Contrasting upper-ocean heat and salt balances and dynamics in SPURS 1 and 2

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SPURS: Salinity Processes Upper-ocean Regional Study

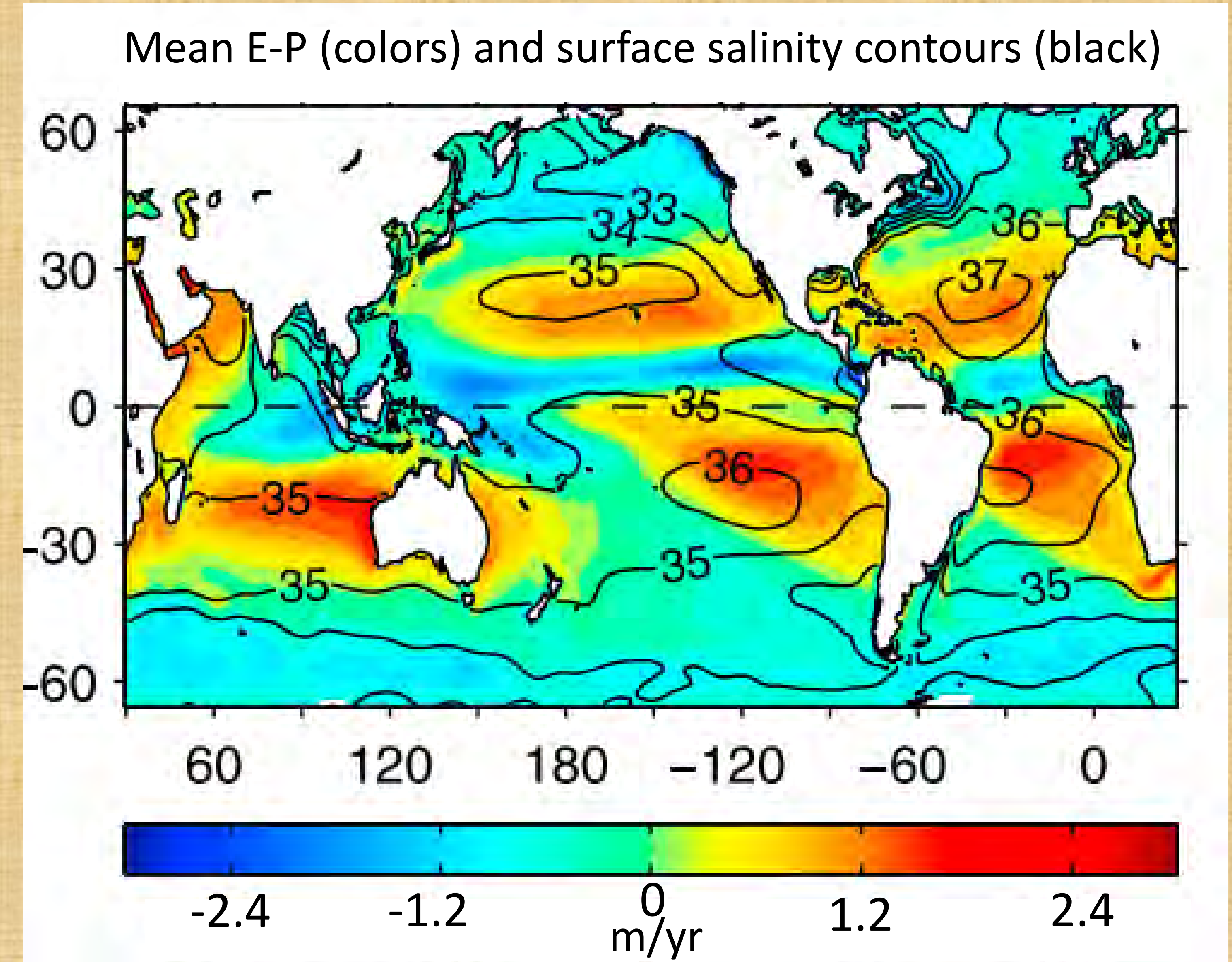


Figure from Yu (2011); data products: OAFlux, GPCP, WOA

The goal of SPURS is to better understand how ocean processes and surface fluxes set surface salinity

SPURS: Salinity Processes Upper-ocean Regional Study

Mean E-P (colors) and surface salinity contours (black)

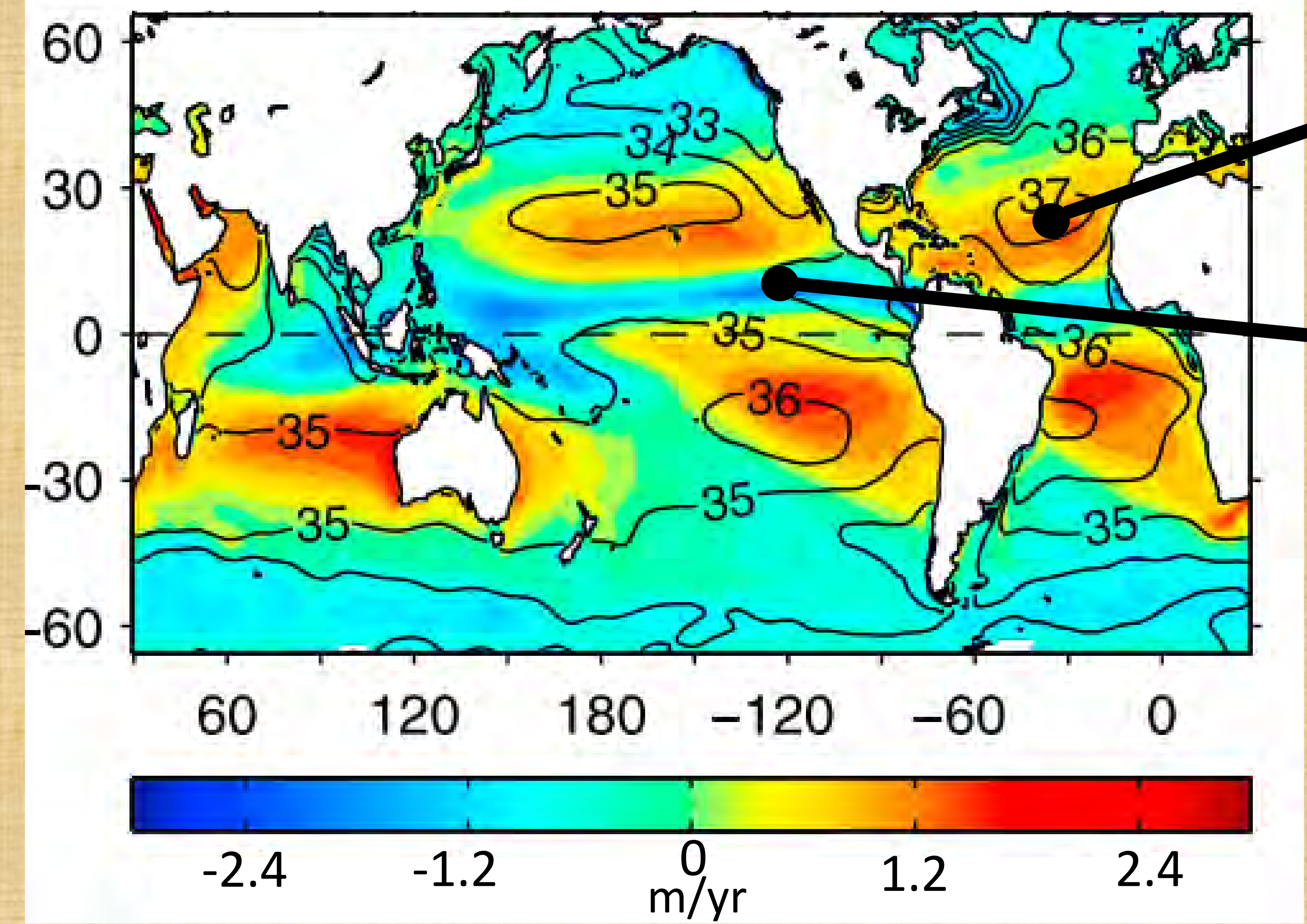


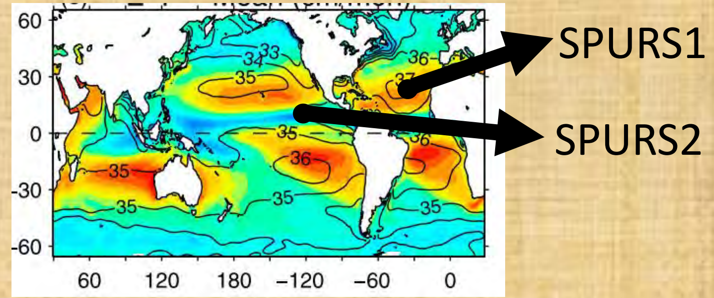
Figure from Yu (2011); data products: OAFlux, GPCP, WOA

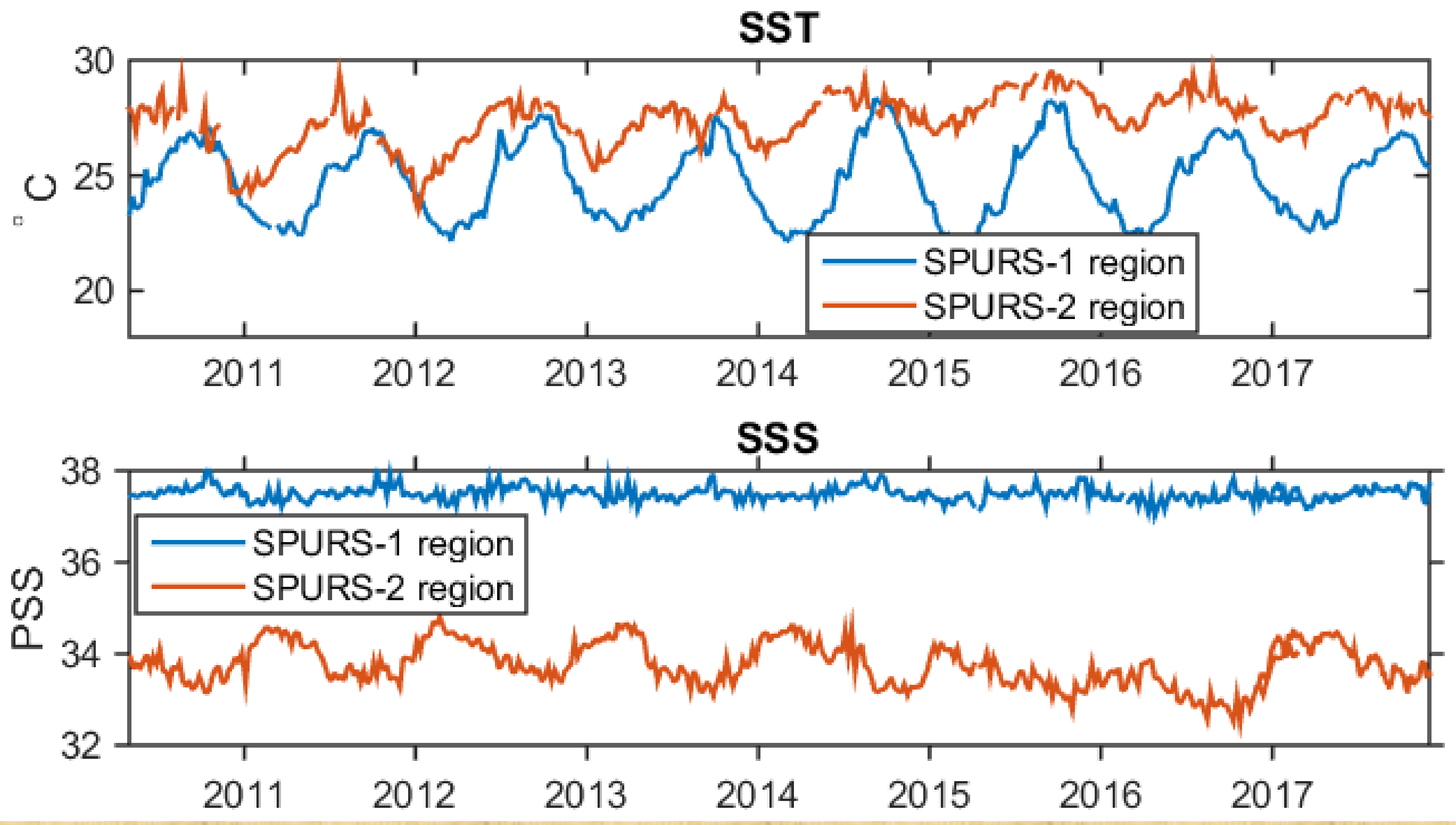
SPURS1: E>>P, weak grad S, weak eddy/mean currents, deep ML (50-150m), 2012-2013

SPURS2: E<<P, strong grad S, intense eddy/mean currents, shallow ML (25-75m), 2016-2017

The goal of SPURS is to better understand how ocean processes and surface fluxes set surface salinity

SPURS: Salinity Processes Upper-ocean Regional Study





SST annual cycle:

SPURS1→strong

SPURS2→weak

SSS annual cycle:

SPURS1→weak

SPURS2→strong

Data products: SMOS (CNES-IFREMER), SMAP (RSS), WindSat SST (RSS)

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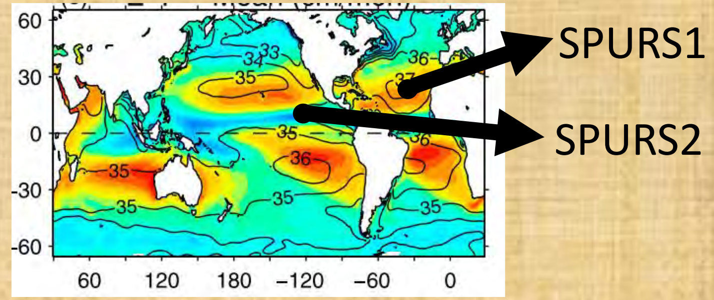
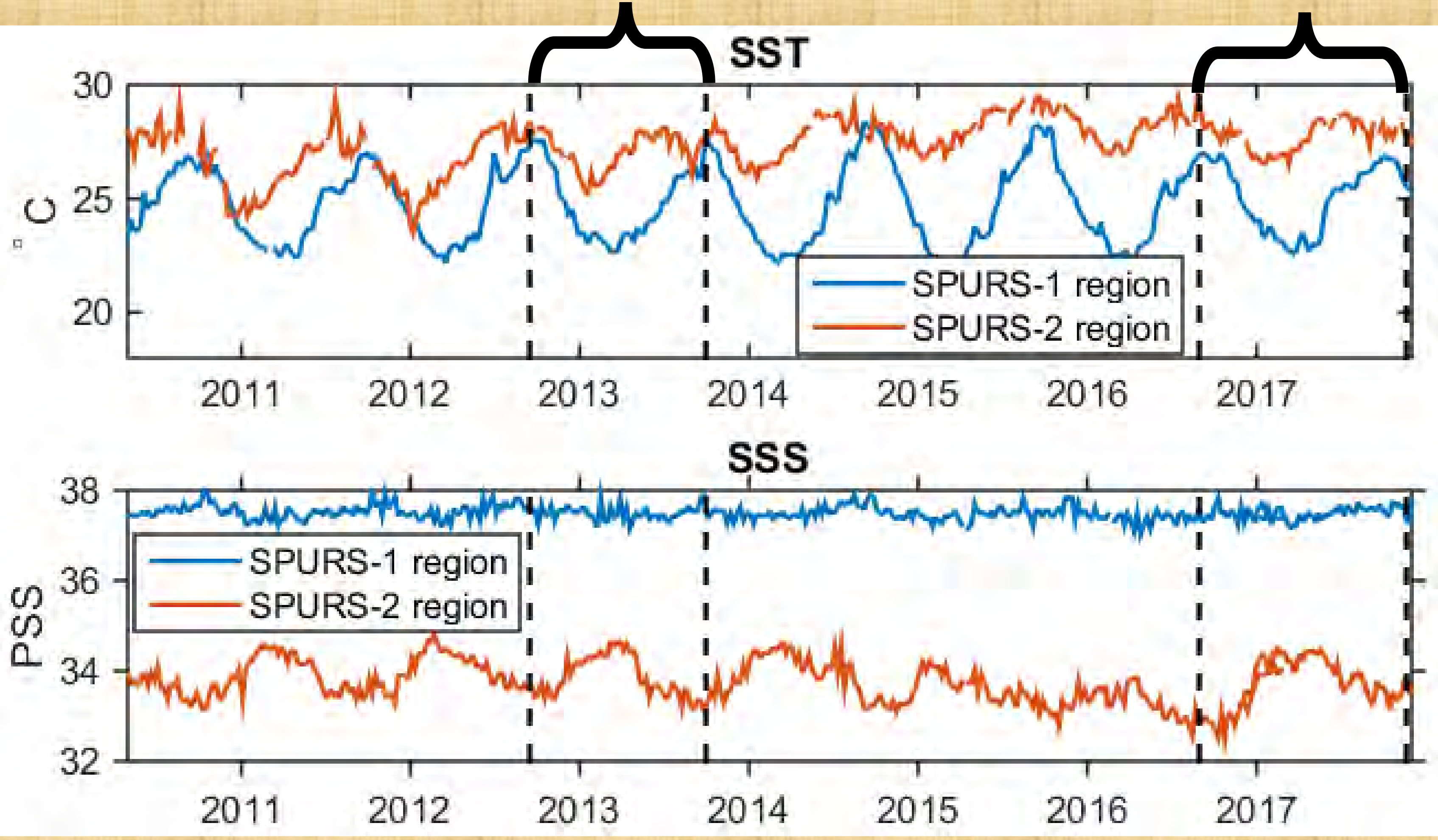


SPURS1 time period

SPURS2 time period



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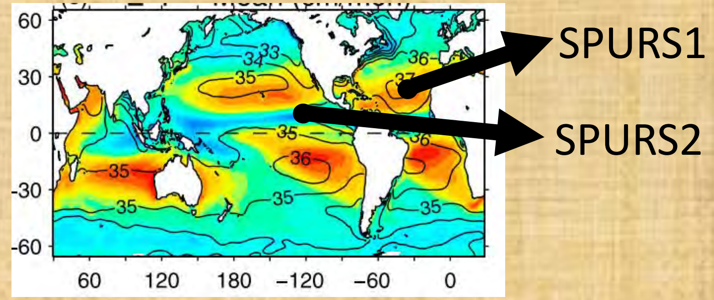
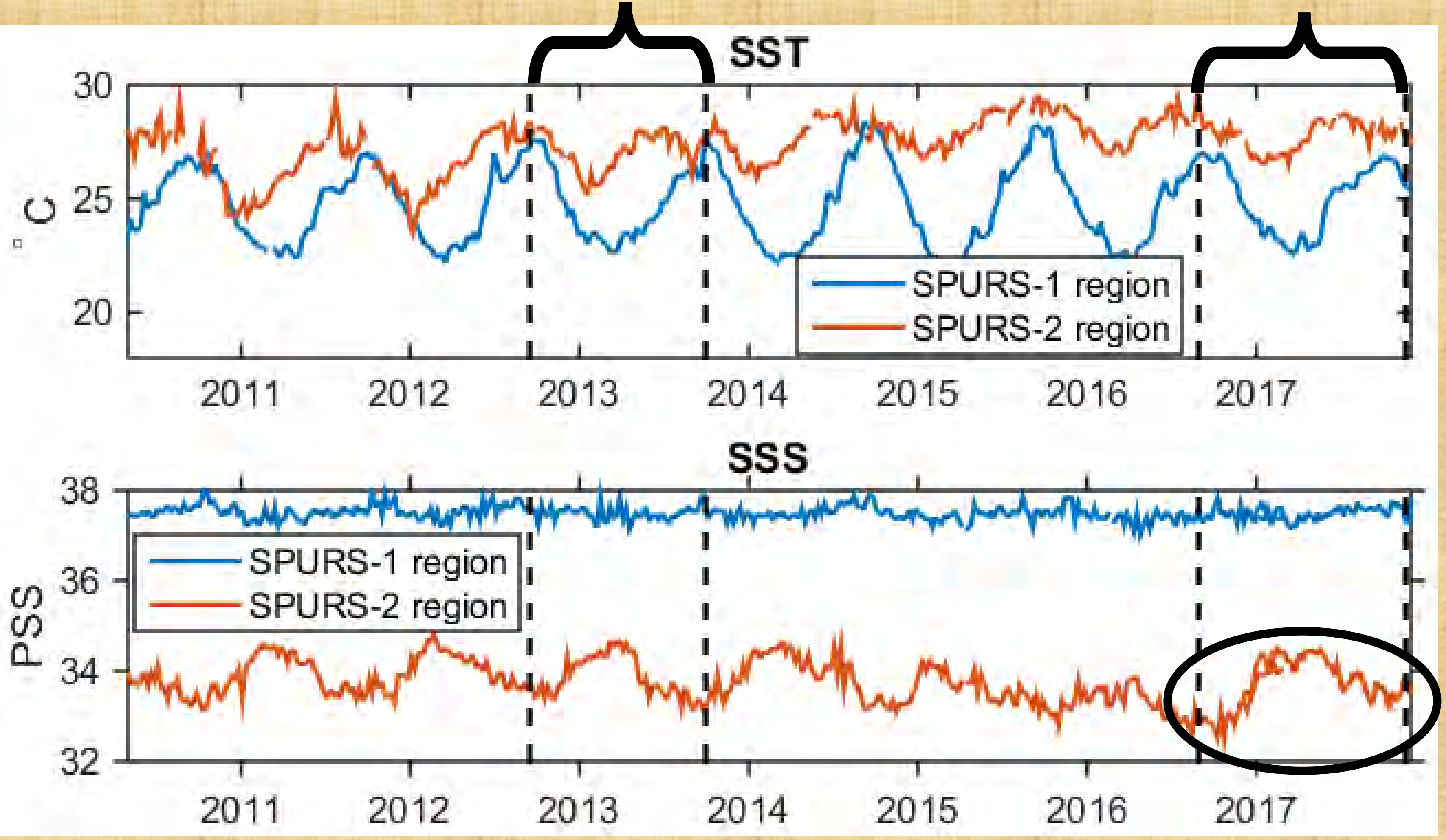


SPURS1 time period SPURS2 time period



SST annual cycle:
SPURS1→strong
SPURS2→weak

SSS annual cycle:
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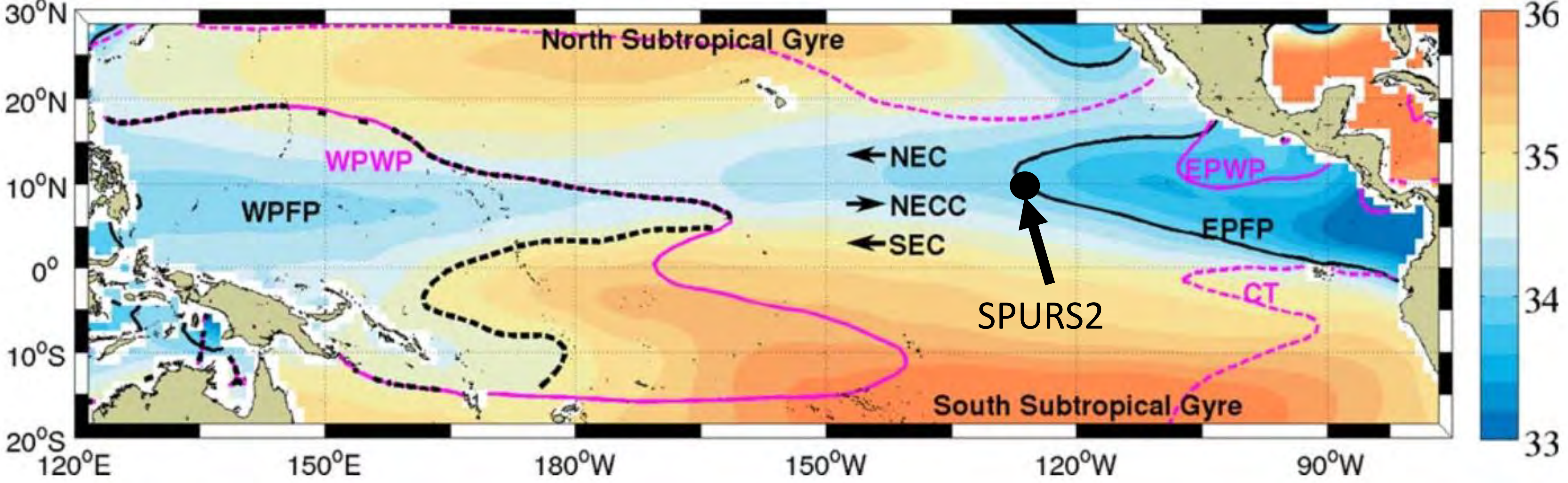
SPURS2→strong

Data products: SMOS (CNES-IFREMER), SMAP (RSS), WindSat SST (RSS)

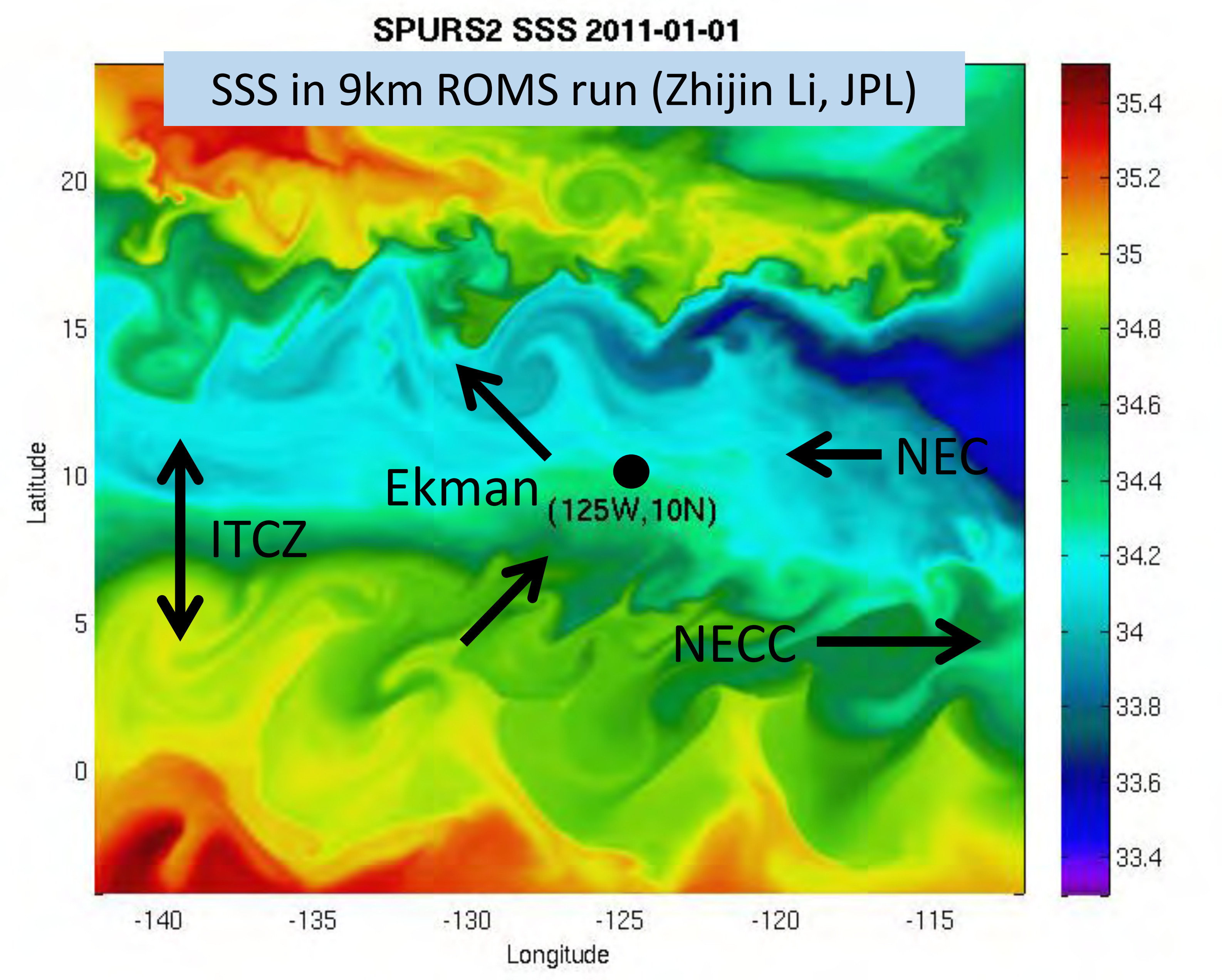
The East Pacific Fresh Pool

Mean surface salinity (colors) with SSS isohalines (black) and SST isotherms (pink)



(Figure from Guimbard et al 2017; also see Alory et al 2012)

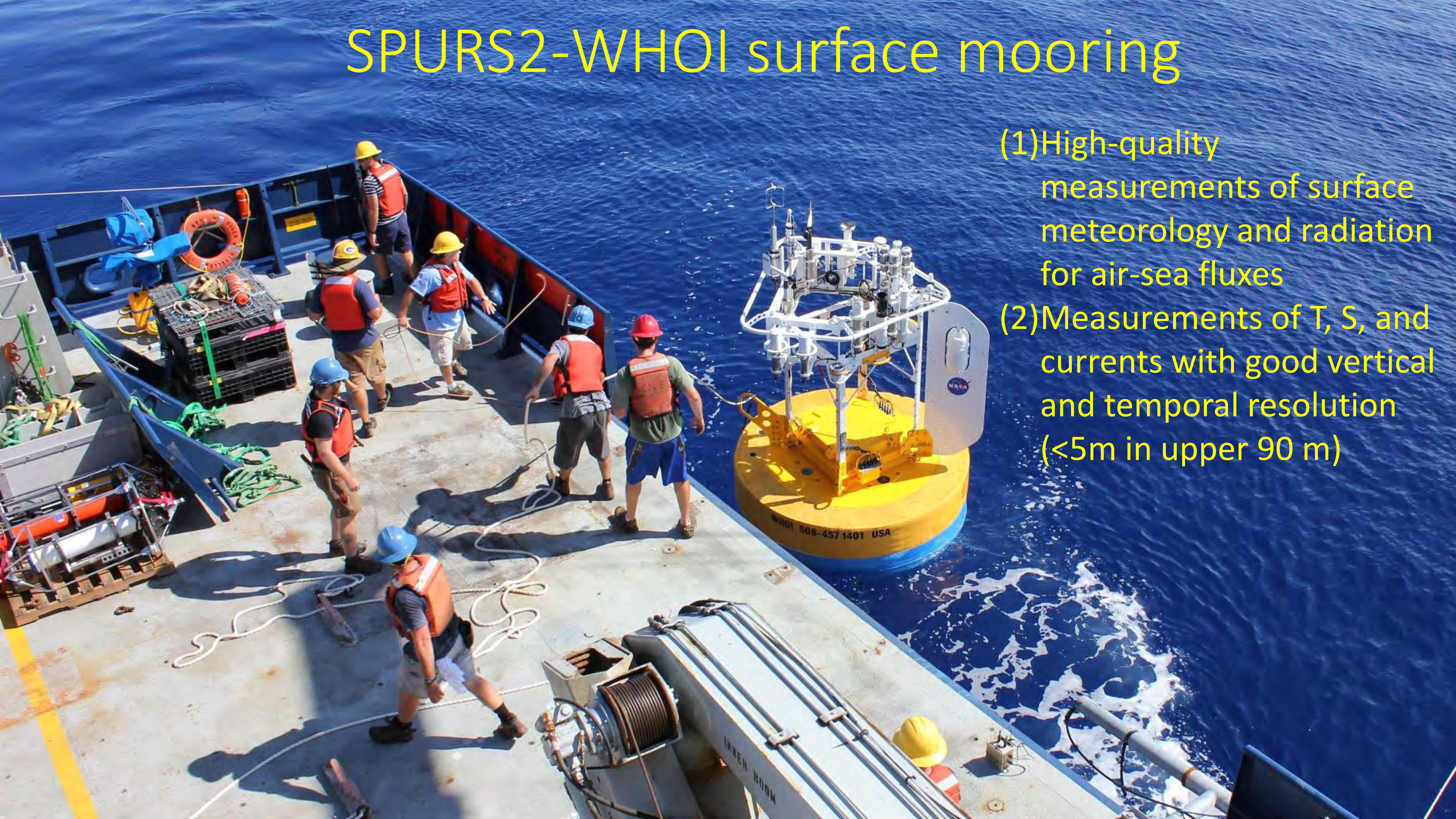
Ocean dynamical influences on E. Pacific SSS



- NEC strong Feb-March
- NECC strong Sept-Nov
- ITCZ Rain strong ~Aug-Oct
- NE Trade winds strong Feb-April (Ekman transport and evaporation)
- Ekman pumping strong Aug-Oct

→See Yu (2015) and Guimbard et al (2017)

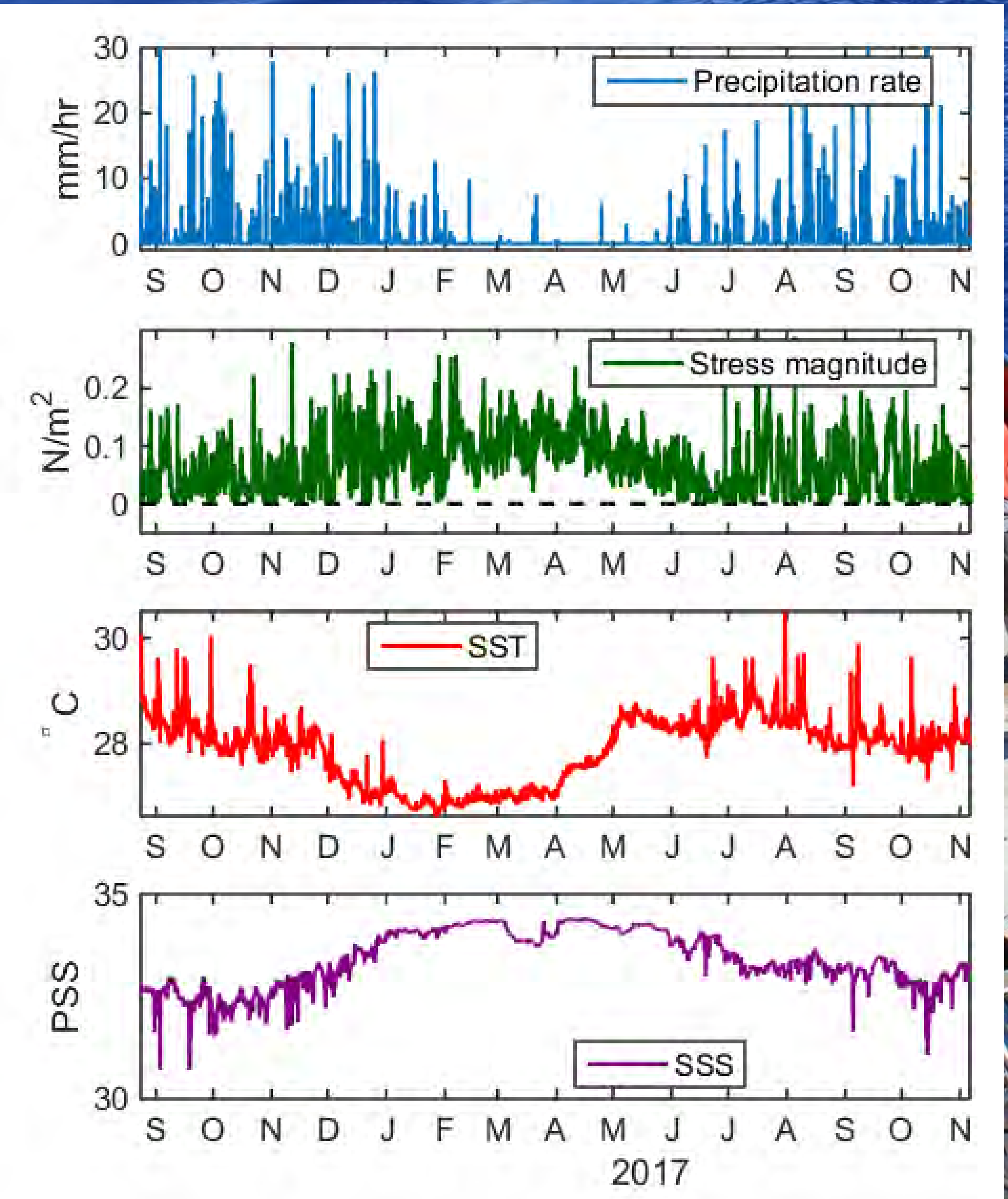
SPURS2-WHOI surface mooring

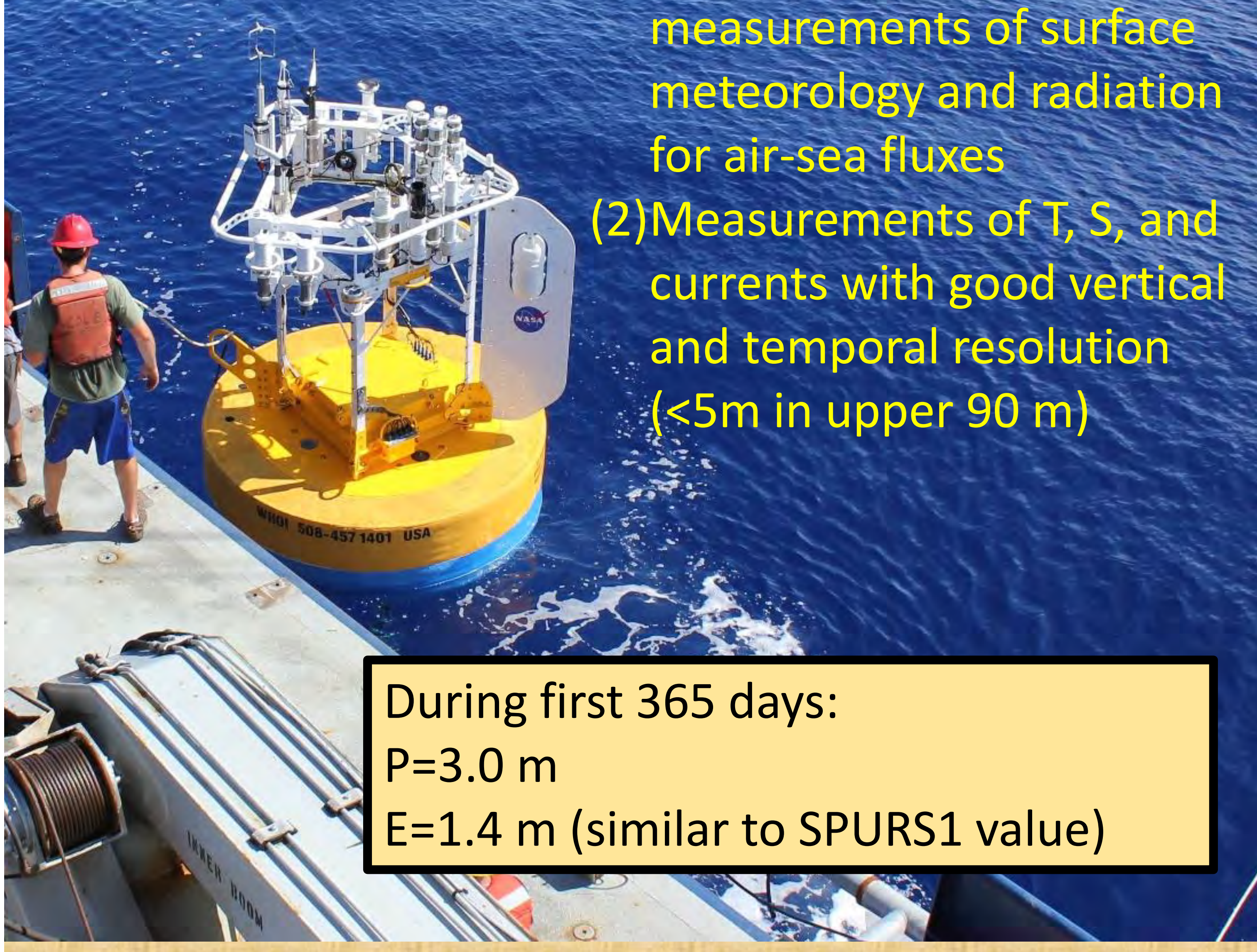


(1) High-quality measurements of surface meteorology and radiation for air-sea fluxes

(2) Measurements of T, S, and currents with good vertical and temporal resolution (<5m in upper 90 m)

SPURS2-WHOI surface mooring



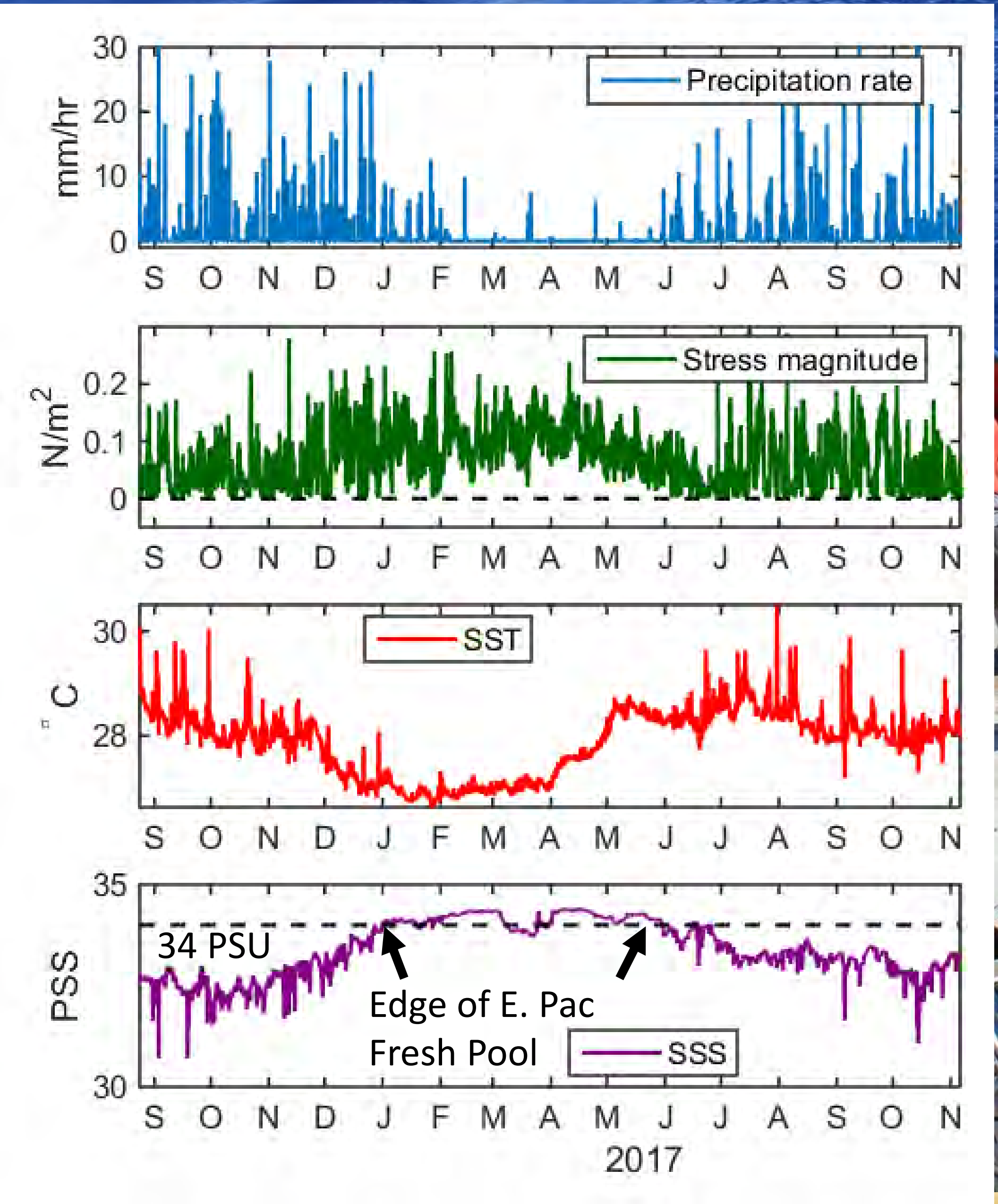


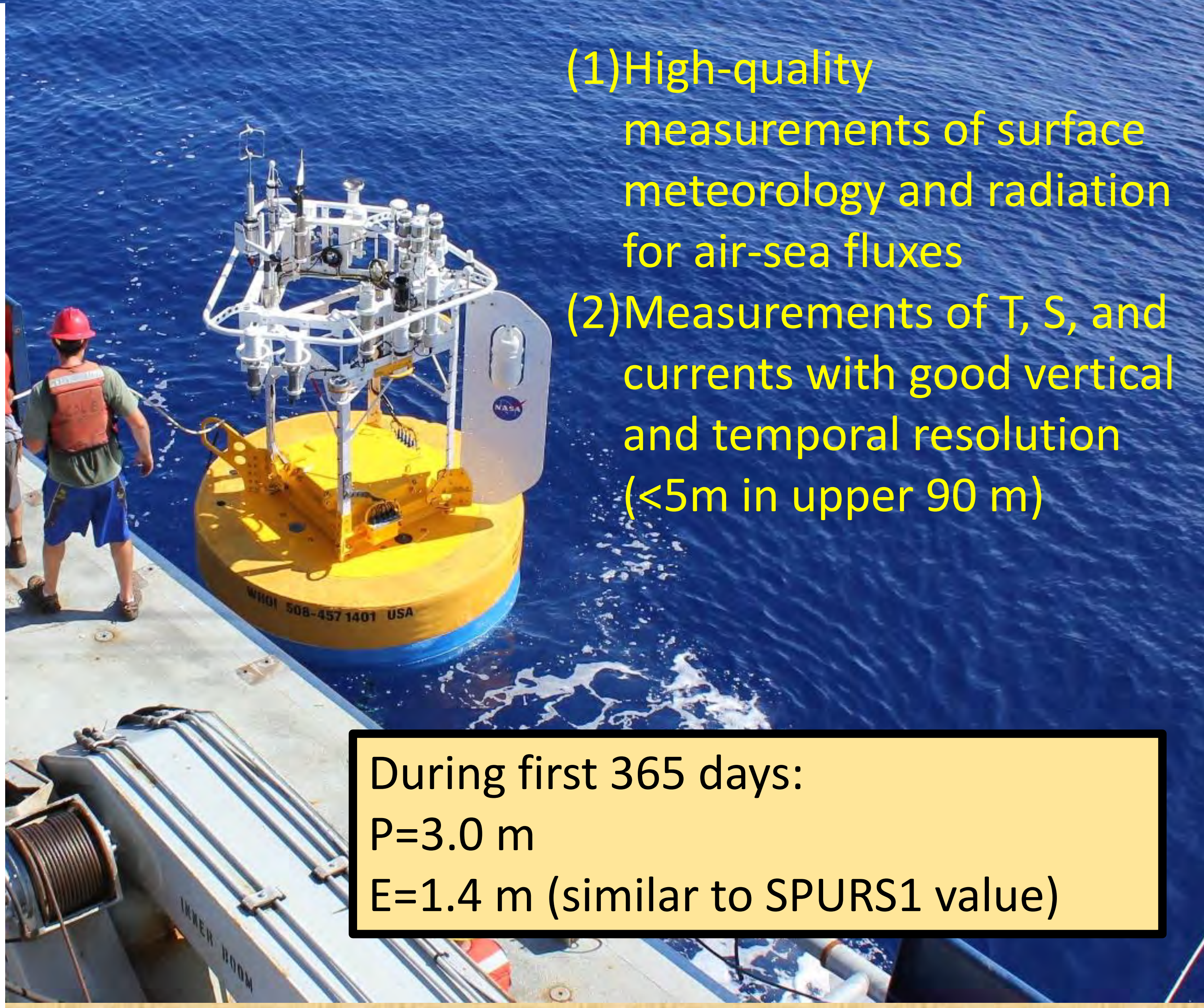
(1) High-quality measurements of surface meteorology and radiation for air-sea fluxes

(2) Measurements of T, S, and currents with good vertical and temporal resolution (<5m in upper 90 m)

During first 365 days:
P=3.0 m
E=1.4 m (similar to SPURS1 value)

SPURS2-WHOI surface mooring





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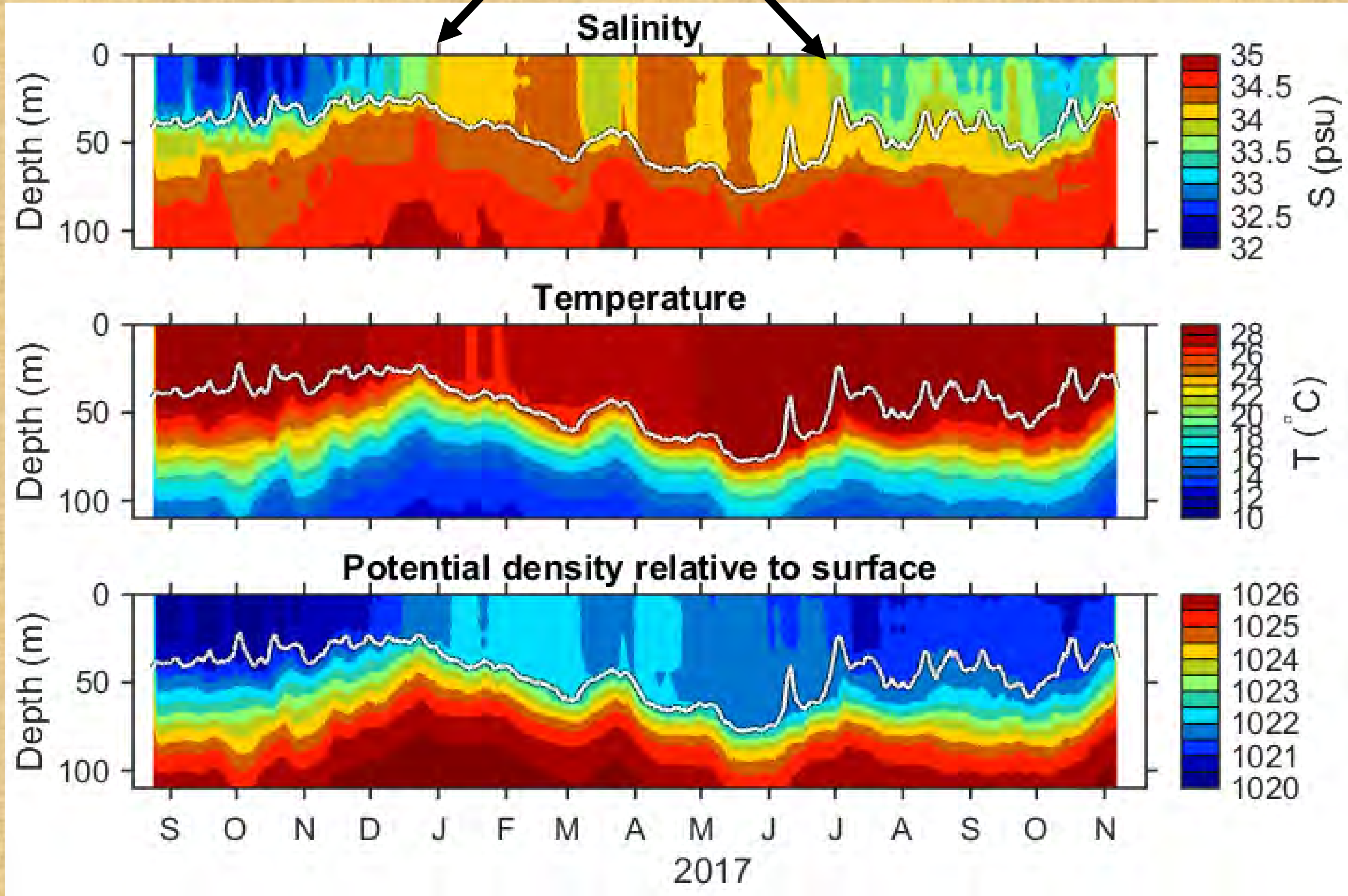
SPURS2-WHOI surface mooring

Measurements of T, S, and velocity with good vertical and temporal resolution (<5m in upper 90 m)

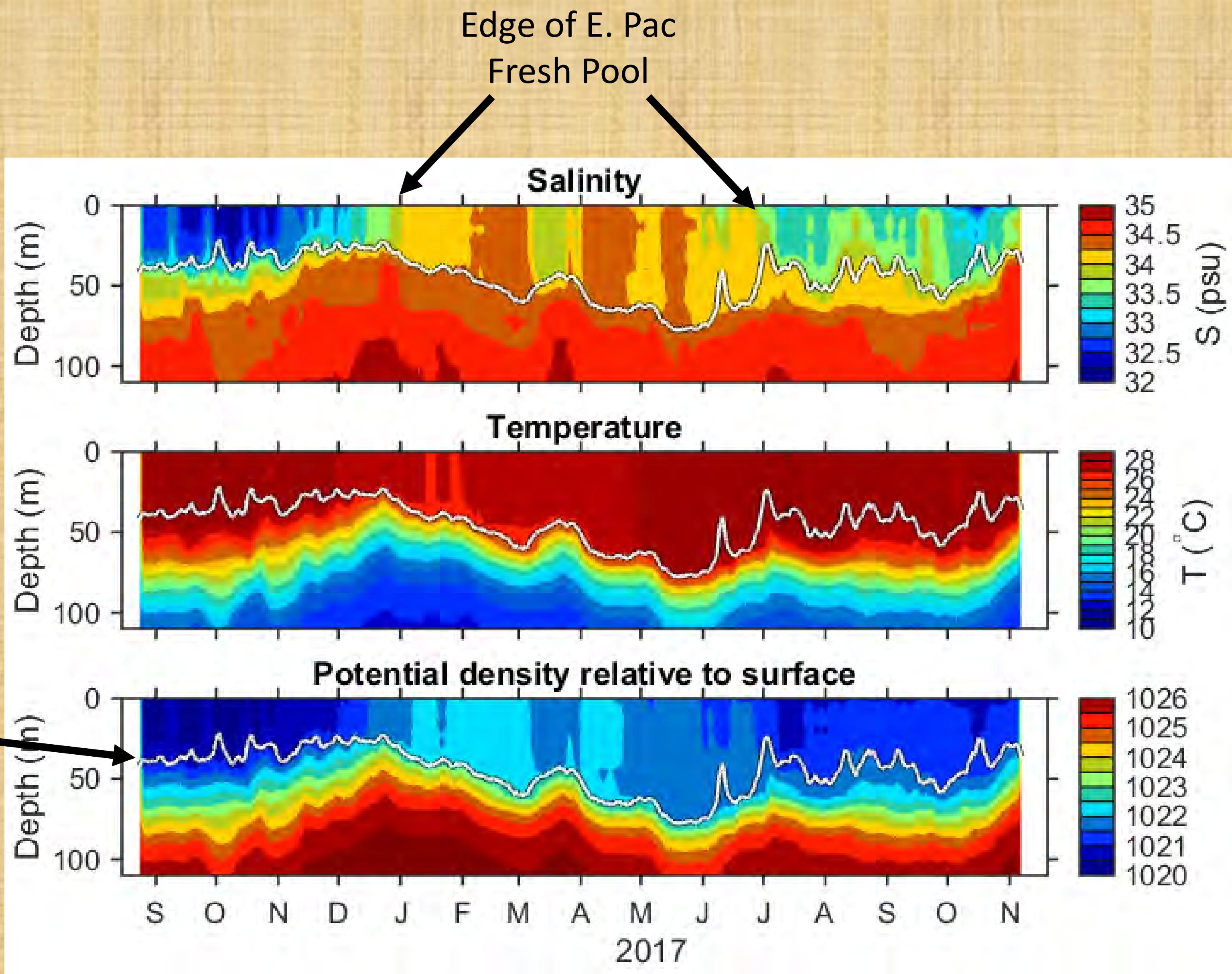
Edge of E. Pac
Fresh Pool



SPURS2-WHOI surface mooring

Measurements of T, S, and velocity with good vertical and temporal resolution (<5m in upper 90 m)

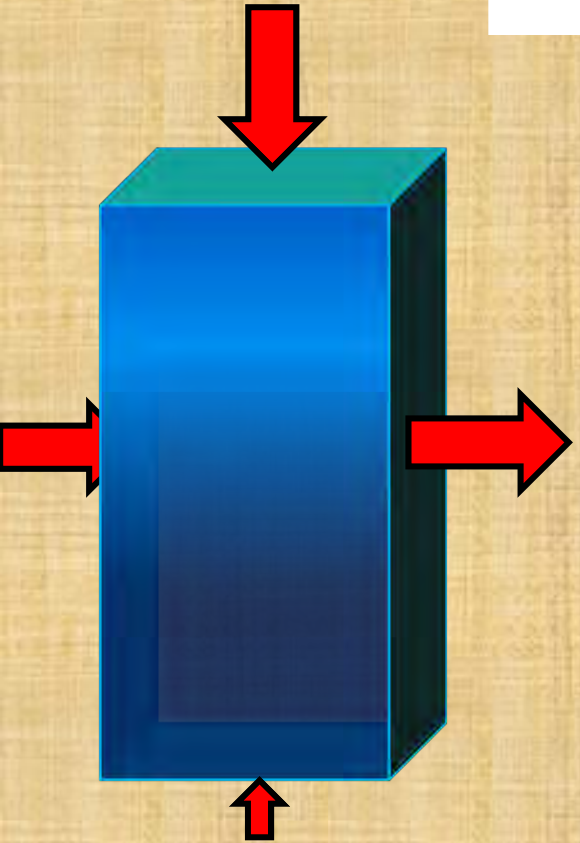
We will examine a surface-layer SSS budget for Δσ=0.4 kg/m^3



Surface-layer salinity budget at the SPURS2 site

(Overbar indicates vertical average over mixed layer)

$$\frac{\partial \overline{S}}{\partial t} = -\overline{\mathbf{u}} \cdot \nabla \overline{S} + \hat{S}_{-h}\left(\frac{\partial h}{\partial t} + w_{-h} + \mathbf{u}_{-h} \cdot \nabla h\right) - \frac{Q_{-h}}{\rho h} + \frac{(E-P)S_o}{\rho h} - \frac{1}{h}\nabla \cdot \int_{-h}^{0} \hat{\mathbf{u}}\hat{S}\,dz$$



SMAP SSS

Attempted (small but non-negligible; not shown)

Not attempted

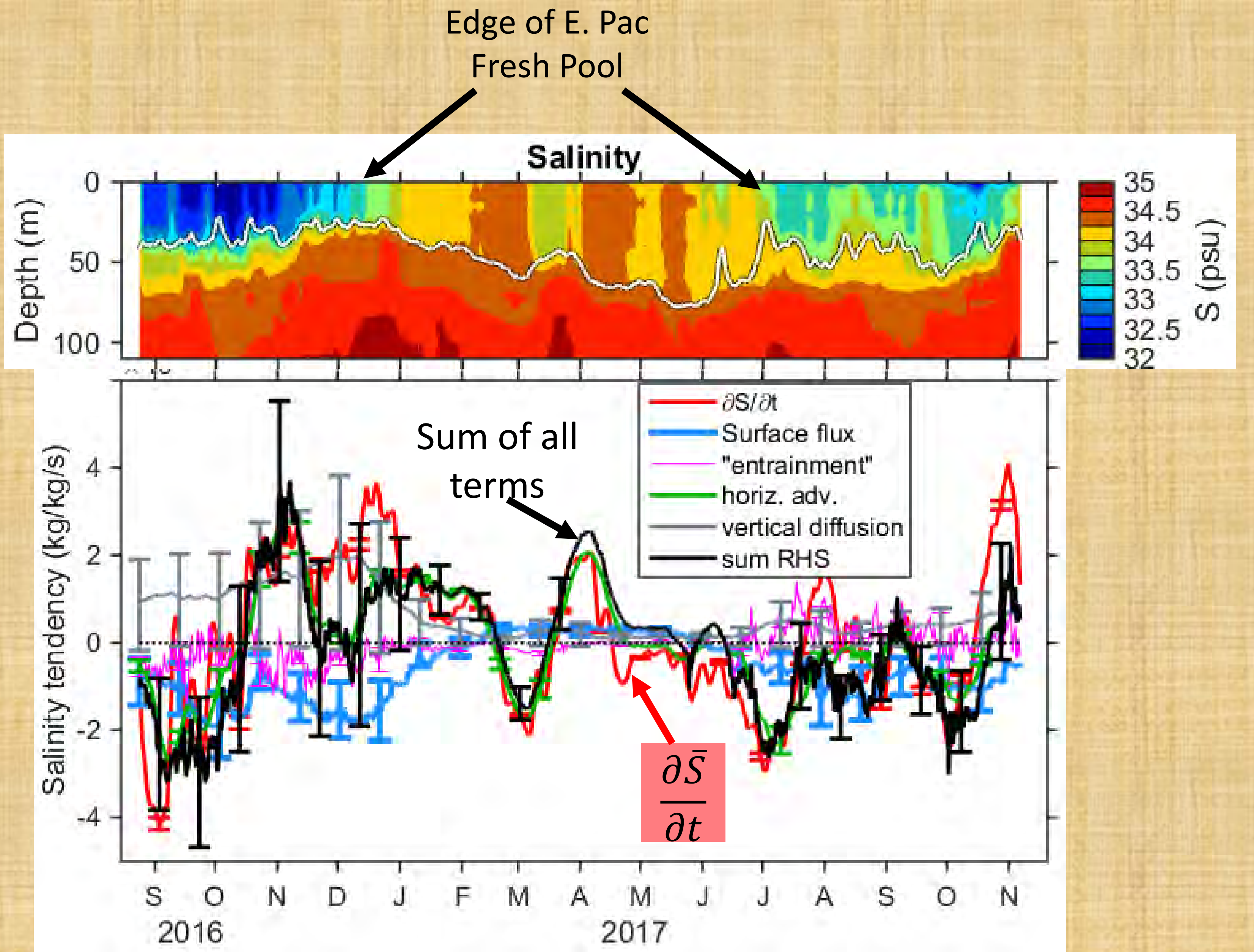
Vertical turbulent flux at ML base; attempted:

$$Q_{-h} = \kappa \frac{\partial\, S}{\partial\, z}$$

$$\kappa = 2 \times 10^{-5} \frac{m^2}{s}$$

Not attempted

Surface-layer salinity budget at the SPURS2 site



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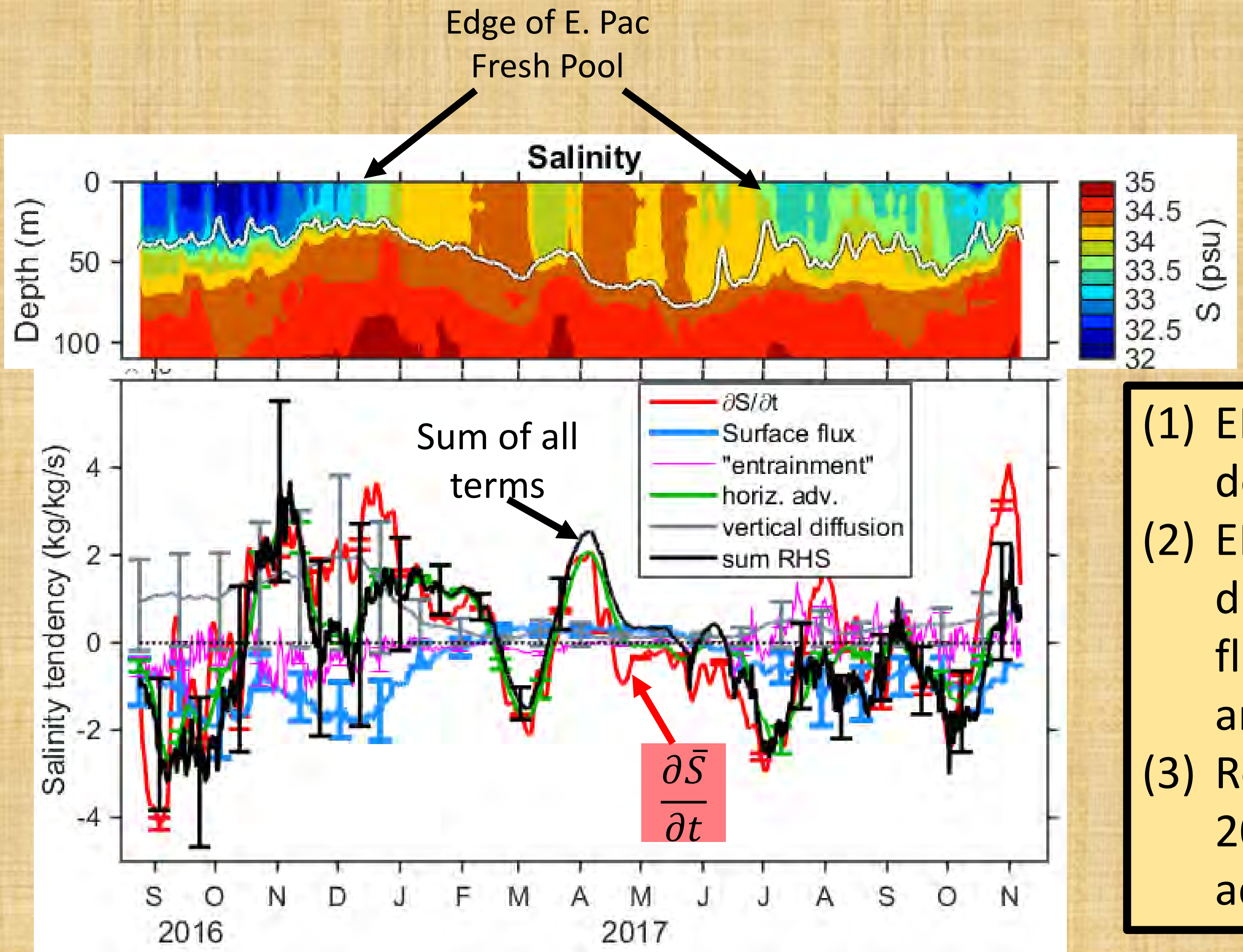
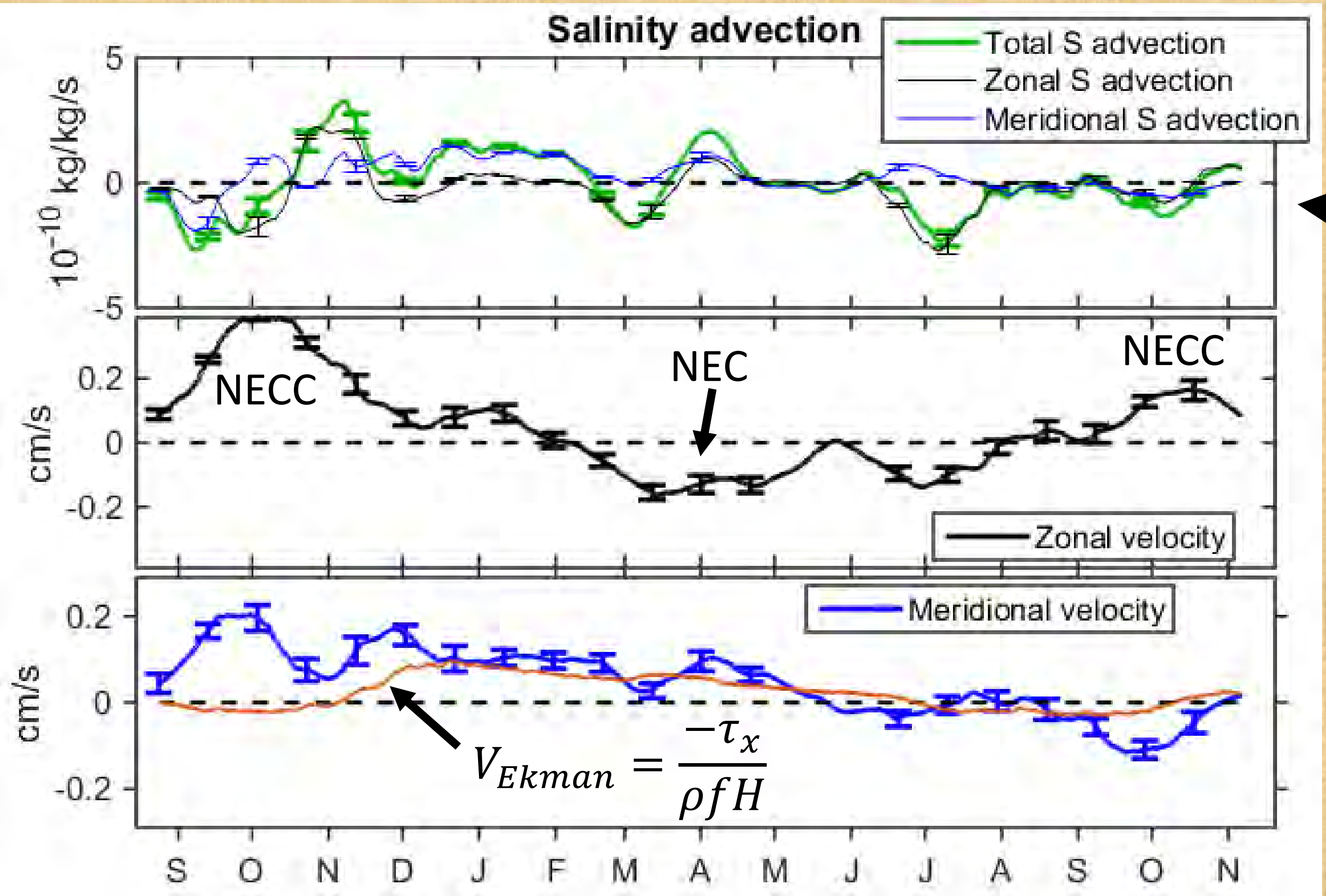


(1) EPFP disappears in Nov-Dec despite heavy rain
(2) EPFP disappearance in Nov-Dec due to 3-way balance of surface flux, subsurface turbulent flux, and advection
(3) Re-appearance of EPFP in June 2017 driven initially by advection, followed by rain

Decomposing horizontal advection



(1) Zonal/meridional advection generally complicated and variable
(2) The NEC/NECC system is moving north and south (associated with ITCZ Ekman pumping)
(3) Northward current and salinification in Jan-May consistent with Ekman advection

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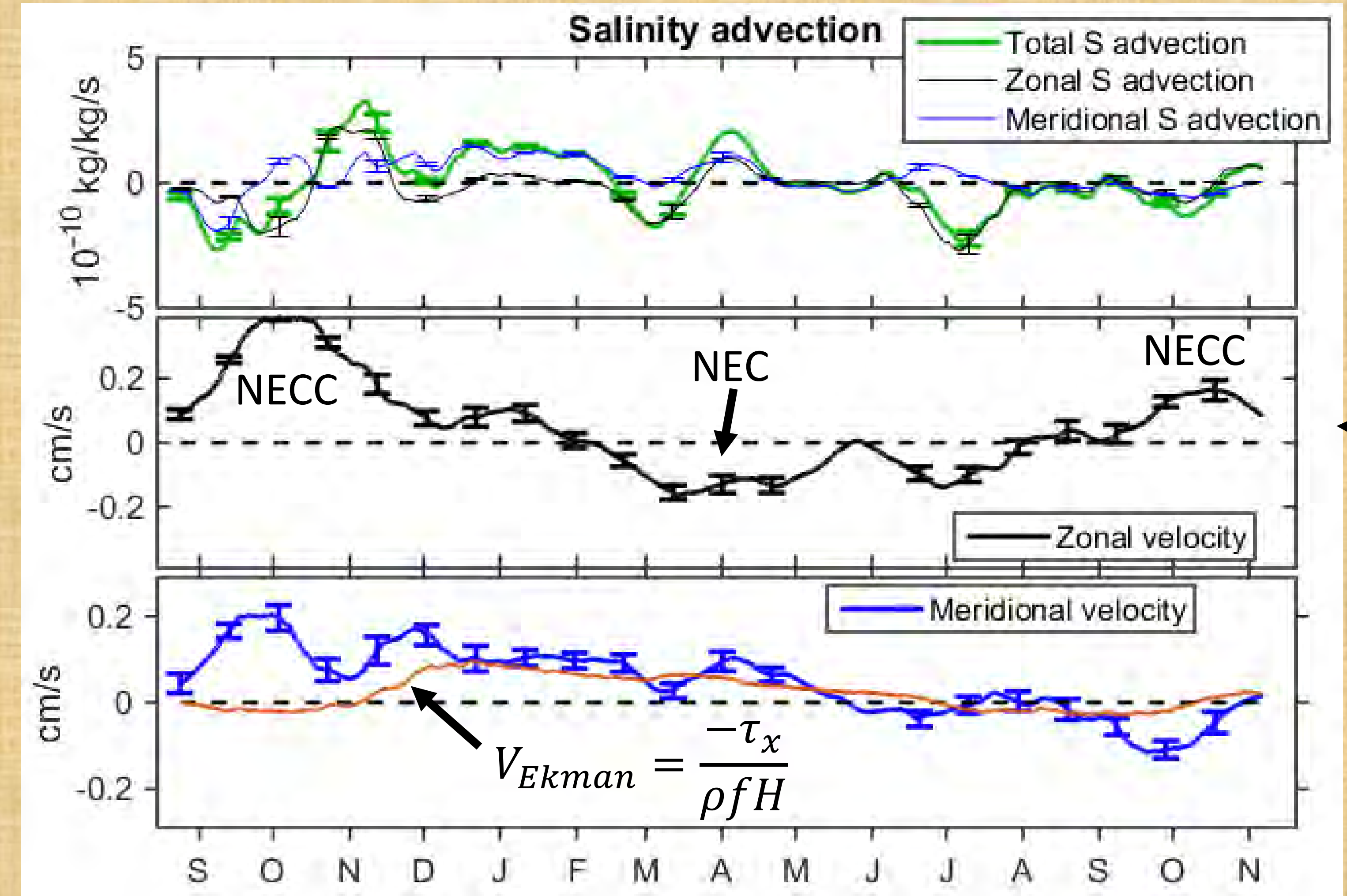

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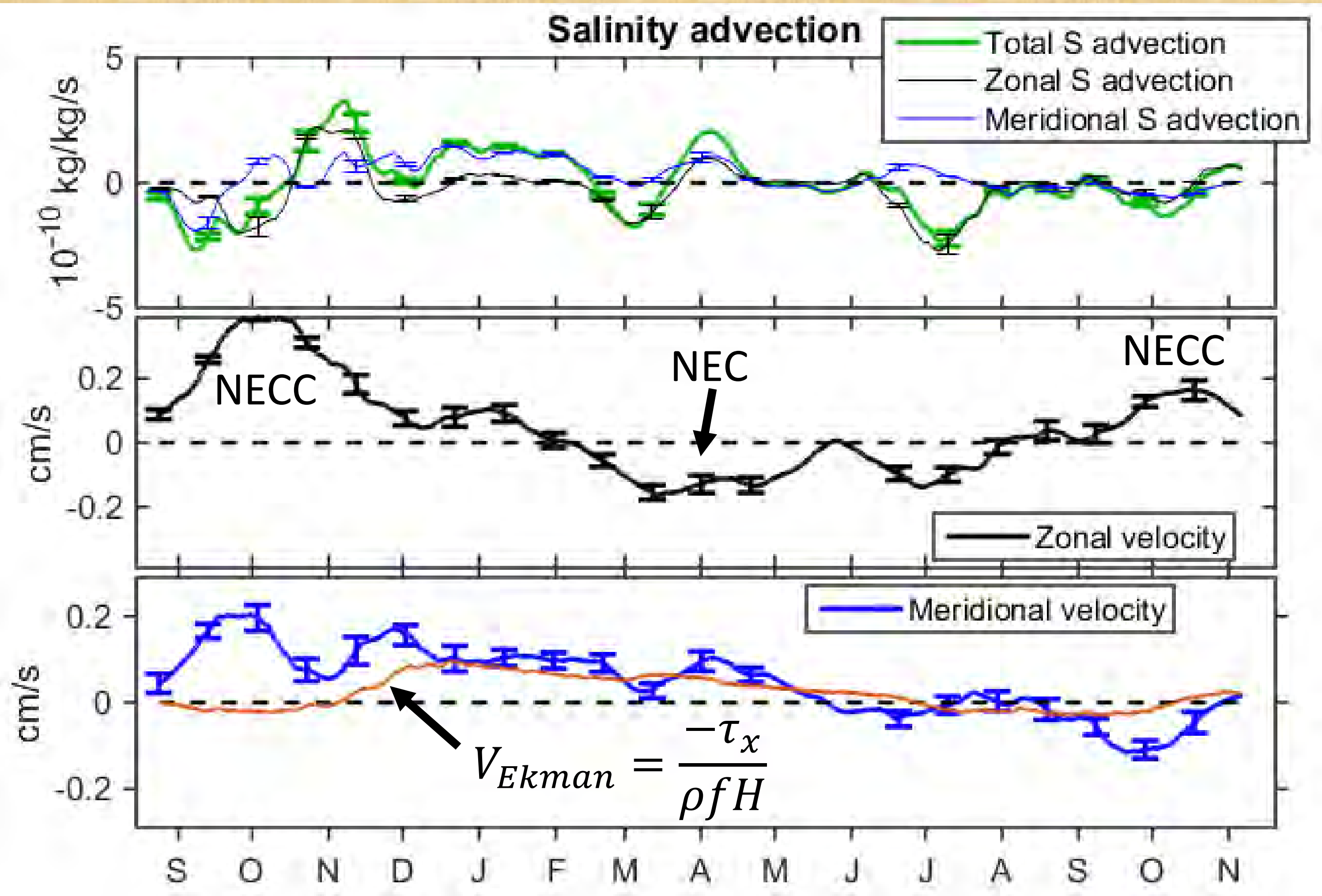

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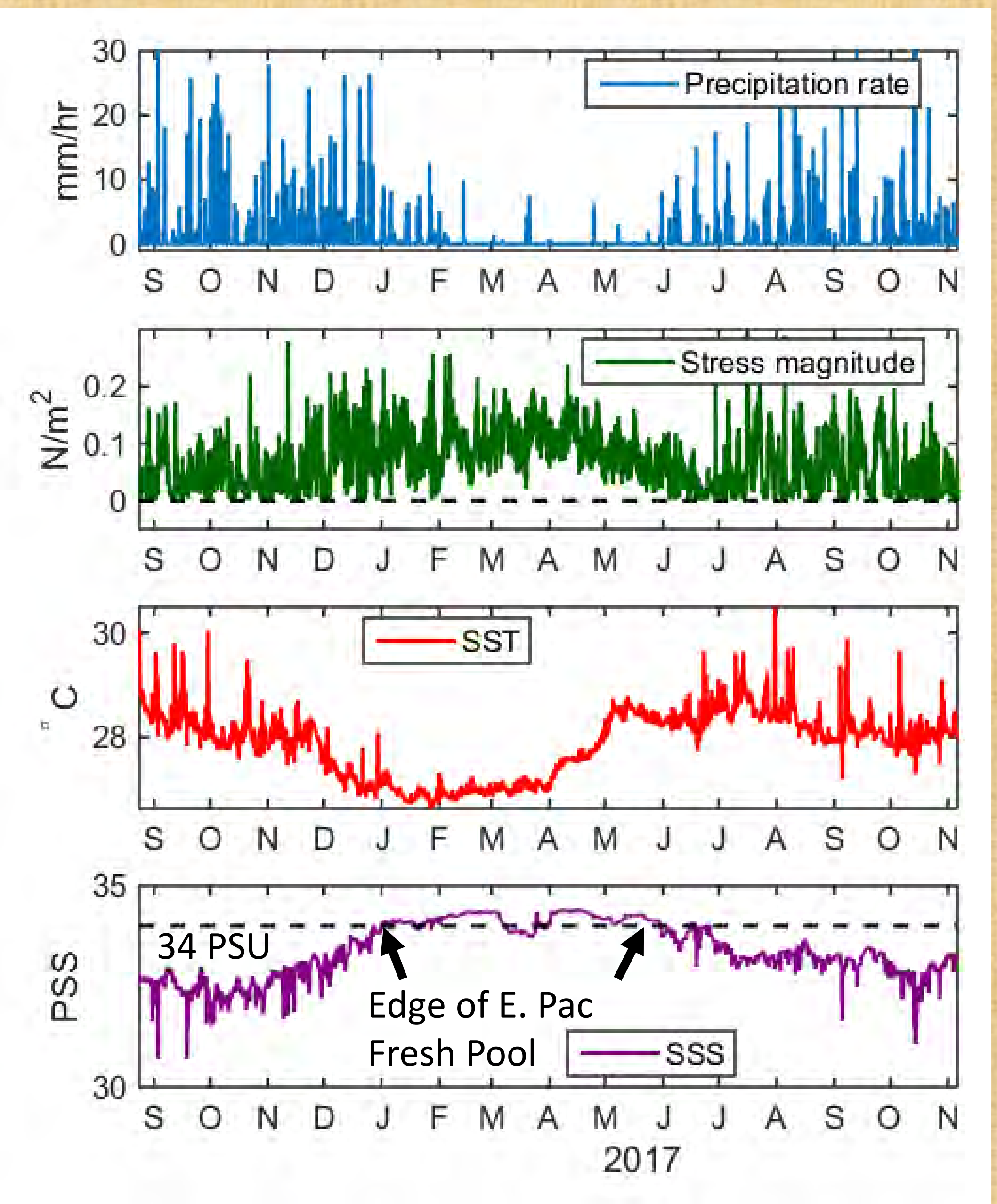
Conclusions

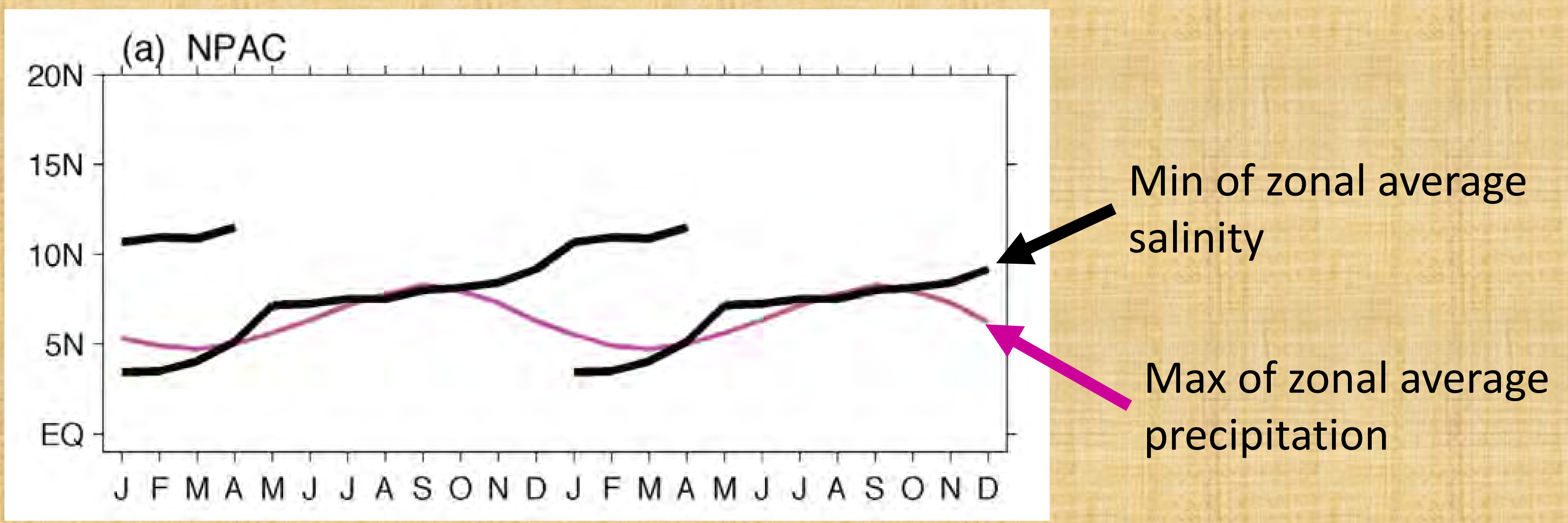
- SPURS-2 was in a highly dynamic region, with strong SSS variability, precipitation, evaporation, and currents
- The transition between salty and fresh seasons coincided with the local NEC/NECC seasonal cycle (similar to Guimbard et al, 2017)
- Ekman advection contributed prolonged salinification after ITCZ moved to the south (similar to Yu, 2015)
- Vertical turbulent flux appears to be important, particularly during anomalously fresh Fall 2016 (as large as local surface flux)



Back-up slides

Ocean dynamical influences on E. Pacific SSS

Yu (2015)→ tropical salinity minimum follows ITCZ northward migration during spring-summer, but then keeps moving north under influence of trade-wind Ekman transport

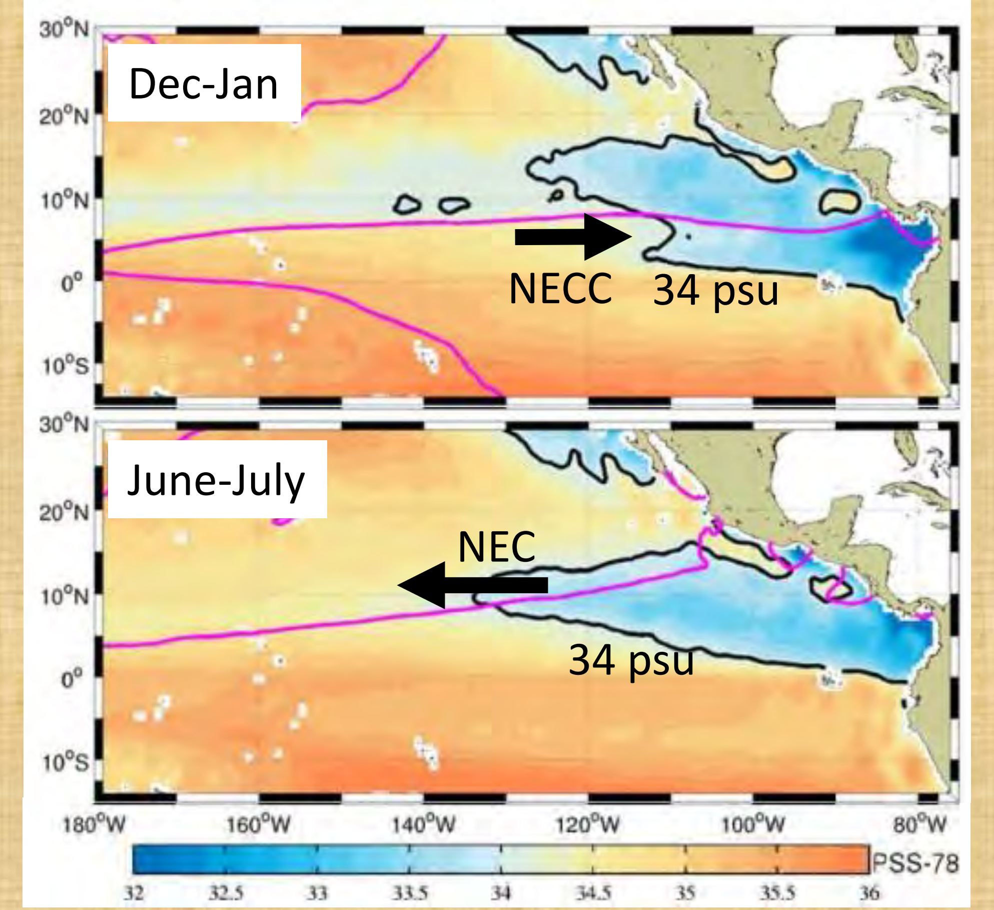


(Yu, 2015; Figure 9a)

Ocean dynamical influences on E. Pacific SSS

Guimbard et al (2017)→ clarifying the relationships of various SSS forcing terms

SSS (color) and ITCZ position (pink)



(Guimbard et al, 2017; Figure 3)

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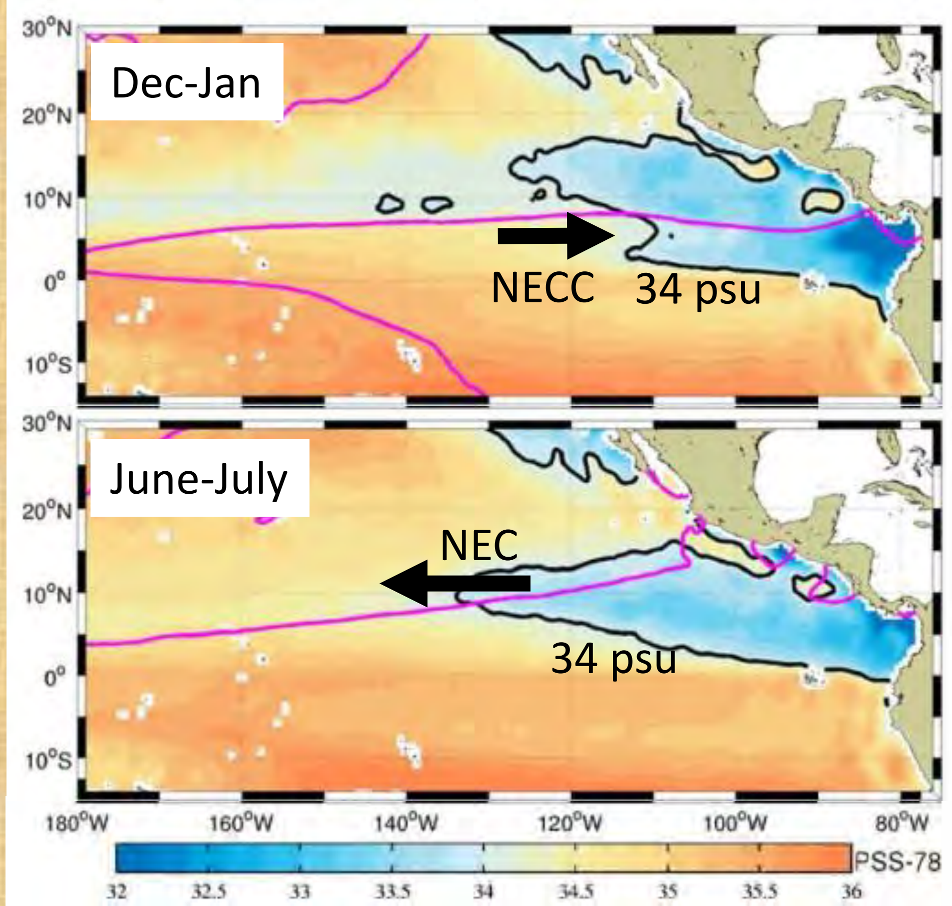
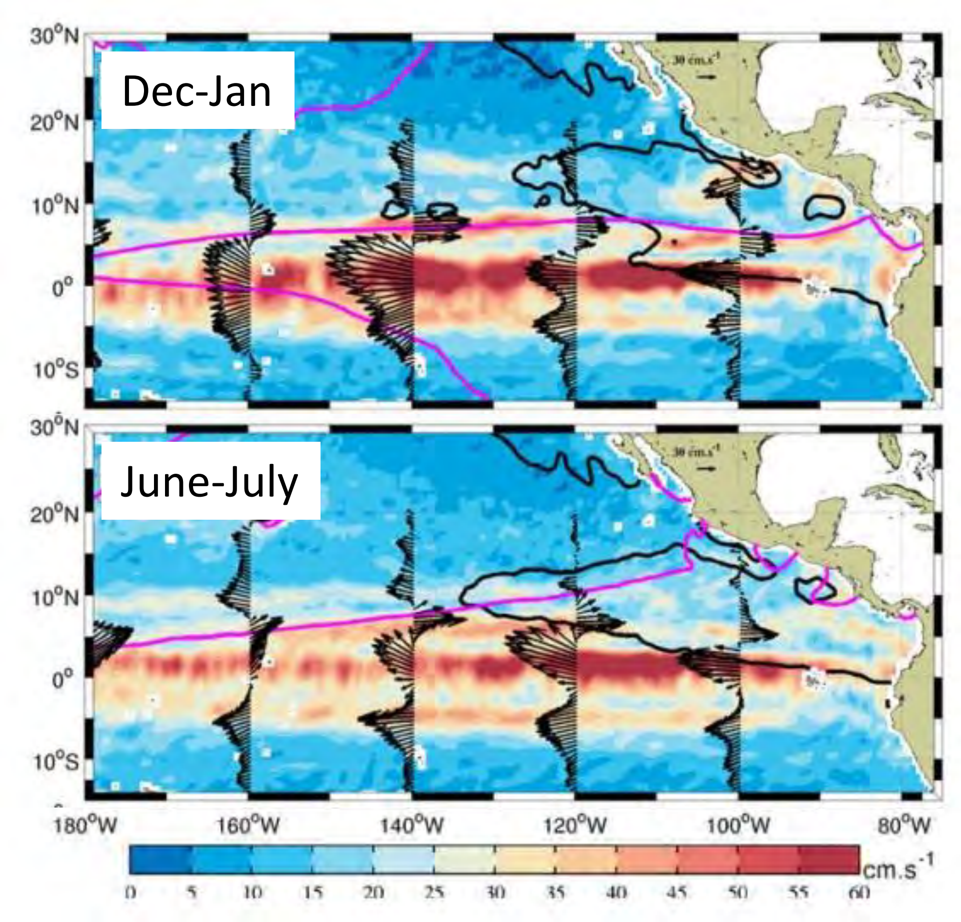


(Guimbard et al, 2017; Figure 3)

Surface currents (color and vectors)



(Guimbard et al, 2017; Figure 4)