

# Storm Surge Forecasting and Products

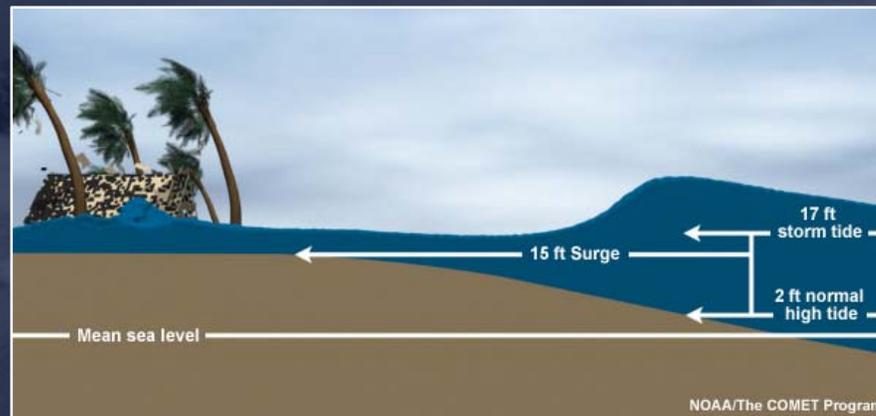


Michael R. Lowry  
National Hurricane Center  
Storm Surge Unit

19.7 ft

# SLOSH

- Sea, Lake, and Overland Surges from Hurricanes
- A computerized numerical model developed by the National Weather Service (NWS) to estimate storm surge heights (and winds) resulting from historical, hypothetical, or predicted hurricanes



# SLOSH

## Strengths and Limitations

- SLOSH **does include**:
  - Flow through barriers/gaps/passages
  - Deep passes between bodies of water
  - Inland inundation (wet/dry cell)
  - Overtopping of **barrier systems, levees**, and roads
  - Coastal reflection (coastally trapped Kelvin waves)
- SLOSH **does not include**:
  - Breaking **waves**/wave run-up
  - Astronomical tide
  - Operational runs can be run at different tide levels via an initial water level (anomaly)
  - Normal **river flow and rain**



# Forecasting Storm Surge

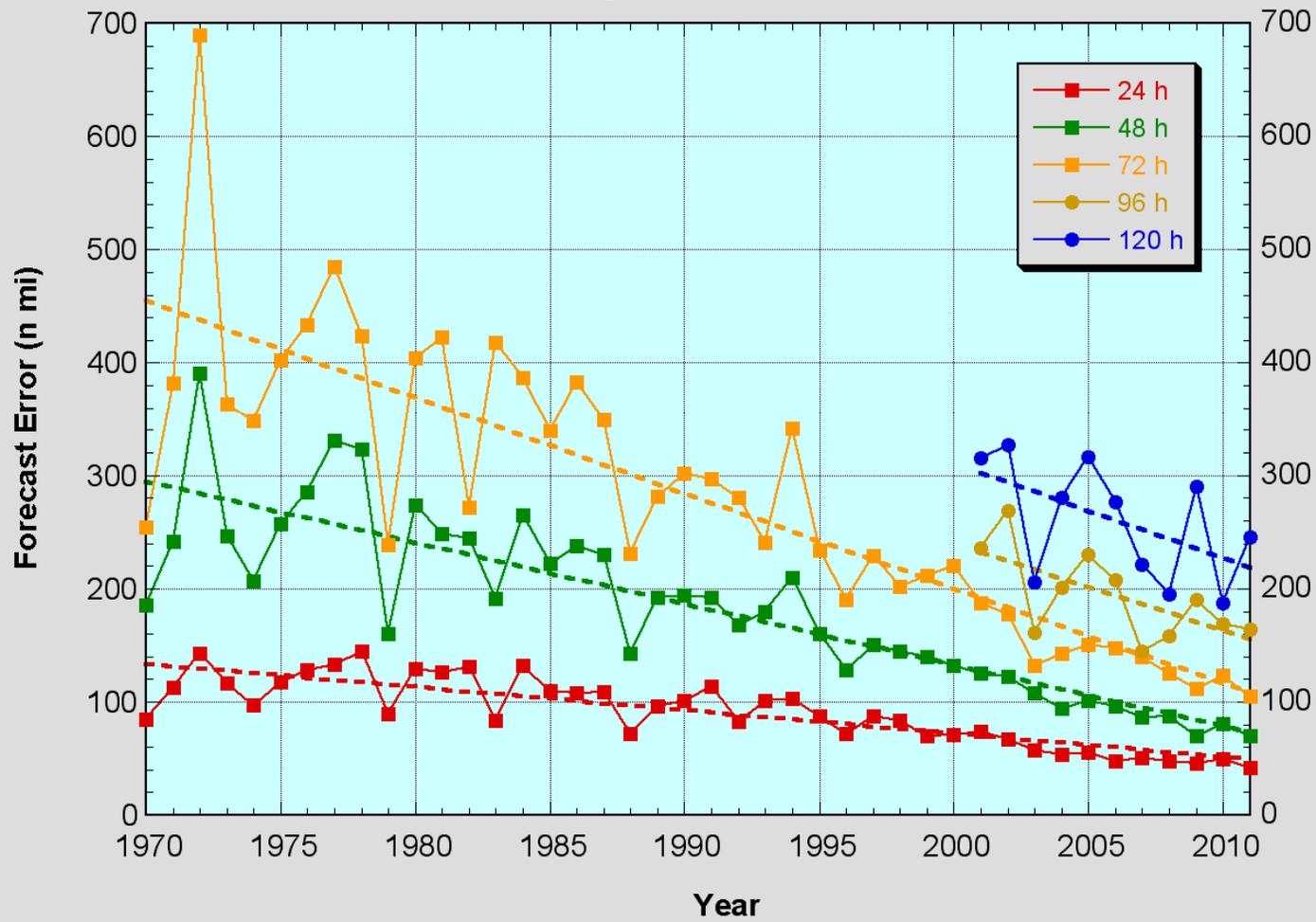
- All storm surge models are **STRONGLY** dependent on the accuracy of the **meteorological input**
- Meteorological uncertainty will dominate over storm surge model specifications (physics, resolution, etc)
- Different vertical datums/reference levels
- Storm surge is only one component in the real water level rise

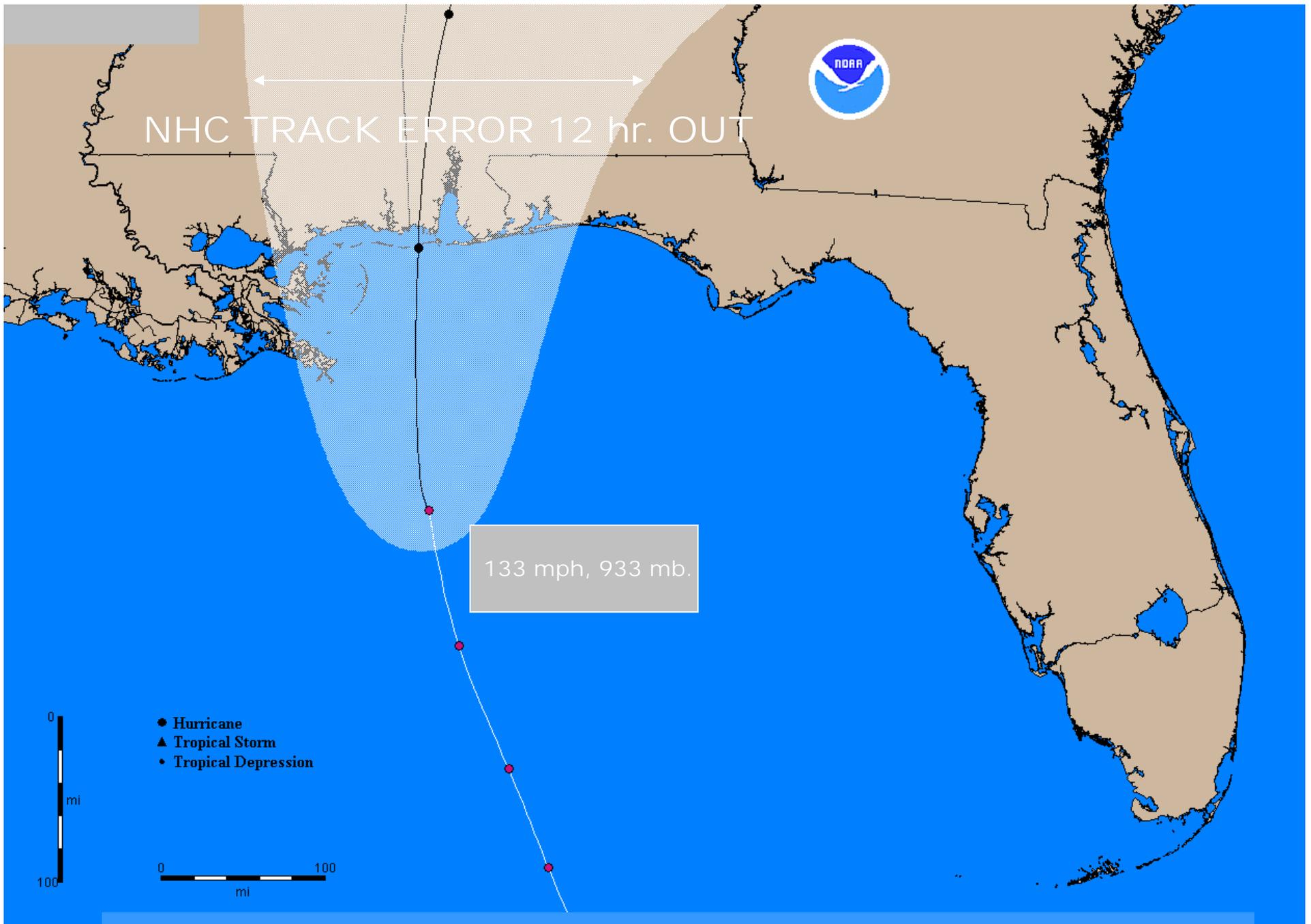
**Total water rise = surge + tides + waves + freshwater flow**



# Track Forecast Uncertainty

**NHC Official Annual Average Track Errors  
Atlantic Basin Tropical Storms and Hurricanes**

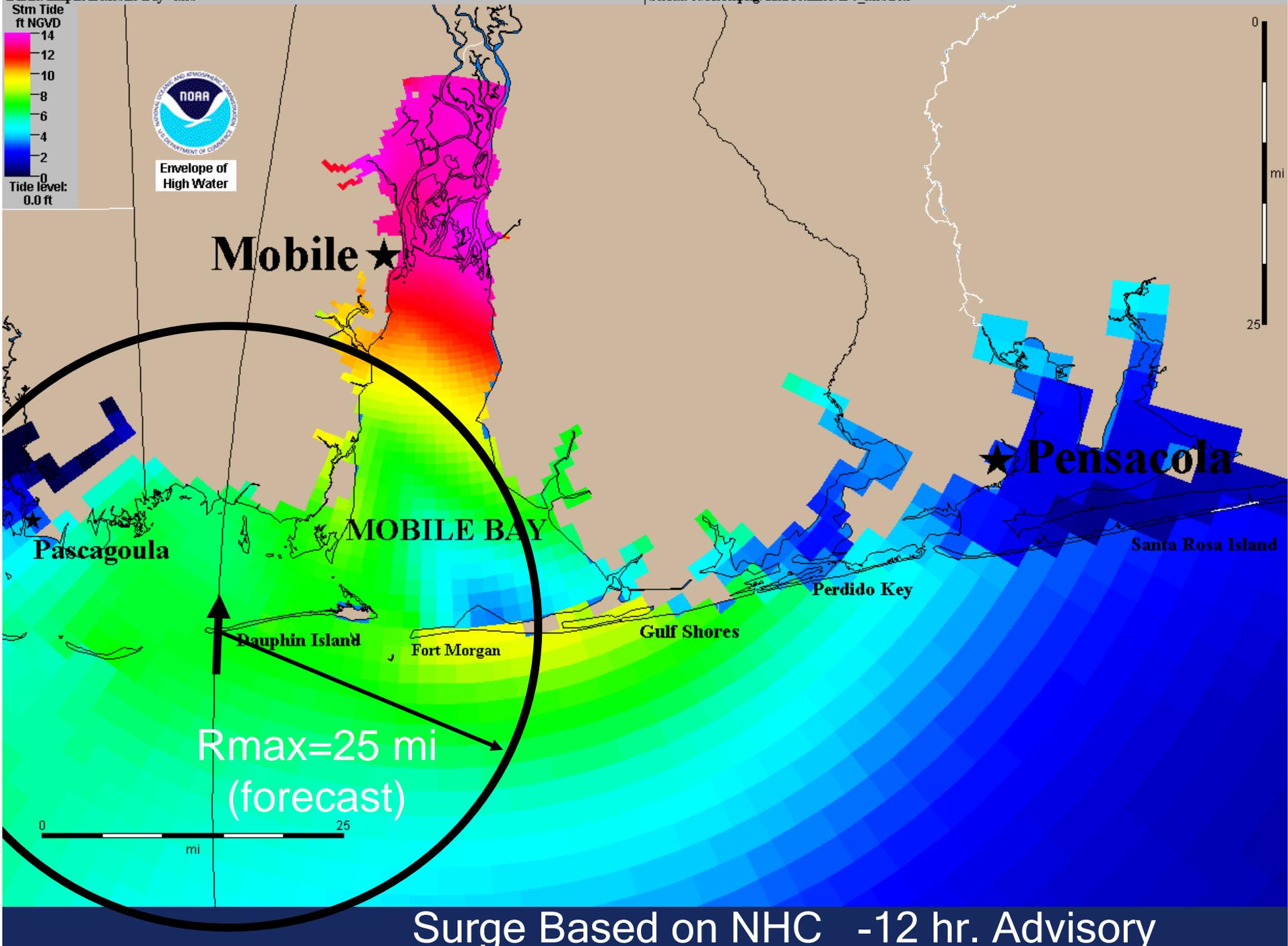




Hurricane Advisory - Approximately 12 hr. before landfall

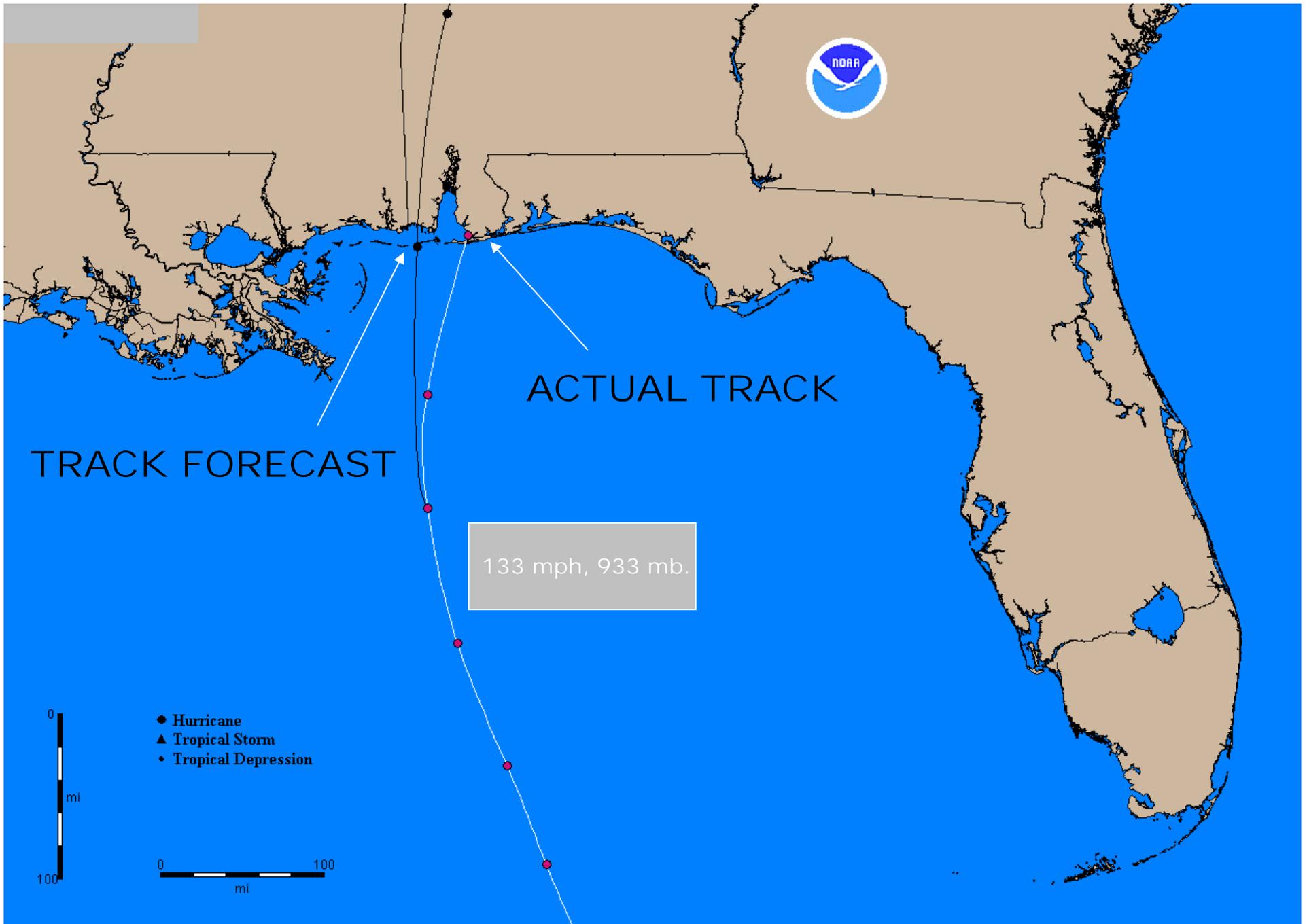
Basin: Elliptical Mobile Bay <mob>

Storm: c:/slosh/pkg/data/rexfiles/i54\_mob.rex



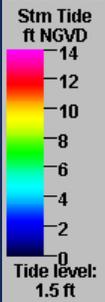
Rmax=25 mi  
(forecast)

Surge Based on NHC -12 hr. Advisory

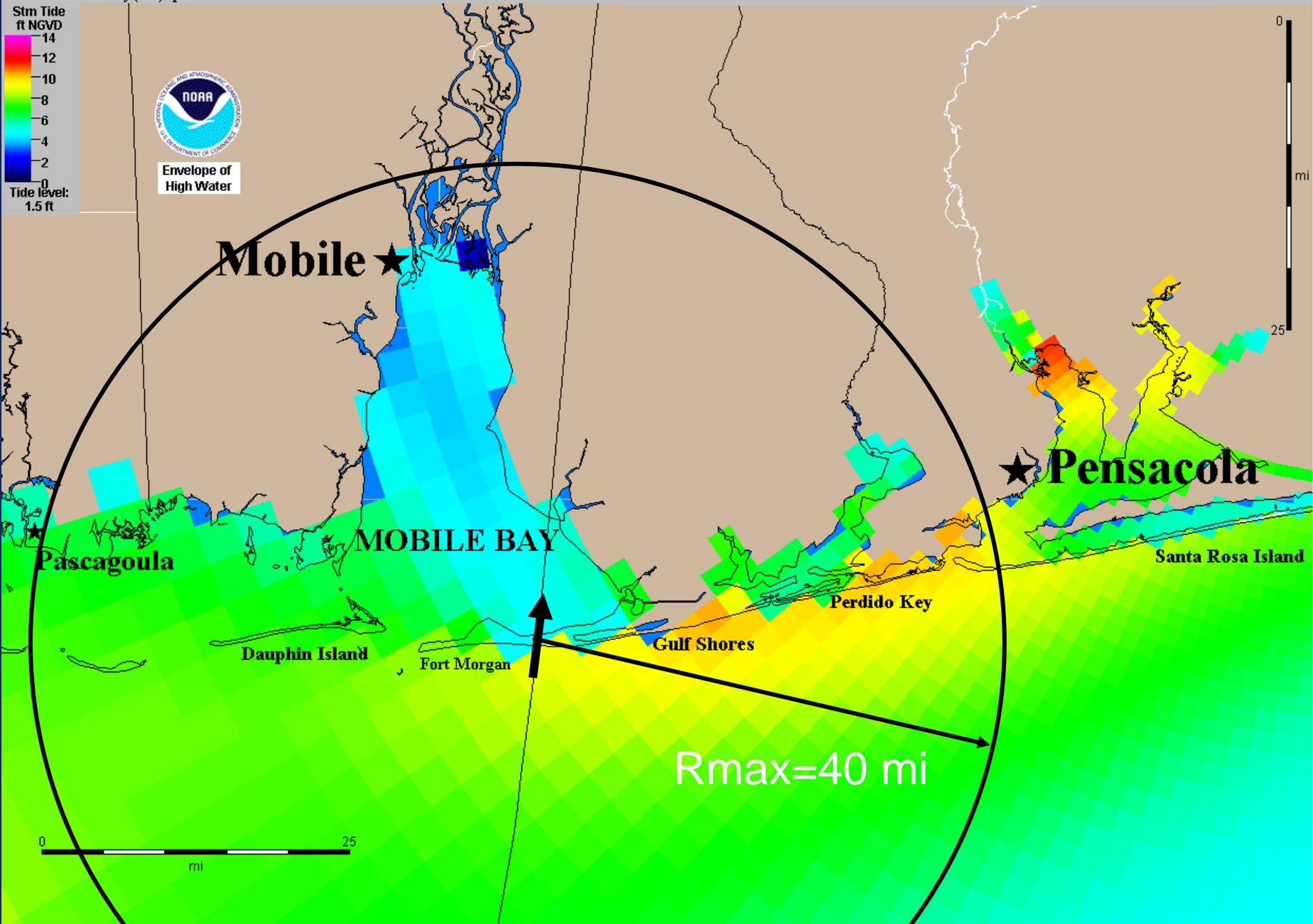


Actual Hurricane Track 30 mi. E of -12 hr. Advisory Forecast Track

Basin: Pensacola Bay (Old) <pns>



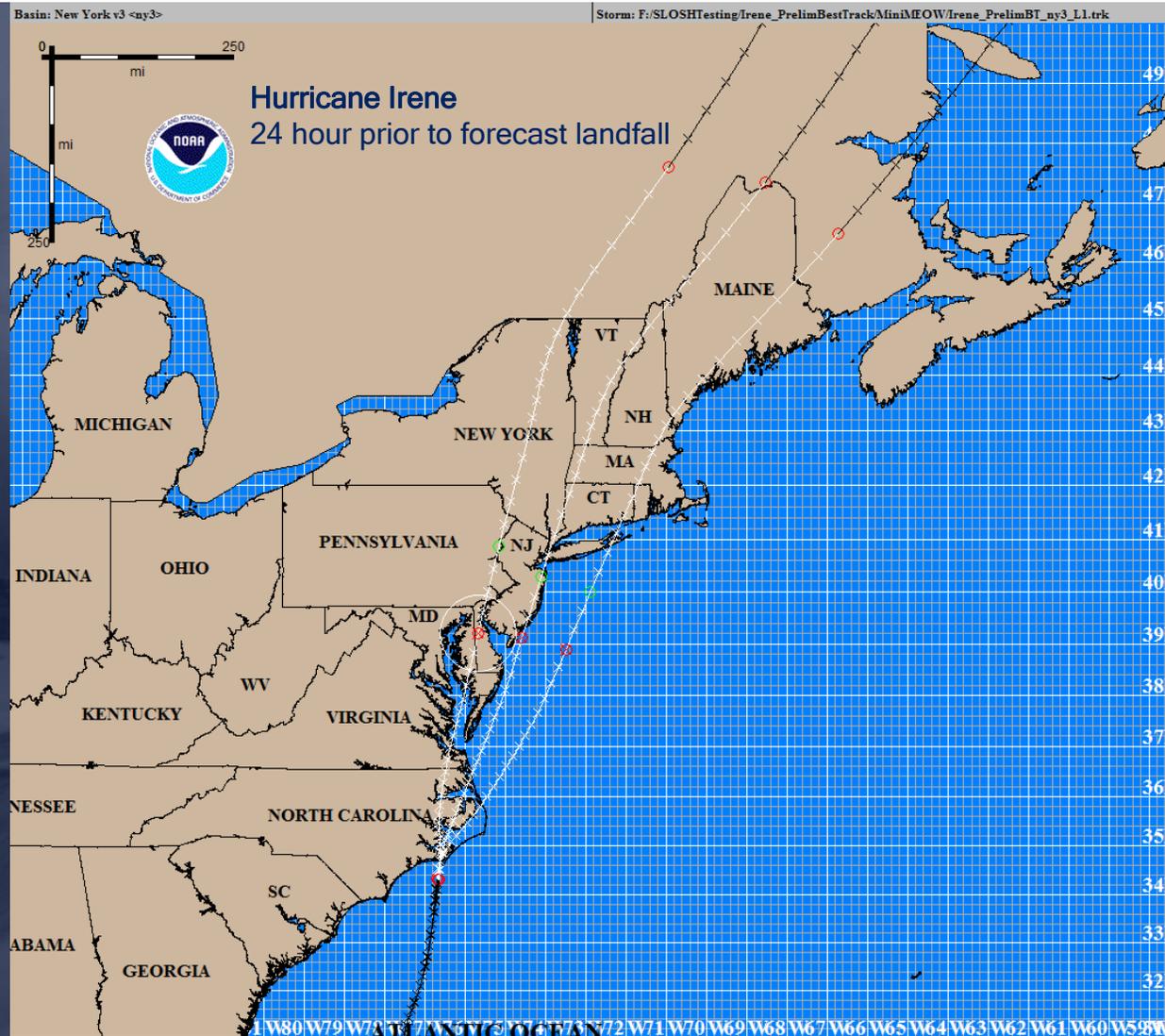
Envelope of  
High Water



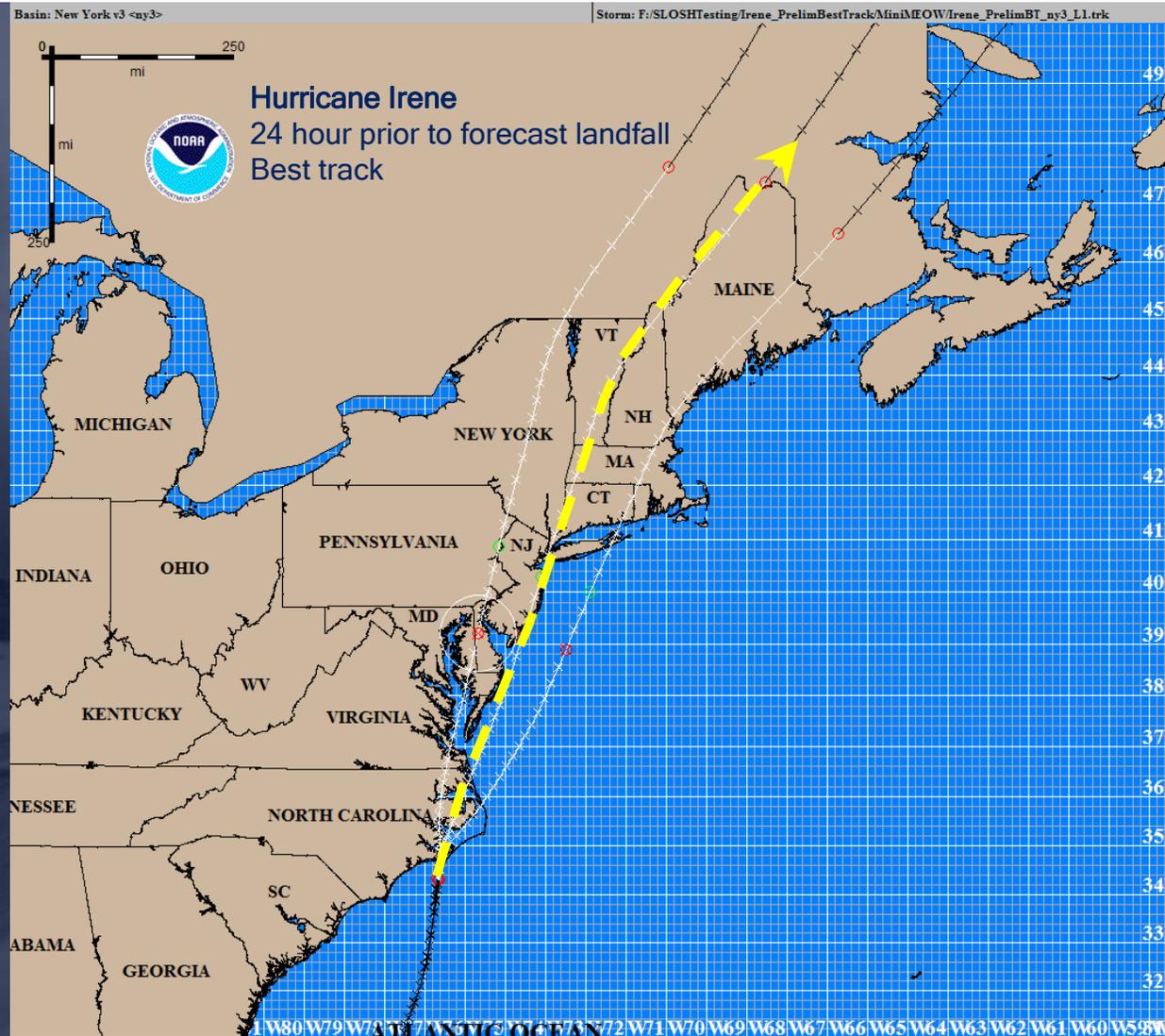
Rmax=40 mi

Surge Based on NHC Storm Best Track

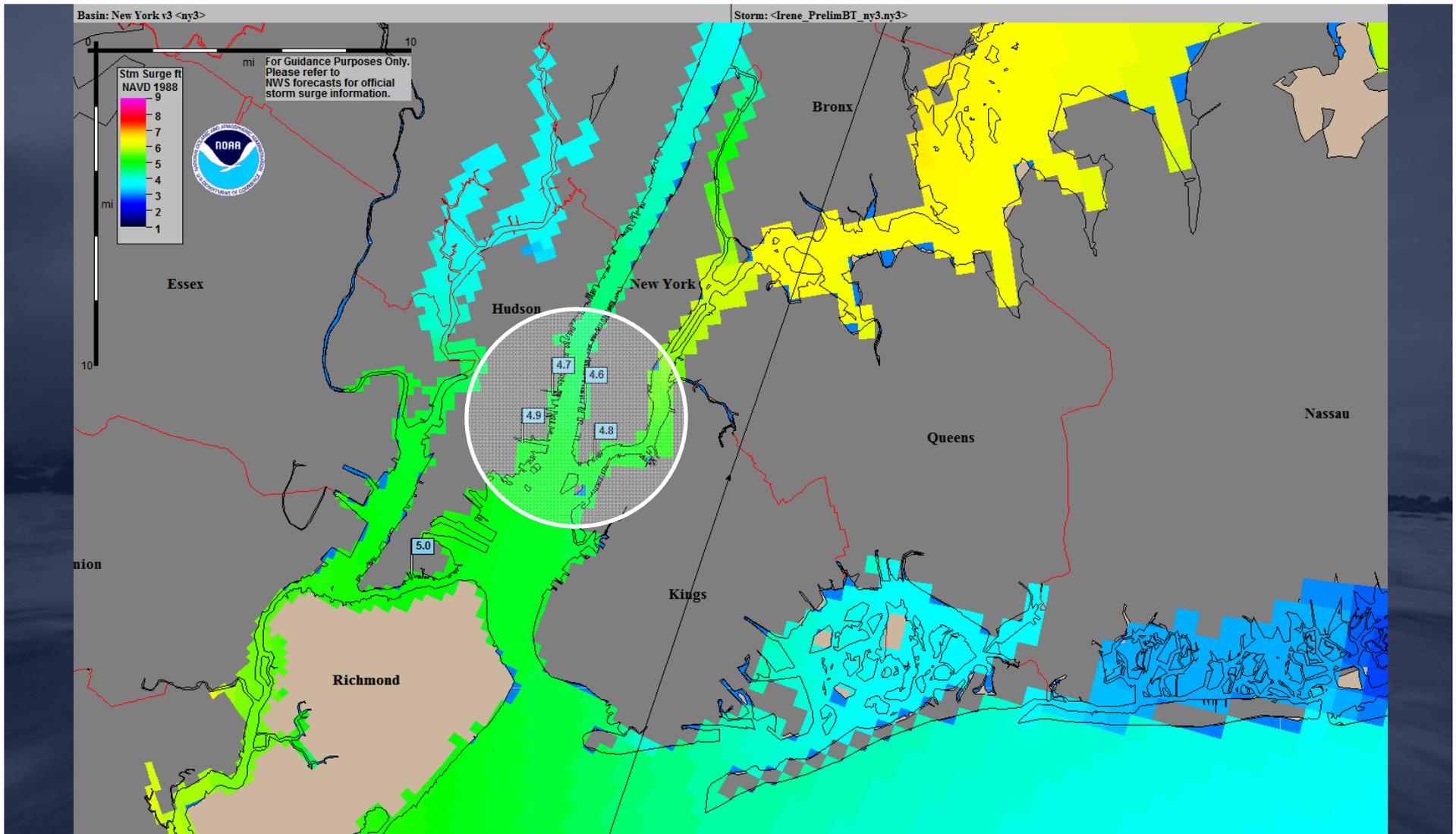
# Perils of Using a Single Track Forecast Hurricane Irene (2011)



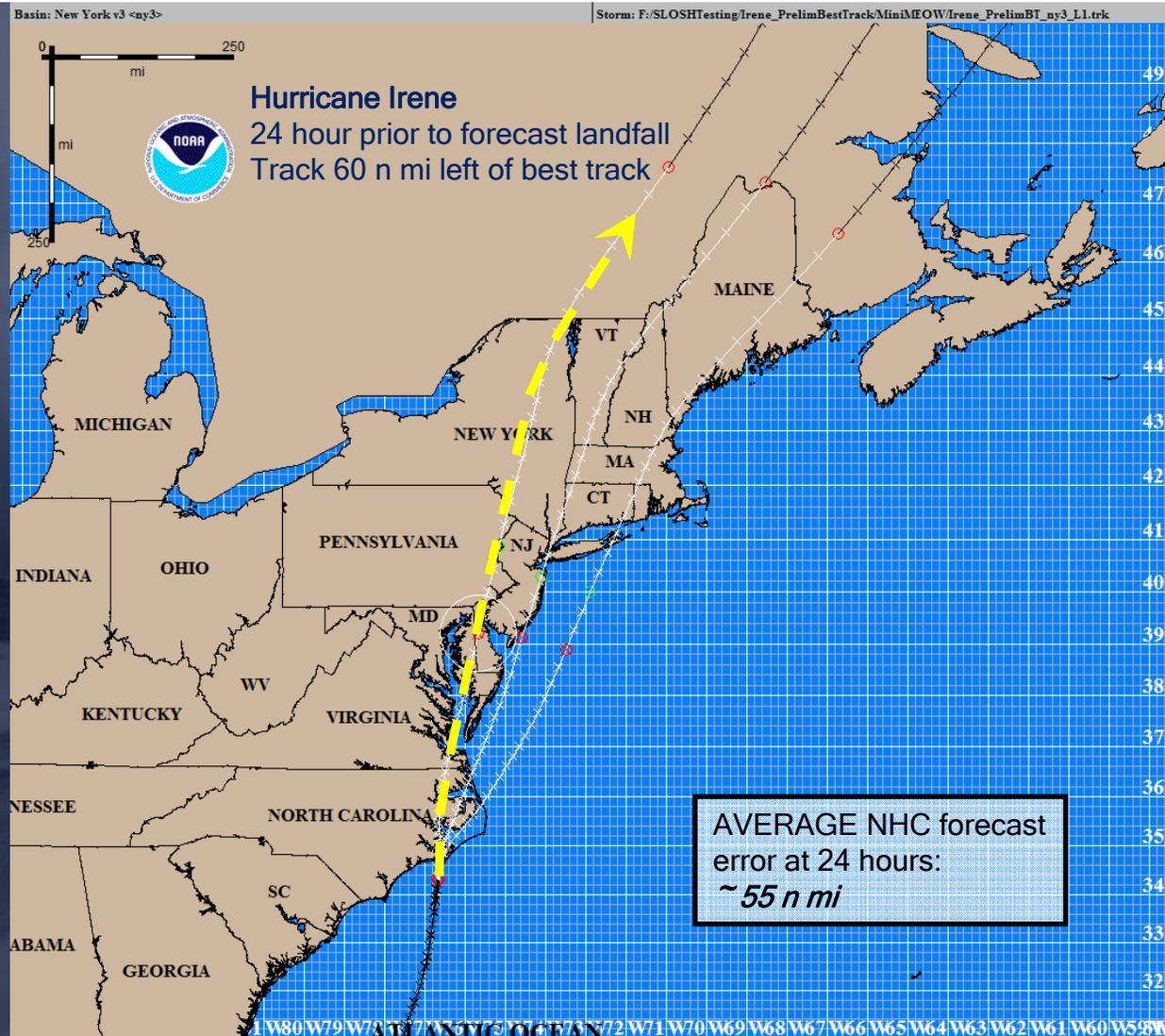
# Perils of Using a Single Track Forecast Hurricane Irene (2011)



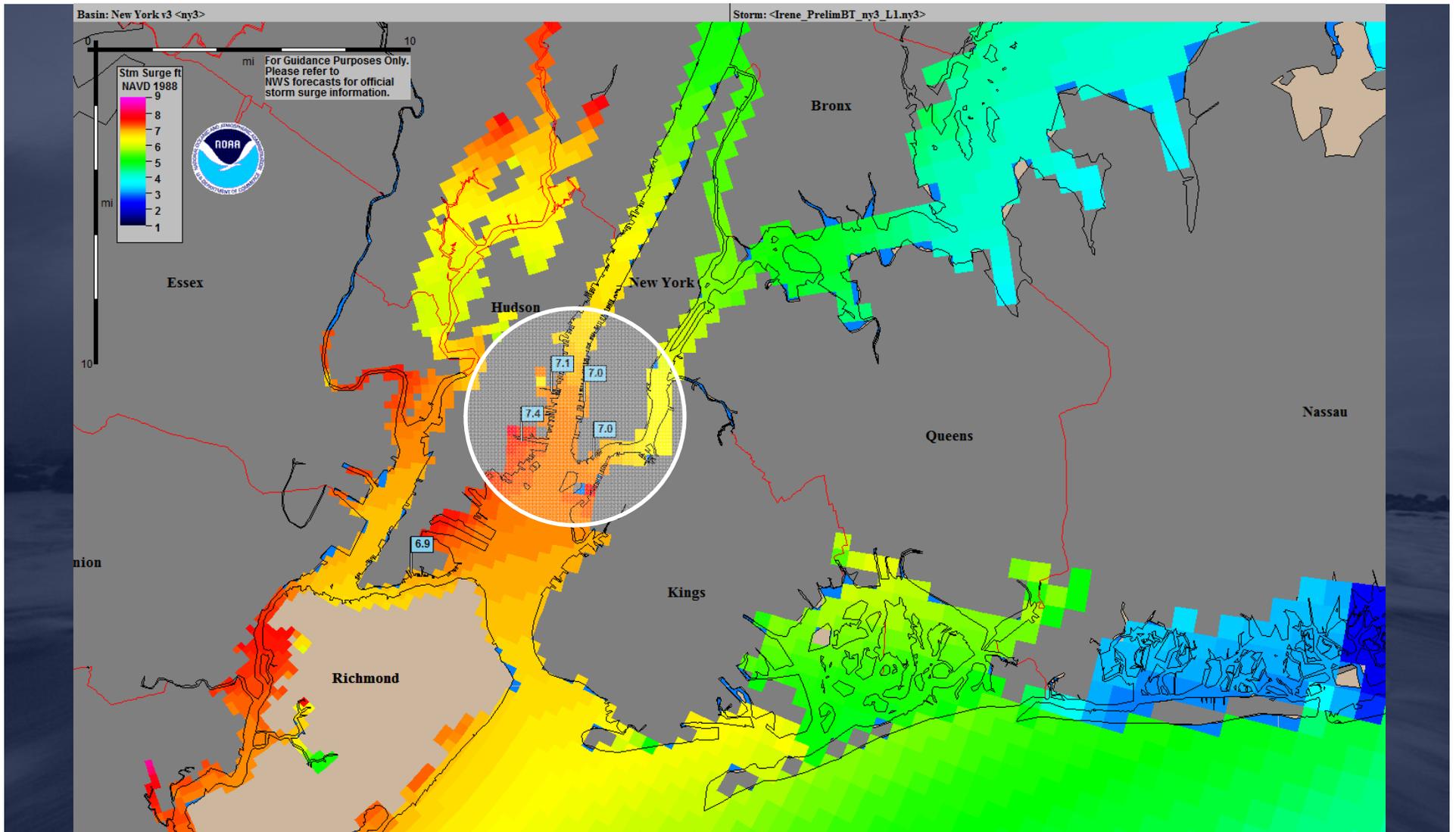
# Perils of Using a Single Track Forecast Hurricane Irene (2011)



# Perils of Using a Single Track Forecast Hurricane Irene (2011)



# Perils of Using a Single Track Forecast Hurricane Irene (2011)



# Alternative to Single Runs

Atlas of pre-computed surge maps based on

- Different directions of motion
- Different landfall locations
- Different intensities
- Different storm sizes
- Different forward speeds



# Ensemble Guidance

MEOWs

Maximum Envelopes Of Water

MOMs

Maximum Of the MEOWs

P-surge

Probabilistic Storm Surge

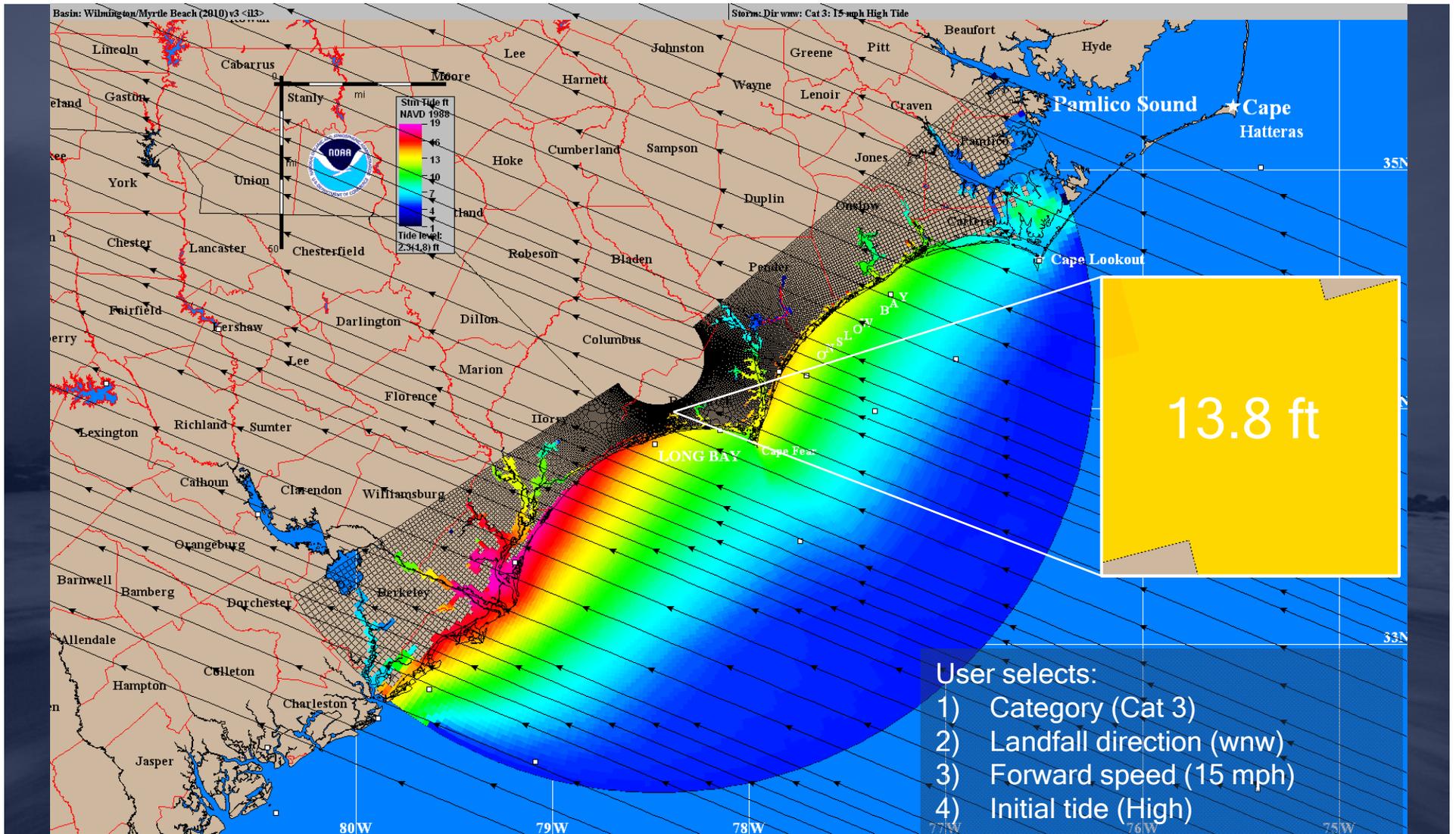




# MEOW Maximum Envelope Of Water



# Maximum Envelope of Water (MEOW)

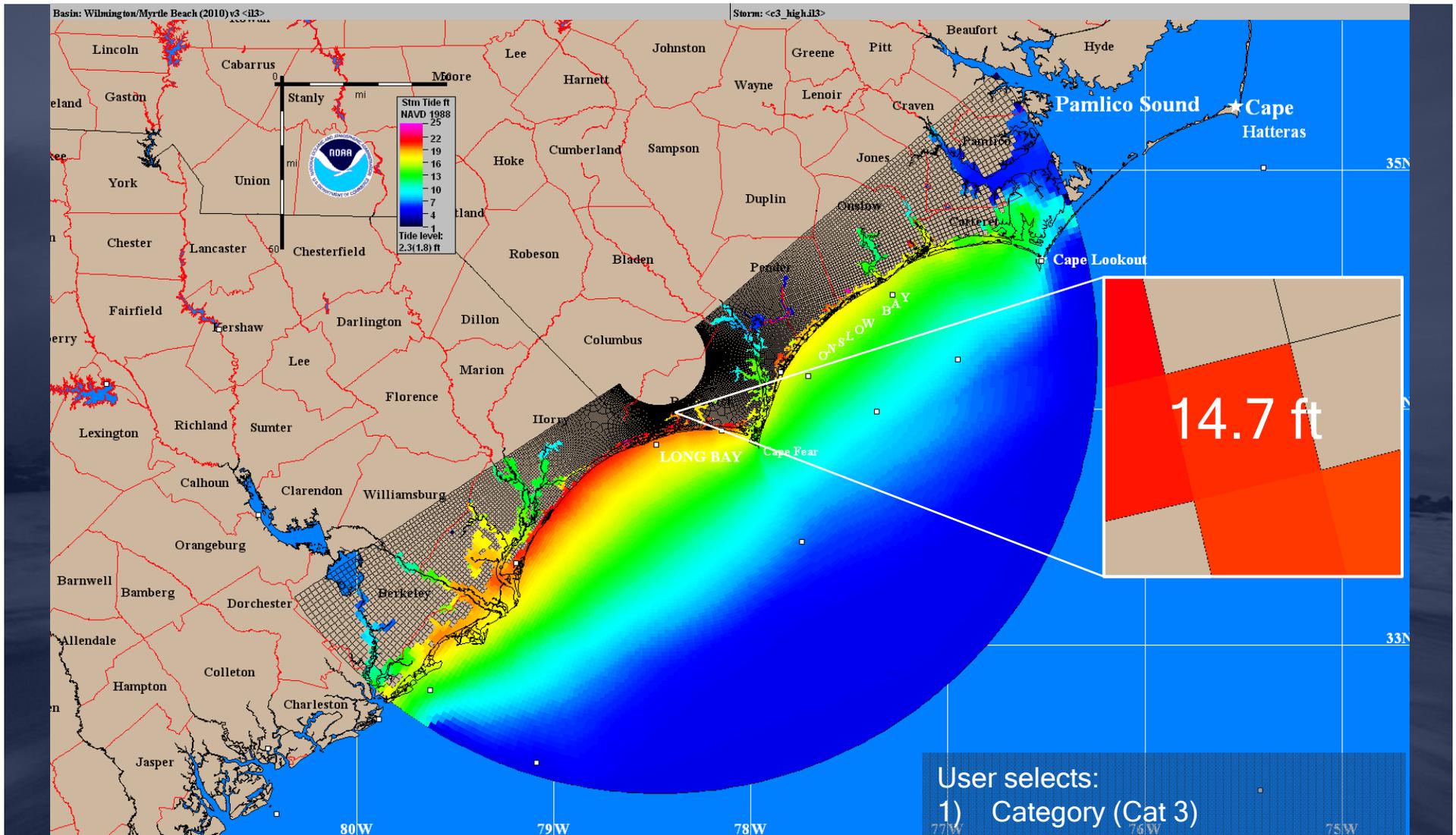


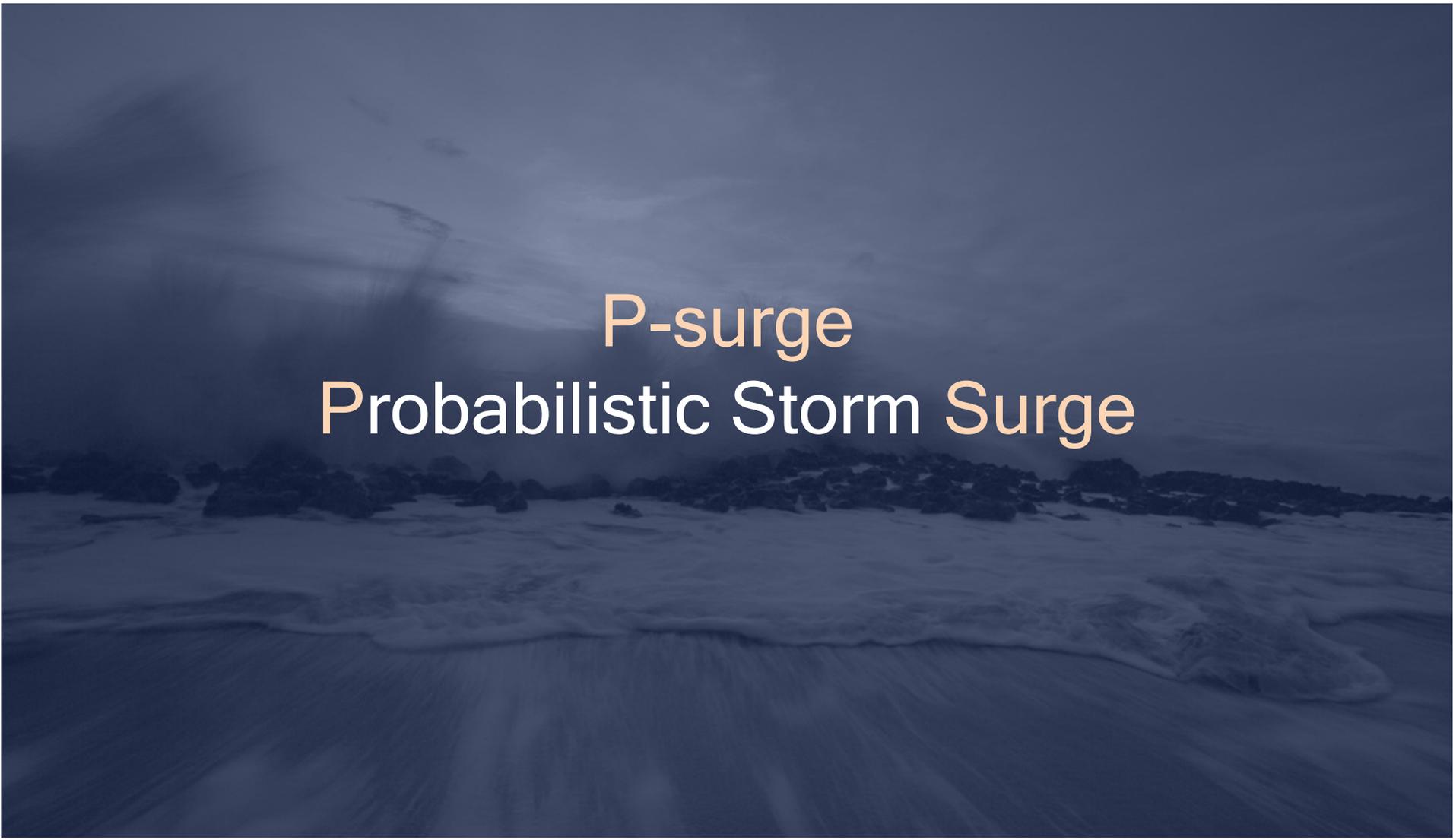


MOM  
Maximum Of the MEOWs



# Maximum of the MEOWs (MOMs)





# P-surge Probabilistic Storm Surge

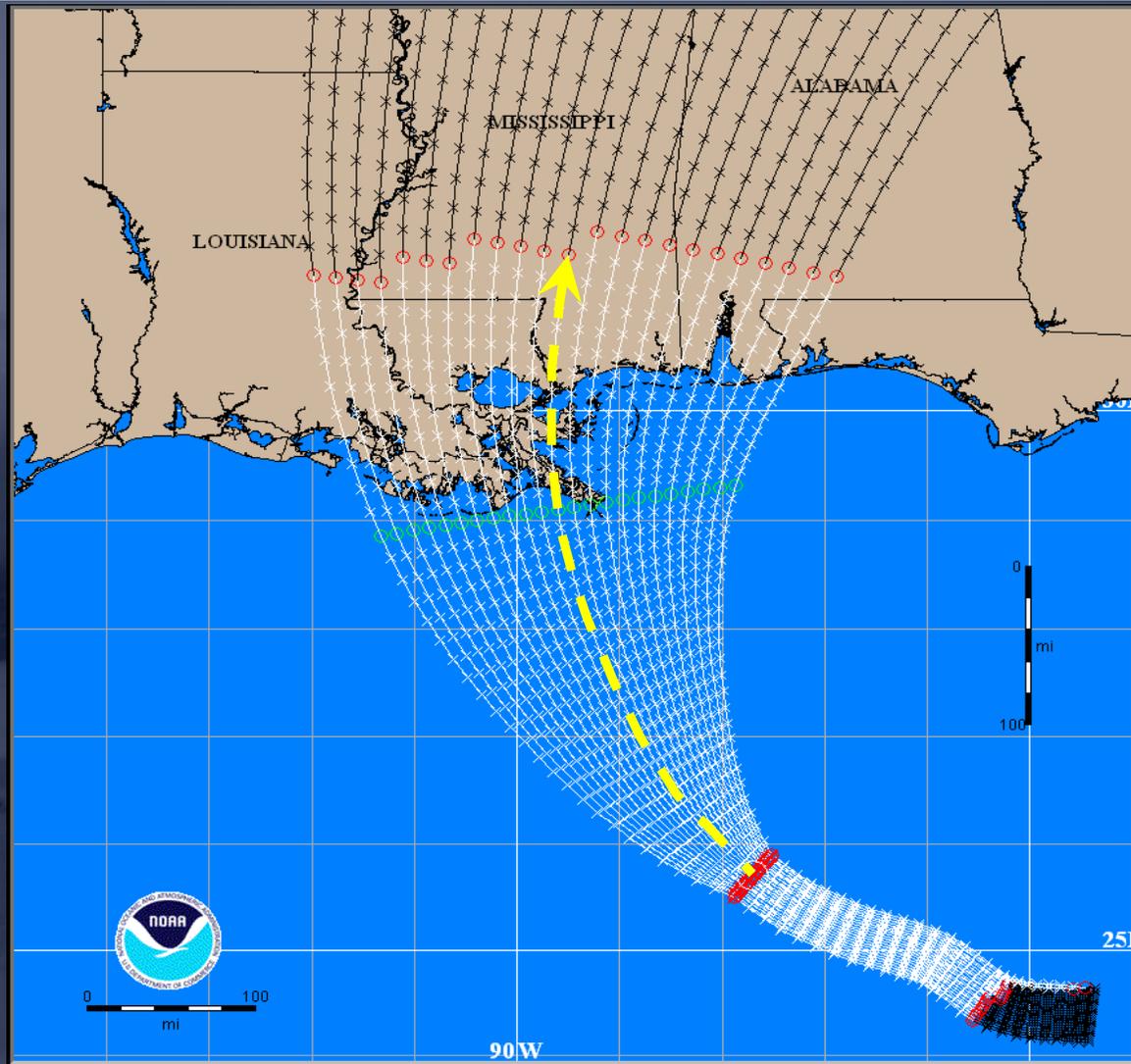


# Probabilistic Storm Surge (P-surge)

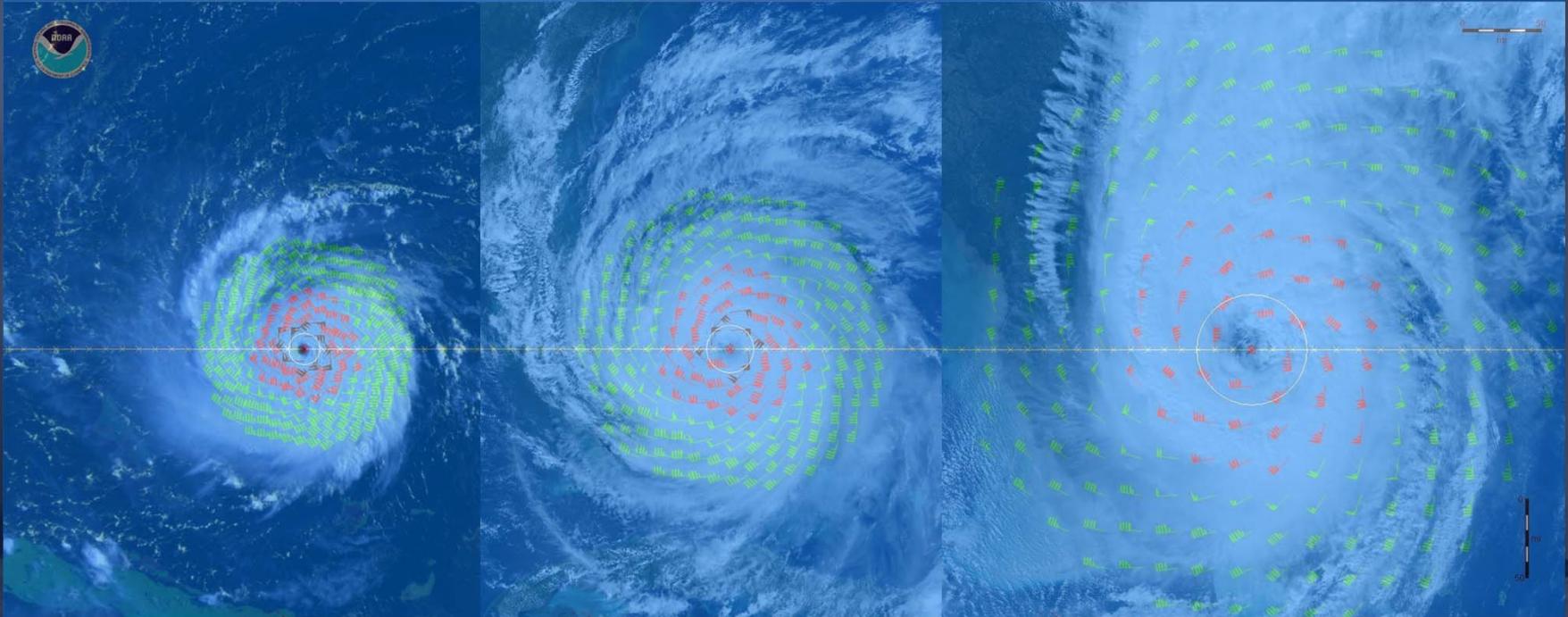
- Storm surge probabilities based on NHC official advisory
- Available approximately 48 hours prior to hurricane landfall
- Accounts for uncertainty in:
  - Track / landfall location
  - Size
  - Forward speed
  - Intensity
- Uncertainties based on historical errors



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



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



Size: Small, Medium, Large

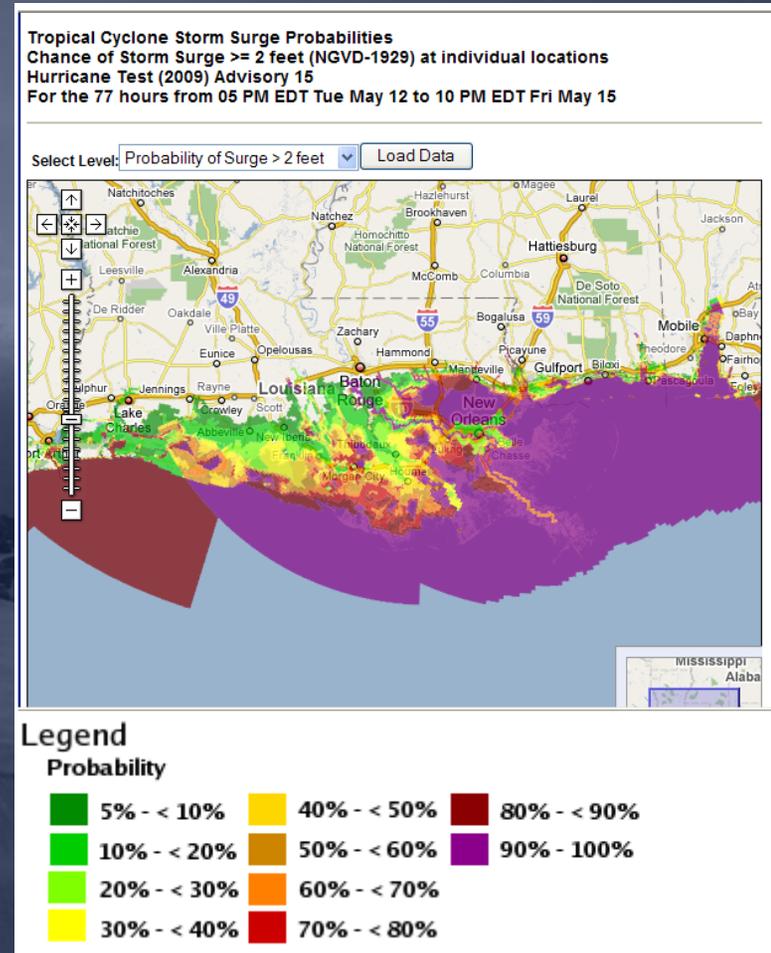
Forward Speed: Fast, Medium, Slow

Intensity: Strong, Medium, Weak



# Probabilistic Storm Surge (P-surge) When is it available?

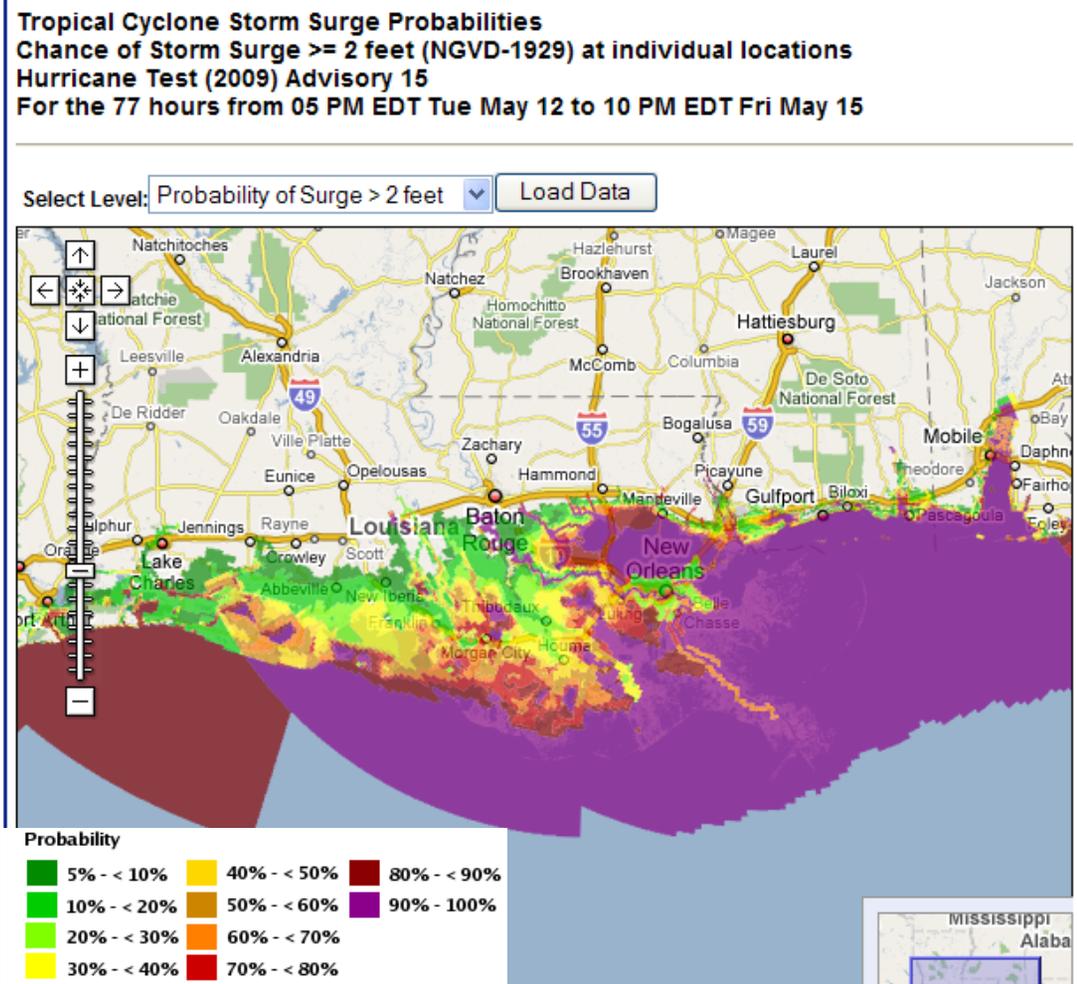
- Whenever a hurricane watch or warning is in effect
  - Approximately 48 hours prior to landfall
- Available approximately 30 minutes after full advisory release time
  - 05:30 EDT
  - 11:30 EDT
  - 17:30 EDT
  - 23:30 EDT



# Understanding and Using Probabilities

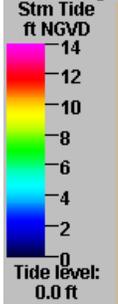
The number one argument against using probability is that users do not understand how to interpret low probabilities of an extreme event.

Would you offer to pick up free lunch if there is a 20% chance of you being involved in a fatal car accident along the way?



Basin: Elliptical Mobile Bay <mob>

Storm: c:/slosh/pkg/data/rexfiles/i54\_mob.rex



Envelope of High Water

Deterministic SLOSH run shows limited surge threat to Pensacola area



Mobile ★

★ Pensacola

Pascagoula

MOBILE BAY

Santa Rosa Island

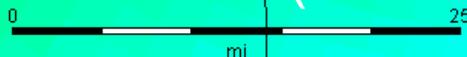
Perdido Key

Dauphin Island

Fort Morgan

Gulf Shores

Rmax=25 mi  
(forecast)



Surge Based on NHC -12 hr. Advisory

Storm: Ivan2004 Adv54 Type: Prob. of surge > 8 feet Zoom Level: Full



# Experimental Tropical Cyclone Storm Surge Probabilities

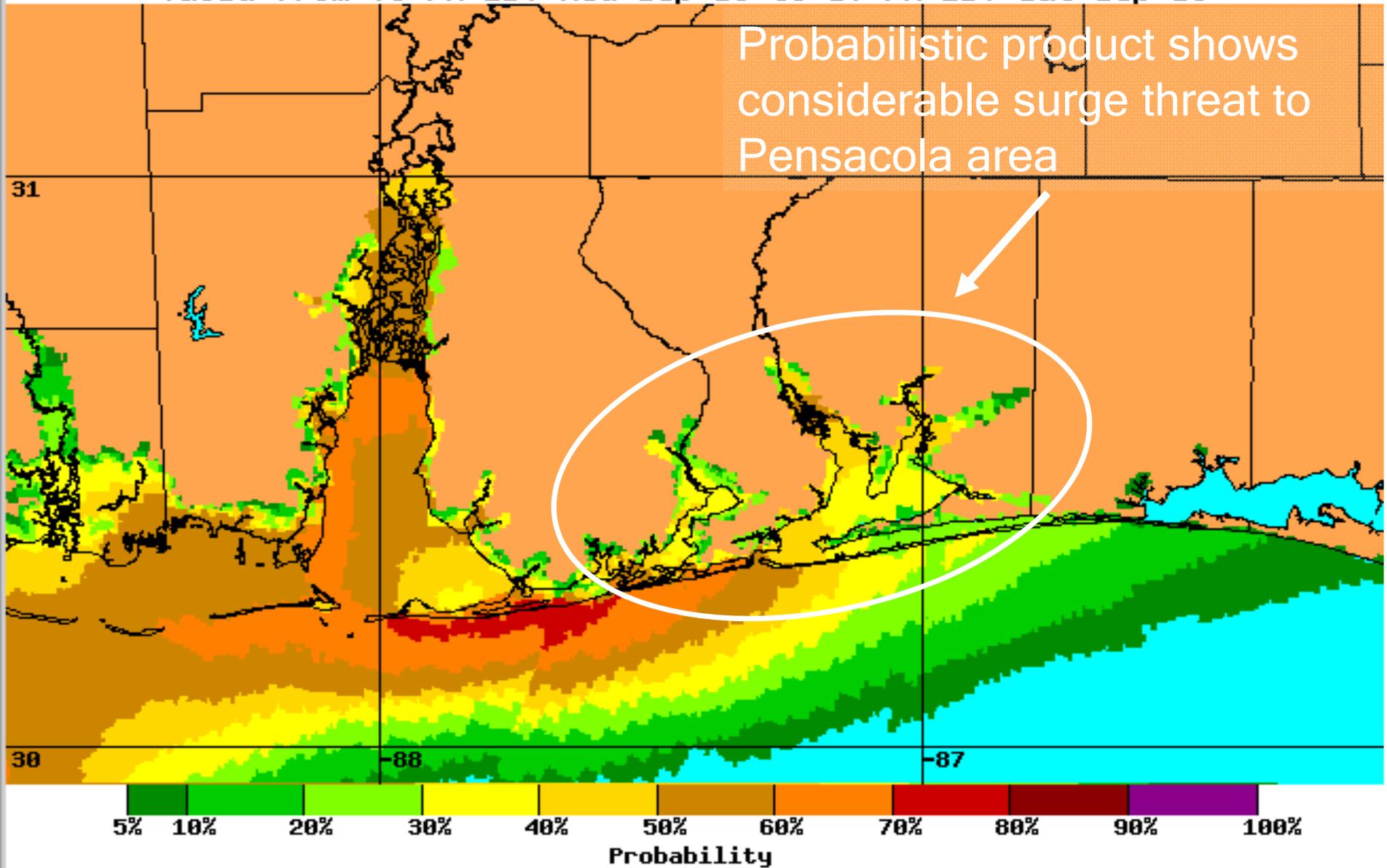
## Chance of Storm Surge $\geq$ 8 feet at Individual Locations

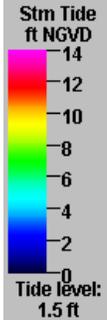
### Hurricane Ivan (2004) Advisory 54

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



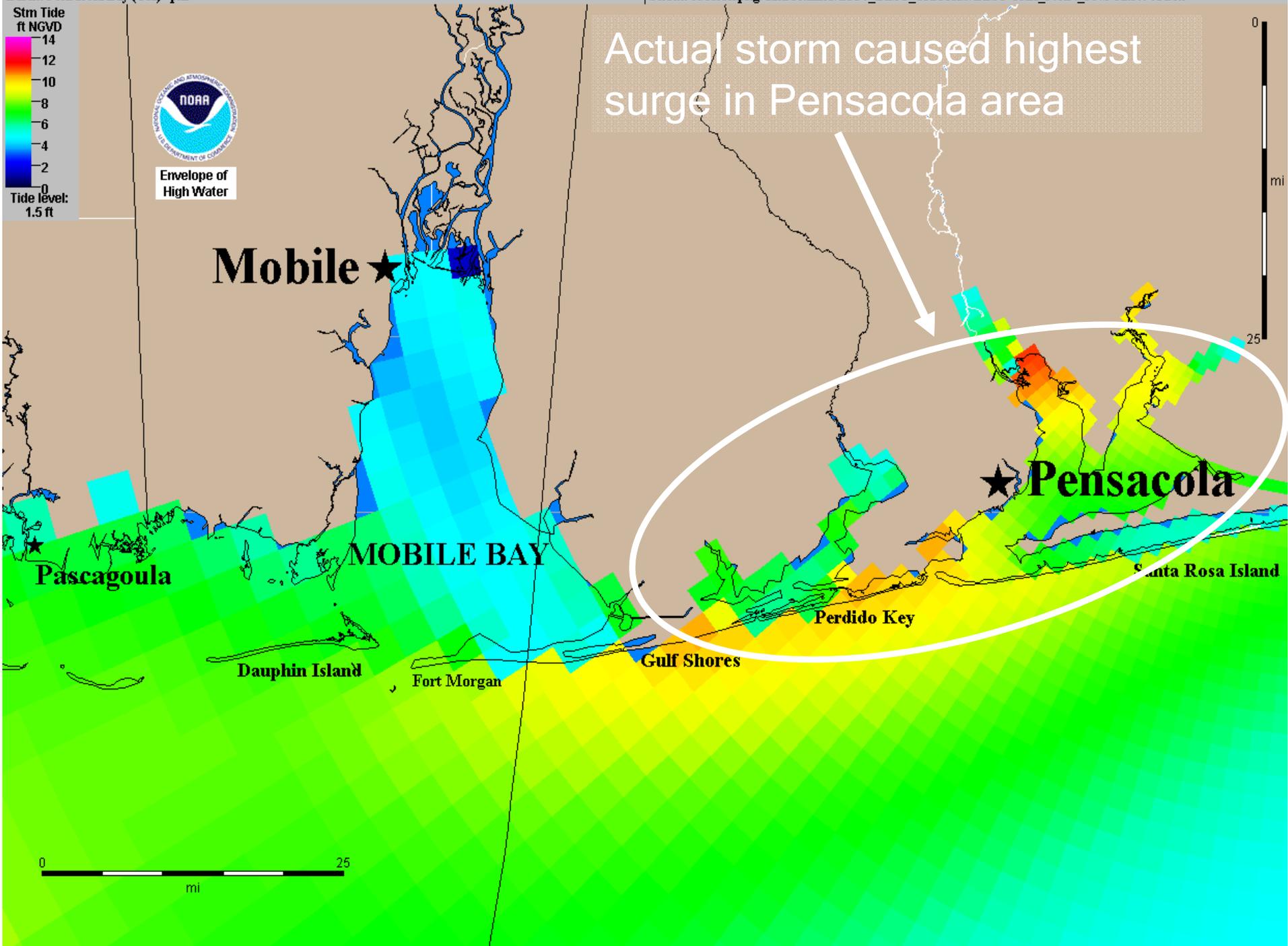
Probabilistic product shows considerable surge threat to Pensacola area





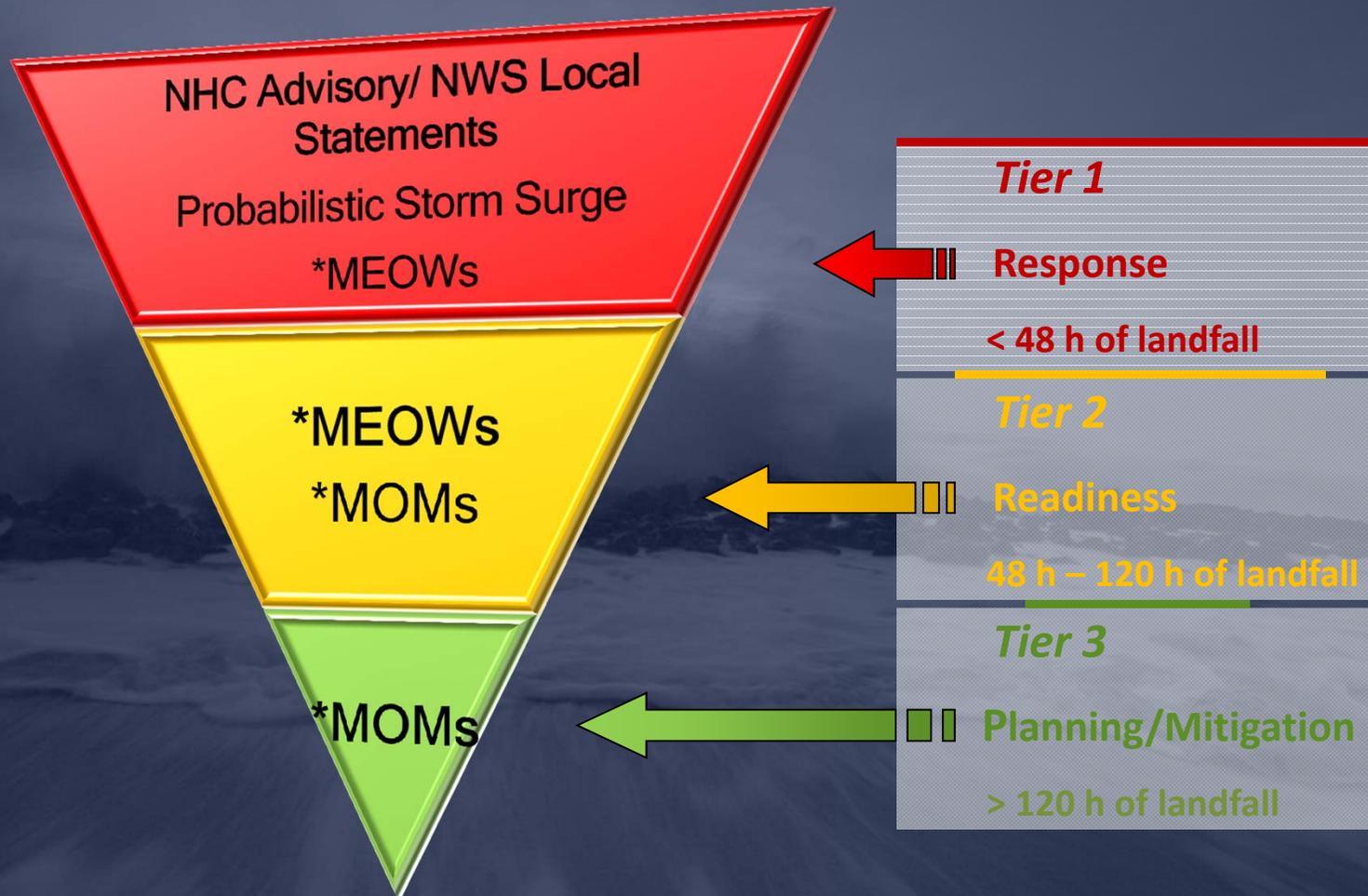
Envelope of High Water

Actual storm caused highest surge in Pensacola area



# Storm Surge Guidance Timeframe

## NHC Storm Surge Product Decision Support Wedge



# New Surge Statement

Storm surge flooding of 2 to 4 feet above normal tide levels ... Can be expected along the west coast of Florida in areas of onshore flow south of Venice and in Florida Bay. Storm surge should begin to decrease along the east coast of Florida.

STORM SURGE WILL RAISE WATER LEVELS BY AS MUCH AS 4 FEET **ABOVE GROUND LEVEL** ALONG THE WEST COAST OF FLORIDA IN AREAS OF ONSHORE FLOW SOUTH OF VENICE AND IN FLORIDA BAY ... WITH LARGE AND DANGEROUS BATTERING WAVES ... **THE SURGE COULD PENETRATE AS FAR INLAND AS** ABOUT 30 MILES FROM THE SHORE WITH DEPTH GENERALLY DECREASING AS THE WATER MOVES INLAND. STORM SURGE SHOULD BEGIN TO DECREASE ALONG THE EAST COAST OF FLORIDA.



# Storm Surge Unit

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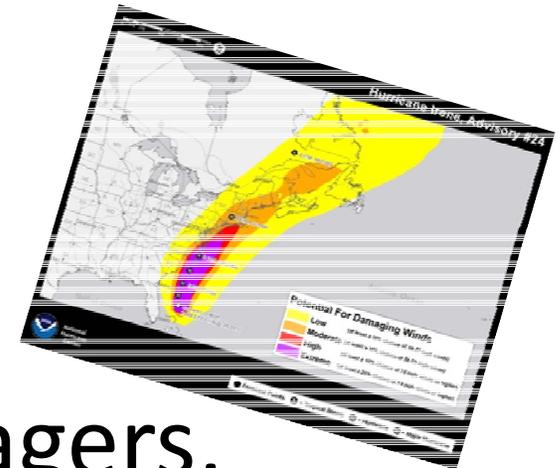
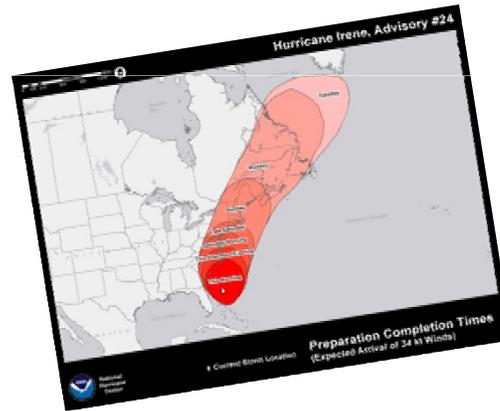
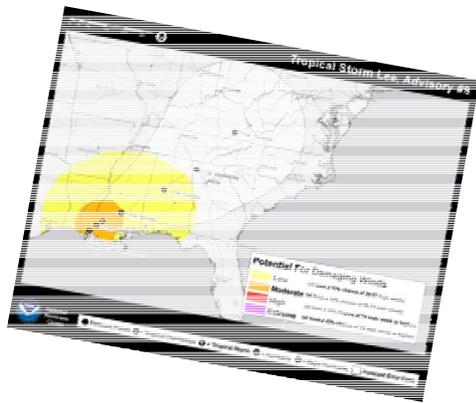
Michael Lowry

Tarah Sharon

Jeff Pereira

[hurricanes.gov/surge](http://hurricanes.gov/surge)  
[nhcsurge.ideascale.com](http://nhcsurge.ideascale.com)





# Emergency Managers, *What do you think?*

- ◆ Be a part of the NOAA/NHC assessment of future surge and wind graphics
- ◆ Visit **Booth 525** and let us know which graphics you think would communicate surge and wind information most effectively to the public.

