Annual Report

LaMer, Ehime University

Date (20 ,3 , 2018)

To Director of LaMer

Principle Investigator:

Affiliation Ocean University of China, OUC

Position Graduate student

Name in print Jie Gao

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

1. Project / Meeting title

The interaction of baroclinic tide and backgroundcurrent inthe Kuroshio

2. Members of project / meeting

Name	Affiliation	Position	Contribution part
PI Jie Gao	College of Oceanic and Atmospheric ,Ocean University of China	Graduate student	Data processing; Paper writing
Members Xinyan Mao	College of Oceanic and Atmospheric, Ocean University of China	Lecturer	Beneficial discussion
Xinyu Guo	Center for Marine Environmental Studies (CMES), Ehime University	Professor	Beneficial discussion

3. Contents (please write in separate sheet, A4-size, within 5 pages including figures and tables. Itemize "Title, members' names and affiliations, aim, procedure, result, publication/conference presentation, perspectives in future").

This report will be opened to the public through LaMer website and printed matter. Please send additional products, i.e., abstract book, reprint, if available to

Title

The generation and propagation of internal tide at Tokara Strait

Members' names and affiliations

Name	Institution and Department	Employment position	E-mail
Jie Gao	Collegeof Oceanic and Atmospheric,Ocean University of China	Graduate student	gaohexizi@163.com
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 and on the generation and propagation of internal waves in Tokara Strait.

Procedure

The principal investigator (PI)has first made an oral presentation "An introduction to internal wave" and shows the presentation into two parts: 1. Theequation and approximations of internal waves; 2. Considering the influence of Kuroshio Current, the generation and propagation of internal wave

The PI also made a discussion withProf. Guo Xinyuand Post doctor tsutsumi in the internal tides influenced by seasonal changes of KuroshioCurrent and the calculation of barotropic and baroclinic tidal energy.

The PI will carry out further research with Prof. Guo Xinyu on the following subjects: 1. Combine the observed data with simulation data to analyze the generation and propagation of internal tide.2.Focus on the baroclinic energy influenced by spring-neap tide.

Results

Our joint research of this year (2017) is focused on the study of internal tides in the Tokara Strait from simulation data from JCOPET(2015). After studying the theoretical background of internal waves .We use POM to simulate the generation and propagation of internal tides at Tokara Strait.

In this research, numerical studies are carried out to investigate the nature and efficiency of the generation of internal tides by tidal flow and low-frequency flow (Kuroshio Current) in Tokara Strait. Model domain including the Tokara Strait, covering a longitudinal range from 126° E to 132° E, and a latitudinal range from 27° N to 32° N with a horizontal grid spacing of 1/36.

The generation of the internal tide can be discusses more quantitatively based on the energetics.

1. The energy flux

The energy flux is defined as

$$EF_{bt} = \langle \rho_0 \, \mathrm{g} \, \mathrm{H} \, \zeta \, (U_{bt}, V_{bt}) \rangle$$

$$EF_x = \left\langle \int_{-H}^{0} p' U_{bc} dz \right\rangle \quad ;$$

$$EF_y = \left\langle \int_{-H}^{0} p' V_{bc} dz \right\rangle \quad ;$$

Where EF_{bt}、 EF_x and EF_y are the barotropic energy flux and baroclinic energy flux [Munroe et al.,2005].Figure 1 shows the distribution of barotropic energy flux and Figure 2 shows the depth-integrated distribution of baroclinic energy flux.

The barotropic energy flux across all sections (blue lines) is 15.2GW. Most energy comes from the Pacific Ocean, after passing through the Tokara Strait, it turns to the Yellow Sea.

The depth-integrated energy flux is seen to propagate toward the Pacific Ocean.

2. The conversation rate from barotropic to baroclinic tide (BEC)

The conversation rate from barotropic to baroclinic tide (BEC) is given by

$$\mathrm{P} = \langle \mathrm{p}'_{\mathrm{h}} \overrightarrow{\mathrm{U}_{\mathrm{bt}}} \cdot \nabla \mathrm{H} \rangle;$$

H is the water depth,$\langle \rangle$ denotes the time average over 25 hours， $\overrightarrow{\mathrm{U}_{\mathrm{bt}}}$ is the barotropic tidal velocity, $p'_h = p'(x, y, z = -H, t)$is the perturbation of pressure.[Sonya et al., 2005]. Figure 3 shows the distribution of conversation rate over the prominent topographic features. The experiment shows that internal tides are effectively generated over prominent topographic such as the subsurface ridges in the Tokara Strait ,the continental shelf slope in the East China Sea.

The barotropic energy flux onto the subsurface ridges in the Tokara Strait is 15.6GW, 43.4% of which (6.6 GW) is converted to baroclinic energy. After passing through the strait, the baroclinic energy flux decreases to 2.1 GW, indicating 4.6 GW of the baroclinic energy dissipated immediately by bottom friction.

3. Influences of spring-neap tide

In the present study, we investigate the distribution and energetic of the internal tides around the Tokara Strait. We then focus on how the spring-neap tide influenced the internal tides.

The numerical simulation is carried out using the Princeton Ocean Model, driven by four major tide constituents. The background temperature and salinity are both assumed to be horizontally homogeneous and vertically stratified.

Figure 4 shows the depth-integrated distribution of baroclinic energy flux between spring and neap tide.

Figure5 shows the baroclinic energy conversion between spring and neap tide period.

Even though the energy generated at Tokara Strait (6.2 GW) at spring tide is larger than neap tide (1.6 GW), the advection of baroclinic energy is negligible. The local dissipation within the Tokara Strait at spring tide is 4.3GW, corresponding to about 69% of the baroclinic energy generated in this region. The same analysis indicates that there is a baroclinic energy dissipation rate of 1.03GW (64%) in the neap tide. It follows that about 65% baroclinic energy generated in the whole analyzed model region is dissipated in close proximity to the baroclinic generation sites.

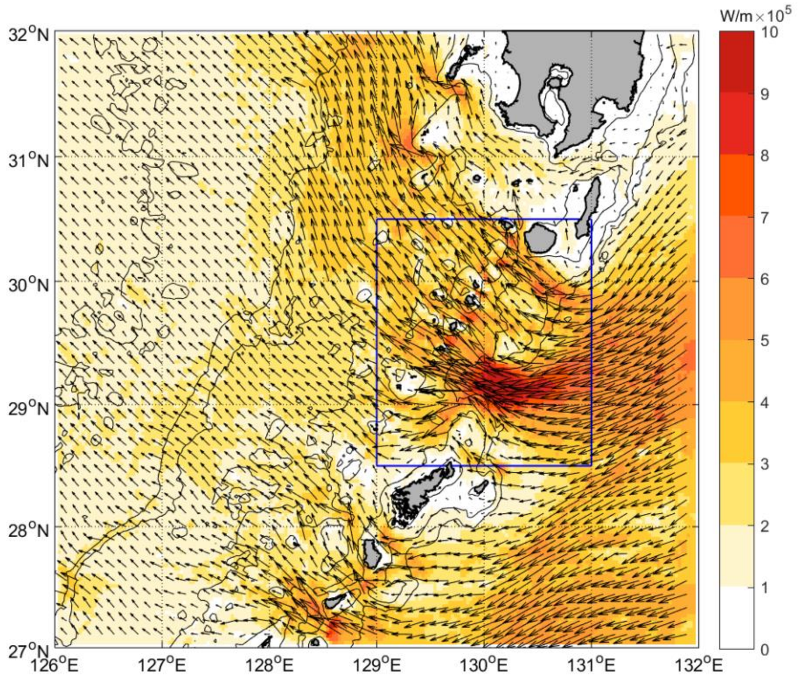

Figure 1, The distribution of barotropic energy flux

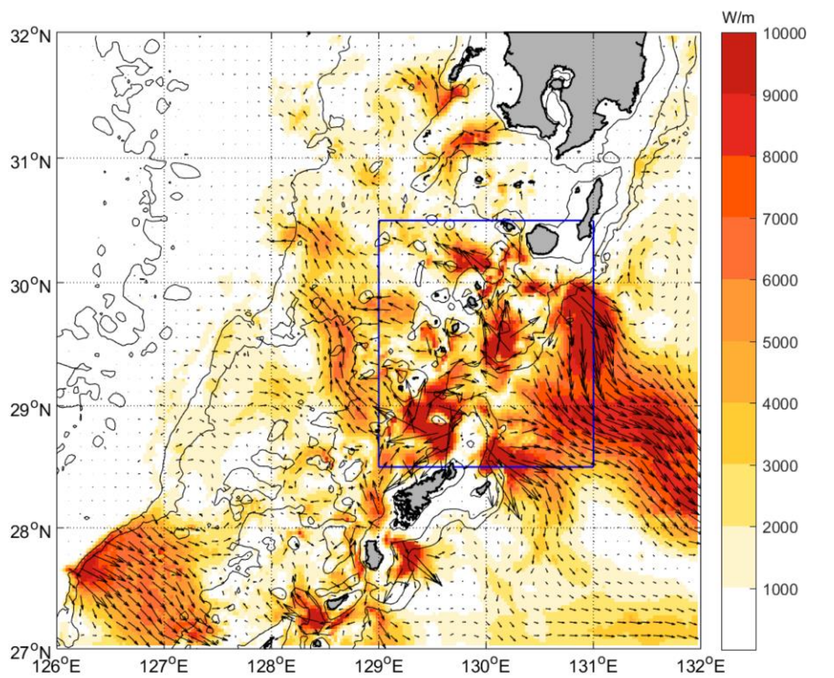

Figure 2, The depth-integrated distribution of baroclinic energy flux.

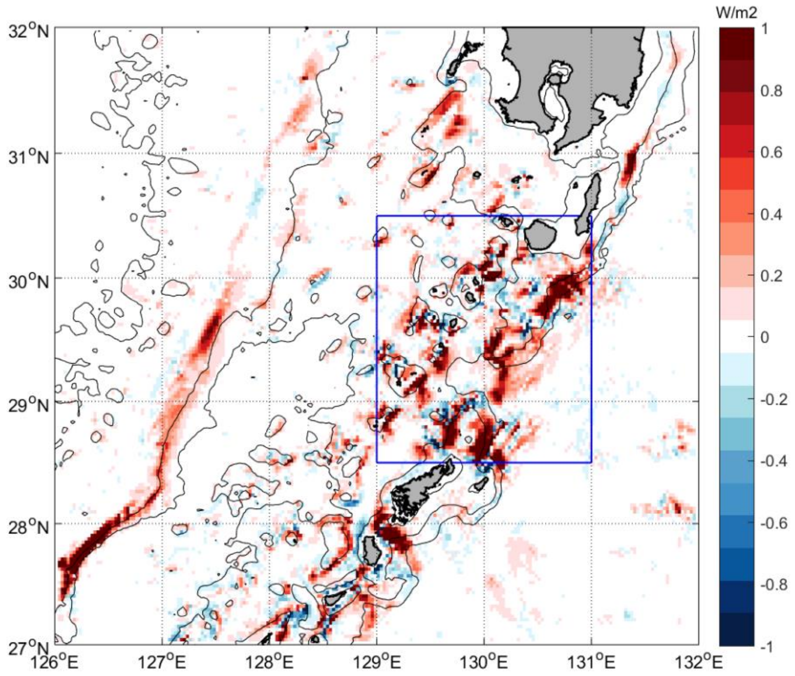

Figure 3, The distribution of baroclinic energy conversion.

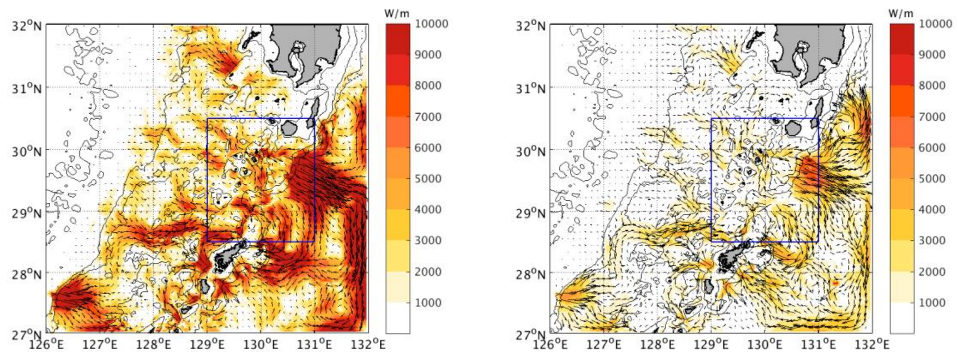

Figure 4, The depth-integrated distribution of baroclinic energy flux between spring and neap tide.

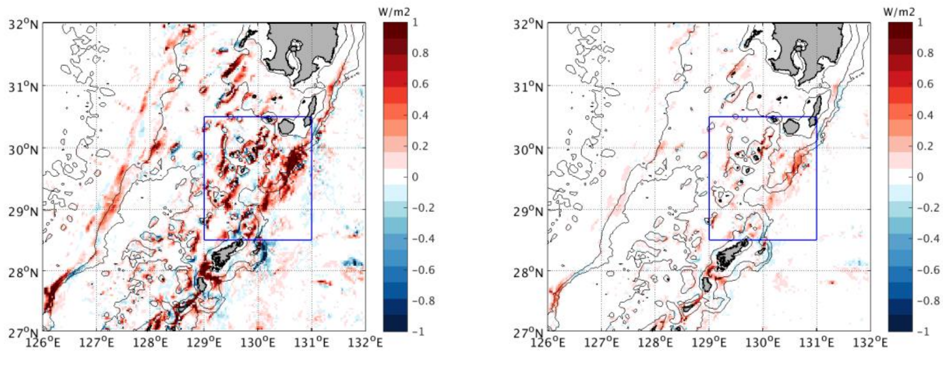

Figure5, The distribution of baroclinic energy conversion between spring and neap tide.

Reference ::

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Publication/conference presentation

Publications:

Oral presentation:

Title: The generation and propagation of internal tide at Tokara Strait

Lecturer: Jie Gao

Time: January 9 , 2018.

Location: Ehime University.

Perspectives in future

We expect great progresses by using simulation data. By using numerical model POM, we will further focus on how Kuroshio Current influences internal tide.

Title: The simulation of internal tide

Lecturer: Jie Gao

Time: June 5, 2017.

Location: Ehime University.

Perspectives in future

We expect great progresses by using simulation data. By using numerical model POM, we will further focus on how spring-neap tide influences internal tide.