

Path of terror

Andrew wreaks havoc in S. Florida



Canes on Canes: Keeping South Florida Prepared During the Calm Before the Storm

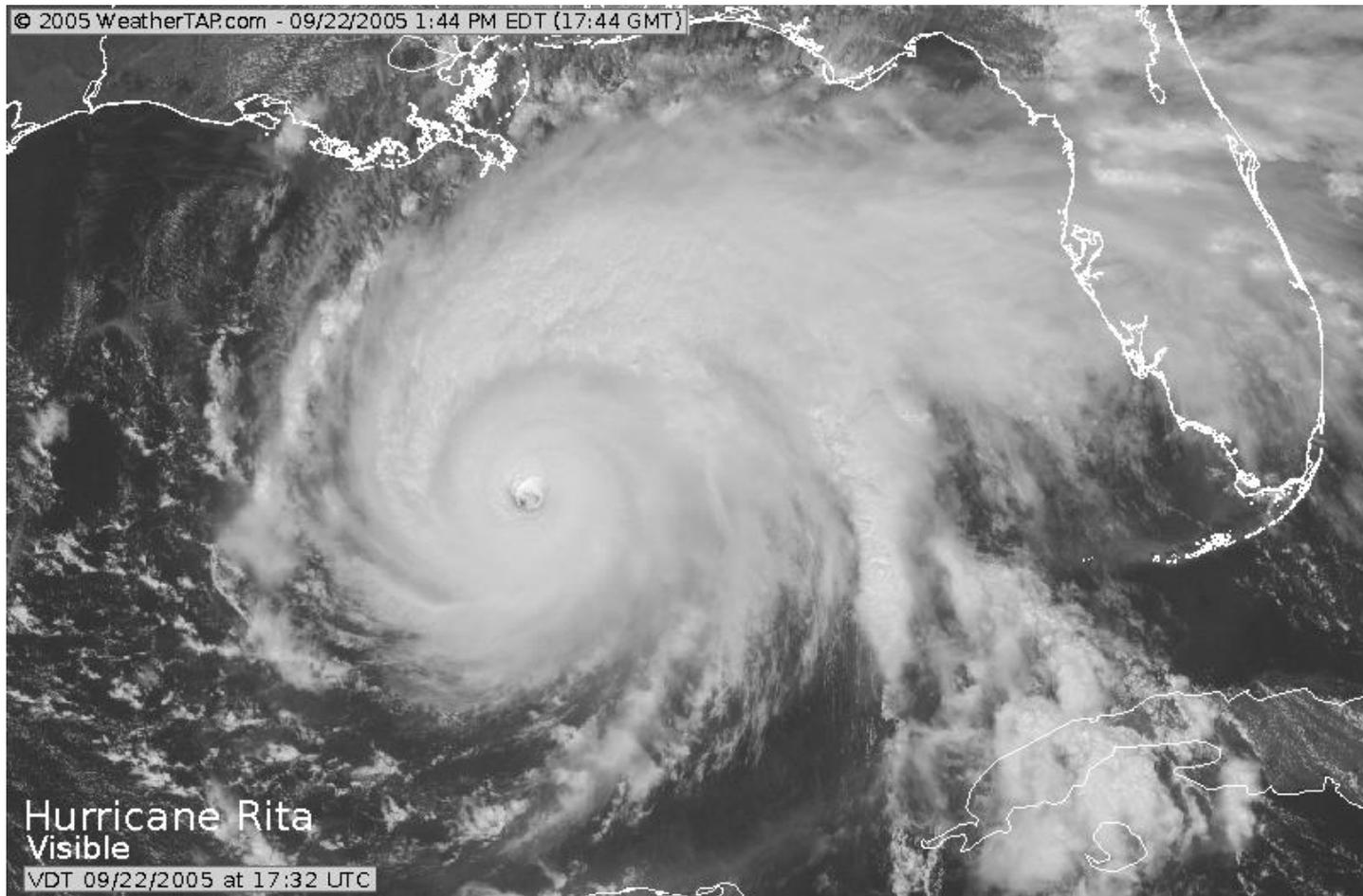
Matt Onderlinde and Kieran Bhatia

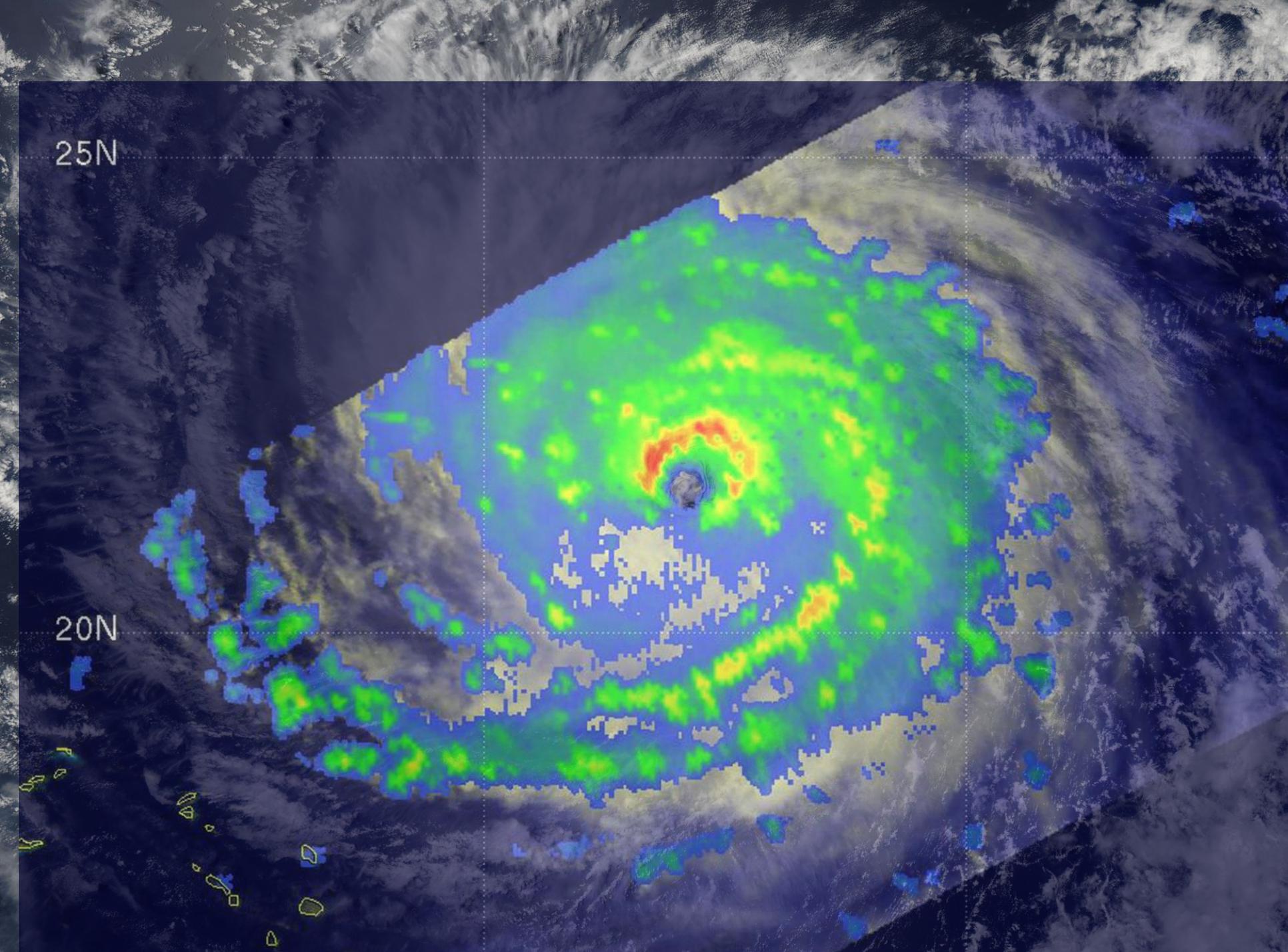


Outline

- The Science of Hurricanes
- Why and When South Floridians Must Be Weather-Ready
- Understanding the Uncertainty in Hurricane Forecasts
- Hurricane Hazards

The Science of Hurricanes

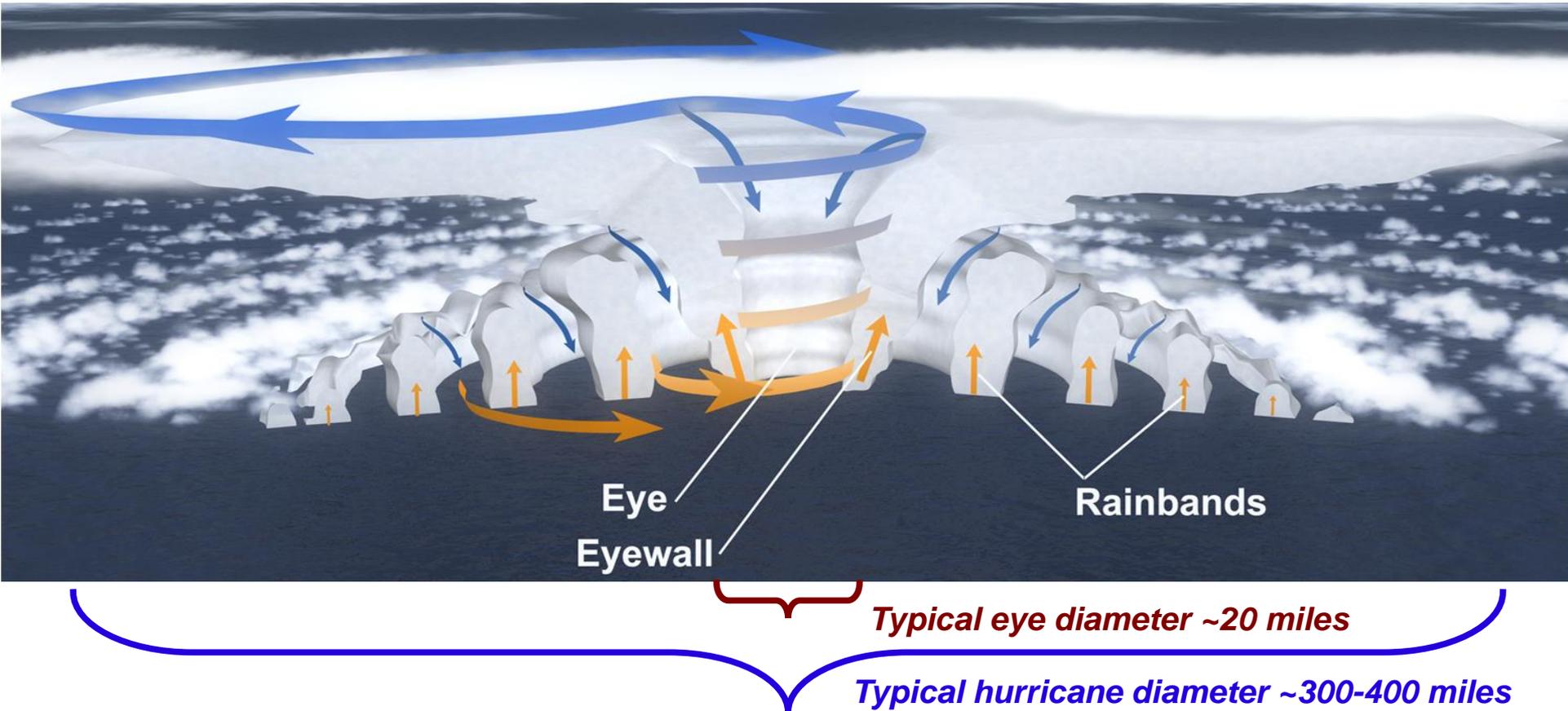




25N

20N

Side-View of a Hurricane

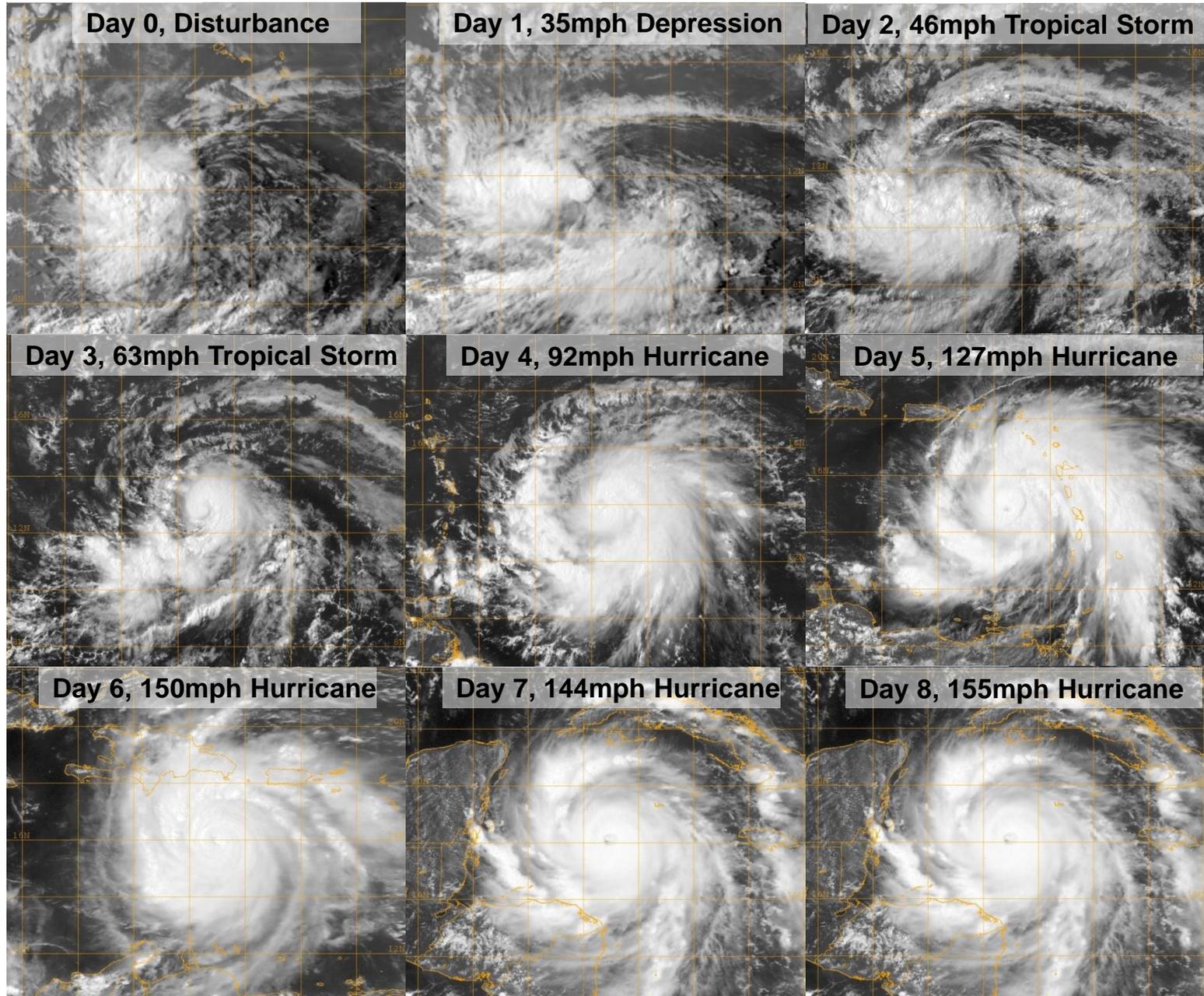


- * The center can have an **eye**, characterized by calm winds and sometimes clear skies.
- * The eye is then surrounded by an abrupt wall of intense thunderstorms and an area typically with the strongest winds: the **eyewall**.
- * Outside of the eyewall, there are typically spiral **rainbands**... these can also be quite strong and contain damaging winds, heavy rain, and even tornadoes.

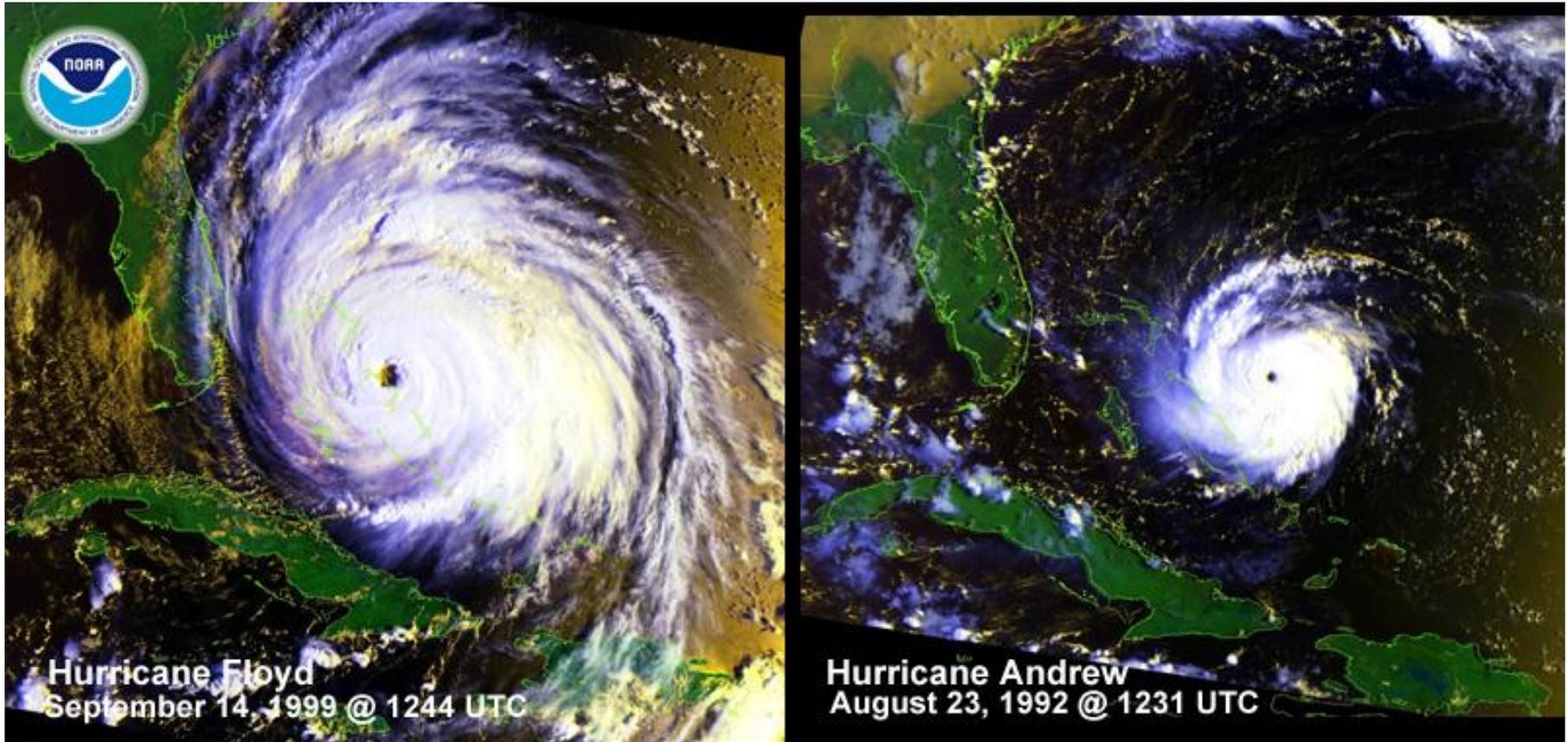
The Saffir-Simpson Intensity Scale

Category	Maximum Sustained Winds	Description
Tropical Depression	< 40 mph	Tie down your trash can and outdoor furniture.
Tropical Storm	40-73 mph	Dangerous winds: Tree branches and loose objects can cause isolated damage to houses and people.
Category 1 Hurricane	74-95 mph	Very dangerous winds will produce some damage: Roof damage, large tree branches, many power lines down leading to power outages.
Category 2 Hurricane	96-110 mph	Extremely dangerous winds will cause extensive damage: Roof and siding damage, some trees uprooted. Extended power loss and road blockages likely.
Category 3 Hurricane	111-130 mph	Devastating damage will occur: Significant home damage, road blockage, extended electricity AND water outages.
Category 4 Hurricane	131-155 mph	Catastrophic damage will occur: Major home damage or destruction, road blockages, power and water outages could last up to months.
Category 5 Hurricane	> 155 mph	Catastrophic damage will occur: Most homes/trees/etc. destroyed. Affected area uninhabitable for weeks or months.

Classic Lifecycle: Disturbance - Category 5



Does Size Matter?



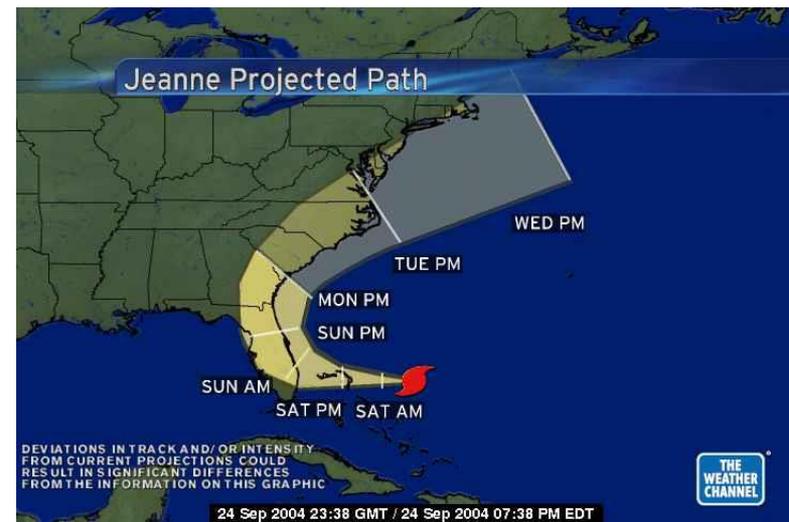
Hurricane Floyd
September 14, 1999 @ 1244 UTC

Hurricane Andrew
August 23, 1992 @ 1231 UTC

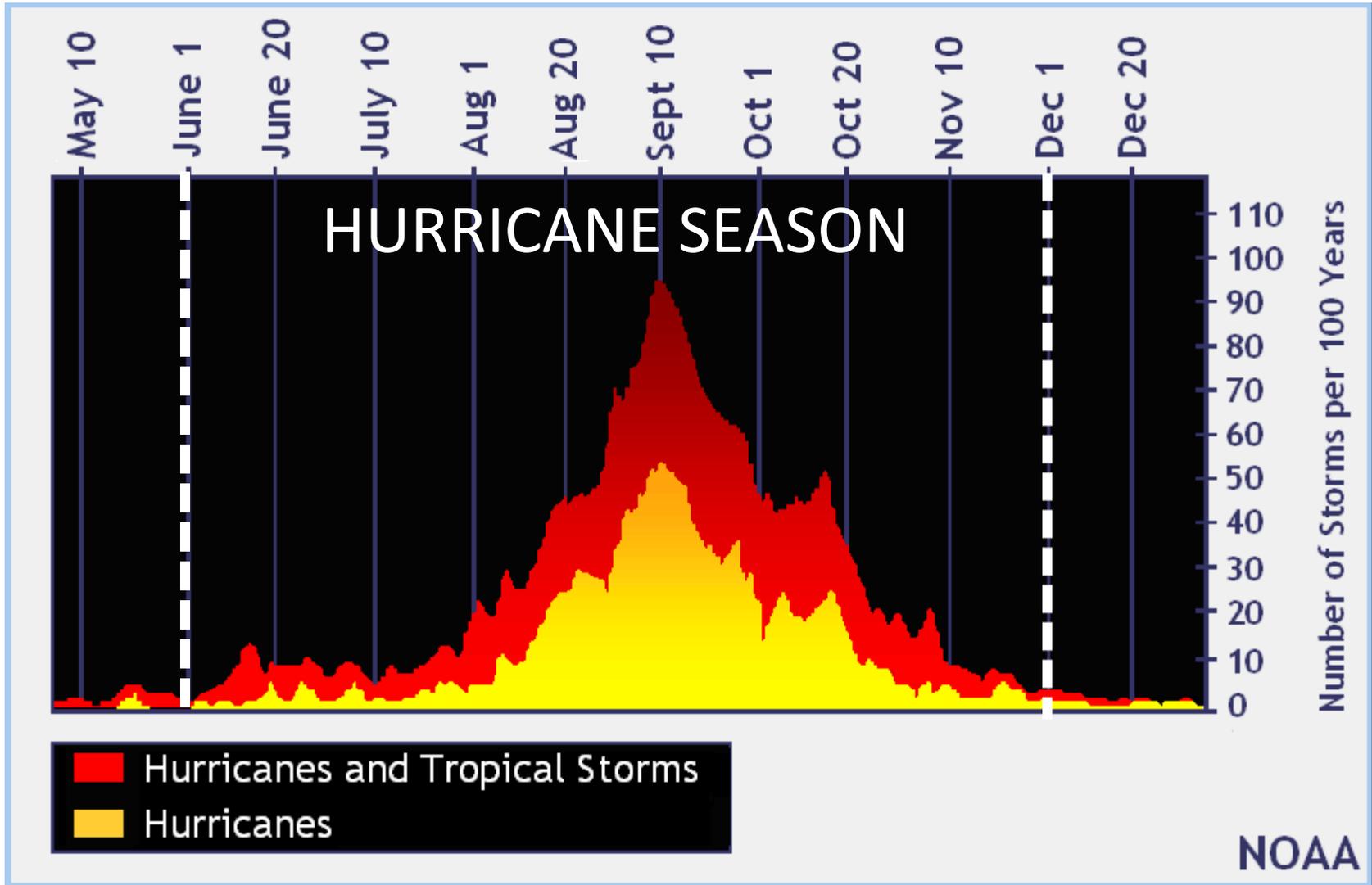
- **Yes**, the bigger a storm is, the more area it will affect with rain, wind, and storm surge, but...
- A larger storm is not necessarily a stronger storm and vice versa.



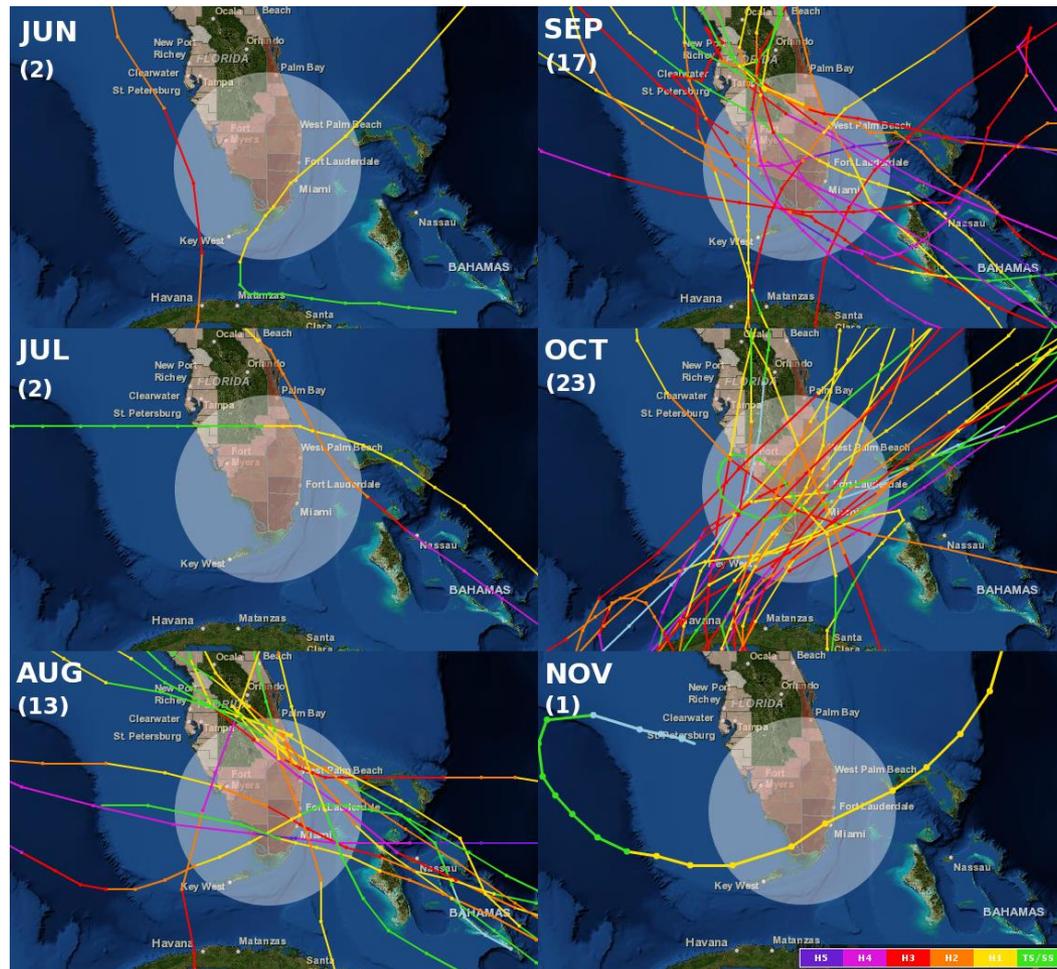
Why and When South Floridians Must Be Weather-Ready



When is it Time to Tune in?

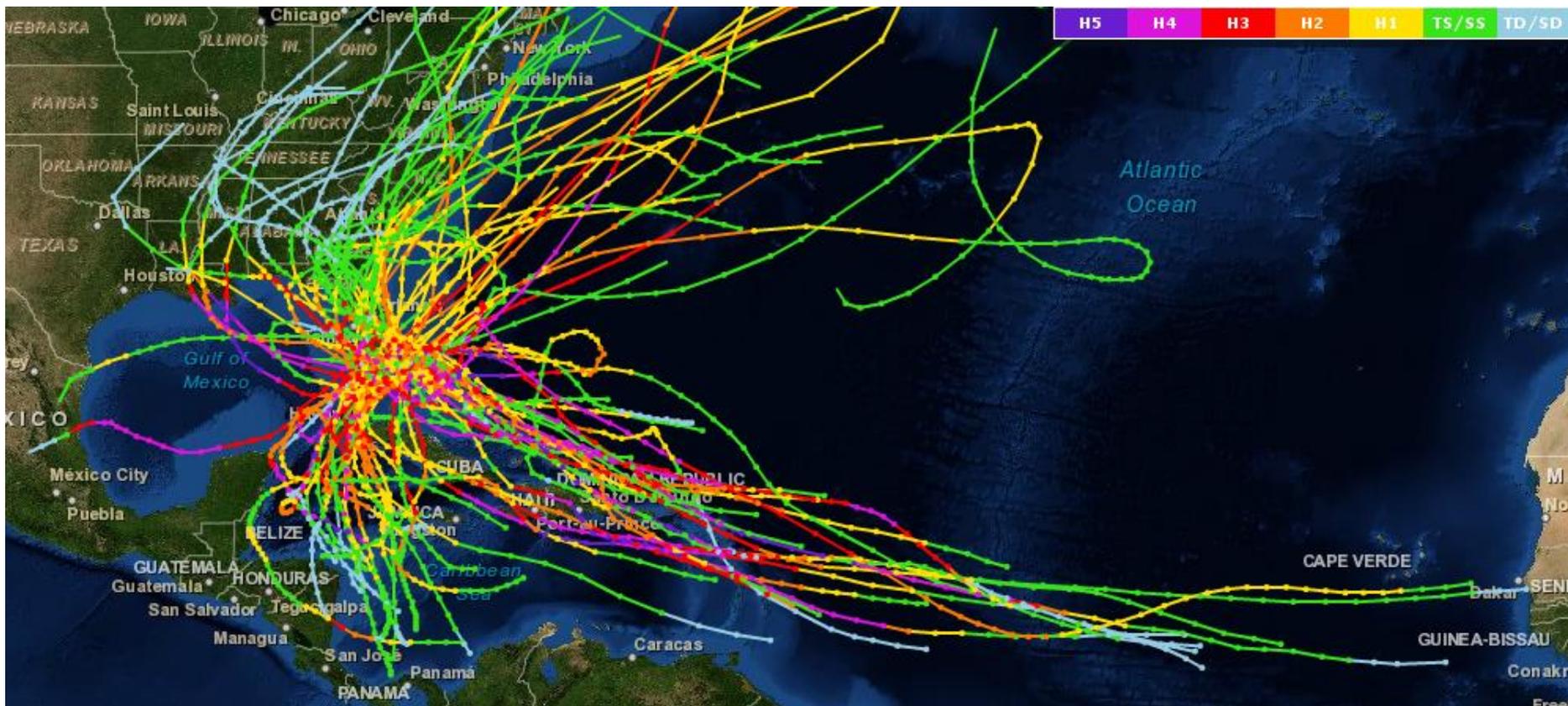


With Great Weather Comes Great Responsibility?



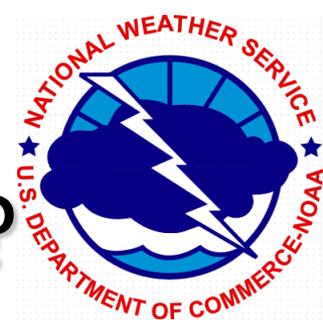
Hurricanes affecting South Florida since 1851

58 (31 major) Hurricanes Passed Through South Florida from 1851-Present





What Month Has Had Most Hurricane Strikes in South FL?

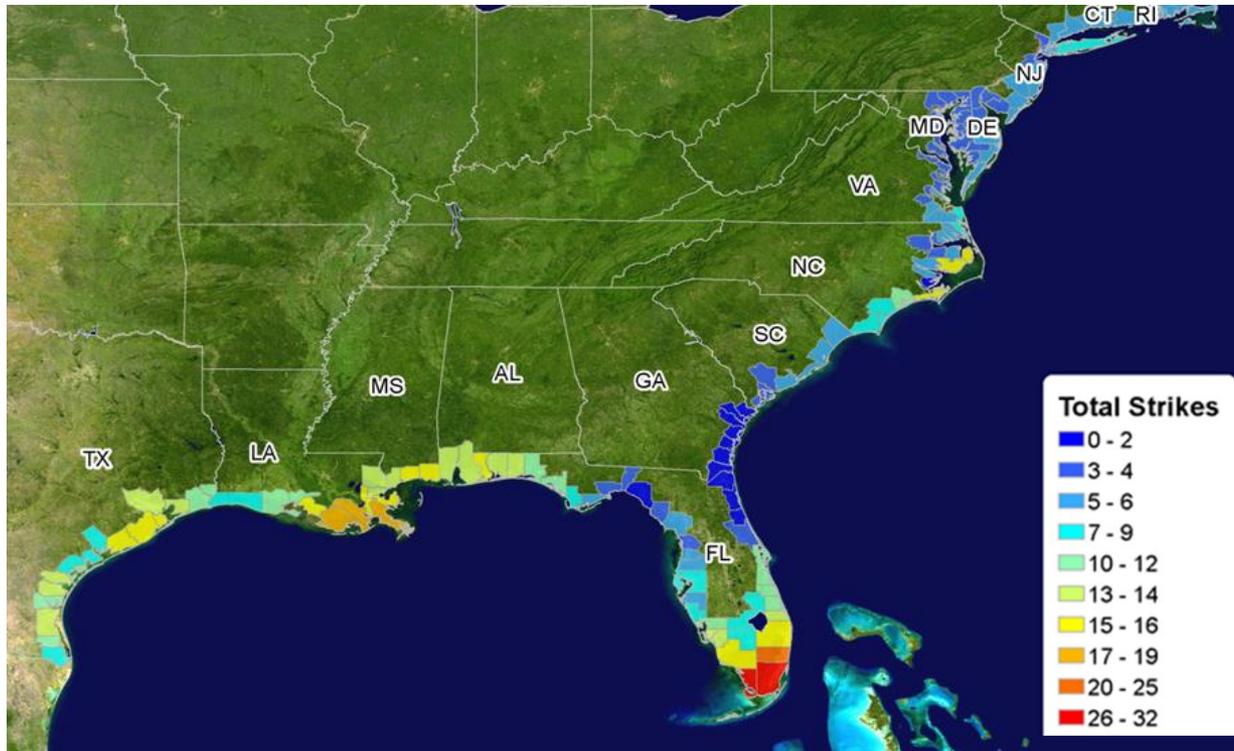


- A) August
- B) October
- C) September
- D) June

Since 1851, 23 hurricanes have struck South Florida in October, compared to 17 in September 13 in August, 2 in July, and 2 in June

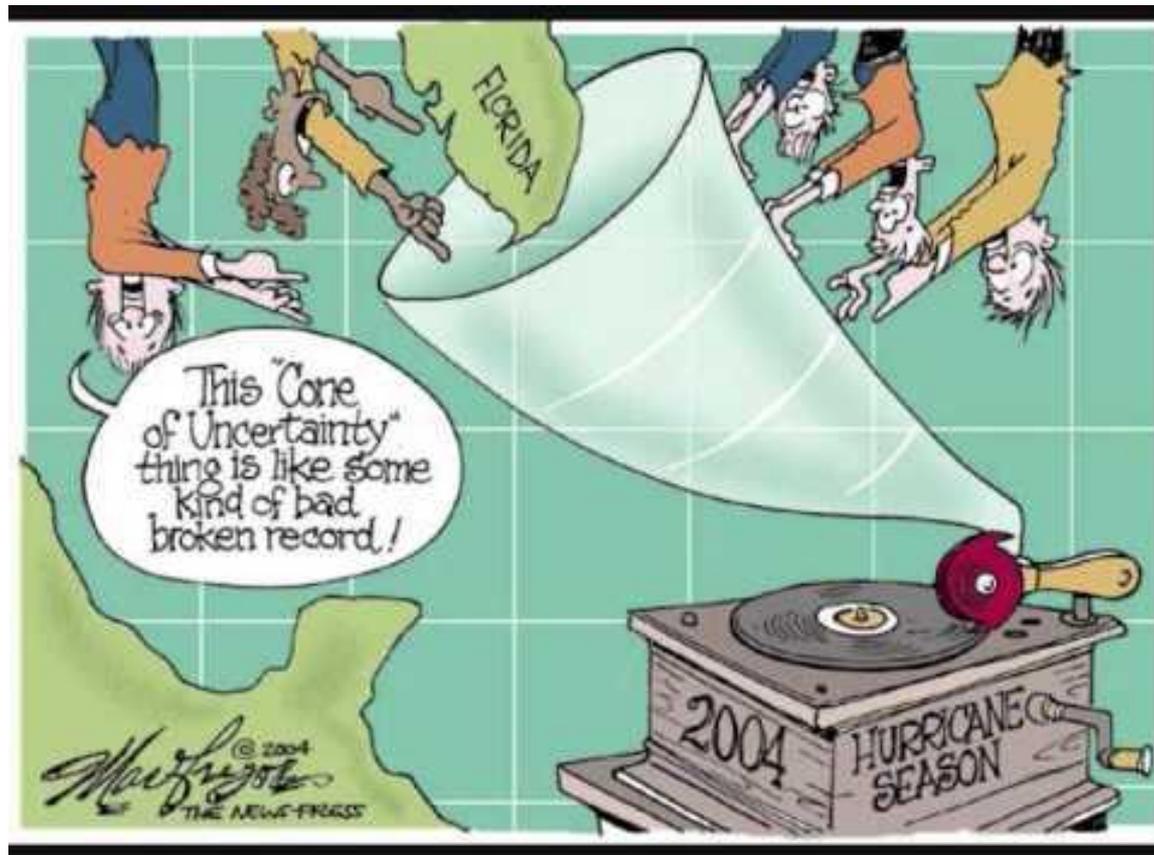
It's not "IF", It's "When"

- South Florida is one of the most frequently hit sections of the entire US coastline
- Average of one hurricane per 3 years and one major hurricane every 5.2 years



Total Number of
Strikes Per County,
1900-2010

The Uncertainty of Forecasting Hurricanes





1) Data Acquisition
 Variety of instruments define current conditions

$$u \frac{\partial u}{r \partial \theta} + v \left(\frac{\partial u}{\partial r} + \frac{u}{r} + f \right) + \omega \frac{\partial u}{\partial p}$$

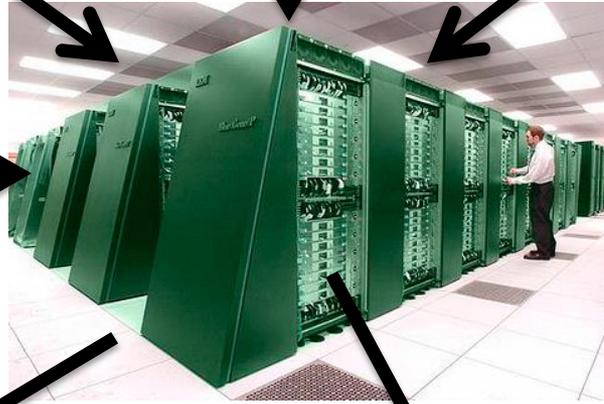
$$- \frac{\partial}{\partial r} \left[v \left(\frac{\partial u}{\partial r} + \frac{u}{r} \right) \right] + \frac{\partial}{r \partial \theta} \left[v \left(\frac{\partial u}{r \partial \theta} \right) \right]$$

$$+ \frac{\partial}{\partial p} \left[\kappa \left(\frac{\partial u}{\partial p} \right) \right],$$

$$u \frac{\partial v}{r \partial \theta} + v \frac{\partial v}{\partial r} - u \left(\frac{u}{r} + f \right) + \omega \frac{\partial v}{\partial p}$$

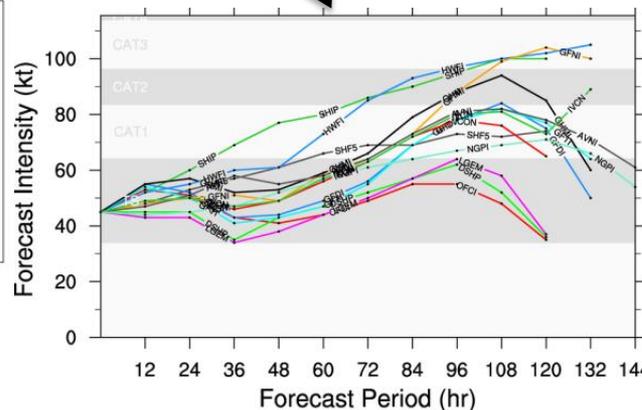
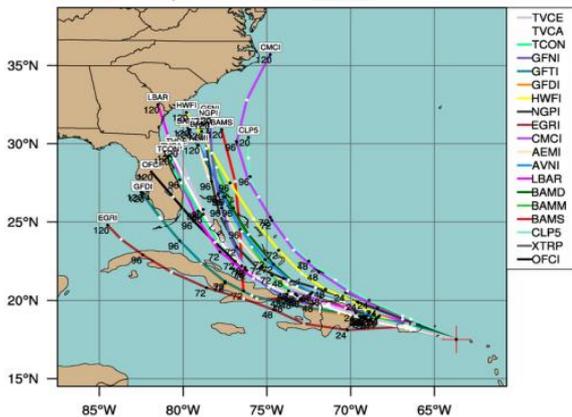
$$- g \frac{\partial z}{\partial r} + \frac{\partial}{\partial r} \left[v \left(\frac{\partial v}{\partial r} + \frac{v}{r} \right) \right] + \frac{\partial}{r \partial \theta} \left[v \left(\frac{\partial v}{r \partial \theta} \right) \right]$$

$$+ \frac{\partial}{\partial p} \left[\kappa \left(\frac{\partial v}{\partial p} \right) \right] - \frac{2}{r^2} \frac{\partial (uv)}{\partial \theta},$$



2) Model Predictions

Weather models on the world's fastest super computers predict the future state of the weather based on current information and approximate equations

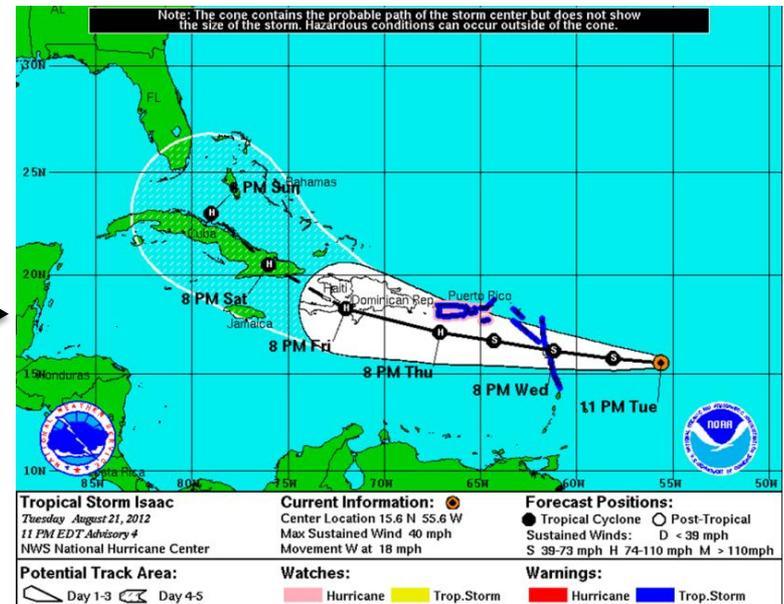


3) "Ensemble" of Forecasts

Different equations and data used lead to a variety of predictions

4) “The Official Forecast”

- Forecasters at the National Hurricane Center examine computer model forecasts and issue the official forecast based on what they deem as the most likely scenario





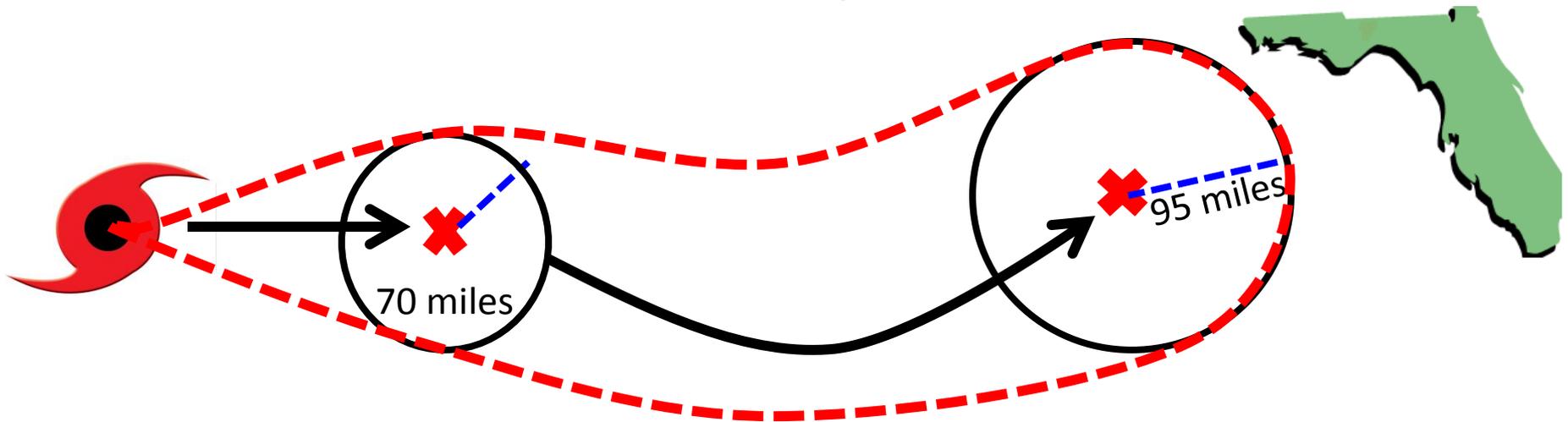
What is the Cone?



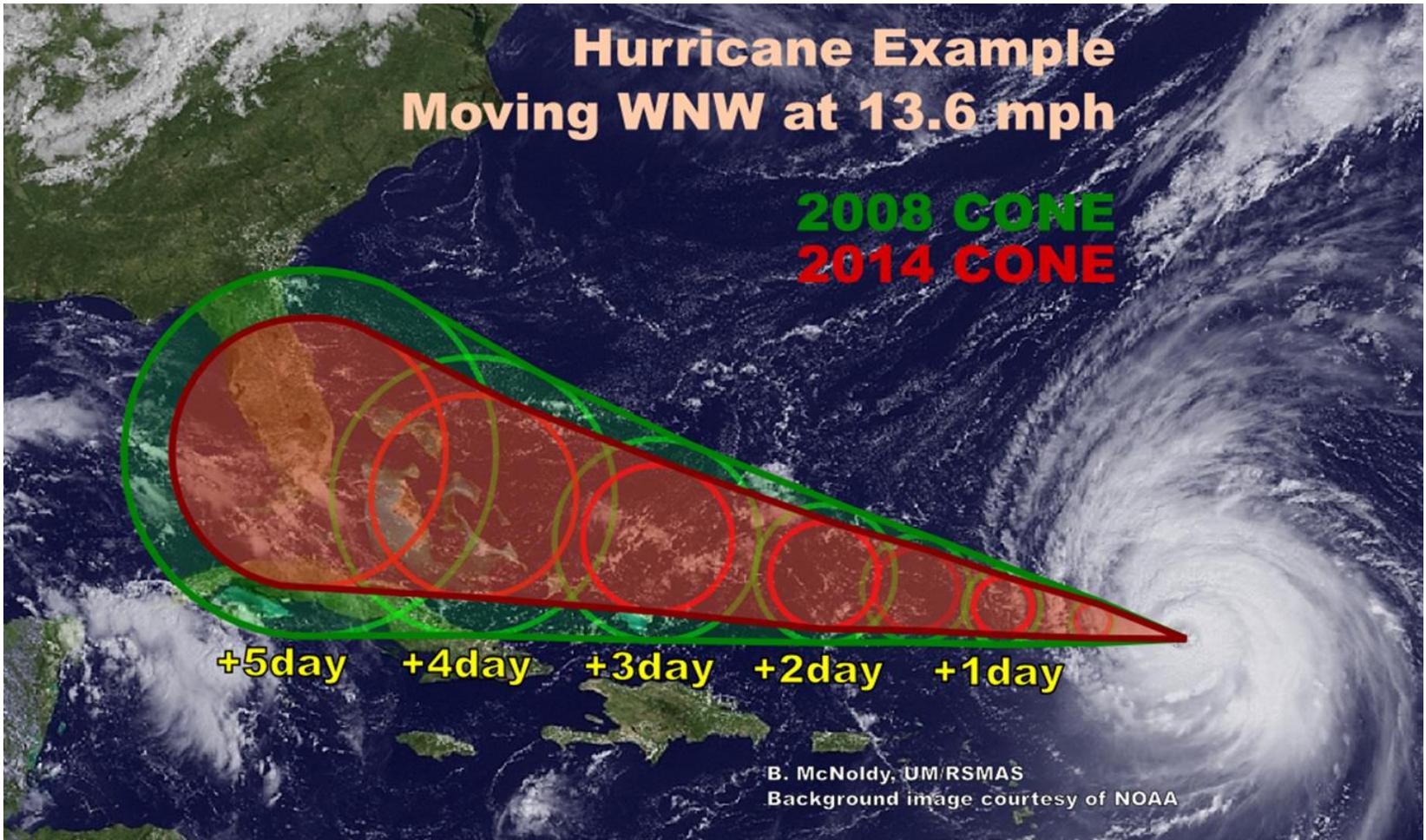
- The “forecast cone” or “cone of uncertainty” predicts the path of the storm **center**.
- It is not an impacts cone!
- The same size cone is used all season long for all storms... although uncertainty is higher in some situations than others.

Making the Cone

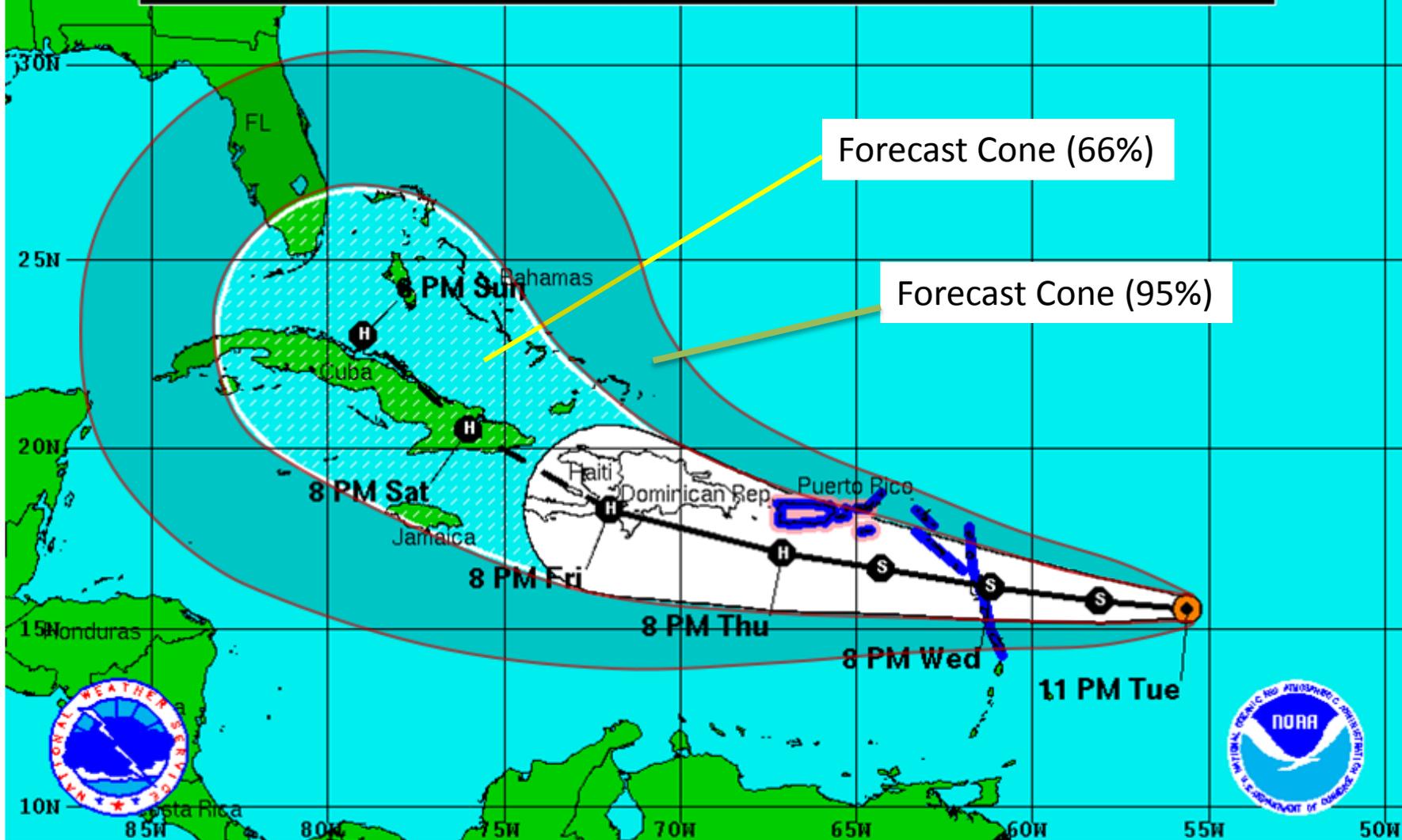
- For two out of three 24-hour forecasts, the center of the hurricane will differ from its predicted track by less than 70 miles, at 48 hours by less than 95 miles, etc.
- Using this information, we can draw a circle for the possible location of the center of the hurricane
- Outline the circles to complete the cone



Smaller Errors = Smaller Cone



Note: The cone contains the probable path of the storm center but does not show the size of the storm. Hazardous conditions can occur outside of the cone.



Tropical Storm Isaac
 Tuesday August 21, 2012
 11 PM EDT Advisory 4
 NWS National Hurricane Center

Current Information: ●
 Center Location 15.6 N 55.6 W
 Max Sustained Wind 40 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

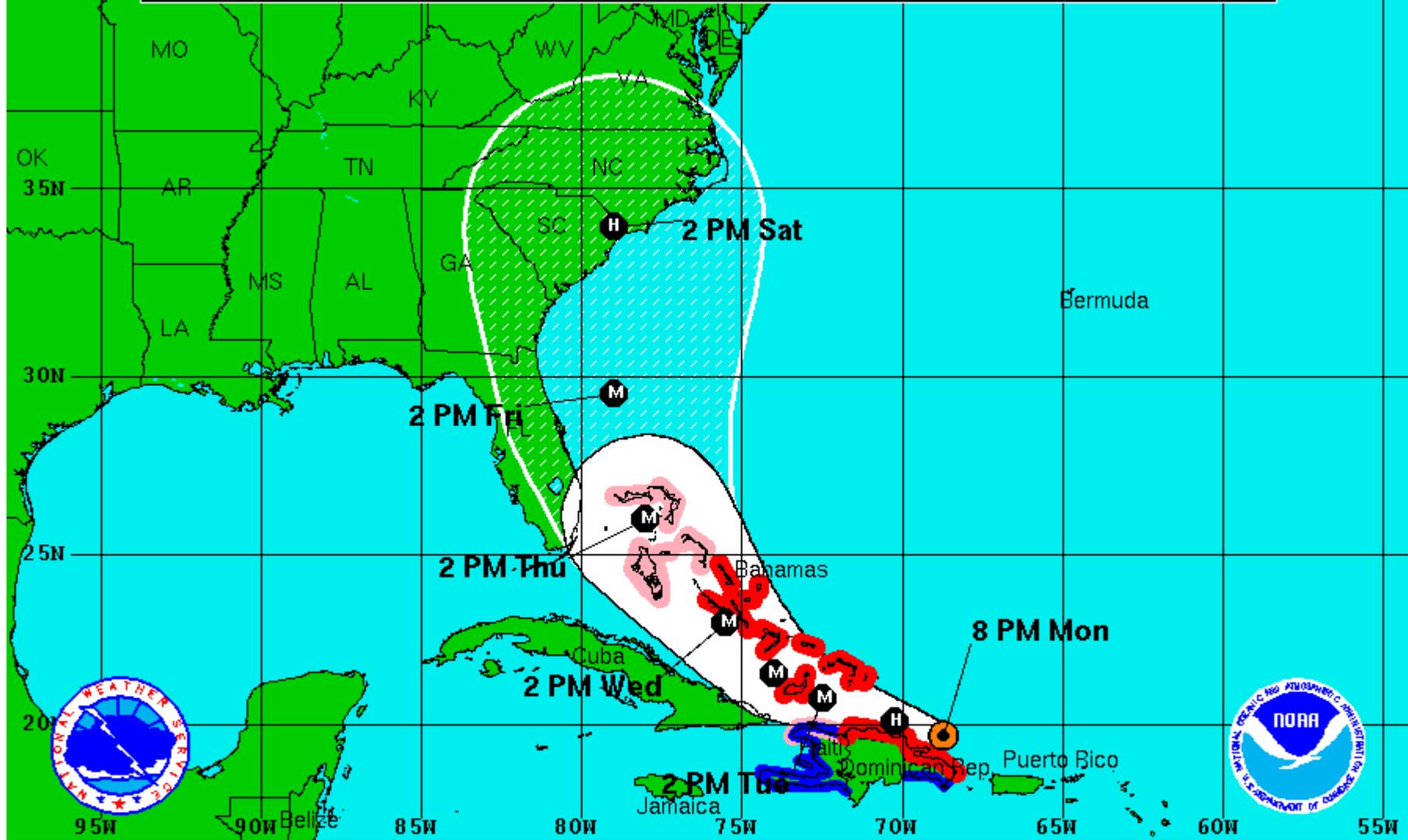
Do You Understand The Cone?

- Track forecasts inherently contain uncertainty... and forecasts further out in time have more uncertainty.
- As track forecasts improve, the size of the cone decreases.
- The center of the storm should track outside of the cone 1/3 of the time.
- The forecast cone is not an impacts cone!

Satellite Image of Irene from August 20, 2011



Note: The cone of the probable path of the storm center but does not show the size of the storm. Hazardous conditions can occur outside of the cone.



Hurricane Irene
 Monday August 22, 2011
 830 PM EDT Advisory 10
 NWS National Hurricane Center

Current Information:
 Center Location 19.7 N 68.7 W
 Max Sustained Wind 100 mph
 Movement WNW at 10 mph

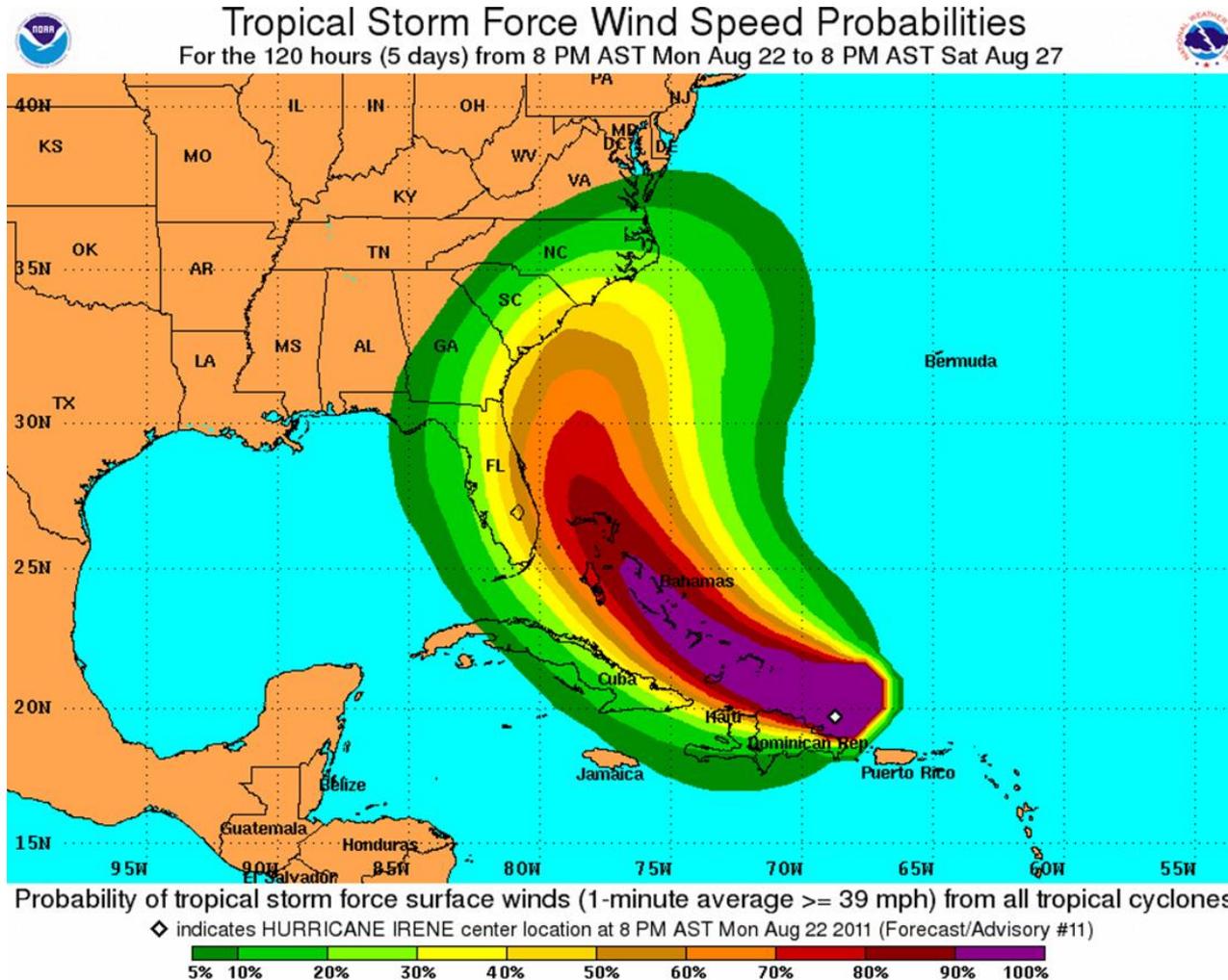
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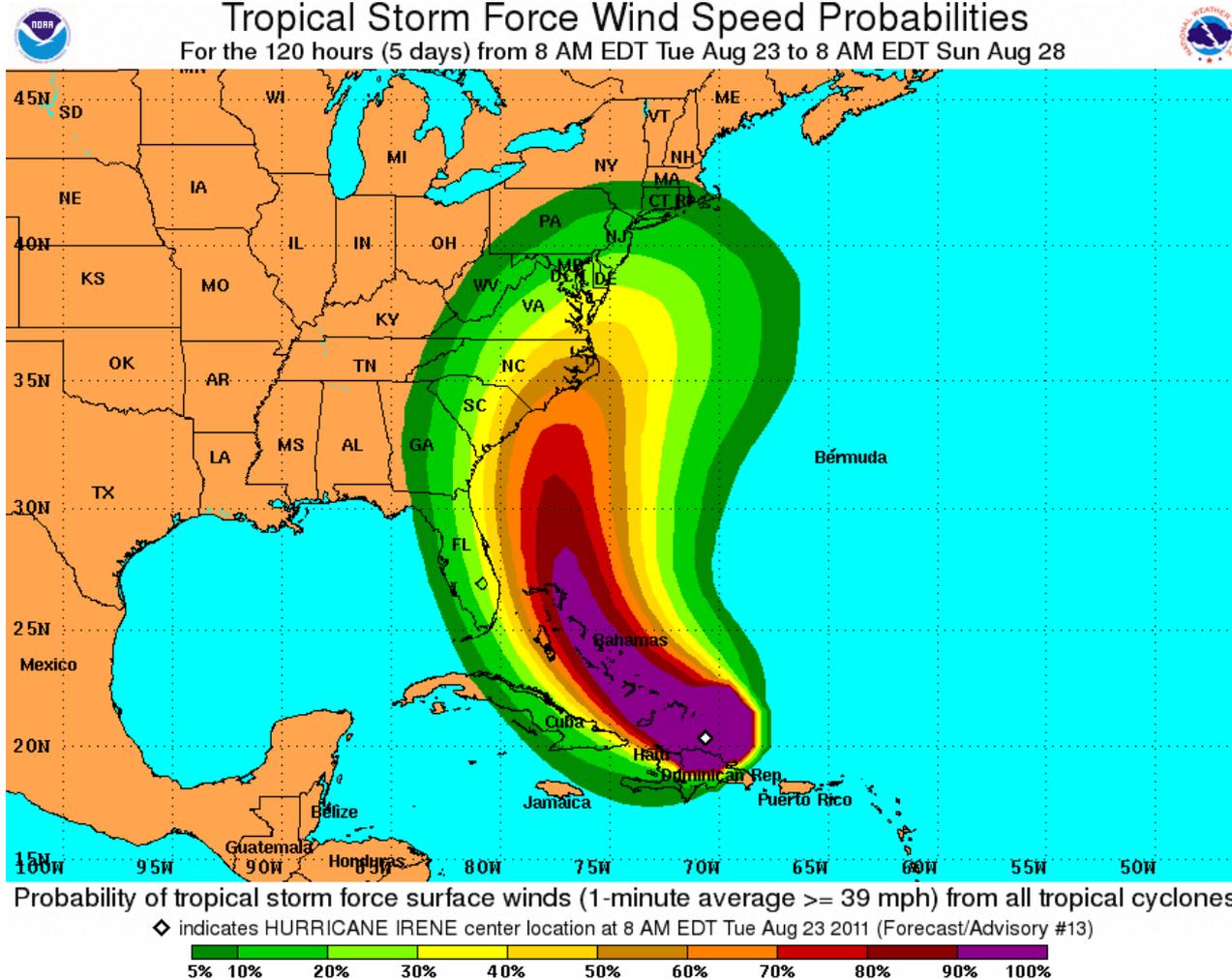
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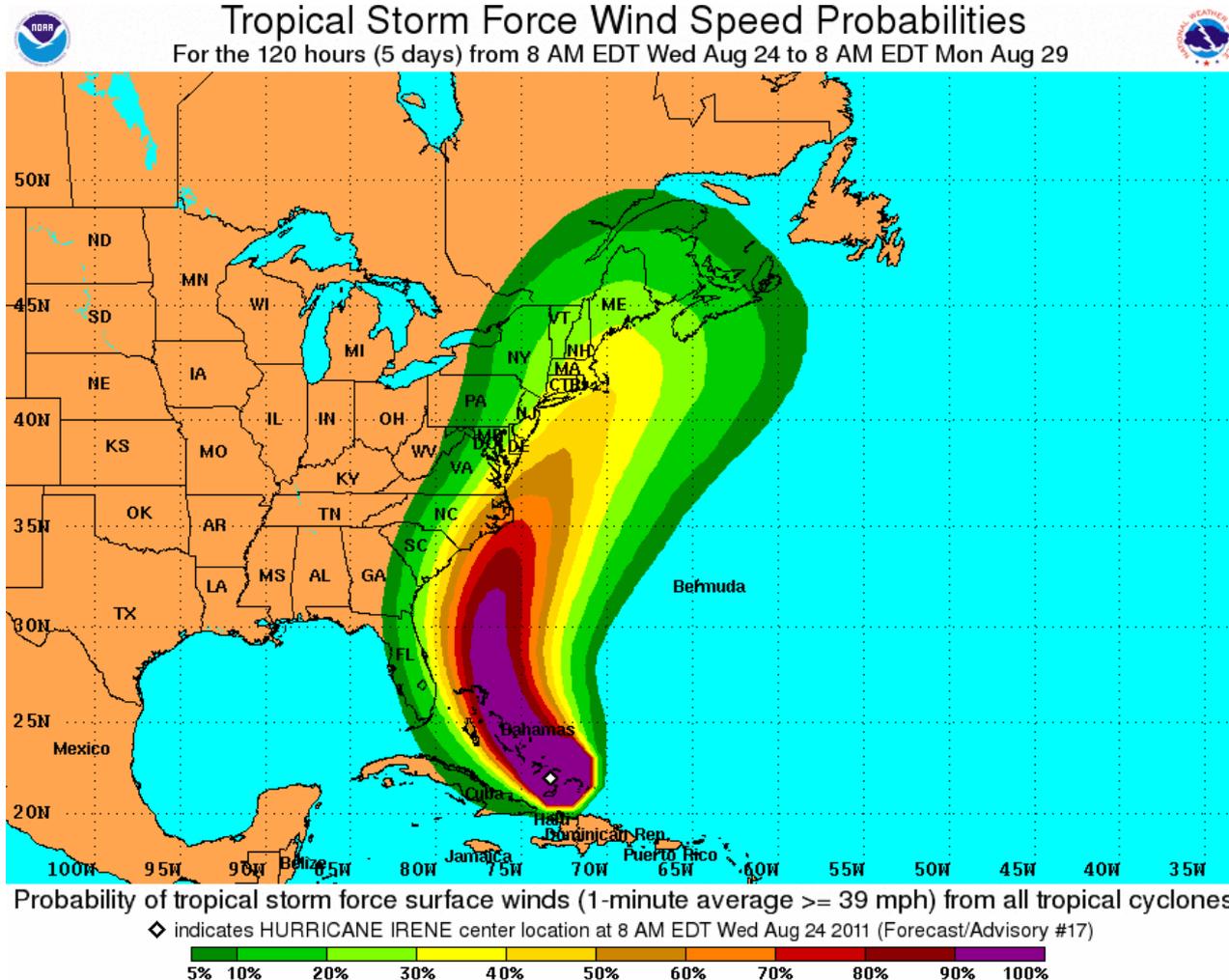
Is There A Wind Speed Cone?



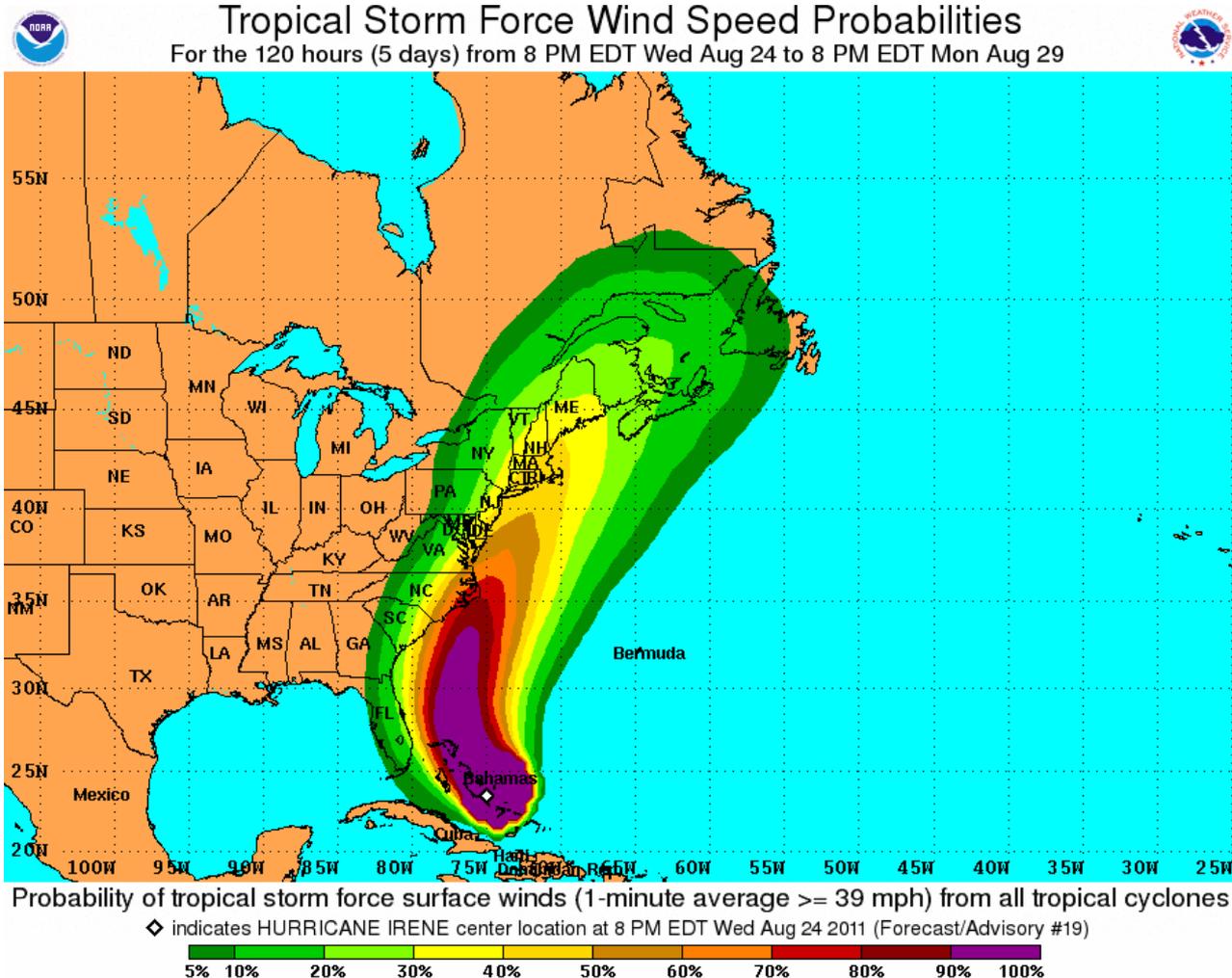
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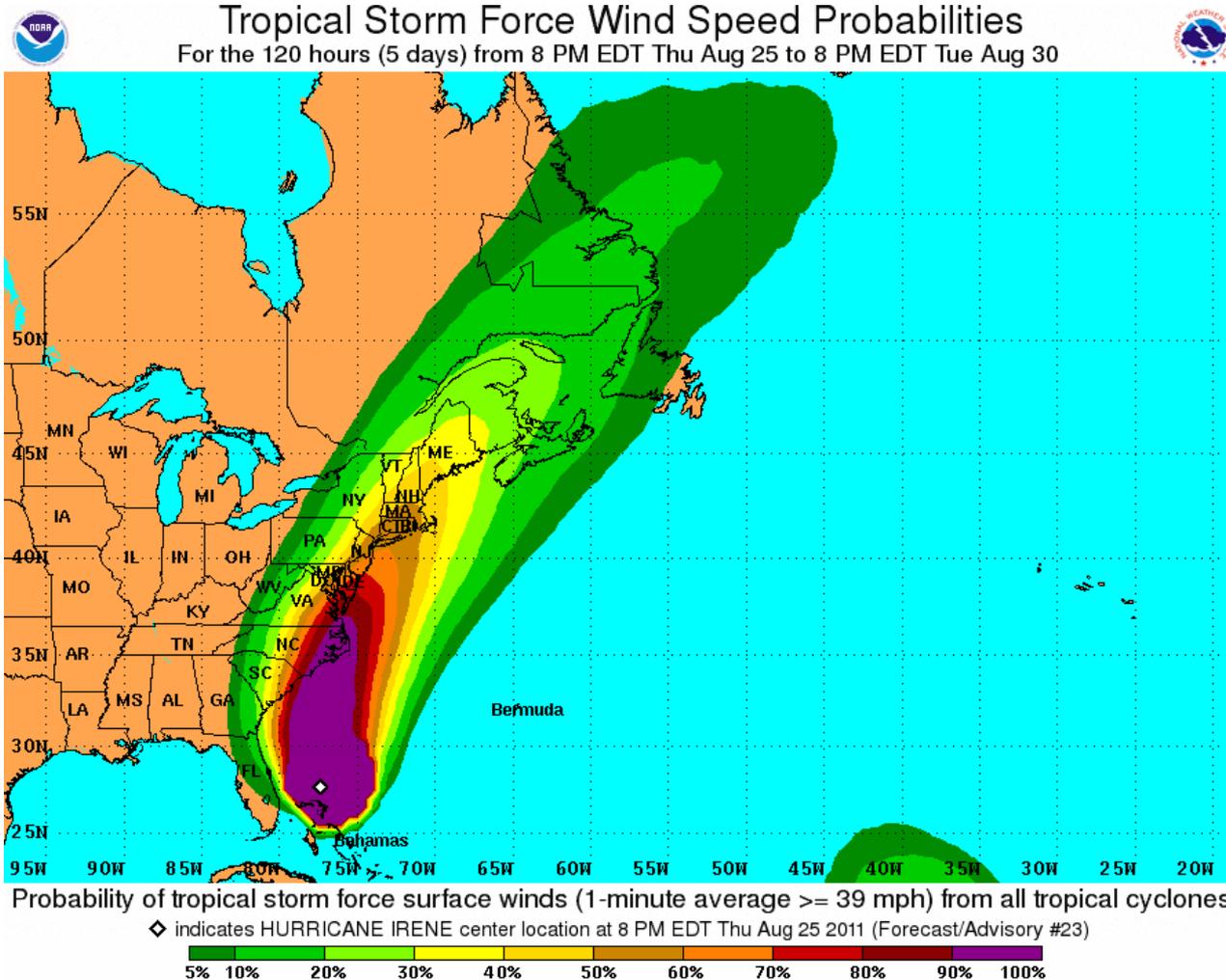
Is There A Wind Speed Cone?



Is There A Wind Speed Cone?



Is There A Wind Speed Cone?



Hurricane Hazards

- Storm Surge
- Wind
- Rain
- Tornadoes
- Waves/Rip Currents



Wind, Rain, and Waves: The Obvious Risks



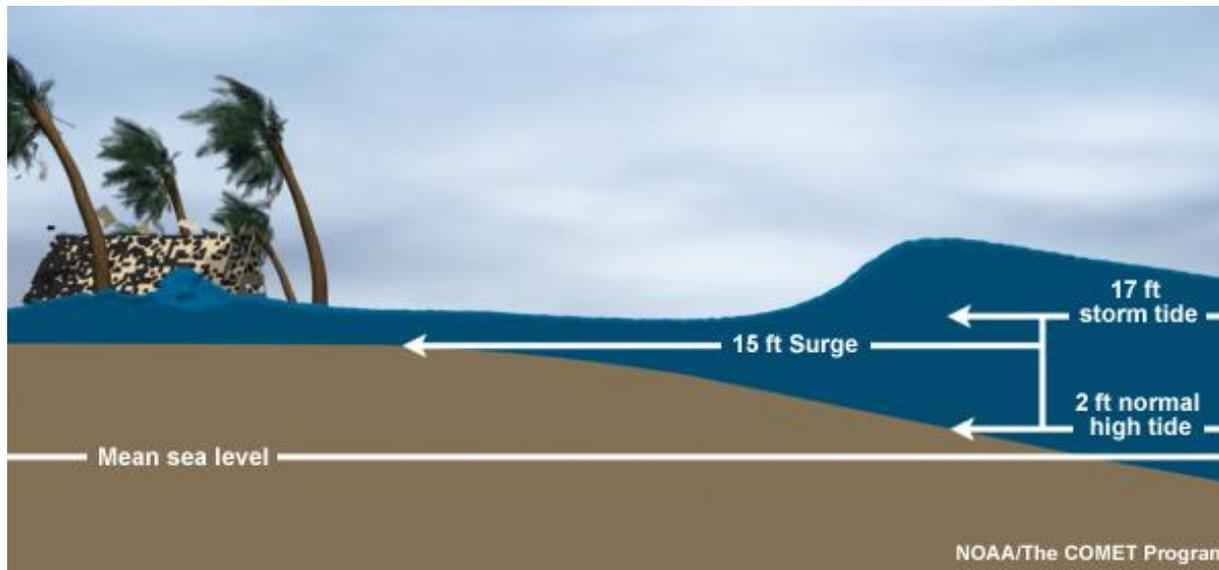
Tornadoes

- Nearly 70% of landfalling hurricanes cause at least 1 tornado.
- These tornadoes most often occur in thunderstorms embedded in rainbands well away from the center of the hurricane.

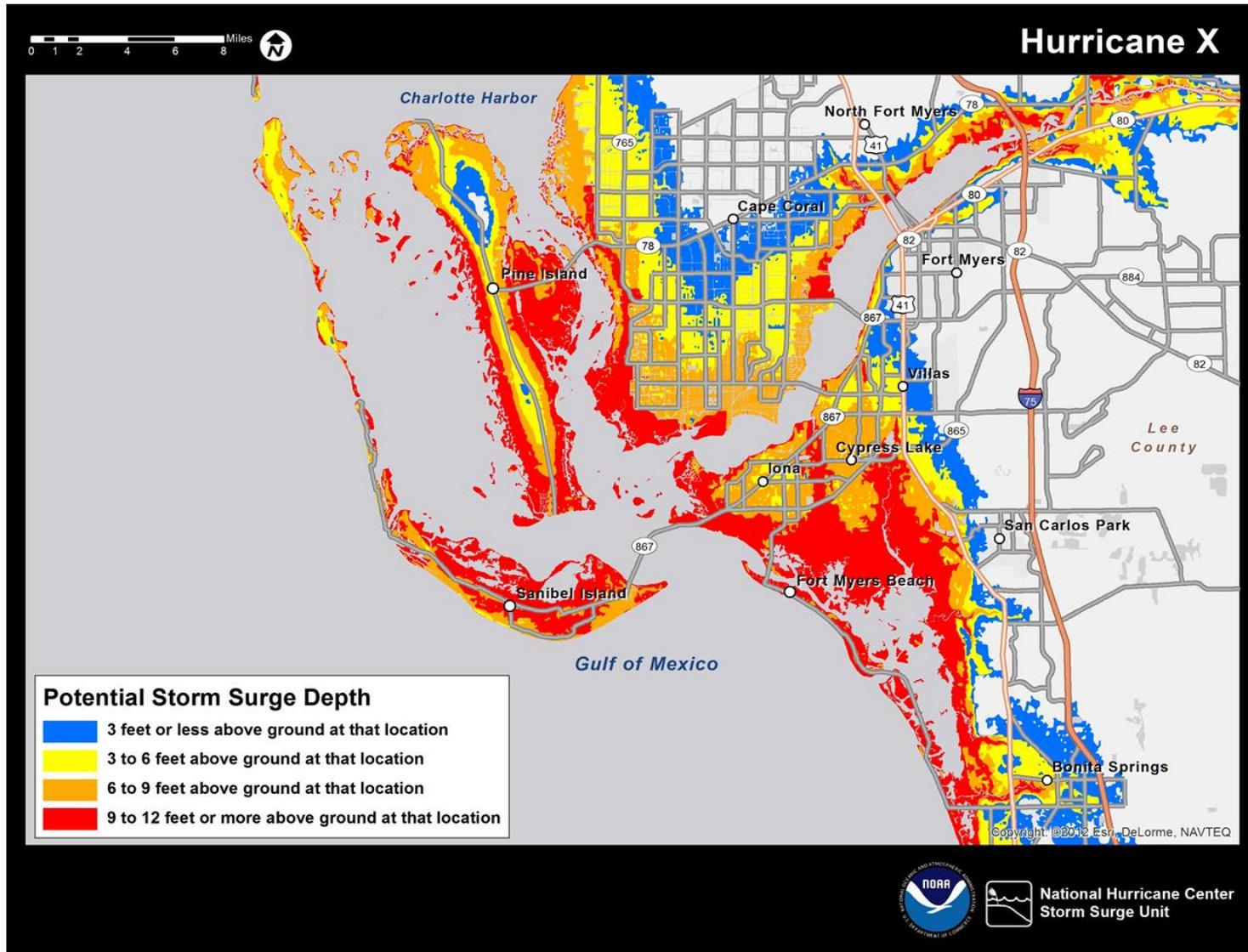


Storm Surge: Needs More Attention

- The #1 cause of deaths in hurricanes
- Storm surge is produced by water being pushed toward the shore by the storm winds
- Low pressure of hurricane has little impact on surge in comparison to the wind



New Storm Surge Graphic

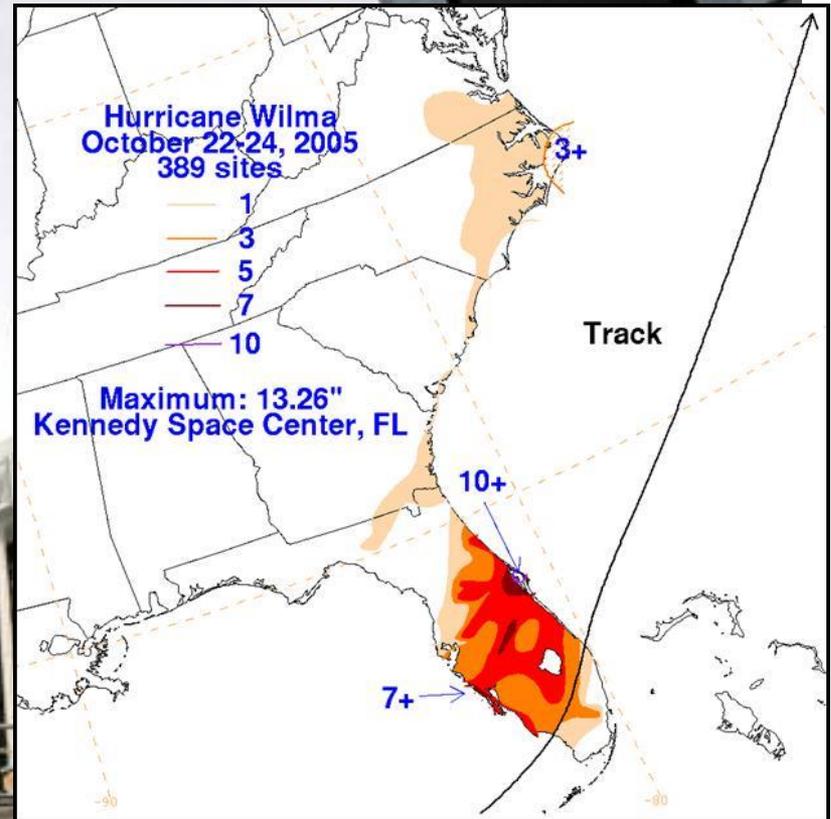
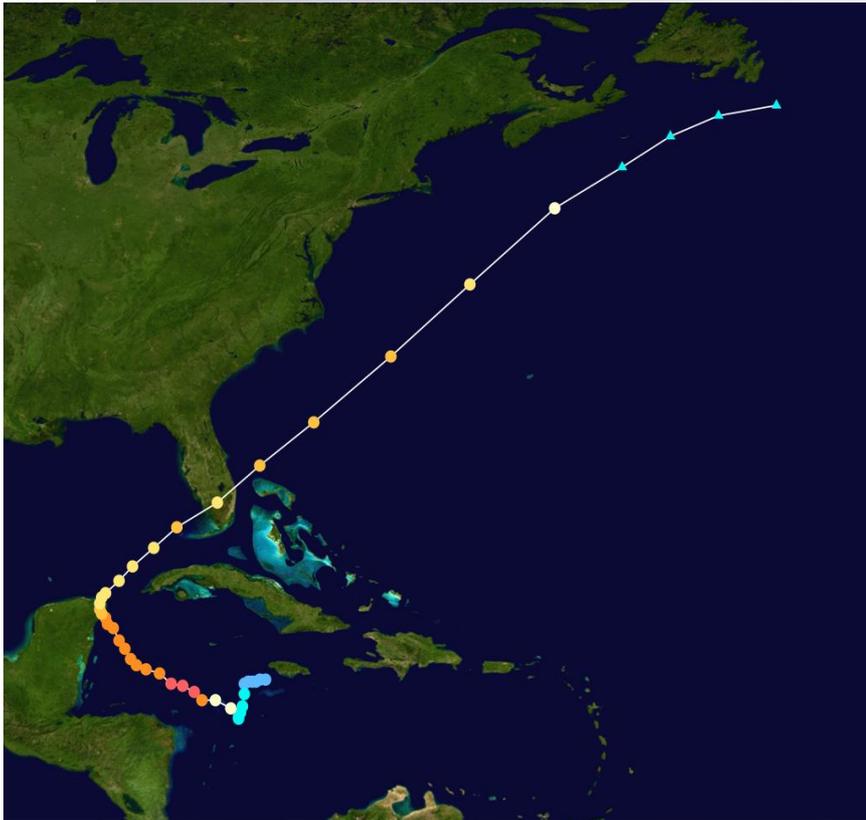


Could we see this type of flooding in South Florida?



Hurricane Katrina (2005): New Orleans

Hurricane Wilma (2005): Miami



Lessons Learned

- Hurricanes and tropical storms (tropical cyclones) are expansive low-pressure systems defined in the media only by their fastest observed wind speed
- August through October is the peak of hurricane season for the U.S. but September and October are South Florida's busiest months
- The “cone of uncertainty” shows where the center of the storm will go 2/3 of time but the storm's impacts can extend far beyond the cone (even if the track forecast is correct)
- Tropical cyclones have a variety of hazards but storm surge is responsible for the most damage and deaths

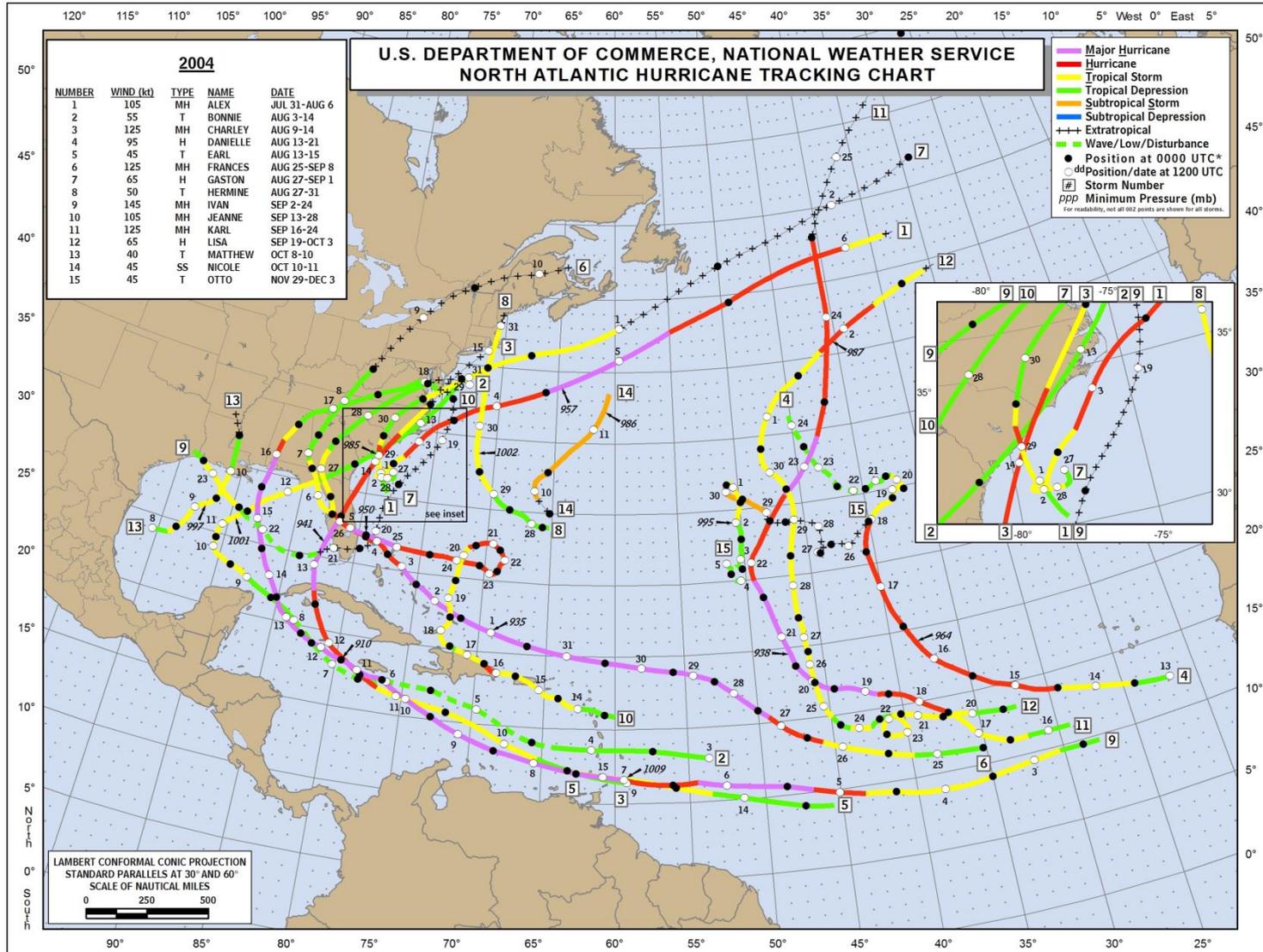
Thank you!



The “Canes on Canes” team from University of Miami Rosenstiel School, from left: Brian McNoldy, Falko Judt, Kieran Bhatia, Jason Godwin and Matt Onderlinde.

Additional Slides based on Questions

El Nino Years



Haiti Hurricane History

- On average, Haiti is exposed to one tropical storm or hurricane every other year, which makes direct landfall on Hispaniola island.

