Form 3

Annual Report

LaMer, Ehime University

Date (26 , 2 , 2018)

To Director of LaMer

Principle Investigator:
Affiliation Second Institute of Oceanography, SOA Position Research Assistant
Name in print Ruixiang Zhao

Include the report on the result of the project/meeting in a separate sheet.

1. Project / Meeting title

Applications of pressure-recording inverted echo sounders

2. Members of project / meeting

Name	Affiliation	Position	Contribution part
PI Ruixiang Zhao	Second Institute of Oceanography, SOA	Research Assistant	Data processing; Paper writing
Members Xiao-Hua Zhu	Second Institute of Oceanography, SOA	Senior Research Scientist	Beneficial discussion
Xinyu Guo	Ehime University	Professor	Beneficial discussion
Xinyu Guo	Ehime University	Professor	Beneficial discussion

Title

Applications of pressure-recording inverted echo sounders

Members' names and affiliations

Name	Institution and Department	Employment	E-mail
Zhu Xiao-Hua	Second Institute of Oceanography, SOA	Senior Research Scientist	xhzhu@sio.org.cn
Xinyu Guo	Faculty member of LaMer	Professor	guoxinyu@sci.ehime-u.ac.jp

Aim

This project aims to carry out cooperative research with Prof. Guo Xinyu of Ehime University on the application of pressure-recording inverted echo sounders (PIESs) deployed in the South China Sea (SCS), Kuroshio and other regions.

Procedure

The principal investigator (PI) has made an oral presentation "Near 5-day nonisostatic response to atmosphere surface pressure and coastal trapped waves observed in the northern South China Sea" and showed the recent studies of PI on the bottom pressure variability in the South China Sea observed by pressure-recording inverted echo sounders (PIESs).

During the visitation to CMES, Ehime University, the PI also made thorough discussions with Prof. Xinyu Guo on the following subjects: 1. The variability of diurnal tides and semidiurnal tides observed by PIESs in the northern South China Sea. 2. The near 7-day bottom pressure variability in the South China Sea. 3. Model results derived from OFES, which may be beneficial for the further study associated with PIES observations.

Results

Our joint research of this year (2017) is focused on the study of bottom pressure variability observed by PIESs in the northern South China Sea. The PIES is a

bottom-mounted instrument equipped with a high-precision pressure sensor (Paroscientific Inc.) which can accurately monitor the bottom pressure variability in the ocean. The bottom pressure variability corresponds to the mass-loading component of the sea surface height (SSH), and records the barotropic wave signals driven by certain physical processes such as coastal trapped waves, Rossby-Haurwitz wave driven nonisostatic responses, etc.

I reported my latest study in CMES, on the near 5-day bottom pressure variability observed by PIESs in the northern South China Sea. Oceanic nonisostatic responses to near 5-day Rossby–Haurwitz atmospheric pressure waves have been observed in open oceans; however, such responses based on observations in marginal seas such as the South China Sea have not been reported owing to the limited ocean bottom pressure (Pbot) records. The Pbot measurements from pressure-recording inverted echo sounders (PIESs) at sites in the northern South China Sea (Figure 1) revealed a nonisostatic-like response near 5 days, although the coastal trapped waves (CTWs) appeared to obscure it because their broad-band periods include the near 5-day band. Cross-spectral analysis revealed that the PIES Pbot records and the sea level (SL) records of Hong Kong all correlate strongly with the atmospheric pressure and winds over the East China Sea (Figure 2). This is indicative of remotely forced CTWs. The PIES Pbot records showed higher coherence near 5 days with the zonal low-pass wavelength filters applied to the atmospheric pressure (Figure 3), and the phase analysis results strongly suggest nonisostatic oceanic responses to the westward-propagating Rossby–Haurwitz waves. Effective separation of CTWs and the nonisostatic responses from the Pbot records at the near 5-day period was achieved. The oceanic responses to the Rossby–Haurwitz waves in the northern South China Sea were nonisostatic; a 1 mbar change in air pressure resulted in a 1.58 mbar change in Pbot with a phase lag of 14.8°. The mean phase speed of CTWs from Hong Kong to station P3 was estimated to be 9.9 m/s.

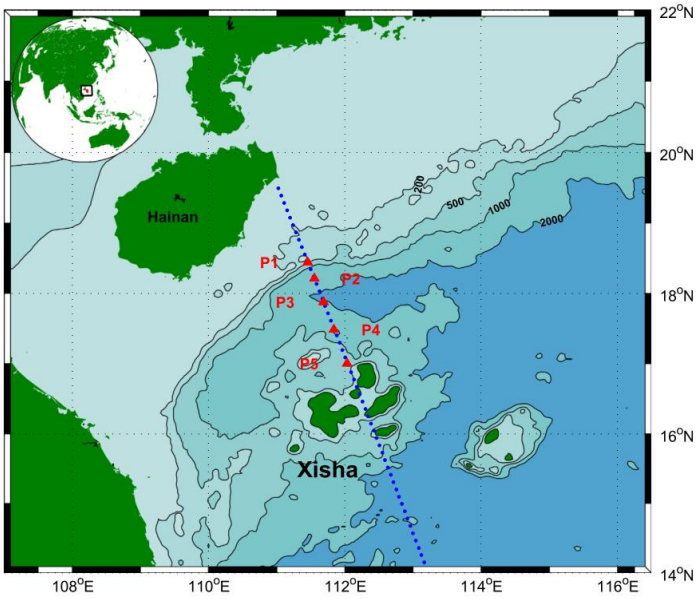

Figure 1. Location map of the PIES stations. Red triangles indicate the individual PIES instruments and blue dots indicate the TOPEX/POSEIDON and Jason-1/2 satellite altimeter track (track 114). Bathymetry is contoured in meters.

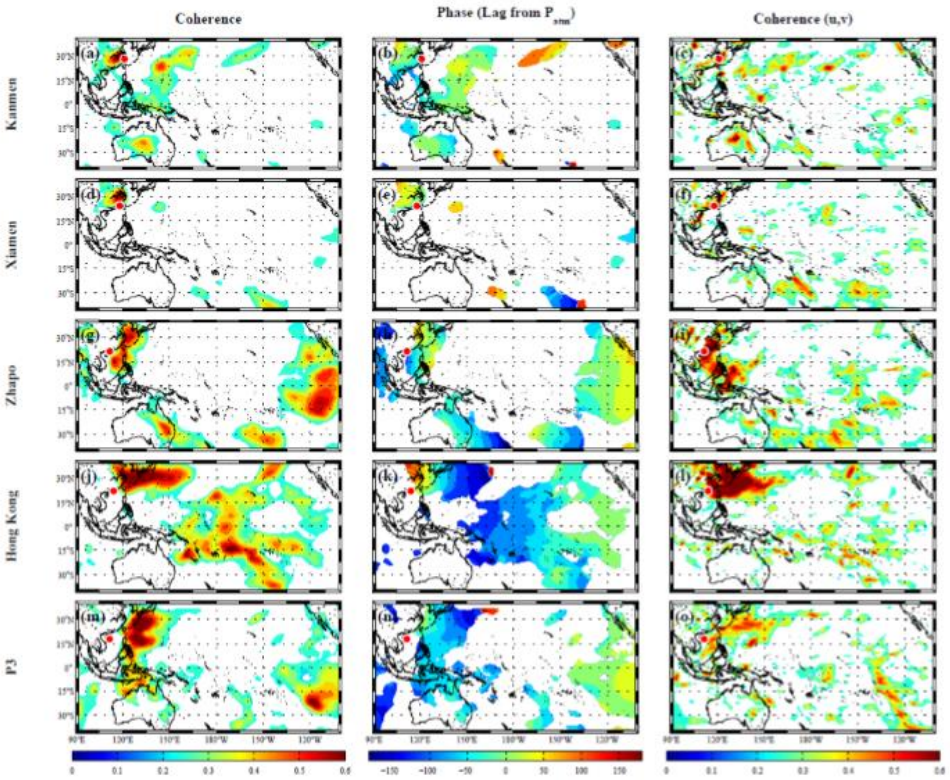

Figure 2. Cross-spectral analysis results at the near 5-day period band for the tide gauges in (a)–(c) Kanmen, (d)–(f), Xiamen, (g)–(i) Zhapo, and (j)–(l) Hong Kong and

(m)–(o) the pressure-recording inverted echo sounder (PIES) station (P3). The first two columns represent coherence and phase including sea level (SL) or ocean bottom pressure (Pbot) lags from Patm in degrees, where the black bold line indicates a value of zero and the contour line interval is 30°. The last column represents coherence for the eastward and northward wind components at 10 m; however, only the larger value is plotted. The red dot for each subfigure denotes a tide gauge station or PIES station. Coherence, gain, and phase were omitted in mapping if the coherence was lower than the 95% confidence level.

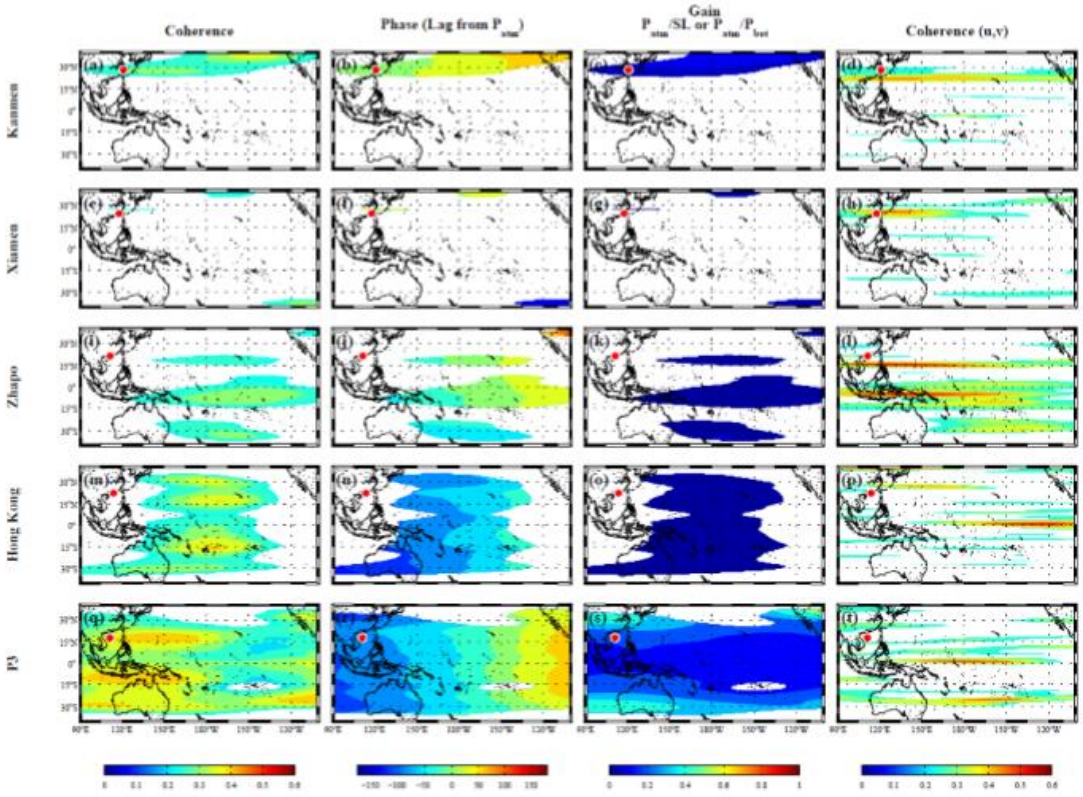

Figure 3. Same as Fig. 2 except that a 300° zonal low-pass filter was applied to the atmospheric surface pressure (Patm), and the third column inserted shows the gain, defined as Patm/SL or Patm/Pbot.

Publication/conference presentation

Publications:

1. Zhu, X.-H., R. Zhao, X. Guo, Y. Long, Y.-L. Ma, and X. Fan (2015), A long-term volume transport time series estimated by combining in situ observation and satellite

altimeter data in the northern South China Sea, J. Oceanogr., 71(3), 663–673, doi:10.1007/s10872-015-0305-5.

2. Zhao, R., X.-H. Zhu, and X. Guo (2016), The impact of monsoon winds and mesoscale eddies on thermohaline structures and circulation patterns in the northern South China Sea, Cont. Shelf Res., 143, 240–256, doi:10.1016/j.csr.2016.06.009.

3. Zhao, R., and X.-H. Zhu (2016), Weakest winter South China Sea western boundary current caused by the 2015–2016 El Niño event, J. Geophys. Res. Oceans, 121, doi:10.1002/ 2016JC012252.

4. Zhao, R., X.-H. Zhu, and J.-H. Park (2017), Near 5-Day Nonisostatic response to atmospheric surface pressure and coastal-trapped waves observed in the northern South China Sea, J. Phys. Oceanogr., 47(9), 2291–2303.

5. Zhang, K., X.-H. Zhu, and R. Zhao (2018), Near 7-day response of ocean bottom pressure to atmospheric surface pressure and winds in the northern South China Sea, Deep-Sea Res. I, doi:10.1016/j.dsr.2017.12.004.

Oral presentation:

Title: Near 5-day nonisostatic response to atmosphere surface pressure and coastal trapped waves observed in the northern South China Sea.

Lecturer: Ruixiang Zhao.

Time: November 7, 2017.

Location: Ehime University.

Perspectives in future

We expect great progresses on the applications of PIES and our understanding of the circulation in the South China Sea, Kuroshio and other regions. We wish to publish our joint research on famous journals if possible.