Authors' response to referee #1: egusphere-2023-122 "A wave-resolving modeling study of rip current variability, rip hazard, and swimmer escape strategies on an embayed beach with irregular rip channels"

Dear Editor and Referees,

Thank you for your constructive comments on our manuscript entitled 'A wave-resolving modeling study of rip current variability, rip hazard, and swimmer escape strategies on an embayed beach with irregular rip channels'. We feel indebted to the reviewers for their time on this manuscript. We have incorporated the suggestions/comments in the revised manuscript. In the response below, all the comments and concerns are replied point by point.

Kind Regards,
Huaiwei Yang and Ye Yuan, on behalf of the co-authors.

The manuscript authored by Yuan et al studies rip current variability, real-time rip hazard identification, and the optimal swimmer escape strategies at Dadonghai Beach, China considering two bathymetric scenarios between 2018 and 2019.
Overall, the document is very well structured, details each section adequately, and is written in fluent English. General comments are indicated below and more detailed comments are in the attached document:

1. How accurate are the bathymetries derived from satellite imagery concerning measurements? Have any checks been made in the study case?

Response: Local bathymetric patterns are critical to the modeling of nearshore circulation. However, in this study the detailed echosounder survey was not performed. Beach morphologies were inverted from two satellite images acquired from Google Earth Historical Database on August 7, 2018 and December 26, 2019 when sea state was calm. Using inverted depth has pros and cons. While accuracy of remote-sensed bathymetry sometimes is questionable, it is easily available by satellite and UAV, making it desirable for numerical forecasting of rip hazards.
The commonly-used techniques which allow indirect measurement of depth by satellite images are based on water color and wave kinematics. Colour-based methods are usually limited to non-turbid or non-breaking waters. The wave kinematics methods work well in turbid or optically deep water. A field trip of Dadonghai Beach was conducted on December 9, 2019 by SOA. During the survey, an UAV was released to observe beach morphology. As shown in Figure R1 and R2, well-developed, periodic crescent sandbars were recorded by the UAV, whose locations coincided with those appeared in the satellite image (Figure R2b). According to photos and public surveys of swimmers and coastal patrols, water depth over the shore-connected sandbars varied approximately between 0.5 - 1.0 m, and 1.5 - 2.0 m over the rip channels. Floating separation ropes were deployed perpendicularly to the beach by coastal patrols to prevent bathers from swimming to deeper rip channels. The survey results were generally consistent with the inverted beach bathymetry. Though no precise bathymetric measurement was conducted by the authors, the beach morphological features could be reflected by the satellite images, which are thought to be adequate for models to grasp the main rip patterns.

Figure R1. Crescent sandbars recorded by the UAV during the rip-hazard field investigation in 2019 (Courtesy of National Marine Hazard Mitigation Service, China).

Figure R2. Crescent sandbars recorded in the satellite (b) and UAV (c) images, respectively. The satellite image was collected in October 2019 (Google Earth Historic Imagery), and the UAV image was collected during the rip-hazard field investigation at the same period (Courtesy of National Marine Hazard Mitigation Service, China).

2. Is the beach in dynamic equilibrium, preserving sediment balance? Are the scenarios analyzed from the 2018 and 2019 satellite-derived bathymetries expected to be representative of all summers?

Response: Dadonghai Beach is a typical medium-size embayment with headlands at both ends. It is classified as a typical headland-embayed beach (Wang et al., 2001). Based on the planform stability, Hsu et al. (2008) classified the headland bay beaches mainly as states of : (1) static equilibrium, (2) dynamic equilibrium, and (3) unstable . Beaches in a state of dynamic equilibrium, waves breaks at an angle to the shoreline at headlands, generating longshore currents capable of transporting sediment shoreward. Beach morphology is constantly adjusting to changes or variations in forcings in different temporal scales, i.e., short-term changes, seasonal variability. It is expected that embayed beach shorelines tend to be relatively stable over long timescales (Silvester and Hsu, 1997; Daly et al., 2015).

At Dadonghai Beach, incoming waves breaks at headlands, which contributes to the continuous sediment supply to the bay interior. The rhythmic sandbars are well developed along the beach, and its periodic evolvement is subject to storm event-driven or seasonal changes (mainly moonsoon seasons and typhoon seasons). According to the historical satellite images (Figure R3), beach morphology at the Dadonghai Beach was evolving periodically, and exhibited different morphological stages, from a nearly straight shore-parallel sandbar approximately 80-100 m seaward from the shoreline, to crescentic or welded bars, and then to transverse bars with incised, narrow rip channels (Figure R3). Sandbar migration can also be observed due to longshore currents. These stages are typical equilibrium beach responses at wave-dominated beaches (Castelle & Masselink, 2023).

Two satellite images of the Dadonghai Beach on August 7, 2018 and December 26, 2019 are used in the study, representing summer and winter scenarios. In summer, frequent typhoon activities in the South China Sea (normally from July to October) generate long-period swells periodically received by the Dadonghai; while in winter the NE and E monsoon prevails in the Northern SCS and brings swells into the embayment. By examining historical images in Figure R3, however we cannot find obvious seasonal variations in beach morphology at Dadonghai Beach. Detailed study on seasonal modulation of beach morphodynamics need to be carried out in future.

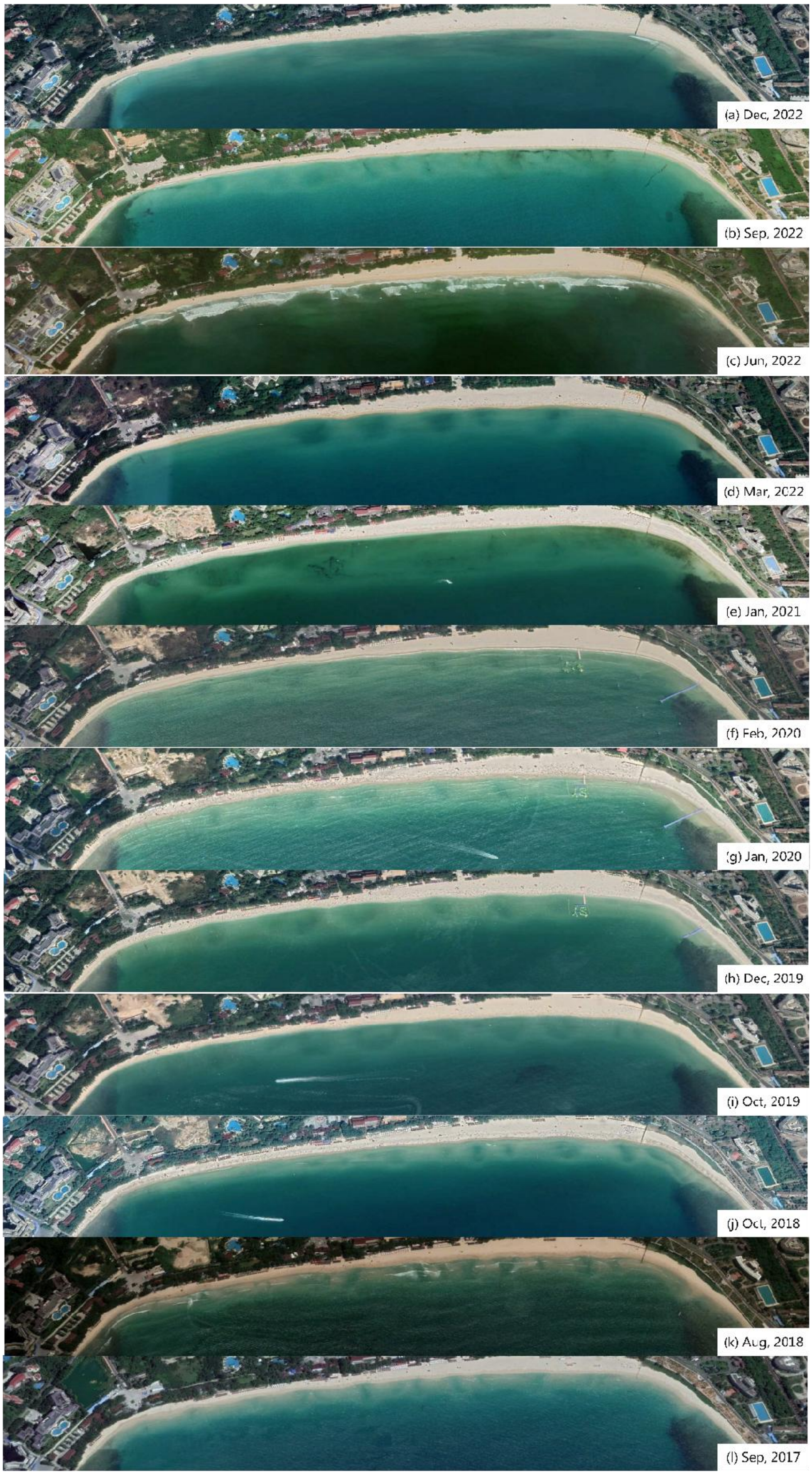

Figure R3. Variations of beach morphology at Dadonghai Beach from 2017 to 2022.

3. The model used to obtain the currents has been validated with field measurements? this is essential to validate the directions and magnitudes of the velocities.

Response: Although FUNWAVE-TVD and similar Boussinesq-type wave model (i.e., FunwaveC) has been widely proved to be an effective tool to study wave-induced nearshore circulations and dispersion (Chen, et al., 1999, 2003; Geiman et al., 2013; Feddersen, 2014), in this study field measurements of rip currents at Dahonghai Beach has not been conducted to validate the model. Lack of field observations considerably limits our further analysis on rip variability, and their response to beach morphology and wave dynamics.

As shown in Figure R4, sediment plumes, or 'rip heads' are clearly visible from the CCTV of the Dadonghai Beach, which are indicative of mega rip modeled by the FUNWAVE-TVD in the study. As described in Section 4.1 of the manuscript, the incident waves shoal and break at the west headland and coral reefs immediately after entering the embayment, and in turn produce strong longshore currents. The longshore currents then deflect to the offshore direction, forming a persistent mega rip. The FUNWAVE can capture this feature properly, which lends us some confidence on FUNWAVE's modeling results.

To remind readers of the absence of observational data, we made some revisions within the manuscript (i.e., emphasizing lack of observations and limitation of the study in the Conclusion; Line * in Abstract, 'rip currents fluctuate' => 'the modeled rip currents fluctuate').

Figure R4. Sediment plumes observed at the westmost corner of the Dadonghai Beach (denoted by black arrows; this image is from Li et al., 2020), which corresponds to the mega rip modeled by FUNWAVE-TVD in the study.

4. Where is the wave point located? It is essential to know its location in order to describe the wave conditions. This point should be indicated on the location map in Figure 1. Why not evaluate the entire wave time series considering the 30 years characterizing summers and winters and then specifically 2017-2018?

Response: The wave point is located at 18.2N, 109.5E, which is marked as a yellow triangle in Figure 1a. Wave rose diagram of 30-year-long time series of wave hindcast off the Dadonghai Bay is included in Figure 2, which is also shown in Figure R5 in this document. *Section 2.2 Wave conditions* has been reformulated as follows:

Based on an analysis of 30-year wave hindcast dataset developed by National Marine Environmental Forecasting Center of China (NMEFC), wave conditions immediately off the Dadonghai Bay are assessed. The wave point for analysis is located at 109.5 E, 18.2 N, which is denoted as a white triangle in Fig. 1a. According to wave rose diagram of 30-year-long wave hindcast (Fig. 2a), generally the Dadonghai Bay receives waves at 2 prevailing directions, including powerful typhoon swells mainly from the south, and monsoon swells from the southeast. The 1-day moving average on the hourly wave hindcast in 2018 is performed and shown in Fig. 2d for further analysis. Waves during the summer months are relatively more energetic than in winter immediately off the Dadonghai Bay, which is interspersed with high-energy events associated with typhoon activities in the northern South China Sea (SCS). Typhoons can send long-period swells to the Dadonghai Bay. Wave-buoy observations along the slope of the Northern SCS demonstrate that while peak wave period during the winter monsoon is between 4 - 8 second, it is capable to reach up to 10 - 14 second during the passage of the tropical cyclones in summer (Xu et al., 2017; Tian et al., 2020). As shown in Fig. 2c, these storm waves arrive over a wide spread of directions from SE to SW. As typhoons enter the northern SCS and move west, the directions of waves receive by the Dadonghai Bay vary over time. Two prominent peaks in July and August are explained by two typhoons moving westward through the Northern SCS in 2018 summer, leading to elevated significant wave height of 1.5 - 2.5 and 2.0 - 4.0 m (without 1-day moving average), respectively. Strong typhoon swells persist for a week. During the winter months, the prevailing winter monsoon sometimes produce northeast wind waves in the Northern SCS with significant wave height of more than 3 m. However, as the monsoon swells propagate into the bay from the open sea, the waves get weaker in wave height and are diffracted to the southeast due to shelter of the peninsula to the east (Fig. 2b). The hourly significant wave height off the Dadonghai Bay generally varies below 1.0 m, and can reach up to 2.0 m with the outbreak of monsoon.

Accordingly, various wave conditions representative of winter monsoon swells and summer typhoon swells are used in the following modeling studies of rip variability and hazards.

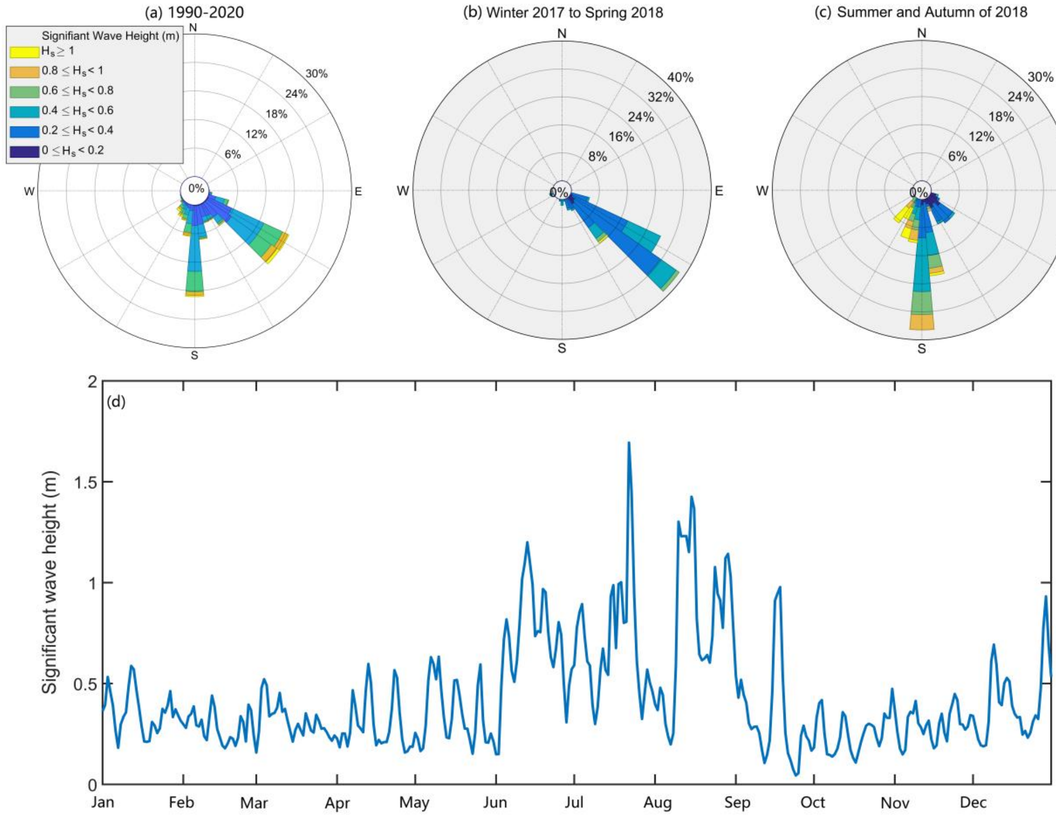

Figure R5. Wave climate in study site. Subplot (a) is wave rose diagram of 30-year-long time series of wave hindcast at a wave point immediately off the Dadonghai Bay (109.5 E, 18.2 N); (b-c) are wave rose diagrams for winter monsoon and summer typhoon seasons in 2018, respectively; (d) is 1 day-averaged time series of significant wave height in 2018.

Details:

1. The abstract is quite long and it is preferable to be more concise in order to attract the readers' attention.

Response: Accepted. The abstract has been shortened. Please refer to the revised manuscript.

2. Paragraph between Line 108 and 112 is not a description of the bathymetry. It should be included as another subsection describing sea levels.

Response: Accepted. Indeed it is inappropriate to include this paragraph in Section 2.1. The first sentence of the paragraph presents the information about tidal range of the Dadonghai Beach, and the rest of the paragraph is about bedrock morphology at both ends of the bay. Instead of starting another subsection about tidal levels, we removed this paragraph from Section 2.1 and merged it into the opening paragraph of Section 2. Please refer to revised manuscript.

3. Table 1: How were these 9 tests defined? Are they the most frequent characteristics of summers? If the selected tests are representative of summer wave conditions, it would be appropriate to deepen this analysis in section 2.2 by considering the complete wave time series.

Response: Accepted. *Section 2.2* has been reformulated. Wave conditions given in 9 tests are representative of winter monsoon swells and summer typhoon swells. Among these wave conditions, T_p = 4.8 s and 8.0 s are representative of short-period monsoon swells in winter, and T_p = 12.0 s is representative of long-period typhoon-induced swells in summer. Wave incident angles of 5° and 20° is also adopted to represent oblique SE or SW swells. The 2nd paragraph of *Section 3.2* has been slightly revised.

6. Line 227 - 235: Do these diagrams consider the results of all simulations in all tests?

Response: Statistical analysis of Test 1, 7 and 8 is not included in Figure 5. The generated rip currents are weak in Test 1 with wave forcing of H_s=0.7 m and T_p=12 s. Test 7 and 8 are aimed to test the effect of wave incident angle on rip currents. The modeling results show that nearshore circulation is dominated by persistent longshore currents. We made a short statement in the caption of Figure 5 to explain that T1 and T7-8 were not included.

Editorial errors:

Line 42: exist => exit;
Line50: determine => determines;
Line 53: hazard => hazards;
Line 54: How => how, level => level of;
Line 94: beach => Beach;
Line 110: coastal coral reef => a coastal coral reef;
Line 112: been => be;
Line 121: add 'the' before NMEFC;
Line 124: averaging => average;
Line 140: In our simulation => In this study;

Table 1: defining λ***;***

Line 155: are => is;
Line 157: add 'the' before 'hydrodynamic response';
Line 166: We define rip currents => In this study the rip currents are defined as...;
Line 171: add 'the' before 'greatest danger';
Line 172: location => locations;
Line 176: add 'the' before 'moverment';
Line 184: add 'a' before 'safe state';
Line 195: move => moves;
Line 204: deflect => deflects
Line 246: an => a;
Line 285: remove space;
Line 298: child => a child;
Line 312: to Child => for children;
Line 342 & 353: AREA => Area;
Line 401: Floating => floating;
Response: All the editorial errors have been corrected in the revised manuscript.

Figure improvement:
Figure1: Indicate geographical north orientation; Define zoom frame panels b and d; Include the location of the wave series point.

Response: Symbols for geographical north orientation and wave point have been added. However, scale in Figure 1a is too large to fit the zoom frame for panels b and d.

Figure 2: Preferable to indicate time in actual dates.

Response: Accepted. The julian day is replaced with month names.

Figure 3 & 4: (1)The "s" in Hs does not need to be subscripted; (2)It is recommended to superimpose guide vectors over the currents to highlight the predominance; (3)Why is the wave direction specified only in the last 2 panels and not in the rest? (4)Panels e to i would correspond to tests 1 to 8. Where would the result of test 9 be?

Response: (1) The bulk parameter Peak Significant Wave Height is denoted with H_s in the study. We also checked with the related literature. Most of them subscript letter 's' to denote significant wave height. (2) There were several versions of Figure 3&4 before we submitted the manuscript. Subplots with guided vectors was one of them. However, each row of subplots in the figure use different length scales of vectors, and labeling them individually may cause confusion. Finally, we decided to use shaded contours overlapped with vectors to highlight the surf-zone flows. Here the vectors are just for illustration.(3) All the parameters defining wave conditions are listed in each subplot. (4) Test 9 shows how variation in tidal level affect rip currents. The result is illustrated in Figure 5f. As the nearshore circulation is too weak in Test 9, we haven't included it in Figure 3&4.

Figure 7: Specify which is this test indicating wave direction and tide level.

Response: Accepted. Figure caption has been revised.

Reference:

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