PS52A-06

Coupled Ocean-Atmosphere Interactions over Oceanic Boundary Currents

wind

Impact of ocean eddy-forced wind stress variability

California Current System (Seo et al. 2016, JPO)
Somali Current (Seo 2017, JCLI)
East India Coastal Current (Seo et al. 2019, DSR-II)

Hyodae Seo, WHOI
(hseo@whoi.edu)

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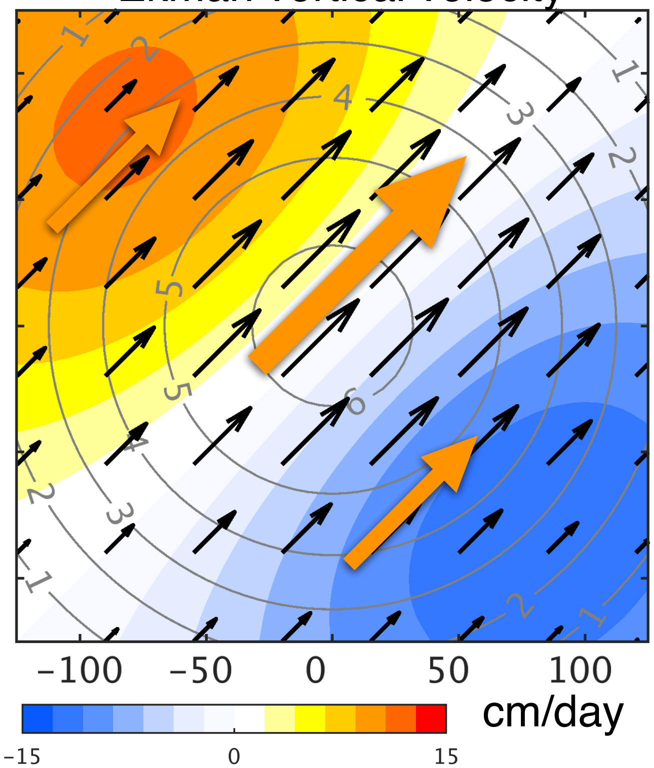
Two ways an ocean eddy influences wind stress

$$\tau = \rho_a C_D (W - U)^2$$

$W = \underline{W} + W'$ $U = \underline{U} + U'$

SST-wind coupling

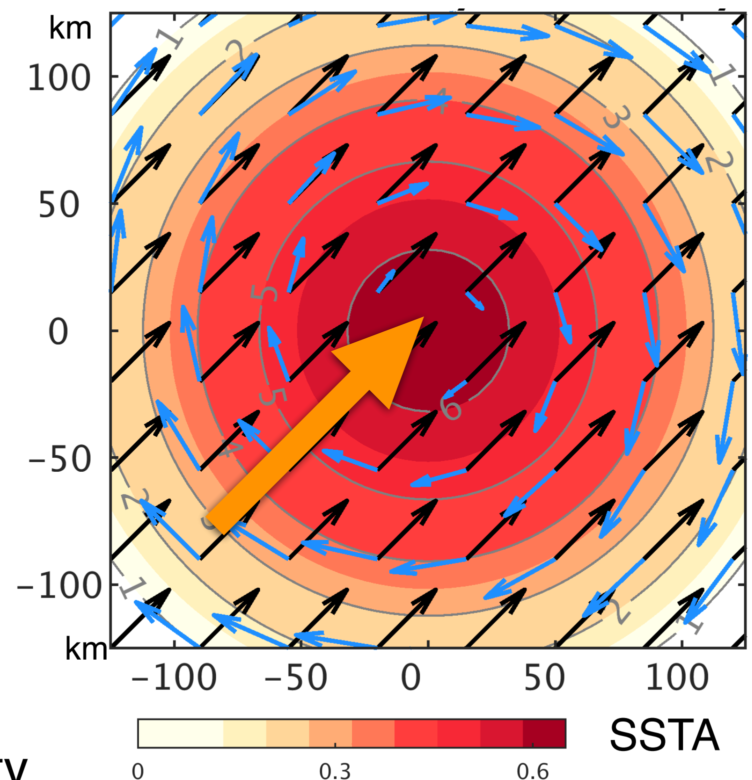
Ekman vertical velocity



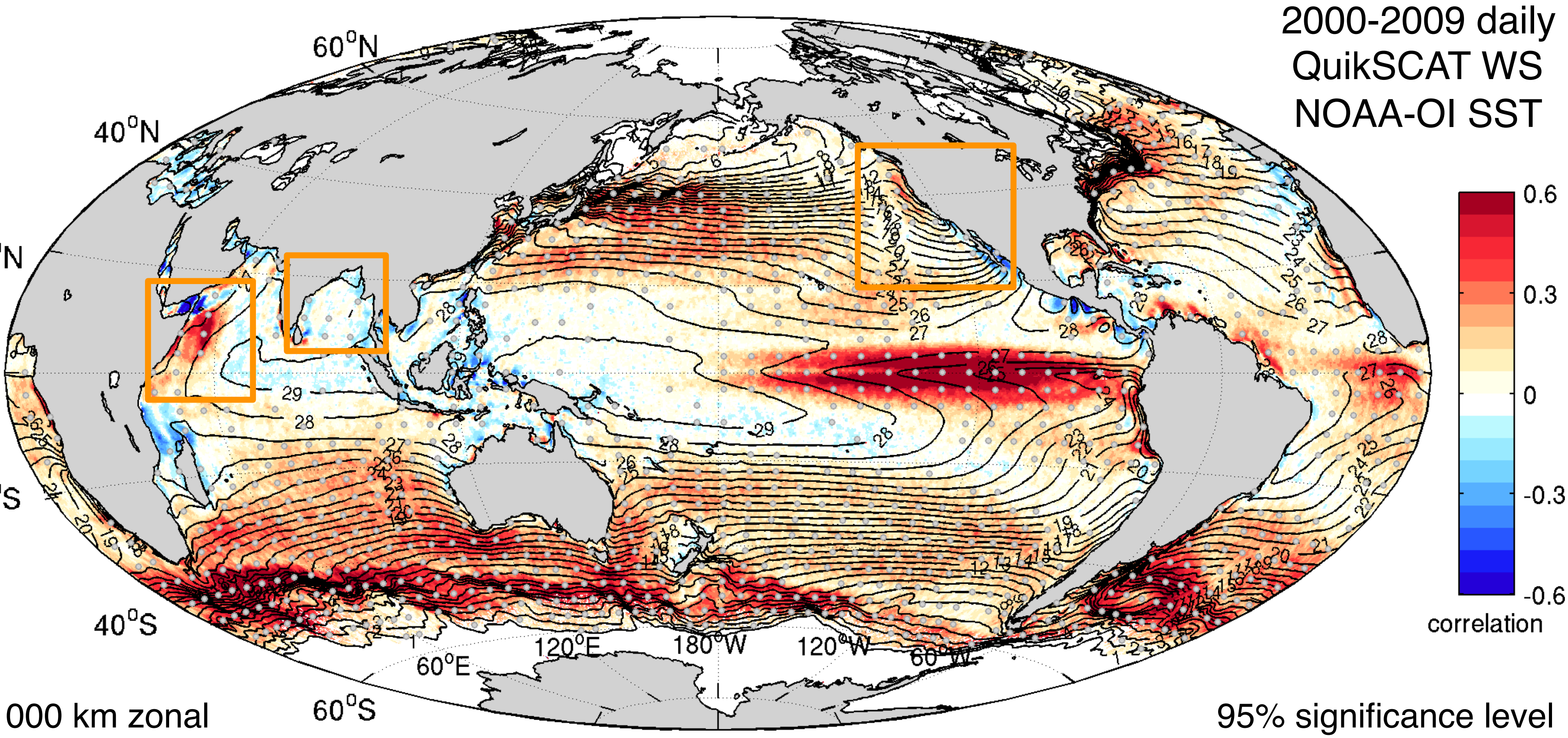
No net effect on eddy intensity but shifts the position

Gaussian warm-core eddy

SSTA=0.63C, u_g=0.13m/s, wind=7m/s



Correlation bet'n high-pass filtered wind speed and SST



1000 km zonal
highpass filter

95% significance level
Seo 2017

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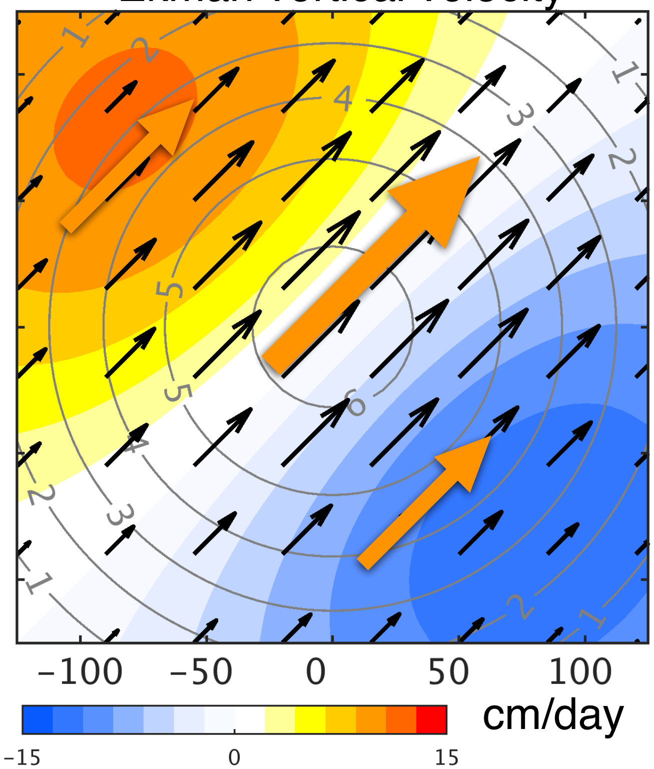

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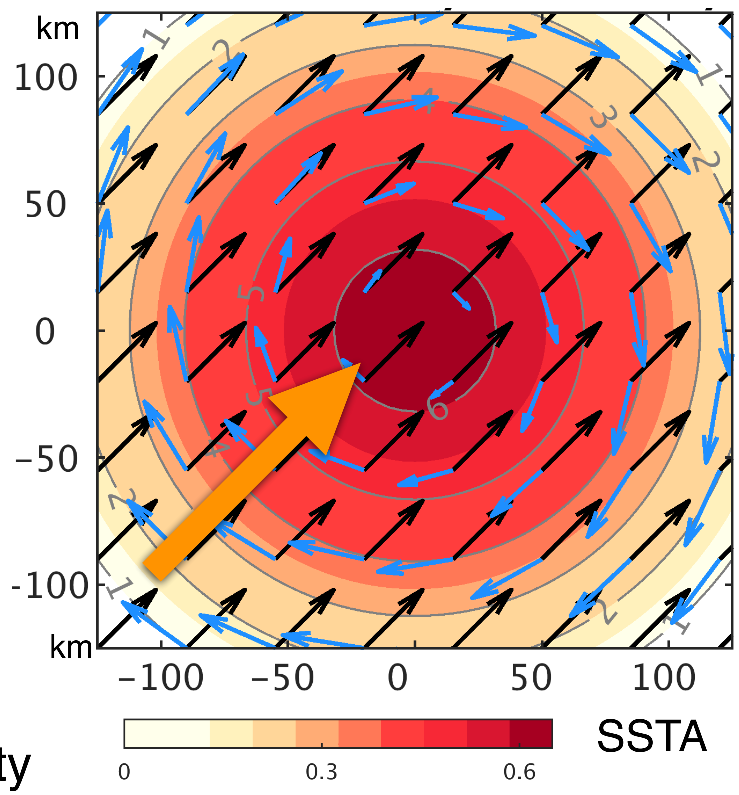
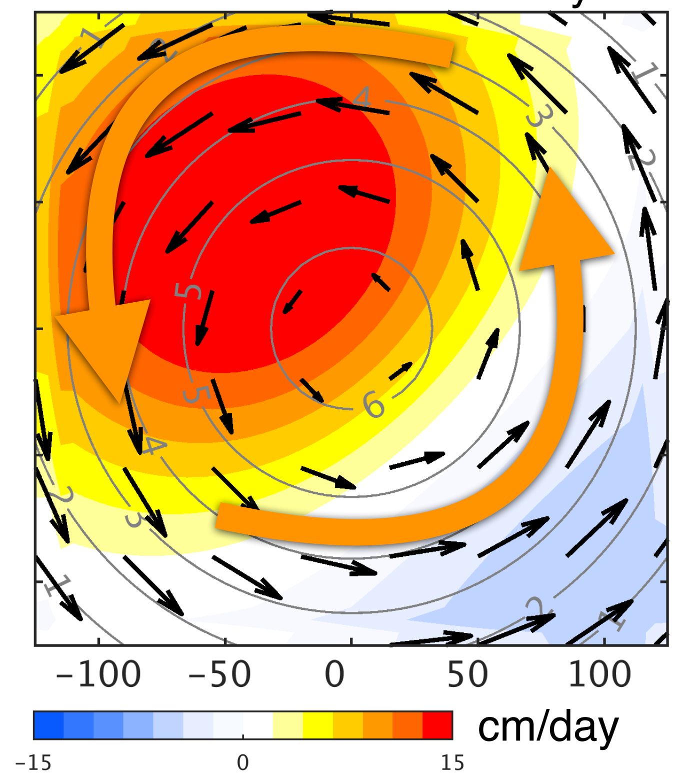


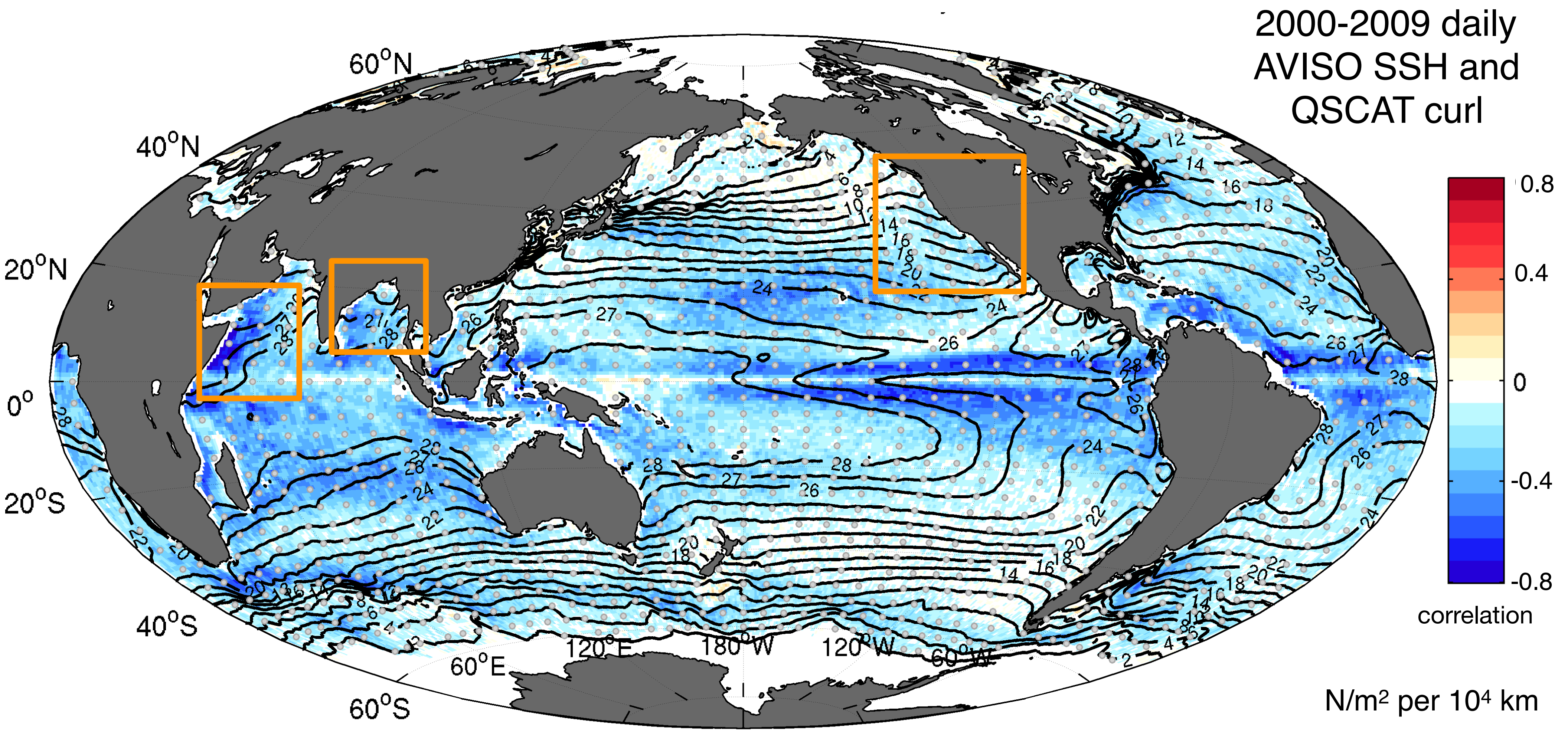
Current-wind coupling

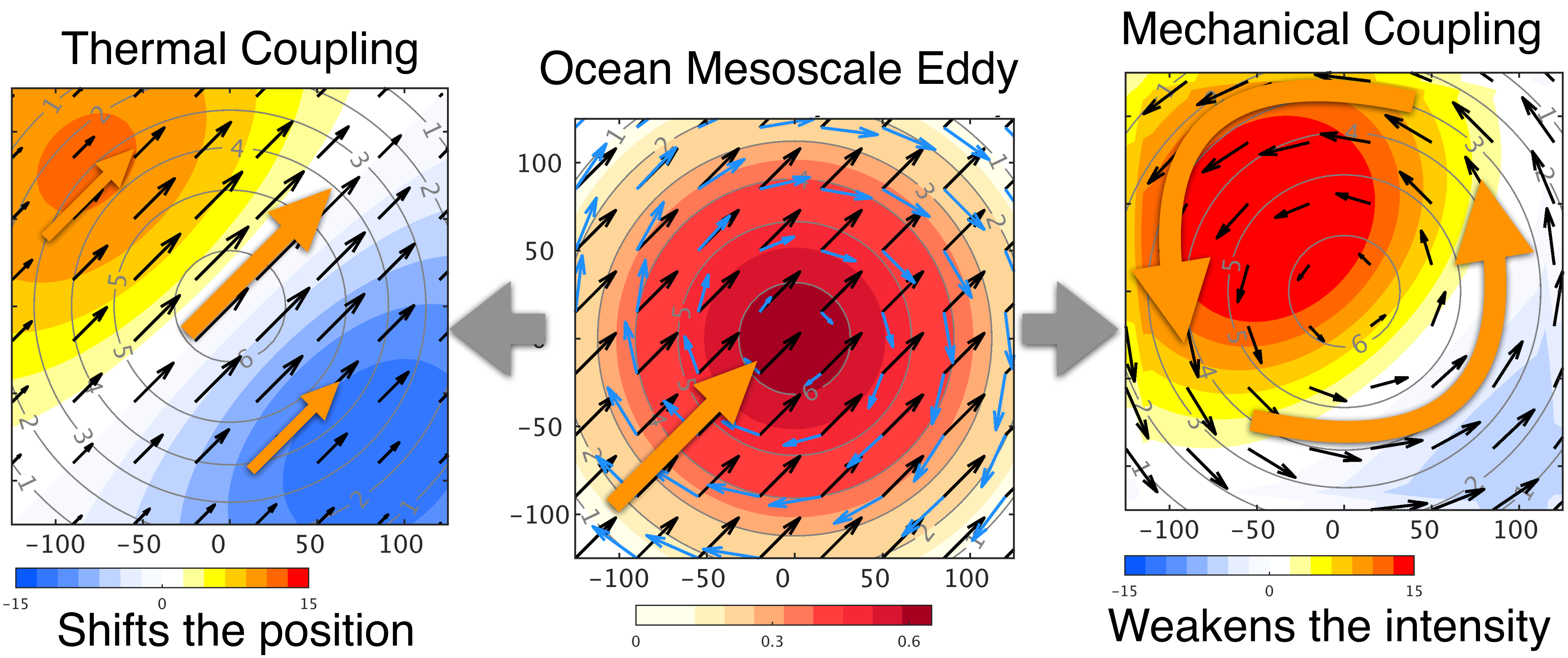
Ekman vertical velocity



Reduces the eddy activity and increases the stratification

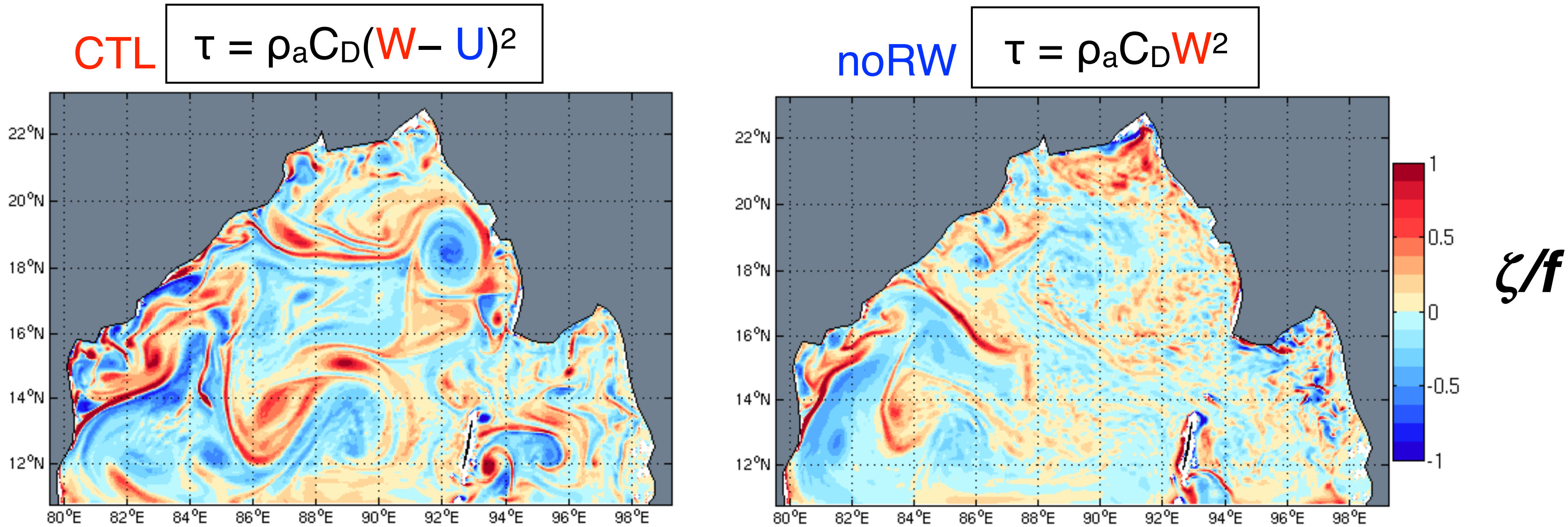
Correlation bet'n **relative vorticity** and **wind stress curl**



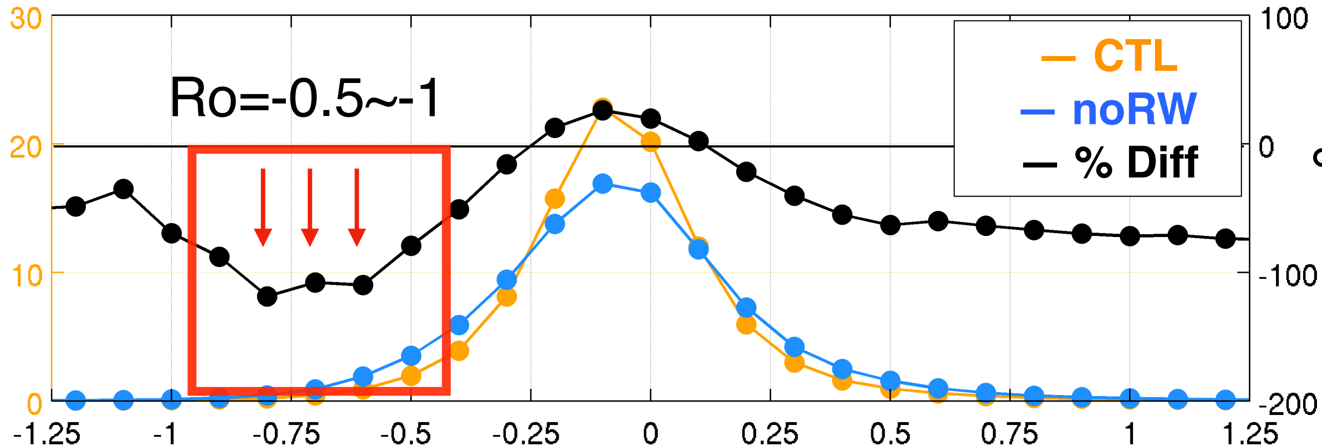


Can we quantify these two distinctive coupled effects on the ocean boundary currents and atmosphere?

Effect of ***total*** ocean currents on stability of flows: Well-known

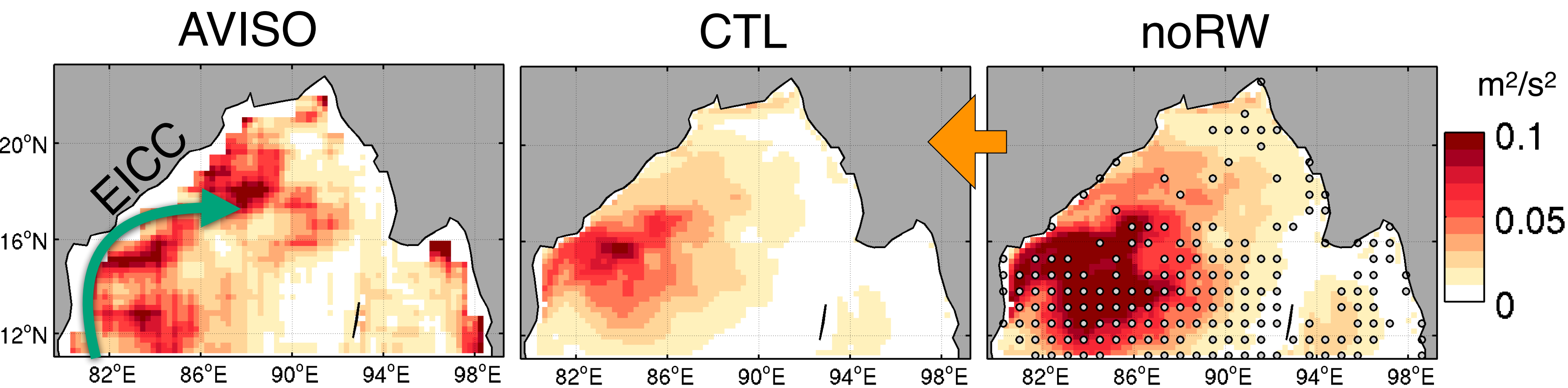


Histogram of Rossby number

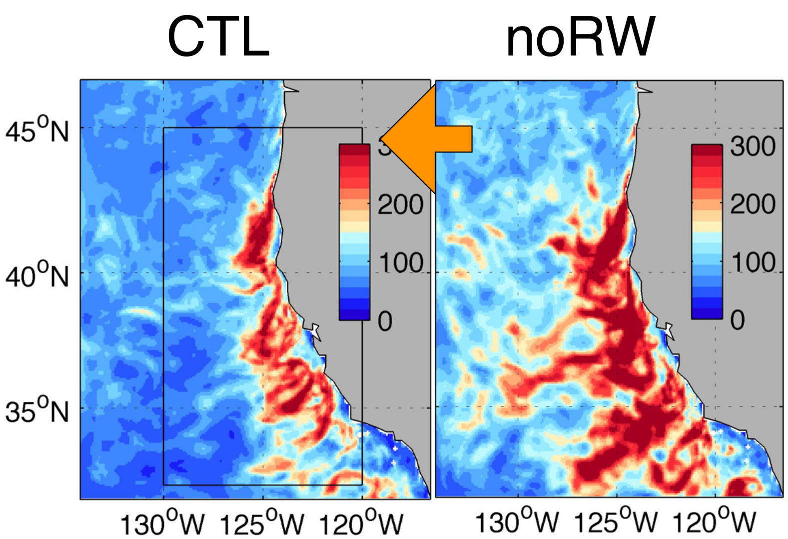


Seo et al. 2019

With the RW effect, depth-integrated EKE is reduced.

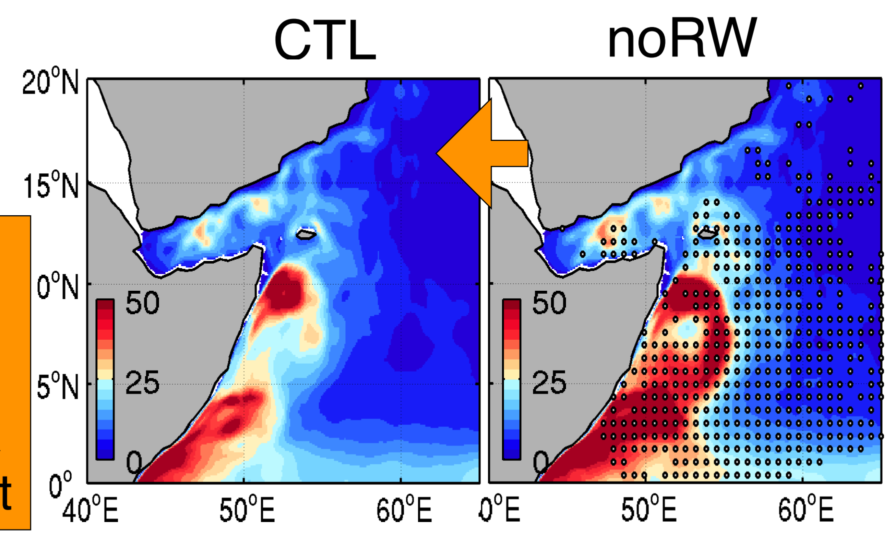


Reduction nearly by 100%

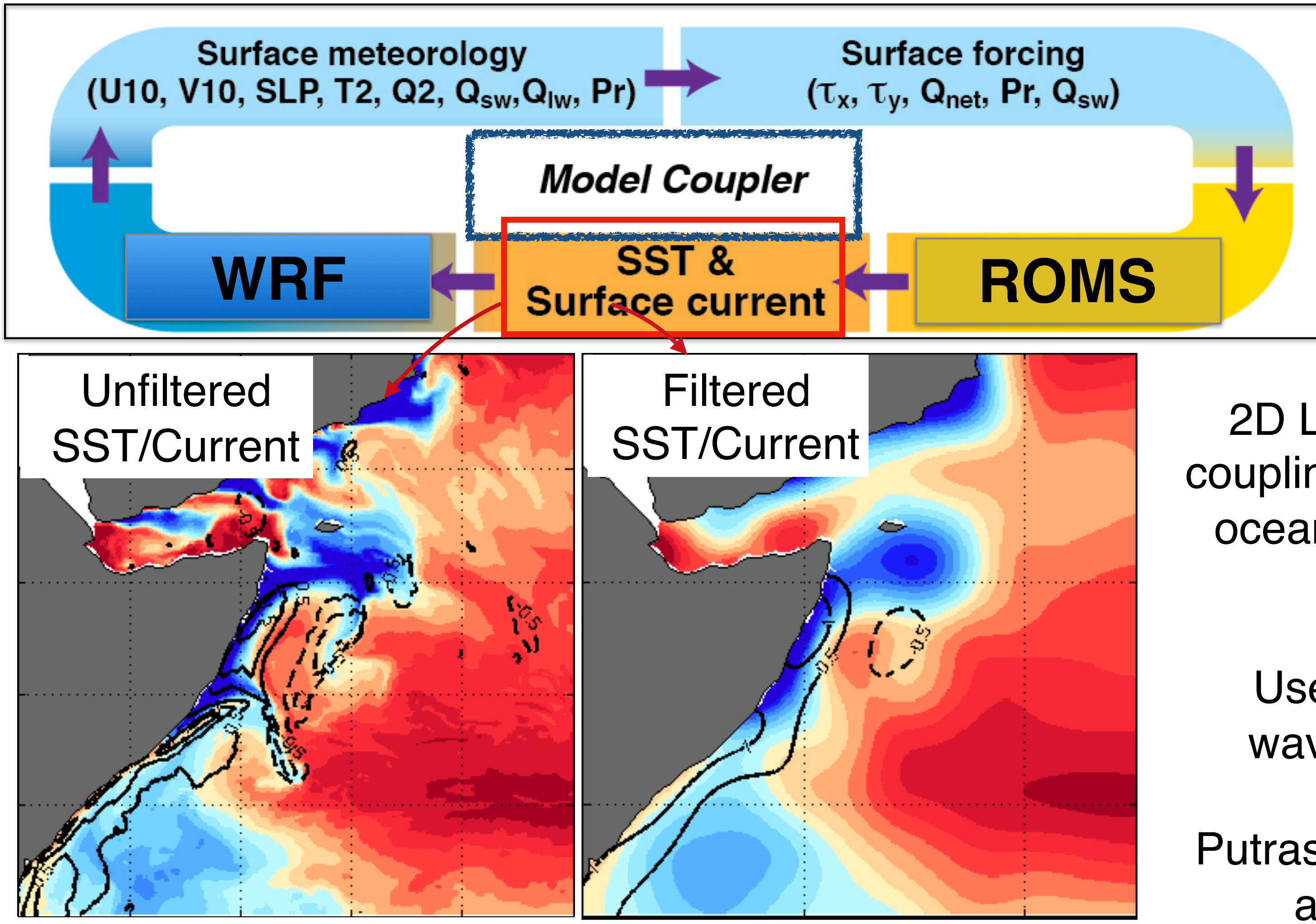


CCS 53%
SC: 26%

EKE damping largely due to reduction in eddy wind work in the KE budget



Testing the effect of *"eddy-mediated"* air-sea coupling in a coupled model



with an online eddy filtering

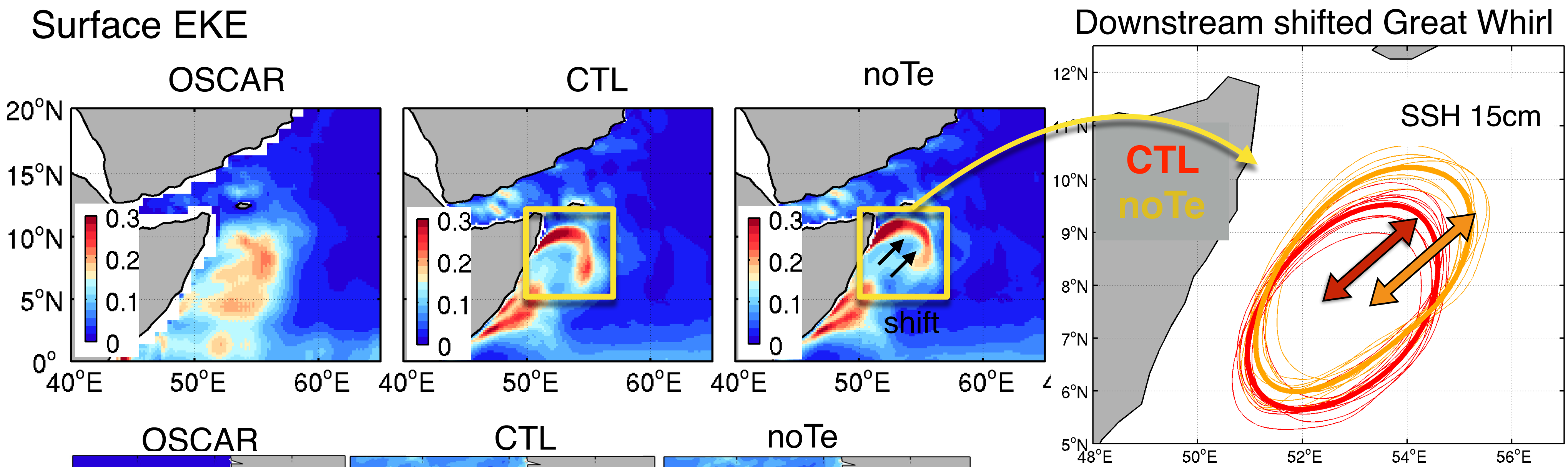
http://hseo.whoi.edu/scoar/
Seo et al. (2007; 2014; 2016)

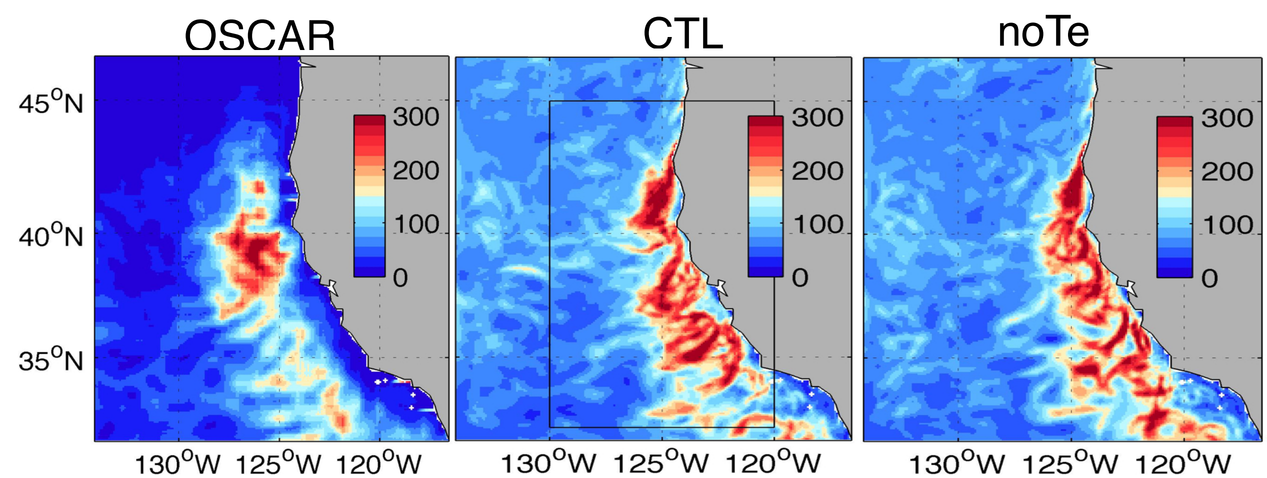
2D Loess smoothing at each coupling to remove the fine-scale ocean variability "seen" by the atmosphere.

Use half-power filter cutoff wavelength of **300-500 km**

Putrasahan et al. (2013); Seo et al. (2016); Seo (2017)

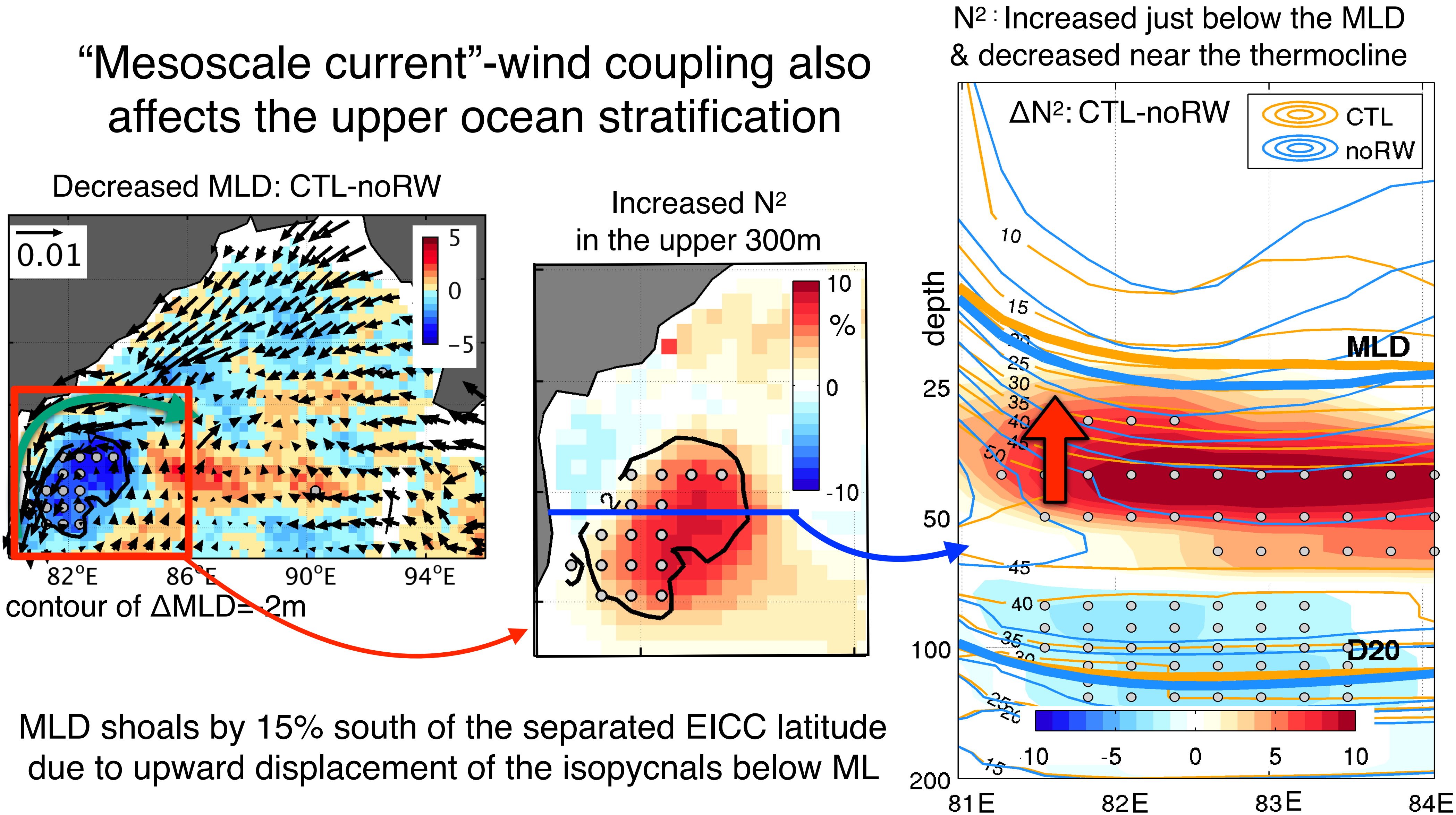
Impact of “mesoscale SST”-wind coupling





- Mesoscale SST-wind coupling shift the position of the eddy fields, with no apparent difference in intensity.

"Mesoscale current"-wind coupling also affects the upper ocean stratification



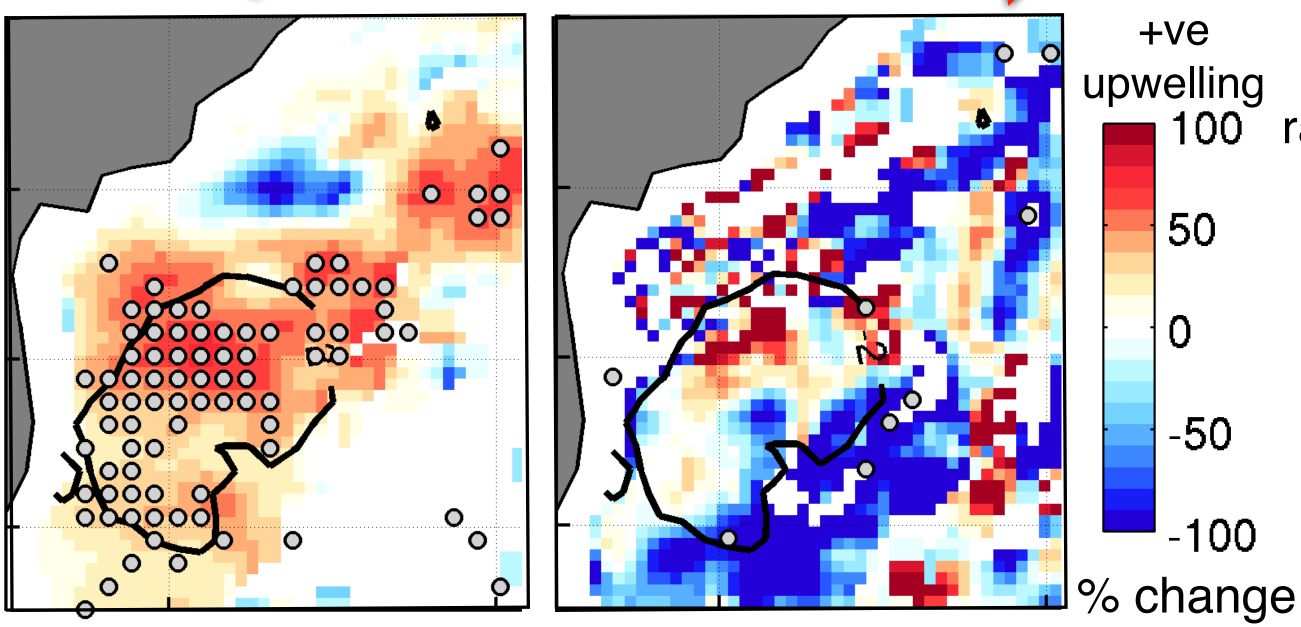
MLD shoals by 15% south of the separated EICC latitude due to upward displacement of the isopycnals below ML

Why upward displaced isopycnals within the anticyclonic eddies?

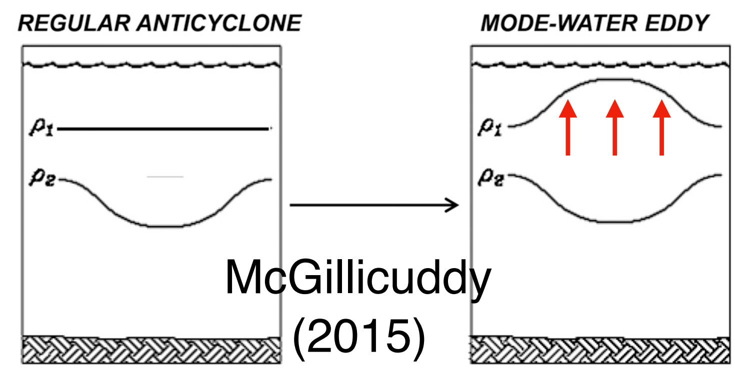
$$W_{tot} = \underbrace{\frac{\nabla \times \tau}{\rho_0 (f+\zeta)}}_{W_c} + \underbrace{\frac{1}{\rho_0 (f+\zeta)^2}\left(\tau_x \frac{\partial \zeta}{\partial y} - \tau_y \frac{\partial \zeta}{\partial x}\right)}_{W_\zeta} + \cancel{\underbrace{\frac{\beta \tau_x}{\rho_0 f^2}}_{W_\beta}} + \cancel{\underbrace{\alpha_T \nabla SST_C}_{W_{SST}}}$$

small

small in the BoB



Ekman upwelling induced by the mesoscale current-wind coupling raises the upper isopycnals under an anticyclonic eddy.



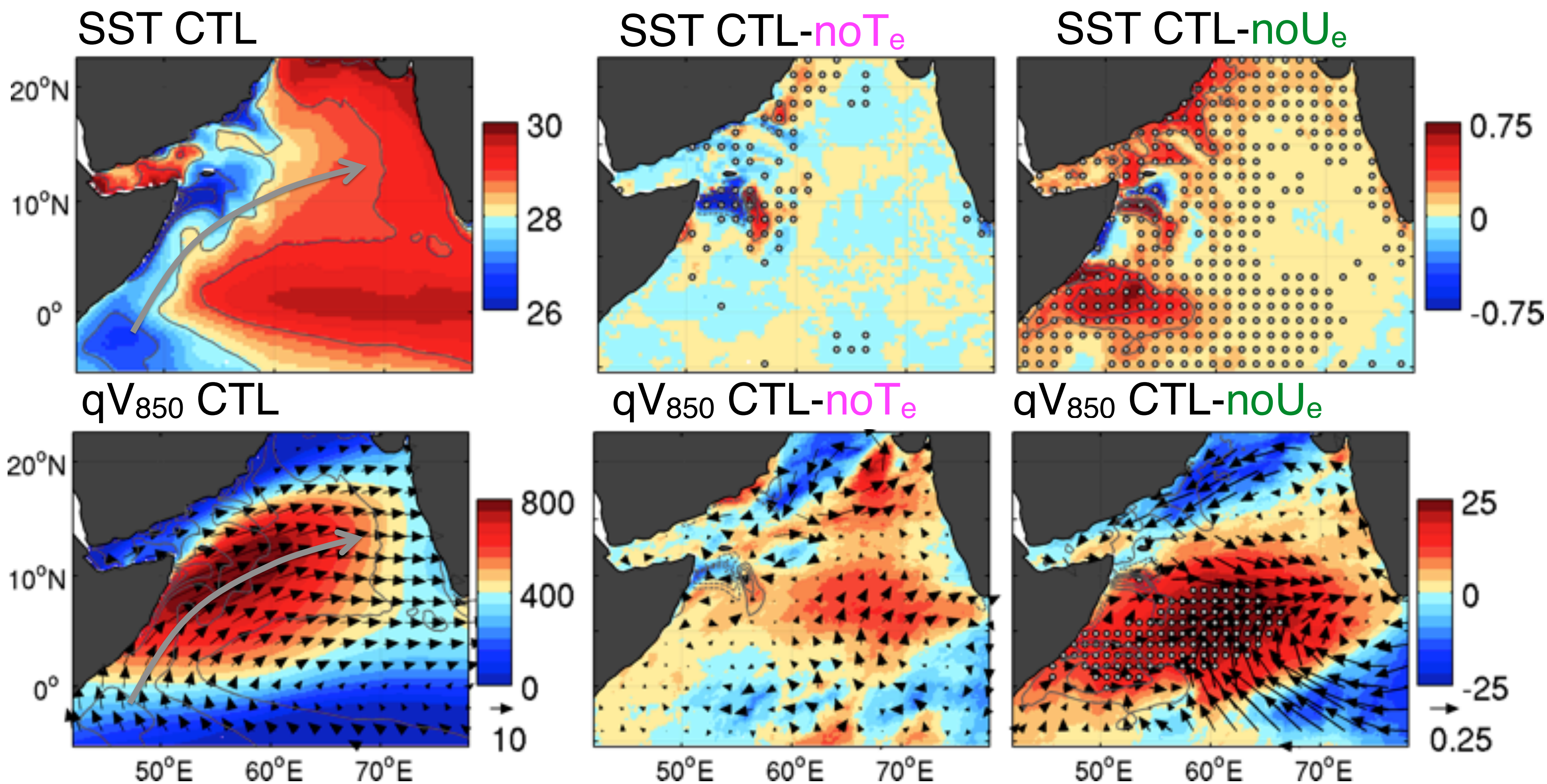
McGillicuddy (2015)

Summary

- Modulation of wind stress by mesoscale processes in the boundary current systems is recognized as a key player in the kinetic energy balance.
    - **Dependent on spatial scales**, strongest in the BoB at Ro~0.5 to 1.
- Mesoscale SST and current influence the wind stress different way, resulting in **distinct feedback impacts** on the oceans.
    - SST-wind affects the positions (GW shifted downstream, SC separation delayed)
    - Current-wind attenuates the intensity and increases the stratification under anticyclones.
- (not discussed today) Eddy-mediated air-sea coupling exerts **rectified effects** on ocean circulation/SST, inducing spatially coherent atmospheric responses.
    - Winter storminess and rainfall in the US West Coast (Seo et al. 2016)
    - Summer Monsoon Findlater Jet in the Arabian Sea (Seo 2017)

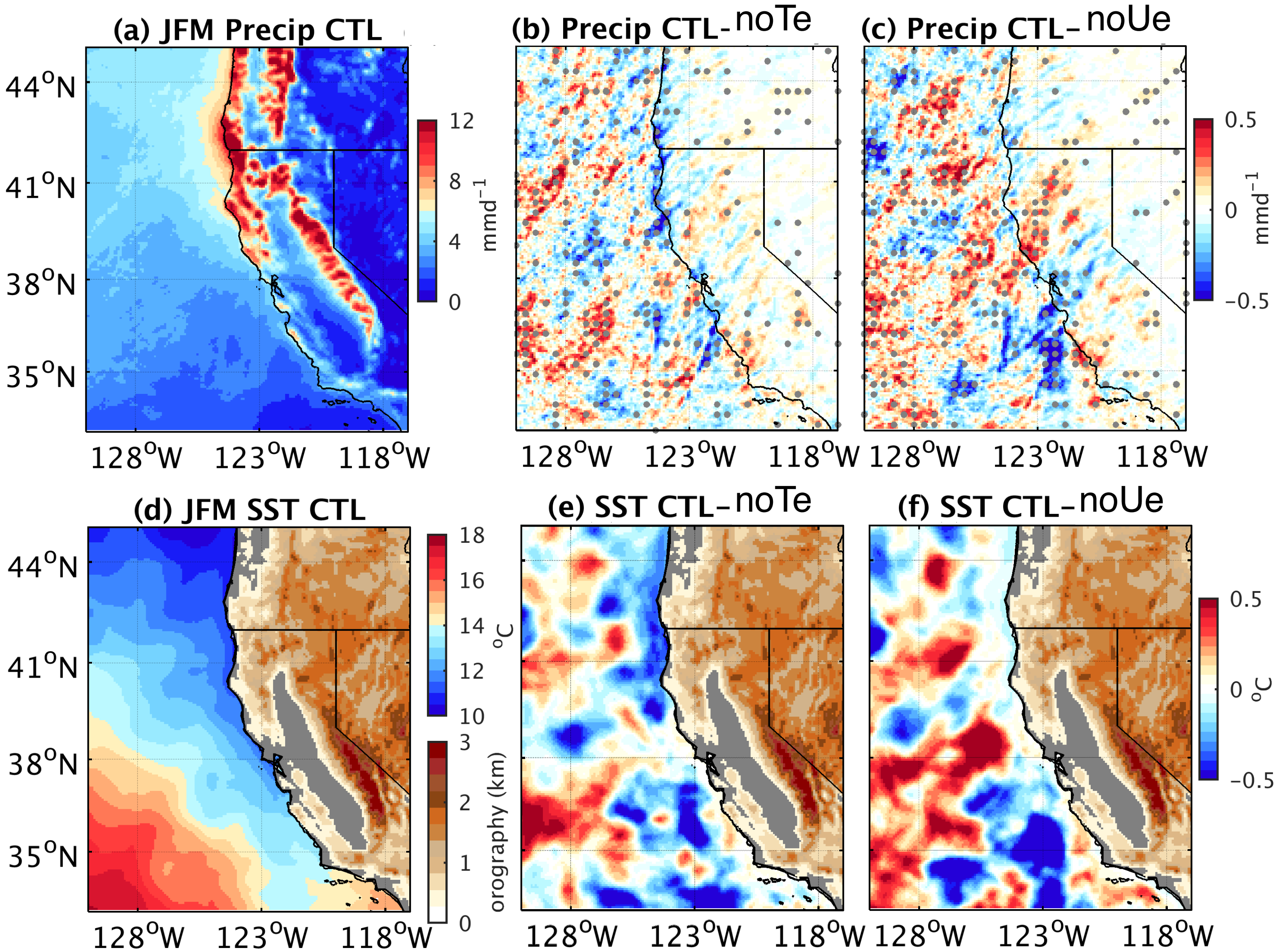
hseo@whoi.edu

Impact on the atmosphere? Yes, some downstream influence…



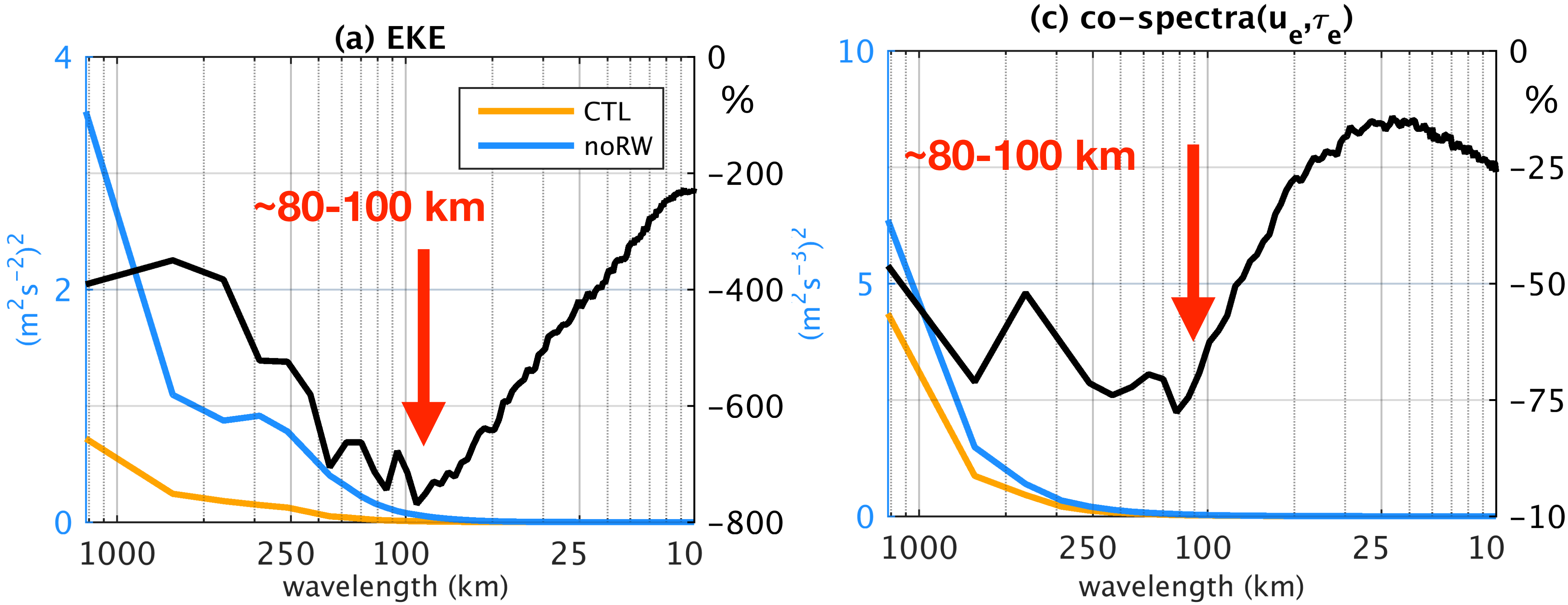
• Small (~5%) but significant changes in the axis of the FJ and the moisture transport

Impact on the atmosphere? Yes, some downstream influence.



- Some rectified effects on mean SST and rainfall; O(5%) changes to the mean.
- The spatial coherency between the offshore patterns and near-coastal patterns suggests a coastal land influence of the perturbed mean SST due to air-sea interaction.

EKE damping and scale dependence



Reduction of EKE and eddy wind work most effective at wavelengths of ~80-100 km, the 1st baroclinic Rossby deformation radius at 16N.