Variability of Barrier Layer in the Equatorial Pacific associated with ENSO

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Definition

BLT (barrier layer thickness) =
ILD (isothermal layer depth) - MLD
(mixed layer depth)

Formation mechanism:
atmospheric freshwater and heat forcing, advection, runoff
Mathematical Expression

Bulk Turner Angle $T_u_b = \tan^{-1}[(\alpha \Delta T - \beta \Delta S)/ (\alpha \Delta T + \beta \Delta S)]$

$\alpha$ and $\beta$ are the expansion coefficients due to temperature $T$ and salinity $S$.

$\Delta T$ and $\Delta S$ are computed between the top at $z=\text{MLD}$, and the bottom at $z=\text{ILD}$.

(Liu et al. 2009)
Global Distribution

Global Persistent in the tropics

(Montegut et al. 2007)
Interannual Variability

130°–160°E Precipitation
160°E–170°W Horizontal advection

BL averaged over 5°S–5°N, 130°–160°E

(Liu et al. 2009)
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SODA Validation

Pattern: Coherent
Magnitude: Not identical
Region Averaged BL (SODA vs. Obs.)

Seasonality
3°S-3°N, 130°E-160°E

Time series
3°S-3°N, 130°E-160°E
Seasonal Variability (Correlation with Niño3.4 Index)

(a) 3°S-3°N, 130°E-160°E

BLT = ILD - MLD
MLD decreased -> BLT increased
ILD decreased -> BLT decreased

(b) 3°S-3°N, 160°E-170°W

Western box: ILD (temperature stratification) controls
Eastern box: MLD (salinity stratification) controls
Seasonal Variability (EOF)

EOF1 negative loading, eastward propagation.

EOF2 central and eastern equatorial Pacific positive loading, western equatorial Pacific negative loading, westward propagation.

EOF3 positive loadings during June–December in the east of the dateline.
Seasonal Variability (EOF1 vs ENSO Transition)
Seasonal Variability (EOF2 vs ENSO Resurgence)
Seasonal Variability (EOF3 vs ENSO Onset)

(a) Regression of SST onto PC1
(b) Regression of SST onto PC2
(c) Regression of SST onto PC3
(d) Regression of zonal wind stress onto PC1
(e) Regression of zonal wind stress onto PC2
(f) Regression of zonal wind stress onto PC3

SST anomaly

El Nino
Onset
Longiude

La Nina
Onset
Longiude

Zonal wind stress anomaly
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Interannual Variability

(a) BLT & Precipitation vs. Niño 3.4 index

(b) Wind Stress & Surface Current vs. Niño 3.4 index
BLT EOF Analysis

(a) EOF1
VAR. = 15%

(b) EOF2
VAR. = 13%
PCs vs. Indexes

PC1 ~ CTI (cold tongue index), WPI (warm pool index) and Niño3.4

PC2 ~ WPI
BLT Composites

EPEN events:
BL thick (east of the dateline along the equator) thin (in the west of 160°E).

CPEN events:
BL thick (160°E to the dateline near the equatorial region, from dateline to the east Pacific between 5°S and 10°S) thin (the tropical north Pacific west of 160°E)
Composites Analysis

(a) EPEN

(b) CPEN

(c) Precipitation anomaly

(d) Zonal wind stress anomaly

(e) Surface current anomaly

(f) Surface current anomaly

[Graphs and images showing various analysis results involving wind stress anomaly, surface current anomaly, and precipitation anomaly.]
Eastern Pacific El Niño

- (a) SST anomaly
- (b) SSS anomaly
- (c) ILD anomaly
- (d) MLD anomaly
- (e) Zonal wind stress anomaly
- (f) Zonal surface current anomaly
- (g) Precipitation anomaly
- (h) BLT anomaly
Central Pacific El Niño

(a) SST anomaly
(b) SSS anomaly
(c) ILD anomaly
(d) MLD anomaly
(e) Zonal wind stress anomaly
(f) Zonal surface current anomaly
(g) Precipitation anomaly
(h) BLT anomaly
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Conclusion

- On the seasonal timescale, three leading modes of the BL along the equatorial Pacific are closely associated with the transition, resurgence and onset of ENSO, respectively.

- On the interannual timescale, during EPEN, the abnormally thick BL appears in the east of the dateline. It follows the sea surface salinity front to shift zonally with the evolution of EPEN event, and propagates toward the central Pacific. In contrast, during CPEN, the abnormally thick BL is confined to the region between 160°E and 180°E around the SSS front without significant west–east displacement. Different from the BL in the EPEN events, it has no evident basin-scale propagating signal.
Thanks!