Dear reviewer,

On behalf of my co-authors, we thank you for giving us a chance to revise and improve the quality of our article.

We have read your comments carefully and have made revision. We have tried our best to revise our manuscript according to the comments: “Application of Wave-current coupled Sediment Transport Models with Variable Grain Properties for Coastal Morphodynamics: A Case Study of the Changhua River, Hainan (egusphere-2024-2154)".

The main revisions in the new manuscript are:

1. **Equation (4) Clarification**
2. **Line 202 Revision**
3. **Unit Usage in Table 2 and Table 3**
4. **Range Expression Correction**
5. **Figure 6 and Geographical Description Consistency**
6. **Comma Removal at Line 314**
7. **Section 3.3 Expansion**
8. **"Code for Design of River Regulation" Method Removal**
9. **Abbreviation Usage at Line 408**
10. **Section 4 has been thoroughly rewritten**

Here is a point-by-point response to the comments and concerns.

Thank you for taking the time to consider our research and we look forward to hearing from you at your earliest convenience.

Sincerely,

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Detailed comments part:

Point 1: Do Txx, Txy, and Tyy in Equation (4) correspond to Tij in Line 140? If so, the corresponding terms should be explained in relation to the variable symbols.

Response: Thank you for your meticulous review and valuable feedback. Regarding the terms Txx, Txy, and Tyy in Equation (4), I understand your query. These terms do indeed correspond to Tij, representing viscous friction, turbulent friction, and differential advection, respectively. In the revised manuscript, I have relocated the description of the hydrodynamic model to Section 3, "Study Area and Settings," to provide clearer background information and model configuration.

Although I have removed the specific descriptions of Txx, Txy, and Tyy from Equation (4), I have provided a detailed account of the hydrodynamic model's setup parameters in Section 3. We believe that this modification will aid readers in better understanding our methodology and will focus the paper more closely on our primary research objectives.

The revised sentence now reads as follows:

"…, *An unstructured grid, finite volume, regional ocean model FVCOM (Chen et al., 2003) was used to simulate the hydrodynamic background and hydrological features. It has been widely used for the study of coastal oceanic and estuarine circulation (Jiang and Xia, 2016; Huang et al., 2008; Lai et al., 2018; Chen et al., 2008).*"

Table 5 Parameters of the hydrodynamic model

Parameter	Value
Shoreline	GSHHS
Bathymetry	ETOPO1 and ADCP in-situ
Grid	0.25 km at the boundaries to 25 m near the coastline
Time period	23/4/2023 00:00-30/4/2023 00:00 (Spring neap tide) 28/6/2022 00:00-1/8/2022 00:00 (High water period)
Manning number	28
Eddy viscosity	Smagorinsky formulation data 0.28 m^2/s
Time step	300 s
Tidal constituents	M2, S2, K1, O1, N2, K2, P1, Q1
Wind/Sea level Pressure	ERA 5

Validation	Basuo Port Station (19°06' N, 108°37' E) ADCP 01, ADCP 02

Point 2: Line 202, what does this sentence mean? Is there an error in the expression? It is suggested to change "riverway" in Line 220 to "channel" to better match the scope of the study.

Response: Regarding the sentence at Line 202, We have revised it to serve as a transition between Section 2.2 and Section 2.3. This modification clarifies the flow of the text and improves the overall narrative of the paper.

As for the term "riverway" at Line 220, I have replaced it with "channel" to align with the terminology that better fits the scope of our study, as you suggested.

The revised sentence now reads as follows:

"*After examining the influence of waves and currents on sediment transport modeling, we now turn our attention to the specific characteristics of sediment properties in the study area. Section 2.3 provides a detailed account of these properties, which are essential for understanding the local sediment dynamics and will be crucial for the model's calibration and validation processes*"

Point 3: There are errors in the use of symbols in Table 2. The mean grain diameter and median grain diameter have units, which are represented by φ, but the sorting coefficient is a unitless value. The same applies to Table 3.

Response: Thank you for your observation regarding the use of symbols in Table 2 and Table 3. I have taken your feedback into account and have made the necessary corrections. In response to your concern about the symbols in Table 2, I have removed the units for the sorting coefficient, as it is indeed a unitless value. Additionally, you suggested changing "riverway" to "channel" at Line 220 to better match the scope of the study. This change has also been implemented to maintain consistency in terminology and to ensure that it accurately reflects the focus of our research.

Point 4: Line 241, the range expression for gravel (>2 mm), sand (2~0.063 mm), silt (0.063~0.004 mm) is problematic; the larger value should be placed after the smaller value. The legend of Figure 5 lacks units.

Response: Thank you for your comment on Line 241 and the legend of Figure 5. In response to your feedback, I have corrected the range expression for gravel (>2 mm), sand (0.063~2 mm), and silt (0.004~0.063 mm) to ensure that the smaller values are placed before the larger ones, following the standard notation for size ranges. Additionally, I have updated the legend of Figure 5 to include the appropriate units, ensuring that all information is clear and accessible to the reader. I believe these amendments address your concerns and improve the precision and readability of the manuscript.

The revised figure now shows as follows:

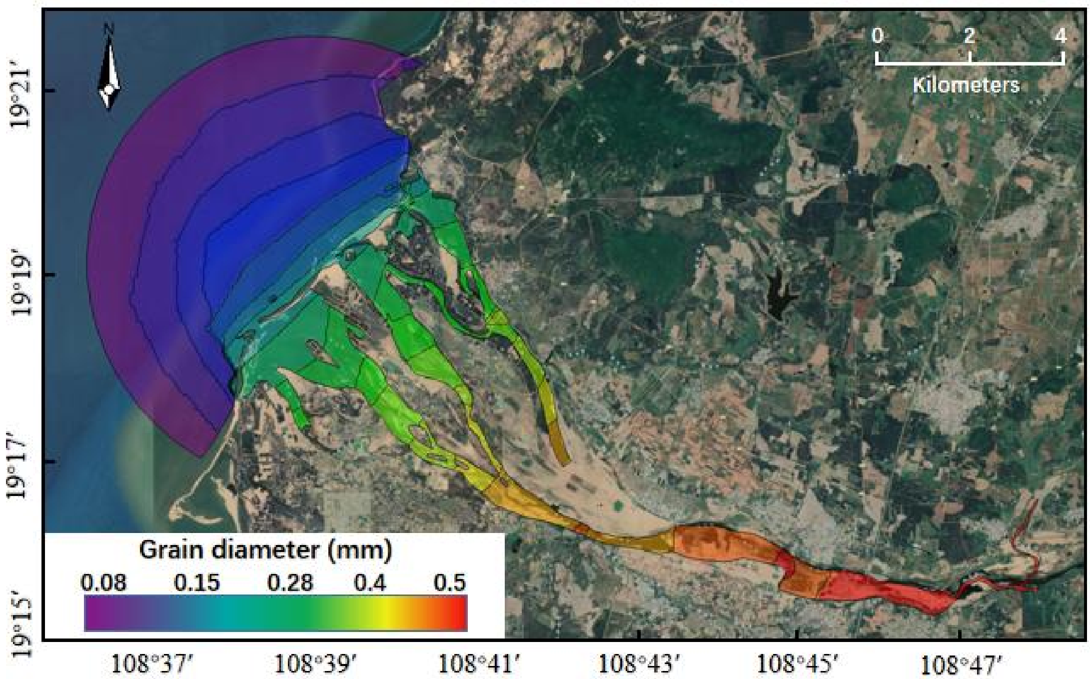

Figure 5 Variation of sediment particle size data (map origination: https://hainan.tianditu.gov.cn/)

Point 5: The scope of the study in Figure 6 is not consistent with the description in Line 280; it is recommended to modify it. Additionally, according to the geographical location of the Changhua River, it is located in the southwest of Hainan Province, but it is described as the western part in Line 278? Line 287, how is the elevation measured by ADCP obtained? Can specific information about the survey vessel be provided to increase the credibility of the article's data?

Response: Thank you for your continued attention to our manuscript. We have made the following corrections in response to your comments:

Figure 6 Scope Consistency: I have revised the scope depicted in Figure 6 to align with the description provided in Line 280.

Line 278: It is important to clarify that while the Changhua River is geographically located in the southwest of Hainan Province, our study focuses on the downstream and estuary areas, which are more accurately described as the western part of Hainan Province when considering the specific segments of the river in question.

Elevation Measurement by ADCP: In response to your question about the elevation measurement by ADCP in Line 287, I have included additional details about the survey vessel in the supplementary material. This information provides specific details about the vessel used during the survey, which adds credibility to the data presented in the article.

The revised figure and supplementary material now shows as follows:

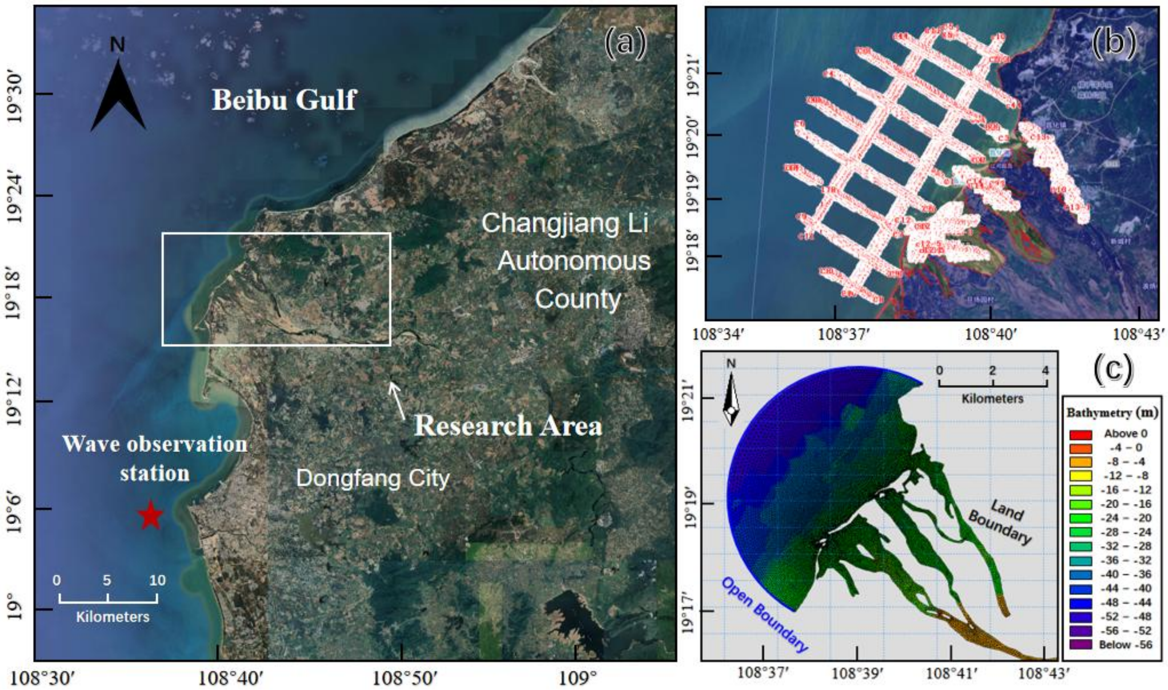

Figure 6 (a) Scope of study area (the white frame) and wave observation (the red star) from Dongfang; (b) ADCP collection points on site; (c) Grids and boundaries (map origination: https://hainan.tianditu.gov.cn/)

Table A.1 List of main parameters of survey vessel

Parameter	Value	Instrument diagram
LOA	11 m	
Breadth	2.8 m	
Modeled Depth	1.2 m	
Design Draft	0.8 m	
Speed	6.0 kn	
Hull Material	Fiber-reinforced plastic (FRP)	

Point 6: Line 314, remove the comma. "Model validation occurs from 10:00 on April 23, 2023, to 00:00 on April 30, 2023." has an extra comma.

Response: We sincerely apologize for the typographical error here. We have removed the extra comma as suggested, and the sentence now reads: "Model validation occurs from 10:00 on April 23, 2023 to 00:00 on April 30, 2023."

Point 7: Section 3.3 lacks analysis of the hydrodynamic results, and the description of the hydrodynamic environment of the study area is insufficient. It is recommended to expand the text and analyze it in conjunction with the sediment transport model.

Response: Thank you for your feedback on Section 3.3 and the concerns raised about the hydrodynamic results analysis and the description of the hydrodynamic environment in the study area.

We have taken your suggestions into account and have expanded the text in Section 3.3 to include a detailed analysis of the hydrodynamic results. The revised section now discusses the flow field conditions during the flood and ebb tides, as well as during high and low tides, which provides a more comprehensive understanding of the hydrodynamic environment specific to our study area.

The revised part now reads as follows:

"The hydrodynamic simulation outcomes, as depicted in Figure 10, indicate a predominantly NE-SW reciprocating current pattern within the study area. This flow is aligned parallel to the coastline, with the tidal current shifting direction according to the tidal phase. Figure 10b and 10c depict the flow field outside the estuary of the Changhua River. Figure 10b shows the flow field at 23:00 on April 23, 2023, corresponding to the peak of the flood tide. At this time, the tidal current flows in a northeast direction with a maximum speed of 0.62 m/s. Figure 10c shows the flow field at 13:30 on April 24, 2023, corresponding to the peak of the ebb tide, where the tidal current flows in a southwest direction with a maximum speed of 0.75 m/s. Overall, the tidal currents outside the Changhua River estuary generally follow a northeast-southwest reciprocating pattern, with flood tides flowing northeast and ebb tides flowing southwest, parallel to the shoreline. The maximum ebb current is faster than the maximum flood current.

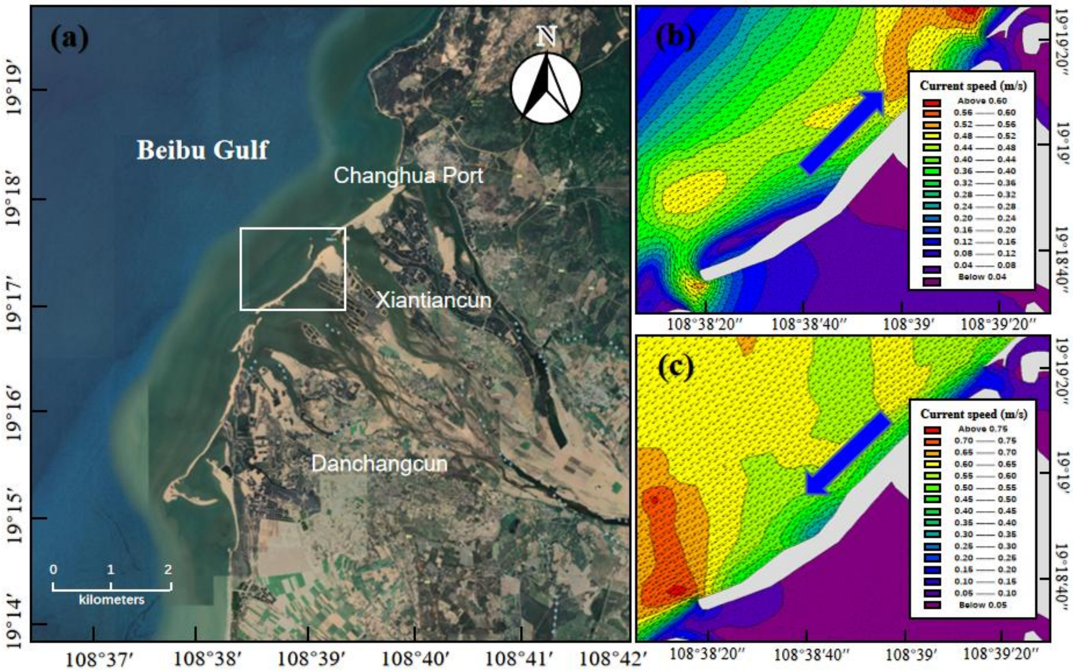

Figure 10 Study area and coastal current direction: (a) location map of the study area; (b) detailed zoom of the map in Fig. 9a with NE current; (c) detailed zoom of the map in Fig. 9a with SW current. (map origination: https://hainan.tianditu.gov.cn/)

Figures 11a and 11b illustrate the flow field inside the estuary of the Changhua River. Figure 11a shows the flow field at 23:00 on April 23, 2023, corresponding to the peak of the flood tide. Inside Estuary A, due to the topography, a large counterclockwise circulation forms around the central island, accompanied by several smaller vortices, with the overall trend of tidal currents flowing southeast along the river channel. In Estuary B, ocean inflows meet with river flows from upstream, ultimately converging into Estuary C through the passage between B and C. In Estuary C, the flow is more unidirectional compared to A and B, with upstream water flowing into the ocean, then following the northeast-directed tidal current outside the Changhua River estuary. Figure 11b shows the flow field at 13:30 on April 24, 2023, at the peak of the ebb tide. At this time, the circulation inside Estuary A reverses to a clockwise direction, and other smaller vortices change direction accordingly, with the overall trend of tidal currents flowing from upstream to the ocean. In Estuary B, the dominant force is the high-speed flow from Estuary C, which enters B through the narrow passage between B and C, splitting into two opposite directions: one part flows into the ocean, and the other flows upstream, forming a circulation within the river channel. In Estuary C, the water flows upstream from the ocean along the river channel.

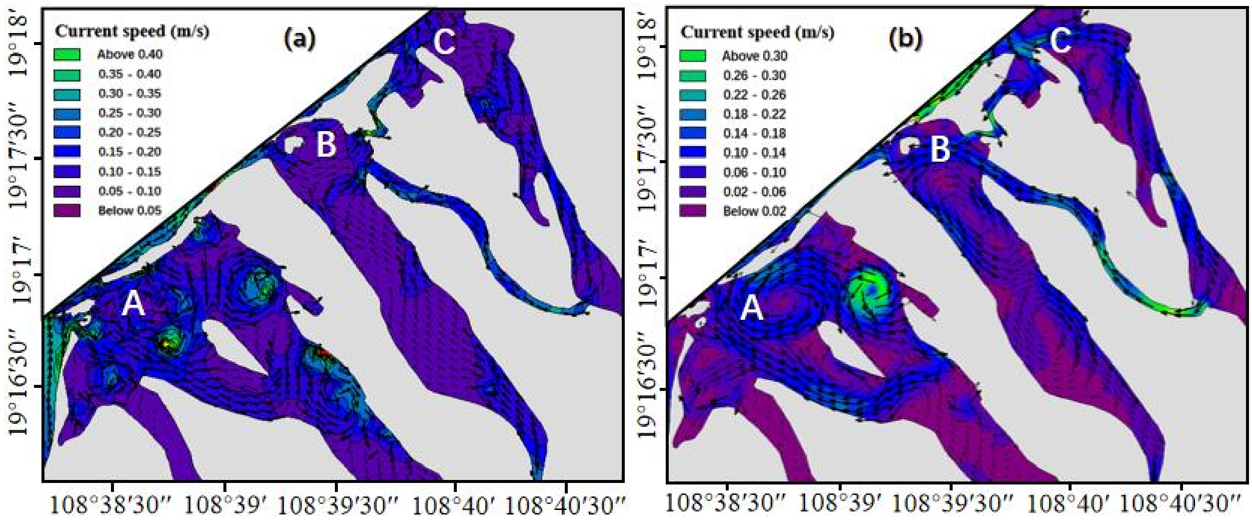

Figure 11 Flow field inside the estuary :(a) moment of the maximum flood current; (b) moment of the maximum ebb current

To further analyze the characteristics of the flow field in the study area, flow fields are selected for analysis during the transition from low tide to high tide and from high tide to low tide. Figure 12f depicts the location of the research area. Figure 12a shows the flow field at low tide, where the tidal current outside the estuary flows northeast, and water in the main river channel downstream of the Changhua River flows upstream from the ocean. After low tide (during flood tide), water flow velocity gradually increases, with the tidal current outside the estuary consistently flowing northeast. During this period, the main river channel maintains an eastward flow.

Figure 12b illustrates the moment of flow direction change during flood tide, when the flow direction outside the estuary rotates clockwise along the shoreline from the south (toward Beili Bay). The northern ocean current (outside Changhua Harbor) also begins to rotate clockwise, flowing into Estuary C, then into the ocean through the passage between B and C, forming a circulation that enhances the clockwise rotation of the northern ocean current. Subsequently, the flow direction gradually changes from northeast to southwest as it moves from the coast toward the open sea. The *sand spit at the downstream estuary alters the flow direction and velocity. The sand spit can act as a natural barrier, causing the tidal current to change direction earlier during flood tide.*

Figure 12c shows the flow field at high tide, where the tidal current outside the estuary has fully shifted to the southwest, while the flow direction further offshore is still transitioning. In the main river channel, the water flows from upstream toward the ocean. Estuaries B and C are influenced by the coastal current outside the northern part of the study area, flowing into the estuary opposite to Estuary A. After high tide (during ebb tide), the water flow velocity in the study area gradually increases, with the tidal current outside the estuary consistently flowing southwest. After some time, the water currents in the southern and northern parts of the study area turn counterclockwise, and the flow direction in the B and C channels changes from inward to outward.

Figure 12d shows the flow field at the moment when the flow direction changes during ebb tide. It is evident that there are two counterclockwise circulations outside the Changhua River estuary: one from Beili Bay and the other from outside Changhua Harbor. The latter has a broader influence and thus plays a dominant role in determining the water flow direction in the study area, gradually shifting the coastal current from southwest to northeast. Figure 12e shows the flow field at low tide once again, where the water flow outside the estuary has shifted back to the northeast, repeating the previous flow pattern.

In summary, during the transition from flood to ebb tide, the flow field outside the estuary is driven by the deflection of water currents from Beili Bay and Changhua Port, shifting the flow direction from northeast to southwest. During the transition from ebb to flood tide, the deflection is primarily influenced by the circulation outside Changhua Port, shifting the flow direction from southwest to northeast. In channels A, B, and C within the study area, the flow direction changes are relatively consistent due to the passage between B and C. The flow direction in channel A aligns with *the main river channel, flowing inward during flood tide and outward toward the ocean during ebb tide.*

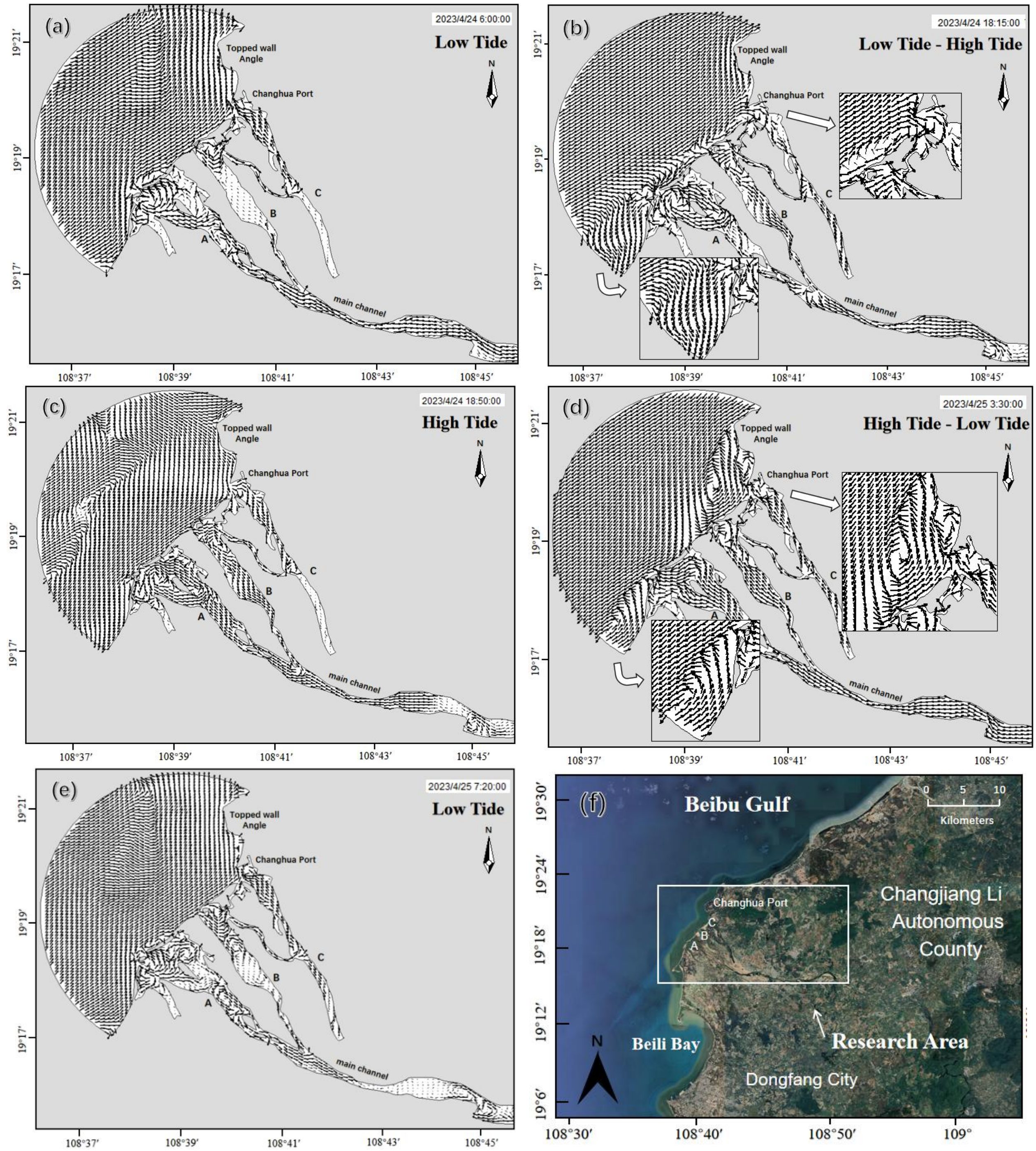

Figure 12 Transition of the flow field (a-e) and location of the study area (f)

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Point 8: Is the "Code for Design of River Regulation" mentioned in Line 370 some kind

of authoritative provision? There are no citations of any literature on this regulation in the text. Is this method applicable to the lower reaches of the Changhua River?

Response: Thank you for your comment regarding the "Code for Design of River Regulation" mentioned in Line 370. Upon reflection, we acknowledge the importance of citing authoritative provisions and discussing the applicability of methods to the specific context of our study.

In response to your feedback, we have decided to remove Section 3.4.1, as we have not provided adequate citation or discussion of its applicability to the lower reaches of the Changhua River. We recognize that including such references without proper context or citation could potentially mislead readers.

Point 9: Line 408, only the first appearance of an abbreviation in the article needs to be spelled out in full; SSC can be expressed directly here.

Response: Thank you for your guidance on the use of abbreviations in the manuscript. We have revised Line 408 accordingly and now directly use the abbreviation "SSC" for Suspended Sediment Concentration without spelling it out in full, as it was previously defined in the article. This change aligns with the standard practice of abbreviating terms after their initial mention.

The revised part now reads as follows:

"To further analyze the simulation validation, Figure 13 presents a histogram of the daily absolute error in SSC at Baoqiao Station. The absolute error is calculated as the absolute difference between the measured and simulated values….. The MAE in SSC for Baoqiao Station in July is 0.071224 kg/m^3. …. Overall, the difference between the daily observed SSC values and the simulated results at Baoqiao Station in July is within a reasonable range, indicating that the model has an acceptable

level of precision.”

Point 10: The simulation results of the sediment transport model only analyze the thickness changes of the sediment, without a detailed description of the specific movement of the sediment. The measures for sediment control mentioned in Section 4 do not propose a specific implementation plan. It is suggested to revise the content of Section 4, combine the simulation results of the sediment transport model with the hydrodynamic results, and analyze the movement of sediment driven by water flow.

Response: Thank you for your constructive criticism regarding the sediment transport model analysis in Section 4 of our manuscript. We have taken your suggestions to heart and have thoroughly revised the section to provide a more comprehensive perspective on the sediment movement driven by water flow dynamics. In the updated Section 6, we have expanded our discussion to focus on the critical role of residual currents in sediment transport. Our analysis now includes a detailed examination of the behavior of residual currents during periods of high and low water levels. This comparative analysis offers insights into how these currents influence sediment dynamics under varying environmental conditions, particularly in the context of the lower reaches of the Changhua River.

The rewritten Section 6 now reads as follows:

“6. Discussion

6.1 Residual Current

Residual currents to some extent reflect the transfer and exchange of water bodies, and their direction is usually the direction of sediment movement and the dispersion and *migration of pollutant substances (Robinson, 1983). They are closely related to the long-term transfer and deposition of estuarine materials. Therefore, studying the characteristics of residual currents in this sea area under the combined action of waves and currents can comprehensively understand the evolution characteristics of the sea area's sediment. Tidal residual currents can be studied using the Lagrangian and Eulerian methods. Eulerian residual current refers to the average transfer caused by the average flow after removing the periodic astronomical tide, and its magnitude and direction mainly depend on the strength and duration of the ebb and flood tidal velocities within the tidal cycle; Stokes' drift characterizes the net drift of the water body, and its numerical size directly reflects the correlation between the tidal range and the change in flow velocity within the tidal cycle, and the sum of the two is the Lagrangian residual current. The Lagrangian residual current is not the result of the long-term tracking of real particles, but is the result of the superposition of Eulerian residual current and Stokes' drift.*

Eulerian residual current refers to the average transfer caused by the average flow after removing the periodic astronomical tide, and its magnitude and direction mainly depend on the strength and duration of the ebb and flood tidal velocities within the tidal cycle; Stokes' drift characterizes the net drift of the water body, and its numerical size directly reflects the correlation between the tidal range and the change in flow velocity within the tidal cycle, and the sum of the two is the Lagrangian residual current. The formulas for calculating Eulerian residual current and Stokes' drift refer to previous studies (Longuet-Higgins, 1969; Uncles and Jordan, 1980; Li and O'Donnell, 1997).

Through the analysis of sediment simulation results from the previous section on the distribution of major sedimentation areas, we have been able to understand the distribution of these areas. However, the causes of sedimentation require further exploration. In this *section, based on the tidal current field data from hydrodynamic numerical simulation, we calculate the residual flow according to the entire study area. The flow velocity measured data from two ADCP stations outside the estuary of the Changhua River was analyzed using the tidal residual current calculation method, thereby enhancing the credibility of the residual flow field.*

Table 8 Residual currents in spring neap tide at each station

Station	Eulerian residual current		Stokes' drift		Lagrangian residual current	
	Speed (m/s)	Degree (°)	Speed (m/s)	Degree (°)	Speed (m/s)	Degree (°)
ADCP01	0.0913	232	0.0006	172	0.0917	231
ADCP02	0.0331	137	0.0007	194	0.0335	138

The Lagrangian residual current at monitoring station ADCP01 is 0.0913 m/s with a direction of 231° (SW), and at station ADCP02 it is 0.0331 m/s with a direction of 138° (NW) (Table 8). In the area outside the Changhua River estuary, the Stokes tidal residual current at the monitoring stations is two orders of magnitude smaller than the Eulerian residual current. Therefore, the flow trend of the composite Lagrangian tidal residual current remains essentially consistent with that of the Eulerian residual current.

6.2 Influence of residual current in low water period

The study area has a distinct monsoon climate, with prevailing southerly winds in the summer and alternating southerly and northeasterly winds in the spring. The figure 20 shows the Eulerian residual current field during the simulation period (low water period). To present the Eulerian residual currents within the study area in a complete and clear manner, a limit on vector length was set when plotting the current field. Consequently, the direction and length of the arrows in the figure represent the direction of the residual currents, but not their intensity. However, the intensity of the Eulerian residual currents can still be discerned *through the data at the grid points. The Eulerian residual current outside the Changhua River estuary generally flows southward. As it flows from north to south, it is obstructed by the sand spit, diverging around it. After the divergence, the southwestward Eulerian residual current splits, with one part following the sand spit to the river mouth near A, and the other part entering channel B and flowing inward. The northeastward Eulerian residual current, after divergence, encounters the obstruction of the headland (Topped wall Angle) and forms a counterclockwise circulation below Junbi Jiao. Headlands are one of the key topographical features where strong residual current vortices occur (Maddock et al., 1978; Pingree et al., 1977; Smith, 2010). At the headland, the water depth shoals in the onshore direction, and the frictional effect is stronger in shallow water areas than in deep water areas. This results in a frictional force moment on the alongshore tidal current, generating vorticity. The transport of vorticity within the closed circulation lines on either side of the headland is not equal in input and output. After a tidal cycle of time averaging, a net vorticity will be produced on both sides of the headland, forming two counter-rotating residual current vortices, with the tidal residual current at the tip of the headland generally pointing seaward (Zimmerman, 1981). Topped wall Angle, being a headland, can produce similar residual current field results. A clockwise residual current vortex opposite to the one below may exist above Topped wall Angle. The Eulerian residual currents in the three river channels where A, B, and C are located all flow towards the river mouths. The Eulerian residual current in the channel between B and C flows from B to C.*

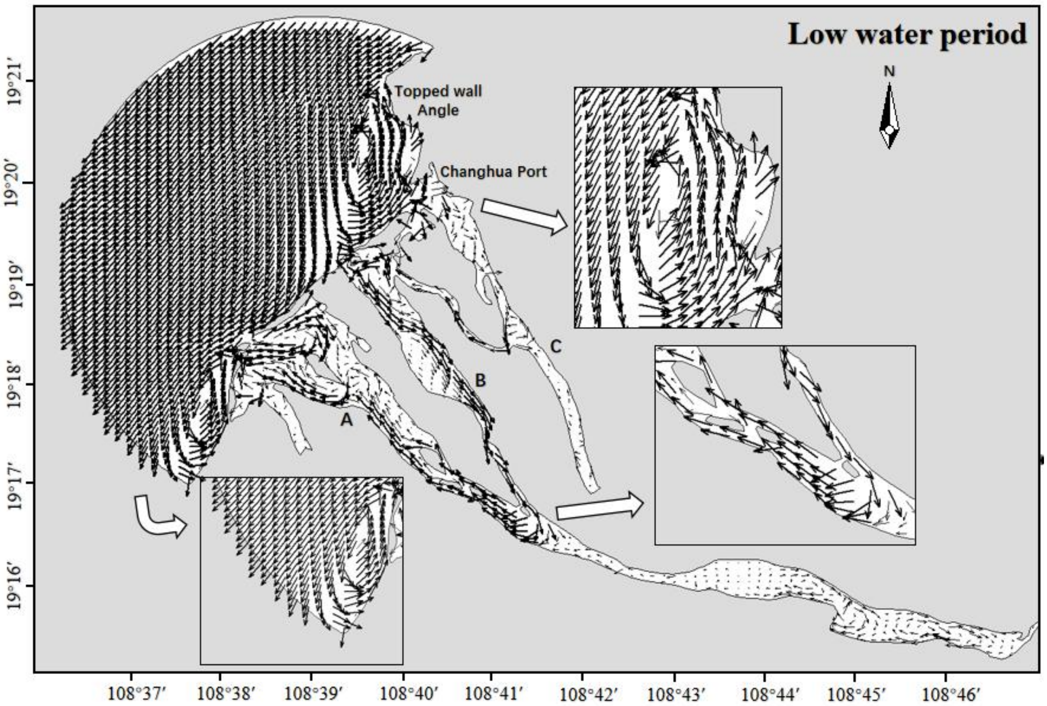

Figure 20 Eulerian residual current field during low water period

6.3 Influence of residual current in hight water period

In order to comprehensively understand the residual current field of the study area, it is essential to analyze the residual current field during the flood season. The figure displays the Eulerian residual current field of the study area for July 2022 (high water period). The Eulerian residual current south of the river mouth in the study area still flows to the south (towards Beili Bay), but the nearshore residual current veers more quickly, resulting in a smaller circulation compared to the dry season. The circulation range in the north has expanded, likely due to the influence of the southerly monsoon during the summer, leading to an increase in the strength and directional deflection of the Eulerian residual current. When it reaches the shore, it is naturally obstructed by the sand spit and disperses to both sides (NE-SW). The upward Eulerian residual current, upon encountering the sea area outside Changhua Port, is deflected by the coastal promontory (Topped wall Angle) and turns westward. The westward Eulerian residual current, continuously affected by the strong *southerly winds during its movement, keeps deflecting. Eventually, a circulation is formed, with a circulation range larger than that of the dry season. The situation in channel A is essentially consistent with the dry season, while the Eulerian residual current directions in channel B and C are the same as that in A, all flowing towards the ocean. This is quite different from the dry season, with a flow direction opposite to that of the dry season, which may be related to the increased rainfall and subsequent increase in downstream flow during the summer flood season.*

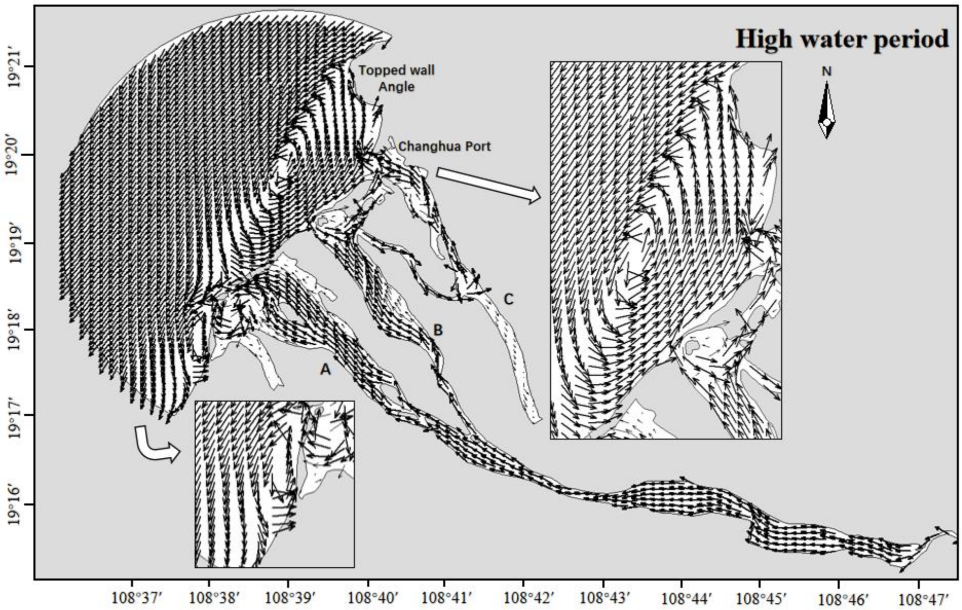

Figure 21 Eulerian residual current field during high water period

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Once again, we appreciate the time and effort you and the reviewers have dedicated to evaluating our manuscript. Your expertise and guidance have been invaluable in strengthening our research!