Coupled modeling of mesoscale dynamics and air-sea interaction in the Arabian Sea
—*Eddy-driven air-sea interaction and feedback*

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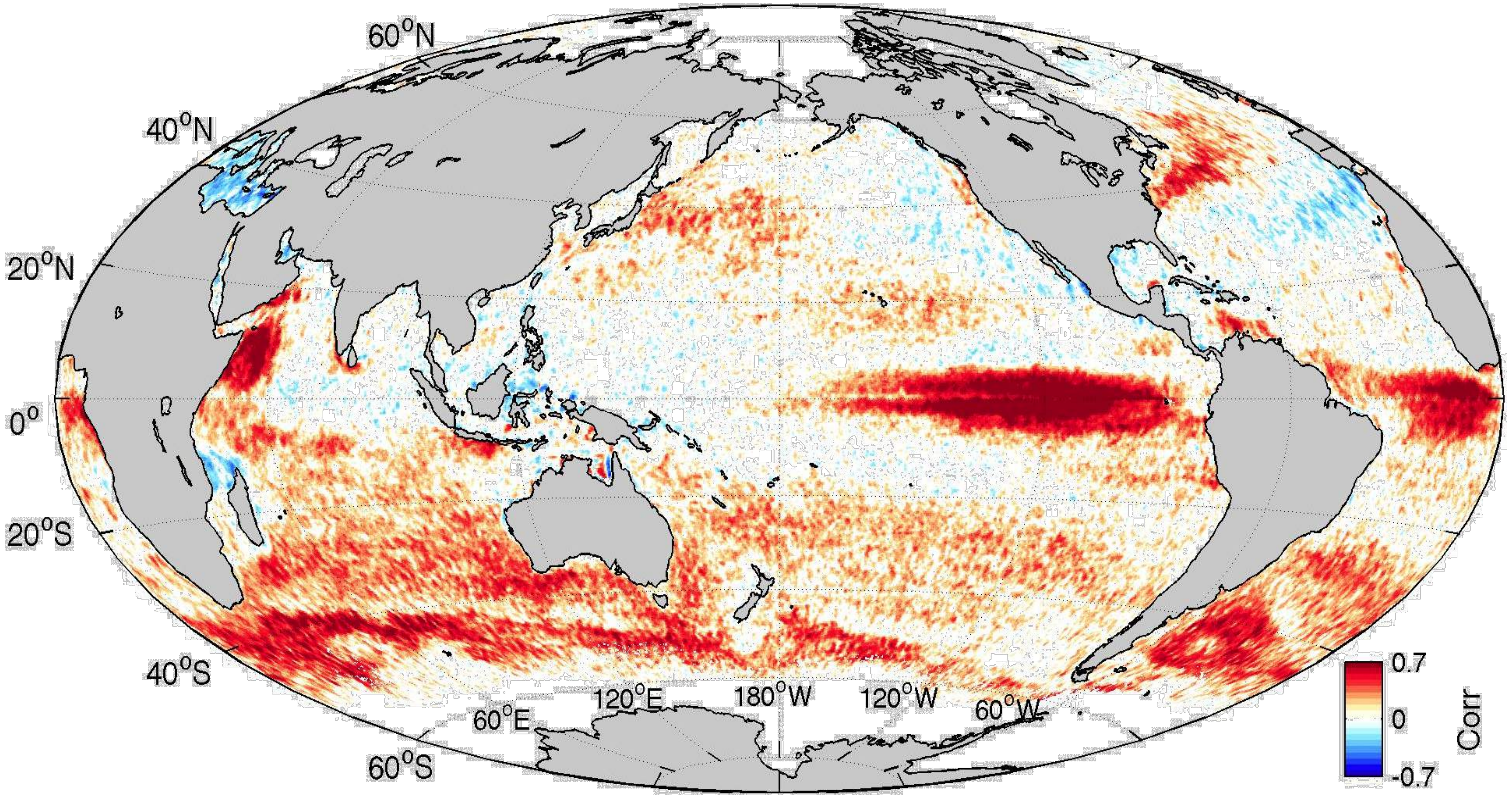
Eddy-driven air-sea interaction through SST and surface current

Correlation bet'n high-passed (<10° lon)
SST & WS in boreal summer based on satellite data

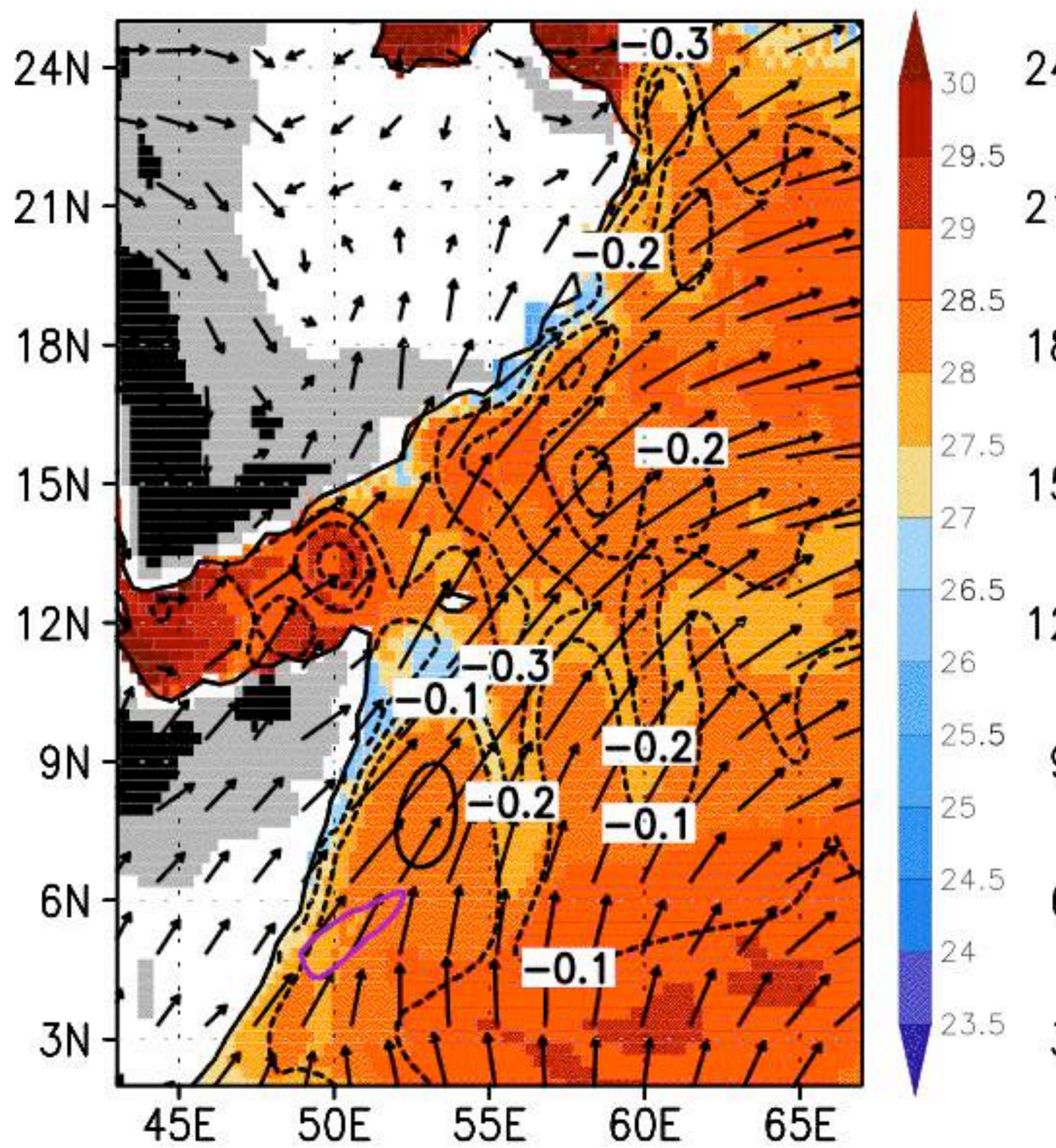


Seo et al. 2008: *Ocean Modell*. Modeling of Mesoscale Coupled Ocean-Atmosphere Interaction and its Feedback to Ocean in the Western Arabian Sea.

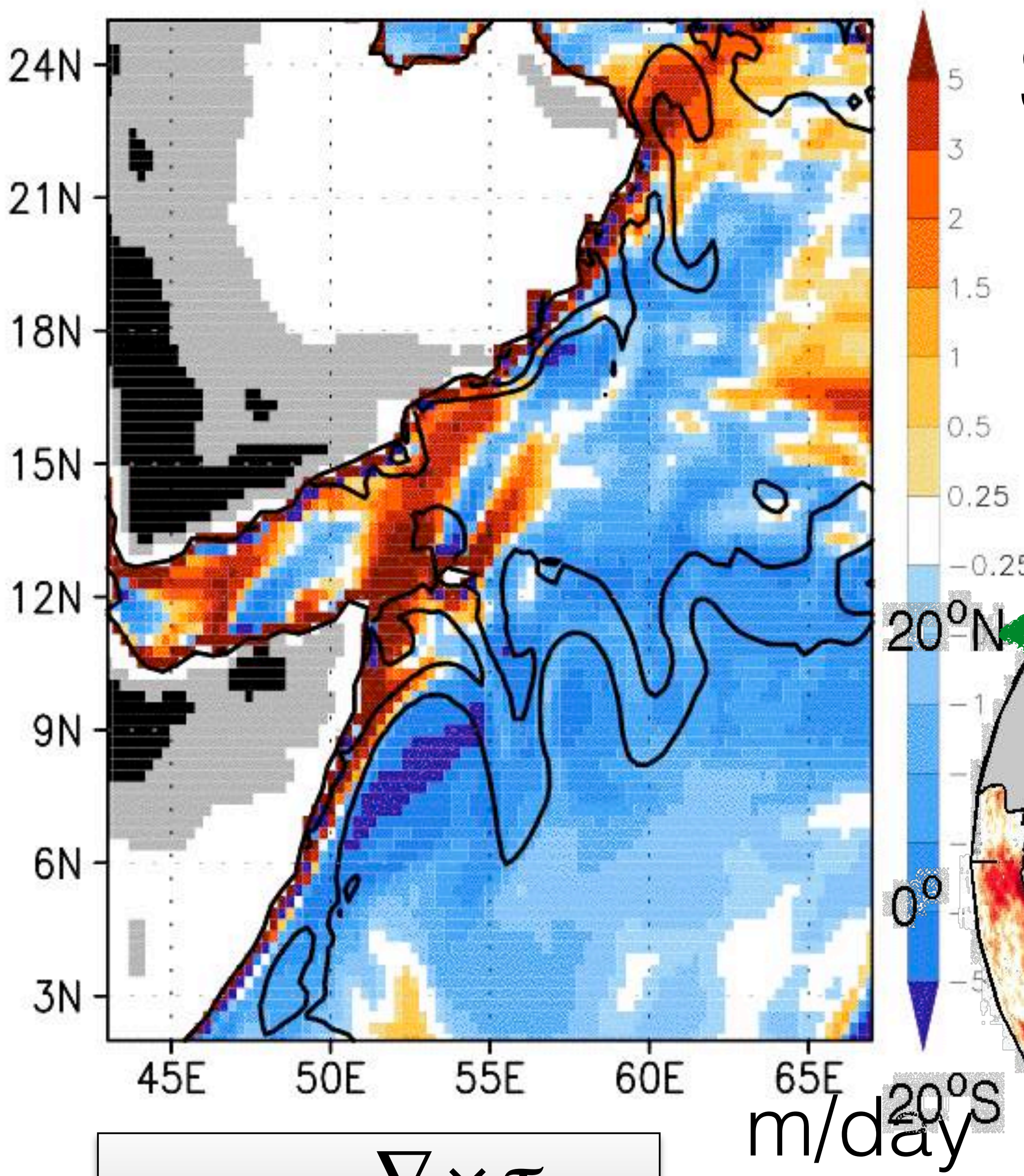
Eddy-driven air-sea interaction through SST and surface current

25km SCOAR model (Seo et al. 2008)

SST & SSH



Wek



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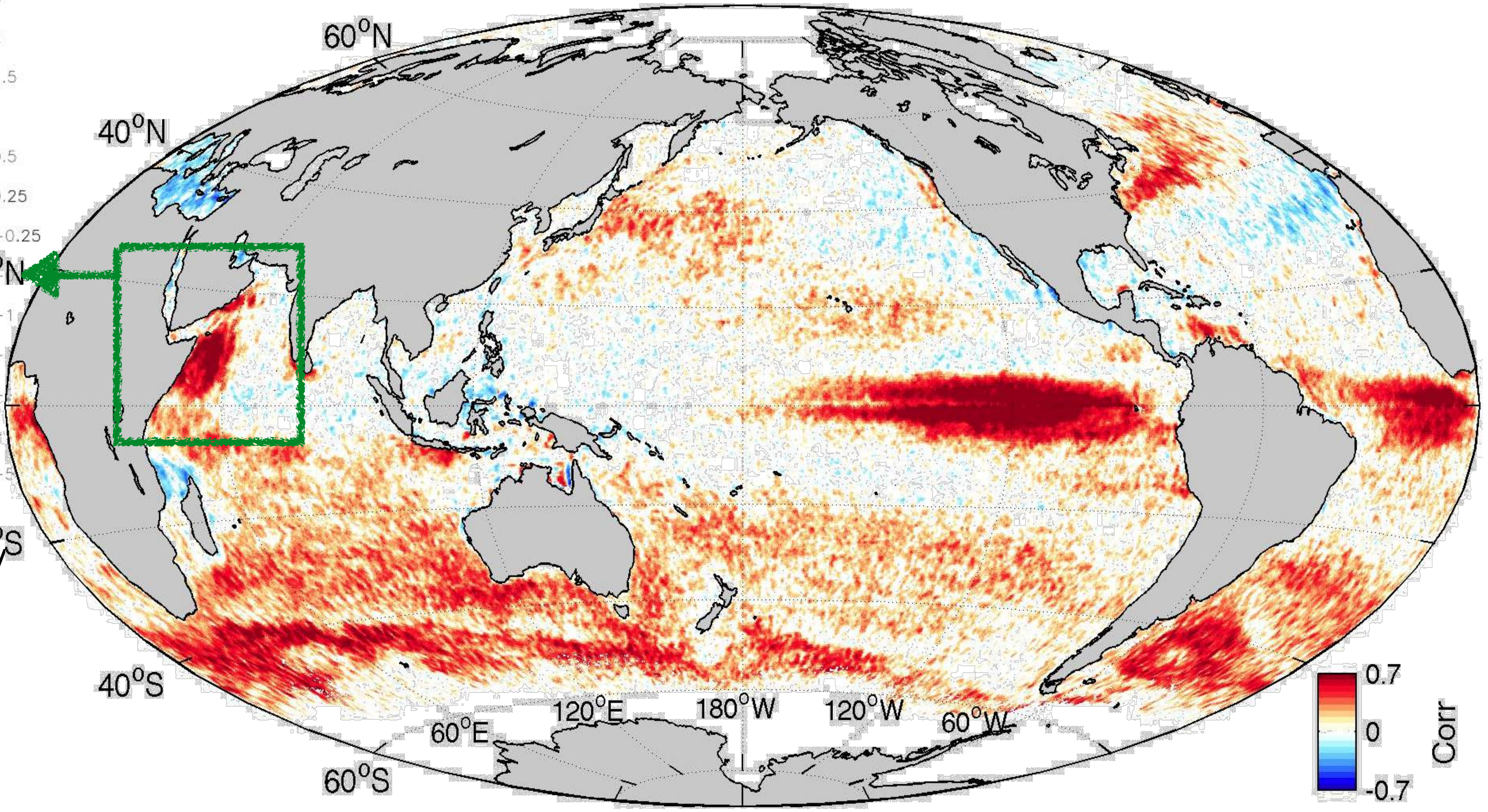
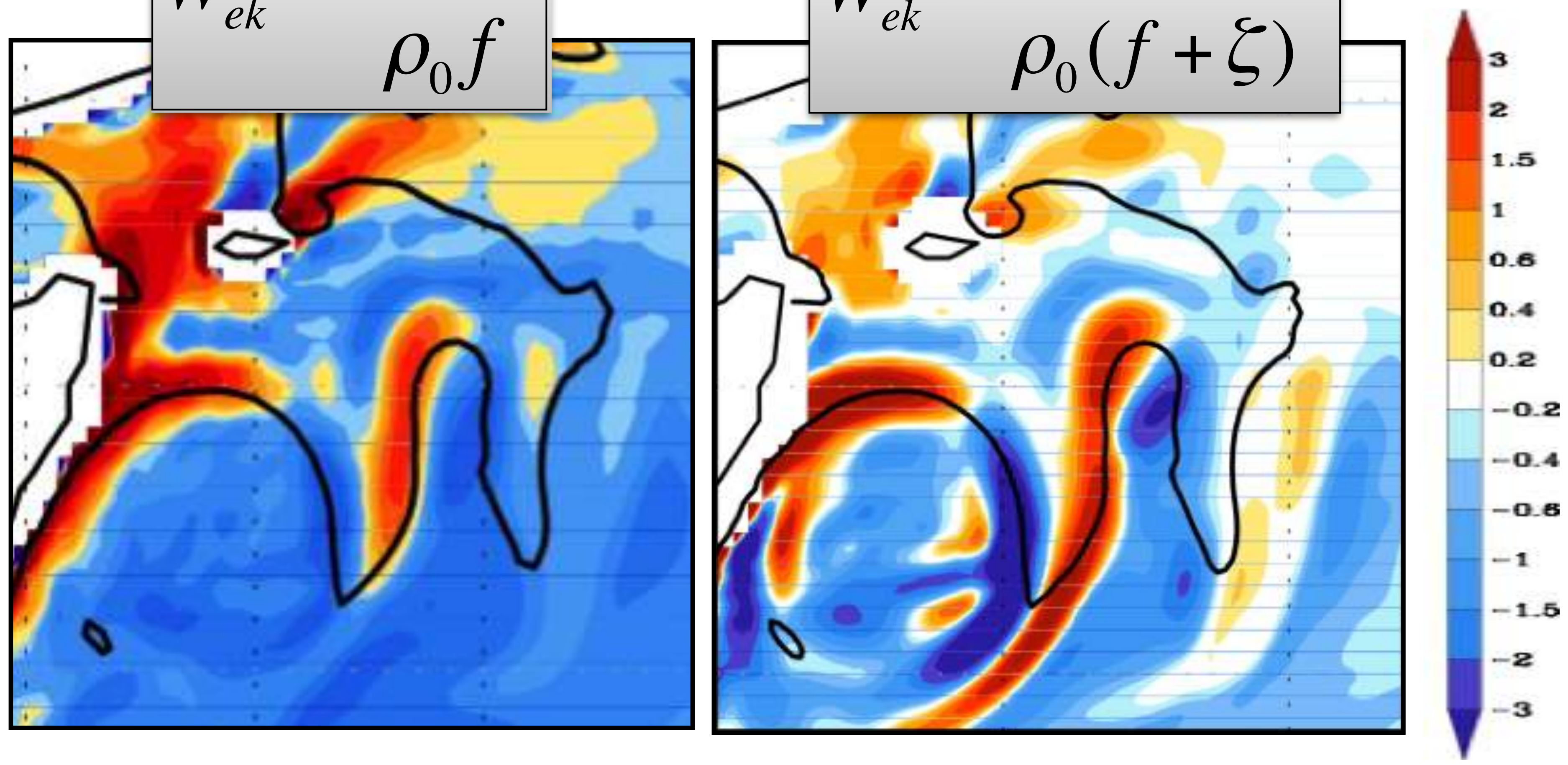
SST & WS in boreal summer based on satellite data



$$W_{ek} = \frac{\nabla \times \tau}{\rho_0 f}$$

$$W_{ek} = \frac{\nabla \times \tau}{\rho_0 (f + \zeta)}$$



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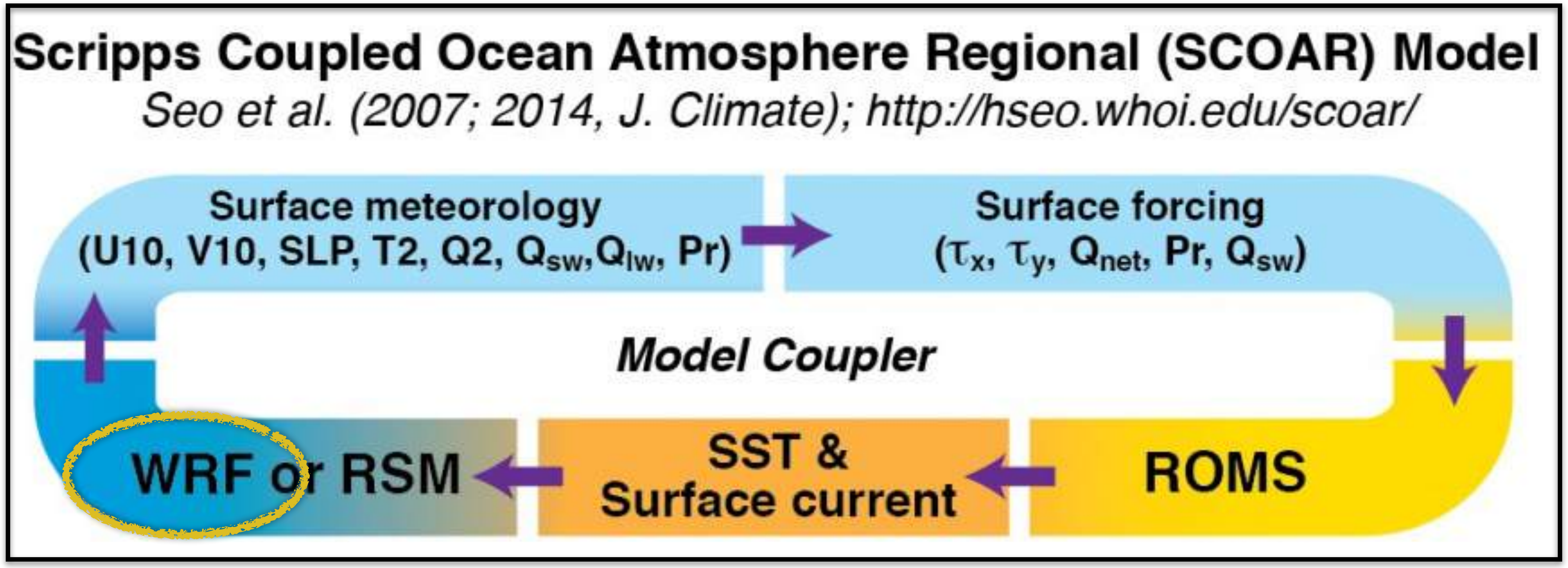
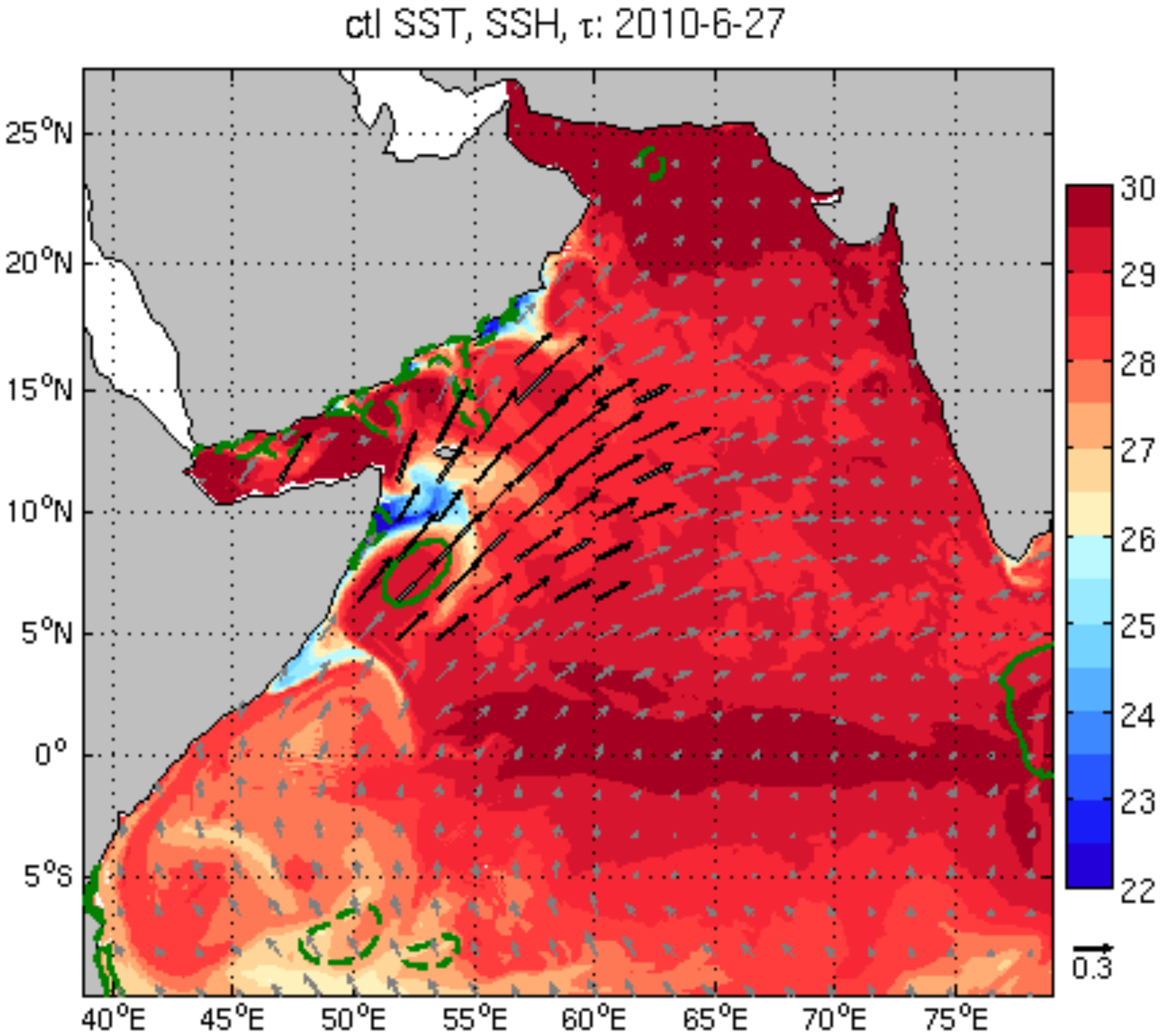
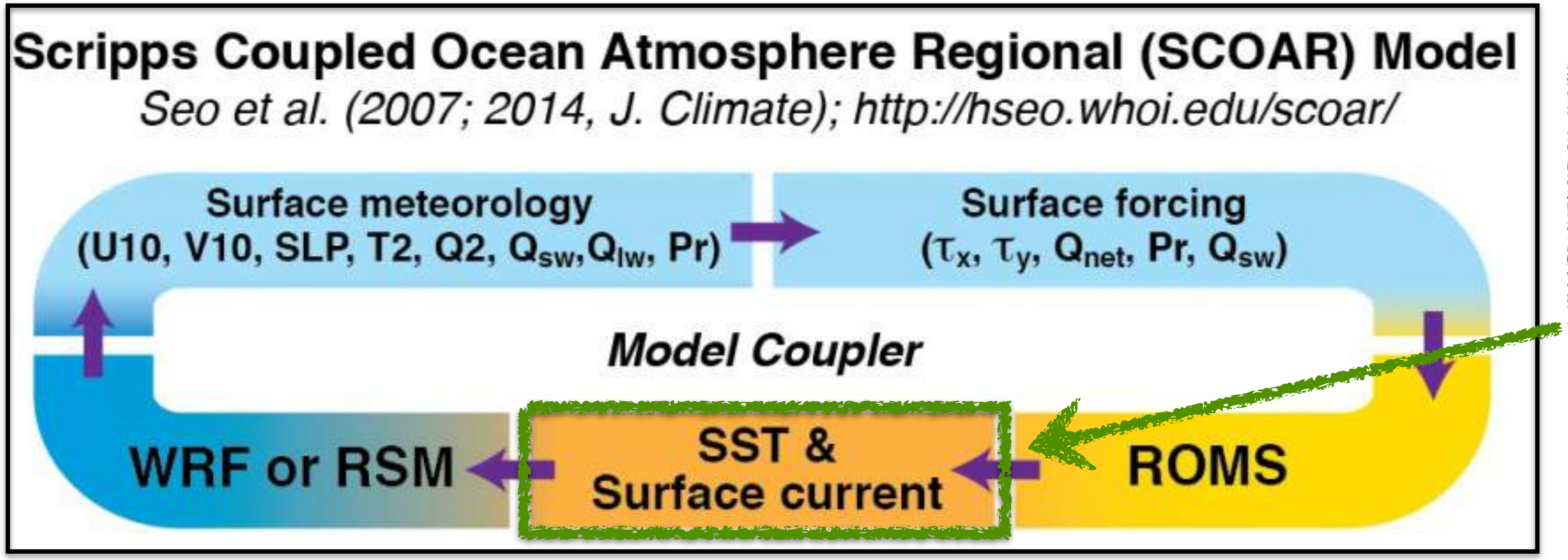
Modeling of eddy-driven air-sea coupling in the AS



- Seo et al. 2014; 2016:
- 9 km resolution in WRF and ROMS
- Matching land/mask and coastlines
- 10-year simulations: 2001-2010



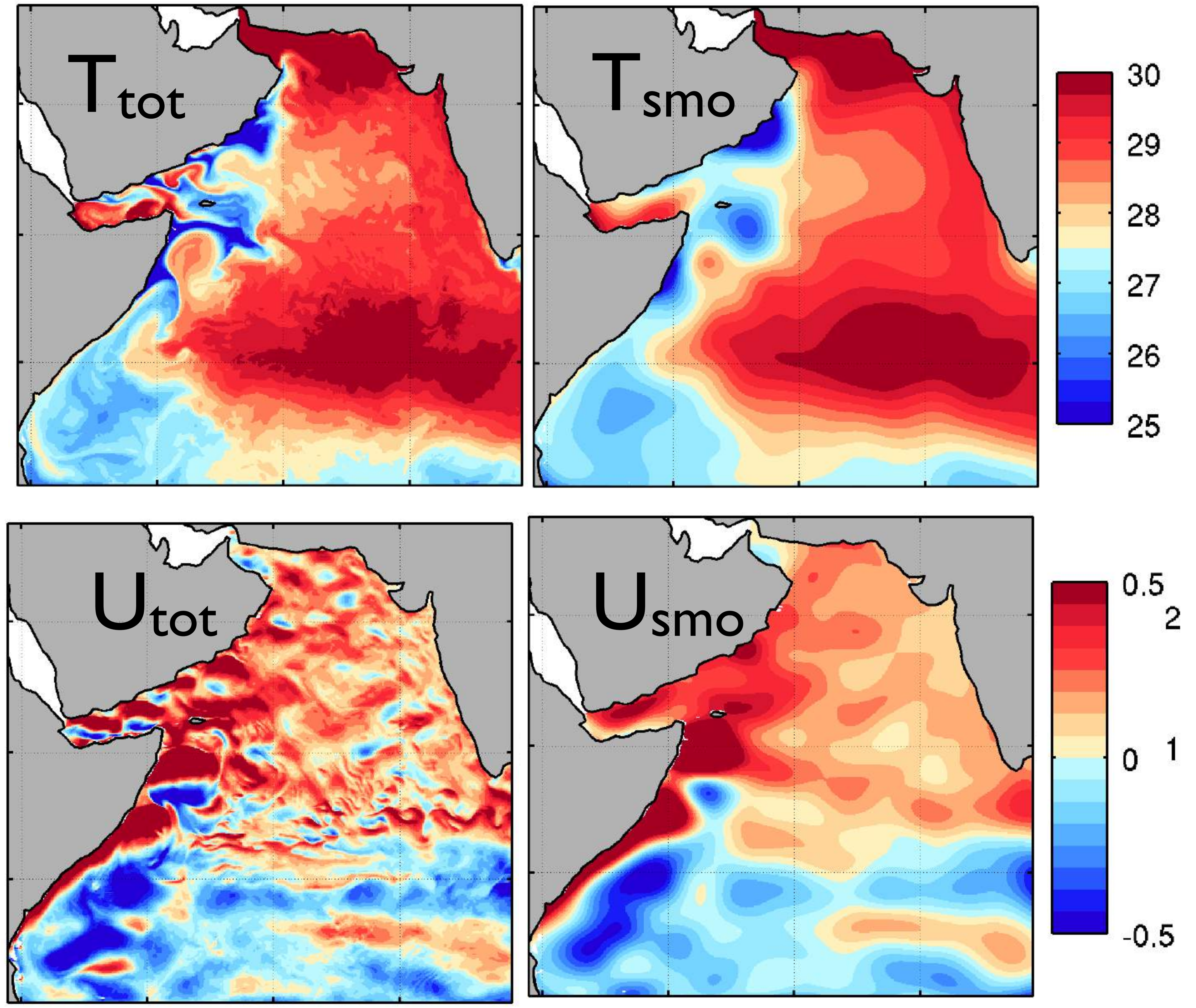
Modeling of eddy-driven air-sea coupling in the AS



Online Loess smoothing (3°) of small-scale SST and current (Seo et al. 2016)

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

Exp	τ includes	
CTL	T_{tot}	U_{tot}
noT_e	T_{smo}	U_{tot}
noU_e	T_{tot}	U_{smo}
noU_{tot}	T_{tot}	no



10-year summertime climatologies of the simulated wind and current fields

Drifter climatology: Lumpkin & Johnson (2005)

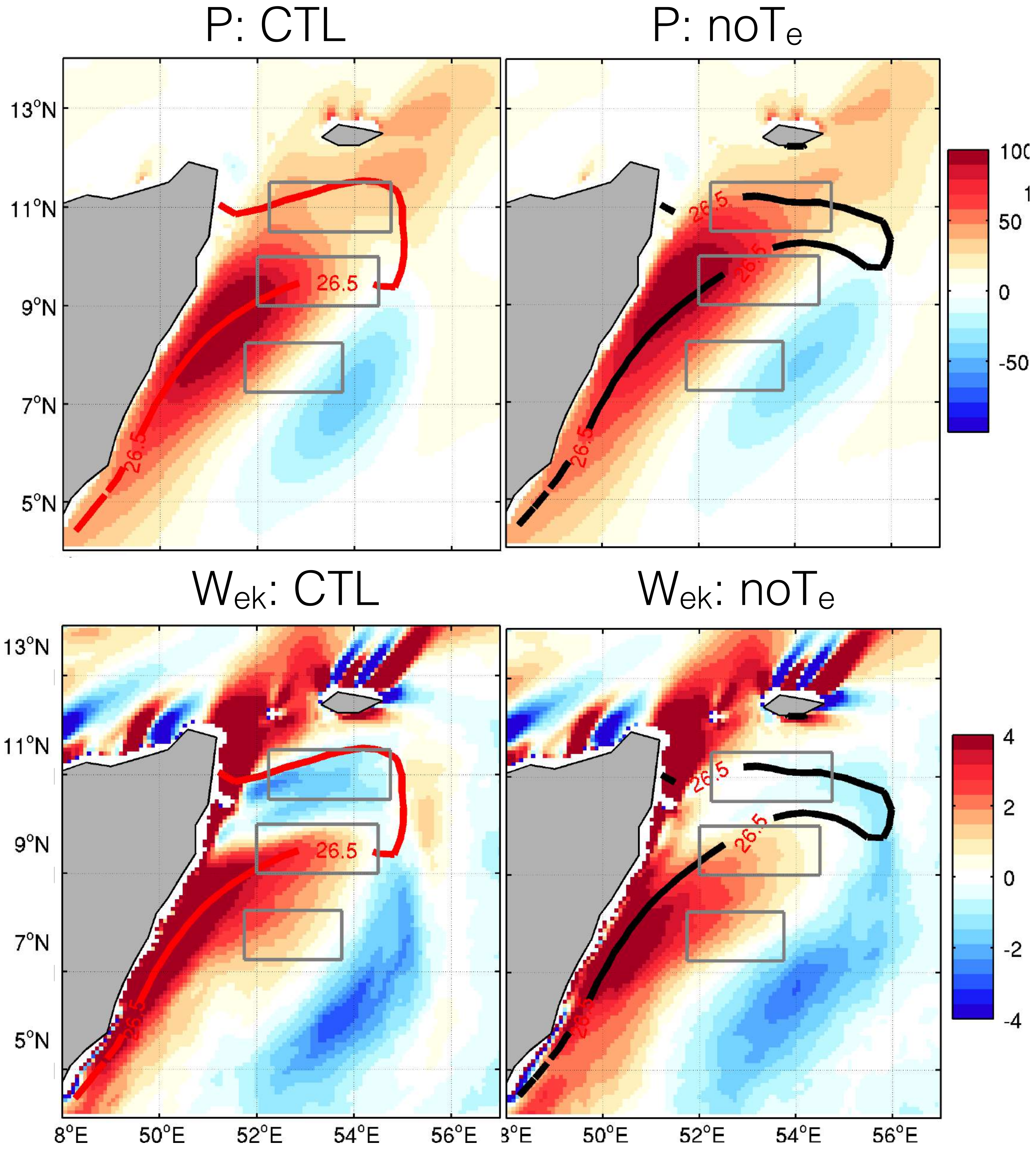
T-τ coupling: Unambiguous influence on the SC, GW, and CF

— Keeps the SC separation at 10°N

Surface current: 1m/s   SSH 15cm   SST: 26.5°C

- About 1° downstream shifts in eastward jet in SC and GW in noT$_e$
- Weaker and narrow cold filament in noT$_e$

T-τ coupling influences on the wind work (P) and Wet



(1) Direct modulation of τ → Reduced P (mostly zonal) over the CF keeps the offshore jet of SC at 10°N

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

(2) Modulation of τ curl: upwelling (downwelling) upwind (downwind) maintains the CF position and intensity

$$We = \frac{\nabla \times \tau}{\rho f} + \frac{\beta \tau_x}{\rho f^2}$$

Wind energy input and energy conversion processes

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

$$C_{PE\rightarrow KE} = -\frac{g}{\rho_0}\int_{-h}^{0}\left(\overline{\rho w} + \overline{\rho' w'}\right)dz$$

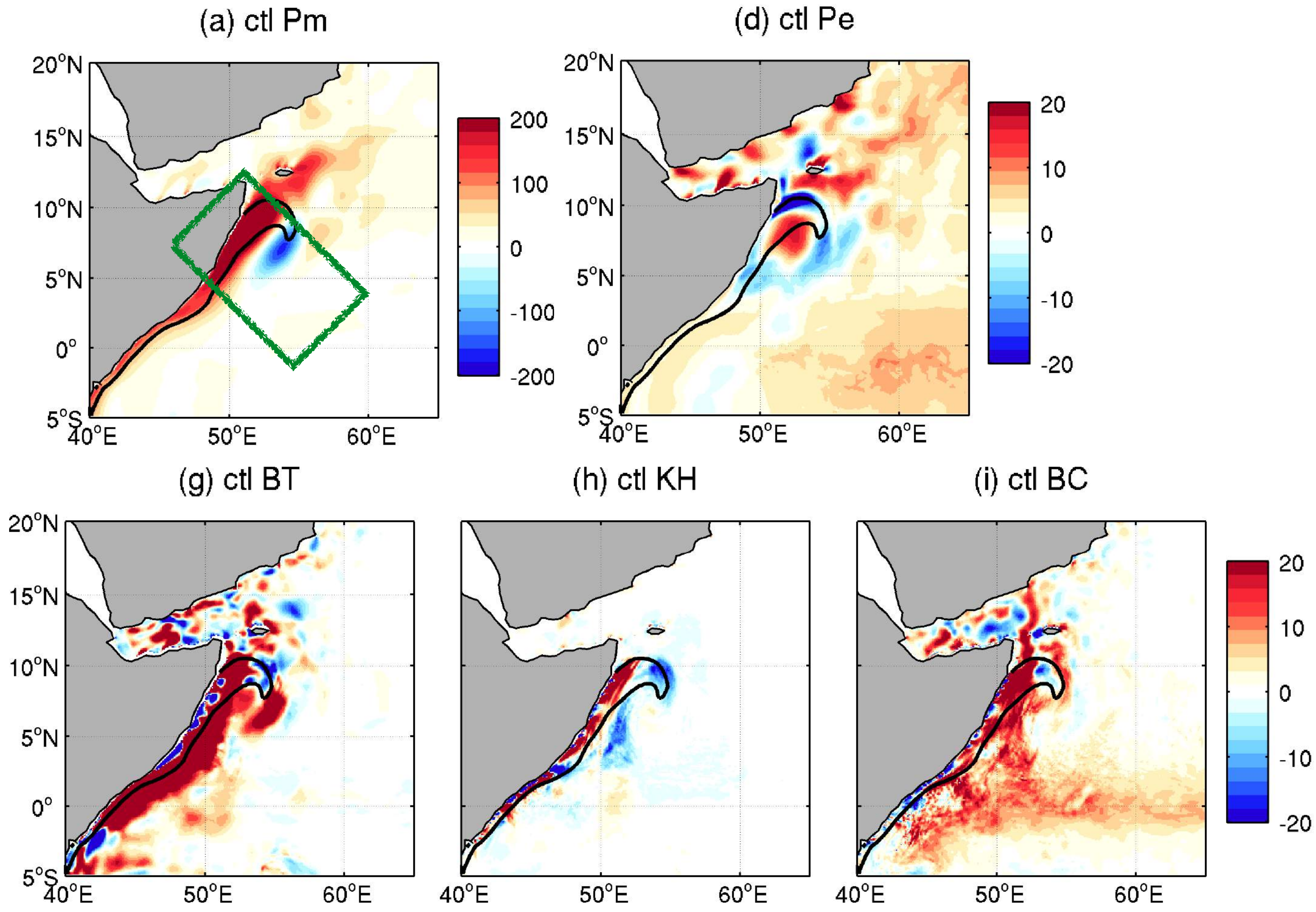
BC

$$C_{MKE\rightarrow EKE} = \int_{-h}^{0} -(\overline{u'u'}\,\overline{U}_x + \overline{u'v'}\,\overline{U}_y + \overline{v'u'}\,\overline{V}_x$$
$$+ \overline{v'v'}\,\overline{V}_y + + \overline{u'w'}\,\overline{U}_z + \overline{v'w'}\,\overline{V}_z)dz$$

BT

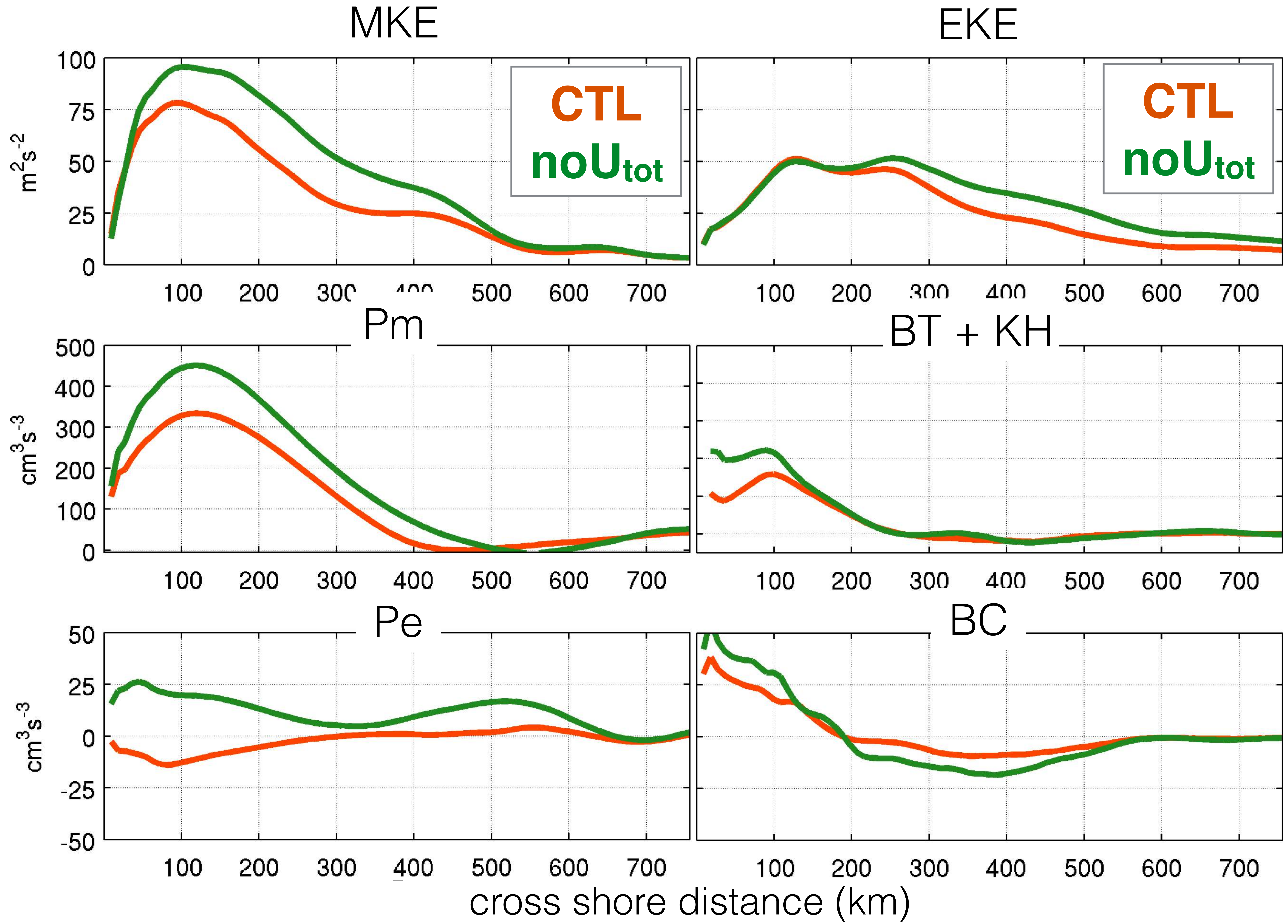
KH

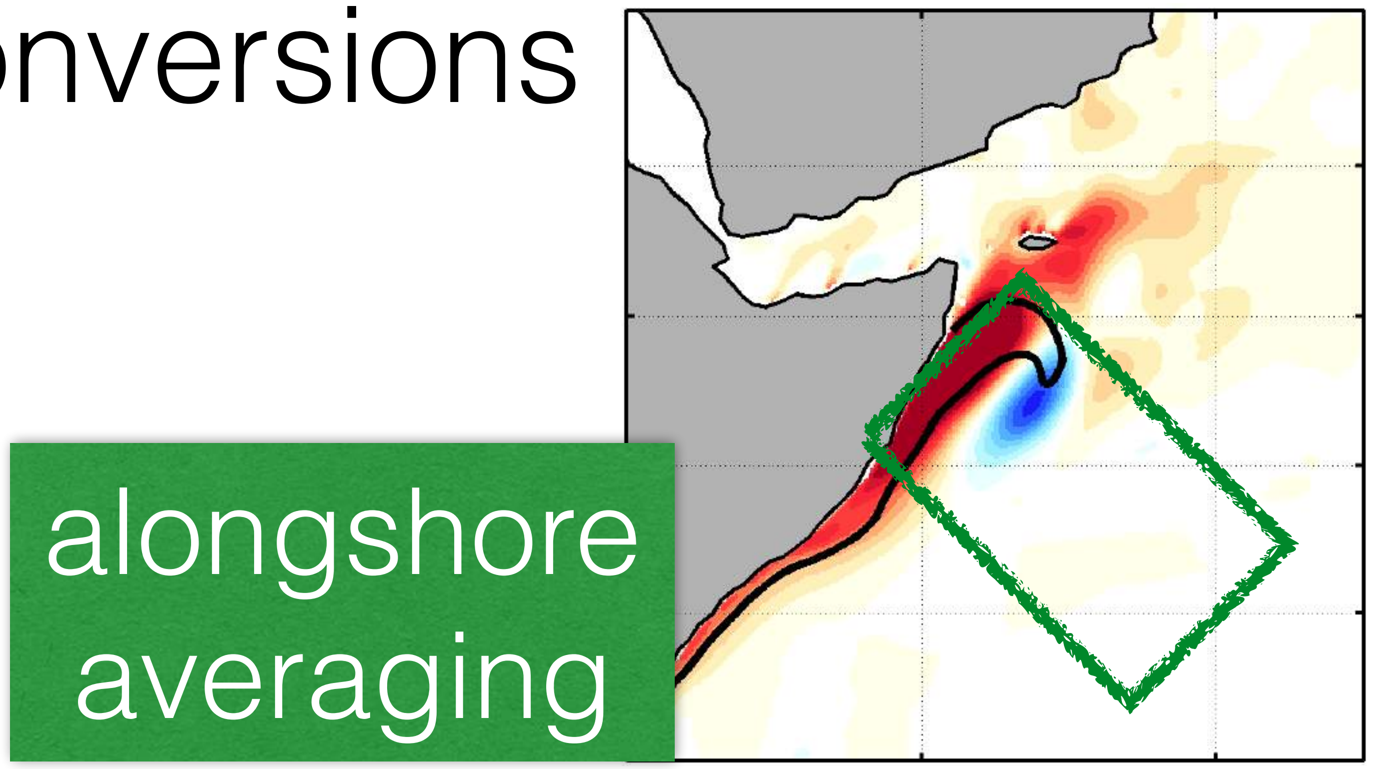
alongshore averaging



Depth integrated (m3/s3)

U-τ coupling: Cross-shore profiles of the energy input and conversions

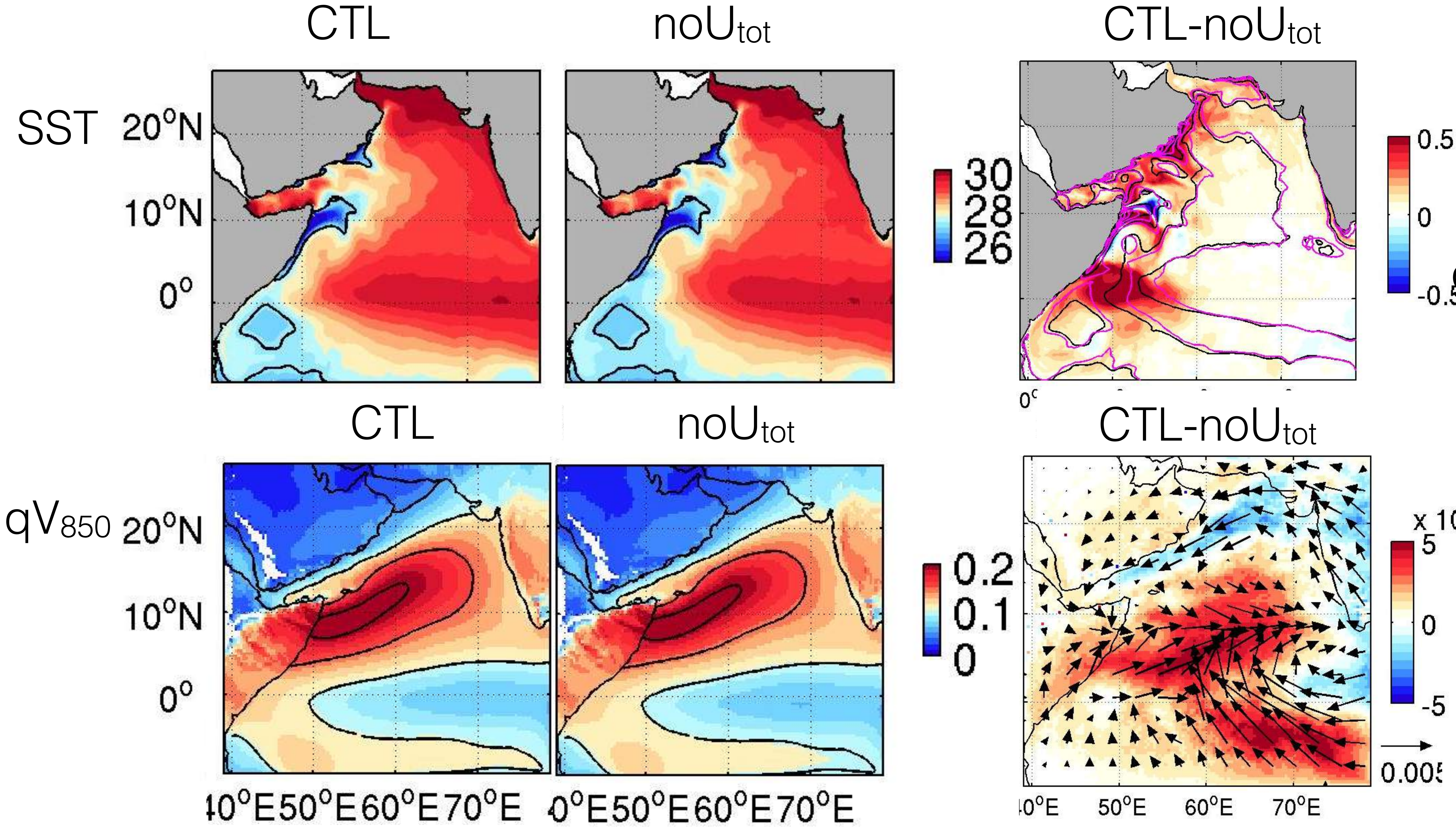




U-τ coupling:
reduces MKE by reducing Pm (mostly Pmx).

Damps the EKE due to reduced BT/BC processes.

Responses in SST and the moisture transport by the Findlater Jet



Reduced upwelling in the Omani coast and general weak warming of SST

small (~5%) but noticeable change in the axis of the FJ

Summary

- A series of 10-yr WRF-ROMS model simulations show that:

- **T-τ coupling** affects the separation latitude of the SC
  → Shifting the offshore jet northeastward by 1-2°.
  → Complementary influences of the wind work and the Ekman pumping

- **U-τ coupling** reduces the MKE and EKE by about 35%.
  → Reducing the mean wind work and increasing the eddy-drag
  → Making the modeled circulation more realistic compared to “observations”
  → Some evidence of the response in moisture transport by the Findlater Jet

- Spatio-temporally well resolved MKE and EKE estimates of the AS currents would be useful to evaluate the dynamics and impact of the coupling.

Thanks!