Yoshida Jets, Diurnal Jets and Fresh Jets: Challenges for the Tropical Pacific Observing System

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OOMD Ocean Observing and Monitoring Division

U.S. CLIVAR Atmospheric Convection and Air-Sea Interactions over the Tropical Oceans

8 May 2019 - Boulder CO USA

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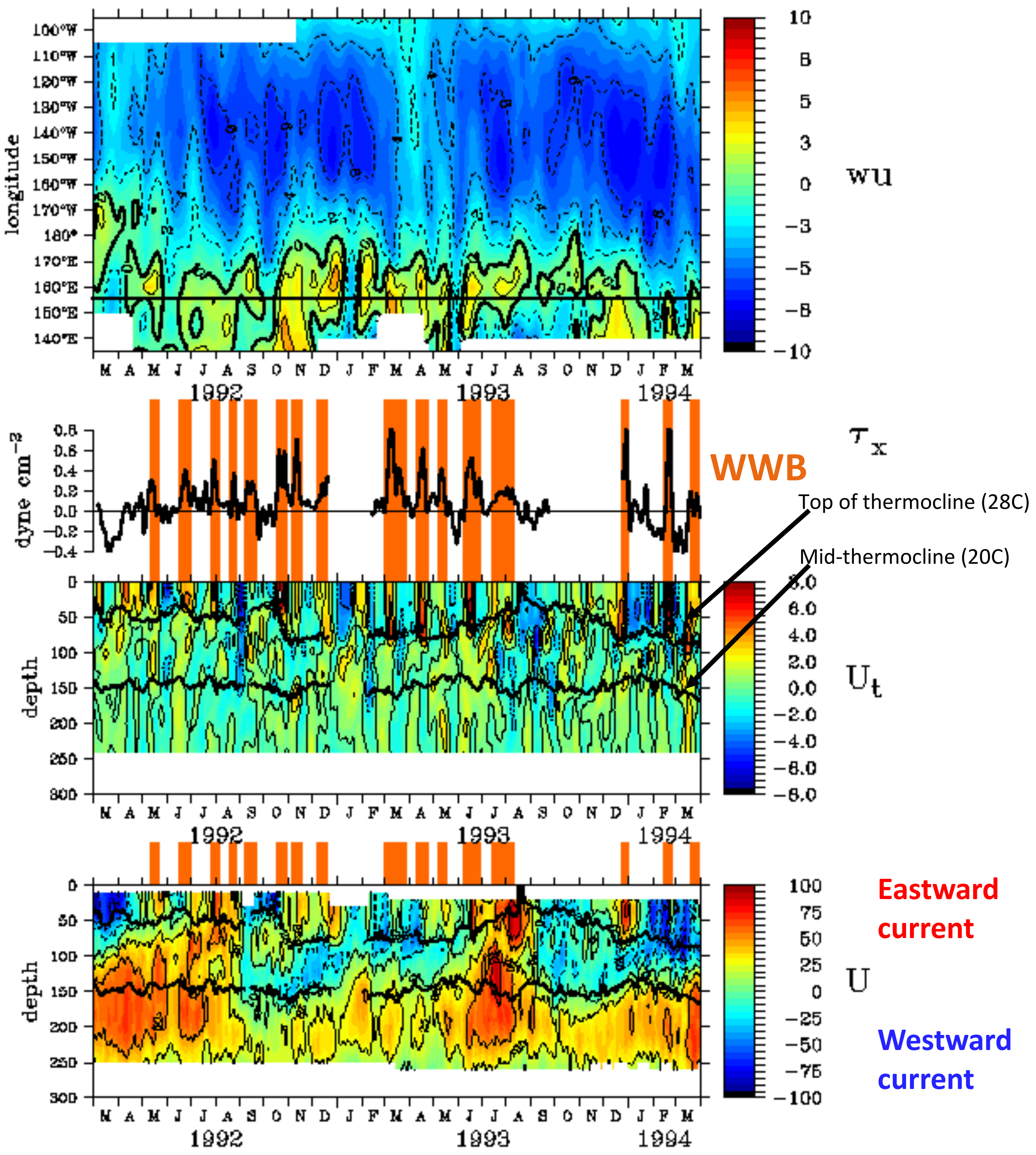
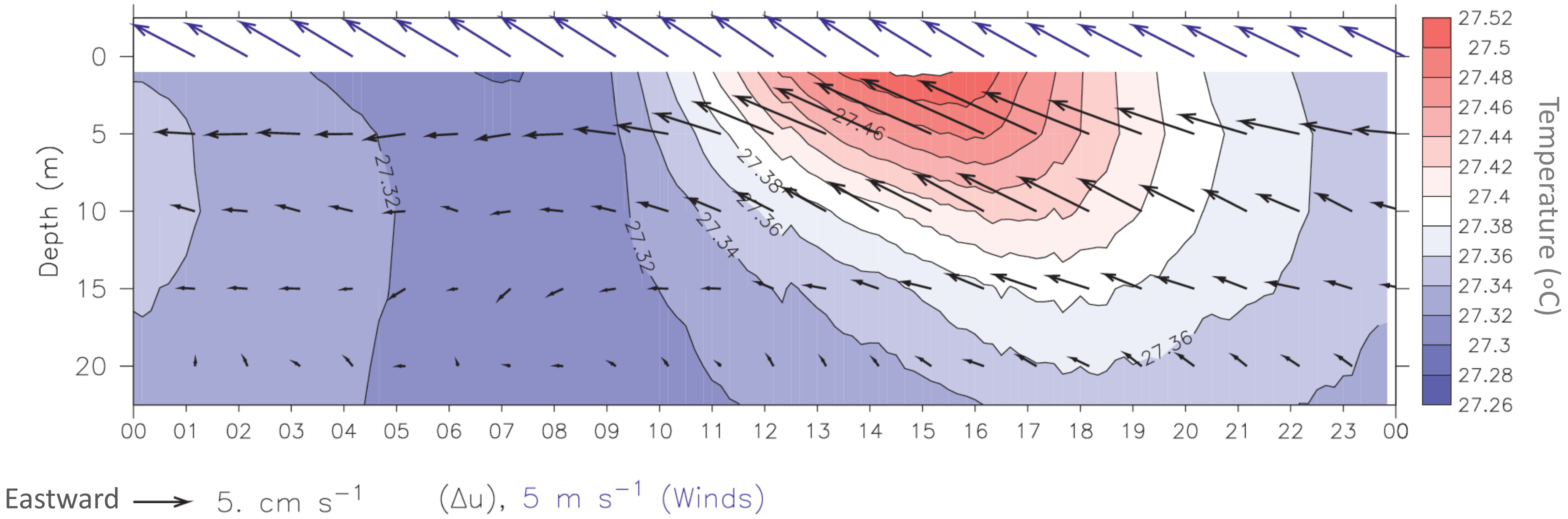
What is a Yoshida Jet?

- An eastward surface current on equator, directly forced by Westerly Wind Burst (WWB).
- Wind forcing sets up zonal pressure gradient, whose depth scale depends upon zonal fetch of wind forcing.
- Depth dependent pressure gradient causes subsurface jet opposing wind forcing (“reversing jet”).



After Cronin et al. (JPO 2000) “Wind forced reversing jets in the western equatorial Pacific”

What is a Diurnal Jet?



2N, 140W **Mean Diurnal Composite** (24 May 2004-7 Oct 2004) of wind **(blue vectors)** and currents relative to 25 m (**black vectors**).

Cronin and Kessler (JPO 2009) "Near-surface shear flow in the Tropical Pacific Cold Tongue Front"

Why is the Diurnal Jet important?

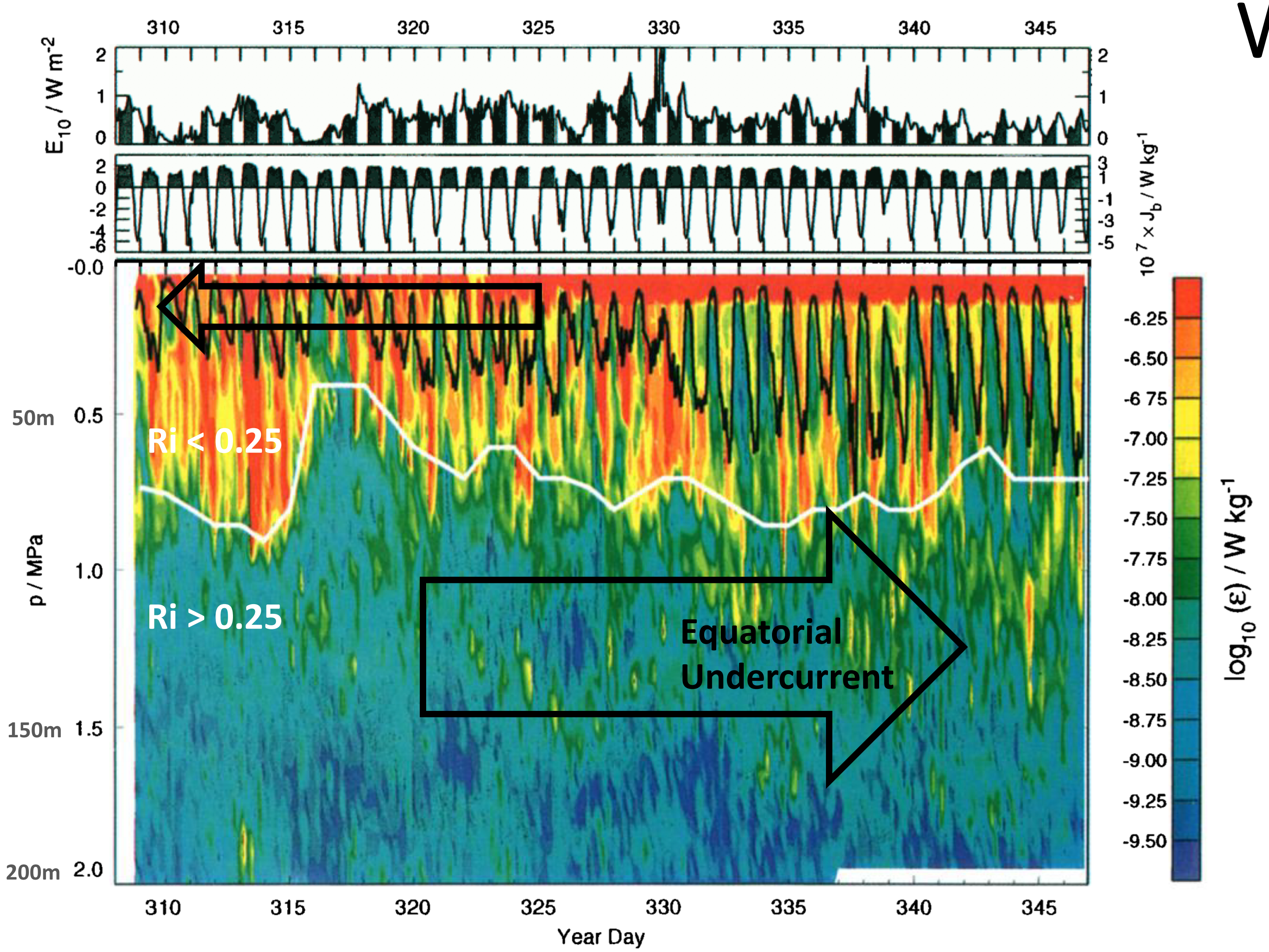
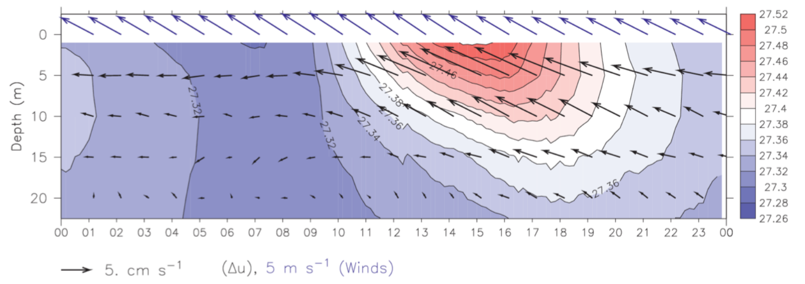


Plate 7. Contours of logarithms of the turbulent kinetic energy dissipation rate ε. Above the ε plot are time series of the 10-m wind power and the buoyancy flux. The mixed-layer depth is indicated by the black line on the contour plot. The depth above which the Richardson number is 1/4 is indicated by the white line.



Mixing! In addition to nighttime convective mixing, diurnal jets modulate shear-instability mixing, leading to **deep cycle turbulence** that extends below the mixed layer.

Lien et al., JGR 1995: "Turbulence variability at the equator in the central Pacific at the beginning of the 1991-1993 El Nino."

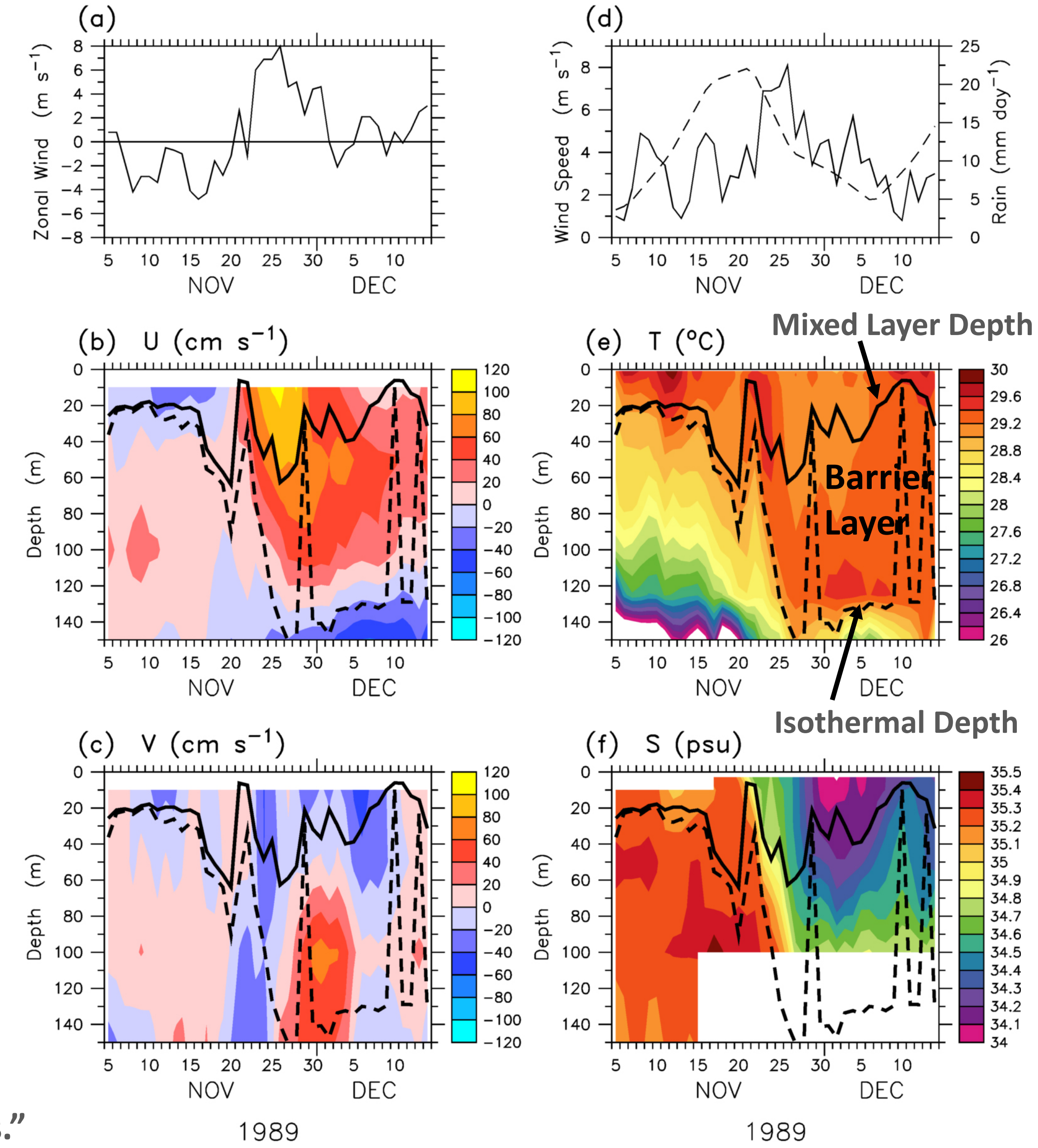
What is a Fresh Jet?

Surface intensified current above a salinity stratified barrier layer forced wind and/or maintained by a zonal or meridional pressure gradient associated with a salinity front (e.g. Roemmich et al. 1994, Cronin and McPhaden 2003, Zhang and Clark 2015). For example, if Salinity front is 0.2 psu / 100 km, …

$$\frac{\partial}{\partial t}u_z = -\frac{1}{\rho_0}\frac{\partial}{\partial x}P_z = \frac{g}{\rho_0}\frac{\partial \rho}{\partial S}\frac{\partial S}{\partial x}$$

$$\sim (0.4ms^{-1}/100m)/3days$$

Nov 1989 WWB at 0°, 165°E



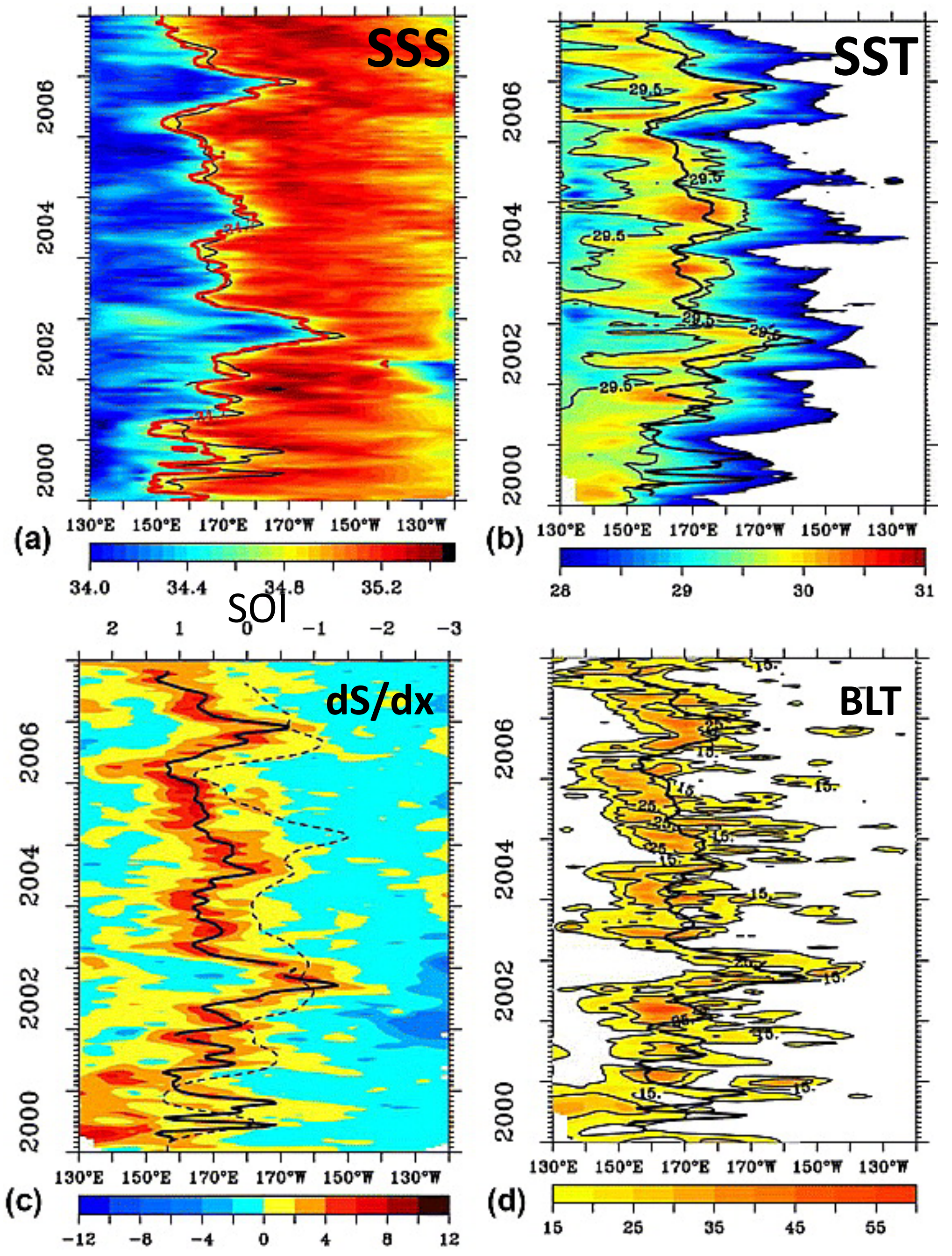
Cronin and McPhaden (JGR 2003): "Barrier layer formation during westerly wind bursts."

Why are Fresh Jets Important?

Barrier layers tend to occur on the eastern edge of the fresh pool, which shift zonally during the ENSO shifts in the eastern edge of the Warm Pool.

What is role of barrier layer physics in ENSO?

What is role of Fresh Jets in ENSO?



Bosc et al. (JGR 2009) “Barrier layer variability in the western Pacific warm pool from 2000 to 2007”

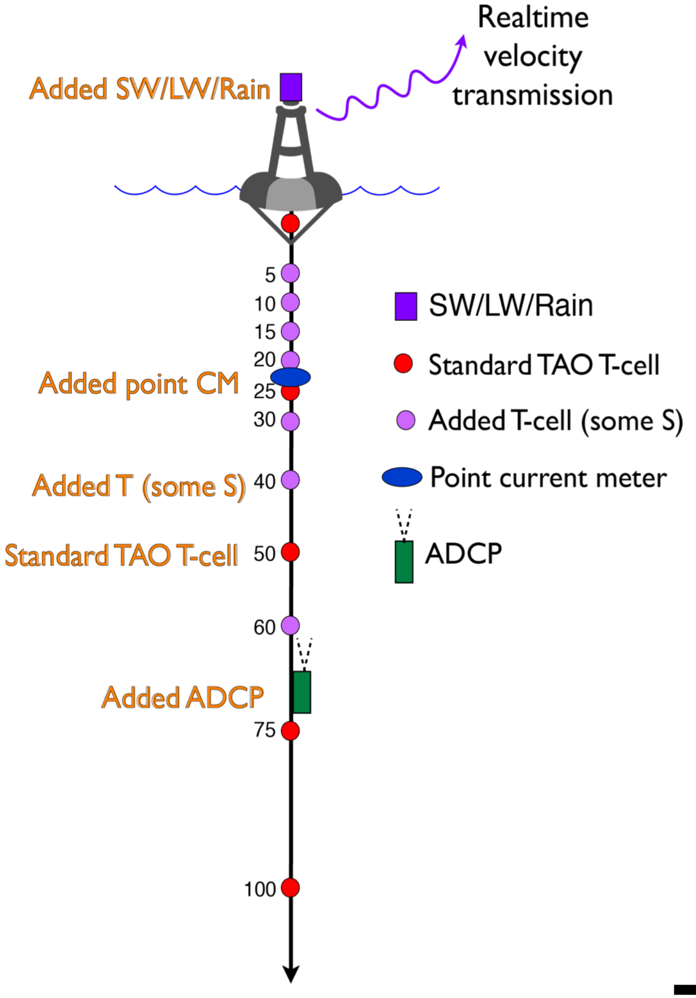
Should Yoshida Jets, Diurnal Jets, Fresh Jets be monitored in the Tropical Pacific Observing System (TPOS)? Why?

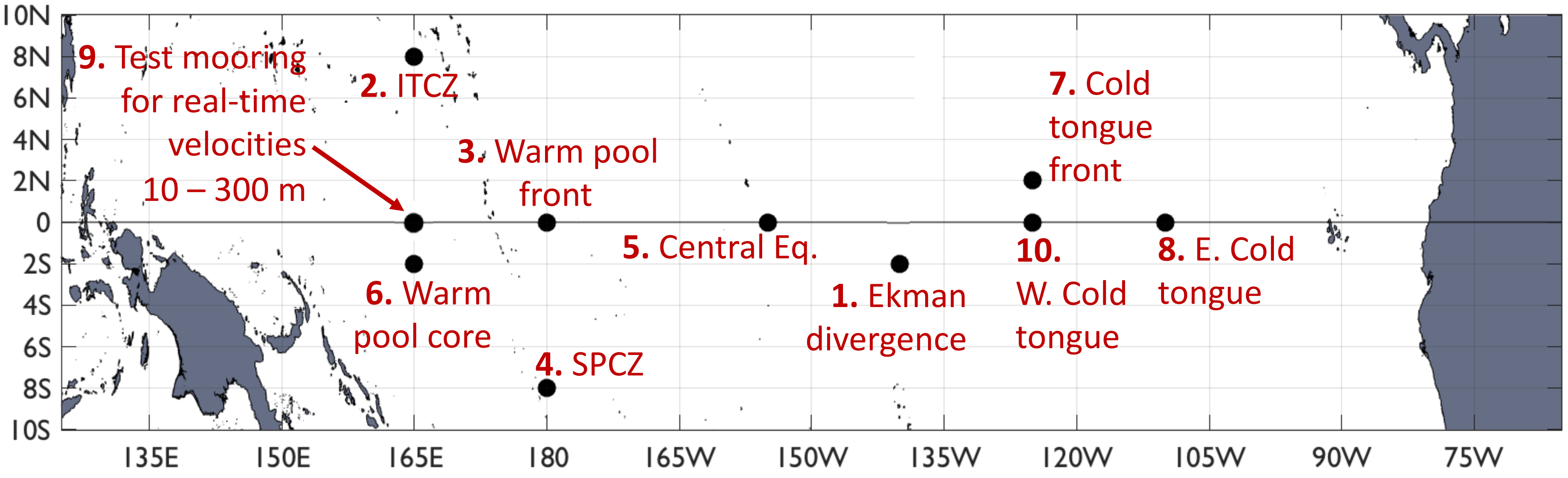
Should these be sustained observations? Where?
Is a process study needed?

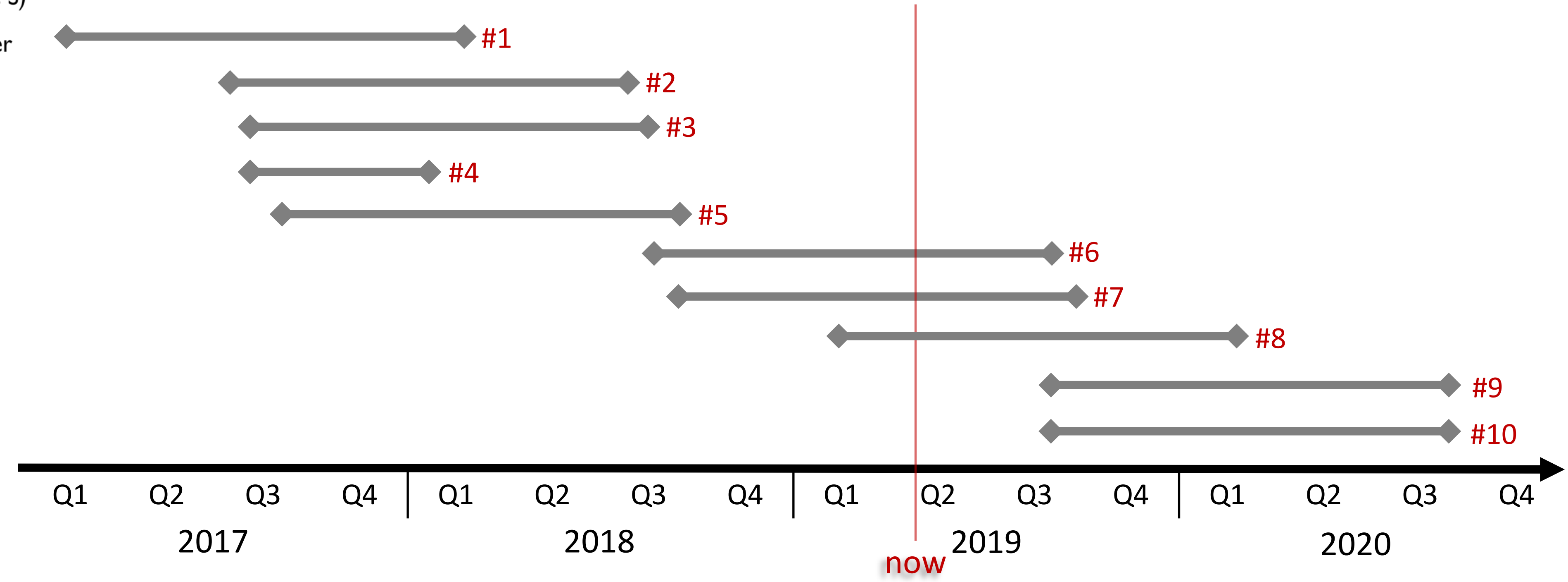
How could these jets be monitored? Start with pilot study to show feasibility of observing these phenomena in near-realtime from NDBC moorings.

NOAA OOMD TPOS-2020 Pilot Study led by **PI:** B. Kessler, **NDBC PI:** K. Grissom, & **co-PI:** M. Cronin

TPOS2020 mooring enhancements







Slide courtesy Jessica Masich

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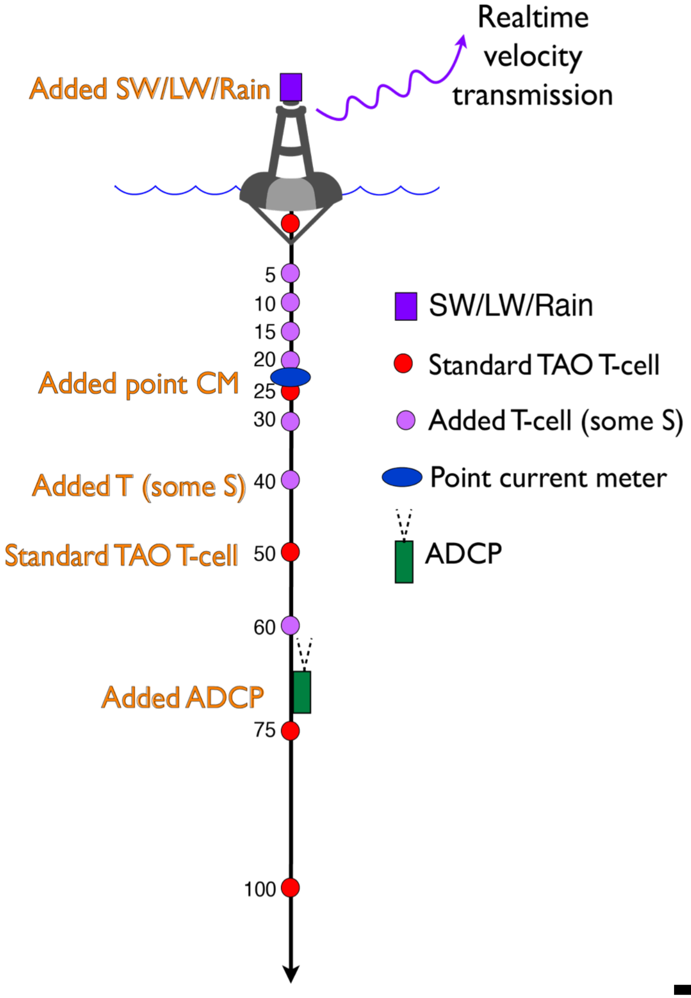

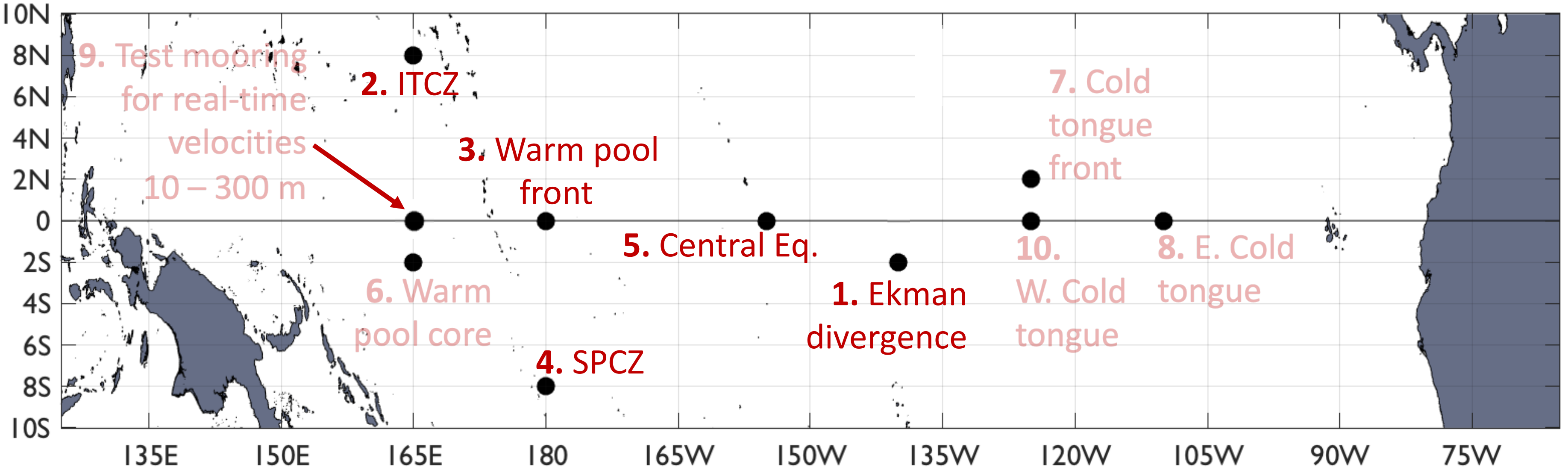

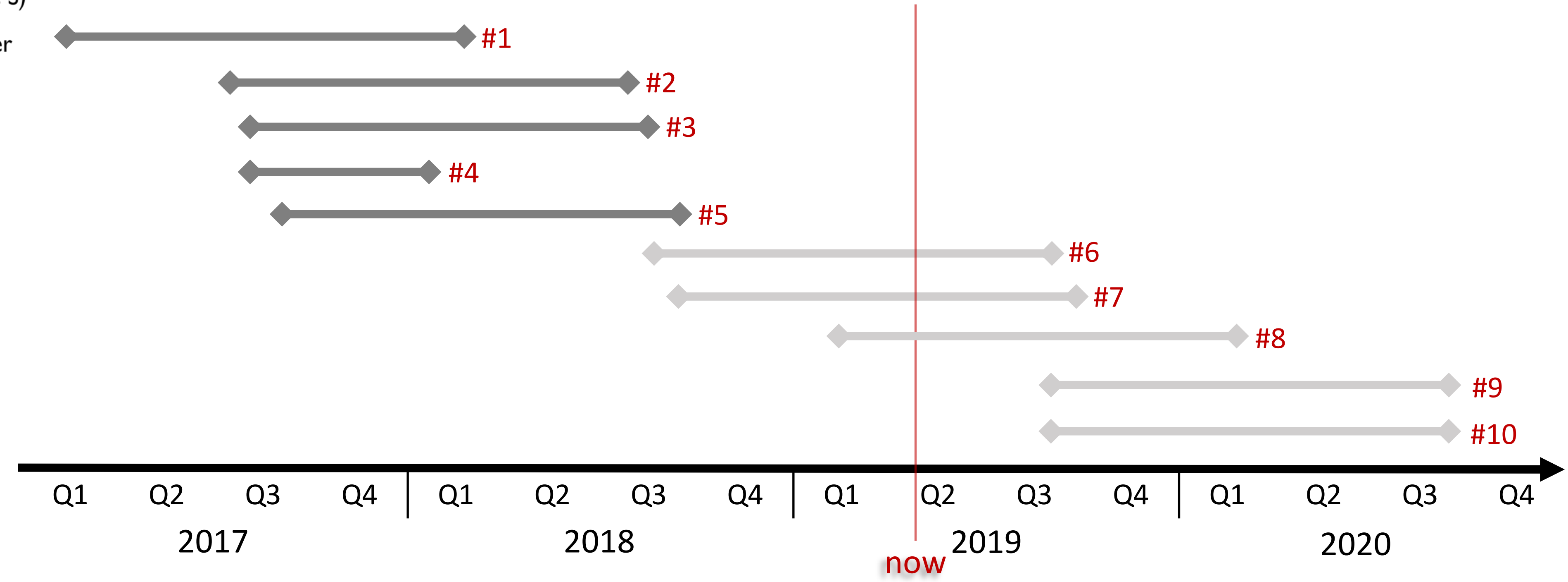

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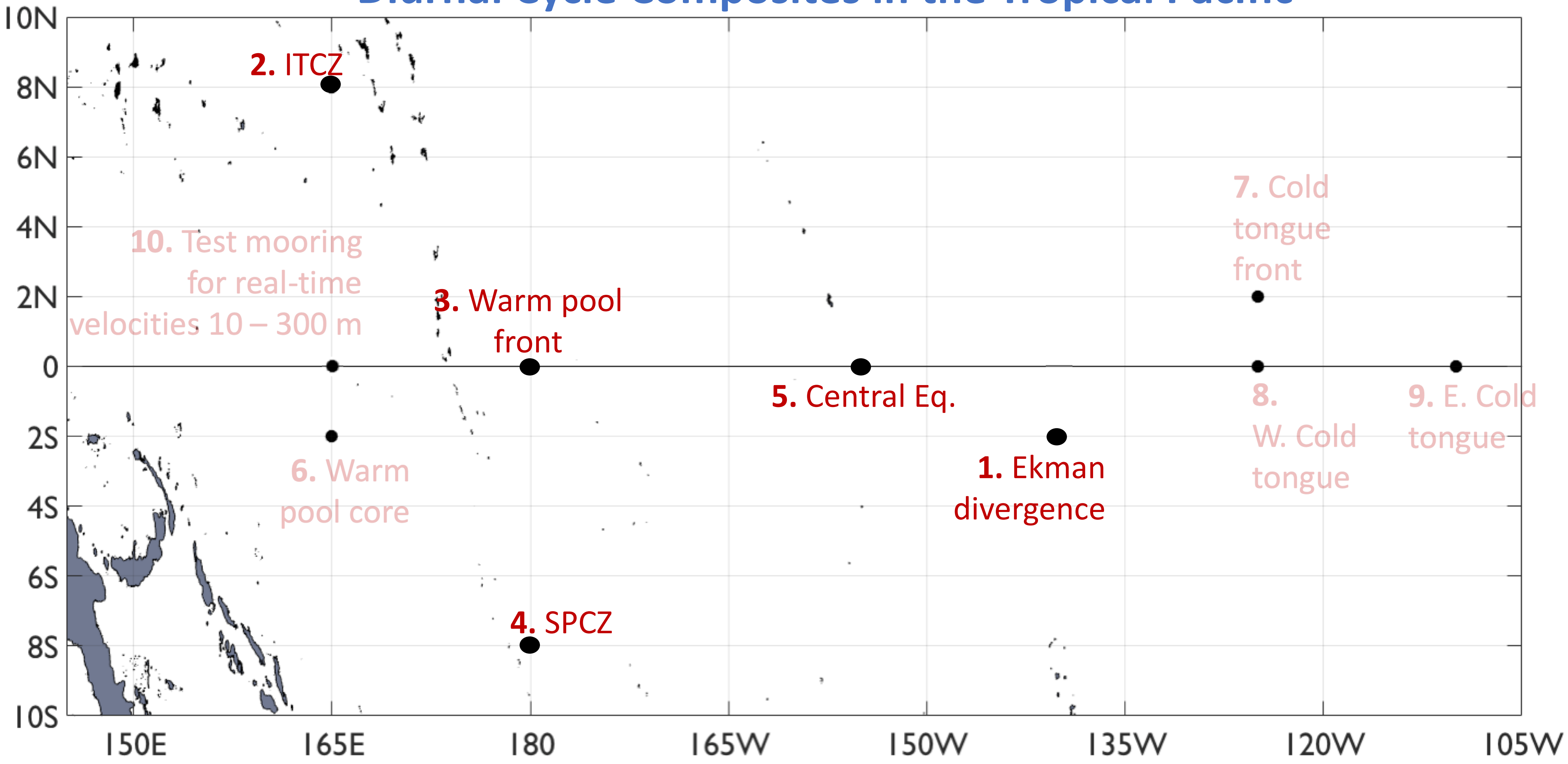
Diurnal Cycle Composites in the Tropical Pacific



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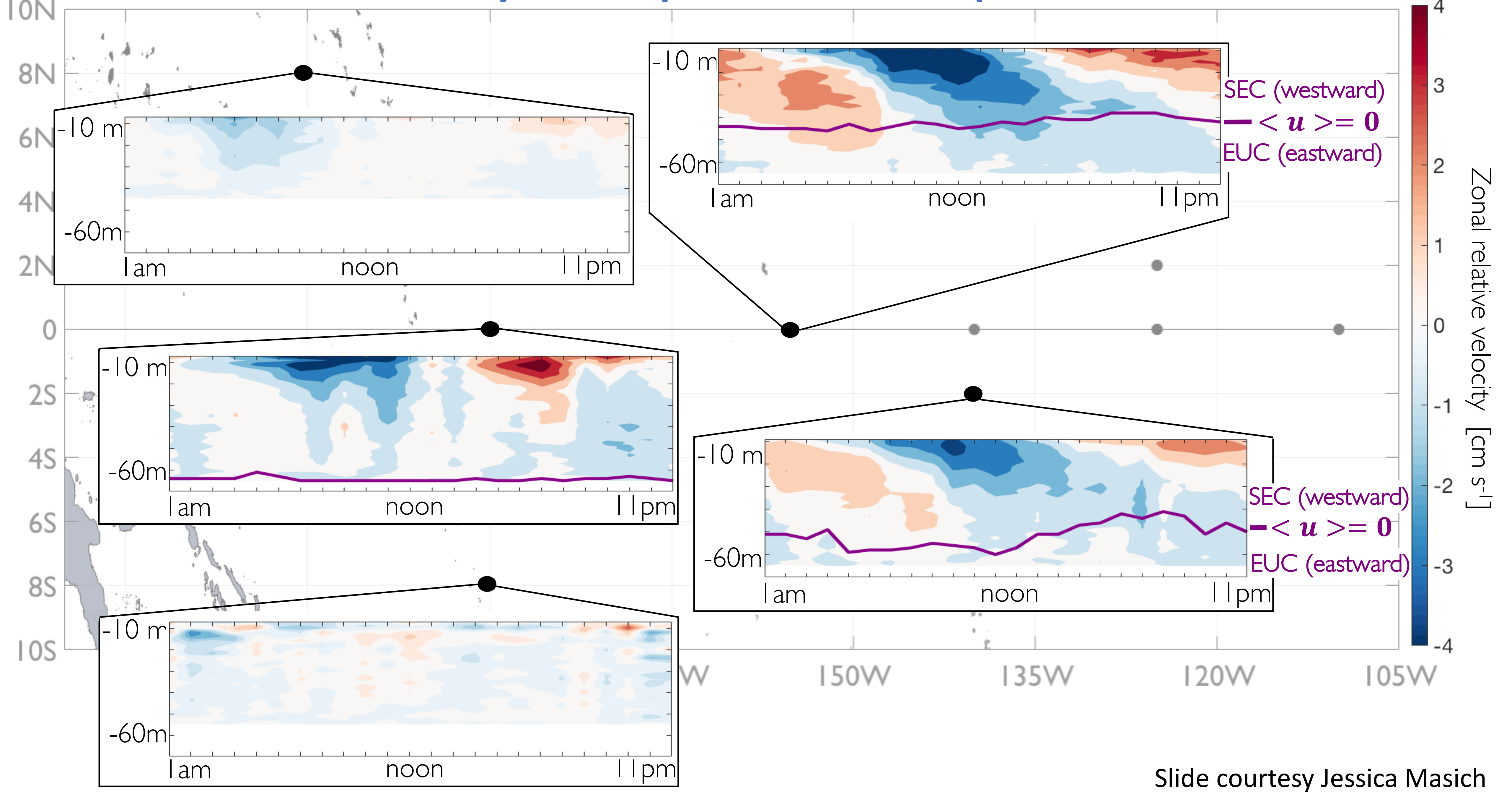

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Summary

- Yoshida, Diurnal, and Fresh Jets are challenging to observe. Require near-surface current profiles and salinity profiles with good temporal, vertical, (and horizontal) resolution.
- Current profiles can be successfully measured by ADCP mounted on NDBC surface mooring.
- ADCP data from NDBC surface mooring can be telemetered in near-realtime. Can we daisy-chain ADCPs to get realtime profile of surface current through Equatorial Undercurrent? Game changer.
- Diurnal Jet is strongest on equator.
- Preliminary results! Just getting started with analyses.

Cronin et al. 2019: **Air-Sea Fluxes with focus on Heat and Momentum.** *Front. Marine Sci.* In Press

Motivation

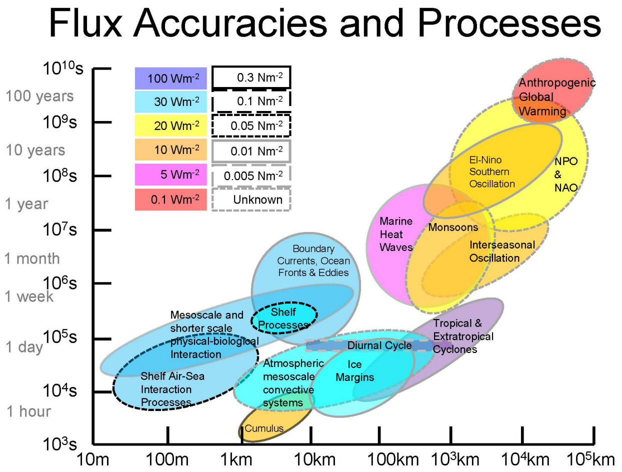
- Air Sea Fluxes are key to understanding and predicting climate from days to decades.
- Large uncertainties in gridded flux products
- New techniques and technologies bring opportunity for progress

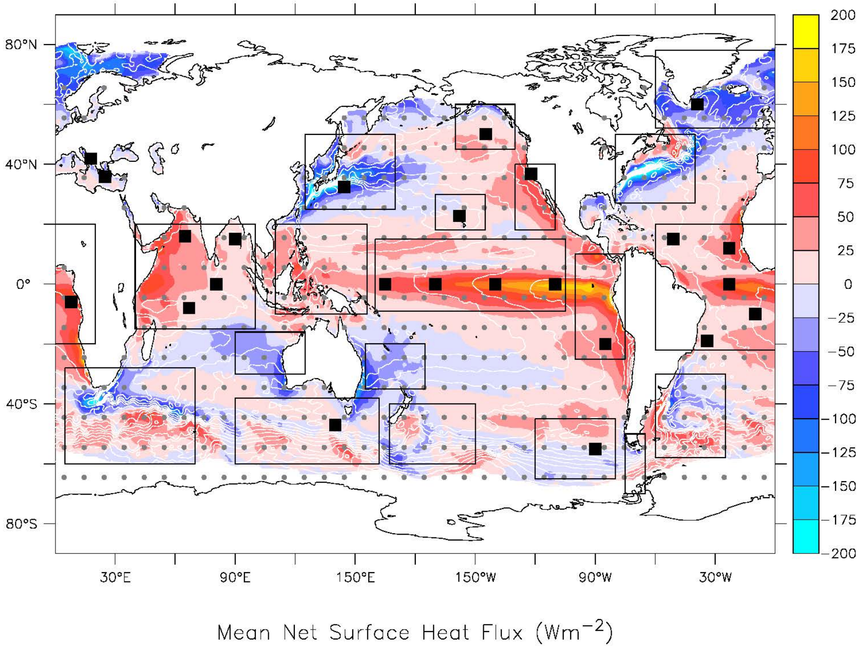
Ambitious 10-year Goal

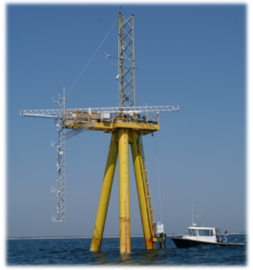
- Gridded 25 km @ 3 hourly (aspirational 10 km @ hourly) air-sea fluxes with 1-day random uncertainties of **15 W m^{-2} (5%) for net heat flux & 0.01 N m^{-2} (5%) for wind stress** and **biases less than 5 W m^{-2} & 0.005 N m^{-2}**

Two Major Recommendations

- **Optimize satellite-based retrievals for boundary layer** measurements of air temperature and humidity, sea surface temperature, and ocean wind stress.
- Create a **global *in situ* array of flux observing platforms,** built around an **expanded OceanSITES** network of time series reference station moorings.







Cronin et al. OO'19 Community Whitepaper

Roadmap for Expansion of *in situ* Array

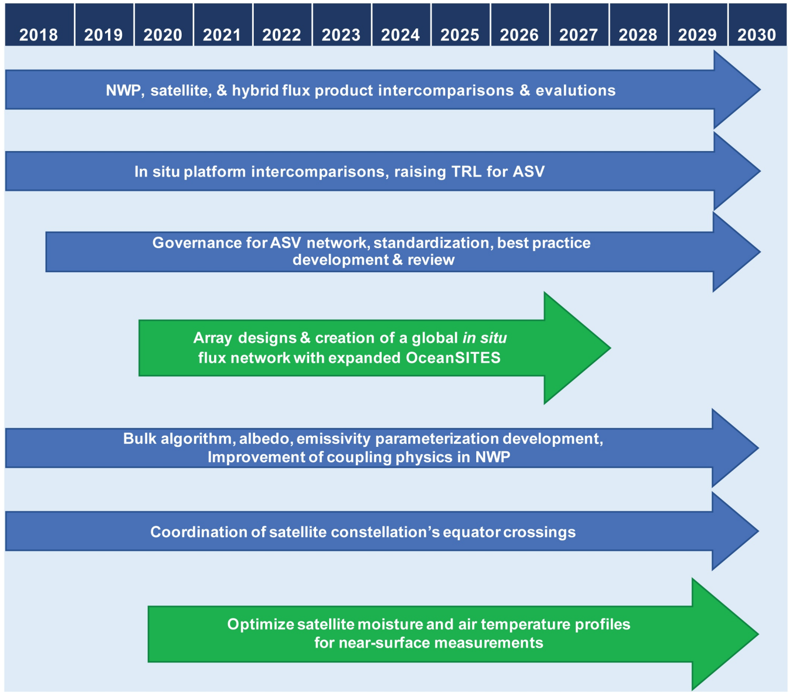
- Evaluate **cross-platform**, **cross-product**, & **ocean vs. land-based** comparisons to quantify uncertainties and **improve best practices** and **model physics and parameterizations**.
  - Ocean & Land **Baseline Surface Radiation Network (BSRN)?**
- Form an international **Autonomous Surface Vehicles (ASV) expert group** to coordinate data stream, evaluate data, and develop best practices and standardizations.
- Perform **array design studies** and **pilot studies** to raise Technical Readiness Levels for flux platforms.
- **Improve bulk algorithms**, including role of sea state, and parameterizations of albedo and emissivity.
- Improve **coupling physics in NWP**.

Roadmap for Optimization of Satellite Retrievals

- Improve **resolution of satellite retrievals, time coincidence** of remotely-sensed flux EOVs/ECVs, and **algorithms** relating retrievals to near-surface conditions.
- Improve parameterizations for transforming bulk EOV/ECV into bulk algorithm state variables.

Flux EOV/ECV	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Bulk SST	Partially met												Adequate
Skin Temperature	Partially met												Adequate
Wind Speed and Direction	Partially met												Adequate
Air Temperature	Not met												Adequate
Humidity	Not met												Adequate
Bulk Surface Currents	Partially met												Adequate
Skin Surface Currents	Not met												Adequate
Surface Solar Radiation	Partially met												Adequate
Surface Longwave Radiation	Partially met												Adequate
Albedo	Partially met												Met
Sea State	Requirement Unknown												Requirement Known

(red)	Requirement not met / inadequate
(orange)	Requirement partially met / threshold
(yellow)	Requirement adequately met / breakthrough
(green)	Requirement fully met / ideal goal



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