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

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National Hurricane Center

Connecticut College
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Outline of Talk

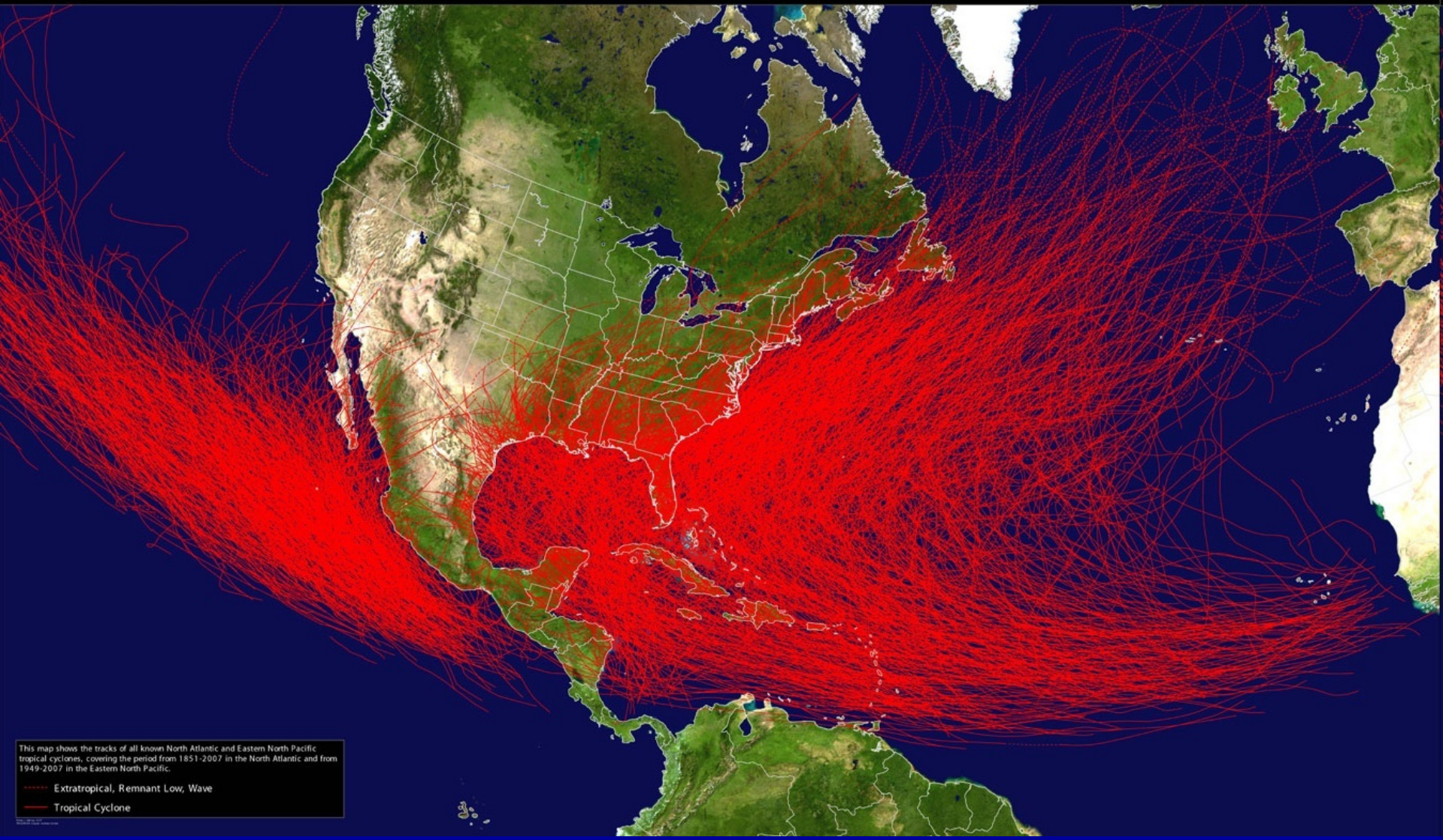
- NHC's Mission and Organizational Structure
- Tropical Analysis and Forecast Branch
- Hurricane Specialist Unit
  - Tropical Cyclone Hazards
  - Observational Platforms
  - Forecast Products
  - Coordination
  - The "Off Season"
- Future Plans
- Reminder of Who We Serve

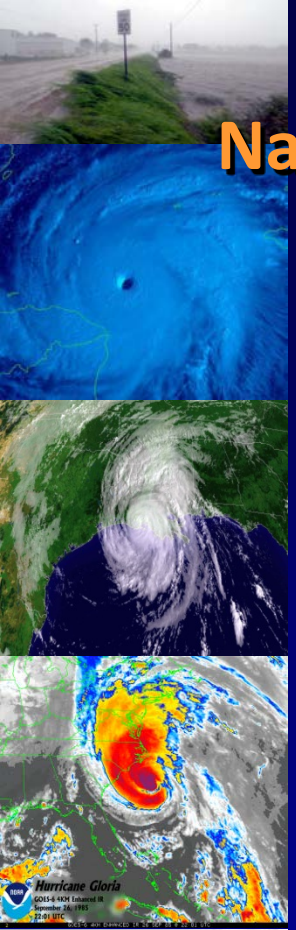
NHC MISSION

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

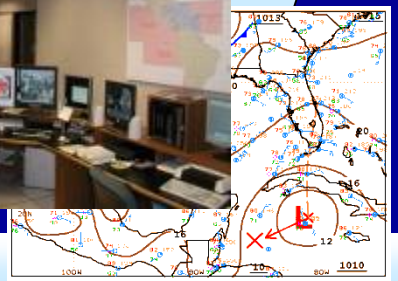
Applied research

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



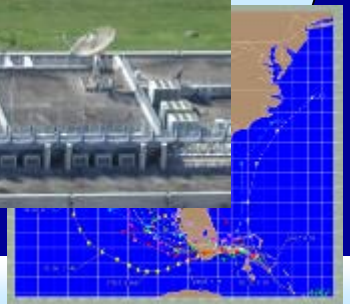
Technology and Science Branch

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

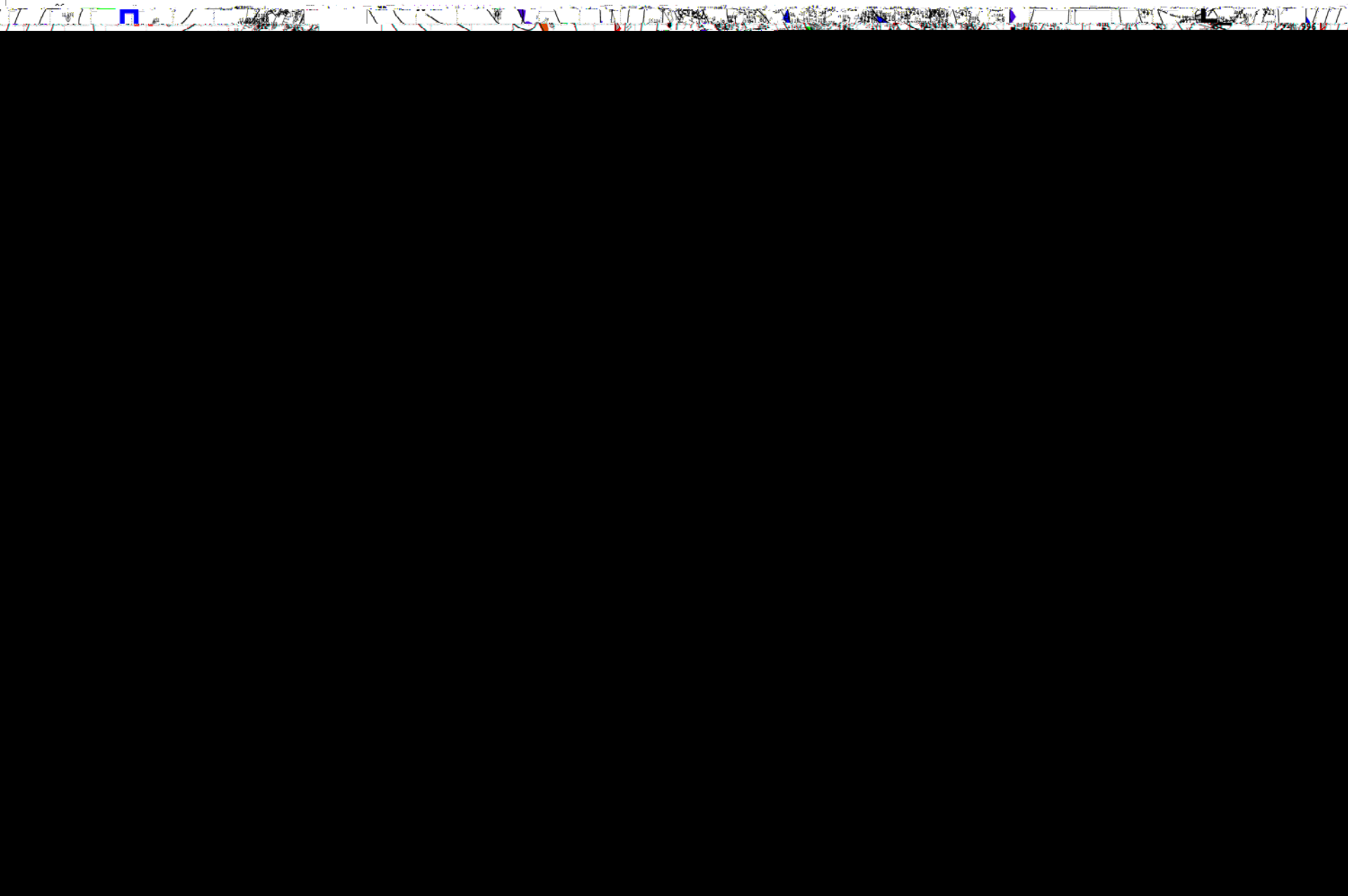
Ships over the Open Ocean

A Bad Cruise

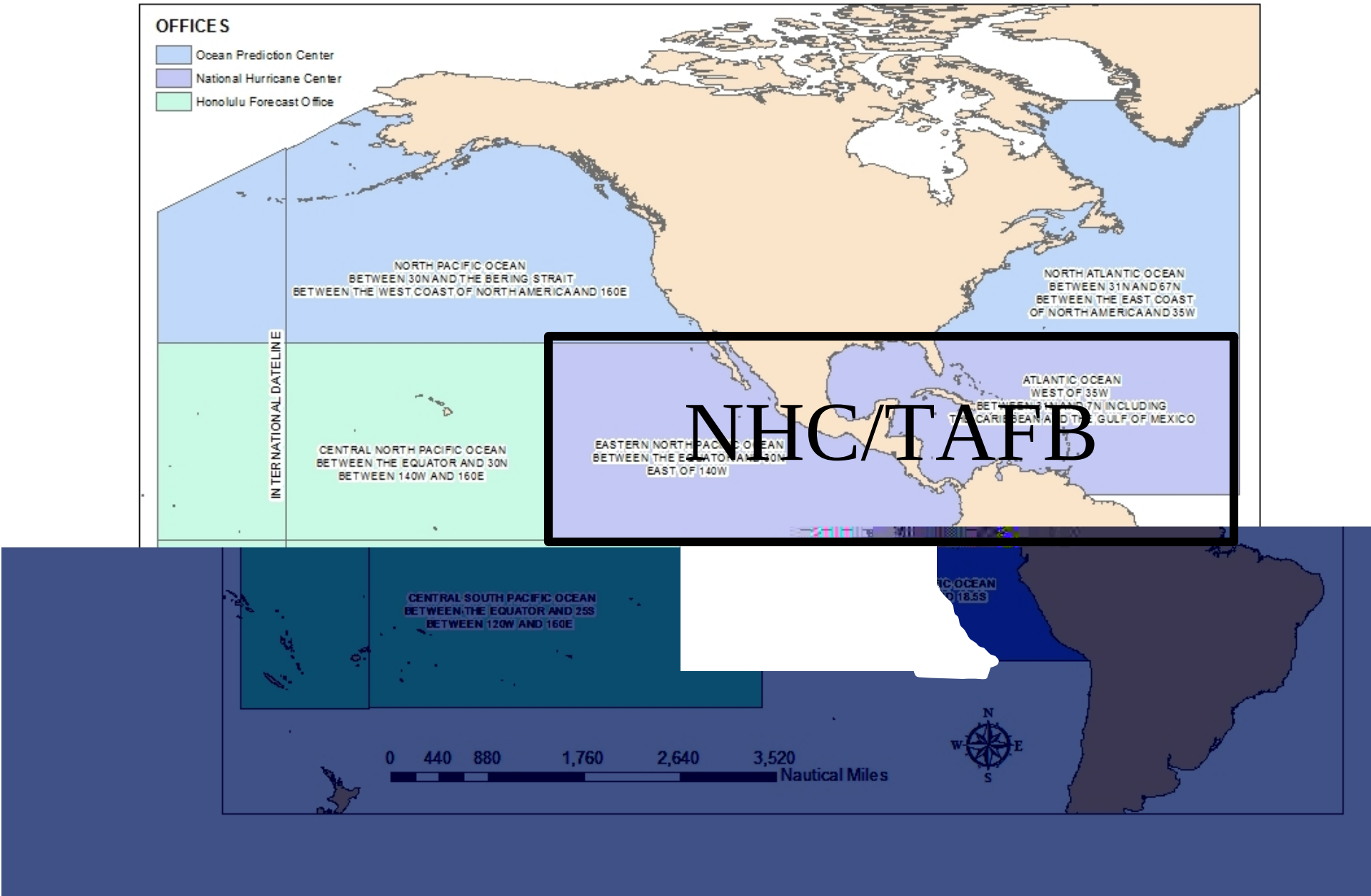
Unified Surface Analysis

https://www.nhc.noaa.gov/tafb_latest/USA_latest.gif

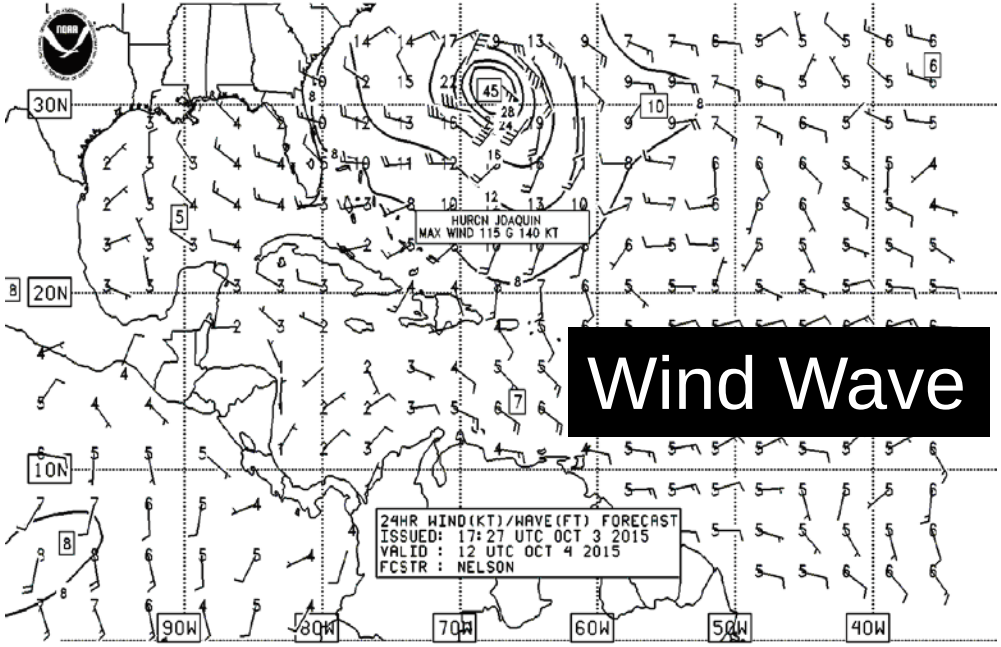
Joint effort from Four Weather Service Offices



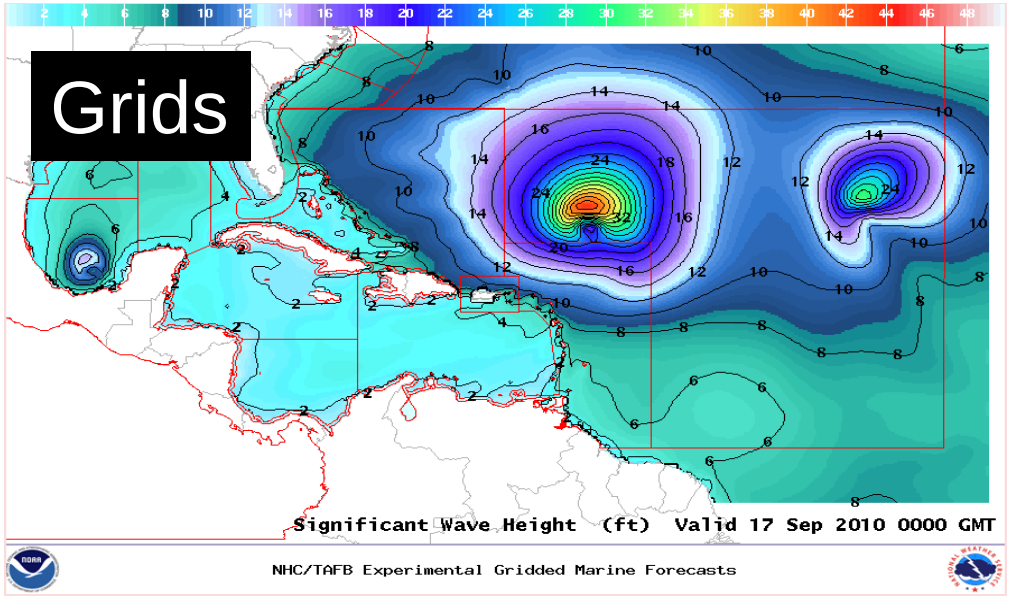
Three Ocean Forecast Centers in the NWS



NHC/TAFB Marine Forecast Products



Wind Wave



Grids

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.

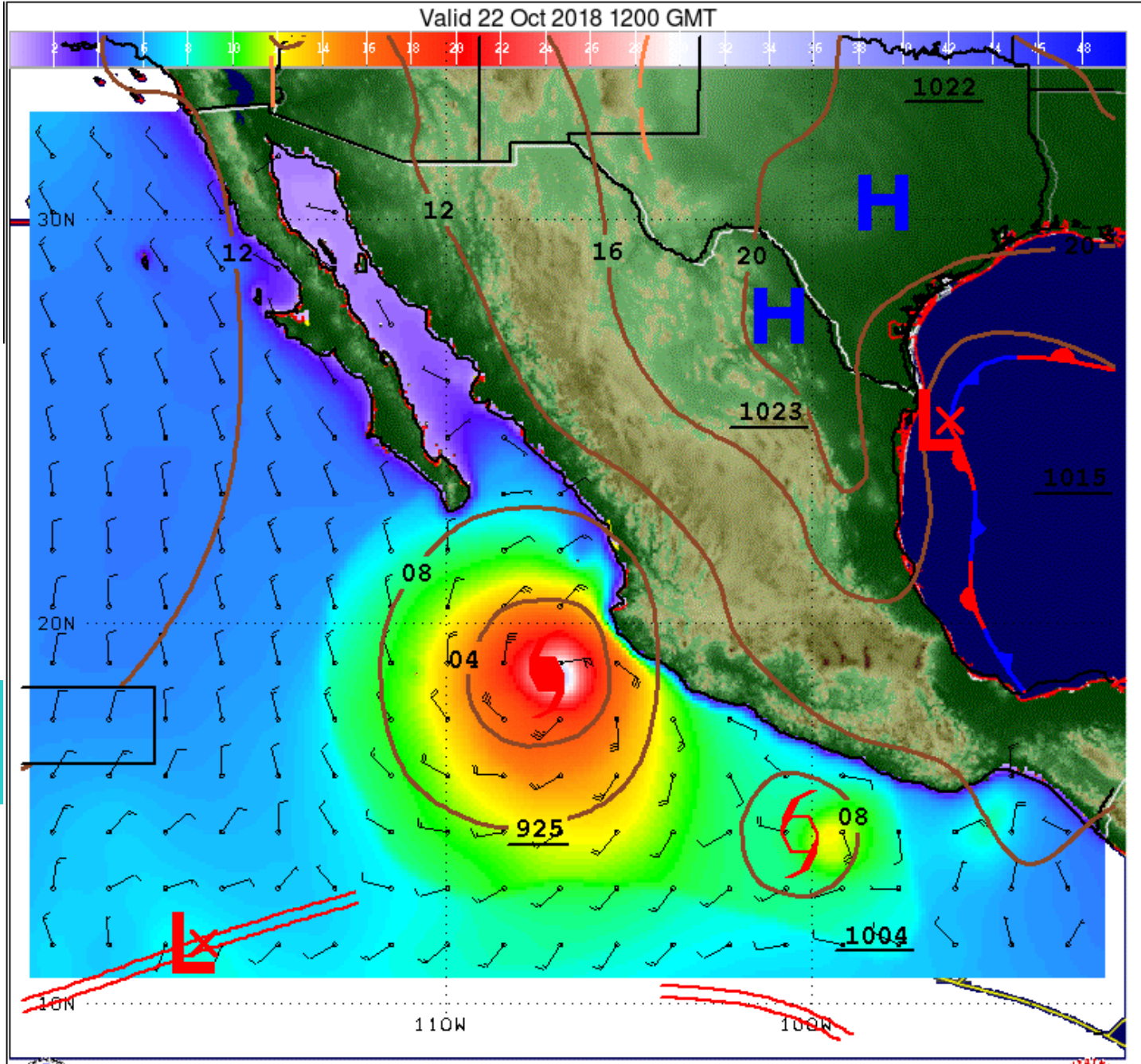
SYNOPSIS VALID 0600 UTC FRI OCT 02.
24 HOUR FORECAST VALID 0600 UTC SAT OCT 03.
48 HOUR FORECAST VALID 0600 UTC SUN OCT 04.

.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_atlcfull.php



NHC/TAFB Experimental Gridded Marine Forecasts

Marine Composite Page – Winds, Waves, and Features

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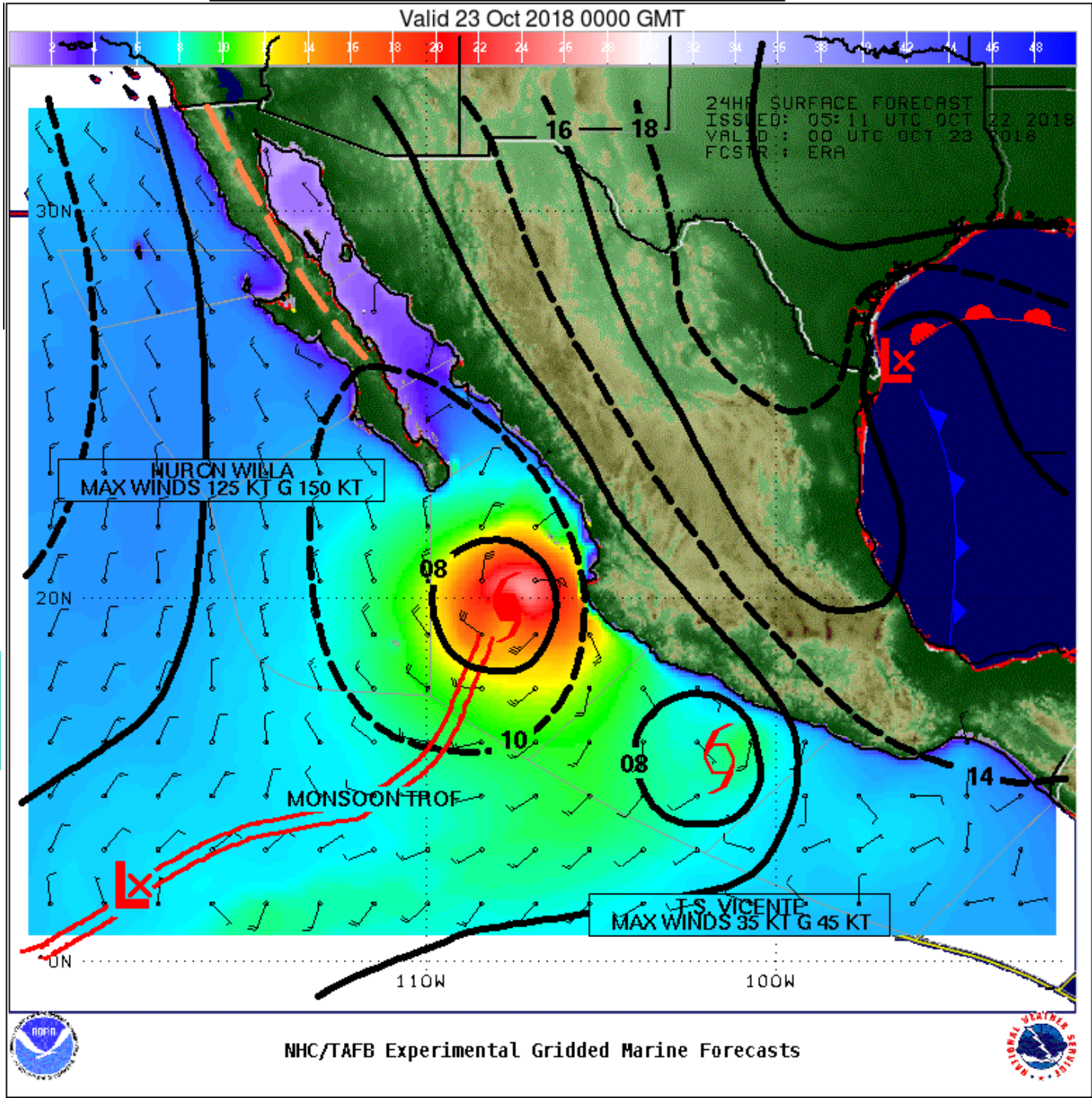

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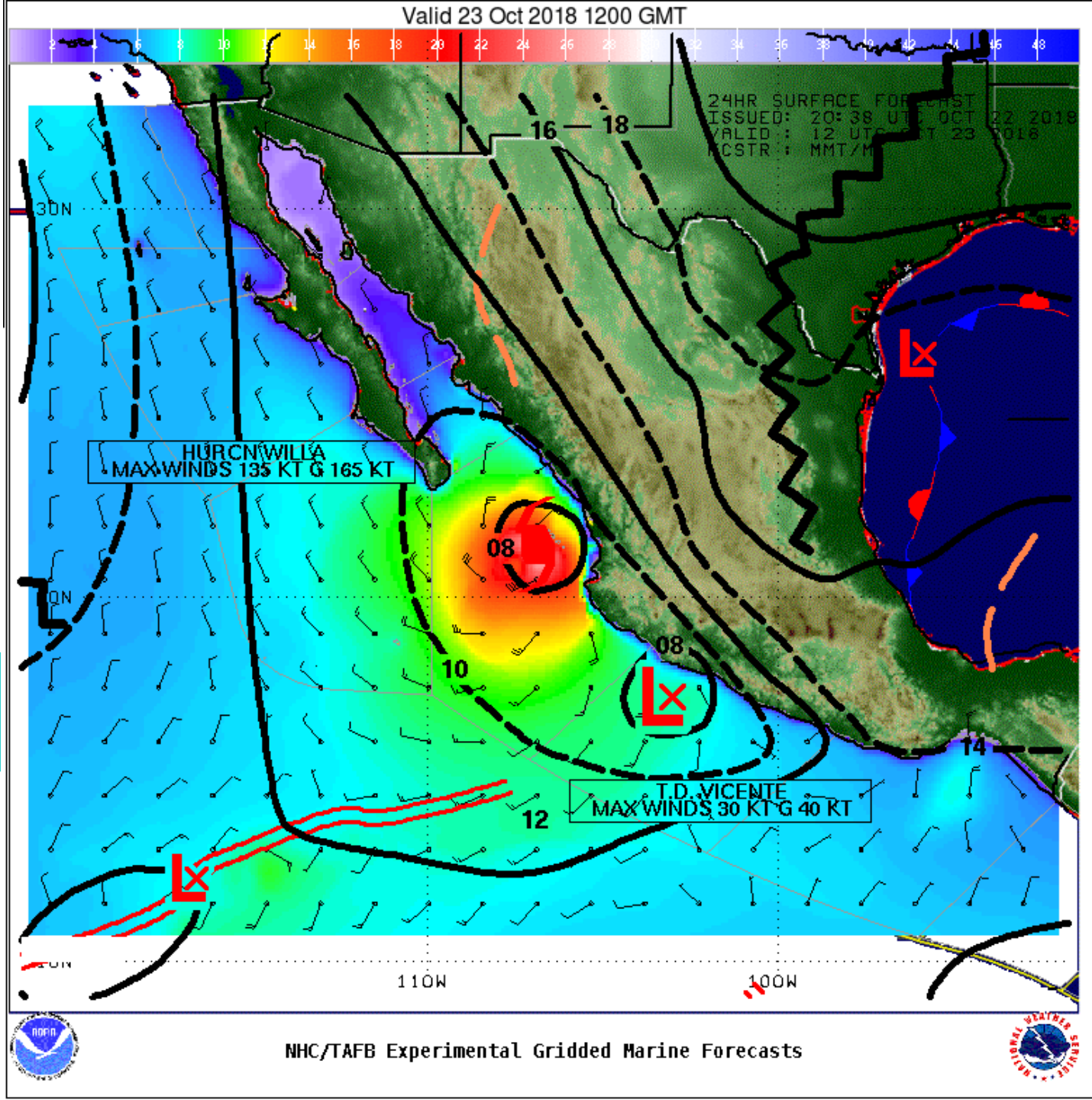

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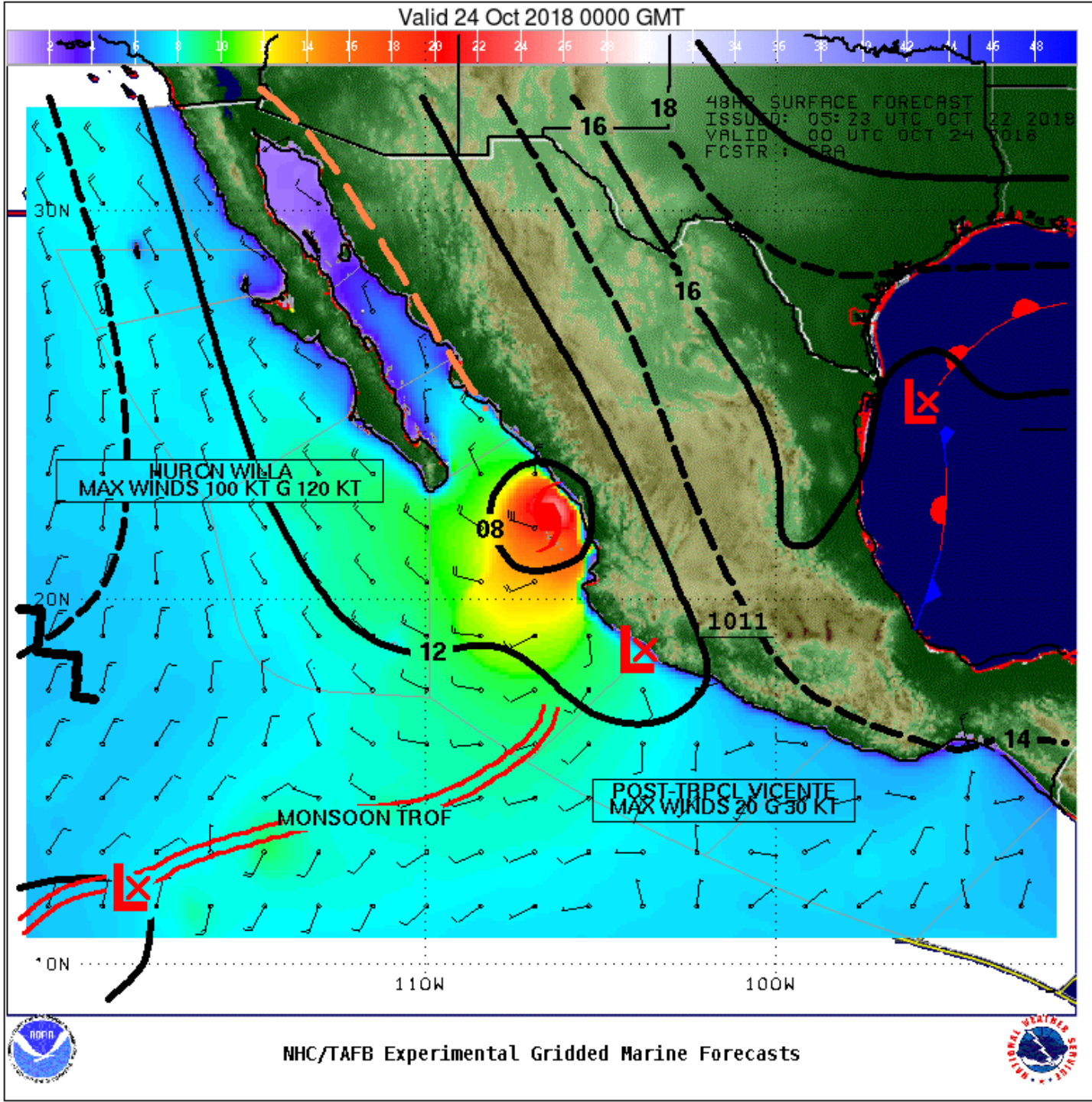

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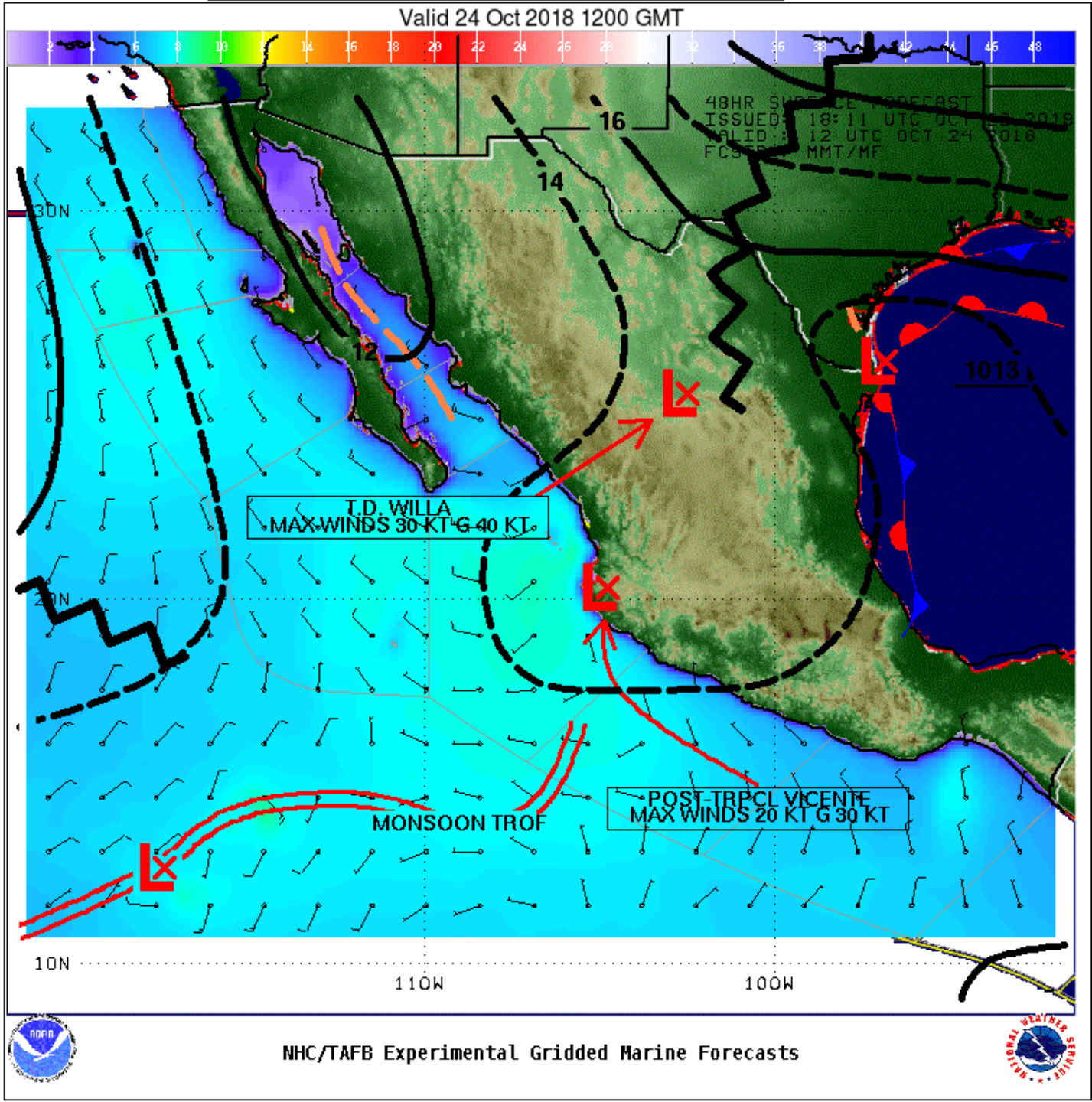


2019 NHC/TAFB Spot Forecasts for U.S. Coast Guard

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

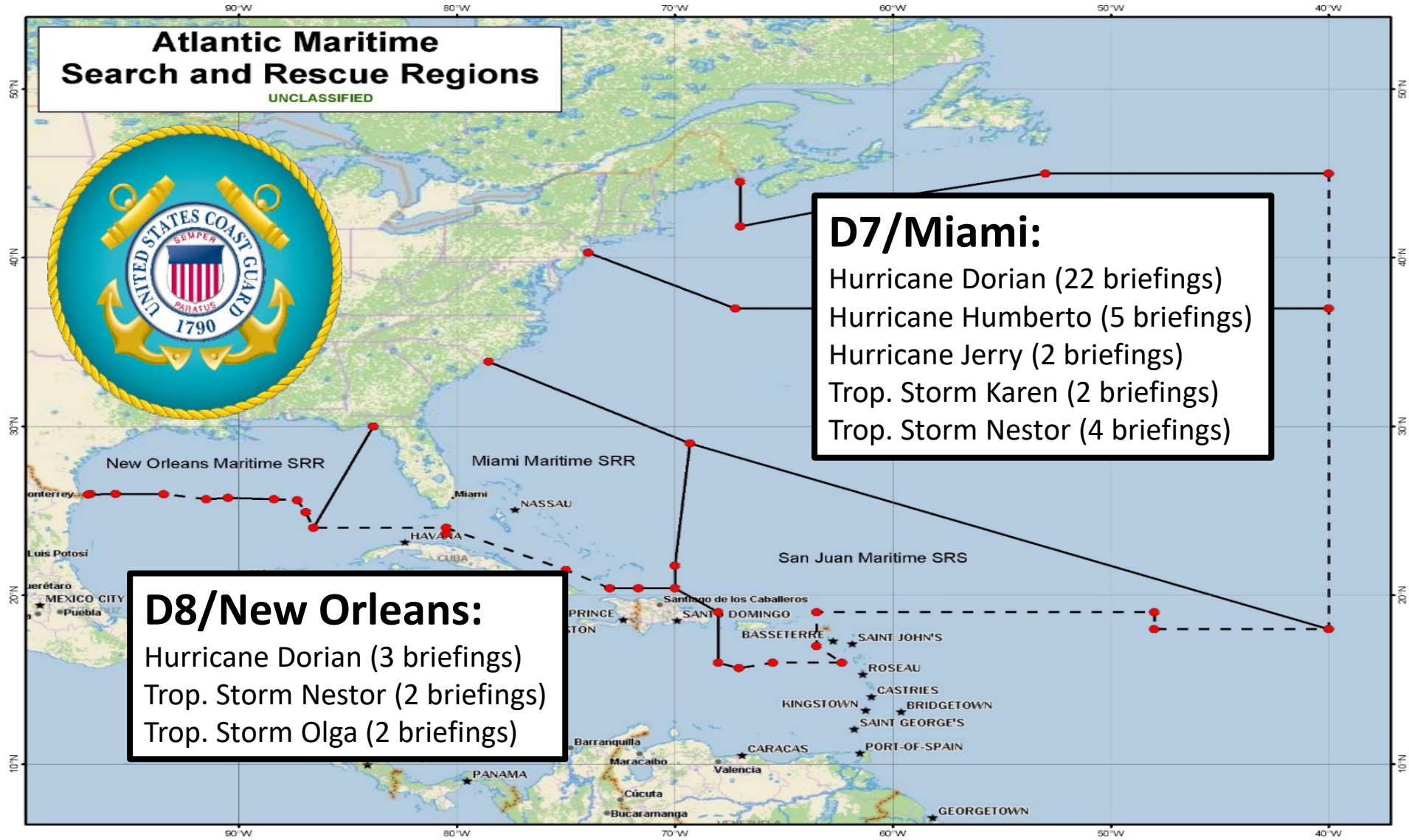
"NWS, SPOT Report received. This information is truly impacting operations. Thank you for the quick response."

- Douglas Samp
  Search Mission Coordinator
  USCG District Eleven Command Center

United States Coast Guard
U.S. Department of Homeland Security

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)



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:

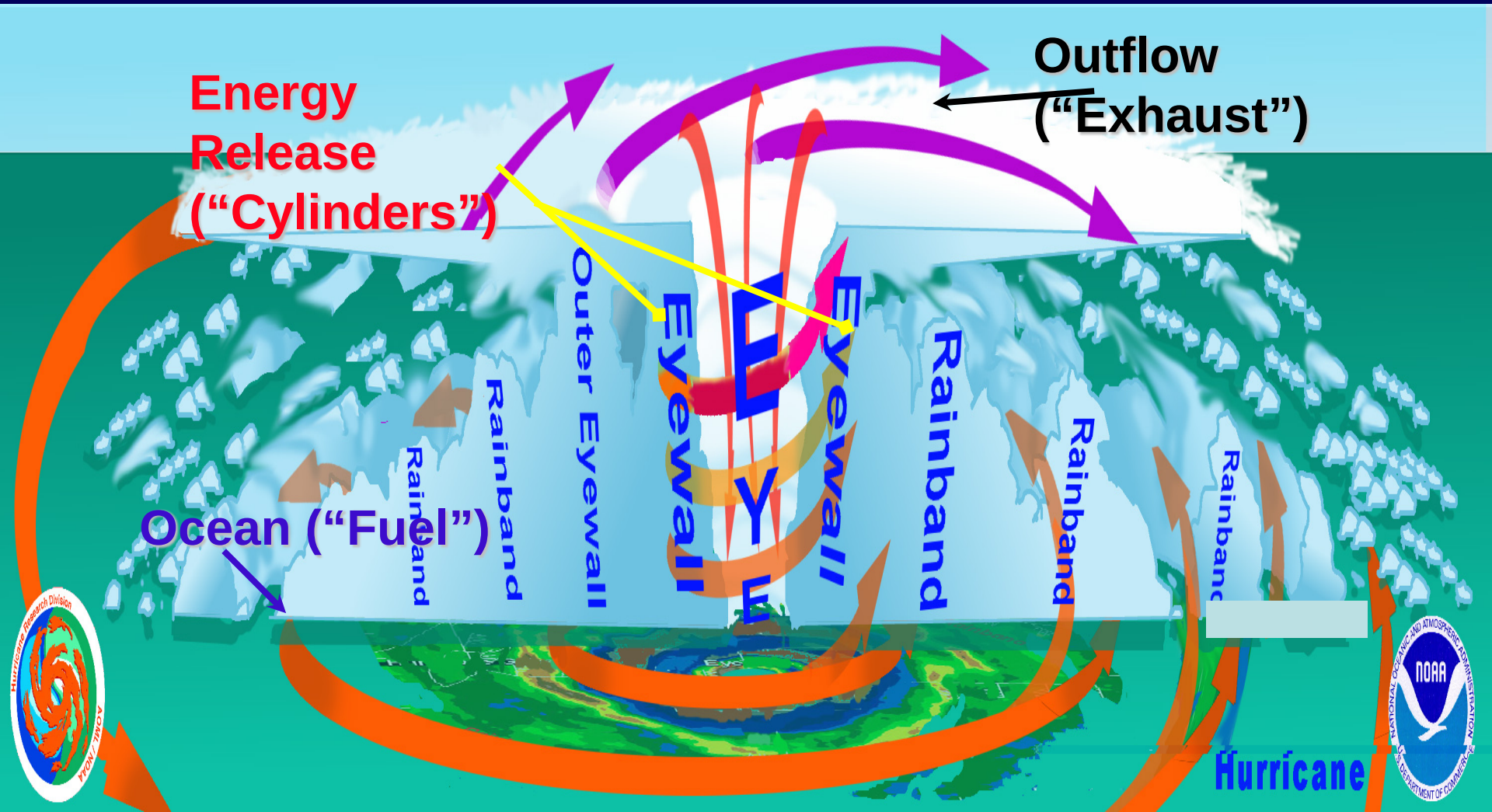
Hurricane Dorian (3 briefings)
Trop. Storm Nestor (2 briefings)
Trop. Storm Olga (2 briefings)

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

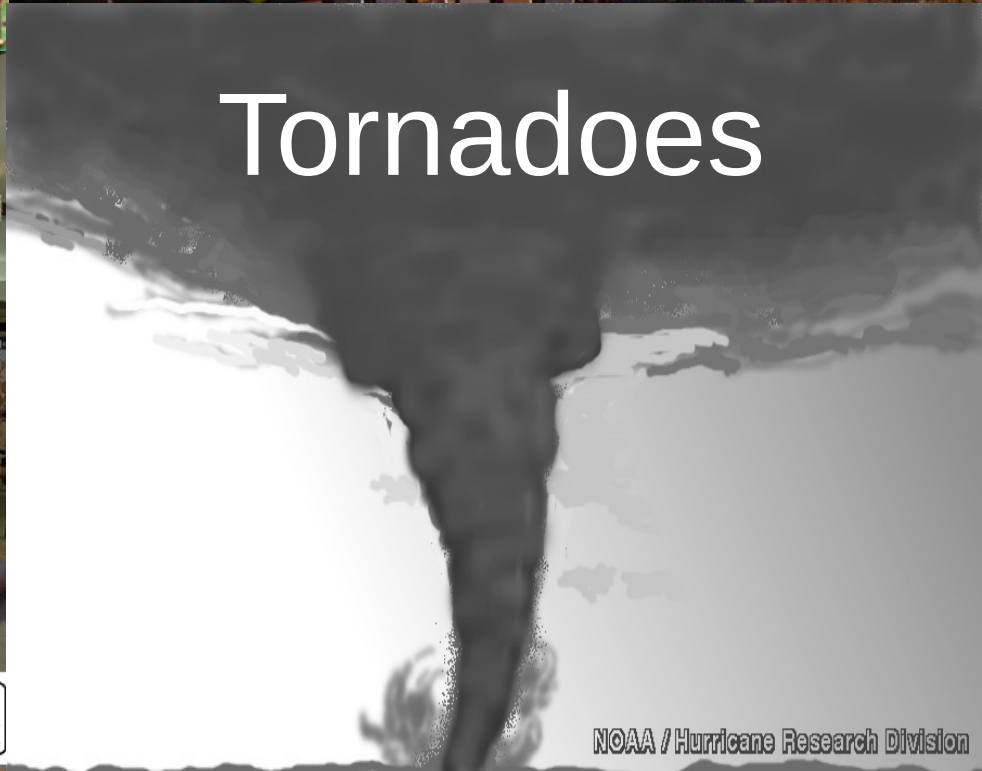


Wind-caused Damage

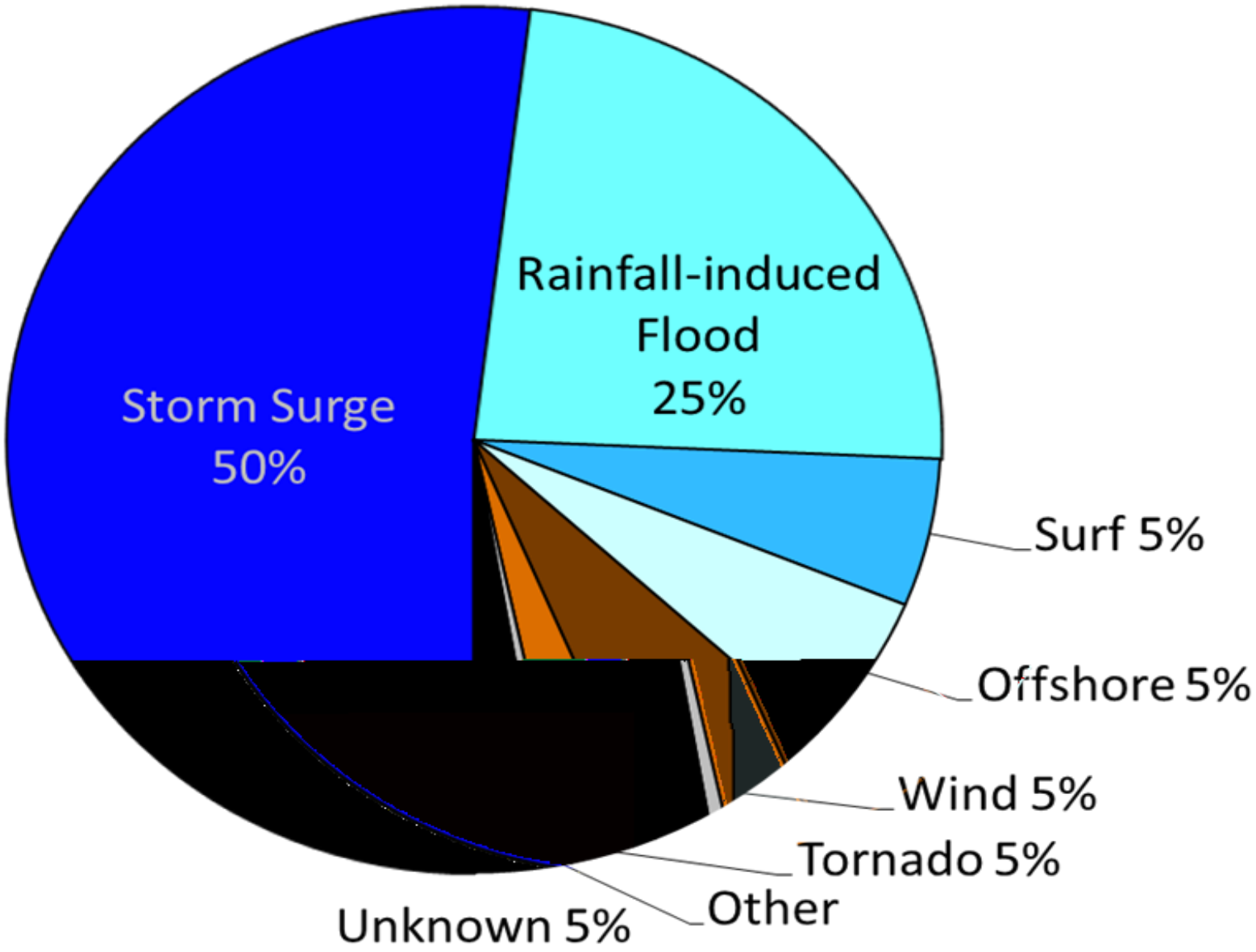
Storm Surge

Inland Flooding

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

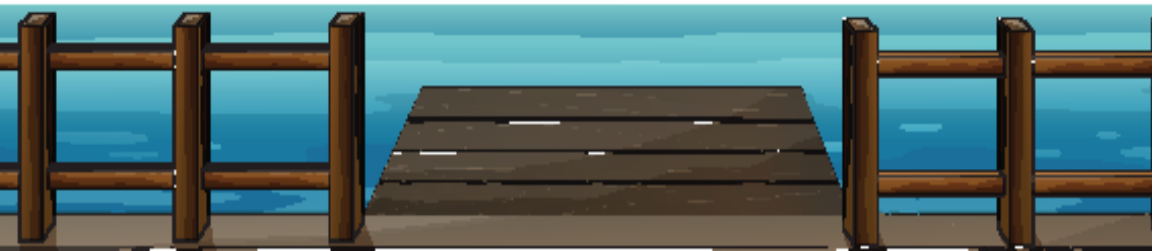
Census Bureau Statistics Can Help Community Leaders Prepare for Hurricanes

185

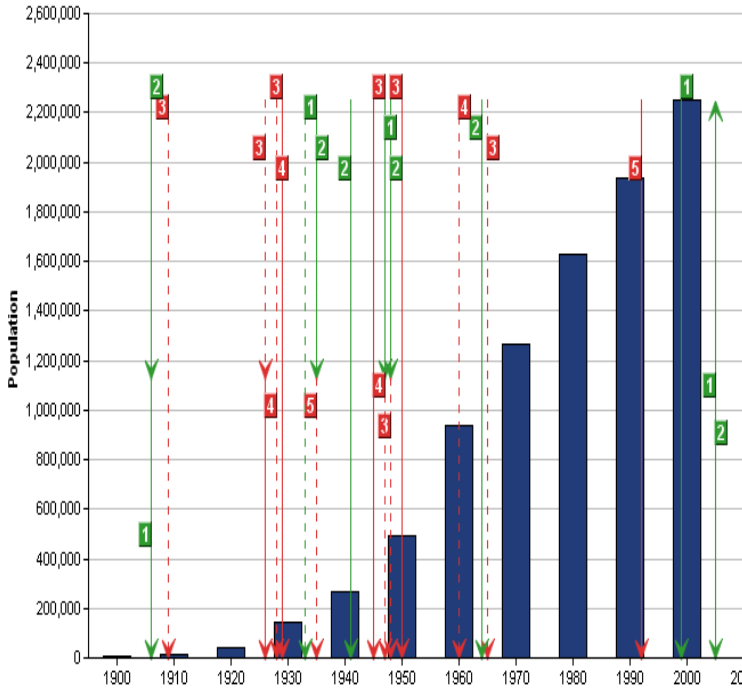
U.S. coastline counties along the Atlantic Ocean (129) and Gulf of Mexico (56)

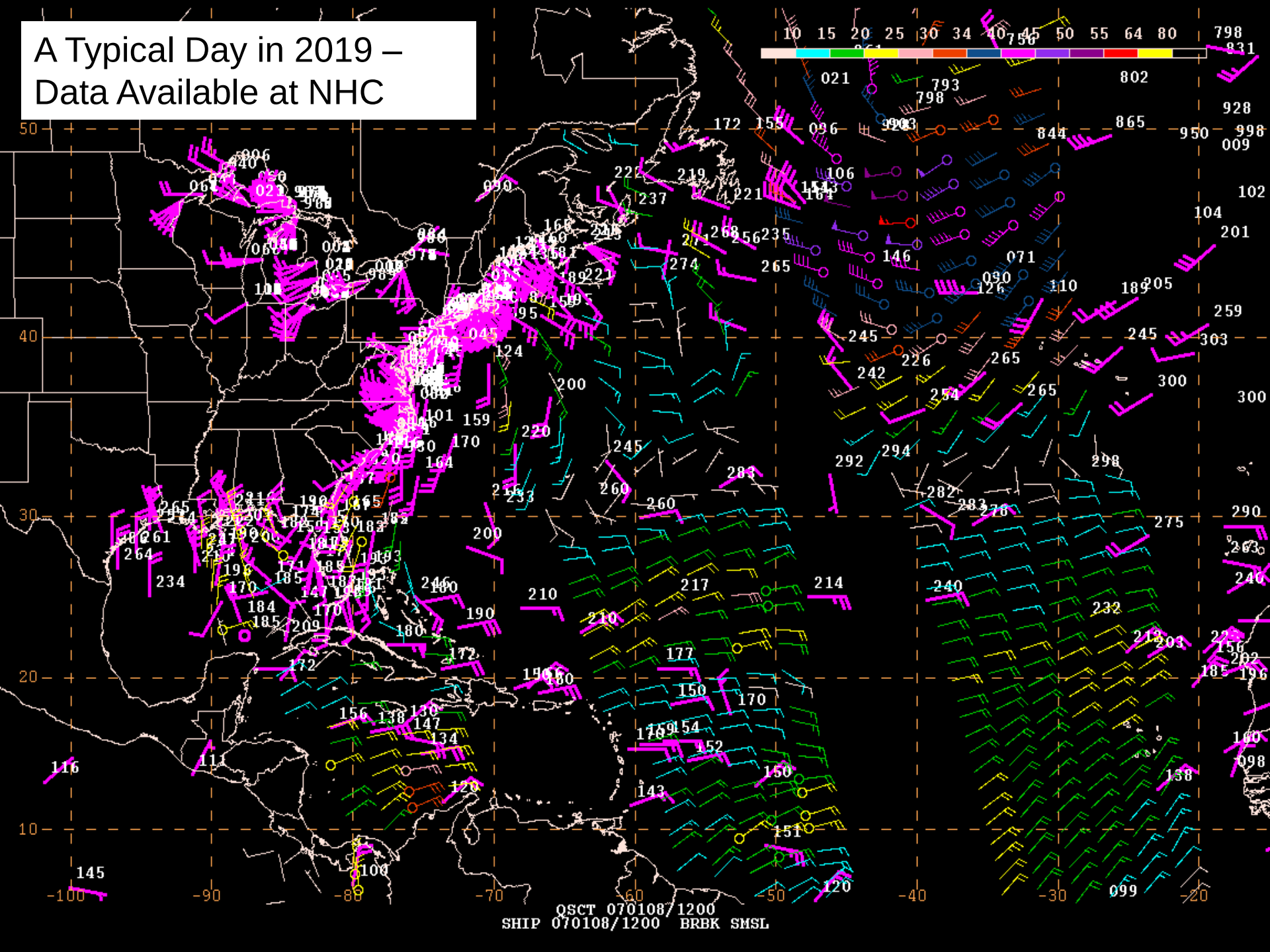
58 million

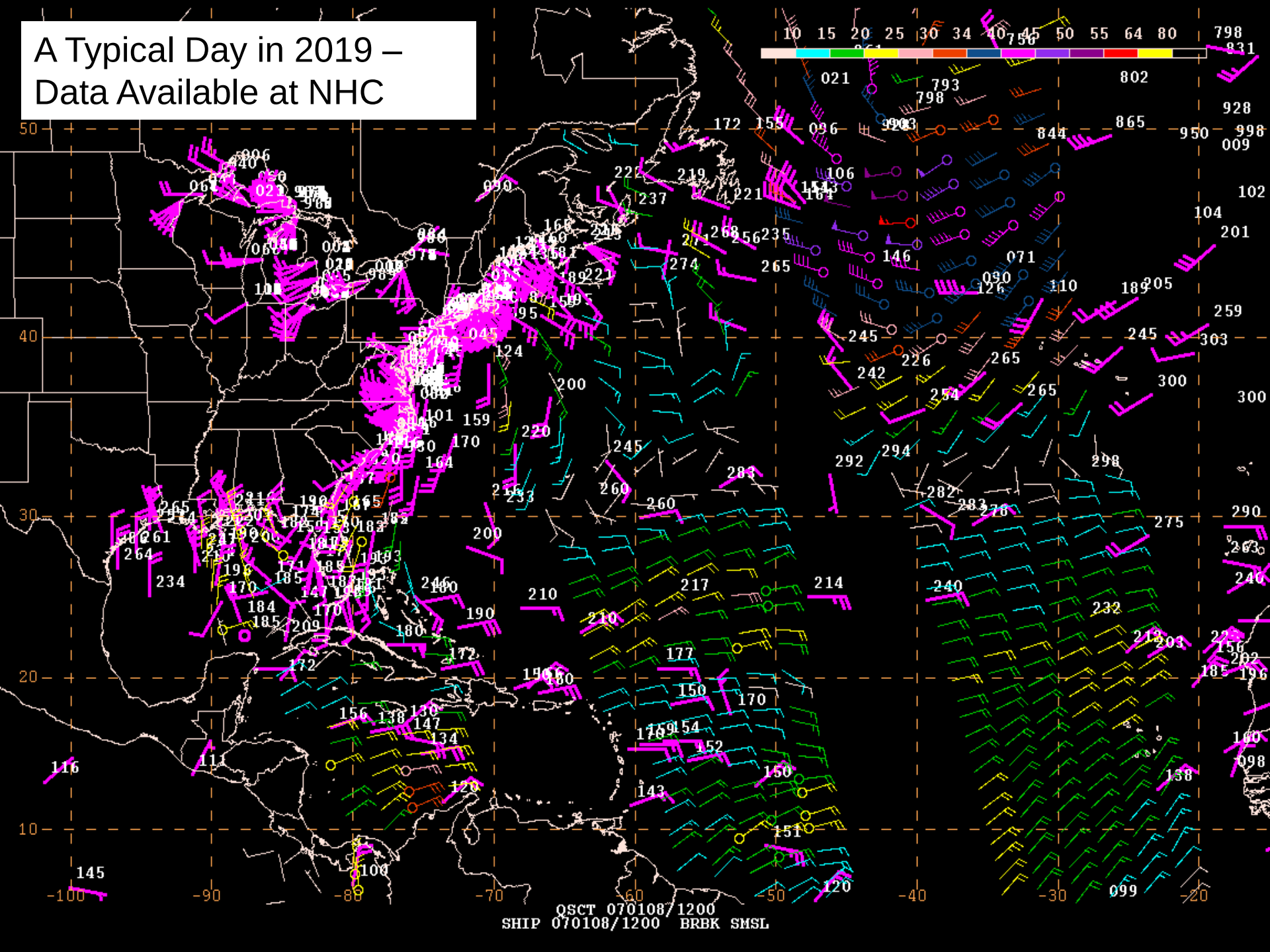
Population of coastline counties stretching from Maine to Texas



Hurricane Strikes vs Population for Miami-Dade, Florida




A Typical Day in 2019 –
Data Available at NHC
10 15 20 25 30 34 40 45 50 55 64 80
50
40
30
20
10
-100
-90
-80
-70
-60
-50
-40
-30
-20
QSCT 070108/1200
SHIP 070108/1200 BRBK SMSL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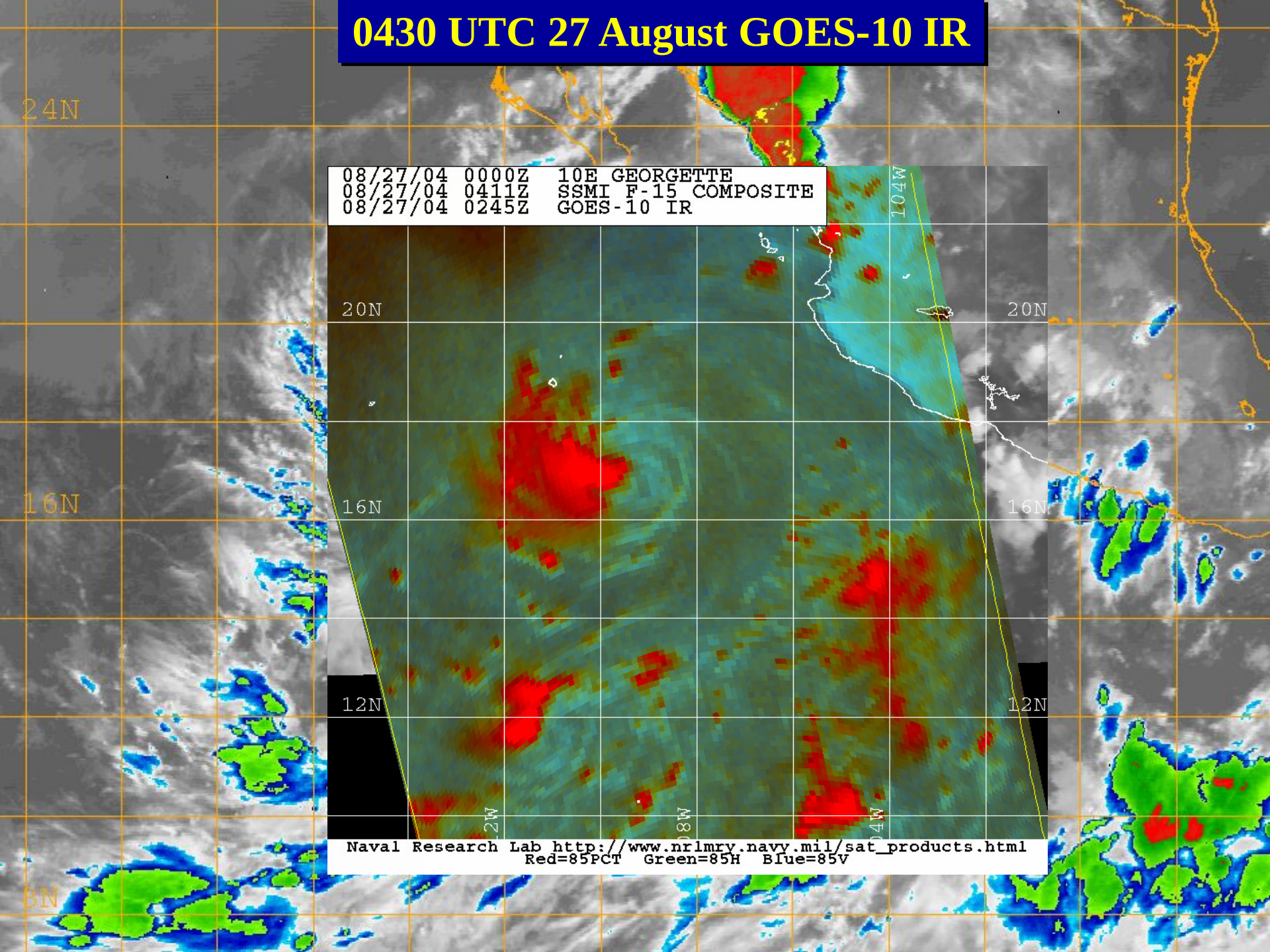
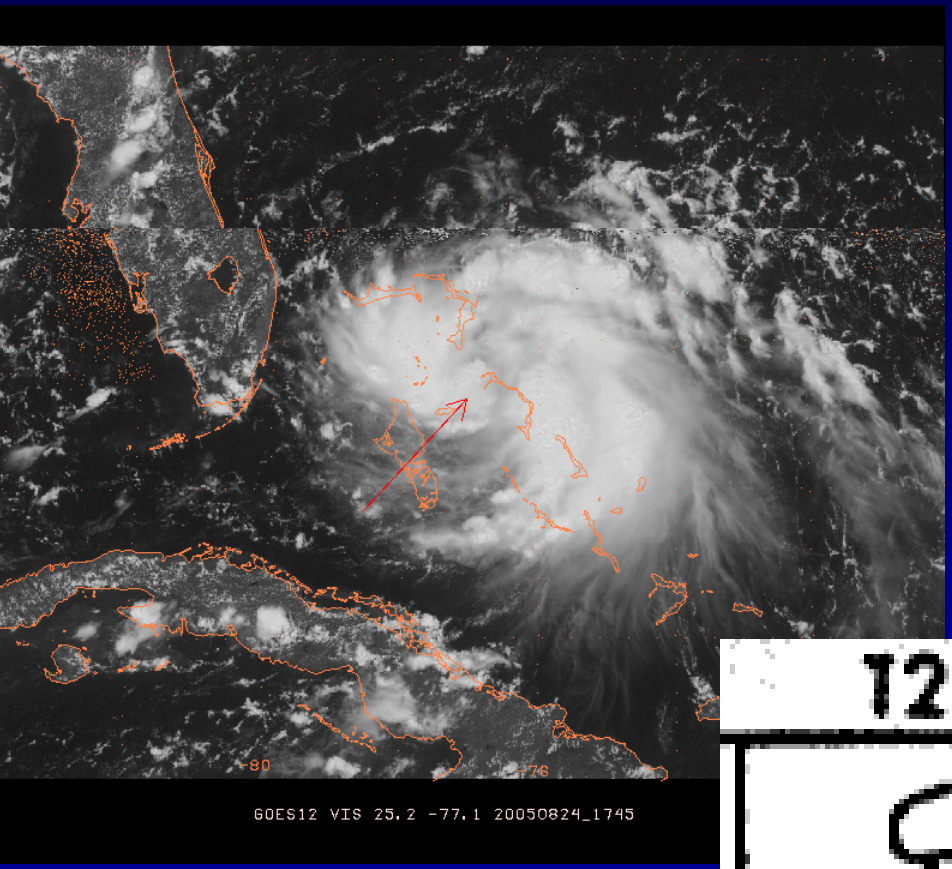
QSCT 070108/1200
SHIP 070108/1200 BRBK SMSL

0430 UTC 27 August GOES-10 IR

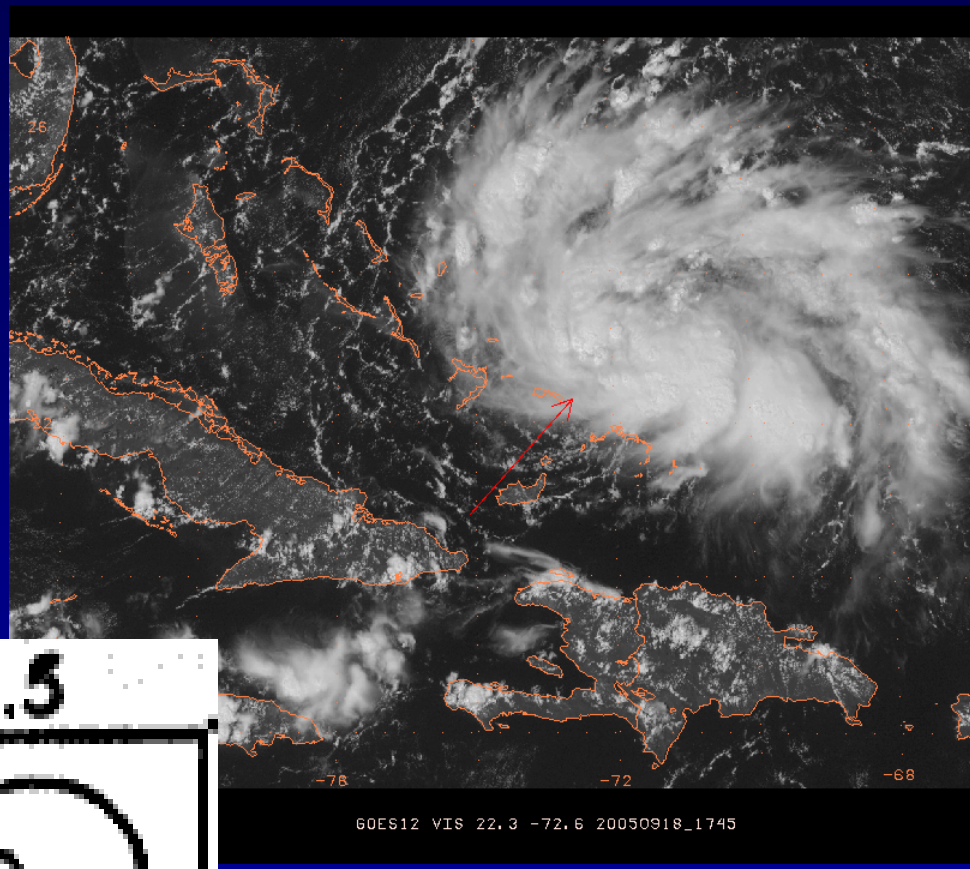


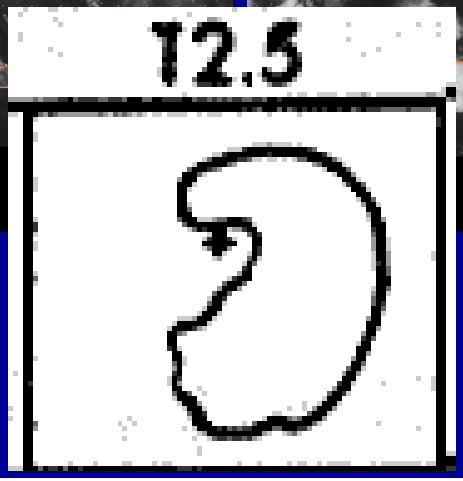
Satellite Imagery – Dvorak Technique

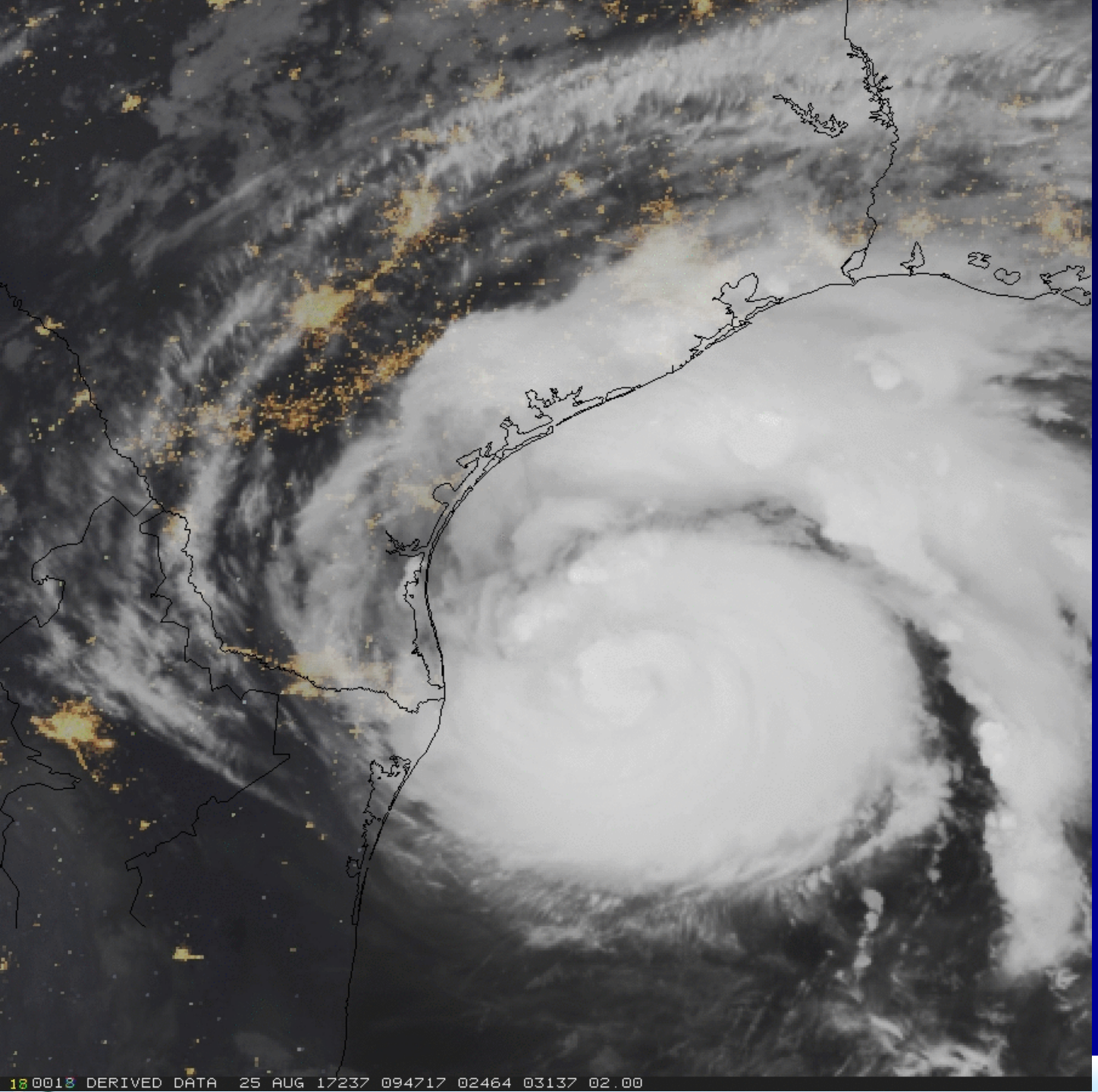
Katrina August 24



Rita September 18







GOES-16: A new era of geo-stationary satellite imagery and data

A Typical Day in 2019 – Data Available at NHC

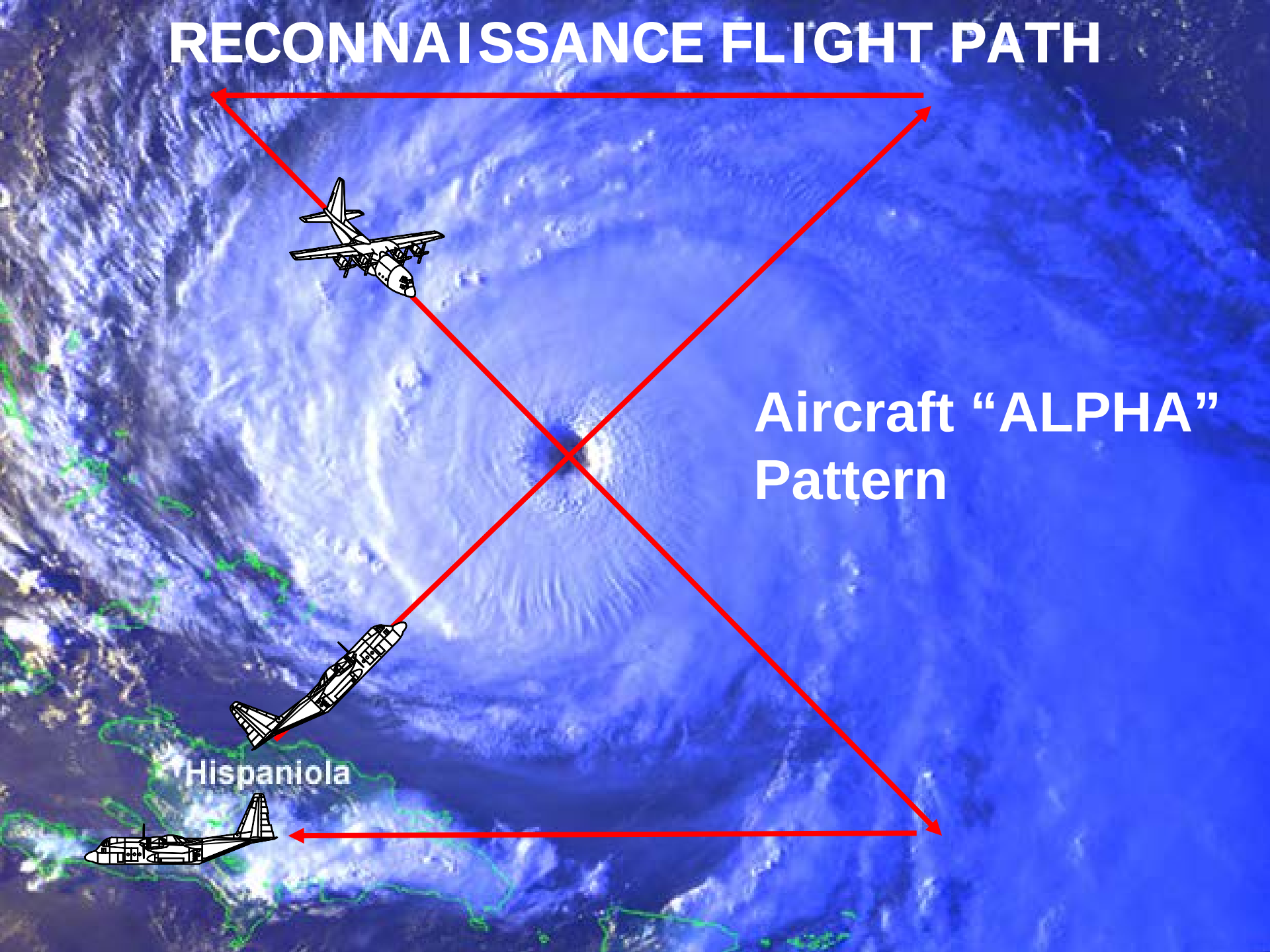
QSCT 070108/1200
SHIP 070108/1200 BRBK SMSL

"Miss Piggy" Built in 1976 at Lockheed-Martin, Marietta, Georgia

"Kermit" Built in 1975 at Lockheed-Martin, Marietta, Georgia

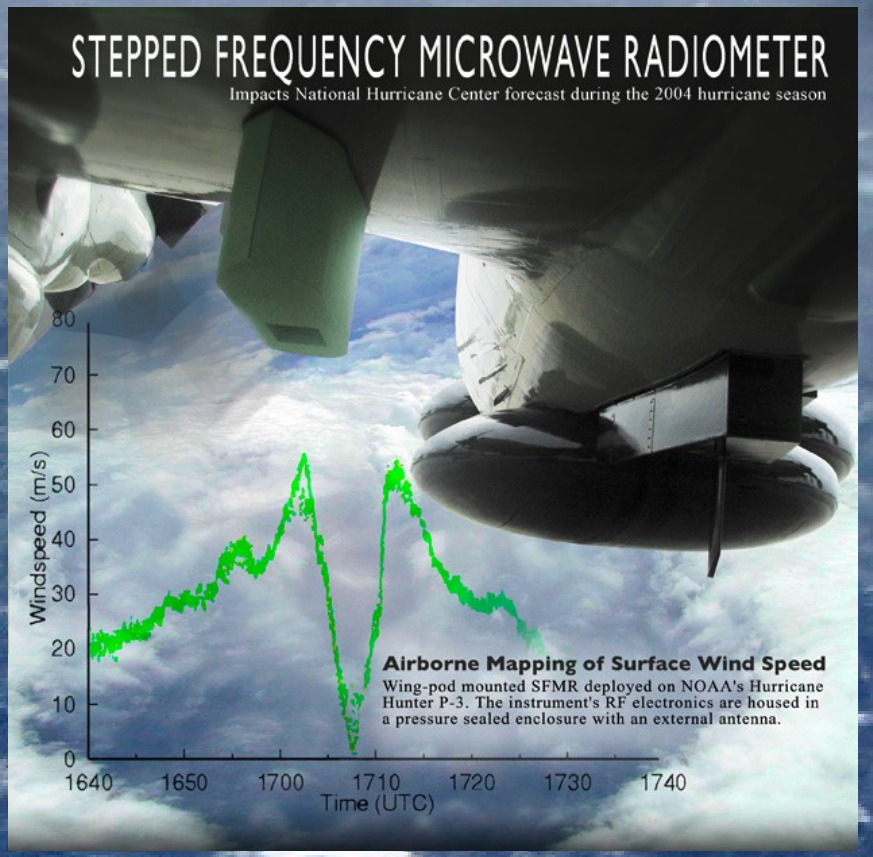
"Gonzo" Built in 1994 at Gulfstream Aerospace Corporation in Savannah Georgia

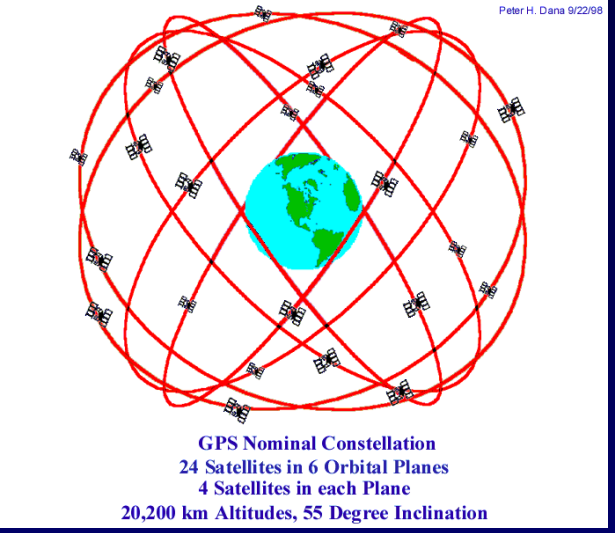
RECONNAISSANCE FLIGHT PATH



Aircraft “ALPHA” Pattern

Sea state under Hurricane Isabel





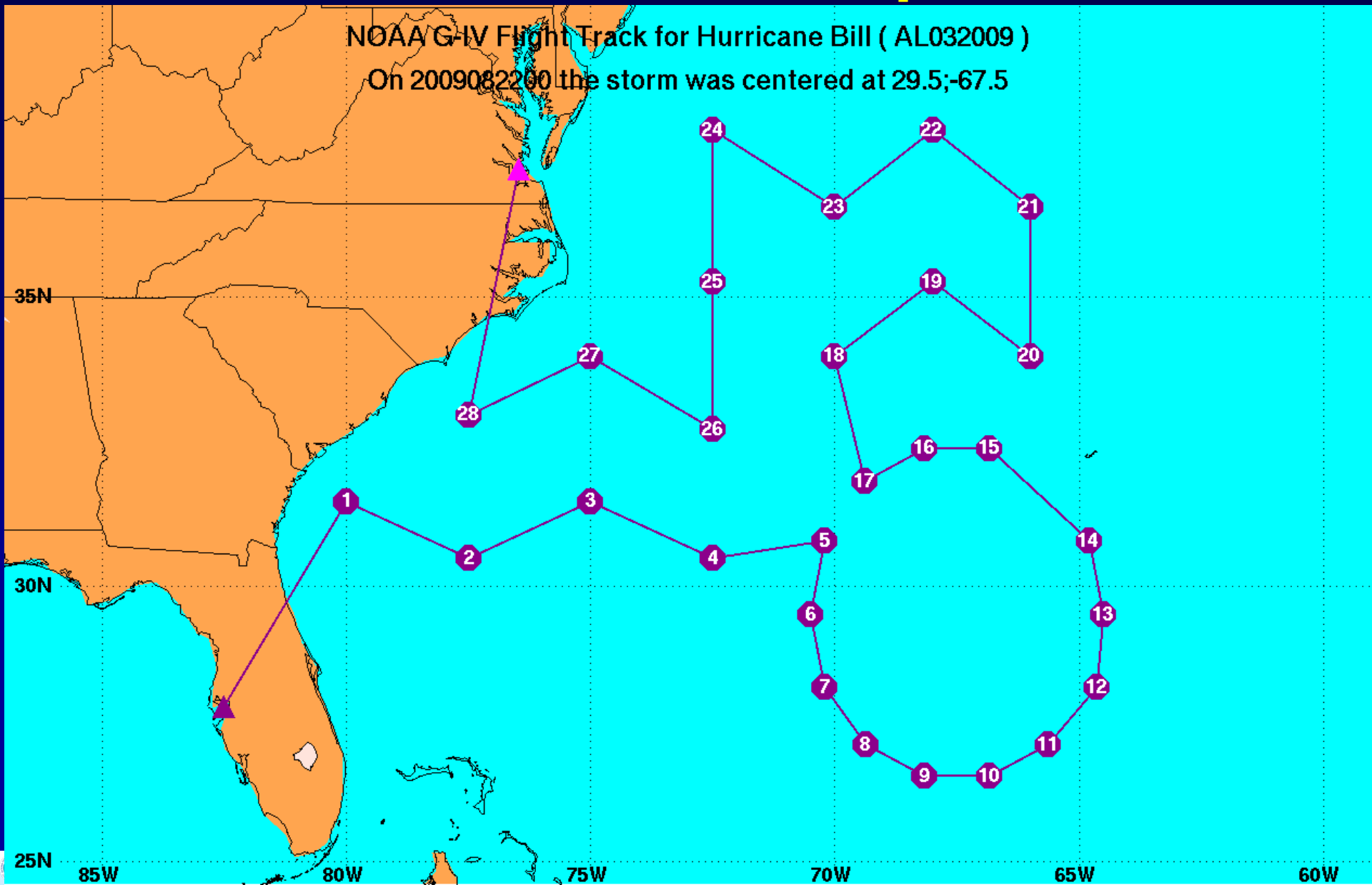
GPS DROPWINDSONDE

- **Developed in conjunction with the NOAA Gulfstream-IV jet aircraft. First use for hurricane was late in 1996 season.**

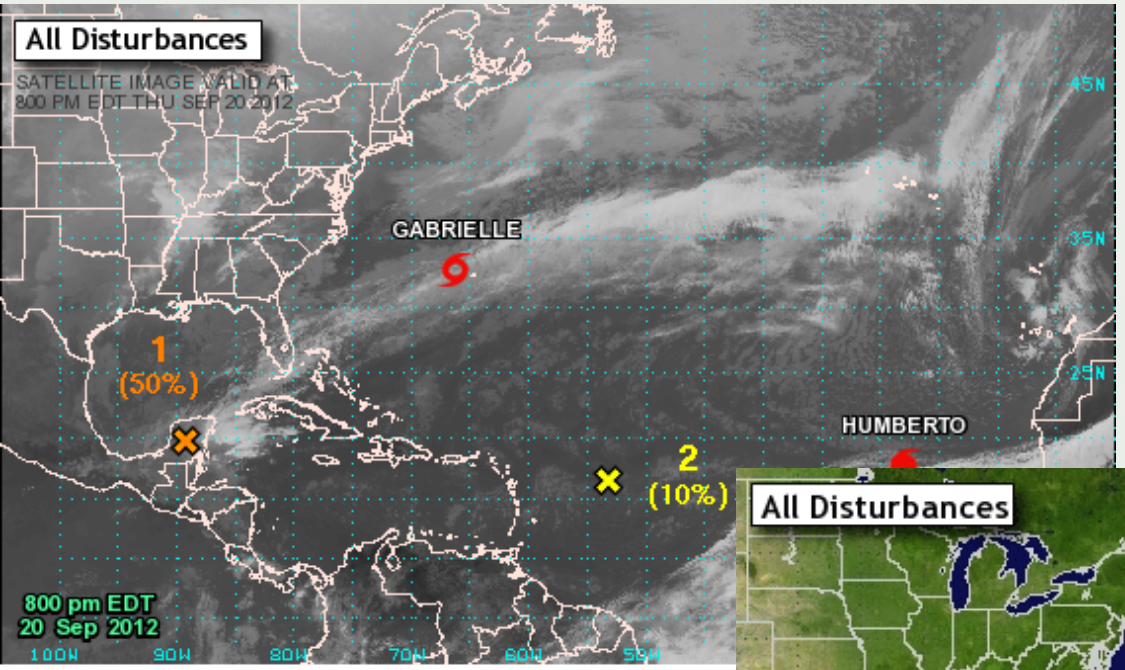
- **GPS dropsondes provide, for the first time, direct measurements of the winds at low levels in the hurricane eyewall.**

- **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



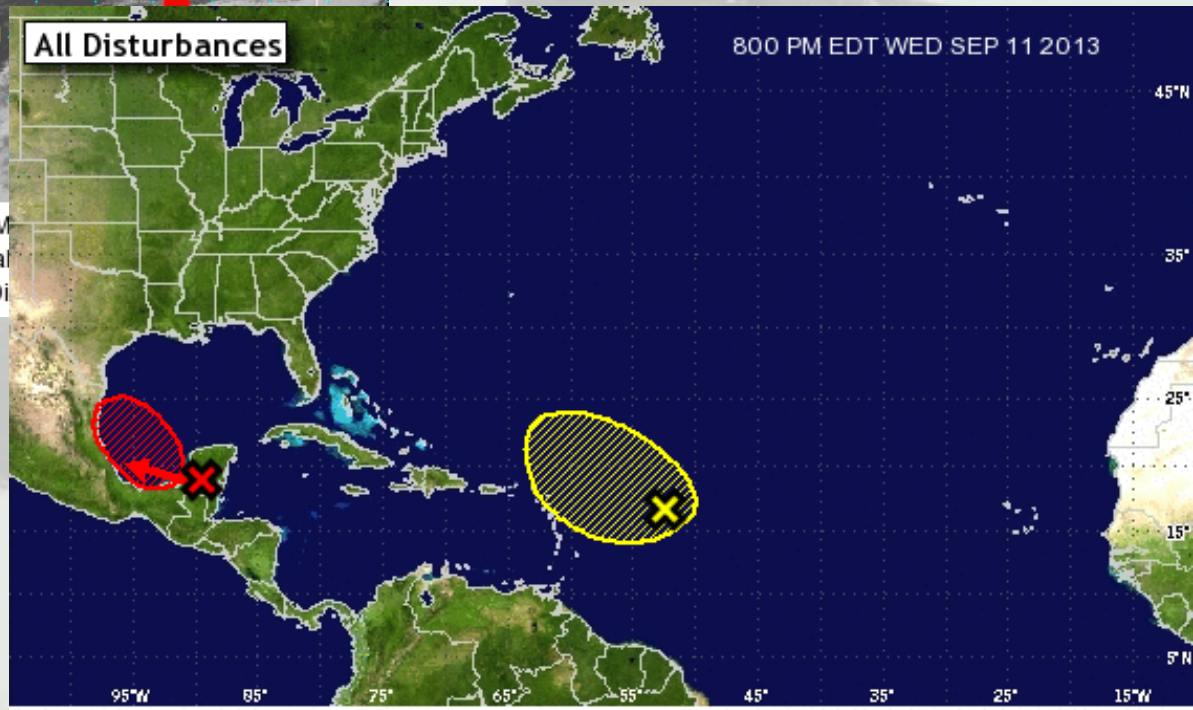
Graphical Tropical Weather Outlook:



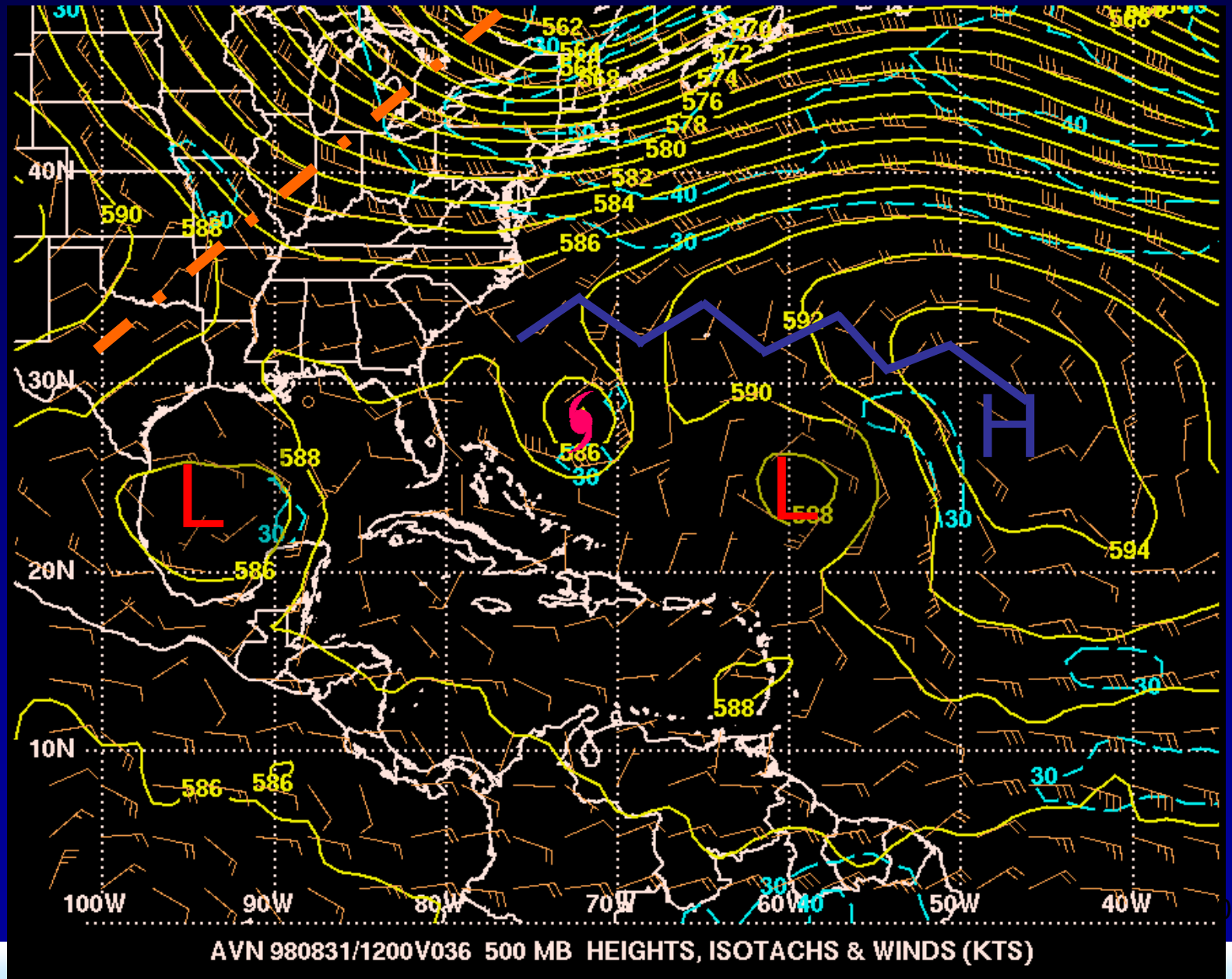
48 hour GTWO

Corresponding text provided as mouse-over on web

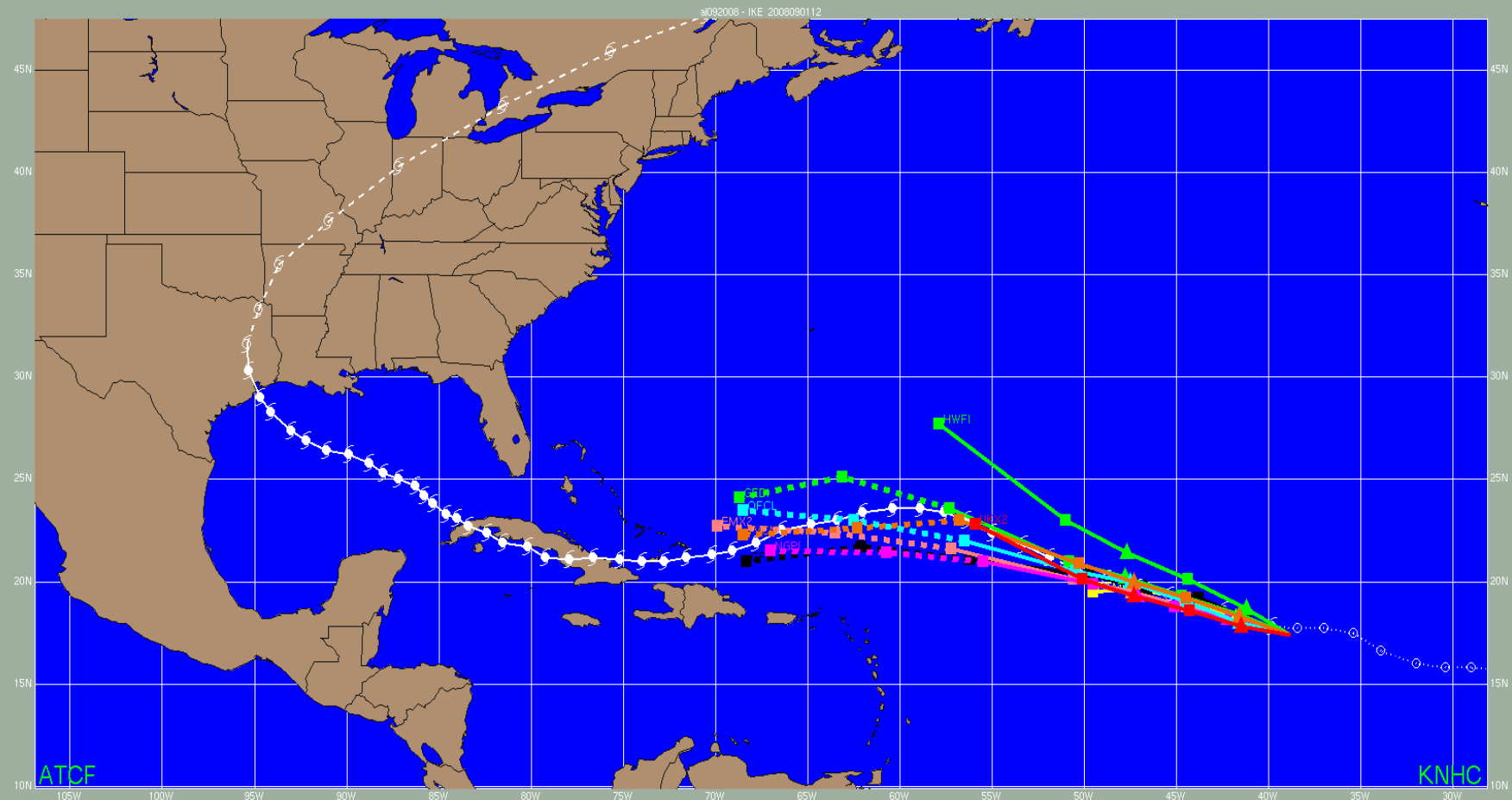
5-day GTWO



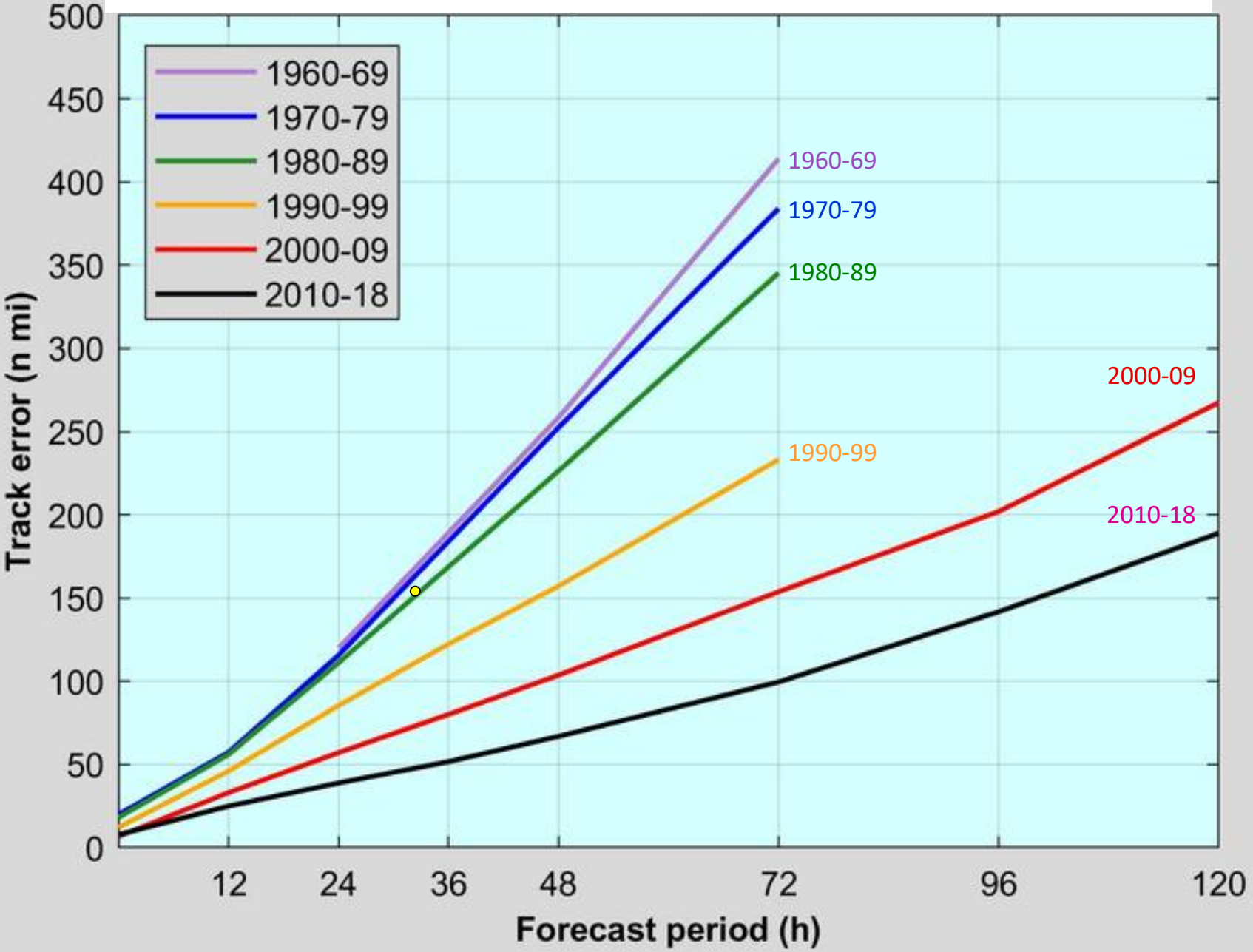
Large-Scale Steering



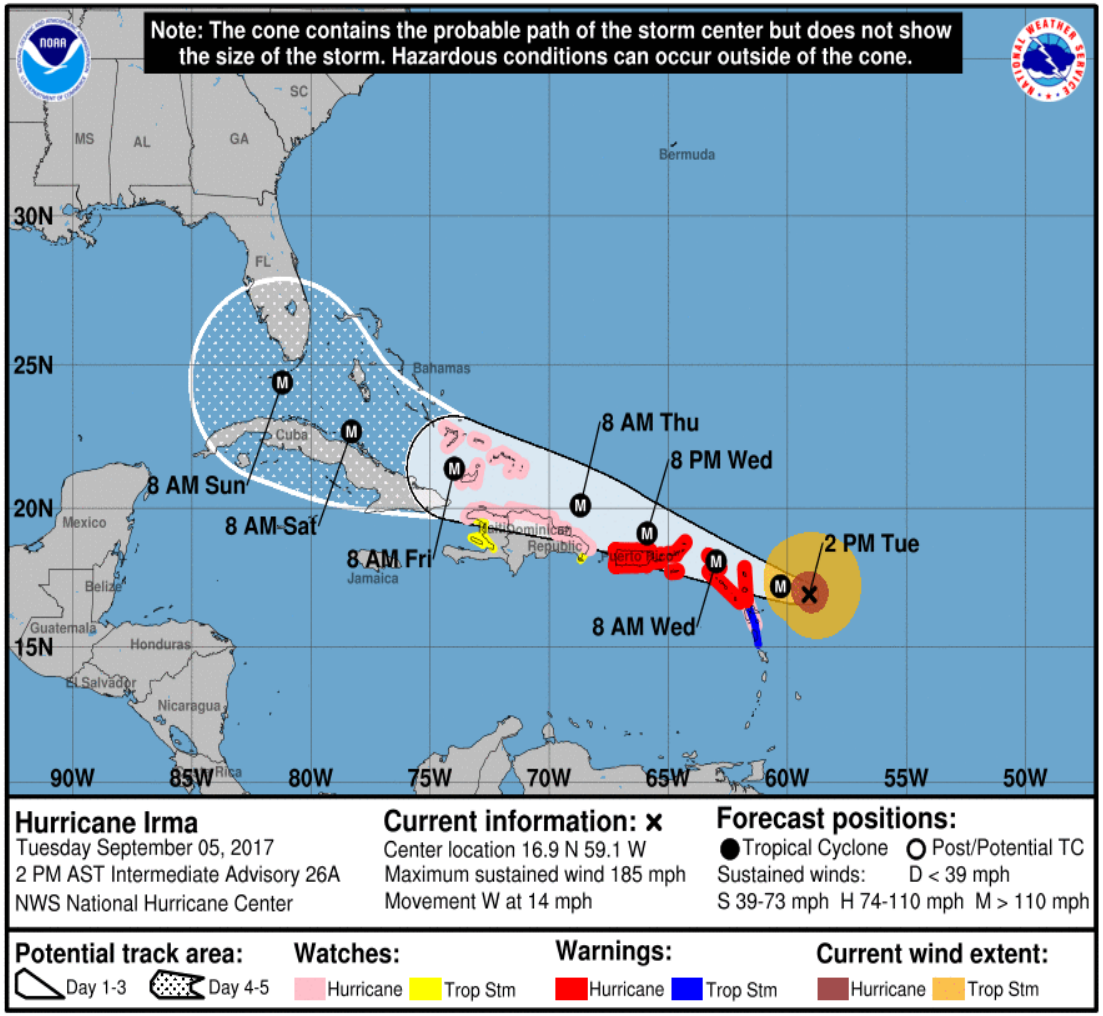
Hurricane Ike Track models



Atlantic Track Error Trends



What does the “Cone” mean?



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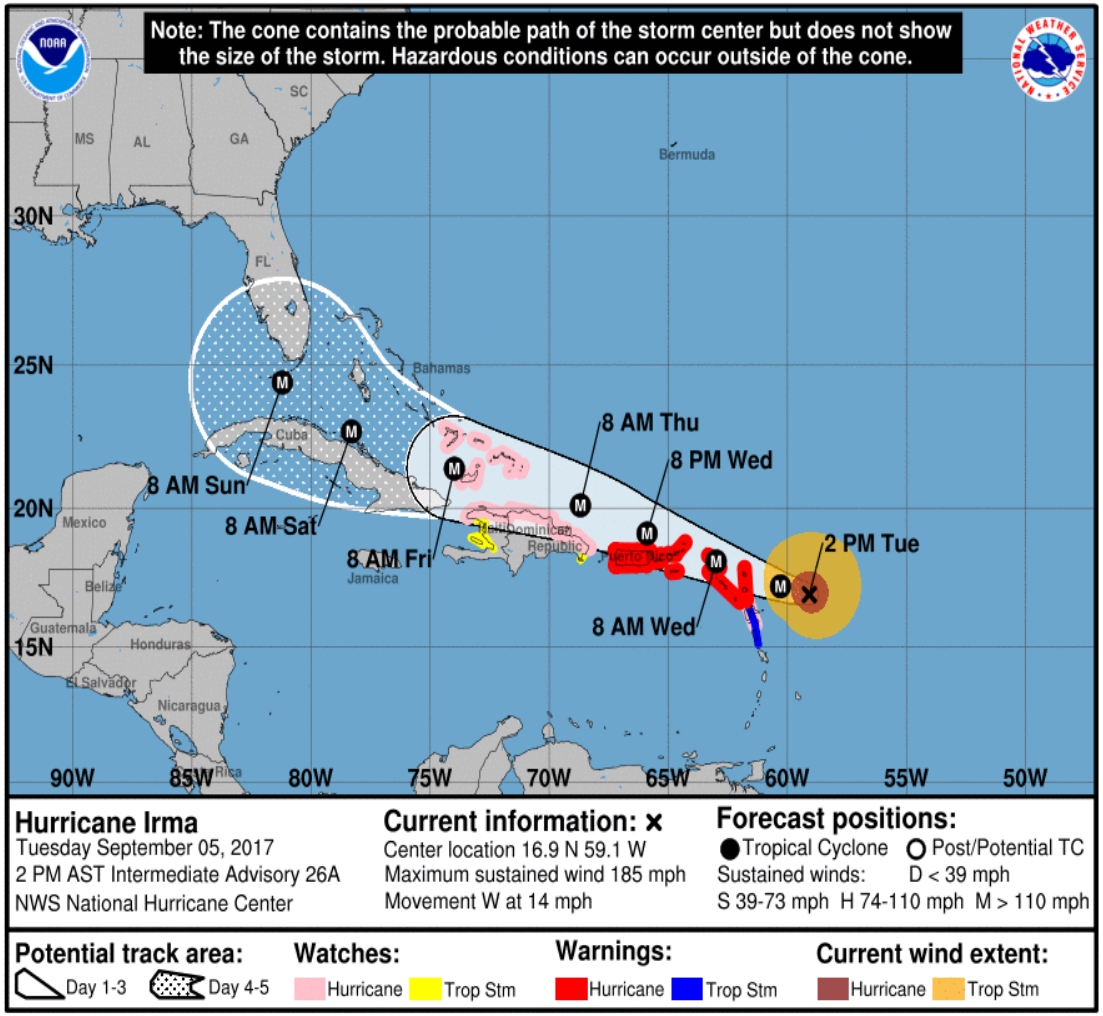

1. **Likely area of tropical storm/ hurricane force winds**

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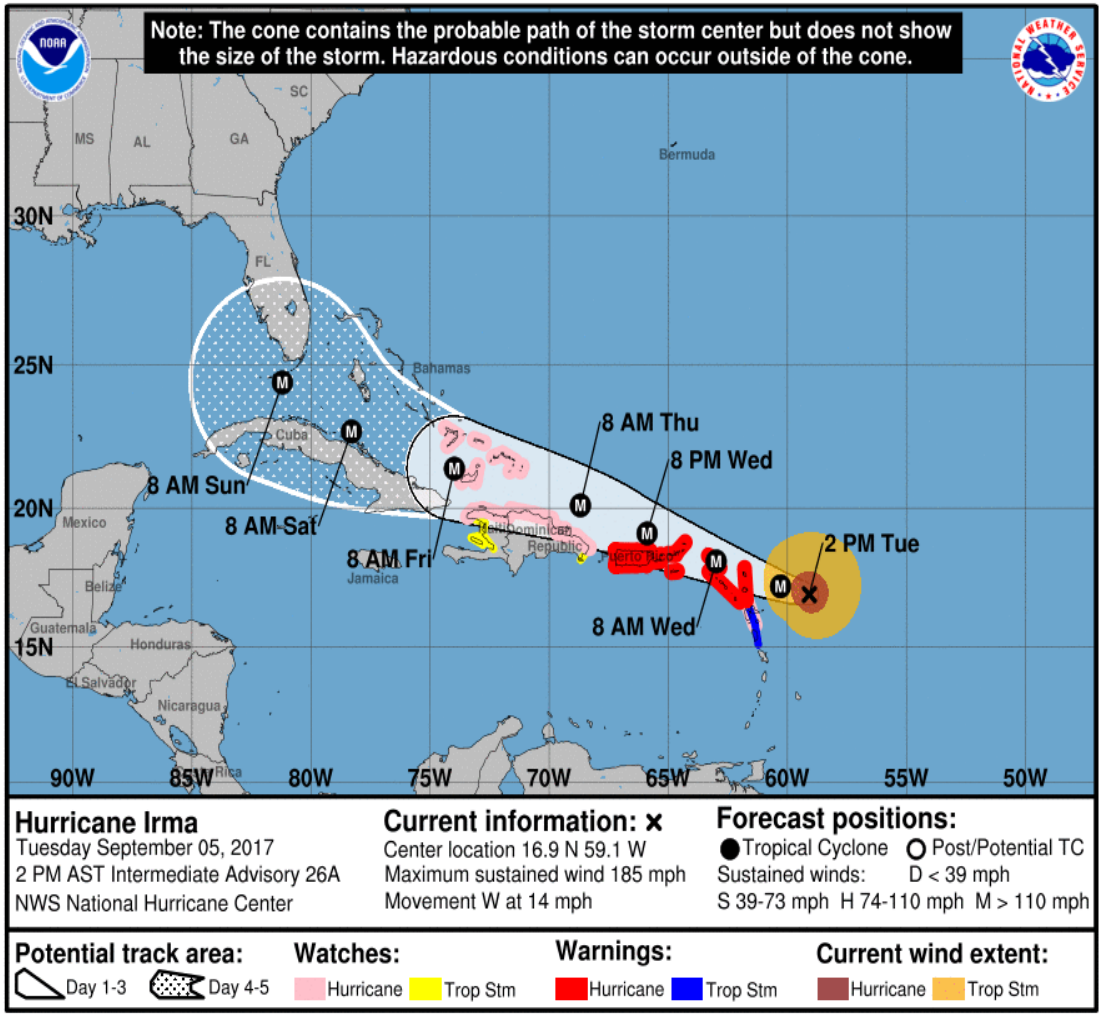
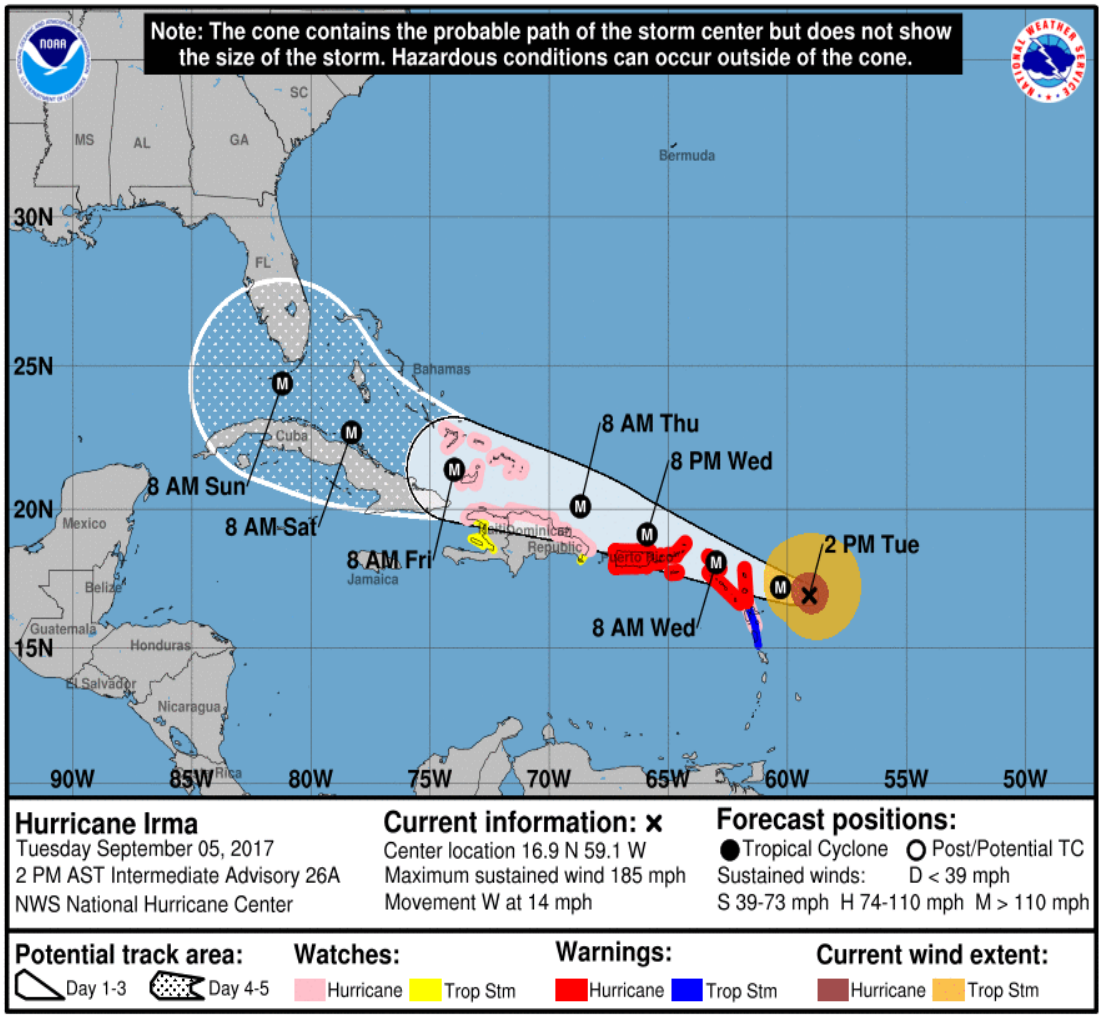


1. **Likely area of tropical storm/ hurricane force winds**
2. **Likely location of the center of the tropical storm/ hurricane**

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

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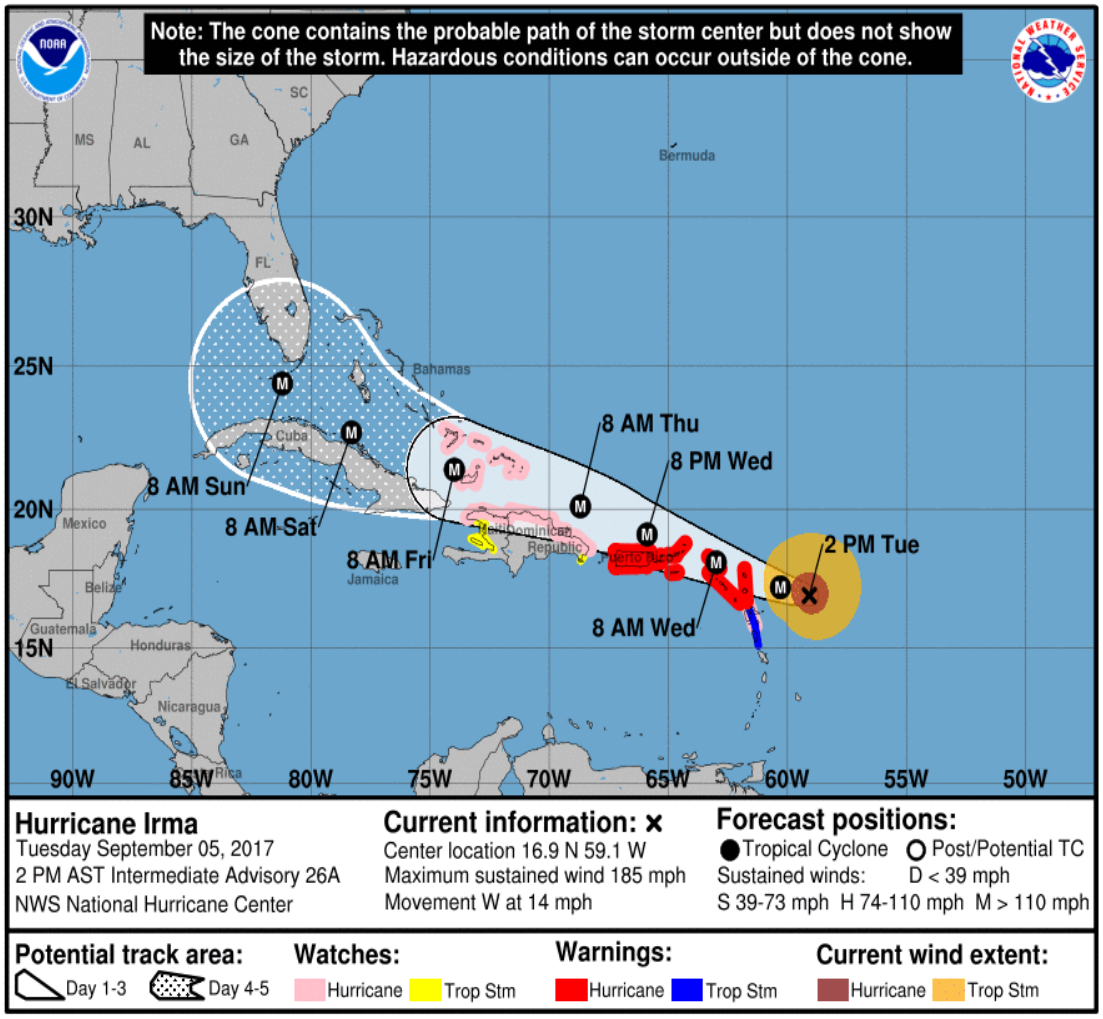

1. Likely area of tropical storm/ hurricane force winds
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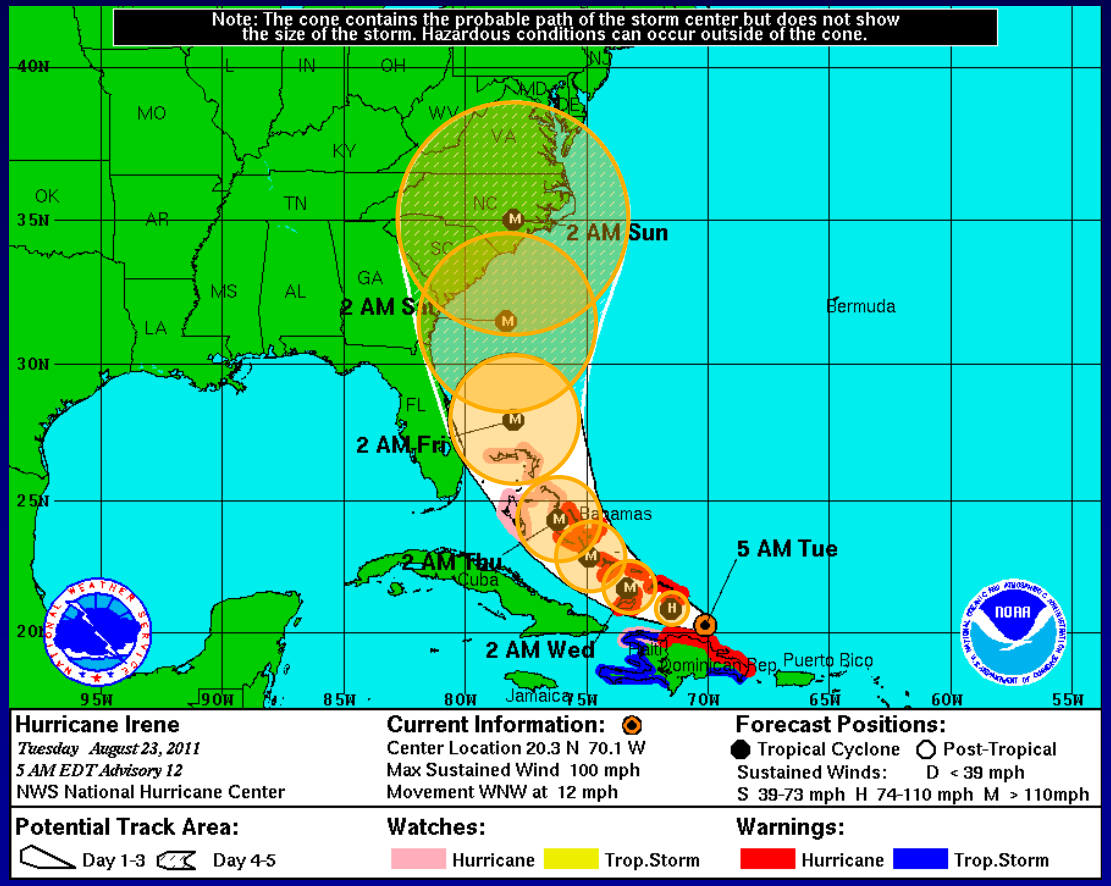
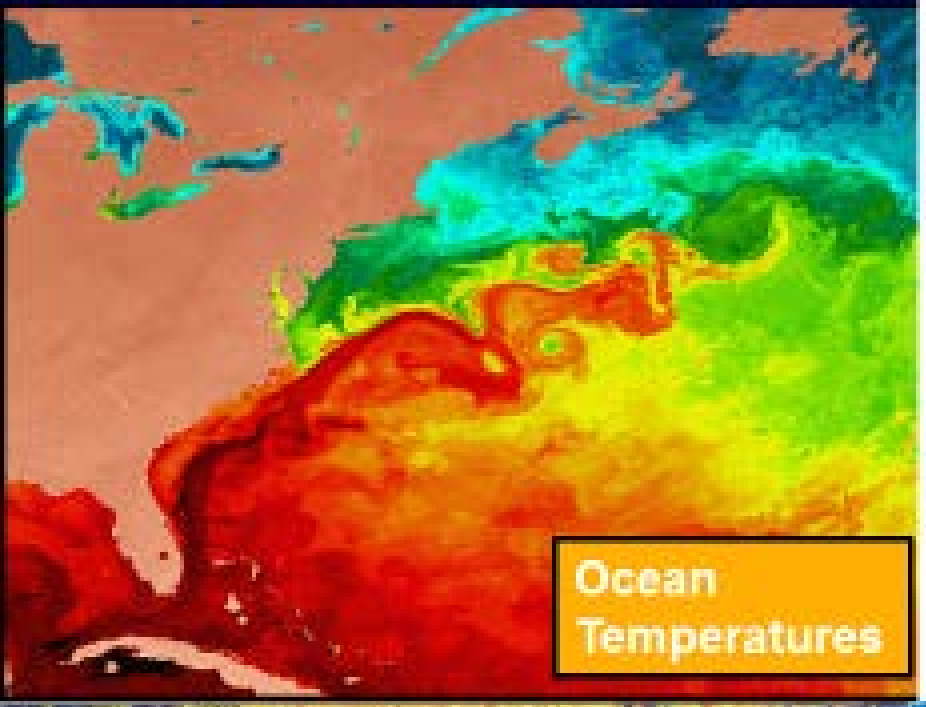
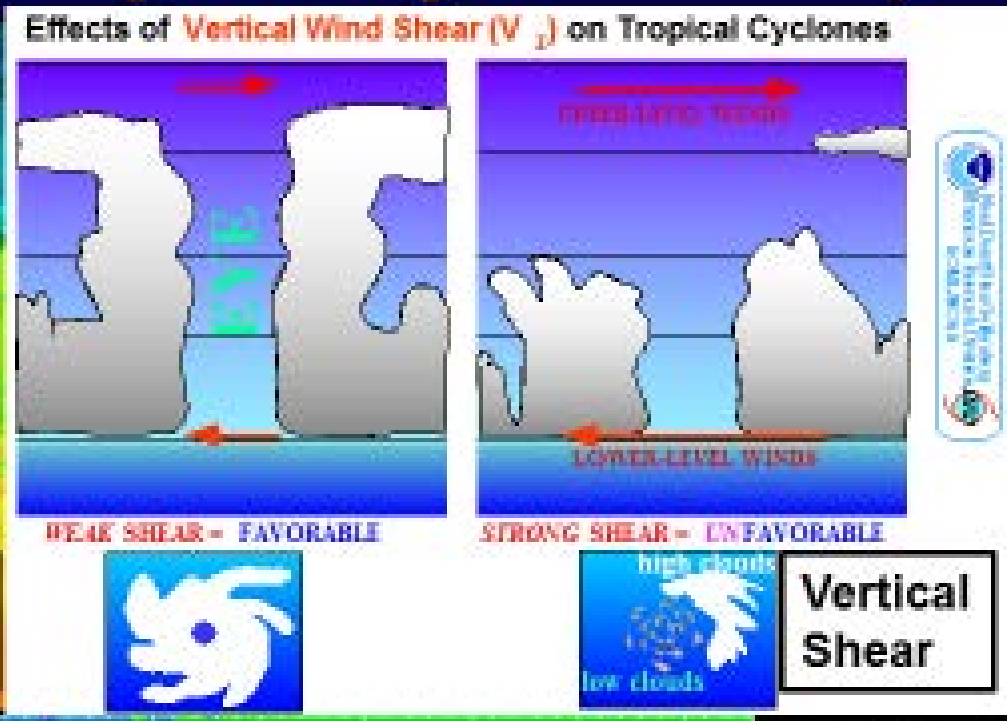
NHC Forecast Cone

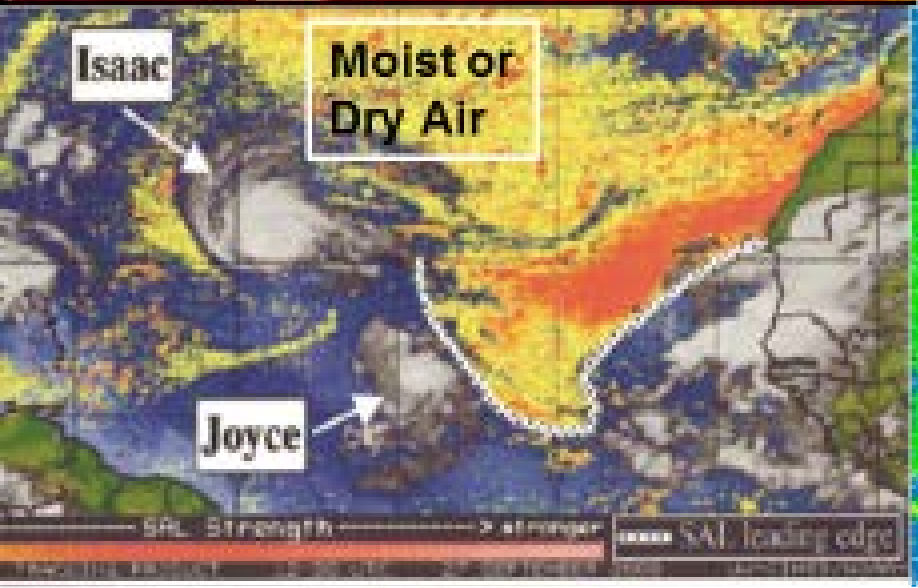
- Represents probable track of tropical cyclone center
- Formed by connecting circles centered on each forecast point (at 12, 24, 36 h, etc.)
- Size of the circles determined so that, for example, the actual storm position at 48 h will be within the 48-h circle 67% of the time

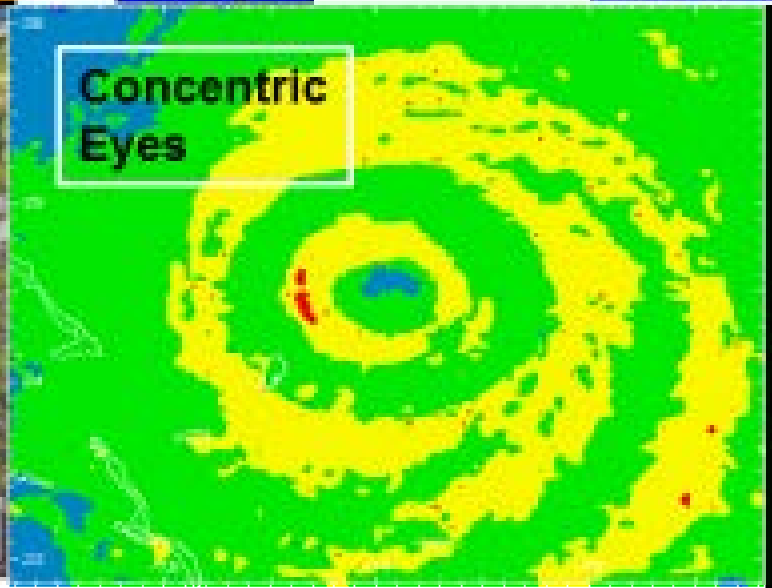


Tropical Cyclone (Wind) Intensity

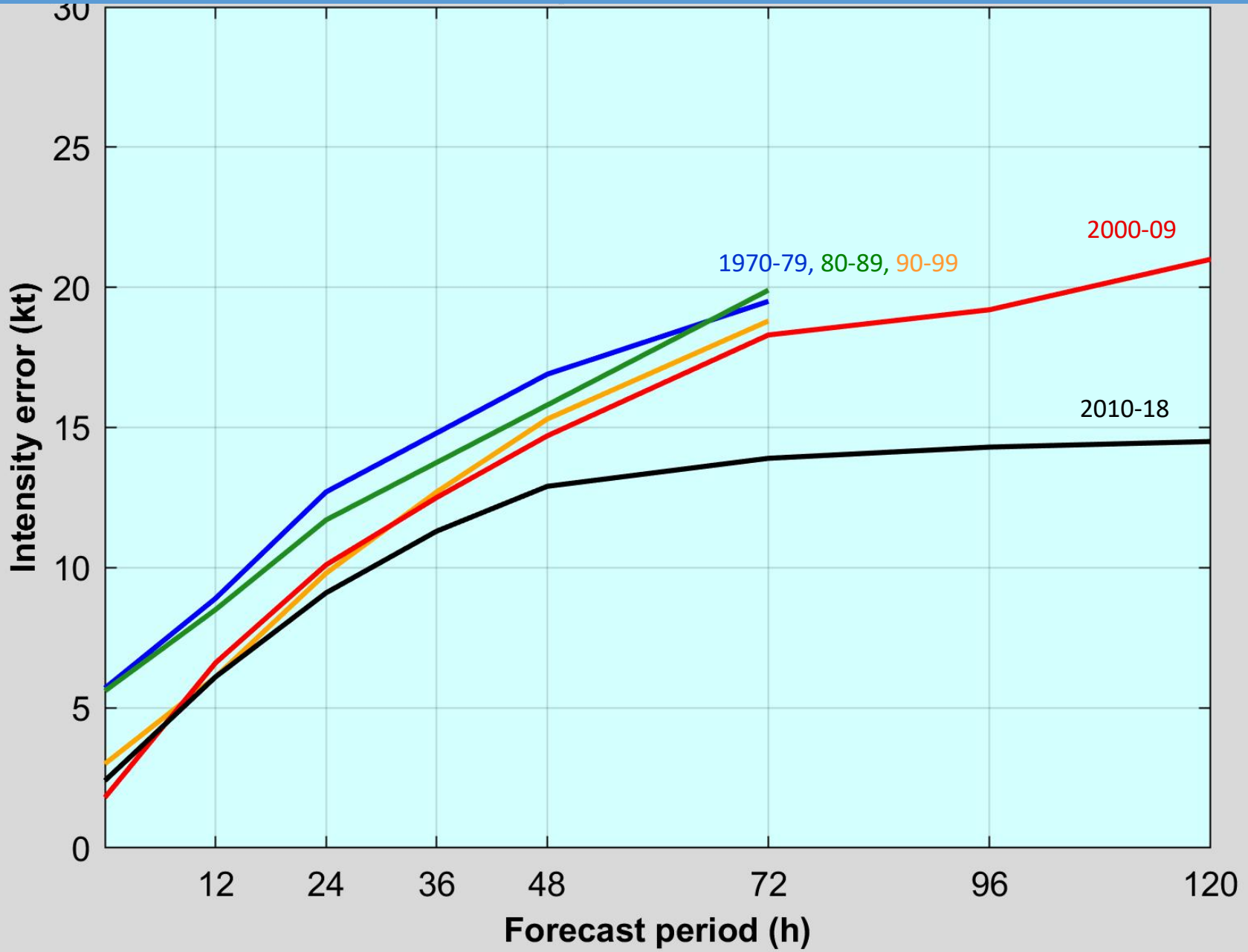




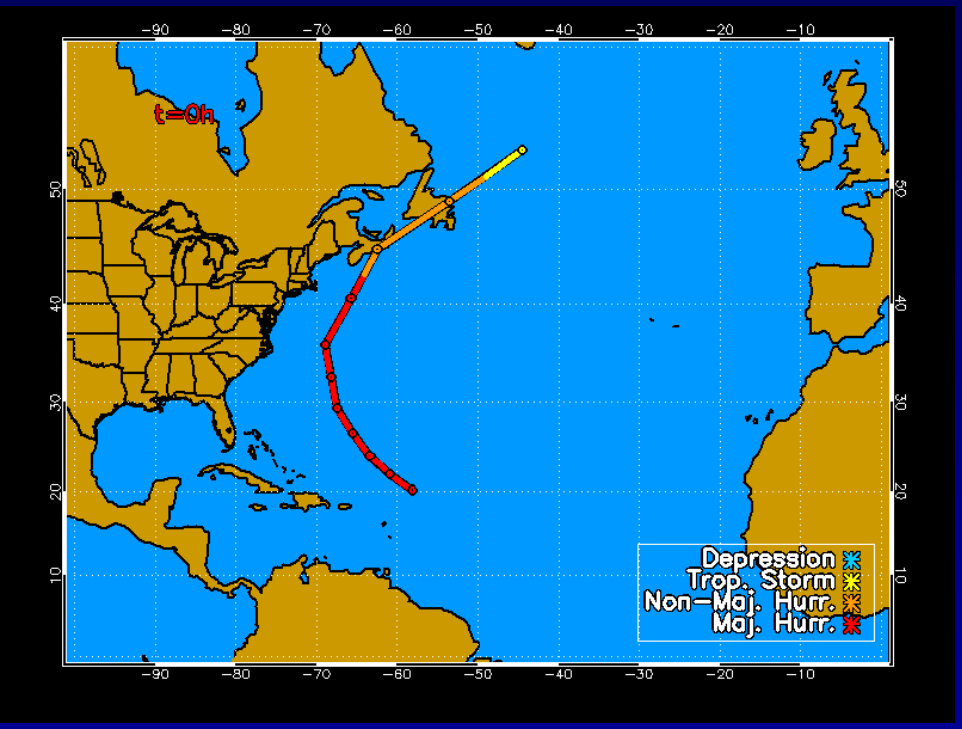


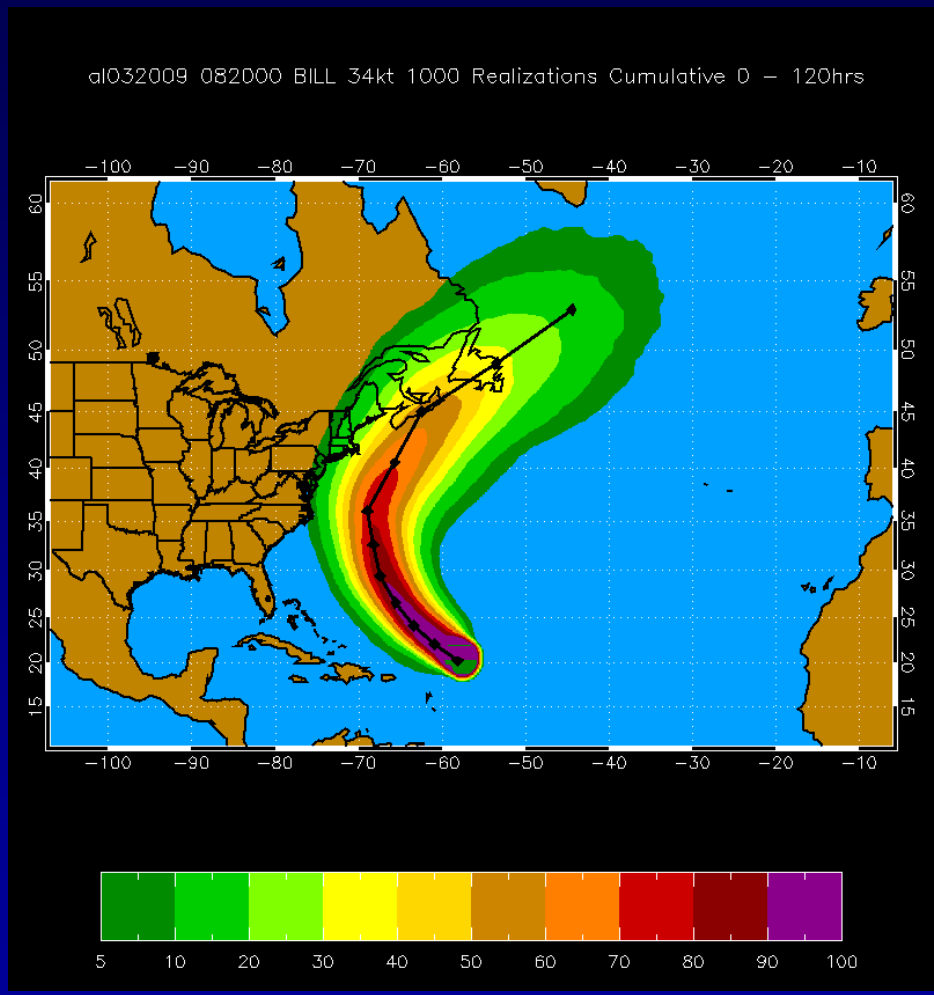


Atlantic Intensity (Maximum Winds) Error Trends



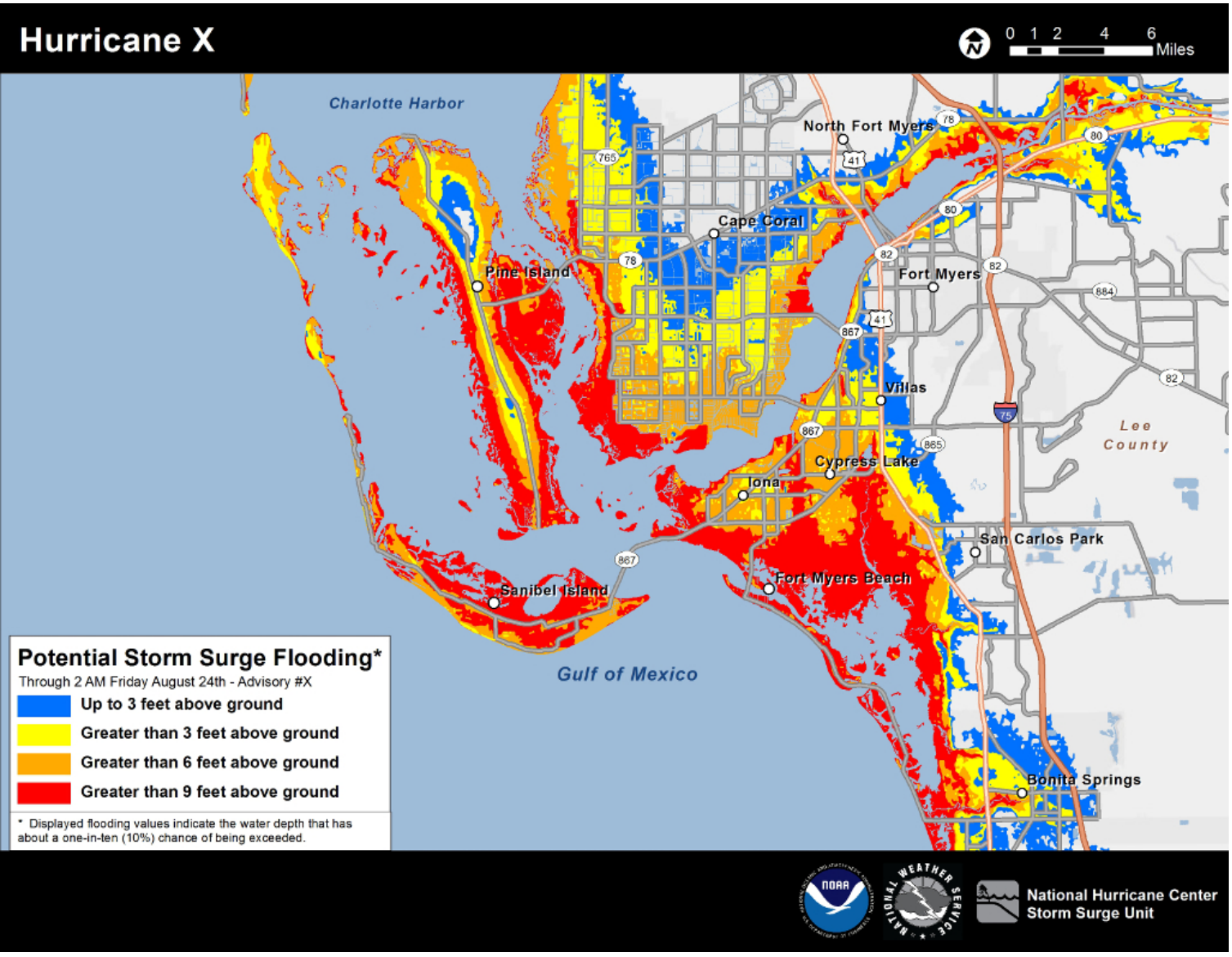
Wind Speed Probabilities
Hurricane Bill 20 Aug 2009 00 UTC





1000 Track Realizations

Storm Surge Inundation

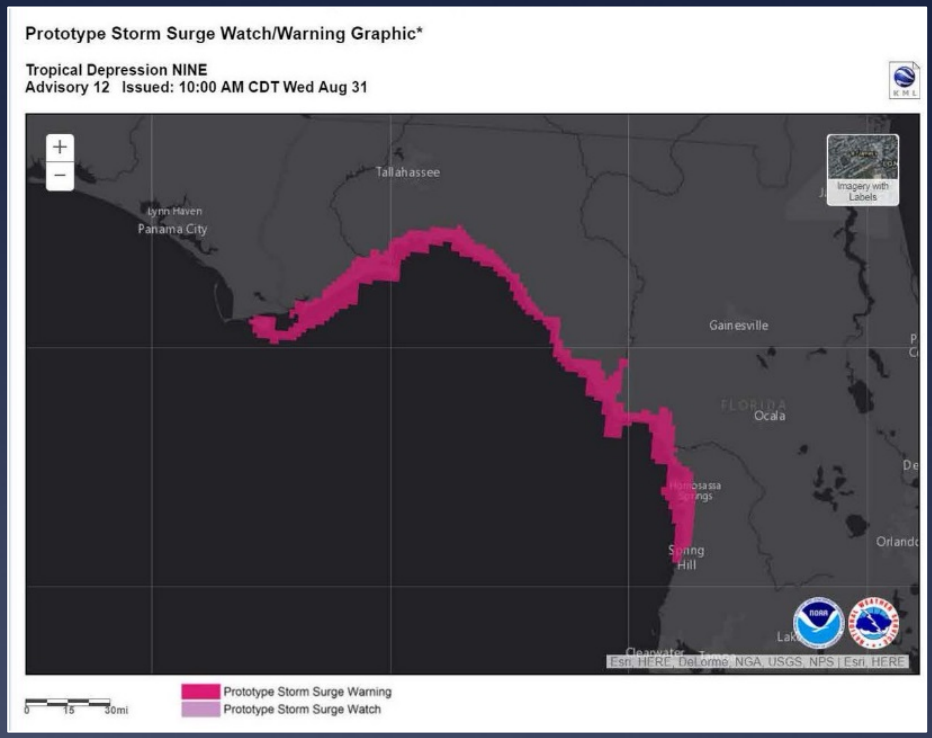


- *Geographical areas where inundation from storm surge could occur*
- *How high above ground the water could reach in those areas*
- *Based upon reasonable worst case scenario (10% exceedance)*

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:

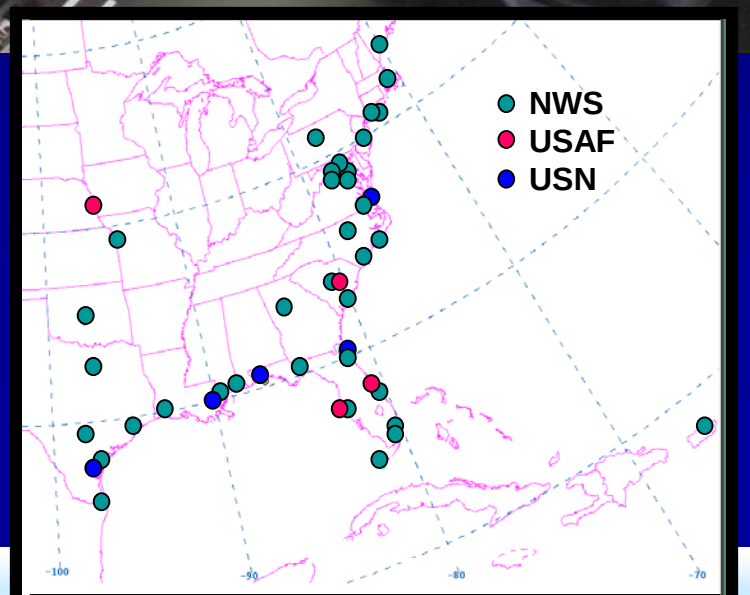
A Hurricane Warning is in effect for…
*** Anclote River to Indian Pass Florida**

A Storm Surge Warning is in effect for…
*** Aripeka to Indian Pass Florida**

Forecast Coordination

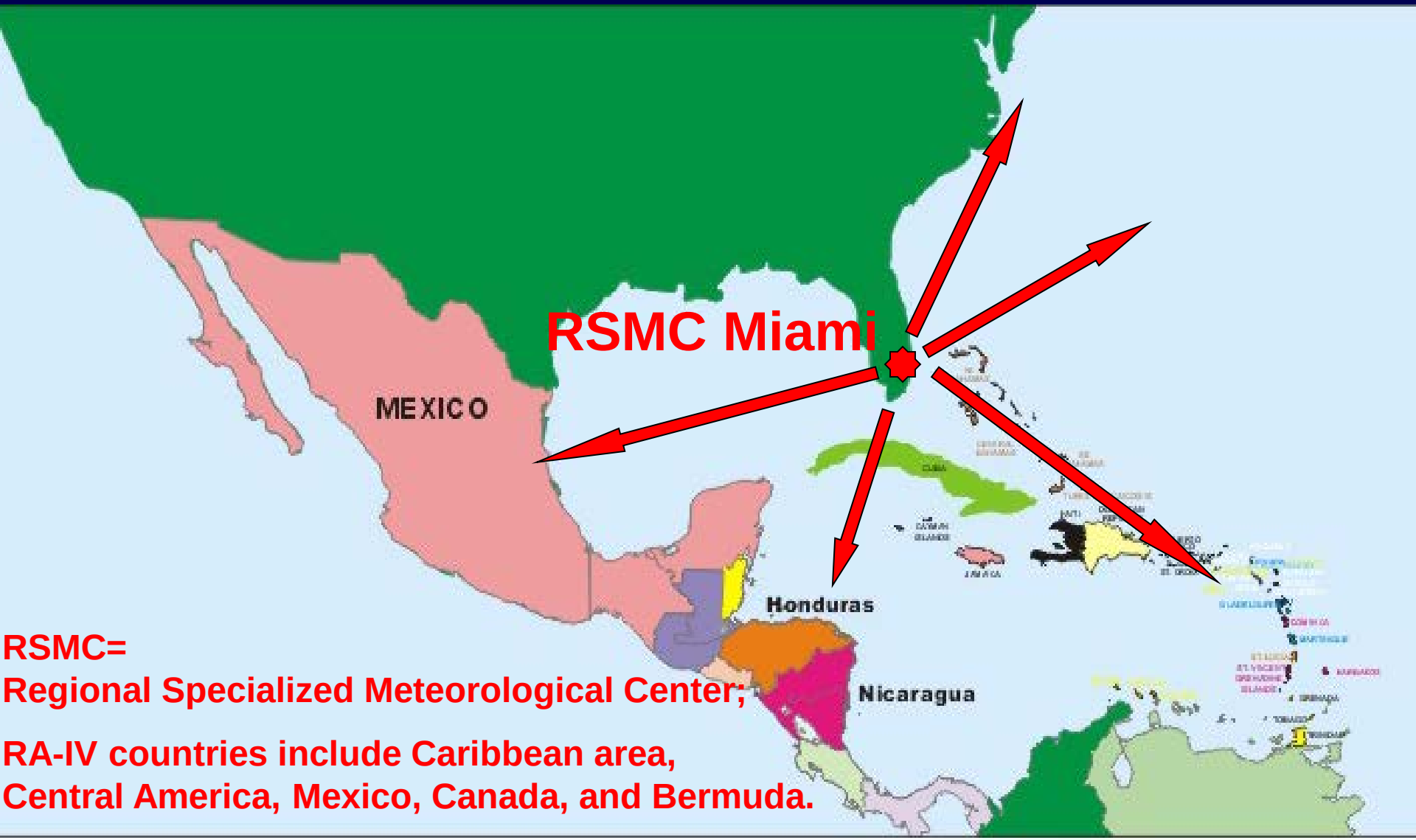
Hurricane Hotline

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



WORLD METEOROLOGICAL ORGANIZATION

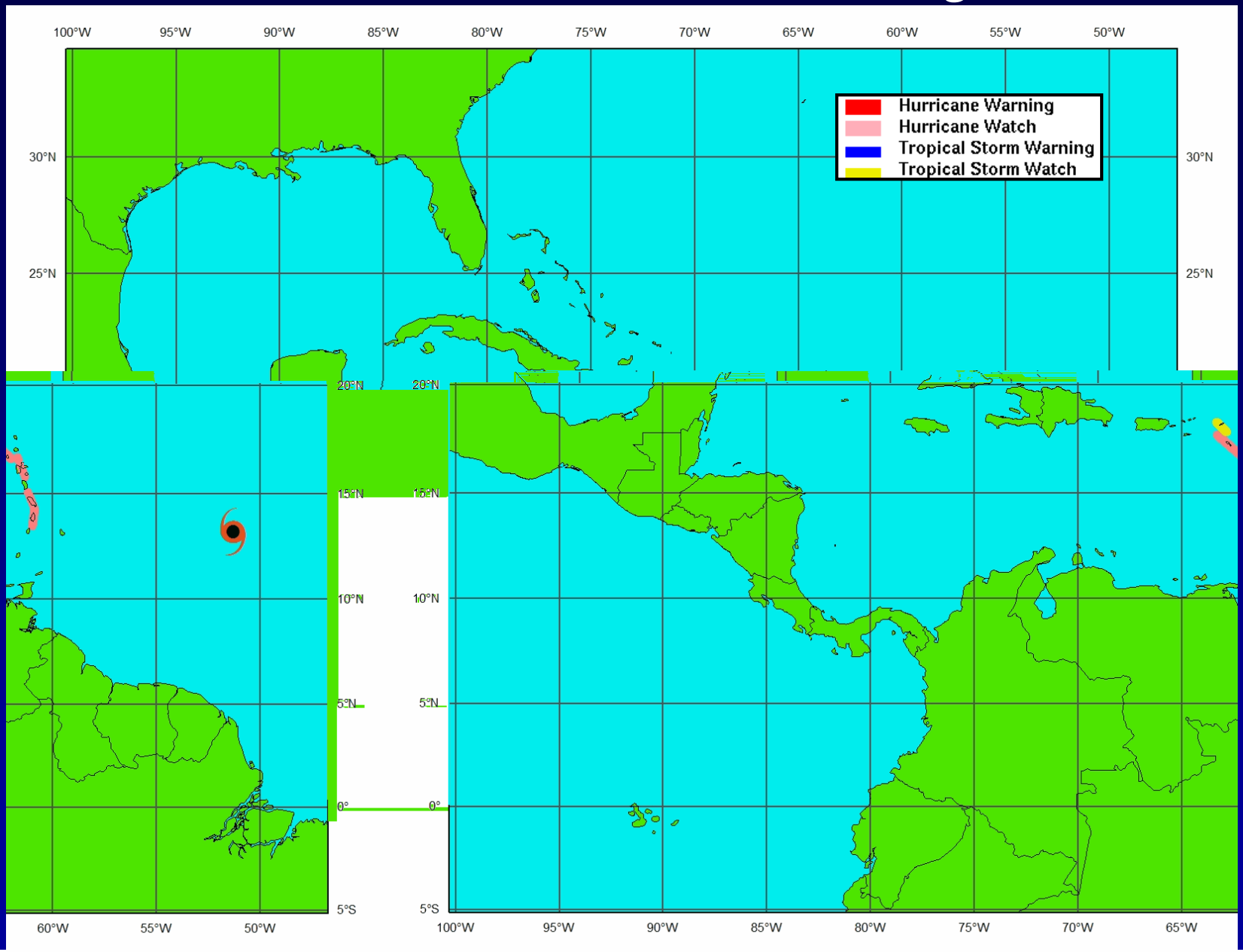
Regional Association IV (RA-IV) Coordination



RSMC=
Regional Specialized Meteorological Center;

RA-IV countries include Caribbean area, Central America, Mexico, Canada, and Bermuda.

Hurricane Dean watches and warnings



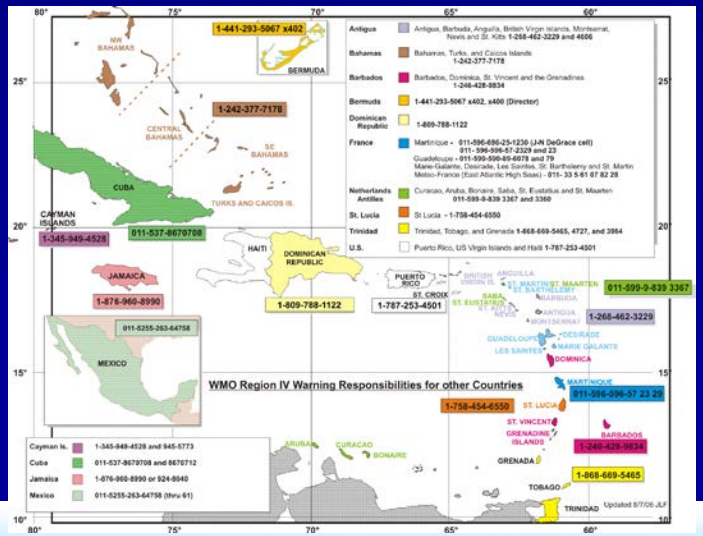
OPERATIONAL COMMUNICATIONS

WITH KEY DECISION-MAKERS

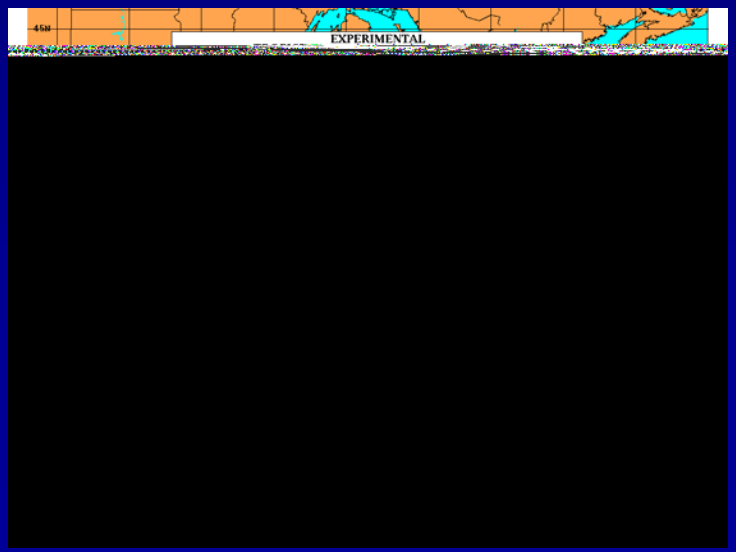
President Barack Obama during a video teleconference with NHC and emergency managers

WITH THE MEDIA

WITH INTERNATIONAL PARTNERS



WITH THE PUBLIC

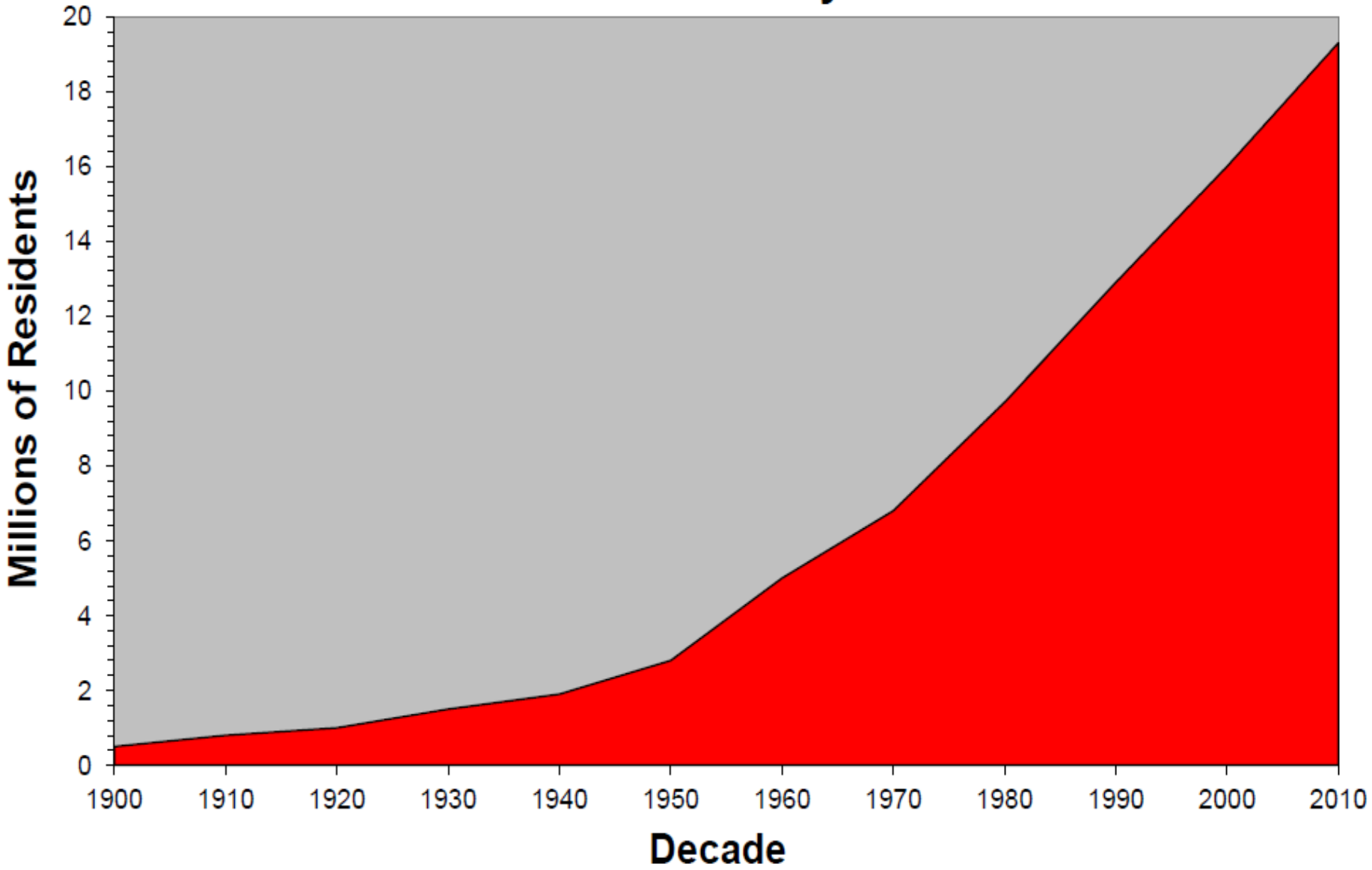


OUTREACH AND EDUCATION

- 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

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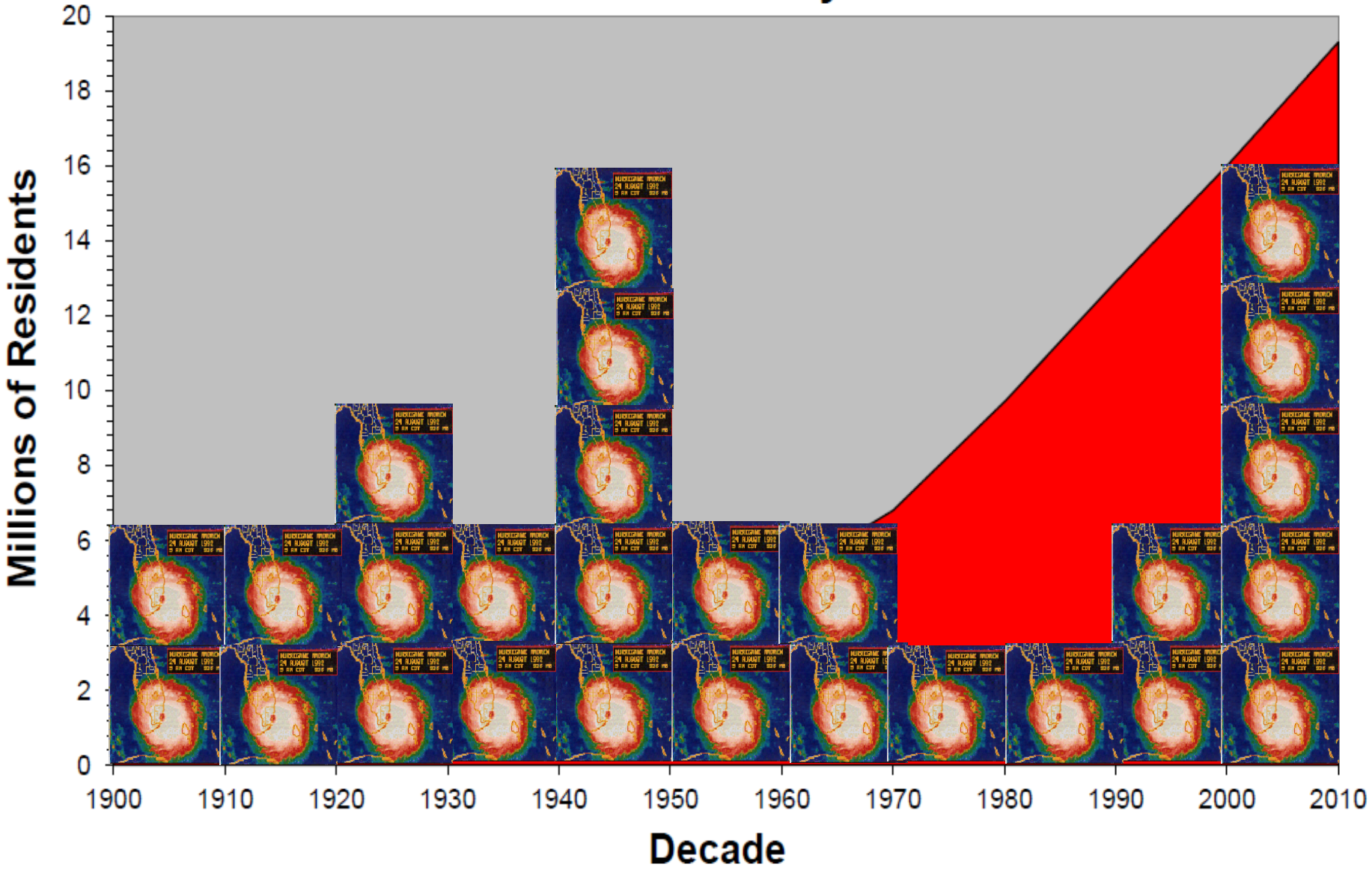


Summary

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)

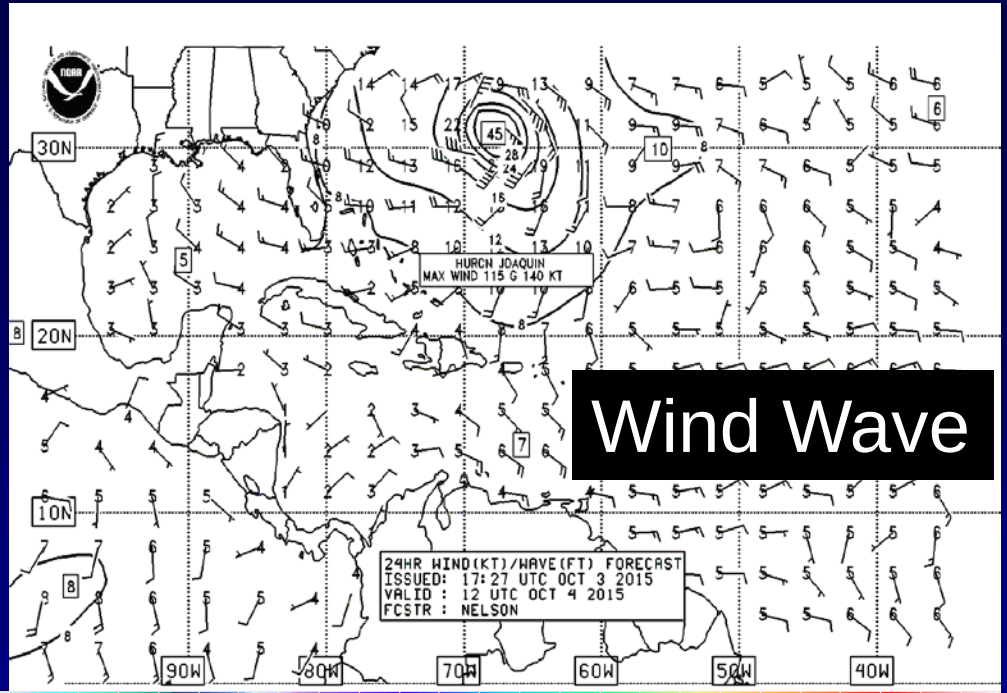
BOUNTY

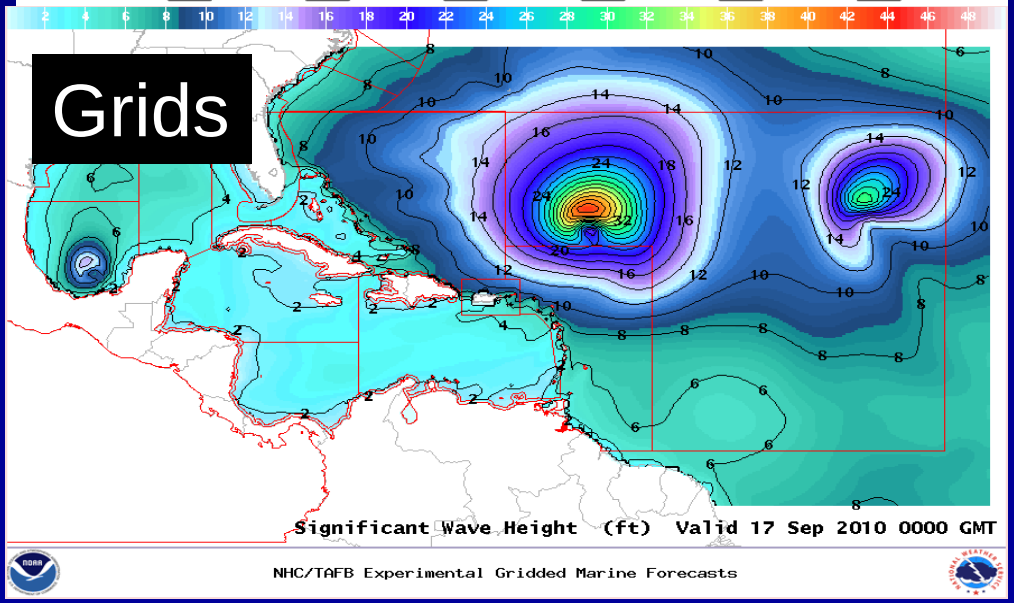
2 fatalities when it sank in Hurricane Sandy (2012)

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.

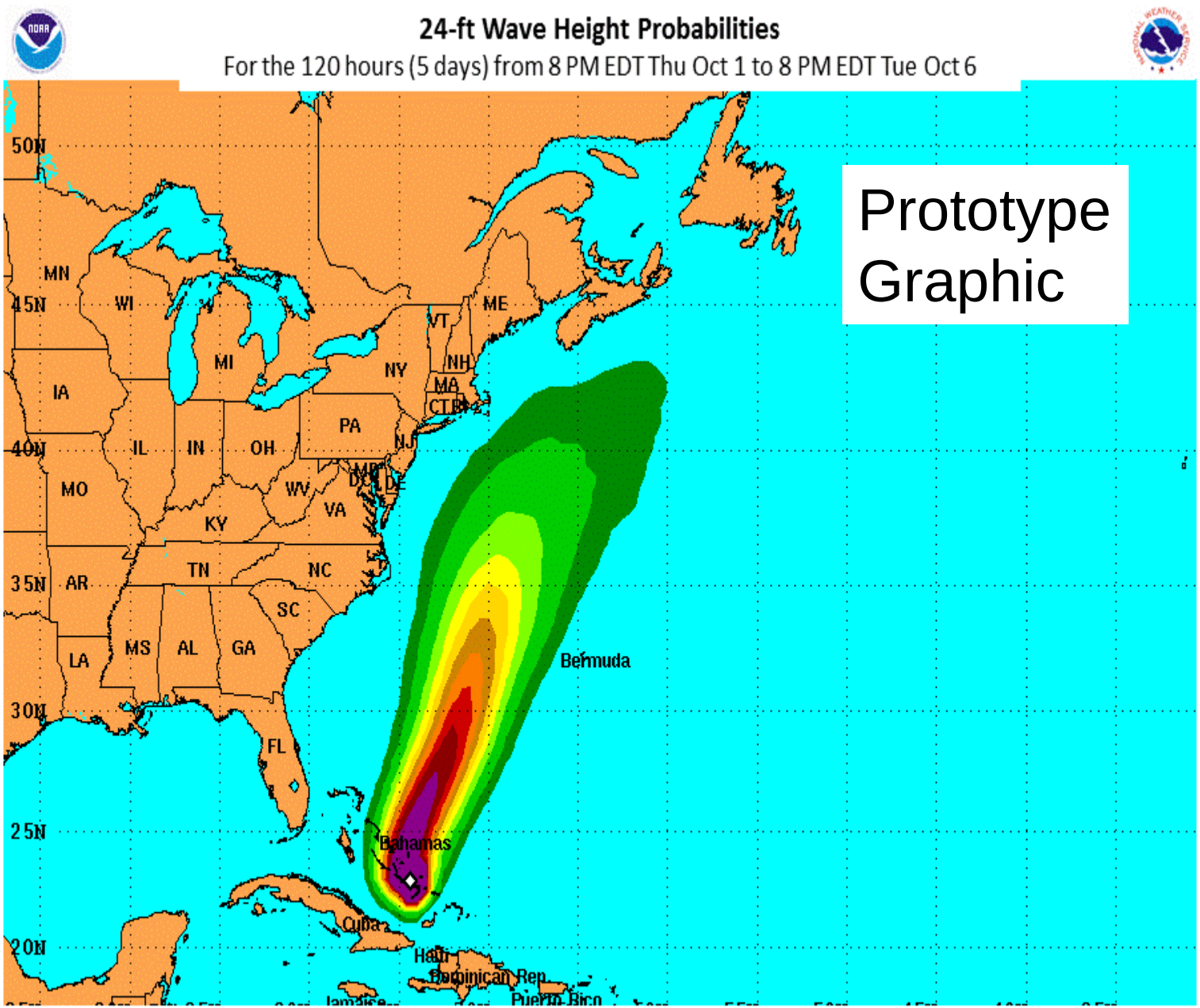
PAN PAN

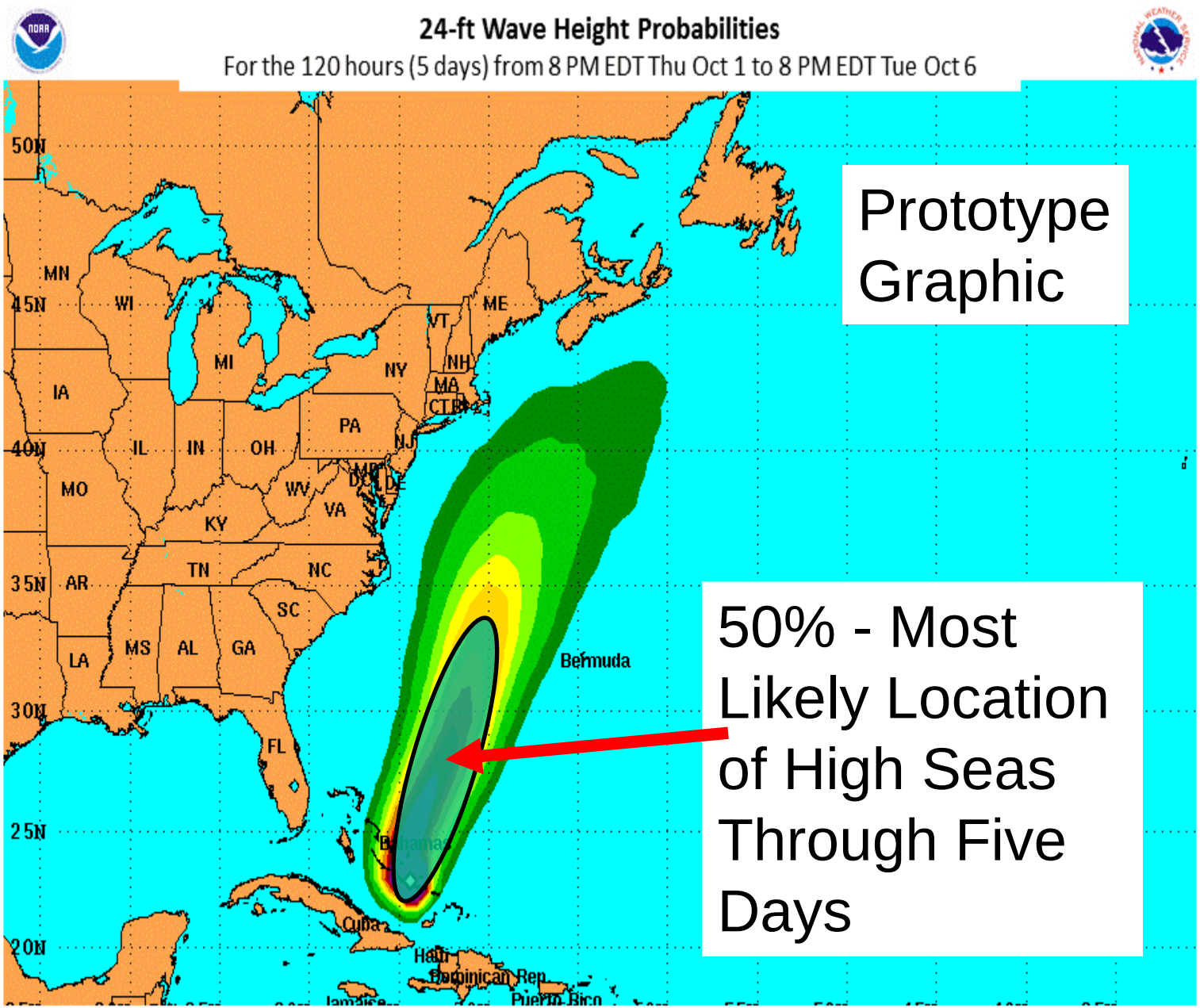
ATLANTIC FROM 07N TO 31N W OF 35W INCLUDING CARIBBEAN SEA AND GULF OF MEXICO.

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
50N
45N
40N
35N
30N
25N
20N
MN
WI
MI
IA
IL
IN
OH
MO
KY
WV
VA
PA
NY
VT
NH
ME
MA
CT
RI
NJ
MD
DE
DC
TN
NC
SC
AR
LA
MS
AL
GA
FL
Bermuda
Bahamas
Cuba
Haiti
Dominican Rep
Puerto Rico
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)
5% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%


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
Bermuda
Cuba
Haiti
Dominican Rep.
Puerto Rico
Jamaica
Bahamas
50N
45N
40N
35N
30N
25N
20N
MN
WI
MI
IA
IL
IN
OH
MO
KY
WV
VA
PA
NY
VT
ME
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MA
CT
RI
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MS
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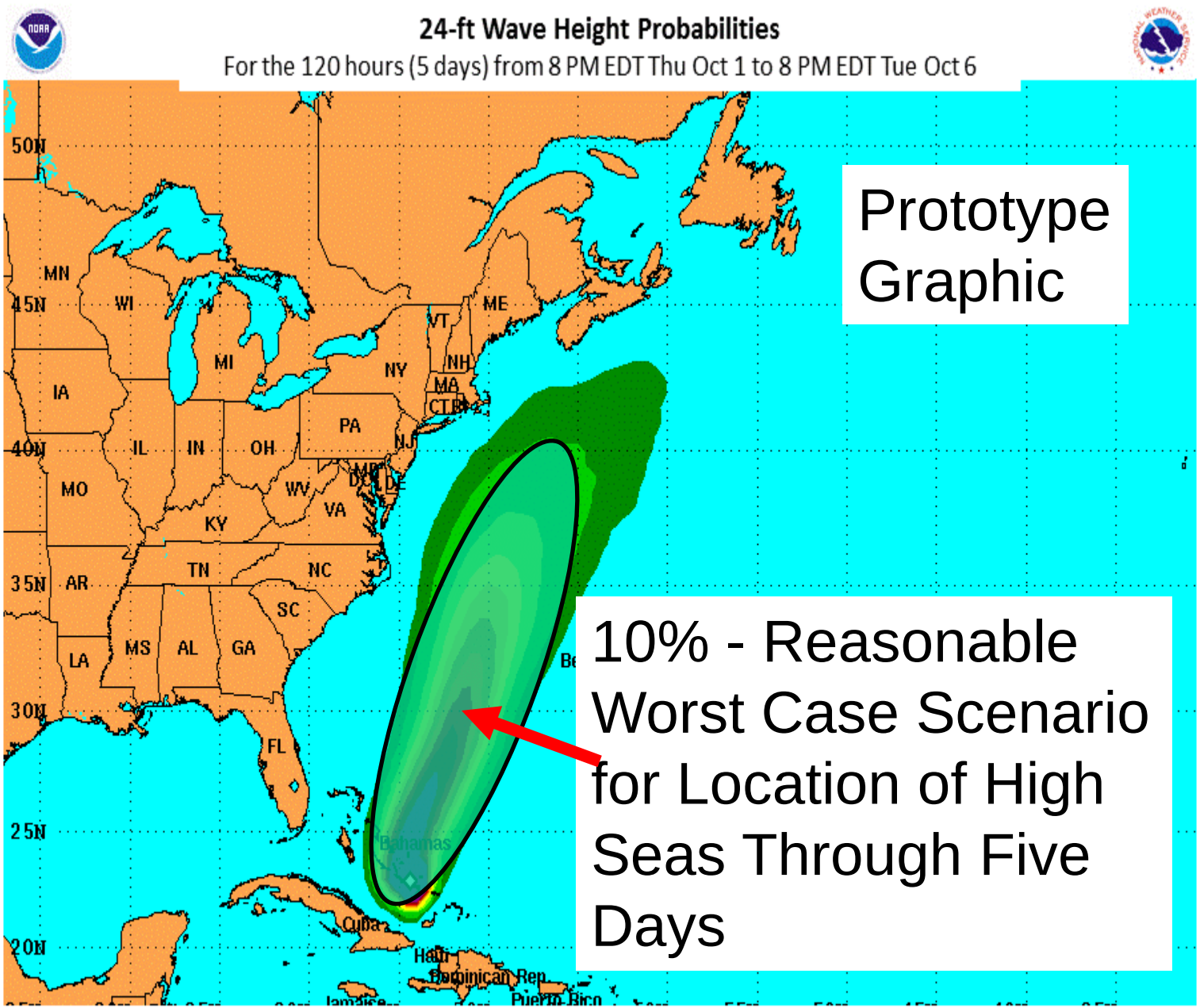
24-ft Wave Height Probabilities
For the 120 hours (5 days) from 8 PM EDT Thu Oct 1 to 8 PM EDT Tue Oct 6
Prototype Graphic
10% - Reasonable Worst Case Scenario for Location of High Seas Through Five Days
50N
45N
40N
35N
30N
25N
20N
MN
WI
MI
IA
IL
IN
OH
MO
KY
WV
VA
PA
NY
VT
NH
ME
MA
CT
NJ
MD
DE
TN
NC
SC
AR
LA
MS
AL
GA
FL
Bahamas
Cuba
Haiti
Dominican Rep
Puerto Rico
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)
5% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%