My air-sea coupling study at Scripps under the influence of Art

Hyodae Seo
Woods Hole Oceanographic Institution

Multi-modal Oscillation in Ocean Basin
Scripps Institution of Oceanography
24 August 2018

Came to Scripps in 2002 to study air-sea coupling…
& met my advisors

John, the RSM guy

coupling!

Art, the ROMS guy

Dove right into modeling!!

Predictors and prediction!

Kana

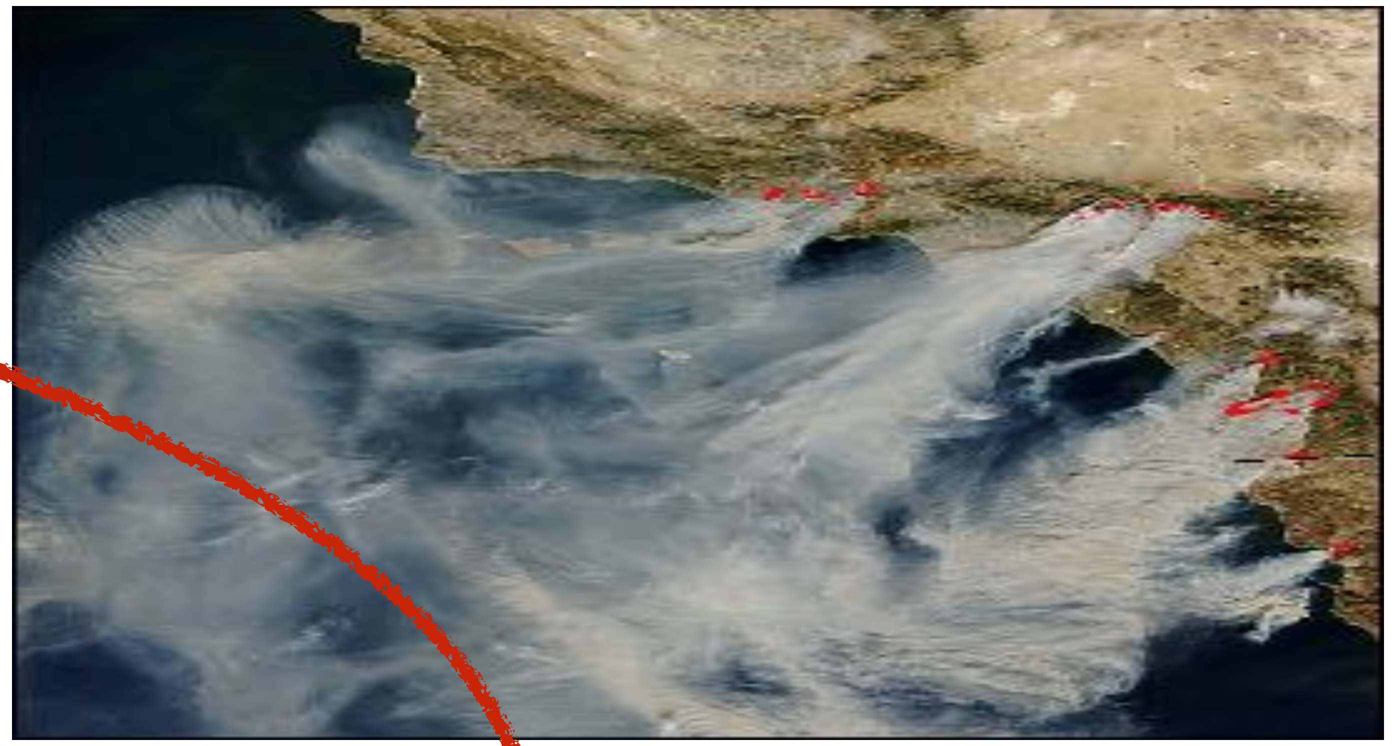
SCOAR

ECPC RSM

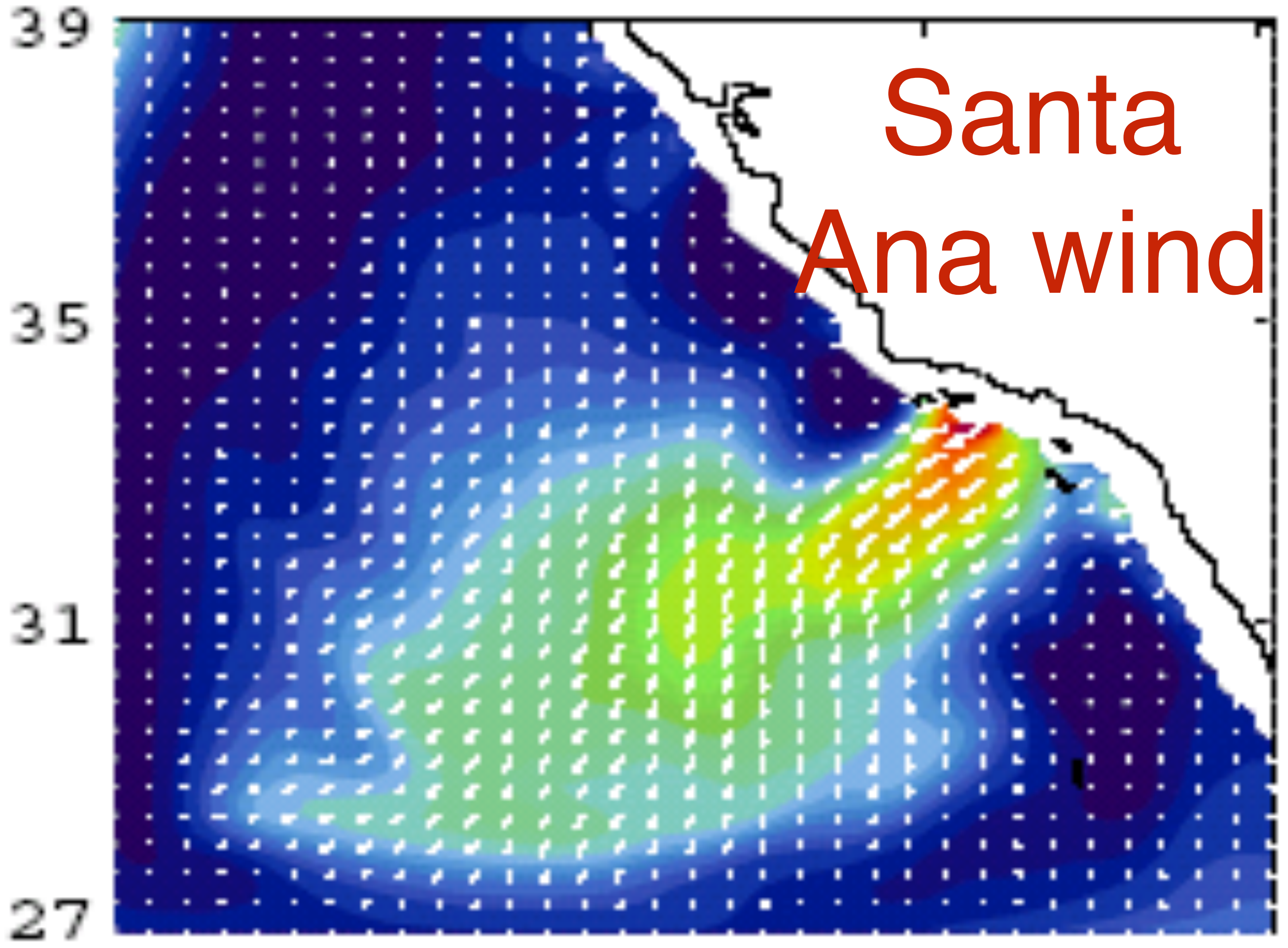
Flux ↓ ↑ SST

ROMS

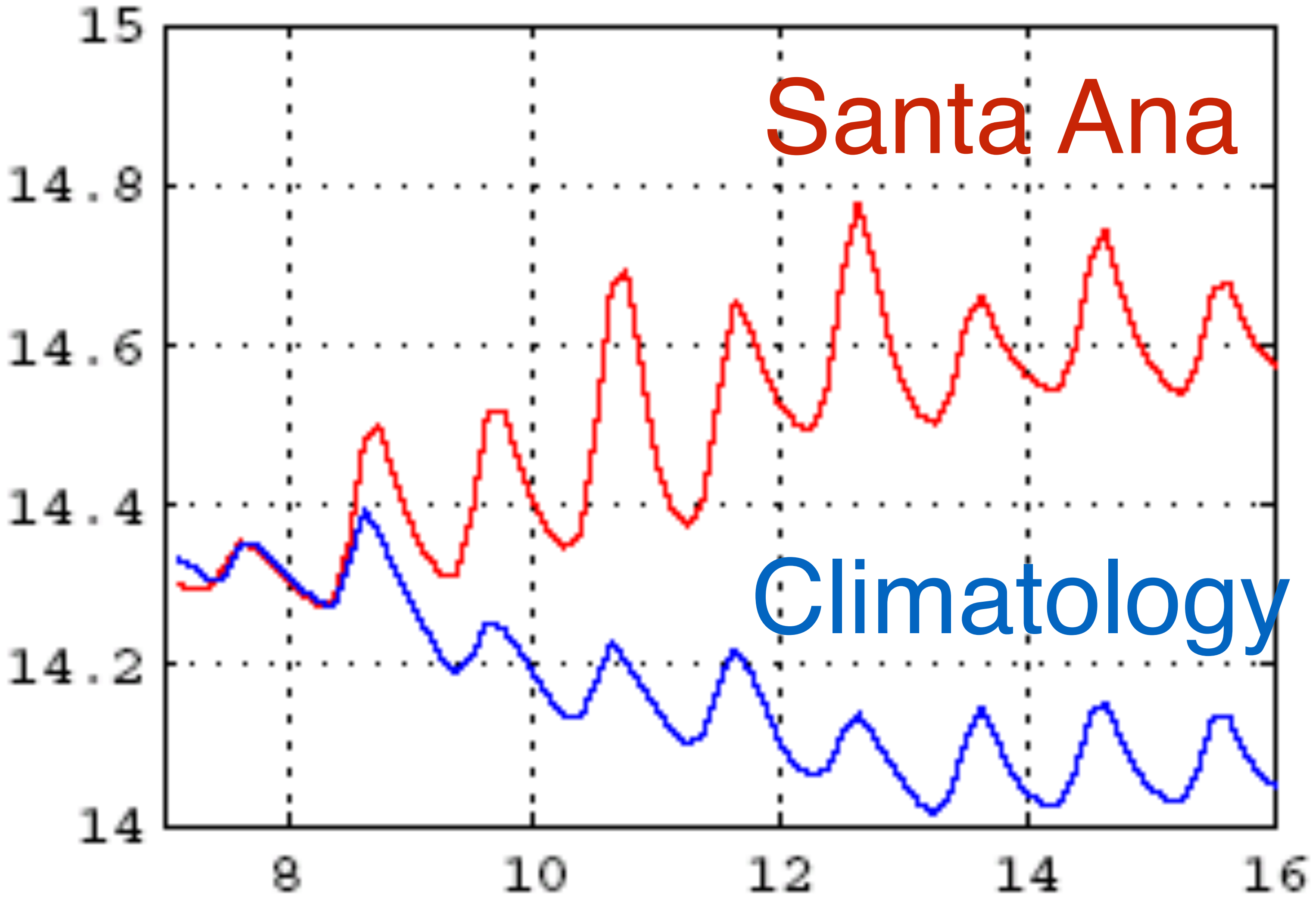
Santa Ana wind event, Feb. 2002



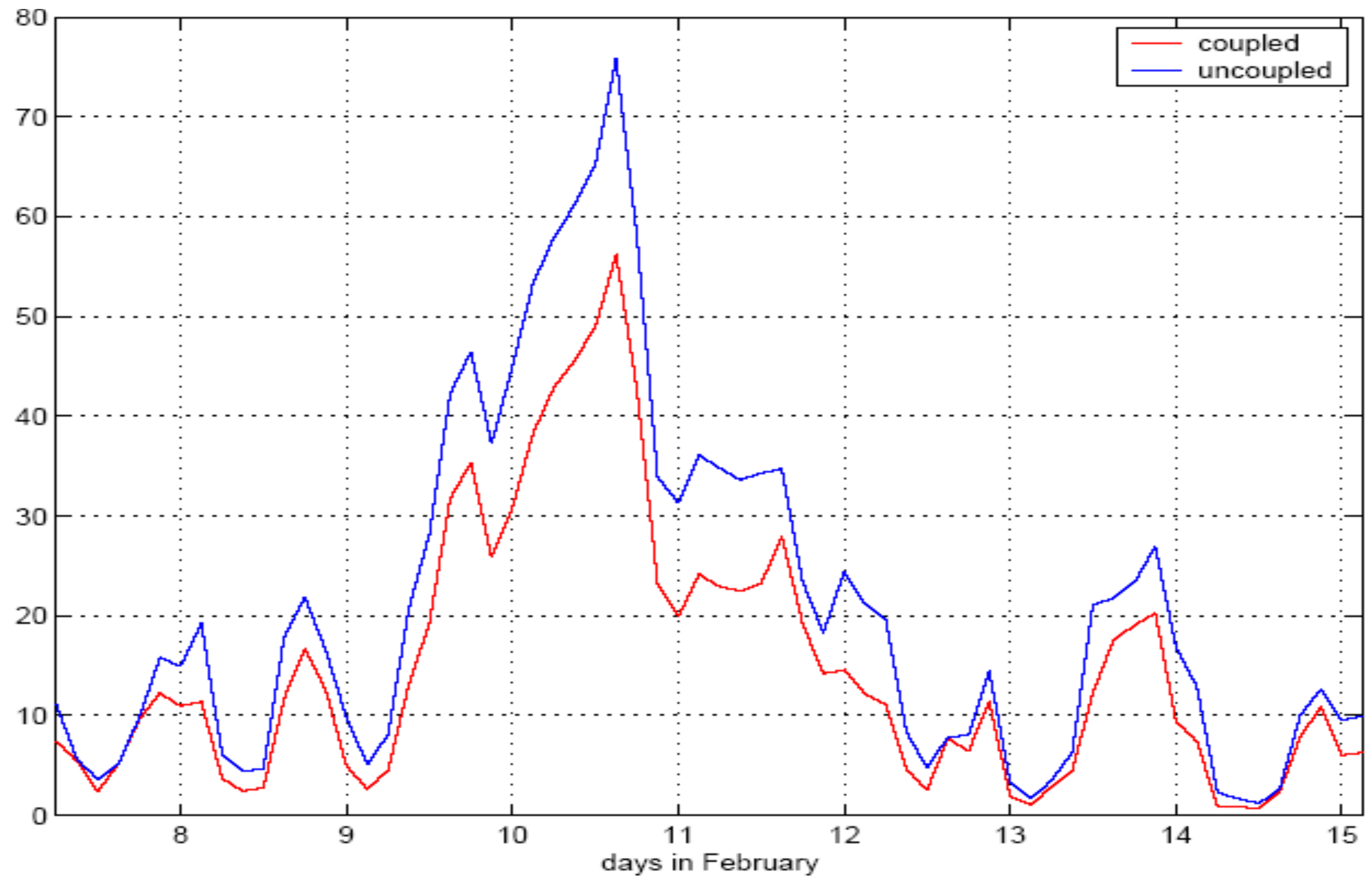
Wind stress Feb 9, 1pm LT



SST in SCB



Fire weather index (FWI), San Diego



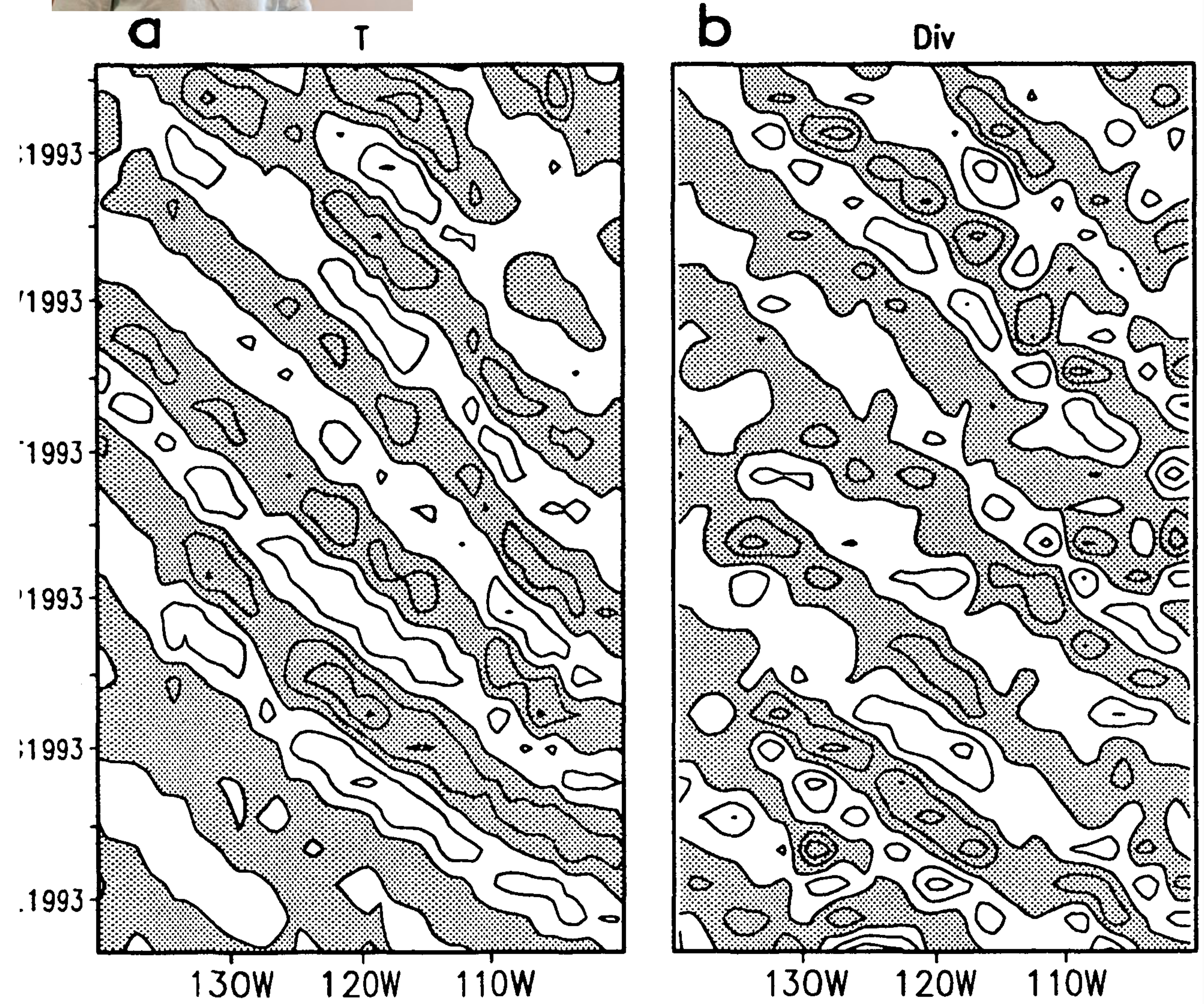
The model sort of worked… But now what??

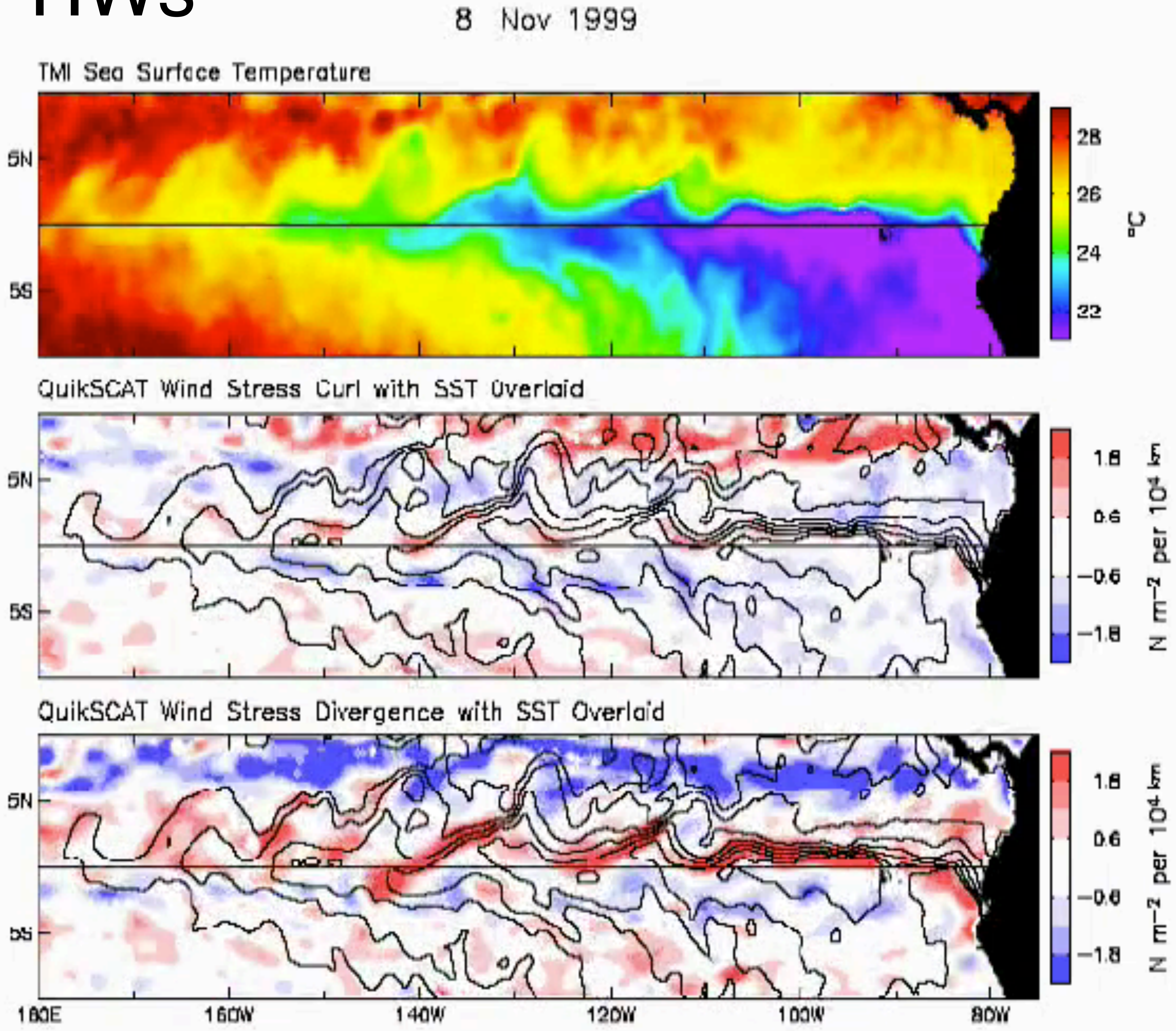
And then we saw these papers….

Xie et al. 1998

Chelton et al. 2001

TIWs



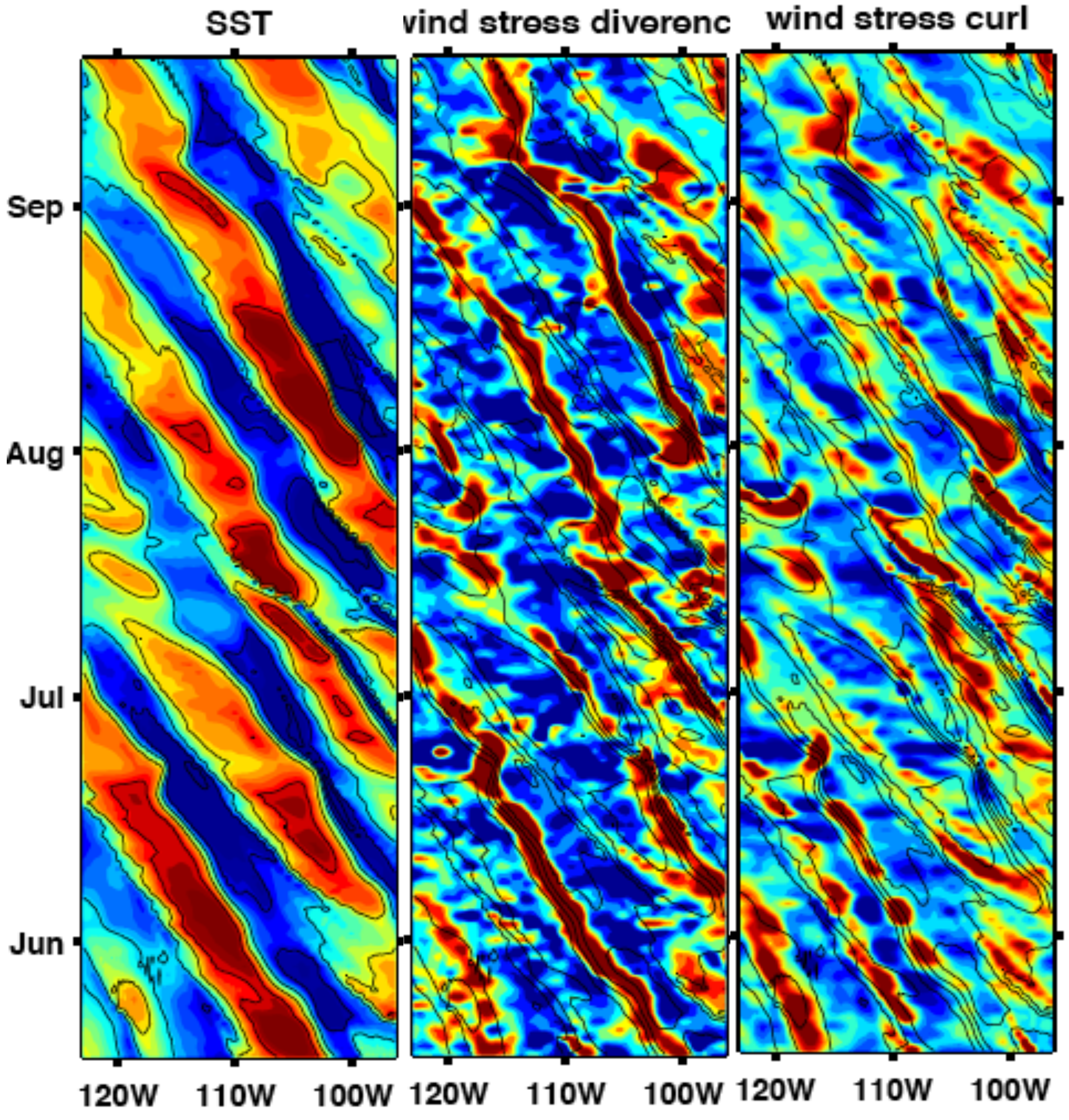


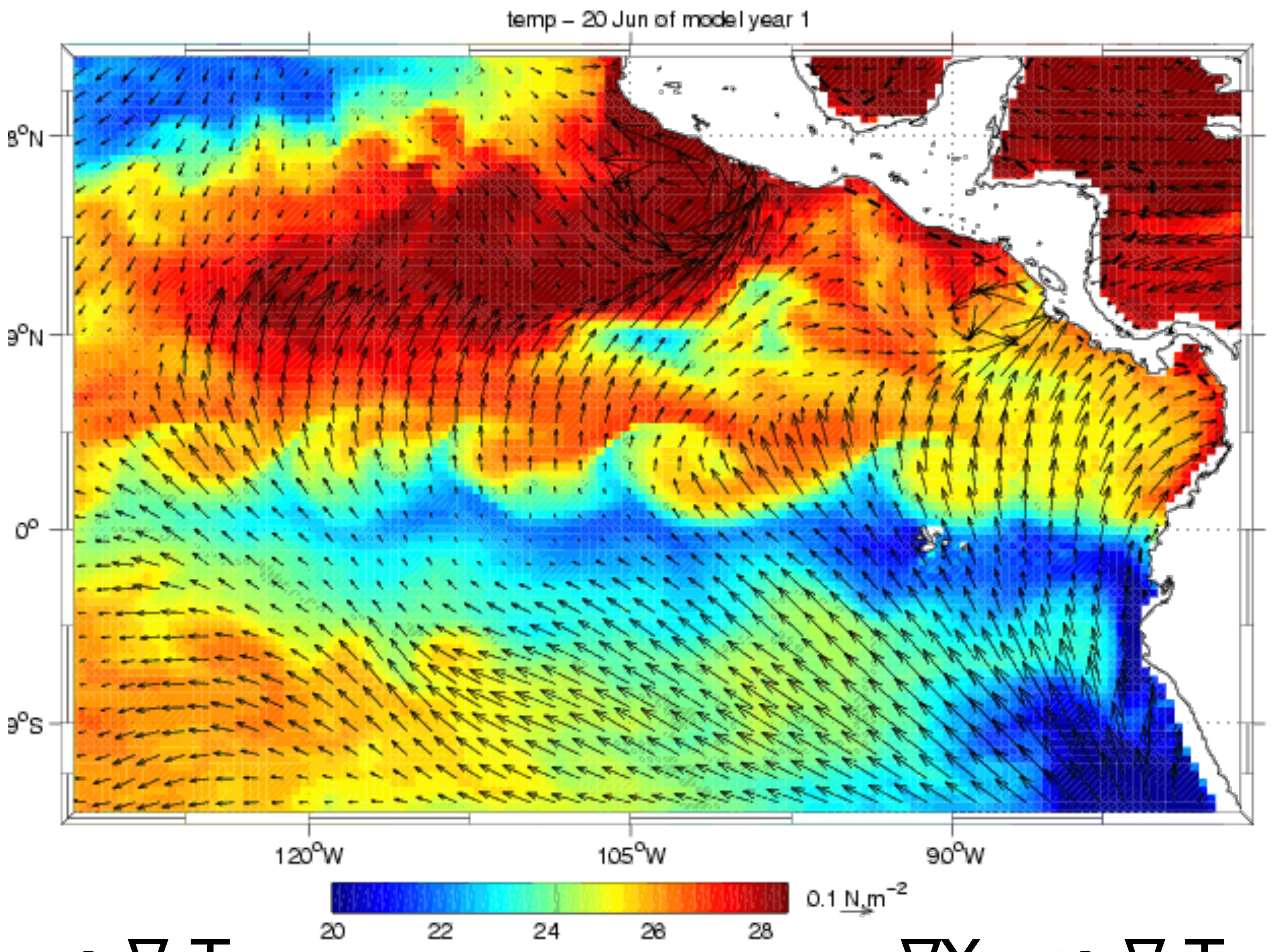
Ugh… wind varies over the scale of eddy…?

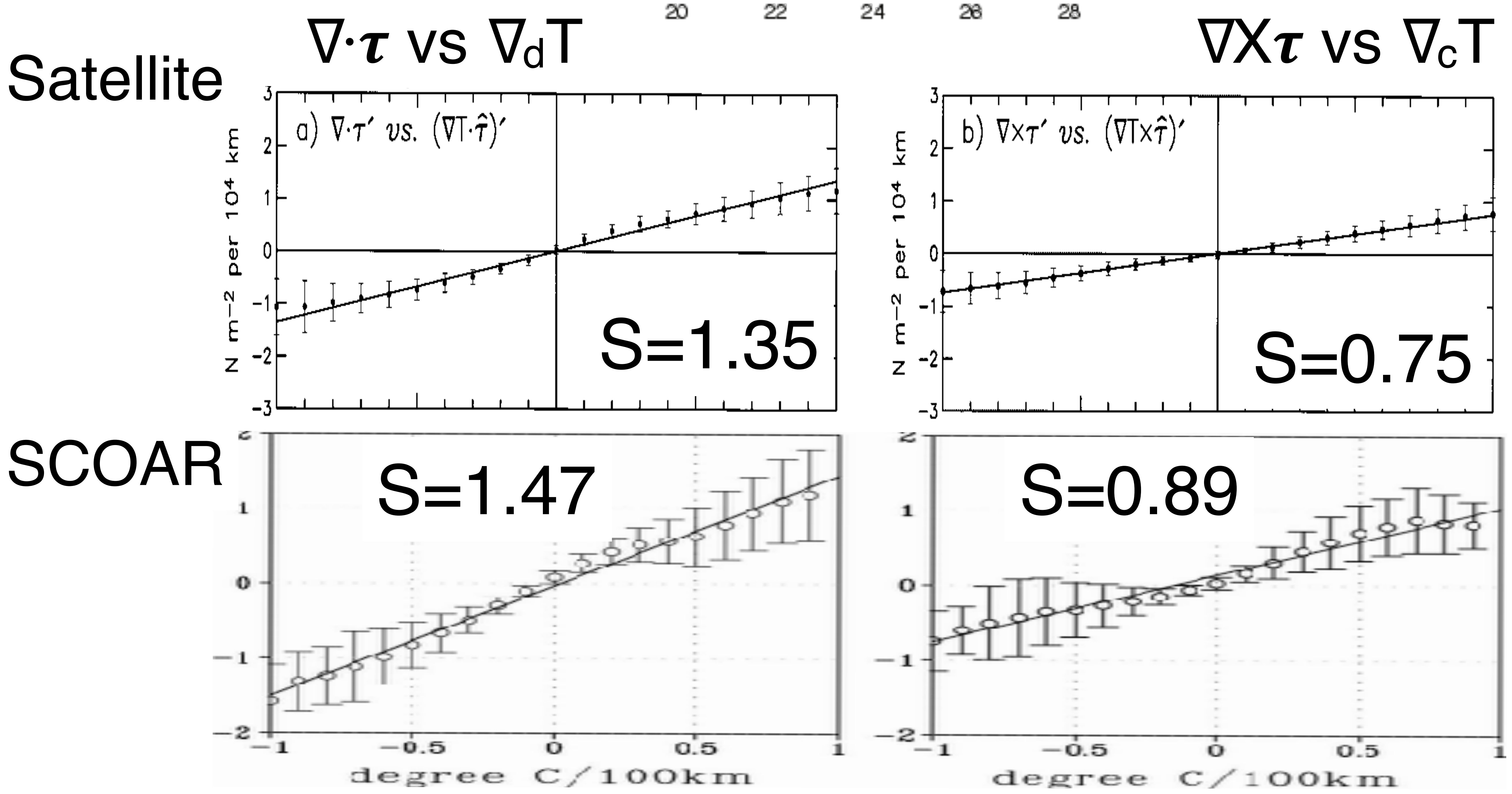
Can the SCOAR simulate it?

Is this atmospheric response important?

The SCOAR reproduced the observed coupling!







and the tour began…

Submission to J. Climate
→ Reject → Major → Major → Minor
→ Accept → Our first SCOAR paper!

The Scripps Coupled Ocean–Atmosphere Regional (SCOAR) Model, with Applications in the Eastern Pacific Sector

HYODAE SEO, ARTHUR J. MILLER, AND JOHN O. ROADS

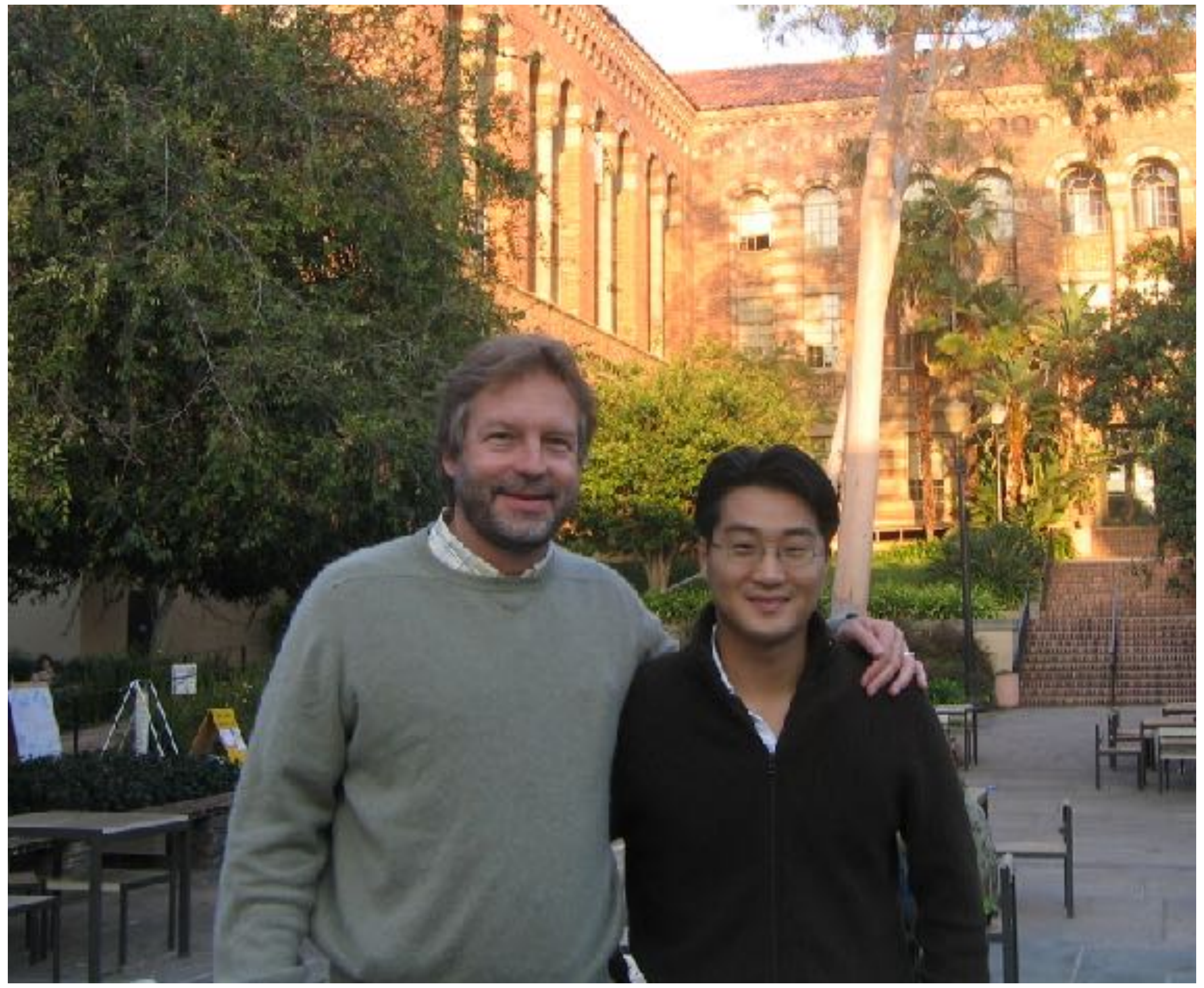
Scripps Institution of Oceanography, La Jolla, California

(Manuscript received 28 October 2005, in final form 13 June 2006)

ABSTRACT

coupled ocean–atmosphere model is introduced. It is designed to admit the air–sea feedbacks
presence of an oceanic mesoscale eddy field. It consists of the Regional Ocean Modeling
MS) and the Regional Spectral Model (RSM). Large-scale forcing is provided by NCEP/DOE
lds, which have physics consistent with the RSM. Coupling allows the sea surface temperature
uence the stability of the atmospheric boundary layer and, hence, the surface wind stress and heat flux fields. The system is denominated the Scripps Coupled Ocean–Atmosphere Regional (SCOAR) Model.

The model is tested in three scenarios in the eastern Pacific Ocean sector: tropical instability waves of the eastern tropical Pacific, mesoscale eddies and fronts of the California Current System, and gap winds of the Central American coast. Recent observational evidence suggests air–sea interactions involving the oceanic mesoscale in these three regions. Evolving SST fronts are shown to drive an unambiguous response of the atmospheric boundary layer in the coupled model. This results in significant model anomalies of wind stress curl, wind stress divergence, surface heat flux, and precipitation that resemble the observations and substantiate the importance of ocean–atmosphere feedbacks involving the oceanic mesoscale.



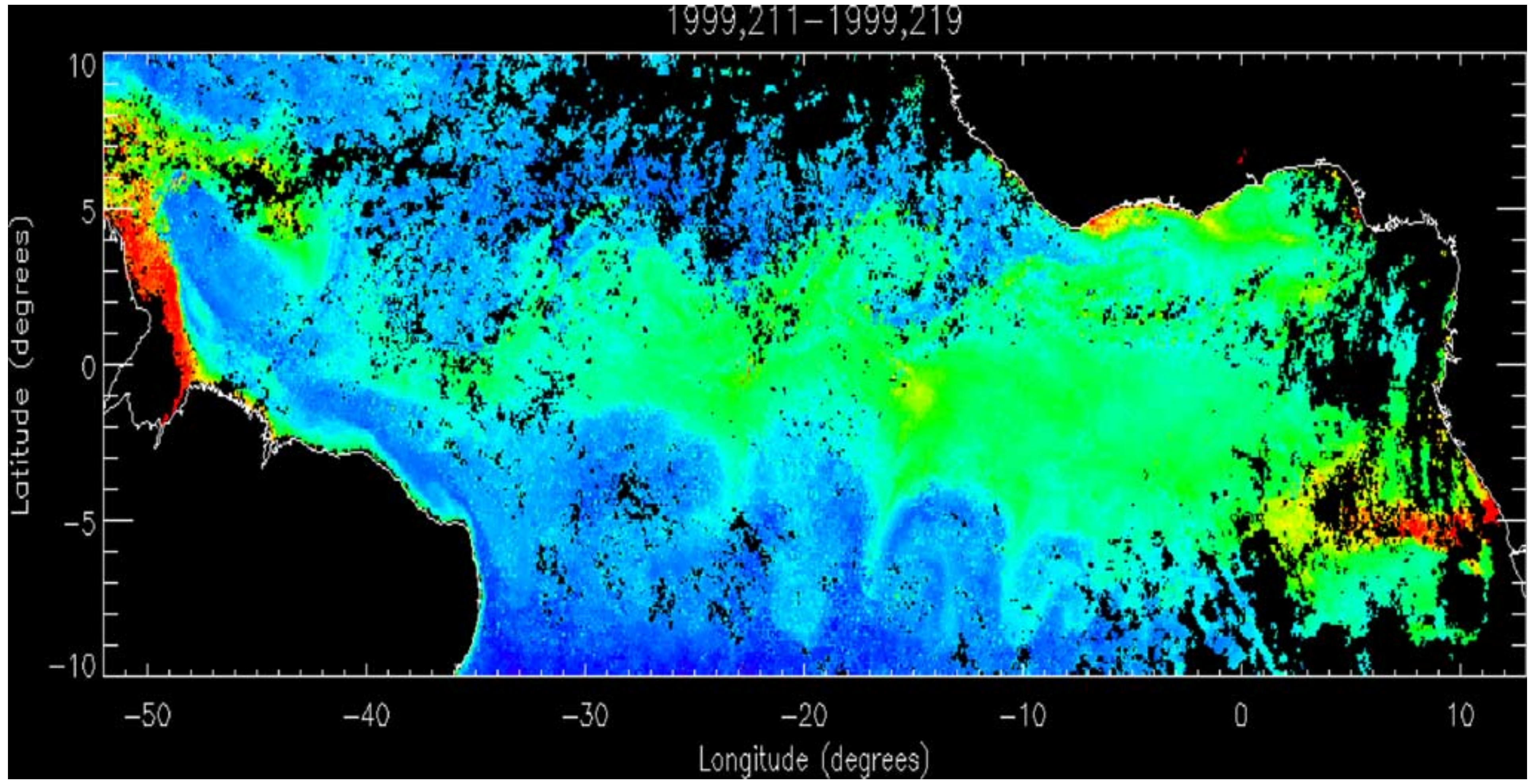
UCLA
2005

NCAR
2006

Then met Markus and Ragu…

… Got me into the Atlantic… and also the habit of heavy drinking…

Energetics of the TIWs
Jochum et al. 2004



But it lacked atmospheric coupling..

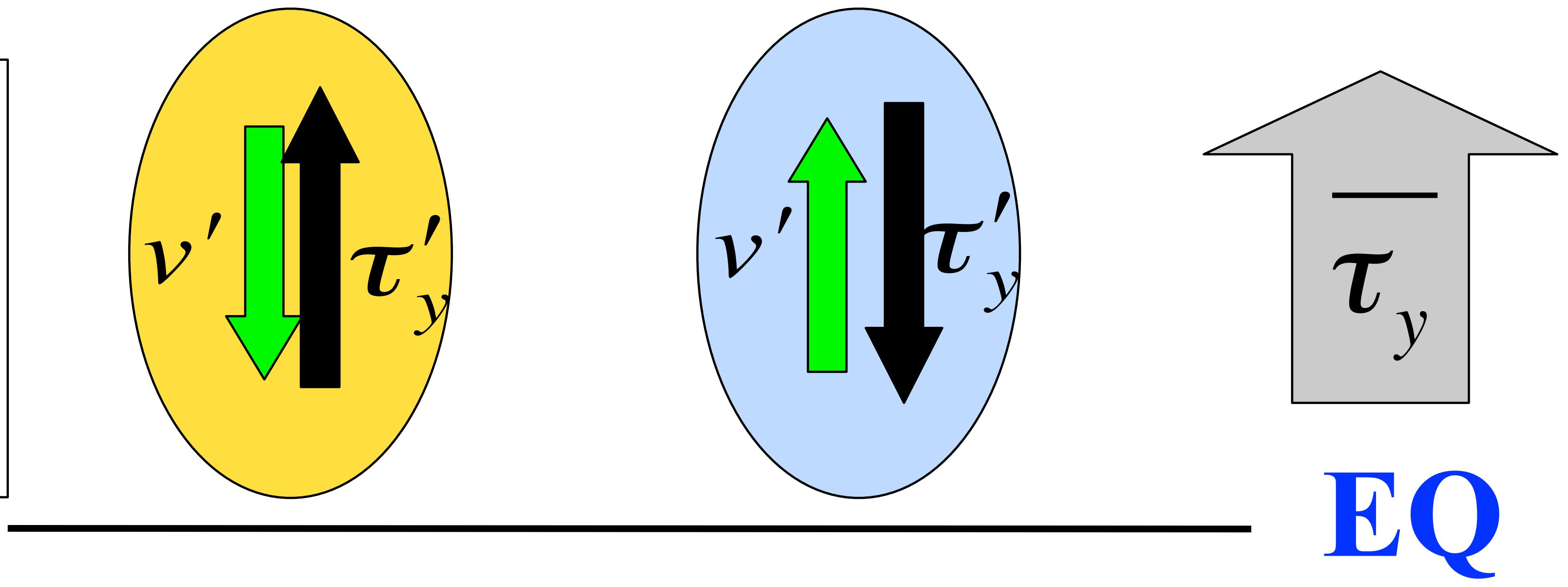
Eddy wind work?

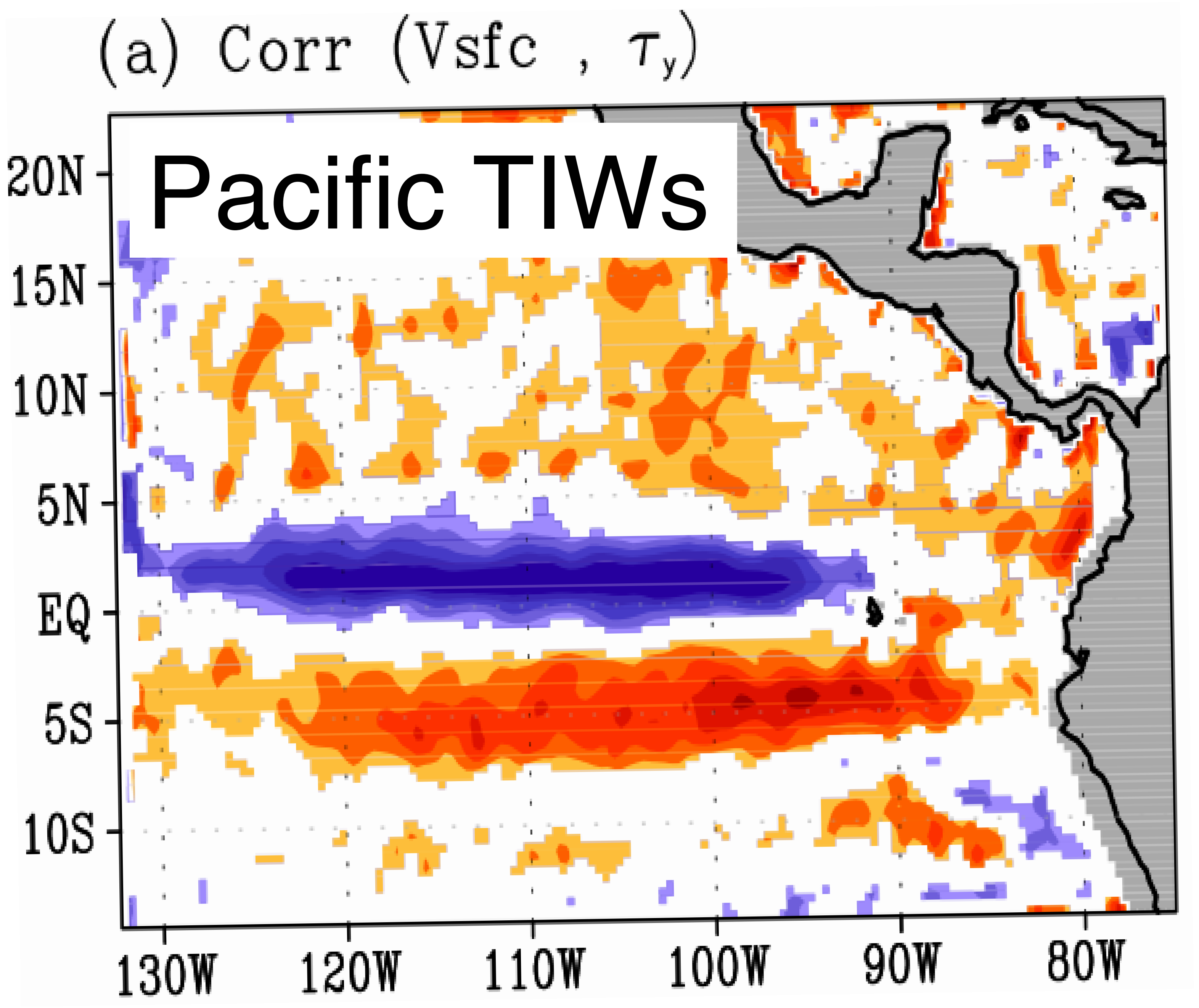
A surprisingly important EKE sink term that no climate models can represent…

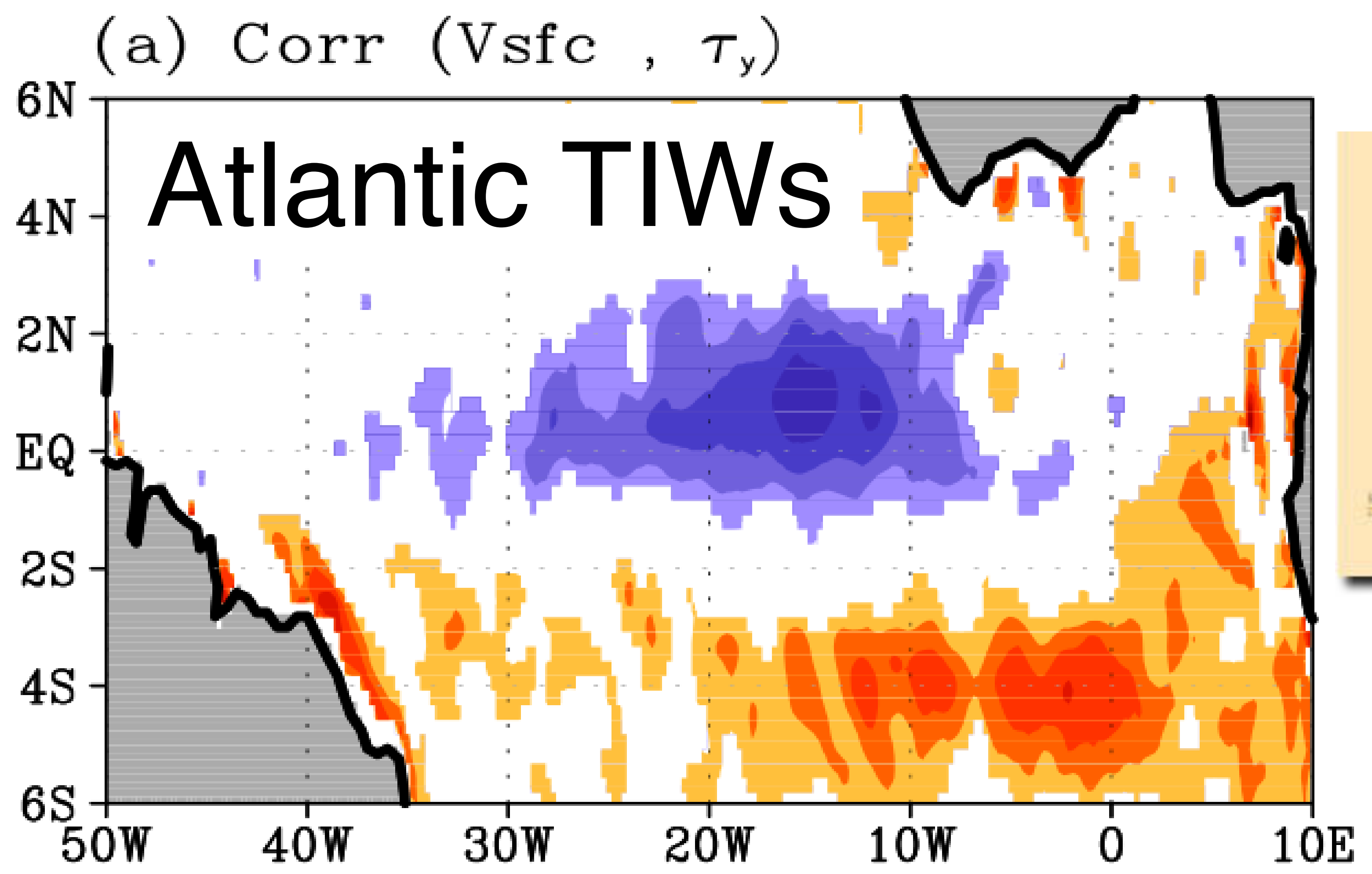
EKE Budget

$$\vec{U}\cdot\vec{\nabla}K_e + \vec{u}'\cdot\vec{\nabla}K_e = -\vec{\nabla}\cdot(\vec{u}'p') - g\rho'w' + \rho_o(-\vec{u}'\cdot(\vec{u}'\cdot\vec{\nabla}\vec{U}))$$
$$+\rho_o A_h \vec{u}'\cdot\nabla^2\vec{u}' + \rho_o\vec{u}'\cdot(A_v\vec{u}'_z)_z + \vec{u}'_{sfc}\cdot\vec{\tau}'_z$$

Masina et al. 1999







Feedback of Tropical Instability-Wave-Induced Atmospheric Variability onto the Ocean

HYODAE SEO
Scripps Institution of Oceanography, La Jolla, California

MARKUS JOCHUM
National Center for Atmospheric Research, Boulder, Colorado

RAGHU MURTUGUDDE
C/DAOS, University of Maryland, College Park, College Park, Maryland

ARTHUR J. MILLER AND JOHN O. ROADS
Scripps Institution of Oceanography, La Jolla, California

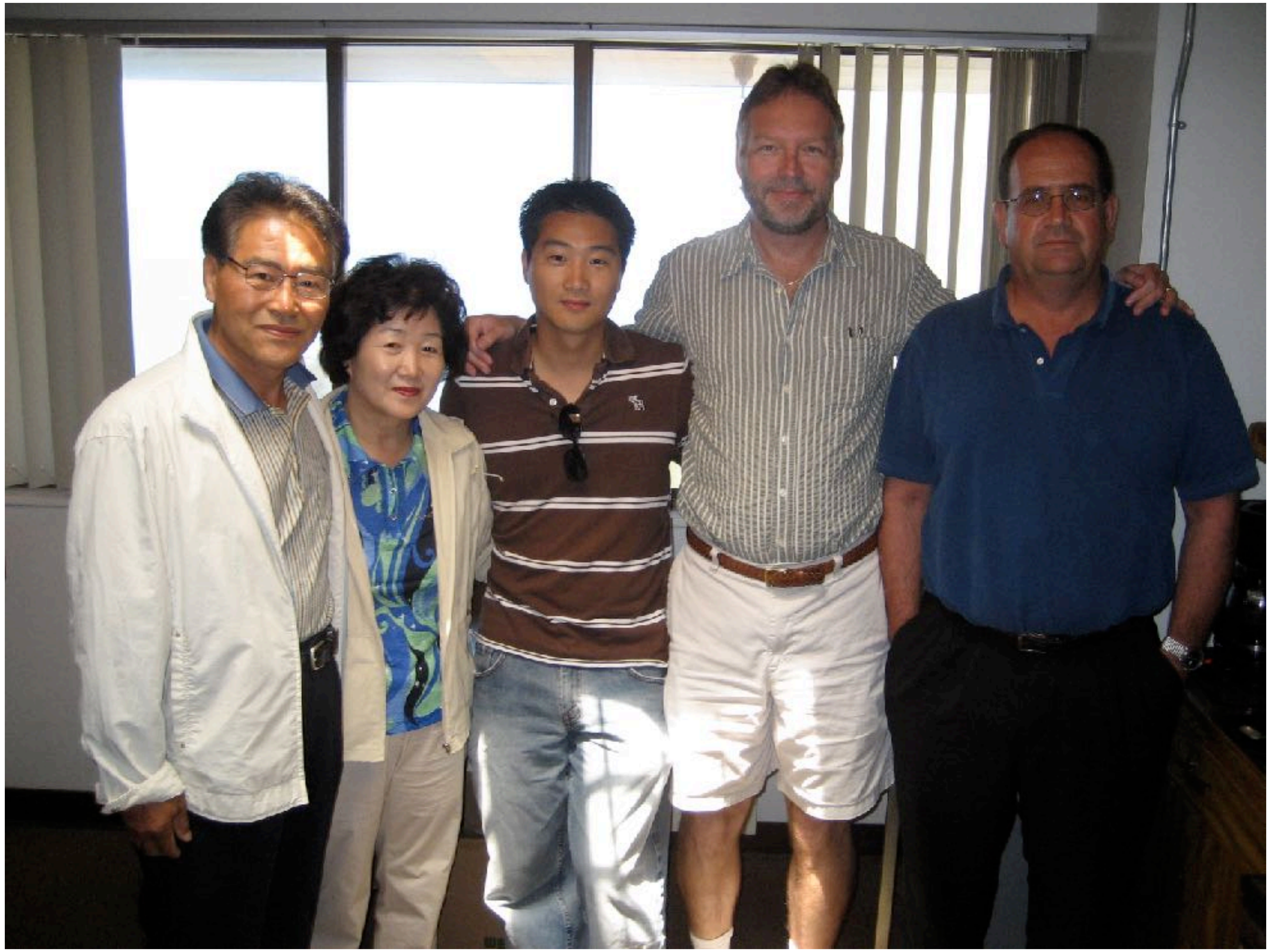
(Manuscript received 27 September 2006, in final form 10 April 2007)

ABSTRACT

The effects of atmospheric feedbacks on tropical instability waves (TIWs) in the equatorial Atlantic Ocean are examined using a regional high-resolution coupled climate model. The analysis from a 6-yr hindcast from 1999 to 2004 reveals a negative correlation between TIW-induced wind perturbations and

Concluding my air-sea research at Scripps…

commencement 2008



my mom & dad, Art & John
2007 summer

Many questions remain unanswered:

How different are the effects by eddy SST-wind coupling vs current-wind coupling?

$$\tau = \rho_a C_D (W-U)|W-U|$$

T_e-τ coupling

Anticyclonic eddy

U_e-τ coupling

Dipolar W_e:
Max. W_e over ∇T

Chelton 2013

Monopole W_e:
Max. W_e over Min. ∇T

Dian’s online spatial smoothing within SCOAR is BRILLIANT!!

Contents lists available at ScienceDirect

Dynamics of Atmospheres and Oceans

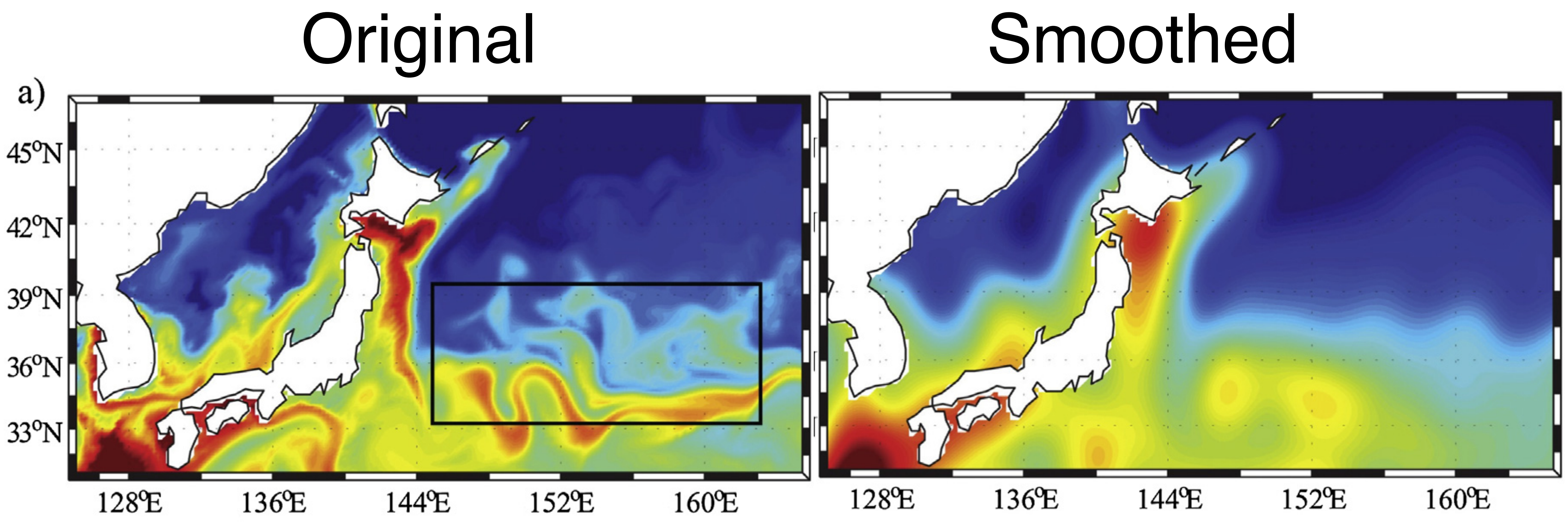
ELSEVIER

journal homepage: www.elsevier.com/locate/dynatmoce

Isolating mesoscale coupled ocean–atmosphere interactions in the Kuroshio Extension region

Dian A. Putrasahan[a,*], Arthur J. Miller[a], Hyodae Seo[b]

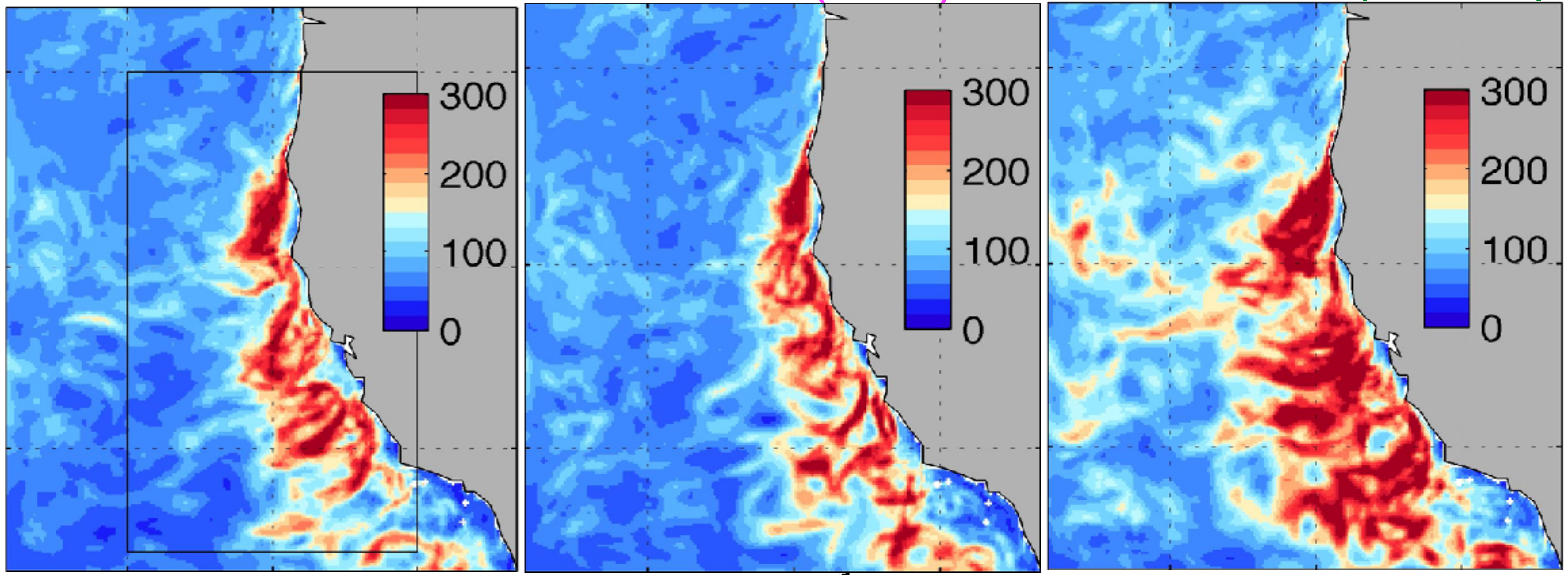
[a] Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093-0224, USA
[b] Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA



Putrasahan, Miller, Seo 2013. DAO

First-time demonstration of distinctive EKE response to two types of mesoscale O-A coupling

CTL: 117 | noT$_e$: 116 (-1%) | noU$_e$: 166 (+42%)

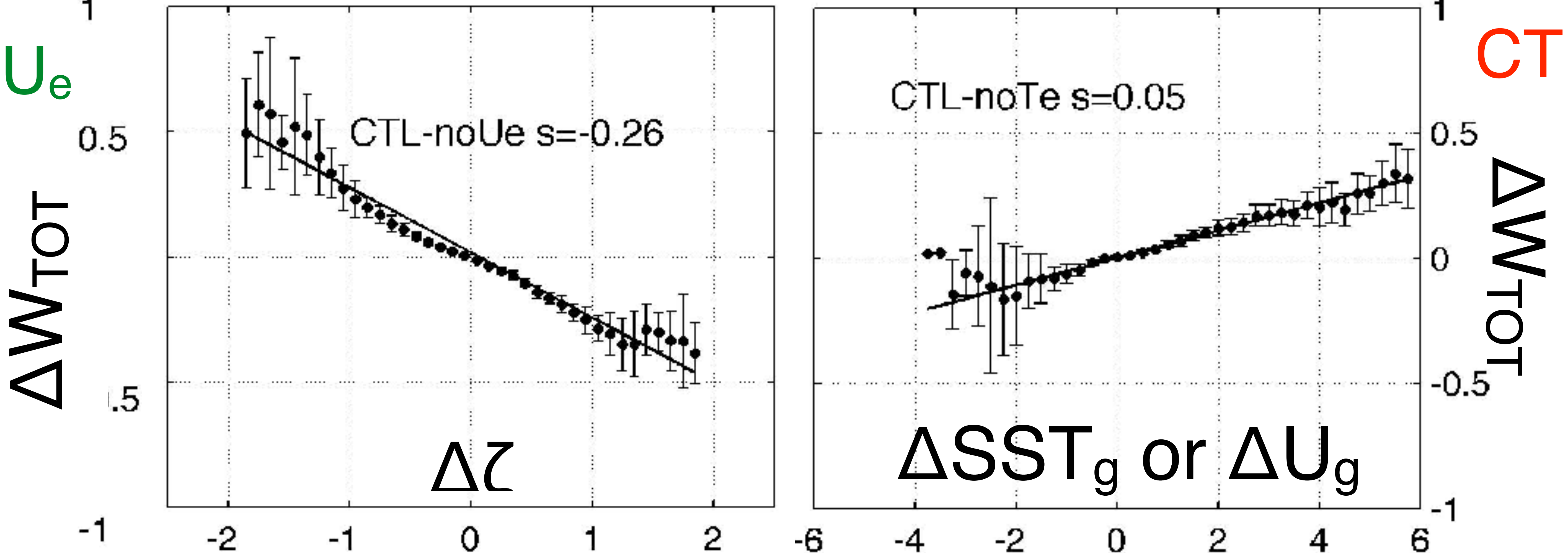


Online smoothing separately applied to SST and surface current

Seo, Miller, Norris 2016, JPO

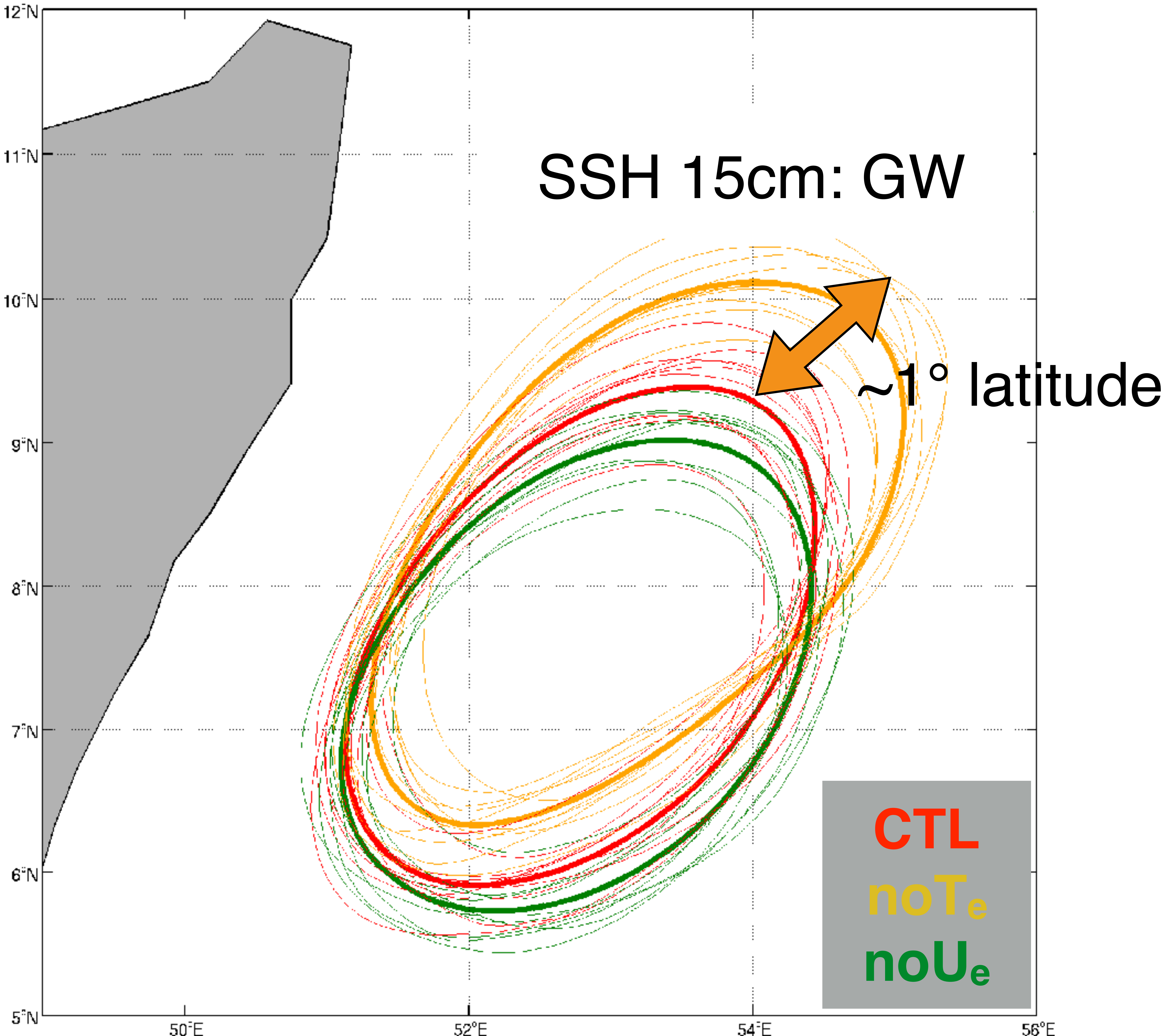
One mechanism based on induced Ekman Pumping velocity

CTL-noU$_e$



CTL-noT$_e$

Does SST-wind coupling *really* shift the eddy position?



Yes!!!!
About 1° downstream shift of the Great Whirl when eddy-SST-wind coupling is suppressed.

Seo 2017 JCLI

Ocean mesoscale air-sea coupling is an *active* area of research now!

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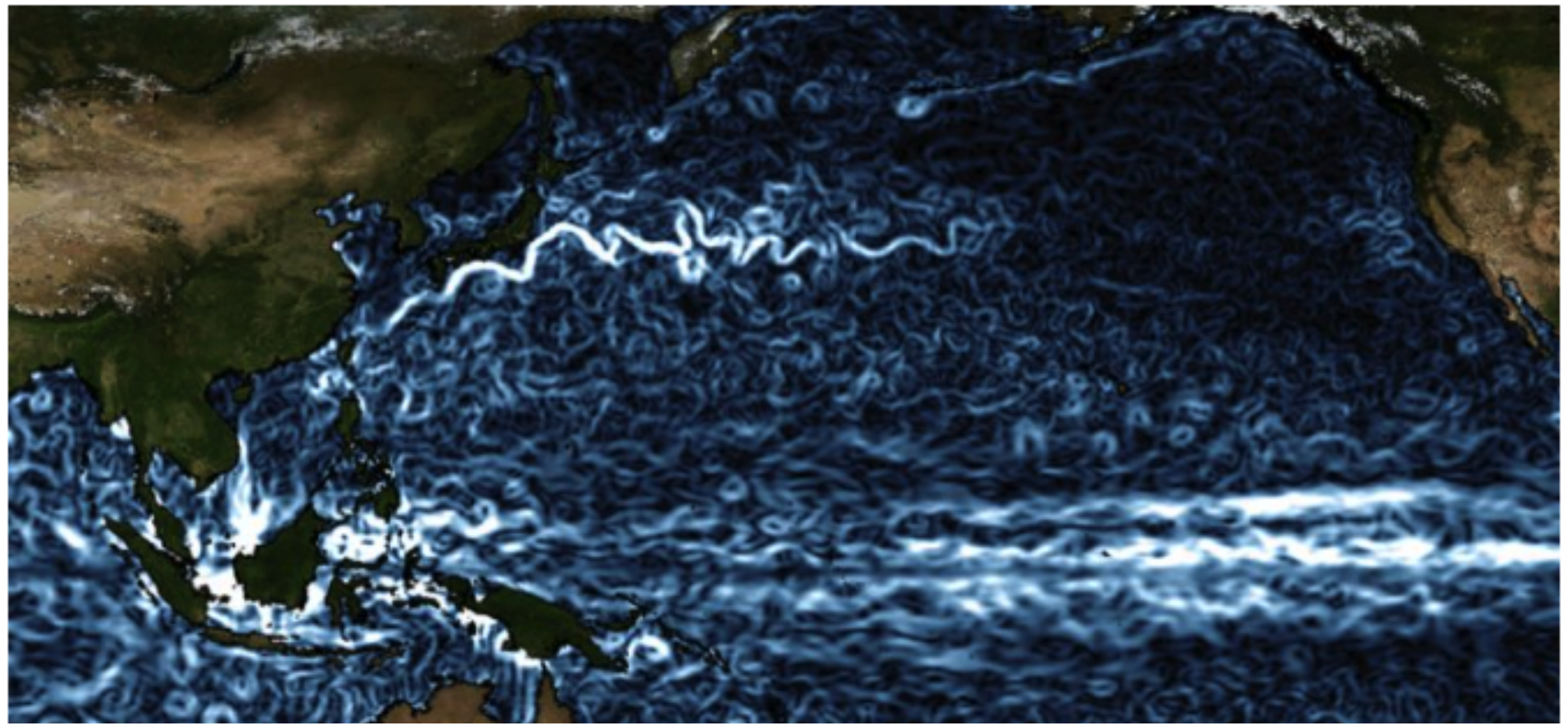
Exploring the Interplay Between Ocean Eddies and the Atmosphere

Ocean Mesoscale Eddy Interactions with the Atmosphere: A CLIVAR Workshop; Portland, Oregon, 17–18 February 2018



It is NOT a high-wavenumber noise, but forms a fundamental part of the coupled system.

It is natural to ask how important it is, how to best measure, simulate, and interpret.

With *insights, opportunities,* and many *unconditional supports* by Art,
I am extremely fortunate to be trained to become part of the community leading this sort of research!

Thank you, Art!!

Happy Birthday!

Thank you, Team Miller!