Imprints of Coastal Mountains on Ocean Circulation and Variability

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Orographic jets $\rightarrow$ Ocean circulation (We) & SST

1. South China Sea: orog. forcing from the west
   Comparative study at similar latitudes

2. Eastern Pacific: orog. forcing from the east

Jul-Aug wind & SST

Xie et al. (2003, 2007, JGR)

Jan-Mar wind & SST

Xie et al. (2005, JC)
Summer (Jun-Sept)

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

Sverdrup relation \( \beta V = \text{curl} \tau \)

Ocean circulation in Sverdrup balance with wind curls

- **Tehuantepec Bowl**
  - Tehuantepec jet
  - AntiCyclonic gyre (SSH high \( \sim 72\text{cm} \))

- **Costa Rica Dome**
  - Zonal Papagayo Jet
  - Cyclonic gyre (SSH low \( \sim 48\text{cm} \))

- **Panama Circulation**
  - Meridional Panama jet
  - Cyclonic gyre (SSH low \( \sim 57\text{cm} \))
Gap Wind Season (Nov-Feb) SSH Variability

STD: Wind (contour) & SSH (color)

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

SSHA Lag Correlation w/ Action Centers

STD (color) & Correlation (contour)

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

Nov-Feb
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

Obs

lag0

lag1

lag2

SSH (color) & Wind Curl(con)

Distance along High Variance Band
Phase velocity of Rossby waves; wavelengths set by the dispersion given intraseasonal frequency

High variance band (con) SSHA from Tehuantepec high wind composite (col) at lag +4

Rossby Wave Dispersion Relation

\[
\left( k + \frac{\beta}{2\omega} \right)^2 + l^2 = \left( \frac{\beta}{2\omega} \right)^2 - \frac{1}{R^2}
\]
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)
Energetics based on OFES

Oct-Apr Mean

SSHA std (cm, contour)

Ug (m/s, vector)

Wind Work

(shade, upper panel)

Instability (BCC+BTC)

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

- Tehuantepec Bowl
- Tehuantepec Bump
- Papagayo Anticyclonic circulation
- Costa Rica Dome
- $6^\circ$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

lag-1

lag 1

lag 4

lag 3
The Tehuantepec jet-forced eddy generation is some captured but simulated eddies deviate in phase from obs.