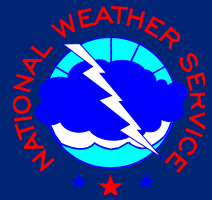
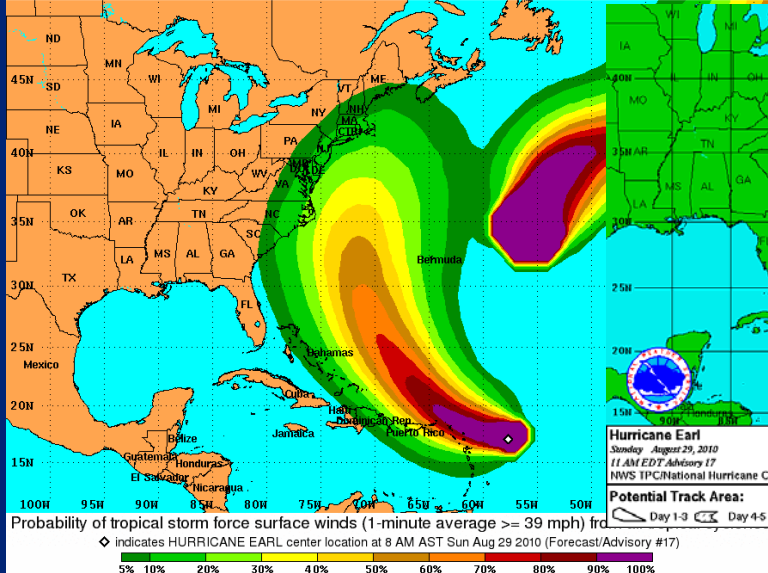




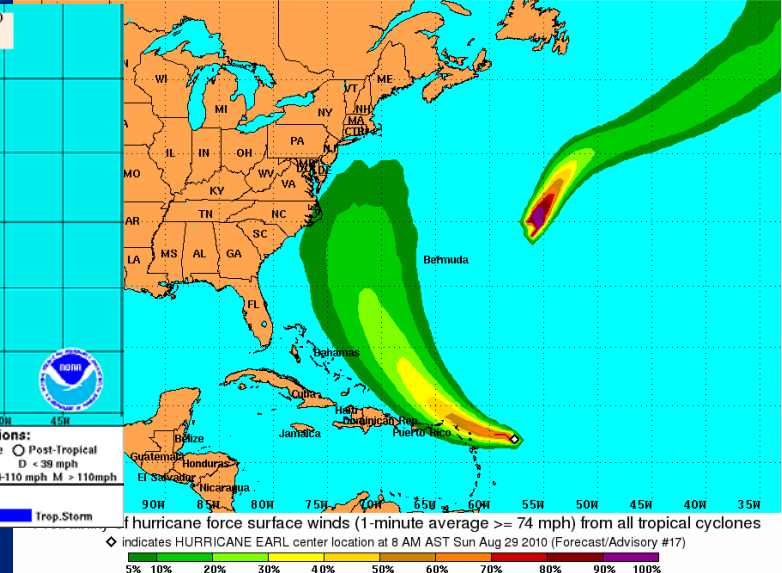
Wind Speed and Intensity Probabilities



Tropical Storm Force Wind Speed Probabilities
For the 120 hours (5 days) from 8 AM AST Sun Aug 29 to 8 AM AST Fri Sep 3



Hurricane Force Wind Speed Probabilities
For the 120 hours (5 days) from 8 AM AST Sun Aug 29 to 8 AM AST Fri Sep 3



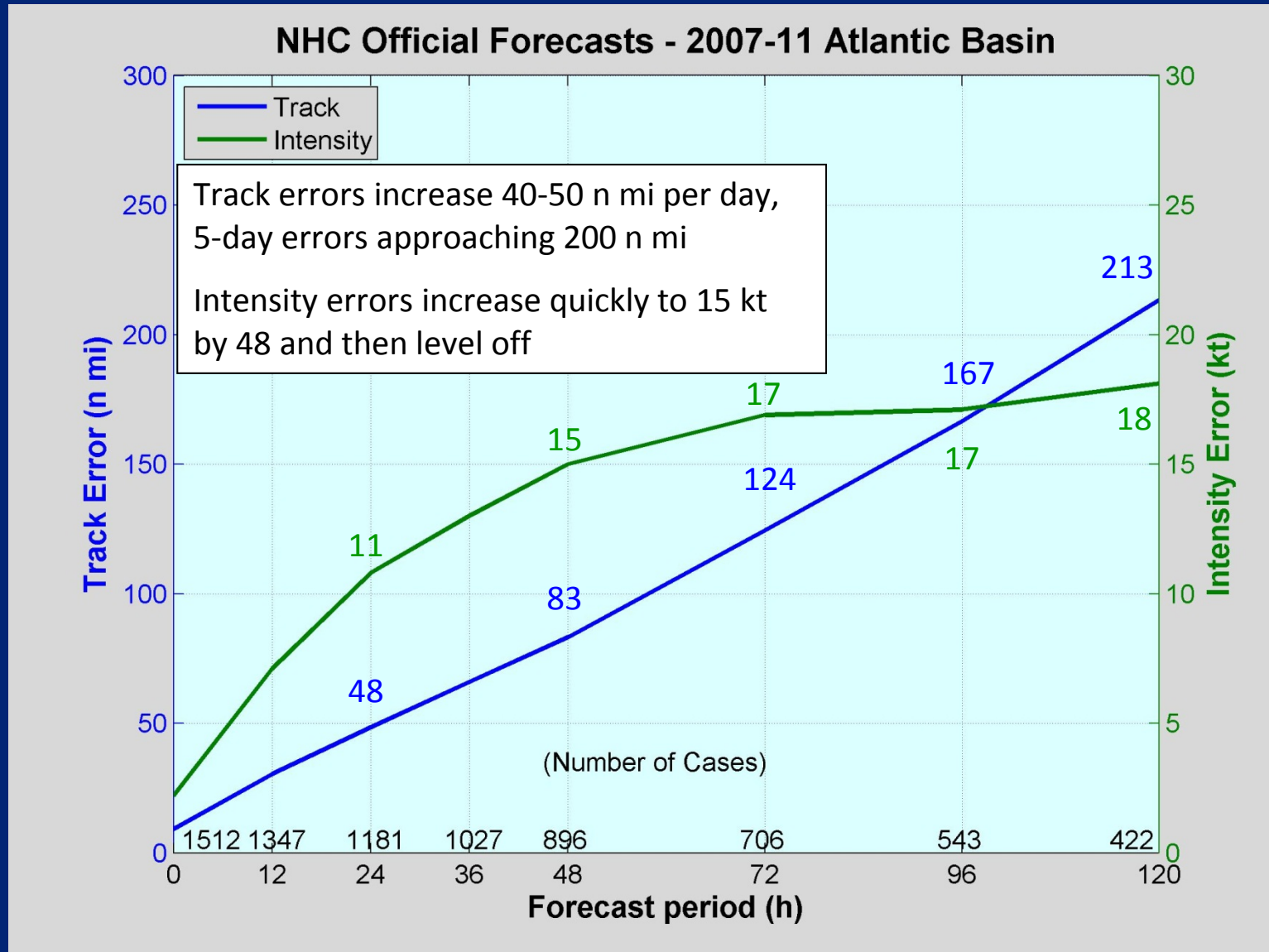
Michael J. Brennan
National Hurricane Center

L311 Course for Coastal Communities
26 March 2012

Outline

- The reality of forecast uncertainty
- Quick overview of probability products
- Why small probabilities for extreme events matter
- Reading and interpreting the probability products
- Examples

Atlantic 5-Year Mean NHC Forecast Errors



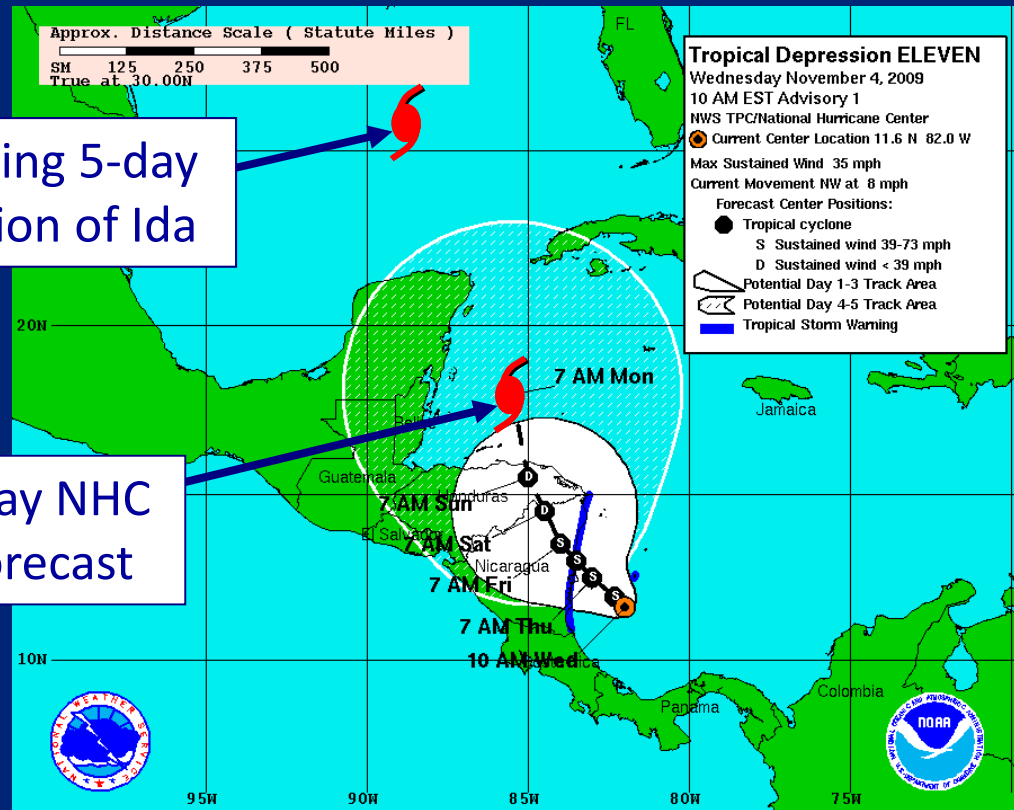
How Can You, as Decision Makers, Deal with Forecast Uncertainties?

TD 11 (later Hurricane Ida)
Advisory Number 1
Issued 10:00 AM EST
4 November 2009

5-day position error
about 600 miles

Verifying 5-day
Position of Ida

5-day NHC
Forecast



NHC probability products can help

Overview of Wind Speed Probability Products

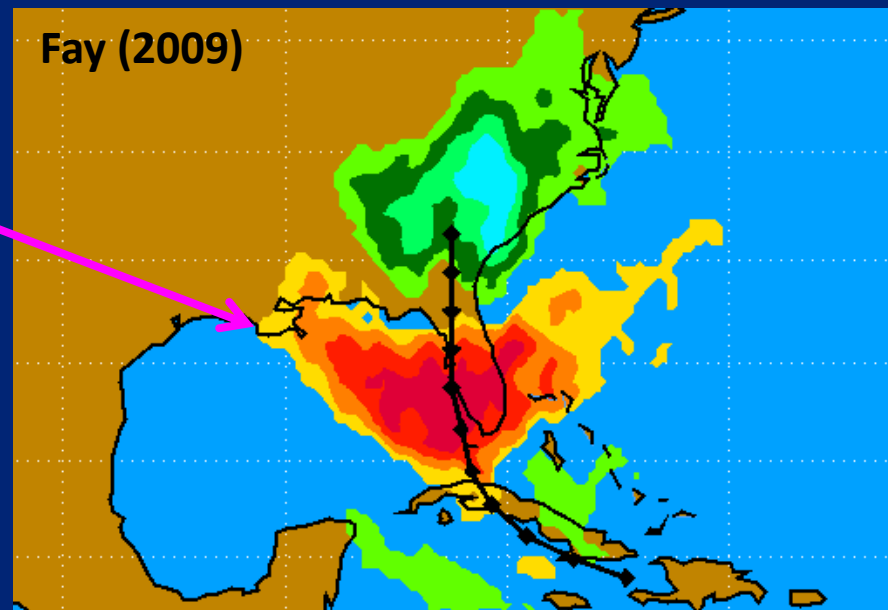
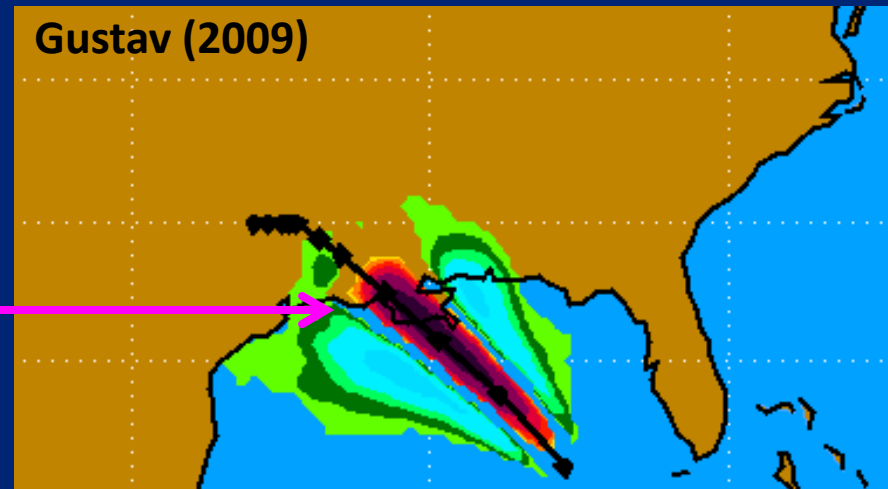
How the Wind Speed/Intensity Probabilities are Created

- 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

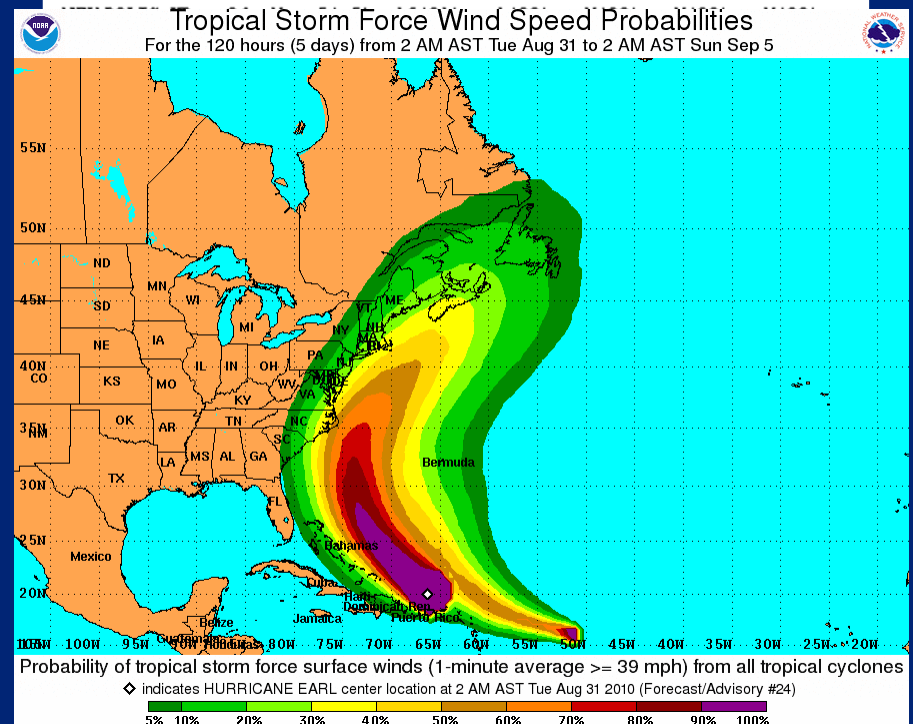


Available Probability Products

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

NEW YORK CITY	34	X	1 (1)	32(33)	11(44)	X(44)	X(44)	X(44)
NEW YORK CITY	50	X	X(X)	3(3)	6(9)	X(9)	X(9)	X(9)
NEW YORK CITY	64	X	X(X)	1(1)	1(2)	X(2)	X(2)	X(2)
NEWARK NJ	34	X	X(X)	26(26)	9(35)	X(35)	X(35)	X(35)
NEWARK NJ	50	X	X(X)	2(2)	3(5)	X(5)	X(5)	X(5)
TRENTON NJ	34	X	1(1)	25(26)	6(32)	X(32)	X(32)	X(32)
TRENTON NJ	50	X	X(X)	3(3)	1(4)	X(4)	X(4)	X(4)
ATLANTIC CITY	34	X	4(4)	44(48)	3(51)	X(51)	X(51)	X(51)
ATLANTIC CITY	50	X	X(X)	9(9)	2(11)	X(11)	X(11)	X(11)
ATLANTIC CITY	64	X	X(X)	3(3)	1(4)	X(4)	X(4)	X(4)
BALTIMORE MD	34	X	3(3)	14(17)	1(18)	X(18)	X(18)	X(18)
DOVER DE	34	X	7(7)	29(36)	2(38)	X(38)	X(38)	X(38)
DOVER DE	50	X	X(X)	6(6)	1(7)	X(7)	X(7)	X(7)
DOVER DE	64	X	X(X)	1(1)	X(1)	X(1)	X(1)	X(1)



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

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 ---

VALID TIME	06Z THU	18Z THU	06Z FRI	18Z FRI	18Z SAT	18Z SUN	18Z MON
FORECAST HOUR	12	24	36	48	72	96	120
DISSIPATED	X	X	X	X	9	26	NA
TROP DEPRESSION	X	X	X	1	17	33	NA
TROPICAL STORM	X	X	3	17	53	36	NA
HURRICANE	99	99	97	81	20	4	NA
HUR CAT 1	X	5	23	42	16	4	NA
HUR CAT 2	2	21	37	23	3	1	NA
HUR CAT 3	63	56	30	12	1	X	NA
HUR CAT 4	34	17	7	3	X	X	NA
HUR CAT 5	1	1	1	X	X	X	NA
FCST MAX WIND	115KT	110KT	100KT	90KT	60KT	40KT	NA



Intensity (Maximum Wind Speed) Probability Table
Hurricane Earl Advisory Number 25
11:00 AM AST Aug 31 2010



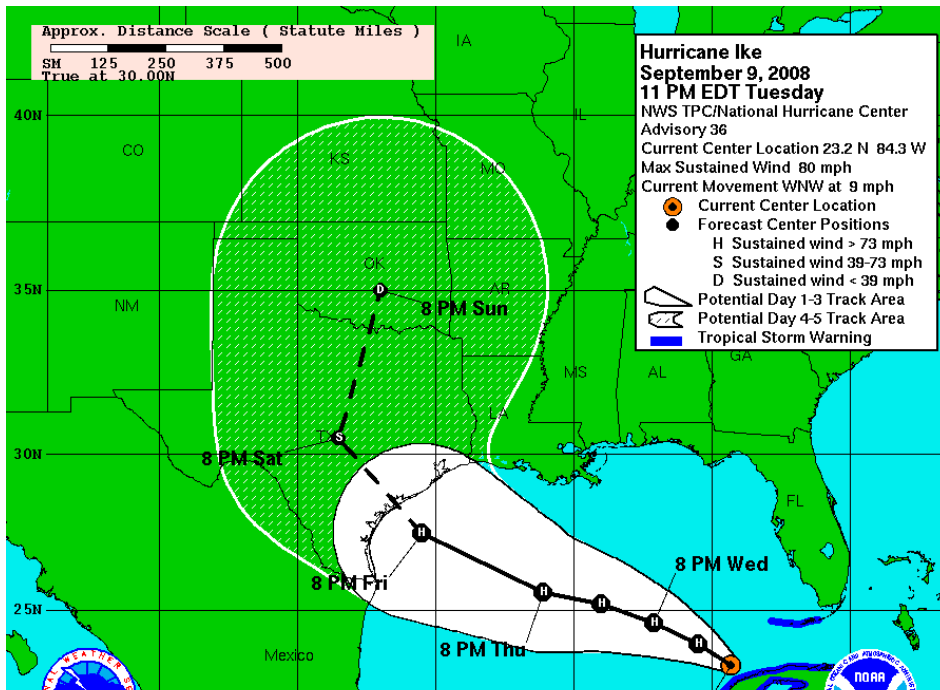
Wind Range (mph)	Forecast Time						
	12 hour for 8 PM Tue	24 hour for 8 AM Wed	36 hour for 8 PM Wed	48 hour for 8 AM Thu	72 hour for 8 AM Fri	96 hour for 8 AM Sat	120 hour for 8 AM Sun
Dissipated	<1%	<1%	<1%	<1%	1%	6%	15%
Tropical Depression (<39)	<1%	<1%	<1%	<1%	2%	11%	13%
Tropical Storm (39-73)	<1%	<1%	1%	2%	19%	44%	43%
Hurricane (all categories)	99%	99%	99%	98%	78%	39%	30%
-- Category 1 (74-95)	<1%	2%	6%	12%	33%	27%	20%
-- Category 2 (96-110)	3%	7%	17%	24%	24%	8%	7%
-- Category 3 (111-130)	60%	47%	48%	39%	16%	3%	2%
-- Category 4 (131-155)	35%	40%	24%	20%	5%	1%	1%
-- Category 5 (>155)	2%	5%	4%	4%	1%	<1%	<1%
Forecast Maximum Wind	135 mph	140 mph	135 mph	135 mph	115 mph	90 mph	65 mph

Why do Small Probabilities of Extreme Events Matter?

U.S. Hurricane **Watch** and **Warning** Statistics (2000-2008)

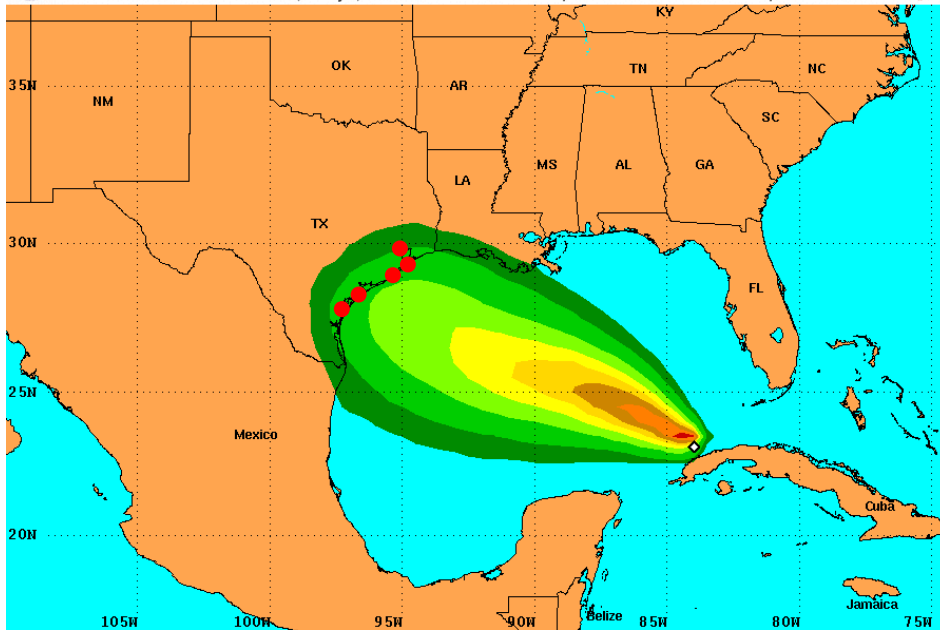
- Average storm-total watch length 477 miles
- Average storm-total length w/ hurricane winds for cases when watch issued 89 miles
- Probability of hurricane winds at point under watch **19%**

- 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%**



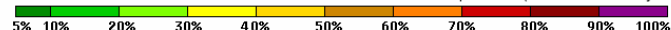
Hurricane Force Wind Speed Probabilities

For the 120 hours (5 days) from 8 PM EDT Tue Sep 9 to 8 PM EDT Sun Sep 14



Probability of hurricane force surface winds (1-minute average ≥ 74 mph) from all tropical cyclones

◊ indicates HURRICANE IKE center location at 8 PM EDT Tue Sep 9 2008 (Forecast/Advisory #36)



ZCZC MIAPWSAT4 ALL
 TTAA00 KNHC DDHMM
 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)	1(1)	6(7)	38(45)	11(56)	2(58)
GALVESTON TX 50	X	X(X)	X(X)	1(1)	20(21)	7(28)	2(30)
GALVESTON TX 64	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)	14(14)	8(22)	1(23)
HOUSTON TX 64	X	X(X)	X(X)	X(X)	5(5)	4(9)	1(10)
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)	2(2)	6(8)	1(9)
AUSTIN TX 64	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)	4(4)	7(11)	X(11)
SAN ANTONIO TX 64	X	X(X)	X(X)	X(X)	X(X)	2(2)	X(2)
FREEPORT TX 34	X	X(X)	X(X)	7(7)	40(47)	12(59)	2(61)
FREEPORT TX 50	X	X(X)	X(X)	1(1)	22(23)	10(33)	2(35)
FREEPORT TX 64	X	X(X)	X(X)	X(X)	10(10)	5(15)	1(16)
GFMX 280N 950W 34	X	X(X)	1(1)	13(14)	44(58)	10(68)	2(70)
GFMX 280N 950W 50	X	X(X)	X(X)	3(3)	29(32)	8(40)	3(43)
GFMX 280N 950W 64	X	X(X)	X(X)	1(1)	16(17)	6(23)	2(25)
PORT O CONNOR 34	X	X(X)	X(X)	5(5)	38(43)	16(59)	4(63)
PORT O CONNOR 50	X	X(X)	X(X)	1(1)	19(20)	10(30)	4(34)
PORT O CONNOR 64	X	X(X)	X(X)	X(X)	9(9)	8(17)	1(18)
CORPUS CHRISTI 34	X	X(X)	X(X)	3(3)	29(32)	16(48)	3(51)
CORPUS CHRISTI 50	X	X(X)	X(X)	X(X)	12(12)	10(22)	3(25)
CORPUS CHRISTI 64	X	X(X)	X(X)	X(X)	5(5)	5(10)	1(11)

2011 NCAA Division I Men's Basketball Championship

Second Round
MARCH 17-18

Third Round
MARCH 19-20

Regional Semifinals
MARCH 24-25

Regional Finals
MARCH 26-27

National Semifinals
APRIL 2

National Semifinals
APRIL 2

Regional Finals
MARCH 26-27

Regional Semifinals
MARCH 24-25

Third Round
MARCH 19-20

Second Round
MARCH 17-18

First Four

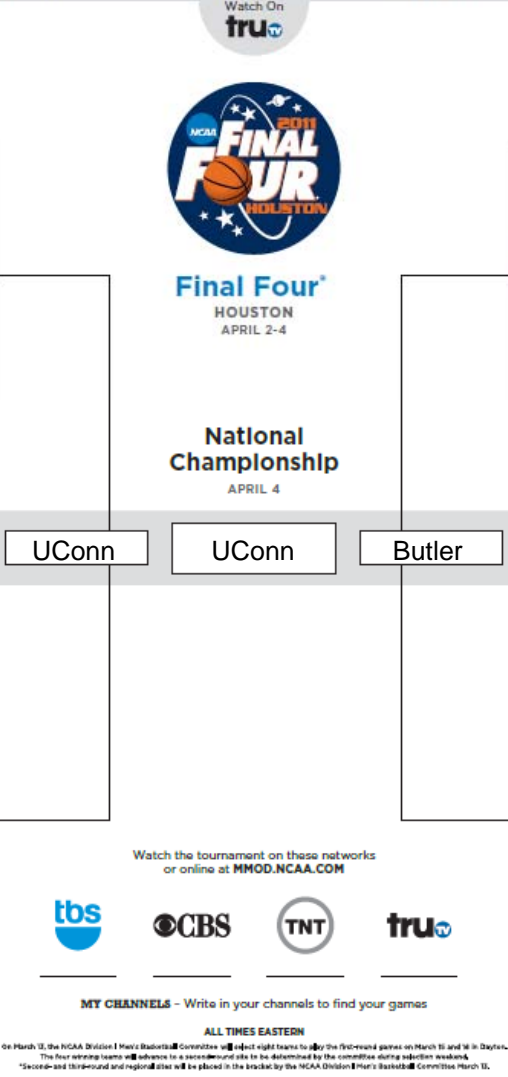
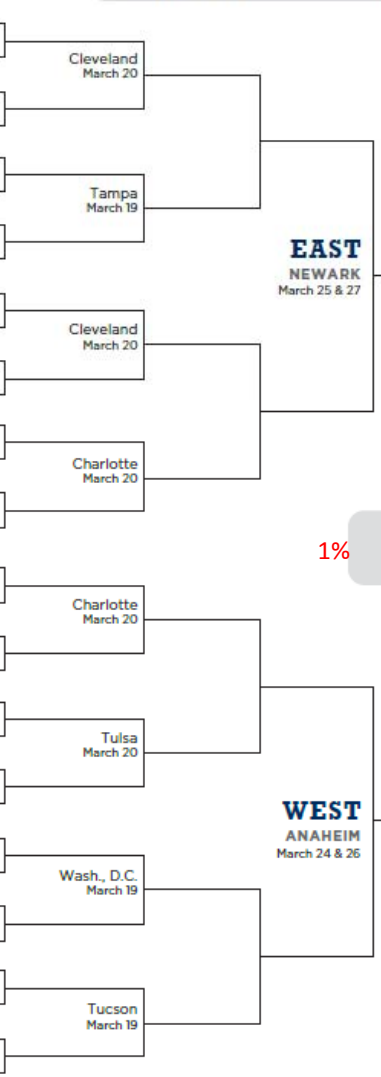
E 16 UTSA (19-13) Mar 16, 6:40PM - TRU	E 12 UAB (22-8) 52	First Round DAYTON March 15-16	SW 11 USC (19-14) Mar 16, 30 min following - TRU	SE 16 UNC Ash. (19-13) 81
16 Ala. St. (17-17)	12 Clemson (21-11) 70	Watch On tru	11 VCU (23-11)	16 UALR (19-16) 77



Final Four
HOUSTON
APRIL 2-4

National Championship
APRIL 4

- 33% 1 **Ohio St.** (32-2)
Mar 18, 30 min following - TNT
- <1% 16 **UTSA/Alabama St.**
- <1% 8 **George Mason** (26-6)
Mar 18, 2:30PM - TNT
- <1% 9 **Villanova** (21-11)
- <1% 5 **West Virginia** (20-11)
Mar 17, 12:15PM - CBS
- <1% 12 **Clemson**
- 3% 4 **Kentucky** (25-8)
Mar 17, 30 min following - CBS
- <1% 13 **Princeton** (25-6)
- 1% 6 **Xavier** (24-7)
Mar 18, 7:27PM - TRU
- <1% 11 **Marquette** (20-14)
- 3% 3 **Syracuse** (26-7)
Mar 18, 30 min following - TRU
- <1% 14 **Indiana St.** (20-13)
- 2% 7 **Washington** (23-10)
Mar 18, 30 min following - CBS
- <1% 10 **Georgia** (21-11)
- 7% 2 **North Carolina** (26-7)
Mar 18, 7:15PM - CBS
- <1% 15 **Long Island** (27-5)
- 20% 1 **Duke** (30-4)
Mar 18, 30 min following - TRU
- <1% 16 **Hampton** (24-8)
- <1% 8 **Michigan** (20-13)
Mar 18, 12:40PM - TRU
- 1% 9 **Tennessee** (19-14)
- 2% 5 **Arizona** (27-7)
Mar 18, 30 min following - CBS
- <1% 12 **Memphis** (25-9)
- 5% 4 **Texas** (27-7)
Mar 18, 12:15PM - CBS
- <1% 13 **Oakland** (25-9)
- 1% 6 **Cincinnati** (25-8)
Mar 17, 30 min following - TNT
- 1% 11 **Missouri** (23-10)
- 1% 3 **Connecticut** (26-9)
Mar 17, 7:20PM - TNT
- <1% 14 **Bucknell** (25-8)
- <1% 7 **Temple** (25-7)
Mar 17, 2:30PM - TNT
- <1% 10 **Penn St.** (19-14)
- 8% 2 **San Diego St.** (32-2)
Mar 17, 30 min following - TNT
- <1% 15 **Northern Colo.** (21-10)



- 1 **Kansas** (32-2) 22%
- 16 **Boston U.** (21-13) <1%
- 8 **UNLV** (24-8) <1%
- 9 **Illinois** (19-13) 1%
- 5 **Vanderbilt** (23-10) 1%
- 12 **Richmond** (27-7) <1%
- 4 **Louisville** (25-9) 3%
- 13 **Morehead St.** (24-9) <1%
- 6 **Georgetown** (21-10) 2%
- 11 **USC/VCU** <1%
- 3 **Purdue** (25-7) 5%
- 14 **St. Peter's** (20-13) <1%
- 7 **Texas A&M** (24-8) 1%
- 10 **Florida St.** (21-10) <1%
- 2 **Notre Dame** (26-6) 3%
- 15 **Akron** (23-12) <1%
- 1 **Pittsburgh** (27-5) 14%
- 16 **UNC Asheville** <1%
- 8 **Butler** (23-9) <1%
- 9 **Old Dominion** (27-6) <1%
- 5 **Kansas St.** (22-10) 3%
- 12 **Utah St.** (30-3) <1%
- 4 **Wisconsin** (23-8) 3%
- 13 **Belmont** (30-4) <1%
- 6 **St. John's** (21-11) 1%
- 11 **Gonzaga** (24-9) 1%
- 3 **BYU** (30-4) 3%
- 14 **Wofford** (21-12) <1%
- 7 **UCLA** (22-10) 2%
- 10 **Michigan St.** (19-14) 1%
- 2 **Florida** (26-7) 6%
- 15 **UC Santa Bar.** (18-13) <1%

Watch the tournament on these networks or online at MMOD.NCAA.COM

tbs CBS TNT tru

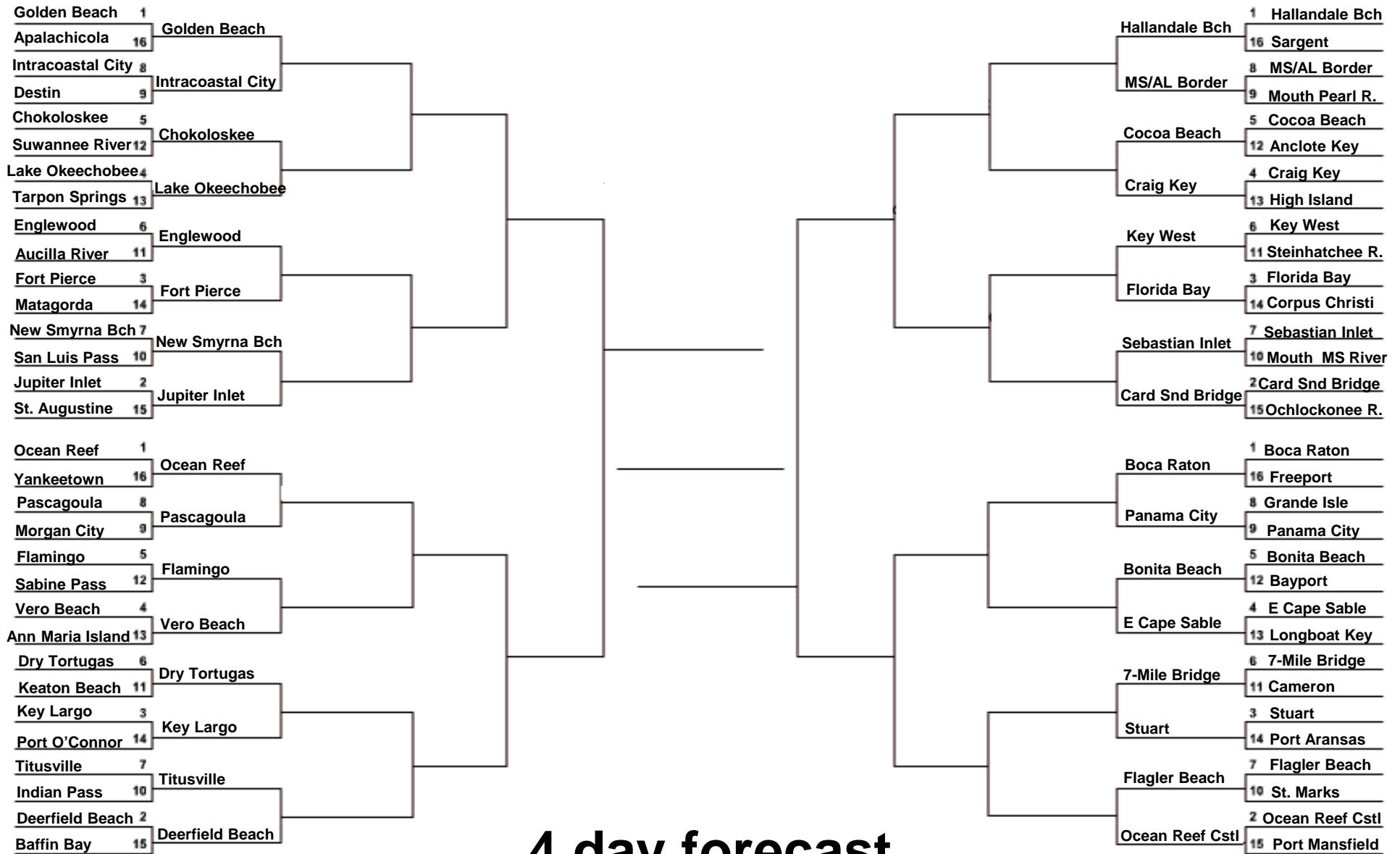
MY CHANNELS - Write in your channels to find your games

ALL TIMES EASTERN
On March 13, the NCAA Division I Men's Basketball Committee will select eight teams to play the first-round games on March 15 and 16 in Dayton. The four winning teams will advance to a second-round site to be determined by the committee during selection week. Second- and third-round and regional sites will be placed in the bracket by the NCAA Division I Men's Basketball Committee March 14.

Who is going to get hurricane force winds?



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?



Interpreting the Wind Speed Probability Text Product

Wind Speed Probability Text Product

ZCZC MIAPWSAT2 ALL
 TTA00 KNHC DDHMM
 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 KM/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 - - -

VALID TIME	18Z TUE	06Z WED	18Z WED	06Z THU	06Z FRI	06Z SAT	06Z SUN
FORECAST HOUR	12	24	36	48	72	96	120
DISSIPATED	X	X	X	X	X	3	21
TROP DEPRESSION	X	X	X	X	1	8	29
TROPICAL STORM	X	X	1	2	13	39	40
HURRICANE	99	99	99	98	86	50	10
HUR CAT 1	X	2	4	12	30	33	9
HUR CAT 2	2	7	12	25	25	11	1
HUR CAT 3	38	48	45	38	22	5	1
HUR CAT 4	57	38	33	19	8	1	X
HUR CAT 5	3	5	5	4	1	X	X
FCST MAX WIND	120KT	120KT	120KT	115KT	105KT	85KT	60KT

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

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

TIME PERIODS	FROM 06Z TUE TO 18Z TUE	FROM 18Z TUE TO 06Z WED	FROM 06Z WED TO 18Z WED	FROM 18Z WED TO 06Z THU	FROM 06Z THU TO 06Z FRI	FROM 06Z FRI TO 06Z SAT	FROM 06Z SAT TO 06Z SUN
FORECAST HOUR	(12)	(24)	(36)	(48)	(72)	(96)	(120)
LOCATION	KT						
EASTPORT ME	34 X	X(X)	X(X)	X(X)	X(X)	5(5)	27(32)
EASTPORT ME	50 X	X(X)	X(X)	X(X)	X(X)	1(1)	13(14)
EASTPORT ME	64 X	X(X)	X(X)	X(X)	X(X)	X(X)	5(5)
BAR HARBOR ME	34 X	X(X)	X(X)	X(X)	X(X)	7(7)	22(29)
BAR HARBOR ME	50 X	X(X)	X(X)	X(X)	X(X)	1(1)	10(11)
BAR HARBOR ME	64 X	X(X)	X(X)	X(X)	X(X)	X(X)	5(5)
AUGUSTA ME	34 X	X(X)	X(X)	X(X)	X(X)	7(7)	15(22)
AUGUSTA ME	50 X	X(X)	X(X)	X(X)	X(X)	X(X)	8(8)
AUGUSTA ME	64 X	X(X)	X(X)	X(X)	X(X)	X(X)	2(2)
PORTLAND ME	34 X	X(X)	X(X)	X(X)	X(X)	10(10)	11(21)
PORTLAND ME	50 X	X(X)	X(X)	X(X)	X(X)	2(2)	5(7)
PORTLAND ME	64 X	X(X)	X(X)	X(X)	X(X)	X(X)	3(3)
CONCORD NH	34 X	X(X)	X(X)	X(X)	X(X)	11(11)	7(18)
CONCORD NH	50 X	X(X)	X(X)	X(X)	X(X)	2(2)	3(5)
CONCORD NH	64 X	X(X)	X(X)	X(X)	X(X)	X(X)	1(1)
BOSTON MA	34 X	X(X)	X(X)	X(X)	X(X)	18(18)	9(27)
BOSTON MA	50 X	X(X)	X(X)	X(X)	X(X)	5(5)	6(11)
BOSTON MA	64 X	X(X)	X(X)	X(X)	X(X)	2(2)	2(4)
HYANNIS MA	34 X	X(X)	X(X)	X(X)	X(X)	29(29)	9(38)
HYANNIS MA	50 X	X(X)	X(X)	X(X)	X(X)	10(10)	7(17)
HYANNIS MA	64 X	X(X)	X(X)	X(X)	X(X)	4(4)	4(8)
NANTUCKET MA	34 X	X(X)	X(X)	X(X)	X(X)	33(33)	10(43)
NANTUCKET MA	50 X	X(X)	X(X)	X(X)	X(X)	13(13)	8(21)
NANTUCKET MA	64 X	X(X)	X(X)	X(X)	X(X)	5(5)	5(10)

Example Interpretation of Output

34 kt
probabilities
at Charlotte
NC

TIME PERIODS	FROM 18Z FRI		FROM 06Z SAT		FROM 18Z SAT		FROM 06Z SUN		FROM 18Z SUN		FROM 18Z MON		FROM 18Z TUE	
	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	
FORECAST HOUR	(12)		(24)		(36)		(48)		(72)		(96)		(120)	
LOCATION	KT													
RALEIGH NC	34	X	X(X)	X(X)	X(X)	2(2)	10(12)	8(20)	10(30)					
RALEIGH NC	50	X	X(X)	X(X)	X(X)	X(X)	2(2)	3(5)	5(10)					
RALEIGH NC	64	X	X(X)	X(X)	X(X)	X(X)	X(X)	2(2)	2(4)					
CAPE HATTERAS	34	X	X(X)	X(X)	X(X)	1(1)	4(5)	3(8)	7(15)					
CAPE HATTERAS	50	X	X(X)	X(X)	X(X)	X(X)	X(X)	1(1)	2(3)					
CHARLOTTE NC	34	X	X(X)	X(X)	X(X)	3(3)	18(21)	12(33)	9(42)					
CHARLOTTE NC	50	X	X(X)	X(X)	X(X)	X(X)	4(4)	6(10)	4(14)					
CHARLOTTE NC	64	X	X(X)	X(X)	X(X)	X(X)	2(2)	2(4)	2(6)					

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

Example Interpretation of Output

34 kt
probabilities
at Charlotte
NC

TIME PERIODS	FROM 18Z FRI TO 06Z SAT	FROM 06Z SAT TO 18Z SAT	FROM 18Z SAT TO 06Z SUN	FROM 06Z SUN TO 18Z SUN	FROM 18Z SUN TO 18Z MON	FROM 18Z MON TO 18Z TUE	FROM 18Z TUE TO 18Z WED
FORECAST HOUR	(12)	(24)	(36)	(48)	(72)	(96)	(120)
LOCATION	KT						
RALEIGH NC	34 X	X(X)	X(X)	2(2)	10(12)	8(20)	10(30)
RALEIGH NC	50 X	X(X)	X(X)	X(X)	2(2)	3(5)	5(10)
RALEIGH NC	64 X	X(X)	X(X)	X(X)	X(X)	2(2)	2(4)
CAPE HATTERAS	34 X	X(X)	X(X)	1(1)	4(5)	3(8)	7(15)
CAPE HATTERAS	50 X	X(X)	X(X)	X(X)	X(X)	1(1)	2(3)
CHARLOTTE NC	34 X	X(X)	X(X)	3(3)	18(21)	12(33)	9(42)
CHARLOTTE NC	50 X	X(X)	X(X)	X(X)	4(4)	6(10)	4(14)
CHARLOTTE NC	64 X	X(X)	X(X)	X(X)	2(2)	2(4)	2(6)

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%

Example Interpretation of Output

34 kt
probabilities
at Charlotte
NC

TIME PERIODS	FROM 18Z FRI		FROM 06Z SAT		FROM 18Z SAT		FROM 06Z SUN		FROM 18Z SUN		FROM 18Z MON		FROM 18Z TUE	
	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	
FORECAST HOUR	(12)		(24)		(36)		(48)		(72)		(96)		(120)	
LOCATION	KT													
RALEIGH NC	34	X	X(X)	X(X)	X(X)	2(2)	10(12)	8(20)	10(30)					
RALEIGH NC	50	X	X(X)	X(X)	X(X)	X(X)	2(2)	3(5)	5(10)					
RALEIGH NC	64	X	X(X)	X(X)	X(X)	X(X)	X(X)	2(2)	2(4)					
CAPE HATTERAS	34	X	X(X)	X(X)	X(X)	1(1)	4(5)	3(8)	7(15)					
CAPE HATTERAS	50	X	X(X)	X(X)	X(X)	X(X)	X(X)	1(1)	2(3)					
CHARLOTTE NC	34	X	X(X)	X(X)	X(X)	3(3)	18(21)	12(33)	9(42)					
CHARLOTTE NC	50	X	X(X)	X(X)	X(X)	X(X)	4(4)	6(10)	4(14)					
CHARLOTTE NC	64	X	X(X)	X(X)	X(X)	X(X)	2(2)	2(4)	2(6)					

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?

Example Interpretation of Output

34 kt
probabilities
at Charlotte
NC

TIME PERIODS	FROM 18Z FRI TO 06Z SAT	FROM 06Z SAT TO 18Z SAT	FROM 18Z SAT TO 06Z SUN	FROM 06Z SUN TO 18Z SUN	FROM 18Z SUN TO 18Z MON	FROM 18Z MON TO 18Z TUE	FROM 18Z TUE TO 18Z WED
FORECAST HOUR	(12)	(24)	(36)	(48)	(72)	(96)	(120)
LOCATION	KT						
RALEIGH NC	34 X	X(X)	X(X)	2(2)	10(12)	8(20)	10(30)
RALEIGH NC	50 X	X(X)	X(X)	X(X)	2(2)	3(5)	5(10)
RALEIGH NC	64 X	X(X)	X(X)	X(X)	X(X)	2(2)	2(4)
CAPE HATTERAS	34 X	X(X)	X(X)	1(1)	4(5)	3(8)	7(15)
CAPE HATTERAS	50 X	X(X)	X(X)	X(X)	X(X)	1(1)	2(3)
CHARLOTTE NC	34 X	X(X)	X(X)	3(3)	18(21)	12(33)	9(12)
CHARLOTTE NC	50 X	X(X)	X(X)	X(X)	4(4)	6(10)	4(14)
CHARLOTTE NC	64 X	X(X)	X(X)	X(X)	2(2)	2(4)	2(6)

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?

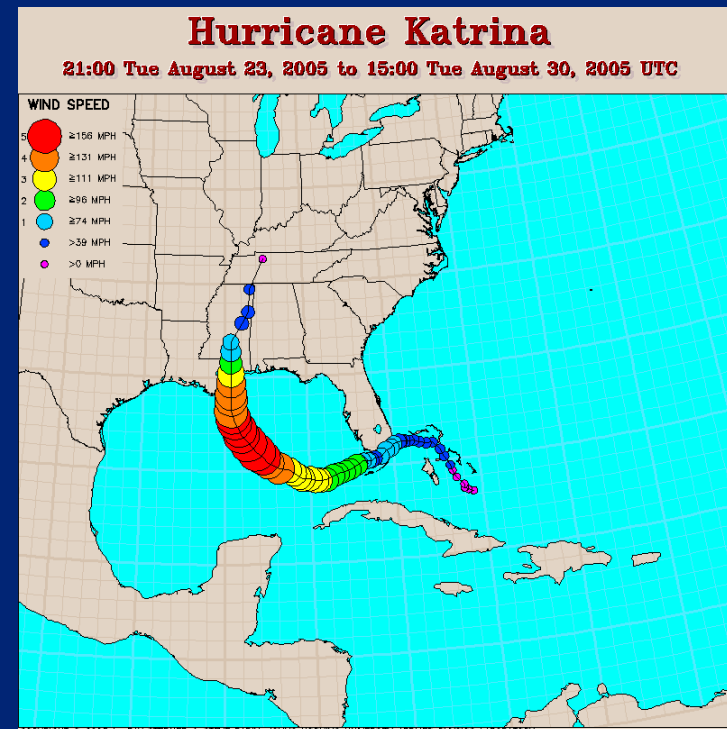
From 18Z Sun to 18Z Mon (18% chance)

Case Example

Hurricane Katrina (2005)

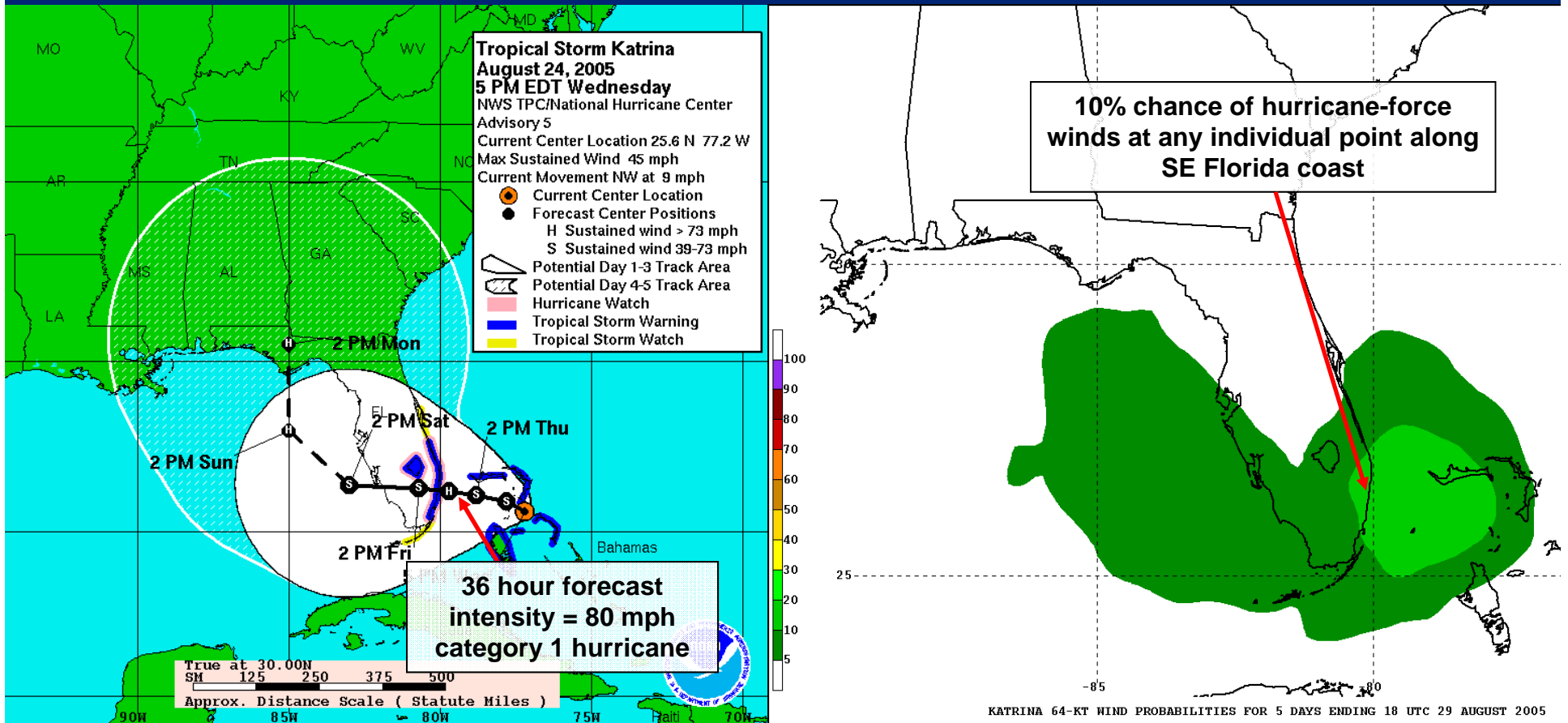
Hurricane Katrina (2005)

- 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

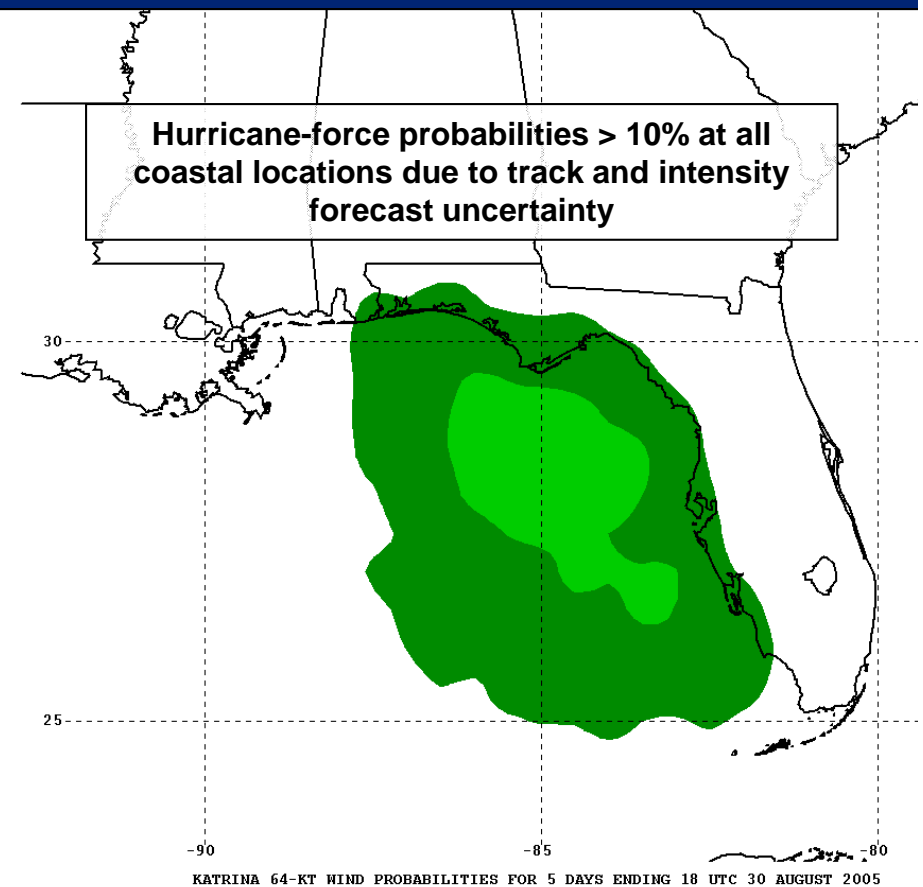
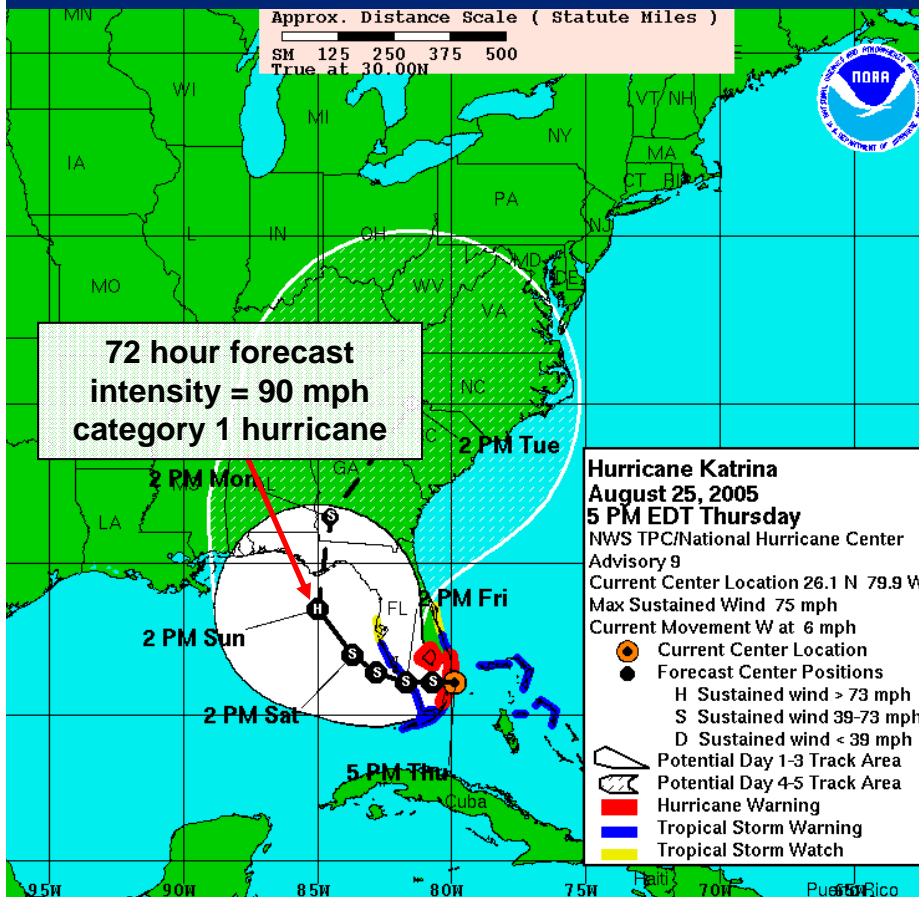
Katrina Advisory #5



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 27

Magnitudes of Cumulative Probabilities Vary Greatly But Realistically

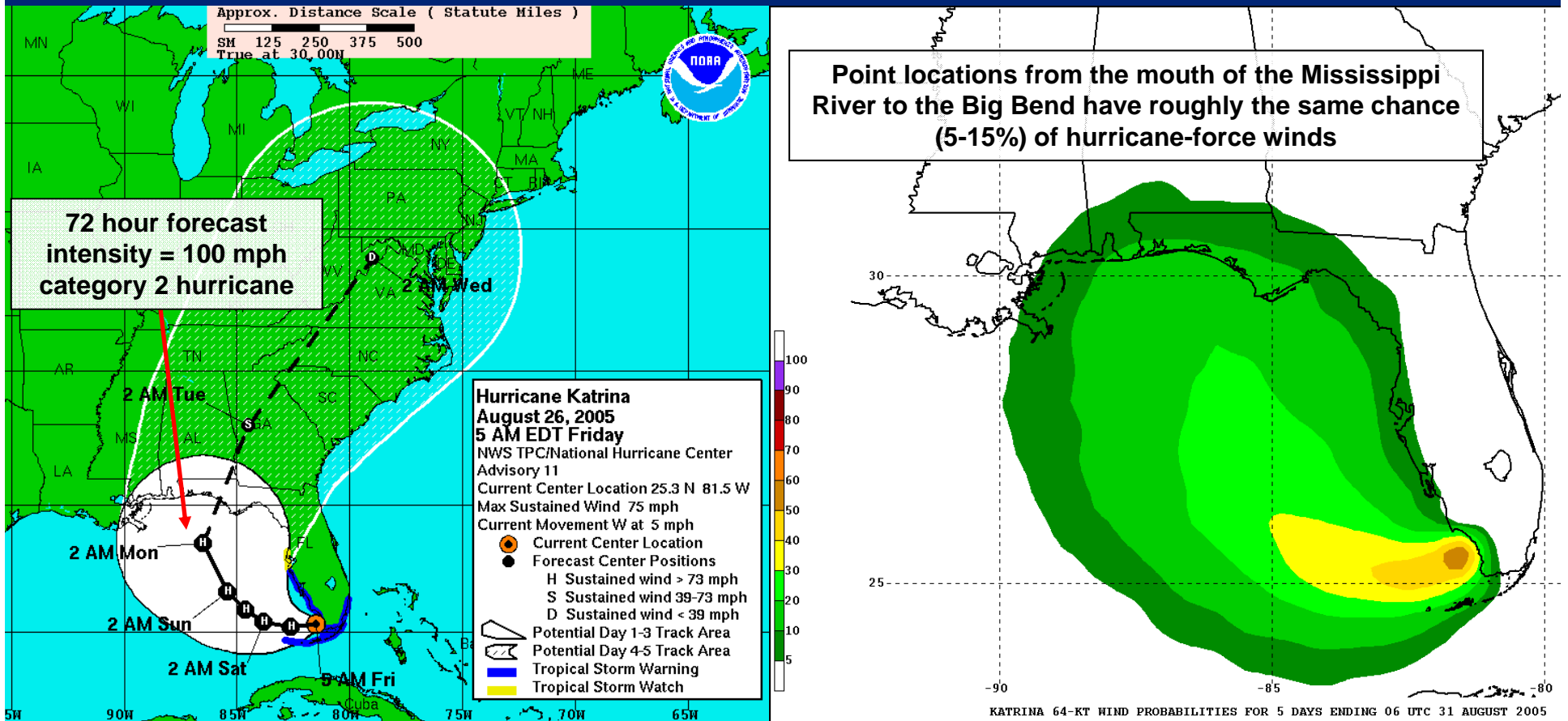
Katrina Advisory #9



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

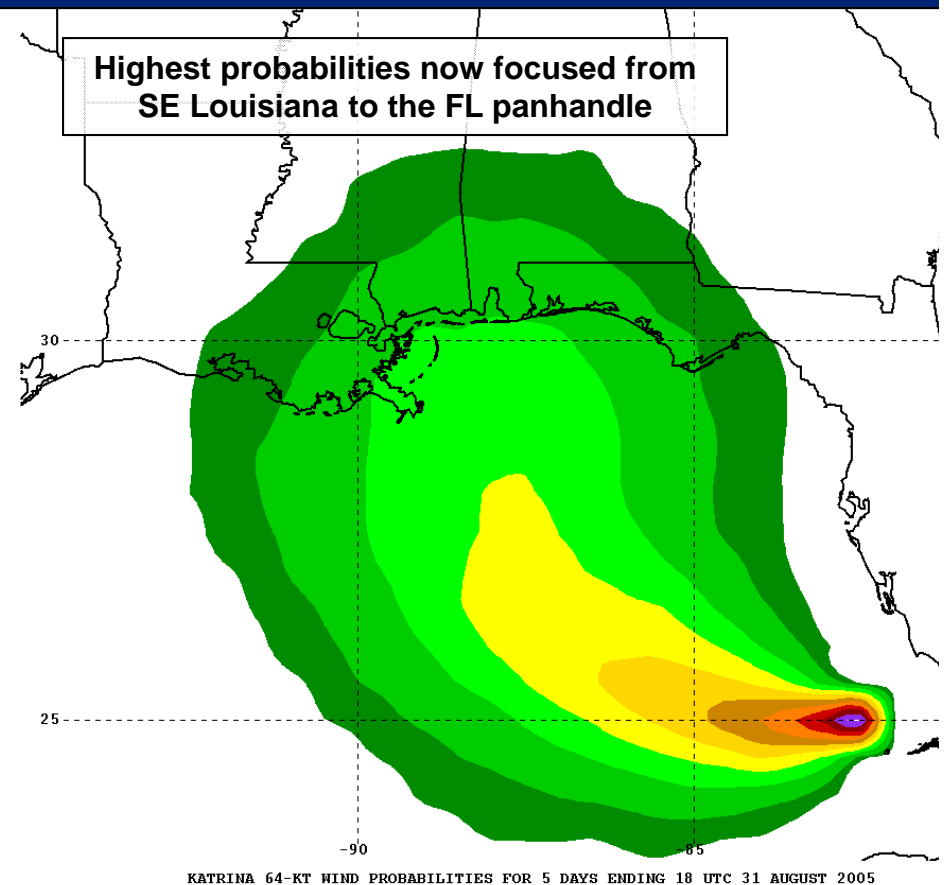
Katrina Advisory #11



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

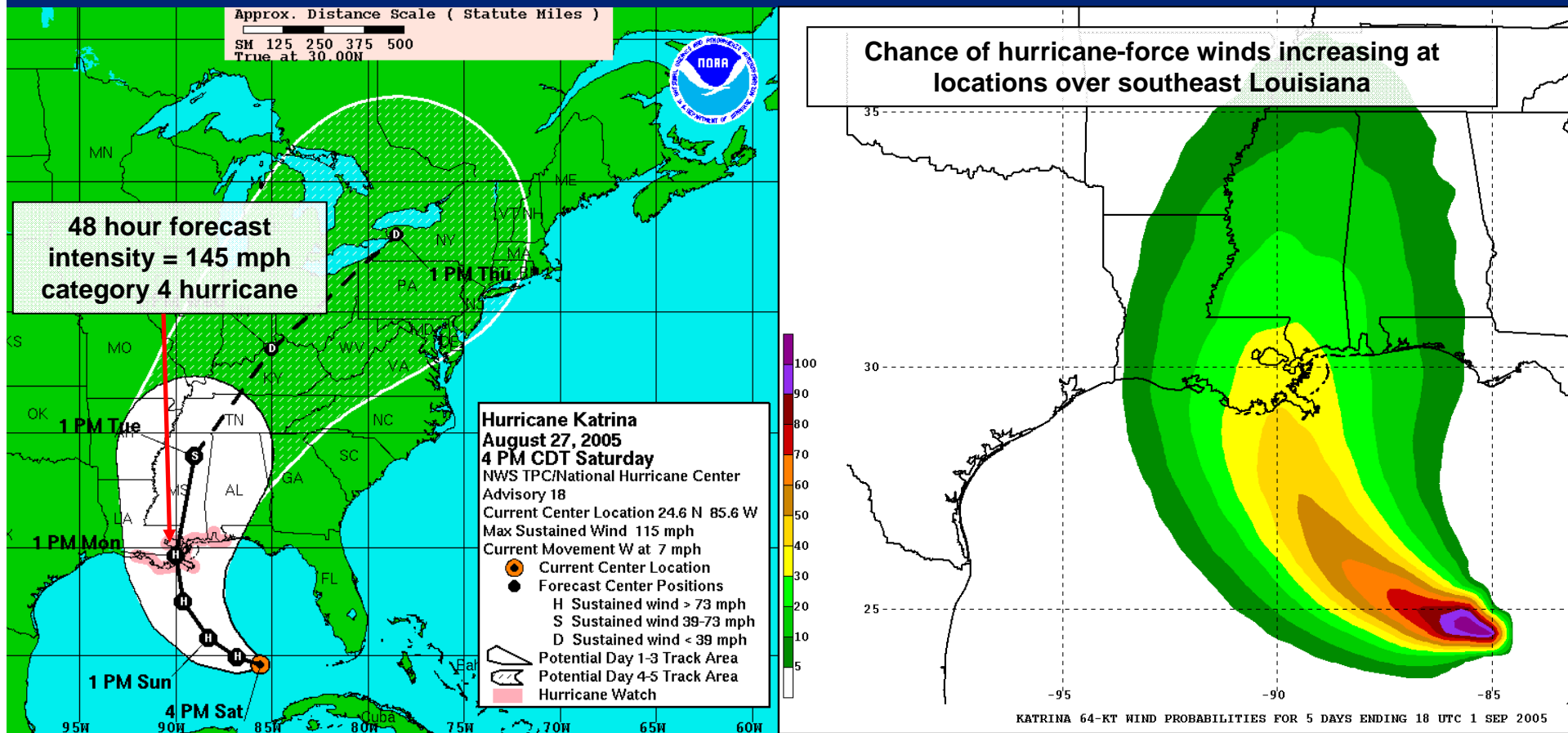
Katrina Advisory #14



Probabilities increase further due to continued increase in intensity forecast and slight decrease in track forecast uncertainty with landfall forecast in about 72 h₃₀

Magnitudes of Cumulative Probabilities Vary Greatly But Realistically

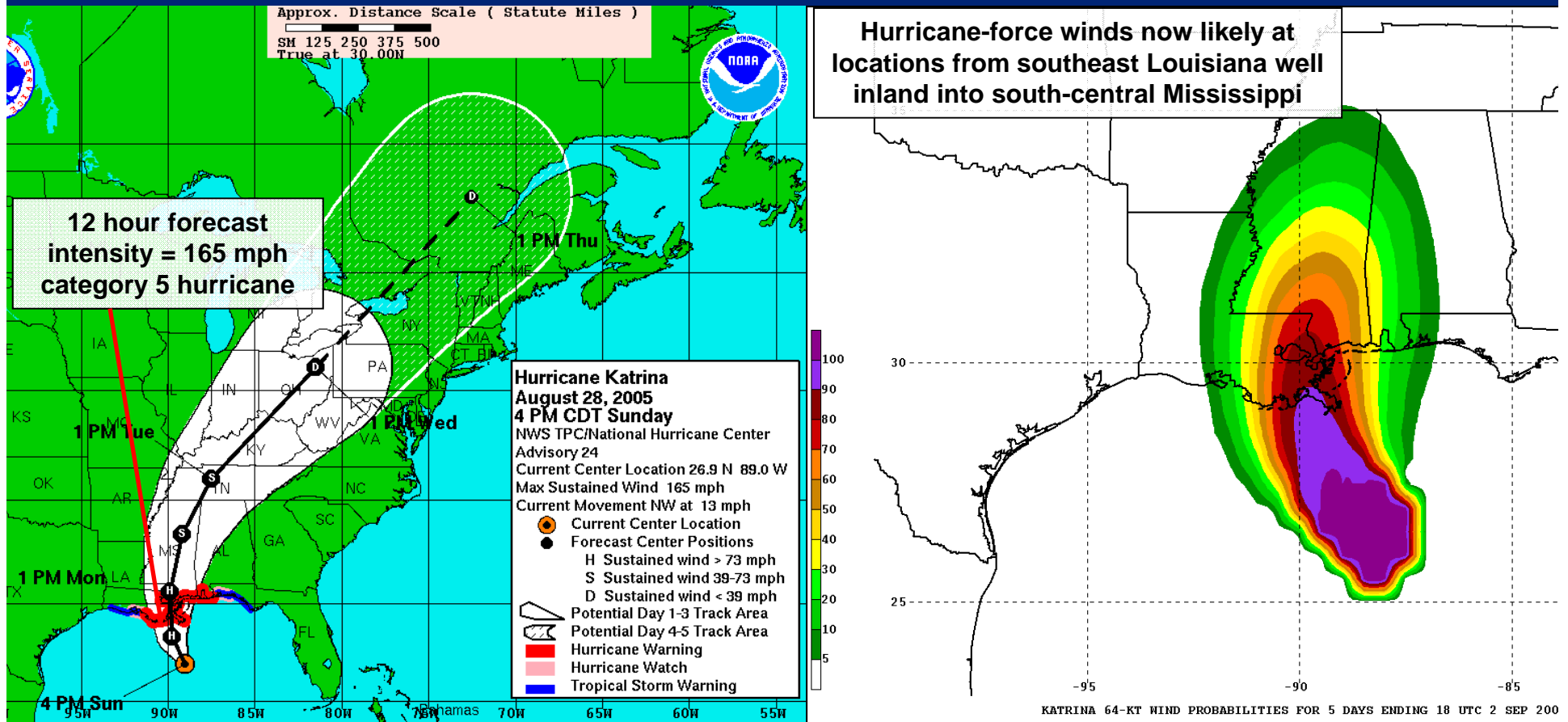
Katrina Advisory #18



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

Magnitudes of Cumulative Probabilities Vary Greatly But Realistically

Katrina Advisory #24

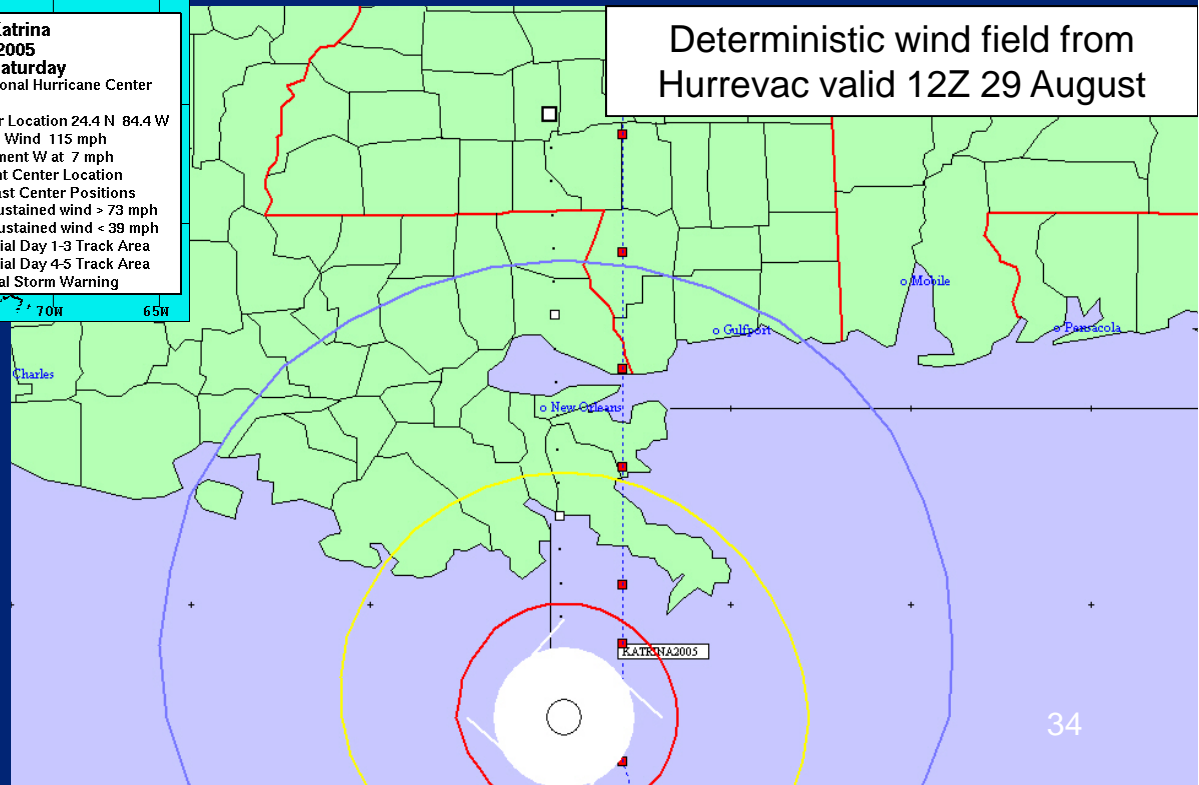
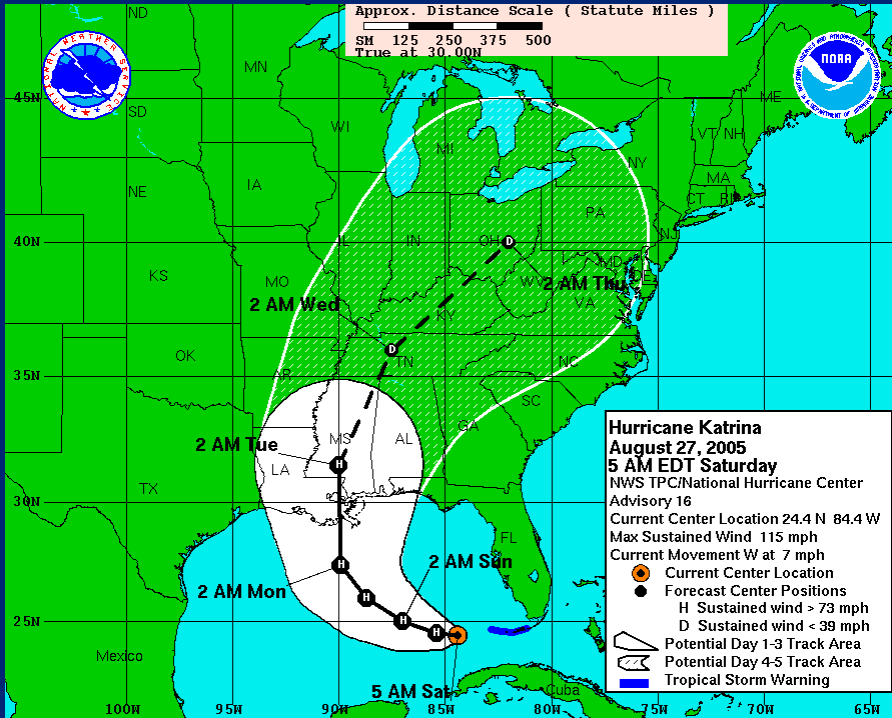


Landfall now within 12 to 24 h, hurricane force winds almost a certainty along forecast track given large size and strength of Katrina along with small short-range track uncertainty

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



Wind Speed Probabilities

Katrina (2005) Advisory 16

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- - - - WIND SPEED PROBABILITIES FOR SELECTED LOCATIONS - - - -
          FROM      FROM      FROM      FROM      FROM      FROM      FROM
TIME      06Z SAT  18Z SAT  06Z SUN  18Z SUN  06Z MON  06Z TUE  06Z WED
PERIODS   TO      TO      TO      TO      TO      TO      TO
          18Z SAT  06Z SUN  18Z SUN  06Z MON  06Z TUE  06Z WED  06Z THU

FORECAST HOUR  (12)      (24)      (36)      (48)      (72)      (96)      (120)

NEW ORLEANS LA  34 X      1( 1)     9(10)    28(38)   34(72)   5(77)    X(77)

GULFPORT MS   34   X      1( 1)     8( 9)    23(32)   35(67)   5(72)    1(73)
  
```

Wind Speed Probabilities

Katrina (2005) Advisory 16

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

	FROM	FROM	FROM	FROM	FROM	FROM	FROM
TIME PERIODS	06Z SAT	18Z SAT	06Z SUN	18Z SUN	06Z MON	06Z TUE	06Z WED
	TO	TO	TO	TO	TO	TO	TO
	18Z SAT	06Z SUN	18Z SUN	06Z MON	06Z TUE	06Z WED	06Z THU
FORECAST HOUR	(12)	(24)	(36)	(48)	(72)	(96)	(120)
NEW ORLEANS LA	34 X	1(1)	9(10)	28(38)	34(72)	5(77)	X(77)
GULFPORT MS	34 X	1(1)	8(9)	23(32)	35(67)	5(72)	1(73)

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

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

	FROM	FROM	FROM	FROM	FROM	FROM	FROM
TIME PERIODS	06Z SAT TO 18Z SAT	18Z SAT TO 06Z SUN	06Z SUN TO 18Z SUN	18Z SUN TO 06Z MON	06Z MON TO 06Z TUE	06Z TUE TO 06Z WED	06Z WED TO 06Z THU
FORECAST HOUR	(12)	(24)	(36)	(48)	(72)	(96)	(120)
NEW ORLEANS LA	34 X	1(1)	9(10)	28(38)	34(72)	5(77)	X(77)
GULFPORT MS	34 X	1(1)	8(9)	23(32)	35(67)	5(72)	1(73)

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

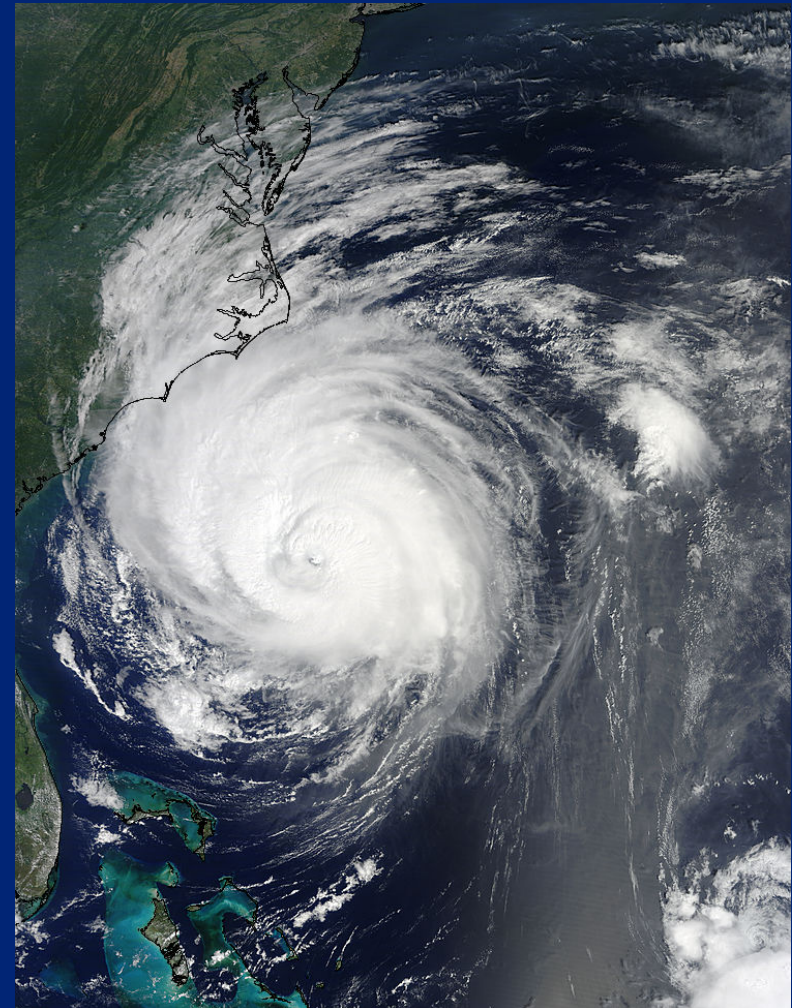
- Important information about the onset of wind conditions is contained in the probabilities
- Examine trends from advisory to advisory
 - How are probabilities of onset changing?
 - Are chances of onset nearly equal between two consecutive time periods?

Case Example

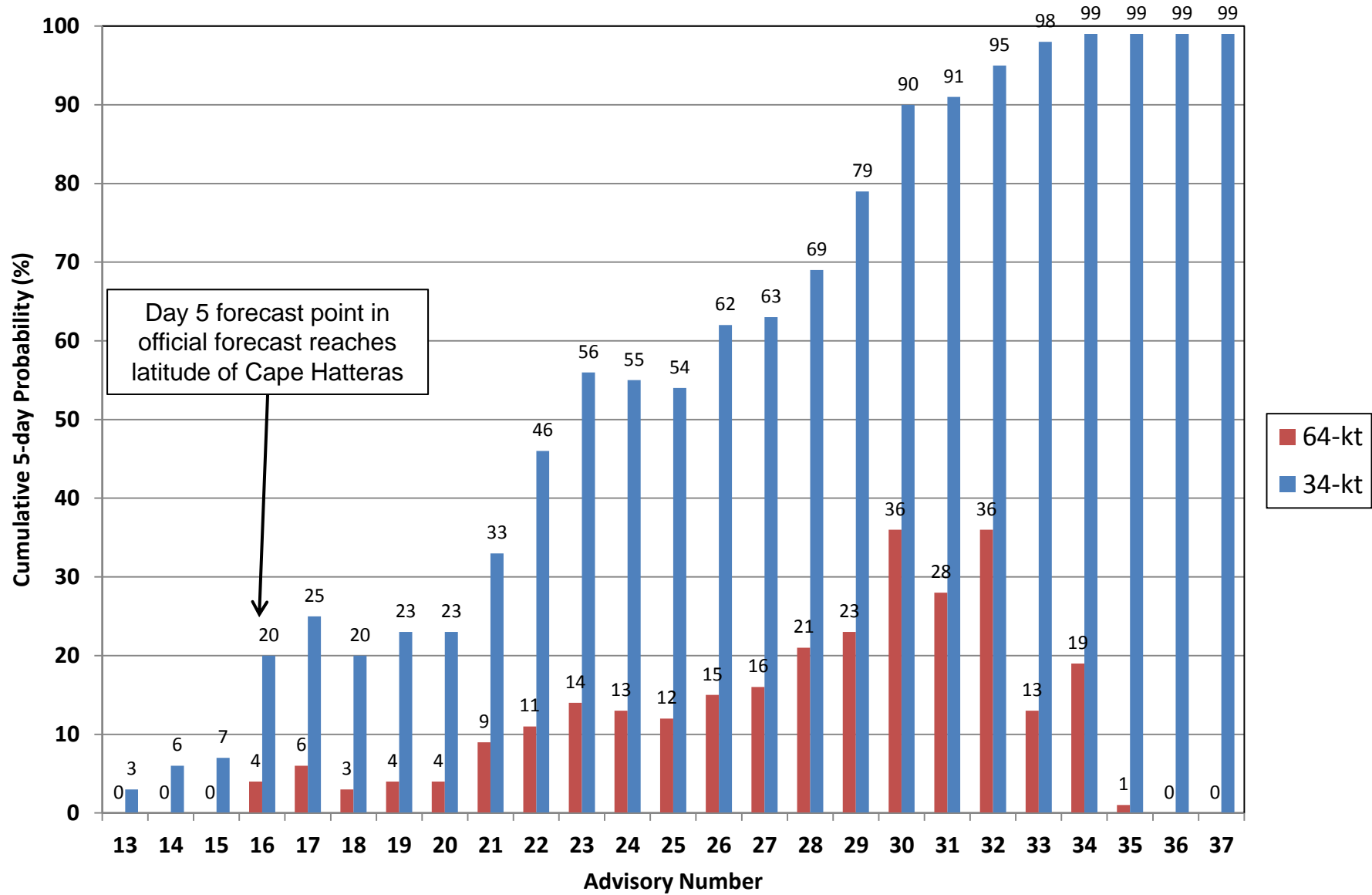
Hurricane Earl (2010)

Hurricane Earl (2010)

- An example of a different type of uncertainty, in contrast to a hurricane that will almost certainly bring hurricane force winds to some area of the Gulf coast (e.g., Katrina, Ike)
- In this case, tropical-storm and hurricane-force winds may or may not affect any locations along the coast of North Carolina depending on the track and size of Earl
- Given the track of Earl parallel to the coast, small changes in the forecast track result in large changes in the wind speed probabilities



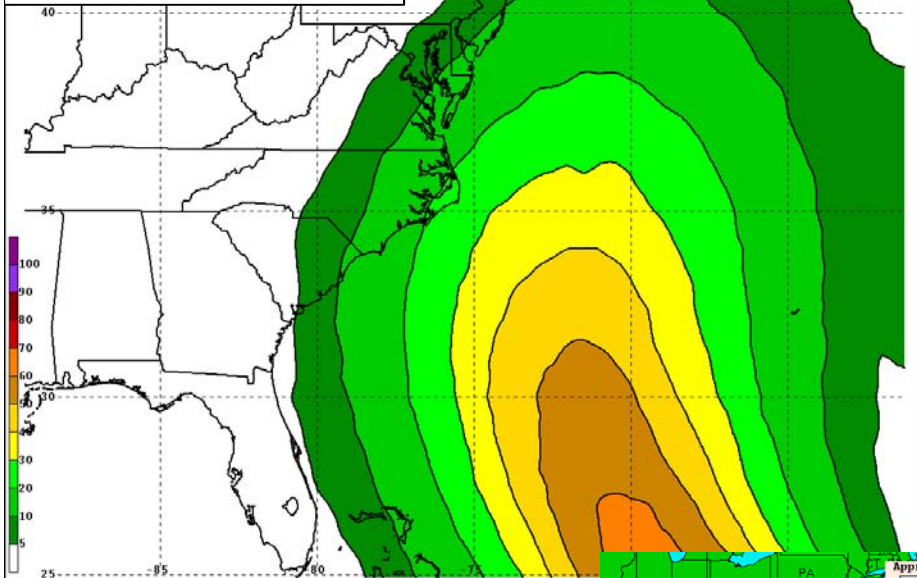
Trend of 34-kt and 64-kt Cumulative Wind Speed Probabilites at Cape Hatteras, NC for Hurricane Earl (2010)



Hurricane Earl

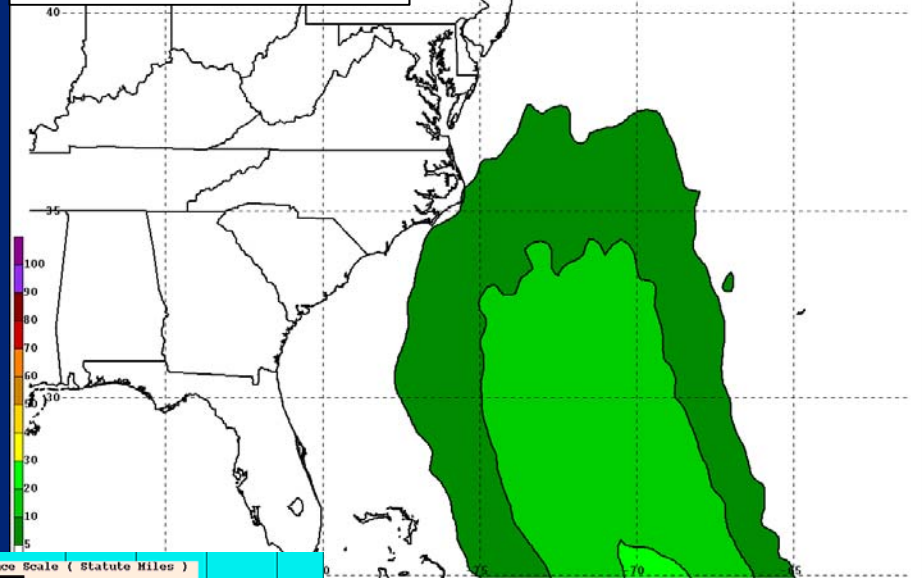
Advisory 16 – 5 AM EDT 29 Aug. 2010

34-kt probabilities

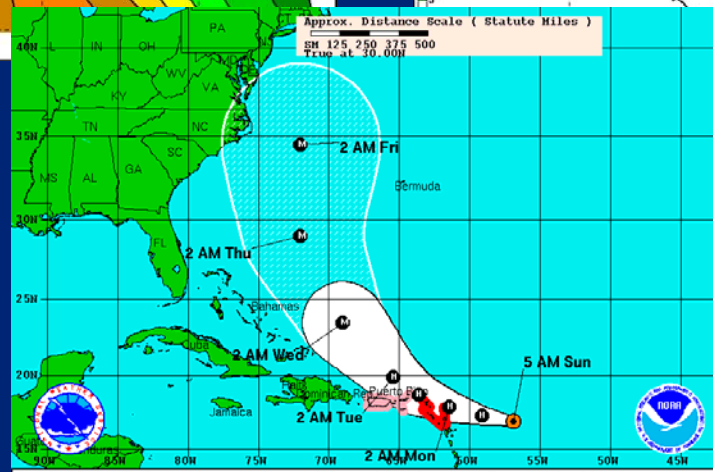


FRI 100829/0600F120 POP

64-kt probabilities



FRI 100829/0600F120 POP



Tropical Storm Earl
 Sunday August 29, 2010
 5 AM EDT Advisory 16
 NWS TPC/National Hurricane Center

Current Information:
 Center Location 16.9 N 86.9 W
 Max Sustained Wind 65 mph
 Movement W at 18 mph

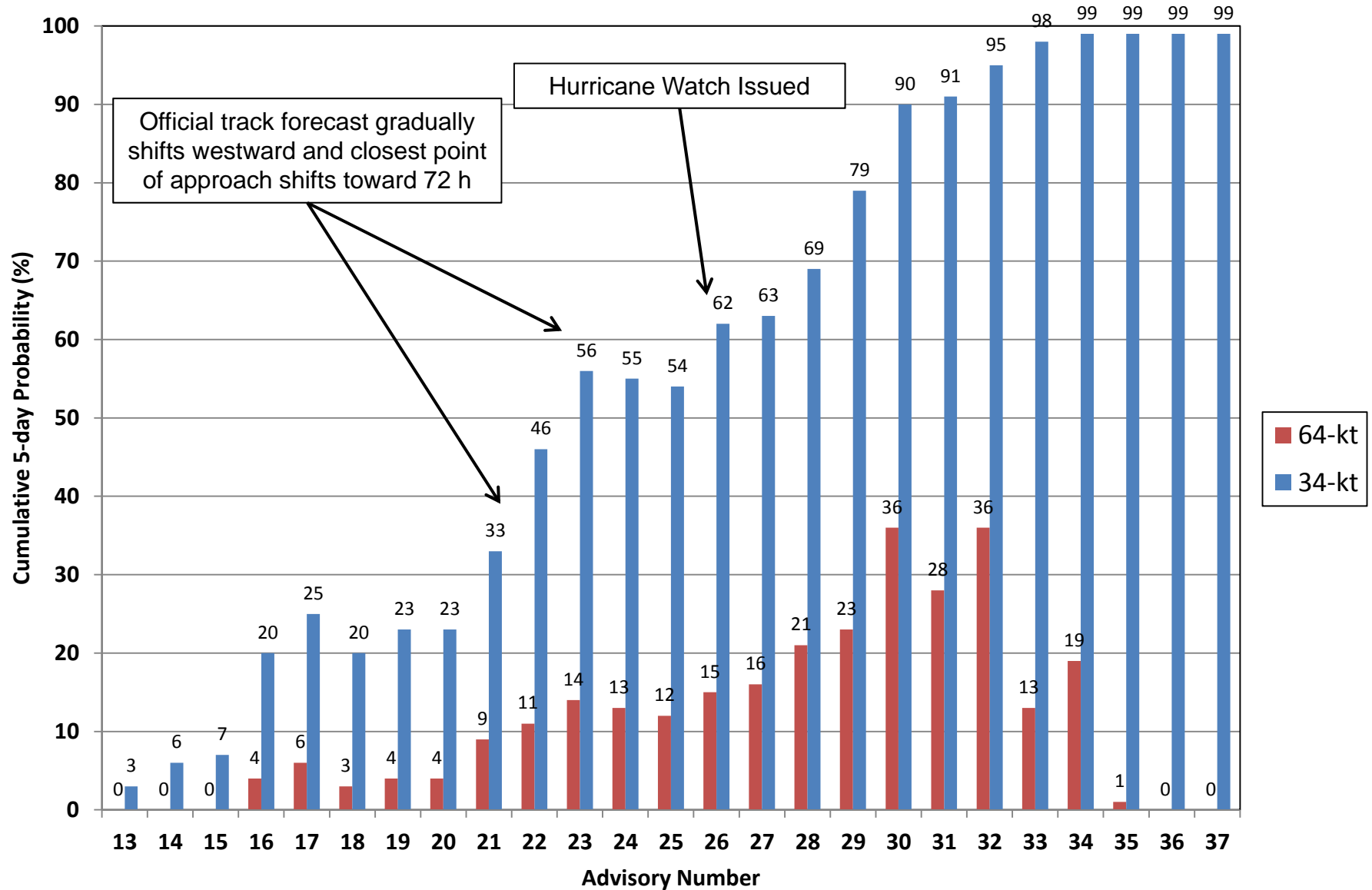
Forecast Positions:
 ● Tropical Cyclone ○ Post-Tropical
 Sustained Winds: D < 39 mph
 S 39-73 mph H 74-110 mph M > 110mph

Potential Track Area:
 Day 1-3 Day 4-5

Watches:
 Hurricane Trop. Storm

Warnings:
 Hurricane Trop. Storm

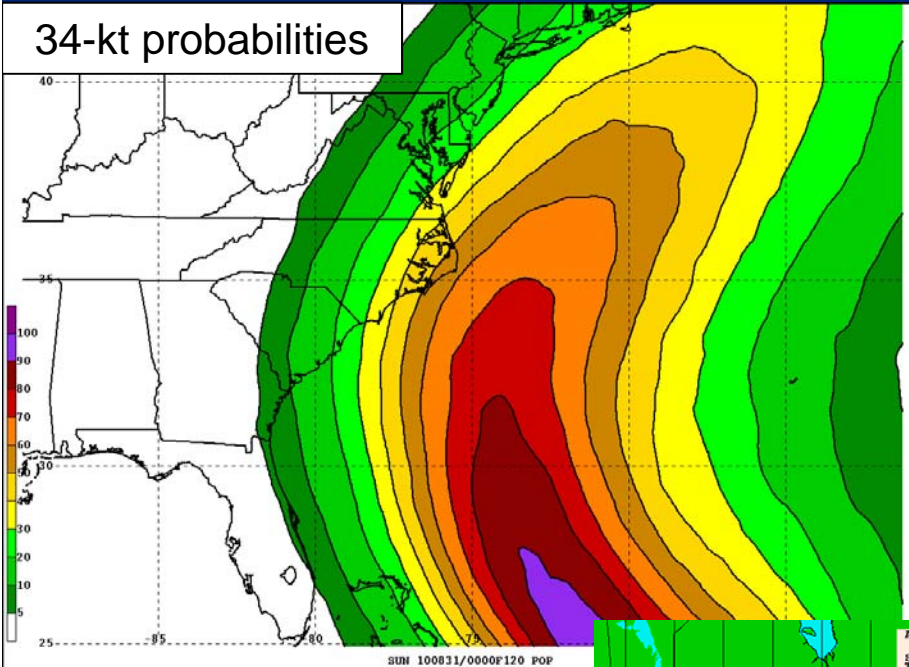
Trend of 34-kt and 64-kt Cumulative Wind Speed Probabilities at Cape Hatteras, NC for Hurricane Earl (2010)



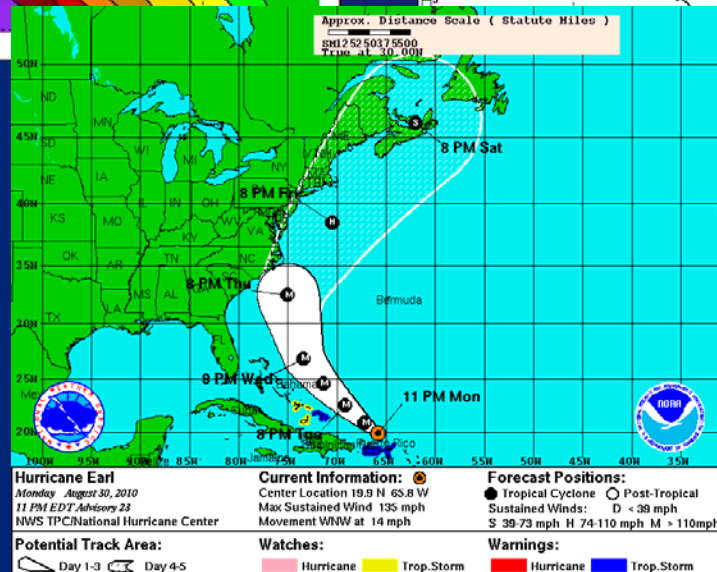
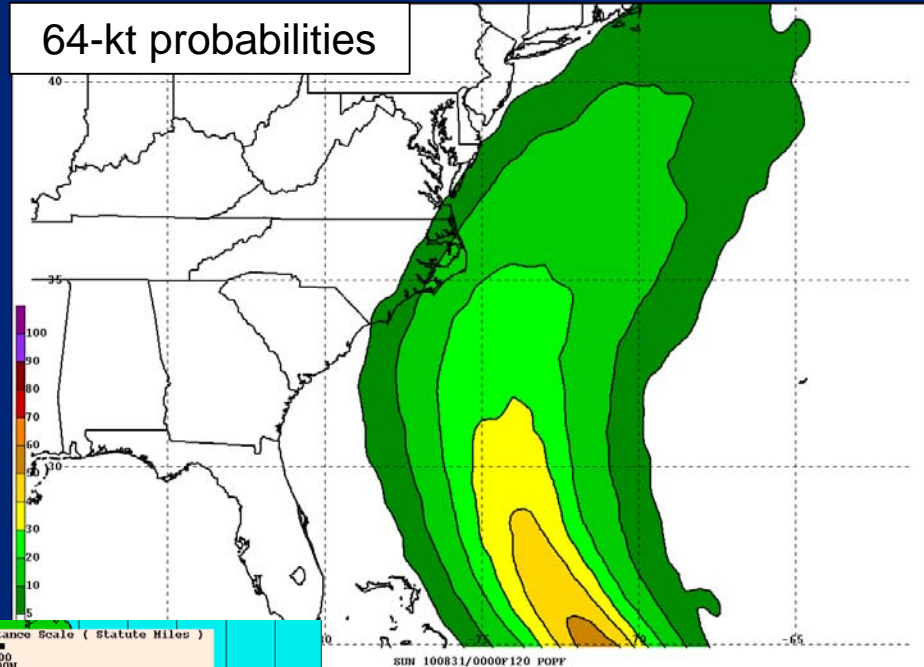
Hurricane Earl

Advisory 23 – 11 PM EDT 30 Aug. 2010

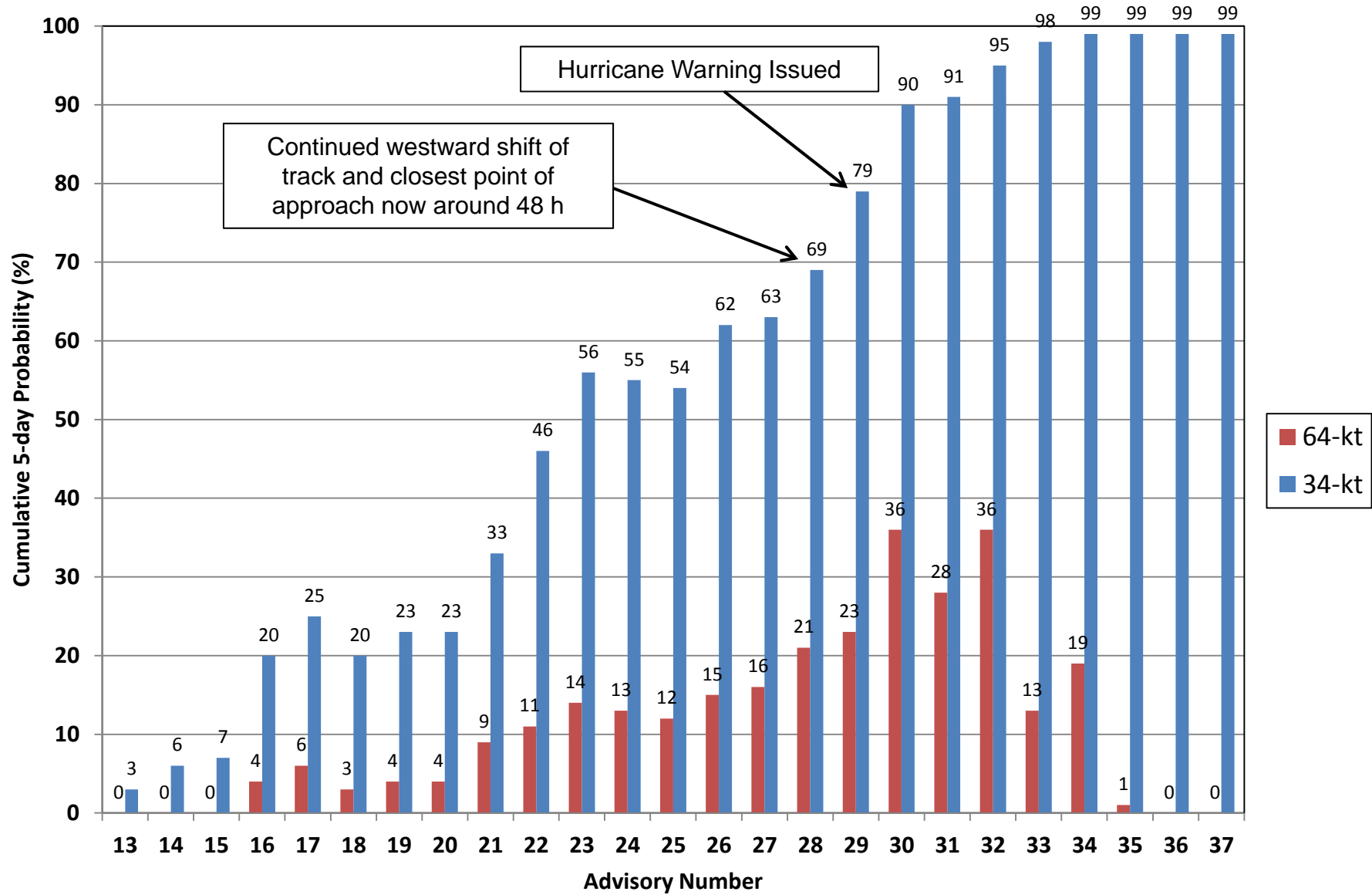
34-kt probabilities



64-kt probabilities



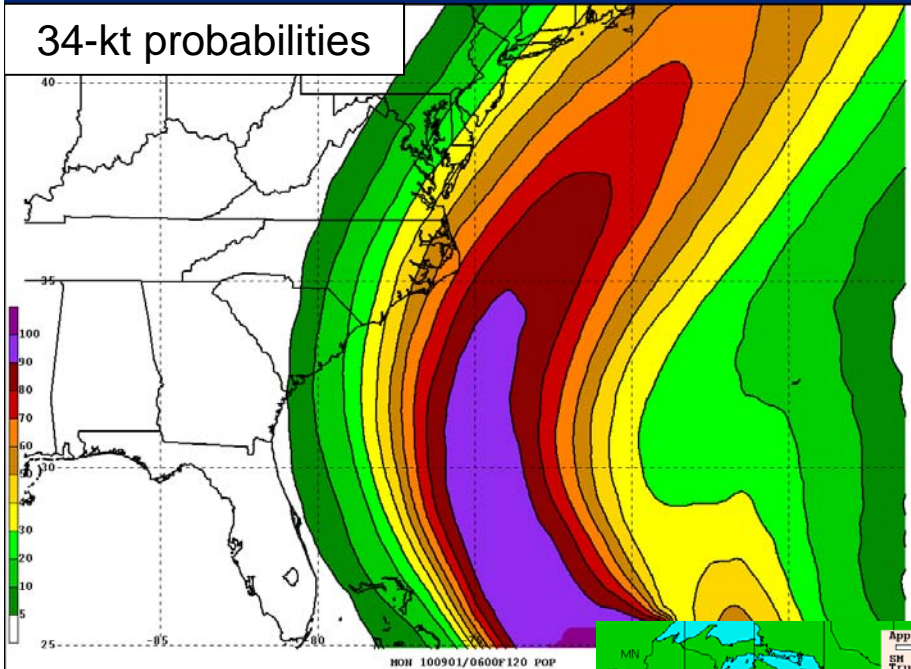
Trend of 34-kt and 64-kt Cumulative Wind Speed Probabilities at Cape Hatteras, NC for Hurricane Earl (2010)



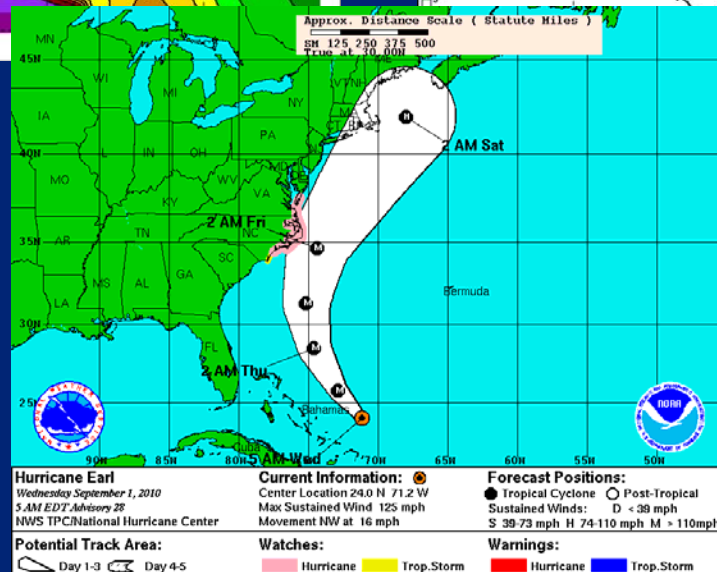
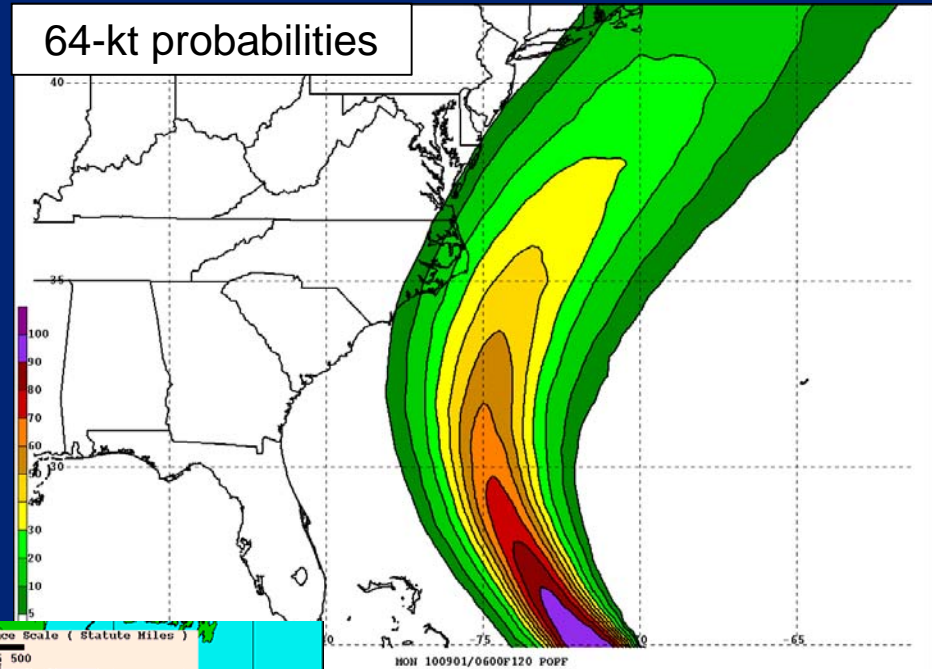
Hurricane Earl

Advisory 28 – 5 AM EDT 1 Sep. 2010

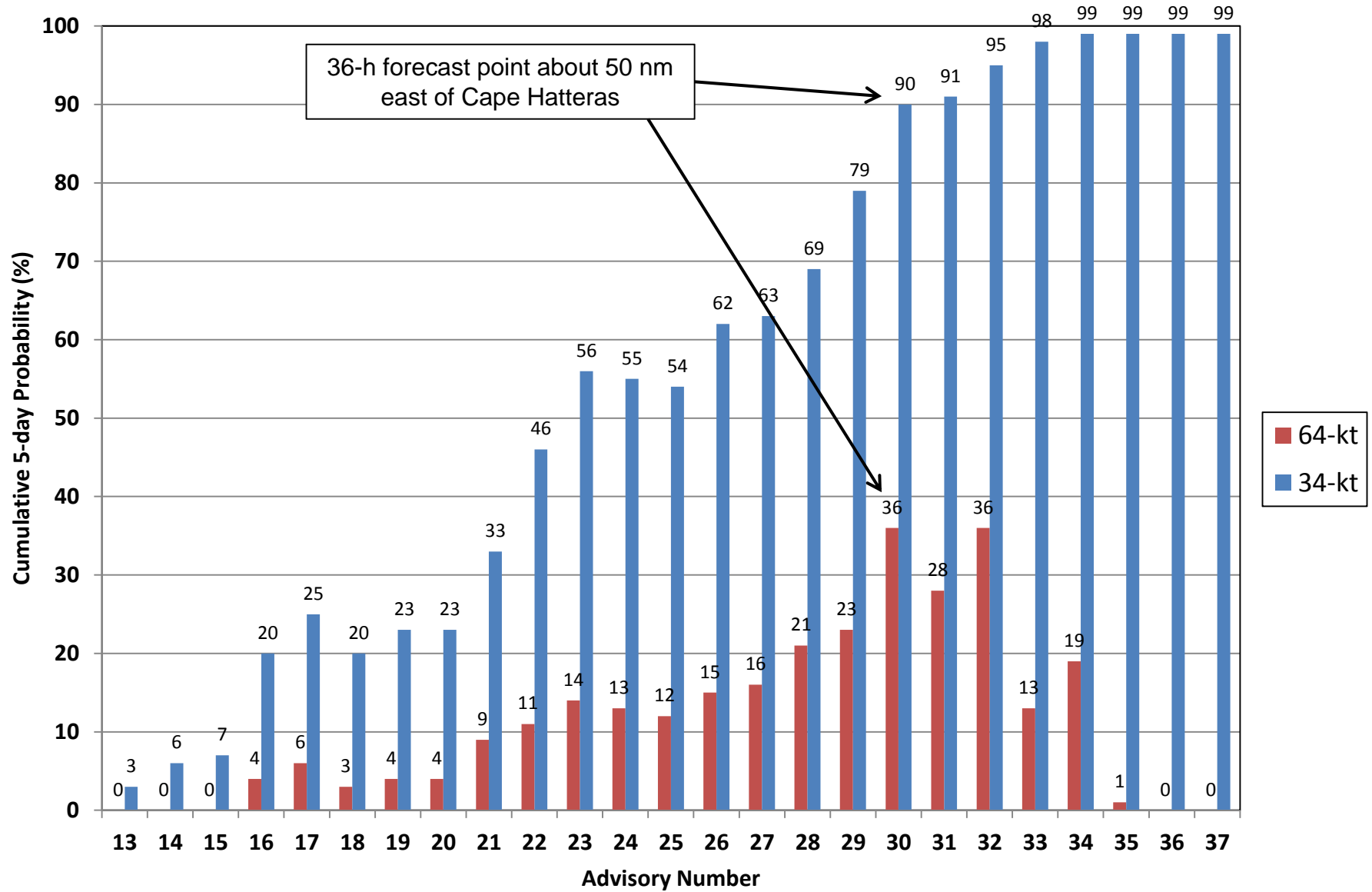
34-kt probabilities



64-kt probabilities



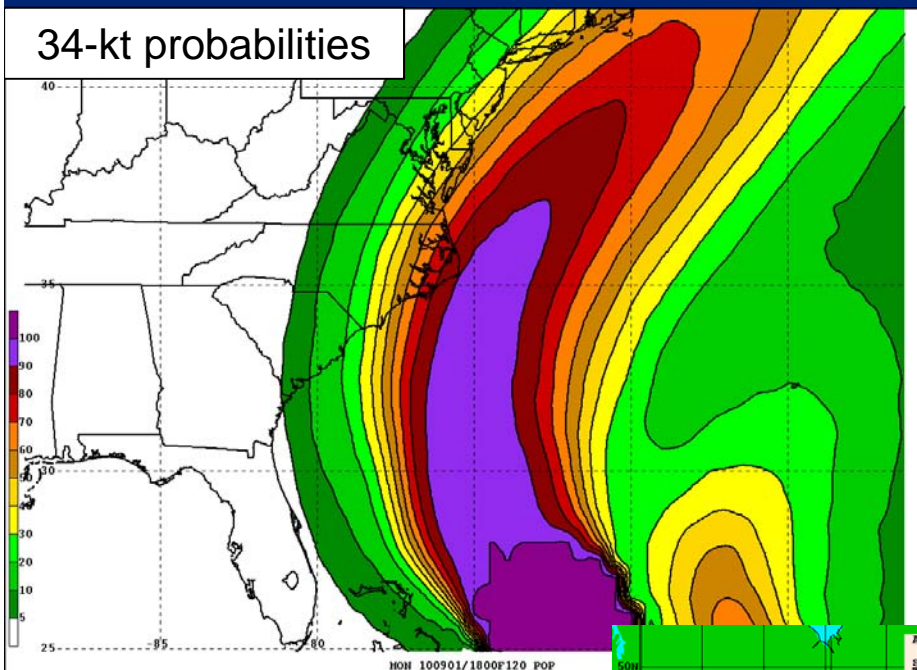
Trend of 34-kt and 64-kt Cumulative Wind Speed Probabilities at Cape Hatteras, NC for Hurricane Earl (2010)



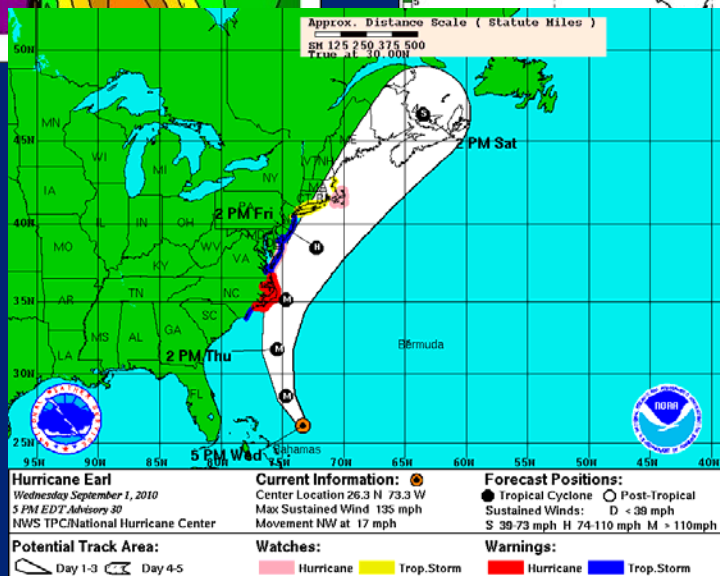
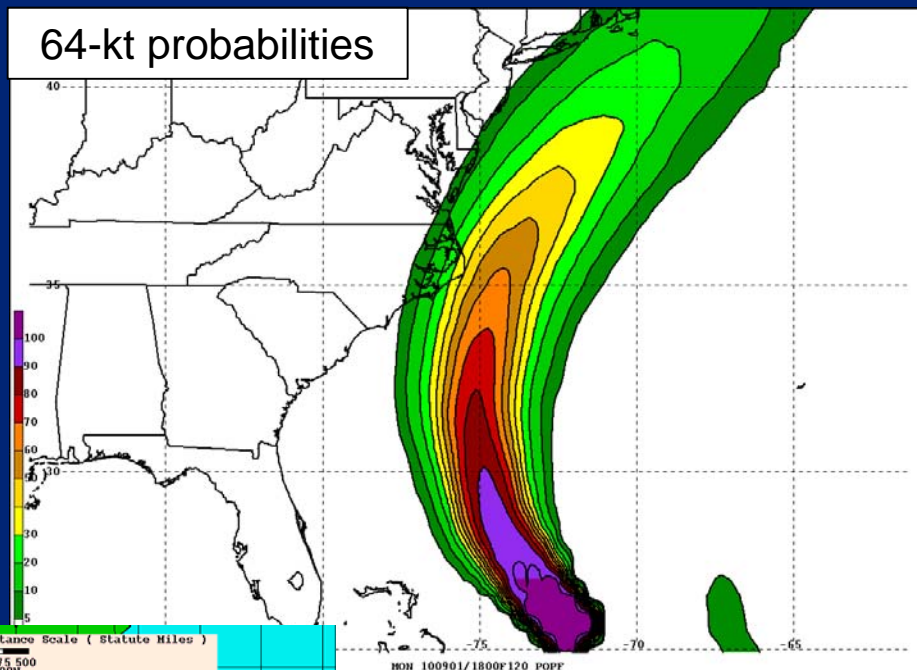
Hurricane Earl

Advisory 30 – 5 PM EDT 1 Sep. 2010

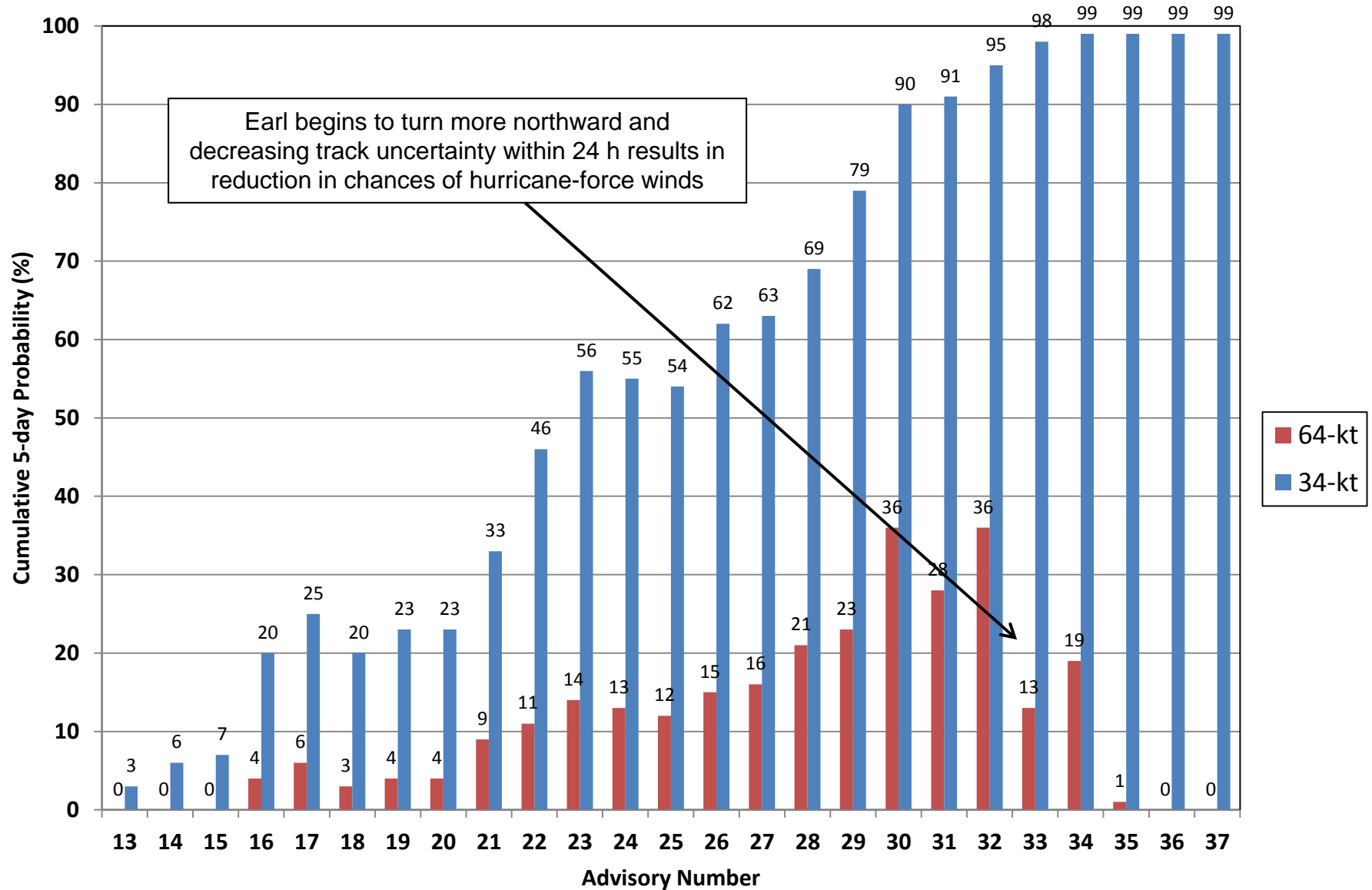
34-kt probabilities



64-kt probabilities



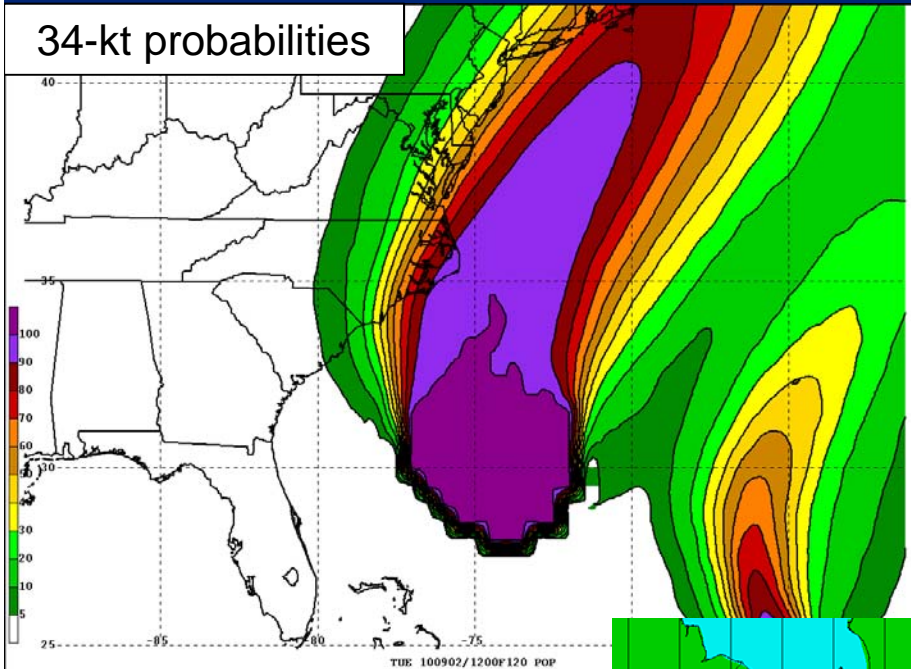
Trend of 34-kt and 64-kt Cumulative Wind Speed Probabilities at Cape Hatteras, NC for Hurricane Earl (2010)



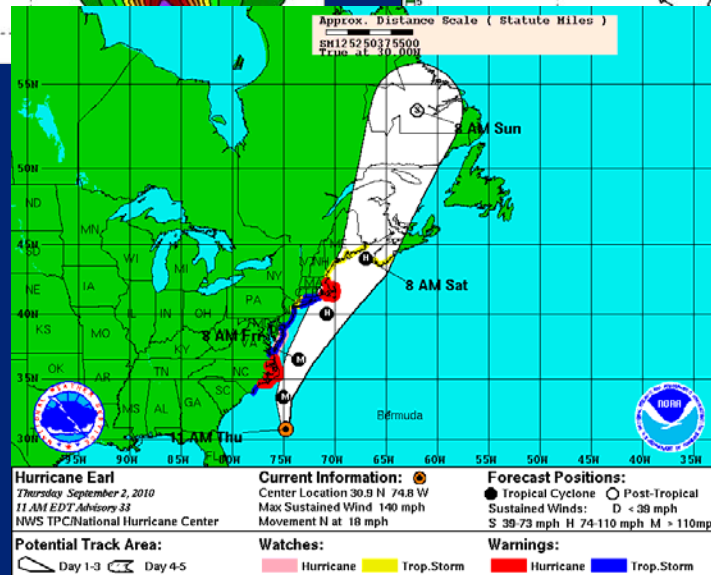
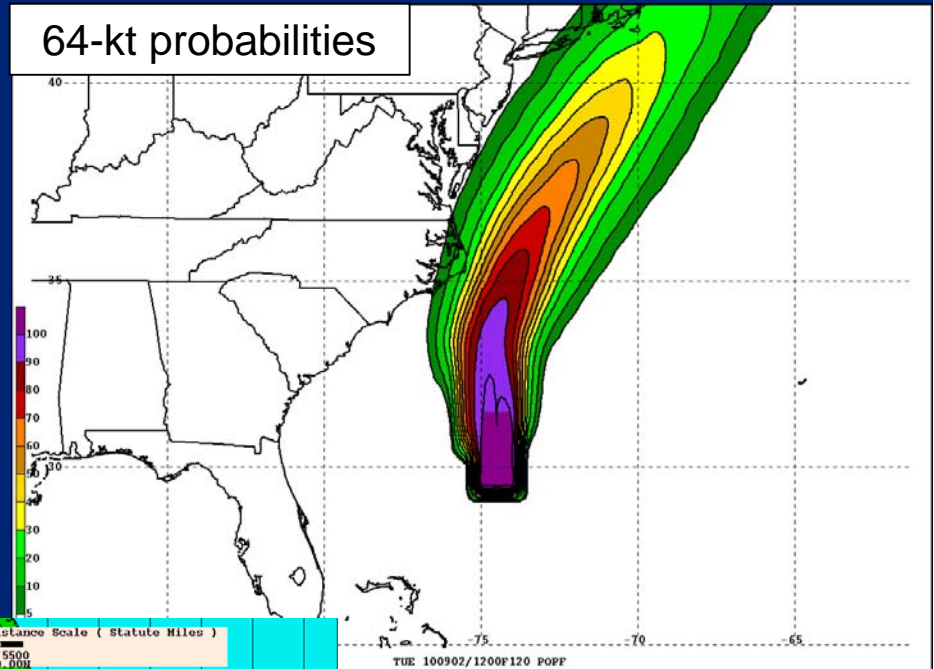
Hurricane Earl

Advisory 33 – 11 AM EDT 2 Sep. 2010

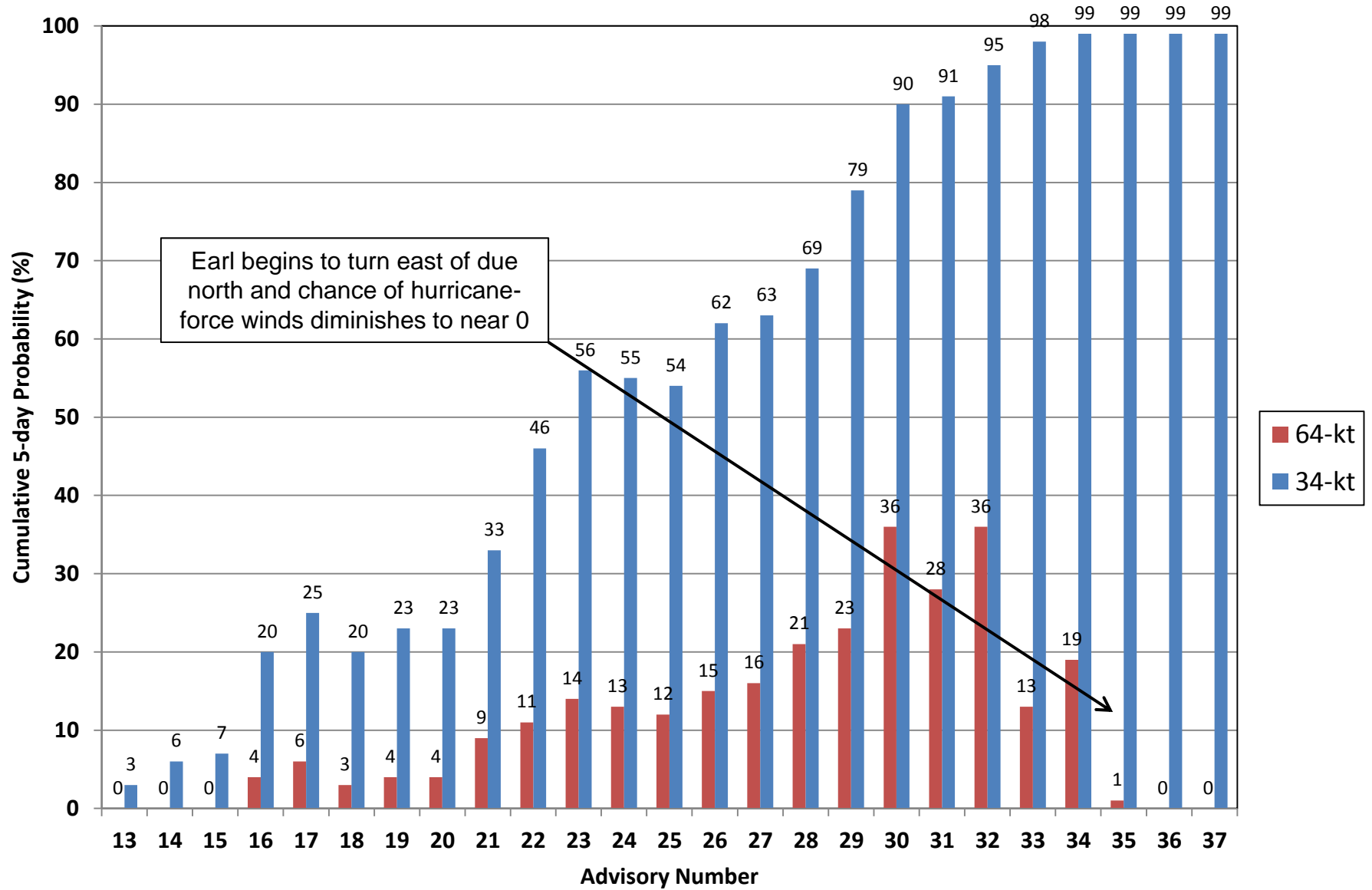
34-kt probabilities



64-kt probabilities



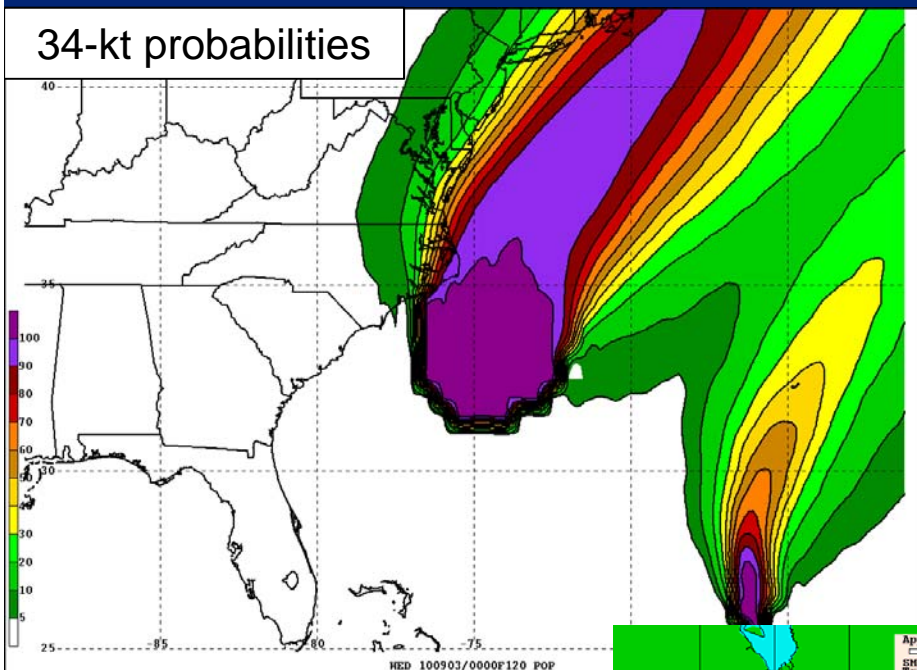
Trend of 34-kt and 64-kt Cumulative Wind Speed Probabilities at Cape Hatteras, NC for Hurricane Earl (2010)



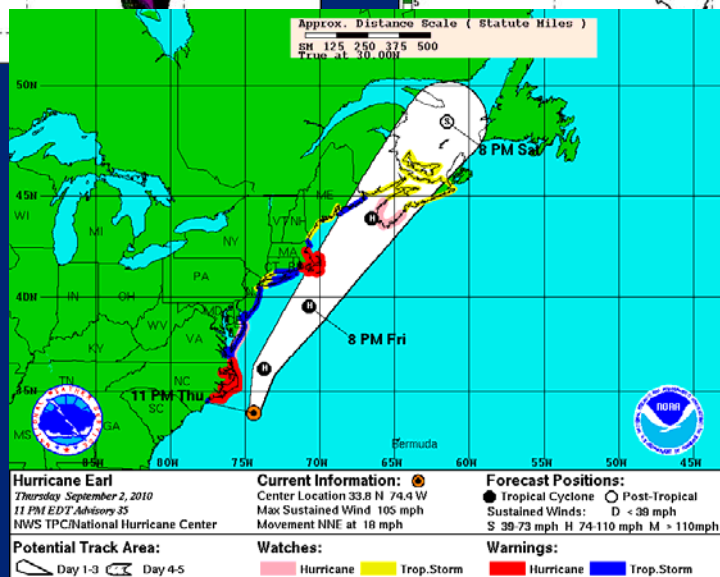
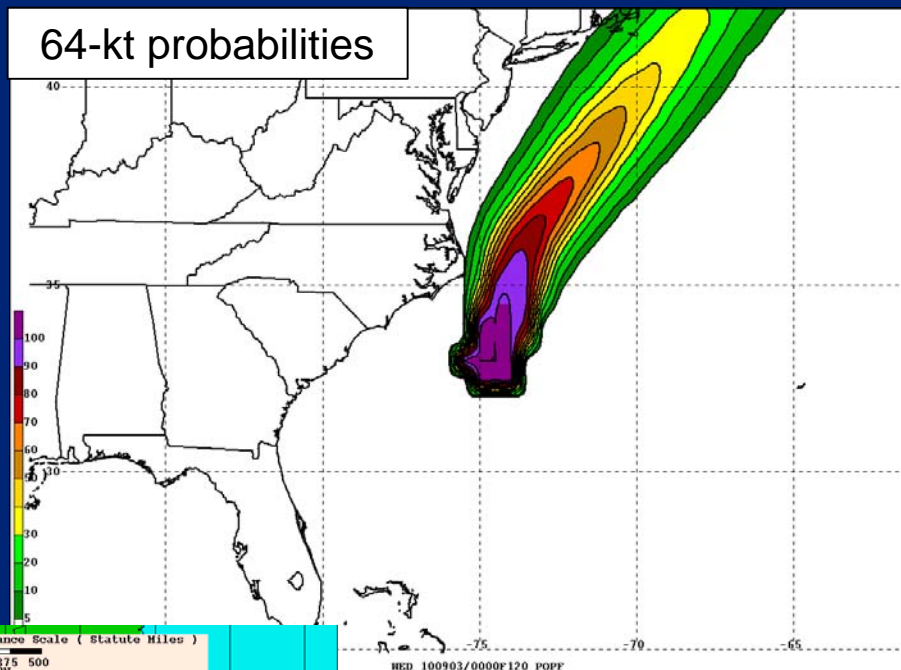
Hurricane Earl

Advisory 35 – 11 PM EDT 2 Sep. 2010

34-kt probabilities

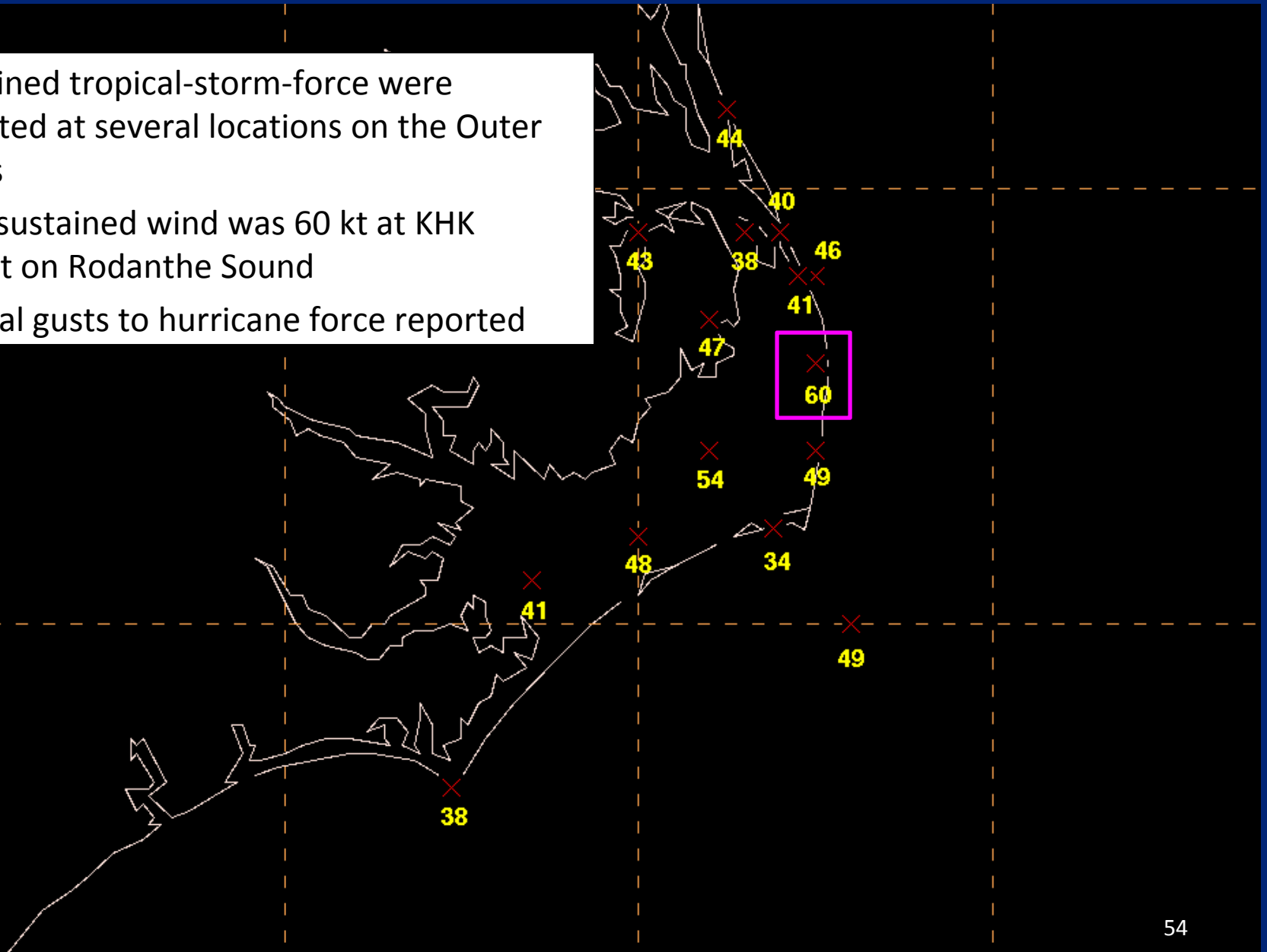


64-kt probabilities



Hurricane Earl – Ground Truth

- Sustained tropical-storm-force were reported at several locations on the Outer Banks
- Peak sustained wind was 60 kt at KHK Resort on Rodanthe Sound
- Several gusts to hurricane force reported



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



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

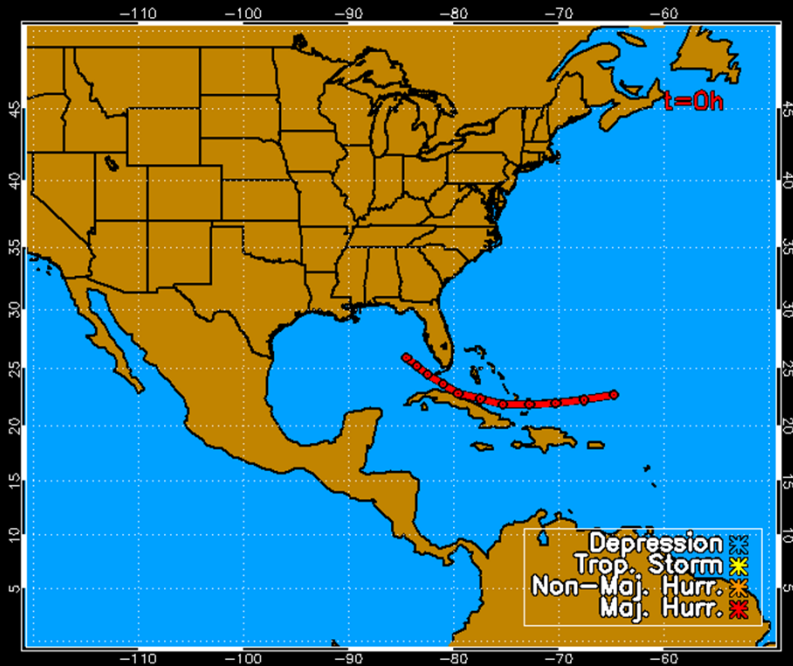
3% chance of category 4 hurricane in 48 h verifies

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

Impact of Land Interaction on Intensity Probabilities

Hurricane Ike – 11 PM EDT 5 Sep 2008



NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Intensity (Maximum Wind Speed) Probability Table
Hurricane Ike Advisory Number 20
11:00 PM AST Sep 5 2008

NATIONAL WEATHER SERVICE

Wind Range (mph)	Forecast Time						
	12 hour for 8 AM Sat	24 hour for 8 PM Sat	36 hour for 8 AM Sun	48 hour for 8 PM Sun	72 hour for 8 PM Mon	96 hour for 8 PM Tue	120 hour for 8 PM Wed
Dissipated	<1%	<1%	<1%	<1%	3%	6%	16%
Tropical Depression (<39)	<1%	<1%	<1%	<1%	3%	5%	8%
Tropical Storm (39-73)	<1%	1%	3%	4%	9%	11%	12%
Hurricane (all categories)	99%	99%	97%	95%	85%	79%	65%
-- Category 1 (74-95)	3%	11%	11%	11%	17%	18%	13%
-- Category 2 (96-110)	32%	35%	25%	14%	19%	18%	14%
-- Category 3 (111-130)	59%	44%	44%	39%	30%	24%	18%
-- Category 4 (131-155)	5%	8%	15%	26%	16%	16%	16%
-- Category 5 (>155)	1%	1%	2%	6%	3%	3%	4%
Forecast Maximum Wind	115 mph	115 mph	120 mph	135 mph	125 mph	125 mph	135 mph

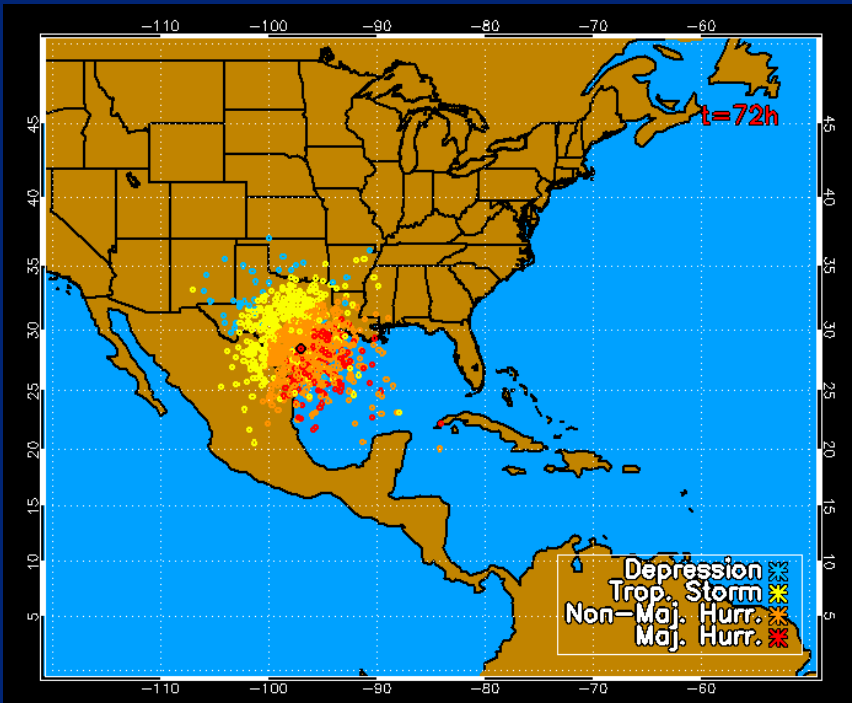
- Official forecast shows Ike avoiding significant land interaction and remaining a major hurricane through 5 days
- Probabilities show the potential for land interaction as intensity probabilities spread out across categories 1-4 by days 4 and 5

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



NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

NATIONAL WEATHER SERVICE

Intensity (Maximum Wind Speed) Probability Table
Hurricane Ike Advisory Number 38
10:00 AM CDT Sep 10 2008

Wind Range (mph)	Forecast Time						
	12 hour for 7 PM Wed	24 hour for 7 AM Thu	36 hour for 7 PM Thu	48 hour for 7 AM Fri	72 hour for 7 AM Sat	96 hour for 7 AM Sun	120 hour for 7 AM Mon
Dissipated	<1%	<1%	<1%	<1%	1%	55%	73%
Tropical Depression (<39)	<1%	<1%	<1%	<1%	4%	20%	16%
Tropical Storm (39-73)	1%	2%	2%	3%	26%	12%	6%
Hurricane (all categories)	99%	98%	98%	97%	69%	13%	6%
-- Category 1 (74-95)	23%	19%	11%	12%	25%	2%	<1%
-- Category 2 (96-110)	59%	43%	24%	20%	16%	2%	1%
-- Category 3 (111-130)	16%	32%	46%	38%	18%	5%	3%
-- Category 4 (131-155)	1%	4%	15%	23%	8%	3%	2%
-- Category 5 (>155)	1%	1%	2%	4%	2%	1%	<1%
Forecast Maximum Wind	105 mph	110 mph	120 mph	125 mph	120 mph	40 mph	30 mph

- 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!