

Abstract

Hurricane Ivan, which varied in intensity from category 5 in the Caribbean to category 4 in the Gulf of Mexico before making landfall at the Alabama/Florida border as a category 3 storm, caused extensive storm surge damage to Pensacola Florida and vicinity. Addressed herein is the question: what may have happened in the Tampa Bay vicinity had Ivan made landfall there? We applied the FVCOM driven by HRD H*Winds and atmospheric pressure to simulate such an Ivan-like storm surge. Several scenarios of different landfall locations within the Tampa Bay region (Indian Rocks Beach, Tarpon Springs, Bayport, Cedar Keys, and Sarasota) are considered, and these scenarios demonstrate that such an event would be catastrophic. The largest surge (exceeding 6 m) is found for a landfall at Tarpon Springs, a position sufficiently north of the bay mouth such that the maximum winds are at the bay entrance. Due to the large eye radius, even if Ivan had made landfall at Cedar Keys, about 200 km north of the bay mouth, the storm surge in the bay would have exceeded 3 m. These results, using a three dimensional, high resolution model, demonstrate the vulnerability of the Tampa Bay region to coastal inundation by hurricane storm surge.

Motivations for Tampa Bay Storm Surge Simulation

- The Southeast U.S. and the Gulf of Mexico are regularly impacted by hurricanes.
- Whereas Tampa Bay has not had a major hurricane hit since 1921, it seems inevitable that one will occur again.
- In the meanwhile population has grown and coastal development has burgeoned.
- Since the region is low-lying the potential for property damage and loss of life is severe.

Hurricane Storm Surge Simulation Requirements

- A high resolution, physics-based circulation model with flooding and drying capabilities.
- A high resolution water depth (bathymetry) and land elevation data set on which to overlay the model.
- Accurate enough wind and pressure fields to drive the model.

Model: FVCOM (Chen et al. 2003)

- An unstructured, triangular grid for representing complex coastal geometry.
- Three-dimensional, primitive equations, with flow dependent turbulence closure.
- Finite-differences for mass, momentum, heat, and salt conservation, plus computational efficiency.
- Provision for flooding and drying land.

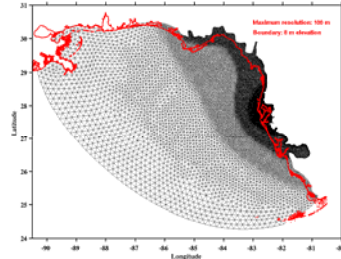


Figure 2. Model grid for the Tampa Bay storm surge experiments. Resolution varies from 100 m in Tampa Bay to 20 km along the open boundary. The coastline is in red.

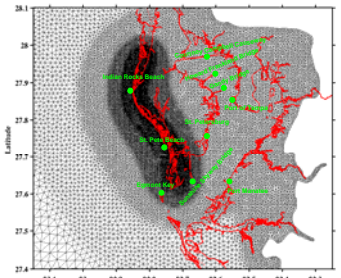


Figure 3. Zoom view of the model grid in the Tampa Bay region. The coastline is in red, and the inland boundary is the 8 m elevation contour. Time series sample locations are in green.

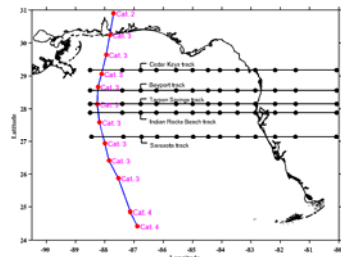


Figure 4. Hurricane Ivan track (blue) and its Saffir-Simpson intensities. Upon rotation of the Ivan track line and the winds relative to the Ivan track line, the black lines are the tracks used for the experiments presented here.

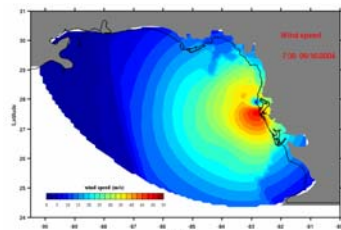


Figure 5. Wind speed distribution at IRB landfall by combining the Ivan HRD H*Wind with peripheral winds from the Holland (1980) prototypical analysis.

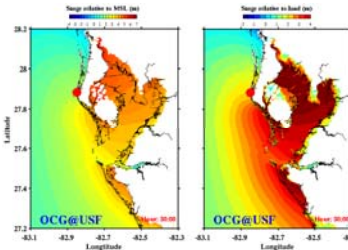


Figure 6. Surge elevation relative to either mean sea level (left) or the land elevation (right) at the time of IRB landfall.

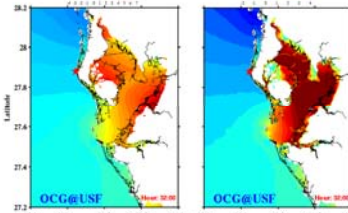


Figure 7. Surge elevation relative to either mean sea level (left) or the land elevation (right) 2 hours after IRB landfall.

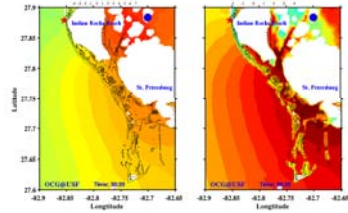


Figure 8. Highest surge elevation relative to either mean sea level (left) or the land elevation (right) for St. Pete Beach as occurred 20 minutes after IRB landfall.

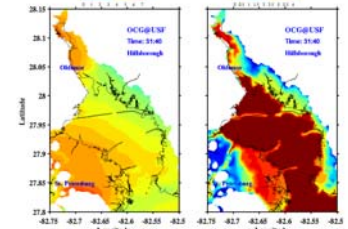


Figure 9. Highest surge elevation relative to either mean sea level (left) or the land elevation (right) for Old Tampa Bay as occurred 1 hour and 40 minutes after IRB landfall.

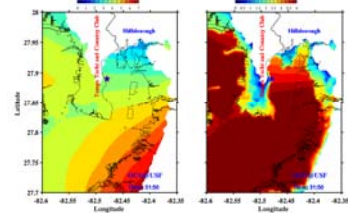


Figure 10. Highest surge elevation relative to either mean sea level (left) or the land elevation (right) for Hillsborough Bay as occurred 1 hour and 50 minutes after IRB landfall.

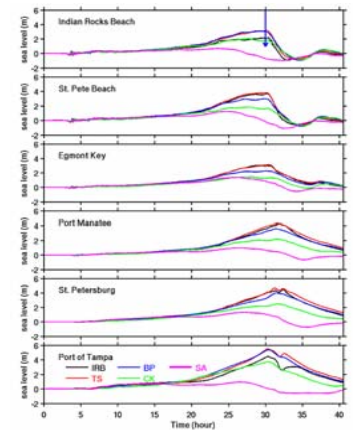


Figure 11. Time series of model-simulated surge elevation sampled at 6 coastal sites (shown at Figure 3) for different tracks.

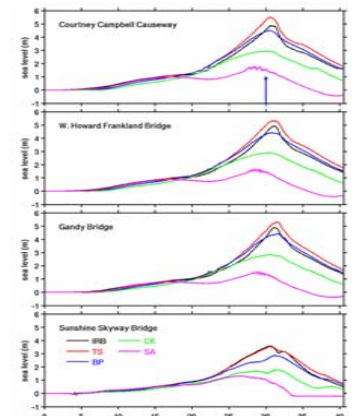


Figure 12. Time series of model-simulated surge elevation sampled at 4 bridges locations (shown at Figure 3) for different tracks.

Conclusions

- Storm surge is sensitive to point of landfall, direction and speed of approach, intensity (category), and size (radius to maximum winds), all being of similar importance (Weisberg and Zheng, 2006a&b).
- We explored the storm surge for an Ivan-like storm making landfall near the Tampa Bay region, the results of which would have been catastrophic. Added to the storm surge would also be highly destructive waves.
- With high resolution necessary to include inlets and barrier islands the FVCOM is demonstrated to be a very effective tool for coastal inundation by hurricane storm surge studies.

References

Chen, C.S., H.D. Liu, and R.C. Beardsley, 2003. An unstructured, finite-volume, three-dimensional, primitive equation ocean model: Application to coastal ocean and estuaries. *Journal of Atmospheric and Oceanic Technology*, 20: 159-185.

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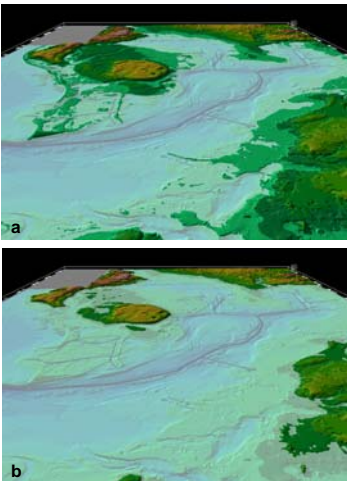


Figure 1. Subaerial configurations for the Tampa Bay region under uniform rises of sea level by 1.5 m (a) and 6 m (b) above mean water (Hess, 2001).