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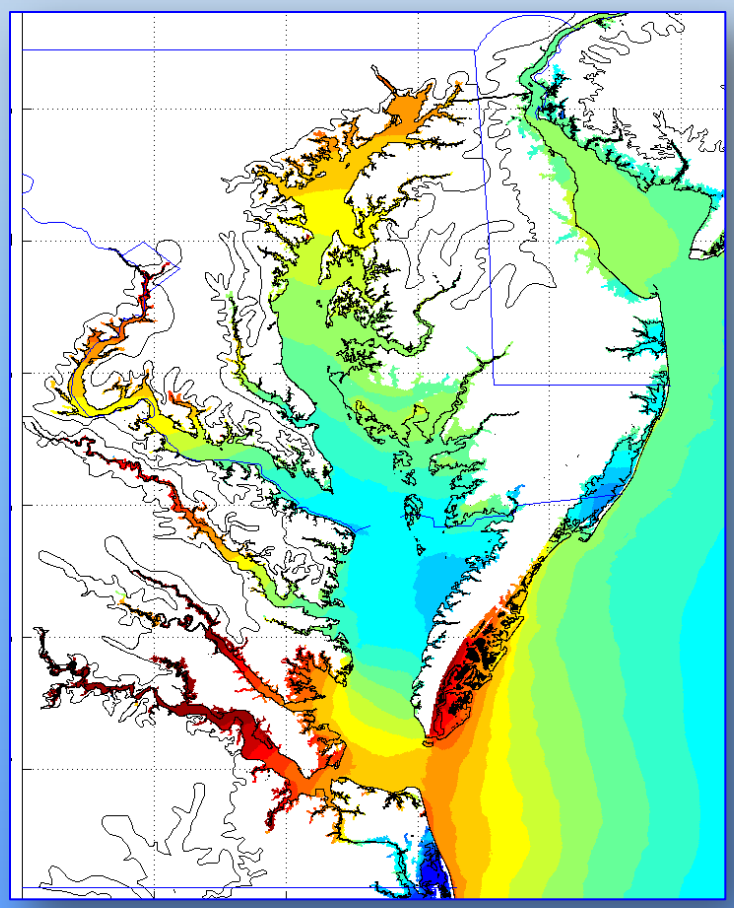
FEMA REGION III

COASTAL STORM SURGE STUDY



Mike Forte
Project Specialist

Jeff Hanson, Ph.D.
Project Leader

US Army Corps of Engineers

Engineering Research & Development Center

Field Research Facility

March 2013

Hampton Roads Sea Level Rise/
Flooding Adaptation Forum

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FEMA Region III Coastal Study

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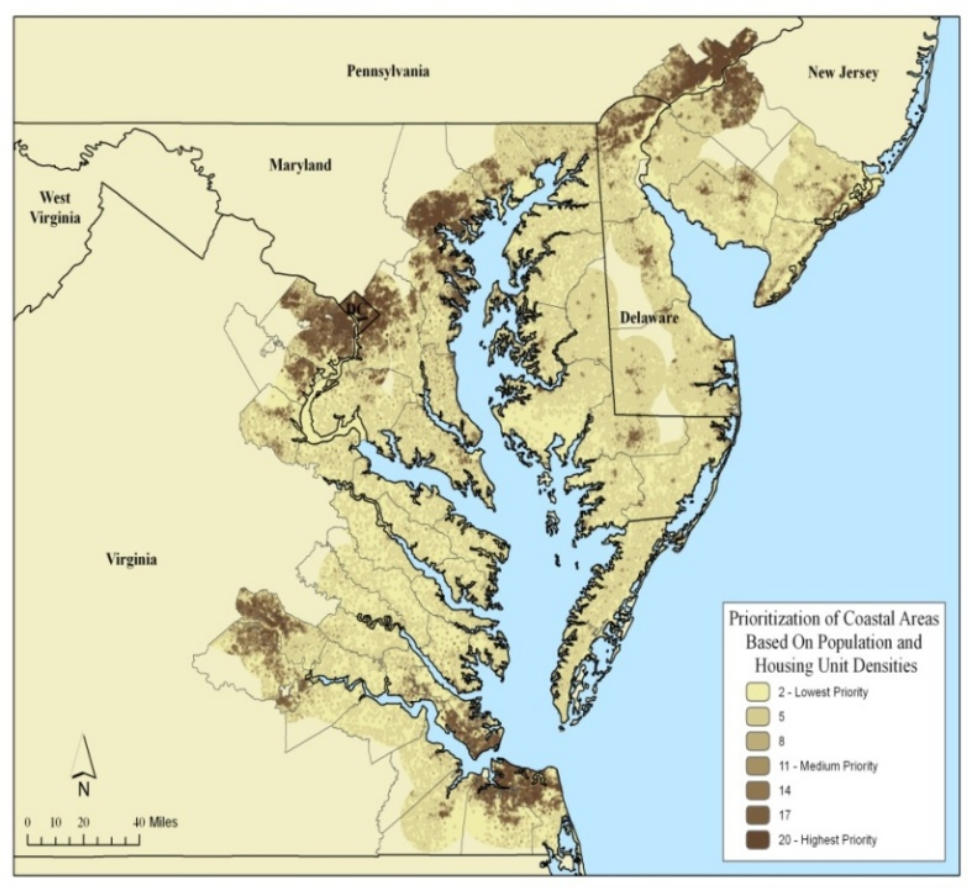
Region III Population Density



Study Motivation

- Implement New Guidelines:
  - *Atlantic Ocean and Gulf of Mexico Guidelines Update (2007)*
  - *Sheltered Water Report (2008)*
  - *PM 50 Limit of Moderate Wave Action (LiMWA) (2008)*

Study Area

- Influenced by six states
- Five metropolitan areas
- Complex coastal geomorphology
- A very ambitious coastal study!

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Study Partners

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USACE – Project Oversight, DEM, Model Validations, Extratropical Analysis, Mapping review

Renaissance Computing Institute – DEM, Modeling System, Production, GIS Viewer, Analysis

University of North Carolina – Water level modeling guidance

Applied Research Associates – Hurricanes, JPM Return Period Analysis

ARCADIS – DEM, Modeling Mesh

Oceanweather – Extratropical and Hurricane Wind Fields

Elizabeth City State University – GIS Displays

RAMPP – Study Review, Mapping Phase Lead

A JV of Dewberry, URS and ESP
RAMPP
Risk Assessment, Mapping, and Planning Partners

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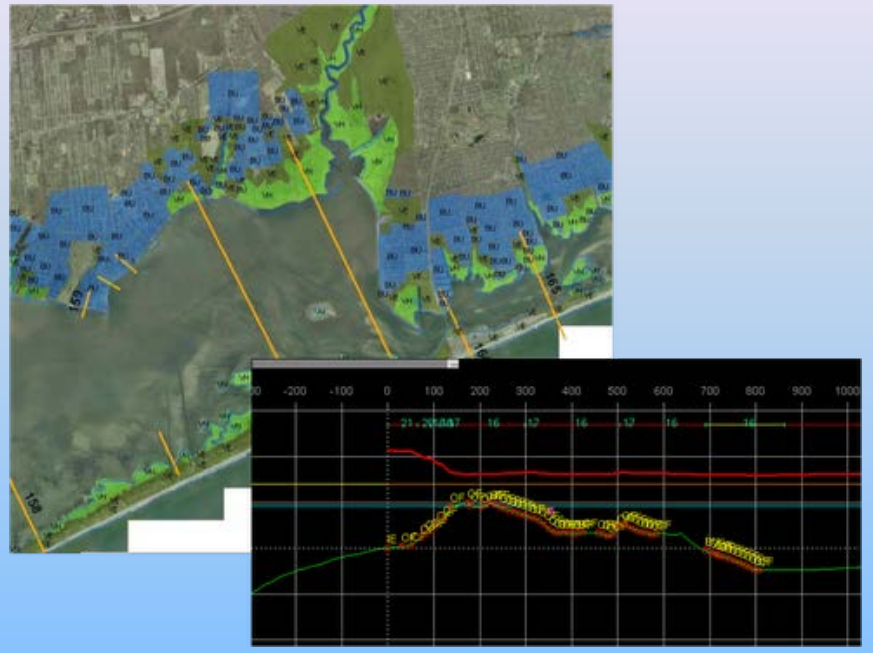
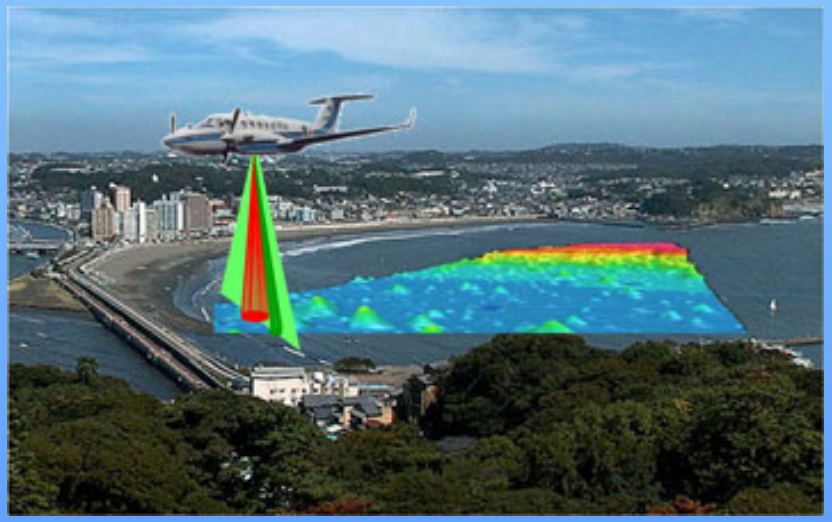
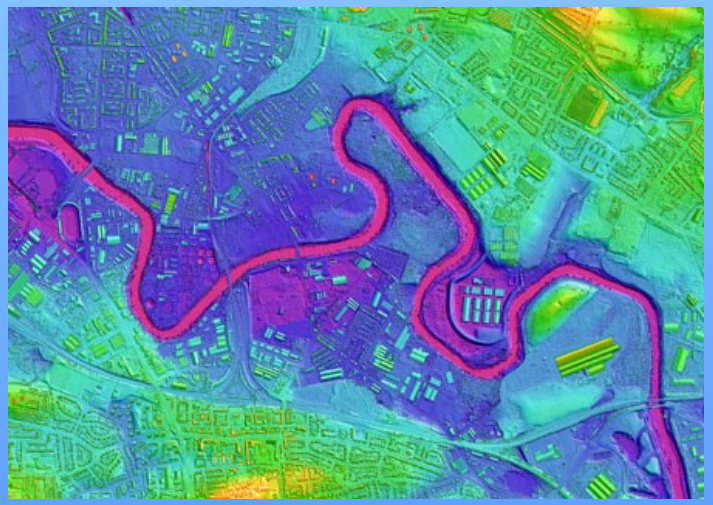
Why Update Now?

Modern Advances

- Longer gage records (20+ years longer)
- Improved models – Hurricane Katrina
- High-performance computers
- High-resolution LiDAR survey data







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Modeling Foundation: Digital Elevation Model (DEM)

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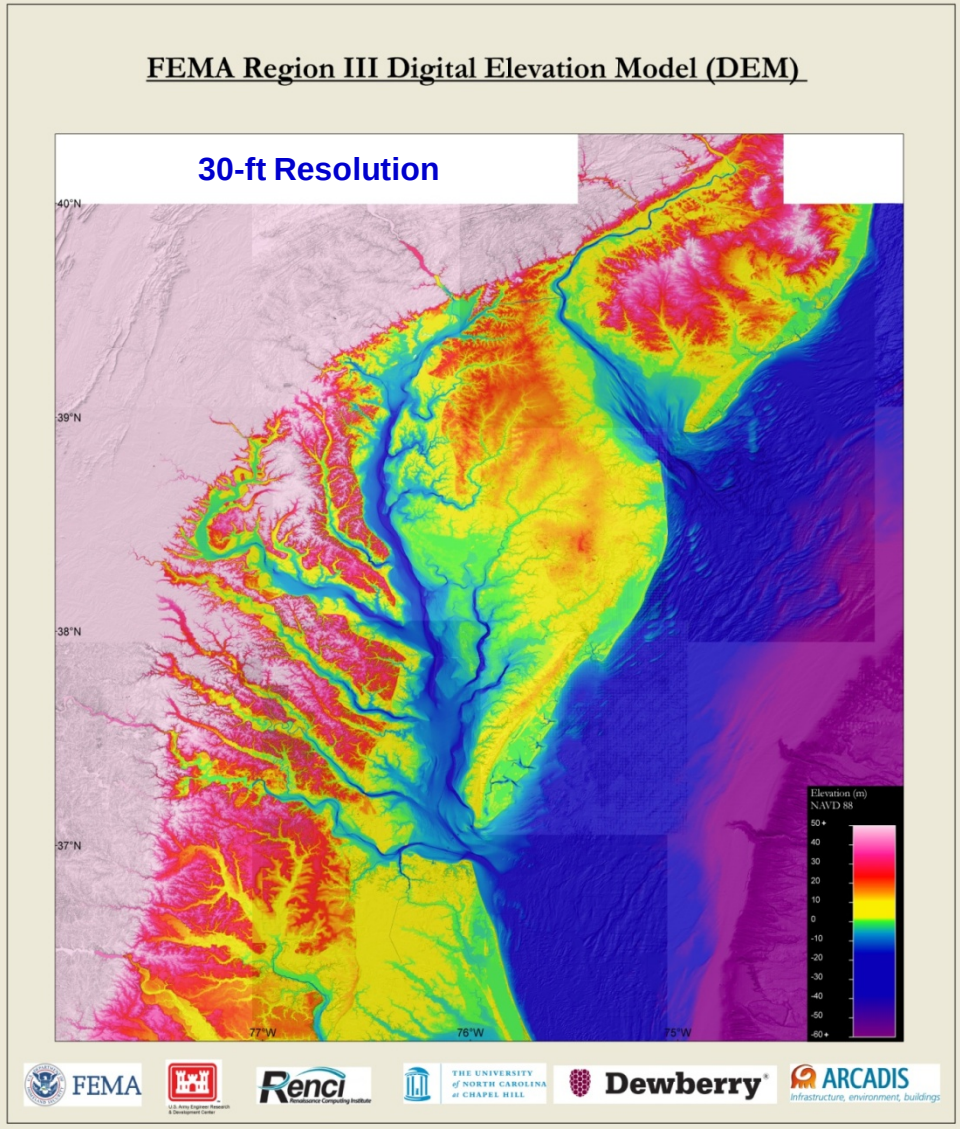
A National Resource

- Most complete, up to date, bathy-topo surface available for Mid-Atlantic Region
- Comprised of 120 datasets (~2TB)
- LiDAR used where available
- Consistent elevation surface with 30-ft horizontal resolution
- Provides quality foundation for storm surge modeling



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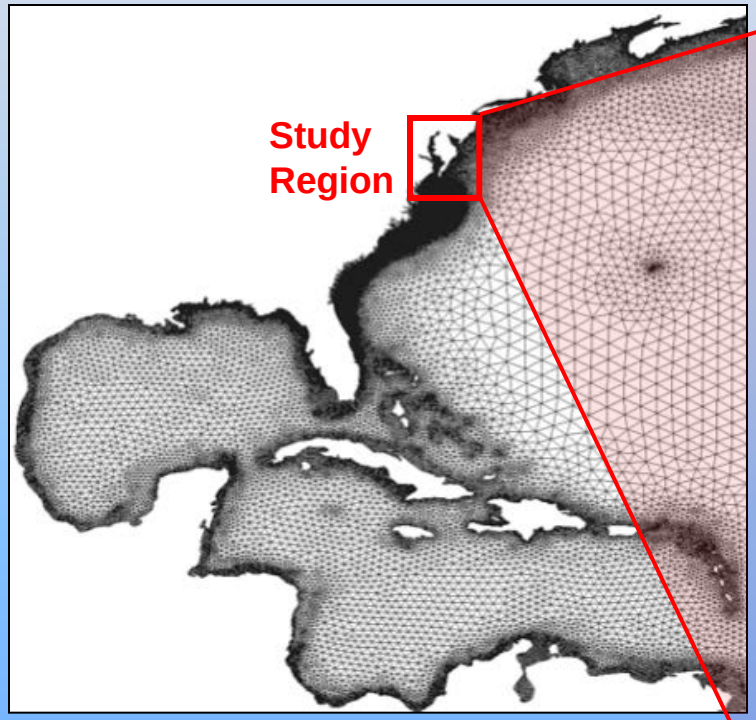
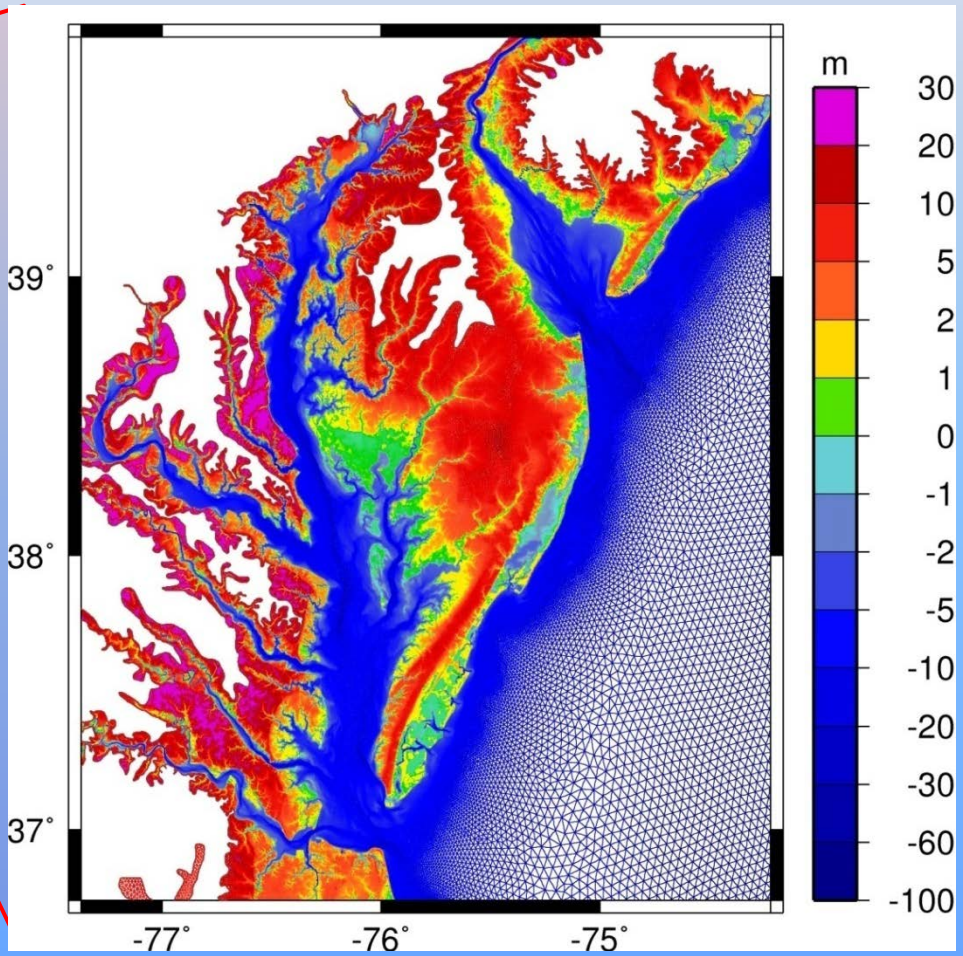
Unstructured Modeling Mesh

DEM Interpolated onto Mesh Elements

Western Atlantic Mesh



Rich Detail in Study Area



- Specifies land elevation at each calculation point
- Provides a framework for all model components

A Significant Advancement

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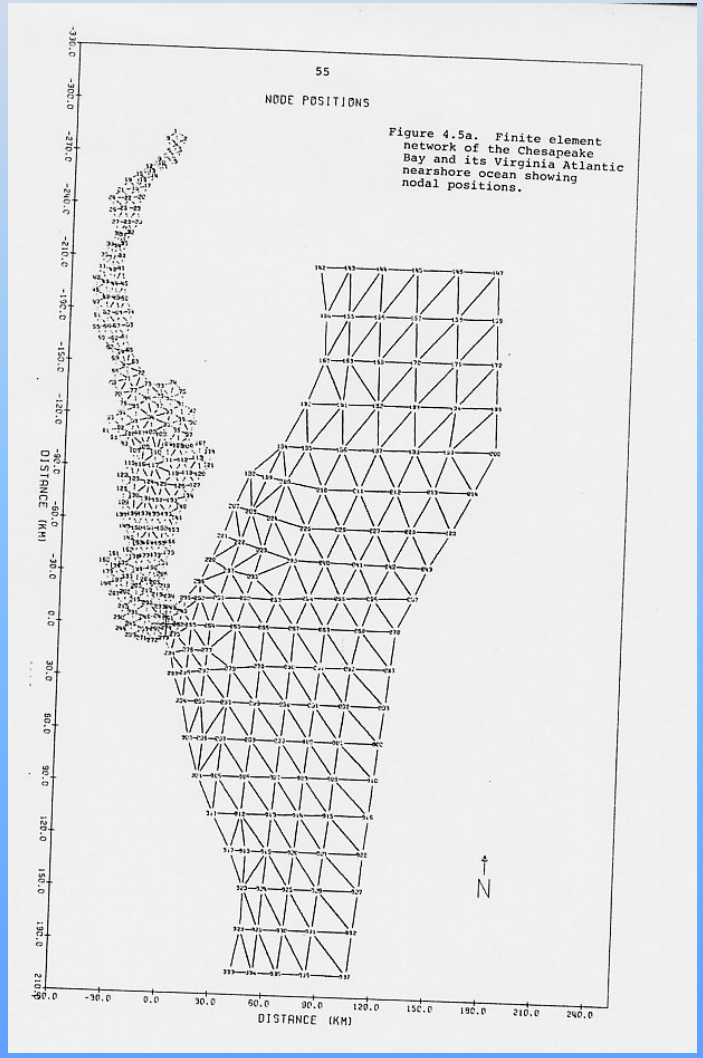
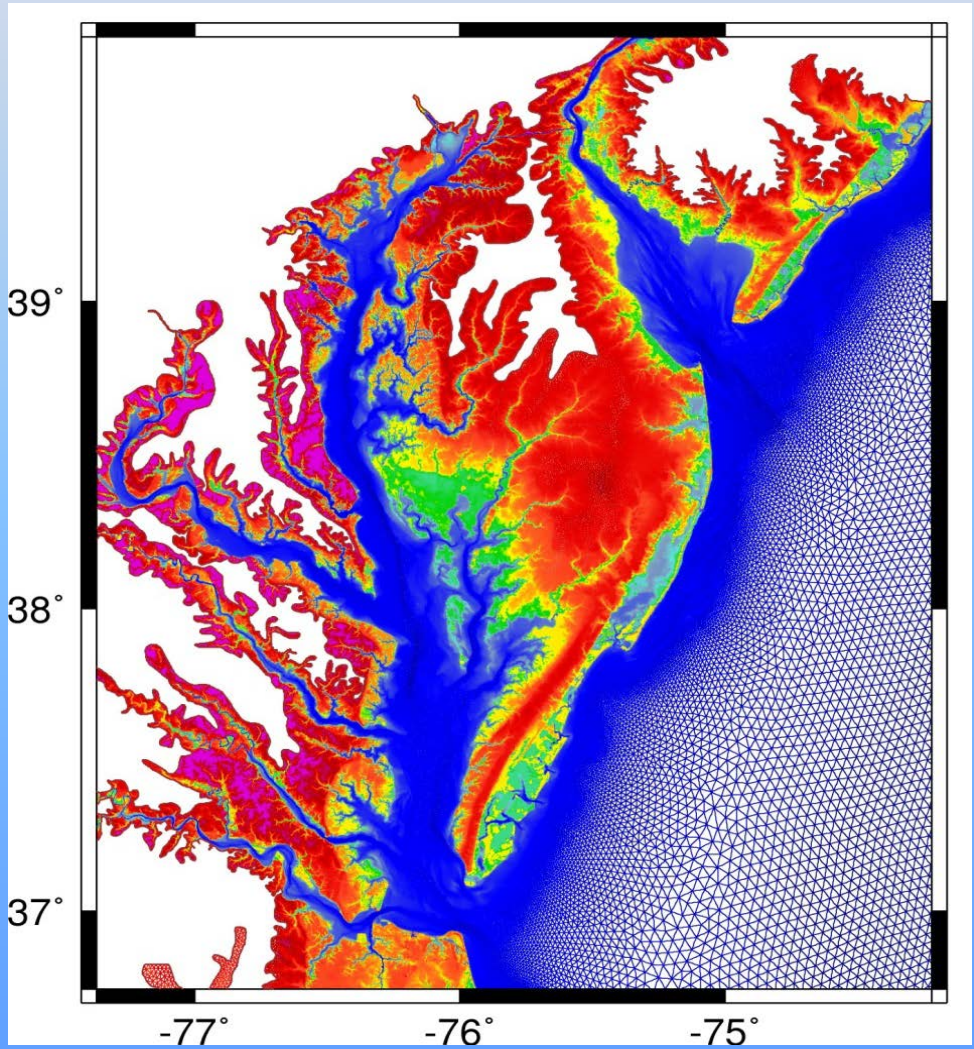
1978 Mesh
3-6 mile resolution



2011 Mesh
100 ft Minimum Resolution



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Storm Surge Modeling System

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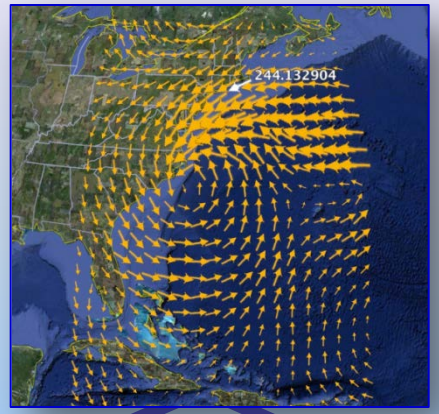
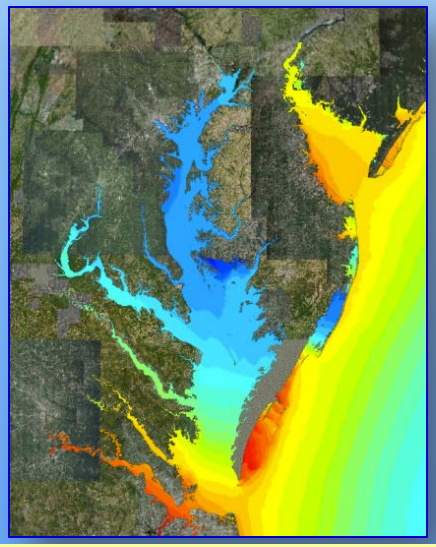
Model Components



Atmospheric Forcing
- Wind and Pressure Fields

HBL Hurricane Boundary Layer Model
Extratropical Storm Reconstructions

Circulation Model
- Tides, - Currents



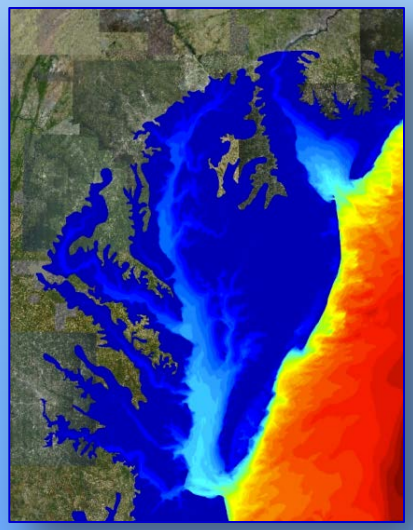
ADCIRC
Advanced CIRCulation model

Coupling

Water Levels

Wave Stress

Wave Model
- Surface waves



unSWAN
un-structured Simulating WAves Nearshore model

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Modeling System Validation

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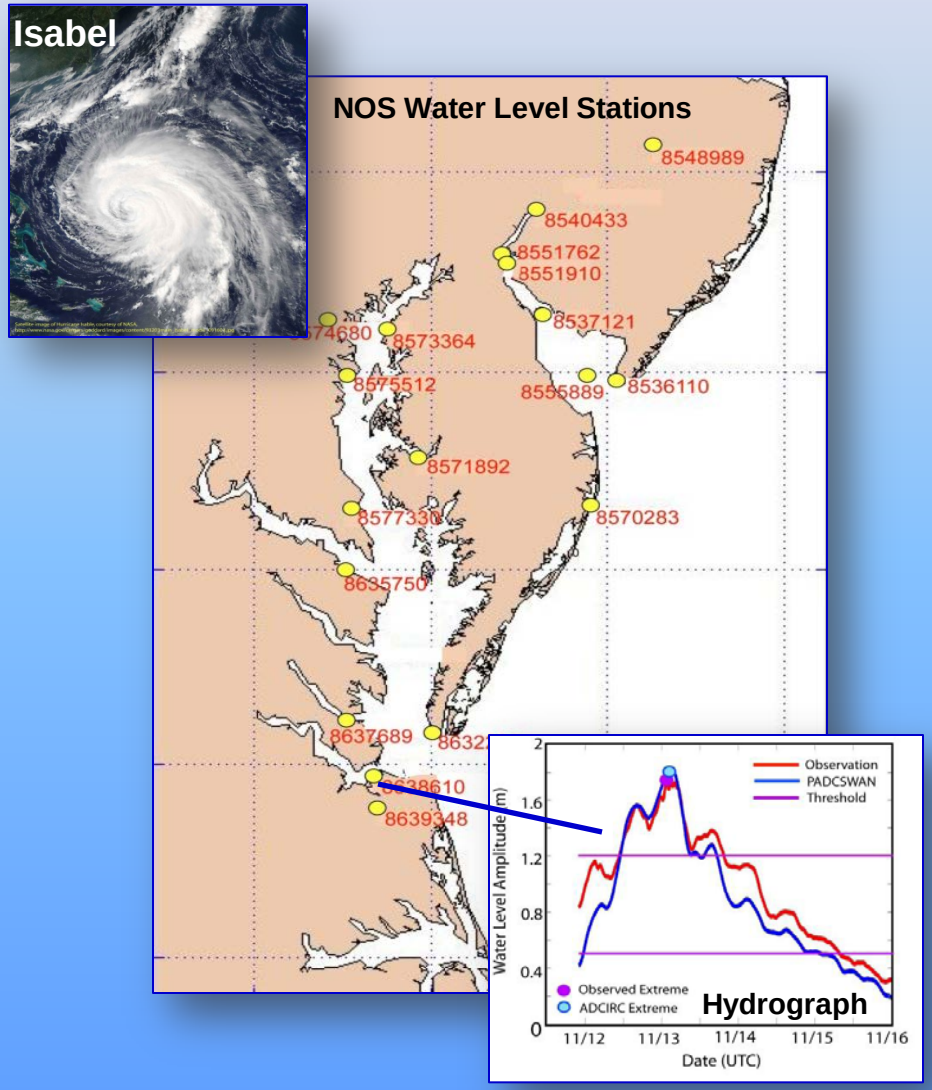
A Critical Step in the Storm Surge Study

Why Validate?

- Establish credibility
- Quantify expected errors
- Demonstrate accuracy
- Build confidence that model can be applied over range of conditions



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Validation Storms

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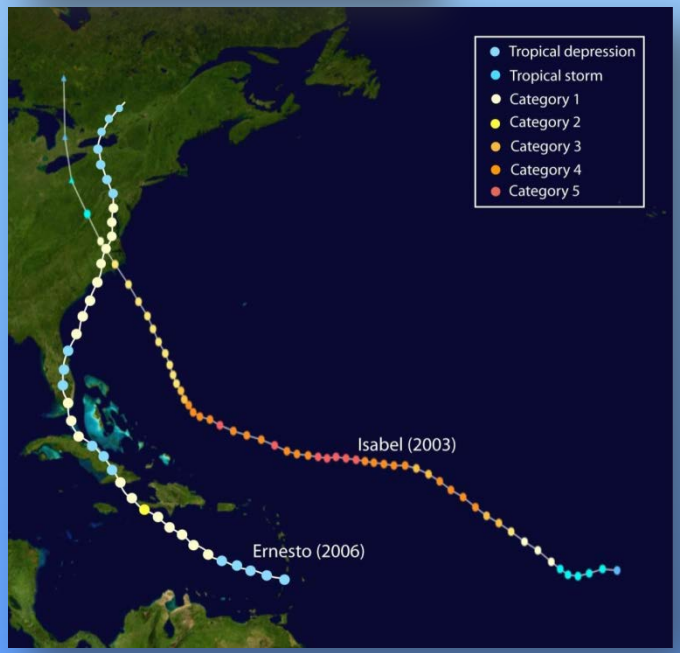
Event Reconstruction

- Three major storms selected
  - Hurricane Isabel
  - Hurricane Ernesto
  - Extratropical Storm Ida (Nor'Ida)

Extra-Tropical Storm Ida, Norfolk, VA



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Nor'Ida: USGS Rapid Response

Water Level Validation

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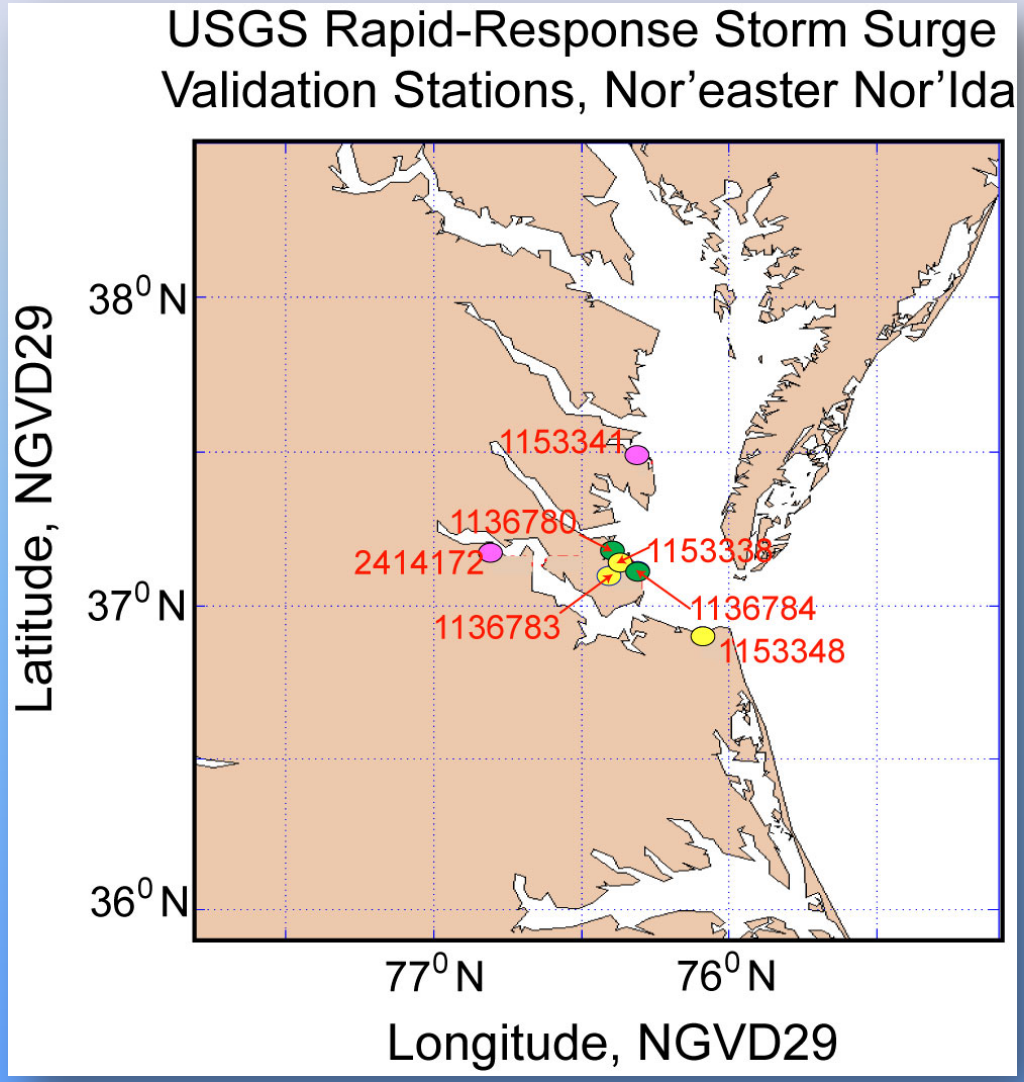

Rapid Response:

- Water level gauges deployed on land in projected storm path
- Observations and validations include tides
- Four stations inundated by Nor'Ida

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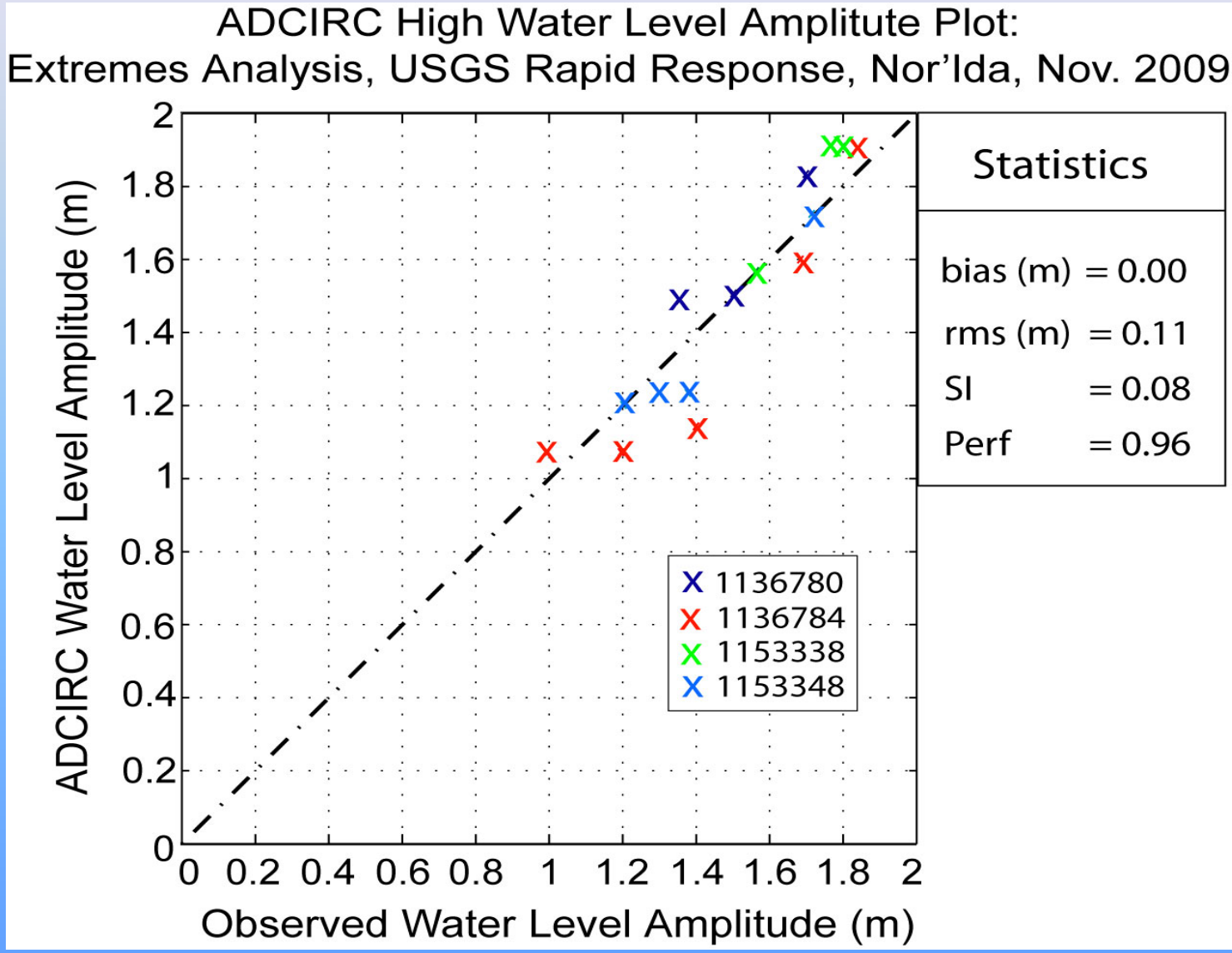
Nor'Ida: USGS Rapid Response

Peak Water Levels

FEMA



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Example Hurricane Isabel Water Levels

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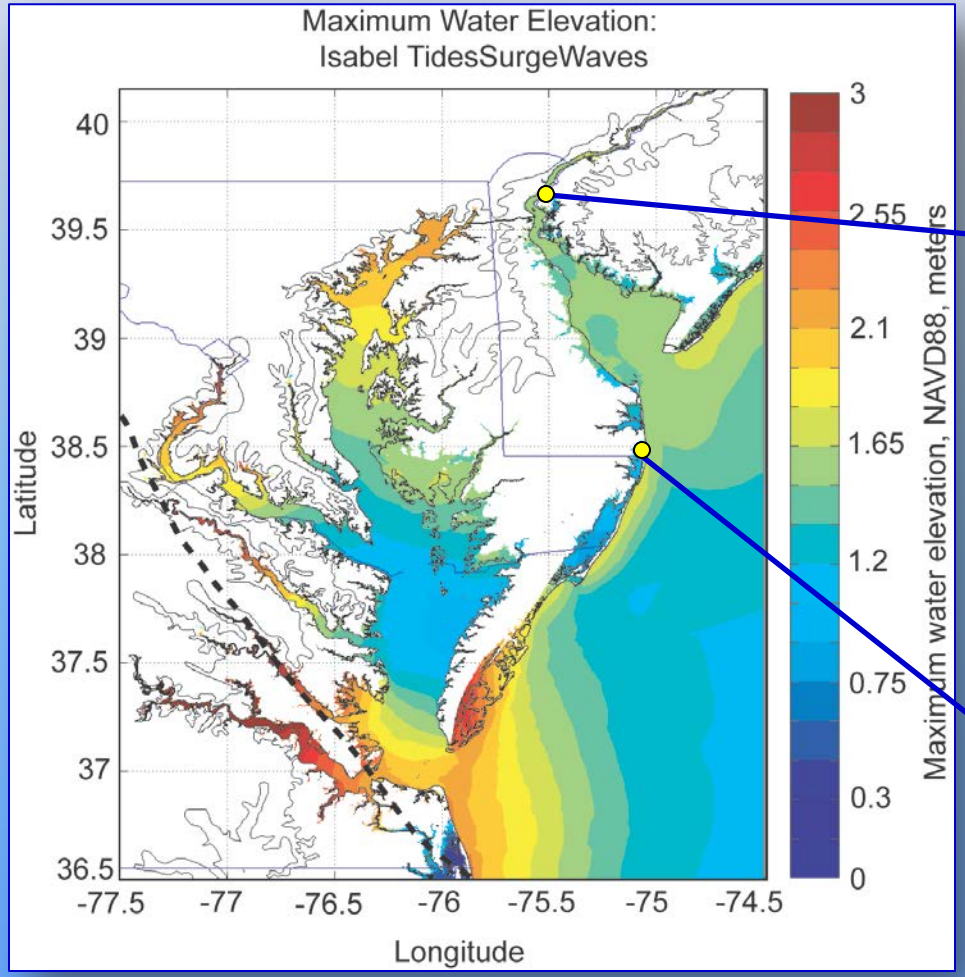
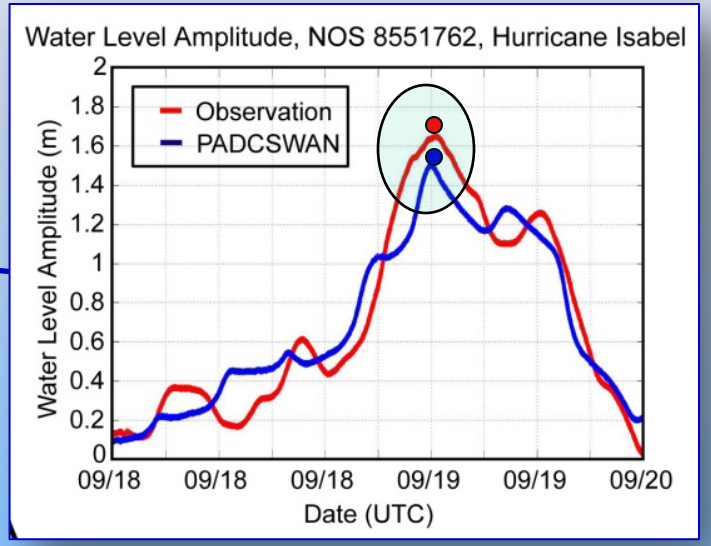
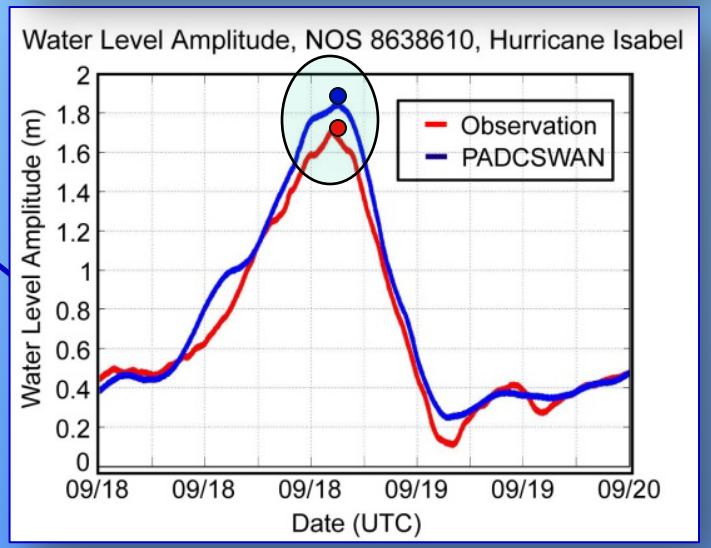
Max Elevation (m)



Hydrographs (m)





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Modeling System Validation

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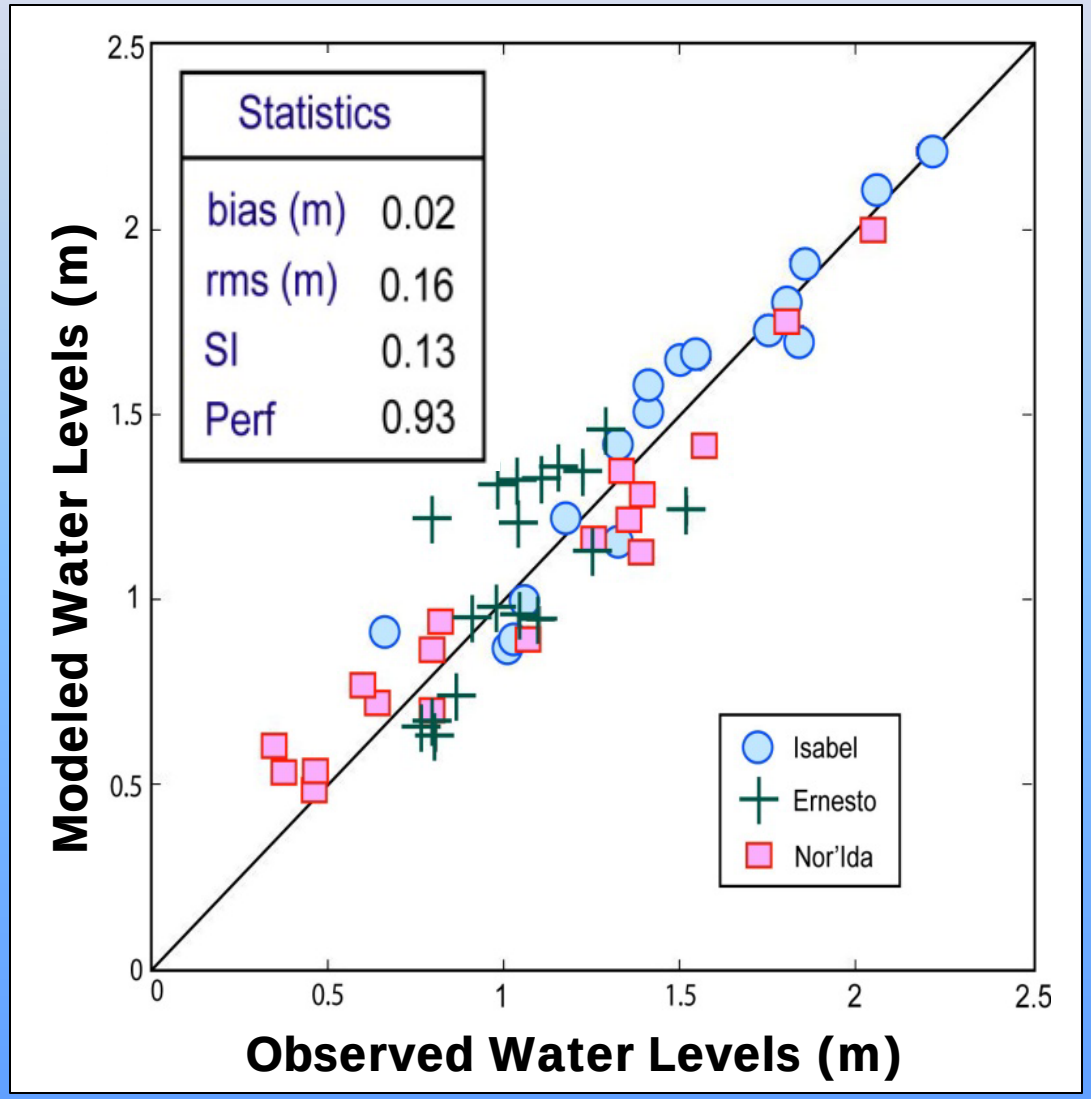
Peak Water levels – NOS Stations



Validation Results

- Modeling system demonstrates an extremely high skill level
- Average offset is < 1 inch
- Mean square error is only 6 inches

Conclusion

- System can be applied with confidence across the Region III Domain for the Risk MAP program

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Production Run Storms

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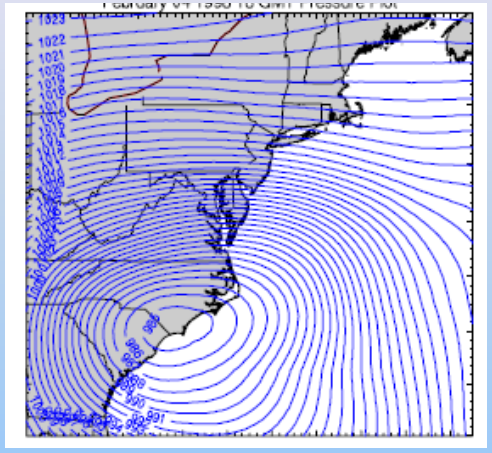
Extratropical Storms

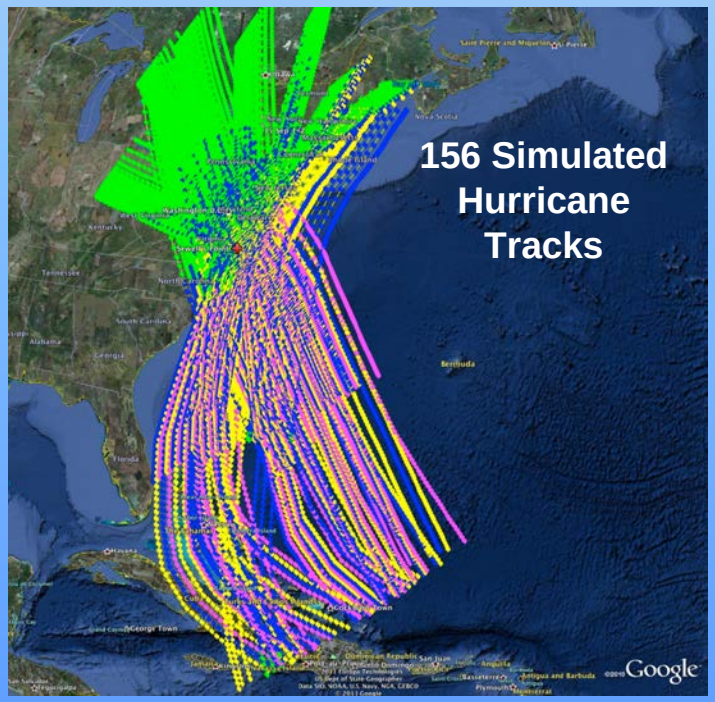
- 30 Top ranked storms 1975-2009
- Based on water levels at 10 stations
- Careful reanalysis of wind/pressure fields

February 4, 1998 Pressure Field



Tropical Storms

- Record of 20 hurricanes in 60 years insufficient for 100- yr analysis
- 156 Representative events sampled from ASCE 100,000-year synthetic storm set
- A 1-year effort!
- Intensities range from Tropical Storm to Cat 3



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Sample Results

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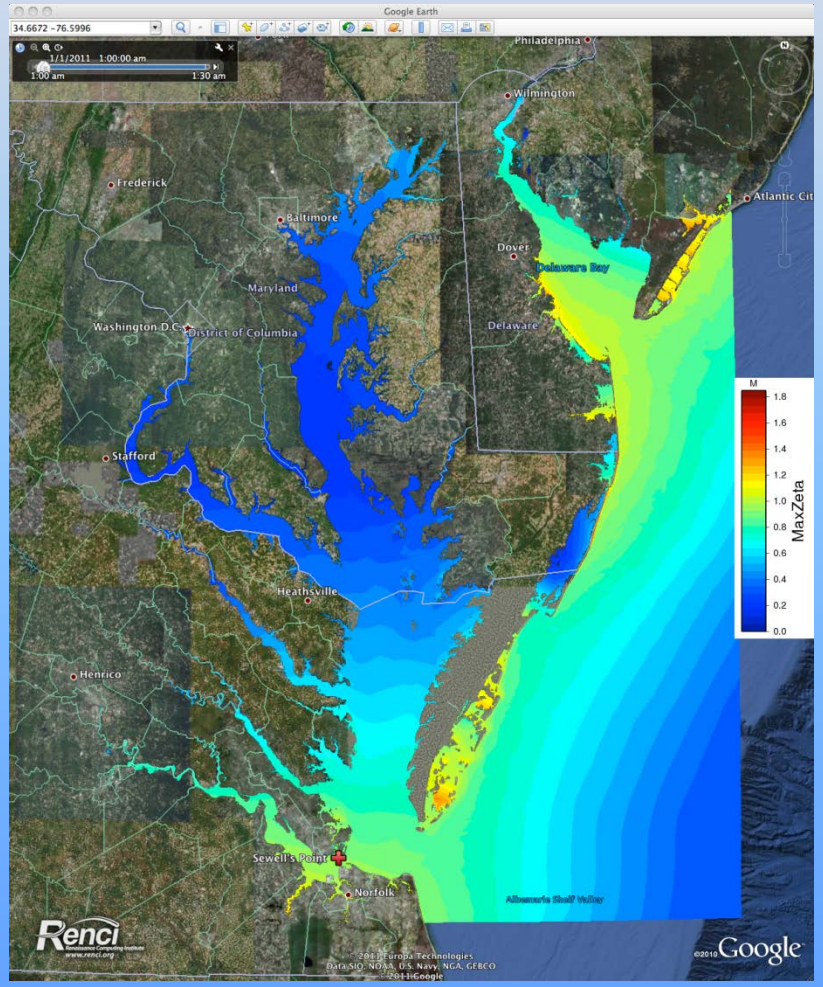
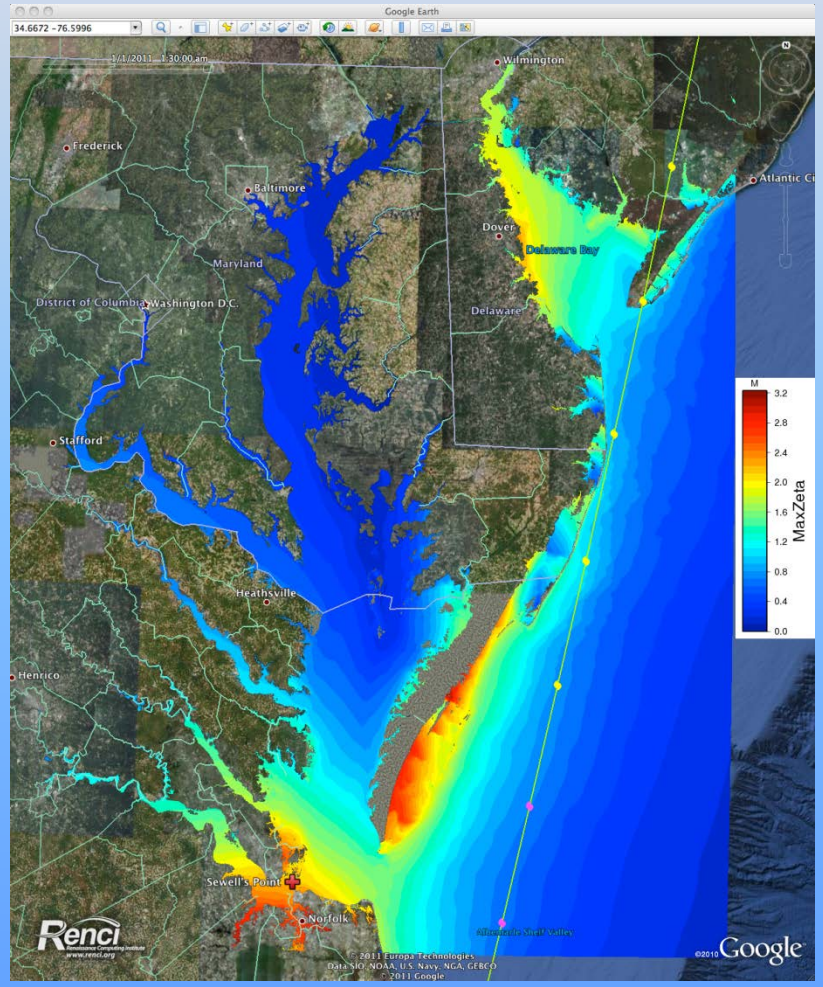
Maximum Water Elevations (m)

Extratropical Storm
2005 10 25



Tropical Storm
dp3rlblclh5ll



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Reoccurrence Analysis

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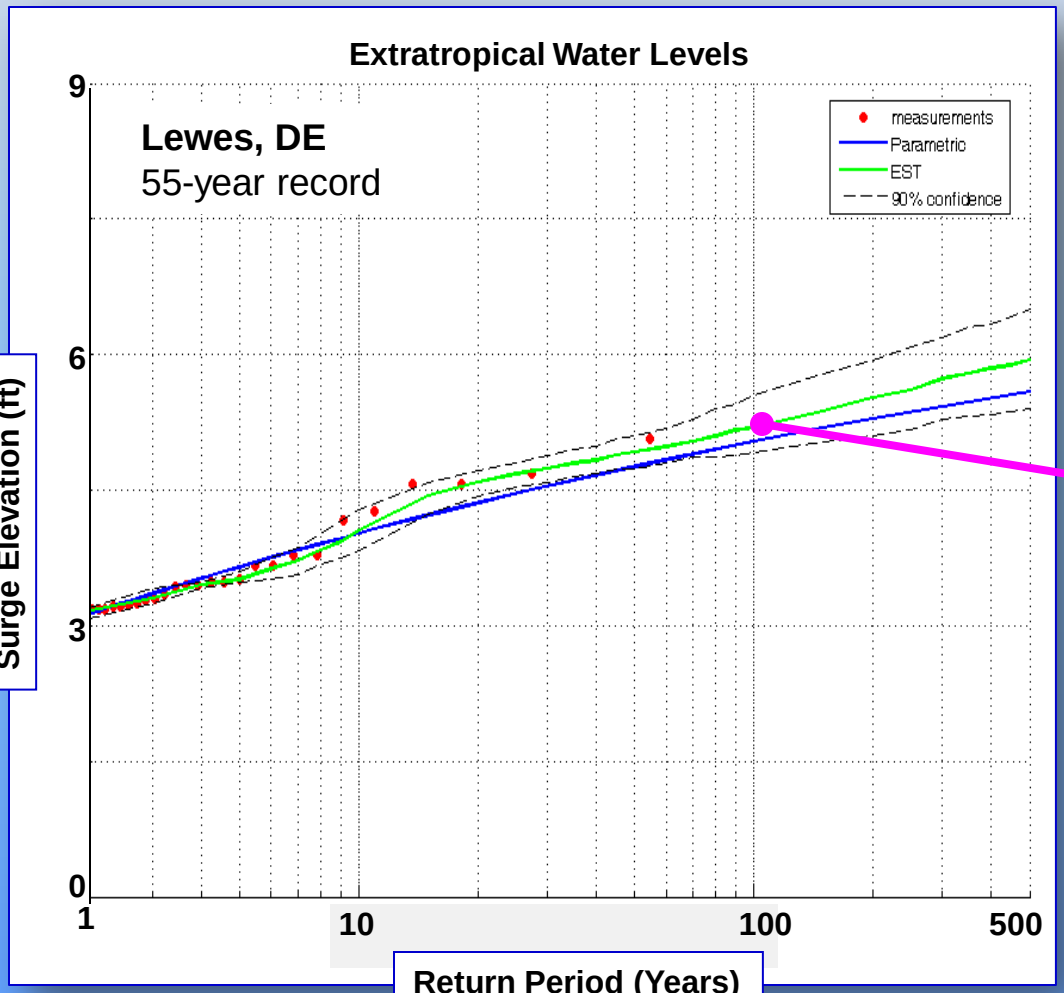
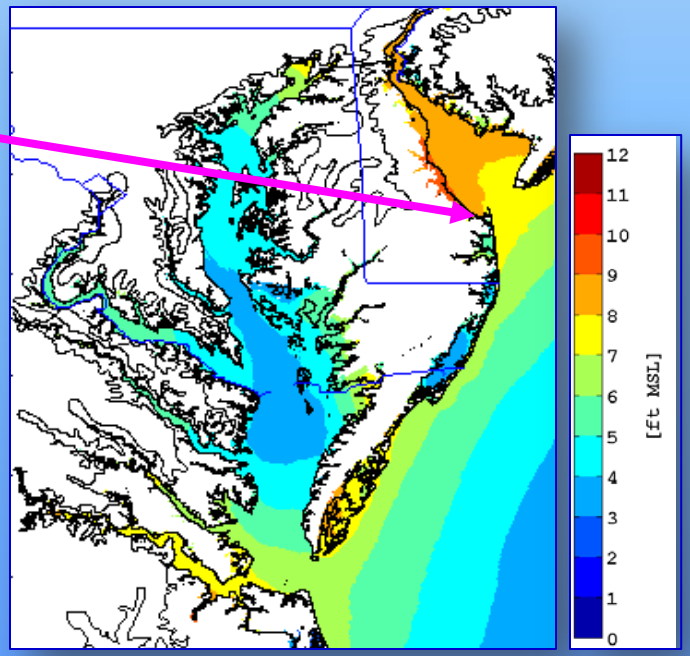
A Projection of Future Flood Risk



Combined Analysis

- Extratropical water levels
- Hurricane water levels
- Tidal contributions

Combined 100-yr Water Levels (ft)



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Updated 100-yr Water Levels (MSL)

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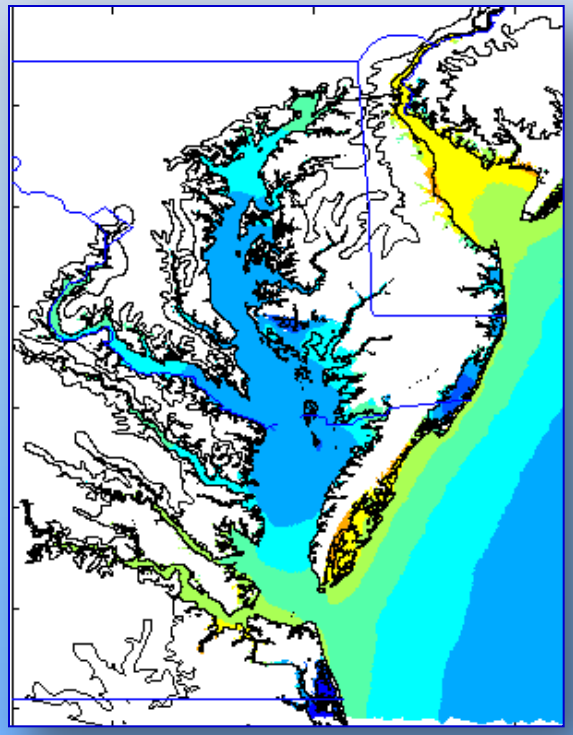
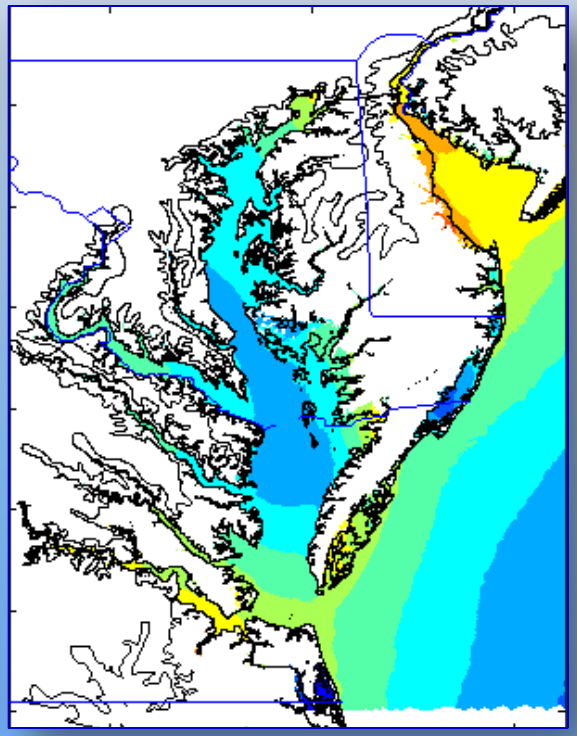
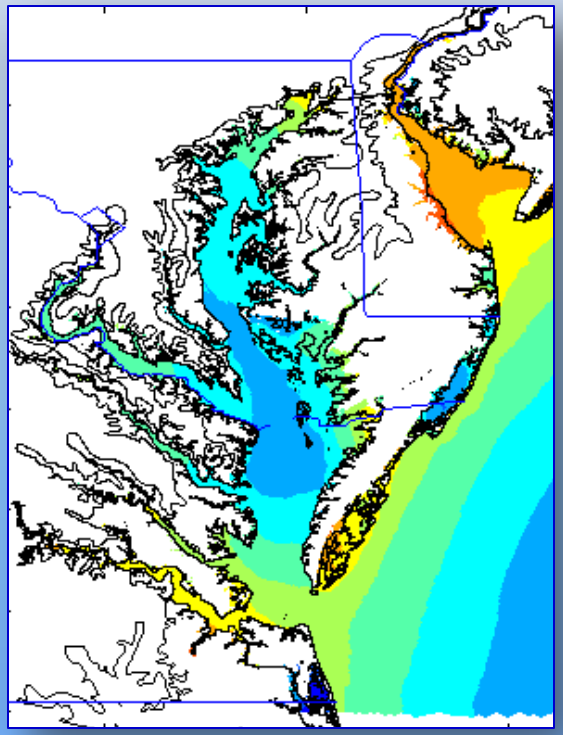
Hurricanes

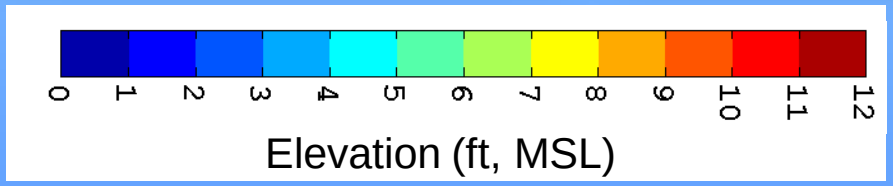


Extratropicals



Combined





On average, updated results are 0.5-ft lower than published levels

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Tidal Contributions

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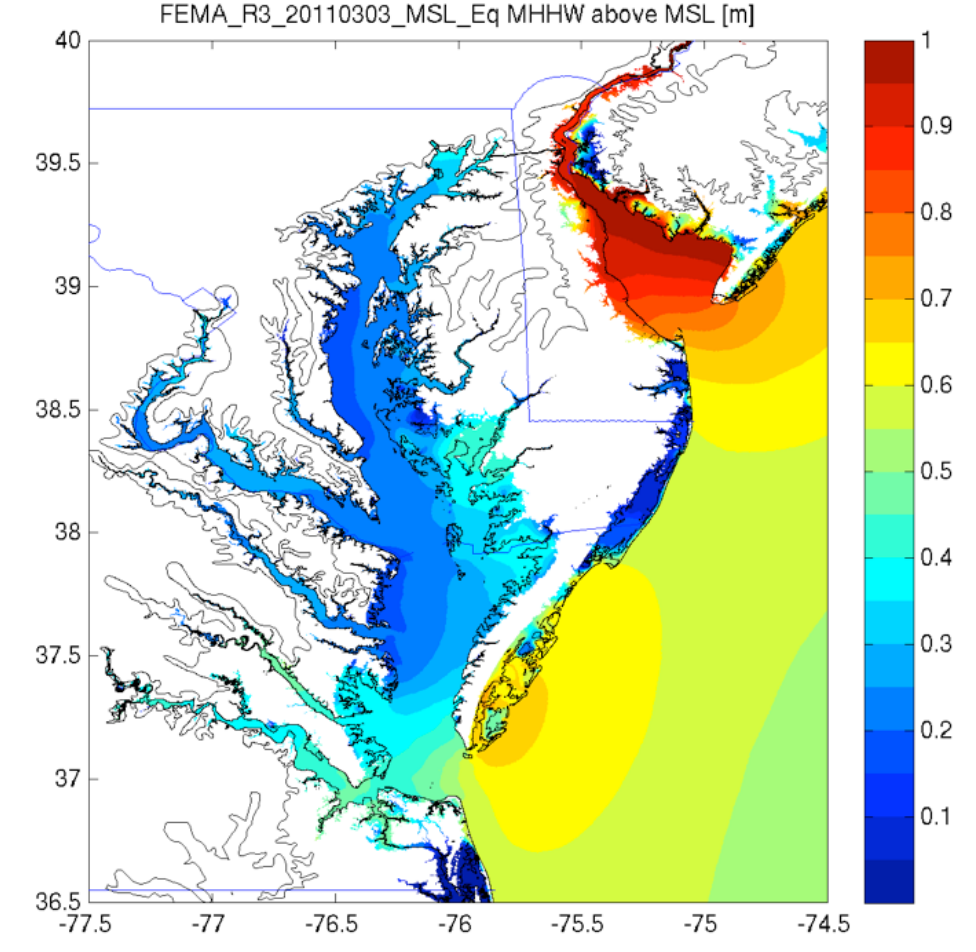
Average High Tide Elevation

MHHW above MSL (m)



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Study Results

DODReports.com

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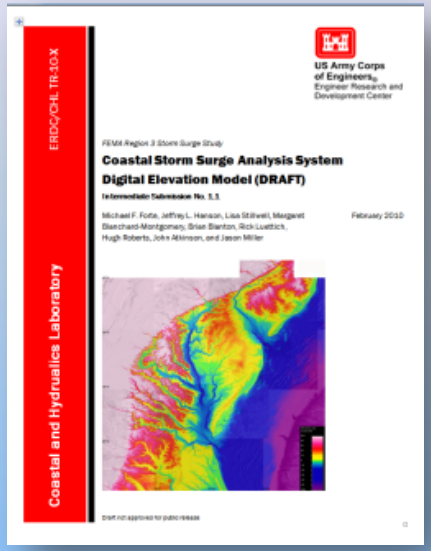
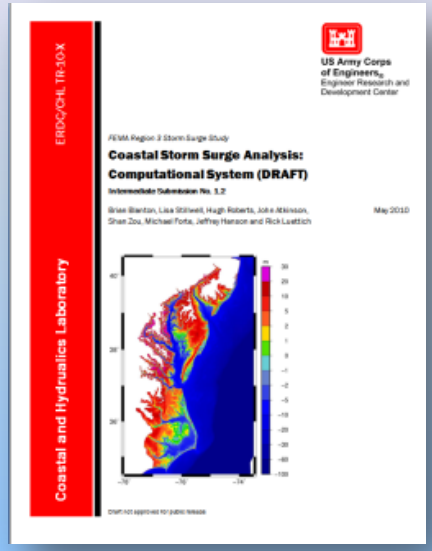
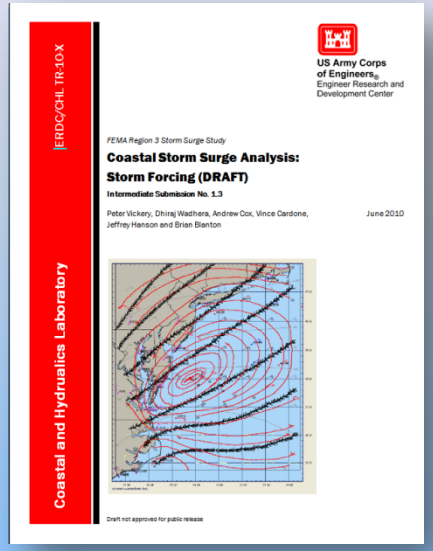
1.1 DEM



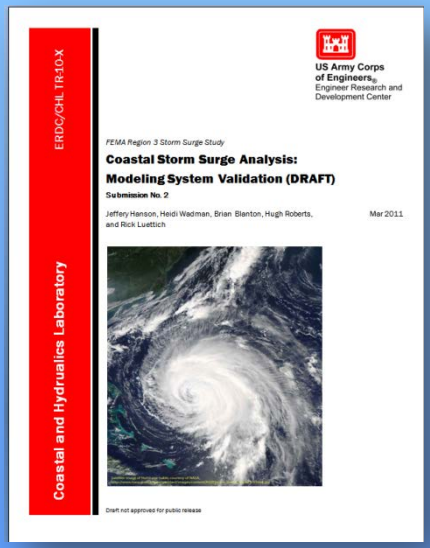
1.2 Modeling System



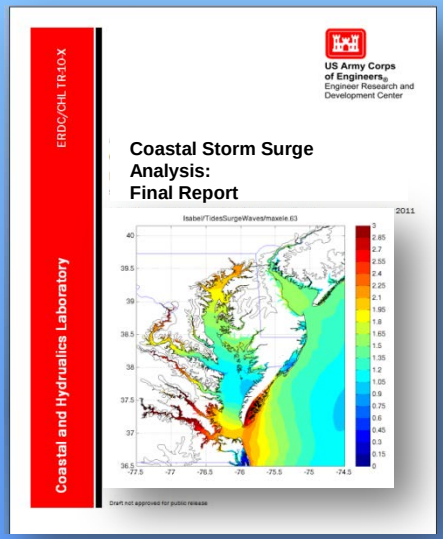
1.3 Storm Forcing



2. Model Validation



3. Final Analysis



- Methods and results
- Multi-tiered review
- Released as formal reports
- Available at http://dodreports.com/