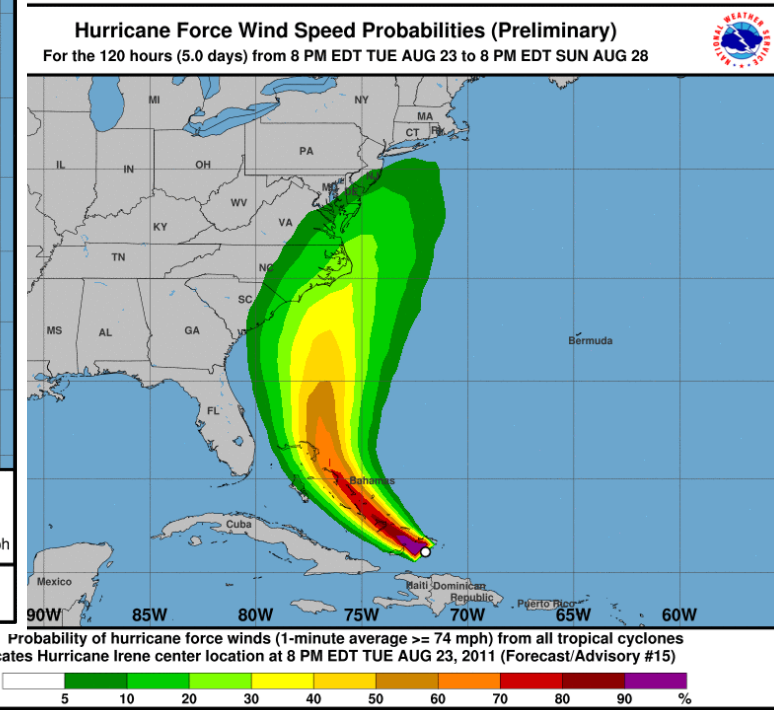
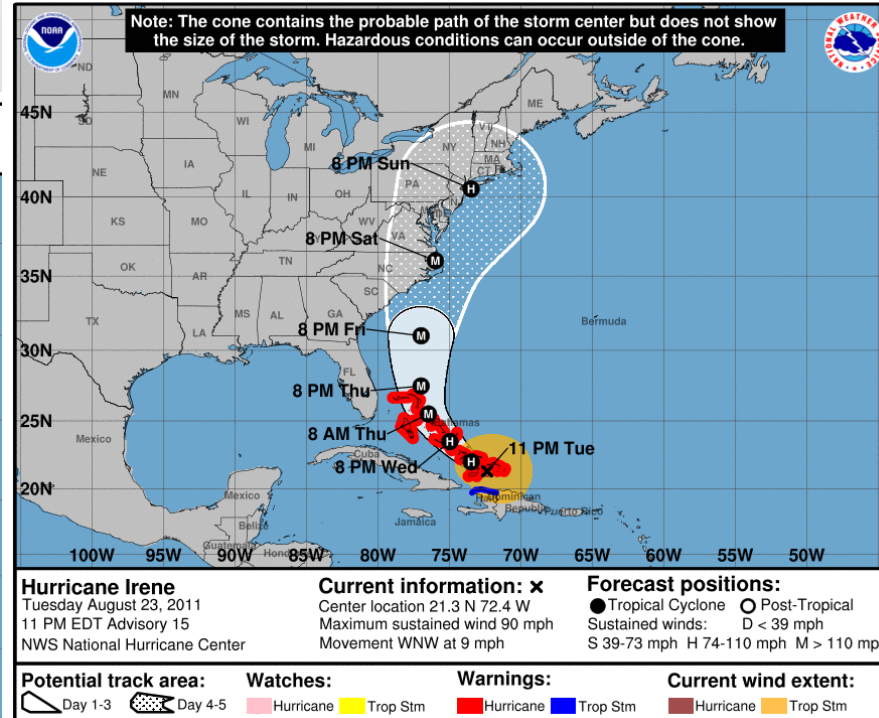
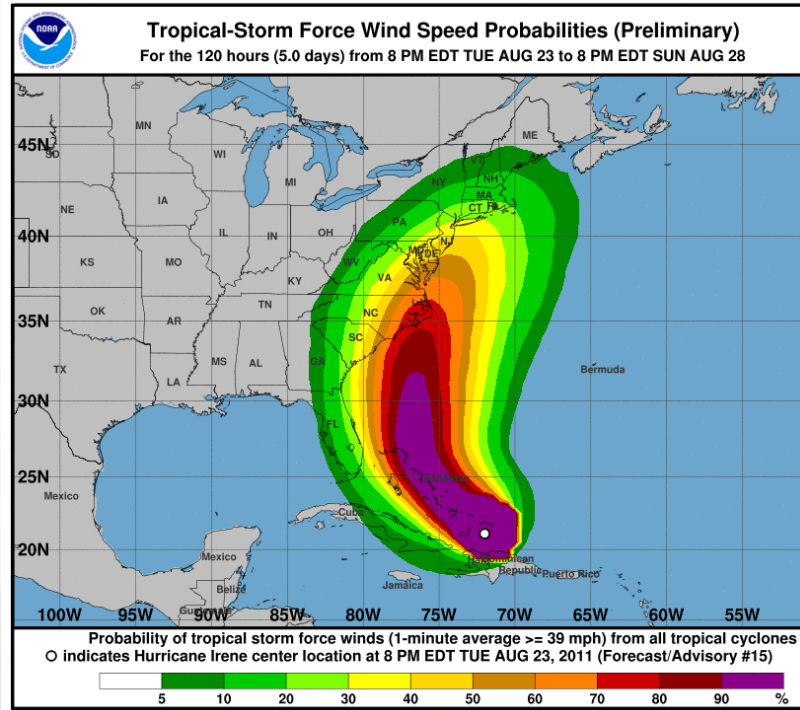


Wind Speed Probabilities



Brad Reinhart
National Hurricane Center
2024 WMO Course

Review the cone of uncertainty for Hurricane Irene. Where will Hurricane Irene be located five days from now? Click the location on the map.



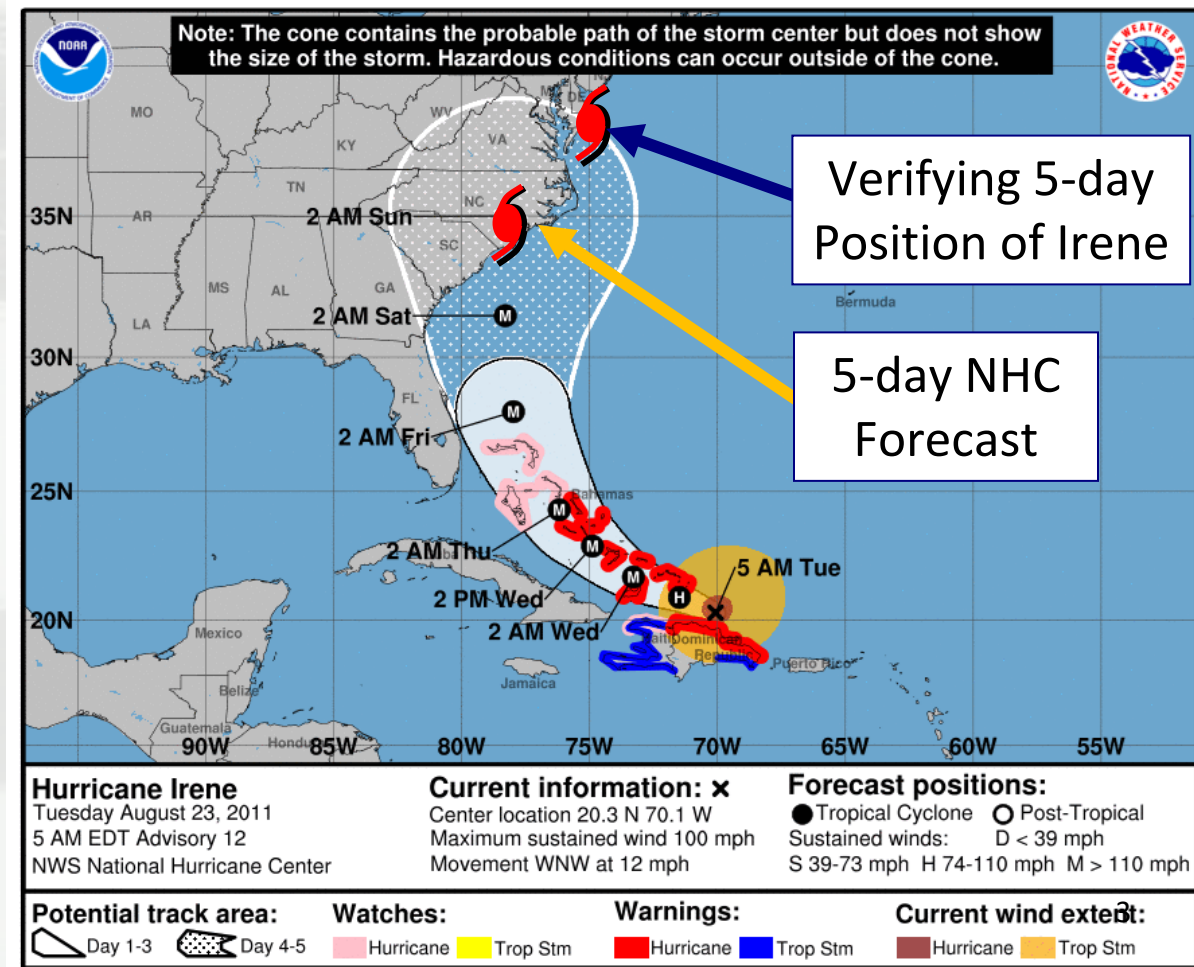
WIND SPEED PROBABILITIES

A Tool to Deal with Uncertainty

Hurricane Irene
Advisory Number 12

Issued 5:00 AM EDT
23 August 2011

5-day position error
about 270 miles

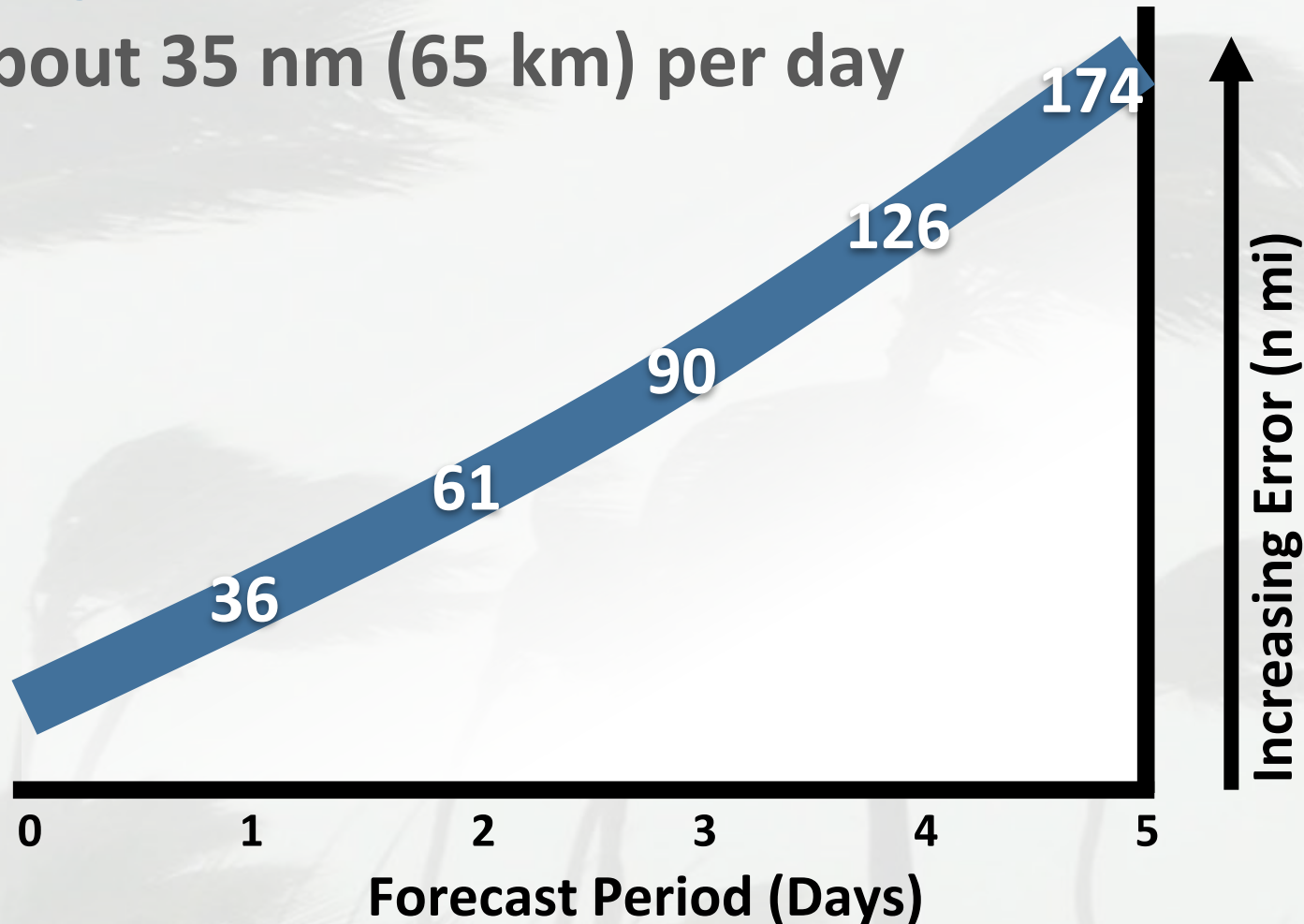


FORECAST TRACK ERRORS

NHC 5-year Averages

TRACK ERRORS

Increase by about 35 nm (65 km) per day

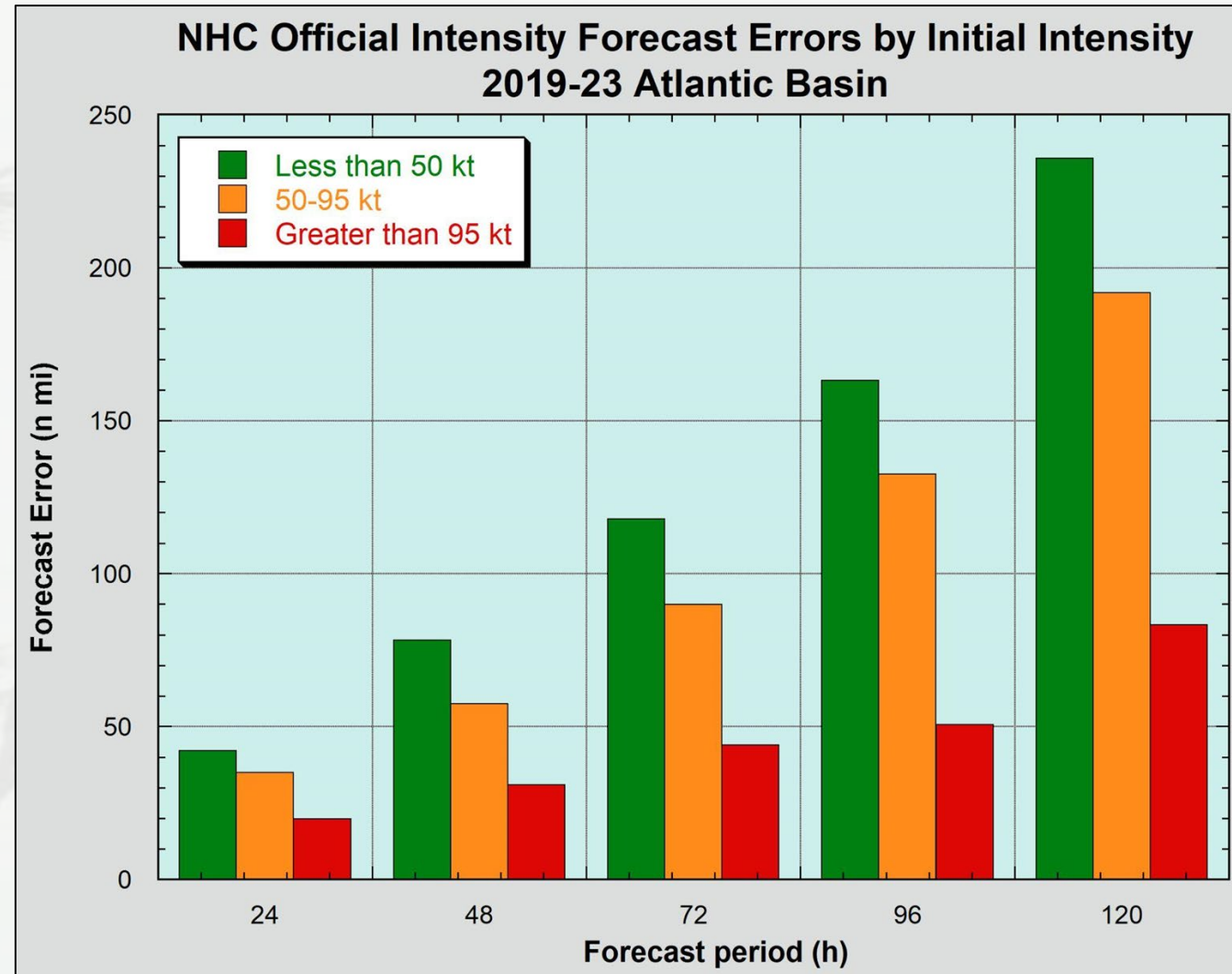


FORECAST TRACK ERRORS

Based on Initial Intensity

More Uncertainty for Tropical Depressions and Weaker Tropical Storms

Track errors for TDs and weaker TSs increase by 40 n mi per day vs. about 25 to 30 n mi per day for stronger storms.

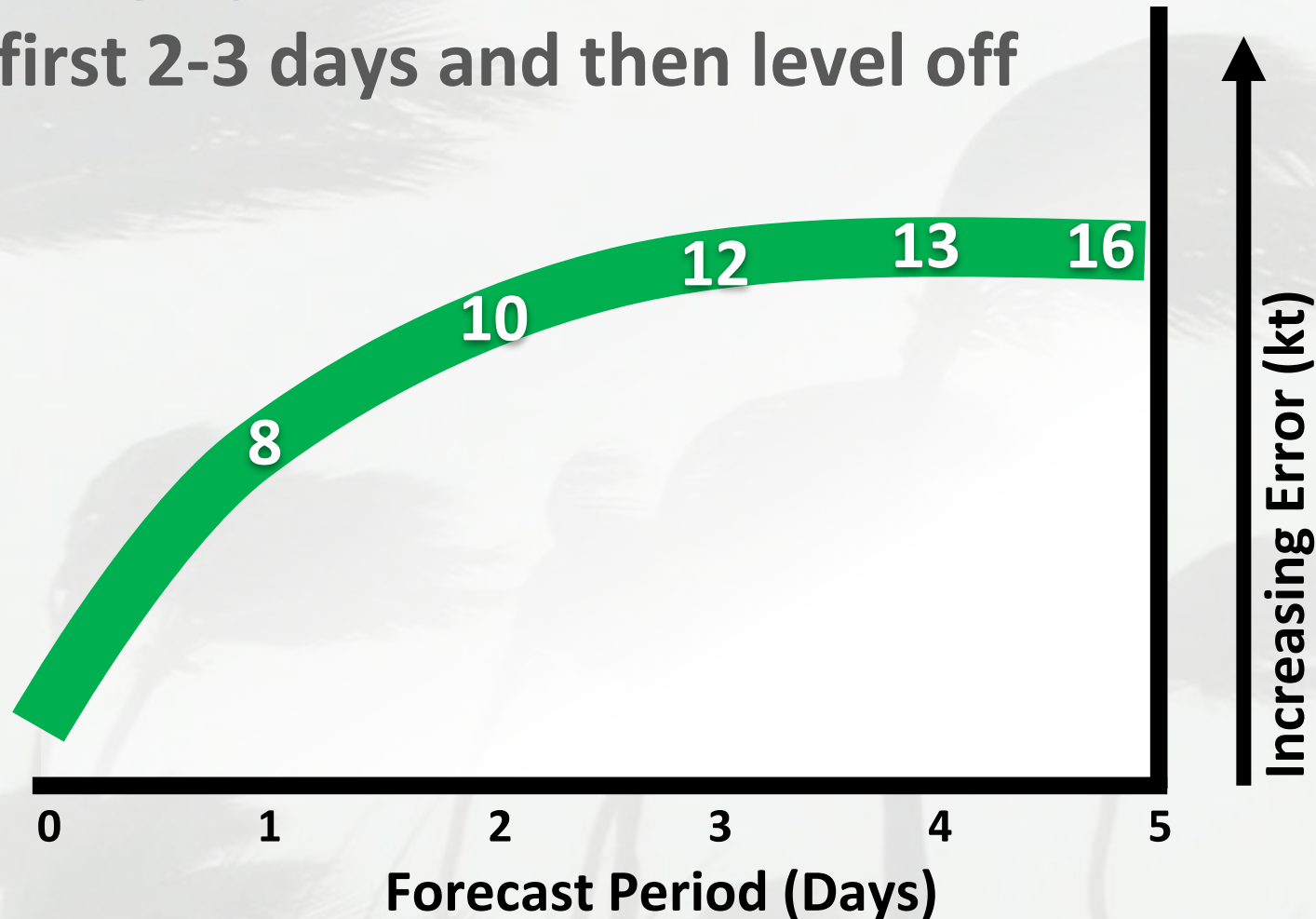


FORECAST INTENSITY ERRORS

NHC 5-year Averages

INTENSITY ERRORS

Increase the first 2-3 days and then level off

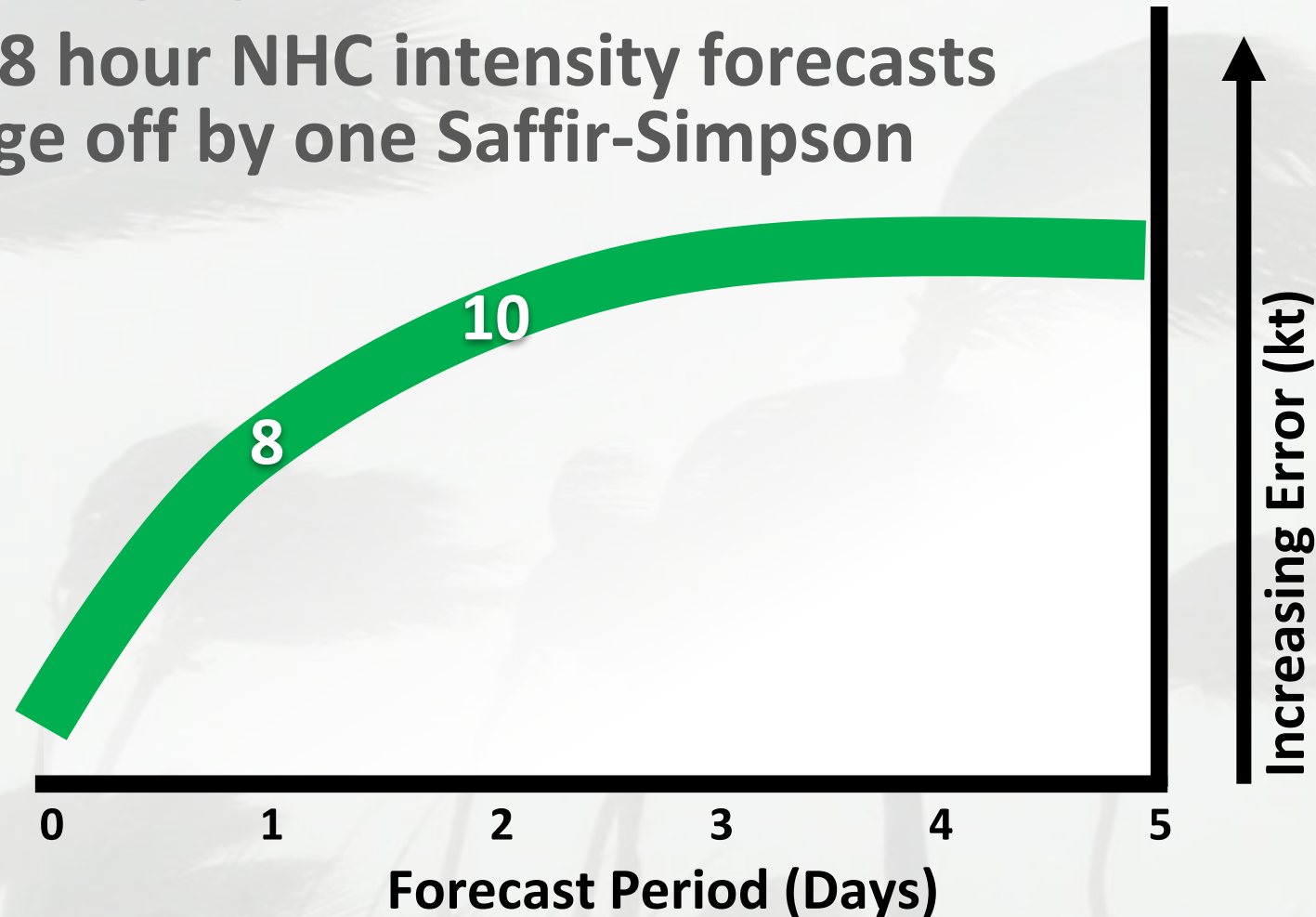


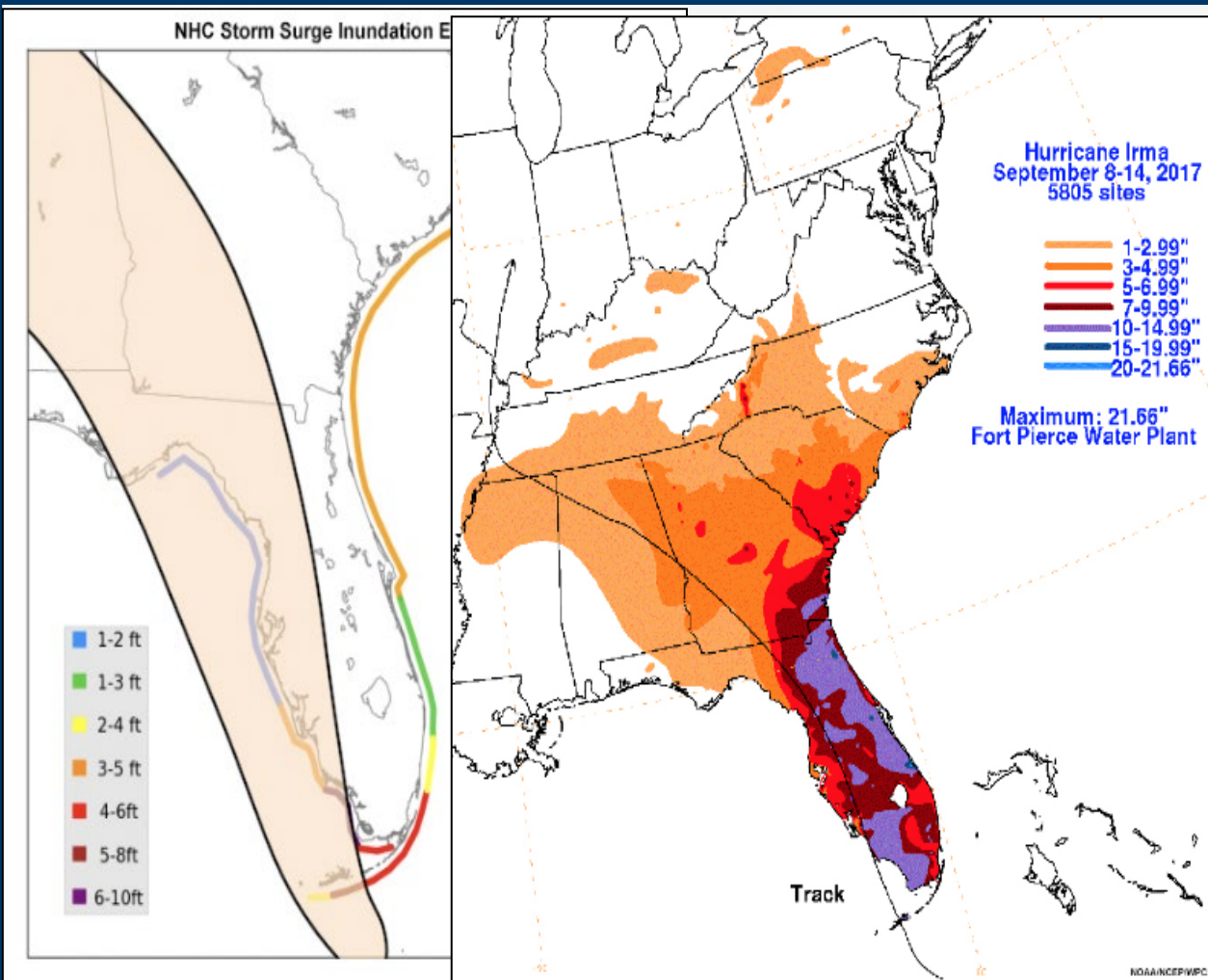
FORECAST INTENSITY ERRORS

NHC 5-year Averages

INTENSITY ERRORS

The 24 and 48 hour NHC intensity forecasts are on average off by one Saffir-Simpson category.





Review the two images of storm surge and rainfall for Hurricane Irma (2017). The storm surge image also shows the cone of uncertainty. Why were hurricane impacts experienced far outside the cone? Select the best answer.

The forecast shown in the cone of uncertainty contained large errors at this time.

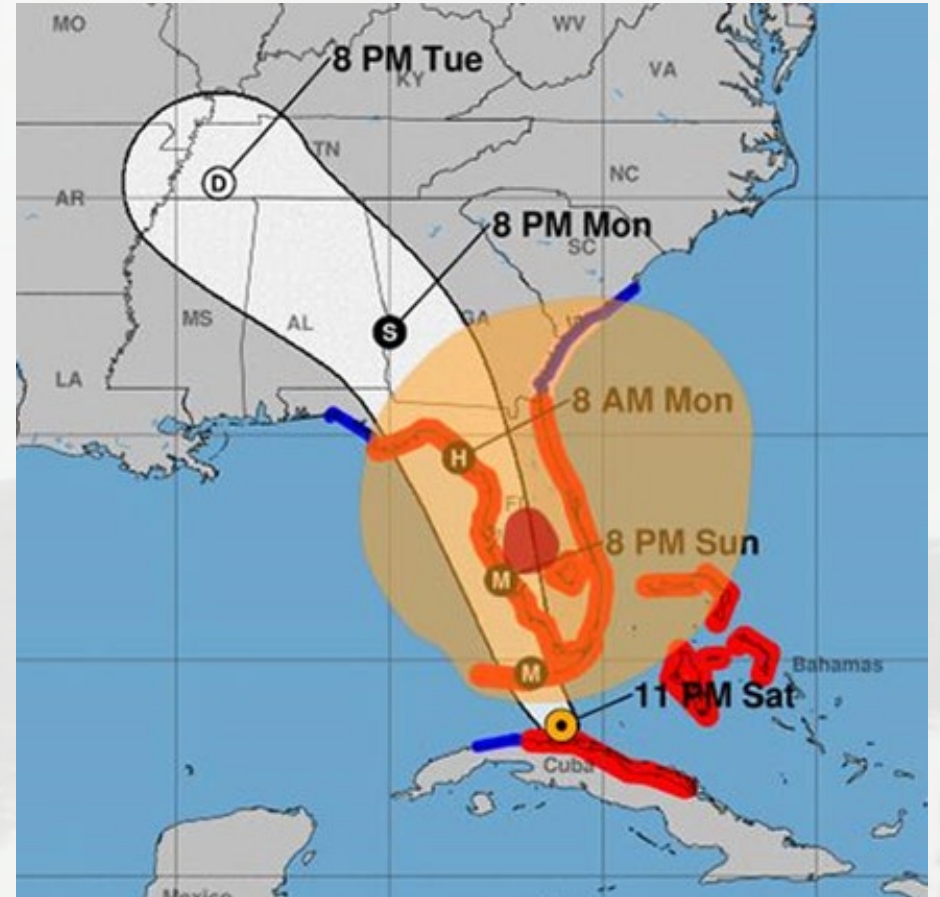
The cone graphic only conveys track forecast uncertainty. 100%

The center of the storm was outside the cone of uncertainty and the impacts were felt well beyond it.

The average track forecast errors are small during the 24 to 48-hr period before landfall.

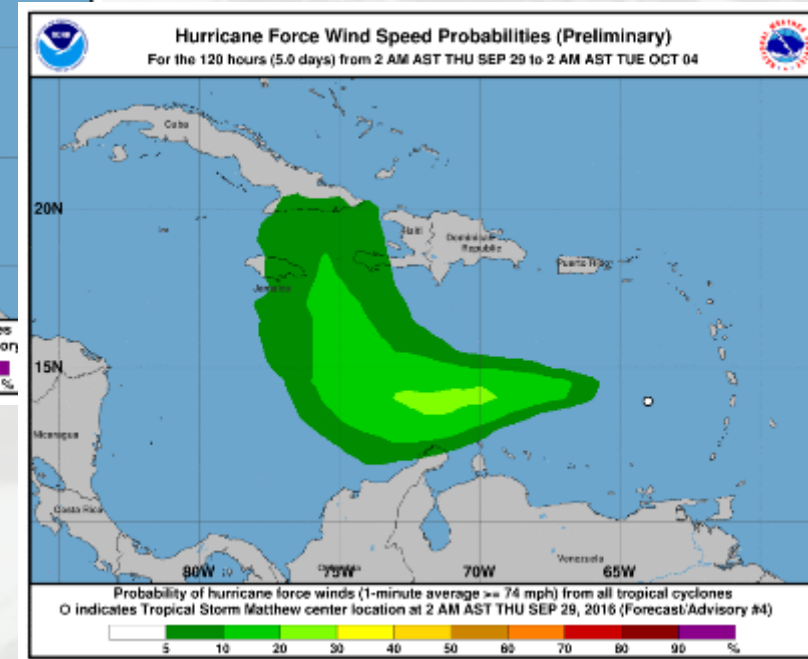
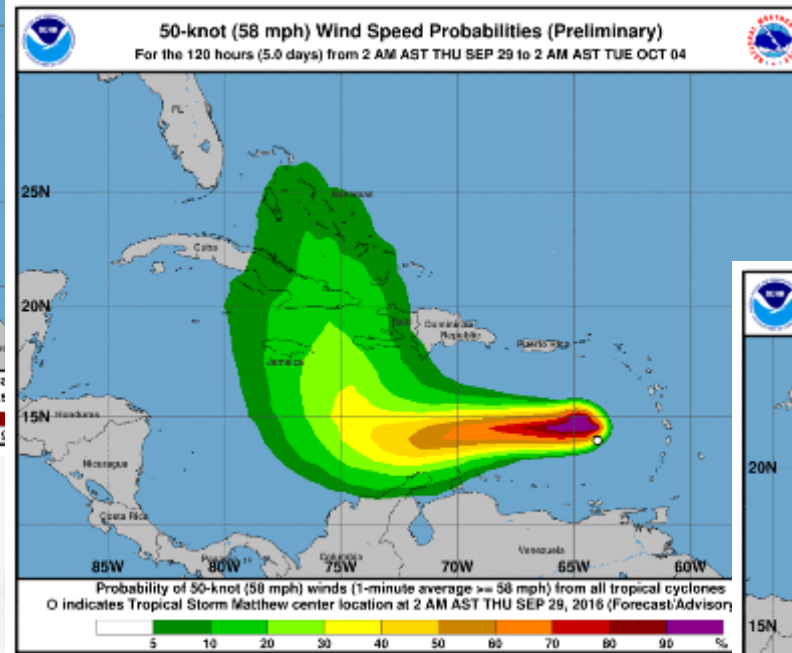
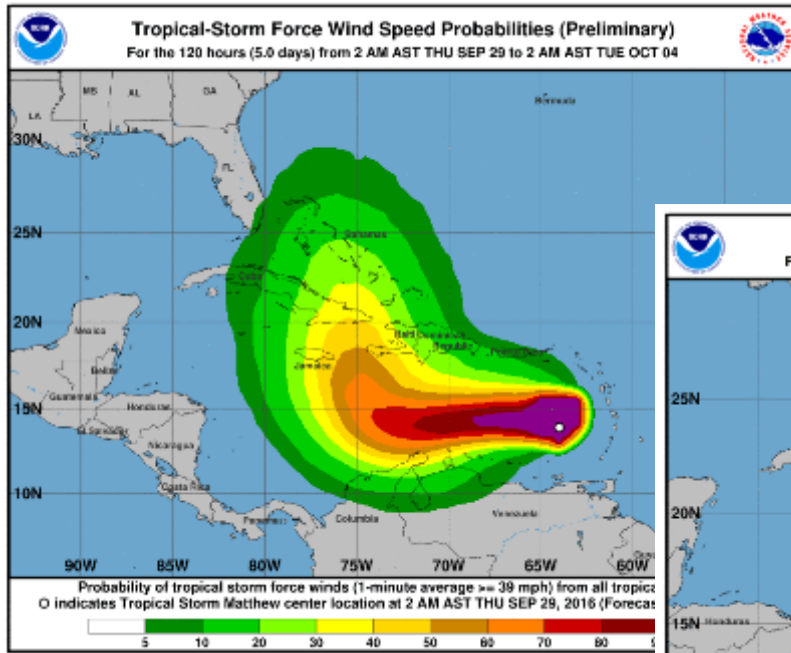
NHC FORECAST CONE

- The cone only displays information about track uncertainty
- It contains no information about specific impacts
- **Tropical Cyclone impacts can occur well outside the area enclosed by the cone**
 - TC center is expected to move outside the cone about 1/3 of the time



WIND SPEED PROBABILITIES

How Likely. Arrival Times. Inland Threat



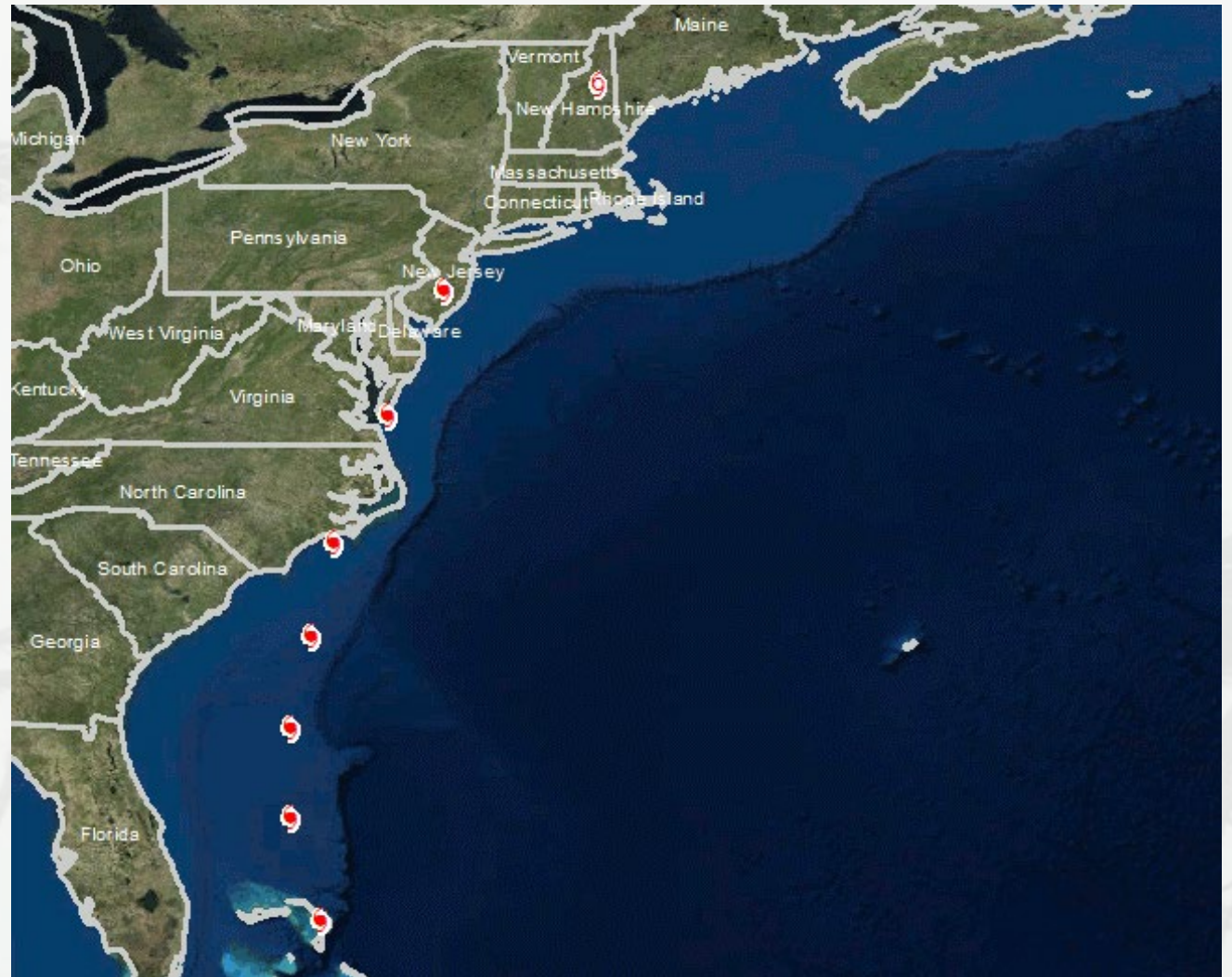
Graphics depict location-specific cumulative probabilities of tropical-storm-force, 50-kt, and hurricane-force winds.

WIND SPEED PROBABILITIES

How are they generated?

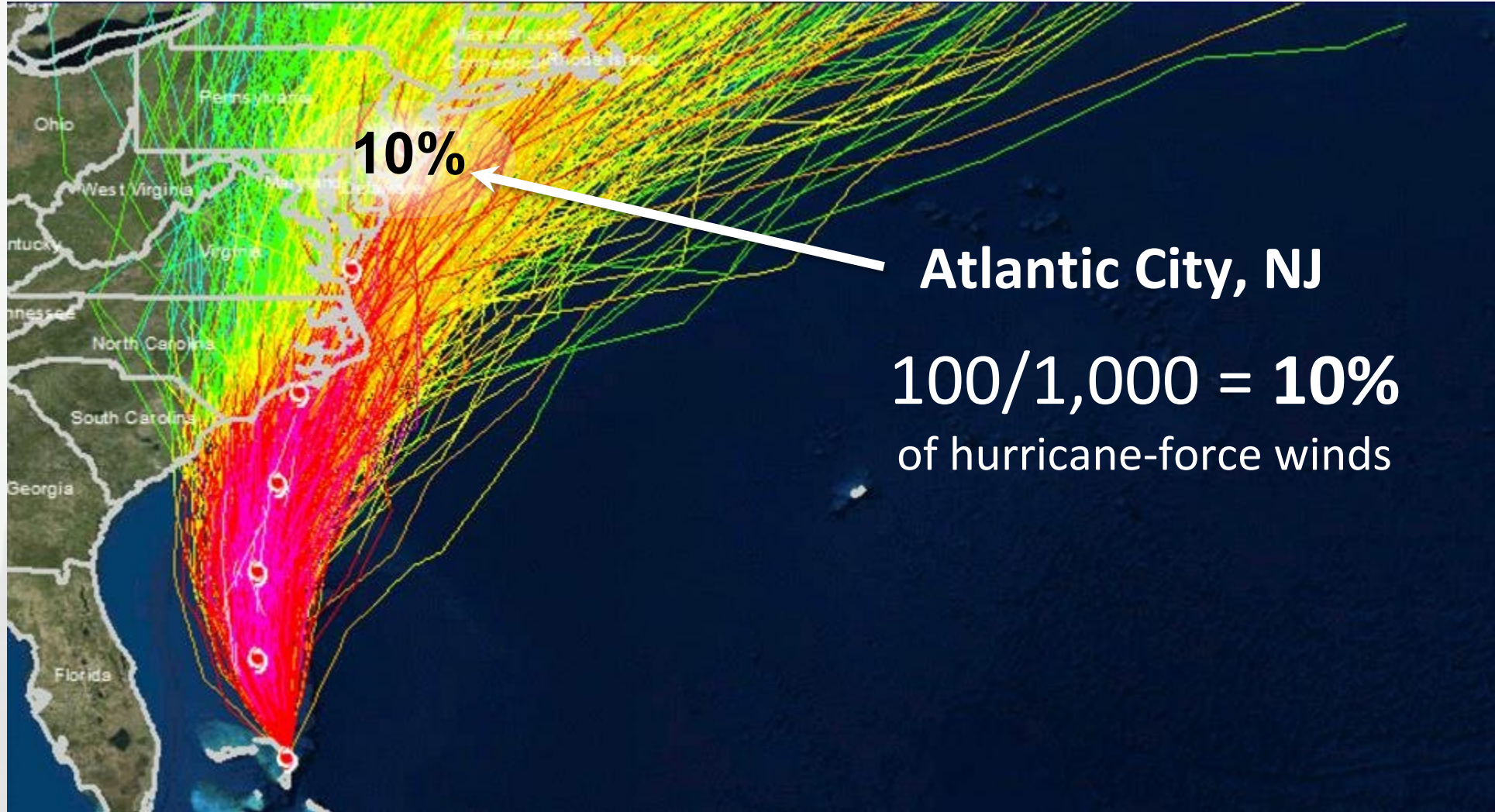
MORE SCENARIOS

- **1,000 realistic alternative scenarios are generated**
 - Official NHC forecast
 - Historical track and intensity forecast errors
- **Weakening over land**
- **Track model spread**
 - Forecast track errors are correlated to the spread of model guidance



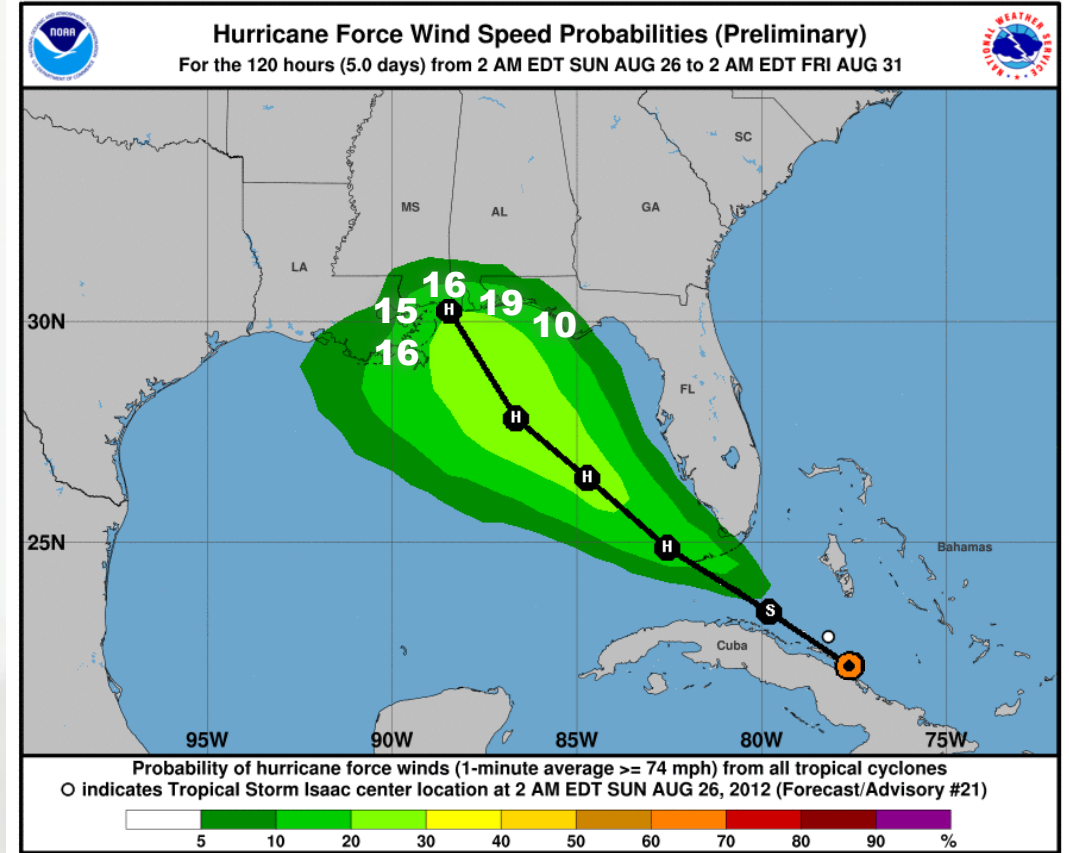
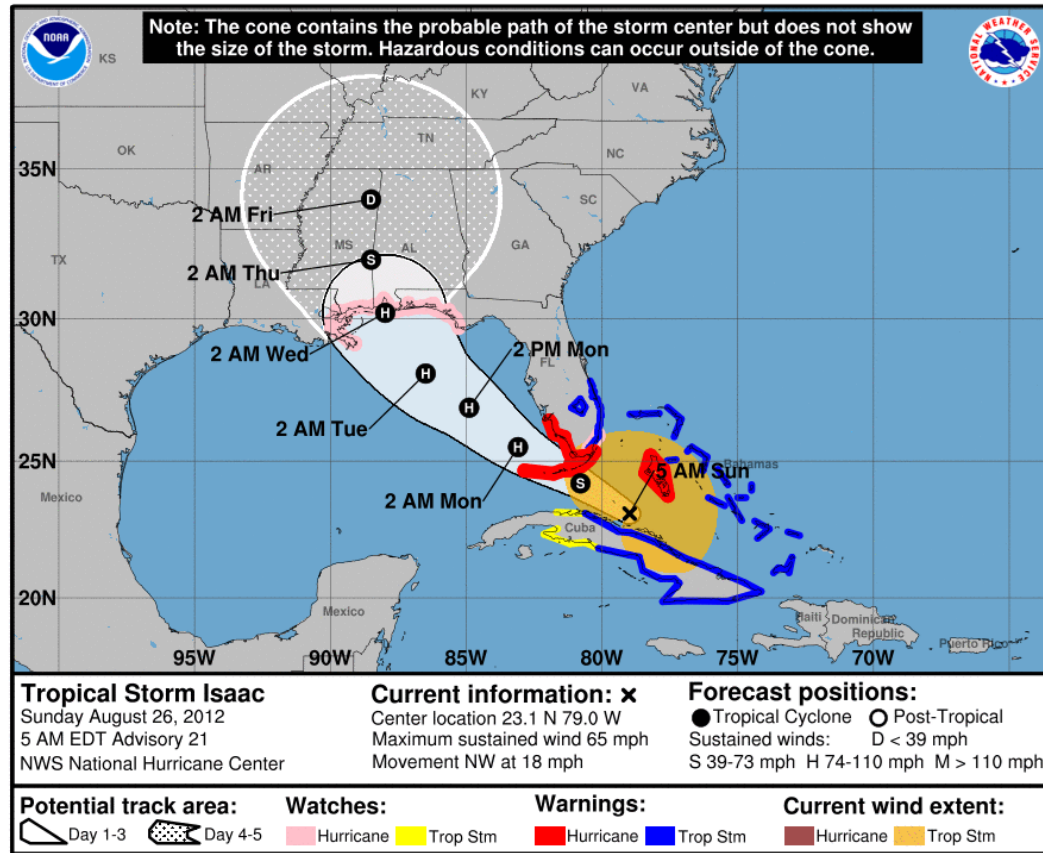
WIND SPEED PROBABILITIES

How are they generated?



WIND SPEED PROBABILITIES

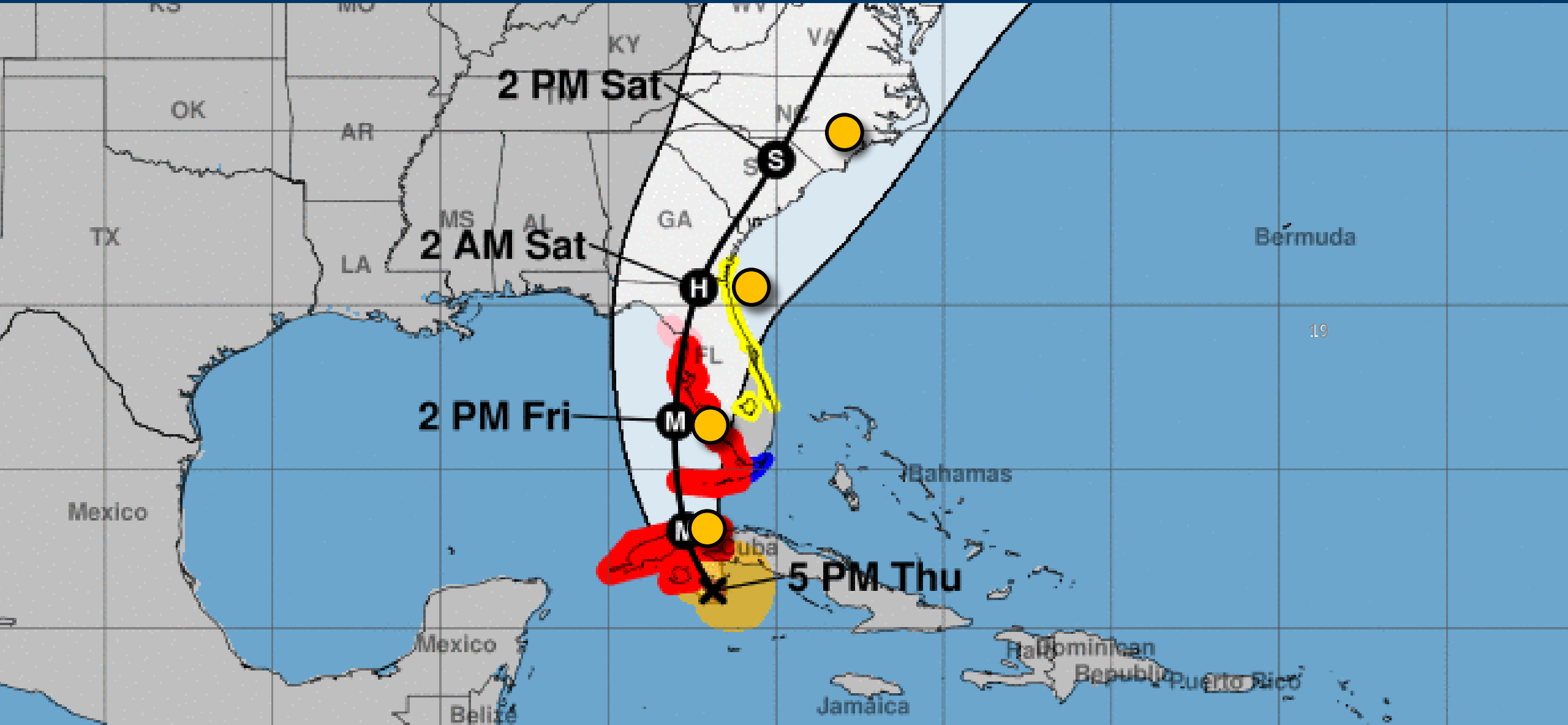
Probabilities vs. The Cone?



Tropical Storm Isaac Advisory 21
 5:00 AM EDT 26 Aug 2012

HURRICANE CHARLEY

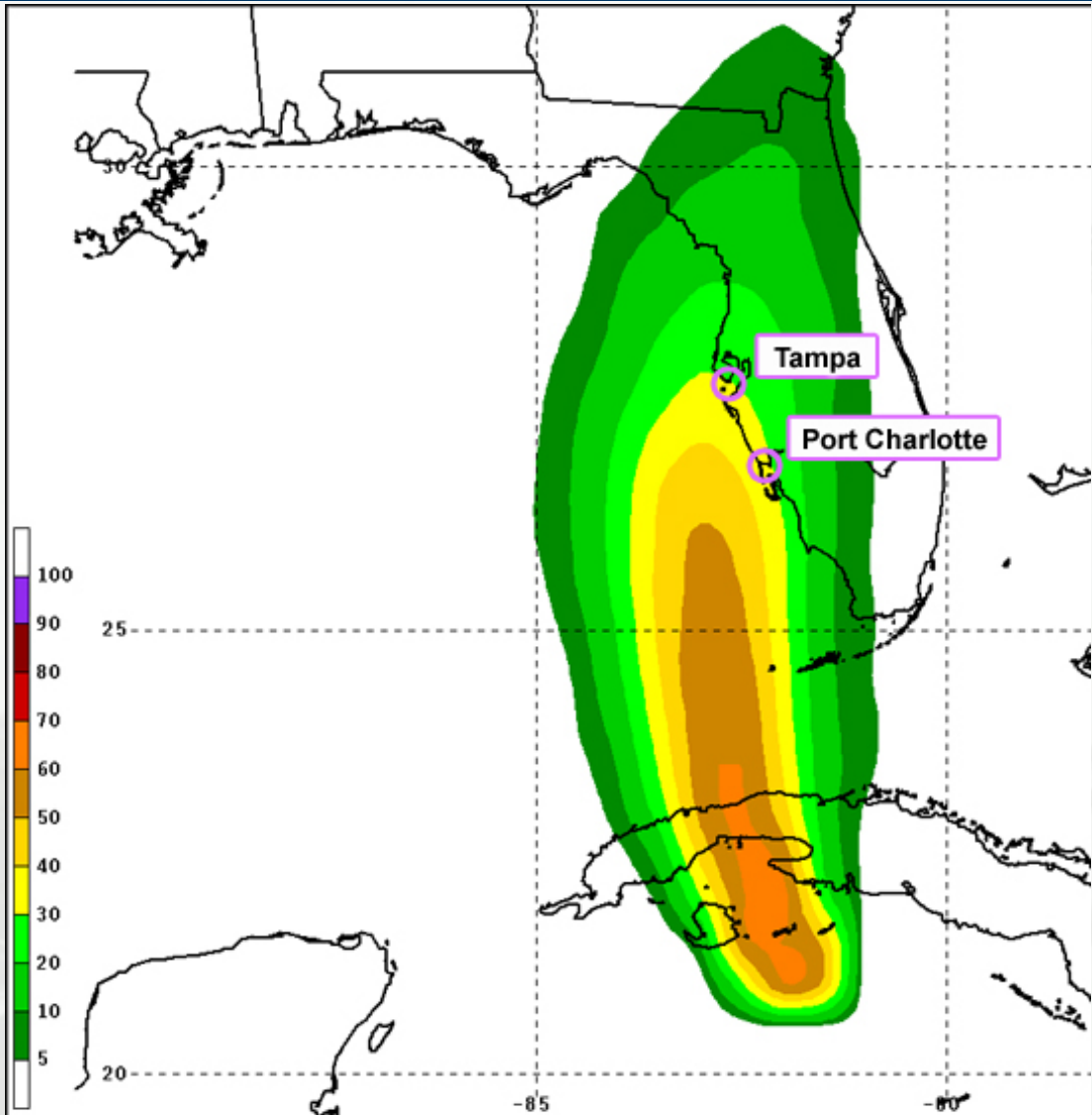
Don't focus on the skinny black line.



HURRICANE CHARLEY

Would alternate scenarios help?





Hurricane Charley 64-kt Wind Probabilities for 5 Days Ending 12 UTC

How will you describe the risk from hurricane-force winds from Hurricane Charley? Select the best answer.

There is a 30-40% chance of hurricane-force winds along the southwest Florida Coast. 0%

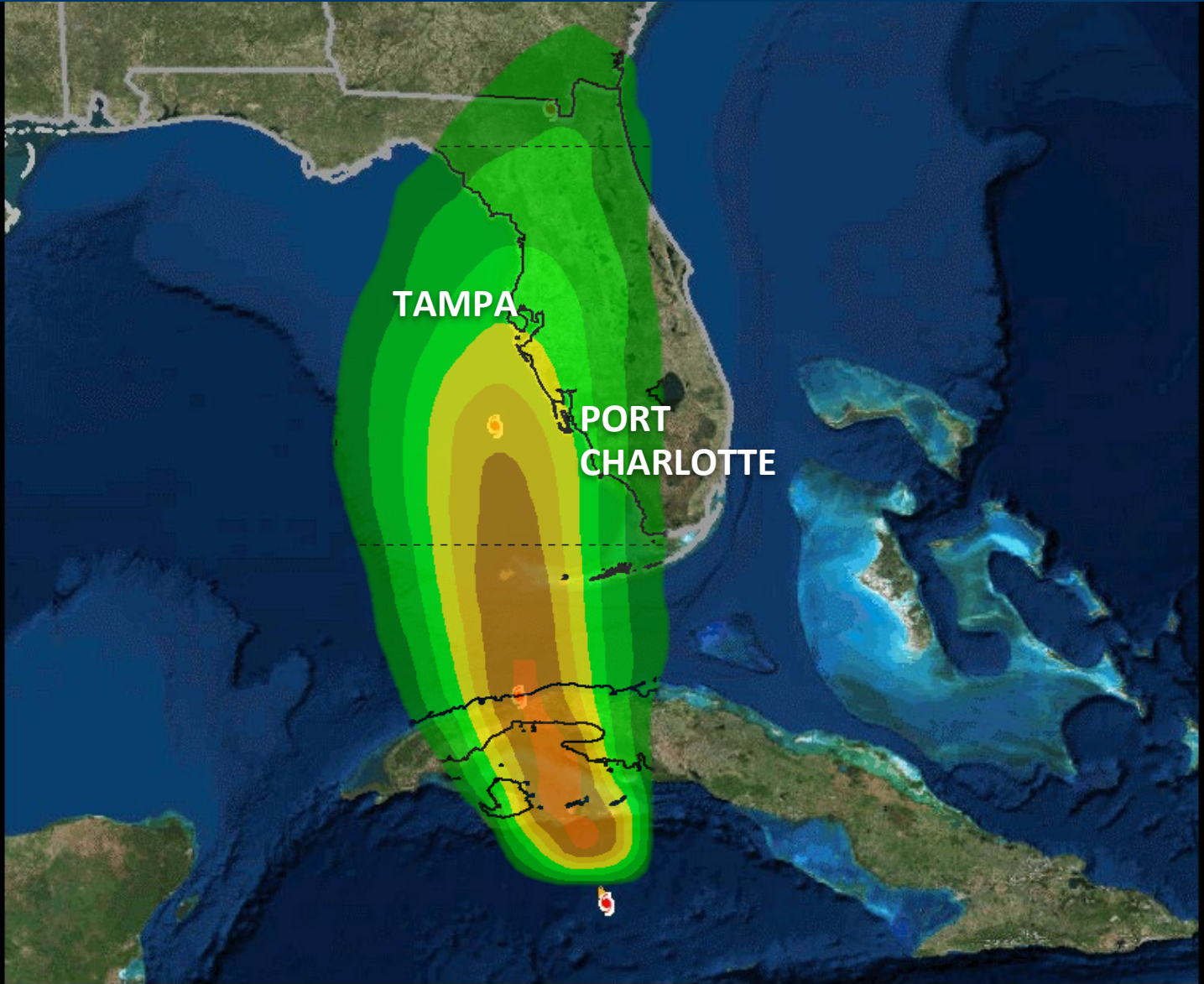
There is a 40-50% chance of hurricane-force winds along the southwest Florida Coast. 0%

There is a 40-50% chance of hurricane-force winds for Tampa and Port Charlotte. 0%

There is a 30-40% chance of hurricane-force winds for Tampa and Port Charlotte. 100%

WIND SPEED PROBABILITIES

Alternate scenarios to understand risk





NATIONAL HURRICANE CENTER

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

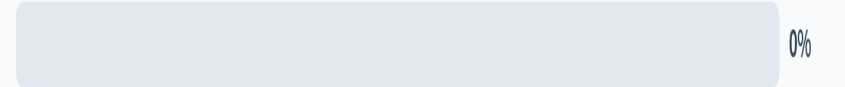
TROPICAL STORM MICHAEL WIND SPEED PROBABILITIES NUMBER 7
NWS NATIONAL HURRICANE CENTER MIAMI FL AL142018
0900 UTC MON OCT 08 2018

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

TIME PERIODS	FROM 06Z MON		FROM 18Z MON		FROM 06Z TUE		FROM 18Z TUE		FROM 06Z WED		FROM 06Z THU		FROM 06Z FRI		
	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO		
	18Z MON	06Z TUE	18Z TUE	06Z WED	06Z THU	06Z FRI	06Z SAT								
FORECAST HOUR	(12)	(24)	(36)	(48)	(72)	(96)	(120)								
LOCATION	KT														
TALLAHASSEE FL 34	X	X (X)	1 (1)	6 (7)	68 (75)	6 (81)	X (81)								
TALLAHASSEE FL 50	X	X (X)	X (X)	1 (1)	41 (42)	6 (48)	X (48)								
TALLAHASSEE FL 64	X	X (X)	X (X)	X (X)	20 (20)	4 (24)	X (24)								
APALACHICOLA 34	X	X (X)	5 (5)	29 (34)	57 (91)	1 (92)	X (92)								
APALACHICOLA 50	X	X (X)	X (X)	6 (6)	59 (65)	2 (67)	X (67)								
APALACHICOLA 64	X	X (X)	X (X)	1 (1)	39 (40)	1 (41)	X (41)								
PANAMA CITY FL 34	X	X (X)	4 (4)	26 (30)	60 (90)	1 (91)	X (91)								
PANAMA CITY FL 50	X	X (X)	X (X)	6 (6)	57 (63)	1 (64)	X (64)								
PANAMA CITY FL 64	X	X (X)	X (X)	1 (1)	37 (38)	X (38)	X (38)								

When are tropical-storm-force winds at Tallahassee, FL most likely to begin? Select the best answer.

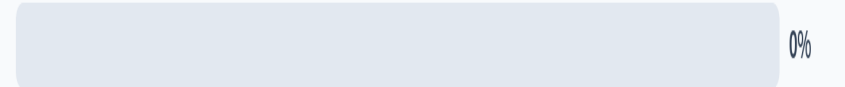
Between forecast hour 36 and 48



Between forecast hour 48 and 72



Between forecast hour 72 and 96



WIND SPEED PROBABILITIES

Text Product



TROPICAL STORM MICHAEL WIND SPEED PROBABILITIES NUMBER 7
 NWS NATIONAL HURRICANE CENTER MIAMI FL AL142018
 0900 UTC MON OCT 08 2018

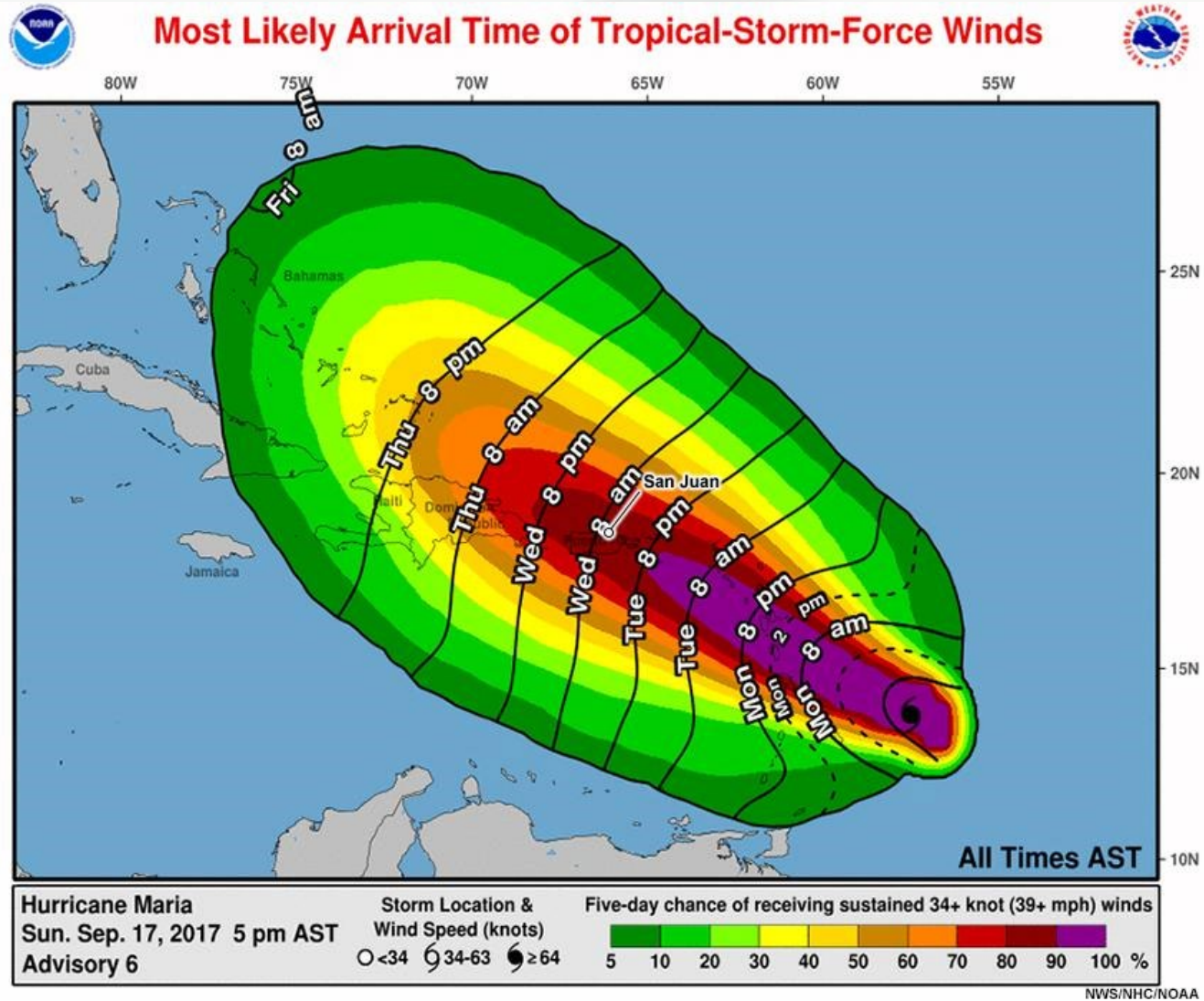
- - - - WIND SPEED PROBABILITIES FOR SELECTED LOCATIONS - - - -

TIME PERIODS	FROM 06Z MON TO 18Z MON	FROM 18Z MON TO 06Z TUE	FROM 06Z TUE TO 18Z TUE	FROM 18Z TUE TO 06Z WED	FROM 06Z WED TO 06Z THU	FROM 06Z THU TO 06Z FRI	FROM 06Z FRI TO 06Z SAT
FORECAST HOUR	(12)	(24)	(36)	(48)	(72)	(96)	(120)
LOCATION	KT						
TALLAHASSEE FL 34	X	X (X)	1 (1)	6 (7)	68 (75)	6 (81)	X (81)
TALLAHASSEE FL 50	X	X (X)	X (X)	1 (1)	41 (42)	6 (48)	X (48)
TALLAHASSEE FL 64	X	X (X)	X (X)	X (X)	20 (20)	4 (24)	X (24)
APALACHICOLA 34	X	X (X)	5 (5)	29 (34)	57 (91)	1 (92)	X (92)
APALACHICOLA 50	X	X (X)	X (X)	6 (6)	59 (65)	2 (67)	X (67)
APALACHICOLA 64	X	X (X)	X (X)	1 (1)	39 (40)	1 (41)	X (41)
PANAMA CITY FL 34	X	X (X)	4 (4)	26 (30)	60 (90)	1 (91)	X (91)
PANAMA CITY FL 50	X	X (X)	X (X)	6 (6)	57 (63)	1 (64)	X (64)
PANAMA CITY FL 64	X	X (X)	X (X)	1 (1)	37 (38)	X (38)	X (38)

Location-Specific Probabilities

- Tropical-Storm-Force
- 58 mph
- Hurricane-Force

You are providing a briefing to the emergency managers on the potential onset of tropical-storm-force winds for San Juan, Puerto Rico. To ensure that the emergency managers have completed preparations before the onset of the winds, which graphic would you use to describe the period of onset? Choose the best answer.

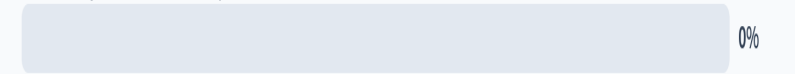


To ensure that the emergency managers have completed preparations before the onset of the winds, which graphic would you use to describe the period of onset? Choose the best answer.

Earliest Reasonable Arrival Time of Tropical-Storm-Force Winds



Most Likely Arrival Time of Tropical-Storm-Force Winds



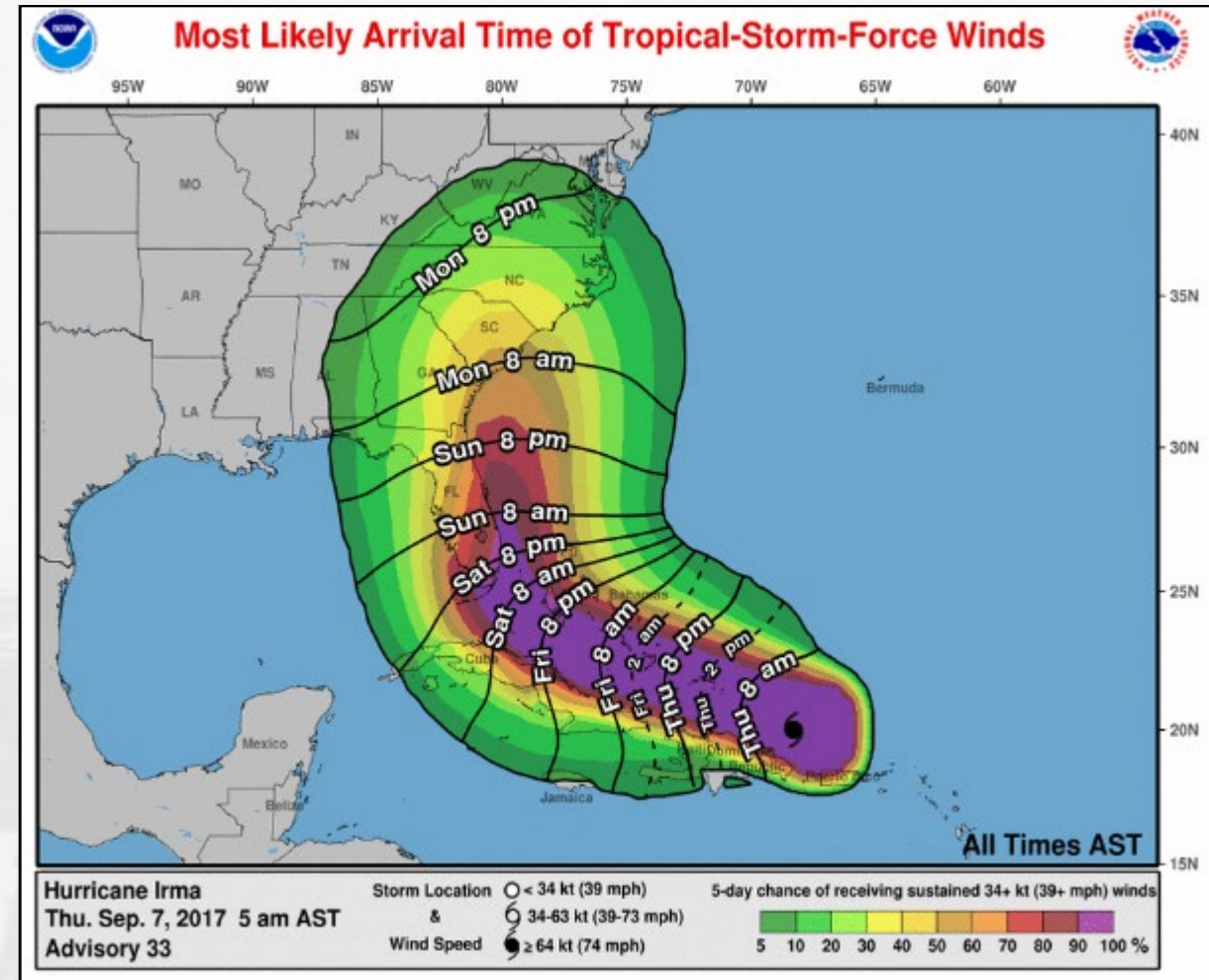
Both



TIME OF ARRIVAL OF TS-FORCE WINDS

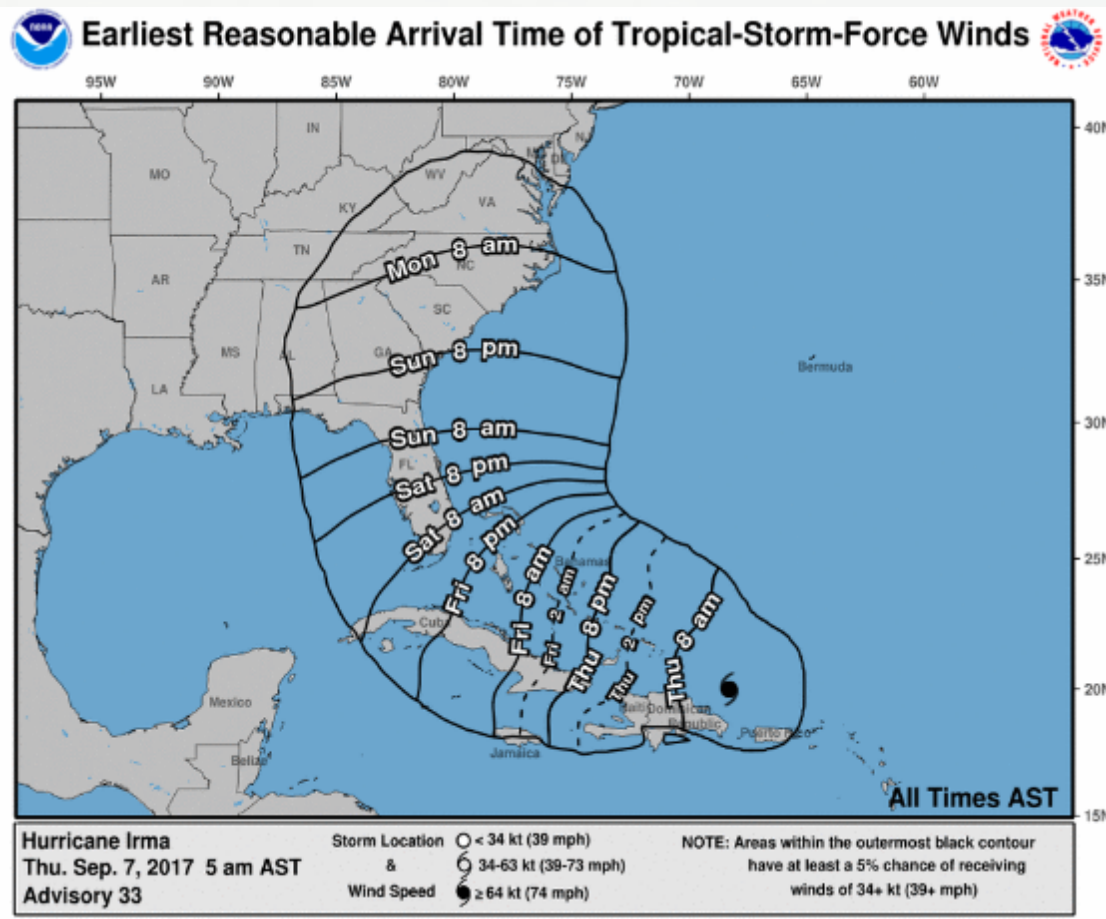
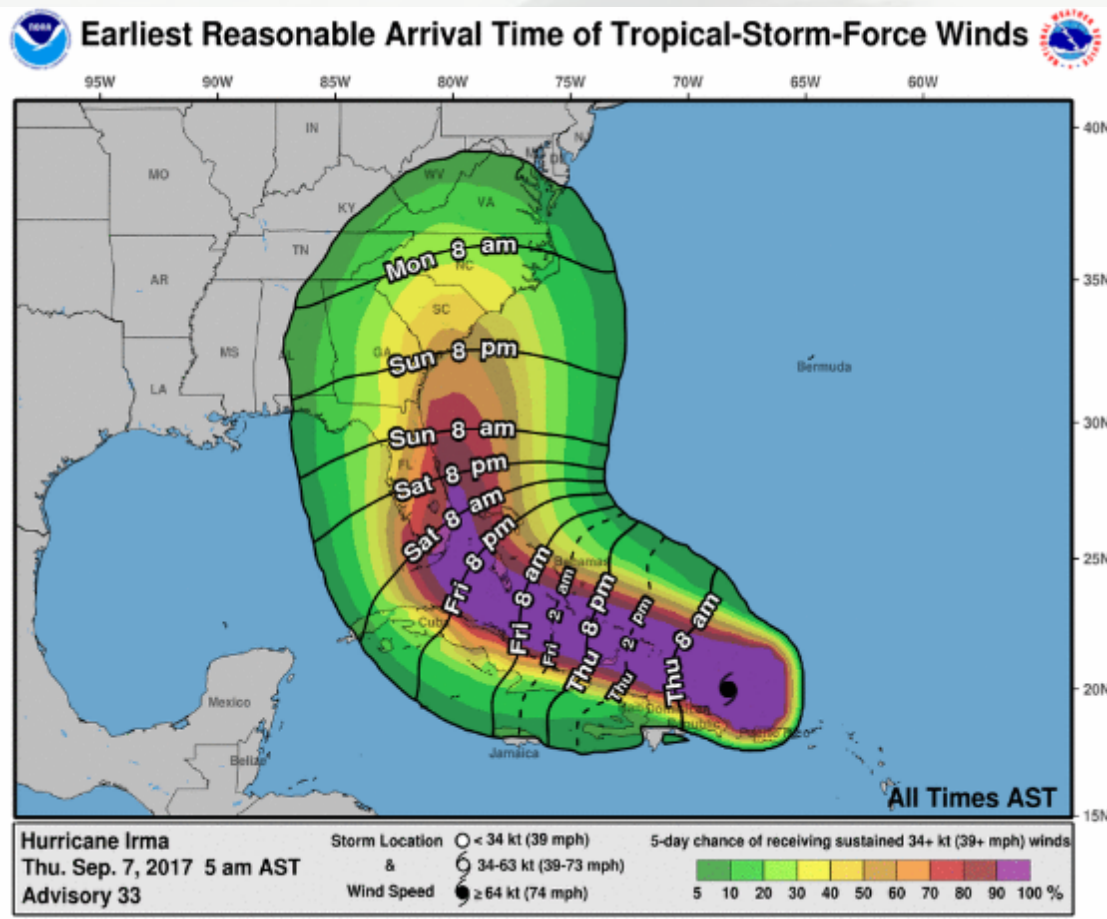
Information on Arrival of Wind Hazard

- Separate graphics provide most likely and earliest reasonable arrival times of TS-force winds
- Accounts for typical track, intensity, and size uncertainty
- **Provides time when preparations should be complete**
- **Earliest Reasonable** - best for users with low tolerance for risk
- **Most Likely** - equal chances of the winds beginning before or after that time



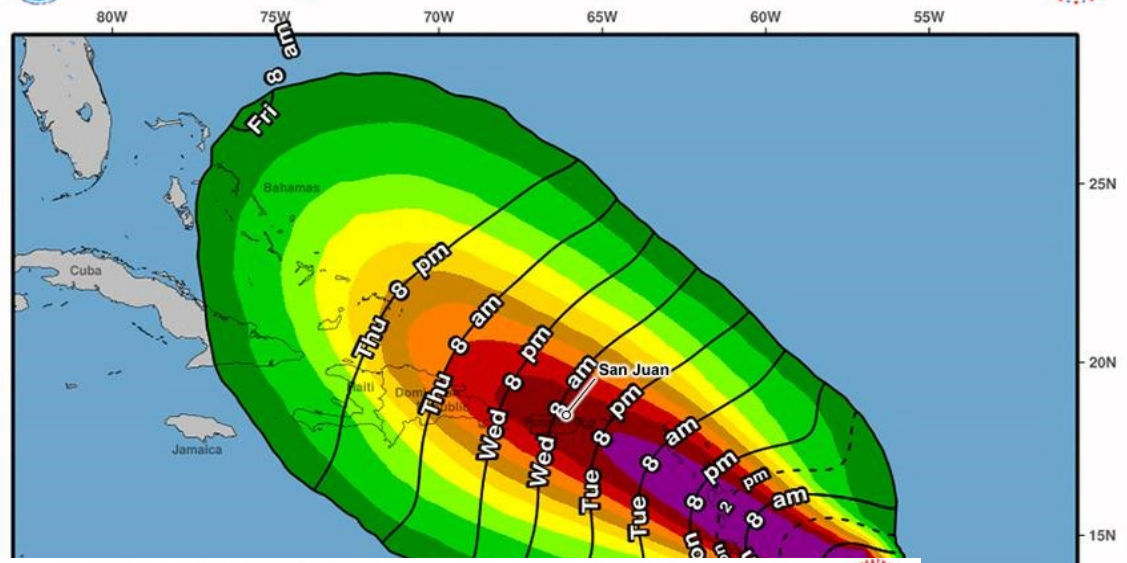
TIME OF ARRIVAL OF TS-FORCE WINDS

Versions of the graphics with and without location specific wind speed probabilities

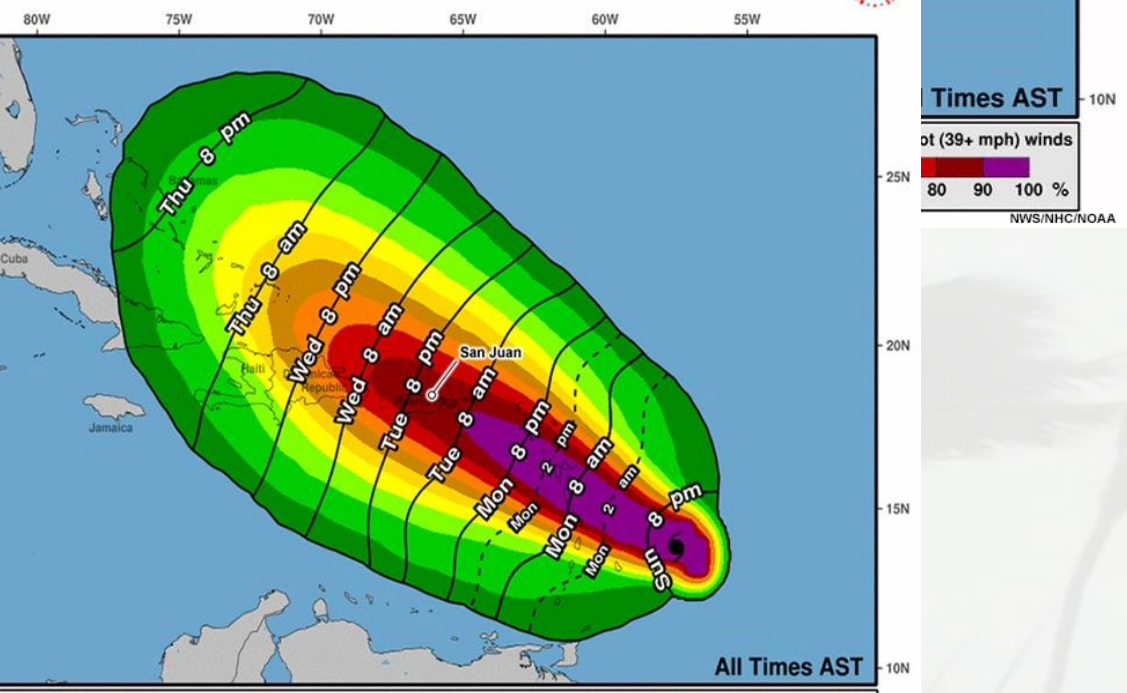




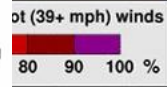
Most Likely Arrival Time of Tropical-Storm-Force Winds



Earliest Reasonable Arrival Time of Tropical-Storm-Force Winds



Times AST



NWS/NHC/NOAA

Hurricane Maria
Sun. Sep. 17, 2017 5 pm AST
Advisory 6

Storm Location & Wind Speed (knots)
○ <34 ○ 34-63 ● ≥64

Five-day chance of receiving sustained 34+ knot (39+ mph) winds
5 10 20 30 40 50 60 70 80 90 100 %

NWS/NHC/NOAA

Which of the following statements will you use to describe the probability of San Juan experiencing tropical-storm-force winds? When could these winds arrive? Choose the best answer.



There is an 80-90% chance of tropical-storm-force winds in San Juan. These winds are most likely to arrive at 8 AM AST on Wednesday, but could arrive as early as 5 PM AST on Tuesday.

There is a 80-90% chance of tropical-storm-force winds in San Juan. These winds are most likely to arrive before daybreak Wednesday, but could arrive as early as late afternoon Tuesday.

There is a 90-100% chance of tropical-storm-force winds in San Juan. These winds are most likely to arrive around 8 AM AST on Wednesday, but could arrive as early as 8 PM AST on Tuesday night.

There is an 90-100% chance of tropical-storm-force winds in San Juan. These winds are most likely to arrive Tuesday evening (around 8 PM AST), but could arrive as early as Tuesday morning (around 8 AM AST).

WIND TIMING UNCERTAINTY

Importance and Causes

WIND TIMING

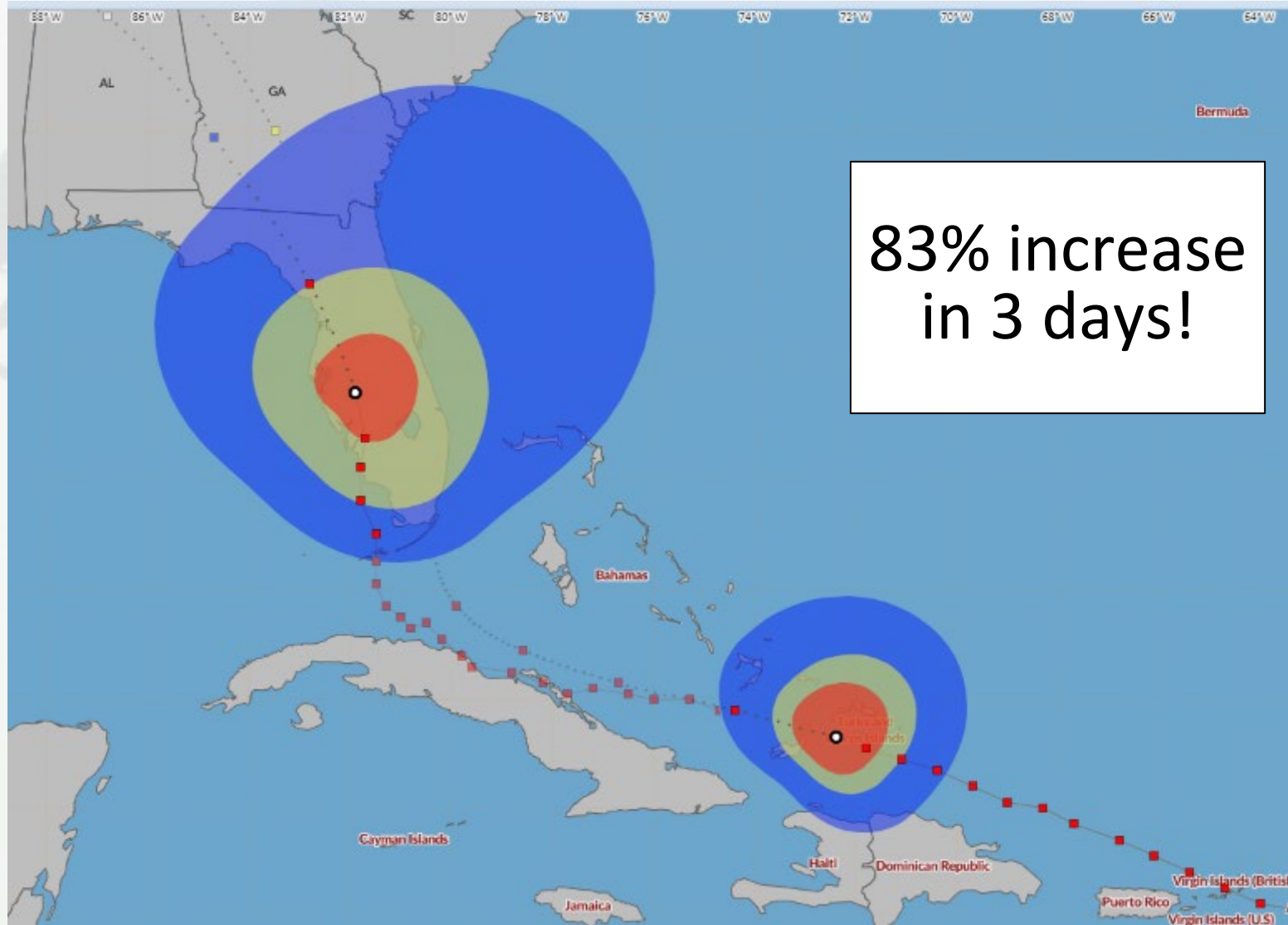
Critical for preparedness and evacuation decision making

- **Major sources of uncertainty in wind timing:**
 - **Track** – Forward speed, direction of motion, and location of center relative to given location
 - **Storm Size** – How far will TS winds extend from the center? Difficult to forecast and highly variable
- **Time of Arrival graphics designed to account for uncertainty in arrival of TS-force winds and provide timing information**



WIND TIMING UNCERTAINTY

Importance and Causes



WIND TIMING UNCERTAINTY

Current product limitations

TIME OF ARRIVAL

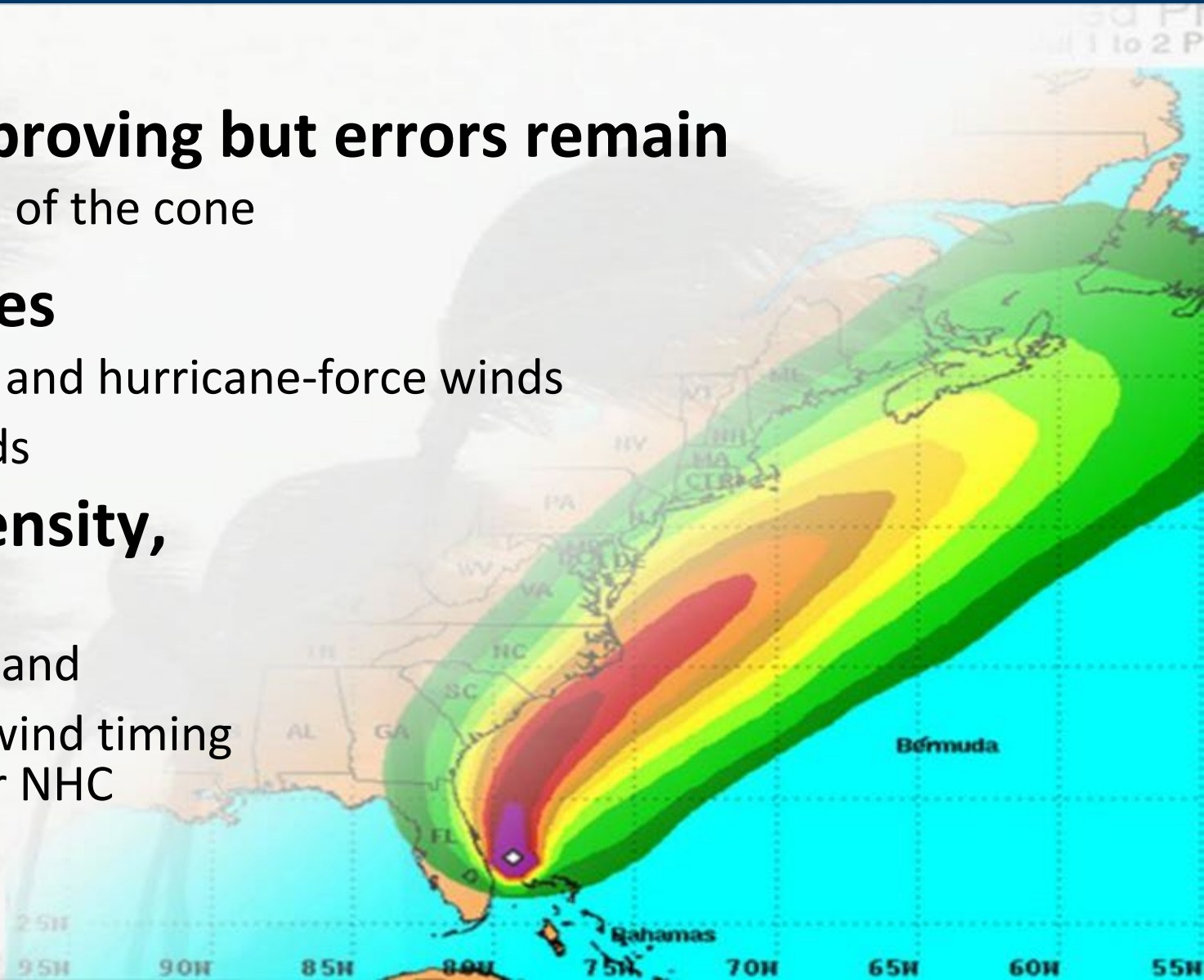
Current Time of Arrival (TOA) products have some limitations:

- **Storms that stall or move very slowly (<5 mph)**
 - TOA products can show much earlier onset times than what is conveyed in the official forecast (e.g., Dorian)
- **Storms with much larger/smaller than typical wind fields**
 - TOA products will not handle the timing of these storms well, especially beyond the first 24-36 hours.

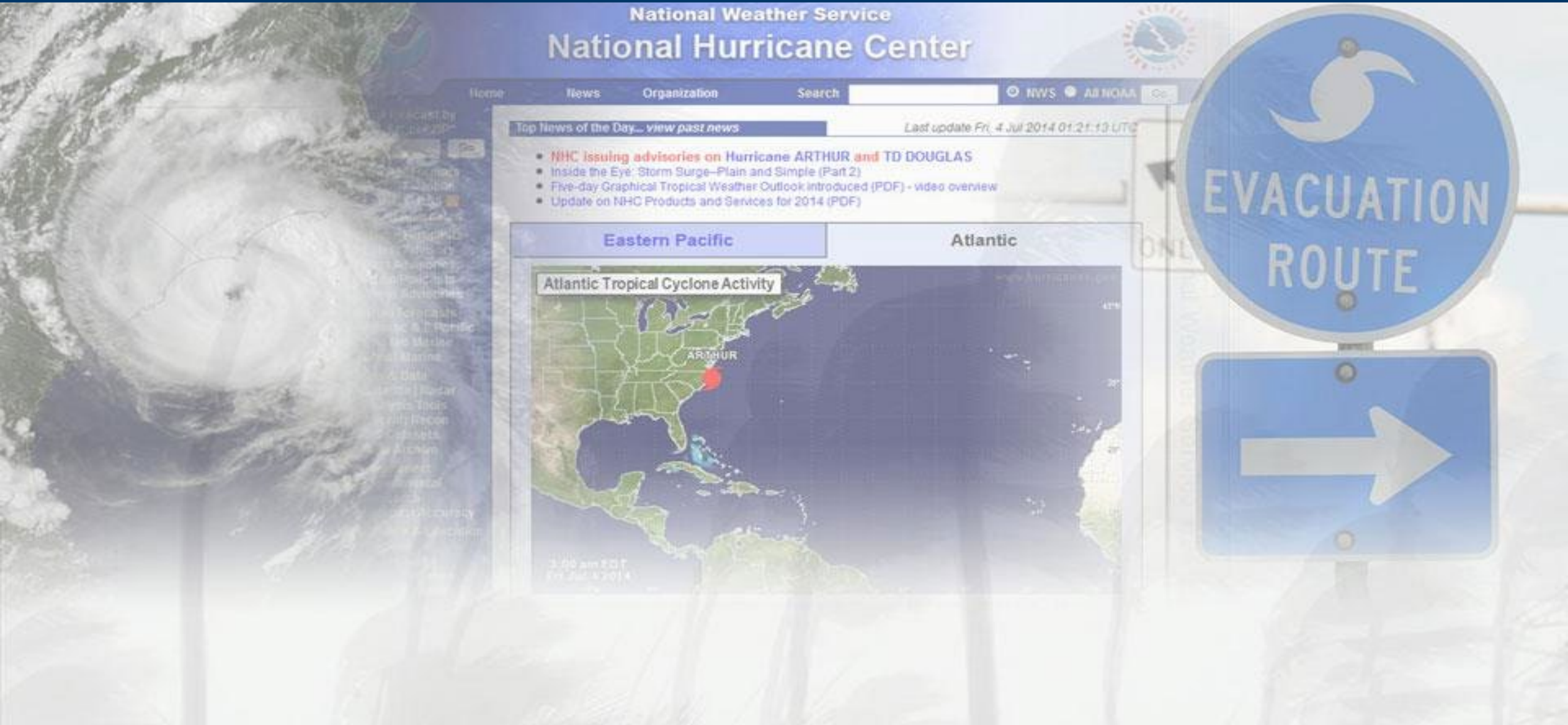
WIND SPEED PROBABILITIES

Summary

- **NHC's forecasts are improving but errors remain**
 - Impacts often occur outside of the cone
- **Wind speed probabilities**
 - Likelihood of tropical storm and hurricane-force winds
 - Onset timing of wind hazards
- **Incorporates track, intensity, and size uncertainty**
 - Includes weakening due to land
 - Provides an assessment of wind timing and threat that accounts for NHC forecast errors



Questions/Comments?



National Weather Service National Hurricane Center

Home News Organization Search [] NWS All NOAA []

Top News of the Day... view past news Last update Fri, 4 Jul 2014 01:21:13 UTC

- **NHC Issuing advisories on Hurricane ARTHUR and TD DOUGLAS**
- Inside the Eye: Storm Surge—Plain and Simple (Part 2)
- Five-day Graphical Tropical Weather Outlook introduced (PDF) - video overview
- Update on NHC Products and Services for 2014 (PDF)

Eastern Pacific

Atlantic

Atlantic Tropical Cyclone Activity

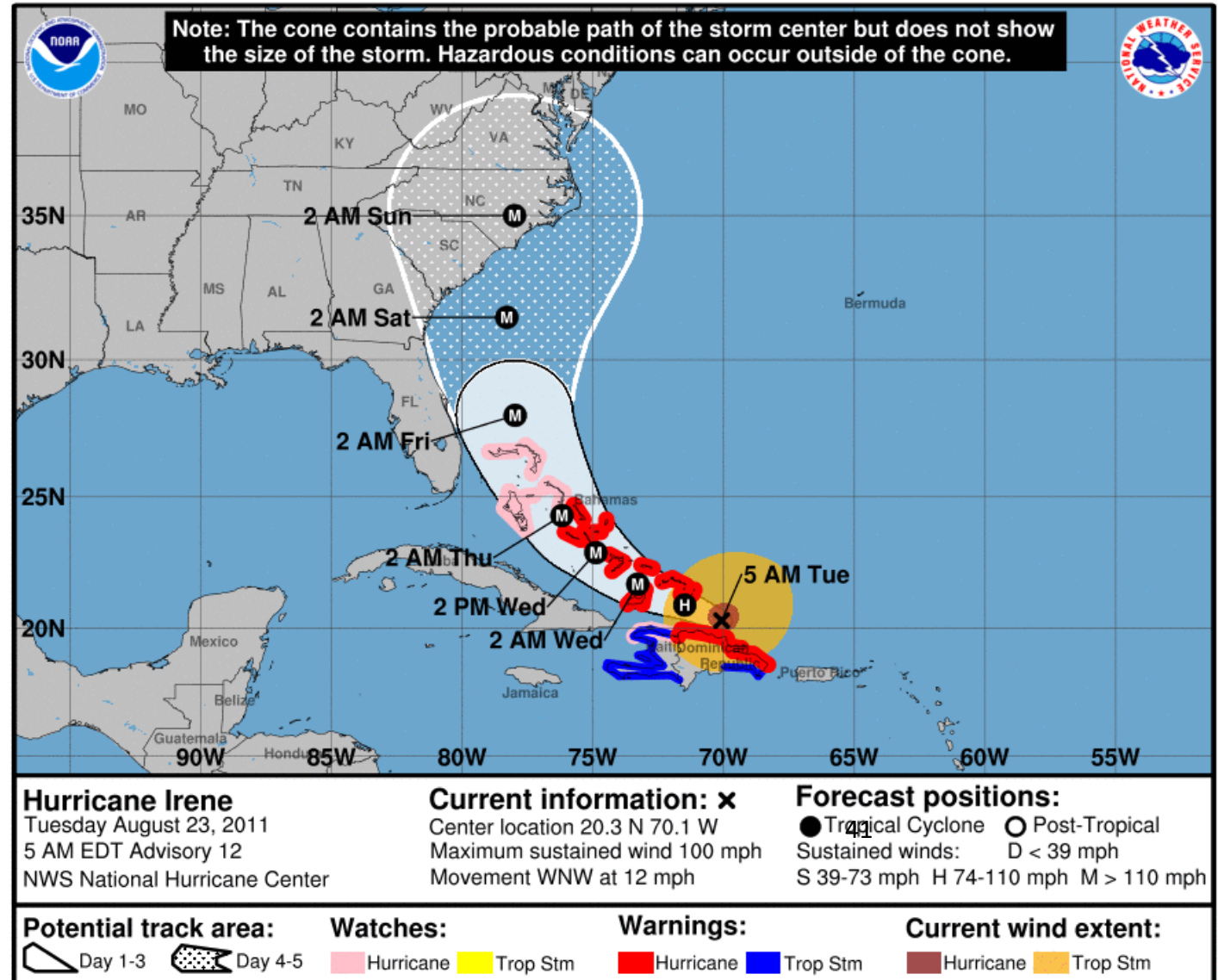


WIND SPEED PROBABILITIES

A Tool to Deal with Uncertainty

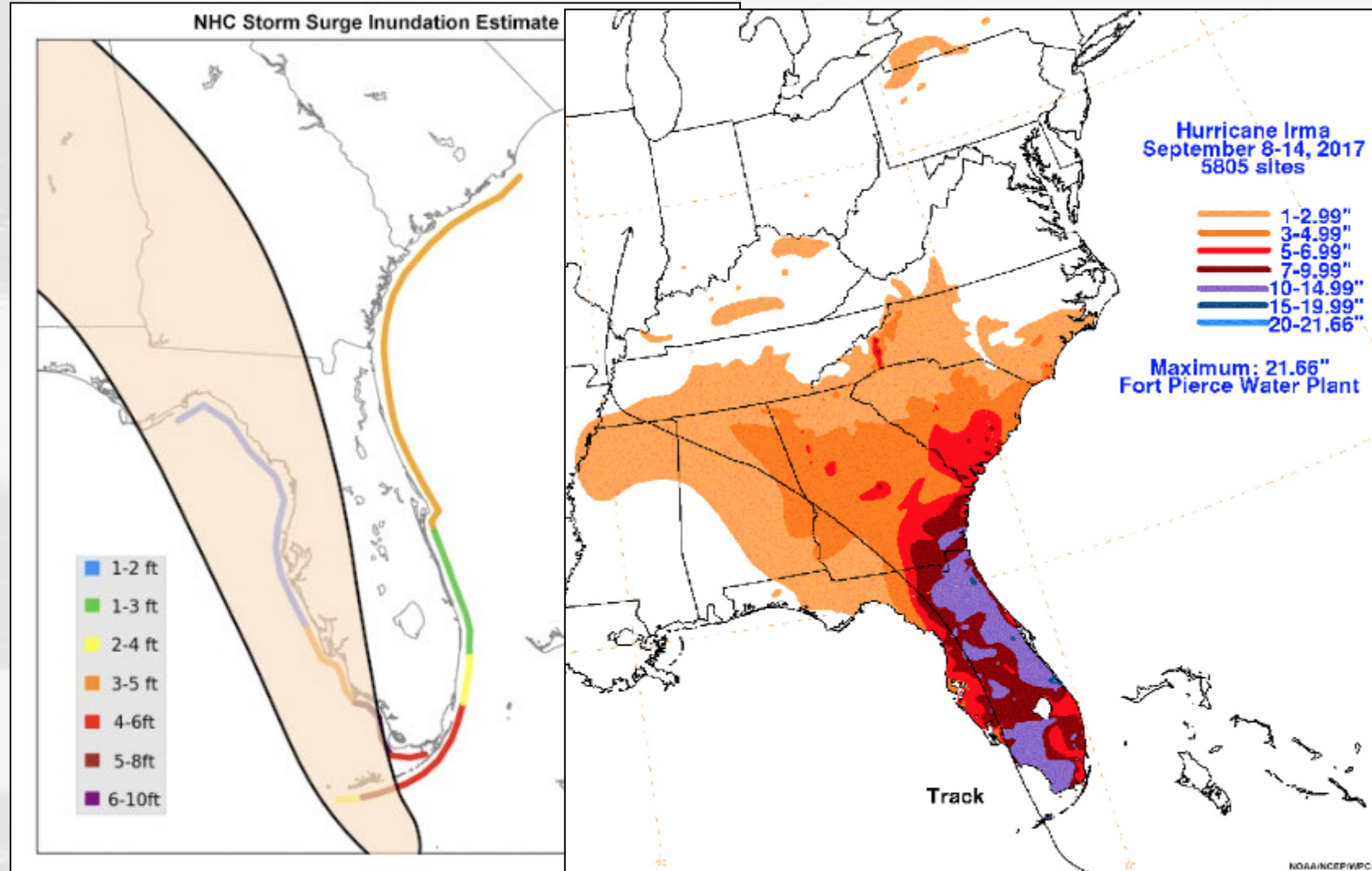
Review the cone of uncertainty for Hurricane Irene. Where will Hurricane Irene be located five days from now?

Click the location on the map.



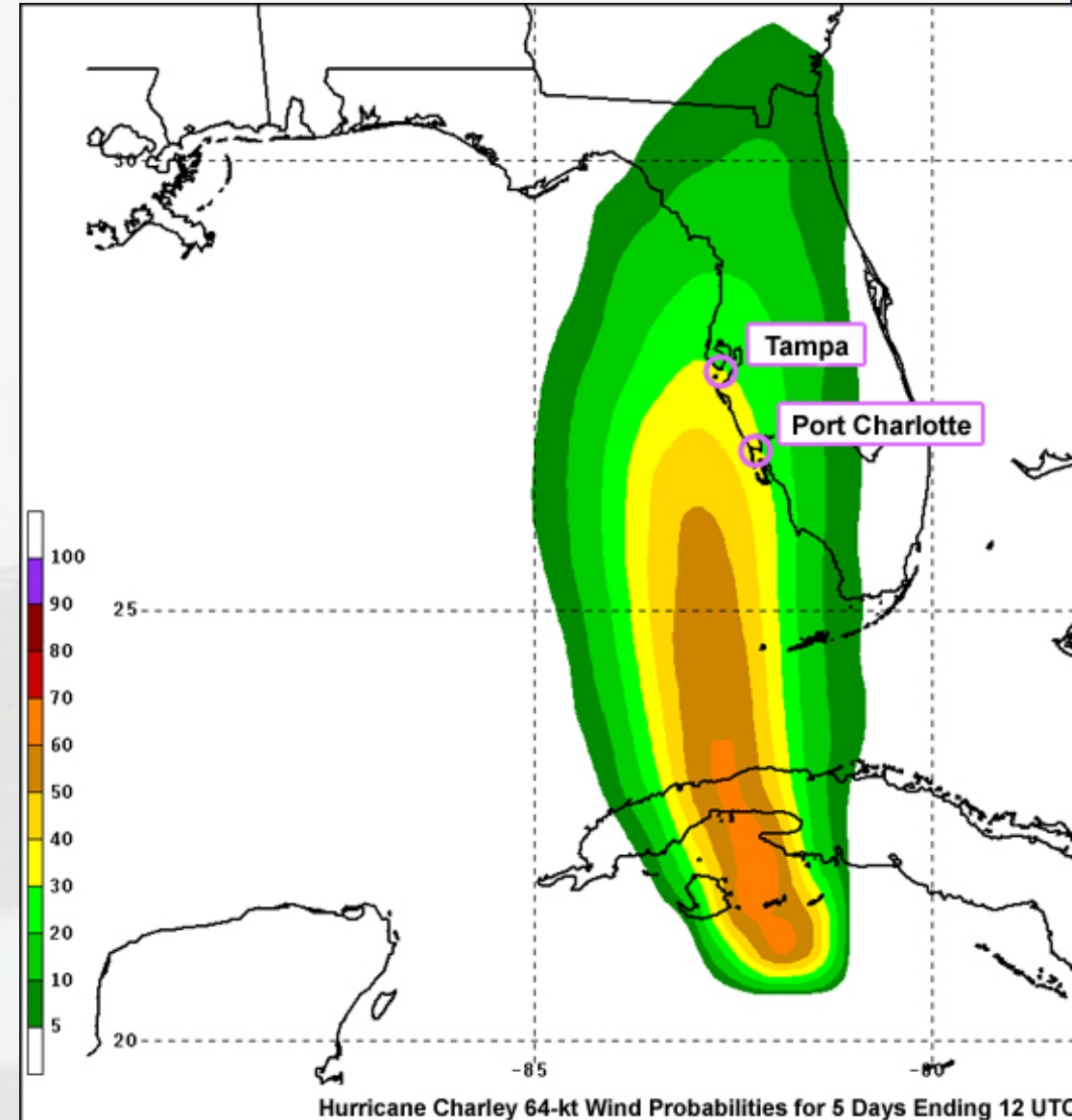
Review the two images of storm surge and rainfall for Hurricane Irma (2017). The storm surge image also shows the cone of uncertainty. Why were hurricane impacts experienced far outside the cone?

- a) The forecast shown in the cone of uncertainty contained large errors at this time.
- b) The cone graphic only conveys track forecast uncertainty.
- c) The center of the storm was outside the cone of uncertainty and the impacts were felt well beyond it.
- d) The average track forecast errors are small during the 24 to 48-hr period before landfall.




How will you describe the risk from hurricane-force winds from Hurricane Charley? Select the best answer.

- a) There is a 30-40% chance of hurricane-force winds along the southwest Florida Coast.
- b) There is a 40-50% chance of hurricane-force winds along the southwest Florida Coast.
- c) There is a 40-50% chance of hurricane-force winds for Tampa and Port Charlotte.
- d) There is a 30-40% chance of hurricane-force winds for Tampa and Port Charlotte.



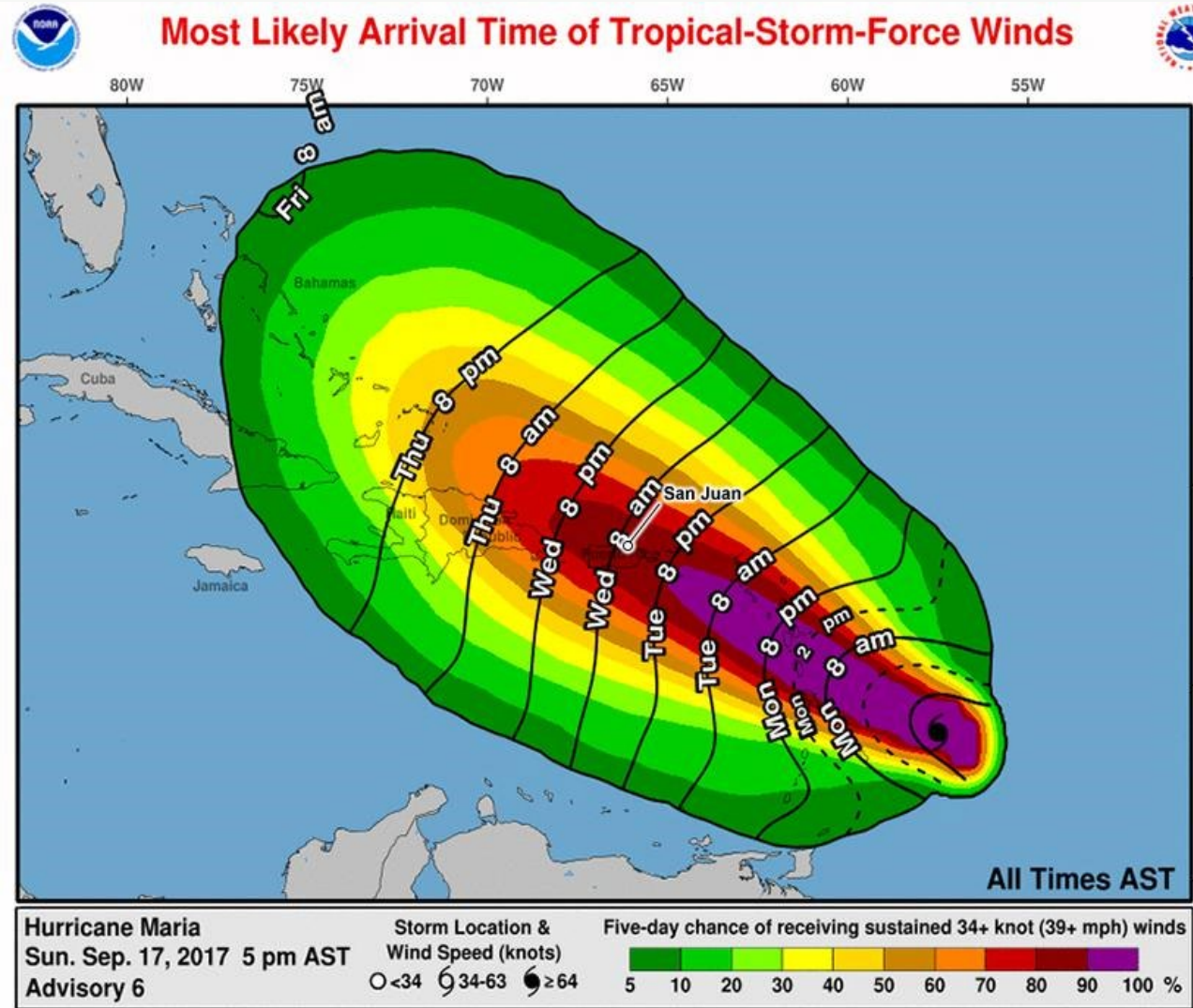
When are tropical-storm-force winds at Tallahassee, FL most likely to begin? Select the best answer.

- a) Between forecast hour 36 and 48
- b) Between forecast hour 48 and 72
- c) Between forecast hour 72 and 96

 NATIONAL HURRICANE CENTER <small>NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION</small>									
TROPICAL STORM MICHAEL WIND SPEED PROBABILITIES NUMBER									7
NWS NATIONAL HURRICANE CENTER MIAMI FL									AL142018
0900 UTC MON OCT 08 2018									
- - - - WIND SPEED PROBABILITIES FOR SELECTED LOCATIONS - - - -									
TIME PERIODS		FROM 06Z MON TO 18Z MON	FROM 18Z MON TO 06Z TUE	FROM 06Z TUE TO 18Z TUE	FROM 18Z TUE TO 06Z WED	FROM 06Z WED TO 06Z THU	FROM 06Z THU TO 06Z FRI	FROM 06Z FRI TO 06Z SAT	
FORECAST HOUR		(12)	(24)	(36)	(48)	(72)	(96)	(120)	
- - - - -									
LOCATION	KT								
TALLAHASSEE FL	34	X	X (X)	1 (1)	6 (7)	68 (75)	6 (81)	X (81)	
TALLAHASSEE FL	50	X	X (X)	X (X)	1 (1)	41 (42)	6 (48)	X (48)	
TALLAHASSEE FL	64	X	X (X)	X (X)	X (X)	20 (20)	4 (24)	X (24)	
APALACHICOLA	34	X	X (X)	5 (5)	29 (34)	57 (91)	1 (92)	X (92)	
APALACHICOLA	50	X	X (X)	X (X)	6 (6)	59 (65)	2 (67)	X (67)	
APALACHICOLA	64	X	X (X)	X (X)	1 (1)	39 (40)	1 (41)	X (41)	
PANAMA CITY FL	34	X	X (X)	4 (4)	26 (30)	60 (90)	1 (91)	X (91)	
PANAMA CITY FL	50	X	X (X)	X (X)	6 (6)	57 (63)	1 (64)	X (64)	
PANAMA CITY FL	64	X	X (X)	X (X)	1 (1)	37 (38)	X (38)	X (38)	

You are providing a briefing to the emergency managers on the potential onset of tropical-storm-force winds for San Juan, Puerto Rico. To ensure that the emergency managers have completed preparations before the onset of the winds, which graphic would you use to describe the period of onset? Choose the best answer.

- a) Earliest Reasonable Arrival Time of Tropical-Storm-Force Winds
- b) Most Likely Arrival Time of Tropical-Storm-Force Winds
- c) Both



Which of the following statements will you use to describe the probability of San Juan experiencing tropical-storm-force winds? When could these winds arrive? Choose the best answer.

- a) There is an 80-90% chance of tropical-storm-force winds in San Juan. These winds are most likely to arrive at 8 AM AST on Wednesday, but could arrive as early as 5 PM AST on Tuesday.
- b) There is a 80-90% chance of tropical-storm-force winds in San Juan. These winds are most likely to arrive before daybreak Wednesday, but could arrive as early as late afternoon Tuesday.
- c) There is a 90-100% chance of tropical-storm-force winds in San Juan. These winds are most likely to arrive around 8 AM AST on Wednesday, but could arrive as early as 8 PM AST on Tuesday night.
- d) There is an 90-100% chance of tropical-storm-force winds in San Juan. These winds are most likely to arrive Tuesday evening (around 8 PM AST), but could arrive as early as Tuesday morning (around 8 AM AST).

