Wind Speed and Intensity Probabilities

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National Hurricane Center
L311 Course for Coastal Communities
25 March 2013
Atlantic 5-Year Mean NHC Forecast Errors

NHC Official Forecasts - 2007-11 Atlantic Basin

- Track errors increase 40-50 n mi per day, 5-day errors approaching 200 n mi
- Intensity errors increase quickly to 15 kt by 48 and then level off

Track Error (n mi)
Intensity Error (kt)

Forecast period (h)

(Number of Cases)
How Can You, as Decision Makers, Deal with Forecast Uncertainty?

Tropical Storm Irene Advisory Number 12
Issued 5:00 AM EDT 23 August 2011

Verifying 5-day Position of Irene

5-day position error about 270 miles

NHC probability products can help
Overview of Wind Speed Probability Products
How the Wind Speed/Intensity Probabilities are Created

- 1,000 realistic alternative scenarios created using
  - Official NHC track, intensity and wind radii forecasts
  - Historical NHC track and intensity forecast errors
  - Climatology and persistence wind radii model
- Probability of exceeding 34, 50, and 64 kt wind thresholds computed
- Accounts for inland wind decay
Influence of Track Forecast Uncertainty on Probability Products

- Different historical NHC track forecast errors are sampled depending on how much spread (disagreement) there is in the track model guidance

- If track model spread is small (good model agreement)
  - Probability swath will be narrower with higher probabilities along the official NHC forecast track and lower values along the edges

- If track model spread is large (poor model agreement)
  - Probability swath will be wider, with lower values along the NHC official forecast track and a wider area of low probabilities along the edges

Gustav (2009)

Fay (2009)
Impacts Can be Felt Well Outside the Cone

- The cone only displays information about track uncertainty
- It contains no information about impacts!
- Impacts can occur well outside the area enclosed by the cone
  - Storm center is expected to move outside the cone about 1/3 of the time
  - Cone narrows near the time of greatest impact due to decreasing official track forecast errors
Available Probability Products

1. Wind Speed Probability Product
   - Depicts location-specific probabilities for 34-kt (TS-force), 50-kt (58-mph), and 64-kt (hurricane-force) winds
   - Text product contains cumulative and individual time period onset probabilities for a fixed set of locations
   - Graphic depicts cumulative probabilities for points over a large domain
Available Probability Products

2. Intensity Probability Table

- Shows probability of tropical cyclone intensity (maximum wind) falling in various categories
- Tropical depression, tropical storm, hurricane, and Saffir-Simpson Hurricane Wind Scale categories 1-5
- Available at the top of the wind speed probability text product and as a stand-alone graphic

<table>
<thead>
<tr>
<th>Wind Range (mph)</th>
<th>Forecast Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12 hour&lt;br&gt;8 PM&lt;br&gt;Tue</td>
</tr>
<tr>
<td>Dissipated</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Tropical Depression (&lt;39)</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Tropical Storm (39-74)</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Hurricane (all categories)</td>
<td>99%</td>
</tr>
<tr>
<td>- Category 1 (74-95)</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>- Category 2 (96-110)</td>
<td>3%</td>
</tr>
<tr>
<td>- Category 3 (111-130)</td>
<td>60%</td>
</tr>
<tr>
<td>- Category 4 (130-155)</td>
<td>35%</td>
</tr>
<tr>
<td>- Category 5 (&gt;155)</td>
<td>2%</td>
</tr>
</tbody>
</table>

| Forecast Maximum Wind | 135 mph | 140 mph | 135 mph | 135 mph | 115 mph | 90 mph | 65 mph |

I. MAXIMUM WIND SPEED (INTENSITY) PROBABILITY TABLE

CHANCES THAT THE MAXIMUM SUSTAINED (1-MINUTE AVERAGE) WIND SPEED OF THE TROPICAL CYCLONE WILL BE WITHIN ANY OF THE FOLLOWING CATEGORIES AT EACH OFFICIAL FORECAST TIME DURING THE NEXT 5 DAYS. PROBABILITIES ARE GIVEN IN PERCENT. X INDICATES PROBABILITIES LESS THAN 1 PERCENT.

<table>
<thead>
<tr>
<th>VALID TIME</th>
<th>MAXIMUM WIND SPEED (INTENSITY) PROBABILITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>06Z Thu 18Z Thu 06Z Fri 18Z Fri 18Z Sat 18Z Sun 18Z Mon</td>
<td>Dissipated</td>
</tr>
<tr>
<td>Forecast Hour 12</td>
<td>24</td>
</tr>
<tr>
<td>Dissipated</td>
<td>X</td>
</tr>
<tr>
<td>Trop Depression</td>
<td>X</td>
</tr>
<tr>
<td>Trop Storm</td>
<td>X</td>
</tr>
<tr>
<td>Hurricane</td>
<td>99</td>
</tr>
<tr>
<td>HUR Cat 1</td>
<td>X</td>
</tr>
<tr>
<td>HUR Cat 2</td>
<td>2</td>
</tr>
<tr>
<td>HUR Cat 3</td>
<td>63</td>
</tr>
<tr>
<td>HUR Cat 4</td>
<td>34</td>
</tr>
<tr>
<td>HUR Cat 5</td>
<td>1</td>
</tr>
<tr>
<td>FCST MAX WIND</td>
<td>115KT</td>
</tr>
</tbody>
</table>
Why do Small Probabilities of Extreme Events Matter?
U.S. Hurricane **Watch** and **Warning** Statistics (2000-2008)

- Average storm-total watch length: 477 miles
- Average storm-total length w/ hurricane winds for cases when watch issued: 89 miles
- Probability of hurricane winds at point under watch: 19%

- Average storm-total warning length: 403 miles
- Average storm-total length w/ hurricane winds for cases when warning issued: 99 miles
- Probability of hurricane winds at warned point: 25%
ZCZC MIAPWSAT4 ALL
TTAA00 ENHC DDHHMM
HURRICANE IKE WIND SPEED PROBABILITIES NUMBER 36
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL092008
0300 UTC WED SEP 10 2008

AT 0300Z THE CENTER OF HURRICANE IKE WAS LOCATED NEAR LATITUDE 23.2
NORTH...LONGITUDE 84.3 WEST WITH MAXIMUM SUSTAINED WINDS NEAR 70 KTS
...80 MPH...130 KM/HR.

PORT ARTHUR TX 34 X X( X) X( X) 6( 6) 32(38) 8(46) 1(47)
PORT ARTHUR TX 50 X X( X) X( X) 1( 1) 12(13) 5(18) 1(19)
PORT ARTHUR TX 64 X X( X) X( X) X( X) 5( 5) 3( 8) X( 8)

GALVESTON TX 34 X X( X) X( X) 6( 7) 38(45) 11(56) 2(58)
GALVESTON TX 50 X X( X) X( X) X( X) 1( 1) 20(21) 7(28) 2(30)
GALVESTON TX 64 X X( X) X( X) X( X) X( X) 9( 9) 5(14) X(14)

HOUSTON TX 34 X X( X) X( X) 4( 4) 33(37) 13(50) 2(52)
HOUSTON TX 50 X X( X) X( X) X( X) X( X) 14(14) 8(22) 1(23)
HOUSTON TX 64 X X( X) X( X) X( X) X( X) 5( 5) 4( 9) X( 9)

AUSTIN TX 34 X X( X) X( X) X( X) 17(17) 17(34) 2(36)
AUSTIN TX 50 X X( X) X( X) X( X) 21(22) 6( 8) 1( 9)
AUSTIN TX 64 X X( X) X( X) X( X) X( X) 1( 1) 1( 2) X( 2)

SAN ANTONIO TX 34 X X( X) X( X) X( X) 16(16) 18(34) 3(37)
SAN ANTONIO TX 50 X X( X) X( X) X( X) 1( 1) 4( 4) 7(11) X(11)
SAN ANTONIO TX 64 X X( X) X( X) X( X) X( X) 2( 2) 2( 2)

FREEPORT TX 34 X X( X) X( X) X( X) 7( 7) 40(47) 12(59) 2(61)
FREEPORT TX 50 X X( X) X( X) X( X) X( X) 11(23) 10(33) 2(35)
FREEPORT TX 64 X X( X) X( X) X( X) X( X) 10(10) 5(15) X(16)

GFTX 280N 95CW 34 X X( X) X( X) 1( 1) 31(14) 44(58) 10(68) 2(70)
GFTX 280N 95CW 50 X X( X) X( X) X( X) 3( 3) 29(32) 8(40) 3(43)
GFTX 280N 95CW 64 X X( X) X( X) X( X) 1( 1) 16(17) 6(23) 2(25)

PORT 0 CONNOR 34 X X( X) X( X) X( X) 5( 5) 38(43) 16(59) 4(63)
PORT 0 CONNOR 50 X X( X) X( X) X( X) X( X) 1( 1) 19(20) 10(30) 4(34)
PORT 0 CONNOR 64 X X( X) X( X) X( X) X( X) 3( 3) 9( 9) 8(17) 1(18)

CORPUS CHRISTI 34 X X( X) X( X) X( X) 3( 3) 29(32) 16(48) 3(51)
CORPUS CHRISTI 50 X X( X) X( X) X( X) X( X) 12(12) 10(22) 3(25)
CORPUS CHRISTI 64 X X( X) X( X) X( X) X( X) 5( 5) 5(10) 1(11)
100% chance someone is going to win
Most likely to win tournament:
1. Louisville 32.4%
2. Florida 21.3%
3. Indiana 10.9%
4. Ohio St. 6.8%
5. Duke 5.9%
Who is going to get hurricane force winds?

5 day forecast
Who is going to get hurricane force winds?

4 day forecast
Who is going to get hurricane force winds?

3 day forecast
Who is going to get hurricane force winds?

2 day forecast
Who is going to get hurricane force winds?

1 day forecast
Interpreting the Wind Speed Probability Text Product
# Wind Speed Probability Text Product

**ZCZC MIAPWSAT2 ALL**
**TTAA00 KHNC D05MM**
**HURRICANE EARL WIND SPEED PROBABILITIES NUMBER 24**
**NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL AL072010**
**0900 UTC TUE AUG 31 2010**

At 0900Z the center of Hurricane Earl was located near latitude 20.5 North...longitude 66.7 West with maximum sustained winds near 115 Kts...135 MPH...215 KT/HR.

Z Indicates Coordinated Universal Time (Greenwich)

Atlantic Standard Time (AST)...Subtract 4 hours from Z time
Eastern Daylight Time (EDT)...Subtract 4 hours from Z time
Central Daylight Time (CDT)...Subtract 5 hours from Z time

## I. Maximum Wind Speed (Intensity) Probability Table

Chances that the maximum sustained (1-minute average) wind speed of the tropical cyclone will be within any of the following categories at each official forecast time during the next 5 days. Probabilities are given in percent. X indicates probabilities less than 1 percent.

### - - - Maximum Wind Speed (Intensity) Probabilities - - -

<table>
<thead>
<tr>
<th>Valid Time</th>
<th>182 Tue 06Z Wed 182 Wed 06Z Thu 06Z Fri 06Z Sat 06Z Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecast Hour</td>
<td>12 24 36 48 72 96 120</td>
</tr>
<tr>
<td>Dissipated</td>
<td>X X X X X X 3 21</td>
</tr>
<tr>
<td>Trope Depression</td>
<td>X X X X X 1 8 29</td>
</tr>
<tr>
<td>Tropical Storm</td>
<td>X X X X X 12 39 40</td>
</tr>
<tr>
<td>Hurricane</td>
<td>X X X X X 98 5 10</td>
</tr>
<tr>
<td>Hur Cat 1</td>
<td>X 2 4 12 30 33 9</td>
</tr>
<tr>
<td>Hur Cat 2</td>
<td>2 7 12 25 25 11 1</td>
</tr>
<tr>
<td>Hur Cat 3</td>
<td>38 48 45 38 22 7 1</td>
</tr>
<tr>
<td>Hur Cat 4</td>
<td>57 38 33 19 8 1 X</td>
</tr>
<tr>
<td>Hur Cat 5</td>
<td>3 5 4 1 X X</td>
</tr>
<tr>
<td>FCST MAX WIND</td>
<td>120KT 120KT 120KT 115KT 105KT 85KT 60KT</td>
</tr>
</tbody>
</table>

## II. Wind Speed Probability Table for Specific Locations

Chances of sustained (1-minute average) wind speeds of at least

- 34 KT (39 MPH...63 KPH)...50 KT (58 MPH...93 KPH)
- 64 KT (74 MPH...119 KPH)

For locations and time periods during the next 5 days.

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**- - - WIND SPEED PROBABILITIES FOR SELECTED LOCATIONS - - -**

<table>
<thead>
<tr>
<th>Location</th>
<th>182 Tue 06Z Wed 182 Wed 06Z Thu 06Z Fri 06Z Sat 06Z Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastport ME</td>
<td>34 X X( X) X( X) X( X) X( X) X( X) 5( 5) 27(32)</td>
</tr>
<tr>
<td>Eastport ME</td>
<td>50 X X( X) X( X) X( X) X( X) X( X) X( X) 1( 1) 13(14)</td>
</tr>
<tr>
<td>Eastport ME</td>
<td>64 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) 5( 5)</td>
</tr>
<tr>
<td>Bar Harbor ME</td>
<td>34 X X( X) X( X) X( X) X( X) X( X) X( X) 7( 7) 22(29)</td>
</tr>
<tr>
<td>Bar Harbor ME</td>
<td>50 X X( X) X( X) X( X) X( X) X( X) X( X) 1( 1) 10(11)</td>
</tr>
<tr>
<td>Bar Harbor ME</td>
<td>64 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) 5( 5)</td>
</tr>
<tr>
<td>Augusta ME</td>
<td>34 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 7( 7) 15(22)</td>
</tr>
<tr>
<td>Augusta ME</td>
<td>50 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 8( 8)</td>
</tr>
<tr>
<td>Augusta ME</td>
<td>64 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 2( 2)</td>
</tr>
<tr>
<td>Portland ME</td>
<td>34 X X( X) X( X) X( X) X( X) X( X) X( X) 10(10) 11(21)</td>
</tr>
<tr>
<td>Portland ME</td>
<td>50 X X( X) X( X) X( X) X( X) X( X) X( X) 2( 2) 5( 7)</td>
</tr>
<tr>
<td>Portland ME</td>
<td>64 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) 3( 3)</td>
</tr>
<tr>
<td>Concord NH</td>
<td>34 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 1( 1) 11(18)</td>
</tr>
<tr>
<td>Concord NH</td>
<td>50 X X( X) X( X) X( X) X( X) X( X) X( X) 2( 2) 3( 5)</td>
</tr>
<tr>
<td>Concord NH</td>
<td>64 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 1( 1)</td>
</tr>
<tr>
<td>Boston MA</td>
<td>34 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 18(18) 9(27)</td>
</tr>
<tr>
<td>Boston MA</td>
<td>50 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 5( 5) 6(11)</td>
</tr>
<tr>
<td>Boston MA</td>
<td>64 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 2( 2) 2( 4)</td>
</tr>
<tr>
<td>Hyannis MA</td>
<td>34 X X( X) X( X) X( X) X( X) X( X) X( X) 29(29) 9(38)</td>
</tr>
<tr>
<td>Hyannis MA</td>
<td>50 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) 10(10) 7(17)</td>
</tr>
<tr>
<td>Hyannis MA</td>
<td>64 X X( X) X( X) X( X) X( X) X( X) X( X) 4( 4) 4( 8)</td>
</tr>
<tr>
<td>Nantucket MA</td>
<td>34 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 33(33) 10(43)</td>
</tr>
<tr>
<td>Nantucket MA</td>
<td>50 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 13(13) 8(21)</td>
</tr>
<tr>
<td>Nantucket MA</td>
<td>64 X X( X) X( X) X( X) X( X) X( X) X( X) X( X) X( X) 5( 5) 5(10)</td>
</tr>
</tbody>
</table>
What is the chance that winds of tropical storm force (34 kt or greater) will occur at Charlotte NC during the next five days?
What is the chance that winds of tropical storm force (34 kt or greater) will occur at Charlotte NC during the next five days?

42%
What is the chance that winds of tropical storm force (34 kt or greater) will occur at Charlotte NC during the next five days?

42%

When are these winds most likely to start?
What is the chance that winds of tropical storm force (34 kt or greater) will occur at Charlotte NC during the next five days?

**42%**

When are these winds most likely to start?

**From 18Z Sun to 18Z Mon (18% chance)**
Case Example
Hurricane Katrina (2005)
Hurricane Katrina (2005)

• Two examples of how probabilities evolve

1. Landfall of a marginal hurricane in South Florida
   – Small probabilities of hurricane force winds over much of south FL due to uncertainty in track and intensity

2. Landfall of a major hurricane along the Gulf Coast
   – Initially small probabilities at locations along the Gulf Coast increase markedly along the track of Katrina as landfall approaches
   – Hurricane conditions are almost a certainty somewhere
Magnitudes of Cumulative Probabilities Vary Greatly But Realistically

Katrina Advisory #5

10% chance of hurricane-force winds at any individual point along SE Florida coast

Low probability of hurricane-force winds due to small size of hurricane force wind field and uncertainty as to whether Katrina will even be a hurricane at landfall.
Magnitudes of Cumulative Probabilities Vary Greatly But Realistically

Katrina Advisory #9

Low probability of hurricane-force winds due to uncertainty in track and whether Katrina will be a hurricane at landfall
Magnitudes of Cumulative Probabilities Vary Greatly But Realistically

Katrina Advisory #11

72 hour forecast intensity = 100 mph category 2 hurricane

Point locations from the mouth of the Mississippi River to the Big Bend have roughly the same chance (5-15%) of hurricane-force winds

Probabilities begin to increase due to increase in intensity forecast even though track uncertainty remains similar – becoming more likely that hurricane-force winds will occur somewhere
Magnitudes of Cumulative Probabilities Vary Greatly But Realistically

Katrina Advisory #14

72 hour forecast intensity = 130 mph category 4 hurricane

Probabilities increase further due to continued increase in intensity forecast and slight decrease in track forecast uncertainty with landfall forecast in about 72 h
Magnitudes of Cumulative Probabilities Vary Greatly But Realistically

Katrina Advisory #18

48 hour forecast intensity = 145 mph category 4 hurricane

Probabilities along central Gulf coast increase dramatically due to increase in intensity forecast and decrease in track forecast uncertainty with landfall forecast in about 48 h
Katrina Advisory #24

12 hour forecast intensity = 165 mph category 5 hurricane

Landfall now within 12 to 24 h, hurricane force winds almost a certainty along forecast track given large size and strength of Katrina along with small short-range track uncertainty.
Timing Information About Wind Onset
Onset of 34-kt Winds
Katrina (2005)

- Onset of 34-kt winds based on deterministic forecast issued with Advisory 16
  - New Orleans, LA – 8/29 (Mon.) 08Z
  - Gulfport, MS – 8/29 (Mon.) 11Z

Deterministic wind field from Hurrevac valid 12Z 29 August
<table>
<thead>
<tr>
<th>Location</th>
<th>Wind Speed Probabilities for Selected Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FROM TIME 06Z SAT 18Z SAT 06Z SUN 18Z SUN 06Z MON 06Z TUE 06Z WED</td>
</tr>
<tr>
<td></td>
<td>FORECAST HOUR (12) (24) (36) (48) (72) (96) (120)</td>
</tr>
<tr>
<td>NEW ORLEANS LA</td>
<td>34 X 1 (1) 9 (10) 28 (38) 34 (72) 5 (77) X (77)</td>
</tr>
</tbody>
</table>
Most likely period of onset of 34-kt winds at New Orleans and Gulfport is between 06Z Monday 8/29 and 06Z Tuesday 8/30
## Wind Speed Probabilities
### Katrina (2005) Advisory 16

<table>
<thead>
<tr>
<th>TIME</th>
<th>FROM</th>
<th>FROM</th>
<th>FROM</th>
<th>FROM</th>
<th>FROM</th>
<th>FROM</th>
<th>FROM</th>
<th>FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>06Z SAT</td>
<td>18Z</td>
<td>SAT</td>
<td>06Z</td>
<td>SUN</td>
<td>18Z</td>
<td>SUN</td>
<td>06Z</td>
<td>MON</td>
</tr>
<tr>
<td>PERIODS</td>
<td>TO</td>
<td>TO</td>
<td>TO</td>
<td>TO</td>
<td>TO</td>
<td>TO</td>
<td>TO</td>
<td>TO</td>
</tr>
<tr>
<td>18Z SAT</td>
<td>06Z</td>
<td>SUN</td>
<td>18Z</td>
<td>SUN</td>
<td>06Z</td>
<td>MON</td>
<td>06Z</td>
<td>TUE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FORECAST HOUR</th>
<th>(12)</th>
<th>(24)</th>
<th>(36)</th>
<th>(48)</th>
<th>(72)</th>
<th>(96)</th>
<th>(120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW ORLEANS LA 34 X</td>
<td>1 (1)</td>
<td>9 (10)</td>
<td>28 (38)</td>
<td>34 (72)</td>
<td>5 (77)</td>
<td>X (77)</td>
<td></td>
</tr>
<tr>
<td>GULFPORT MS 34 X</td>
<td>1 (1)</td>
<td>8 (9)</td>
<td>23 (32)</td>
<td>35 (67)</td>
<td>5 (72)</td>
<td>1 (73)</td>
<td></td>
</tr>
</tbody>
</table>

However, the probability that 34-kt winds will start **prior to** 06Z Monday 8/29 at both New Orleans and Gulfport is nearly as large!
What Actually Happened?

• Onset of 34-kt winds occurred between 00Z and 06Z Monday 8/29 at New Orleans and Gulfport
  – At least 3 hours earlier than shown by the official forecast at New Orleans
  – At least 5 hours earlier than shown by the official forecast at Gulfport
Lesson

- Important information about the onset of wind conditions is contained in the probabilities
- Examine trends from advisory to advisory
  - How are probabilities of onset changing?
  - Are chances of onset nearly equal between two consecutive time periods?
Intensity Probability Table Examples
### Hurricane Danielle Intensity Probability Table

**Advisory 16 – 11 AM EDT 25 Aug. 2010**

Intensity (Maximum Wind Speed) Probability Table
Hurricane Danielle Advisory Number 16
11:00 AM AST Aug 25 2010

<table>
<thead>
<tr>
<th>Wind Range (mph)</th>
<th>12 hour for 8 PM Wed</th>
<th>24 hour for 8 AM Thu</th>
<th>36 hour for 8 PM Thu</th>
<th>48 hour for 8 AM Fri</th>
<th>72 hour for 8 AM Sat</th>
<th>96 hour for 8 AM Sun</th>
<th>120 hour for 8 AM Mon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissipated</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Tropical Depression (&lt;39)</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
<td>6%</td>
</tr>
<tr>
<td>Tropical Storm (39-73)</td>
<td>8%</td>
<td>12%</td>
<td>19%</td>
<td>17%</td>
<td>14%</td>
<td>17%</td>
<td>38%</td>
</tr>
<tr>
<td>Hurricane (all categories)</td>
<td>92%</td>
<td>88%</td>
<td>81%</td>
<td>82%</td>
<td>85%</td>
<td>81%</td>
<td>55%</td>
</tr>
<tr>
<td>-- Category 1 (74-95)</td>
<td>76%</td>
<td>57%</td>
<td>49%</td>
<td>41%</td>
<td>31%</td>
<td>32%</td>
<td>32%</td>
</tr>
<tr>
<td>-- Category 2 (96-110)</td>
<td>13%</td>
<td>22%</td>
<td>21%</td>
<td>23%</td>
<td>24%</td>
<td>24%</td>
<td>14%</td>
</tr>
<tr>
<td>-- Category 3 (111-130)</td>
<td>2%</td>
<td>7%</td>
<td>8%</td>
<td>14%</td>
<td>21%</td>
<td>19%</td>
<td>7%</td>
</tr>
<tr>
<td>-- Category 4 (131-155)</td>
<td>&lt;1%</td>
<td>1%</td>
<td>2%</td>
<td><strong>3%</strong></td>
<td>7%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>-- Category 5 (&gt;155)</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
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<td>&lt;1%</td>
</tr>
</tbody>
</table>

**Forecast Maximum Wind**
- 85 mph
- 90 mph
- 90 mph
- **100 mph**
- 110 mph
- 110 mph
- 100 mph

- Official NHC 48-h intensity forecast: 100 MPH (Category 2)
- Verifying intensity: 135 MPH (Category 4)

**3% chance of category 4 hurricane in 48 h verifies**
Impact of Land Interaction on Intensity Probabilities

• Even if the official track forecast does take the TC over land, many of the 1,000 track realizations can move over land to track uncertainty

• This often occurs in the western part of the Atlantic basin due to numerous islands and large landmasses

• When this occurs, the intensity probabilities will often spread out over a large range of possible intensities, particularly late in the forecast period
• Official forecast shows Ike avoiding significant land interaction and remaining a major hurricane through 5 days
• Probabilities show the potential for land interaction as intensity probabilities spread out across categories 1-4 by days 4 and 5
Impact of Land Interaction on Intensity Probabilities

• The intensity probability table CANNOT be used to estimate the intensity at landfall

• Probabilities are valid at a specific TIME – not location
  – Some realizations will move faster than the official forecast and already be inland at the time of landfall in the official forecast
  – These inland realizations will be weaker and contribute to lower intensity probabilities at the forecast time period closest to landfall

• We are working with a new tool that computes the probability of landfall occurring in specific categories
Hurricane Ike
Advisory 38 – 10 AM CDT 10 Sep 2008

- Official Forecast shows landfall around 72 h with forecast intensity of 120 mph (Category 3)
- Many realizations are already well inland by 72 h, and intensity probabilities shows nearly equal or higher probability of category 1 or 2 at 72 h
- Actual landfall intensity: 110 MPH (Category 2)
- Intensity at 72 h (12Z 13 September): 100 MPH (Category 2)
Summary

• Wind speed probability products help you deal with the uncertainty inherent in forecasting tropical cyclones
• Provide additional information beyond what is available in deterministic forecasts for:
  – Timing of event onset
  – Likelihood of various wind speeds occurring at your location
  – Likelihood of tropical cyclone intensity
• “Low” probabilities of extreme events often warrant action!
• https://cdp.dhs.gov/femasid