Understanding Hurricanes

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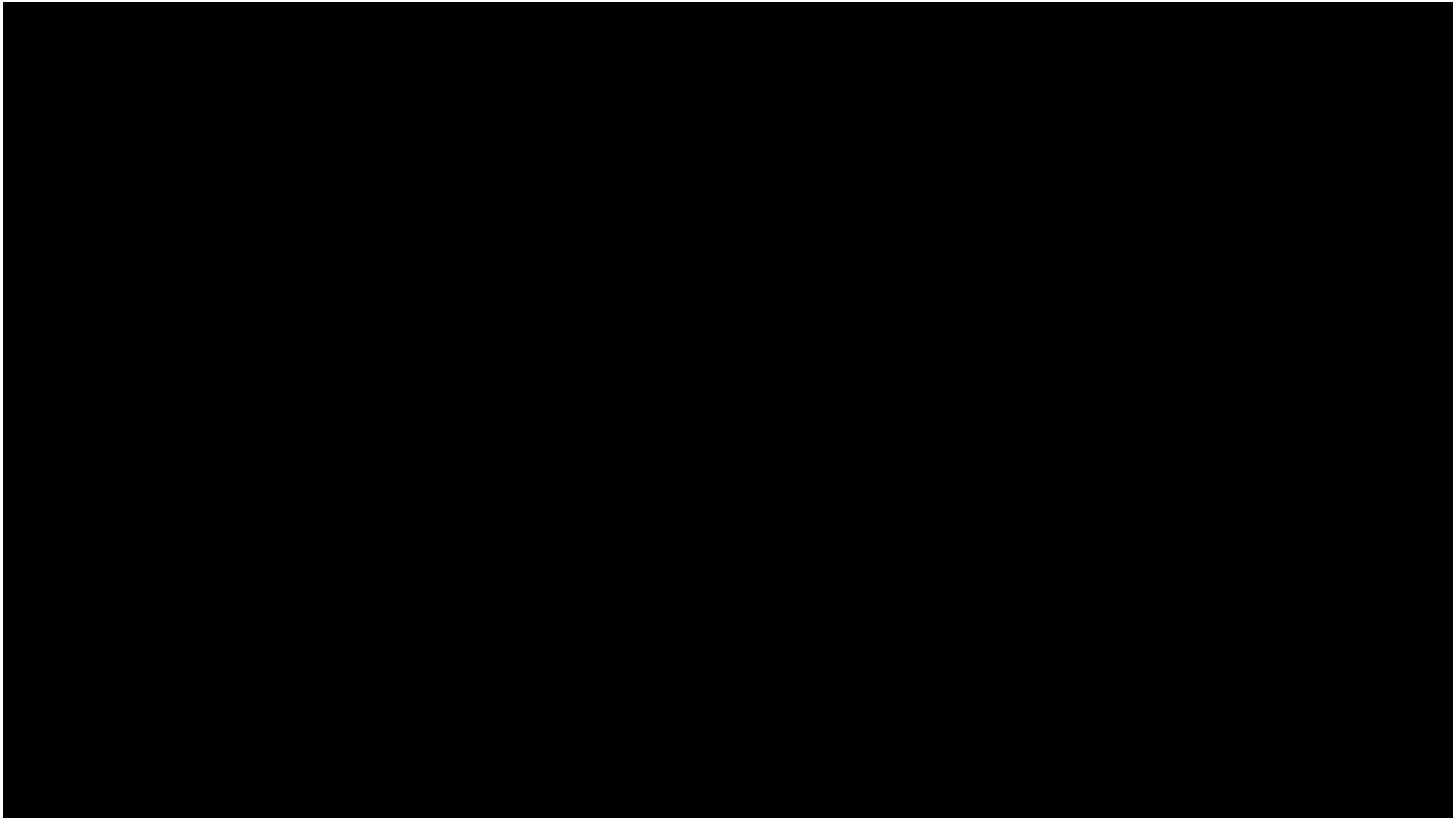
What do you know about hurricanes?

What do you want to know?

Outline

- Why do we care?
- What are they?
- When should we be ready?
- Why aren’t forecasts perfect?
- If a hurricane makes landfall, what should we expect?

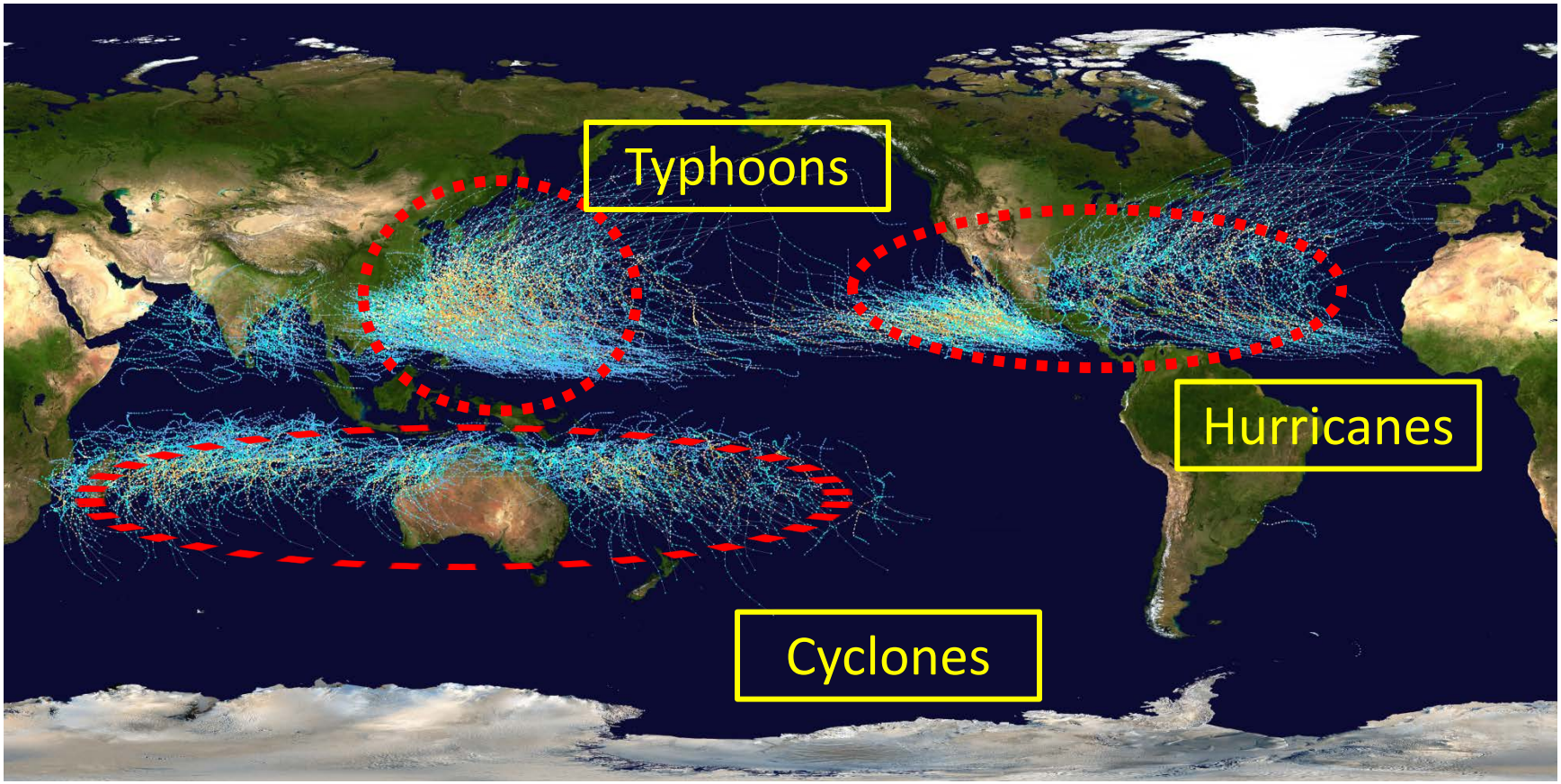
Why Do We Care?



The Name Game

- Tropical cyclones have different names, depending on their location.
  - In the Atlantic Ocean and Eastern Pacific Ocean, weaker systems are called tropical storms and the stronger ones are called hurricanes.
  - In the Northwest Pacific Ocean, weaker systems are also called tropical storms, but the stronger ones are called typhoons.
  - In the Southwest Pacific and Indian Oceans, they are simply called cyclones.

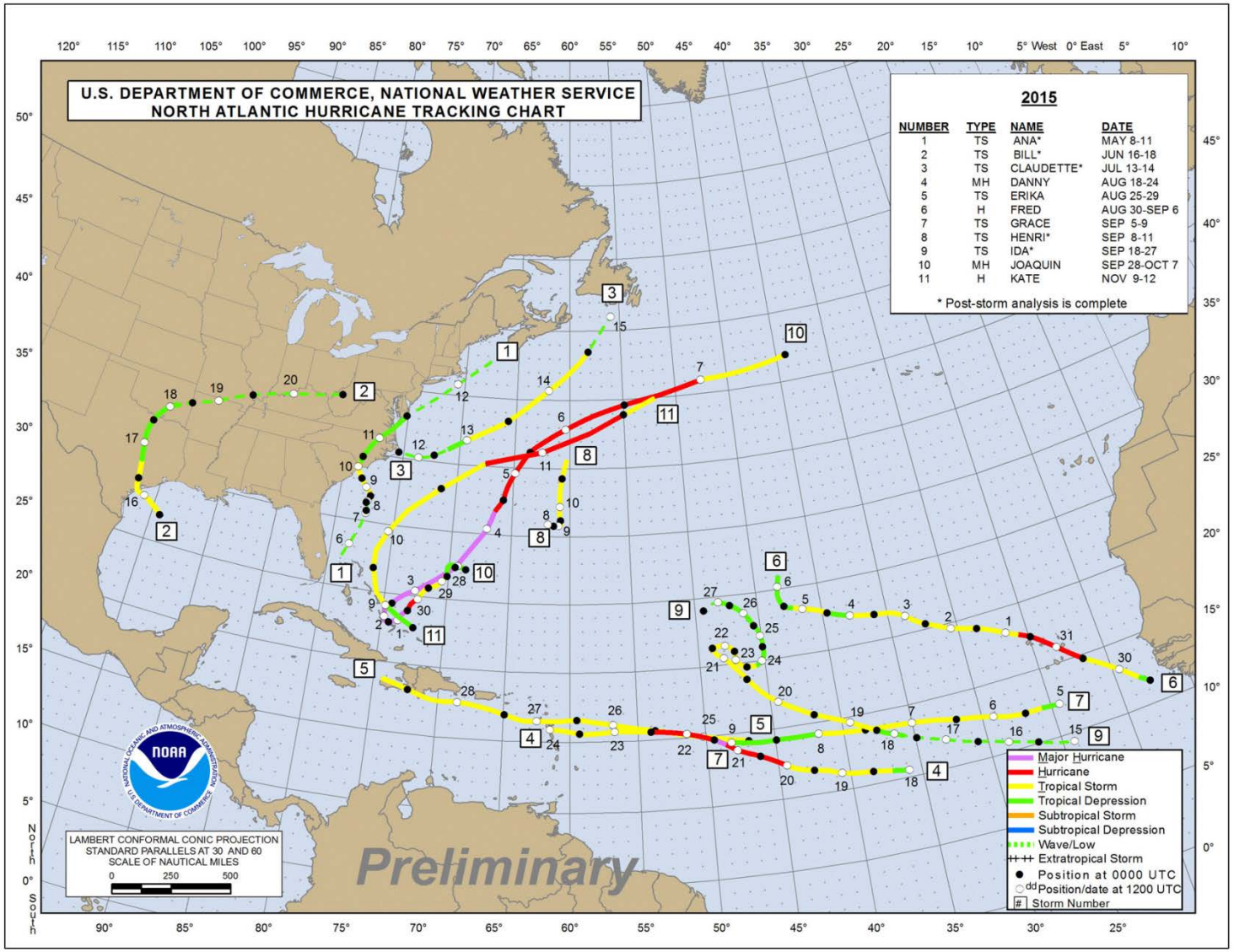
Tropical Cyclone Tracks



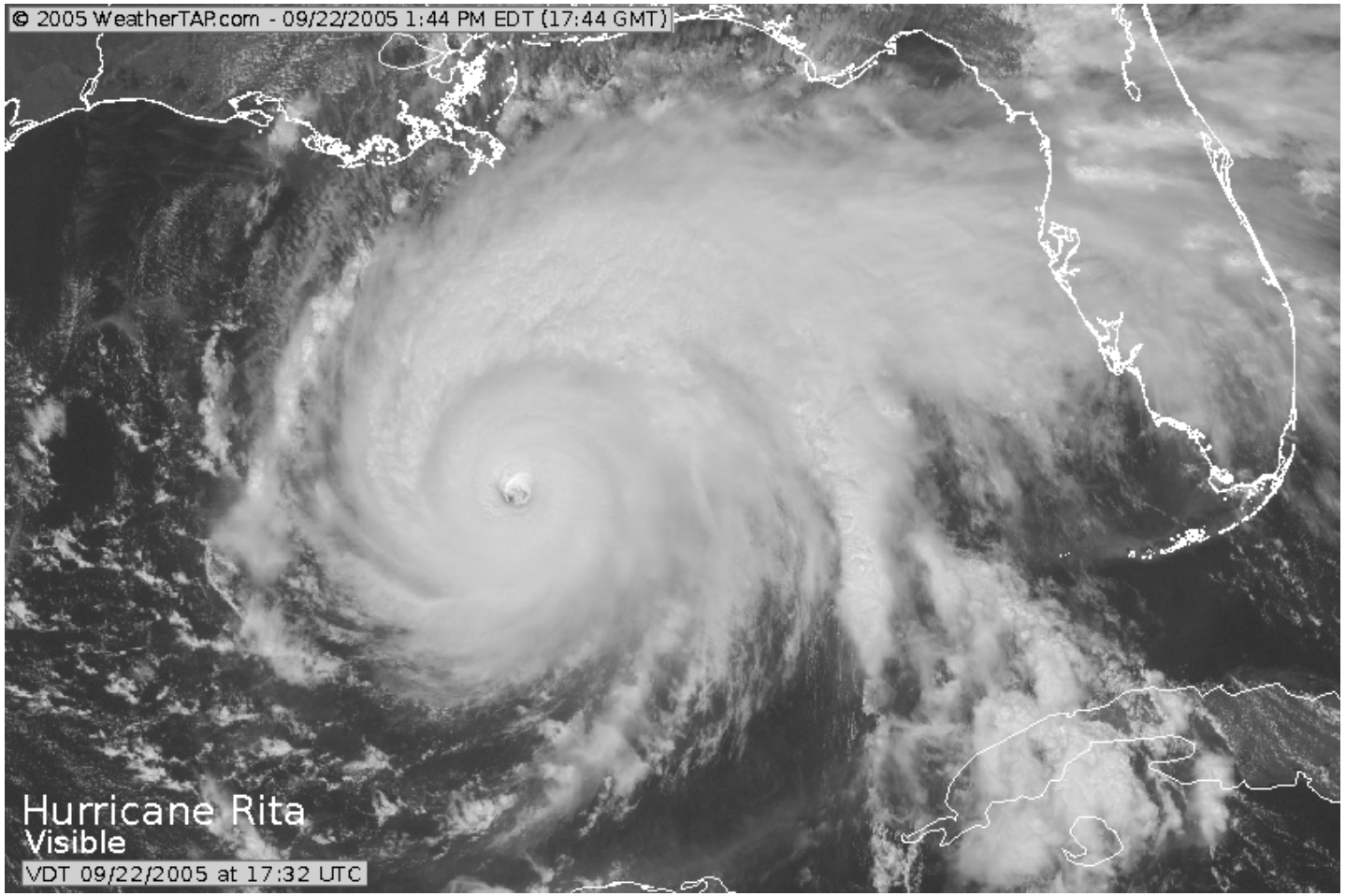
More Names

2015	2016	2017	2018	2019	2020
Ana	**Alex**	Arlene	Alberto	Andrea	Arthur
Bill	Bonnie	Bret	Beryl	Barry	Bertha
Claudette	Colin	Cindy	Chris	Chantal	Cristobal
Danny	Danielle	Don	Debby	Dorian	Dolly
Erika	Earl	Emily	Ernesto	Erin	Edouard
Fred	Fiona	Franklin	Florence	Fernand	Fay
Grace	Gaston	Gert	Gordon	Gabrielle	Gonzalo
Henri	Hermine	Harvey	Helene	Humberto	Hanna
Ida	Ian	Irma	Isaac	Imelda	Isaias
Joaquin	Julia	Jose	Joyce	Jerry	Josephine
Kate	Karl	Katia	Kirk	Karen	Kyle
Larry	Lisa	Lee	Leslie	Lorenzo	Laura
Mindy	Matthew	Maria	Michael	Melissa	Marco
Nicholas	Nicole	Nate	Nadine	Nestor	Nana
Odette	Otto	Ophelia	Oscar	Olga	Omar
Peter	Paula	Philippe	Patty	Pablo	Paulette
Rose	Richard	Rina	Rafael	Rebekah	Rene
Sam	Shary	Sean	Sara	Sebastien	Sally
Teresa	Tobias	Tammy	Tony	Tanya	Teddy
Victor	Virginie	Vince	Valerie	Van	Vicky
Wanda	Walter	Whitney	William	Wendy	Wilfred

2015 Hurricane Season



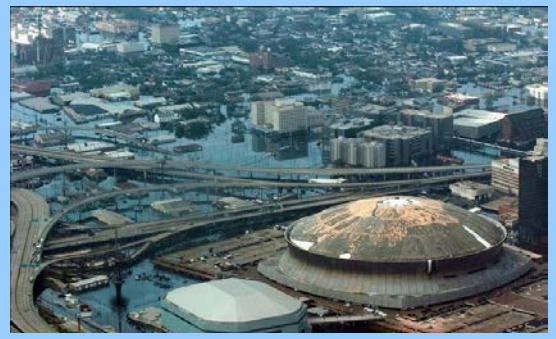
What Are They?

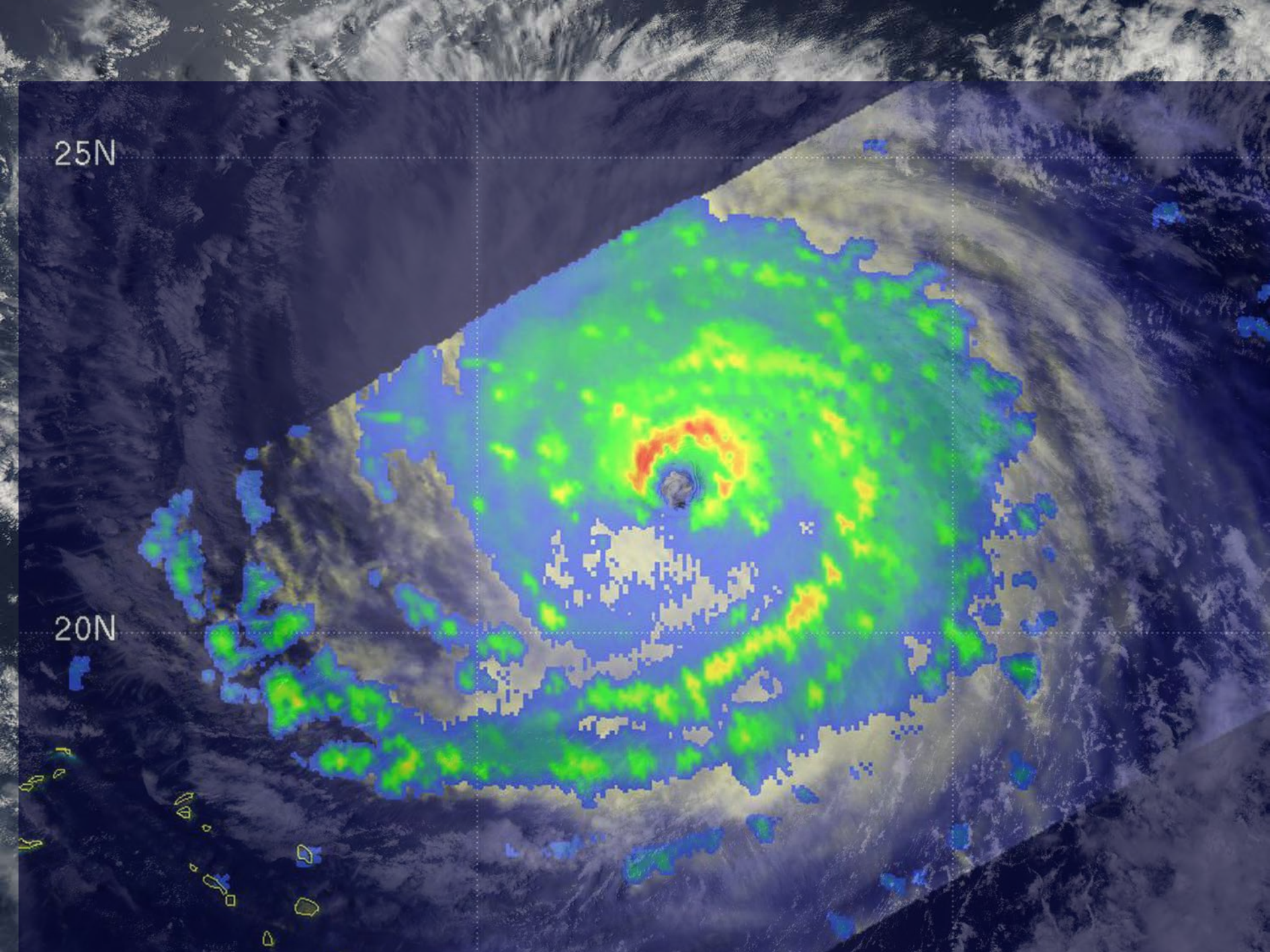


A ‘Cane?

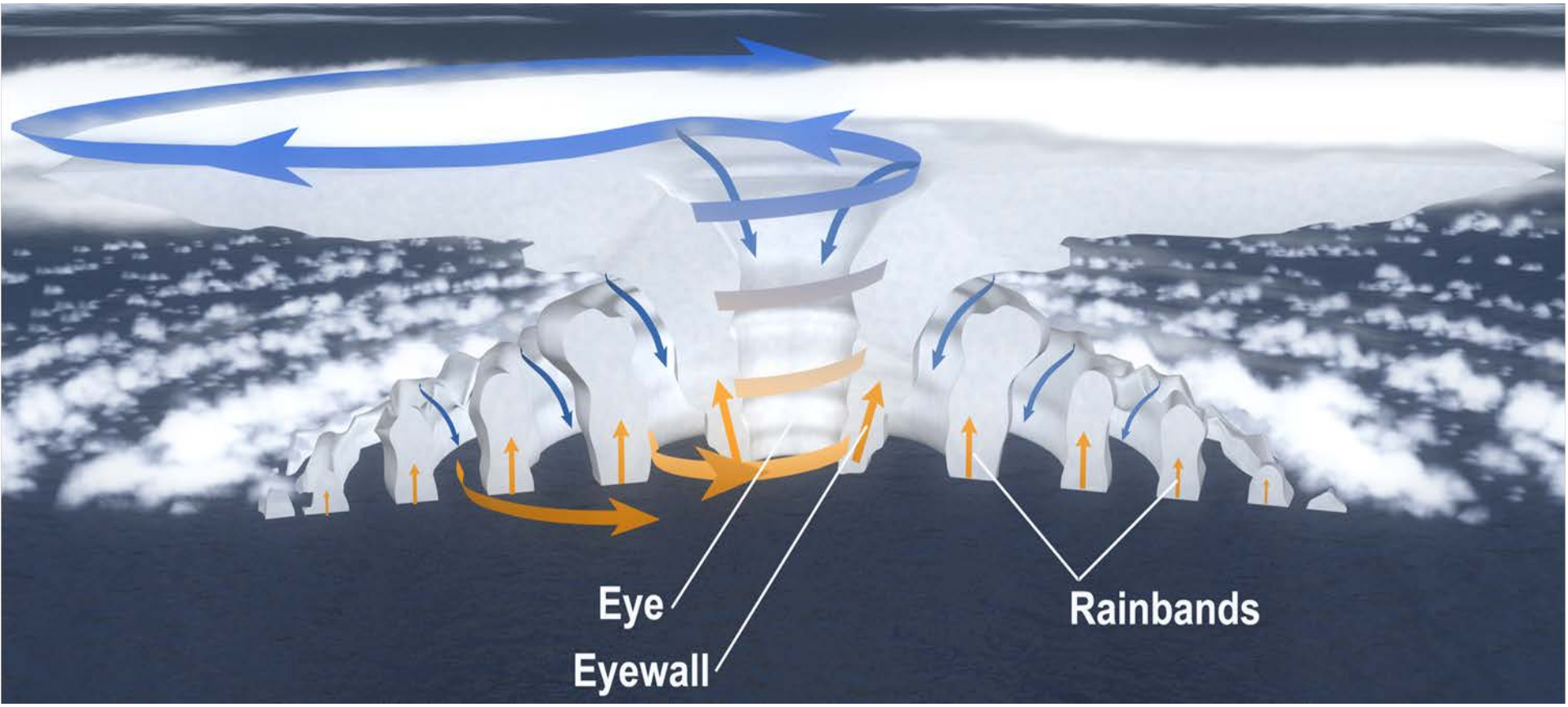
- Counter-clockwise rotating thunderstorms spinning around a massive low pressure system
- Energy comes from sea water evaporating, rising, and releasing heat
- An area of strong winds and heavy rain
- Only classified by surface wind speed… Saffir-Simpson Scale:
  - Tropical Depression (numbered but not named)
  - Tropical Storm (named... 40mph+, better organized)
  - Hurricane (named... 74mph+, assigned a category 1-5)

The Saffir-Simpson Intensity Scale

Category	Maximum Sustained Winds	Description
Tropical Storm	40-73 mph	
Category 1 Hurricane	74-95 mph	
Category 2 Hurricane	96-110 mph	
Category 3 Hurricane	111-130 mph	
Category 4 Hurricane	131-155 mph	
Category 5 Hurricane	> 155 mph	


25N
20N

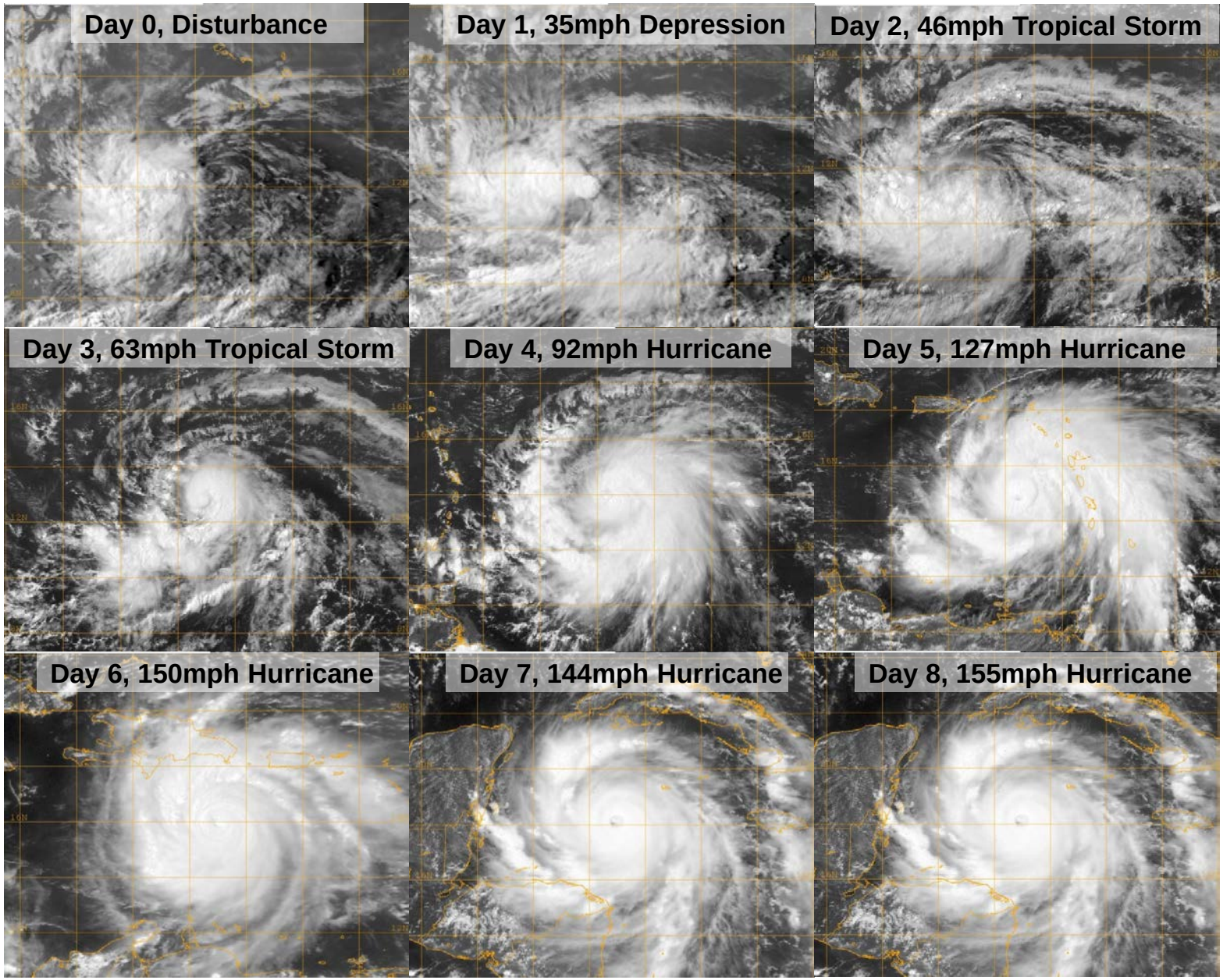
Side-View of a Hurricane



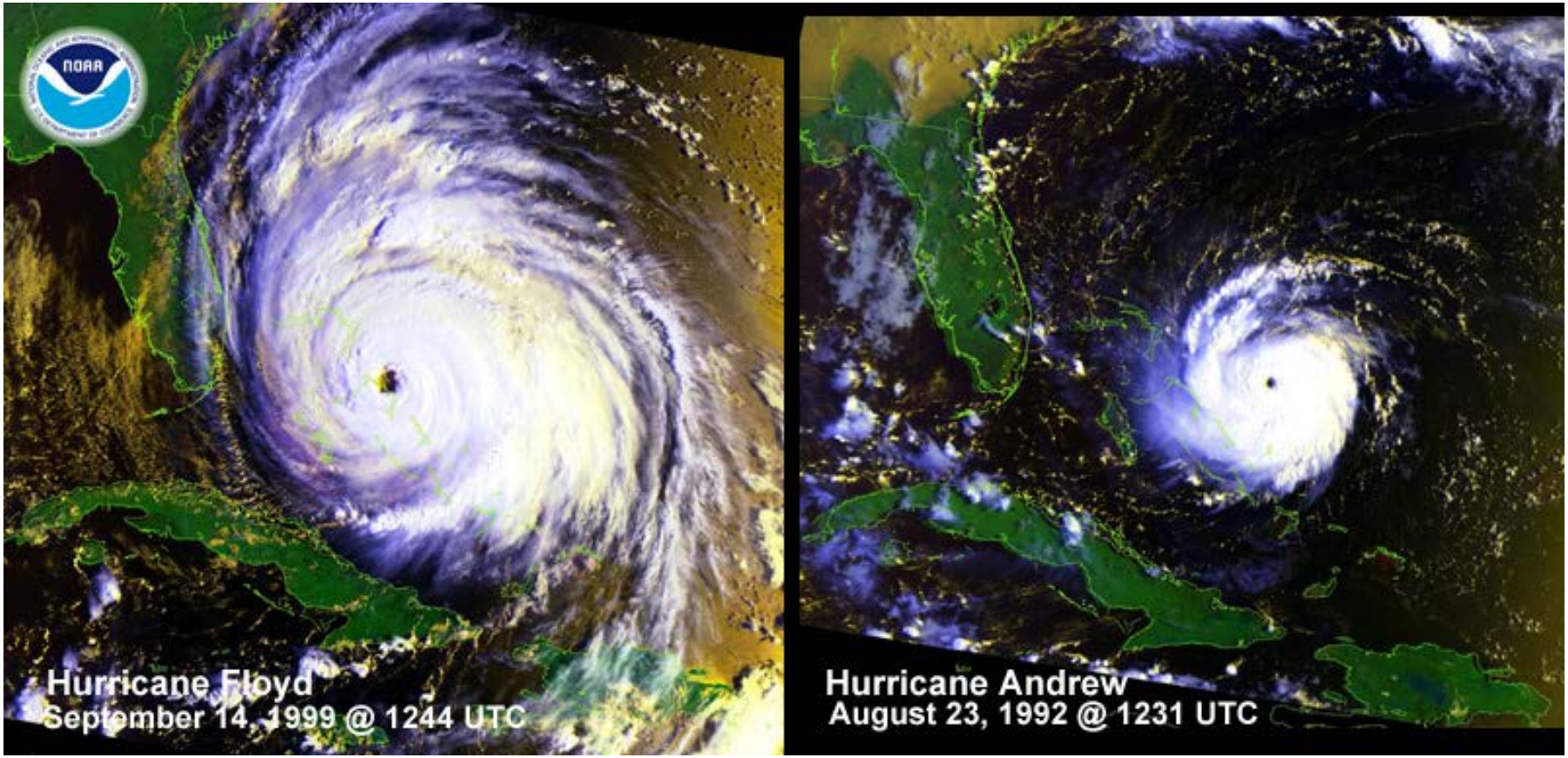
Typical eye width~20 miles

Typical hurricane width~300-400 miles

Life Expectancy

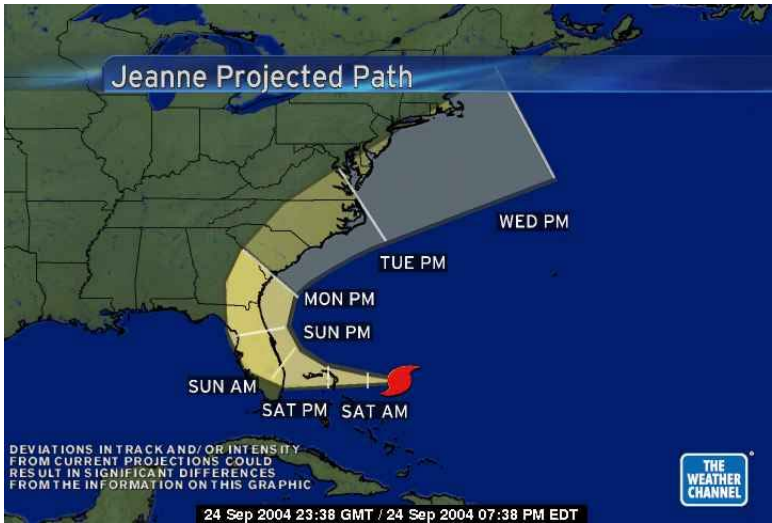


Does Size Matter?

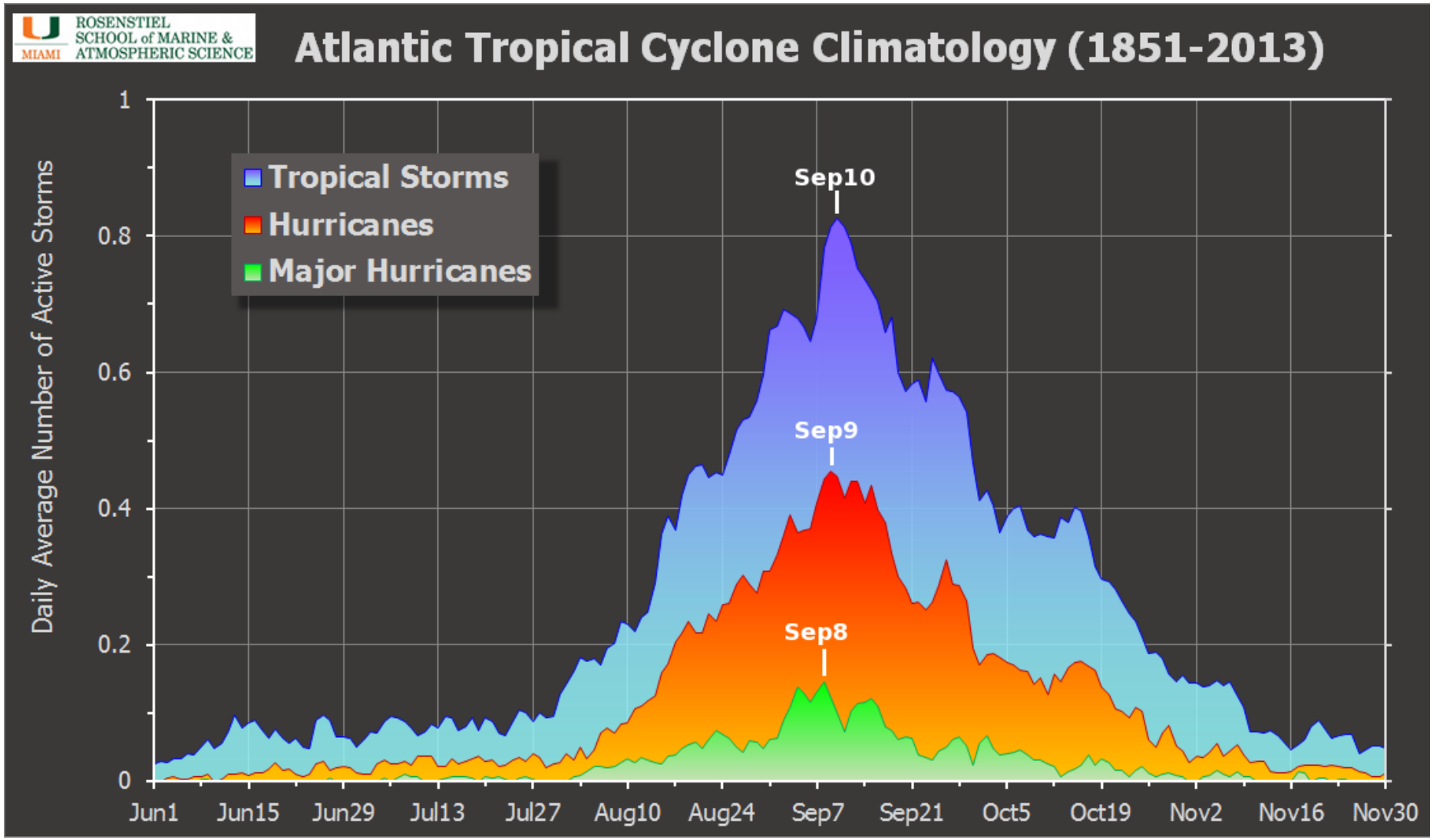


- **Yes**, the bigger a storm is, the more area it will affect with rain, wind, and storm surge, but...
- A larger storm is not necessarily a stronger storm and vice versa.

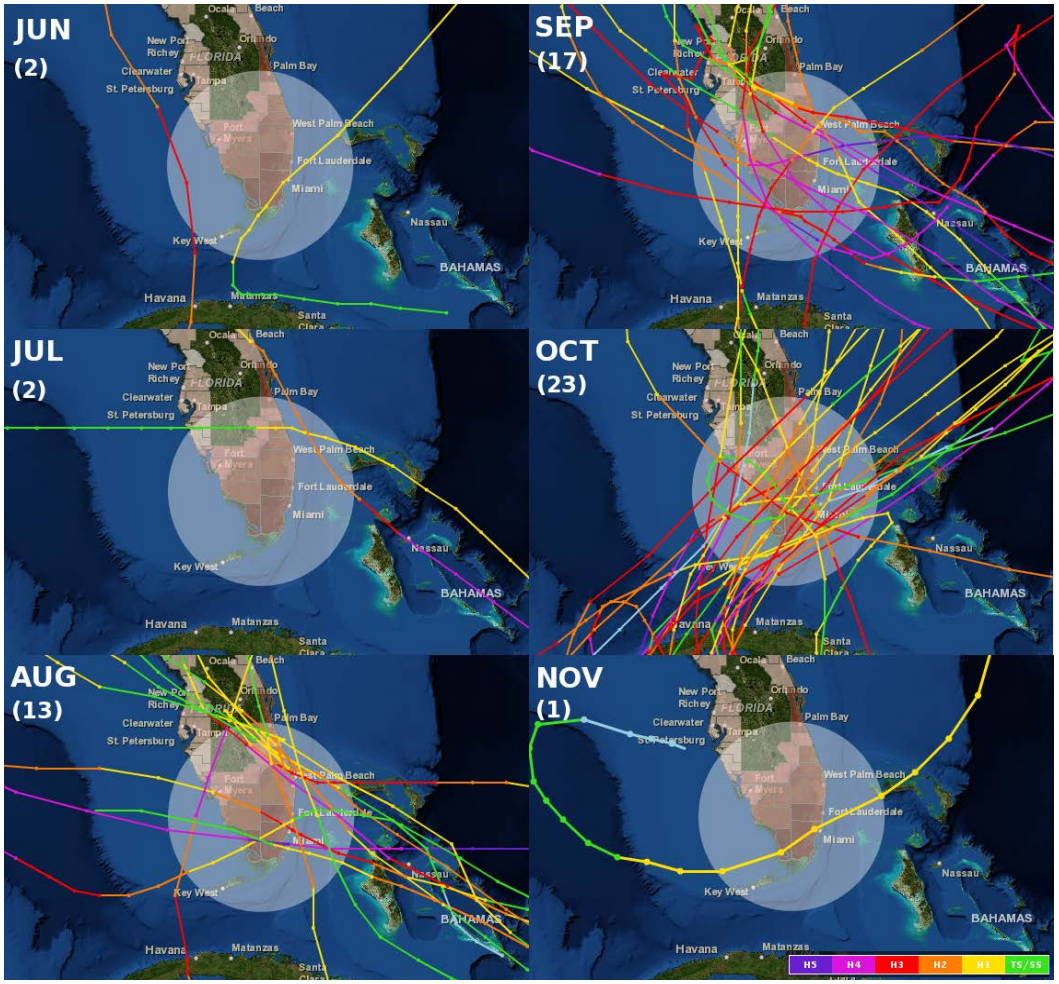
When Should We Be Ready?



When is it Time to Tune in?

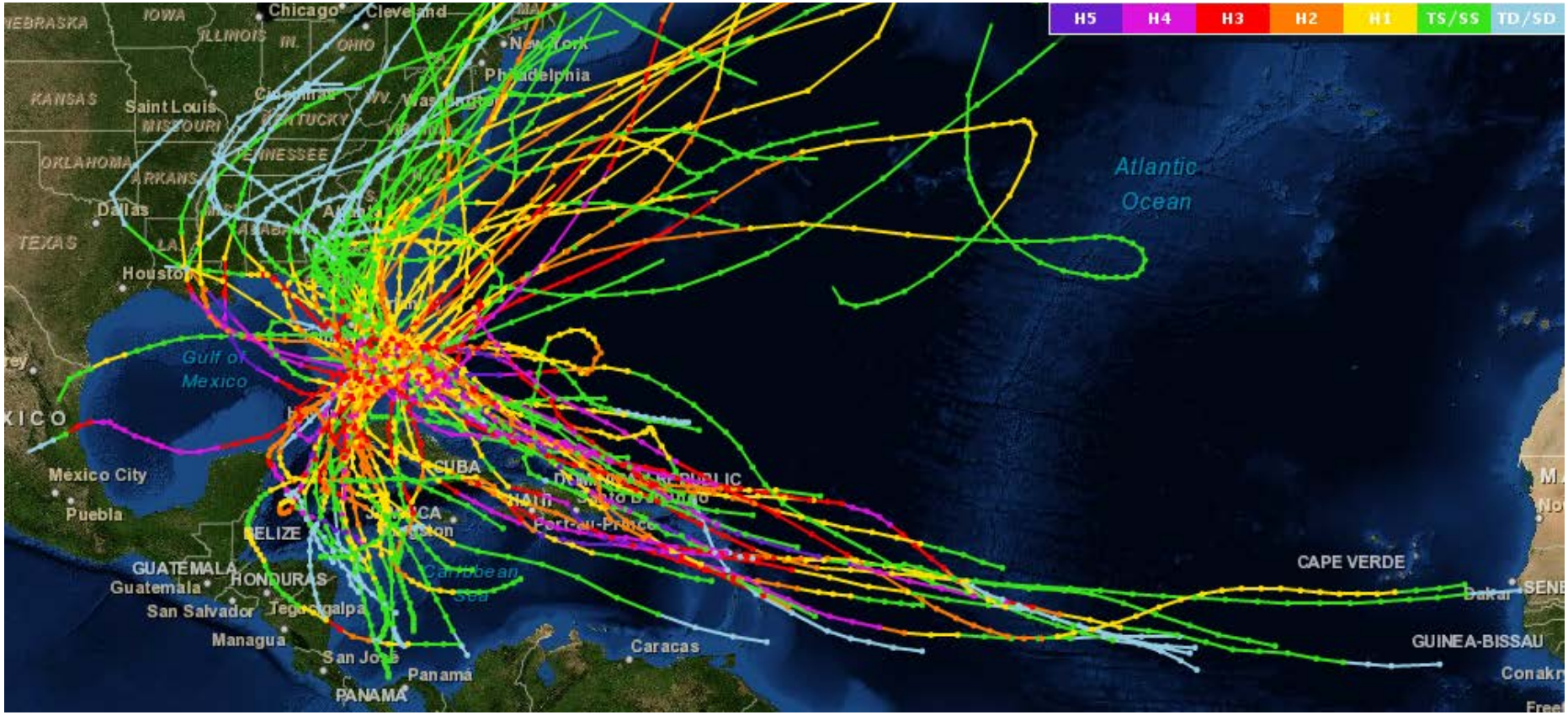


With Great Weather Comes Great Responsibility?



Hurricanes affecting South Florida since 1851

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



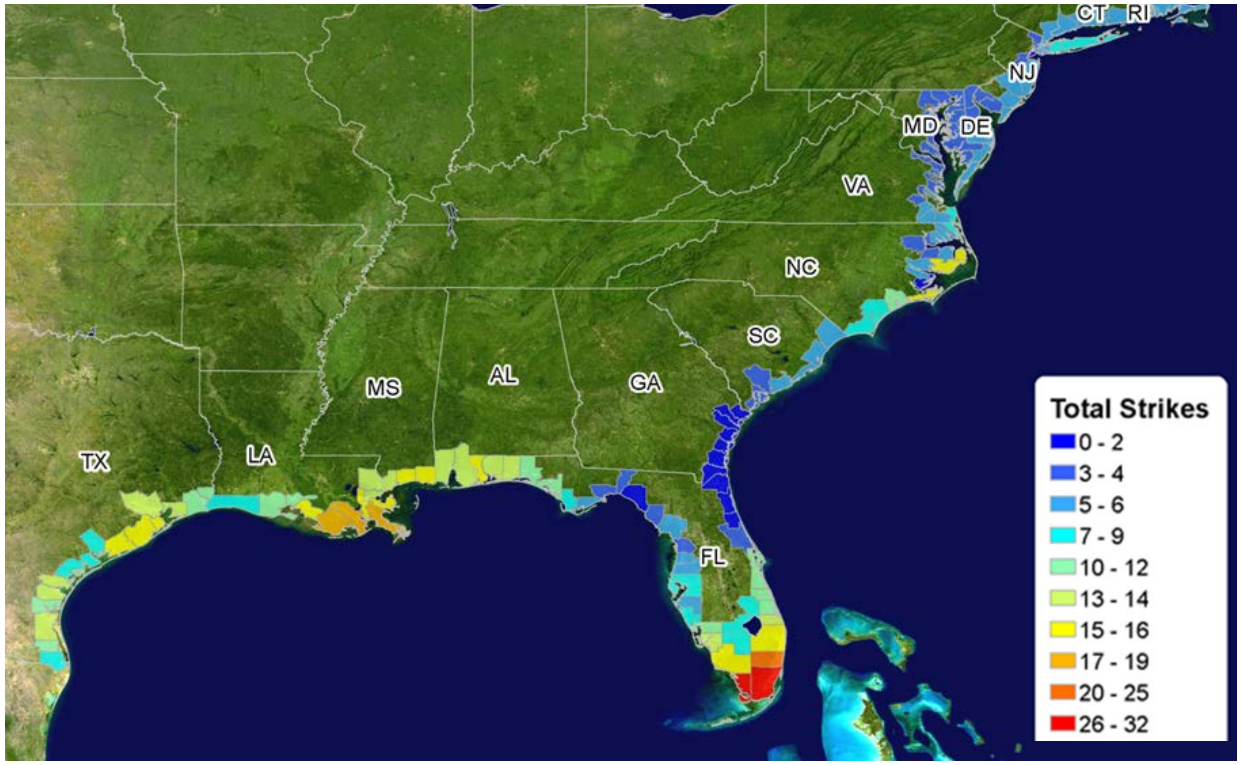
What Month Has Had Most Hurricane Strikes in South FL?

- 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

Why Aren't Hurricane Forecasts Perfect?

1) Taking Measurements

Variety of instruments define initial conditions (starting point for forecasts)

2) Model Predictions

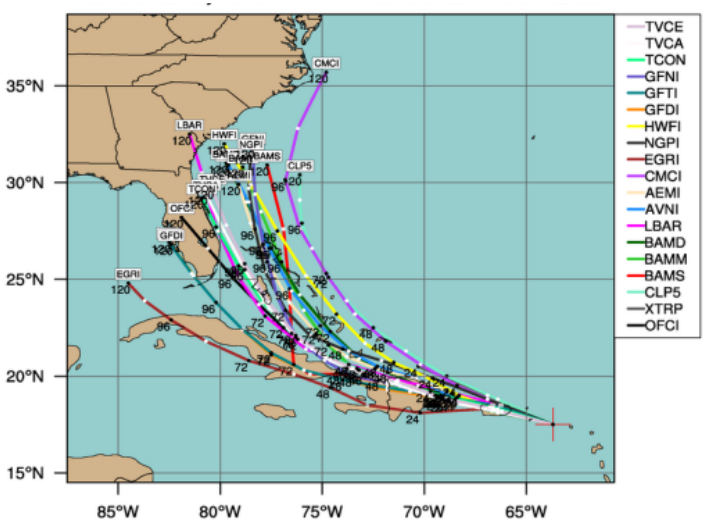
Weather models on the world's fastest super computers predict the future state of the weather based on current information and approximate equations

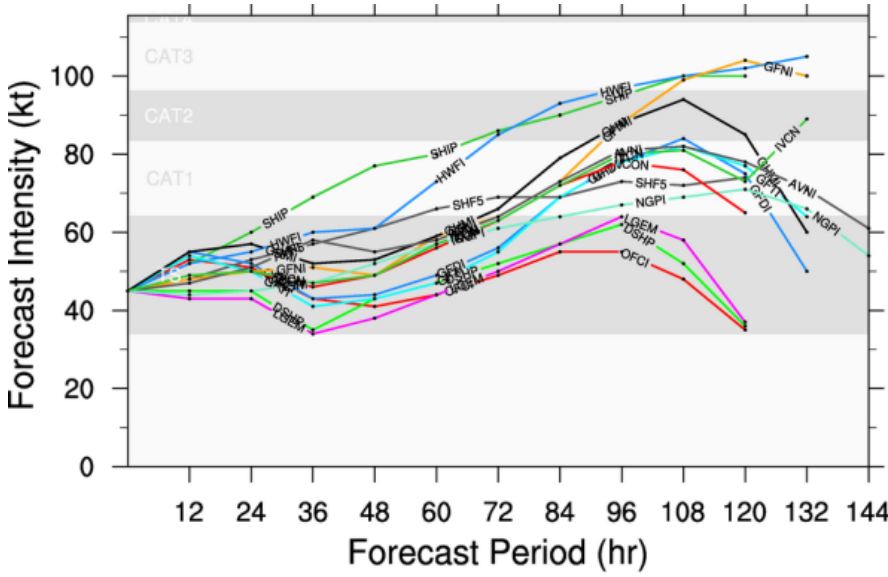
$$u\frac{\partial u}{r\partial\theta}+v\left(\frac{\partial u}{\partial r}+\frac{u}{r}+f\right)+\omega\frac{\partial u}{\partial p}$$
$$=-\frac{\partial}{\partial r}\left[\nu\left(\frac{\partial u}{\partial r}+\frac{u}{r}\right)\right]+\frac{\partial}{r\partial\theta}\left[\nu\left(\frac{\partial u}{r\partial\theta}\right)\right]$$
$$+\frac{\partial}{\partial p}\left[\varkappa\left(\frac{\partial u}{\partial p}\right)\right],$$

$$u\frac{\partial v}{r\partial\theta}+v\frac{\partial v}{\partial r}-u\left(\frac{u}{r}+f\right)+\omega\frac{\partial v}{\partial p}$$
$$=-g\frac{\partial z}{\partial r}+\frac{\partial}{\partial r}\left[\nu\left(\frac{\partial v}{\partial r}+\frac{v}{r}\right)\right]+\frac{\partial}{r\partial\theta}\left[\nu\left(\frac{\partial v}{r\partial\theta}\right)\right]$$
$$+\frac{\partial}{\partial p}\left[\varkappa\left(\frac{\partial v}{\partial p}\right)\right]-\frac{2}{r^2}\frac{\partial(uv)}{\partial\theta},$$

3) “Ensemble” of Forecasts

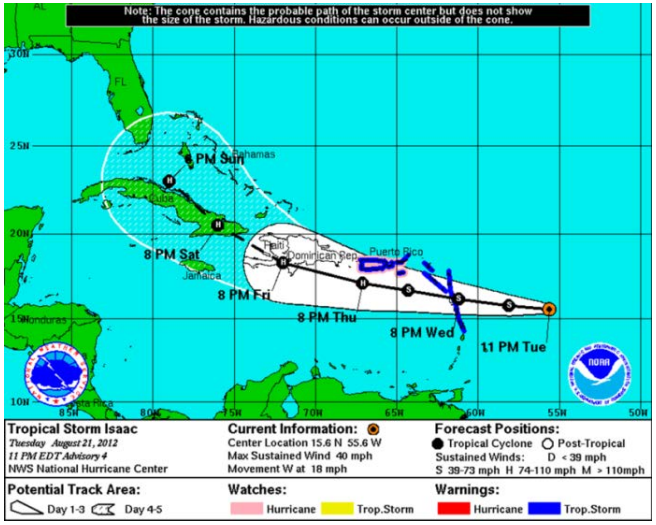
Different equations, initial conditions, and modelling techniques lead to a variety of predictions





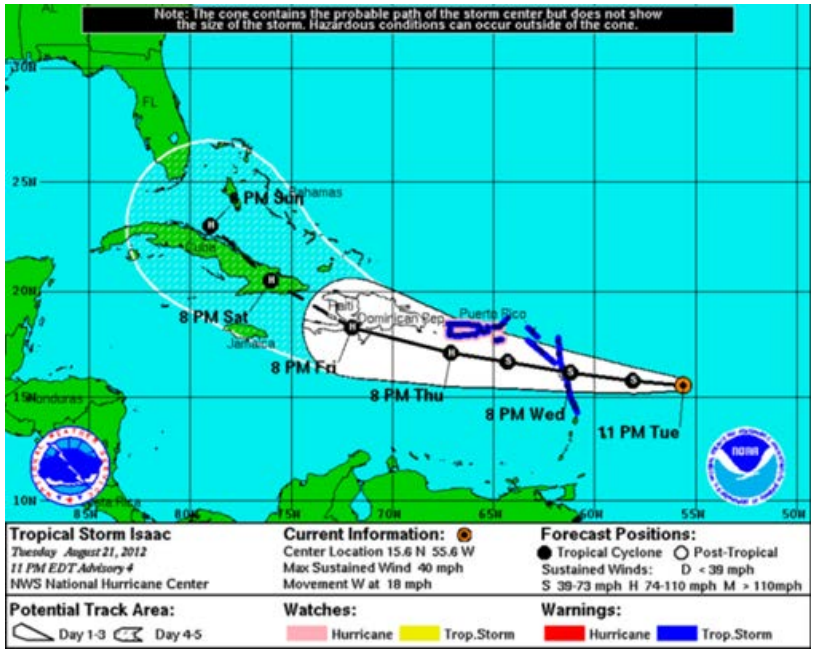
4) The Official Forecast

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



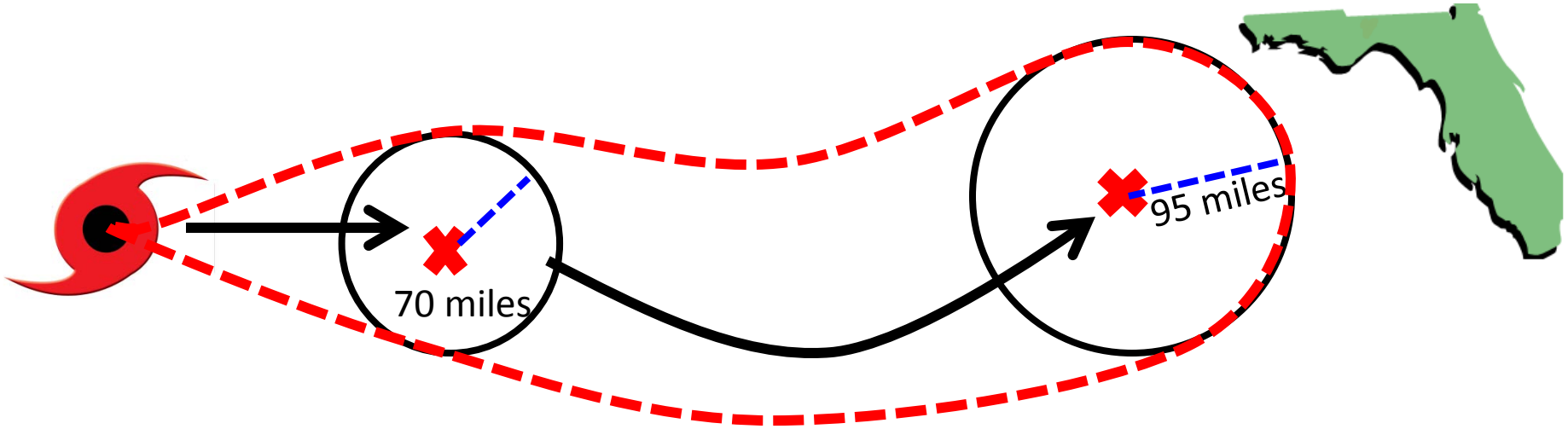
What is the Cone?

- The “forecast cone” or “cone of uncertainty” predicts the path of the storm center **(track forecast).**
- It is not an impacts cone!

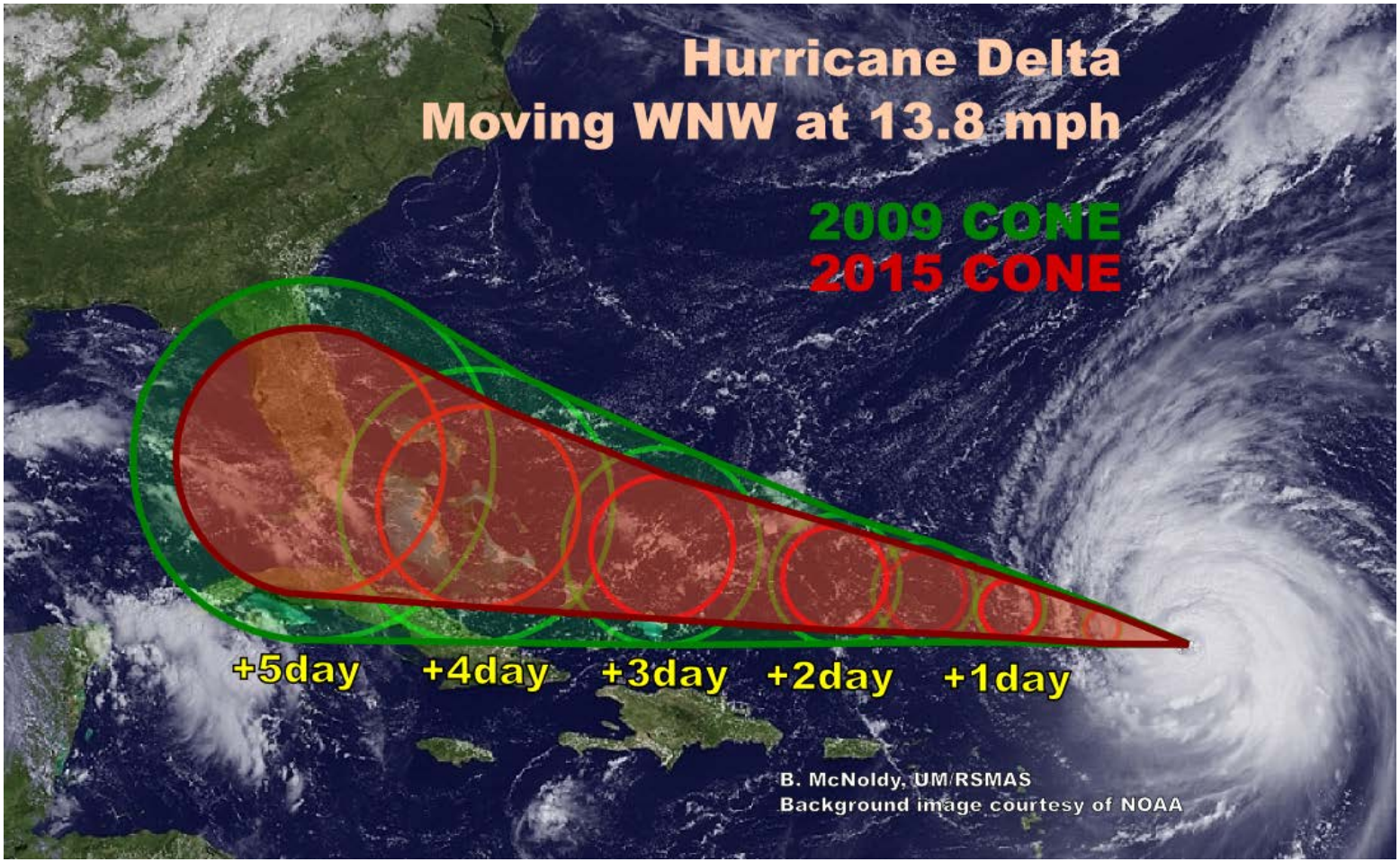


Making the Cone

- For 2 out of 3 forecasts:
  - The 24-hour true storm location will differ from its predicted track by less than 70 miles
  - At 48 hours … by less than 95 miles
- Draw a circle for the possible location of the center of the hurricane at each forecast hour
- Outline the circles to complete the cone

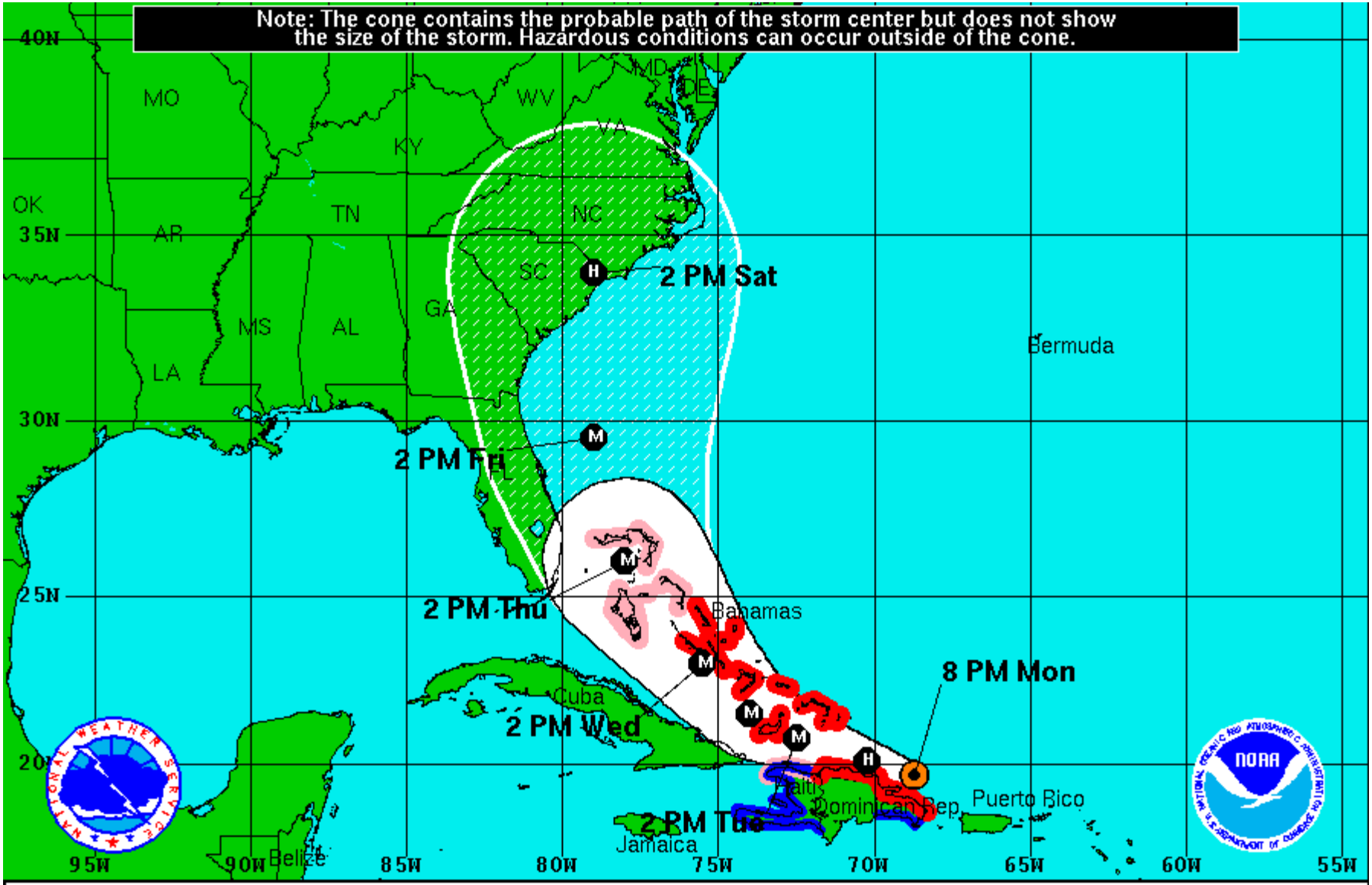


Smaller Errors = Smaller Cone



Do You Understand The Cone?

- Forecasts further out in time have more uncertainty.
- As track forecasts improve, the size of the cone decreases.
- Storms should leave the cone 1/3 of the time.
- The forecast cone is not an impacts 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

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

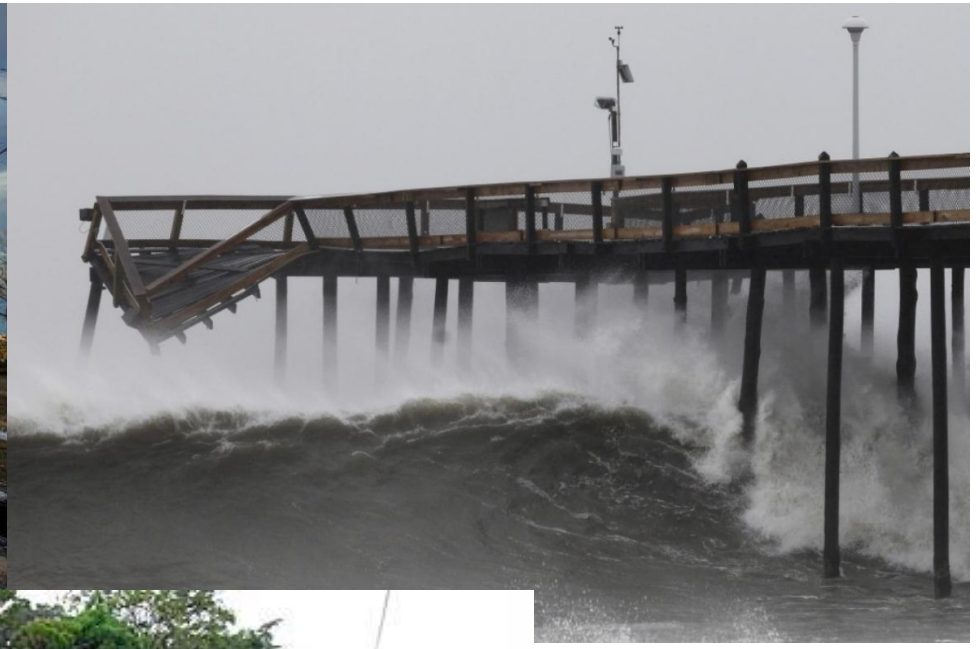
Watches:
Hurricane Trop.Storm

Warnings:
Hurricane Trop.Storm

What to Expect During a Hurricane Landfall

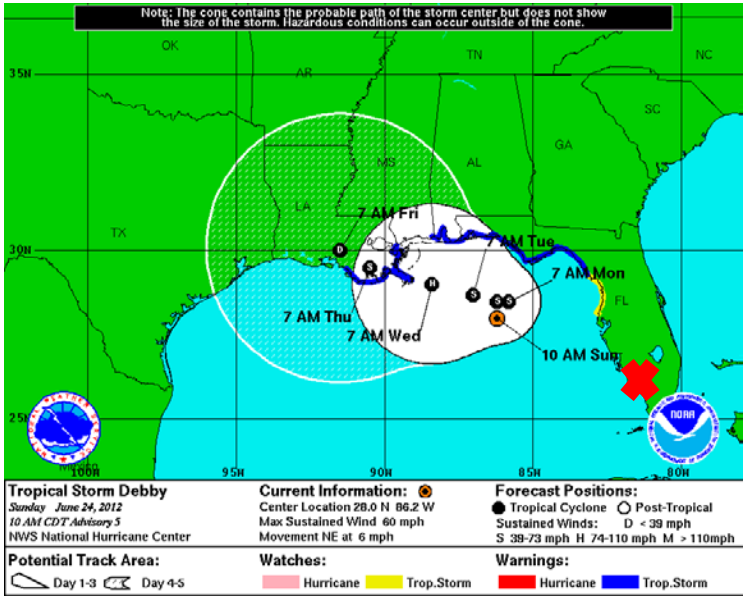
- Storm Surge
- Wind
- Rain
- Tornadoes
- Waves/Rip Currents

Wind, Rain, and Waves



Tornadoes

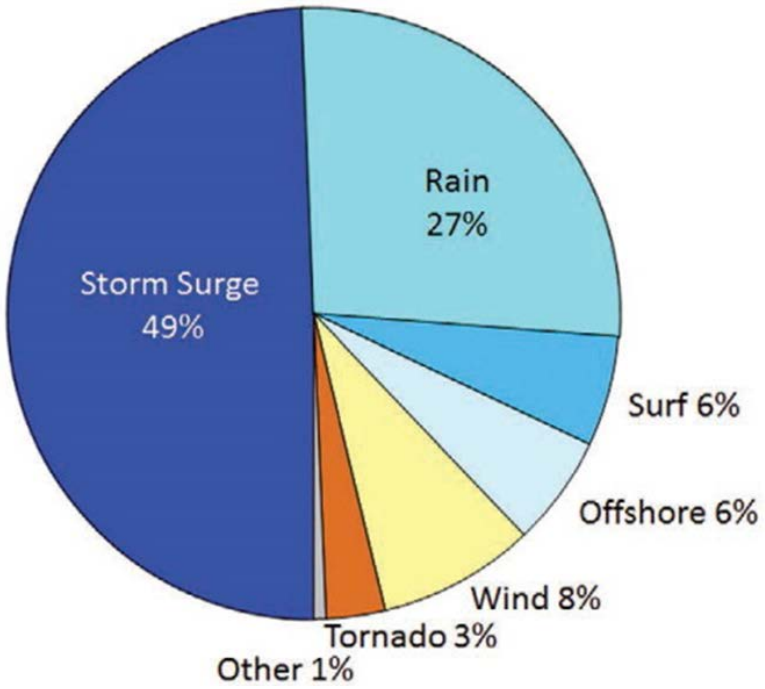
- Nearly 70% of landfalling hurricanes cause at least 1 tornado.
- These tornadoes most often occur in thunderstorms in rainbands away from the center of the hurricane.



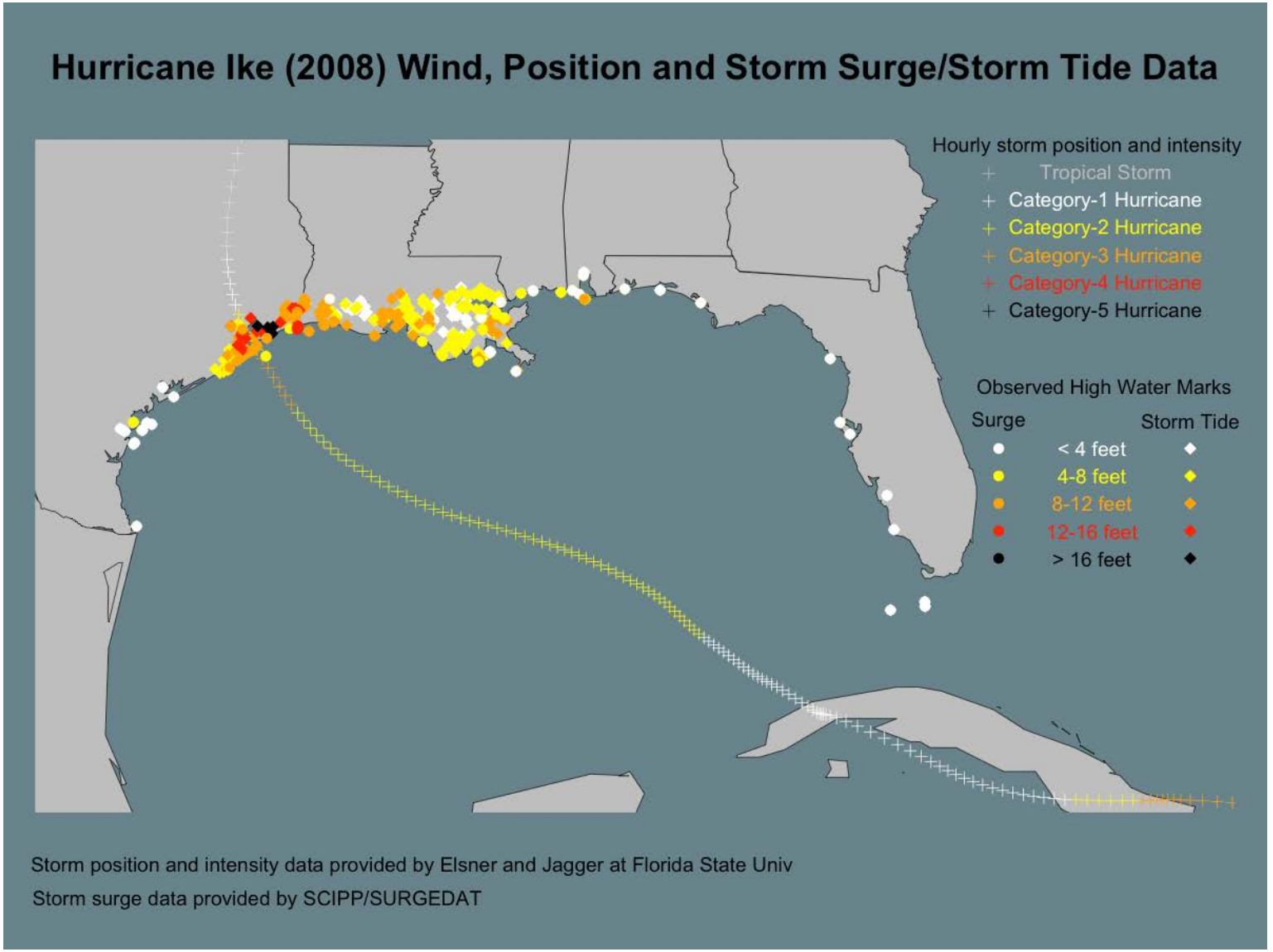
Storm Surge: Wind Pushing Water

- The #1 cause of deaths in hurricanes

- Storm surge is produced by water being pushed toward the shore by the storm winds



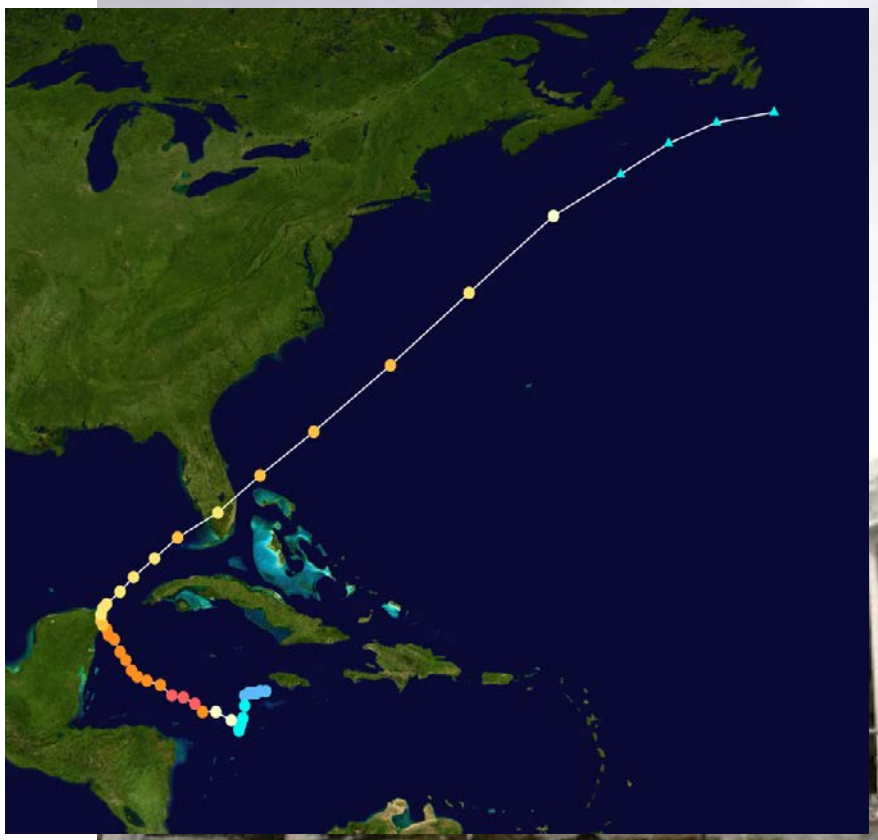
A Long-Distance Relationship

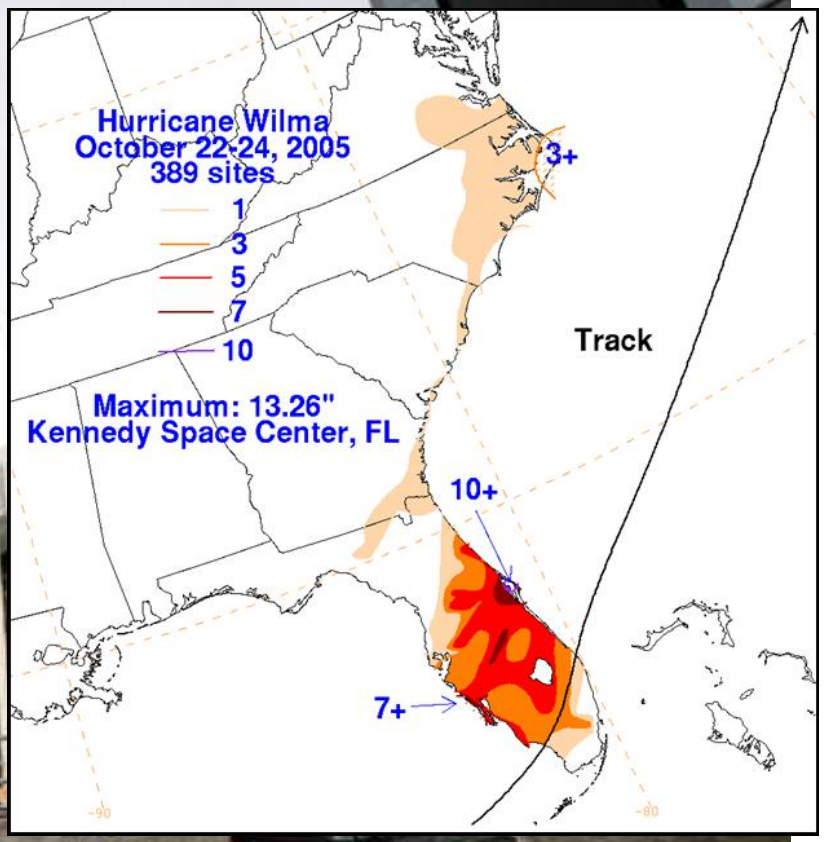


Could we see this type of flooding in South Florida?

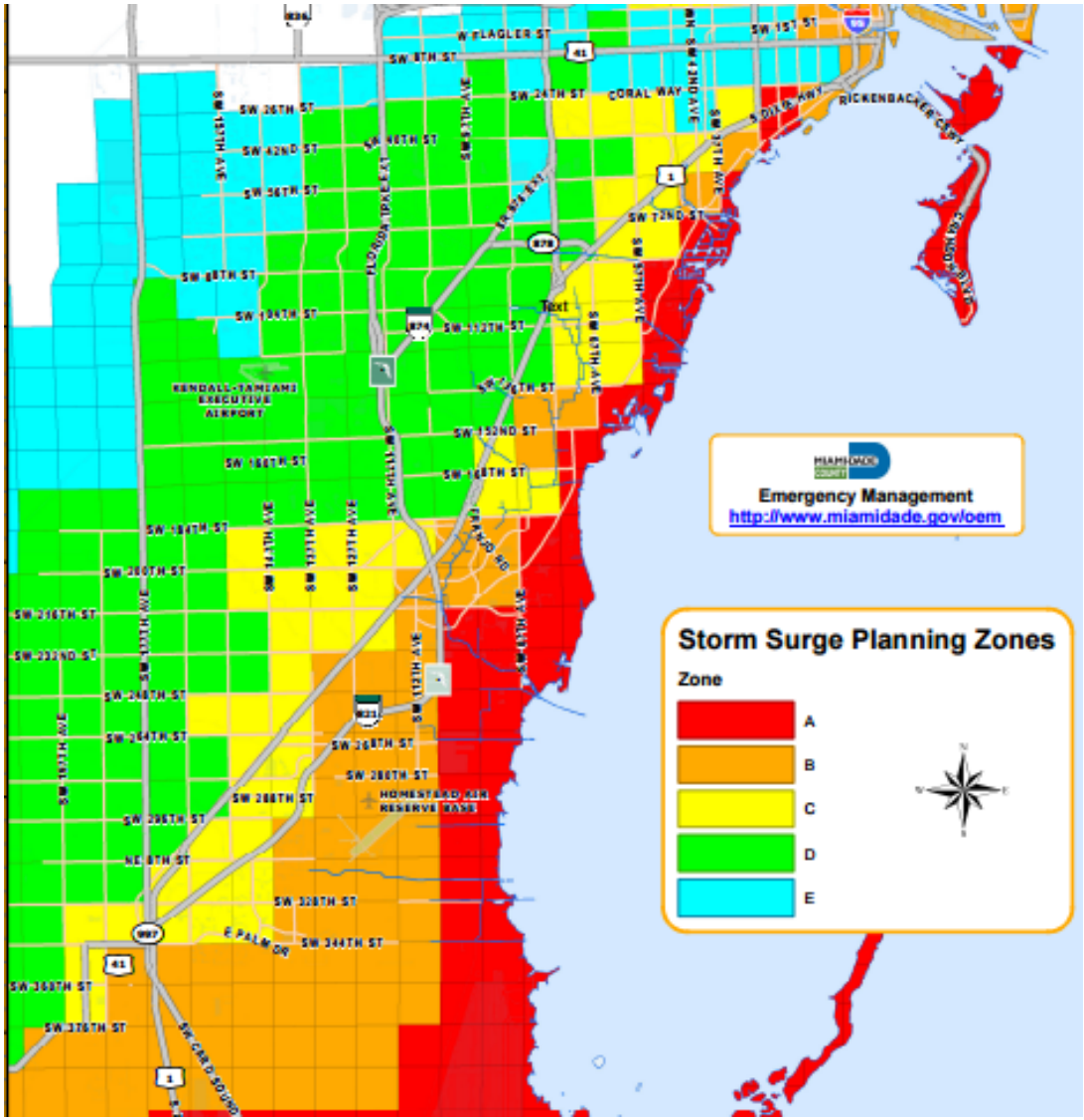
Hurricane Katrina (2005): New Orleans

Hurricane Wilma (2005): Miami





So… Know Your Zone



Lessons Learned

- Hurricanes and tropical storms (tropical cyclones) are named differently in different oceans and based on their wind speeds

- August through October is the peak of hurricane season for the U.S. but October is the busiest month for Florida

- The “cone of uncertainty” shows where the center of the storm will go 2/3 of time but the storm’s destruction 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