy Lighthouse Activity (LHA).

Action 2: To finalize the review paper and submit it by summer 2023.

Action 3: To formulate a small subset of the WG for CLIVAR MOOC on ENSO Conceptual Model, and connect it to WCRP Academy LHA.

1.3 TPDV Working Group (Antonietta Capotondi)
● Established in 2021. The WG includes 12 past and present PRP members, seven ECSs and seven invited experts.
● Main motivation of WG: review paper by PRP (Power et al, 2021), suggesting that TPDV can originate as an ENSO residual, a null hypothesis that is difficult to disprove. Aim to look into oceanic/atmospheric processes contributing to decadal variability.
● Terms of References: role of STCs in TPDV; interaction between PO and IO through ITF; atmospheric teleconnections from extra-tropical pacific and IO and AO that can lead TPDV; TPDV paleo archived; fidelity of models in reproducing TPDV; TPDV under different warming scenarios; Summarize and prepare a paper.
● Activities:
  o Quasi-monthly telecon to review different aspects of TPDV: Launch on 18 May 2021.
  o Review paper: *Nature Review Earth & Environment*, summarize the body of knowledge collected during our meetings and associated discussions. Submission deadline: 15 March 2023 (extended for two weeks).
● Future activities (as joint research projects):
  o Use the guidance of the review paper on the most TPDV-relevant oceanic/atmospheric processes to assess the fidelity of CMIP-type models (or their oceanic components) to represent those processes.
  o Assess possible TPDV changes in future climate projections.

Discussion:

Q: What is the main difference to the paper published by Power et al. 2019?

A: We intend to go into depth describing the mechanisms.

Action 4: To finalize and submit the review paper to Nature Review Earth & Environment by the end of March.

1.4 ENSO summer school (Antonietta Capotondi)
● Summer school on Tropical oceans, ENSO and their teleconnections (18-29 July 2022, ICTP, Trieste, Italy). Hybrid format is also strongly encouraged by CLIVAR SSG.
● 100 students (35 in person) from countries on all six continents. Week 1-School; Week 2-a workshop.
● Various topics covered in the summer school:
  o Mike McPhaden "ENSO observations"
  o Alexey Fedorov "ENSO-mean state interactions"
  o Fei-Fei Jin "ENSO theory"

- o   Ben Kirtman "ENSO predictability"
- o   Antonietta Capotondi "ENSO diversity"
- o   Eric Guilyardi "ENSO modeling"
- o   Michelle L'Heureux "ENSO prediction"
- o   Andy Robertson "Societal Applications"
- o   Andrew Wittenberg "ENSO decadal modulation"
- o   Agus Santoso "ENSO projections"
- o   Yann Planton "ENSO metrics tutorial"

Slides and recordings for the ENSO summer school is available on ICTP webpage: https://indico.ictp.it/event/9817/

Action 5: Connect the ENSO summer school to WCRP Academy.

1.5 ENSO metrics: Status and next steps (Andrew Wittenberg)
- ● Originated from CLIVAR RF on ENSO in a changing climate ([ENSO RF](#), 2014-2018), 12 experts; Yann Planton (IPSL/PMEL/Monash) and Jiwoo Lee (PCMDI) are currently leading this effort.
- ● Goals: understand ENSO processes & past/future changes; develop evaluation protocol for ENSO in GCMs; target observations to improve models & projections.
- ● Three foci: ENSO performance, teleconnections, and processes.
- ● Community package liaisons: PMP, ESMValTool and CliMAF.
- ● ENSO metrics strategy:
  - o   Start with a small subsets of essential, simple metrics
  - o   Metrics are first step in a diagnostic hierarchy
  - o   Account for internal variability & observation uncertainty
  - o   Written in Python
- ● Metric requirements: documentation, definition, frequency and grid, observation and epoch, reference, sample size, diagnostics, normalization.
- ● Examine warm/cold events (including SSTA, Nino3 SSTA, air-sea feedbacks), examine ENSO performance, dive down diagnostics (including important background fields for context, such as annual means and seasonal cycle).
- ● ENSO Metrics: Public Release & Documentation.
- ● Recent studies using the ENSO metrics package (Lee et al, 2021; Xu et al., 2022; Planton et al., *in prep*; Lee et al., *in prep*)
- ● Community connections:
  - o   CLIVAR/ICTP ENSO summer school.
  - o   CMIP7 Climate model benchmarking task team.
  - o   Connection to other community efforts: PMP, ESMValTool, CliMAF, MDTF, ES-Doc and Comparator.
  - o   Connect to TPOS: obs targetting and new reference data.
- ● Next steps
  - o   Leverage recent enhancements (obs datasets, index statistics, inter-event wait times)
  - o   New metrics in development
  - o   New and proposed projects
- ● Action items for PRP
  - o   Feedback from PRP members on metrics, interfaces, development, dissemination;

- o Recommend new obs references;
- o Recommended realizations / data lengths needed for models and obs;
- o Ideas for new metrics;
- o Ideas for applications & tiering of metrics;
- o Resources (postdocs, web/data tech, funding opportunities).

Discussion:

Q1: Do people know what good models have in common?

A1: Focus on the following questions: How strong is your equatorial Pacific cold/dry/easterly bias? How shallow is your equatorial thermocline? Metrics package allows one to find correlations among different metrics, and how they are related to the background mean state.

Q2: ENSO metrics remain a WG of PRP?

A2: Need to bring new people in. The effort has made steady and substantial progress, with huge potential for further development (especially on ENSO processes/feedbacks, and identifying emergent constraints for ENSO biases & future change). But Yann and Jiwoo are moving on in their careers, and will likely have less time to devote to the project going forward. So we need to pass the torch to another energetic postdoc or two. It'd also be good to have more users and feedback on the package.

1.6 Ocean isotopes (Samantha Stevenson)
- US WG on observation and modelling of water isotopes in the climate system (2018-2021).
  - o Goal: to assess the state of knowledge of water isotope science; identify opportunities for advancing modelling and observational work in the area.
  - o WG sunset but members continue to collaborate. Major products: two review papers.
- Review paper 1: Water Isotopes as Constraints on Climate Variability and the Hydrological Cycle (Dee et al, *in prep*)
  - o Water isotope and scales of climate information: past present and future
  - o The connected water isotope cycle: linking models and observations.
- Review paper 2: water isotopes as constraints on climate sensitivity and feedbacks (Bailey et al., in prep)
- Future outlook/areas of interests for PRP
  - o Long term: need to maintain isotope expertise on PRP
  - o Also maintain dialogue with other working groups:
    - CLIVAR regional panels
    - Community Earth System Model working groups @ NCAR
    - TPOS
  - o PRP can have input into observational strategies, data management practices.
  - o "observations of opportunity" which may arise.

2. Observations and TPOS funded process studies

2.1 NPOCE progress and future perspective (Huizhou on behalf of Fan Wang)

- SSC membership updates: 14 members from 6 countries, Term: 2022-2025. Fan Wang (chair); Janet Sprintal & Fei Chai (Co-chairs).
- Field experiments:
  - Leg1: Nov.2021 – Jan. 2023: in western pacific along Philippine coast; Leg2: Feb. – Apr 2022:
    - 6 moorings retrieved, 9 moorings deployed, 161 CTD stations and water samples in Leg 1&2.
  - Feb.13 – Apr. 13, 2023 (60 stations): along Philippine coast, 1.5N – 5N.
  - Buoy observation in W Pacific by JAMSTEC, 13N, 137E, last over 5 years – to reveal water mass modification in the NE of WP.
  - IOCAS-BRIN joint cruises in Indonesia seas (Apr – May 2023)
  - MINTIE field programme led by Janet is under implementation (Jan to Mar 2023) – quantitative understanding of the ITF and its role in the global overturning circulation.
- **4th open science symposium** on western Pacific Circulation and Climate (Oct. 24-27, Xiamen China and online), 273 registrants from 10 countries; 88 presentations; 1364 participants.
- **NPOCE webinars**: 5 webinars, 16 reports, over 500 participants.
- Collaboration with partner programmes:
- Collaboration on data sharing: NPOCE Global Data Portal (NGDP)
  - SSG member contributed data
  - Existing satellite data links
  - Existing model data links
  - Other data sharing systems
- NPOCE session at AGU 2023.

2.2 TPOS update (Sophie)

2.2.1 TPOS update

- TPOS2020 main outcomes: to enhance and redesign the international tropical, specific observing system.
  - Final meeting was held virtually on 17-18 May 2022
  - 3 reports of recommendations (with extensive review from the broader community): Report 1 (Cravatte et al. 2016); Report 2 (Kessler et al. 2019); Report 3 (Kessler et al. 2021). **– Called for denser obs in cold tongue; more currents & surface fluxes.**
  - Recommendations for backbone, western and eastern pacific region, and pilots and process studies.
  - New website: http://tropicalpacific.org/
- New governance of TPOS:
  - Science Advisory Committee (SAC): co-chaired by Billy Kessler and Fei Chai.
  - ICG: co-chaired by Karen Grissom and Iwao Ueki
- Recommendations for backbone:
  - Reconfiguration of TPOS2020.
  - Plan for an integrated system responding to multiple needs from various users.

- o Implementation:
  - - TPOS China (Ding array pilot study): two cruises, 4 buoys, 20 Argo, data availability issue. Fei Chai & Feng Zhou.
  - - NDBC/NOAA TAO Recapitalization Project.
  - - Air-sea interaction at the north edge of the WP warming pool.
  - - Air-sea interaction at the east edge of the warming pool.
  - - Monitoring the LLWBCs
  - - Pacific upwelling and mixing physics
- ● TPOS in situ implementation to date
  - o Present status: 576 Argo, 36 BGC Argo.
- ● TPOS funded process studies
  - o 8 NOAA-CVP Pre-Field Modelling studies (2018 -2022)
  - o 8 new NOAA-CVP projects (2023-2025)
  - o NCEP-ECMWF-JMA-BOM: planned coordinated OSEs experiments
- ● Top issues to be considered in the future
  - o Traceability and interoperability
  - o Take care of data flow and data quality
  - o Keep track of the whole of the observing system: advocate and monitor all pieces
  - o Continue dialogue with forecasting centers and providers of blended products.

2.2.2 ODYSEA satellite (Ocean Dynamics and Surface Exchange with the Atmosphere)

- ● Will be formally proposed in mid-2023 as a competed mission in NASA's Earth System Explorers program, with a potential launch date in the 2029—2031 timeframe. A revolutionary look at winds and surface currents.
- ● First mission to measure simultaneously the winds and total surface currents
  - o Daily global total surface currents
  - o Wind-current interaction
  - o Near-real time data to meet operational needs in search-and-rescue, weather and climate
- ● Joint effort by NASA (USA) and CNES (France). PI: Sarah Gille (SIO/UCSD, USA)
- ● Two objectives:
  - o S01: To better understand the coupling mechanism (feedback) between currents and winds.
  - o S02: Dynamical ocean processes underlying patterns of surface currents.
- ● Join the discussion:
  - ○ Github; https://github.com/awineteer/odysea-science-simulator
  - ○ webinars, sign up by the form: https://odysea.ucsd.edu

2.3 TPOS funded process study update: Understanding Equatorial Pacific Climate Processes via Hierarchical Coupled Modelling (Andrew Wittenberg)

- ● Motivation: TPOS2020 report called for denser obs (Y&Z) in cold tongue, more currents & surface fluxes.
- ● Key focus: What should TPOS measure to improve understanding, modelling and prediction?
- ● Focus on improving CGCMs for forecasts and projections (Wittenberg et al.), with a focus on equatorial biases in CGCMs. Objectives:

- o Improve the diagnostic hierarchy
- o Advance understanding of the Eq Pac's role in climate and ENSO and of coupled nonlocal feedbacks across scales
- o Attribute & reduce biases
- o Inform the TPOS strategy
- Approach:
  - o Hierarchy of Simulations, metrics and reference datasets.
  - o Main modelling tools: GFDL SPEAR & CM4 global CGCMs (large ensembles & reforecasts, ¼ degree resolution), GFDL MOM6 OMIP2, GFDL ECDA (Ensemble Coupled Data Assimilation system)
- Relevance & broader impacts:
  - ○ TPOS process studies & backbone design – better **observations**
  - ○ Better scientific **understanding**
  - ○ GFDL SPEAR model + ECDA -> NMME -> S2D **forecasts**
  - ○ GFDL-CM5/ESM5 models -> CMIP7 -> IPCC **projections**
- Recent progress:
  - o Completed **SPEAR free & FA ensembles** (1851-2100, 30 members each)
  - o **MOM6 OMIP2** tests (1d, regional, global) vs. Argo & LES
  - o Finalizing & analyzing **SPEAR_HI_25** (0.25°A, 0.25°O)
  - o Revised ePBL mixing → more realistic eqPac upper-ocean diurnal cycle
  - o Reduced vertical viscosity, increased vertical diffusivity → better eqPac dT/dz
- Next Steps
  - o Test/tune ocean mixing improvements in global coupled SPEAR
  - o Finalize SPEAR_HI_25
  - o Monthly CVP/TPOS PI meetings
  - o Postdoc Xian Wu starts at GFDL on 13 March

2.4 TPOS funded process study update: Improved Understanding of air-sea interaction processes and biases in the Tropical Western Pacific using observation sensitivity experiments and global forecast models (Kris Karnauskas)

- Two projects:
  - o 9/2018 – 8/2021: Improved understanding of air-sea interaction processes and biases in the Tropical Western Pacific using observation sensitivity experiments and global forecast models
  - o 9/2022 – 8/2025: Optimizing coupled boundary layer process studies in the tropical Pacific using high-resolution models and in situ observations
- Two papers from project 1:

  - o Paper 1: Tropical Pacific Air-sea Interaction Processes and Biases in CESM2 and their Relation to El Niño Development (Wei *et al.,* 2021, *JGR-Oceans)*

  Summary (without the details) of the impact of mean state biases on ENSO

  - - Composite equatorial SSTA evolution of strong El Nino events
  - - ILD and BLT biases are significant before the onset of El Nino
  - - They influence vertical mixing and entrainment processes (which we calculated), ultimately inhibiting warming

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- Annual cycle also too strong, which aligns with an odd yet consistent "break" in the onset of El Nino events

  o Paper 2: The role of in-situ ocean data assimilation in subseasonal forecasts of the tropical Pacific Ocean (Wei *et al.,* in revision, *QJRMS)*

  - Examining influence (of *in situ* ODA) on both **initial conditions** and **forecast evolution**, since forecast models tend to drift to a model-dependent, biased mean state

  - Using ECMWF-IFS coupled subseasonal forecasts initialized with two OSEs: **with ODA** and **without ODA**

- Focus of project 2:
  o Focusing on barrier layer formation mechanisms, momentum/heat/salt budgets, and air-sea fluxes east & west of the SST front, and the scales required to optimally observe them (temporal, horizontal, vertical)
- Objectives of project 2:
  o Identify and study the physical mechanisms that play a key role in the evolution of the coupled boundary layer and air-sea interaction at the eastern edge of the warm pool.
  o Identify optimal strategies to observe these processes by isolating coupled and uncoupled processes using short-term high resolution coupled and uncoupled regional model experiments and observing system simulation experiments.

3. Workplan for 2023 and onward?

3.1 Member introductions (All)
- Cristian: An ECR with two main lines of research: Pacific climate dynamics, and tropical convection and precipitation extremes.
- Samantha Stevenson: Water isotopes, ENSO response to climate change.
- Jerome: Indo-pacific climate research variability and change, ENSO dynamics, chair of ENSO CM WG.
- Andrew Wittenberg: Interested in ENSO metrics, Tropical Pacific and ENSO climate variability and change, CGCMs.
- Malte: not PRP member, but invited and involved in ENSO CM WG, TPDV WG.
- Kris: climate health.
- Antonietta: former co-chair of PRP. Interested in ENSO, TPDV, Oceanic process related to climate, ocean extreme MHW.
- Sophie (co-chair): SPICE experiment, TPOS, fine scale oceanic processes and marine heatwaves
- Shayne: decadal variability, ENSO, interbasin interaction.
- Yukiko Imada: ENSO and tropical air-sea interaction, extreme event attribution, member of DCPP and WCRP EPESC LHA.
- Jing Jia Luo: TC model prediction, AI for climate prediction improvements.
- Dhruba Samanta: ocean dynamics and sea level changes, MHW changes in EP, TC changes under CC, impact of TP model biases.

- Sayaka: BGC, TPOS BGC group, RECAP, ocean carbon uptake. Japan-Philippines-Indonesia project on MHW and its impacts on coral reef.
- Mike McPhaden: ex-officio of PRP, interested in ocean circulation, climate variability and change. ENSO. Tropical oceans interaction.
- Jing Li: Staff Scientist at International CLIVAR Project Office (ICPO) based in Qingdao, China. Liaison staff to support PRP.

3.2 Marine heatwave CLIVAR research focus (Antonietta)

- Motivation for this RF by reviewing the status of MHW research, and scientific challenges:
  - Problem with the **definition of MHW** (duration threshold, limited daily SST data, climatology): Need to create a common framework among different groups.
  - **Mechanisms** (important for predictability): We need to better isolate the local processes from the large-scale drivers to clarify and exploit sources of predictability.
  - **Subsurface characteristics:** Improved understanding of the subsurface signature of MHWs, including amplitude and persist ENSO (Shaeffer & Roughan, 2017) is needed.
  - **Compound events**: MHW associated other extreme events.
  - **Biogeochemical extremes:** e.g., ocean acidity and low oxygen events.
  - **MHWs in a changing climate:** similar analyses should be systematically extended to climate models.
- Objective and membership of the CLIVAR MHW RF: refer to the [webpage.](#)
- Deliverables: CLIVAR/ICTP MHW Summer school in Trieste (July 2023); set of tools; conference sessions; workshop with participation of GOOS Ocean Observing Co-design and PICES; special collection of paper; review or group papers; inputs to observational group (e.g., PICES WG49).

Discussion:

- Jerome: Impacts on coral and other moving creatures are different. Need to consider the impacts of MHW, short-time but intensified MHW Vs. MHW that has long-term impacts.
- Sayaka: Seasonality is important for BGC impacts (coral reef blooming in spring and autumn). Coral reef impacts is not impacted anomaly, but the total temperature itself. It is different from the definition of MHW.
- Sophie: new TT on MHW impacts on top predators in the Tropical Oceans in the framework of CLIOTOP/ May potentially linked with MHW RF.
- Jing-Jia: timescale of MHW, 3-5 days.
- Antonietta: need to consider the impacts in the MHW definition.

3.3 Future PRP research topics (round table)

A summary of past PRP activities can be found in the [PRP 2022 annual report](#). However, there are not large-scale activities that the whole community is working on. There used to be an [ENSO forecasts webpage](#) on CLIVAR website, summarizing the models and model assessments, real-time observations and ocean analysis related to ENSO forecasts.

- MHW RF/ PICES/SPC (explore South Pacific Links) (Antonietta, Cristian, and Sayaka).
  - Make a bigger link with South Pacific islands; This could be achieved through better links with the Pacific Community (SPC: https://www.spc.int/) and its department focusing on tuna fisheries (https://oceanfish.spc.int/).

- Measuring upwelling rate (PUMP covering this) (Kris).
- **Observed and projected warming pattern across the Pacific (Jerome):**
  - Simple models based on physical processes (Zhang and Li, 2014; Xie et al., 2010)
- **Model biases -> equatorial cold tongue biases (Mike McPhaden).**
- AI - > many uses including model bias reduction (Jing-Jia)
  - Investigate the existing effort within CLIVAR (e.g., OMDP).
- Data access, quality of reanalysis, community engagement:
  - Integrated effort in publishing datasets, e.g., South America mooring data.
  - Data access: climate data guide, but still issues getting observation data.
- May consider collaborating with CLIVAR Global Synthesis and Observation Panel (GSOP). There used to be a webpage maintained by GSOP to collect the resources for Ocean Synthesis/Reanalysis Efforts.
- Pattern of atmospheric teleconnections, including models, flavors, and impacts on background state (linked with model biases) and **in a changing climate**. Expanding from tropical Pacific focus to other parts of the Pacific, as recommended by CLIVAR SSG.
- Midlatitude (e.g., 15-yr drought in Chile). Stochastic forcing of ENSO.
- Overlapping/potential links to WCRP My Climate Risk LHA, EPESC LHA.
- **Sea level rise (pattern) in the Pacific.**
- Led by Mike McPhaden, Malte Stucker, and Christina Karamperidou, **a US CLIVAR prospectus for a possible symposium & summer school on "ENSO: Past, Present, & Future --- Celebrating the Scientific Legacy of Klaus Wyrtki.**" is being developed. This would be targeted for U. Hawaii in 2025 (centered on their spring break, roughly 12-21 March 2025). Planning is in very early stages, but committees have formed and we met (virtually) in early May. If it works out, this could be a great contribution to the WCRP Academy.

Action 6: focus during the new telecon on some of these subjects that the PRP would like to develop in the coming years.

3.4 Can the diverging observed and modelled changes in the Pacific be reconciled? (Shayne)

- Why does spatial pattern matter?
  - The spatial pattern, particularly the central/eastern Pacific relative to the rest of the tropics, acts to modulates the surface warming level.
  - Wind changes driven by SST gradients can create regional variations in the Sea level rise.
  - This includes the dramatic acceleration of W Pacific Sea level between 1990-2010, can be largely explained by wind stress change.
  - Climate sensitivity (AR6)/
  - Projected changes: **'warmer gets wetter'**; amplification of atmospheric response to ENSO; associated projected teleconnection amplification.
- Detail the discrepancies the modelled and observed changes
  - Longer term trends (patterns): clear divergence between model predicted trends and observed trend. ENSO's role in the observed trend.
  - How about forcing on a period where we have more confidence in the observations? So since the international geophysical year.
  - How about focusing on the observations during altimeter record?

- Observed temperature trends in the central and eastern Pacific are largely outside of the range of modelled trends in the region. We have more confidence in this statement in the more recent periods as the observational uncertainty is smaller.
- Causes for the model/observed discrepancy:
  - Model under-representation of internally driven decadal variability
  - Observational errors?
  - Model mis-representation of the response to anthropogenic forcing
- Way forward:
  - To determine whether the observed record of a strengthening zonal SST gradient is indeed a forced response, or a product of natural variability on decadal and longer timescales, or perhaps even a combination or both; or perhaps obs data and sampling problems underpin this discrepancy?
  - Fundamental analysis of mechanisms of variability and change in obs and models, considering all the relevant physical processes.
  - To correct biases in the mean state precipitation and SST, and process representation of models in the tropical regions.
  - A storyline approach could provide a possible way to describe risks to users.

3.5 Tropical Pacific SST trends Working Group (Malte Stuecker, invited)
- Motivation: Review paper by Cai et al. ([2021](#)).
- A proposal for CLIVAR RF has been submitted but unfortunately not funded.
- Urgent need to coordinate research effort on the topic given its global importance spanning multiple subfields of climate change:
  - **CLIVAR Pacific Region Panel (PRP):** whether the observed trends are due to internal variability or (partially/transiently) forces.
  - **WCRP CFMIP:** impacts of tropical Pacific SST pattern on global radioactive responses and the estimates of equilibrium climate sensitivity (ECS). [US CLIVAR workshop on the Pattern Effect: Coupling of SST Patterns, Radiative, Feedbacks, and Climate Sensitivity](#).
  - **CLIVAR Climate Dynamics Panel (CDP):** Potential impacts of extra-tropical inter-hemispheric energy imbalance on tropical Pacific climate.
- Proposal for a joint CLIVAR/CFMIP WG: **TRO**pical **P**ac**I**fi**C** SST warming pattern**S** ([TROPICS](#)) – already approved by CLIVAR SSG.
  - Three components:
    - Air-sea interaction (CLIVAR PRP, Cai et al., 2021; Timmermann et al., 2018)
    - Global Dynamics (CLIVAR CDP, Collins et al., 2018)
    - Cloud and radiation (WCRP Cloud Feedback Model Intercomparison Project, Webb et al, 2017; Bony et al, 2015)
  - No need to get CLIVAR SSG's approval for the WG, but could document the ToR and get comments from SSG. No implication for financial support from WCRP/CLIVAR.

Action 7: To identify possible membership from PRP to the new TROPICS WG (Shayne, Antonietta, Kris, Jerome, Samantha).

Annex A: Agenda

09:00 – 17:00, GMT+11, 13ᵗʰ February 2023
Virtual access (Zoom Meeting ID: 81236460705; Passcode: 708429)

Time	Topic	Speaker
	1.Updates on panel activities	
9am	1.1 Opening	Shayne/ Sophie/Antonietta
09.10-09.30	1.2 ENSO conceptual model working group	Jerome
09.30-09.50	1.3 TPDV working group	Antonietta
09.50-10.00	1.4 ENSO summer school (Antonietta)	Antonietta
10.00-10.15	1.5 ENSO metrics: Status and next steps	Andrew
10.15-10.30	1.6 Ocean isotopes	Samantha Stevenson
10.30-11.00	Coffee break	
	2. Observations and TPOS funded process studies	
11.00-11.15	2.1 NPOCE update	Fan Wang
11.15-11.40	2.2 TPOS update	Sophie
11.40-12.05	2.3 *TPOS funded process study update*: Understanding Equatorial Pacific Climate Processes via Hierarchical Coupled Modelling.	Andrew Wittenberg
12.05-12.30	2.4 *TPOS funded process study update:* **Improved Understanding of air-sea interaction processes and biases in the Tropical Western Pacific using observation sensitivity experiments and global forecast models.**	Kris Karnauskas
12.30-13.30	Lunch break	
	3. Workplan for 2023 and onward?	
13.30-13.50	3.1 Member introductions	All
13.50-14.30	3.2 Marine heat wave CLIVAR research focus	Antonietta
14.30-15.00	3.3 Future PRP research topics (round table)	All
15.00-15.30	Coffee break	
	3. Workplan for 2023 and onward?	
15.30-16.00	3.4 Can the diverging observed and modelled changes in the Pacific be reconciled?	Shayne
16.00-16.30	3.5 Tropical Pacific SST trends Working Group	Malte Stuecker
16.30-17.00	3.6 Discussion	All

Annex B: List of Participants

Name	Affiliation	Country	Role	Attendance
Shayne McGregor	Monash University	Australia	Co-Chair	In-person
Sophie Cravatte	LEGOS/IRD	France/New Caledonia	Co-Chair	In-person
Antonietta Capotondi	NOAA Physical Sciences Laboratory	USA	Member	In-person
Samantha Stevenson	University of California at Santa Barbara	USA	Member	In-person
Andrew Wittenberg	NOAA GFDL	USA	Member	In-person
Fan Wang	IOCAS	China	Member	Online
Jing-Jia Luo	NUIST	China	Member	In-person
Ivonne Montes	Geophysics Institute of Peru	Peru	Member	
Kristopher Karnauskas	University of Colorado Boulder	USA	Member	In-person
Andrea Taschetto	University of New South Wales	Australia/Brazil	Member	In-person
Cristian Martinez Villalobos	Universidad Adolfo Ibáñez	Chile	Member	In-person
Tsubasa Koyama	Ochanomizu University	Japan	Member	Online
Dhrubajyoti Samanta	Nanyang Technological University	Singapore	Member	Online
Sayaka Yasunaka	Tohoku University	Japan	Member	Online
Michael McPhaden	NOAA/PMEL	USA	Ex-officio	In-person
Jerome Vialard	IRD/LOCEAN-IPSL	France	Former member	In-person
Yukiko Imada	MRI-JMA	Japan	Former member	In-person
Yu Kosaka	The University of Tokyo	Japan	Former member	Online
Malte Stuecker	University of Hawaii at Manoa	USA	Invited	In-person
Jing Li	International CLIVAR Project Office	China	Secretariat	Online

Group photo of PRP-15