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Assessing Coastal Flooding in Data-Scarce Regions: A Case Study for A Caribbean Island

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Compound Inundation Team
for Resilient Applications

Agenda

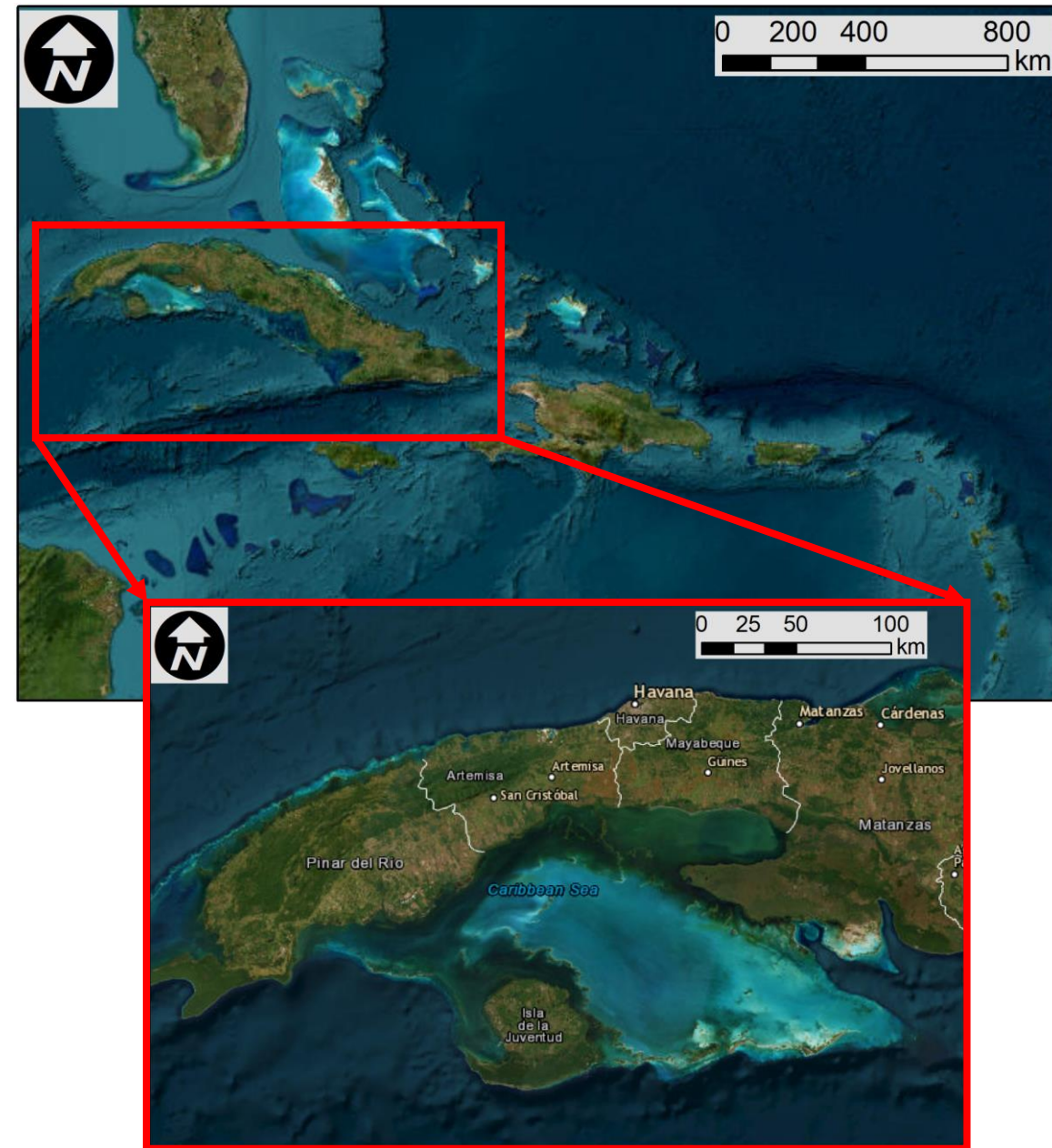
- Background
- Motivation
- Collaboration History
- Numerical Modeling Approach
- Unstructured Mesh
- Storm Events Selected
- Results
- Future Work
- Final Remarks



UGA field visit to the El Malecon Seawall at La Habana

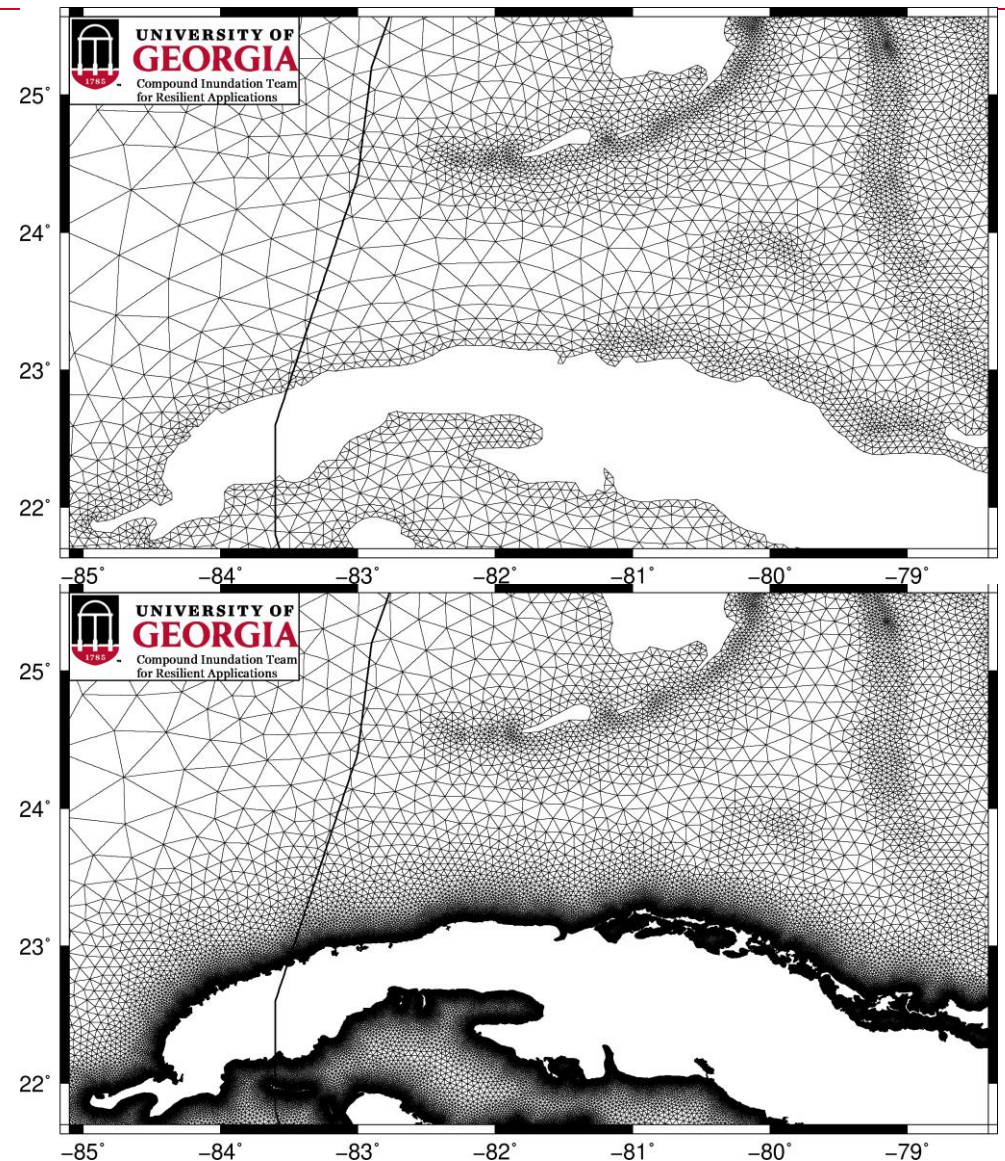
Background: Cuba

- La Havana & Northwest shoreline
 - Steep bathymetry (1km deep within 6km)
 - Extreme flooding from cold fronts
- Gulf of Batabano
 - Shallow waters (< 30 m deep)
 - Highest storm surge floods recorded



Motivation

- Flood resiliency equity
 - Can we do applied research to help less advantageous countries?
- Proximity to FL Panhandle
 - How does refining the resolution around Cuba improve currents and wave dynamics in the Straits of Florida?
 - 160km between FL Keys and Varadero



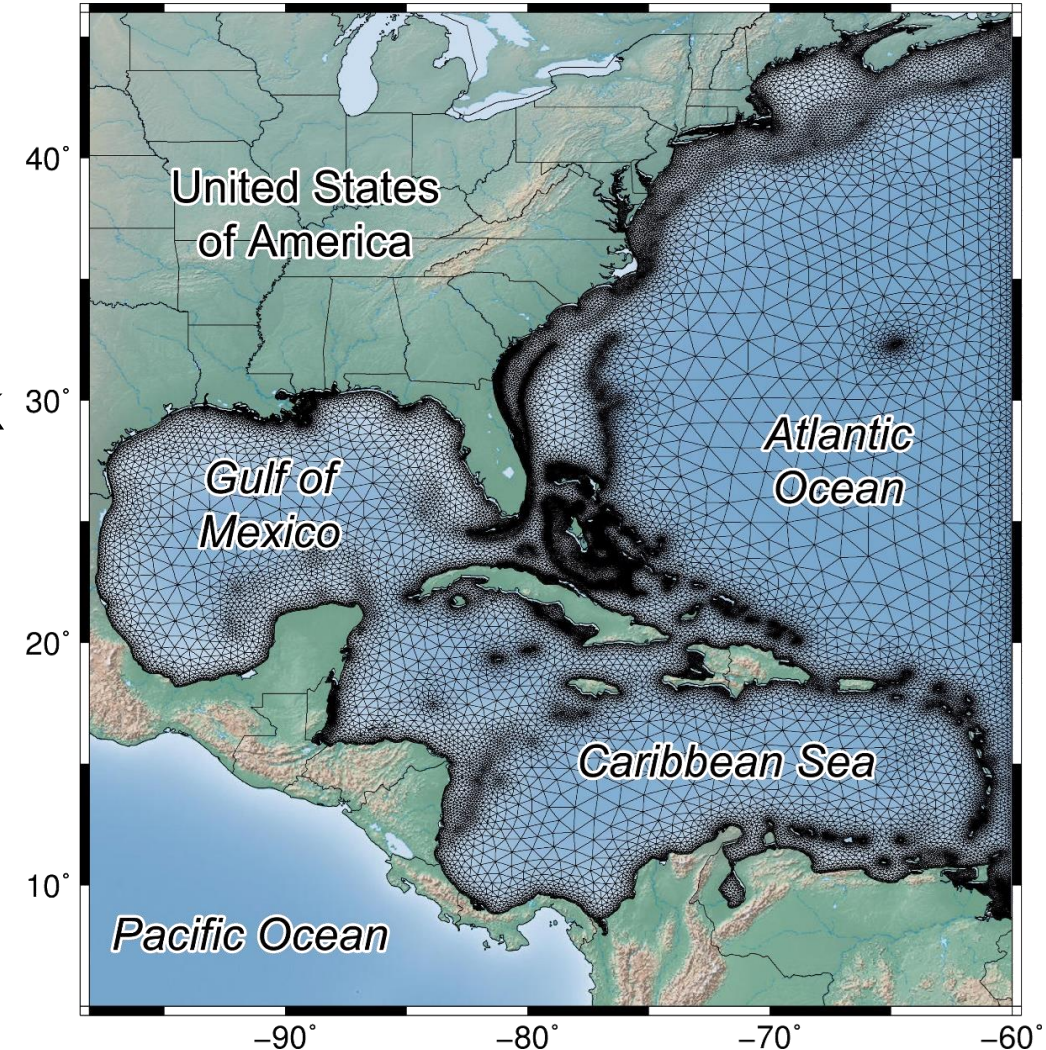
Straits of Florida for the 53K mesh (top) and 317K mesh (bottom). Hurricane Ian's track is shown as a black line.

Collaboration History with CUJAE



Numerical Modeling Approach

- ADCIRC modeling
 - Astronomic Tides + Storm Surge
- Asymmetrical vortex model: NHC Best Track
 - 14 days of tidal spin-up (10 days of ramp)
- Running on 192 cores at Sapelo2 (UGA)...
 - 39K mesh: 7 min average wall-clock
 - 317K: 20 min average wall-clock

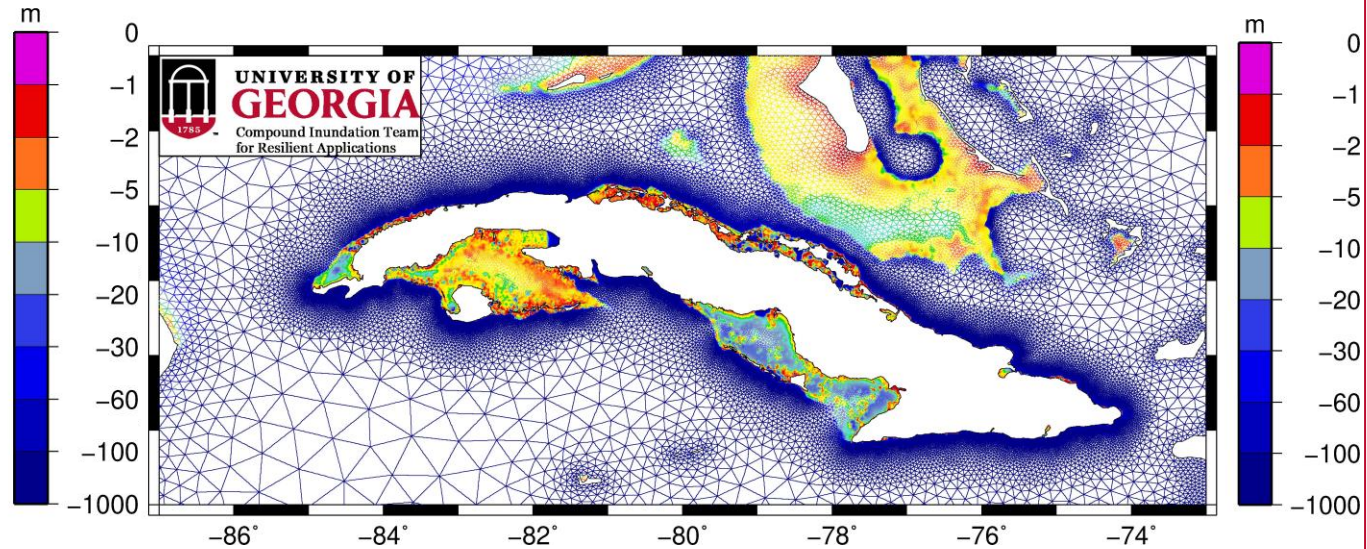
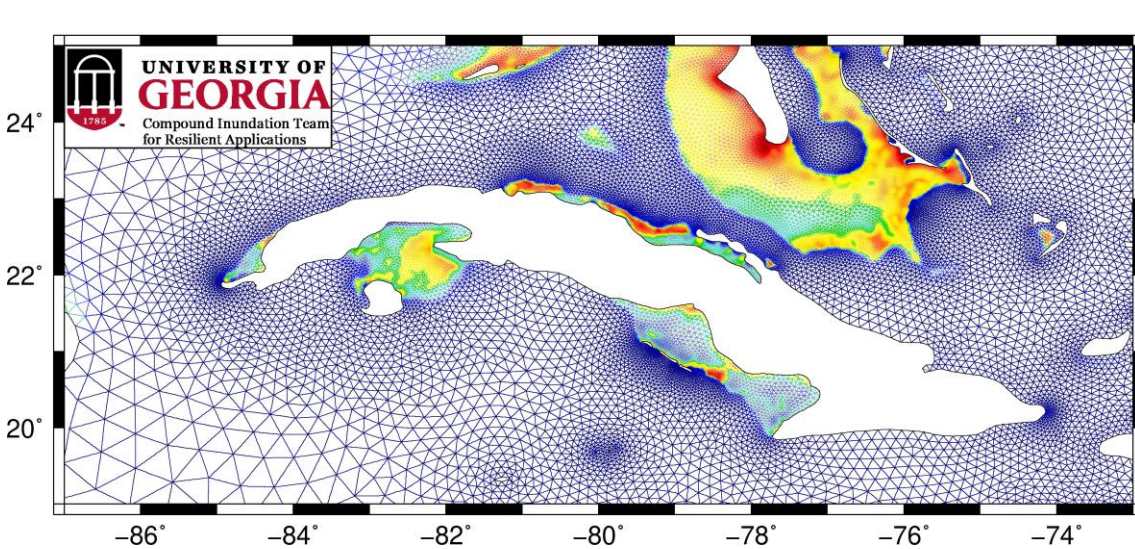


53K Mesh for the WNAT domain

Image courtesy of Dr. Matthew Bilskie



Unstructured Mesh



- Developed using LTEA
 - ~39K nodes;
 - Shoreline resolution: 1-10 km

- Developed using OceanMesh2D
 - ~317K nodes (83% in Cuba)
 - Shoreline resolution: 200-m

Storm Events Selected

Gustav (2008)

- Category 4 at landfall (150 mph/ 240kmh⁻¹)
- 140,000 houses destroyed
- \$80-\$120 million (USD) in losses
- 0 casualties

Irma (2017)

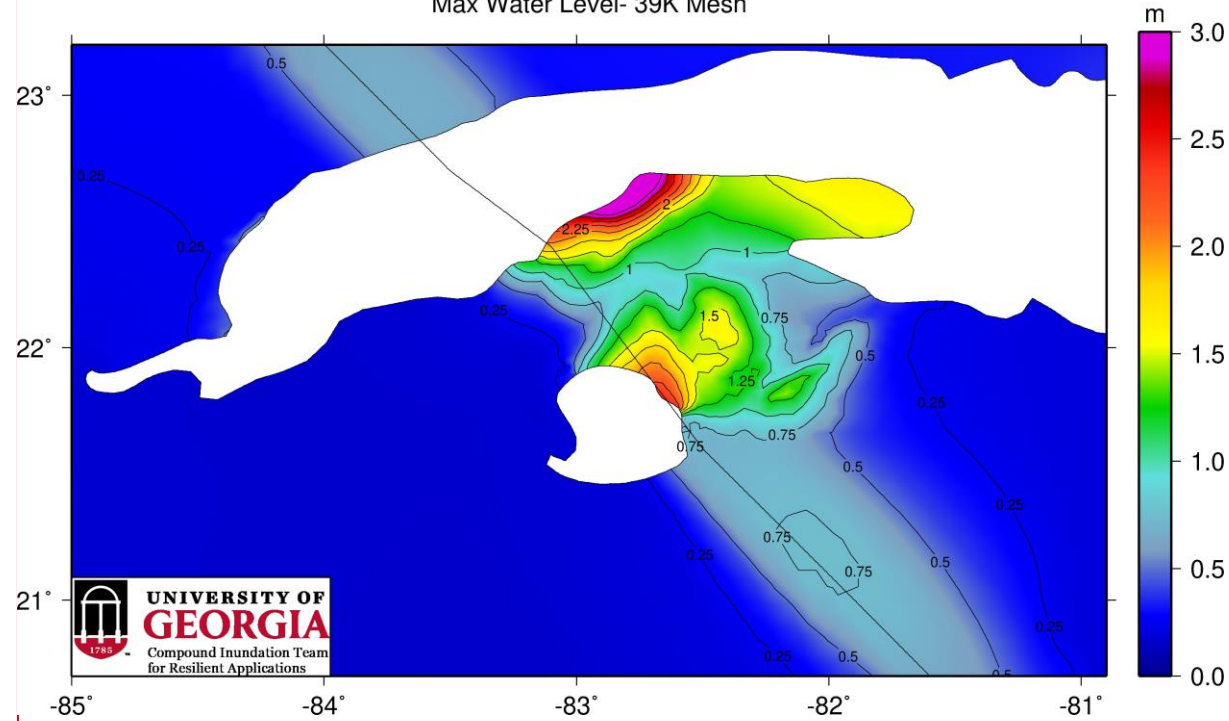
- Category 5 at landfall (158 mph/ 254kmh⁻¹)
- Significant impact to agriculture



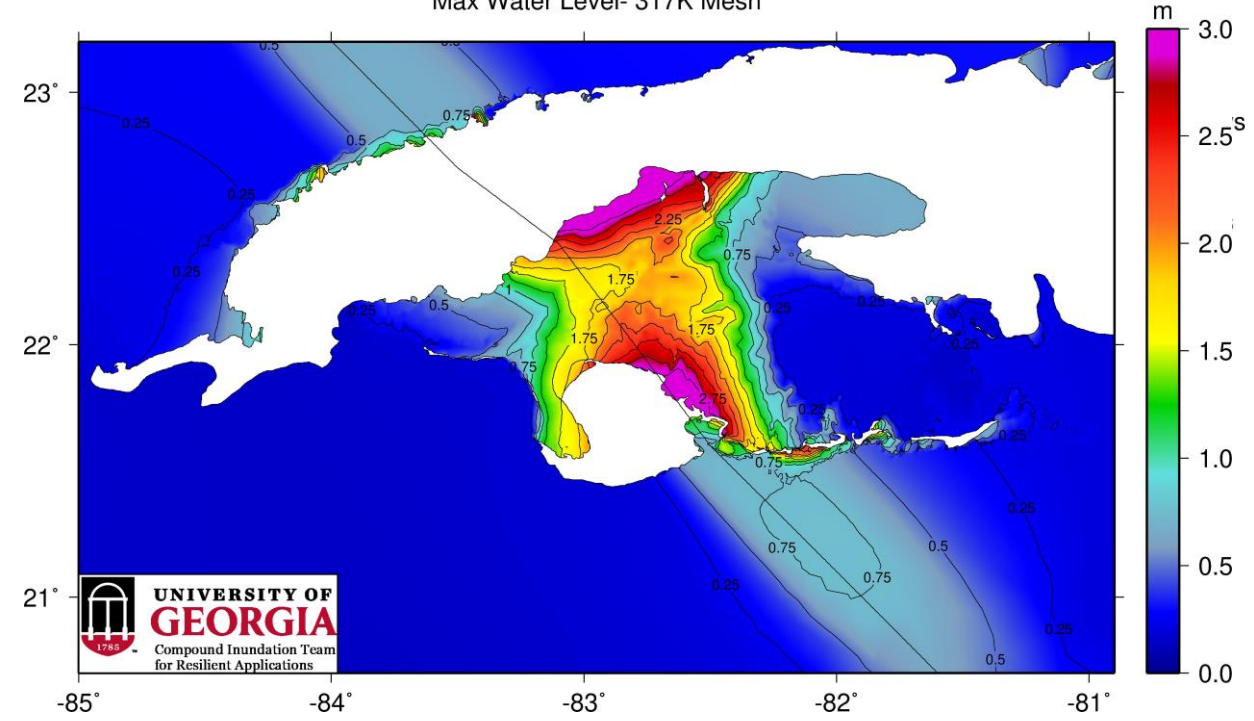
Malecon seawall impact during Irma
Image courtesy of Cubadebate / Ismael Francisco

Results for Gustav: Water Levels

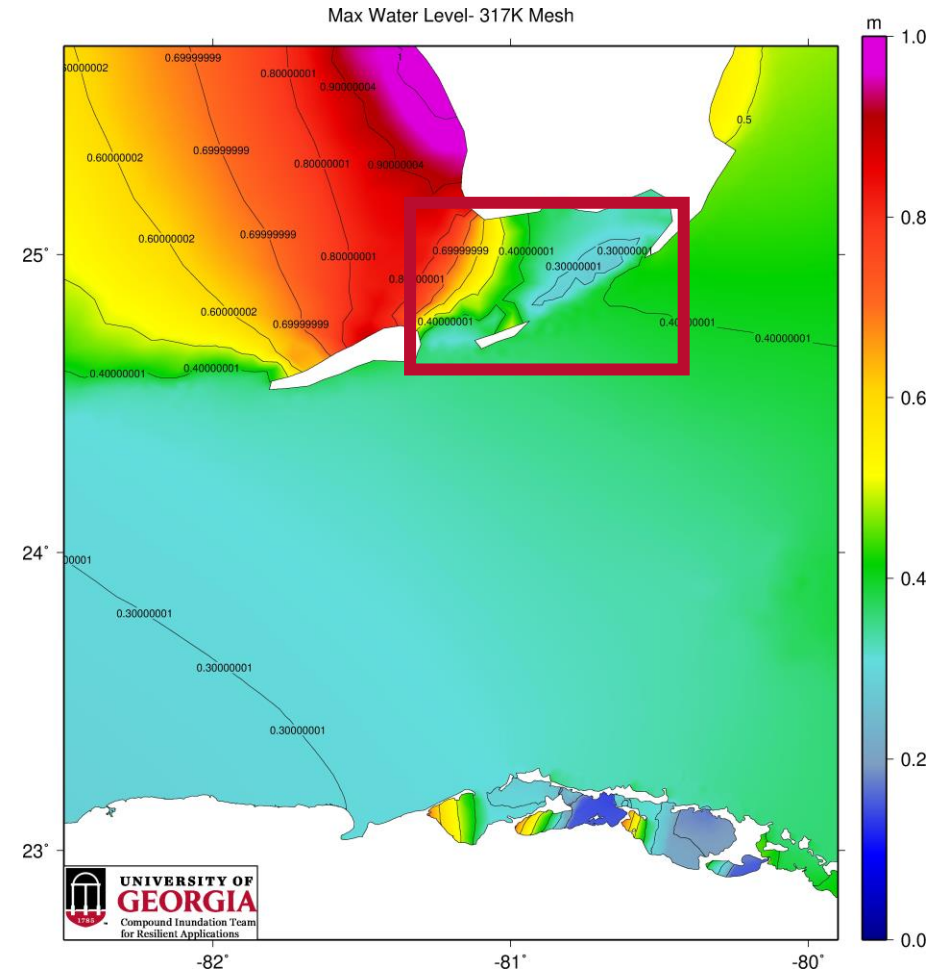
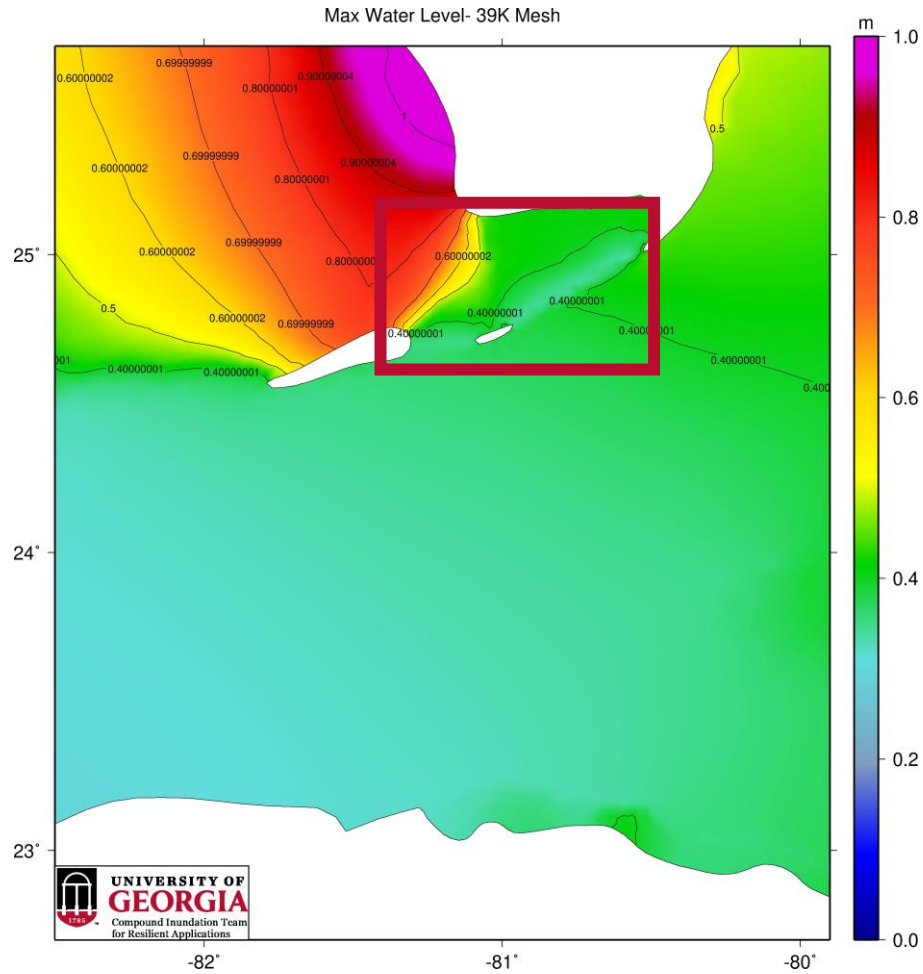
Max Water Level- 39K Mesh



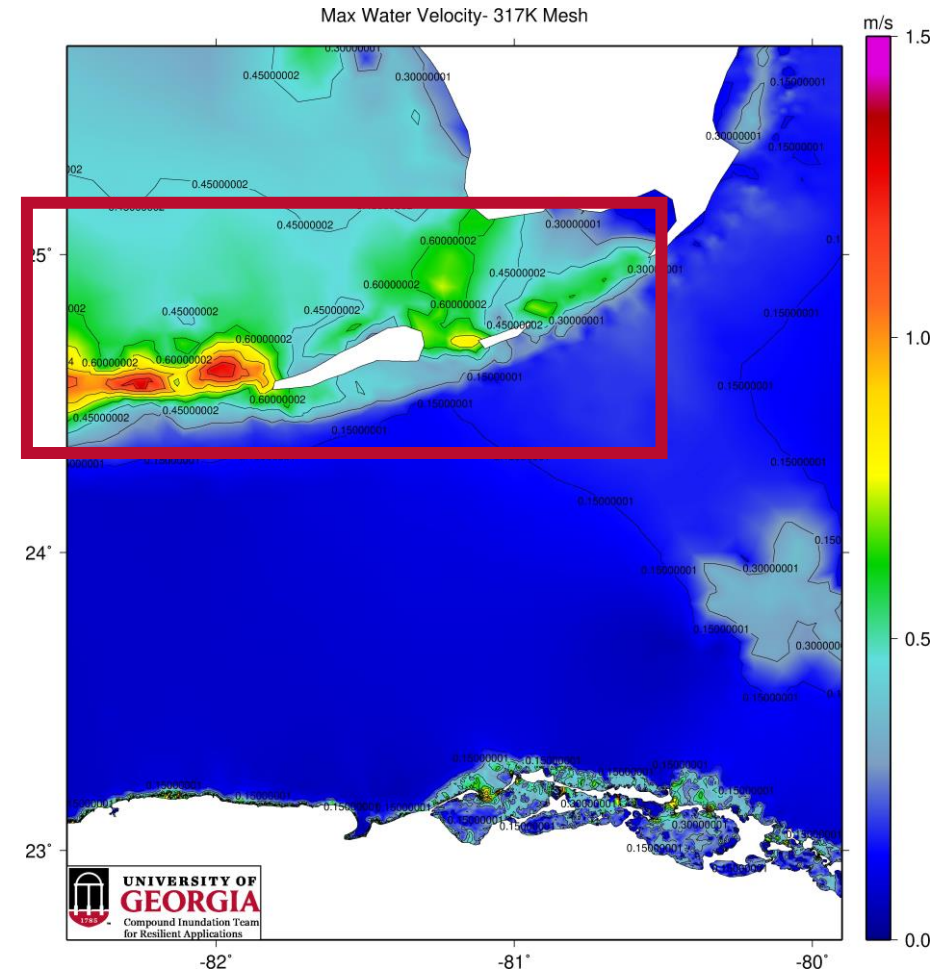
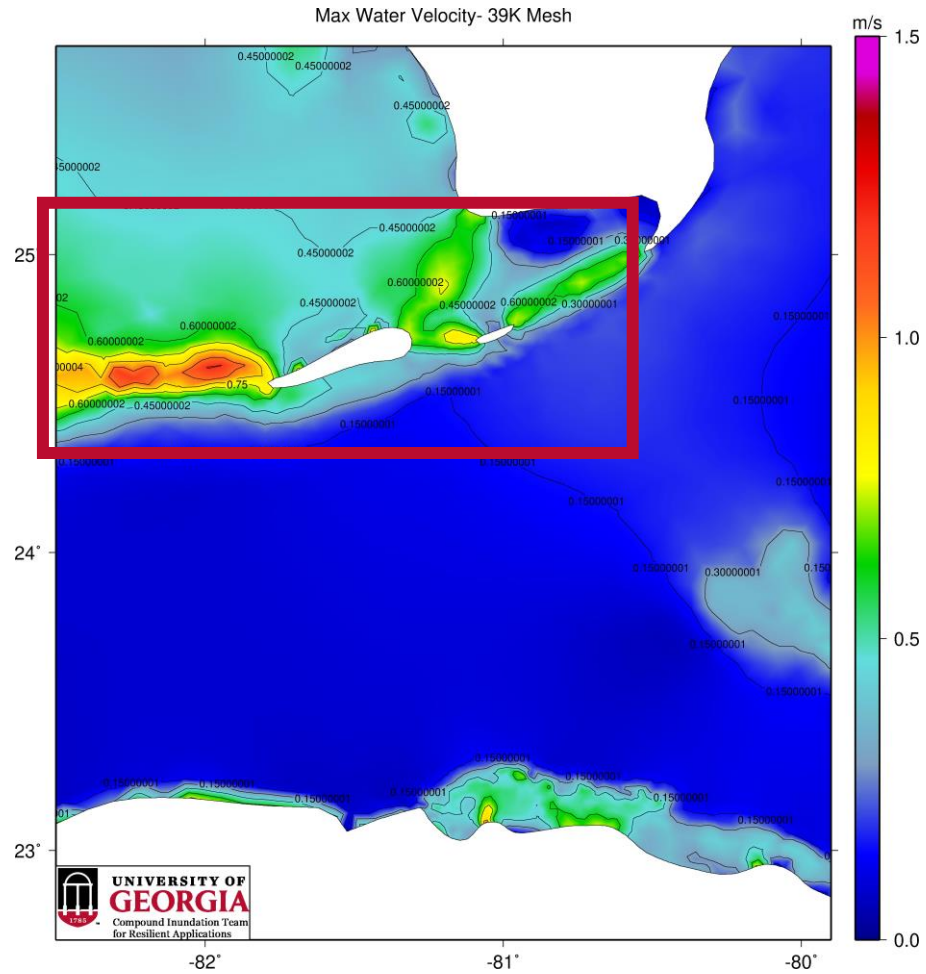
Max Water Level- 317K Mesh



Results for Gustav: Water Levels

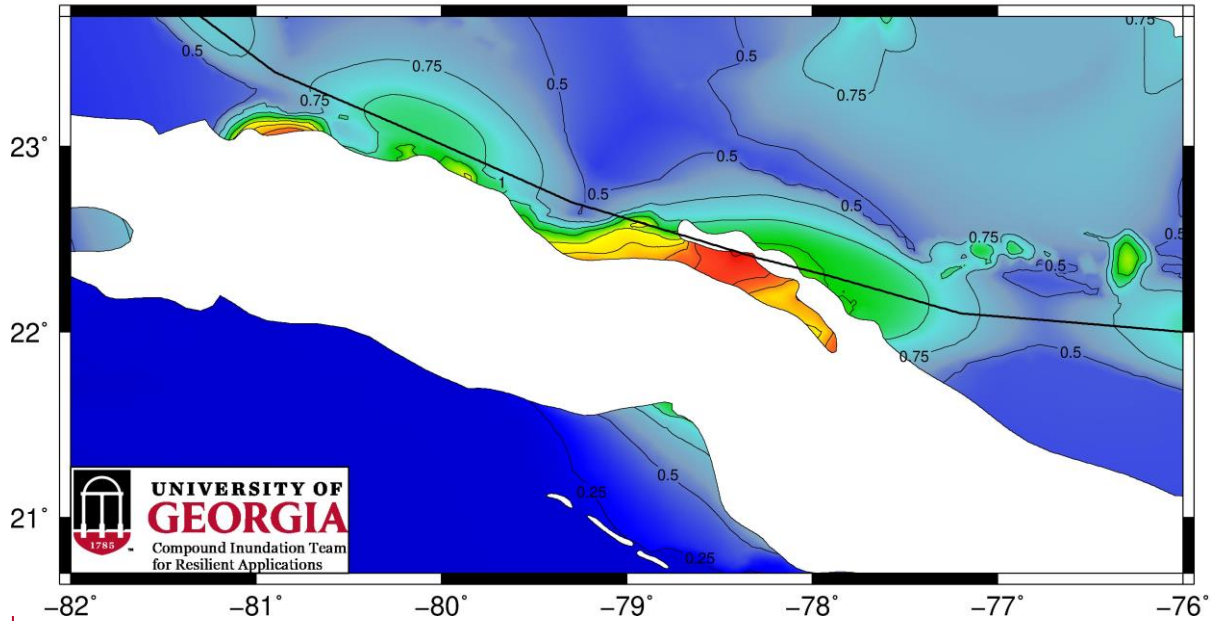


Results for Gustav: Velocity

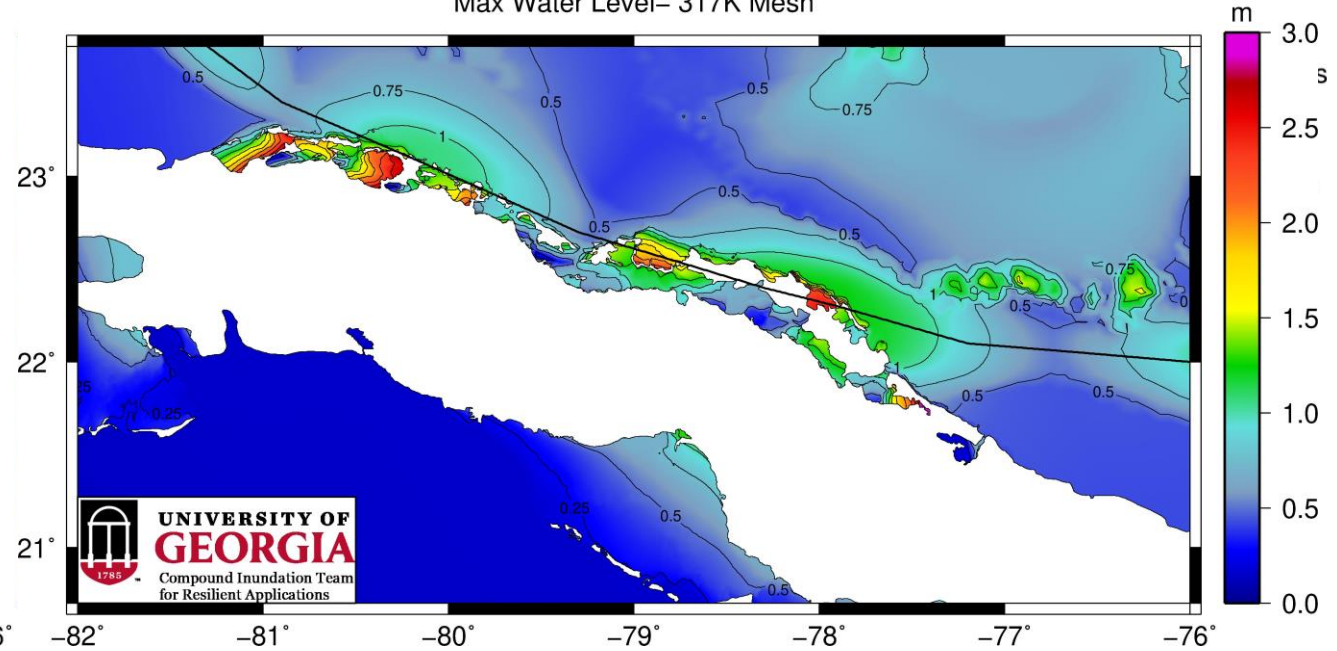


Results for Irma: Water Levels

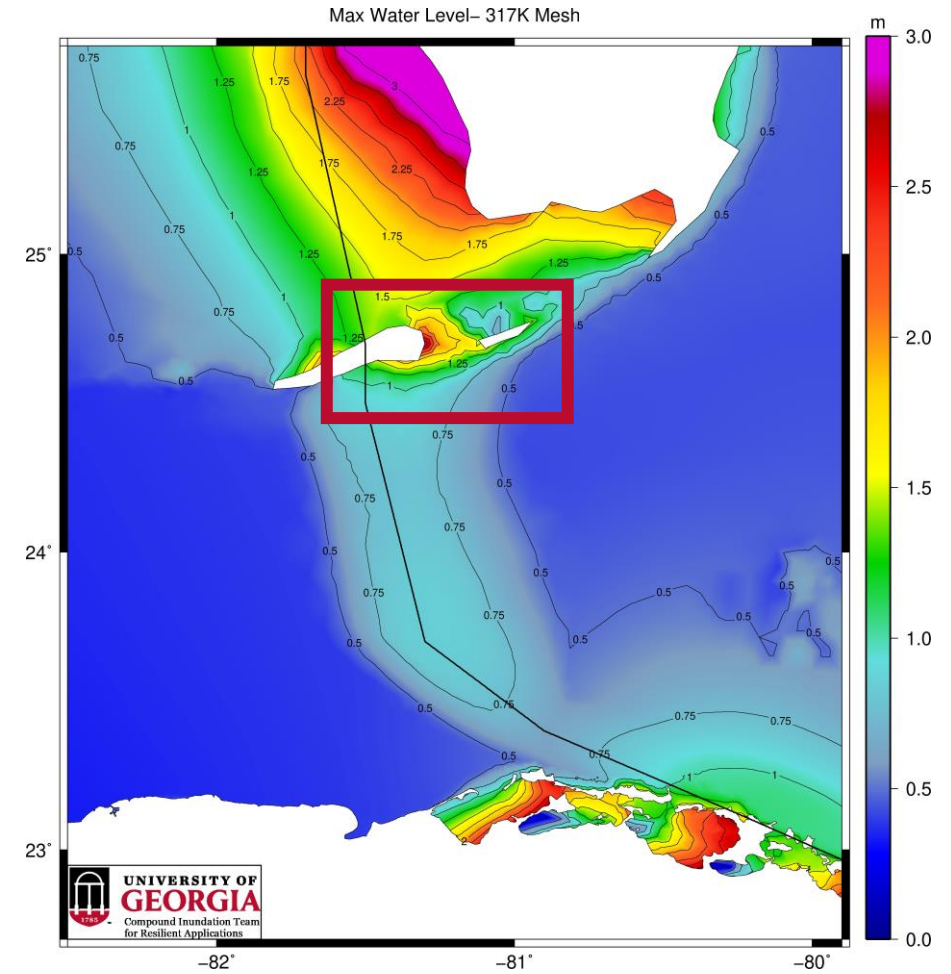
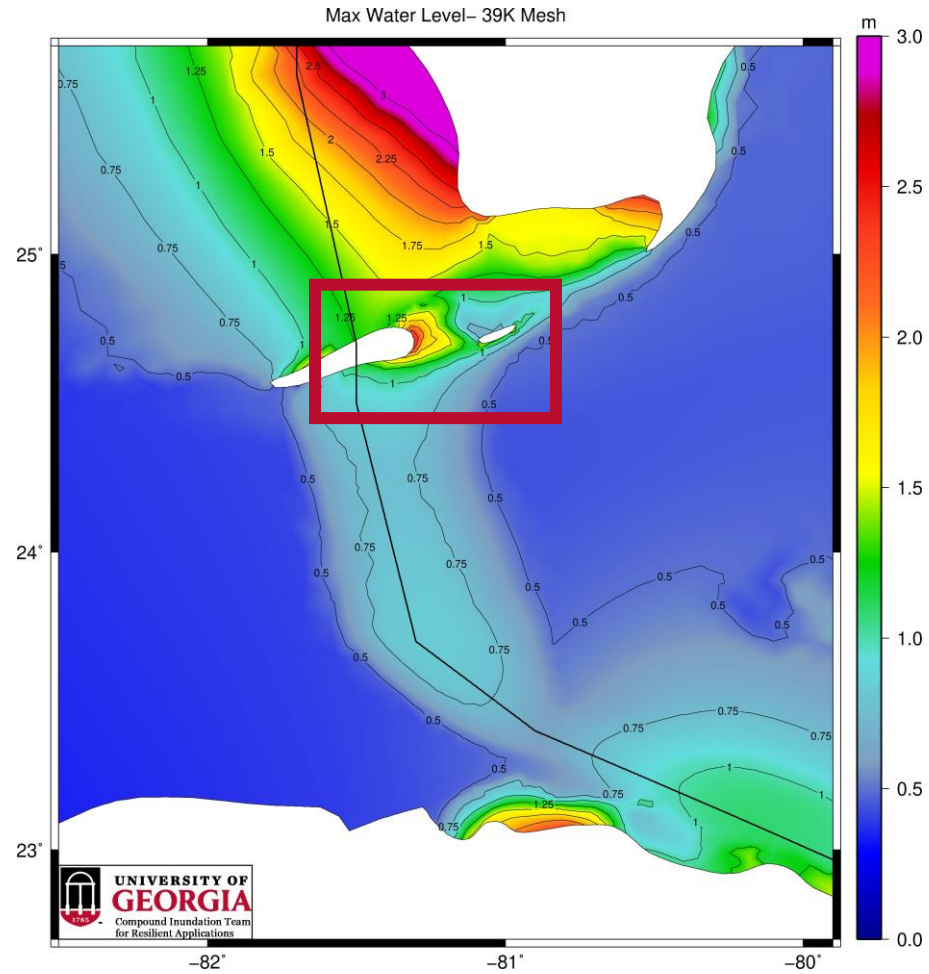
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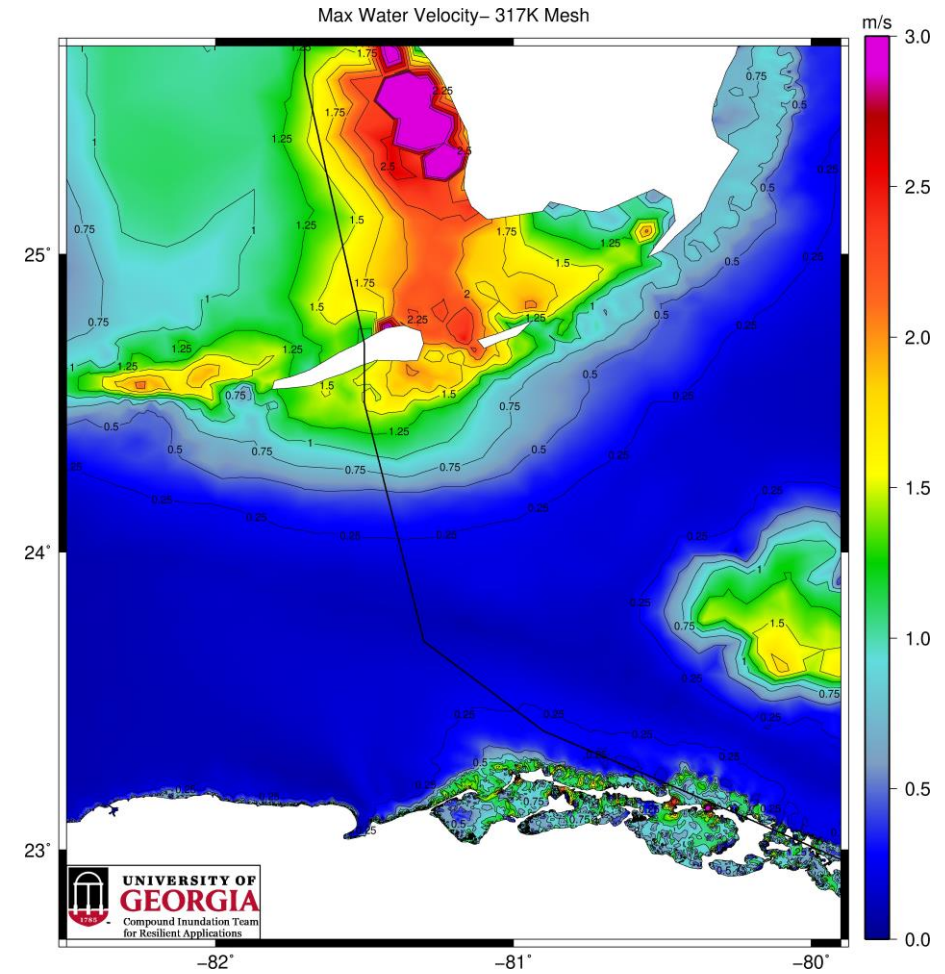
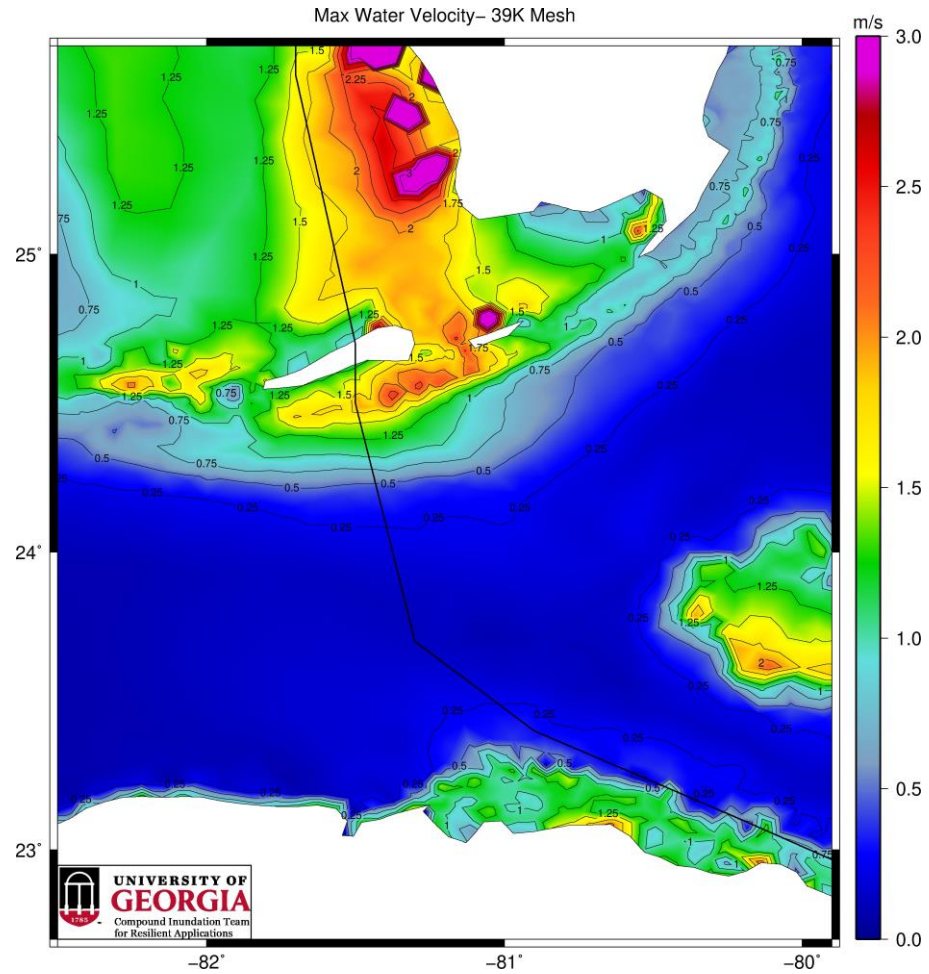
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Results for Irma: Water Levels

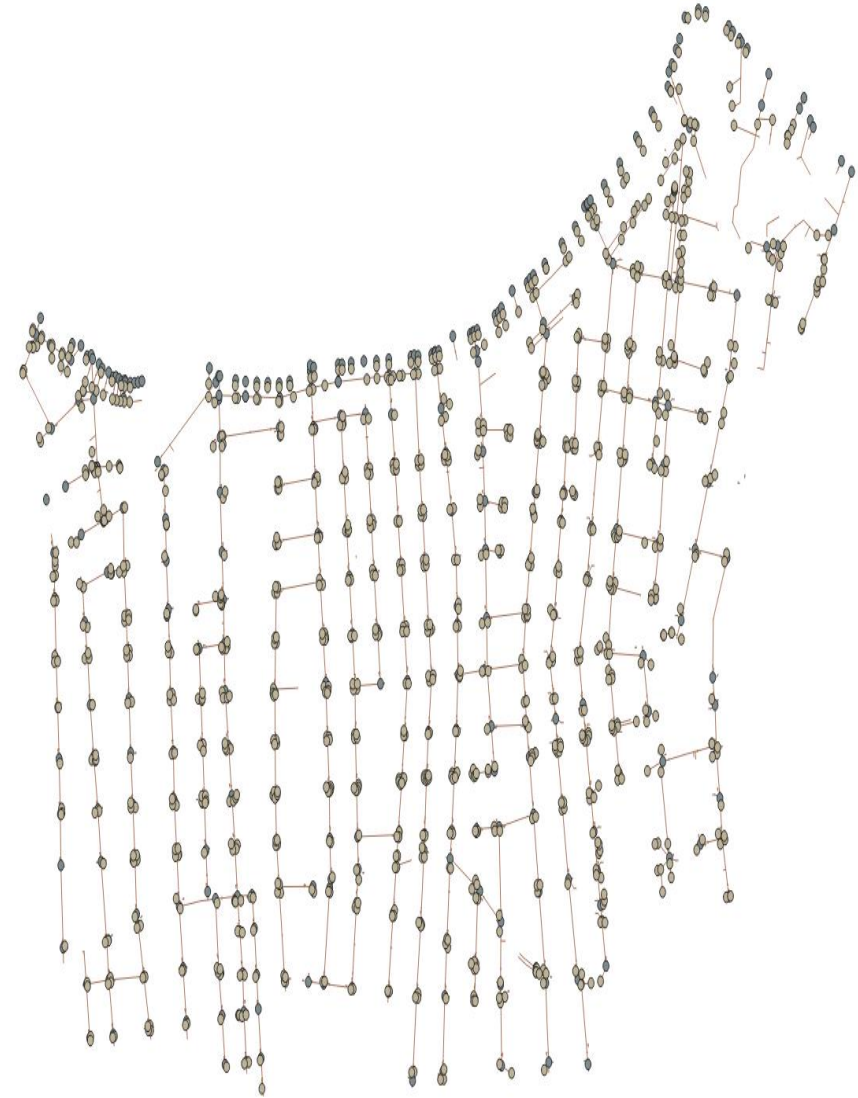


Results for Irma: Velocity



Future Work

- Hyper-resolution Model La Habana
 - 30-m shoreline resolution with seawall
 - 5-m resolution bathymetry
 - 25-cm resolution topography
- Compound Flood
 - Pluvial + storm surge + tides + waves
 - Include stormwater drainage system

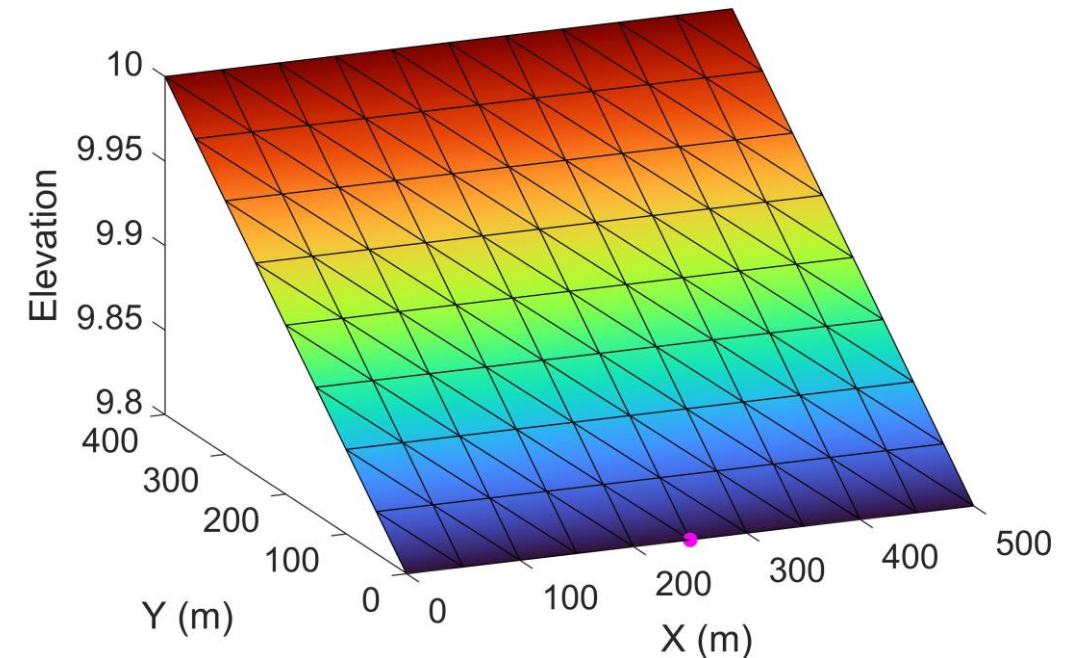


Stormwater drainage system

Credits: Daniela Córdova y Dr. Luis Córdova (CUJAE)

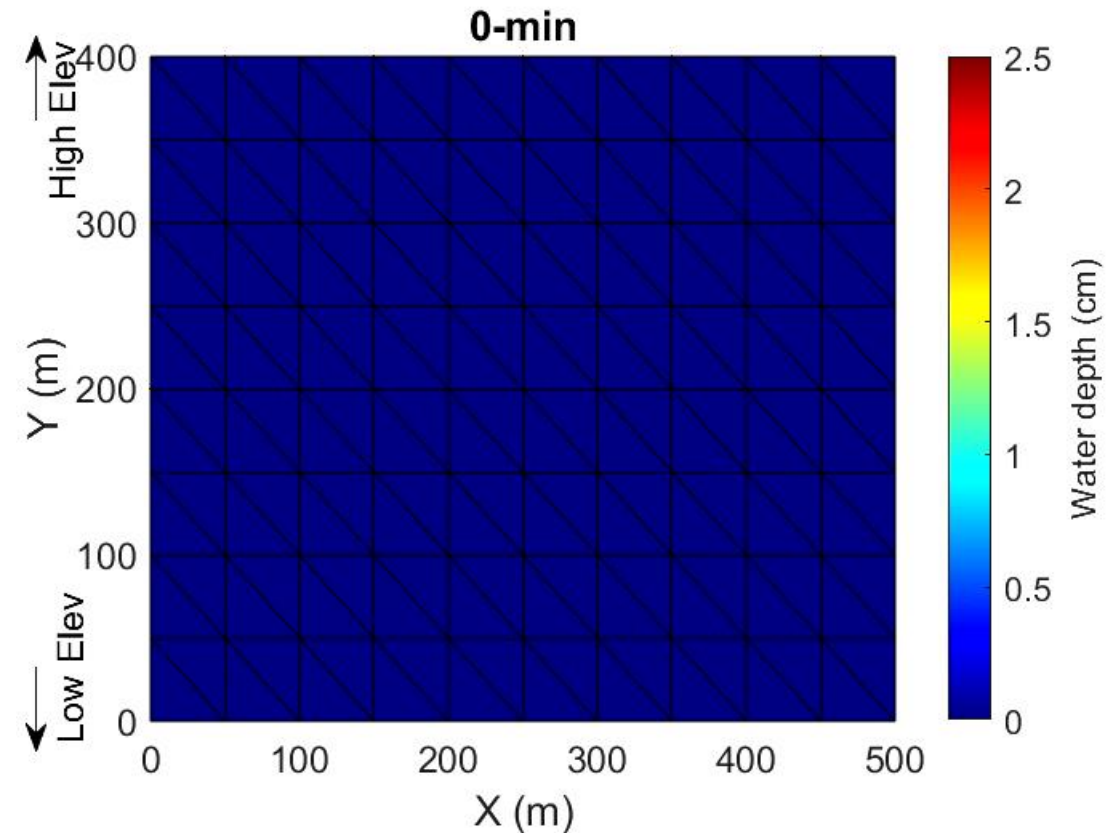
Future Work

- 2-D rainfall-runoff model based on the ADCIRC framework
- Adopts many of the current subroutines used in ADCIRC
- 2-D overland flow: KWE
- 1-D riverine flow: DWE or KWE
- 2-D & 1-D processes incorporated into a single code



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Final Remarks

- Cuba's resolution affects the water levels within the Straits of Florida
- Storms that affect both Cuba & Florida can benefit from improving Cuba's resolution
- Move towards service-driving research opportunities



Acknowledgements

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<https://citra.engr.uga.edu/>



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