NOAA
Hurricane Storm Surge

Judith Gray
National Oceanic and Atmospheric Administration
Oceanic and Atmospheric Research
Atlantic Oceanographic and Meteorological Laboratory

November 1, 2005

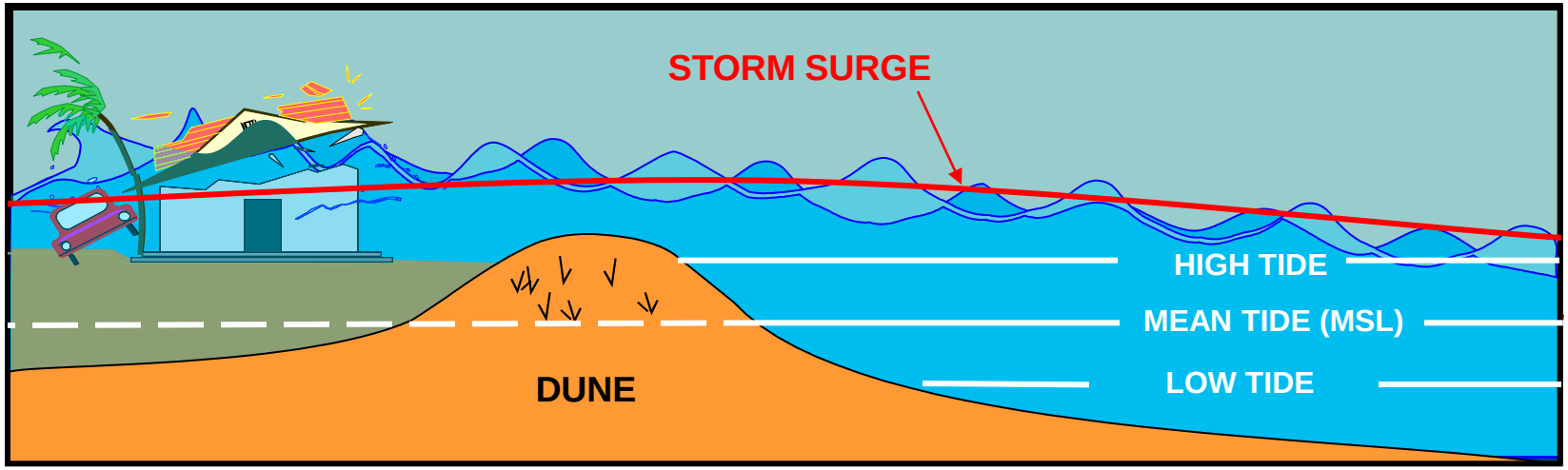
STORM SURGE:

• water pushed ashore by the winds around the eye of a hurricane

• combines with normal tides to create a storm tide that can increase mean water level by 15 feet or more

• has historically brought most of the death and destruction during hurricanes, claiming nine of ten victims, and is the primary reason that coastal areas are evacuated as storms approach

Tide with Storm Surge



GENERALIZATIONS:

- The higher the hurricane's category, the higher the storm surge.

- Maximum storm surge occurs to the right of the storm track, roughly at the radius of max winds.

- Faster-moving hurricanes cause higher surges AT THE COASTLINE than do slower-moving hurricanes.

GENERALIZATIONS:

- For areas with gentle slopes of the continental shelf, storm surge is large but waves are small.

- Areas with deep water just offshore experience large waves, but little storm surge.

- Very small, compact hurricanes cause less storm surge than do large-sized hurricanes.

S EA

L AKE

O VERLAND

S URGE

from

H URRICANES

NON-LINEAR TRANSPORT EQUATIONS

$$\frac{\partial U}{\partial t} = -g(D+h)\frac{\partial h}{\partial x} + fv + \frac{D}{\rho}\frac{\partial P}{\partial x} + \frac{{}^{x}\tau_{a}}{\rho} + \frac{{}^{x}\tau_{b}}{\rho}$$

$$\frac{\partial V}{\partial t} = -g(D+h)\frac{\partial h}{\partial y} - fu + \frac{D}{\rho}\frac{\partial P}{\partial y} + \frac{{}^{y}\tau_{a}}{\rho} + \frac{{}^{y}\tau_{b}}{\rho}$$

$$\frac{\partial h}{\partial t} = -\left[\frac{\partial U}{\partial x} + \frac{\partial V}{\partial y}\right] \quad \text{where: } U = \int_{-D}^{h} u\,dz \quad \text{and} \quad V = \int_{-D}^{h} v\,dz$$

u,v = **Components of Horizontal Motion**

ρ = **Density of Water**

P = **Atmospheric Pressure**

${}^{x}\tau_{a}$ ${}^{y}\tau_{a}$ ${}^{x}\tau_{b}$ ${}^{y}\tau_{b}$ = **Components of Surface and Bottom Stress**

D = **Depth of Undisturbed Fluid**

h = **Height of Free Surface**

g = **Acceleration of Gravity**

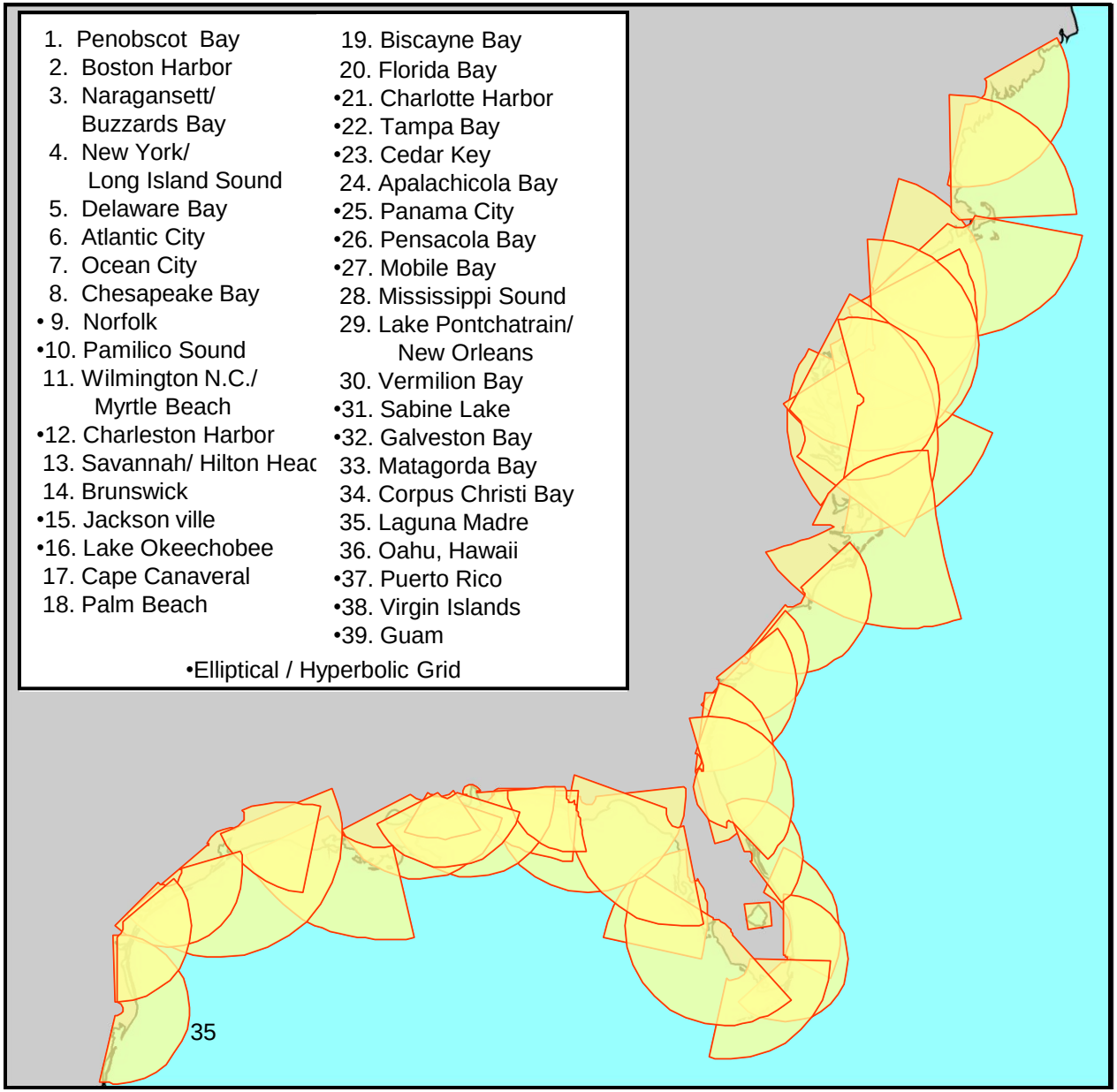
f = **Coriolis Parameter**

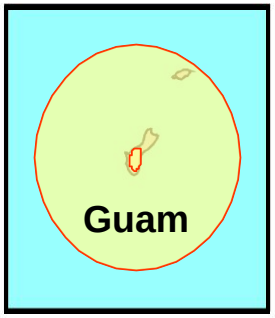

GULF OF MEXICO
0
100
mi
93W
91W
90W
89W
88W
87W

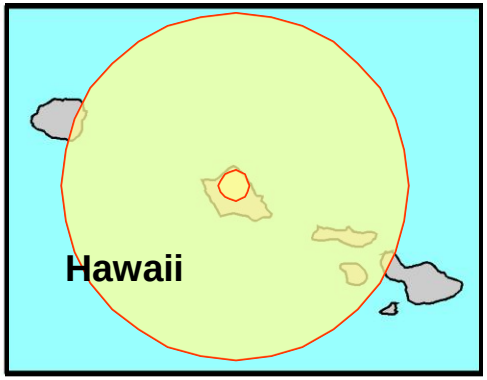
SLOSH BASINS

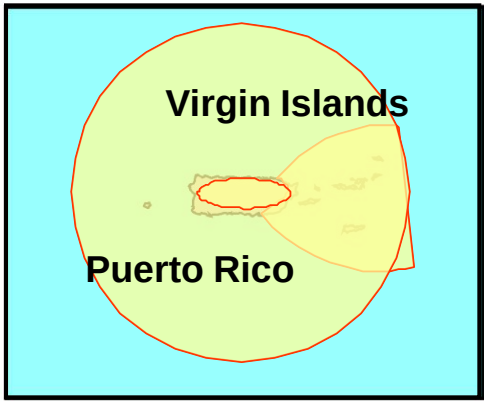
1. Penobscot Bay
2. Boston Harbor
3. Naragansett/ Buzzards Bay
4. New York/ Long Island Sound
5. Delaware Bay
6. Atlantic City
7. Ocean City
8. Chesapeake Bay
• 9. Norfolk
•10. Pamilico Sound
11. Wilmington N.C./ Myrtle Beach
•12. Charleston Harbor
13. Savannah/ Hilton Head
14. Brunswick
•15. Jackson ville
•16. Lake Okeechobee
17. Cape Canaveral
18. Palm Beach
19. Biscayne Bay
20. Florida Bay
•21. Charlotte Harbor
•22. Tampa Bay
•23. Cedar Key
24. Apalachicola Bay
•25. Panama City
•26. Pensacola Bay
•27. Mobile Bay
28. Mississippi Sound
29. Lake Pontchatrain/ New Orleans
30. Vermilion Bay
•31. Sabine Lake
•32. Galveston Bay
33. Matagorda Bay
34. Corpus Christi Bay
35. Laguna Madre
36. Oahu, Hawaii
•37. Puerto Rico
•38. Virgin Islands
•39. Guam

•Elliptical / Hyperbolic Grid









Data Input to SLOSH Model:

Meteorological

Bathymetric & Topographic

Tide

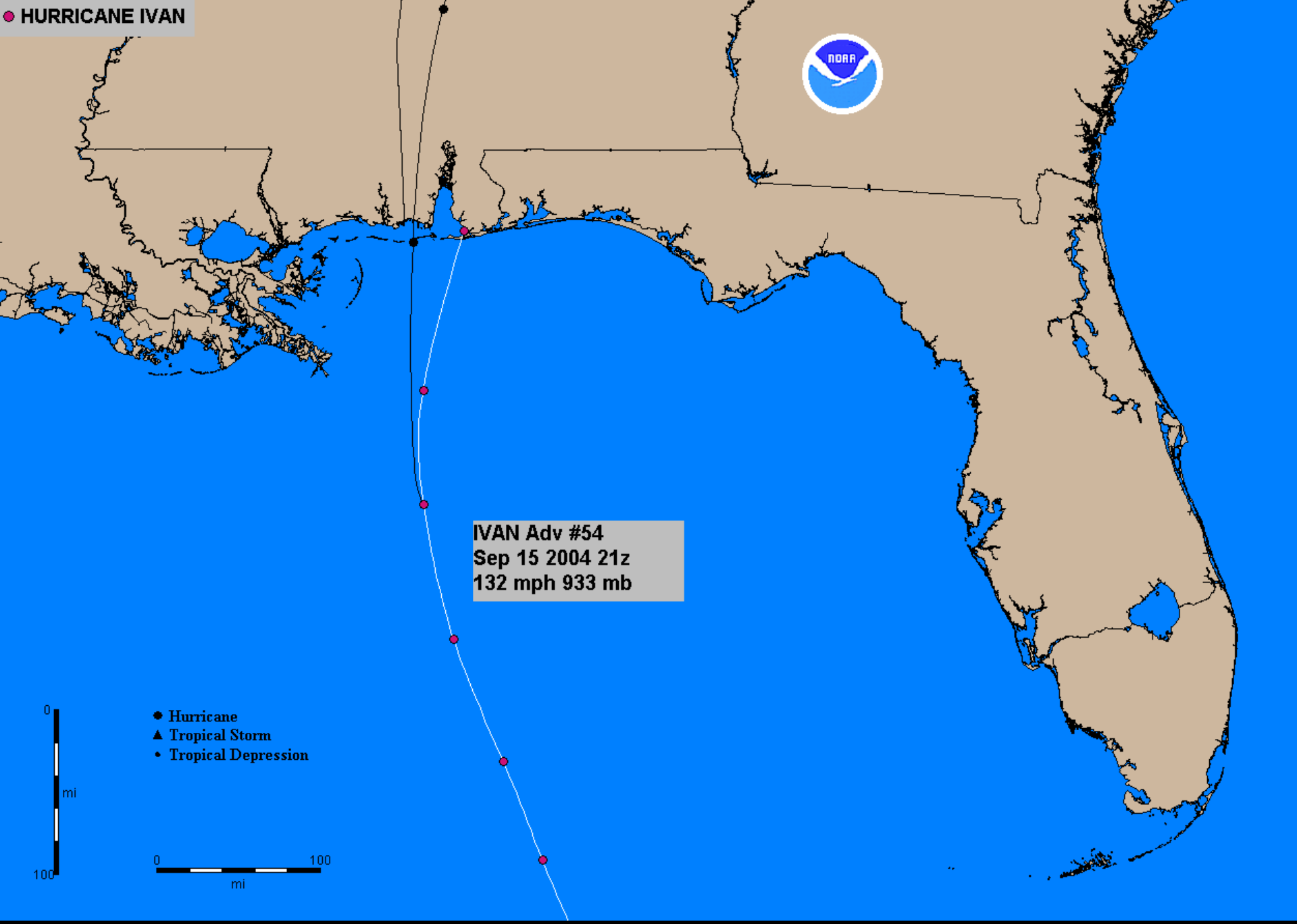
Reference Levels

METEOROLOGICAL INPUT TO SLOSH

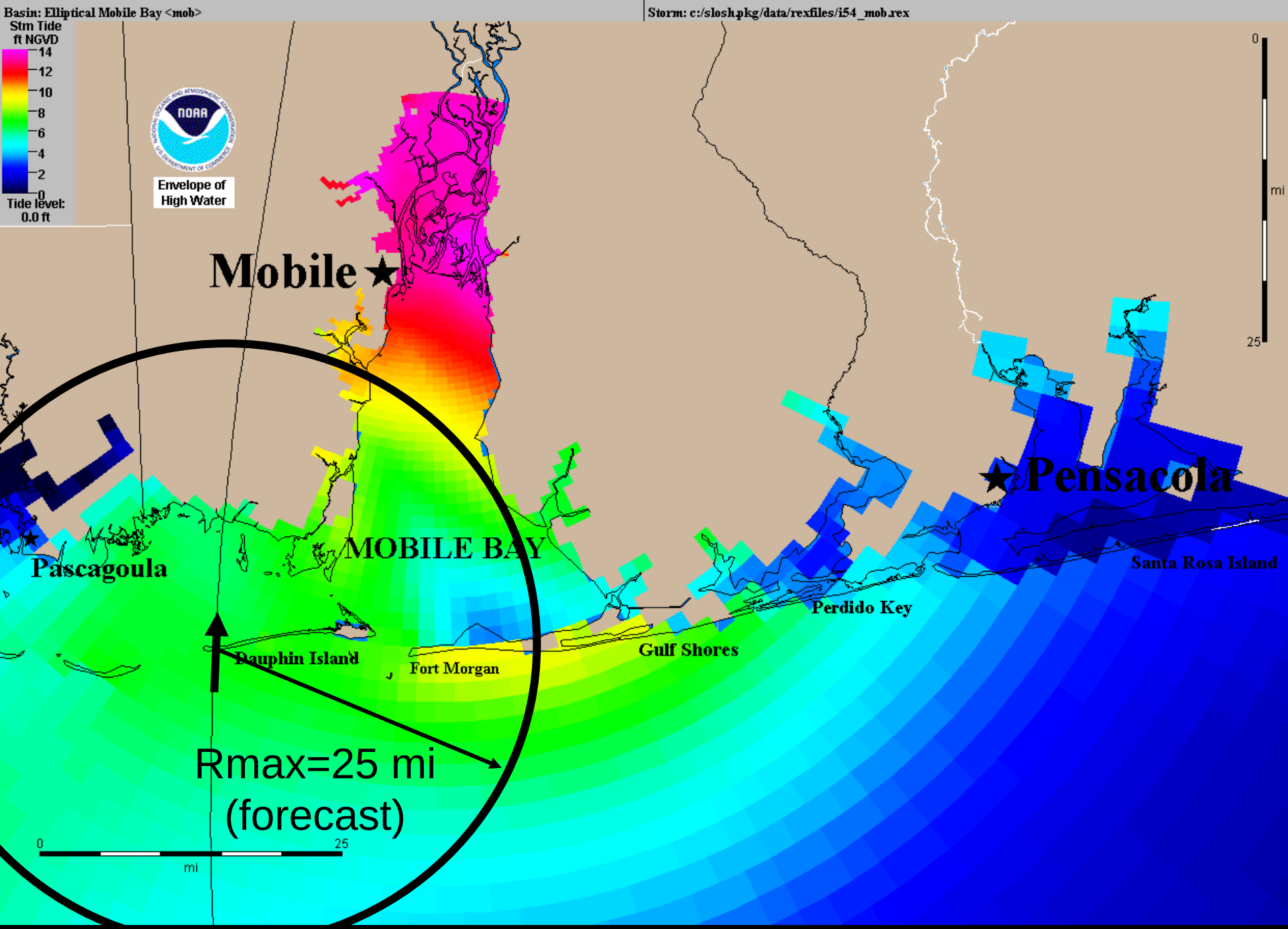
TRACK Positions - latitude & longitude

INTENSITY - (pressure)

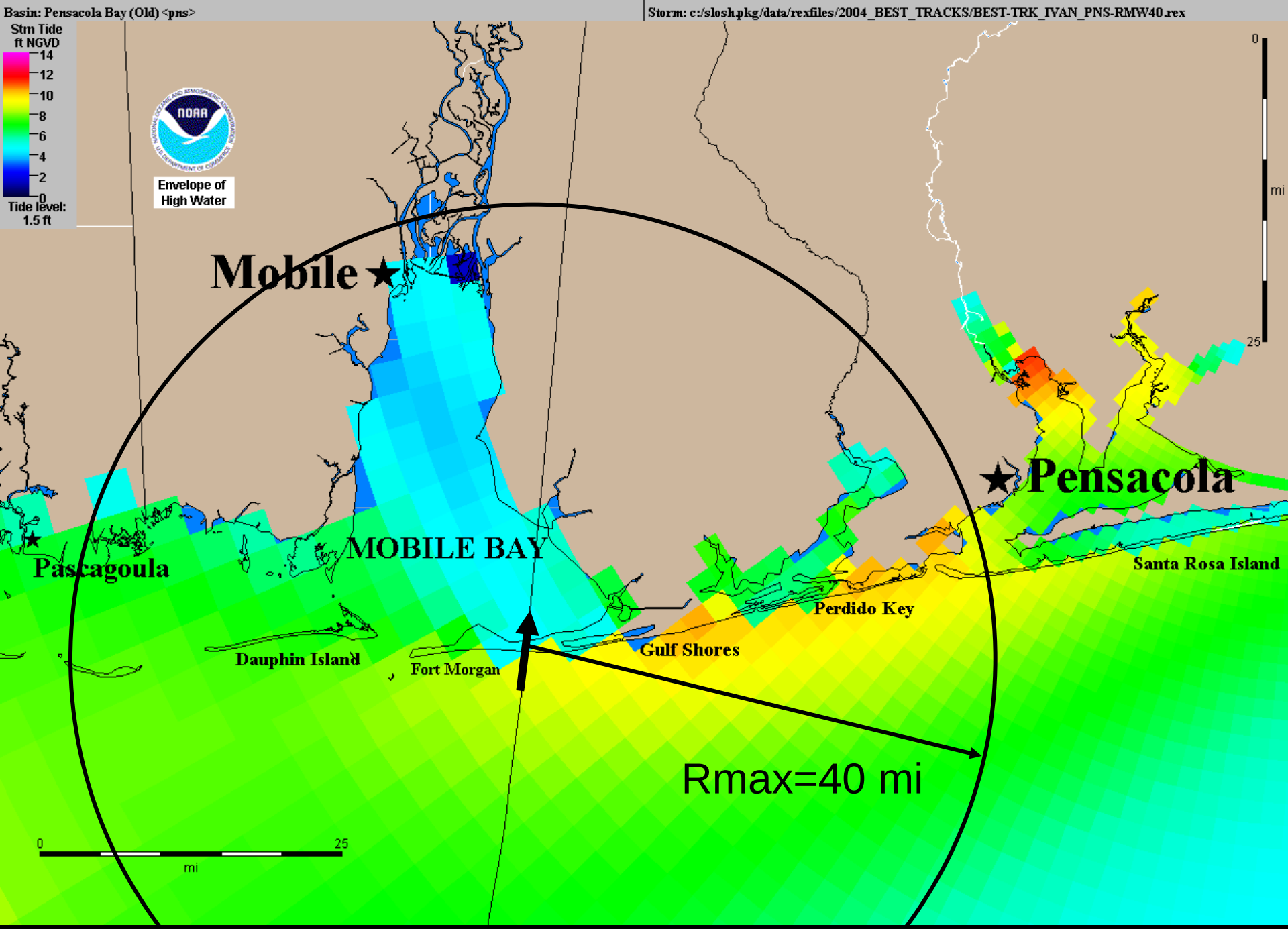
SIZE - Radius of maximum wind



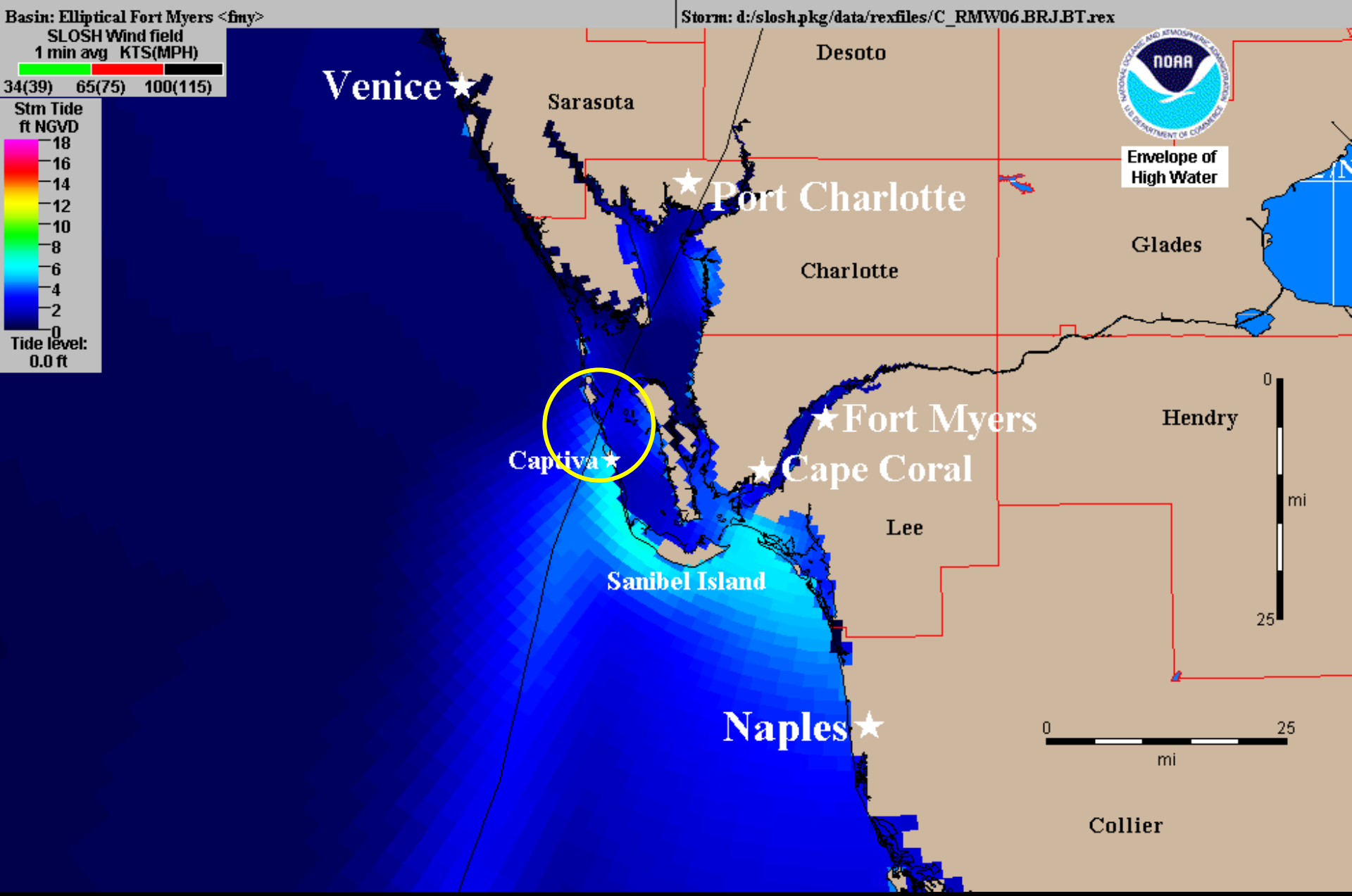
Hurricane Ivan – Actual Track 30 mi E of Adv 54 Forecast Track



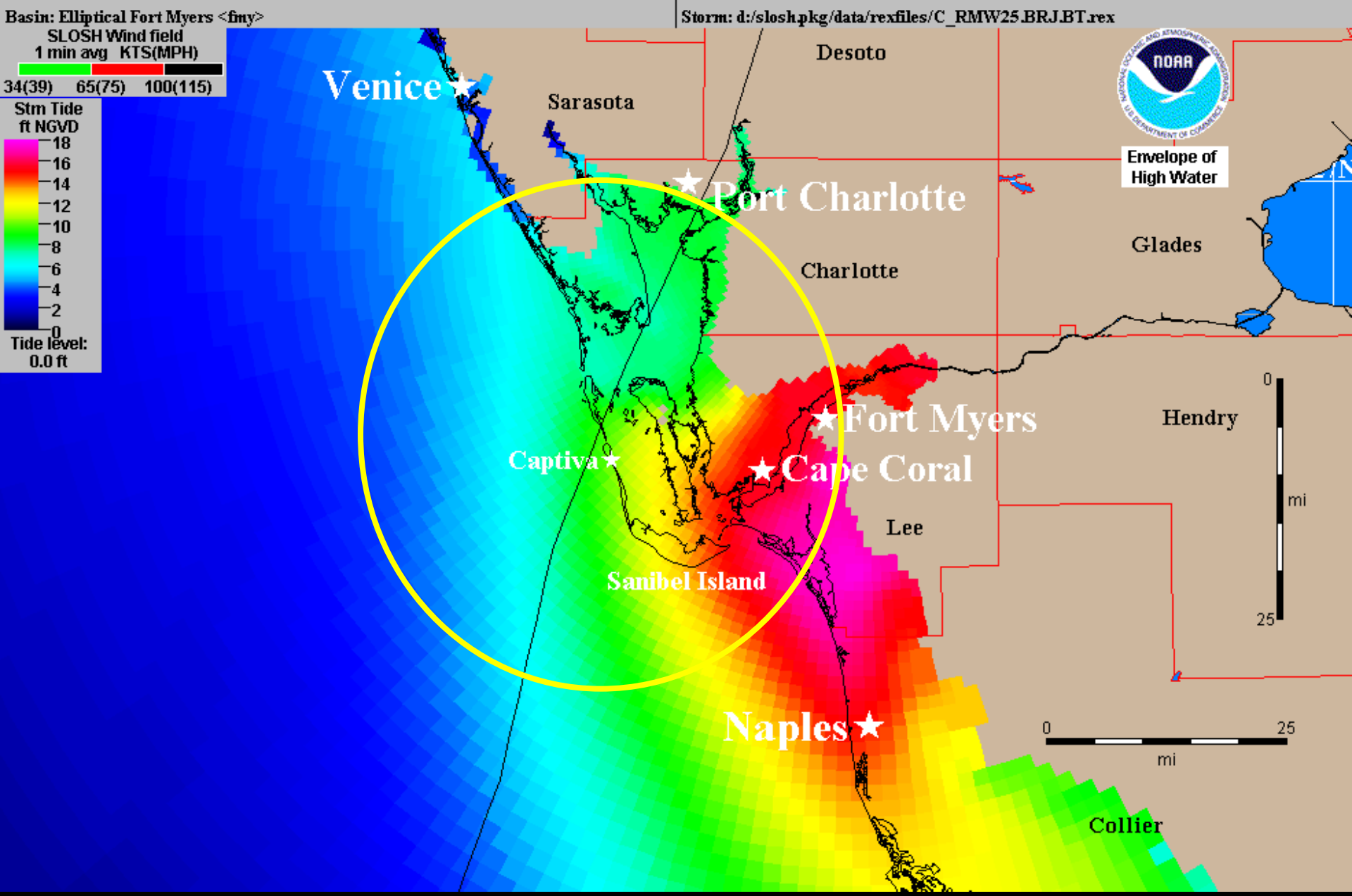
Surges based on NHC Advisory 54 for Ivan



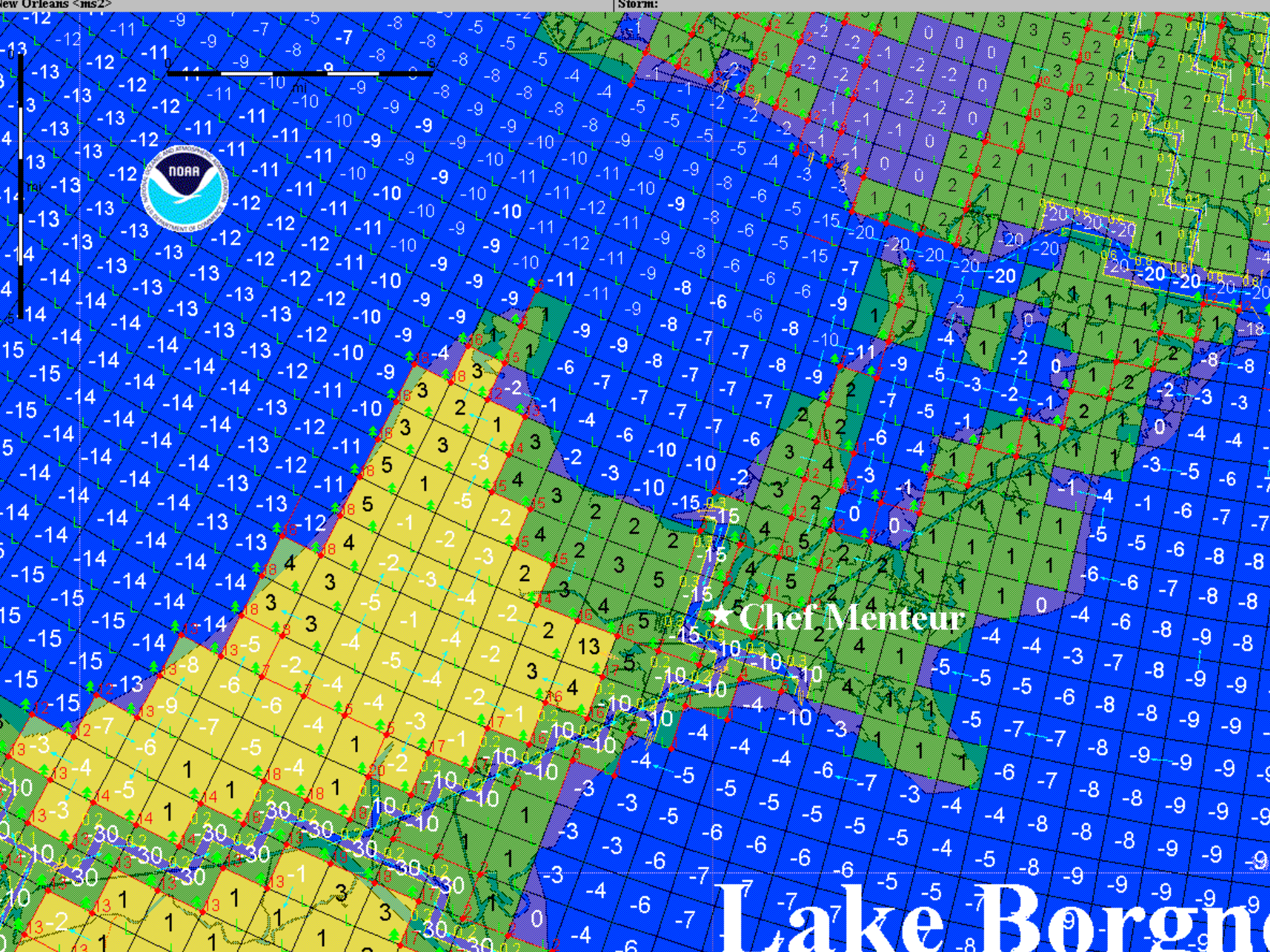
Surges based on NHC best track for Ivan

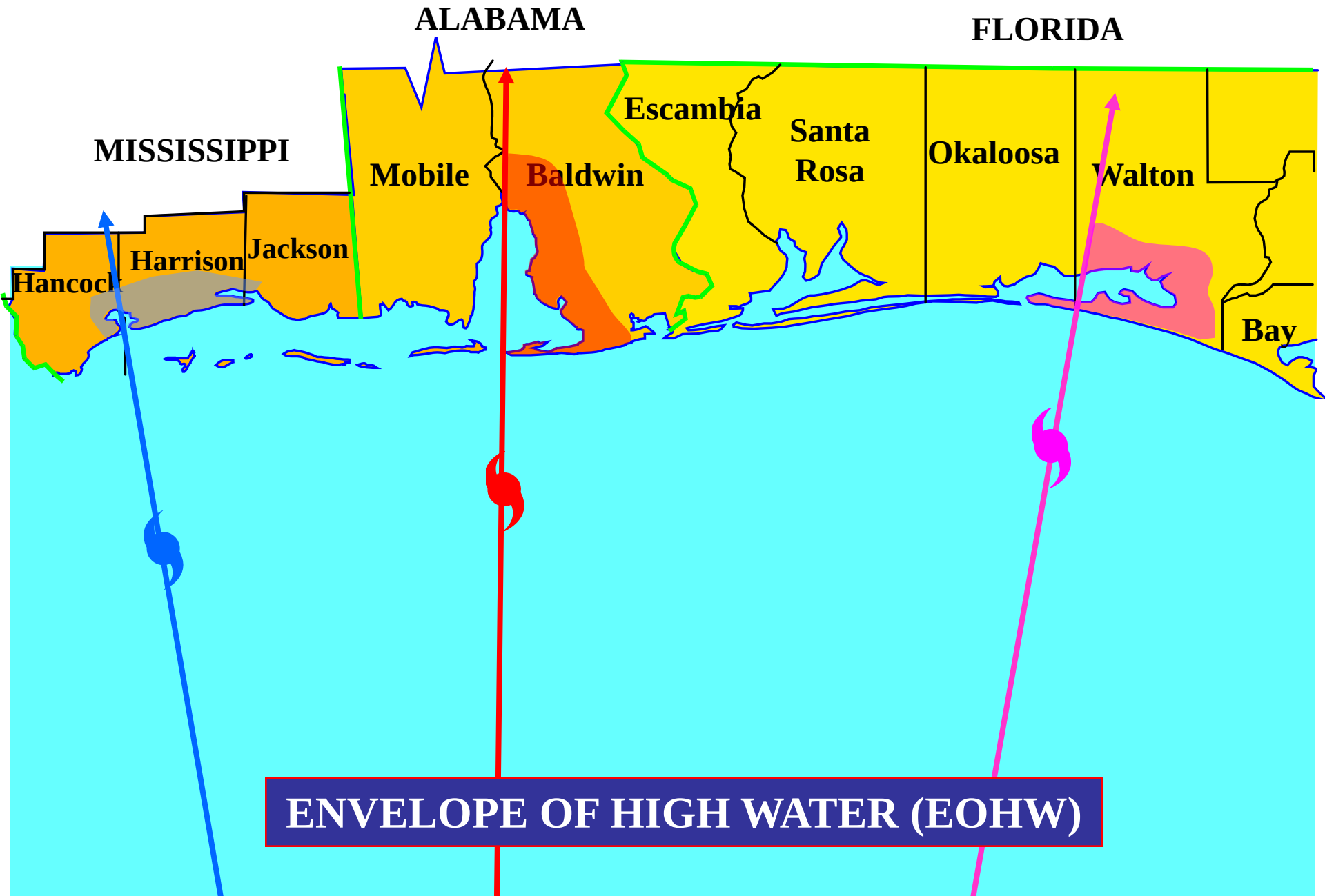

Basin: Elliptical Fort Myers <fmy>
Storm: d:/slosh.pkg/data/rexfiles/C_RMW06.BRJ.BT.rex
SLOSH Wind field
1 min avg KTS(MPH)
34(39) 65(75) 100(115)
Stm Tide
ft NGVD
18
16
14
12
10
8
6
4
2
0
Tide level:
0.0 ft
Venice
Sarasota
Desoto
Port Charlotte
Charlotte
Glades
Envelope of
High Water
Fort Myers
Cape Coral
Captiva
Sanibel Island
Lee
Hendry
Naples
Collier
0
25
mi
0
25
mi

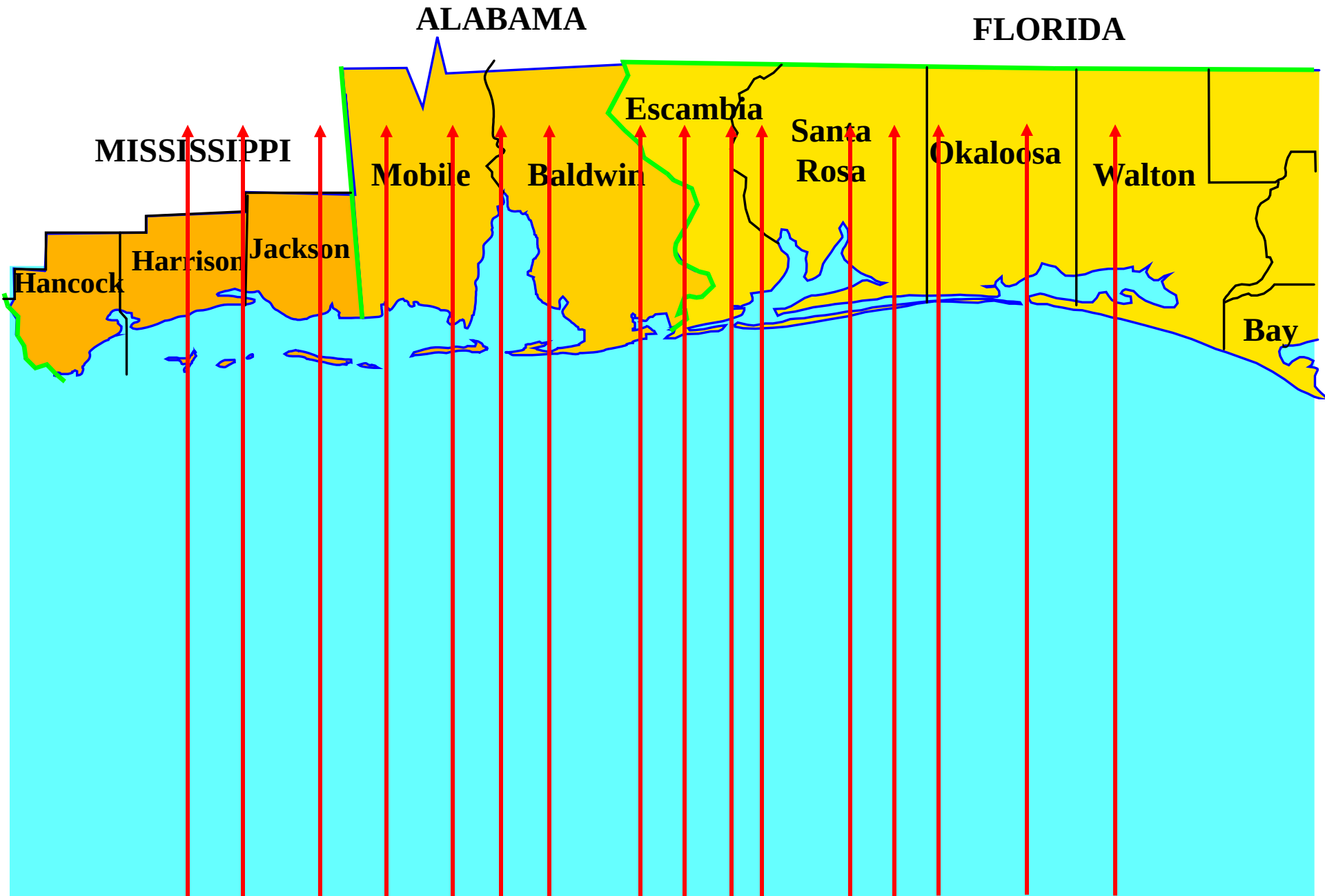
RMW=6



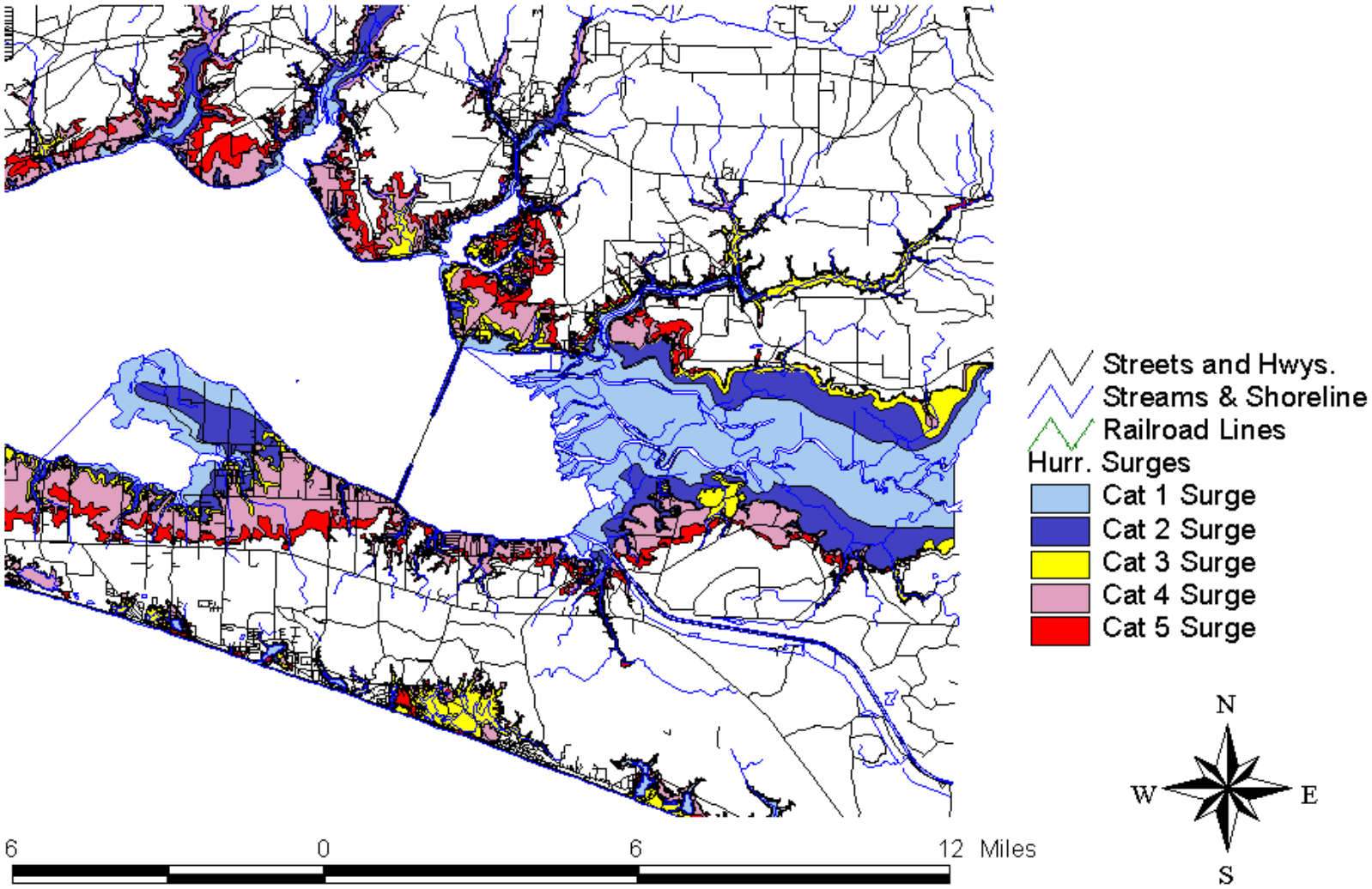
RMW=25 “Average” size


New Orleans <ms2>
Storm:
NOAA
10 mi
★Chef Menteur
Lake Borgne


ALABAMA
FLORIDA
MISSISSIPPI
Escambia
Santa Rosa
Okaloosa
Walton
Mobile
Baldwin
Jackson
Harrison
Hancock
Bay
ENVELOPE OF HIGH WATER (EOHW)


ALABAMA
FLORIDA
MISSISSIPPI
Escambia
Santa
Rosa
Okaloosa
Walton
Mobile
Baldwin
Jackson
Harrison
Hancock
Bay

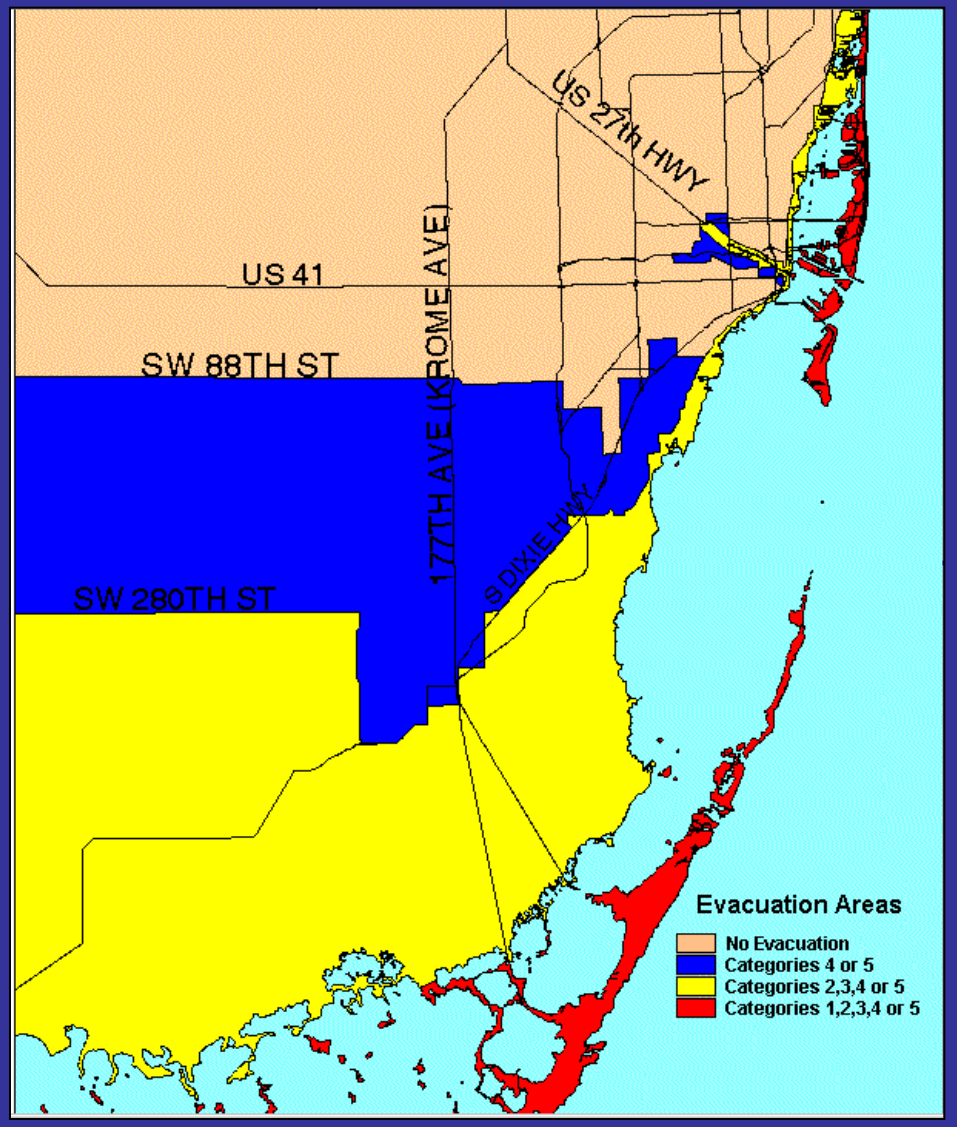
Surge Mapping



Evacuation Zones

1. Delineated by major geographic features

2. Conform to existing political or demographic boundaries



Improvements to Storm Surge Forecasting from Improved HURRICANE FORECASTING

- TRACK
- INTENSITY
- SIZE / STRUCTURE

Improvements to Storm Surge Forecasting from Improved STORM SURGE MODELING

- ENSEMBLES OF MODELS
- PROBABALISTIC FORECASTS
- HIGHER RESOLUTION
- COUPLING
- ADDING WAVES