Coupled ocean-atmosphere interaction mediated by the ocean mesoscale eddies in the Northwest Tropical Atlantic Ocean

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NBC rings:
7-14 km/day for ~100 days
ECCO2 ocean state estimate

Hypotheses

1. Mesoscale ocean current and SST cause significant spatio-temporal variations (sub-monthly and sub-100-200 km) in the momentum, heat and moisture fluxes.

2. This ocean-forced variability in air-sea fluxes influences the vertical mixing and wind work on the ocean and drives atmospheric boundary layer and cloud responses.

Specific Questions and Approaches

1) How well does the numerical model with the COARE bulk flux algorithm reproduce the observed fluxes on oceanic mesoscale?

— Simulated vs. observed air-sea fluxes across the fronts & Pre-cruise modeling experiments.

2) What are the controlling factors on the spatial structure and temporal variability of the observed air-sea fluxes?

— Various 1D and 3D sensitivity experiments. Develop a diagnostic metric.

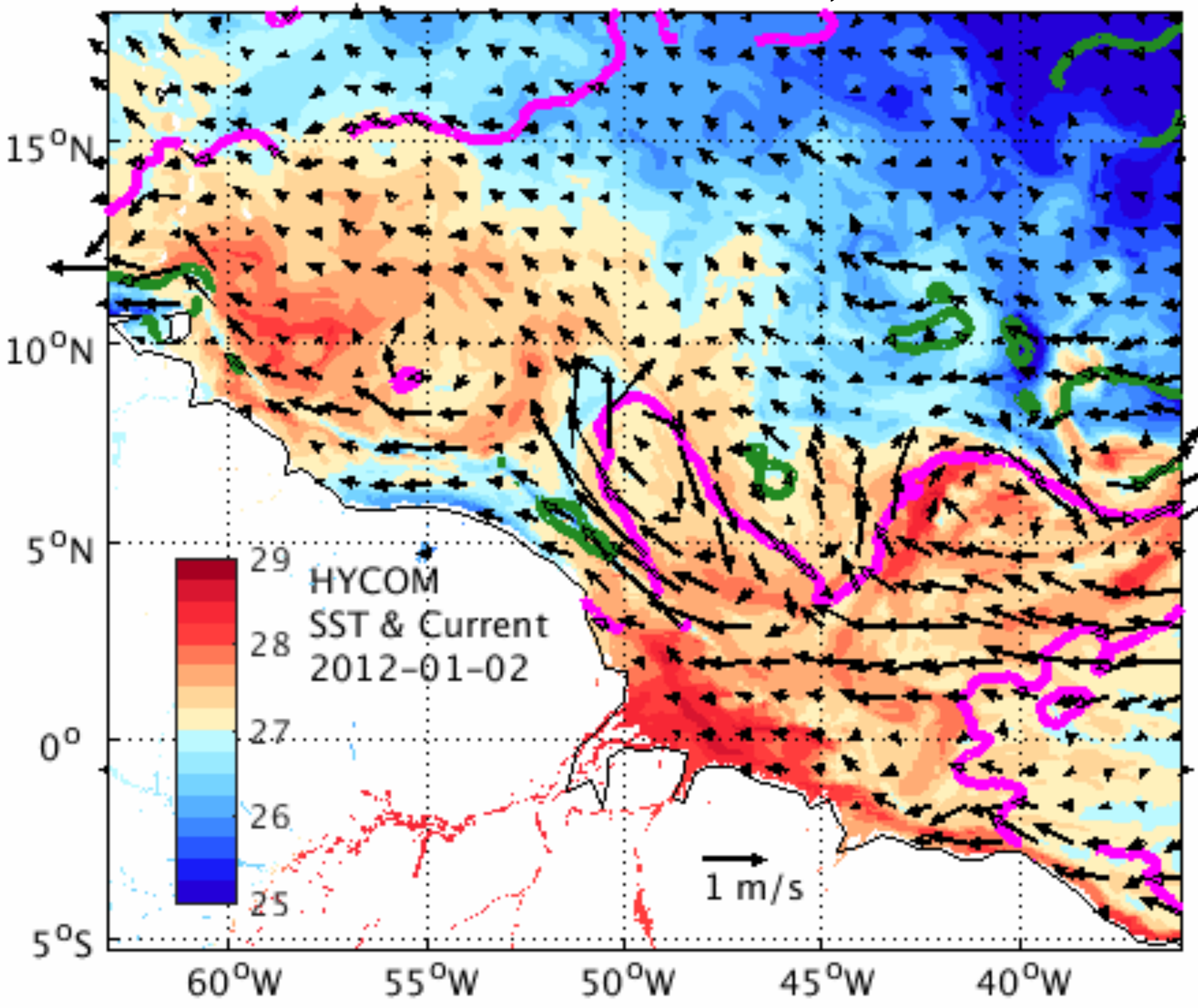
3) How does the resulting air-sea flux variability impact the atmospheric boundary layer, and what are the critical feedback mechanisms?

— Long-term mesoscale-resolving coupled experiments

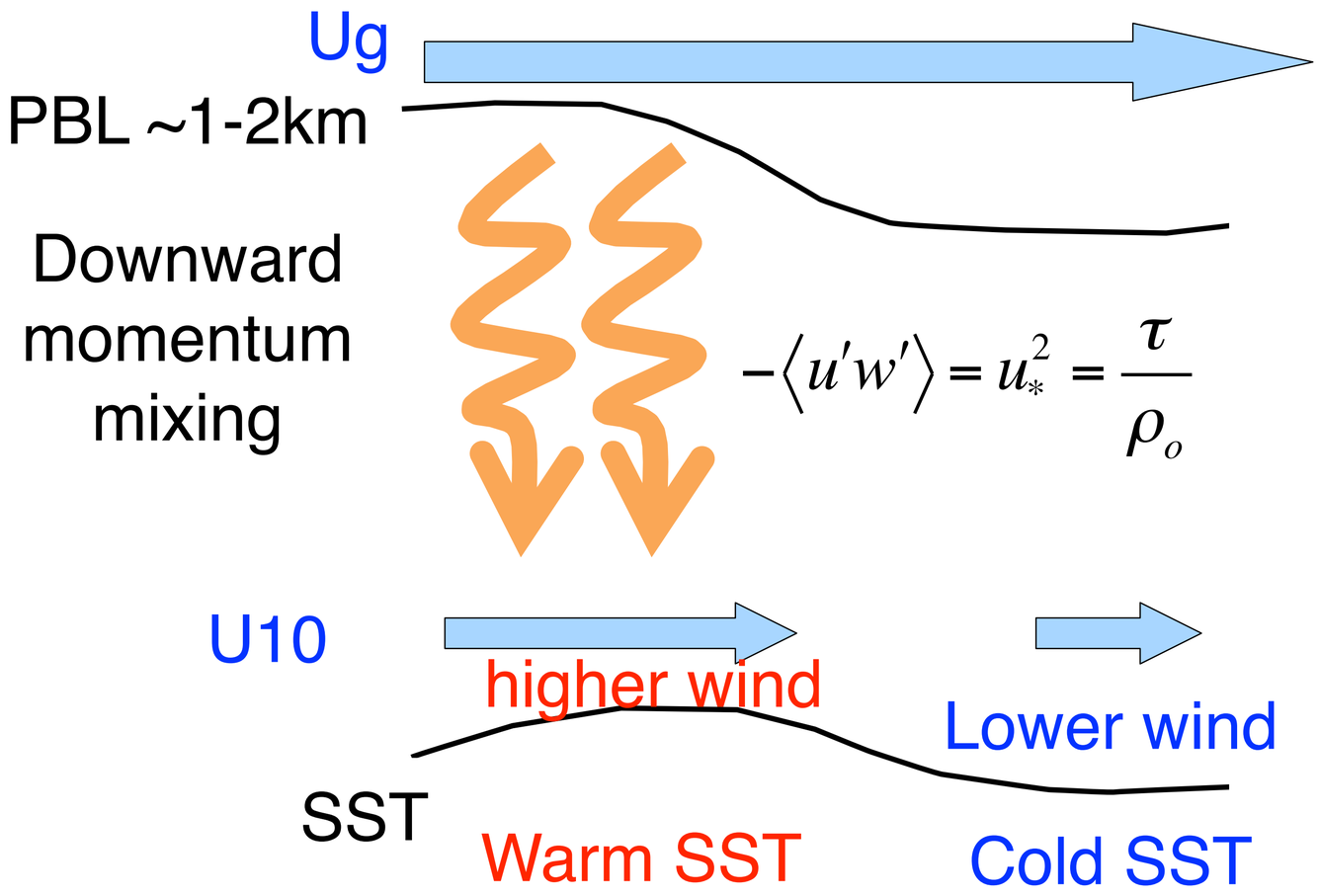
Significant
eddy-wind interactions?

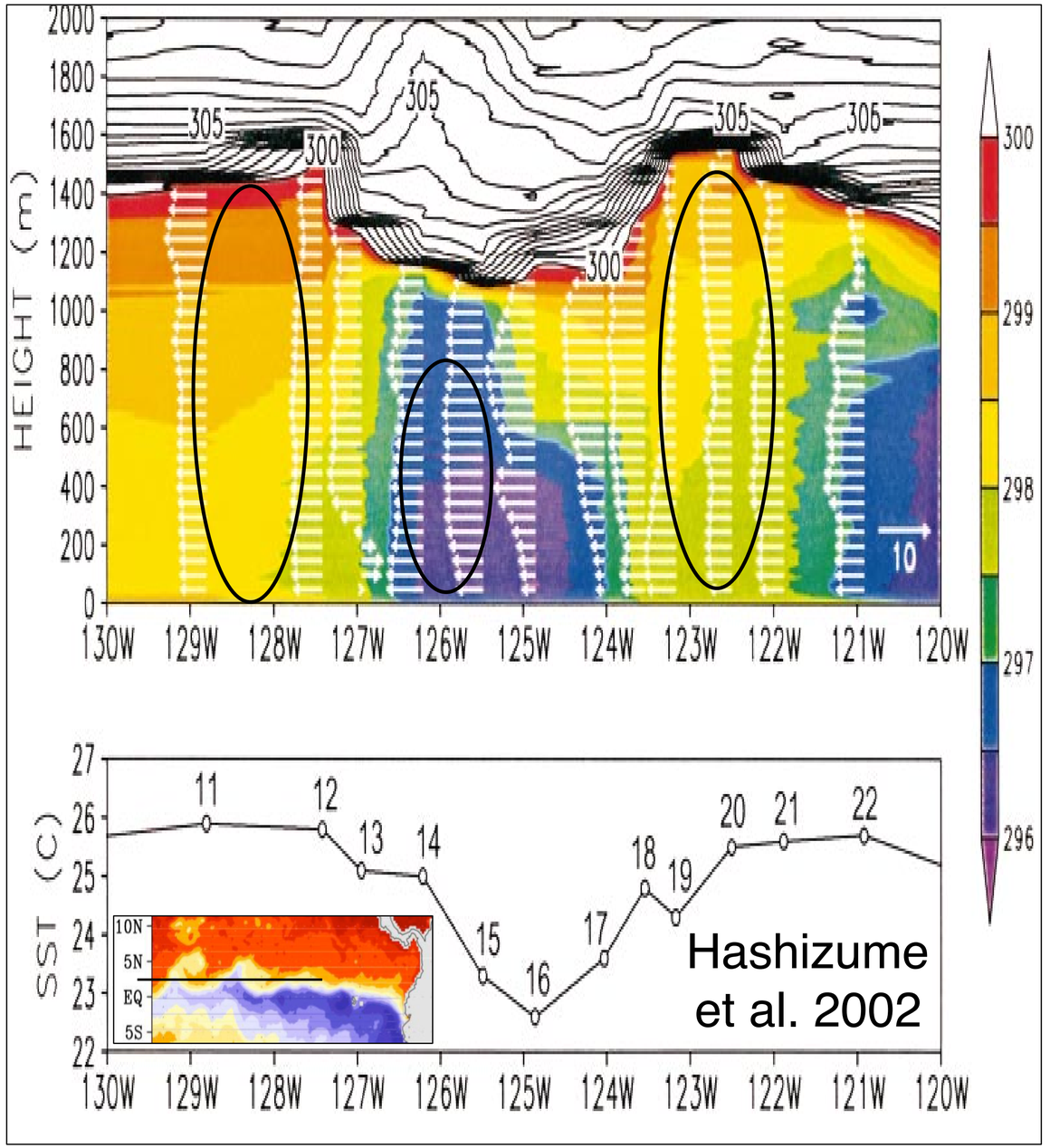
Strong surface
current and eddy
activity
under the steady
northeasterly trade
winds

HYCOM SST and Surface current, Jan-Feb 2012



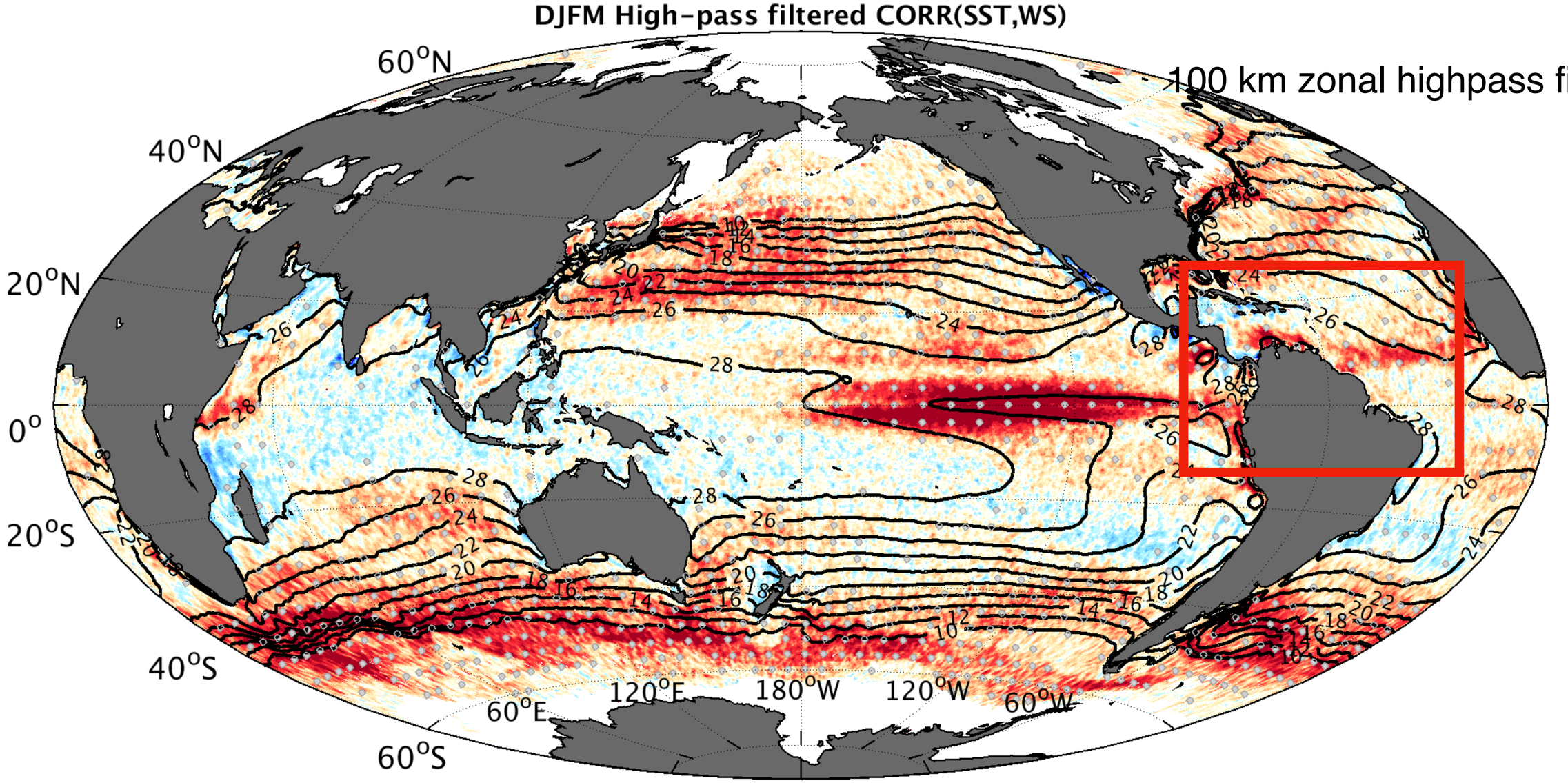
Mesoscale SST alters the vertical mixing in the ABL





- 1-D turbulent boundary layer process
- A shallow and rapid adjustment (~hrs)

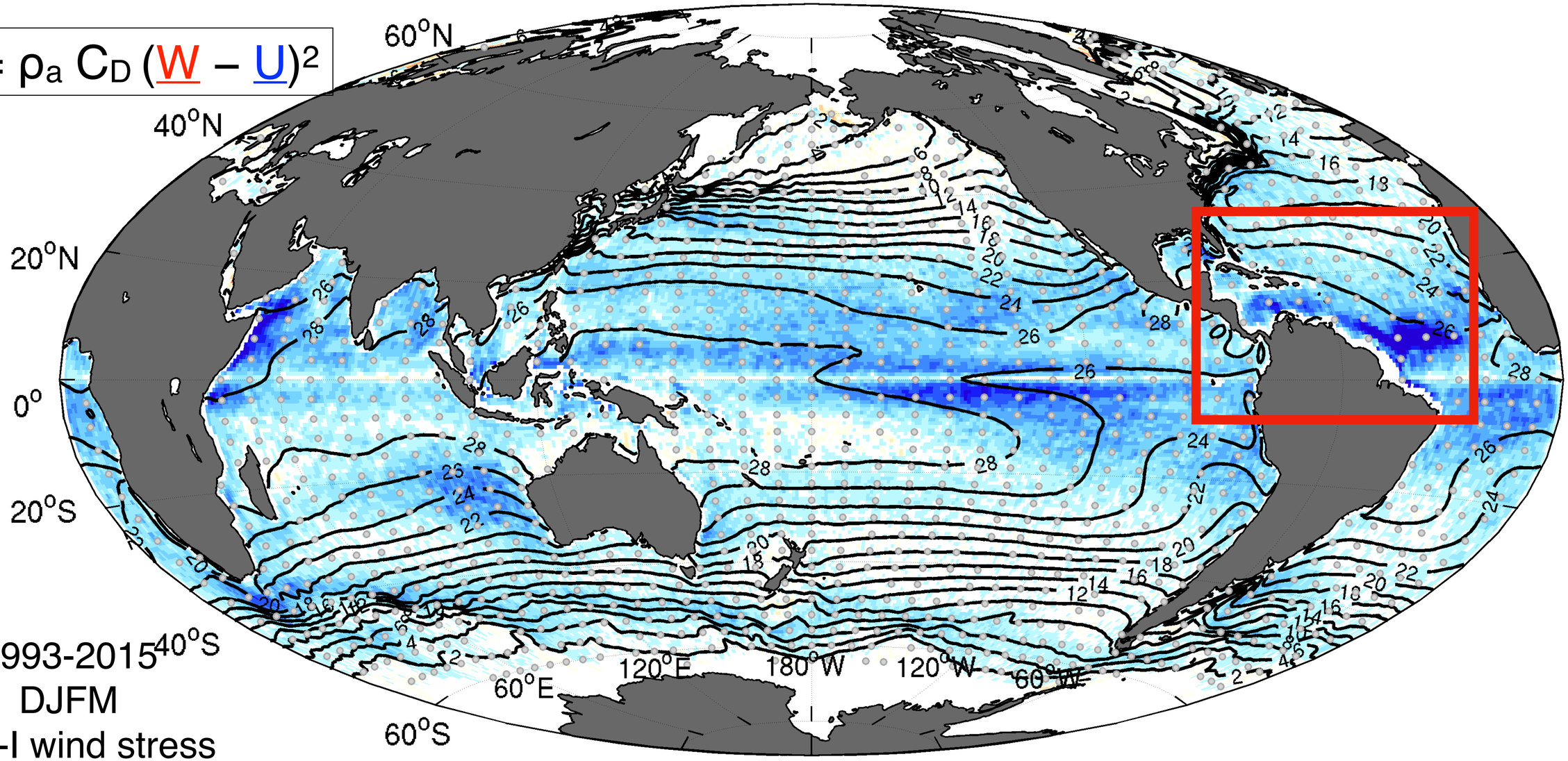
Eddy-SST impacts on surface wind



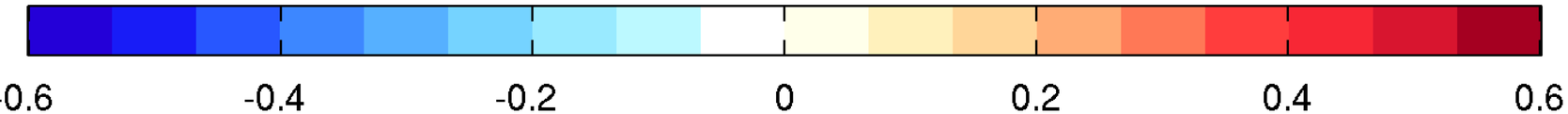
Imprints of surface current in wind stress curl

correlation: wind stress curl and surface voriticity; 1993-2015 DJFM

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

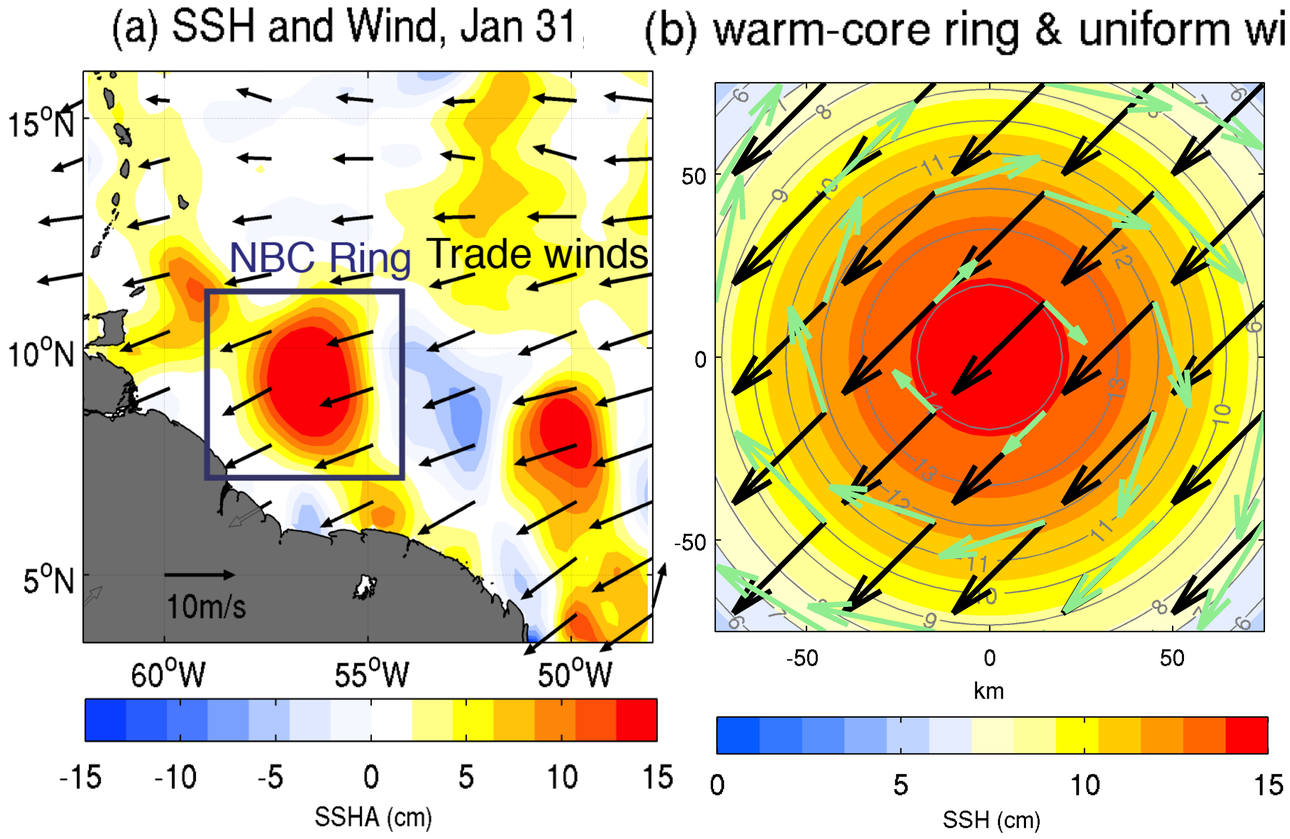


1993-2015
DJFM
ERA-I wind stress
AVISO geostrophic current



Air-sea interaction over an idealized NBC ring

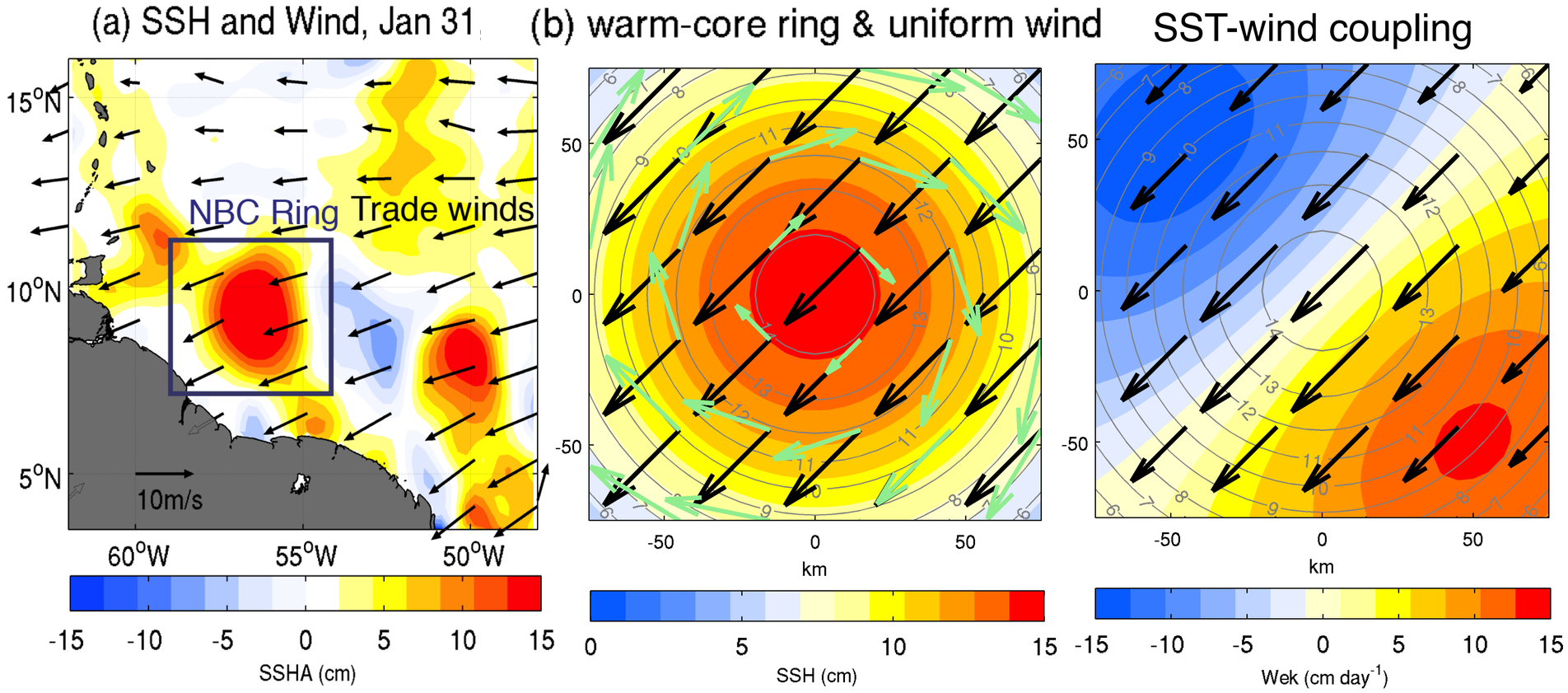
$$\tau = \rho_a C_D (\underline{W} - \underline{U})^2$$



Air-sea interaction over an idealized NBC ring

SST effect on wind

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

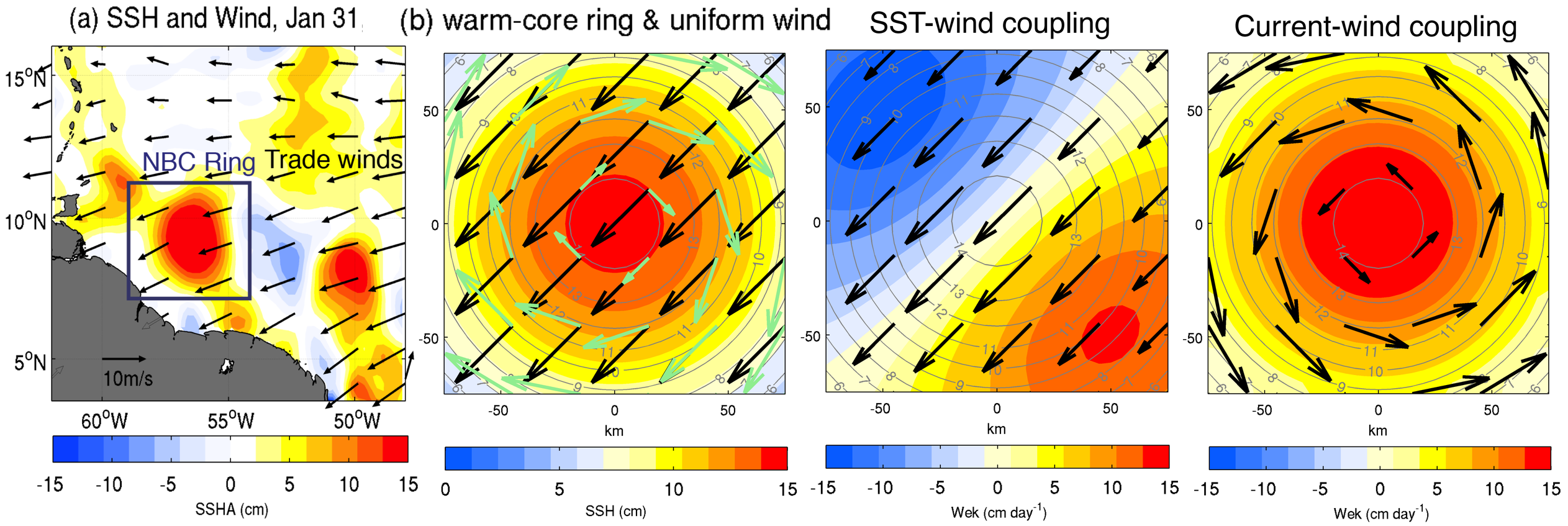


SST-wind: small change in wind work, affect the eddy propagation

Air-sea interaction over an idealized NBC ring

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

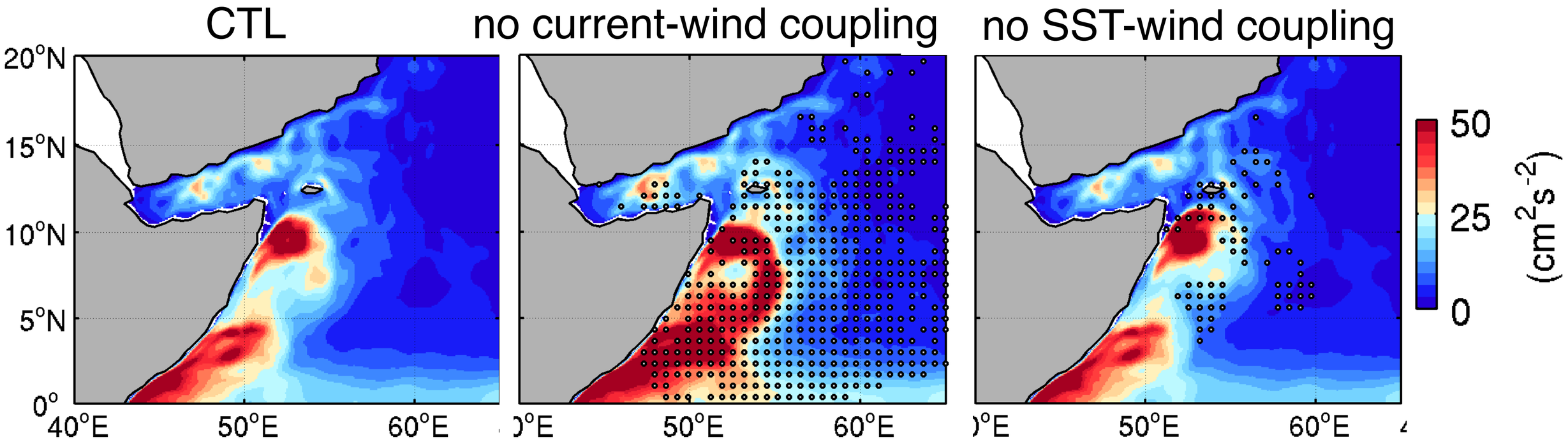
ocean current



SST-wind: small change in wind work, affect the eddy propagation

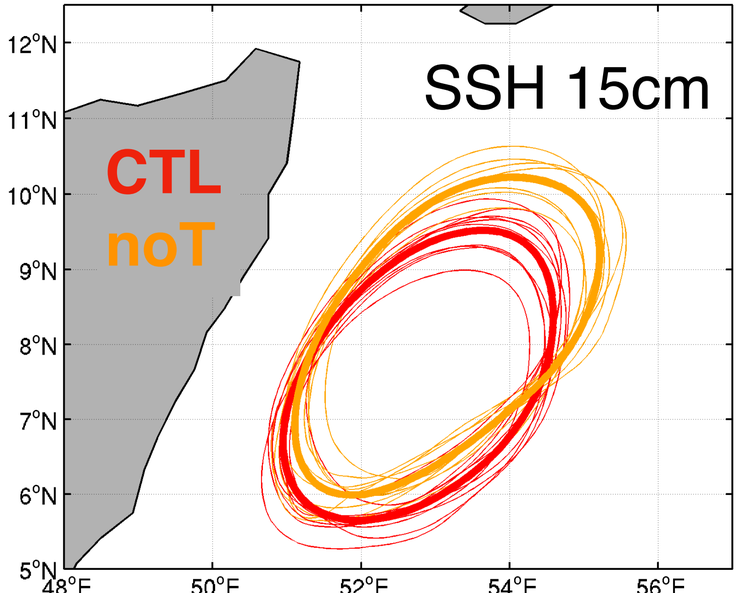
Current-wind: negative eddy wind work, damp the eddy activity

Quantifying the impacts of air-sea coupling



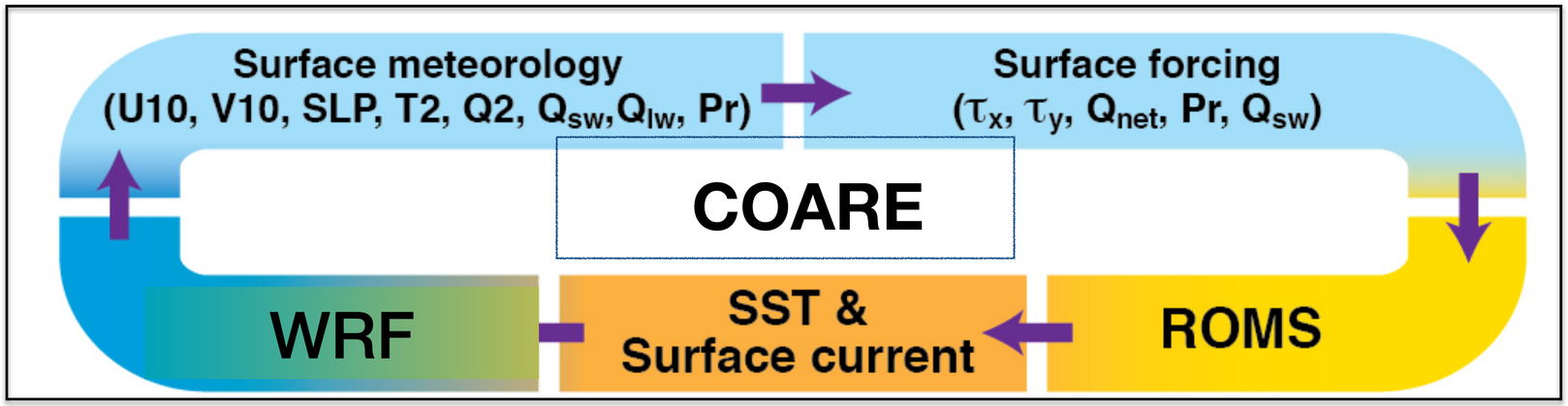
Significant EKE damping effect (26%) by the current-wind coupling

~1° downstream shifts of the Great Whirl without the SST-wind coupling



Seo 2017, JCLI

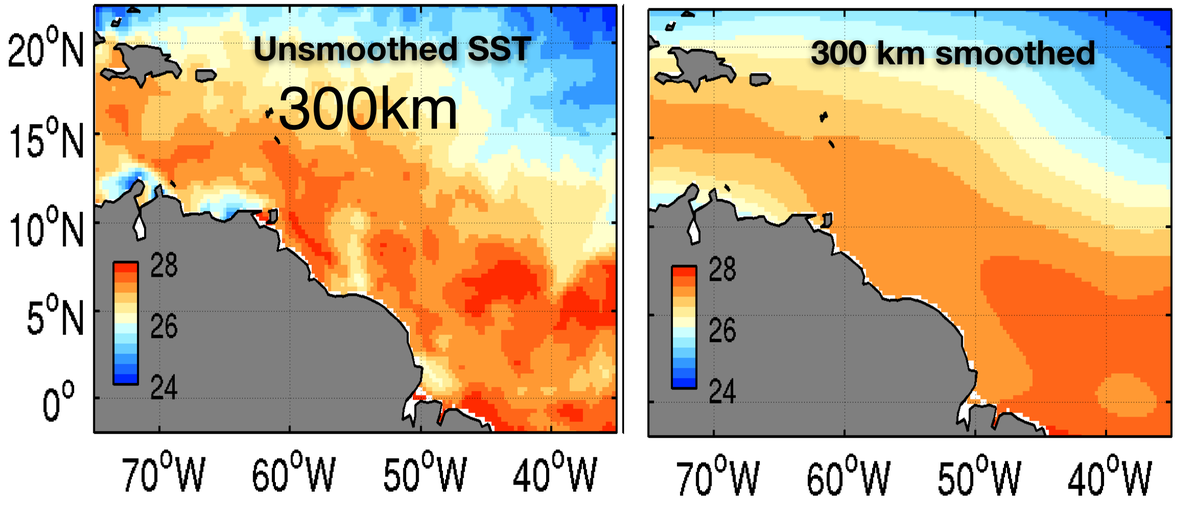
Scripps Coupled Ocean-Atmosphere Regional (SCOAR) Model



Seo et al. (2007; 2014; 2016, JCLI)

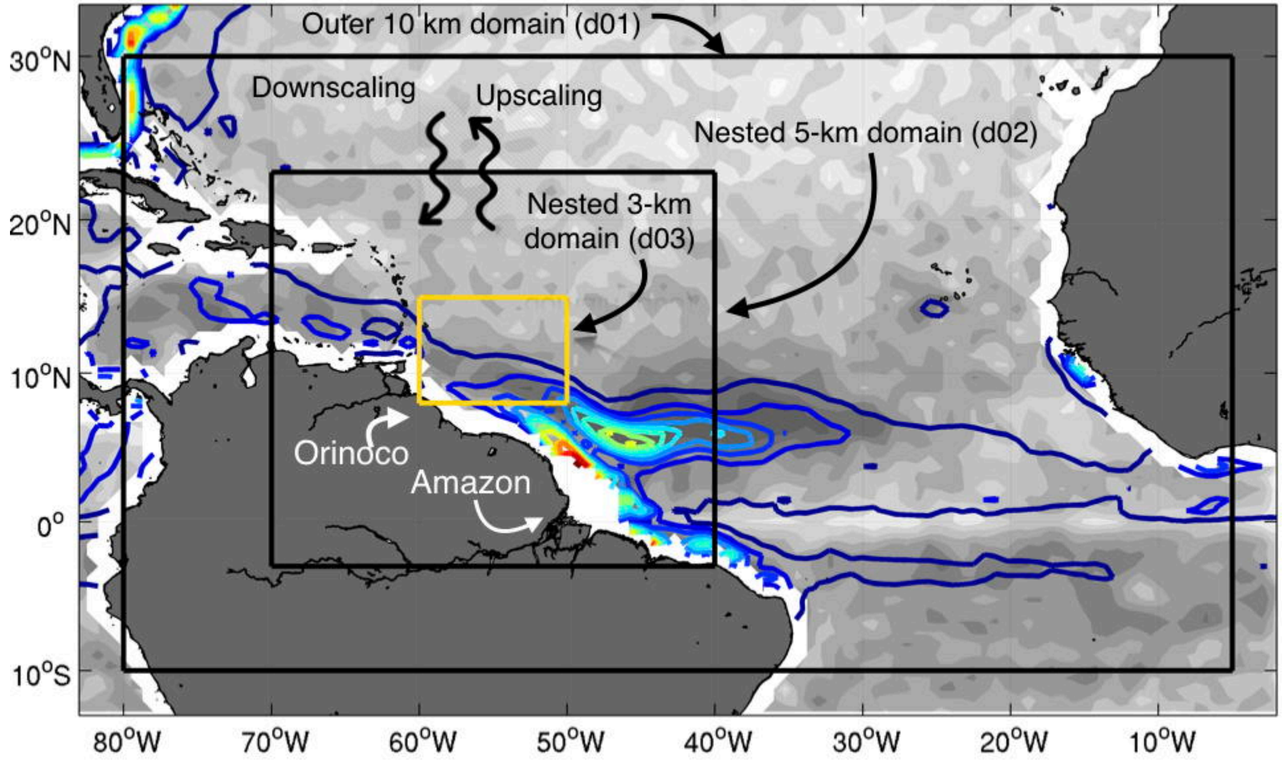
http://hseo.whoi.edu/scoar/

Scale-selective air-sea coupling



Physics of air-sea coupling and impacts on upper ocean mixing and stratification

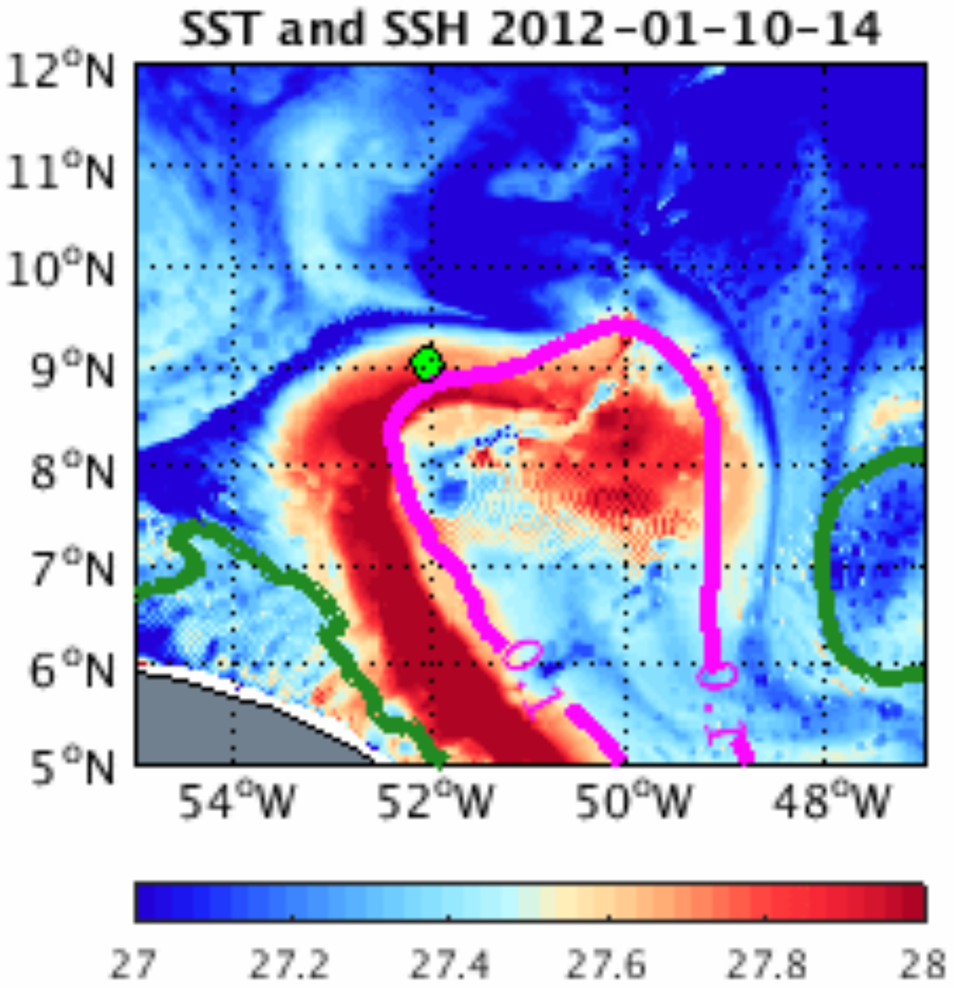
Upscaling effects on regional precipitation patterns

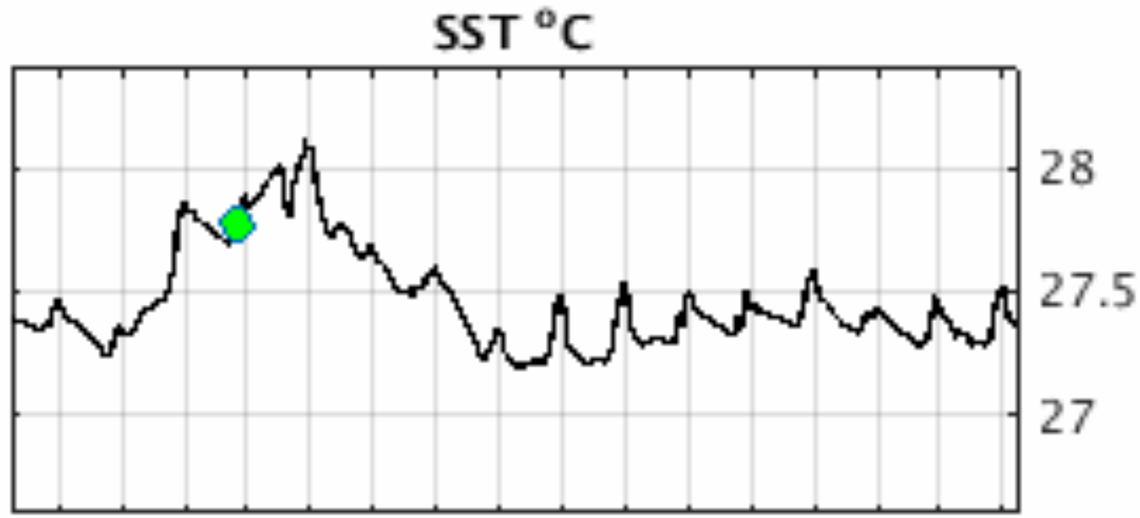


Exploring sampling possibilities

5km WRF-ROMS test simulations Jan-Feb 2012

Stationed at 9°N,52°W



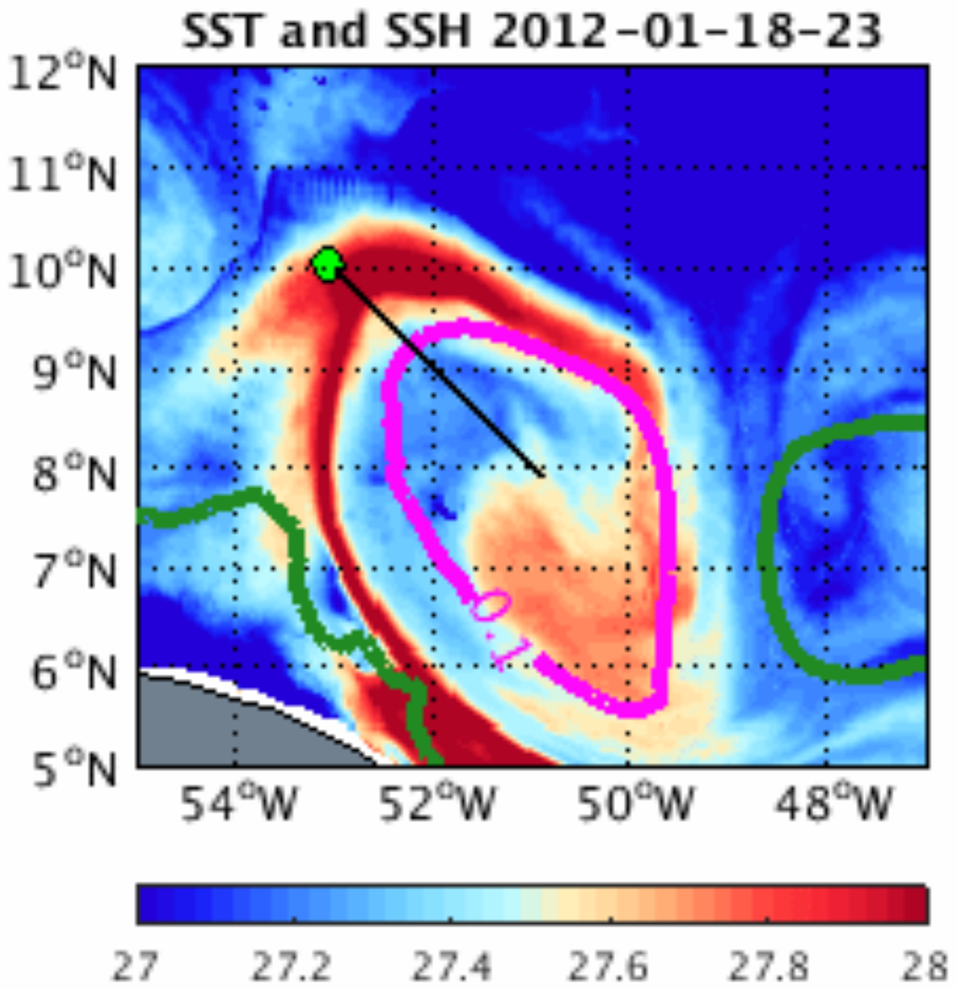


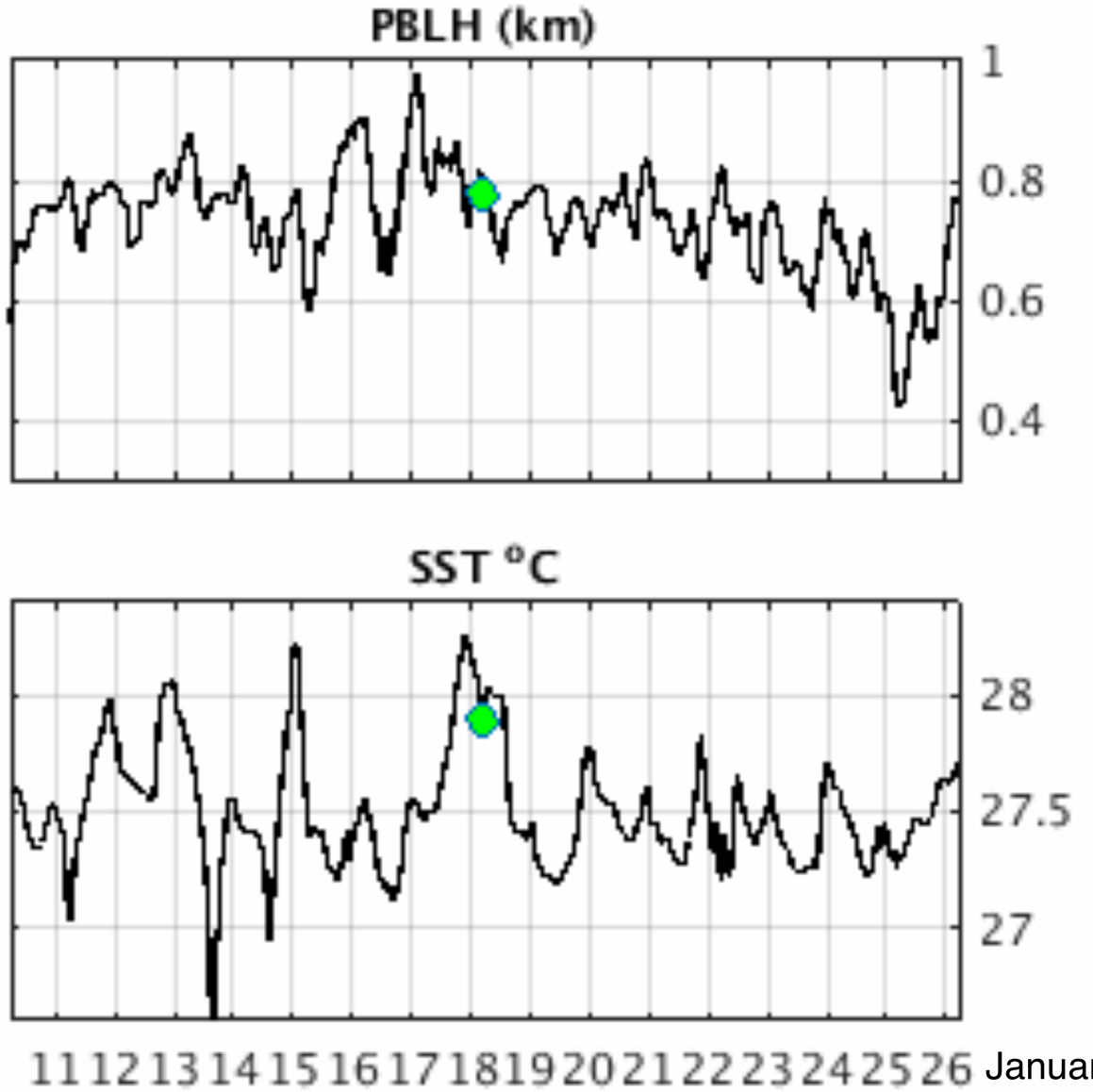
7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 January 2012

Exploring sampling possibilities

5km WRF-ROMS test simulations Jan-Feb 2012

Repeat sampling
across the front at ~2kt





Collaborations

- Coordinated experiments with LES and submesoscale-resolving modeling (e.g., McWilliams, Renault, Sullivan)
  - Use common sets of model physics. Share the input and forcing data.
- Effect of wave coupling in the air-sea fluxes
  - Refine and test the wave-based formulation in the COARE against the wave properties and flux measurements

Thanks

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