January 5, 2025.

1 Author remarks

Thank you for taking the time to review this paper and offer suggestions for improving the quality of the research and writing. We have worked our way through the reviewer comments and addressed them below. Under each point brought up by the reviewers we have made comments addressing their concern (grey boxes) and added or updated the paper. Our added or updated text is in blue with strikeout for removed text and underlines for added text. In Green are references to the line numbers, both original and revised manuscripts. If only Revised is listed that is an indication that this is added text.

Author reply to comments

~~Original text~~ and added text

Line numbers from Original and Revised manuscripts

Reviewer 1

1.1. The Discussion is a very well written interpretation of the results, but lacks any connectivity to other research. It is unbelievable that not a single reference is cited in the Discussion! I urge the authors to compare their results and interpretations with the work of others who have conducted similar analyses in coastal barrier island systems. The authors could also compare their findings with the findings from other sandy coastal systems, and from other types of coastal hazards.

Thank you for your comment. We have updated our discussion to include references to other works that our study can be compared with

2 Discussion

The results of this study show that the location, size, and number of breaches affect coastal flooding. There is a clear relationship between total breach area and flooding in the bay and on the mainland coastline. The histograms in Fig. 5 illustrate various bay locations. The west surge point near the Forge River mouth shows that, with the original breach locations, the surge distribution is clustered and overlaps across scenarios. However, when breach locations vary, the maximum surge is much higher from nearby breaches. This location initially experiences surge from the eastern side of the bay, and after landfall, surge is pushed again from the western connection to Great South Bay and the nearby breaches. Figures 8and ulineFigs. 8, 9 further illustrate that the maximum surge in the bay and along the mainland alters due to breach location. We further discuss the surge patterns of Fig. 8 and Fig. 9 below.

The central location is adjacent to the mainland coastline near Seatuck Cove. Varying breach locations and numbers increases surge, but to a smaller degree than in the west. The maximum surge here is lower than in the west likely due to its proximity to the inlet. The peak surge from western breaches reaches the inlet before Seatuck Cove, allowing water to exit the bay and reducing the surge. Additionally, the coastline's shape helps protect this location from surge coming from the southwest. However, *East of Inlet* breaching is the second largest contributor of surge at this location. Surge from eastern breaches is directed westward by hurricane wind circulation impacting the central location. soutFigure Fig. 10a displays surge patterns from eastern island breaching.

The east location, which is closest to the barrier island, has the smallest maximum surge in the bay. Breaches formed eastward of the original locations do bring more surge to this location. However, its proximity to the inlet means that bay surge traveling east after peak ocean surge flows out of the inlet, reducing the total surge. Additionally, wind pushes the eastern surge towards the southwest, further reducing the total surge.

~~Figure~~ Fig. 4 shows how surge timing and maximum surge vary across scenarios for each bay section. Many *Location* simulations have breaches in the southwest portion of the barrier island. The peak ocean surge spreads from the southwest to northeast before landfall causing these breaches to open earlier than in other scenarios. This is evident in west gauges (a and b), where the surge arrives earlier and is larger than simulations with breaches closer to the inlet. The central gauges illustrate that while the *Location* surge remains larger, its timing is more aligned with other scenarios. The eastern gauges maximum surge is not much higher than the other categories, but the surge still arrives earlier due to water entering the bay from the southwest breaches.

Additionally, Fig. 4 shows a change in surge direction in the no-breach scenario. Around landfall, the surge direction is from northeast to southwest, and reversed shortly after where water is pushed from the connection to Great South Bay. This created a local setdown for gauges not protected by the mainland's contours. This setdown is observed on Gauges a, e, and d ~~show this setdown, seen in gauge a,~~ at approximately one hour after landfall ~~and in in gauges e and d~~ on gauge a, and 30 minutes later on gauges e and d . The *Width and Depth* simulations also exhibit this setdown, having the least impact on bay surge. Two to three hours post-landfall, the breaches allow water to flow back into the ocean, leading to a more rapid reduction in bay flooding than in the no-breach scenario. We see this especially in the *Location*, *East of Inlet*, and *West of Inlet* simulations where the water recorded at the gauges are reduced below the no-breach scenario.

In Fig. 7a we show that the total breach dimensions are related to the total area of inundation, with larger and more numerous breaches bringing more water inland. Total breach area across all breaches is the strongest predictor of coastal inundation, until the island is significantly eroded, after which inundation growth slows considerably. Figure Fig. 7b adds nuance to this relationship. While there is a stronger correlation between breach width and inundation than depth and inundation, the maximum breach depth of two meters is at least a factor of 20 smaller than total width for these scenarios, reducing the impact of depth on the hydrodynamics of each breach. Experiments on breach growth in dikes also illustrated this order of magnitude difference between breach width and depth (Visser, 1999, 2001). The cluster of breaches above the main group are the *Depth* scenarios, whereas the *Width* scenarios exhibit a more linear relationship with total inundation area. The secondary and tertiary curves in Fig. 7a show that inundation is capped if half of the barrier island still exists. These simulations were isolated to only the west and east sides of the inlet. Both scenarios have a smaller total impact on inundation; however, the *West of Inlet* scenarios contribute to a larger total inundation than the *East of Inlet* breaches. This is because breaching starts earlier in the west due to the storm's approach direction, and water moving southwest out of the inlet relieves some of the inundation that accumulates on the east.

Figure Fig. 8 illustrates that different inundation and bay surge patterns correlate with the number and size of breaches. Panel a) depicts a no-breach scenario, which is similar in surge and inundation distribution to the minimum inundation (panel b) featuring a single small breach. The difference between these simulations is approximately 500 wet vs. dry cells, which is 163,200 m^2 (0.1632 km^2 km^2) of inundation. Panel d) represents a simulation with eleven medium sized breaches, totalling totaling 0.0029 km^2 in breach area and 14.54 km^2 in inundation change, closely approximating the mean inundation change from all 1900 simulations. The simulation closest to the median of the scenarios (not shown) has six medium sized breaches and 9.36 km^2 of inundation. The surge contours in the bay and the total horizontal coastal inundation are very different from the no-breach or minimum inundation scenarios, with higher flooding potential in the coves, creeks and rivers that border the bay and along the lower elevation coastlines. The maximum inundation scenario (panel c) where most of the island has been breached, shows a bay surge of approximately two meters resulting in complete flooding of the lowest elevation areas of the coastline.

The impact of differing breach locations on inundation as illustrated in Fig. 8c, can be further seen in Fig. 9, which compares two simulations with a similar total breach area, but different total inundation. Figure Fig. 9a, shows a scenario with six moderately sized breaches in the locations from the 1938 hurricane, with a total breach area of 0.0039 km^2, and total inundation of 10.44 km^2. In contrast, Figure Fig. 9b, has a smaller total breach area of 0.0036 km^2 but a larger inundation at 12.03 km^2. In this scenario the breaches are generally smaller but more spread out across the barrier island, with closer to Great South Bay in the western portion.

While the bay surge patterns are similar, the surge contours differ, and the breaches between Great South Bay and Moriches Bay allow more water to flow in from the southwest prior to peak ocean surge. This results in more coastal inundation along the western coastline (see inset of Fig._ 9a and b). The Forge River surge is higher in Fig. 9b and the inlet region has a lower total water depth. The eastern portion of the bay has less inundation in Fig. 9b, likely due to most breaches being in the west, the inlet allowing water to flow out, and the lower elevation of the western half of the bay's coastline.

Breaching isolated to one side of the inlet creates notable changes in bay surge and total inundation, as shown in Fig. 10. As Fig. 7 indicates, the *West of Inlet* scenarios result in higher total coastal inundation which is evident in Fig. 10b where the western mainland coastline is significantly inundated compared to other scenarios. In contrast, the *East of Inlet* simulations can push the surge further down the bay. As the storm continues past landfall the surge is pushed southwest and not all of it floods out through the inlet.

~~Figures 8,~~ Figs. 8, 9, and 10 highlight the key findings from our simulations. Total breach area is a strong predictor of total inundation; however, breach location is also crucial, especially given the storm's forcing dynamics and surge direction. Similarly, a study by Gharagozlou et al. on breaching's impact on lagoon circulation during Hurricane Isabel illustrates how breaches alter flow patterns and introduce larger volumes of ocean water into the lagoon. These findings can be compared to our results, which demonstrate that breach location significantly influences storm surge behavior and its subsequent effects on coastal flooding Gharagozlou et al. (2021). While this study does not include tides and waves, they significantly influence bay surge dynamics and contribute strongly to breach initiation and growth as described in Smallegan and Irish (2017); Sherwood et al. (2014); Safak et al. (2016). The stochastic nature to these processes makes them difficult to model, and much of our understanding relies on empirical observations from geological studies or post-storm surveys of barrier island systems Kraus et al. (2002); Buynevich and Donnelly (2006) . Incorporating tidal or wave components into our simulations could result in different patterns of breaching and inundation. Our use of offshore water levels to model breaching assumes wave action contributes to breach initiation, based on prior studies and observations.

Original: 255 - 330
Revised: 263 - 346

1.2. line 12 we've

The insights ~~we've~~ we have gleaned from this study can help prepare shoreline communities for the differing ways that breaching affects the mainland coastline.

Original: 11 - 13
Revised: 11 - 13

1.3. 50 space between), these

Thank you for pointing this out, we have added a space

1.4. 51 formatting incorrect, check latex

Thank you for showing me this error I have changed it to an in text citation

Lab and field experiments by ~~(Visser, 1999)~~ Visser (1999) for breaches in dikes are useful but the breach is initiated with a pre-drilled hole in the dike and does not simulate exactly what occurs to barrier islands during storms.

Original: 51
Revised: 52

1.5. 80 what is the difference between Moriches and Moriches bay?, could these be labeled in fig 1?

Moriches is a small region in Suffolk county New York, Moriches Bay is the bay in the same region that separates the mainland coastline from the barrier island that parallels the coastline.

We updated the map to include new annotations for other regions, Moriches, NY (the small town) is under the inset

1.6. 81 please provide detail on the damage

We have added details on the damage from the 1938 hurricane

The 1938 Hurricane made landfall as a category 3 hurricane near Moriches, NY on September 21, 1938. The maximum sustained wind speed recorded during this hurricane was 178 km/hr at Blue Hill Observatory, MA (Brooks, 1939). The center of the storm passed over the western side of Great South Bay, less than 75 km from Moriches Bay. Figure 1 illustrates the location of Moriches Bay, NY and the storm's location as it made landfall. It generated 10 breaches across the barrier island system and caused widespread damage (Morang, 1999; Coch, 1994; Cañizares and Irish, 2008). The damage caused by this hurricane included 564 deaths, widespread flooding from both storm surge and high rainfall amounts, thousands of structures were damaged or destroyed and widespread power outages across southern New England (Vallee and Dion, 1997) Six breaches were opened during the hurricane at Moriches, NY specifically, three each on either side of the inlet (Howard, 1939). Aerial photographic evidence illustrates that widespread breaching of the island occurred during the storm (Howard, 1939) and described the breaches as widening of the original inlet which was opened in 1931. These breaches were closed after the storm but the timeline and method for closure is unclear in the literature (Cañizares and Irish, 2008; Howard, 1939)

Original: 88 - 92
Revised: 90 - 100

1.7. Figure 1 Is this a lidar image? What is the vertical scale? The storm track on the inset can be more pronounced, please label the features, Moriches bay, various islands in the main image, what is the weird cross hatching in the barrier island between b and c

This is an image created from a topobathy dataset that was partially created with lidar yes. The cross hatching is a part of a manmade series of channels to control mosquito populations, (). Please see the updated figures below for figure edits

1.8. 91-92 what is the evidence for this? How quickly did they close after the hurricane? Please explain the significance these breaches were for flooding. Please show the breaches location on figure 1

Please see updated figure 1, We included the original breach locations as stars on the figure. We've added a citation to discuss the breaches that formed, See comment 1.6 above for the revised sentences and citations

1.9. 100 in what case? Recommend deleting

thank you for pointing out this interesting phrasing, I have corrected the sentence

GeoClaw has been validated by the US National Tsunami Hazard Mitigation Program (NTHMP) for tsunami modeling. González et al. (2011) describes the benchmarking process used to validate GeoClaw ~~in that case~~.

Original: 99 - 100
Revised: 106 - 108

1.10. 102 spell out adcirc then use acronyms

thank you for pointing this out, it is fixed

Storm surge modeling with GeoClaw has been proposed to provide a robust but less computationally expensive model than ~~ADCIRC~~ the ADvanced CIRCulation model (ADCIRC), a commonly utilized finite element model (Westerink et al., 2008; Mandli and Dawson, 2014; Bates et al., 2021).

Original: 101-103
Revised: 109 -111

1.11. figure 5 hanging sentence, west - ?

This was a typo, it has been fixed

Reviewer 2

2.1. unify fonts and scales, size of text in figs 8,9,10 also seems odd the lat/lons are in larger font than scale and features annotate to highlight key features

Thank you for pointing on the inconsistencies in the figures. They have been updated to share a common scale and font and additional features added to Figure 1

See below for all updated figures

2.2. 30-33 awkward sentence

Thank you for pointing out the awkward section, we have updated the wording.

Storm surge that ~~causes~~ creates a water level gradient between the ocean and back-barrier region forces water to flow rapidly over the barrier island ~~, eroding sediment~~ . This flow erodes sediment in an effort to equalize the water ~~level. This~~ levels. The water level gradient involves a critical elevation of water ~~levels that may not inundate the island, but can still cause erosion~~ that can cause significant erosion without inundating the island (Kraus et al., 2002; Kraus, 2003).

Original: 30 - 35
Revised: 30 - 35

2.3. 40, 44 reference format

Thank you for pointing out the reference issues. We have fixed these to be in text citations

2.4. 46 at and at in same sentence

Thank you for showing this grammar issue. We have fixed it per below

The sediment transport model generated two breaches at ~~locations at~~ peak erosion sites, but neither breach location matched the observed breach that opened during Hurricane Sandy (van der Lugt et al., 2019).

Original: 46 - 48
Revised: 47 - 49

2.5. 53 just geological mapping, no need for 'a'

Buynevich and Donnelly (2006) performed ~~a~~ geologic mapping of some New England, USA barrier islands and found geologic signatures to indicate the islands' past history with breaching and overwash.

Original: 53 - 54
Revised: 55 - 57

2.6. 83 change especially to a real word like particularly? C2.6

Thank you for suggesting this change. We have updated it.

Our study focuses on Moriches, NY a section of the barrier island that spans Long Island, New York, USA along the Atlantic Ocean. This region is heavily populated and is regularly impacted by storms~~. It was especially damaged by~~ , in particular, the 1938 hurricane caused extensive damage at Moriches, NY.

Original: 83
Revised: 81 - 84

2.7. 88 more details on max winds

We've added the maximum wind speeds and a citation

The 1938 Hurricane made landfall as a category 3 hurricane near Moriches, NY on September 21, 1938. The maximum sustained wind speed recorded during this hurricane was 178 km/hr at Blue Hill Observatory, MA (Brooks, 1939) . The center of the storm passed over the western side of Great South Bay, less than 75 km from Moriches Bay.

Original: 88 - 89
Revised: 90 - 92

2.8. 159 should be computation time

We have updated this typo

We restricted GeoClaw's adaptive refinement for Moriches Bay and its adjacent barrier island to an 18 x 18 meter grid, balancing resolution with ~~compute~~ computation time.

Original: 159 - 160
Revised: 166 - 168

2.9. 282 awkward sentence

This setdown is observed on Gauges a, e, and d ~~show this setdown, seen in gauge a,~~ at approximately one hour after landfall ~~and in in gauges e and d~~
ulineon gauge a, and 30 minutes later on gauges e and d.

Original: 282 - 283
Revised: 291 - 293

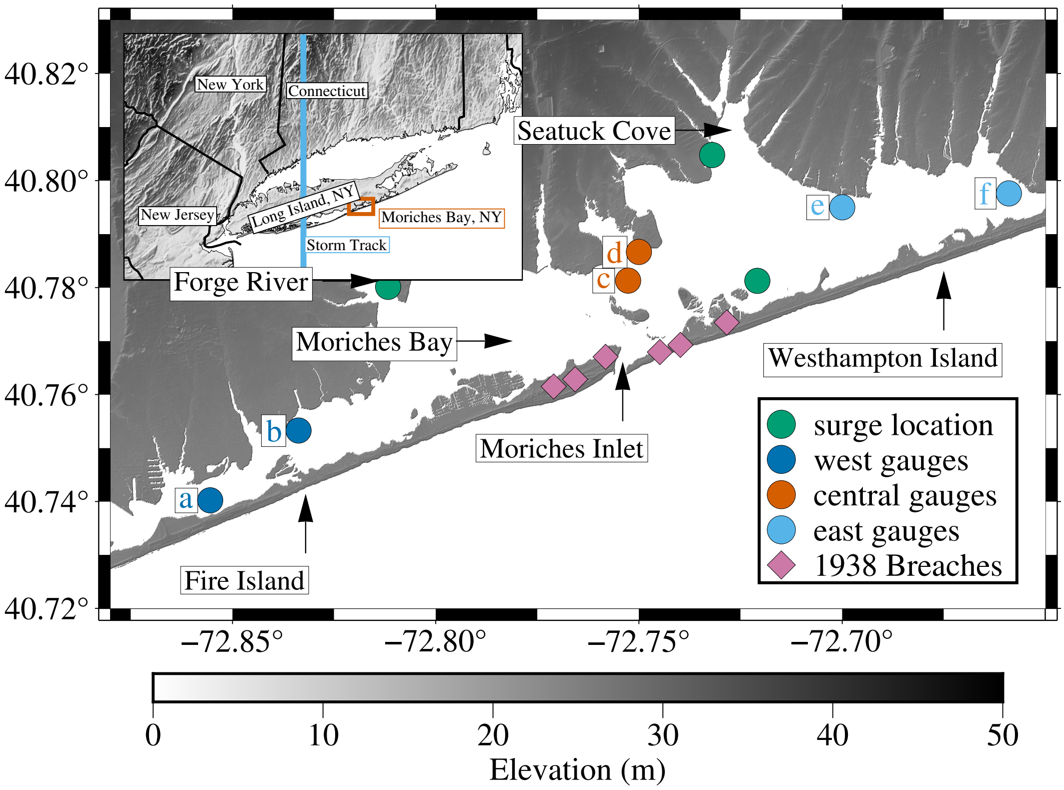

Figure 1: Map of study area Moriches Bay, NY. Inset shows region surrounding Moriches Bay, NY (orange box). Storm track for the 1938 Hurricane (light blue line) and our simulated storm. Green circles are locations of surge measurements from Table 2. Remaining circles are locations of synthetic water level gauges illustrated in Fig. 4. Original breach locations marked by stars

3 Figures

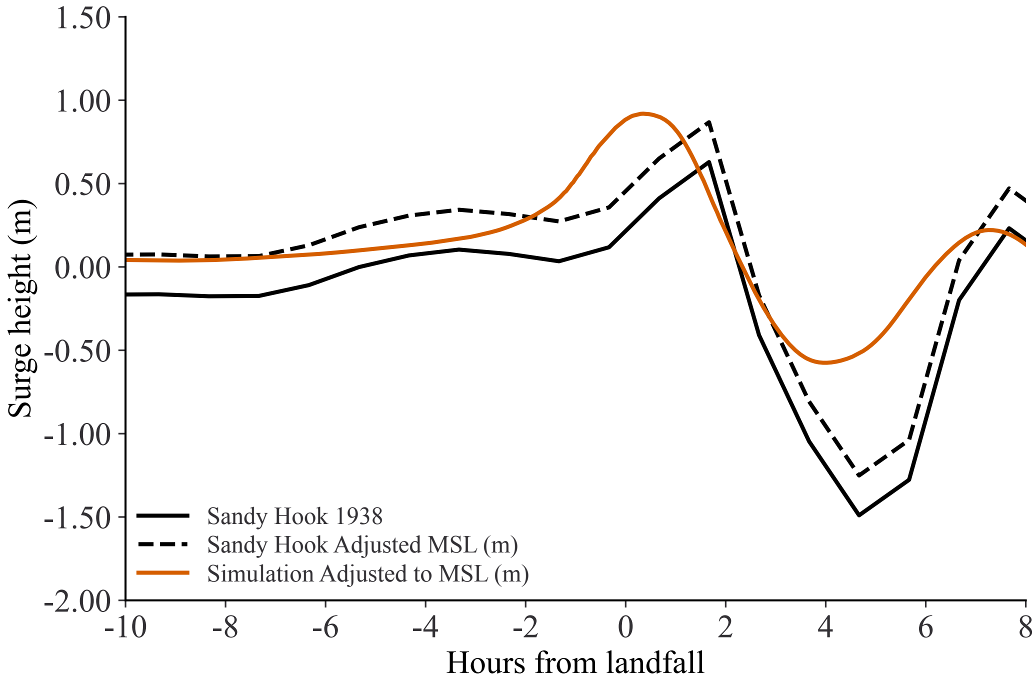

Figure 2: NOAA water level gauge data from the 1938 hurricane compared with simulated water level gauge data at Sandy Hook, NJ. Black line is original data before adjusting for modern mean sea levels. Dotted black lines are the data adjusted 0.239 to match the datum used by NOAA. Orange line is the simulation output adjusted -0.073 for the difference between NAVD88 and local MSL.

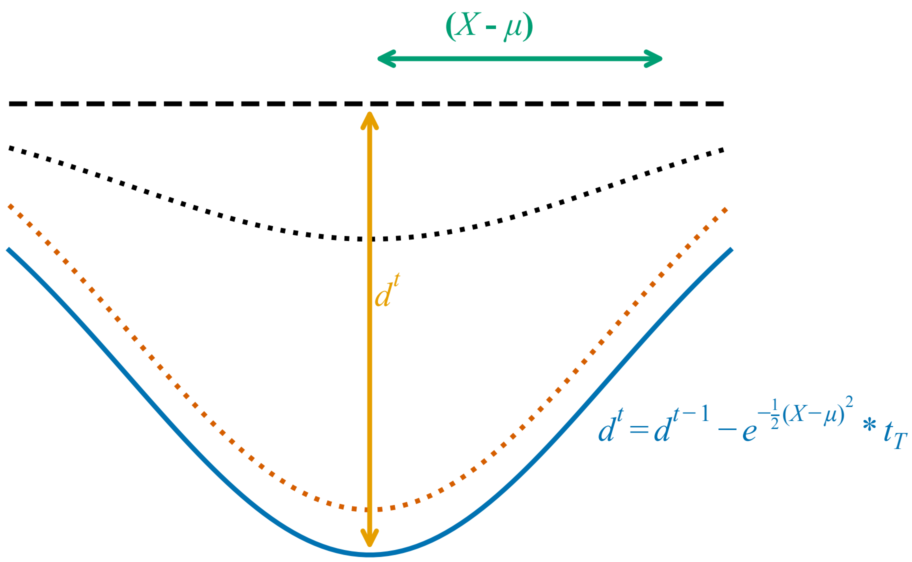

Figure 3: Schematic of breach growth based on equation 1 $(X - \mu)$ is width of breach for each location lowered. d^t is total depth of center of breach. Black dashed line indicates original barrier height. Black dotted line indicates breach growth at an intermediate time t. Orange dotted line is breach growth at nearly final time t. Blue line is final breach.

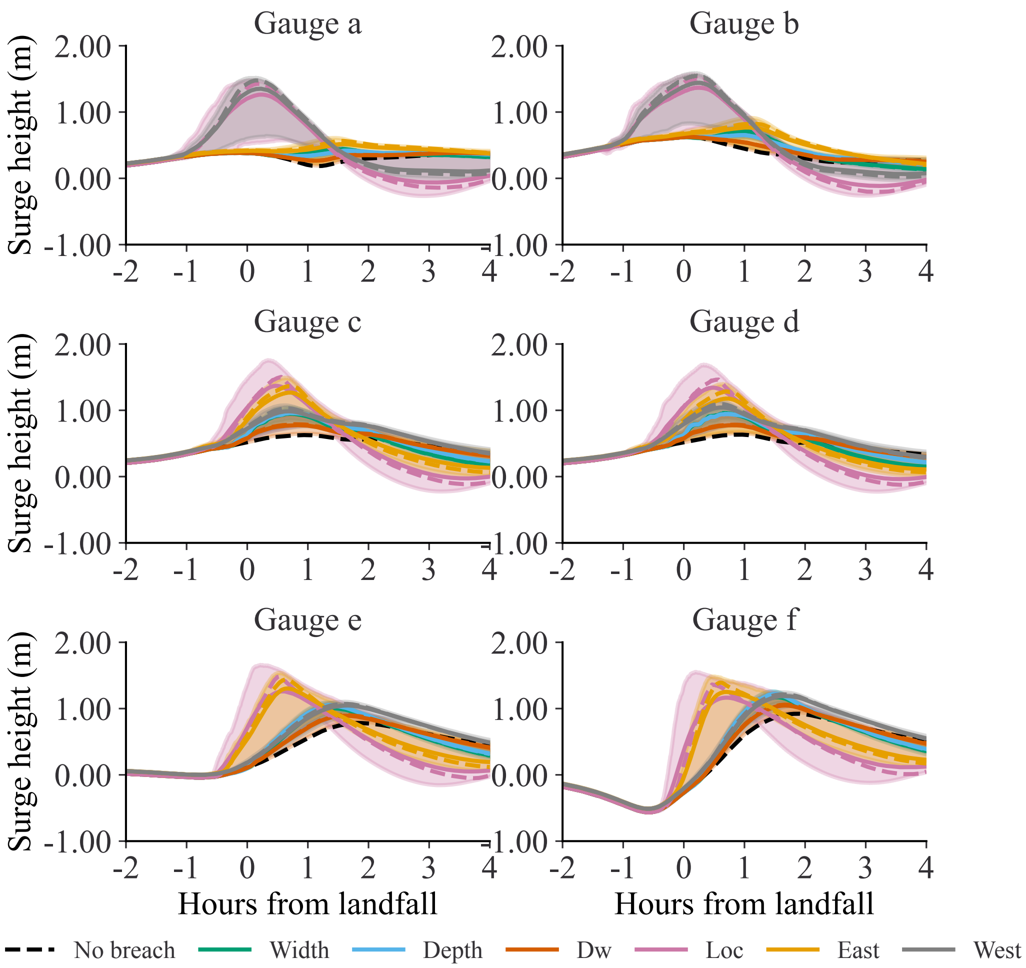

Figure 4: Synthetic water level gauges for each section of the bay. See Fig. 1 for locations. Each dark line is the mean of all of the simulations in that category, the dotted lines in each color represent the median of that category. Each shaded area covers the 5 - 95 percentile of the category

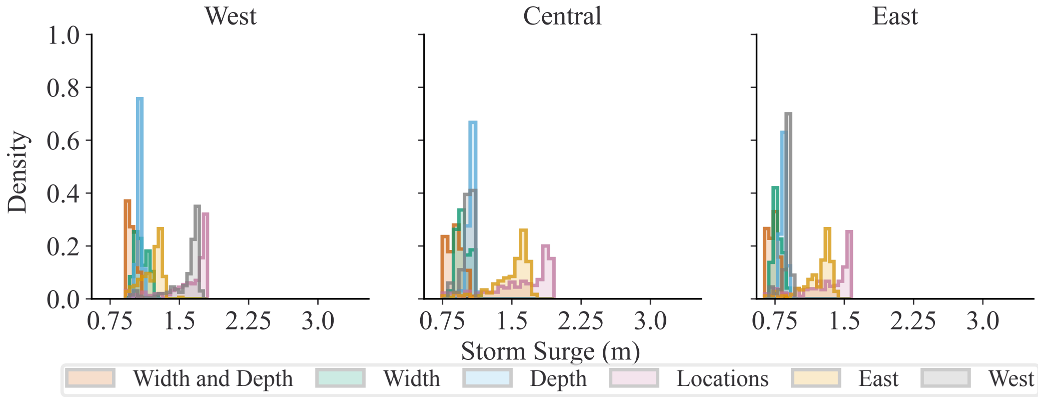

Figure 5: Maximum surge height in meters for each selected location shown in Figure 1 (green dots). Data shows 1900 scenarios split into six categories. Six breaches where width is randomized (blue) (464 scenarios), six breaches where depth is randomized (green) (424 scenarios). Varying width, depth, and number of breaches up to six breaches (orange) (297 scenarios). Varying width, depth, location, and number of breaches up to 295 breaches (315). Varying width, depth, number of breaches up to 100 but limiting breach location to the east of the inlet (yellow) (200) and west of the inlet (grey)

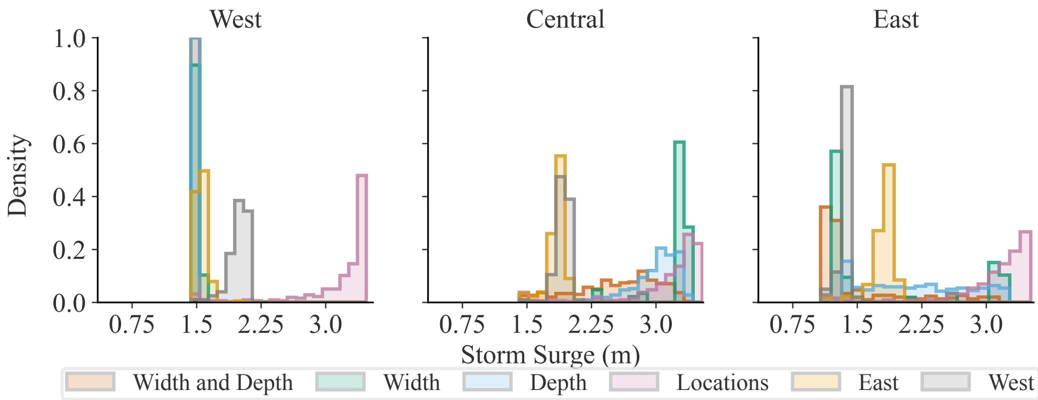

Figure 6: Maximum surge height (m) for each category of breach simulations across each entire section of the bay

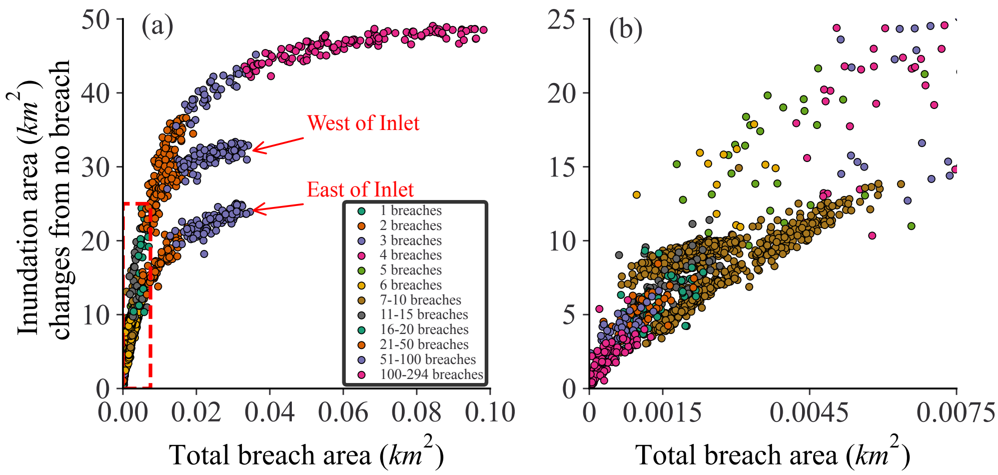

Figure 7: a) Total inundation vs. total breach size for all 1900 scenarios, points are colored per number of breaches. b) zoom in of a) panel to show differentiation of breach area and number of breaches and how the inundation can vary

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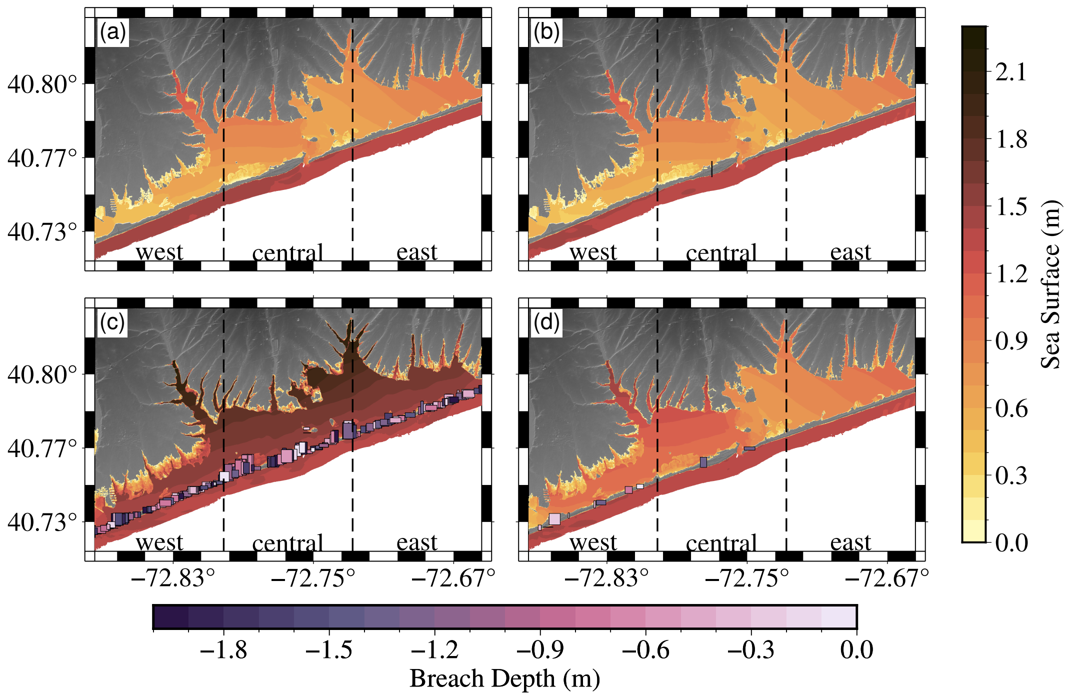

Figure 8: Maps Moriches Bay, NY. Each panel is a separate simulation representing different values of storm surge inundation. Panel (a) is our no-breach scenario. Panel (b) is the minimum inundation of 0.162 km^2 with a single small breach. Panel (c) is the largest inundation scenario of 49.06 km^2 with 259 breaches. Panel (d) is a simulation that has the closest inundation to the mean of all 1900 simulations 14.54 km^2, with eleven breaches.

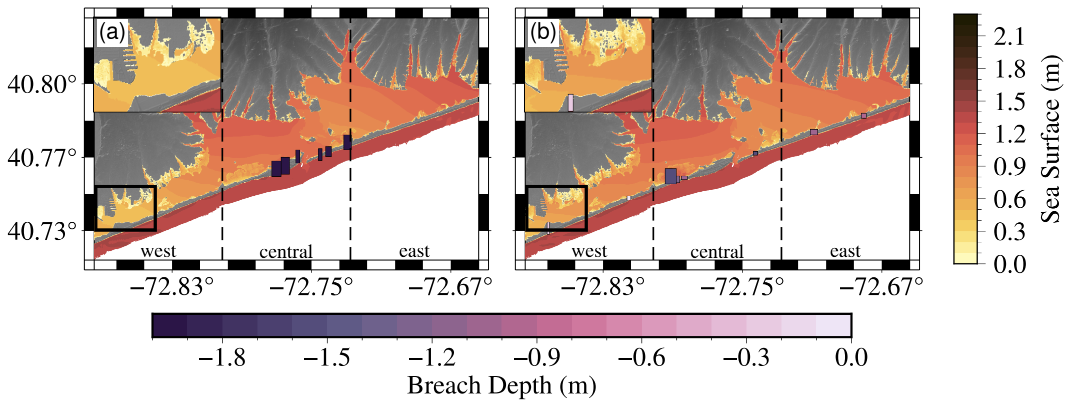

Figure 9: a) Maximum surge and inundation for simulations with 6 breaches and total breach area 0.0039 km^2. b) Maximum surge and inundation for simulation that has 11 breaches and a total breach area of 0.0036 km^2.

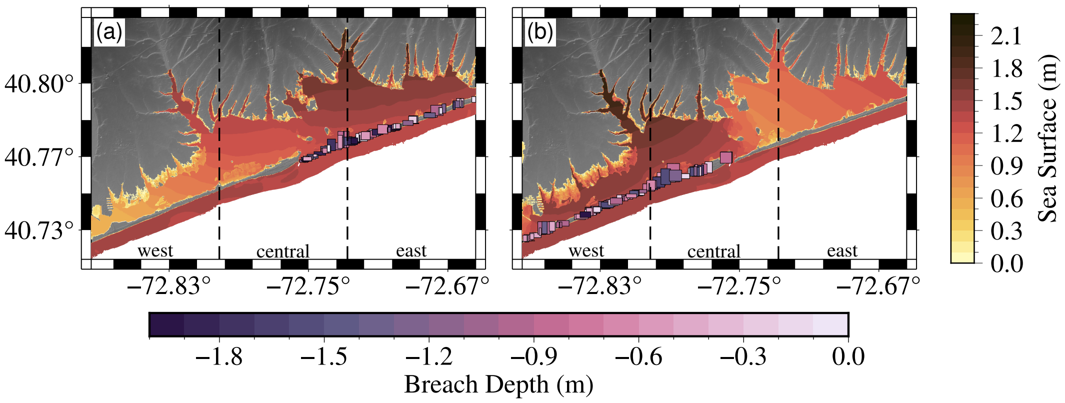

Figure 10: a) Maximum surge and inundation for *East of Inlet* simulations with a total inundation of 24.87 km^2. b) Maximum surge and inundation for *West of Inlet* simulation that has a total breach area of 26.85 km^2.

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