POC-Paper Session

Barotropic Rossby waves induced by tropical instability waves in the Northeastern Pacific Ocean from observation and simulation

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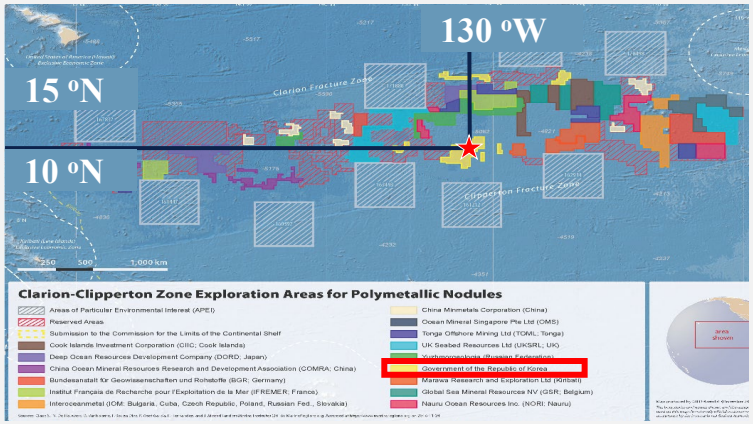
PICES-2022, 30 September 2022

Observation: near-bottom current measurements

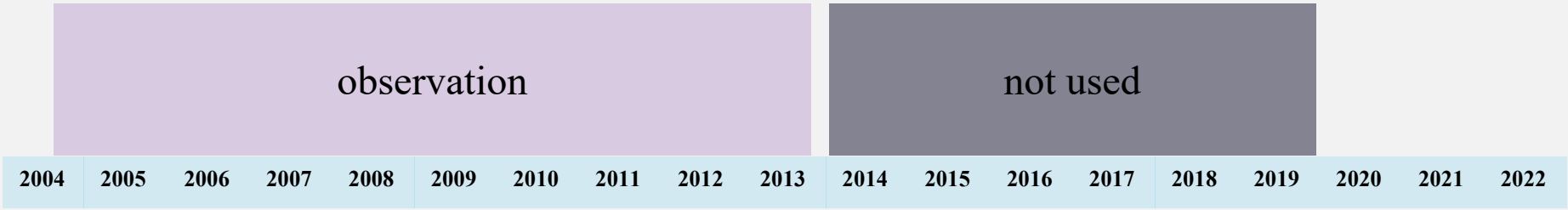
In-situ observation site (10.5°N, 131.3°W; KOMO station)

https://ocean-energyresources.com/2021/09/10/deep-sea-polymetallic-nodule-collection-with-hidden-gem/



https://dsmobserver.com/2017/10/reference-zones-measure-deep-sea-mining/

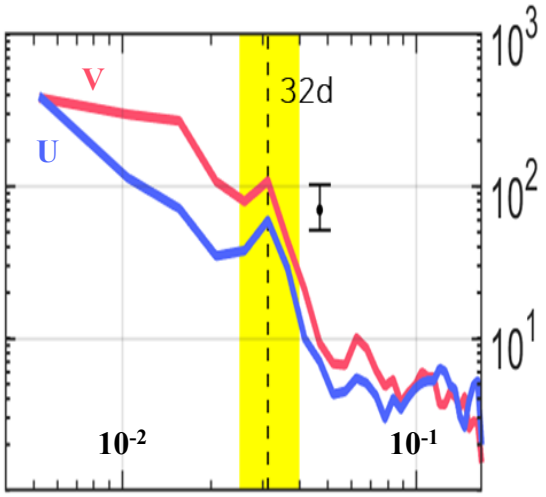
- Clarion-Clipperton Zone (CCZ)
- Korea Deep Ocean Study (KODOS)
  : environmental estimation for mining of manganese nodules
- Long-term observation
  : during 2004~2013
- Near-bottom current (~5000 m)



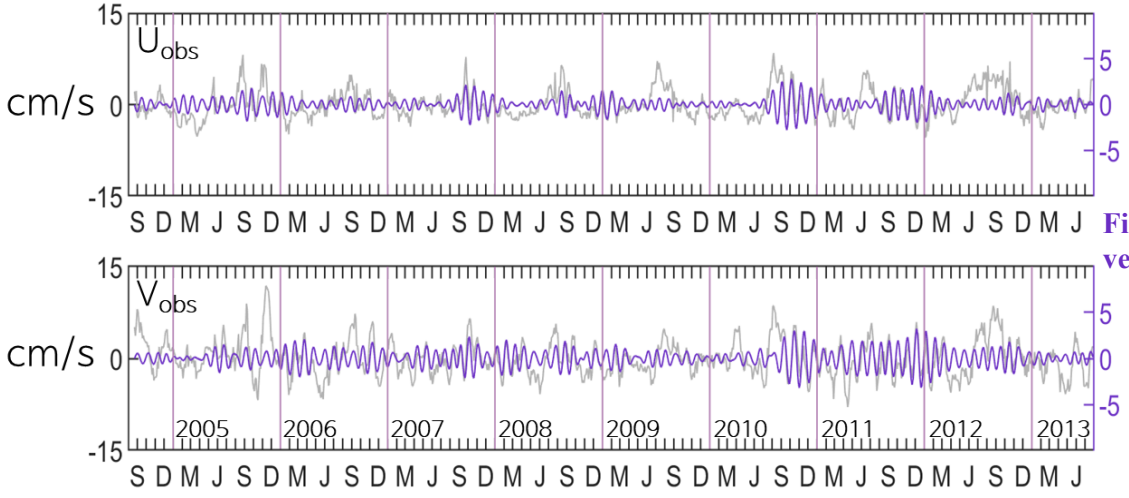
- No one has found why the near-bottom currents vary.
- In order to figure out the variability: power spectral density (PSD)

Connection between near-bottom current & TIW

PSD and time series: seasonal and interannual variation with period of ~32 days



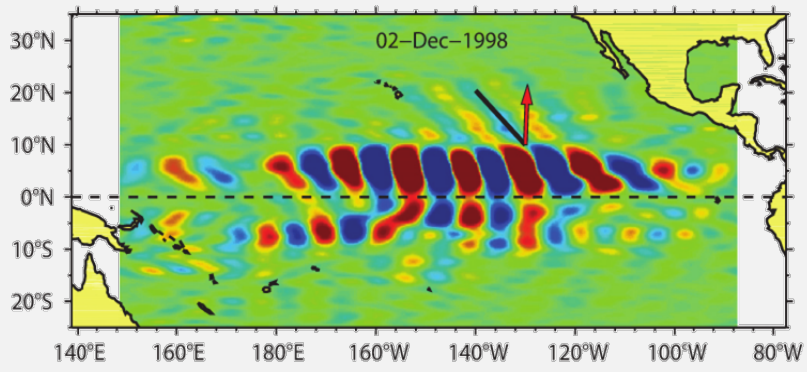
Frequency (cpd)



Filtered velocity

Months since January 2004

Farrar (2011): filtered SSH satellite measurements

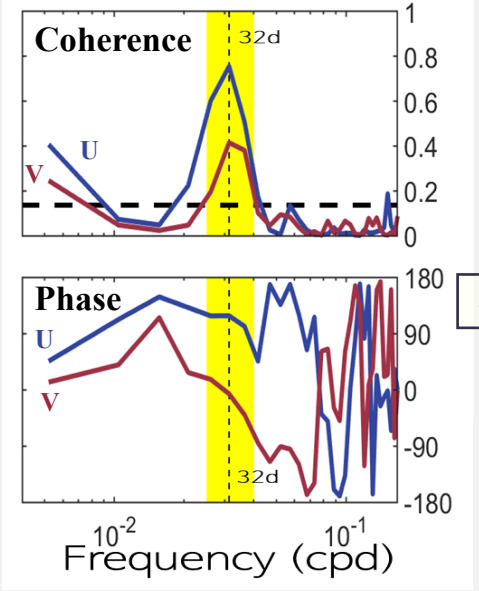


- Tropical Instability Waves (TIWs)
  : westward, periods of ~30 days,
  seasonal and interannual variations
- TIWs can induce the Barotropic Rossby Waves (BTRWs) which can propagate north of 10°N

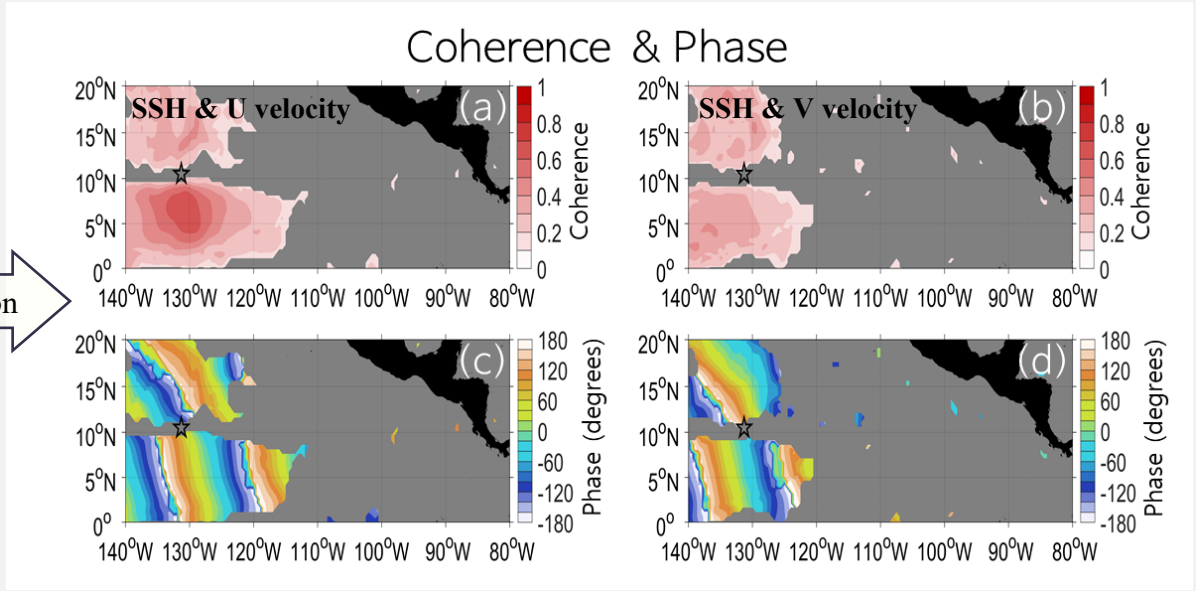
There are barotropic signal in our near-bottom current data

Relation between SSH and deep ocean currents

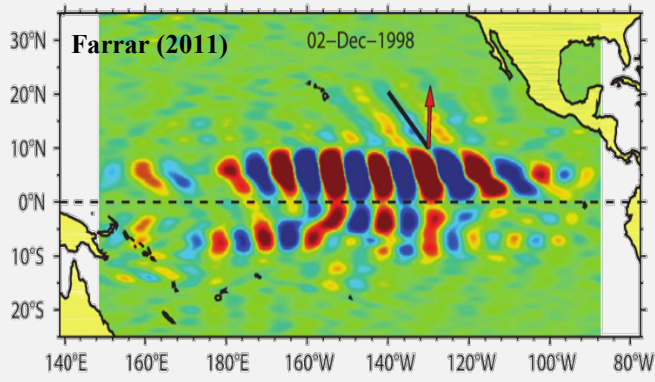
Coherence map between SSH and in-situ near-bottom velocity



expansion

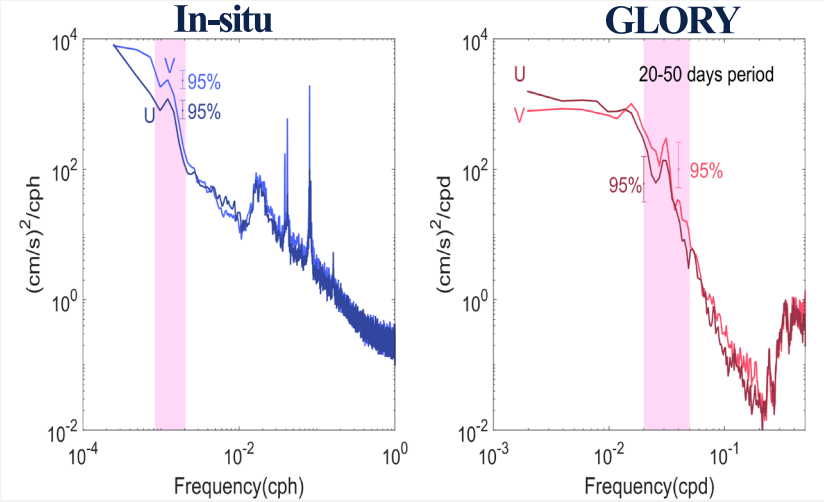


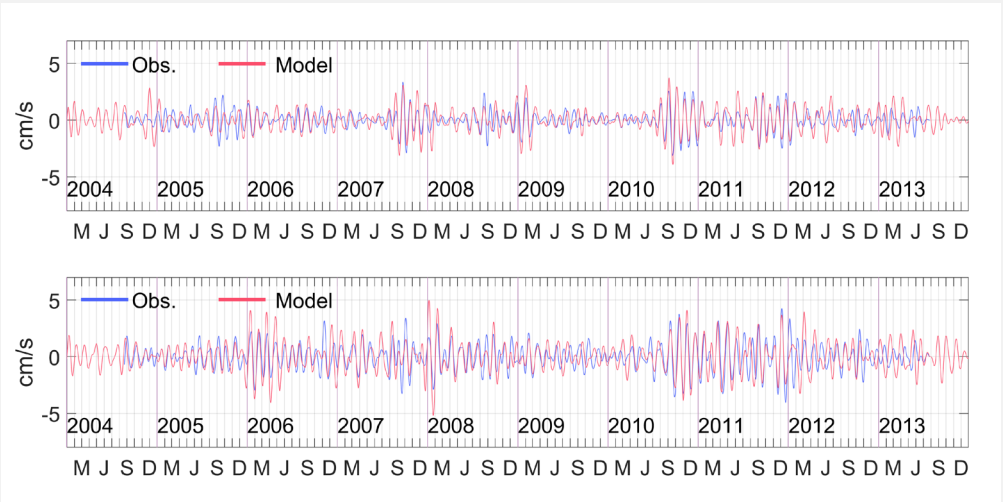
- Averaging over the frequency range of periods 25-40 days
- High values of coherence
  SSH & U velocity: south of the mooring observation site
  SSH & V velocity: southwest of the mooring observation site
- latitude 10°N: no significant coherence and abrupt change in phase
  => superposition of TIWs with BTRWs



BTRWs in GLORYS12V1 results

Correlation between filtered in-situ near-bottom velocity and velocity results of GLORYS12V1

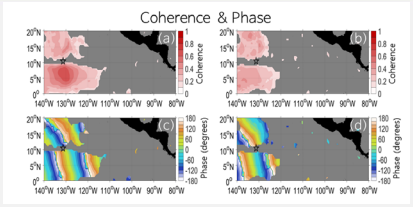


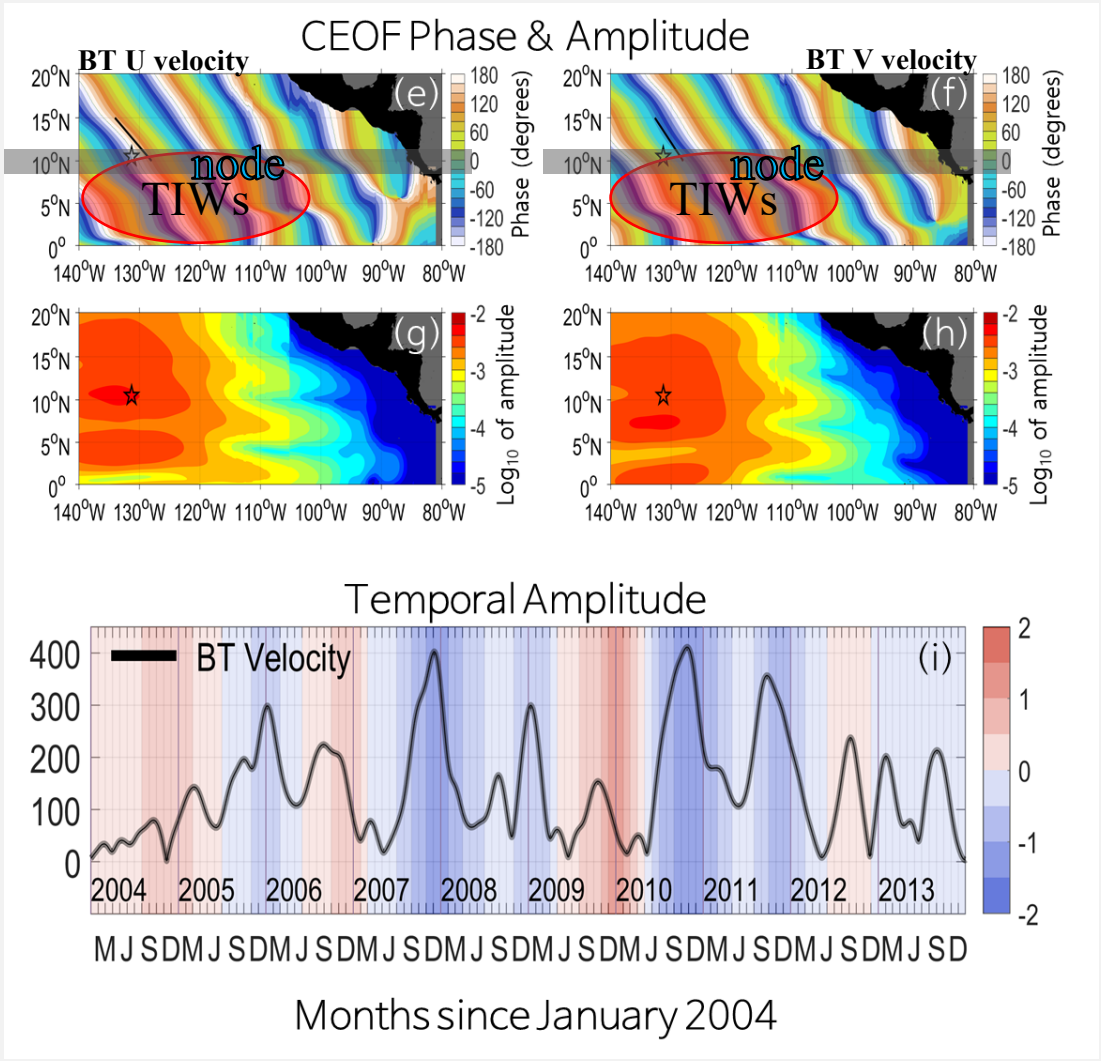


- **PSD of near-bottom velocity of in-situ measurements (left) and GLORYS12V1 (right) : correlation of ~0.8**
- **Assumption: BTRWs have same frequency and zonal wavenumber with TIWs**
- **Using barotropic velocity results of GLORYS12V1 (depth average) band-pass filter with wavelengths and periods of TIWs => filtered barotropic velocity**

BTRWs in GLORYS12V1 results

First-mode(56.5%) CEOF phase, amplitude and amplitude of principal component

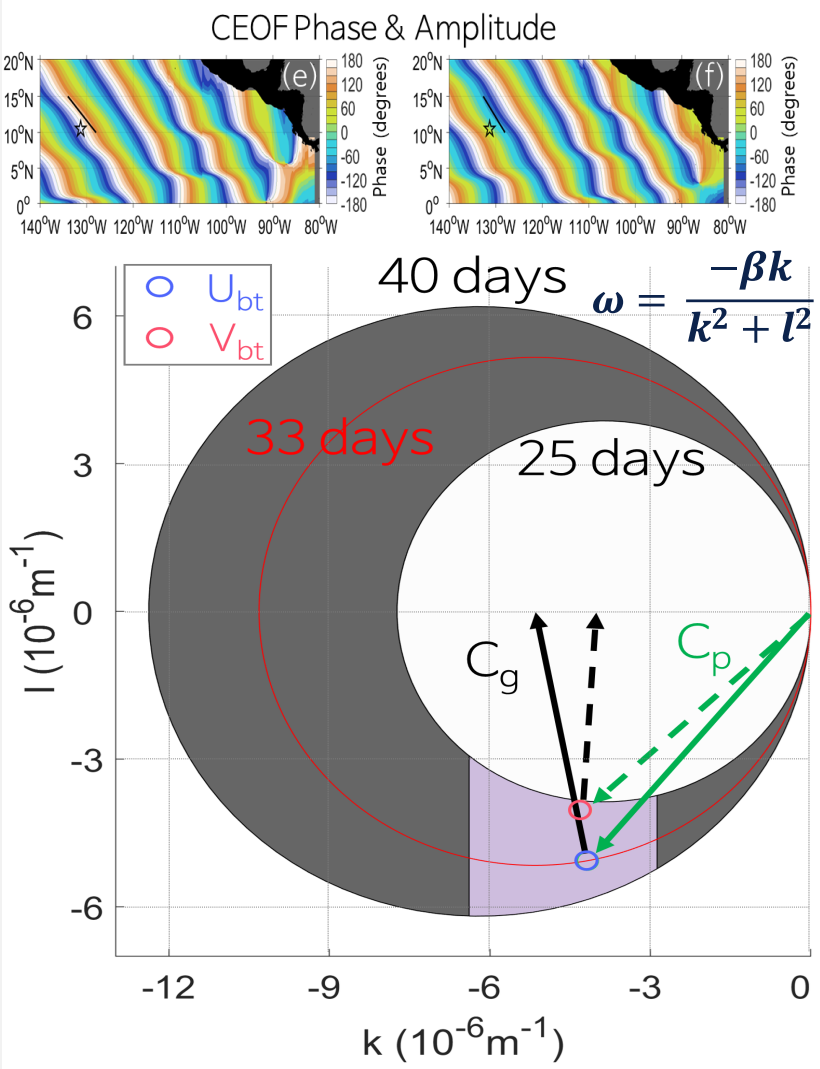




- Filtered barotropic velocity
- Uniform phase of $BTRW_{TIW}$: southwestward progress
- Coexistence of TIWs and BTRWs => no significant coherence
- TIWs lead to radiation of BTRWs
- fluctuations of near-bottom current : $BTRW_{TIW}$
- Red/ blue shade : El Niño/ La Niña periods
- Seasonal and inter-annual variation similar to that of the TIWs : intense amplitudes during La Niña periods

Verifying CEOF phase

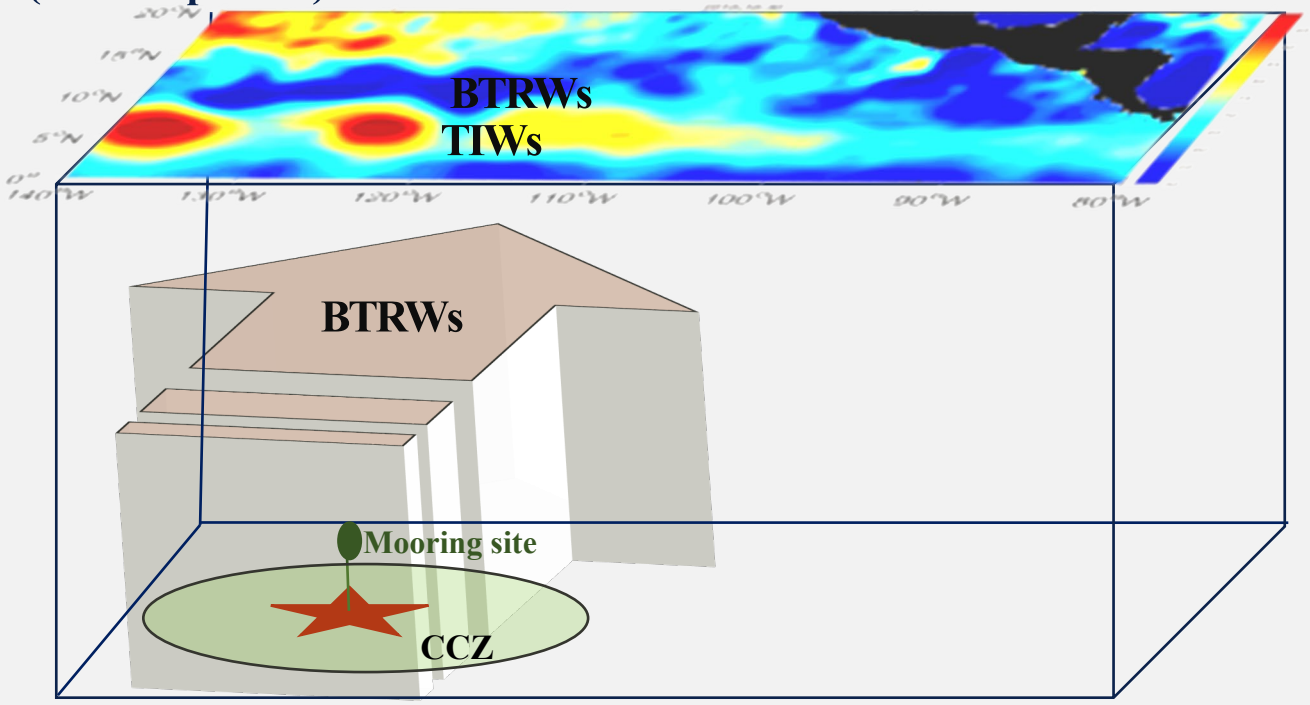
Comparison the wavenumbers



- The dispersion relation of BTRW on wavenumber axis
- Smallest circle
  : dispersion relation with a period of 25 days
- Largest circle
  : dispersion relation with a period of 40 days
- Purple shading
  : theoretically possible ranges for $BTRW_{TIW}$
- Wavenumbers calculated from the CEOF phase
  : blue and pink small circles
- Propagating direction of $BTRW_{TIW}$
  C_p (direction of phase velocity): southwestward
  C_g (direction of group velocity): northward

summary

- New evidence
  to confirm $BTRW_{TIW}$ signals at 10.5°N
  by using the long-term in-situ near-bottom current measurements
- Clear evidence
  that $BTRW_{TIW}$ transport their energy to the abyssal ocean in high latitudes
- It is also verified from numerical simulation (GLORYS12V1)
  : northward energy propagation by $BTRW_{TIW}$
  inter-annual variations (La Niña periods)



Thank you for your attention

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Geophysical Research Letters

RESEARCH LETTER
10.1029/2022GL098327

Observational Evidence of Generation and Propagation of Barotropic Rossby Waves Induced by Tropical Instability Waves in the Northeastern Pacific

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Key Points:

- In situ near-bottom current velocity records are coherent with satellite-measured sea surface height related to tropical instability waves
- The near-bottom current variations are likely caused by northward propagating tropical instability wave-induced barotropic Rossby waves
- Tropical instability wave-induced barotropic Rossby waves vary interannually with maxima during the La Niña periods

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Abstract Tropical instability waves (TIWs) in the equatorial eastern Pacific exhibit 25–40-day westward-propagating fluctuations with seasonal and interannual variations, which are stronger during July–December and La Niña periods. There is evidence that the instability of the equatorial currents that generates TIWs also induce radiation of barotropic Rossby waves ($BTRW_{TIW}$). Long-term near-bottom current measurements at 10.5°N and 131.3°W during 2004–2013 revealed a spectral peak at 25–40 days, where significant coherences were found with satellite-measured sea surface height with maxima approximately 5°N. Simulated deep currents from a data-assimilated ocean model concur with the observed near-bottom currents, and both currents vary seasonally and interannually, consistent with the typical characteristics of TIW. Further analyses using 25–40-day bandpass-filtered barotropic velocity data from the model revealed that they reasonably satisfied the theoretical dispersion relation of $BTRW_{TIW}$. The in situ and model analysis support the conclusion that $BTRW_{TIW}$ propagate north of 10°N in the northeastern Pacific.

Plain Language Summary Tropical instability waves (TIWs), which are located at the boundary between the warm pool and the cold tongue in the eastern Pacific, propagate westward with 25–40-day periods and vary seasonally and interannually, which are stronger during July-December and La Niña periods. Near-bottom velocity measured over a 10-year period at 10.5°N, 131.3°W just above the northern boundary of the waves fluctuates with 25–40-day periods, coinciding with that of sea surface height (SSH) in the