A31K: Regional Climate Modeling II
AGU, 2015

Dynamics and impacts of eddy-driven air-sea interaction in a regional air-sea coupled model for the US West Coast

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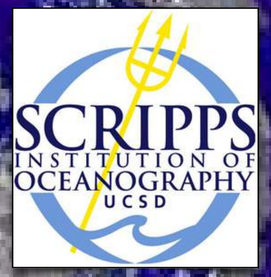
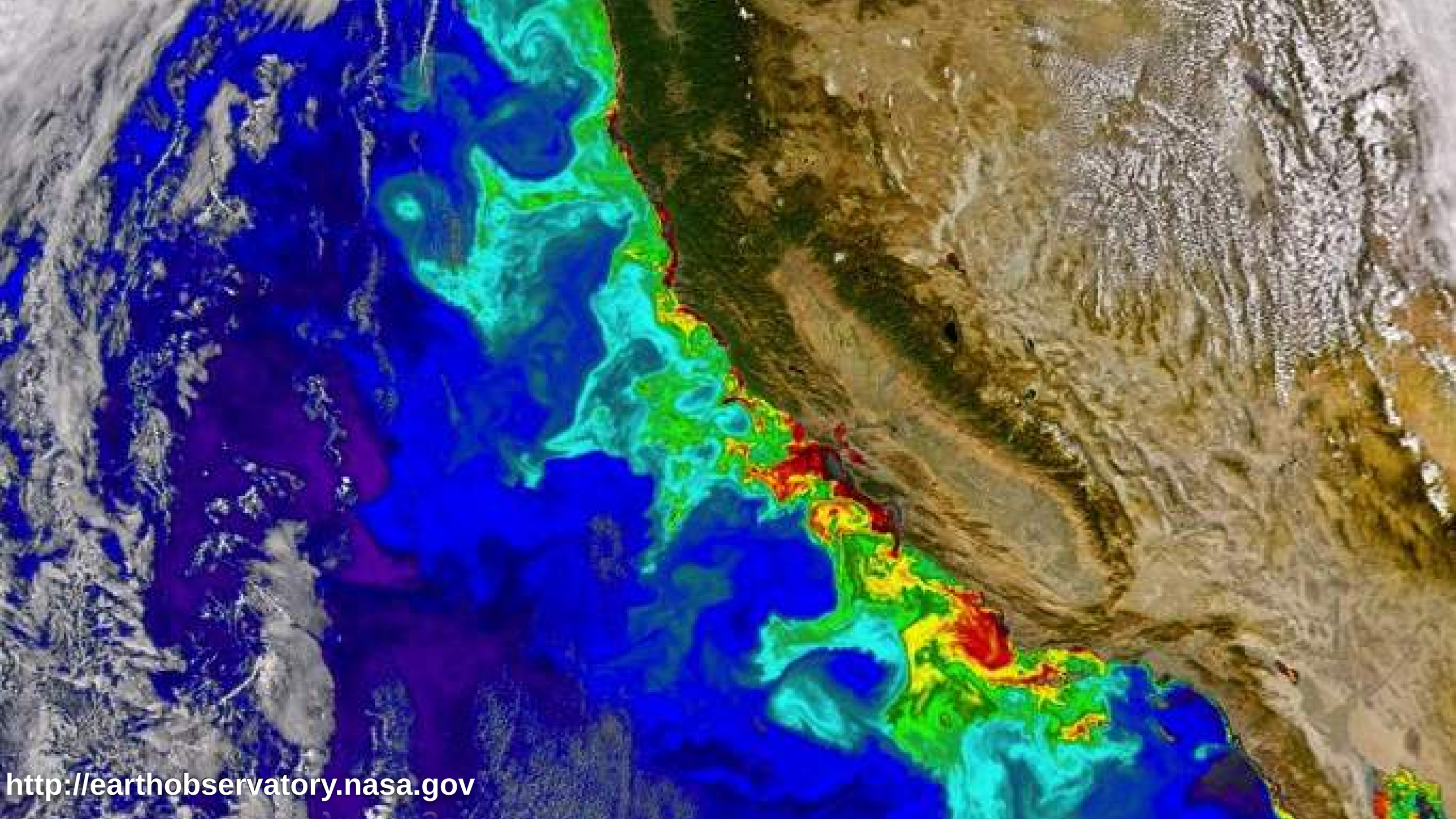


http://earthobservatory.nasa.gov

Seo, Miller, Norris: Eddy-wind interaction in the California Current System: dynamics and impacts. *J. Phys. Oceanogr.*, 2016


http://earthobservatory.nasa.gov

Eddy-driven air-sea interactions: wind stress

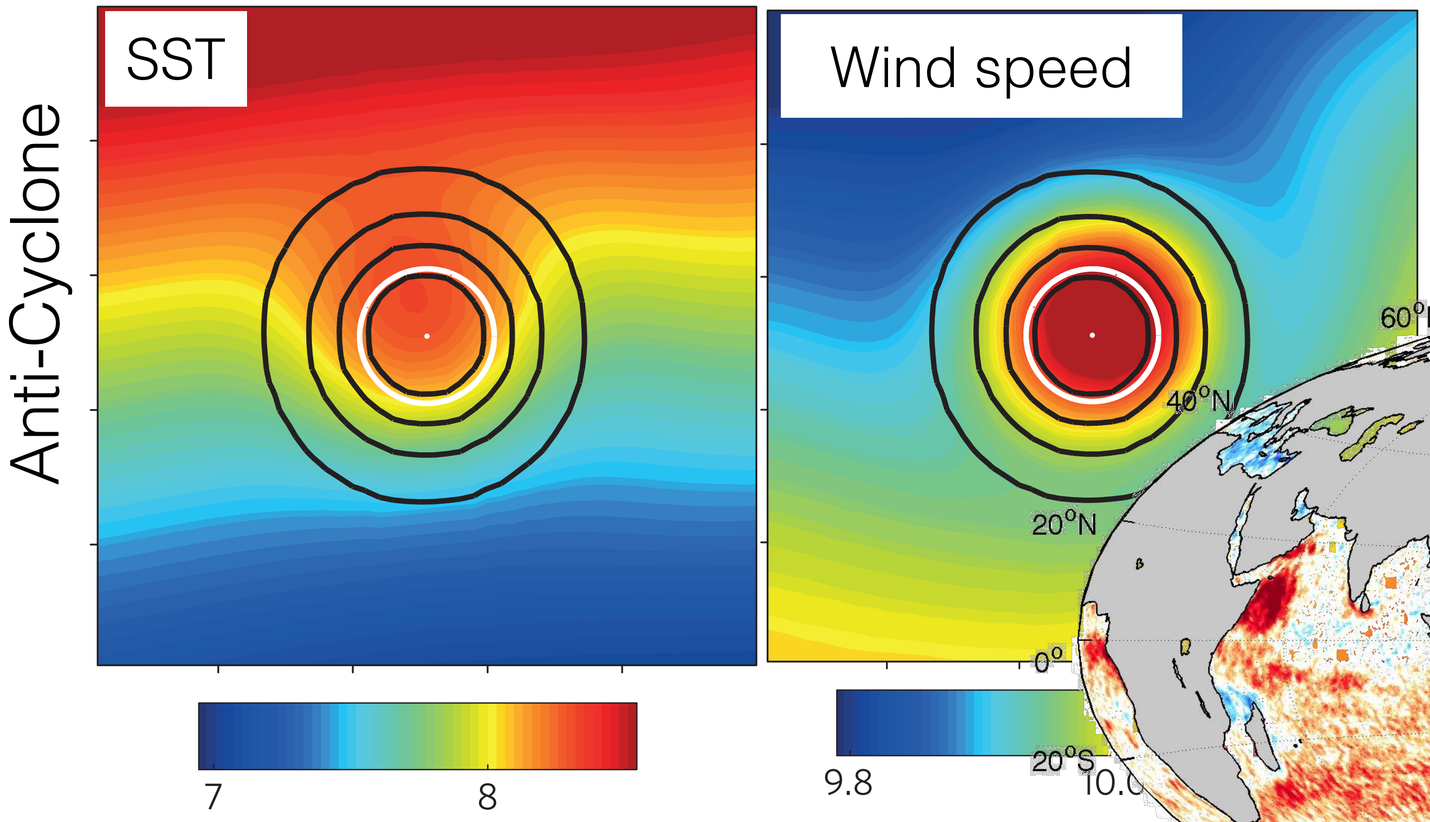
$$\tau = \rho C_D (U_a - U_o) |U_a - U_o|$$

surface current

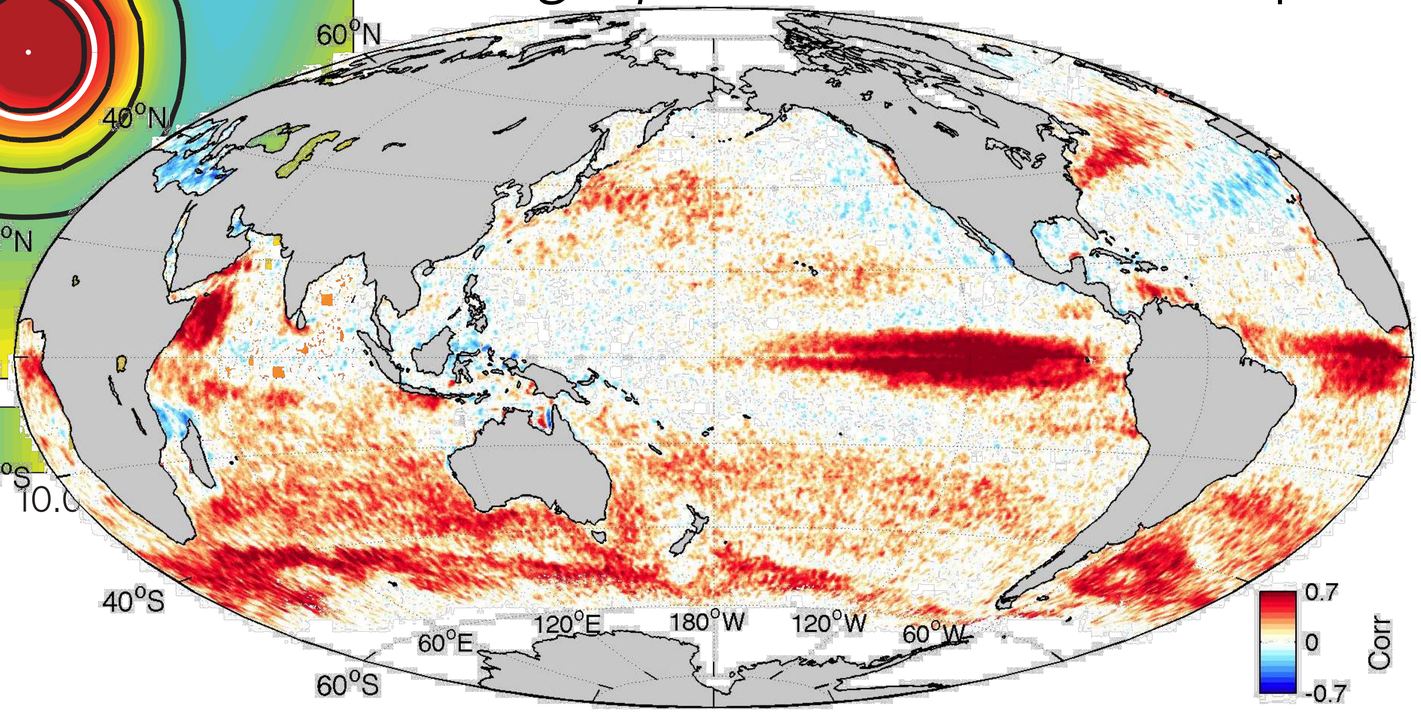
10m wind

$U_a = U_{ab} + \underline{U_{aSST}}$

Eddy composites in the Southern Oceans



+ve CORRELATION: summer *high-passed* SST & wind speed



Frenger et al. 2013

Eddy-driven air-sea interactions: Ekman pumping (W)

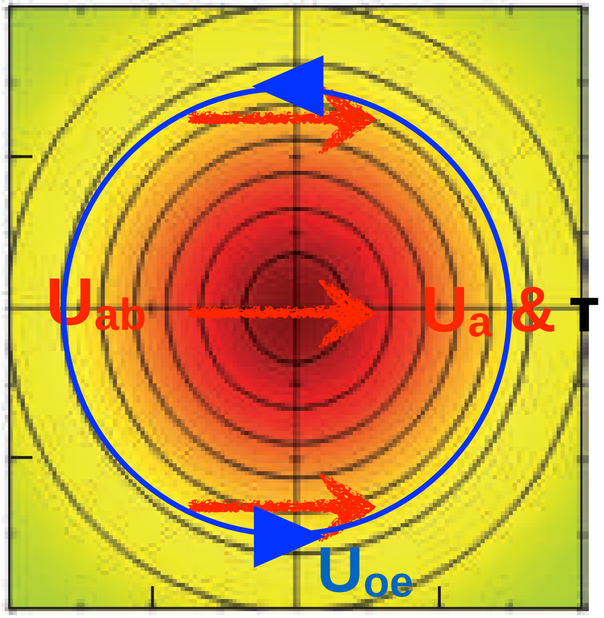
$$\tau = \rho\, C_D\, (U_a - U_o)\, |U_a - U_o|$$

surface current
$U_o = U_{ob} + U_{oe}$

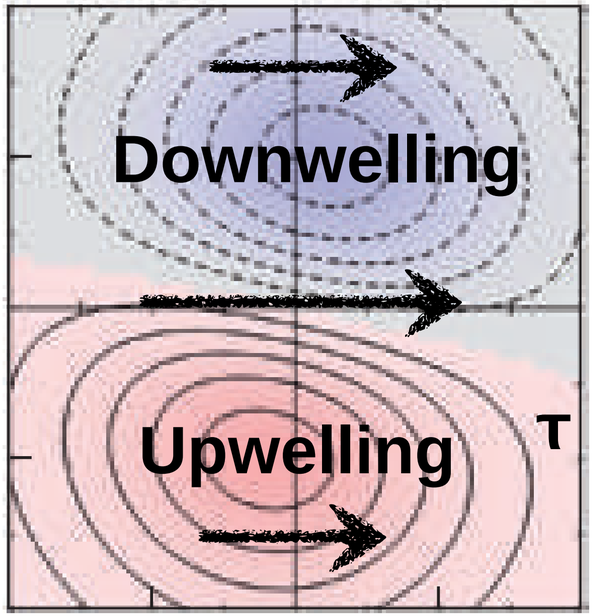
10m wind
$U_a = U_{ab} + \underline{U_{aSST}}$

Consider an anticyclonic eddy in the Southern Ocean (Chelton 2013)

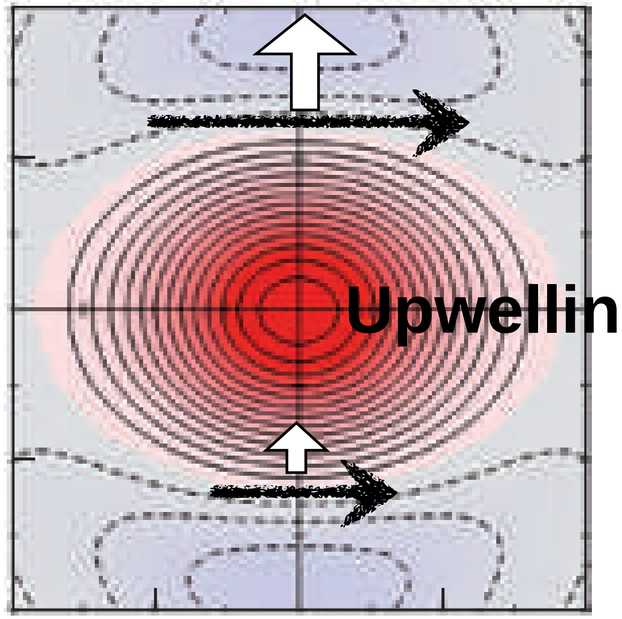
SST and SSH



Dipole W



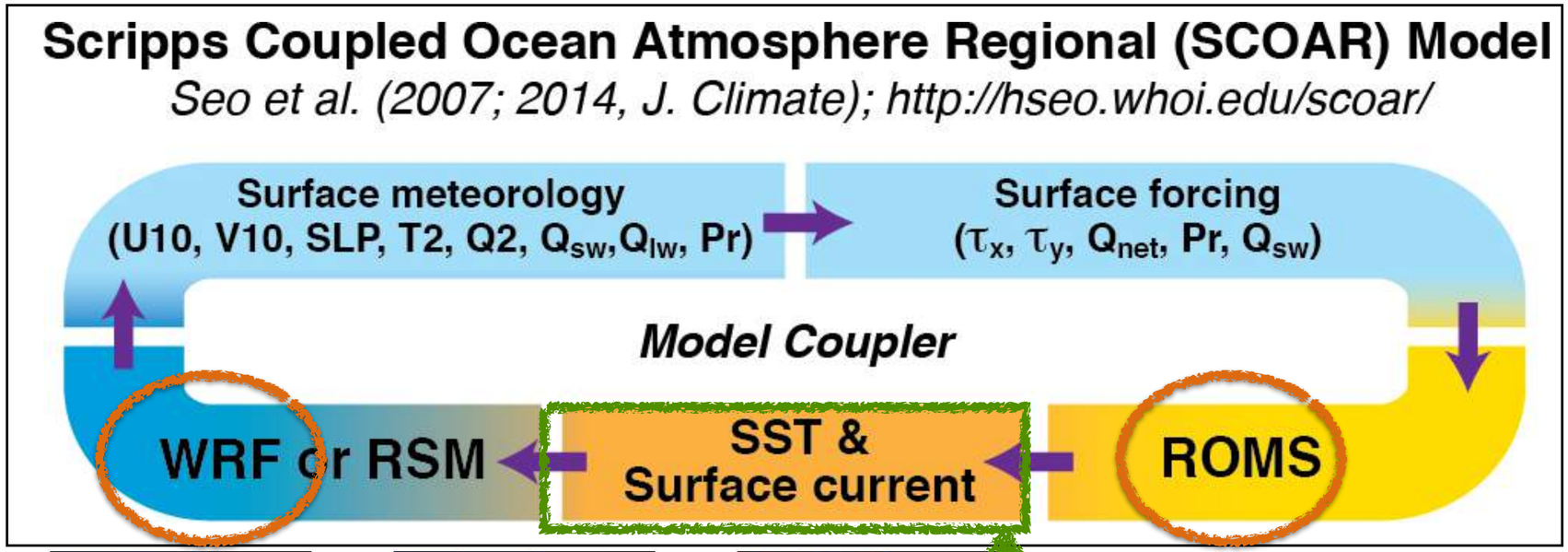
Monopole W



Affect the propagation Affect the amplitude

Quantifying dynamics and rectified effect:

Regional O-A coupled model with an online spatial smoother

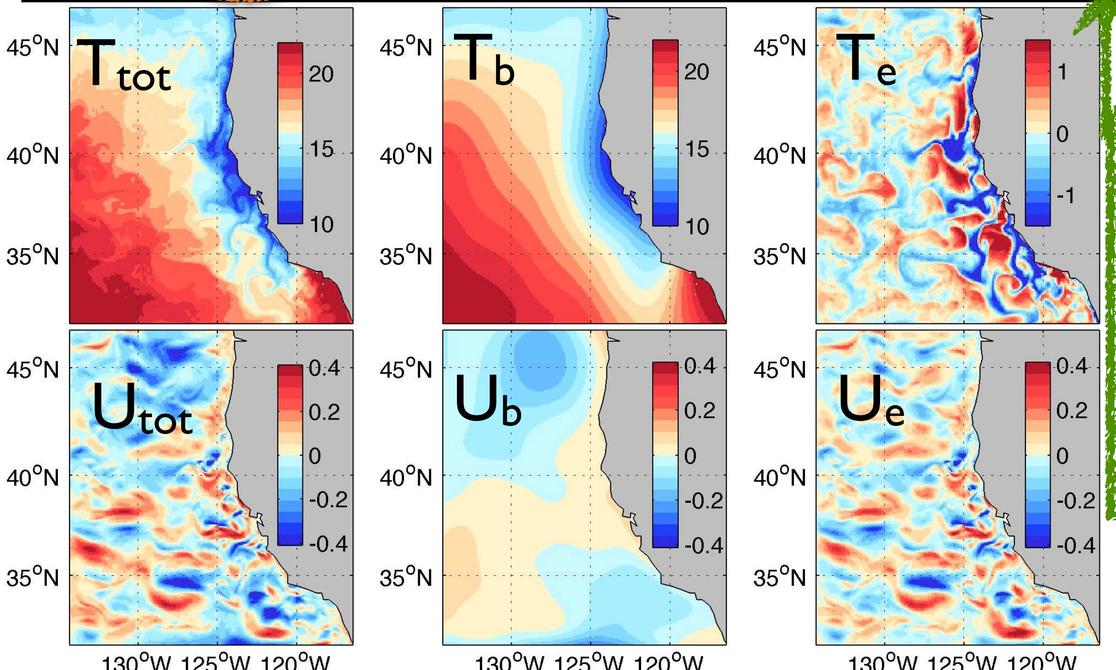


- WRF—ROMS coupling
- Identical 7 km O-A res.
- 6-yr simulations: 2005-2010

CTL-noT_e: effect of T_e

CTL-noU_e: effect of U_e

$$\tau=\rho C_D(U_a-U_o)|U_a-U_o|$$

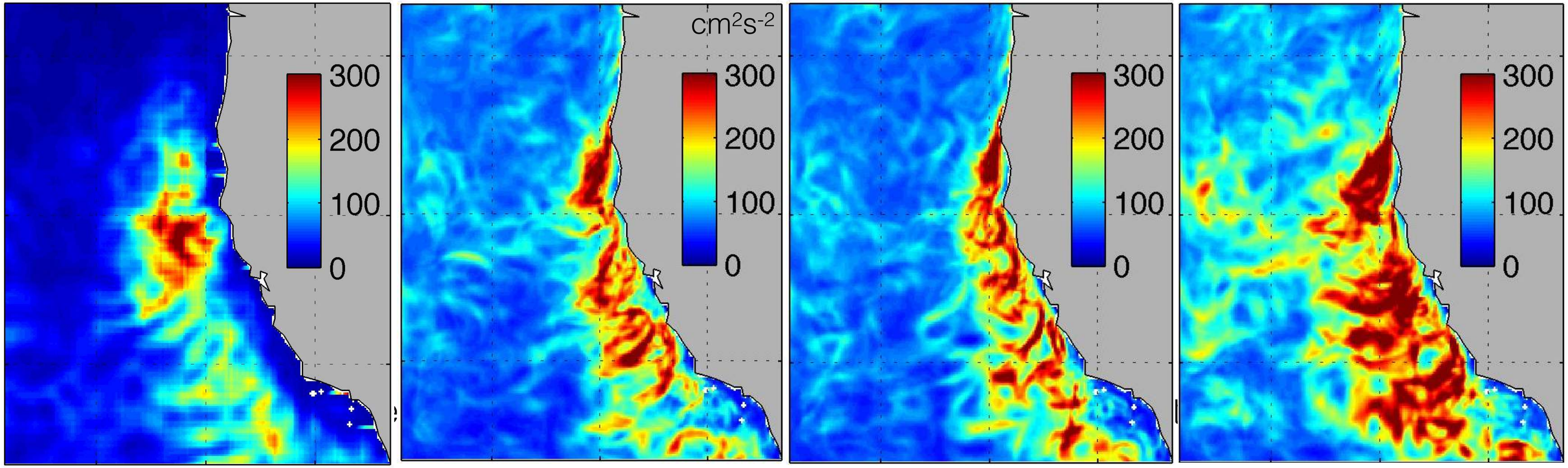


2-D loess spatial smoothing (3°×3°)

Exp	τ formulation includes			
CTL	T_b	T_e	U_b	U_e
noT_e	T_b	~~T_e~~	U_b	U_e
noU_e	T_b	T_e	U_b	~~U_e~~

Weakened summertime eddy kinetic energy
with eddy-wind interaction

AVISO EKE (cm^2s^{-2}) **CTL:** T_e & U_e **noT_e** **noU_e**



- Te has no impact on EKE
- 42% weaker EKE with Ue

JAS 2005-2010

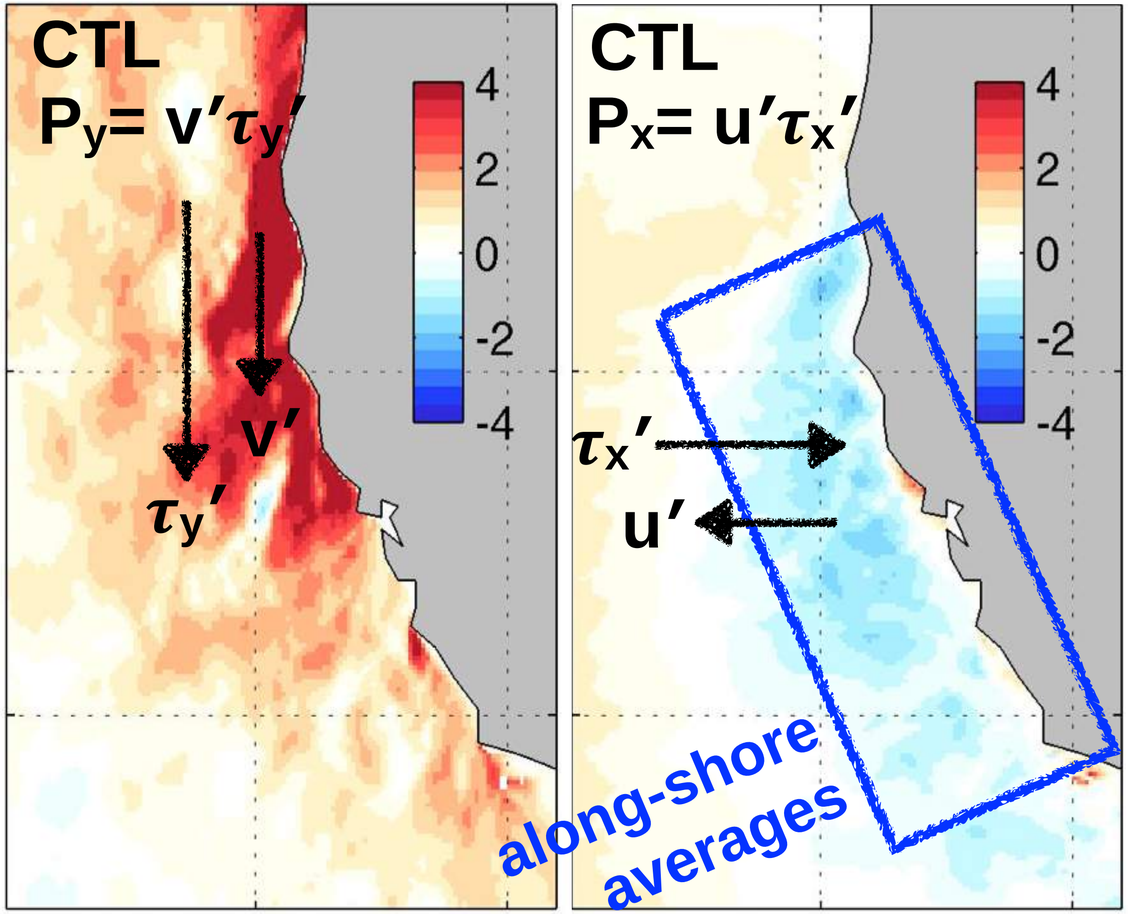
Reduced EKE due to <u>reduced wind work</u> and <u>enhanced eddy drag</u>

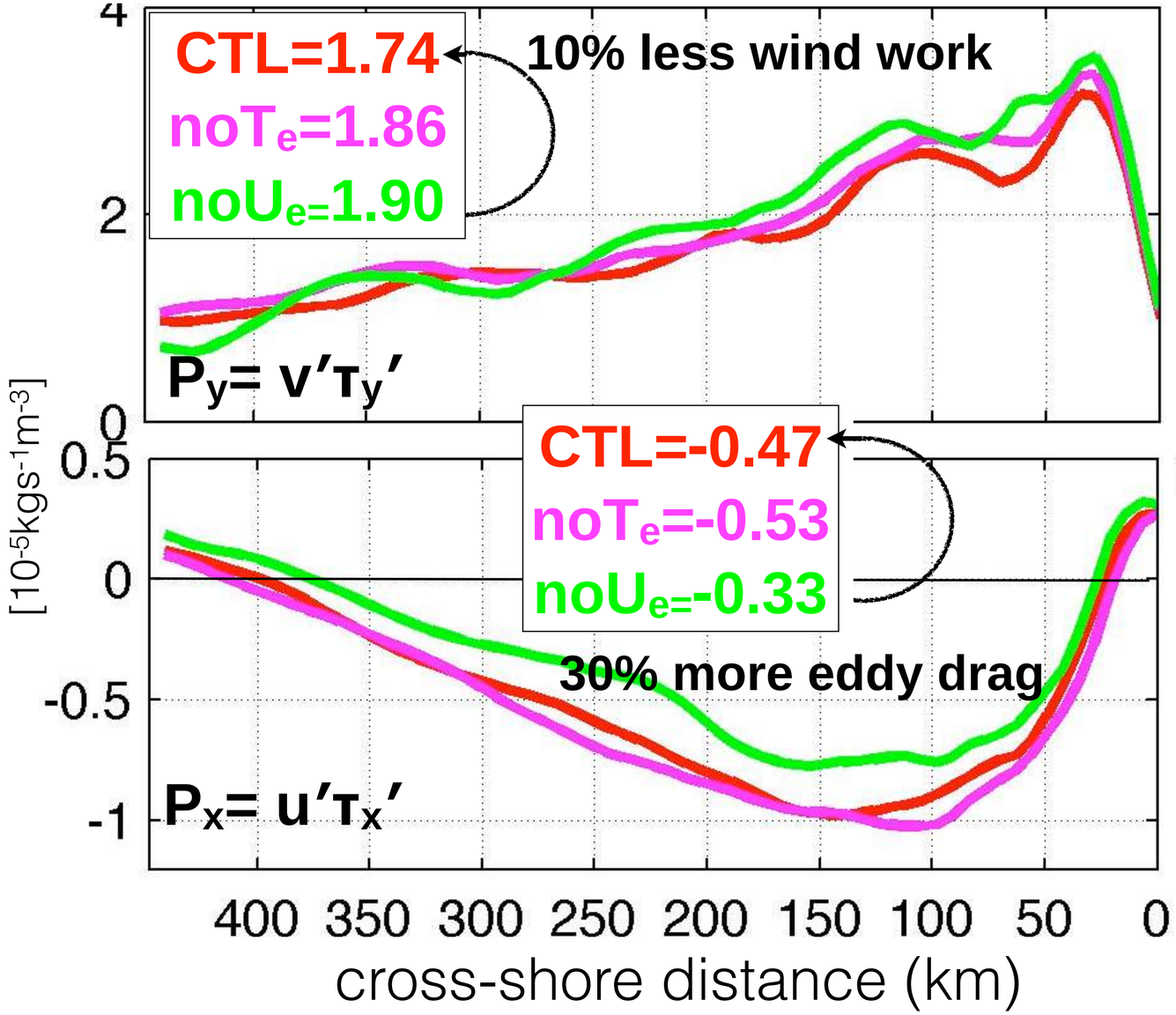
dominant EKE terms

$$P = \frac{1}{\rho_0}\left(\overline{u'\tau'_x} + \overline{v'\tau'_y}\right)$$

v'$\boldsymbol{\tau}_y$: Wind work (P)

$u'\boldsymbol{\tau}_x$: Eddy drag (ε)





Eddy-driven Ekman pumping velocity

$$W_{tot} = \frac{1}{\rho_o}\nabla \times \left(\frac{\boldsymbol{\tau}}{(f+\zeta)}\right)$$

Stern 1965
Gaube et al. 2015

$$= \underbrace{\frac{\bar{\nabla} \times \tilde{\boldsymbol{\tau}}}{\rho_o (f+\zeta)}}_{W_{LIN}} \underbrace{- \frac{1}{\rho_o (f+\zeta)^2}\left(\tilde{\tau}^y \frac{\partial \zeta}{\partial x} - \tilde{\tau}^x \frac{\partial \zeta}{\partial y}\right)}_{W_\zeta} + \underbrace{\frac{\nabla \times \boldsymbol{\tau}'_{SST}}{\rho_o (f+\zeta)}}_{W_{SST}}.$$

W_{LIN}

Curl-induced linear Ekman pumping

W_ζ

Surface vorticity gradient-induced nonlinear Ekman pumping

W_{SST}

SST induced Ekman pumping (Chelton et al. 2007)

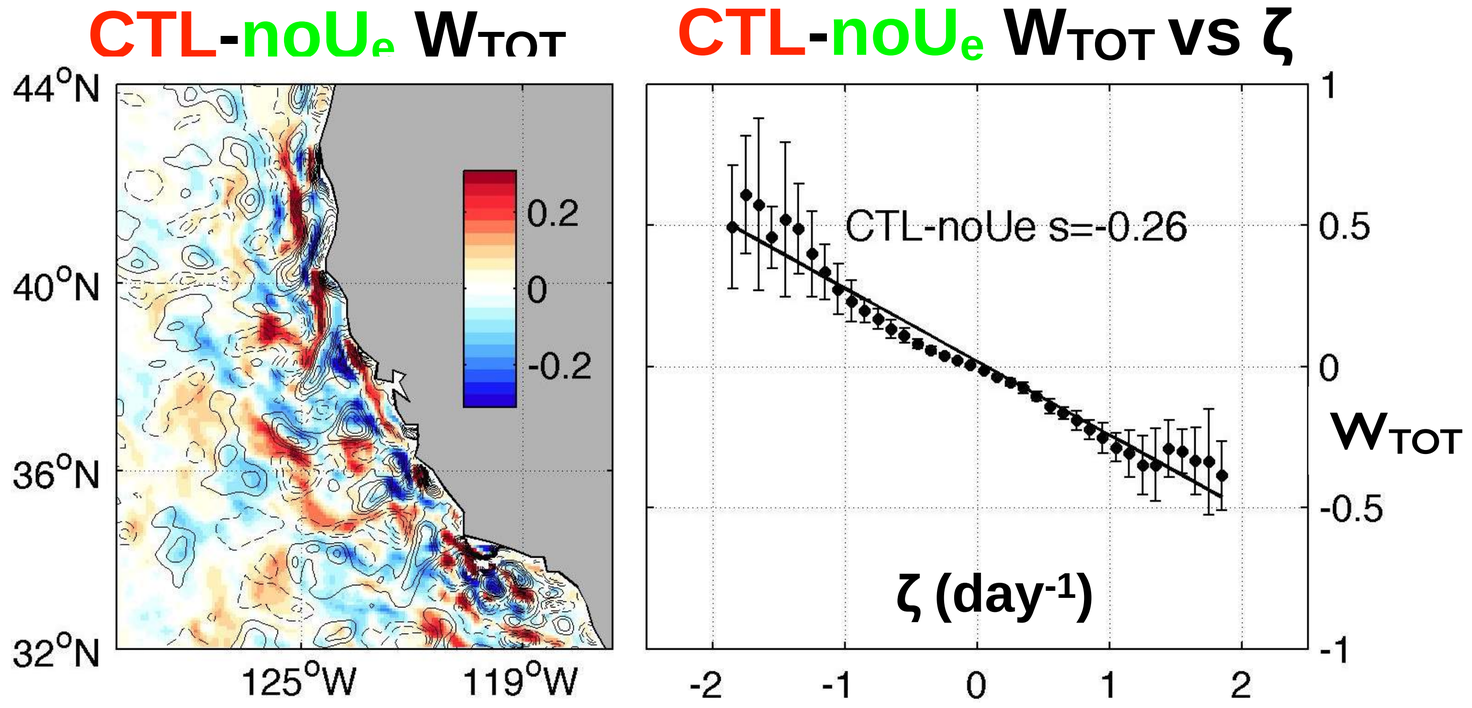
Feedback to eddy activities

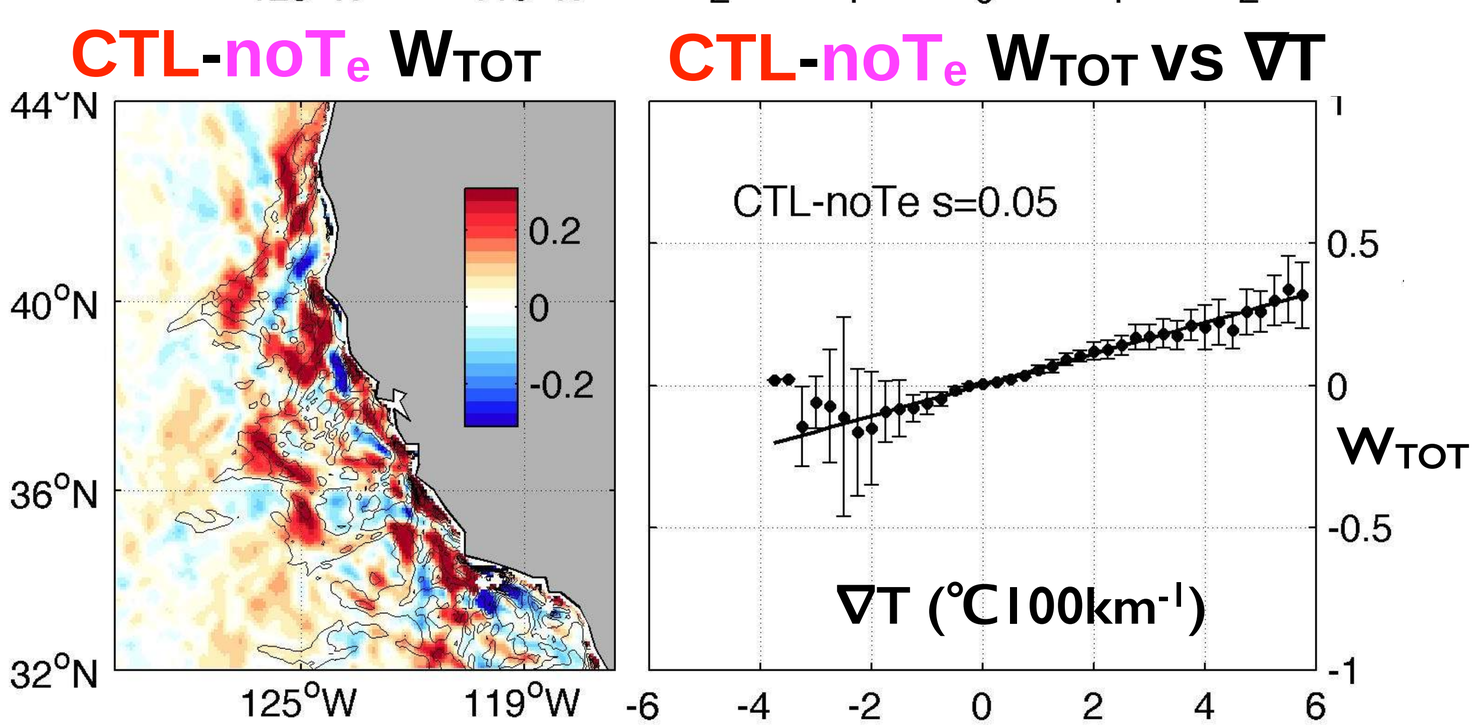
Mean difference in total W

Weakens the amplitude

Influences the propagation

JAS 2005-2010





Summary and Discussion

A surprisingly strong role of eddy-driven air-sea interaction through the surface current!

- The weakened EKE due to
  - Reduced wind momentum input
  - Enhanced eddy drag
- Eddies modify Ekman vertical velocities
  - W_ζ suppresses the eddy activity
  - W_{SST} influences the eddy propagation
- Expect strong impacts on the air-sea process and storm tracks in the WBC

Thanks!

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