Ocean Working Group Meeting
Wednesday, February 7th 2024

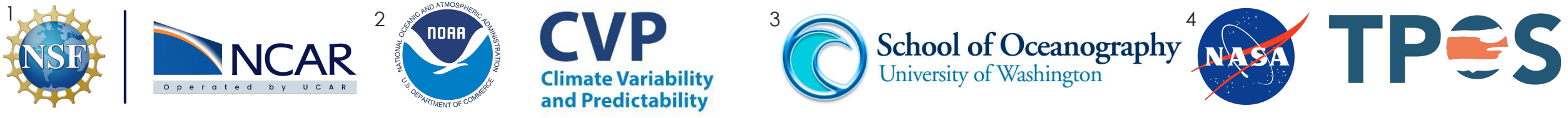
The TEPEX observational campaign

Opportunities for ocean model improvement

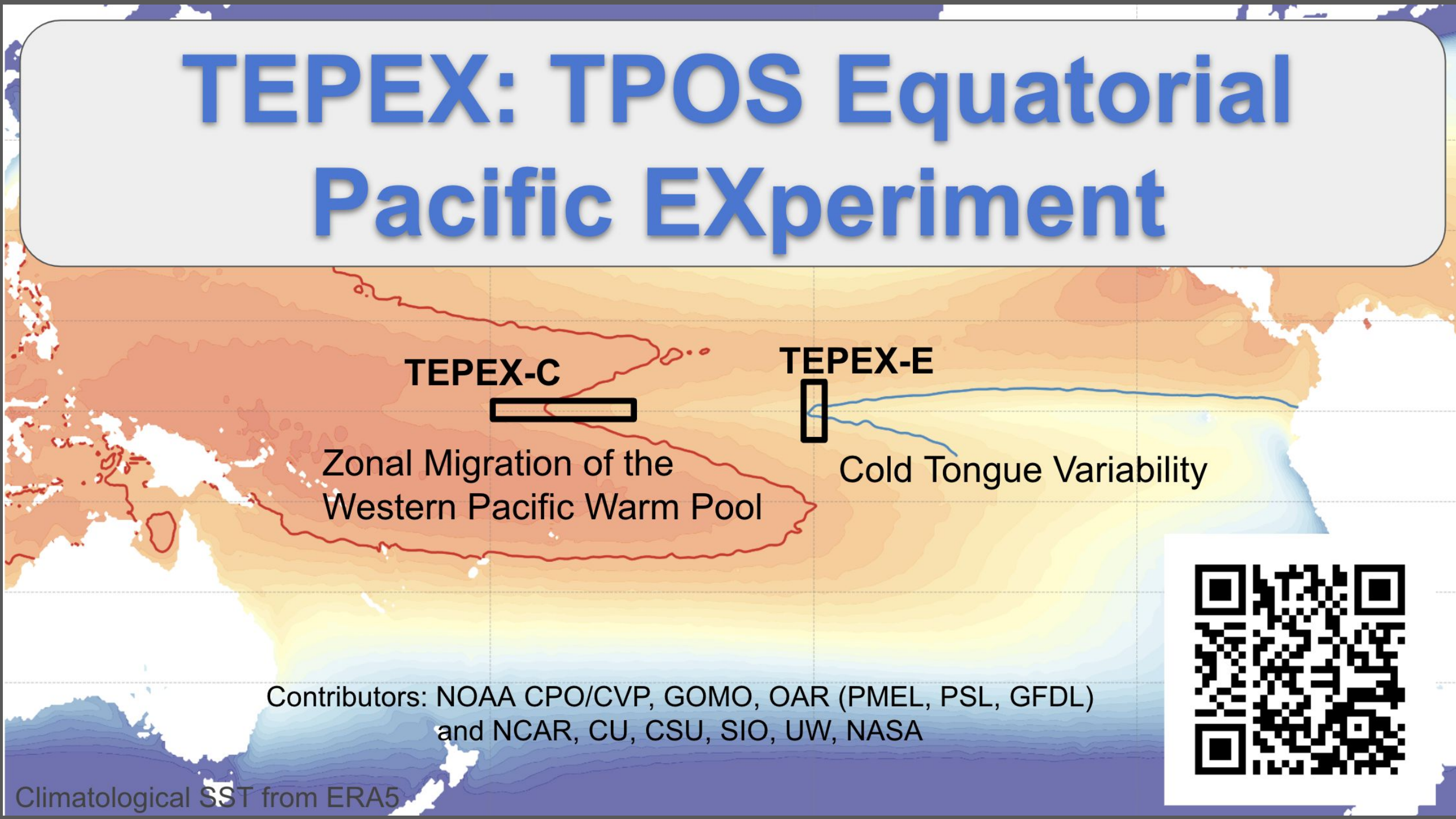
Anna Deppenmeier[1]

Elizabeth Thompson[2], Frank Bryan[1], William Kessler[2], LuAnne Thompson[3], Daniel Whitt[4], Deepak Cherian[1]

With slides from Charlotte DeMott

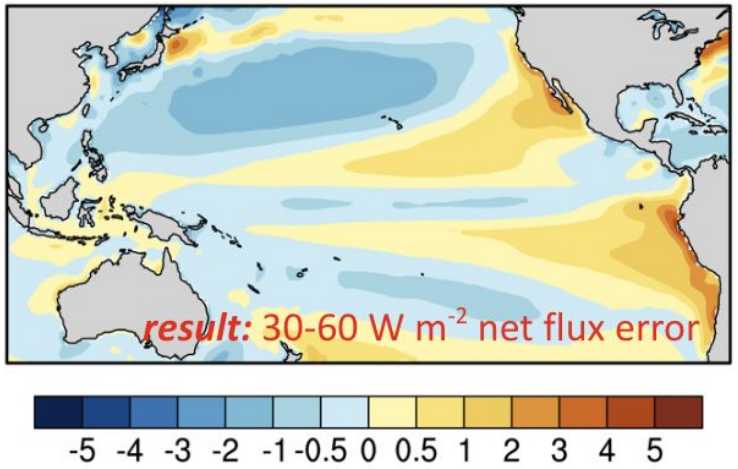


TEPEX: TPOS Equatorial Pacific EXperiment



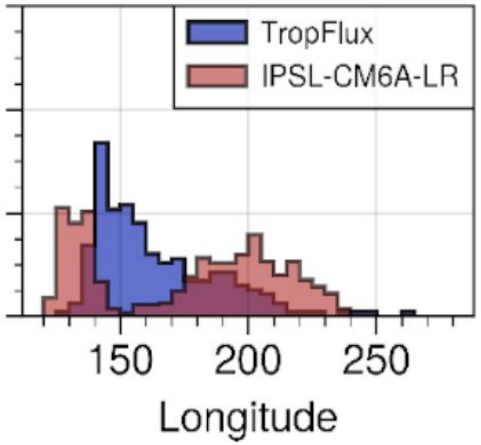
Model biases in the tropical Pacific

CMIP6 SST bias



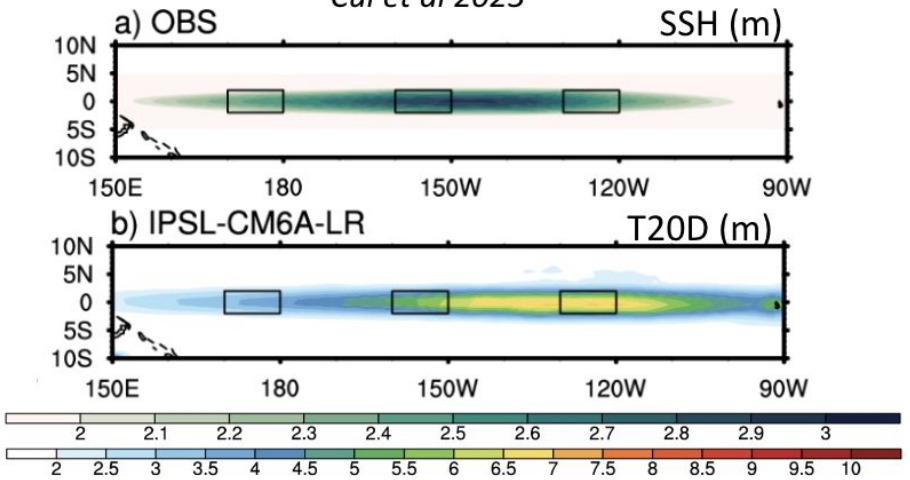
WWB frequency

Riley Dellaripa et al 2023



Ocean Kelvin wave st. dev.

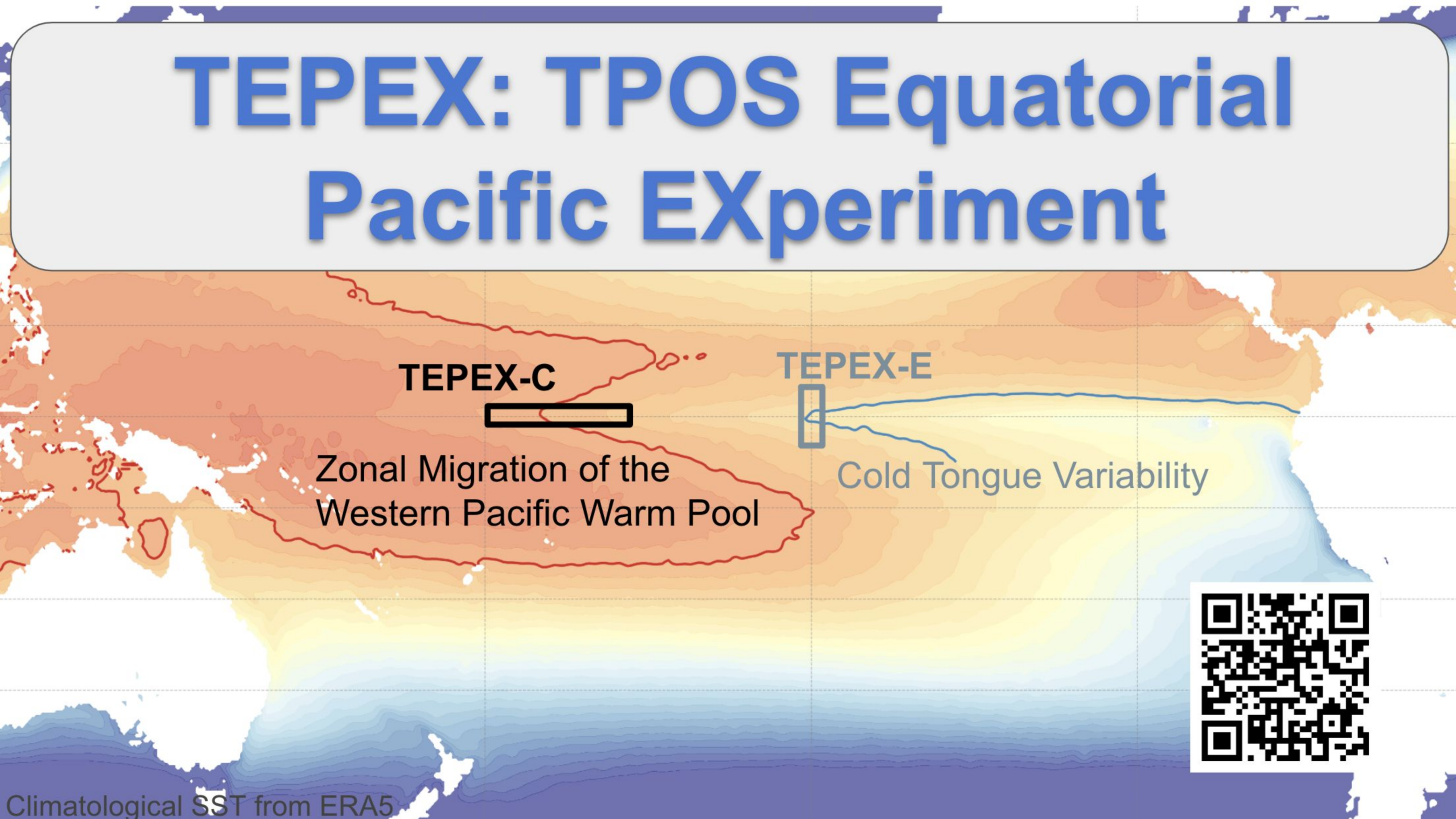
Cui et al 2023



Ocean state bias

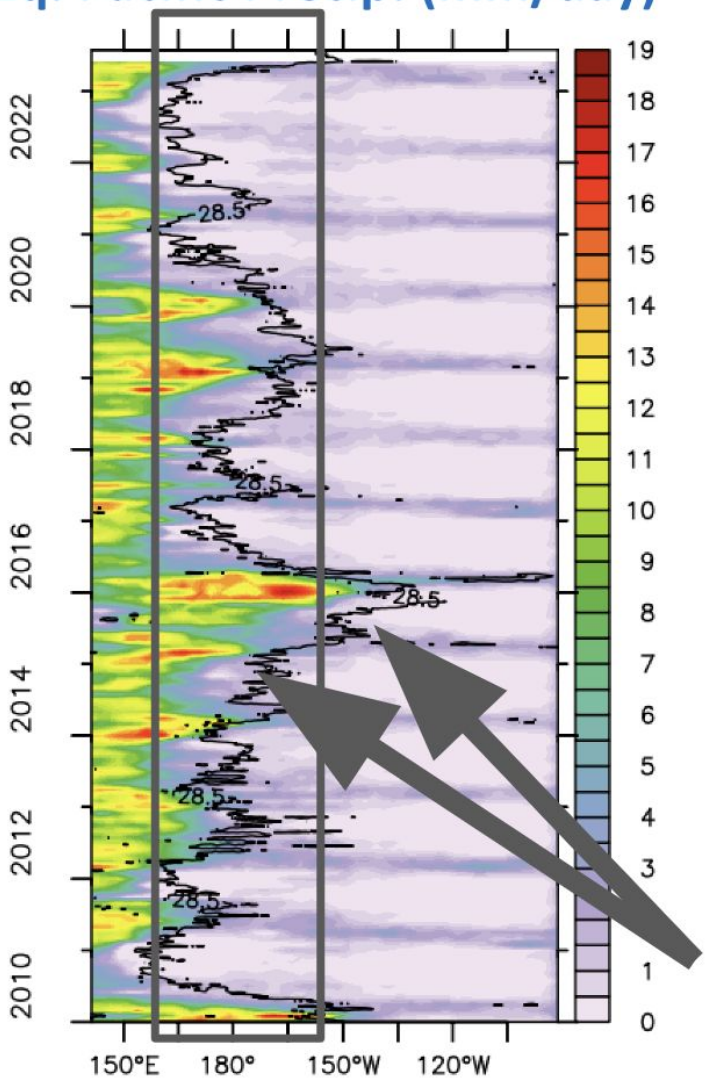
Process representation bias

TEPEX: TPOS Equatorial Pacific EXperiment



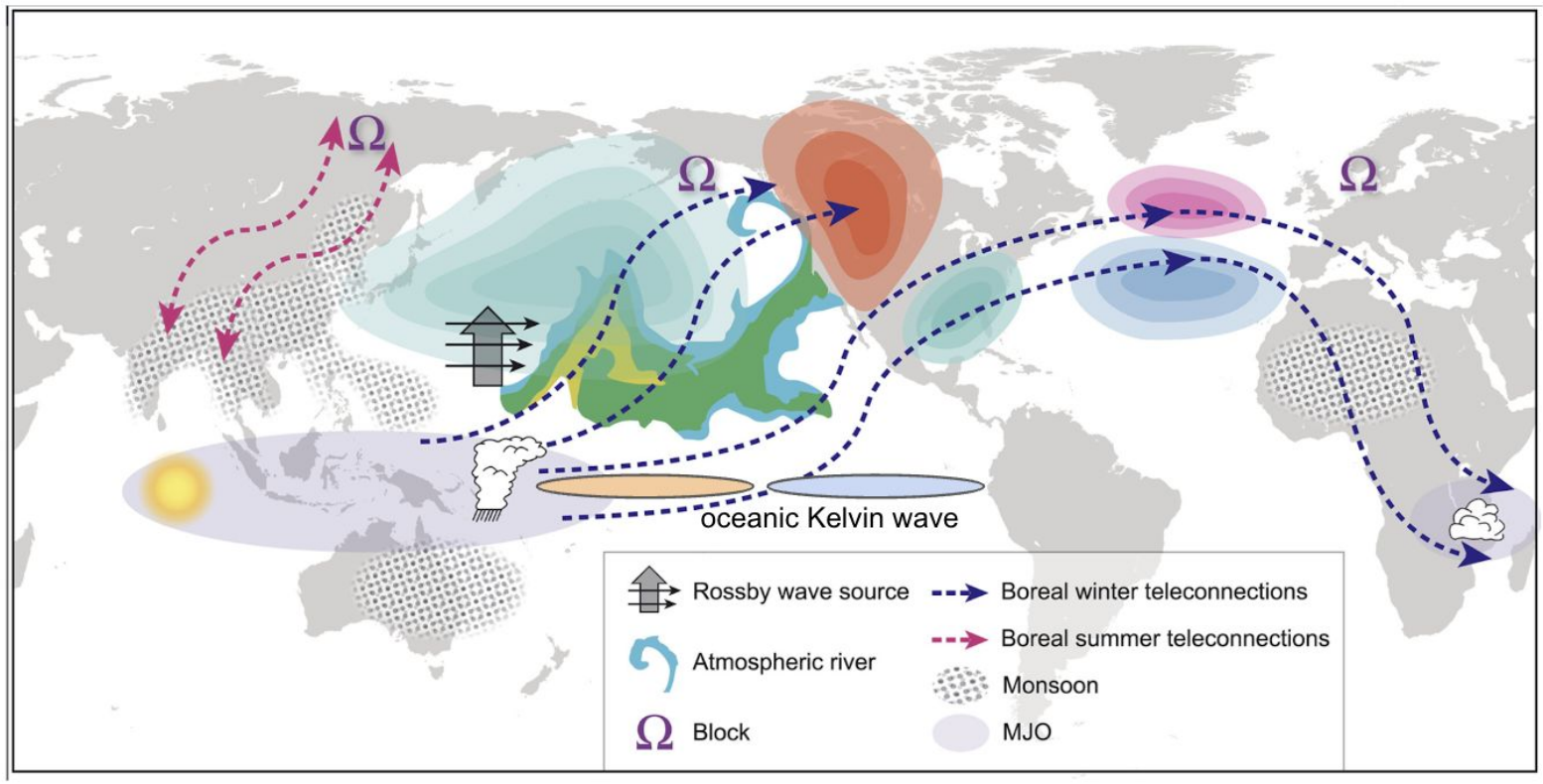
TEPEX-Central: observe processes governing zonal movement of the coupled hydrological cycle at the eastern edge of the warm pool

Eq. Pacific Precip. (mm/day)



Warm pool edge (SST=28.5°C) migrates zonally on Subseasonal-to-Interannual (S2I) timescales

MJO teleconnections and ENSO interactions

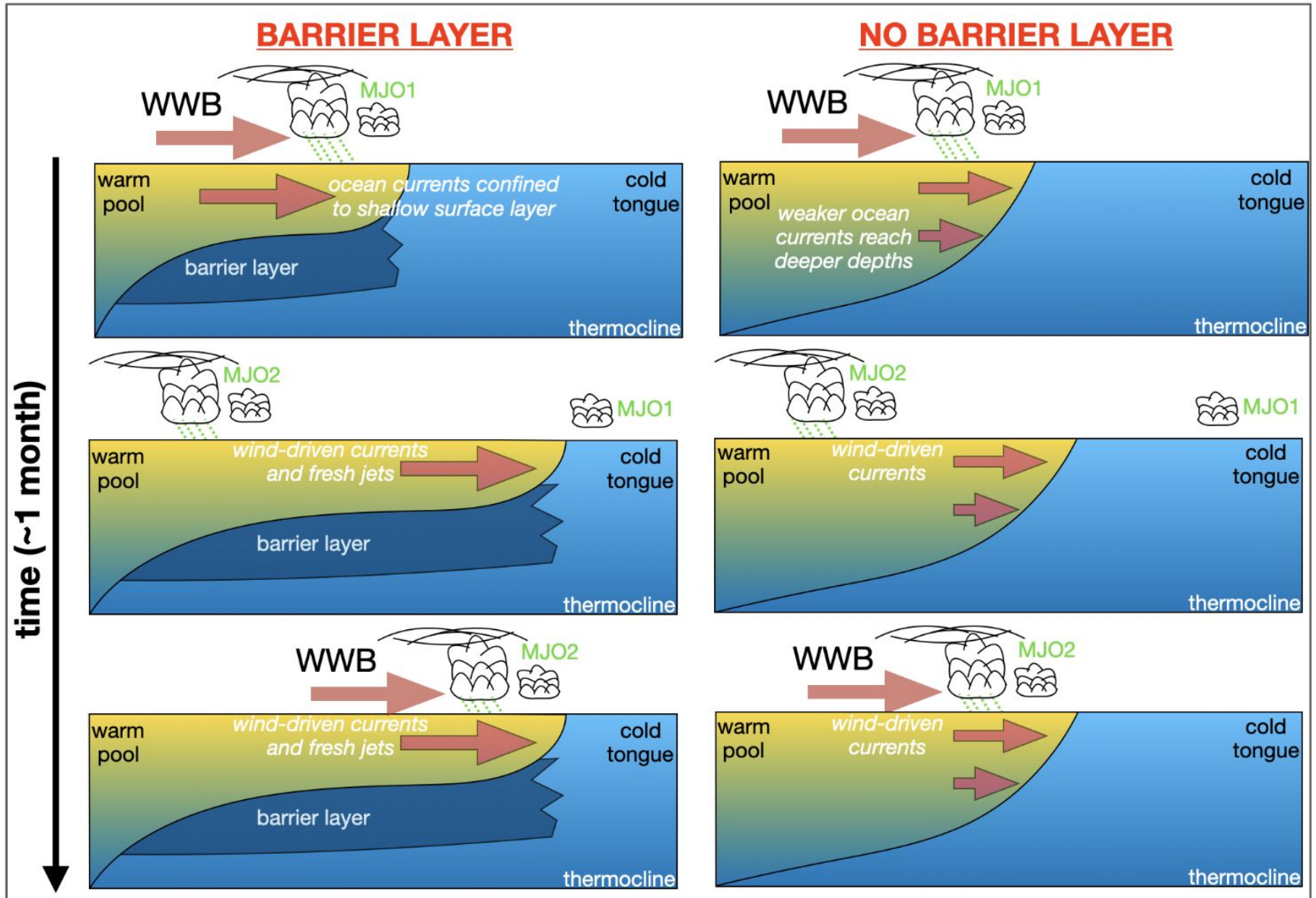


adapted from Stan et al. 2017

Warm pool edge migration affects global weather patterns and predictability across scales

TEPEX-Central

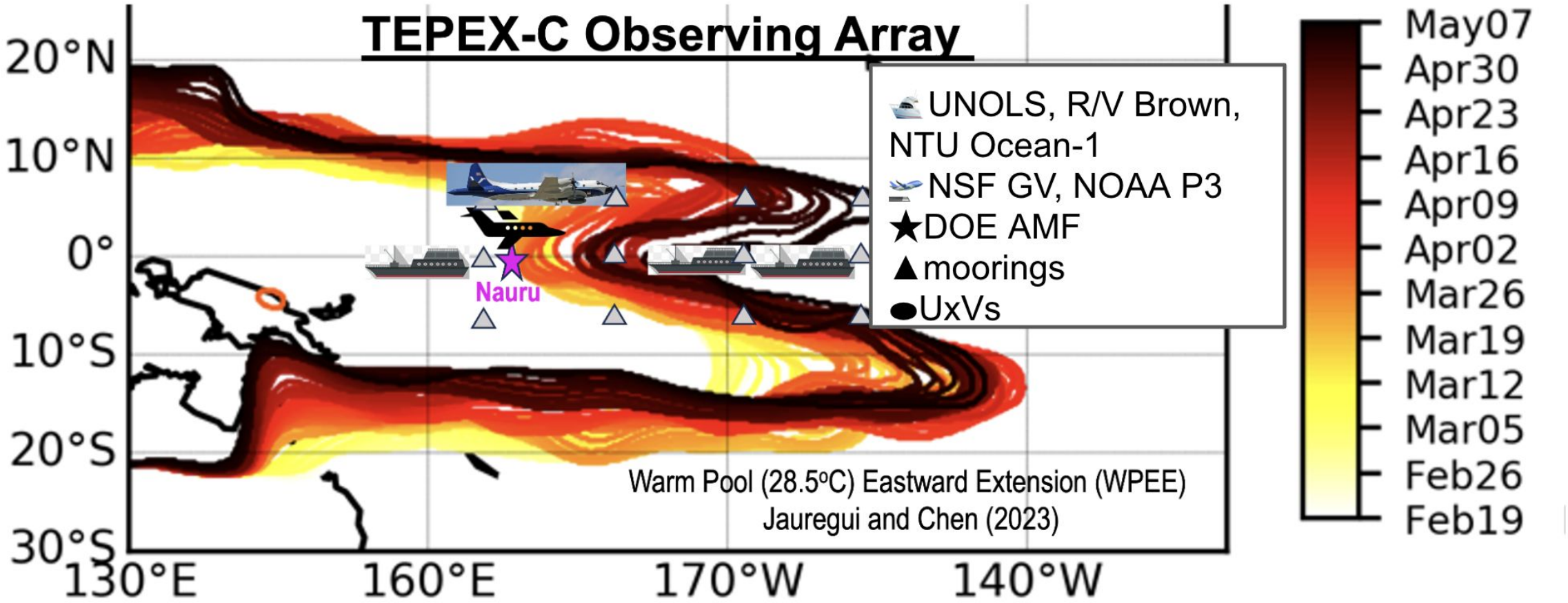
ocean-atmosphere coupled processes



- With barrier layer:
  - Stronger surface currents
  - Potential for fresh jets
  - Greater EEWP extension
- Without barrier layer:
  - Weaker surface currents
  - Weaker fresh jets
  - Less EEWP extension
- Important consequences for MJO activity & MJO-ENSO interactions

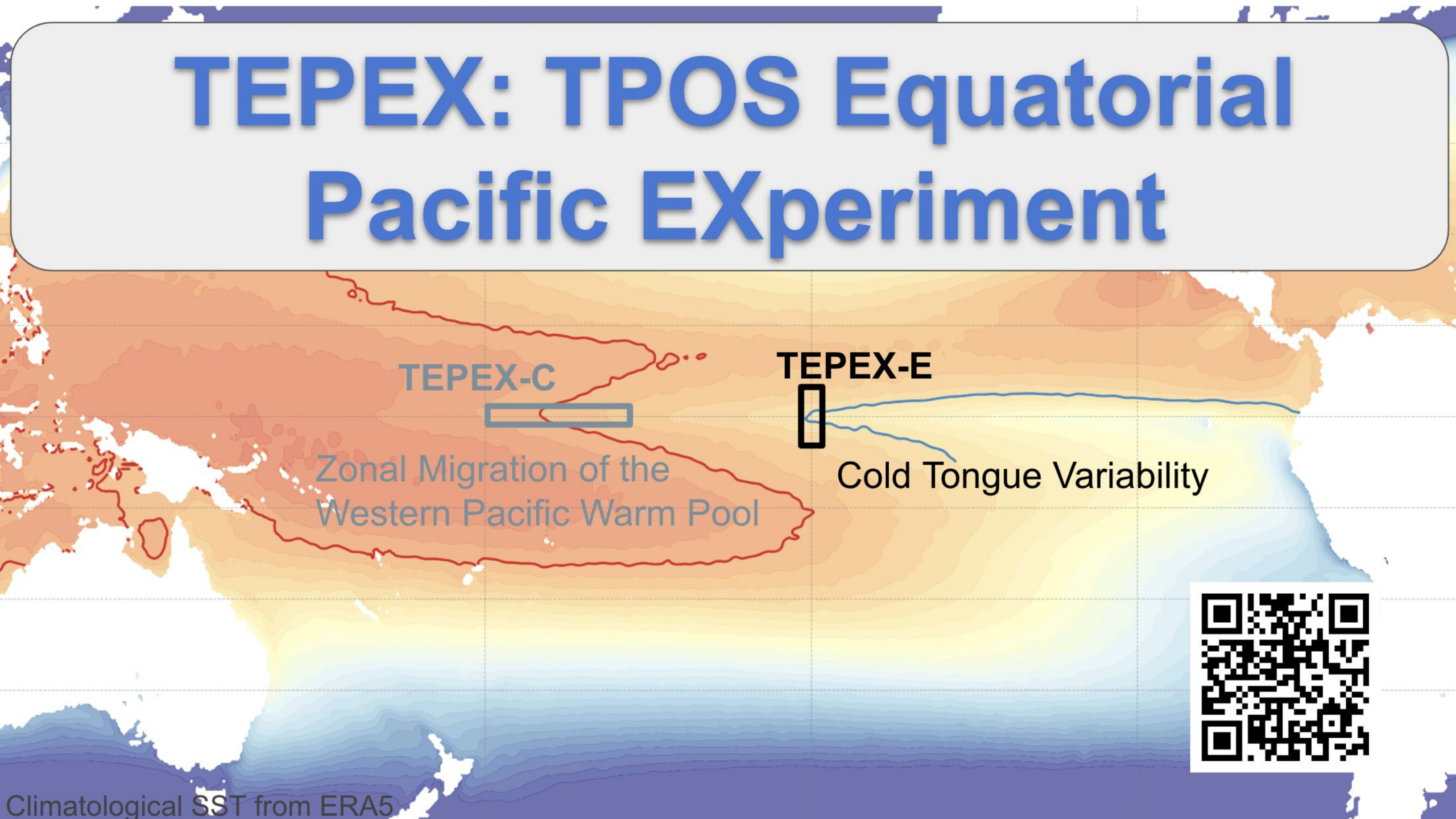
TEPEX-Central

How to accomplish this?



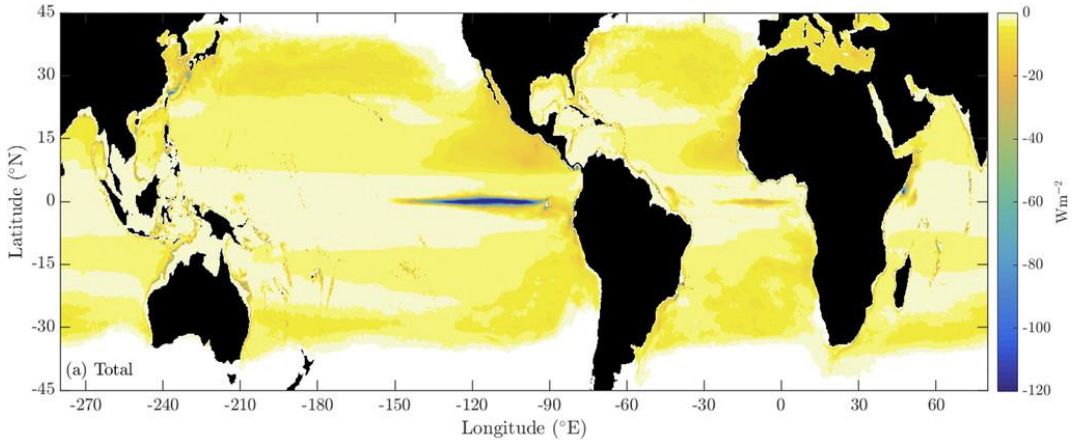
- intensive field campaign at warm pool edge during spring (season of climatological expansion).
- land-based assets: MABL profilers, deployable aircraft, UAVs
- edge-following ship-based assets: radar, sondes, ocean probes, DC flux packages, UAVs
- near-edge uncrewed assets: UUVs, USVs

TEPEX: TPOS Equatorial Pacific EXperiment



Eastern tropical Pacific ocean processes

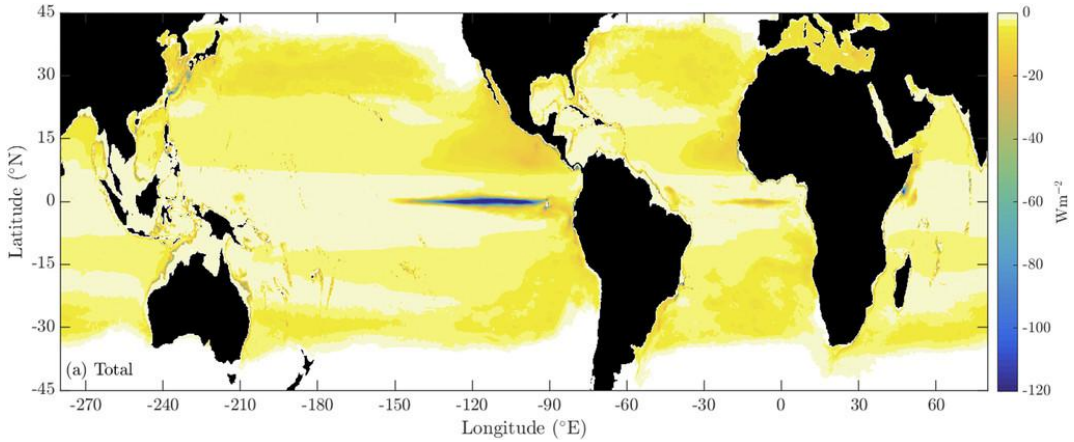
Heat uptake by vertical mixing



Holmes et al (2019). "Diathermal heat transport in a global ocean model". Journal of Physical Oceanography, 49(1), 141-161.

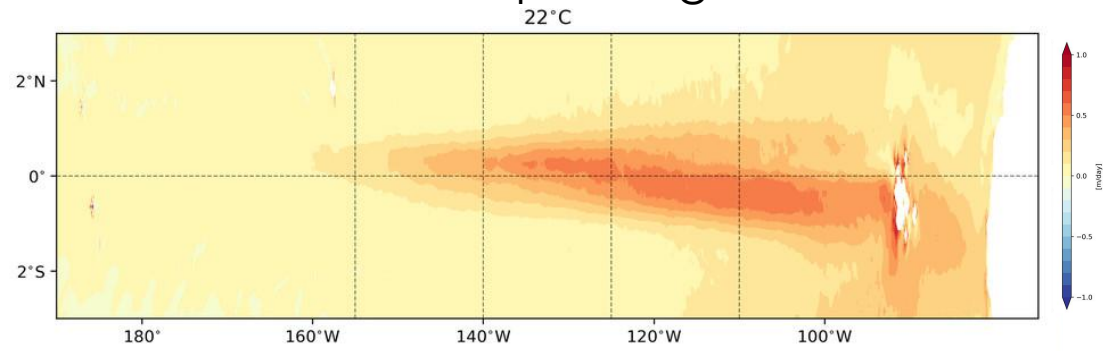
Eastern tropical Pacific ocean processes

Heat uptake by vertical mixing



Holmes et al (2019). "Diathermal heat transport in a global ocean model". Journal of Physical Oceanography, 49(1), 141-161.

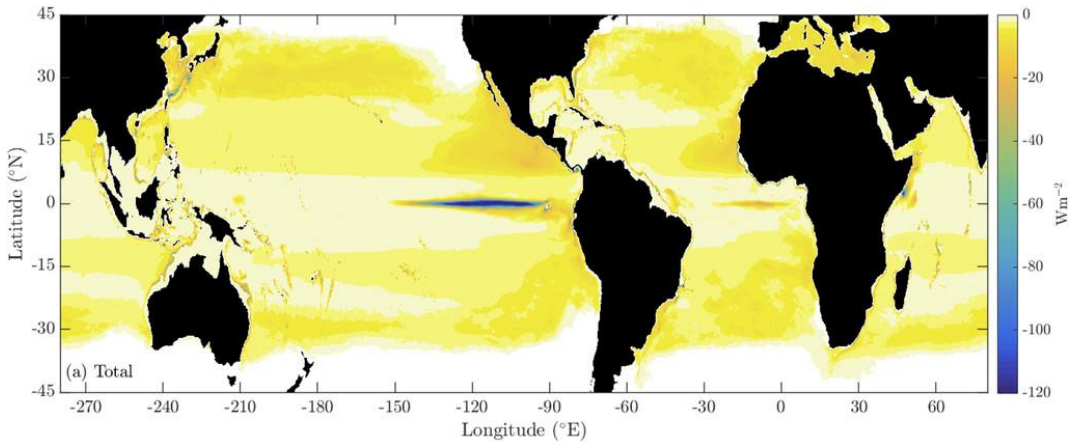
Diabatic upwelling



Deppenmeier et al. "Modulation of cross-isothermal velocities with ENSO in the tropical Pacific cold tongue." *Journal of Physical Oceanography* 51.5 (2021)

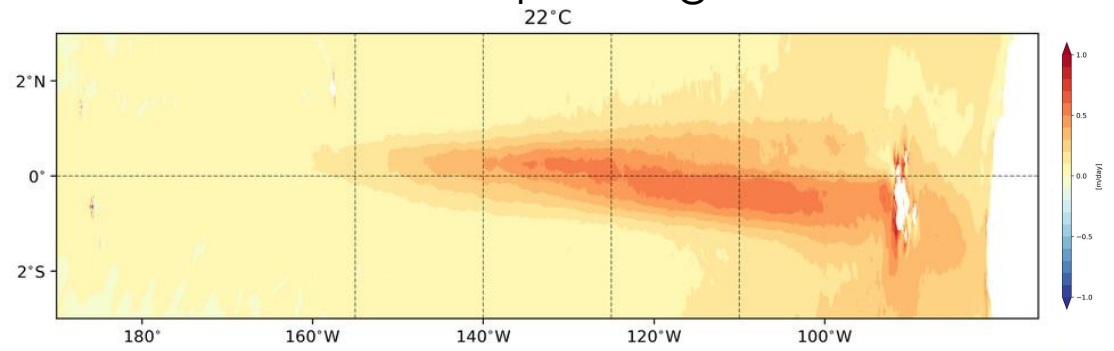
Eastern tropical Pacific ocean processes

Heat uptake by vertical mixing

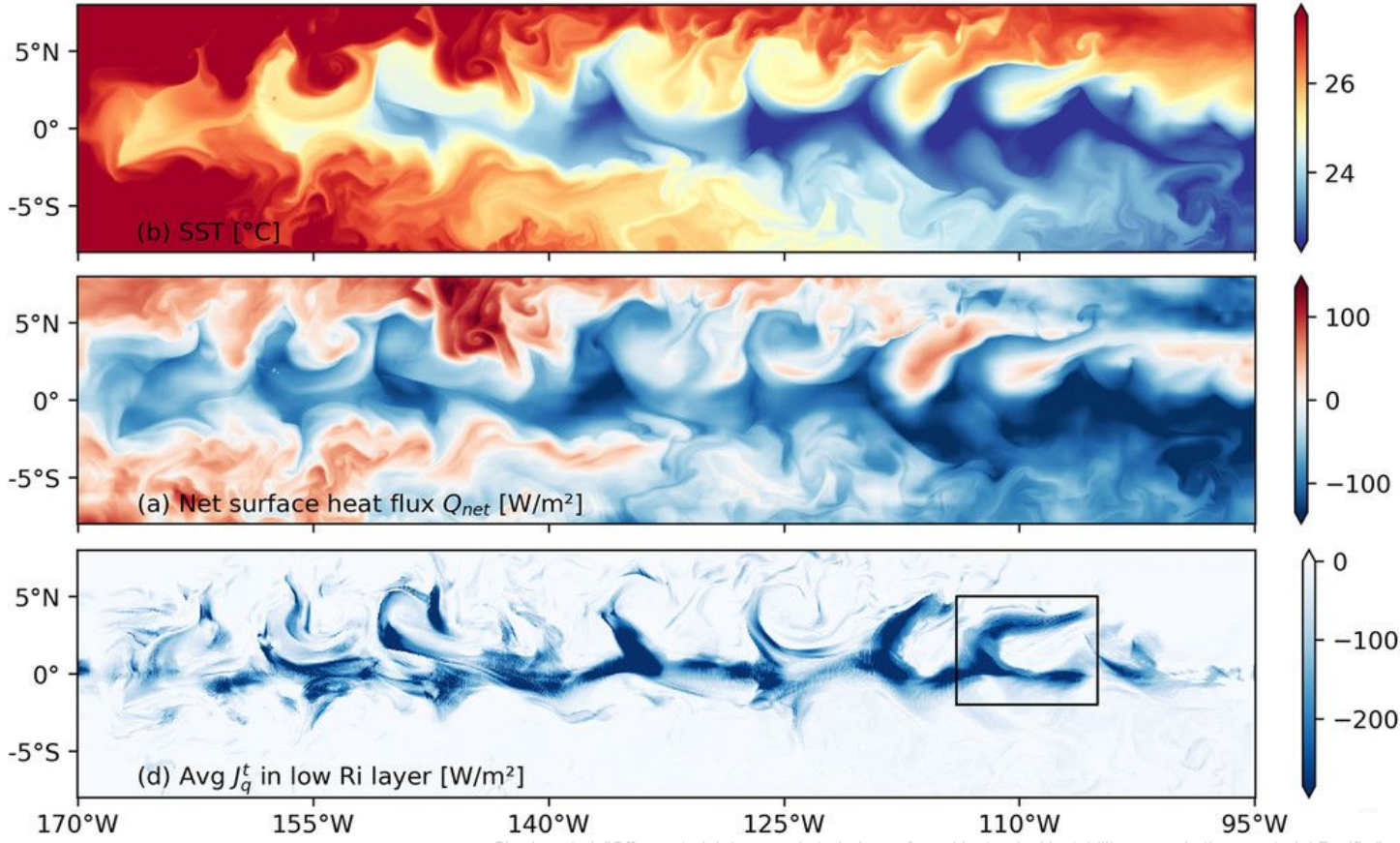


Holmes et al (2019). "Diathermal heat transport in a global ocean model". Journal of Physical Oceanography, 49(1), 141-161.

Diabatic upwelling



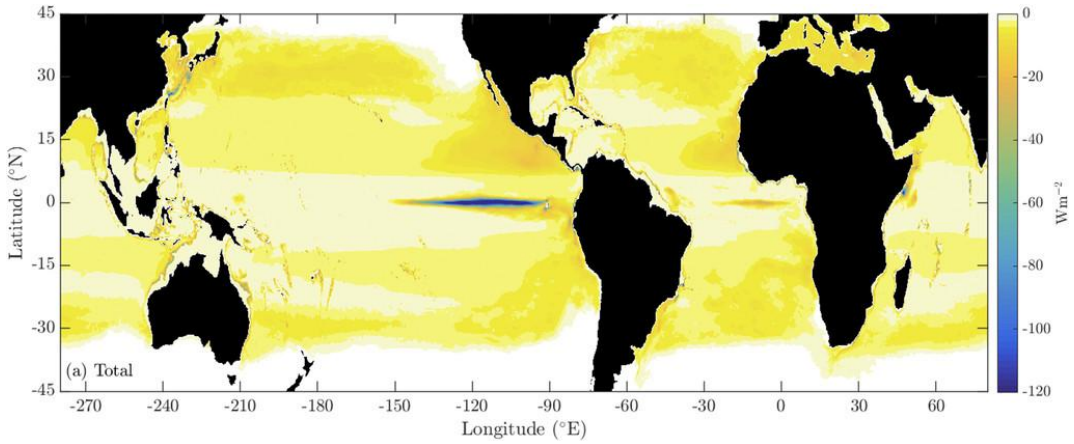
Deppenmeier et al. "Modulation of cross-isothermal velocities with ENSO in the tropical Pacific cold tongue." *Journal of Physical Oceanography* 51.5 (2021)



Cherian et al. "Off-equatorial deep-cycle turbulence forced by tropical instability waves in the equatorial Pacific." Journal of Physical Oceanography 51.5 (2021)

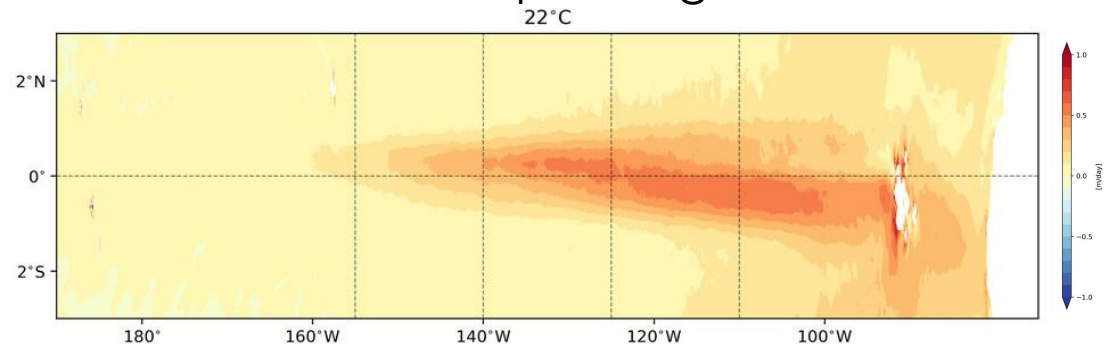
Eastern tropical Pacific ocean processes

Heat uptake by vertical mixing

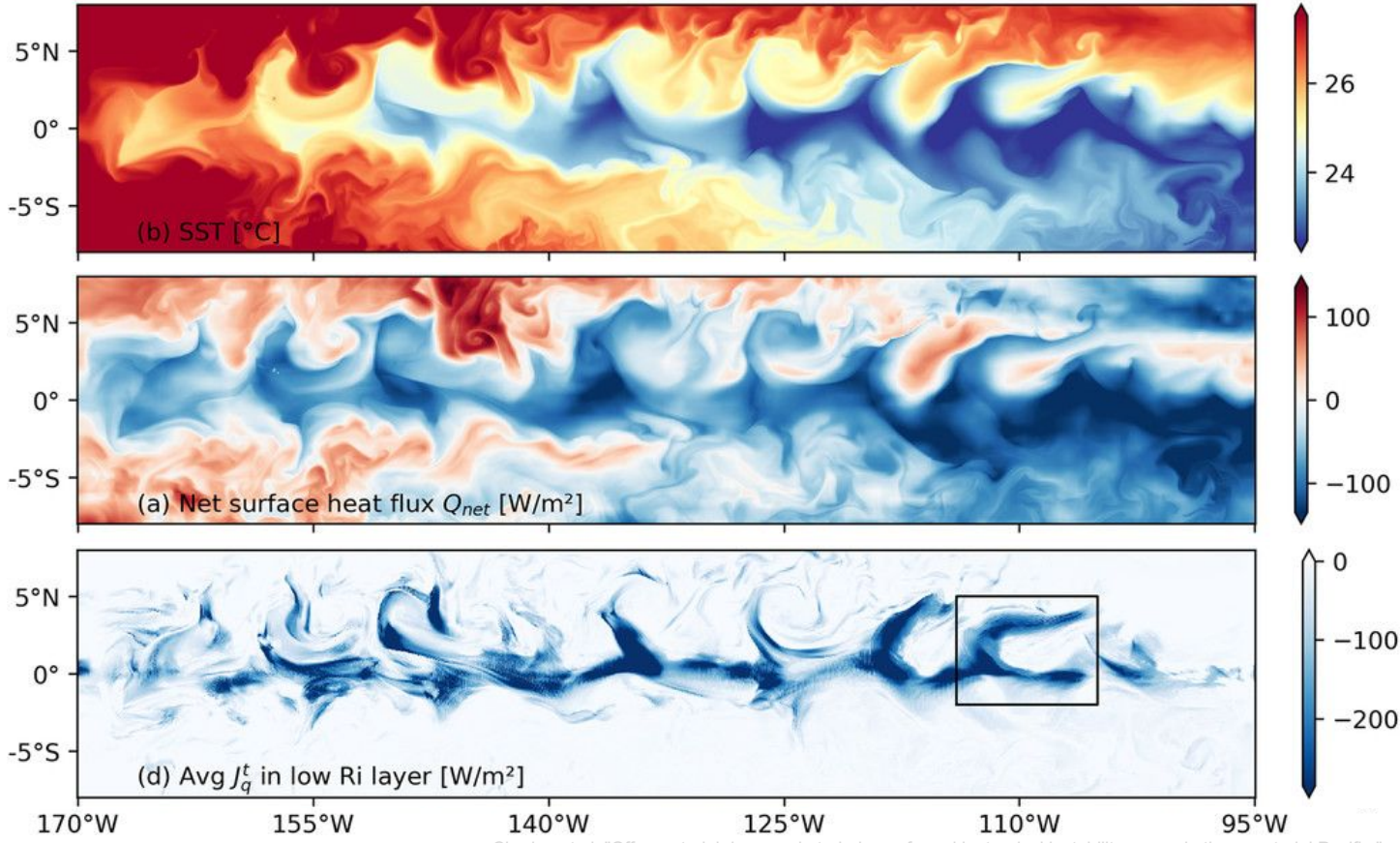


Holmes et al (2019). "Diathermal heat transport in a global ocean model". Journal of Physical Oceanography, 49(1), 141-161.

Diabatic upwelling



Deppenmeier et al. "Modulation of cross-isothermal velocities with ENSO in the tropical Pacific cold tongue." *Journal of Physical Oceanography* 51.5 (2021)

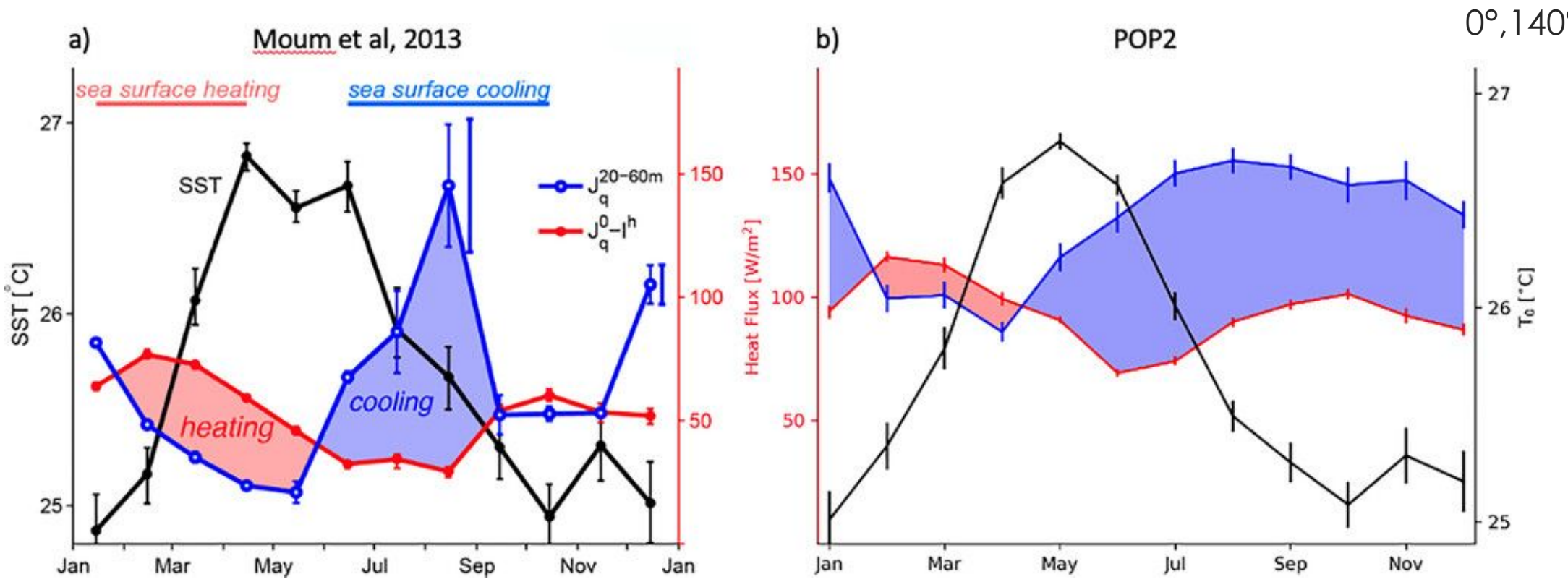


Cherian et al. "Off-equatorial deep-cycle turbulence forced by tropical instability waves in the equatorial Pacific." Journal of Physical Oceanography 51.5 (2021)

Results from model output

Vertical mixing biases

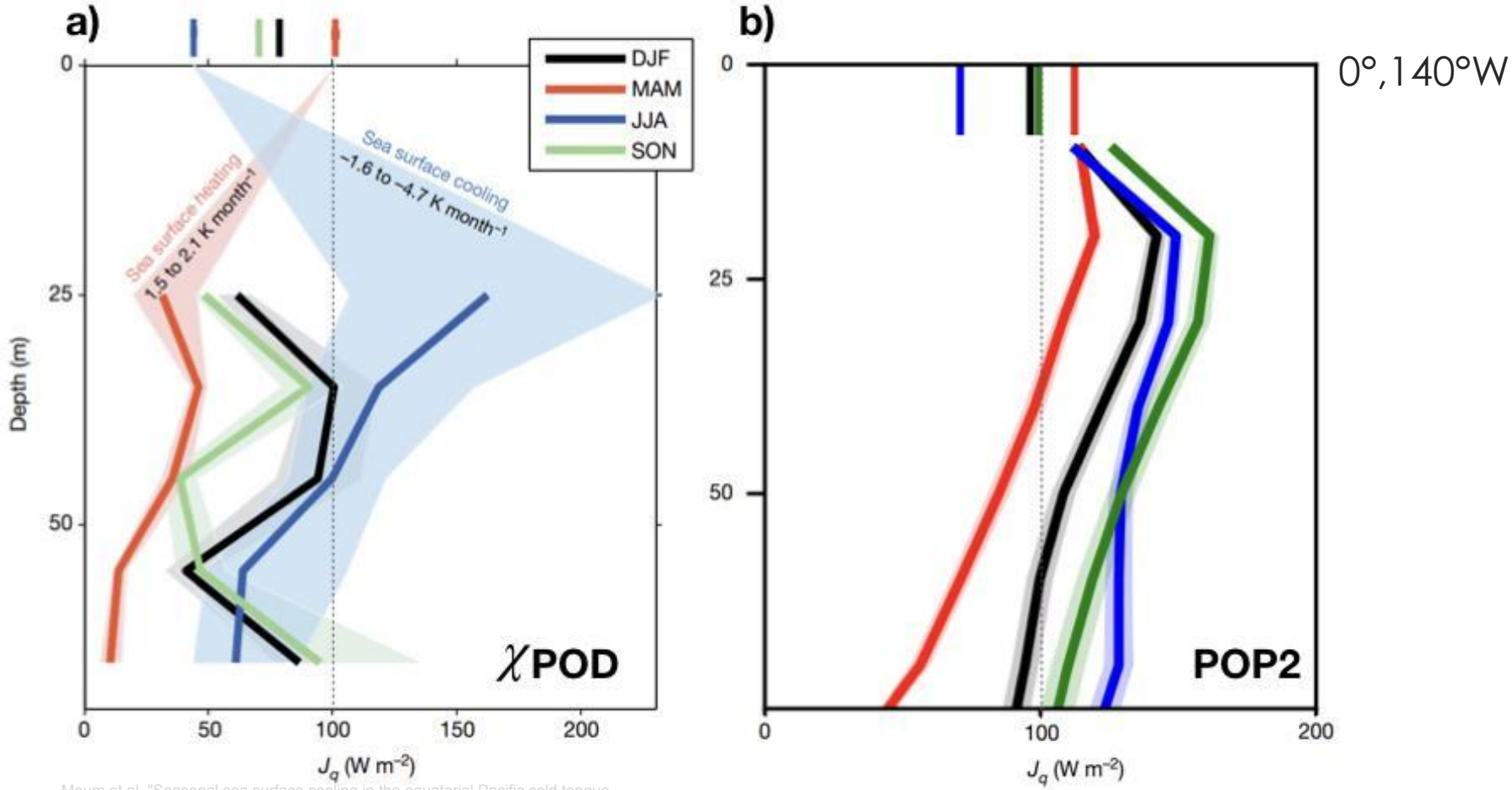
from a direct comparison



Deppenmeier et al. "Diabatic Upwelling in the Tropical Pacific: Seasonal and subseasonal variability." *Journal of Physical Oceanography* 52.11 (2022): 2657-2668.

Vertical mixing biases

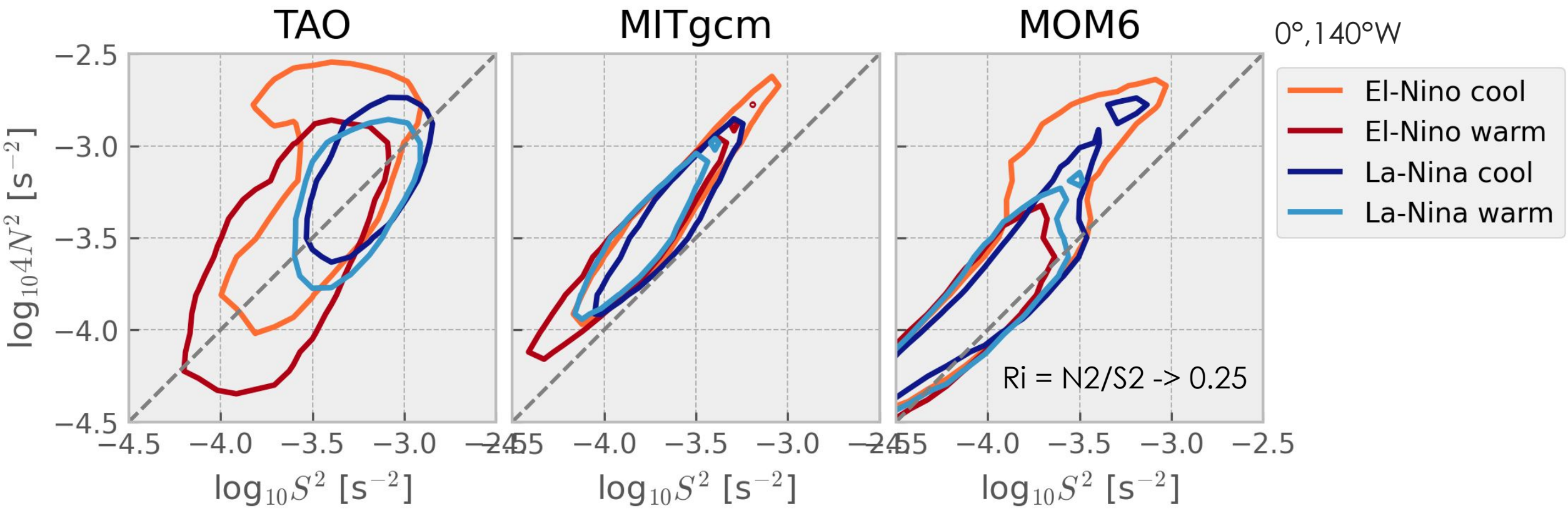
from a direct comparison



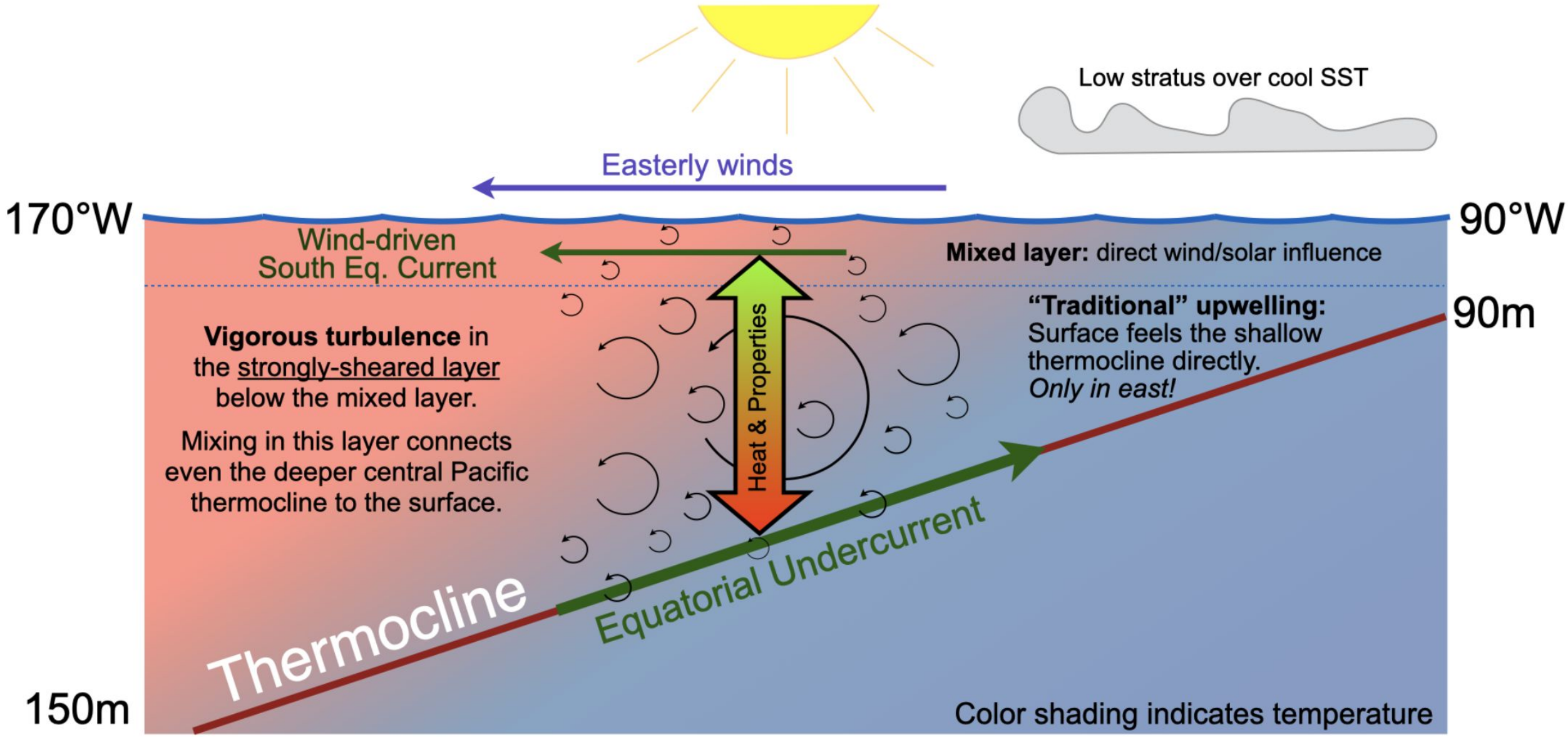
Moum et al. "Seasonal sea surface cooling in the equatorial Pacific cold tongue controlled by ocean mixing." *Nature* 500.7460 (2013)

Vertical mixing biases

from an indirect comparison



Shear driven mixing couples thermocline to surface

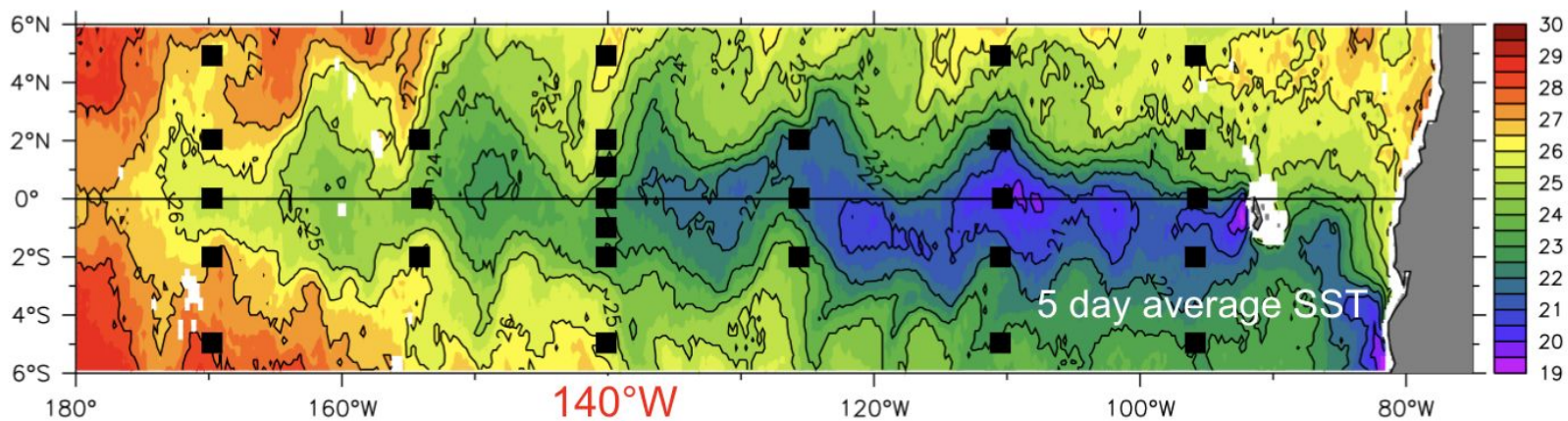


TEPEX-East

Science Goals

- Build a comprehensive understanding of the processes and interactions that determine the **structure, strength, and temporal variability of upwelling, mixing, and ocean-atmosphere coupling** across the cold tongue.
- **Improve model representation of these upwelling and mixing processes.**
- Learn to infer and diagnose process-level information from the **sustained observing system**.
- Inform the future evolution of the sustained observing system.

TAO moored array over example SST (new NWS enhancements)



Campaign builds on NOAA's implementation of the TPOS 2020 recommendations for the 140°W line

TEPEX-East

Observing Strategy

- Co-located observations from the thermocline into the atmospheric boundary layer
- Meridional section across the cold tongue, including the front and TIW

Ocean variables: Temperature, velocity, solar penetration and **mixing profiles**

MABL variables: Temperature, humidity, velocity profiles; thickness, cloudiness

Proposed Field campaign:

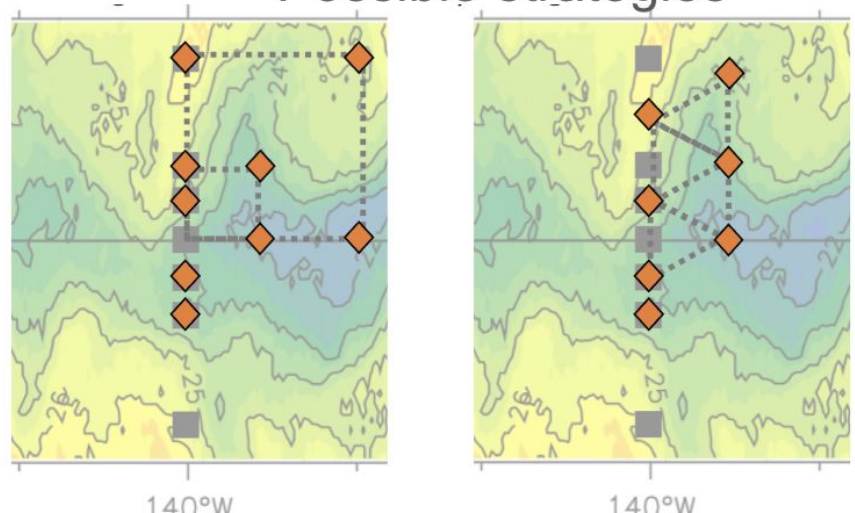
Enhanced moorings across the cold tongue and its front along 140°W

Shipboard measurements (3 cruises 6 months apart)

Uncrewed systems (surface, subsurface ocean, aircraft: TBD)

- Model analysis and Observing System Simulation Experiments to determine most effective sampling

Possible strategies



Field Program Targets

TEPEX-Central

Targets the mechanism behind the zonal shifts of the eastern edge of the warm pool

What:

- Combined roles of WWBs and convection in air-sea interaction
- Turbulence in the MABL and OML
- Role of barrier layers in variability of edge

How:

- Shipboard, aircraft, uncrewed ocean vehicles, and land-based measurements

When:

- Spring: largest zonal variability of edge, WWB 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 to thermocline

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 MABL and its clouds

How:

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

When:

- Fall + Spring + Fall (TIW reliably present)

Please provide input

- What (other) variables should we measure?
- What should we prioritize?
- What would be helpful from model development point of view?