Dear Editor:

We are truly grateful to you and the reviewers for your meticulous and comprehensive examination of our manuscript, 'Effect of nonlinear tide-surge interaction in the Pearl River Estuary during Typhoon Nida (2016)', MS No. egusphere-2024-1940. We sincerely appreciate the reviewers providing constructive remarks and useful suggestions, which have significantly enhanced the quality of the manuscript and enabled us to make substantial improvements. Each suggested revision and comment from the reviewer has been carefully considered and incorporated. Please find below our point-by-point response to the reviewer's comments and revisions.

Comments for Reviewer 1:

1. In the paper I miss the time series of wind direction and wind speed for the trumpet-shaped bay. The authors investigate wind surge, which depends on the wind direction in this area. It is important to know, when there was onshore or offshore wind.

Response:

Thank you for your insightful comment and kind suggestion. We fully agree that understanding the temporal variations in wind direction and speed is crucial for accurately investigating wind surges, as these phenomena are significantly influenced by the characteristics of the wind field within the region. Specifically, onshore winds tend to enhance storm surges, while offshore winds can mitigate their impact. Unfortunately, due to the specific geographic and topographic features of the trumpet-shaped bay, comprehensive time series data for wind direction and speed may not be readily available in the public domain. However, the reconstruction of the wind field from Holland (1980) itself is based on observational or reanalysis data, which has a relatively high credibility (Yang et al., 2019; Hu et al., 2023; Sebastian et al., 2024).

The model wind has been added in Figure 4 of the manuscript, and the spatial and temporal characteristics of the storm tide has been described (Line 229-246), as follows.

'At 9:00 on 1 August, during the lowest low water (LLW) tidal phase, the PRE area showed a decrease in water level which was influenced by the tide (Fig 4a). The offshore wind exhibited a tendency to decrease the water level. While the nonlinear residuals were positive in Shenzhen Bay and the northern part of Qi'ao Island (Fig 4b). At 15:00 on 1 August, which coincides with the lowest high water (LHW) tidal phase, the total water elevation in PRE exhibited a negative to positive trend from northeast to southwest, the offshore wind make some contribution. The most notable decline in water level is observed in Shenzhen Bay (Fig 4d). At the same time, the nonlinear residuals are negative throughout Lingding Bay, with the exception of its upper region (Fig 4e). At 19:00 on 1 August, during the highest low water (HLW) tidal phase, both offshore wind and tide conditions resulted in a negative trend in the elevation of storm tide in the PRE area, with the most significant negative values occurring from northeast to southwest. Notably, the most substantial decrease in water level was observed in Shenzhen Bay (Fig 4g). While the nonlinear residuals are positive, their impact is particularly significant in Shenzhen Bay and the northern part of Qi'ao Island (Fig 4h). During the HHW tidal phase, the storm tide elevation in the PRE area exhibits a most substantial increase (Fig 4j), and the onshore wind enhance storm surges (Fig 4l). Conversely, during the same phase, the nonlinear residuals exhibit a most significant decrease (Fig 4k). Furthermore, at 10:00 on 2 August, during the LLW tidal phase, the storm tide elevation in the PRE area was negative which was predominantly attributed to the tide. The onshore wind exhibited a negligible effect on the water level, while the nonlinear resudials were positive.'

Reference

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.

Sebastian, M., Behera, M. R., Prakash, K. R., and Murty, P.L.N.: Performance of various wind models for storm surge and wave prediction in the Bay of Bengal: A case study of Cyclone Hudhud. Ocean Engineering, 2024, 297: 117113, https://doi.org/10.1016/j.oceaneng.2024.117113.

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.

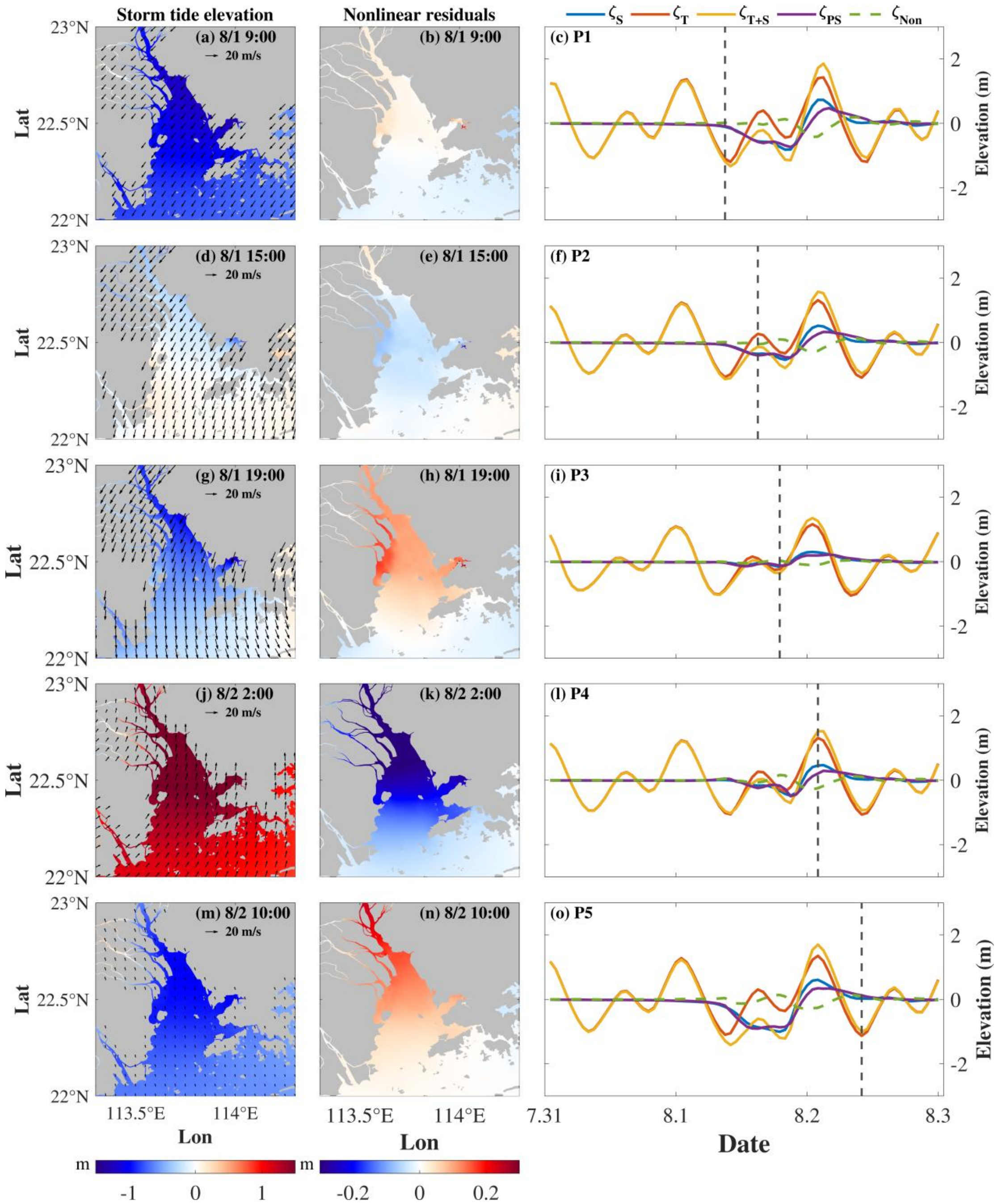

Figure 4. Storm tide elevation and wind vector (left), nonlinear level (middle) at different tidal phase and time series of water elevations (right) for P1, P2, P3, P4 and P5 locations; The dashed line indicates the time corresponding to the time on the left and middle graphs.

2. For example, in Figure 4, you see the tide is higher than the storm tide for 1 Aug, because of the offshore wind (P1, P2, P5). Please use an offshore station for the wind direction. In this complex area the wind direction is very important. Also, observations of wind direction should compared with modelled wind direction.

Response:

Thank you for pointing out this question. We fully agree that accurate wind direction data are crucial for understanding the complex interactions between offshore winds and storm surges in the study area. We acknowledge that obtaining direct offshore wind direction data from the study area presents significant challenges due to the lack of available observational stations. We have provided an explanation of the impact of wind and tide on storm surges as outlined in response to comment 1.

3. Figure 4, please check the legends and titles.

Response:

Thank you for your kind suggestion. We appreciate it gratefully and have duly made the necessary corrections, as shown in Fig 4. Specifically, we have replaced 'Nonlinear elevation' with 'Nonlinear level' in the title of Fig 4b.

4. In my review (number 27) I suggested to see some results from the model. I'm still interested in the model data for table 2.

Response:

We appreciate your interest in enhancing the robustness of our study. It should be noted that the primary focus of our research is the Lingding Bay area, so we selected five points to represent the special area with the intention of providing an illustration of the nonlinear effect at the internal, middle, external of the bay, and the shallow water area. The three gauge stations were used exclusively for the purpose of validating the water level between simulations and observations. The contributions of these stations have been calculated as illustrated in the following table. For Guangzhou station, the contribution of wind, tide and nonlinear effect are the most significant among the three stations.

Table The contribution to the storm tide elevation

Stations	Storm surge (%)	Tide (%)	Practical storm surge (%)	Nonlinear effect (%)
Chiwan	32.57	85.3	14.7	-17.88
Hong Kong	23.53	80.94	19.06	-4.46
Guangzhou	40.33	88.18	11.82	-28.51

5. Line 260 – 268 I do not understand this paragraph. From my point of view, the surge (wind) is overestimated because of the flat bathymetry.

Response:

We sincerely apologize if our explanation caused any confusion. In our research, we have carefully considered the influence of bathymetry on the storm surge modeling. The north of Qi'ao Island and the Shenzhen Bay are affected by the shallow water effect. The shallow water effects is expected to play an important role in the generation of the tide-surge interaction (Zhang et al., 2017). A division of the nonlinear terms from the momentum equation reveals that the tide-surge interaction nonlinear effects within the PRE are primarily caused by the velocity of the tide. In areas of shallow water, such as the northern part of Qi'ao Island and Shenzhen Bay, the tide-surge interaction nonlinear effects are predominantly influenced by a combination of wind and bottom friction.

Reference

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. 3.3 Changing the time of landfall means a wind direction and wind speed change in PRE.

Response:

We sincerely apologize for any confusion. We would like to clarify that in our study, changing the landfall time was specifically designed to align the maximum storm surge with different tidal phases, with the aim of investigating the interaction between storm surge and tidal conditions more effectively. Importantly, the wind speed and wind direction themselves were not altered by this change in landfall time. The primary effect was on the tidal phase during which the storm surge occurred, allowing us to explore the combined impact of storm surge and tidal conditions under various scenarios. It is means the nonlinear interaction has a significantly negative correlation with the tidal level (Zhang et al., 2021).

Reference

Zhang, X., Chu, D., and Zhang, J.: Effects of nonlinear terms and topography in a storm surge model along the southeastern coast of China: a case study of Typhoon Chan-hom, Natural Hazards, 107, 551-574, 2021.

7. My question about this experiment would be, what would your experiment look like, if the track of the typhoon were more south-easterly, i.e. landfall 113°E and 22°N?

Response:

Thank you for pointing out this question. We would like to clarify that in our study, the alteration of the landfall time was specifically designed to align the maximum storm surge with different tidal phases. This modification was made to investigate the interaction between storm surge and tidal conditions more effectively. It is noteworthy that the wind speed and wind direction were not altered by this adjustment of the landfall time. Instead, the primary effect was on the tidal phase during which the storm surge occurred, allowing us to explore the combined impact of storm surge and tidal conditions under various scenarios. This paper explores the nonlinear interactions between typhoons and tides in the Pearl River Estuary. It is important to note that if the landfall location of the typhoon is altered, the tidal state at the landfall point is also likely to change, which could potentially lead to an increase in nonlinear factors and a more complex process. The impact of TC tracks, such as different landfall locations, approach directions and speeds, has also been considered in other work.

8. I wonder how the analyses in chapters 3.2-3.4 can be carried out without wind direction and wind force. How are you going to convince me that you are drawing the right conclusions for the bay? In my opinion the surge is very dependent on the wind direction for this trumpet-shaped bay.

Response:

Thank you for pointing out this question. The wind direction and wind speed were reconstructed using empirical formulas based on typhoon data from the China Meteorological Administration (CMA). This technique is a commonplace one in storm surge modeling, as outlined in detail in chapter 2.3 of the manuscript. The typhoon landfall time was modified to align the maximum storm surge with various tidal phases, while maintaining the wind speed and direction constant. Utilising mathematical formulas, a comparison was made between the nonlinear interactions between storm surge and astronomical tide under different phase combinations. It was determined that the landfall time exerts a significant influence on surge peak through tide-surge interactions (Zhang et al., 2022).

Reference

Zhang, Z., Guo, F., Song, Z., Chen, P., Liu, F., and Zhang, D.: A numerical study of storm surge behavior in and around Lingdingyang Bay, Pearl River Estuary, China. Natural Hazards, 2022: 1-26, https://doi.org/10.1007/s11069-021-05105-w

Comments for Reviewer 3:

1. Lines 046–047: The present work focuses on the mechanisms and behaviors of water levels in estuary areas, which is a valuable contribution. However, when describing certain phenomena as "widely known," it's important to do so with caution. For instance, on beaches and barrier islands, the contribution of wave runup to total water levels is significant and cannot be overlooked. Studies such as Hsu et al. (2023; https://doi.org/10.5194/nhess-23-3895-2023) and Vicens-Miquel et al. (2025; https://doi.org/10.2112/JCOASTRES-D-24-00016.1) have highlighted the critical role of wave runup during extreme weather events. Including references to such relevant research in the introduction would enhance the context and provide a more comprehensive perspective.

Response:

Thank you for your constructive comment and kind reminder. We have reviewed the manuscript and made the necessary corrections (Line 49). The revisions are as follows:

‘The total water level can be divided into three main components ...’

We have added more references to illustrate the current state of research on storm surges (Line 45-48). The revisions are as follows:

‘During periods of extreme water levels, nonlinear interactions occur within the estuarine area among tide, storm surge, wave, and river streamflow (Hu et al., 2023). For instance, on beaches and barrier islands, the contribution of wave runup to total water levels is significant and cannot be overlooked (Vicens-Miquel et al., 2025).’

2. Lines 106–107: Did the authors intend to refer to a "severe tropical storm (STS)"? Additionally, the statement could be clarified by revising it as follows: "As shown in Fig. 1a, Typhoon Nida, classified as a severe tropical storm (STS), passed over the Philippines and entered the South China Sea (SCS) on July 31, 2016."

Response:

Thank you for your kind suggestion. We appreciate it gratefully, and have made the necessary corrections to the manuscript (Line 106-108). The revisions are 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.’

3. Lines 139–155: The analytical wind and pressure model proposed by Holland (1980) has been widely utilized in various experiments. Later, Holland (2008; https://doi.org/10.1175/2008MWR2395.1) introduced an updated analytical model that incorporates the effects of storm translation speed on hurricane wind and pressure. While studies have demonstrated that the revised model provides improved accuracy in accounting for storm translation effects, the authors are encouraged to discuss the potential differences in results had the older Holland (1980) model been used in the current work. This comparison could provide valuable insights into the model's influence on the study's outcomes.

Response:

Thank you for your insightful comment and kind suggestion. The Holland (2008) model refined the use of the Holland B parameter, which significantly affects the shape of the pressure gradient and wind speed profile. By adjusting this parameter, the model can better simulate the wind field characteristics of different typhoons. We compared the simulation result of the two models, as shown in the following figure, it appears that the water level simulation of Holland (1980) may be a more suitable model for the case of Typhoon Nida than the Holland (2008) model.

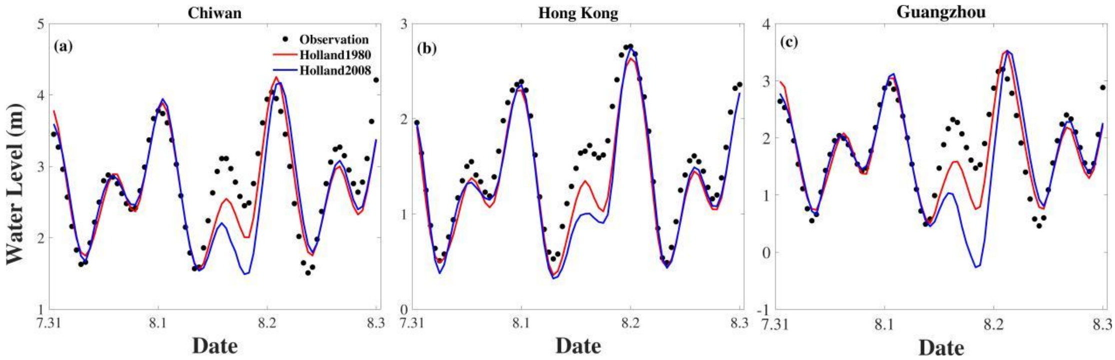

Figure Time series comparisons of measured and modeled water levels at (a) Chiwan gauge (b) Hong Kong gauge (c) Guangzhou gauge

4. The font size in certain figures, such as the legend in the subplots on the right-hand side of Figure 4 and the tick labels on the x- and y-axes in Figures 7 through 9, is too small and may be difficult for readers to interpret.

Response:

We are grateful for your constructive proposal and have made the necessary corrections to the right-hand label of Figure 4 in the manuscript, also has shown in Fig 1. Additionally, we have adjusted the font size of the tick labels in Figures 6 to 9 as outlined below.

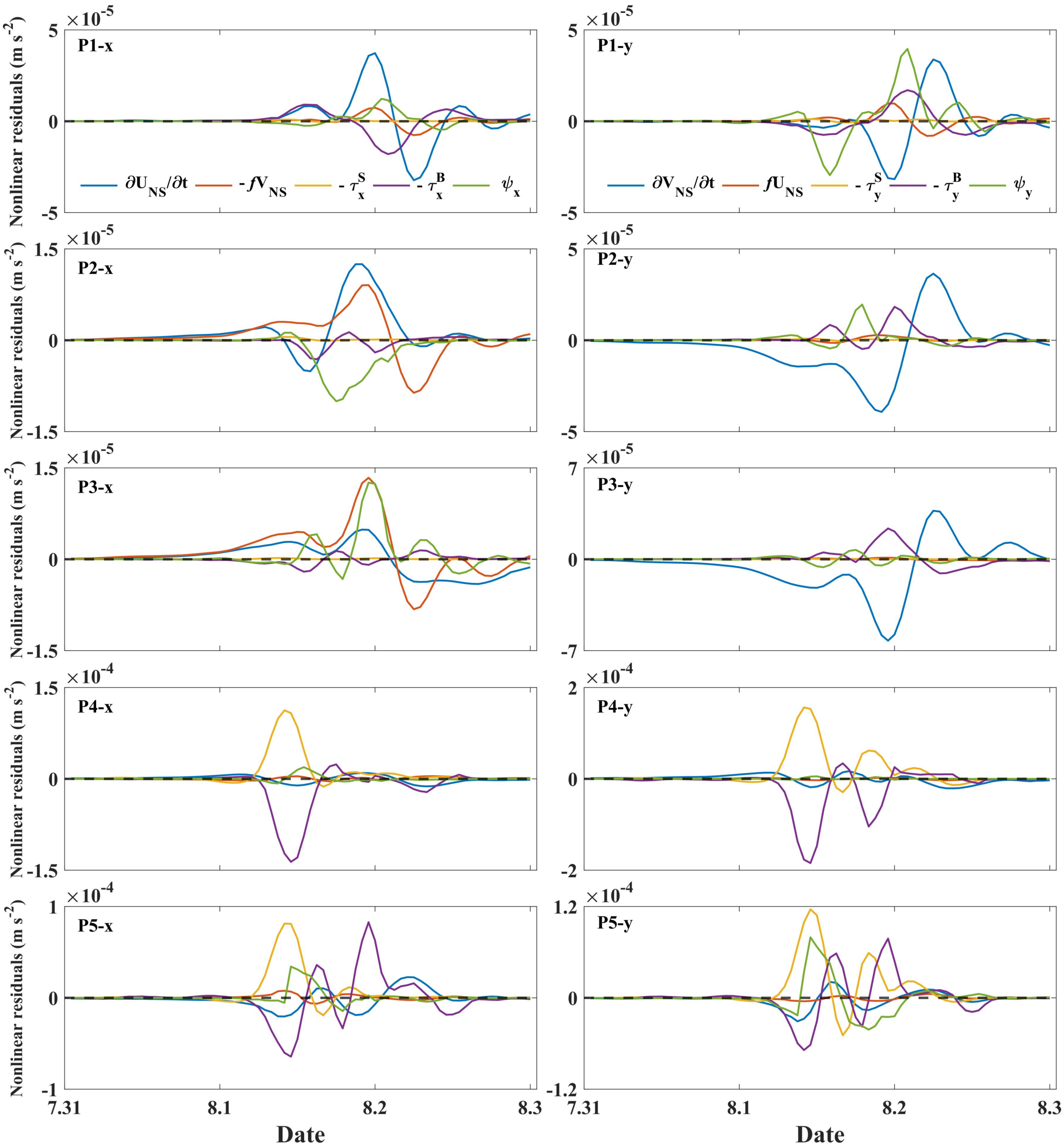

Figure 6. Time series of the nonlinear components of Typhoon Nida at P1, P2, P3, P4 and P5 in x direction (left) and y direction (right)

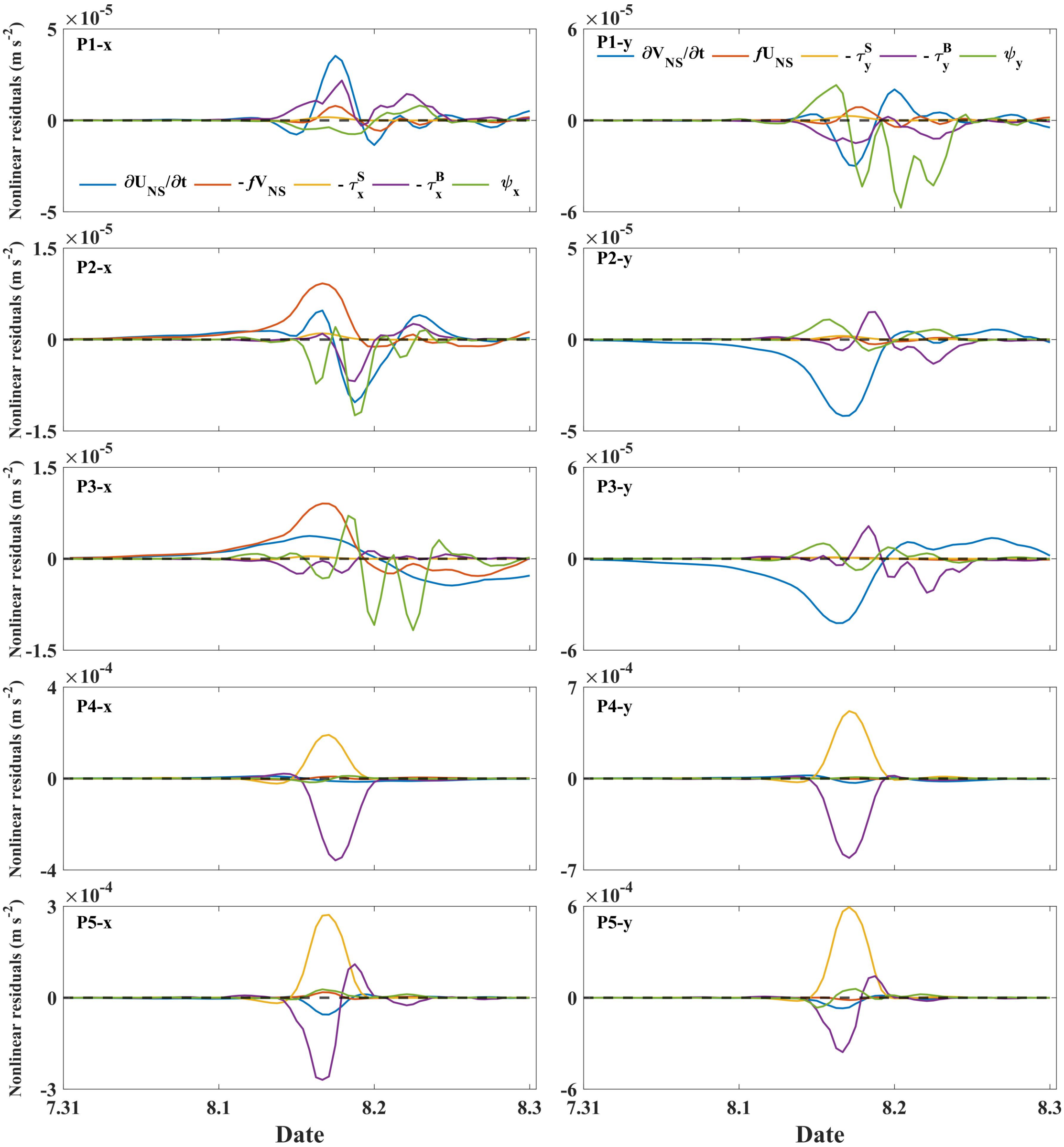

Figure 7. Time series of the nonlinear components at P1, P2, P3, P4 and P5 in x direction (left) and y direction (right) when maximum storm surge coincides with the HLW tidal phase

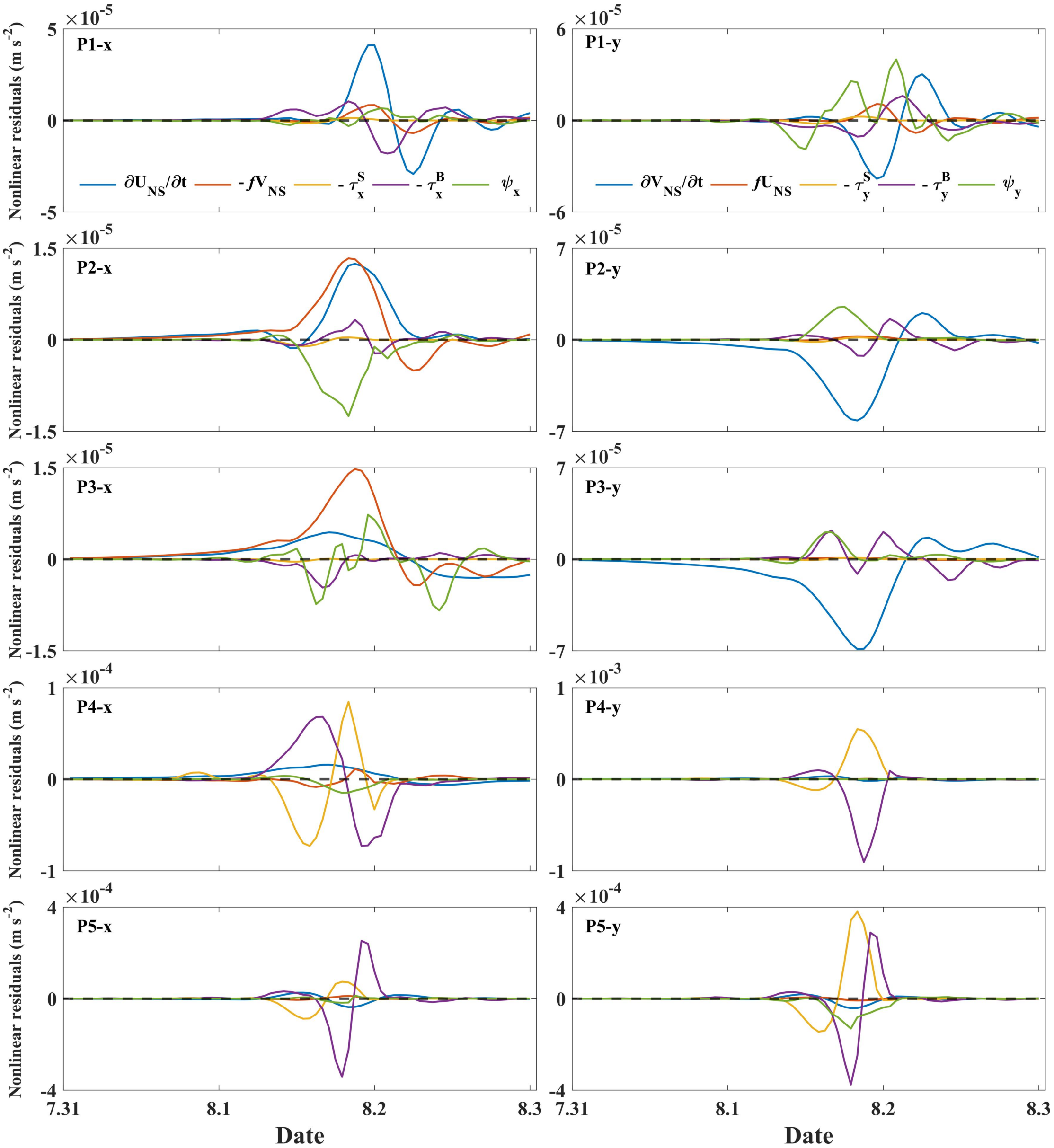

Figure 8. Time series of the nonlinear components at P1, P2, P3, P4 and P5 in x direction (left) and y direction (right) when the maximum storm surge coincides with the LHW tidal phase

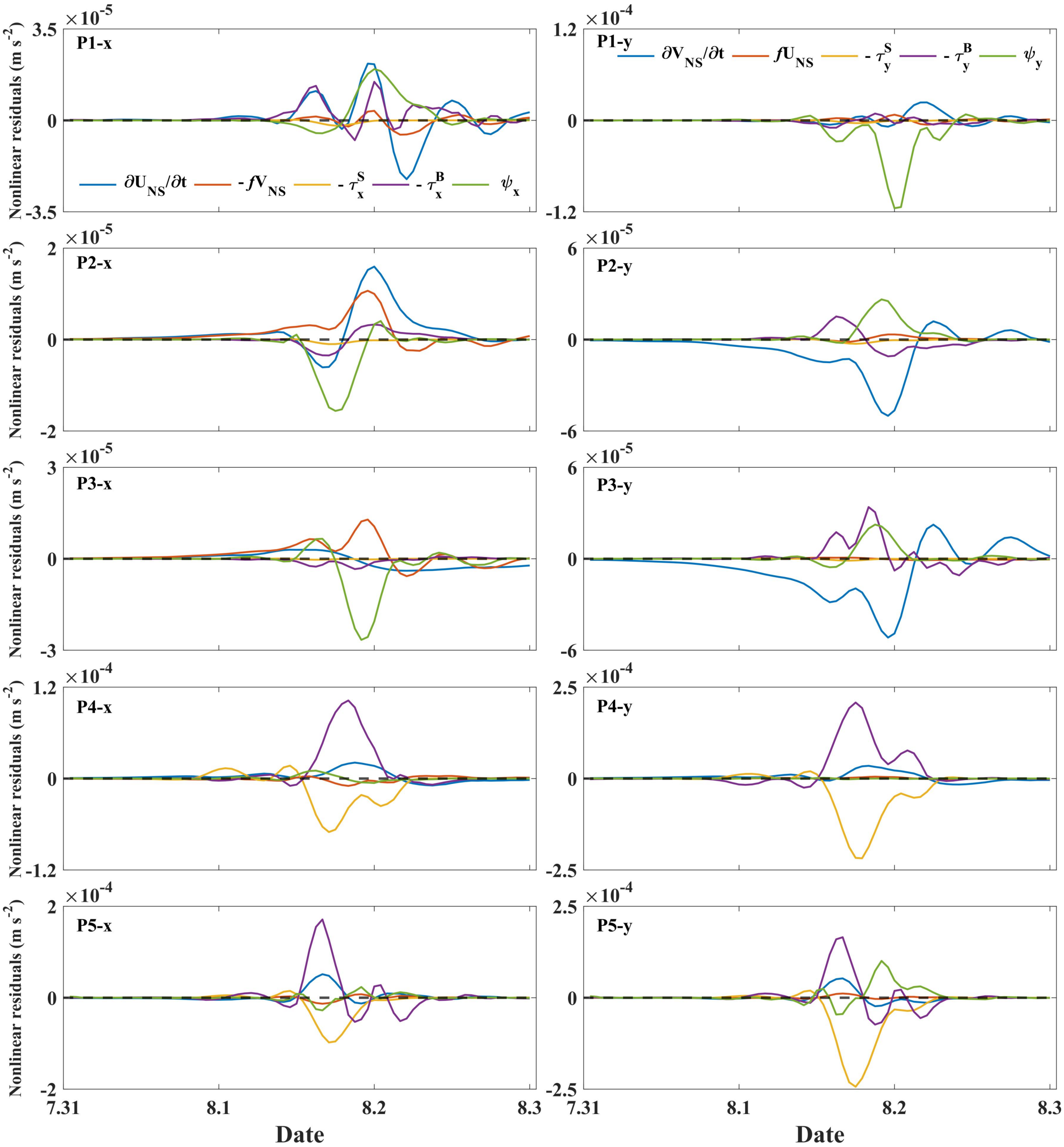

Figure 9. Time series of the nonlinear components at P1, P2, P3, P4 and P5 in *x* direction (left) and *y* direction (right) when the maximum storm surge coincides with the LLW tidal phase.