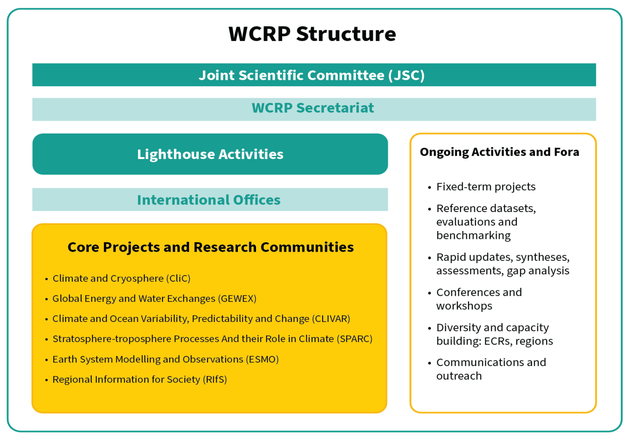
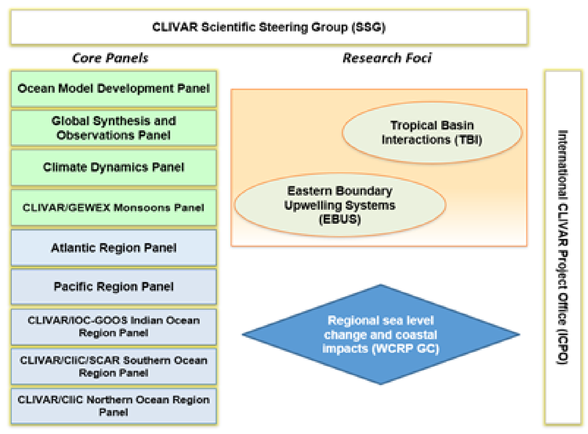
Climate and Ocean: Variability, Predictability and Change (CLIVAR)

1. Introduction of CLIVAR

Mission: to understand the dynamics, the interaction, and the predictability of the climate system with emphasis on ocean-atmosphere interaction. To this end, it facilitates observations, analysis, predictions and projections of variability and changes in the Earth's climate system, to the benefit of society and the environment in which we live.

Objective: to describe, understand and model the dynamics of the coupled climate system emphasizing ocean-atmosphere interactions and to identify processes responsible for climate variability, change and predictability on subseasonal-to-seasonal, interannual, decadal and centennial time scales.



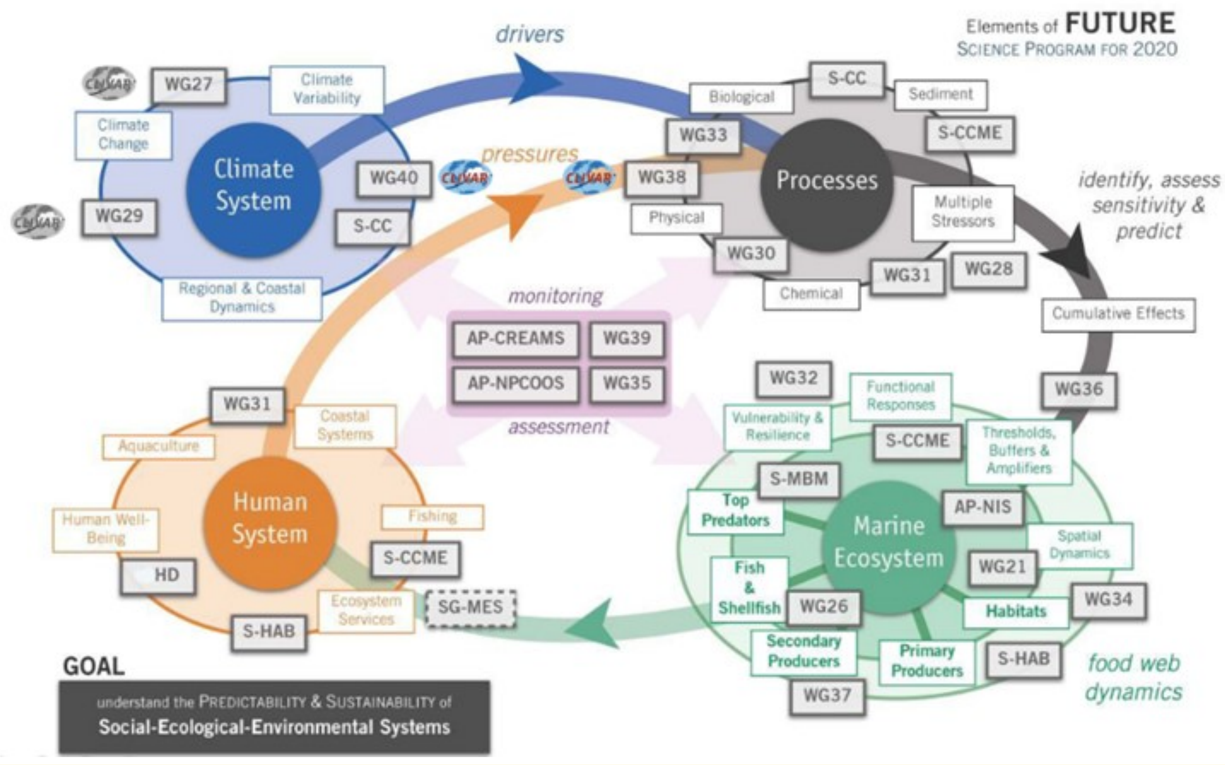


Established in 1995, the Climate and Ocean: Variability, Predictability and Change (CLIVAR) is one of the six core projects of the World Climate Research Programme (WCRP). Within WCRP, CLIVAR works closely with its sister WCRP core projects, including the two new WCRP core projects: the Regional Climate Information for Society (RifS) and the Earth System Modelling and Observational Capabilities (ESMO), in particular in the implementation of the WCRP Lighthouse Activities.

2. Existing cooperation between CLIVAR and PICES

CLIVAR and PICES have demonstrated long-time successful interdisciplinary cooperation, mainly on the North Pacific Climate Variability and Change (WG-27), Regional Climate Models (WG-29), Mesoscale and Submesoscale Processes (WG-38), Climate and Ecosystem Changes (WG-40), and etc.

- CLIVAR-PICES Joint Working Group on Climate and Ecosystem Predictability (WG-40) aims to identify, diagnose and quantify predictable response in North Pacific marine ecosystems that arise from regional- and large-scale climate processes;
- The special issue in *Frontier in Marine Science*: North Pacific Climate and Ecosystem Predictability on Seasonal to Decadal Timescales co-ordinated by WG-40, resulting from the 2019 Qingdao workshop and papers from the PICES-2019 Annual Meeting in Victoria (Jan. 2021);
- PICES/CLIVAR co-sponsored FUTURE/POC Topic Session on Predictions of extreme events in the North Pacific and their incorporation into management strategies at PICES-2021.



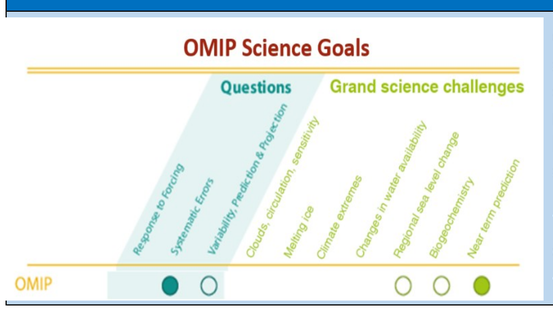
3. Future cooperation

Sidebar 1: New CLIVAR Working Group established by the Pacific Region Panel

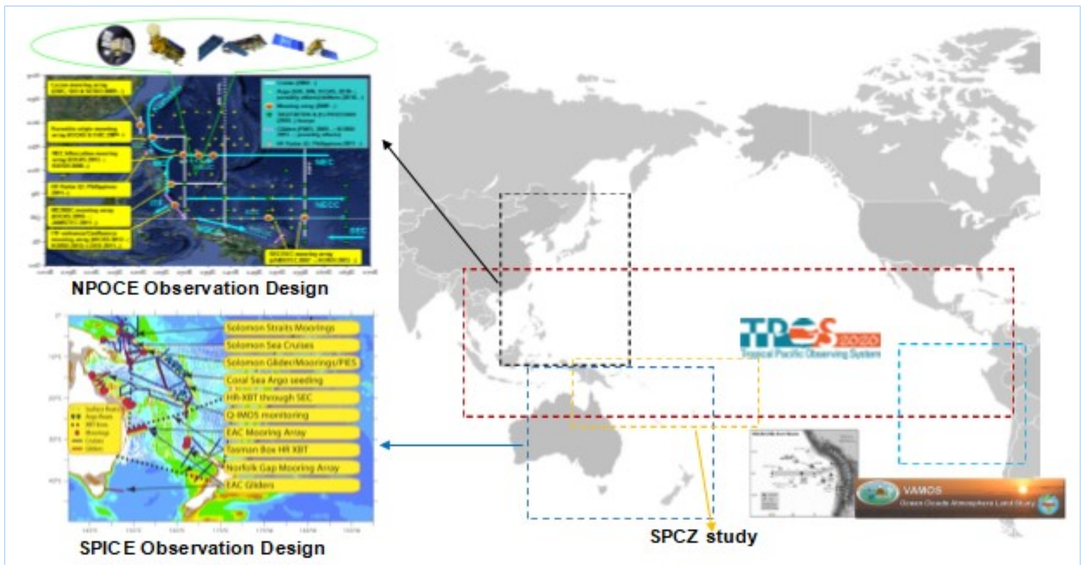
ENSO Conceptual Model Working Group: To bring experts of ENSO theory, modelling, and observations together to review knowledge on ENSO conceptual models and identify possible avenues for improved conceptual models that can more fully account for ENSO complexity.

Tropical Pacific Decadal Variability (TPDV) Working Group: To understand the nature and predictability of TPDV, its representation in climate models, and its projected change.

Sidebar 2: CLIVAR promotes the ocean model development



OMDP has been enhancing the development of an ocean circulation model through identifying the challenges and prospects in ocean circulation models, organizing the Co-ordinated Ocean-Ice Reference Experiments (CORE-I and CORE-II) and the newest variants, the Ocean Model Intercomparison Projects (OMIP-1 and OMIP-2). The panel was involved through the coordinated development of forcing datasets: CORE-I, CORE -II, and now JRA55-do.



Sidebar 3: CLIVAR's contribution to the ocean observing system in the Pacific

1. Improved Process understanding	Mechanisms that influence the structure of tropical Pacific ocean heat content and transport (WG-40 and TPDV WG) Ocean meso- and sub meso-scale processes (WG-38 and OMDP) Advancement of understanding and predictability of ENSO (CLIVAR PRP); Inter-basin teleconnection and tropical-extratropical interaction (TBI RF, NORP, PRP, IORP) Boundary current and coastal processes (CLIVAR EBUS RF and PRP) Better understanding and prediction of extreme events and societal impacts in the North Pacific
2. Advanced modeling and prediction	•Through seamless prediction, model downscaling, model intercomparison as well as coordinating experiments, etc (with OMDP).
3. Enhanced observing system	To support **observing system design and capacity** which will contribute to the understanding, modeling and forecasting of marine ecosystem particularly in the Pacific island states (CLIVAR PRP, TPOS2020, OOPC, link to CLIVAR-GOOS Ocean Observation Workshop in 2022).
4. Increased societal relevance	To better address the societal needs for **climate and marine ecosystem services** at regional level (WCRP/CLIVAR, linking to WCRP CRF and RifS core project).
5. Capacity building and ECS invovement	To engage more **early career scientists** in (Become CLIVAR Panel members, showcase in CLIVAR ECS Spotlight, cooperate with PICES ECOP ST and YESS). To enhance **capacity building and data, technology and knowledge sharing**, in particular for early career scientists and less developed states (WCRP/CLIVAR).

Relevant activities:

1. 2022 Sea Level Conference (11-15 July 2022, Singapore)
2. CLIVAR-FIO Summer School on Ocean Macroturbulence and Its Role in Earth's Climate (19-25 June 2022, Qingdao, China)
3. CLIVAR-GOOS Workshop: From global to local: Cultivating new solutions and partnerships for an enhanced Ocean Observing System in a decade of accelerating change (TBC, 2022, Trieste, Italy)

Relevant publications:

Cai, W., Santoso, A., Collins, M. et al. Changing El Niño–Southern Oscillation in a warming climate. *Nat Rev Earth Environ* (2021). https://doi.org/10.1038/s43017-021-00199-z

Cai, W., Ng, B., Geng, T. et al. Butterfly effect and a self-modulating El Niño response to global warming. *Nature,* 585, (2020). 68–73.

McPhaden, M.J.(Editor), A. Santoso (Editor), W. Cai (Editor), El Niño Southern Oscillation in a Changing Climate, Wiley, (2020), 528pp.

A. Solomon et al., Freshwater in the Arctic Ocean 2010-2019. *Ocean Sci. Discuss.* [preprint], https://doi.org/10.5194/os-2020-113, in review, 2020.