NOAA RESEARCH

The Tropical Pacific Observing System (TPOS) Equatorial Pacific Experiment (TEPEX):

Bridging Tropical Air-Sea Coupling and Global Forecast Accuracy

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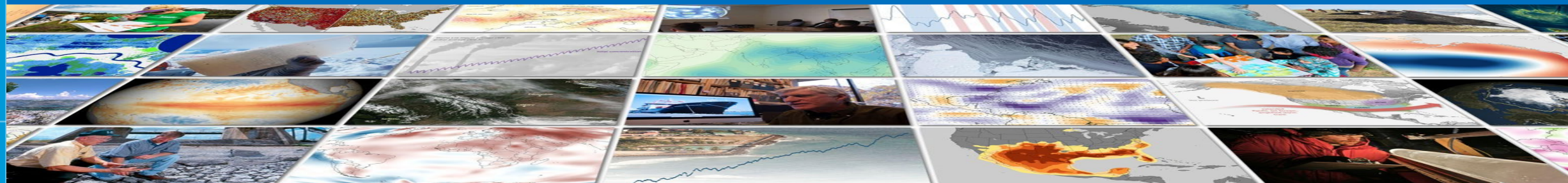
NOAA Climate Program Office

2nd Observational campaigns workshop for better weather forecasts
ECMWF, Reading, UK - 1 July 2026



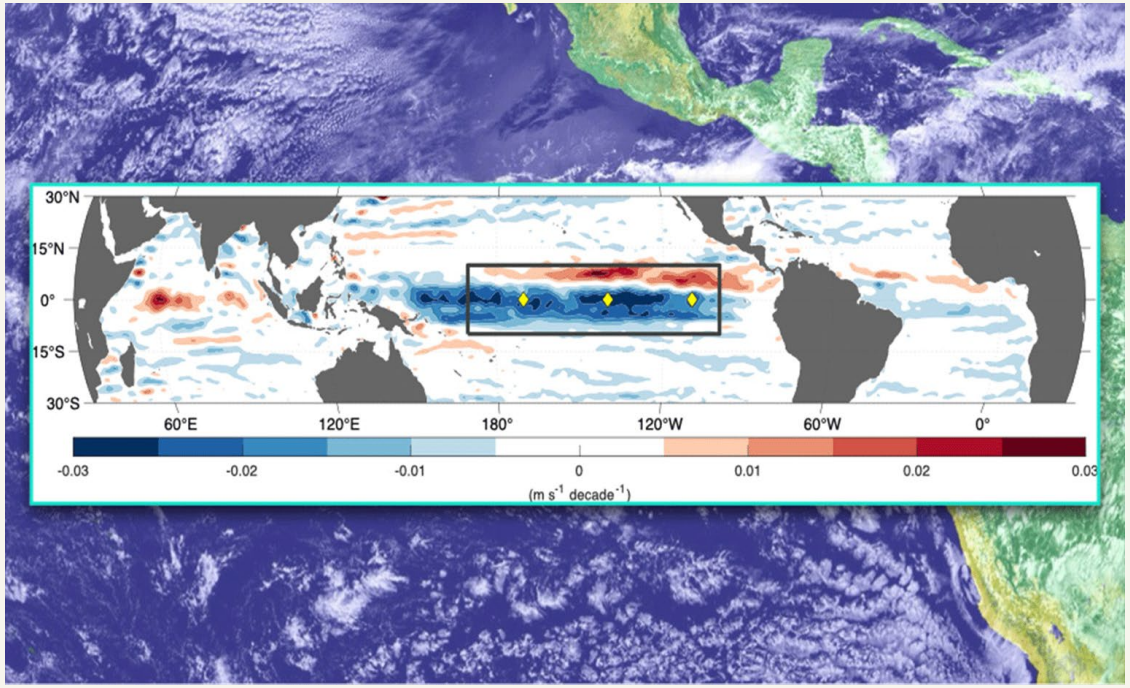
Background and Historical Overview

Tracing the evolution of tropical observing systems from high-impact historical field experiments to the present.

The Equatorial Pacific Climate Engine

The **tropical Pacific** operates as a highly synchronized, basin-wide **thermodynamic engine** that dictates **global weather (ENSO, MJO).**

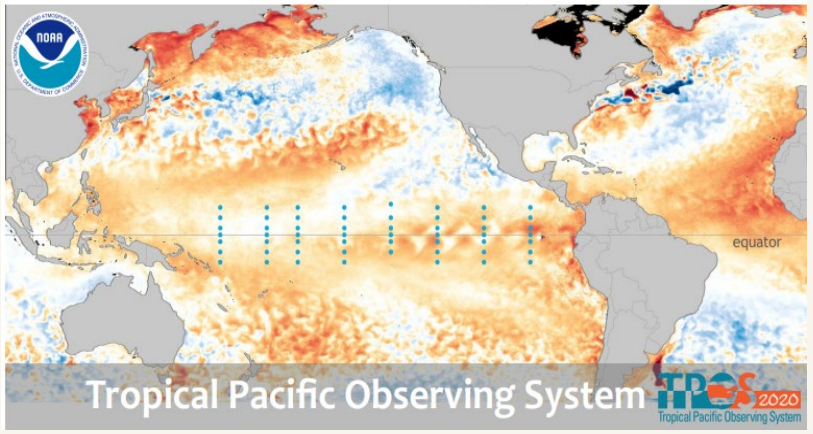
Consequently, a comprehensive **system of measurements** is absolutely **essential** to predict its next shifts.



The Tropical Pacific Observing System (TPOS)

Overview

- It is an observing system designed to measure the **subsurface and surface ocean plus the atmosphere** spanning the tropical Pacific from approximately **10°S to 10°N.**
- Several institutions **contribute to and operate elements** of this observing system.
- It seeks to accelerate **advances in technology, understand and predict tropical Pacific variability**, inform policymakers and benefit society.

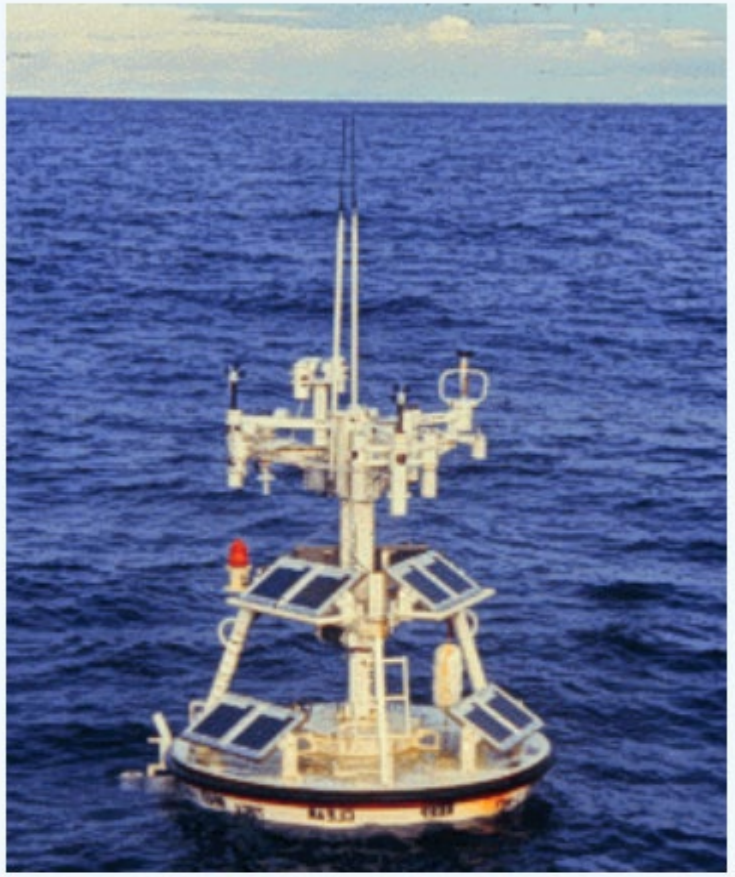


The Tropical Pacific Observing System (TPOS)

History

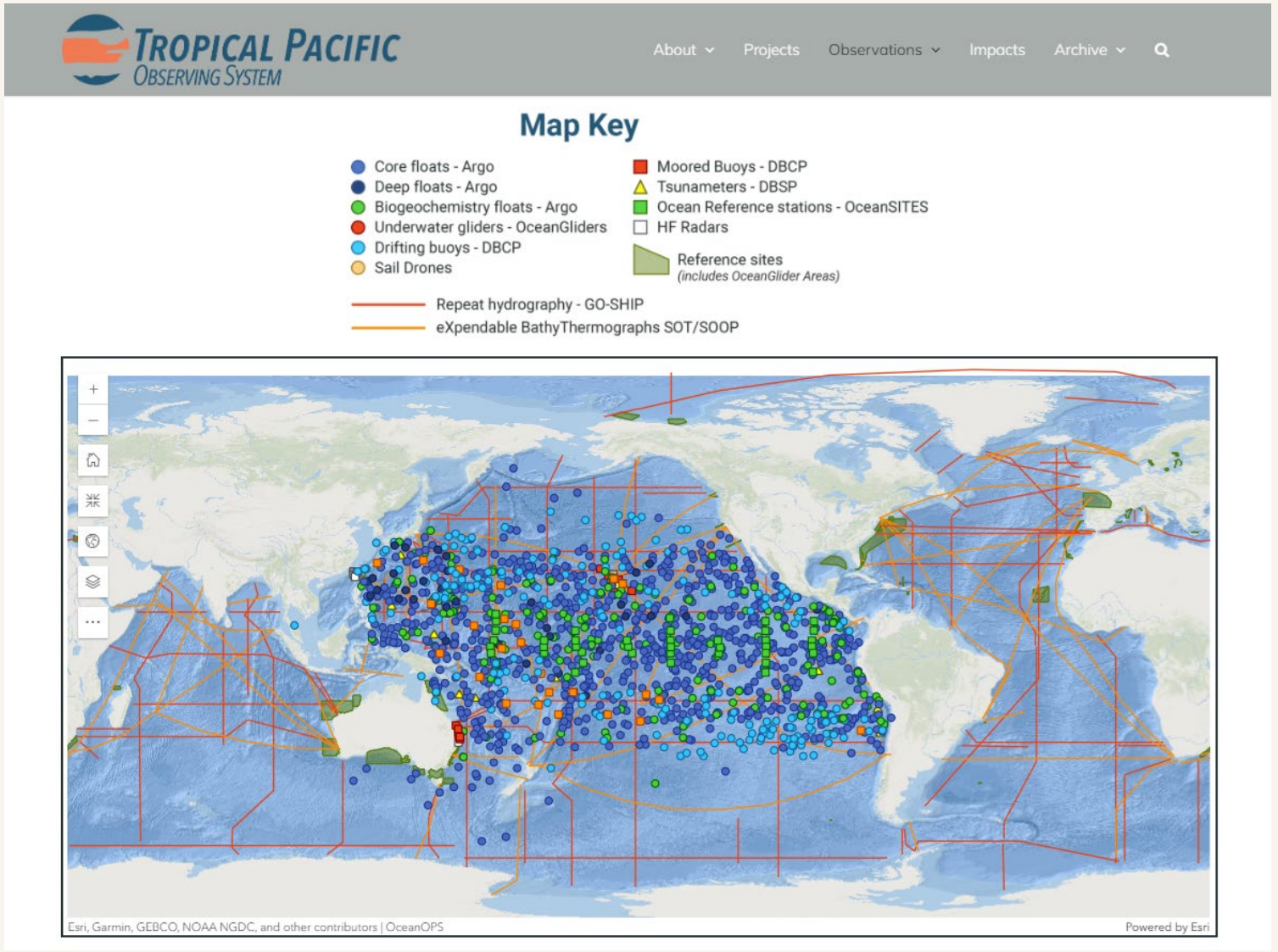
- It was designed during the highly successful **Tropical Ocean – Global Atmosphere (TOGA) Coupled Ocean Atmosphere Response Experiment (COARE)** field campaign in the early 1990s

- Revolutionized **observational understanding of the tropical Pacific and ENSO dynamics**
  - Measurements collected from the region form the foundational capability for predictions of ENSO



TOGA COARE surface buoy

The Tropical Pacific Observing System (TPOS)



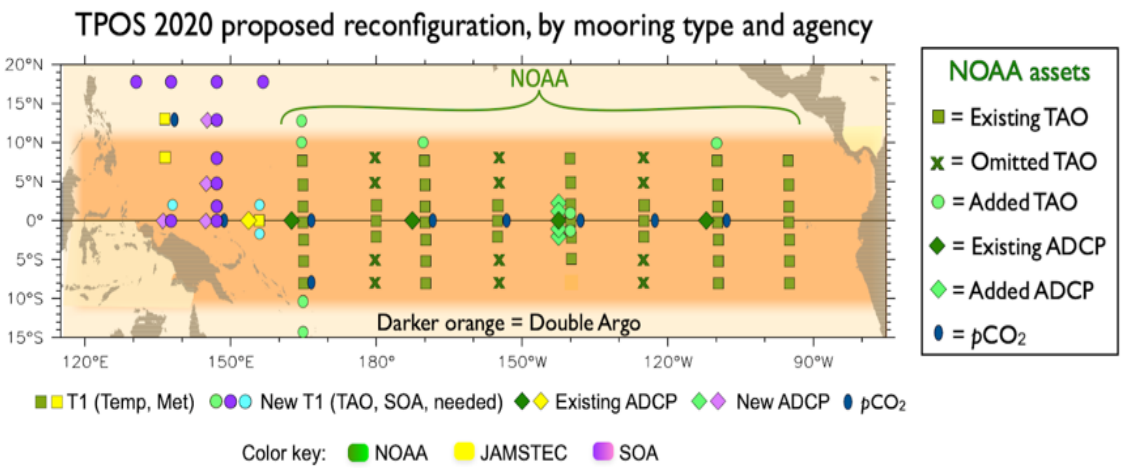
The TPOS 2020 Project

- **An Advisory Group of Scientists**
- TPOS after 20 years
- Worked during 7 years (2014, 2019, 2021)

The TPOS 2020 Project

TPOS 2020

Tropical Pacific Observing System



- **Identified Observation Needs:** Determined the specific observations required to enhance global prediction skills.
- **Recommended Field Campaigns:** Called for intensive campaigns to resolve coupled ocean-atmosphere processes that models poorly represent

The TPOS 2020 Project

TPOS 2020

Tropical Pacific Observing System

- **Targeted Two Core Domains:** Focused fieldwork on two critical regions: the Eastern Edge of the Warm Pool and the Cold Tongue.

TEPEX: The Scientific Community's Response

A Strategic Field Campaign

Tropical Pacific Observing System (TPOS) Equatorial Pacific Experiment (TEPEX)

- Upcoming field campaign (2027-2028) that will deploy a targeted, multi-platform effort to address the gaps identified by the TPOS 2020 Project
- Enhance our understanding of the key processes behind intraseasonal to interannual variability of the tropical Pacific

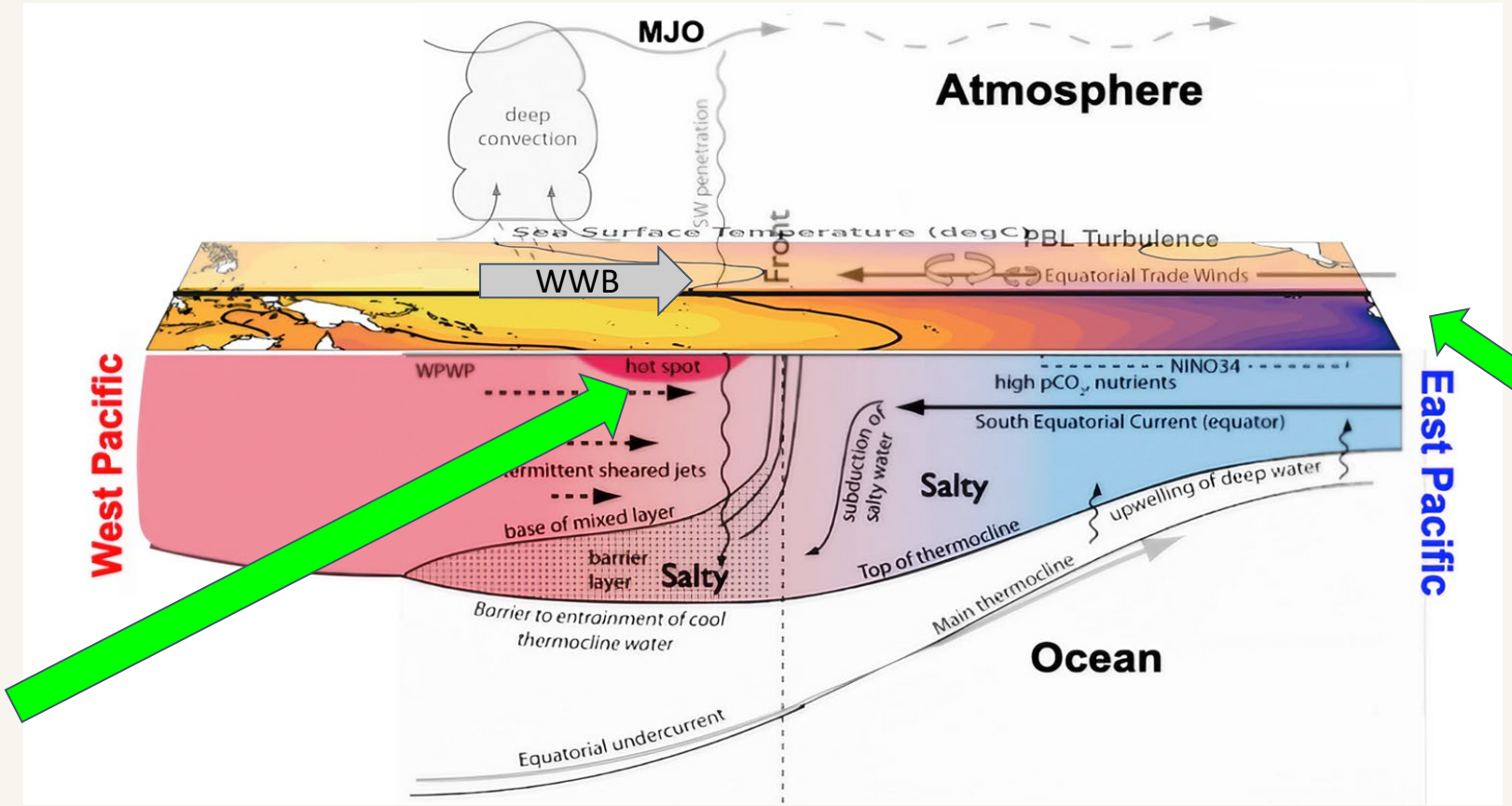
A Strategic Field Campaign

TEPEX is a NOAA-lead Field Campaign

- NOAA's Climate Program Office (CPO) within NOAA's OAR
  - Climate Variability and Predictability (CVP) Program
    - Led DYNAMO (2010), YMC (2017), ATOMIC (2020)
- Leveraging collaborations from NOAA laboratories (PSL, PMEL are leads), Cooperative Institutes, and academic institutions in the US
- Possible collaboration with NSF, NASA
- Potential connection with AR Recon (ONR/CW3E)
- Conversations with international partners – express interest!

Equatorial Pacific Predictability Gaps

Eastern Edge of the Warm Pool (Central Pacific)



Cold Tongue (Eastern Pacific)

Equatorial Pacific Predictability Gaps

Central Pacific (Eastern Edge of the Warm Pool)

The Atmospheric Driver: Convection couples tightly with massive zonal displacements of the Warm Pool.

The Gap: Poor representation of boundary layer movement - disrupts global teleconnections and energy distribution.

Eastern Pacific Cold Tongue

The Ocean Memory: Intense vertical mixing and upwelling regulate the ocean's core thermal memory.

The Gap: Models consistently fail to simulate downward heat fluxes - leading to systemic cold biases.

As identified in the TPOS 2020 Report

TEPEX: Genesis of the Experiment

TPOS 2020: International effort to evolve the Tropical Pacific Observing System to improve monitoring and prediction led by NOAA OAR/GOMO

- TPOS 2020 First Report (2016), Second Report (2019), Final Report (2021)

OAR/CPO/CVP supported process studies/**pre-field modeling** to advance TPOS field campaign recommendations

- 2017-19 Maritime Continent
- 2019-21, 2022-24 Pre-field Studies

OAR/GOMO supported obs tech development at PMEL, PSL, and Universities to better observe this region

NWS/NDBC supporting redesign, new instrumentation to be deployed on parts of TPOS

Many **US CLIVAR science community** workshops focused on Air-Sea Transition Zone studies

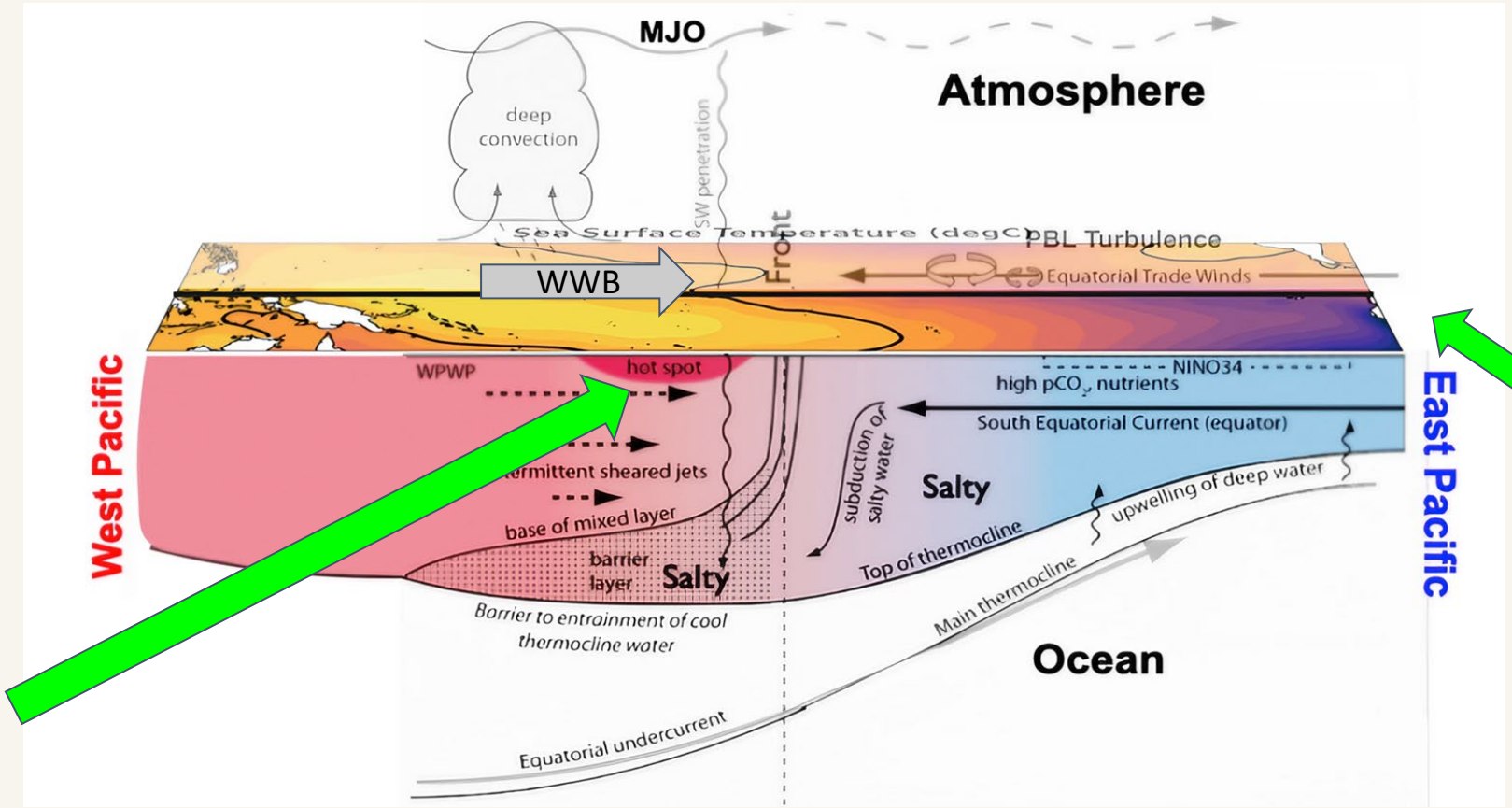
Tropical Pacific Observing System (TPOS) Equatorial Pacific Experiment (TEPEX) Science Plan

NOAA Precipitation Prediction Grand Challenge (PPGC) Initiative

OAR Marine Atmospheric Boundary Layer workshop

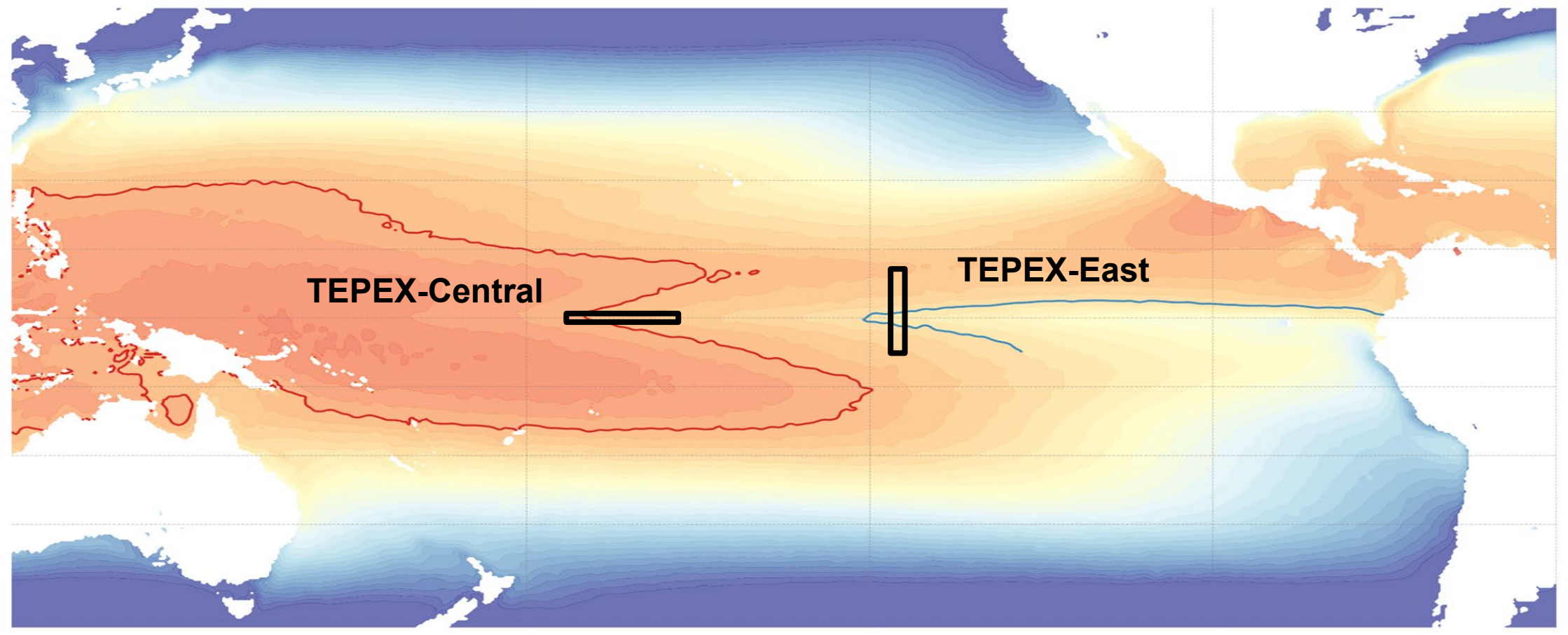
Equatorial Pacific Predictability Gaps

Eastern Edge of the Warm Pool (Central Pacific)



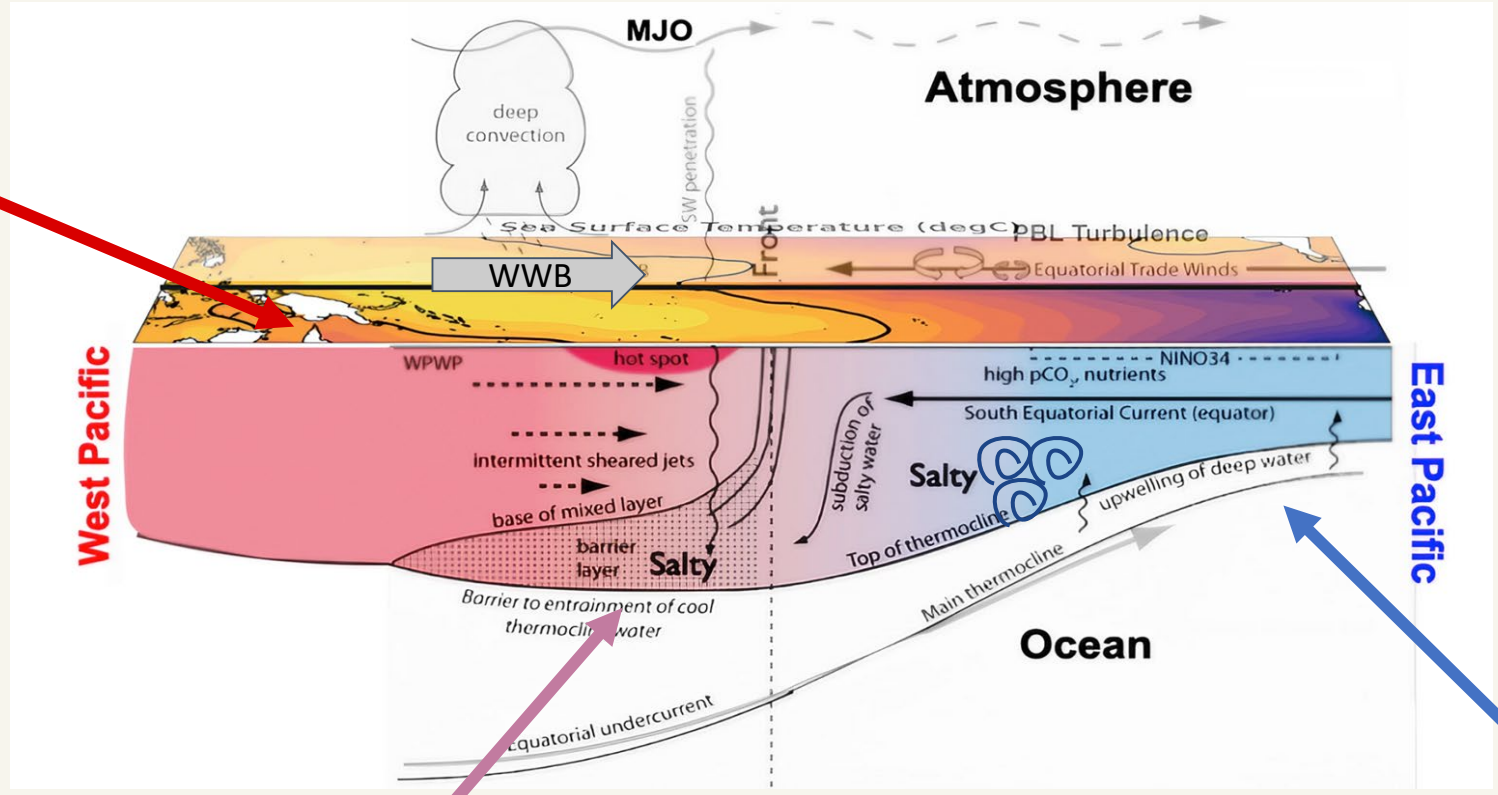
Cold Tongue (Eastern Pacific)

TEPEX Campaign Configurations



Past and Future

Warm Pool:
TOGA COARE
1992-1993



Eastern Edge of Warm Pool (EEWP)
TEPEX-Central
Spring 2028

Cold Tongue
TEPEX-East
Fall 2027

Part of GPEX

WCRP Lighthouse Activities | Global Precipitation EXperiment (GPEX)

A) Field Campaigns under various stages of development

Several field campaigns are under development (Fig. 1 and Table 1.)

Figure 1. Geographical locations of the field campaigns

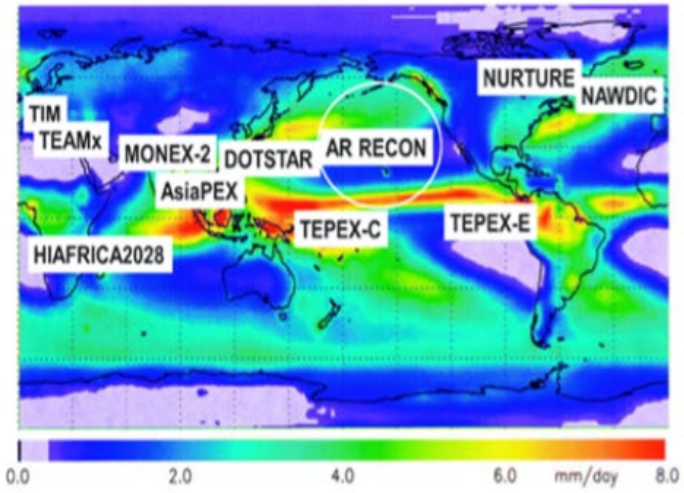


Table 1. Various field campaign activities at different stages

Campaign Name	Country/Region	Contact	Scientific Focus	Stage
AsiaPex	South/Southeast/East Aisa	Toru Terao	Monsoons	2029-2030 (?)
AR Recon	Northern Pacific	Marty Ralph	Atmospheric River	Ongoing
TEPEX	Central/Eastern Pacific	Chidong Zhang	ENSO	
TIM	Europe	Jannick Fischer	Orographic Precipitation	
Teamx-InCAPO	Europe	Claudia Acquistapace	Orographic Precipitation	05/16-09/12 2025
NAWDIC	North Atlantic	Julian Quinting	Atmospheric River	
DOTSTAR	Taiwan	Po-Hsiung Lin	Tropical Cyclone	
MONEX2	South/Southeast Asia	Krishnan Raghavan and Suryachander Rao	Monsoon	NH winter 2028

TEPEX-Central

Targets the mechanism behind the zonal shifts of the EEWP
(Lead – Chidong Zhang, NOAA PMEL)

What:

- Combined roles of Westerly Wind Bursts (WWBs) and convection in air-sea interaction
- Turbulence in the Marine Atmospheric Boundary Layer (MABL) and Ocean Mixed Layer (OML)
- Role of barrier layers in variability of edge

How:

- Shipboard, aircraft, uncrewed ocean vehicles
- **When:** Spring (largest zonal variability of edge, WWBs are more prevalent)

Clayson et al. 2023

TEPEX-East

Targets the meridional structure of Pacific upwelling and mixing and how they act to couple atmosphere/thermocline
(Lead – Elizabeth Thompson, NOAA PSL)

What:

- Role of shear driven mixing above the thermocline
- Role of variable wind regimes in air-sea interaction and mixing
- Interaction of the upper ocean with the MABL and its clouds

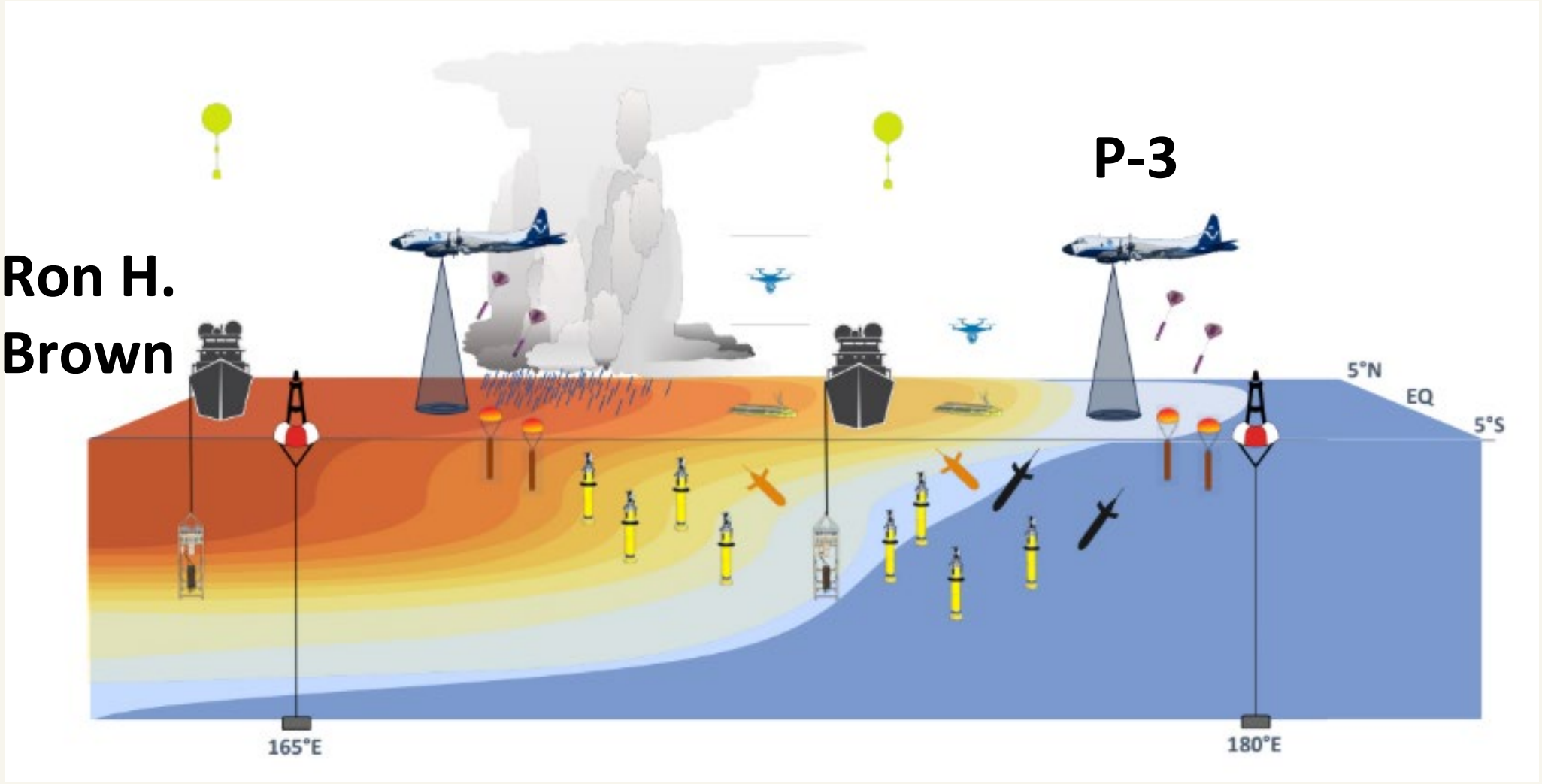
How:

- Build on TAO enhancements along 140°W: deploy additional enhanced moorings, cruises, uncrewed assets

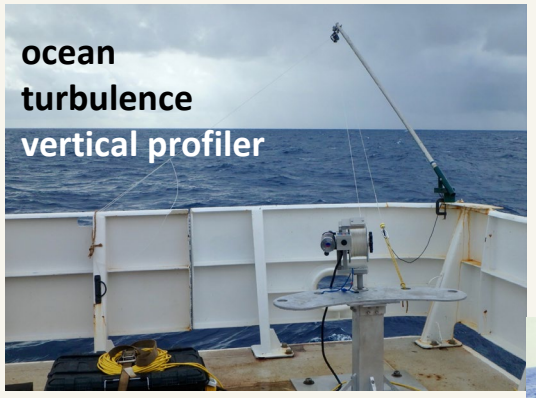
When:

- Fall + Spring (Tropical Instability Waves reliably present)

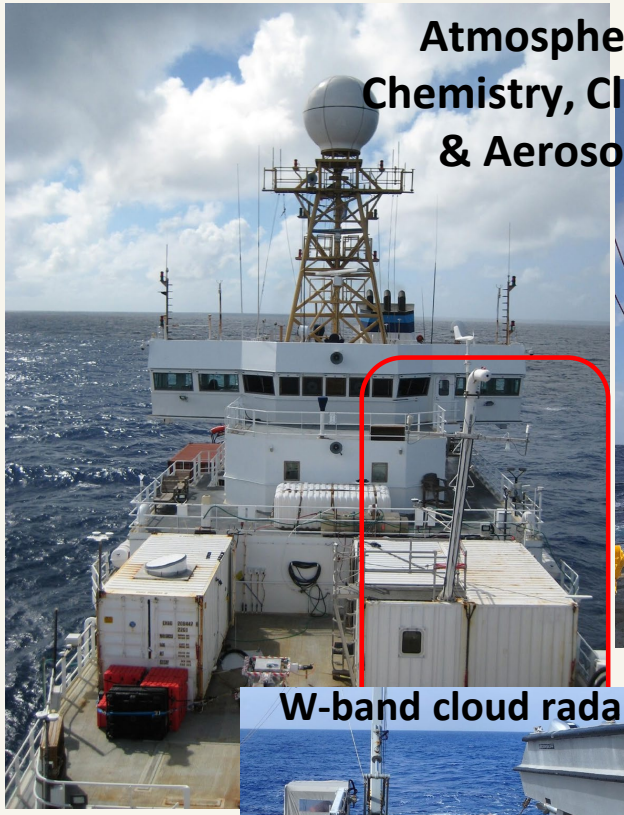
TEPEX Schematic Illustration

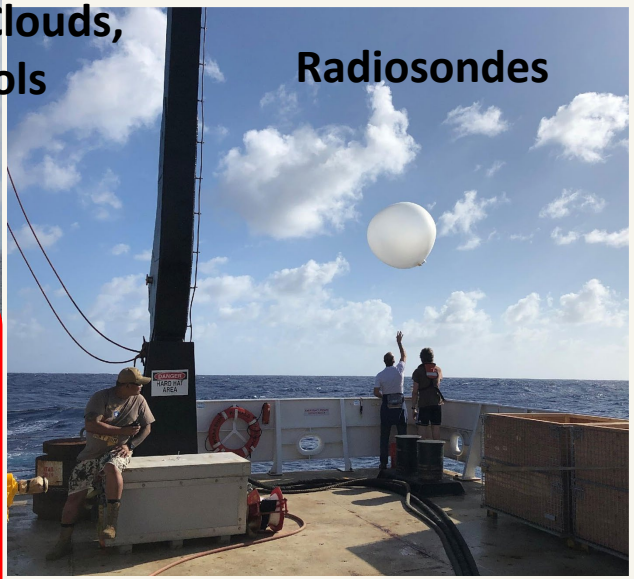


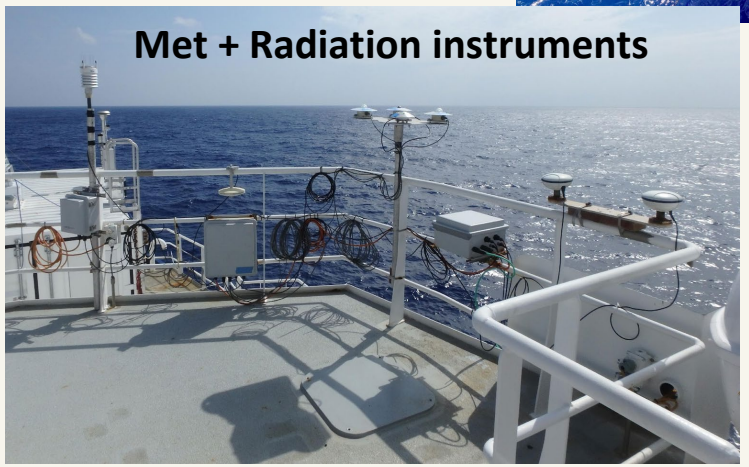
TEPEX Instrumentation

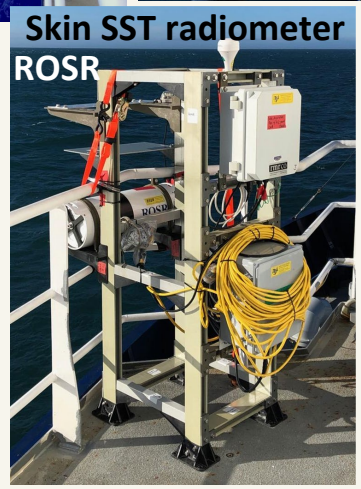


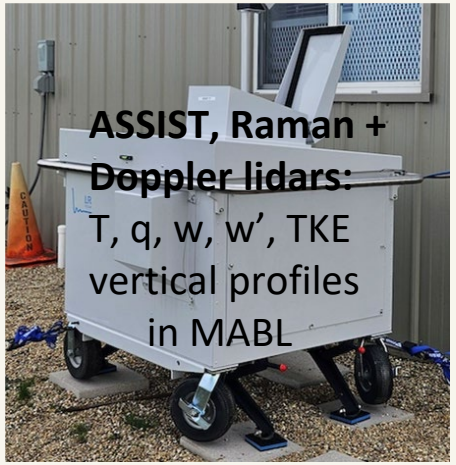
Ceilometer:
clouds











NOAA Research/CPO Support Framework

Competitive Research Grants

- Directing funding toward researchers targeting MABL, upper-ocean mixing, and convective parameterization gaps.
- A pre-field to post-field pipeline has been developed.

Sustained Observational & Logistical Support

- Coordinating core funding for platform optimization (USVs, TAO arrays)
- Leveraging NOAA ship time and aircraft hours to maximize geographic coverage.

Operational Transition Testbeds

- Establishing collaborative environments where empirical field discoveries are fast-tracked directly into operational NOAA and partner numerical weather prediction systems.

TEPEX Implementation Timeline

2022-2025

TPOS Pre-field modeling studies, pre-field campaign plan development (TEPEX)

2025 - 2026

Results from pre-field modeling studies, request for field campaign proposals, pre-campaign planning

Early-Mid 2027

Initial field deployments, sensor validation, and collaboration workshops

Mid-late 2027 - 2028

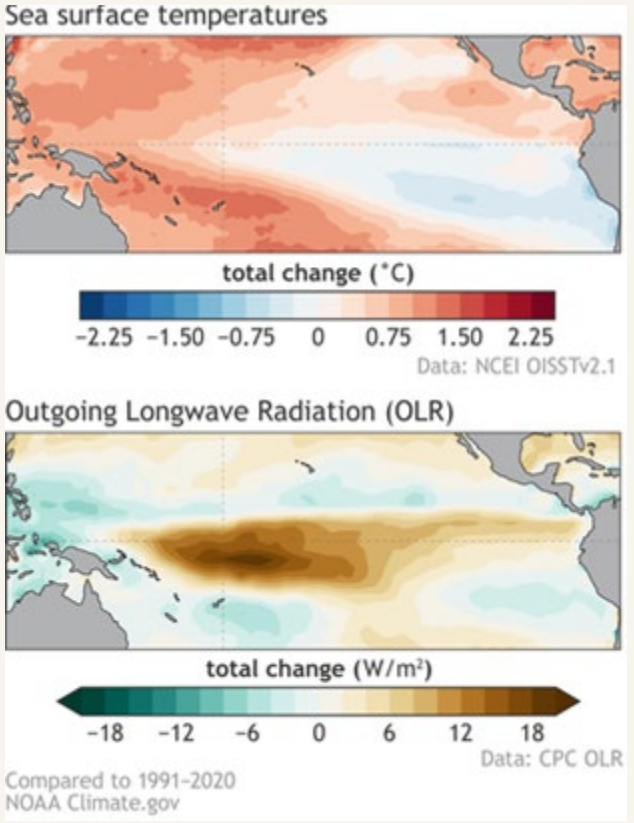
Coordinated active field campaigns utilizing ship, uncrewed, and moored components.

2029+

Multi-year model integration, data-assimilation research, and forecasting updates.

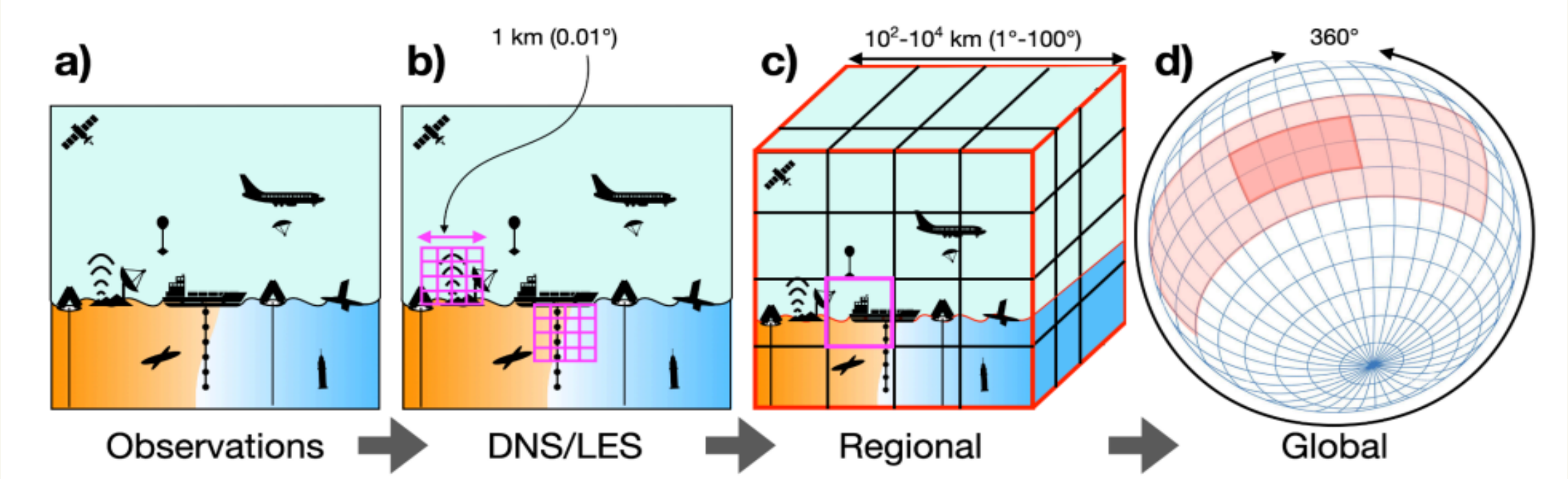
Field Campaign Data Assimilation and Forecasts

- **New Coupled Dataset:** Generates unique, co-located ocean-atmosphere boundary layer profiles.
- **Better Forecasts & Data Assimilation:** Enables coupled model verification and advances data assimilation capabilities.
- **Solves Initialization Gaps:** Fixes independent initialization issues to power modern, seamless weather-to-climate prediction.



TEPEX Field and Modeling Components Deliverables

Accelerated Model Improvement with Novel Process-Level Observation



Observe and better **understand** targeted phenomena

SCM

Simulate targeted phenomena, generate statistical properties **for new/improved parameterizations**

Incorporate and test **params** in regional or single column models

Incorporate and test **params and coupling** in GCMs. Evaluated for ability to improve the mean state and modes of climate variability

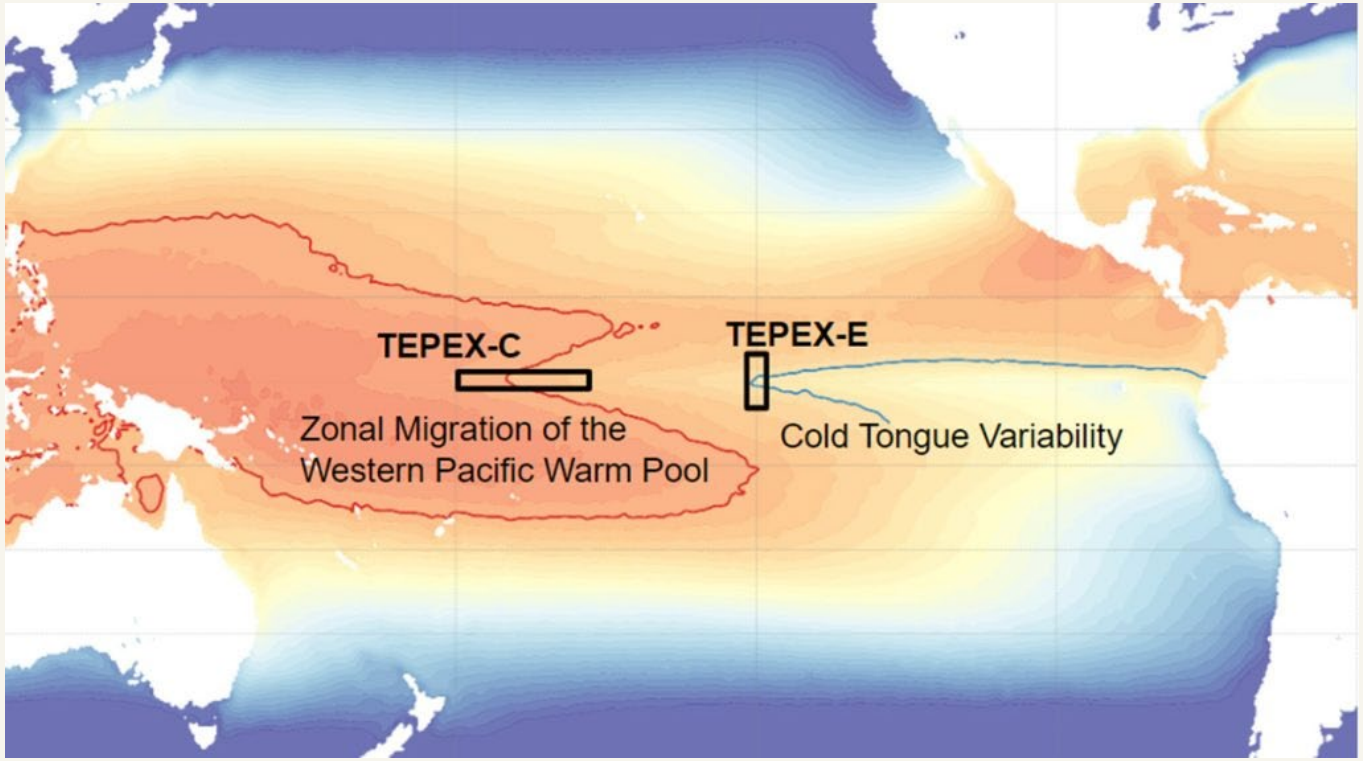
TEPEX will…

- Conduct field observations targeting **two regions**: the equatorial Cold Tongue of the eastern Pacific and the EEWP of the central Pacific.
- Combine observational analysis and numerical modeling to **better understand the detailed processes critical to air-sea interaction** of the equatorial Pacific and **ENSO dynamics**.
- Use the observational data to **advance model representation of the key processes** governing the tropical Pacific.

The Strategic Vision

TEPEX SCIENCE PLAN

Thank You!
Questions?



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