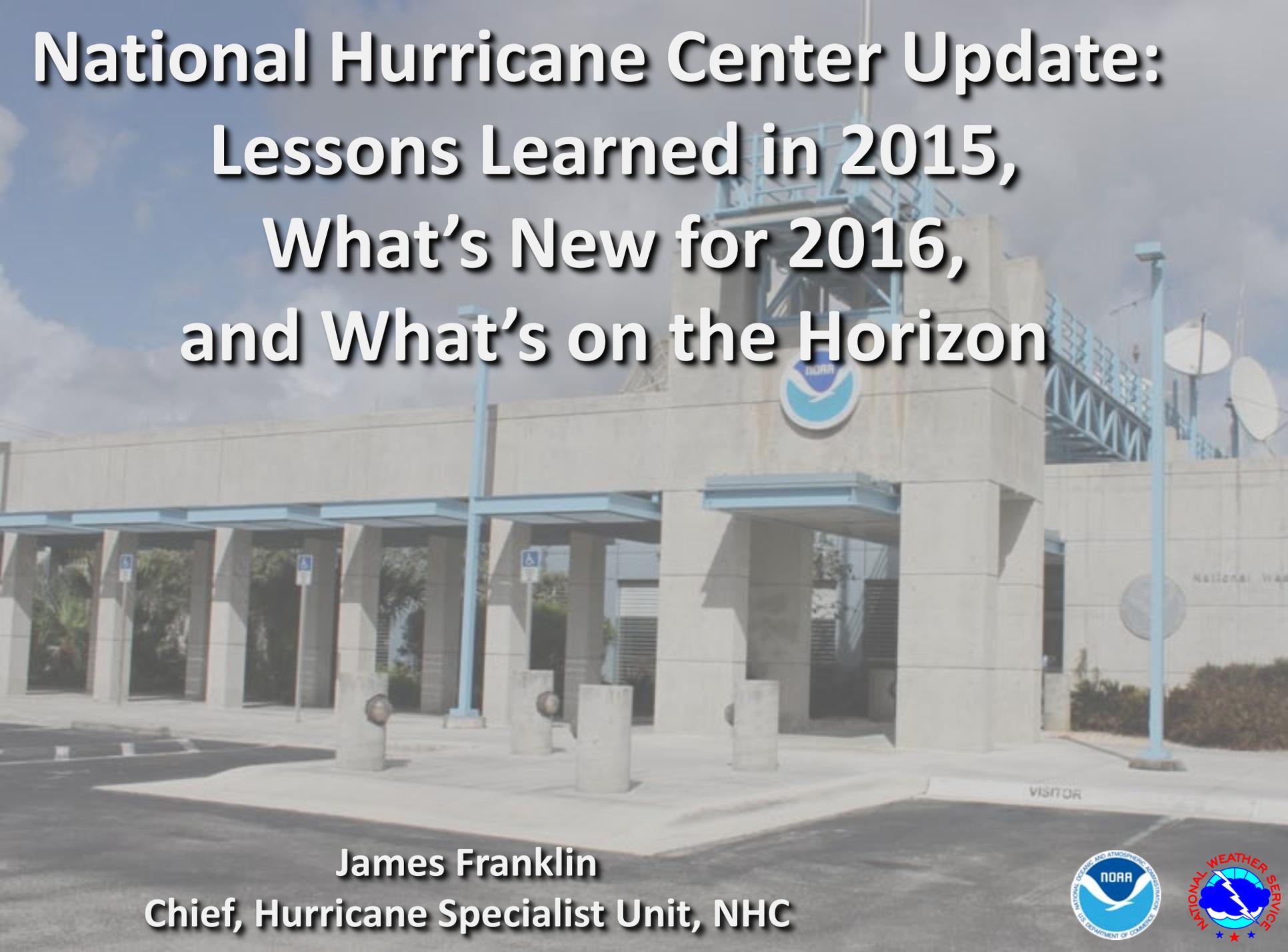


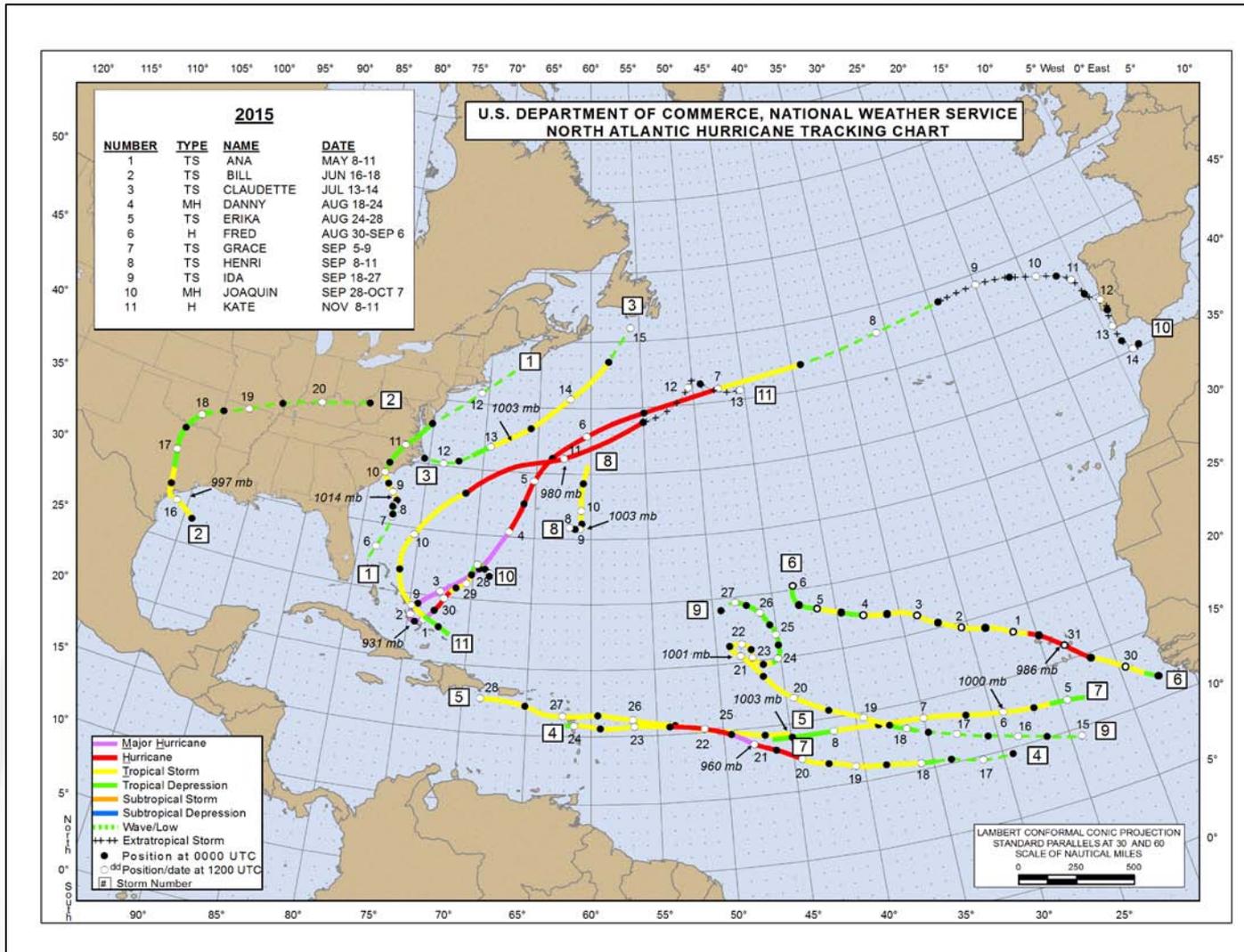
National Hurricane Center Update: Lessons Learned in 2015, What's New for 2016, and What's on the Horizon



James Franklin
Chief, Hurricane Specialist Unit, NHC



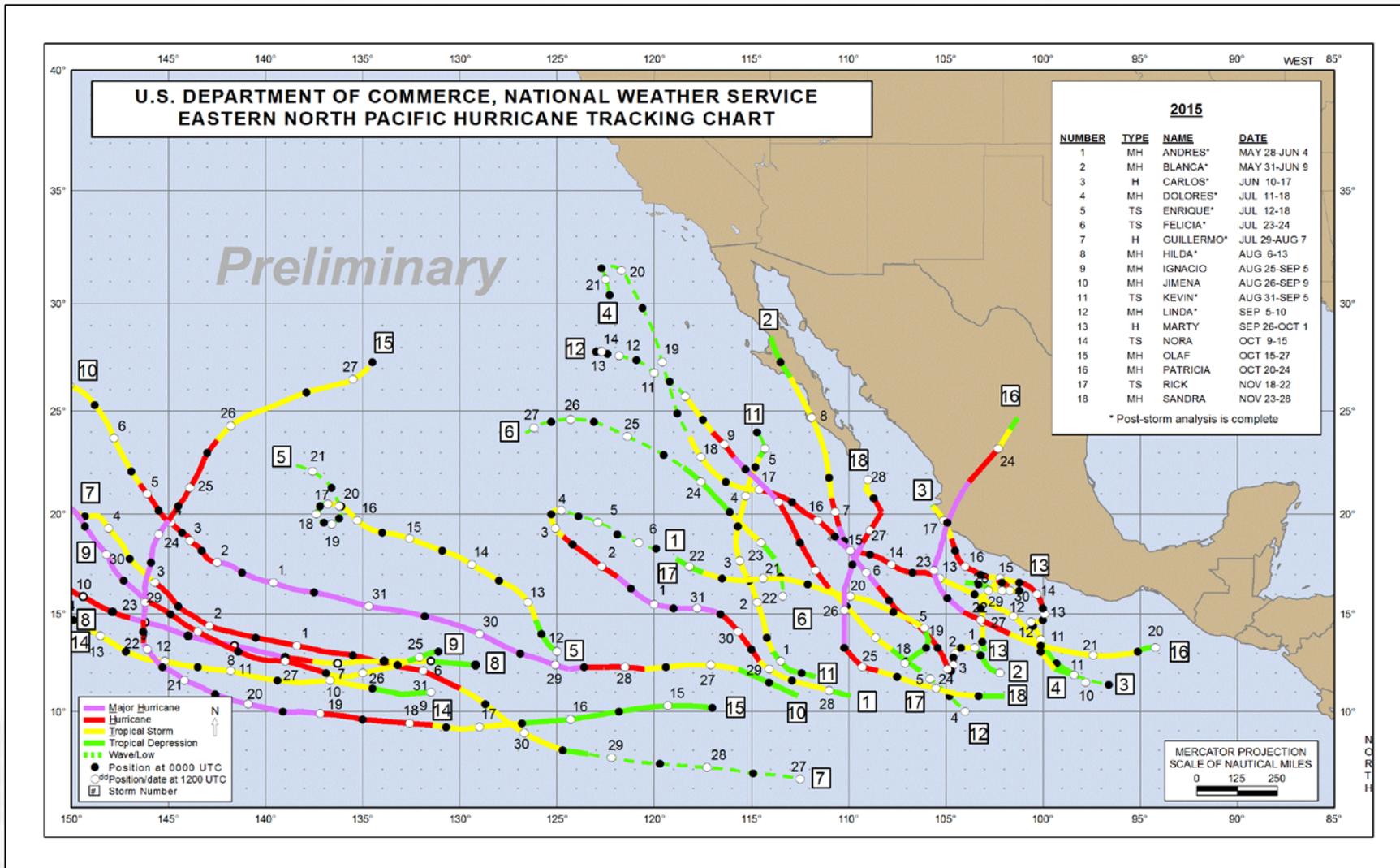
2015 Atlantic Hurricane Season



Minimal U.S. impacts but significant damage in the Bahamas, Dominica, and the Cape Verde Islands



2015 East Pacific Hurricane Season



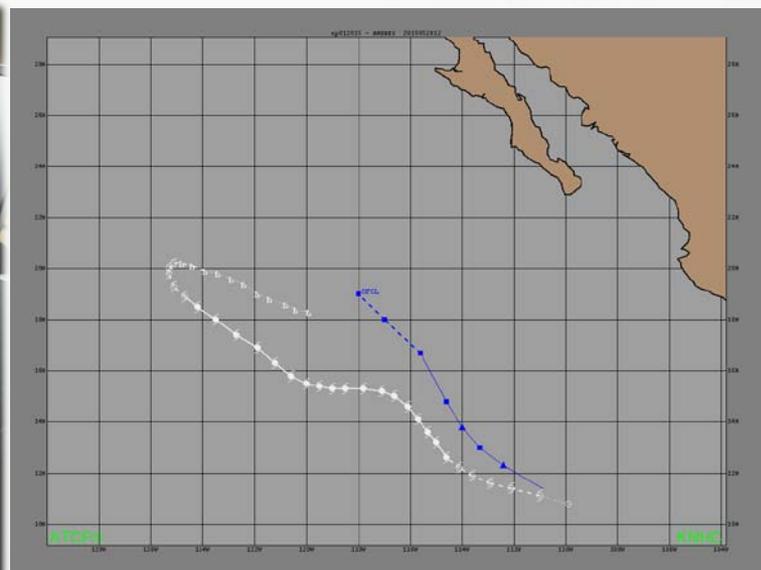
Very active in the east and central Pacific. Patricia became the strongest hurricane on record in NHC's AOR.



Forecast Challenges 2015



Hurricane Andres- East Pacific



FORECAST POSITIONS AND MAX WINDS

INIT	28/1500Z	11.6N	111.3W	35 KT	40 MPH
12H	29/0000Z	12.3N	112.4W	45 KT	50 MPH
24H	29/1200Z	13.0N	113.3W	60 KT	70 MPH
36H	30/0000Z	13.8N	114.0W	70 KT	80 MPH
48H	30/1200Z	14.8N	114.6W	80 KT	90 MPH
72H	31/1200Z	16.7N	115.6W	80 KT	90 MPH
96H	01/1200Z	18.0N	117.0W	65 KT	75 MPH
120H	02/1200Z	19.0N	118.0W	50 KT	60 MPH

\$\$

Forecaster Brown and Barack Obama (PRESIDENT)





Forecast Challenges 2015



Claudette's Unexpected Formation

NHC Atlantic Ops @NHC_Atlantic · 12 Jul 2015

A low pressure area just east of N. Carolina has a low chance of becoming a tropical cyclone. hurricanes.gov

Two-Day Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida

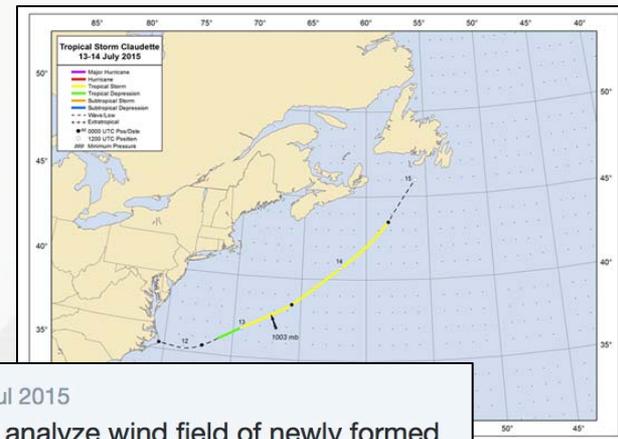
Five-Day Graphical Tropical Weather Outlook
National Hurricane Center Miami, Florida

Disturbances and 2-Day Cyclone Formation Chance: ☁ < 40% ☁ 40-60% ☁ 60-80% ☁ 80-90% ☁ 90-100%
 Tropical or Sub-Tropical Cyclone: ○ Depression ○ Storm ○ Hurricane
 Post-Tropical Cyclone: ○ Remnants

94 likes, 34 hearts

July 12

Some fraction of the low-likelihood disturbances will develop!



NHC Atlantic Ops @NHC_Atlantic · 13 Jul 2015

HC forecaster uses ASCAT data to analyze wind field of newly formed Tropical Storm Claudette. hurricanes.gov

43 retweets, 19 hearts

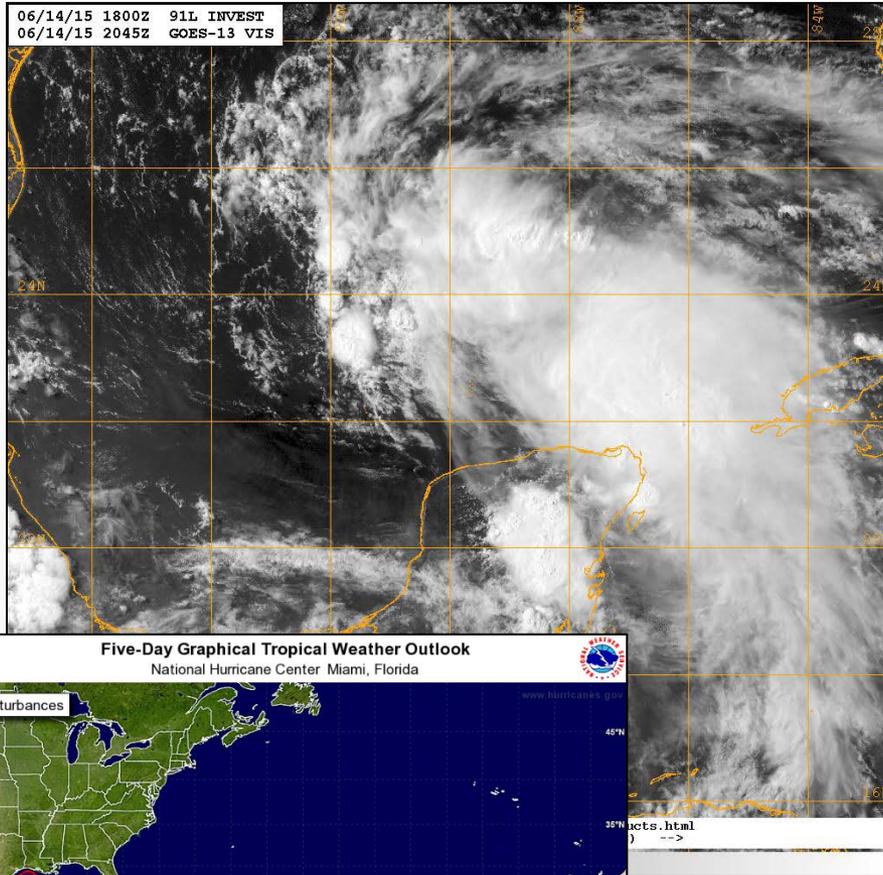
24 h later – Claudette is born



Forecast Challenges 2015



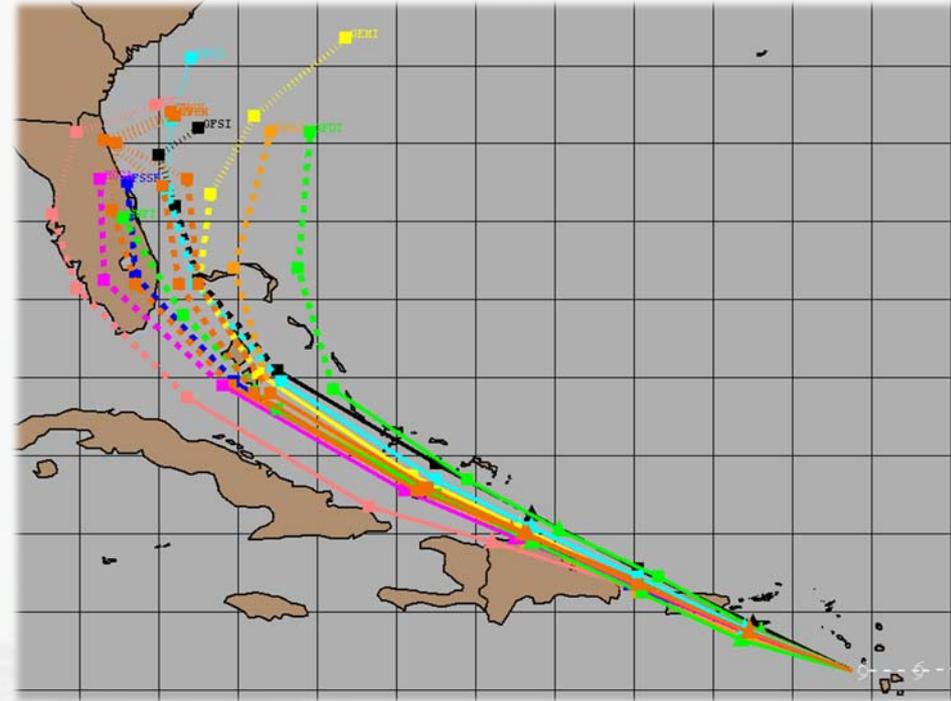
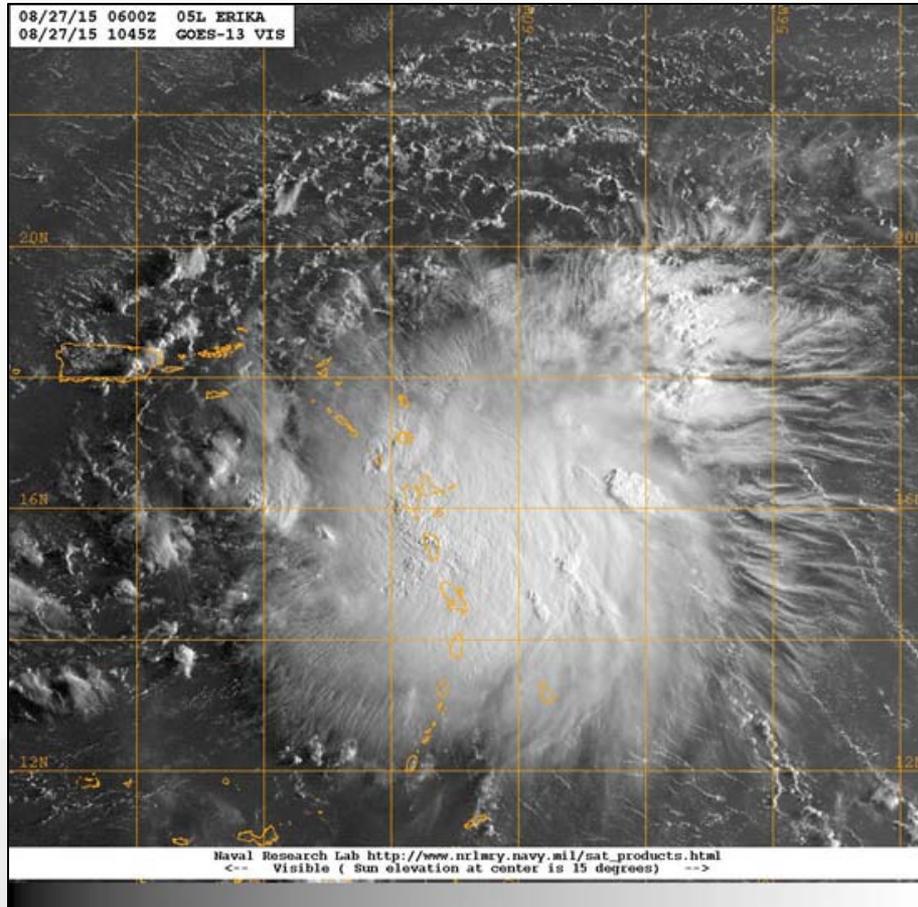
Bill's Development Near the Coast



Tropical Storm Bill made landfall along the coast of Texas less than 18 hours after formation. No (current) mechanism to issue warnings prior to formation.

Forecast Challenges 2015

Erika's Heavy Rainfall and Dissipation



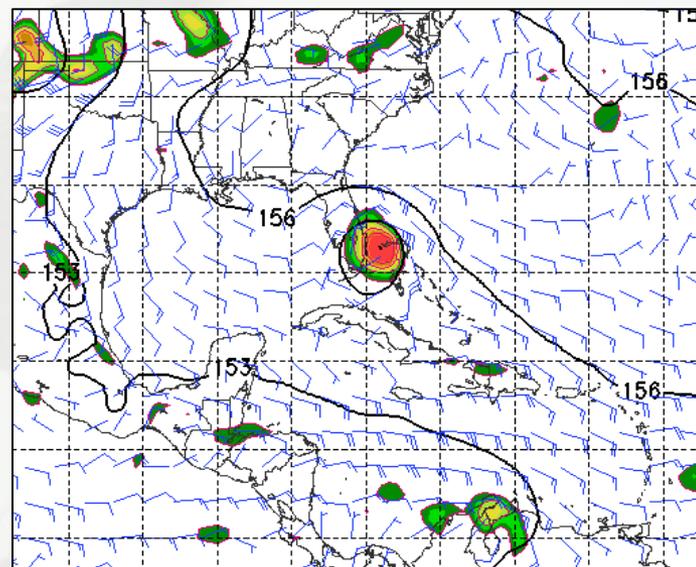
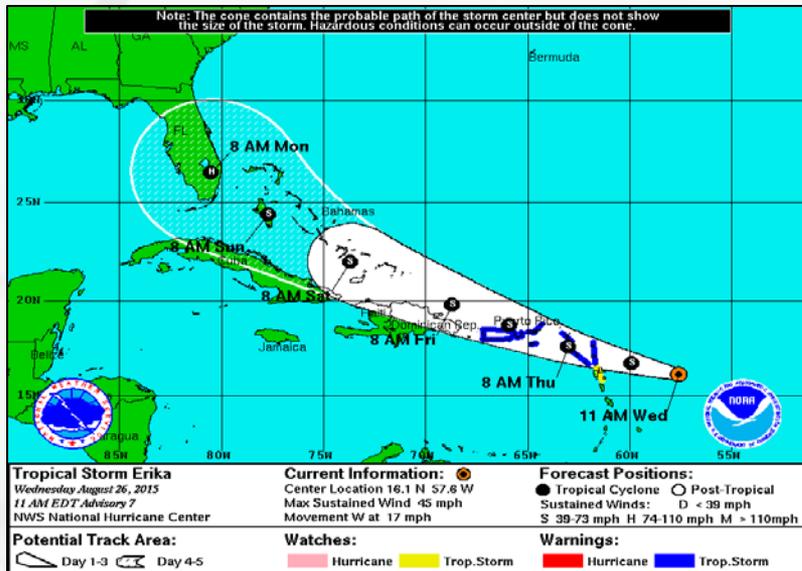
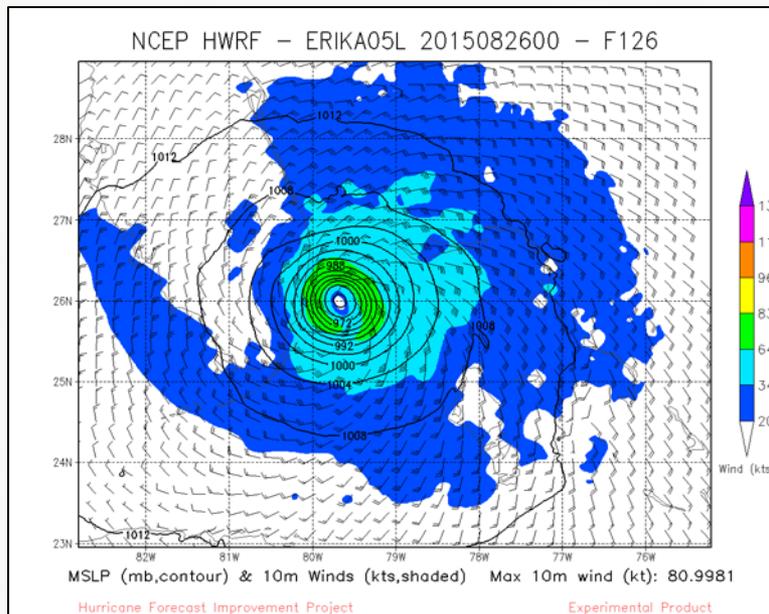
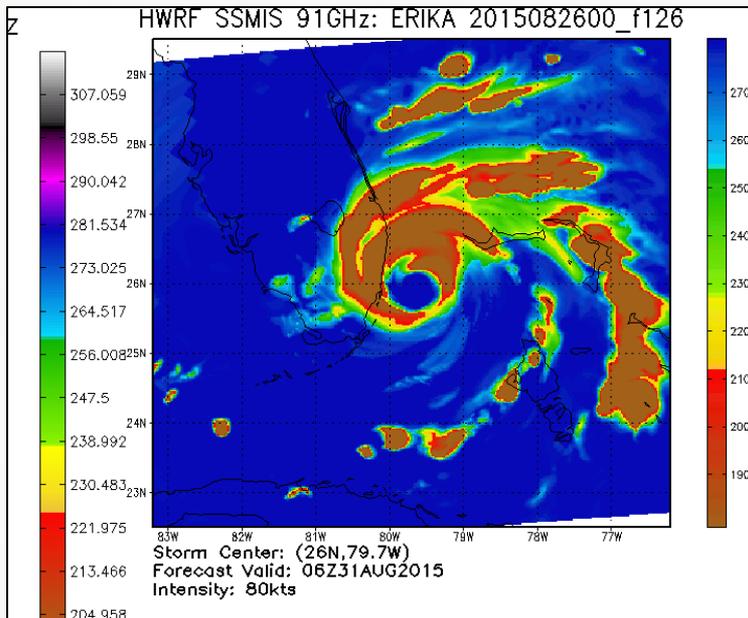
30 fatalities in Dominica on August 27th due to heavy rainfall and catastrophic flooding. No tropical storm warning in effect because TS winds were passing north of there.



Forecast Challenges 2015



Hurricane Hype for Florida!

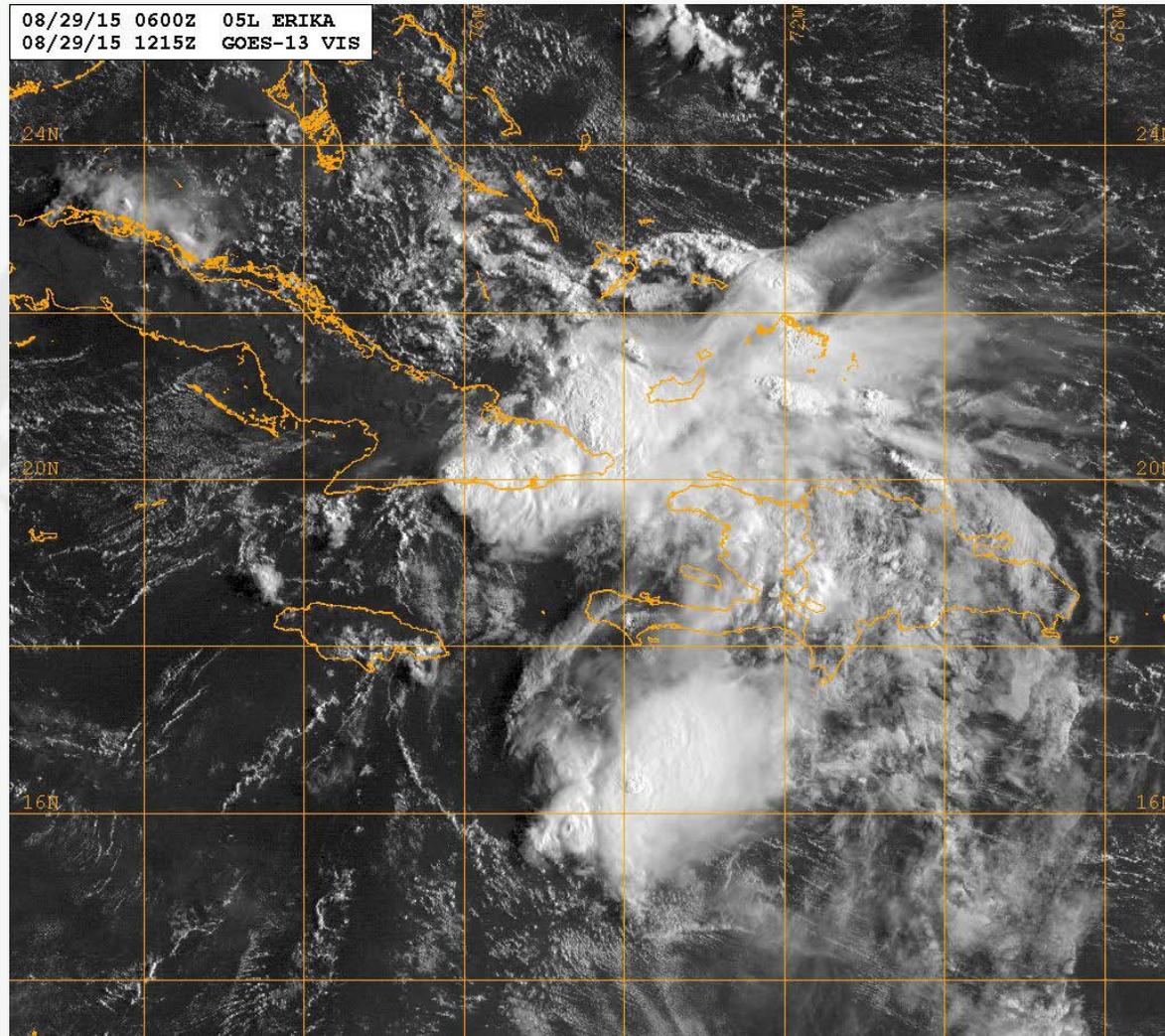




Forecast Challenges 2015

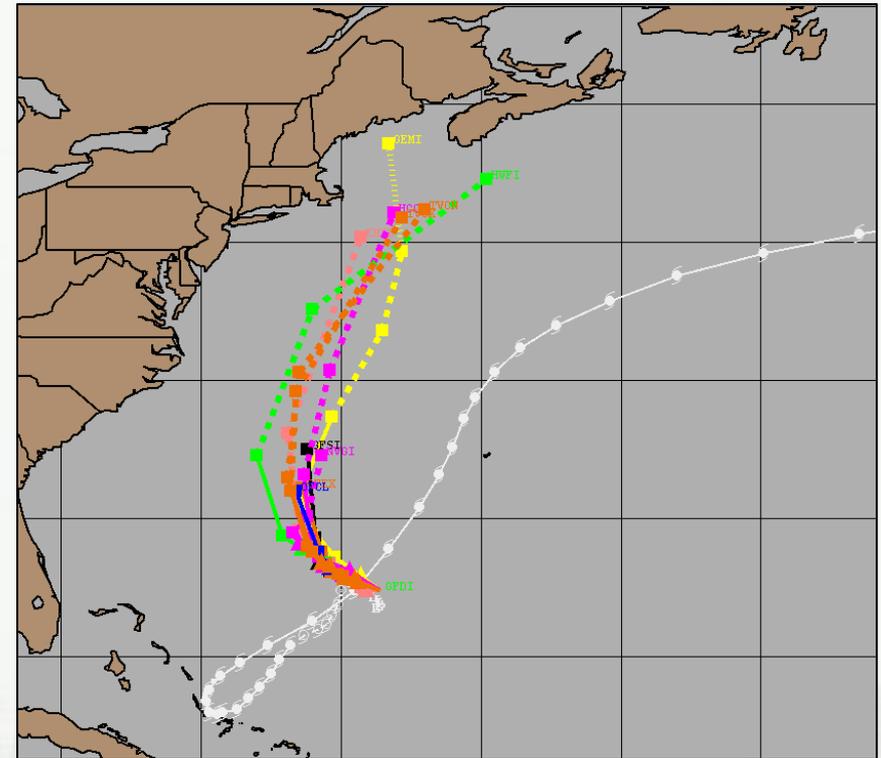
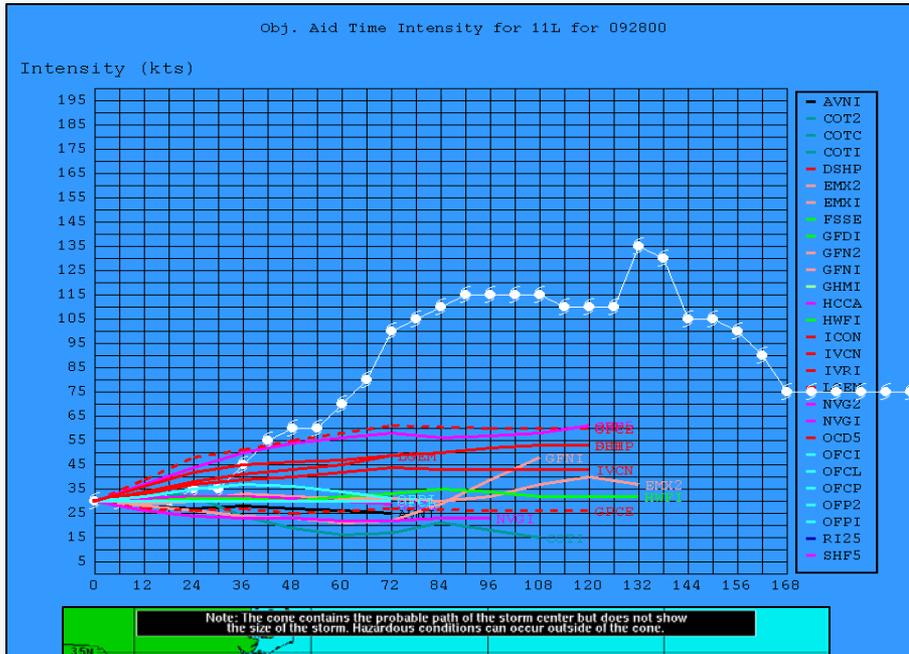


Nothing Left by the Time Erika reach Cuba

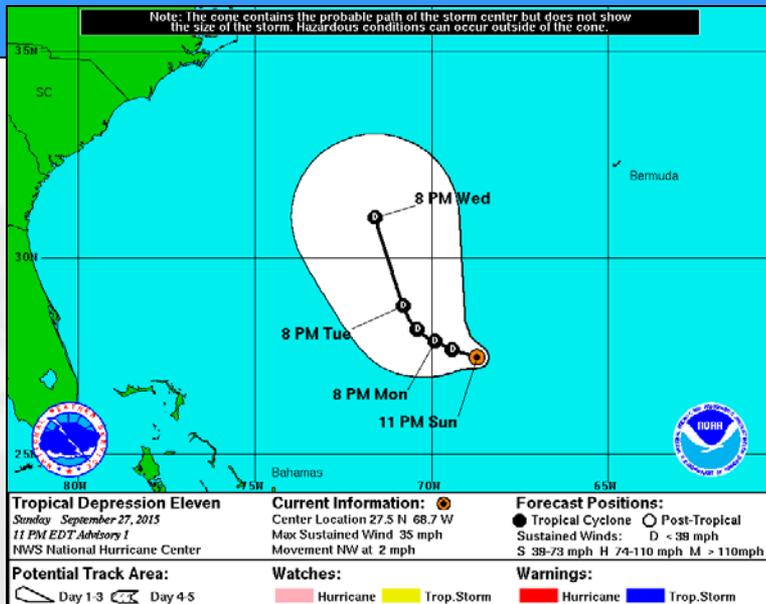


Erika dissipated before reaching Florida. Some in the media accused NHC of not taking sufficient control of the message.

Joaquin's Unusually Large Track Forecast Uncertainty



First NHC Advisory predicted that Joaquin would remain weak and move northwestward.

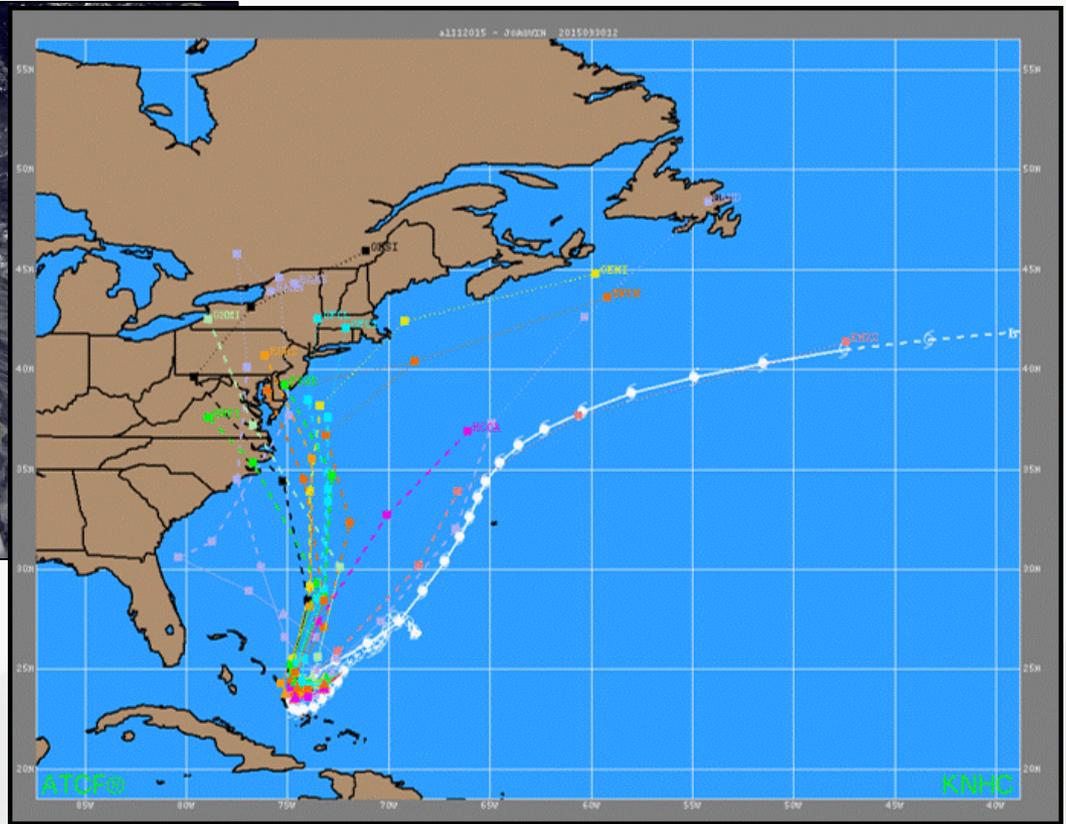
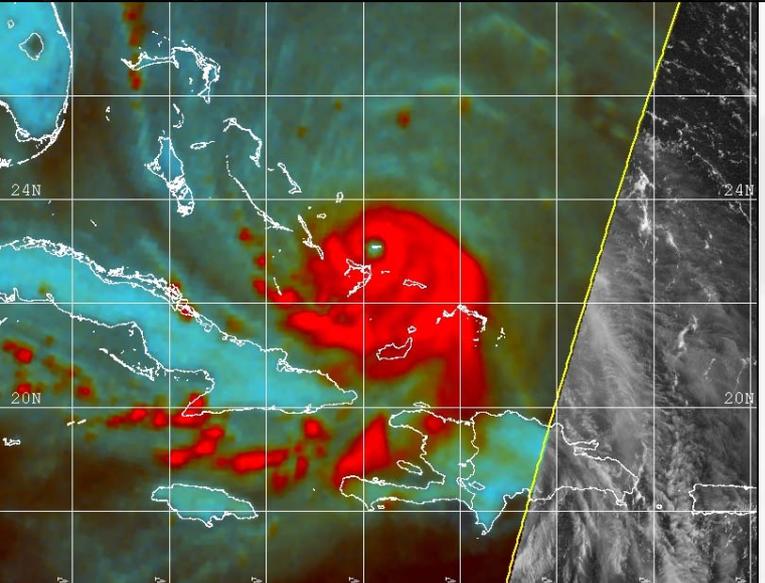




2015 Forecast Challenges



Joaquin's Unusually Large Track Forecast Uncertainty

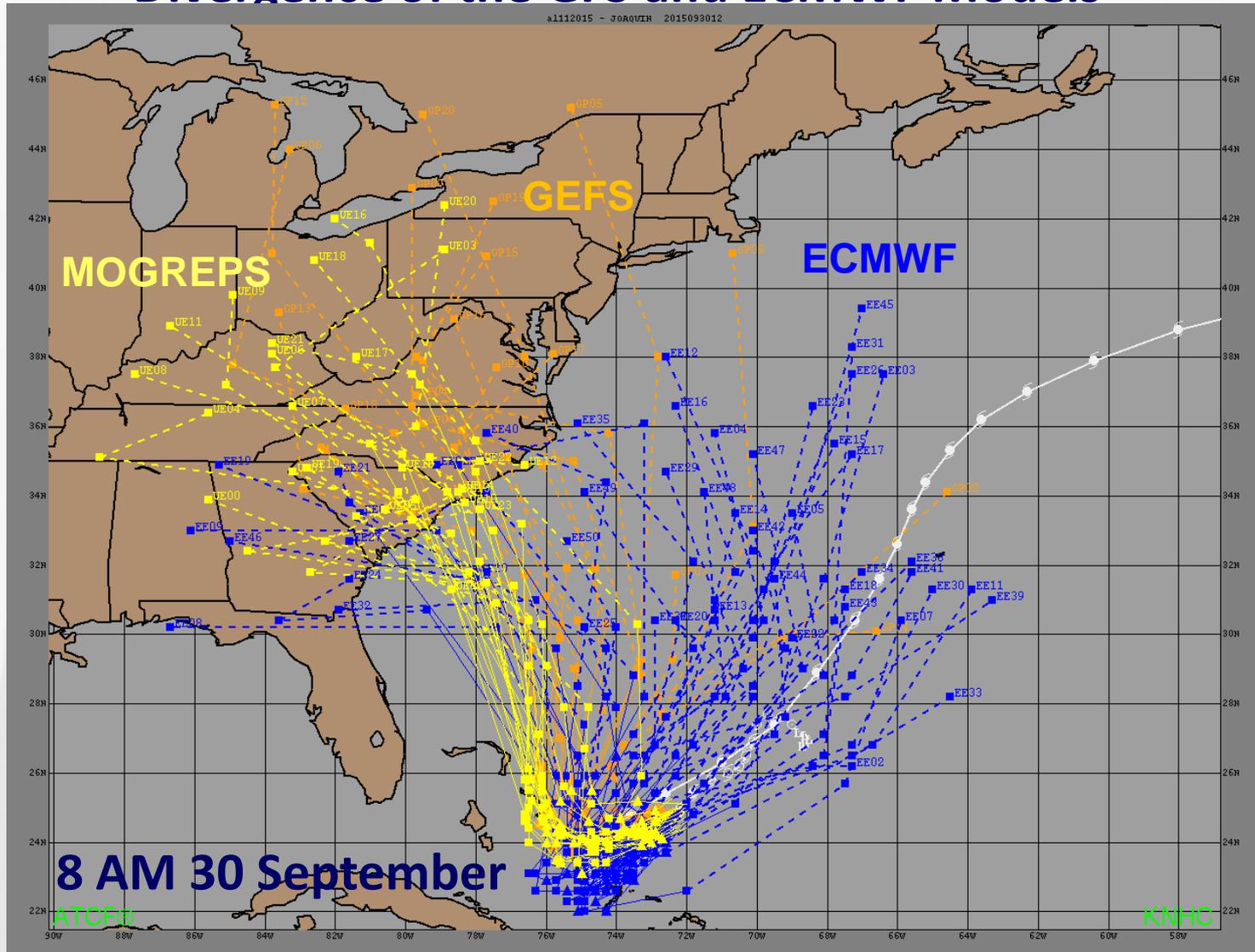




2015 Forecast Challenges

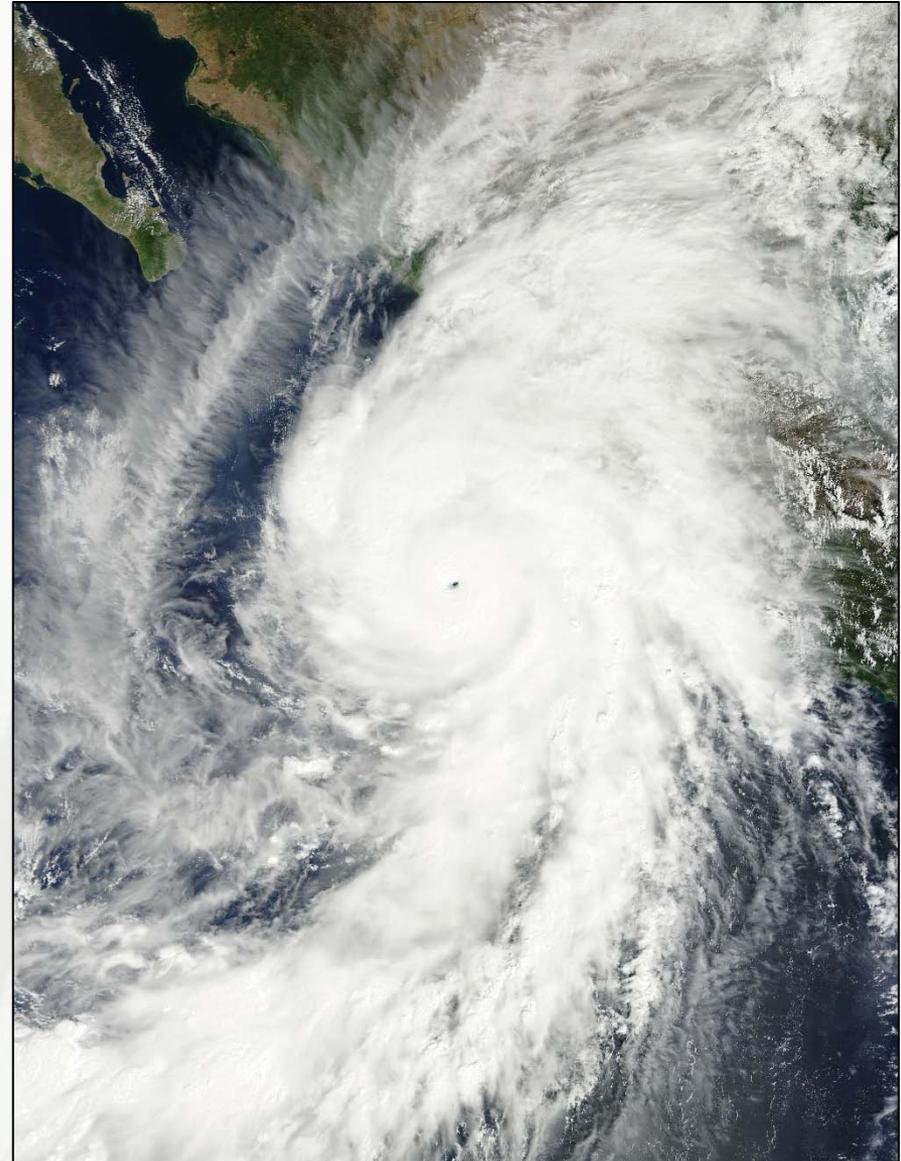
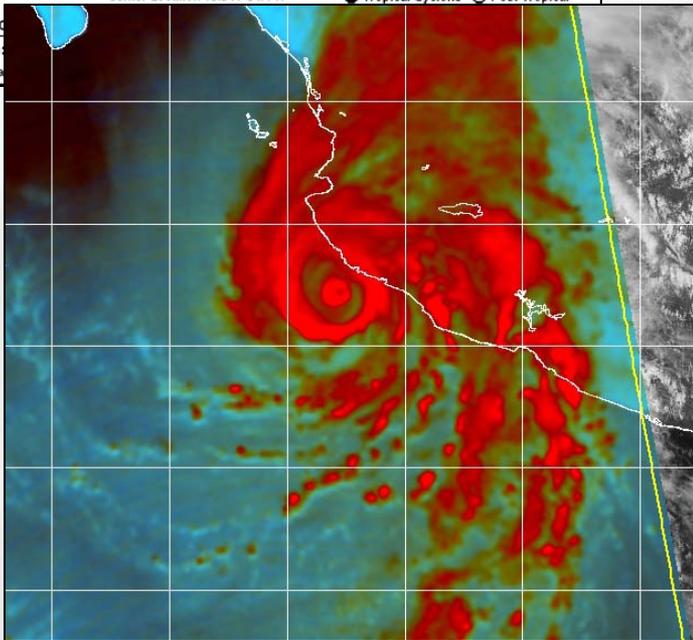
Joaquin's Unusually Large Track Forecast Uncertainty

Divergence of the GFS and ECMWF Models

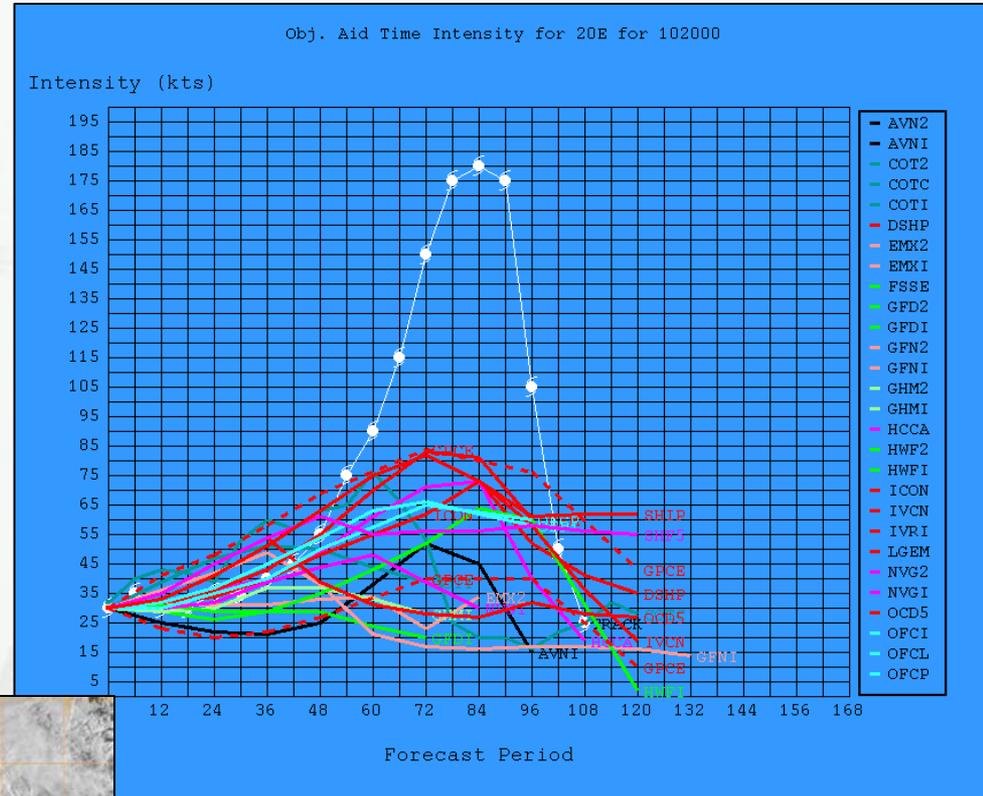
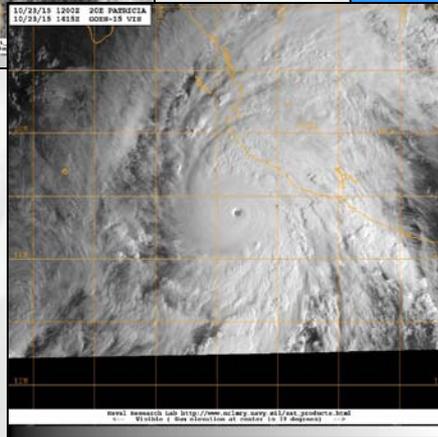
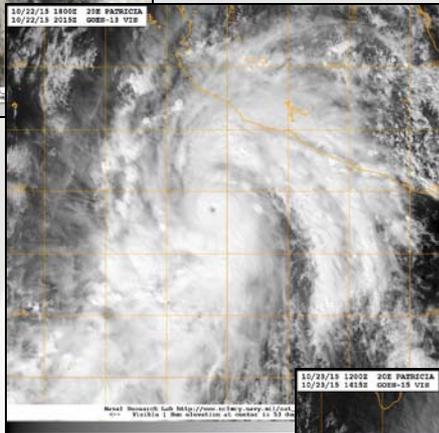
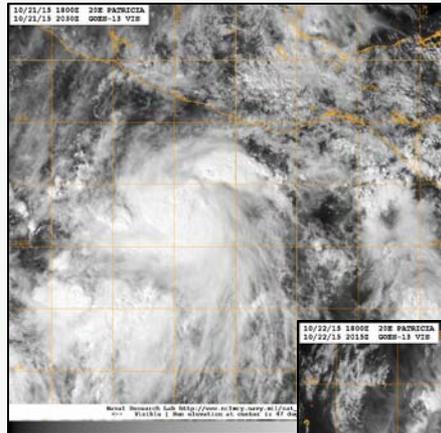




2015 Forecast Challenges Patricia's Rapid Intensification



Patricia's Rapid Intensification – Extreme Event!



First NHC forecast and models predicted intensification but not at the rate that was observed.



Enhanced Messaging



Key messages added to the NHC Tropical Cyclone Discussion

Hurricane Joaquin

ZCZC MIATCDAT1 ALL
TTAA00 KNHC DDHMM

HURRICANE JOAQUIN DISCUSSION NUMBER 11
NWS NATIONAL HURRICANE CENTER MIAMI FL AL112015
1100 AM EDT WED SEP 30 2015

Joaquin has continued to strengthen overnight. Satellite imagery shows that the convection has become more symmetric, and recent visible images show what might be an eye trying to form. An Air Force Reserve Hurricane Hunter aircraft reported 700-mb flight-level winds of 83 kt and estimated 70 kt surface winds from the Stepped Frequency Microwave Radiometer, with a central pressure of 971 mb estimated from the aircraft data. Based on these, the initial intensity is increased to 70 kt.

KEY MESSAGES:

- Confidence in the details of the track forecast late in the period remains low, since the environmental steering currents are complex and the model guidance is inconsistent. A wide range of outcomes is possible, from a direct impact of a major hurricane along the U.S. east coast to a track of Joaquin out to sea away from the coast. It is therefore way too soon to talk about specific wind, rain, or surge impacts from Joaquin in the U.S.
- Should the threat to the U.S. increase, any further adjustments of the forecast to the west would likely be accompanied by an increase in the forecast forward speed, with impacts along the coast occurring sooner than currently forecast. A hurricane watch could be required for portions of the U.S. coast as early as Thursday evening.
- Many areas of the eastern U.S. are currently experiencing heavy rains and gusty winds associated with a frontal system. This inclement weather is expected to continue over the next few days, which could complicate preparations for Joaquin should it head toward the coast.

FORECAST POSITIONS AND MAX WINDS

INIT	30/1500Z	24.7N	72.6W	70 KT	80 MPH
12H	01/0000Z	24.3N	73.2W	80 KT	90 MPH
24H	01/1200Z	24.1N	74.0W	85 KT	100 MPH
36H	02/0000Z	24.4N	74.4W	90 KT	105 MPH
48H	02/1200Z	25.3N	74.5W	95 KT	110 MPH
72H	03/1200Z	28.5N	73.5W	100 KT	115 MPH
96H	04/1200Z	34.0N	73.0W	90 KT	105 MPH
120H	05/1200Z	38.5N	74.0W	75 KT	85 MPH

\$\$
Forecaster Beven

Hurricane Patricia

ZCZC MIATCDEP5 ALL
TTAA00 KNHC DDHMM

HURRICANE PATRICIA DISCUSSION NUMBER 15
NWS NATIONAL HURRICANE CENTER MIAMI FL EP202015
1000 AM CDT FRI OCT 23 2015

There has been little change in the satellite appearance of Patricia since the earlier Hurricane Hunter aircraft left the hurricane. Based on this, the initial intensity remains 175 kt. Some fluctuations in strength are possible before landfall, but it is expected that Patricia will make landfall as a Category 5 hurricane in southwestern Mexico in less than 12 hours. After landfall, a com she lik

KEY MESSAGES:

- Confidence is high that Patricia will make landfall in the hurricane warning area along the coast of Mexico as an extremely and dangerous category 5 hurricane this afternoon or evening. Preparations to protect life and property in the hurricane warning area should have been completed, or rushed to completion, as tropical storm conditions are spreading across the area. Residents in low-lying areas near the coast in the hurricane warning area should evacuate immediately, since the storm surge could be catastrophic near and to the east of where the center makes landfall.
- In addition to the coastal impacts, very heavy rainfall is likely to cause life-threatening flash floods and mud slides in the Mexican states of Jalisco, Colima, Michoacan and Guerrero continuing into Saturday.
- At this time, the Category 5 winds are occurring over a very small area near the center - about 15 miles across. A NOAA Hurricane Hunter aircraft is scheduled to investigate Patricia before landfall to see what changes in intensity and structure have occurred.

FORECAST POSITIONS AND MAX WINDS

INIT	23/1500Z	17.6N	105.5W	175 KT	200 MPH
12H	24/0000Z	19.8N	105.1W	130 KT	150 MPH...INLAND
24H	24/1200Z	22.9N	103.6W	60 KT	70 MPH...INLAND
36H	25/0000Z	25.7N	101.6W	20 KT	25 MPH...POST-TROP/REMNT LOW
48H	25/1200Z	...	DISSIPATED		

\$\$
Forecaster Beven

Jc
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Key Messages

Shared on Social Media



Key Messages on Hurricane Joaquin

Wednesday Evening, September 30, 2015



- Preparations to protect life and property within the warning areas in the Bahamas should be rushed to completion.**
- A significant adjustment to the forecast has been made this afternoon to reflect an increased threat to the mid-Atlantic states and the Carolinas.** However, confidence in the details of the forecast after 72 hours remains low, since we have one normally excellent model that keeps Joaquin far away from the United States east coast. The range of possible outcomes is still large, and includes the possibility of a major hurricane landfall in the Carolinas.
- Every effort is being made to provide the forecast models with as much data as possible.** The NOAA G-IV jet has begun a series of missions in the storm environment, and the National Weather Service has begun launching extra balloon soundings.
- Because landfall, if it occurs, is still more than three days away, it's too early to talk about specific wind, rain, or surge impacts from Joaquin in the United States.** Regardless of Joaquin's track, strong onshore winds will create minor to moderate coastal flooding along the coasts of the mid-Atlantic and northeastern states through the weekend.
- A hurricane watch for a portion of the U.S. coast could be required as early as Thursday evening.**
- Many areas of the eastern U.S. are currently experiencing heavy rains and gusty winds associated with a frontal system.** This inclement weather is expected to continue over the next few days, which could complicate preparations for Joaquin should it head toward the coast, and greatly exacerbate the impacts from the hurricane.

National Hurricane Center: www.hurricanes.gov



Hurricane Joaquin
Wednesday September 30, 2015
12 PM CDT Advisory 12
NWS National Hurricane Center



Key Messages on Hurricane Patricia

October 22, 2015 – 10 p.m. CDT



- Confidence is high that Patricia will make landfall in the hurricane warning area along the southwestern coast of Mexico as an extremely dangerous major hurricane during Friday afternoon or evening.** Preparations to protect life and property in the hurricane warning area should be completed as tropical storm conditions will begin to affect the warning area overnight or early Friday.
- In addition to the coastal impacts, very heavy rainfall is likely to cause life-threatening flash floods and mud slides in the Mexican states of Jalisco, Colima, Michoacan and Guerrero beginning late tonight and continuing into Saturday.**



Hurricane Patricia
Thursday October 22, 2015
10 PM CDT Advisory 12
NWS National Hurricane Center

Current Information: ● Center Location 16.2 N 105.1 W
Max Sustained Wind 100 mph
Movement NNW at 10 mph

Forecast Positions: ● Tropical Cyclone ○ Post-Tropical
Sustained Winds: ○ < 20 mph
● 20-39 mph II 40-59 mph III 60-75 mph IV 76-110 mph V > 110 mph

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

Watches: ● Hurricane ● Trop. Storm

Warnings: ● Hurricane ● Trop. Storm

PRELIMINARY (SINGLE STORM) Hurricane Force Wind Speed Probabilities
For the 120 hours (5 days) from 5 PM PDT Thu Oct 22 to 5 PM PDT Tue Oct 27



NOAA National Hurricane Center: www.hurricanes.gov



Enhanced Messaging

NHC Special Messages



NHC Atlantic Ops ✓

@NHC_Atlantic



Following

NHC is initiating advisories on Tropical Storm Bill and expects to release the advisory in the next 20 minutes.

RETWEETS

438

LIKES

155



6:51 PM - 15 Jun 2015



NHC Atlantic Ops ✓

@NHC_Atlantic



Following

NHC will initiate advisories on Subtropical Storm Alex, located over the far eastern Atlantic Ocean, at 4 pm EST/2100 UTC.

RETWEETS

164

LIKES

77



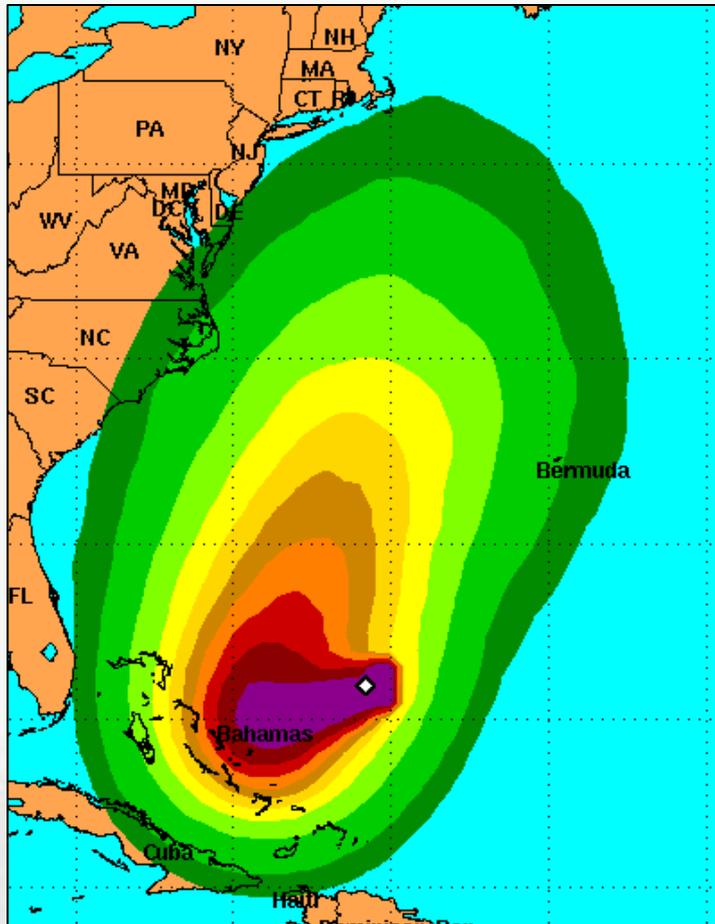
12:06 PM - 13 Jan 2016



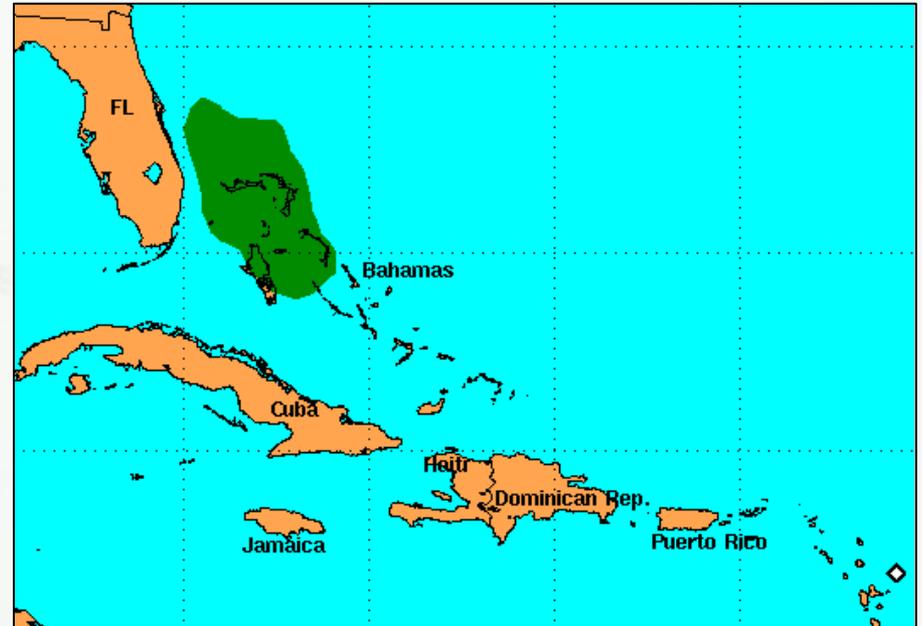
Example of special messages that are posted to the NHC website and Twitter simultaneously to indicate when advisories will be initiated.



NHC Wind Speed Probabilities Help Deal with Uncertainty



Early Joaquin forecasts indicated equal chances of tropical-storm-force winds at Cape Hatteras and Bermuda.



Although NHC forecasts predicted Erika to be a hurricane near South Florida, the probability of hurricane-force winds at any specific location in south Florida remained less than 5%.

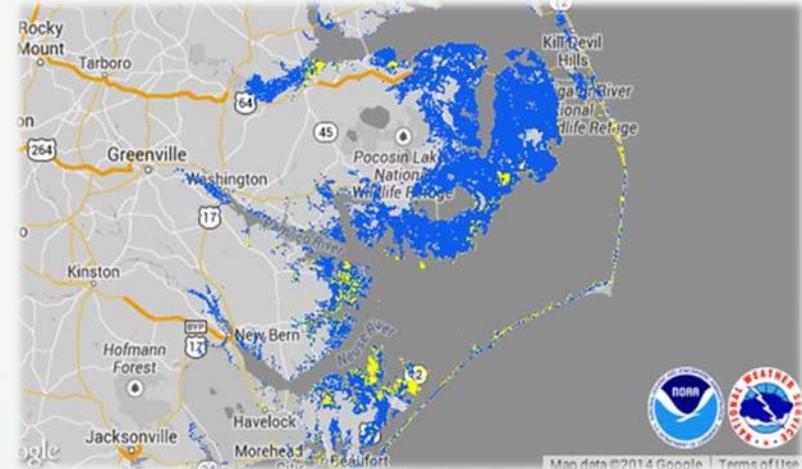


Look Ahead to 2016 & 2017

Primary NHC Thrust Areas



- **Storm Surge Products**
 - Prototype Storm Surge Watch/Warning Graphic
 - Potential Storm Surge Flooding Map (becomes operational in 2016)
- **Wind Products**
 - Watches/Warnings/Forecasts for Potential Tropical Cyclones
 - Time of Arrival Graphic

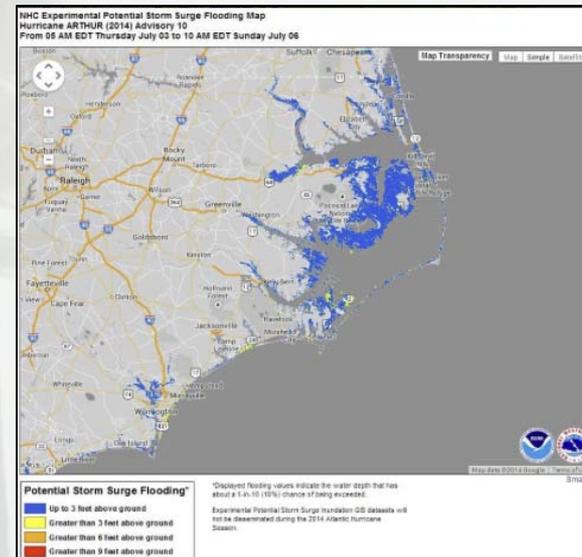
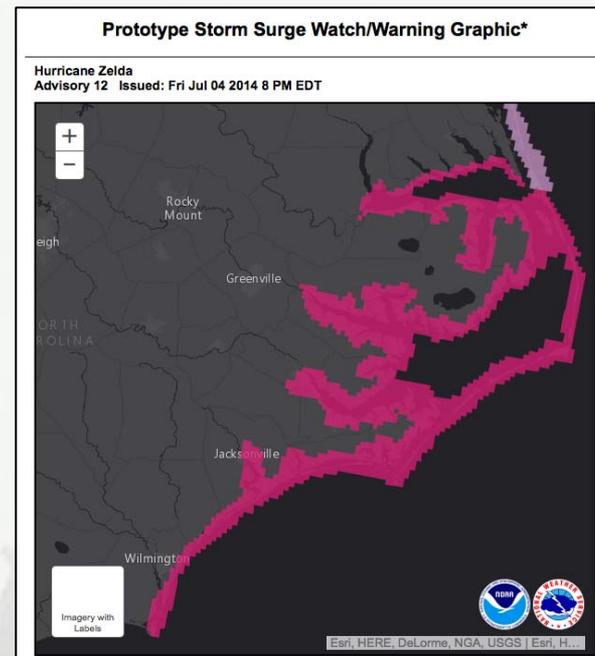


Watch/Warning Graphic

- Primary audience is the general public.
- Highlights areas that have a significant risk of life-threatening surge, but does not provide any quantitative inundation levels.
- Although driven by objective guidance, W/W areas also based on subjective factors such as forecaster confidence, continuity with previous issuances, wind trigger, smoothing, isolated areas, etc.

Potential Storm Surge Flooding Map

- Objective guidance on where inundation from surge could occur and height above ground the water could reach.
- Intended for decision makers. *Displays reasonable worst case scenario flooding at individual locations.*
- Based solely on the latest NHC forecast and historical error characteristics. No guaranteed continuity from cycle to cycle, or consistency with W/W graphic.

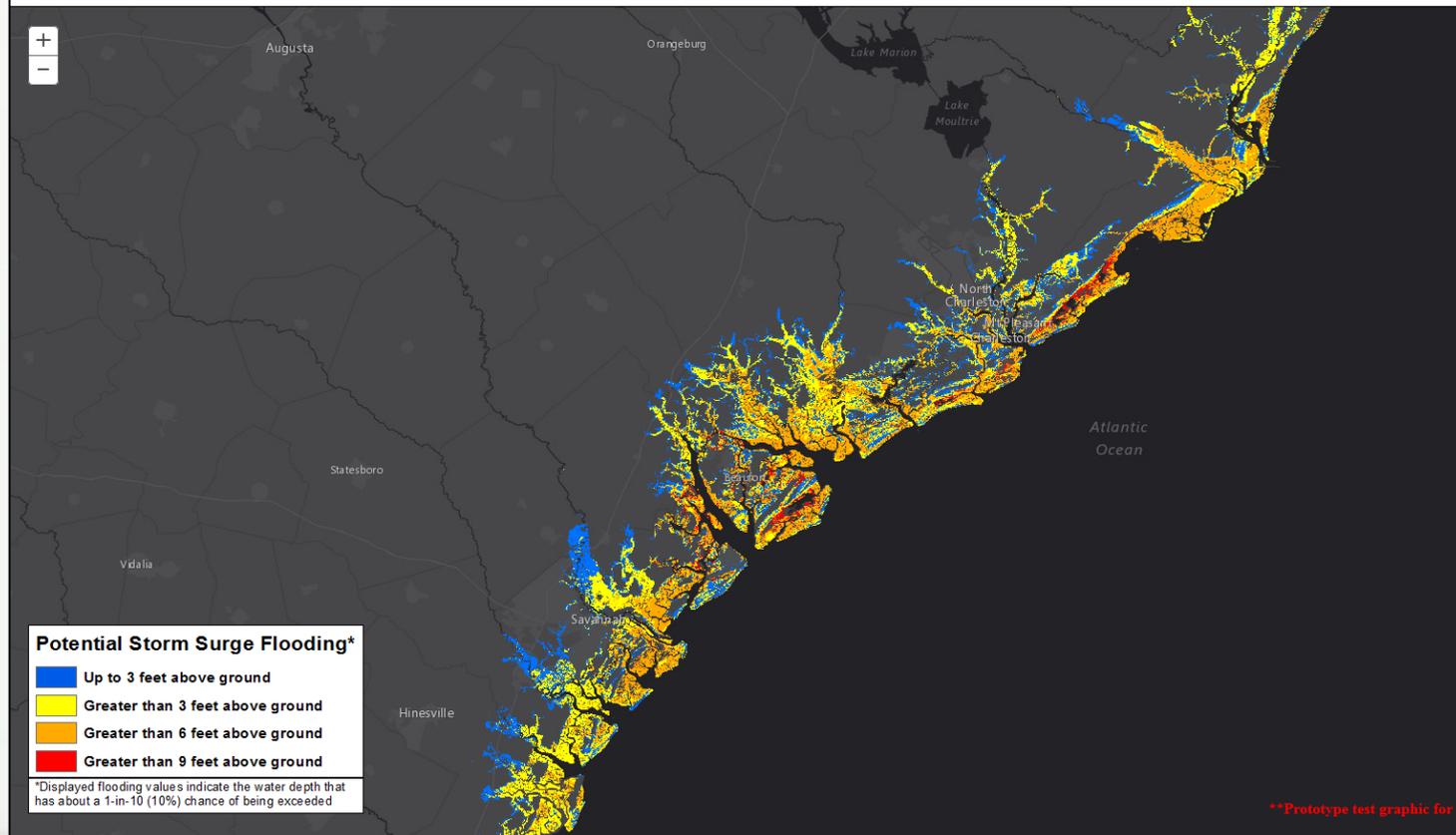




Real-time NHC Storm Surge Products



NHC Experimental Potential Storm Surge Flooding Map
Hurricane FEMASOUTHEAST EXERCISE (YEAR) Advisory 24
From 05 PM EDT Sunday September 08 to 11 PM EDT Wednesday September 11



- **Graphic is meant to convey the reasonable worst-case scenario *at individual locations*.**
- **Does NOT represent the flooding footprint from any particular possible scenario, but essentially composites the risk from many possible scenarios.**
- **Storms that flood north part of domain will likely not flood the south part.**



Forecasts and Warnings for *Potential Tropical Cyclones*



- Broaden the definition of tropical storm and hurricane watches and warnings to allow their use for disturbances
- Regular watch/warning criteria would apply
 - Watch – possible within 48 h
 - Warning – expected within 36 h
- Issued through the standard suite of NHC advisory products
 - *Potential Tropical Cyclone*
 - Current numbering system (for depressions) would apply
- Possible implementation in 2017

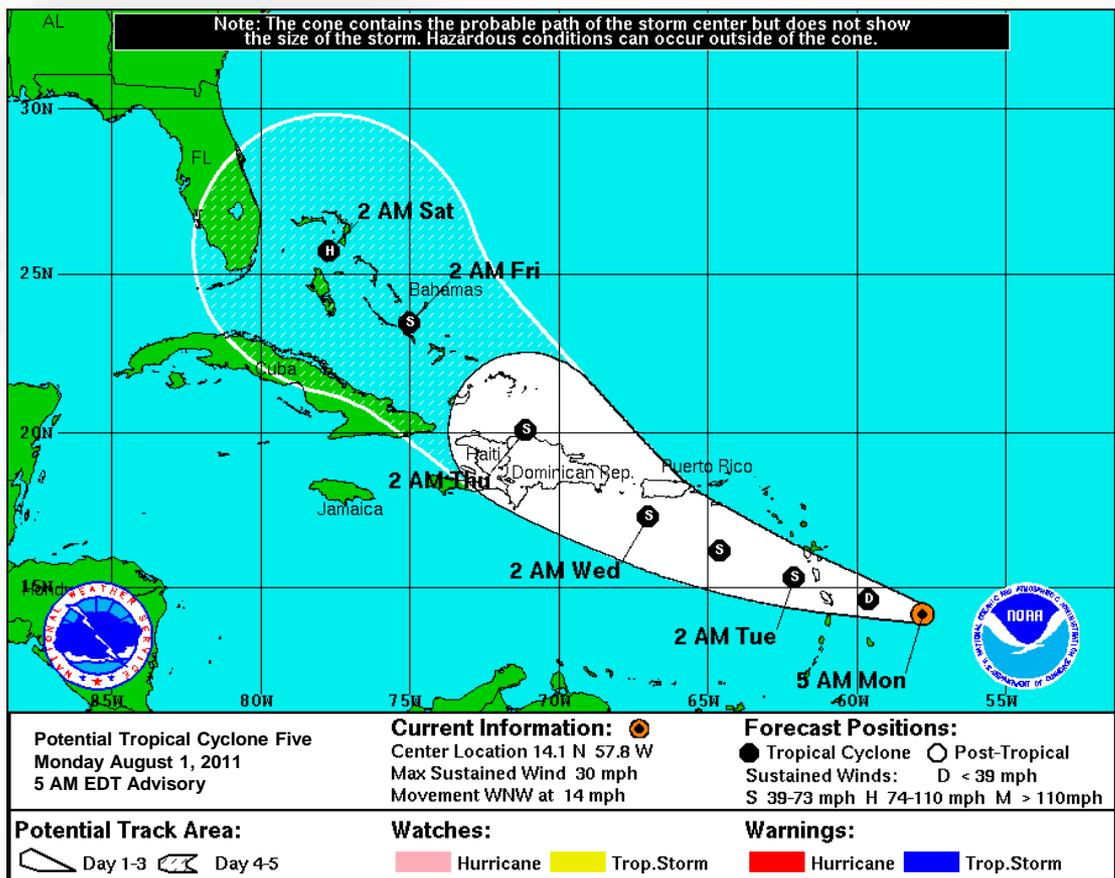




Concerns Regarding Expanded Use of Watches and Warnings



- Earlier NHC advisories for systems that pose a long-range threat to the United States or other land areas



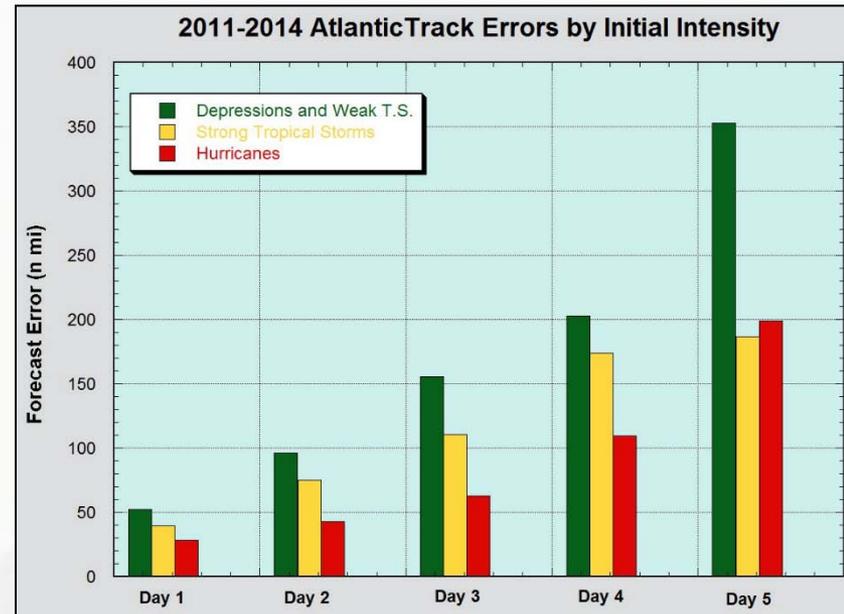
Emily (2011) precursor forecast as it was entering the Caribbean with the 5-day cone showing a threat to Florida. This forecast was created about 18 hour prior to the first NHC advisory.



Concerns of Expanding Use of Watches and Warnings



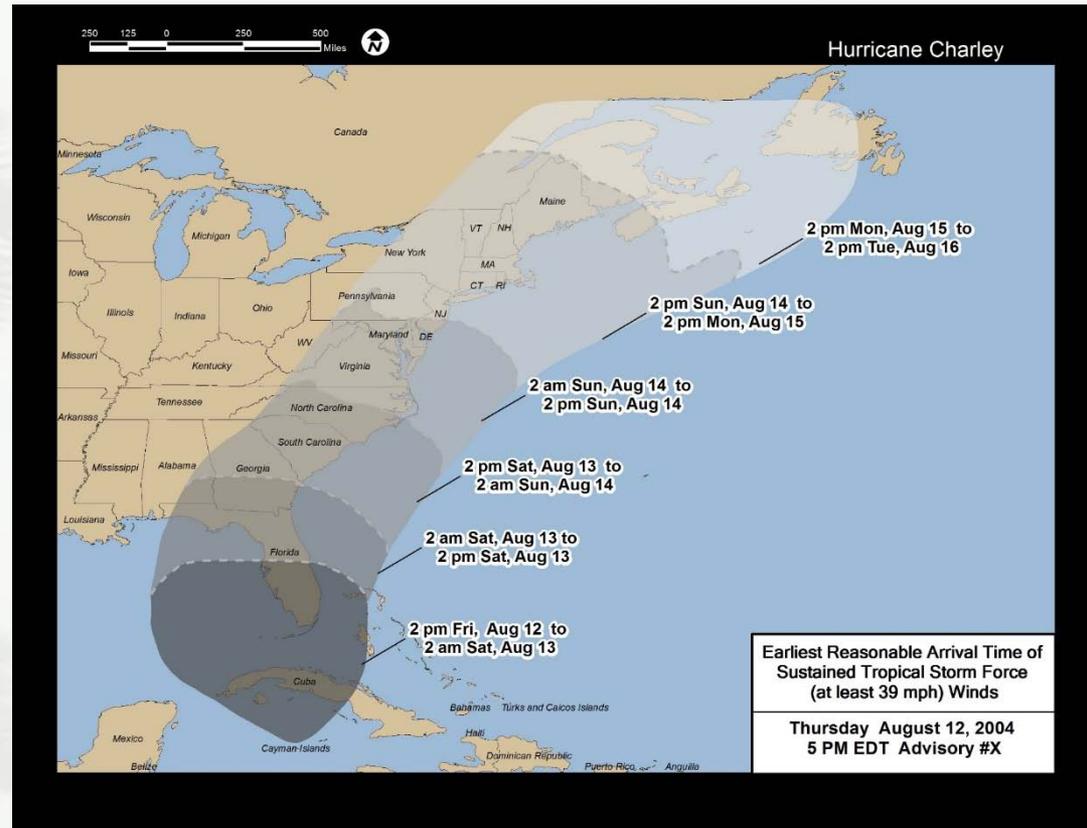
- Forecasts likely to have greater uncertainty
 - Would likely be represented by a larger “cone”
- Has the potential to reduce the long-term effectiveness of watches & warnings through false alarms and minimal impacts
- False alarms and increased uncertainty could affect the reputation & trust of current NWS/NHC tropical cyclone forecasts.



Average NHC track errors by initial intensity. Note the much larger 4- and 5-day track errors for tropical depression and weak (<50 kt) tropical storms.

Prototype Time of Arrival Graphic

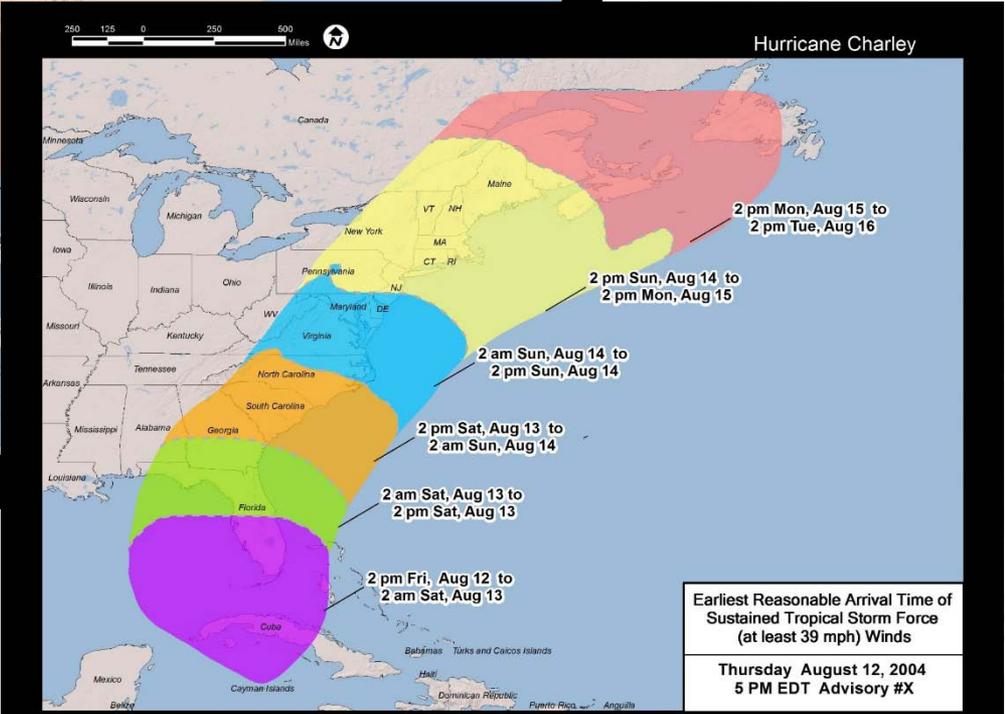
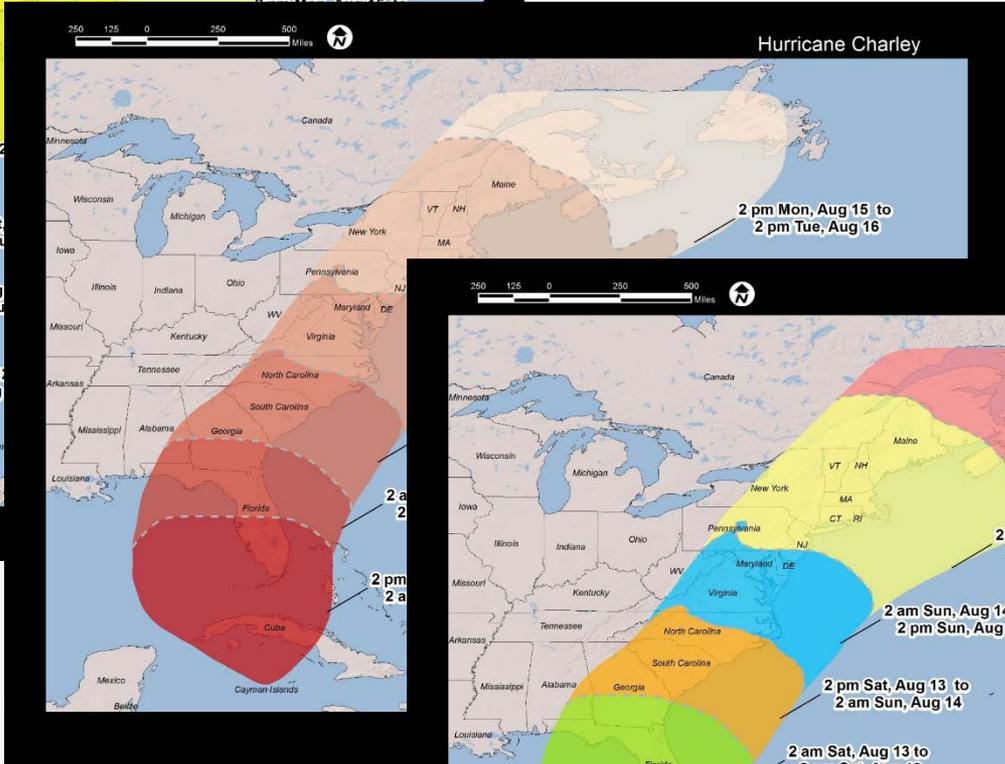
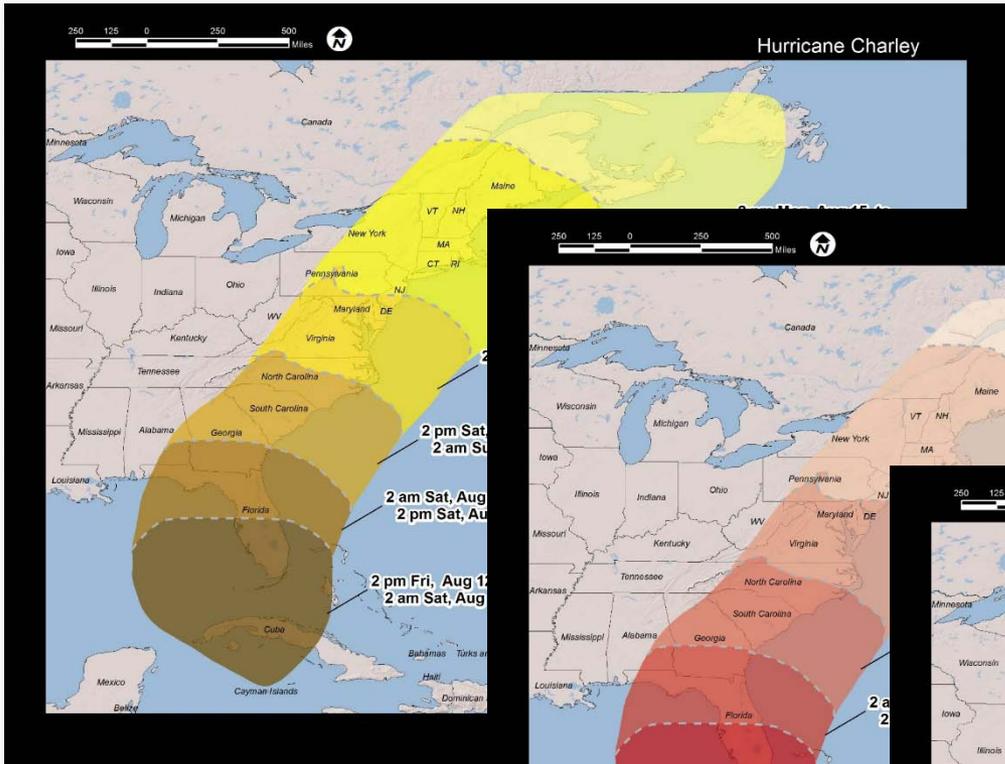
- Uses timing information from the NHC wind speed probabilities
- Accounts for typical track, intensity, and size forecast uncertainty
- Provides graphical depiction of potential arrival times of tropical-storm-force winds



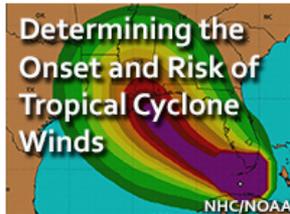


Social Science Testing Continues

Colors vs. Grey Scale



- New storm surge and tropical cyclone related COMET modules online
 - Introduction to Tropical Cyclone Storm Surge
 - Storm Surge and Datums
 - Forecasting Tropical Cyclone Storm Surge
 - Determining the Onset and Risk of Tropical Cyclone Winds
 - Tropical Cyclone Forecast Uncertainty
 - Real-Time Storm Surge Products (Spring 2016)

	<p>Use of Probabilistic Surge Guidance in Local Storm Surge Forecasting</p> <p>Languages: English Publish Date: 2015-07-20 Skill Level: 2 Completion Time: .75 - 1.00 h Topics: Tropical/Hurricanes</p> <p>☆☆☆☆☆ (0 reviews)</p>
	<p>Determining the Onset and Risk of Tropical Cyclone Winds</p> <p>Languages: English Publish Date: 2015-07-01 Skill Level: 1 Completion Time: .50 - .75 h Topics: Tropical/Hurricanes</p> <p>☆☆☆☆☆ (0 reviews)</p>
	<p>Tropical Cyclone Forecast Uncertainty</p> <p>Languages: English Publish Date: 2015-09-09 Skill Level: 1 Completion Time: .50 - .75 h Topics: Tropical/Hurricanes</p> <p>☆☆☆☆☆ (2 reviews)</p>



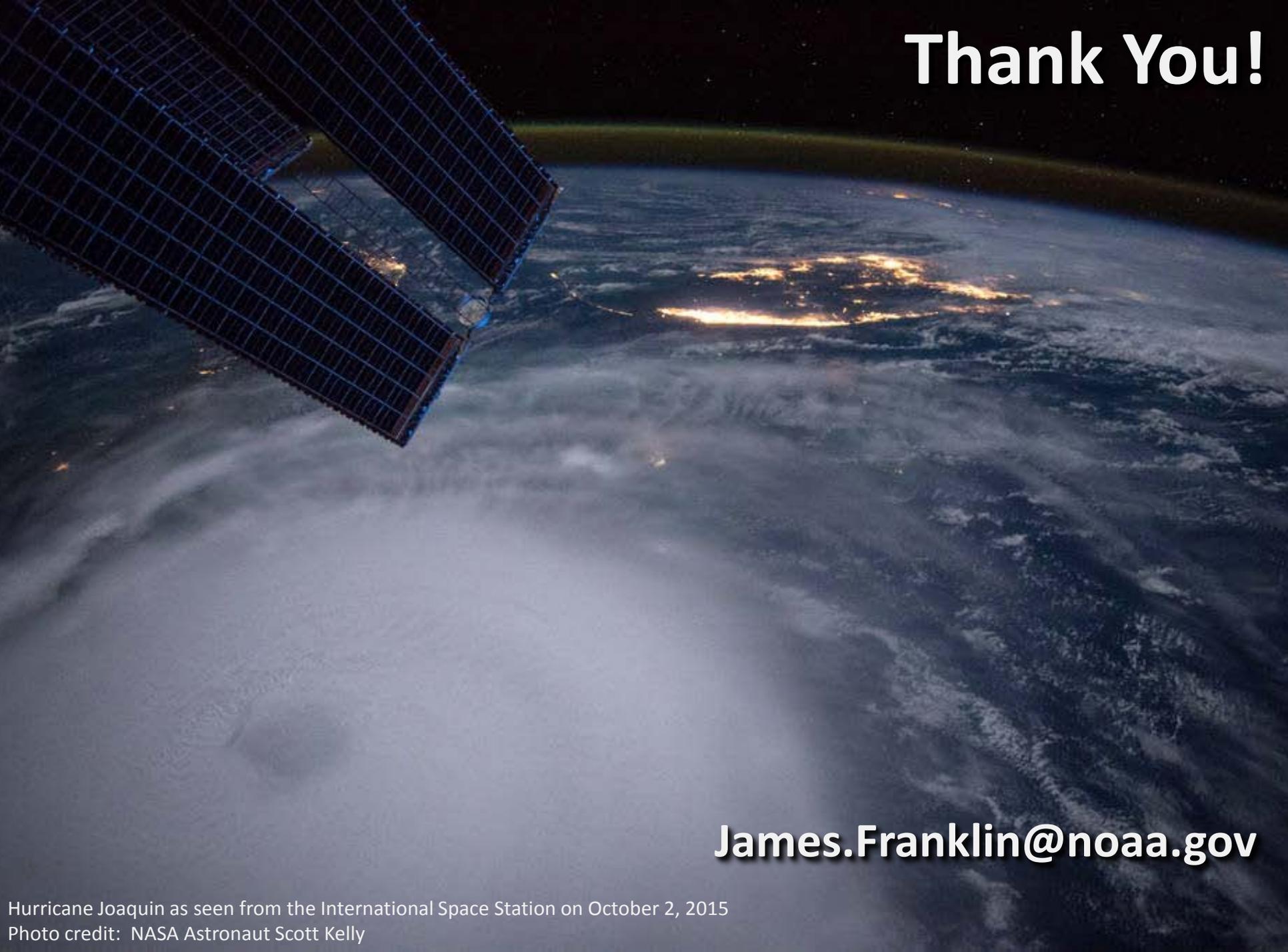
NHC on Social Media



The screenshot shows the 'Inside the Eye' blog page. The main article is 'Solving the Jigsaw Puzzle of Hurricane History', posted on February 11, 2016. It features a map of the Atlantic and Pacific Oceans with puzzle pieces representing hurricane tracks. The article includes a quote from Pearl S. Buck: "If you want to understand today, you have to search yesterday." Below the article, there are sections for 'National Hurricane Center' and 'NHC Atlantic', each with a link to a related article.

The screenshot shows a YouTube video player. The video content is a cartoon illustration of a house being hit by a storm surge. The house is tilted, and water is crashing against it. A car is being pushed away from the house. The words 'STORM' and 'SURGE!' are written in large, bold letters. The video player shows a progress bar at 0:42 / 1:27.

- Twitter - @NWSNHC, @NHC_Atlantic, @NHC_Pacific, @NHC_TAFB, @NHC_Surge, @NHCDirector
- Facebook – www.facebook.com/NWSNHC
- NHC Blog – www.noaanhc.wordpress.com
- YouTube – www.youtube.com/user/NWSNHC



Thank You!

James.Franklin@noaa.gov

Hurricane Joaquin as seen from the International Space Station on October 2, 2015
Photo credit: NASA Astronaut Scott Kelly