



Miami and Hurricanes: Now and in the future

Rebecca Evans
Josh Wadler

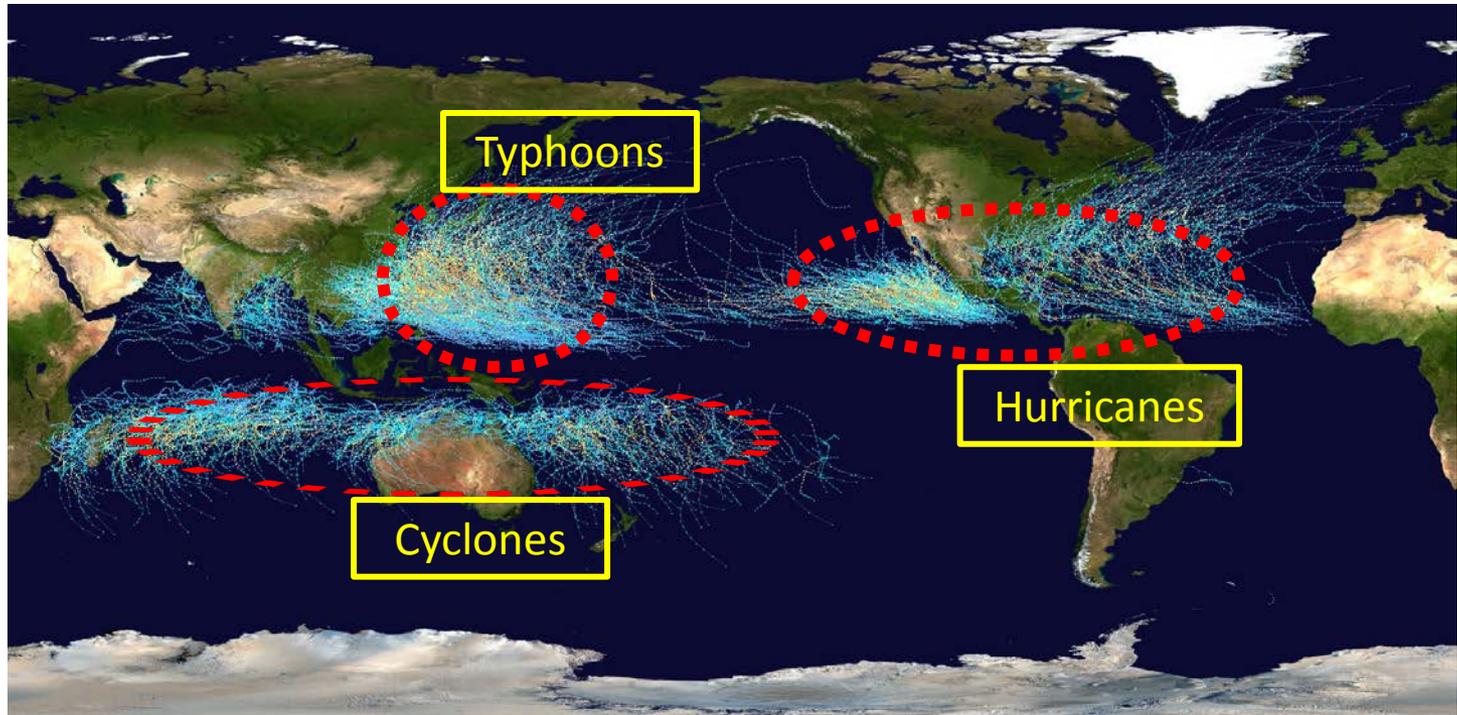
Carrollton School - JAN 30TH 2018

Overview

- 1) The science of hurricanes
- 2) Forecasts
- 3) Hurricane hazards
- 4) Hurricanes and climate change



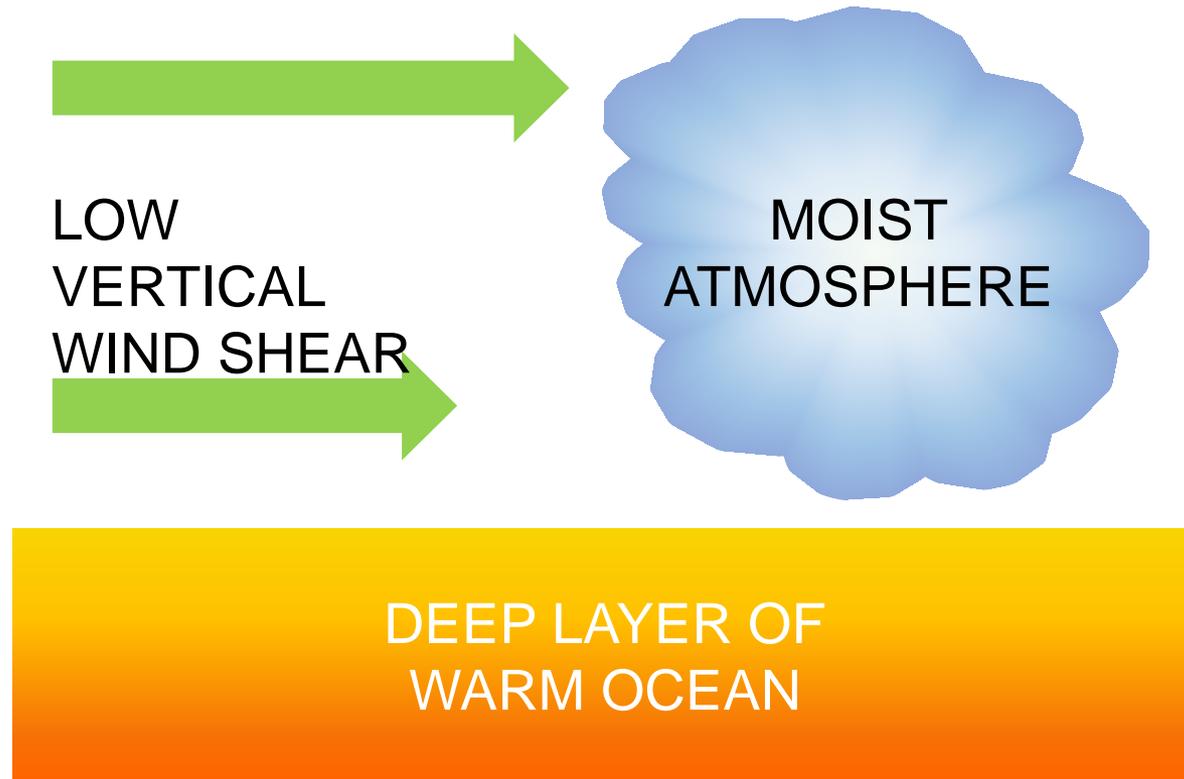
Tropical Cyclones Around the World



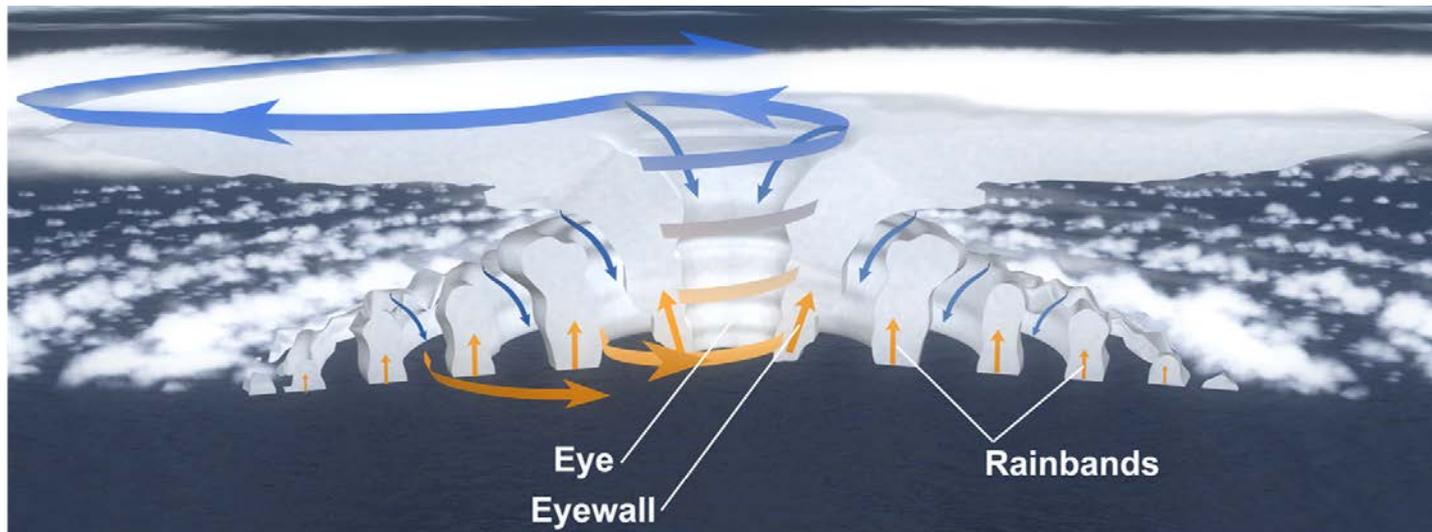
Hurricane Recipe



Recipe For a Hurricane



Into the Storm



~20 miles



~300-400 miles

Categories

Wind Speeds	Category						
	Tropical Depression ≤38mph	Tropical Storm 39-73mph	One 74-95mph	Two 96-110mph	Three 111-129mph	Four 130-156mph	Five ≥157mph

Based *only* on sustained wind speeds in the eyewall

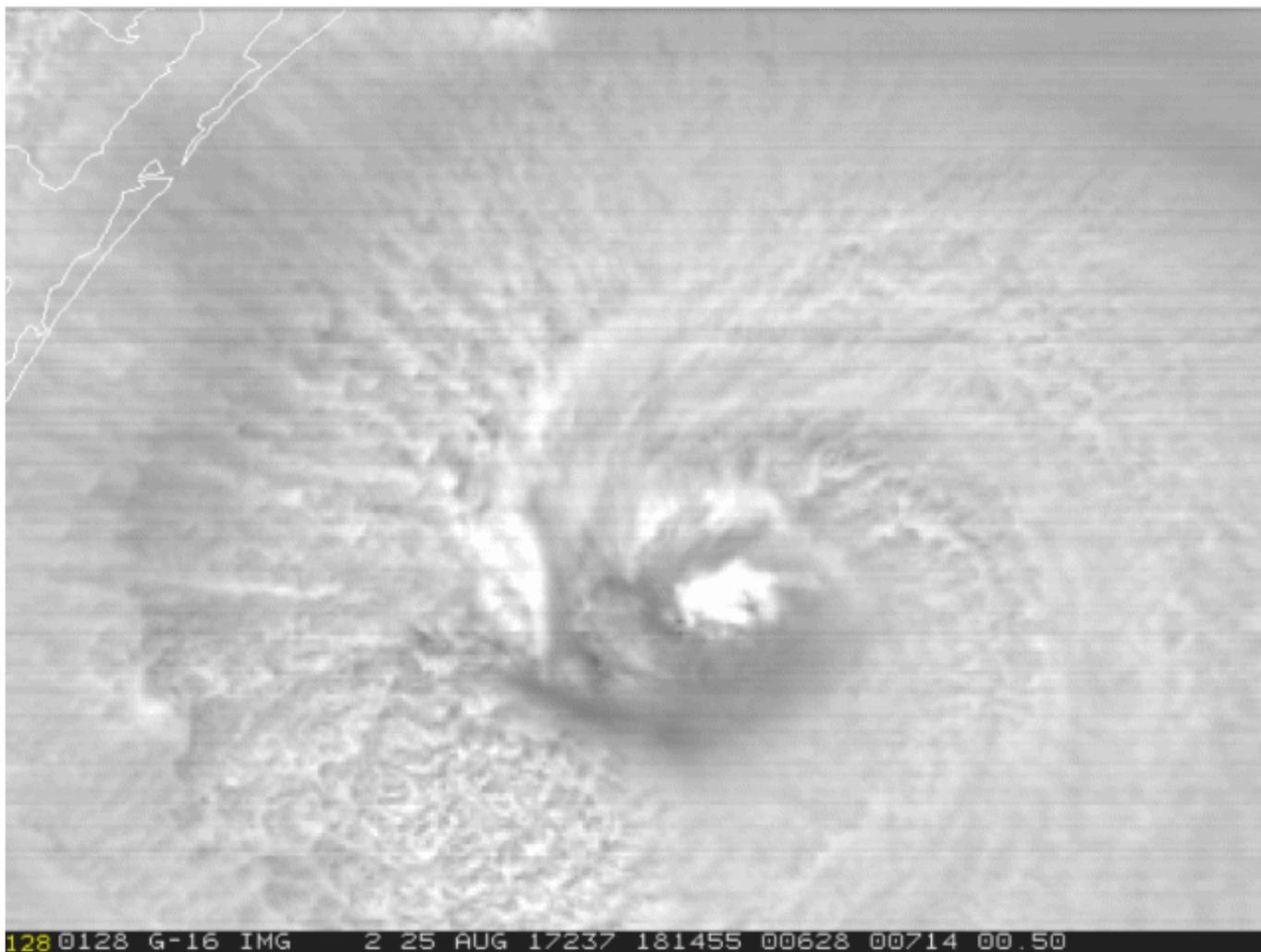
Even weak hurricanes and tropical storms can be very destructive

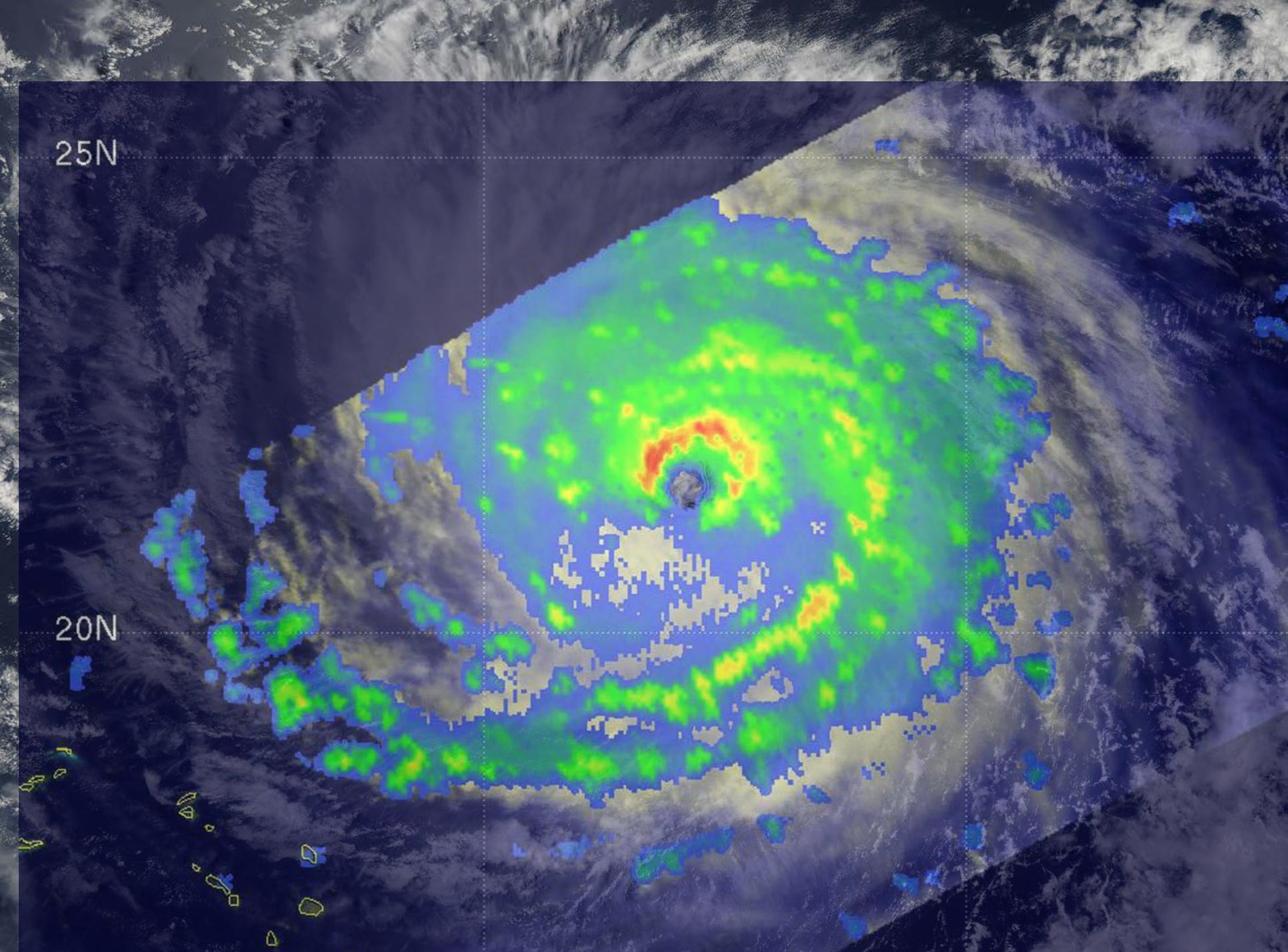
Does size matter?



However, Hurricane Andrew was a small storm but was devastating for Miami-Dade

What does a forecaster look at?

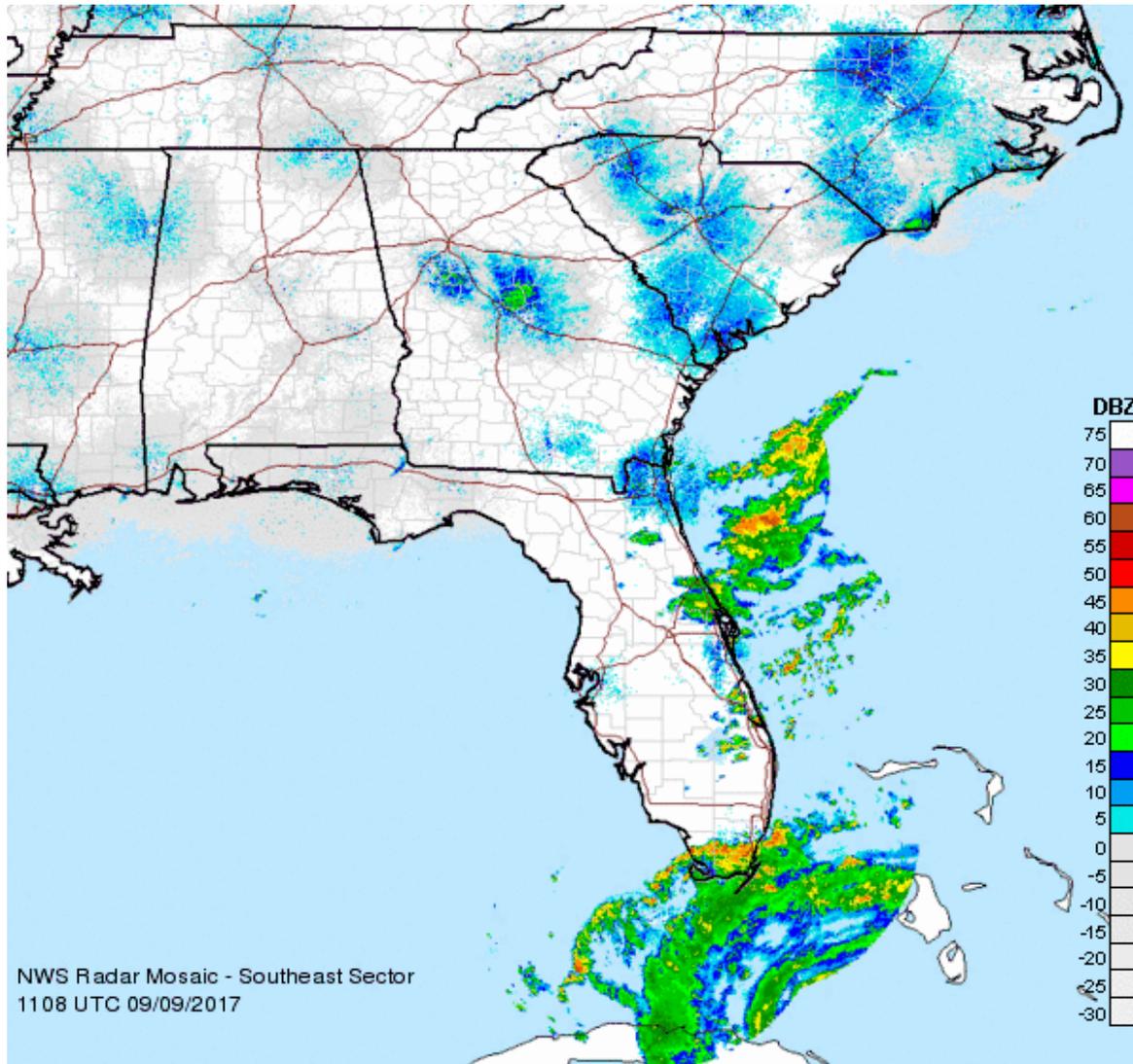




25N

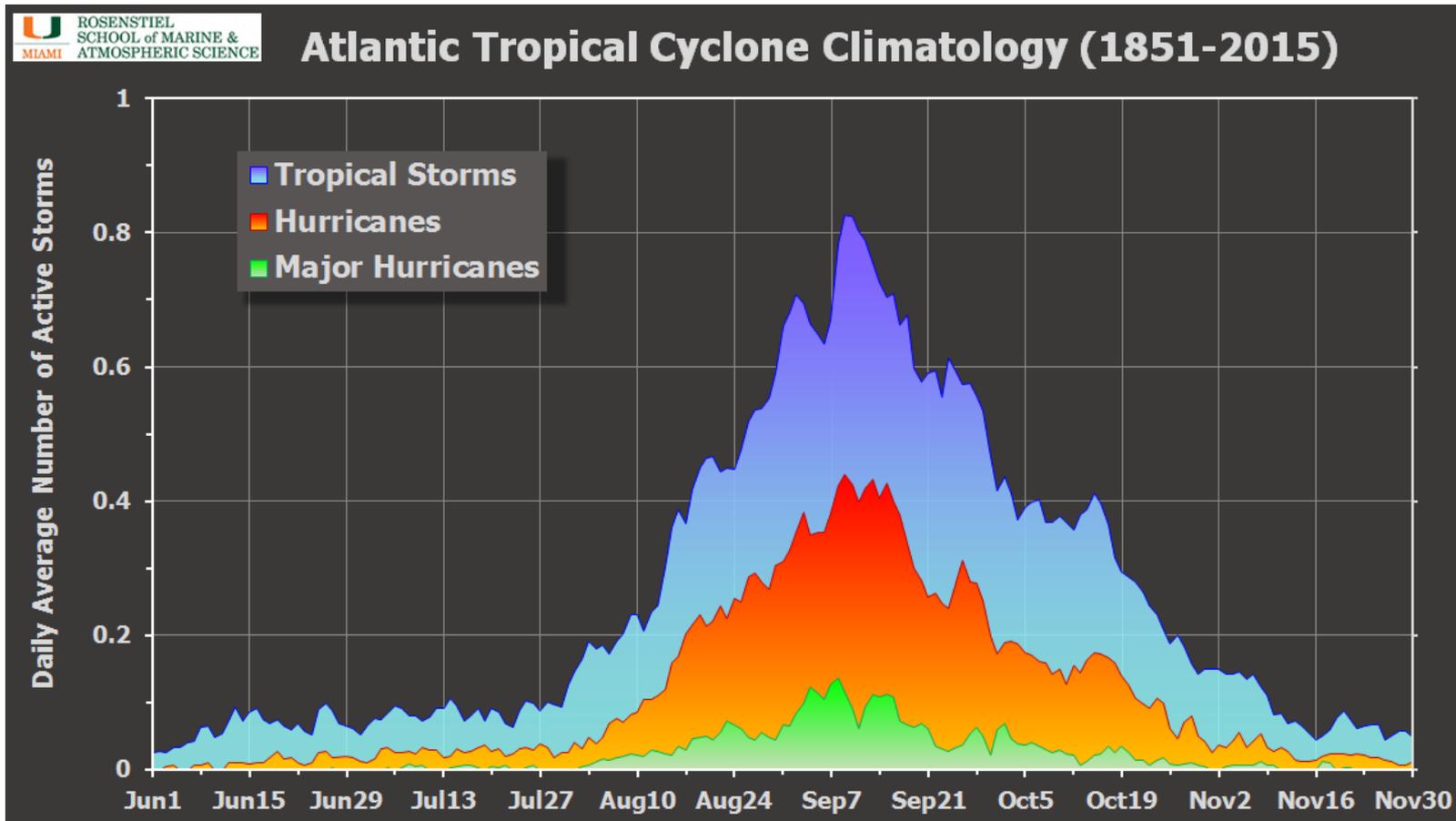
20N

HURRICANE IRMA



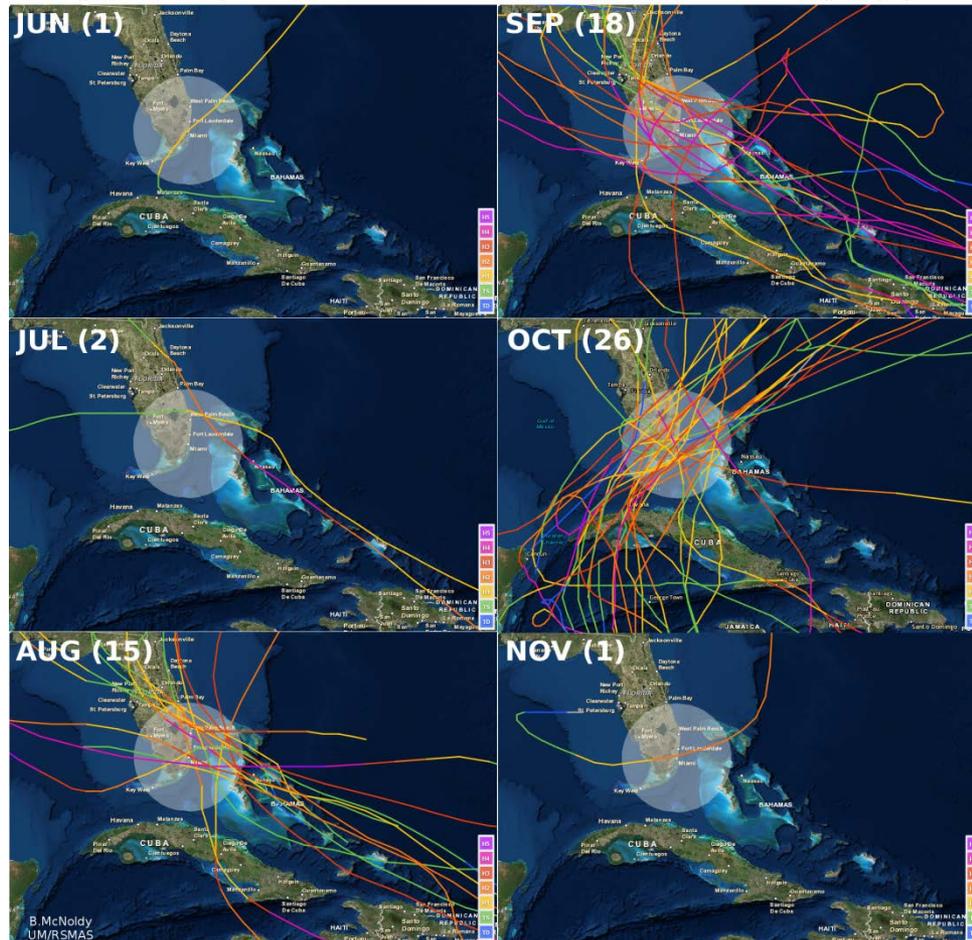
Irma was a very large storm (the size of Texas before FL landfall), having impacts over the entire state

The Atlantic Hurricane Season



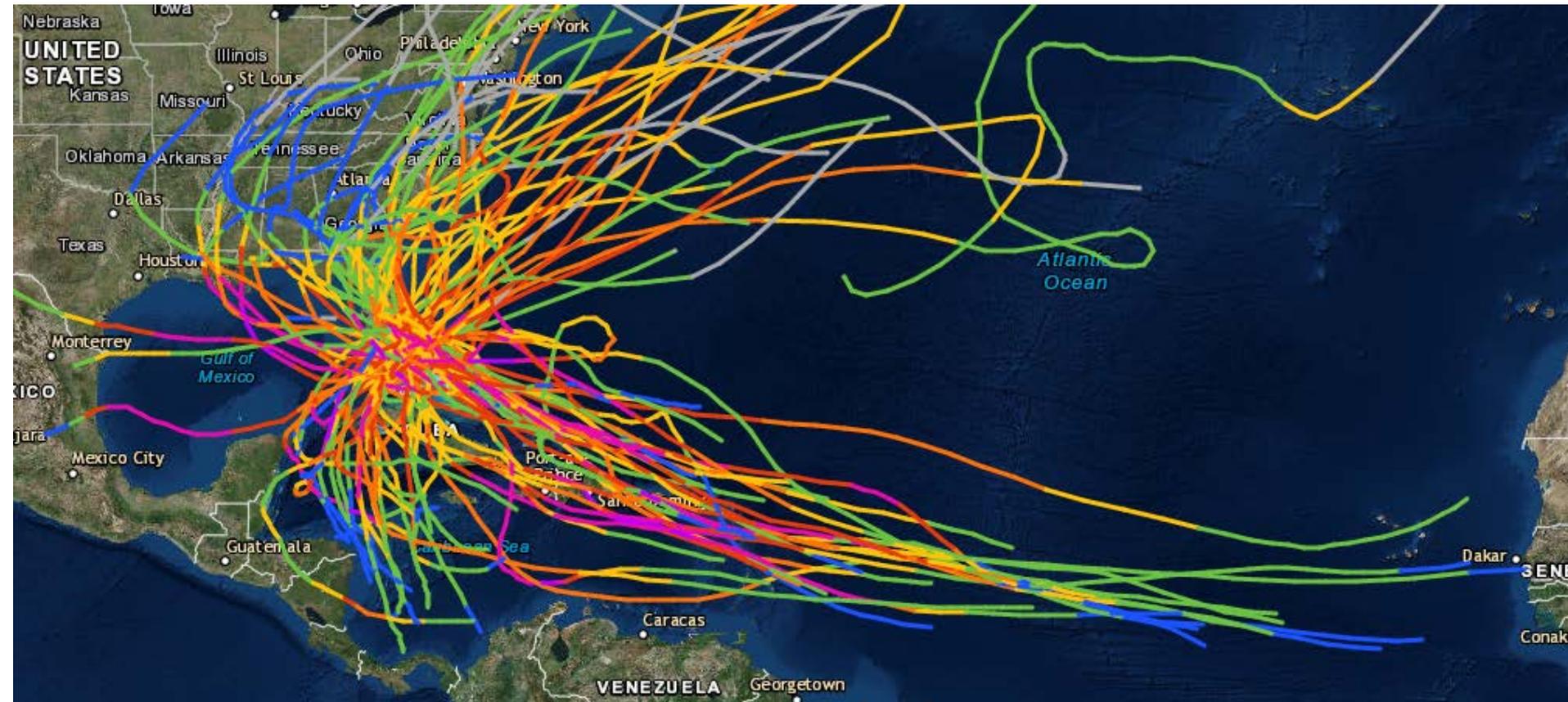
Hurricane Season in South FL

Monthly Tracks of Hurricanes that Passed within 150 miles of Miami, 1851-2016
(average radius of tropical storm force winds in Atlantic hurricanes is 150 miles, shown by the gray circle)



Hurricanes passing near South Florida since 1851

63 (31 major) Hurricanes Passed Over or Near South Florida from 1851-2016



The forecast cone

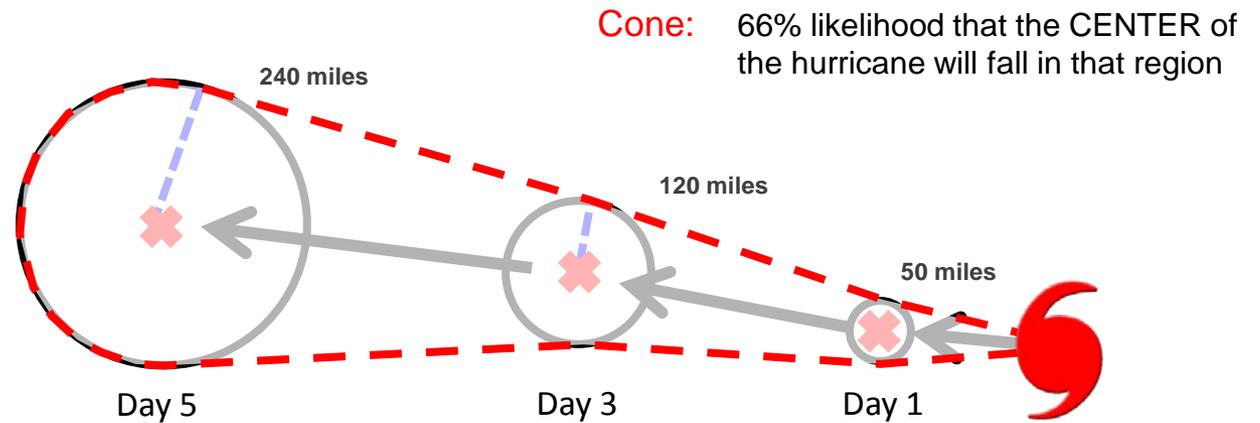


“Forecast cone” contains the probable path of the storm center

Important notes:

- A) The cone is 2/3 probability of the **center** falling in that region
- B) The same sized cone is used for the whole season – uncertainty can vary from storm to storm
- C) THIS IS NOT AN IMPACTS CONE – impacts extend far beyond the boundary of the cone

Making the cone

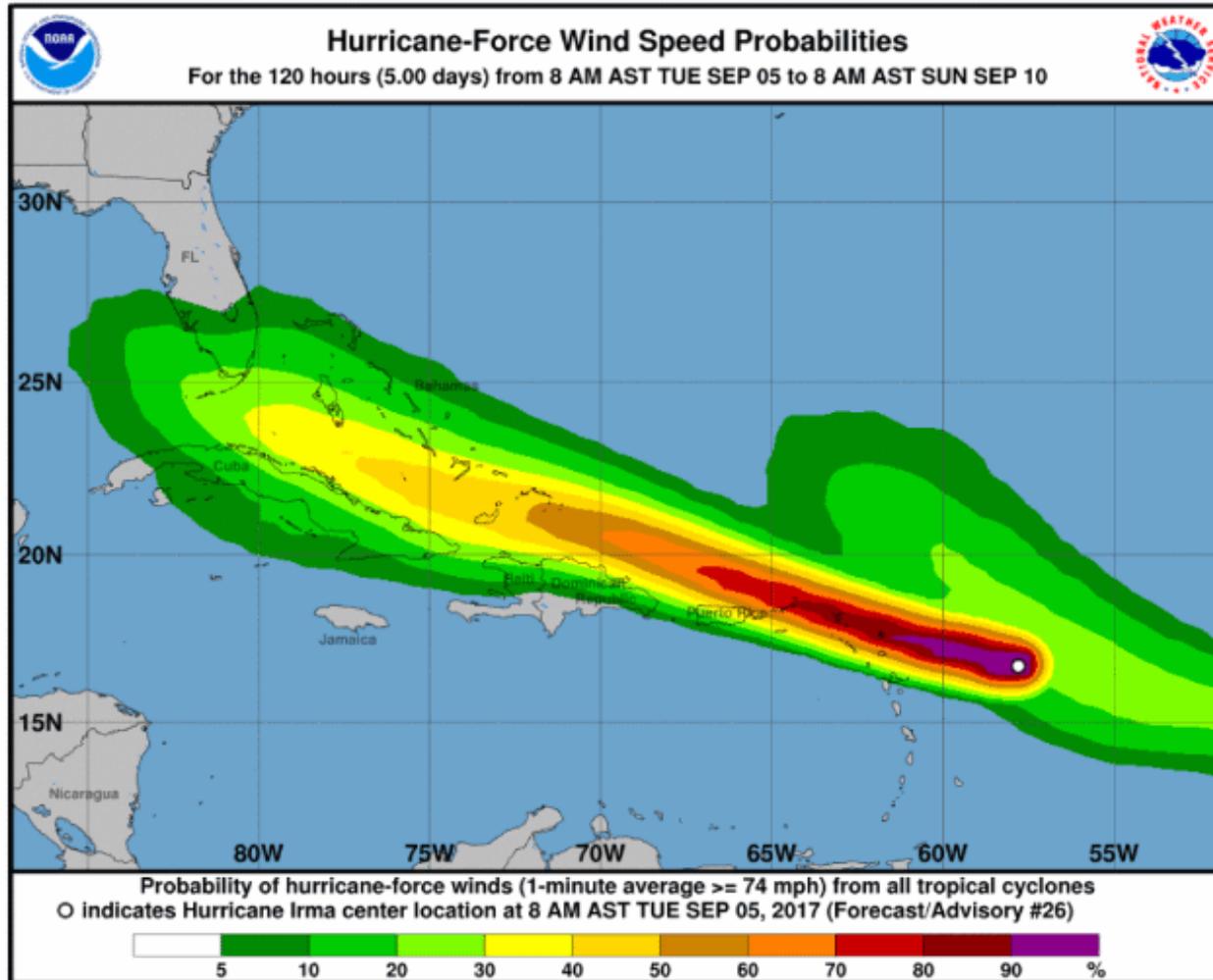


Error in track at 1 day out is 50 miles

Error increases with increasing length of time of forecast

Better forecasts (averaged over 5 years) = smaller error = a smaller cone!

Wind speed probability



QUICK QUIZ TO SEE IF YOU'RE PAYING ATTENTION

**What month has had the
most hurricane strikes in
South FL?**

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

**Was Hurricane Andrew a
smaller than average
storm?**

- A) No
- B) Yes

Hurricane Hazards

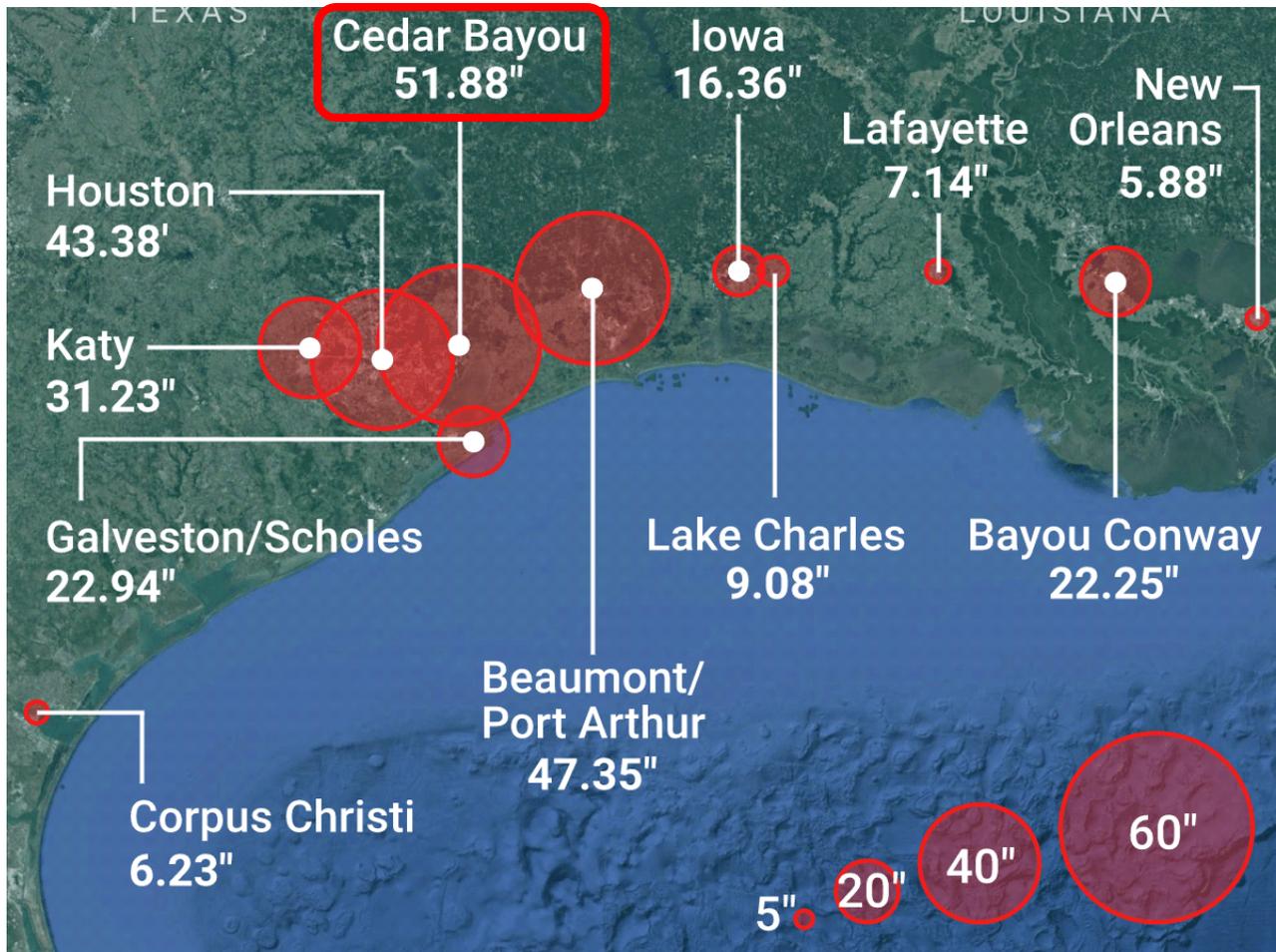
- Storm Surge
- Wind
- Rain
- Tornadoes
- Waves/Rip Currents



Wind, Rain, and Waves



Rain – Hurricane Harvey



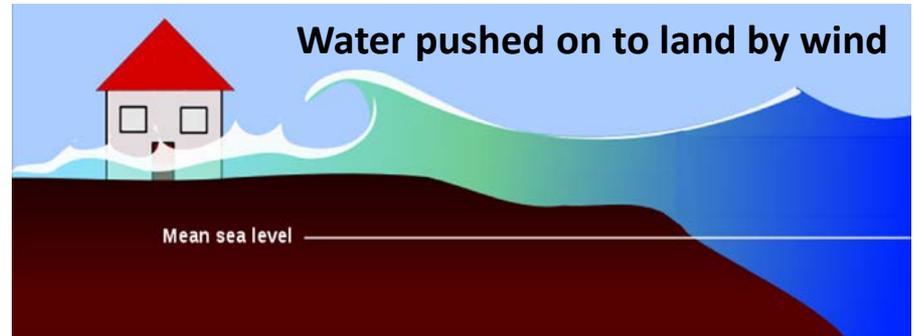
Tornadoes

- ~70% of landfalling hurricanes cause at least 1 tornado
- Most often occur in rainbands well away from the storm center



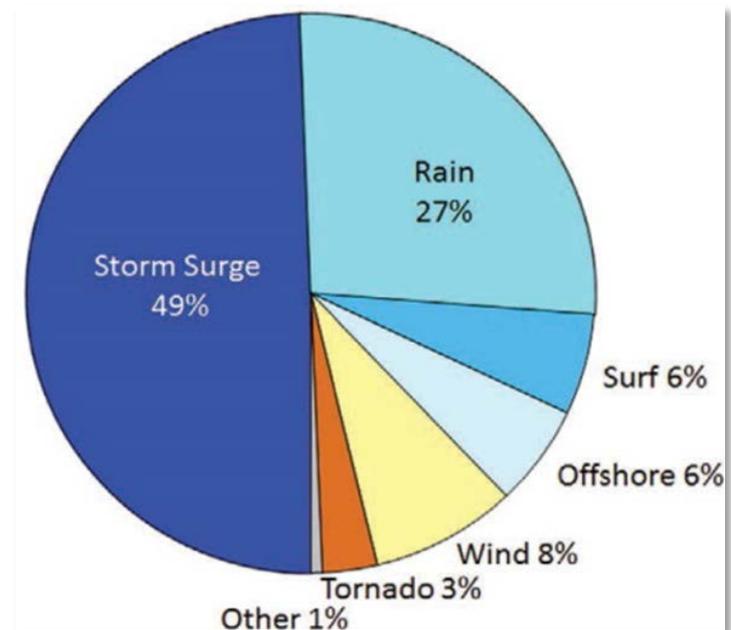
Storm surge

What is storm surge?



FACT:

- The #1 cause of deaths in hurricanes (49%)

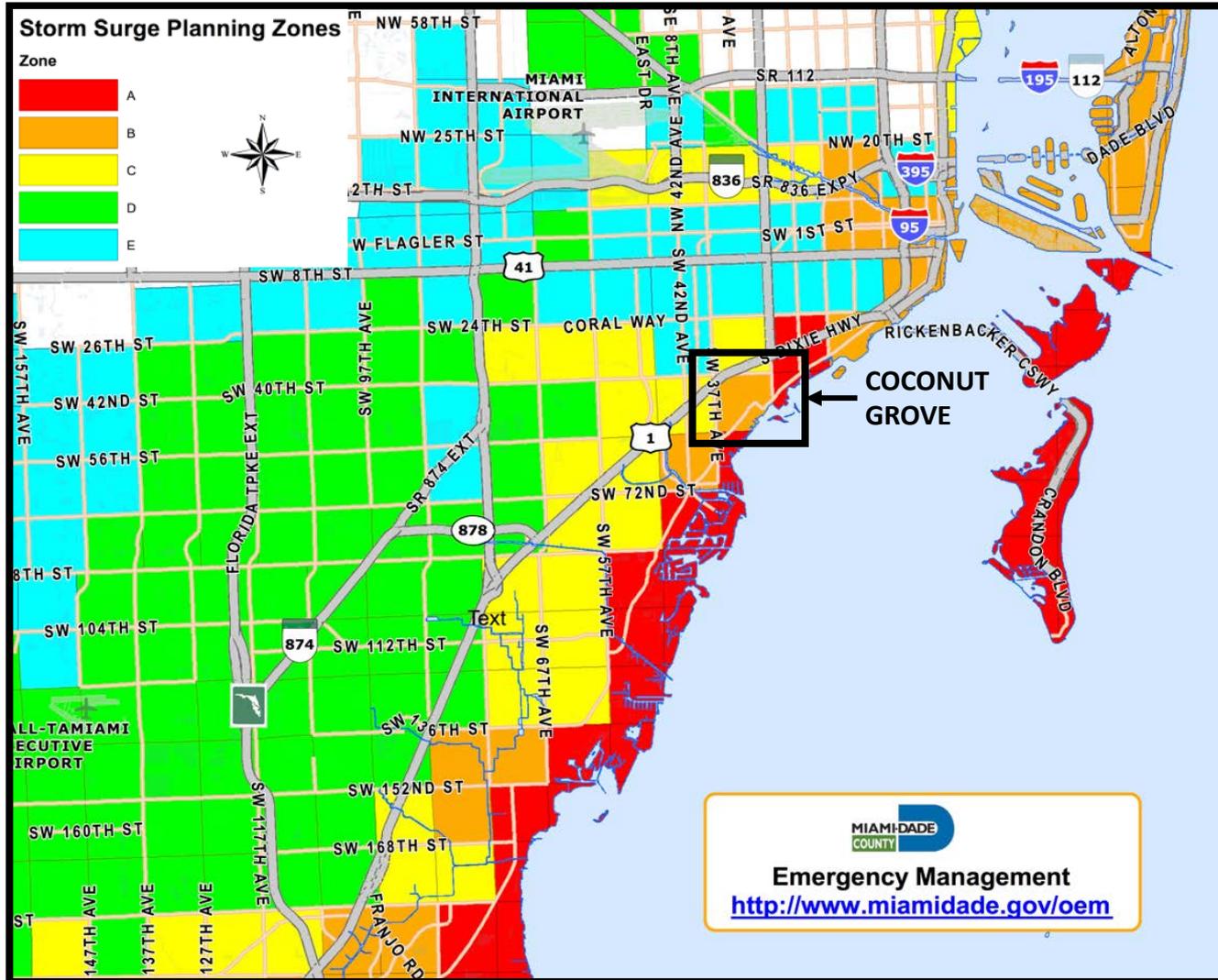


Storm Surge



Brickell during Hurricane Irma (2017)

So...Know Your Zone



HURRICANE MATTHEW



Hurricanes
& climate
change

*" Alright,
Alright,
Alright "*

JAMAICA HAITI

4-Oct-16 11 EDT

The future of hurricanes

What does a climate modeler look at?

Observations of the past 150 years of climate



Equations that describe fluid flow

(The Navier-Stokes equations – similar to those used for weather forecasting)



Projections of future climate

Question: How does this relate to hurricanes?

The future of hurricanes

Hurricanes strongly depend on both the ocean and atmosphere

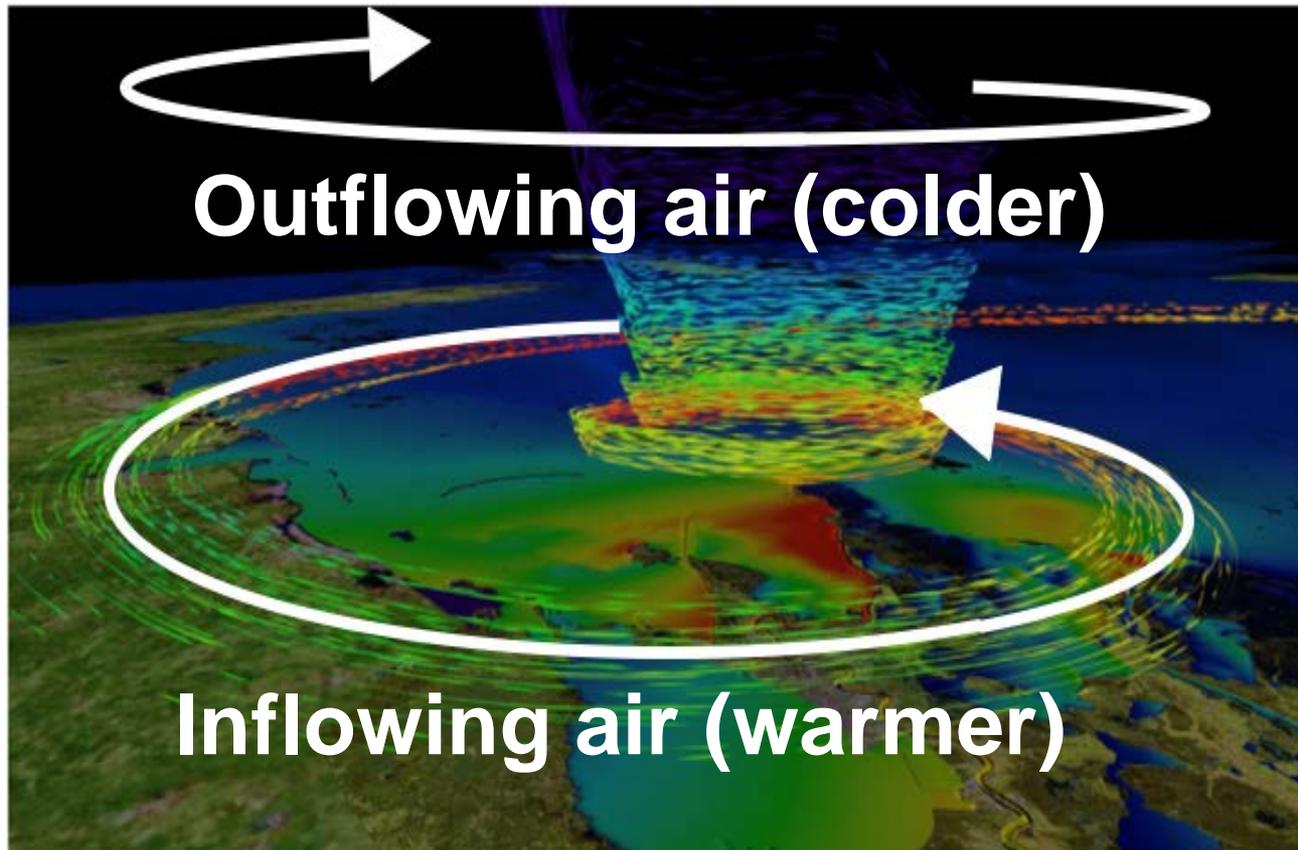
Both the ocean and atmosphere will get warmer, but the spatial differences in temperature may change



Temperature distribution is very important

Let's consider the ocean and atmosphere separately to understand why

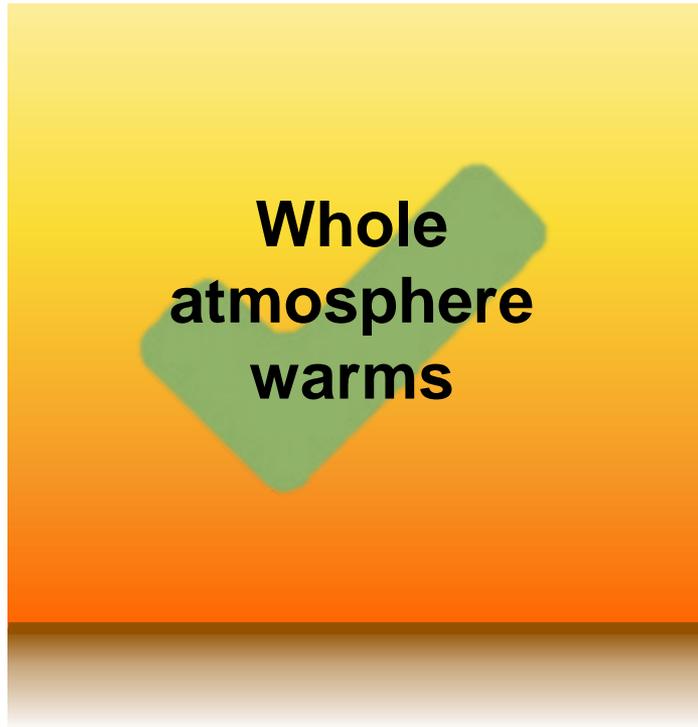
The atmosphere



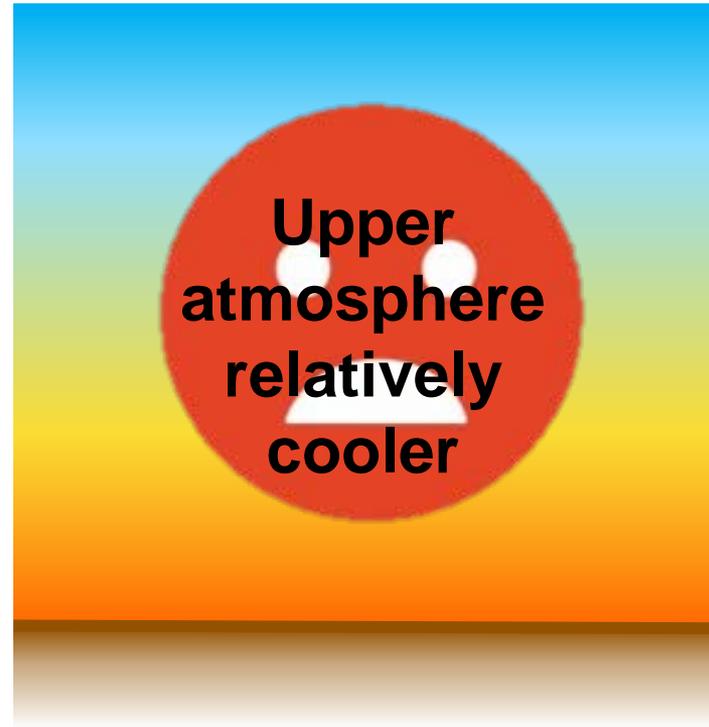
Benger et al. (2006): Hurricane Katrina

The atmosphere

Options



*Better – temperature difference
between upper and lower
atmosphere doesn't change*



*Bad because it promotes
convection/disturbance development*

The ocean

Atlantic SSTs will **definitely warm** due to climate change

Question: Does this mean more intense tropical cyclones?

Answer:



**Better
Answer:**

There are two possibilities:

- A. Warmer Atlantic = more intense hurricanes
- B. Warmer Atlantic but it warms at the same rate as the rest of the tropics

No relative difference = no hurricane activity change (Vecchi et al., 2008)

Options A and B

Option A

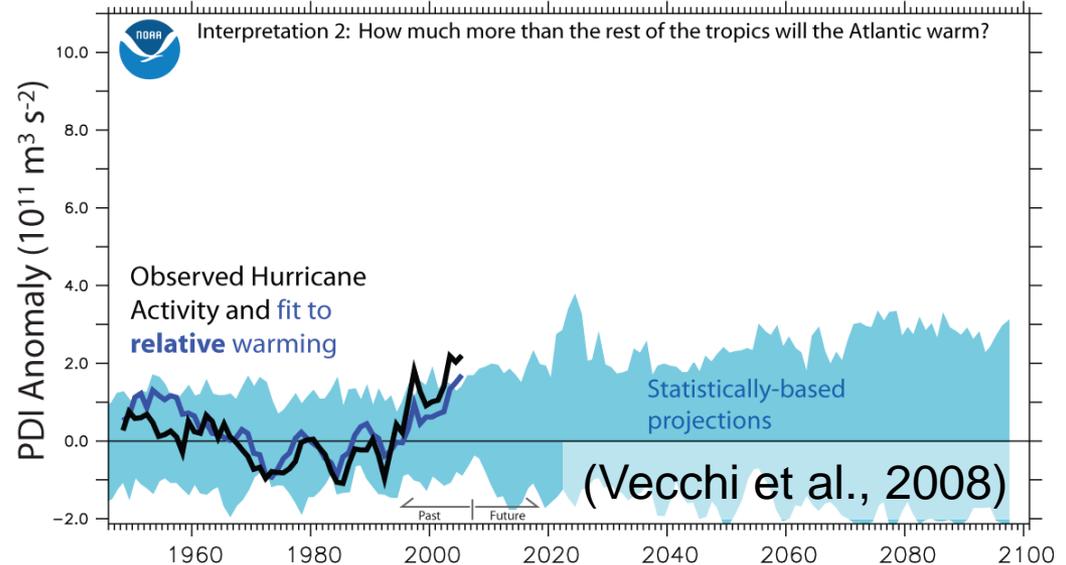
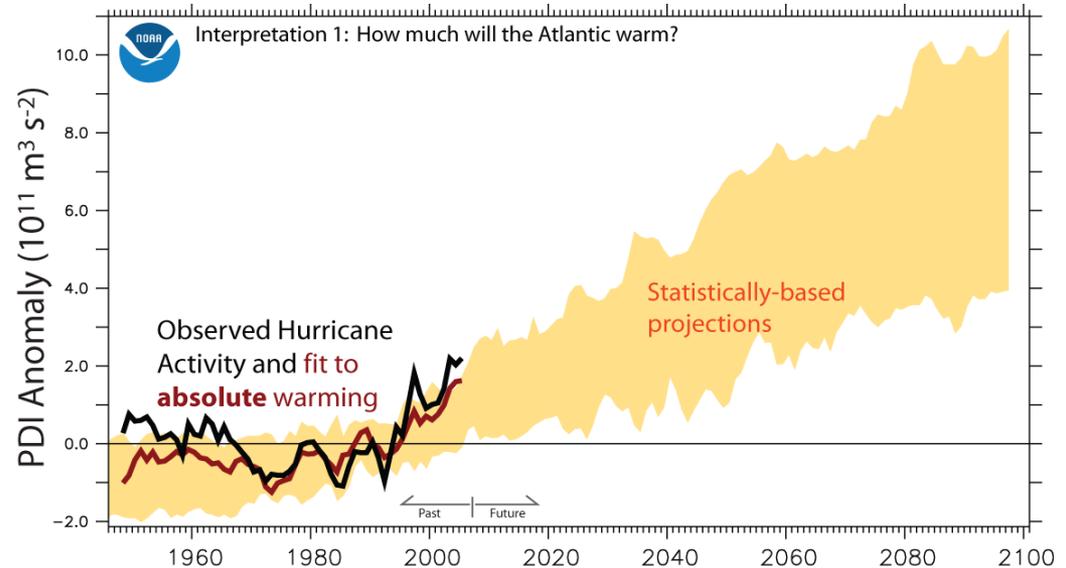
Atlantic is warmer

→ hurricanes more intense

Option B

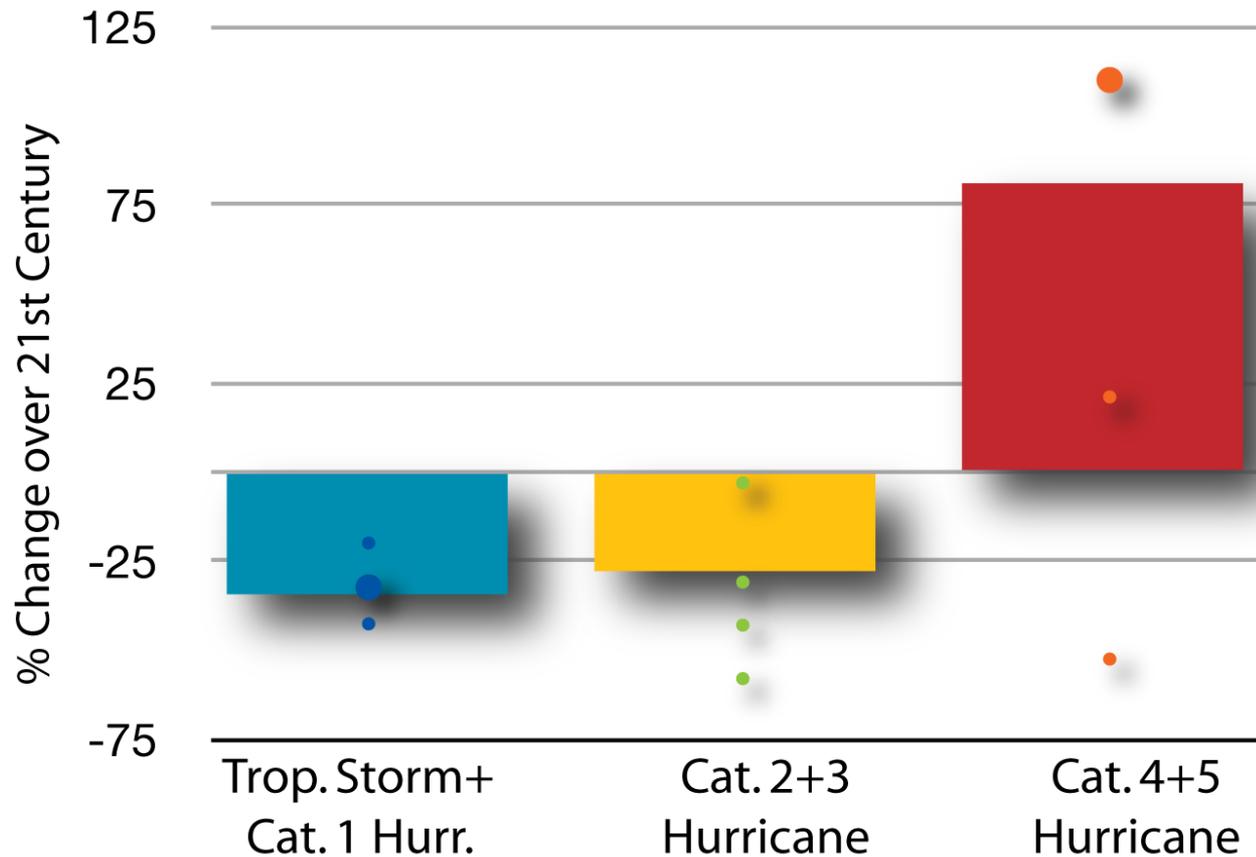
Atlantic is warmer but
temperature relative to the rest
of the tropics same as today

→ No change in intensity



Could it be both?

Projected Changes in Atlantic Hurricane Frequency over 21st Century



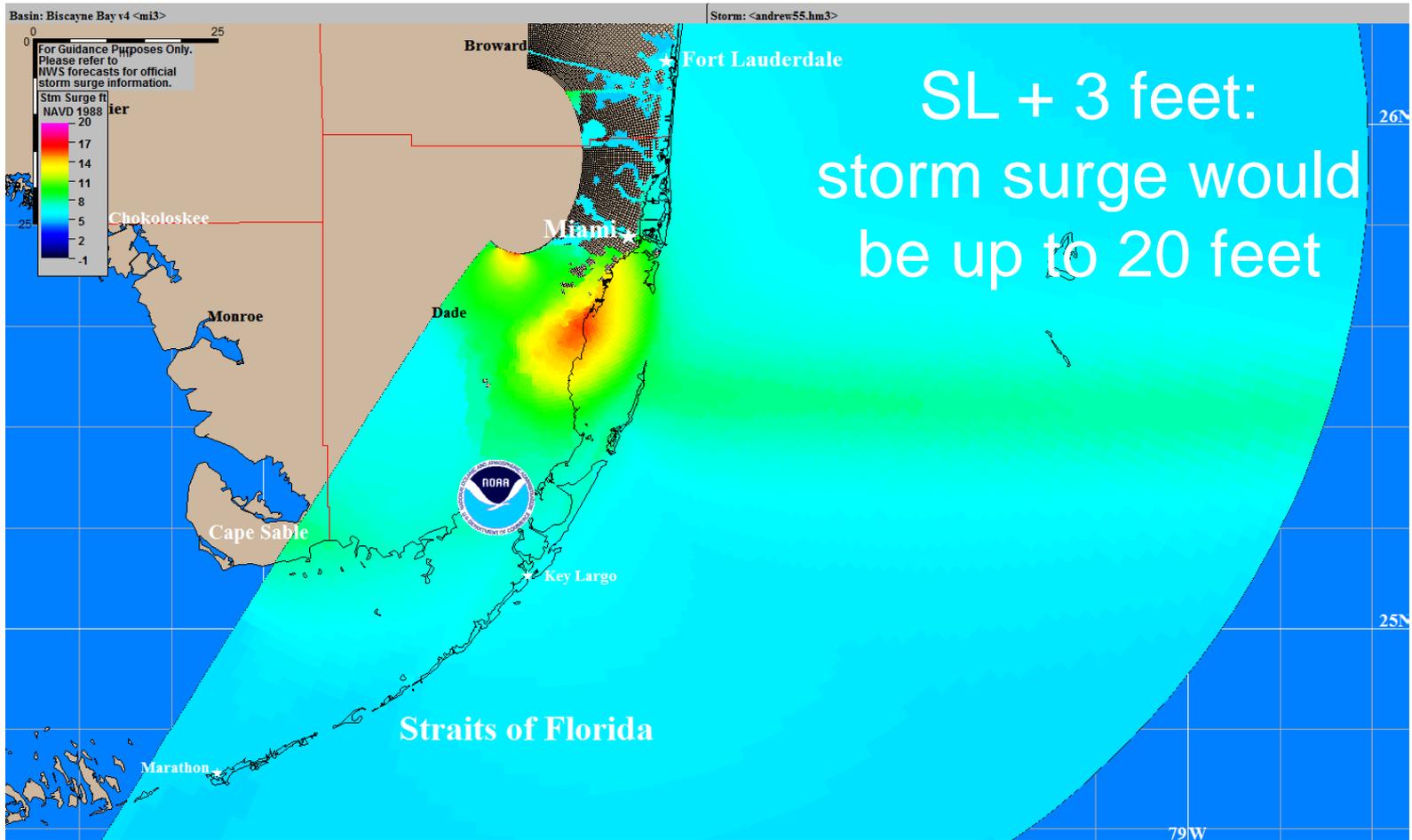
If all of the ice melts



The future of sea level in Miami

[Sea-level rise simulation - Miami](#)

SLOSH storm surge prediction



Courtesy of Brian Soden

Summary

- Hurricanes are extremely dangerous weather phenomena
- They need very specific conditions to form:
Away from equator, warm ocean, low wind shear, moist air
- The forecast cone should be taken with a pinch of salt
- Hurricanes will be affected by climate change
Sea-level rise, warming ocean and atmosphere

