Impact of Sea Level Rise on Storm Surge and Inundation in the Northwestern Gulf of Mexico

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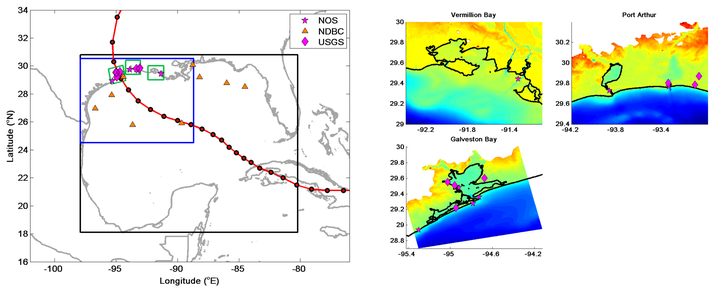
INTRODUCTION

Climate change increases vulnerability of the coastal environment due to changes in
- Intensity of storms
- Return periods of severe storms
- Frequency of occurrence of mild to moderate intensity storms
- Threat of inundation further inland
- Precipitation associated with storms

Effects on tropical cyclone impact important for
- Coastal adaptation
- Mitigation efforts

Objective:
Investigate what could happen if a Hurricane Ike makes landfall at Galveston, TX, combined with increased sea-level rise? Study effect of 0.5m, 1.0m, 2.0m rise in mean sea level (SLR).

MODEL SETUP



Hurricane Ike:
Landfall: 2008/09/13 0710 UTC, North end Galveston Island

Model setup
- Domains:
  - Gulf of Mexico (Black) – 178 x 128, @ 0.1° (~10 km) resolution
  - Northern Gulf of Mexico (Blue) – 462 x 302 @ 0.02° (~2 km) resolution
  - Local, right to left: Vermillion Bay, Port Arthur, Galveston Bay (Green) – ~300 x 250 @ 0.004°(~400 m) resolution

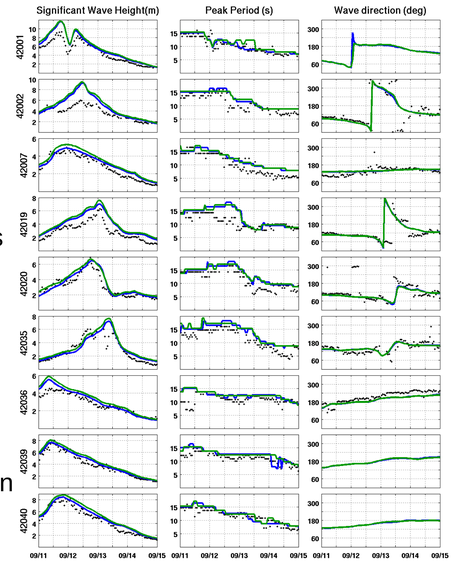
Model physics:
- Coupled Delft3D-FLOW (currents) & -WAVE
- Delft3D-WAVE: SWAN with updated physics – Rogers et al. (2012)
- Delft3D-FLOW: winds, waves, tides and precipitation driven
- Model coupling: Dissipation based (Dingemans, 1987)
- Winds: H*Wind post storm reconstruction (OceanWeather)
- Precipitation: TRMM data
- Tides: TPXO 7.2

- Bulk of momentum transfer from atmosphere to waves is via waves
- Viscous supported stress computed in FLOW
- Morphology changes due to change in mean sea level (MSL) not accounted for
- **Relative change** defined as (**total change – SLR)** is presented

WAVES

Legend:
Blue line – original MSL
Green line – 2m SLR
Black dots – data

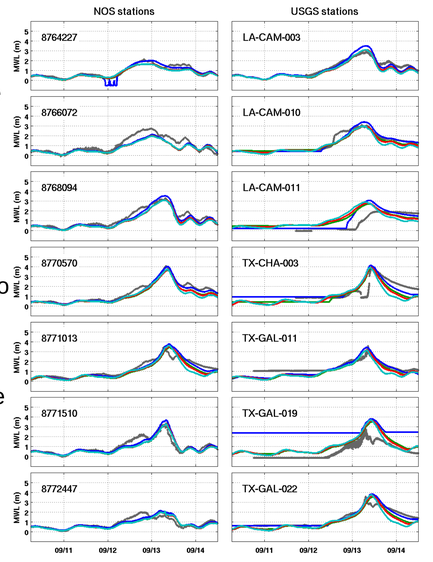
No significant relative changes resulting from increasing sea level:
- Wave buoys are far enough offshore and in deep enough water that waves do not feel the bottom and winds are not affected by land interaction



WATER LEVELS

Legend:
Blue line – original
Green, red and cyan lines – relative water level change due to 0.5m, 1m, 2m SLR
Black dots – data

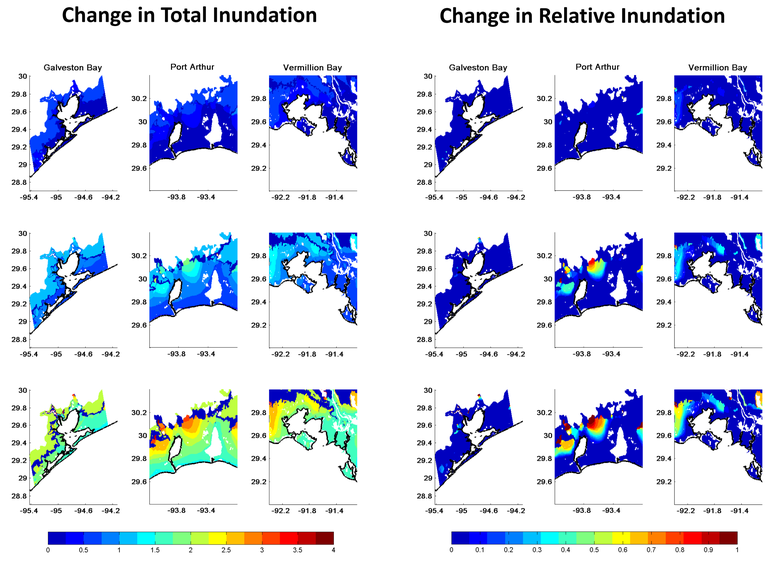
No significant relative changes resulting from increasing sea level
- Water level stations are close to water, thus most of the change in MWL is due to the SLR and not from storm.
- Is the grid resolution too coarse + need better bathy data? Tsunami database has 10m resolution bathy + topo for Galveston area but not others.



INUNDATION

Legend: Maximum water levels (in m) with SLR minus original maximum levels
Rows (top to bottom): 0.5m SLR, 1m SLR, 2m SLR

Appreciable changes in inundation levels over land result from increasing sea level
- Including rainfall did not increase peak water levels significantly – need higher resolution grids and data to model rainfall induced flooding



CONCLUSIONS

Sea level rise does not significantly affect waves in locations where measurements are available. These locations are typically in deep water, hence even a 2m rise in sea level is not going to impact the waves here since wave conditions here are dictated by the wind field.

Relative change in water levels are minimal. Water level stations are also either in the water or close to water, thus most of the change in WL is due to the SLR and not from storm.

Relative change in inundation due to storm surge is significant, increasing the inundation levels by more than 50% on top of the sea level rise.

Precipitation was increased by up to 50%, but the model results did not show much additional over-land flooding, most likely a result of too coarse grid resolution and in bathymetry. Also, TRMM data is at resolution of 0.25º.