Coupled ocean-atmosphere interaction mediated by mesoscale SST and current: Distinctive impacts and scale dependence

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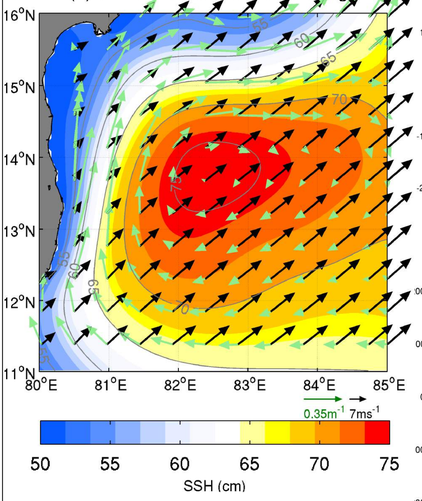
Objective: Energetic surface current and SST in the ocean mesoscales modulate the wind stress. Effects of the eddy-forced wind stress via the ocean current and SST are highly distinctive and scale-dependent. Our goal is to tease out and better understand the effects of the two coupled feedback effects and explore their scale dependence and impacts on mixed layer depth.

Introduction

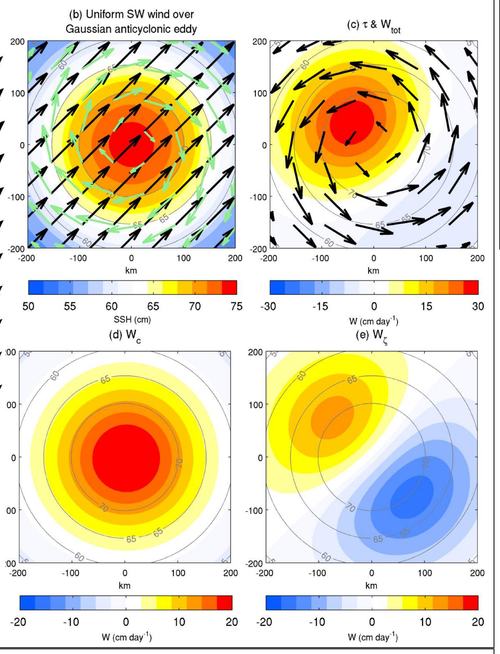
An anticyclonic warm-core eddy in the Bay of Bengal

(a) CTL SSH and Wind Climatology

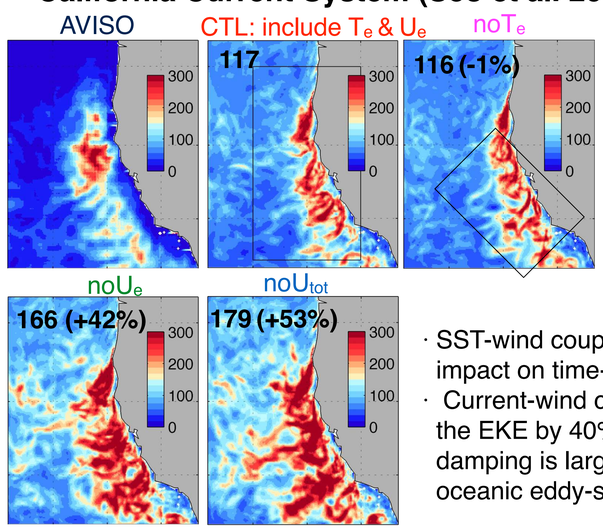


max U_g=0.27m/s A=25cm
wind=7m/s r_0=200km

Ekman pumping velocity over a gaussian warm-core eddy



California Current System (Seo et al. 2016, JPO)

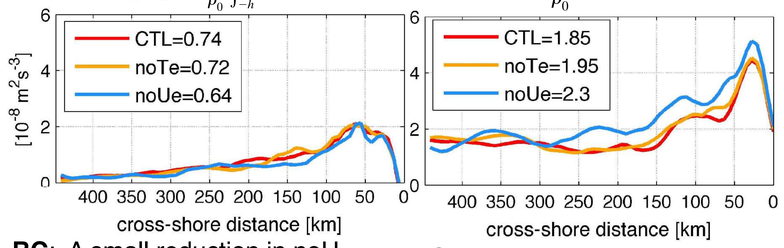


Summertime mean surface EKE (cm²/s²)

- SST-wind coupling has no impact on time-mean EKE
- Current-wind coupling reduces the EKE by 40% → EKE damping is largely at the oceanic eddy-scales.

Changes in energy conversion and source terms

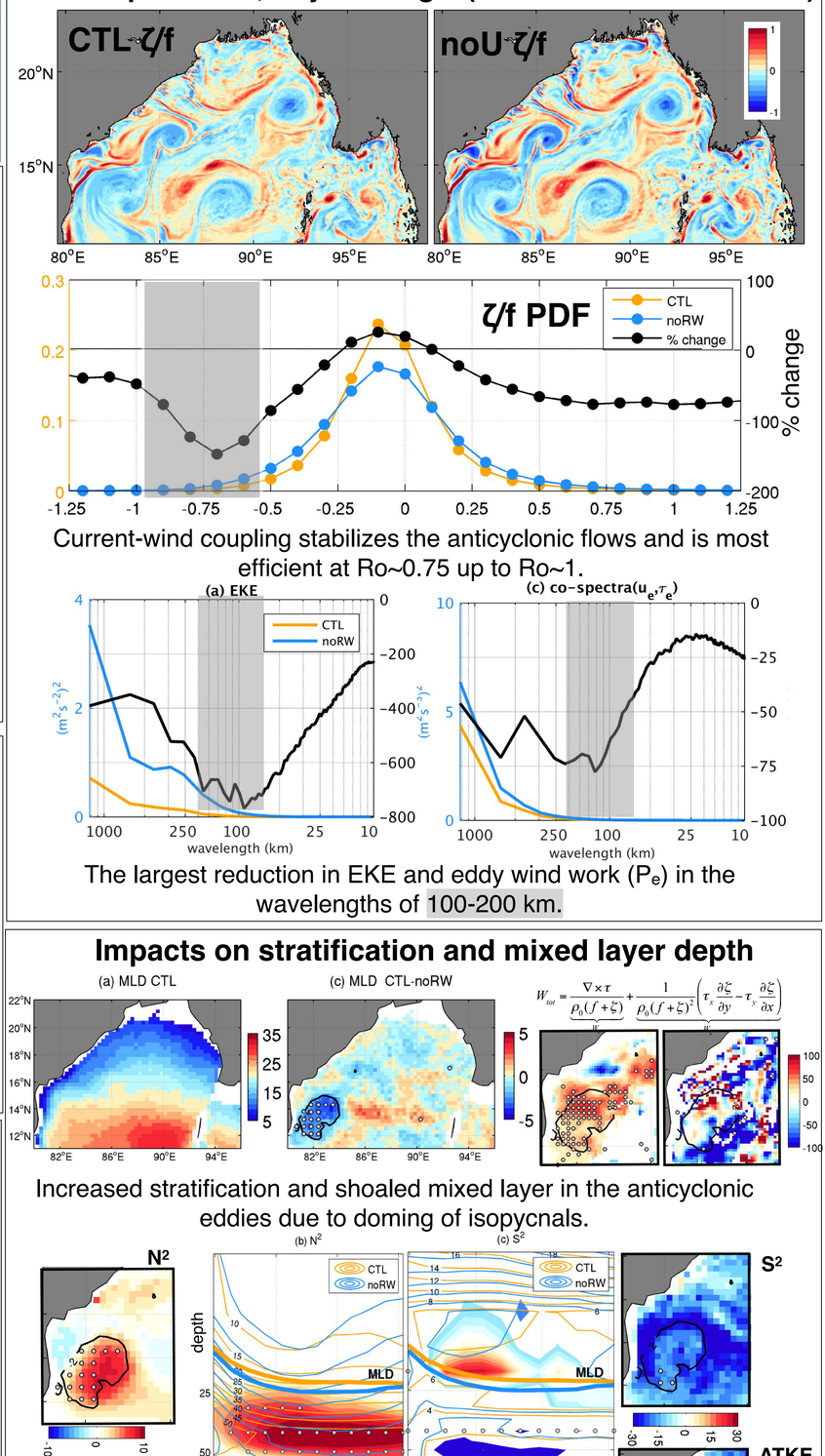
$$C_{\mathrm{PE}\to\mathrm{KE}} = -\frac{g}{\rho_0}\int_{-h}^{0}(\overline{\rho}\,\overline{w}+\overline{\rho' w'})\,dz, \qquad P = \frac{1}{\rho_0}(\overline{u'\tau_x'}+\overline{v'\tau_y'}).$$



BC: A small reduction in noU_e → Can't explain the higher EKE

Current-wind coupling reduces the eddy wind work

Scale dependence, Bay of Bengal (Seo et al. DSR Submitted)



Current-wind coupling stabilizes the anticyclonic flows and is most efficient at Ro~0.75 up to Ro~1.

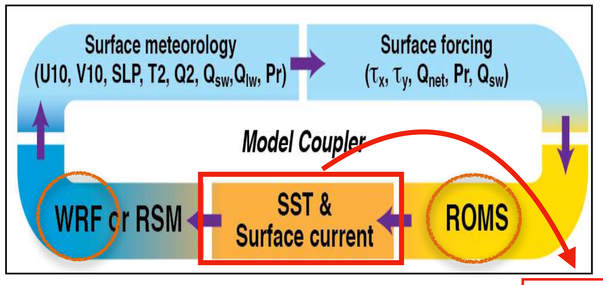
The largest reduction in EKE and eddy wind work (P_e) in the wavelengths of 100-200 km.

Impacts on stratification and mixed layer depth

Increased stratification and shoaled mixed layer in the anticyclonic eddies due to doming of isopycnals.

Approach: Scripps Coupled Ocean-Atmosphere Regional (SCOAR, WRF-ROMS) with an online 2-D smoothing (Seo et al. 2007; 2014)

SCOAR Model

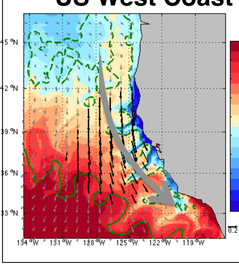


Experiments

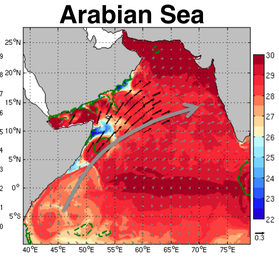
$\tau = \rho_a C_D (W - U)^2$

	τ formulation			
	T_b	T_e	U_b	U_e
CTL	Y	Y	Y	Y
noT_e	Y	N	Y	Y
noU_e	Y	Y	Y	N
noU_{tot}	Y	Y	N	N

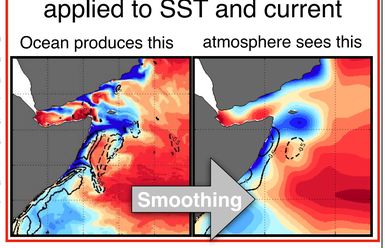
US West Coast



Arabian Sea

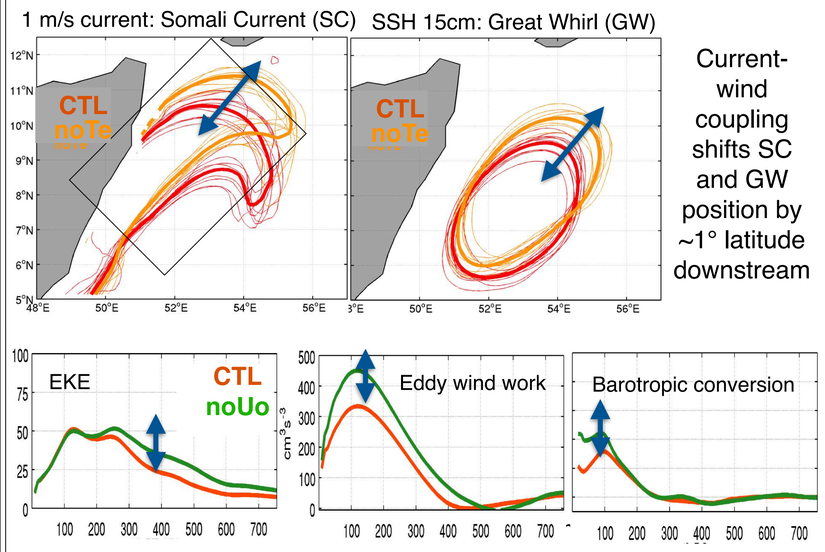


online 2-D smoothing applied to SST and current



Somali Current (Seo 2017, JCLI)

Confirming two distinct influences of air-sea coupling



Current-wind coupling shifts SC and GW position by ~1° latitude downstream

Current-wind coupling reduces the wind work and (also BT near coast) and EKE.

Summary: SST-wind coupling shifts the eddy fields while current-wind coupling damps the eddy activity. This damping effect is most effective on length scales equivalent to the first baroclinic Rossby deformation radius but also touches the oceanic submesoscale regime of Ro~O(1). In the anticyclonic regime, current-induced Ekman pumping increases the upper ocean stratification, shoaling the mixed layer depth.