



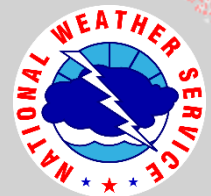
Real-Time Storm Surge Products

Cody Fritz

L324 Hurricane Preparedness for Decision Makers

Miami, Florida

2018



Storm Surge Products

Pre-Computed

MEOWs

Maximum Envelopes Of Water

MOMs

Maximum Of the MEOWs

Real-Time

Probabilistic Storm Surge (Psurge)

Potential Storm Surge Flooding Graphic

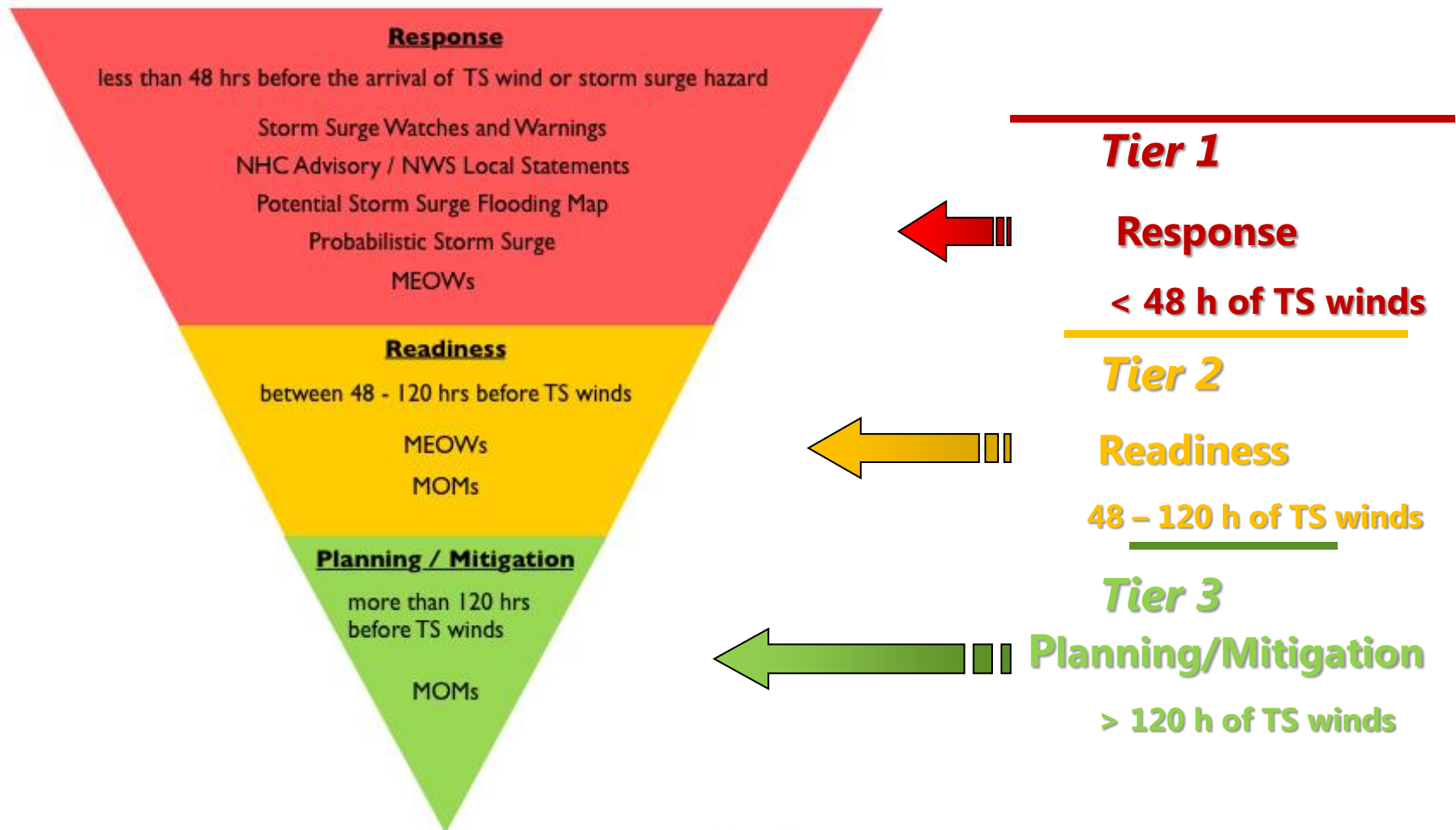
Storm Surge Watch/Warning



Storm Surge Guidance Timeframe

NHC Storm Surge Product Decision Support Wedge

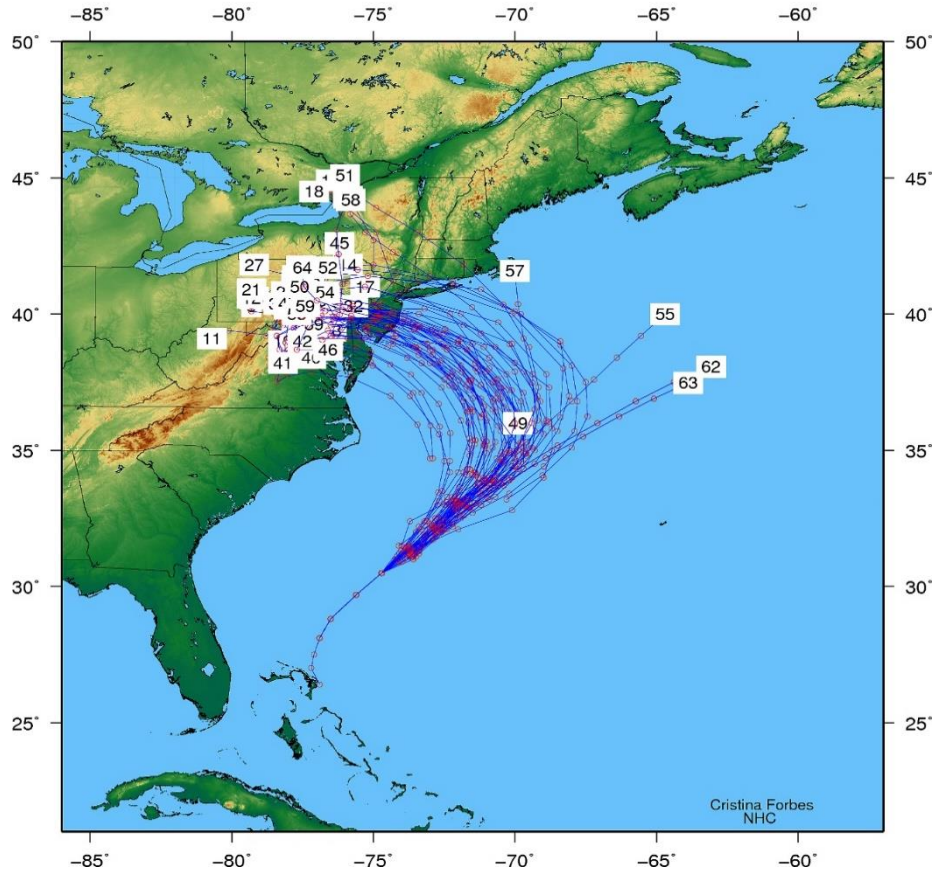
Decision Support Wedge Based on the Arrival of Tropical-Storm-Force Winds



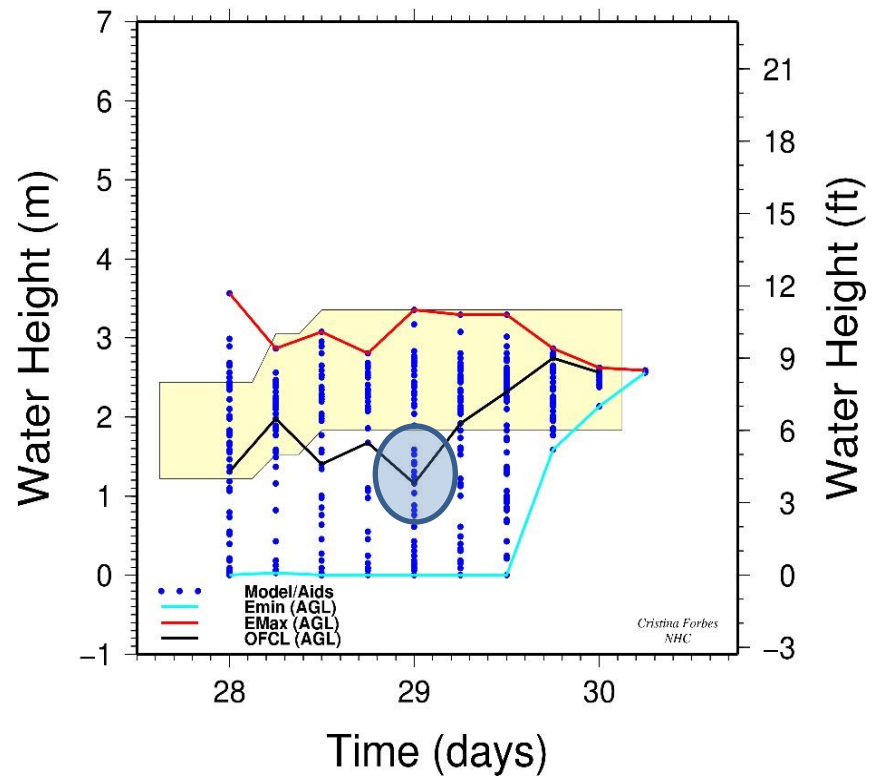
NHC / The COMET Program

Why Probabilistic?

SLOSH Basin ny3
Time of Forecast Advisory 2012102800

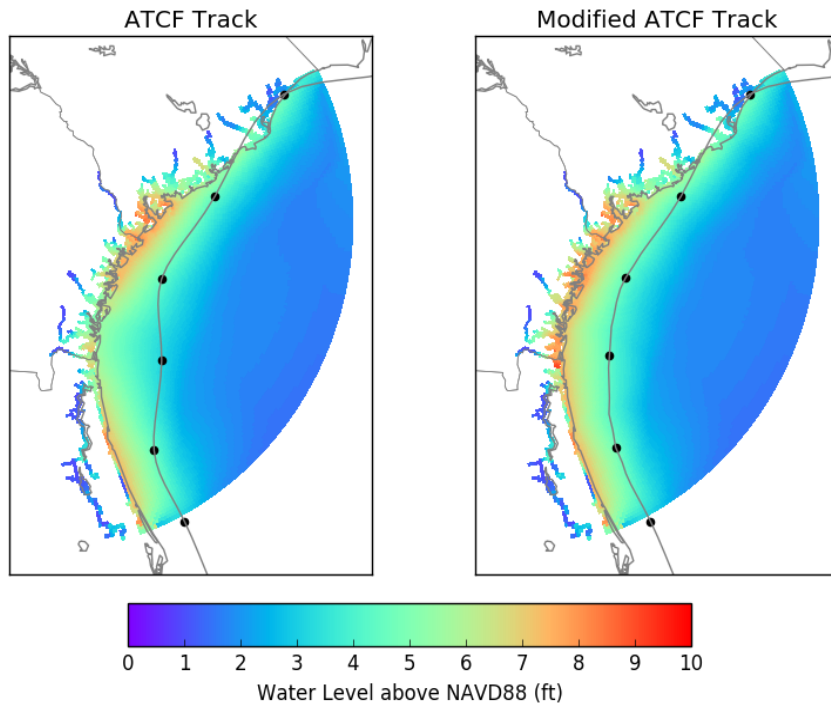


Trend of Water Height Above Ground
al182012 – ny3

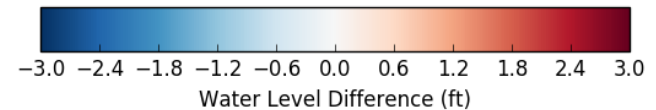
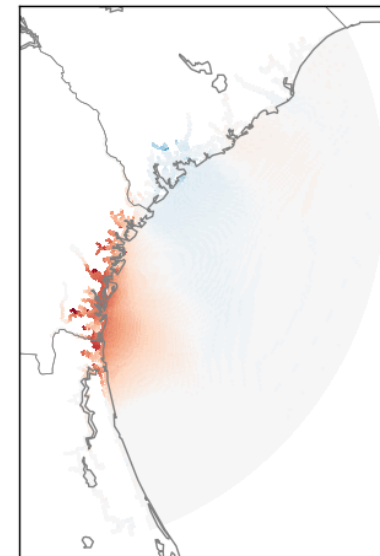


Forbes C., J. Rhome, C. Mattocks, A. Taylor, 2014: Predicting the Storm Surge Threat of Hurricane Sandy with the NWS SLOSH Model, *Journal of Marine Science and Engineering*, in press.

Why Probabilistic



Modified ATCF Track - ATCF Track



A dark, moody photograph of a storm surge with waves crashing onto a sandy beach under a heavy, grey sky. The image is used as a background for the title text.

P-surge **Probabilistic Storm Surge**

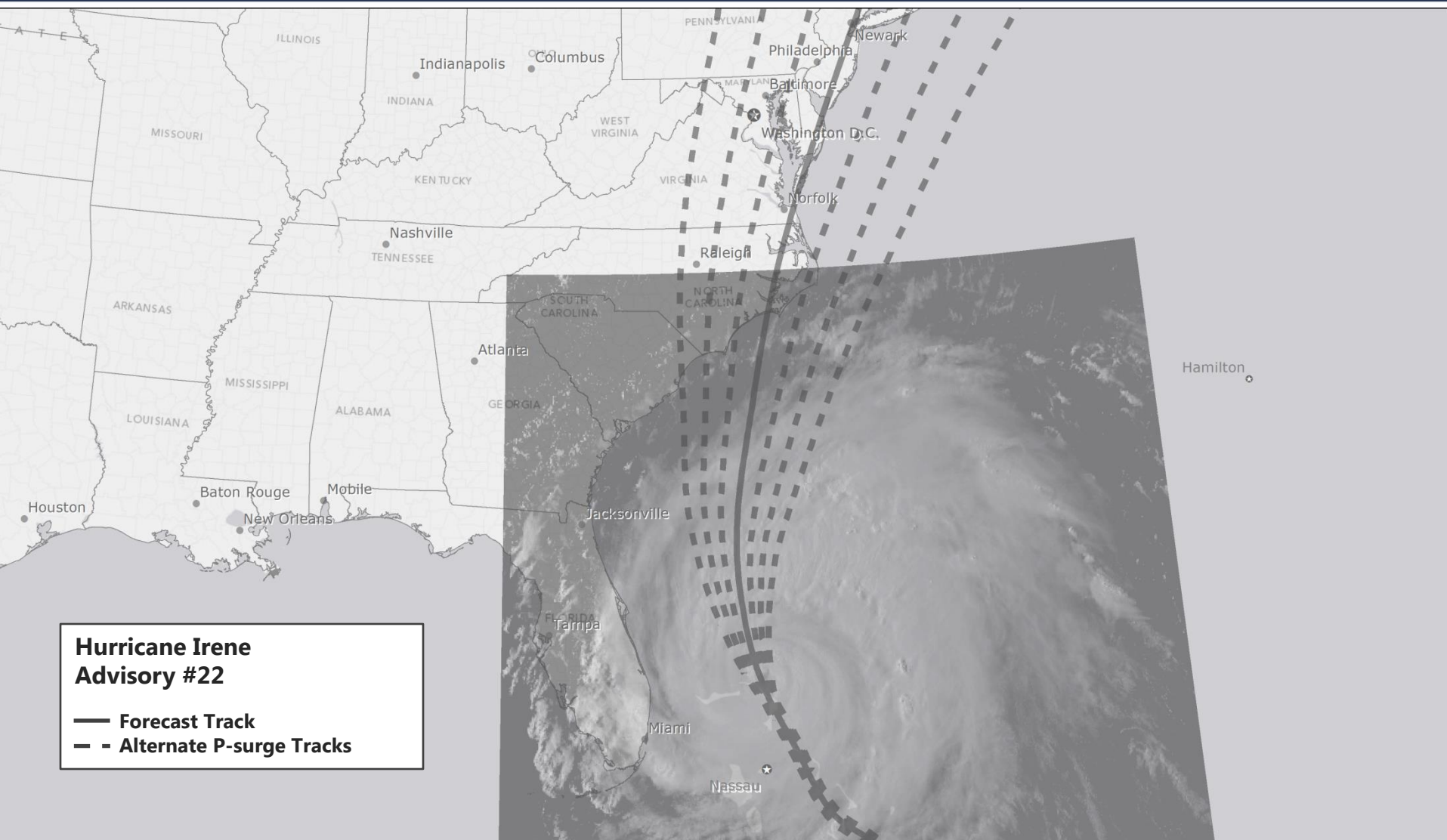


Probabilistic Storm Surge (P-surge)

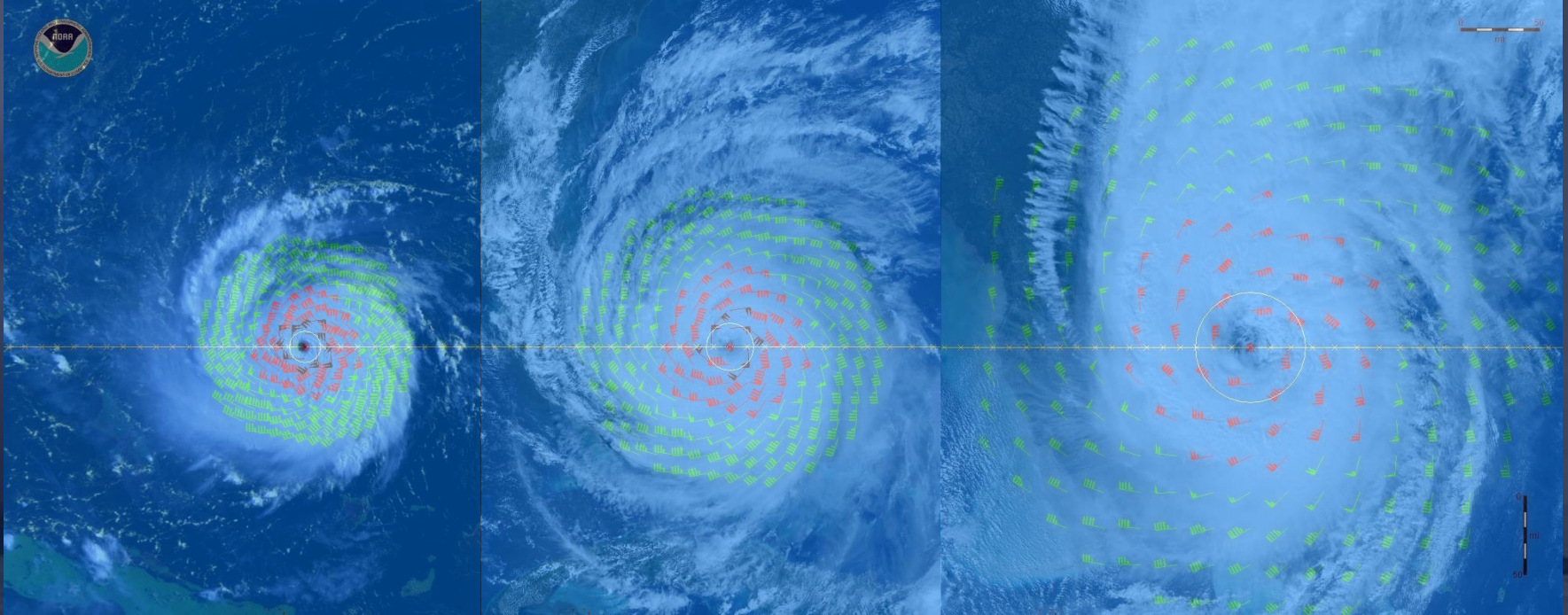
- Storm surge probabilities **based on NHC official advisory**
- **Available approximately 48 hours prior to arrival of TS winds**
- **Accounts for uncertainty in:**
 - Track / landfall location
 - Size
 - Forward speed
 - Intensity
- **Uncertainties based on historical errors**
- **Version 2.x also accounts for the tide and is available above NAVD88 and above ground level**



Probabilistic Storm Surge (P-surge) Multiple Tracks and Landfall Locations



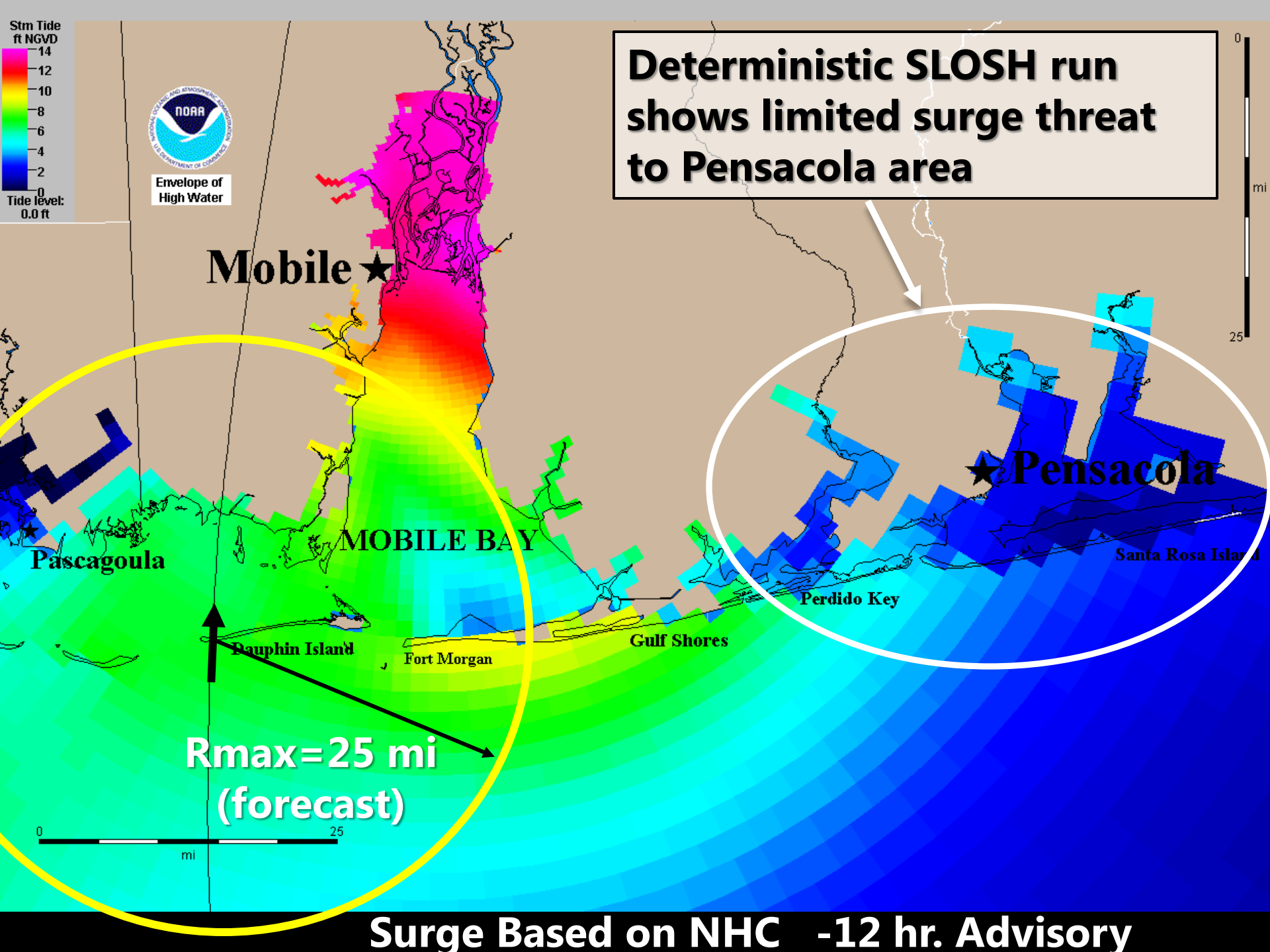
Probabilistic Storm Surge (P-surge) Multiple Tracks and Landfall Locations



Size: Small, Medium, Large

Forward Speed: Fast, Medium, Slow

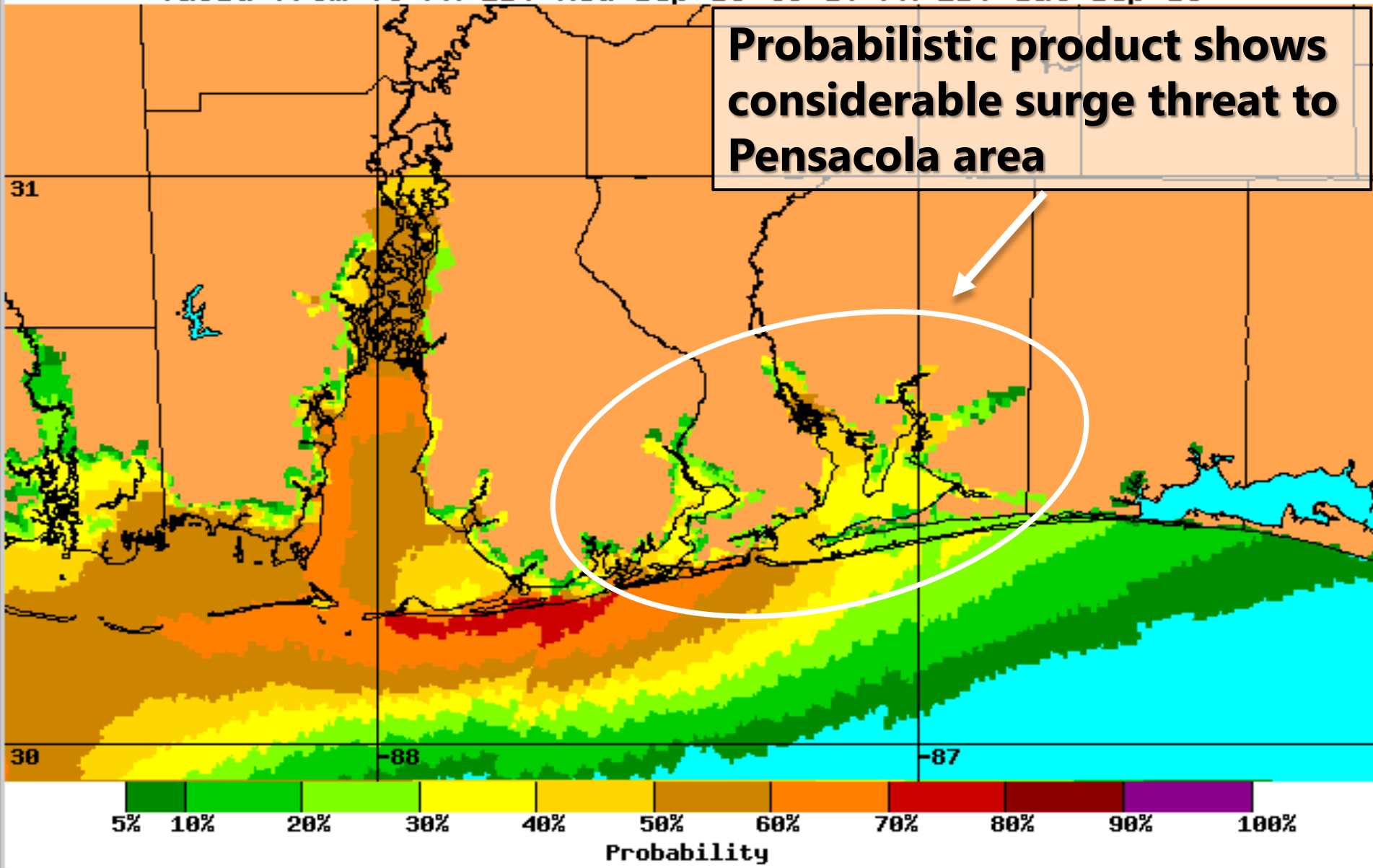
Intensity: Strong, Medium, Weak

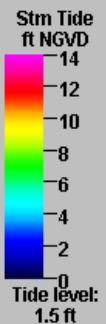




Experimental Tropical Cyclone Storm Surge Probabilities
Chance of Storm Surge \geq 8 feet at Individual Locations
Hurricane Ivan (2004) Advisory 54
Valid from 05 PM EDT Wed Sep 15 to 10 PM EDT Sat Sep 18

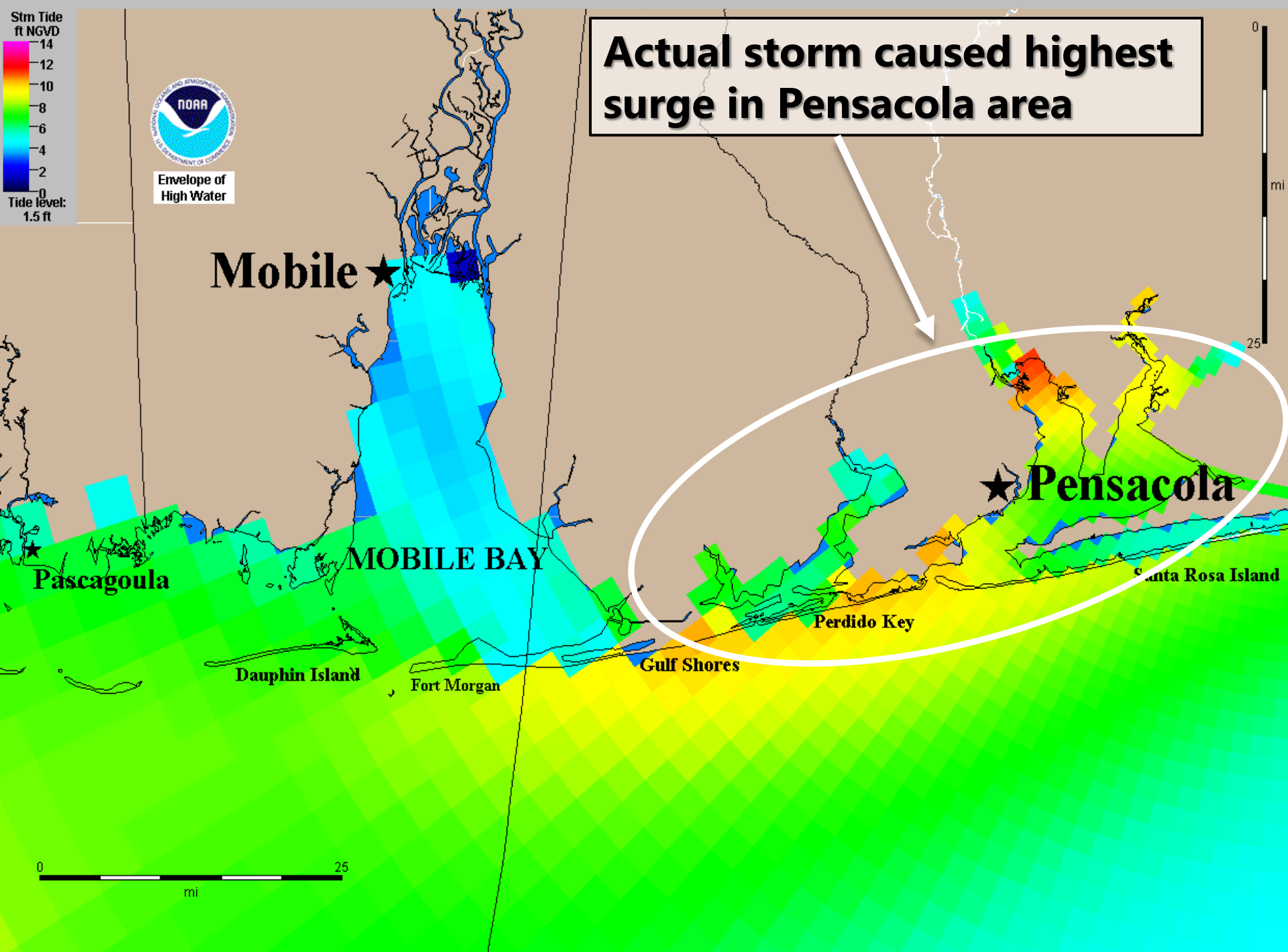
Probabilistic product shows considerable surge threat to Pensacola area





Envelope of
High Water

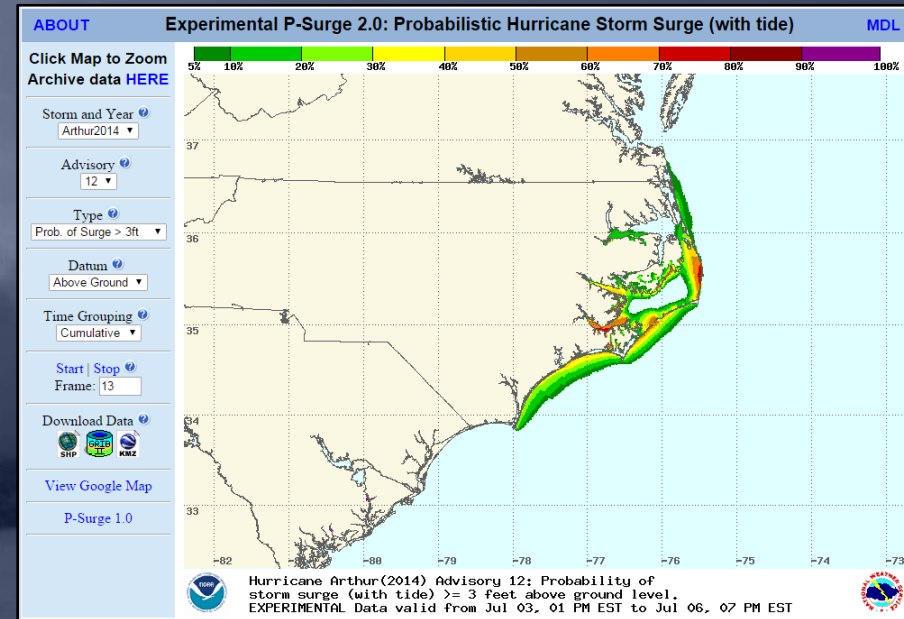
**Actual storm caused highest
surge in Pensacola area**



When is P-Surge Available?

(On the NHC Website)

- Whenever a hurricane (and sometimes tropical storm) watch or warning is in effect
 - Approximately 48 hours prior to arrival of TS winds
- Available approximately 30 minutes after full advisory release time
 - 05:30 EDT
 - 11:30 EDT
 - 17:30 EDT
 - 23:30 EDT

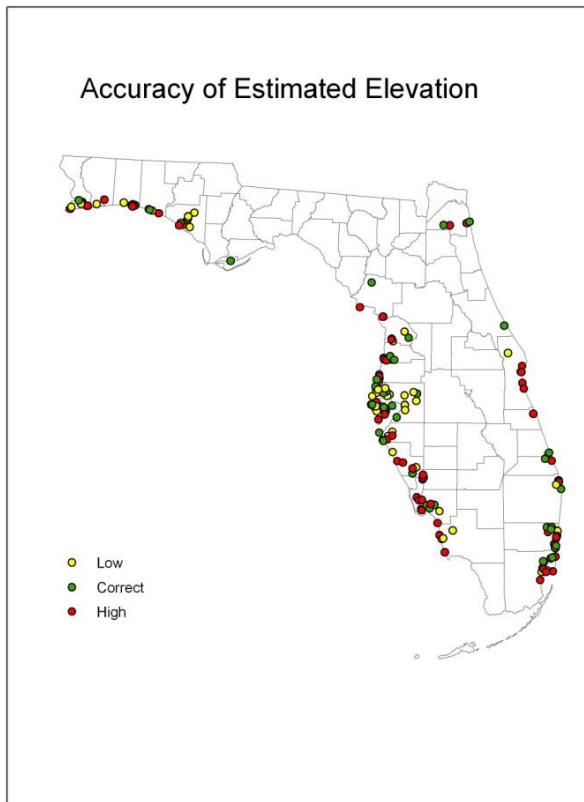


A background image showing a coastal area with dark, turbulent waves crashing onto a sandy beach under a dark, stormy sky. The text is overlaid on this image.

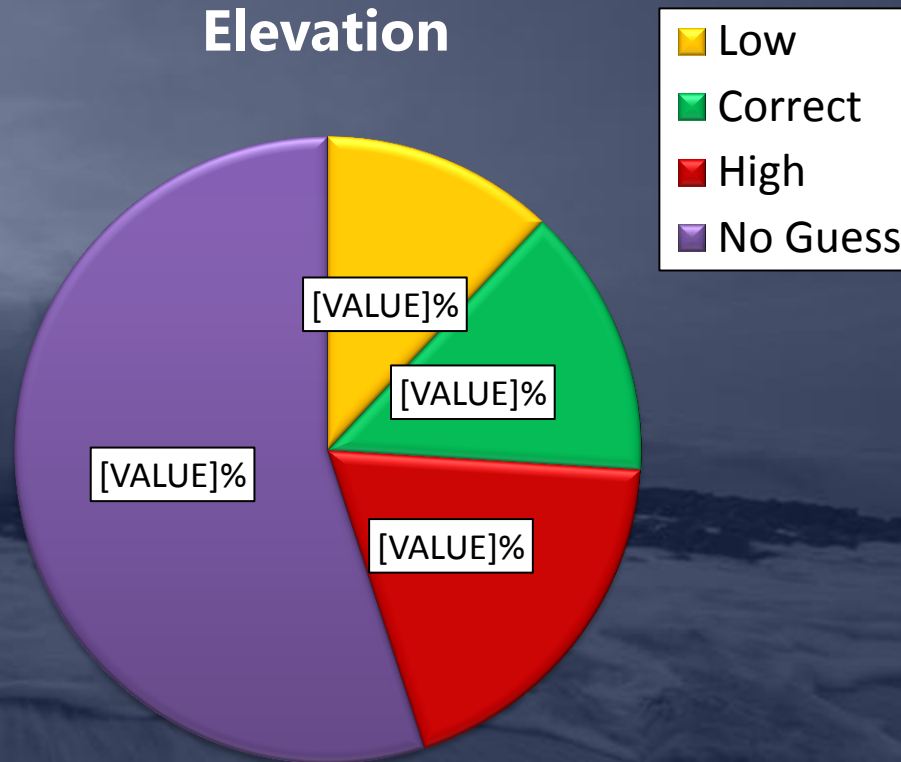
Potential Storm Surge Flooding Map



Do People Know Their Elevation? (within a 5-foot interval)

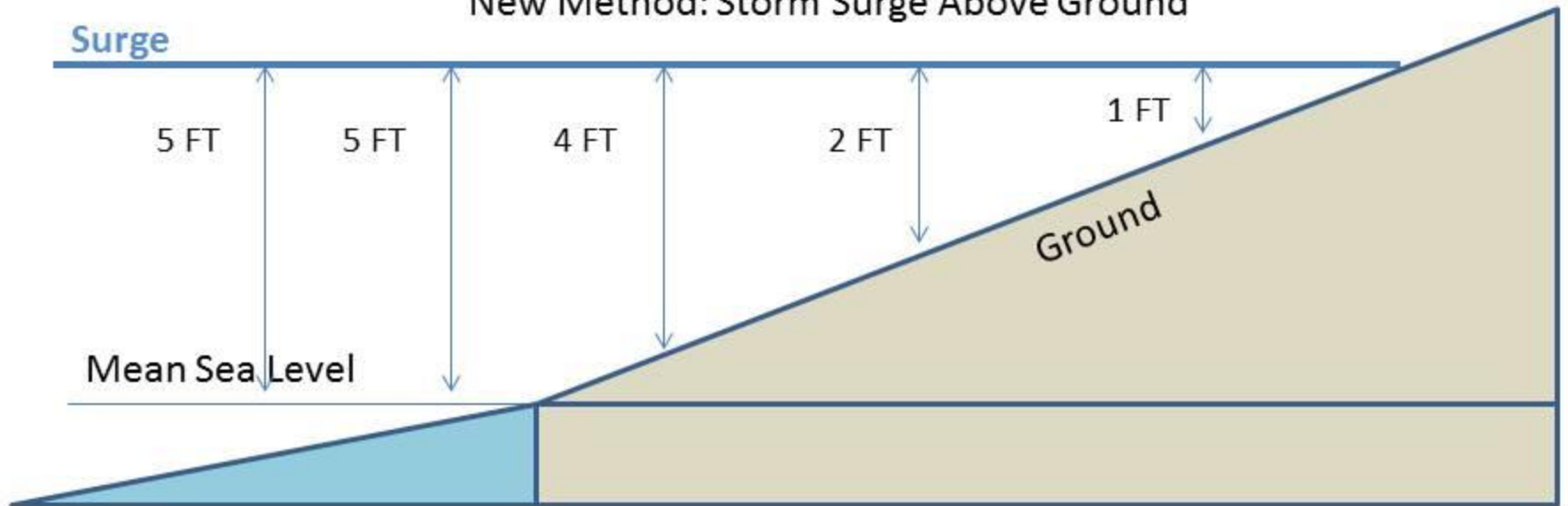


Accuracy of Perceived Elevation

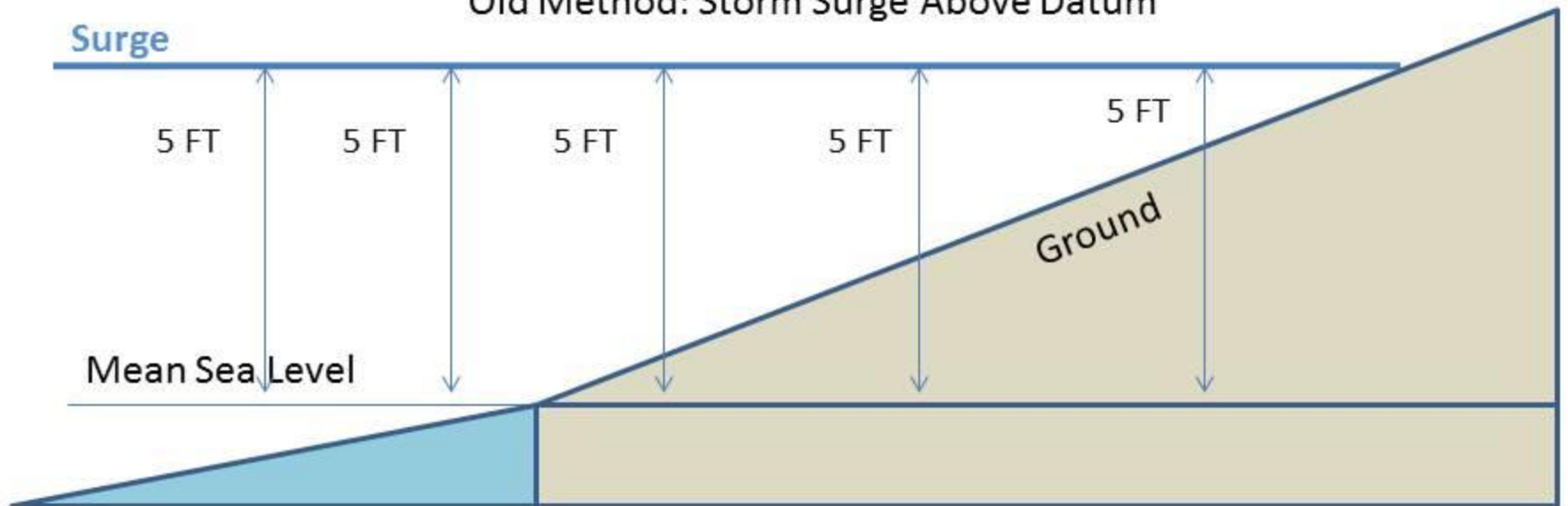


Courtesy Jay Baker, FSU

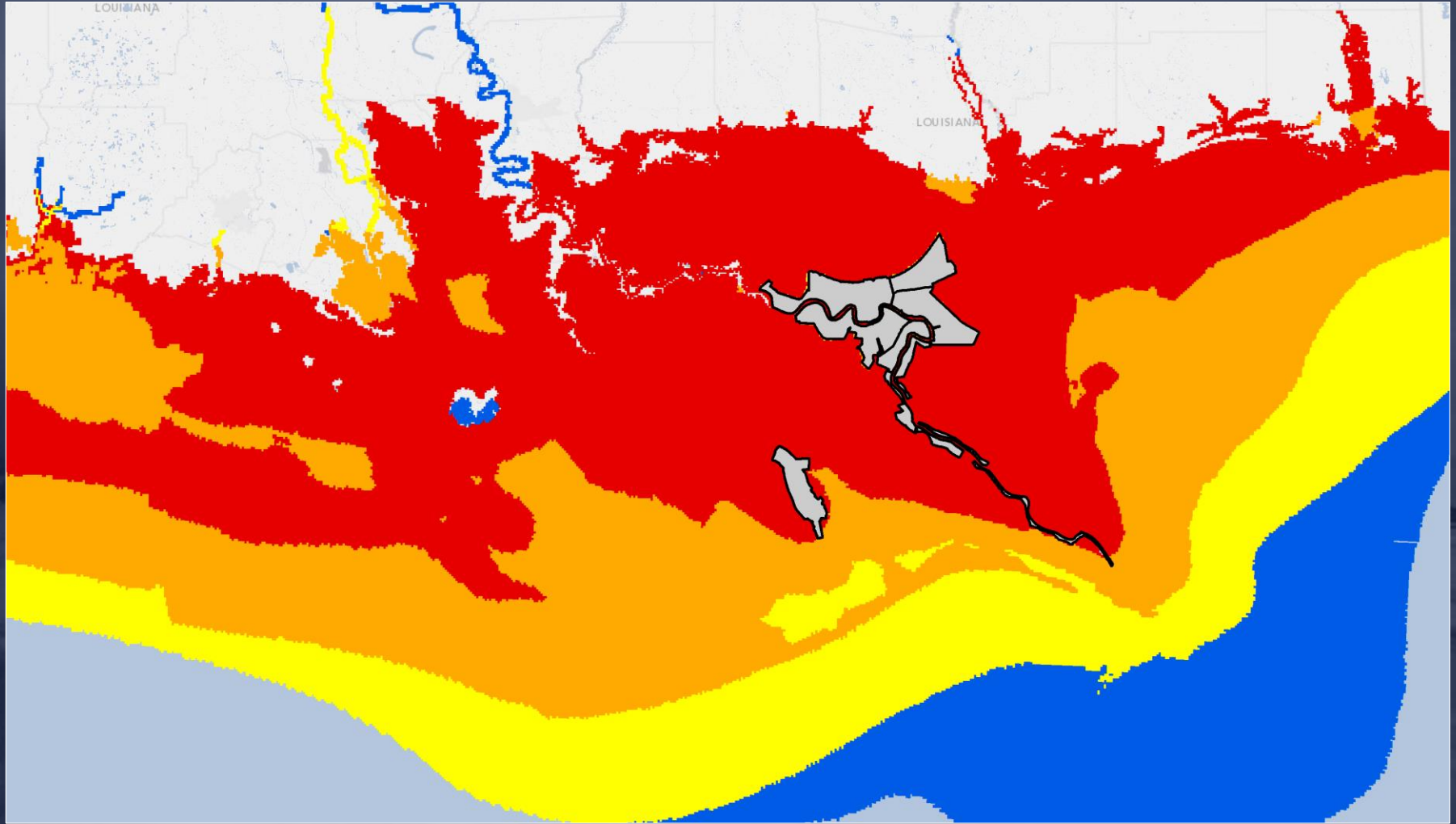
New Method: Storm Surge Above Ground



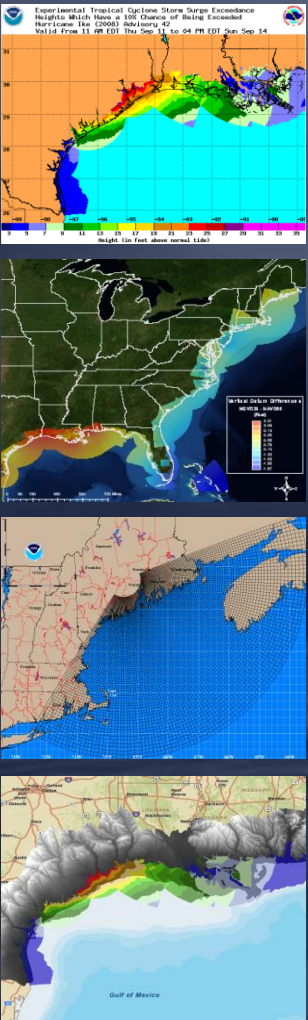
Old Method: Storm Surge Above Datum



Storm Surge Inundation

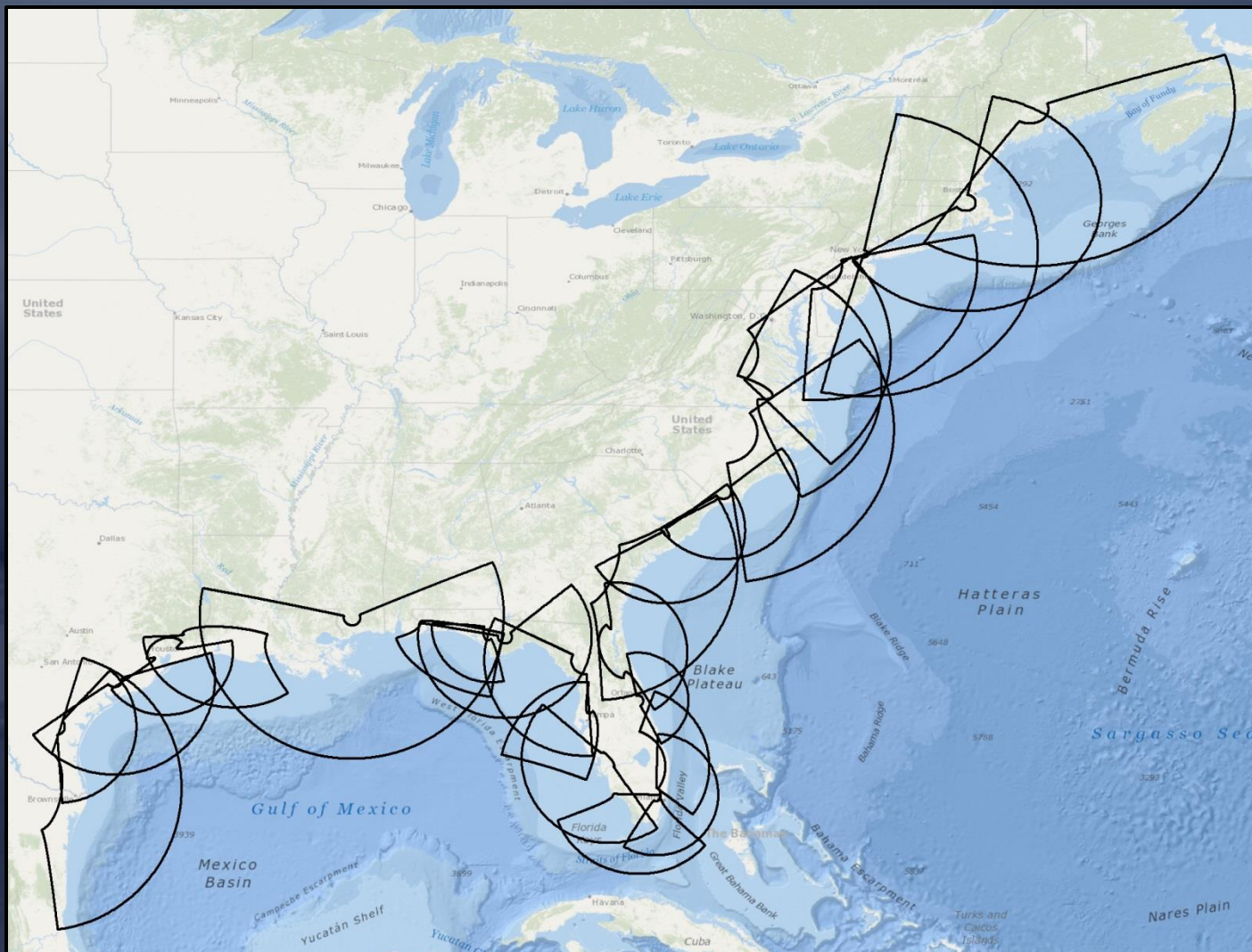


NHC Potential Storm Surge Flooding Map

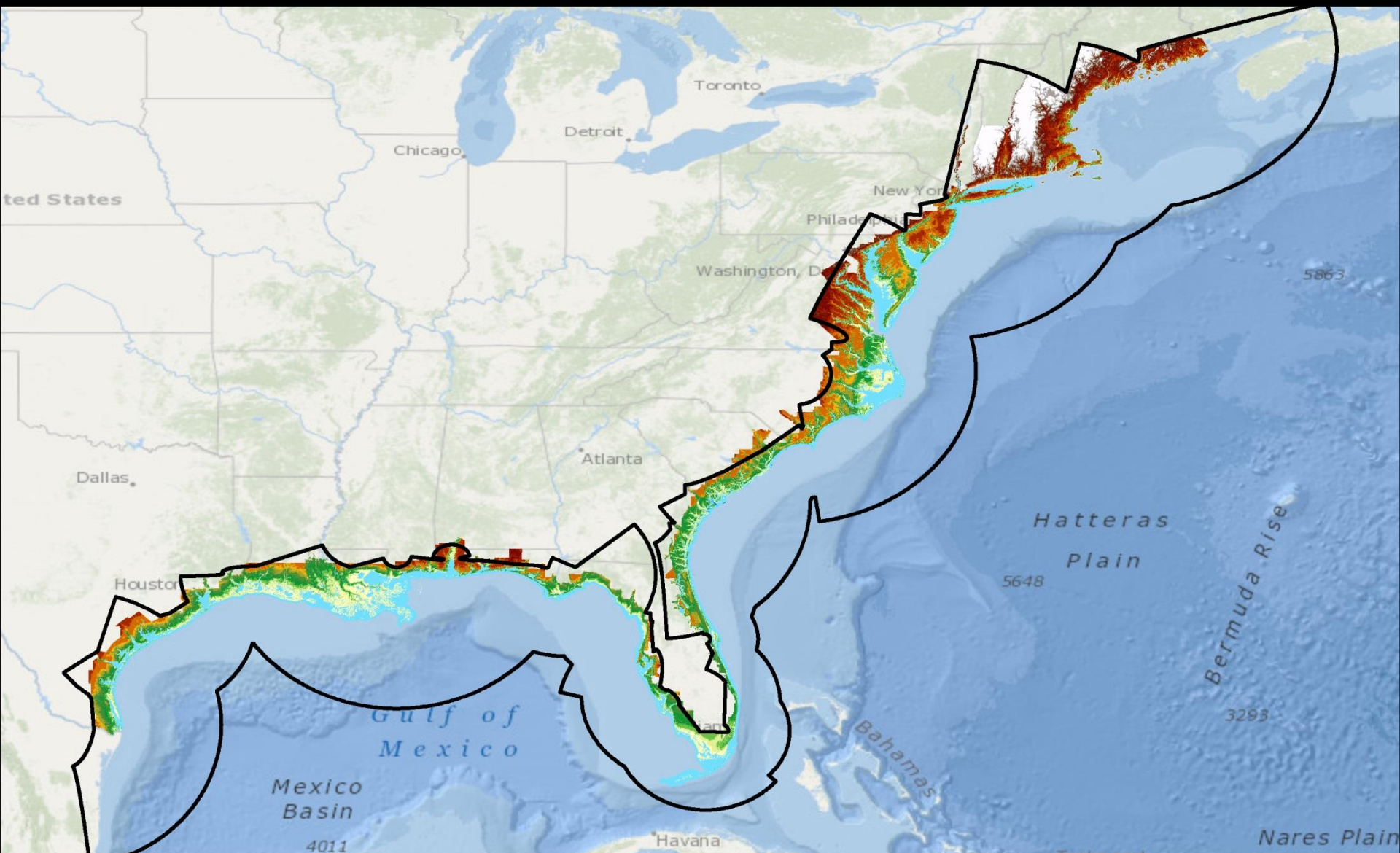


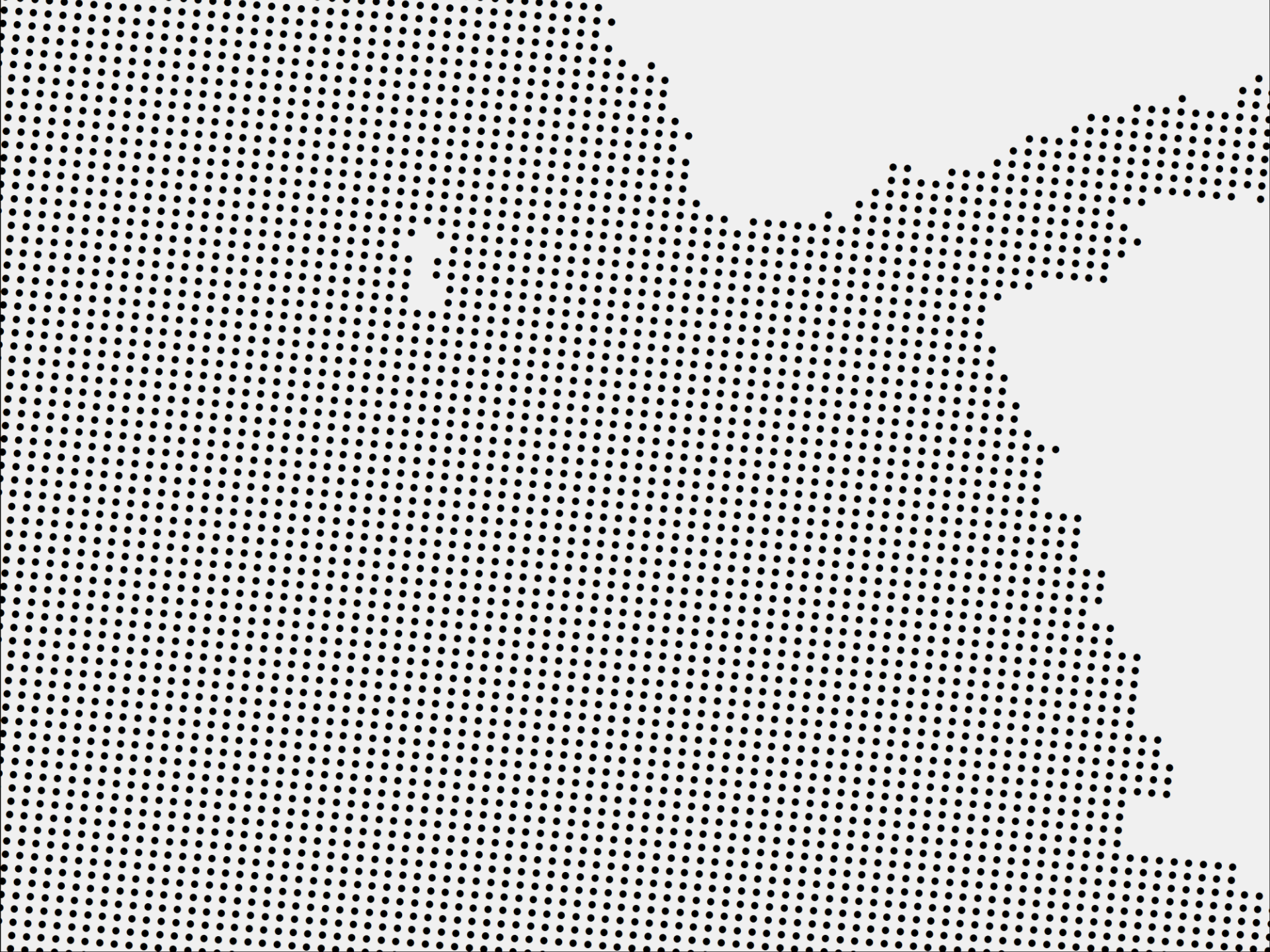
- Which product will drive the flooding map?
 - Psurge 2.x (includes tides)
 - 10% Exceedance
- Grids
 - Latest SLOSH basins updated to **NAVD88**
- Topography/Digital Elevation Models (DEMs)
 - NOAA OCM Sea-level rise DEM
 - Resampled to smoother resolution
 - Augmented with USGS NED
- Processing
 - Locally using **ArcGIS** for Server and Desktop

SLOSH Grids

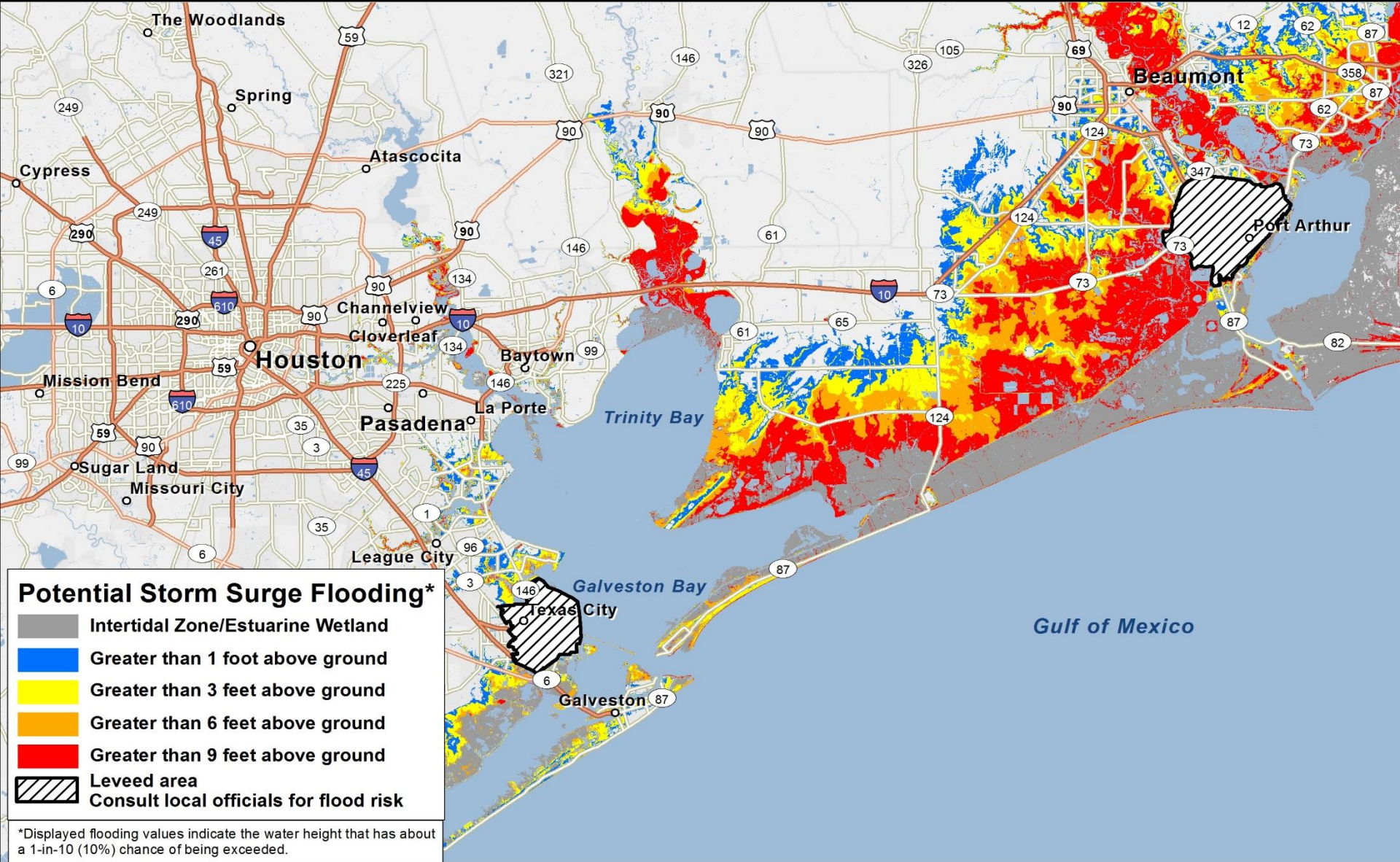


SLOSH Basins and DEMs





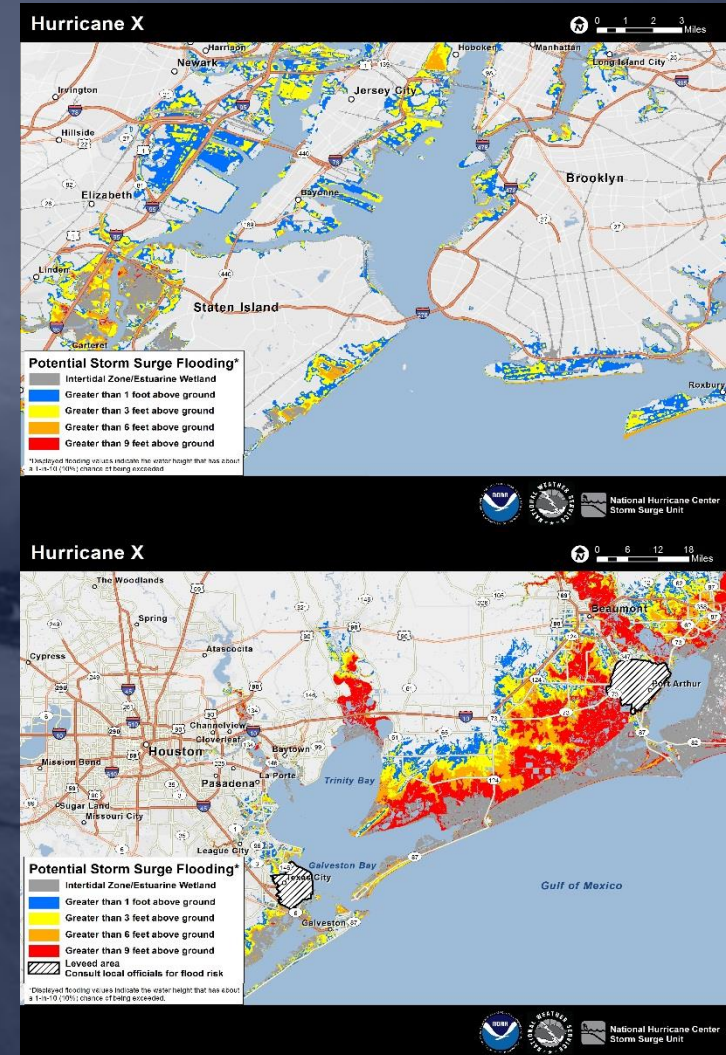
Hurricane X



National Hurricane Center
Storm Surge Unit

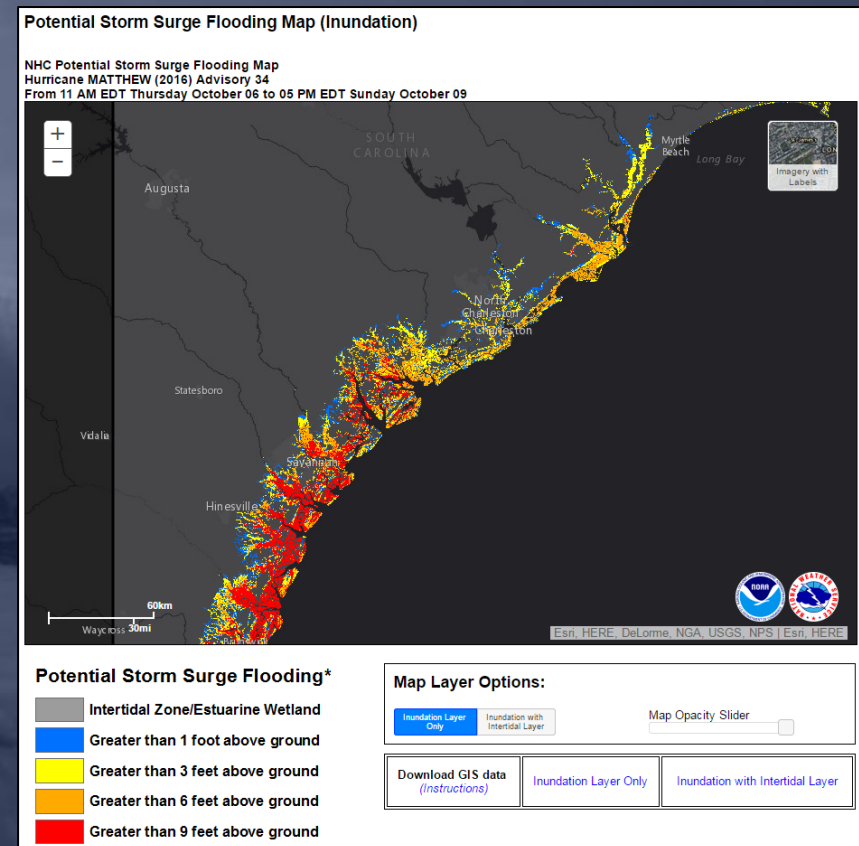
Potential Storm Surge Flooding Map

- Provides a quantitative risk assessment for decision makers.
- Shows height above ground that the water **could** reach.
- Depicts the reasonable worst-case scenario at any individual location.
- Shows inundation levels that have a 10% chance of being exceeded.
- First map issued at the same time as the initial hurricane watch or in some cases, with a tropical storm watch.
- Available about **60 to 90 minutes following** the advisory release.

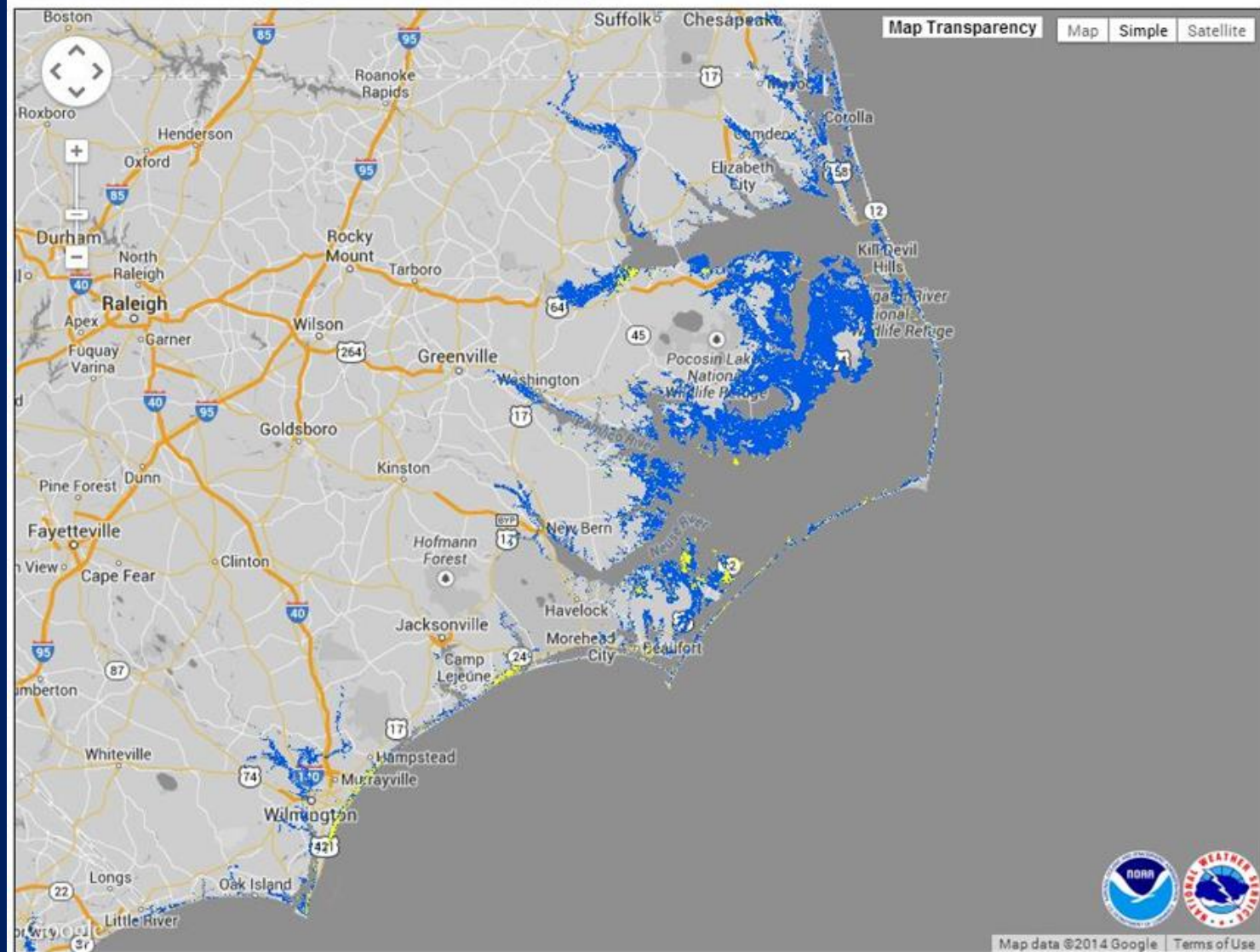


Interactive Interface and Data Access

- Interactive viewer available on hurricanes.gov
- Intertidal layer can be turned on/off (NHC recommends leaving it on)
- GIS data available for download
- Available on NOAA's nowCOAST
 - <https://nowcoast.noaa.gov/>
 - Map Services (REST and WMS)



NHC Experimental Potential Storm Surge Flooding Map
Hurricane ARTHUR (2014) Advisory 10
From 05 AM EDT Thursday July 03 to 10 AM EDT Sunday July 06



Potential Storm Surge Flooding*

- Up to 3 feet above ground
- Greater than 3 feet above ground
- Greater than 6 feet above ground
- Greater than 9 feet above ground

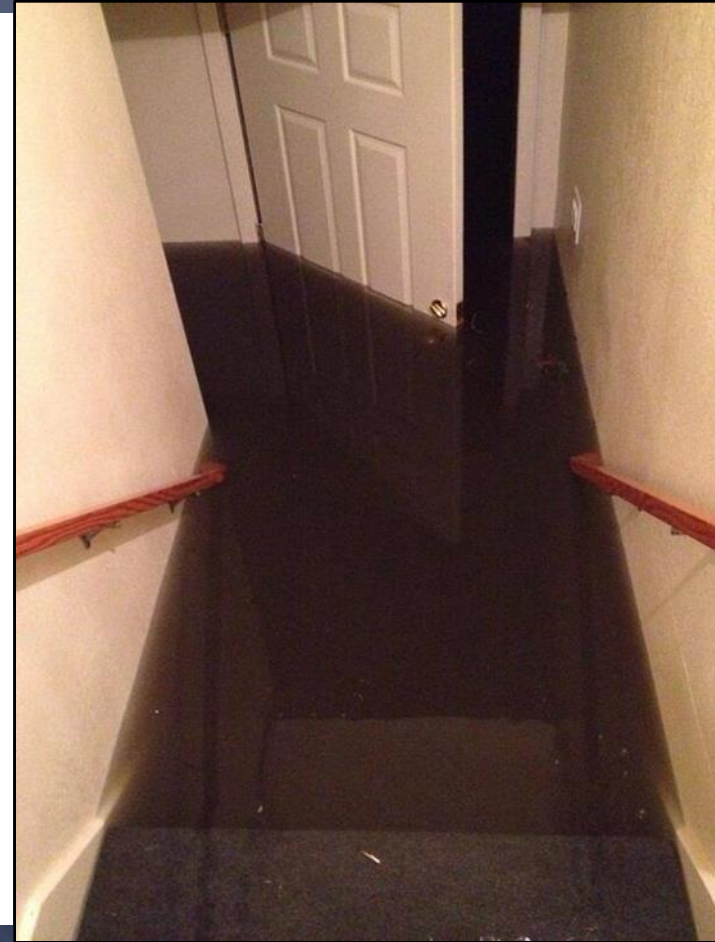
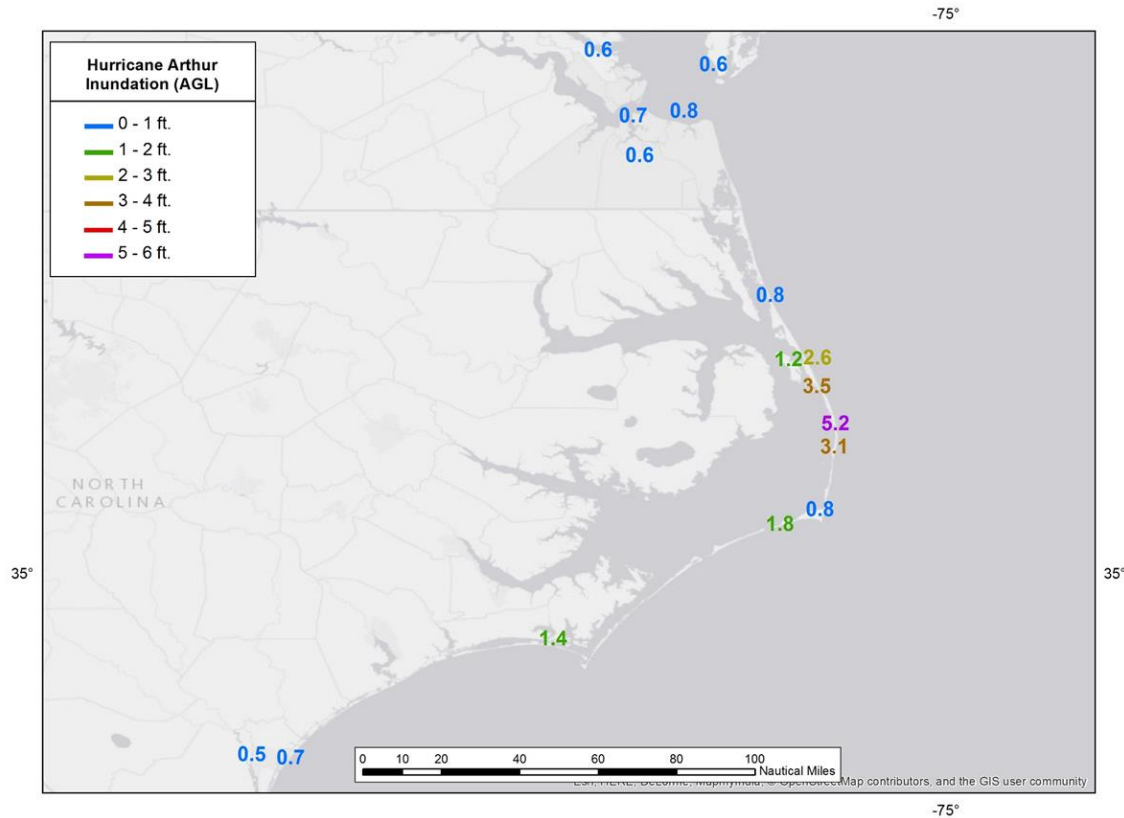
*Displayed flooding values indicate the water depth that has about a 1-in-10 (10%) chance of being exceeded.

Experimental Potential Storm Surge Inundation GIS datasets will not be disseminated during the 2014 Atlantic Hurricane Season.



Smaller

Hurricane Arthur Storm Surge Inundation

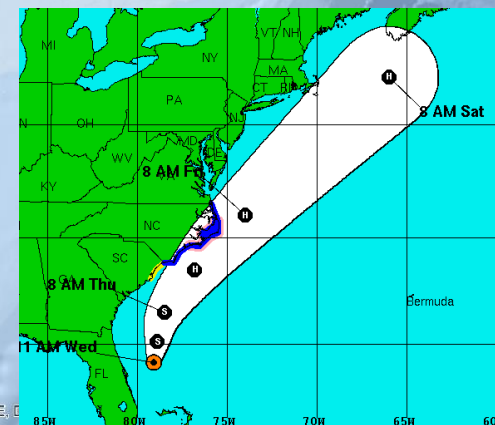


Potential Storm Surge Flooding*

- Up to 3 feet above ground
- Greater than 3 feet above ground
- Greater than 6 feet above ground
- Greater than 9 feet above ground

Advisory 7
11 AM EDT July 2

Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors. Esri, HERE, DeLorme, Mapbox, OpenStreetMap (OSM), NOAA/NWS/National Hurricane Center/Storm Surge Unit



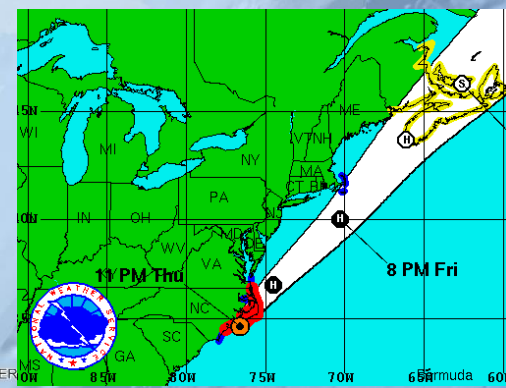
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors. Esri, HERE, DeLorme, Mapbox, OpenStreetMap (OSM), NOAA/NWS/National Hurricane Center/Storm Surge Unit

Potential Storm Surge Flooding*

- Up to 3 feet above ground
- Greater than 3 feet above ground
- Greater than 6 feet above ground
- Greater than 9 feet above ground

Advisory 13
11 PM EDT July 3

Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors. Esri, HER
NOAA/NWS/National Hurricane Center/Storm Surge Unit



Esri, DeLorme, GEBCO, NOAA NGDC, and
NOAA/NWS/National Hurricane Center/Storm Surge Unit

Storm Surge Watch/Warning





Storm Surge Watch/Warning



- Storm Surge Warning program is intended to enhance public response to instructions from local officials, and, ultimately, to help guide EM decisions.

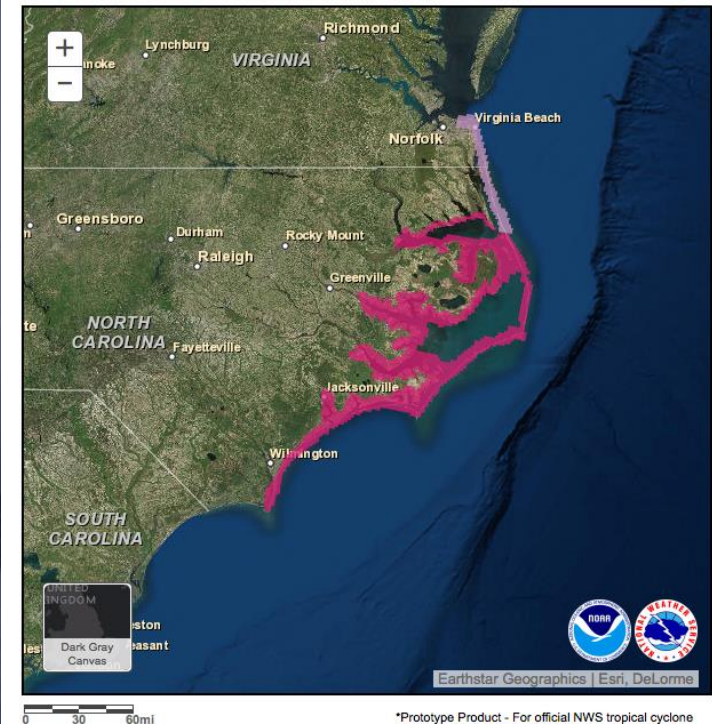
- W/W Graphic highlights areas that have a **significant risk of life-threatening inundation** from storm surge.

- Issued 48 hours before possibility of life-threatening surge, *or other hazards that would hinder evacuations.*

- Represents collaboration of NHC's Hurricane Specialists, Storm surge experts, and local NWS WFOs.

Prototype Storm Surge Watch/Warning Graphic*

Hurricane Zelda
Advisory 12 Issued: Fri Jul 04 2014 8 PM EDT



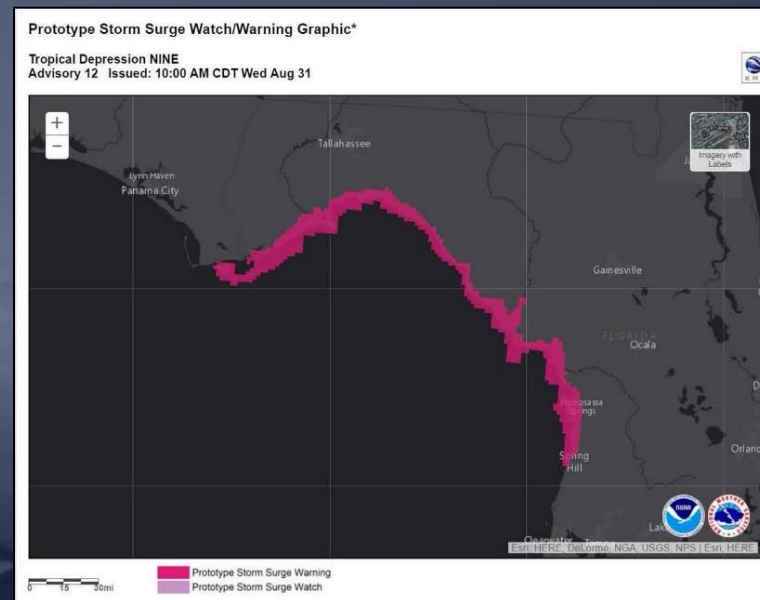
Prototype Storm Surge Watch/Warning

- Prototype Storm Surge Warning
- Prototype Storm Surge Watch

*Prototype Product - For official NWS tropical cyclone information, see hurricanes.gov. This graphic displays areas that would qualify for inclusion under a storm surge watch/warning that is under development by the National Weather Service. A storm surge warning indicates there is a danger of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within 36 hours. A storm surge watch indicates that life-threatening inundation is possible somewhere within the specified area, generally within 48 hours. All persons, regardless of whether or not they are in the highlighted areas shown in the graphic, should promptly follow evacuation orders and other instructions from local officials. User feedback on the prototype storm surge watch/warning graphic can be provided at LINK. Upon completion of development, formal public comment/review of this graphic and the experimental storm surge watch/warning will take place in 2016, with operational implementation planned in 2017, if approved.

Storm Surge Watch/Warning

- Storm Surge Watch and Warning is now **operational**.
- W/W is communicated using:
 - **Graphic** on NHC website
 - Watch/warning section of the NHC **Public Advisory** using coastal breakpoints
 - NWS WFO Hurricane Local Statements
 - Approximate representation in terms of zones in National and WFO TCV products.
 - NDFD grid



SUMMARY OF WATCHES AND WARNINGS IN EFFECT:

A Hurricane Warning is in effect for...

* Anclote River to Indian Pass Florida

A Storm Surge Warning is in effect for...

* Aripeka to Indian Pass Florida



Storm Surge Watch/Warning Definitions and Call-to-Action

Storm Surge Warning

There is a *danger* of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within *36 hours*.

This is a life-threatening situation. Persons located within these areas should take all necessary actions to protect life and property from rising water and the potential for other dangerous conditions. Promptly follow evacuation and other instructions from local officials.

Storm Surge Watch

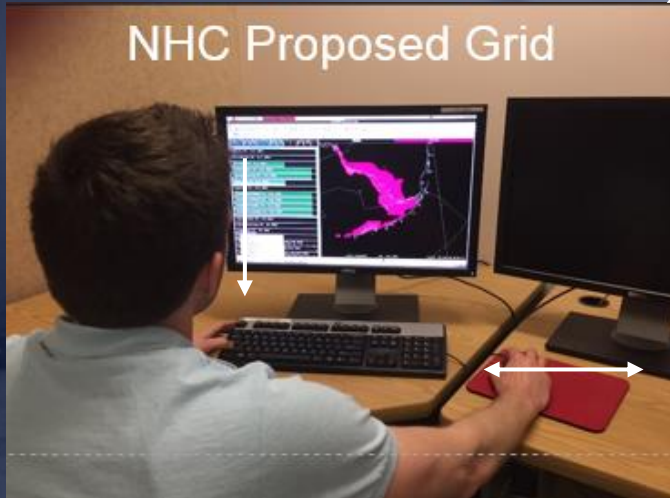
There is the *possibility* of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within *48 hours*.



NWS Collaborative Process

**Run SLOSH P-Surge on NOAA
Supercomputer using official NHC forecast**

NHC Proposed Grid



Collaboration

WFO Miami Collaborated Grid



Dissemination of Storm Surge Watch/Warning



Prototype storm surge warning graphic (2015)
National TCV for wind and storm surge and surge added to WFO TCV (2016)
Operational: 2017



Storm Surge Values in NHC Public Advisory



- Peak storm surge inundation expected to occur somewhere within outlined area
 - Not location-specific
- Introduced when a watch or warning is issued
 - Generally 48 hours before onset of conditions
- Values in the Public Advisory will differ from those in the Potential Storm Surge Flooding Map, since that map depicts location-specific reasonable worst case scenarios
 - 10% exceedance

**NATIONAL HURRICANE CENTER**
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HAZARDS AFFECTING LAND

Storm Surge: The combination of a dangerous storm surge and the tide will cause normally dry areas near the coast to be flooded by rising waters moving inland from the shoreline.

The water could reach the following heights above ground if the peak surge occurs at the time of high tide...

Destin to Indian Pass...1 to 3 feet
Indian Pass to Chassahowitzka...4 to 7 feet
Chassahowitzka to Aripeka...2 to 4 feet
Aripeka to Bonita Beach...1 to 3 feet
Florida-Georgia line to Cape Fear...1 to 3 feet





Potential Storm Surge Flooding Map

How does this differ from the warning?



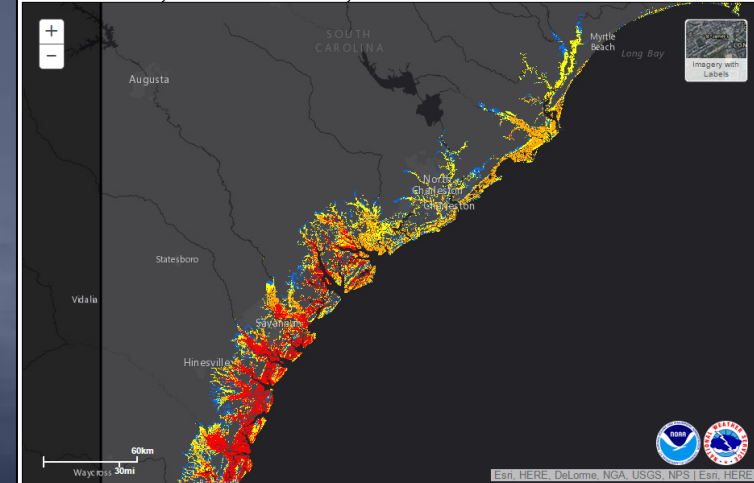
The Potential Storm Surge Flooding Map is for decision makers, whereas the Storm Surge Watch/Warning is intended for the general public.

The Potential Storm Surge Flooding Map provides objective quantitative guidance on where inundation could occur. The Storm Surge Watch/Warning is subjectively determined and not quantitative, and simply identifies those areas at risk for life-threatening inundation.

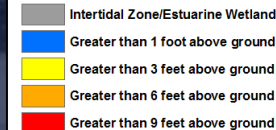
The Potential Storm Surge Flooding Map *does not depict expected inundation*, rather, it estimates a reasonable worst-case scenario (10% chance of being exceeded) at any individual location.

Potential Storm Surge Flooding Map (Inundation)

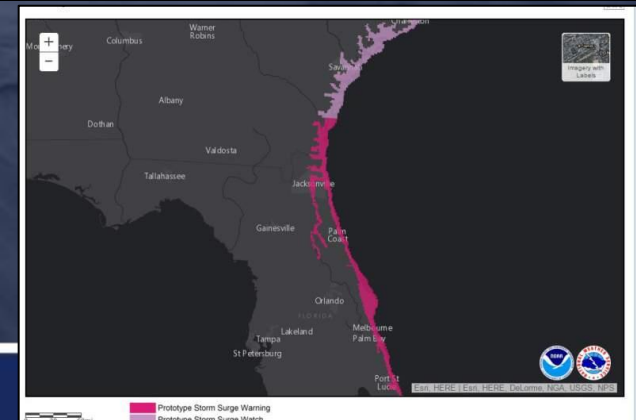
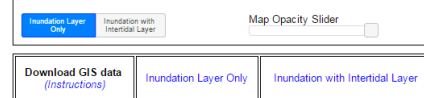
NHC Potential Storm Surge Flooding Map
Hurricane MATTHEW (2016) Advisory 34
From 11 AM EDT Thursday October 06 to 05 PM EDT Sunday October 09



Potential Storm Surge Flooding*



Map Layer Options:



Questions?

