Imprints of Coastal Mountains on Ocean Circulation and Variability

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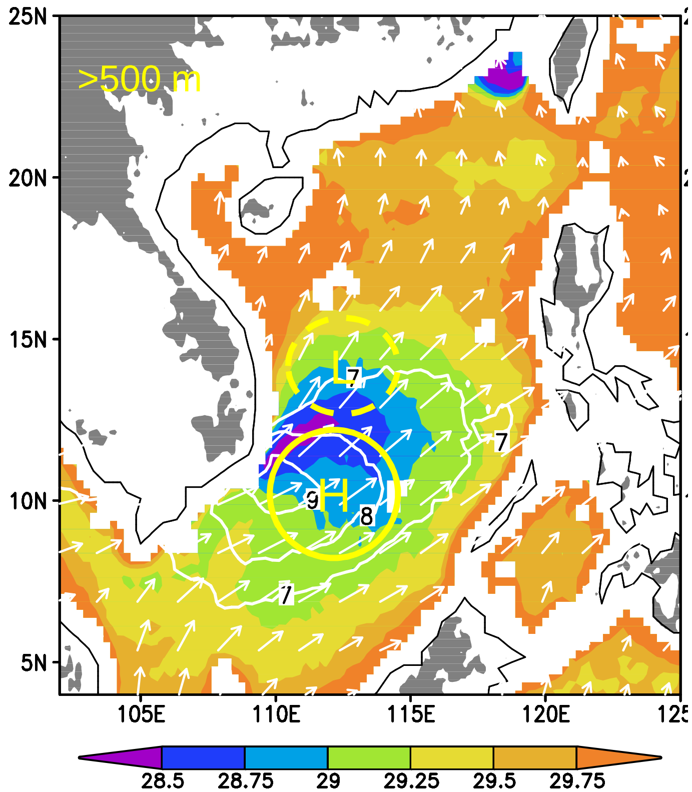
Orographic jets → Ocean circulation (We) & SST

① South China Sea: orog. forcing from the west

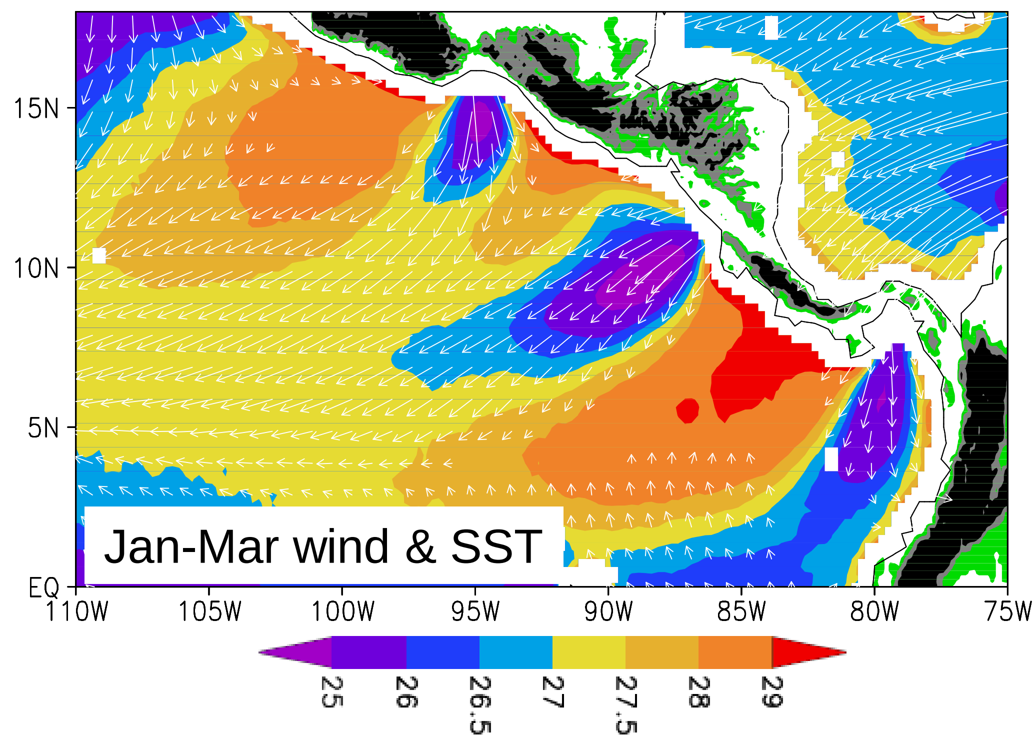


Jul-Aug wind & SST

Xie et al. (2003, 2007, JGR)

Comparative study at similar latitudes

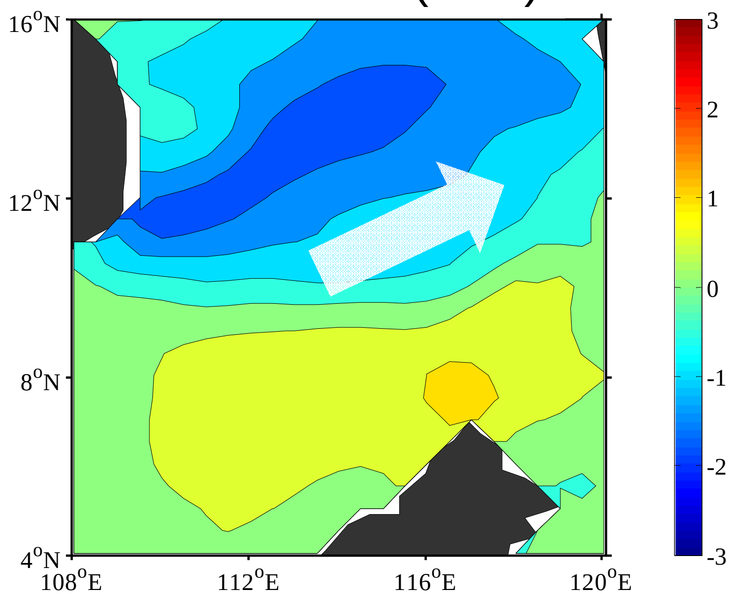
② Eastern Pacific: orog. forcing from the east



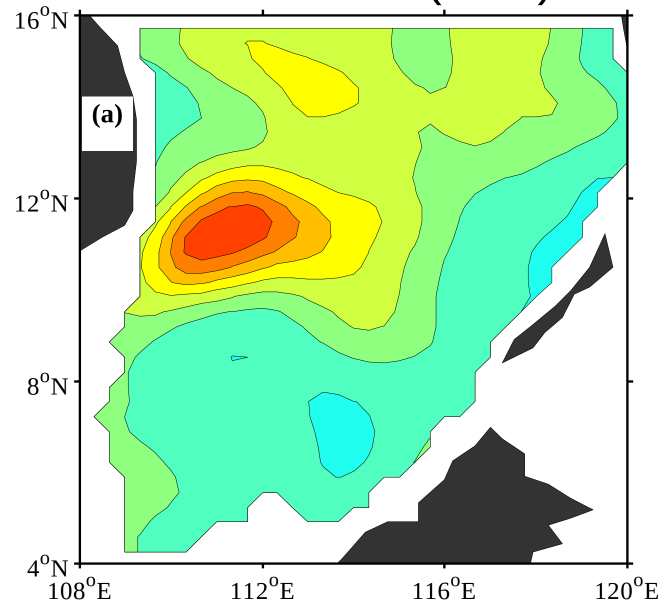
Xie et al. (2005, JC)

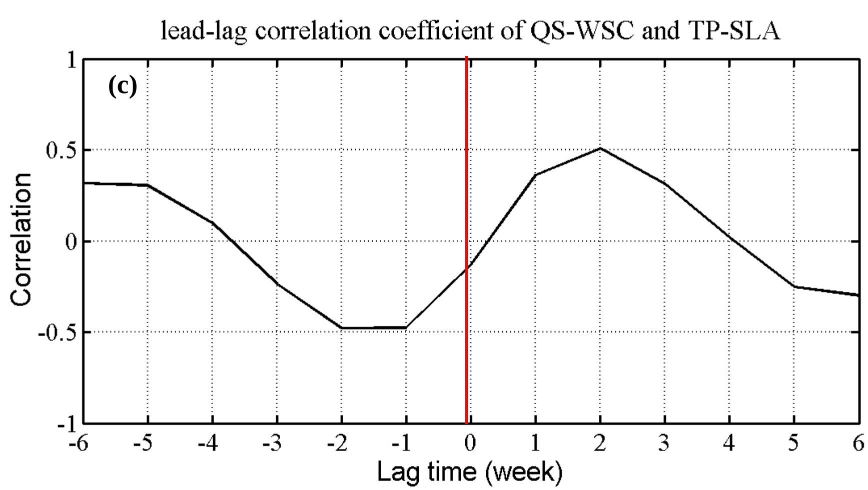
Summer (Jun-Sept)

Wind curl EOF (41%)



SSH EOF (17%)



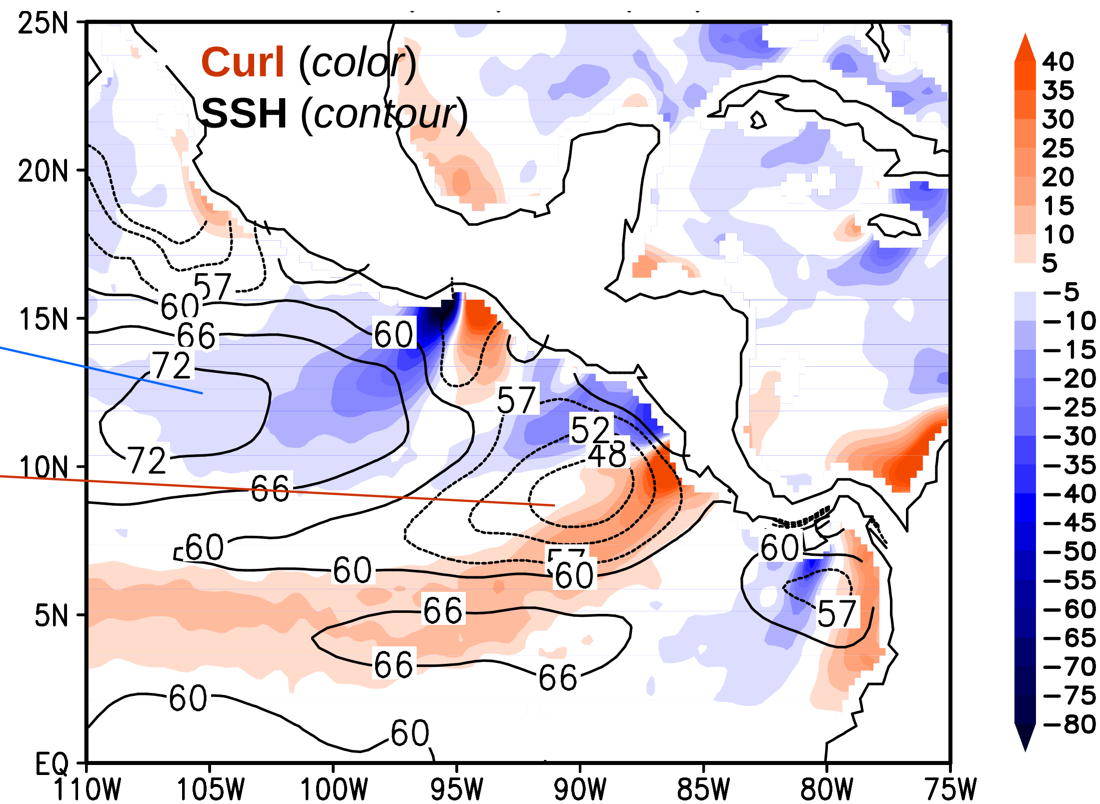


- Max correlation ~ 0.5 when wind curl leads SSH by 2 weeks ← MJO, wind-forced Rossby wave adjustment (Xie et al. 2007, JGR-Oceans)
- Max SSH response on the gyre boundary ← organization along the inertial jet (e.g., localized increase of beta on the gyre boundary)

Winter Mean Circulation in Sverdrup Balance

Sverdrup relation $\beta V = curl\,\tau$

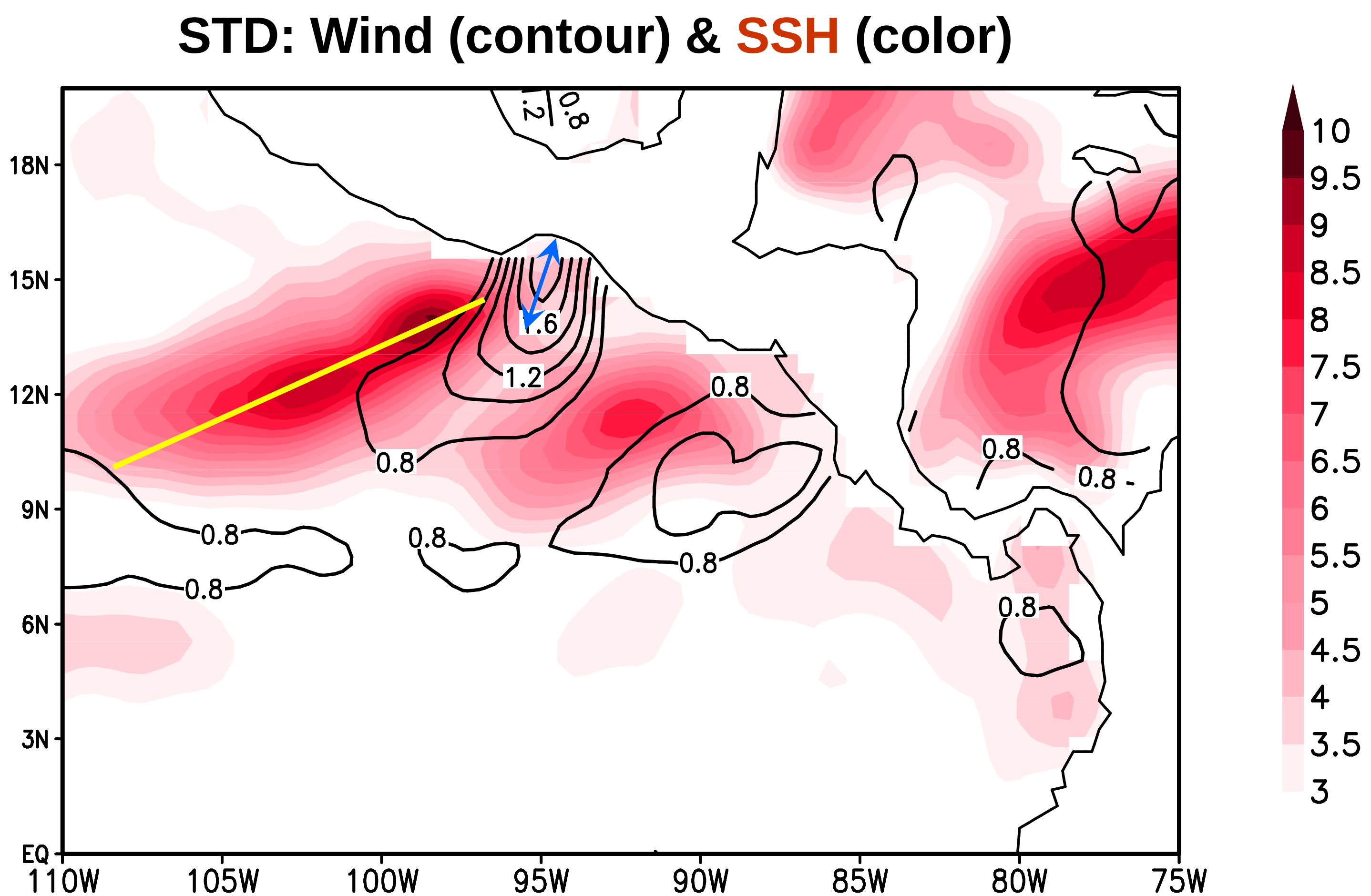
Winter Wind + Spring Circulation



Ocean circulation in **Sverdrup balance with wind curls**

- **Tehuantepec Bowl**
  - Tehuantepec jet
  - AntiCyclonic gyre (SSH high ~72cm)
- **Costa Rica Dome**
  - Zonal Papagayo Jet
  - Cyclonic gyre (SSH low ~ 48cm)
- **Panama Circulation**
  - Meridional Panama jet
  - Cyclonic gyre (SSH low ~ 57 cm)

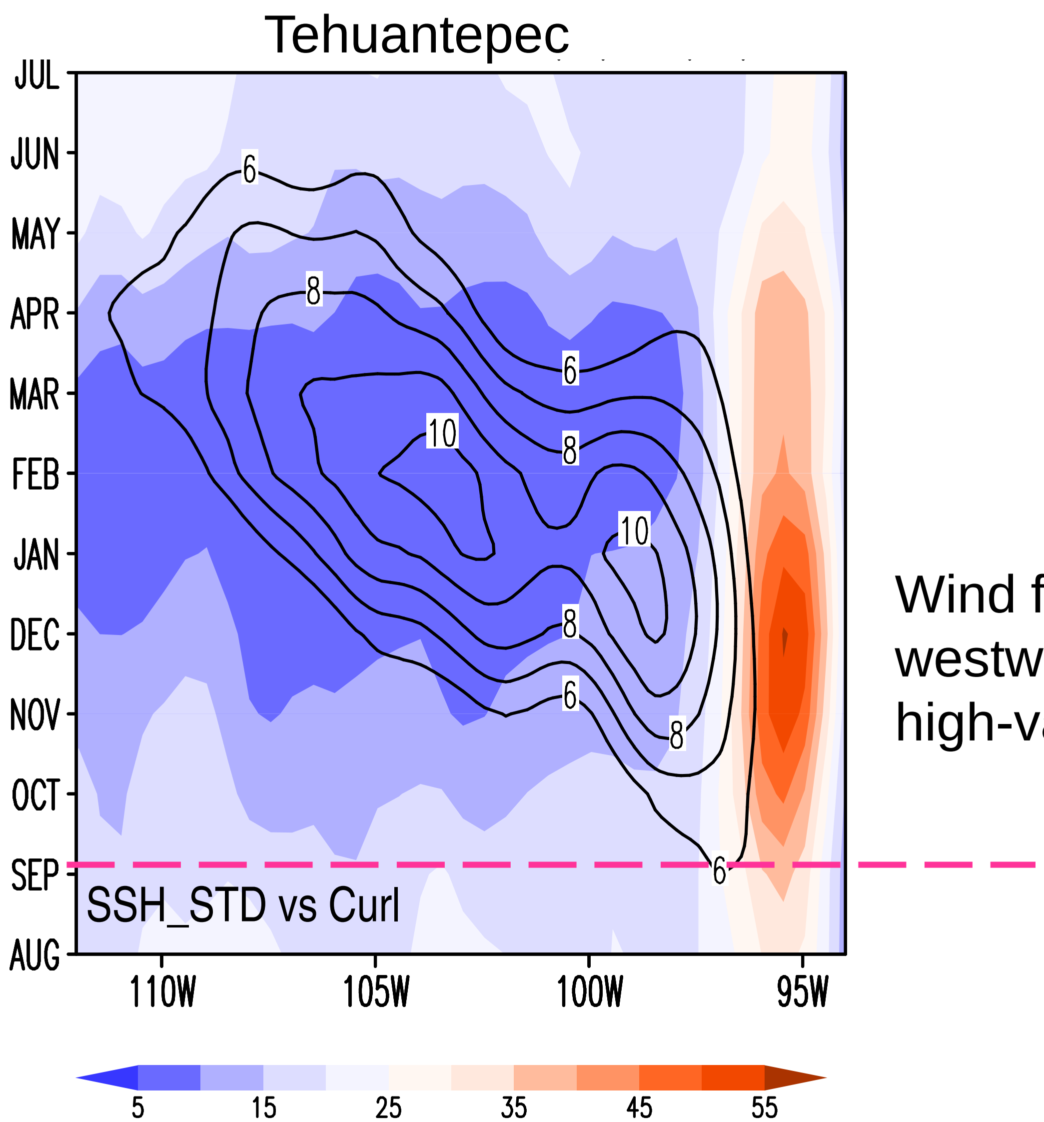
Gap Wind Season (Nov-Feb) SSH Variability



Spatial relationship b/w **Wind & SSH (color)**

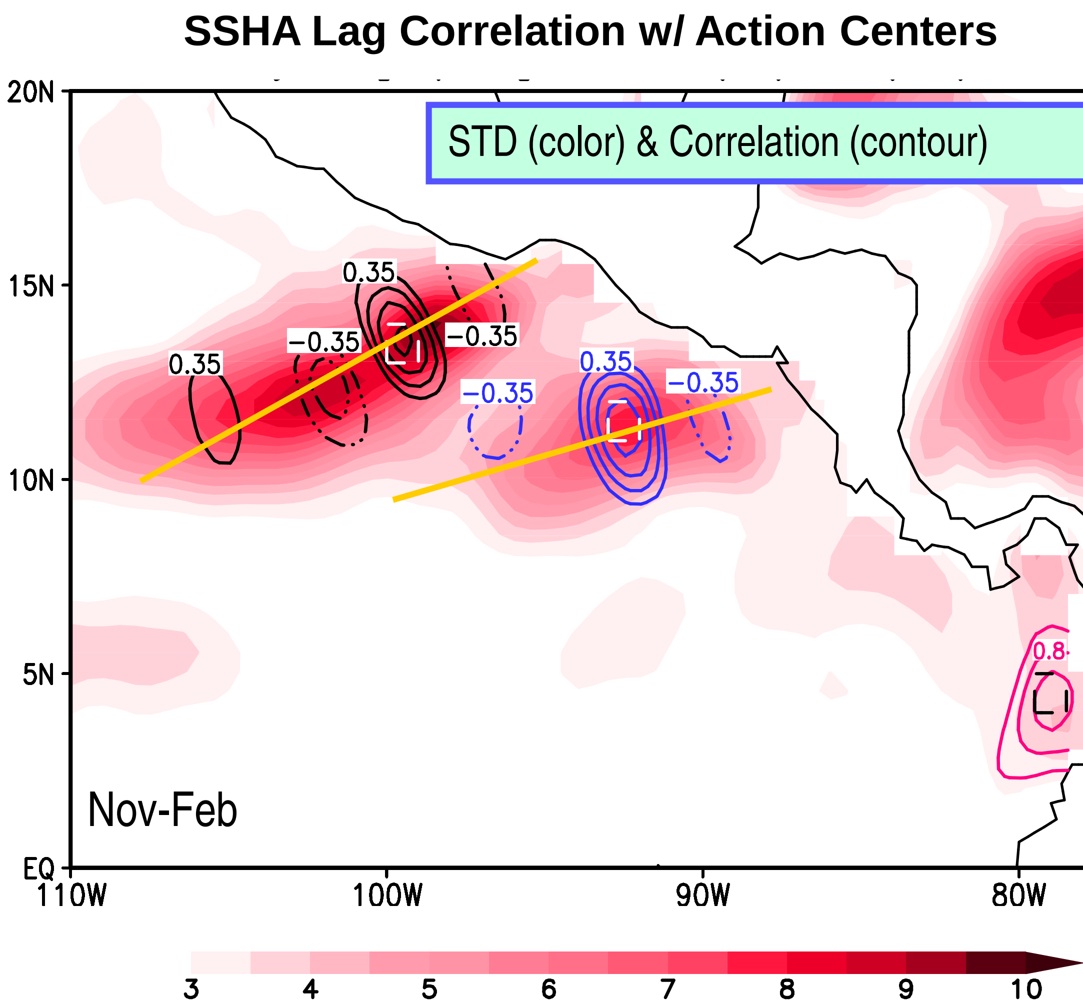
→**SSHA variability may be forced by wind via Ekman pumping mechanism**

Standard deviations of intraseasonal variability in SSH (contour) & Wind Stress Curl (color)



Wind forced,
westward propagation along the high-variance band

Coherent Eddy-train Structure in High Variance Band



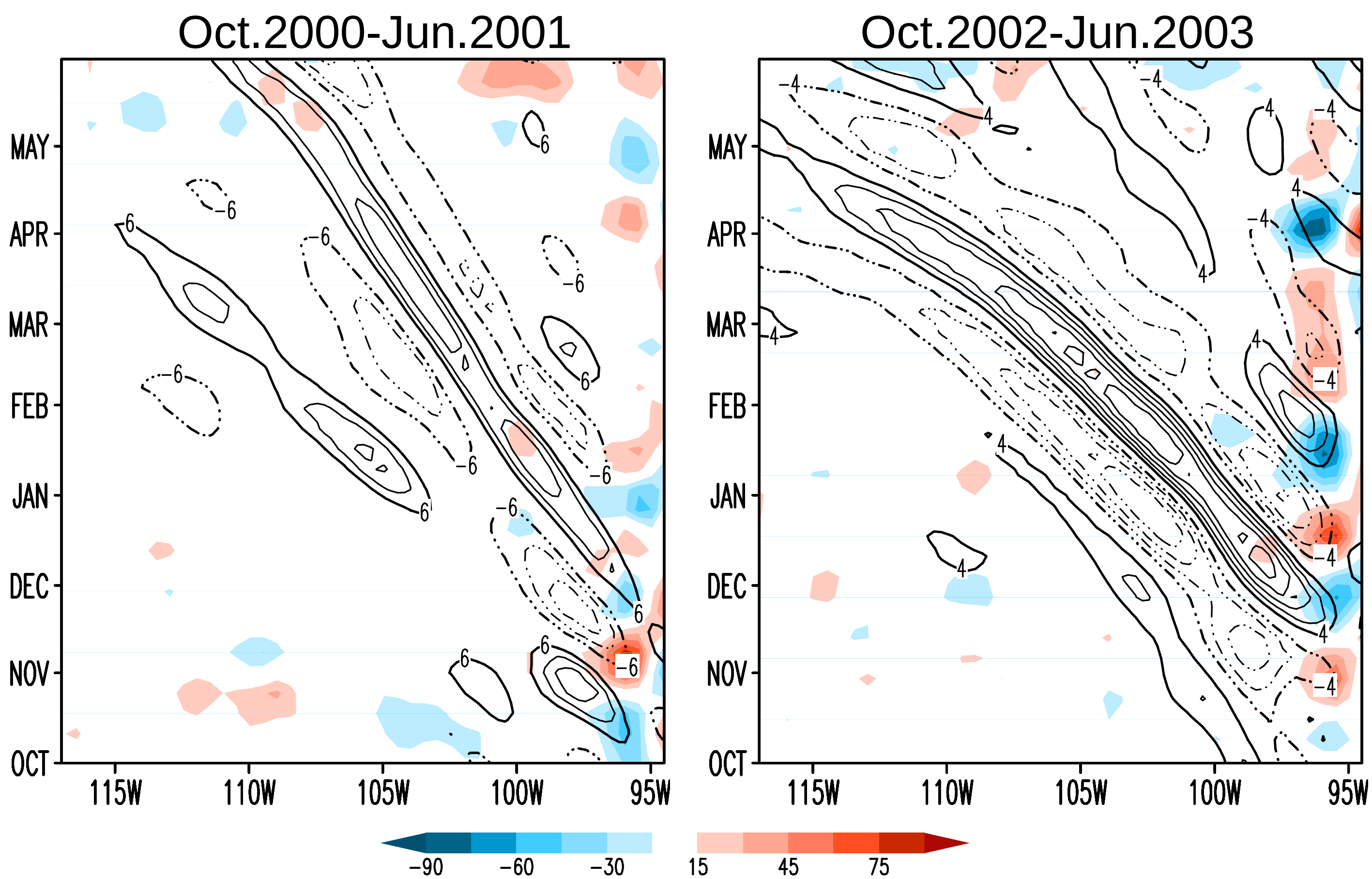
Lag Correlation
w/ **Action Centers**
near Three Gaps

Action Center
=: **local max SSHA STD**
(marked by squares)

Correlation in contours
Black: w/ Tehuantepec AC
Blue: w/ Papagayo AC
Pink w/ Panama AC

Tehuantepec Time-Distant Diagram
SSHA vs Wind Stress Curl (2000-01; 2002-03)

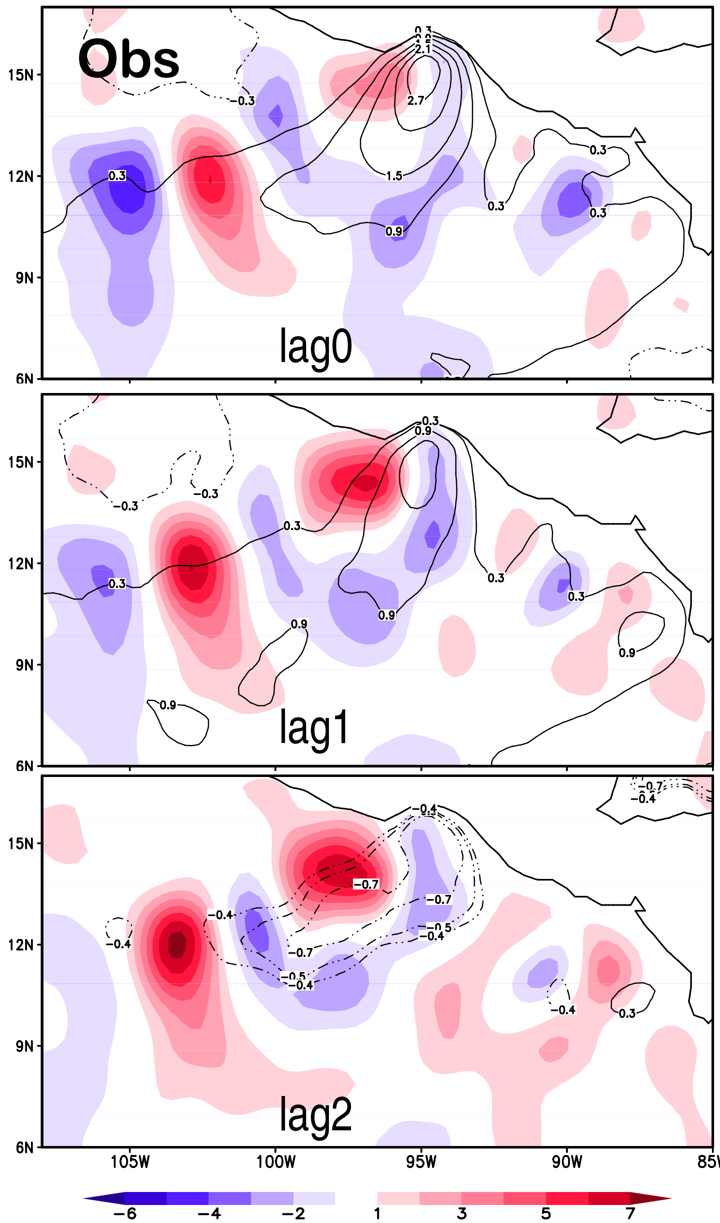
Still along the same axis (will change later)



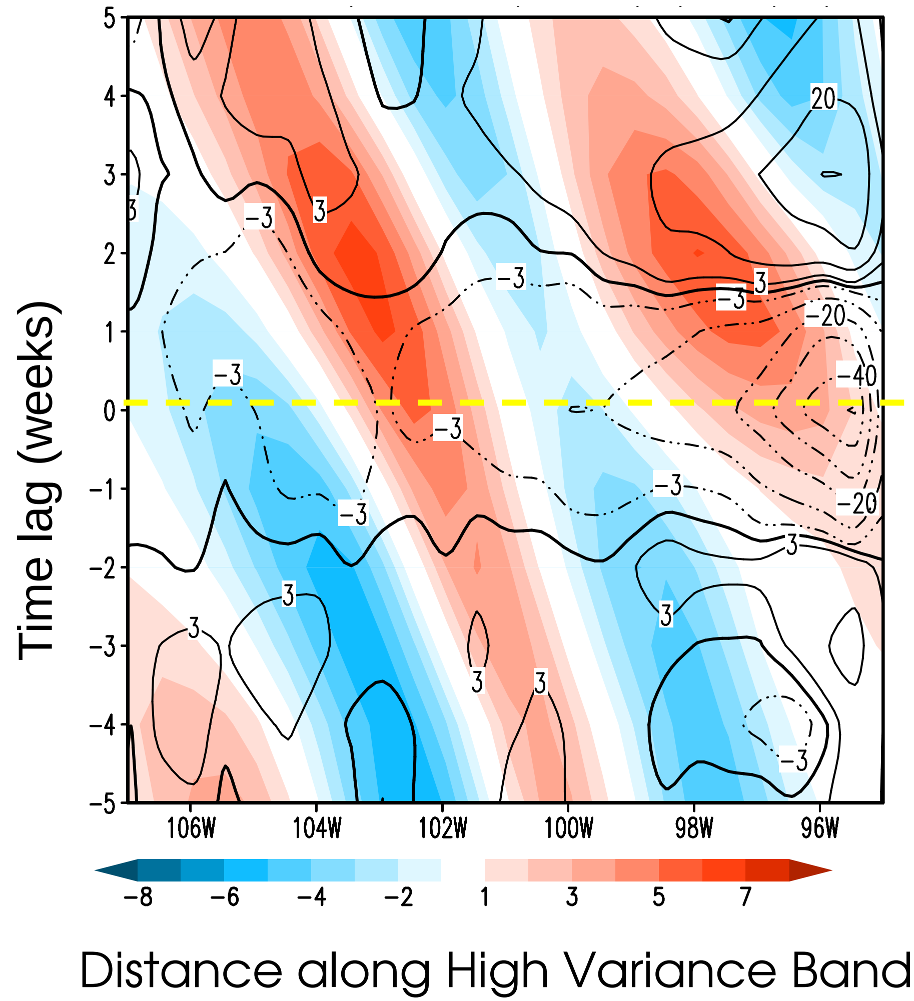
SSHA clearly responding to wind forcing: offshore propagation of **Positive SSHA signal** seen right after strong coastal **negative Wind Stress Curl**

High-wind composites

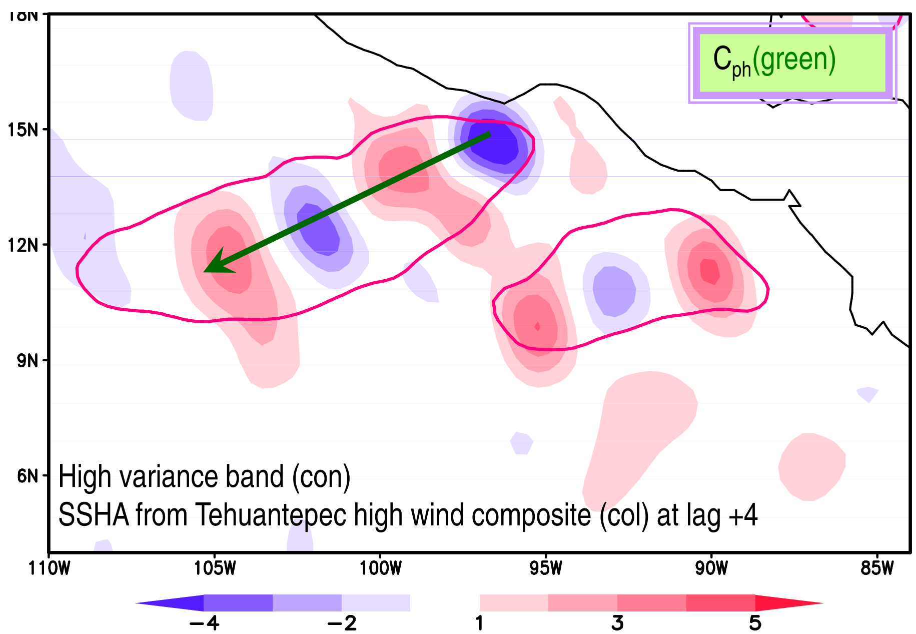
SSH (color) & Wind speed

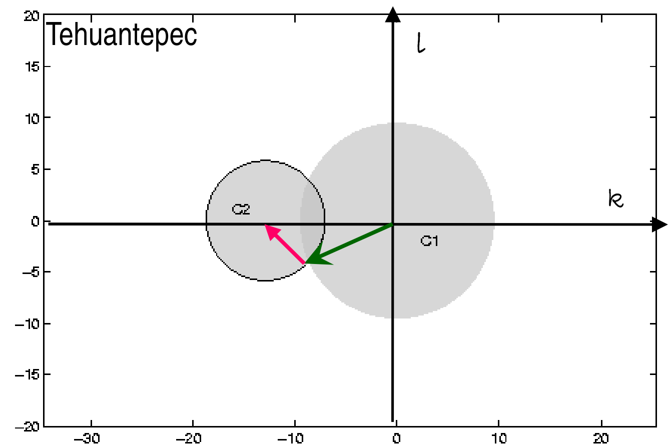


SSH (color) & Wind Curl(con)



Phase velocity of Rossby waves; wavelengths set by the dispersion given intraseasonal frequency



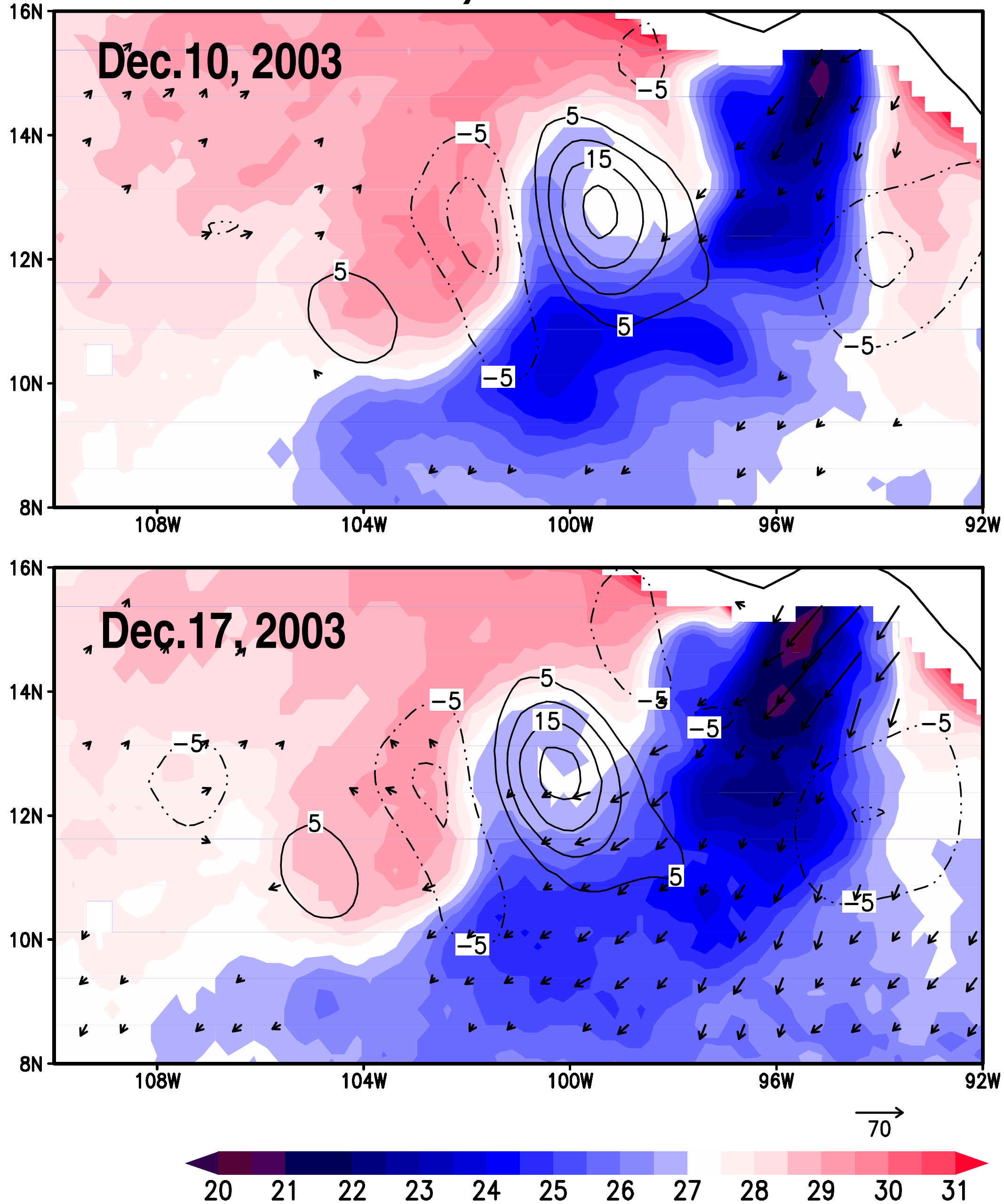


	Tehuantepec
L	660 km
R	87 km
ω^{-1}	85 days

Rossby Wave Dispersion Relation

$$\left(k+\frac{\beta}{2\omega}\right)^2+l^2=\left(\frac{\beta}{2\omega}\right)^2-\frac{1}{R^2}$$

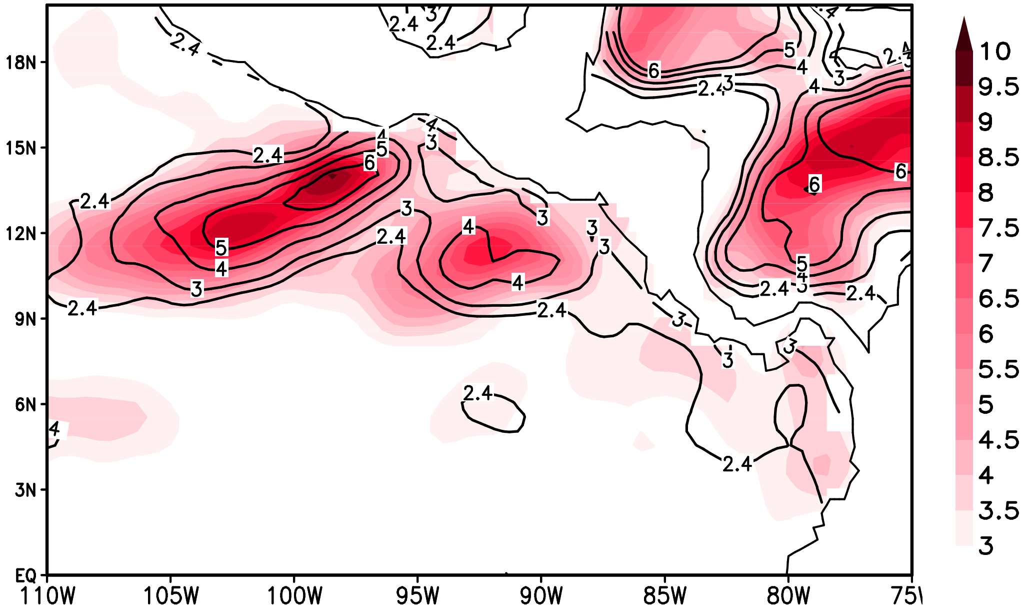
SST, SSH & Wind



Eddy train on the northwest flank of the cool SST band, causing meanders & cusps of the SST front.

Global, eddy-resolving (0.1°) hindcast (OFES) forced by QuikSCAT winds (1999 -)

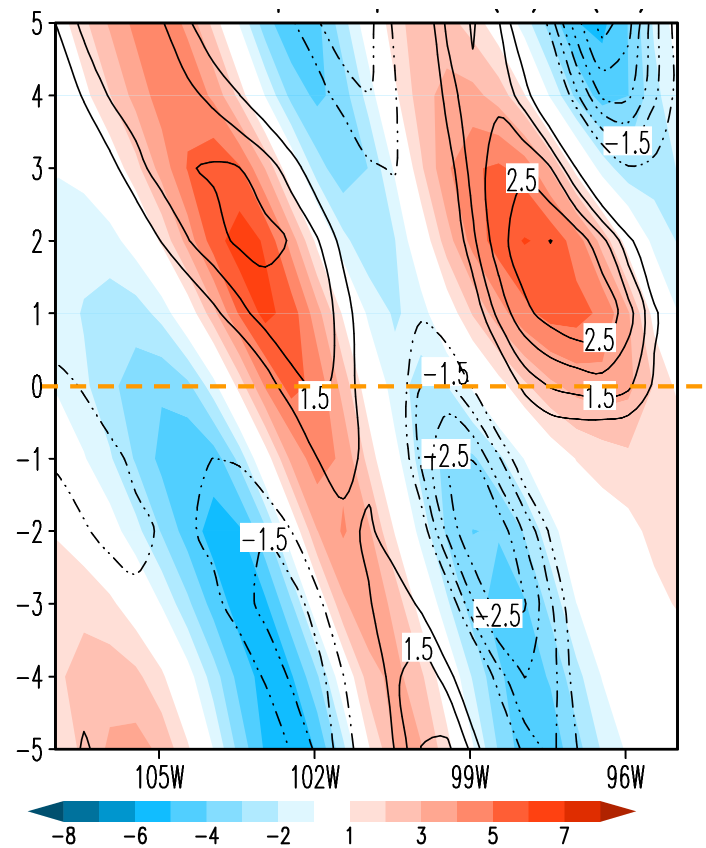
Obs (color) vs OFES ISV

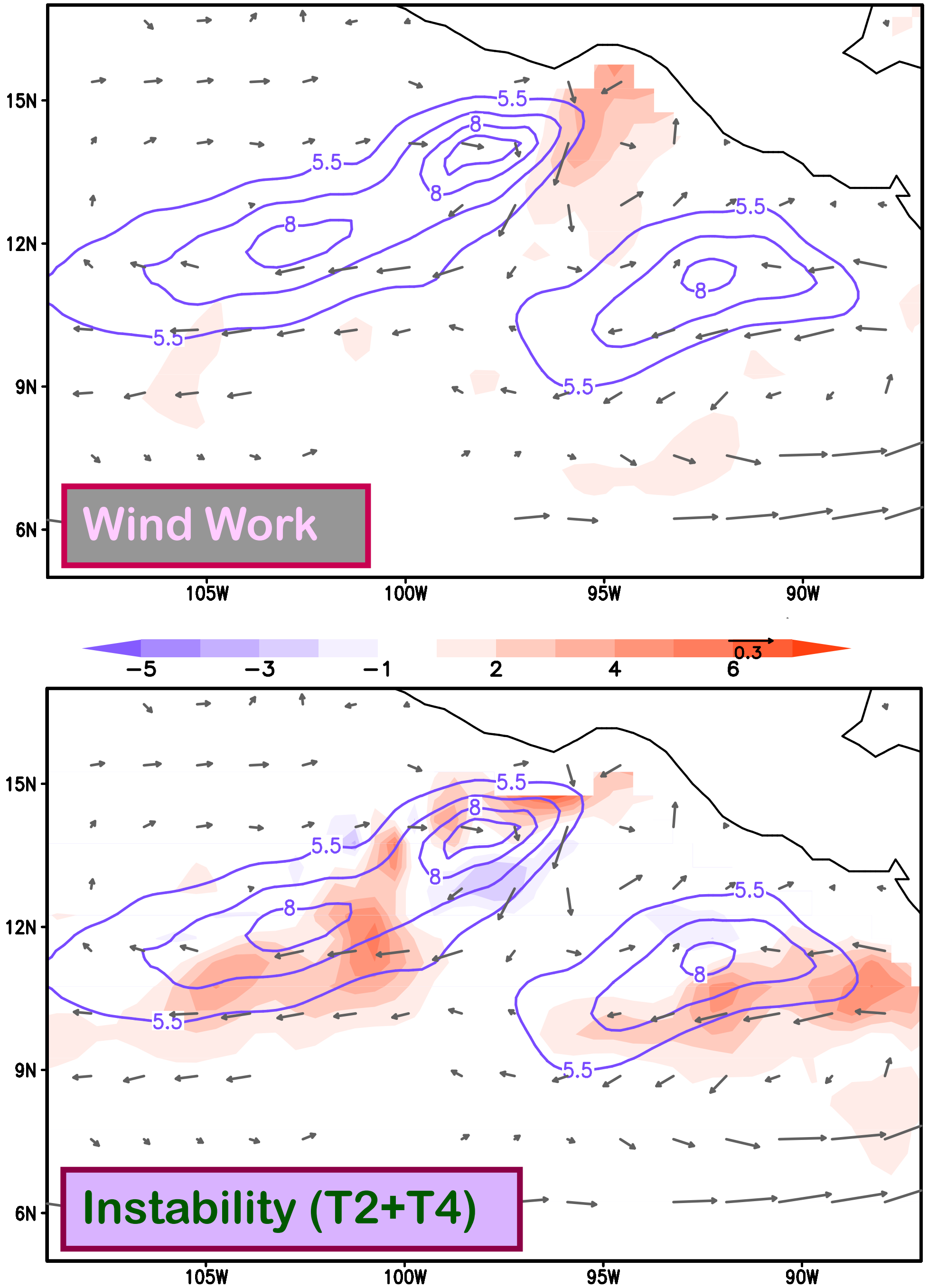


20-120-day SSHA STD (Nov-Feb)

- Obs (col) (1993—2005)
- OfES(con) (Jul.1999—Dec.2005)

High-wind Composite of SSHA
Obs (color) vs model (contour)





Energetics
based on OFES

Oct-Apr Mean
SSHA std *(cm, contour)*
Ug *(m/s, vector)*

Wind Work
(shade, upper panel)

Instability (BCC+BTC)
(shade, lower panel)
(integrate over entire water column)

Summary

- Pronounced intraseasonal variability in SSH off Tehuantepec and Papagayo, producing cusps on the northwest flank of the cool SST band.
- Organized into eddy train in the high-variance band, its wavelength set by intraseasonal frequency and phase propagation consistent with Rossby waves. (The mean response to wind jets propagates westward as long waves.)
- Wind variability is important for eddy shedding off Tehuantepec, a mechanism supported by QuikSCAT-forced, high-resolution ocean simulation.
- Dynamical instabilities contribute to downstream development.
- Intraseasonal variability of SSH is also high off Papagayo but is not highly correlated with wind variability: why?

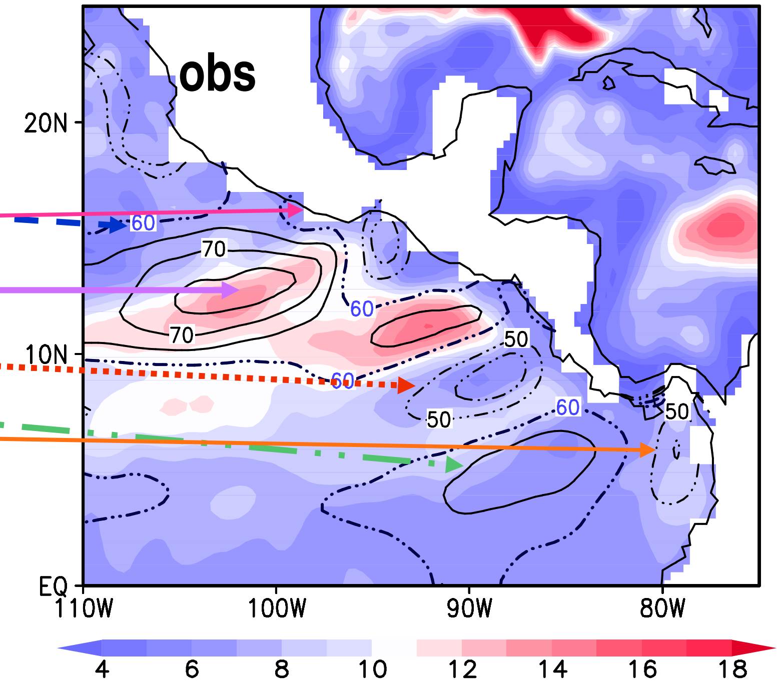
Enhanced variability and predictability of orographical-induced upwelling
→ Fisheries applications

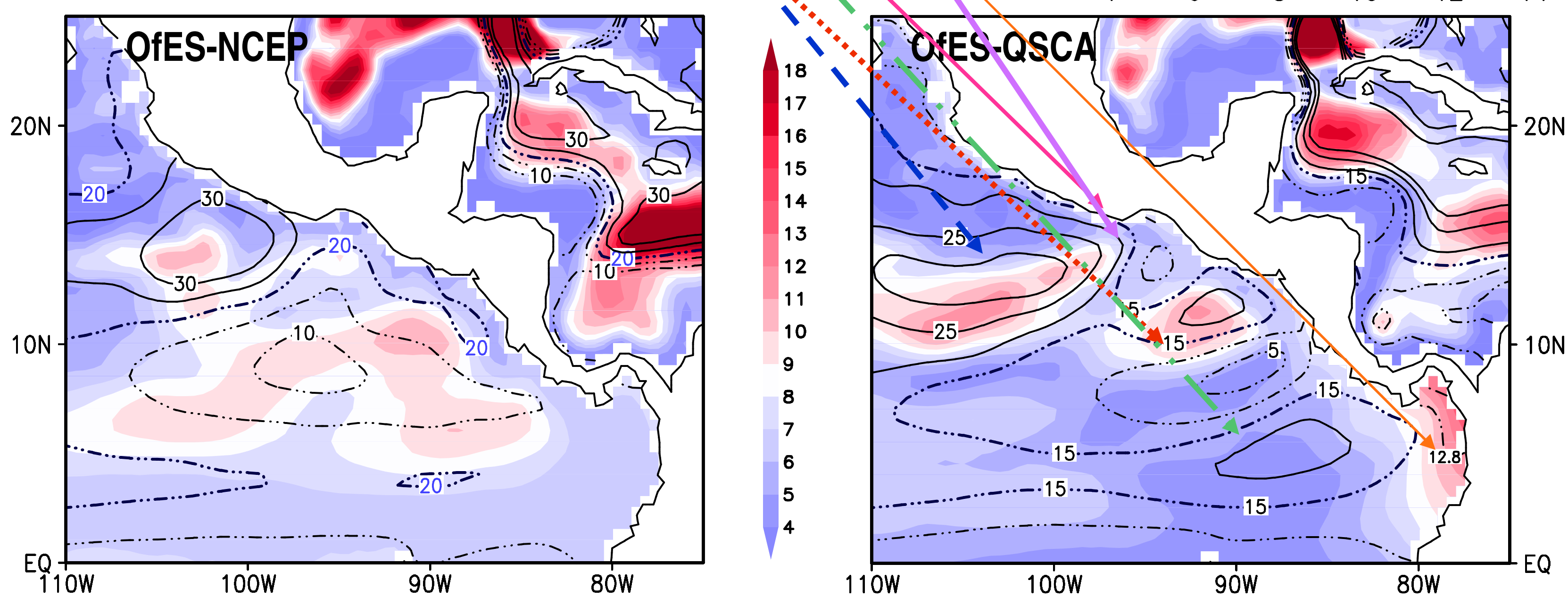
Winter *SSHM (contour) SSH.STD (shade)*

Six features in winter circulations
seen in **OfES-QSCAT** (from north):

Tehuantepec Bowl
Tehuantepec Bump
Papagayo Anticyclonic circulation
Costa Rica Dome
6^{o}N Anticyclonic circulation
Panama Single Cyclonic Circulation

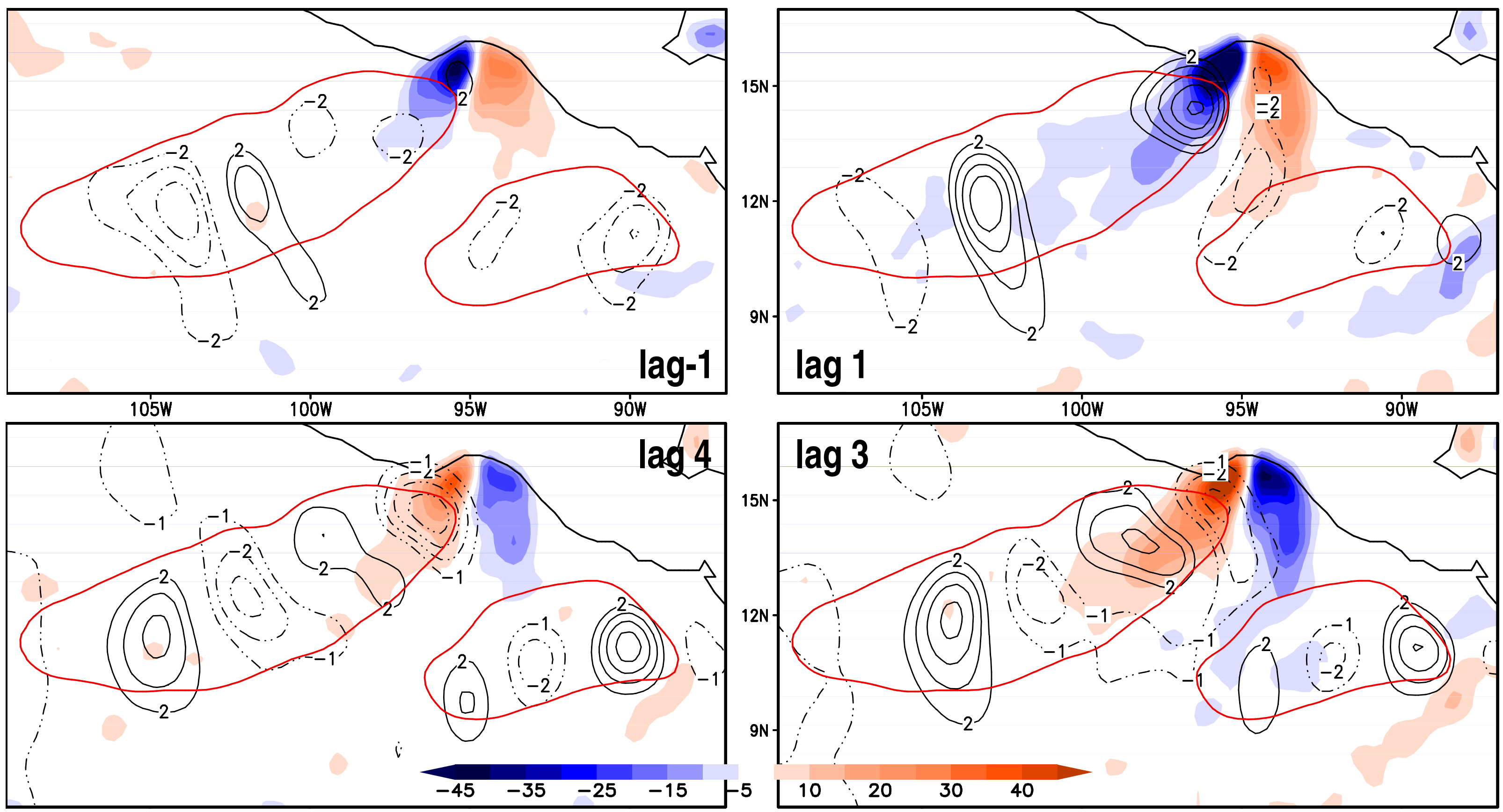
In OfES-NECP only Tehuantepec Bowl and Costa Rica Dome are seen in winter circulation (below)





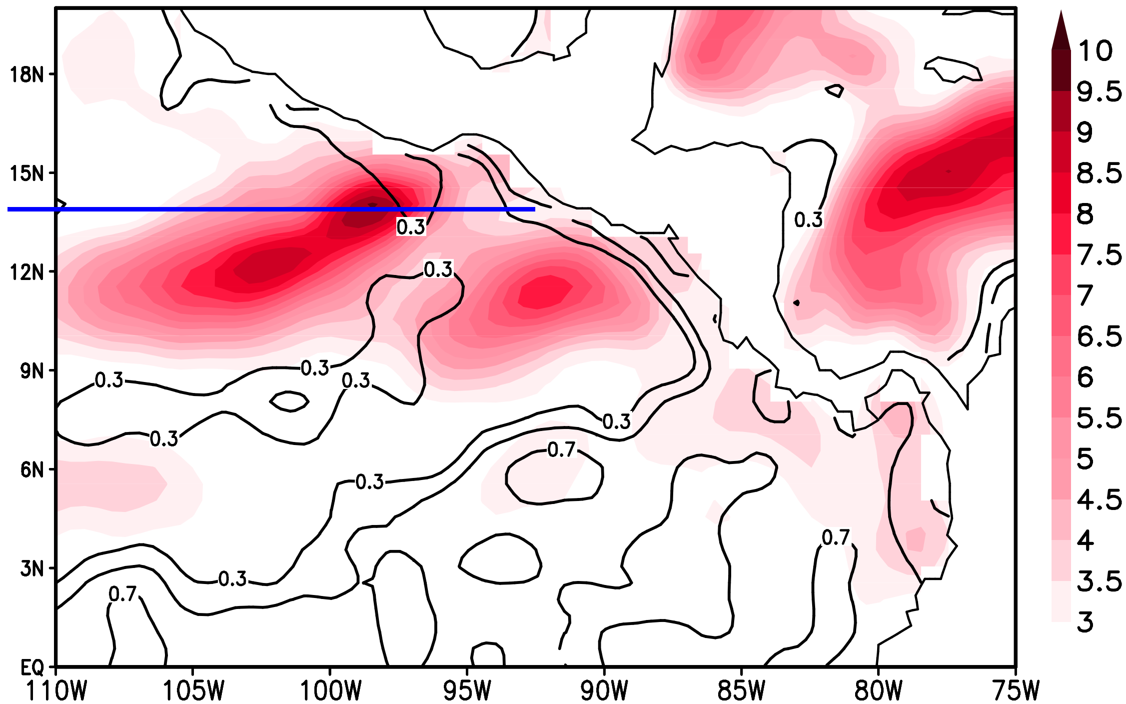
High Wind Composite—Observation

Tehuantepec Composite



Correlation SSHA btw Obs and Model

The Tehuantepec jet-forced eddy generation is some captured but simulated eddies deviate in phase from obs.



SSH Variance (col) during Nov-Feb
Corr b/w Obs and Model (20-120-dy)