Upwelling in the equatorial Pacific
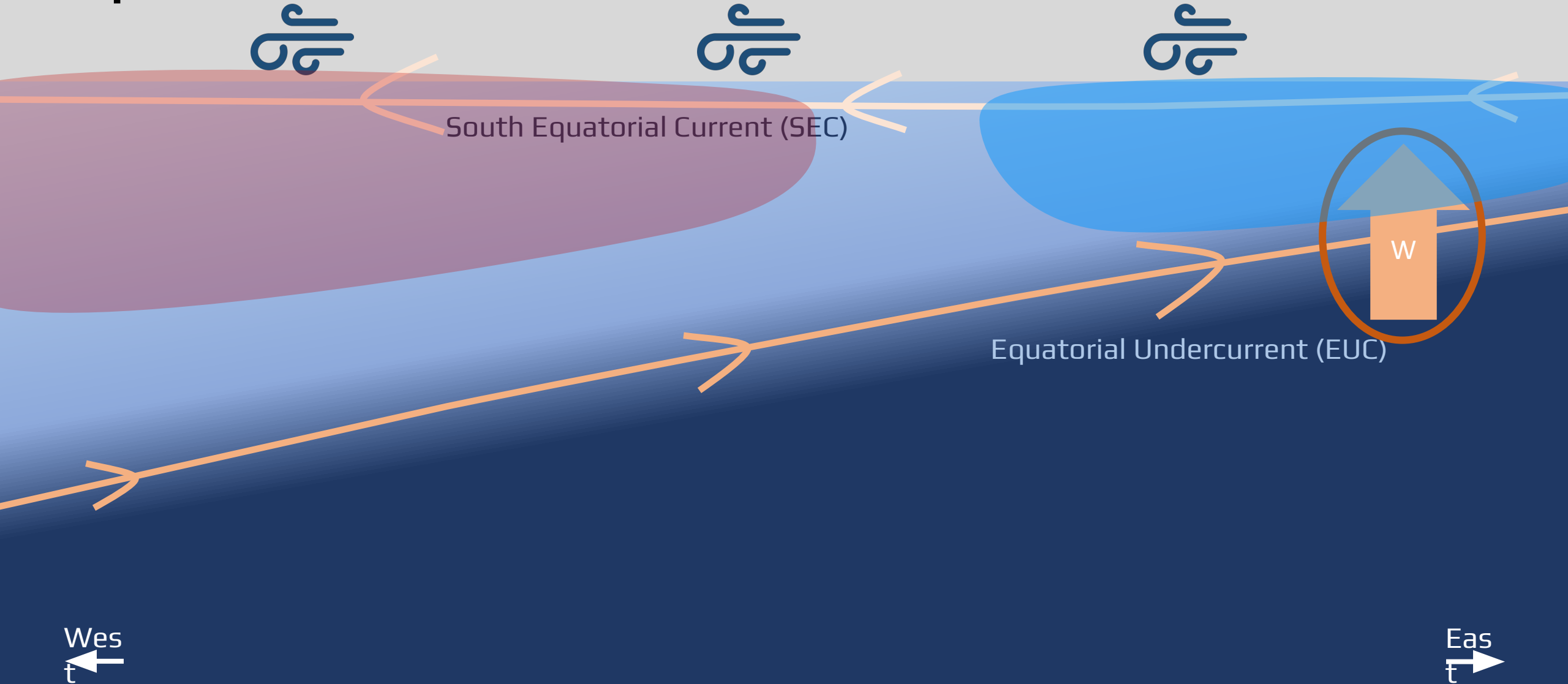## In a high resolution ocean model

Anna-Lena Deppenmeier[1]
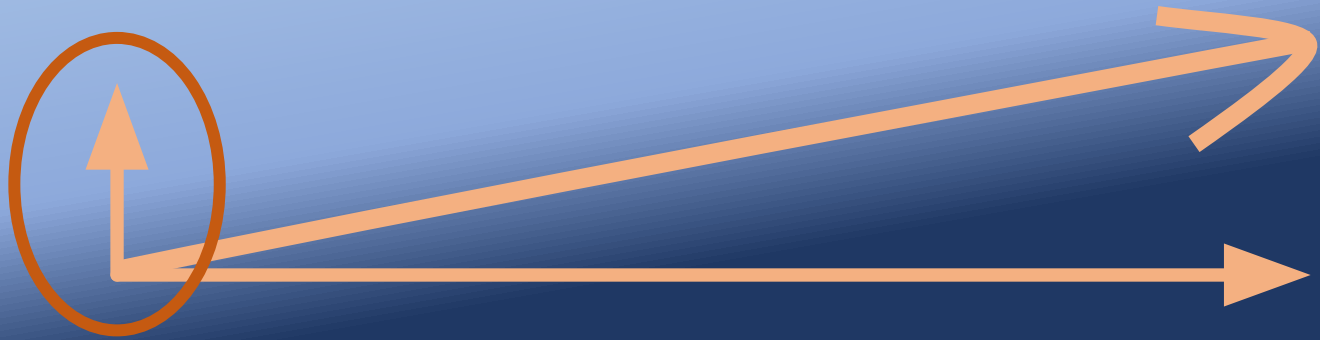
Frank Bryan,[1] Billy Kessler,[2] LuAnne Thompson,[3] Deepak Cherian[1]

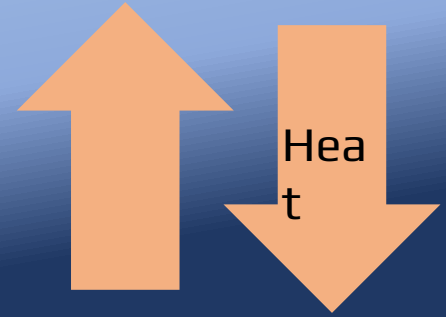Ocean Modeling Working Group Meeting
February 10th 2023

[1] NCAR | CLIMATE & GLOBAL DYNAMICS   [2] PMEL   [3] School of Oceanography University of Washington

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Equatorial Pacific Circulation

South Equatorial Current (SEC)

Equatorial Undercurrent (EUC)

W

West

East

Adiabatic Upwelling

Diabatic Upwelling
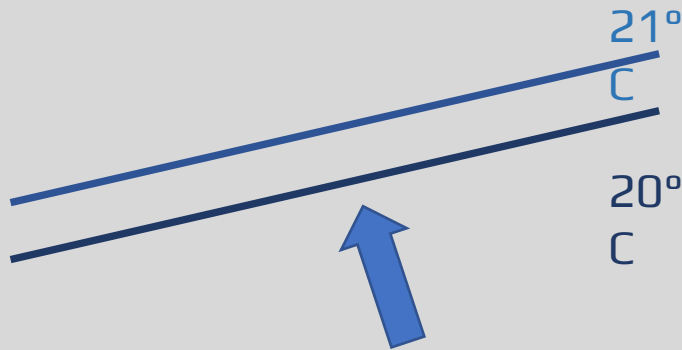
Heat

Diabatic Upwelling Diagnostics

Thermodynamic:

$$\overline{w_{ci}} = \frac{\vec{u} \cdot \nabla \bar{\theta}}{|\nabla \bar{\theta}|} + \frac{1}{|\nabla \bar{\theta}|} \frac{\partial \bar{\theta}}{\partial t} = \frac{1}{\rho_0 c_p |\nabla \bar{\theta}|} \left(\frac{\partial \bar{I}}{\partial z} + \frac{\partial \bar{J}}{\partial z} + \nabla \cdot \overline{H_{diff}} + \rho_0 c_p \nabla \cdot (\overline{u'T'}) \right) + hot$$
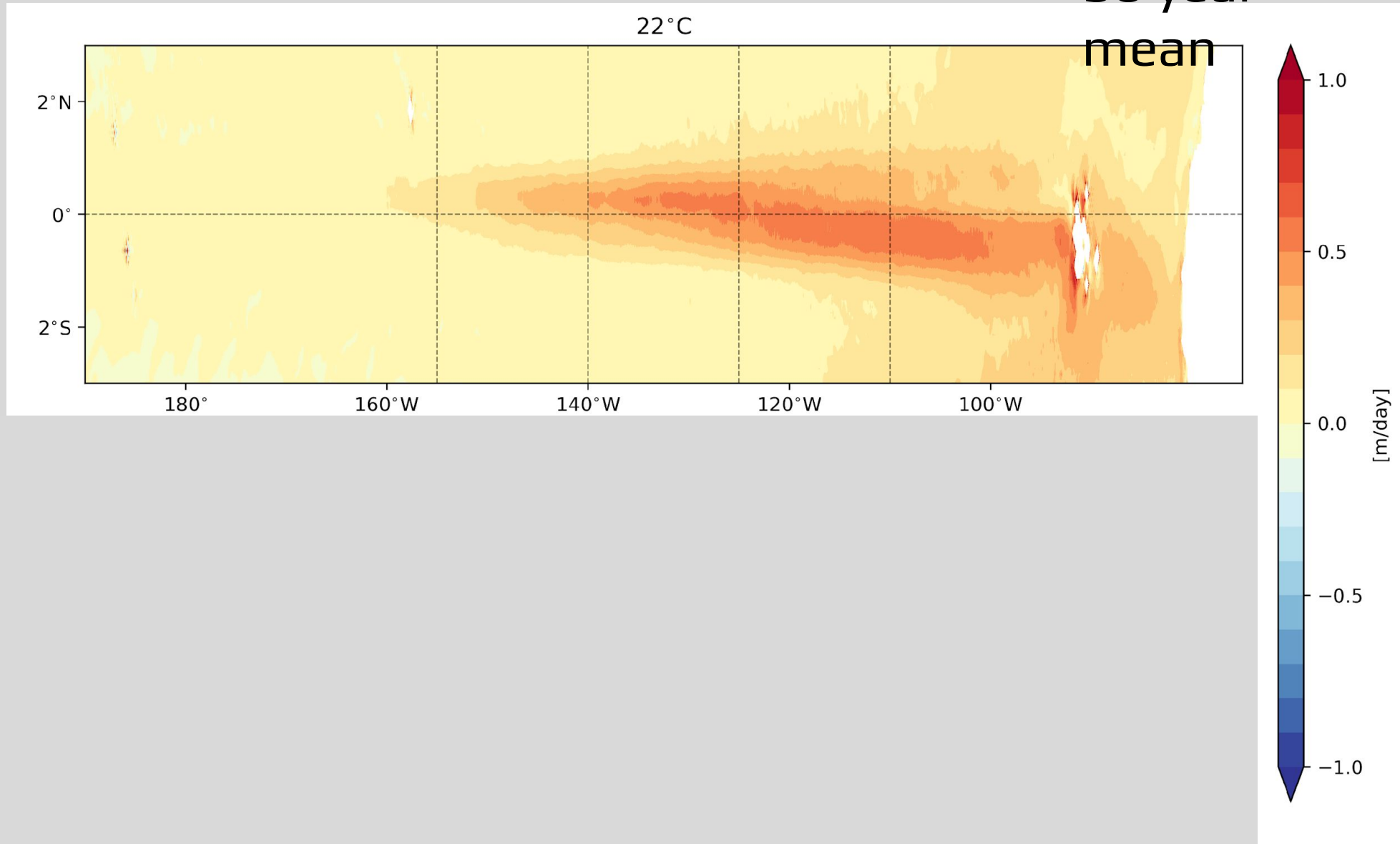
Solar penetration   Vertical Mixing   Horizontal Mixing   Covariance term

21° C

20° C

36 years POP 0.1° JRA-55do forced simulation
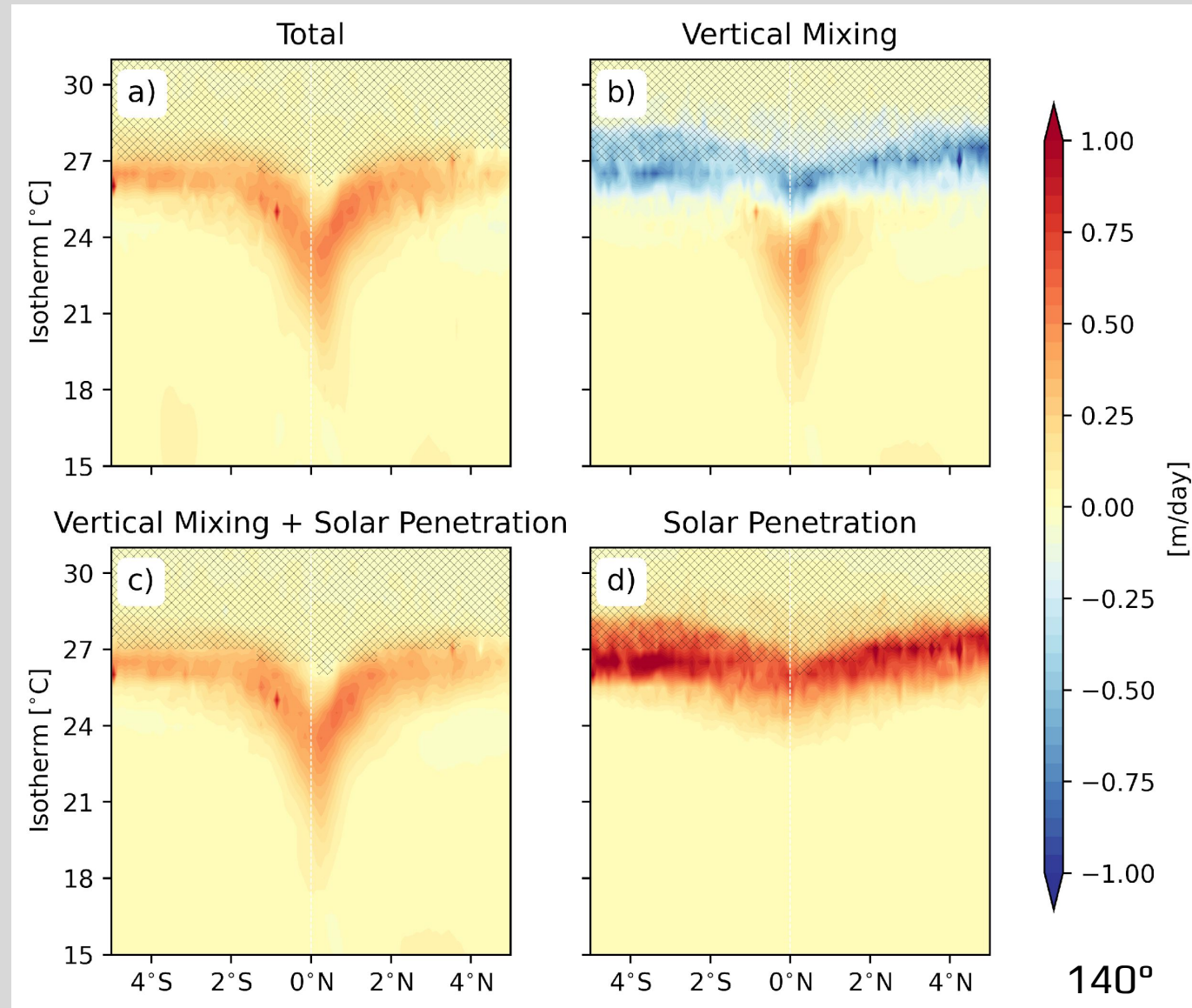Heat budget available
Validated in the papers

Groeskamp, Sjoerd, et al. "The water mass transformation framework for ocean physics and biogeochemistry." *Annual review of marine science* 11 (2019): 271-305.

Deppenmeier, A. L., Bryan, F. O., Kessler, W. S., & Thompson, L. (2021). Modulation of cross-isothermal velocities with ENSO in the tropical Pacific cold tongue. Journal of Physical Oceanography, 51(5), 1559-1574.

Diabatic Upwelling in the long term mean

36 year mean

$\overline{w_{ci}}$

Deppenmeier, A. L., Bryan, F. O., Kessler, W. S., & Thompson, L. (2021). Modulation of cross-isothermal velocities with ENSO in the tropical Pacific cold tongue. Journal of Physical Oceanography, 51(5), 1559-1574
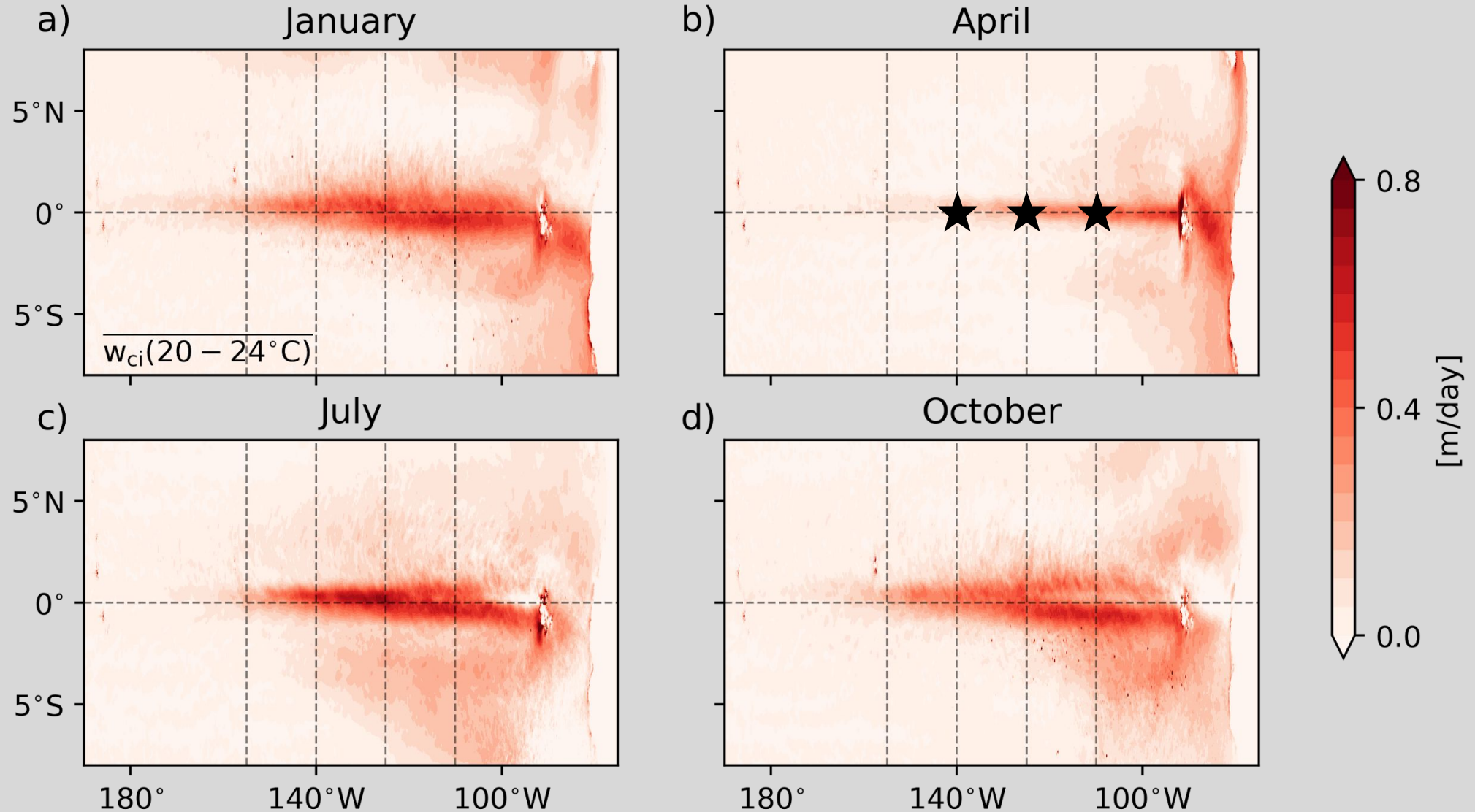
Diabatic Upwelling processes

$$\overline{w_{ci}} \approx \frac{\partial \bar{I}}{\partial z} + \frac{\partial \bar{J}}{\partial z}$$
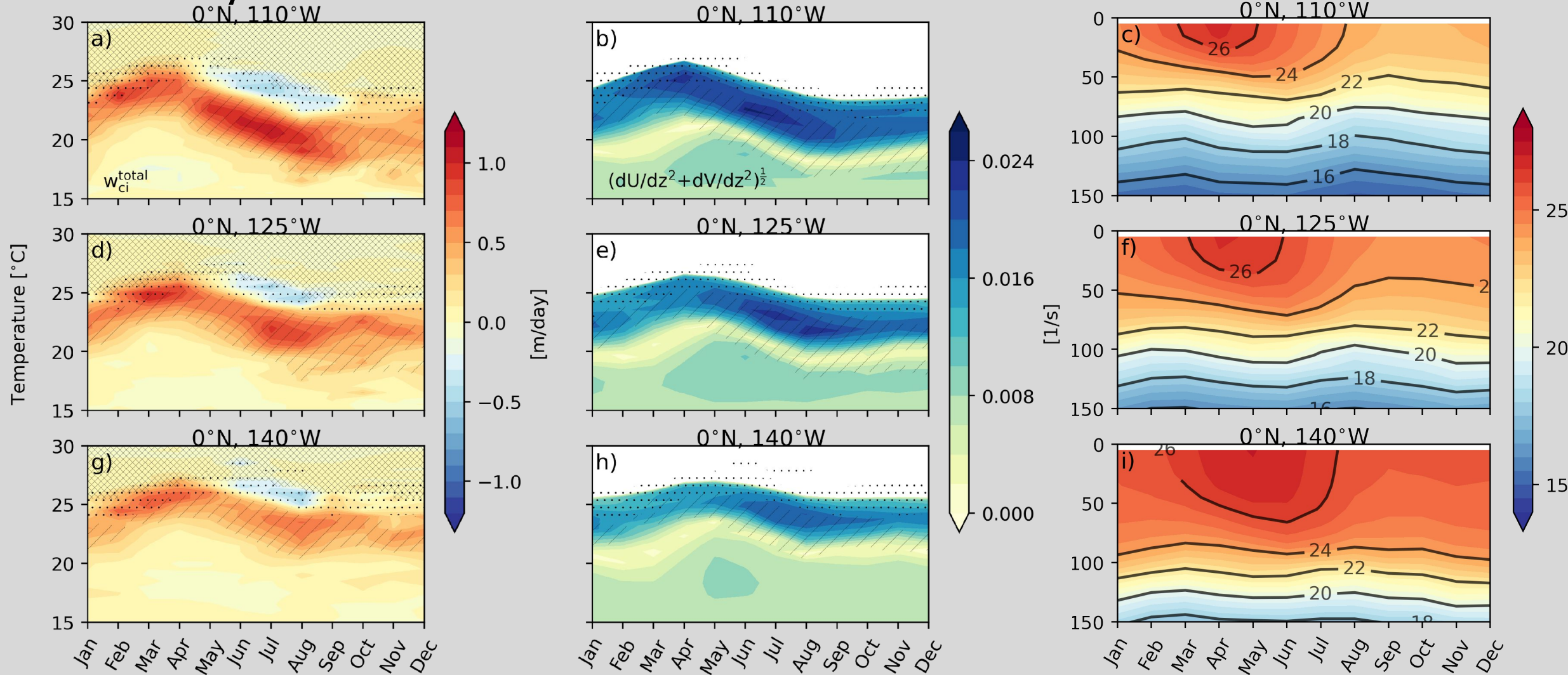
Long Term Mean

140° W

Deppenmeier, A. L., Bryan, F. O., Kessler, W. S., & Thompson, L. (2021). Modulation of cross-isothermal velocities with ENSO in the tropical Pacific cold tongue. Journal of Physical Oceanography, 51(5), 1559-1574

Diabatic Upwelling in the seasonal cycle

a) January   b) April   c) July   d) October

$\overline{w_{ci}(20-24°C)}$

[m/day]

Diabatic Upwelling processes

$$\overline{w_{ci}} \approx \frac{\partial \bar{I}}{\partial z} + \frac{\partial \bar{J}}{\partial z}$$
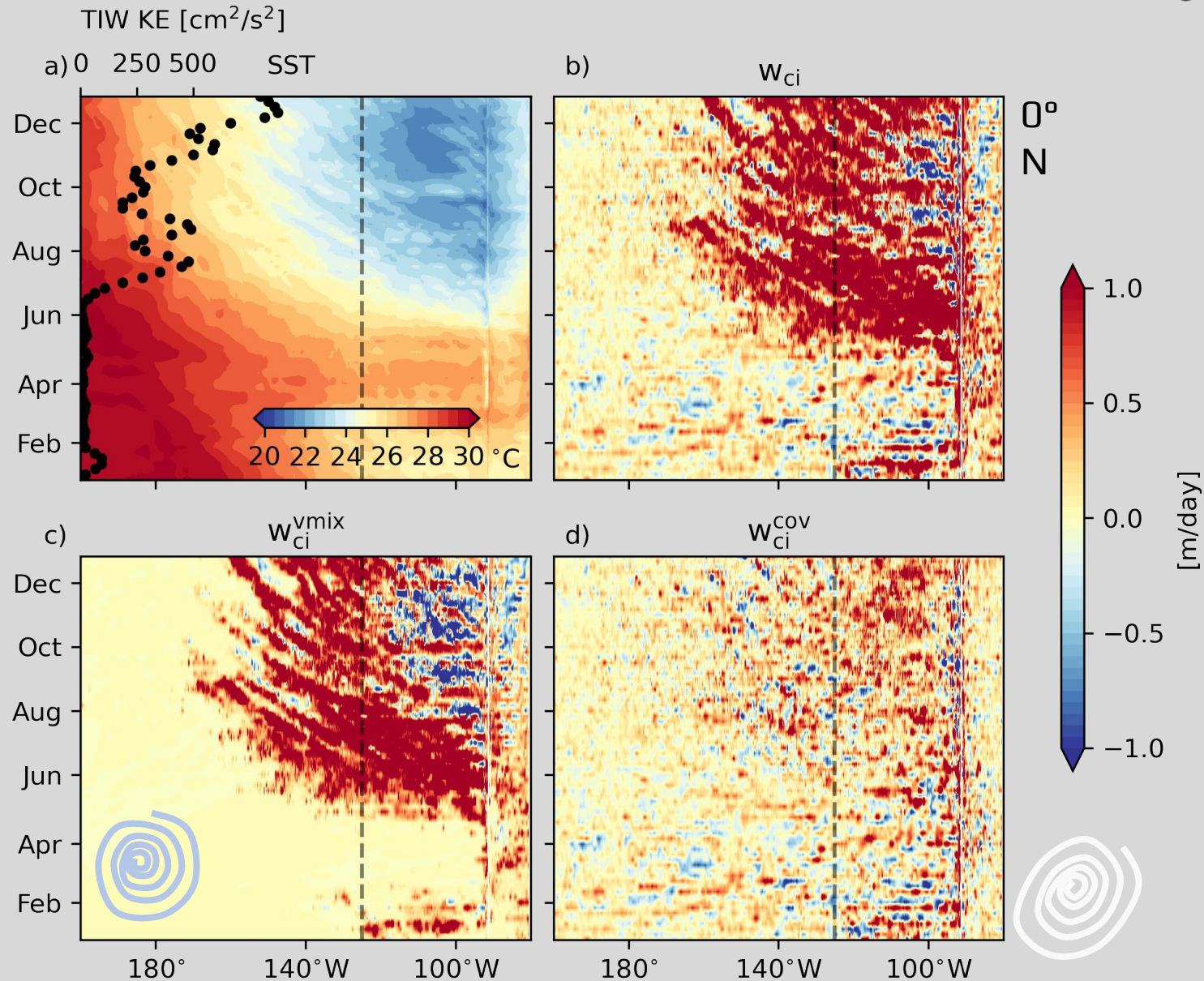
Seasonal Cycle

Diabatic Upwelling processes

Subseasonal

$$\overline{w_{ci}} \approx \frac{\partial \bar{I}}{\partial z} + \frac{\partial \bar{J}}{\partial z} \ ?$$
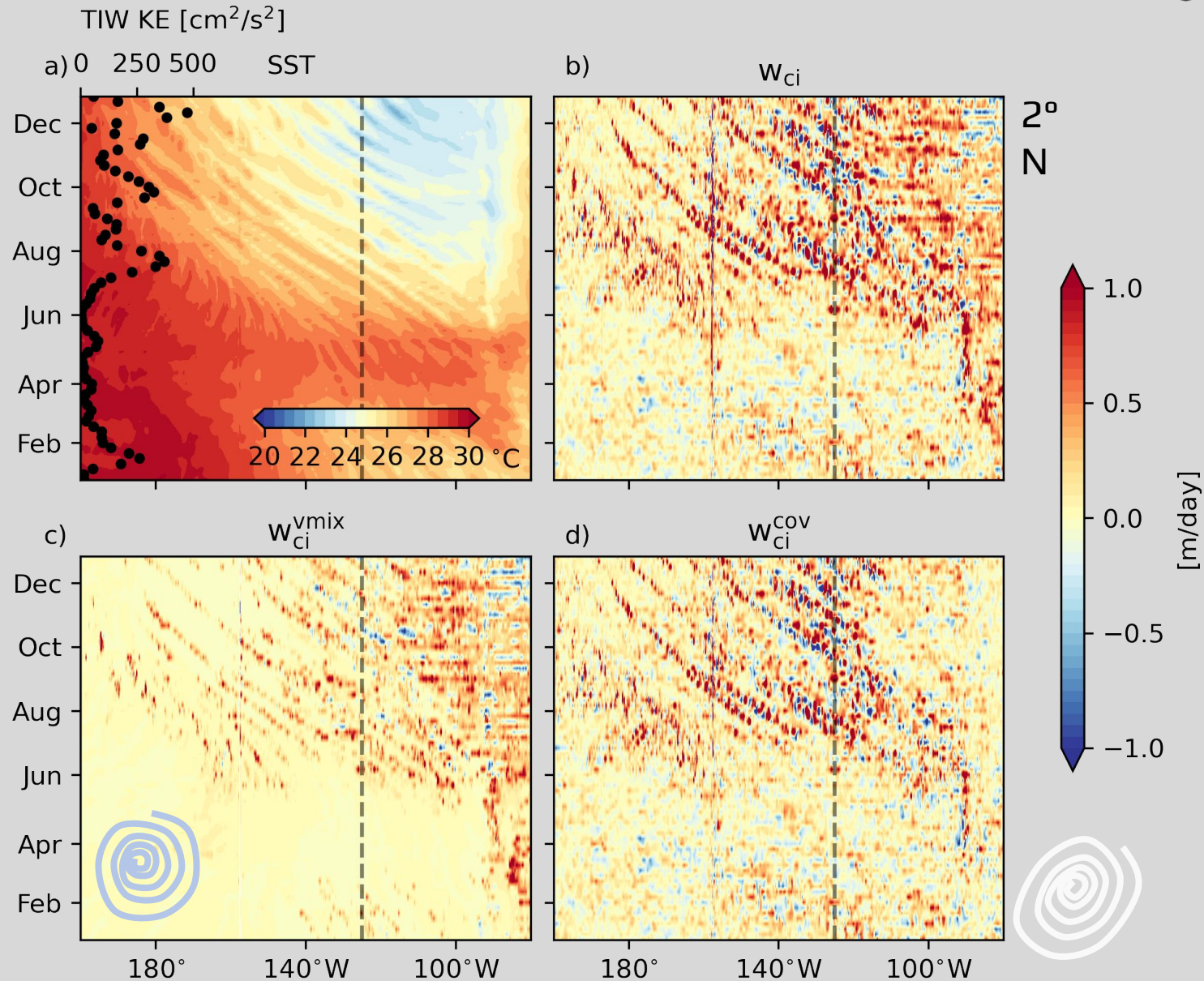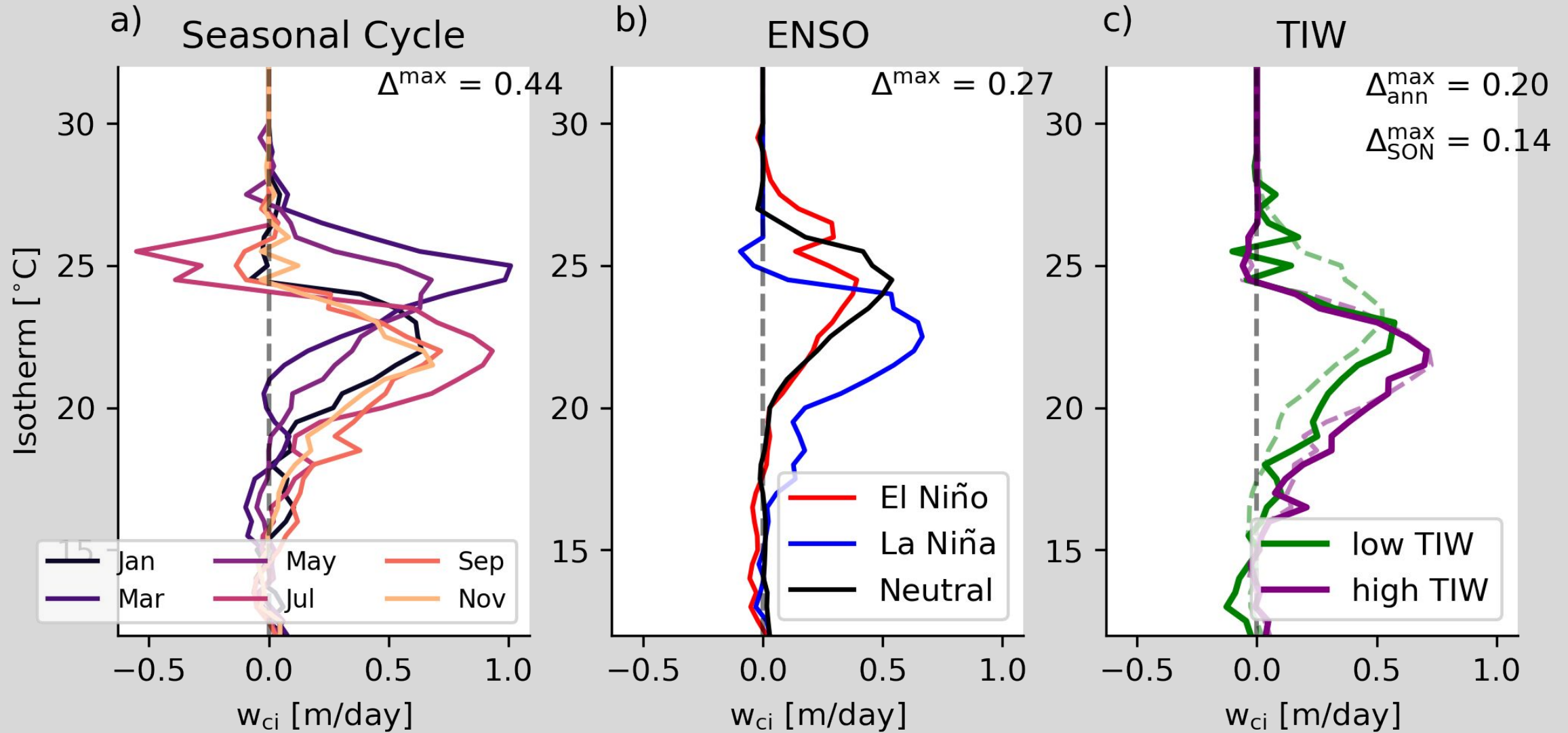

Deppenmeier, A. L., Bryan, F. O., Kessler, W. S. & Thompson, L. (2022). Diabatic Upwelling in the Tropical Pacific: Seasonal and subseasonal variability

Diabatic Upwelling processes

Subseasonal

$$\overline{w_{ci}} \approx \frac{\partial \bar{I}}{\partial z} + \frac{\partial \bar{J}}{\partial z} \ ?$$

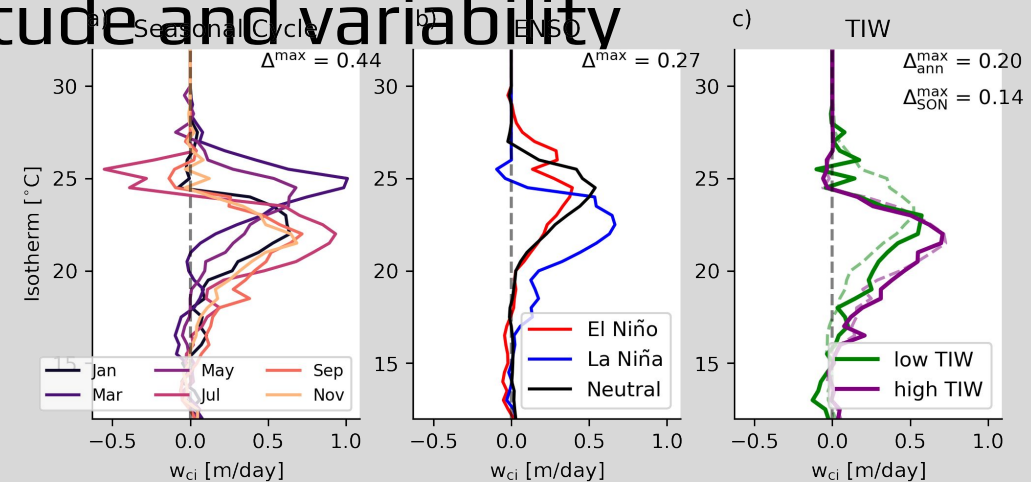Deppenmeier, A. L., Bryan, F. O., Kessler, W. S. & Thompson, L. (2022). Diabatic Upwelling in the Tropical Pacific: Seasonal and subseasonal variability

Diabatic Upwelling across timescales

a) Seasonal Cycle $\Delta^{max} = 0.44$

b) ENSO $\Delta^{max} = 0.27$

c) TIW $\Delta^{max}_{ann} = 0.20$ $\Delta^{max}_{SON} = 0.14$

Deppenmeier, A. L., Bryan, F. O., Kessler, W. S. & Thompson, L. (2022). Diabatic Upwelling in the Tropical Pacific: Seasonal and subseasonal variability
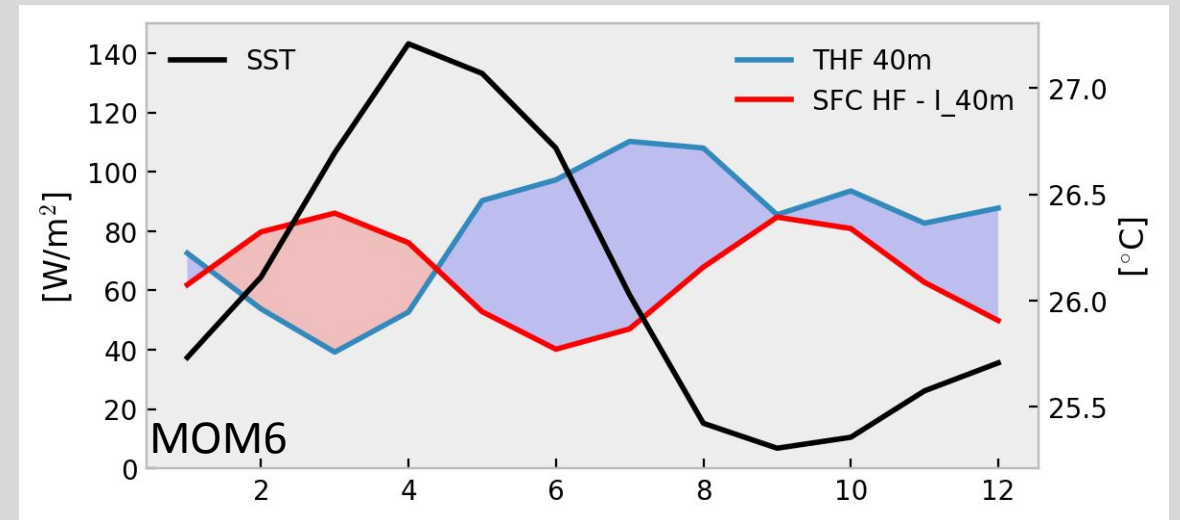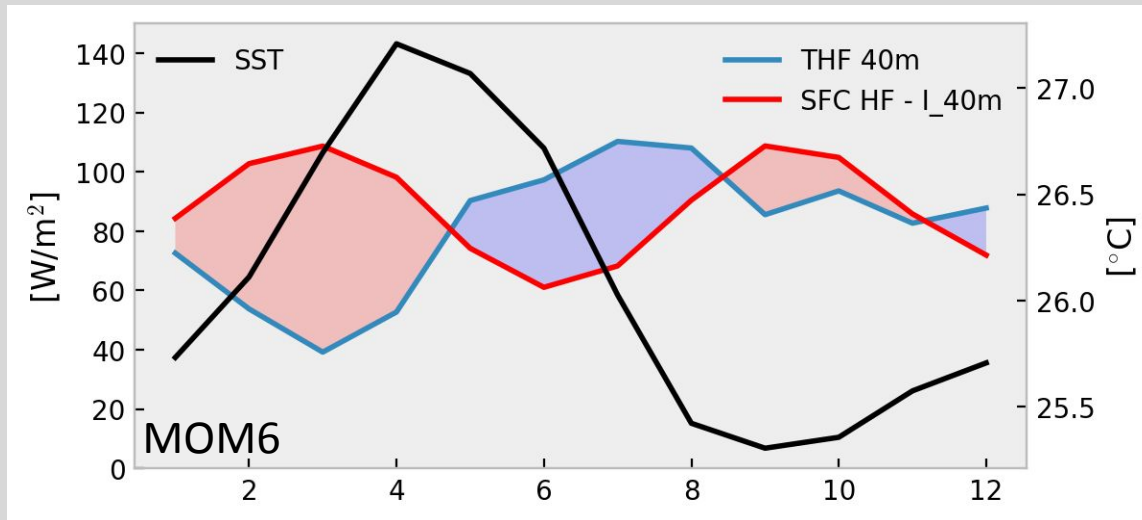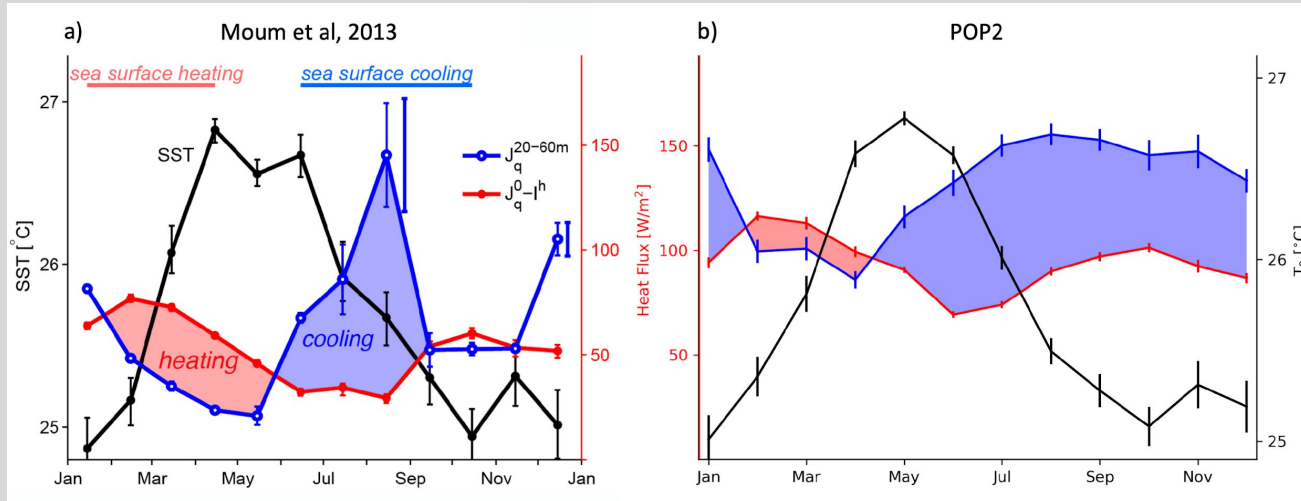
Diabatic Upwelling across timescales

- Mostly vertical mixing and solar penetration driven

- Off-equatorial Tropical Instability Wave signal eddy covariance driven

- All timescales show similar amplitude and variability

Deppenmeier, A. L., Bryan, F. O., Thompson, L., & Kessler, W. S. (2022). Diabatic Upwelling in the Tropical Pacific. Seasonal and subseasonal variability

Diabatic Upwelling depends on mixing parameterization

0°N, 140°W
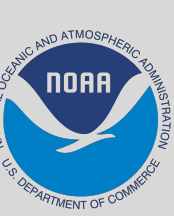
Thank you!

Anna-Lena Deppenmeier

Frank Bryan,[1] Billy Kessler,[1] LuAnne Thompson[3], Deepak Cherian[1]

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