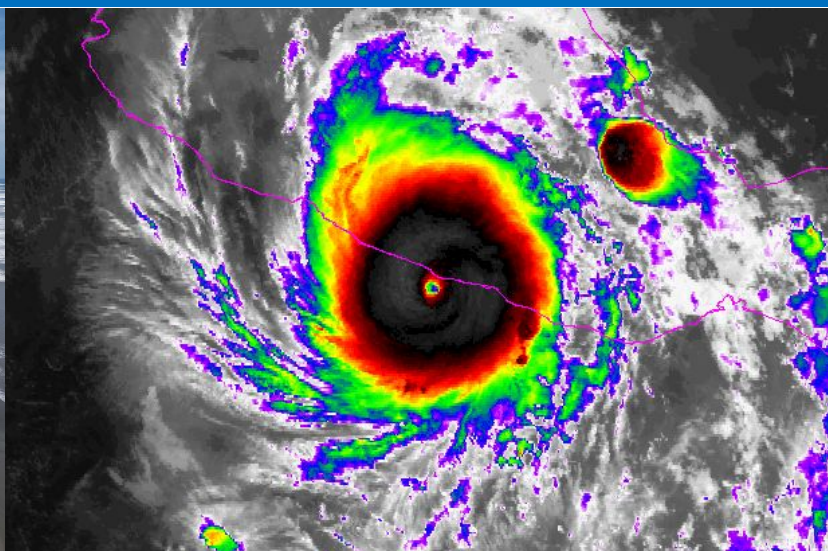
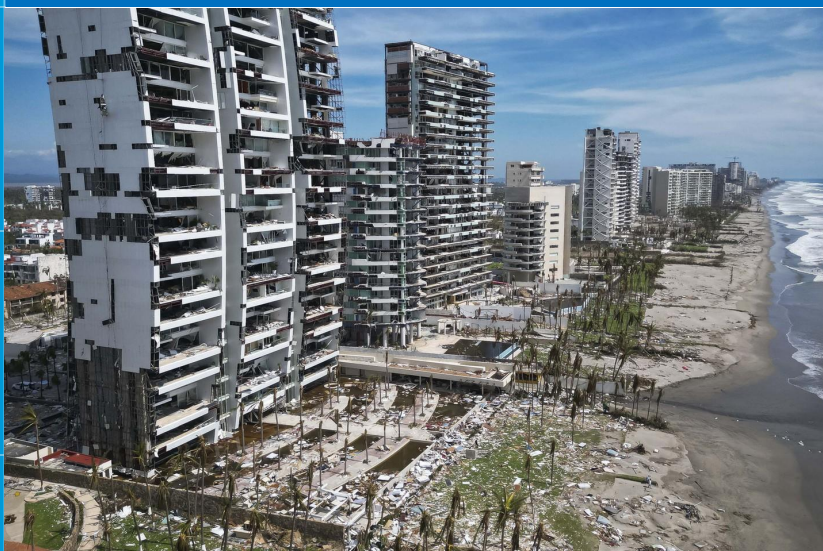


NOAA

**National
Weather
Service**

National Hurricane Center Product and Service Updates 2024 and Beyond

Daniel Brown
National Hurricane Center
National Hurricane Conference
March 27, 2024



Review of 2023 Changes

- Tropical Weather Outlook

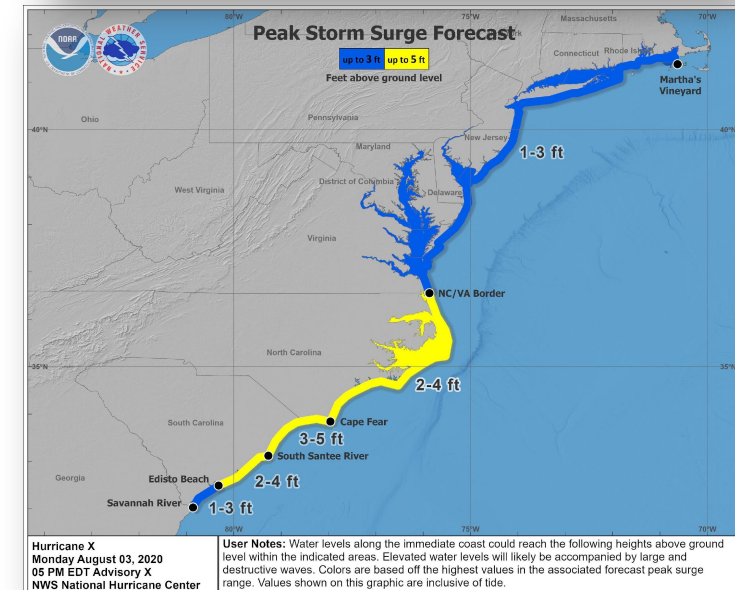
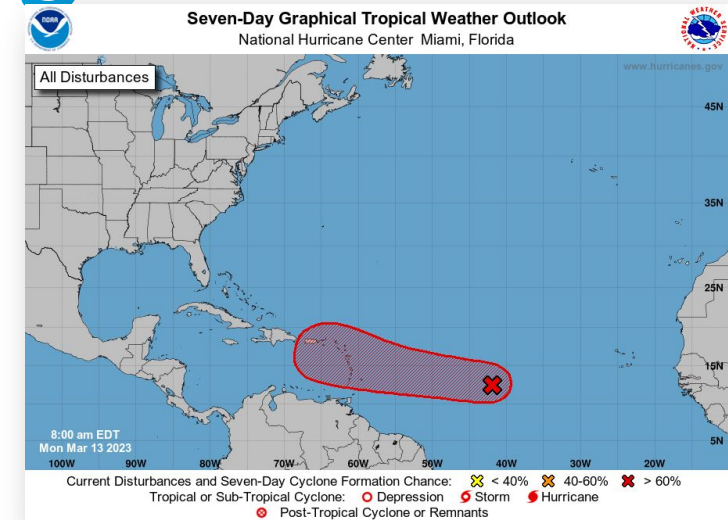
- ✓ Extension to 7 days
- ✓ Addition of Invest Numbers

- Forecast Advisory

- ✓ Removal of Watches/Warnings

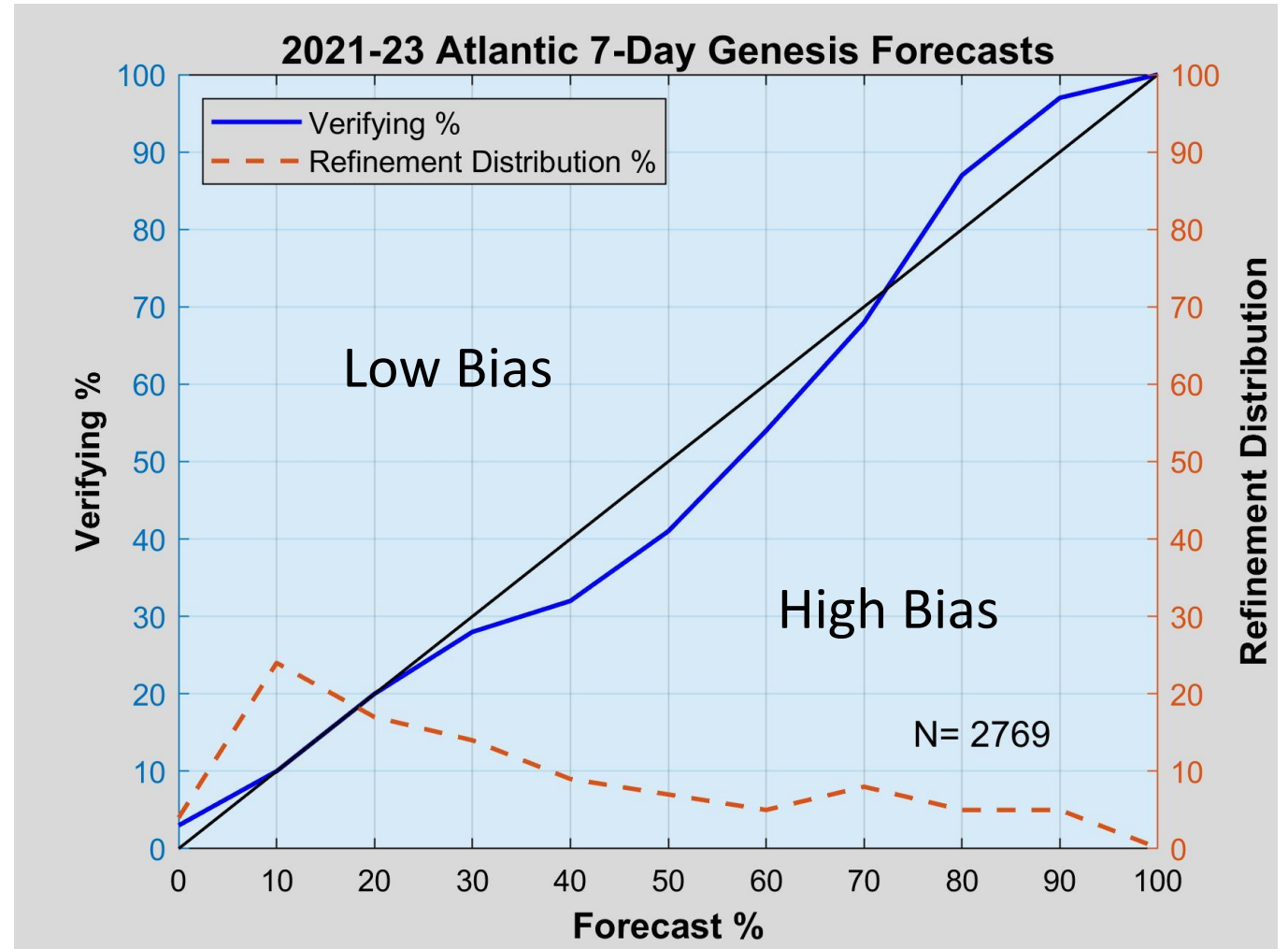
- Storm Surge

- ✓ Extension of the Potential Storm Surge Flood Map to Puerto Rico and U.S. VI
- ✓ Peak Storm Surge Graphic became operational



Atlantic 7-Day Genesis Forecast Verification

- 7-day forecasts of TC formation were well calibrated
- Slight high bias for forecast probabilities of 40-60%



2024 NHC Product Updates

- Spanish language advisory text products (experimental Pacific)
- U.S. watches and warnings issued on intermediate advisories (previously this could only be done for international W/Ws)
- Operational day four and five 34- and 50-kt wind radii forecasts
- Added weblinks in the public advisory (TCP) to help shorten hazard information
- Time zone modifications in the eastern Pacific
- Cone size essentially unchanged for 2024
- International tropical cyclone rainfall graphics (experimental)
- Inland U.S. watches/warnings on cone graphic (experimental)



Spanish Advisory Text Products

BOLETÍN

Advertencia Intermedia del Huracán Otis Número 13A
Centro Nacional de Huracanes del SNM Miami FL EP182023
700 AM CDT miércoles 25 de octubre de 2023

...FUERTES VIENTOS CONTINUANDO EXTENDIÉNDOSE TIERRA DENTRO SOBRE EL SUR DE MÉXICO.....FUERTES LLUVIAS E INUNDACIONES REPENTINAS QUE OCURREN SOBRE PORCIONES DEL SUR DE MÉXICO...

RESUMEN DE 700 AM CDT...1200 UTC...INFORMACIÓN

UBICACIÓN...17.7N 100.30

ALREDEDOR DE 60 MI...100 KM NO DE ACAPULCO MÉXICO

VIENTOS MÁXIMOS SOSTENIDOS...110 MPH...175 KM/H

MOVIMIENTO ACTUAL...NNO O 345 GRADOS A 10 MPH...17 KM/H

PRESIÓN CENTRAL MÍNIMA...965 MB...28.50 PULGADAS

VIGILANCIAS Y AVISOS

CAMBIOS CON ESTA ADVERTENCIA:

Ninguno.

RESUMEN DE VIGILANCIAS Y AVISOS EN EFECTO:

Un Aviso de Huracán está en efecto para...

* Punta Maldonado hacia el oeste a Zihuatanejo

- NWS San Juan has translated NHC's Atlantic Public Advisories (TCPs) and Tropical Weather Outlooks (TWOs) for many years
- New AI translation techniques were incorporated and tested in 2023
- NHC takes over operational Spanish Atlantic TCPs and TWOs in 2024
- NHC issues experimental Spanish Atlantic Tropical Cyclone Discussions (TCDs) and Key Messages, and the full suite in the eastern Pacific

Examples available at <https://www.weather.gov/translate/>



Spanish Advisory Text Products

<i>Spanish Product</i>	<i>WMO ID</i>	<i>AWIPS PIL</i>
TWO - Atlantic	ACCA62 KNHC	TWOSAT
TWO - Eastern Pacific	ABPZ21 KNHC	TWOSEP
TCP - Atlantic	WTCA/41-45/KNHC	TASAT/1-5/
TCP - Eastern Pacific (NHC)	WTPZ/11-15/ KNHC	TASEP/1-5/
TCD - Atlantic (NHC)	WTNT/51-55/ KNHC	TDSAT/1-5/
TCD - Eastern Pacific (NHC)	WTPZ/51-55/ KNHC	TDSEP/1-5/
TCU - Atlantic	WTNT/71-75/ KNHC	TUSAT/1-5/
TCU - Eastern Pacific	WTPZ/71-75/ KNHC	TUSEP/1-5/

Examples available at <https://www.weather.gov/translate/>



U.S. Watches/Warnings on Intermediate Advisories

Pre-2024:

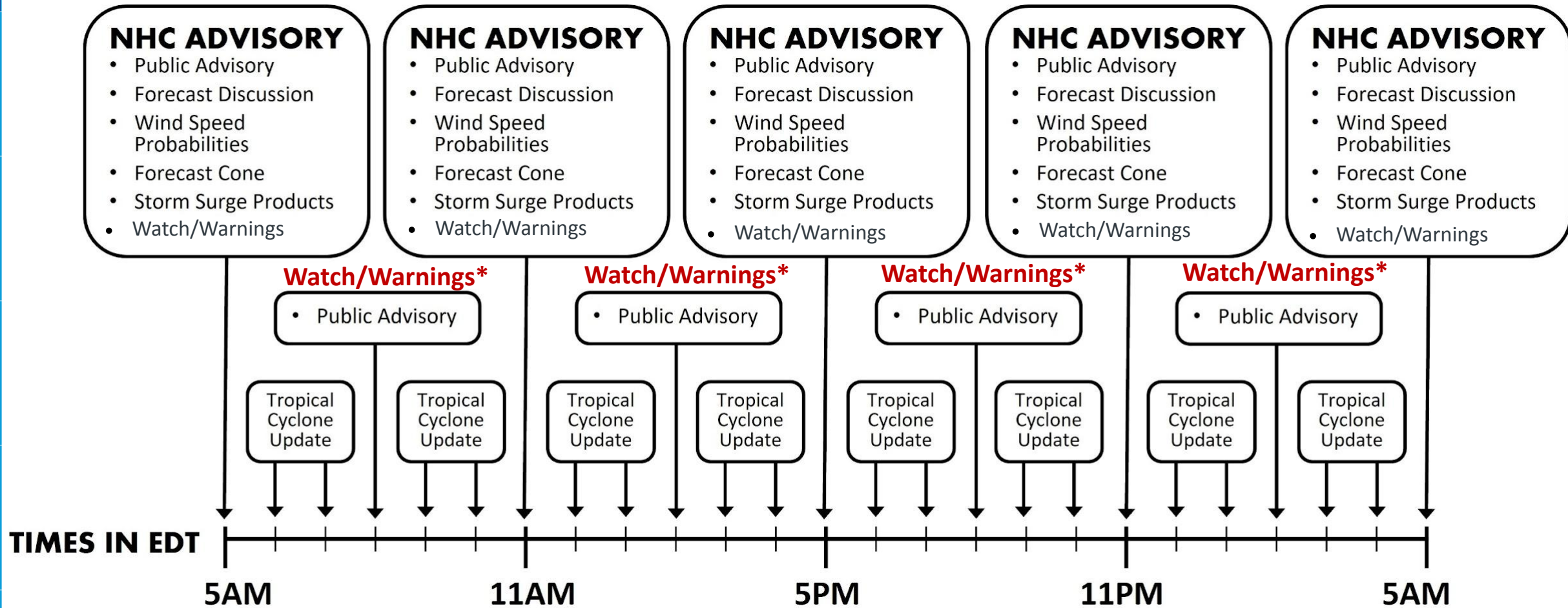
- NWS policy prevented NWS/NHC from issuing U.S. watches and warnings on intermediate advisories (only discontinuations or downgrades were allowed)
- International watch/warning issuances could be communicated via intermediate advisories
- Any necessary U.S. additions/upgrades required the issuance of a Special Advisory
- Watches/warnings were removed from the forecast/advisory (TCM) in 2023, which allows greater flexibility for the public advisory (TCP)

2024:

- ***U.S. wind and storm surge watches and warnings can be issued on intermediate advisories***
- Allows for expansion of watches/warnings along the peripheries of an event or low-end events without requiring a Special Advisory
- Can help alleviate WEA alerting concerns by allowing issuance of hurricane/storm surge warnings at less intrusive times (e.g., 8 am instead of 5 am).
- NWS retains the option to issue Special Advisories for significant/unexpected changes to watches/warnings



U.S. Watches/Warnings on Intermediate Advisories



***New in 2024**

Day 4-5 Wind Radii Forecasts

HURRICANE IDALIA FORECAST/ADVISORY NUMBER 12
NWS NATIONAL HURRICANE CENTER MIAMI FL AL102023
1500 UTC TUE AUG 29 2023

NOTICE... LAND-BASED TROPICAL CYCLONE WATCHES AND WARNINGS ARE NO LONGER INCLUDED IN THE TROPICAL CYCLONE FORECAST/ADVISORY...(TCM). CURRENT LAND-BASED COASTAL WATCHES AND WARNINGS CAN BE FOUND IN THE MOST RECENTLY ISSUED TROPICAL CYCLONE PUBLIC ADVISORY...(TCP).

HURRICANE CENTER LOCATED NEAR 24.6N 84.8W AT 29/1500Z
POSITION ACCURATE WITHIN 15 NM

PRESENT MOVEMENT TOWARD THE NORTH OR 5 DEGREES AT 12 KT

ESTIMATED MINIMUM CENTRAL PRESSURE 976 MB
MAX SUSTAINED WINDS 75 KT WITH GUSTS TO 90 KT.
64 KT... 15NE 15SE 05W 10NW.
50 KT... 30NE 40SE 20SW 20NW.
34 KT... 100NE 140SE 50SW 60NW.
12 FT SEAS.. 90NE 150SE 60SW 75NW.
WINDS AND SEAS VARY GREATLY IN EACH QUADRANT. RADII IN NAUTICAL MILES ARE THE LARGEST RADII EXPECTED ANYWHERE IN THAT QUADRANT.

REPEAT...CENTER LOCATED NEAR 24.6N 84.8W AT 29/1500Z
AT 29/1200Z CENTER WAS LOCATED NEAR 23.8N 84.8W

FORECAST VALID 30/0000Z 26.5N 84.6W
MAX WIND 90 KT...GUSTS 110 KT.
64 KT... 20NE 20SE 10SW 10NW.
50 KT... 40NE 50SE 30SW 20NW.
34 KT...120NE 150SE 70SW 80NW.

FORECAST VALID 30/1200Z 29.3N 83.7W
MAX WIND 110 KT...GUSTS 135 KT.
64 KT... 25NE 25SE 10SW 10NW.
50 KT... 40NE 40SE 20SW 20NW.
34 KT... 90NE 150SE 70SW 70NW.

FORECAST VALID 31/0000Z 31.8N 81.7W...INLAND
MAX WIND 55 KT...GUSTS 65 KT.
50 KT... 40NE 40SE 20SW 20NW.
34 KT... 70NE 140SE 50SW 40NW.

FORECAST VALID 31/1200Z 33.5N 78.8W...OVER WATER
MAX WIND 45 KT...GUSTS 55 KT.
34 KT... 70NE 120SE 70SW 40NW.

FORECAST VALID 01/0000Z 34.1N 75.6W
MAX WIND 45 KT...GUSTS 55 KT.
34 KT...120NE 100SE 70SW 60NW.

FORECAST VALID 01/1200Z 33.8N 73.0W
MAX WIND 45 KT...GUSTS 55 KT.
34 KT...140NE 60SE 90SW 120NW.

EXTENDED OUTLOOK. NOTE...ERRORS FOR TRACK HAVE AVERAGED NEAR 125 NM ON DAY 4 AND 175 NM ON DAY 5...AND FOR INTENSITY NEAR 15 KT EACH DAY

OUTLOOK VALID 02/1200Z 32.5N 70.2W
MAX WIND 45 KT...GUSTS 55 KT.

OUTLOOK VALID 03/1200Z 32.0N 68.8W
MAX WIND 45 KT...GUSTS 55 KT.

REQUEST FOR 3 HOURLY SHIP REPORTS WITHIN 300 MILES OF 24.6N 84.8W

INTERMEDIATE PUBLIC ADVISORY...WTNT35 KNHC/MIATCPAT5...AT 29/1800Z

NEXT ADVISORY AT 29/2100Z

- NHC has been making in-house 34- and 50-kt wind radii forecasts at days 4 and 5 for several hurricane seasons
- These radii forecasts will become operational in 2024
- Official forecast radii will replace climatology-persistence (DRCL) radii that have been used in downstream applications (wind speed probs, WTCM, etc.)

EXTENDED OUTLOOK. NOTE...ERRORS FOR TRACK HAVE AVERAGED NEAR 125 NM ON DAY 4 AND 175 NM ON DAY 5...AND FOR INTENSITY NEAR 15 KT EACH DAY

OUTLOOK VALID 02/1200Z 32.5N 70.2W
MAX WIND 45 KT...GUSTS 55 KT.

OUTLOOK VALID 03/1200Z 32.0N 68.8W
MAX WIND 45 KT...GUSTS 55 KT.

34- and 50-kt radii will now be included in the TCM for days 4 and 5

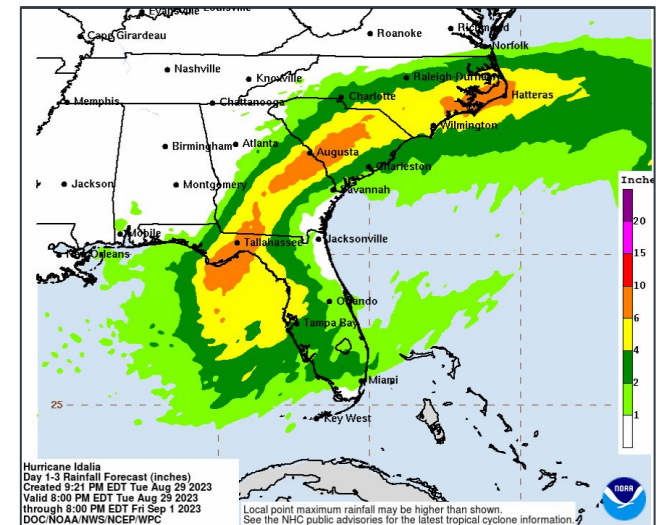
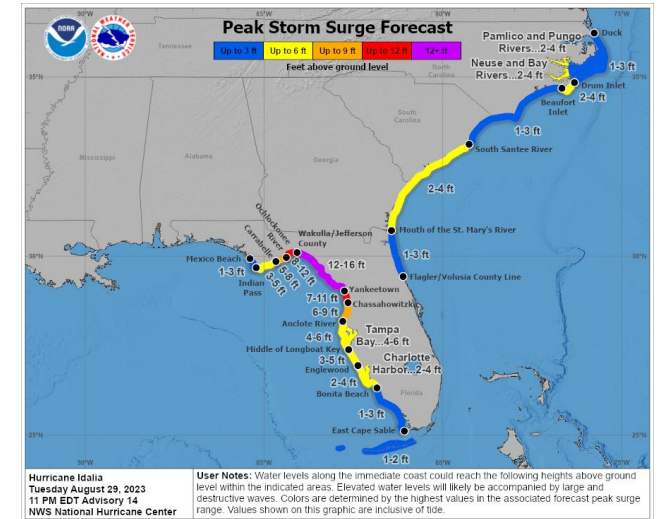
Weblinks in the TCP for Hazard Information

STORM SURGE: The combination of a dangerous storm surge and the tide will cause normally dry areas near the coast to be flooded by rising waters moving inland from the shoreline. The water could reach the following heights above ground somewhere in the indicated areas if the peak surge occurs at the time of high tide...

- Wakulla/Jefferson County line, FL to Yankeetown, FL...12-16 ft
- Ochlockonee River, FL to Wakulla/Jefferson County line, FL...8-12 ft
- Yankeetown to Chassahowitzka, FL...7-11 ft
- Chassahowitzka, FL to Anclote River, FL...6-9 ft
- Carrabelle, FL to Ochlockonee River, FL...5-8 ft
- Anclote River, FL to Middle of Longboat Key, FL...4-6 ft
- Tampa Bay...4-6 ft
- Middle of Longboat Key, FL to Englewood, FL...3-5 ft
- Indian Pass, FL to Carrabelle, FL...3-5 ft
- Englewood, FL to Bonita Beach, FL...2-4 ft
- Charlotte Harbor...2-4 ft
- Mouth of the St. Mary's River to South Santee, SC...2-4 ft
- Beaufort Inlet to Drum Inlet, NC...2-4 ft
- Pamlico and Neuse Rivers...2-4 ft
- South of Bonita Beach to Chokoloskee, FL...1-3 ft
- South Santee, SC to Beaufort Inlet, NC...1-3 ft
- Drum Inlet to Duck, NC...1-3 ft
- Chokoloskee, FL to East Cape Sable, FL...1-3 ft
- Flagler/Volusia County Line, FL to Mouth of St. Mary's River...1-3 ft
- Indian Pass to Mexico Beach...1 to 3 ft
- Florida Keys...1-2 ft

The deepest water will occur along the immediate coast in areas of onshore winds, where the surge will be accompanied by large and dangerous waves. Surge-related flooding depends on the relative timing of the surge and the tidal cycle, and can vary greatly over short distances. For information specific to your area, please see products issued by your local National Weather Service forecast office.

- Add weblinks directing users to Peak Storm Surge and WPC rainfall forecast graphics
- Only keep the most significant or impactful forecast values in the TCP instead of listing every segment/area



Time Zone Modifications in Eastern Pacific

- Mexico abolished Daylight Saving Time for most areas on October 30, 2022
- Central Standard and Mountain Standard will now be used within those time zones
- Since portions of Baja California and the southwestern U.S. still use Daylight Saving Time, Pacific Daylight Time will still be used at appropriate times of year

Central Standard Time: advisory position east of 106.0°W

Mountain Standard Time: advisory position from 106.0°W to 114.9°W

Pacific Daylight Time: advisory position from 115.0°W westward

Note: if the final forecast point is west of 140°W, Hawaiian Standard Time is used

- *Note: There are NO changes to time zone references in Atlantic products*



Time Zone Modifications in Eastern Pacific

During Daylight Saving Time

Eastern Time	Central Time	Mountain Time	Pacific Time	Hawaiian Time
5 AM EDT	3 AM CST	2 AM MST	2 AM PDT	11 PM HST
11 AM EDT	9 AM CST	8 AM MST	8 AM PDT	5 AM HST
5 PM EDT	3 PM CST	2 PM MST	2 PM PDT	11 AM HST
11 PM EDT	9 PM CST	8 PM MST	8 PM PDT	5 PM HST

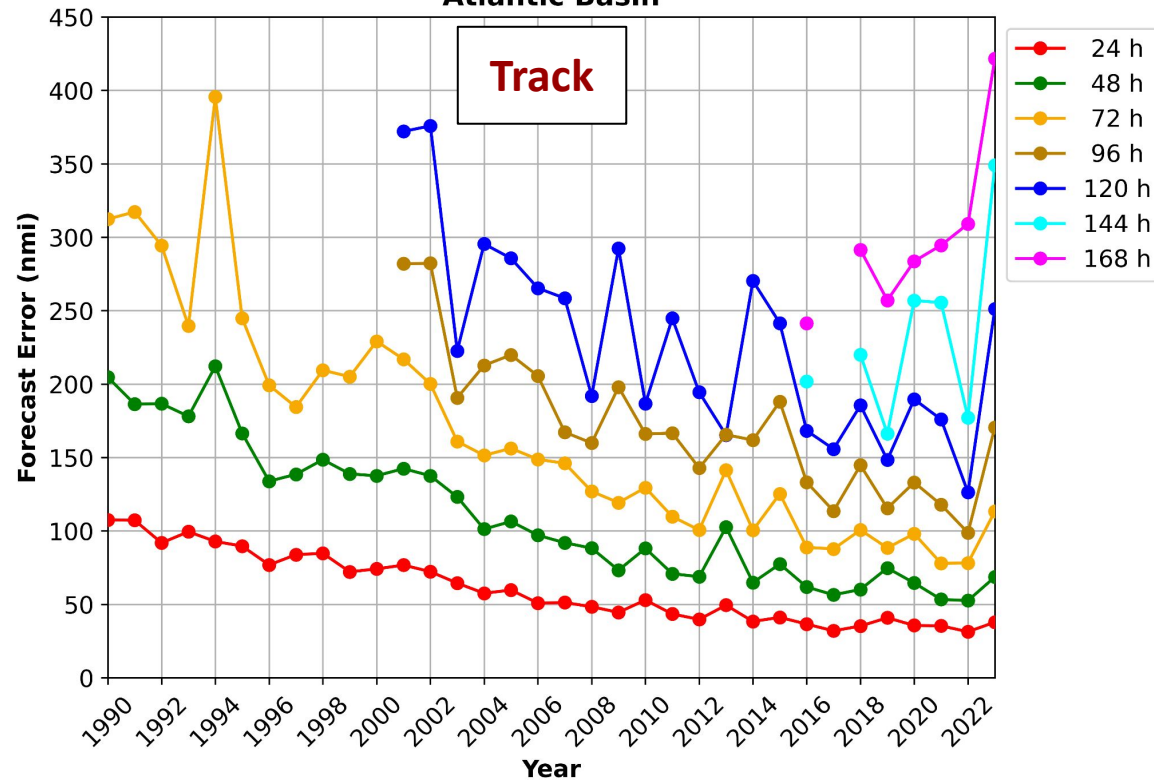
During Standard Time

Eastern Time	Central Time	Mountain Time	Pacific Time	Hawaiian Time
4 AM EST	3 AM CST	2 AM MST	1 AM PST	11 PM HST
10 AM EST	9 AM CST	8 AM MST	7 AM PST	5 AM HST
4 PM EST	3 PM CST	2 PM MST	1 PM PST	11 AM HST
10 PM EST	9 PM CST	8 PM MST	7 PM PST	5 PM HST

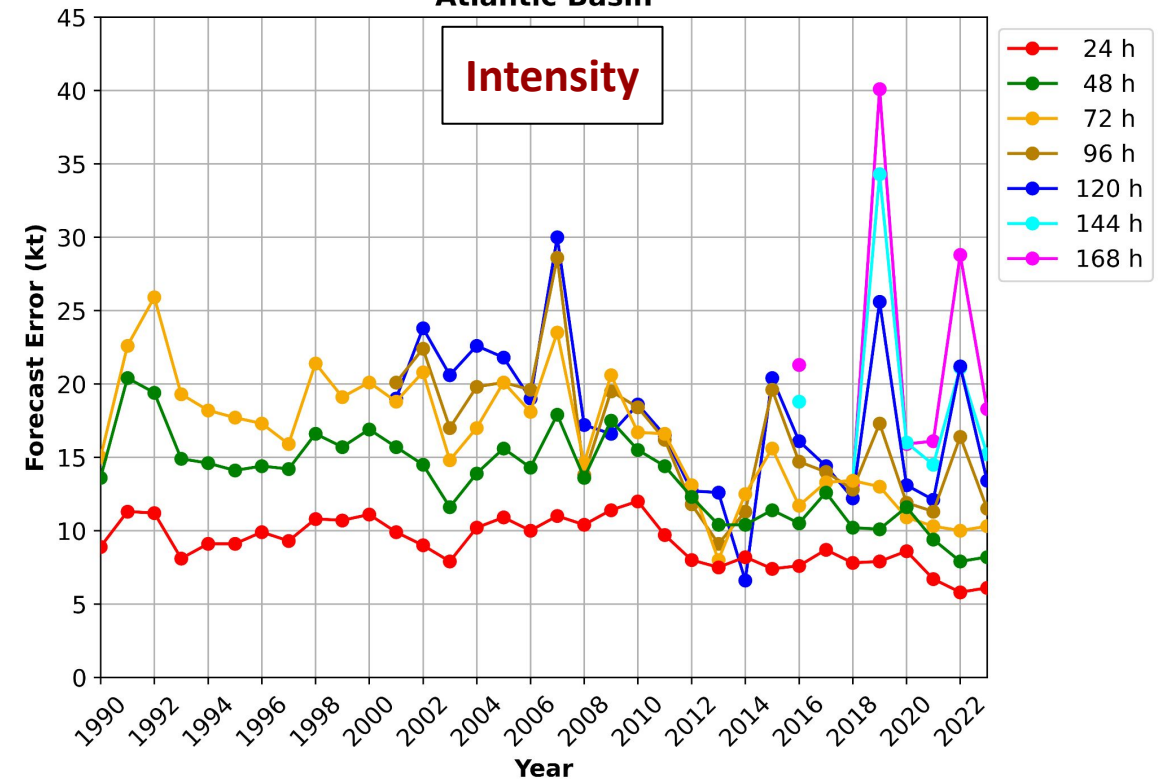
6- and 7-Day Track and Intensity Forecasts (Potentially In a Couple of Years)

- NHC has been making internal 6- and 7-day track and intensity forecasts since 2016 (except for a 1-year hiatus in 2017)
- 6- and 7-day forecasts are generally as good as the 4- and 5-day forecasts when they were introduced in 2001
- NHC tentatively plans to make 6- and 7-day forecasts public in a couple of years, but how they are communicated is still to be determined
- Word of CAUTION: As 2023 showed, there can still be large track errors at 6 and 7 days (~350-425 n mi)

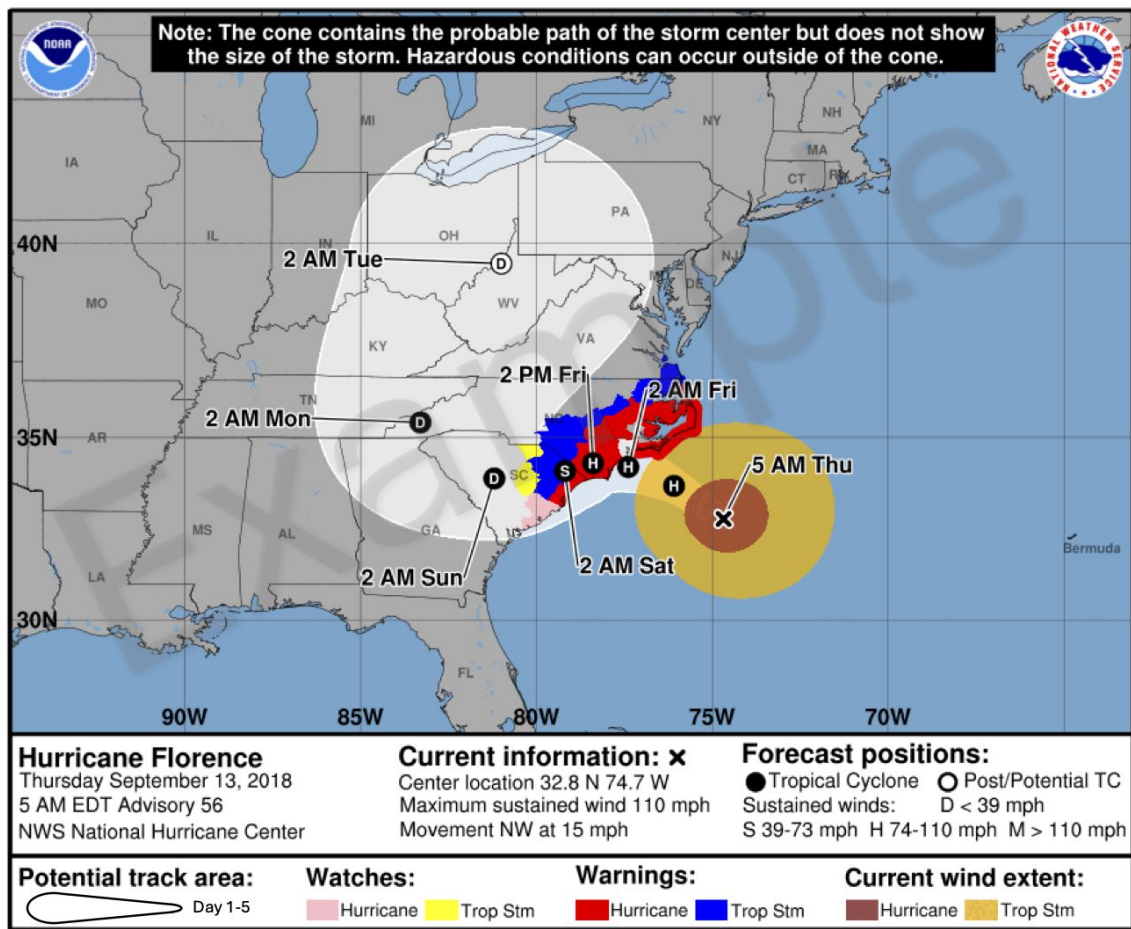
**NHC Official Track Forecast Error Trend
Atlantic Basin**



**NHC Official Intensity Forecast Error Trend
Atlantic Basin**



New for 2024: Depicting Inland Watches/Warnings on Cone

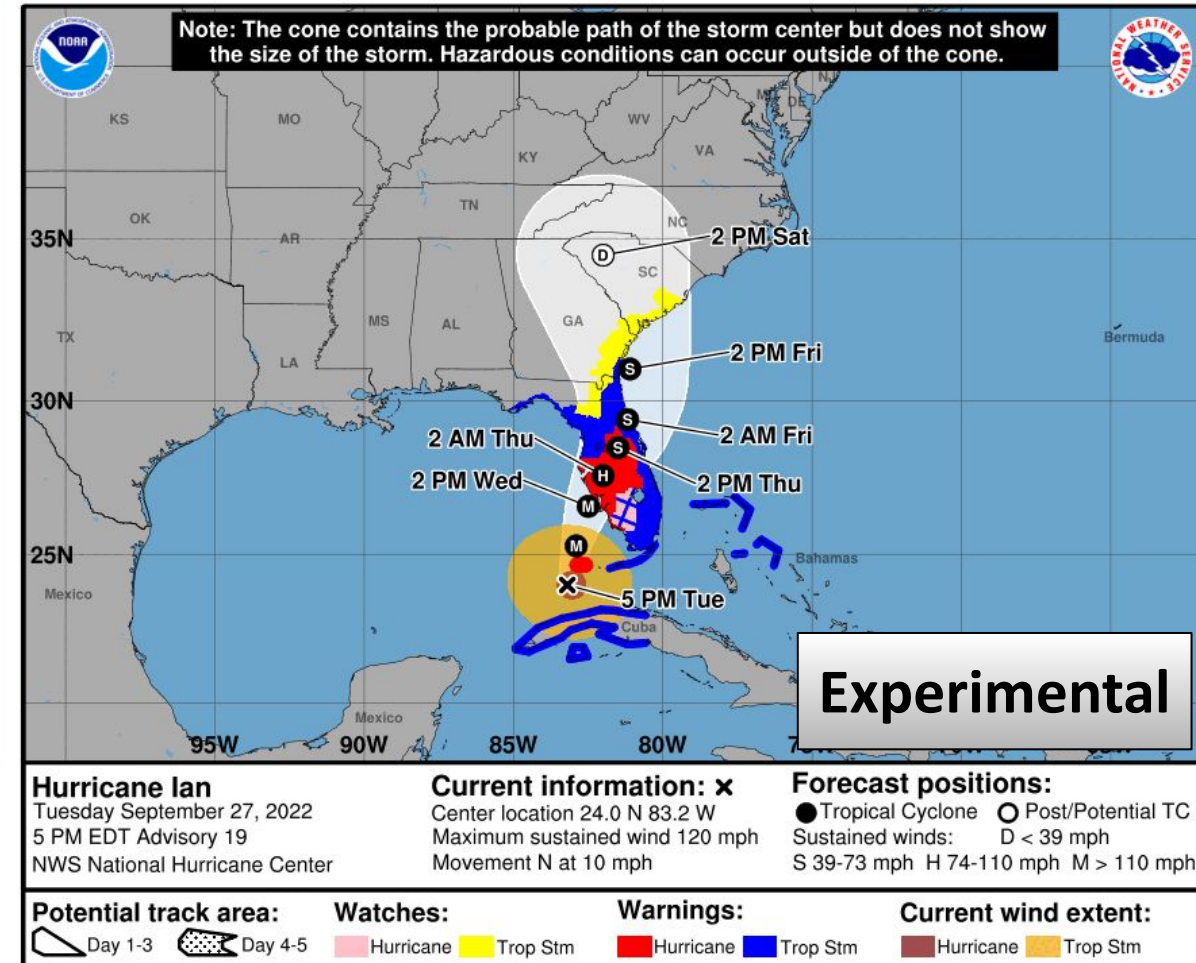
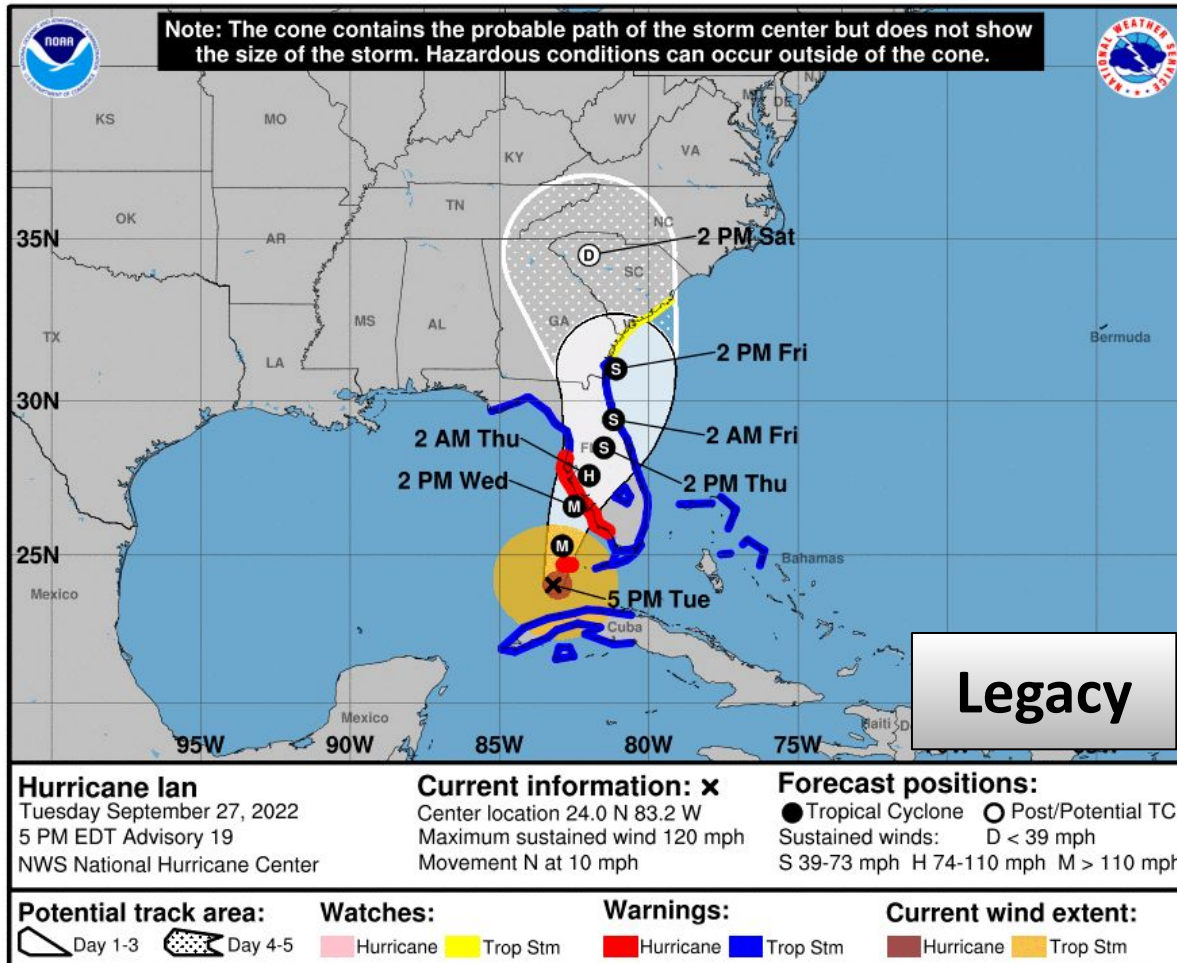


- Experimental cone graphic depicting inland U.S. tropical storm and hurricane watches and warnings will be available in 2024 around mid August
- Will better convey wind hazard risk
- Graphic may not be available as soon as the current cone graphic due to the time need to compile complete inland watch and warning information
- Feedback and comments will be collected during experimental period



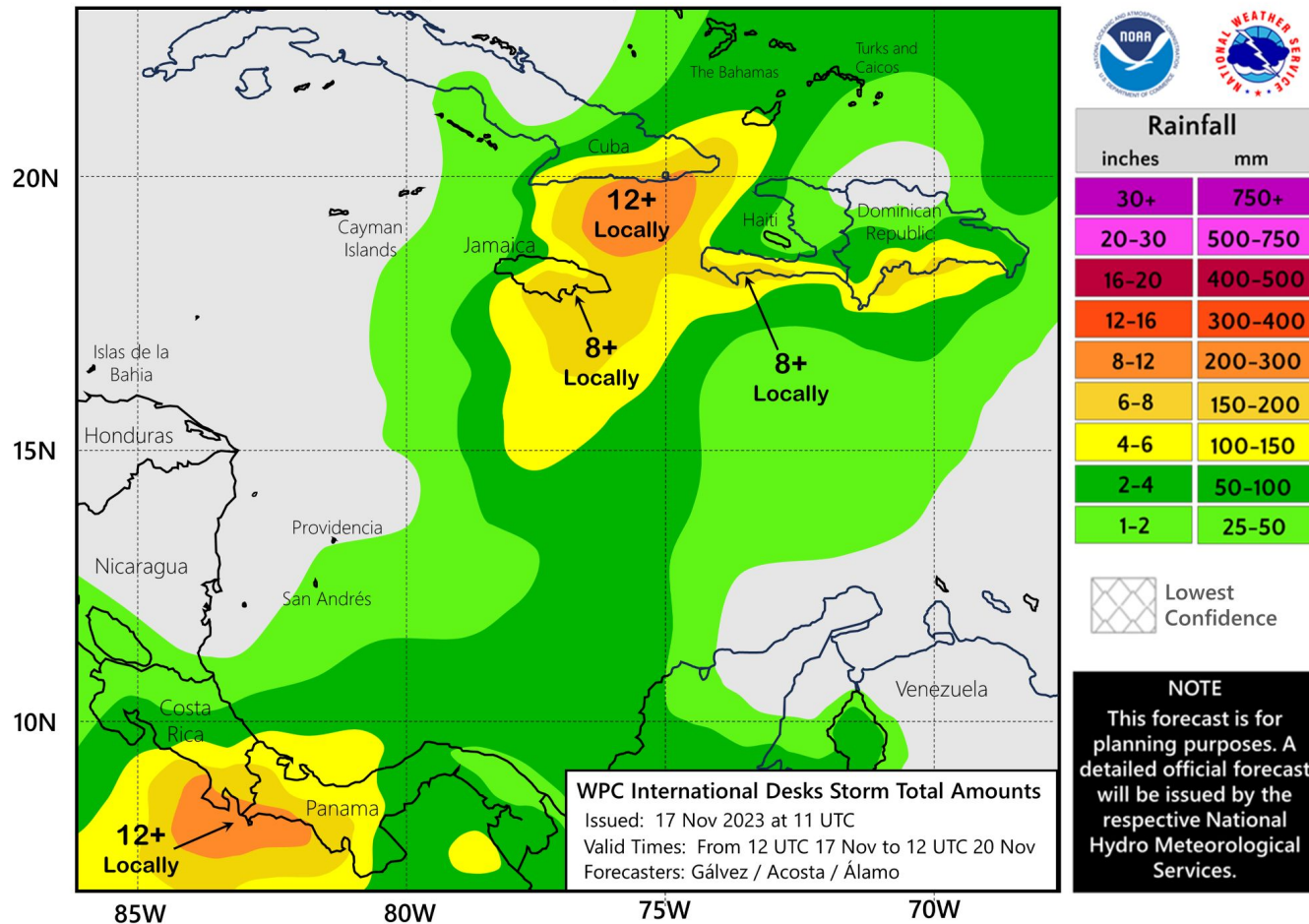
Inland U.S. Watches/Warnings on Cone Graphic (Experimental)

Beginning in August 2024, NHC will provide an experimental cone option with coastal and inland (U.S.) wind watches and warnings, along with the legacy cone graphic



International Tropical Cyclone Rainfall Graphics (Experimental)

Total Rainfall with Potential Tropical Cyclone Twenty-Two (Experimental)

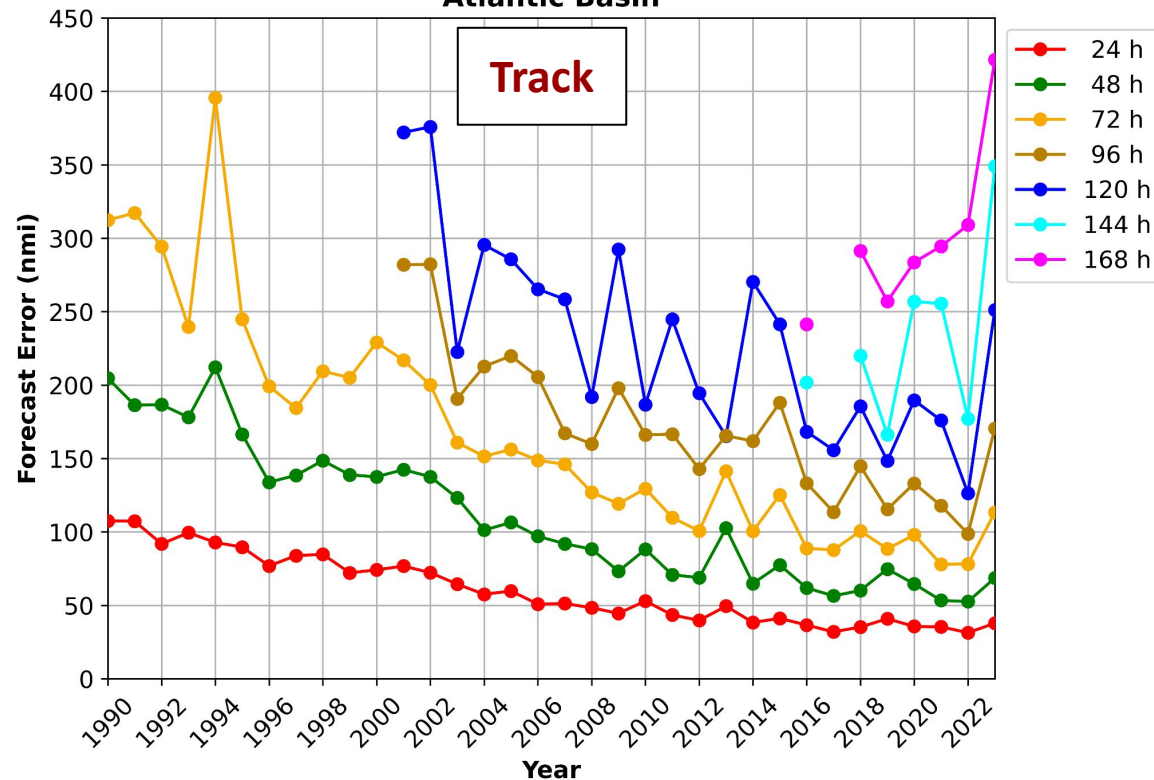


- Experimental graphics created by the Weather Prediction Center and available on hurricanes.gov
- Available for tropical cyclones affecting the Caribbean, Central America, or Mexico
- Complements the rainfall forecast provided in the TCP

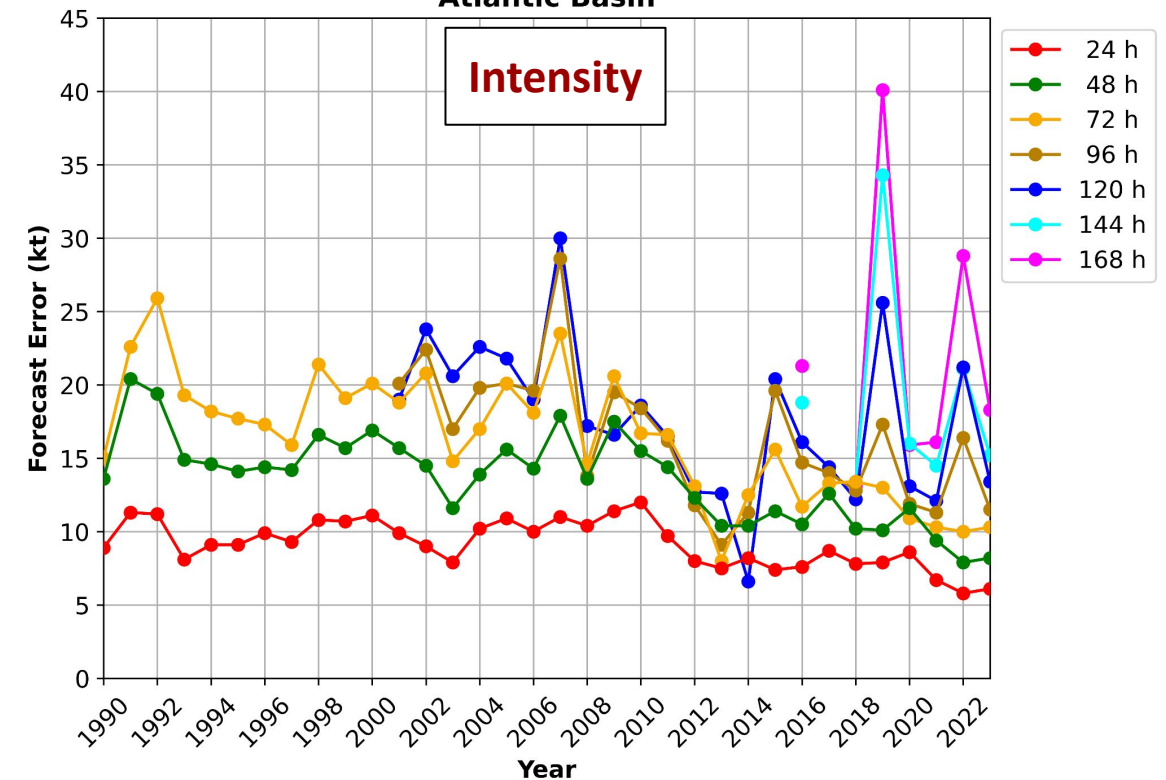
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**NHC Official Track Forecast Error Trend
Atlantic Basin**

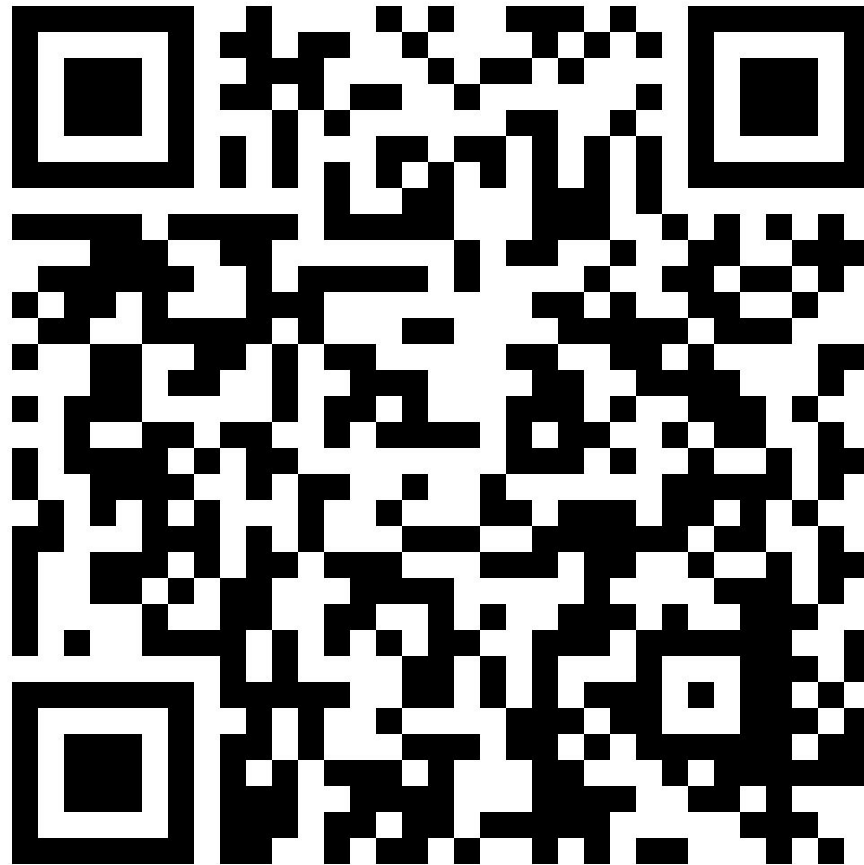


**NHC Official Intensity Forecast Error Trend
Atlantic Basin**



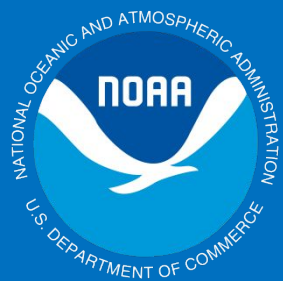


Summary Document can be found at:



Comments/Questions: daniel.p.brown@noaa.gov





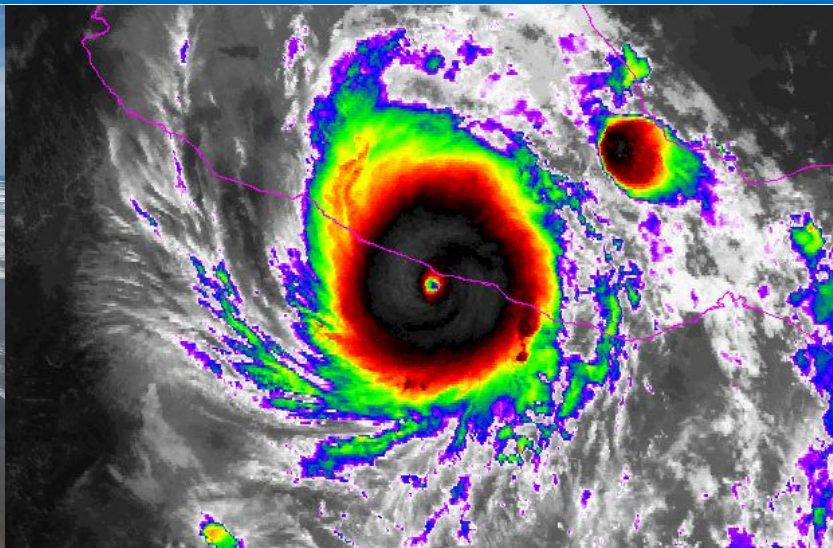
NOAA

**National
Weather
Service**

Defining the Warning

Robbie Berg
Senior Hurricane Specialist
National Hurricane Center

National Hurricane Conference
Orlando, Florida
March 27, 2024





Outline

- Wind watch/warning definitions and philosophy
- Verification of hurricane and tropical storm watches/warnings



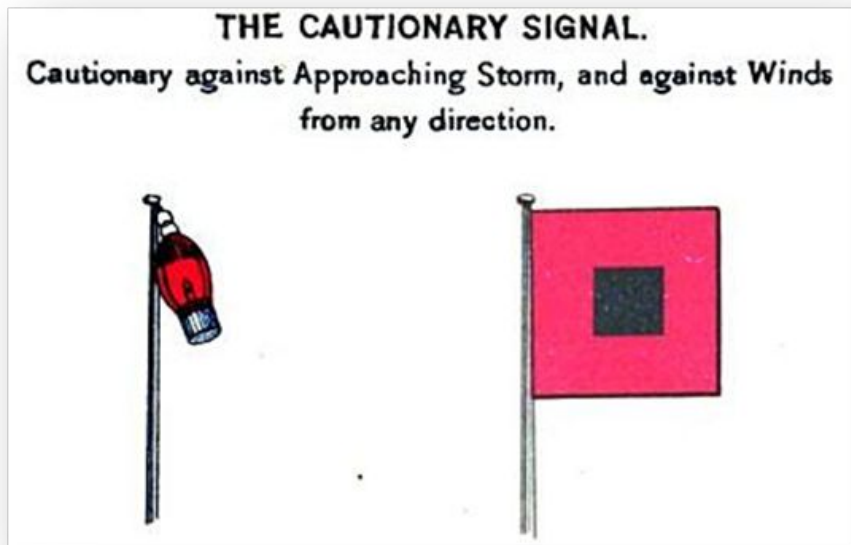
Wind Watch/Warning Definitions and Philosophy



1871: Signals on Sea-Coasts and Lakes

On the organization of the United States weather service in 1870, General Myer began with great caution to prepare for this difficult and delicate part of his arduous task; and on the 24th of October, 1871, the display of signals on the sea-coasts and lakes commenced. The order regulating this display contemplated that the warning should be sent only to stations at which a wind having a velocity of twenty-five miles or more per hour would occur. As the anemometer at every station registers the

History of the Signal Service with Catalogue of Publications, Instruments, and Stations. U. S. Signal Office, 1884.



Cautionary Signal

“premonishing (advance warnings) dangerous winds to blow from any direction”

display of either signal, however, is always intended to be *cautionary*, and calls for great vigilance on the part of vessels within sight of it.

Official danger, distress, and storm-signal codes for Signal Service sea-coast stations and mariners. Washington: Government Printing Office, 1883.




Current Tropical Cyclone Wind Warning Definitions

(from National Weather Service Instruction 10-601 and WMO RA-IV Hurricane Operations Plan)



Hurricane Warning



Sustained winds of 64 knots (74 mph) or higher are ***expected somewhere*** within the specified area in association with a potential or ongoing tropical cyclone, a subtropical cyclone, or a post-tropical cyclone. Because hurricane and typhoon preparedness activities become difficult once winds reach tropical storm force, the hurricane warning is issued 36 hours in advance of the anticipated onset of tropical storm force winds.



Tropical Storm Warning



Sustained winds of 34 to 63 knots (39 to 73 mph) are ***expected somewhere*** within the specified area within 36 hours in association with a potential or ongoing tropical cyclone, a subtropical cyclone, or a post-tropical cyclone.




Current Tropical Cyclone Wind Watch Definitions

(from National Weather Service Instruction 10-601 and WMO RA-IV Hurricane Operations Plan)




Hurricane Watch



Sustained winds of 64 knots (74 mph) or higher are **possible** within the specified area in association with a potential or ongoing tropical cyclone, a subtropical cyclone, or a post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm force, the hurricane watch is issued 48 hours in advance of the anticipated onset of tropical storm force winds.



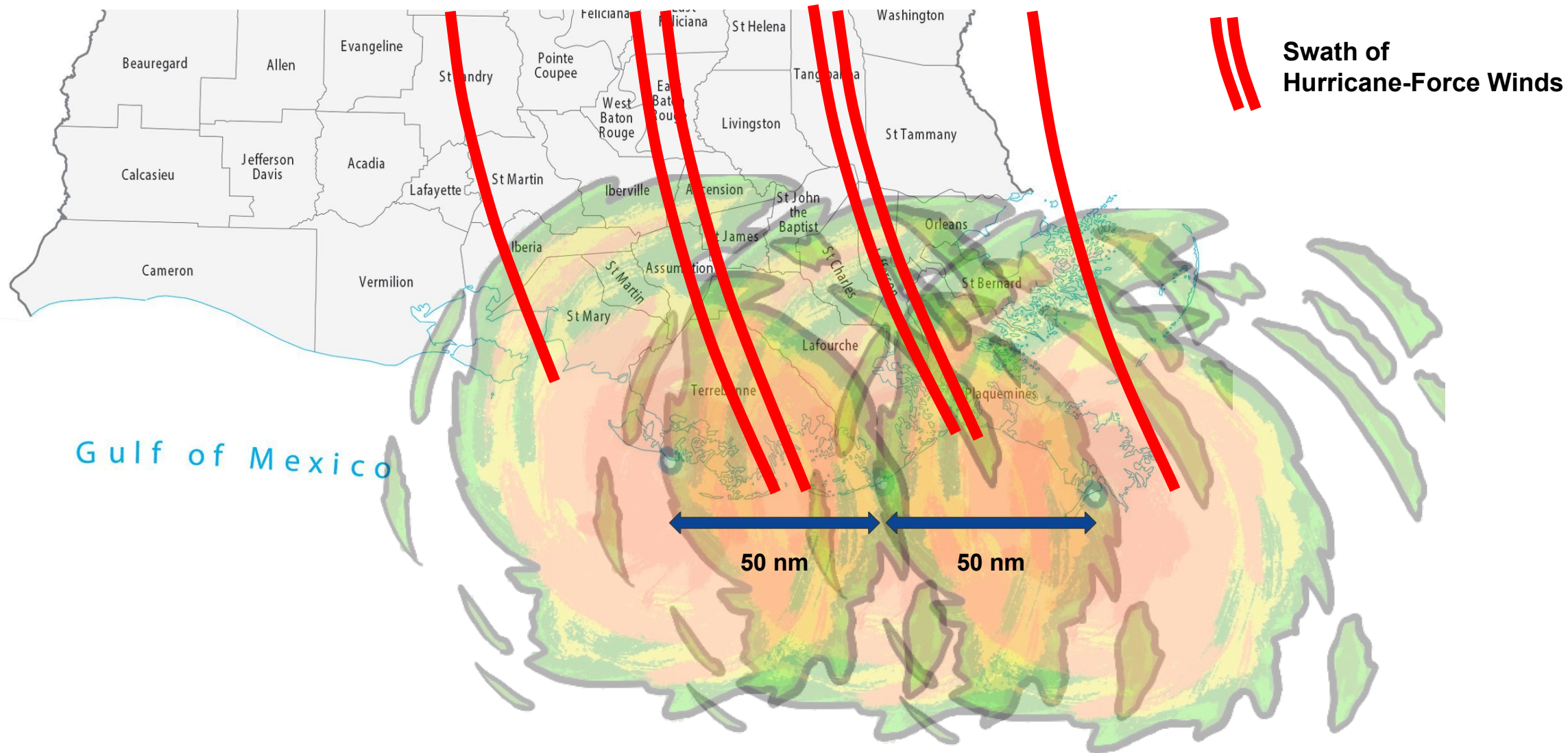
Tropical Storm Watch



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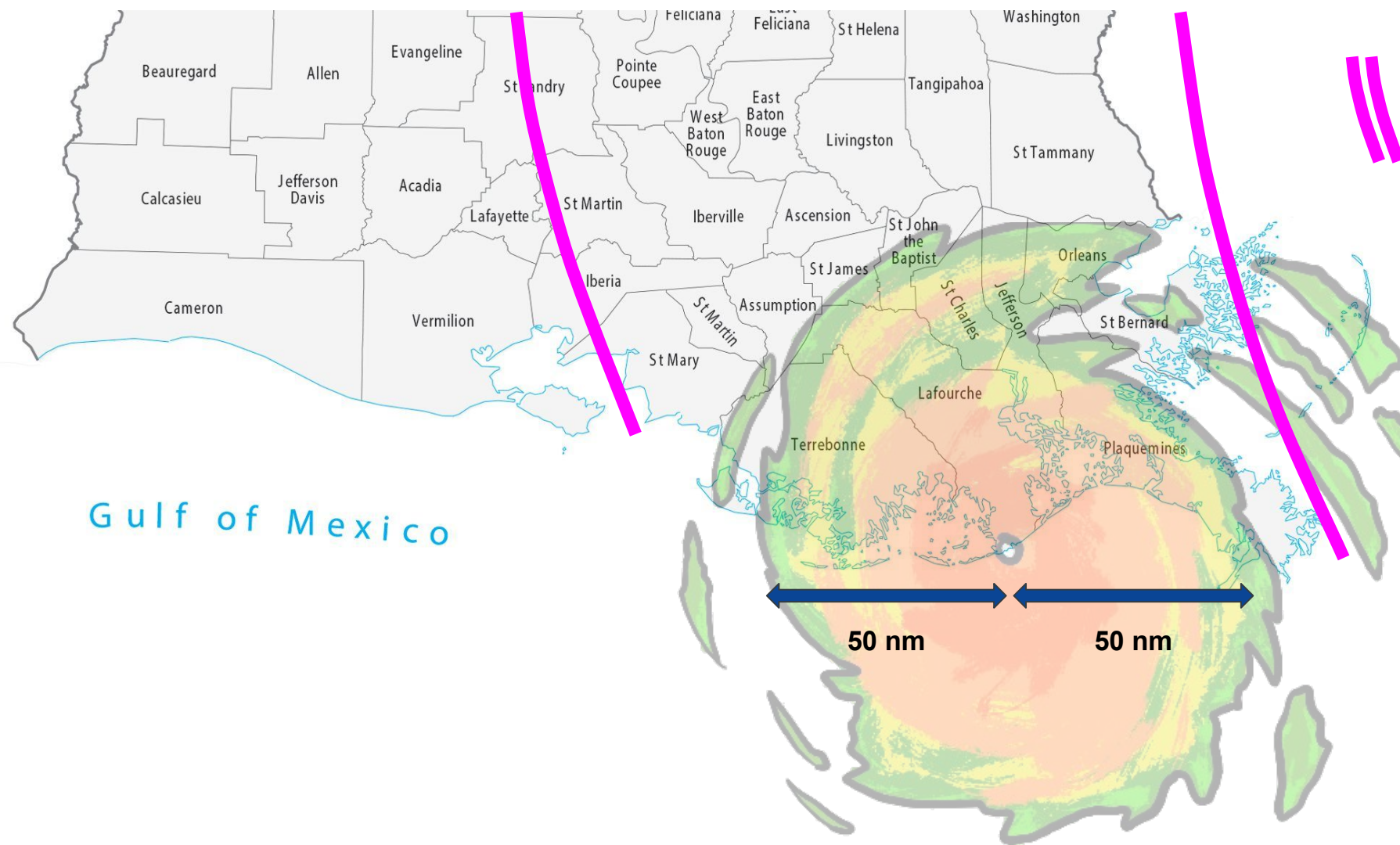
Accounting for Uncertainty When Warning

NHC's track forecasts are off by an average of 50 nm at 36 hours (warning lead time)



Accounting for Uncertainty When Warning

NHC's track forecasts are off by an *average* of 50 nm at 36 hours (warning lead time)



Potential Swath of Hurricane-Force Winds Where a Hurricane Warning Should be Issued

Gulf of Mexico

50 nm

50 nm

Watch/Warning Considerations

- Maintain continuity with previous watches/warnings.
- Expectations about future changes to the NHC forecast.
- Assessment of uncertainty substantially different from historical error distribution.
 - Particularly challenging forecasts
 - Potential tropical cyclones
- Vulnerability of area under consideration
- Time of day; day of week; holidays



Wind Watch/Warning Verification



How Does “Expected Somewhere” Verify?

(1987-2018)

● Hurricane Warnings

- 943 NHC advisories with coastal hurricane warnings in effect
- Hurricane conditions did not occur somewhere in the warning area after 258 of those advisory issuances (27%)
- **Hurricane warnings verified from 73% of advisories**

● Tropical Storm+ Warnings

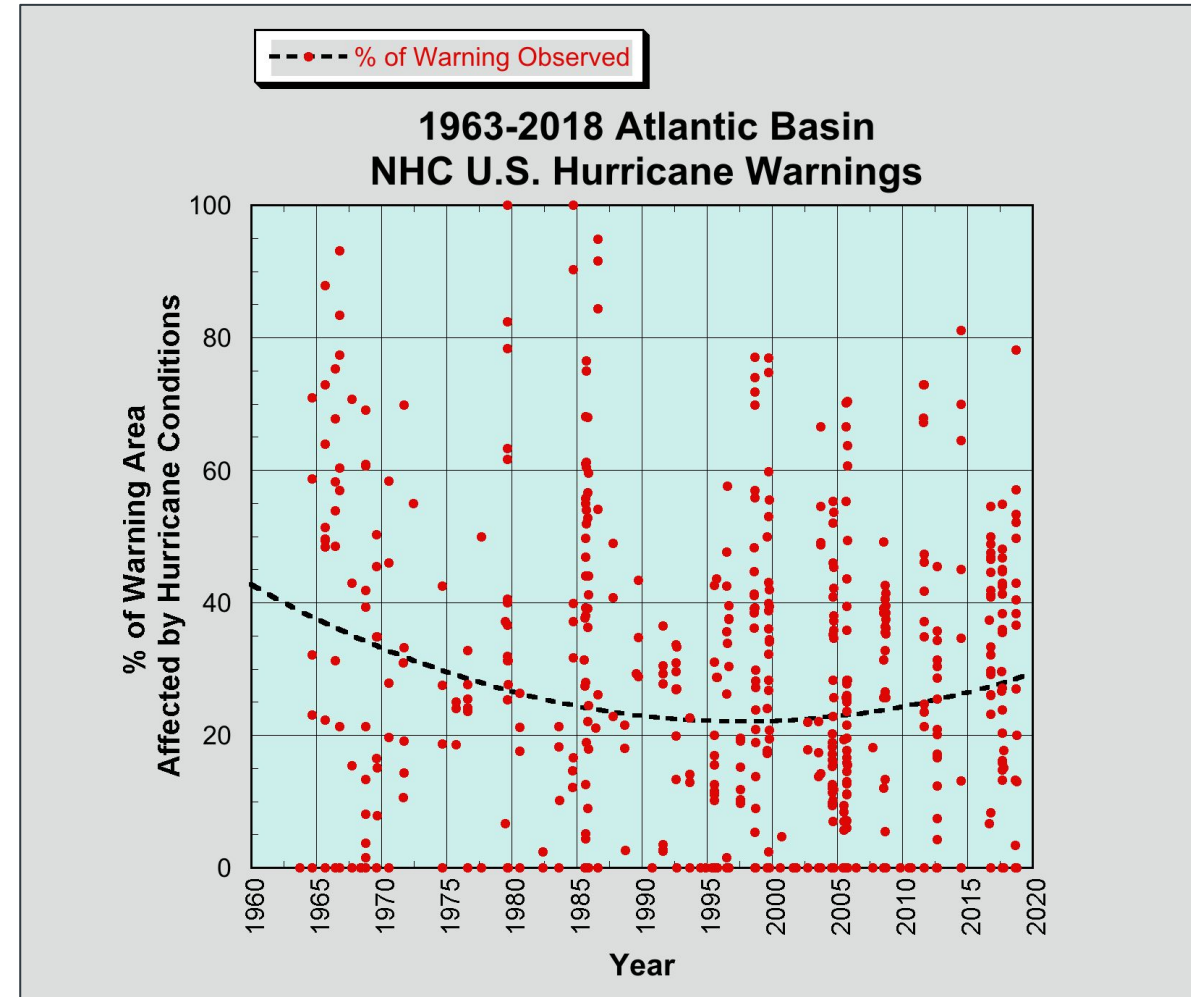
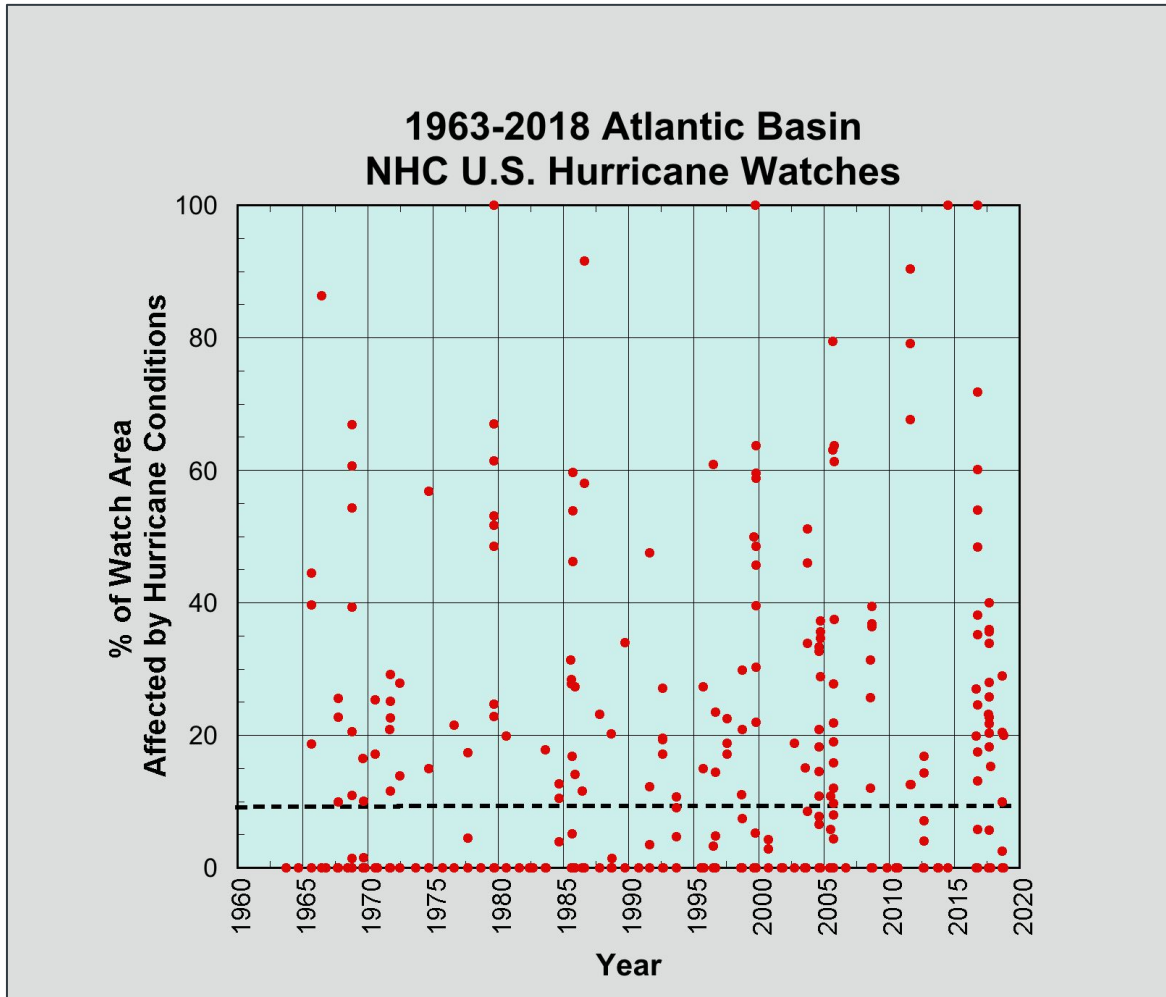
- 2247 NHC advisories with coastal tropical storm or hurricane warnings in effect
- Tropical storm+ conditions did not occur somewhere in the warning area after 281 of those advisory issuances (13%)
- **Tropical storm+ warnings verified from 87% of advisories**

Note: The warnings only verified if the conditions began within a pre-set time window (e.g. 48 hours) after the advisory release. The time window increased when lead times were increased in 2010.

Franklin and DeMaria (personal communication)

If I'm under a Hurricane Watch or Warning, will I get hurricane-force winds?

On average, ~10% of Hurricane Watch and ~30% of Hurricane Warning coastal areas get hurricane-force winds, but it's highly variable

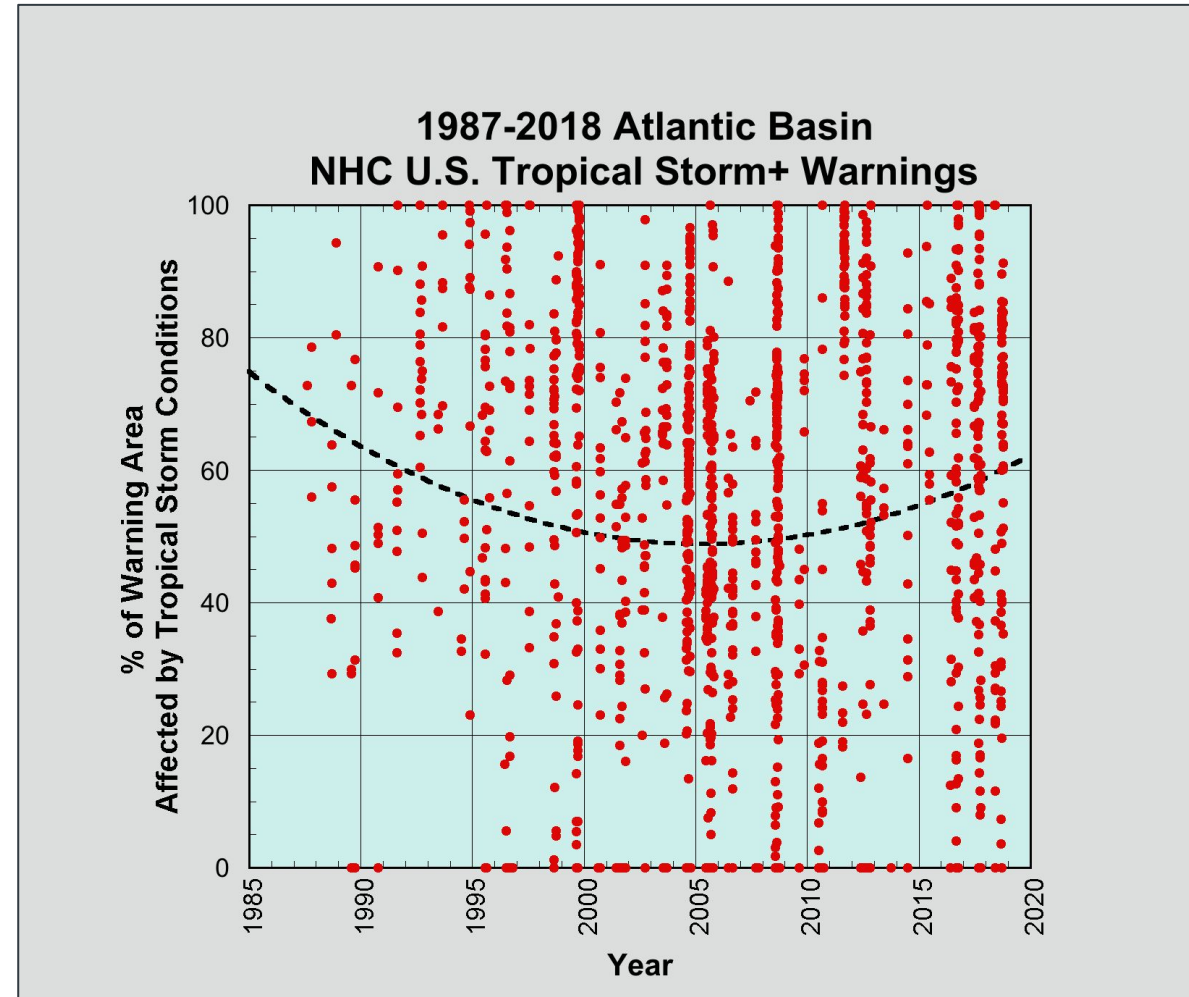
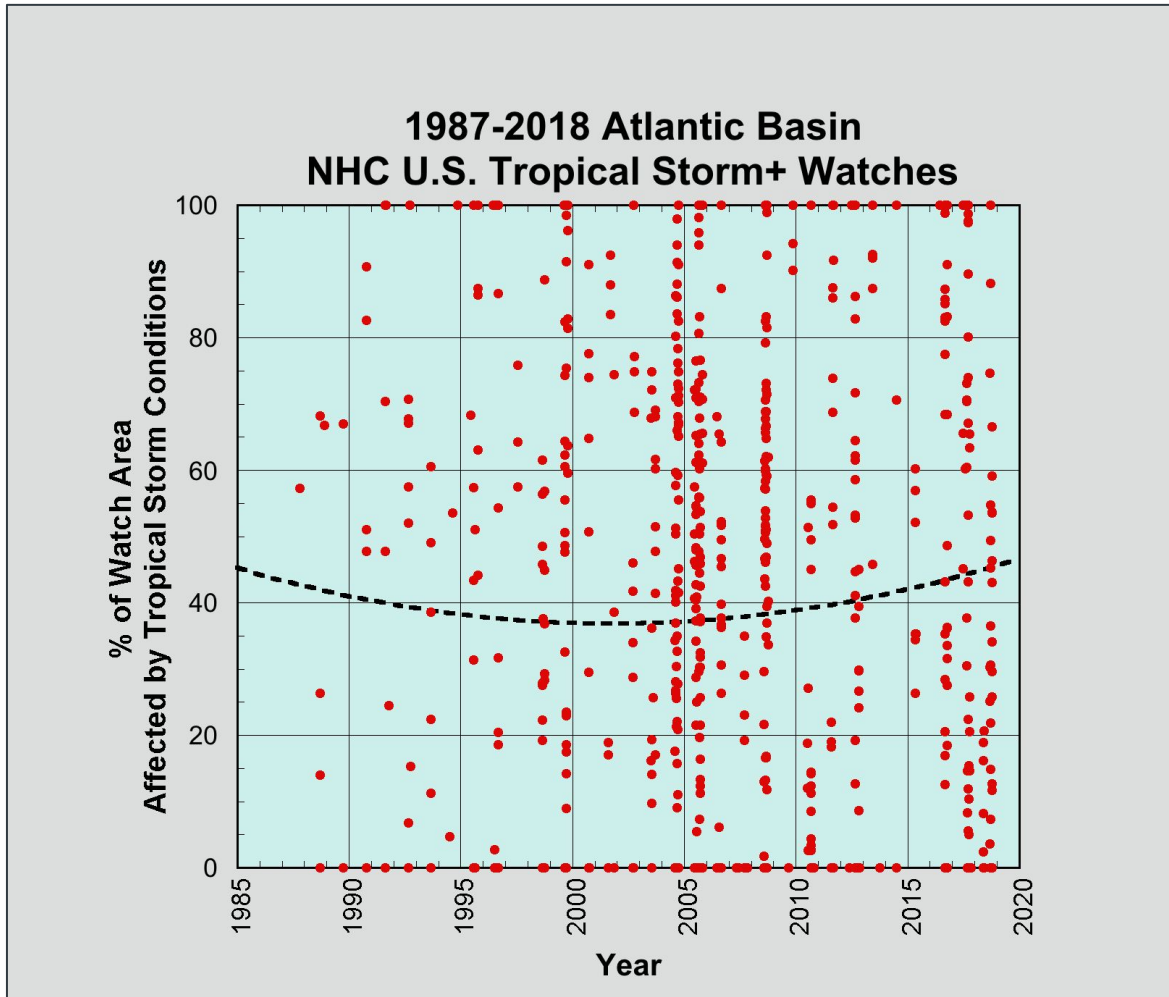


Franklin and DeMaria



If I'm under any kind of watch or warning, will I get at least tropical-storm-force winds?

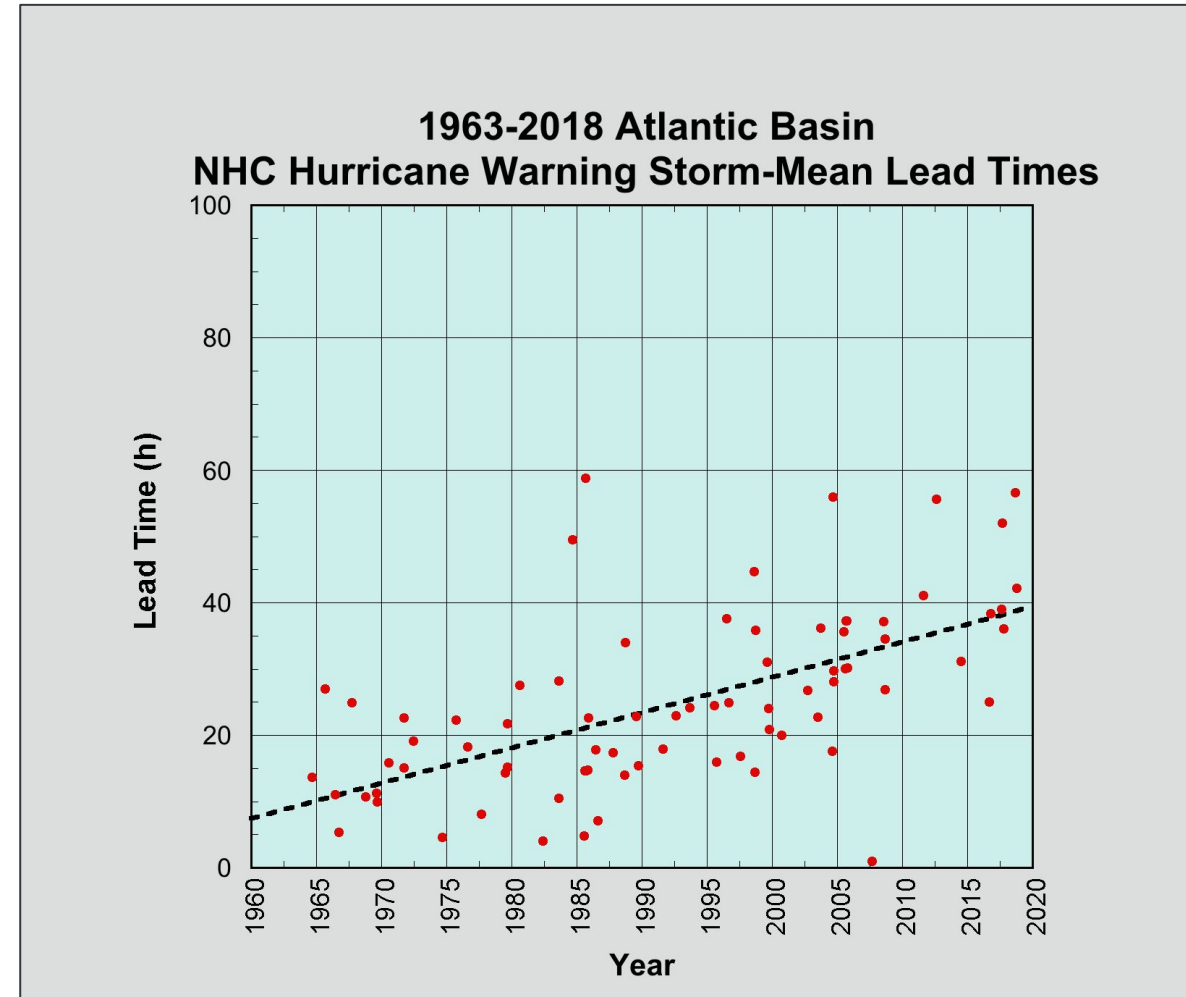
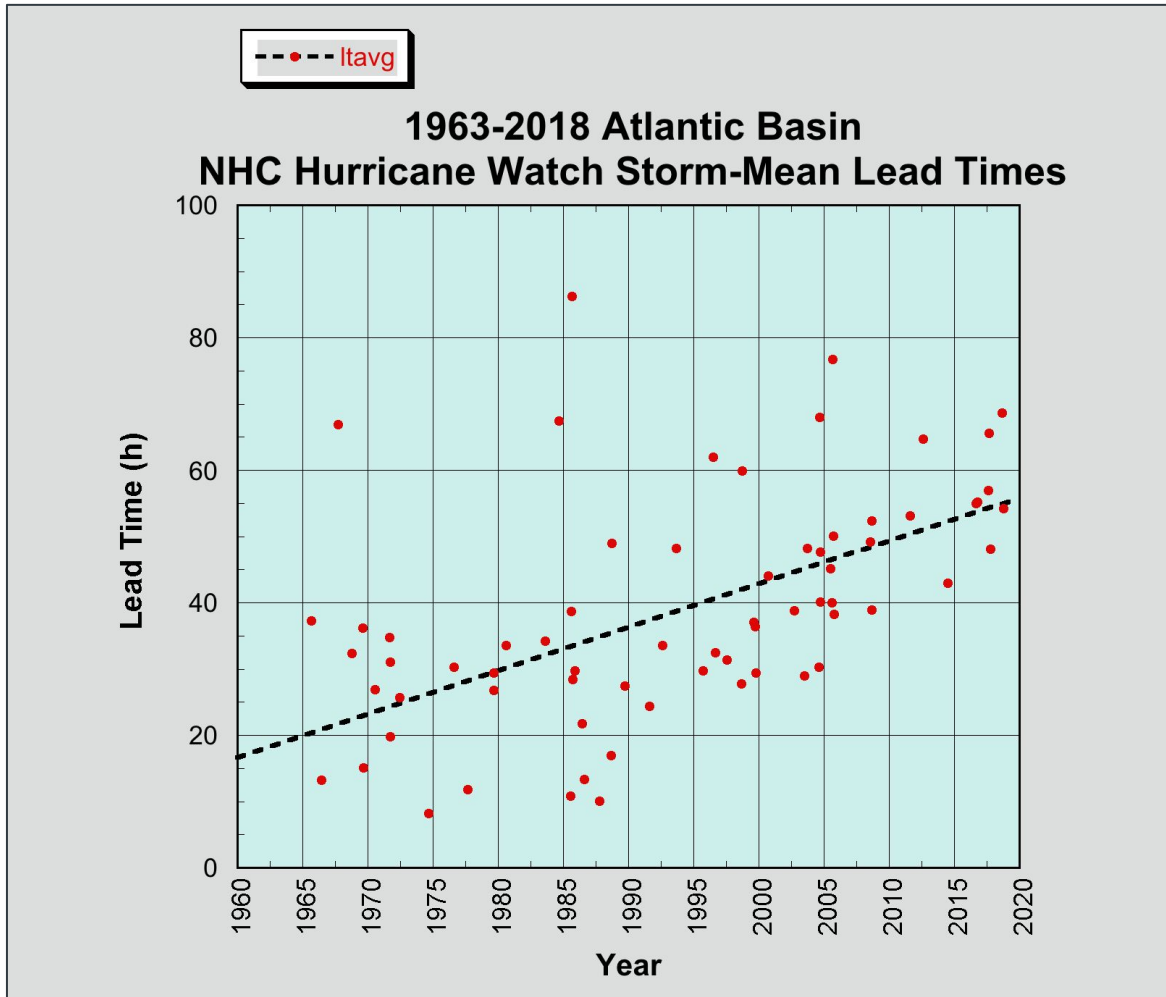
On average, **~45% of Tropical Storm+ Watch** and **~60% of Tropical Storm+ Warning** coastal areas get at least tropical-storm-force winds, *but it's highly variable from storm to storm*



Franklin and DeMaria

Once a Hurricane Watch or Warning is issued, how long is it before tropical-storm-force winds begin?

On average, **Hurricane Watches** have a lead time of **~55 hours**, and **Hurricane Warnings** have a lead time of **~40 hours**, which are both just over the nominal lead times of 48 and 36 hours, respectively

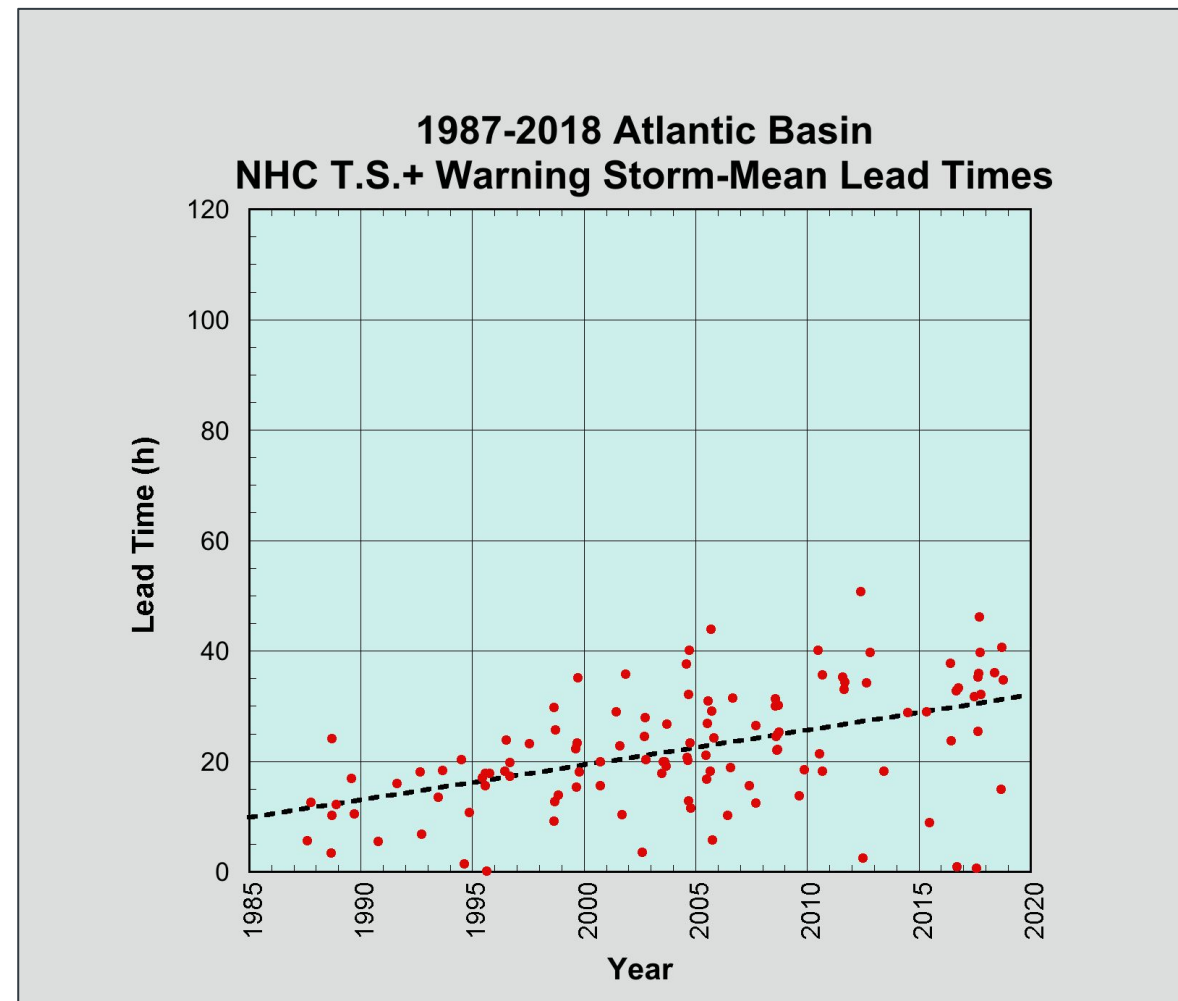
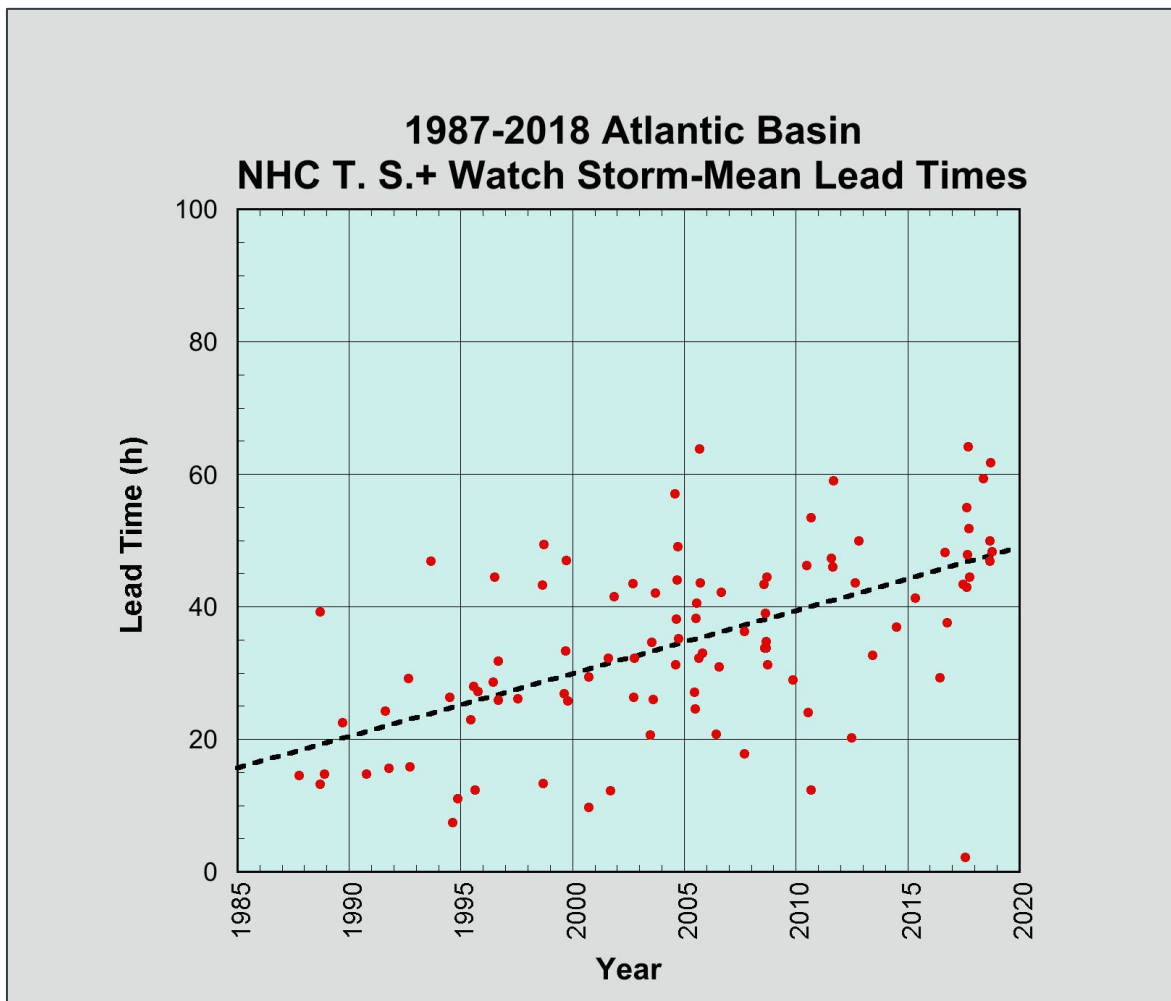


Franklin and DeMaria



Once any kind of watch or warning is issued, how long is it before tropical-storm-force winds begin?

On average, **Tropical Storm+ Watches** have a lead time of **~50 hours**, and **Tropical Storm+ Warnings** have a lead time of **~30 hours**, which are near the nominal lead times of 48 and 36 hours, respectively

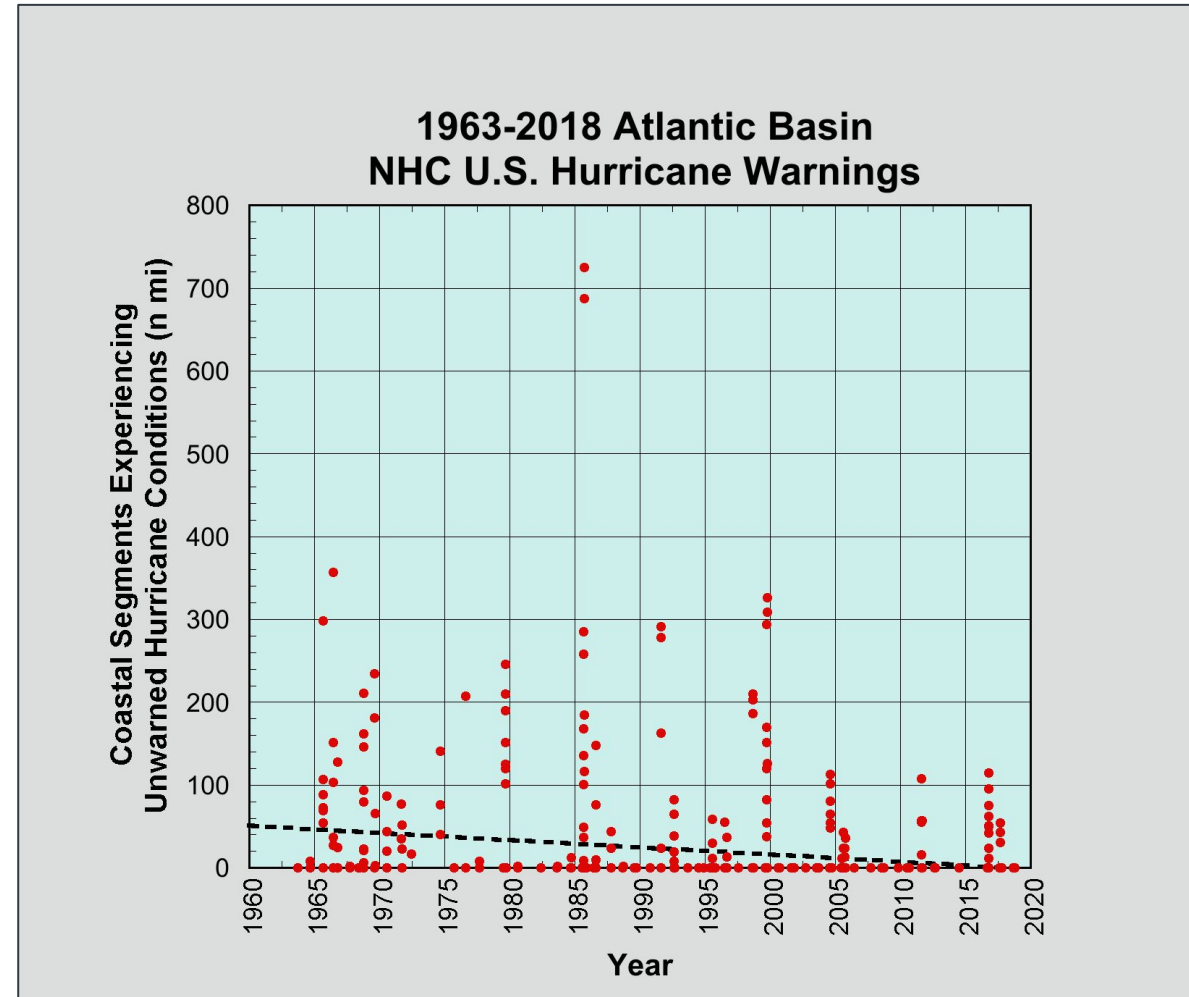
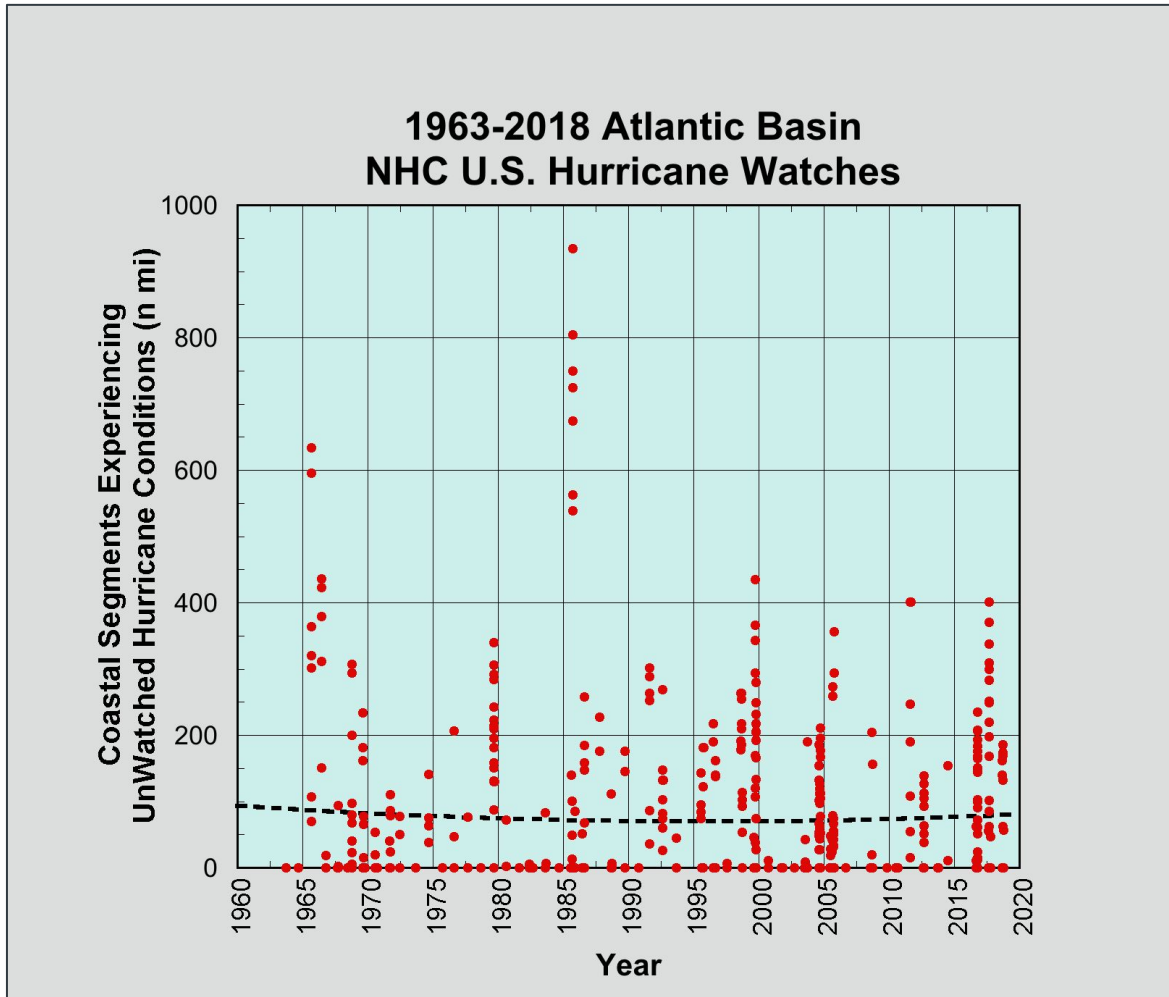


Franklin and DeMaria



Is it possible to get hurricane-force winds and not be in a Hurricane Watch or Warning?

Yes, but Hurricane Warnings are fairly effective at communicating where there's a risk of hurricane-force winds.
We could be more generous with issuing Hurricane Watches

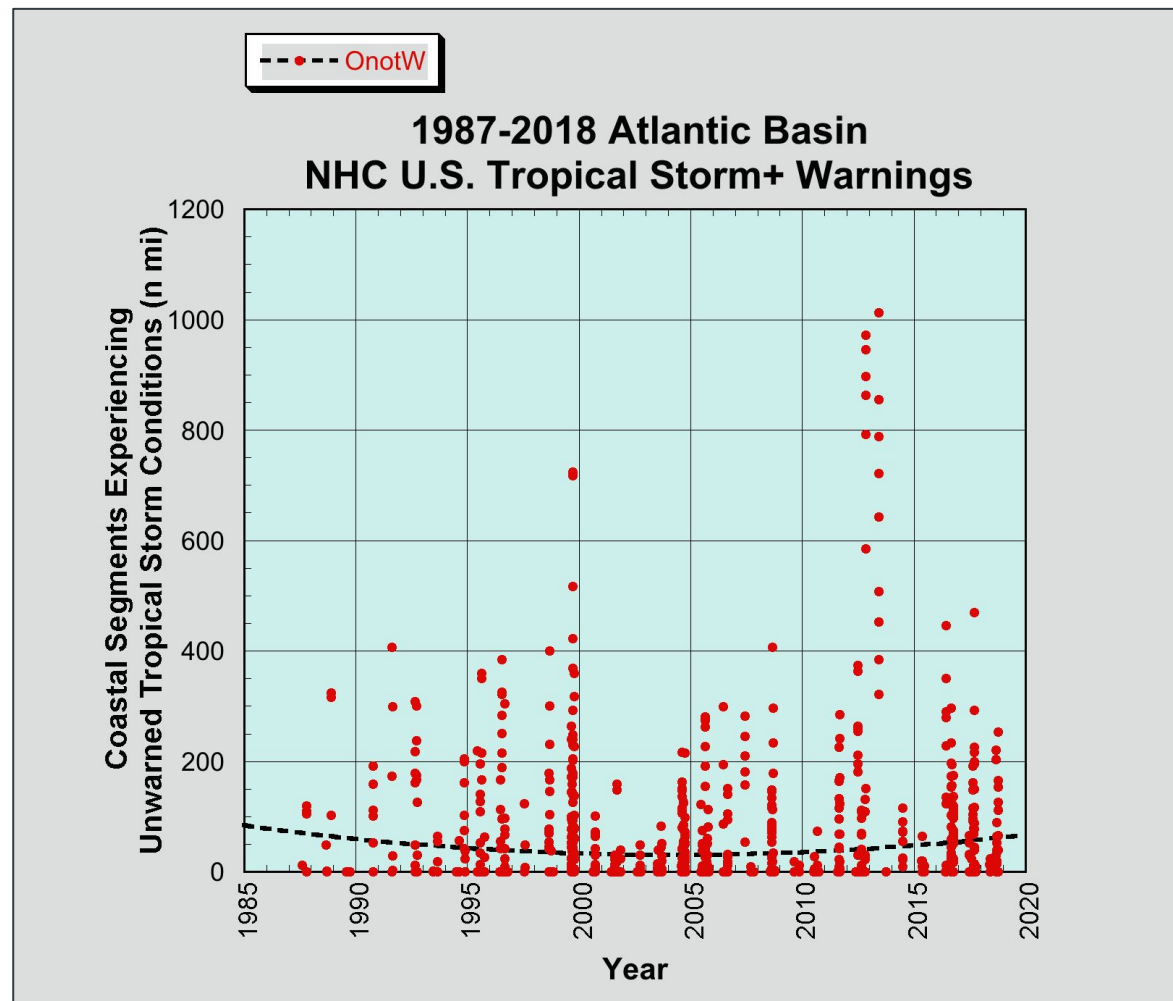
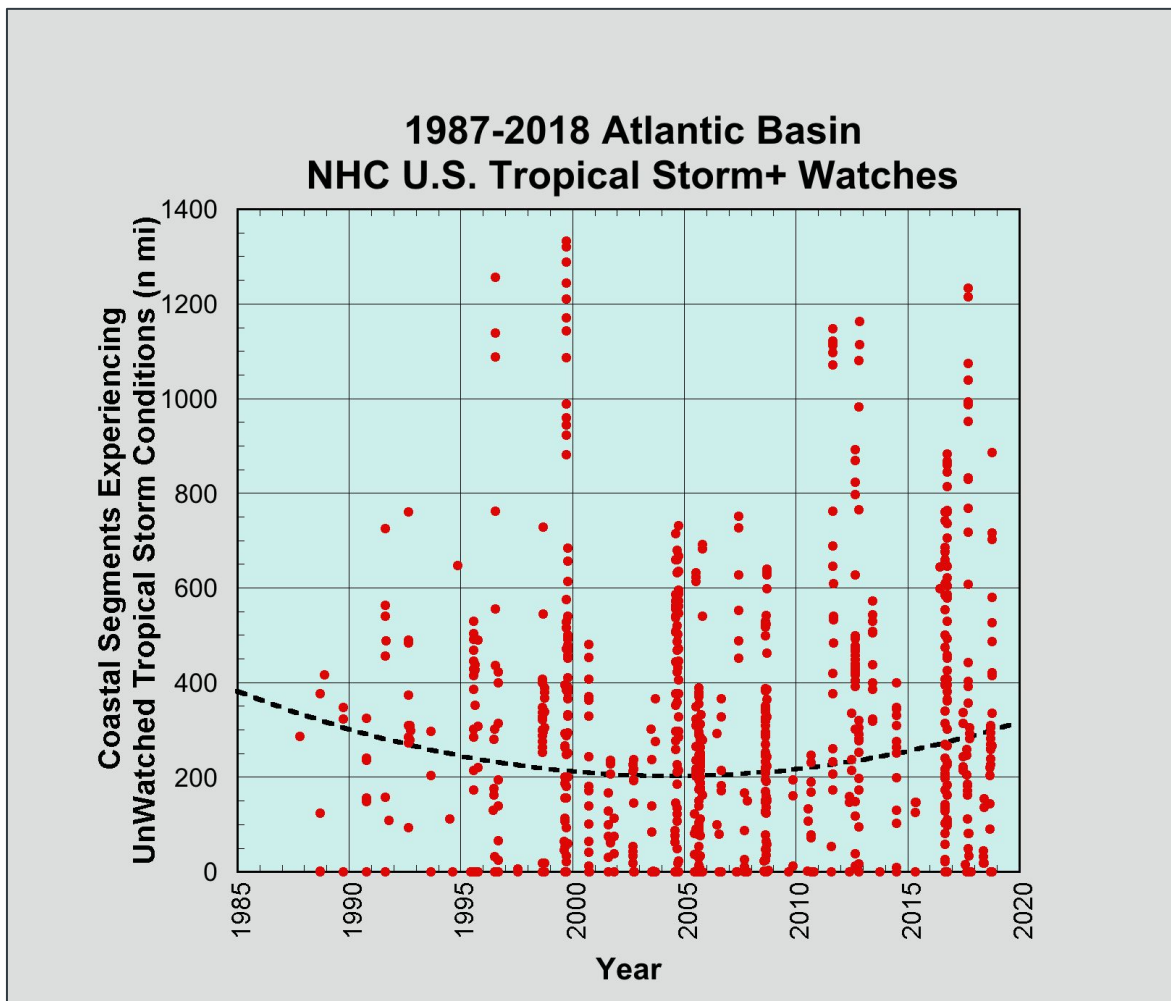


Franklin and DeMaria



Is it possible to get at least tropical-storm-force winds and not be in any kind of watch or warning?

Yes, but we (and society) have a higher risk tolerance for missing lower-end tropical storm events. We could still be more generous in issuing Tropical Storm Watches and Warnings



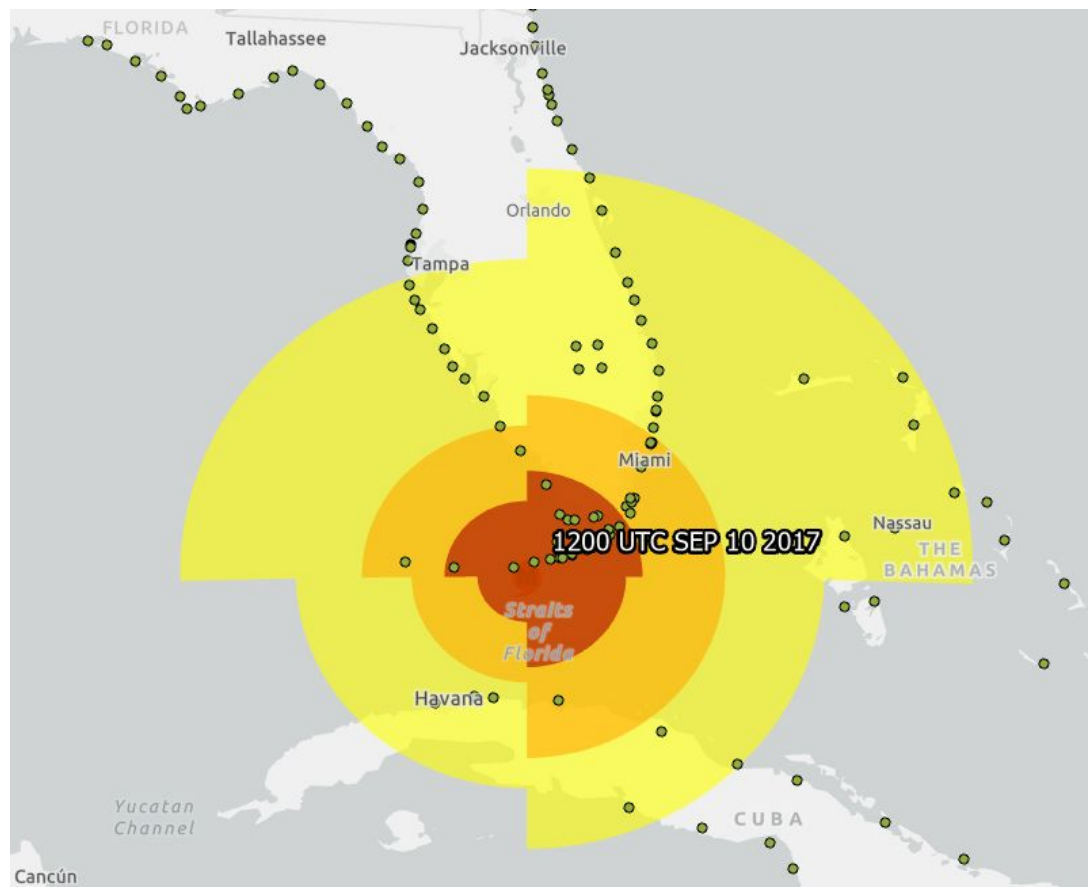
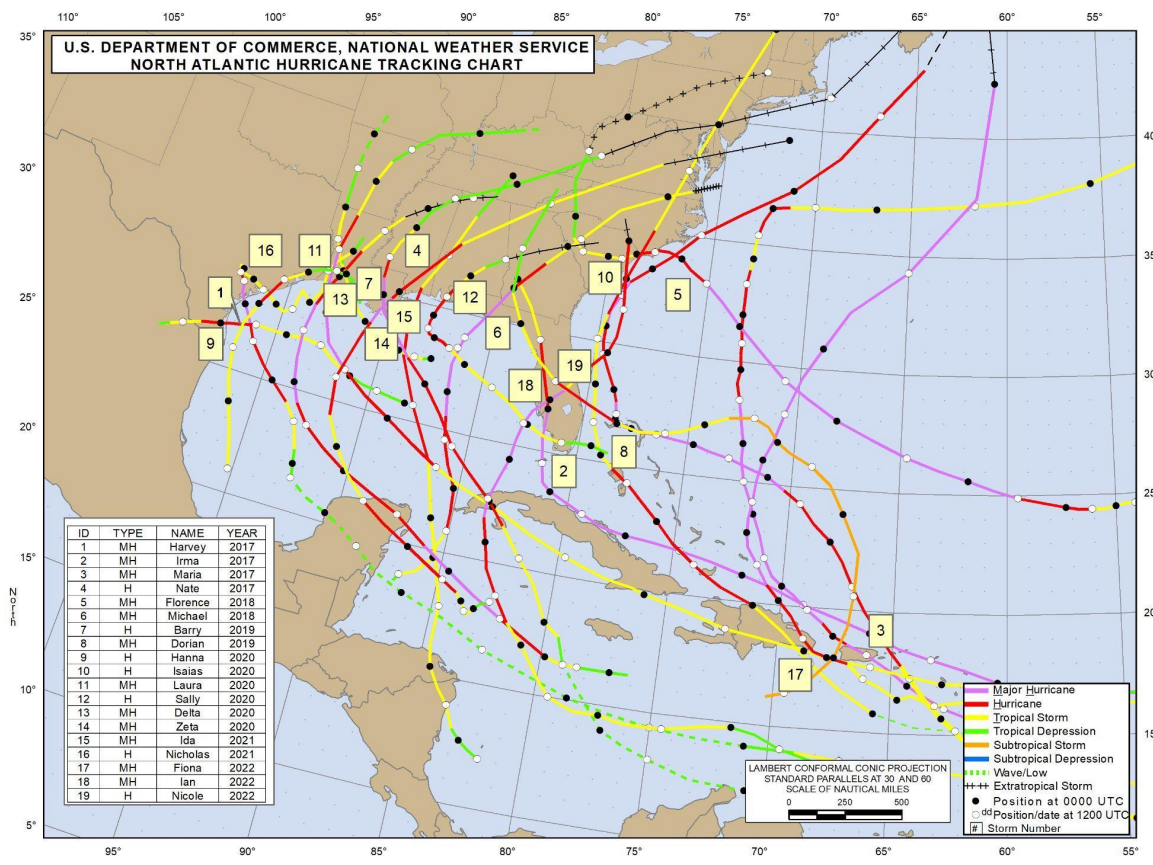
Franklin and DeMaria



US Watch/Warning Verification

19 U.S. landfalling tropical cyclones in the Atlantic from 2017-2022 (including Puerto Rico and US Virgin Islands)

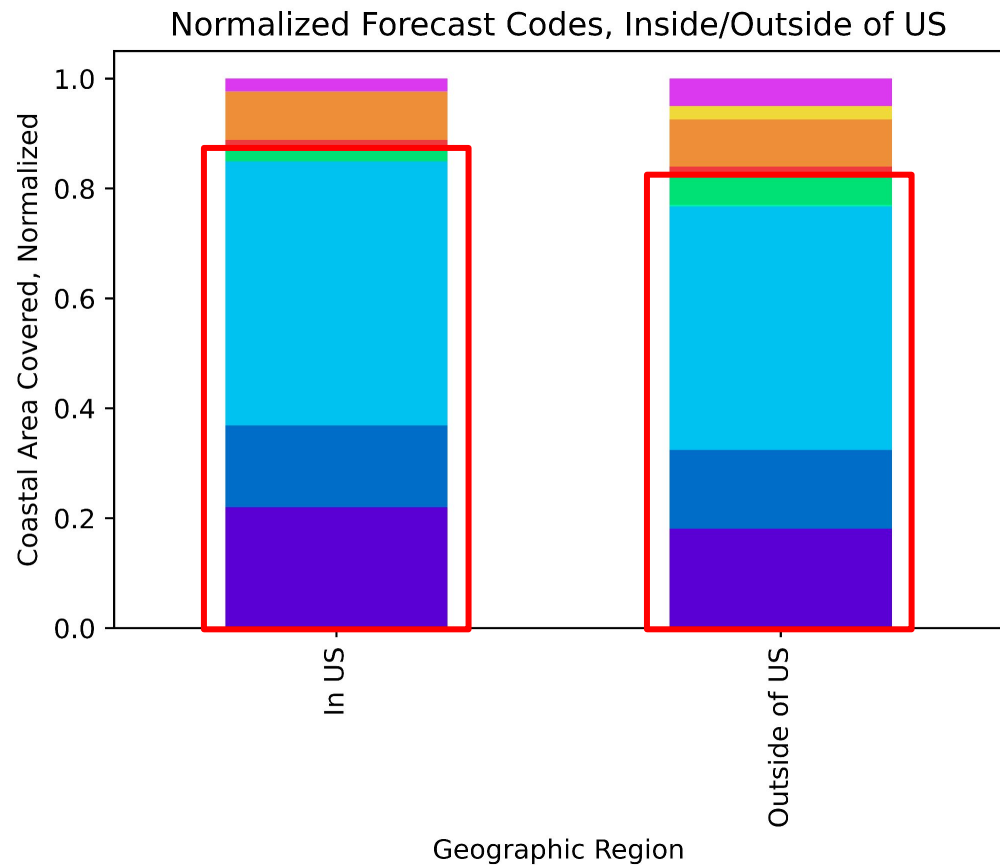
- Code assigned to each segment between coastal breakpoints based on “highest” watch/warning issued and what occurred



Crowe et al.

US Watch/Warning Verification (Crowe et al.)

About 85% of coastal breakpoint segments put under a watch or warning end up getting tropical storm or hurricane force winds



- HWG, FC
- HWG, TSFW
- TSWG, FC
- HWA, FC
- TSWA, FC
- HWG, OW
- TSWG, OW
- HWA, OW
- TSWA, OW

These are considered "correct" watches and warnings

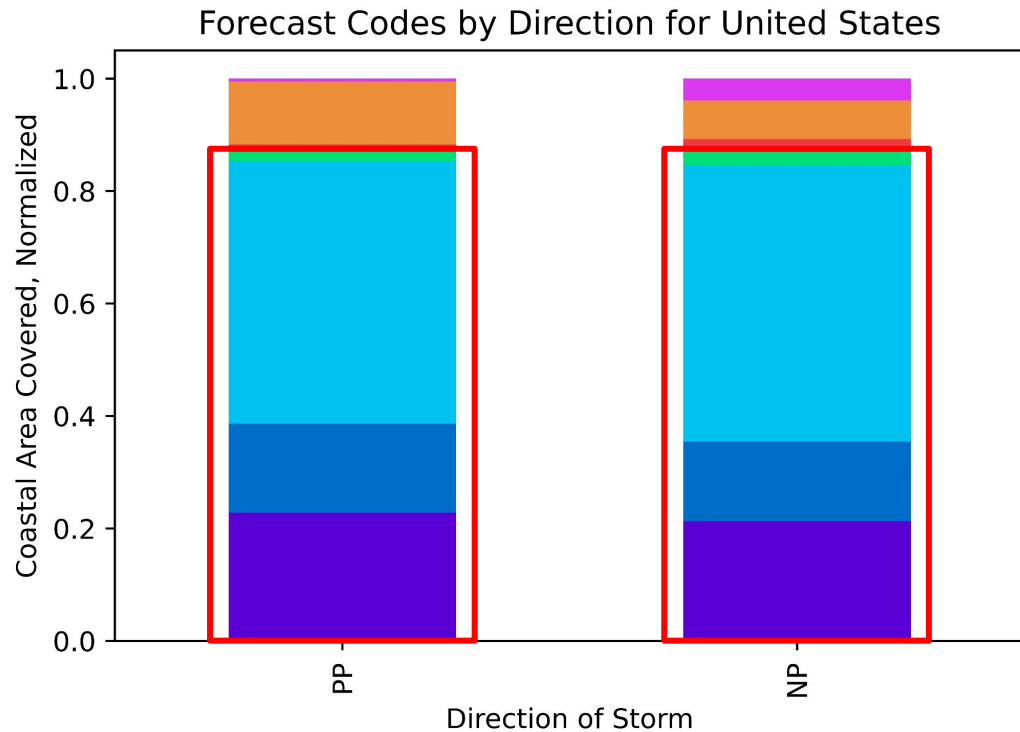
	United States	International
Correctly Covered by a Watch or Warning	87%	82%
"Overwarned"	13%	18%

Crowe et al.



Are watches and warnings less accurate for coast-parallel storms?

No, there is no difference in the accuracy of watches and warnings for coast-parallel and coast-perpendicular storms.



These are considered “correct” watches and warnings

	Parallel	Non-Parallel
Correctly Covered by a Watch or Warning	87%	87%
“Overwarned”	13%	13%

What Do All These Stats Tell Us?

- ***From a national/regional perspective, watches and warnings do a good job communicating overall wind risk from hurricanes and tropical storms***
 - Hurricane and tropical storm conditions occur somewhere within 73% of the hurricane warnings and 87% of the tropical storm+ warnings, respectively, outlined in individual advisories
 - 85% of coastal segments put under a watch or warning end up getting hurricane or tropical storm conditions
- ***But from a local perspective, the probability of experiencing hurricane or tropical storm conditions while in a watch or warning can be relatively low***
 - On average, hurricane conditions occur within 10% of individual Hurricane Watch areas and 30% of individual Hurricane Warning areas
 - On average, tropical storm+ conditions occur within 45% of individual Tropical Storm+ Watch areas and 60% of Tropical Storm+ Warning areas



Acknowledgements:

- **James Franklin (NHC/HFIP) and Dr. Mark DeMaria (CIRA/CSU)**
- **Declan Crowe (NHC Lapenta Intern), John Cangialosi (NHC), and Dr. Lisa Bucci (NHC)**



NHC Next Generation Wind Speed Probability Model - WSP 2.0

National Hurricane Center (NHC) Technology and Science
Branch (TSB)

Cooperative Institute for Research in the Atmosphere
(CIRA)

Mark DeMaria*, Alan Brammer*, Pablo Santos**, Wallace Hogsett**, Matt Onderlinde**

* CIRA ** NHC



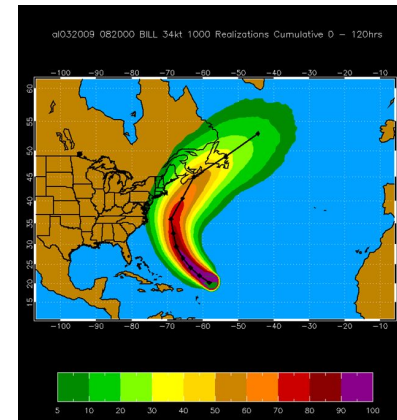
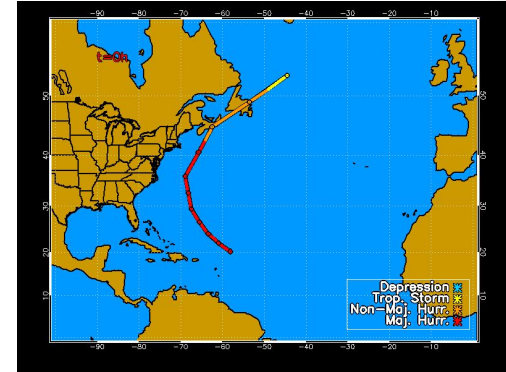
Outline

- Overview of the Legacy Wind Speed Probability Model
- The 2D Wind Tropical Cyclone Forecast Advisory Message (WTCM)
- Proposed new WTCM-Based WSP Model (WSP 2.0)
- New Wind Speed Probability Products
 - Probability of Major Hurricane Force Winds
 - Exceedance Charts
- Operational Transition Plan



NHC Legacy WSP Model

- Operational since 2006
- Monte Carlo model with 1000 ensembles
- Resolution: 0.5 Degrees. Nominal ~ 50 km
- Track and intensity ensembles based on previous 5-year NHC/CPHC errors
 - Weak dependence of track errors on dynamical model track spread
- Wind structure perturbations based on radii-CLIPER errors
 - Does not include TCM forecast radii
- Suite of text and graphical products
 - 34, 50, 64 kt wind probabilities 0-120 h
 - Time of arrival of 34 kt winds
 - Earliest reasonable and most likely





NHC Legacy WSP Model

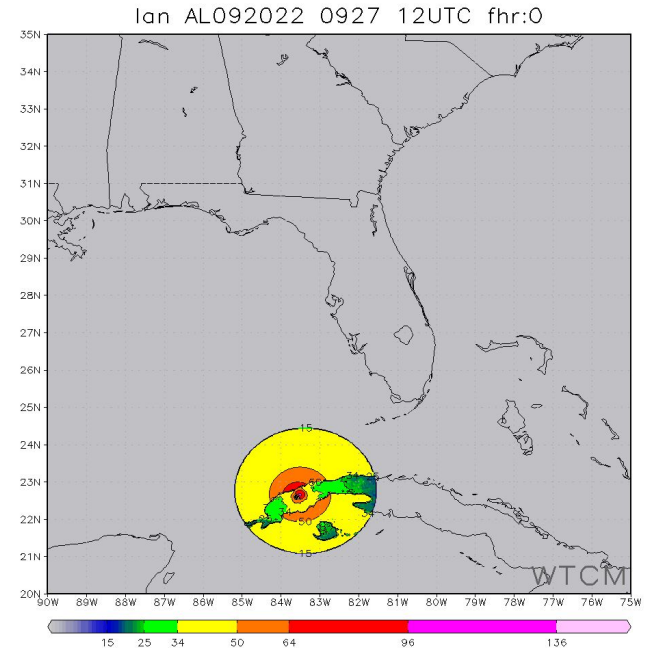
- Changes since 2006
 - Annual updates to track/intensity error distributions
 - 2011-2018: Adjustments to track interpolation, land reduction
 - 2010: Track uncertainty function of track model spread
 - 2018: Time of arrival of 34 kt wind products
 - 2020: NHC forecast radii input added. Removed mid-season due to time continuity issues.
 - 2020: 7-day version developed, running internally at NHC
 - 2021-23 - Land database updated, changes to intensity extrapolation
- Run by NCO on WCOSS
 - Early run: Initiated 58 min before advisory time (Internal NWS distribution)
 - Final run: Initiated 2 min after advisory time (Internal and public distribution)
- Run by NHC on local servers
 - Preliminary graphics for NHC web page
 - Version for text product and time of arrival





The WTCM

- Full 2D surface wind field derived from NHC/CPHC official forecast advisory message (TCM).
- Enhanced version of the wind model used in the Legacy WSP. Hence called WTCM.
- TCM radii fitted to generalized Rankine vortex + wavenumber 1 asymmetry
- Wind reduction over land uses surface layer model with 16 land surface types





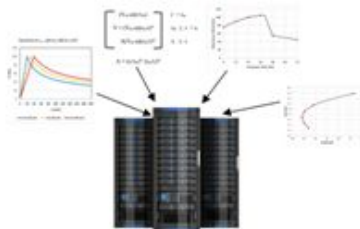
The WTCM - Algorithm

NHC Forecast Points - Position/MaxW/Radii

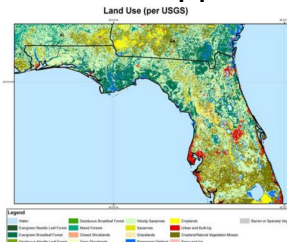


15% radii reduction

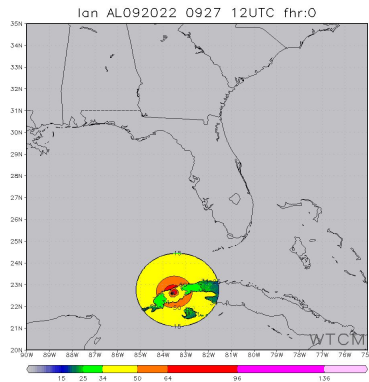
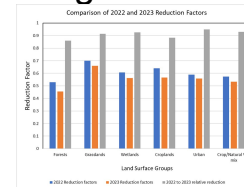
Modified Rankine vortex/2-D wind computed



Surface roughness reduction applied



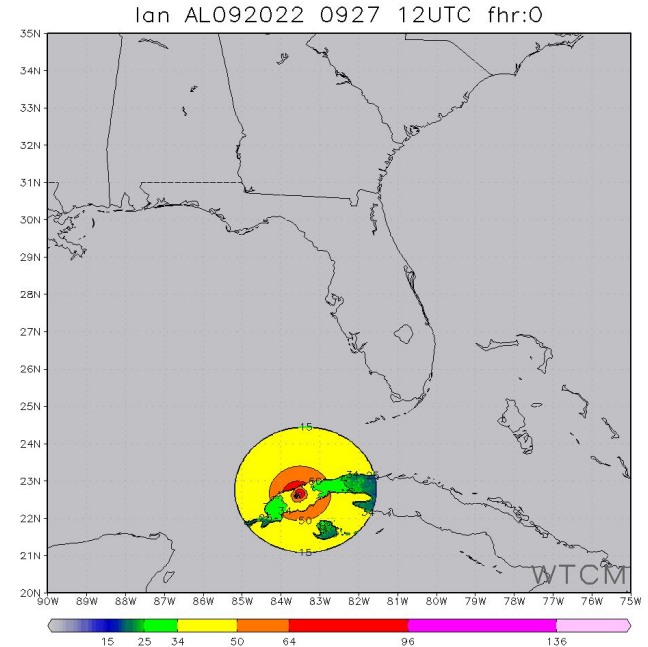
Sfc roughness tuned to give zero bias for training data





The WTCM

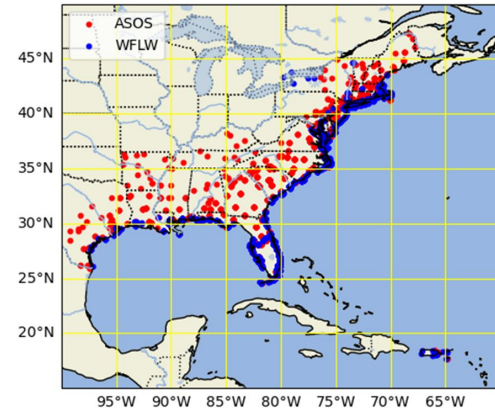
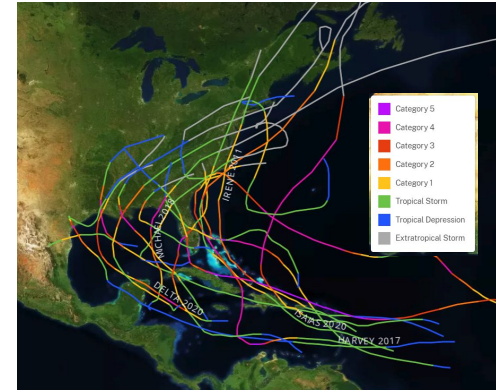
- Calibrated with ASOS and WeatherFlow data from U.S. landfalling hurricanes since 2011
- 1 km horizontal resolution, 1 hour temporal resolution
- Run in real time since 2020 for evaluation and feedback, used in NCEP and WFO grids
- Upcoming improvements include:
 - Adding gust parameterization
 - Adding elevation adjustments
 - Update land-surface database
- POCs: M. DeMaria, A. Brammer, K. Musgrave, L. Lu (JTTI+HFIP support), P. Santos, M. Onderlinde (NHC)





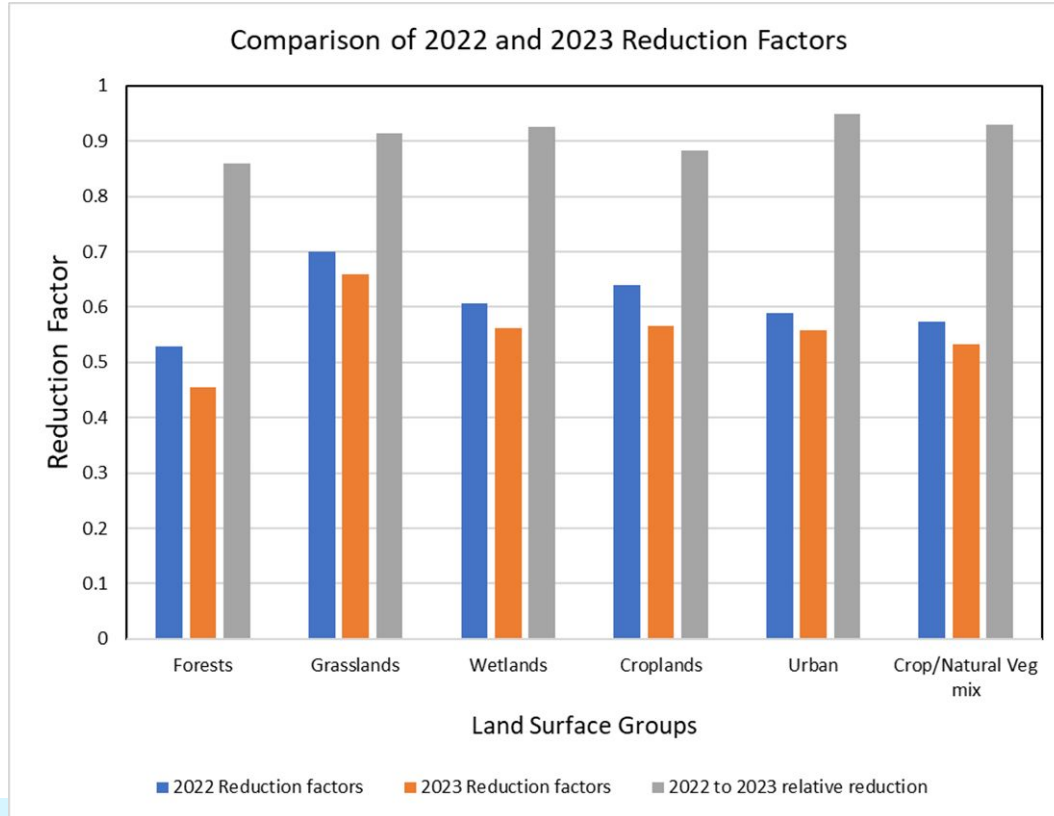
The WTCM - Validation/Calibration

- Run WTCM model with best track input, 15 min time step, 1 km grid spacing
- 22 recent landfalling TC
 - 2011 Irene
 - 2016 Hermine, Matthew
 - 2017 Harvey, Irma
 - 2018 Florence, Michael
 - 2019 Dorian
 - 2020 Hanna, Isaias, Laura, Sally, Delta, Zeta
 - 2021 Henri, Ida
 - 2022 Fiona, Ian, Nicole
 - 2023 Idalia, Lee, Ophelia
- Match model forecasts to WeatherFlow and ASOS observations
- 324,000 15 min observations within 500 km of TC centers
- Adjust model surface roughness length for each land surface type to minimize the difference between model winds and observations





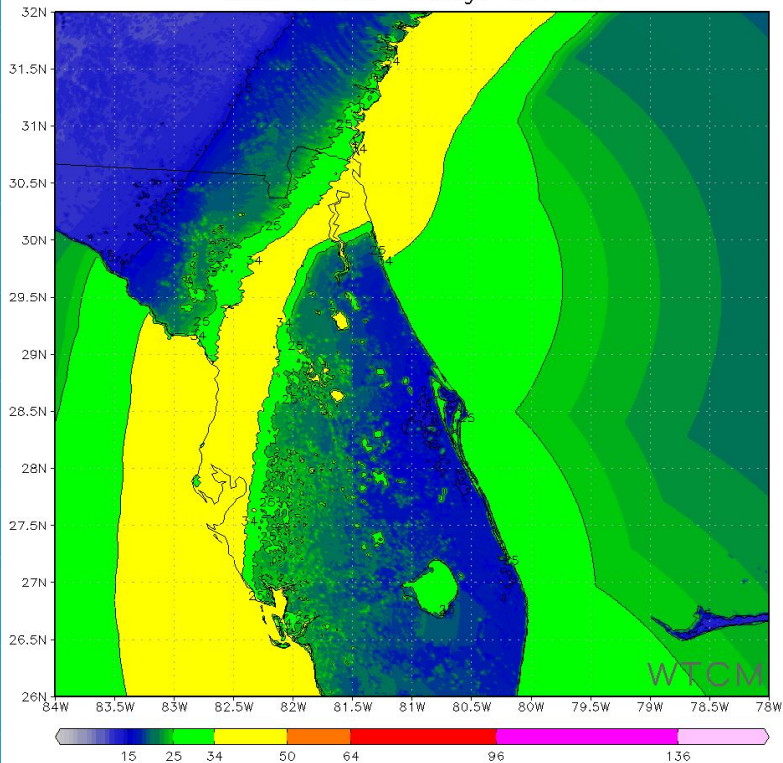
Wind Reduction Factors - 2022/2023



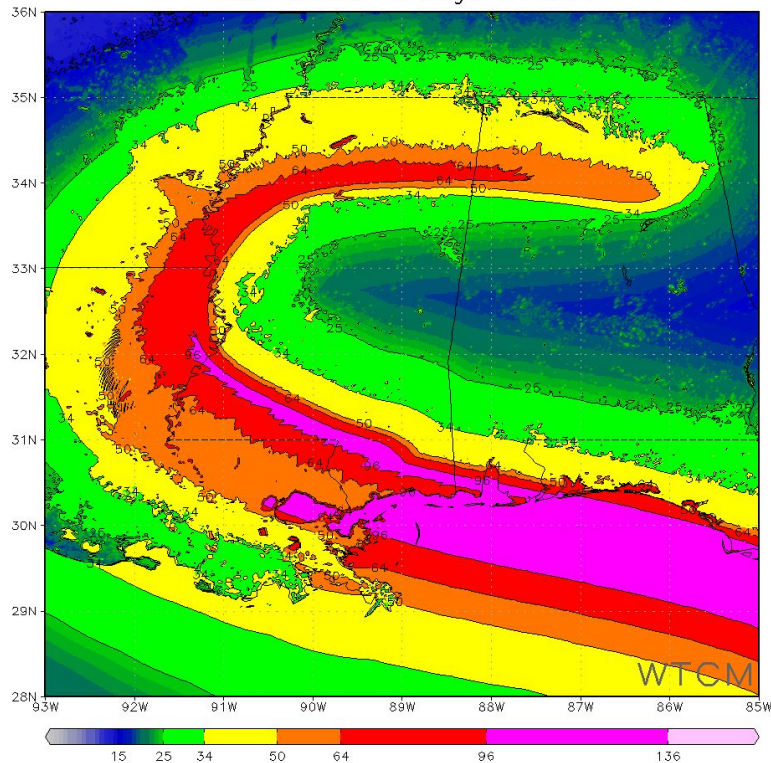


Sample Output for Elsa (L) and Test Case (R)

ELSA AL052021 0704 12UTC
Wind Swath Through fhr:120



CTEST AL842022 0426 12UTC
Wind Swath Through fhr:120



NHC Next Generation WSP 2.0



What we are currently working on

- 1000 WTCM ensemble runs with complete surface wind fields
 - Legacy WSP model estimates wind radii for each ensemble but not full wind field
 - Detailed land surface information. Legacy does not account for land friction on 2D wind field.
 - Easier generation of new products (Exceedances, Probability of > 96 kts, etc).
- Testing with 5 km resolutions in computational grid
 - Legacy WSP uses 50 km computational grid



NHC Next Generation WSP 2.0



What comes next in the development

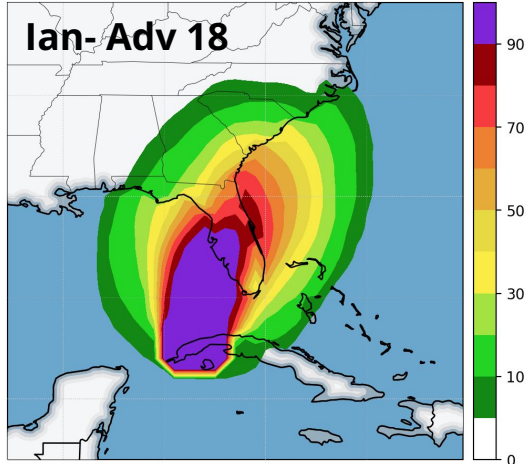
- New method for radii perturbations in the work that uses NHC/CPHC forecast input
 - Replacing the radii-CLIPER method that perturbs the TCM Radii forecasts in legacy
- Testing adding more situationally dependent information
 - Maybe replacing GPCE input with ensemble input
 - Replacing climatology based error distributions with new machine learning method for tracks and intensities
- Validation/Calibration
- Coordinating w/ P-Surge group to increase consistency of wind forcing in WSP and P-Surge
- Work is underway to add a gust parameterization and elevation adjustments to WTCM
 - This could be added to a future version of WSP including Wind Gust Probabilities



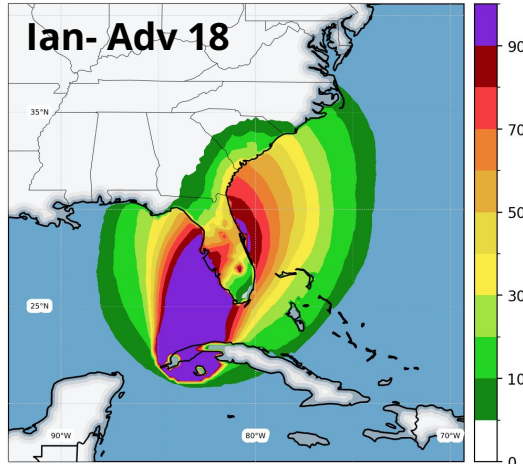
NHC Next Generation WSP 2.0

- Adding new products to the output to include:
 - Probability of exceeding 96 kts (in addition to legacy 34/50/64 kts and TOA/TOD products)
 - Exceedance charts
 - Potentially Adding Wind Gust Probability Data since it will be part of WTCM

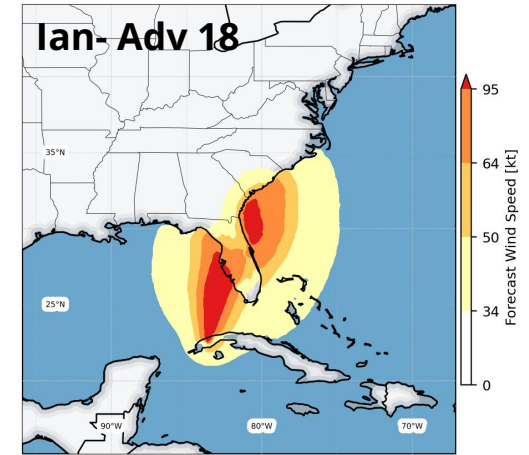
Prob > 34 kts - Legacy



Prob > 34 kts - WSP 2.0



10% Exceedance Map

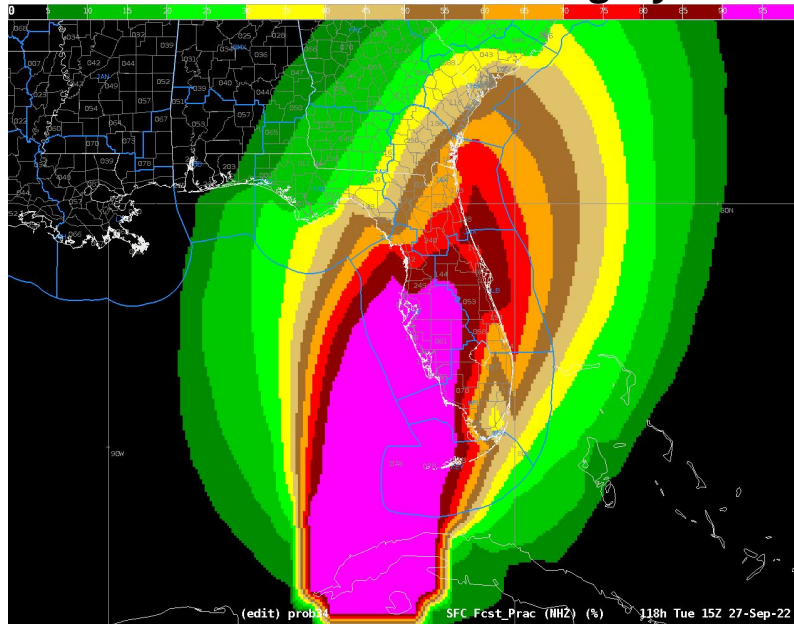


NHC Next Generation WSP 2.0

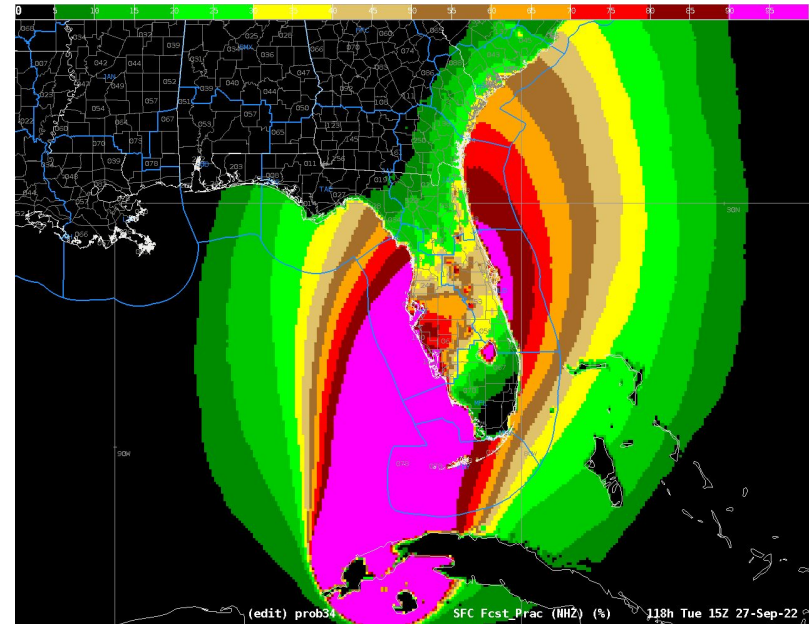
Ian Adv 18



Prob of 34 kts Winds - Legacy



Prob of 34 kts Winds - WSP 2.0

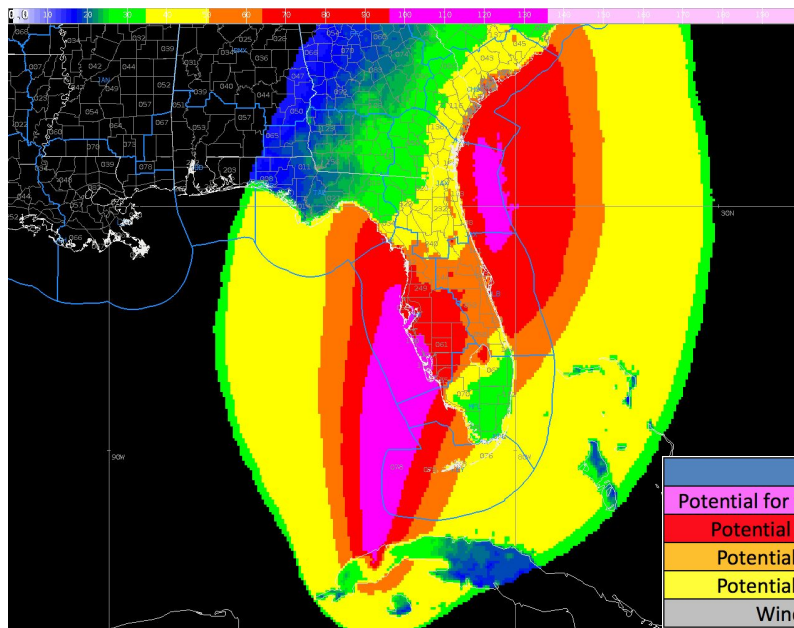


NHC Next Generation WSP 2.0

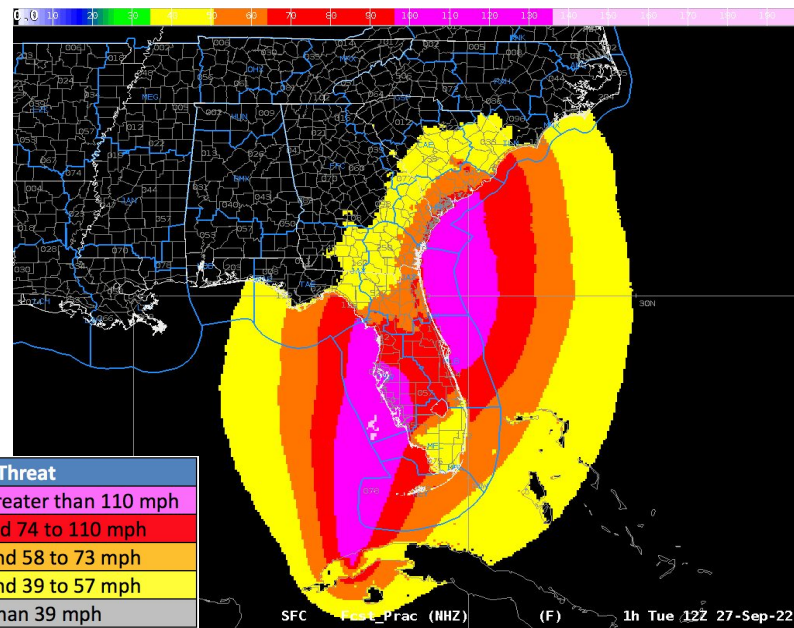


Ian Adv 18

Winds with a 1/10 chance of exceedance



Combined Wind Threat with a 1/10 chance of exceedance



Wind Threat
Potential for wind greater than 110 mph
Potential for wind 74 to 110 mph
Potential for wind 58 to 73 mph
Potential for wind 39 to 57 mph
Wind less than 39 mph





WSP 2.0 Model - Status

- Observations and issues based on development/testing so far
 - Large differences from legacy model, especially over land
 - Overall inland probabilities much smaller than legacy model inland. This was expected.
 - How much detail to include?
 - High resolution of new model results in strong gradients along land/water interfaces.
 - Time of Arrival graphics. Higher resolution/strong gradients along land water interfaces make it a challenge to replicate legacy graphics. Working on sorting out alternatives.
- Impact on downstream applications
 - Public and Marine Forecasts, Wind Watch/Warning Applications, Hurricane Threat and Impact Graphics, Messaging in General
 - Recalibration needed after new model development is finalized
 - Social science being incorporated to help address impacts of new model on downstream applications and how to best use it on messaging



NHC WTCM/WSP 2.0

Transition to Ops

- WTCM
 - 2024 - Internally
 - 2025 - Operational
- WTC -> WSP 2.0
 - Internally while development continues 2024 and 2025
 - Aiming for experimental implementation in 2026





NHC WTCM/WSP 2.0

- Contacts

- Mark DeMaria, Alan Brammer, Kate Musgrave - CIRA/CSU
- Pablo Santos, Matt Onderlinde, Wallace Hogsett - NHC/TSB

- Other Contributors

- Lixin Lu, Jonathan Rogers, Greg DeMaria - CIRA/CSU
- Olivia Ostwald - NCEP/EMC
- Samantha Camposano- NCEP/NHC