

# Forecasting at the National Hurricane Center: Past, Present and Future

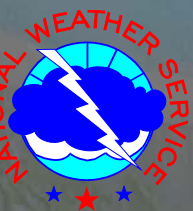
Chris Landsea

[Chris.Landsea@noaa.gov](mailto:Chris.Landsea@noaa.gov)

Chief, Tropical Analysis and Forecast Branch  
National Hurricane Center

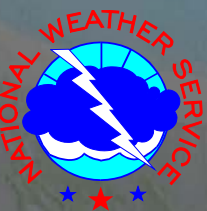
Connecticut College

October 29, 2019



# Outline of Talk

- NHC's Mission and Organizational Structure
- Tropical Analysis and Forecast Branch
- Hurricane Specialist Unit
  - Tropical Cyclone Hazards
  - Observational Platforms
  - Forecast Products
  - Coordination
    - The "Off Season"
- Future Plans
- Reminder of Who We Serve





# NHC MISSION

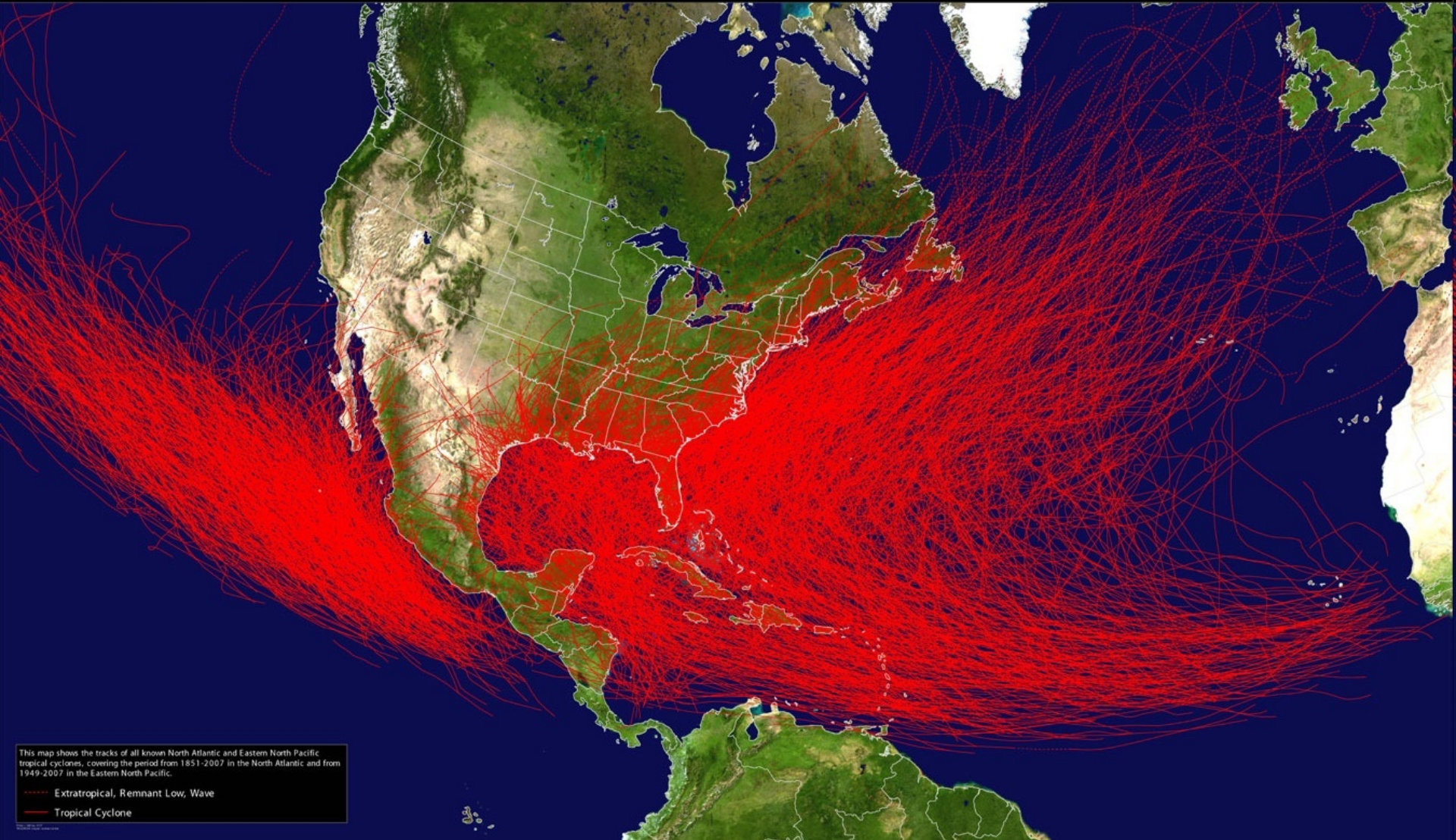
To save lives, mitigate property loss, and improve economic efficiency by issuing the best watches, warnings, forecasts and analyses of hazardous tropical weather, and by increasing understanding of these hazards





# Tropical Cyclone History

Data from 1949 in the Pacific, from 1851 in the Atlantic





# National Hurricane Center National Weather Service Miami Forecast Office



- Building opened 1995
- 25,000 square feet
- Design team included Herb Saffir
- 10-inch thick walls made from 3000 cubic yards of concrete, reinforced with 45 miles of steel reinforcing rods
- More than 50 miles of electrical and communications wiring
- Base rests five feet above flood plain



# National Hurricane Center

## Hurricane Specialist Unit

Develop, coordinate (domestically and abroad), and issue tropical cyclone warnings, forecasts, and outlooks in text and graphical formats (~700 full advisory packages/yr)

“Off-season” outreach and public awareness programs

Applied research

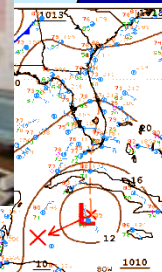


## Tropical Analysis and Forecast Branch

Marine/ocean and satellite analyses, forecasts and warnings in text and graphical formats, 24x7, (~100 products/day)

Conduct tropical cyclone (Dvorak) analyses for the hurricane specialists

Augments operational support staffing



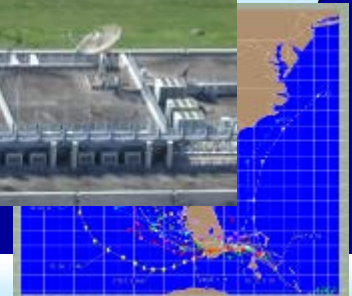
## Technology and Science Branch

Computer systems support 24x7

Applications development and technology infusion

Storm surge guidance (real time; community planning; preparedness)

Emergency operational support staffing





# Tropical Analysis and Forecast Branch Marine Forecasts





# Ships over the Open Ocean





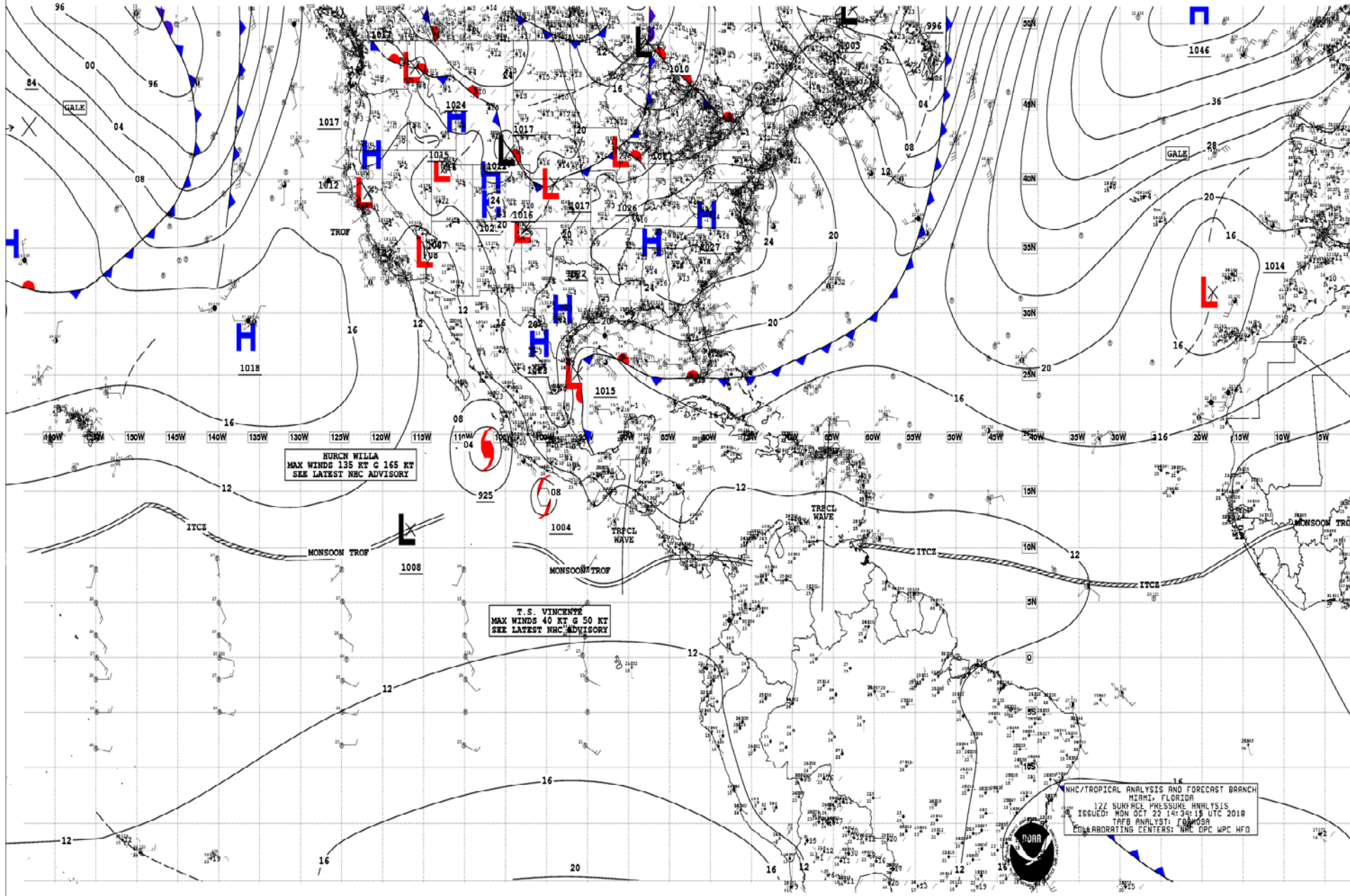
# A Bad Cruise



# Unified Surface Analysis

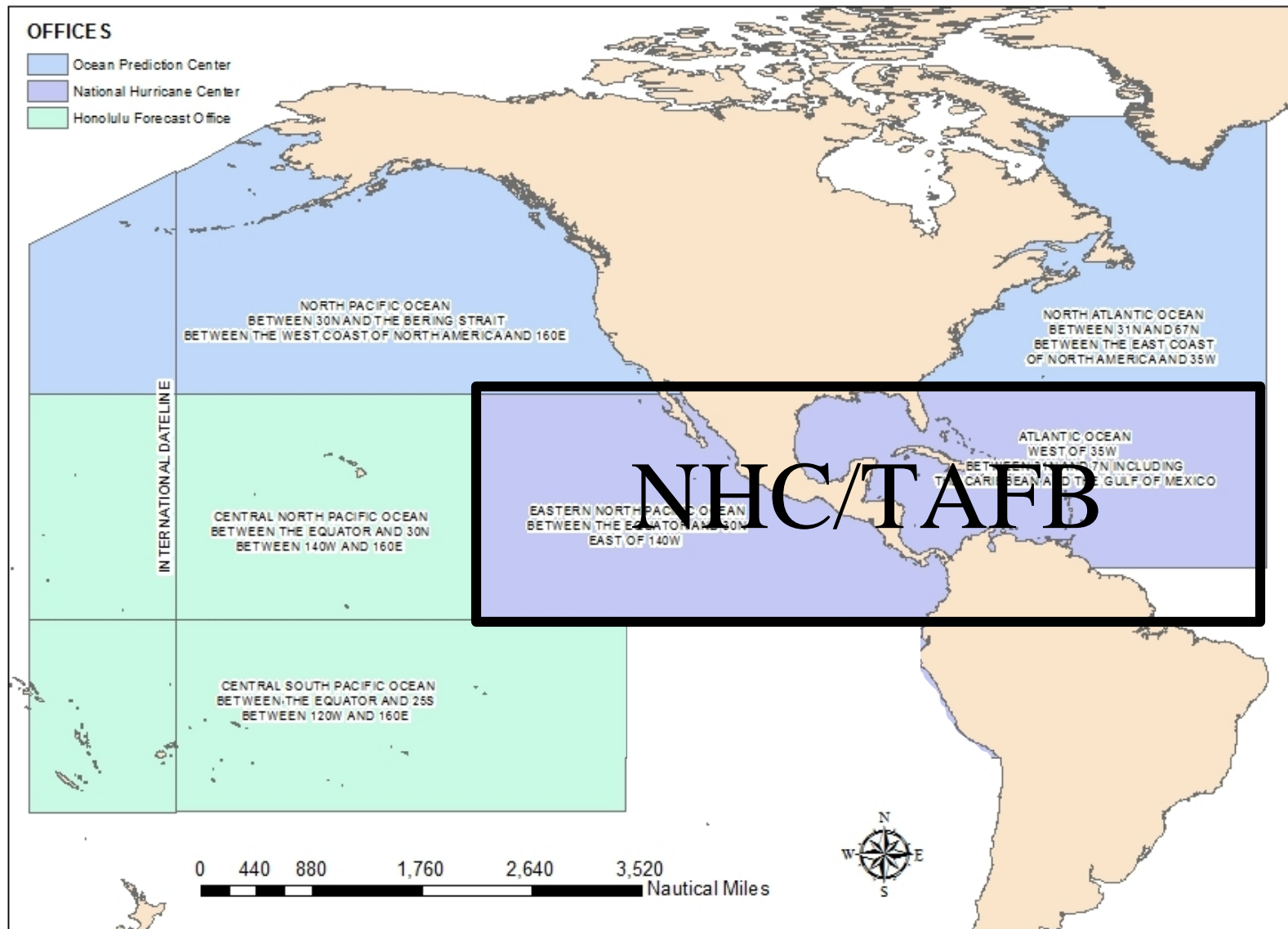
[https://www.nhc.noaa.gov/tafb\\_latest](https://www.nhc.noaa.gov/tafb_latest)  
USA\_latest.gif

Joint effort from Four Weather Service Offices





# Three Ocean Forecast Centers in the NWS



# NHC/TAFB Marine Forecast Products

## High Seas and Offshores Text Forecasts

HIGH SEAS FORECAST  
NWS NATIONAL HURRICANE CENTER  
1030 UTC FRI OCT 02 2015

SUPERSEDED BY NEXT ISSUANCE IN 6 HOURS

SEAS GIVEN AS SIGNIFICANT WAVE HEIGHT...WHICH IS THE AVERAGE HEIGHT OF THE HIGHEST 1/3 OF THE WAVES. INDIVIDUAL WAVES MAY BE MORE THAN TWICE THE SIGNIFICANT WAVE HEIGHT.

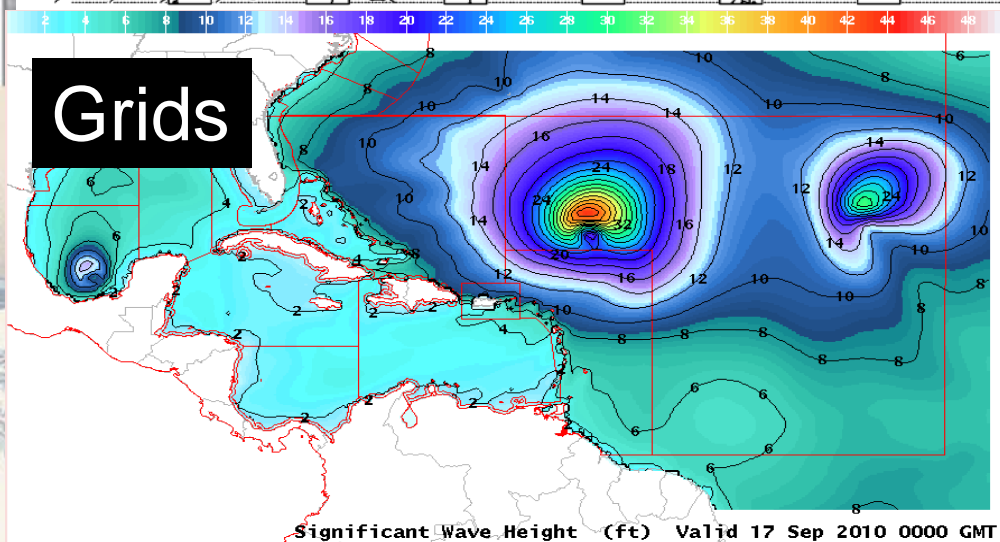
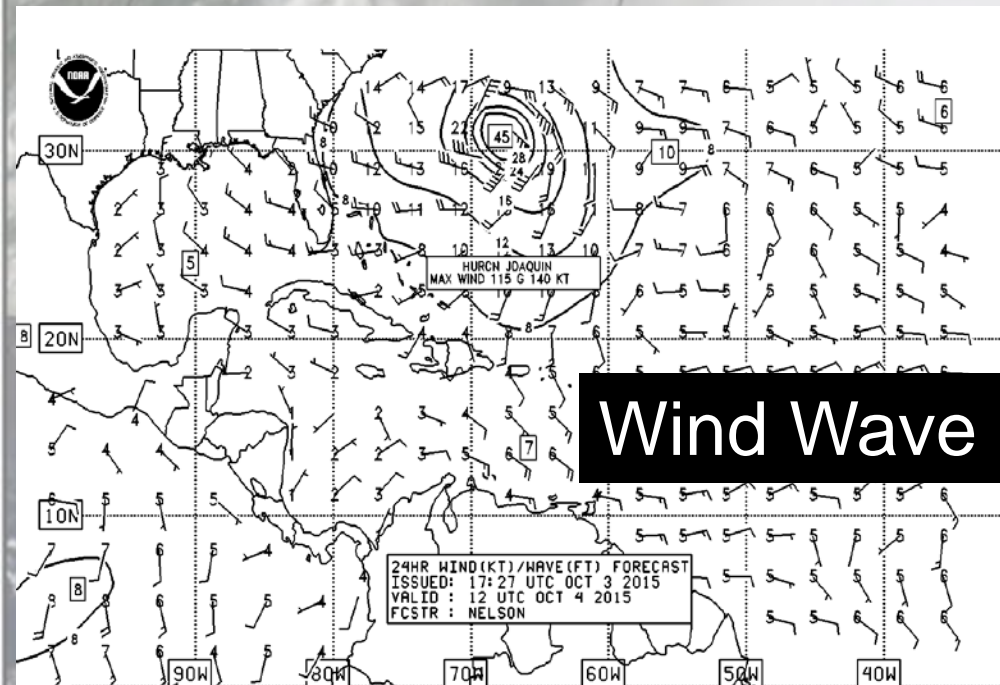
PAN PAN

ATLANTIC FROM 07N TO 31N W OF 35W INCLUDING CARIBBEAN SEA AND GULF OF MEXICO.

SYNOPSIS VALID 0600 UTC FRI OCT 02.  
24 HOUR FORECAST VALID 0600 UTC SAT OCT 03.  
48 HOUR FORECAST VALID 0600 UTC SUN OCT 04.

.WARNINGS.

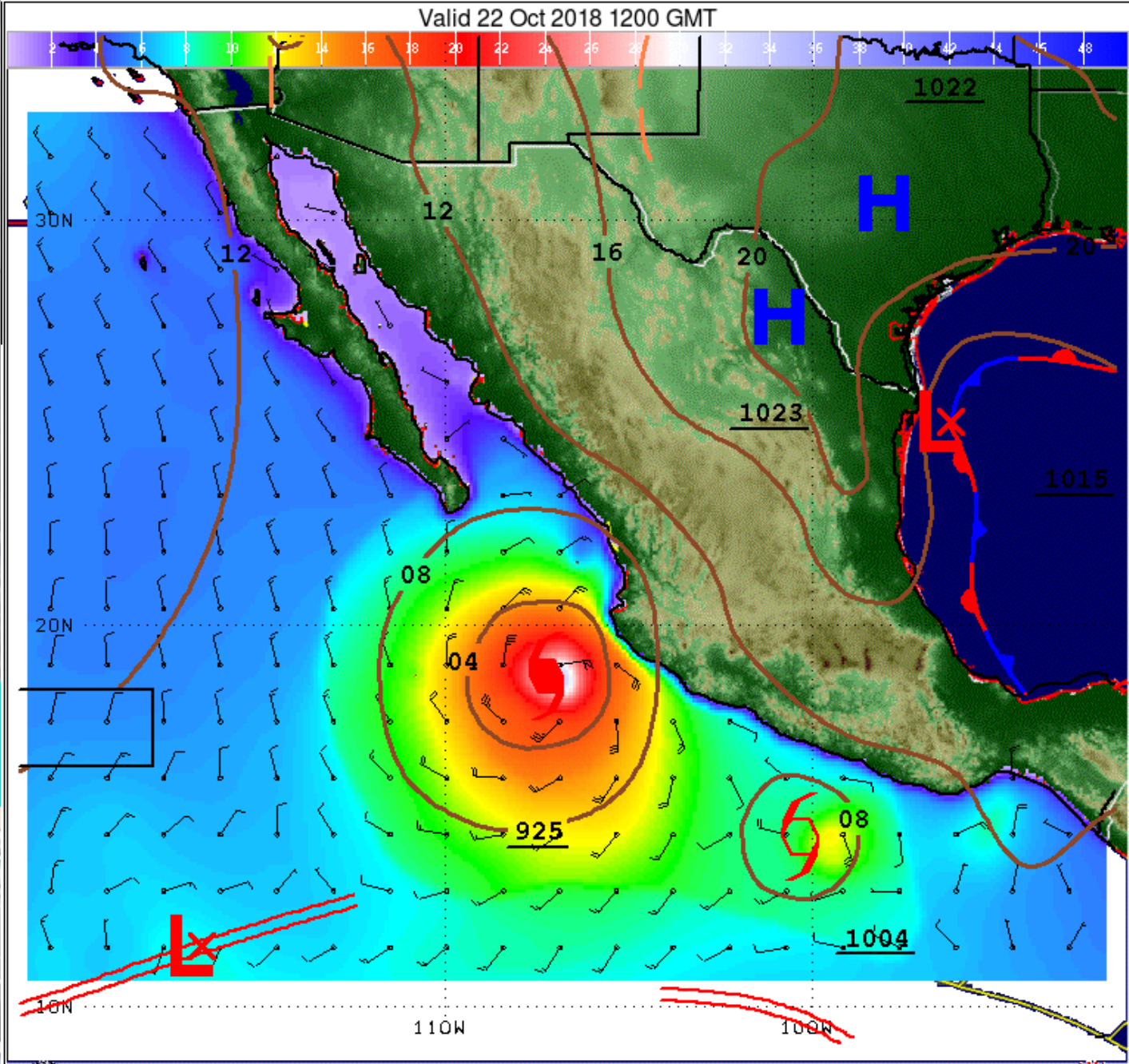
...HURRICANE WARNING...  
.HURRICANE JOAQUIN NEAR 23.3N 74.7W 935 MB AT 0900 UTC OCT 02 MOVING NW OR 315 DEG AT 3 KT. MAXIMUM SUSTAINED WINDS 115 KT GUSTS 140 KT. TROPICAL STORM FORCE WINDS WITHIN 160 NM W SEMICIRCLE...140 NM NE QUADRANT AND 180 NM SE QUADRANT. SEAS 12 FT OR GREATER WITHIN 400 NM NE QUADRANT...150 NM SE QUADRANT...120 NM SW QUADRANT...AND 300 NM NW QUADRANT WITH SEAS TO 39 FT. ELSEWHERE S OF 28N BETWEEN 70W AND 78W WINDS 20 TO 33 KT. SEAS 9 TO 12 FT. N OF 28N BETWEEN 70W AND 75W E WINDS 20 TO 25 KT SEAS 8 TO 10 FT. REMAINDER OF AREA N OF 21N BETWEEN 65W AND 78W AND OUTSIDE OF THE BAHAMAS WINDS 20 KT OR LESS. SEAS 8 TO 11 FT IN MIXED SWELL.





# Marine Composite Page – Winds, Waves, and Features

<https://www.nhc.noaa.gov/marine/forecast/enhanced/atcfull.php>



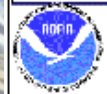
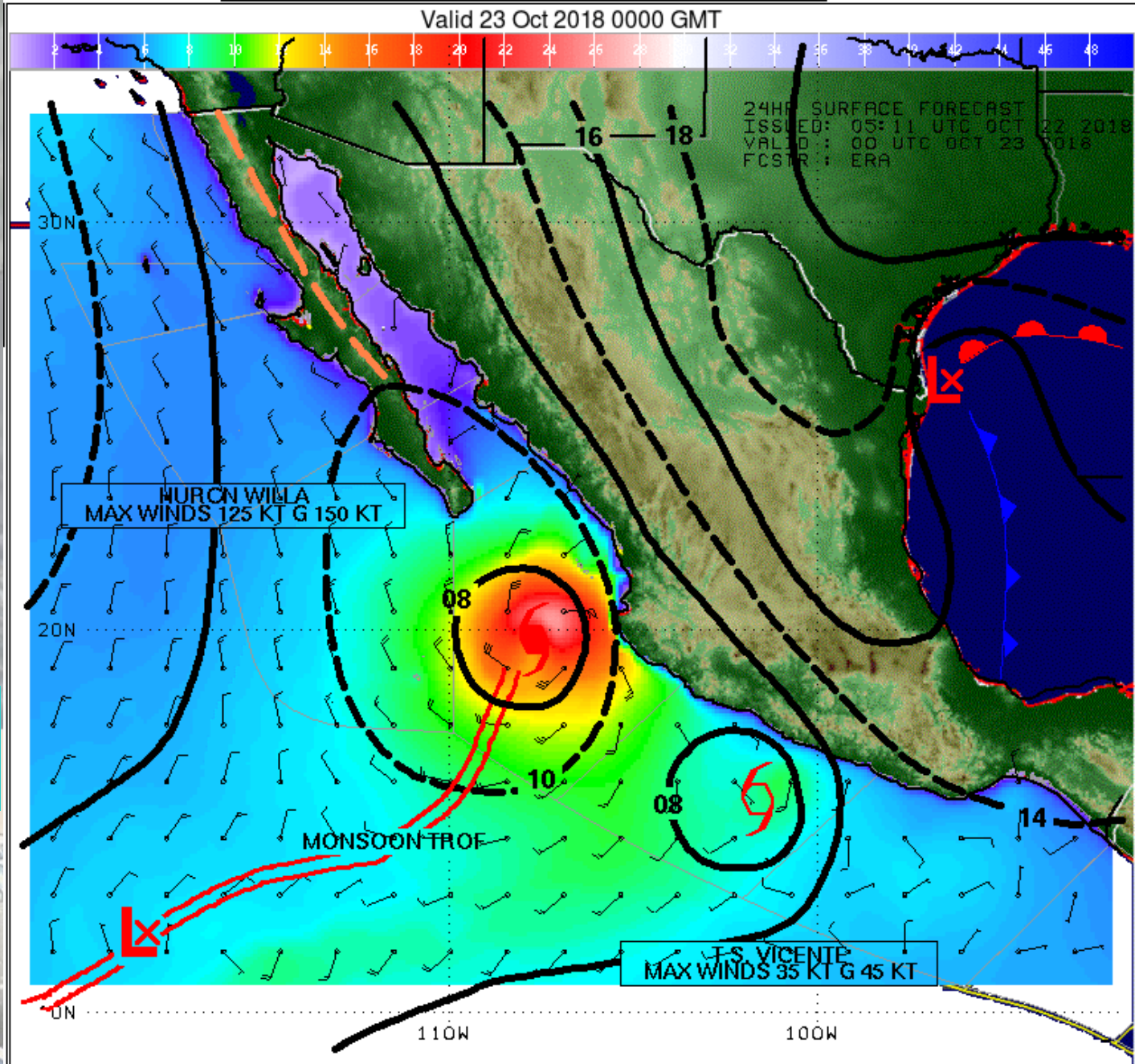
NHC/TAFB Experimental Gridded Marine Forecasts





# Marine Composite Page – Winds, Waves, and Features

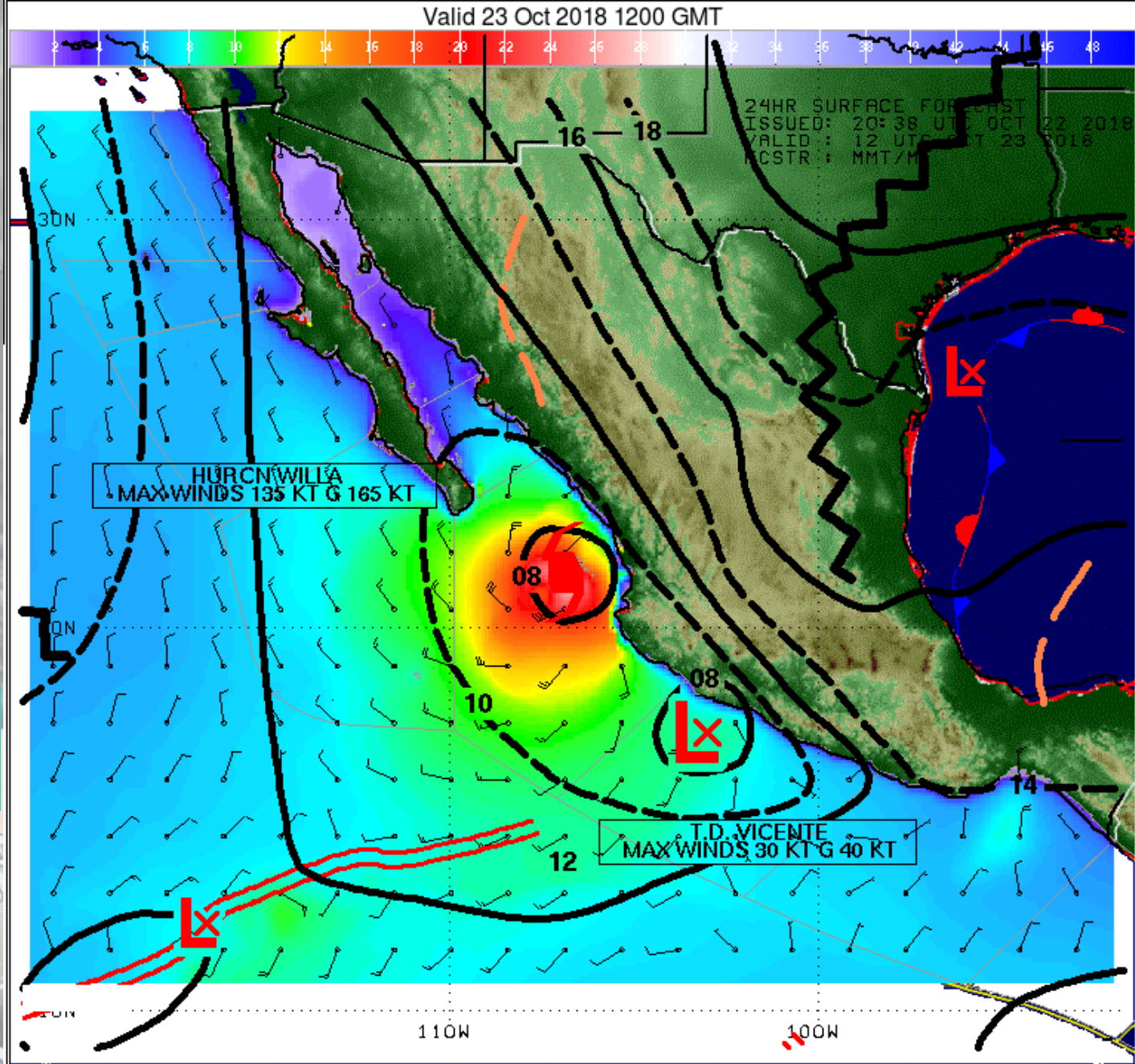
<https://www.nhc.noaa.gov/marine/forecast/enhanced/atcfull.php>





# Marine Composite Page – Winds, Waves, and Features

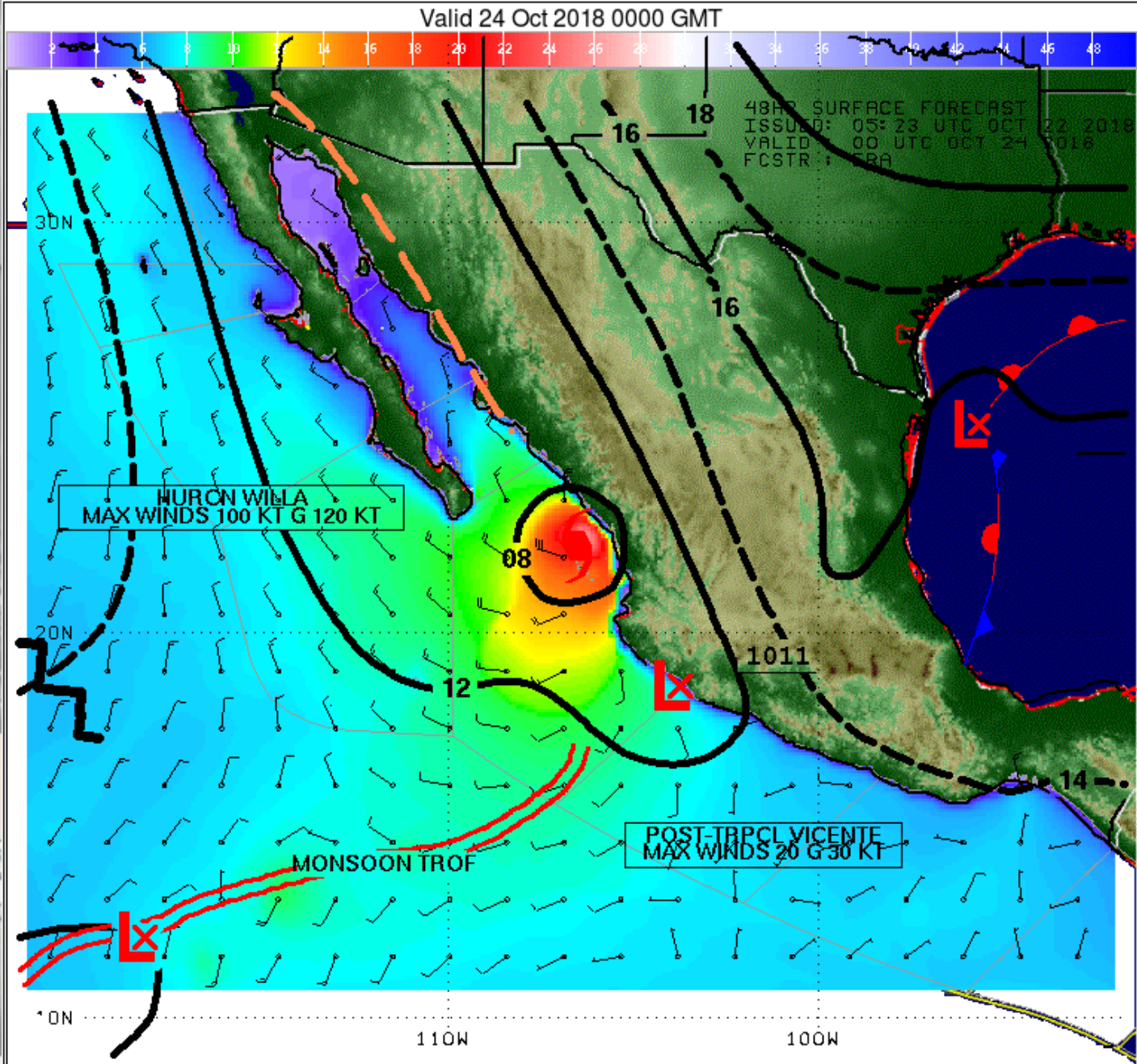
<https://www.nhc.noaa.gov/marine/forecast/enhanced/atcfull.php>





# Marine Composite Page – Winds, Waves, and Features

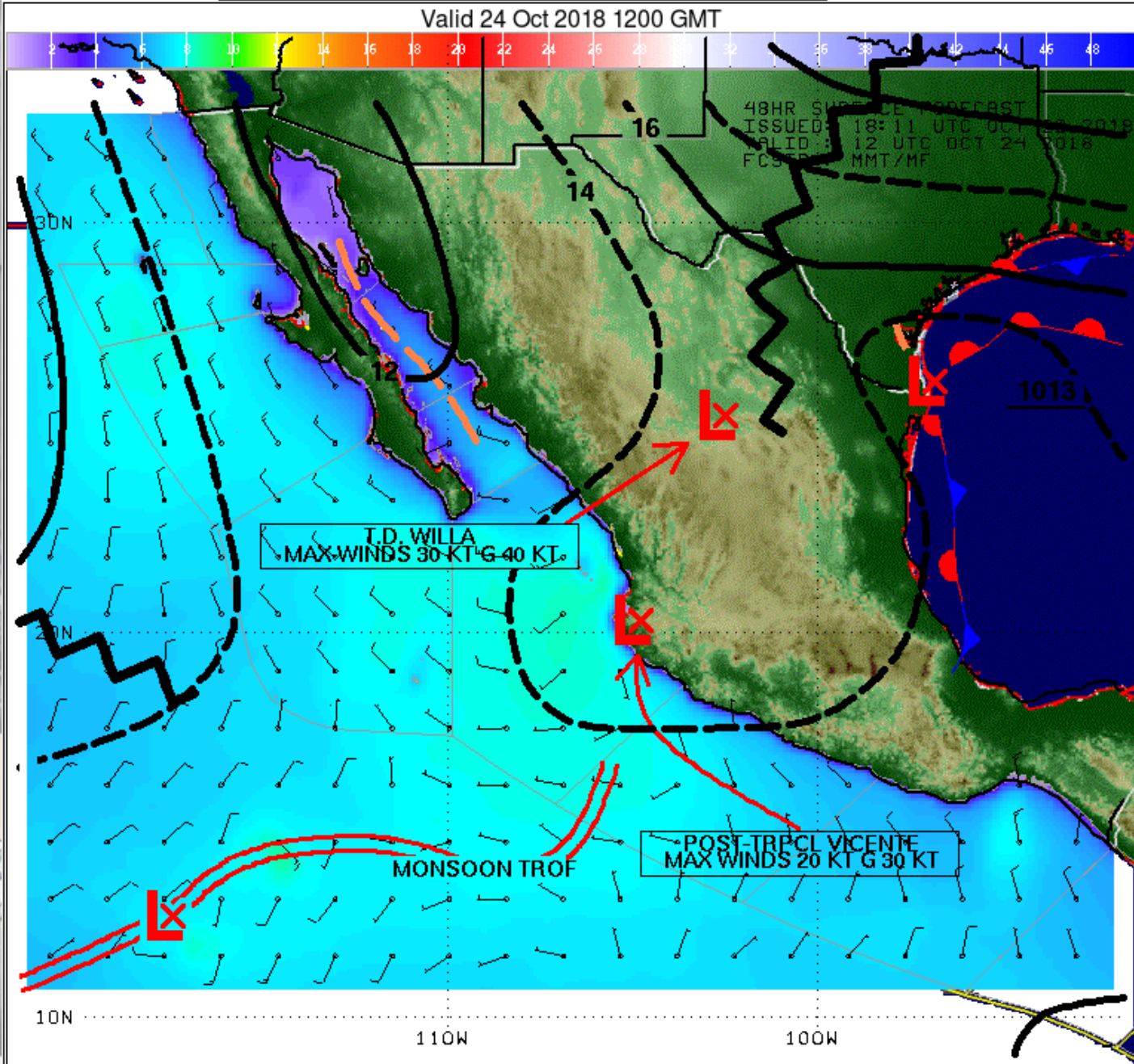
<https://www.nhc.noaa.gov/marine/forecast/enhanced/atcfull.php>





# Marine Composite Page – Winds, Waves, and Features

<https://www.nhc.noaa.gov/marine/forecast/enhanced/atcfull.php>



# 2019 NHC/TAFB Spot Forecasts for U.S. Coast Guard





# 2019 NHC/TAFB Spot Forecasts for U.S. Coast Guard



**"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

Honolulu  
HAWAII  
Hilo



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





# Decision Support Services to U.S. Coast Guard Districts by Tropical Analysis and Forecast Branch (TAFB)/ National Hurricane Center (NHC)



## Atlantic Maritime Search and Rescue Regions

UNCLASSIFIED

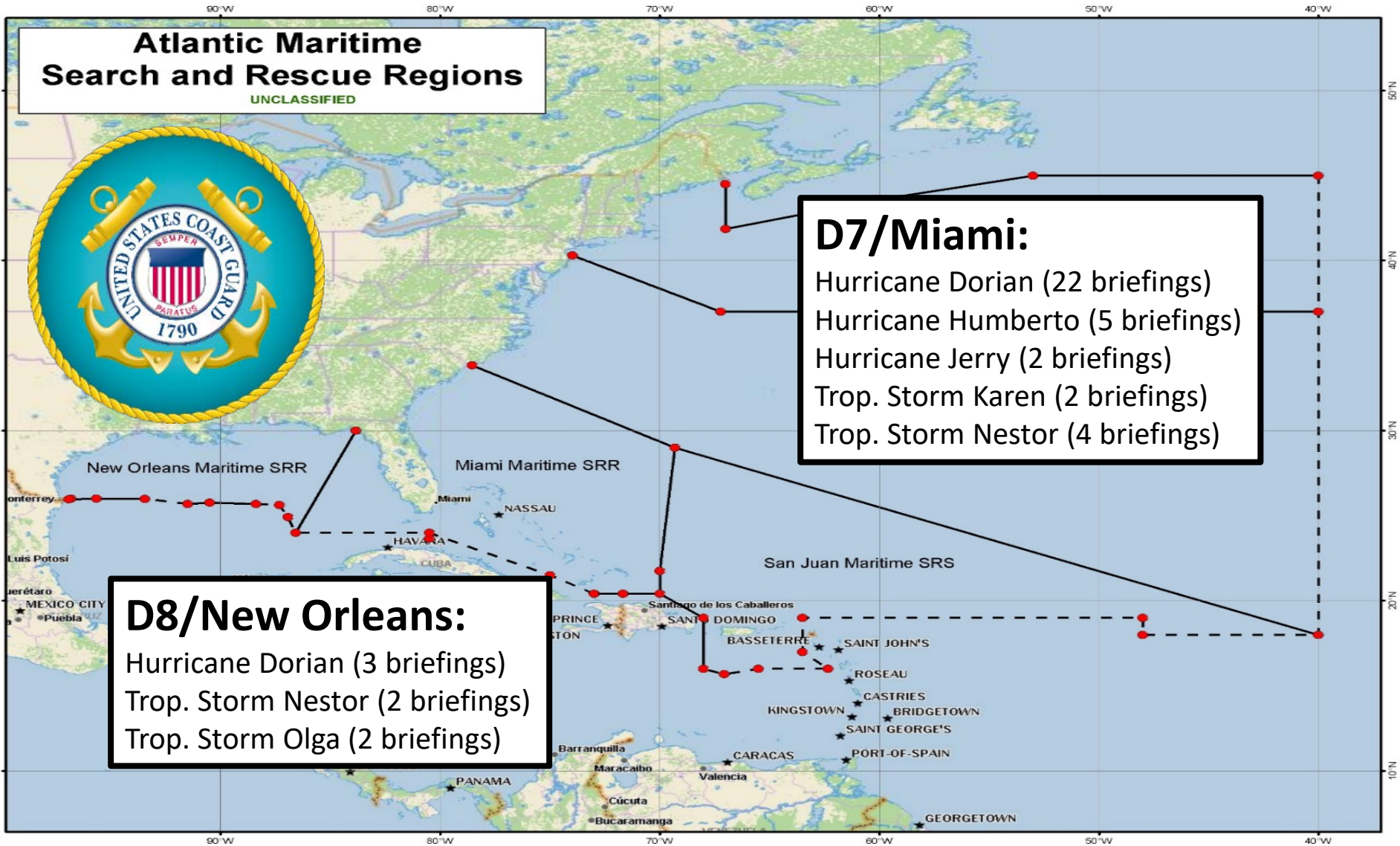


### D7/Miami:

- Hurricane Dorian (22 briefings)
- Hurricane Humberto (5 briefings)
- Hurricane Jerry (2 briefings)
- Trop. Storm Karen (2 briefings)
- Trop. Storm Nestor (4 briefings)

### D8/New Orleans:

- Hurricane Dorian (3 briefings)
- Trop. Storm Nestor (2 briefings)
- Trop. Storm Olga (2 briefings)







# What is a Hurricane?

- *A type of Tropical Cyclone*
- *Closed surface circulation*
- *Winds rotate counter-clockwise*
- *Produces organized thunderstorm activity*
- *Not associated with a frontal boundary*

- ***Tropical Depression***

*Sustained winds are less than 39 mph*

- ***Tropical Storm***

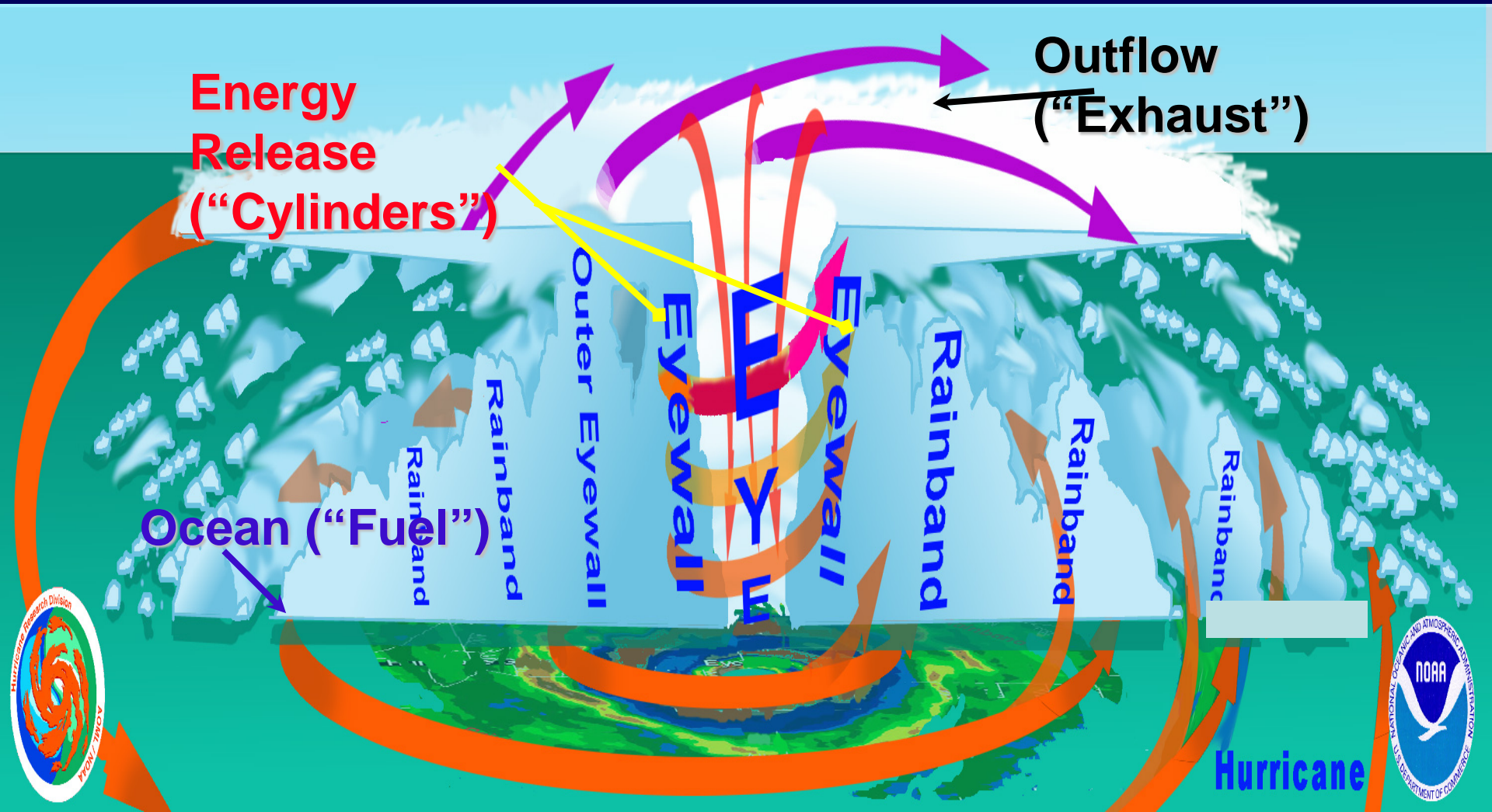
*Sustained winds are between 39-73 mph*

- ***Hurricane***

*Sustained winds are 74 mph or greater*

# Nature's great heat engine...

# The Hurricane





# Wind-caused Damage



# Storm Surge



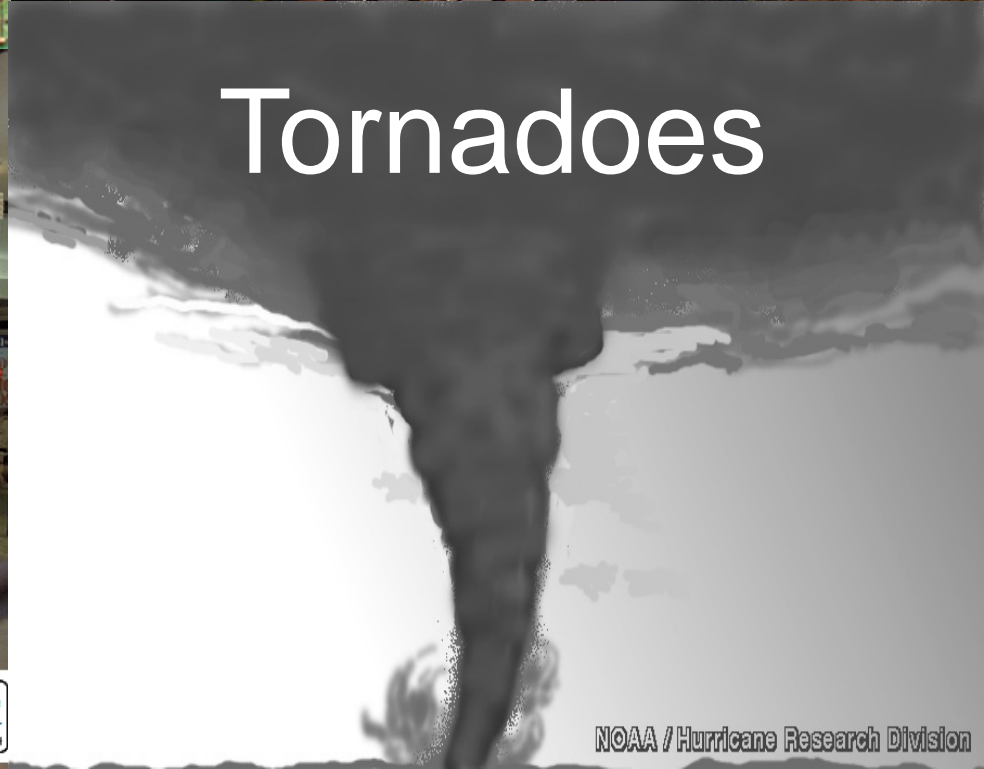
# Inland Flooding



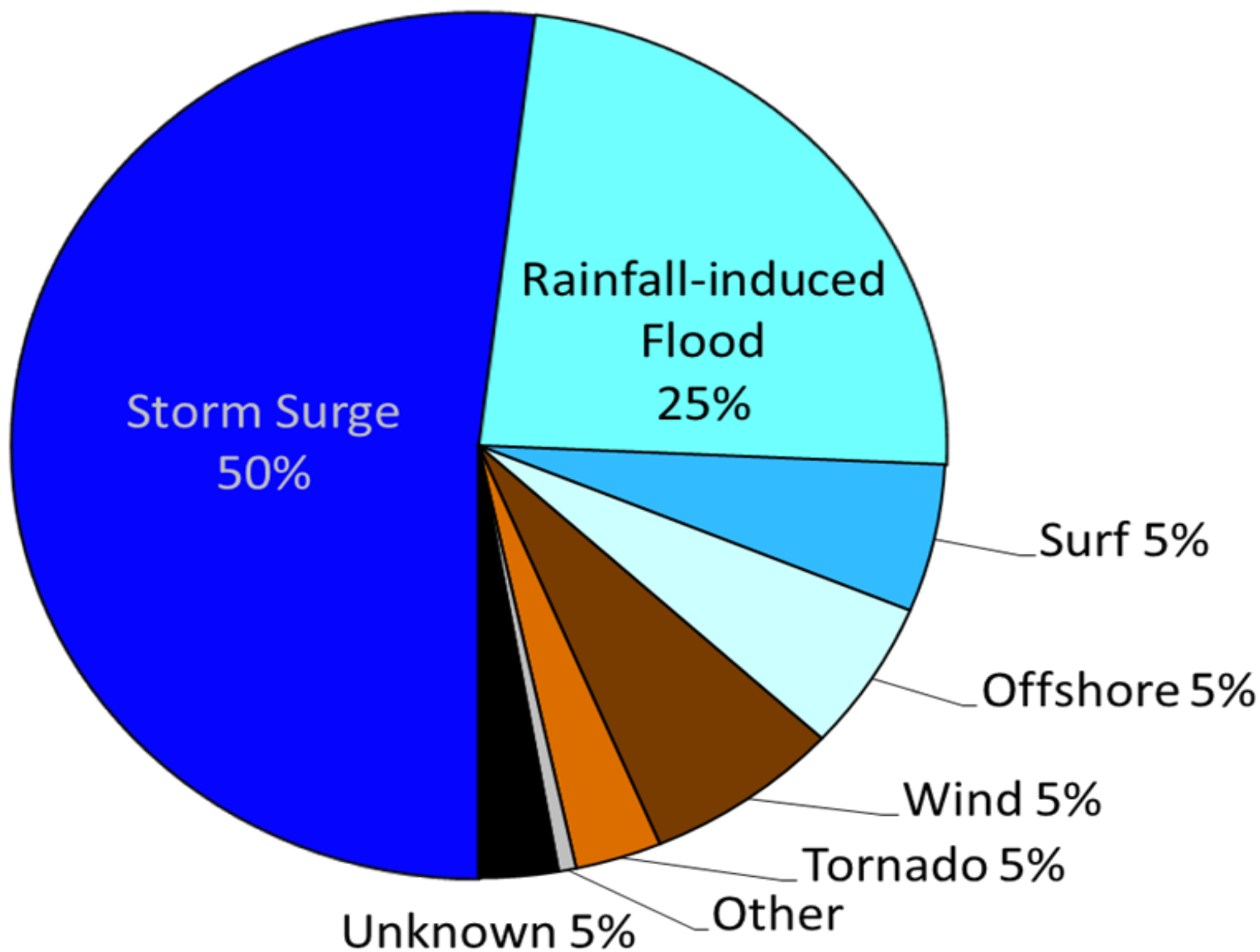
Buffalo Bayou, Downtown Tunnel Flooded, 6/9/01



# Tornadoes



# U.S. Atlantic Tropical Cyclone Deaths, 1962-2011







Before Katrina...

David & Kimberly King  
Waveland, MS



...After Katrina

David & Kimberly King  
Waveland, MS



# Emergency Planning

Census Bureau Statistics Can Help Community Leaders Prepare for Hurricanes



**185**

U.S. coastline counties along the Atlantic Ocean (129) and Gulf of Mexico (56)

**58 million**

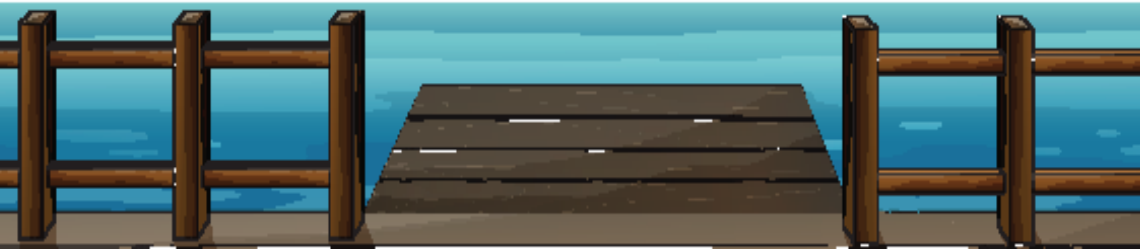
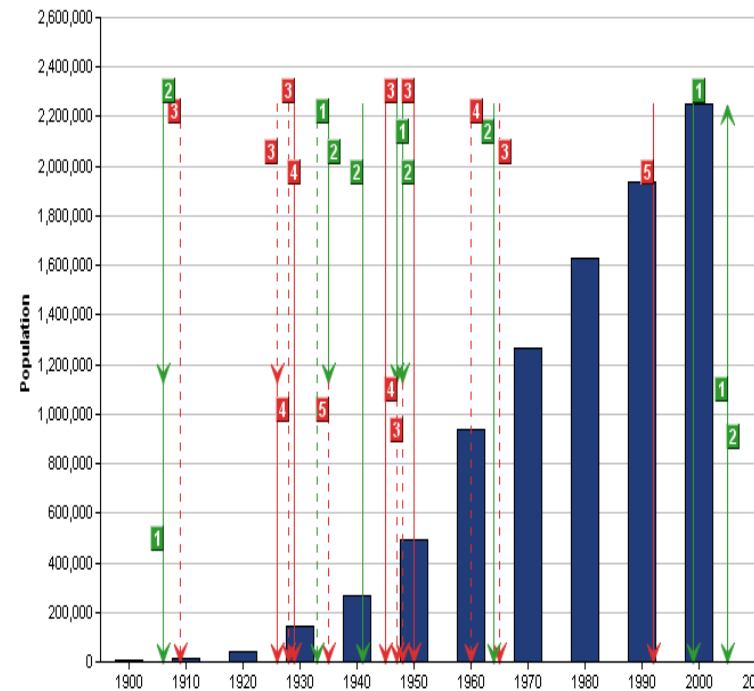
Population of coastline counties stretching from Maine to Texas



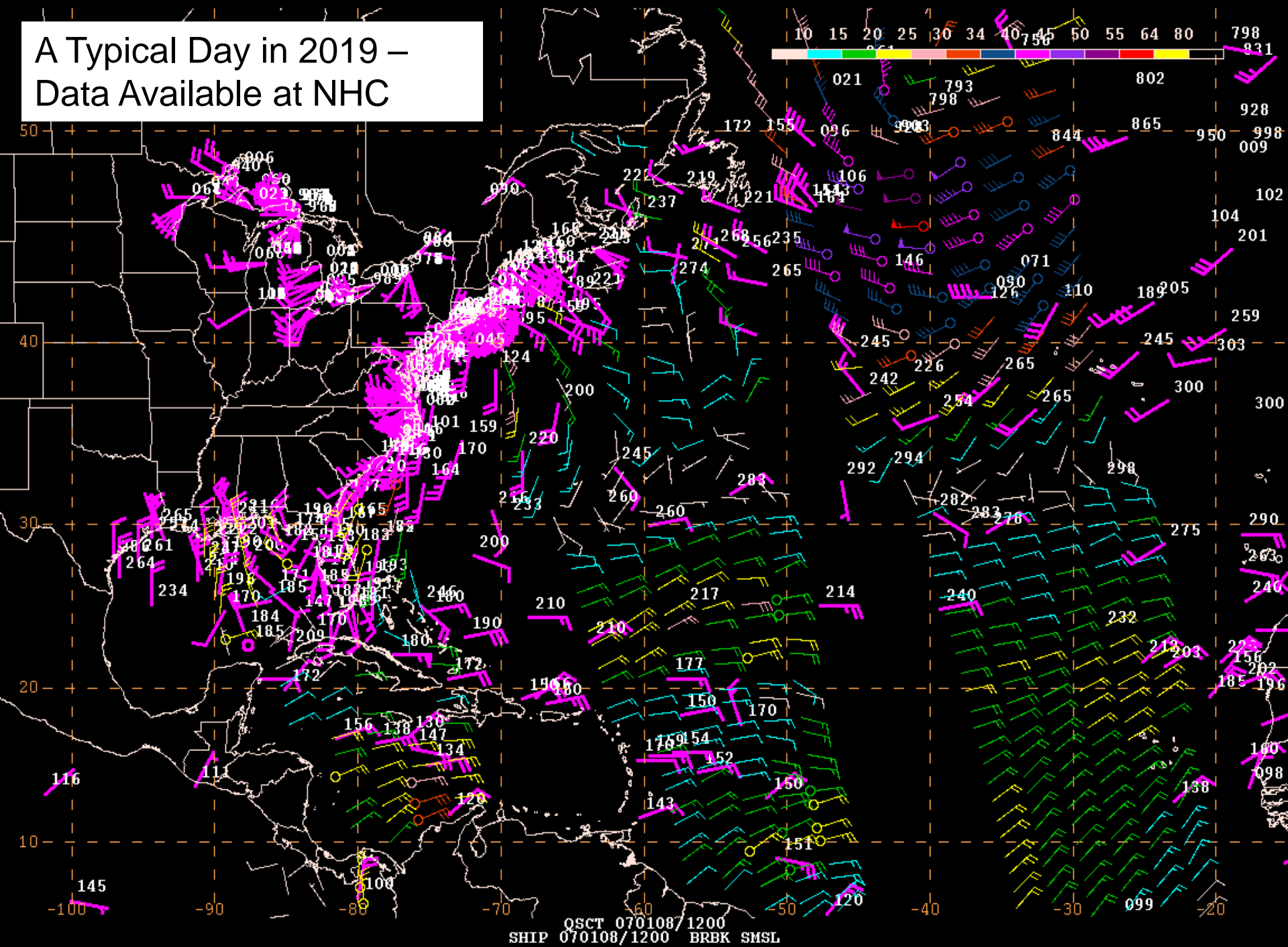
Coastline region  
 Atlantic Ocean  
 Gulf of Mexico



Hurricane Strikes vs Population for Miami-Dade, Florida

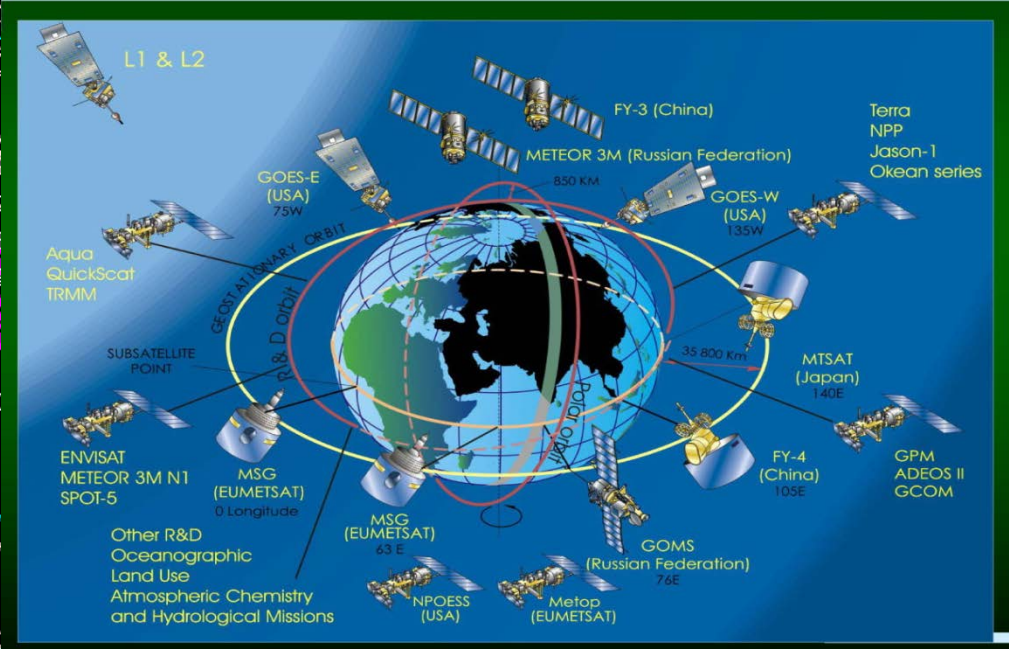
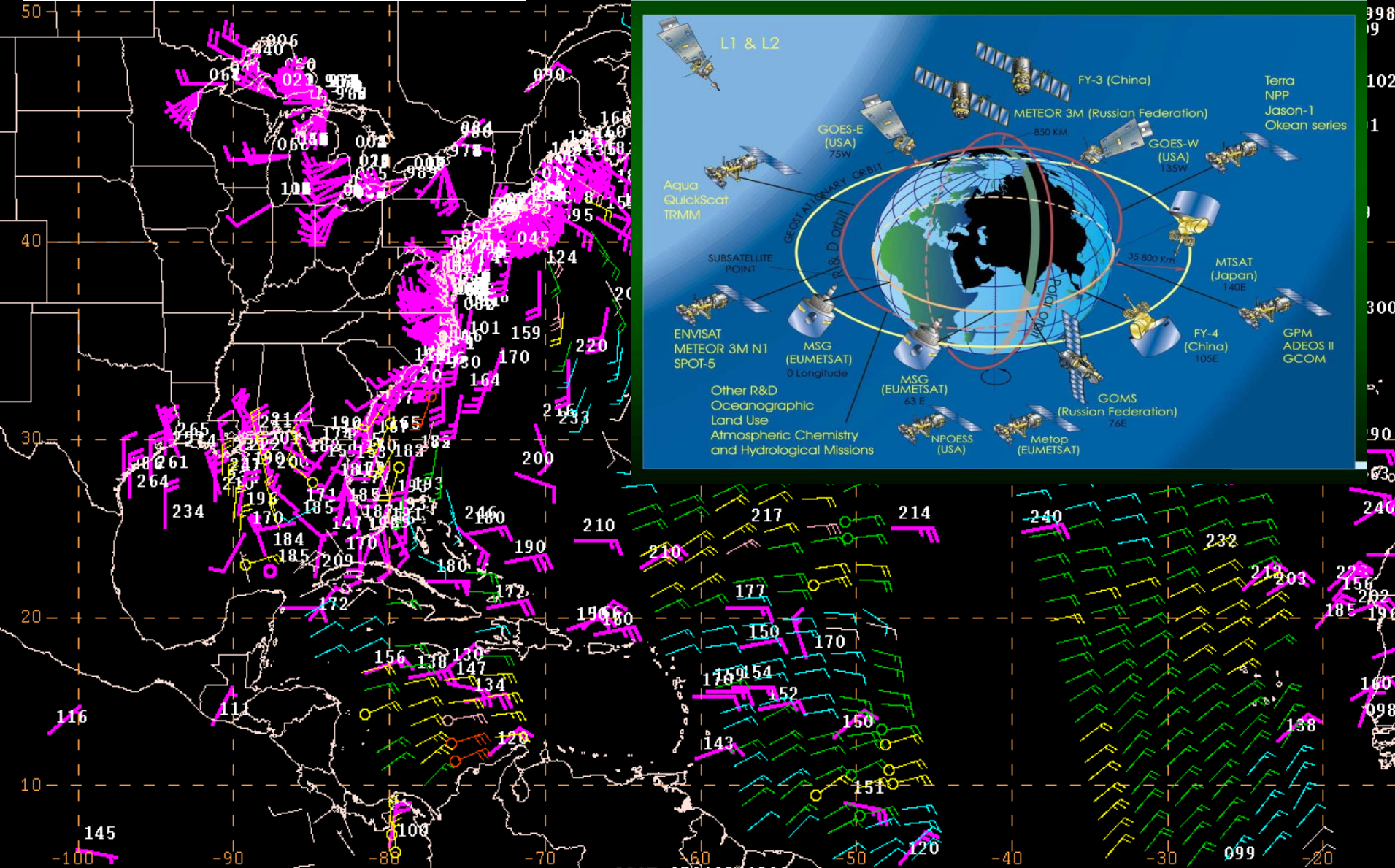


# A Typical Day in 2019 – Data Available at NHC





# A Typical Day in 2019 – Data Available at NHC

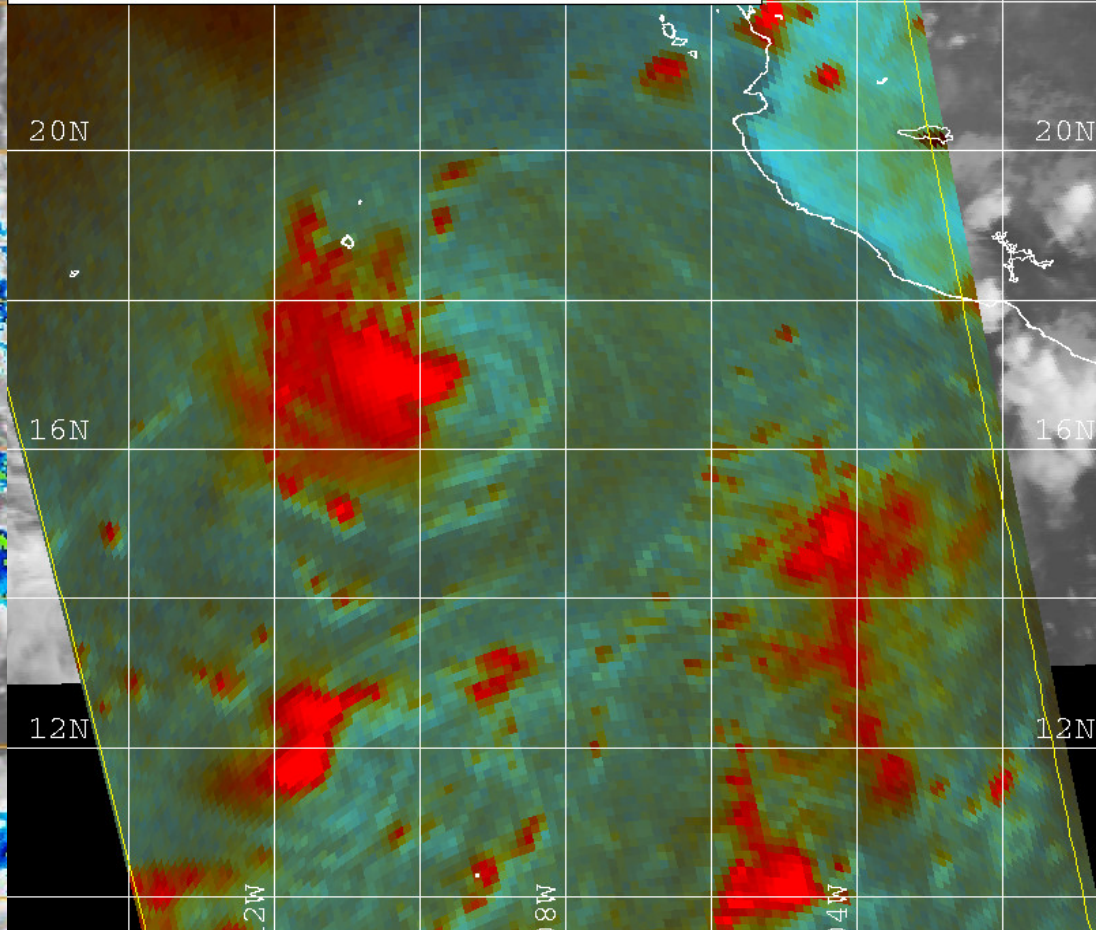


QSCAT 070108/1200  
SHIP 070108/1200 BRBK SMSL



# 0430 UTC 27 August GOES-10 IR

08/27/04 0000Z 10E GEORGETTE  
08/27/04 0411Z SSMI F-15 COMPOSITE  
08/27/04 0245Z GOES-10 IR



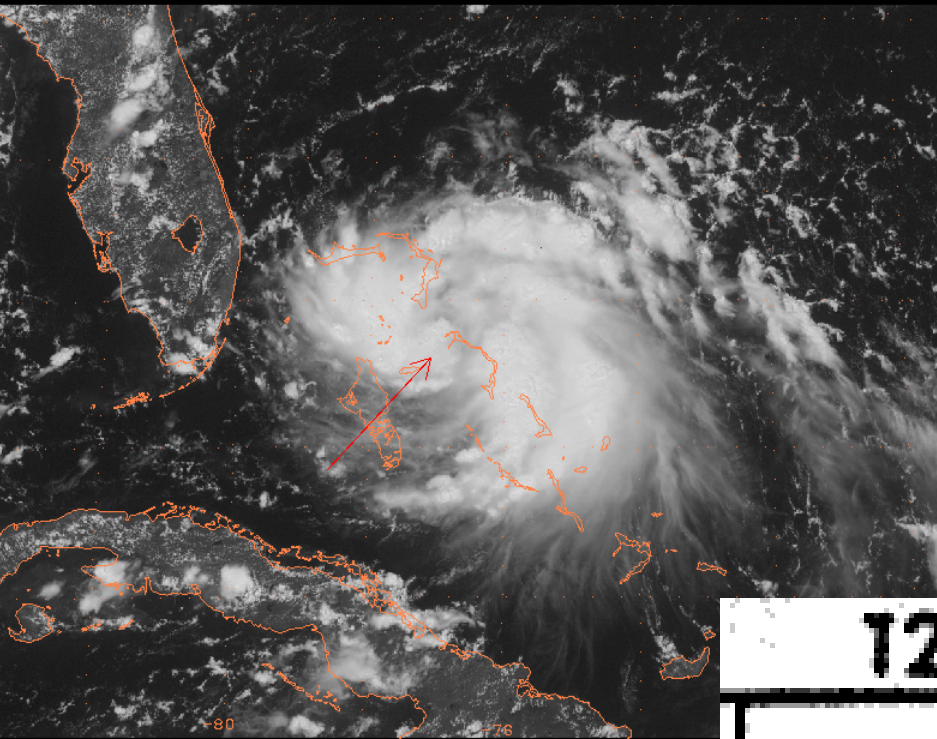
Naval Research Lab [http://www.nrlmry.navy.mil/sat\\_products.html](http://www.nrlmry.navy.mil/sat_products.html)  
Red=85PCT Green=85H Blue=85V



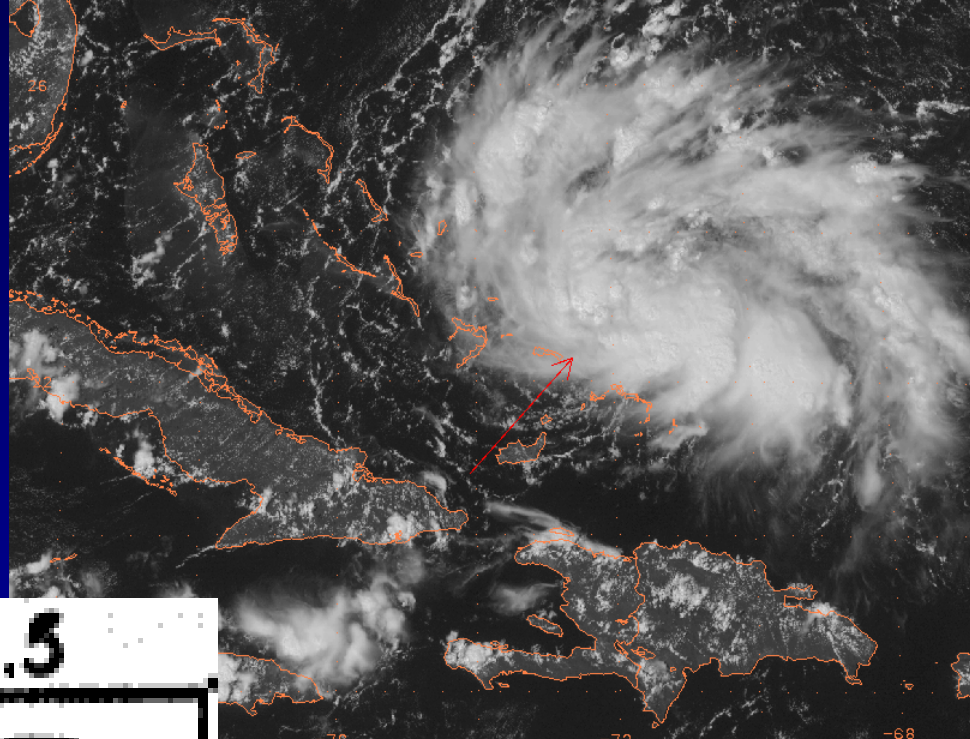
# Satellite Imagery – Dvorak Technique

Katrina August 24

Rita September 18

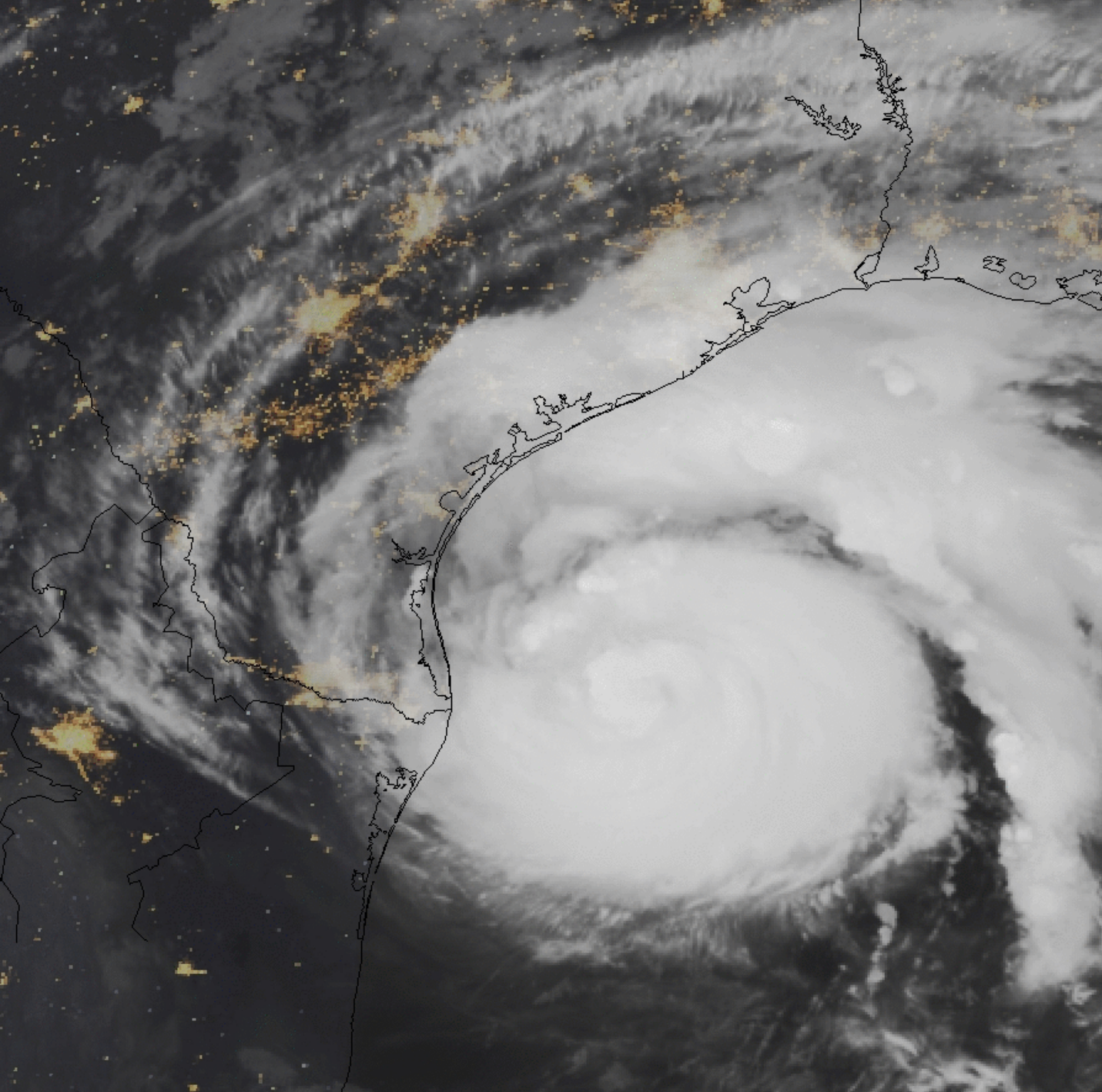


GOES12 VIS 25.2 -77.1 20050824\_1745



GOES12 VIS 22.3 -72.6 20050918\_1745





**GOES-16: A new era of geostationary satellite imagery and data**







**“Miss Piggy” Built in 1976 at Lockheed-Martin, Marietta, Georgia**



**“Kermit” Built in 1975 at Lockheed-Martin, Marietta, Georgia**

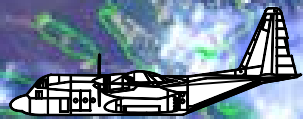


**“Gonzo” Built in 1994 at Gulfstream Aerospace Corporation in Savannah Georgia**

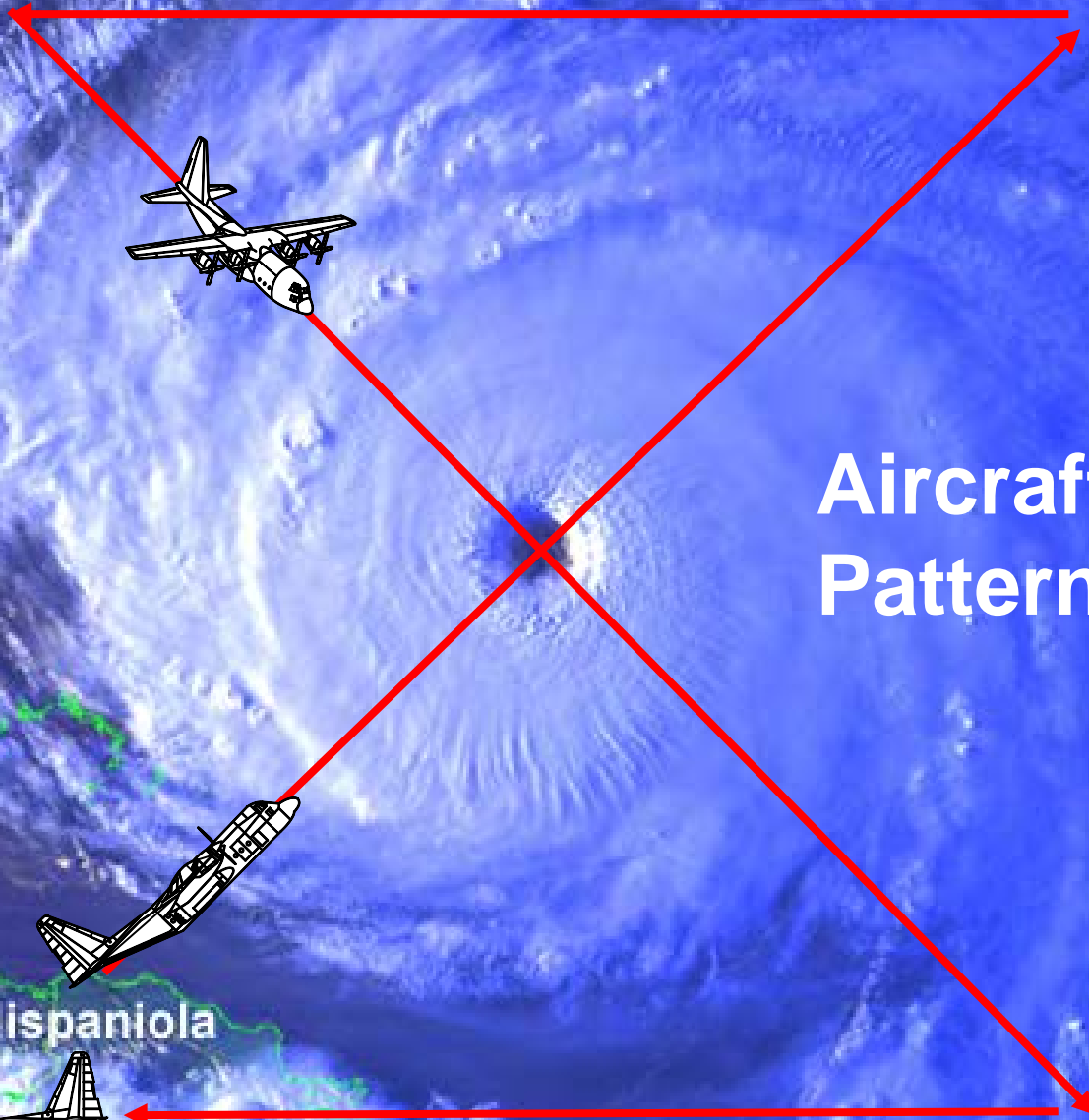


# RECONNAISSANCE FLIGHT PATH

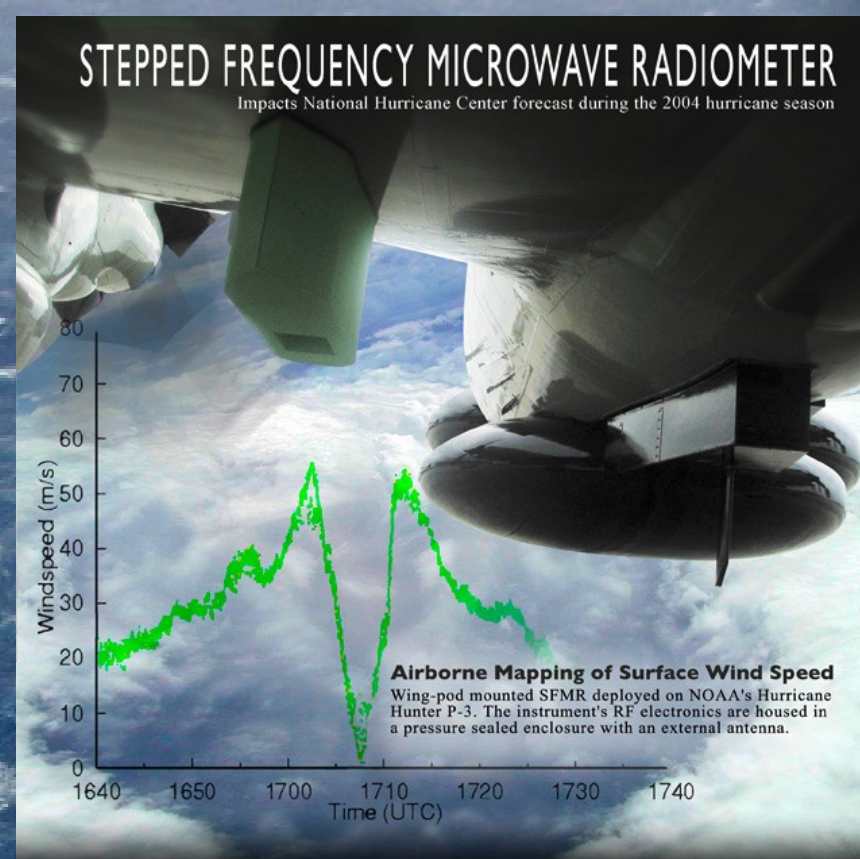
Aircraft "ALPHA"  
Pattern



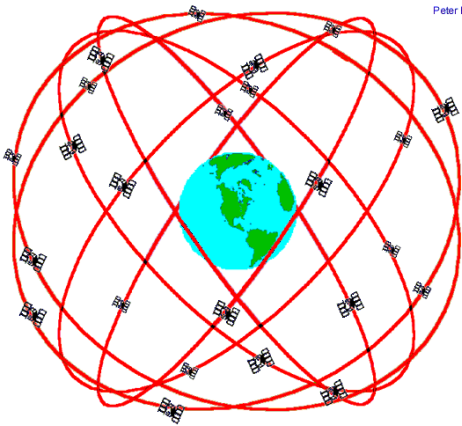
Hispaniola



# Sea state under Hurricane Isabel







GPS Nominal Constellation  
24 Satellites in 6 Orbital Planes  
4 Satellites in each Plane  
20,200 km Altitudes, 55 Degree Inclination

# GPS DROPWINDSONDE

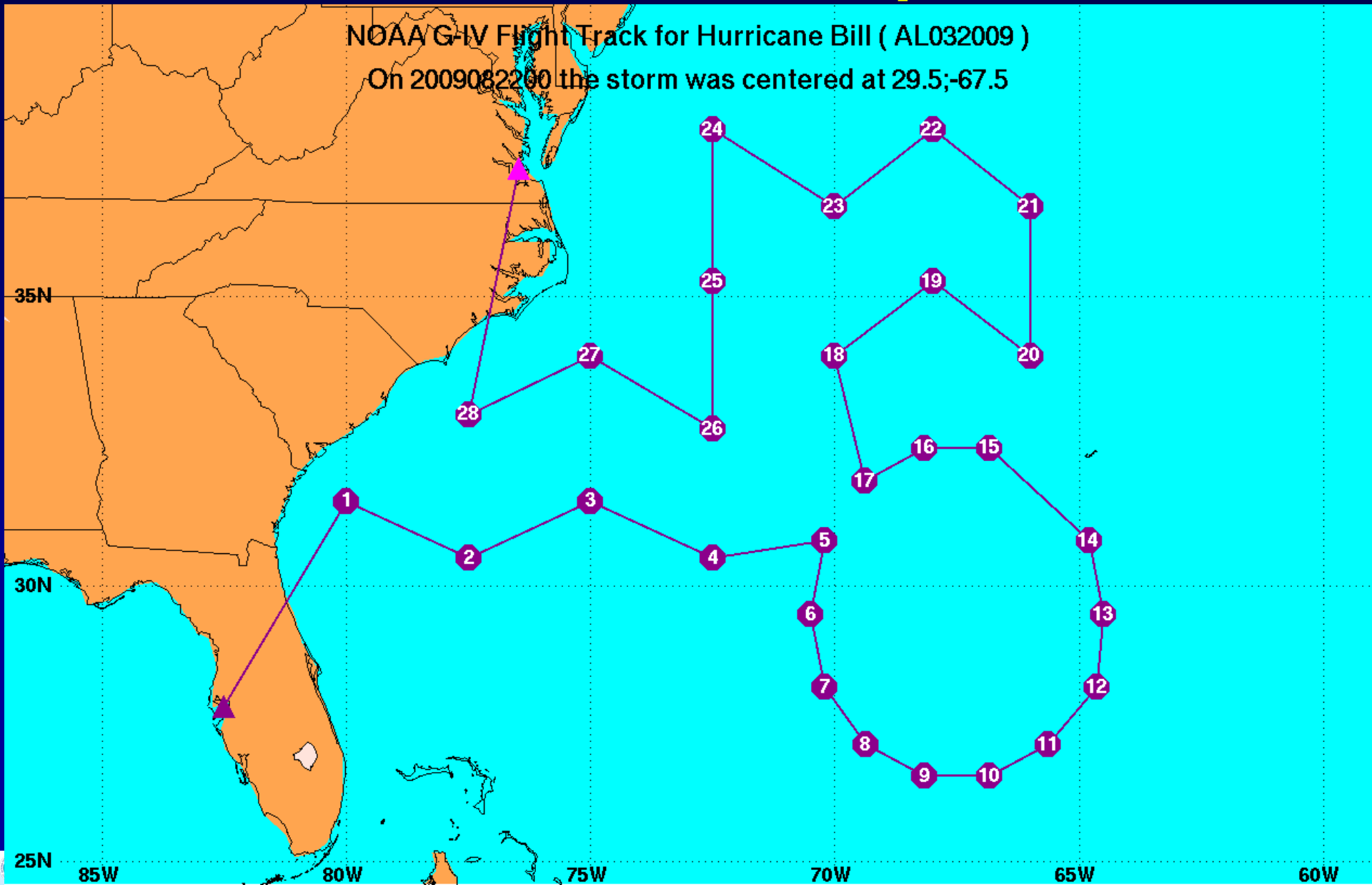
- **Developed in conjunction with the NOAA Gulfstream-IV jet aircraft. First use for hurricane was late in 1996 season.**
- **GPS dropsondes provide, for the first time, direct measurements of the winds at low levels in the hurricane eyewall.**
- **Dropsonde data reveal that the structure of the eyewall is very complex, and can vary tremendously from storm to storm.**



# G-IV Aircraft Synoptic Surveillance Mission and GPS Dropsondes

NOAA G-IV Flight Track for Hurricane Bill ( AL032009 )

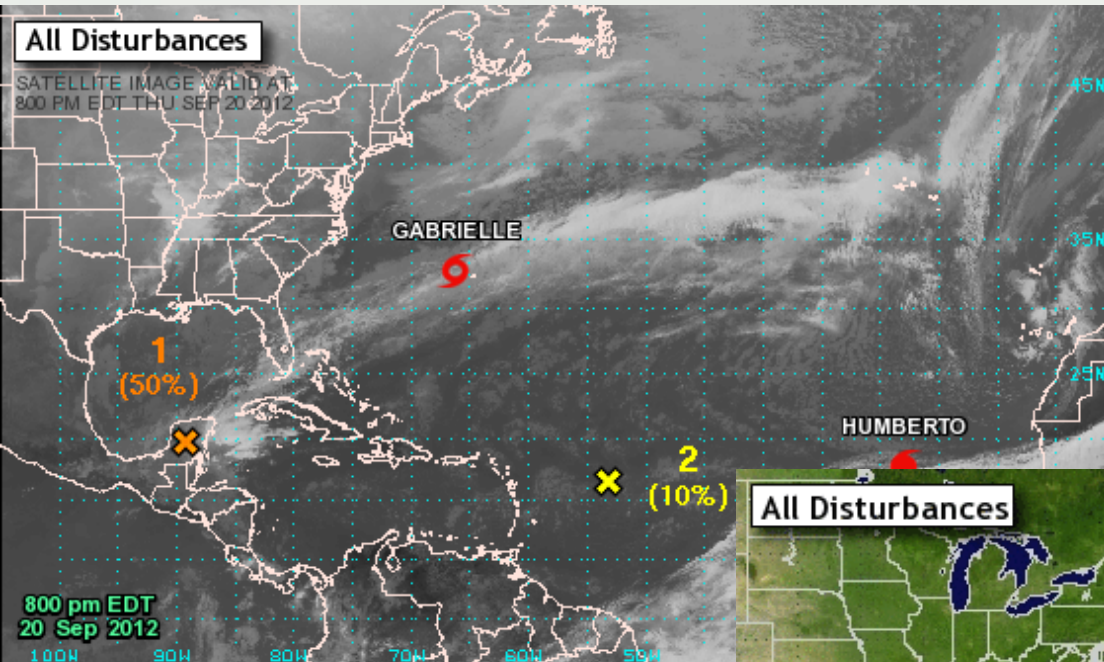
On 2009082200 the storm was centered at 29.5;-67.5







# Graphical Tropical Weather Outlook:

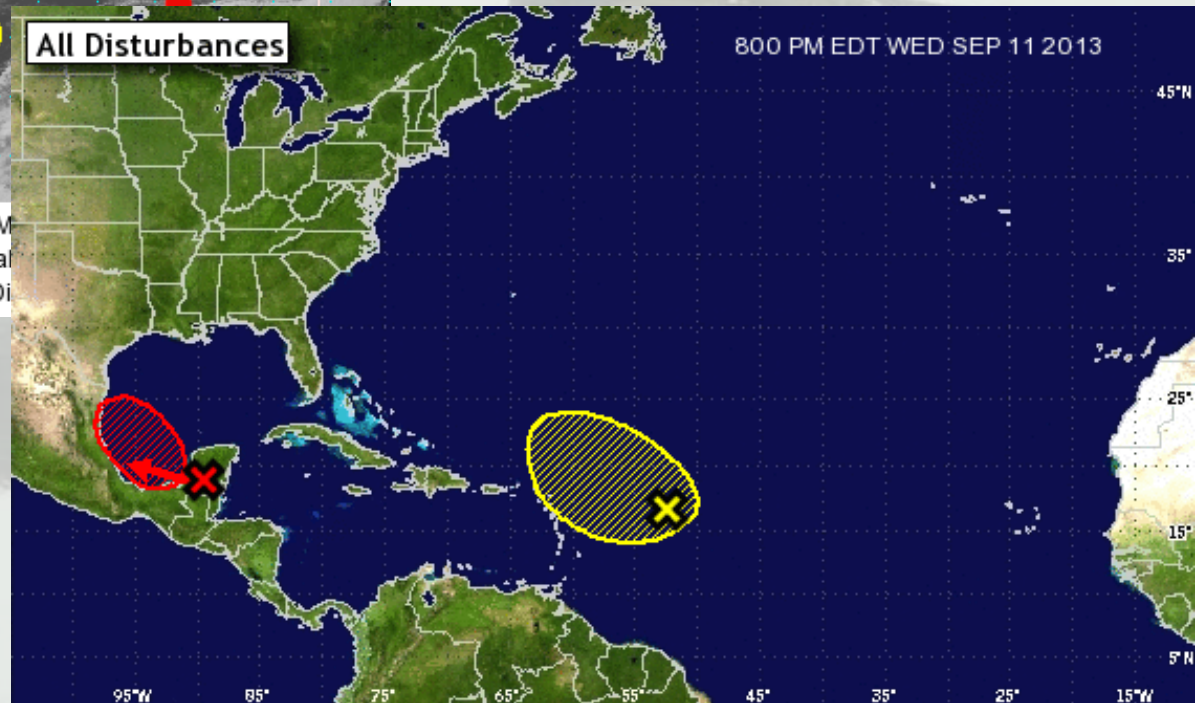


Corresponding text provided as mouse-over on web

5-day GTWO

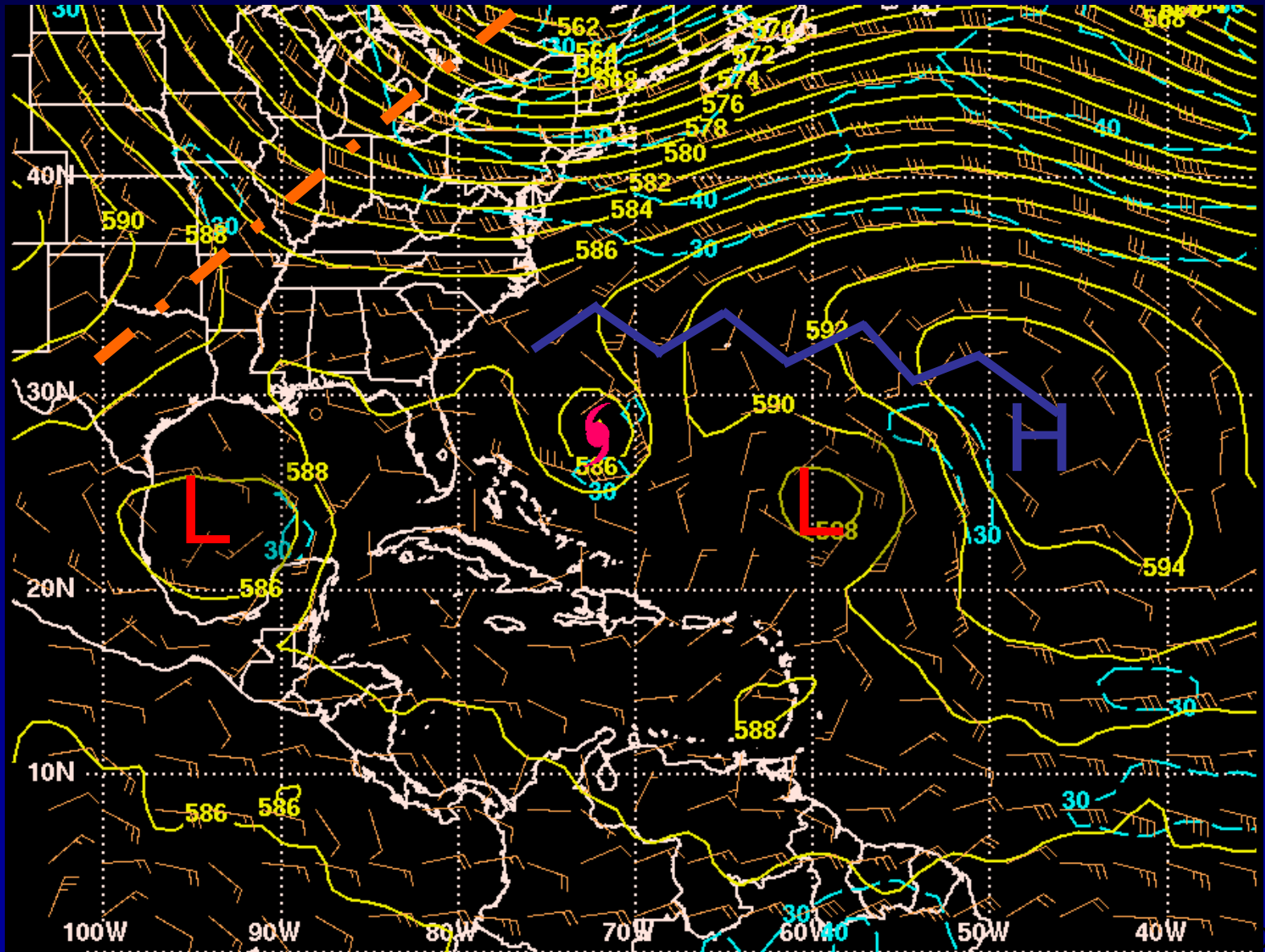


48 hour GTWO



Tropical Cyclone Formation Potential for Five-Day Period Ending 800 PM EDT MON SEP 16 2013  
Chance of Formation: Low < 30% Medium 30-50% High > 50%  
X indicates current disturbance location; shading indicates potential formation area.

# Large-Scale Steering

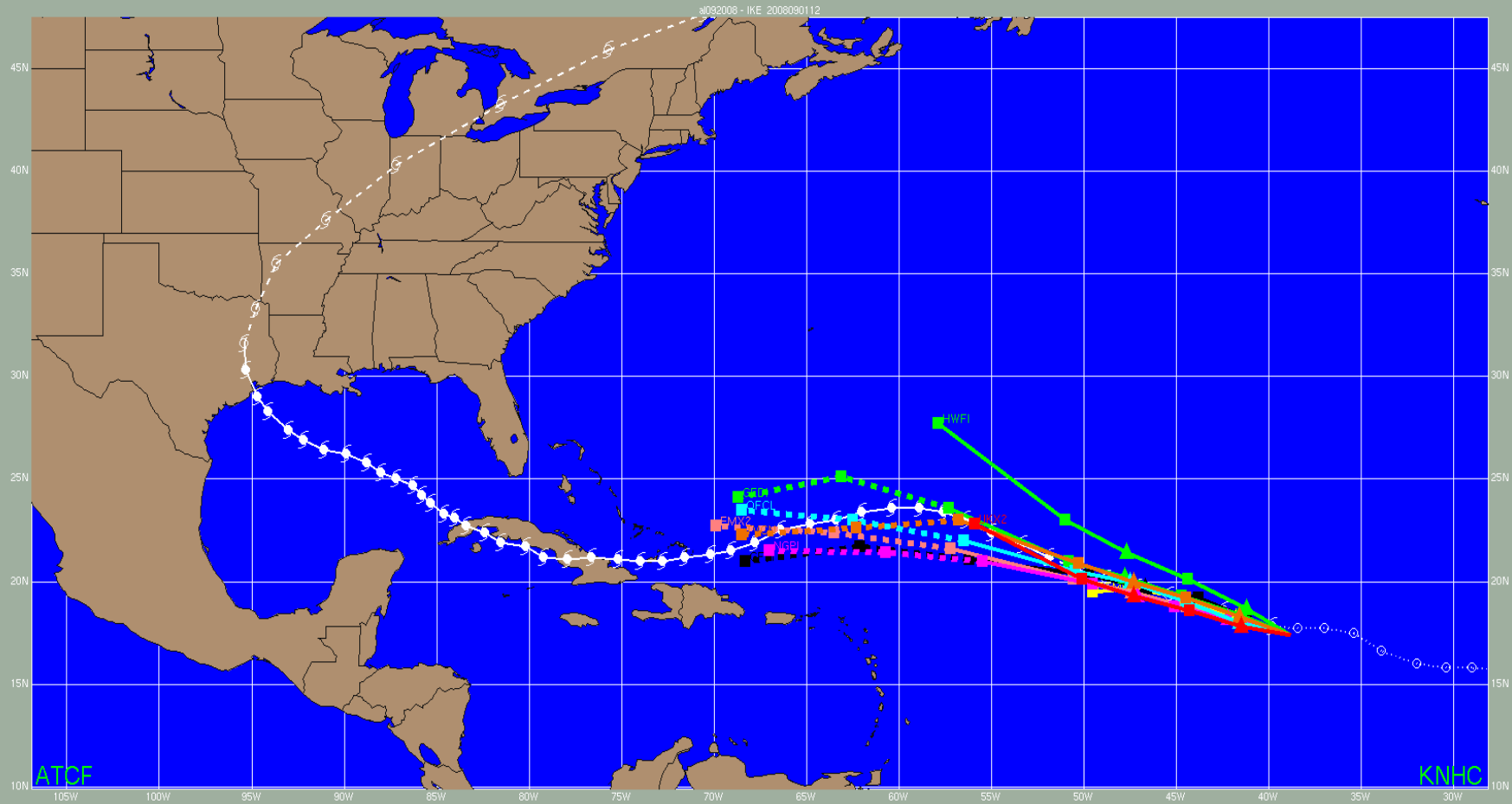


AVN 980831/1200V036 500 MB HEIGHTS, ISOTACHS & WINDS (KTS)

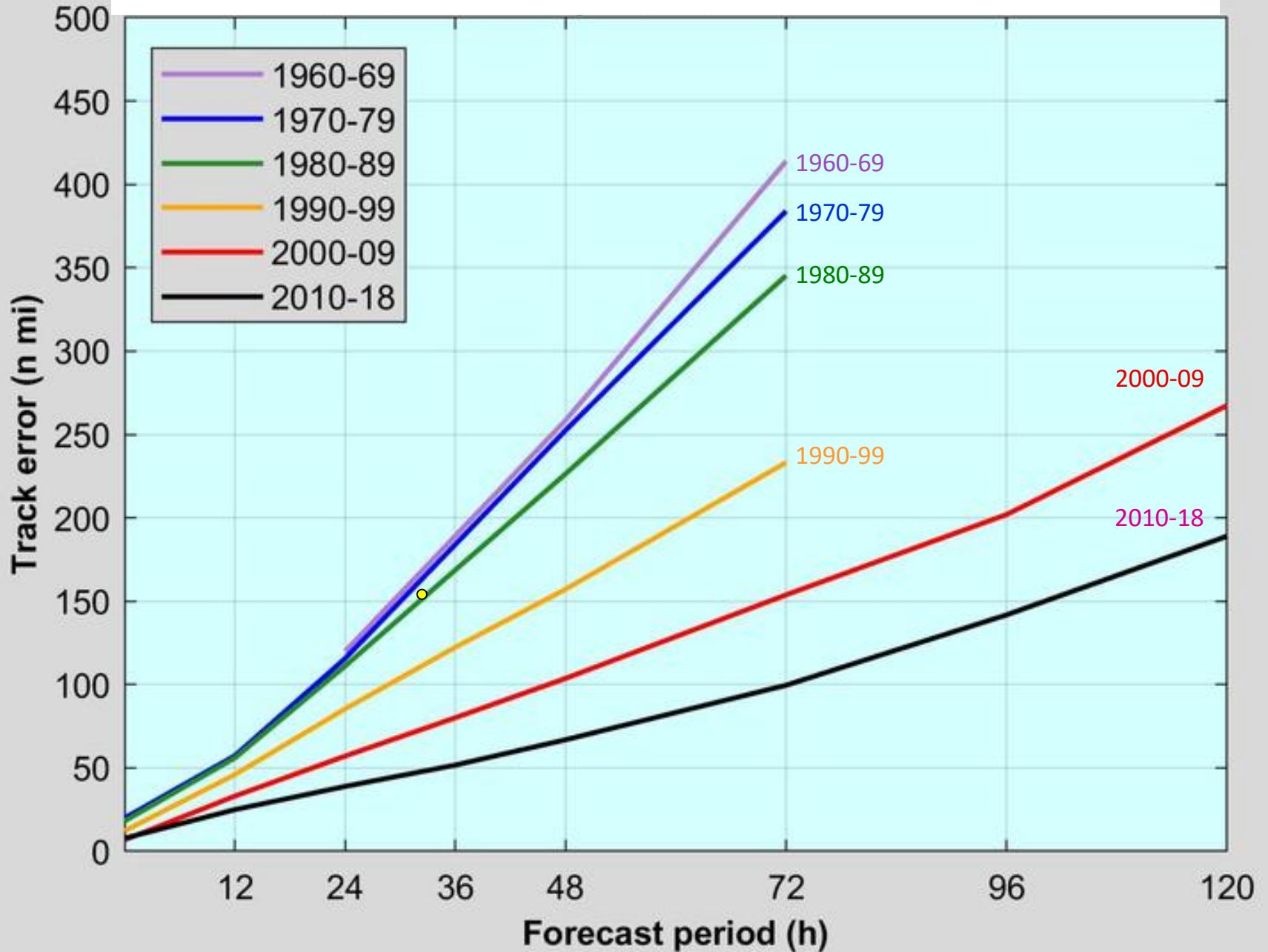




# Hurricane Ike Track models

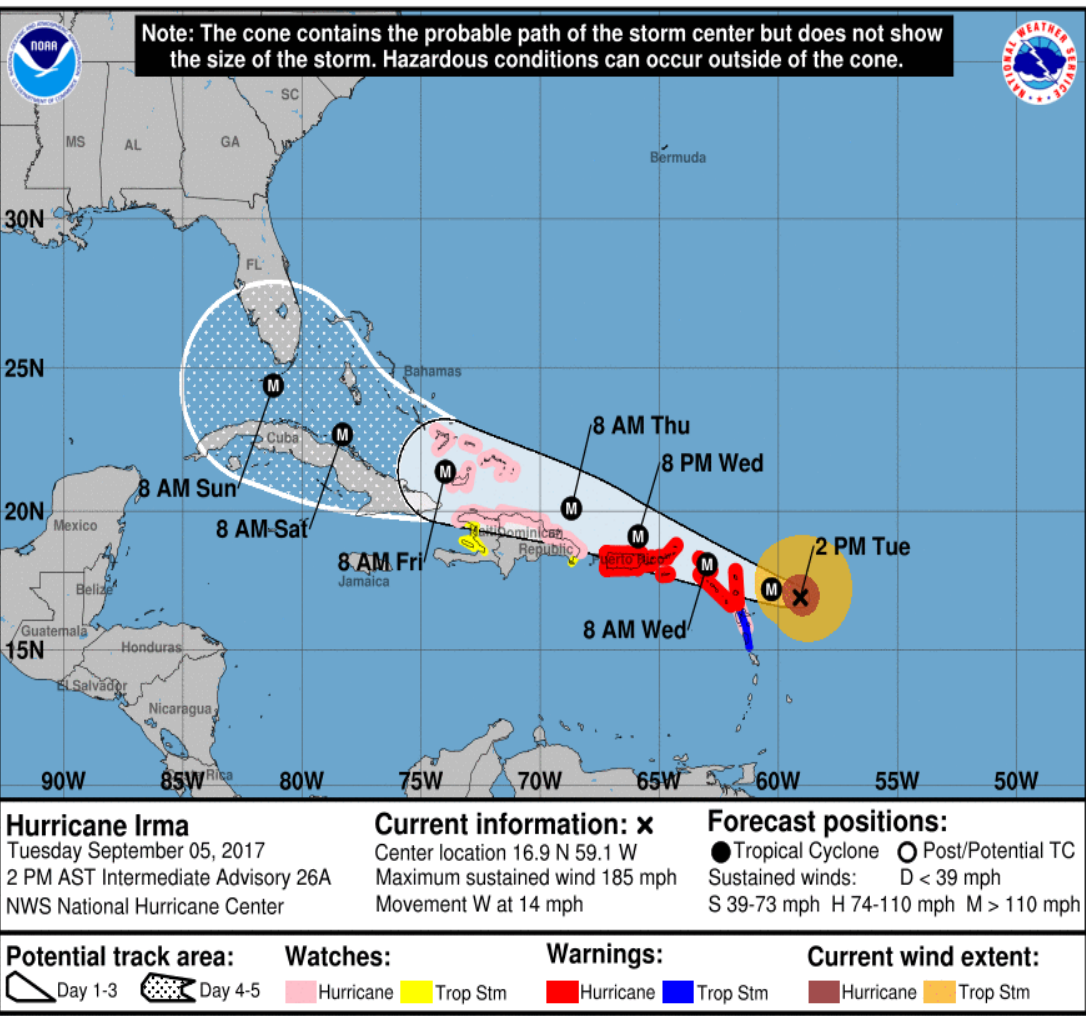


# Atlantic Track Error Trends

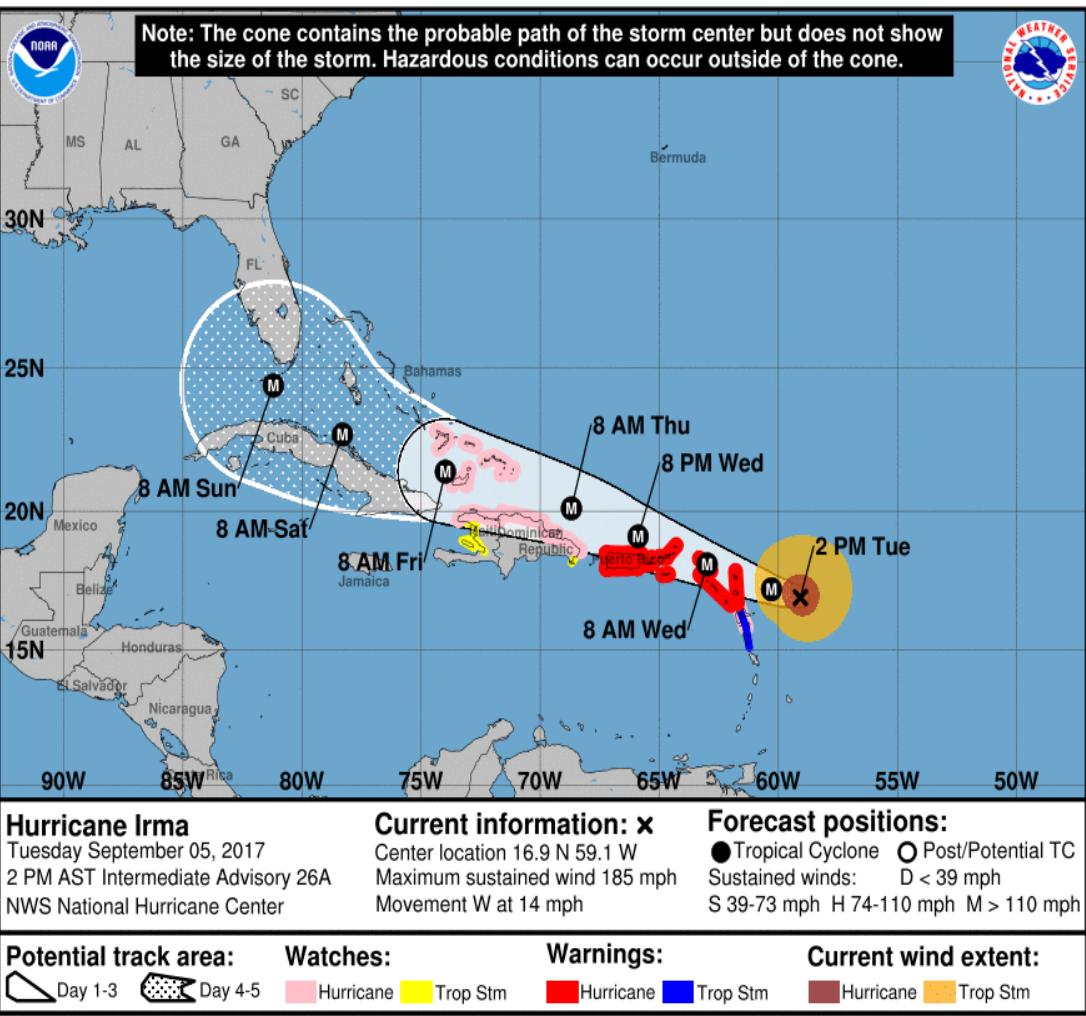




# What does the "Cone" mean?



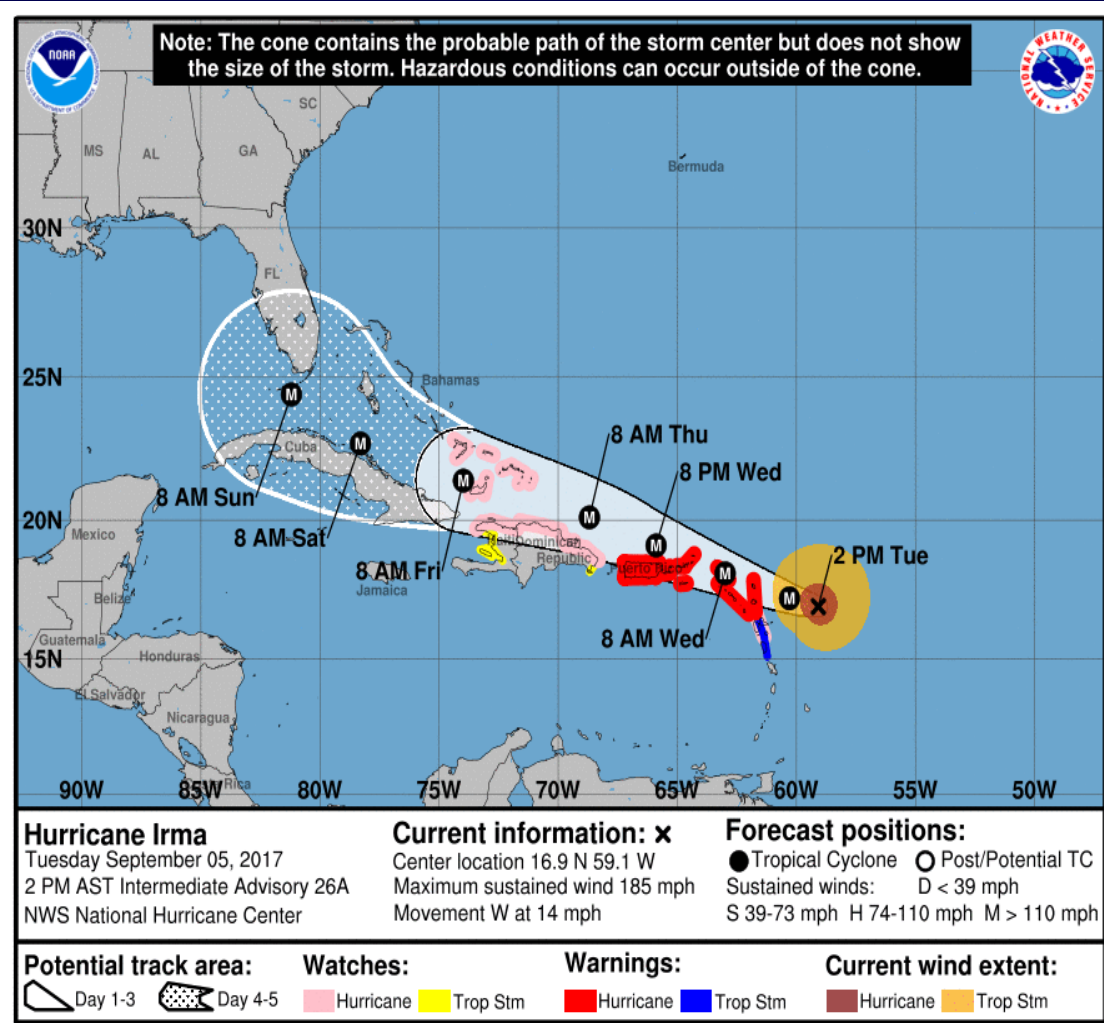
# What does the “Cone” mean?



1. Likely area of tropical storm/hurricane force winds



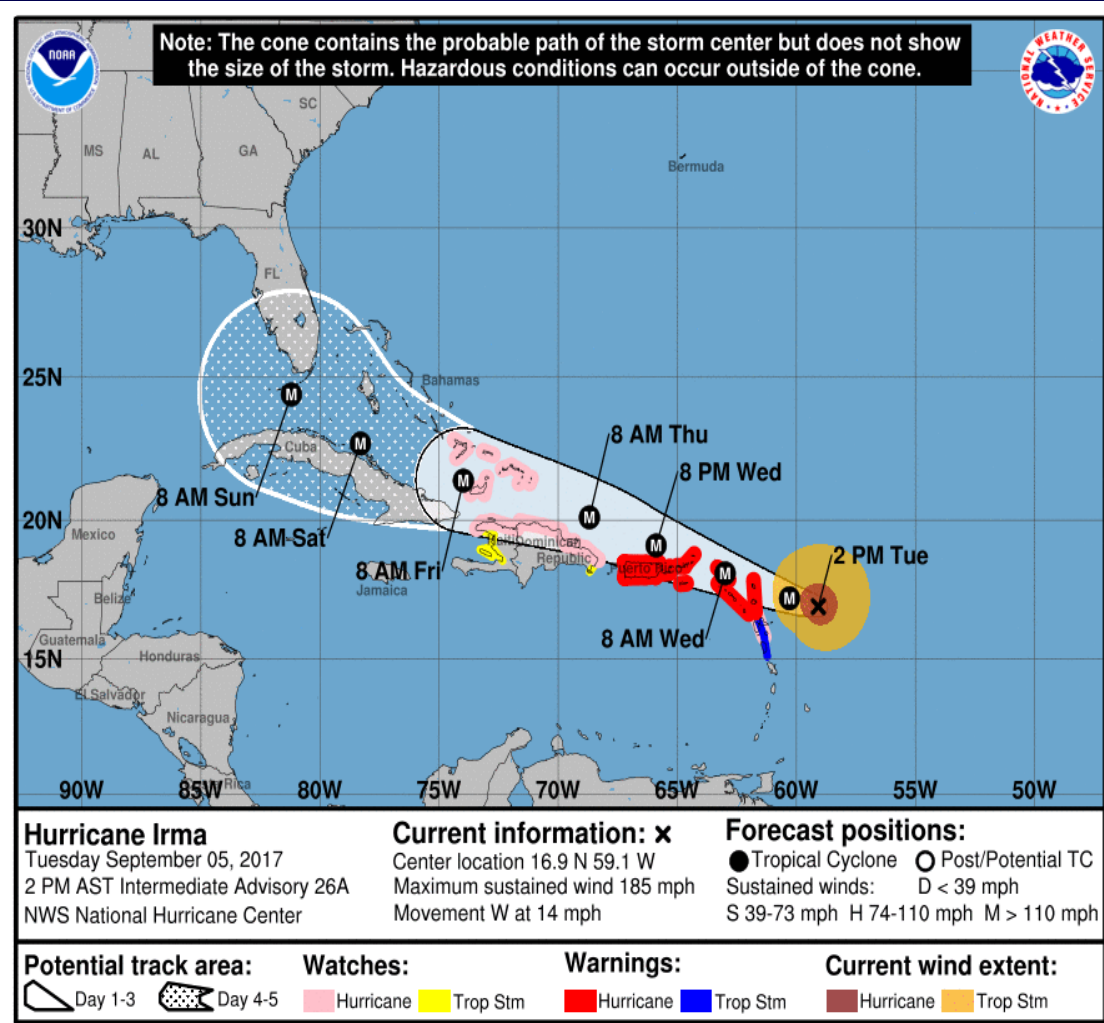
# What does the “Cone” mean?



1. Likely area of tropical storm/ hurricane force winds

2. Likely location of the center of the tropical storm/ hurricane

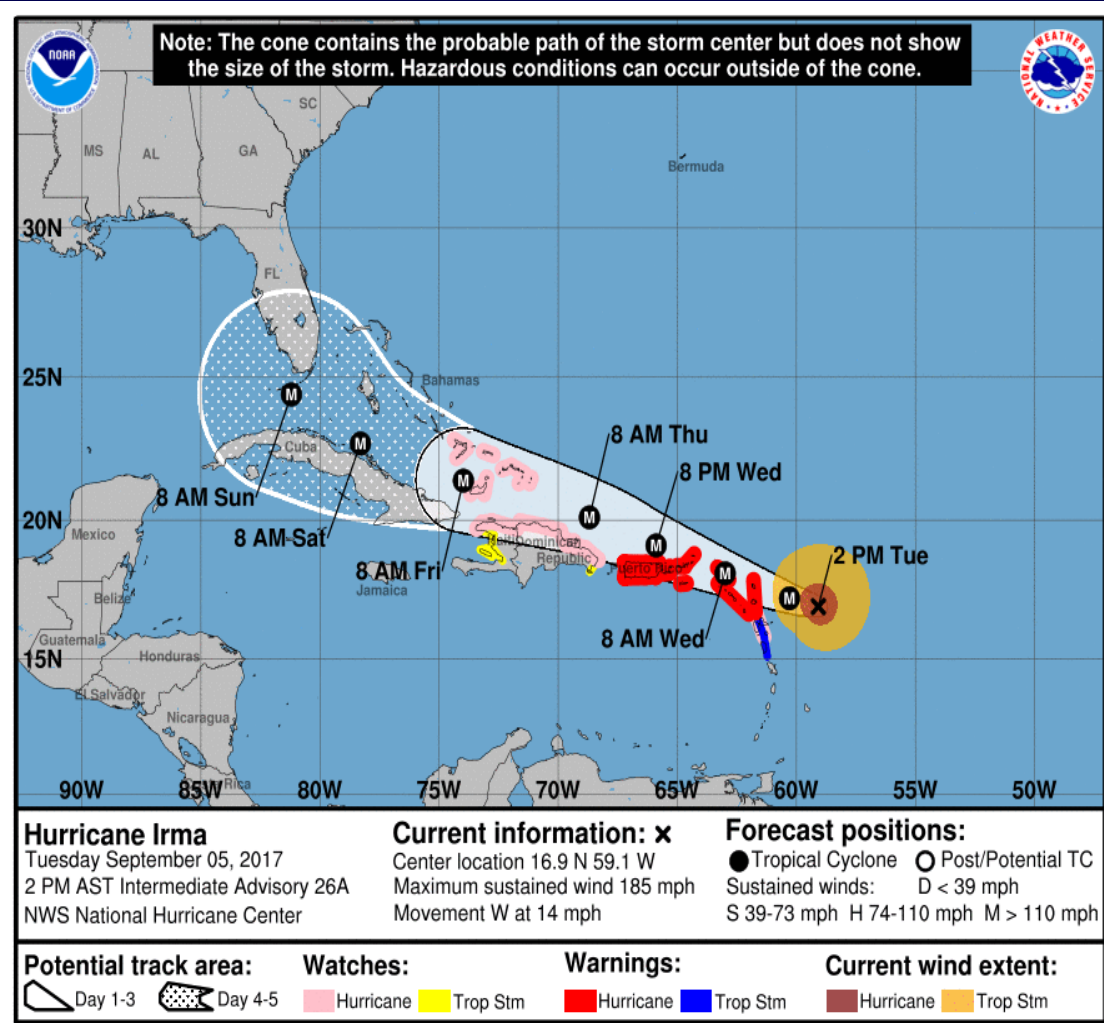
# What does the “Cone” mean?



1. Likely area of tropical storm/ hurricane force winds
2. Likely location of the center of the tropical storm/ hurricane
3. Likely area of tropical storm/ hurricane force winds, extreme rain, and/or life-threatening storm surge



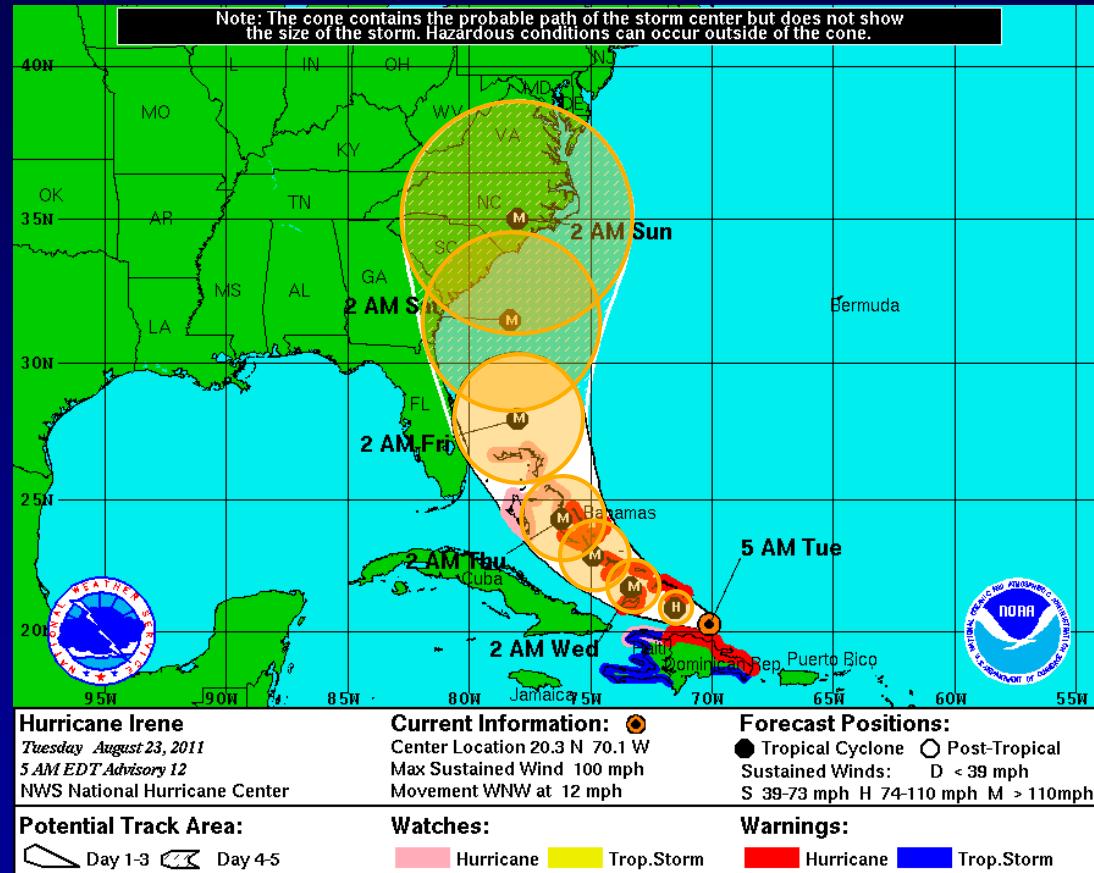
# What does the “Cone” mean?



1. Likely area of tropical storm/ hurricane force winds
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# NHC Forecast Cone

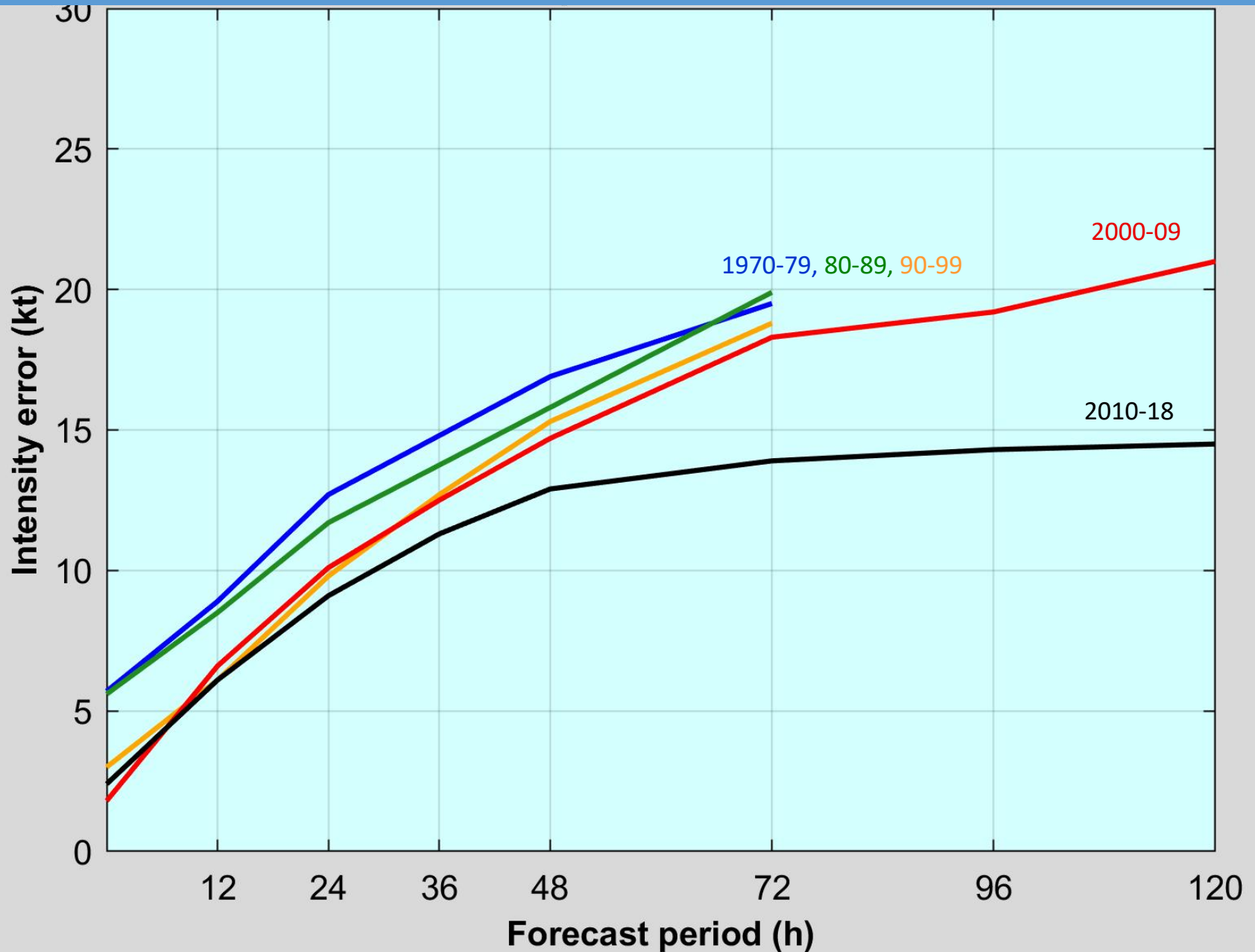
- Represents probable track of tropical cyclone center
- Formed by connecting circles centered on each forecast point (at 12, 24, 36 h, etc.)
- Size of the circles determined so that, for example, the actual storm position at 48 h will be within the 48-h circle 67% of the time





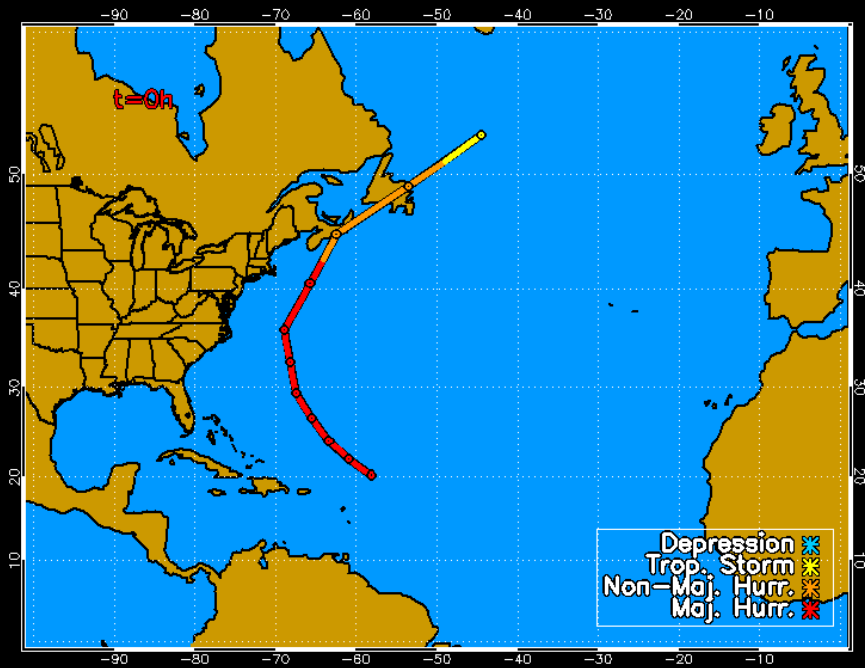


# Atlantic Intensity (Maximum Winds) Error Trends

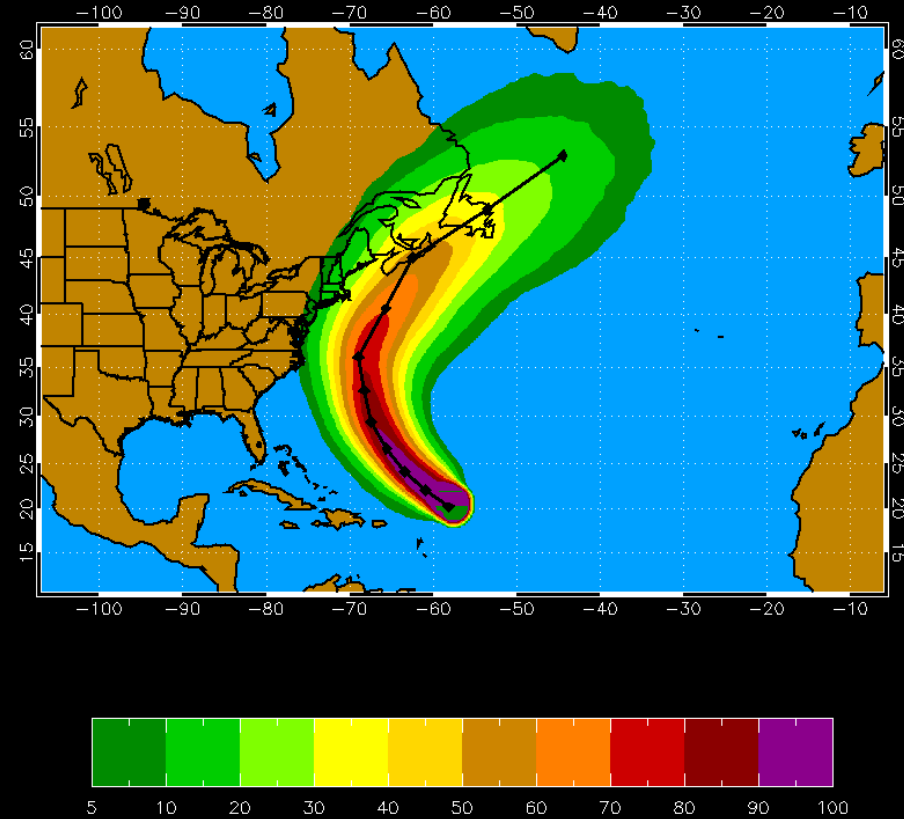




# Wind Speed Probabilities Hurricane Bill 20 Aug 2009 00 UTC



a1032009 082000 BILL 34kt 1000 Realizations Cumulative 0 - 120hrs



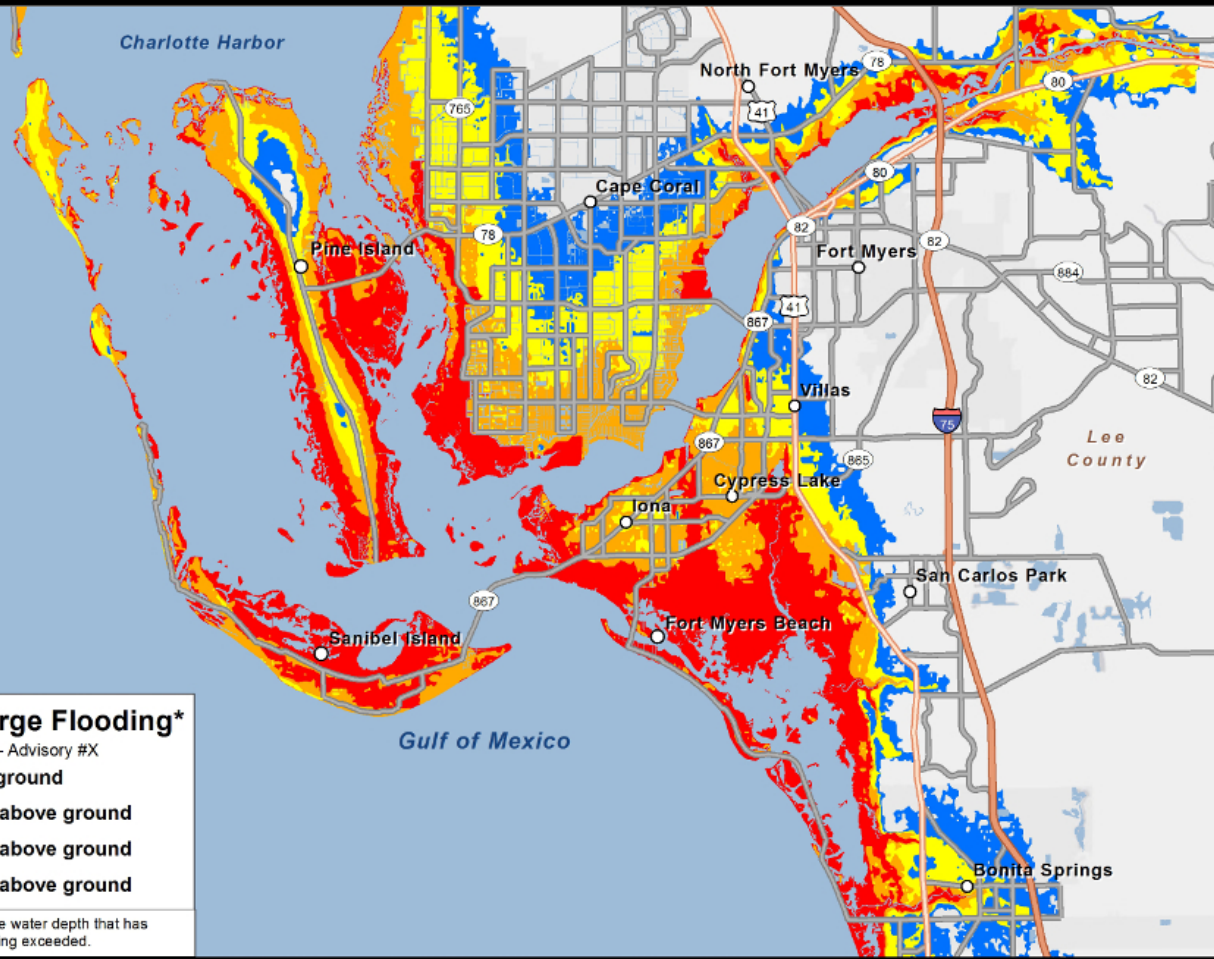
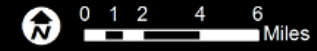
# 1000 Track Realizations



# Storm Surge Inundation



## Hurricane X



- Geographical areas where inundation from storm surge could occur
- How high above ground the water could reach in those areas
- Based upon reasonable worst case scenario (10% exceedance)

### Potential Storm Surge Flooding\*

- Up to 3 feet above ground
- Greater than 3 feet above ground
- Greater than 6 feet above ground
- Greater than 9 feet above ground

\* Displayed flooding values indicate the water depth that has about a one-in-ten (10%) chance of being exceeded.



National Hurricane Center  
Storm Surge Unit

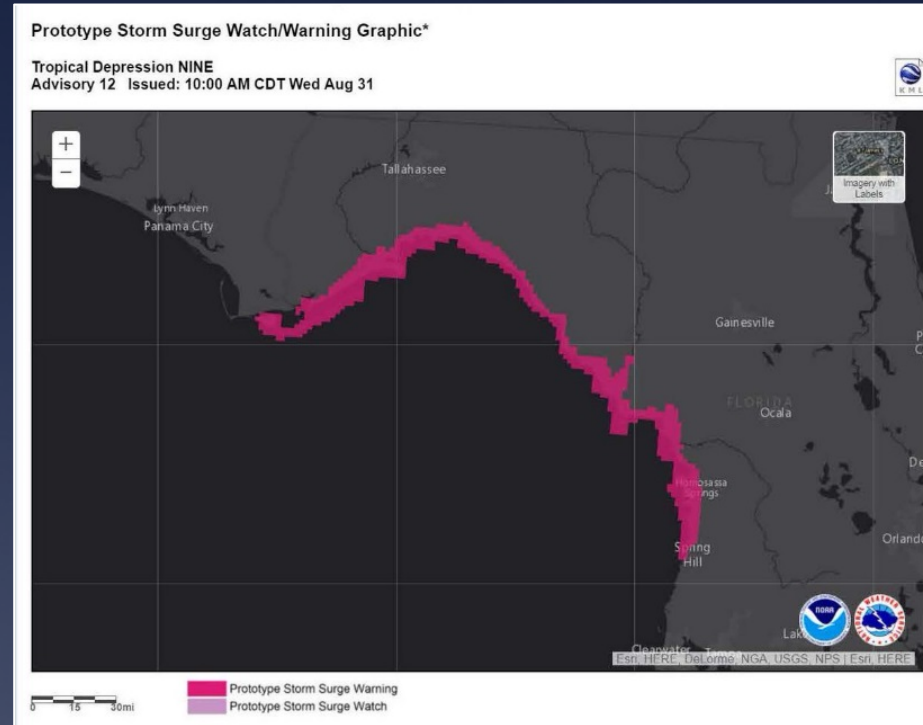




# Storm Surge Watch/Warning



- Storm Surge Watch and Warning became operational in 2017.
- W/W will be communicated using:
  - Graphic on NHC website
  - Watch/warning section of the NHC Public Advisory using coastal breakpoints
  - NWS WFO Hurricane Local Statements
  - Approximate representation in terms of zones in National and WFO TCV products.
  - NDFD grid



## SUMMARY OF WATCHES AND WARNINGS IN EFFECT:

A Hurricane Warning is in effect for...

- \* Anclote River to Indian Pass Florida

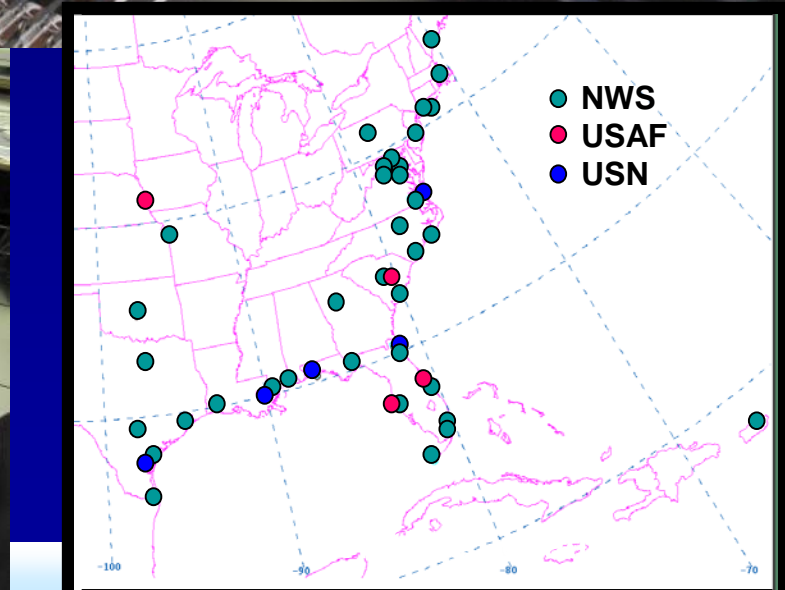
A Storm Surge Warning is in effect for...

- \* Aripeka to Indian Pass Florida

# Forecast Coordination

## Hurricane Hotline

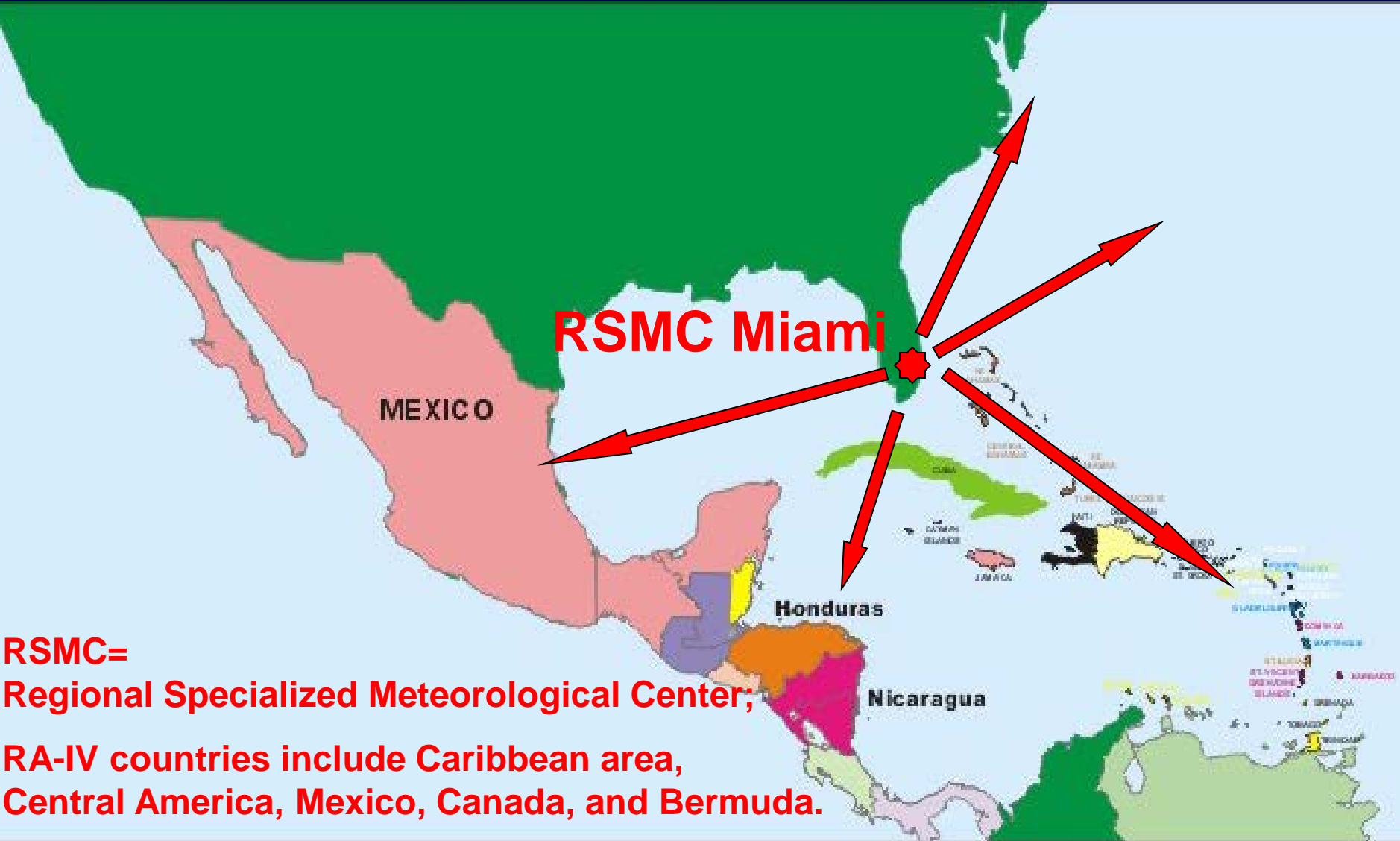
- ✓ Weather Prediction Center, Ocean Prediction Center, Storm Prediction Center
- ✓ Local Weather Forecast Offices
- ✓ Department of Defense
- ✓ Other federal agencies





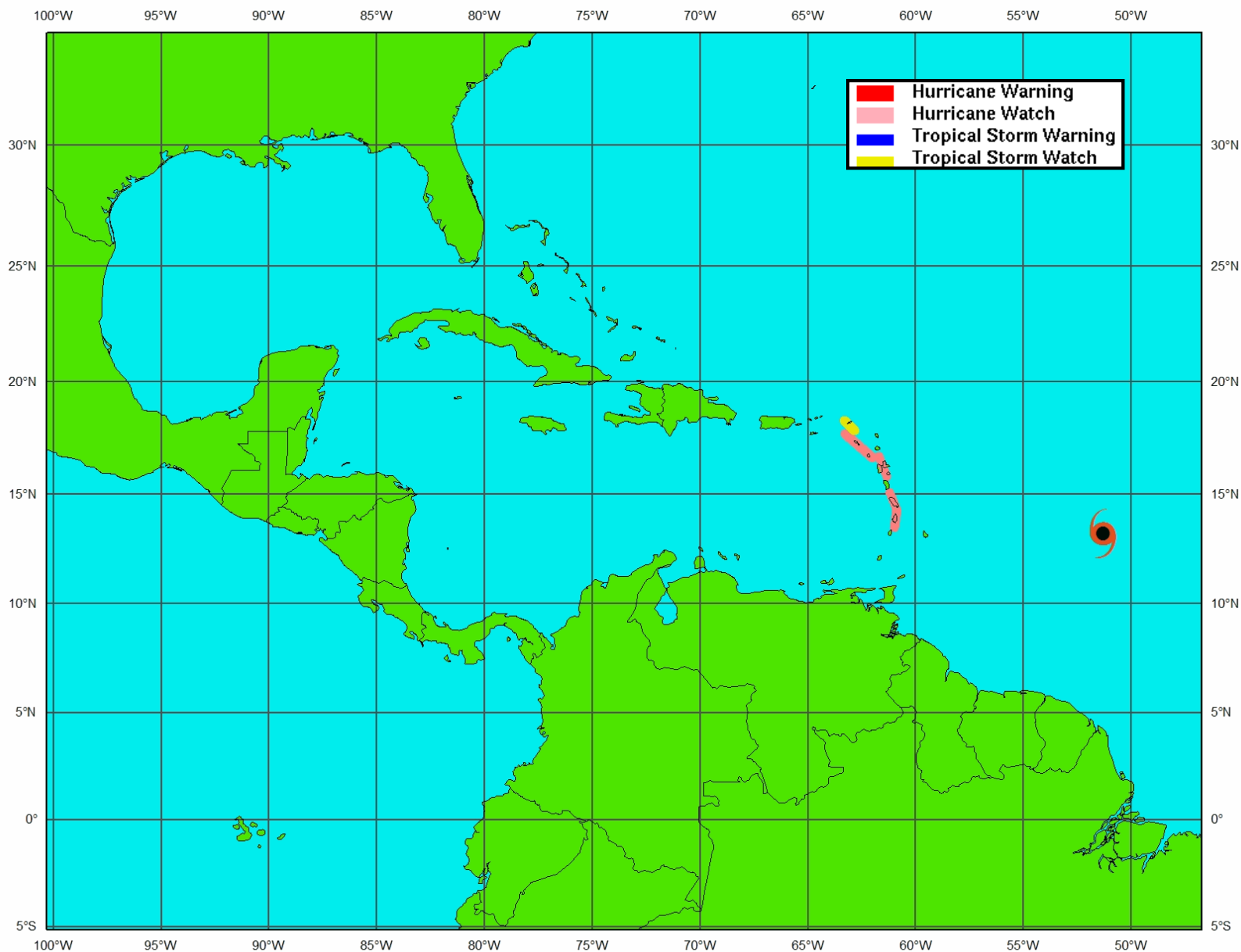
# WORLD METEOROLOGICAL ORGANIZATION

## Regional Association IV (RA-IV) Coordination



**RSMC=**  
**Regional Specialized Meteorological Center;**  
**RA-IV countries include Caribbean area,**  
**Central America, Mexico, Canada, and Bermuda.**

# Hurricane Dean watches and warnings





# OPERATIONAL COMMUNICATIONS

## WITH KEY DECISION-MAKERS



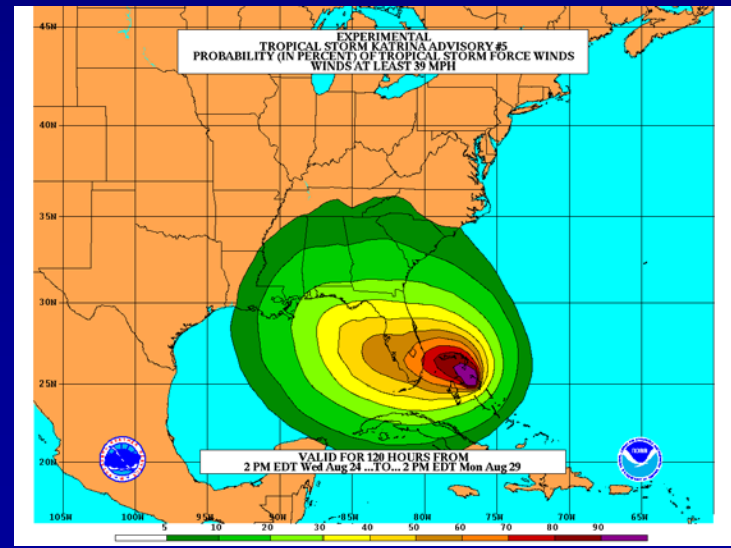
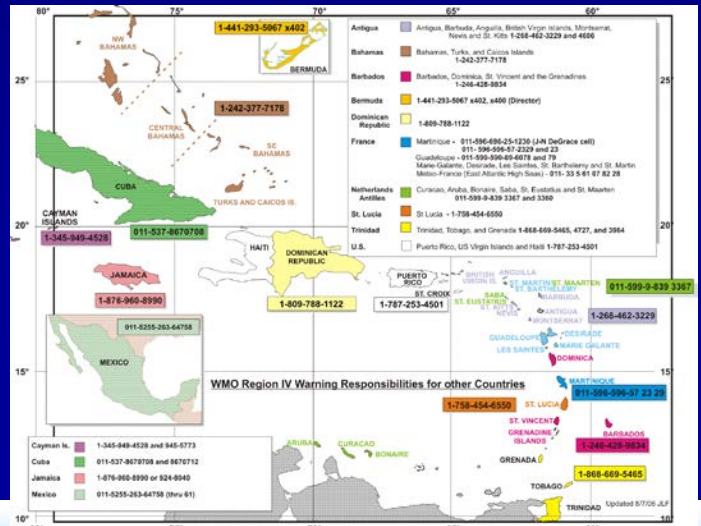
President Barack Obama during a video teleconference with NHC and emergency managers

## WITH THE MEDIA



## WITH THE PUBLIC

## WITH INTERNATIONAL PARTNERS

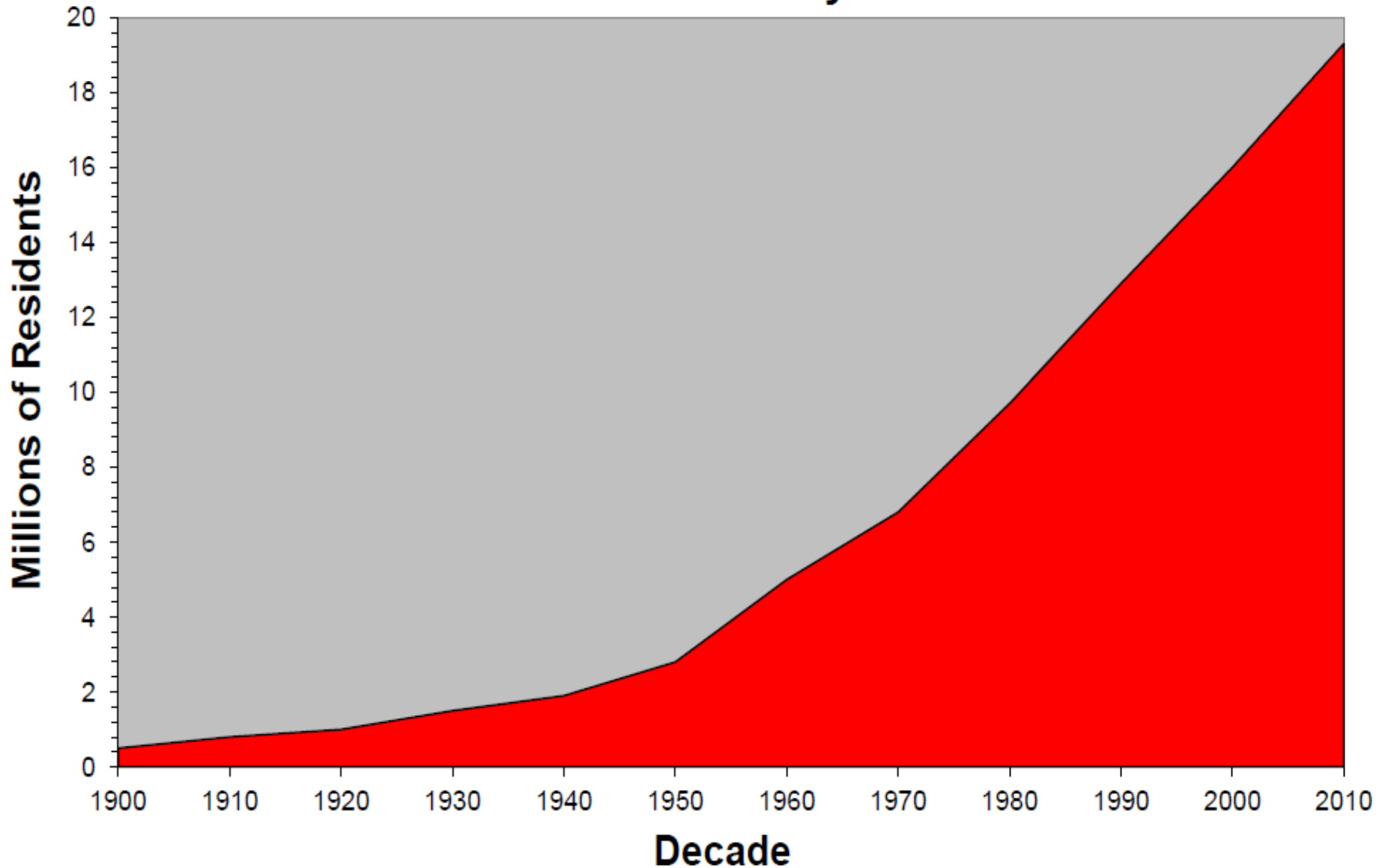


# OUTREACH AND EDUCATION



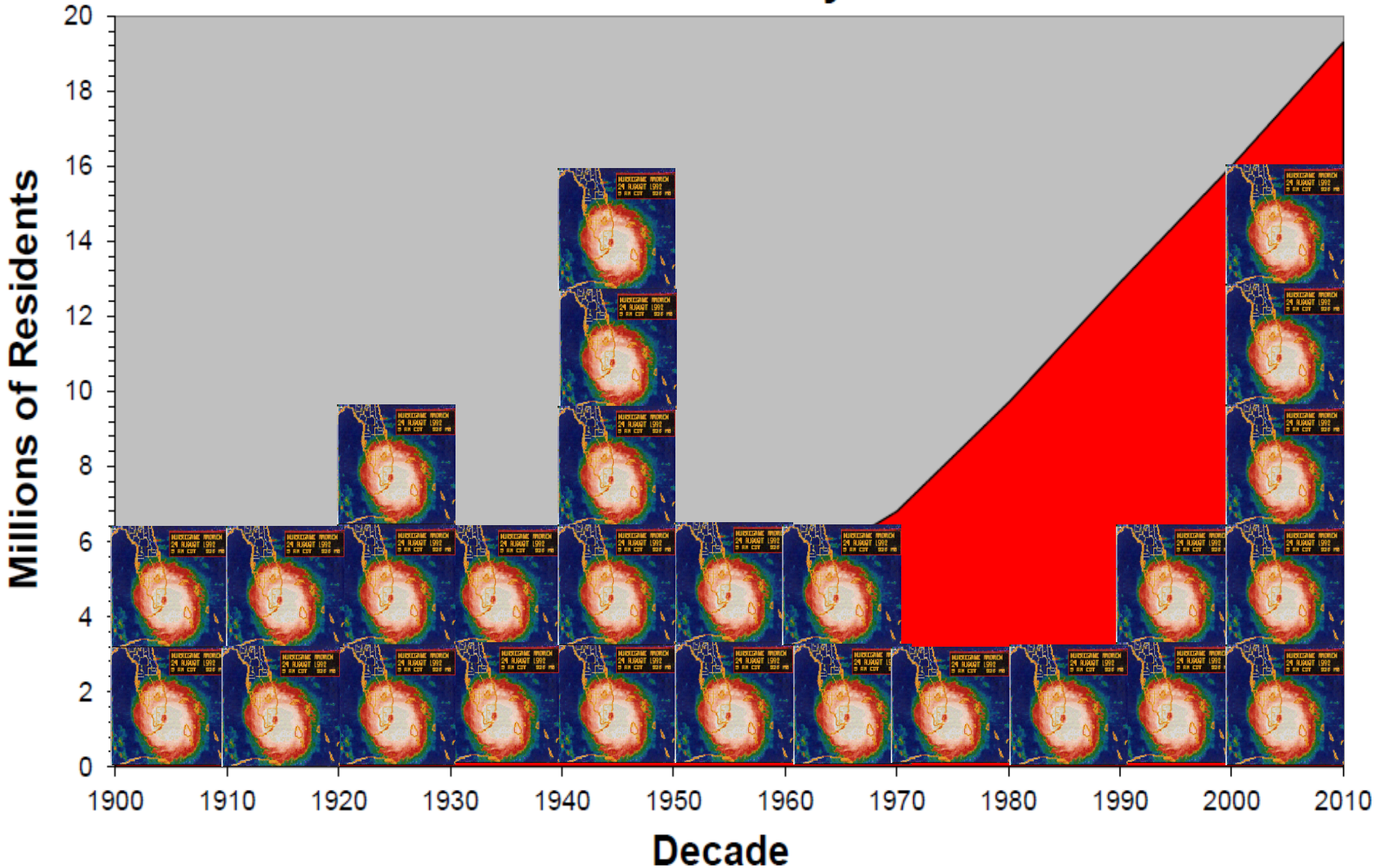
- ❖ National Hurricane Preparedness Week
- ❖ FEMA workshop for emergency managers
- ❖ Hurricane Awareness Tours
- ❖ National Hurricane Conference (& others)
- ❖ WMO workshop for international meteorologists
- ❖ U.S. Interdepartmental Hurricane Conference

# Major Hurricane Strikes and Population for Florida 1900 to today





# Major Hurricane Strikes and Population for Florida 1900 to today







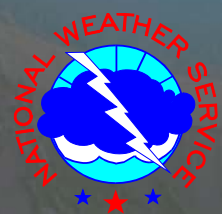
Bayland Hospital  
1231209 8:48 PM

Bayland Hospital  
1231209 8:48 PM



# Summary

1. The National Hurricane Center - predicting hurricanes to help protect life and property
2. Forecasting has improved, but will never be perfect – always account for uncertainties
3. Focus recently is on probabilistic impacts of wind and storm surge
4. Much more hurricane risk today because of increased coastal populations







# Recent Major NHC Product Improvements



- **2003: 5 day track and intensity forecasts**
- **2005: Wind Speed Probabilities**
- **2007: Storm Surge Probabilities**
- **2007: Graphical Tropical Weather Outlook – location only**
- **2008: Graphical Tropical Weather Outlook - color-coded probabilities**
- **2008: Surface Wind Field graphic**
- **2009: Wind Speed Probabilities – based on track model spread**
- **2010: Tropical Storm and Hurricane Watch and Warning lead times increased**
- **2013: Time covered by the NHC Tropical Weather Outlook increased from 48 hours to 5-days**
- **2014: Potential Storm Surge Flood Map**
- **2014: Graphical Tropical Weather Outlook – 5 day formation locations**
- **2017: Potential Tropical Cyclone Advisories**
- **2017: Storm Surge Watches/Warnings introduced**
- **2018: Time of Arrival for Tropical Storm Force Winds**

# EL FARO

33 fatalities when it sank in Hurricane Joaquin (2015)



# BOUNTY

2 fatalities when it sank in Hurricane Sandy (2012)

# FANTOME

31 fatalities when it sank in Hurricane Mitch (1998)

# Existing Wave Products for Tropical Cyclones

## High Seas and Offshores Text Forecasts

HIGH SEAS FORECAST  
NWS NATIONAL HURRICANE CENTER  
1030 UTC FRI OCT 02 2015

SUPERSEDED BY NEXT ISSUANCE IN 6 HOURS

SEAS GIVEN AS SIGNIFICANT WAVE HEIGHT...WHICH IS THE AVERAGE HEIGHT OF THE HIGHEST 1/3 OF THE WAVES. INDIVIDUAL WAVES MAY BE MORE THAN TWICE THE SIGNIFICANT WAVE HEIGHT.

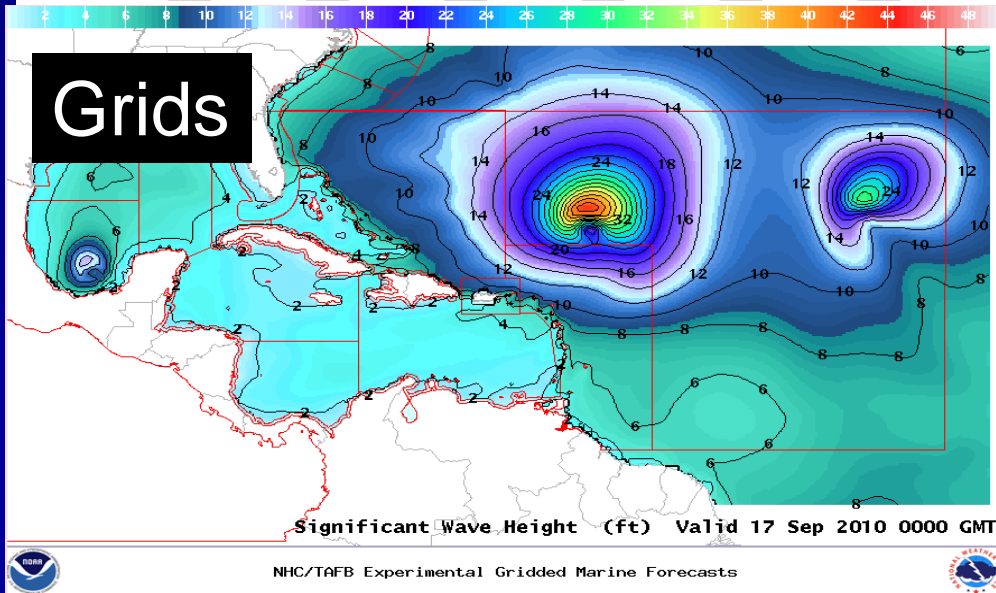
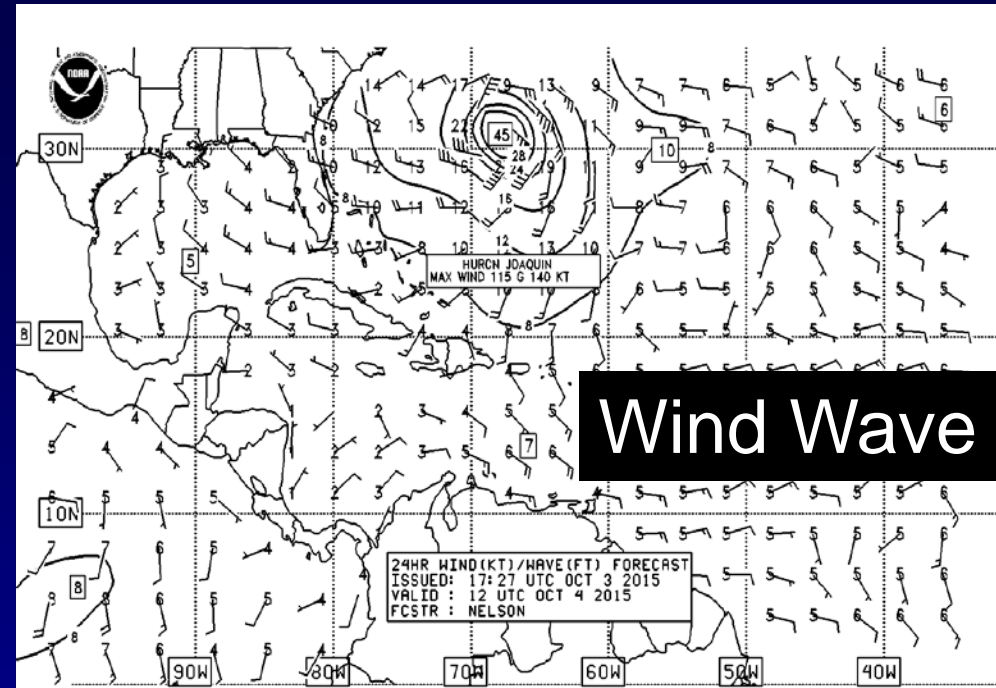
PAN PAN

ATLANTIC FROM 07N TO 31N W OF 35W INCLUDING CARIBBEAN SEA AND GULF OF MEXICO.

SYNOPSIS VALID 0600 UTC FRI OCT 02.  
24 HOUR FORECAST VALID 0600 UTC SAT OCT 03.  
48 HOUR FORECAST VALID 0600 UTC SUN OCT 04.

.WARNINGS.

...HURRICANE WARNING...  
.HURRICANE JOAQUIN NEAR 23.3N 74.7W 935 MB AT 0900 UTC OCT 02 MOVING NW OR 315 DEG AT 3 KT. MAXIMUM SUSTAINED WINDS 115 KT GUSTS 140 KT. TROPICAL STORM FORCE WINDS WITHIN 160 NM W SEMICIRCLE...140 NM NE QUADRANT AND 180 NM SE QUADRANT. SEAS 12 FT OR GREATER WITHIN 400 NM NE QUADRANT...150 NM SE QUADRANT...120 NM SW QUADRANT...AND 300 NM NW QUADRANT WITH SEAS TO 39 FT. ELSEWHERE S OF 28N BETWEEN 70W AND 78W WINDS 20 TO 33 KT. SEAS 9 TO 12 FT. N OF 28N BETWEEN 70W AND 75W E WINDS 20 TO 25 KT SEAS 8 TO 10 FT. REMAINDER OF AREA N OF 21N BETWEEN 65W AND 78W AND OUTSIDE OF THE BAHAMAS WINDS 20 KT OR LESS. SEAS 8 TO 11 FT IN MIXED SWELL.





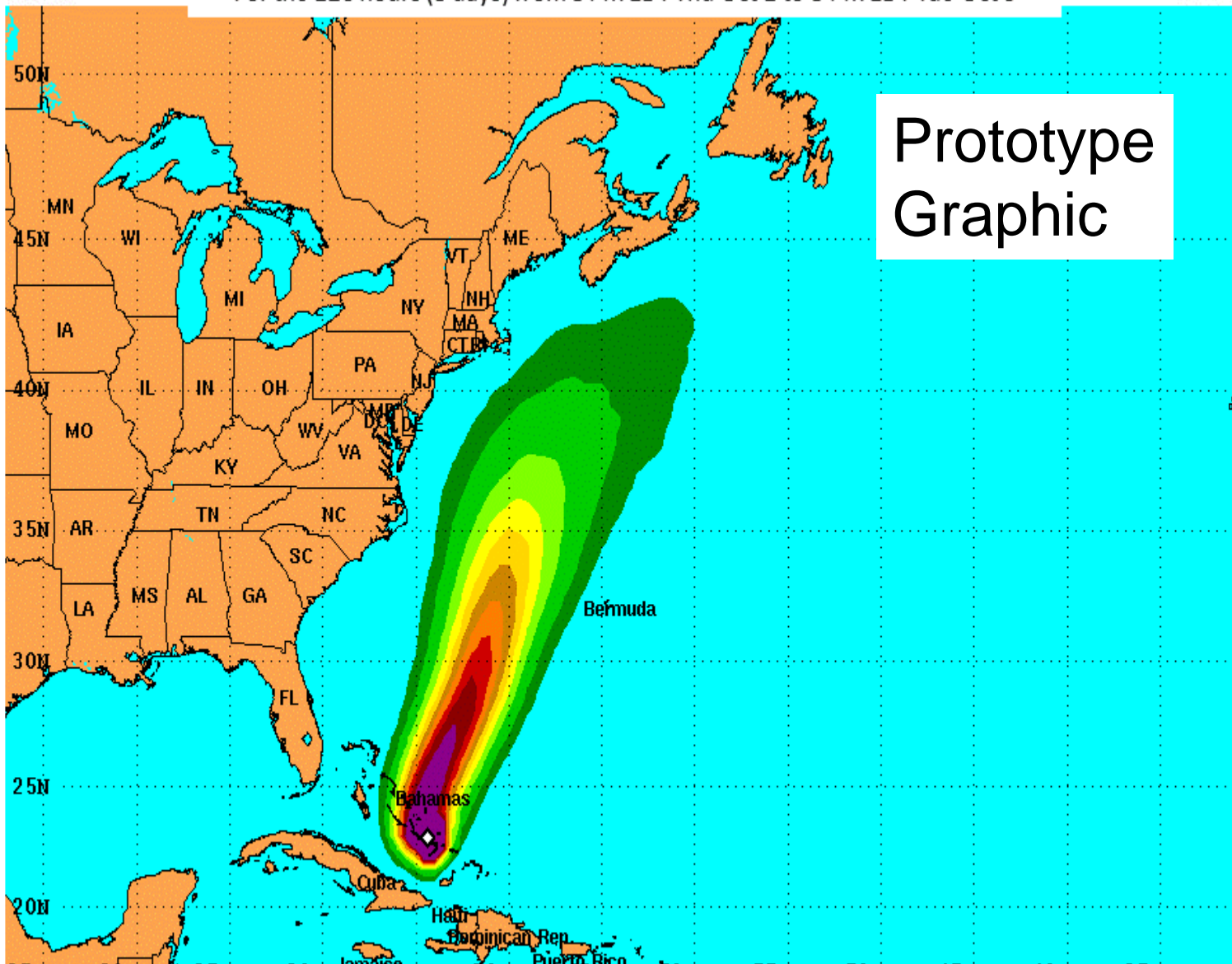


# 24-ft Wave Height Probabilities



For the 120 hours (5 days) from 8 PM EDT Thu Oct 1 to 8 PM EDT Tue Oct 6

Prototype  
Graphic



Probability of 24-ft Significant Wave Height (the average height of the highest 1/3 of the waves) from all tropical cyclones

◇ indicates HURRICANE JOAQUIN center location at 8 PM EDT Thu Oct 1 2015 (Forecast/Advisory #17)



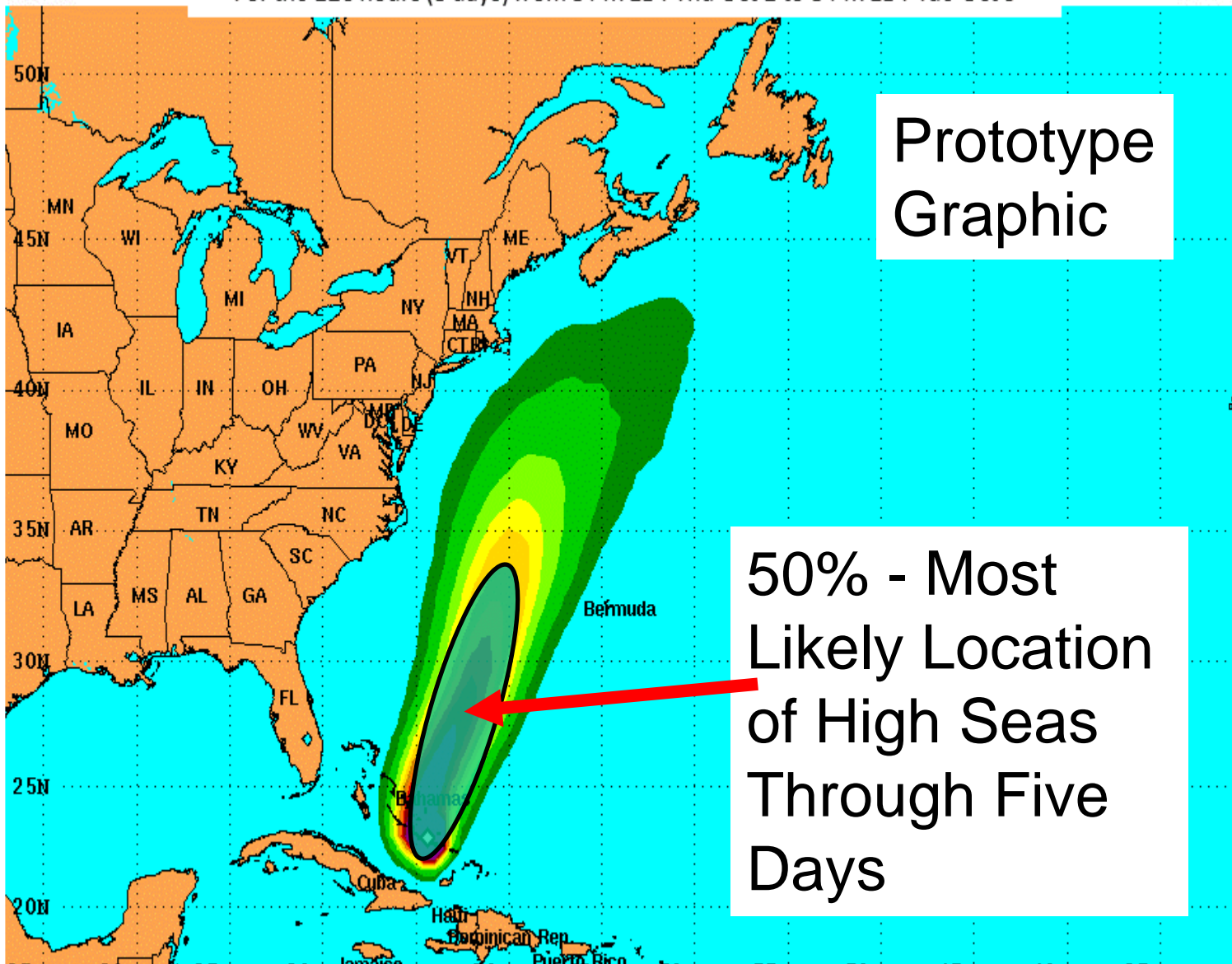


# 24-ft Wave Height Probabilities



For the 120 hours (5 days) from 8 PM EDT Thu Oct 1 to 8 PM EDT Tue Oct 6

Prototype Graphic



50% - Most Likely Location of High Seas Through Five Days

Probability of 24-ft Significant Wave Height (the average height of the highest 1/3 of the waves) from all tropical cyclones

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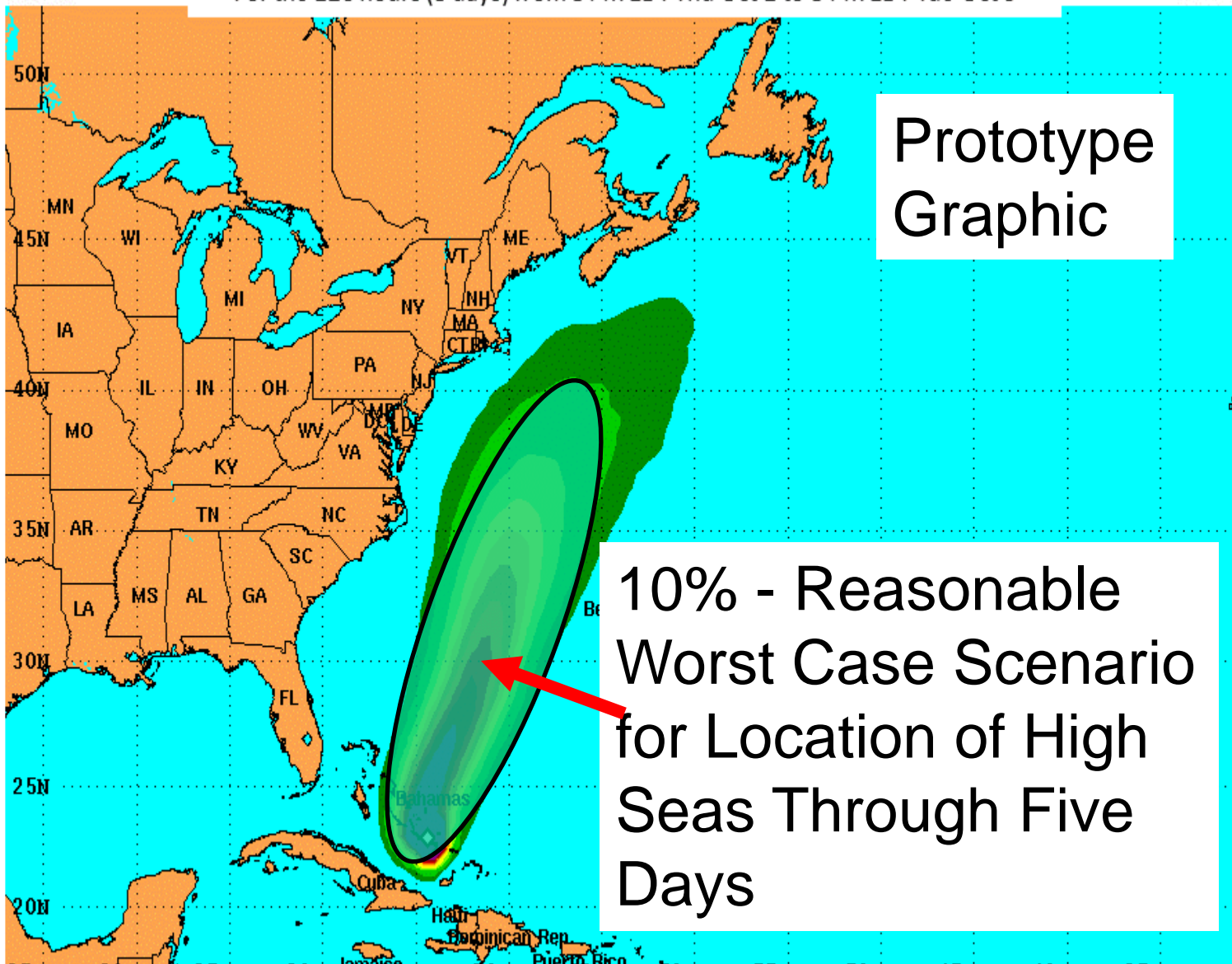


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