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
<table>
<thead>
<tr>
<th>Category</th>
<th>Wind (mph)</th>
<th>Pressure (inches)</th>
<th>Surge (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>74-95</td>
<td>&gt; 28.94</td>
<td>4 - 5</td>
</tr>
<tr>
<td>2</td>
<td>96-110</td>
<td>28.50-28.93</td>
<td>6 - 8</td>
</tr>
<tr>
<td>3</td>
<td>111-130</td>
<td>27.91-28.49</td>
<td>9 - 12</td>
</tr>
<tr>
<td>4</td>
<td>131-155</td>
<td>27.17-27.90</td>
<td>13 - 18</td>
</tr>
<tr>
<td>5</td>
<td>&gt; 155</td>
<td>&lt; 27.16</td>
<td>&gt; 18</td>
</tr>
</tbody>
</table>
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
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_AHCR from 1734 - 1920 z; BAKGUARDI FIELD from 1930 - 1930 z; CHAN 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; MOORING_BUOY from 1739 - 1849 z; AIDS from 1736 - 1900 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 GPPSONDE_SFC from 1034 - 1400 z; SPHR43 from 1030 - 1400 z; MOORED_BUOY from 1030 - 1359 z; GPPSONDE_WL150 from 1034 - 1400 z; SHIP from 1100 - 1400 z; QCCAT_HIERES from 1055 - 1057 z; GOES from 1302 - 1305 z; TAIL_DOPPLER (User-defined adjusted) from 0851 - 0951 z; AOGS from 1033 - 1400 z; METAR from 1030 - 1400 z; CRAN from 1033 - 1359 z; FCMP_TOWER from 1030 - 1404 z; BACKGROUND_FIELD from 1330 - 1330 z; SPHR_AFRIC 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 - 0239 z; MOORED_BUOY from 0159 - 0349 z; ASCAT from 0156 - 0401 z;
GPSSONDE_SFC from 0135 - 0214 z; SHIP from 0200 - 0400 z;
MADIS from 0202 - 0353 z; METAR from 0155 - 0408 z;
KMP_TOWER from 0200 - 0424 z; GPSSONDE_WL50 from 0155 - 0322 z;
WEATHER_FLOW from 0155 - 0355 z; BACKGROUND_FIELD from 0430 - 0430 z;
SFMR_AFRIC 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
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.
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.

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.
Doubling the wind speed = 4 times the wind force

60 kts = 4 pts

120 kts = 16 pts

Assignment of Intensity Points Based on Max Sustained Winds

ImpactWeather
Your Weather Department

Hurricane Severity Index
# Hurricane Severity Index

## Saffir-Simpson Hurricane Scale vs. HSI

<table>
<thead>
<tr>
<th>Classification</th>
<th>HSI Size</th>
<th>HSI Intensity</th>
<th>Total HSI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Depression</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>TS</td>
<td>1</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Cat. 1 Hurricane</td>
<td>3</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Cat. 2 Hurricane</td>
<td>3</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>Cat. 3 Hurricane</td>
<td>4</td>
<td>25</td>
<td>11</td>
</tr>
<tr>
<td>Cat. 4 Hurricane</td>
<td>4</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>Cat. 5 Hurricane</td>
<td>4</td>
<td>25</td>
<td>22</td>
</tr>
</tbody>
</table>
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.
### Not All Storms Are Alike

**Highlighted area: 74+ mph winds**

<table>
<thead>
<tr>
<th>Hurricane Ivan</th>
<th>Hurricane Dennis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>105 kts / 120 mph</strong></td>
<td><strong>105 kts / 120 mph</strong></td>
</tr>
<tr>
<td><strong>Category 3</strong></td>
<td><strong>Category 3</strong></td>
</tr>
<tr>
<td><strong>HSI at landfall: 33</strong></td>
<td><strong>HSI at landfall: 18</strong></td>
</tr>
<tr>
<td><strong>Damage: $15 billion</strong></td>
<td><strong>Damage: $2.2 billion</strong></td>
</tr>
</tbody>
</table>

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.*
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.
## HSI Values for US landfalling 2008 Storms

<table>
<thead>
<tr>
<th>Name</th>
<th>Wind (mph) Saffir-Simpson</th>
<th>HSI</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ike</td>
<td>110 – Cat 2</td>
<td>20</td>
<td>10</td>
<td>30</td>
<td></td>
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<tr>
<td>Gustav</td>
<td>105 – Cat 2</td>
<td>11</td>
<td>9</td>
<td>20</td>
<td></td>
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<tr>
<td>Dolly</td>
<td>100 – Cat 2</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Hanna</td>
<td>70 – TS</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Edouard</td>
<td>60 – TS</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td></td>
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<tr>
<td>Fay</td>
<td>50 – TS</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Hurricane</td>
<td>Size</td>
<td>Intensity</td>
<td>Total</td>
<td></td>
<td></td>
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<tr>
<td>------------</td>
<td>------</td>
<td>-----------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Carla ‘61</td>
<td>25</td>
<td>17</td>
<td>42</td>
<td></td>
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<tr>
<td>Betsy ‘65</td>
<td>25</td>
<td>15</td>
<td>40</td>
<td></td>
<td></td>
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<tr>
<td>Wilma ‘05</td>
<td>21</td>
<td>12</td>
<td>33</td>
<td></td>
<td></td>
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<tr>
<td>Camille ‘69</td>
<td>14</td>
<td>22</td>
<td>36</td>
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<tr>
<td>Katrina ‘05</td>
<td>23</td>
<td>13</td>
<td>36</td>
<td></td>
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<tr>
<td>Opal ‘95</td>
<td>25</td>
<td>11</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audrey ‘57</td>
<td>16</td>
<td>17</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ivan ‘04</td>
<td>20</td>
<td>12</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ike ‘08</td>
<td>20</td>
<td>10</td>
<td>30</td>
<td></td>
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<tr>
<td>Andrew ‘92</td>
<td>11</td>
<td>16</td>
<td>27</td>
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</tr>
<tr>
<td>Rita ‘05</td>
<td>16</td>
<td>10</td>
<td>26</td>
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<td>Alicia ‘83</td>
<td>11</td>
<td>11</td>
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<td></td>
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<tr>
<td>Gustav ‘08</td>
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<td>9</td>
<td>20</td>
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<tr>
<td>Bret ‘99</td>
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<td>11</td>
<td>16</td>
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<tr>
<td>Lili ‘02</td>
<td>8</td>
<td>6</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dolly ‘08</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Claudette ‘03</td>
<td>4</td>
<td>7</td>
<td>11</td>
<td></td>
<td></td>
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<tr>
<td>Humberto ‘07</td>
<td>3</td>
<td>5</td>
<td>8</td>
<td></td>
<td></td>
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<tr>
<td>Edouard ‘08</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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
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

- Galveston - 1.0
- Katrina - 1.75
  25-28 ft
  (Gulfport)
- Ivan - 0.6
  10-15 ft
  (Pensacola)
- NW Galveston Bay – about 1.8

Coastal Shoaling Factor Breakdown:
- Brownsville, TX
- Port Aransas, TX
- Matagorda, TX
- Freeport, TX
- Galveston, TX
- High Island, TX
- Sabine Pass, TX
- Cameron, LA
- Vermilion Bay, LA
- Atchafalaya Bay, LA
- Timbalier Bay, LA
- Grand Isle, LA
- Lake Borgne, LA
- Bay St. Louis, MS
- Gulfport, MS
- Biloxi, MS
- Pascagoula, MS
- Mobile, AL
- Pensacola, FL
- Ft. Walton Beach, FL
- Panama City, FL
For Guidance Purposes Only. Please refer to NWS forecasts for official storm surge information.

Sml Tide ft NAVD 1988

Hardin

Orange

Calcasieu

Jefferson

Cameron

Lake

Chambers

Vermilion

Envelope of High Water

NOAA National Oceanic and Atmospheric Administration

Storm: c:slosh.pkg/data/rexfiles/146_bp3.rex
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