Response to Referee #2 by Guohong Fang and Di Wu

This paper contains an original contribution to the co-oscillating tide in Sea of Japan (East Sea) using an extended Taylor method. Writing is considered to be reasonably good with fine piece of references. However, there is an important point authors need to make correction to enhance the quality of the paper. Specifically, extension of the three sub-region model to four sub-region model is requested. Reviewer think the extension work is not difficult but considerable time around two months might be required to make correction of the content of manuscript. For that, a major revision is recommended.

Reply: We sincerely thank Reviewer for his carefully reading and constructive comments. We have extended the model domain from three sub-regions to four sub-regions in the revised manuscript. Please see the following for details.

Detailed comments:

Pg.4, Lines 14-20: Authors constructed a model with three sub-regions as seen in Fig. 3. However, water depth of Fig.1 and tidal chart of Fig.2 indicate the necessity of including Tartar Strait region in the analytical model. Extension of the three sub-region model to the four sub-region model is requested. On the while, review think, though not much important, representing the Japan Sea (East Sea) as the Area 2 with width W1+W3 might be sufficient rather than width W2 unless the shallow water depth along the northern coastline of Japan is considered.

Reply: According to this comment, we have extended the model domain from three sub-regions to four sub-regions in the revised manuscript. For convenience, we call the models with three sub-regions and with four sub-regions the 3-area model and the 4-area model respectively. The 4-area model domain fitting the KS and JS is shown in Fig. R1 below. Please note that we can only artificially place Area4 northeast of Area3 rather than north of Area3 due to the limitation of the Taylor method. So that the Area4 cannot overlap the actual Tartar Strait.

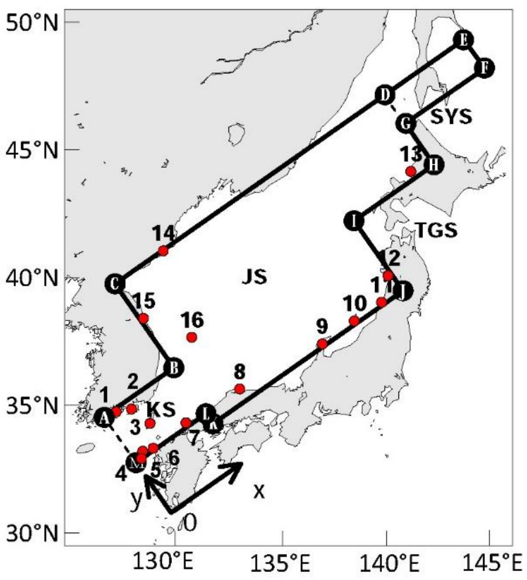

Fig. R1: Idealized 4-area model domain fitting the Korea Strait and Japan Sea. Copied from

Figure 4 of the revised manuscript.

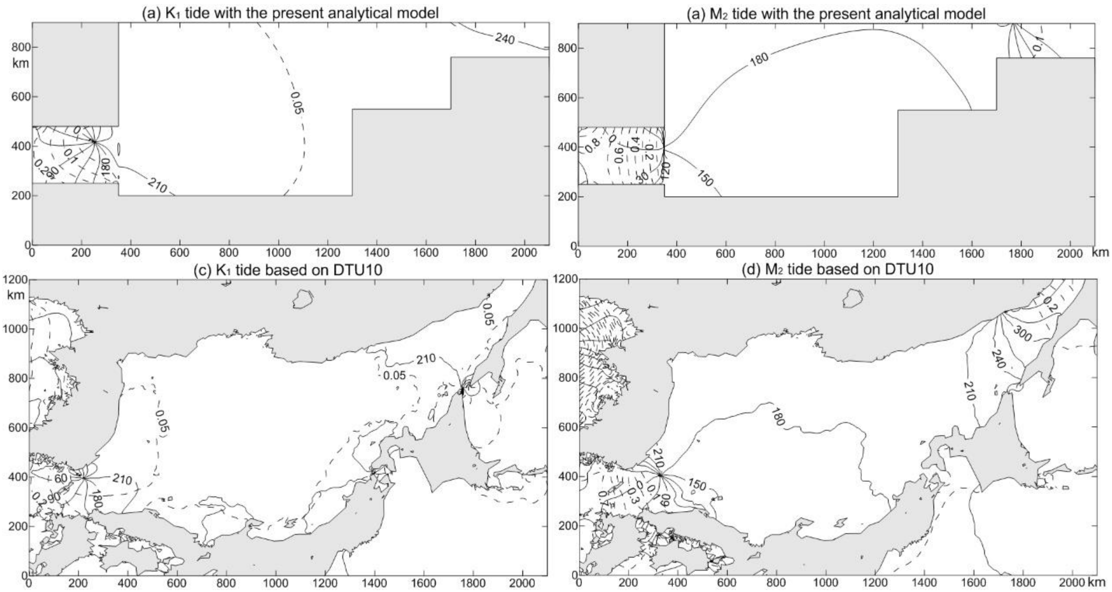

Fig. R2: Comparison of tidal system charts. (a) K_1 and (b) M_2 tides from the present analytical model; and (c) K_1 and (d) M_2 tides from DTU10 (Chen and Andersen, 2011). Copied from Figure 5 of the revised manuscript.

The comparison between model results and observations is shown in Fig. R2. Correspondingly, the results in Area1 (representing the KS) of the 3-area model mentioned from page 13, line 29 to page 14, line 14 in the original manuscript are replaced with the 4-area model results in the revised manuscript. The changes in Area1 are less than 0.01 m and 2° for amplitudes and phase lags of K_1 respectively, and less than 0.01 m and 1° for amplitudes and phase lags of M_2 respectively, indicating that adding Area4 does not significantly change the tidal systems in Area1.

Pg.7, Line 16: Authors used the Collocation approach. In fact there is another approach called Galerkin approach. Briefly comment why authors used Collocation approach. Is it mainly due to its simplicity?

Reply: Yes, it is mainly due to its simplicity. In Taylor's original work, he used the Fourier method, which involved the Fourier expansions at the closed cross-sections, and thus making the solution more complicated. To our knowledge, nobody has employed the Galerkin method in the Taylor problem, though it has been widely used in the numerical computations.

Pg.8, Lines 11-12: Authors state that the influence of tide-generating force on the KS is negligible. Reviewer does not agree on this statement because the influence of direct tide generating force (DTGF) on the tide in JS can be significantly large, indirectly affecting on the tide in KS even though its direct influence on the KS is small. Reviewer think co-oscillating tide may be dominant in Japan Sea (East Sea) but DTGF has some non-negligible effects.

Reply: This comment correctly points out a limitation of the Taylor method. The classical and extended Taylor methods solve the homogeneous differential equations as shown in the governing equations in our manuscript (please see also Taylor, 1922; Hendershott and Speranza, 1971; among others). Once the DTGF is included, the governing equations will become non-homogeneous, and the basic wave forms (namely the Kelvin wave and the Poincare wave) will no longer satisfy the governing equations. This is the reason why all existing studies (please see references listed in our manuscript) do not include DTGF.

To examine the influence of the DTGF on the tides in the Korea Strait, we have numerically computed the tides in the Korea Strait and Japan/East Sea with and without DTGF using MIKE21 model, and make comparison between these two results. As an example, Fig. R3 displays the comparison of the model-produced M_2 tidal systems with and without DTGF.

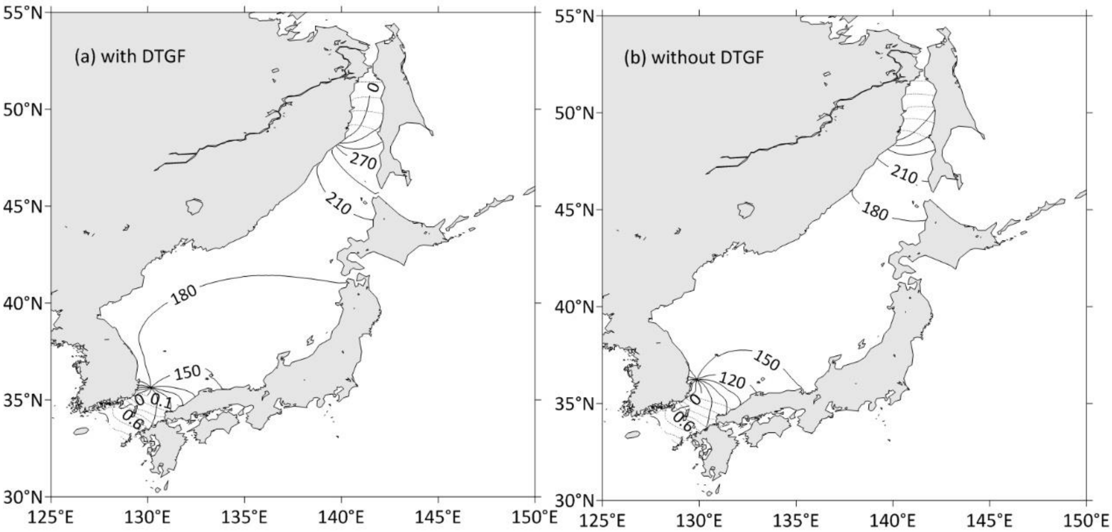

Fig. R3: Comparison of the model-produced M_2 tidal system charts, (a) with DTGF, and (b) without DTGF.

As shown in our paper title, the present study focuses on the tides in the KS. To quantitatively evaluate the influence of the DTGF on the tides in the KS, we select evenly distributed 893 points in the KS as shown in Fig. R4, and calculate the root-mean-square (RMS) vector differences between two sets of model results according the following equation:

$$\Delta = \left\{\frac{1}{K}\sum_{k=1}^{K}\left[\left(H_{2,k}\cos G_{2,k} - H_{1,k}\cos G_{1,k}\right)^2 + \left(H_{2,k}\sin G_{2,k} - H_{1,k}\sin G_{1,k}\right)^2\right]\right\}^{1/2} \quad \text{(R1)}$$

in which $k = 1, 2, \ldots, K$ are indices of the points shown in Fig. R4, with K representing the total number of the points (=893); H and G are model-produced amplitude and phase lag respectively, with subscripts 1 and 2 representing the results with and without DTGF respectively. The characteristic model-produced mean amplitude with DTGF can be calculated from the following equation:

$$\bar{H} = \left(\frac{1}{K}\sum_{k=1}^{K} H_{1,k}^2\right)^{1/2} \quad \text{(R2)}$$

The relative difference is represented by

$$\delta = \Delta/\bar{H} \quad \text{(R3)}$$

The results are given in Table R1 below. From Table R1 we find that the differences between the model results in the KS with and without DTGF are not significant, indicating that the KS is dominated by co-oscillating tides.

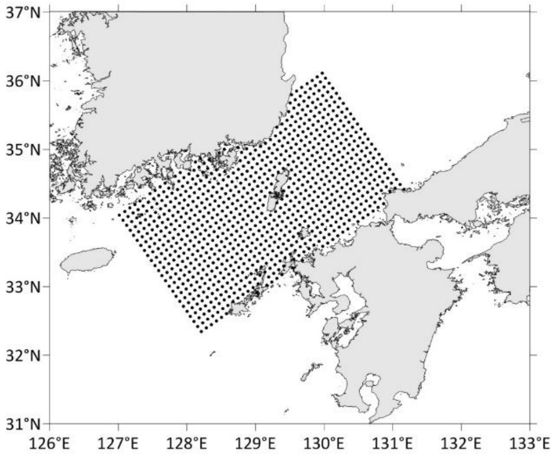

Fig. R4: Distribution of the points for comparison between the model-produced results with and without DTGF.

Table R1. Difference and relative difference between model results with and without direct tidal generating force (DTGF)

	Δ	$\overline{H}$	δ
M_2	0.0092	0.6731	0.0137
K_1	0.0075	0.1625	0.0459

Pg.9, Lines 10-12: In Table 1, it is noted that water depth of area 3 is 1783m, which is comparable with that of Area 2. With the model reproduction of tide in Tartar Strait shown in Fig.2 is hardly expected.

Reply: We have changed Table 1 to include Area4, which represents the Tartar Strait. The depth of Area4 is taken 90 m, much shallower than Area3.

Pg.11, Lines 11-12: Authors' statement such that the model-produced tidal systems agree fairly well with the DTU10 result is reasonably acceptable. Reviewer however notices that there are some important points authors did not comment. Close examination of Fig.5 reveals that DTU10 produces amphidromic point further north than that calculated by the analytic model and that DTU10 and analytic model produces different contour patterns in Area 2 and Area 3. Reviewer thinks that these are due to neglecting the shallow Tartar Strait region in the analytic model. Again it is addressed that Area 3 is too deep and short to include the effects of presence of the Tartar Strait. According to reviewer's modeling experience, the tides in JS (East Sea) and KS vary sensitively with change of bottom frictional coefficient in the Tartar Strait.

Reply: We accept this comment and add the fourth sub-region (Area4) to represent the Tartar Strait in the revised manuscript. The water depth of Area4 is taken 90 m, which is equal to the mean depth of the main part of the Tartar Strait. After adding Area4, the agreement between model results and DTU10 data is slightly improved.

Pg.12, Lines 3-5: Authors state with regard to Fig. 6 that the greatest phase lag error occurred at the northernmost corner of JS due to the existence of degenerated amphidromic point near the area. This supports the necessity of developing an extended model which takes into account the shallow Tartar Strait region.

Reply: The 4-area model does show a degenerated amphidromic point for M_2 in Area4, which is consistent with observed feature as shown in Fig. R2.

Pg.16, Line 1: Authors discussed tidal dynamics in KS-JS basin with emphasis on the amphidromic point. However, it is hard to find any discussions related to the influence of Area 2. Reviewer think this is because no meaningful contribution by Area 2. Again, it is strongly addressed that extension of the three sub-region model to the four subregion model is required.

Reply: In the text of the original manuscript from page 17, line 6 onward in Section 4 our focus of discussion is on the role of Area2 which representing the JS. To emphasize the importance of the JS, we insert "Eq. (36) indicates that the length, width and depth of Area2 are also important in determining the phase-lag increase of the reflected wave relative to the incident wave in Area1" in page 17 of the revised text; and add "(5) The length, width and depth of the JS is also important in determining the phase-lag increase of the reflected Kelvin wave in the KS" to the end of Section 5 (Summary) in the revised text.