Process studies and TPOS 2020

(Tropical Pacific Observing System)

TPOS 2020 is complete. Our design is being implemented.

Highlights:

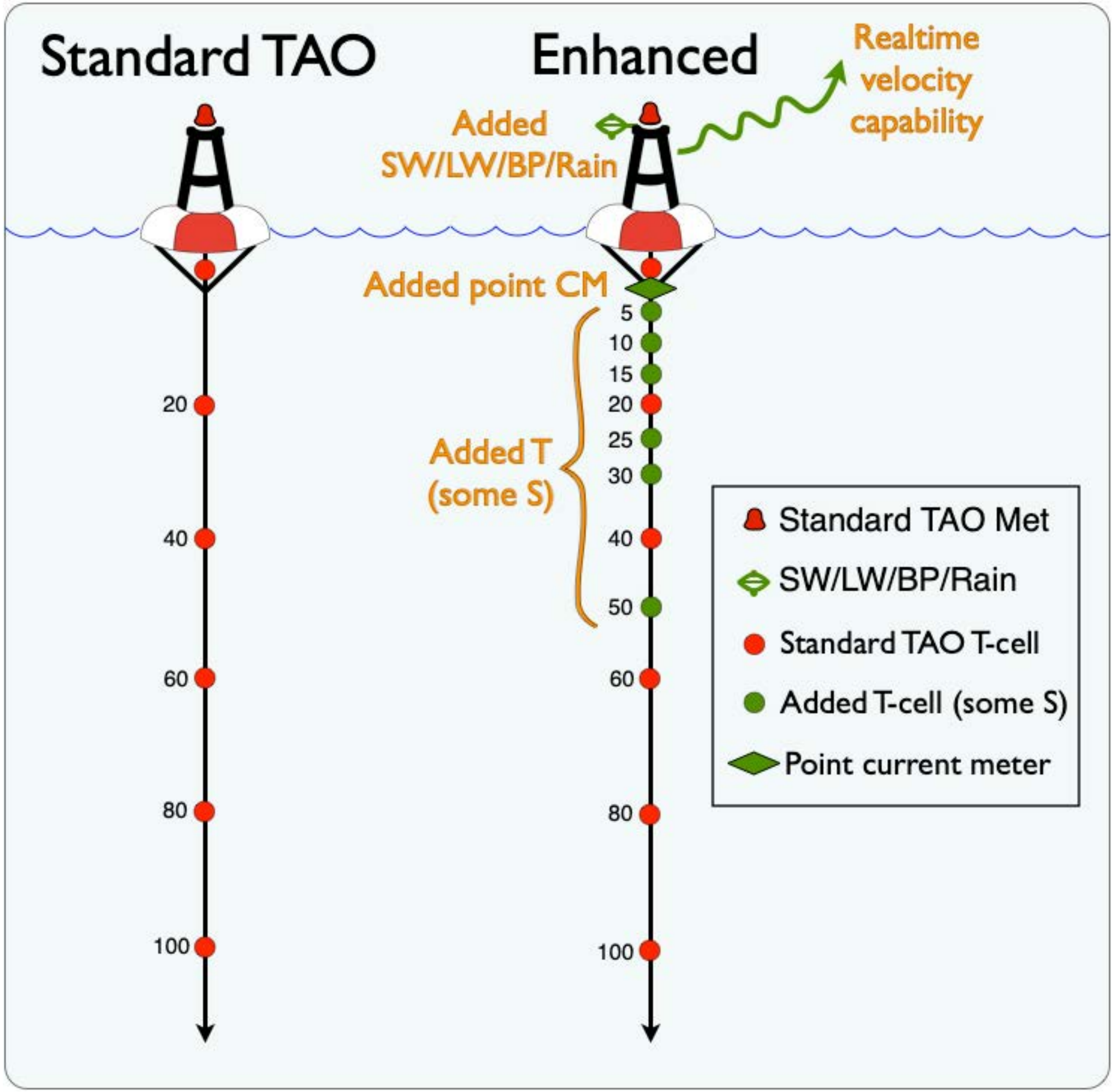
- NOAA accepted our recommendations for TAO; moving forward
- China's Ding array is building; mostly replaces TRITON in the west
- Both the US and China are deploying many new Argo floats ... closing in on double Argo, and populating BGC Argo
- NOAA (Climate Variability Program) is funding pre-field modeling for process studies (topic of this talk ... work in progress)

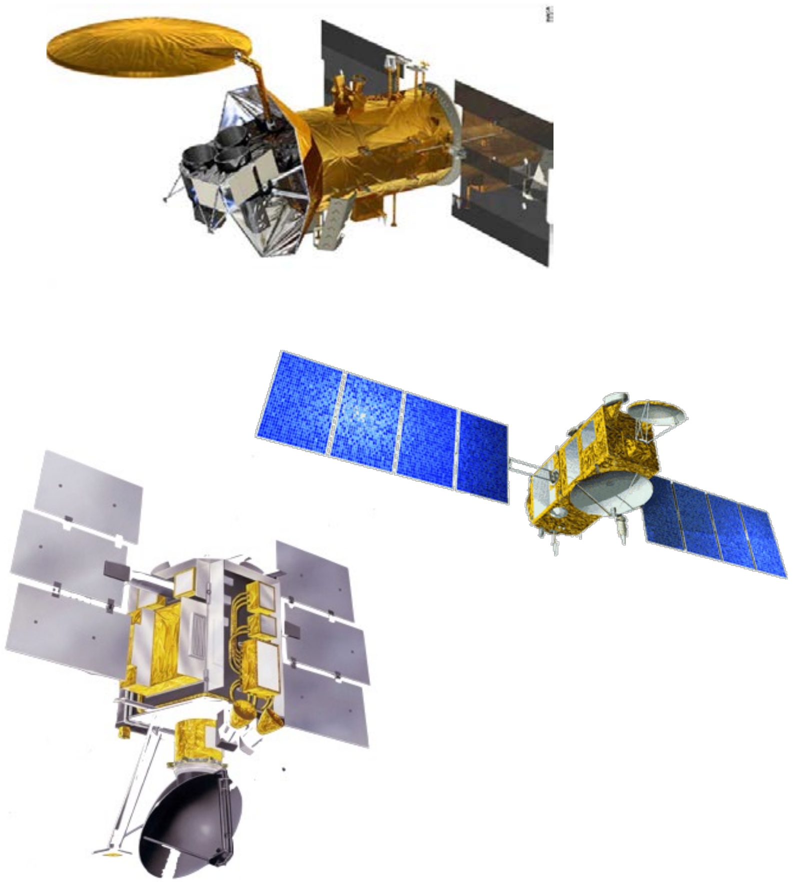
TPOS 2020's most important advance

Every TAO mooring will be enhanced for more complete surface met, and denser mixed layer sampling.

⇒ Use moorings where their strengths are needed: Fast timescales, co-located ocean-atmosphere obs.

These will provide geographical and temporal context for a process study.





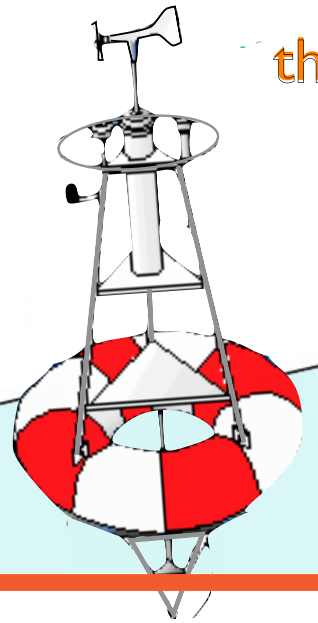
An integrated vision

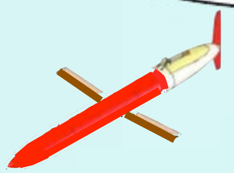
Complementary "backbone" technologies:

- Satellites give global coverage, horizontal detail
- Moorings sample across timescales, allow co-located ocean-atmosphere observations, velocity sampling
- Argo resolves fine vertical structure, adds salinity, maps subsurface T and S, connects to subtropics

Sustained diagnoses will occur largely through model products that integrate diverse data sources, remote and in situ.

We will never observe everything.





TPOS 2020 vision for process studies

Sustained diagnoses will occur largely through model products that integrate diverse data sources, remote and in situ.
We will never observe everything.

Thus, we advocate for process studies that:

- Are explicitly coordinated with parameterization development: Identify a path to improvement that needs observational guidance not available from the sustained obs (CPT model)
- Increase the ability of models and assimilation systems to infer the action of a process from ongoing sparser sampling, and thus steer refinements of the sustained observing system ...

Years of discussion, consultation, workshops ...

- What are the phenomena where models require (and can make use of) guidance from observations?

Focus on the coupled boundary layers

⇒ Mechanisms and impacts of ocean - atmosphere communication

Two phenomena stood out as having far-reaching impacts and desired by model developers:

- Air-sea interaction at the east edge of the warm pool
- Cold tongue upwelling and mixing

PUMP: Pacific Upwelling and Mixing Physics

Communication between the surface and the thermocline in the cold tongue:

- mediates Bjerknes feedbacks (global consequences)
- drives heat, momentum and property transports (including BGC/CO_2)
- is now unconstrained by observations (differs among model formulations/resolutions)

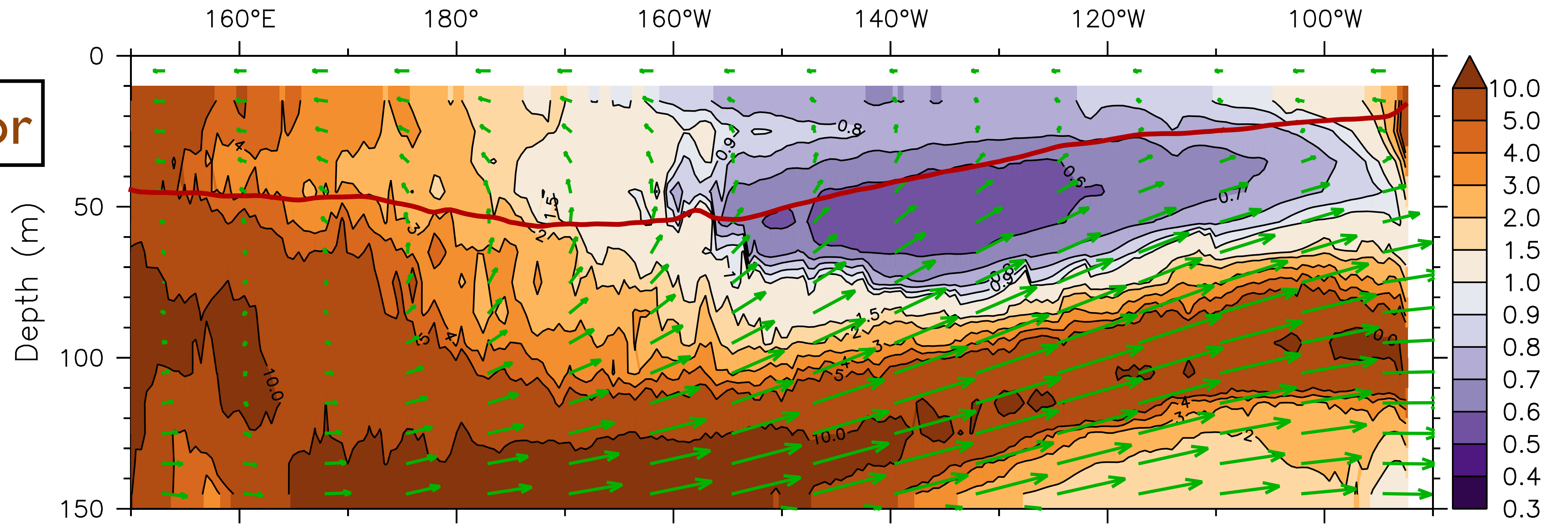
Hypothesis:

Shear-driven turbulence, building on the background (marginally-unstable) shear above the EUC, enables mixing extending below the shallow layer that is directly wind-driven and solar-heated.

This mixing is the primary communication mechanism transmitting surface input to the thermocline, and remotely-forced thermocline signals to the surface.

POP 0.1° along the equator

Ri (color shading)
u,w (green vectors)
MLD (red line)

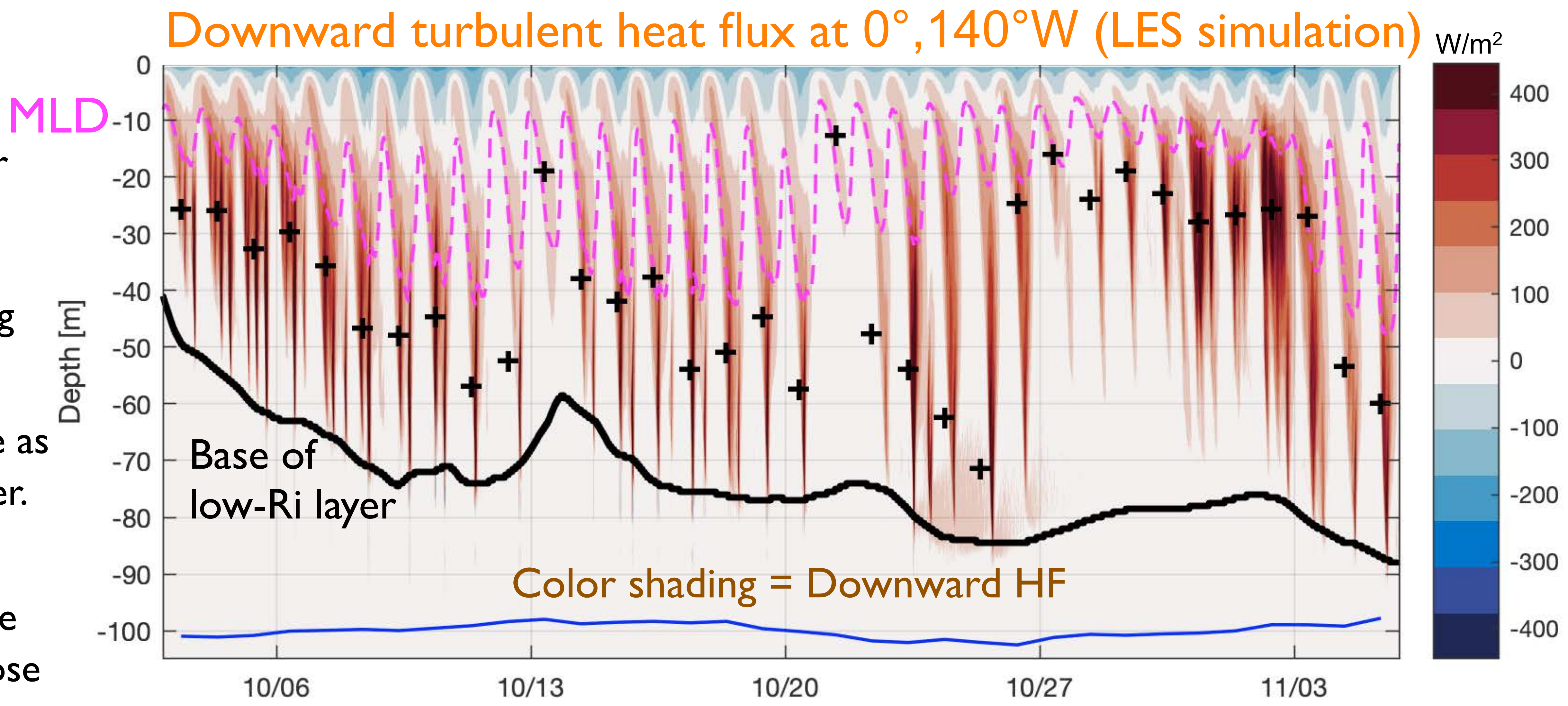


Deep-cycle turbulence is initiated by the afternoon warm layer

On a background of low Ri, the extra shear due to the afternoon warm layer initiates downward-propagating turbulence.

It extends about twice as deep as the mixed layer.

This has long been known, but we are able to simulate and diagnose it in very-high-resolution models.
LES is a step towards implementing this in climate models.



Whitt et al (in rev.)

Marginal instability produced at larger scales also drives ocean - then surface - heat fluxes in the TIW cusps

Marginal instability below the mixed layer extends north of the cold tongue in TIW cusps

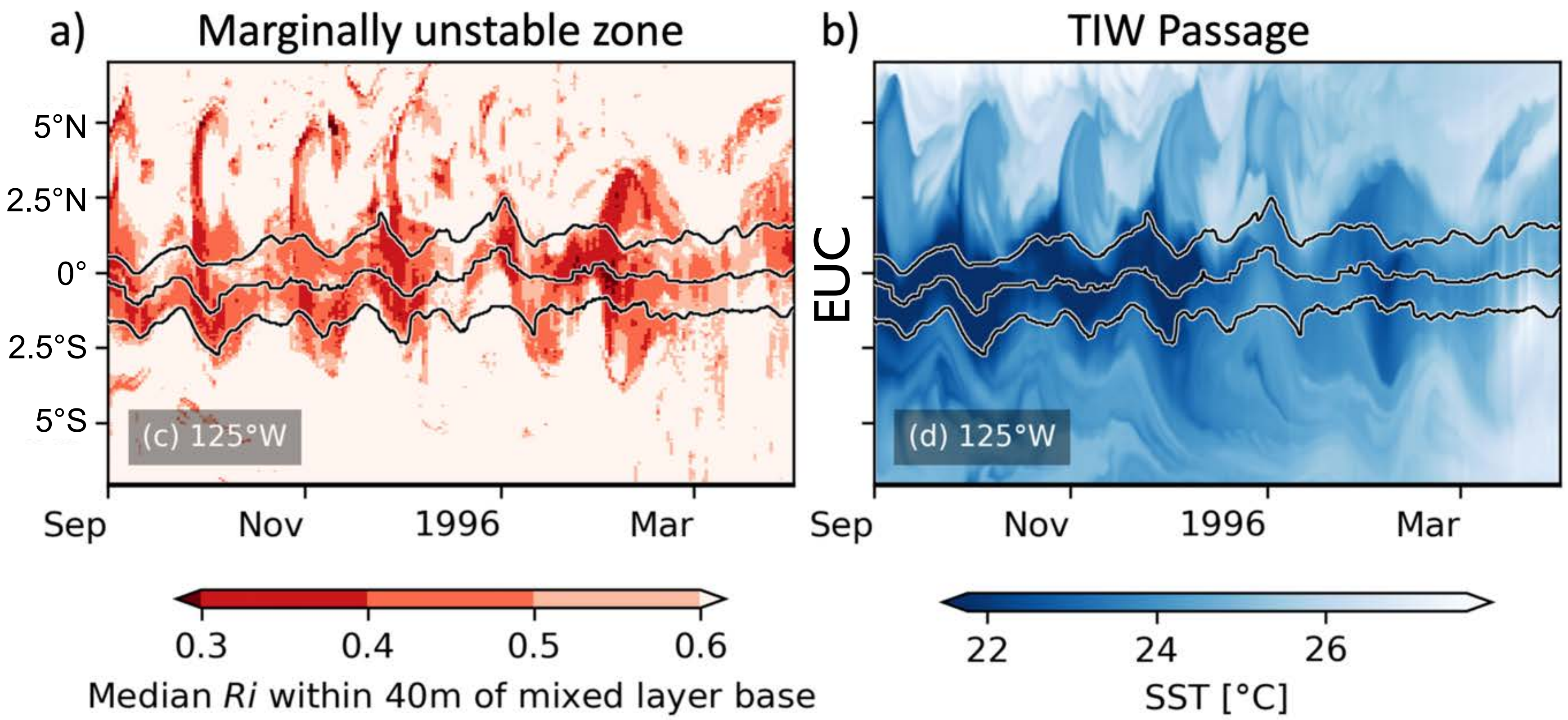
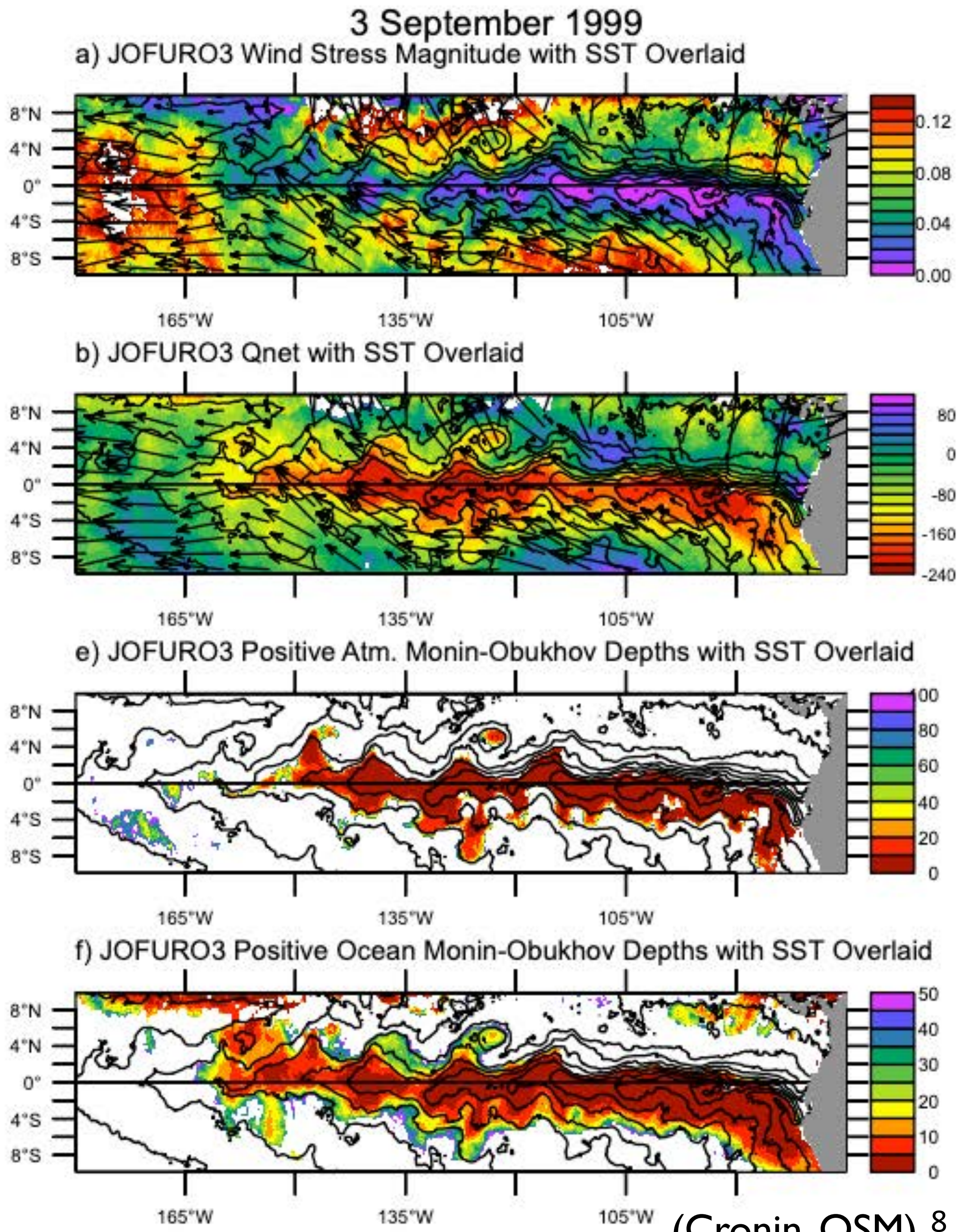


Figure 6: Time-varying extent of marginally unstable layer (dark red) at 125W highlighted using median Ri within 40m below mixed layer base from a regional forced ocean MITgcm simulation (a, for MITgcm configuration see Table 1). Note that this simulation represents marginally stable flow for Ri ⇡ 0.4 as discussed in Cherian et al. (2021). Time-Latitude plot of SST at 125W. Black lines indicate northern, central (latitude of EUC maximum), and southern latitude of EUC (b). Panels reproduced from Cherian et al. (2021).

MITgcm, Cherian et al (2021)

SST fronts

are also fronts of stability in both ocean and atmospheric boundary layers

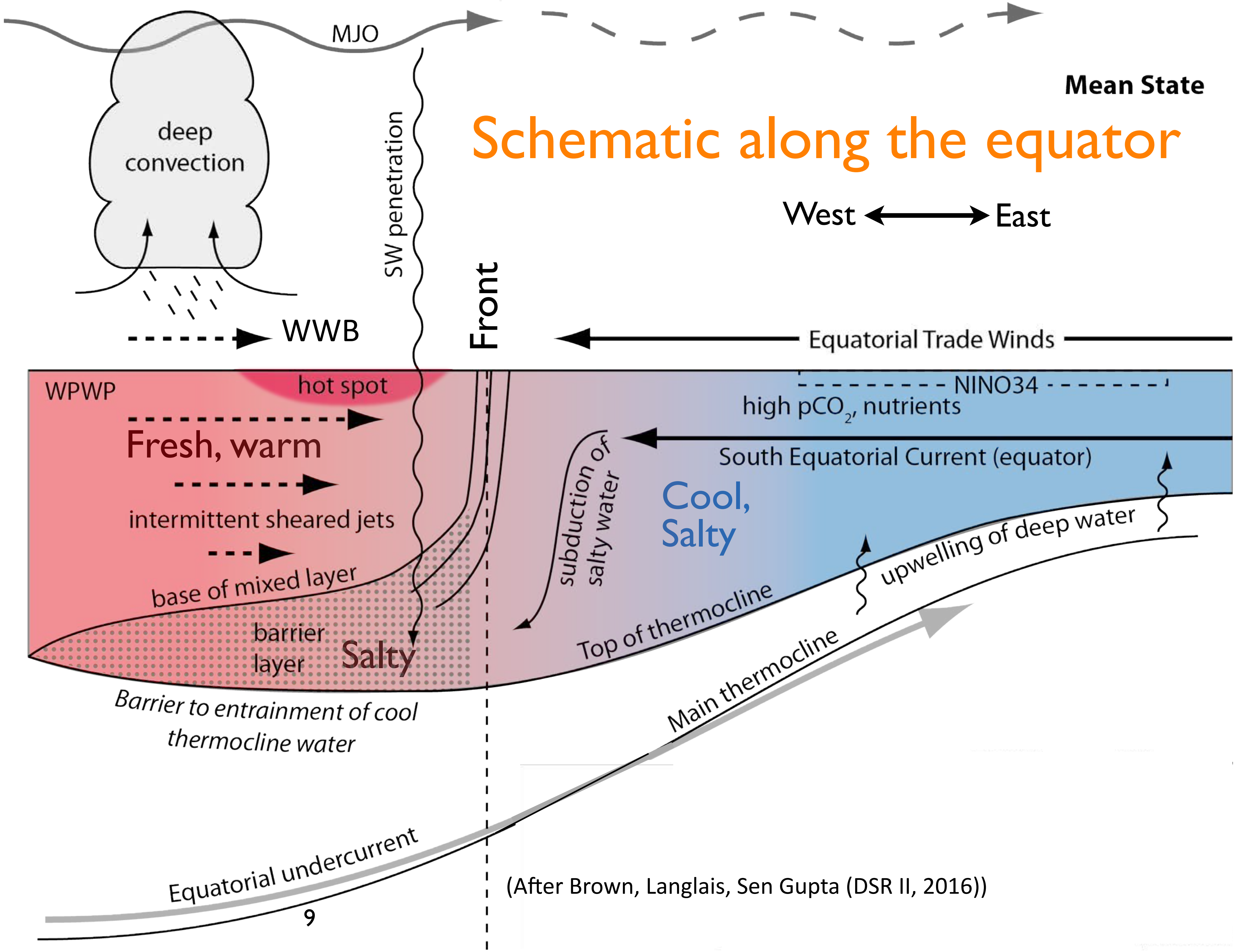


(Cronin, OSM)

Processes at the East Edge of the Warm Pool

This figure has informed numerous discussions, especially about:

- The front at the east edge of the warm pool
- The persistent barrier layer under the fresher, warmer surface layer

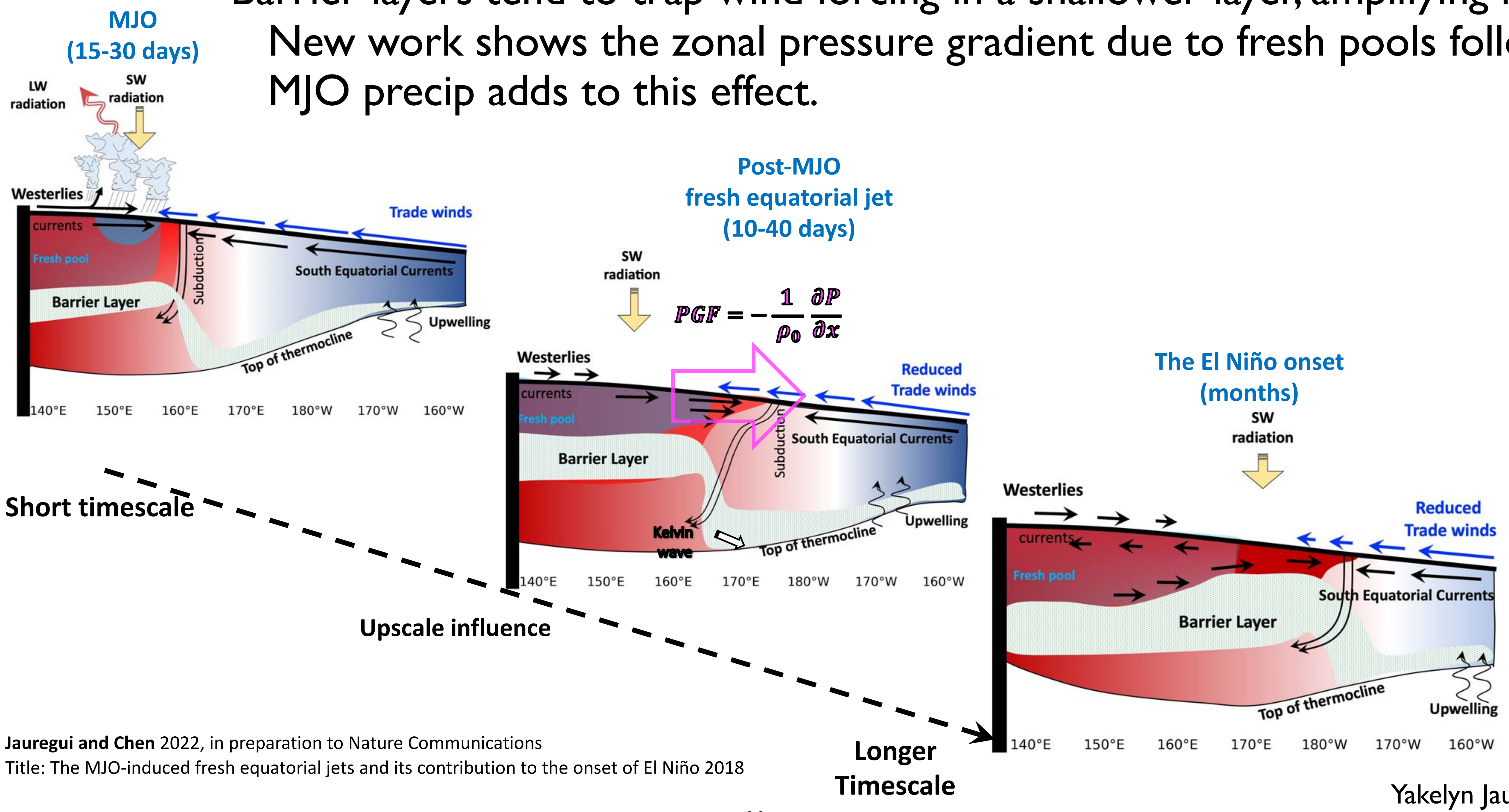


(After Brown, Langlais, Sen Gupta (DSR II, 2016))

MJO-caused fresh pools can rectify small scales into large

Barrier layers tend to trap wind forcing in a shallower layer, amplifying it.

New work shows the zonal pressure gradient due to fresh pools following MJO precip adds to this effect.



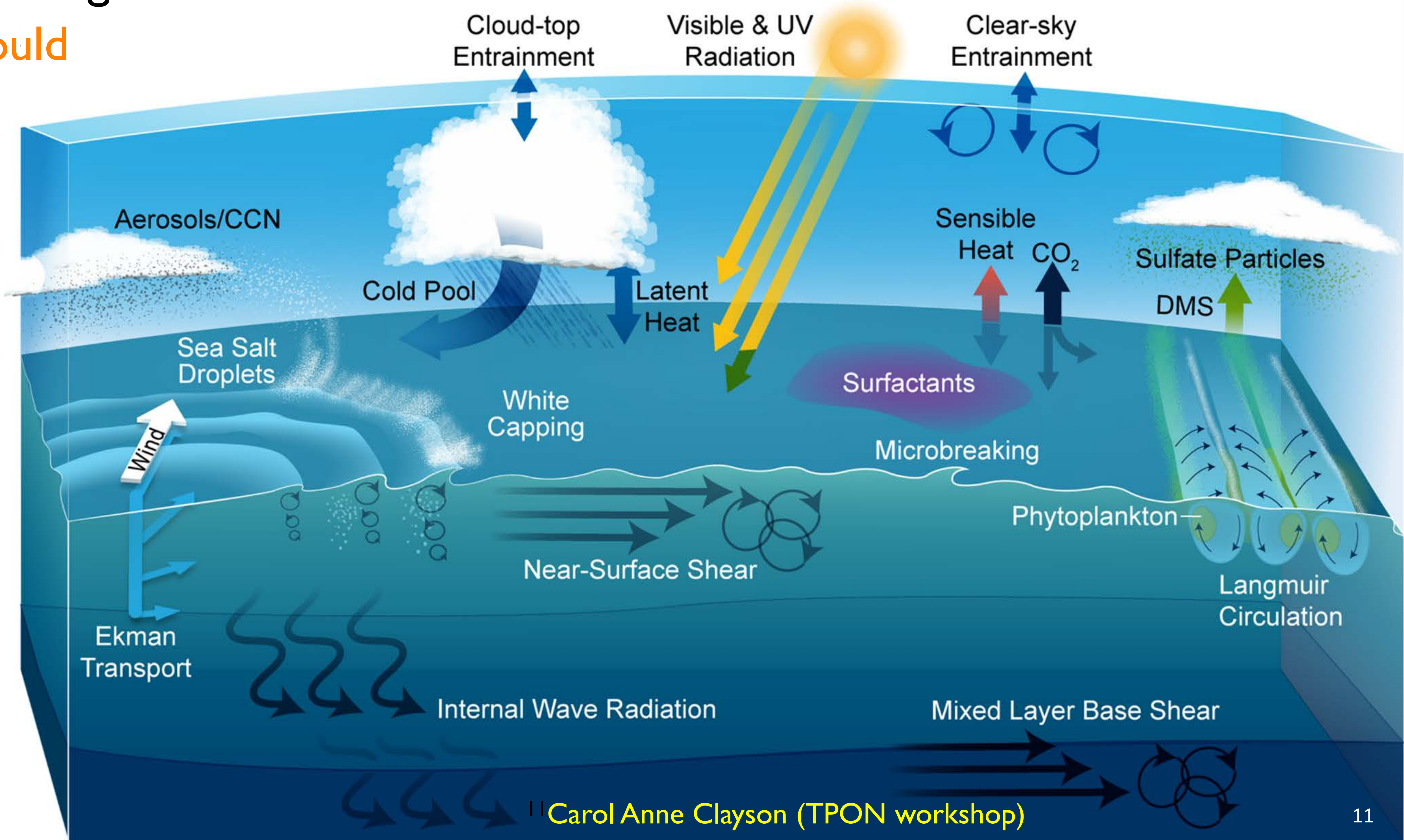
Jauregui and Chen 2022, in preparation to Nature Communications
Title: The MJO-induced fresh equatorial jets and its contribution to the onset of El Niño 2018

Yakelyn Jauregui (OSM)

The TPON workshop advocated a broad set of coupled air-sea processes

Small scales ⇒ Large

Any of these could be important!
Many open questions.
What to do?



Carol Anne Clayson (TPON workshop)

My opinion:
The next step is basic research to define the targets:

1. Which are critical?
2. Which are tractable?
3. Which offer a clear path to incorporate into models?

Research or process study?

A supersite!