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The Hurricane Severity Index – A New Method of Classifying the Destructive Potential of Tropical Cyclones

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Saffir-Simpson Scale

- Developed in the late 1960's and early 1970's by Herbert Saffir and Robert Simpson
- Entered operational use in 1975
- Designed to assess the damage potential of a landfalling hurricane and provide guidance to emergency response officials
- Scale numbers range from 1 to 5

Saffir-Simpson Scale

Category	Wind (mph)	Pressure (inches)	Surge (feet)
1	74-95	> 28.94	4 - 5
2	96-110	28.50-28.93	6 - 8
3	111-130	27.91-28.49	9 - 12
4	131-155	27.17-27.90	13 - 18
5	> 155	< 27.16	> 18

Why a new scale?

The Saffir-Simpson scale has limitations…

- Based only on maximum sustained winds
- Max winds may be isolated
- Storm surge is more related to a hurricane's size
- Does not include size and scope of a hurricane's wind field
- Not a good estimate of potential damage
- Doesn't consider tropical storms
- Assumes all hurricanes are alike


Ike vs. Marco Composite Image
Ike
9/12/08
Marco
10/6/08
SATELLITE IMAGE VALID FRI SEP 12 4:15 AM CDT 2008

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2008 Hurricanes

- Hurricane Dolly – landfall lower Texas coast – July 23rd
- Hurricane Gustav – landfall southeast Louisiana coast – September 1st
- Hurricane Ike – landfall Galveston Island on September 12-13th

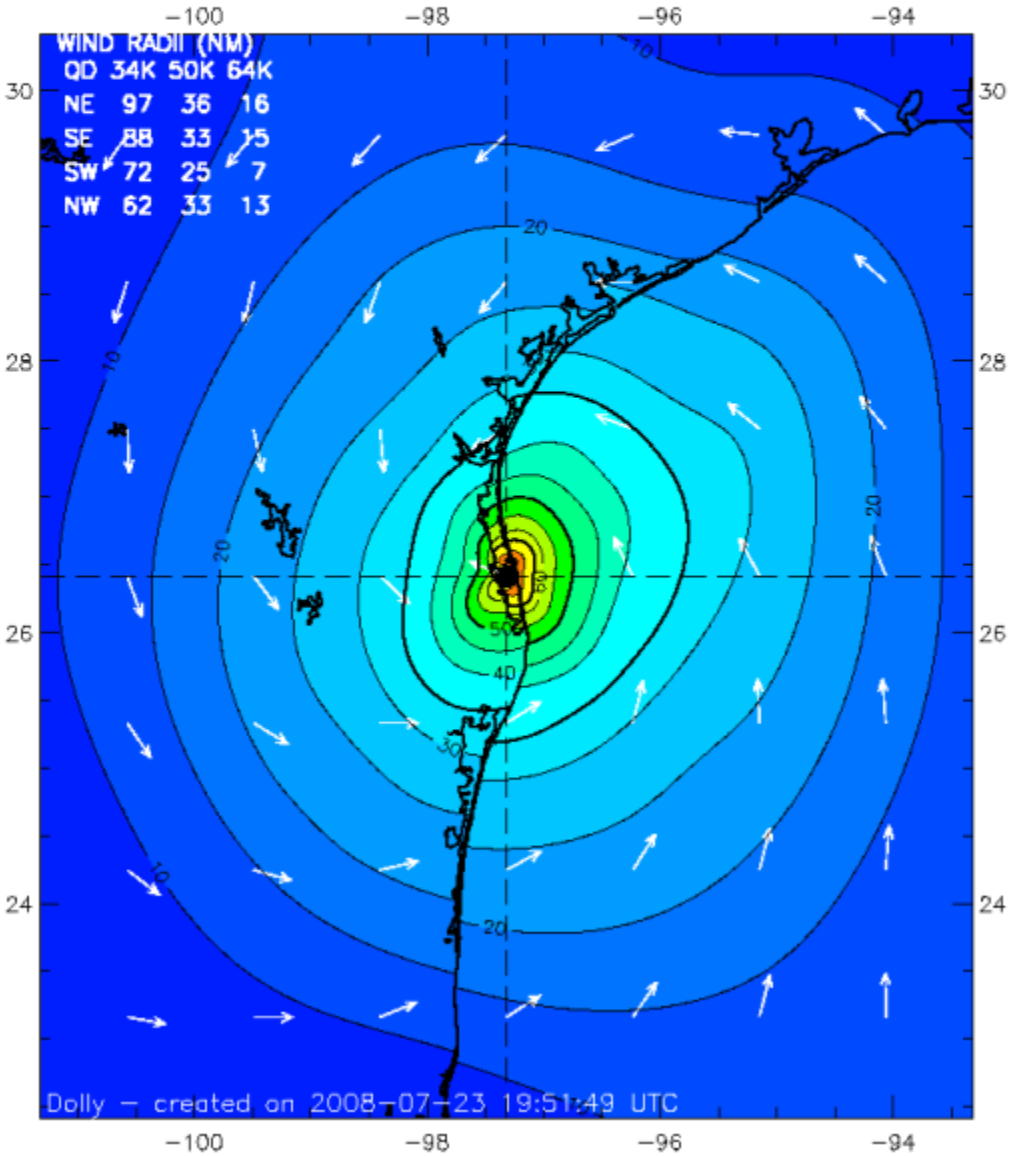
All were classified as Category 2 on the Saffir-Simpson Scale at landfall

Hurricane Dolly 1930 UTC 23 JUL 2008

Max 1-min sustained surface winds (kt)

Valid for marine exposure over water, open terrain exposure over land

Analysis based on SFMR_AFRC from 1734 - 1920 z; BACKGROUND_FIELD from 1930 - 1930 z; CMAN from 1739 - 1859 z; GPSSONDE_SFC from 1734 - 1824 z;
METAR from 1735 - 1928 z; GPSSONDE_WL150 from 1734 - 1824 z;
WEATHER_FLOW from 1735 - 1915 z; MOORED_BUOY from 1739 - 1849 z;
ASOS from 1736 - 1930 z;
1930 z position extrapolated from 1820 z Vortex wind center using 305 deg @ 6 kts; mslp = 968.0 mb



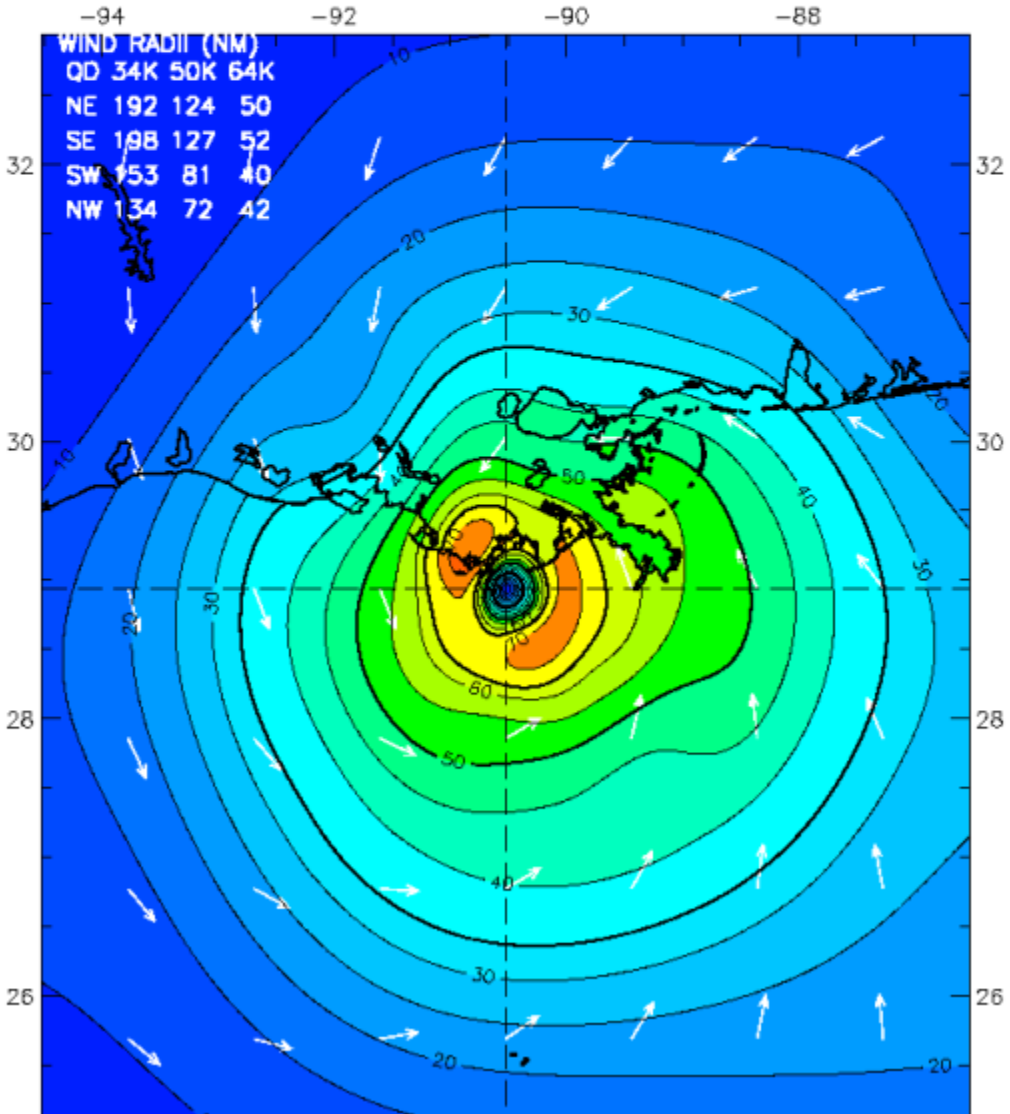
Hurricane Gustav 1330 UTC 01 SEP 2008

Max 1-min sustained surface winds (kt)

Valid for marine exposure over water, open terrain exposure over land

Analysis based on GPSSONDE_SFC from 1034 - 1405 z; SFMR43 from 1030 - 1406 z; MOORED_BUOY from 1030 - 1359 z;
GPSSONDE_WL150 from 1034 - 1405 z;
SHIP from 1100 - 1400 z; QSCAT_HIRES from 1055 - 1057 z;
GOES from 1302 - 1302 z; TAIL_DOPPLER (User-defined adjusted) from 0951 - 0951 z;
ASOS from 1033 - 1400 z; METAR from 1030 - 1406 z;
CMAN from 1039 - 1359 z; FCMP_TOWER from 1030 - 1404 z;
BACKGROUND_FIELD from 1330 - 1330 z; SFMR_AFRC from 1030 - 1321 z;

1330 z position interpolated from 1230 Vortex; mslp = 955.0 mb

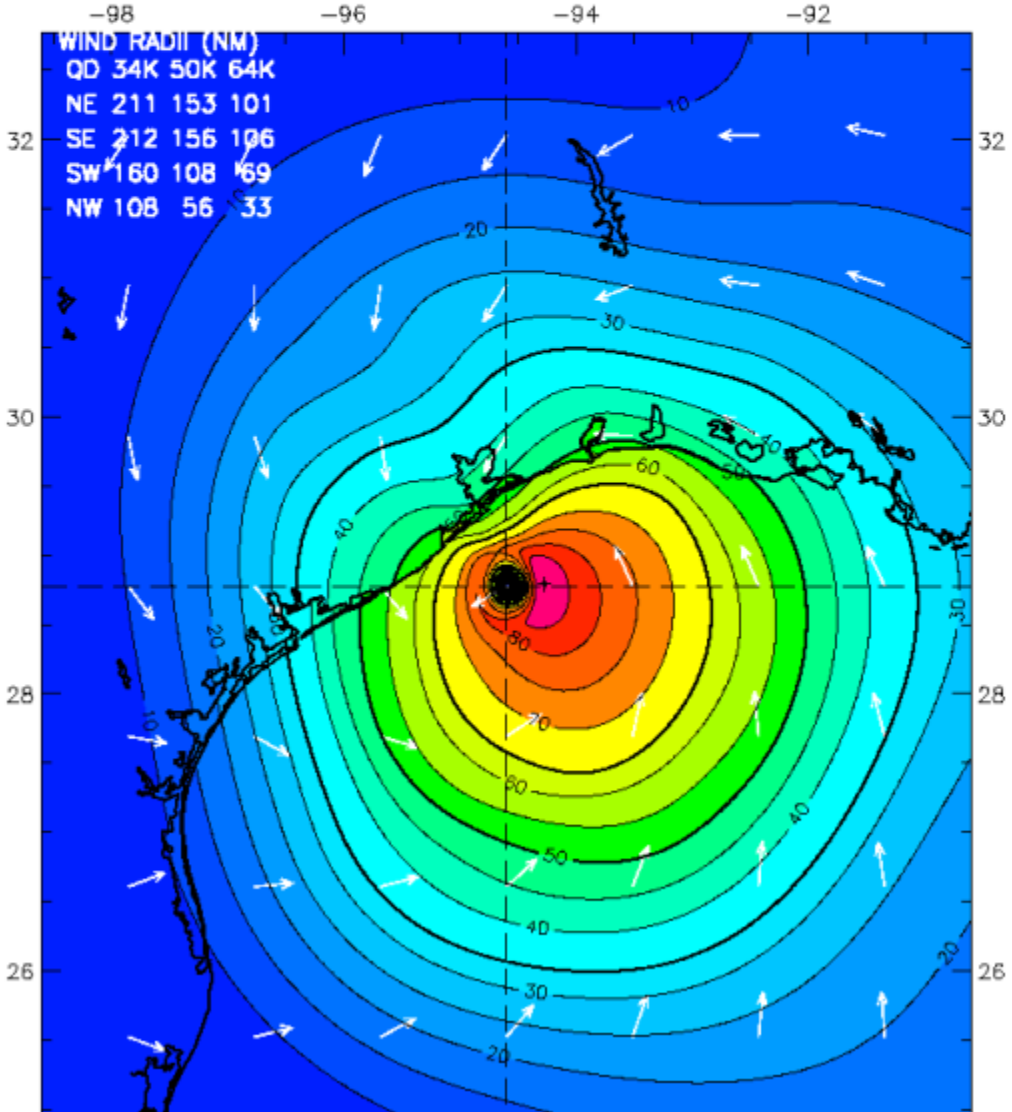


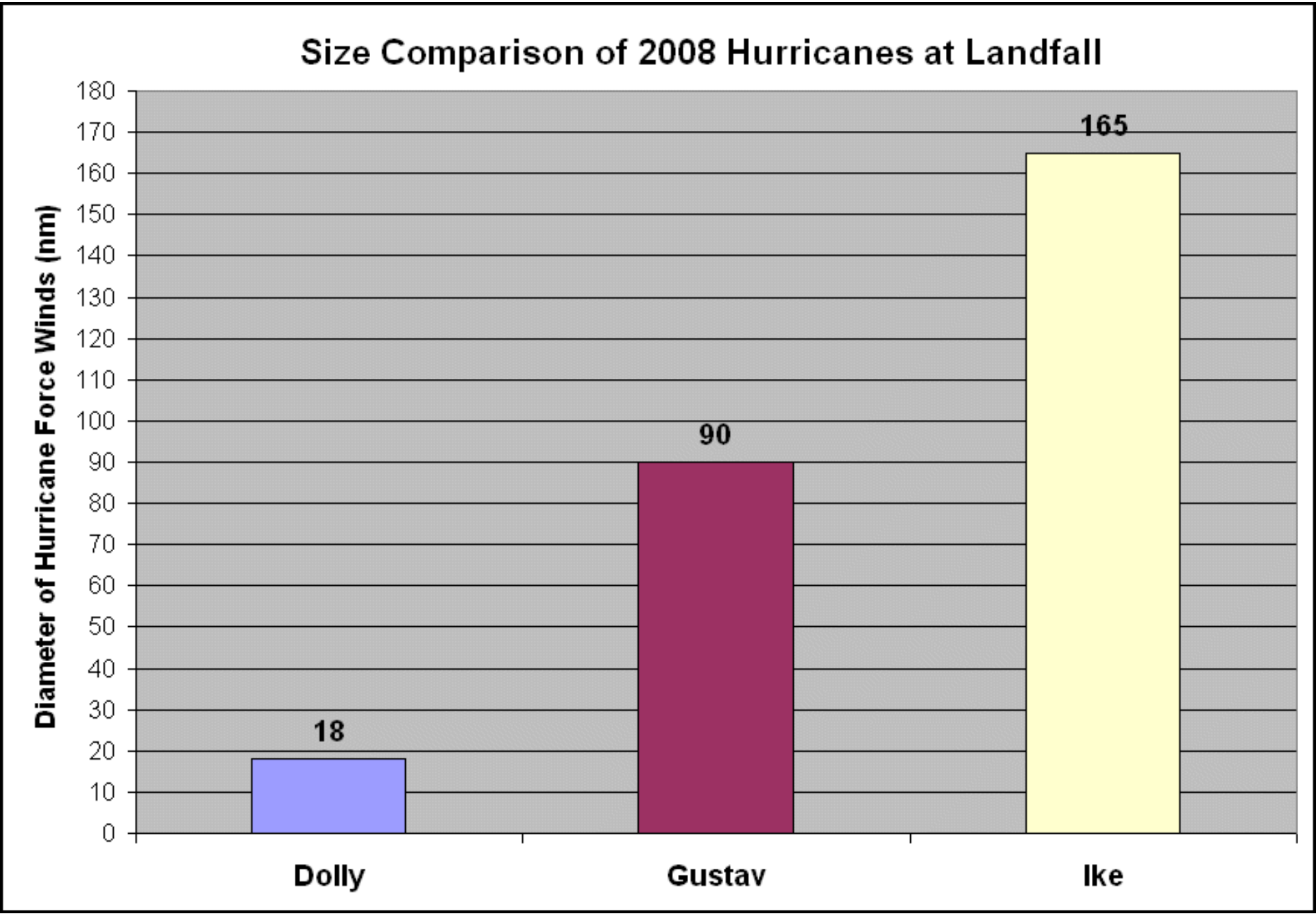
Hurricane Ike 0430 UTC 13 SEP 2008

Max 1-min sustained surface winds (kt)

Valid for marine exposure over water, open terrain exposure over land

Analysis based on CMAN from 0159 - 0259 z; MOORED_BUOY from 0159 - 0349 z; ASOS from 0156 - 0401 z;
GPSSONDE_SFC from 0155 - 0314 z; SHIP from 0200 - 0400 z;
MADIS from 0202 - 0353 z; METAR from 0155 - 0408 z;
FCMP_TOWER from 0204 - 0424 z; GPSSONDE_WL150 from 0155 - 0322 z;
WEATHER_FLOW from 0155 - 0355 z; BACKGROUND_FIELD from 0430 - 0430 z;
SFMR_AFRC from 0155 - 0316 z; SFMR42 from 0159 - 0402 z;
0430 z position extrapolated from 0300 z OFCL_ATCF wind center using 315 deg @ 10 kts; mslp = 952.0 mb




Size Comparison of 2008 Hurricanes at Landfall
Diameter of Hurricane Force Winds (nm)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
18
90
165
Dolly
Gustav
Ike

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Hurricane Severity Index

Our Solution: Devise a new scale for classifying hurricanes that takes into consideration more than just maximum surface winds.

Size (1-25 points)

- Examines the total coverage of the 39+, 58+, 74+ and 100+ mph wind fields

Intensity (1-25 points)

- Points assigned using the exponential relationship between wind speed and the force exerted on an object

The Result: A 50-point scale that better represents a tropical cyclone's true destructive potential, the **Hurricane Severity Index.**

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Hurricane Severity Index

Determining Size Points

Wind radii data from every named storm since 1988 were studied. From these data, we found typical wind radii ranges of four wind fields, 39, 58, 74 and 100 mph. Once the typical ranges were established, we divided each wind field range into sections.

Since hurricane-force winds are much more damaging than tropical storm-force winds, we weighted the size scale more toward the 74 and 100 mph wind fields. On the HSI, a tropical storm can receive no more than 7 total points for size.

Wind Radii	Size Point Range
35 kts	**1-3**
50 kts	**1-4**
65 kts	**1-8**
87 kts	**1-10**

A total of 25 size points is possible.

Determining Intensity Points

- Wind force on an object is an exponential function (twice the wind speed equals four times the wind force)
- Developed an exponential intensity scale that assigns 1 point for a 30 kt (35 mph) tropical depression and up to 25 points for a hurricane with winds above 150 kts (175 mph)

A total of 25 size points is possible.

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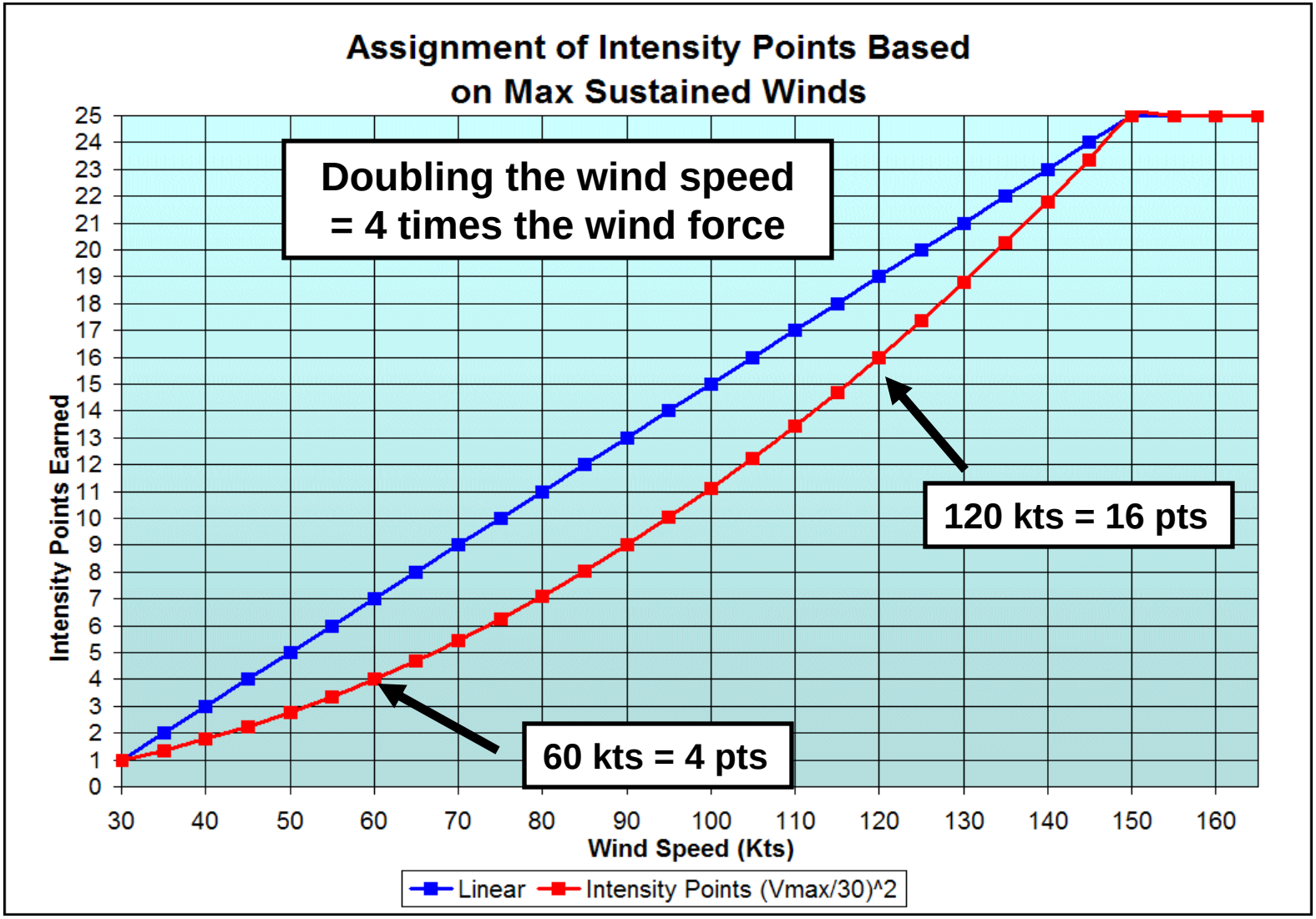
Hurricane Severity Index



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Hurricane Severity Index

Saffir-Simpson Hurricane Scale vs. HSI						
Classification	**HSI Size**		**HSI Intensity**		**Total HSI**	
	Low	High	Low	High	Low	High
Depression	0	0	1	1	1	1
TS	1	7	1	4	2	11
Cat. 1 Hurricane	3	15	5	7	8	22
Cat. 2 Hurricane	3	25	8	10	11	35
Cat. 3 Hurricane	4	25	11	14	15	39
Cat. 4 Hurricane	4	25	15	20	19	45
Cat. 5 Hurricane	4	25	22	25	26	50

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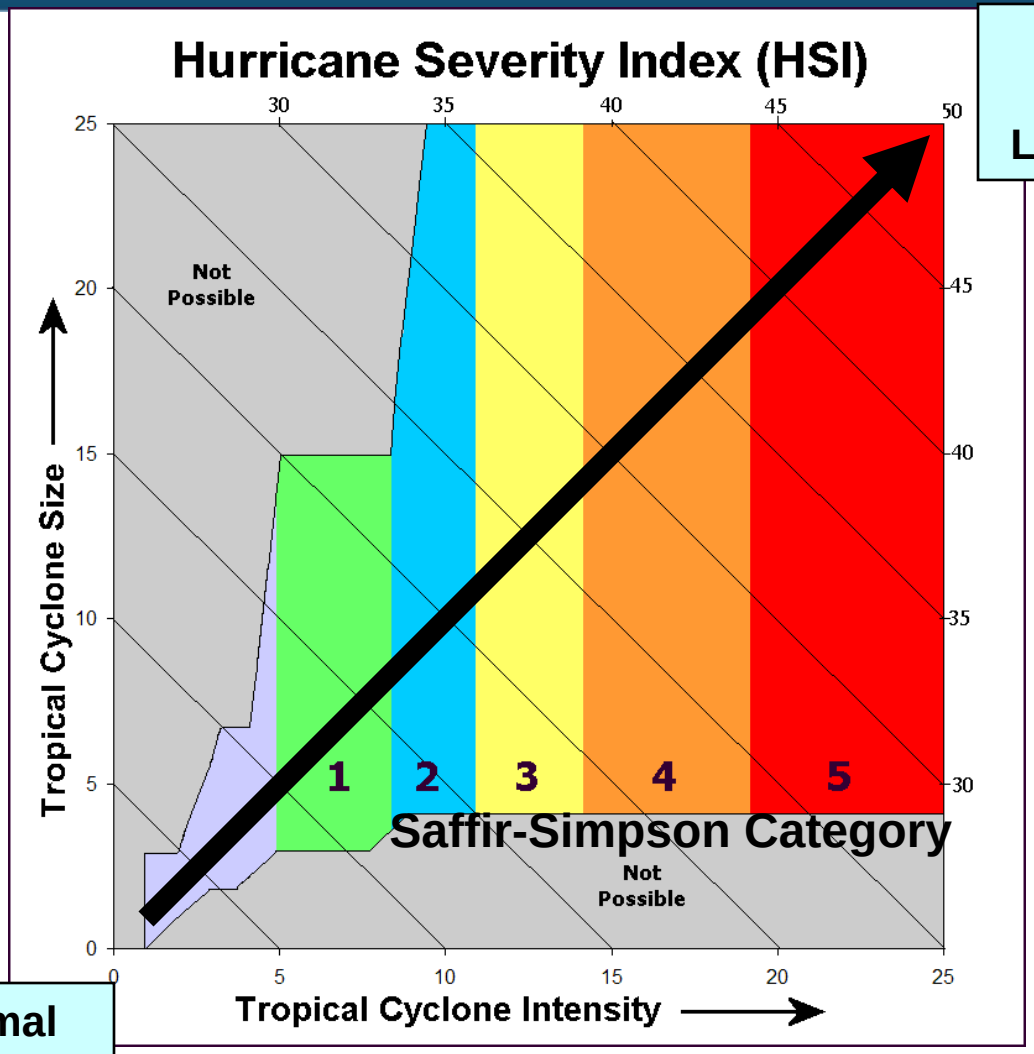

Severe Damage Large Area

Minimal Damage Small Area

A hurricane's size is represented along the left axis, with intensity along the bottom axis. Severity increases from the lower left to the upper right of the graph.

Note that a large Saffir-Simpson Category 1 hurricane can have 20 pts., as can a very small Category 4 hurricane. The size of the storm definitely matters when considering potential damage.

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Hurricane Ivan
105 kts / 120 mph
Category 3
HSI at landfall: 33
Damage: $15 billion

Hurricane Dennis
105 kts / 120 mph
Category 3
HSI at landfall: 18
Damage: $2.2 billion

ImpactWeather's **Hurricane Severity Index** is an enhanced hurricane rating system which more accurately defines the strength and destructive capability of a given storm than other scales currently utilized. The Hurricane Severity Index uses comprehensive equations which incorporate *not only the intensity of the winds but the size of the area the winds cover.*

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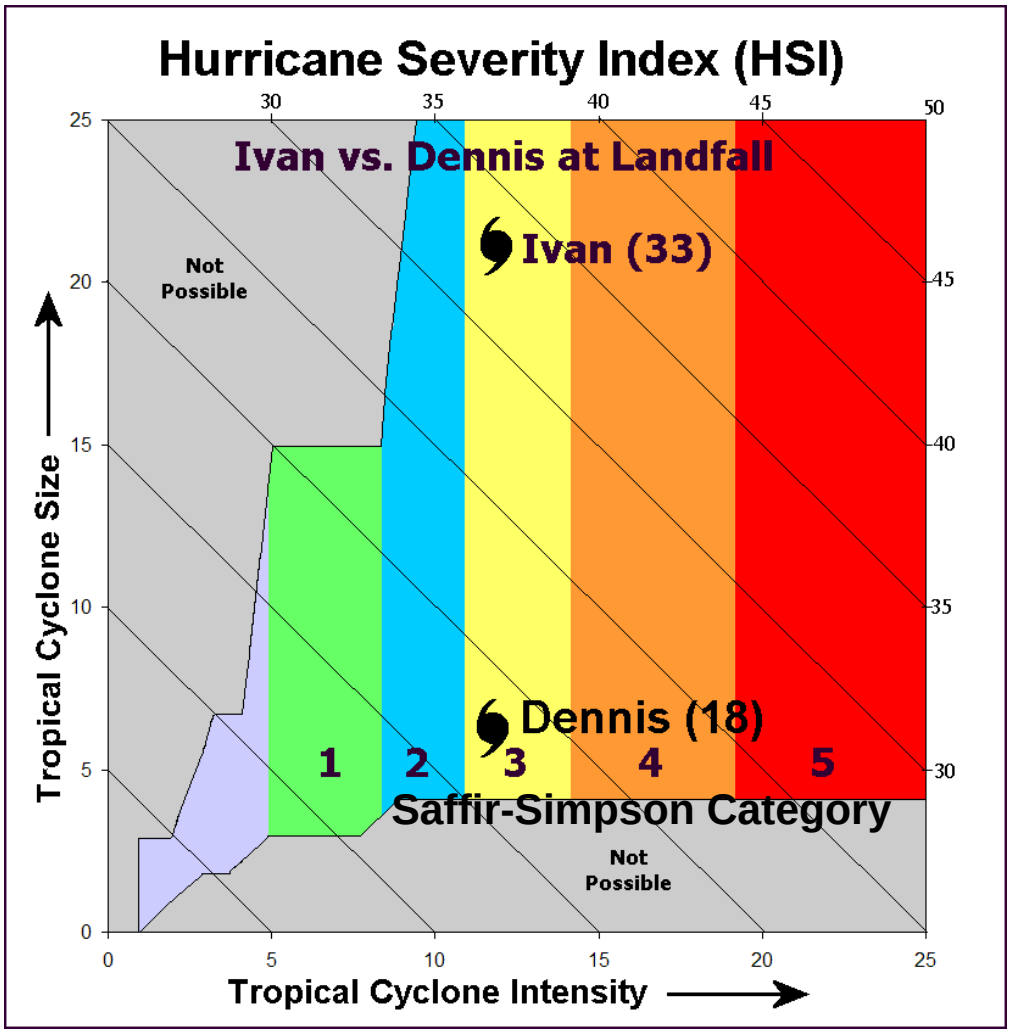

Both hurricanes were “identical” on the Saffir-Simpson scale, each a moderate Category 3.

But look at the size difference. Ivan’s wind field was 2-3 times that of Dennis, earning it a total of 21 size points and a total of 33 points on the HSI. Dennis, on the other hand, earned only 6 size points and a total of 18 points on the HSI.

That’s why Ivan produced so much more damage over a larger area than did Dennis.

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HSI Values for US landfalling 2008 Storms

Name	Wind (mph) Saffir-Simpson	HSI		
		Size	Intensity	Total
Ike	110 – Cat 2	20	10	30
Gustav	105 – Cat 2	11	9	20
Dolly	100 – Cat 2	4	8	12
Hanna	70 – TS	4	4	8
Edouard	60 – TS	2	3	5
Fay	50 – TS	1	2	3

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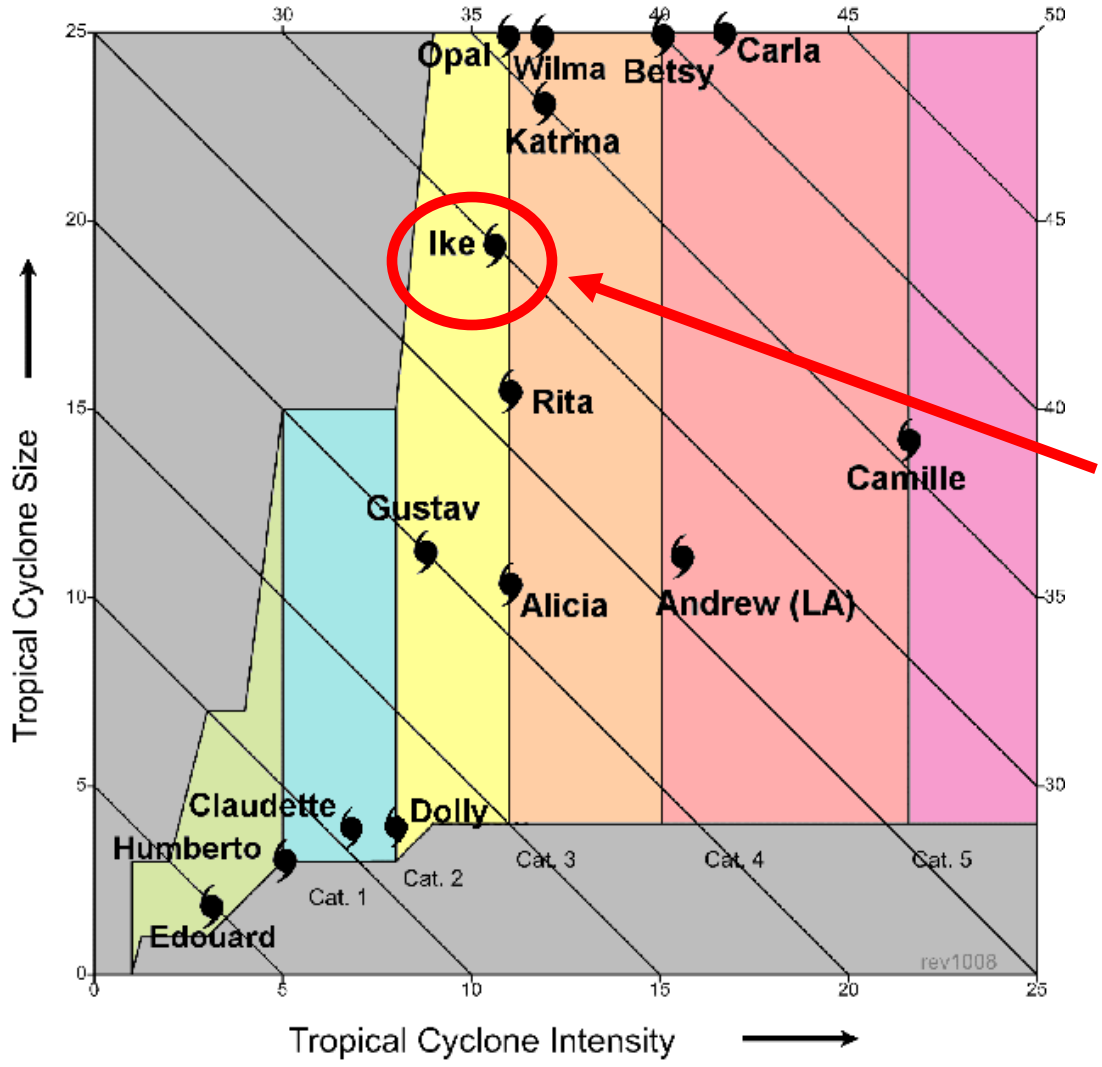
HSI Values for Well-Known Tropical Cyclones



Hurricane	HSI		
	Size	Intensity	Total
Carla ‘61	**25**	17	42
Betsy ‘65	**25**	15	40
Wilma ‘05	21	12	33
Camille ‘69	14	22	36
Katrina ‘05	23	13	36
Opal ‘95	25	11	36
Audrey’57	16	17	33
Ivan ‘04	20	12	32
Ike ‘08	**20**	**10**	**30**
Andrew ’92	11	16	27
Rita ‘05	16	10	26
Alicia ‘83	11	11	22
Gustav ‘08	11	9	20
Bret ‘99	4	11	16
Lili ‘02	8	6	14
Dolly ’08	4	8	12
Claudette ’03	4	7	11
Humberto ’07	3	5	8
Edouard ’08	2	3	5

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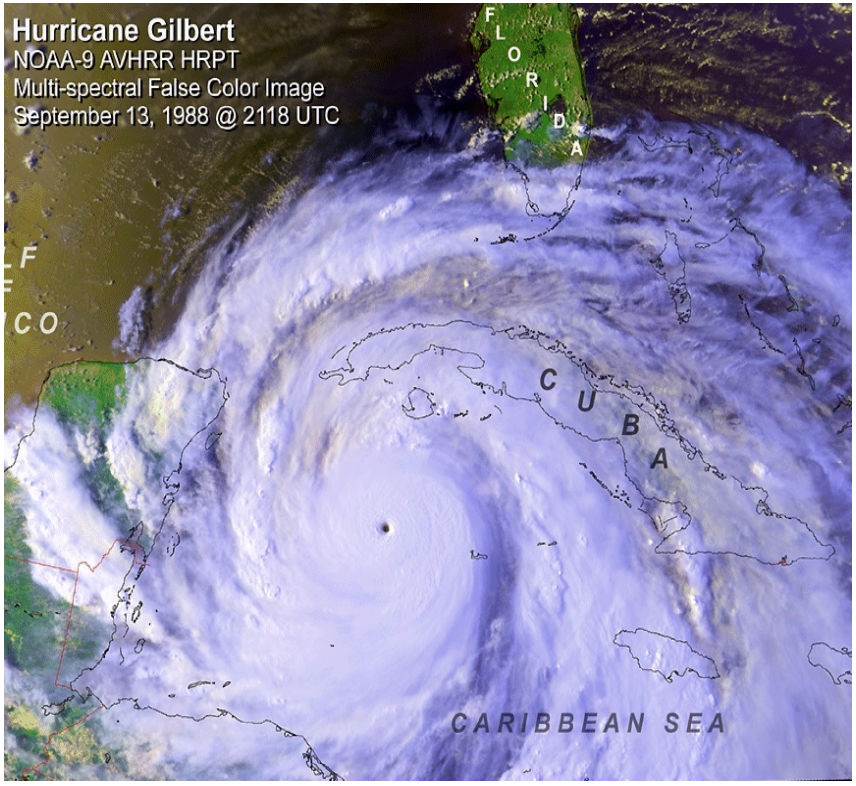
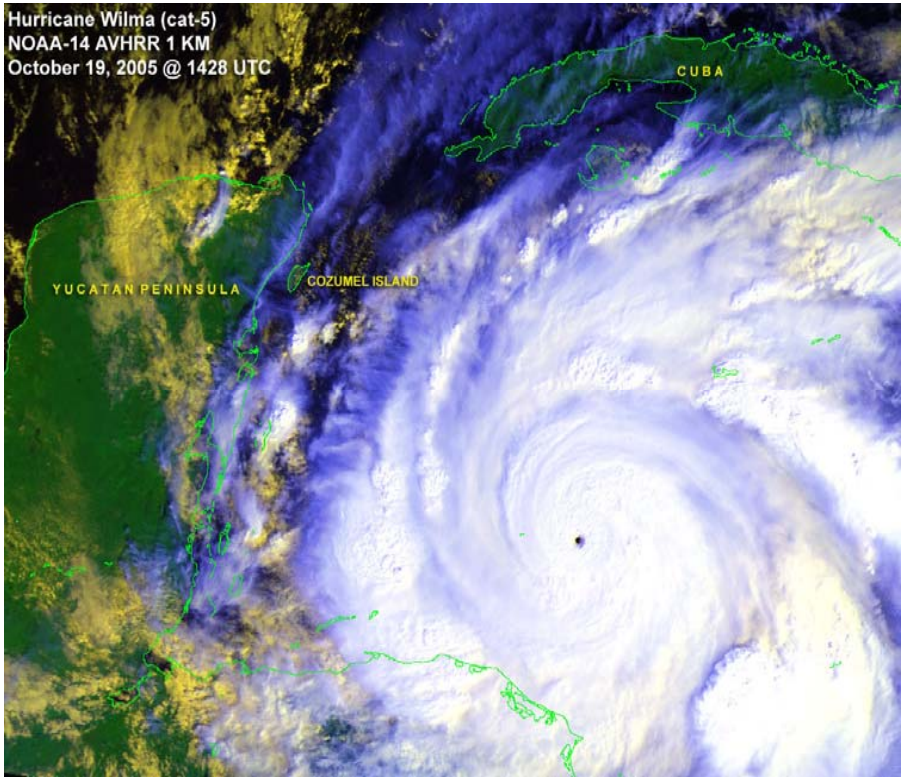
Category 5 Hurricanes Gilbert and Wilma at Peak Intensity

Hurricane Gilbert – 160 kts / 185 mph
Size Points – 24
Intensity Points – 25
HSI at Landfall = 49



Hurricane Wilma – 160 kts / 185 mph
Size Points – 5
Intensity Points – 25
HSI at Landfall = 30



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Hurricane Severity Index

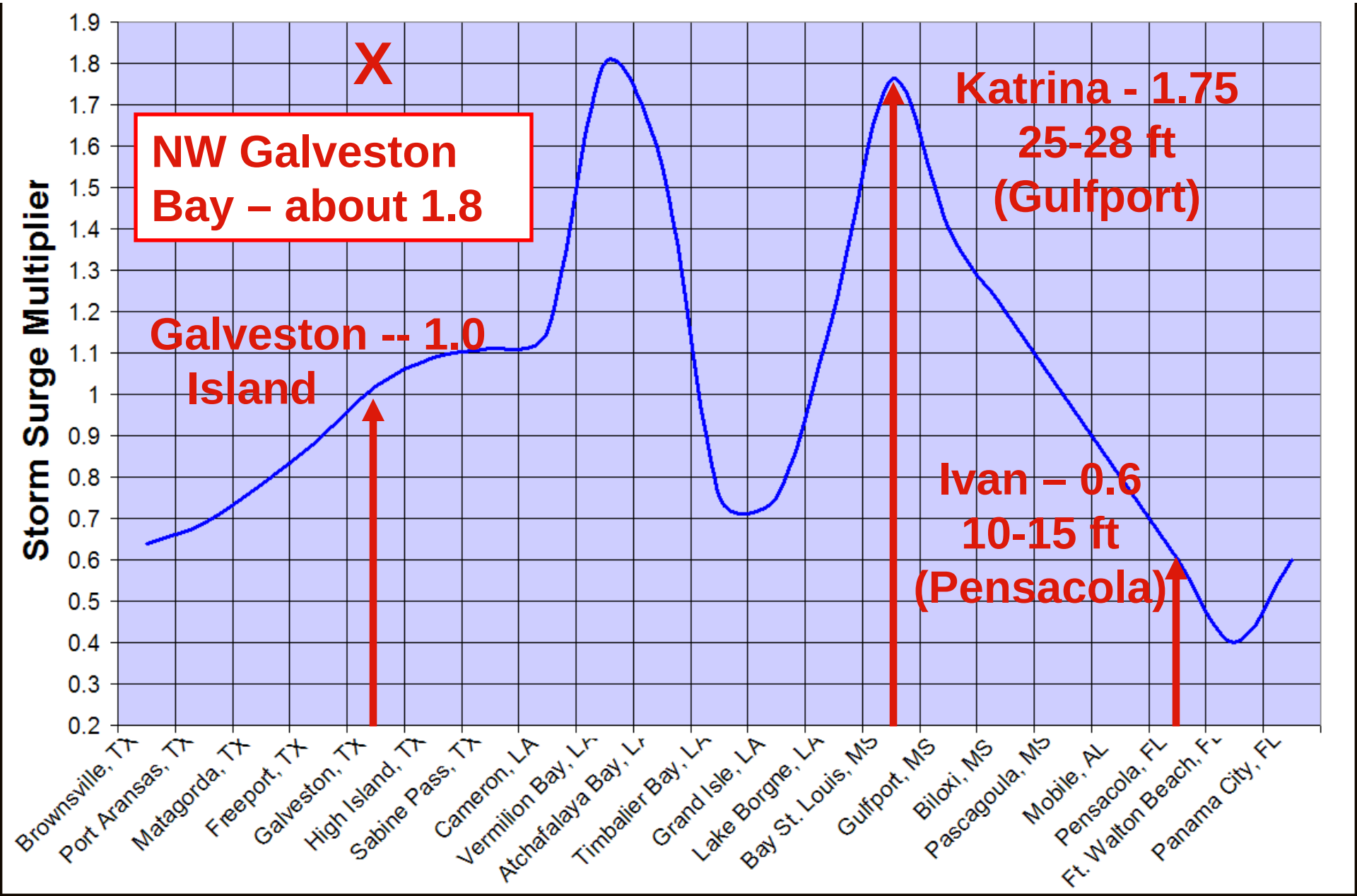
- Size of the storm has implications for:
  - Duration of the event
  - Amount of rainfall
  - Size of the potential storm surge
  - Wave heights offshore

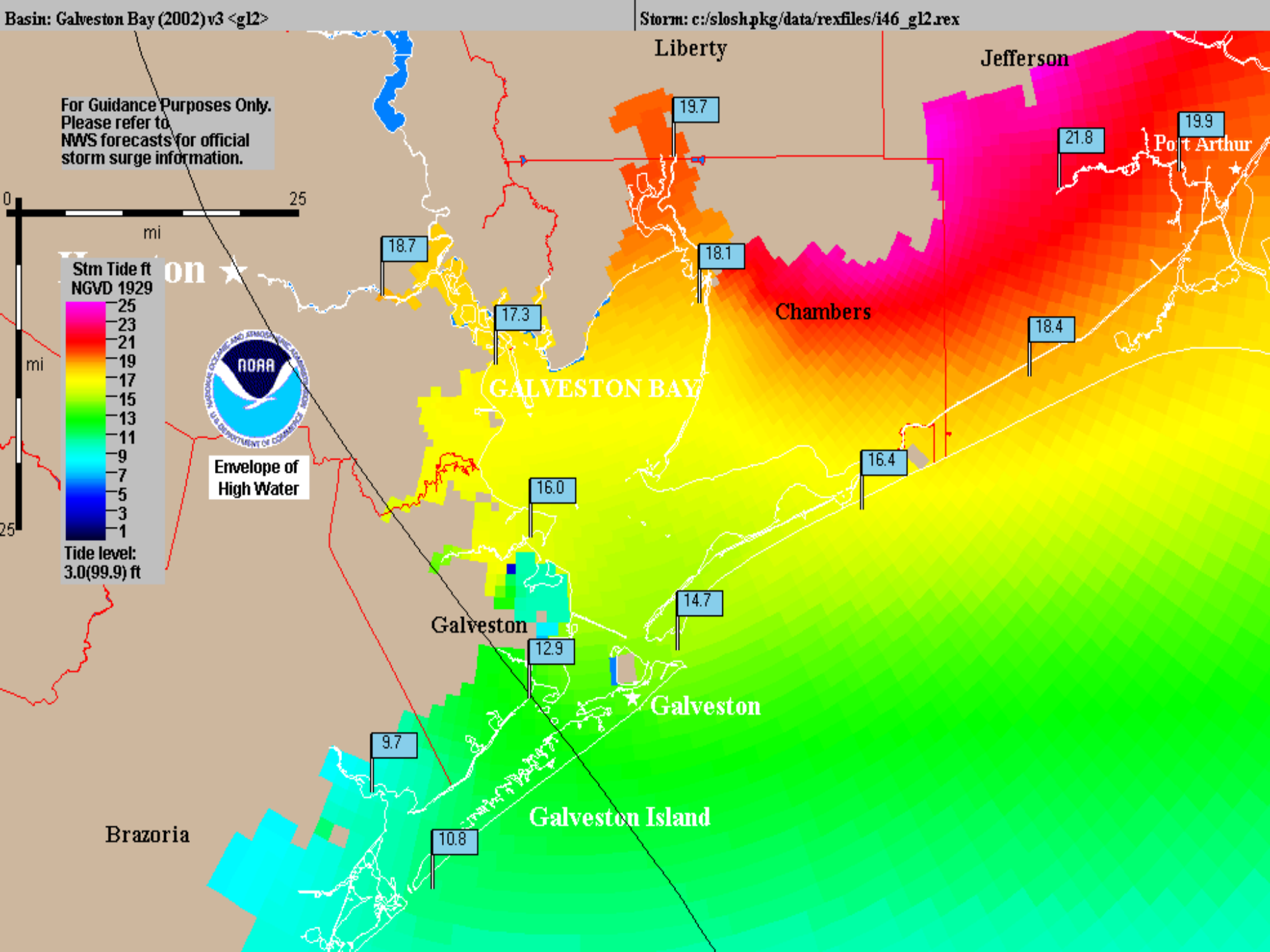
Factors That Contribute to Storm Surge:

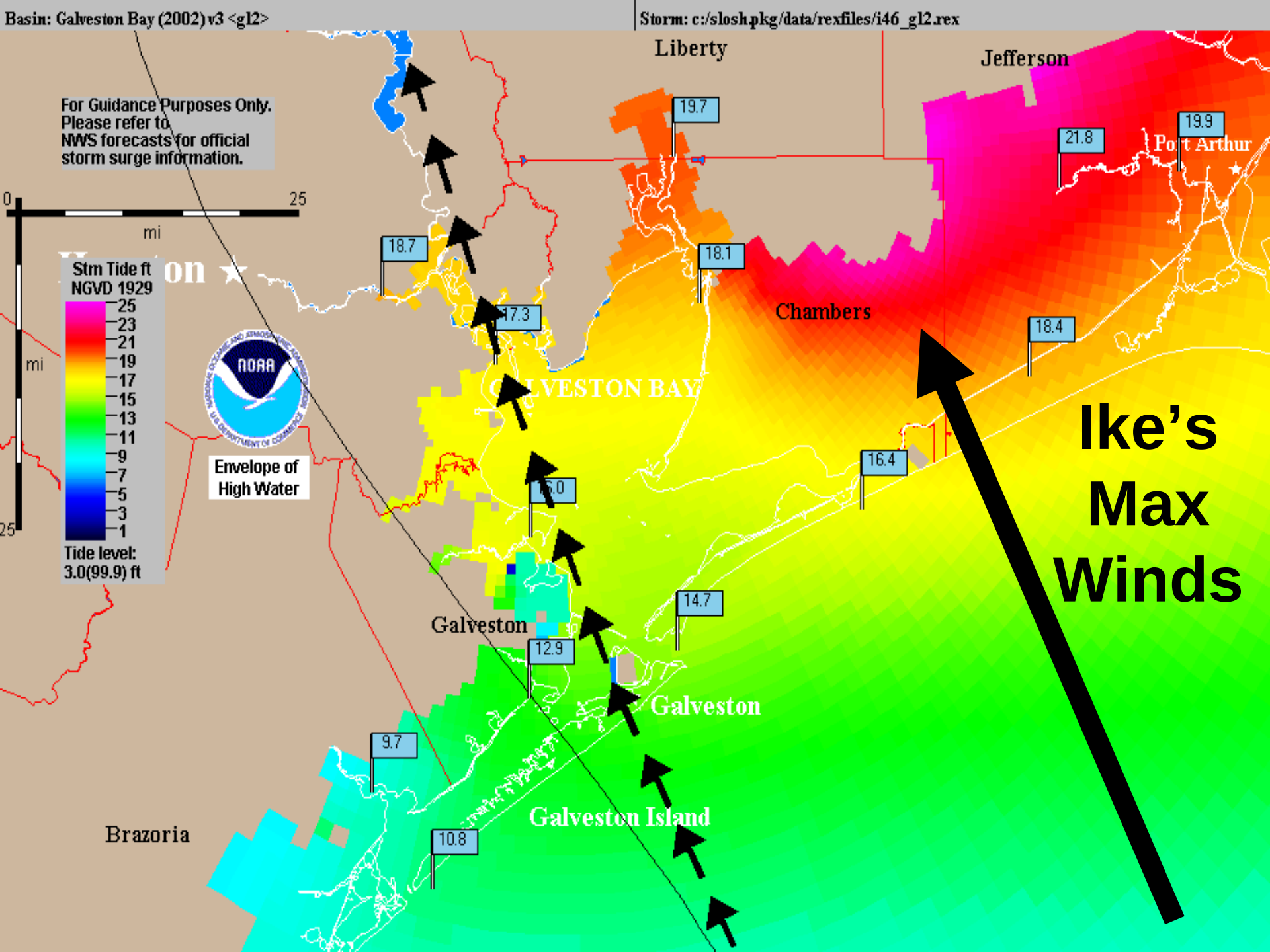
- Strength and size of the hurricane’s wind field
- Forward speed at landfall (slower = higher surge)
- Angle at which the center crosses the coast
- Slope of the sea floor (shallow water enhances)
- Shape of the coastline (bays enhance surge)

Coastal Shoaling Factor

Multiply "normal" Surge by This Value




Basin: Galveston Bay (2002) v3 <gl2>
Storm: c:/sloshpkg/data/rexfiles/i46_gl2.rex
Liberty
Jefferson
For Guidance Purposes Only.
Please refer to
NWS forecasts for official
storm surge information.
0
25
mi
Stm Tide ft
NGVD 1929
25
23
21
19
17
15
13
11
9
7
5
3
1
Tide level:
3.0(99.9) ft
Envelope of
High Water
19.7
21.8
19.9
Port Arthur
18.7
18.1
Chambers
17.3
18.4
GALVESTON BAY
16.4
16.0
14.7
Galveston
12.9
Galveston
9.7
Galveston Island
Brazoria
10.8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Jefferson
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0
25
mi
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NGVD 1929
25
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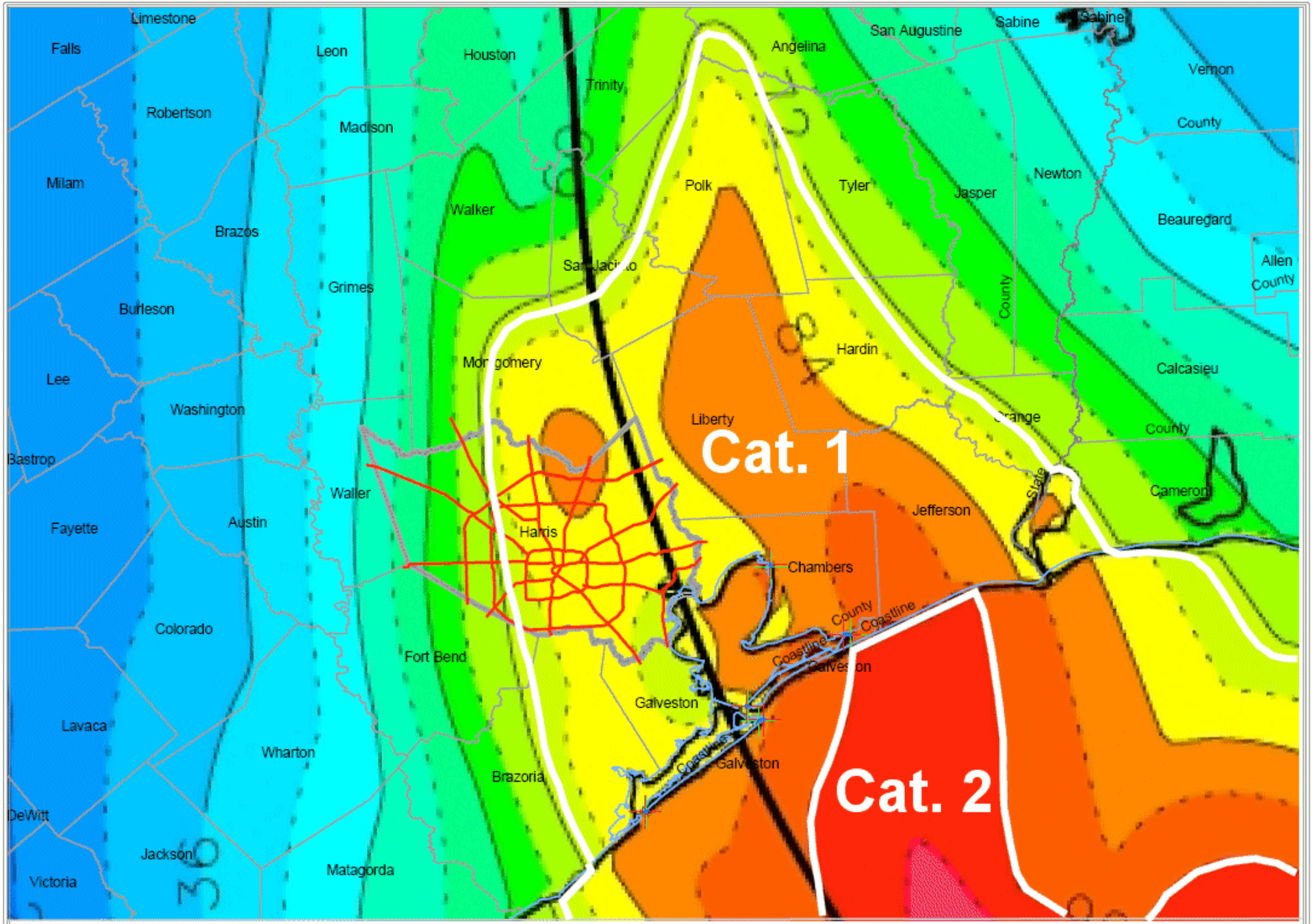
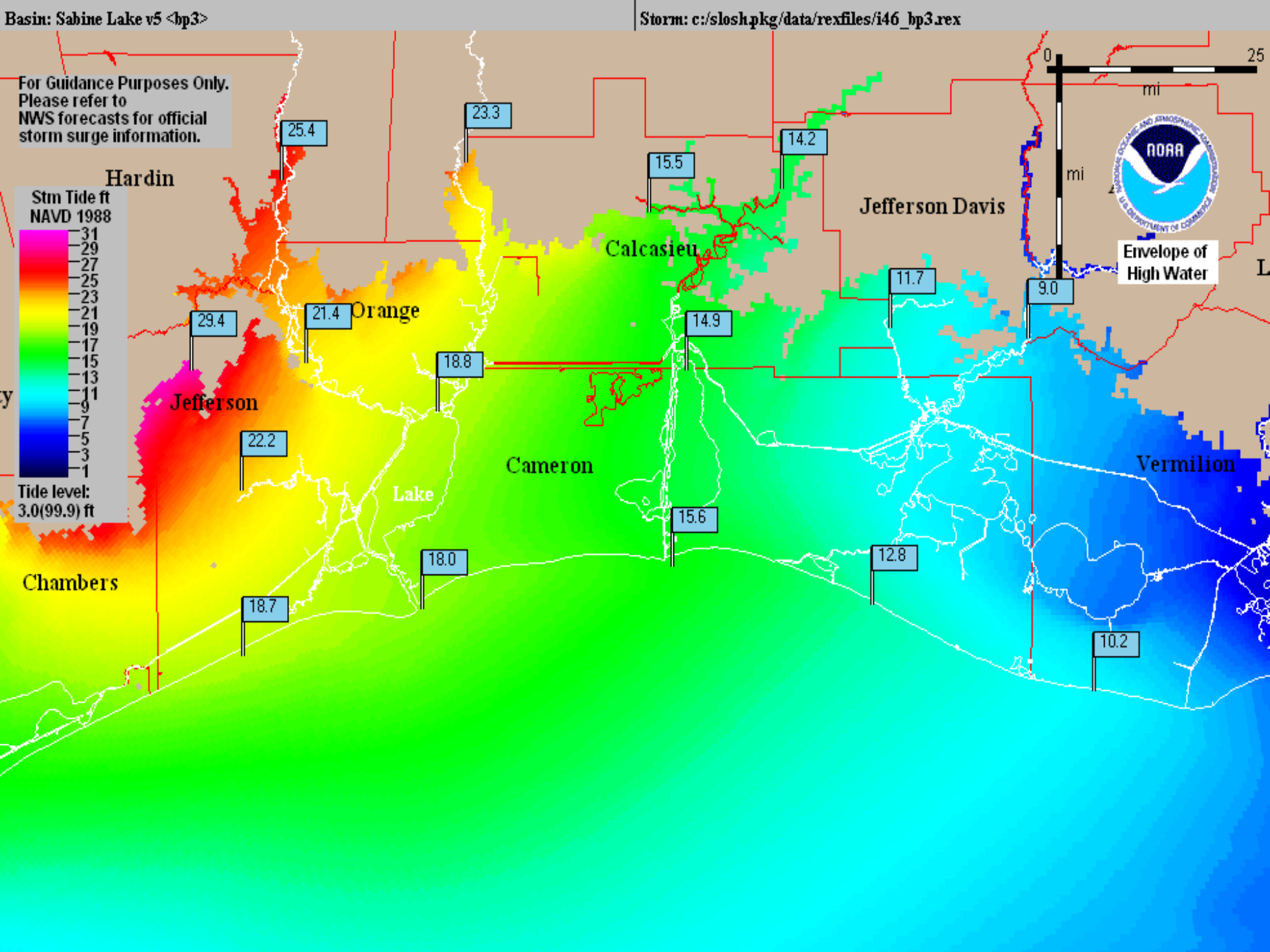
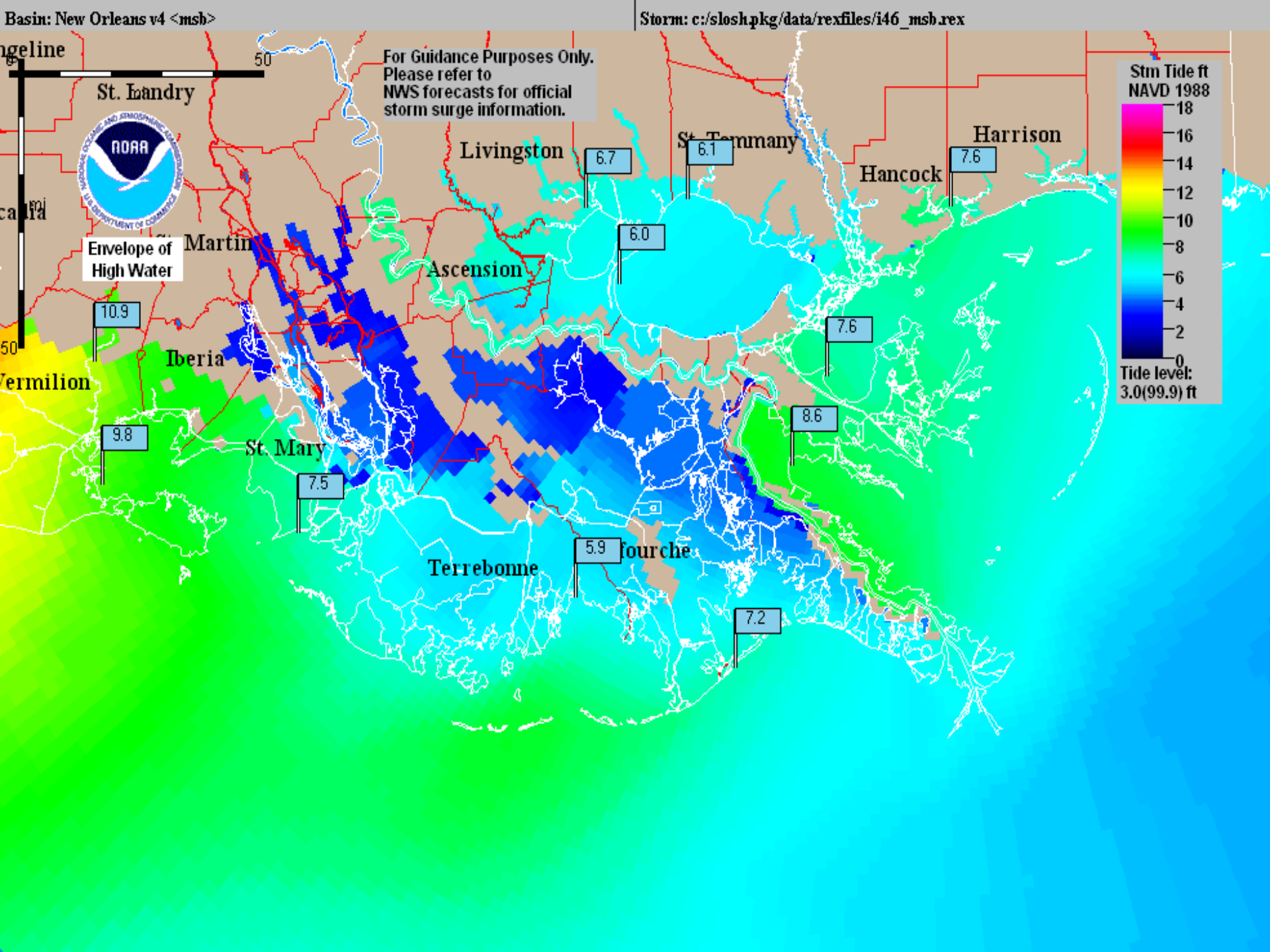
1
Tide level:
3.0(99.9) ft
Envelope of
High Water
19.7
21.8
19.9
Port Arthur
18.7
18.1
17.3
Chambers
18.4
GALVESTON BAY
16.4
14.7
Galveston
12.9
Galveston
9.7
Galveston Island
Brazoria
10.8
Ike's
Max
Winds



HARRIS COUNTY APPRAISAL DISTRICT

Ike Wind Countours


Basin: Sabine Lake v5 <bp3>
Storm: c:/sloshpkg/data/rexfiles/i46_bp3.rex
For Guidance Purposes Only.
Please refer to
NWS forecasts for official
storm surge information.
Stm Tide ft
NAVD 1988
31
29
27
25
23
21
19
17
15
13
11
9
7
5
3
1
Tide level:
3.0(99.9) ft
0
25
mi
mi
NOAA
Envelope of
High Water
Hardin
Jefferson
Chambers
Orange
Calcasieu
Jefferson Davis
Cameron
Lake
Vermilion
25.4
23.3
14.2
15.5
29.4
21.4
18.8
11.7
9.0
14.9
22.2
15.6
18.0
12.8
18.7
10.2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For Guidance Purposes Only.
Please refer to
NWS forecasts for official
storm surge information.
Envelope of
High Water
Stm Tide ft
NAVD 1988
18
16
14
12
10
8
6
4
2
0
Tide level:
3.0(99.9) ft
St. Landry
Livingston
St. Tammany
Harrison
Hancock
St. Martin
Ascension
Iberia
Vermilion
St. Mary
Terrebonne
6.7
6.1
7.6
6.0
10.9
7.6
8.6
9.8
7.5
5.9
7.2
50

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Conclusions

- Hurricane size is very important in predicting potential damage
- Greater risk of prolonged hurricane-force wind
- Greater expanse of 74+ mph wind leads to much larger wave generation offshore and more widespread damage inland
- The HSI provides a much more accurate method for classifying the destructive potential of tropical cyclones