

A satellite image of a large hurricane with a well-defined eye and spiral cloud bands, positioned over the Atlantic Ocean. The coastline of North America is visible on the left side of the frame. The text is overlaid in yellow with a black drop shadow.

Hurricane Forecasting and Messaging

Sharing My Top 10 Lessons Learned

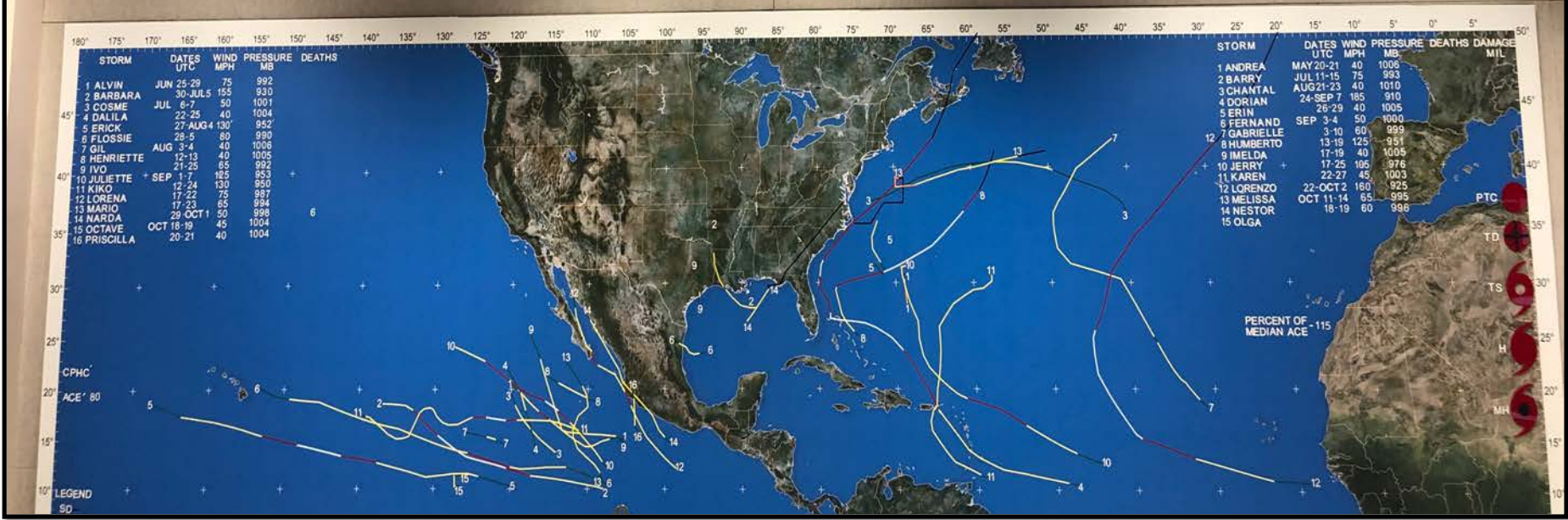
Ken Graham
National Hurricane Center



NATIONAL HURRICANE CENTER

NATIONAL WEATHER SERVICE

AT FLORIDA INTERNATIONAL UNIVERSITY

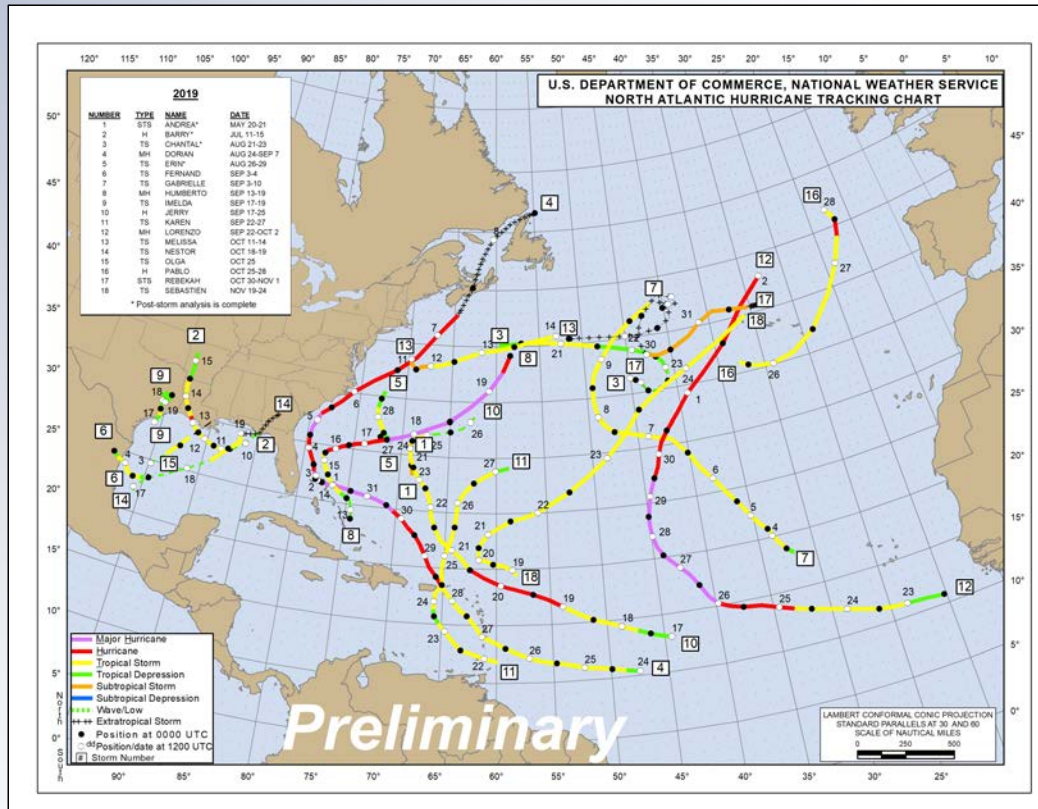


STORM	DATES UTC	WIND MPH	PRESSURE MB	DEATHS
1 ALVIN	JUN 25-29	75	992	
2 BARBARA	30-JUL 5	155	930	
3 COSME	JUL 6-7	50	1001	
4 DALILA	22-25	40	1004	
5 ERICK	27-AUG 4	130	952	
6 FLOSSIE	28-5	80	990	
7 GIL	AUG 3-4	40	1006	
8 HENRIETTE	12-13	40	1005	
9 IVO	21-25	65	992	
10 JULIETTE	SEP 1-7	125	953	
11 KIKO	12-24	130	950	
12 LORENA	17-22	75	987	
13 MARIO	17-25	65	994	
14 NARDA	29 OCT 1	50	998	
15 OCTAVE	OCT 18-19	45	1004	
16 PRISCILLA	20-21	40	1004	

STORM	DATES UTC	WIND MPH	PRESSURE MB	DEATHS	DAMAGE MIL
1 ANDREA	MAY 20-21	40	1006		
2 BARRY	JUL 11-15	75	993		
3 CHANTAL	AUG 21-23	40	1010		
4 DORIAN	24-SEP 7	185	910		
5 ERIN	26-29	40	1005		
6 FERNAND	SEP 3-4	50	1000		
7 GABRIELLE	3-10	60	999		
8 HUMBERTO	13-18	125	951		
9 IMELDA	17-19	40	1005		
10 JERRY	17-25	105	976		
11 KAREN	22-27	45	1003		
12 LORENZO	22-OCT 2	160	925		
13 MELISSA	OCT 11-14	65	995		
14 NESTOR	18-19	60	996		
15 OLGA					

2019 Atlantic Hurricane Season

18 named storms, 6 hurricanes, including 3 major hurricanes



- Dorian impacted the northern Bahamas as a category 5 hurricane producing catastrophic wind and water damage
- Hurricanes Humberto and Lorenzo affected Bermuda and the Azores, respectively
- 6 storms affected the U.S. including Dorian and Barry as hurricanes

U.S. DEPARTMENT OF COMMERCE, NATIONAL WEATHER SERVICE
EASTERN NORTH PACIFIC HURRICANE TRACKING CHART

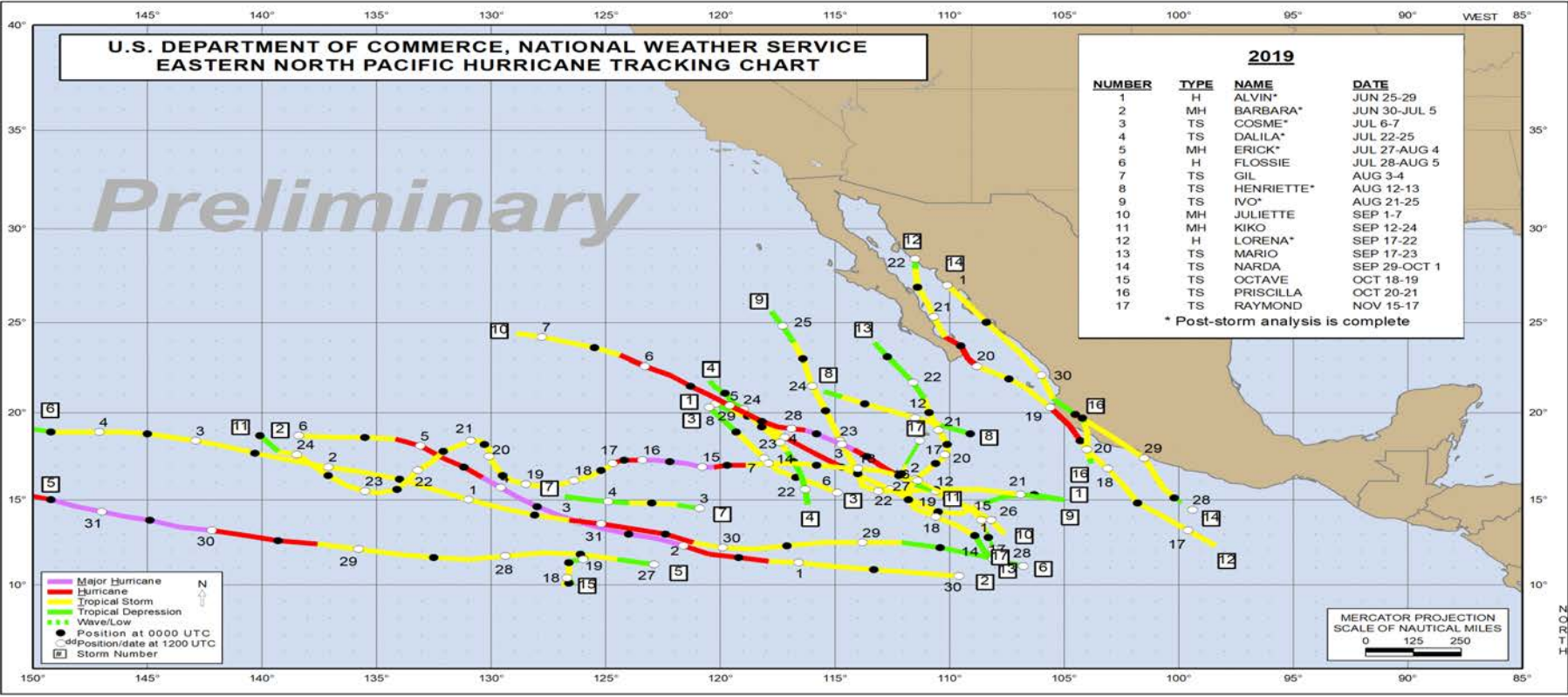
Preliminary

2019			
NUMBER	TYPE	NAME	DATE
1	H	ALVIN*	JUN 25-29
2	MH	BARBARA*	JUN 30-JUL 5
3	TS	COSME*	JUL 6-7
4	TS	DALILA*	JUL 22-25
5	MH	ERICK*	JUL 27-AUG 4
6	H	FLOSSIE	JUL 28-AUG 5
7	TS	GIL	AUG 3-4
8	TS	HENRIETTE*	AUG 12-13
9	TS	IVO*	AUG 21-25
10	MH	JULIETTE	SEP 1-7
11	MH	KIKO	SEP 12-24
12	H	LORENA*	SEP 17-22
13	TS	MARIO	SEP 17-23
14	TS	NARDA	SEP 29-OCT 1
15	TS	OCTAVE	OCT 18-19
16	TS	PRISCILLA	OCT 20-21
17	TS	RAYMOND	NOV 15-17

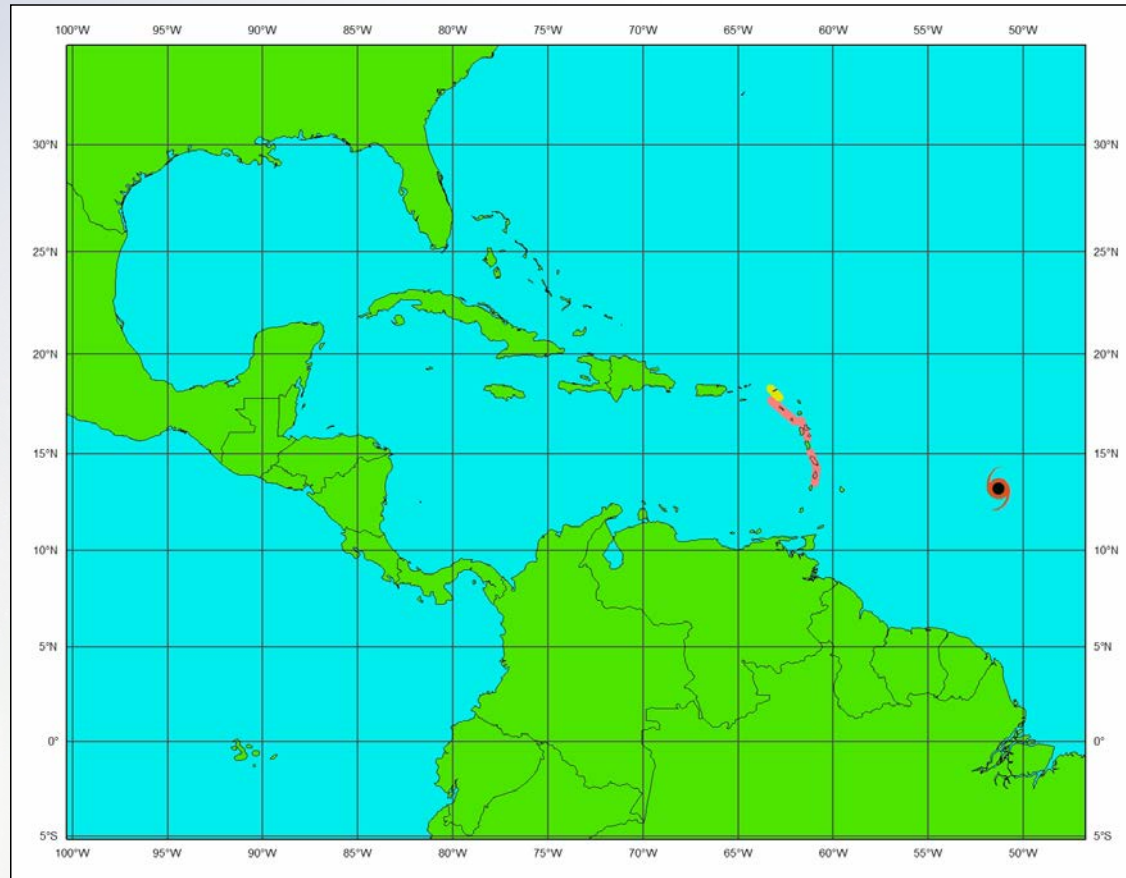
* Post-storm analysis is complete

— Major Hurricane
— Hurricane
— Tropical Storm
— Tropical Depression
— Wave/Low
● Position at 0000 UTC
○ Position/date at 1200 UTC
 Storm Number

MERCATOR PROJECTION
SCALE OF NAUTICAL MILES
0 125 250



Lesson 1. No Such Thing as a “Fish” Storm



Behind Dorian, which 2019 Atlantic basin named storm was the second deadliest of the season?

2019 Atlantic Tropical Cyclone Names*

Andrea	Humberto	Olga
Barry	Imelda	Pablo
Chantal	Jerry	Rebekah
Dorian	Karen	Sebastien
Erin	Lorenzo	Tanya
Fernand	Melissa	Van
Gabrielle	Nestor	Wendy

*Names provided by the World Meteorological Organization

Be prepared: Visit [hurricanes.gov](https://www.hurricanes.gov) and follow @NWS and @NHC_Atlantic on Twitter.

May 23, 2019

Behind Dorian, which 2019 Atlantic basin named storm was the second deadliest of the season?

2019 Atlantic Tropical Cyclone Names*

Andrea	Humberto	Olga
Barry	Imelda	Pablo
Chantal	Jerry	Rebekah
Dorian	Karen	Sebastien
Erin	Lorenzo	Tanya
Fernand	Melissa	Van
Gabrielle	Nestor	Wendy

*Names provided by the World Meteorological Organization

Be prepared: Visit [hurricanes.gov](https://www.hurricanes.gov) and follow @NWS and @NHC_Atlantic on Twitter.

May 23, 2019

Behind Dorian, which 2019 Atlantic basin named storm was the second deadliest of the season?

The infographic features a satellite image of a tropical cyclone in the background. The NOAA logo is in the top left corner. The title '2019 Atlantic Tropical Cyclone Names' is prominently displayed in yellow and white. Below the title, three columns of names are listed, each with a horizontal red line through it. The names 'Dorian' and 'Lorenzo' are circled in red. At the bottom, there is a note about the source of the names and a call to action to visit hurricanes.gov and follow @NWS and @NHC_Atlantic on Twitter. The date 'May 23, 2019' is also present.

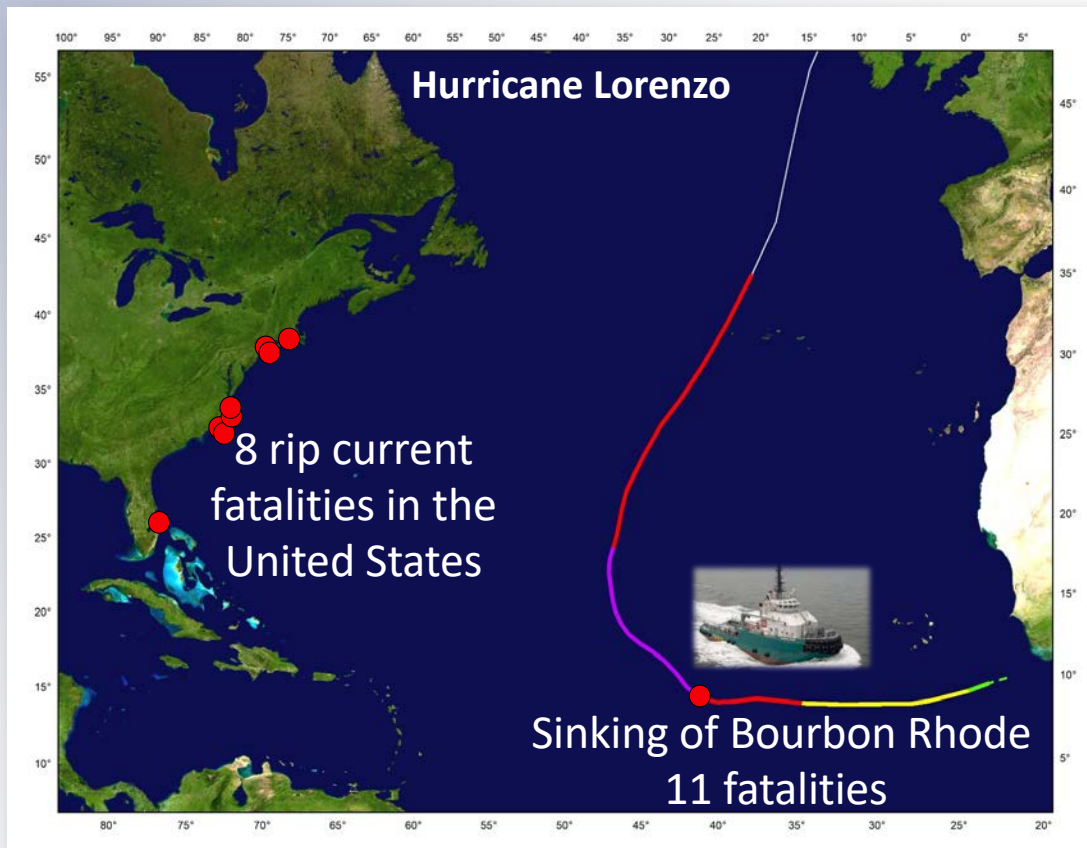
Andrea	Humberto	Olga
Barry	Imelda	Pablo
Chantal	Jerry	Rebekah
Dorian	Karen	Sebastien
Erin	Lorenzo	Tanya
Fernand	Melissa	Van
Gabrielle	Nestor	Wendy

*Names provided by the World Meteorological Organization

Be prepared: Visit [hurricanes.gov](https://www.hurricanes.gov) and follow @NWS and @NHC_Atlantic on Twitter.

May 23, 2019

Second Deadliest 2019 Atlantic Basin Storm Lorenzo – 19 Direct Fatalities – All Water Related



- **11 offshore deaths due to sinking of the tug boat *Bourbon Rhode***
 - **3 crewmen rescued**
- **8 rip current deaths in the United States from Florida to Rhode Island**
 - **Including the passing of NOAA employee**

TAFB IDSS Efforts

Bourbon Rhode Sinks in Hurricane Lorenzo: September 26 – October 5, 2019



Tropical Analysis and Forecast Branch
NWS National Hurricane Center

Bourbon Rhode Sinks in Atlantic Ocean; Three Rescued – Update

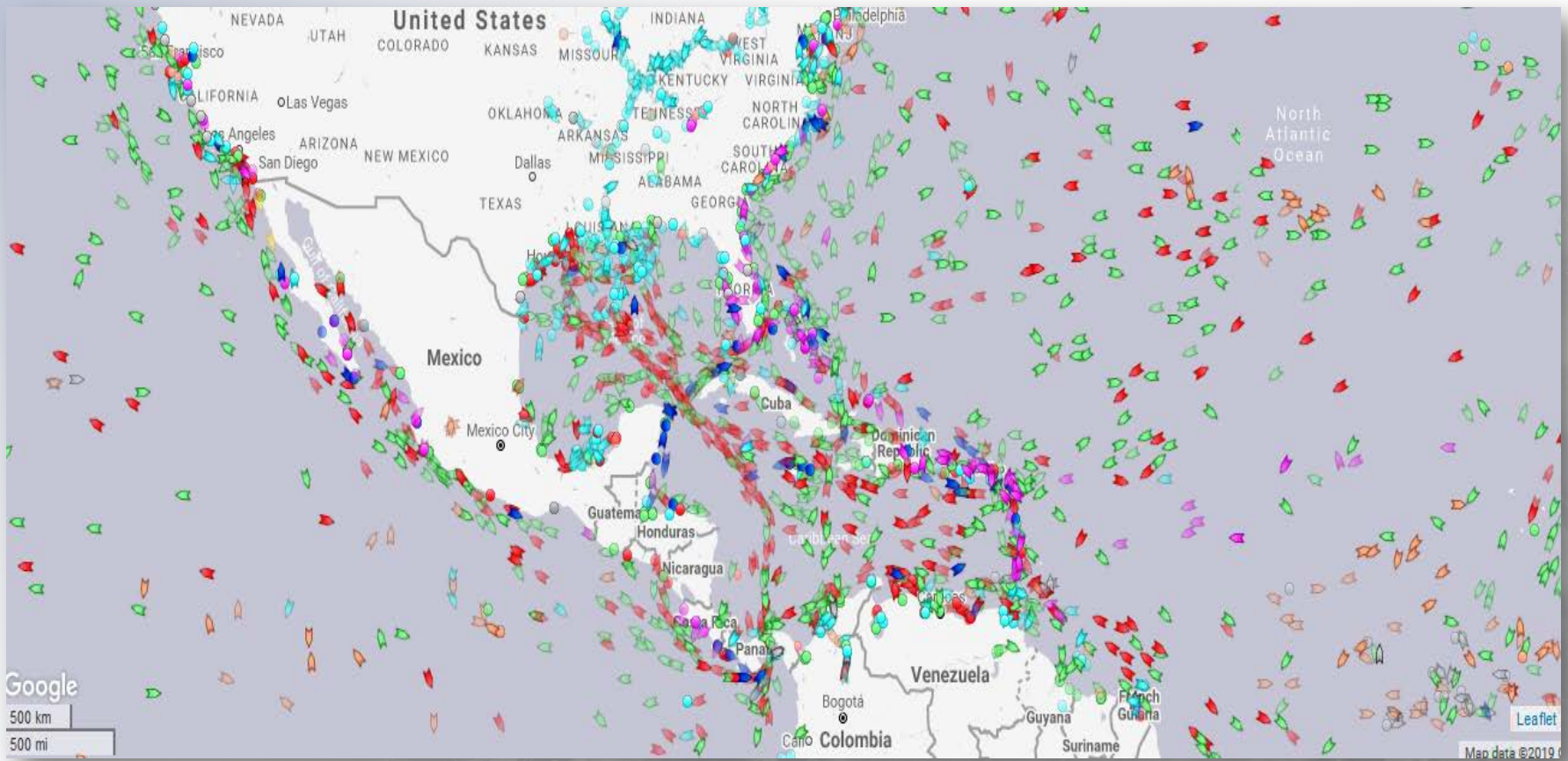
- Offshore tug sank in Hurricane Lorenzo
- NOAA reconnaissance aircraft supported French Navy's SAR efforts
- 35 marine spot forecasts provided by TAFB
- Three mariners rescued from life raft in central Atlantic Ocean



*Photo courtesy: Marine Nationale
via gCaptain*



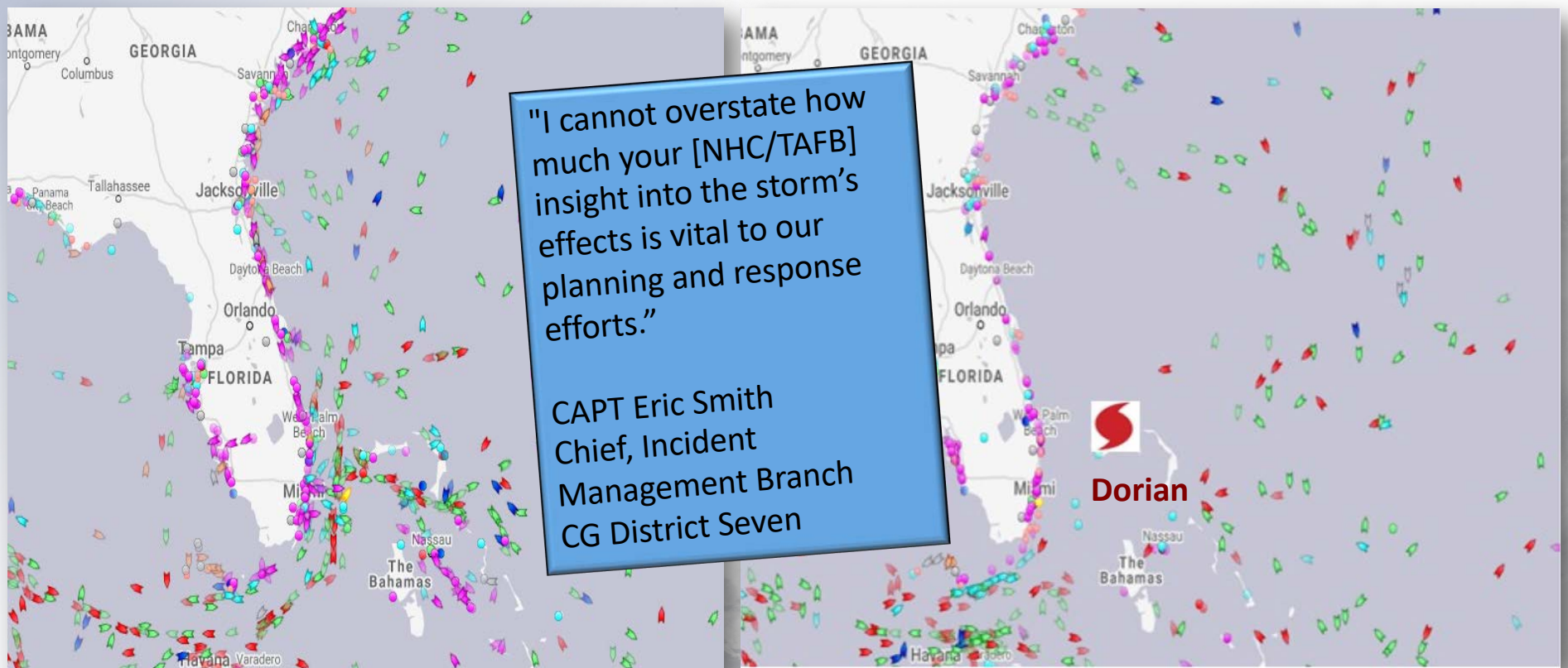
No Such Thing as a “Fish” Storm Lots of Ships/People Offshore Everyday



No Such Thing as a “Fish” Storm

Ship Traffic Before Dorian

Avoidance for the Hurricane



NHC's TAFB Life-Saving Mission

More than 50 life-saving spot forecasts provided in 2019

Coast Guard coordinates multiple day rescue of injured fisherman 1300 miles southwest of San Diego

“NWS, SPOT Report received. This information is truly impacting operations. Thank you for the quick response.”

- Douglas Samp
Search Mission Coordinator
USCG District Eleven Command Center



Air Force medical team parachuted to save injured crewmembers





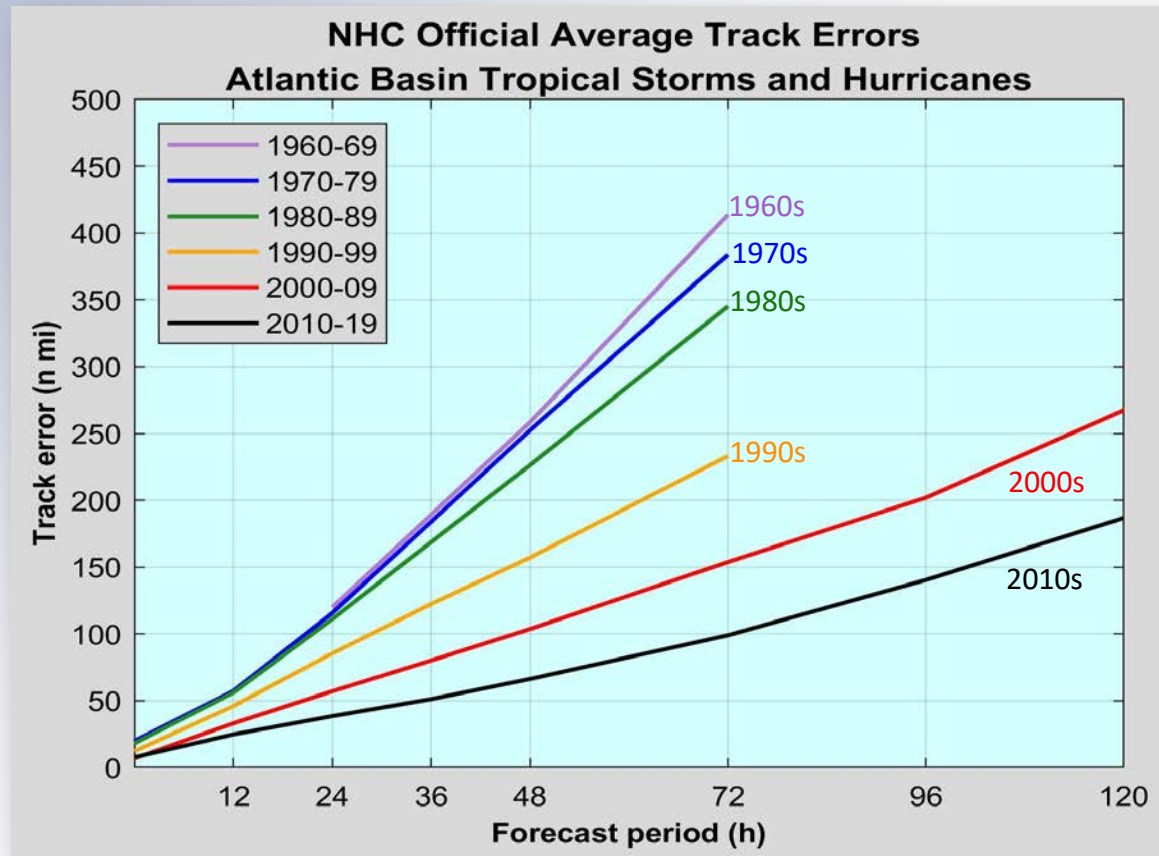
Lesson 2. Be careful looking at your favorite model

“Ah yes, all those lines miss us, we’re good”

“Oh no, one of those lines hits us in 10 days”

“This model was best last time”

Leaps in Track Forecasting

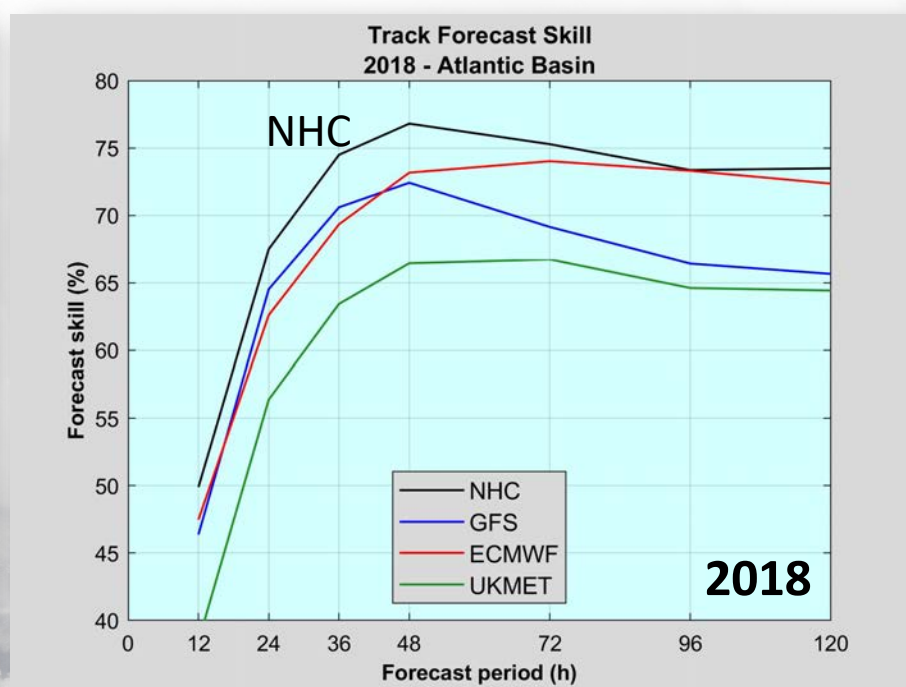
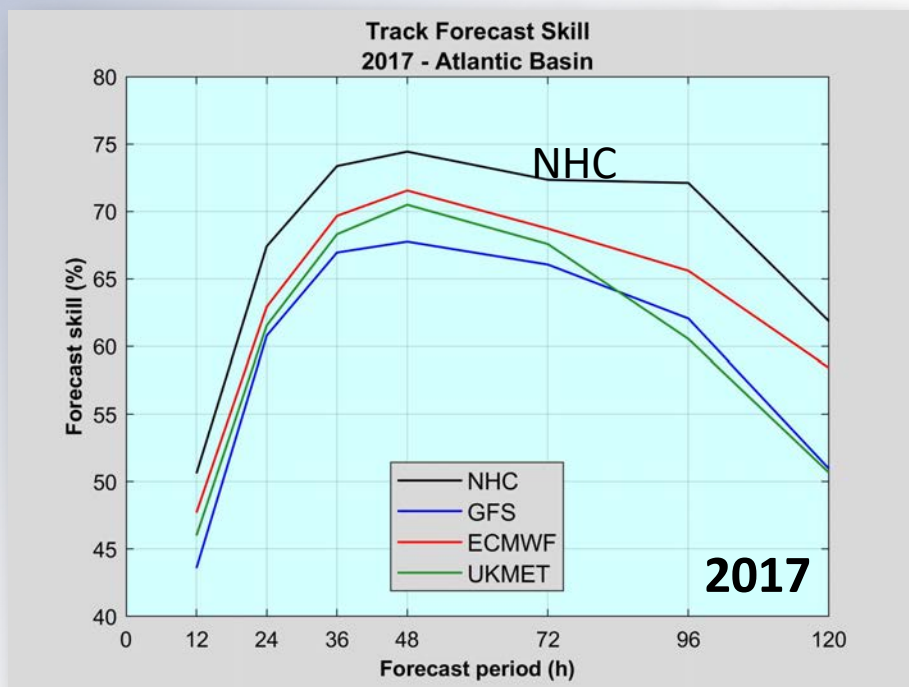


Advances in track forecasting are a testament to improvements in observational networks, computing power, and modeling.

True scientific success!

NHC vs. Global Models in 2017 & 2018

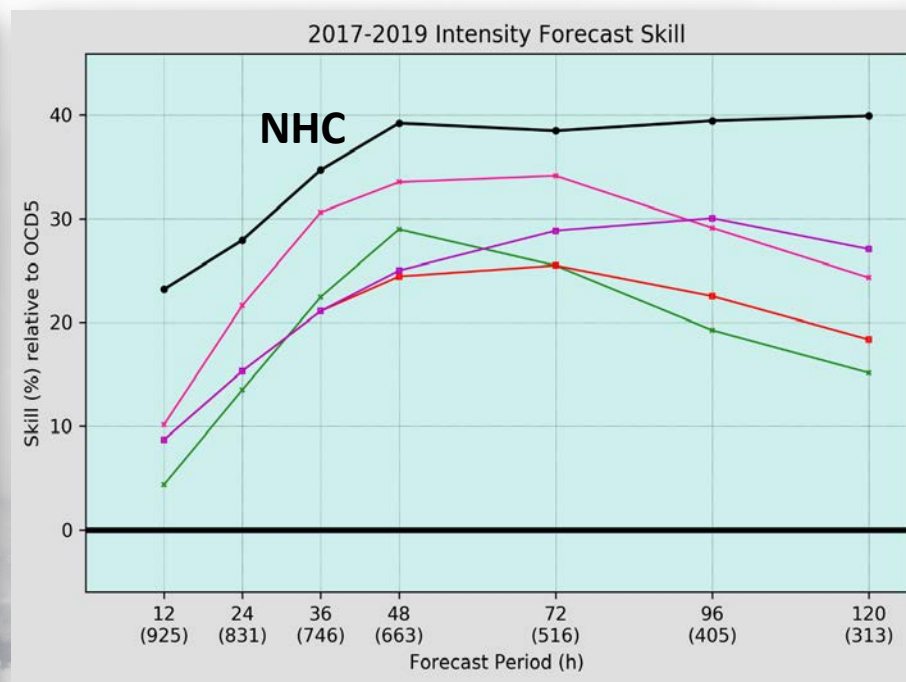
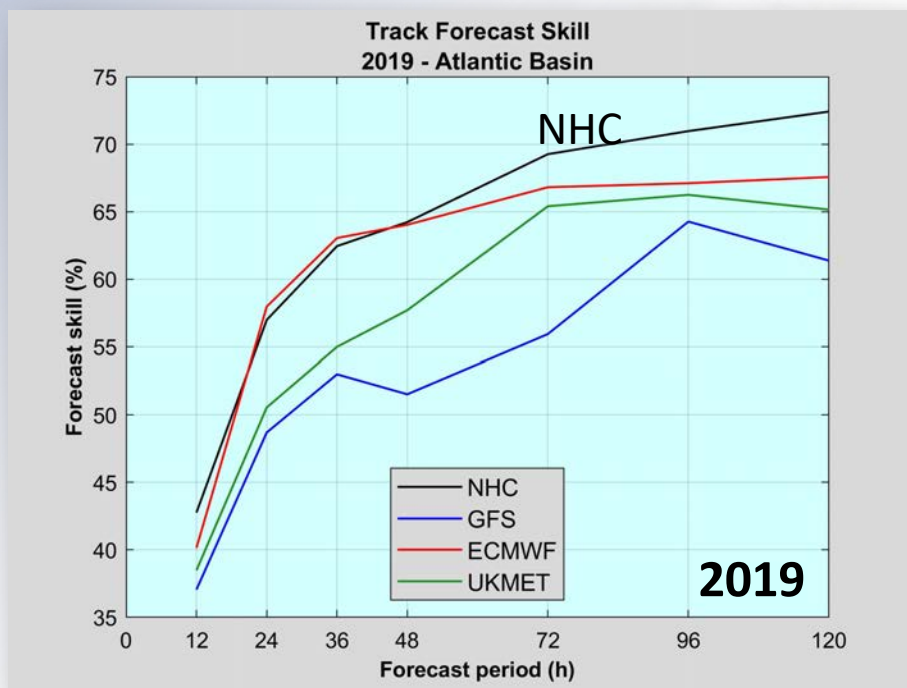
NHC more skillful than the GFS, ECMWF, and UKMET



*Skill vs Climatology and Persistence (OCD5)

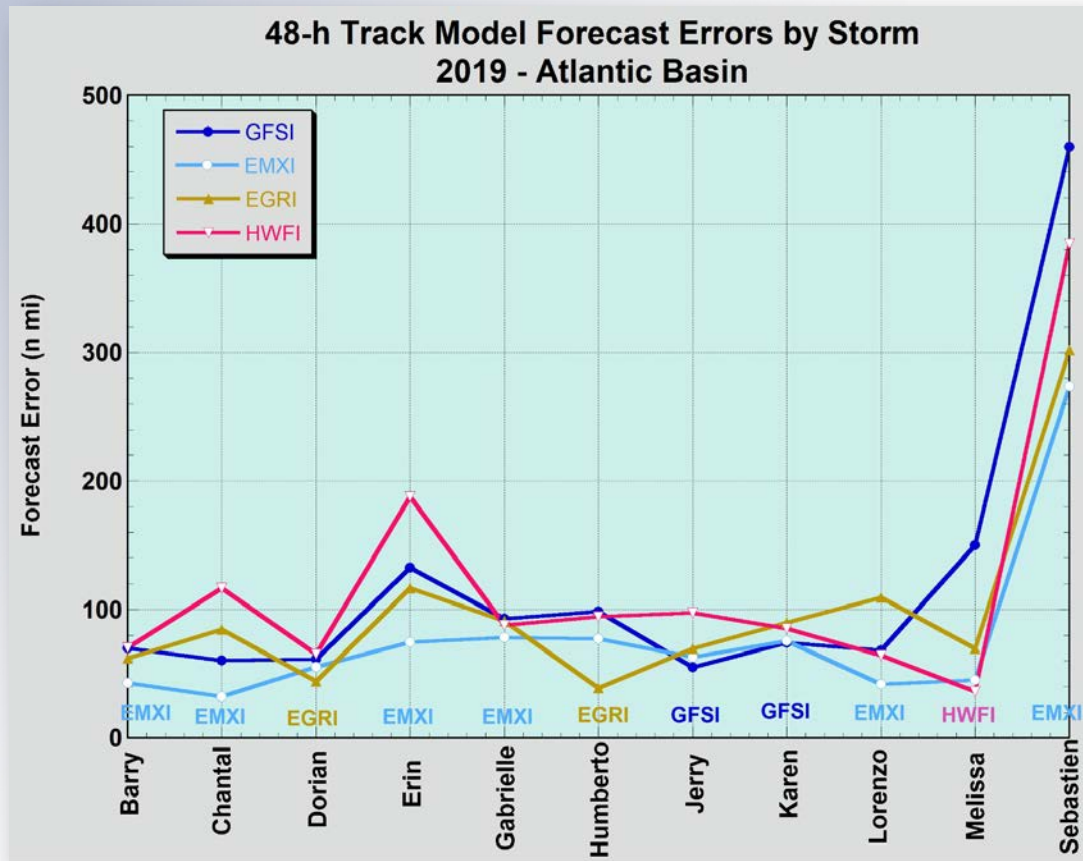
NHC vs. Global Models in 2019

NHC neck and neck with ECMWF through 48 h, but NHC more skillful at days 3, 4, and 5



*Skill vs Climatology and Persistence (OCD5)

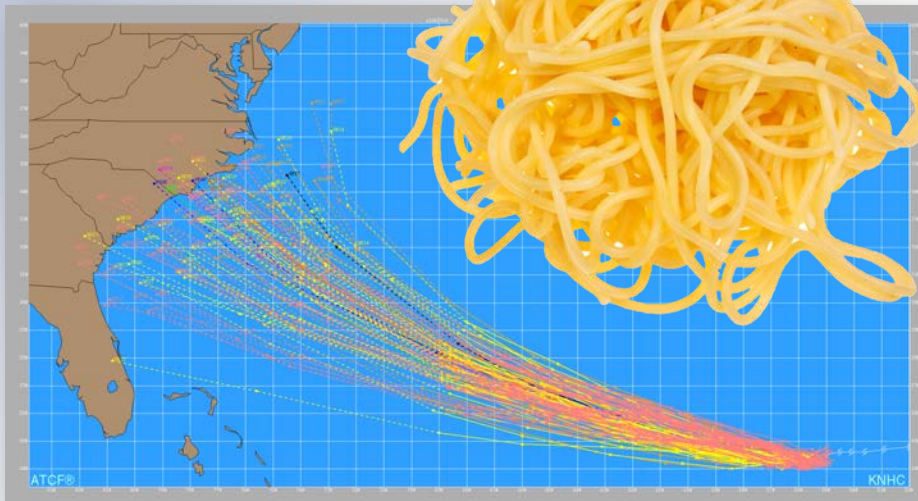
No “real” model of the day or storm!



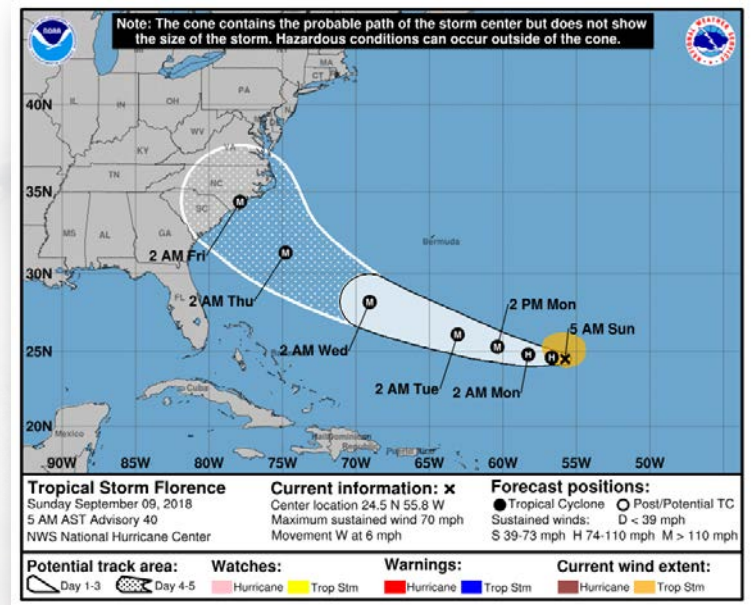
Models have their good and bad days (storms) too!

A reason why NHC depends on consensus models.

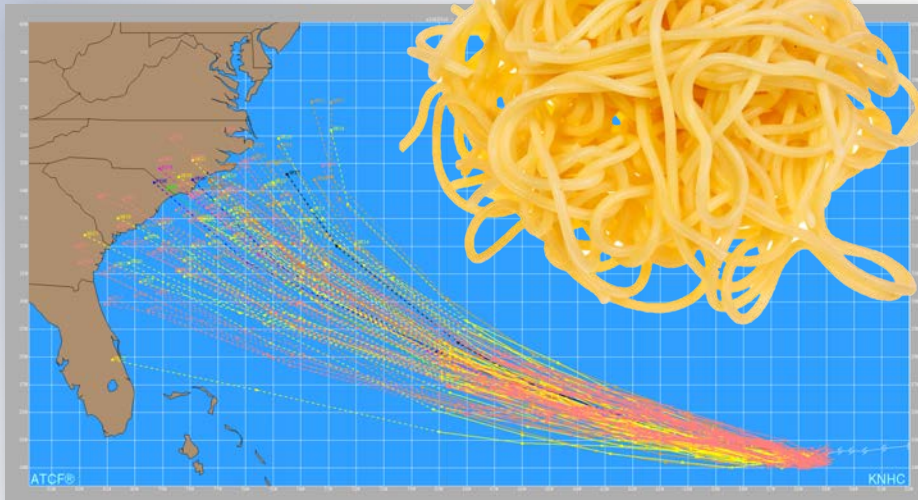
Spaghetti Models vs. NHC Forecasts



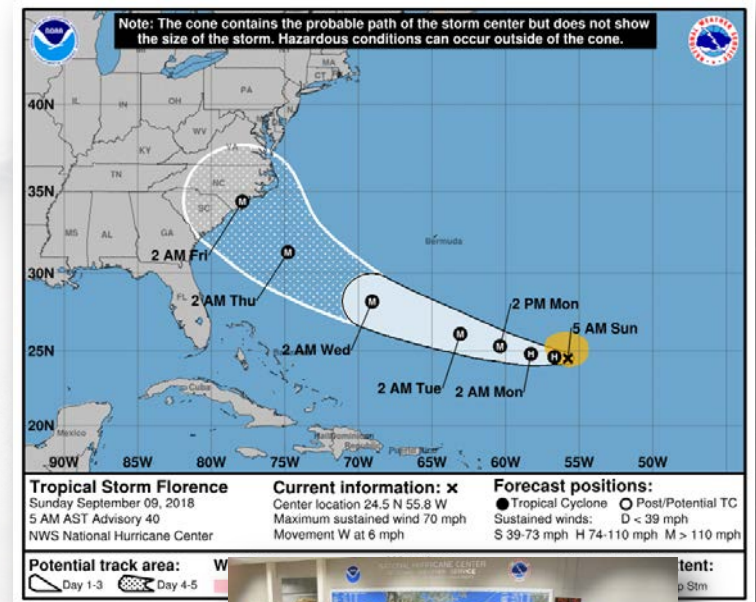
vs.



Spaghetti Models vs. NHC Forecasts



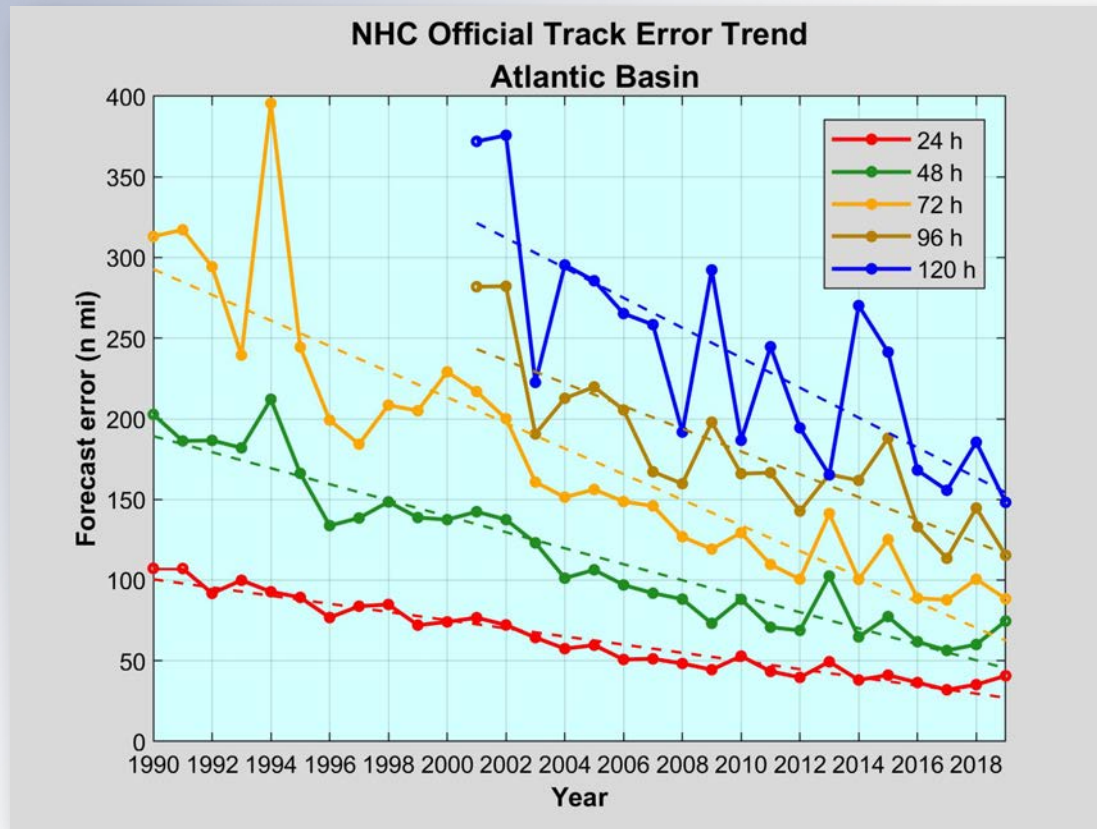
vs.



About 175 years of experience combined!

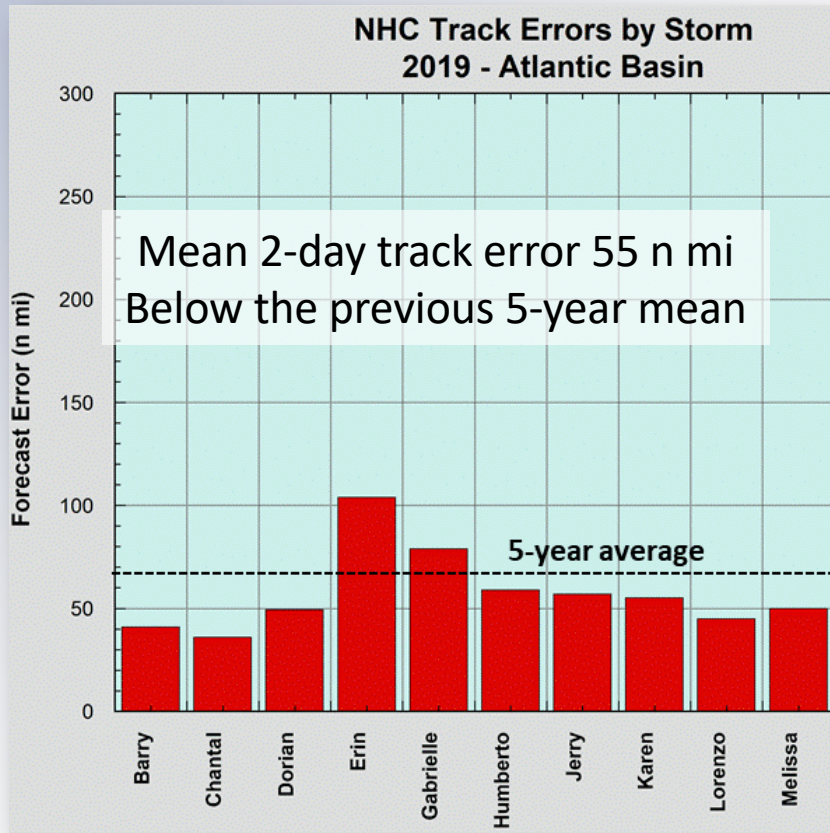


Atlantic Track Error Trends



24- and 48-h track errors up slightly in 2019, but overall trend continues to show significant improvements over the longer term.

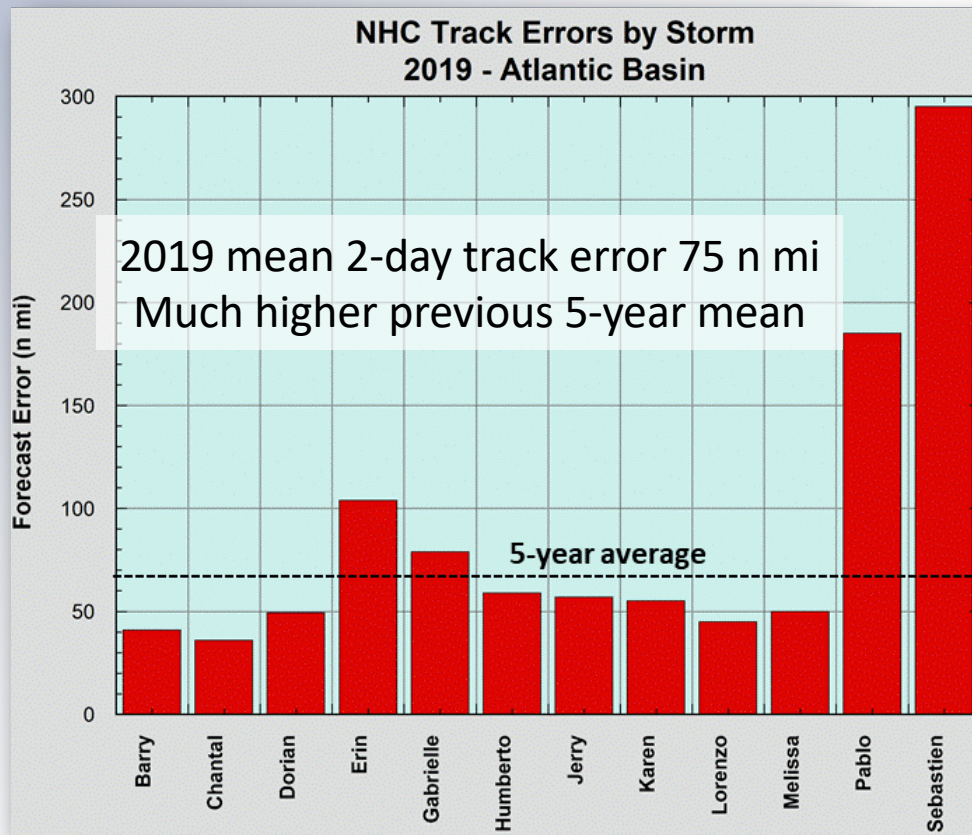
2019 NHC Track Forecasting Off to a Good Start



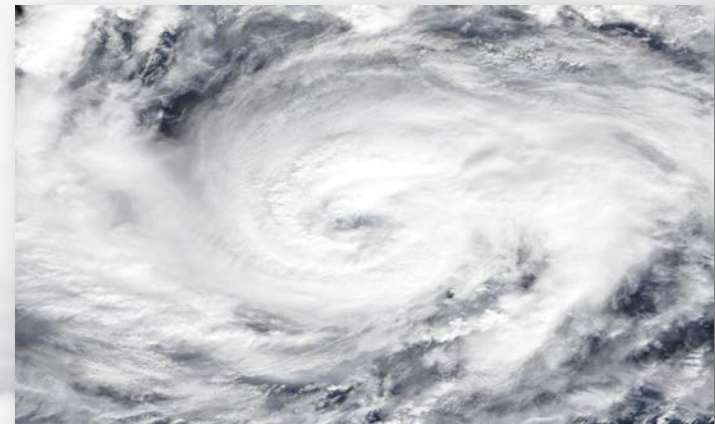
All but Erin & Gabrielle's mean 2-day track errors were above the 5-year average.

*Only includes storms with verifying 48-h forecasts

Didn't Finish as Well



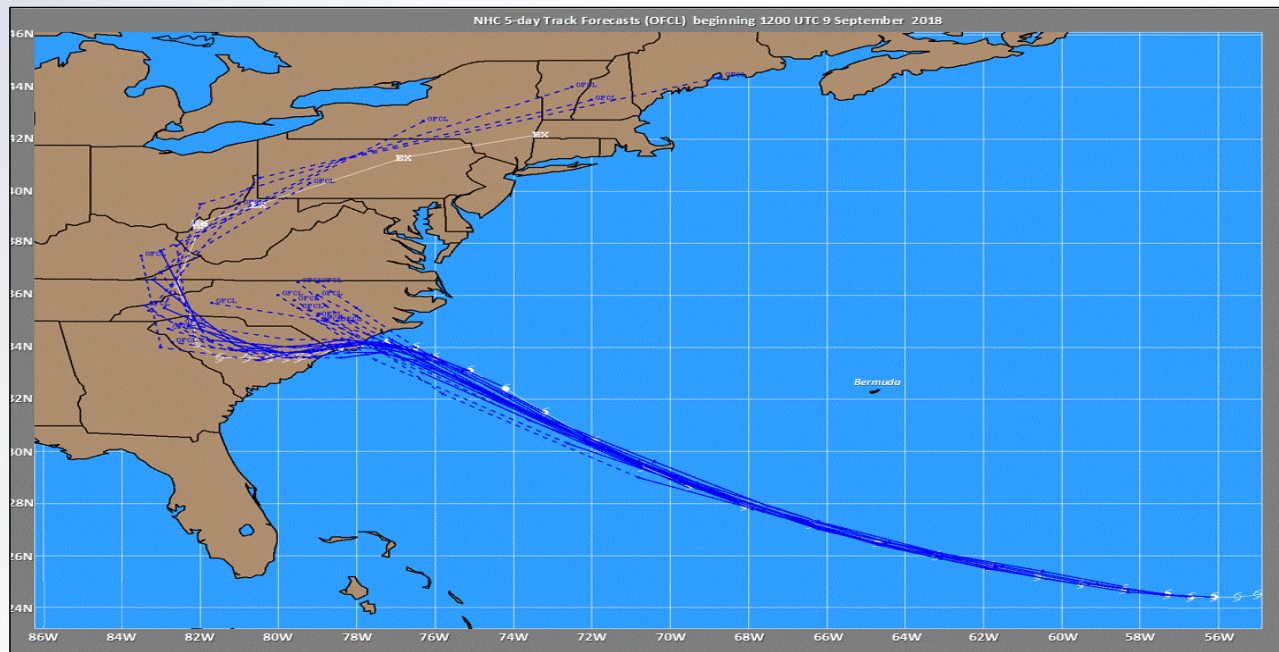
Pablo & Sebastien were late-season, high latitude storms that NHC and the models struggled with.



Hurricane Pablo

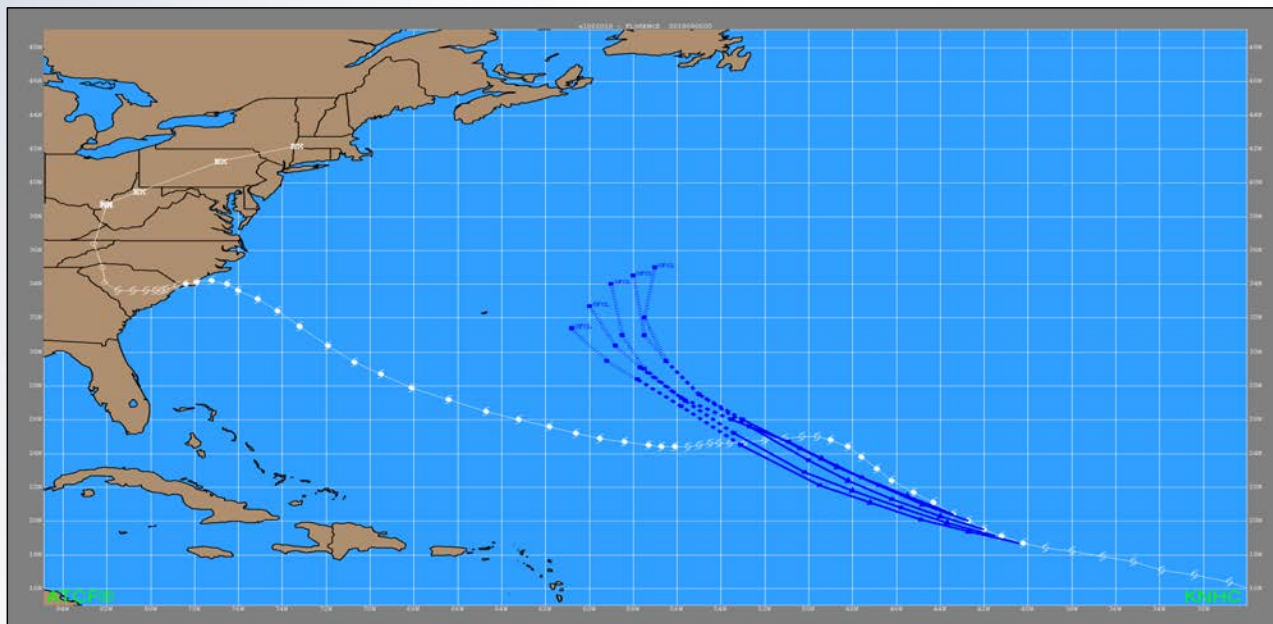
*Only includes storms with verifying 48-h forecasts

Track Forecast Success During Florence's Approach to the U.S.



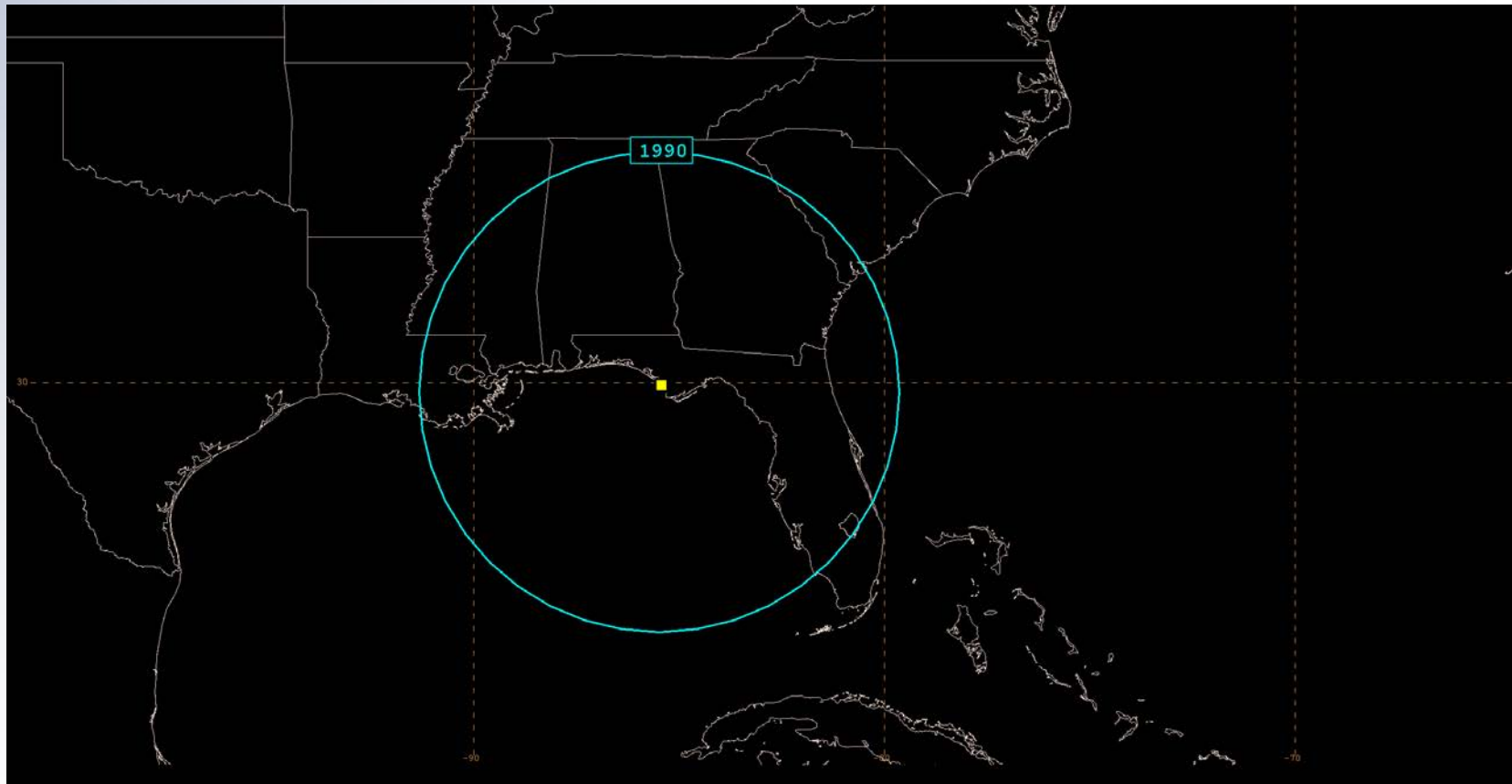
Hurricane Florence In-house 6- and 7-day Forecasts

NHC Experimental 6- and 7-day forecasts

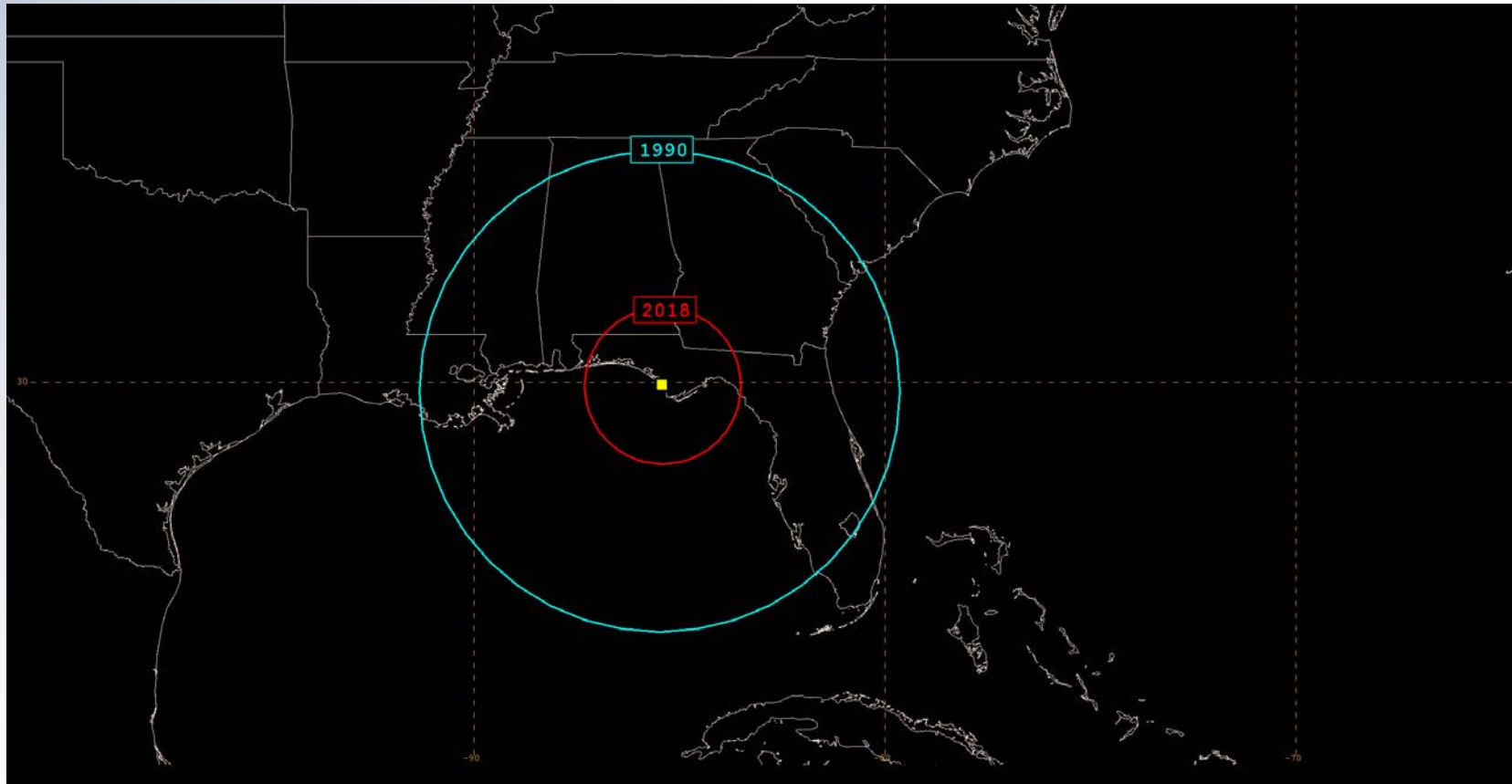


Some long-range forecasts suggested Florence would re-curve over the central Atlantic

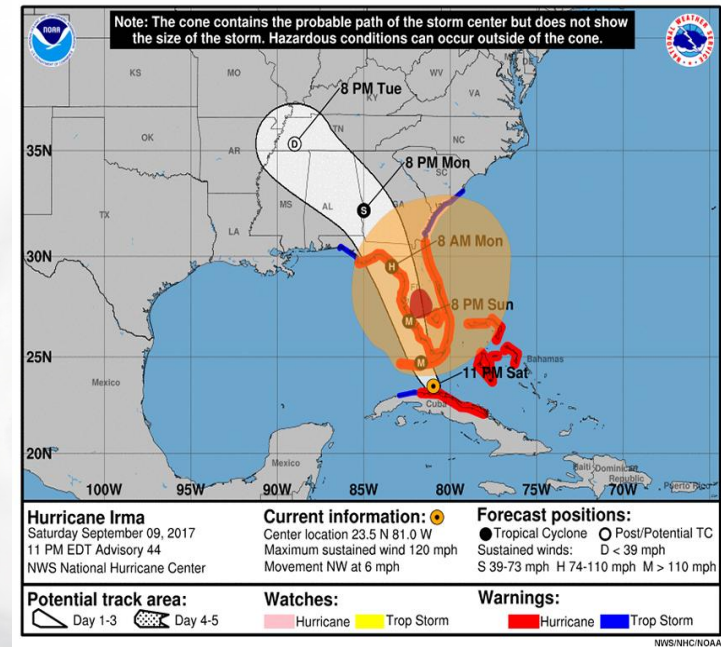
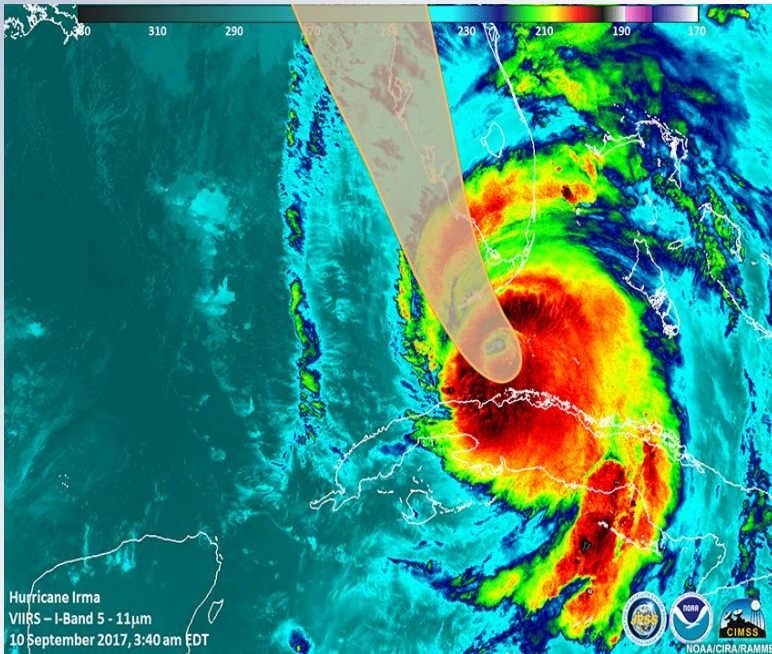
Improvements in Track Forecasting 3-day Forecasts in 1990



Improvements in Track Forecasting 3-day Forecasts in 1990

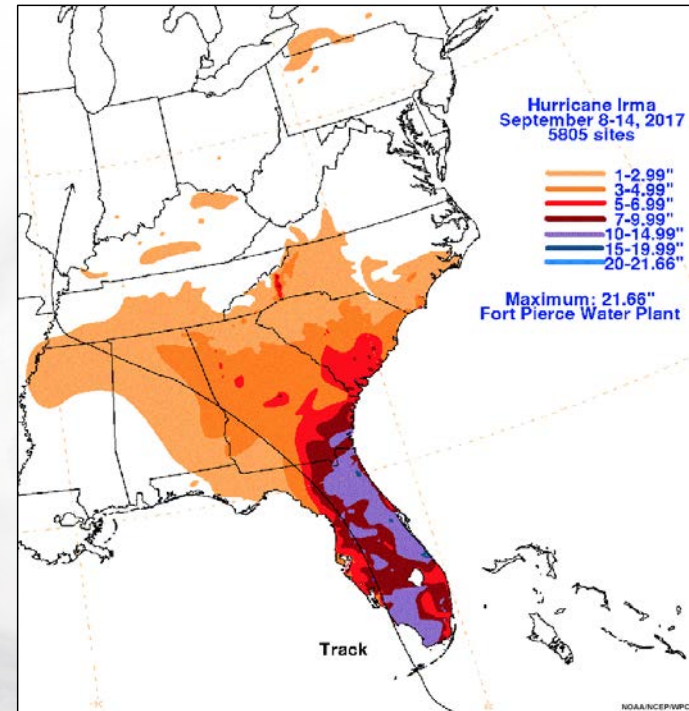
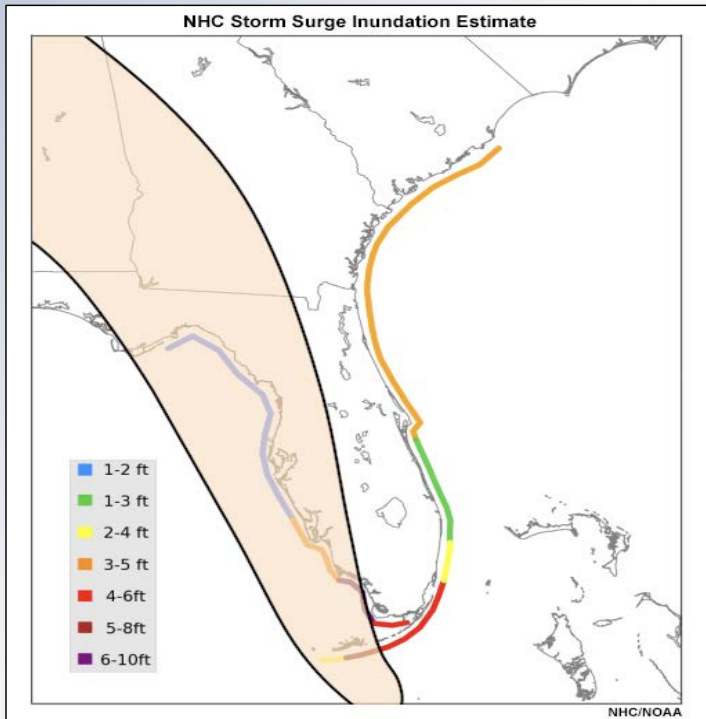


Lesson 3. It's About the Impacts



**Hazards Extent Far From the Center!
A Hurricane is Not a Point!**

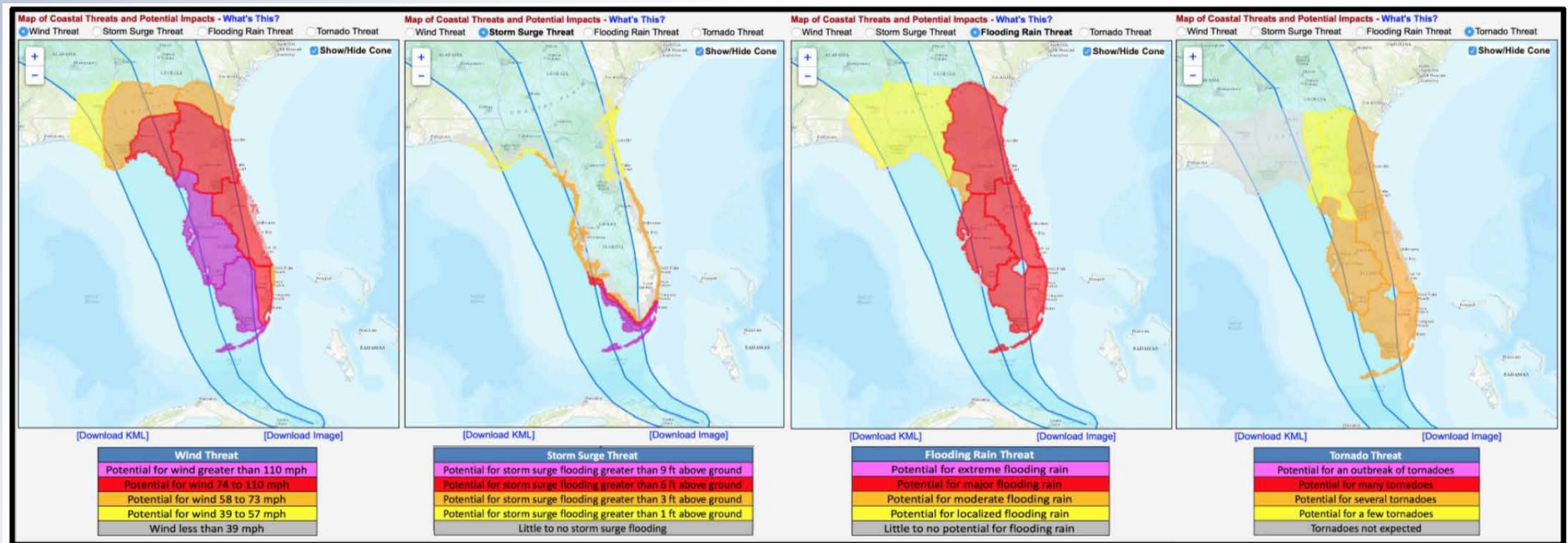
It's About the Impacts



**Hazards Extent Far From the Center!
A Hurricane is Not a Point!**

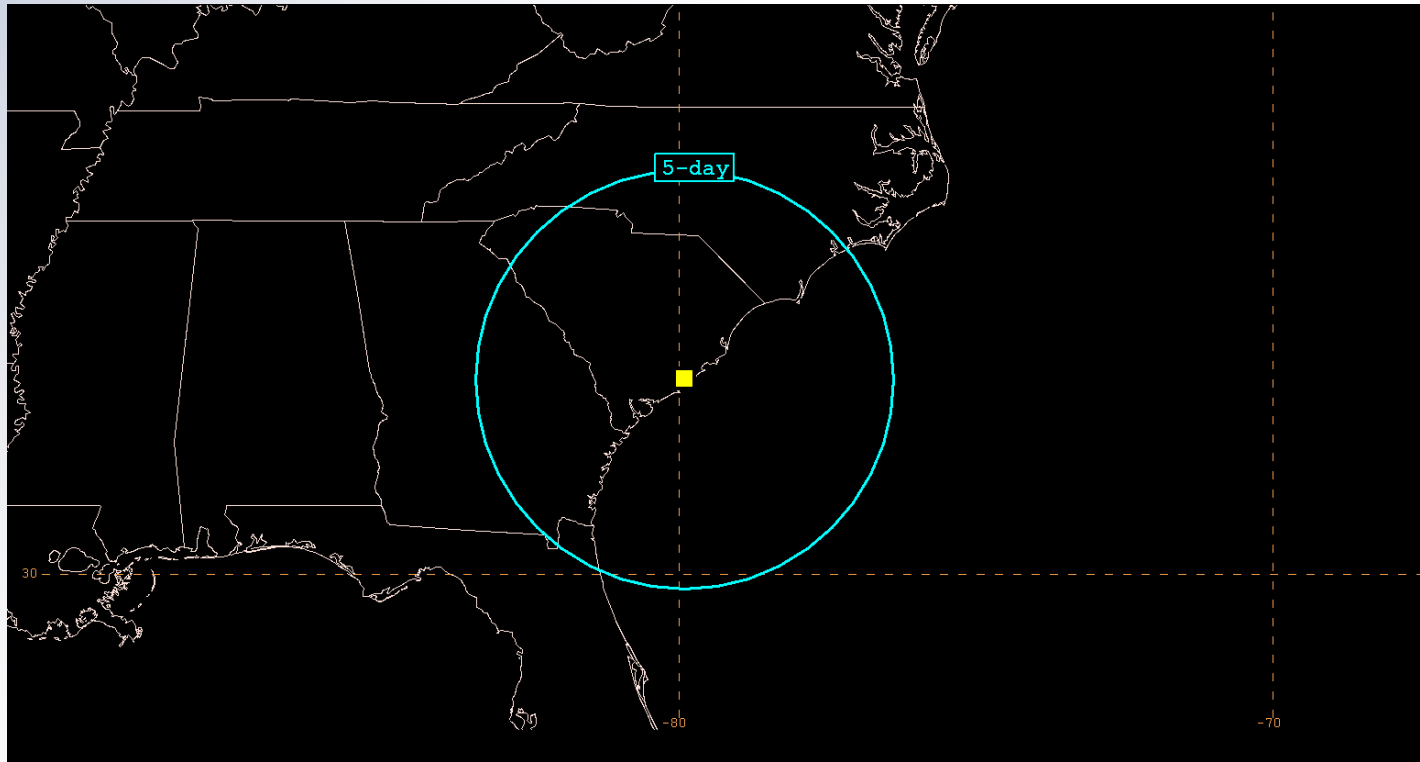
Successes of New NHC/NWS Products

WFO Threats and Impacts Graphics

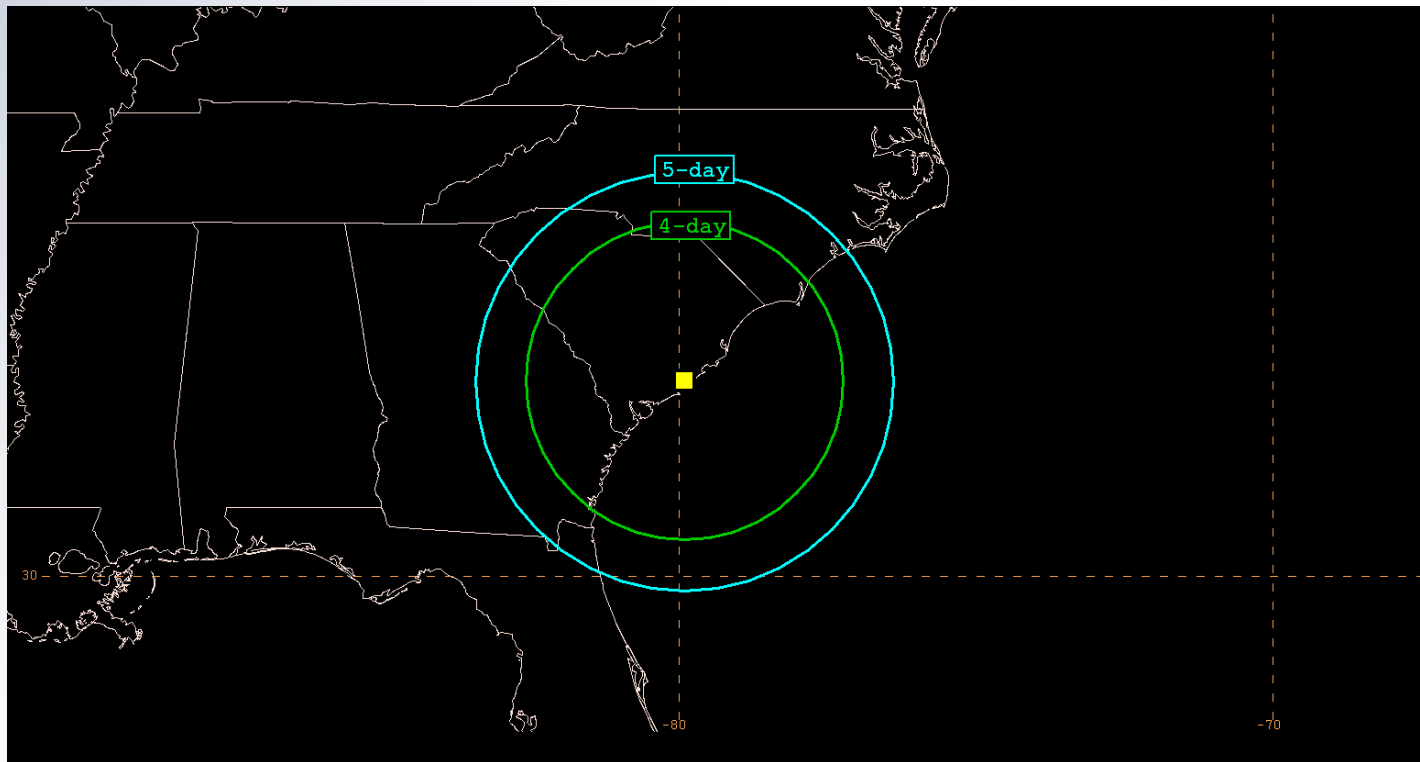


Examples of Wind, Storm Surge, Rainfall, and Tornado threat graphics for Hurricane Irma (2017)

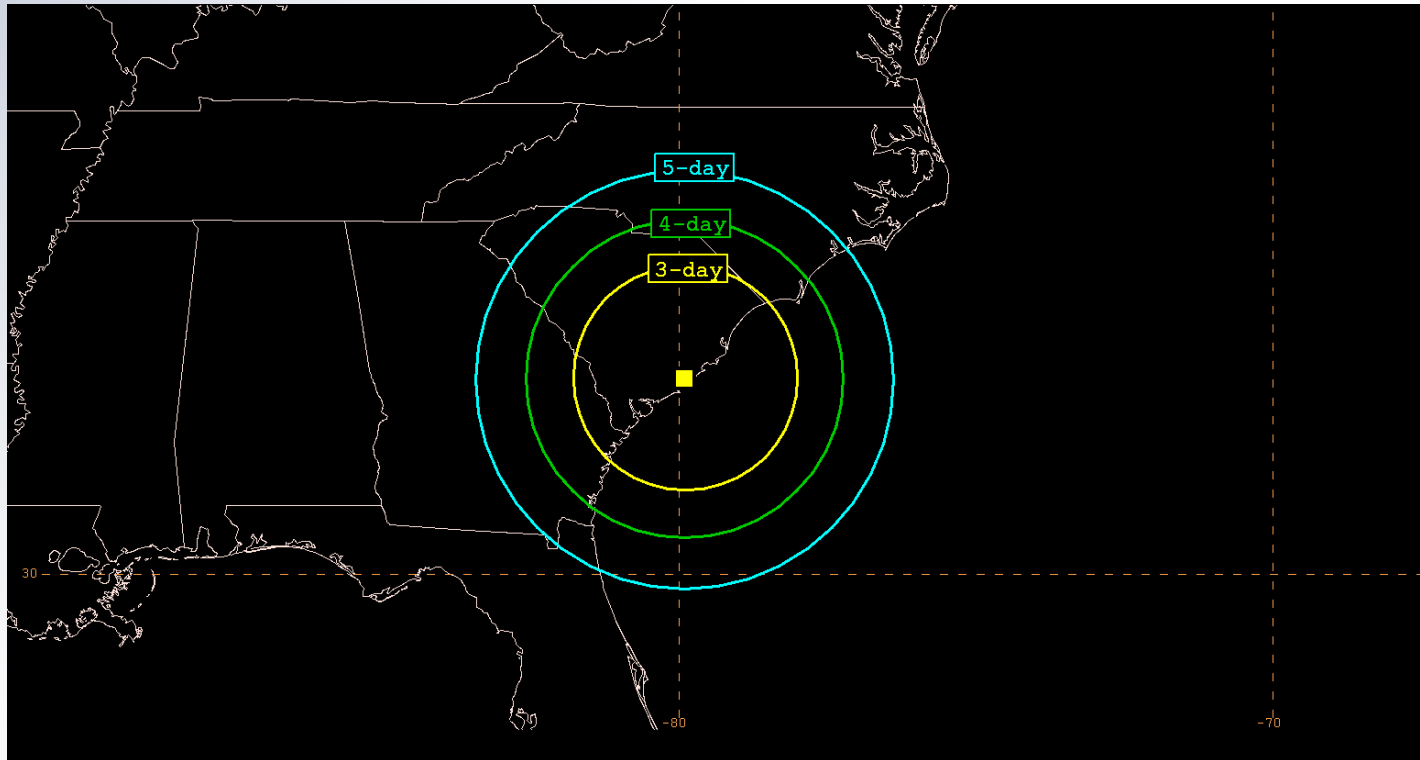
5-day Average Track Error



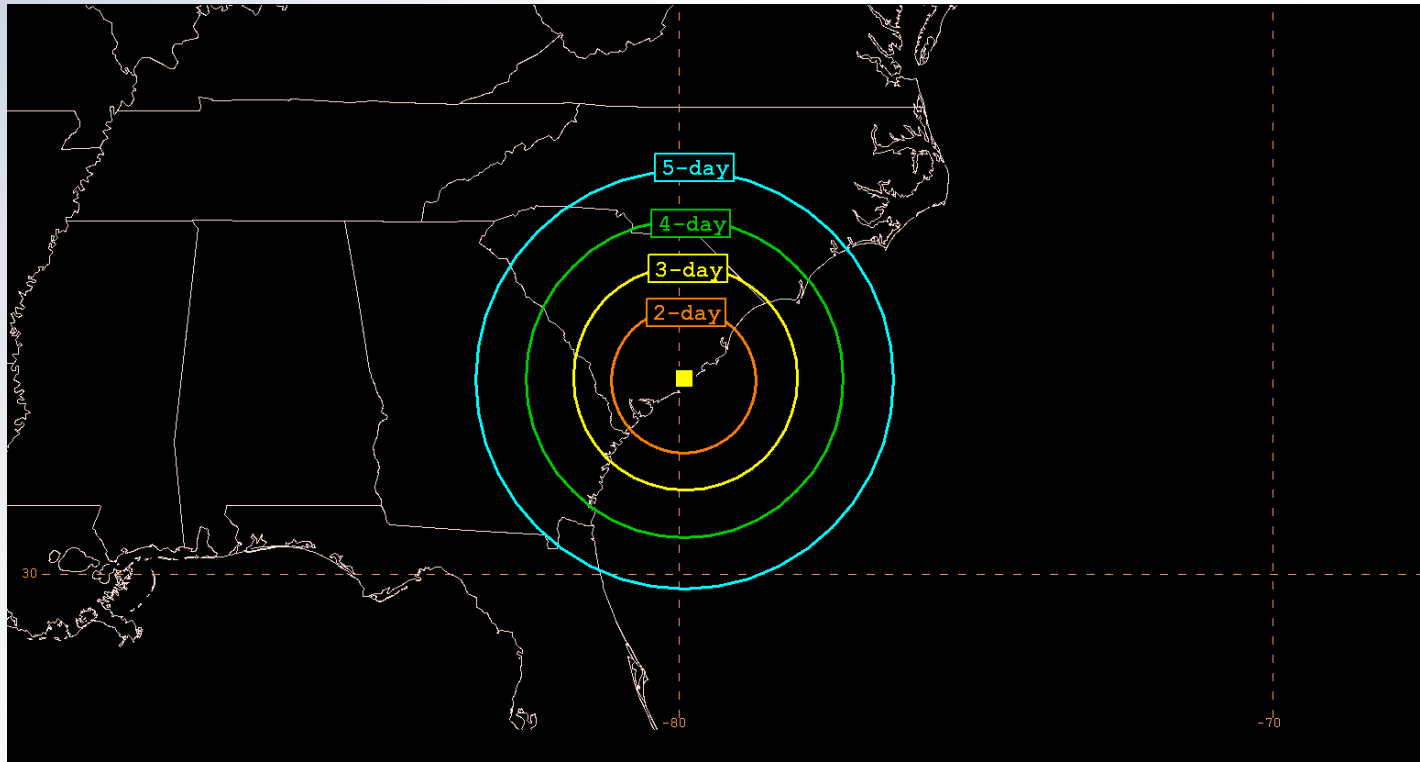
4-day Average Track Error



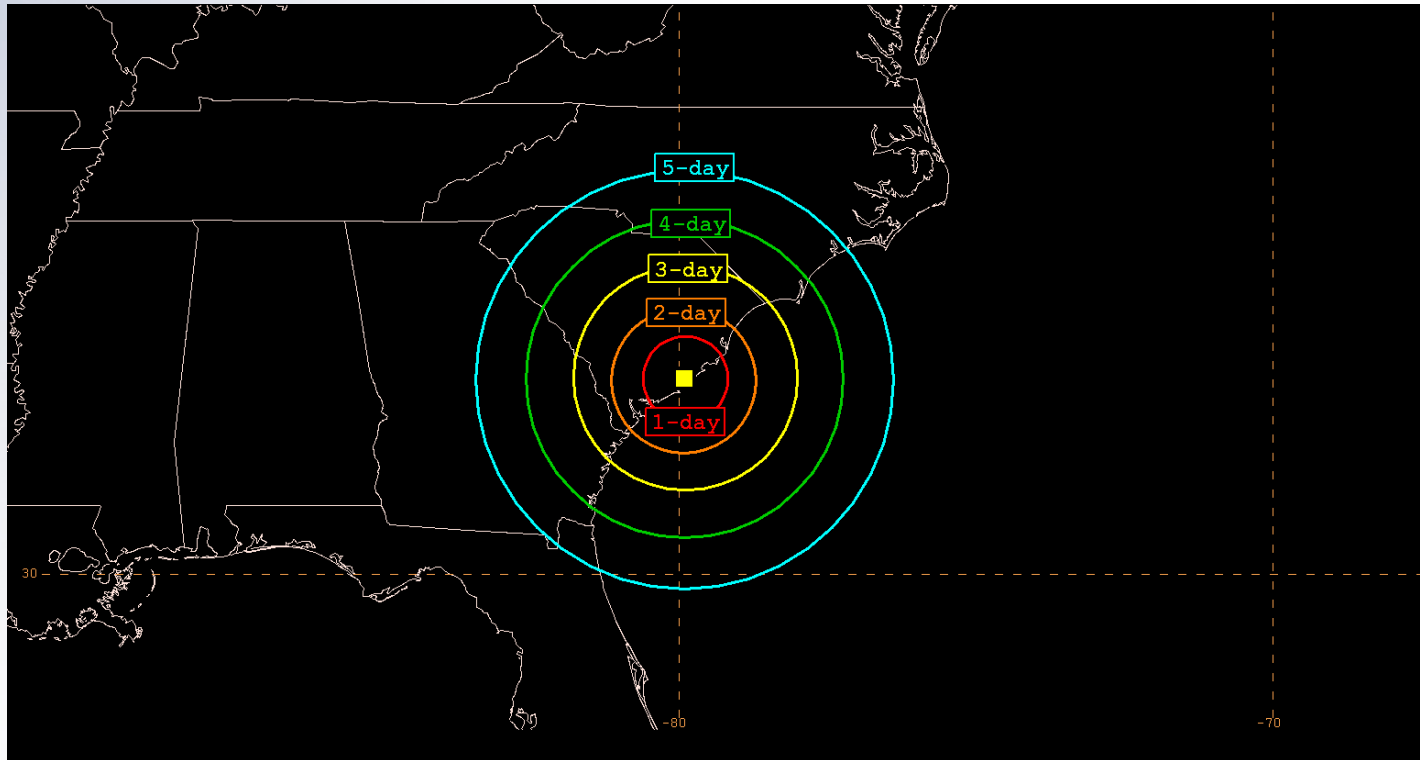
3-day Average Track Error



2-day Average Track Error

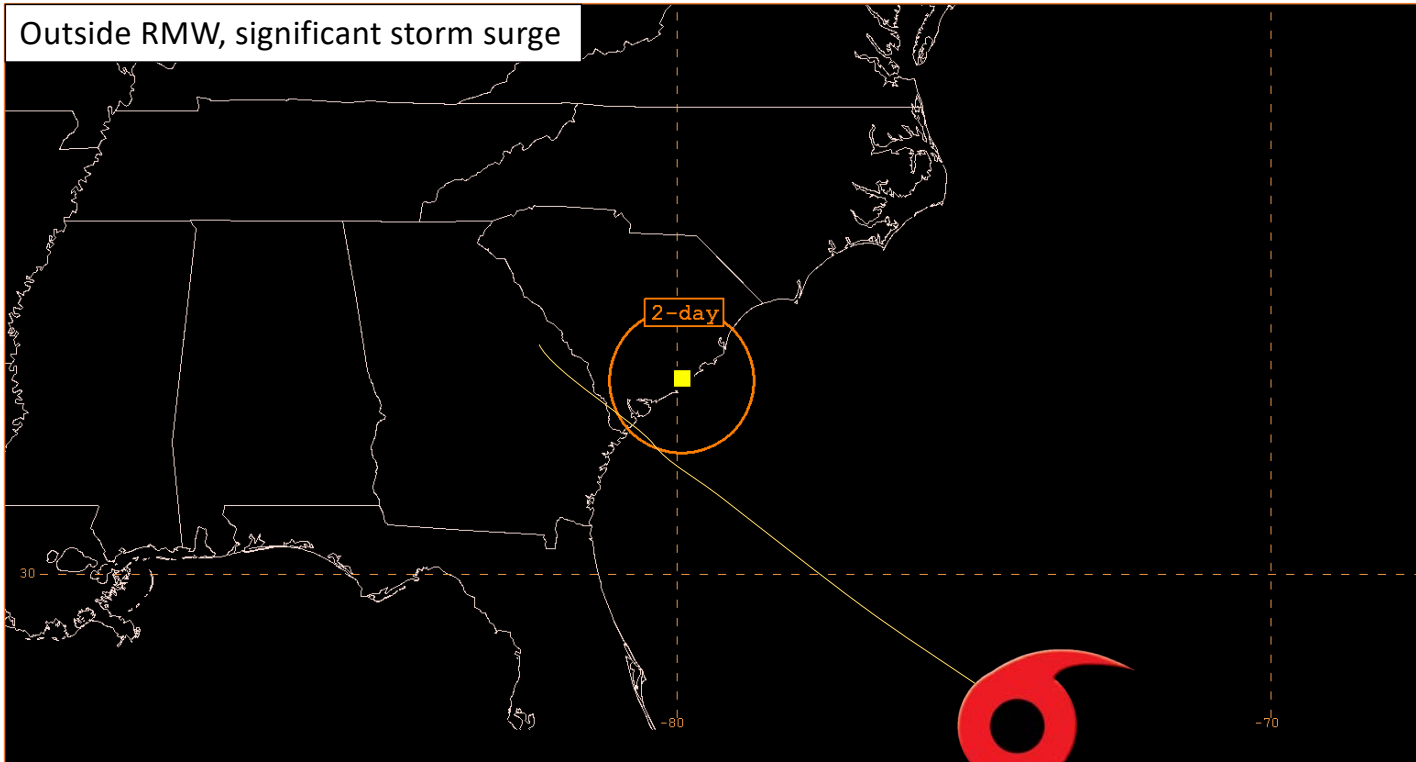


1-day Average Track Error

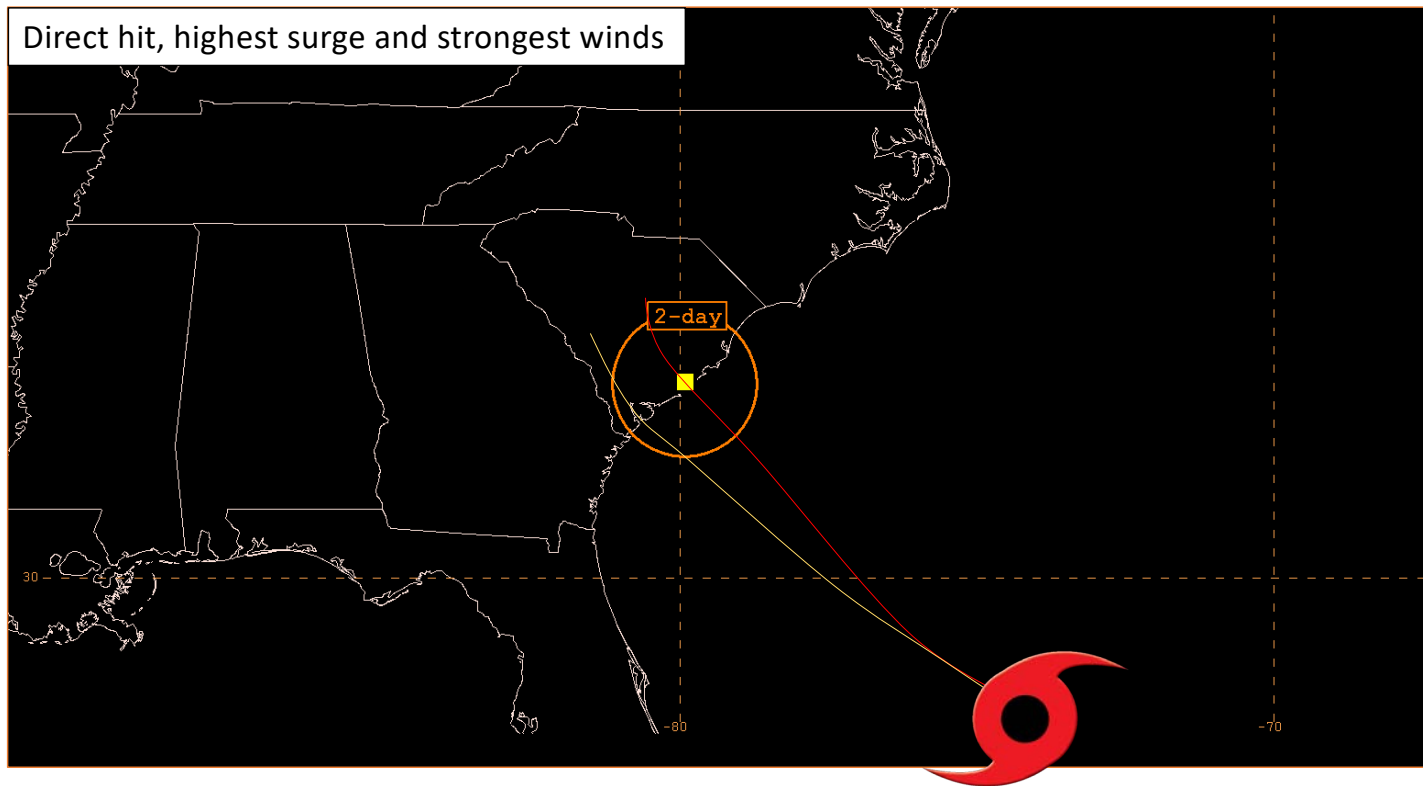




2-day Average Track Error

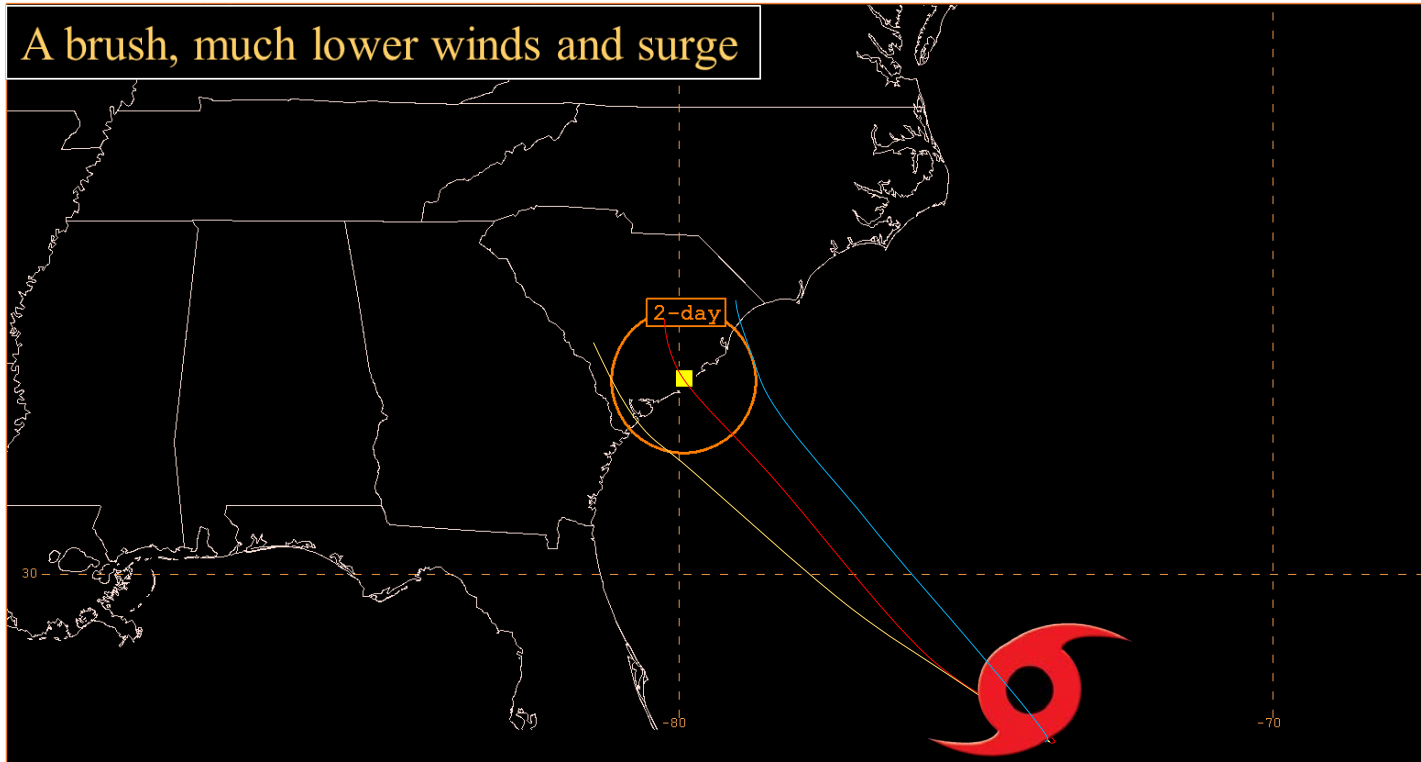


2-day Average Track Error



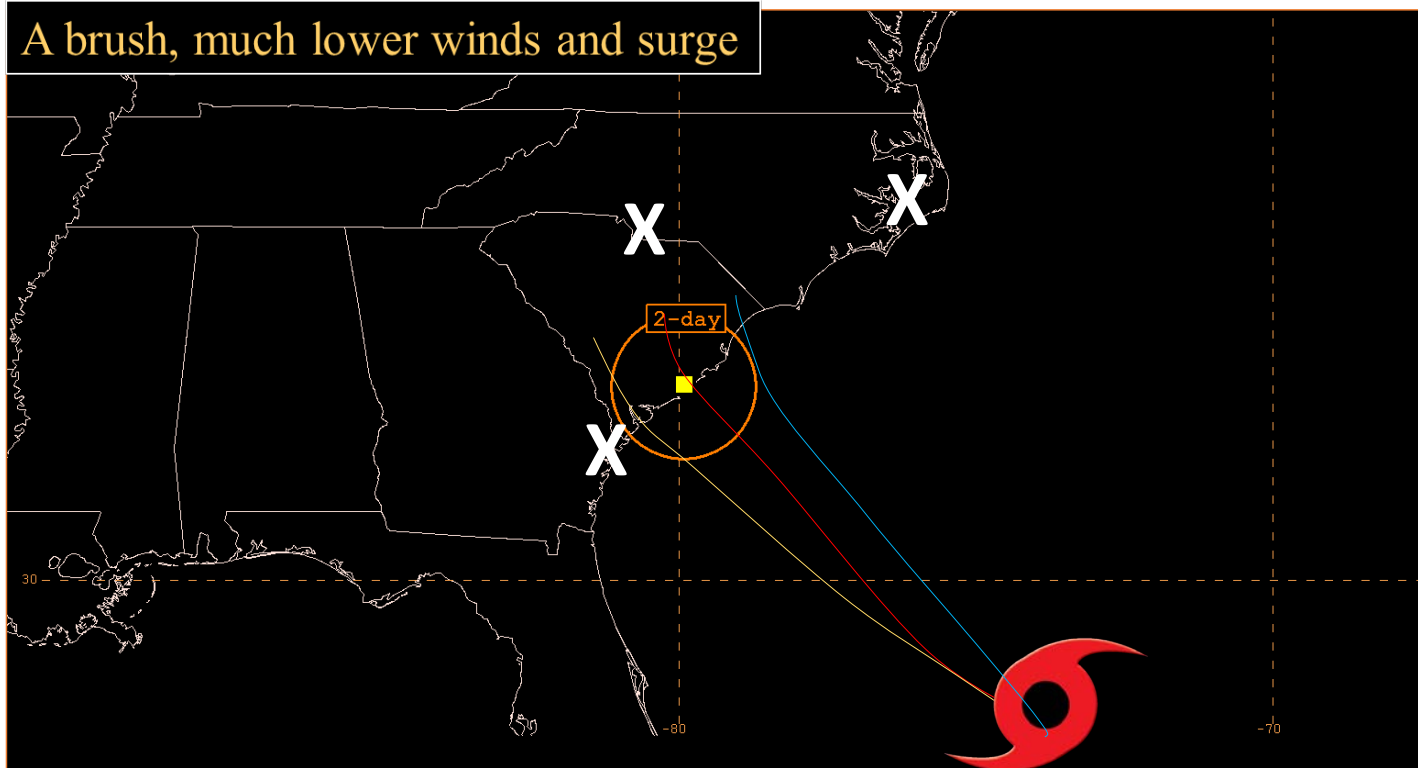


2-day Average Track Error





2-day Average Track Error



It's About the Impacts



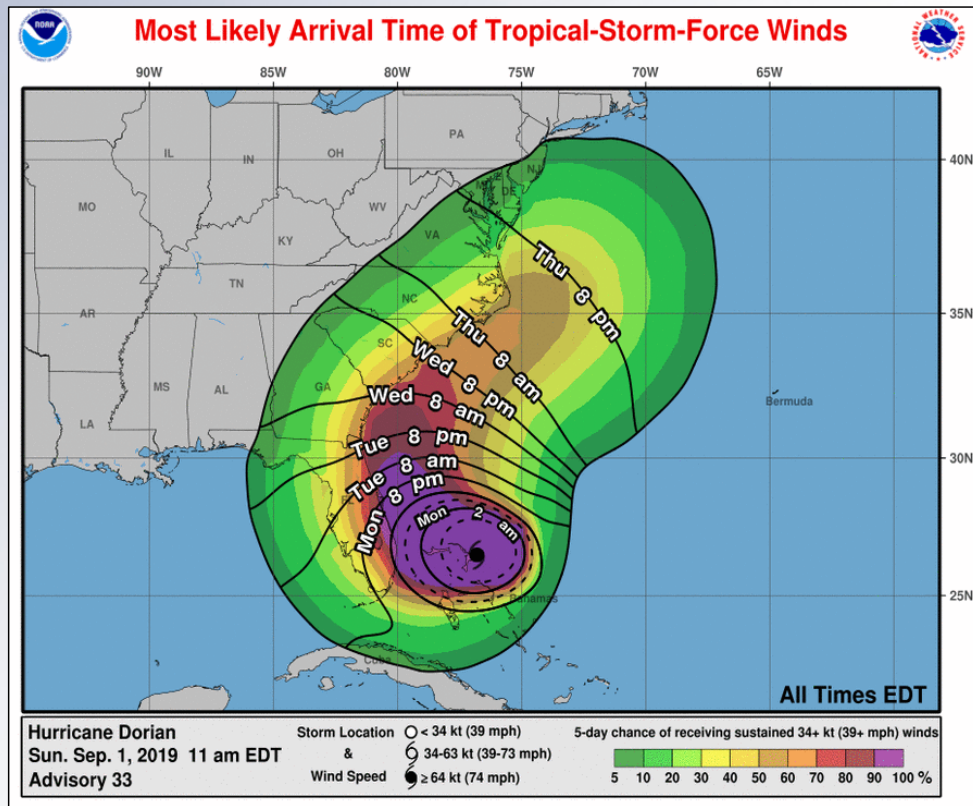
**Since 2010 in the U.S.,
Category 1 hurricanes***

**175 direct deaths
\$105 billion**

***Irene, Isaac, Sandy, Hermine, Matthew, Nate, Florence, Barry, Dorian**

Lesson 4. Social Science Matters

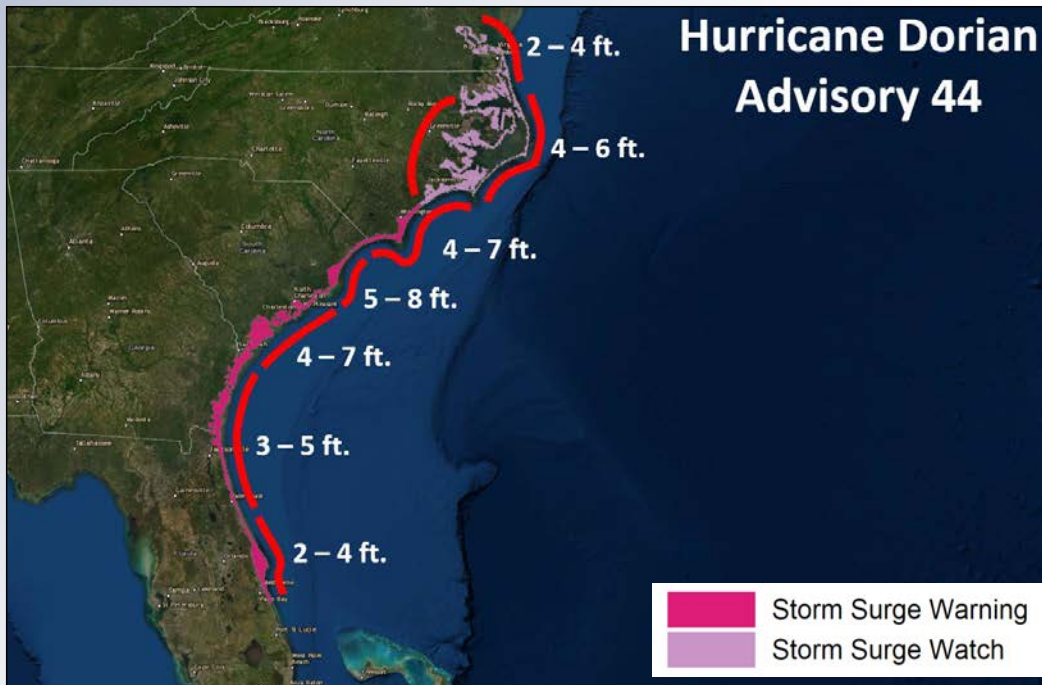
Time of Arrival Graphics



- **Earliest Reasonable and Most Likely graphics provide range of potential TS-force wind arrival times**
- **Accounts for typical forecast track, intensity, and size uncertainties**

Using Physical and Social Science Together

Storm Surge Products

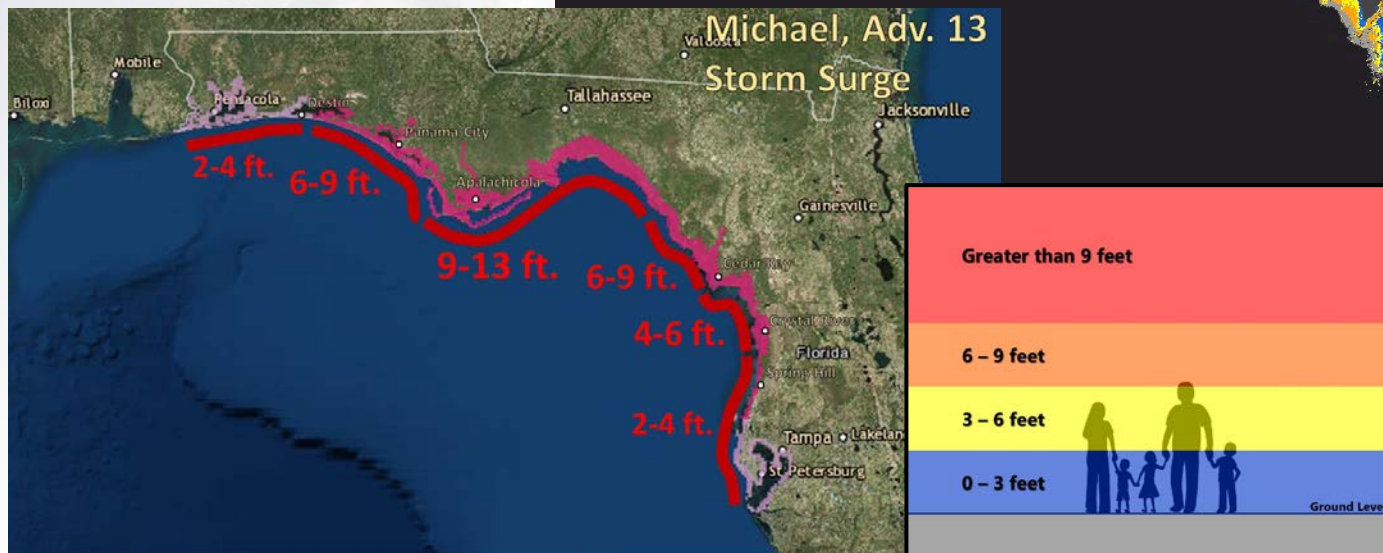
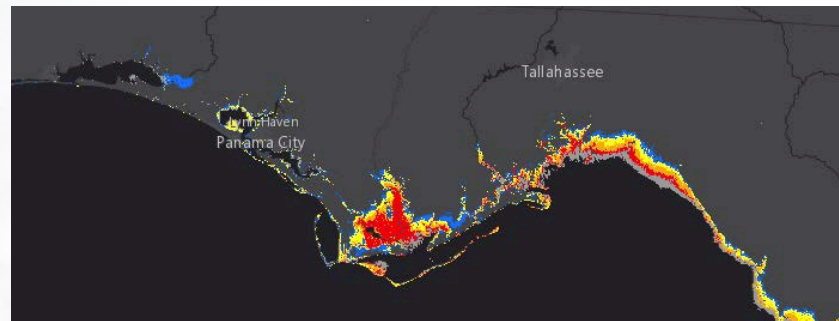


Storm Surge Watch/Warning graphic with forecast storm surge amounts

- **Storm Surge Watch and Warning**
 - Watch/Warning to aid in public response
- **Potential Storm Surge Flooding Map**
 - *Reasonable worse case scenario to aid in decision making

Using Physical and Social Science Together

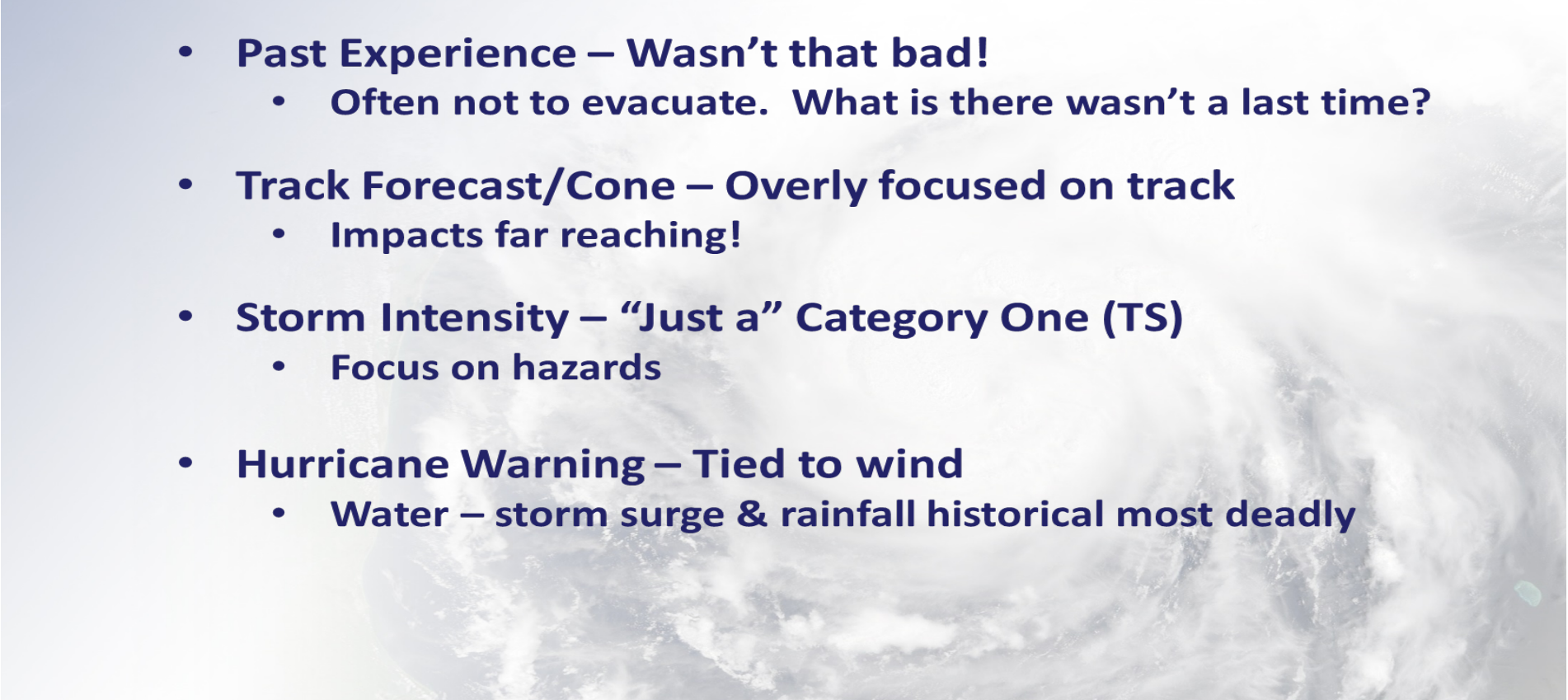
**Storm Surge Products
Provide
“Reasonable Worst-
Case” Scenario**





What's Influencing Evacuation Decisions

From Dr. Laura Myers Research

- **Past Experience – Wasn't that bad!**
 - Often not to evacuate. What is there wasn't a last time?
 - **Track Forecast/Cone – Overly focused on track**
 - Impacts far reaching!
 - **Storm Intensity – “Just a” Category One (TS)**
 - Focus on hazards
 - **Hurricane Warning – Tied to wind**
 - Water – storm surge & rainfall historical most deadly
- 

Communicating Risk Challenge

First Out 21%	Anxious and eager to leave if a hurricane is in the forecast
Constrained 14%	Aware of risks & willing to evacuate but face barriers
Optimists 16%	Doubt that a hurricane will occur but willing to evacuate
Reluctant 27%	Reluctant to evacuate but will leave if ordered to
Diehards 22%	Confident they can safely ride out hurricanes at home

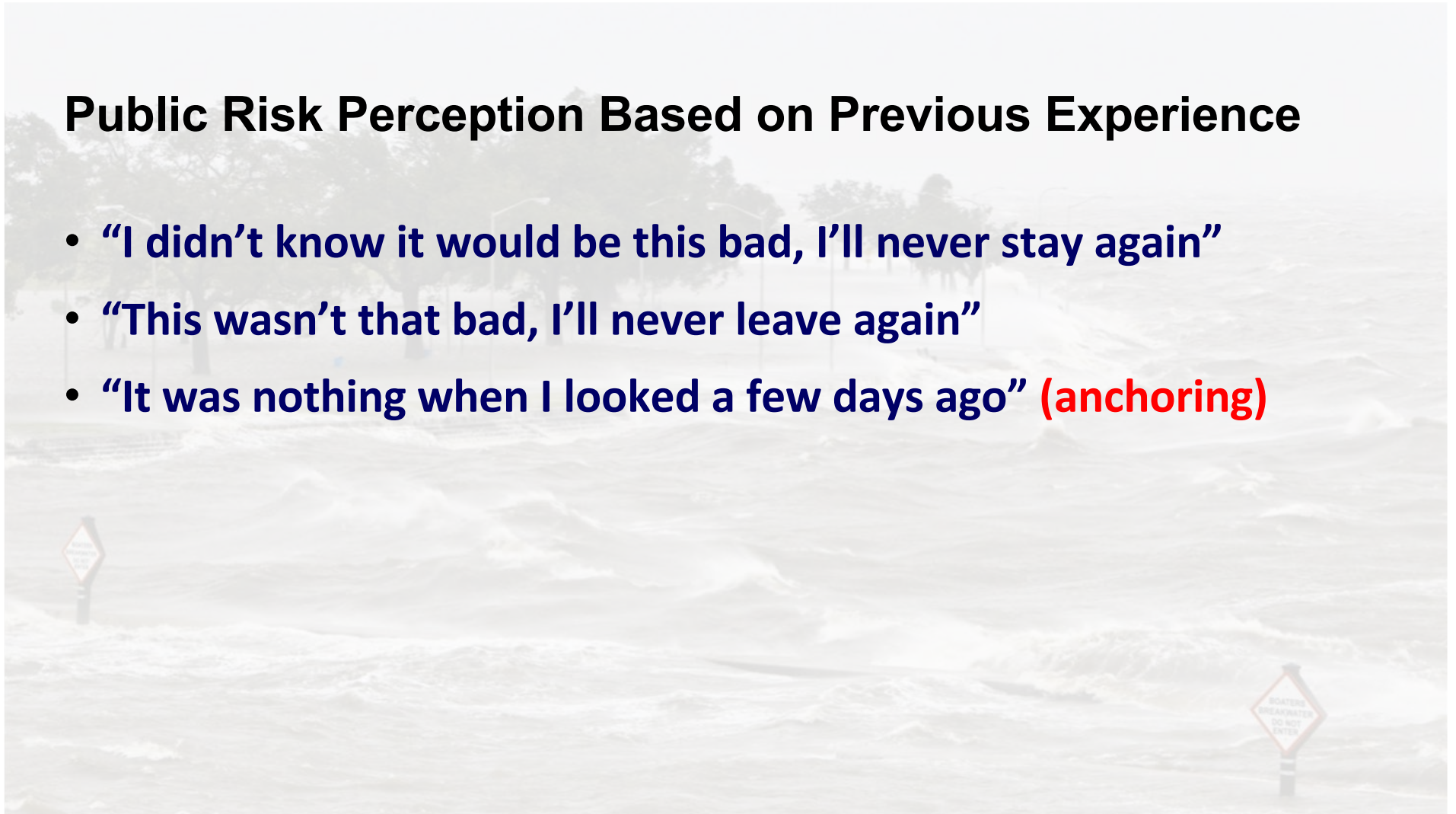
Sandy study by Jennifer Marlon, Yale University

Public Risk Perception Based on Previous Experience

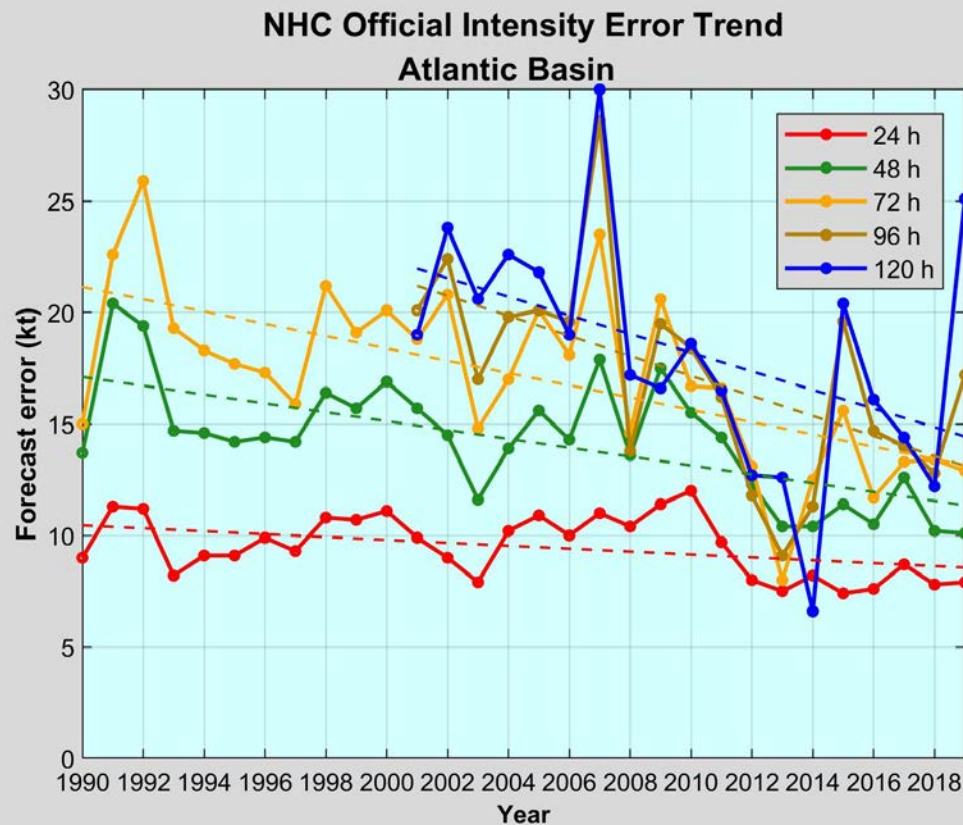
- “My house is elevated, I thought we would be just fine”
- “It’s never flooded here before”
- “They always turn”
- “I thought these floods come once in a 100 years”
- “It’s just a tropical storm”
- “I live a hundred miles from the coast, I didn’t expect this”
- “This didn’t happen last time”

Public Risk Perception Based on Previous Experience

- “I didn’t know it would be this bad, I’ll never stay again”
- “This wasn’t that bad, I’ll never leave again”
- “It was nothing when I looked a few days ago” (anchoring)

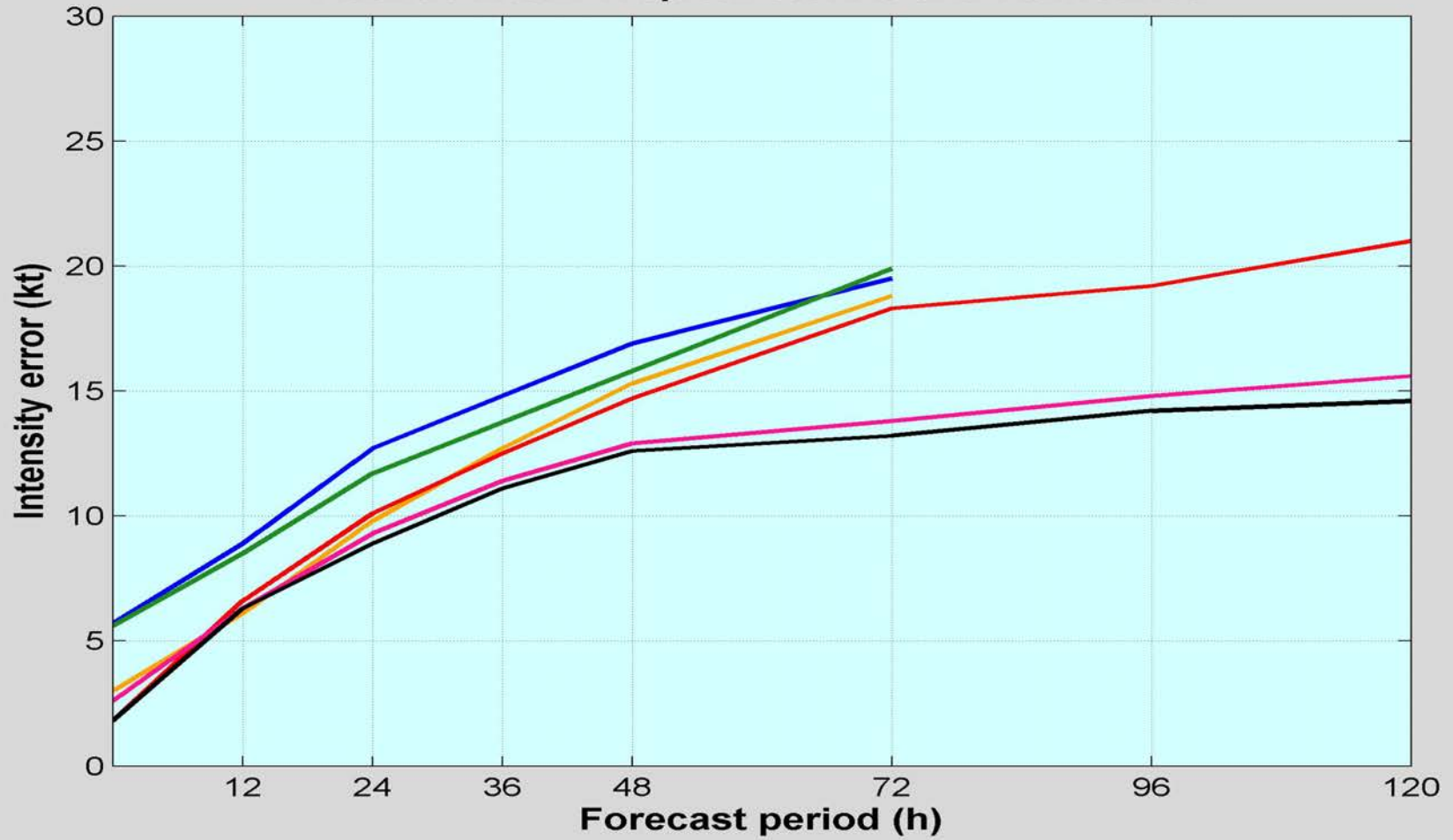


Lesson 5. Intensity Forecasting is Difficult

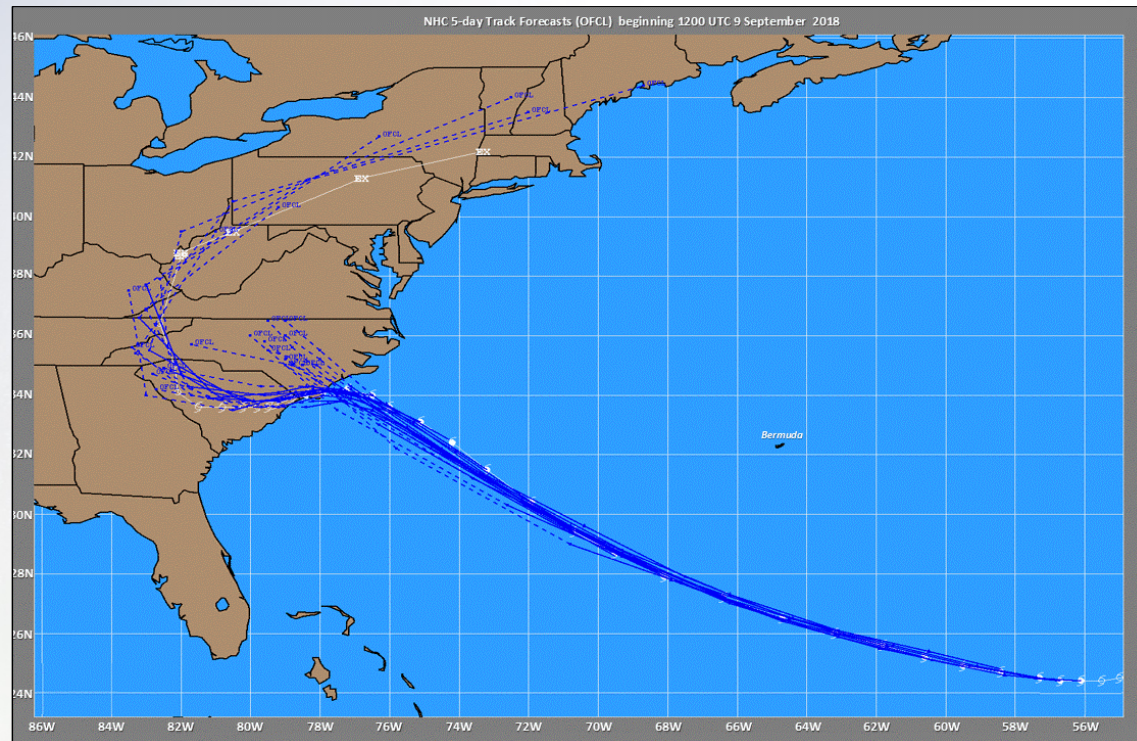


- Errors decreased for the short lead times, but spiked upward at days 4 and 5 in 2019.
- Second largest annual error at 5 days – mostly because of Dorian

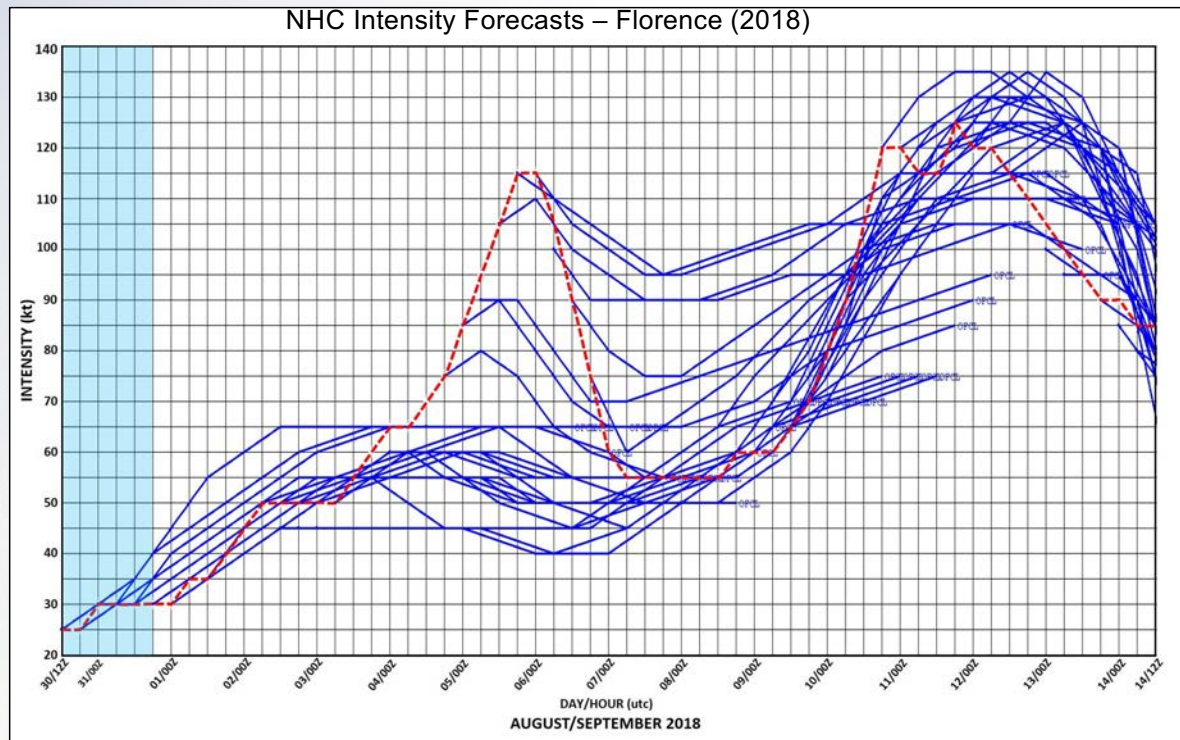
NHC Official Average Intensity Errors Atlantic Basin Tropical Storms and Hurricanes



Track Forecast Success During Florence's Approach to the U.S.

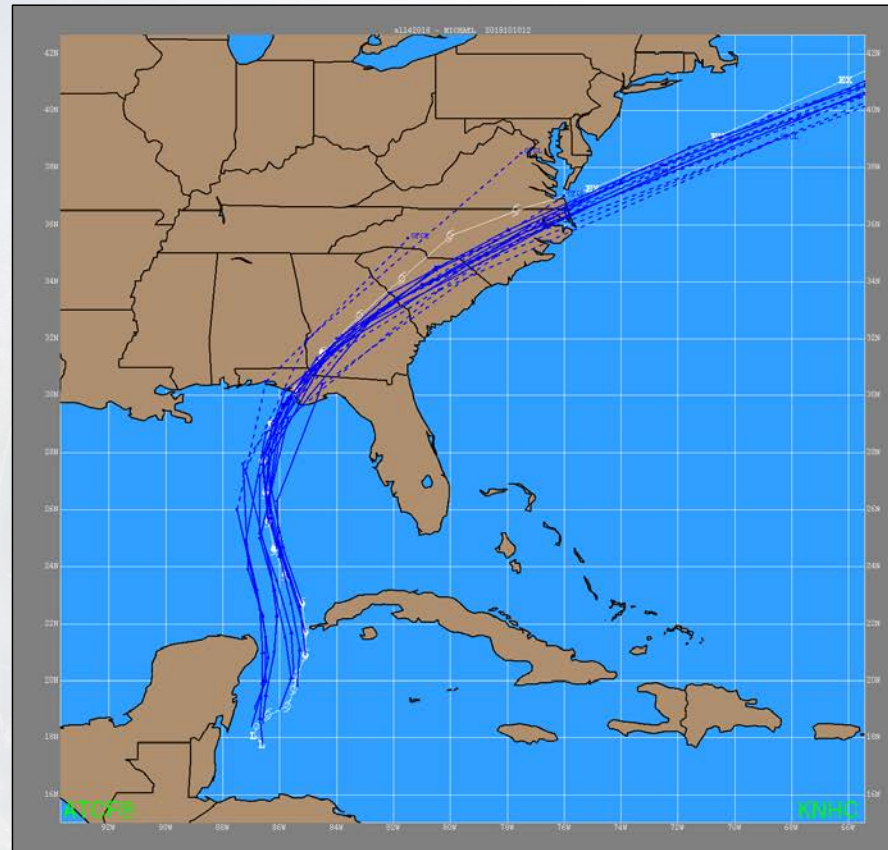


Hurricane Florence Intensity Forecast Difficulty

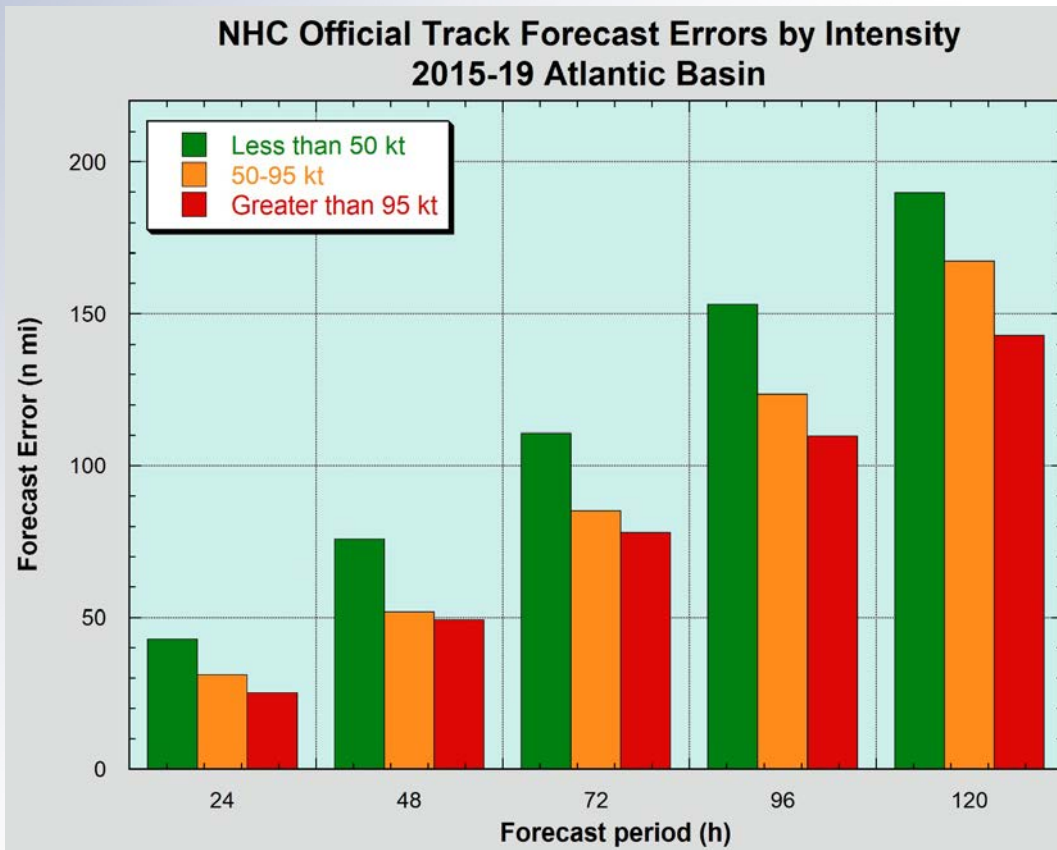


Struggled with period of rapid strengthening and then over-forecast intensity near landfall

Track Forecasts Very Consistent in Showing Threat to the Florida Panhandle



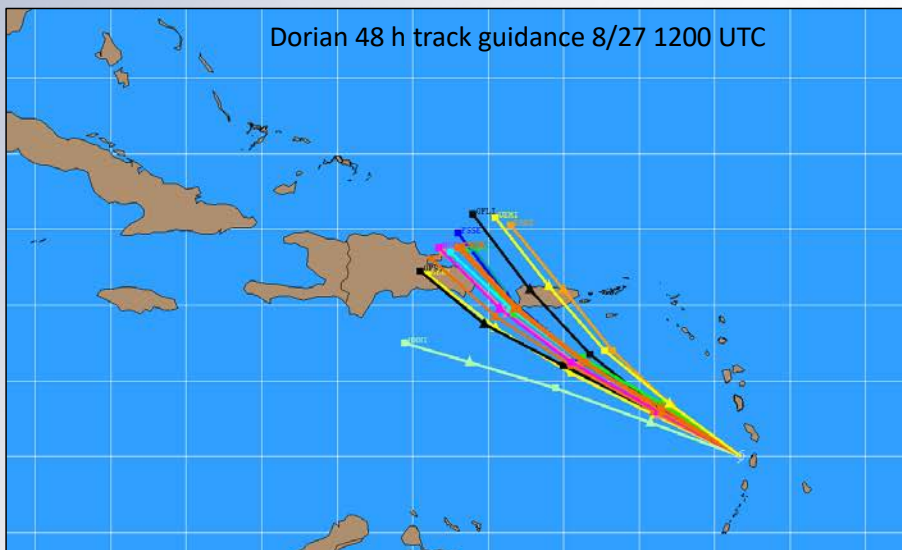
Track Error by Intensity



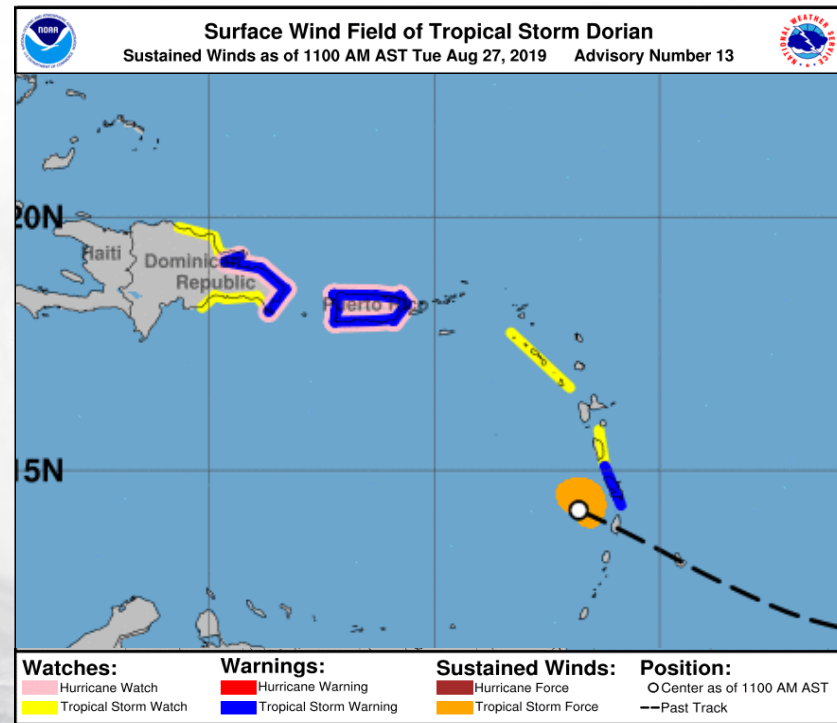
As the initial intensity of the storm increases, NHC track errors on average get smaller.

Lesson 6. Lots of Potential Error in Genesis Phase

Dorian's Track and Intensity



Short-term track forecast difficulty occurred when Dorian's center reformed farther northward on 27 August. Multiple centers during genesis

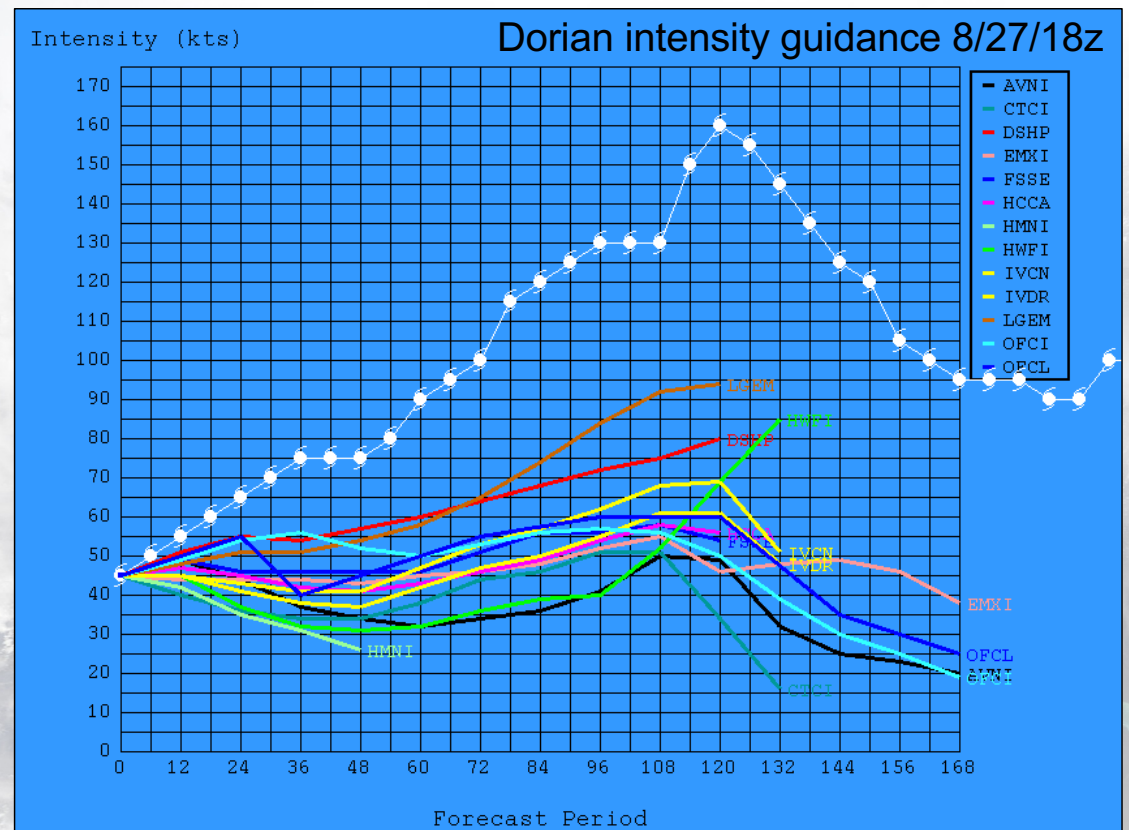


Resulted in short warning lead time for the Virgin Islands

2019 Forecast Successes & Challenges

Dorian's Track and Intensity

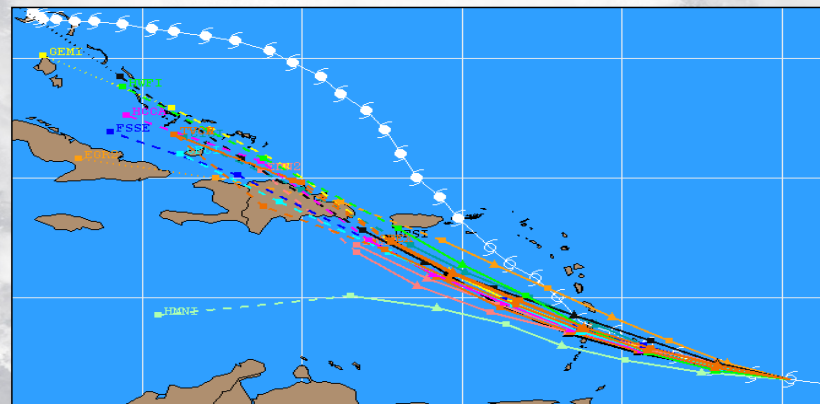
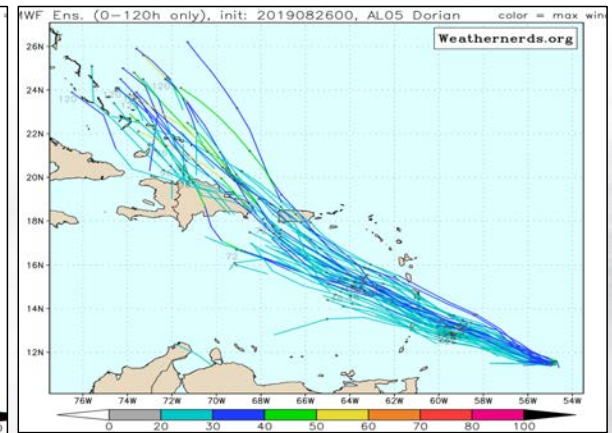
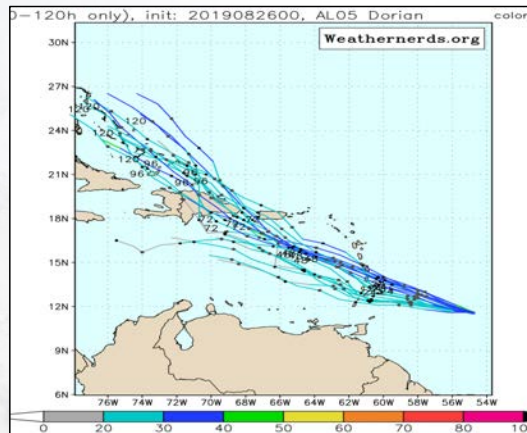
- Difficulty in Dorian's intensity forecast:
 - 100 kt error in 5 day intensity forecast
 - No model even a had major hurricane



2019 Forecast Successes & Challenges

Dorian's Track and Intensity

- Why such large intensity errors?
- Most of the track guidance initially predicted significant land interaction



Hurricane Dorian – Bahamas



Image courtesy of AP



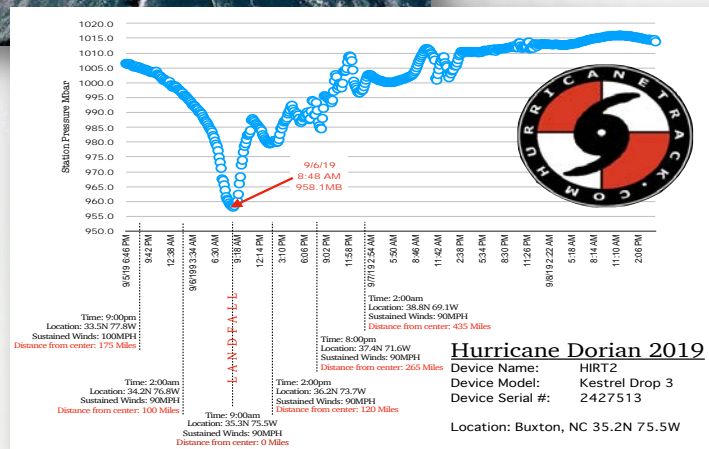
Courtesy of Getty Images

- **Most intense hurricane to make landfall in the Bahamas**
- **Struck Abaco Islands on 1 September, then became nearly stationary near Grand Bahamas for more than 24 hours**
- **Catastrophic wind and storm surge damage – death toll still unknown**

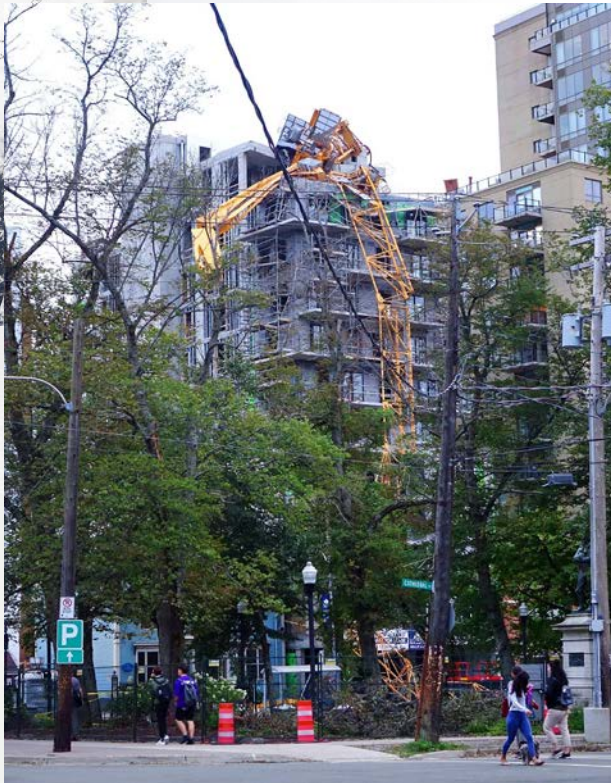
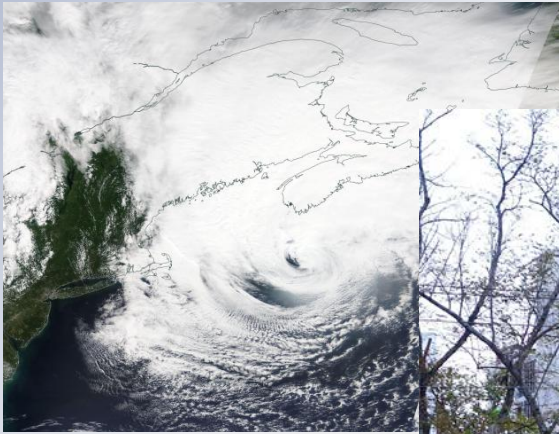
Hurricane Dorian – United States



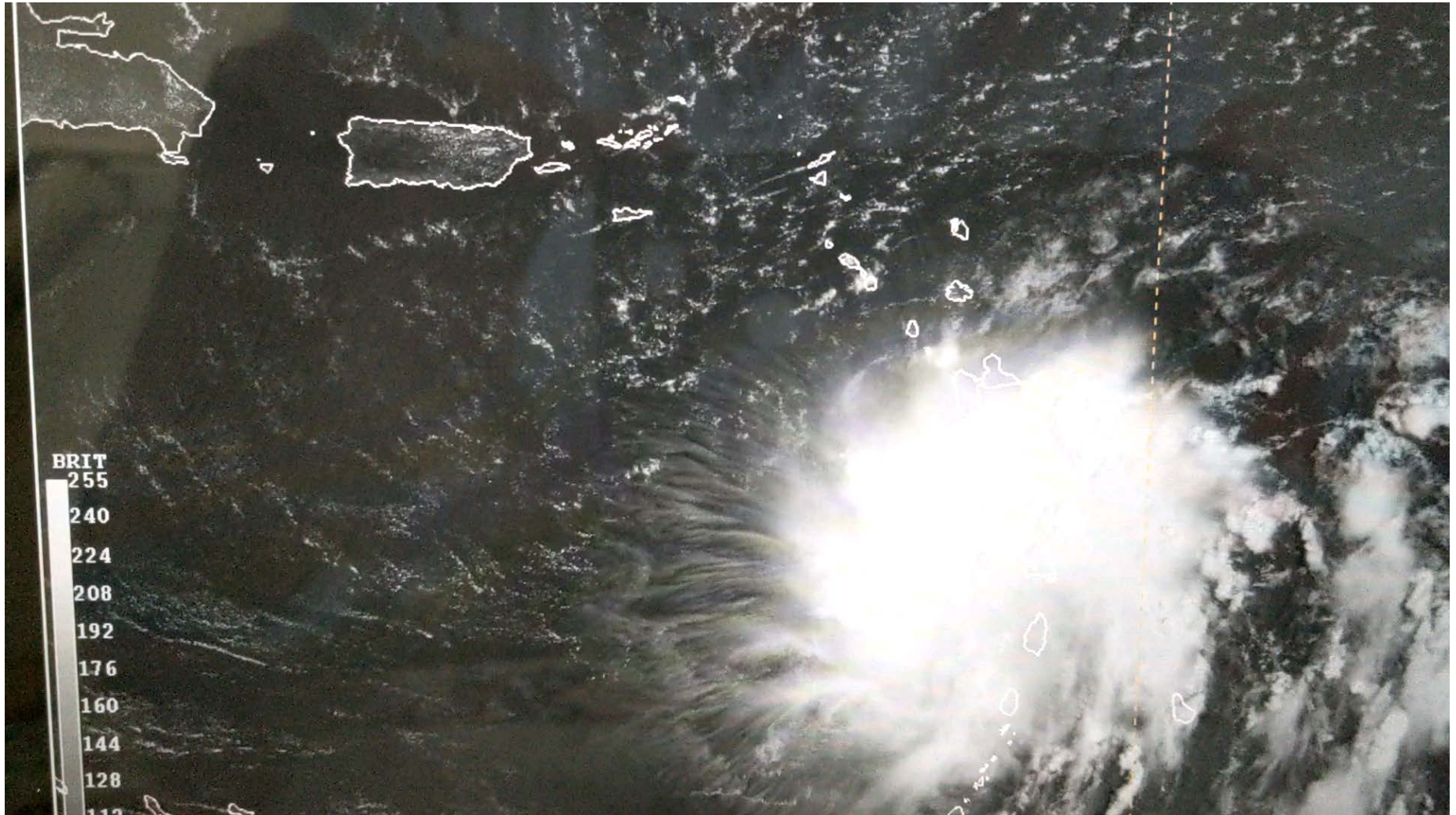
- Coastal impacts from Florida through the Carolinas
- Made landfall at Cape Hatteras as a category 1 hurricane



Post-Tropical Dorian – Canada



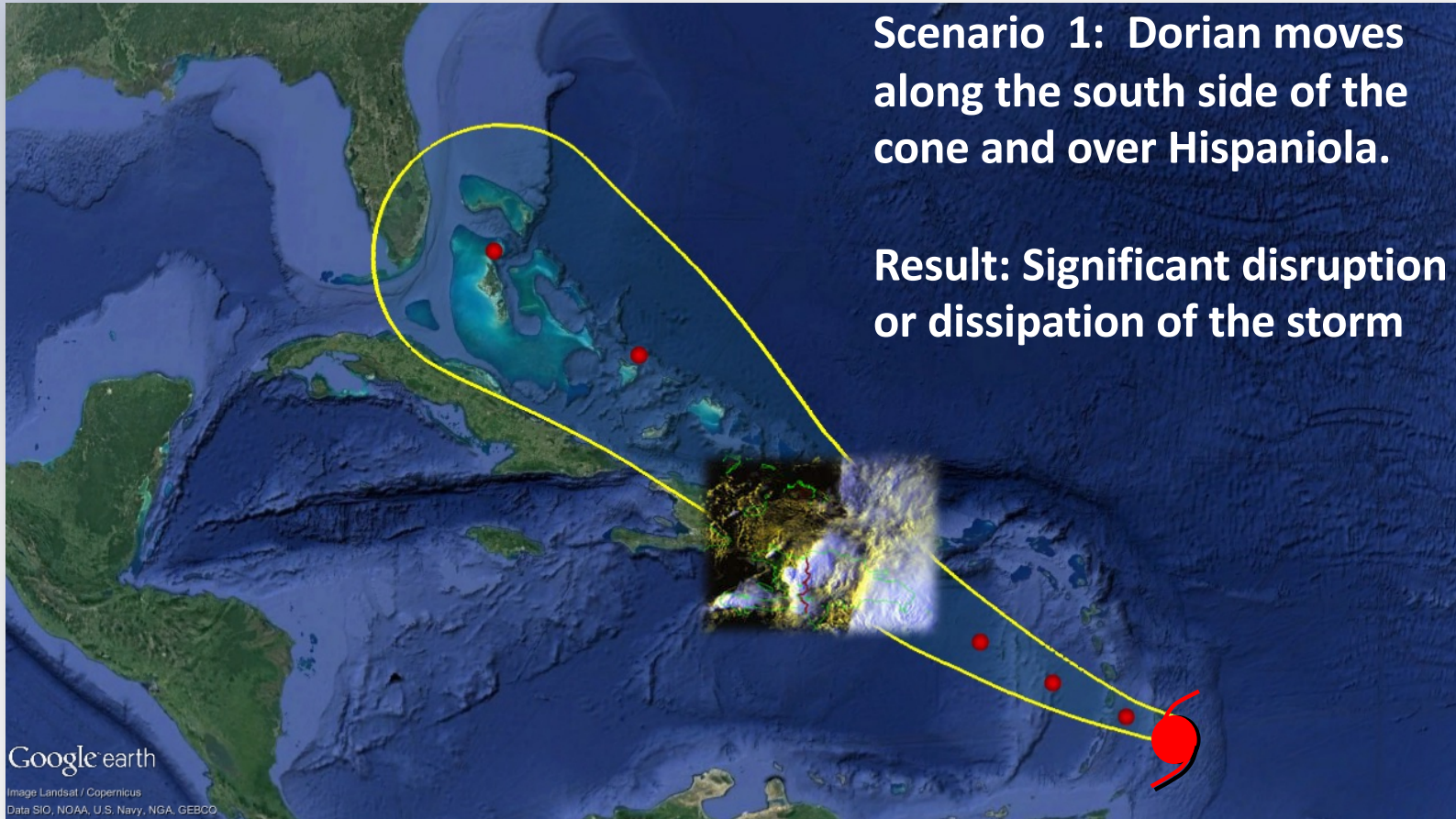
- Hurricane-force winds in Atlantic Canada with center of the storm moving over Halifax
- Over half-million power outages with 80% power loss in Nova Scotia



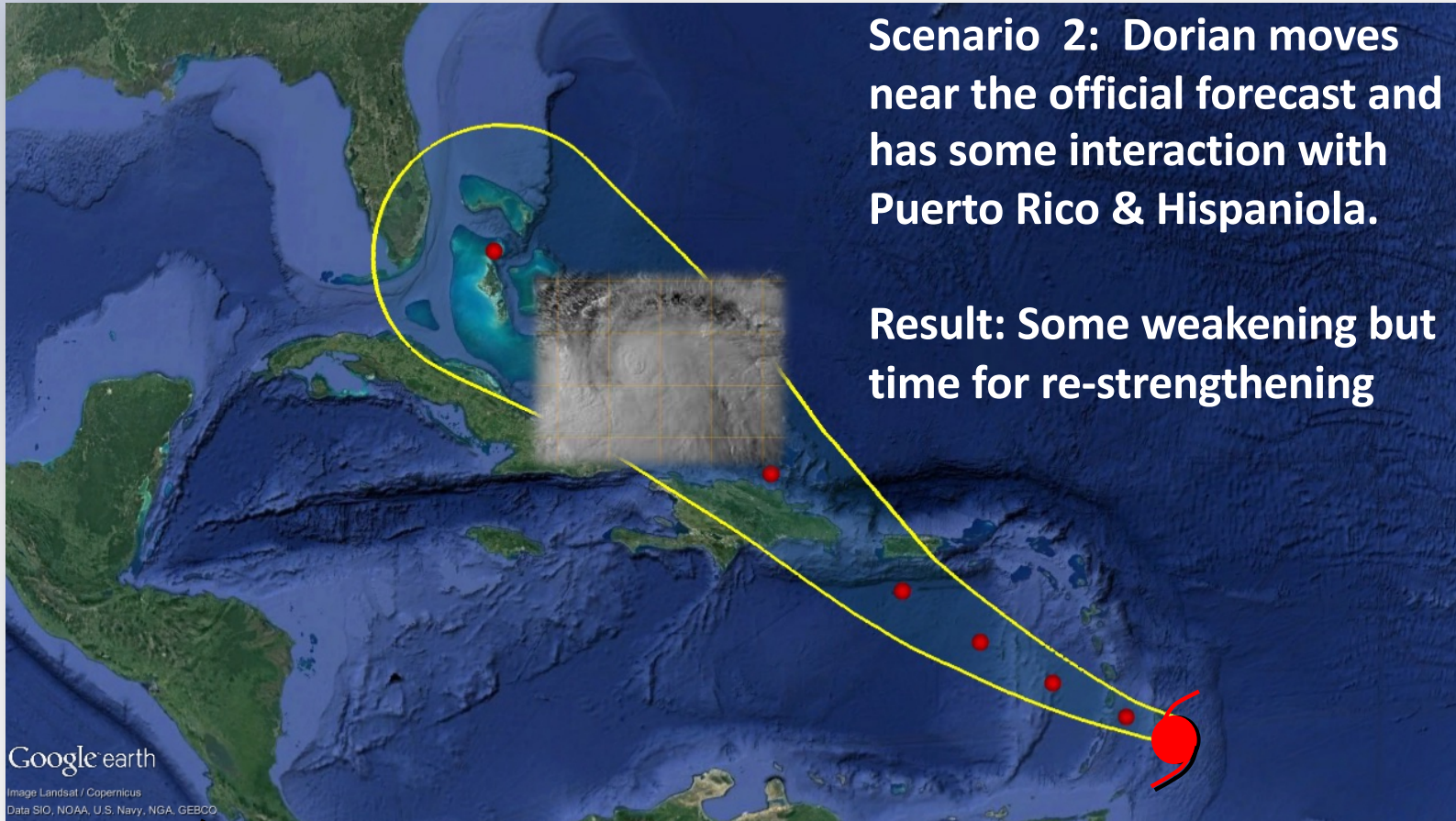
Dorian What If's

Scenario 1: Dorian moves along the south side of the cone and over Hispaniola.

Result: Significant disruption or dissipation of the storm



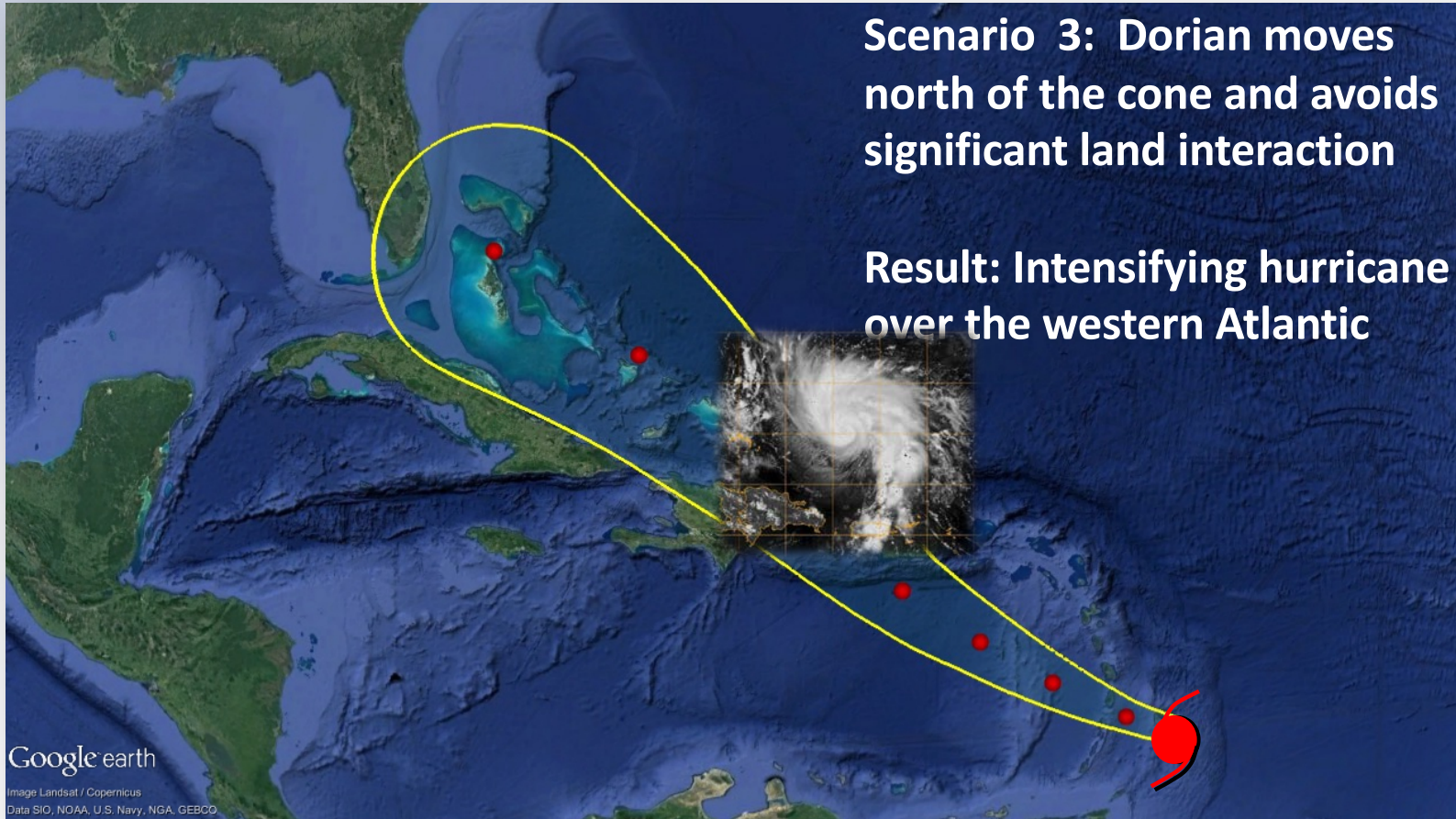
Dorian What If's



Dorian What If's

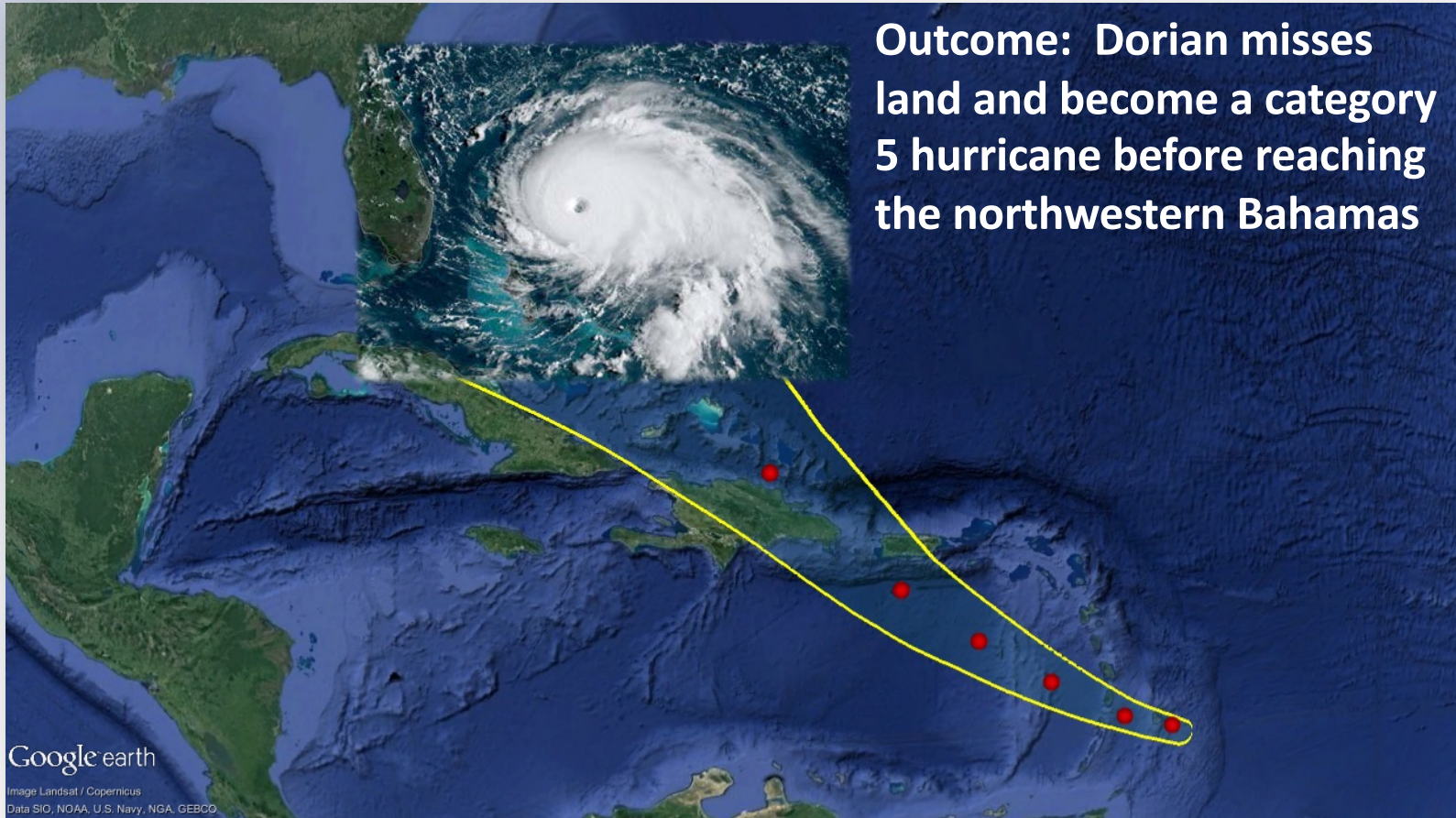
Scenario 3: Dorian moves north of the cone and avoids significant land interaction

Result: Intensifying hurricane over the western Atlantic



Dorian What If's

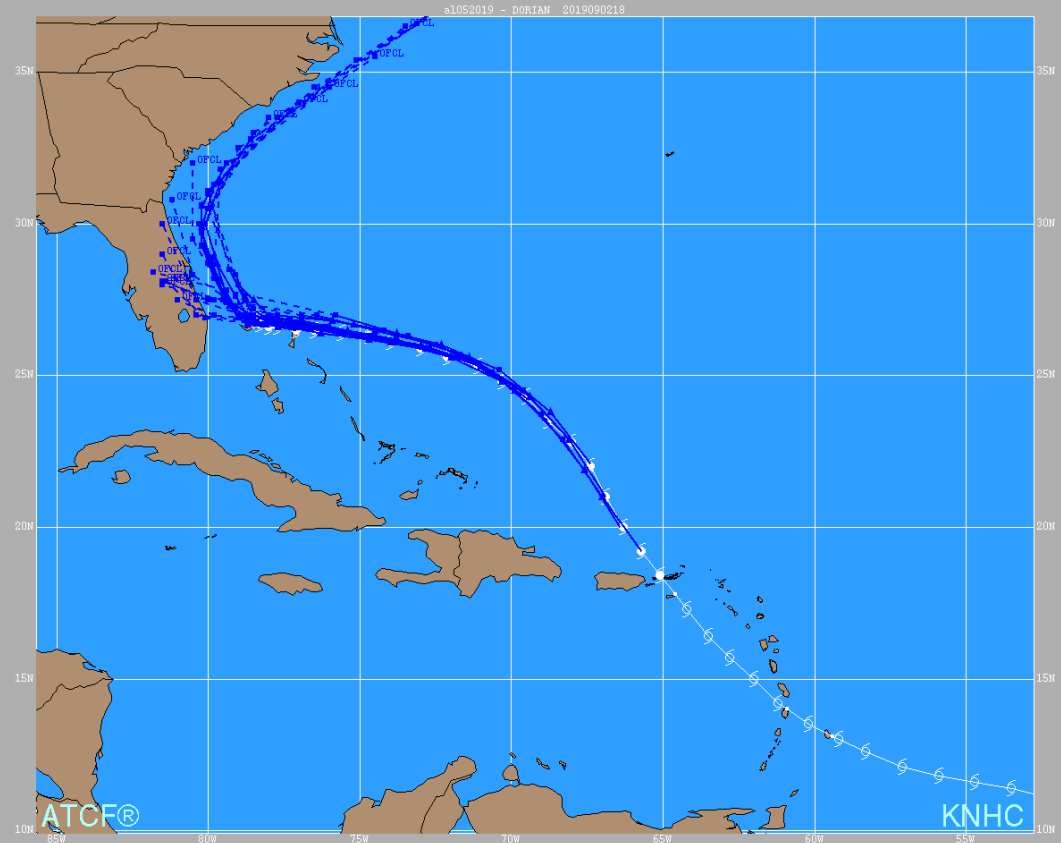
Outcome: Dorian misses land and become a category 5 hurricane before reaching the northwestern Bahamas



Dorian Official Forecasts

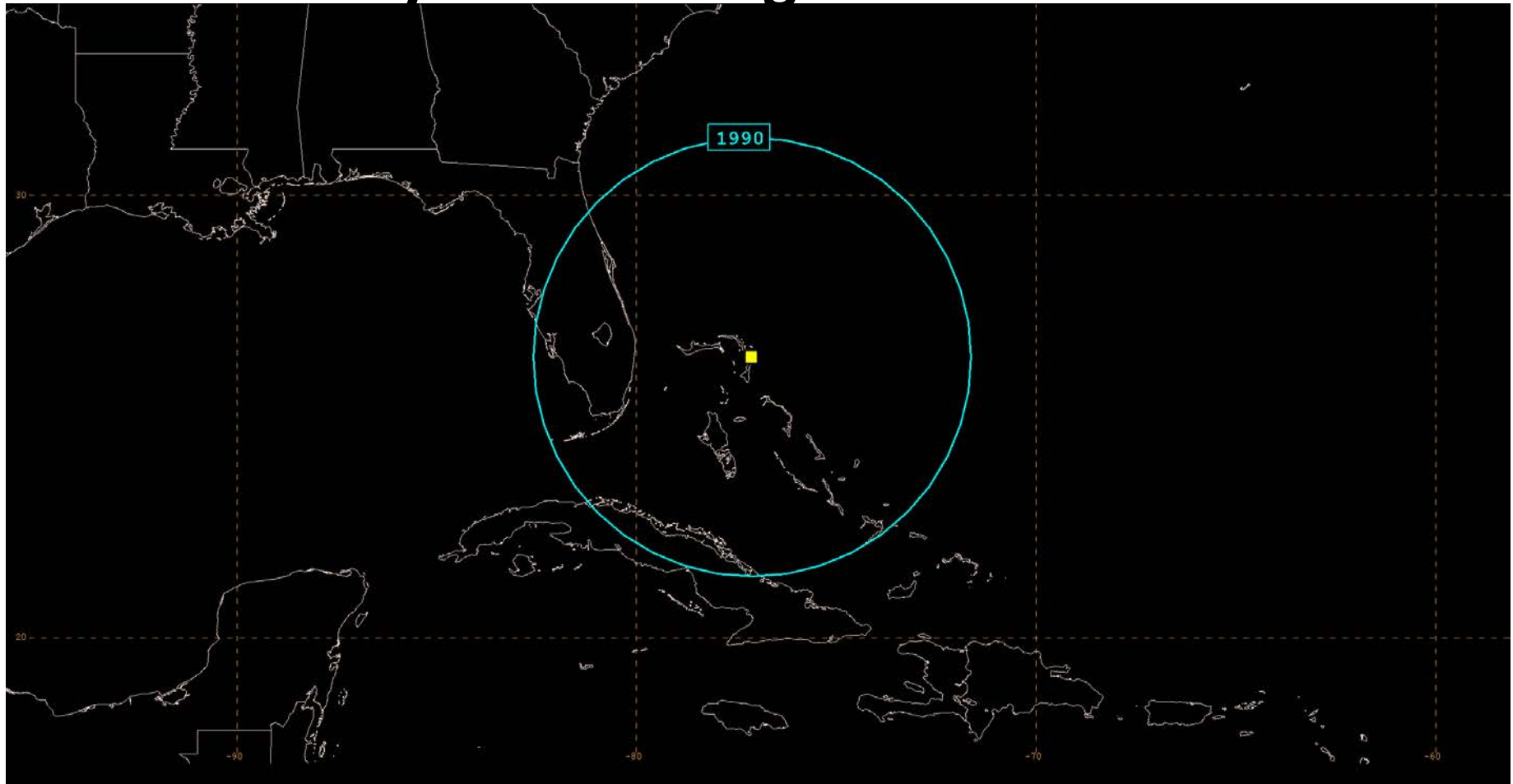
Average NHC track errors (nm) for the forecast made from 00Z 29 August through 00Z 3 September:

Day 5: 87.4
Day 4: 58.9
Day 3: 31.0
Day 2: 26.0
Day 1: 16.4



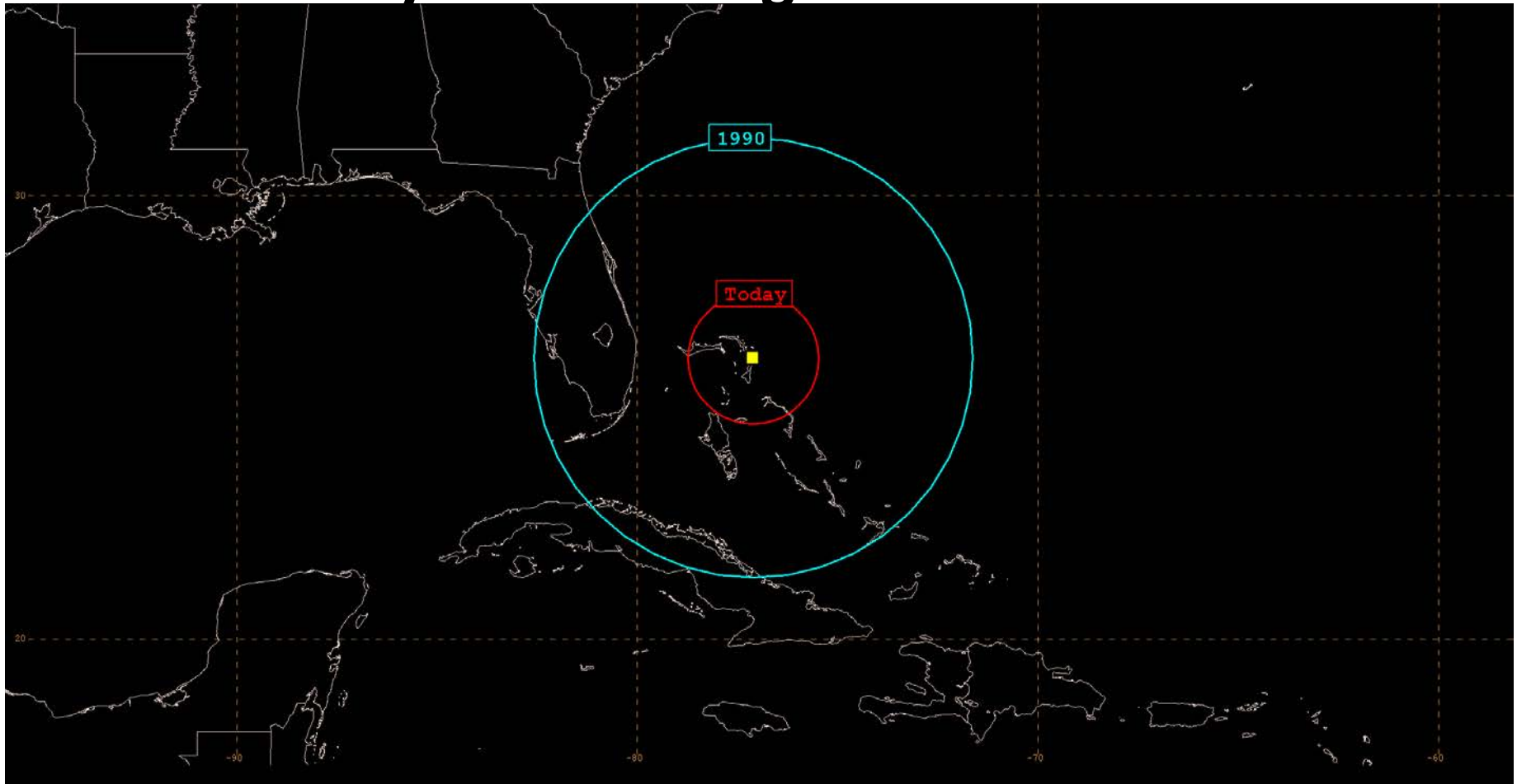


3-day NHC Average Track Error



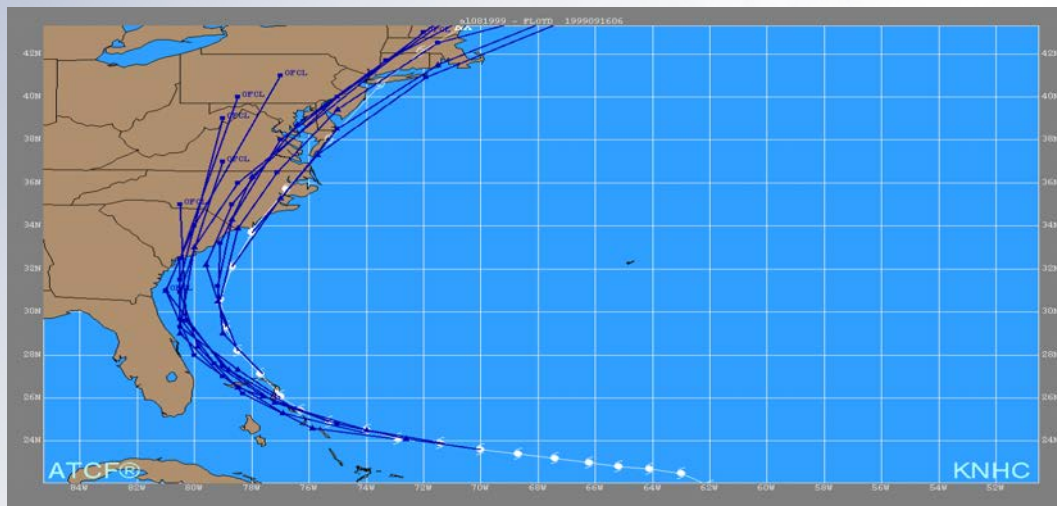


3-day NHC Average Track Error



2019 Forecast Successes & Challenges

How Far Have We Come Since Floyd?

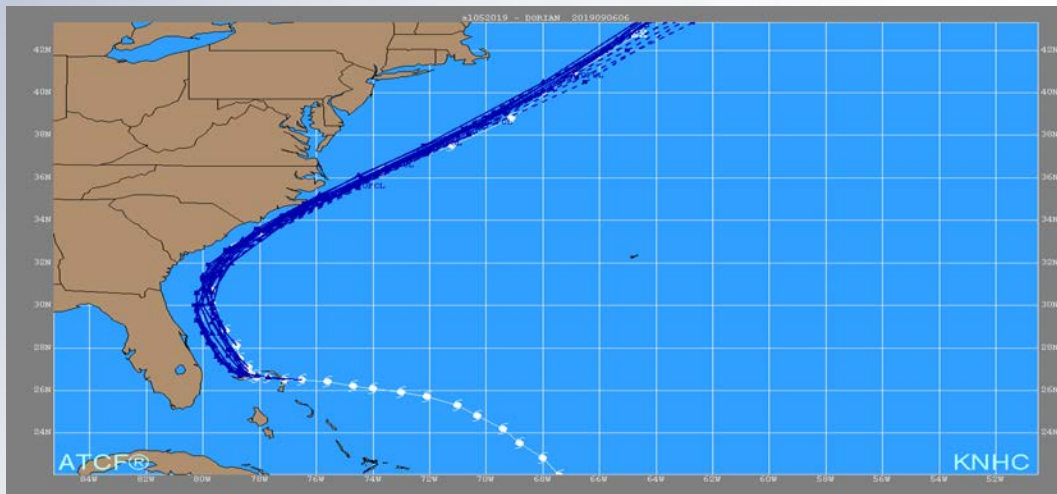


NHC Track Forecasts for Floyd from
06Z 13 Sep - 06Z 16 Sep 1999

- Average 3-day NHC track forecast error of 236 n mi for forecasts issued within 3 days of landfall in North Carolina
- Triggered the largest evacuation in U.S. history at the time – 2.6 million coastal residents from 5 states

2019 Forecast Successes & Challenges

How Far Have We Come Since Floyd?



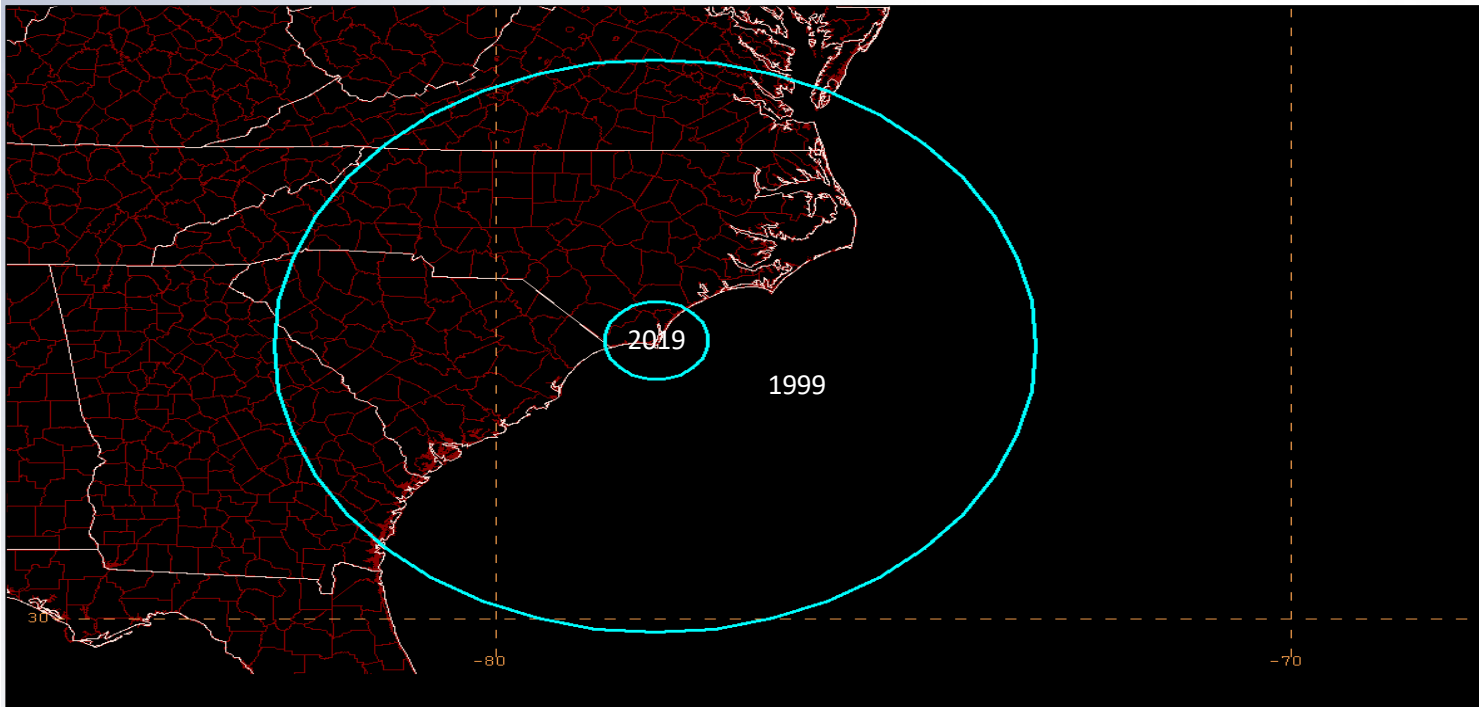
NHC Track Forecasts for Dorian from
06Z 1 Sep - 06Z 6 Sep 2019

- Average 3-day NHC track forecast error (preliminary) of 35 n mi for forecasts issued during the 5 days prior to landfall in NC
- No watches/warning for Miami-Dade County, and no Hurricane Warning for Broward County


As many as 3 million did NOT have to evacuate (preliminary data)

2019 Forecast Successes & Challenges

How Far Have We Come Since Floyd?



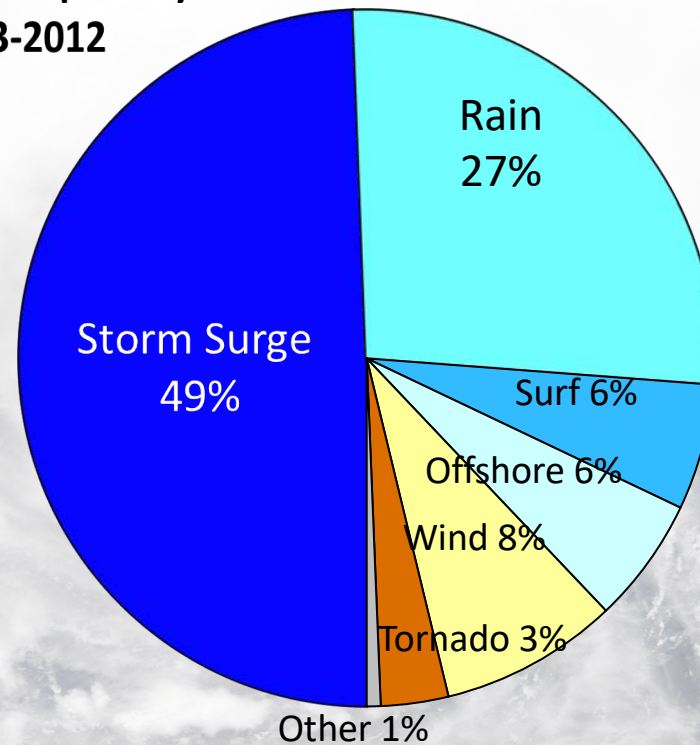
Difference in average 3-day track forecasts for Floyd (1999) and Dorian (2019)



When you close your eyes, what do you see when you think of a hurricane?

Lesson 7. Water is What KILLS!!!

U.S. Tropical Cyclone Fatalities
1963-2012



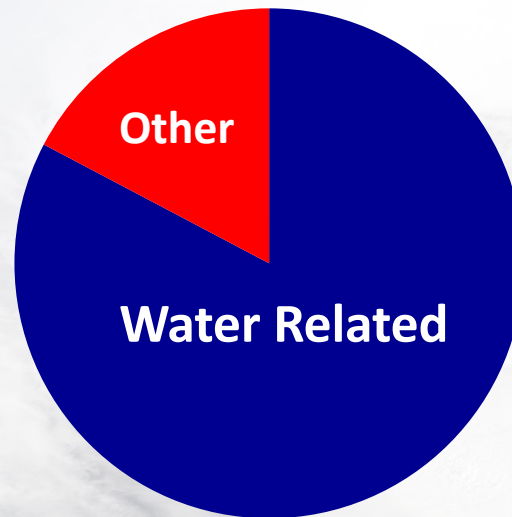
**Water
accounts
for about
90% of
the direct
deaths**

Rappaport 2014



Water is What KILLS!!!

2016-18 Fatalities*



83% Water Related

Most Inland Flooding – Only 4% Storm Surge Related

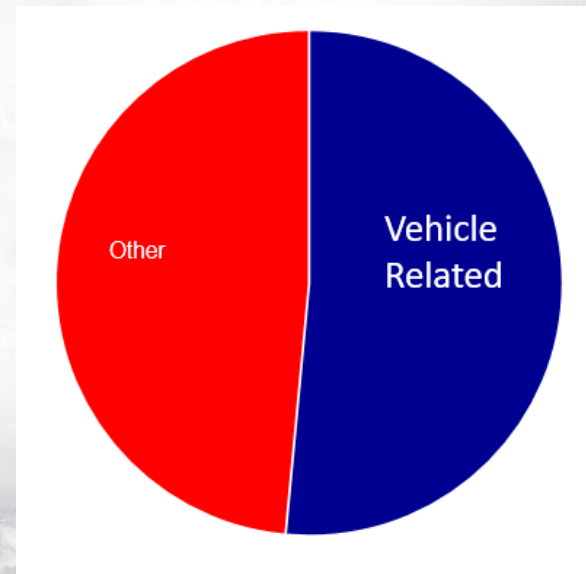
*excludes Maria due to uncertainty related to causes of direct deaths

Water is What KILLS!!!

- During the past three seasons, more than half the U.S. tropical cyclone water-related fatalities were vehicle related!

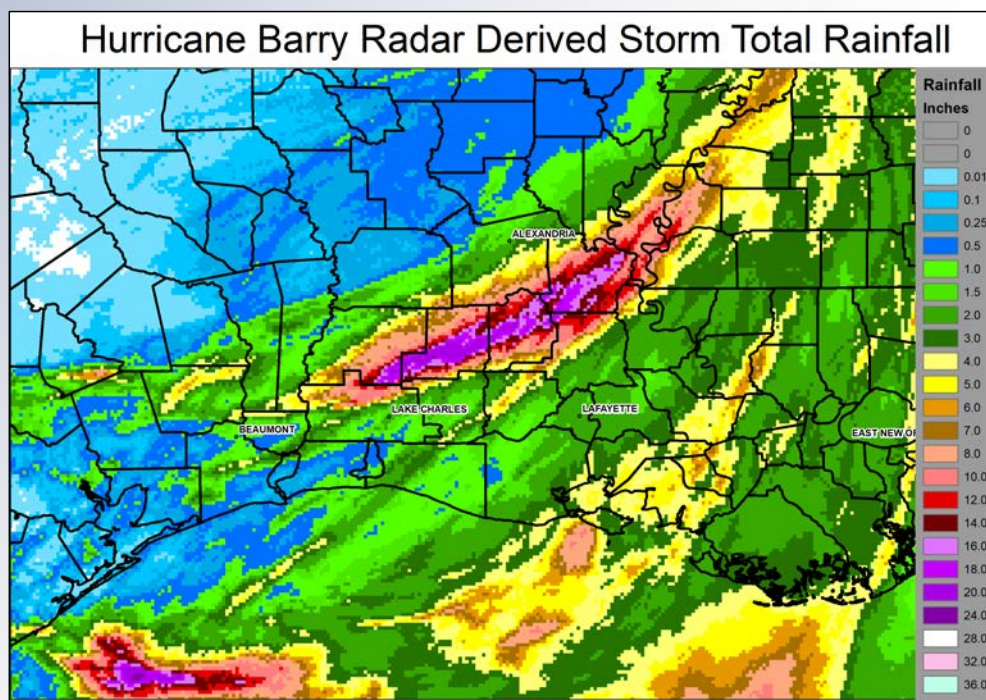


2016-18 U.S. Tropical Cyclone Water Related Fatalities

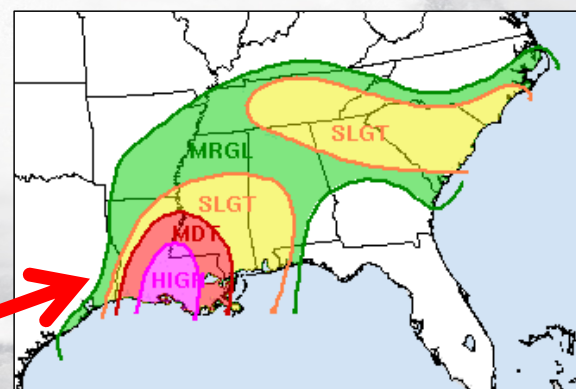


2019 Forecast Successes & Challenges

Barry's Swath of Heavy Rainfall



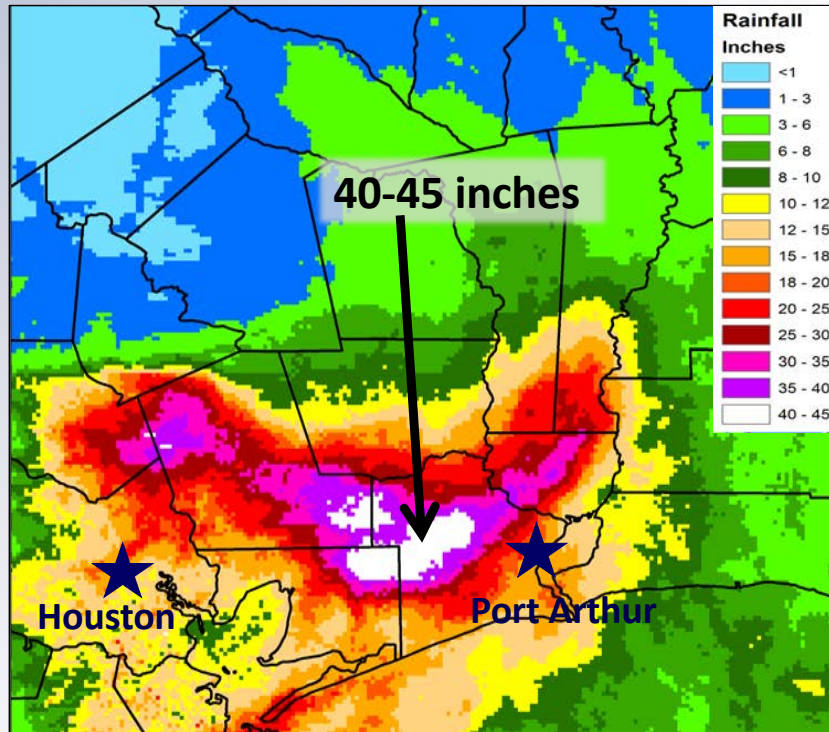
- Area of 20-25 inches of rainfall over portions of southern Louisiana, but heaviest generally missed large population centers



Excessive Rainfall Outlook issued July 13

2019 Forecast Successes & Challenges

Another Record Setting Rainfall Event



Radar estimated storm total rainfall

- 44.29 inches near Fannett, TX
- 4th wettest tropical cyclone in Texas history, 5th wettest in continental U.S.



Courtesy Chron.com

On the Heels of These Record Setting Events

Hurricanes Harvey, Florence, and Lane each set state records for tropical cyclone rainfall with Harvey's rainfall of 60+ inches setting the U.S. record



**Harvey (2017) - 60.58 inches
Texas & US Record**

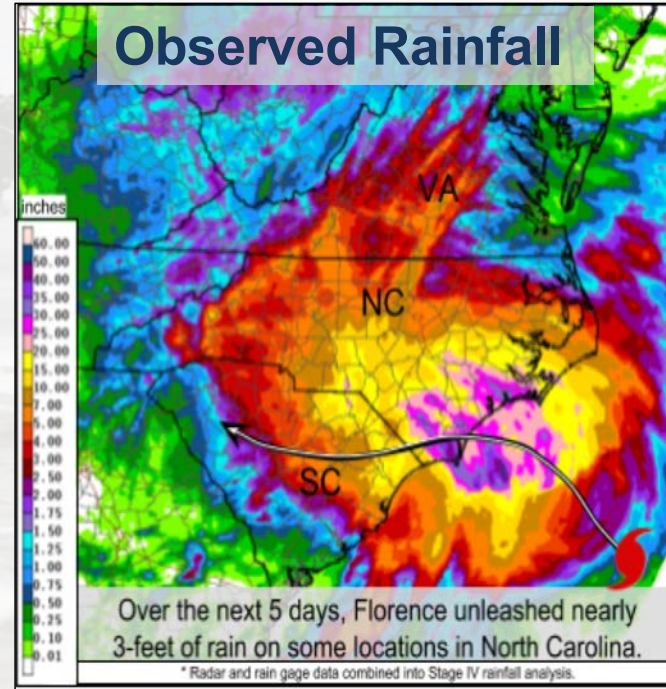
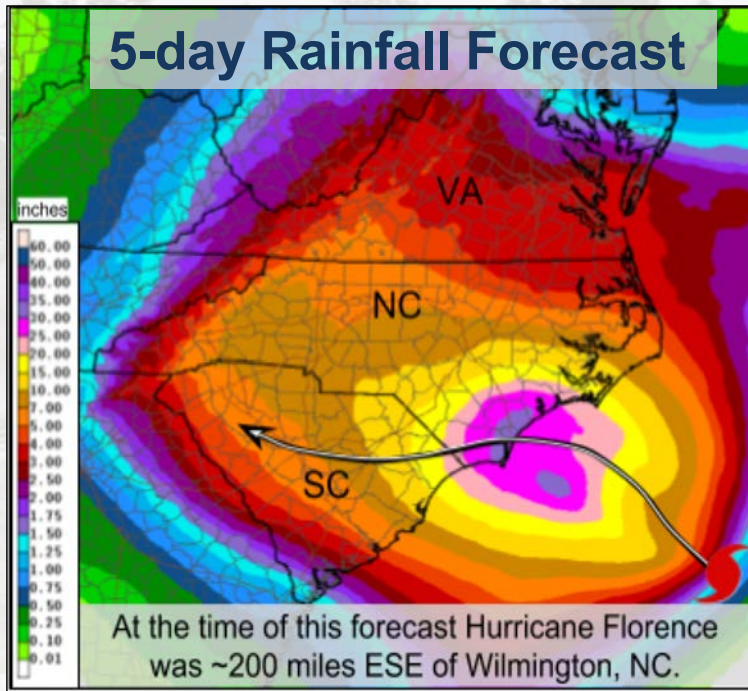


**Florence (2018) – 35.93 inches
North Carolina Record**



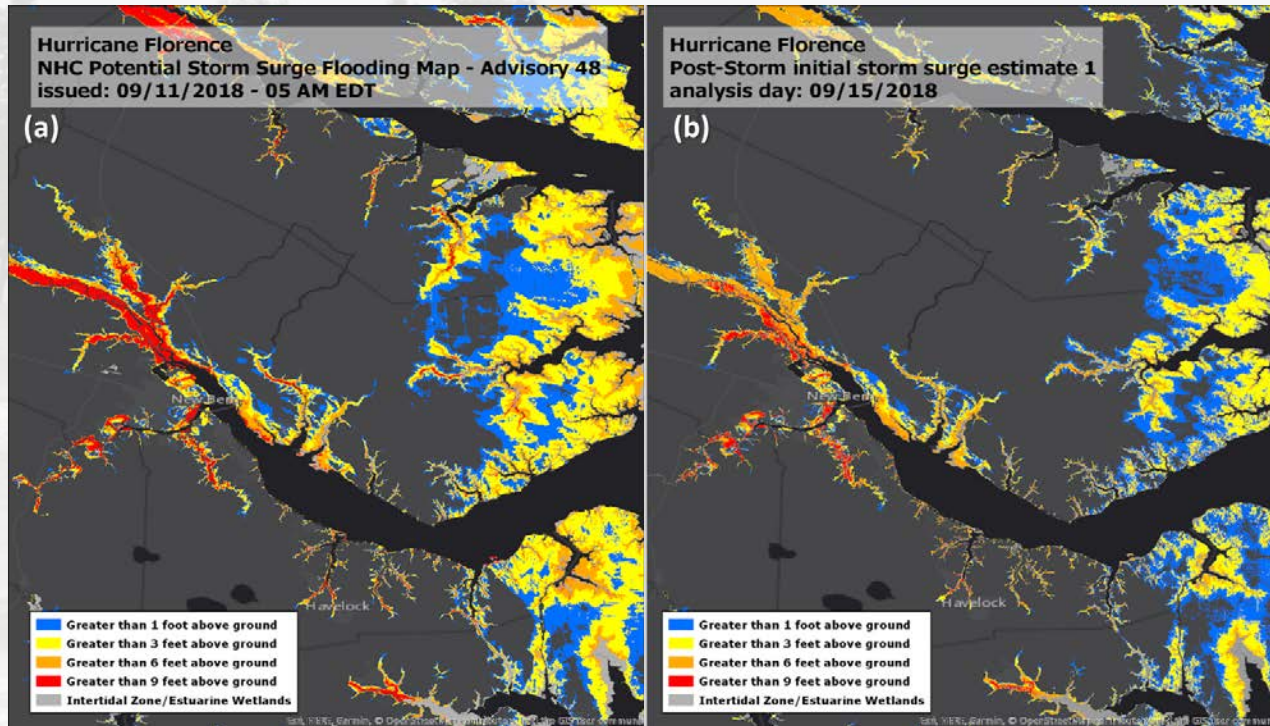
**Lane (2018) – 52.02 inches
Hawaii Record**

Hurricane Florence



Excellent Forecasts – Yet 16 out of 17 flood related fatalities were in vehicles!

Storm Surge Forecasting



Most Inland Flooding – Only 4% Storm Surge Related (2017-2018)

*excludes Maria due to uncertainty related to causes of direct deaths

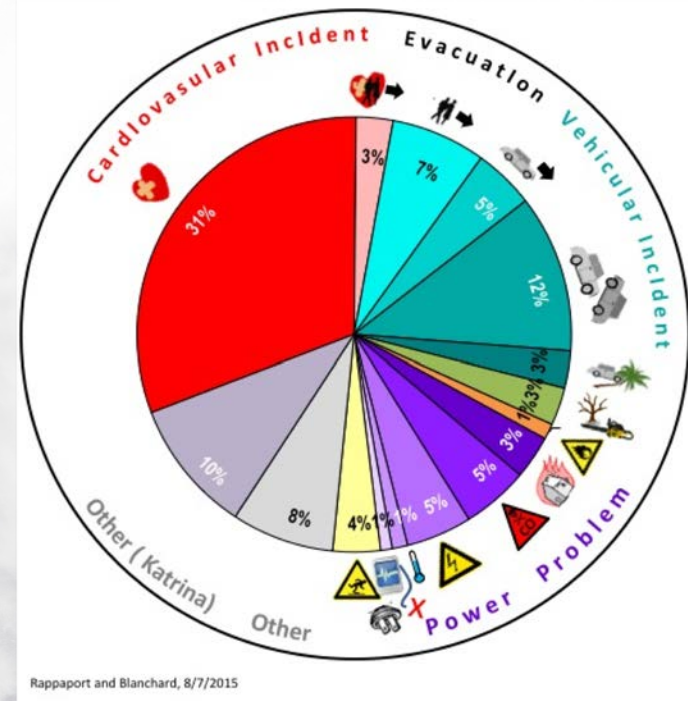


Lesson 8. It isn't over till it's over

“The storm is past me, I'm safe now”

Indirect Fatalities

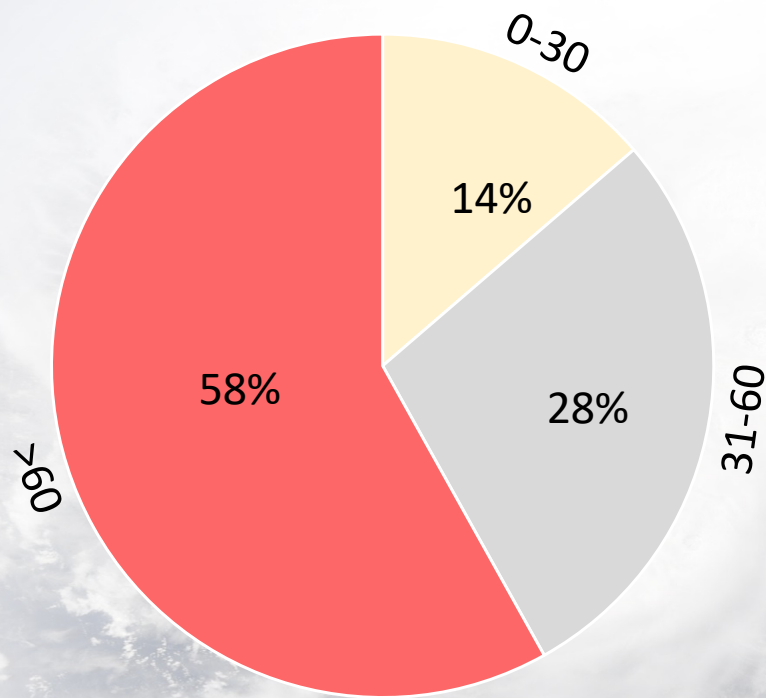
Longer-Term Impacts



Most frequent factors: cardiovascular, loss of electricity, vehicle accident, and evacuation

U.S. Tropical Cyclone Indirect Deaths by Age

8 *times* as many victims age over 60 as under 21 years old

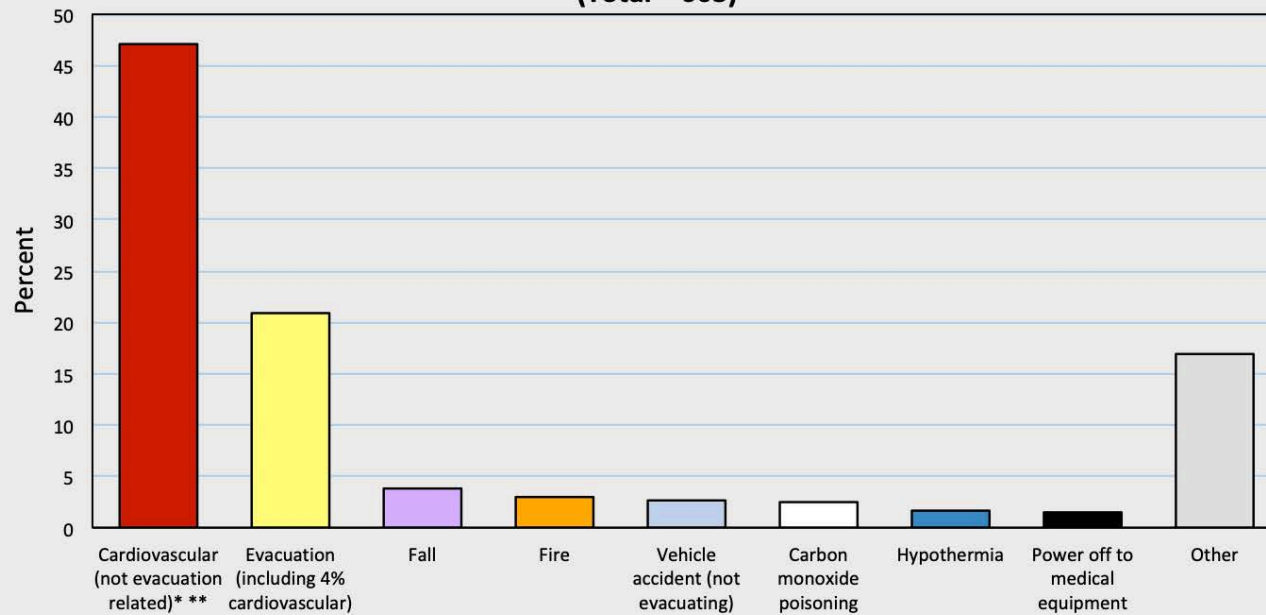


1963-2012 indirect deaths (heart attacks, power problems (e.g., no A/C, lights, medical equipment), etc.). Outnumber direct deaths in some storms.

Based on Rappaport and Blanchard (2016)

Leading Causes of Indirect Fatalities Over 60 years old

U.S. Tropical Cyclone Indirect Deaths of Seniors (age > 60 years)
(Total = 603)

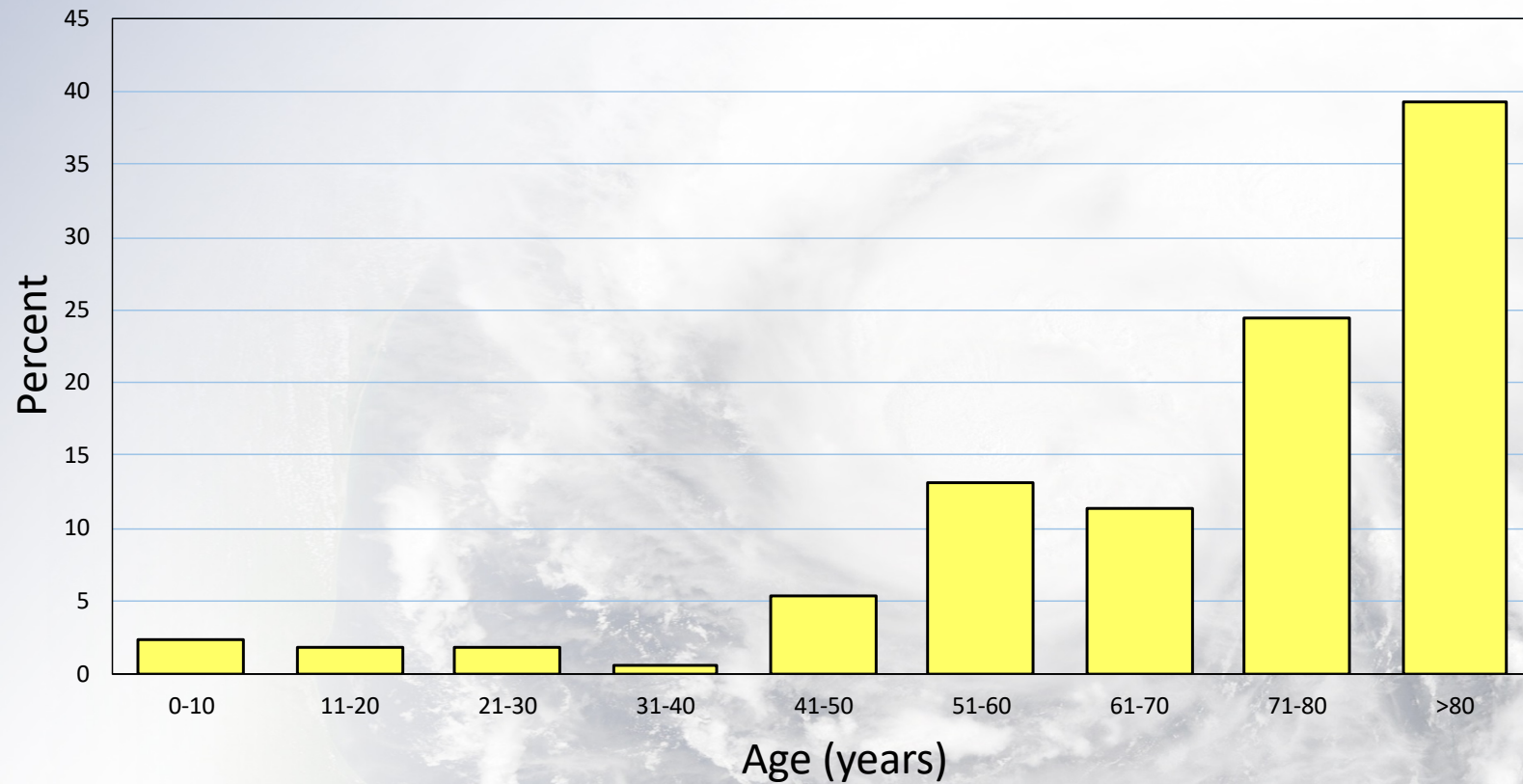


* Heart attacks and other heart ailments

** 90% from Katrina in LA

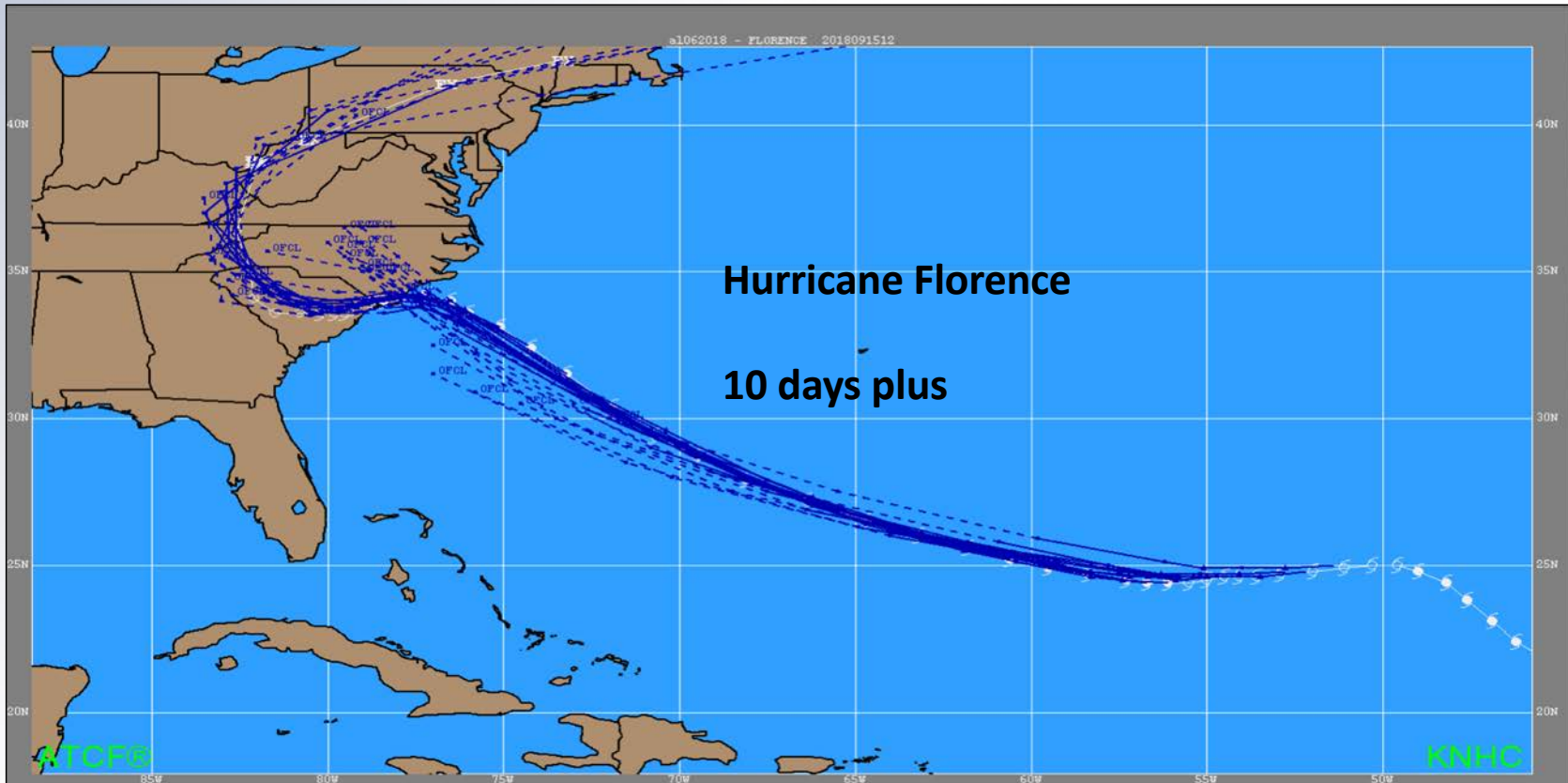
Based on Rappaport and Blanchard (2016)

U.S. Tropical Cyclone Indirect Deaths associated with Evacuation (Total = 168)

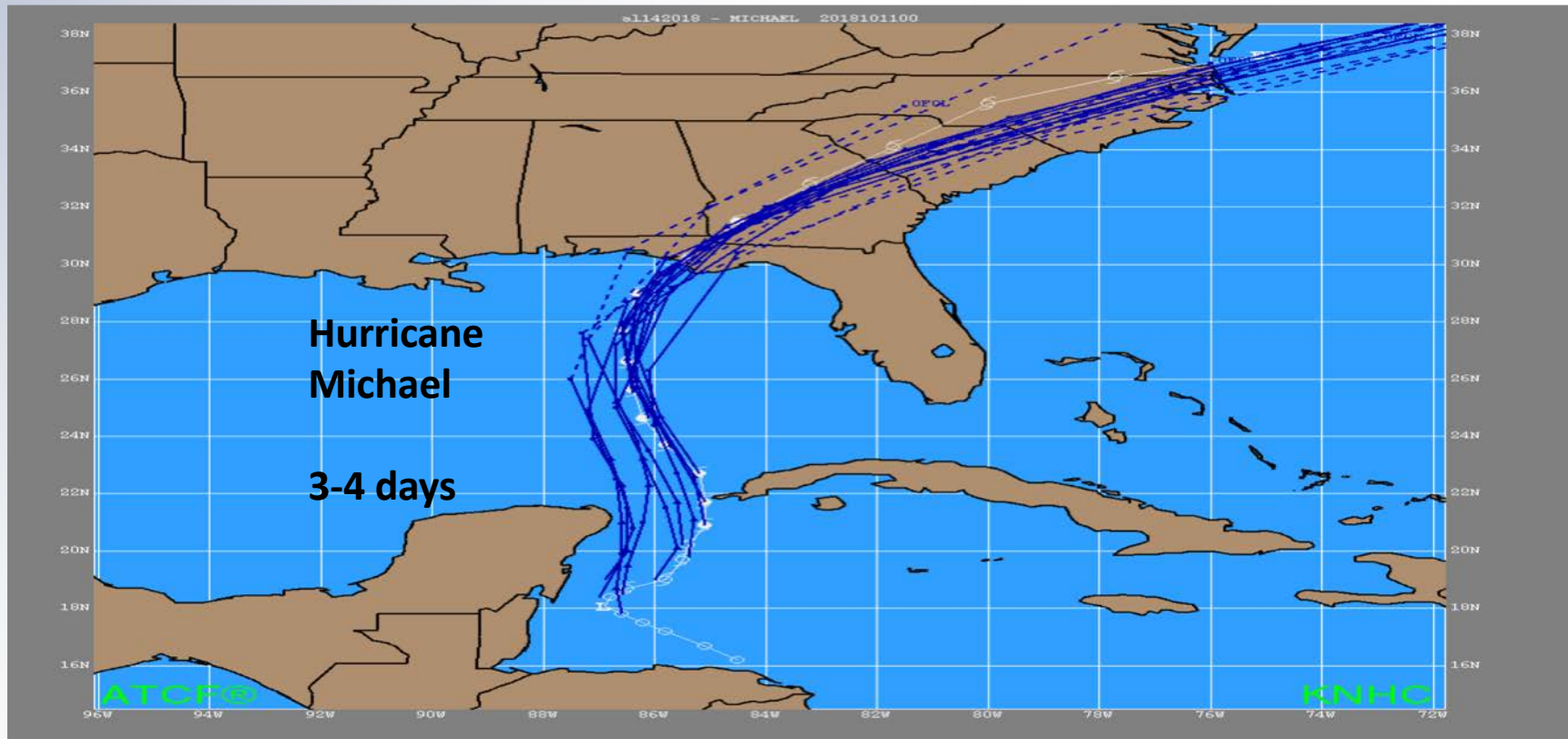


Based on Rappaport and Blanchard (2016)

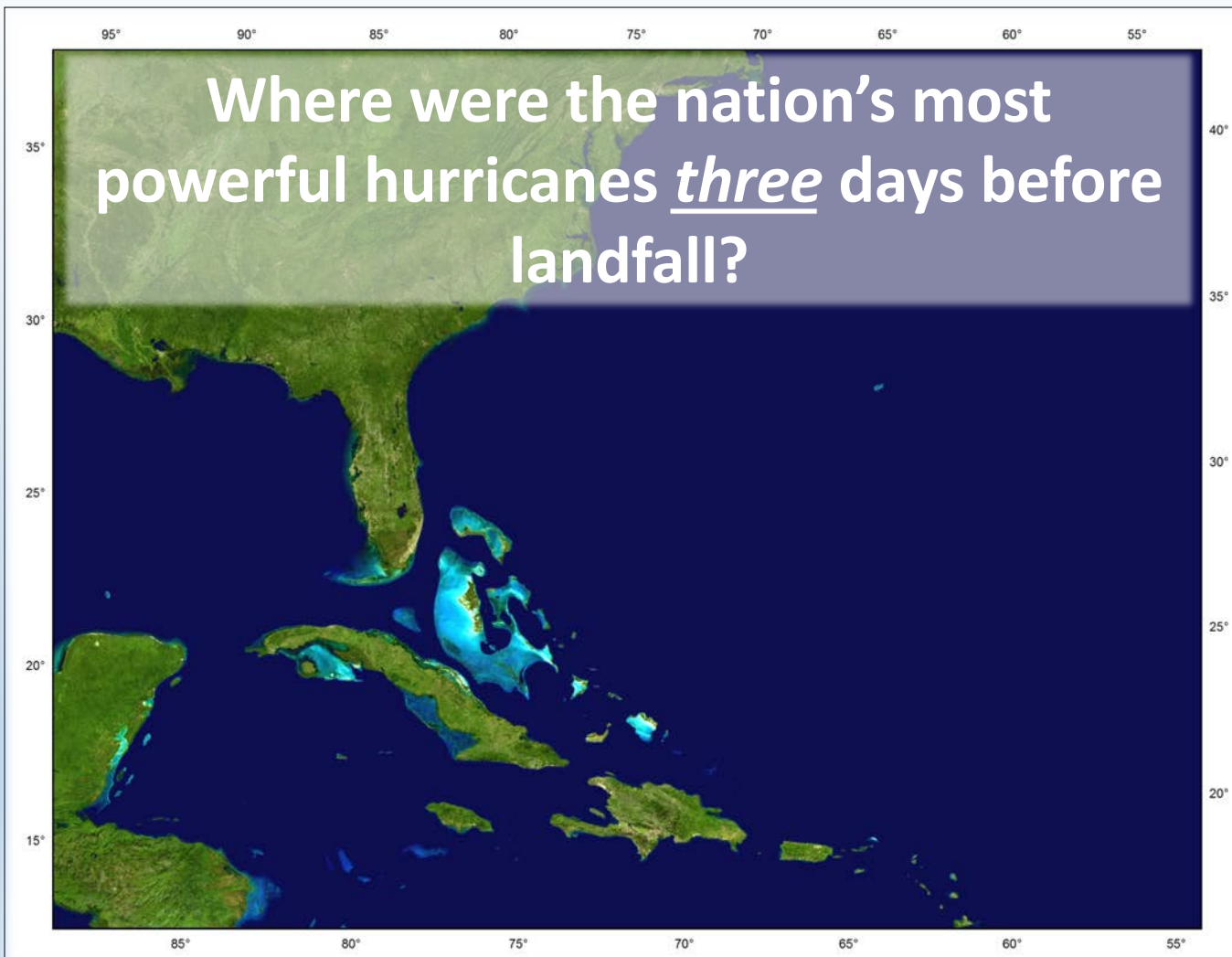
Lesson 9. Storms don't care about your timeline



Storms don't care about your timeline

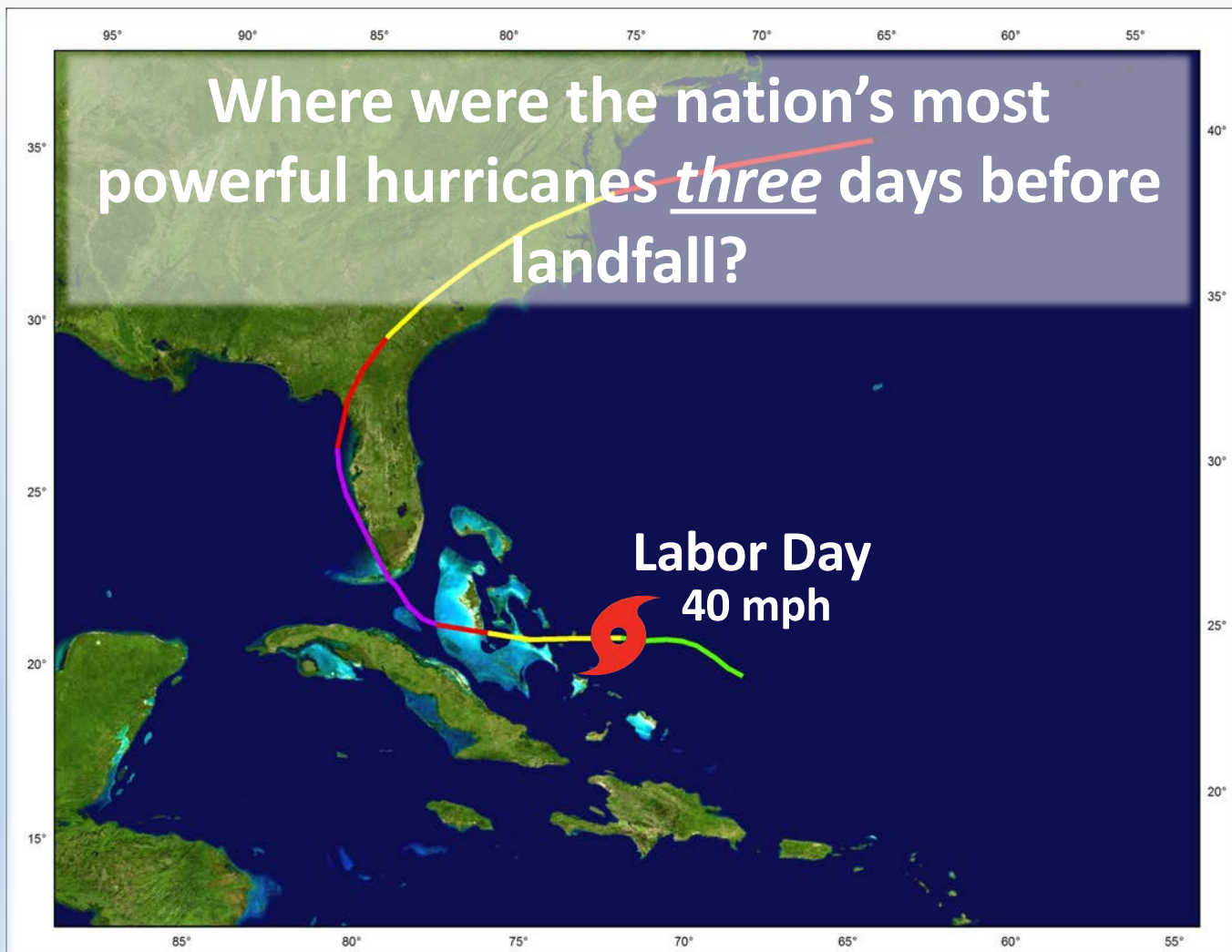


Where were the nation's most powerful hurricanes three days before landfall?

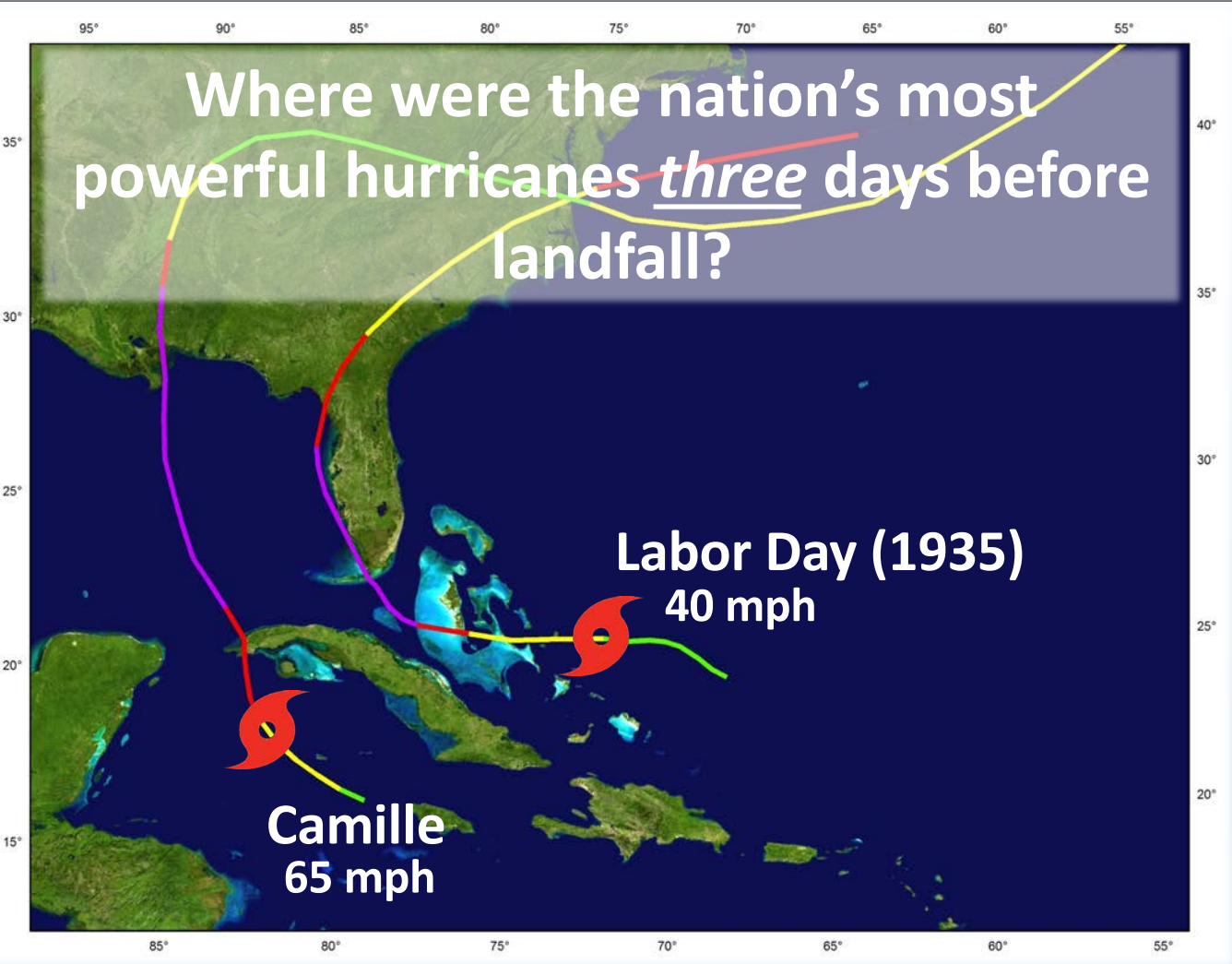


Where were the nation's most powerful hurricanes three days before landfall?

Labor Day
40 mph



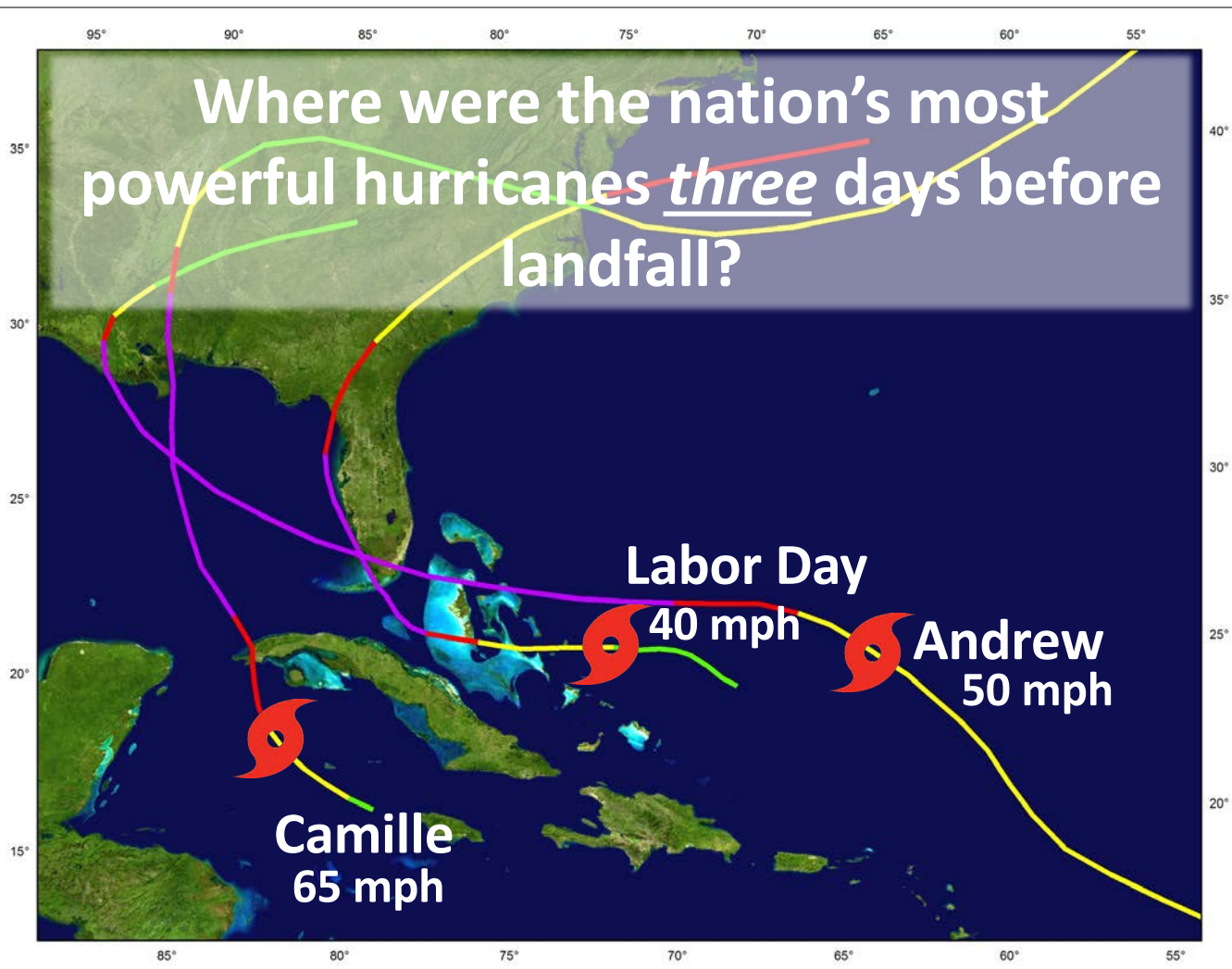
Where were the nation's most powerful hurricanes three days before landfall?



Camille
65 mph

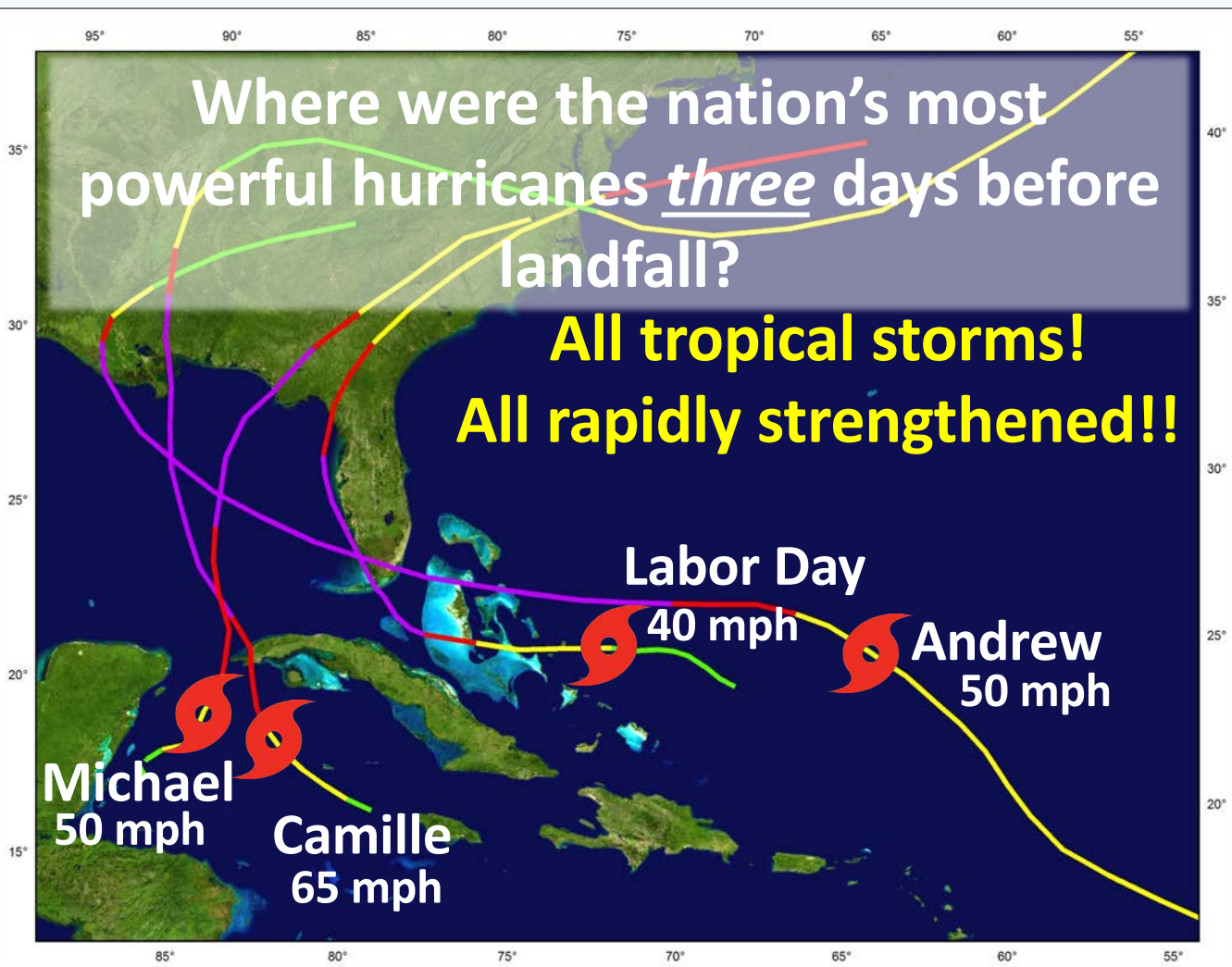
Labor Day (1935)
40 mph

Where were the nation's most powerful hurricanes three days before landfall?



Where were the nation's most powerful hurricanes three days before landfall?

**All tropical storms!
All rapidly strengthened!!**



Michael
50 mph

Camille
65 mph

Labor Day

40 mph

Andrew
50 mph

Lesson 10. Message in Many Ways

2018 Season Web Hits: 9,632,372,000

2018 Max One Day Hits: Sept 12, 2 days before Florence landfall, 739,965,060

June 1 to November 30 unique devices:
32,155,492

Live Internet Broadcasts in Florence and Michael:
2.5 million viewers.

In 2019, Dorian resulted in 6 million views.

Social Media to provide live storm updates



Key Messages

Key Messages for Hurricane Michael
Advisory 8: 11:00 AM EDT Mon Oct 08, 2018

1. Michael is forecast to be a dangerous major hurricane when it reaches the northeastern Gulf Coast on Wednesday, and life-threatening storm surge is possible along portions of the Florida Gulf Coast regardless of the storm's exact track or intensity. Residents in the storm surge and hurricane watch areas should follow any advice given by local officials, as storm surge and hurricane warnings will likely be issued later today.
2. Heavy rainfall from Michael could produce life-threatening flash flooding from the Florida Panhandle and Big Bend region into portions of the Carolinas through Thursday.
3. Hurricane conditions will spread over portions of western Cuba this afternoon, where a hurricane warning is now in effect. Tropical storm conditions are expected over the northeastern Yucatan Peninsula and the Isle of Youth today.
4. Michael is expected to produce heavy rainfall and flash flooding over portions of western Cuba and the northeastern Yucatan Peninsula of Mexico during the next couple of days.

For more information go to [hurricanes.gov](#)



National Hurricane Center @NHC_Atlantic

#Michael will continue to produce life-threatening hurricane-force winds well inland across portions of the Florida Panhandle, southeast Alabama, and southwestern Georgia this evening as the core of the hurricane continues to move inland. [hurricanes.gov](#)

Hurricane and Tropical Storm Watches and Warnings

A map of the United States showing the areas under hurricane and tropical storm watches and warnings for Hurricane Michael. The Florida Panhandle, southeast Alabama, and southwestern Georgia are highlighted in red, indicating hurricane force winds. Other areas are highlighted in blue, indicating tropical storm force winds. The map includes state names and major cities.

2:13 PM - 10 Oct 2018

NOAA NWS National Hurricane Center
 October 10, 2018

NHC Director Ken Graham will provide a Facebook Live broadcast regarding Category 4 Hurricane Michael at 8:45 a.m. EDT (7:45 am CDT)

A photograph of NHC Director Ken Graham in a control room. He is standing at a workstation with multiple computer monitors. One monitor displays a satellite image of Hurricane Michael, while others show various weather data and maps. He is wearing a light blue shirt and khaki pants.

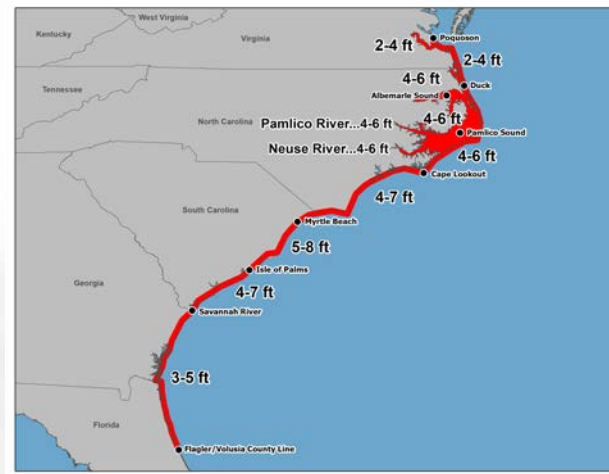
National Hurricane Center @NHC_Atlantic - 9 Oct 2018

#Michael is expected to produce a destructive & life-threatening storm surge along portions of the Florida Panhandle, Big Bend & Nature Coast on Wednesday & Wed night. The worst storm surge is expected to be between Mexico Beach & Keaton Beach with 9-13' of inundation possible.

A map titled "Michael, Adv. 13 Storm Surge" showing the expected storm surge along the Florida Panhandle. The map uses color-coded areas to indicate inundation levels: 2-4 ft (blue), 6-9 ft (orange), and 9-13 ft (red). The highest surge is expected between Mexico Beach and Keaton Beach.

Use of Twitter, Facebook, and Facebook Live to provide live storm updates

National Hurricane Center Product Changes for 2020



Michael Brennan

Branch Chief, Hurricane Specialist Unit, National Hurricane Center

NOAA Southeast and Caribbean Regional Collaboration Team Webinar

29 April 2020

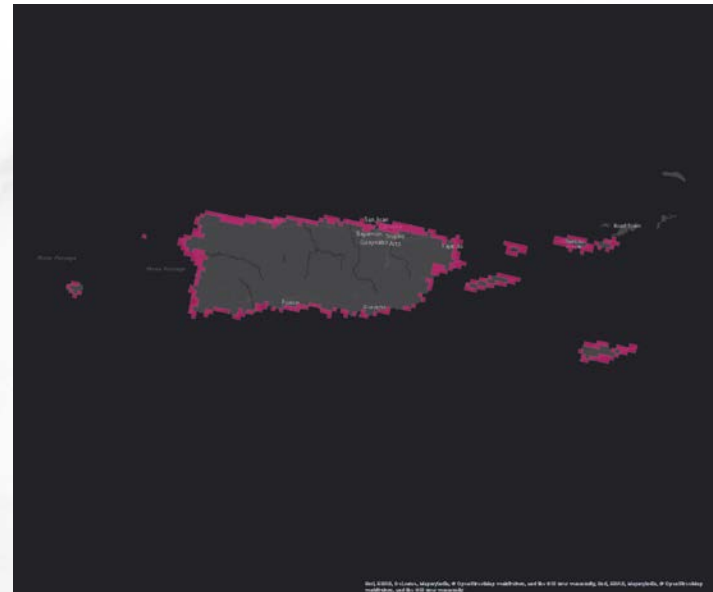


NHC Product Changes for 2020

- Storm Surge Watch/Warning for Puerto Rico and U.S. Virgin Islands (became operational in 2019)
- Experimental peak storm surge forecast graphic
- New 60-h forecast information
- Same advisory issuance times, but additional local time zones for eastern Atlantic

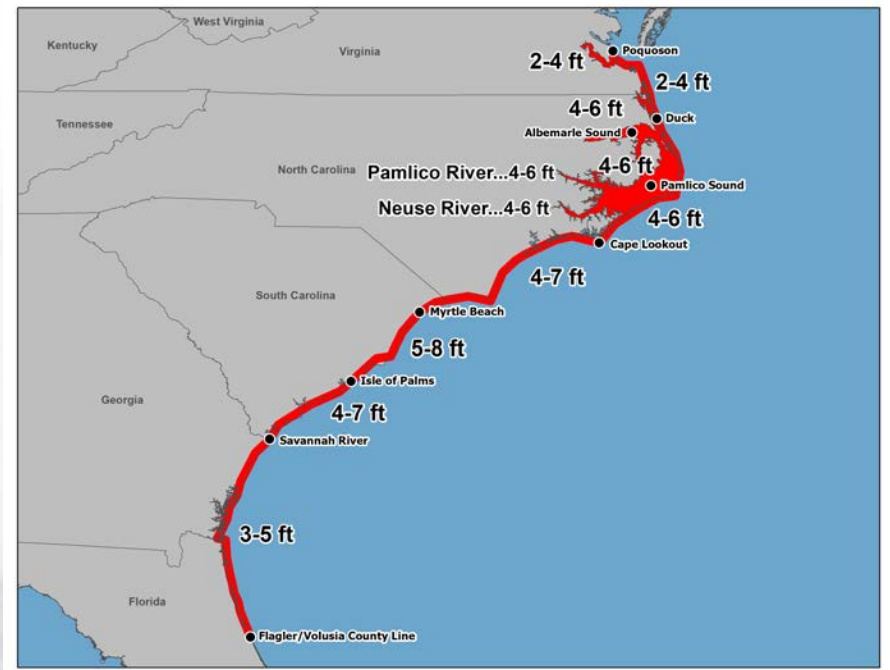
Storm Surge Warning

- Expanded to Puerto Rico and USVI in 2019
- Storm Surge watch/warning will appear on graphic on NHC webpage
- No inundation graphic for PR/USVI in 2020



Experimental Peak Storm Surge Forecast Graphic

- Visual representation of peak storm surge forecast values from NHC Public Advisory (TCP) for U.S. East and Gulf coasts, PR, USVI
 - Same approach and interpretation as values in TCP
 - Areal threat (i.e. somewhere within specified area) not point or location specific
 - Includes/assumes peak storm surge occurs at high tide
 - Includes wave setup for areas with steep bathymetry (i.e., PR, USVI)
- Primarily for media and social media applications where point probabilities and/or high-resolution inundation mapping not easily displayed
- Experimental for 2020 – NHC interested in comments and feedback



New for 2020

60-h Forecast Information

Tropical Cyclone Forecast/Advisory

ZCZC MIATCMAT5 ALL
TTAA00 KNHC DDHMM

HURRICANE DORIAN FORECAST/ADVISORY NUMBER 21
NWS NATIONAL HURRICANE CENTER MIAMI FL AL052019
1500 UTC THU AUG 29 2019

FORECAST VALID 31/1200Z 26.3N 73.4W
MAX WIND 110 KT...GUSTS 135 KT.
64 KT... 20NE 10SE 10SW 10NW.
50 KT... 30NE 30SE 20SW 30NW.
34 KT... 80NE 60SE 40SW 60NW.

FORECAST VALID 01/0000Z 26.7N 75.2W
MAX WIND 110 KT...GUSTS 135 KT.
50 KT... 40NE 30SE 20SW 30NW.
34 KT... 80NE 70SE 40SW 70NW.

FORECAST VALID 01/1200Z 27.0N 76.9W
MAX WIND 115 KT...GUSTS 140 KT.
50 KT... 40NE 40SE 30SW 30NW.
34 KT... 90NE 80SE 50SW 80NW.

NHC will begin providing 60-h forecast information in 2020: position, intensity, and 34-kt and 50-kt wind radii

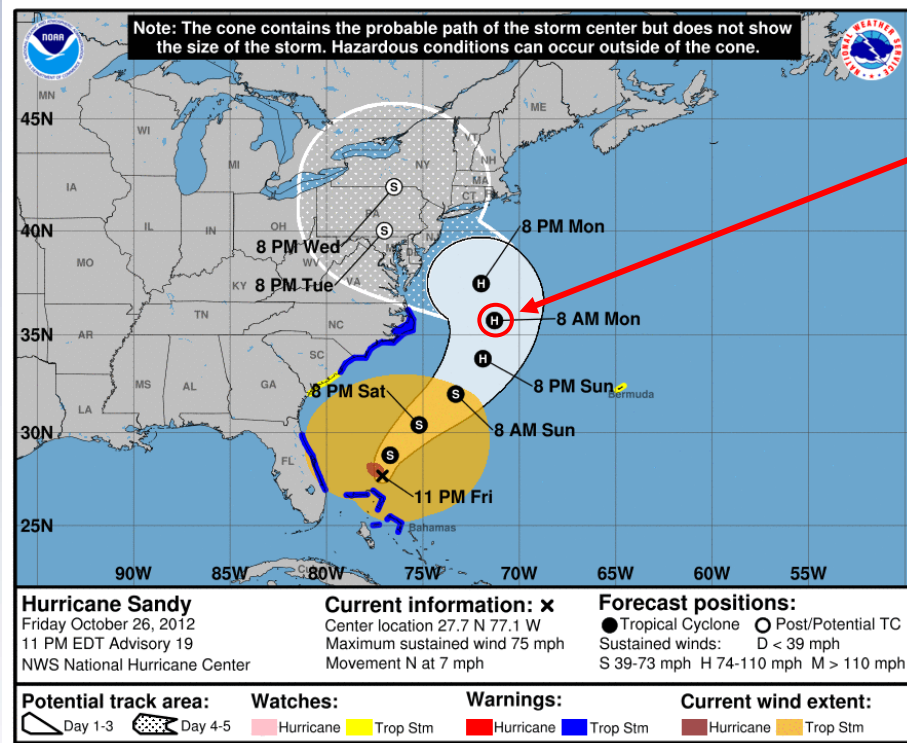
Tropical Cyclone Discussion Table

FORECAST POSITIONS AND MAX WINDS

INIT	29/1500Z	21.4N	67.2W	75 KT	85 MPH
12H	30/0000Z	22.9N	68.1W	85 KT	100 MPH
24H	30/1200Z	24.5N	69.6W	100 KT	115 MPH
36H	31/0000Z	25.6N	71.4W	105 KT	120 MPH
48H	31/1200Z	26.3N	73.4W	110 KT	125 MPH
60H	01/0000Z	26.7N	75.2W	110 KT	125 MPH
72H	01/1200Z	27.0N	76.9W	115 KT	130 MPH
96H	02/1200Z	27.5N	79.8W	115 KT	130 MPH
120H	03/1200Z	28.1N	81.5W	65 KT	75 MPH...INLAND

New for 2020

60-h Forecast Information

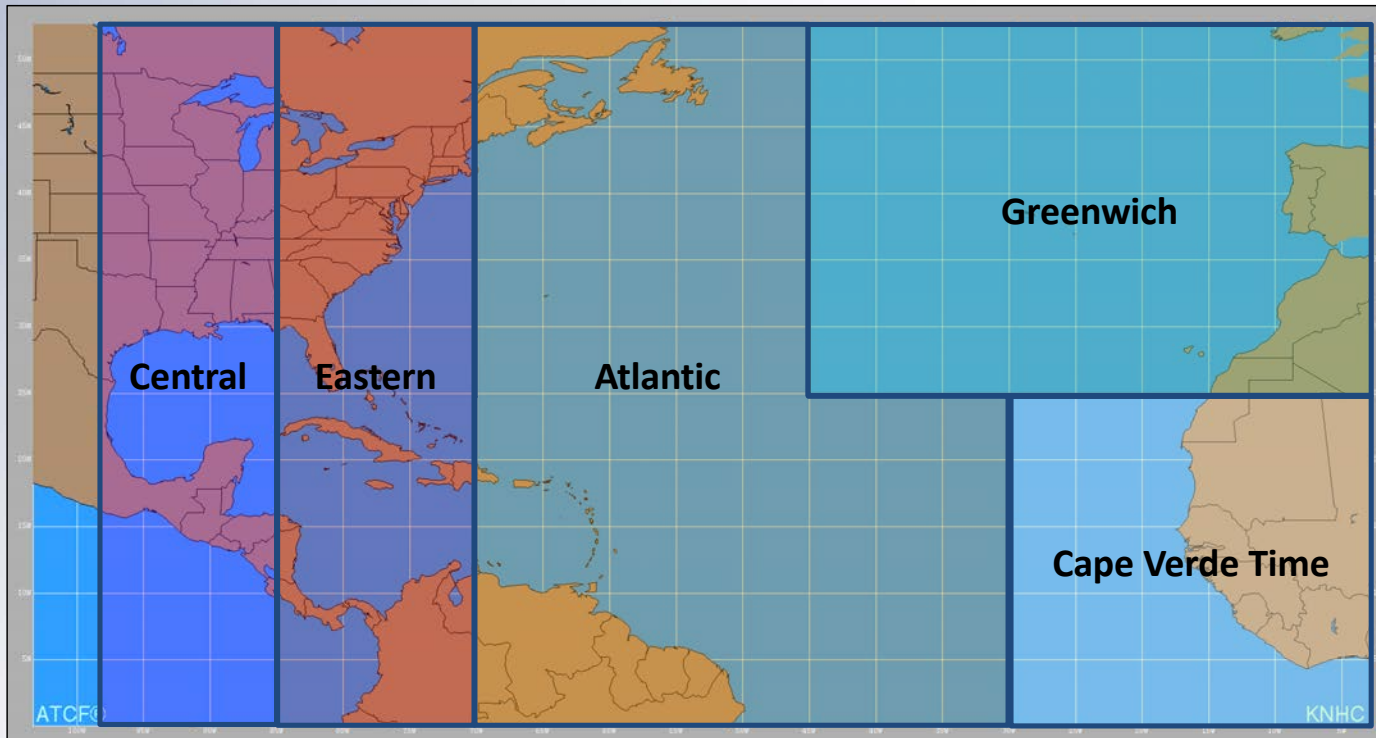


60-h Forecast Information on Cone Graphic

60-h forecast information also used as input for P Surge and for TC wind speed probabilities

New for 2020

Local Time Zones in NHC Products



Products Using Local Time

- Public Advisory
- Discussion
- Update
- Time of Arrival Graphics

Still 5 AM, 11 AM, 5 PM, 11 PM Eastern Daylight Time!

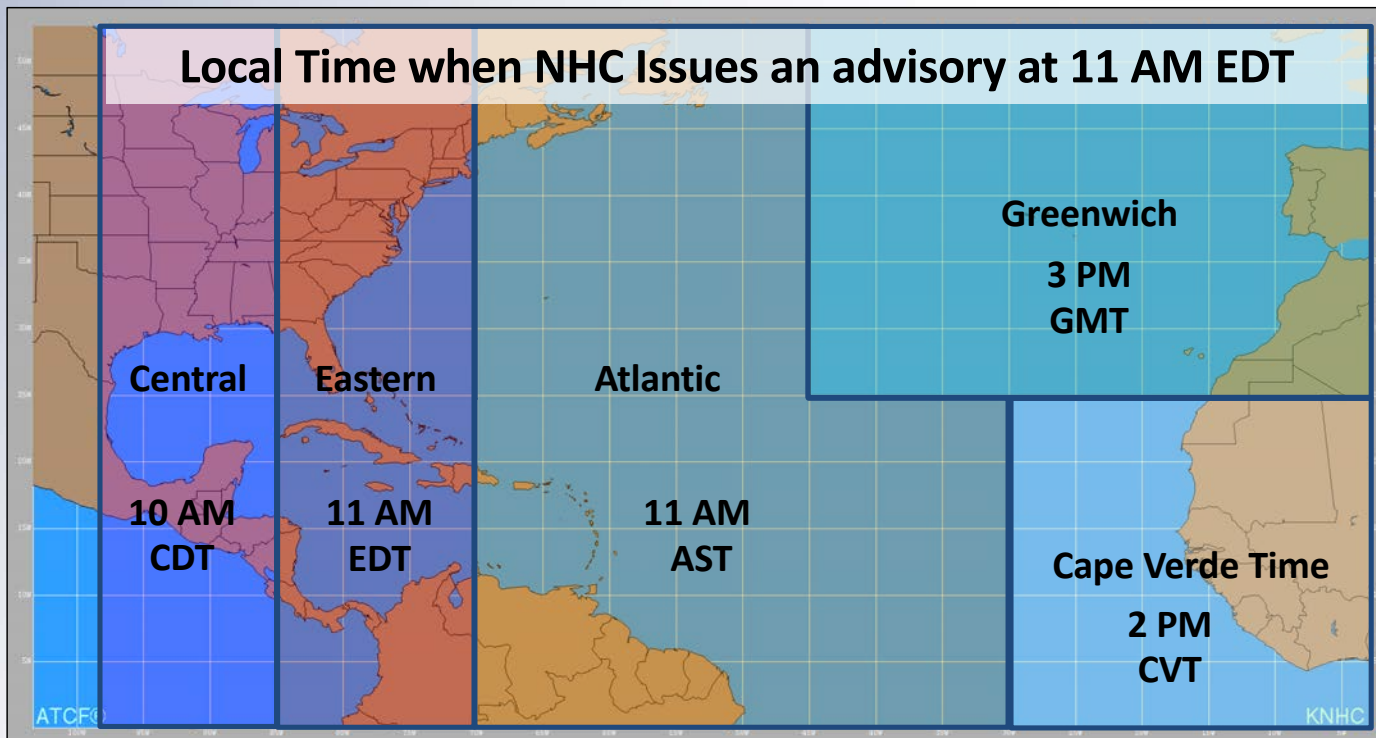
4/29/2020

SECART Webinar

101

New for 2020

Local Time Zones in NHC Products



Products Using Local Time

- Public Advisory
- Discussion
- Update
- Time of Arrival Graphics

Still 5 AM, 11 AM, 5 PM, 11 PM Eastern Daylight Time!

Questions/Comments

Michael.J.Brennan@noaa.gov


10/22/2020

NOAA Webmail

103



What's Next in Storm Surge?

- **Storm Surge model improvements**
 - Puerto Rico storm surge modeling – 2019 Watch/Warning and Potential Inundation Forecast
 - Southern California (waves too)
 - Higher resolution work in Florida (superbasin)
 - Moving towards incorporation of waves and expanding from 48 to 72 hours
 - **NOAA/OFDA/USAID partnership to further expand storm surge capability**
 - Dominican Republic (2018) and Haiti (2019)
 - Belize and Yucatan Peninsula (2021)
 - Bahamas will be next starting. (Start 2021, completed 2023)
 - Vision is to develop storm surge capability throughout the RAIV Caribbean nations
- 



What's Next in Social Science?

Improve hazard guidance and risk communication based on **social and behavioral science** to modernize the tropical cyclone product suite for actionable lead-times for storm surge and all other threats

- **Hurricane Forecast Improvement Project**
 - Web-based survey on economic value of improved forecasts
 - Use study for the Cone of Uncertainty
- **Supplemental**
 - Wait, that forecast changed? – Assess consumption and processing of a changing forecast
 - NHC website – Optimizing tropical cyclone information
 - Minding the Gap – looking at the product suite by evaluating partner needs
 - There's a Chance of What? – numeracy analysis of forecasters, partners, and the public when it comes to uncertainty products

Thank You from the National Hurricane Center!

