Hurricane Storm Surge Simulations for Florida's Tampa Bay Region

by
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Abstract

A high resolution, coastal ocean model with flooding and drying capabilities is used along with a merged bathymetric/topographic data set to simulate storm surges for the Tampa Bay region. Results are given for prototypical, category 2 and 4 hurricanes that approach the shore from the west making landfall at Indian Rocks Beach. We show maps of flooding and time series of elevations at specific points, including the causeways for the four bridges that span the bay. The effects of wind-waves are not included, and these can add significantly to the storm surges shown.

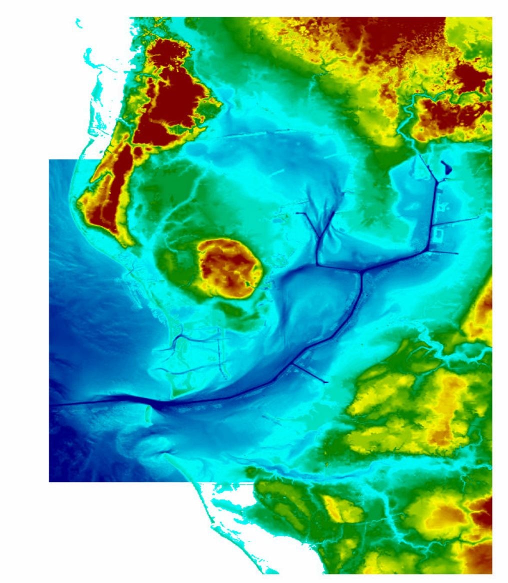

Fig. 1: Merged bathymetry and topography for the Tampa Bay region. This, plus the following Figs. 2 & 3, are from the NOAA/USGS Bathy./Topo. Demonstration Project.

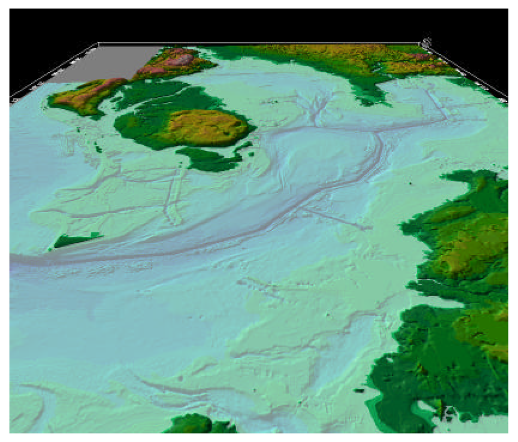

Fig. 2: Submerged areas assuming a 10 ft (3.048 m) deep flood uniformly distributed over the Tampa Bay region.

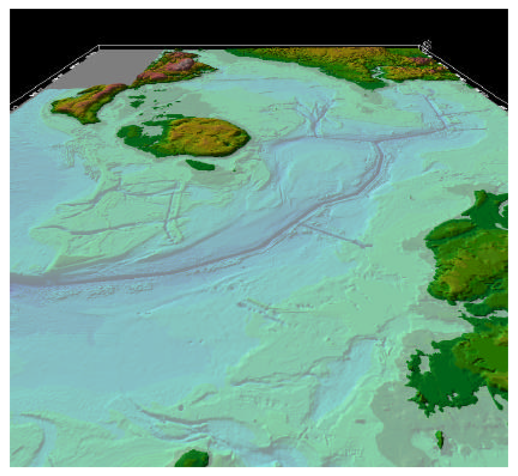

Fig. 3: Submerged areas assuming a 20 ft (6.096 m) deep flood uniformly distributed over the Tampa Bay region.

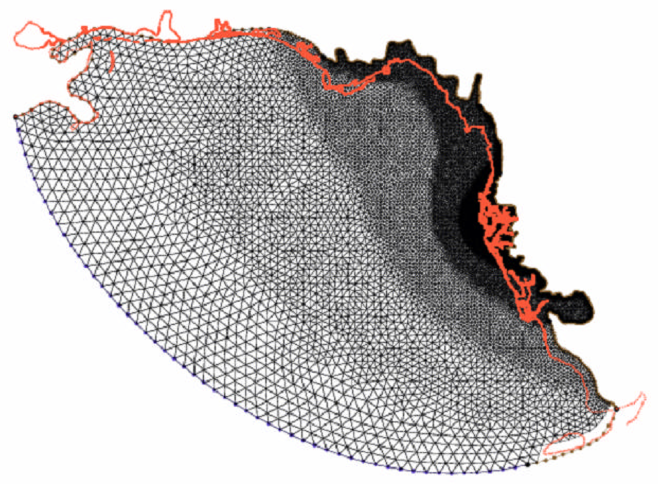

Fig. 4: The model grid used for the Tampa Bay hurricane surge experiment. The minimum grid size is 100 m. The red line denotes the coast line, and the inland boundary is the 8 m elevation line.

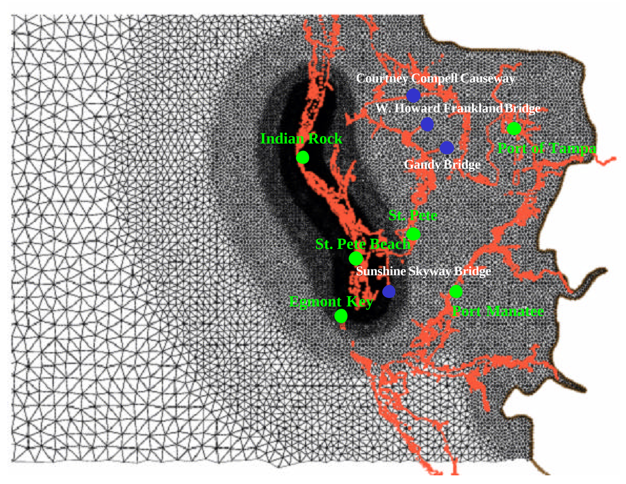

Fig. 5: A zoom view of model grid within the Tampa Bay region with maximum resolution for the Pinellas Co. beaches.

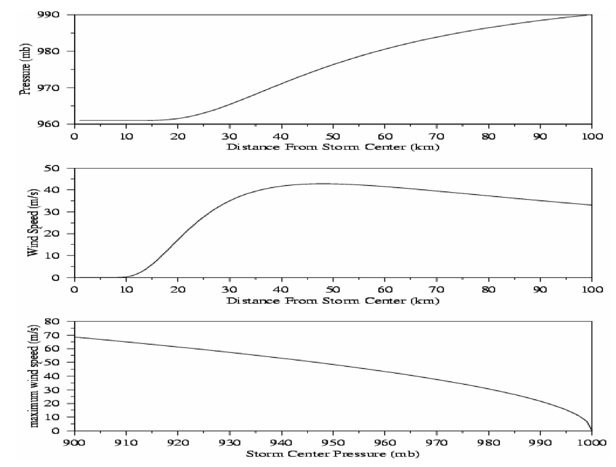

Fig. 6: Radial distributions of pressure (upper) and wind speed (middle) for the cat. 2 (with P_c=961 mb) simulation, plus wind speed as a function of storm center pressure (lower) for other hurricanes (after Holland, 1980). For cat. 4 we used P_c=935 mb.

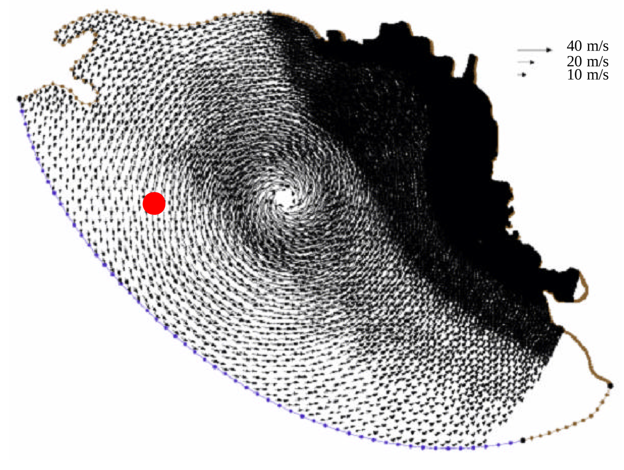

Fig. 7: Prototypical cat. 2 hurricane wind field at 12 hrs relative to the initial position (red dot). The eastward translation speed is 5 m/s. These experiments, using improved model and bathy./topo. data, are fashioned after Yang and Weisberg (2000).

Category 2

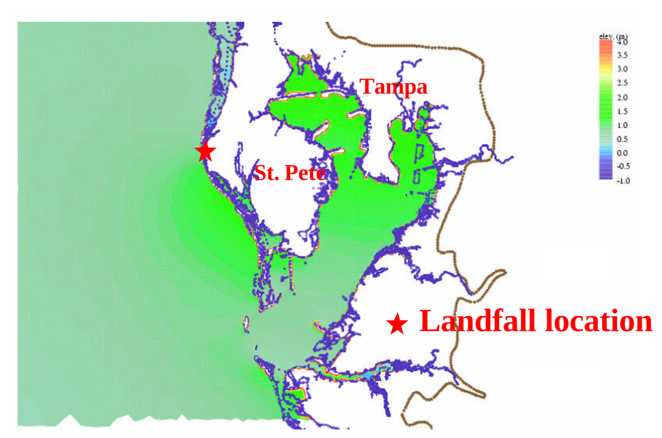

Fig. 8: Sea-surface elevation distribution at hour 24 of the simulation. Blue denotes the shoreline, and the red asterisk denotes the eventual point of landfall. The color bar to the right gives the storm surge elevation above mean sea level.

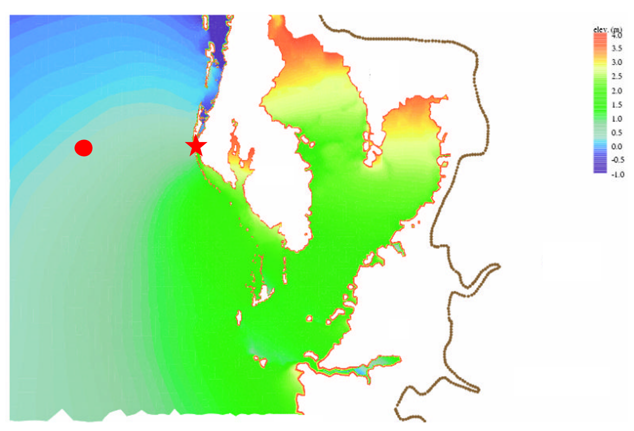

Fig. 9: Same as Fig. 8 except at hour 28 where the storm center is denoted by the red dot. Note the submergence of land relative to Fig. 8. In contrast with this flooding, sea level is set down along the coast to the north of the storm center.

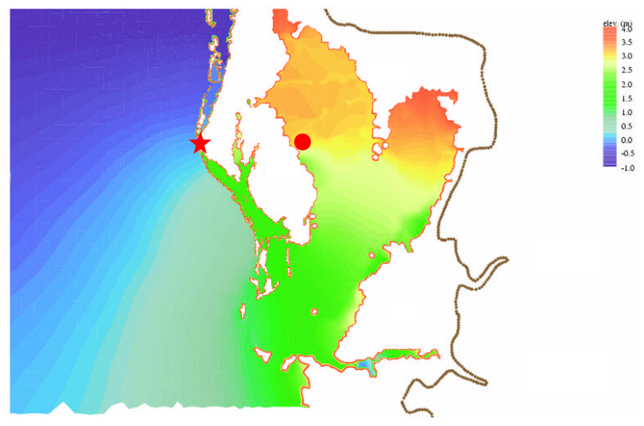

Fig. 10: Same as Fig. 8 except at hour 30 where the storm center is denoted by the red dot. The worst flooding occurs over the northern regions of the bay.

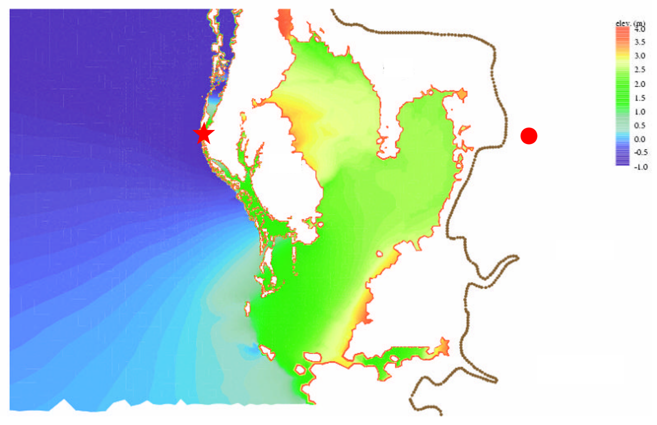

Fig. 11: Same as Fig. 8 except at hour 32 where the storm center is denoted by the red dot. Sea level at this time is generally subsiding except over the bay's eastern shore and by the Manatee River.

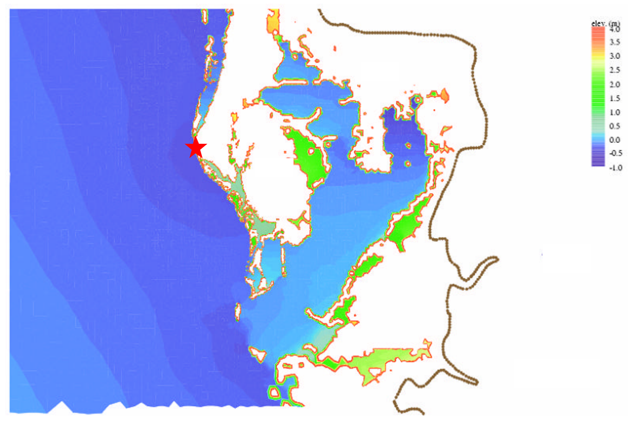

Fig. 12: Same as Fig. 8 except at hour 40 after the storm center has translated inland past the Tampa Bay region. The surge is now abated except for pockets of water remaining to drain off of the land.

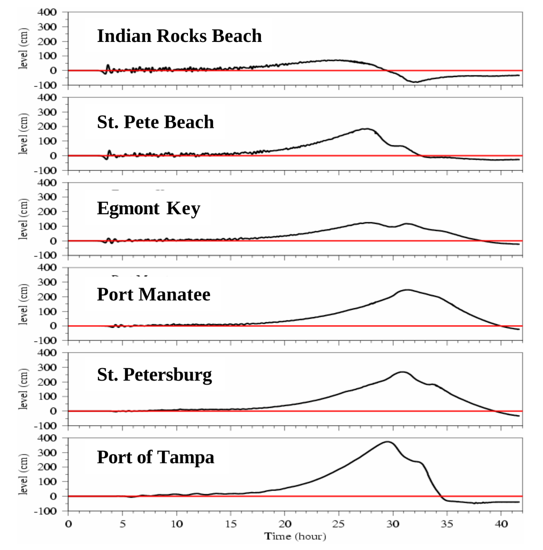

Fig. 13: Storm surge elevation time series at the selected coastal stations shown in Fig. 5 for the prototypical cat. 2 hurricane making landfall at Indian Rocks Be. with an eastward approach speed of 5 m/s.

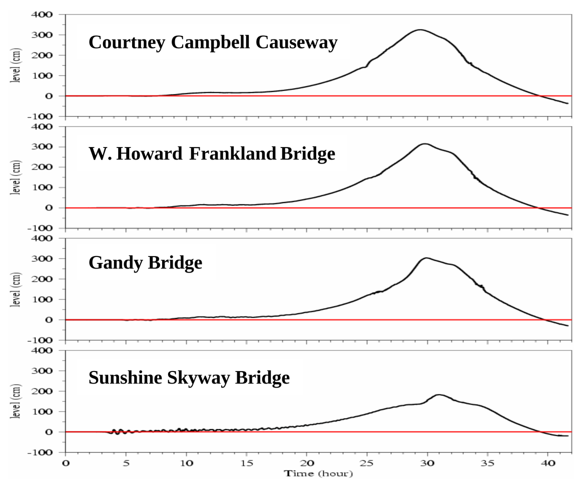

Fig. 14: Same as Fig. 13, but at the causeways leading to the four bridges across Tampa Bay shown in Fig. 5. Note that the flooding at the Courtney Campbell Causeway is in excess of 3 m.

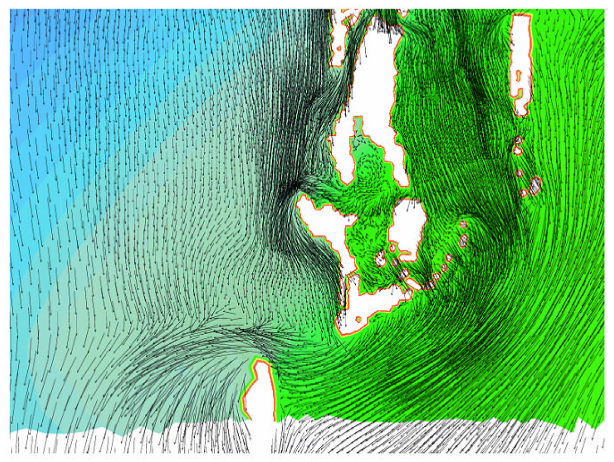

Fig. 15: A zoom view of the surface currents at hour 32 showing how the surge exits the bay in the vicinity of Ft. DeSoto Park.

Category 4

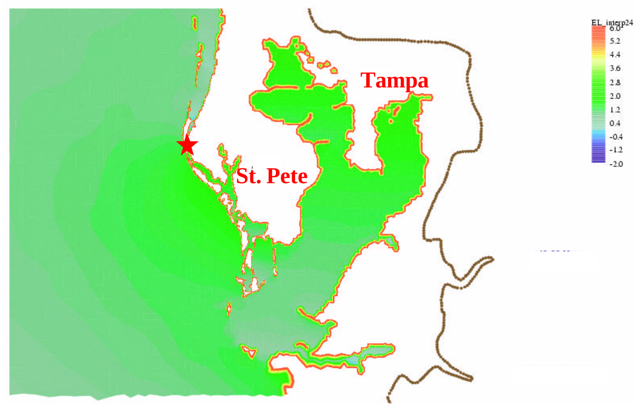

Fig. 16: Sea surface elevation distribution at hour 24 for the cat. 4 hurricane simulation. In contrast with Fig. 8 (the cat. 2 simulation), an appreciable surge already exists both in the bay and along the beaches.

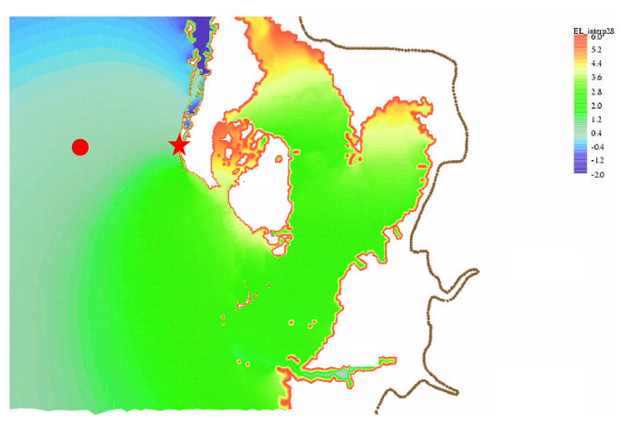

Fig. 17: Same as Fig. 16 except at hour 28 where the storm center is denoted by the red dot. Relative to the cat. 2 surge, note the flooding of the Pinellas beaches and the new island of St. Petersburg.

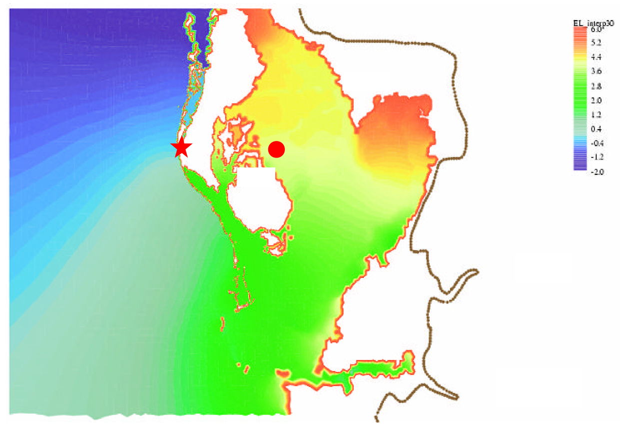

Fig. 18: Same as Fig. 16 except at hour 30 where the storm center is denoted by the red dot. The Pinellas beaches are beginning to re-emerge.

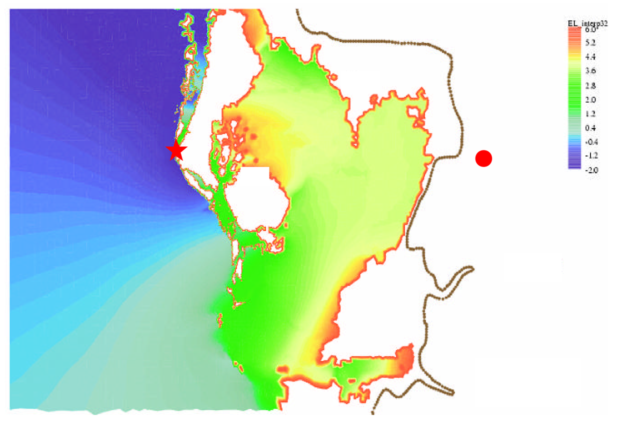

Fig. 19: Same as Fig. 16 except at hour 32 where the storm center denoted by the red dot.

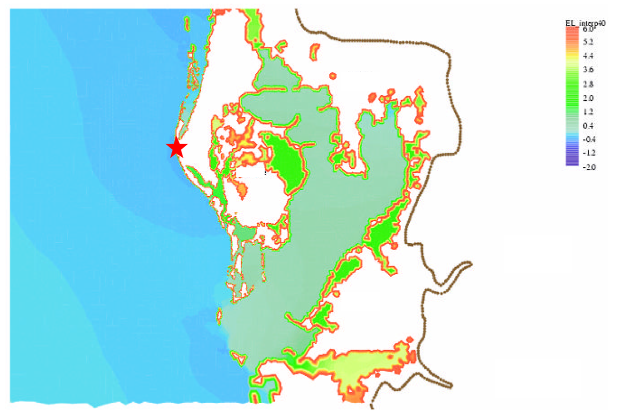

Fig. 20: Same as Fig. 16 except at hour 40 after the storm center has translated inland past the Tampa Bay region. The surge is now abated except for pockets of water remaining to drain off of the land.

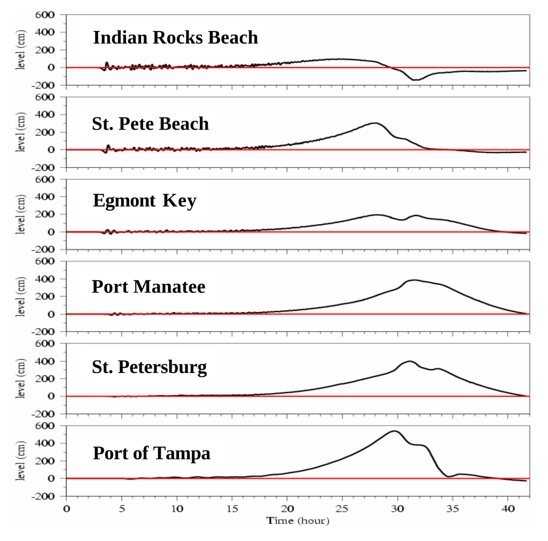

Fig. 21: Same as Fig. 13 except for a cat. 4 hurricane. Maximum flooding near the Port of Tampa exceeds 5 m.

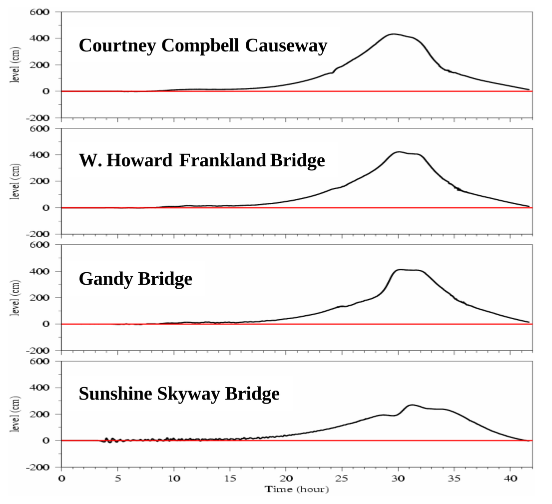

Fig. 22: Same as Fig. 14 except for a cat. 4 hurricane. Flooding near the Courtney Campbell Causeway exceeds 4 m.

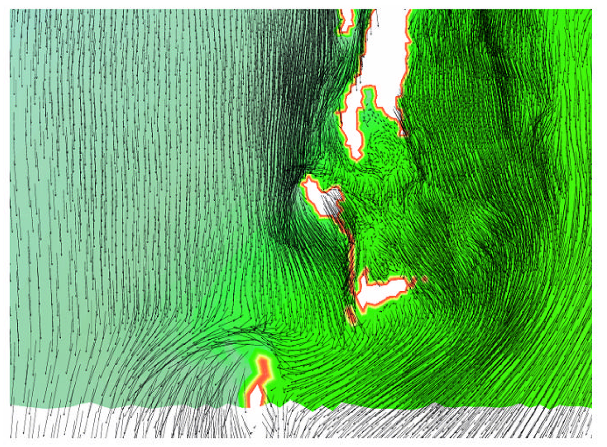

Fig. 23: Same as Fig. 15 except for a category 4 hurricane. Relative to the cat. 2 case, some over-wash now occurs.

Summary

We presented storm surge simulations for categories 2 and 4 hurricanes using a high resolution numerical model and a merged bathy./topo. data set. We showed approximate worst case scenarios for the Tampa Bay region since, with landfall in the vicinity of Indian Rocks Beach, the winds at the bay mouth are flood favorable. Substantial flooding is predicted even for the milder cat. 2 storm, especially over the northern reaches of Tampa Bay. Predicted flooding for a category 4 storm is more catastrophic, causing an inundation of the Pinellas Co. beaches and an isling of St. Petersburg. In either case, the causeways leading to all of the four bridges that cross the bay are impassable.

Adding to the direct wind driven surge as simulated, wind waves that accompany any storm will increase both the surge elevation and damage.

Thus, while the Tampa Bay region has not had a direct hit in the modern era, as simulated, the potential for damage is extreme and advisements by emergency management agencies should be treated very seriously.

Acknowledgments:

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