46th Session of the World Climate Research Programme

Joint Scientific Committee

CLIVAR

Climate and Ocean: Variability, Predictability, and Change

Cochairs: Francois Engelbrecht & Gokhan Danabasoglu

ICPO Director: Agus Santoso

13 May 2025

WCRP World Climate Research Programme

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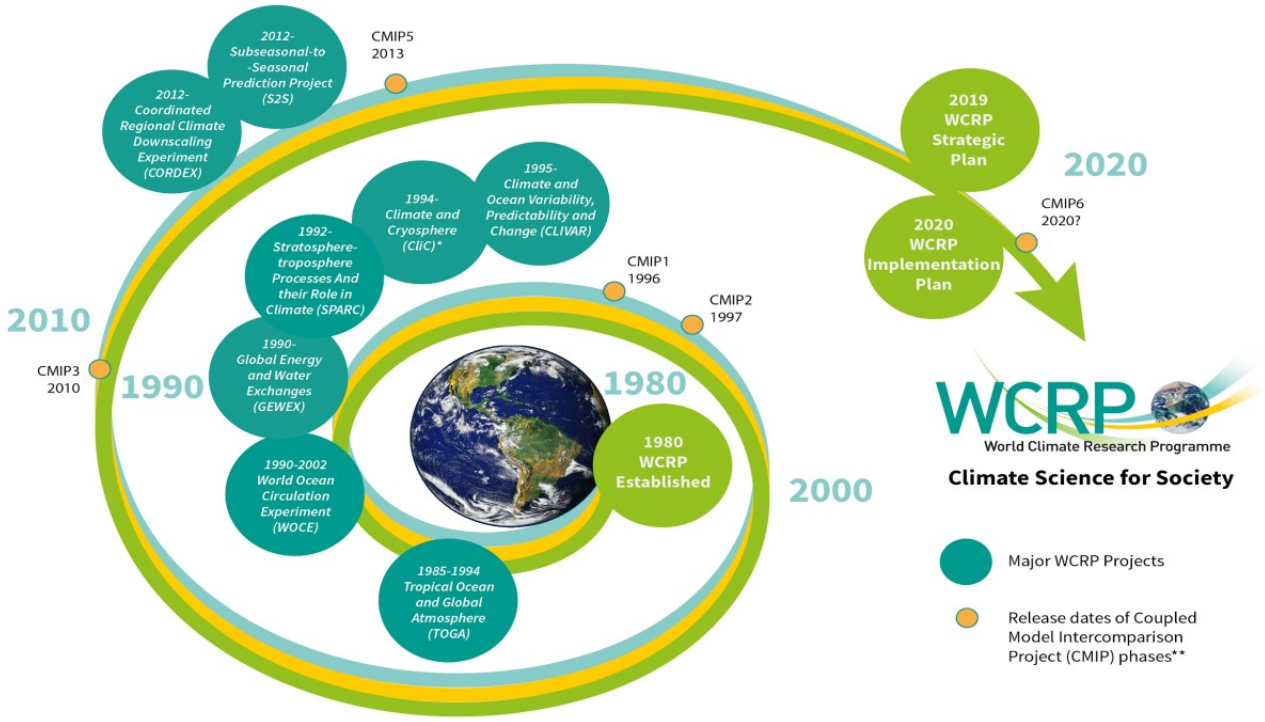
Outline

- Brief introduction to CLIVAR
- Key highlights
- New efforts
- Future plans and priorities
- Challenges



CLIVAR's **objective** is to facilitate observations, analysis, predictions, and projections of variability and changes in the Earth's climate system, with emphasis on ocean-atmosphere interactions, to the benefit of society and the environment in which we live.

CLIVAR was established in 1995 as one of the core-projects of the World Climate Research Programme, building on WOCE and TOGA.

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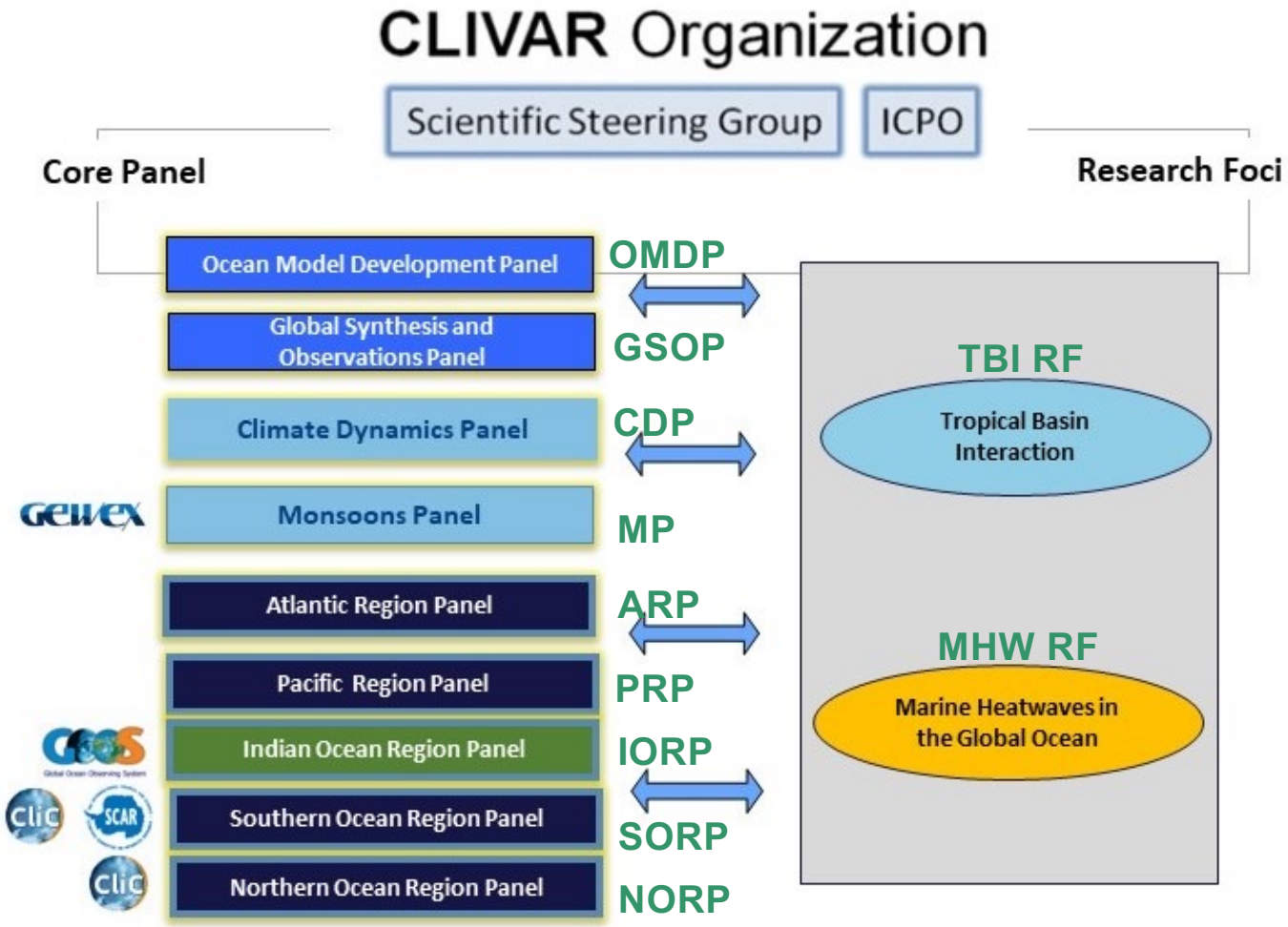


The CLIVAR SSG provides overall guidance for CLIVAR activities, in concert with WCRP objectives, and establishes CLIVAR Panels and Working Groups (+Task Teams) and their terms of reference.

Research Foci address urgent and actionable research challenges. RFs have a limited life-time (3-5 yrs).

CLIVAR Marine Heat Waves in the Global Ocean RF

communications earth & environment

Review article

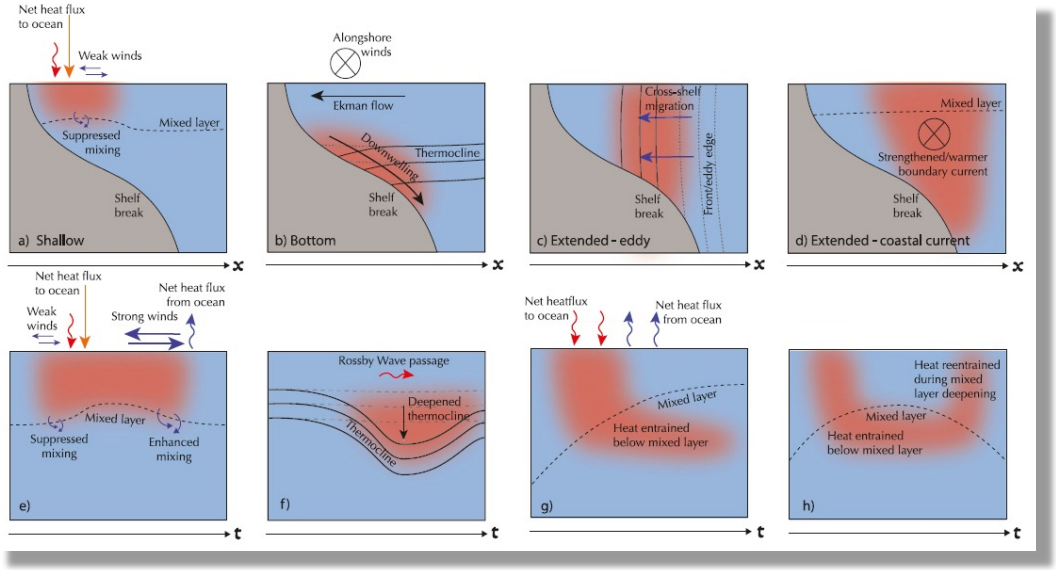
https://doi.org/10.1038/s43247-024-01806-9

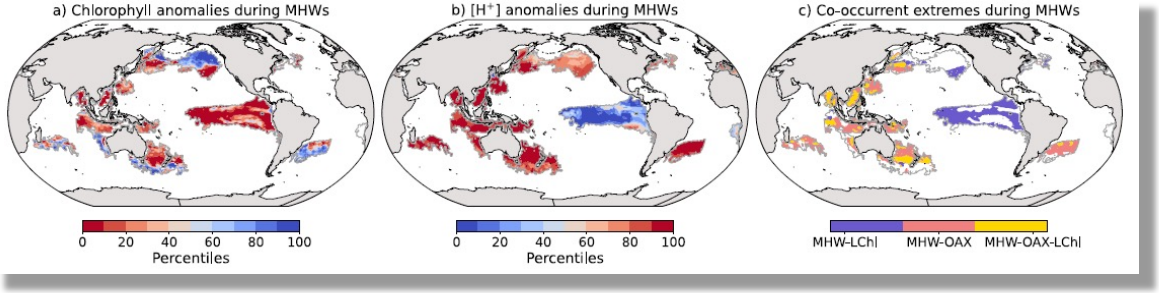
A global overview of marine heatwaves in a changing climate

Check for updates

Antonietta Capotondi[1,2] ✉, Regina R. Rodrigues[3], Alex Sen Gupta[4,5], Jessica A. Benthuysen[6], Clara Deser[7], Thomas L. Frölicher[8,9], Nicole S. Lovenduski[10], Dillon J. Amaya[2], Natacha Le Grix[8,9], Tongtong Xu[1,2], Juliet Hermes[11], Neil J. Holbrook[12,13], Cristian Martinez-Villalobos[14,15], Simona Masina[16], Mathew Koll Roxy[17], Amandine Schaeffer[18,19], Robert W. Schlegel[20], Kathryn E. Smith[21] & Chunzai Wang[22,23,24]

Marine heatwaves have profoundly impacted marine ecosystems over large areas of the world oceans, calling for improved understanding of their dynamics and predictability. Here, we critically review the recent substantial advances in this active area of research, including the exploration of the three-dimensional structure and evolution of these extremes, their drivers, their connection with other extremes in the ocean and over land, future projections, and assessment of their predictability and current prediction skill. To make progress on predicting and projecting marine heatwaves and their impacts, a more complete mechanistic understanding of these extremes over the full ocean depth and at the relevant spatial and temporal scales is needed, together with models that can realistically capture the leading mechanisms at those scales. Sustained observing systems, as well as measuring platforms that can be rapidly deployed, are essential to achieve comprehensive event characterizations while also chronicling the evolving nature of these extremes and their impacts in our changing climate.

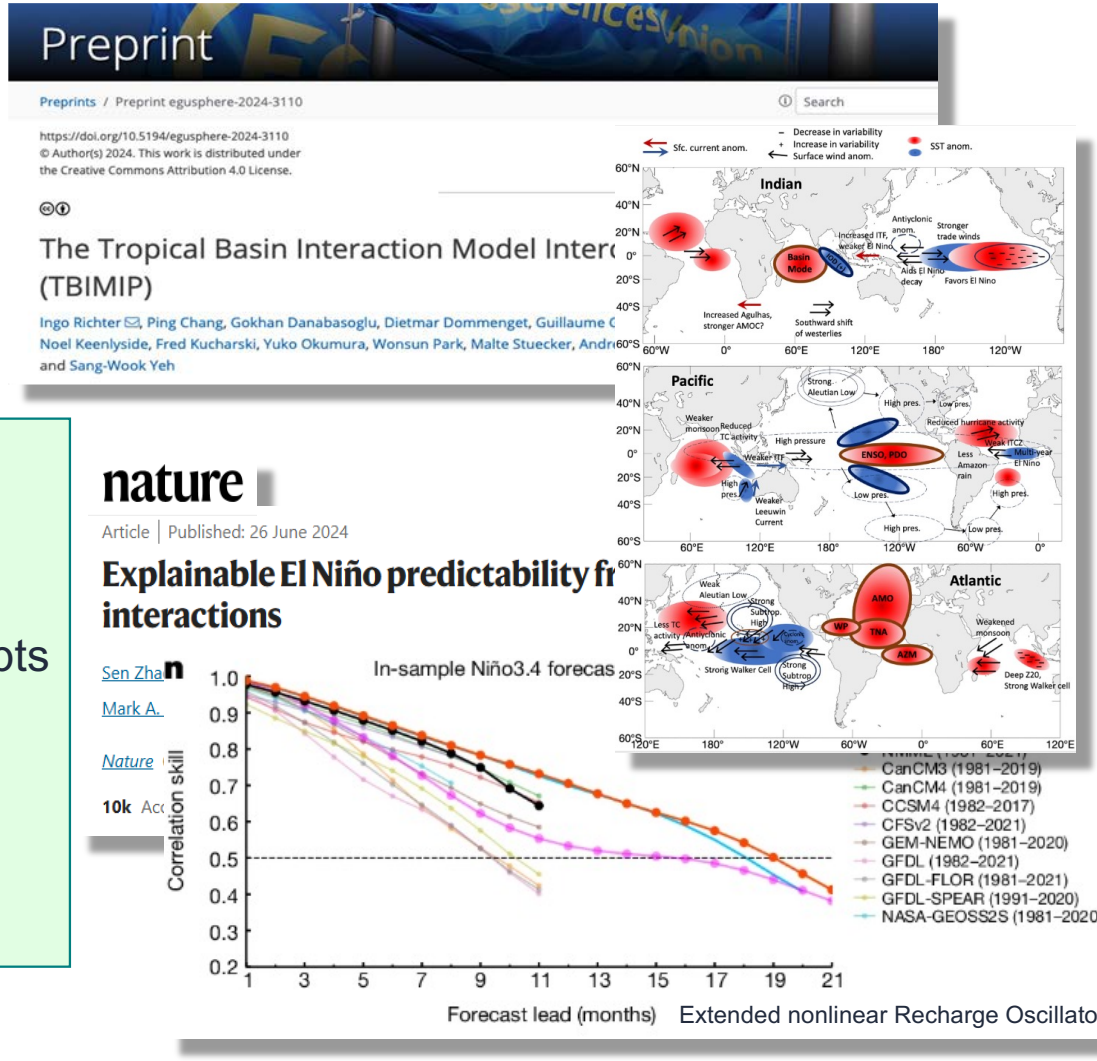




CLIVAR Tropical Basin Interaction RF sunsetting in 2025

TBI RF has 4 Working Groups:

- WG1: Coordinated GCM Experiments
- WG2: Conceptual and Intermediate Complexity Models and Statistical Approaches
- WG3: Observations
- WG4: Paleo Proxies



What's next for TBI RF

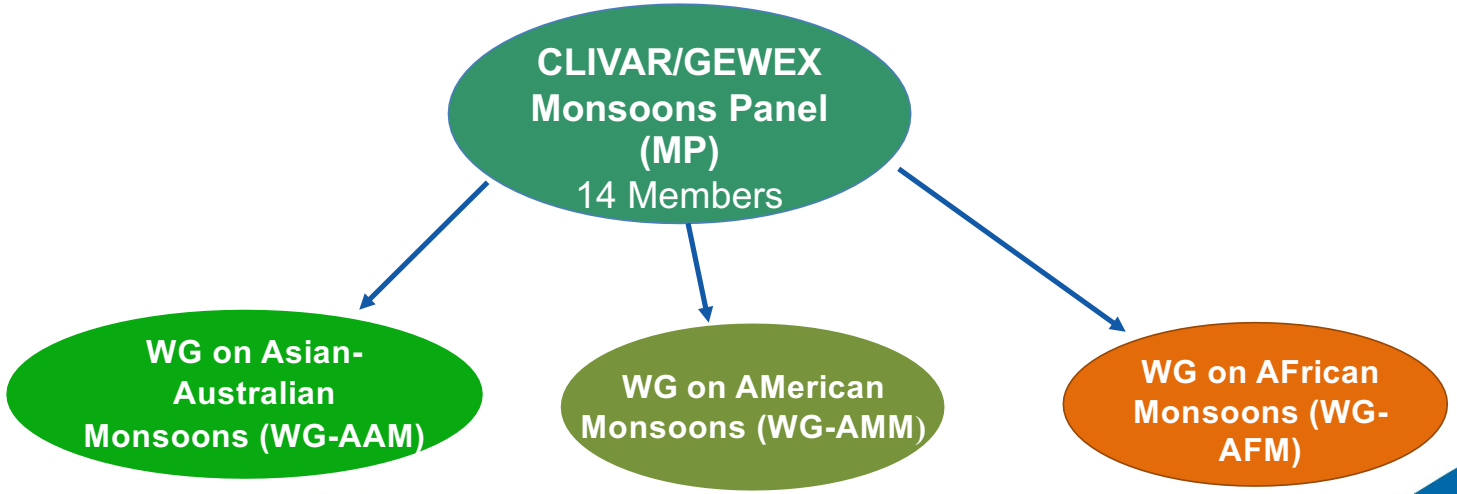
- TBI RF meeting at Pan-CLIVAR Meeting in Indonesia
- analyze TBIMIP output; submit 1-2 manuscripts
- make TBIMIP output available to public
- publish TBI/AMV review paper
- integrated review (combining 4 WGs)
- continue TBI Webinar series

Working Groups / Task Teams

Panel structure: Monsoon Panel (MP) & 3 regional Working Groups (WG)

Regional WGs are:

- tasked with identifying priority areas for targeting advances; and
- relatively flexible to organize themselves under the guidance of MP



Three working groups of Atlantic Region Panel

- **AMOC**
- **Ocean Climate Risk** – linked to WCRP Lighthouse Activity My Climate Risk, CLIVAR Marine Heatwaves RF, other CLIVAR panels
- **Tropical Atlantic** – linked to CLIVAR TBI RF

Task Teams:
e.g., SOFIA of Southern Ocean Region Panel

Southern Ocean Freshwater Input from Antarctica (SOFIA) Initiative

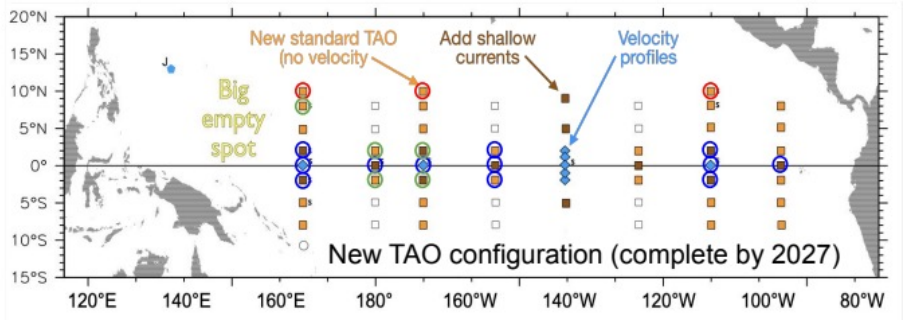
SOFIA proposes a standardized Southern Ocean freshwater forcing protocol to quantify the impact of missing Antarctic meltwater on climate simulations across multiple models

- Coordinates a model intercomparison (>11 models, growing) to test meltwater-climate feedbacks in idealized, historical, and future scenario contexts with a focus on quantifying model uncertainty in the response

https://sofiamip.github.io/ **mail.sofiamip@gmail.com**

New Efforts

PRP is leading efforts to fill observational gaps in the Western Tropical Pacific, also assessing impacts of gaps.



PRP Working Group on **Tropical Pacific BGC-Physical Interactions** to bring together the community across physical and biogeochemical disciplines to identify and advance research questions and observing and modeling needs for understanding ocean biogeochemical (BGC) cycles and their interactions with climate and ocean dynamics in the tropical Pacific (TP).

IORP Task Team on **Quantitative evaluation of the Indian Ocean Observing System** to evaluate the impacts of IndOOS data losses during COVID on model-based analyses, simulations, and forecasts of Indian Ocean Dipole (IOD), Madden-Julian Oscillation (MJO), and monsoons.

New Efforts

OMDP Working Group on **Ocean Model Intercomparison Project (OMIP).**

Geosci. Model Dev., 9, 3231–3296, 2016
www.geosci-model-dev.net/9/3231/2016/
doi:10.5194/gmd-9-3231-2016

Geoscientific Model Development
Open Access
EGU

OMIP contribution to CMIP6: experimental and diagnostic protocol for the physical component of the Ocean Model Intercomparison Project

Stephen M. Griffies[1], Gokhan Danabasoglu[2], Paul J. Durack[3], Alistair J. Adcroft[1], V. Balaji[1], Claus W. Böning[4], Eric P. Chassignet[5], Enrique Curchitser[6], Julie Deshayes[7], Helge Drange[8], Baylor Fox-Kemper[9], Peter J. Gleckler[3], Jonathan M. Gregory[10], Helmuth Haak[11], Robert W. Hallberg[1], Patrick Heimbach[12], Helene T. Hewitt[13], David M. Holland[14], Tatiana Ilyina[11], Johann H. Jungclaus[11], Yoshiki Komuro[15], John P. Krasting[1], William G. Large[2], Simon J. Marsland[16], Simona Masina[17], Trevor J. McDougall[18], A. J. George Nurser[19], James C. Orr[20], Anna Pirani[21], Fangli Qiao[22], Ronald J. Stouffer[1], Karl E. Taylor[3], Anne Marie Treguier[23], Hiroyuki Tsujino[24], Petteri Uotila[25], Maria Valdivieso[26], Qiang Wang[27], Michael Winton[1], and Stephen G. Yeager[2]

Create and maintain the next generation of atmospheric forcing datasets based on ERA5/6 for use in OMIP

New Efforts

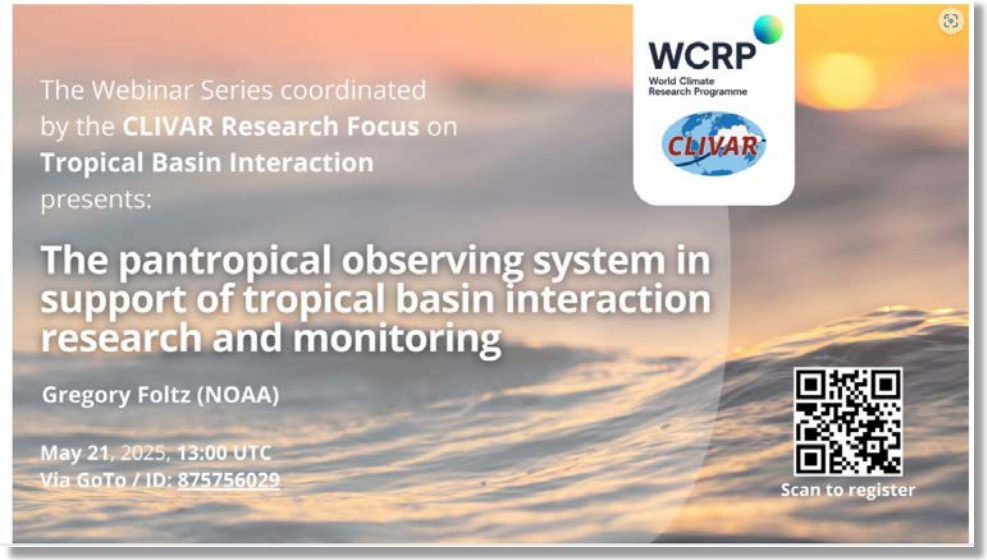
OMDP & RIfS CORDEX Task Team on **Regional Ocean-Climate Projections** to develop coordinated simulation protocols and deliver standardised datasets towards coordinated regional ocean-climate projections.

PRP Working Group on **Pacific Atmospheric Teleconnections in a wArming Climate (PATAC)** to consolidate current knowledge of atmospheric teleconnections and enhance our understanding of their potential changes in a warming future.

CDP **TROPICS** Working Group aims to bring communities together to resolve the important issue of model-observation discrepancy in tropical Pacific sea surface temperature trend pattern.

Regular Webinars

- PROS4SORP: Presenting Recent Ocean Science for the Southern Ocean Region Panel
- WCRP/WWRP Webinar Series organized by the CLIVAR/GEWEX Monsoons Panel
- More seminar series are planned (TBI, MHW, ENSO)



Research Foci (RF) are focused research activities on topics with high potential for significant progress in a 3-5-year time-scale, and that would benefit from enhanced international coordination.

The topics should be aligned with the CLIVAR Science Plan, in particular they should focus on one of the following scientific priorities;

1. **Mechanisms of climate variability and change** that require further investigation with the ultimate goal of better constraining the fluxes of energy and carbon in the climate system;

2. **Ocean processes** that modulate climate variability and change for which open questions remain;

3. **Climate predictability** challenges that exist over a broad range of space and time scales.

Current research foci:

MHW in the Global Ocean (2023-2027)

Tropical Basin Interaction (2020-2025)

Former research foci:

Eastern Boundary Upwelling Systems

Decadal climate variability and predictability

Prediction and Attribution of Extreme Events

ENSO in a changing climate

Planetary heat balance and ocean heat storage

Application deadline: **15 June 2025**

In-person and online

- **Meetings**:
  - individual panels
  - Cross-panels
  - SSG
  - CLIVAR partners (inc. WCRP core projects)
- **Plenary Sessions**
- **1-day Symposium (24 Sep. + morning of 25 Sep.)**

The Pan-CLIVAR Meeting 2025 will bring together CLIVAR members from all panels, research foci, and SSG, as well as invited representatives from WCRP core-projects and external partners with the aims to:

1. **develop ideas and input for the next CLIVAR science and implementation plans;**
2. foster interactions across panels, WCRP core projects, and partners;
3. evaluate progress, formulate future priorities, and enhance members cohesion;
4. establish new research foci; and
5. engage scientists and stakeholders in southeast Asia.

Participation to Pan-CLIVAR Meeting is by invitation only and is prioritised for CLIVAR members, partners, and the WCRP activities. The Symposium, however, is open to all, subject to seat limitation.

Addressing funding challenges

- Reduced event duration to save on accommodation costs;
- Charging registration fees;
- Encouraging members to cover their own expenses to the extend possible;
- Requested funding from the Ocean University of China and Laoshan Laboratory that may add up to CHF 50K.

Summer School Agreement

Agreement

on the establishment of the World Climate Research Programme, Climate and Ocean: Variability, Predictability and Change Summer School

Signed Oct 2017

The agreement is between the First Institute of Oceanography of the State Oceanic Administration of China (FIO) and the World Meteorological Organization (WMO) on behalf of the World Climate Research Programme (WCRP)

This agreement is valid for 5 years starting from the date of signature and may be renewed subject to the consensus of FIO and WCRP.

Ocean University of China (ICPO host) is interested in a new agreement.

Major Planned Activities for 2026

Workshop on Ocean Heat in Polar Regions and Connections to Lower Latitudes

Joint with polar- and model-focused panels of CLIVAR (NORP, SORP, ARP, OMDP) and CliC

February 2026, Glasgow, Ocean Science Meeting

CLIVAR/GEWEX Monsoons Panel training school on Monsoon Prediction Capabilities for Developing Nations

November 2026, IITM Pune, India

Panel activities, as well as other workshops (Climate Dynamics Panel Workshop and Pacific Panel Workshop on Biogeochemical Physical-Interaction)

Also supporting WCRP CliC-GEWEX-GPEX-CLIVAR Joint Workshop on Mountain Hydroclimates: Advancing Understanding of Uncertainty, Variability, and Predictability

Challenges

Impacts of US funding withdrawal

US CLIVAR funding in jeopardy along with reduced US participation

Engagement in virtual meetings across time zones

Meaningful engagement with other core projects, etc.

Thank You

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Update on Global Synthesis and Observations Panel (GSOP)

GSOP Goals:

- Develop and promote ocean, atmosphere, and climate model-data synthesis;
- Define requirements for sustained observing;
- Develop metrics for assessing reanalyses;
- Engage with various other panels and working groups;
- Demonstrate data impacts (including future observing platforms); and
- Perform and promote model/reanalysis validation and data rescue.

To reinvigorate the panel:

- Established cross-panel links with GSOP members acting as liaison to other CLIVAR panels
- Maintained links to Argo
- Strengthened links with OceanPredict
- Formed Task Team on Coupled Prediction, Data Assimilation, Machine Learning, and Marine Environment Reanalysis Intercomparison Project

New initiatives:

- **Machine Learning** offering guidance to the community using machine learning in GSOP-related domain.
- **Metrics** seeking better ways to evaluate reanalysis, forecast, and coupled systems

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Pacific Region Panel (PRP) is spearheading efforts to fill observational gaps in the Western Pacific

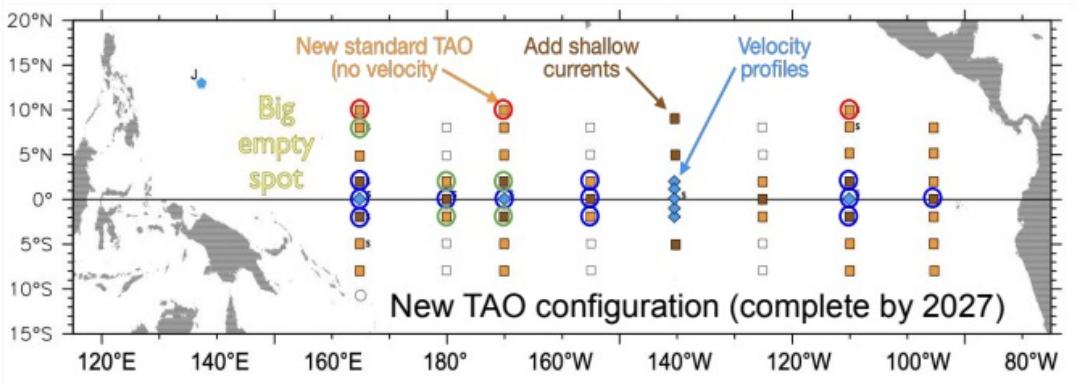
Abstract submitted to Pan-CLIVAR Symposium

An absence of moorings in the western Tropical Pacific: what are the main consequences and risks to climate research and prediction?

Sophie Cravatte et al.

- The Tropical Pacific Observing System (TPOS), established more than 40 years ago, now consists of many platforms, including satellite constellations and Argo floats
- One key component of TPOS is the backbone moored array, with a unique ability to provide collocated oceanic and surface atmospheric observations at high temporal resolution.
- The TAO-TRITON moored array suffered from deterioration to the eastern Pacific TAO array in 2012, followed by a decommissioning of the western Pacific TRITON array since 2014

Moorings west of 165°E is currently absent, and poses an immediate risk to TPOS capability and our ability to observe, understand and forecast ocean-atmosphere coupled variability

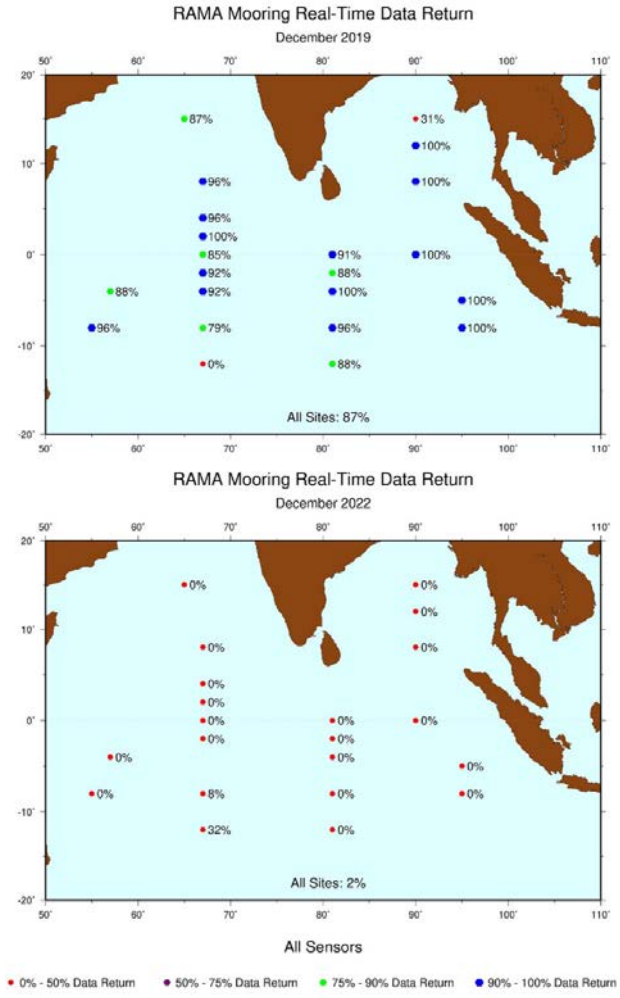


New Working Groups and Task Teams

IORP formed a New Task Team (QIndOOS - Quantitative evaluation of the Indian Ocean Observing System to improve climate forecasts).

- To evaluate the impacts of IndOOS data losses during COVID on model-based analyses, simulations, and forecasts of Indian Ocean Dipole (IOD), Madden-Julian Oscillation (MJO), and monsoons;
- To assess the optimization of the IndOOS using OSSEs;
- To collaborate with other CLIVAR panels and focus groups for coordinating scientific initiatives.

They are proposing to SCOR to have this included as a SCOR working group, framed in a global perspective, but with Indian Ocean as a pilot case under uncertainties in international affairs, e.g., pandemic, institutional funding.



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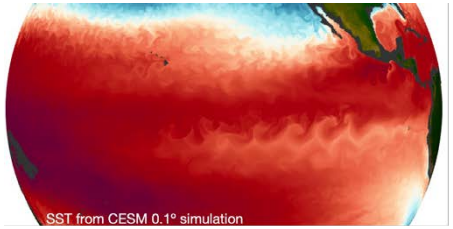
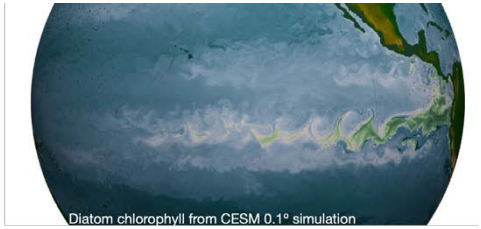
New PRP Working Group: Tropical Pacific BGC-Physical Interactions





Mission: *To Bring together the community across physical and biogeochemical disciplines to identify and advance research questions and observing and modeling needs for understanding ocean biogeochemical (BGC) cycles and their interactions with climate and ocean dynamics in the tropical Pacific (TP).*

Engagement with IMBeR

Themes:

1. How does TP climate and ocean dynamics modulate ocean BGC? e.g. **how do transport and climate variability (e.g. ENSO) influence carbon flux/export**, nutrients/productivity, & OMZ?

2. How does TP ocean biogeochemistry affect ocean physics/climate? e.g. via SW attenuation, ENSO, aerosol modulation of clouds, N2O production, carbon outgassing, etc.?

3. How can biogeochemical tracers inform our understanding of climate and physical ocean processes? E.g. how can variability in OMZs inform changes in Water mass sourcing, mixing and upwelling?

New CLIVAR OMDP Ocean Model Intercomparison Project (OMIP) Working Group

Objectives:

- Oversee and coordinate activities under OMIP
- Promote international collaboration among model developers and users
- Serve as a hub for communication between participating institutions, helps maintain and evolve OMIP protocol suite, and provides guidance on technical implementation
- Encourage open data sharing, reproducibility of results, and dissemination of best practices (e.g., model tuning strategies, diagnostic methods)
- Foster commitment to advancing fidelity and utility of global ocean modeling in support of climate science
- Create and maintain the next generation of atmospheric forcing datasets for use in OMIP

Geosci. Model Dev., 9, 3231–3296, 2016
www.geosci-model-dev.net/9/3231/2016/
doi:10.5194/gmd-9-3231-2016

OMIP contribution to CMIP6: experimental and diagnostic protocol for the physical component of the Ocean Model Intercomparison Project

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New CLIVAR OMDP/RIfS CORDEX Task Team on Regional Ocean-Climate Projections

Motivation:

- Need to provide refined regional information relevant for societal services and adaptation measures
- Need for dynamical downscaling approaches as most coupled global climate models will not be able to run with high-resolution ocean models
- Lack of international coordination of regional ocean modelling and climate projections

Mission:

- Develop coordinated simulation protocols and deliver standardised datasets towards coordinated regional ocean-climate projections
- Advance the science of regional ocean climate modelling and projections, through multi-model assessments, identification of biases and underlying processes
- Provide a forum for regional ocean modelers and model users to share knowledge and experience
- Serve climate impact and adaptation needs by engaging with users/stakeholders and providing data and expertise to ocean climate services
- Contribute to international and regional expert assessment reports

Pacific Atmospheric Teleconnections in a wArming Climate (PATAC)

*The working group, hosted by the CLIVAR **Pacific Region Panel**, aims to consolidate current knowledge of atmospheric teleconnections and enhance our understanding of their potential changes in a warming future. The group will investigate interactions across spatial-time scales, ranging from large-scale interannual variability to regional synoptic patterns and extremes with societal impacts. The focus will be on the mechanisms of atmospheric teleconnections associated with Pacific variability and their effects over land through extreme events such as heatwaves, floods, and droughts.*

"TROPICS" working group aims to bring communities together to resolve the important issue of model-observation discrepancy in tropical Pacific sea surface temperature trend pattern.

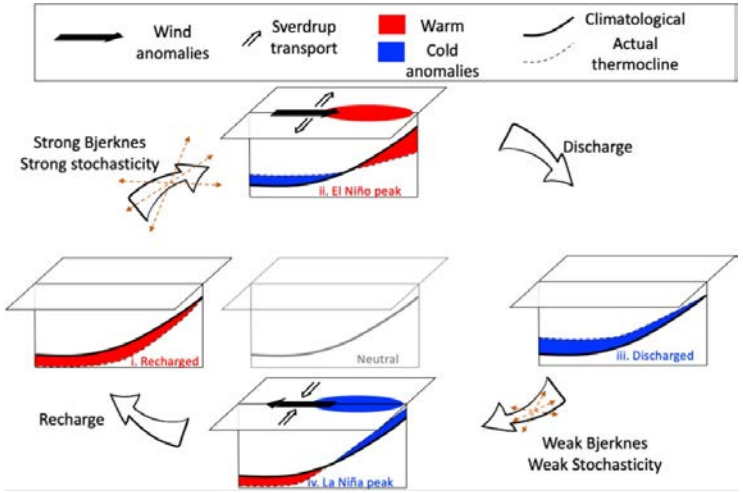
Watanabe, M., et al., 2024: Possible Shift in Controls of the Tropical Pacific Surface Warming Pattern. ***Nature****,* doi: 10.1038/s41586-024-07452-7

Reviews of Geophysics

Review Article | Open Access

The El Niño Southern Oscillation (ENSO) Recharge Oscillator Conceptual Model: Achievements and Future Prospects

J. Vialard, F.-F. Jin, M. J. McPhaden, A. Fedorov, W. Cai, S.-I. An, D. Dommenget, X. Fang, M. F. Stuecker, C. Wang, A. Wittenberg, S. Zhao, F. Liu, S.-K. Kim, Y. Planton, T. Geng, M. Lengaigne, A. Capotondi, N. Chen, L. Geng, S. Hu, T. Izumo, J.-S. Kug, J.-J. Luo, S. McGregor, B. Pagli, P. Priya, S. Stevenson, S. Thual



- The recharge oscillator (RO) simple mathematical model explains most of El Niño Southern Oscillation (ENSO) key properties
- The RO can be extended to account for ENSO pattern diversity (some events peak in the central, others in the eastern equatorial Pacific)
- We propose research avenues for using the RO to address the influence of climate change and other climate modes on ENSO

One of the tasks that the ENSO conceptual model working group will soon undertake is to publish a technical paper on the RO technical implementation and numerics, along with a RO tools distribution in python.

CLIVAR Tropical Basin Interaction RF sunsetting in 2025

TBI RF has 4 Working Groups

WG1: Coordinated GCM Experiments

- TBIMIP: pacemaker experiments in which SSTs are prescribed in selected basins to follow the observed values.
- A manuscript on experiment design has been accepted in GMD.

https://egusphere.copernicus.org/preprints/2024/egusphere-2024-3110/

- Analysis of the data is underway.
- TBIMIP registered on CMIP website

Status of TBI MIP

Model	Center	Type of expmnt	Status
CESM2	NCAR	hindcast+standard	completed
CESM2	SCSIO, China	Tier 2 expmnts	completed
NorCPM	U. of Bergen	hindcast+standard	completed
SINTEX-F2	JAMSTEC	pmaker hindcast	completed
MIROC6	JAMSTEC	hindcast+standard	completed
IPSL-CM6A-LR	IPSL, France	standard pmaker	completed
ACCESS-CM2	CSIRO, Australia	standard pmaker	in preparation
ACCESS-CM2	CSIRO, Australia	Tier3 expmnts	completed

CLIVAR Tropical Basin Interaction RF sunsetting in 2025

WG2: Conceptual and Intermediate Complexity Models and Statistical Approaches

nature

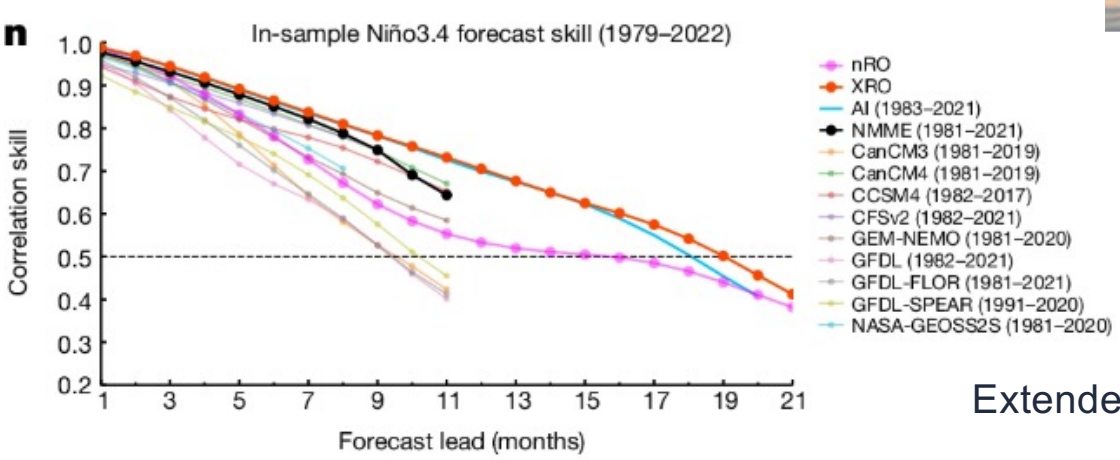
Article | Published: 26 June 2024

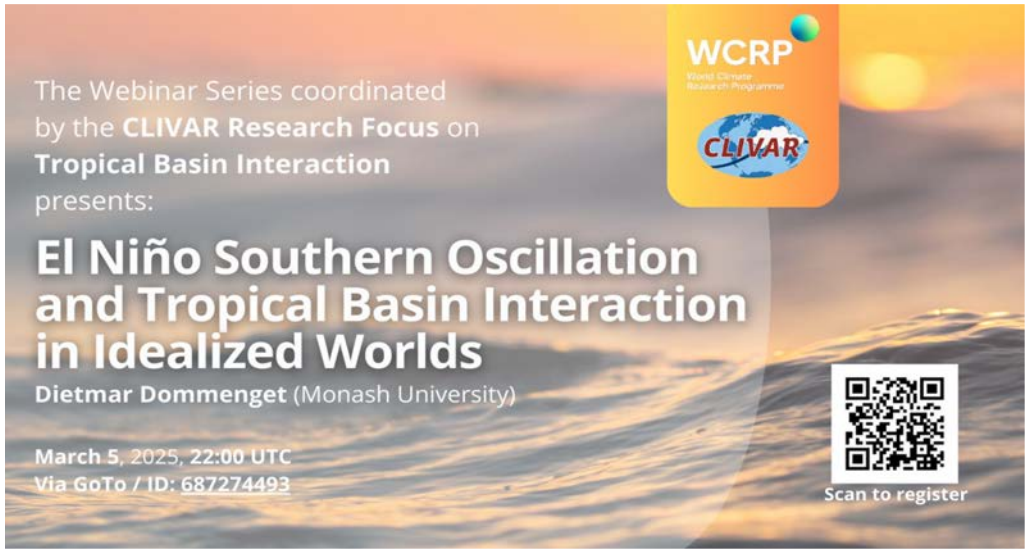
Explainable El Niño predictability from climate mode interactions

Sen Zhao, Fei-Fei Jin ✉, Malte F. Stuecker, Philip R. Thompson, Jong-Seong Kug, Michael J. McPhaden, Mark A. Cane, Andrew T. Wittenberg & Wenju Cai

Nature **630**, 891–898 (2024) | Cite this article

10k Accesses | **12** Citations | **163** Altmetric | Metrics





Extended nonlinear Recharge Oscillator

CLIVAR Tropical Basin Interaction RF sunsetting in 2025

WG3: **Observations**

- interaction Ocean Observations Physics and Climate Panel (OOPC); joint satellite event at the Ocean Decade Conference in Barcelona: Co-designing ocean observing system for better societal services – Pan tropics and basin use areas
  https://www.clivar.org/news/un-ocean-decade-conference-session-co-designing-ocean-observing-tropics

- review article on pantropical observing system published in Frontier in Marine Science

REVIEW article

Front. Mar. Sci. , 07 February 2025

Sec. Ocean Observation

Volume 12 - 2025 | https://doi.org/10.3389/fmars.2025.1539183

Toward an integrated pantropical ocean observing system

Gregory R. Foltz[1*] Yassir A. Eddebbar[2] Janet Sprintall[2] Antonietta Capotondi[3,4]

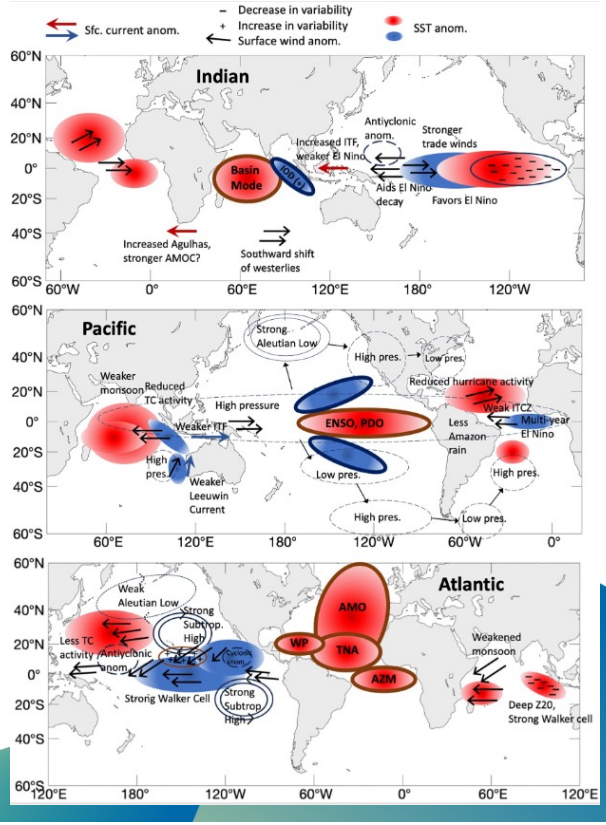
Sophie Cravatte[5,6] Peter Brandt[7,8] Adrienne J. Sutton[9] Tamaryn Morris[10]

Juliet Hermes[10,11] Clive R. McMahon[12] Michael J. McPhaden[9] Lev B. Looney[1,13,14]

Franz Philip Tuchen[1,13] Mathew Koll Roxy[15] Fan Wang[16] Fei Chai[17]

Regina R. Rodrigues[18] Belen Rodriguez-Fonseca[19,20] Aneesh C. Subramanian[21]

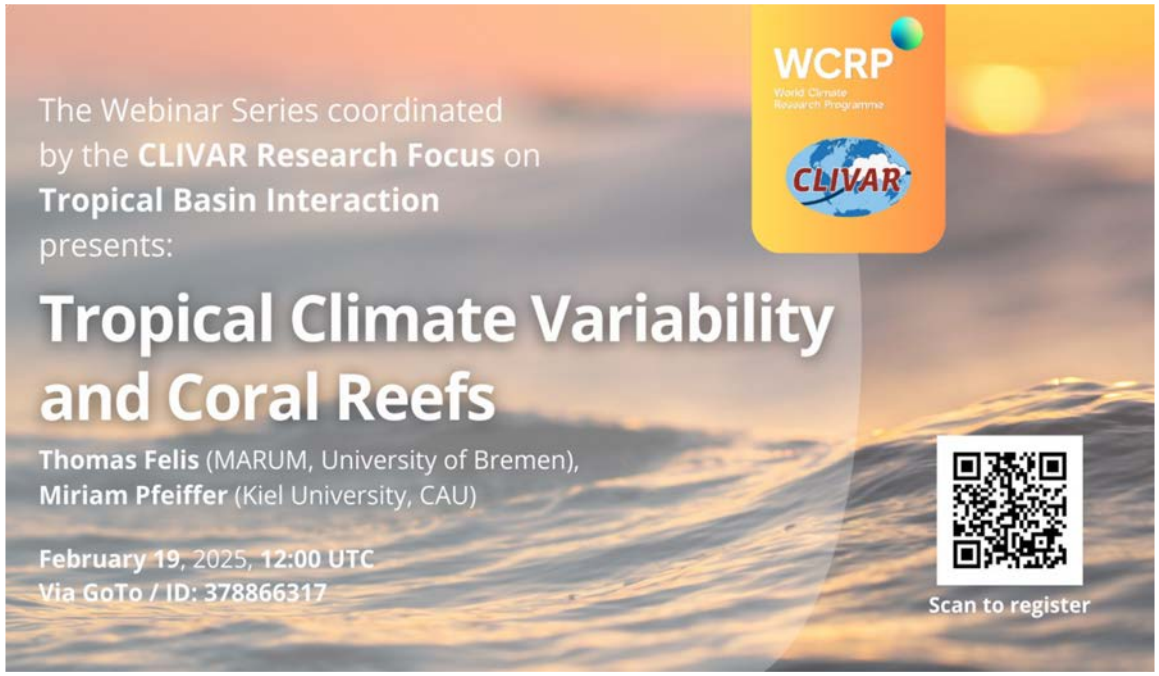
Marcus Dengler[7] Cheyenne Stienbarger[22] Kathleen Bailey[23] Weidong Yu[24]



CLIVAR Tropical Basin Interaction RF sunsetting in 2025

WG4: Paleo Proxies

- International collaborations: develop a paleoclimate section in the Climate Data Guide at NCAR; Topical Meeting of the DFG Priority Programme "Tropical Climate Variability & Coral Reefs"; paleo proxy reanalysis generated at Univ. of Bergen



What's next for TBI RF

- TBI RF meeting at Pan-CLIVAR Meeting in Indonesia
- analyze TBIMIP output; submit 1-2 manuscripts
- make TBIMIP output available to public (hopefully through ESGF)
- publish TBI/AMV review paper
- integrated review (combining 4 WGs)
- continue TBI Webinar series

Day 1 22/9		**Day 2** 23/9		**Day 3** 24/9	*Symposium*	**Day 4** 25/9	*Symposium*	**Day 5** 26/9	
		8:30-9:00	Plenary	8:30-9:00	Opening	8:30-10:30	Parallel Sessions	8:30-10:30	Plenary and Closing Remarks
		9:00-10:30	Panel Meetings (parallel)	9:00-10:30	Keynotes		*Symposium*		
		10:30-11:00	Coffee Break	10:30-11:00		10:30-11:00		10:30-11:00	
		11:00-12:30	Panel Meetings (parallel)	11:00-12:30	Parallel Sessions	11:00-12:20	Breakout Sessions *Symposium*	11:00-13:00	Parallel Meetings (SSG, cross-project)
						12:30-13:00	Plenary *Symposium Closing*		
		12:30-13:30	Lunch	12:30-13:30		13:00-14:00		13:00-14:00	
13:30-15:00	SSG Meeting	13:30-15:00	Panel Meetings (parallel)	13:30-15:00	Parallel Sessions	14:00-15:30	Cross-project meetings (parallel)	14:00-15:30	Parallel Meetings (SSG, cross-project)
15:00-15:30	Coffee Break	15:00-15:30	Coffee Break	15:00-15:30		15:30-16:00			**End of Event**
15:30-17:30	SSG Meeting	15:30-17:00	Panel Meetings (parallel)	15:30-17:00	Parallel Sessions or Poster Session	16:00-17:30	Cross-project meetings (parallel)		
		17:00-18:00	Plenary	17:00-18:00	Plenary	17:30-18:00	Plenary		
				18:30	Symposium Dinner	18:30	Pan-CLIVAR Dinner		

Symposium themes:

- Climate Variability and Change
- Ocean Processes and Extremes
- Atmospheric Processes and Climate Dynamics Cascading and Compound Events
- Biogeochemical Processes and Climate Interactions
- Artificial Intelligence: Role in Climate-Ocean Research and Prediction
- Ocean-Climate Observations and Modelling
- Societal Impact