Response to Referee #1

Anonymous Referee #1

Received and published: 24 September 2018

General Comments:

Overall, the manuscript investigates the resonant period of the Gulf of Thailand (GOT) via numerical experiments and tries to establish a conceptual understanding of resonance in the gulf over two-channel model. The authors found that the resonant period of the GOT is closely related to that of the South China Sea body (SCSB) and is close to the period of the major diurnal tide, K1. They speculate that the resonance of the SCSB has a critical impact on the resonance of the GOT. On contrary, the resonance of the GOT has little influence on the resonance of the SCSB. I suggest that though this work seems to present interesting results speculating the interconnection of resonance between coastal bays and deep sea. However, the substantial analysis/discussion for convincing their findings/conclusions are inadequate and not up to the standard of the journal. For consideration of OS editor, some critical issues are addressed below:

Reply: We sincerely thank the referee for his careful reading of our manuscript and comments. We have revised this paper and addressed all these comments; our responses are given below.

In this response, the referee's comments are copied in black, our replies are shown in red, and the following abbreviations are used:

R1 – Revision #1 - an updated manuscript, which will be submitted as a supplement to this response.

Specific Comments:

1. Theoretically, the characteristic of the effective region for the resonance of long waves in the semi-enclosed sea can be calculated via the phase speed. For the GOT, the effective length of the basin for resonance of the diurnal tides can be approximately 1700 km. Besides, the co-tidal chart for K1 tide in the gulf suggests more precision length such as 1500 km. From this information, the resonant periods for the fundamental and first mode would be calculated as 73.8 and 24.61 hours (based on semi-enclosed basin formula). From these numbers, we could say that the period of diurnal tides in the gulf can be predominated by influence of the first mode instead of the fundamental mode. The role of the quarter wavelength resonant theory on tidal resonance in the GOT is insignificant and is easy to prove. However, this issue tends to be highlighted in the abstract and conclusion of the manuscript. But, it does not represent a substantial contribution to scientific progress in oceanography.

Reply: The GOT is a subsidiary gulf of the SCS, and the SCS is mainly composed of deep-sea basin and continental shelf (Figure 1). The SCS deep basin (abbreviated as SCSDB, where the water depth is more than 500 m, the blue line in Figure 1) connects with the GOT through the Sunda shelf (abbreviated as SS, where the water depth is less than 500 m). The average depth of the SCSDB is 2500 m, and the average depth of the SS and GOT are 66 m and 36 m, respectively. The water depth from the SCSDB to the SS varies dramatically (Figure 1).

The average depth within 1700 km (the length of the red line in Figure 1) of the semi-enclosed sea area is 173 m, of which the average depths of the GOT and SS are respectively 36 m and 66 m, and the average depth of a small part of the SCSDB is approximately 1000 m. According to the semi-closed basin formula, the resonance period should be approximately 15 hours, not 24 hours. If the range of 1700 or 1500 km is considered covering the whole continental shelf (including GOT and SS), its average depth is only 46 m and its resonance period is between 26 and 29 hours, not 24 hours.

Furthermore, in Cui et al. (2015), we find that the resonant period of the SCSDB is approximately one day because the one-quarter wavelength resonance in the SCSB. In this paper, we carried out two experiments by changing the depth of SCSB; the depths are one half and two times that of the real depth, and we find that the resonant frequencies (periods) are approximately 0.5 cycle/day (period is 43 hours) and 1.5 cycle/day (period is 16 hours), respectively. The experimental results are consistent with those from the one-quarter wavelength of the SCSB. Again, it is proved that the strong diurnal tide in the SCSB is caused by the quarter-wavelength resonance, so the SCSB (covering the SS and SCSDB) can be regarded as a system subject to the one-quarter wavelength resonance.

Both the GOT and the Gulf of Tonkin are subsidiary gulfs of the SCS, and the strong diurnal tide in the Gulf of Tonkin is caused by the quarter-wavelength resonance (Cui et al, 2015; Fang et al, 1999). We speculate whether the strong diurnal tide in the GOT can be explained by the quarter-wavelength resonance, but we find that it cannot. We don't know the reasons for the strong response around one cycle/day in the GOT. Since the tidal energy of the GOT comes mainly from the SCS, we speculate that the strong response in the GOT may be related to the SCS. In R1, we conclude that the GOT does have a large amplitude response around one cycle/day, and the results indicate that is just a passive response of the gulf to the increased amplitude of the SCSB along its southern boundary.

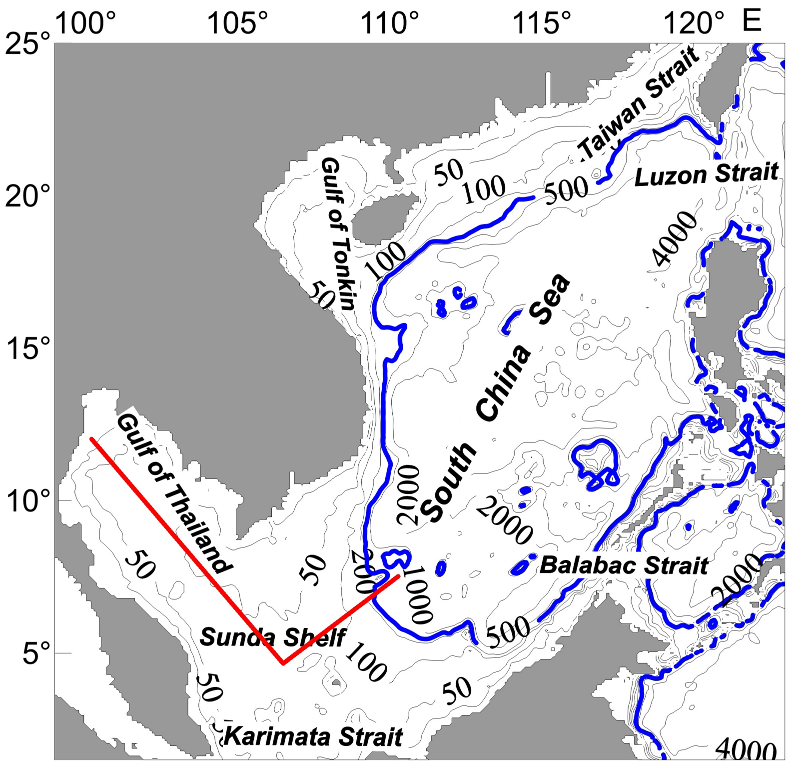

Figure 1. The length of the red line 1 is 1700 km; the blue line shows the 500 m isobath.

2. I wonder why the length of the GOT system is limited by the 660 km. The mentioned length may represent only the territorial sea of Thailand but does not involve the effective resonator system for tidal waves in true nature. Contrary, the size of the effective system should be larger as the entire western shelf of the South China Sea or Sunda Shelf (see the previous comment). Therefore, I suggest that the perception of a basin resonance oscillator and the dynamics of tidal waves in the GOT, the division of the computational domain, especially, the judgment of the authors for the application of classic quarter wavelength resonant theory for determining a diurnal resonant period of the GOT are altogether possible misconceptions.

Reply: Please kindly see the previous reply.

3. There are several resonance mechanisms (standing waves or basin mode and shelf mode) that might control oscillation of sea levels in the GOT system. Entirely, the impact of the standing waves modes associated with the period of approximately 24 hours is mostly accounted for. It is recognized that their modal structure distribution (nodal and anti-nodal bands) along the major axis of the system (the distance from the inner GOT to Kalimata strait, NS mode).

Reply: The SCSB plays a decisive role in the response peak in the GOT at the frequency of one cycle/day, and one-quarter wavelength of this frequency is approximately equal to the length of the SCSB, which leads a significant peak at the south of the SCSB, where is also the entrance to the GOT. The significant amplitude at the entrance of the GOT causes the GOT to have a strong response at the frequency of one cycle/day. The large amplitude in the GOT at this frequency is just a passive response to the increased amplitude caused by the one-quarter wavelength resonance in the SCSB.

Supported by the geometry defined by the distance from the Malaysia Peninsular to the eastern of the Taiwan Strait, the modal structure of mentioned period may also be fitted into the SCSB. But, it should have a different modal structure (East-West, EW mode). The existence of the mentioned modal structures revealed in the manuscript.

Reply: Please kindly see the previous reply.

Besides, the experiment in determining the effect of bottom topographies of the SCSB on the resonant response of the GOT is presented. As present in this part of the results, it seems that the consistency of the resonant periods are the main reason to judge that the GOT is not an independent sea area regarding tidal resonance. On the other hand, the amplification mechanism is not involved although the response (amplitude gain) of the GOT is probably higher than that of the SCSB (See Exp. 3 Result). The real phenomenon similar to the Exp.3 can be such as the resonance of M2 in the Bay of Bengal, Andaman seas and Malaca Strait.

Reply: Please kindly see the previous reply.

The part of the deeper and shallow sea of the mentioned system may have the same resonant period but amplification become more intensified near the shelf zone. Indeed, the resonance of the Andaman seas and Malaca Strait are not independent from the Bay of Bengal. But, they have the locality regarding the modal structure and amplification processes. Importantly, we might explain dynamic of tidal waves in the mentioned area as an influence of a combined-role of basin and local resonance modes. I suggest that this concept would also explain the interconnection of the GOT and SCSB. Hence, I reject that judgment as mentioned above because the locality of the GOT and the SCSB are found in their results.

Reply: Please kindly see the previous reply.

Moreover, for the idealized model part, the authors only show preliminary results that mostly identical to the numerical experiment. They do not present some discussion showing the benefit of the model to gain more comprehension of the tidal resonance in the GOT.

Reply: We added a new part containing content about this idealized model in R1 as follows: “If we apply the quarter-wavelength resonance theory to channel 1, we can obtain resonant frequencies of 0.99 d^{-1}. If we apply the quarter-wavelength and three-quarter-wavelength resonance theories to channel 2 we can obtain resonant frequencies of 0.61 and 1.84 d^{-1}, respectively. Therefore, we can conclude that the major peaks around the frequency of 1.04 d^{-1} in Figure 6 are caused by resonance in channel 1. This indicates that channel 1 plays a determinative role in the two-channel system. Similarly, we can also conclude that the secondary and third peaks around the frequencies of 0.55 and 1.85 d^{-1} in Figure 6 are caused by resonances in channel 2, associated with the quarter-wavelength and three-quarter-wavelength resonances. Although the frequencies of the peaks shown in Figure 6 correspond well with those estimated based on the quarter-wavelength and three-quarter-wavelength theories, there are small discrepancies. This is due to the connection of the two channels. In fact, the resonant frequencies of the two-channel system also depend on the depth ratio of two channels, as shown in Eq. (14). In comparison to channel 2, the secondary, especially the third peak, in channel 1 is much more less significant. This can be explained as follows: The tidal incident wave from the channel 1 partially enters channel 2 across the steep topography at $x = 0$, and here, the rest of the wave is reflected. The reflected wave is superimposed with the incident wave, and tidal resonance occurs around the frequency of 1.04 d^{-1}. That is, the steep topography at $x = 0$ acts as a wall for channel 1, which causes the quarter-wavelength resonance to occur in the channel. Furthermore, the steep topography can also block most energy of the wave in channel 2 from entering channel 1. Therefore, the relatively large amplitudes in channel 2 at frequencies around 0.55 d^{-1} and 1.85 d^{-1} are not obvious in channel 1 under the action of friction".