Dear Reviewer:

We sincerely thank you for your time spent making your constructive remarks and useful suggestions, which has significantly enhanced the quality of the manuscript and enabled us to improve the manuscript. We carefully considered and incorporated each suggestion and comment from the reviewer. Please find below our point-by-point responses to the reviewer's comments as well as indications of the revisions made.

General comments

In the presented study, the authors used a storm surge model to analyse the characteristics of Typhoon Nida in the Pear River Estuary (PRE). In order to gain a thorough understanding of how tidal forces, storm surges, and their nonlinear interactions influence total water levels in the region, the authors defined a series of scenarios (tidal forcing only, atmospheric forcing only, combined tidal and atmospheric forcing, and varying landfall). The results demonstrated that nonlinear tide surge-interactions were most significant when landfall times coincided with lowest high water (LHW). Moreover, the authors explored the various mechanisms underlying these nonlinear tide-surge interactions, identifying the local acceleration term and the nonlinear convection term as primary contributors, although other terms might dominate in shallow water areas.

While the title aptly reflects the paper's content and the study is compelling, there are several issues that should be addressed by the authors. Specific comments and suggestions are outlined below:

Specific comments

1. In my view, the manuscript includes an excessive amount of (sub)figures and tables, which detracts from its focus. The descriptions of all these (sub)figures and tables in the results section make that section challenging to read. It would enhance the paper if some of these figures and tables were moved to a Supplementary Material, thereby allowing a more concentrated and generalized description and discussion of the remaining key figures and tables. For instance, are Tables 4-7 all essential to the main manuscript? Additionally, is it necessary to present results for all five locations (P1-P5)? Given that some locations exhibit similar behaviour, focusing on two or three representative locations might suffice. This would streamline the manuscript and make the key findings more accessible to readers.

Response:

Thank you for your insightful comments and kind suggestions. Tables 4 - 7 are necessary to the study. We would like to suggest that it might be beneficial to consider the nonlinear effect at different tidal phases. The ratio of the nonlinear residuals to the storm surge could be a useful way to represent the extent to which the nonlinear effect amplifies or diminishes the direct impact of the storm surge. These five points represent specific area. P1 to P3 represent the internal, middle, and external of Lingding Bay, respectively, and P4 representing the northern part of Qi'ao Island, and P5 representing Shenzhen Bay, which are two shallow water areas.

2. As you mentioned, there are already comparable studies in similar settings or even specifically focusing on the Pear River Estuary (e.g., Hu et al., 2023). How does your study compare to these previous studies and what are the novel contributions of your research?

These aspects should be more clearly highlighted in the manuscript.

Response:

Thank you for your insightful comments and helpful suggestions. Our study is primarily concerned with the interaction between tides and storm surges, with a particular focus on the influence of tidal phases on the nonlinear effects. Additionally, our research offers a refinement of the momentum terms by distinguishing between wind induced friction and bottom induced friction, which represents an advancement over the work of Hu et al. (2023) and Yang et al. (2019). The results show that the wind stress term and bottom friction term played different role in the process.

Reference

Yang, W., Yin, B., Feng, X., Yang, D., Gao, G., and Chen, H.: The effect of nonlinear factors on tide-surge interaction: A case study of Typhoon Rammasun in Tieshan Bay, China. Estuar. Coast Shelf S, 219, 420-428, https://doi.org/10.1016/j.ecss.2019.01.024, 2019.

Hu, S., Liu, B., Hu, M., Yu, X., Deng, Z., Zeng, H., and Li, D.: Quantification of the nonlinear interaction among the tide, surge and river in Pearl River Estuary, Estuar. Coast Shelf S., 290, 108415, https://doi.org/10.1016/j.ecss.2023.108415, 2023.

3. An outlook of your results would be beneficial. Are there any findings that can be generalized and applied to other regions? Or how do your results contribute to improving forecasting skills, as mentioned in your abstract? Providing potential applications of findings will only increase the impact of a study!

Response:

Thank you for your insightful comment and kind suggestion. The PRE is characterized by its distinctive funnel-shaped bay, where the dynamics and tides are greatly influenced by its complex coastline, which is composed of numerous islands and other features, setting it apart from estuaries that are discharged directly into the open shelf. Our results are also applicable to similar geographical environments and typhoon tracks. Although our work is based on a specific area, it has been found in the research of others that nonlinear effects are strongest at top of the bay (Yang et al., 2019). In our experiments, we took into account the number of tidal harmonic constituents, as well as the rendering of the topography, in order to enhance the accuracy of the simulation. This model has also been applied to storm surge forecasting, with satisfactory simulation results.

Reference

Yang, W., Yin, B., Feng, X., Yang, D., Gao, G., and Chen, H.: The effect of nonlinear factors on tide-surge interaction: A case study of Typhoon Rammasun in Tieshan Bay, China. Estuar. Coast Shelf S, 219, 420-428, https://doi.org/10.1016/j.ecss.2019.01.024, 2019.

4. Please elaborate on why Typhoon Nida was chosen for your study. Would the results differ significantly for typhoons with other tracks and intensities? Do your findings represent general characteristics of the PRE during storm surges, or are they only specific to events similar to Typhoon Nida? This should be discussed in detail.

Response:

Thank you for your insightful comments. We selected Typhoon Nida for our study because the maximum storm surge induced by Nida coincided with the highest high water (HHW). Additionally, we conducted simulations for Typhoon Hato and Typhoon Mangkhut to investigate the underlying the mechanisms. As shown in Figs 1-2, in the momentum analysis for these events, similar to Nida, suggests that the nonlinear effect is mainly generated by the nonlinear local acceleration term and the convection term resulting from the tide-surge interactions in the study area. Additionally, it seems that variations in the y component of the nonlinear momentum terms are more significant than those in the x component, which is similar to what was analysis conducted through Nida. So, these findings reflect the general characteristics of the PRE during storm surges. Meanwhile, our other study delves into the specifics of Typhoon Hato and Typhoon Mangkhut.

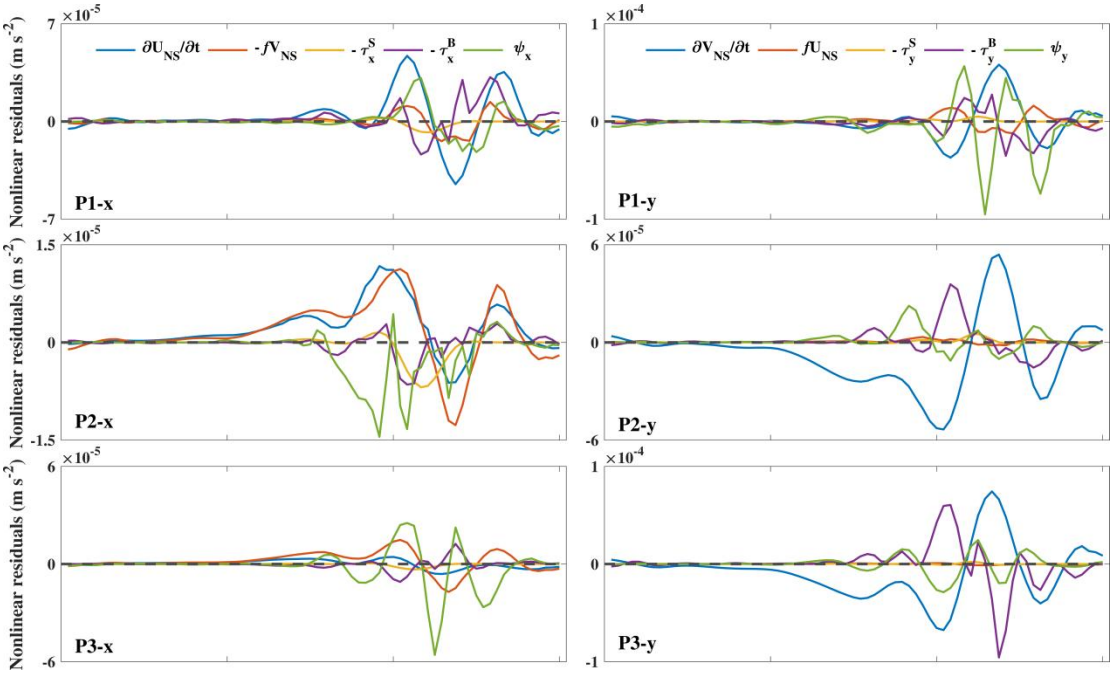

Fig 1 Time series of the nonlinear components of Typhoon Hato at P1, P2 and P3 in x direction (left) and y direction (right)

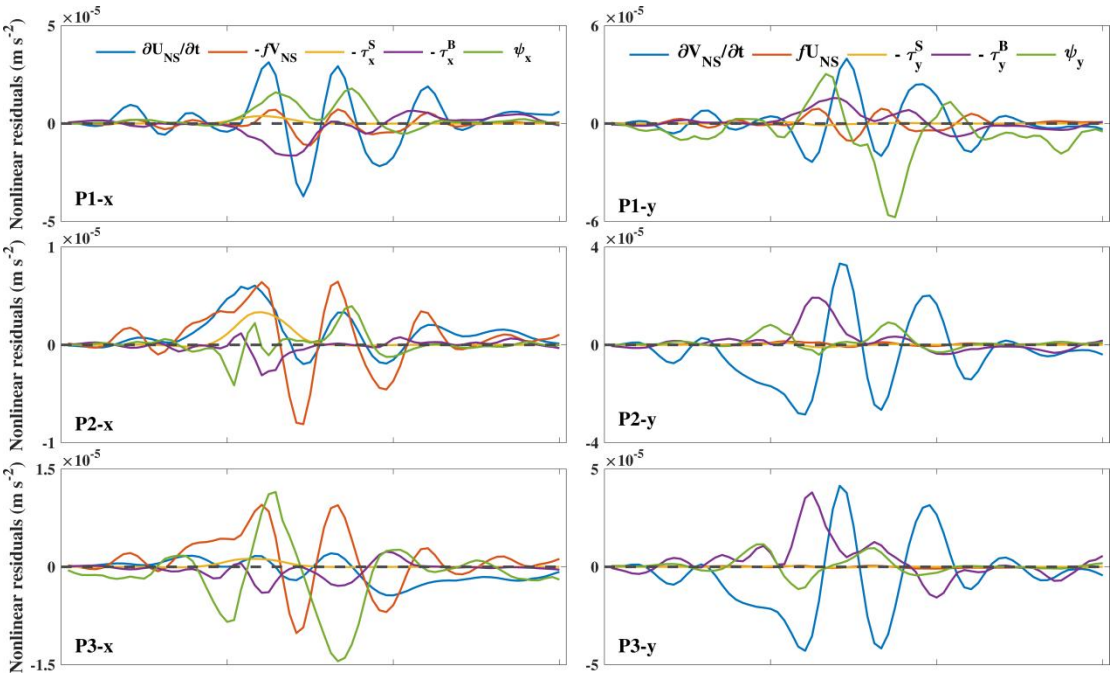

Fig 2 Time series of the nonlinear components of Typhoon Mangkhut at P1, P2 and P3 in x direction (left) and y direction (right)

5. In the description of the numerical model, there is no mention of whether a 2D or 3D model was applied. This information is only found towards the end of the paper. Please include this detail in the initial description of the numerical model. Additionally, please briefly explain why a 2D model was deemed sufficient for your model domain?

Response:

Thank you for your insightful comments and helpful suggestions. We opted to use a two-dimensional (2D) hydrodynamic ADCIRC model. The vertical current shear in well-mixed environment at shallow water depth is relatively small. This suggests that a 2D depth averaged model is sufficient to revel the physical processes of tide-surge interaction (Idier et al., 2012; Song et al., 2020; Zhang et al., 2017). We have introduced them in section 2.3, where you will find further details on this topic.

Reference

Idier, D., Dumas, F., and Muller, H.: Tide-surge interaction in the English Channel, Natural Hazards Earth System Sciences, 12, 3709-3718, 2012.

Song, H., Kuang, C., Gu, J., Zou, Q., Liang, H., Sun, X., and Ma, Z.: Nonlinear tide-surge-wave interaction at a shallow coast with large scale sequential harbor constructions, Estuarine, Coastal Shelf Science, 233, 106543, 2020.

Zhang, H., Cheng, W., Qiu, X., Feng, X., and Gong, W.: Tide-surge interaction along the east coast of the Leizhou Peninsula, South China Sea, Continental Shelf Research, 142, 32-49, 2017.

6. Is it truly necessary to include all these formulas? When discussing a numerical model like ADCIRC, providing a reference for readers to find additional implementation details should be sufficient. Additionally, common metrics such as the RMSE are generally

well-known to readers, so including their formulas is redundant. It would be more effective to only focus on the formulas that are essential for understanding your specific work (e.g., Formula 12).

Response:

Thank you for your insightful comment and kind suggestion. While many readers are familiar with metrics such as the root mean square error (RMSE) and the correlation coefficient (R), it is possible that not everyone is as acquainted with Skill. Therefore, we have taken the decision to delete the formulas for RMSE and R, but to retain the formula for Skill in order to ensure clarity for all readers.

7. I also have difficulty understanding some of your terminology. Could you clarify what is meant by terms such as "negative/positive surge levels" and "negative maximum"?

Response:

We apologize for that caused any confusion. Our initial intention was to emphasize the extreme values resulting from both increased and decreased water levels, which cloud have either negative or positive implications. We have amended the manuscript to address this issue as follows:
'The numerical results shows that when Nida approached to the PRE, the simulation of increased water levels was underestimated, resulting in significant errors in prediction storm tides. However, the simulated results for maximum water levels closely match the observed values, demonstrating that the model employed in this study effectively represents the tidal-surge interactions within the study area.'

8. LL82-84: "In this paper, we utilize a recently developed ADCIRC based PRE surge model, which is nested within the China Sea tide and surge model, to investigate the mechanism of tide-surge interaction."
Could you specify which China Sea tide and surge model is being referred to here? If there is an existing publication and a reference for this model, please include it here.

Response:

We apologize for any confusion this may have caused. This model is independent design based on the ADCIRC model and represents a distinctive approach to simulating storm surges in PRE. It takes into account both tides and storm surges, thus offering a more comprehensive representation of this phenomena.

Technical corrections

1. The manuscript would greatly benefit from some language editing. Below, you will find an incomplete list of issues that I have noticed. One recurring issue, for instance, is the inconsistent use of articles. Here are a few examples:
"Advanced Circulation Model […]" should be "The Advanced Circulation Model […]
"[…] while advection term […]" should be "[…] while the advection term […]"
"[…] makes positive contribution […]" should be "[…] makes a positive contribution […]"

Response:

Thank you for your constructive comment and kind reminder. We have reviewed the manuscript and made the necessary corrections.

2. LL60-62: "Rego and Li (2010) studied the storm surge induced by Hurricane Rita revealed that the advection terms were dominant over bottom friction with significant spatial-temporal variations in the nonlinear terms."
"[…] Hurricane Rita and revealed that […]"

Response:

Thank you for your kind reminder. We have checked the manuscript and corrected the mistakes.

3. LL67-68: "The characteristics of storm surges and nonlinear effects in the Pearl River Estuary (PRE) are especially complex, as the PRE is one of the most important economic regions of China."
The first and second parts of this sentence are not logically connected. In my opinion, it would be better to connect this sentence with the following one: "The characteristics of storm surges and nonlinear effects in the Pearl River Estuary (PRE) are especially complex, as its topography consists of deep channels, shallow shoals, and tidal flats […]."

Response:

Thank you for your kind suggestion, we appreciate it gratefully, and have corrected the mistakes in our manuscript.

4. L98: "2.1 Typhoon NIDA"
Why are capital letters used for Typhoon Nida here?

Response:

We are apologize for any confusion caused by our careless mistake. We have checked the manuscript and corrected the mistake.

5. LL99-100: "Typhoon Nida generated in the western North Pacific Ocean on 29 July 2016 and began to move westward rapidly."
"Typhoon Nida was generated […]"

Response:

Thank you for your kind suggestion. We appreciate it gratefully, and have made the necessary corrections to the text.

6. Figure 1 Please consider that some readers may have colour vision deficiencies. Therefore, it is advisable to avoid using 'jet' colourmaps in your figures. Additionally, you should ensure that all figures are checked for appropriate colour choices and contrast. It is also important to define all abbreviations used in the figures, such as TD, TS, STS, and TY.

Response:

Thank you for your kind suggestions. We have revised this figure and have added an explanation of the typhoon levels, as shown in Fig 3. We have also added some information about Typhoon Nida to the manuscript text as follows:

‘As shown in Fig 1a, Typhoon Nida, classified as a sever tropical storm (STS) passed across the Philippines and entered the South China Sea (SCS) on July 31, 2016. It then proceeded westward and made landfall as a typhoon (TY) at 19:30 on August 1 in Shenzhen, Guangdong Province, China. The typhoon had a central pressure of 970 hPa and maximum wind speed exceeding 42 m/s. After that, it was weakening as a tropical storm (TS). On August 3 0:00, it as a tropical depression (TD) and dissipated.’

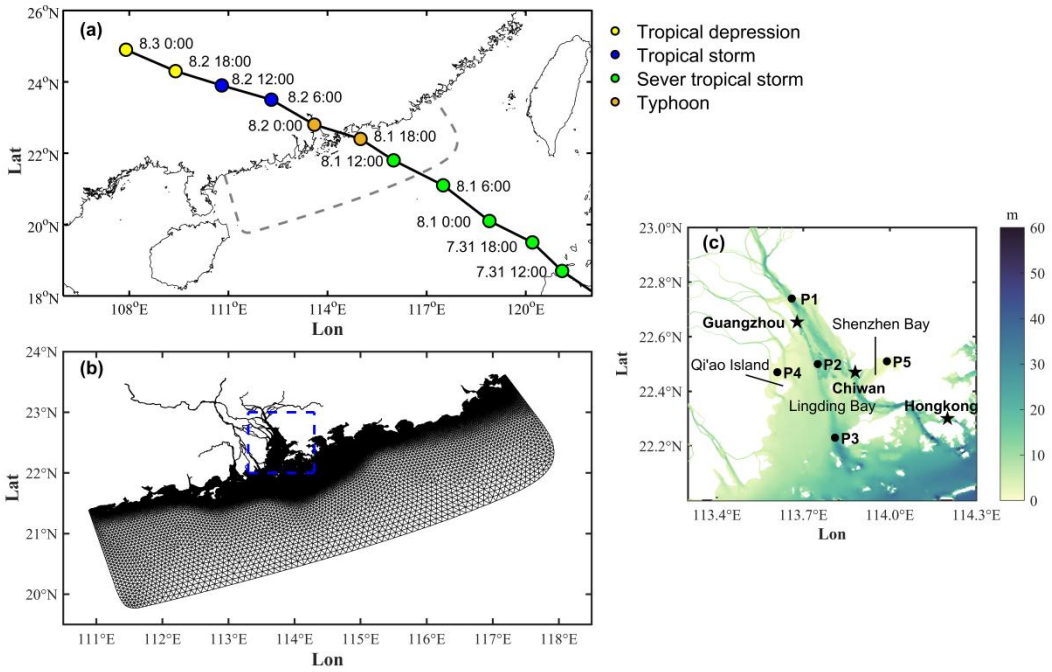

Fig 3 (a) The track and intensity of Typhoon Nida; (b) Model domain and grids of the study area; (c) Location and bathymetry of PRE. Stars represent the tidal gauges, and dots denote the calculation points of surge levels.

7. LL115-116: “Which is unstructured triangular grids in the horizontal plane to resolve dynamics in complex shorelines.”
This sentence is unclear. A better way to phrase it might be: “Unstructured triangular grids were used in the horizontal plane […]”

Response:

Thank you for your kind suggestion, and we appreciate it gratefully. We have rephrased the sentence following your suggestions.

8. LL134: “2.3 wind field of typhoon”
Capitalisation should be used at the beginning of your header. However, I believe that introducing a new subchapter for the wind field model may be unnecessary, as this information would seamlessly fit into the previous subchapter.

Response:

Thank you for your insightful comment and useful suggestion. We have taken your suggestion and have made the necessary revisions accordingly.

9. LL135-136 “We employed the analytical wind model from Holland (1980), which has

applied in reconstructing the wind field during Typhoon Nida."
"[…] which was applied for reconstructing […]"

Response:

Thank you for your kind suggestion. We appreciate it gratefully, and have made the necessary corrections to the manuscript.

10. LL163-164: "As a semi-enclosed bay, Lingdingyang Bay is regularly affected by both storm surges and irregular semi-diurnal tides."
Not everyone is familiar with your study area. Ideally, all relevant geographical names should be shown on a map of your study area.

Response:

Thank you very much for the positive feedback and constructive suggestions. We have redrafted this figure and added the relevant geographical names as shown in Fig 3.

11. Figures 2 and 3 What do the lines and points represent in Figures 2 and 3? It is not explained, which elements correspond to the measurements and which to the simulations.

Response:

We apologize for that confused you, and thank you for your kind reminder. The points in Figure 2 represent the observed values, while the lines represent the simulated values. Figure 3 (manuscript) also represents observed values with points and simulated values with lines, in a similar to Figure 2 (manuscript). We have redrafted these figures as shown in Figs 4-5.

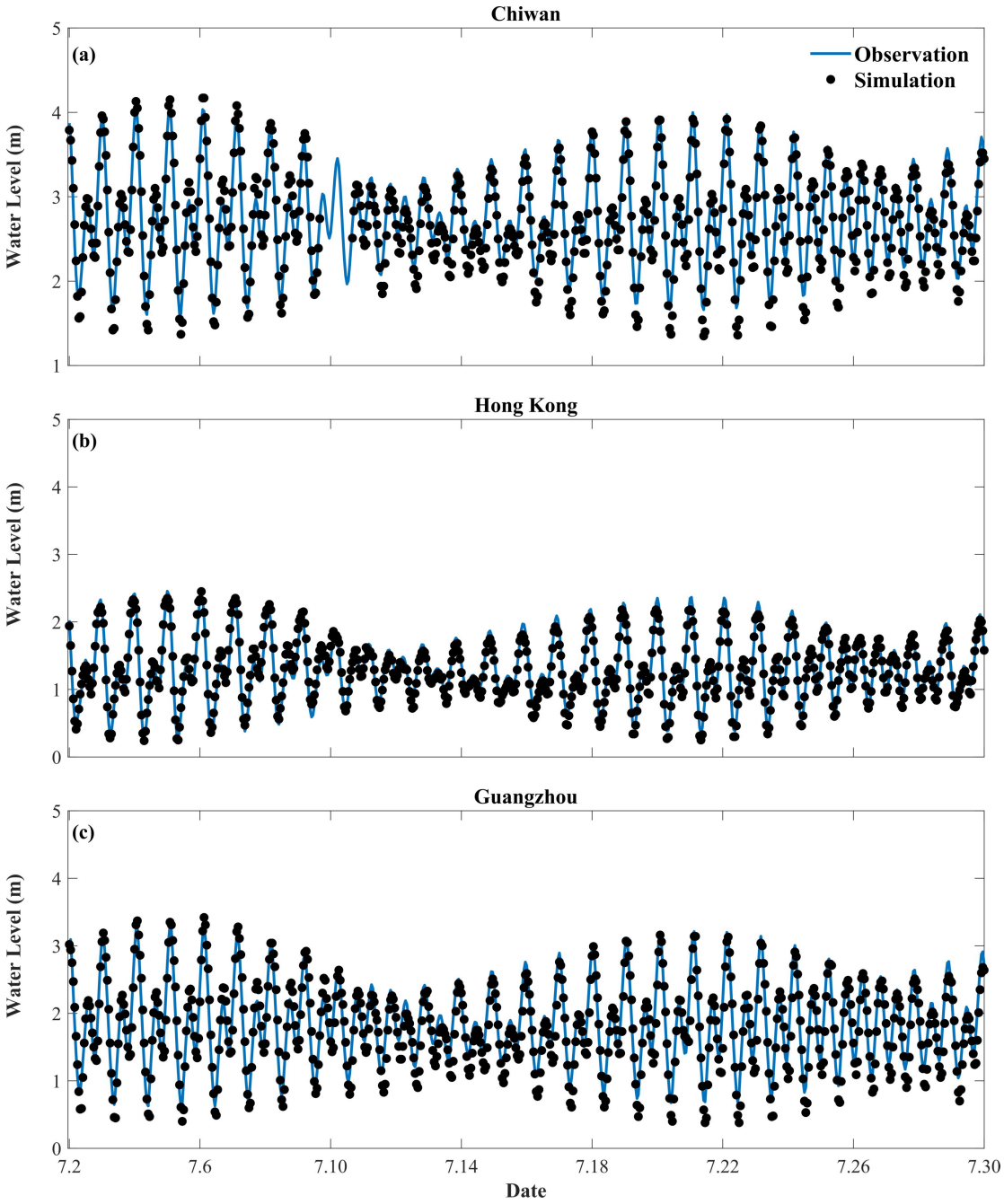

Fig 4 Time series comparisons of measured and modeled astronomical tide levels at (a) Chiwan gauge (b) Hongkong gauge (c) Guangzhou gauge

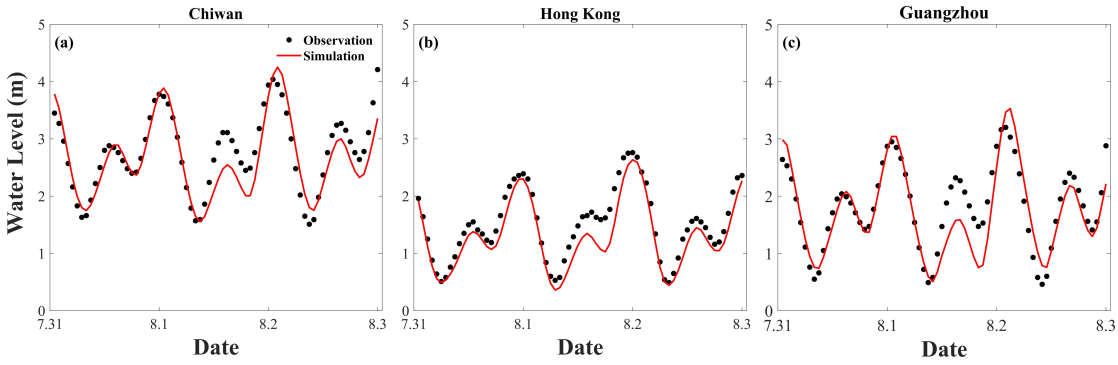

Fig 5 Time series comparisons of measured and modeled storm surge levels at (a) Chiwan gauge (b) Hong Kong gauge (c) Guangzhou gauge

12. LL227-228: "At the same time, the nonlinear residual levels shows that it is negative in Lingdingyang Bay, except for its top region (Fig 4e)."
"[…] the nonlinear residual levels show that […]"

Response:

Thank you for your kind suggestion. We appreciate it gratefully, and have corrected the mistakes in the manuscript.

13. LL240-243: "When the typhoon landfall, the nonlinear residual levels peaked at their maximum positive value and subsequently reached their maximum negative value before the water level experienced its most substantial increase."
"When the typhoon made landfall, […]"

Response:

Thank you for your kind suggestion. We appreciate it gratefully, and have corrected the mistakes in the text.

14. Figure 4 Highlighting the times shown in the left and middle panels within your right panels would enhance clarity.

Response:

Thank you for your insightful comment and helpful suggestion. We have redrafted this figure, including the addition of dashed lines, as shown in Fig 6.

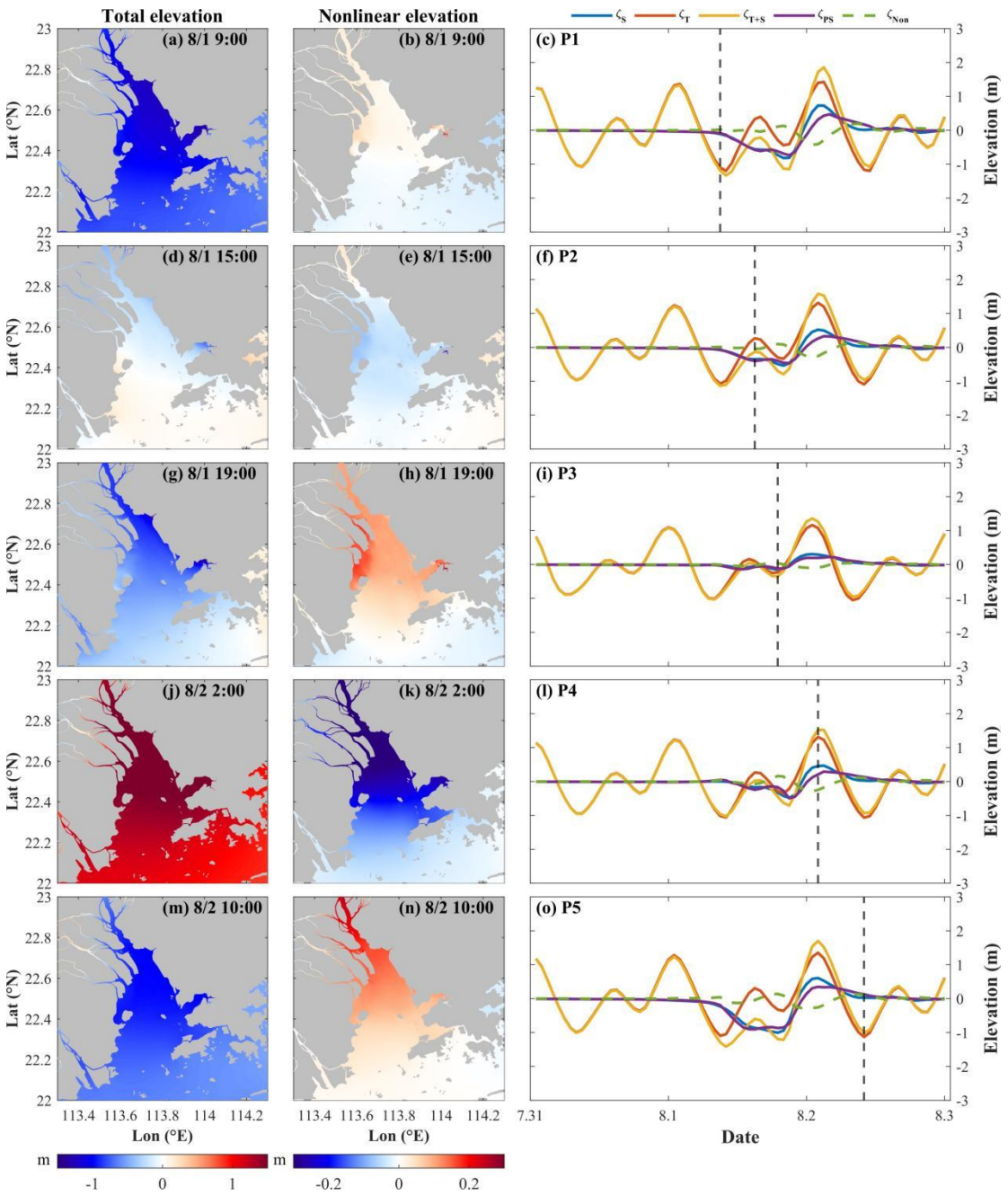

Fig 6 Total water elevation (left) and nonlinear water elevation (middle) at different tidal phase; Time series of water levels for P1, P2, P3, P4 and P5 locations (right); The dashed line indicates the time corresponding to the time on the left and middle graphs.

15. Table 6 Could you clarify what the percentages in Table 6 actually represent? Are these percentages indicative of changes compared to your baseline scenario?

Response:

We apologize for any confusion caused. The contributions of the practical storm surge and the nonlinear effect to the total elevation (we would use 'storm tide' replace it) are analyzed with different landfall times. This analysis aims to gain a deeper understanding of the role played by tide-surge interaction, taking into account the influence of different tidal phases.

16. LL367-369: "In the eastward direction at P2, the values of various nonlinear terms were relatively small, contributing little to the overall nonlinear effect, with the wind stress term plays a minor role of all nonlinear terms."
"[…] with the wind stress term playing a minor role among all nonlinear terms."

Response:

Thank you for your kind suggestion. We appreciate it gratefully, and have corrected the mistakes in the manuscript.

17. LL372-373: "In the eastward direction at P3, the nonlinear Coriolis dominated, the values reached its positive maximum at 23:00 on 1 August 2016."
"[…] the nonlinear Coriolis term dominated, with values reaching […]"

Response:

Thank you for your kind suggestion. We appreciate it gratefully, and have corrected the mistakes in the manuscript.

18. LL449-451: "In the eastward direction at P2, both bottom friction term and wind stress term exhibit significantly smaller compared to other terms."
"[…] wind stress term are significantly smaller […]"

Response:

Thank you for your helpful suggestion. We appreciate it gratefully, and have corrected the mistakes in the manuscript.

19. LL561-564: "However, further studies on additional typhoon events may be need, along with a comprehensive consideration of meteorological processes and the mechanisms of tidal-wave propagation within and outside the estuary, and the model system could still be improved in the future."
"[…] events may be needed […]"

Response:

Thank you for your kind suggestion. We appreciate it gratefully and have corrected the mistakes in the manuscript.