
UNITED STATES DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION


# Ocean Observations

## Better Forecasts, Better Decisions

Ken Graham
NOAA/National Weather Service
National Hurricane Center

DBCP-37: Thirty Seventh Session of the Data Buoy Cooperative Panel

# Observation History

- Looking outside – Long history
- 1644 systematic weather observations in North America
- Hurricane movement from Philadelphia to Boston documented by Benjamin Franklin in 1743
- 1776-1800 volunteer weather observers. By 1891, there were 2,000 stations
- 1814 the order was given to collect weather observations at Army posts

# Observation History

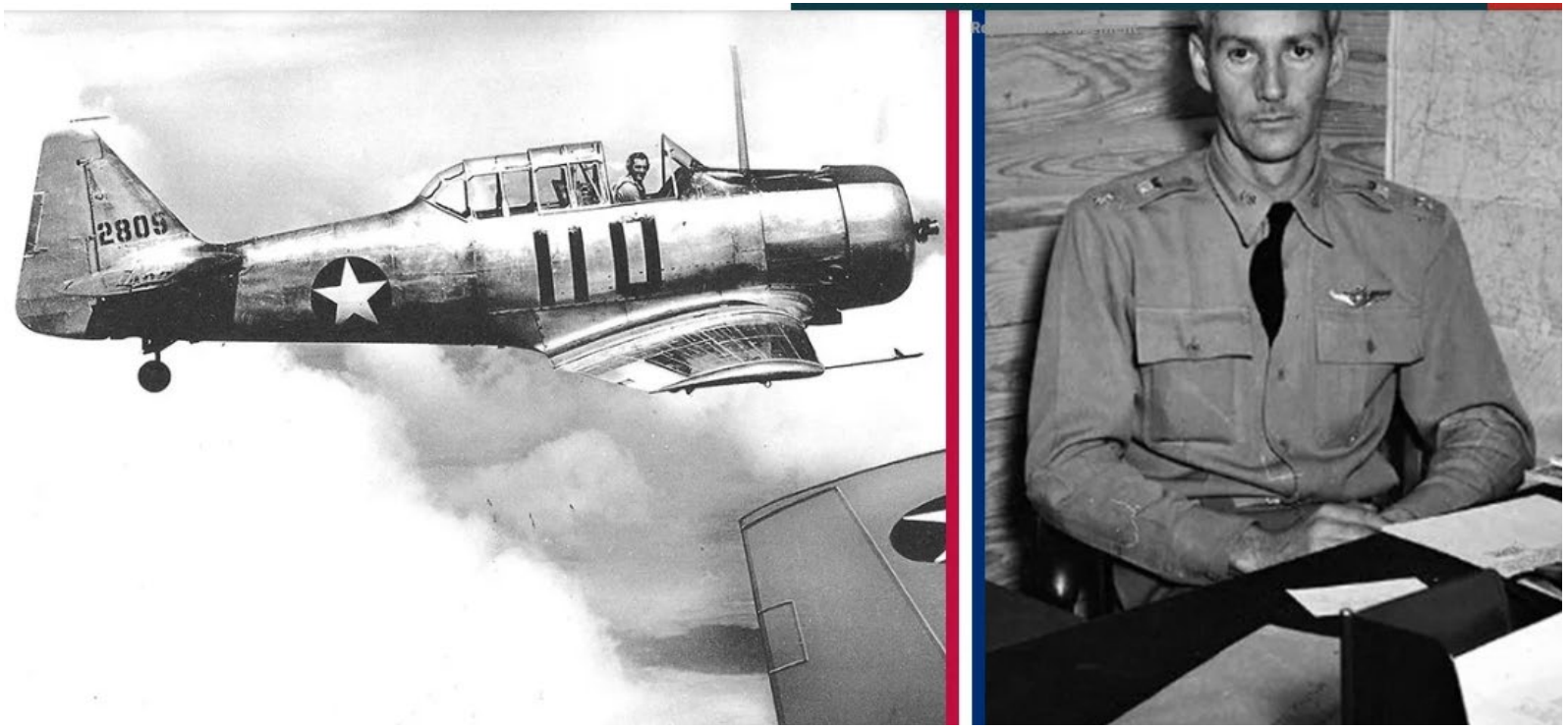
- 1885 marked the first weather balloon and U.S. Weather Bureau began to use weather kites in 1898 then balloons in 1909.
- 1926, U.S. Navy and Weather Bureau observations from aircraft. Aviation observations at sea, 1927. U.S. Coast Guard ship weather observations 1939.
- Hurricane Hunters start on July 17, 1943.
- First weather radar operations in 1954 by the U.S. Army. First Weather Bureau radar in Miami, 1959.
- First weather satellite, April 1, 1960.

# Observation History

- Moored weather buoys since the 1950s
- Drifting weather buoys since 1979

# Hurricane Hunters

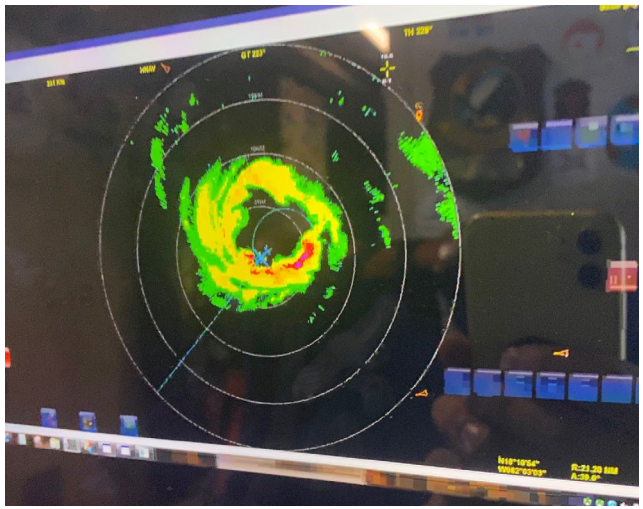
## First Flight in 1943



# Hurricane Hunters


**Carla was the first tropical cyclone to have its entire life history recorded by research flights. September 1961**

# Hurricane Hunters



NOAA OMAO Aircraft Operations Center (AOC) Hurricane Hunters fly the P3 and G-IV, with the US Air Force Reserve flying the WC-130J, all for hurricane surveillance and in-situ data reconnaissance

# Hurricane Hunters

NOAA LCDR Waddington and CAPT Twining piloting a G-IV hurricane surveillance mission

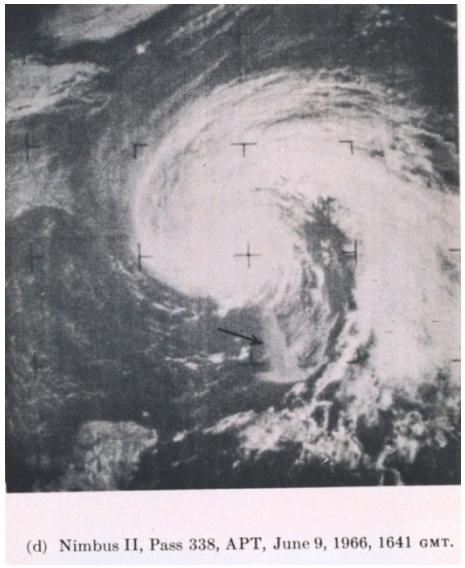
# Forecast Accuracy

## Dropsondes

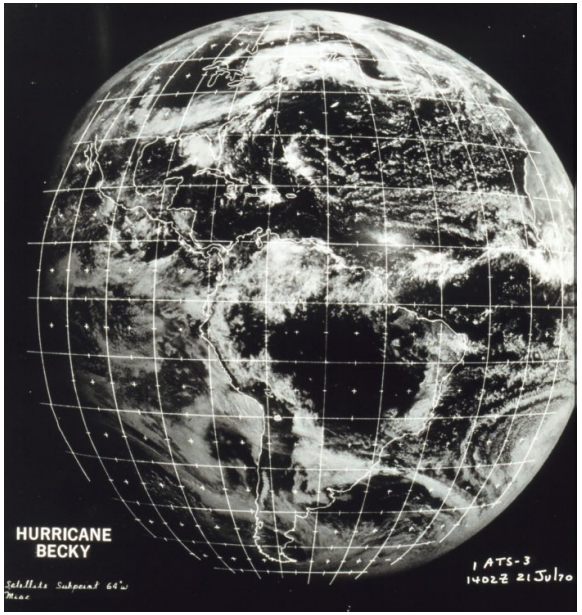
- Developed in conjunction with the NOAA Gulfstream-IV jet aircraft. First systematic use for intensity was in 1998's Hurricane Bonnie.
- 1772 dropsondes deployed during the 2020 hurricane season
- Combined with vital radiosonde balloon releases at WFOs (and many non-synoptic releases in 2020)
- Data to help model accuracy

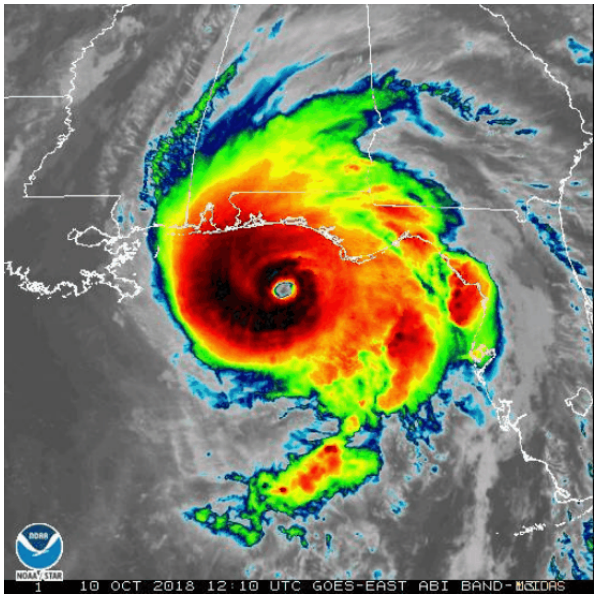
# Forecast Accuracy

## Evolving Satellite data



(d) Nimbus II, Pass 338, APT, June 9, 1966, 1641 GMT.

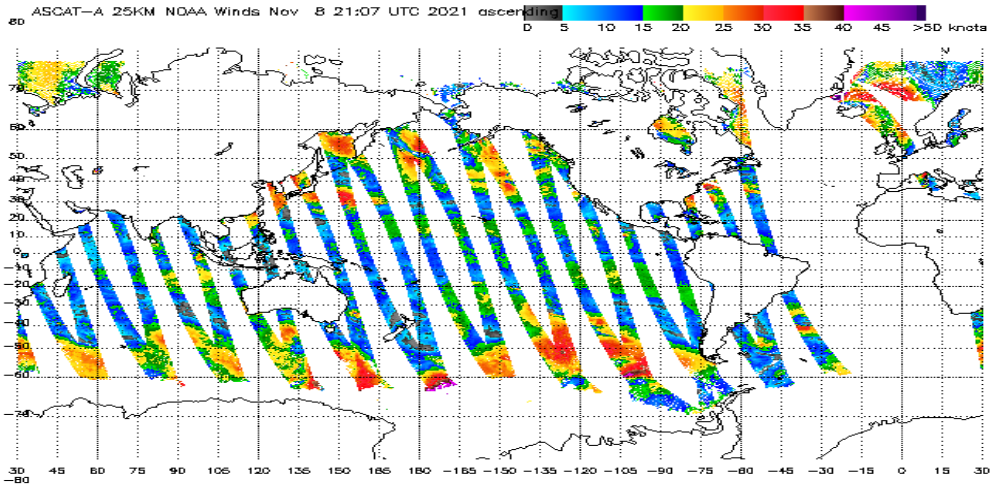


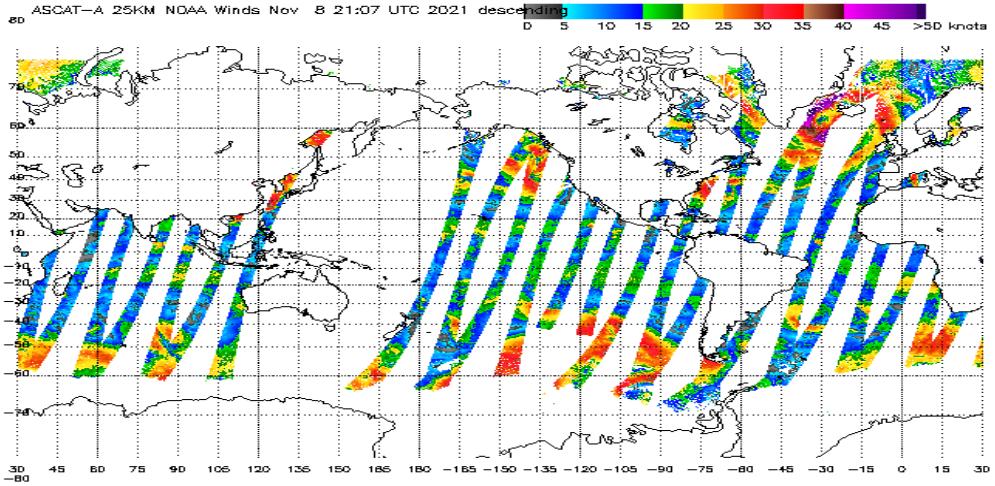
# Forecast Accuracy

**Evolving Satellite data**

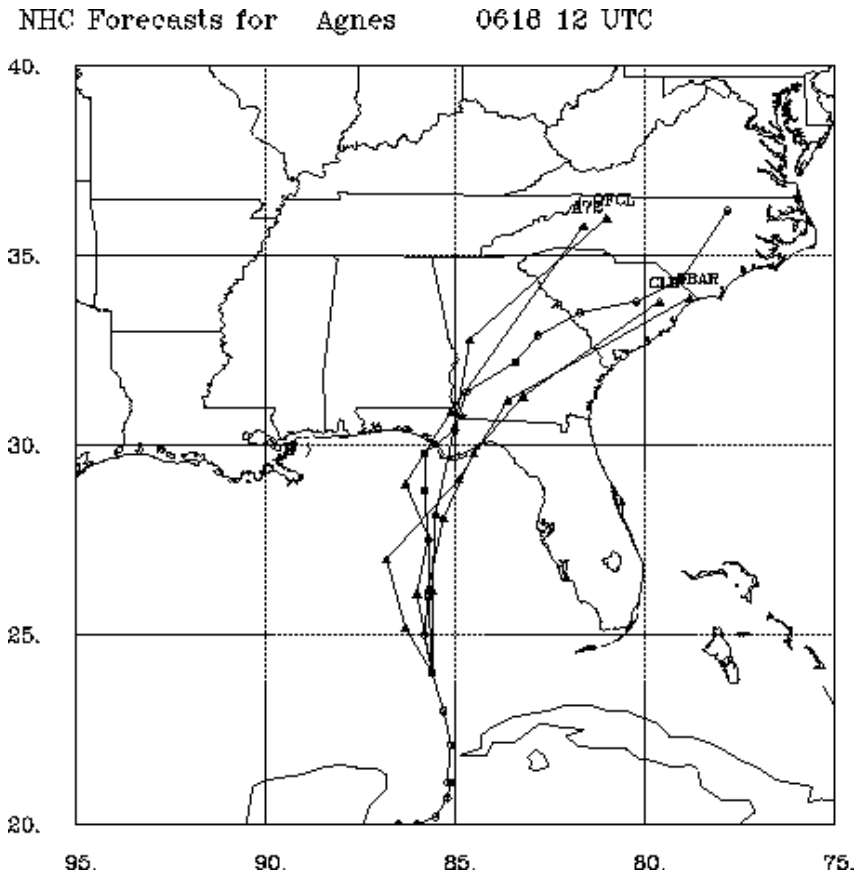
Ascending Pass




Descending Pass



# Forecast Accuracy

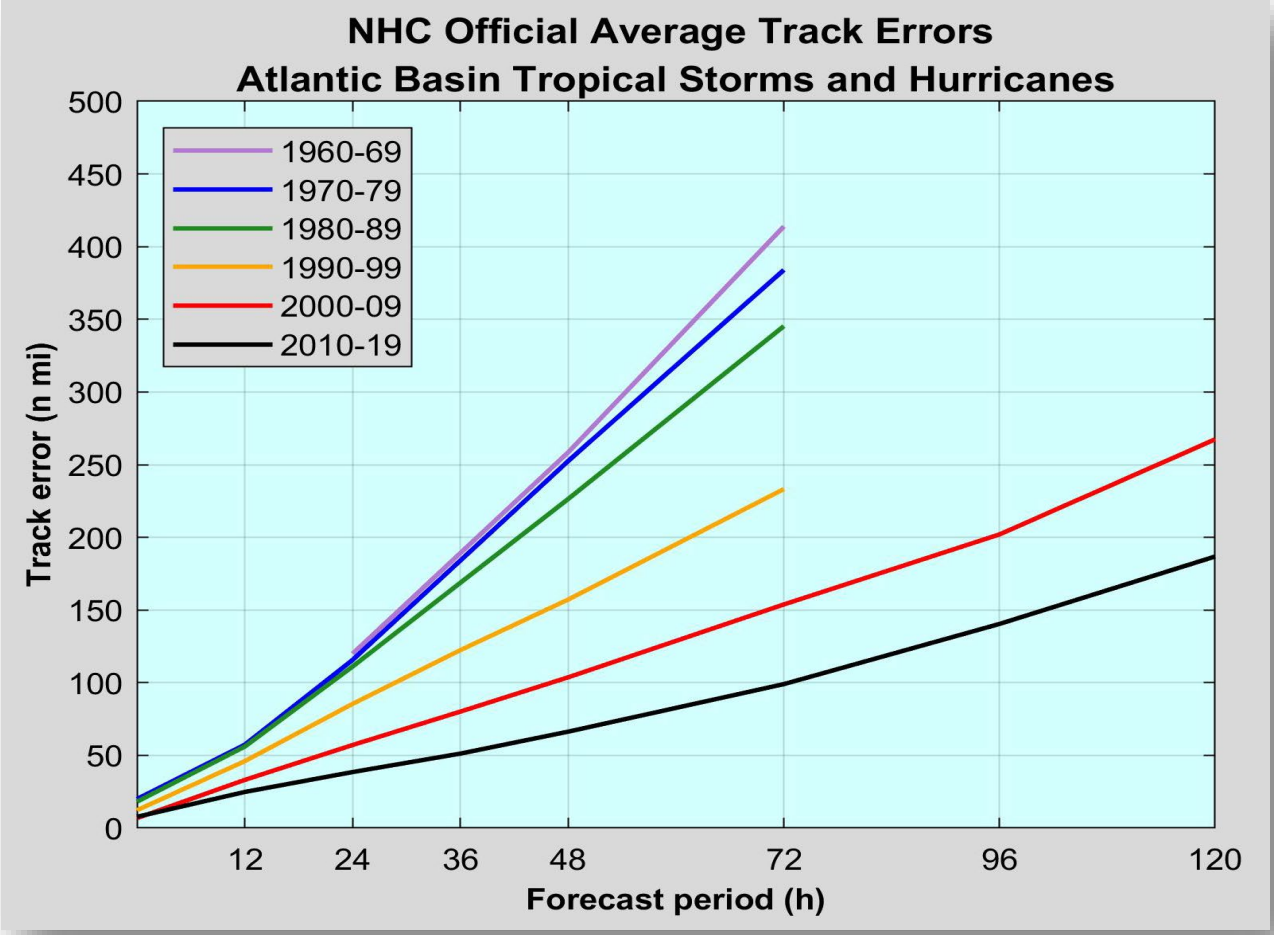



## Forecast Models

*Track Models used for Agnes in 1972:*

***CLIPER – Climatology and Persistence***
***HURRAN – Analog***
***NHC67 – Statistical-Synoptic***
***NHC72 – Statistical-Synoptic***
***SANBAR - Barotropic***

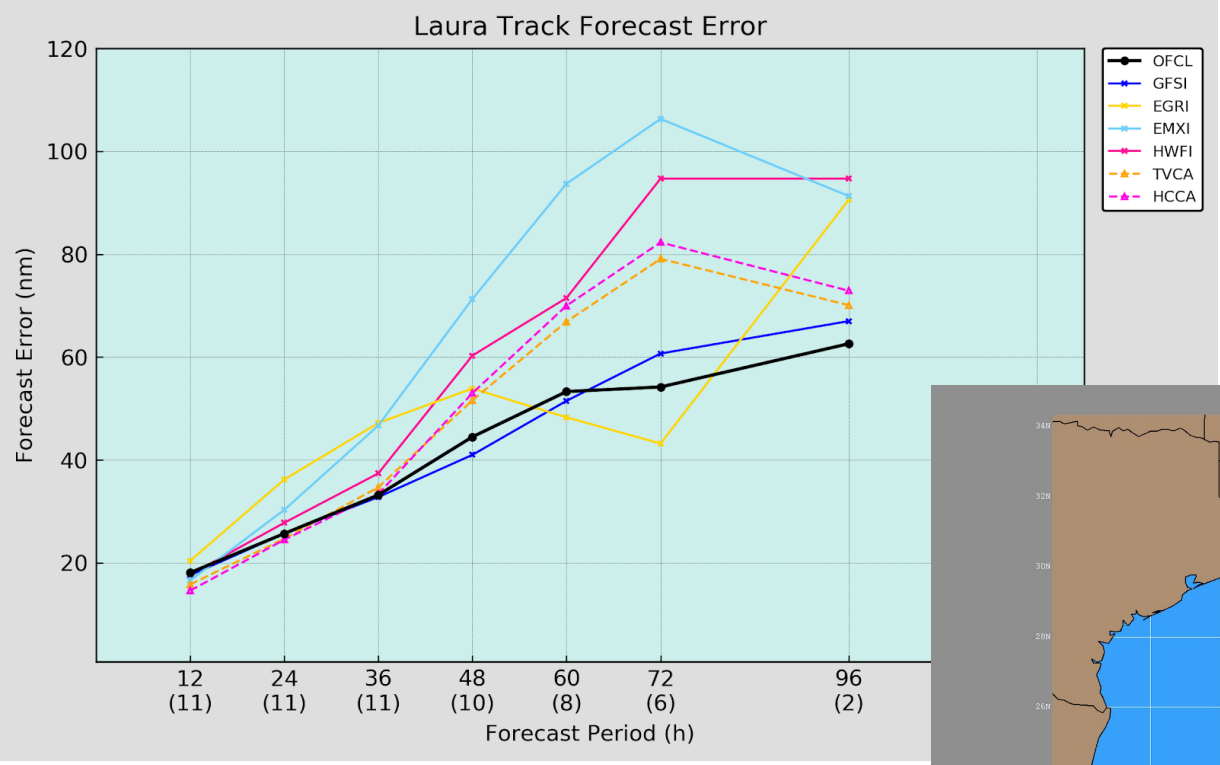
# Forecast Accuracy




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

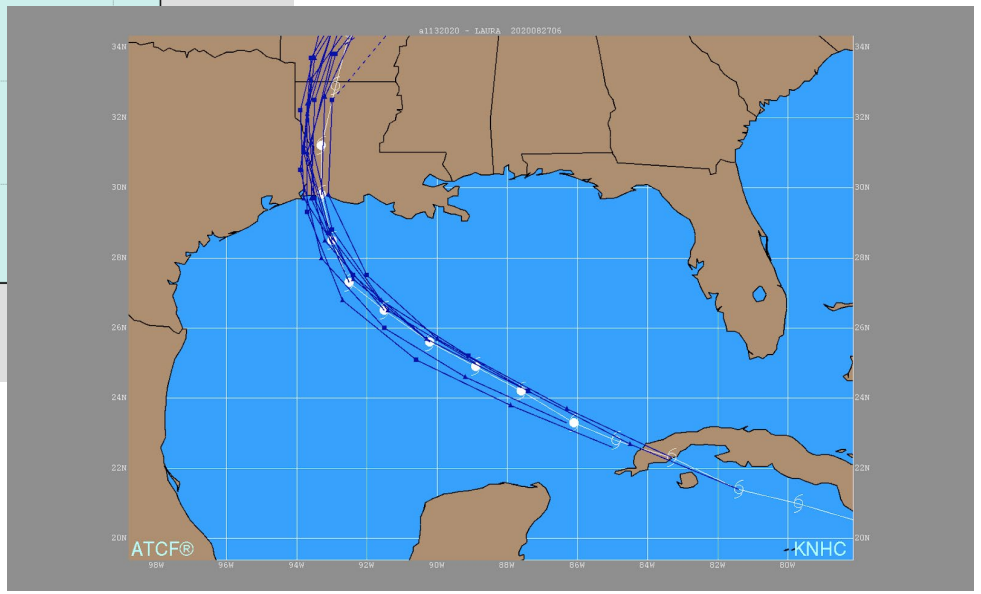
**True scientific success!**

# Forecast Accuracy




## Hurricane Laura

**Not just forecast accuracy, but consistency in NHC forecasts help decision makers**



# Better Observations…

Better Services

Better Decisions

# The First Hurricane Warning
## 11 September 1875

Partes telegráficos de St. Thomas y Puerto-Rico recibidos ayer noche en la Comandancia General de Marina y que el Excelentísimo Sr. Comandante de Marina ha tenido la dignación de comunicarme por conducto de su digno Secretario, anuncian un huracán que se ha originado en el Sur, en las Islas de Barlovento. Yo creo lo más probable que este huracán avance con dirección N.O. [noroeste] y que no llegue á alcanzar la longitud de La Habana, en cuyo caso cruzaría al N.E. [nordeste] de ella y á mucha distancia. Hacia el 13 á más tardar, pudiéramos tal vez sentir muy marcada su lejana influencia.

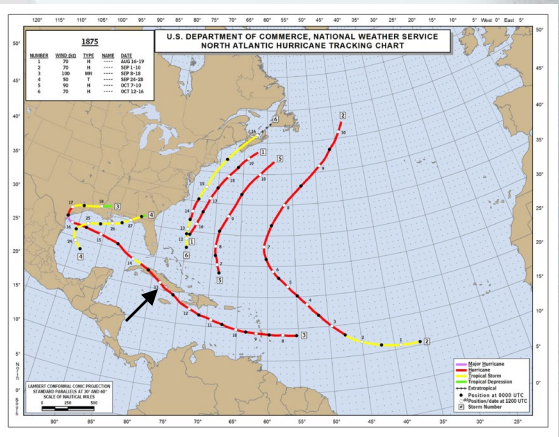
El barómetro, que se había mantenido estos días pasados más alto de lo ordinario, tiene actualmente marcada tendencia á un constante descenso, bien que no rápido. Bueno es que estén advertidos del peligro los capitanes de los buques que tuvieran que hacer rumbo al E. [este] ó al N. [norte]. Con respecto á la navegación al O. [oeste] y en el Golfo [de México] creo que no ofrece peligro por ahora.

Estas no pasan de ser apreciaciones mías, fundadas únicamente en las leyes generales de las tormentas jiratorias (sic.) y en mi corta experiencia de algunos años de observación.

Quedo en remitirle á V. [Usted] las observaciones y tenerle al corriente de las diversas fases del meteoro á medida que vayan estas presentándose. Los datos que hasta ahora tenemos del huracán son insuficientes para fijar con precisión la dirección de su trayectoria.

Soy de V. muy atento y Seguro Servidor quien besa su mano,

Benito Viñes, S. J.
Observatorio del Colegio de Belén. Habana 12 de setiembre de 1875"




***La Voz de Cuba.*** **La Habana, Cuba, September 12, 1875**

# Commencement of Signals on the Sea-Coasts and Lakes

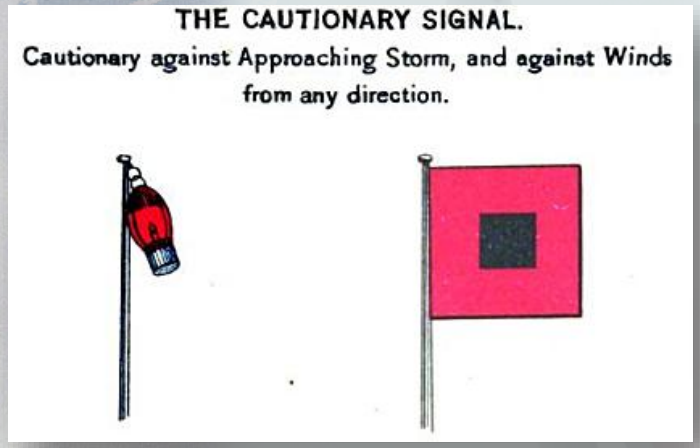
## 24 October 1871

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 whole cost and warrant its extension. It is one of the most difficult and responsible tasks which can fall to the meteorologist, to put his science to the utmost stretch of accurate prevision, (and often it must be done with a very few minutes for deliberation) to decide at what points on the coast the storm-wind will strike with dangerous effect. It is, practically, fatal to the value of his warnings if they are found to be superfluous, since, in that case, they cease to command the attention of seamen. Nor, for like reason, must they be displayed too late; nor yet too early, lest they should interfere with the movements of vessels which might run out of the dangerous vicinity before the storm can reach them. Thus the perplexing questions which spring up at every display of the signals, lend to this part of the service intense interest. No such work had ever been undertaken in this country when the Signal Service was organized, and maritime storm-signalling in other countries had only been as yet rewarded by very moderate success.

General Albert J. Myer

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

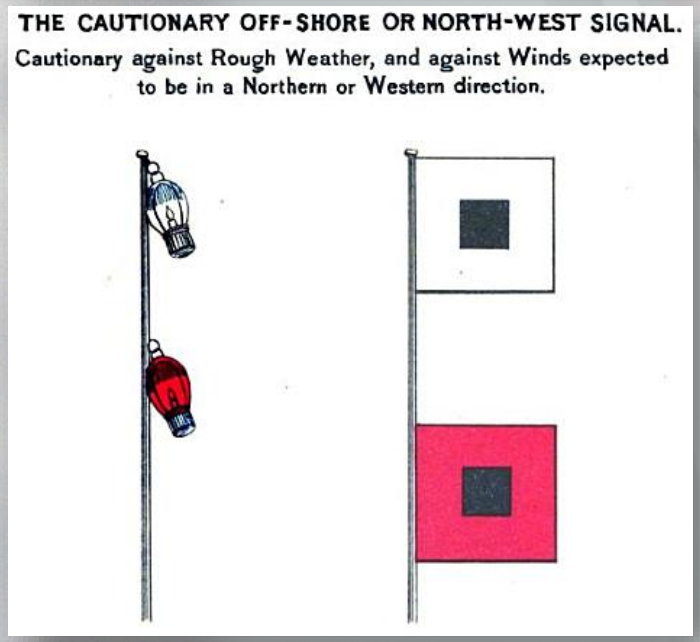
# Cautionary Signals




## 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.




## Cautionary Offshore Signal

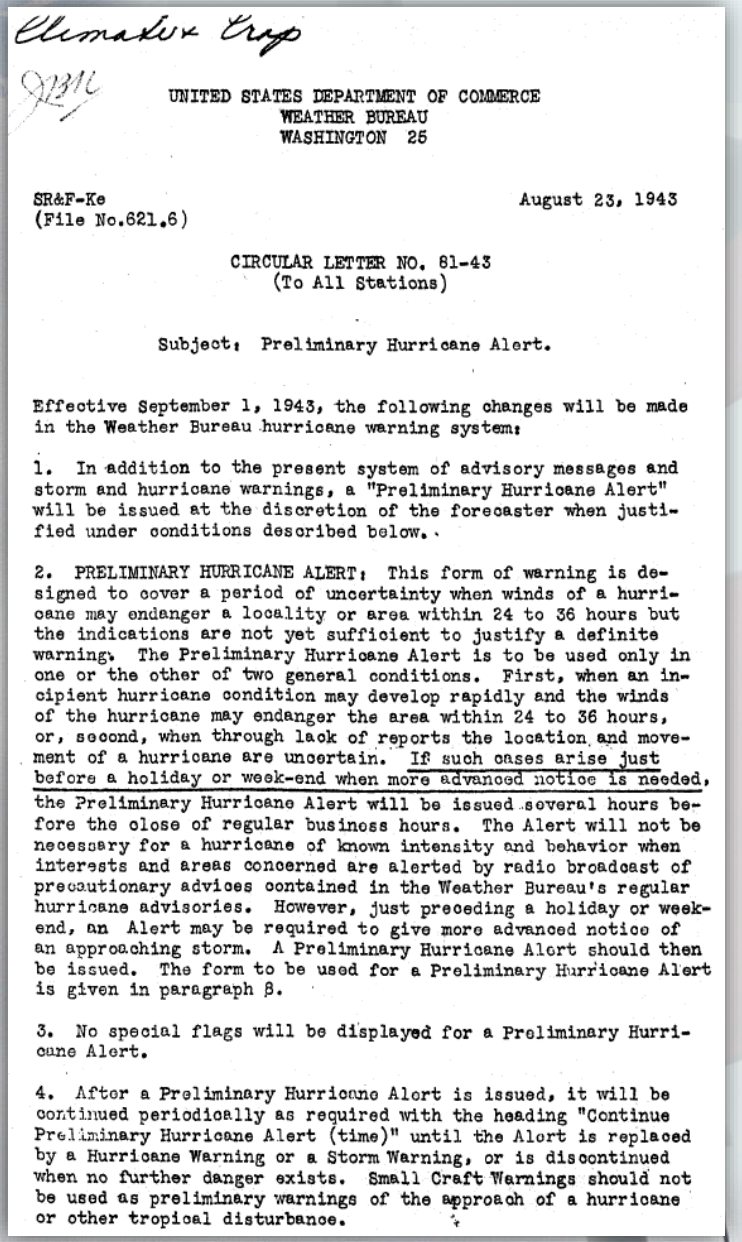
"premonishing off-shore winds, likely to drive vessels out to sea"


The cautionary signal flags as seen in New York harbor.

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

# Preliminary Hurricane Alert

## 1 September 1943



Climatic Data

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
WASHINGTON 25

SR&F-Ke
(File No.621.6)

August 23, 1943

CIRCULAR LETTER NO. 81-43
(To All Stations)

Subject: Preliminary Hurricane Alert.

Effective September 1, 1943, the following changes will be made in the Weather Bureau hurricane warning system:

1. In addition to the present system of advisory messages and storm and hurricane warnings, a "Preliminary Hurricane Alert" will be issued at the discretion of the forecaster when justified under conditions described below.

2. PRELIMINARY HURRICANE ALERT: This form of warning is designed to cover a period of uncertainty when winds of a hurricane may endanger a locality or area within 24 to 36 hours but the indications are not yet sufficient to justify a definite warning. The Preliminary Hurricane Alert is to be used only in one or the other of two general conditions. First, when an incipient hurricane condition may develop rapidly and the winds of the hurricane may endanger the area within 24 to 36 hours, or, second, when through lack of reports the location and movement of a hurricane are uncertain. If such cases arise just before a holiday or week-end when more advanced notice is needed, the Preliminary Hurricane Alert will be issued several hours before the close of regular business hours. The Alert will not be necessary for a hurricane of known intensity and behavior when interests and areas concerned are alerted by radio broadcast of precautionary advices contained in the Weather Bureau's regular hurricane advisories. However, just preceding a holiday or week-end, an Alert may be required to give more advanced notice of an approaching storm. A Preliminary Hurricane Alert should then be issued. The form to be used for a Preliminary Hurricane Alert is given in paragraph 3.

3. No special flags will be displayed for a Preliminary Hurricane Alert.

4. After a Preliminary Hurricane Alert is issued, it will be continued periodically as required with the heading "Continue Preliminary Hurricane Alert (time)" until the Alert is replaced by a Hurricane Warning or a Storm Warning, or is discontinued when no further danger exists. Small Craft Warnings should not be used as preliminary warnings of the approach of a hurricane or other tropical disturbance.

- Hurricane winds may endanger area within 24 to 36 hours
- Used when
  - Hurricane conditions may develop rapidly or
  - The location and movement of a hurricane are uncertain

- "*If reports indicate an incipient hurricane disturbance that may develop rapidly and affect the coast within 24 to 36 hours, but indications are not yet sufficient to justify definite warning*"

# Hurricane Alert
## 4 March 1955

UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
Washington 25, D. C.

O-5.32

March 4, 1955

File: 656.4 CL 14-55

CIRCULAR LETTER NO. 14-55
(To All First Order Stations)

Subject: Hurricane Alerts

A system of preliminary hurricane alerts was instituted as part of the hurricane warning service with the issue of Circular Letter 81-43 effective September 1, 1943. The instructions were included in the hurricane warning service manual. Experience during 1954 indicates that such alerts should be used more frequently by hurricane forecasters. In order to bring this about the instructions are being rewritten with increased emphasis on the use of the alert.

The following paragraph will replace paragraph B-5007e in the present hurricane warning service instructions (present instructions were issued as a draft chapter to the Weather Bureau Manual with Multiple Address Letter of January 23, 1951 and will be issued as a chapter to the Manual in the near future).

B-5007e HURRICANE ALERT: (Hurricane Alerts)

Hurricane Alerts will be issued to alert the public that winds of a hurricane may endanger a locality or area within 36 hours even though indications are not yet sufficient to justify a definite hurricane warning. Examples of conditions under which hurricane alerts will be issued are: (a) When an incipient hurricane condition exists and may develop so rapidly that winds of hurricane force may be experienced in the area within 36 hours; or (b) when, for any reason, the movement and speed of a hurricane which is in a threatening position cannot be forecast with sufficient confidence to justify either immediate hurricane warnings or the conclusion that no hurricane danger exists. In view of the difficulty in making exact hurricane forecasts, provision (b) will apply and Hurricane Alerts should be issued in most cases when storm warnings are ordered or small craft are advised to remain in port in connection with a hurricane which is nearby or which is developing or approaching.

If hurricane winds are a possibility over a weekend or holiday, the Alert will be issued several hours before the close of regular business hours.

The Hurricane Alert will be discontinued after all danger of hurricane conditions striking the particular area has passed. The Hurricane Alert does not take the place of coastal warnings or displays but is intended to alert the public to the fact that some hurricane danger exists even though conditions are not yet sufficiently certain to warrant the issuance of definite hurricane warnings.

Forecast centers responsible for issuance of coastal warnings will advise the forecast office currently issuing the formal public hurricane advisories as to the portion of their areas for which a Hurricane Alert should be included in the next advisory.

Examples of Hurricane Alerts are attached.

Washington 25, D. C.

APR 29 1955

WEATHER BUREAU

F. W. Reichelderfer,
Chief of Bureau

- Experience from 1954 season suggested that alerts should be used more frequently
  - Carol
  - Edna
  - Hazel

**New Methods Will Be Tried On Hurricanes**

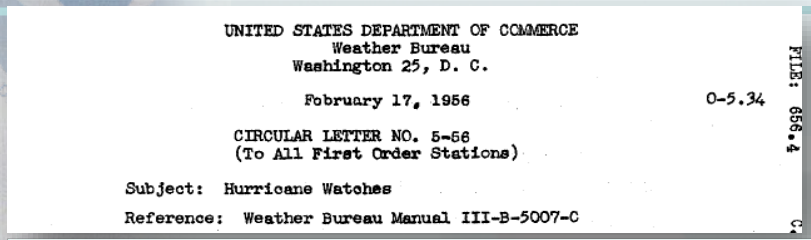
During the coming season, Dunn said he hoped to extend the early warning period on a storm to 36 hours if possible through the use of a "hurricane alert."

The alert was used to some extent by Norton, Dunn said. It is planned to expand its use to the entire Atlantic Coast.

"The alert will cover an area larger than we know will be affected by the hurricane," he said. "It is merely to put people on notice to watch for later advisories and the actual hurricane warning.

"If interest requires 24 hours or more to take precautions against a storm, they should do so" when an alert is issued he said.

# Hurricane Watch
## 17 February 1956



UNITED STATES DEPARTMENT OF COMMERCE
Weather Bureau
Washington 25, D. C.

February 17, 1956 O-5.34

CIRCULAR LETTER NO. 5-56
(To All First Order Stations)

Subject: Hurricane Watches

Reference: Weather Bureau Manual III-B-5007-C

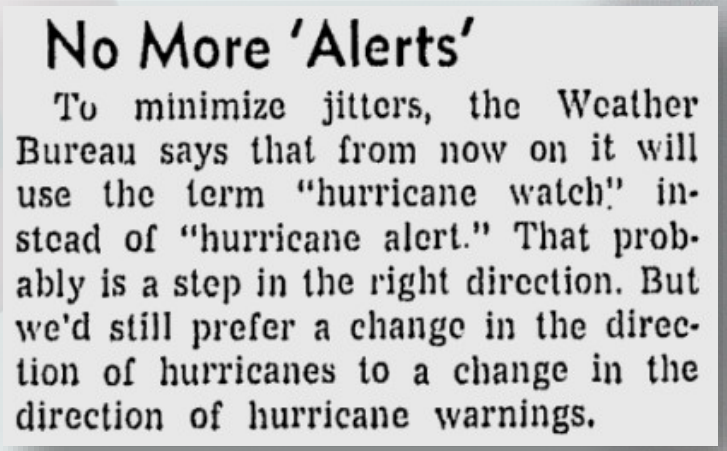
FILE: 656.4

**From "Alert" to "Watch" in Weather Bureau Verbiage.** *The Baltimore Sun*. Jan 3, 1956.

The United States Weather Bureau has acknowledged the influence of semantics upon our everyday living and dropped the word "alert" from its system of hurricane advisories. Henceforth what the storm forecasters had called a "hurricane alert" will be known as a "hurricane watch." **There was too strong a connotation of imminent danger in the term "alert," they decided.**

Our English word, according to Webster's New International Dictionary, comes down **through the French "*alerte*" from the Italian "*all'erta*," meaning on the watch, "*erta*" being a lookout position. Thus, "on the alert" and "on the watch" originally would seem to have had the same meaning.** But our language is not static and words grow or die like living things. The call that once summoned the sentry to his watch tower is much more forceful today with the threat of sudden, surprise attacks by jet and rocket aircraft.

- Studies showed that people mistook "alert" as synonymous with "warning"
- Reduce interpretations which came from different uses of "alert" in storm advices and in civil defense and military practices
- First Weather Bureau use of "Watch"
  - Severe thunderstorm/tornado 1966
  - Flash floods 1969
  - Winter storm 1973/74



No More 'Alerts'

To minimize jitters, the Weather Bureau says that from now on it will use the term "hurricane watch" instead of "hurricane alert." That probably is a step in the right direction. But we'd still prefer a change in the direction of hurricanes to a change in the direction of hurricane warnings.

***The News and Courier, January 3, 1956, Charleston, SC***

# Communicating the Warning

## ROCKETS FOR STORM SIGNALS

### Mr. Dunn Receives Authority for His Plan to Give Warning to Vessels at Night.

The United States Weather Bureau in this city is going to employ rockets to warn ships when on dark nights there are evidences of approaching hurricanes or severe storms that are likely to prove dangerous to shipping.

The idea originated with Elias B. Dunn, local weather forecast official, and he has been authorized by Willis L. Moore, the new chief of the department, to put the plan in operation. Hereafter, when storms are brewing in the nighttime, and it becomes important to give warning before the tempest breaks, there will be a display of rockets from the lofty tower on the Manhattan Life Building, in which the Weather Bureau is situated.

Mr. Dunn has also suggested to Prof. Moore to employ rockets at signal stations in the region of the orange groves of Florida and other places remote from telegraph stations where the fruit-growing interests are large to warn farmers of the approach of cold waves.

Mr. Dunn said yesterday: "Rockets are being manufactured now for our use. They are to be made without sticks and constructed so as not to burst until they are high up in the air. They will be sent up from the top of this building, and they will be visible from a great distance away. They will be made on the mortor bomb plan. They will look like balls of fire as they shoot up to a great height, and when they explode they will make an intense light.

"They will be used, of course, only at night. By employing them I hope to supplement greatly our ordinary system of weather signals. Arrangements have been made also to have coast line steamships fly hurricane signals from their masts, so that as they proceed along the coast they will carry the warning to vessels bound up the coast. Among the boats that will carry these signals are those of the United States Government. In order to make it impossible for the commander of any vessel to leave harbor in ignorance of approaching storms, signals will be displayed at Perth Amboy, Sandy Hook, City Island, North Brothers' Island and Bath Beach."

*New York Times.* New York, New York, August 13, 1895.

## ROCKETS TO WARN OF STORMS.

### WEATHER OFFICE GETS BIG SUPPLY OF FIREWORKS.

**From Warning Stations Along the Coast Balls of Red Fire will be Hurled Five Hundred Feet into the Air Upon Approach of Hurricane—Precautions Taken to Prevent Repetition of Last Year's Experience when Storm Found Coast Unprepared.**

Hundreds of skyrockets and not one for July 4! That is the state of affairs at the weather office. It would seem that with so many explosives at hand Forecaster Scott were expecting a warm time—just a little way ahead. There are fireworks at the weather office sufficient to celebrate a national Democratic victory, but these rockets are for a greater storm than any political achievement has ever set in motion.

They are hurricane warnings to be distributed among the thirty-odd stations that the forecaster is equipping and getting in readiness for the opening of the hurricane season, which is now almost at hand. Each of the big rockets carries a charge sufficient to throw into the heavens a tremendous ball of red fire for the distance of 550 feet. At each hurricane warning station a number of these rockets will be placed, with instructions that in case of severe storm they be fired—three of them—at intervals of fifteen minutes each, beginning at 7.45 P. M.

**A Chain of Rockets.**

The hurricane warning is sent out from Washington and then come the fireworks! From station to station the warning is picked up and sent along the entire chain of warning places, the persons being under instruction at each station to fire the three rockets at fifteen-minute intervals. The hurricane warning stations are not confined to the immediate coast, but are located along inland streams, as well, where the damage to property is often very great during a severe hurricane. The reason the station keepers are instructed to fire the warning of three rockets beginning at 7.45 o'clock P. M. is because during the hurricane season it is scarcely dark enough for a noticeable display of fireworks in the heavens before that hour.

**To Keep Tab on Storms.**

The Government weather bureau is taking every precaution this year that no hurricane steal in unawares, as did the great storm of last August. The big hurricane last year was in state of formation as early as August 23, though it did not strike the coast until the 27th. Wireless telegraphy from coastwise vessels is to play an important part this year for the first time in sending in warnings of the presence of hurricanes at sea. Recently the weather bureau arranged to send out during the coming season on a number of coastwise vessels, especially those plying to and from the Caribbean Sea, expert observers who will send in reports twice daily to the central office at Washington, or to the nearest land wireless station, whence they will be forwarded to Chief Moore at the central office. Chief Moore, in commenting on the importance of wireless reports, says:

**Value of Wireless.**

"That this storm (August 27-28, 1911,) in its full intensity should exist off the South Atlantic coast for four days without any indication of its presence being afforded coast stations clearly demonstrates the value of reports by wireless telegraph from vessels plying southern waters. Had such reports been at hand it would have been possible to have given warning of its presence, intensity and direction of movement several days previous to the time that it reached the coast. In the absence of such reports the forecaster has to rely absolutely on the indications shown by the land stations, and necessarily such indications are not shown until the storm is close to shore."

*The News and Courier.* Charleston, South Carolina, June 23, 1912.

## Guard Will Use Loud Speakers In Planes

### Pilots to Broadcast Warnings of Storms From Skies; Service To Help Spongers

By FRANK A. KENNEDY
(Special To The Independent)

Washington, Dec. 2. — Coast Guard airplanes equipped with loudspeakers, will carry future hurricane warnings to the Everglades and the Florida keys.

Plans for the new storm-warning service now are being worked out by Coast Guard headquarters here, and experimental equipment already has been ordered.

The loud speakers will be similar to those used by public address systems and airplanes advertising. The voice of the speaker broadcasting the warnings will be heard for several miles. Residents of remote sections and the crews of fishing fleets, such as the sponge fleets of Tarpon Springs and Key West, will receive the service.

In addition to the loud speakers, the Coast Guard planes will tow behind them huge kite-like signals painted with the conventional symbols of the regulation storm warnings hoisted by the weather bureau stations along the coast. Prior to the inauguration of the service, its purpose will be systematically publicized in order to acquaint all residents of the hurricane areas with the meaning of the symbols.

The new equipment is intended to supersede the "block system" now used by the Coast Guard to warn the fishermen and others of approaching storms. These blocks are small floats containing the warning message, which are dropped near the boats or remote villages intended to be warned.

Later, Coast Guard aviators will be given special instruction in radio announcing and specially trained radio technicians will operate the speakers.

### Driver Is Freed On Drunk Charge

Municipal Judge Byron T. Sauls last week dismissed a charge of drunkenness against Thomas McElroy, 439 Central avenue.

McElroy was arrested Thursday night after his car allegedly sideswiped one automobile and crashed itno the rear end of another.

Judge Sauls dealt severely with Marvin Edwards, 4670 Nineteenth avenue north, sentencing him to pay a $50 fine or serve 30 days in jail on a disorderly conduct charge.

He was arrested Thanksgiving night after Mrs. Edna C. Helm, 331 First street south, complained that he was "wrecking" her house.

**OPPOSE SPLITTING STATE**

Tampa, Fla., Dec. 2. —AP—Commissioners of Hillsborough county were on record as officially refusing to take part in plans to divide Florida into two states. They took the action after receiving a letter from Ray Seldon, Daytona Beach attorney, calling a meeting at Sarasota.

*The Independent.* St. Petersburg, Florida, December 2, 1935.

# Tropical Storm Watches and Warnings

## 1987 Hurricane Season

**Hurricane Warnings Changing**
*South Florida Sun-Sentinel*. April 2, 1987.

The system used to warn coastal communities of tropical storms and hurricanes will be changed this year to eliminate confusion, weather service officials said Wednesday.

The National Hurricane Center, based in Coral Gables, will issue watches and warnings for tropical storms and hurricanes, but gale warnings will not be issued for tropical weather disturbances, said Robert Sheets, who in June will become acting director of the hurricane center.

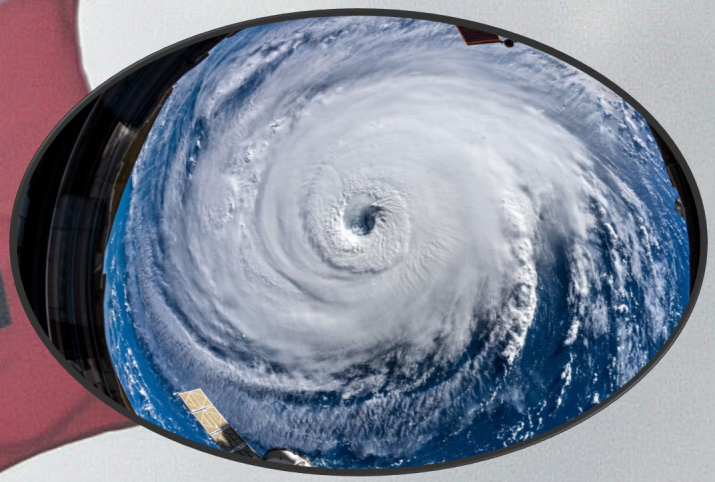
Forecasters define a gale as winds between 39 and 54 mph -- part of the tropical storm range -- but mariners use a different definition, Sheets said. The new system ``makes the definition much cleaner,`` he said.

Under the old system, the hurricane center may have issued gale warnings, storm warnings and hurricane warnings for different parts of the coast, all because of one weather system. Now, the center will post either a tropical storm watch or warning or a hurricane watch or warning.

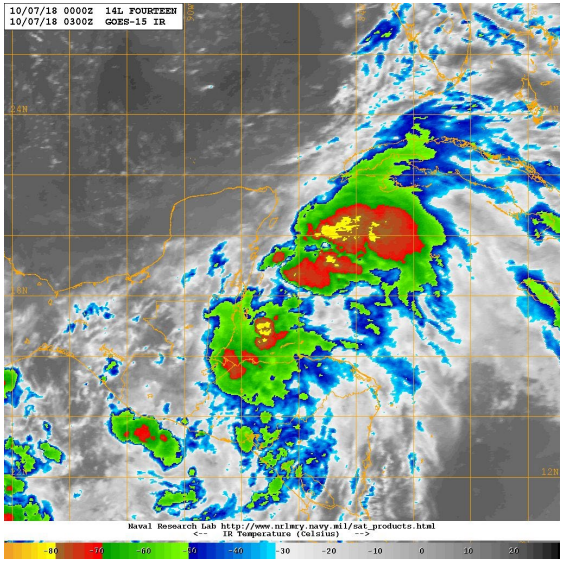
For 2010 Hurricane Season:

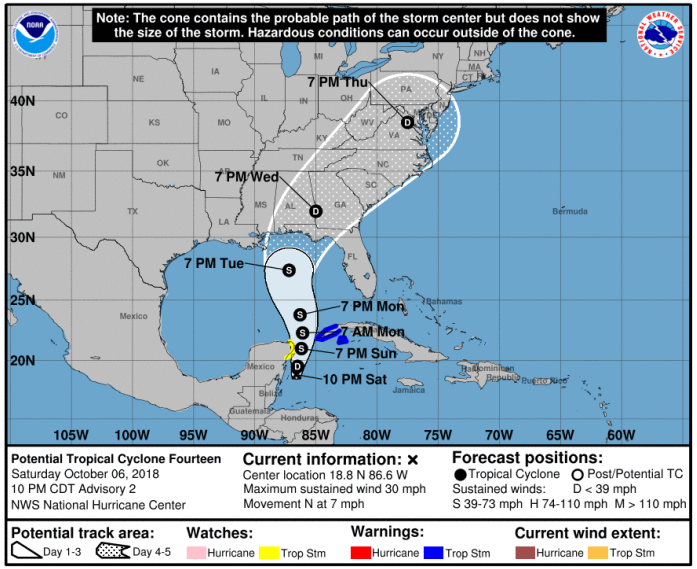
Watch 36 to 48 H

Warning 24 to 36 H



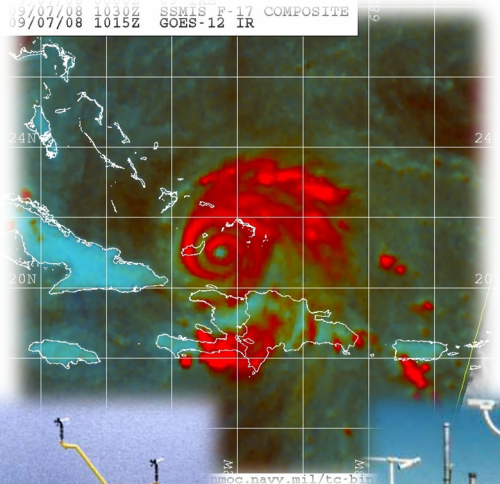
# Potential Tropical Cyclone Advisories

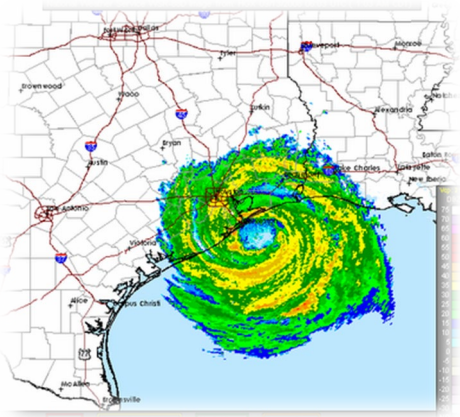



- Allows timely issuance of watches and warnings before a tropical cyclone has formed
- Earlier NHC advisories for systems that pose a long-range threat to the United States or other land areas

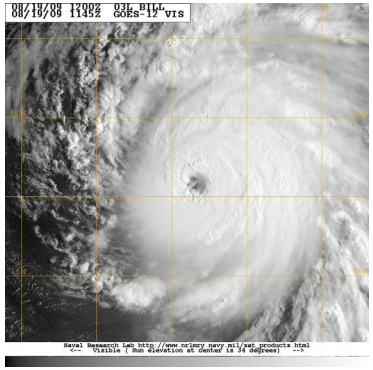
# Observations to Make a Hurricane Forecast



# Data for Analysis

- Geostationary Satellites
  - Help determine center location (with varying degrees of confidence)
  - Apply Dvorak technique to imagery to estimate a system's intensity
  - Allows forecasters to see features that might influence the future track/intensity

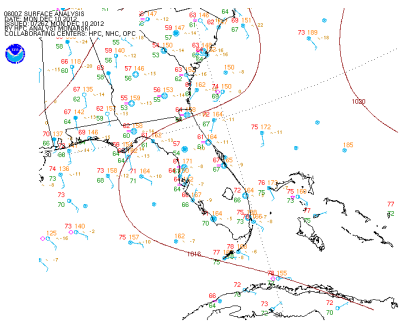


- Low-Earth Orbiting Satellites
  - Can be used to look at storm structure
  - Other instruments can provide intensity estimates

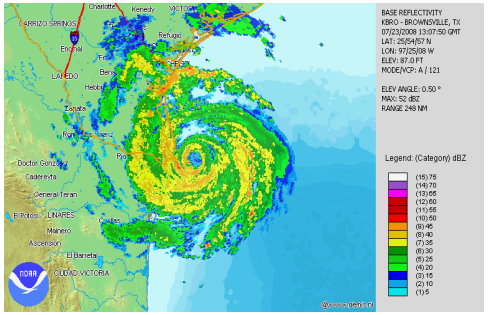
- Reconnaissance Aircraft
  - Flight-level winds
  - Dropwindsonde Data
  - Surface wind data from the SFMR

# Data for Analysis

- Surface observations
  - Ship and buoy reports
  - Land based observing sites



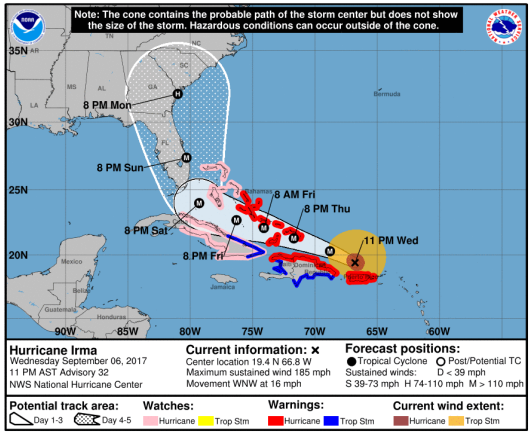
- Radar
  - Provides reflectivity and velocity data
  - Useful for “now-casting” during an event and a few hours prior) but little forecast utility



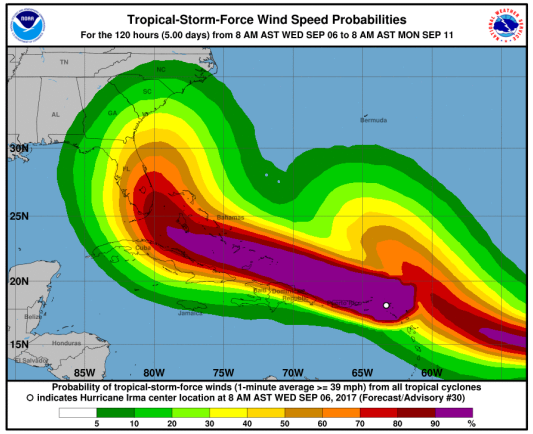

Sounds like a lot of data but…

Only a tiny fraction of the storm circulation is sampled and the chances of encountering the storm’s peak winds are very small

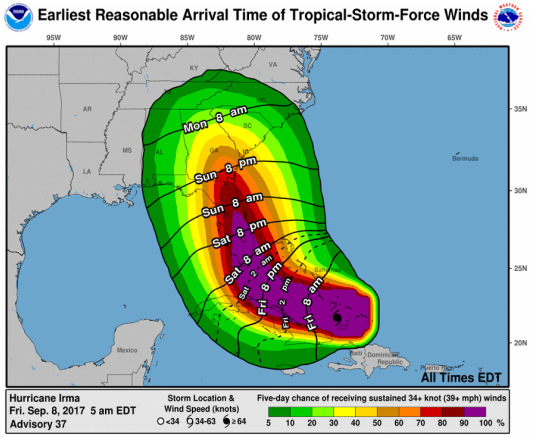
# Today



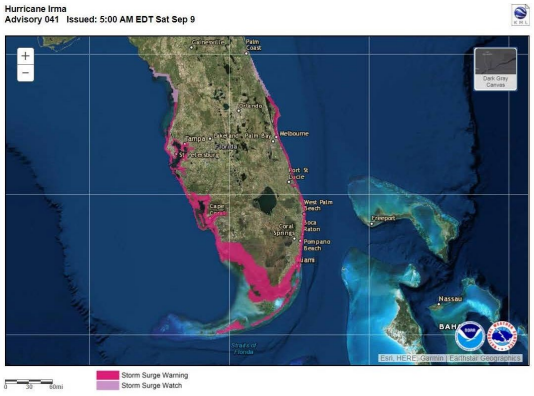

Forecast Cone/Wind Warnings/Size



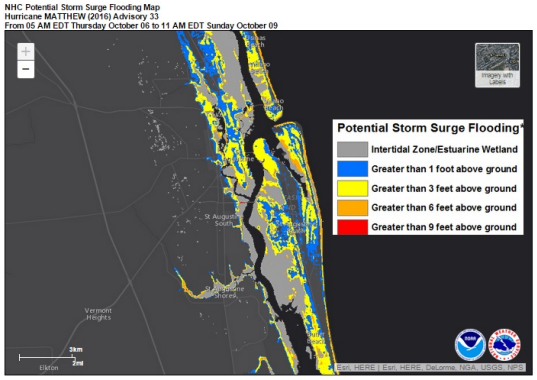

Wind Speed Probabilities



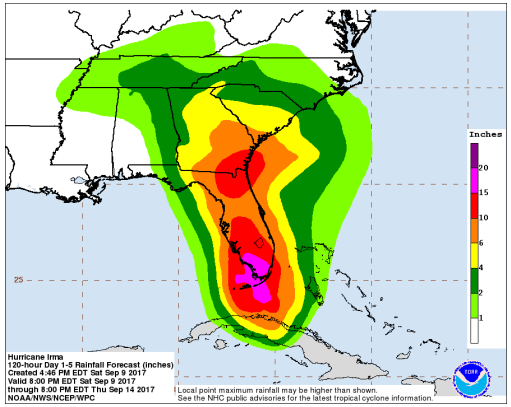

Time of Arrival of Winds




Storm Surge Warnings




Storm Surge Potential Inundation




Weather Prediction Center Rainfall

# Timelines

## Example: Emergency Manager

**You are now in the hot seat. You have some decisions to make. You will brief the media with the governor and mayor twice a day and you are accountable and judged on the response.**

Evacuate or not evacuate?
Evacuate a hospital, assisted living center? Consider some patients cannot be moved.
Evacuate a prison, your largest has a population of 6300 prisoners and 1800 staff?
Do we have state police begin contraflow preparation of major highways and interstates, and when?
Do we need to evacuate oil rig staff in the Gulf of Mexico via helicopter and shut down oil production?
What shelters should we open? (general population, other states, special needs, special requirements)
Do we need to activate the bus contract, whether you use it or not you will have to pay?
Where to put emergency food, medicine, water, tarps, gasoline, Diesel, pumps, and generators?
Do we need swift water teams and where should they stage?
Where do we stage charity organizations so they can get in quickly, but remain safe?
Do I activate the contract to feed and house emergency operations center staff?
Do we need to close gates to keep water out and what levees need extra height?

# Timelines

## Example: New Orleans

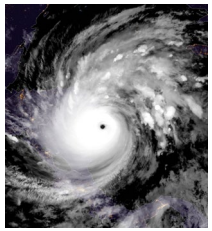
CITY OF NEW ORLEANS


- **72** — Mayor announces mandatory evacuation.
- **58** — Visitors shuttled to airport from Sheraton & Harrah's.
- **54** — Resident pickup at Evacuspots begins.
- **48** — State evacuates residents from coastal regions.
- **30** — Resident pickup at Evacuspots ends. Last evacuees are bussed out of the city. Contraflow begins. All lanes travel out of the city.
- **12** — Airport shuts down.
- **0** — Tropical storm winds reach the coast.
- **-12** — Hurricane landfall.

# Timelines

## Example: New Orleans

CITY OF NEW ORLEANS

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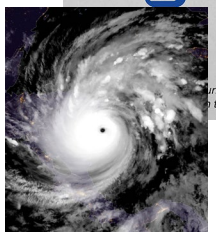

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# Timelines

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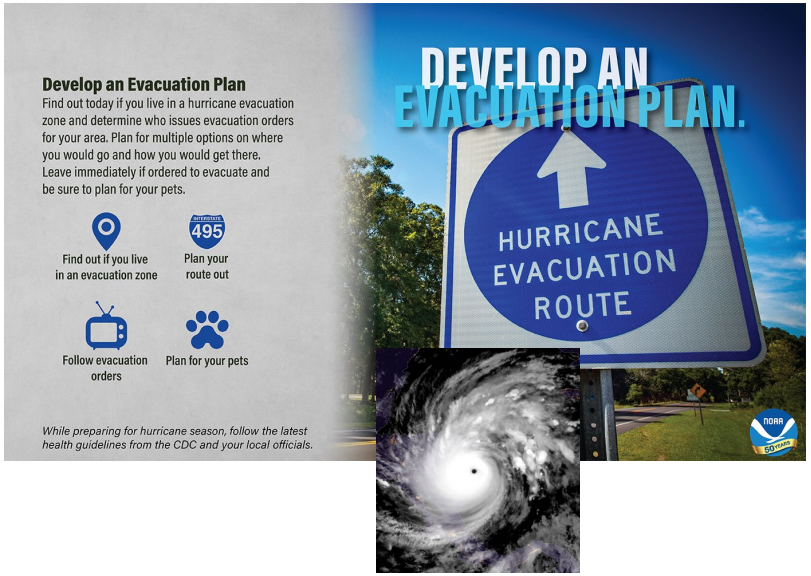
CITY OF NEW ORLEANS

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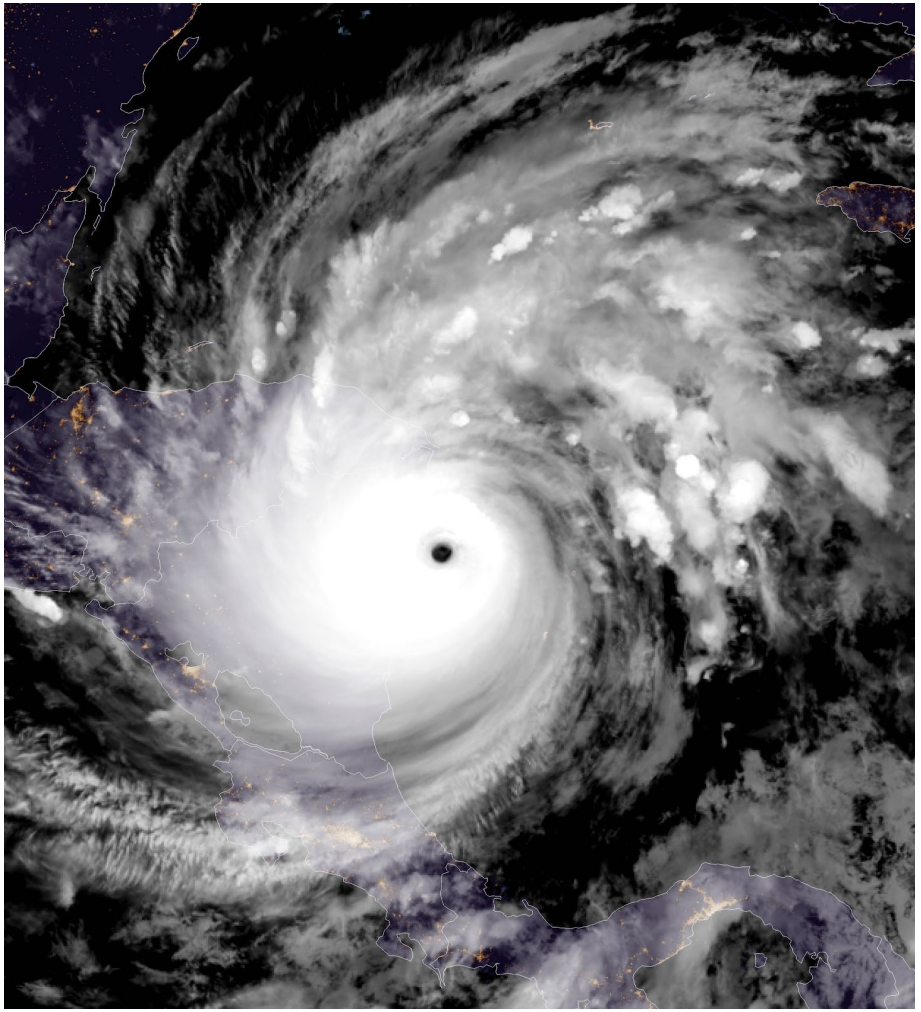
- **-12**

# Forecast Intensity Challenge

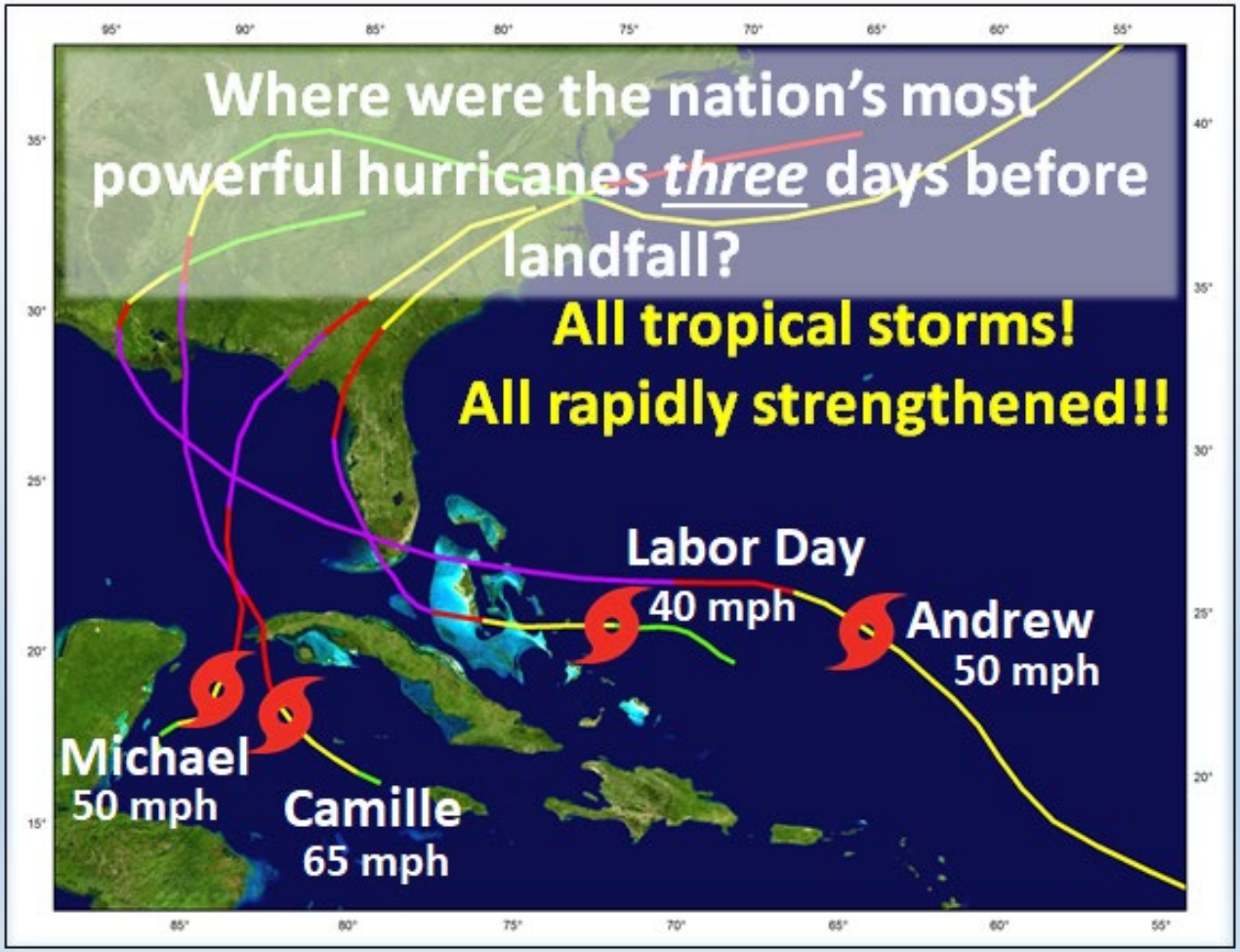
9 Atlantic TCs in 2020 underwent RI, **several just before landfall and several rapidly weakened and/or fluctuated**

Largest 24-h intensity change:

- Hanna: 30 kt (50 -> 80 kt)
- Laura: 40 kt (90 -> 130 kt)
- Sally: 20 kt in 12 h (70 -> 90 kt)
- Teddy: 35 kt (85 -> 120 kt)
- Delta: 65 kt (55 -> 120 kt)
- Epsilon: 45 kt (55 -> 100 kt)
- Zeta: 40 kt (55 -> 95 kt)
- Eta: 70 kt (60 -> 130 kt)
- Iota: 70 kt (70 -> 140 kt)

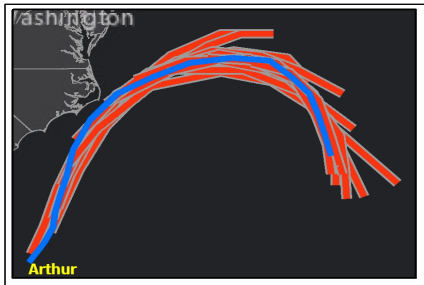


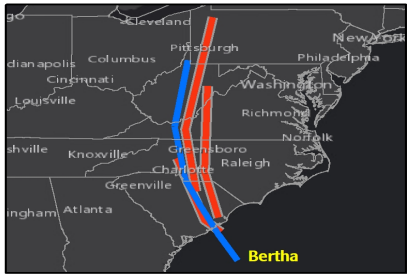
# Forecast Intensity Challenge

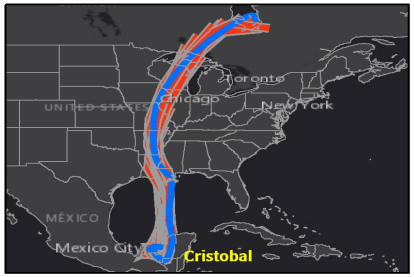


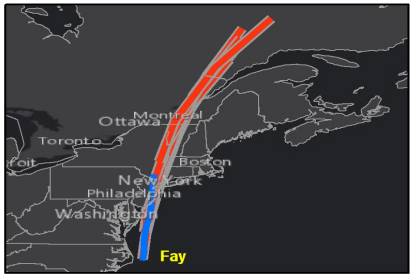
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

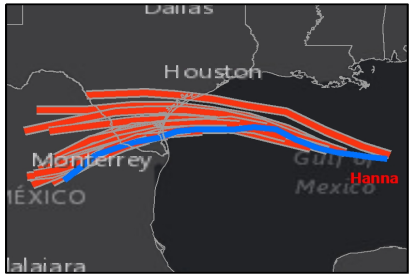
# 2020 CONUS Landfall Tracks

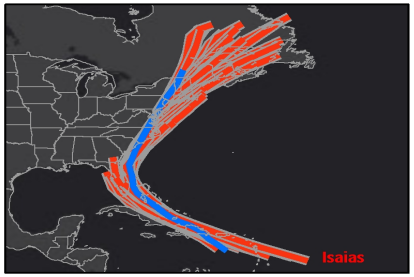


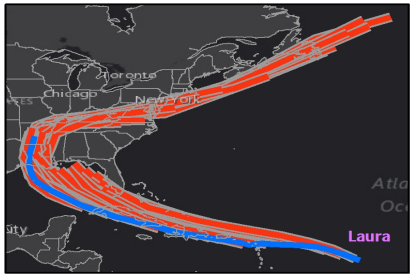



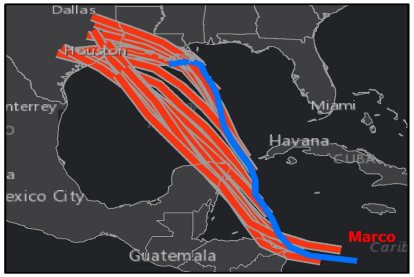



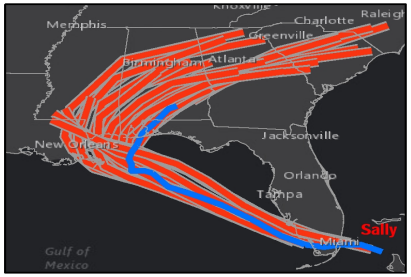



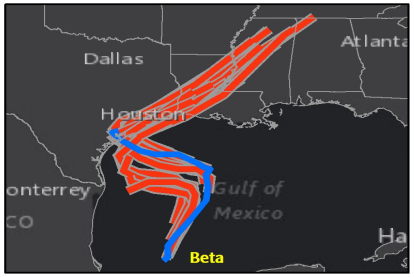



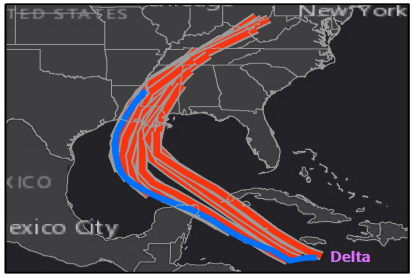



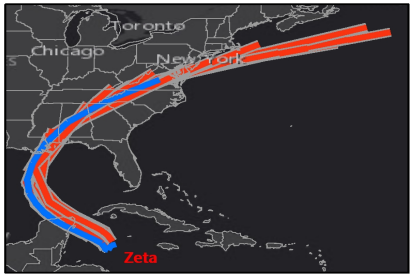



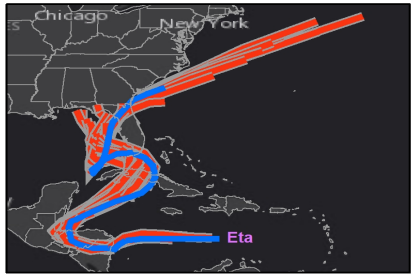




Forecast tracks and preliminary best tracks of the **THIRTEEN** 2020 U.S. landfalling tropical cyclones (tropical storms and hurricanes).

Maximum lifetime intensity (and SSHWS Category reached), if applicable.

| | |
|---|---|
| Tropical Storm Bertha - 45kt | Hurricane Marco - 65kt (Cat. 1) |
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| Tropical Storm Fay - 50kt | Hurricane Isaias - 75kt (Cat. 1) |
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| Tropical Storm Arthur - 55kt | Hurricane Zeta - 90kt (Cat. 2) |
| Major Hurricane Delta - 120kt (Cat. 4) | |
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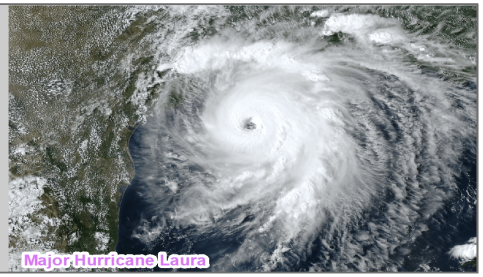
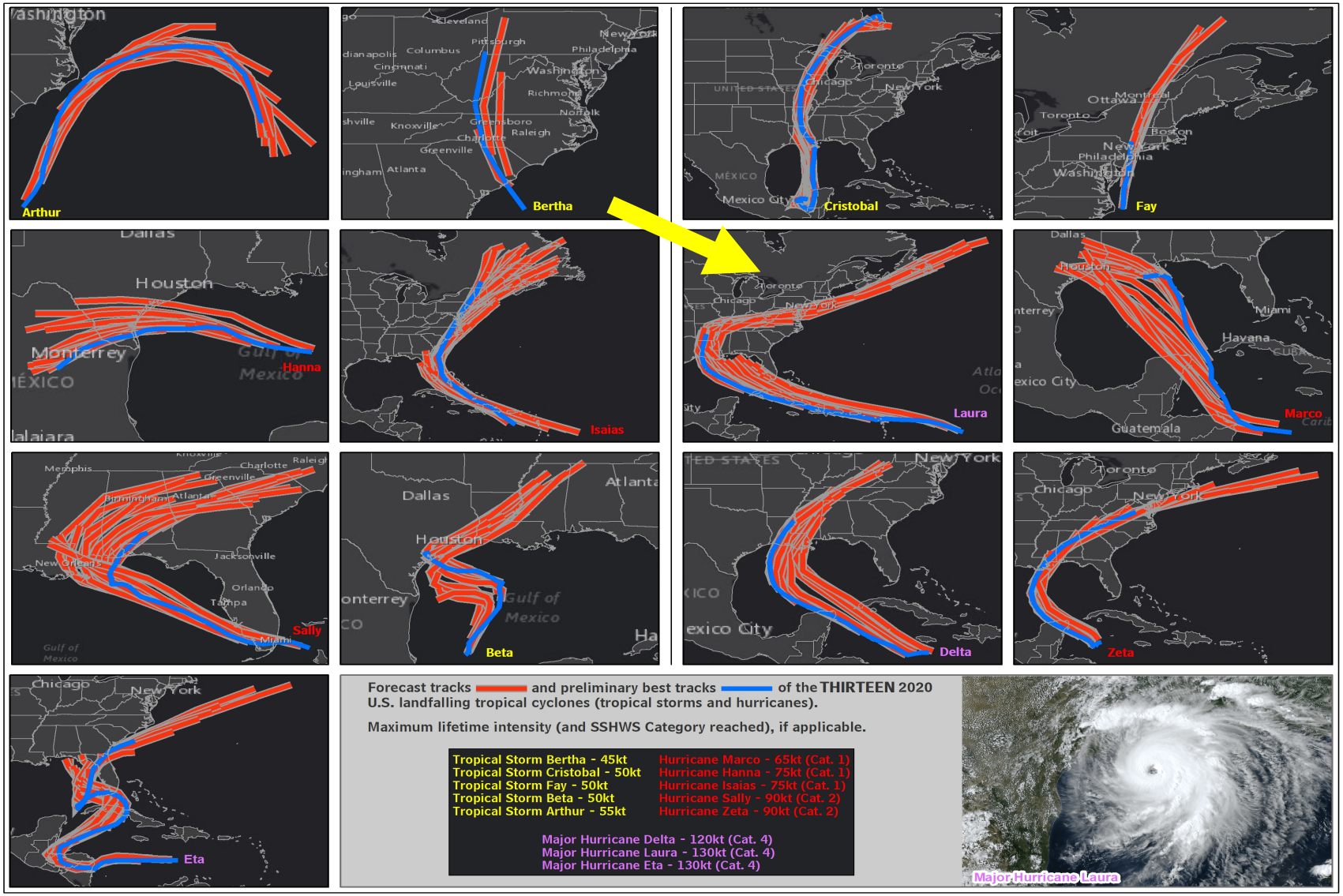
| Major Hurricane Eta - 130kt (Cat. 4) | |



NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

# Hurricane Laura

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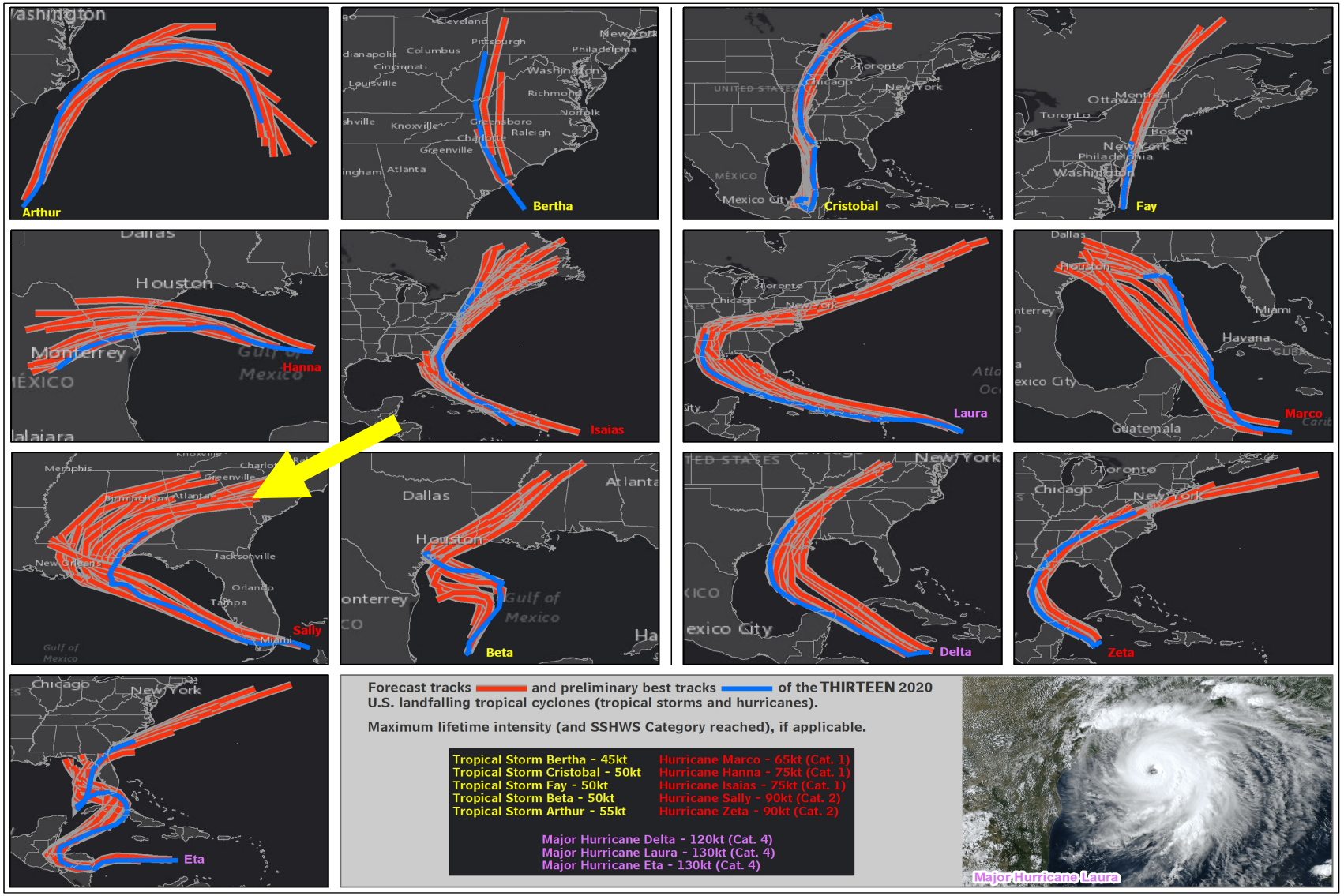
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

# Hurricane Sally

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

# 2020 LA Surge

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

# 2020 LA Surge

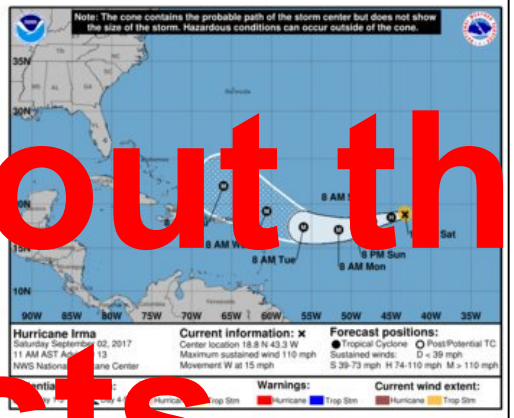
# Communicating the Danger

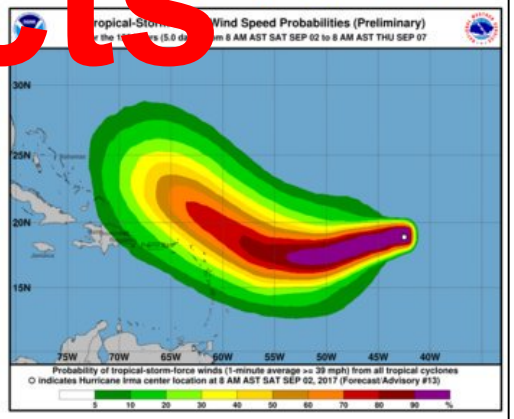
## Key Messages for Hurricane Irma

**Advisory 13: 11:00 AM AST Sat Sep 02, 2017**

1. Irma is expected to be a major hurricane when it moves closer to the Lesser Antilles early next week, producing rough surf and [illegible] currents. Irma could also cause [illegible] dangerous wind, storm surge, and rainfall impacts on some islands, though it is too soon to specify where and when those hazards could occur. Residents in the Lesser Antilles should monitor the progress of Irma through the weekend and listen to any advice given by local officials.

2. It is much too early to determine what direct impacts Irma will have on the Bahamas and the continental United States. Regardless, everyone in hurricane-prone areas should ensure that they have their hurricane plan in place, as we are now near the peak of the season.

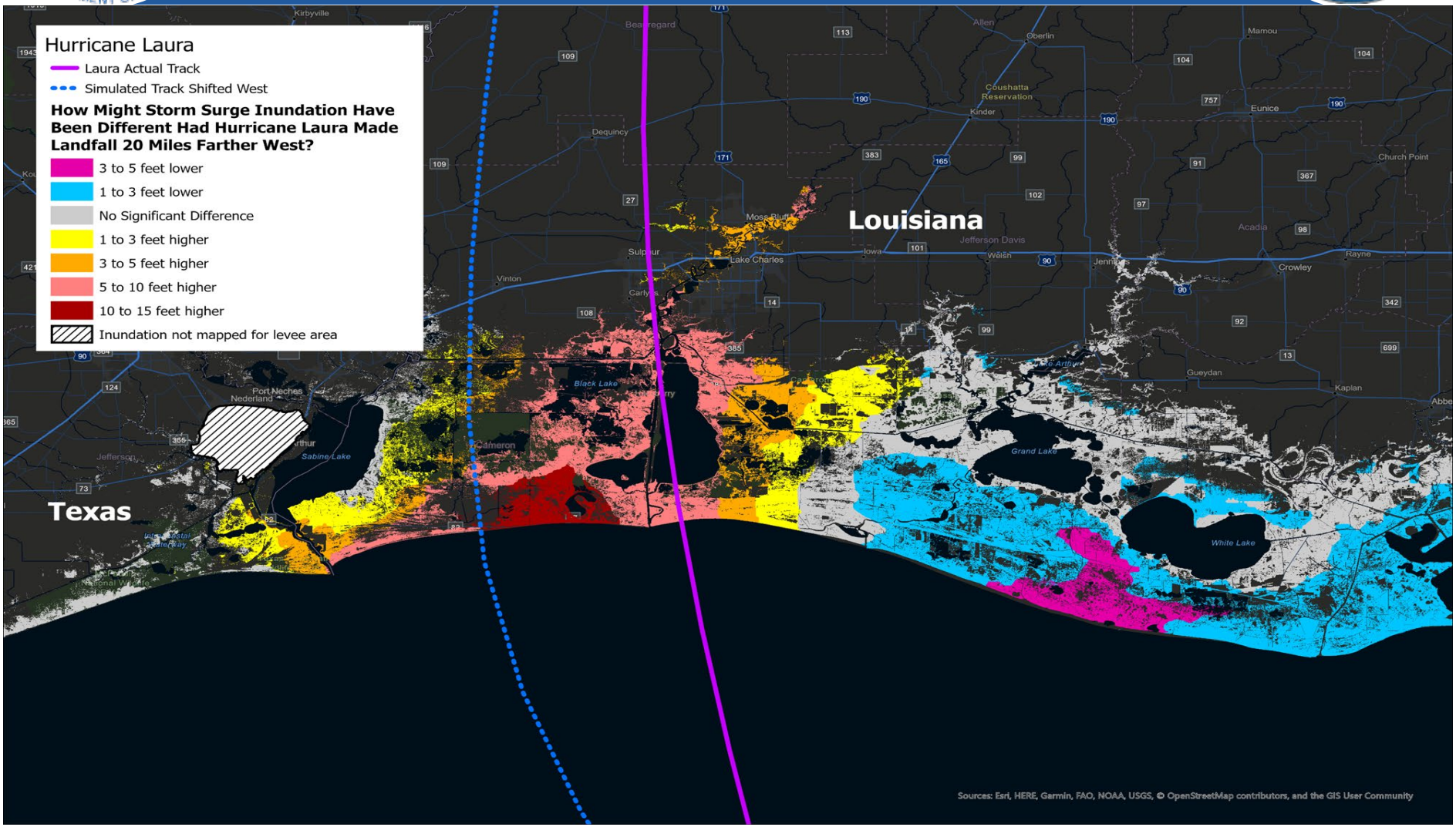


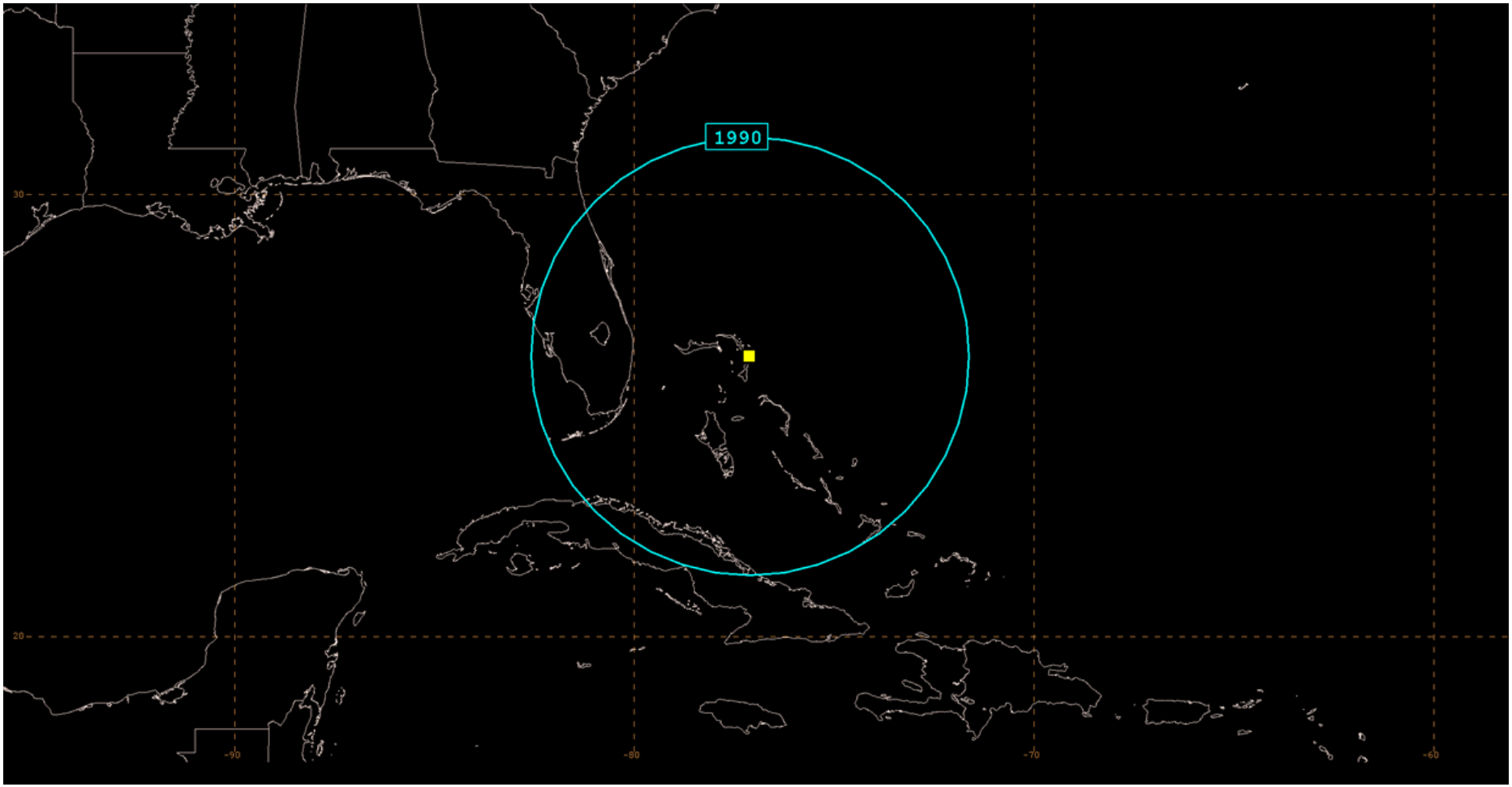

**For more information go to hurricanes.gov**

**It's All About the Impacts**

# Little Wiggles Matter



# Forecast Accuracy



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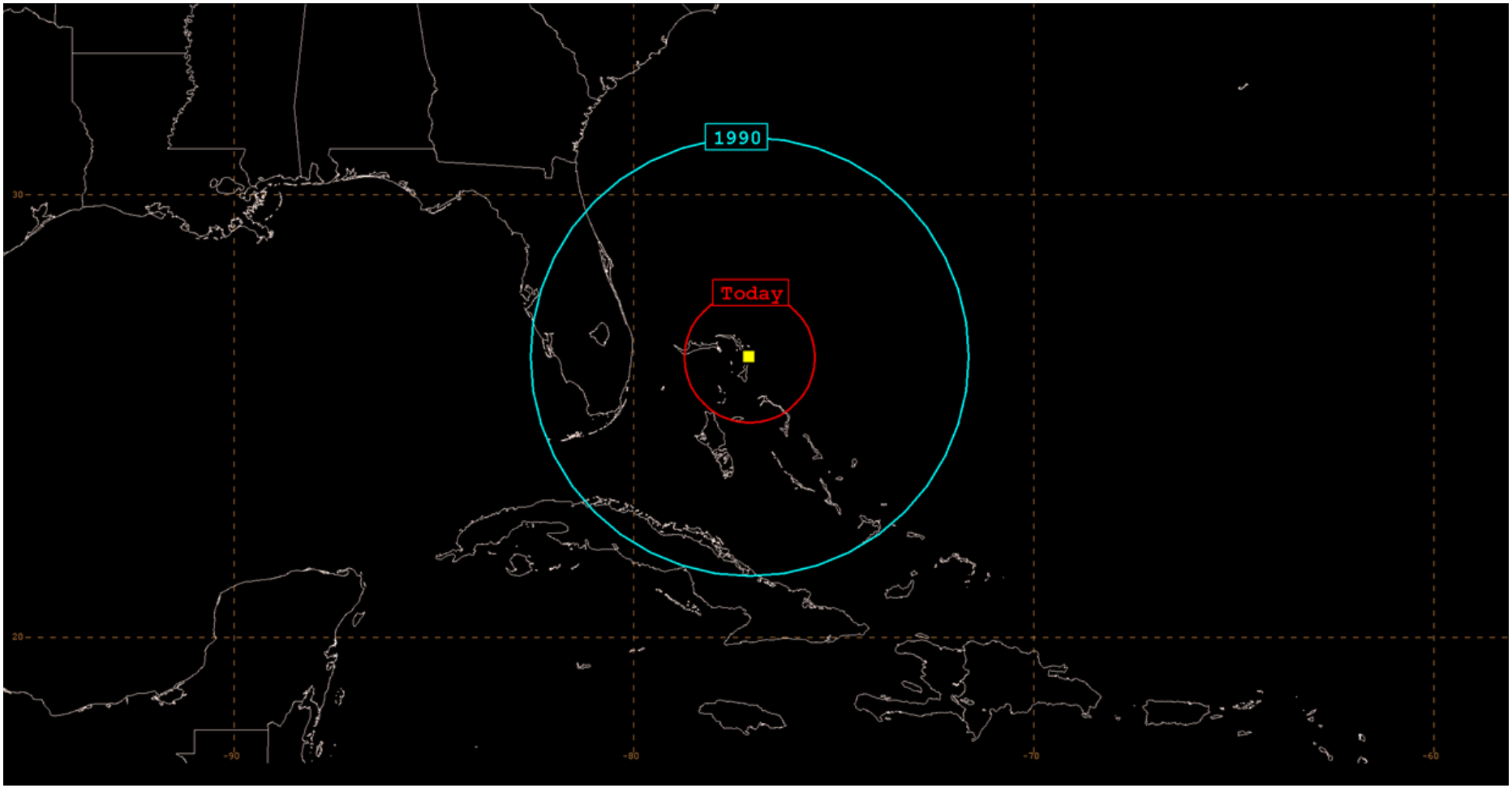
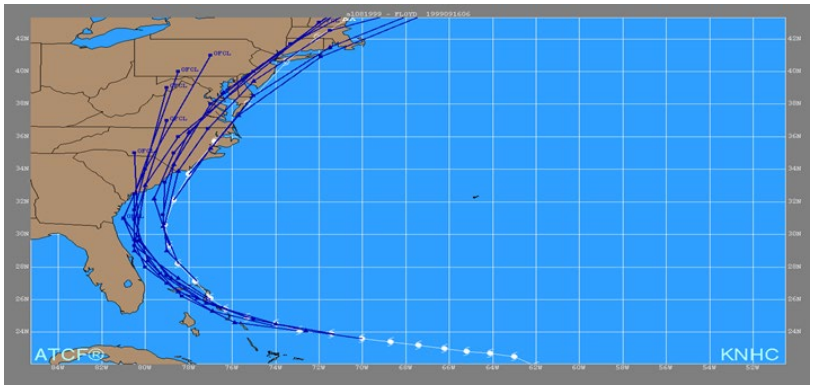


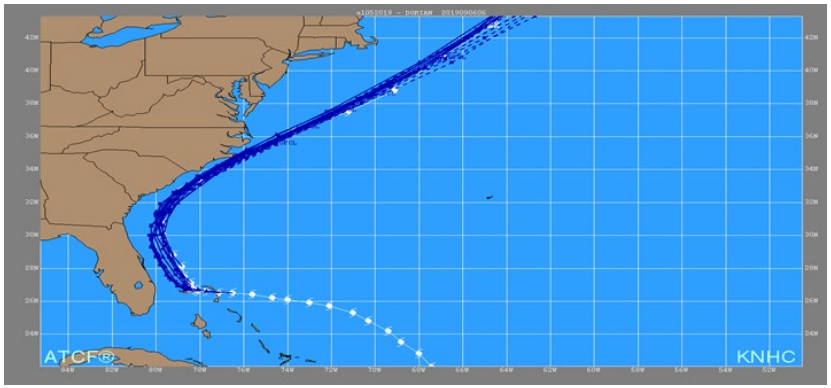
# Why does it matter?

## Track – Intensity – Storm Structure - Speed




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

**2.6 million people evacuated**




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

**As many as 3 million people NOT evacuated**

# Thank you from the National Hurricane Center!

Ken Graham
NOAA/NWS National Hurricane Center
kenneth.graham@noaa.gov
hurricanes.gov