Response to reviewer #1

We gratefully thank the editor and all reviewers for their time spent making their constructive remarks and useful suggestions, which has significantly raised the quality of the manuscript and has enabled us to improve the manuscript. Each suggested revision and comment, brought forward by the reviewers, was accurately incorporated and considered. Below the comments of the reviewers are responses point by point and the revisions are indicated.

RC1

The study reports on characteristics of mode-2 internal waves in the Pacific coast of Central America using marine seismic survey data. Observations of mode-2 internal waves in the ocean are relatively few. The research may contribute to our understanding of this wave phenomenon. I have some major concerns.

1. Comment: Line 27: Satellite remote sensing can not see the ocean interior. Thus, there is not an issue of vertical resolution.

1. Reply: Thank you for your valuable comment. Our description of the vertical resolution of remote sensing is indeed inappropriate. We have changed our statements in the corresponding places in the introduction of the revised manuscript (lines 25-27). We also show the revised text as follow:

Conventional physical oceanography observation and remote sensing observation have their limitations. That is, the horizontal resolution of conventional physical oceanography observation methods (such as mooring) is low. And satellite remote sensing cannot see the ocean interior.

2. Comment: Line 35: Most of the cited references in the paragraph use very ideal stratification. I am not sure how much these researches are relevant to mode-2 internal waves in the ocean.

2. Reply: Thank you for your valuable comment. Yes, these researches maybe don't have much relevance to mode-2 internal waves in the ocean because of the use of the very ideal stratification. We feel very sorry for our inaccurate statement and have changed our statement in the corresponding place in the introduction of the revised manuscript (line 36). We also show the revised text as follow:

At present, the researches on the mode-2 ISW are mainly based on simulation.

3. Comment: Line 103: The mode-2 ISWs in the actual ocean has continuous structure?

3. Reply: Thank you for your comment. Yes, we think the mode-2 ISWs in the actual ocean have continuous structure based on our observation. That is, the mode-2 ISWs in the actual ocean have multiple continuous density displacements above and below the mid-depth of the pycnocline. We have added the above description in the corresponding place in section 2 (Data and Methods) of the revised manuscript (lines 115-116). We also show the revised text as follow:

But the mode-2 ISW in the actual ocean has a multilayer structure (multiple continuous density displacements above and below the mid-depth of the pycnocline).

4. Comment: Line 106: I am sorry I do not understand why the equivalent three-layer model is used to define the amplitude of mode-2 ISWs. In oceanography, the amplitude is defined as the maximum vertical displacement of isopycnals (e.g. Shroyer,2010,JGR).

4. Reply: Thank you for your comment. We noticed that the amplitude, defined as the maximum vertical displacement of isopycnals, is used less in quantitatively describing the amplitude-related characteristics of mode-2 ISW. Particularly, in mode-2 ISW simulation research, the scholars often use the dimensionless amplitude $2a/h_2$ to quantitatively describe the amplitude-related characteristics of mode-2 ISW, like the relationship between the propagation speed and the dimensionless amplitude (Brandt et al., 2014; Carr et al., 2015). It is important to point that in mode-2 ISW simulation research, the dimensionless amplitude the scholars used comes from the three-layer model, which is different from the continuous structure (multilayer structure) of mode-2 ISW in the actual ocean. Because there is almost no work of the previous scholars to define the dimensionless amplitude of the mode-2 ISW based on the mode-2 ISW in the actual ocean (with multiple continuous density displacements above and below the mid-depth of the pycnocline) for our reference. To compare our observation results to the simulation results and quantitatively describe the amplitude-related characteristics of mode-2 ISW, we try our best to build an equivalent three-layer model. The equivalent three-layer model results from the mode-2 ISW with the continuous structure in the actual ocean. And we use this equivalent three-layer model to define the amplitude (dimensionless amplitude). Besides, we also try to use the maximum amplitude (the maximum vertical displacement of isopycnals) to study the amplitude-related characteristics of mode-2 ISW, like the relationship between the propagation speed and the maximum amplitude in Figure 9. But the correlativity is not very strong. That is another reason we try our best to build the equivalent three-layer model to define the amplitude of mode-2 ISW. We have added the above descriptions in the corresponding places in section 2 (Data and Methods) of the revised manuscript (lines 108-123).

5. Comment: Line 135: I am not familiar with the seismic reflection method, and I can not ensure the correctness of Eq.(1) and Eq.(2). However, my intuitive idea is that the actual wave form need to be obtained first.

5. Reply: Thank you for your comment. In a seismic survey, the sound is sent from a towed source, reflected from aquatic structures, and received by an array of towed hydrophones with time delays that depends on the geometry of the ray paths taken. The detailed introduction to seismic principles is described by Ruddick et al. (2009). Traditional seismic reflection imaging assumes that the underground structure is fixed. In the seawater, the mode-2 ISWs move relatively fast in the horizontal direction (about 0.5m/s), so the seismic reflection imaging of the mode-2 ISWs needs to consider the influence of the horizontal motion of the ISWs. We believe Eq.(2) and Eq.(3) in the revised manuscript are correct. We have added the above descriptions in the corresponding places in section 2 (Data and Methods) of the revised manuscript (lines 144-149).

6. Comment: Line 172: Is the dimensionless amplitude 2a/h2 equivalent to the one used by Brandt et al. 2014? The equivalent three layer model differs from Fig. 1 in Brandt et al. (2014).

6. Reply: Thank you for your comment. The dimensionless amplitude 2a/h2 is not completely equivalent to the one used by Brandt et al. 2014. And the equivalent three-layer model is not completely the same as Fig. 1 in Brandt et al. (2014). Because there is almost no work of the previous scholars to define the dimensionless amplitude of the mode-2 ISW based on the mode-2 ISW in the actual ocean (with multiple continuous density displacements above and below the mid-depth of the pycnocline) for our reference. The equivalent three-layer model is defined by trying our best to analogize with the three-layer model. We have added the above descriptions in the corresponding places in section 2 (Data and Methods) of the revised manuscript (lines 123-128). We have also modified the description related to the content of the equivalent amplitude in the full text (lines 196-197). These modifications aimed to express that the equivalent amplitude is defined by trying our best to analogize with the three-layer model, and is not completely equivalent to the definition of the three-layer model in the simulation experiment. We show the revised text (lines 196-197) as follow:
We define the ISW, whose $\tilde{a}$ value (dimensionless amplitude) is less than 2, as the mode-2 ISW with a small amplitude. And define the ISW, whose $\tilde{a}$ value is larger than 2, as the mode-2 ISW with a large amplitude.

7. Comment: Line 322: In Figure 8, the nondimensional wavelength does not seem to decrease with increasing nondimensional amplitude when 2a/h2<1. My observation is that the nondimensional wavelength may change from 2.5 to 7 for a fixed nondimensional amplitude.
7. Reply: Thank you for your valuable comment. We realized that it is not accurate to describe the nondimensional wavelength decreases with the increasing nondimensional amplitude when 2a/h2<1. We have changed our statement into "The nondimensional wavelengths seem to change from 2.5 to 7 for a fixed nondimensional amplitude when 2a/h2<1" in the corresponding places in the abstract, section 3.2, and conclusions of the revised manuscript (lines 14-15, lines 331-333, and line 612). We also show the revised text (lines 331-333) as follow:
Observing Fig. 8, it can be found that when $\tilde{a}<1$, the relationship between the λ_0 values and the $\tilde{a}$ values of the observed mode-2 ISWs in the study area is closer to the result predicted by the deep-water weakly nonlinear theory (Benjamin, 1967). But the λ_0 values change from 2.5 to 7 for a fixed $\tilde{a}$ value.

8. Comment: Line 400: How is the wave frequency defined? It is very important because the eigenfunction crucially depends on the wave frequency. Moreover, I note that Holloway et al.(1999) do not use wave frequency in the eigenvalue problem.
8. Reply: Thank you for your valuable comment. The formula for calculating the wave frequency is $w=v/\lambda$, where the wavelength λ (the wavelength here is two times the wavelength used in our manuscript) is measured from stacked seismic section, and the propagation speed v is estimated by the method described in section 2 (Data and Methods) of our manuscript. But actually, we used the $w=0$ in our study. We try to use the wave frequency to compute the eigenfunction during the revising process. Maybe because the wave frequencies of the mode-2 ISWs we studied are around $0.003s^{-1}$, the eigenfunction does not change much when using the wave frequency. In order not to cause misunderstanding, we have deleted the wave

frequency in the eigenvalue equation and the related description in the revised manuscript (lines 461-465). We also show the revised text (lines 461-465) as follow:

The linear vertical mode function can be obtained by solving the eigenvalue equation that satisfies the Taylor-Goldstein problem (Holloway et al., 1999):

$$\frac{d^2\varphi(z)}{dz^2}+\frac{N^2(z)}{C^2}\varphi(z)=0$$
$$\varphi(0)=\varphi(-H)=0 \qquad (6)$$

where *φ(z)* represents the linear vertical mode function, *C* is the linear phase speed, *N(z)* is the Brunt-Väisälä frequency.

9. Comment: Please consider to reduce the use of long sentences in the manuscript.

9. Reply: Thanks for your valuable suggestion. We have reduced the use of long sentences in the manuscript.