

NHC Storm Surge Products and NWS Storm Surge Warnings

Robbie Berg

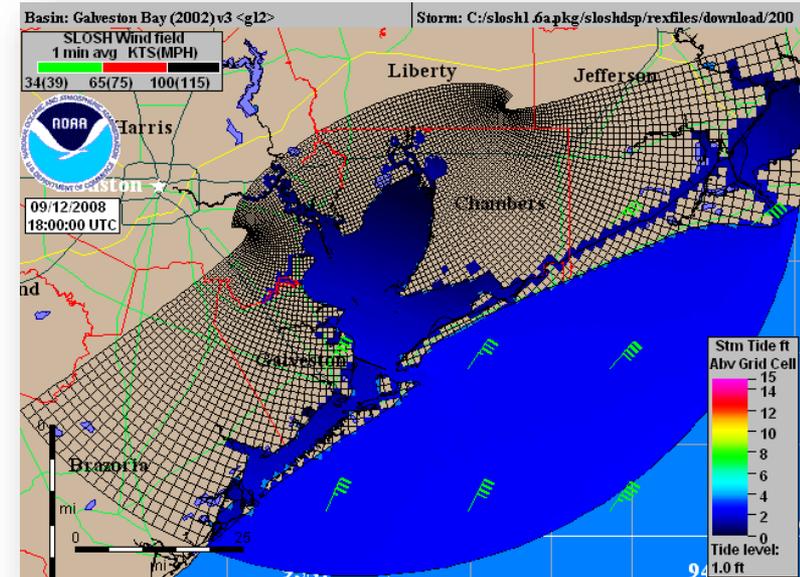
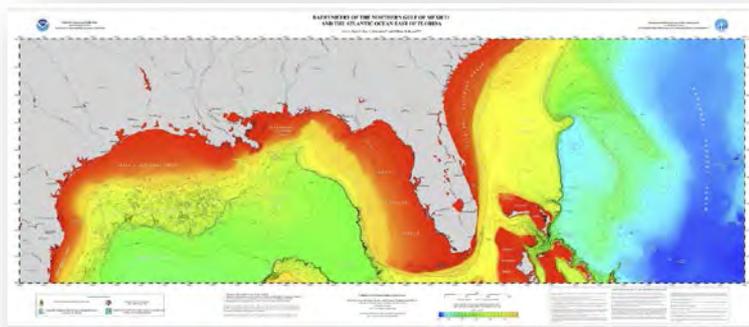
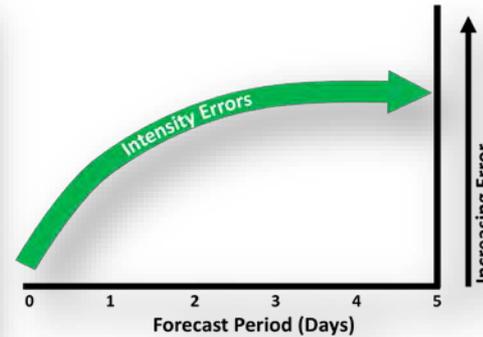
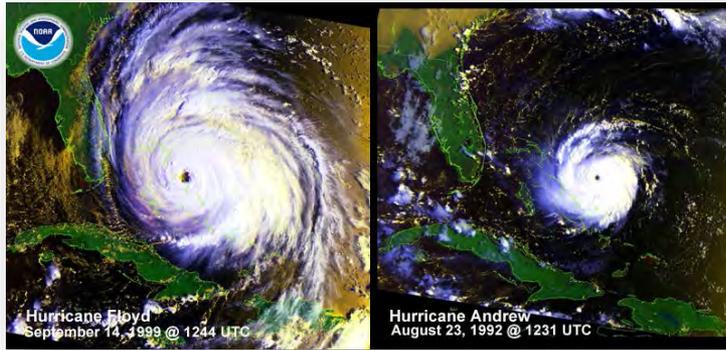
National Hurricane Center

NOAA Southeast and Caribbean Team (SECART) Webinar

May 9, 2017



Making the Perfect Storm Surge Forecast





NHC TRACK ERROR 12 hr. OUT

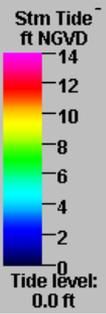
130 mph, 933 mb

- Hurricane
- ▲ Tropical Storm
- Tropical Depression

Hurricane Advisory – Approximately 12 hr. before landfall

0
100
mi

0 100
mi



Envelope of
High Water

Mobile ★

★ **Pensacola**

Pascagoula

MOBILE BAY

Santa Rosa Island

Dauphin Island

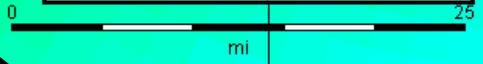
Fort Morgan

Gulf Shores

Perdido Key

**Rmax=25 mi
(forecast)**

Surge Based on NHC -12 hr. Advisory





ACTUAL TRACK

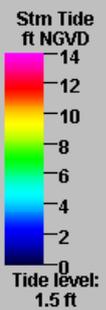
TRACK FORECAST

130 mph, 933 mb

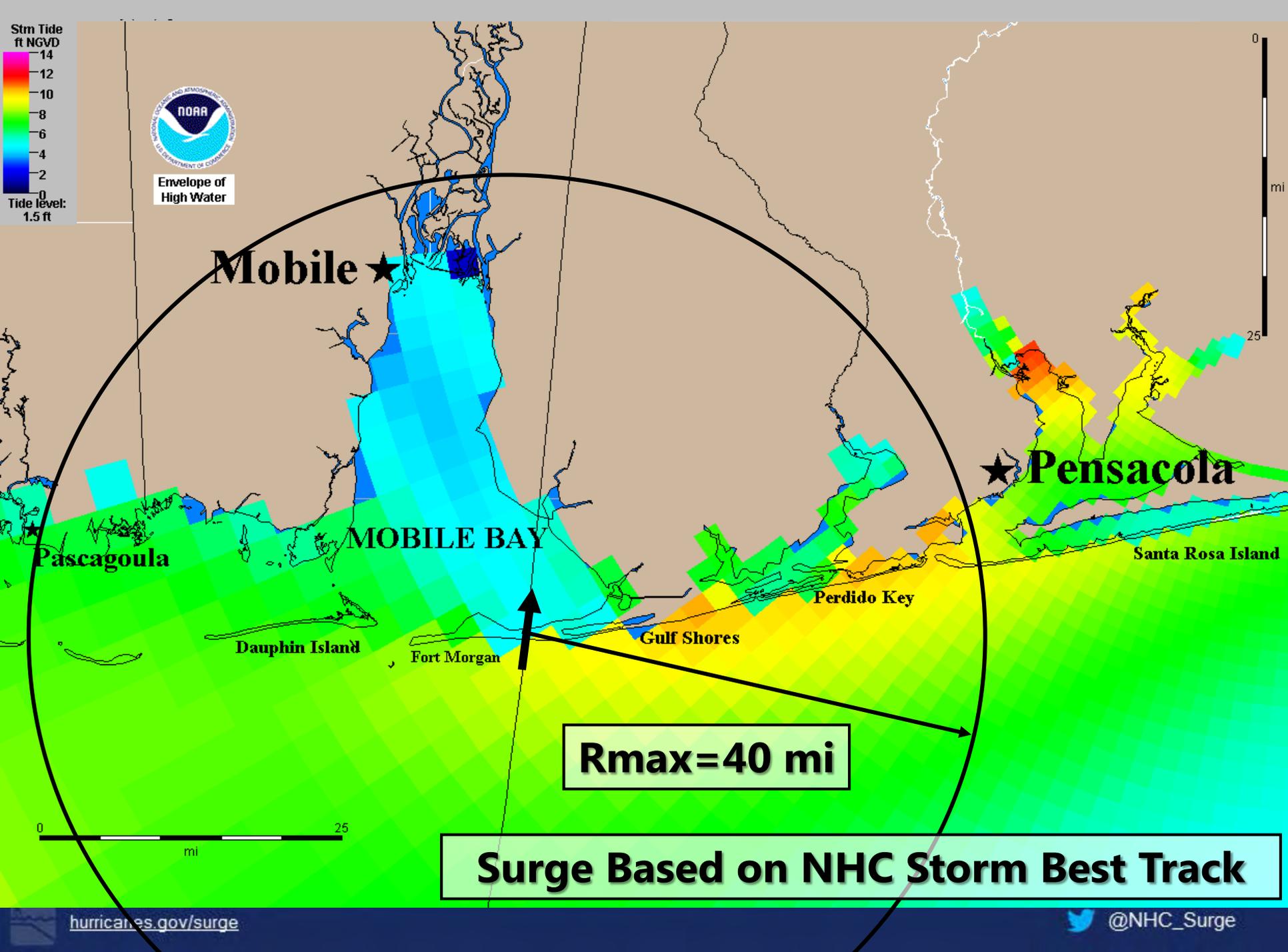
- Hurricane
- ▲ Tropical Storm
- Tropical Depression

Actual Hurricane Track 30 mi. E of -12 hr. Advisory Forecast Track





Envelope of
High Water



Mobile ★

MOBILE BAY

★ **Pensacola**

Pascagoula

Dauphin Island

Fort Morgan

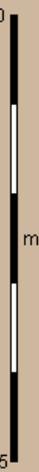
Gulf Shores

Perdido Key

Santa Rosa Island

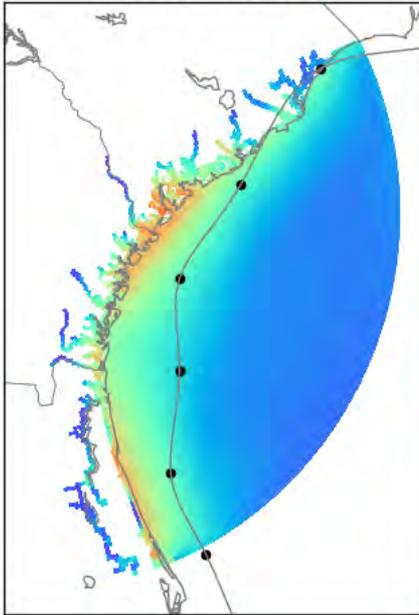
Rmax=40 mi

Surge Based on NHC Storm Best Track

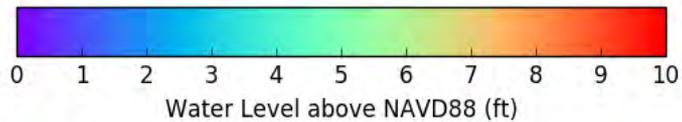
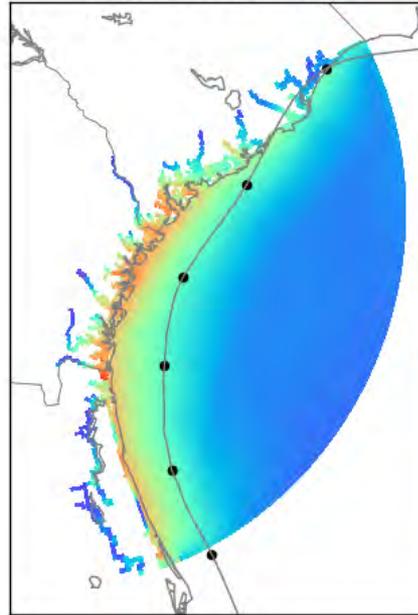


Why Probabilistic?

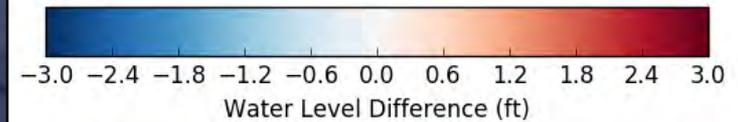
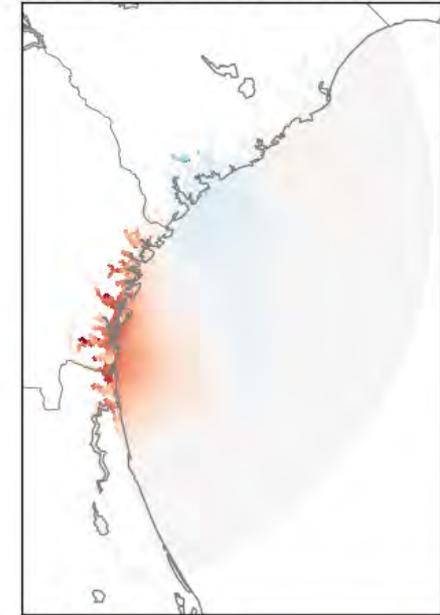
ATCF Track



Modified ATCF Track



Modified ATCF Track - ATCF Track

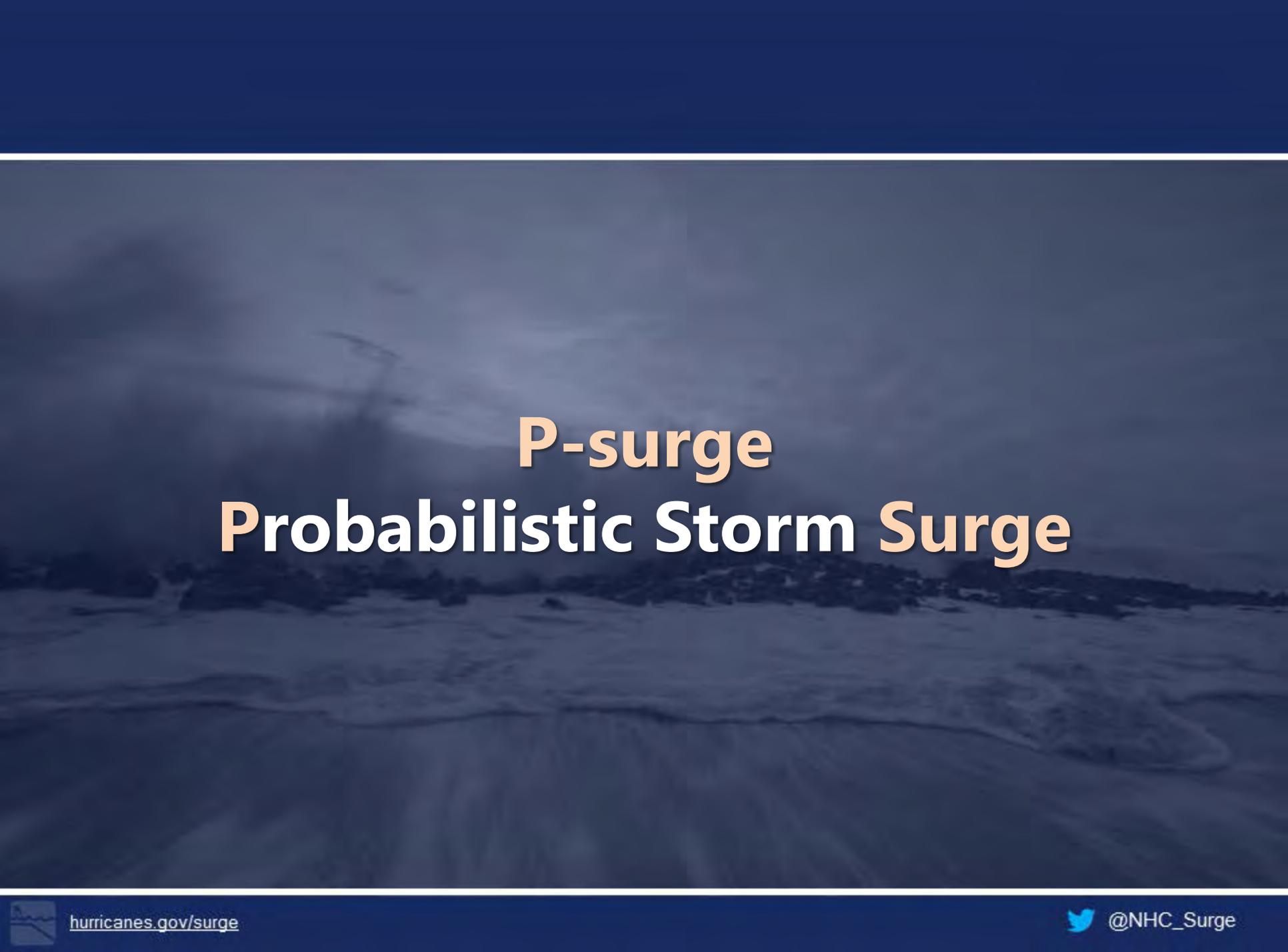


The Challenge

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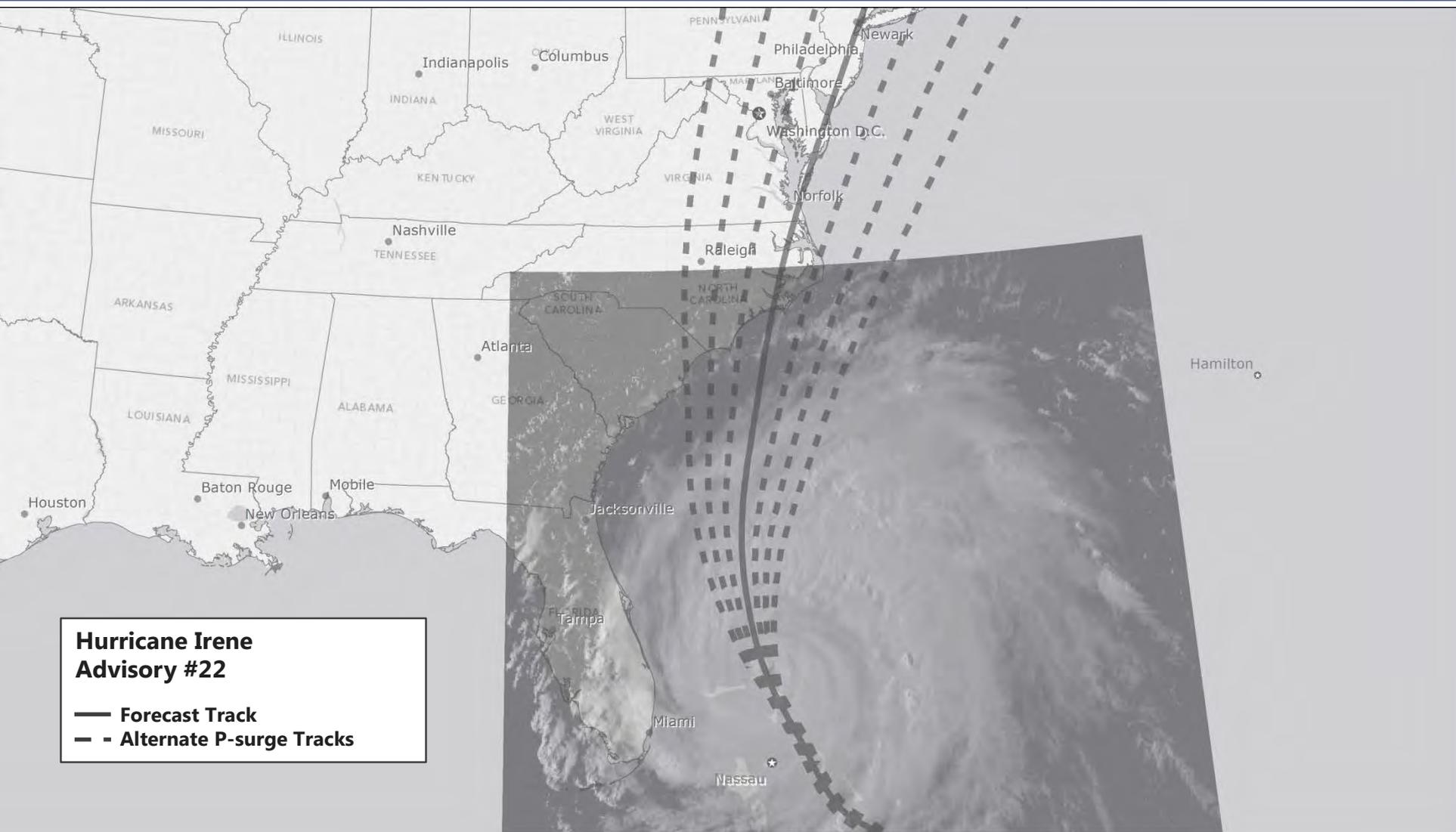


P-surge Probabilistic Storm Surge

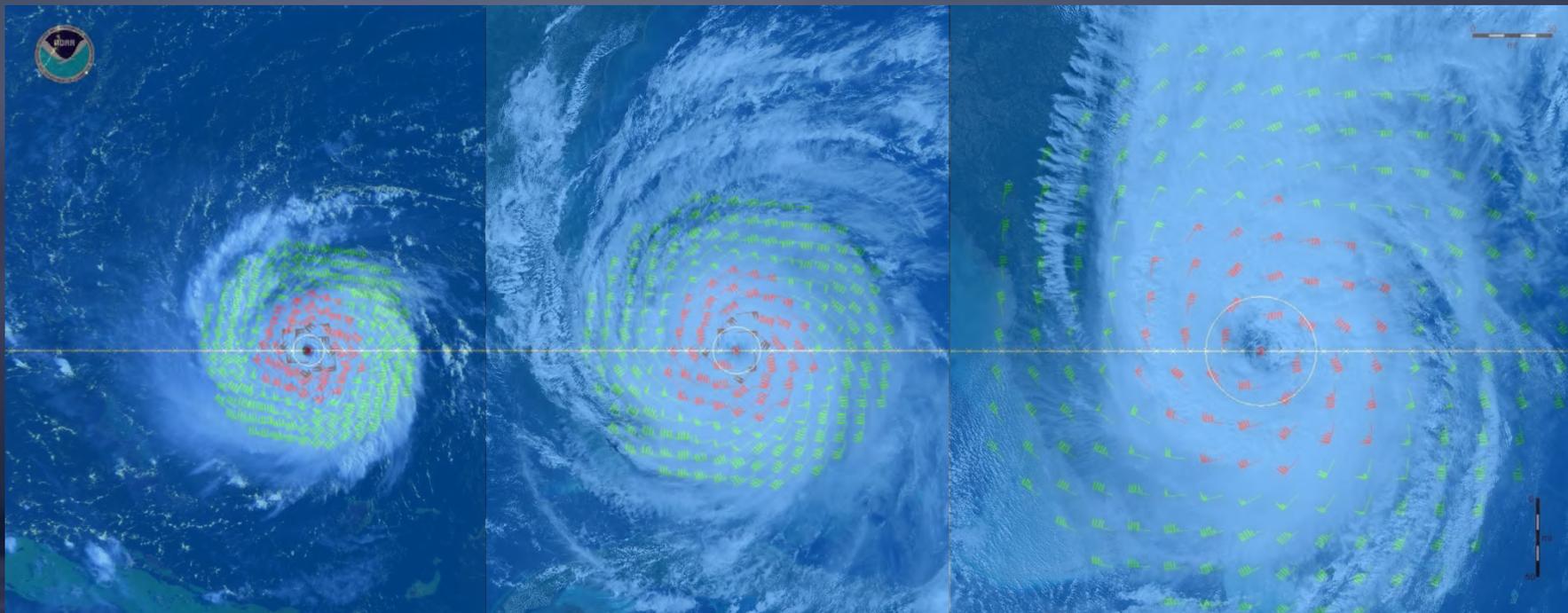
Probabilistic Storm Surge (P-surge)

- 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



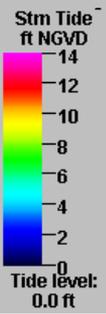
Probabilistic Storm Surge (P-surge) Multiple Tracks and Landfall Locations



Size: Small, Medium, Large

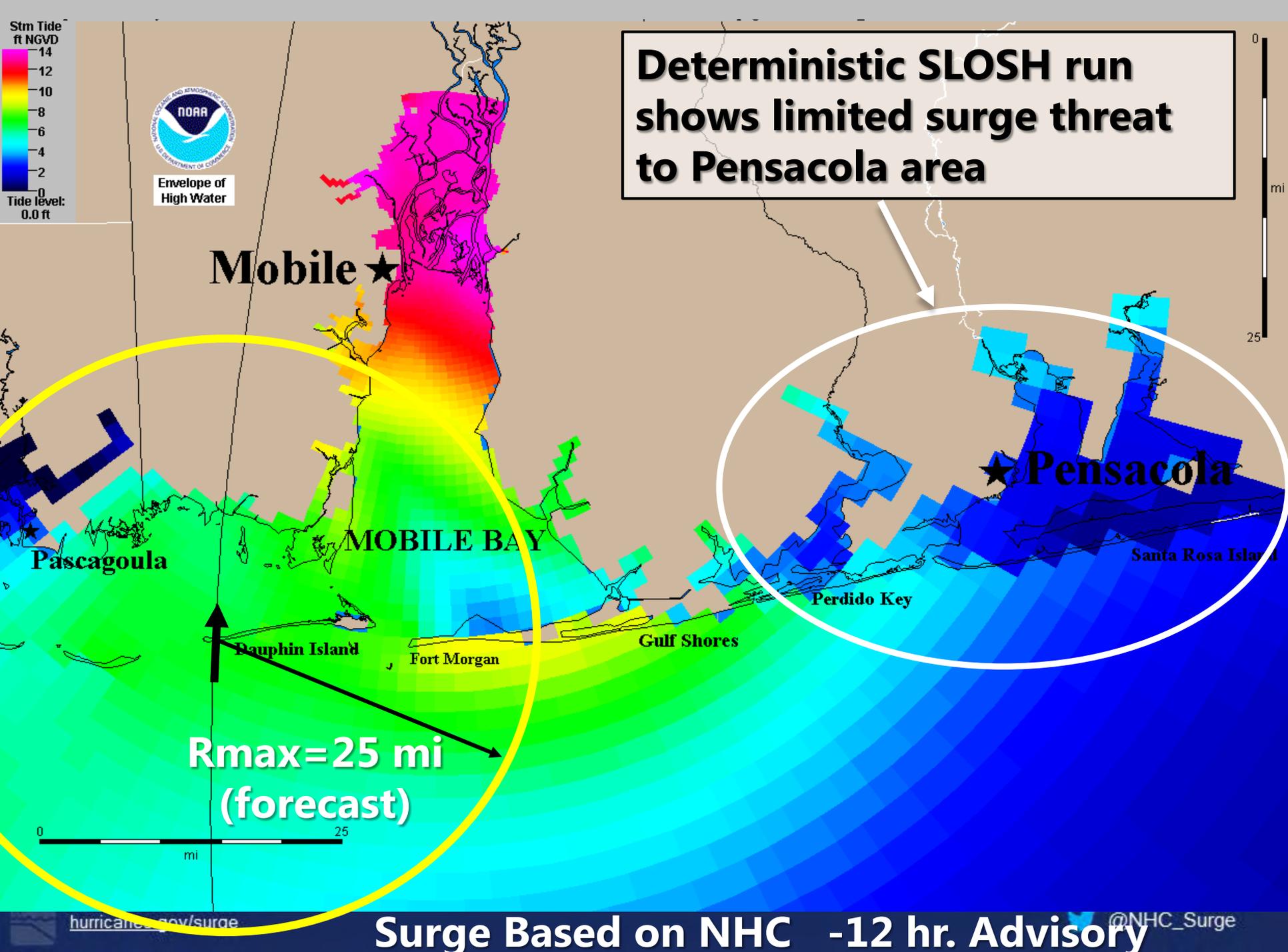
Forward Speed: Fast, Medium, Slow

Intensity: Strong, Medium, Weak



Envelope of
High Water

**Deterministic SLOSH run
shows limited surge threat
to Pensacola area**



Mobile ★

Pascagoula

MOBILE BAY

★ **Pensacola**

Santa Rosa Island

**Rmax=25 mi
(forecast)**



Surge Based on NHC -12 hr. Advisory

@NHC_Surge

Storm: Ivan2004 Adv54

Type: Prob. of surge > 8 feet

Zoom Level: Full



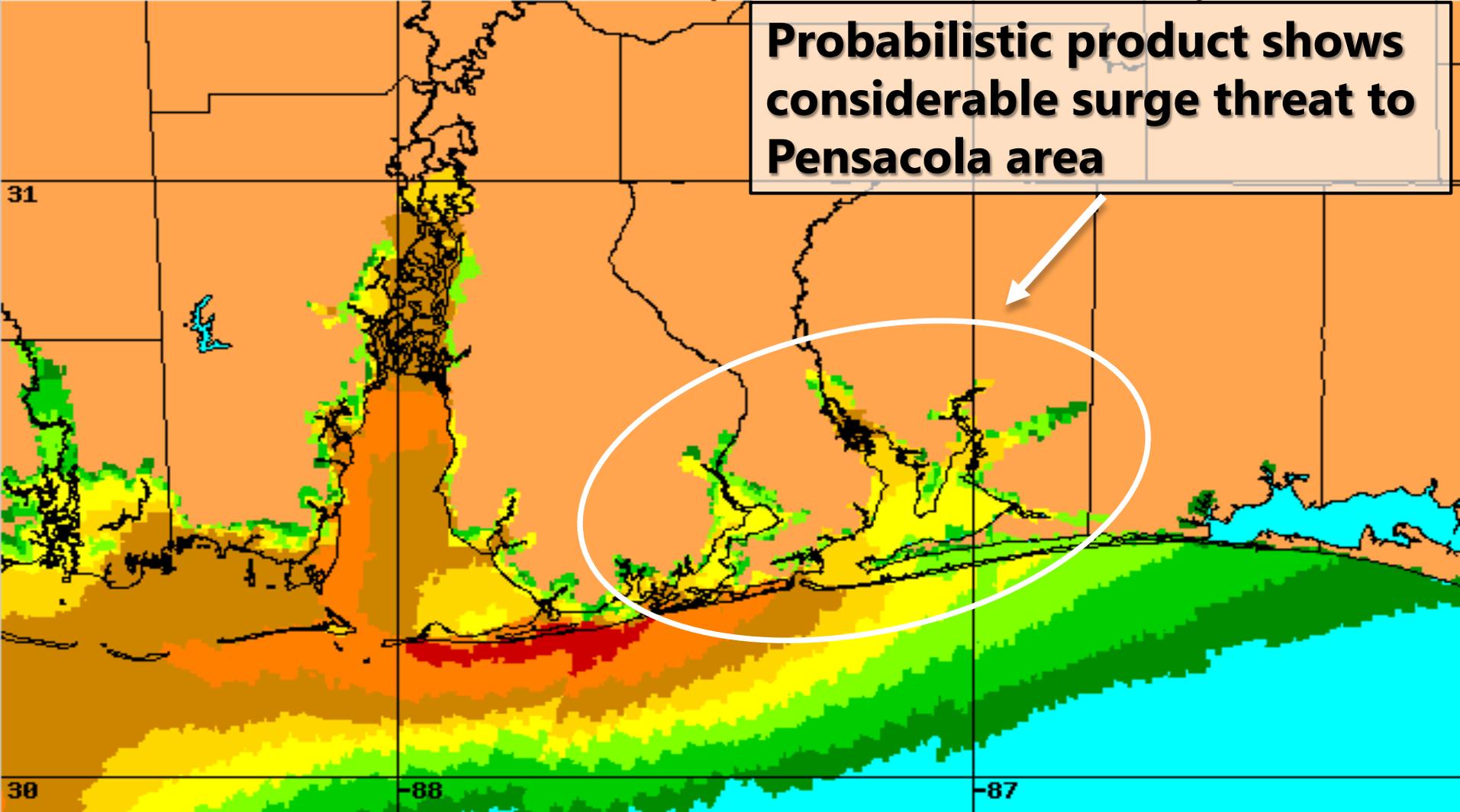
Experimental Tropical Cyclone Storm Surge Probabilities

Chance of Storm Surge \geq 8 feet at Individual Locations

Hurricane Ivan (2004) Advisory 54

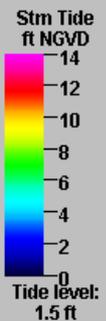
Valid from 05 PM EDT Wed Sep 15 to 10 PM EDT Sat Sep 18

Probabilistic product shows considerable surge threat to Pensacola area



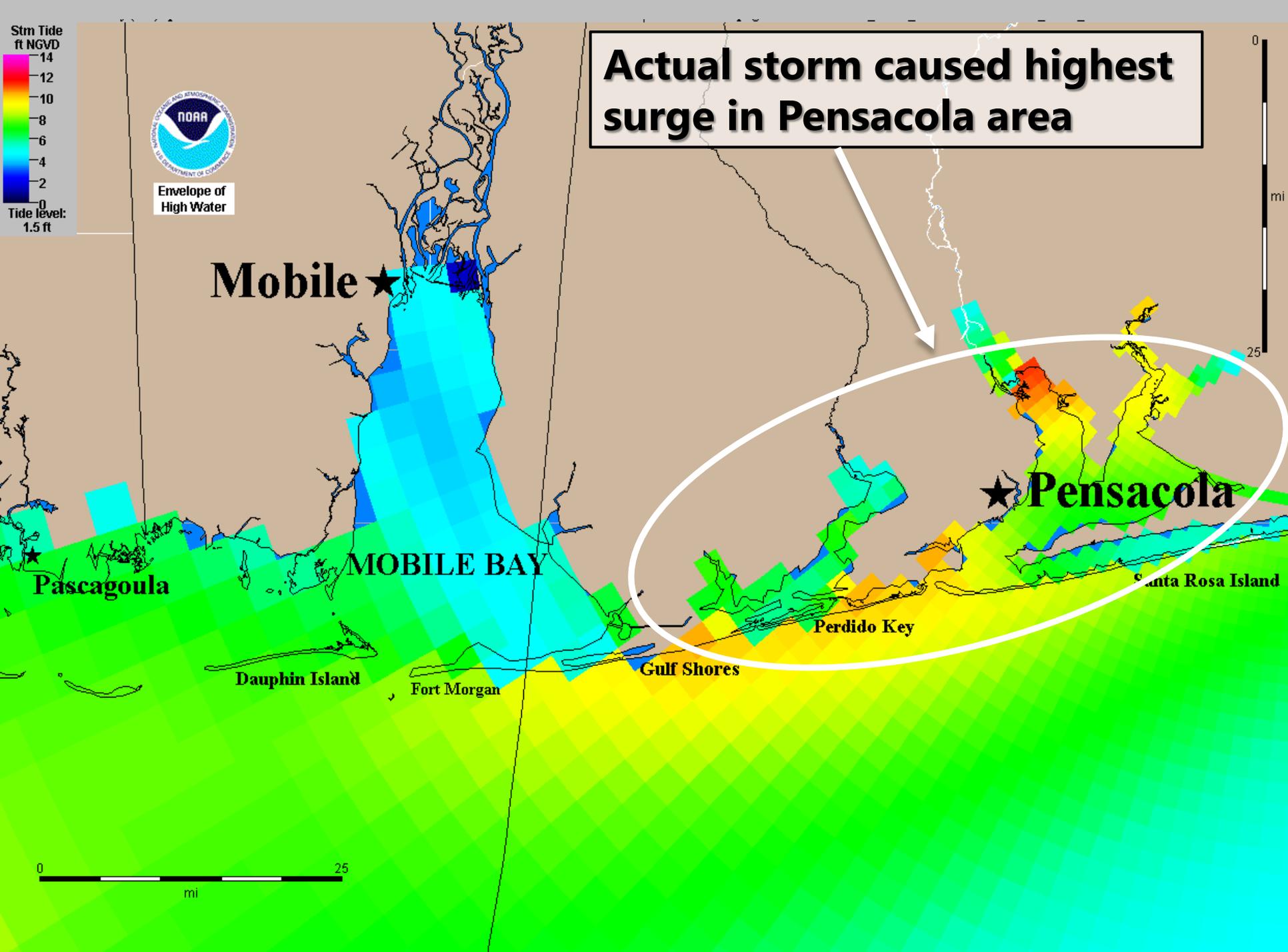
5% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Probability



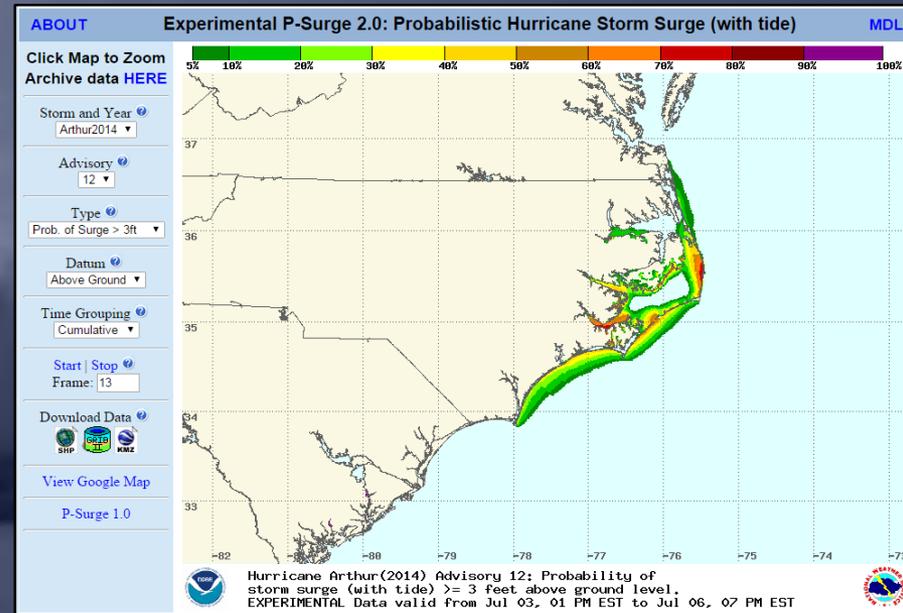
Envelope of
High Water

Actual storm caused highest surge in Pensacola area



When is P-Surge Available? (On the NHC Website)

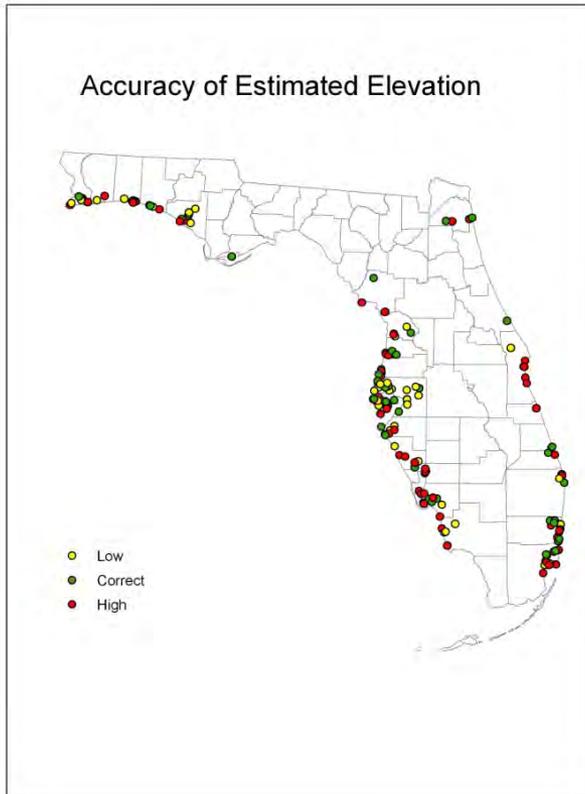
- Whenever a hurricane (and sometimes tropical storm) watch or warning is in effect
 - Approximately 48 hours prior to arrival of TS winds
- Available approximately 30 minutes after full advisory release time
 - 05:30 EDT
 - 11:30 EDT
 - 17:30 EDT
 - 23:30 EDT



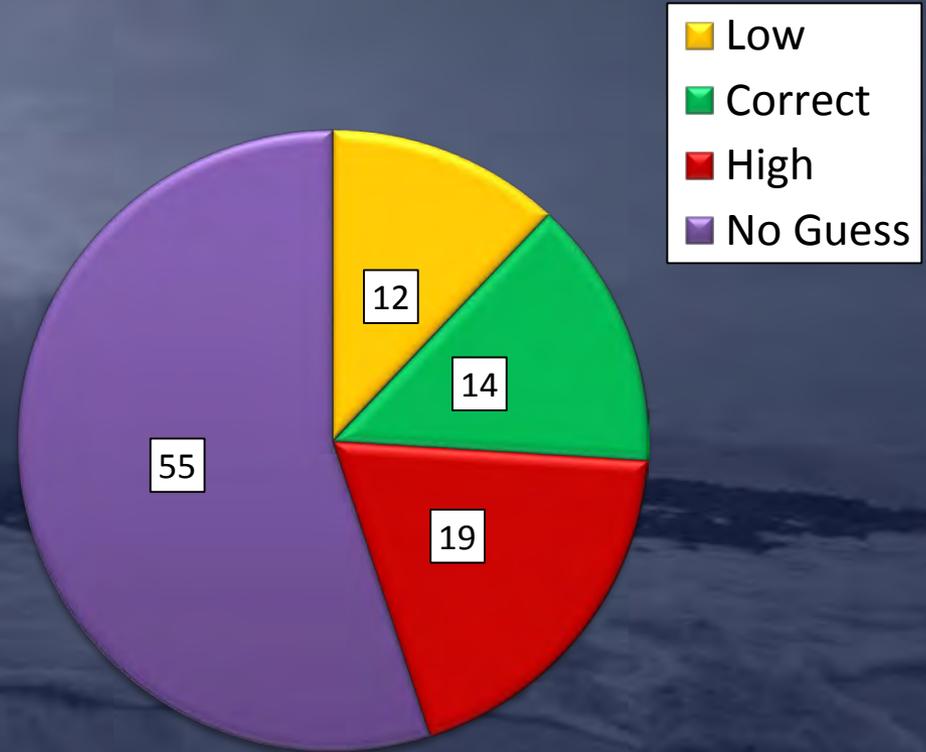
Potential Storm Surge Flooding Map



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

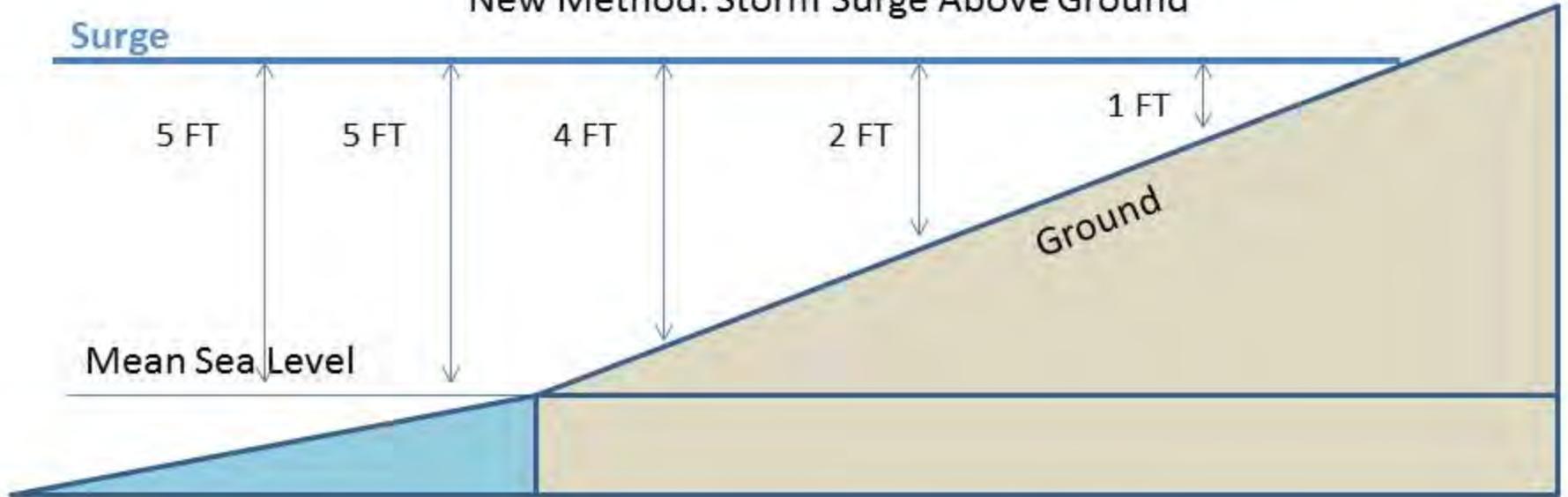


Accuracy of Perceived Elevation

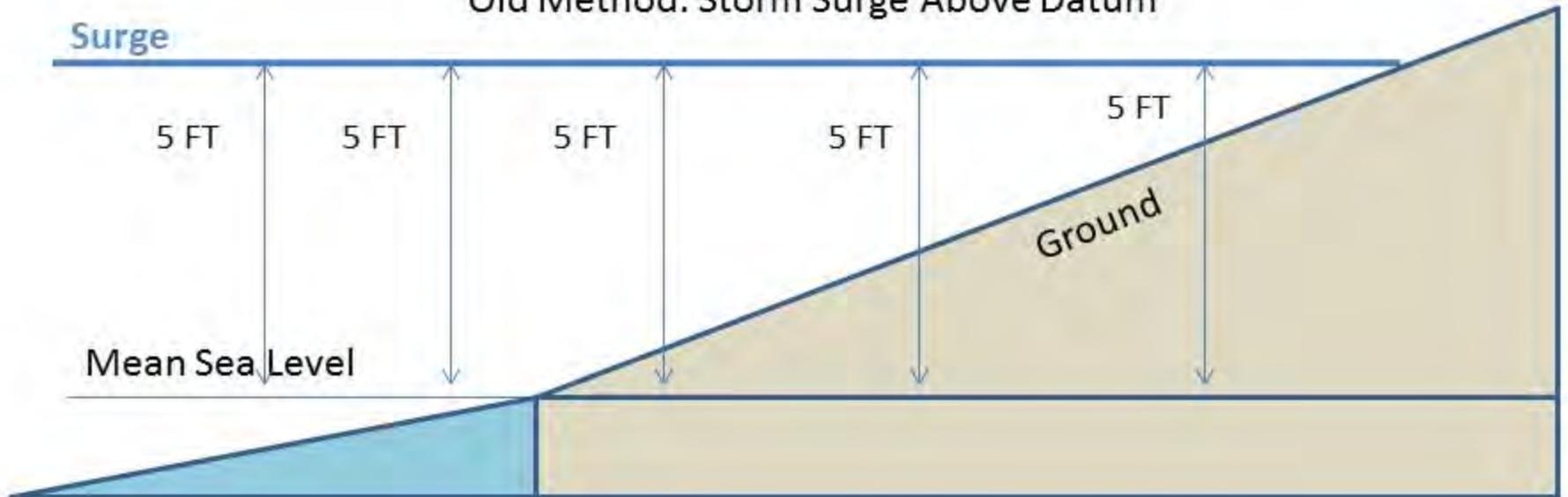


Courtesy Jay Baker, FSU

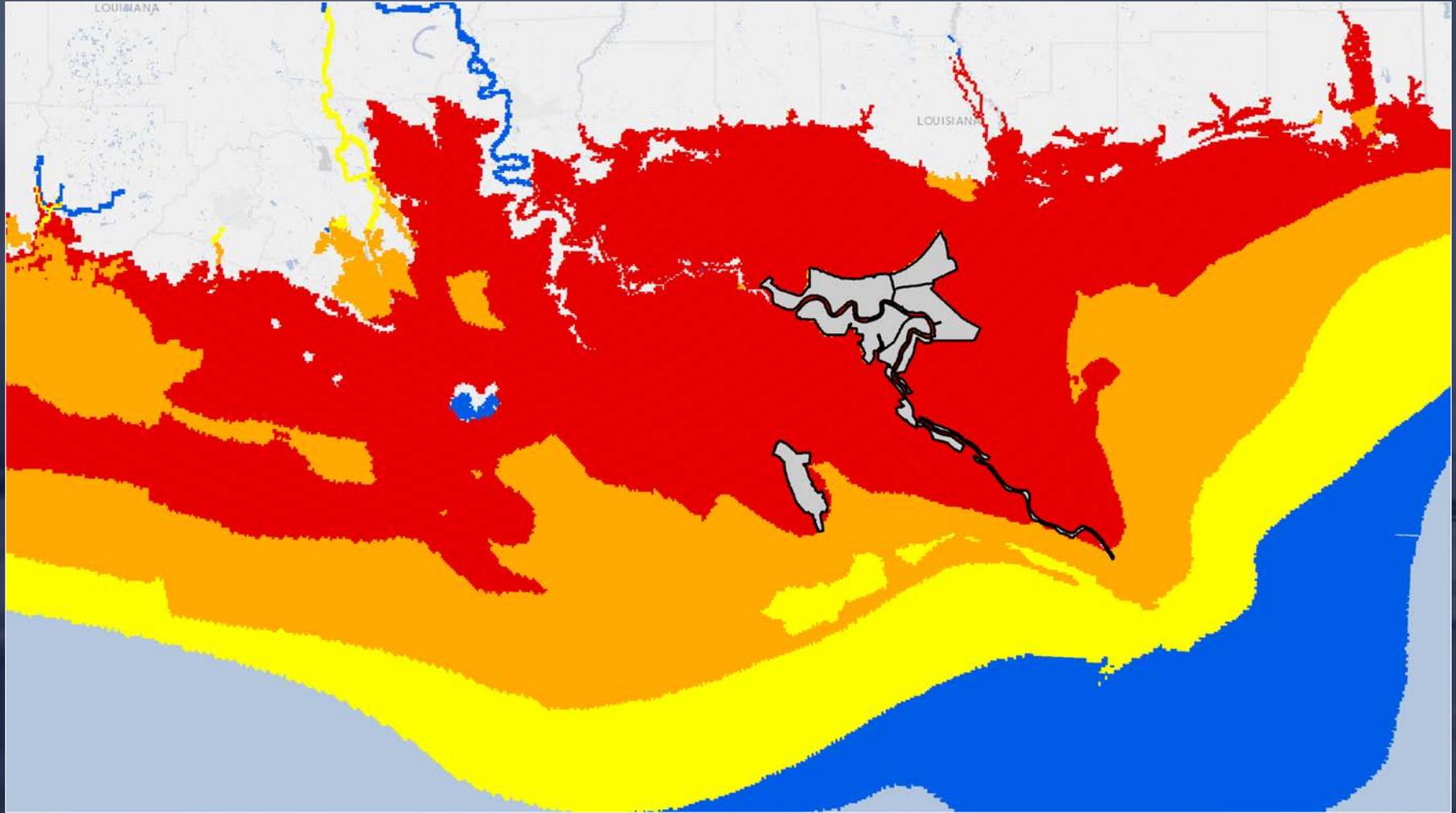
New Method: Storm Surge Above Ground



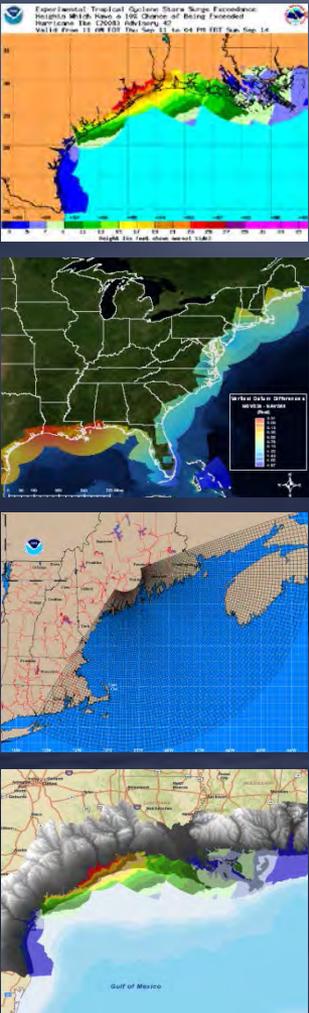
Old Method: Storm Surge Above Datum



Storm Surge Inundation

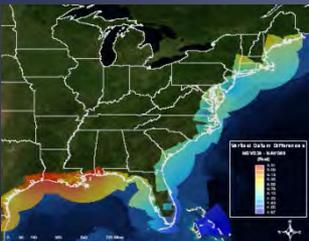
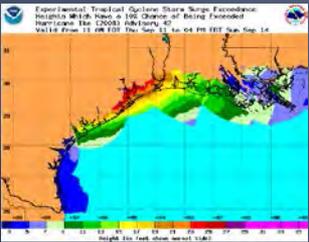


NHC Potential Storm Surge Flooding Map



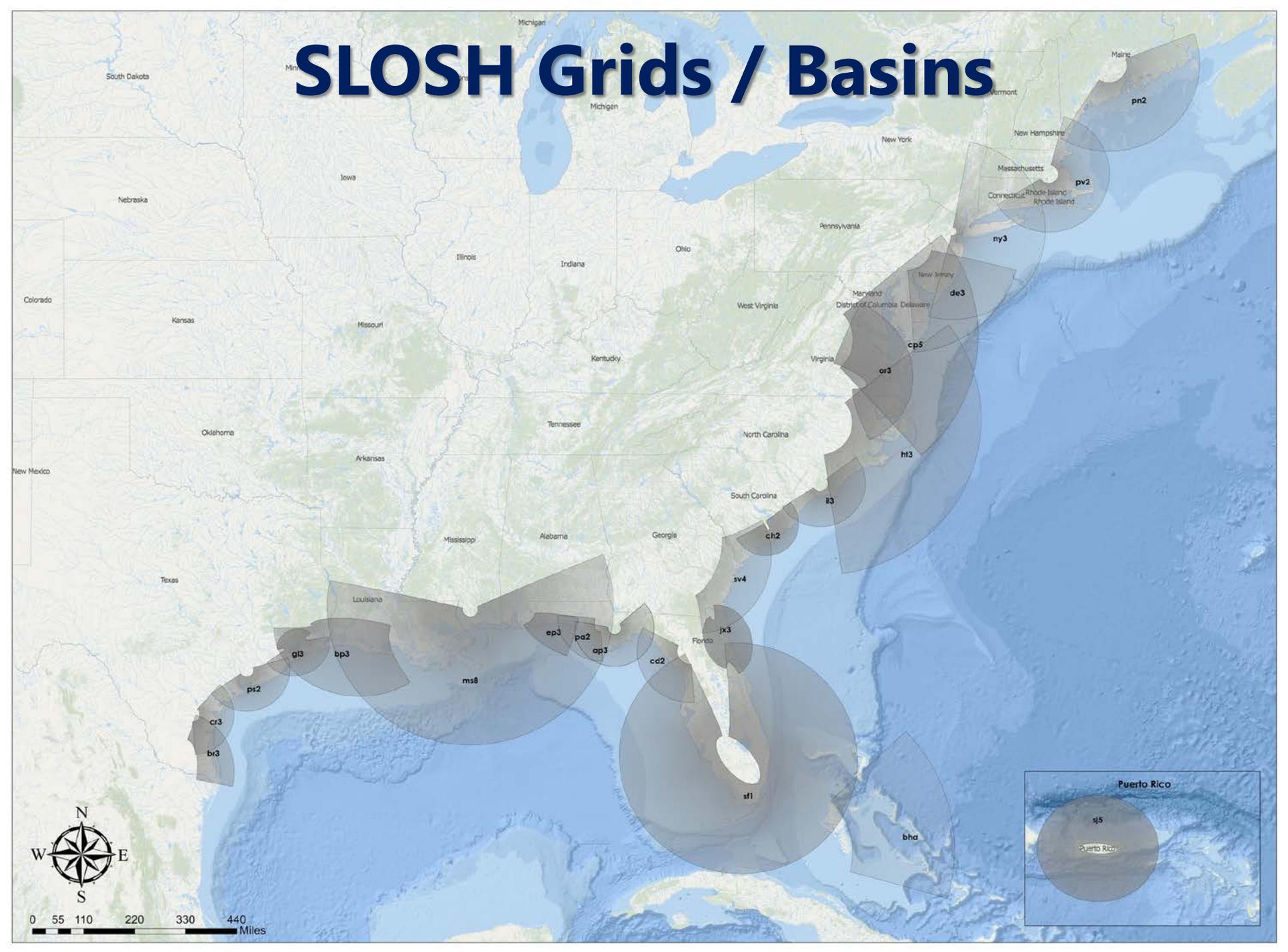
- Which product will drive the flooding map?
 - Psurge 2.x (includes tides)
 - 10% Exceedance (a reasonable worst-case scenario)
- Grids
 - Latest SLOSH basins updated to **NAVD88**
- Topography/Digital Elevation Models (DEMs)
 - NOAA OCM Sea-level rise DEM
 - Resampled to smoother resolution
 - Augmented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

NHC Potential Storm Surge Flooding Map

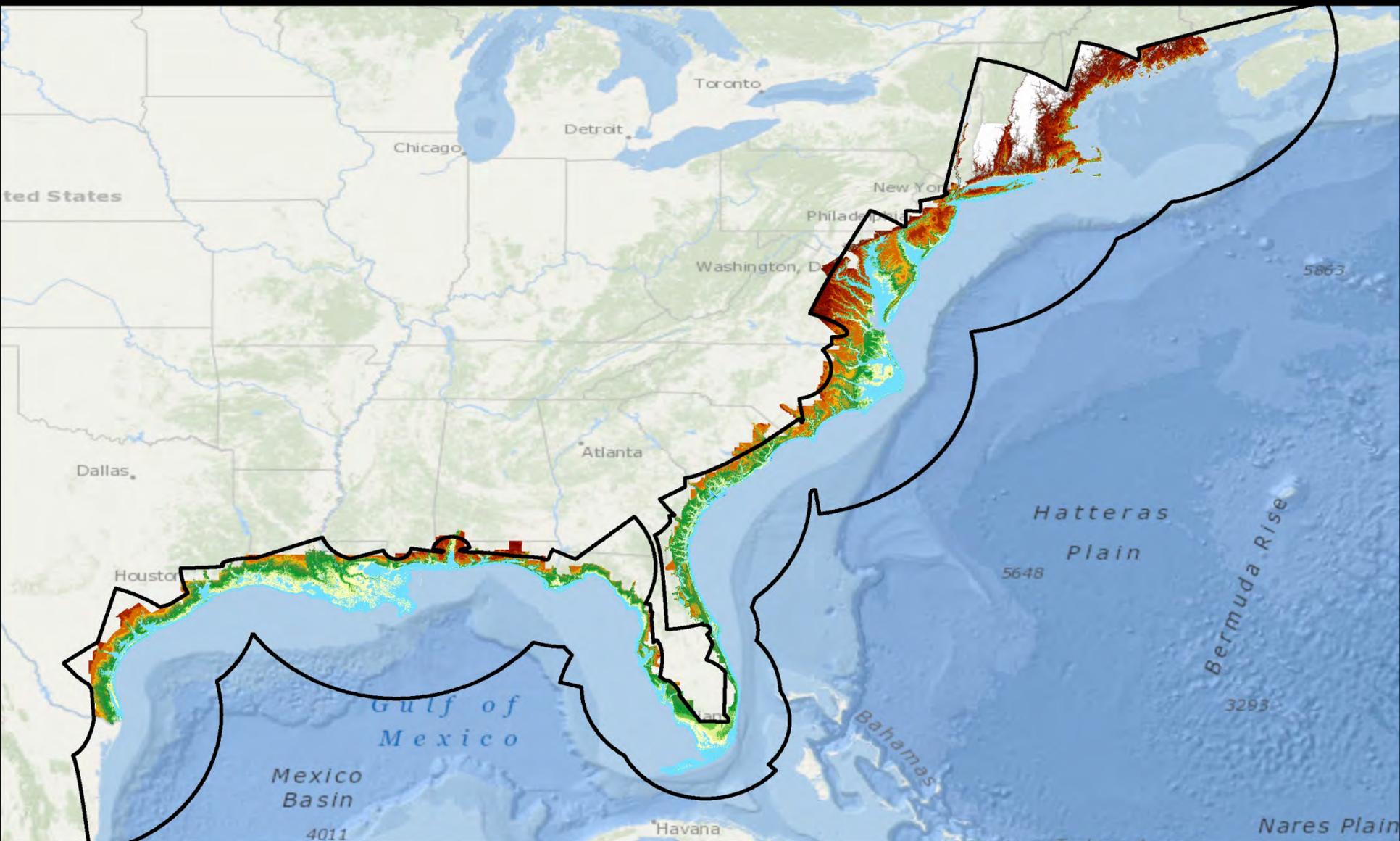


- **What it does account for**
 - Flooding due to storm surge from the ocean, including adjoining tidal rivers, sounds, and bays
 - Normal astronomical tides
 - Land elevation
 - Uncertainties in the landfall location, forward speed, angle of approach to the coast, intensity, and wind field of the cyclone
- **What it does NOT account for**
 - Wave action
 - Freshwater flooding from rainfall
 - Riverine discharge
 - Flooding resulting from levee failures
 - For mapped leveed areas, flooding inside levee systems and overtopping of levees

SLOSH Grids / Basins



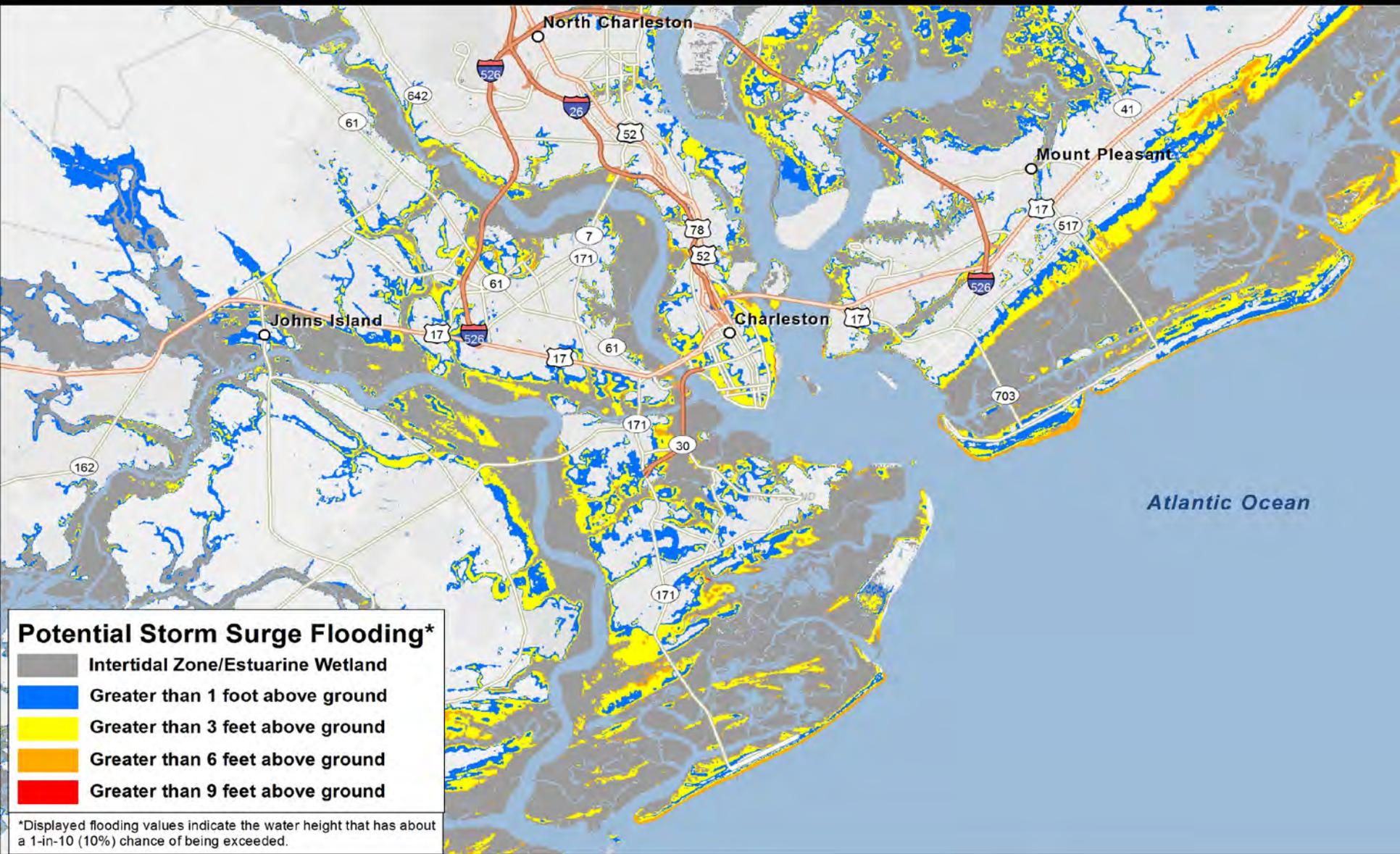
SLOSH Basins and DEMs



National Hurricane Center
Storm Surge Unit



Hurricane X

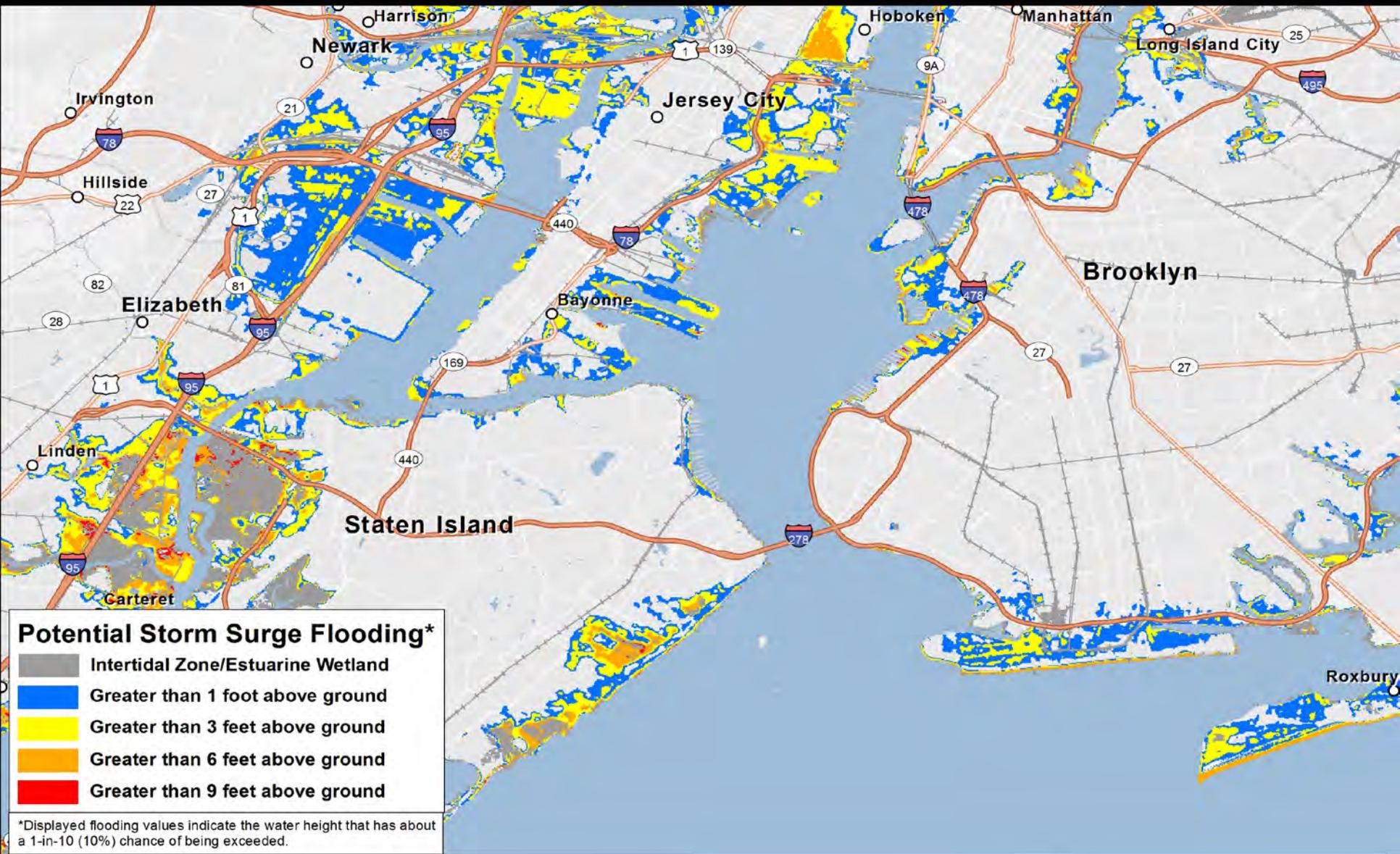


Potential Storm Surge Flooding*

- Intertidal Zone/Estuarine Wetland
- Greater than 1 foot 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 height that has about a 1-in-10 (10%) chance of being exceeded.

Hurricane X

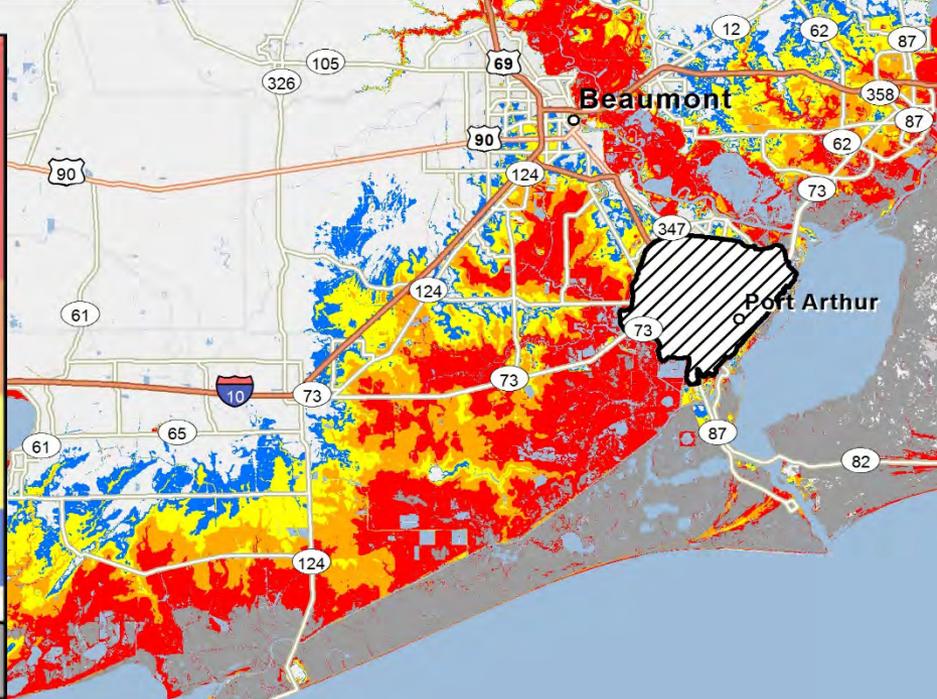
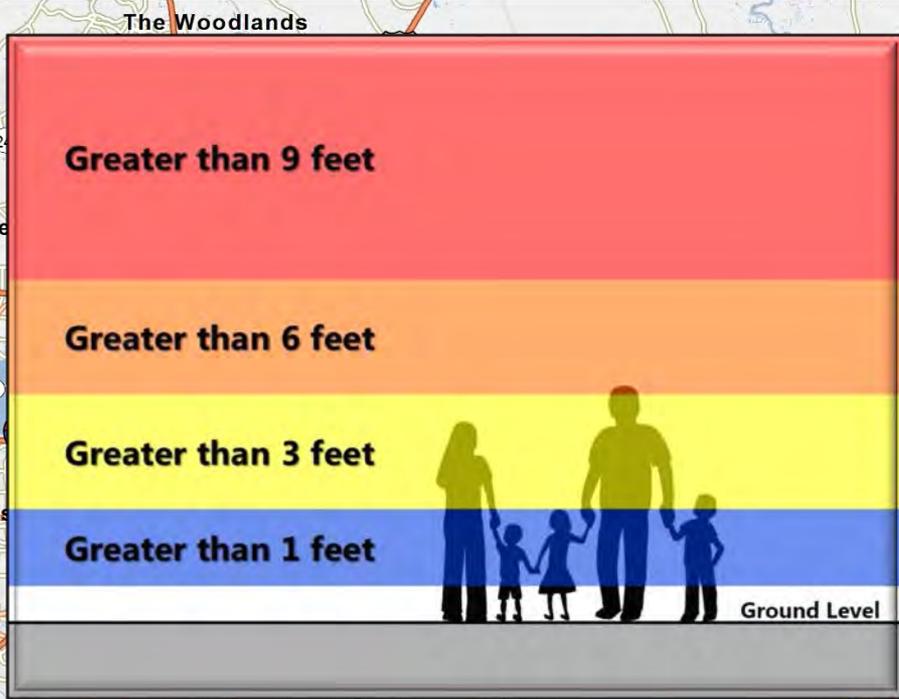


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Hurricane X



Potential Storm Surge Flooding*

- Intertidal Zone/Estuarine Wetland
- Greater than 1 foot above ground
- Greater than 3 feet above ground
- Greater than 6 feet above ground
- Greater than 9 feet above ground
- Leveed area
Consult local officials for flood risk

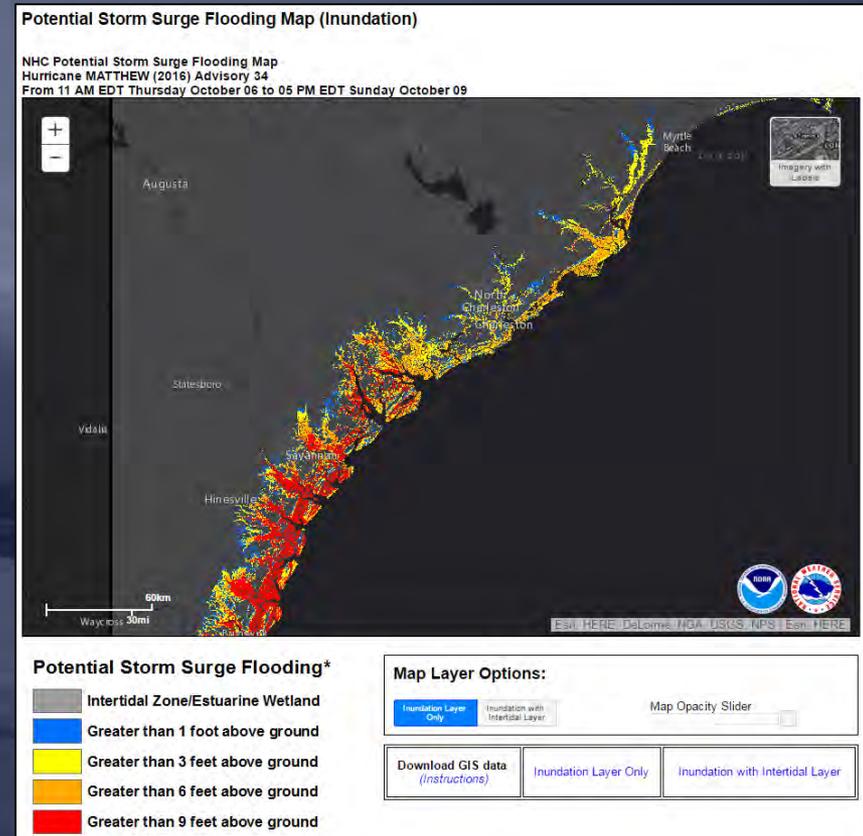
*Displayed flooding values indicate the water height that has about a 1-in-10 (10%) chance of being exceeded.



National Hurricane Center
Storm Surge Unit

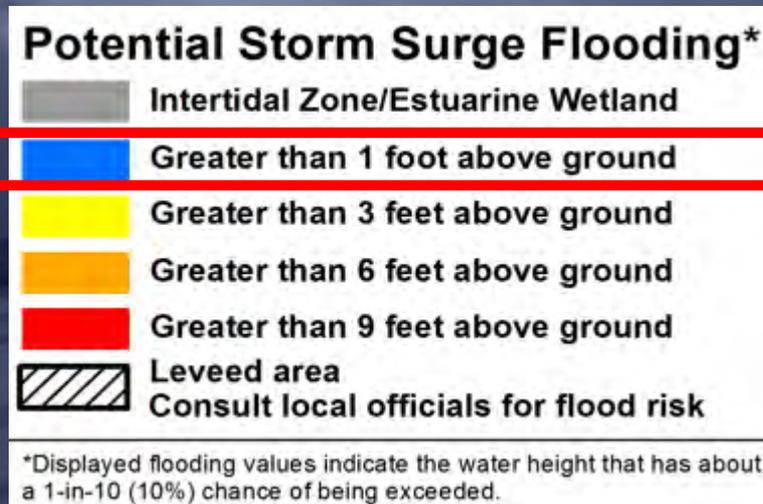
Interactive Interface and Data Access

- 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)



Lower Bound Cut-Off

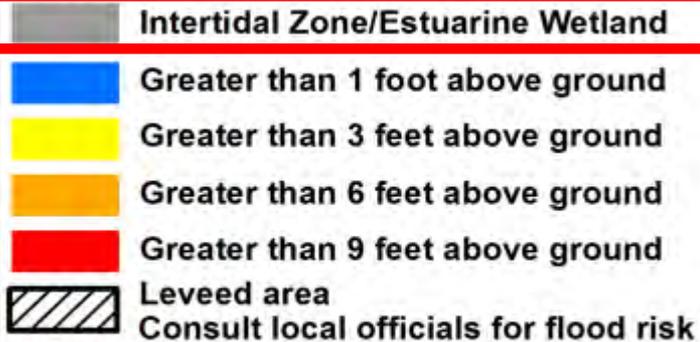
- The data is only displayed in areas where there is at least a 10% chance of at least **1 foot** of inundation



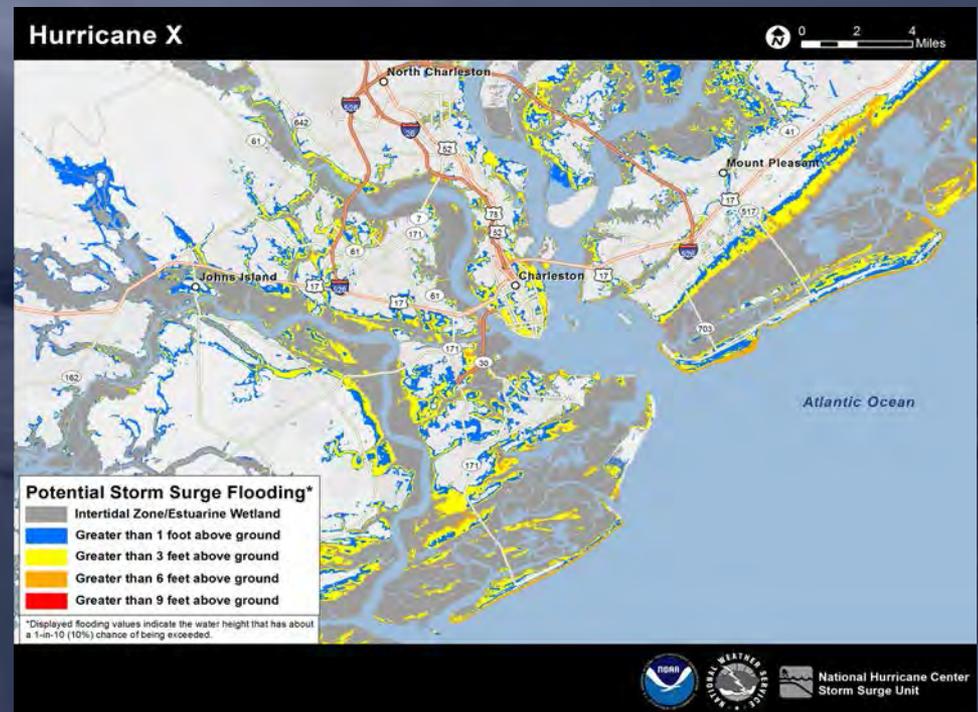
Intertidal Zone/Estuarine Wetland Mask

- Areas that are often inundated by seawater without a storm are masked in gray. This allows users to focus on areas that could experience consequential flooding of normally dry ground.

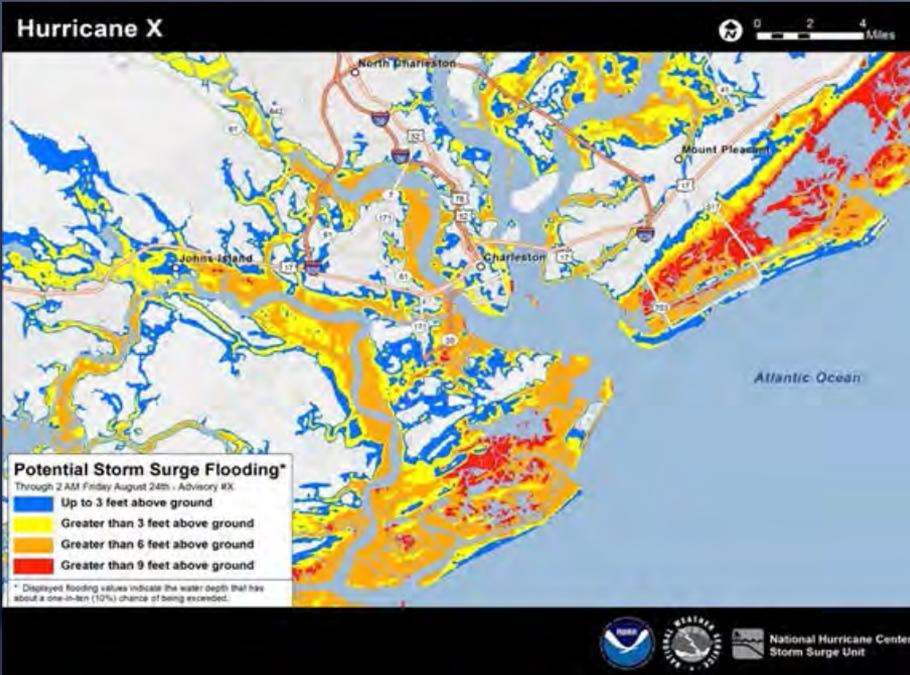
Potential Storm Surge Flooding*



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



Intertidal Zone/Estuarine Wetland Mask



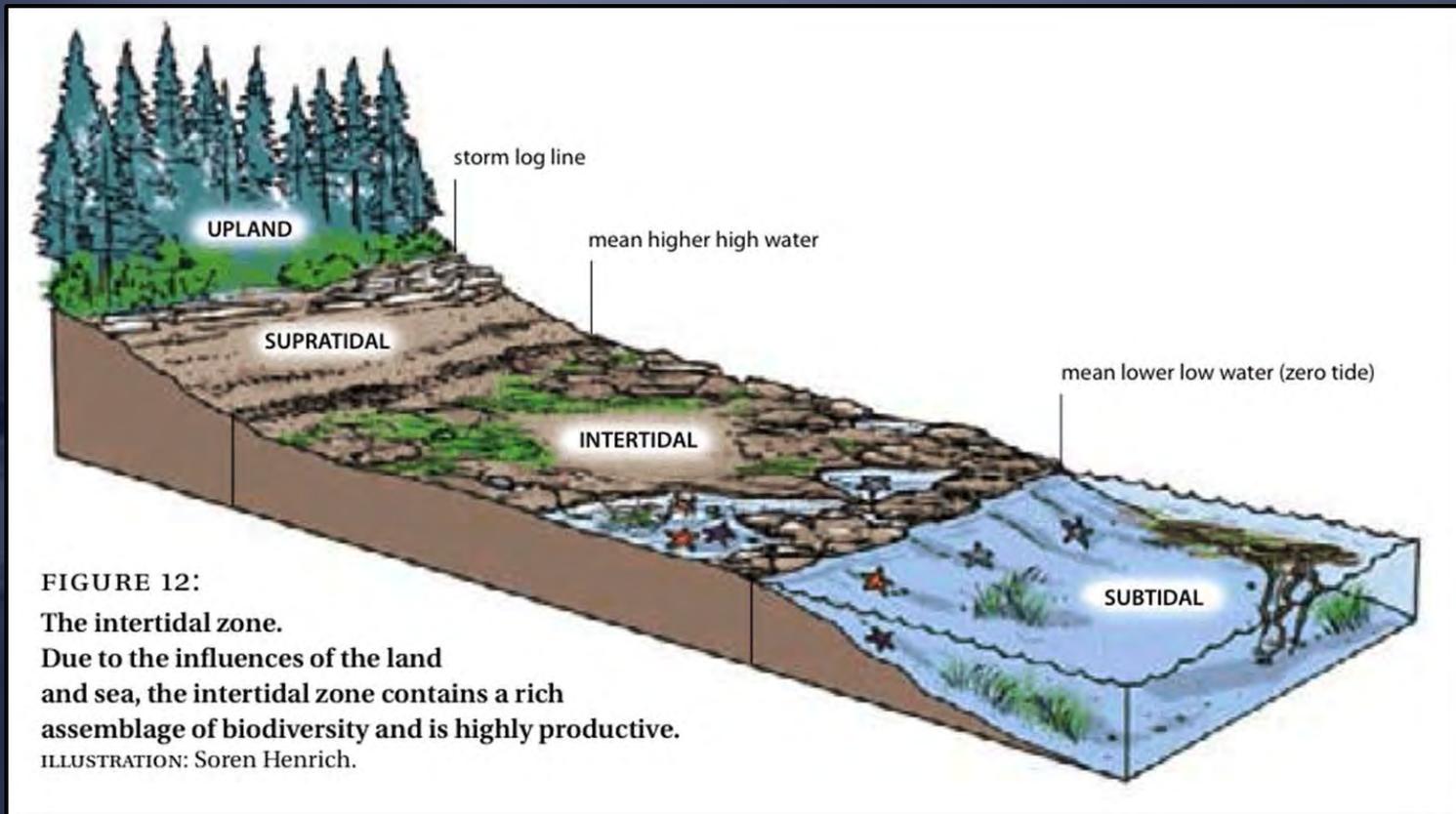
No Tidal Mask

Tidal Mask



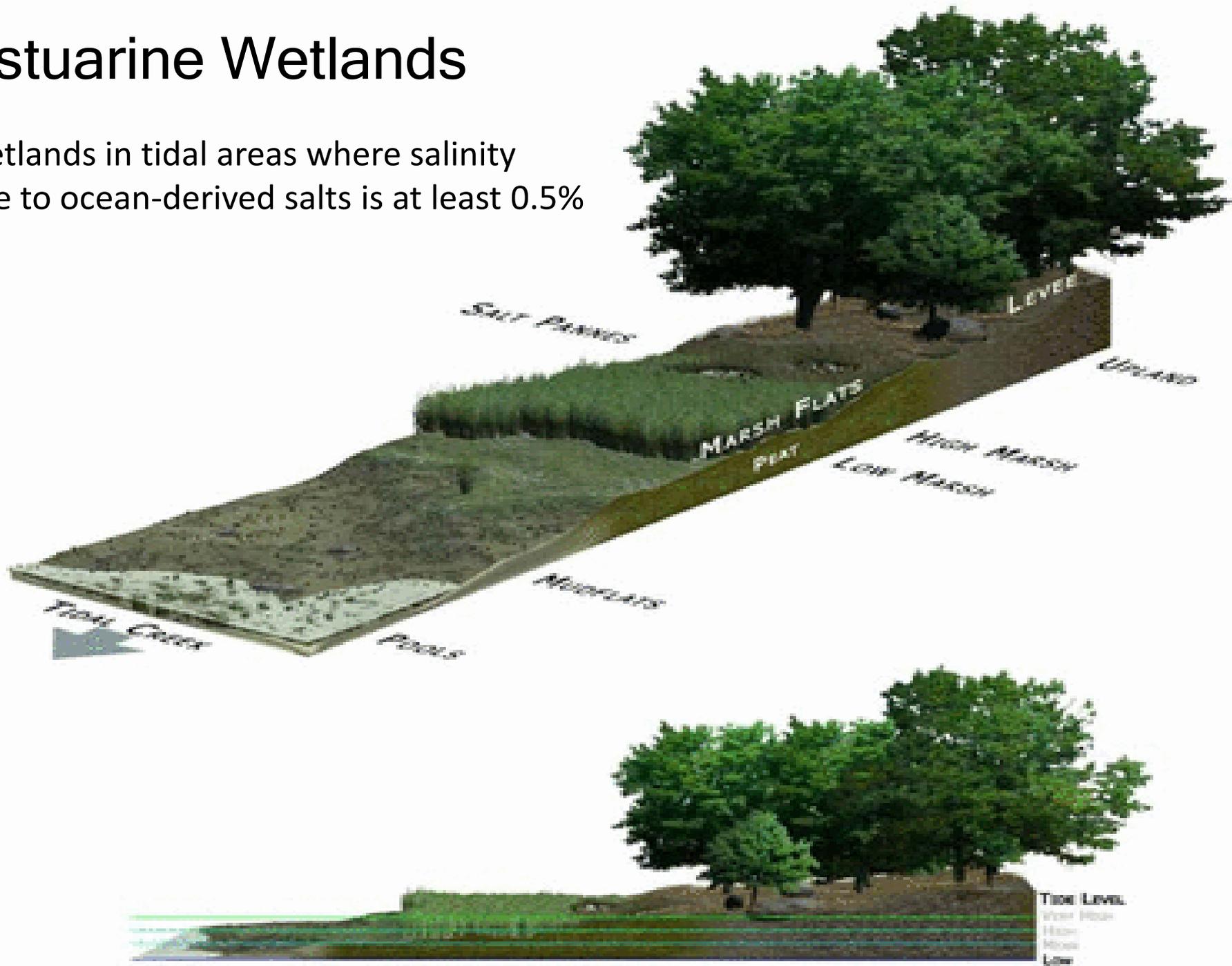
Intertidal Zone

- Land that is exposed at low tide and under water at high tide



Estuarine Wetlands

Wetlands in tidal areas where salinity due to ocean-derived salts is at least 0.5%



Salt Marshes



Sapelo Marsh, Georgia

Mangroves



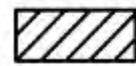
Southwest Florida

Estuarine Forests



Shell Bank Bayou, Louisiana

Leveed Areas



Leveed area
Consult local officials for flood risk

- Flooding levels inside leveed areas due to overtopping and failure of the levee is nearly impossible to predict
- Consult local officials for the flood risk in these leveed areas

Hurricane & Storm Damage Risk Reduction System (Louisiana)



Port Arthur Hurricane Protection Structure (Texas)





Potential Storm Surge Flooding Map



- Provides a quantitative risk assessment for decision makers.

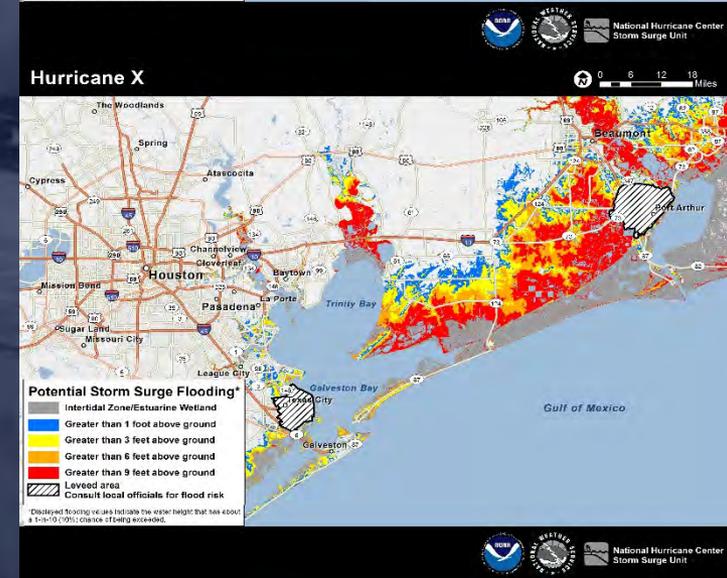
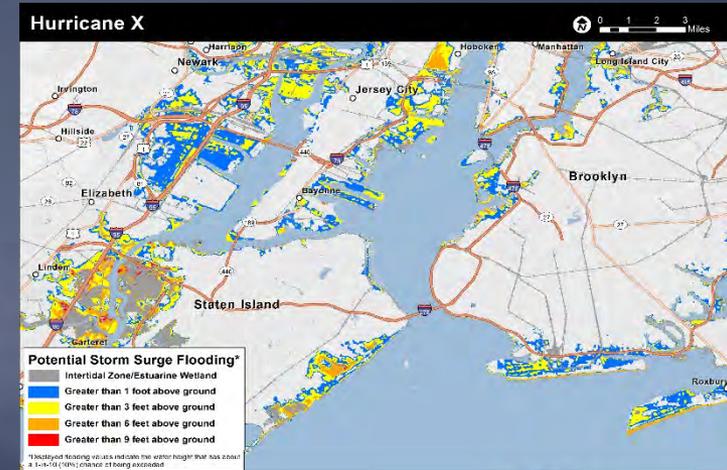
- Shows height above ground that the water **could** reach.

- 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.



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.

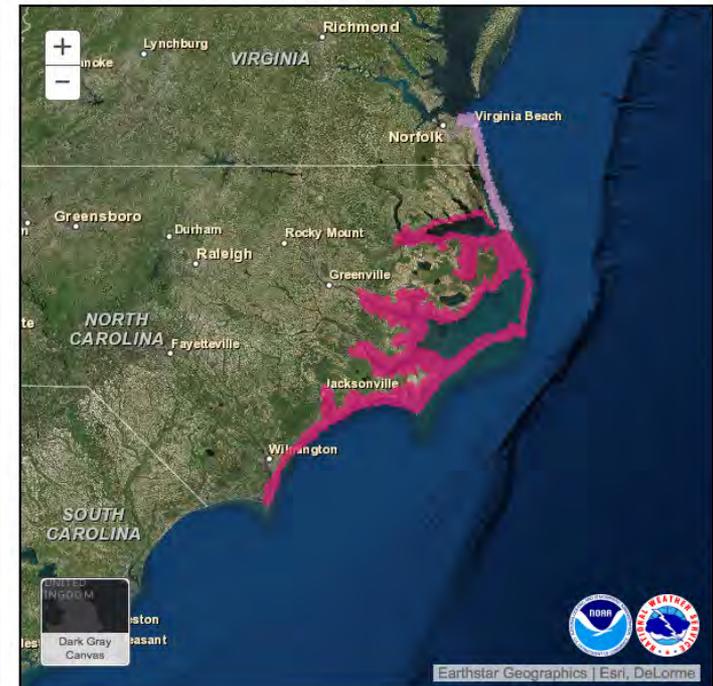
- W/W Graphic highlights areas that have a **significant risk of life-threatening inundation** from storm surge.

- 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 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 will become **operational in 2017**.
- W/W will be 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

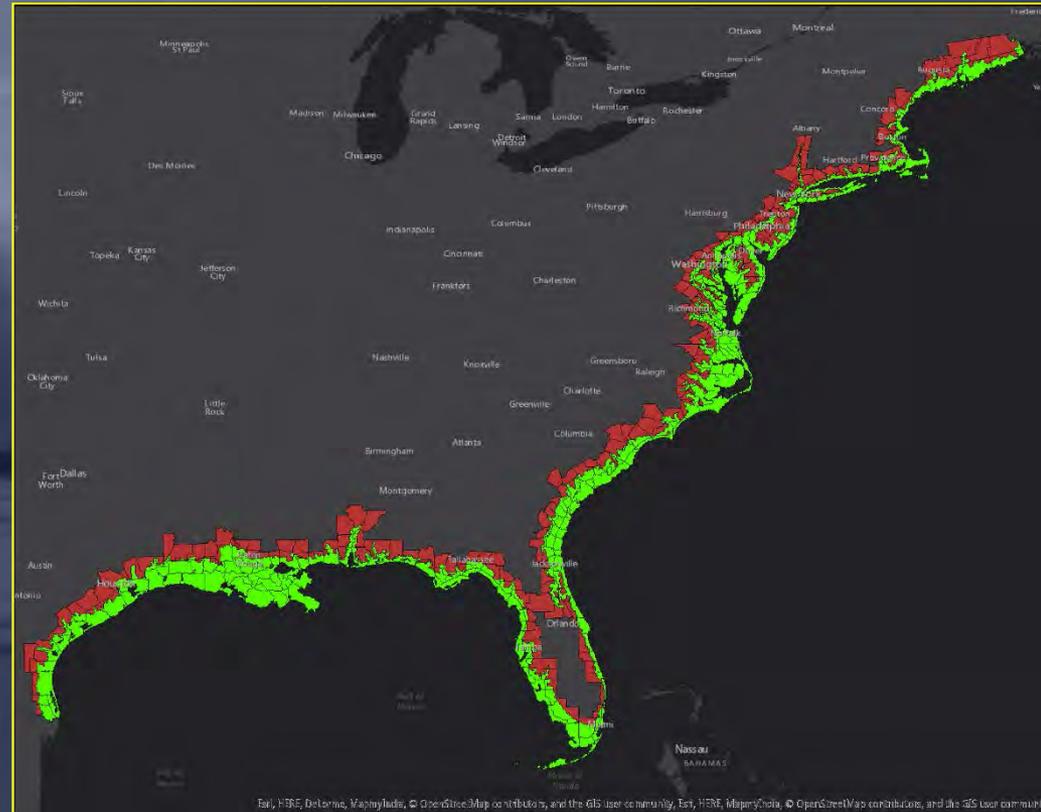
A Storm Surge Warning is in effect for...
* Aripeka to Indian Pass Florida

Storm Surge Watch/Warning Dissemination

STORM SURGE WEA

Red = All areas that can be alerted for a Storm Surge Watch/Warning via VTEC, EAS and NWR (*entire zone is alerted*)

Green = All areas that can be alerted for a Storm Surge Watch/Warning via WEA and the NWS front page (WWA) map and “Point and Click” pages (*zones and portions of zones that lie within the largest possible area for tropical cyclone storm surge flooding*)

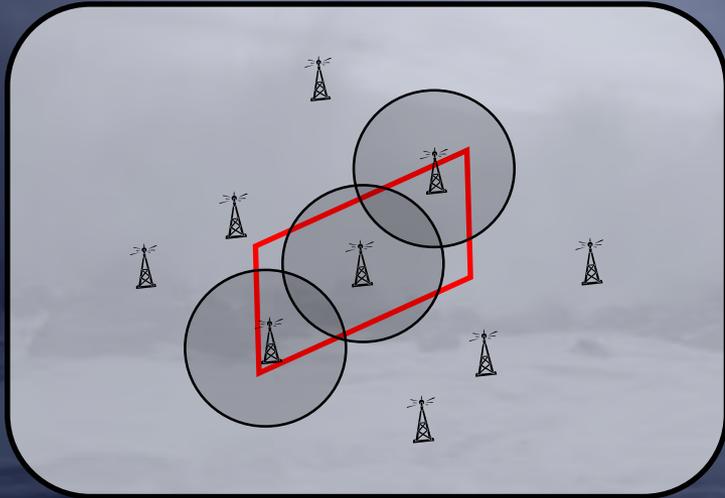


Map, HERE, DeLorme, Mapbox, © OpenStreetMap contributors, and the GIS user community, Esri, HERE, Mapbox, © OpenStreetMap contributors, and the GIS user community

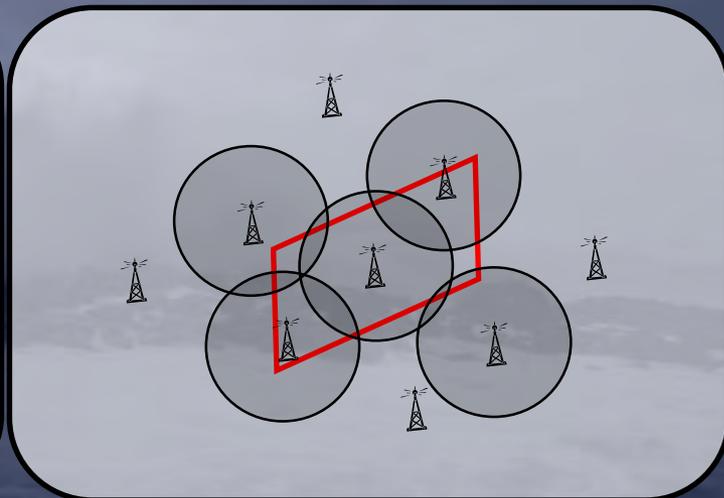
Storm Surge Watch/Warning Dissemination

How Carriers Geotarget WEA

While efforts are underway to make NWS triggered WEA activations more targeted, there is still the potential for the message to be spread outside the intended warning area



Carriers generally broadcast WEA from cell towers within the defined warning area



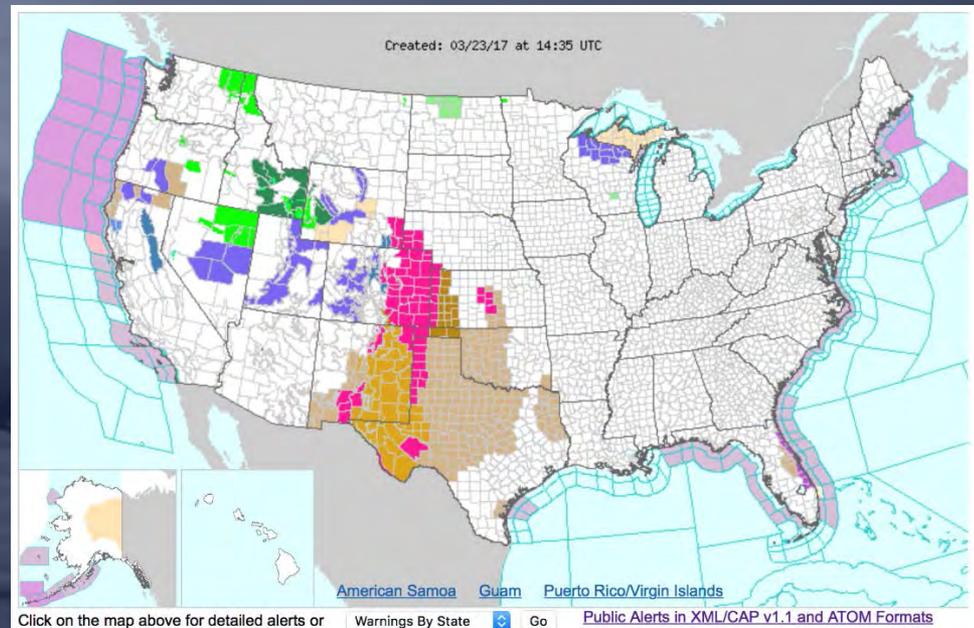
They may broadcast from towers where signal overlaps the defined warning area

Note: Map is not drawn to scale and is for illustrative purposes only.

Storm Surge Watch/Warning Dissemination

NWS Front Page Map WWA (Watch/Warning/Advisory) Map

- SSWWs on the NWS' weather.gov Front Page (WWA) Map will be populated using CAP 1.2 data
- The WWA Map will display the geographic coverage of the entire area in each zone that is vulnerable to storm surge when the zone is included in the WFO TCV
 - It will be larger than the intended gridded warning area
 - The point forecast will be based on this area and will direct some users outside the gridded warning to the TCV for warning information
- SS Warning will be **Dark Purple**
- SS Watch will be **Light Purple**



NOTE: There is no SSWW in this example



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



Collaboration

Dissemination of Storm Surge Watch/Warning

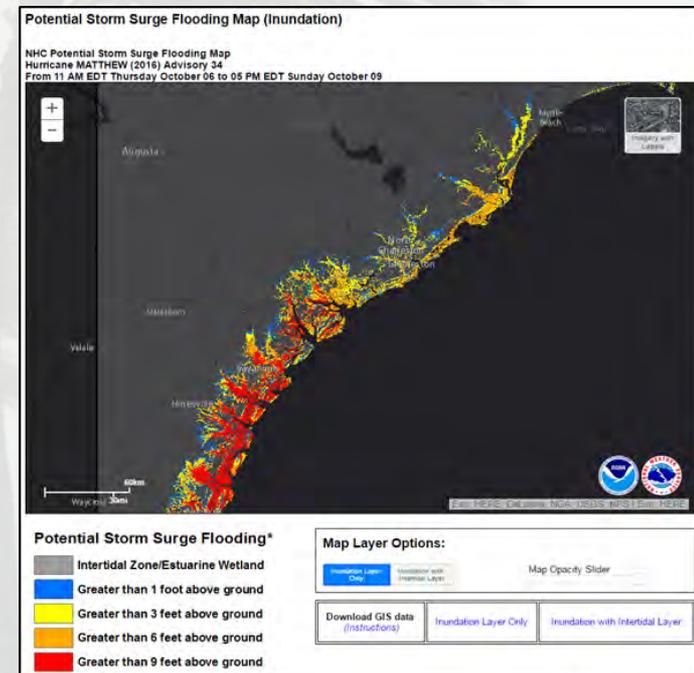
Storm Surge Watch/Warning

- Primary audience is the general public.
- Highlights the areas that have a significant risk of life-threatening surge, but does not provide any quantitative inundation levels.
- Although driven by objective guidance, W/W areas also based on subjective factors such as forecaster confidence, continuity with previous issuances, wind trigger, smoothing, isolated areas, etc.



Potential Storm Surge Flooding Map

- Intended for decision makers.
- Objective guidance on where inundation from surge could occur and height above ground the water could reach.
- Based solely on the latest NHC forecast and historical error characteristics. No guaranteed continuity from cycle to cycle, or consistency with W/W graphic.



Questions?

