Dear Editor,

Please find enclosed our response to the reviewer's comment regarding the manuscript entitled, "Morphological Response of Vegetated and Urbanized Barrier Islands to Hurricane Ian" for publication in Natural Hazards and Earth System Sciences (NHESS).

We appreciate the constructive comments on our manuscript. We have adopted most of their suggestions, but we also have identified some suggestions that we do not agree with. In those cases, we have tried to be very clear about why we differ from the reviewer's opinion and we have made an effort to clarify our writing and explanations. In the following paragraphs we detail our rebuttal (in blue) regarding the modifications we made to the manuscript to the reviewers' comments (in black).

General Comments from Reviewer #1:

Reviewer's Comment: This manuscript describes the morphologic responses of two barrier islands to the extreme conditions produced by Hurricane Ian. This manuscript uses a combination of multiple scenarios that incorporate different landcover classifications to determine which of the modeled scenarios most accurately replicates the observed morphological responses. The manuscript makes a couple of important points. First, spatially variable bed roughness elements are important to include to best simulate the morphodynamic response of barrier islands during large storm events. Second, increased secondary vegetation densities can reduce erosion along dune environments. However, this manuscript is limited in that it focuses only on dune response, instead of incorporating multiple morphological responses (i.e., changes in shoreline position, beach volume, beach slope, barrier-island interior volume, etc.) within the analyses. This study would benefit by incorporating more details about the total morphologic changes, instead of only focusing on impacts to dune crest height and dune crest cross-shore position.

Authors' Response: We thank the reviewer for their positive assessment of the manuscript. We agree that incorporating additional morphological metrics (e.g., shoreline position, beach volume, and beach slope) would provide a more complete assessment of storm-driven coastal change. However, shoreline-position analysis was not included because XBeach is not specifically designed or commonly used for robust shoreline change analysis. Following the reviewer's suggestion provided later in the specific comments, we have revised the section headings to explicitly reflect a focus on the dune response. Accordingly, Section 4.1 has been renamed to Storm-Induced Dune Morphodynamics at Lovers Key, and Section 4.2 has been renamed to Storm-Induced Dune Morphodynamics at Fort Myers Beach.

Reviewer's Comment: Additionally, this manuscript fails to contextualize the results within the body of existing literature in the discussion. The discussion section could benefit by adding two different sections:

1. How the modeled results presented in this manuscript compare to existing interpretations of the morphologic responses of Lovers Key and Fort Myers Beach resulting from Hurricane Ian (e.g., Wang et al., 2024; McCormick et al., 2025; Hauptman et al., 2024).

2. How the modeled results presented in this manuscript compare to the existing body of literature that modeled the morphological responses of previous large storm events that have impacted developed barrier islands such as Hurricanes Michael and Sandy (e.g., Ma et al., 2024; Smallegan et al., 2016)

Authors' Response: We agree with the reviewer that the Discussion section benefits from contextualization within existing literature. In response, we have revised the Discussion section to explicitly include the comparison of the modelled dune responses presented in this manuscript with published field-based interpretations of Hurricane Ian impacts at Lovers Key and Fort Myers Beach (e.g., Wang et al., 2024; Hauptman et al., 2024; McCormick et al., 2025), focusing on similarities and differences in dune erosion patterns and spatial variability and results within the broader context of previous XBeach-based modeling studies of large storm events impacting barrier islands, including Hurricanes Michael and Sandy (e.g., Smallegan et al., 2016; Ma et al., 2024), which is presented below.

We have added the text as follows [Line 377-395]: The modelled morphologic responses presented here indicate that dune crest lowering and landward crest migration were dominant responses at Lovers Key, with spatial variability influenced by vegetation cover, consistent with post-storm LiDAR-based interpretations of widespread beach–dune erosion under an inundation-dominated regime during Ian (Wang et al., 2024).At Fort Myers Beach, the modeled response exhibits pronounced alongshore variability that corresponds to the built environment, in agreement with observations from developed Estero Island showing spatially heterogeneous erosion and overwash, with landward sediment transport pathways enhanced along roads and between anthropogenic structures (McCormick et al., 2025). While these observational studies quantify measured post-storm change, the present framework reproduces the primary spatial patterns of dune response, supporting an inundation-dominated interpretation of storm impacts. XBeach simulations of Hurricane Sandy at Bay Head, New Jersey, further demonstrate that hard structures (a buried seawall) can materially alter modeled dune erosion and island response relative to an unarmored case (Smallegan et al., 2016), providing a relevant analogue for interpreting how development can modulate storm-driven morphodynamics. In contrast, the study by Ma et al. (2024) is useful primarily for methodological context (e.g., motivation for using non-hydrostatic XBeach for storm conditions such as Hurricane Michael) rather than as a direct analogue to our land-cover/structure-focused analysis, as its emphasis is on hydrodynamic representation and broader model capability rather than isolating the role of urban roughness elements or engineered features in controlling alongshore variability; therefore, it has not been included in our detailed discussion. Similarly, Hauptman et al. (2024) provides valuable post-storm, remote-sensing–based documentation of elevation-change patterns and damage hotspots on Estero Island, but it is not included as a primary model–data comparison framework here because its analysis focuses on event-scale damage assessment rather than process-based morphodynamic metrics.

Specific Comments from Reviewer #1:

Authors' Response:

For the specific comments (*), each has been addressed by first restating the reviewer's comment, followed by the original text from the manuscript and the corresponding revised text, as presented below.

[40-45] * – There is a lot of information on global mean sea level, which is not carried through the rest of the manuscript. I would suggest either limiting the amount of info about sea level, or carry it throughout the rest of the manuscript.

Existing Text [40-45]: Barrier islands are becoming increasingly vulnerable not only as human occupation intensifies, but also as extreme events become more frequent and sea level rise accelerates (IPCC, 2018; Jiménez et al., 2011). During the latter half of the 20th century, global mean sea level rose at about 2.5 mm/year and in recent decades has accelerated to about 3.9 mm/year (Brooks et al., 2017; IPCC, 2021). Projections for the coming decades indicate that even modest increases in sea level will amplify storm impacts, leading to extensive inundation and substantial morphological alterations of low-lying coastal landscapes and sandy barrier systems (FitzGerald et al., 2008; Tebaldi et al., 2012).

We have shortened the text as follows [Line 37-40]: Barrier islands are becoming increasingly vulnerable as human occupation intensifies and extreme storm events become more frequent (IPCC, 2018; Jiménez et al., 2011). This vulnerability is further exacerbated by sea-level rise, as even modest increases in mean sea level are projected to amplify storm impacts (FitzGerald et al., 2008; Tebaldi et al., 2012).

[70–71] * – There should be more information about measured (or modeled) conditions produced by Hurricane Ian, including storm track, duration, wind speeds, water levels, etc. These conditions are published and available through Bucci et al. (2022) but should be included to provide context for the storm.

Existing Text [70–71]: Hurricane Ian originated from a tropical wave that emerged off the west coast of Africa. It intensified over the Gulf of Mexico and made landfall as Category 4 in Lee County, Florida on 28 September 2022.

We have revised the text as follows [Line 64-68]: Hurricane Ian originated from a tropical wave that emerged off the west coast of Africa. It intensified over the Gulf of Mexico and made landfall as Category 4 in Lee County, Florida on 28 September 2022 at 2:05 PM EST. The storm followed a northward track across southwest Florida produced prolonged extreme forcing, with maximum sustained winds of ~65–70 m s^{-1}, minimum central pressure of ~941 mb, and storm surge exceeding 3–4 m above mean sea level, resulting in widespread inundation of barrier islands including Fort Myers Beach and Lovers Key (Bucci et al., 2022)

[80–99]* – There are a lot of different data sources that were used for the "observed changes" resulting from Hurricane Ian. These datasets are presented here but there are no specific details or information about the spatial uncertainties (both horizontal and vertical) of the different datasets, and the specific methodologies used to collect those data. For example, the authors discuss “LiDAR surveys” accessed by NOAA’s Digital Coast and different LiDAR surveys provided by Florida Gulf Coast University. Were these surveys collected using the same methods? Do they have the same uncertainties? Clarification and increased specificity for each of the datasets is needed here. Additionally, CEC transects extend up to 1km into the nearshore, were those collected by a total station, as noted in the manuscript, or was it done using bathymetric surveying (i.e., single beam sonar)?

Authors’ Response: We thank the reviewer for highlighting the need for greater clarity regarding the data sources; this information has been added to Section 2, Study Area and Data Availability.

We have revised the text as follows [Line 77-98]: The topo-bathymetric data sources consist of “NOAA Pre-Ian” and “NOAA Post-Ian” rasterized topo-bathymetric Digital Elevation Models (DEMs). These Hurricane Ian LiDAR datasets were obtained from NOAA’s Digital Coast and collected using airborne LiDAR systems under standardized USACE–NOAA protocols, with a 1 m horizontal resolution and referenced to NAVD88. The NOAA Pre-Ian dataset (OCM Partners, 2025a) was collected between May and June 2022, and the NOAA Post-Ian dataset (OCM Partners, 2025b) in November 2022. The topographic data have a reported vertical accuracy of approximately 19.6 cm (95% confidence), while bathymetric returns exhibit depth-dependent accuracy. The NOAA Post-Ian dataset has a smaller spatial coverage compared to the pre-storm dataset because LiDAR penetration was limited under high turbidity conditions following the hurricane. Additionally, an in-situ dataset is provided by Coastal Engineering Consultants (CEC). These transects, referred to as “CEC Pre-Ian” and “CEC Post-Ian”, were surveyed before and after Hurricane Ian in June–July 2022 and October–November 2022, respectively. In total, 57 transects were surveyed, with 43 transects on Fort Myers Beach (Transect No. 1 to Transect No. 43) and 14 transects on Lovers Key (Transect No. 44 to Transect No. 57). The surveys were conducted using RTK GPS across the subaerial beach and into the surf zone (to approximately −4 m NAVD88), while deeper nearshore bathymetry was collected using single-beam sonar, with an overlap of approximately 6 m between RTK GPS and sonar measurements to ensure continuity (Mr. M. Poff, CEC, pers. comm.). Note that in this paper we retain the original numbering assigned during the CEC field survey to maintain consistency with the source dataset, even though model-data comparisons are not shown for every transect.

An additional dataset with a smaller spatial extent compared to the NOAA and CEC datasets is provided by Florida Gulf Coast University (FGCU), which conducted pre- and post-Hurricane Ian LiDAR surveys for Lovers Key in June 2022 and October 2022, respectively, referred to as “FGCU Pre-Ian” and “FGCU Post-Ian”. The post-storm LiDAR data were collected using a UAV-mounted Velodyne HDL-32 sensor flown at approximately 50 m altitude, with a swath width of about 60 m and an overlap of around 20 m between adjacent flight lines. The dataset is referenced to NAVD88 and has a reported vertical accuracy of approximately 5 cm (C. Daly, FGCU, pers. comm.; Bhatta et al., 2023).

[116] * – The continuously updated digital elevation model that is cited through the NOAA (2018) reference is a 1/9 arc second DEM, which has a 3m pixel resolution.

Existing Text [116] - The bathymetry was generated by combining the NOAA Pre-Ian DEM, which extends to depths of up to 7 meters, with the 1-meter-resolution Continuously Updated Digital Elevation Model (CUDEM) dataset (NOAA, 2018) to provide coverage of deeper waters.

We have revised the text as follows [Line 118]: The bathymetry was generated by combining the NOAA Pre-Ian DEM, which extends to depths of up to 7 meters, with the 3-meters-resolution Continuously Updated Digital Elevation Model (CUDEM) dataset (NOAA, 2018) to provide coverage of deeper waters.

[121] * – How do the modeled wave and water levels compare to the measured total water levels during Hurricane Ian on Fort Myers Beach and Lovers Key? I think this should be addressed to validate the modeled water levels during the storm. These are accessible through the USGS Flood Event Viewer (https://apps.usgs.gov/fev/event/2022-ian)

Authors' Response:

We have clarified in the text as follows [Line 195-203]: At the time of the execution of the first author's 'MSc study only the NOAA tide gauge data was available. The modelled peak water levels were in close agreement with the observations at the closest NOAA station 8725520 at Ft. Myers (see Van Dongeren et al., 2024). We have now checked against the observations of ad hoc installed pressure sensors FLLEE03382 and FLLEE03284 on Ft Myers Beach (https://apps.usgs.gov/fev/event/2022-ian) and they indicate that the observed peak water levels are underestimated by 0.6 m on those locations. However, both in the modelled case and in the observations the peak water level indicates that the island is in the Inundation Regime (Sallenger, 2000) with a modelled peak water depth of about 1 meter over the pre-storm dune crest and 1.5 m and more over the main part of the island. Also, because both modelled and observed water level increases during the surge phase are similar, the processes governing the morphological change of the dune and beach are represented by the model. We have discussed the underestimation in lines 203-211. The installed pressure transducers recorded at intervals of 30 seconds which means that no wave information could be retrieved from that data.

[150–152] * – Can the authors speculate as to why there were differences in the land cover classifications? Was it the result of differences in cell size or a different reason?

Existing text [150–152]: For Lovers Key, several patches of primary vegetation along the back-barrier and foredune zones are classified as secondary vegetation in Scenario 3, highlighting differences in vegetation classification between the two datasets.

We have updated the text as follows [Line 158-161]: For Lovers Key, several patches of primary vegetation along the back-barrier and foredune zones are classified as secondary vegetation in Scenario 3, highlighting differences between the two land-cover datasets. These differences are related to variations in source data resolution, classification methodology, and preprocessing approaches, rather than representing actual changes in vegetation condition.

[167–170] * – How did the authors differentiate beach berm crests from primary dune crests in Equation 3 at locations where beach berms (or berm ridges associated with ridge and runnel morphologies) existed following the storm?

Existing [167–170]: For Lovers Key, the change in dune crest elevation was evaluated by plotting transects perpendicular to the coastline, extending approximately 200 meters inland to intersect the primary dune. The dune crest is defined as the first maximum elevation along each transect

(Equation 3), and crest shift is defined as the horizontal displacement of the dune crest relative to its initial position, as predicted or observed (Equation 4): $zcrest = max(zb\ (x,y))$

We have revised the text as follows [Line 175-180]: For Lovers Key, changes in dune crest elevation were evaluated using shore-normal transects extending approximately 200 m landward from the shoreline, a distance selected to ensure intersection with the primary dune. Along each transect, the dune crest was defined as the maximum elevation associated with the primary dune, thereby excluding lower-elevation berm crests that may exist seaward before or following the storm (Equation 3). The dune crest location was identified along each transect, and post-storm crest elevation was evaluated at the same location. Crest shift was defined as the horizontal displacement of this primary dune crest relative to its pre-storm position (Equation 4).

[175–225]* – This whole section does a nice job of comparing the modeled outputs to the observed changes but only considers dune crest height and dune position as “morphological responses”. With many other morphologic responses (including changes in shoreline position, beach volume, beach slope, barrier-island interior volumes, etc.) excluded from this section (and excluded from the entire manuscript), this section should either be renamed to be focused only on dune responses, or expand it significantly to encapsulate more of the morphologic responses resulting from Hurricane Ian.

Authors’ Response: We agree with the reviewer that this section focuses specifically on dune-related metrics. We have revised the section headings to emphasize dune morphodynamics rather than implying a broader assessment of coastal morphology. Accordingly, Section 4.1 has been renamed to Storm-Induced Dune Morphodynamics at Lovers Key (instead of Morphological Response of Lovers Key), and Section 4.2 has been similarly renamed for Fort Myers Beach.

[Figure 6] *– Why are the observed Pre- and Post-storm profiles labeled as NOAA+CEC? I thought those were two different datasets, with varying spatial scales and data collection methods (i.e., one is LiDAR and one is a total station survey)?

Authors’ Response: We clarified this in the text as follows [Line 212-216]: The profiles are labeled as NOAA+CEC because the two datasets were merged to construct continuous cross-shore profiles extending from the subaerial beach and dune into deeper nearshore waters. NOAA LiDAR provides high-resolution coverage of the subaerial and shallow nearshore regions but does not reliably capture deeper bathymetry, whereas the CEC surveys extend offshore beyond the LiDAR coverage. Both datasets are referenced to NAVD88 and were spatially aligned prior to merging, resulting in a continuous profile with consistent vertical referencing.

[230–275]* – See above comment ([175–225]) about morphological responses. Additionally, there is no section here about lateral or vertical changes in dune crest. Was this section excluded due to a lack of prominent primary dunes on Fort Myers Beach, or a different reason? A short explanation for why this was excluded from the Fort Myers Beach section should be included.

Authors’ Response: We clarified this in the text as follows [Line 325-327]: Section 4.2 has been revised to Storm-Induced Dune Morphodynamics at Fort Myers Beach to reflect the dune-focused scope of the analysis. The dune crest changes were not evaluated at Fort Myers Beach due to the absence of well-defined, continuous primary dunes and the strong influence of urban development, which makes consistent crest identification difficult.

[261–263] * – The observed deposition within the nearshore was a trend found in other field-based studies on Hurricane Ian (cited in the general comments section and next comment). Could you provide hypotheses as to why this is not seen in the modeled output of this study?

Existing [261–263]: In Transect 13 (Fig. 8a), the post-storm profile shows offshore sand accumulation between x = 400–600 m, which is not captured in any of the modelled scenarios.

We have clarified this in the text as follows [Line 312-316]: The absence of this offshore accumulation in the modeled results is likely related to localized alongshore gradient in sediment redistribution that may not be fully captured by the spacing of the cross-shore transects. Additionally, the parameterization of XBeach during storm events can favor onshore-directed sediment transport when wave skewness- and asymmetry-driven processes dominate, which may limit the representation of offshore deposition. These factors could contribute to the differences between the observed and simulated nearshore sediment accumulation.

[278–282]* – How do your results fit into the bigger context of the growing body of literature already published on Hurricane Ian, as well as the modeled results from other previous large storm events from around the US and the World? The sensitivity analyses should still be a part of the discussion section, but the authors do not address how their work fits into the existing body of literature. For example, the authors could compare the modeled water levels from Hurricane Ian to the findings of McCann et al. (2024) and the modeled morphologic changes to the results of McCormick et al. (2025), Hauptman et al. (2024), and Wang et al. (2024). Additionally, the authors could provide more context for how their approach to incorporating variable bed roughness values for vegetation and built environments could have improved the results of previous studies that focused on other large storm events that impacted developed islands, such as Hurricane Michael or Sandy.

Authors' Response: We thank the reviewer for this valuable suggestion. In response, we have revised the Discussion section to compare our modeled morphodynamic results with published studies, as presented above in the general comments section.

[294–303] * – Are these examples of available datasets collected frequently enough, or at a fine enough resolution, to be useful for coastal managers?

Existing text[294–303]: The modelling approach applied in this study for South-West Florida is transferable to barrier-island locations worldwide. This study has shown that the critical input and forcing data required to obtain meaningful results are high-resolution topo bathymetric data, land-use land-cover (LULC) data, and water levels. The availability of these input data may vary. Other U.S. locations can use the same NOAA sources of input and forcing data sets used here. For other locations, the availability and quality of the input and forcing data may vary, although it is improving. Data for European locations are available through Copernicus databases such as the Copernicus DEM (GLO-30, GLO-90 and EU-DEM) (ESA, 2025) and products such as DeltaDTM (Pronk et al., 2024) which provide high-resolution topographic and bathymetric data. In addition, global bare-earth elevation data can be obtained from FABDEM, global bare-earth DEM derived from Copernicus GLO-30 (Meadows et al., 2024).

We have clarified this in the text as follows [Line 355-358]: These datasets generally provide sufficient spatial resolution for storm-impact assessment and scenario-based modeling, which are commonly used by coastal managers. However, their update frequency varies by region and dataset, and they may not be collected frequently enough to support continuous monitoring or rapid-response management applications in all locations.

[303–305] * – This claim seems to be a bit of a stretch for the scope of this manuscript. Also, "vegetation restoration" is a little ambiguous and could use some clarification.

Existing text [303–305] With these inputs and the approach presented here, coastal managers can assess coastal hazards related to erosion and flooding under current conditions on urbanized and natural barrier islands and evaluate mitigation measures such as vegetation restoration. The sensitivity study may also provide guidance on the interpretation of results in cases where the input and forcing data are of lower than desired quality.

We have revised this in the text as follows [Line 359-363]: With these inputs and modelling approach presented here, coastal managers can assess storm-driven erosion and flooding hazards on urbanized and natural barrier islands under current conditions. The framework may also be used to explore the relative influence of land-cover characteristics, such as the presence or absence of vegetated dune areas, on modelled morphologic response. The sensitivity study may also provide guidance on the interpretation of results in cases where the input and forcing data are of lower than desired quality.

[308–309] *– This statement is not well supported in this context. This paper shows that the XBeach model can "reasonably" approximate the results of the inundation regime during Hurricane Ian and does not provide citations to support that the model can accurately approximate the three other regimes. Please provide citations of other studies that have successfully replicated the three other impact regimes.

Existing text [308–309] The results of this study add to the evidence base showing that it is now possible to predict morphological changes across all Sallenger (2000) regimes with a single numerical model. For instance, Van der Lugt et al. (2019) showed good skill for cases of barrier-island breaching on Fire Island (New York, USA) and Matanzas Inlet (Florida, USA) but also highlighted that variations in boundary water levels and wave characteristics influenced breach formation and dune response.

We have revised this in the text as follows [Line 364-369]: The results of this study add to the evidence base showing that it is now possible to predict morphological changes across all Sallenger (2000) regimes with a single numerical model. In this paper we show that the model can reasonably approximate the behavior in the Inundation Regime, while Van der Lugt et al. (2019) showed skill in simulating collision- and overwash-dominated responses, including cases of barrier-island breaching such as those documented for Fire Island (New York, USA) and Matanzas Inlet (Florida, USA), but also highlighted that variations in boundary water levels and wave characteristics influenced breach formation and dune response.

[320–334] – This section would be better suited in the results section, as it is presenting new results relating to a different land cover scenario. The results of this then could be elaborated on within the discussion and include appropriate references that corroborate the results.

Authors' Response: We have moved that section (4.1.3) to results.

Technical Corrections:

[75] – “Lovers Key State Park comprises…”

This has been updated as suggested.

[141] – Incorrect citation; should be “Salgano (2023)”

This has been updated as suggested.

[Figure 3] – Need scale bars and North arrows on both sets of maps with different spatial extents and different rotations; maps of Fort Myers Beach are too small to determine the differences in land cover classification

Figure 3 has been updated as suggested.

[194–195] – Elevations should include the vertical datum (NAVD88?)

All elevations reported in the manuscript and figures are referenced to NAVD88, as indicated on the y-axes of the relevant figures. To avoid unnecessary repetition, the vertical datum is not restated for every elevation value mentioned in the text.

[203] – What do you mean by “waning flows”? Decreased flow velocities or ebbing flows, or both?

This has been revised as “ebbing flows”.

[Figure 5] – Dashed lines and shading are difficult to distinguish in greyscale, you may want to consider making these colored lines (in addition to the different dash types) to make them more distinguishable; may want to put orientation indicator to show which direction is North/South along the x-axis to orient reader.

The figure originally used colored lines; however, these were revised to greyscale following recommendations from the editorial support team to ensure accessibility for readers with color-vision deficiencies, based on guidance from the Coblis – Color Blindness Simulator.

[212–213] – Elevations should include the vertical datum (NAVD88?)

All elevations reported in the manuscript and figures are referenced to NAVD88, as indicated on the y-axes of the relevant figures. To avoid unnecessary repetition, the vertical datum is not restated for every elevation value mentioned in the text.

[230] – “Hurricane Ian”

This has been updated as suggested.

[241–244] – “A noticeable effect…”: This sentence is awkwardly worded and redundant, and should be revised.

Existing: A noticeable effect of urbanization was the formation of overwash with reduced deposition immediately landward of buildings or roads and the accumulation of sand on their seaward side, with urbanized areas also experiencing overwash deposits and local scouring, highlighting how built environment influences flow and sediment deposition (Hapke et al., 2015; Houser et al., 2008).

We have revised this in the text as follows [Line 290-293]:Buildings and infrastructure influenced overwash patterns by limiting landward sediment deposit behind buildings and roads while promoting sand accumulation on their seaward sides; urbanized areas also exhibited localized overwash deposits and scouring, reflecting the role of built structures in modifying flow pathways and sediment redistribution (Hapke et al., 2015; Houser et al., 2008).

[259] – “4.2.1 Model Versus…”

This has been updated as suggested.

[324] – Elevations should include the vertical datum (NAVD88?)

All elevations reported in the manuscript and figures are referenced to NAVD88, as indicated on the y-axes of the relevant figures. To avoid unnecessary repetition, the vertical datum is not restated for every elevation value mentioned in the text.

[350–353] – “Three model scenarios… Scenario 2 is based on…”: Need to reword these two sentences as there are typos and could be combined into one sentence.

Existing: Three model scenarios were developed: In Scenario 1, the baseline sandy-bed case, in which vegetation and built environments are not taken into account. Scenario 2 is based on NOPP Land Use and Land Cover (LULC) data, and Scenario 3 uses NOAA LULC data; both incorporate vegetation and built environments.

We have revised this in the text as follows [Line 400-402]: Three model scenarios were developed: Scenario 1 represents a baseline sandy-bed case that does not account for vegetation or the built environment, while Scenarios 2 and 3 incorporate vegetation and built environments using NOPP and NOAA land use landcover (LULC) datasets, respectively.

[364] – “(waves and surge)”

This has been updated as suggested.

Overall Comments from Reviewer #2:

Reviewer's Comment: This paper investigates the effects of vegetation and built environments on modelled barrier island morphodynamics in a case study in southwest Florida. The sensitivity of the model XBeach to dune vegetation cover and non-erodible surfaces was tested, using a baseline constant Manning's roughness value, and two datasets of land cover (varying in resolution) from the National Oceanographic Partnership Program and NOAA. Using the 2022 Hurricane Ian event, the authors demonstrate firstly that including variable surface roughness in the XBeach boundary conditions significantly improves the skill of the sediment transport predictions. Secondly, using the two land cover datasets as different scenarios, they show lower resolution land cover data does not significantly impact the prediction skill. This is particularly impactful for land cover data availability when modelling coastal storm responses. What is also appreciated is the added test of the most successful model setup, which involves including vegetation patches to assess the morphodynamic response to revegetation. These results may be useful for modelling nature-based solutions to erosion in a coastal management context.

With the above being said, it would be interesting to see the study expanded beyond the dune elevation metrics used. Change in elevation maps and dune profiles are helpful for assessing before- and after-event topography, but I agree with the other reviewer that shoreline position change (and the seaward limit of vegetation) would build a richer picture of surface/environmental change being modelled by XBeach. Furthermore, the discussion does not delve into the uncertainties and potential flaws for consideration in the methodology, particularly where combining different datasets is concerned.

The manuscript makes a short but useful contribution to the field of barrier island modelling, but could be enhanced with broader analyses, to solidify its impacts suggested in the discussion.

Authors' Response: We appreciate the recognition of the study's contribution in demonstrating the importance of spatially variable surface roughness and evaluating the sensitivity of XBeach to land-cover resolution, as well as the potential relevance of the revegetation scenario for nature-based coastal management applications.

We agree that incorporating additional morphologic metrics, such as shoreline position change and seaward vegetation limits, would provide a broader assessment of storm-driven coastal change. However, consistent with our response to Reviewer 1, the present study was designed to focus specifically on dune morphodynamics as a controlled framework for evaluating land-cover-dependent roughness parameterization in Xbeach. Moreover, Xbeach is not designed as a shoreline model which is why we hesitate to analyse shoreline change results from this model. To clarify this scope, we have revised the relevant section headings and discussion text to explicitly emphasize dune-focused metrics rather than broader island-scale morphologic change.

Regarding uncertainties and methodological limitations, particularly those associated with combining multiple datasets, we agree that further clarification is warranted. The revised manuscript includes expanded discussion of dataset collection methods, spatial resolution, vertical referencing, and reported uncertainties

Specific Comments from Reviewer #2:

Authors' Response:

For the specific comments (*), each has been addressed by first restating the reviewer's comment, followed by the original text from the manuscript and the corresponding revised text, as presented below.

[Line 58]*: Please adjust the wording or grammar of this sentence, the phrasing is hard to understand.

Existing Text [Line 58]: Note that the increased Manning's coefficients directly affect the hydrodynamics but only indirectly, through reduced velocities, affect the sediment transport and morphology.

We deleted the sentence, as it provides too much detail that is not needed in the introduction.

[Line 104]*: Is there a reason for the inconsistent numbering of the transects? Do these come from another source with breaks in the transect numbering? It might be helpful to just do 1–8 if these are contained within this study.

We have clarified this in the text [Line 91-92]. The transects retain the original numbering assigned during the CEC field survey to maintain consistency with the source dataset. All additional datasets (e.g., LiDAR-derived profiles and modeled outputs) were plotted along these same numbered transects. Renumbering the transects sequentially (e.g., 1–8) would limit the analysis to only the northern portion of Fort Myers Beach and could create confusion when cross-referencing the survey data. Therefore, the original CEC transect numbering has been preserved for clarity.

[Line 115]*: Is there a difference in the capture date between these two datasets? If so, it would be worth explaining the potential impact of mismatched conditions between bathymetry models.

Existing Text [Line 115]: The bathymetry was generated by combining the NOAA Pre-Ian DEM, which extends to depths of up to 7 meters, with the 1-meter-resolution Continuously Updated Digital Elevation Model (CUDEM) dataset (NOAA, 2018) to provide coverage of deeper waters.

Authors' Response: The NOAA Pre-Ian DEM and the CUDEM dataset were not collected on the exact same date; however, the deeper-water bathymetry incorporated from CUDEM represents comparatively stable offshore morphology, where short-term storm-driven variability is typically lower than in the nearshore zone.

[Line 128]*: Lovers Key shows a higher post-peak wave height than Fort Myers, but it sits (at least from Figure 1) behind the barrier and is mainly bay. If these timeseries are both taken from the seaward nearshore, this should probably be reflected more clearly in Figure 1. In any case, it might be helpful to briefly suggest reasons for this difference.

We have revised this in the text as follows [Line 128-131]: The slightly higher post-peak wave heights at Lovers Key are likely related to differences in offshore bathymetry and local exposure along the Gulf-facing boundary. Although Lovers Key includes back-barrier environments, the wave time series presented here correspond specifically to the open-coast boundary conditions rather than the bay side, where wave energy is substantially reduced.

[Line 132]*: It would be worth clarifying that the Manning's roughness coefficient values used come from empirical studies in similar environments (both the uniform value and the LULC specific ones). Also Line 141 has a typo in how Salgado is cited (no brackets around author).

Authors' Response: The existing manuscript (Lines 50–58) highlights the studies in which both the uniform Manning's roughness coefficient and the LULC-specific values were applied in comparable coastal environments. In particular, the LULC-specific Manning's coefficients used in this study follow the approach applied by Salgado (2023), and the relevant citation has been corrected in the text [Line 156].

[Line 184]*: It would be helpful to specify that the lack of difference between Scenario 2 and 3 are between each other, and not in relation to Scenario 1. This is clearer in Figure 4 but a slight rewording would help in the text.

Existing Text [Line 184]: The application of the two different LULC datasets in Scenario 2 and Scenario 3 do not result in significant different sedimentation and erosion patterns, despite the differences in land use classification (Fig 3c and d).

Authors' Response: The comparison in Line 184 refers specifically to differences between Scenario 2 and Scenario 3. As noted in Lines 158–161, the differences in land-cover classification between these two scenarios are described; however, their morphodynamic responses are similar.

[Figure 7]*: I appreciate the choice in colour ramp for topography, but in the context of this study (which includes land cover as a metric), I feel it is misleading to include green as a colour for topography thresholds. It is partially true that higher topography tends to be because of the existence of vegetation cover in digital surface models, but not in all cases and not for these barrier islands. I would suggest steering from blue and green which are suggestive.

Authors' Response: The selected colormap was chosen to ensure accessibility and compatibility with color-vision deficiencies, and it was verified using colorblindness simulation tools to maintain distinguishability across elevation thresholds. While we acknowledge that green tones can sometimes be associated with vegetation, in this case the colormap represents elevation values only and is not intended to imply land-cover characteristics.

[Line 278–282]*: This feels repetitive/redundant, consider shortening.

Existing Text [Line 278–282]: In this section, we discuss the sensitivity of different XBeach input parameters and forcing conditions that affect morphodynamic response, as well as the role of supplemental vegetation. We used default parameter settings and tested sensitivity to Manning's n value, wave skewness and asymmetry (facua), morphological acceleration factor (morfac), water levels, and offshore wave heights. In addition, we investigated how supplemental vegetation influences bed-level changes under similar forcing conditions, as discussed in the sections below.

We have revised this in the text as follows [Line 333-335]: In this section, we discuss the sensitivity of XBeach to key input parameters and forcing conditions influencing morphodynamic response, including Manning's n, wave skewness and asymmetry (facua), morphological acceleration factor (morfac), water levels, and offshore wave heights.

[Figure 9]*: I would suggest colouring the added vegetation pixels in a different colour from the original primary vegetation green, to help the reader differentiate between existing and simulated veg cover.

Authors' Response: In Figure 9b and 9c, the existing vegetation and the added vegetation patches are highlighted in the legend to clarify their locations along the transects. However, we agree that this distinction is less clear in Figure 9a. Accordingly, we have revised Figure 9a to use a distinct color for the added vegetation patches to improve visual differentiation from the original primary vegetation cover.

[Lines 347 and 353] *: Please address the spacing typos.

Authors' Response: We have addressed the spacing typos in the revised manuscript.

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