Integrated Coastal Urban Flood Modeling, Applications, Lessons Learned, Future Directions

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US Army Corps of Eng. / ERDC/
Coastal & Hydraulics Lab

Ocean Sciences
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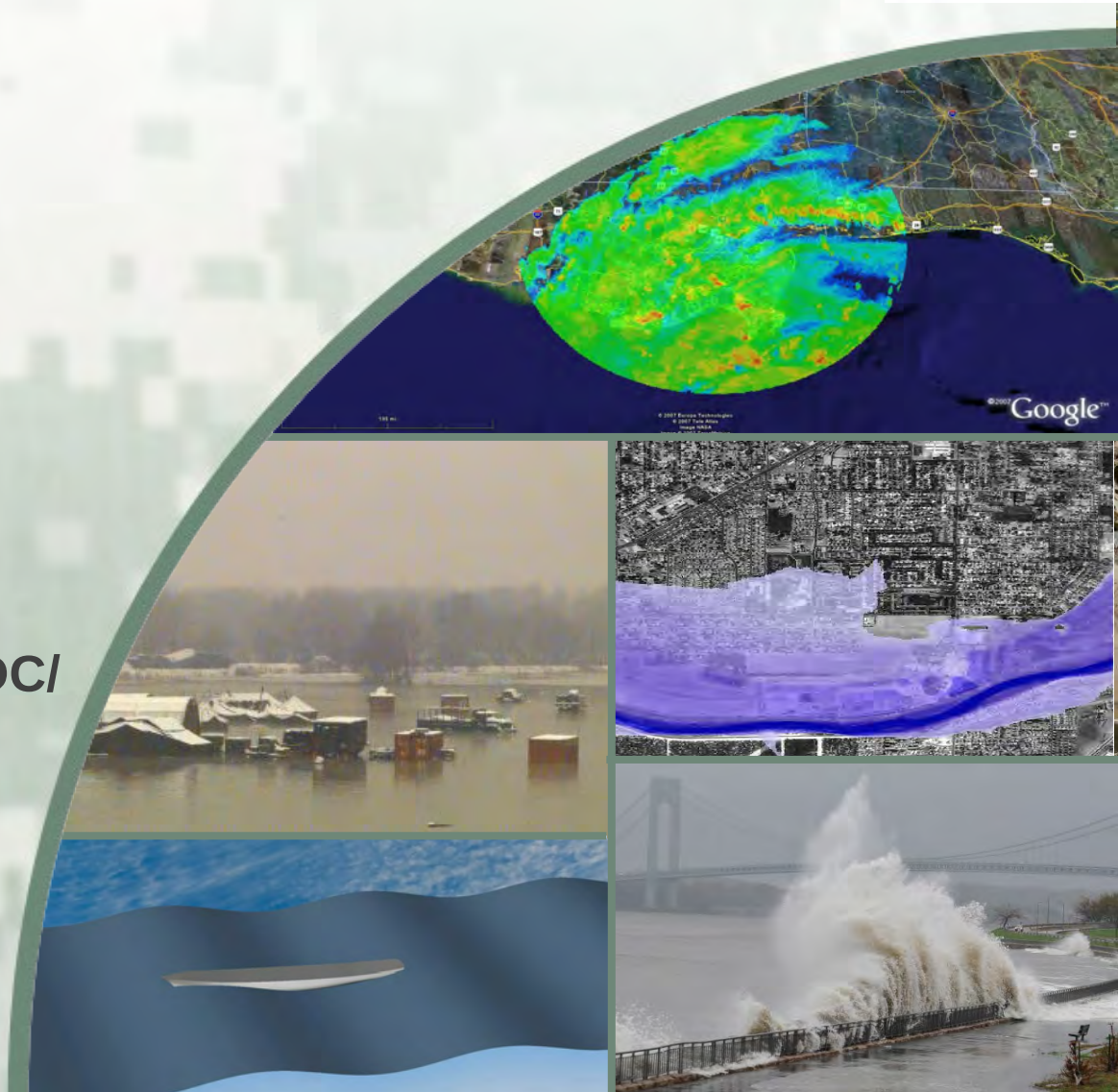
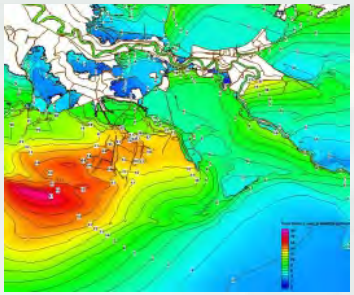


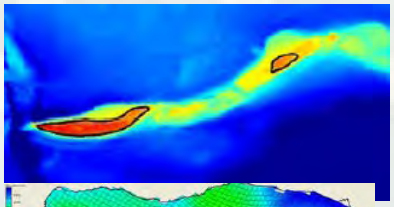
US Army Corps of Engineers' Coastal & Hydraulics Lab's Three Focus Areas

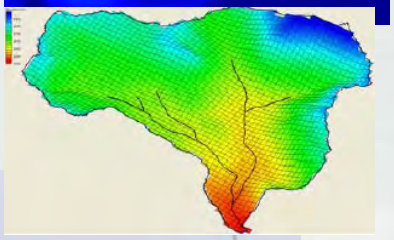
COASTAL & HYDRAULICS LABORATORY

Navigation

Flood and Coastal Storm Damage Reduction





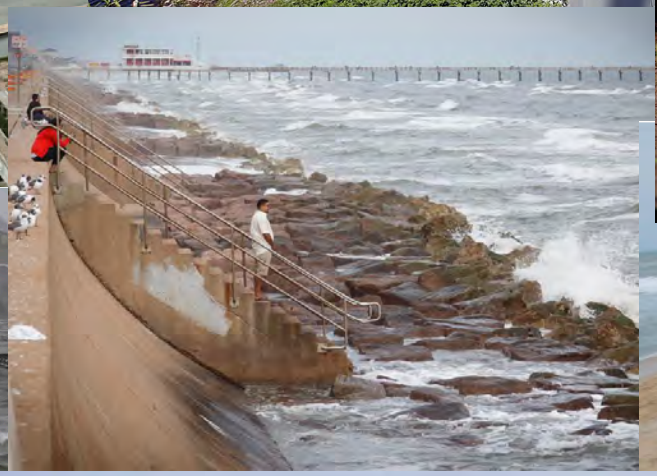


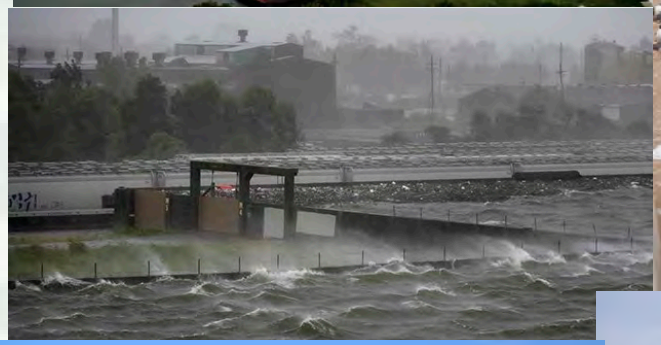
Military Hydrology

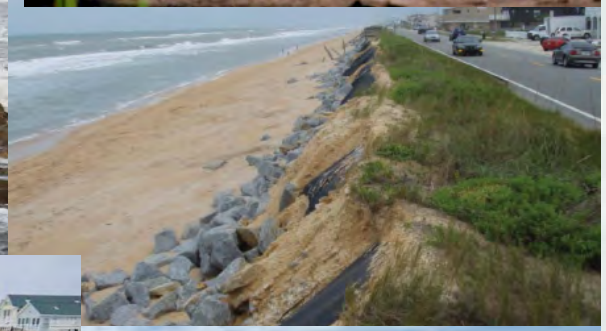
- CHL deploys & develops both physical and numerical models to answer operational questions in these areas

ERDC

Example Flood Protection Measures



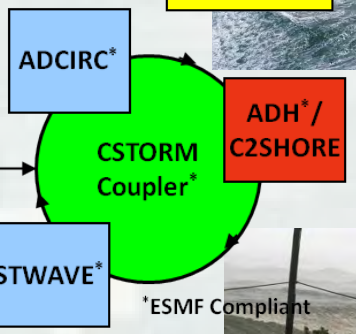




ERDC's Coastal Storm - Modeling System

Application of high-resolution, highly skilled numerical models in a tightly integrated modeling system with user friendly interfaces

Readily relocatable and flexible forcing features.



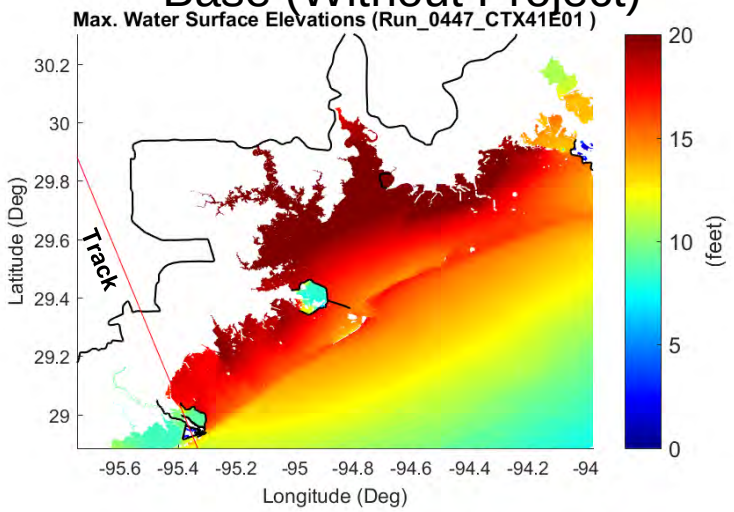
Next Generation Workflow

Plug-n-Play design for expandable and upgradeable system.

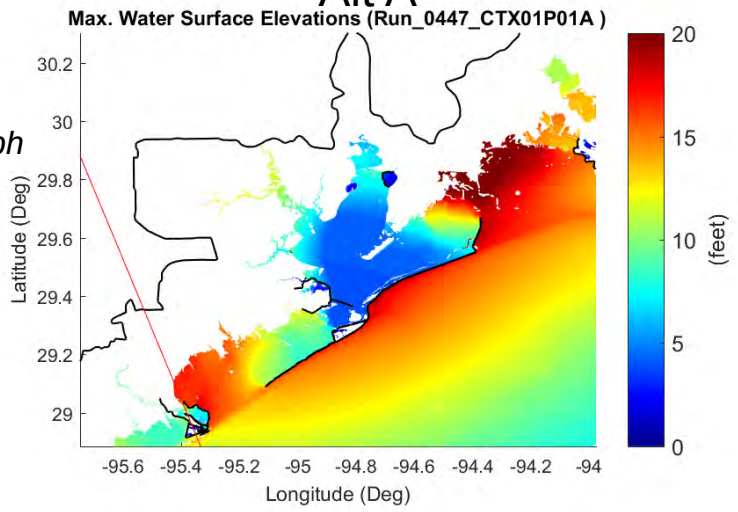
Provides for a robust, standardized approach to model coupling. Used for establishing the risk of coastal communities to future occurrences of storm events.

EXAMPLE COASTAL TX PROJECT ALTERNATIVE COMPARISON

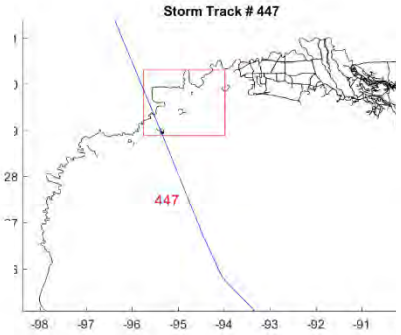
Base (Without Project)



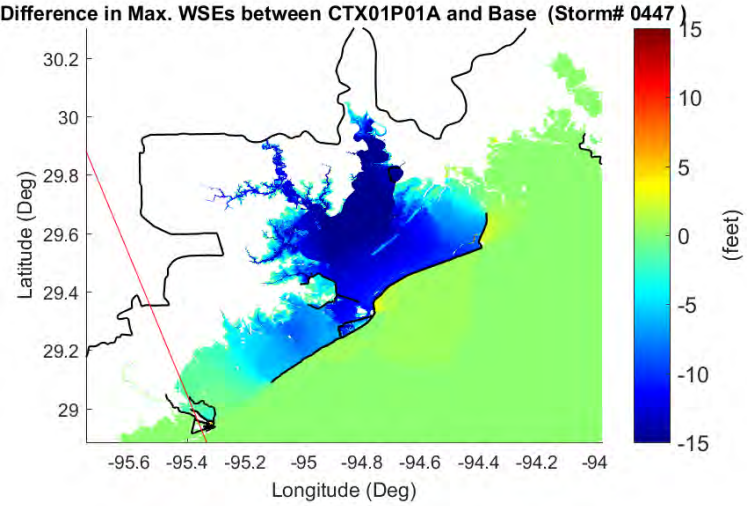
Alt A



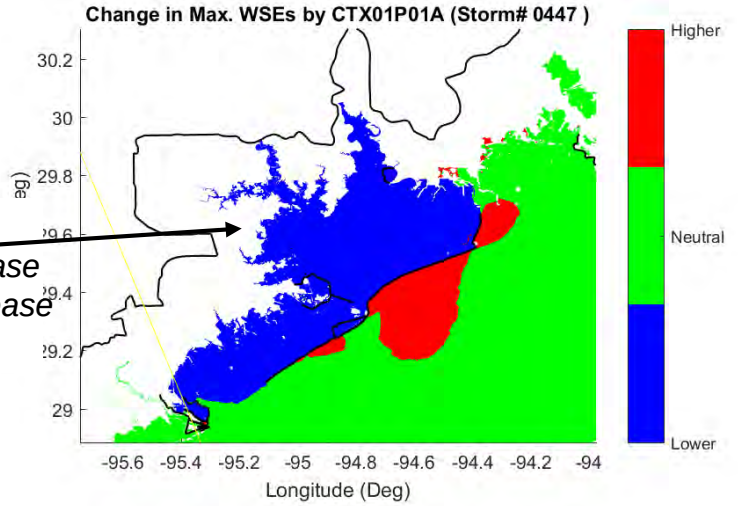
Max. Wind Speed: 105 mph (Cat. 2)
Min. Cp: 905 mb
Rmax: 44.6 nm
Forward Speed: 8.6 kts



Difference (Alt A – Base)



Difference (Alt A – Base)



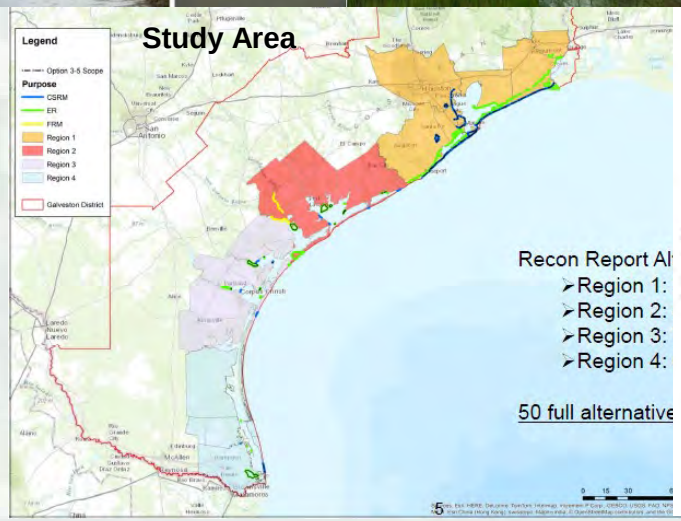
Change in WSEs:
Higher: > 1/2 ft increase
Lower: > 1/2 ft decrease
Neutral: in between

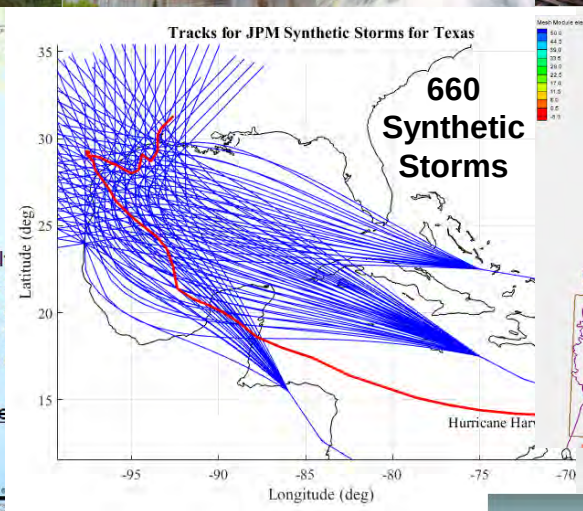
Combined Joint Probability of Coastal Storm Hazards

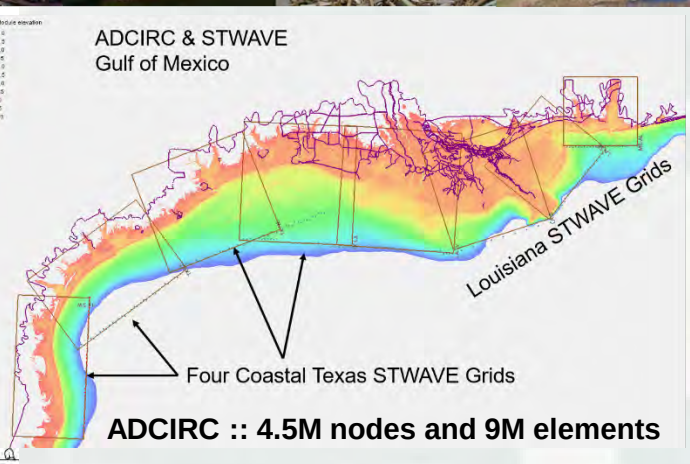
- ***Forcing***
  - Tropical cyclones
  - Extratropical cyclones
  - Rainfall
- ***Response***
  - Water level (storm surge, astronomical tide, SLC) (Runoff)
  - Currents
  - Wave height, peak period, direction
  - Wind speed, direction
  - Precipitation

***Next Pieces for Inclusion**

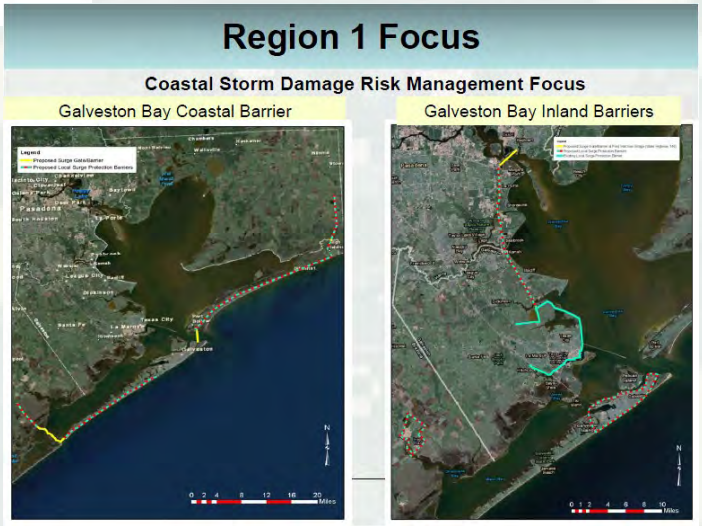
Coastal Texas Comprehensive Study







- Over 1,900 high resolution base CSTORM simulations for winds, waves and surge levels including 2 sea level rise scenarios
- 660 Synthetic Tropical Storms
- Water Levels: Present Day, 1m SLR, and 0.75m SLR
- With project alternatives simulations for feasibility study (Three alternative designs)

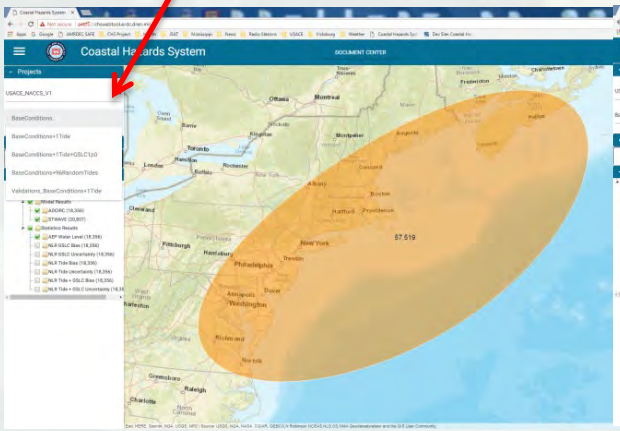


Innovative solutions for a safer, better world

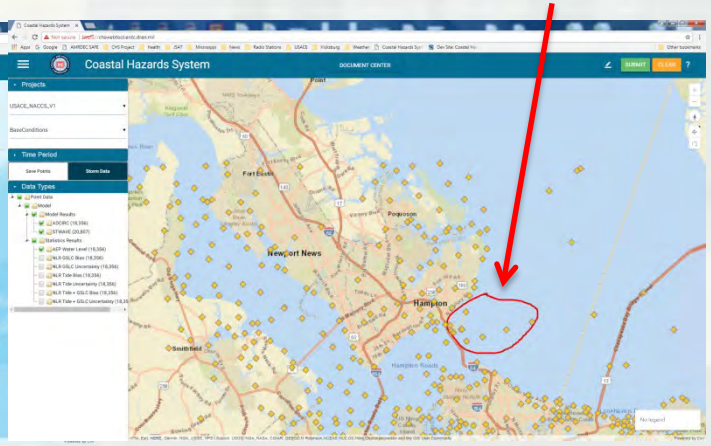
Coastal Hazards System
NACCS Example

Click on “CHS Web Tool”

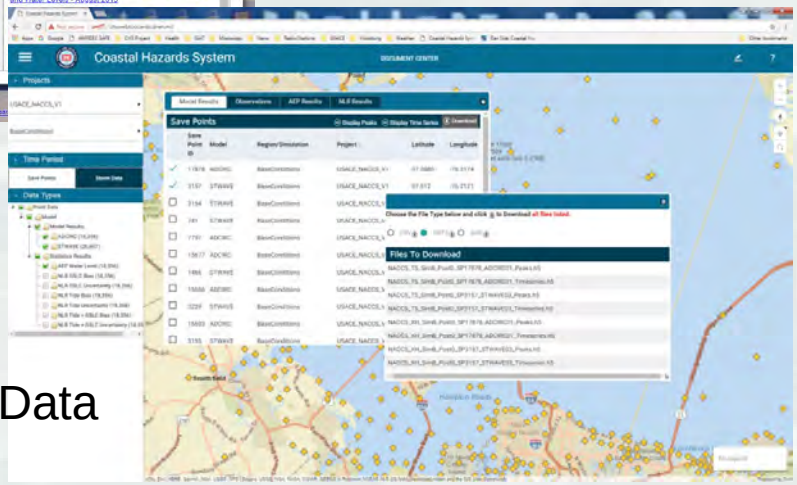
Select Project

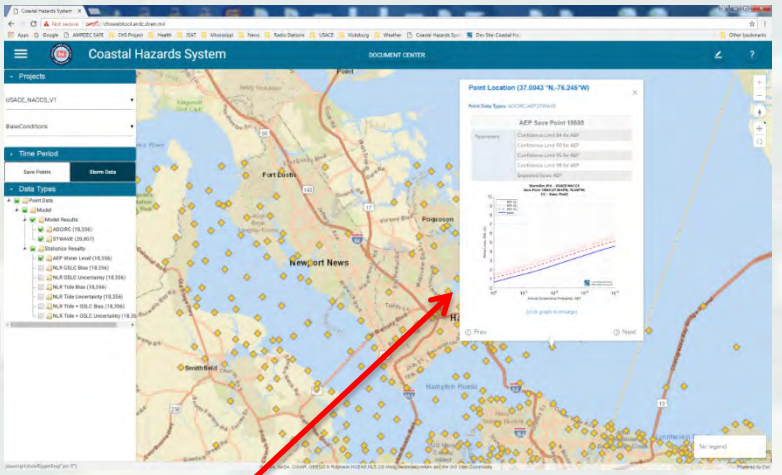


Zoom to AOI and Select Points



Download Data





Click point icon for parameter info and statistics plots

https://chs.erdc.dren.mil

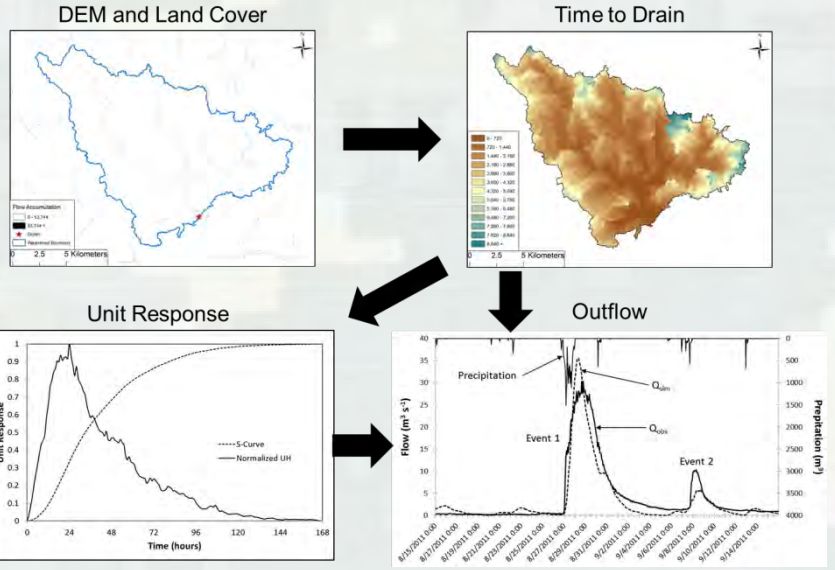
Chris Massey, USACE-ERDC-CHL

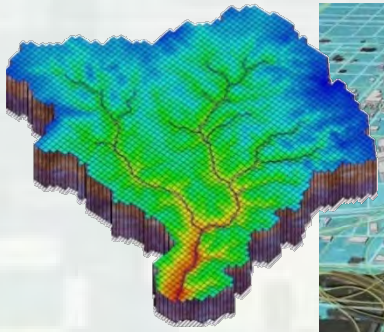
Hydrologic Capabilities

Standard Practice:
- HEC-HMS, HSPF, Unit Hydrograph, etc.

Simple, Fast, and Accurate:
- Flow Regression Analysis
- Statistical Analysis
- Automated Clark Synthetic Hydrograph

Complex Tasks:
- GSSHA
  - Land cover change
  - Extreme events / Climate change
  - Katrina and Sandy
  - Surface / Subsurface interaction
  - Variable terrain/soils/hydrology
- Land Surface Models

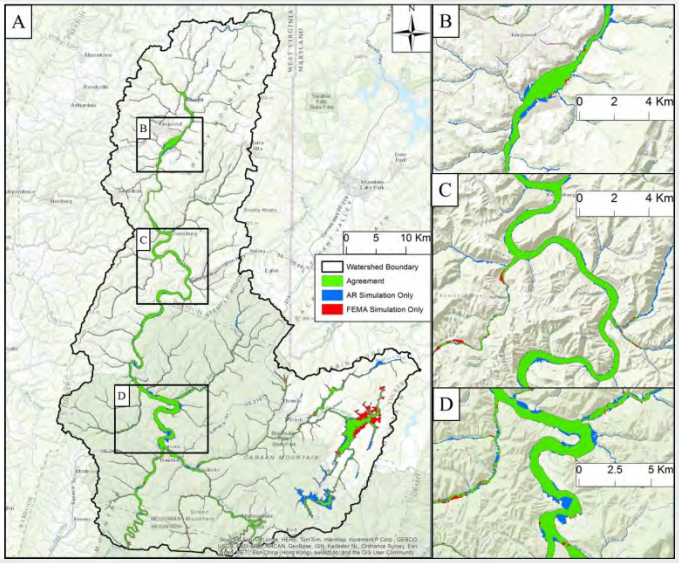




Hydraulic Capabilities

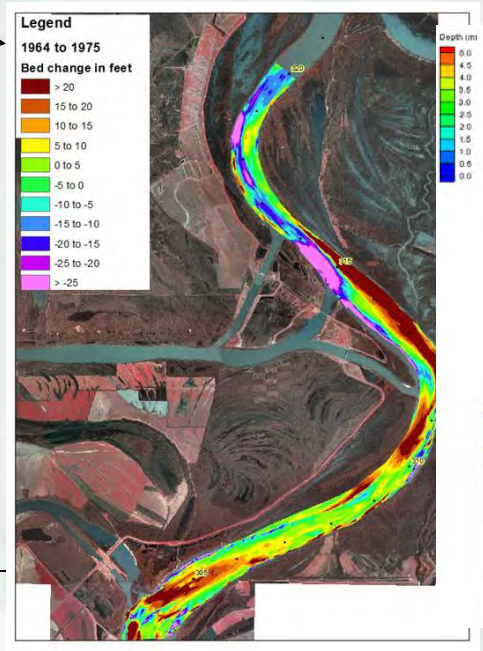
Standard Practice:
- HEC-RAS, Flow-Stage Curves, etc.

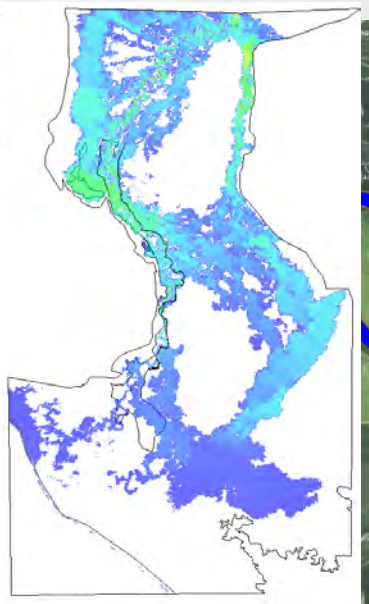
Simple, Fast, and Accurate:
- AutoRoute (for large areas)
  - Requires DEM and Land Cover
  - Uses Flow Regression Equations

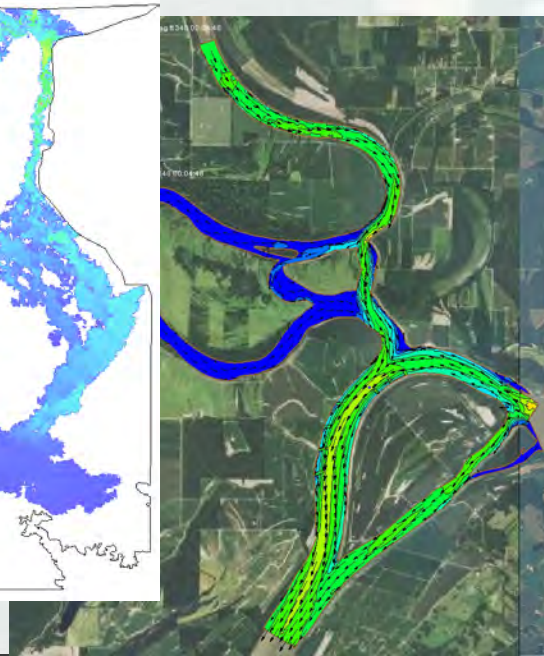


Cheat River, WV
100 YR flood event
Area: 1,800 km^2
Completed in ~1 day
Compared to FEMA

Complex Tasks:
- ADH (2- or 3-D)
- DamBreak (2-D)
- GSSHA (1-D Channel, 2-D Overland)





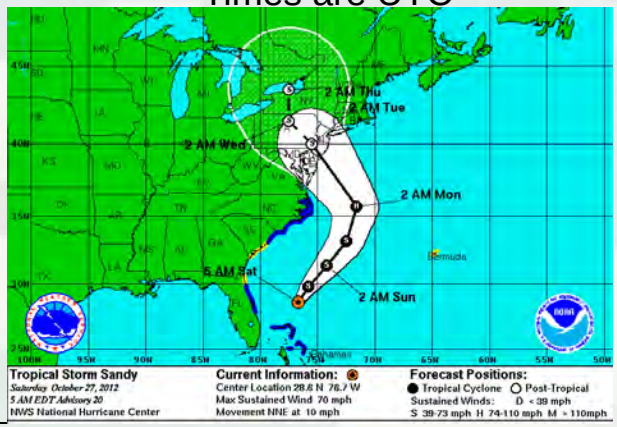


BUILDING STRONG®

Hurricane Sandy Response

Advisory 31 Time Series Water Elevation (ft MSL)

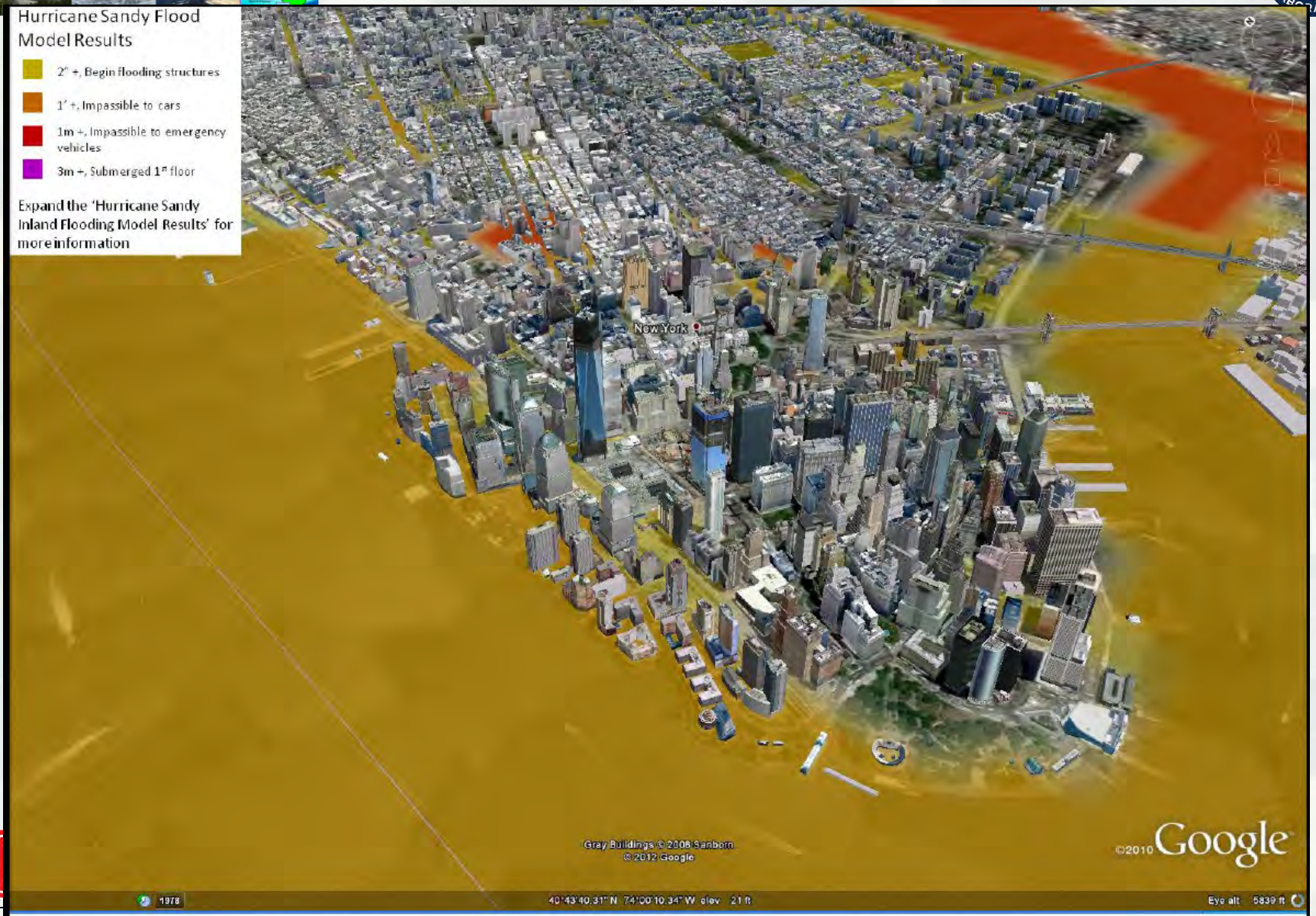
Times are UTC



- Used two ADCIRC meshes
  - EC2001FIMP Grid
  - FEMA Region 2 Grid
- Used tidal forcing
- Used an imbedded asymmetric vortex Holland wind/pressure model with inputs derived from the NHC forecast using the ASGS
- *Now able to use winds/pressure from NOAA's GFDL models*

Hurricane Sandy Urban Flooding (Rainfall & Surge)

GSSHA Results from Advisory 26



Advisory 26

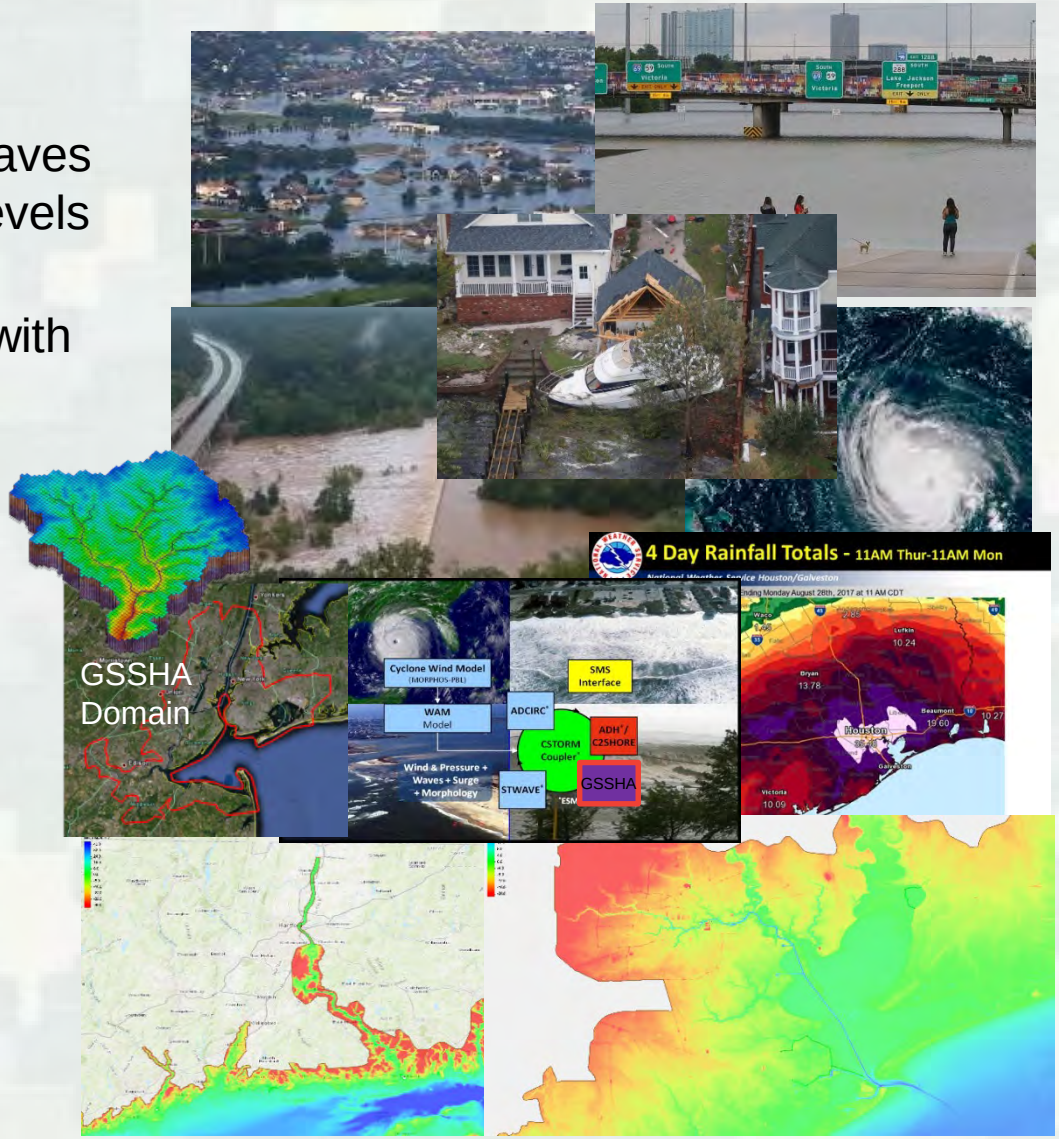
What is Next?

Needed Innovations:

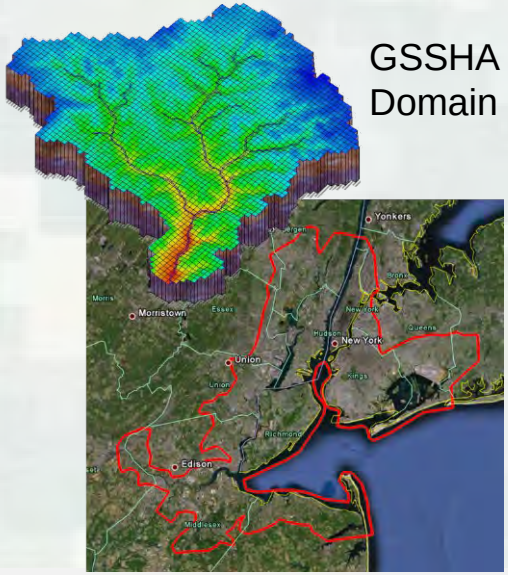
- Directly Incorporate Combined Flood Hazards from Coastal Storm Surge/Waves and Rainfall/Runoff into Total Water Levels with Associated Probabilities
- Dynamic Coupling of Coastal Models with Hydraulic Models and Linkage with Rainfall Estimate Models
- Coastal/Inland Flood Hazards System

Benefits:

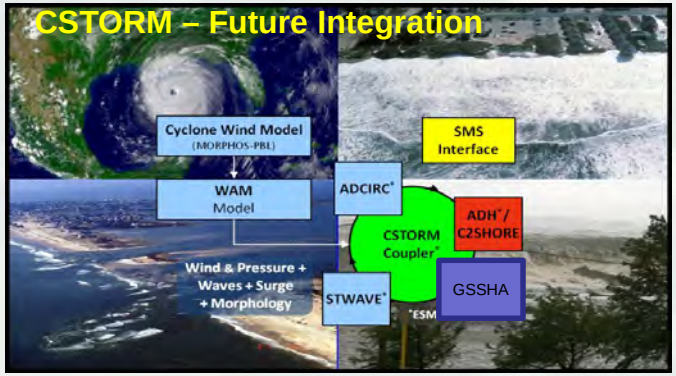
- Lowered Uncertainty for Flood Hazard Estimates
- Readily Available Standardized National Level Data & Statistics (NCIHS)
- Capability for Rapid Total Flood Hazard Estimates

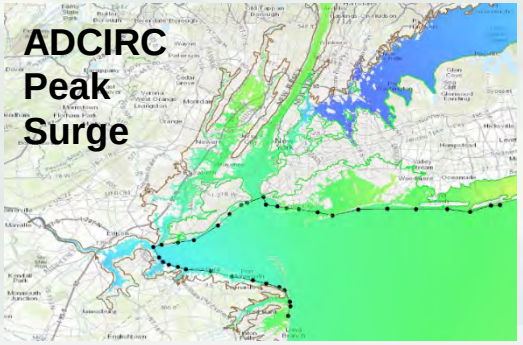


Coastal Urban Flooding



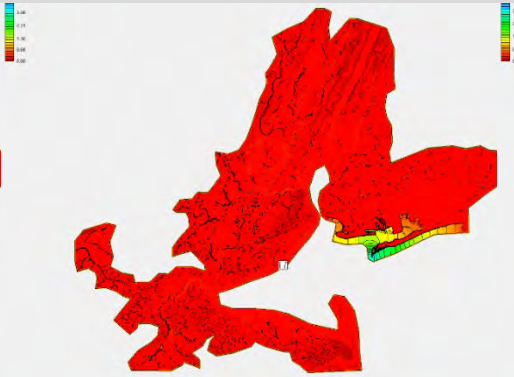
GSSHA Domain





Hurricane Sandy GSSHA Flood Map Using Multiple ADCIRC Forcing Locations

No ADCIRC Locations



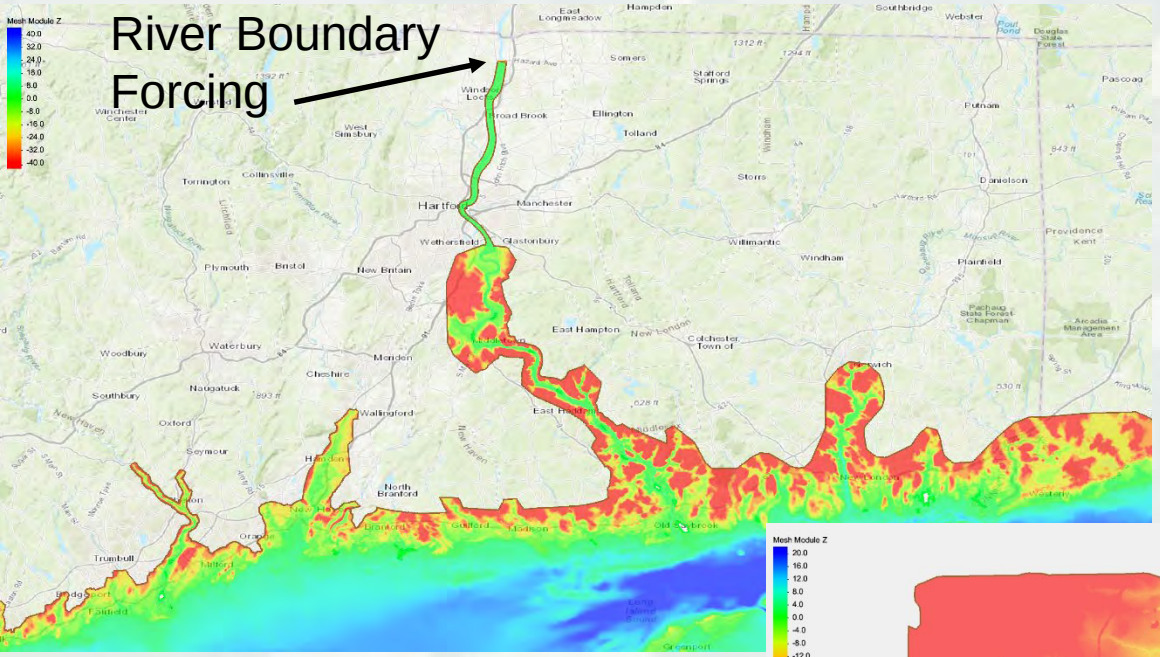
One ADCIRC Location

Two ADCIRC Locations

Actual Flooding

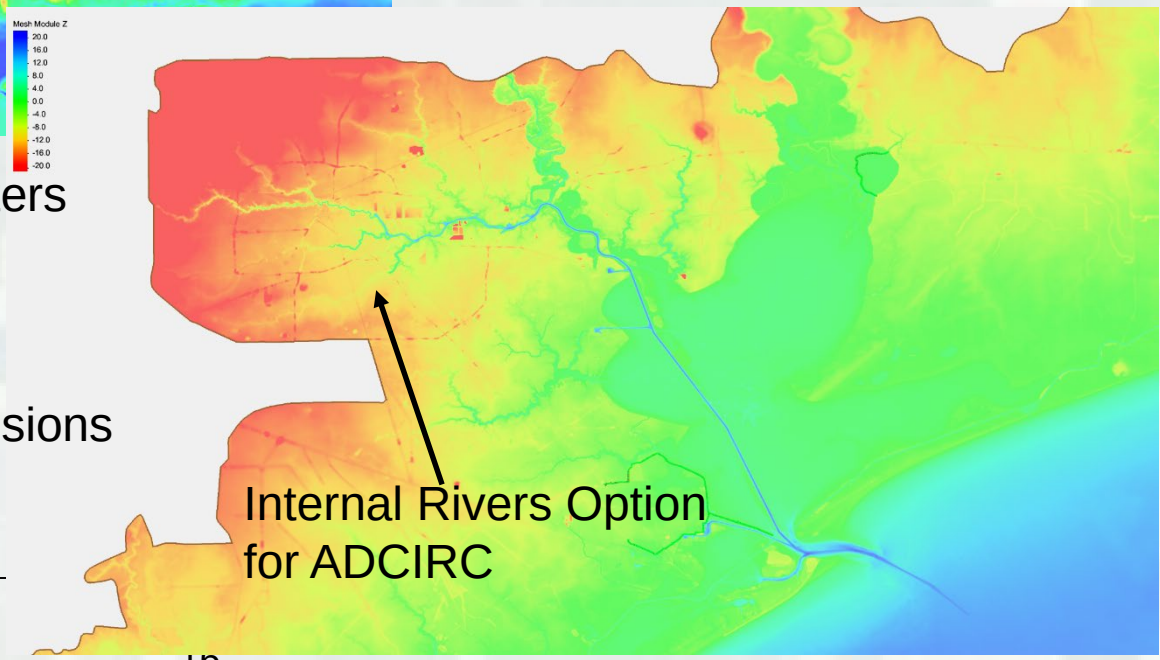
Chris Massey, USACE-ERDC-CHL

Dynamic Coupling of Coastal & Hydraulic Models



- Where to link the two models?
- Under what conditions is one-way coupling sufficient versus two-way?
- Statistical characterization of combined events for informing what modeling to perform.

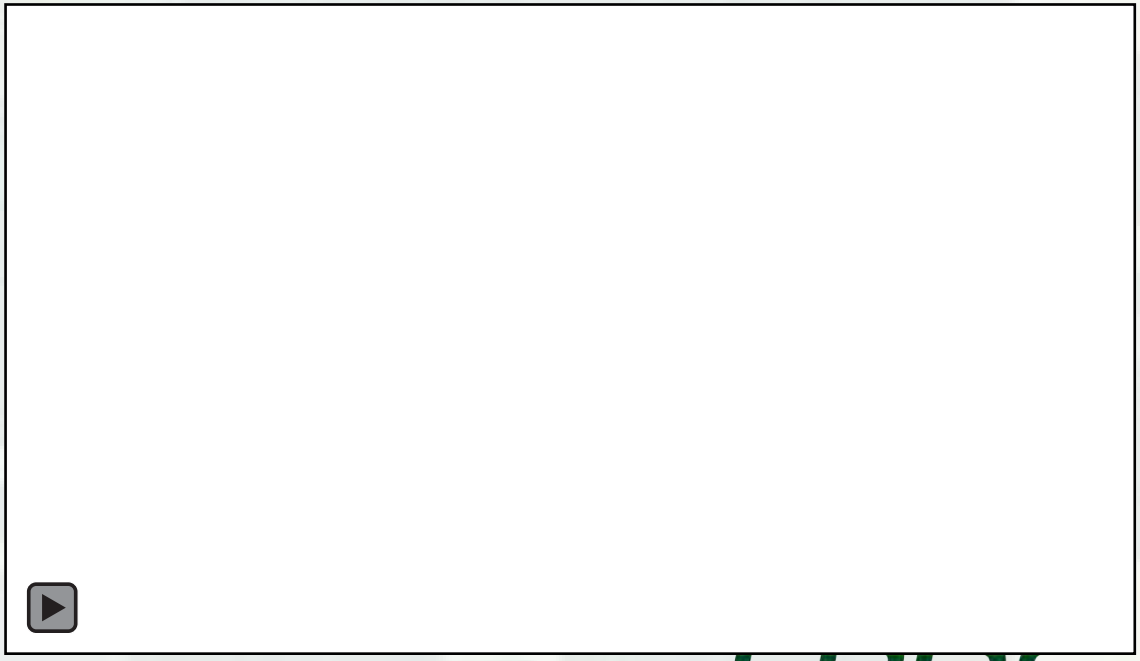
- Duration of elevated coastal waters impact on upland river flooding.
- Intrusion of surge tides through drainage networks.
- Impacts of SLR / Mitigation Decisions



Application of AdH Framework to Harvey

- 1.4 million nodes/2.6 million elements
- 80% of resolution in Harris county
- 0.5in/hr rainfall
- Addicks and Braker discharge into Buffalo Bayou from 226.5 cms (08/29/17) to 396.5 cms (08/30/2017)

Total Water Level (meters)



	Harris County	Buffalo Bayou	Others
Equation	2D-DWE	2D-SWE	2D-SWE
Wind	No	Yes	Yes
Pressure	No	Yes	Yes
Rain	Yes	Yes	No
Freshwater Inflow	No	Yes	No

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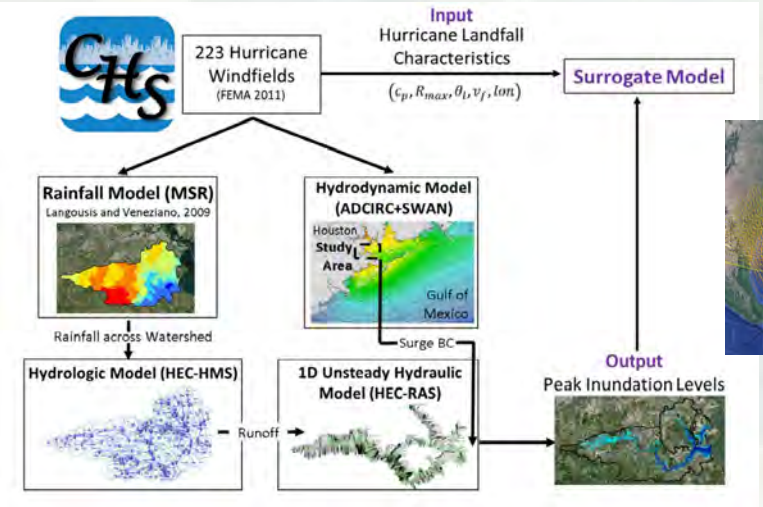
Combined Storm Surge & TC Rainfall Hazards

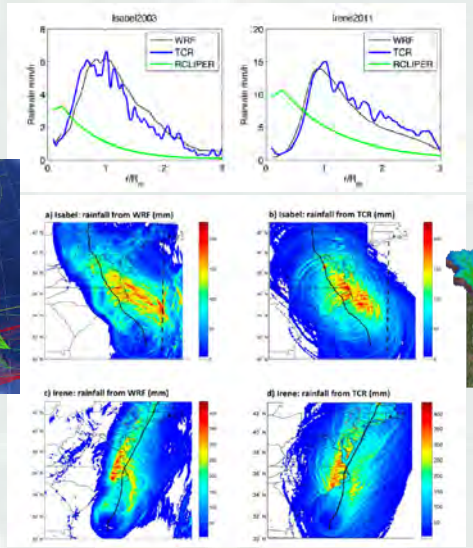
PCHA + Physics-based Parametric TC Rainfall Model

Bass and Bedient (2018)



CHS
3,700+
Synthetic TCs

Lu et al. (2018)



Thank You

Presenter Contact Information:

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