Generation of the Equatorial Intermediate Current in the eastern Pacific Ocean

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1. Introduction

The Equatorial Intermediate Current (EIC) is a westward current along the equator from 500 m to at least 2000 m and has a basin-wide zonally uniform structure in the Pacific Ocean[1]. Though deep velocity estimates from Argo float show the presence and special distribution of the EIC (Fig. 1), current ocean models typically do not represent the Pacific deep equatorial circulations including the EIC. Recently, Argo observations have revealed the existence of 30-day period Yanai waves (Mixed-Rossby-Gravity waves) at 1000 m in the eastern Pacific Ocean[2], which is a possible energy source of the EIC generation[3].

Here we revisit the observation and conduct numerical experiments to
1) identify the source of the deep 30-day Yanai wave in the eastern Pacific
2) explore the role of the Yanai wave in the EIC generation

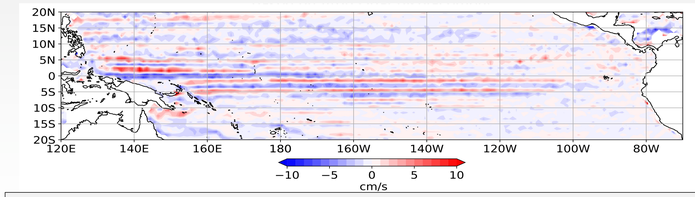


Figure 1 Mean zonal velocity at 1000m depth (1997-2022) based on Argo Float displacement. Westward flow along the equator (EIC) exists west of 110W.

2. Vertical propagation of Yanai waves

- NOAA OI SST, Temperature & velocity from TAO buoy, and velocity estimates from Argo floats are analyzed to seek the origin of the deep 30-day Yanai waves concentrated in the eastern basin (Fig. 2).
- Near-surface observations suggest vertical propagation of the 30-day Yanai wave and its downward energy transfer (Fig. 3).
- Comparison between variabilities at the surface and 1000 m show similar annual & inter-annual modulations with a lag of 3 months (Fig. 4).
- 3-month lag is consistent with the vertically propagating 30-day Yanai wave, which takes about 3 months to reach 1000 m from the upper layer.

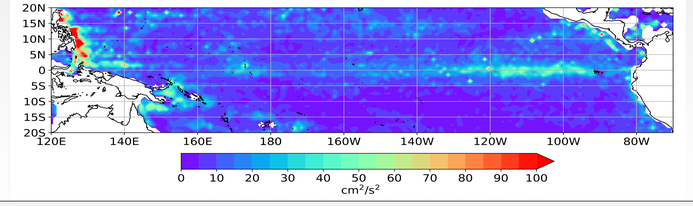


Figure 2 v component of Eddy Kinetic Energy (V-EKE) at 1000m depth (1997-2022) based on Argo Float displacement. High V-EKE near the equator reflects the presence of energetic intra-seasonal Yanai waves.

3. Numerical simulation of Pacific EIC

Name	Boundary condition
Control	Temperature relaxation on surface & zonal side boundary
WeakTIW	Temperature relaxation on surface

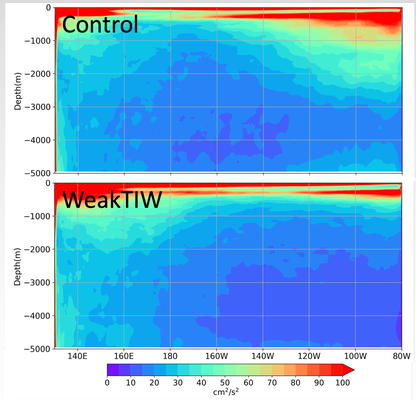


Figure 5 V-EKE along the equator (year 51-100)

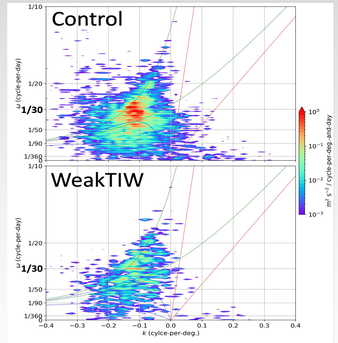
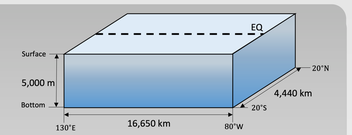


Figure 6 Power spectrum of v at 1000m, EQ (140W-80W,year 50-100). Green lines indicate the dispersion relations of Yanai waves

Model : MITgcm
Resolution : 0.25°×0.25° (horizontal), 100 levels (vertical)
Integration span : 100 years
Initial condition: no motion, horizontally uniform T (WOA2023,1991-2020)
Surface forcing: temporally & zonally averaged wind (NCEP reanalysis)



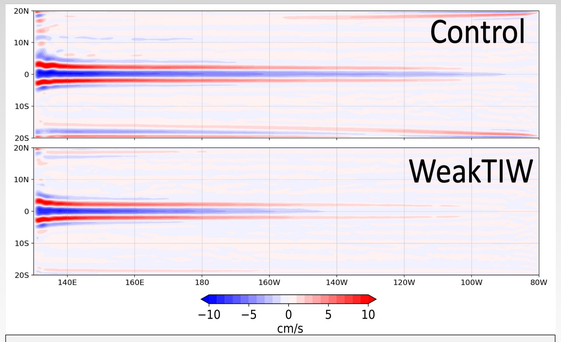


Figure 7 50-year mean zonal velocity at 1000m (year 50-100)

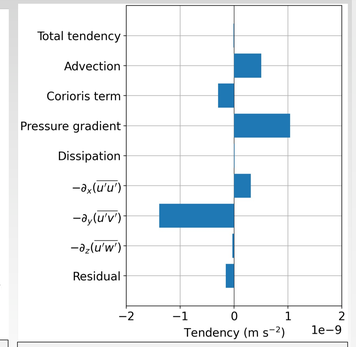


Figure 8 Zonal momentum budget along EQ in Control experiment (500-2000m depth, 1S-1N, 160W-80W, year 50-70)

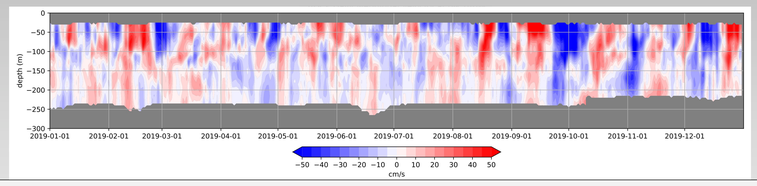


Figure 3 Daily mean meridional velocity from TAO ADCP (EQ,140W). 30-day oscillation appeared from Nov. 2019 with upward phase propagation, suggesting downward energy transfer by Yanai waves.

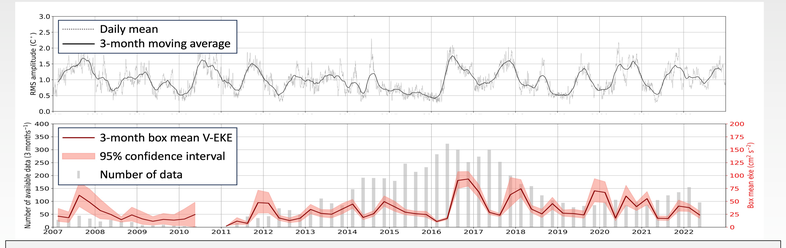


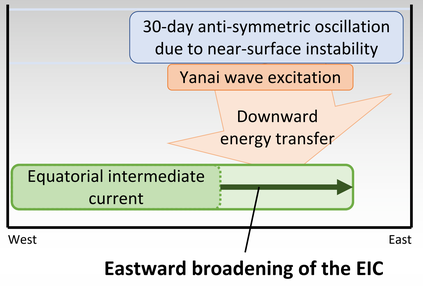
Figure 4 Time series of (a) root mean squared SST difference (2N minus 2S, averaged over 140W-100W) and (b) 3-month, box mean V-EKE at 1000 m depth (1S-1N, 130W-90W). Maximum lag correlation > 0.7 when surface variability leads by 3 months, consistent with vertical propagation of 30-day Yanai waves.

- Control experiment successfully reproduces
  - instability of upper ocean circulation
  - emitted vertically propagating 30-day Yanai wave
  - basin-wide westward EIC at 1000m
- Shear production $-\partial_y(\overline{u'v'})$ primarily provides westward momentum in the eastern basin, consistent with the zonal jet maintenance by Yanai waves[4].
- WeakTIW experiment has weaker Yanai waves shed by upper ocean instability and the EIC only appears in the western basin.

4. Conclusion

1) The 30-day vertically propagating Yanai wave shed by upper ocean instability is the source of the deep V-EKE in the eastern basin.

2) The 30-day Yanai wave provides energy to the EIC and contributes to the maintenance of the EIC's basin-wide structure



References

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