Near 13-day Barotropic Ocean Response to the Atmospheric Forcing in the Northwestern Pacific

THE UNIVERSITY OF RHODE ISLAND GRADUATE SCHOOL OF OCEANOGRAPHY

B1887

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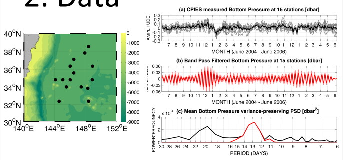
Summary

Near 13-day ocean bottom pressure variability is spatially in-phase in the Northwestern Pacific and amplifies during the winter. Most of the KESS bottom pressure variance (~57%) is driven by the large-scale wind stress curl over a broad region of the North Pacific; in addition ~28% is driven by local wind stress curl. Modeling results closely follow the observations, and indicate that topographic controls concentrate the barotropic response west of Emperor Seamount Chain.

1. Introduction

- In the Kuroshio Extension System Study (KESS) east of Japan, bottom pressures exhibited strong high-frequency variability near 13 days.
- Quinn and Ponte [3] have noted that high frequency (< 60 days) bottom pressure variability is significantly underestimated in current modeling approaches, and its understanding is crucial to minimize aliasing in satellite gravity missions.
- We analyze high frequency ocean bottom pressure signals using two-year long records.

2. Data



- CPIES measured bottom pressure at 15 stations (12 hourly)
- ECMWF Reanalysis Wind
- Time period: June 1, 2004-June 8, 2006 (738 days)
- Band pass filter (4th order Butterworth, 11-15 days)

3. Methods

Conventional EOF analysis

$$T(r,t)=\sum_n PC_n(t)LV_n(r)$$

- Space-time data are represented in terms of loading vectors (LVs) and their principal components (PC).
- LVs represent spatial patterns of variability, PC time series represent temporal evolution of these patterns.

CSEOF (Cyclostationary EOF) analysis [1, 2]

$$T(r,t)=\sum_n PC_n(t)CSLV_n(r,t)$$

$$CSLV_n(r,t)=CSLV_n(r,t+d)$$

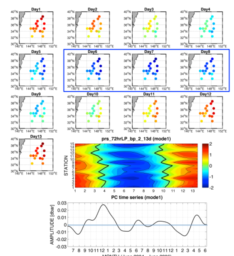
- CSEOFs, however, have time-dependent Loading Vectors.
- The temporal evolution of the Cyclostationary Loading Vectors (CSLVs) is constrained to be periodic with *d*, a “nested period”.
- The PC time series shows the varying strength of the CSLV spatial pattern.
- Useful for extracting spatio-temporal evolving patterns

Regression analysis

$$PC_i^{(T)}(t)=\sum_n a_n PC_n^{(P)}(t)+\varepsilon(t)$$

$$CSLV_i^{(PR)}(r,t)=\sum_n a_n CSLV_n^{(P)}(r,t)$$

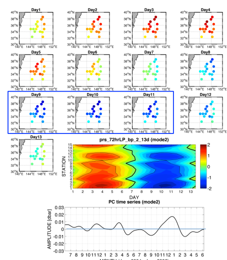
4. Near 13-day Ocean Variability



CSEOF mode 1

- ~57% of the total (near 13-day) variance
- in-phase among the stations
- larger amplitude in the northeastern region/smaller amplitude in the southwestern region
- amplifies during the winter time

Near 13-day in-phase bottom pressure variability



CSEOF mode 2

- ~28% of the total (near 13-day) variance
- similar spatial pattern as the CSEOF mode 1 but with 90° (~3days) offset

5. Atmospheric Forcing

Wind Stress Curl over the North Pacific

Negative correlation between wind stress curl and bottom pressure consistent with Ekman divergence

positive wind stress curl

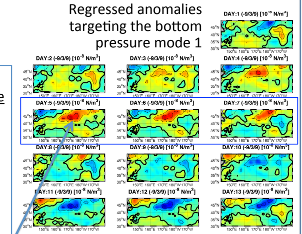
↓

mass divergence

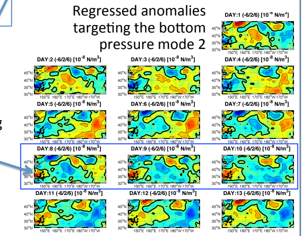
↓

negative bottom pressure

Regressed anomalies targeting the bottom pressure mode 1



Regressed anomalies targeting the bottom pressure mode 2



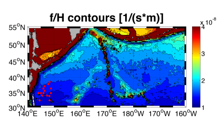
Regression of wind stress curl

- bottom pressure mode 1 is strongly correlated (r^2 = 0.80) to large-scale wind stress curl forcing
- bottom pressure mode 2 is strongly correlated (r^2 = 0.79) to local wind stress curl forcing

6. Comparison with the Barotropic Model Results

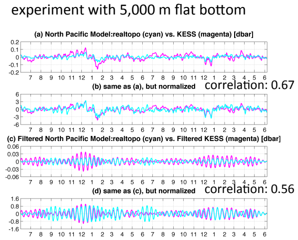
Motivation

- Spatial patterns of the regressed wind stress curl anomalies targeting the first bottom pressure mode suggest that this bottom pressure response may be widely spread in the North Pacific.
- To test this, a wind-only-forced barotropic model is applied over the North Pacific.



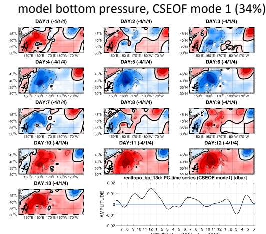
North Pacific Barotropic Model

- ROMS based
- experiment with real topography
- experiment with 5,000 m flat bottom



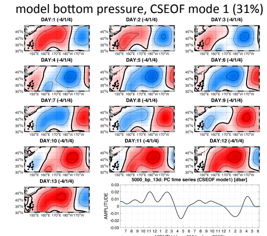
real topography

model bottom pressure, CSEOF mode 1 (34%)



5,000 m flat bottom

model bottom pressure, CSEOF mode 1 (31%)



7. Conclusion

- Near 13-day bottom pressure variability in the Northwestern Pacific amplifies during the winter time.
- The near 13-day variability shows spatially in-phase characteristics, and its amplitude increases to the north.
- More than half (~60 %) of the near 13-day bottom pressure signal is driven by large scale wind stress curl in the North Pacific, which suggests that this bottom pressure signal may extend farther across the North Pacific, moreover...
- Barotropic model results in the North Pacific reveal that the near 13-day bottom pressure variability is controlled by the bottom topography and concentrated west of the Emperor Seamount Chain.

References

[1] Kim, K.-Y., G. R. North, J. Huang, 1996: EOFs of one-dimensional cyclostationary time series: Computations, examples and stochastic modeling. *J. Atmos. Sci.*, **53**, 1007-1017.

[2] Kim, K.-Y. and G. R. North, 1997: EOFs of harmonizable cyclostationary processes. *J. Atmos. Sci.*, **54**, 2416-2427.

[3] Quinn, K. J., and R. M. Ponte, 2011: Estimating high frequency ocean bottom pressure variability. *Geophys. Res. Lett.*, **38**, L08611, doi: 10.1029/2010GL046537.

Related poster: B1417

Zamorski, S. E., and K. A. Donohue, 2012: Kuroshio Extension meanders: Model data-intercomparison. *Ocean Sciences 2012 poster B1417.*

Acknowledgements

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