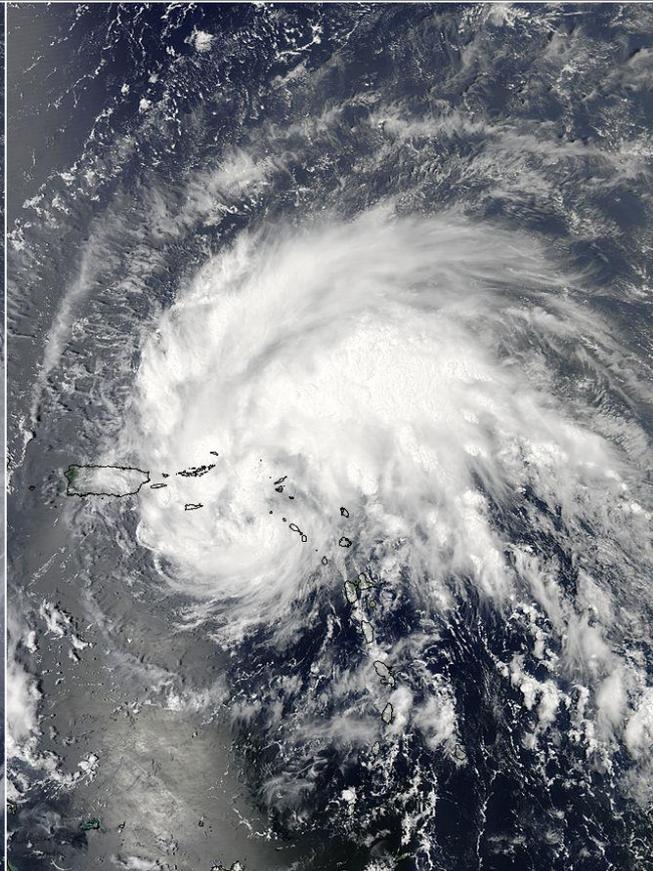




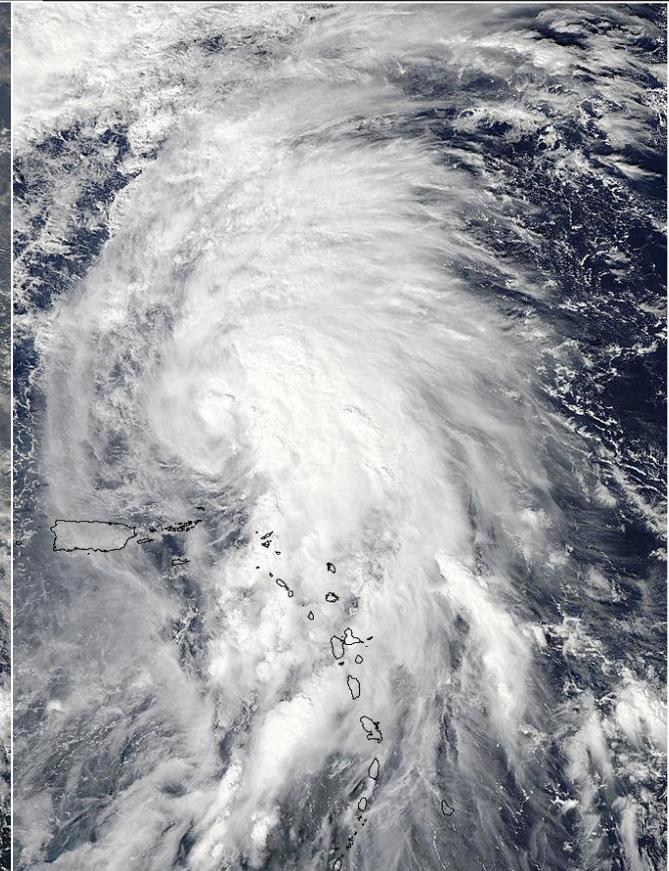
# A Look Back at the 2012 Hurricane Season and a Look Ahead to 2013 & Beyond



**Earl 2010**



**Irene 2011**



**Rafael 2012**

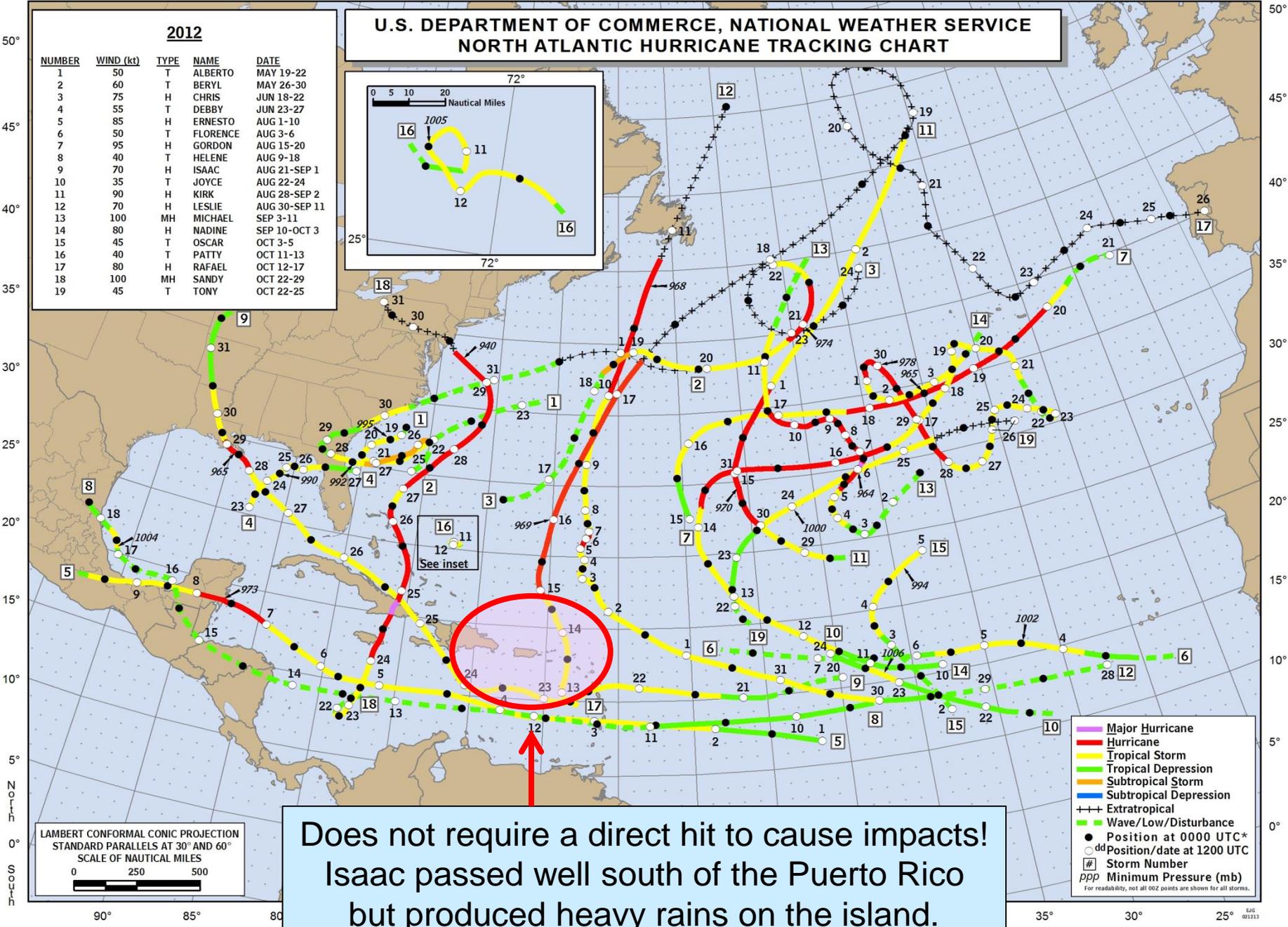
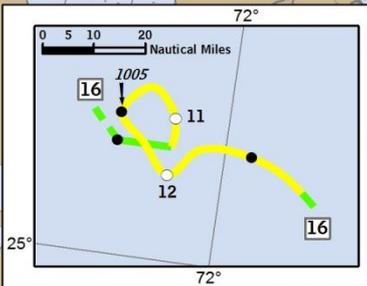
# The 2012 Atlantic Season

- Nineteen tropical storms formed (average is 12), with ten becoming hurricanes (average is 6) and two major hurricanes (average is 3).
- Accumulated Cyclone Energy about 40% above the 1981-2010 median value
- Sandy was the deadliest and most destructive storm of the season, and it is now the 2<sup>nd</sup> costliest tropical cyclone in U.S. history. Impacts extended from the Caribbean northward through the Bahamas and the eastern United States and then westward to the Great Lakes.
- Isaac had impacts from the Caribbean across the Bahamas and Florida to the northern Gulf coast and the central United States.
- Beryl, Debby, Ernesto, Gordon, Helene, Leslie, Nadine, and Rafael also hit or affected land areas.
- The season started early with two storms in May.
- Nadine was one of the longest-lived Atlantic storms of record.
- A number of relatively weak TCs, 8 were 50 kt or less

**U.S. DEPARTMENT OF COMMERCE, NATIONAL WEATHER SERVICE  
NORTH ATLANTIC HURRICANE TRACKING CHART**

**2012**

NUMBER	WIND (kt)	TYPE	NAME	DATE
1	50	T	ALBERTO	MAY 19-22
2	60	T	BERYL	MAY 26-30
3	75	H	CHRIS	JUN 18-22
4	55	T	DEBBY	JUN 23-27
5	85	H	ERNESTO	AUG 1-10
6	50	T	FLORENCE	AUG 3-6
7	95	H	GORDON	AUG 15-20
8	40	T	HELENE	AUG 9-18
9	70	H	ISAAC	AUG 21-SEP 1
10	35	T	JOYCE	AUG 22-24
11	90	H	KIRK	AUG 28-SEP 2
12	70	H	LESLIE	AUG 30-SEP 11
13	100	MH	MICHAEL	SEP 3-11
14	80	H	NADINE	SEP 10-OCT 3
15	45	T	OSCAR	OCT 3-5
16	40	T	PATTY	OCT 11-13
17	80	H	RAFAEL	OCT 12-17
18	100	MH	SANDY	OCT 22-29
19	45	T	TONY	OCT 22-25



**Does not require a direct hit to cause impacts!  
Isaac passed well south of the Puerto Rico  
but produced heavy rains on the island.**

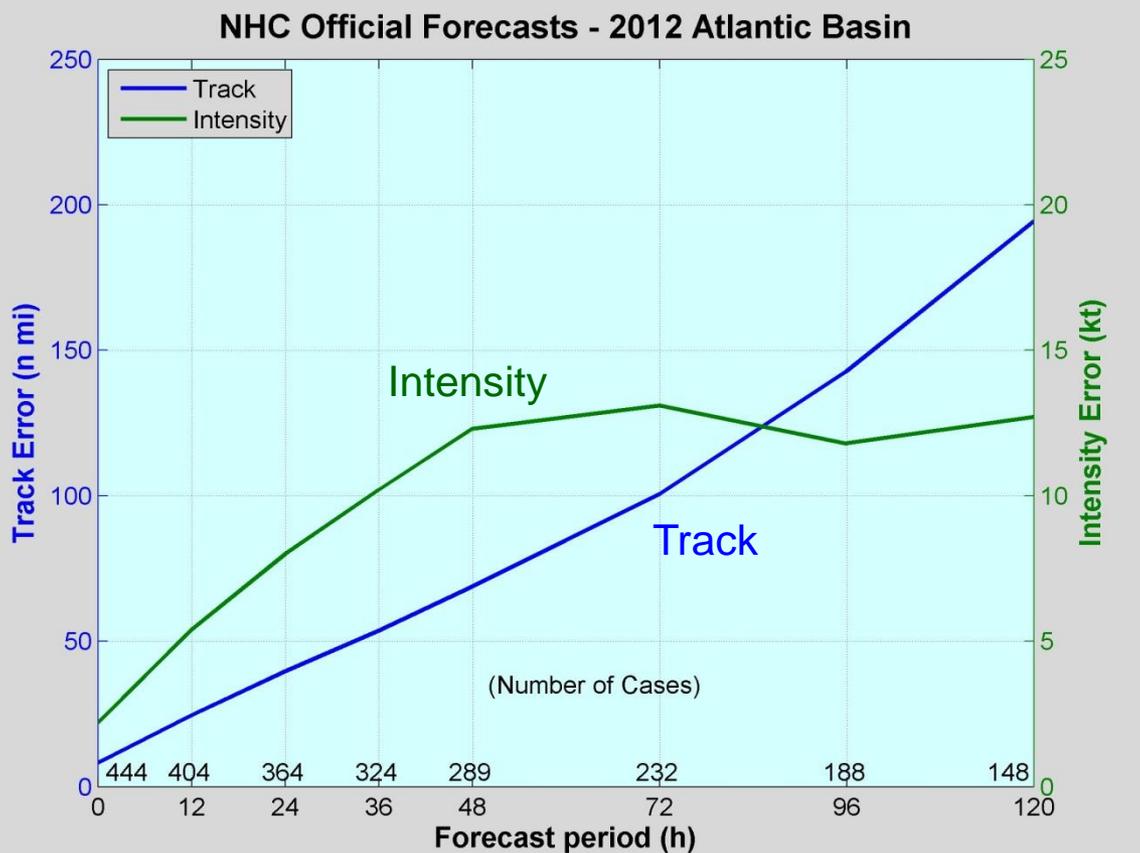
LAMBERT CONFORMAL CONIC PROJECTION  
STANDARD PARALLELS AT 30° AND 60°  
SCALE OF NAUTICAL MILES  
0 250 500

■ Major Hurricane  
■ Hurricane  
■ Tropical Storm  
■ Tropical Depression  
■ Subtropical Storm  
■ Subtropical Depression  
+ Extratropical  
- Wave/Low/Disturbance  
● Position at 0000 UTC\*  
○ Position/date at 1200 UTC  
# Storm Number  
ppp Minimum Pressure (mb)  
For readability, not all 00Z points are shown for all storms.



# 2012 NHC Forecast Verification

## Good News- Lots of Accuracy Records Set



VT (h)	NT	TRACK (n mi)	INT (kt)
012	404	24.6	5.4
024	364	39.7	8.0
036	324	53.6	10.2
048	289	68.8	12.3
072	232	100.6	13.1
096	188	142.8	11.8
120	148	194.4	12.7

Values in red exceed all-time records.

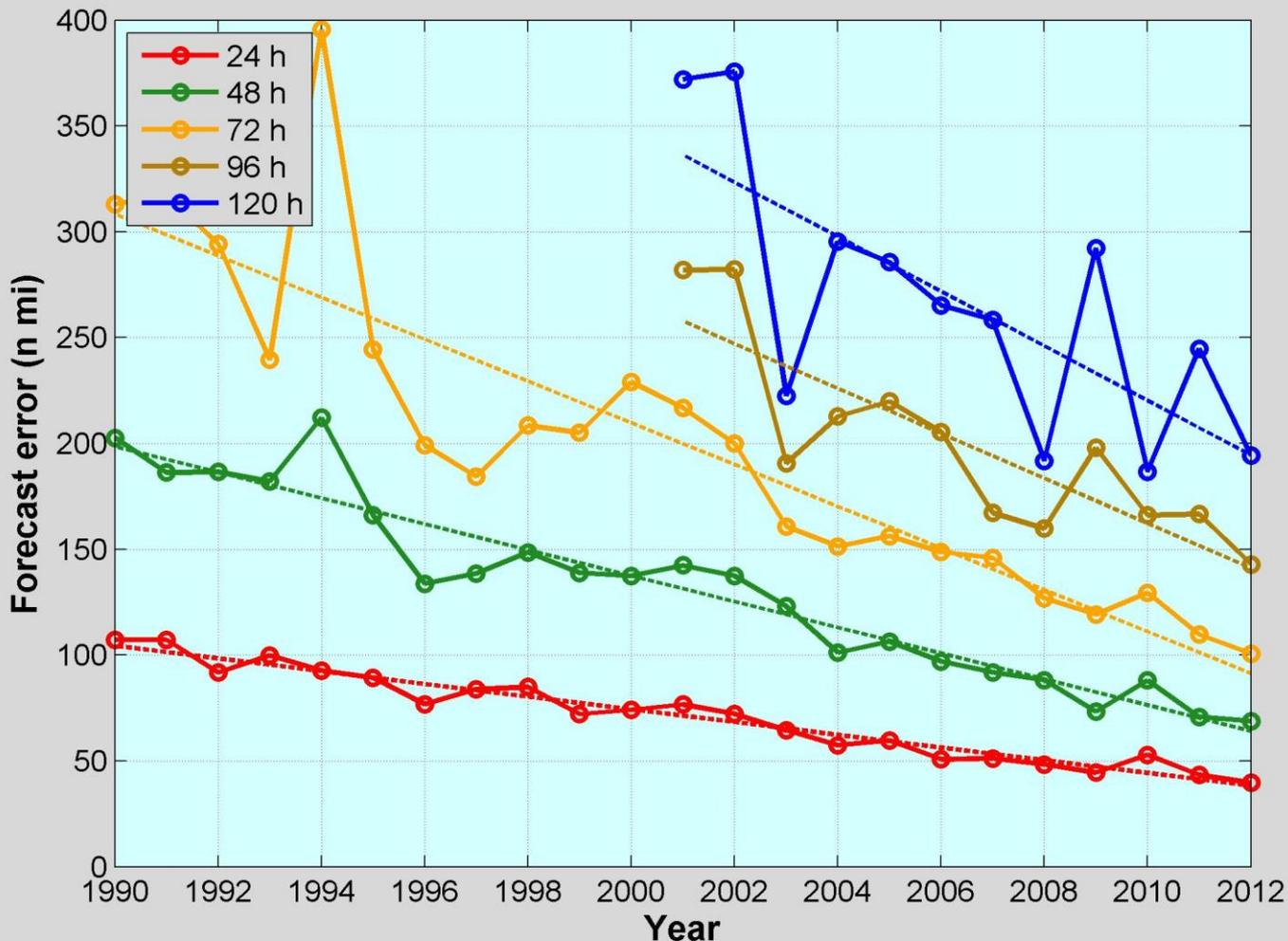


# NHC Atlantic Track Error Trends



## Reduction in Track Errors Continues

NHC Official Track Error Trend  
Atlantic Basin



Error  
Reduction  
since 1990

72 h: 67%

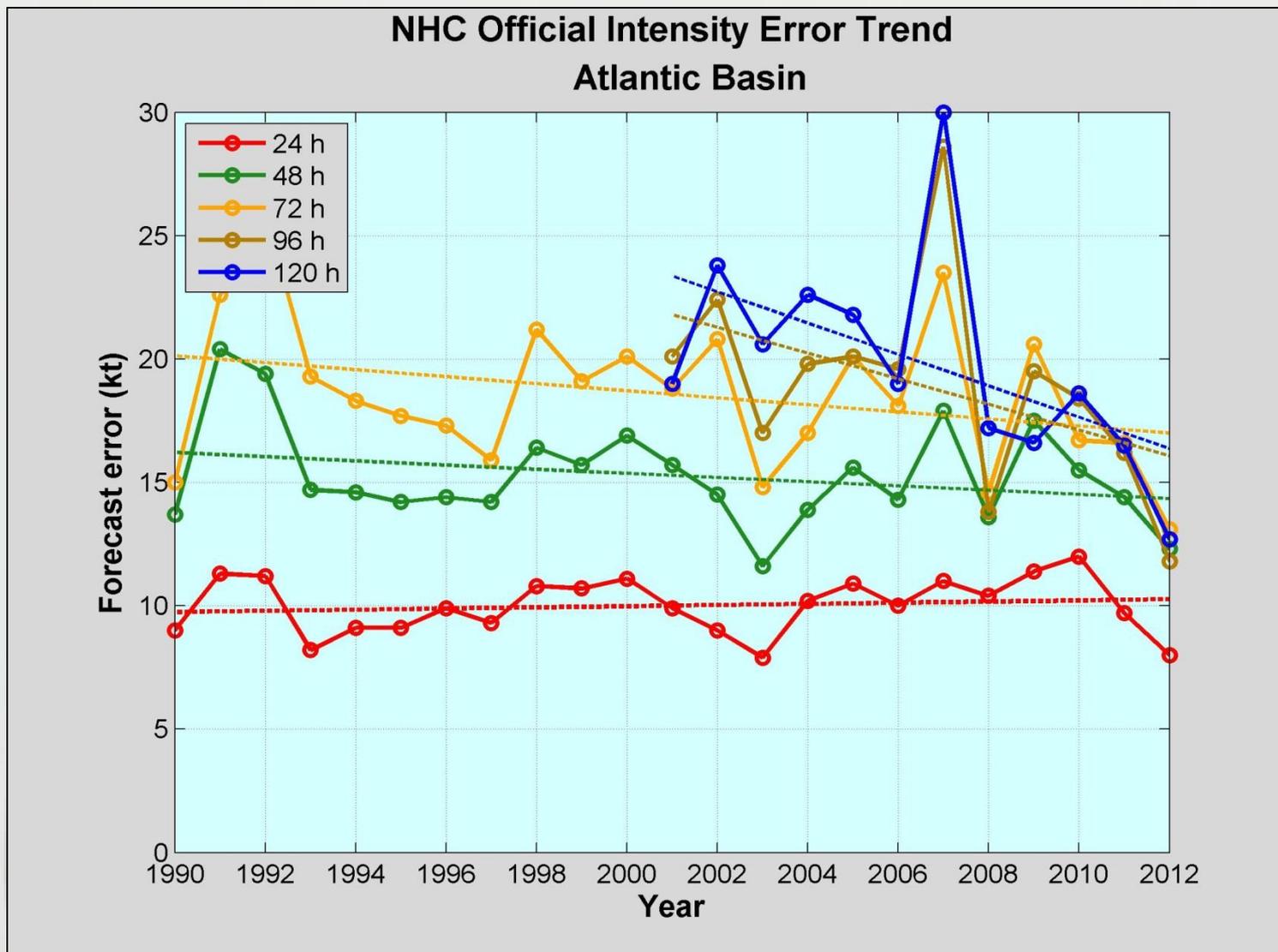
48 h: 65%

24 h: 58%



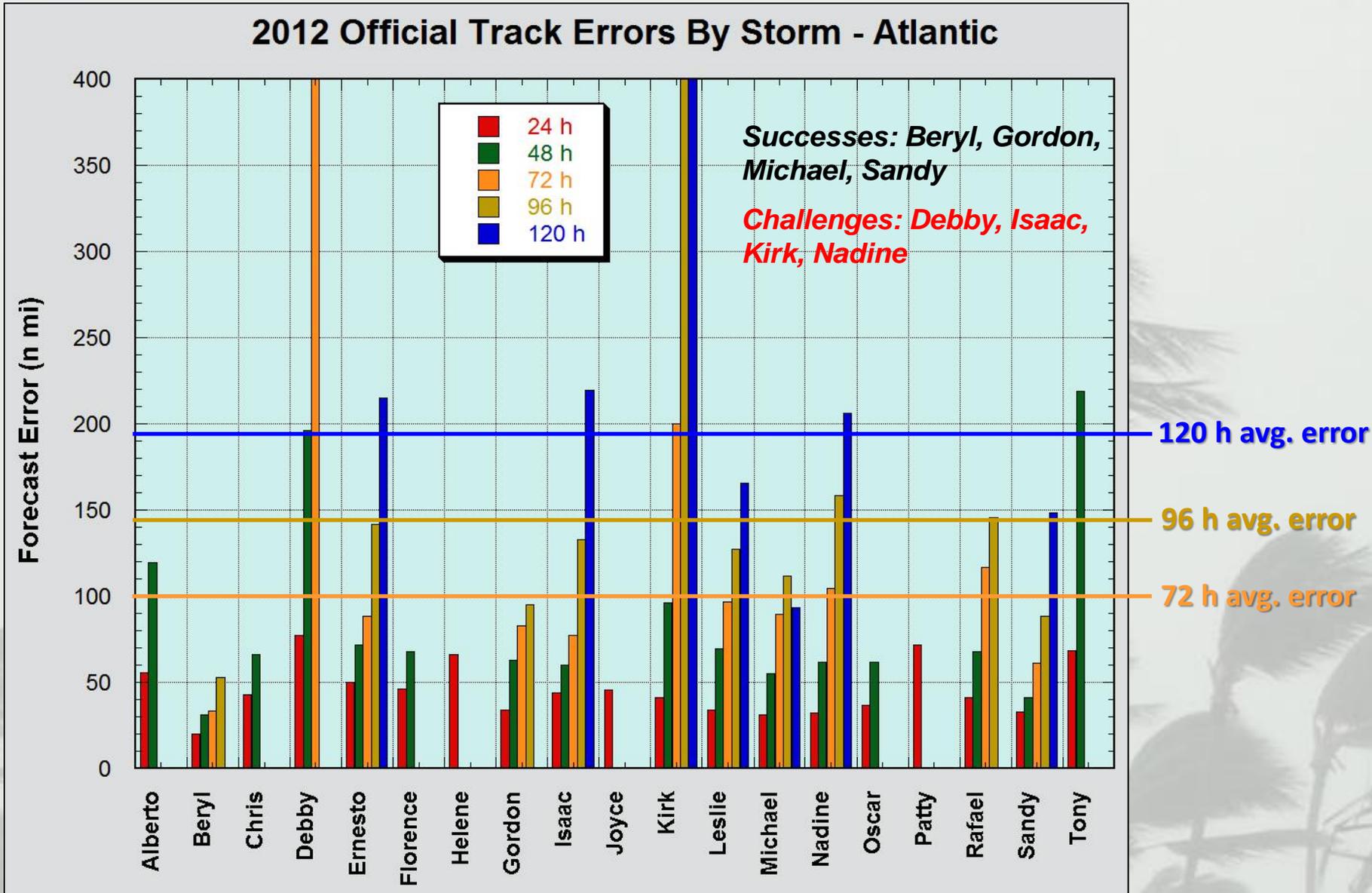
# Atlantic Intensity Error Trends

## Little Progress Overall - But a Very Recent Downward Trend



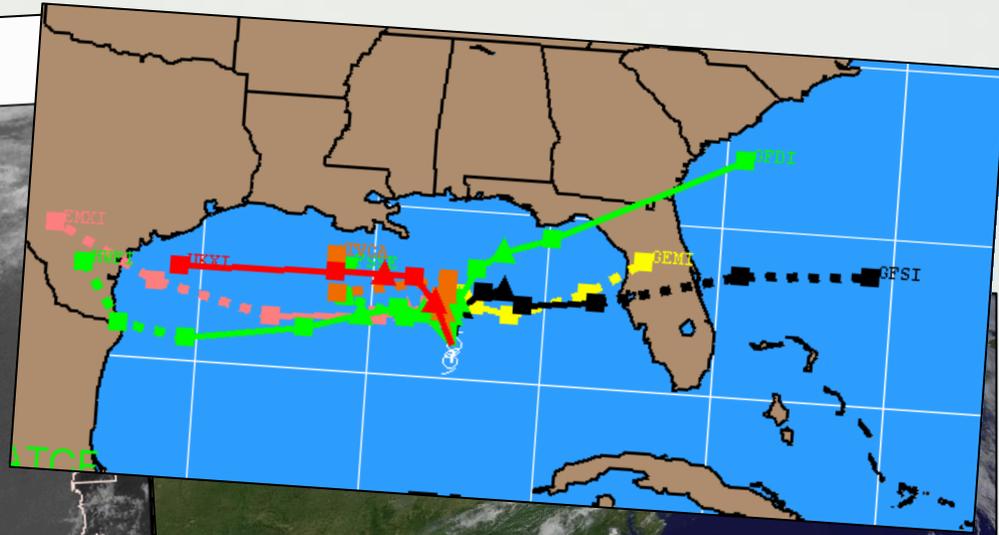
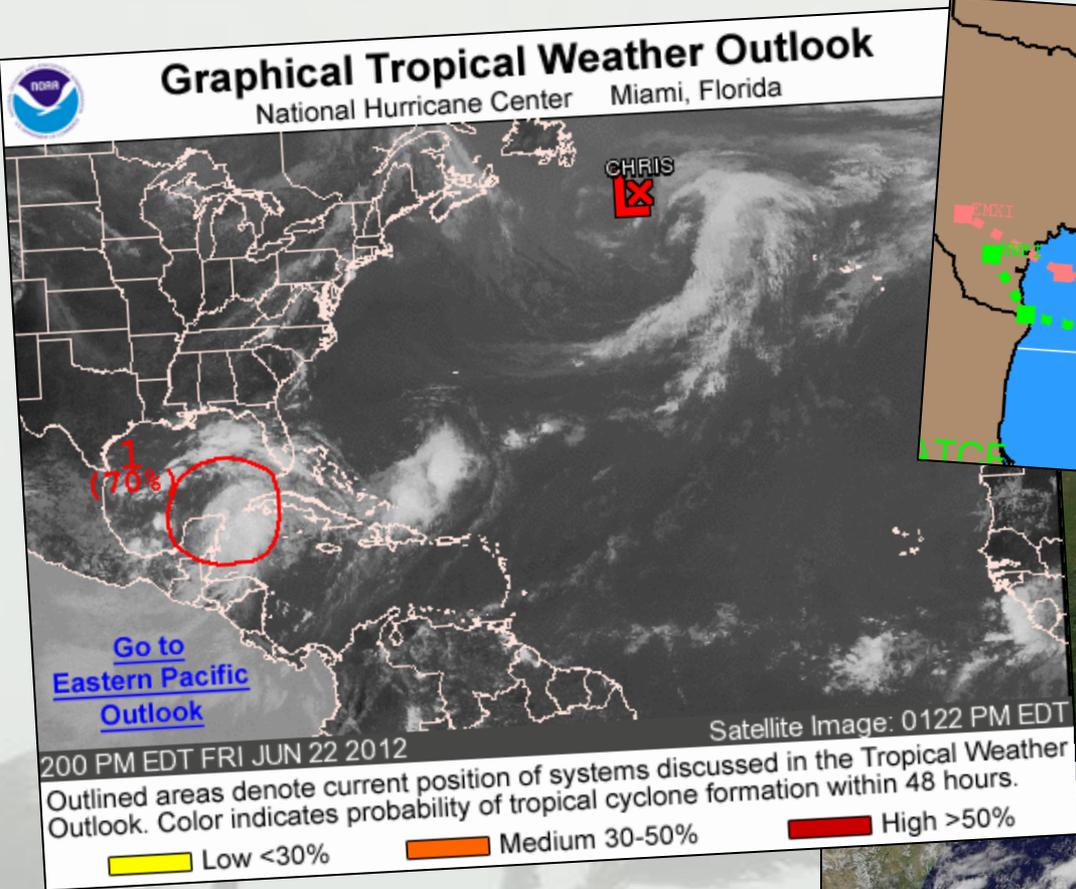


# Still Some Forecast Challenges





# Debby- Formation well anticipated but where would it go





# Debby Forms

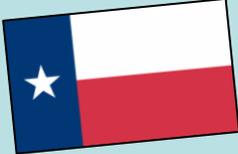
## Diverging Forecast Guidance

### Texas or Florida?



Tropical Storm Debby Track Guidance  
June 23, 2012 5 PM Advisory

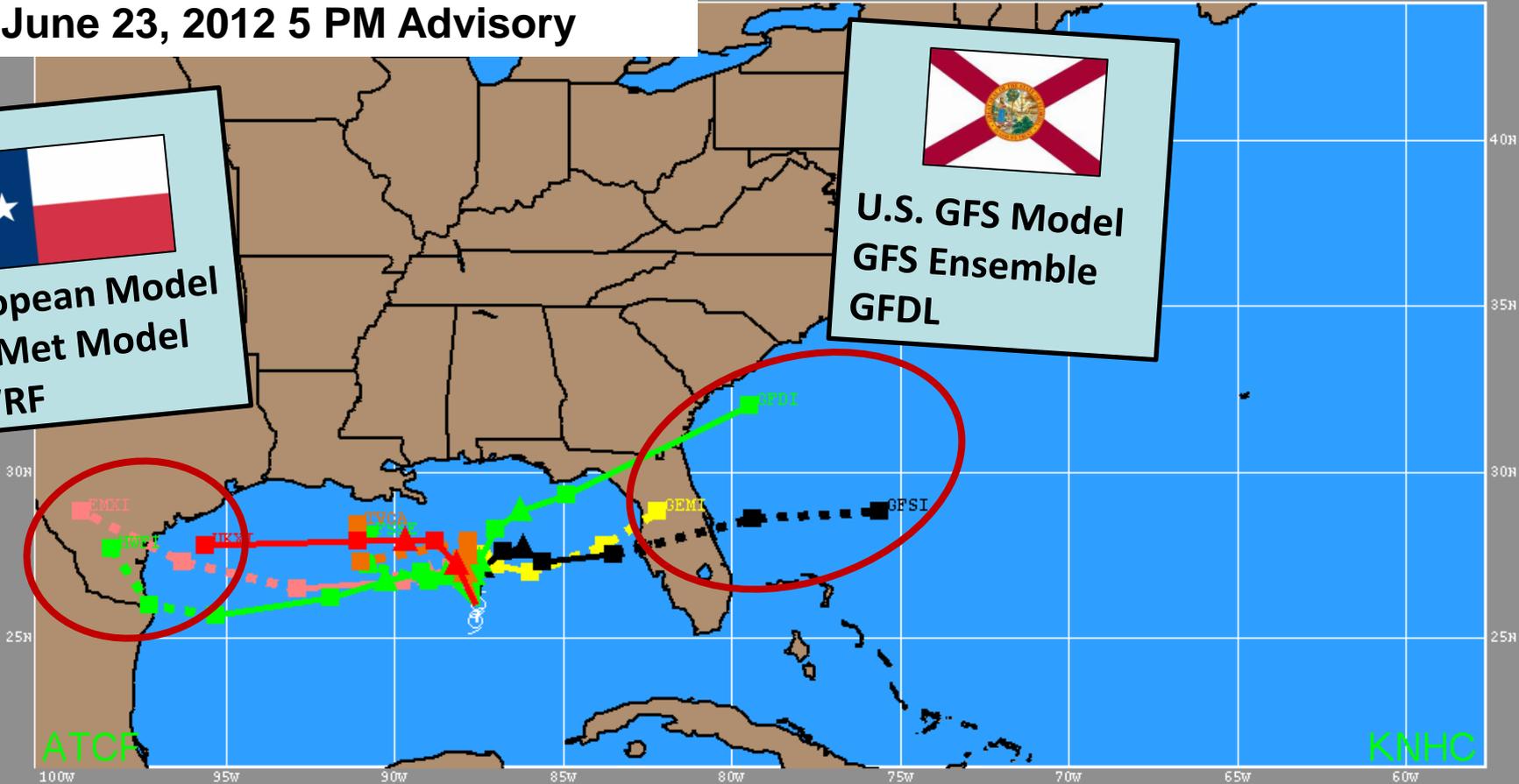
2 - DEBBY 2012062318

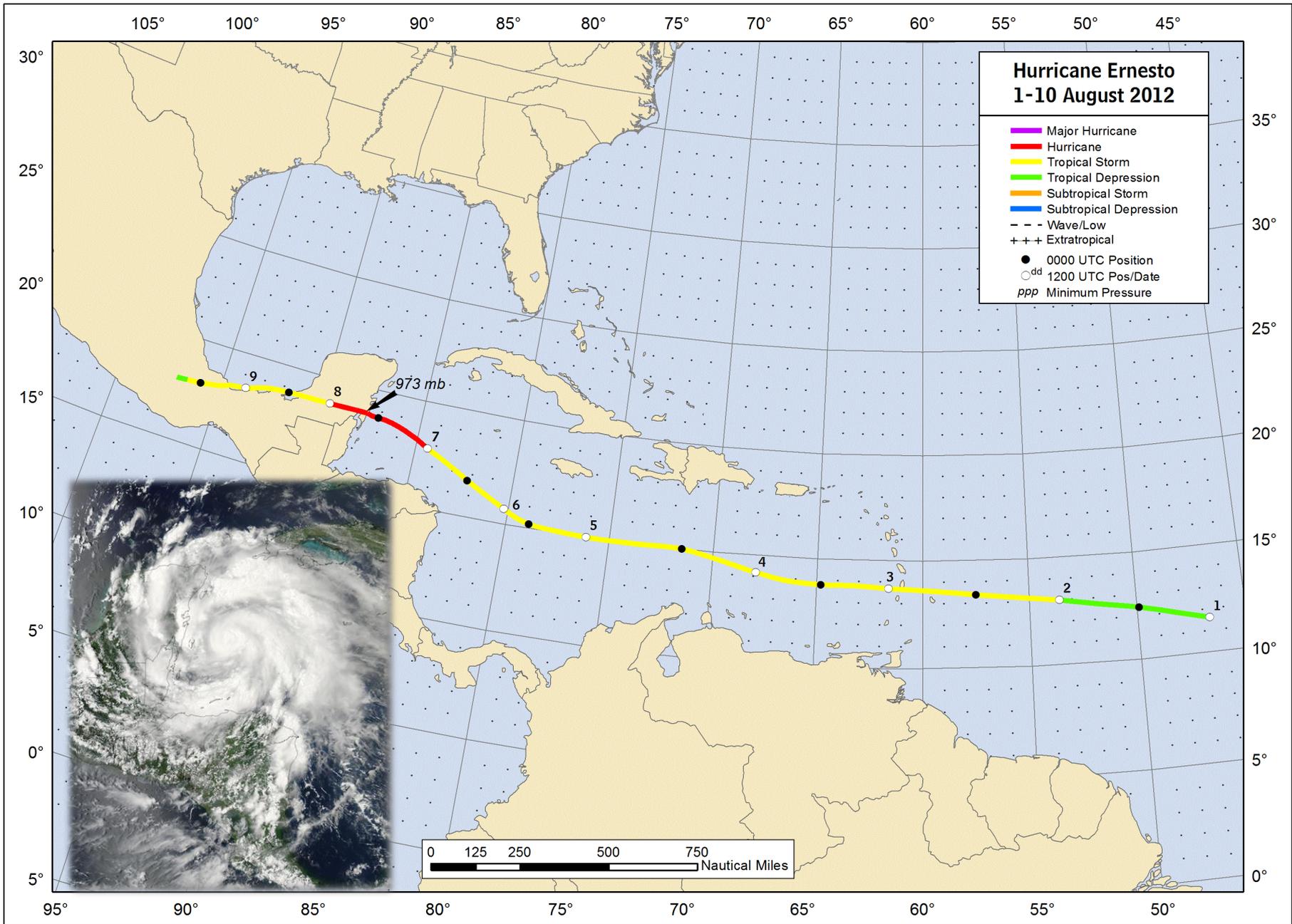


European Model  
UK Met Model  
HWRF

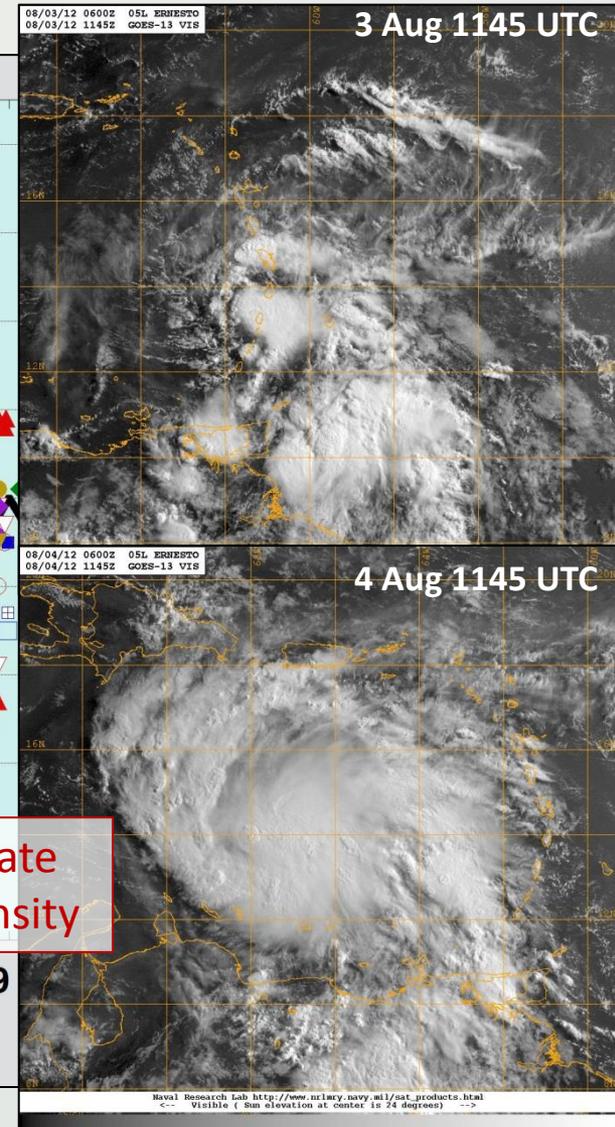
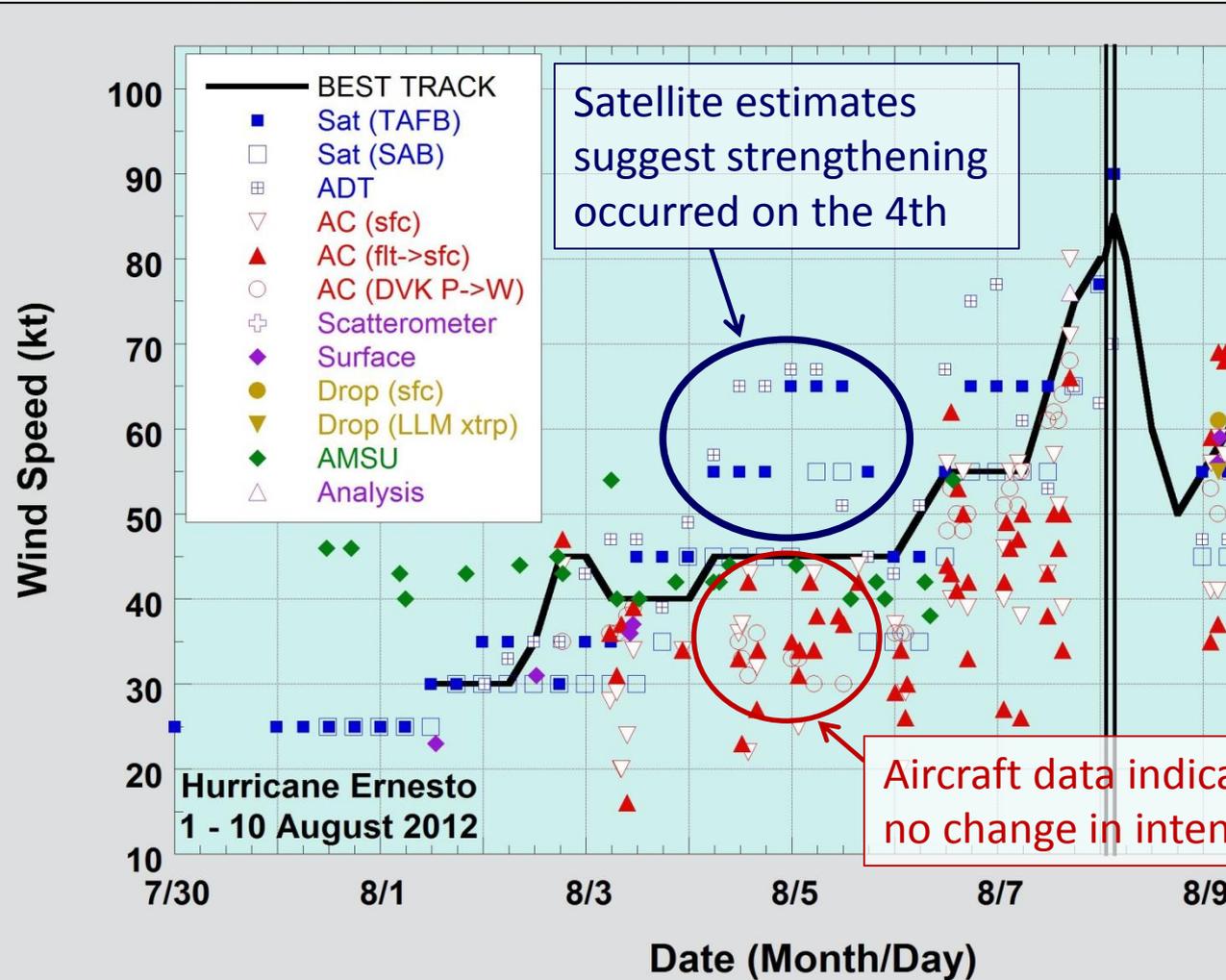


U.S. GFS Model  
GFS Ensemble  
GFDL



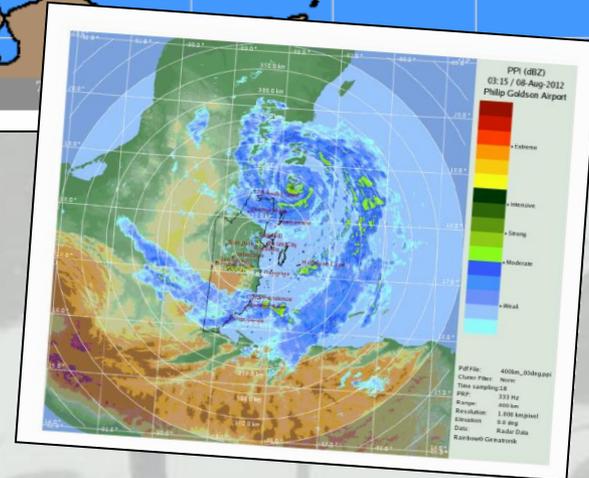
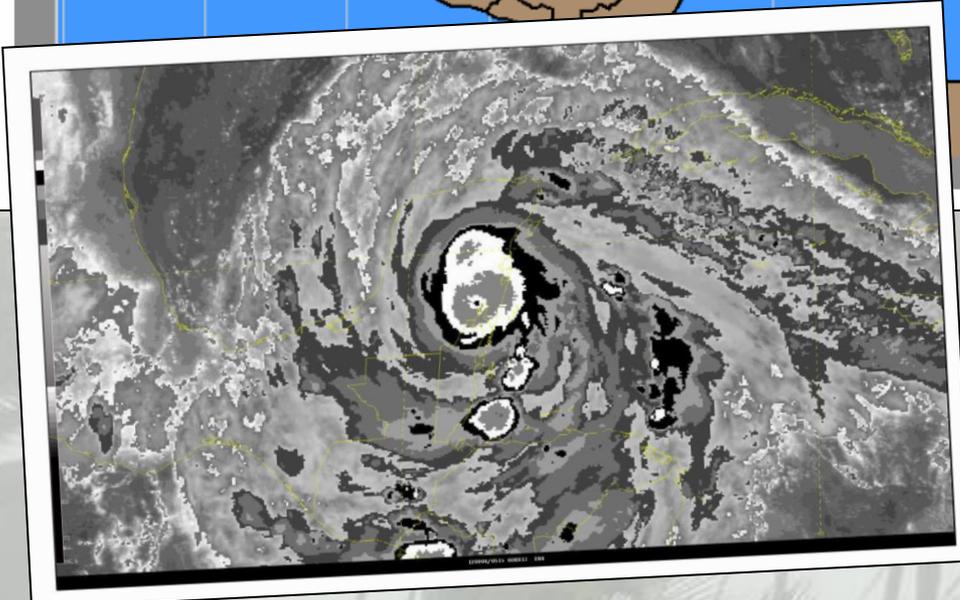
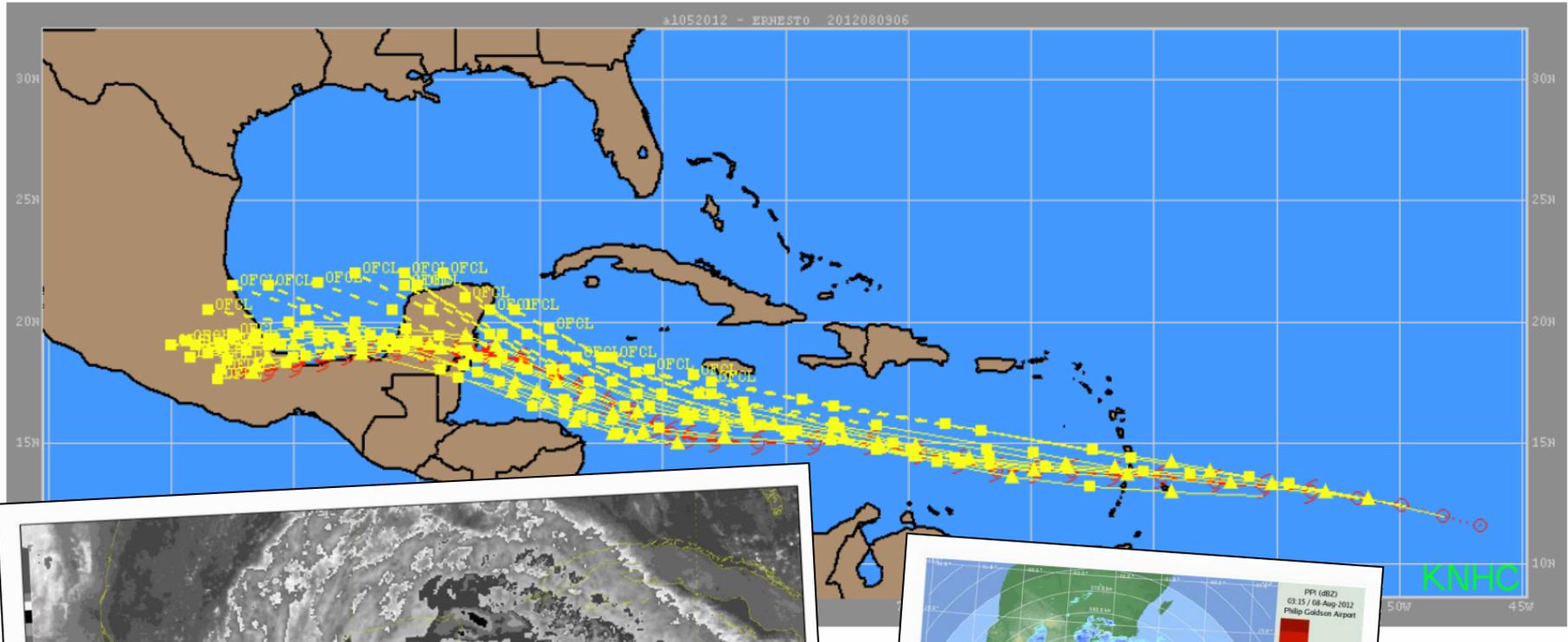


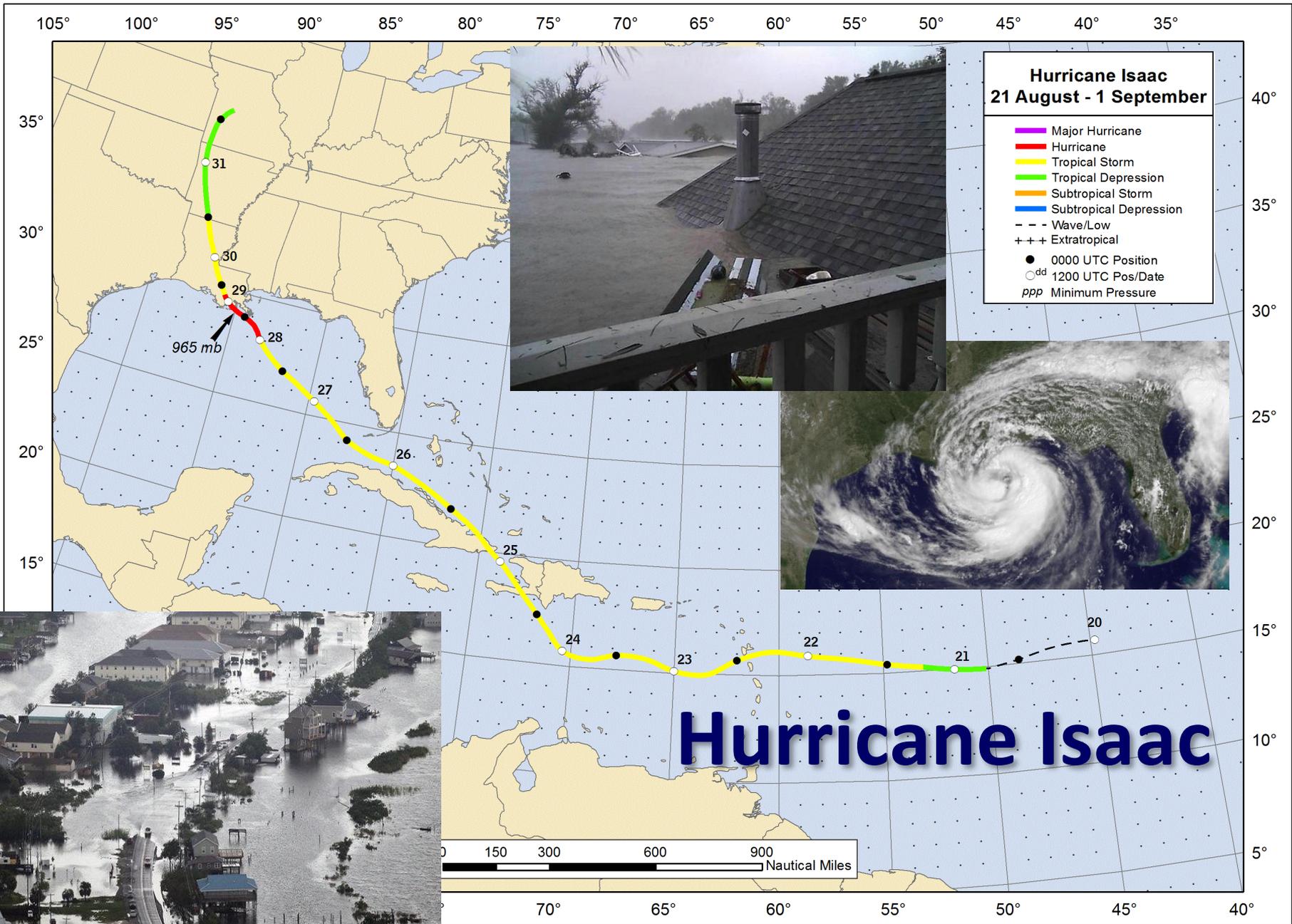
# Ernesto- Improved satellite appearance, but no change in strength





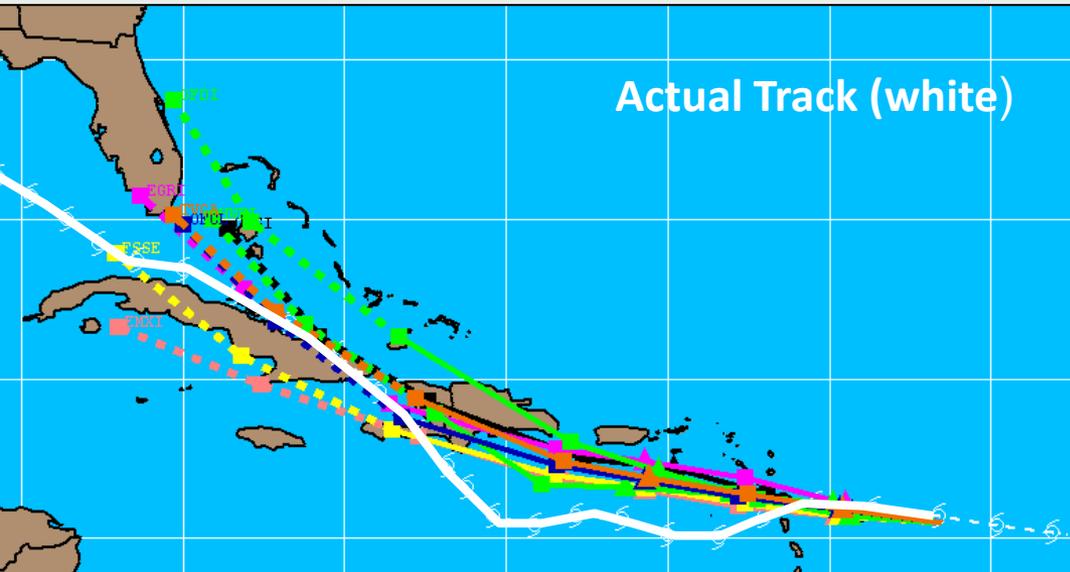
# Track Guidance and NHC Forecasts for Ernesto Exhibited a Northward Bias







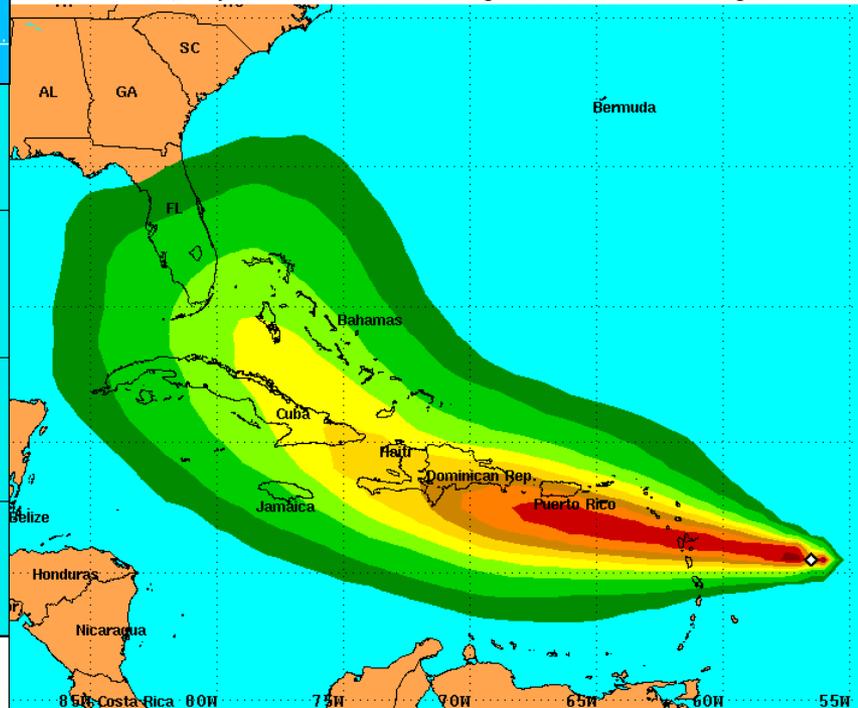
# Isaac Track Guidance- 5 am Aug 27



Center of Isaac moved south of the tightly cluster model guidance. Illustrates the importance of using NHC/NWS probabilistic products.



Tropical Storm Force Wind Speed Probabilities for the 120 hours (5 days) from 2 AM AST Wed Aug 22 to 2 AM AST Mon Aug 27



**Tropical Storm Isaac**  
 Wednesday August 22, 2012  
 5 AM EDT Advisory 5  
 NWS National Hurricane Center

**Current Information:** ●  
 Center Location 15.5 N 57.3 W  
 Max Sustained Wind 45 mph  
 Movement W at 18 mph

**Forecast Positions:**  
 ● Tropical Cyclone ○ Post-Tropical  
 Sustained Winds: D < 39 mph  
 S 39-73 mph H 74-110 mph M > 110mph

**Potential Track Area:**  
 Day 1-3 Day 4-5

**Watches:**  
 Hurricane Trop.Storm

**Warnings:**  
 Hurricane Trop.Storm

Tropical storm force surface winds (1-minute average >= 39 mph) from all tropical cyclones that tracks TROPICAL STORM ISAAC center location at 2 AM AST Wed Aug 22 2012 (Forecast/Advisory #5)

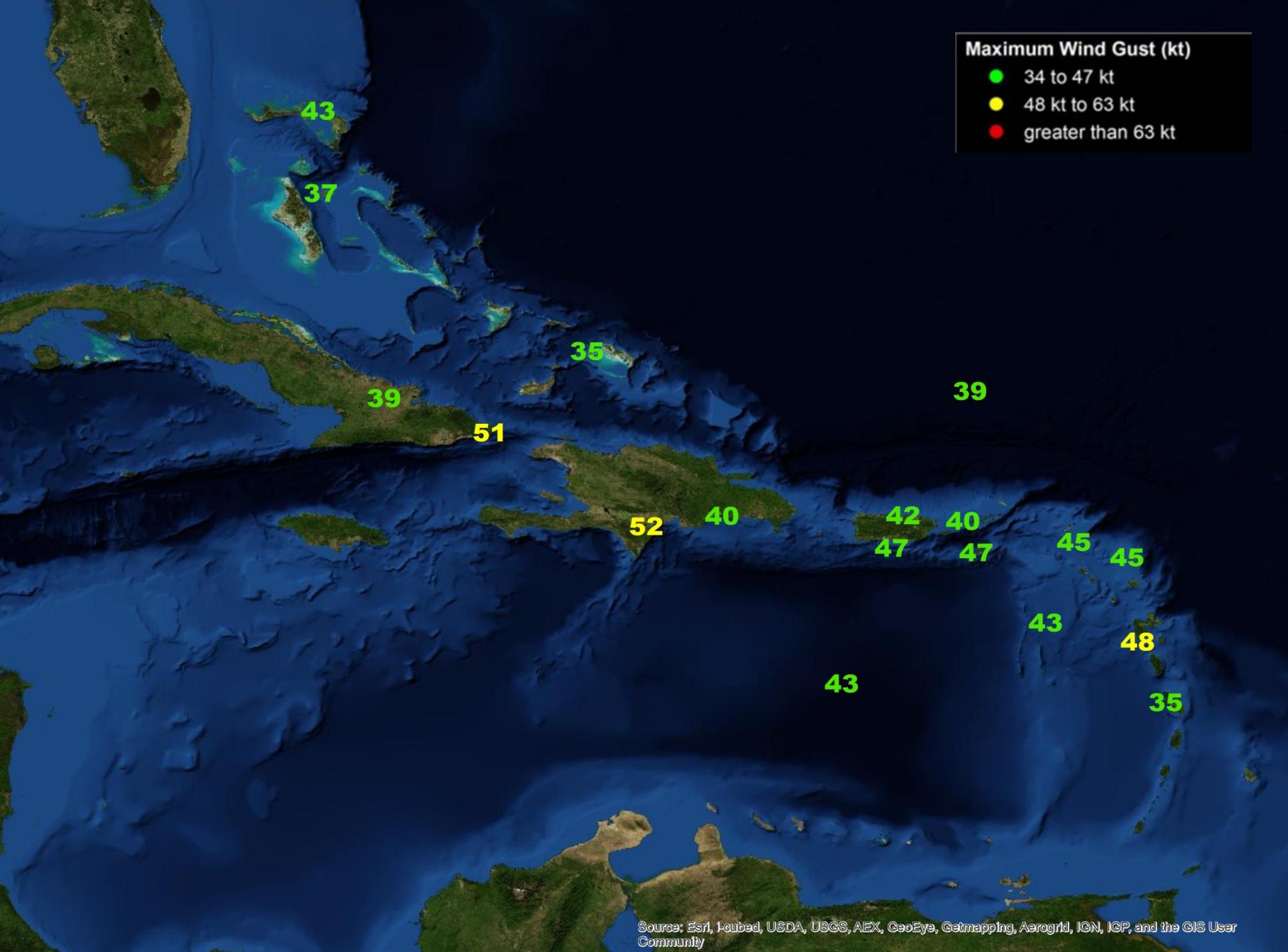
**Maximum Sustained Wind (kt)**

- 34 to 47 kt
- 48 kt to 63 kt
- greater than 63 kt



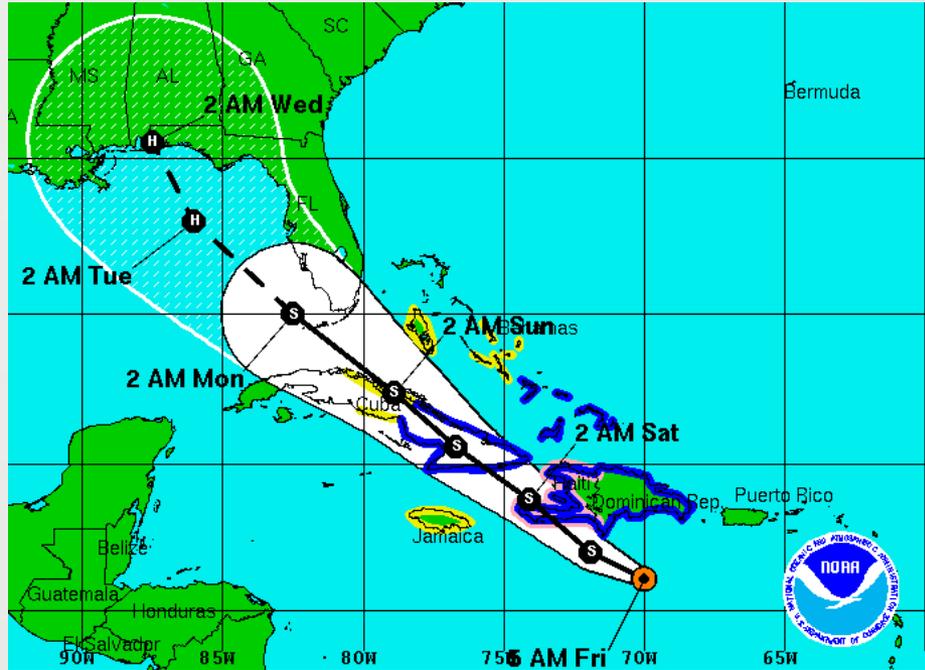
**Maximum Wind Gust (kt)**

- 34 to 47 kt
- 48 kt to 63 kt
- greater than 63 kt



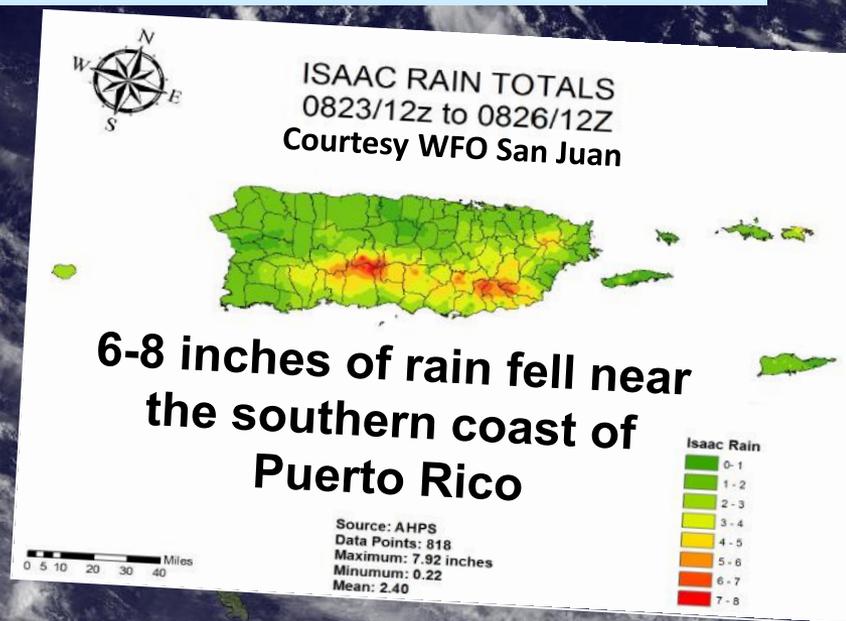
# Don't Focus on the Skinny Black Line

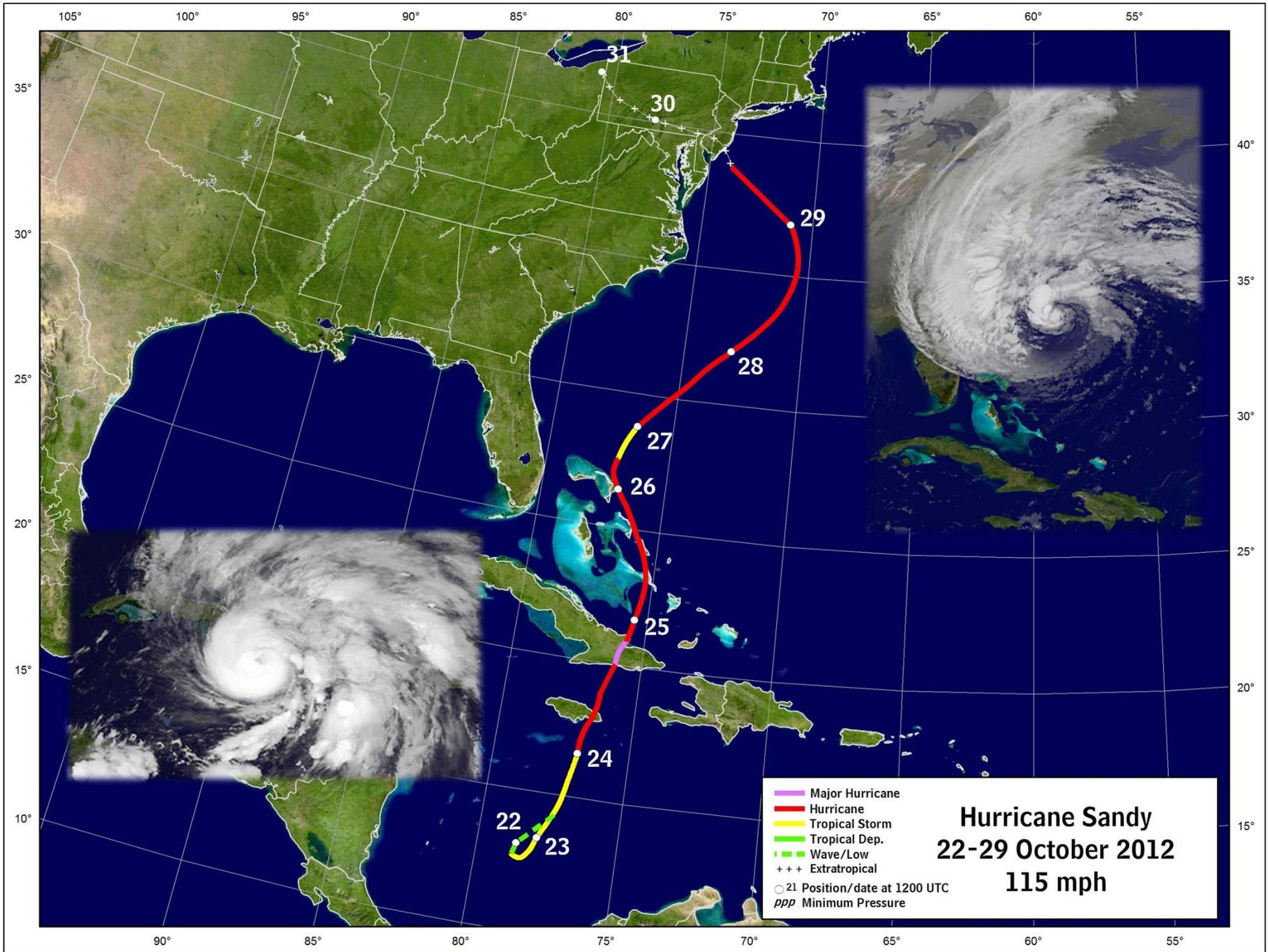
- Center of Isaac moved south of Puerto Rico on August 23
- Band of heavy rain developed well northeast of the center which produced flooding in Puerto Rico.
- Most of this rain fell after the Tropical Storm Warning (for wind) was discontinued.



**Must maintain vigilance and stay in contact with NWS San Juan as they are monitoring local impacts!!**

# Heavy Rains Occurred Well After the Center of Isaac Passed South and West of Puerto Rico





**Hurricane Sandy**  
**22-29 October 2012**  
**115 mph**

# Sandy Damage in Cuba



Mayarí, Holguín



Antilla, Holguín



Banes, Holguín



Hotel Baconao, near Santiago de Cuba

Photos courtesy of the Cuban Meteorological Service



PATH station, Hoboken, NJ  
AFP PHOTO / The Port Authority of New York & New Jersey



Harvey Cedars, Long Beach Island, New Jersey  
(AP Photo/The Philadelphia Inquirer, Clem Murray)



Atlantic City, NJ (Tom Mihalek/Reuters)

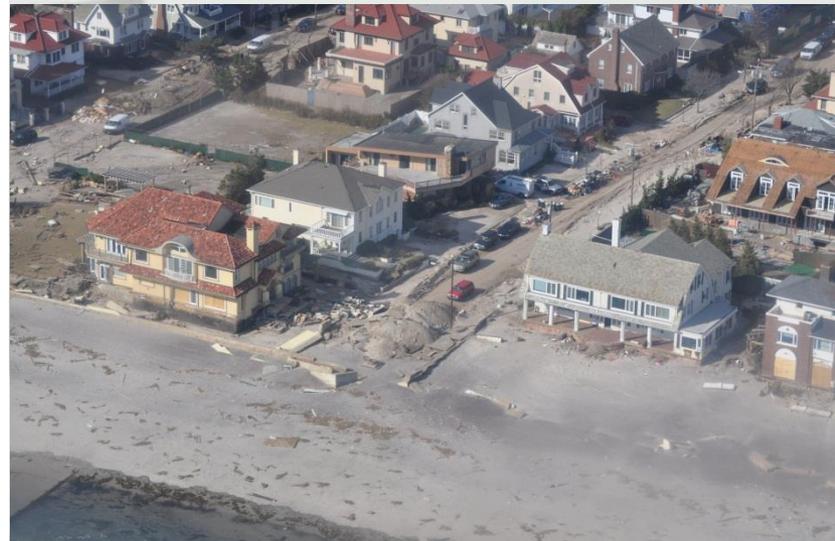
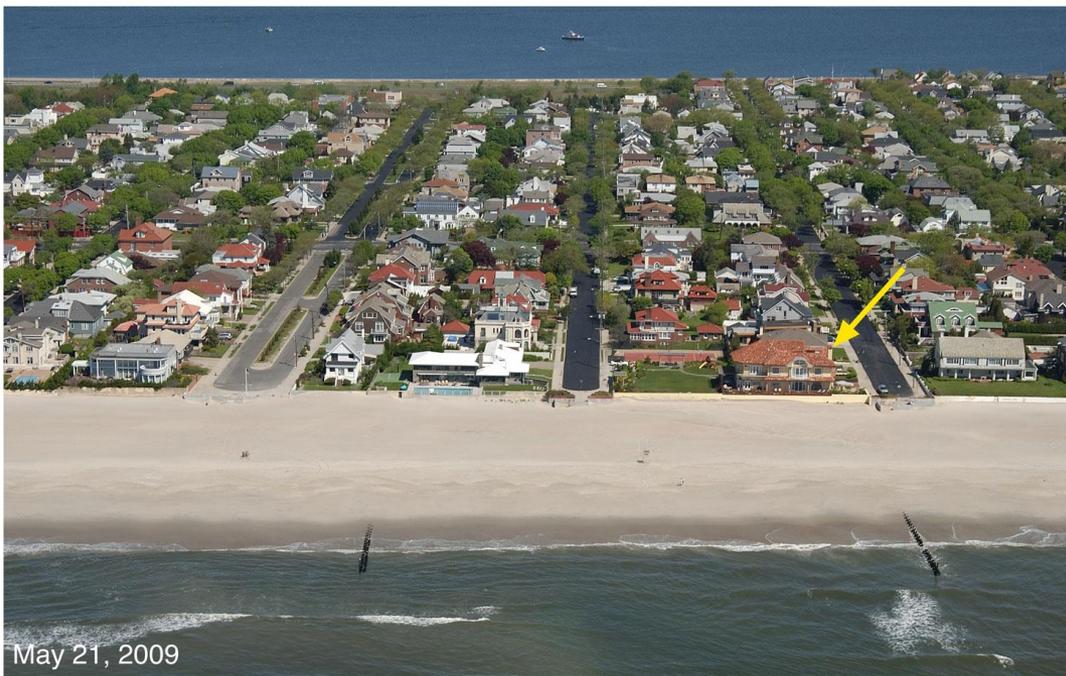


Union Beach, NJ (blog, Spleeness)

# Between Mantoloking and Point Pleasant, NJ



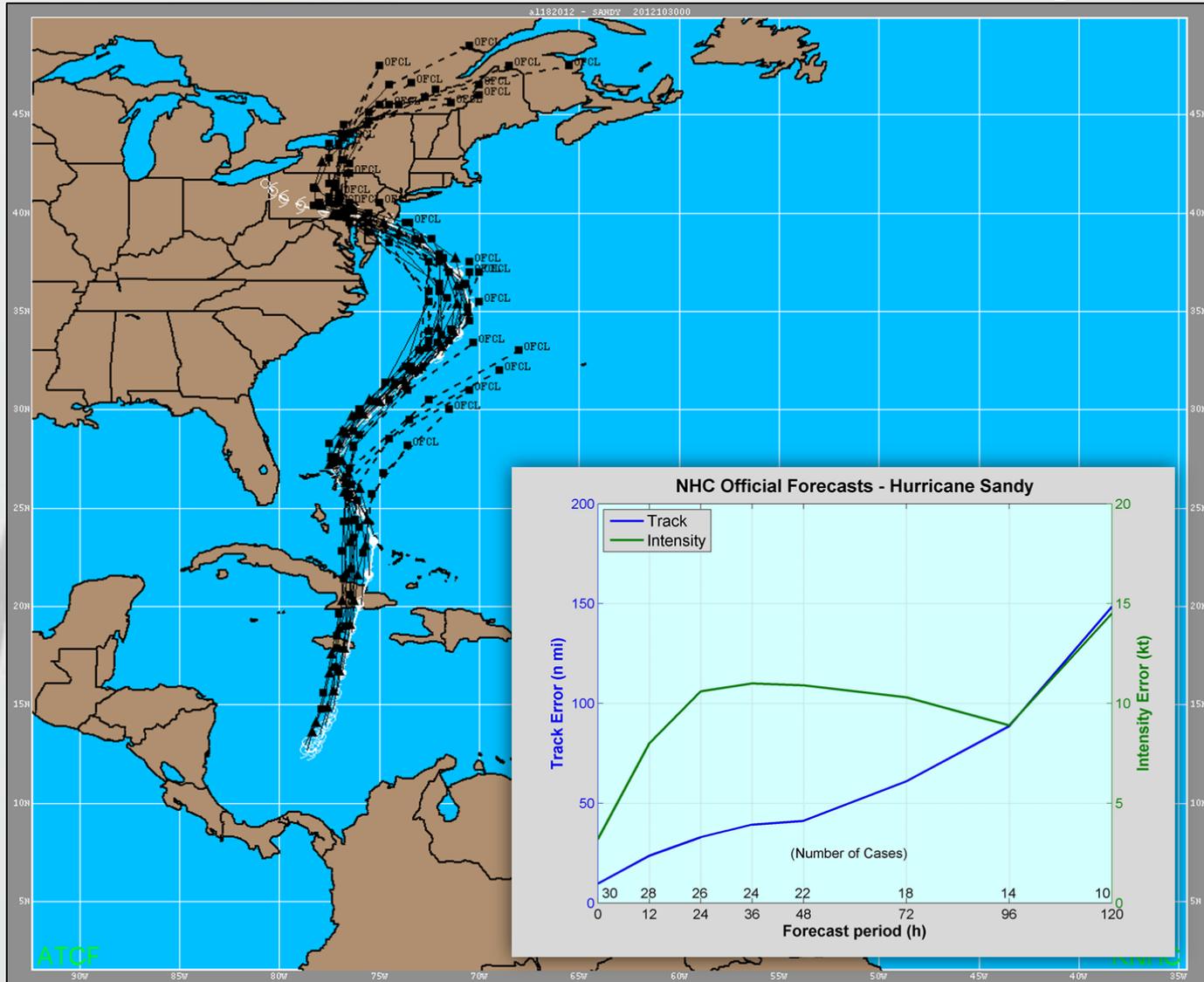
# Rockaway New York





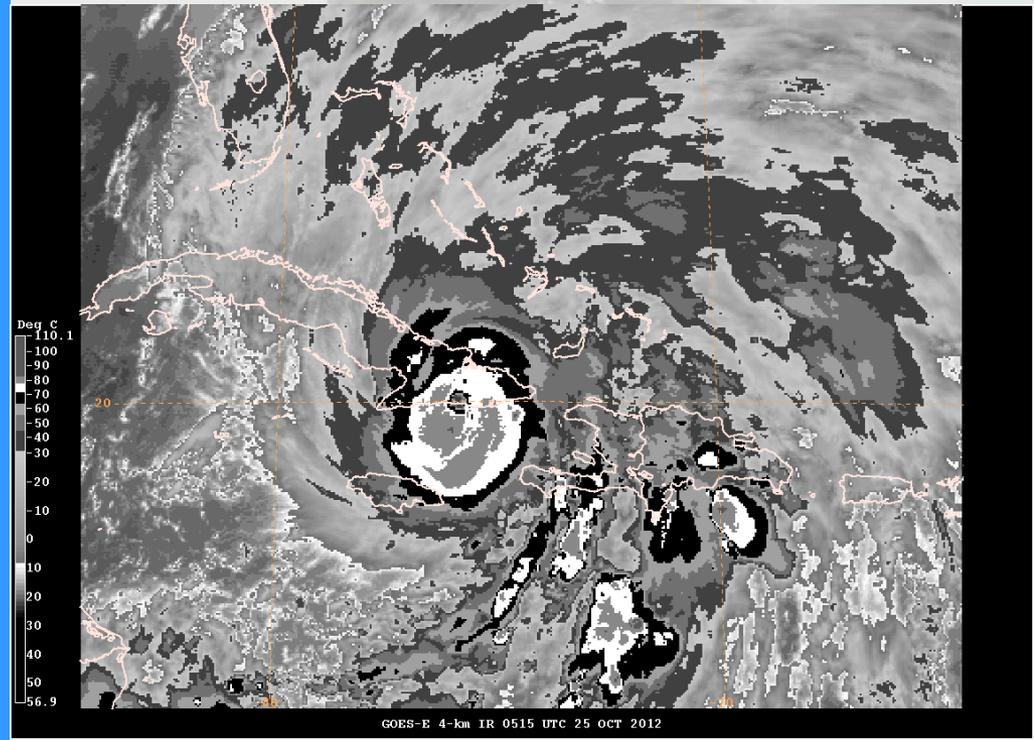
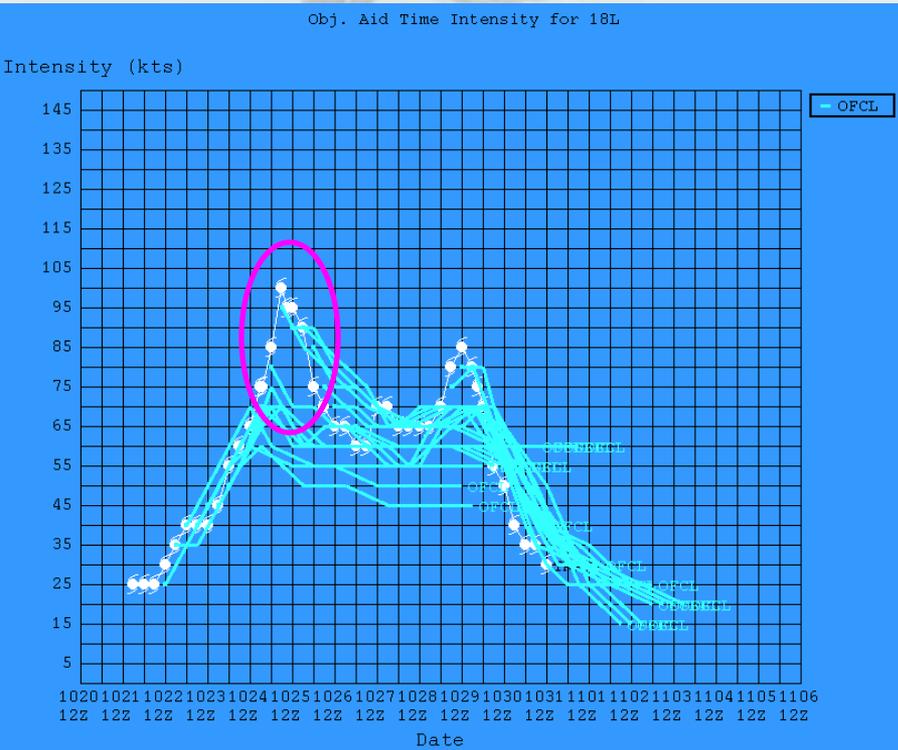
# Many Challenges During Sandy

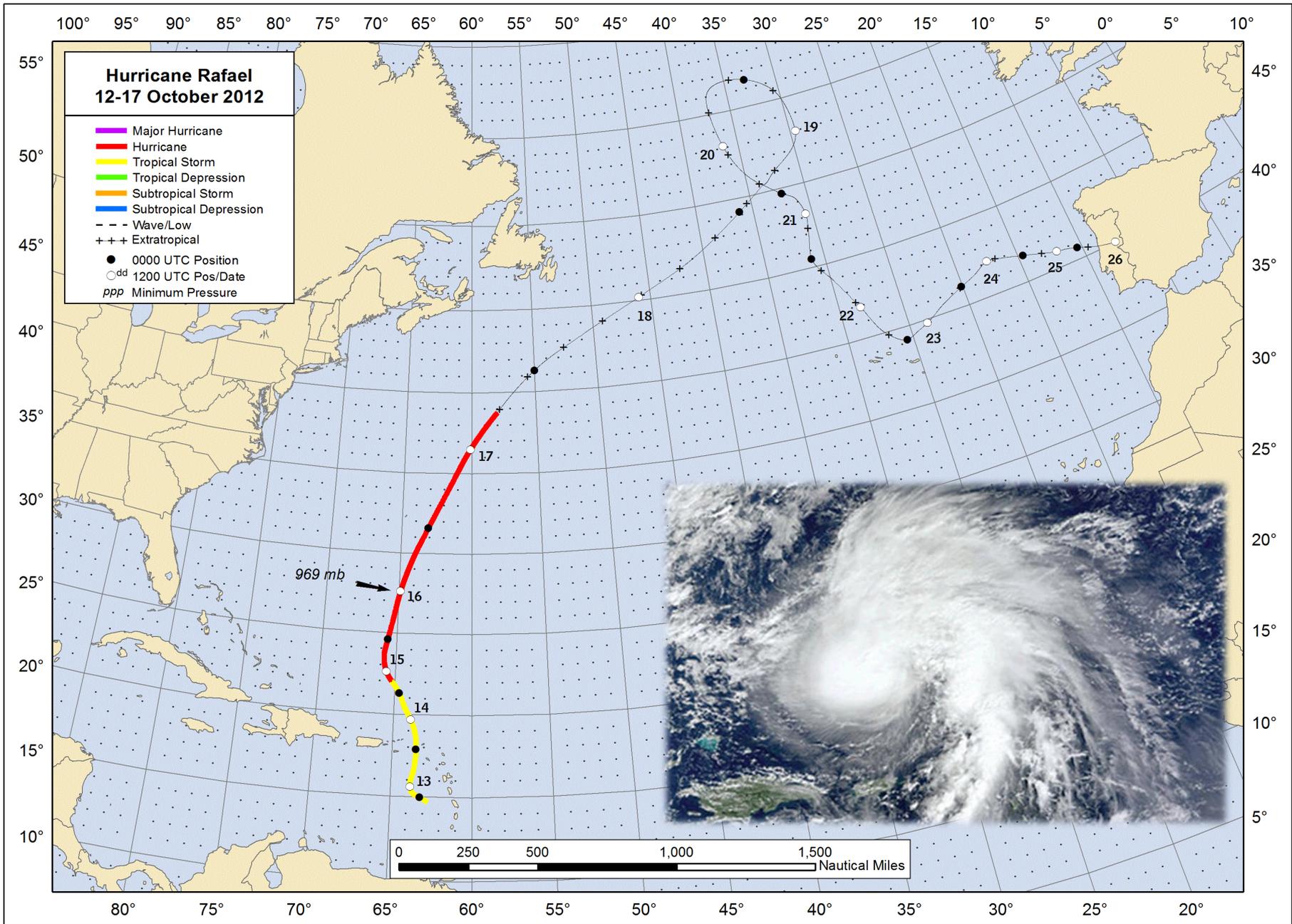
## But the Track and Intensity Forecasts Were Better than Average



# Rapid Intensification: A Recurring Challenge

- Sandy intensified rapidly between Jamaica and Cuba, and this was poorly forecast.
- Despite ongoing efforts (e.g. the Hurricane Forecast Improvement Program), forecasting rapid intensification remains a major problem.







Basseterre, St. Kitts (Mission: St. Kitts)

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10/12/2012

St. Kitts (Newz Chronicles Express)



Guadeloupe (Horizon Aero)



Marigot, Guadeloupe (Dominica News Online)



# 2013 NHC Product Changes



- **Definitions of TS and hurricane watches/warnings have been broadened and issuance criteria of advisories have changed to allow NHC the option to use both for post-tropical cyclones that pose a significant threat to life and property**
- **New use of NHC's Tropical Cyclone Update (TCU) product replaces need for Position Estimate (TCE)**
- **Planned extension of Tropical Weather Outlook to 5 days**
- **Cone size has again been reduced**

# How will the Outlook change in 2013?

Additional information about the 0 to 5 day formation potential will be included in the Text TWO



TROPICAL WEATHER OUTLOOK  
NWS NATIONAL HURRICANE CENTER MIAMI FL  
800 PM EDT WED OCT 10 2012

FOR THE NORTH ATLANTIC...CARIBBEAN SEA AND THE GULF OF MEXICO...

A VIGOROUS TROPICAL WAVE ACCOMPANIED BY A BROAD LOW PRESSURE SYSTEM IS LOCATED ABOUT 475 MILES EAST-SOUTHEAST OF THE WINDWARD ISLANDS. SHOWERS AND THUNDERSTORMS HAVE BECOME A LITTLE BETTER ORGANIZED THIS EVENING...AND REPORTS FROM BUOYS WELL NORTH OF THE CIRCULATION CENTER INDICATE TROPICAL-STORM-FORCE WINDS HAVE BEEN OCCURRING IN SOME OF THE HEAVIER SQUALLS. ALTHOUGH UPPER-LEVEL WINDS ARE CURRENTLY ONLY MARGINALLY FAVORABLE...SOME SLOW DEVELOPMENT OF THIS LARGE DISTURBANCE WILL BE POSSIBLE DURING THE NEXT COUPLE OF DAYS AS ENVIRONMENTAL CONDITIONS GRADUALLY BECOME MORE CONDUCTIVE. THIS

SYSTEM HAS A MEDIUM CHANCE...40 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS AS IT MOVES WEST-NORTHWESTWARD AT AROUND 15 MPH REGARDLESS OF DEVELOPMENT. STRONG GUSTY WINDS AND

HEAVY RAINFALL ARE POSSIBLE ACROSS PORTIONS OF THE LESSER ANTILLES DURING THE NEXT COUPLE OF DAYS. ENVIRONMENTAL CONDITIONS COULD BECOME SLIGHTLY MORE FAVORABLE IN A FEW DAYS WHEN THE DISTURBANCE TURNS NORTHWESTWARD AND PASSES NEAR OR OVER THE NORTHEASTERN CARIBBEAN ISLANDS...AND EMERGES OVER THE WESTERN ATLANTIC IN A FEW DAYS. THIS

SYSTEM HAS A HIGH CHANCE...80 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS.

A WELL-DEFINED LOW PRESSURE SYSTEM LOCATED ABOUT 250 MILES EAST OF THE CENTRAL BAHAMAS HAS CONTINUED TO BECOME BETTER DEFINED OVER THE PAST SEVERAL HOURS. HOWEVER...ENVIRONMENTAL CONDITIONS ARE ONLY MARGINALLY CONDUCTIVE FOR DEVELOPMENT DURING THE NEXT DAY OR SO BEFORE THE LOW MERGES WITH A COLD FRONT THURSDAY NIGHT OR FRIDAY. THIS SYSTEM HAS A LOW CHANCE...20 PERCENT...OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 48 HOURS AS IT MOVES LITTLE. ENVIRONMENTAL CONDITIONS WILL BECOME HOSTILE FOR ANY SIGNIFICANT DEVELOPMENT TO OCCUR BY FRIDAY AS THE LOW MOVES SOUTHWARD INTO A REGION OF STRONG UPPER-LEVEL WINDS. THIS SYSTEM HAS A LOW CHANCE...20 PERCENT... OF BECOMING A TROPICAL CYCLONE DURING THE NEXT 5 DAYS.

&&

AN EXPERIMENTAL 5-DAY FORMATION PROBABILITY IS ALSO INCLUDED IN THIS PRODUCT FOR THE 2013 HURRICANE SEASON.

FIVE-DAY FORMATION PROBABILITIES ARE EXPERIMENTAL IN 2012.

\$\$

FORECASTER STEWART

NNNN

THIS SYSTEM HAS A MEDIUM CHANCE...  
40 PERCENT...OF BECOMING A TROPICAL  
CYCLONE DURING THE NEXT 48 HOURS...

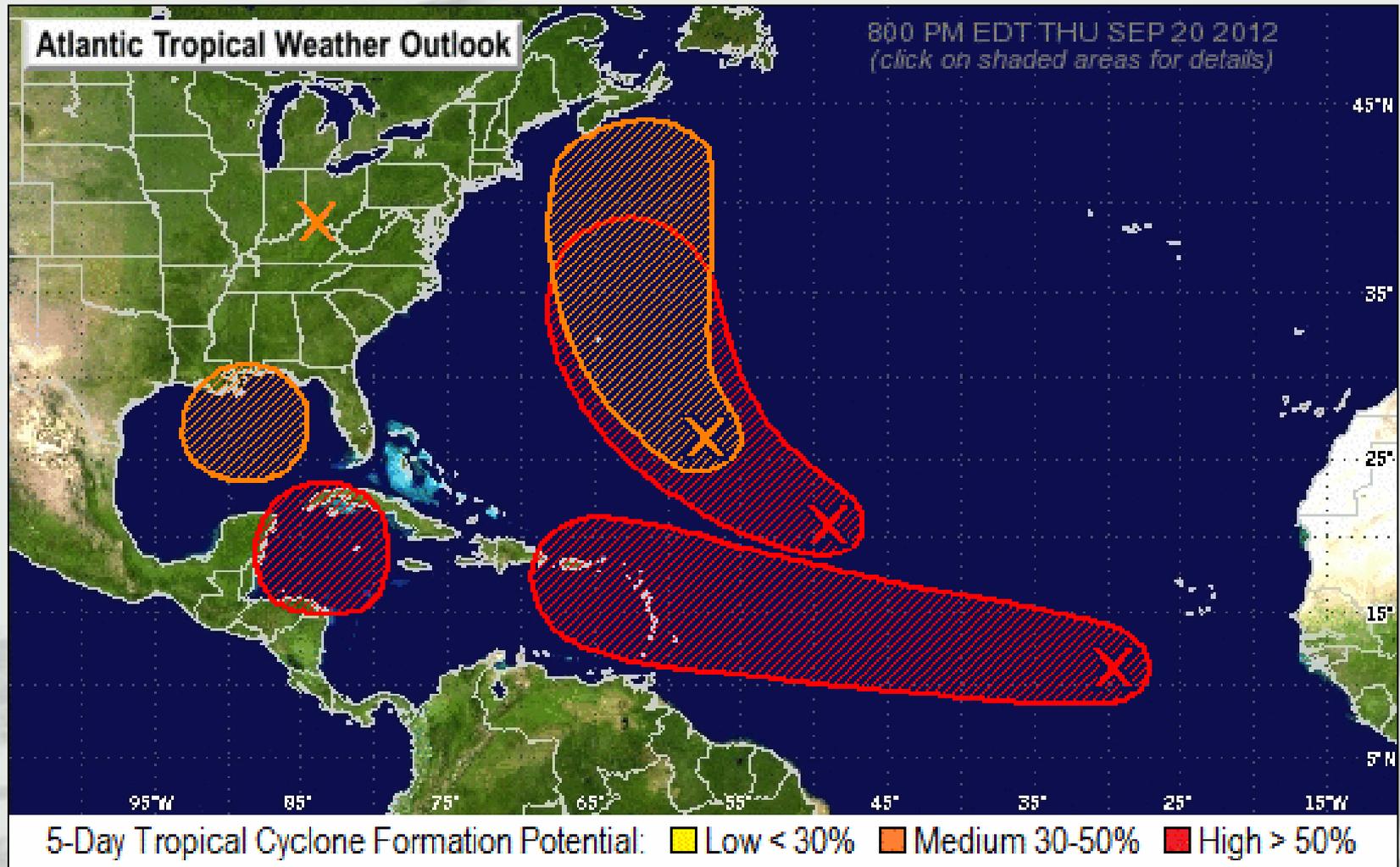
THIS SYSTEM HAS A HIGH CHANCE...  
80 PERCENT...OF BECOMING A TROPICAL  
CYCLONE DURING THE NEXT 5 DAYS.

- NHC still has some development and testing to complete.
- This addition to the TWO is not planned to occur until July or August.

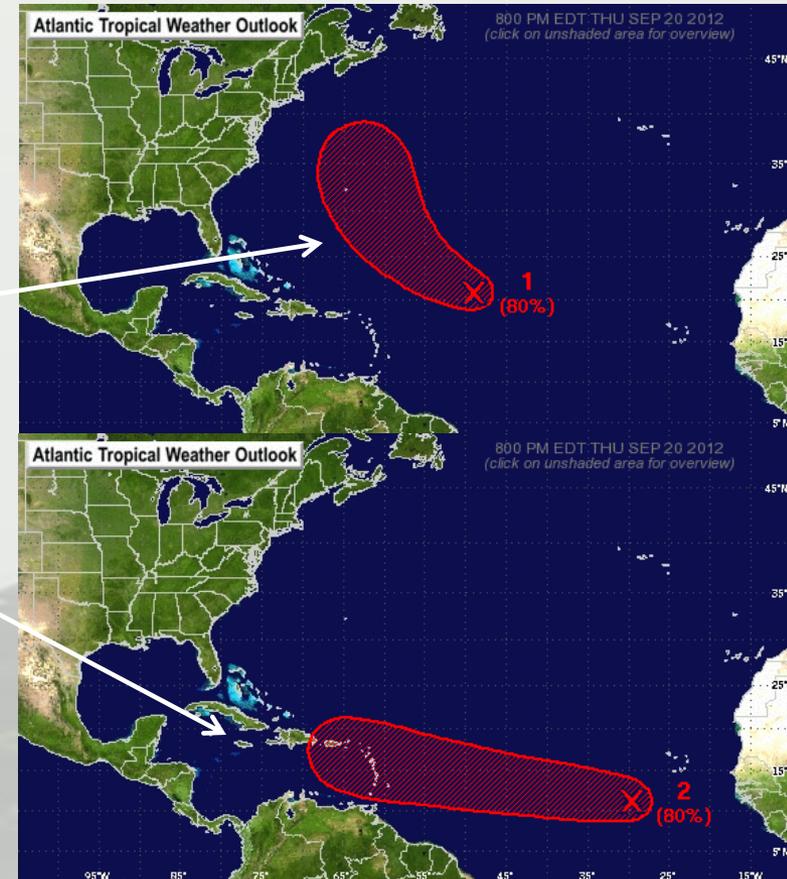
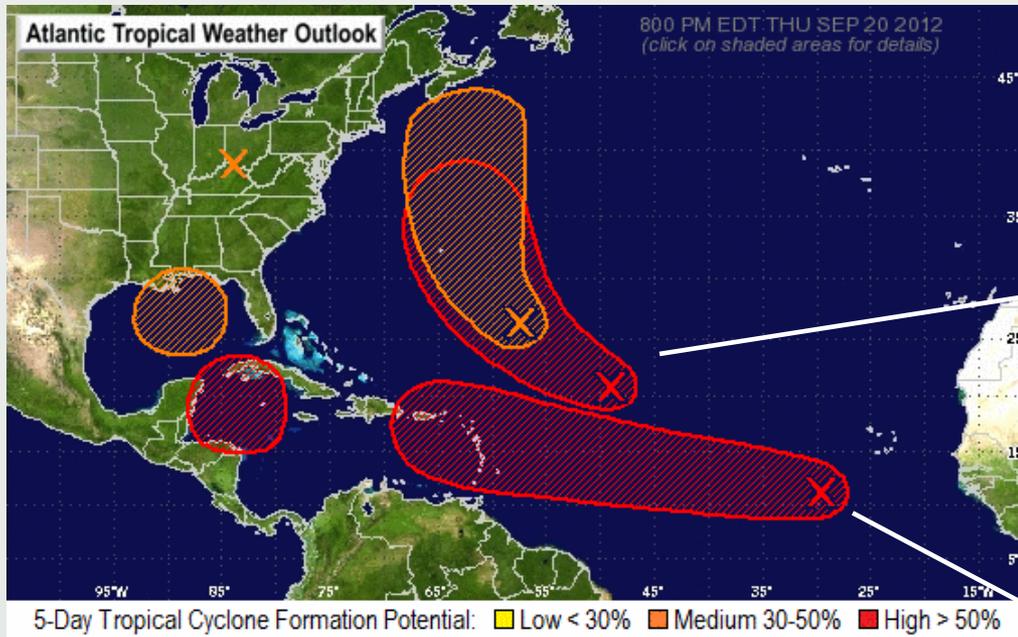


# Prototype 5-day Graphic

Might be available sometime in 2013



# New Graphic Shows 5-day Potential Formation Area



- Overview graphic shows entire basin, with single disturbance graphics to aid in display when overlapping areas
- Indicates initial location of disturbance (X), if existing at issuance time
- Existing 2-day graphical Outlook will remain unchanged



# Atlantic Cone Radii – 2013 vs. 2012



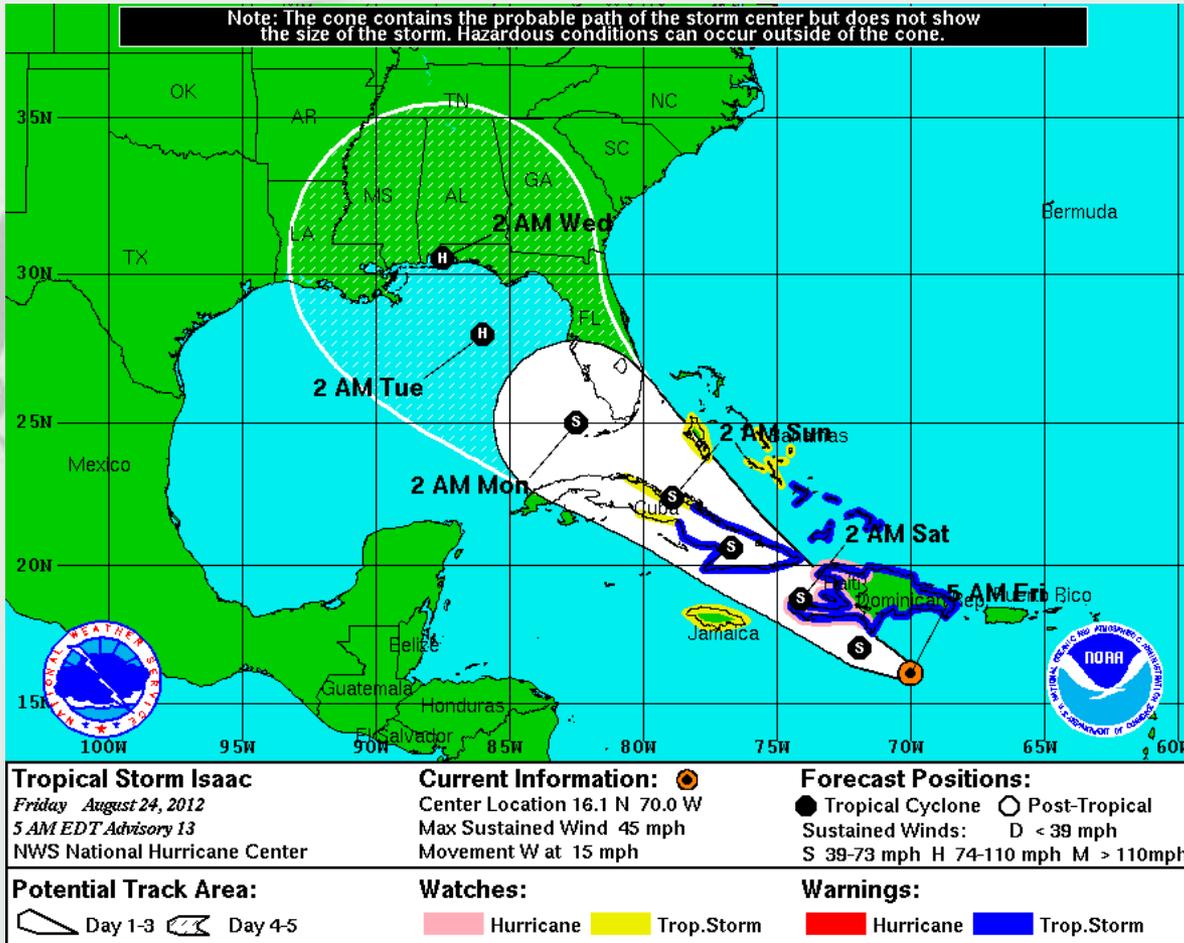
Improving track accuracy = smaller cone size

Forecast Period (h)	2012 Circle Radius (n mi) ('07 – '11 errors)	2013 Circle Radius (n mi) ('08 – '12 errors)	Percent Change
12	36	33	-8%
24	56	52	-7%
36	75	72	-4%
48	95	92	-3%
72	141	128	-9%
96	180	177	-2%
120	236	229	-3%

**Storm size has not changed = more impacts outside cone**

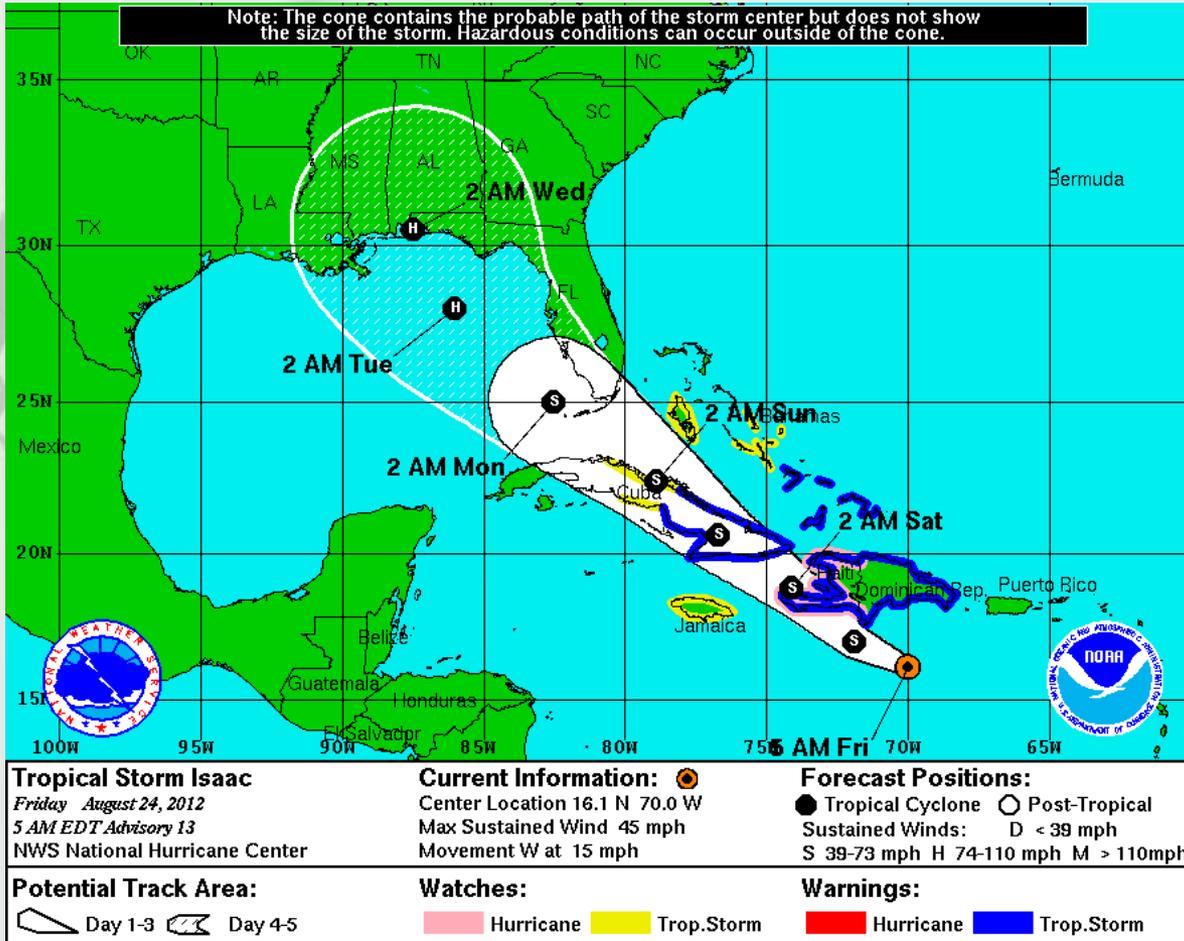


# Isaac Advisory 13 with 2008 Cone





# Isaac Advisory 13 with 2013 Cone

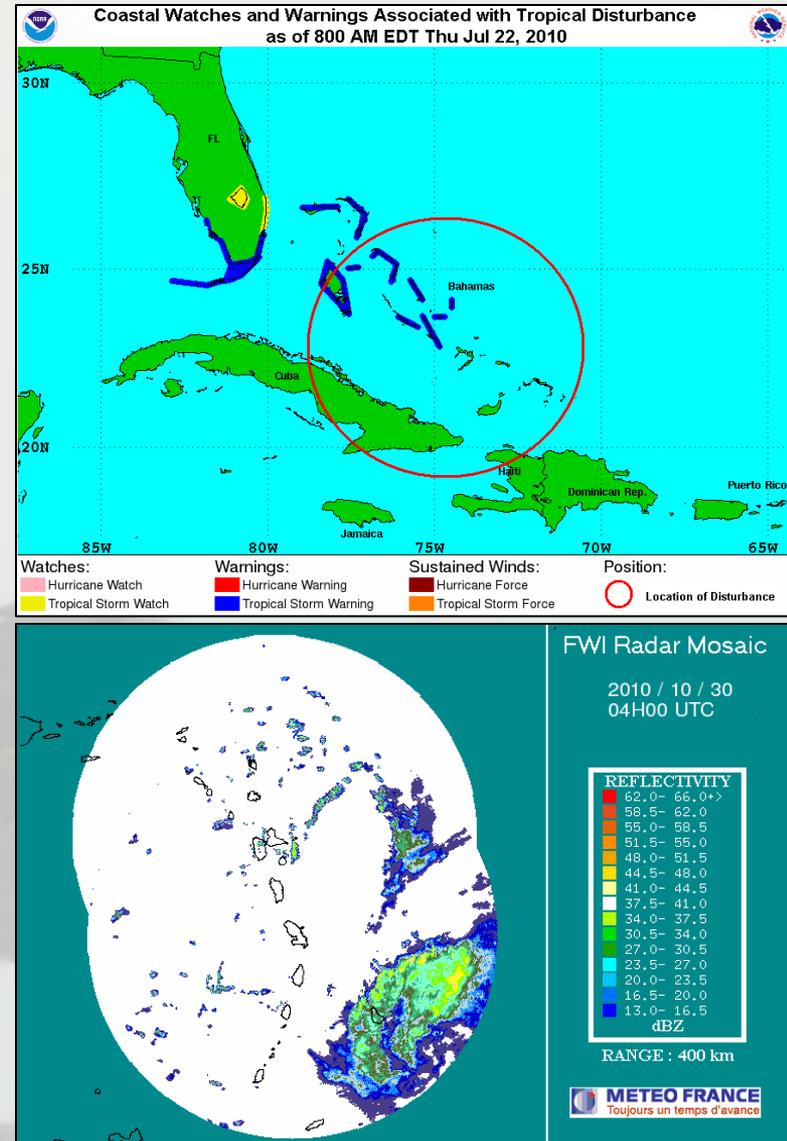




# Potential Long Term NHC Forecast Enhancements



- Track and intensity forecasts for disturbances
- Watches/Warning before formation
- Extension of tropical cyclone forecasts to 7 days

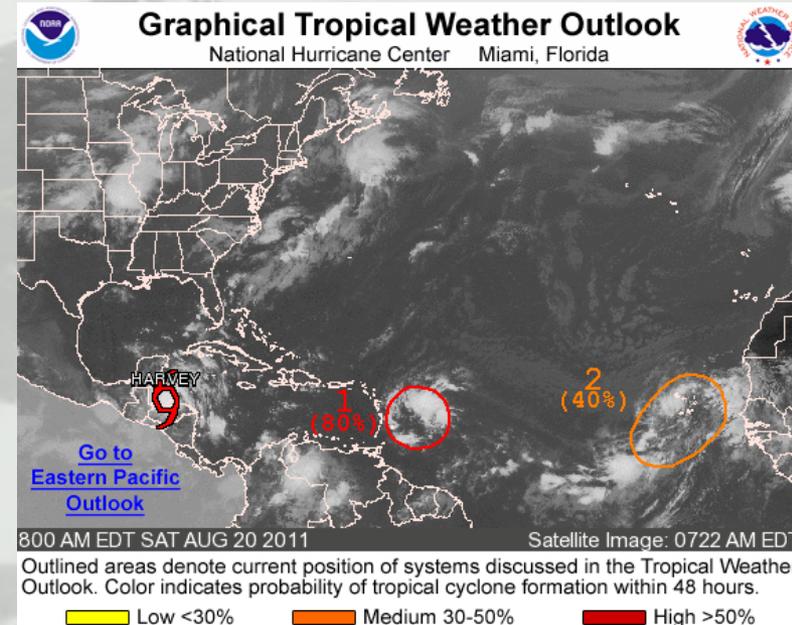
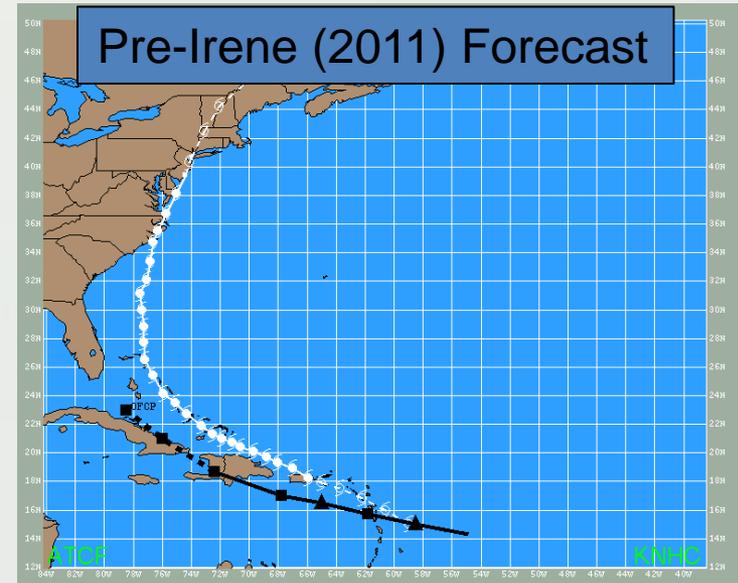




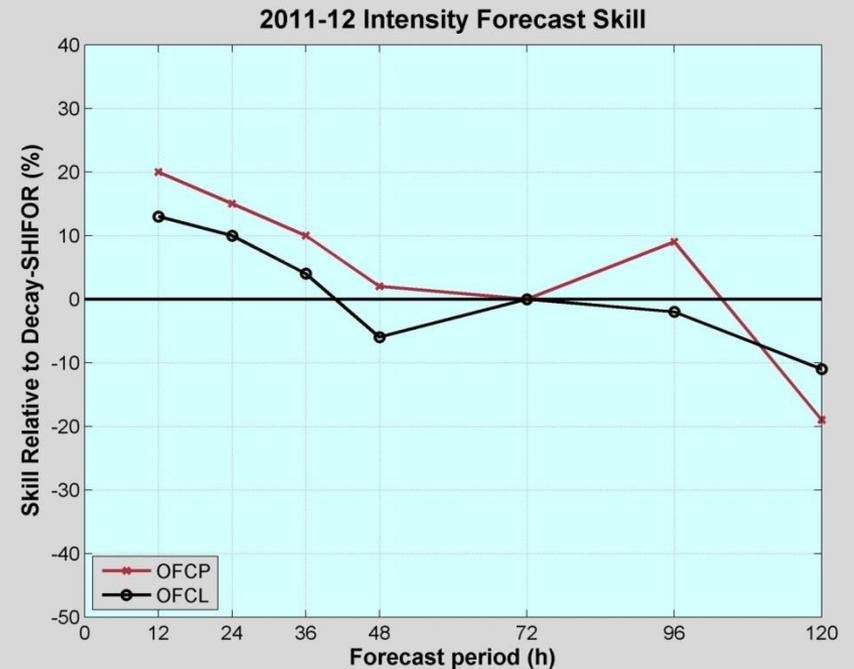
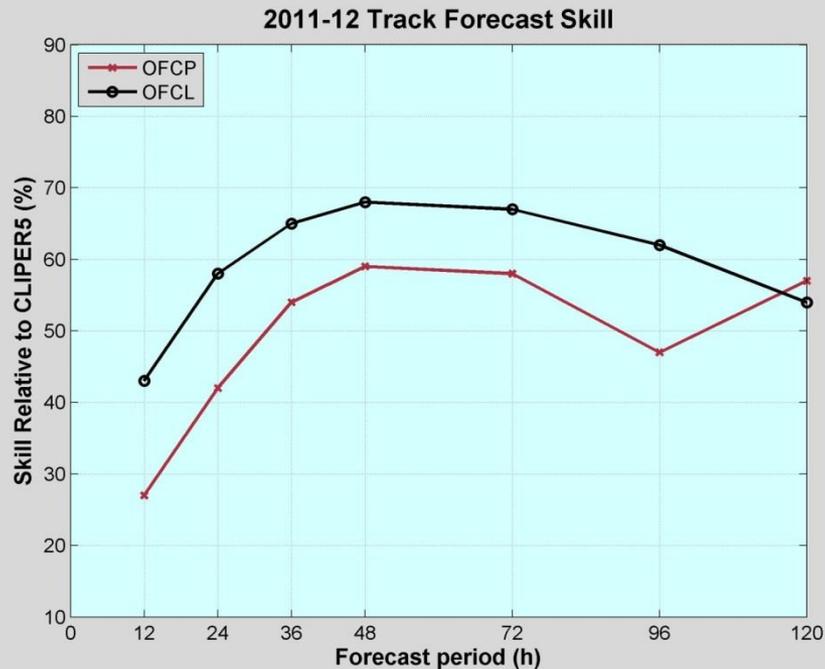
# Pre-Tropical Cyclone Track & Intensity Forecasts



- **Motivation**: Issued for systems prior to genesis in support of the watch/warning process
- In 2011, the NHC began making forecasts only for tropical disturbances with a high chance of formation in the Tropical Weather Outlook
- Forecasts include predictions of track, intensity, wind radii, and system status (e.g. “TD/TS/HU”, or “DB”) out to 5 days



# Verification of NHC Disturbance Track & Intensity Forecasts

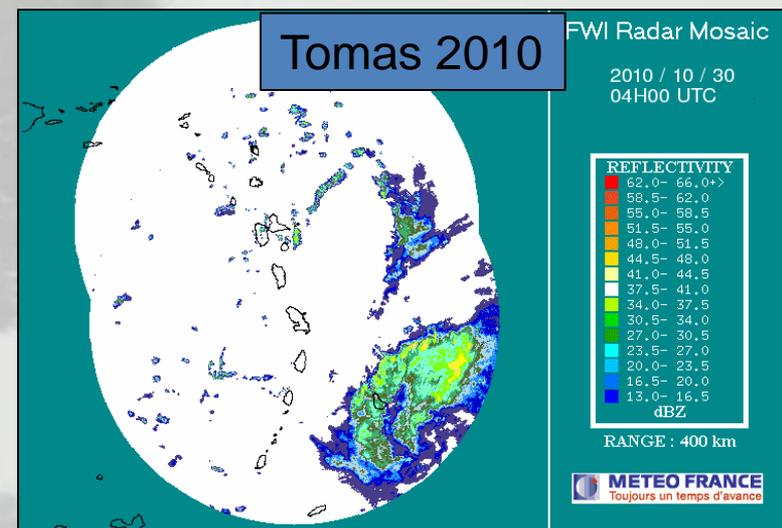
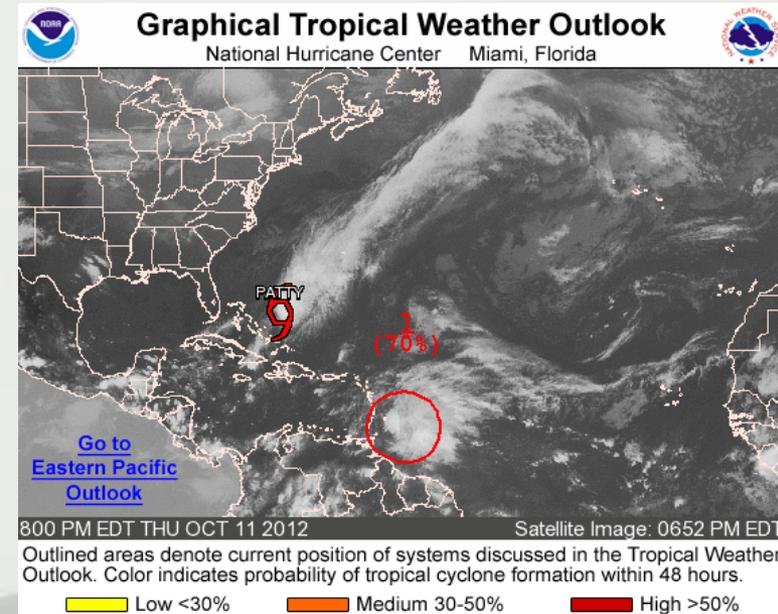


Disturbance track forecasts are generally 10-20% less skillful than the forecasts for tropical cyclones.

Intensity skill is minimal for both provisional and operational forecasts.

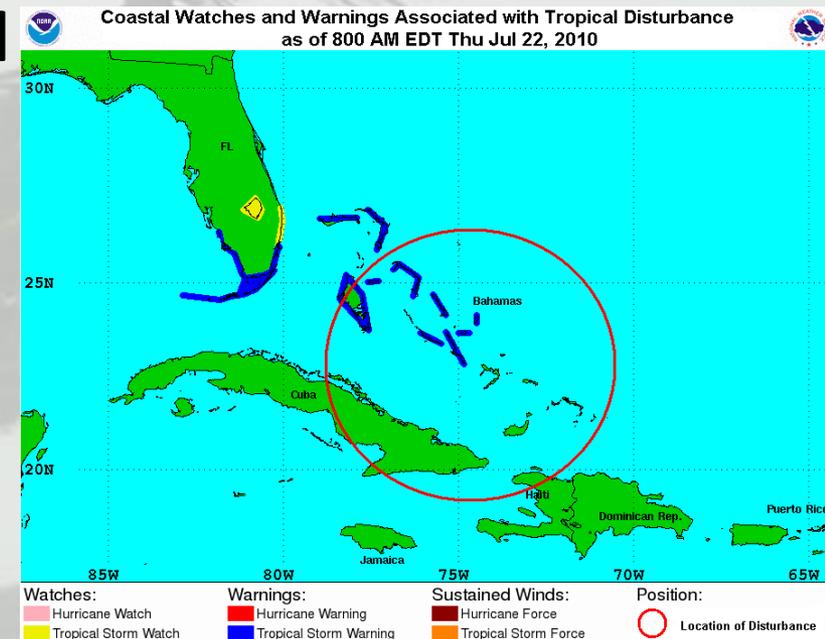
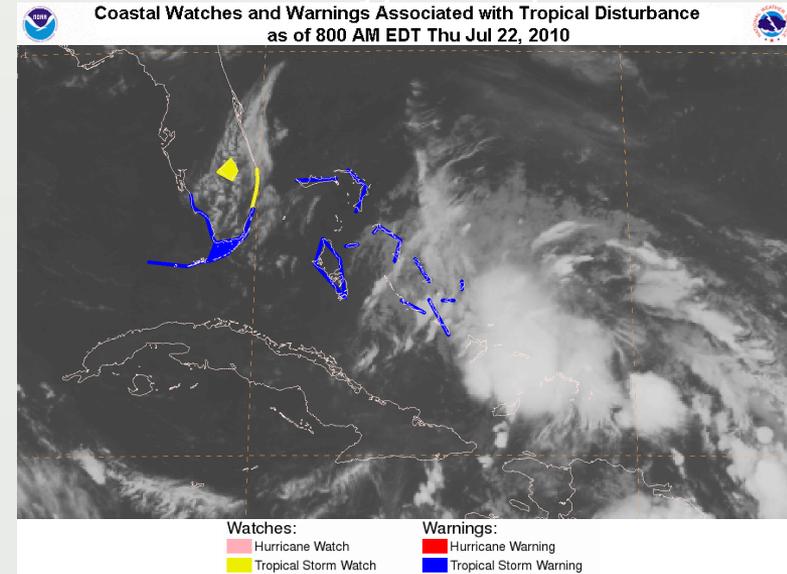
# Watches and Warnings before Formation?

- Currently tropical storm watches and warnings are not issued until a tropical depression or storm has formed.
- Dissemination of watches/warnings are tied administratively to tropical cyclone advisories.
- Difficult to determine placement of watch and warning areas when system is poorly defined and track & intensity prognosis is highly uncertain.



# Watches and Warnings before Formation?

## Prototype Graphics



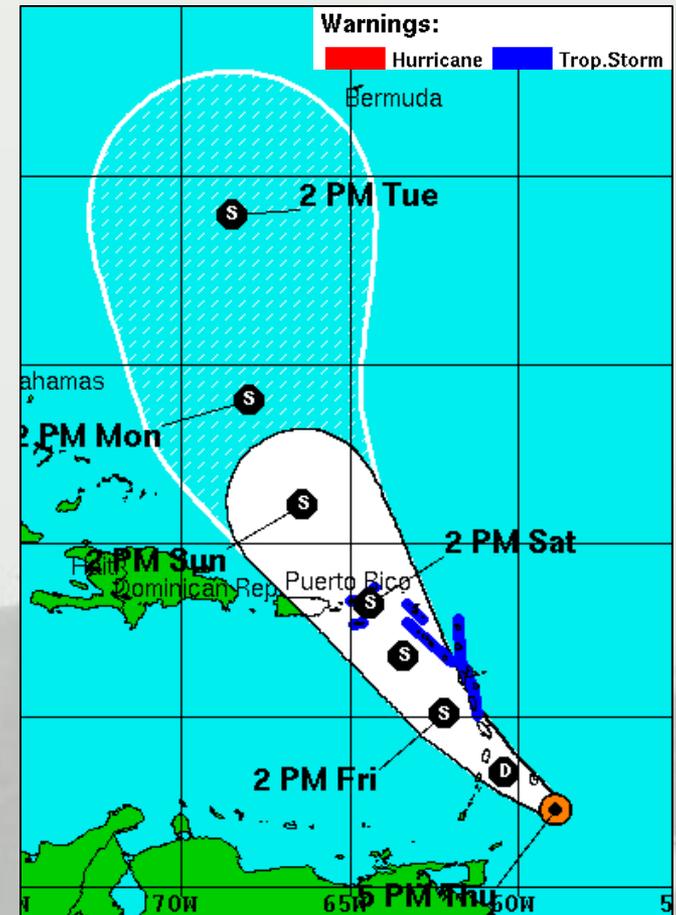
- NHC conducted an in-house experiment during the 2012 season by issuing Pre-TC watches/warnings
- Could take a few years to have enough cases to evaluate
- NHC exploring ways to issue and communicate pre-TC watches & warnings
  - Through graphical and text TWO?
  - Through advisory-like products?
  - New products?



# NHC In-House Pre-TC Watch/Warning Experiment



- Example of pre-Rafael forecast with recommended tropical storm warnings (in blue).
- This forecast was made about 24 hours before the system became a tropical depression.
- This would have given about 24 hours additional lead time to portions of the Leeward Islands.

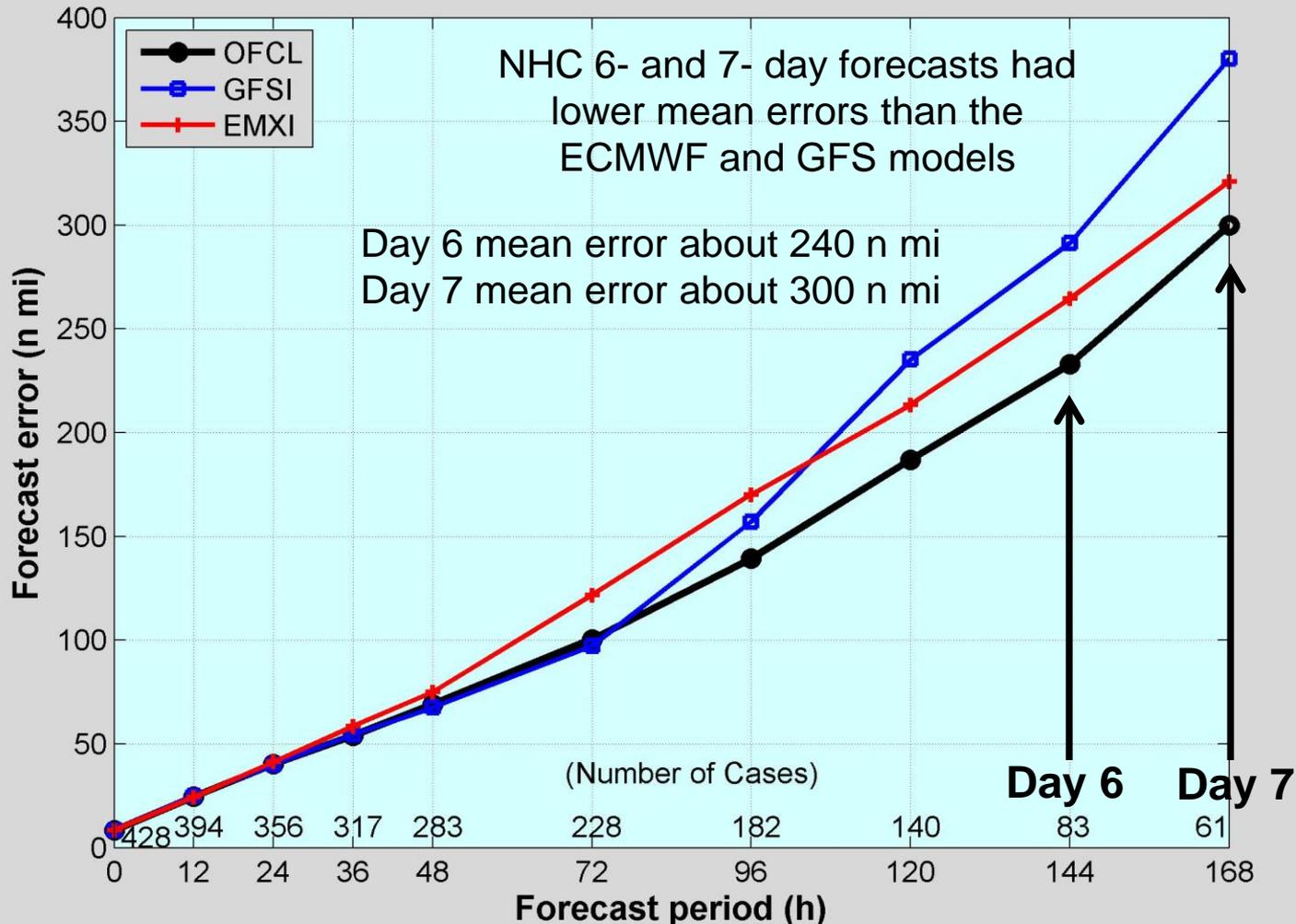




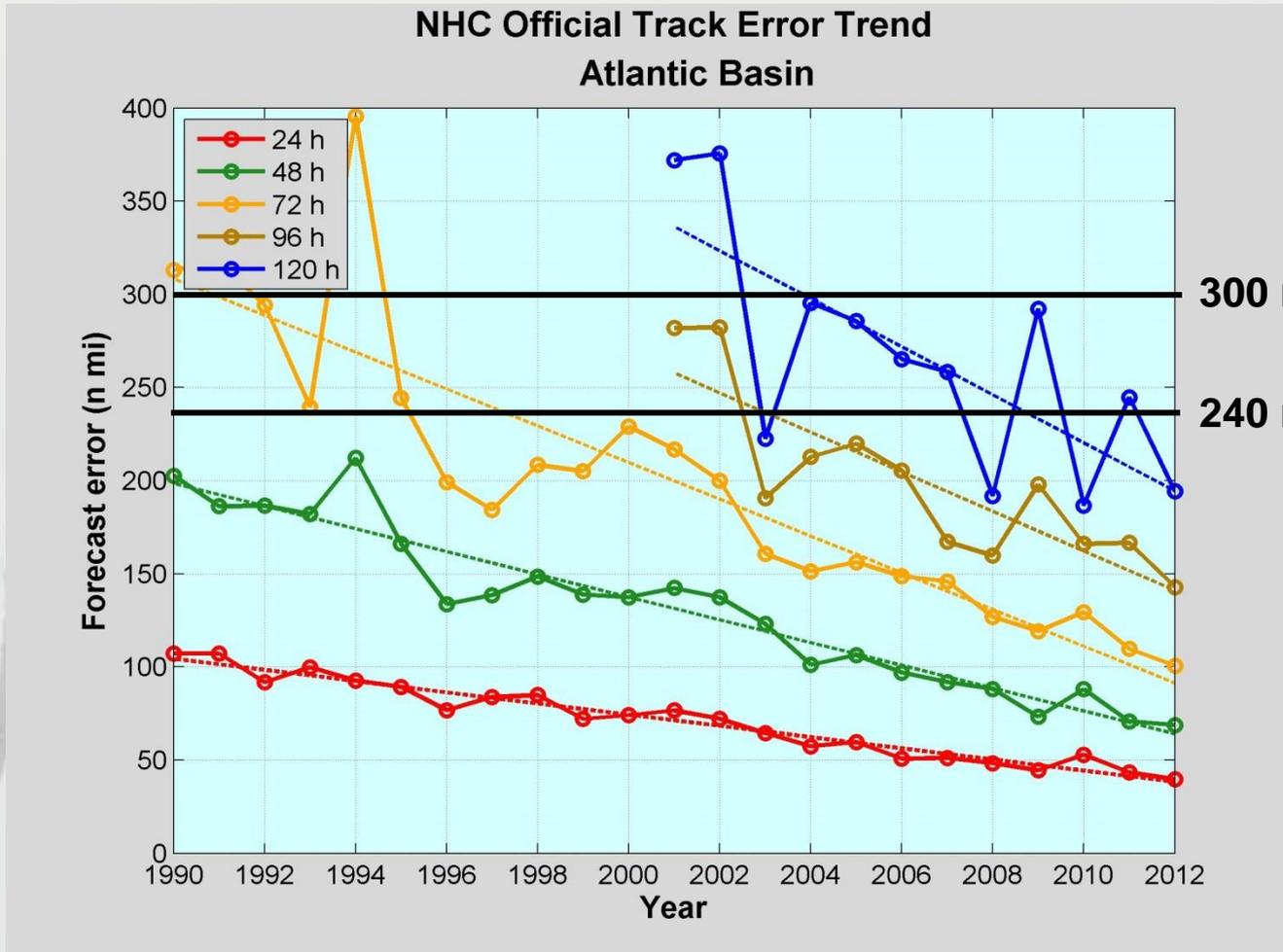
# 6- and 7-Day Track Forecasts

## 2012 NHC 6- and 7-day Track Forecast Verification

Track Forecast Skill (Early Models)  
2012 - Atlantic Basin



# 6- and 7-day Forecasts



**2012 verification results indicate the 6- and 7-day forecasts were about as good as NHC 4- and 5-day forecasts were when introduced a decade ago.**

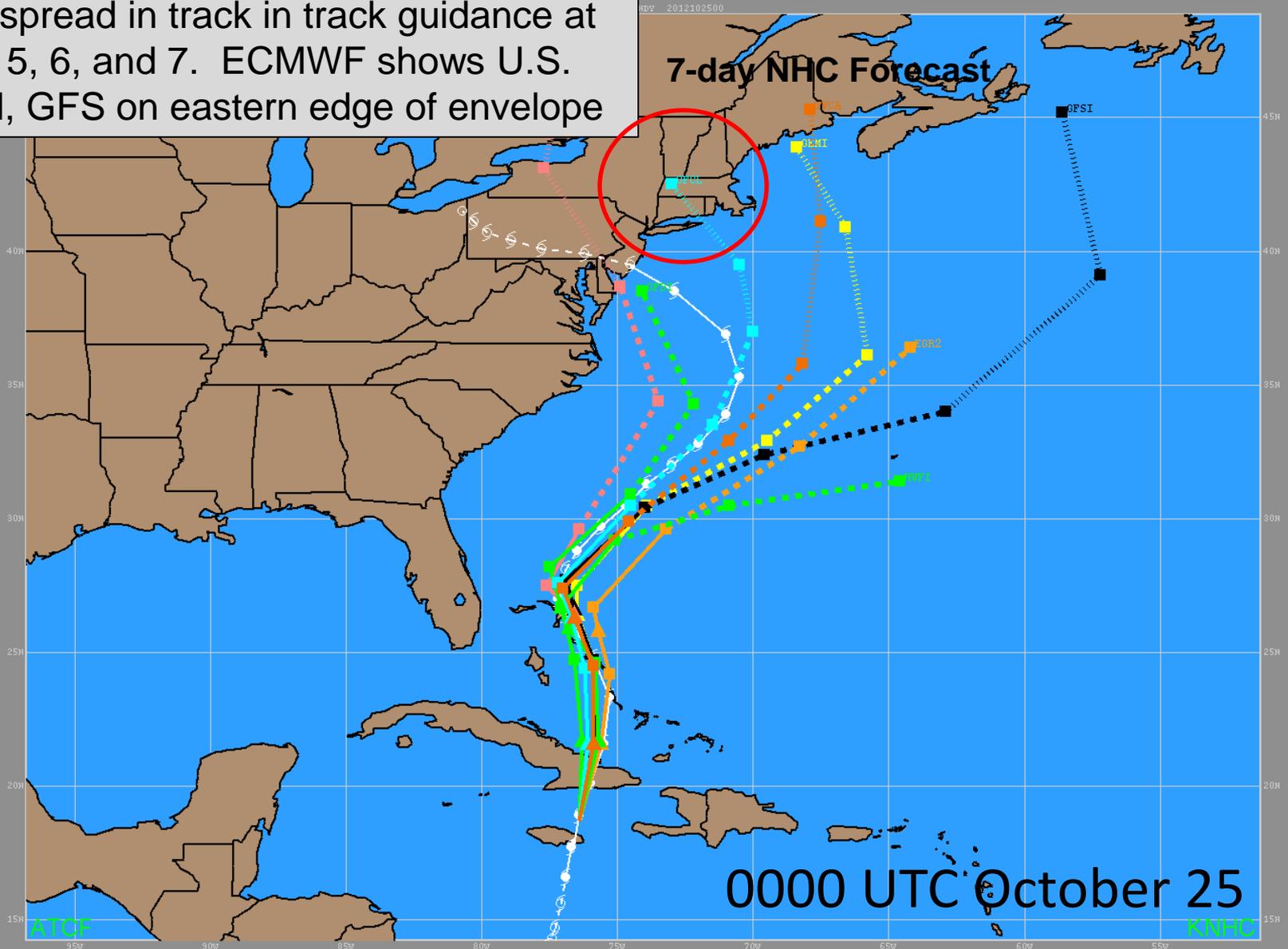




# Forecasts Shifted Westward about 6 Days Before Landfall



Large spread in track in track guidance at days 5, 6, and 7. ECMWF shows U.S. landfall, GFS on eastern edge of envelope

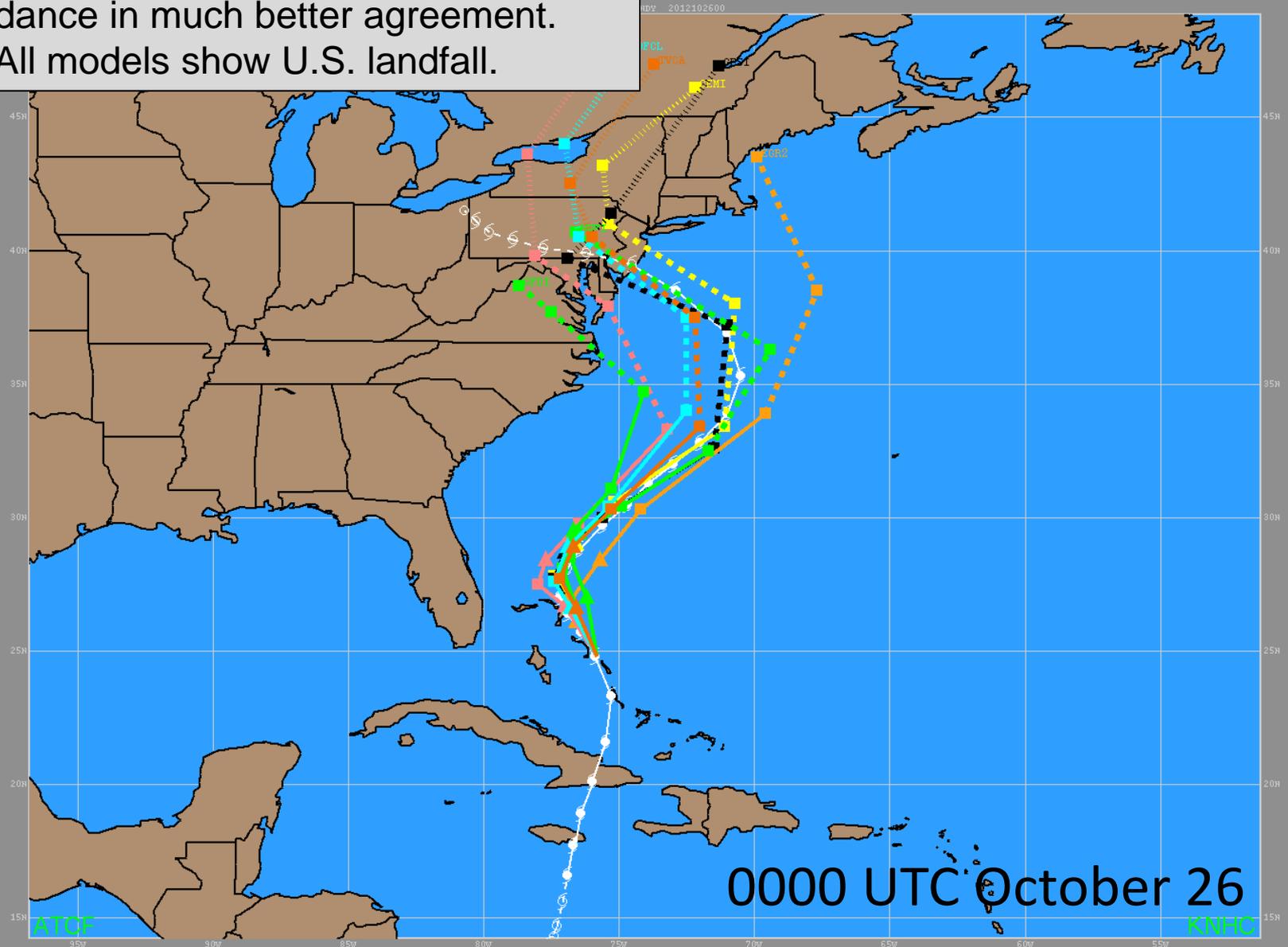




# Models in Better Agreement About 5-days from Landfall



Guidance in much better agreement.  
All models show U.S. landfall.

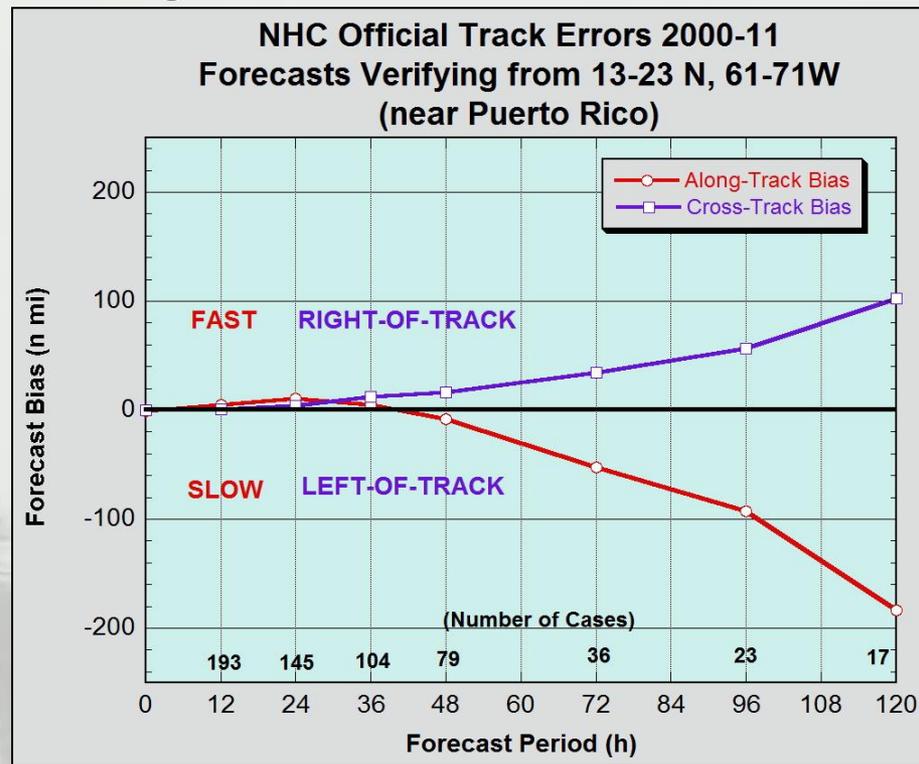
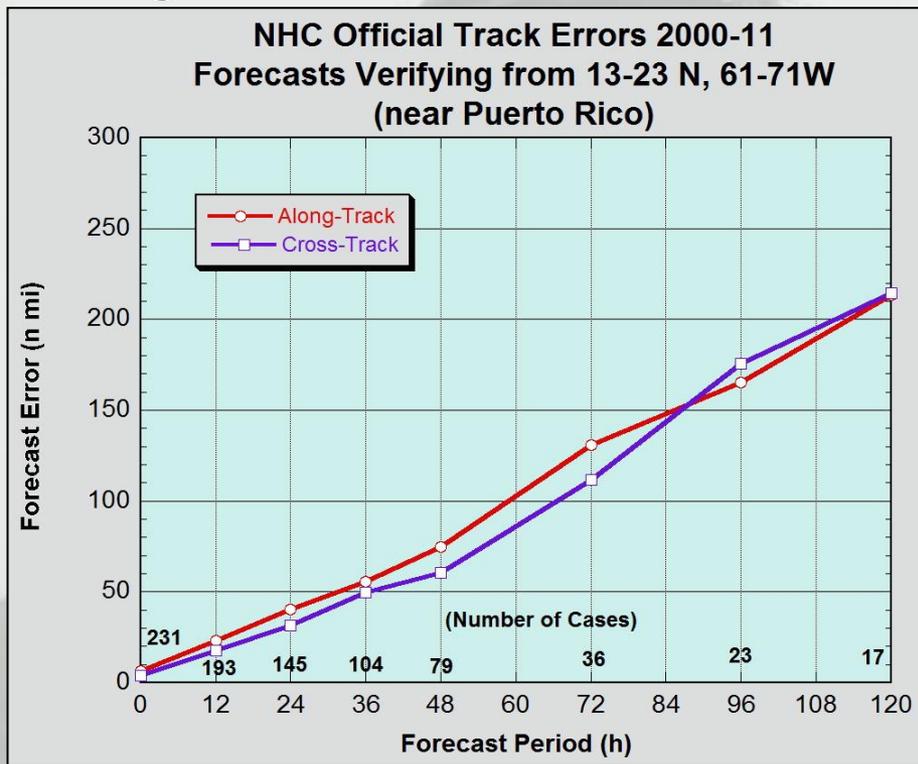




# For Storms Near Puerto Rico, NHC Forecasts have had a Pronounced Slow Bias at Days 3-5 = Less Preparation Time

## Right/Left & Fast/Slow Errors

## Right/Left & Fast/Slow Errors



Along- and cross-track errors are about equal

Biases are small through 48 h but right of track and slow biases severely increase at days 3-5



# NHC Outreach and Education



*“Battle is won (or lost) during the off-season...”*

Highlights of annual NHC involvement with federal partners and Caribbean countries:

- National Hurricane Conference
- State and local emergency management conference
- FEMA/Emergency Management Institute training courses (L-0324, L-0311, L-0320)
- **Caribbean Hurricane Awareness Tour**
  - Canceled in 2013
  - Hopeful for a resumption in the future
- National Hurricane Preparedness Week (ongoing this week)





# FEMA/EMI Course Held in Puerto Rico in March 2012

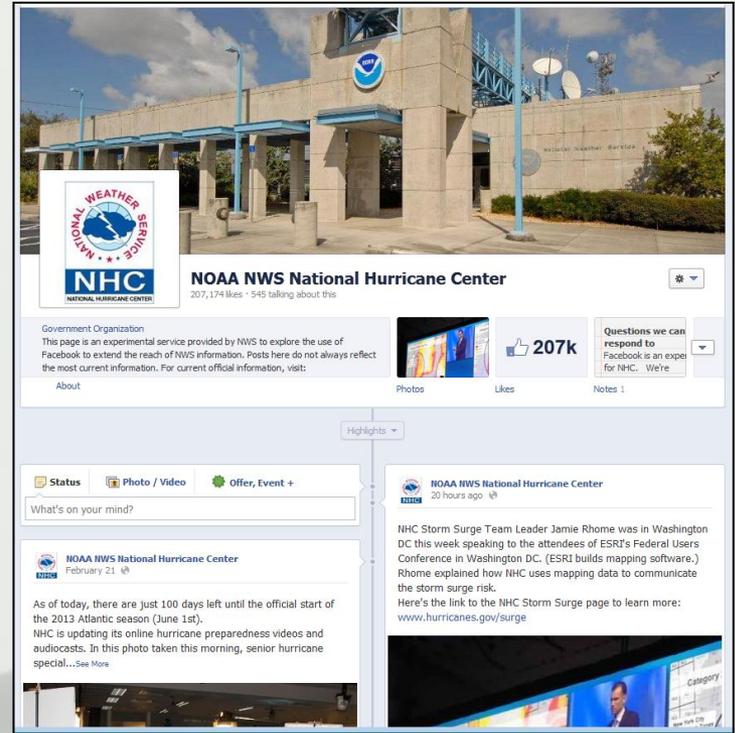




# Social Media and NHC



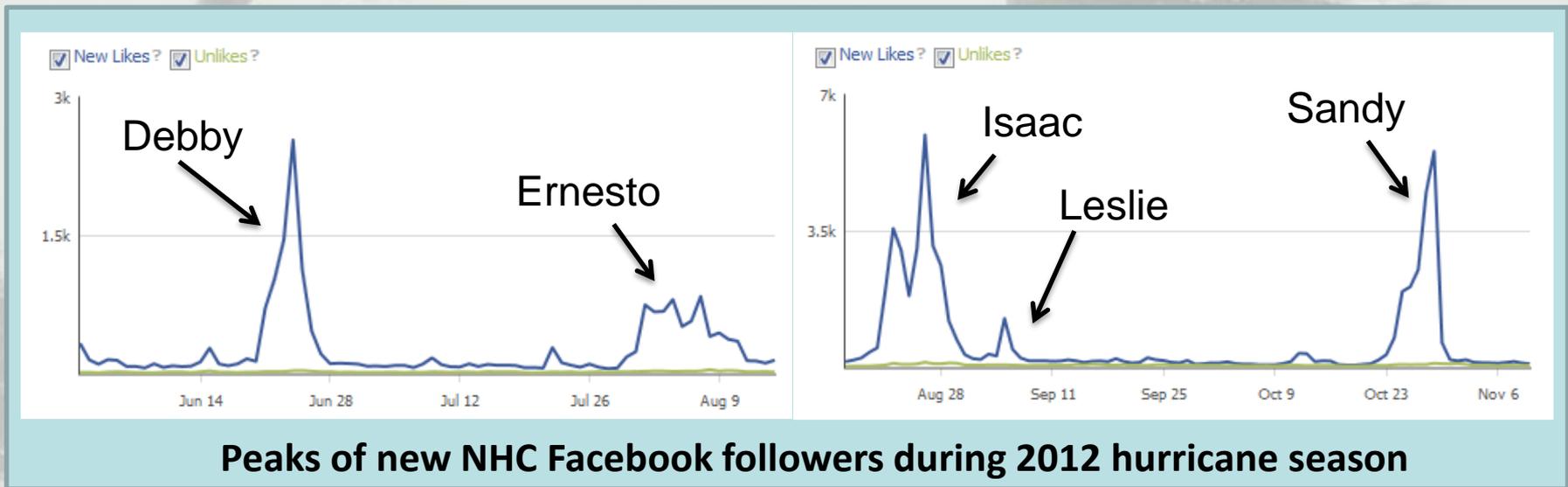
- NHC Facebook & Twitter feed began in 2011
- Hurricane Awareness Week- Public Service Announcements





# Social Media and NHC

- Nearly 210,000 Facebook followers
  - One of the most followed government Facebook pages
- Nearly 115,000 Twitter followers
- Significant increase of followers during hurricane threats





# Thanks for your time!



## NHC Hurricane Forecasters

Brown

Roberts

Blake

Pasch

Beven

Landsea



Berg

Avila

Cangialosi

Kimberlain

Brennan

Stewart

Franklin

# Questions?