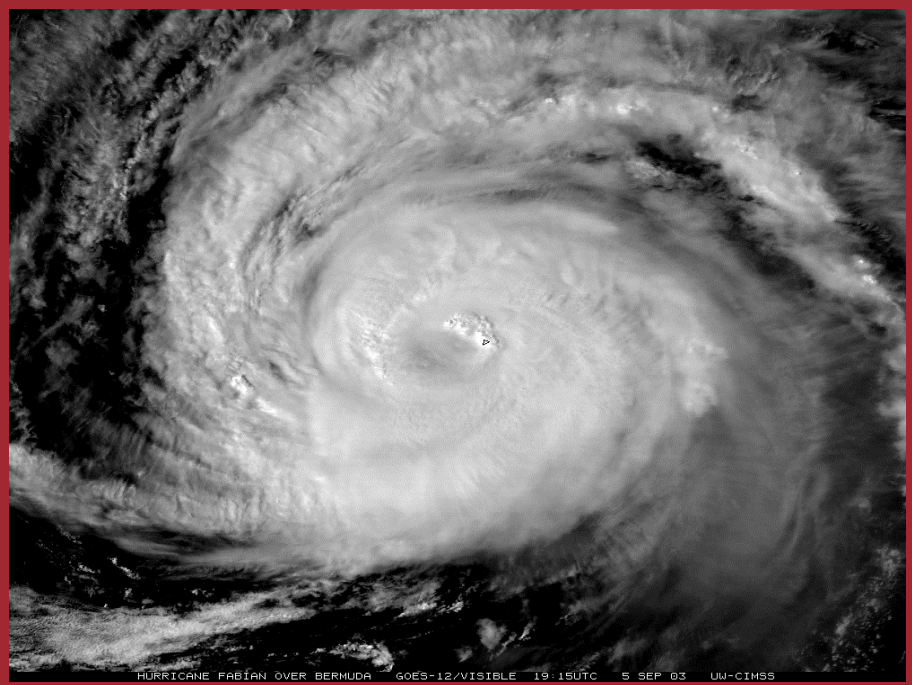
5 Things You Never Knew About Hurricanes

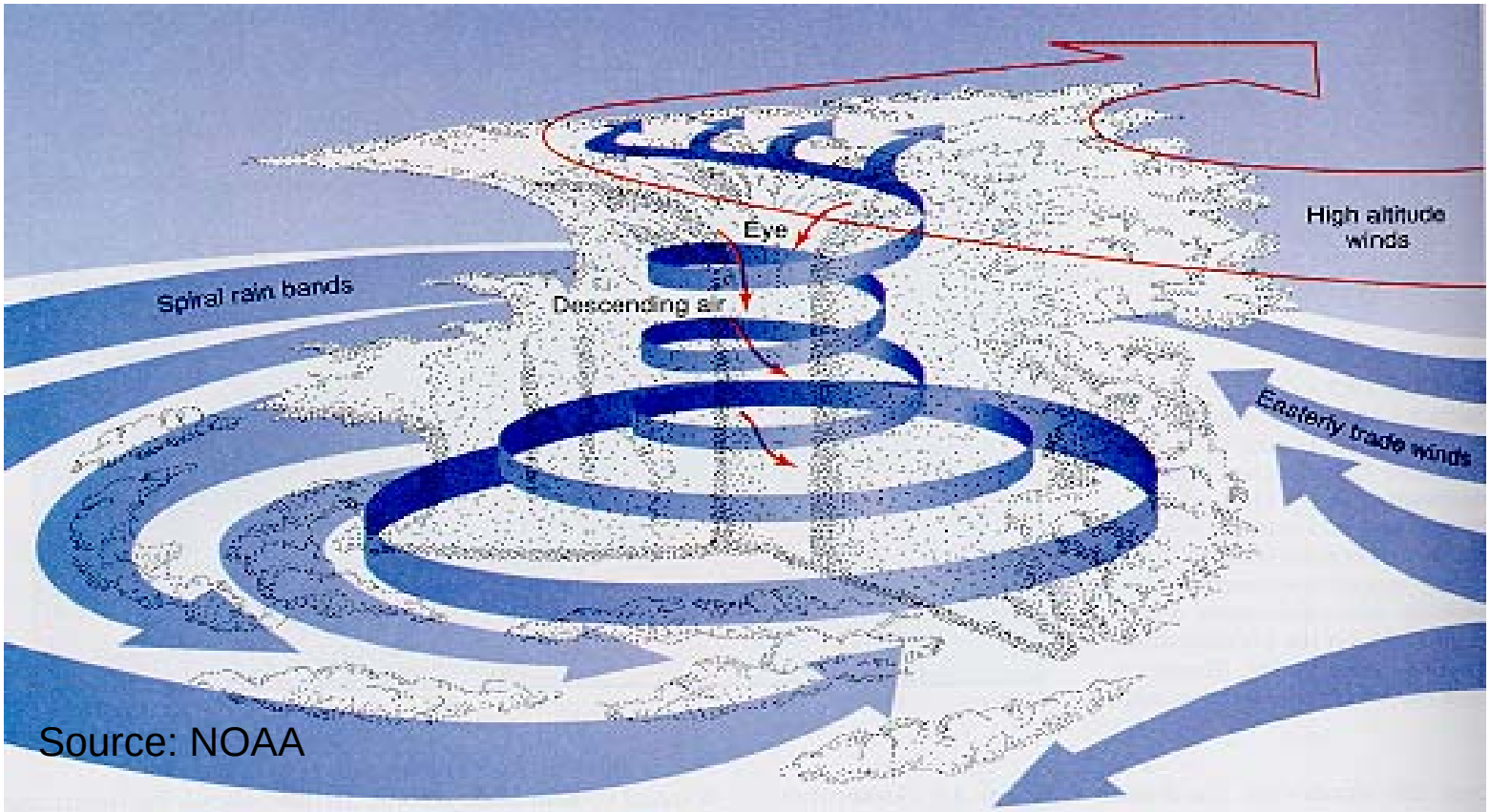


Dr. Mark Guishard

Director,

Bermuda Weather Service

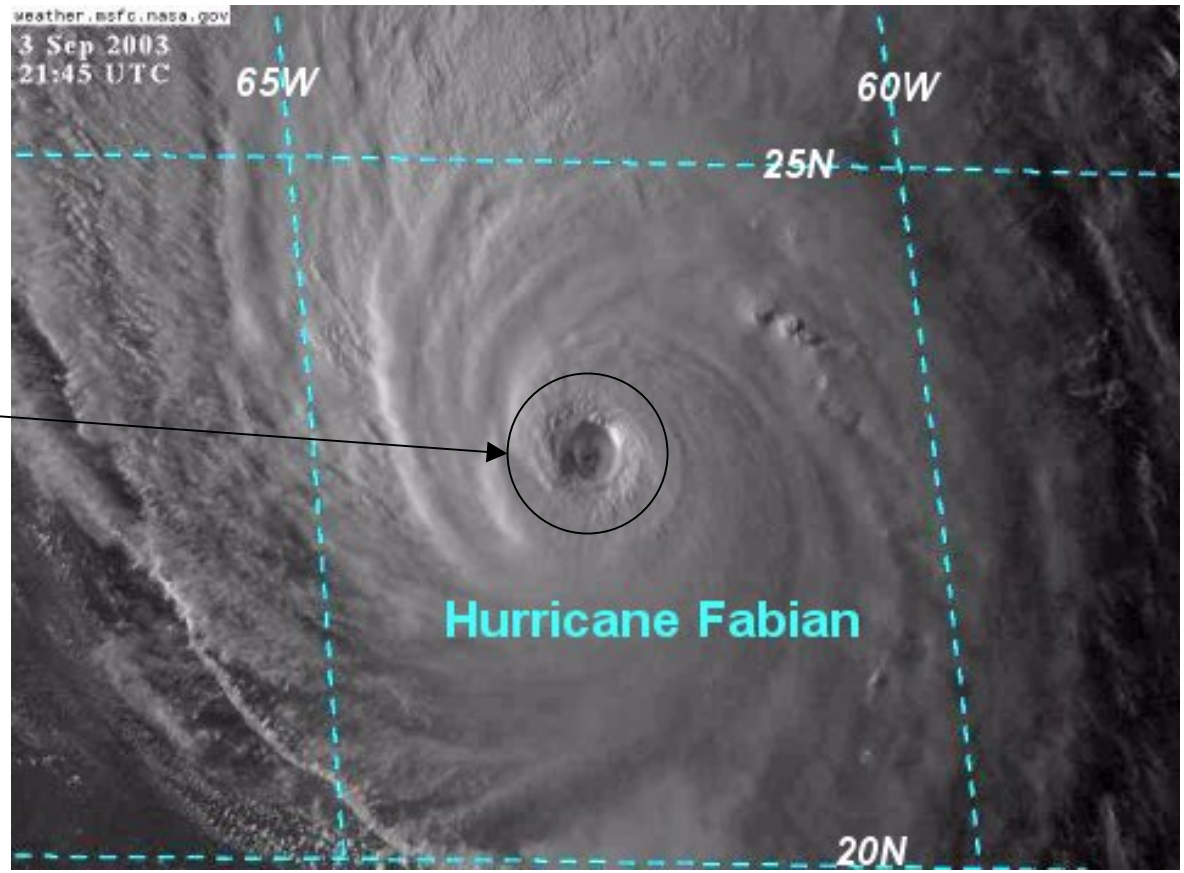
Background



- Hurricanes are:
- Large low pressure systems triggered by pre-existing disturbances
- Fueled by the energy released from the ocean surface

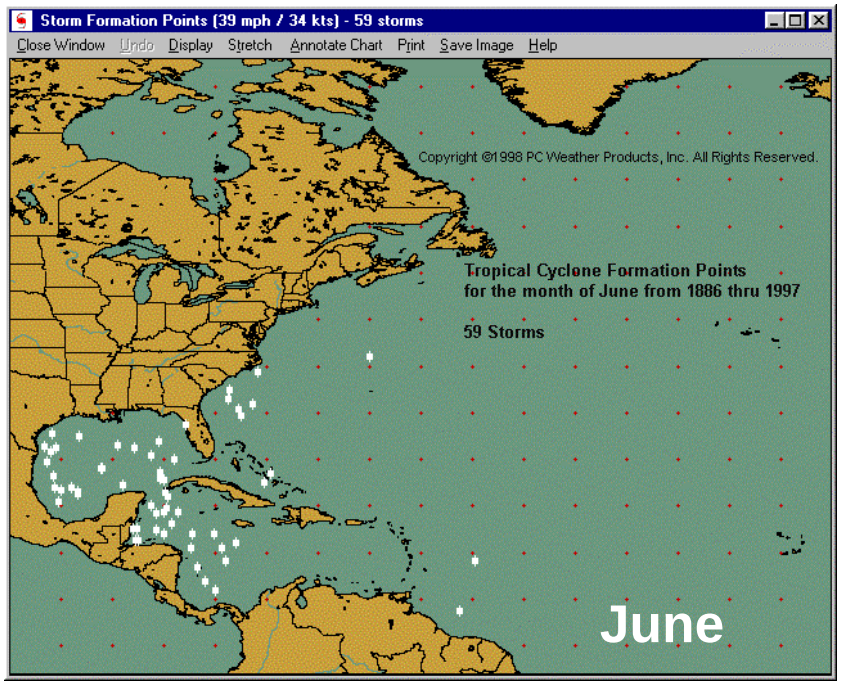
Background

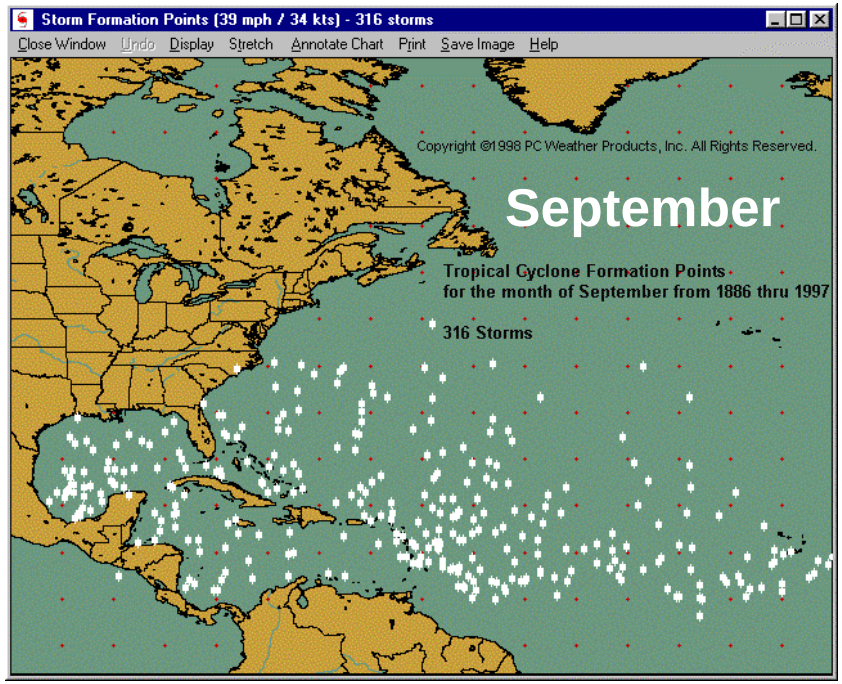
- Most of the energy and mass in a hurricane is focused quite near the centre
- Strongest in a concentric ring of severe weather, called the “eyewall”
- Surrounds a calm central “eye”



Source: NASA

Background

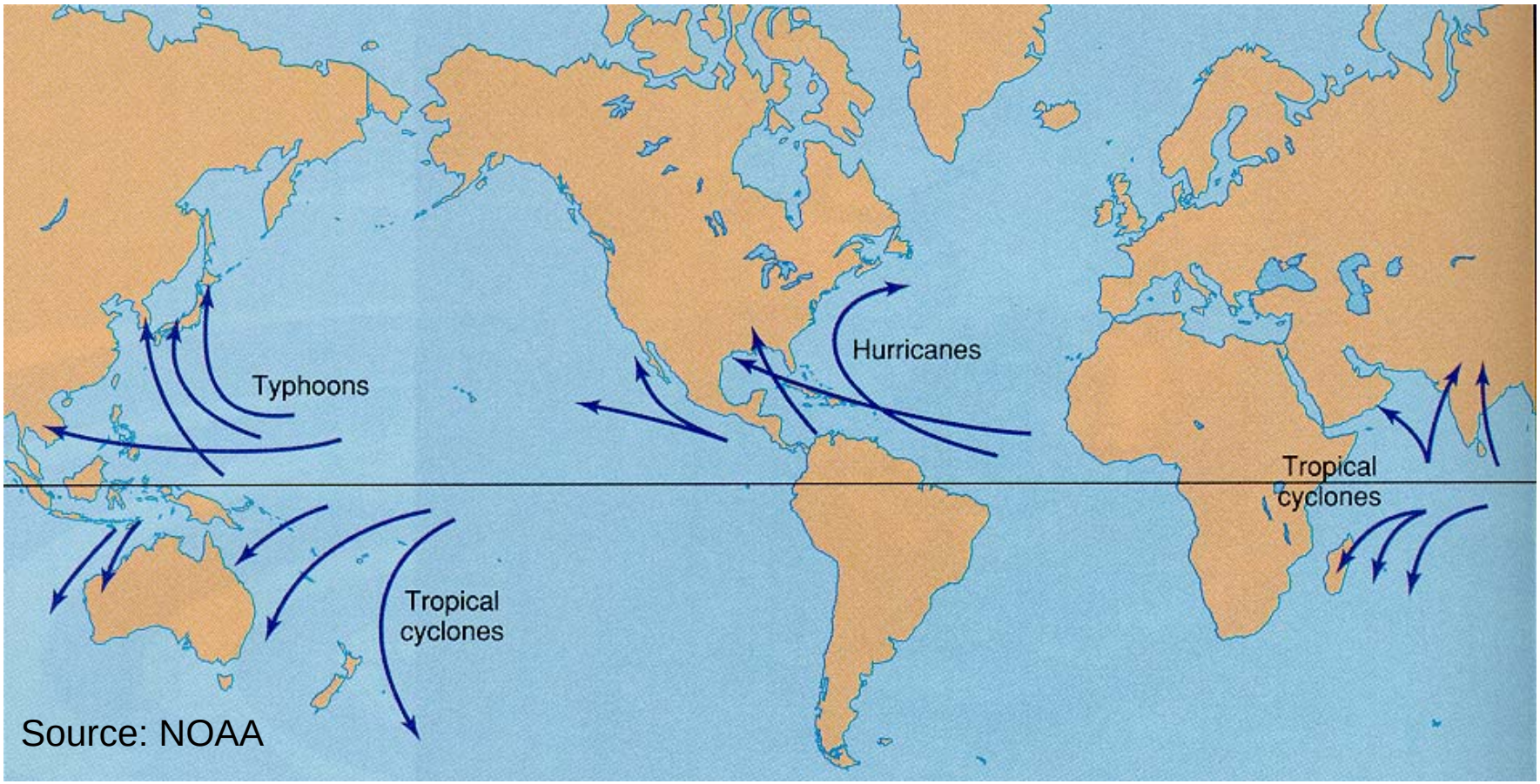




Birthplaces of Hurricanes

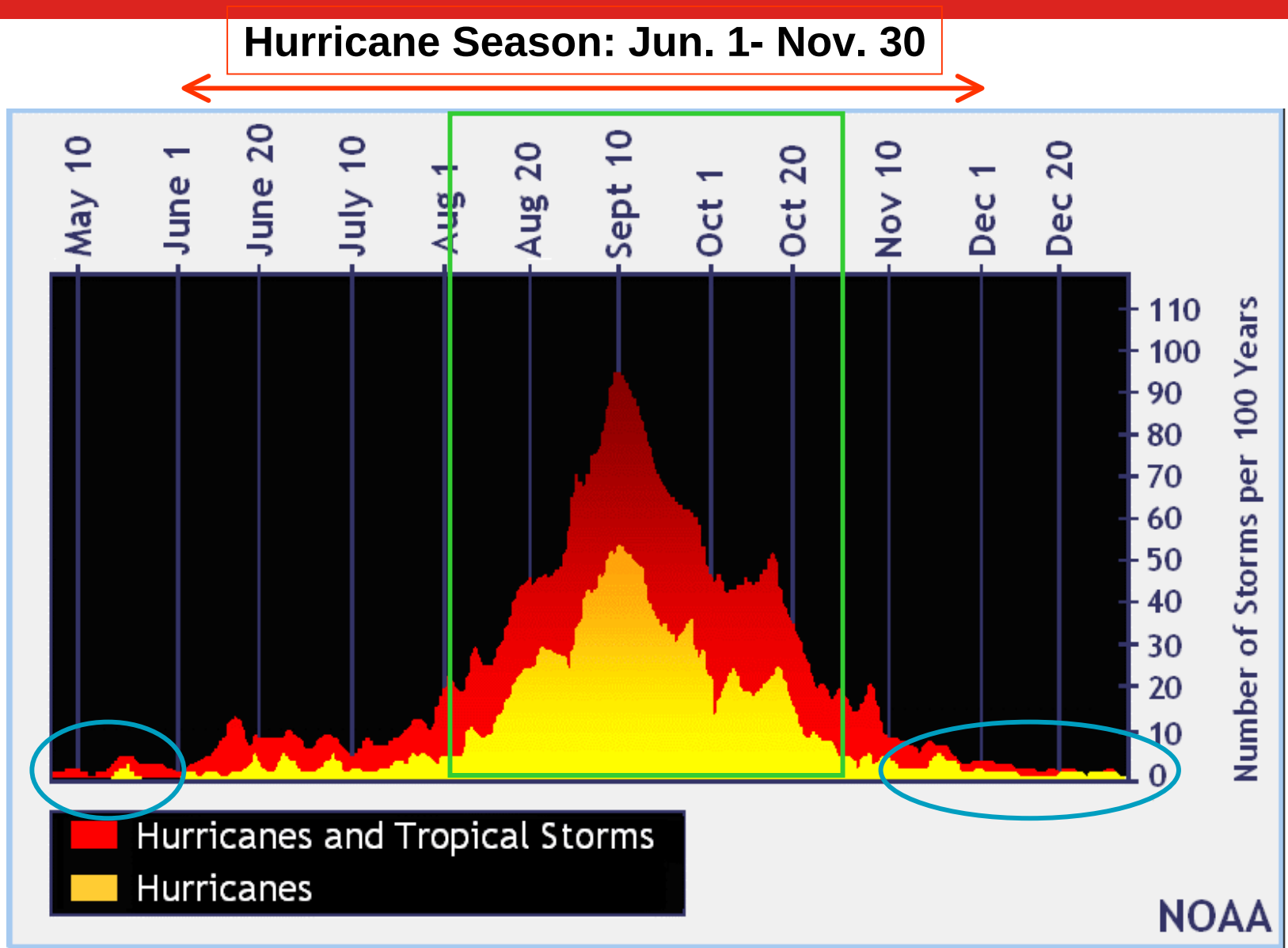
BAS serco

Background

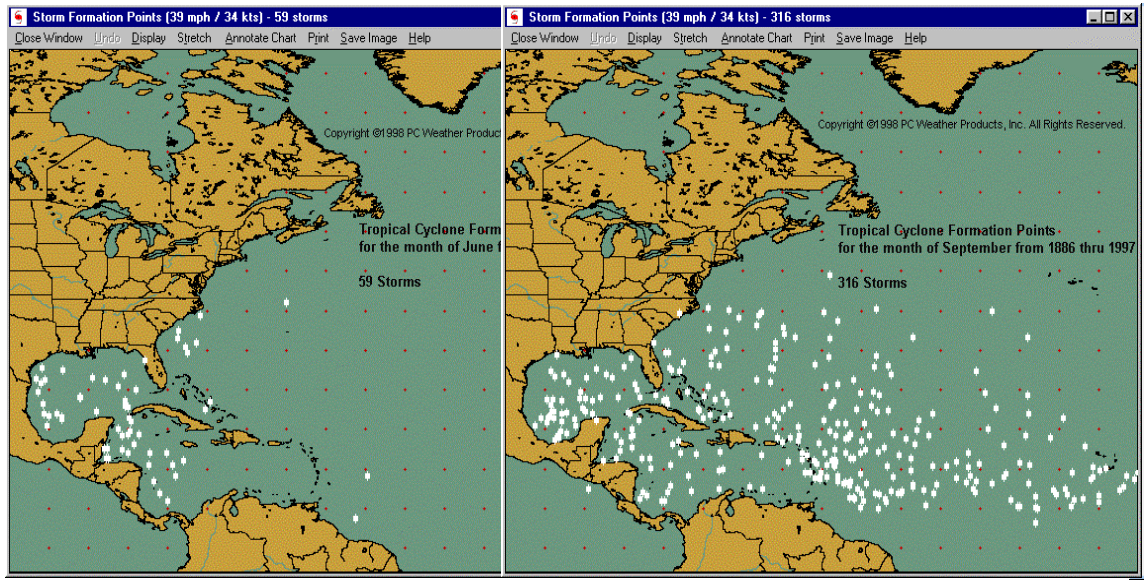


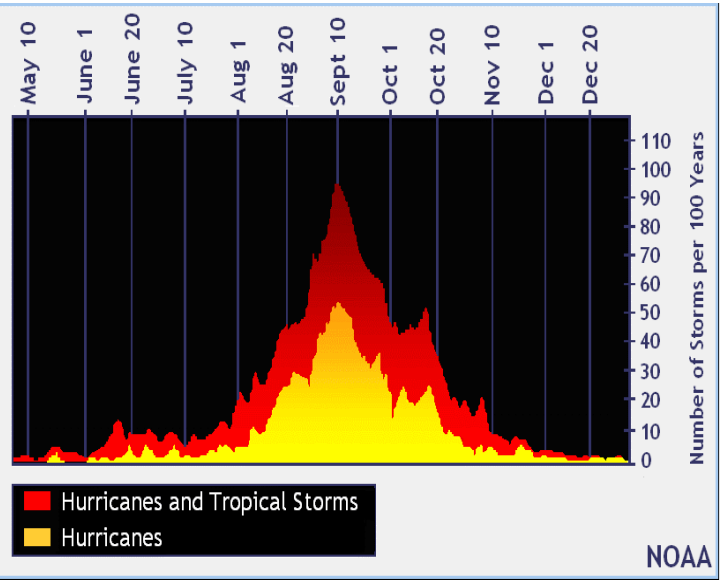
Birthplaces of Hurricanes

Background


Hurricane Season: Jun. 1- Nov. 30
May 10
June 1
June 20
July 10
Aug 1
Aug 20
Sept 10
Oct 1
Oct 20
Nov 10
Dec 1
Dec 20
110
100
90
80
70
60
50
40
30
20
10
0
Number of Storms per 100 Years
Hurricanes and Tropical Storms
Hurricanes
NOAA

Background





- Sea Surface Temperature shows a direct relationship with hurricane activity
  - Represents the ocean energy source for fueling the storms

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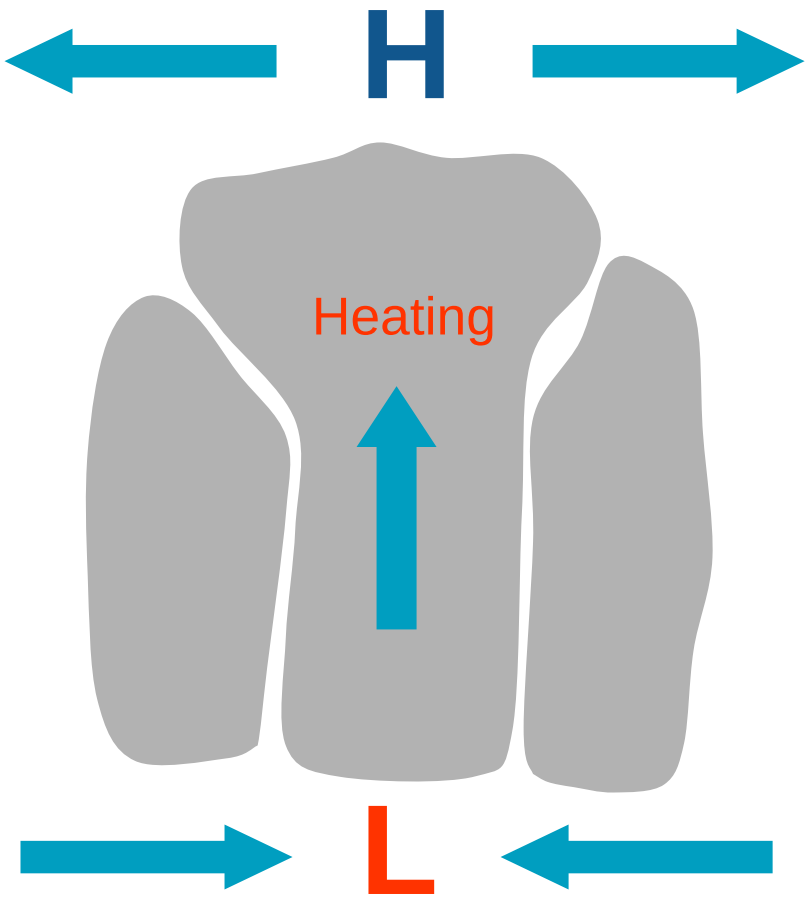
Background

In order to keep the heating in the core above the surface disturbance, there must be little or no shear.

Strong shear in the medium levels would rip the storm apart.



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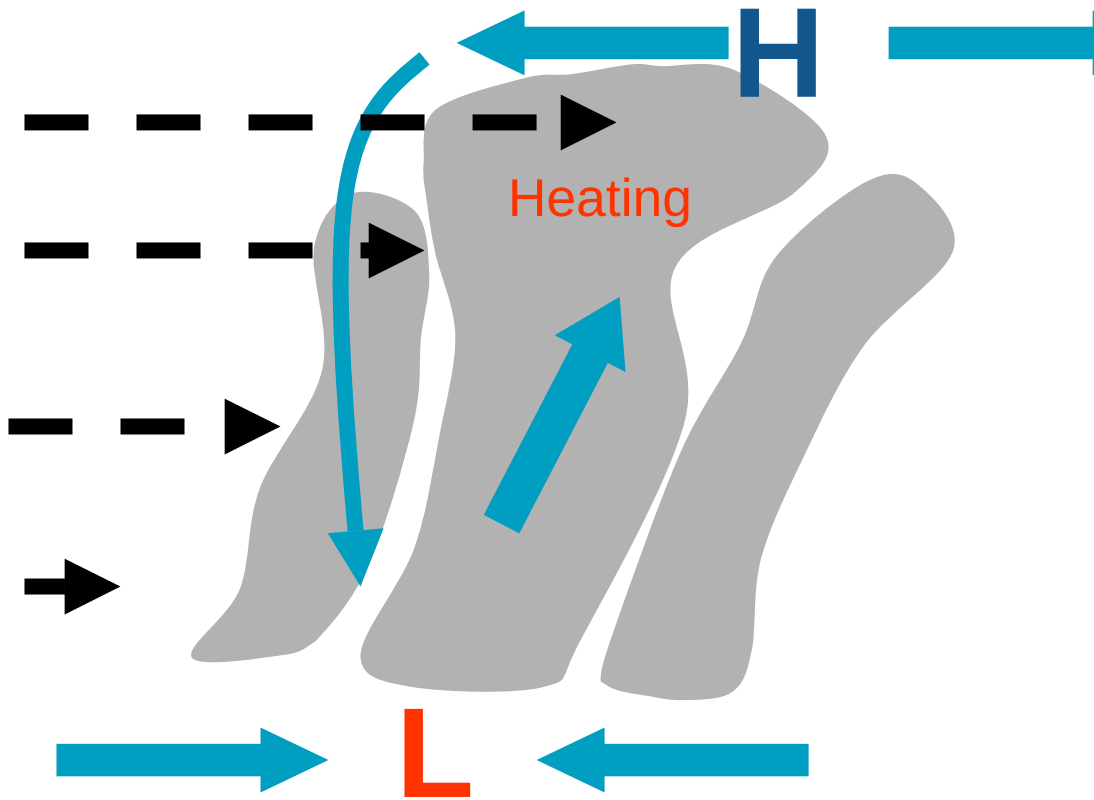


- Vertical wind shear has a destructive effect on storm formation

1) El Niño Influences Atlantic Hurricane Numbers

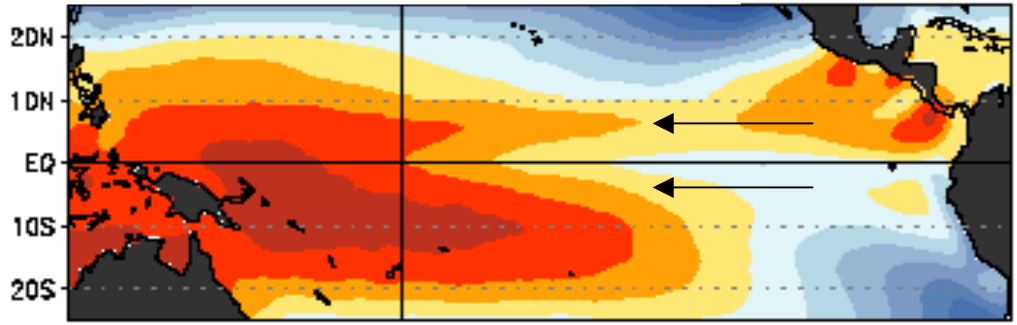
- What is El Niño?
  - A climate cycle that occurs every few years.
  - A shift of warm surface water across the tropical Pacific from west to east.
  - Caused by the relaxation of the trade winds.

El Niño conditions

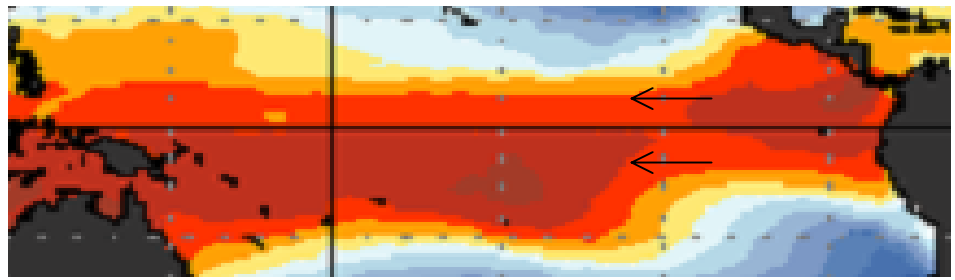
Sea Surface Temperature

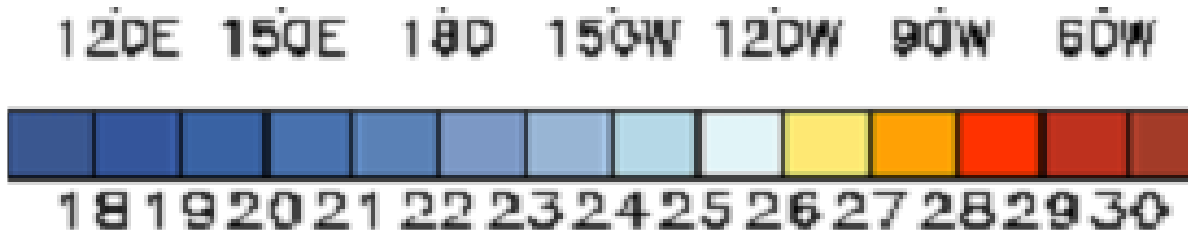
- **Named by South American fishermen for the Christ child. Warming of waters off Peru coincided with Christmas.**

Average conditions - January - March



El Niño conditions - January - March





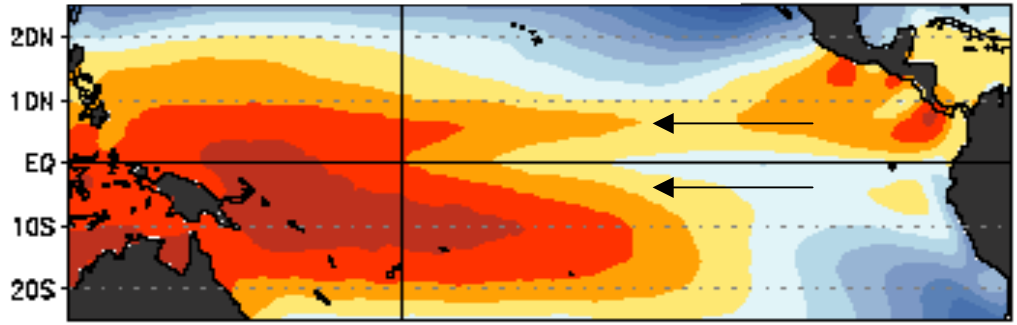
Source: NOAA

El Niño conditions

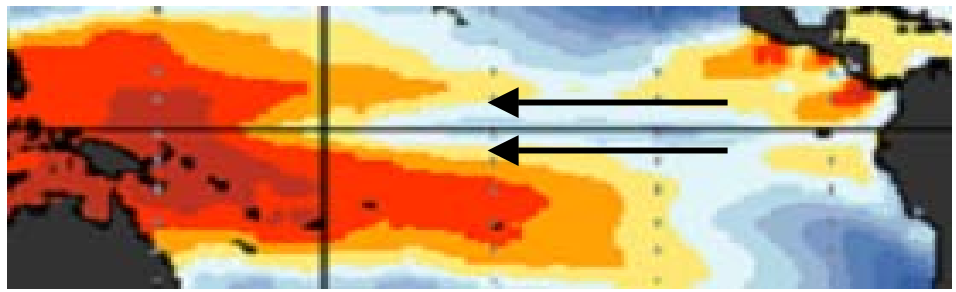
Sea Surface Temperature

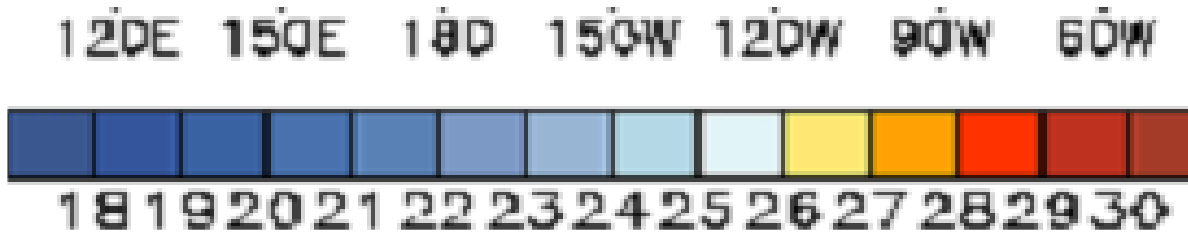
- Named by South American fishermen for the Christ child. Warming of waters off Peru coincided with Christmas.
- The opposite effect is named “La Niña”

Average conditions - January - March



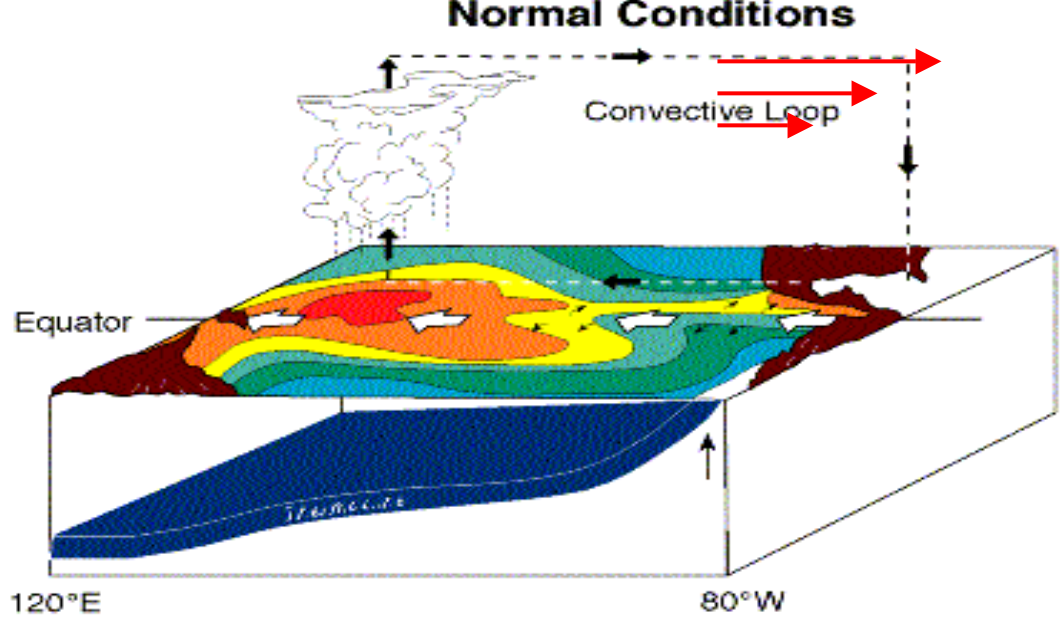
La Niña conditions - January - March

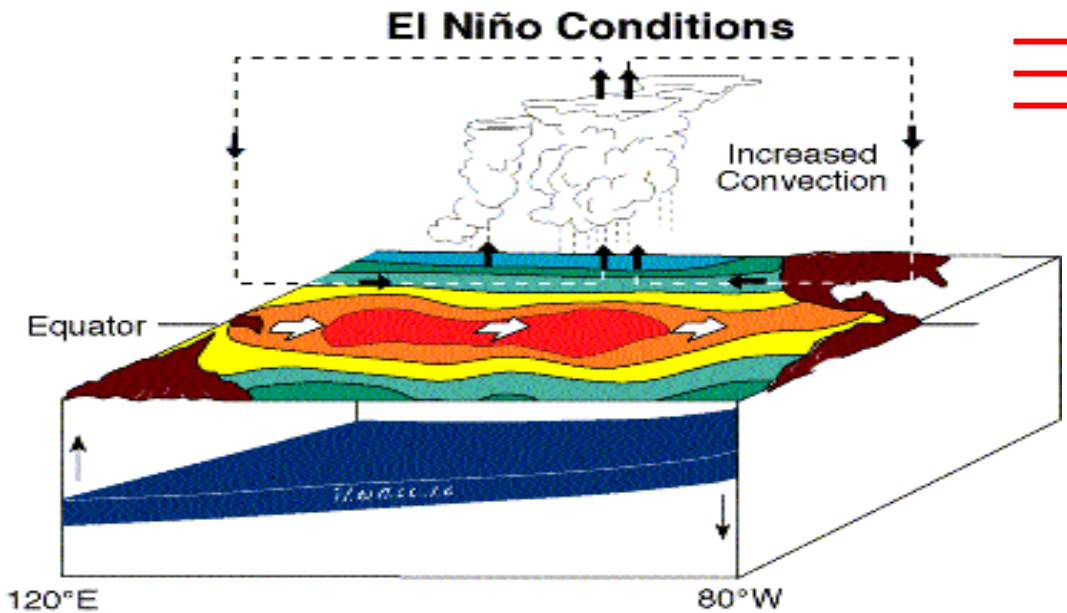




Source: NOAA

El Niño Effects





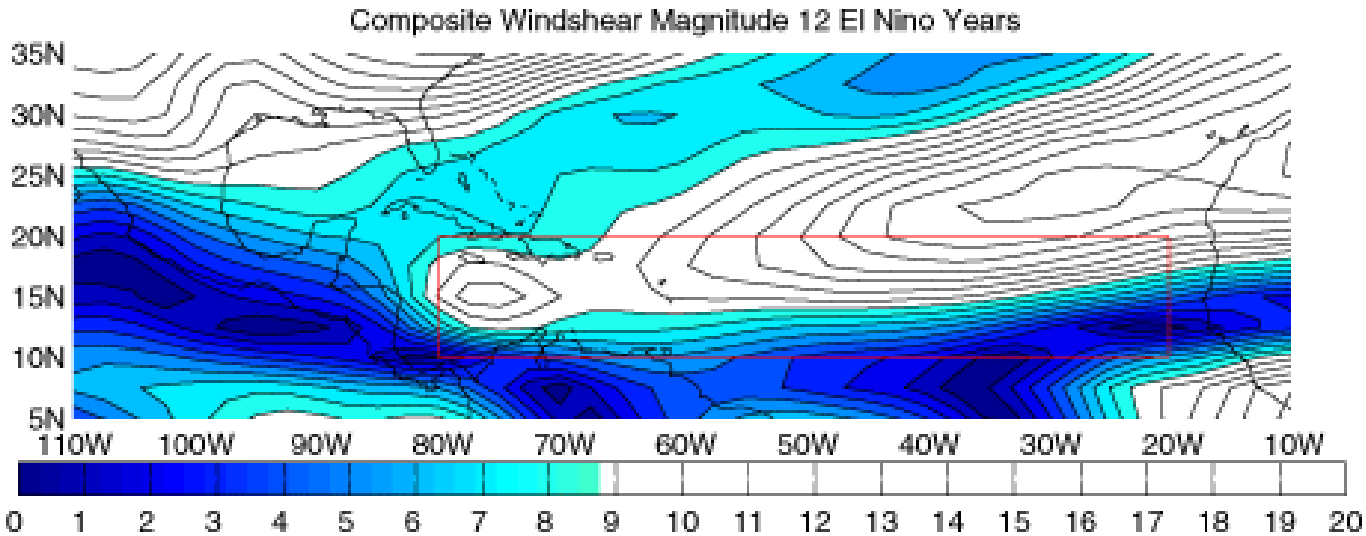
Increased wind shear downstream – suppressed hurricane formation in the main Atlantic development region

Source: NOAA

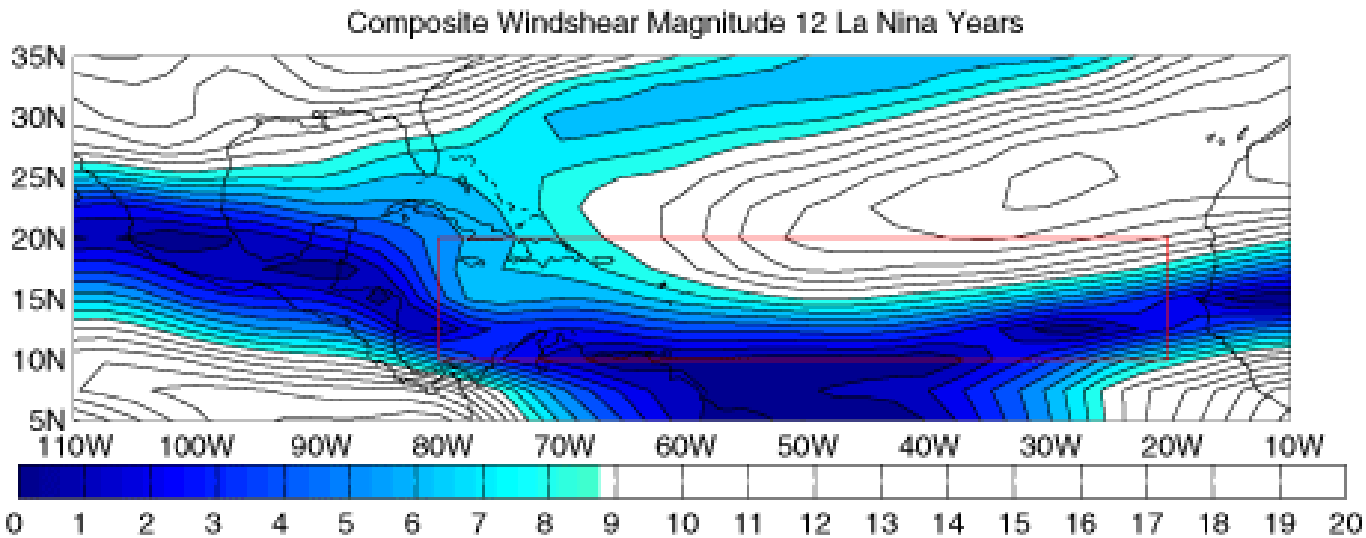
NOAA/PMEL/TAO

Effects on Hurricane season

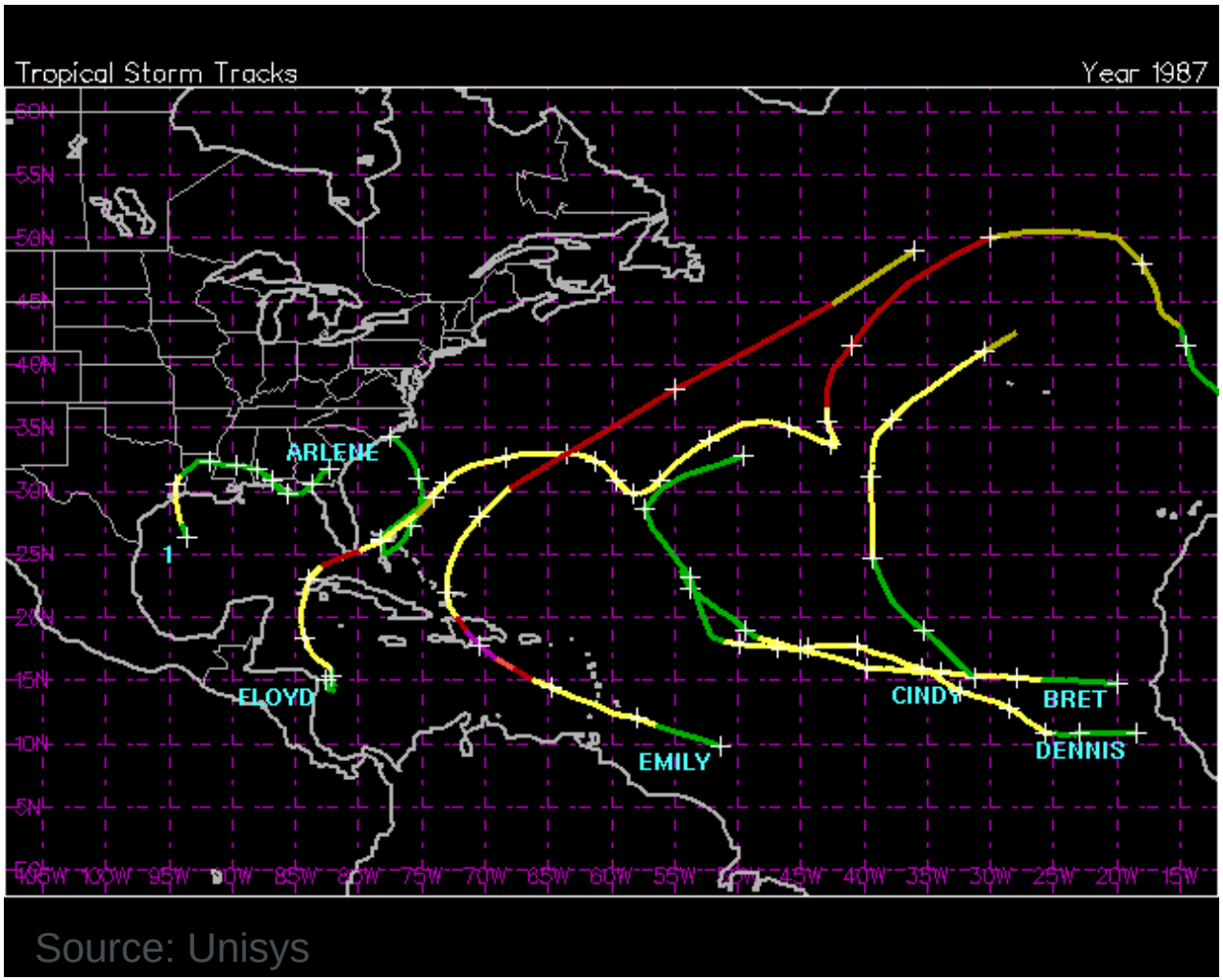
- The disruption of the upper winds translates to the Atlantic, suppressing Hurricane activity for El Niño years in this part of the world.



- The opposite occurs in a La Niña year, when Atlantic Hurricane Season tends to be very active.



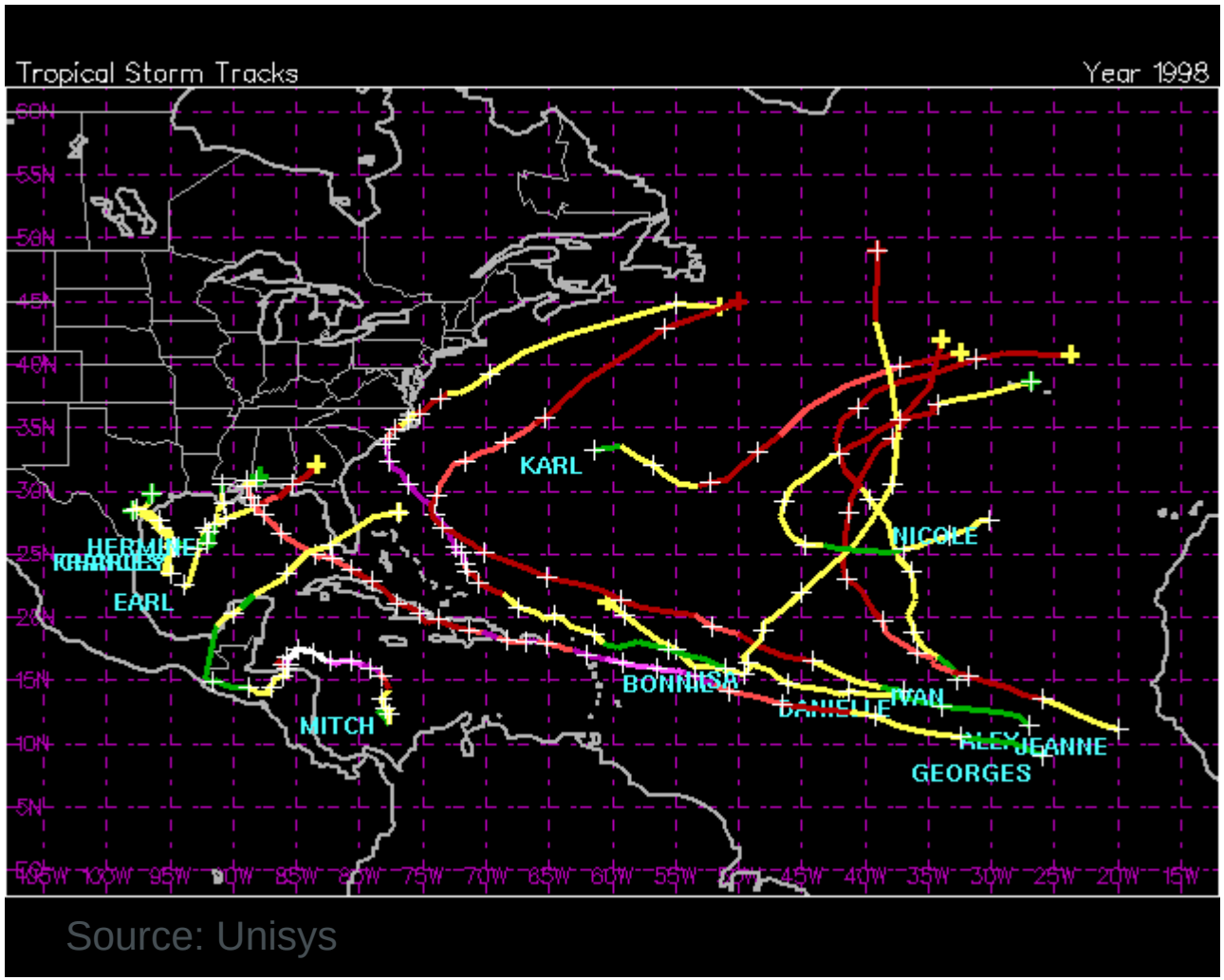
1987 - an El Niño year



Only 8 Named Storms in the Atlantic. But what else happened in 1987?

Hurricane Emily!

1998 - A La Niña Year



Source: Unisys

14 Named Storms in the Atlantic. Cat 5 Hurricane Mitch dumped up to 800mm of rain within 48 hours in Honduras & Nicaragua. Mitch caused over 9,000 deaths.

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2) Vulnerability to Hurricanes

- **Vulnerability** is the susceptibility to physical or emotional injury or attack.
- “Disasters occur when hazards meet vulnerability". A natural hazard will hence never result in a natural disaster in areas without vulnerability, e.g. strong earthquakes in uninhabited areas.
- Some factors influencing vulnerability:
  - Social
  - Physical

Source: Wikipedia

Social aspects of vulnerability

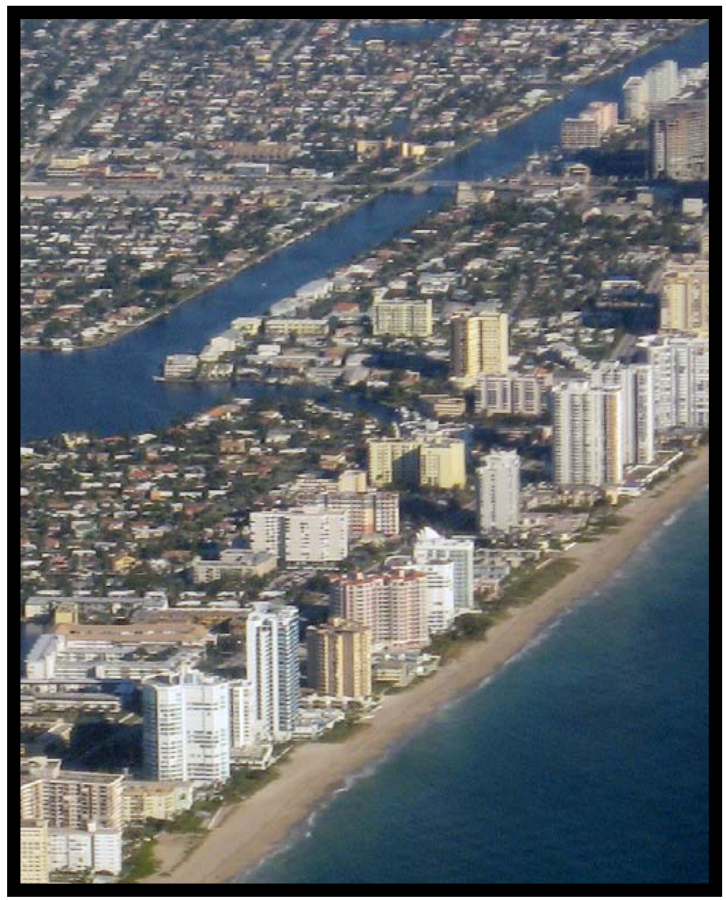
- Awareness/Preparedness
- **1900 Galevston Hurricane**
  - The Galveston Hurricane of 1900 is to date the deadliest natural disaster ever to strike the United States: estimated 8,000 fatalities.
  - Large death toll may be attributed to lack of awareness that the storm was coming

Social aspects of vulnerability

Miami Beach 1926

Wendler Collection

Miami Beach 2006



Joel Gratz © 2006

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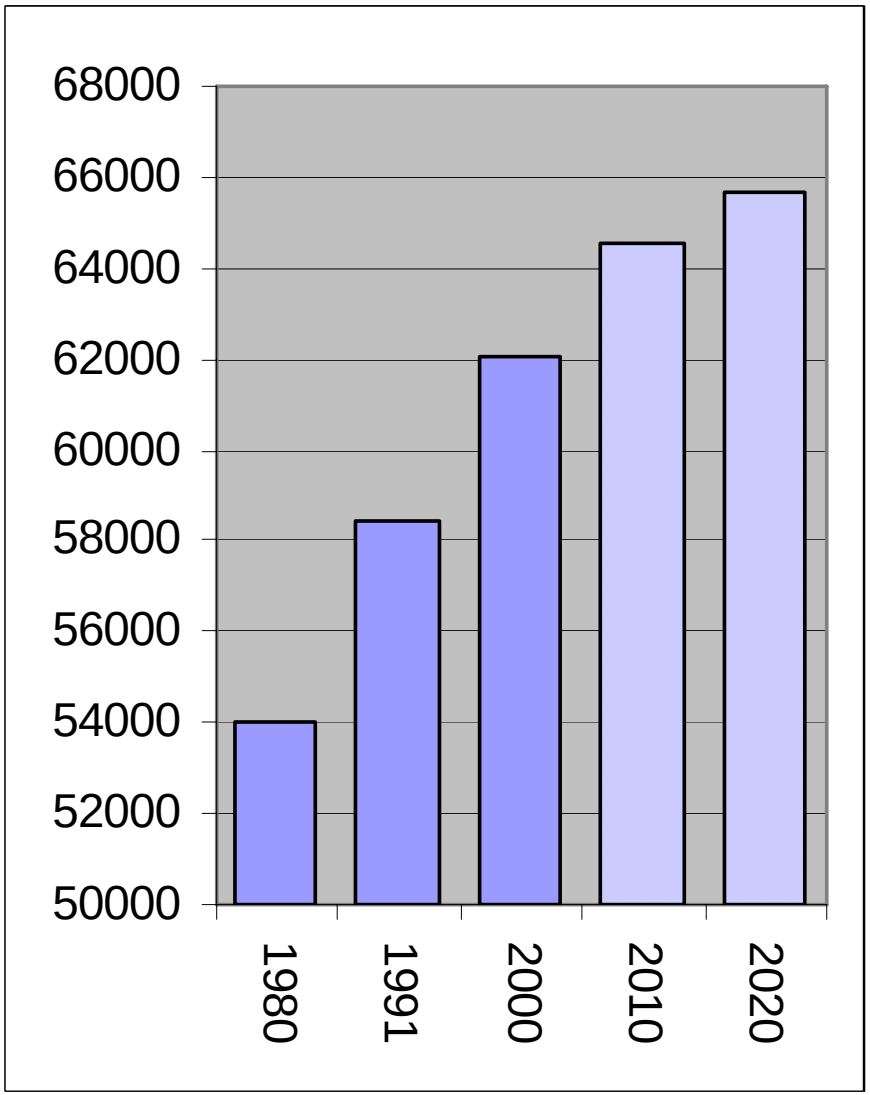
Projected Bermuda Population Growth



- Our own poulation density well exceeds 1000 people per km ^{2}
- Only forecast to get higher…

Source: Government of Bermuda Dept. of Statistics

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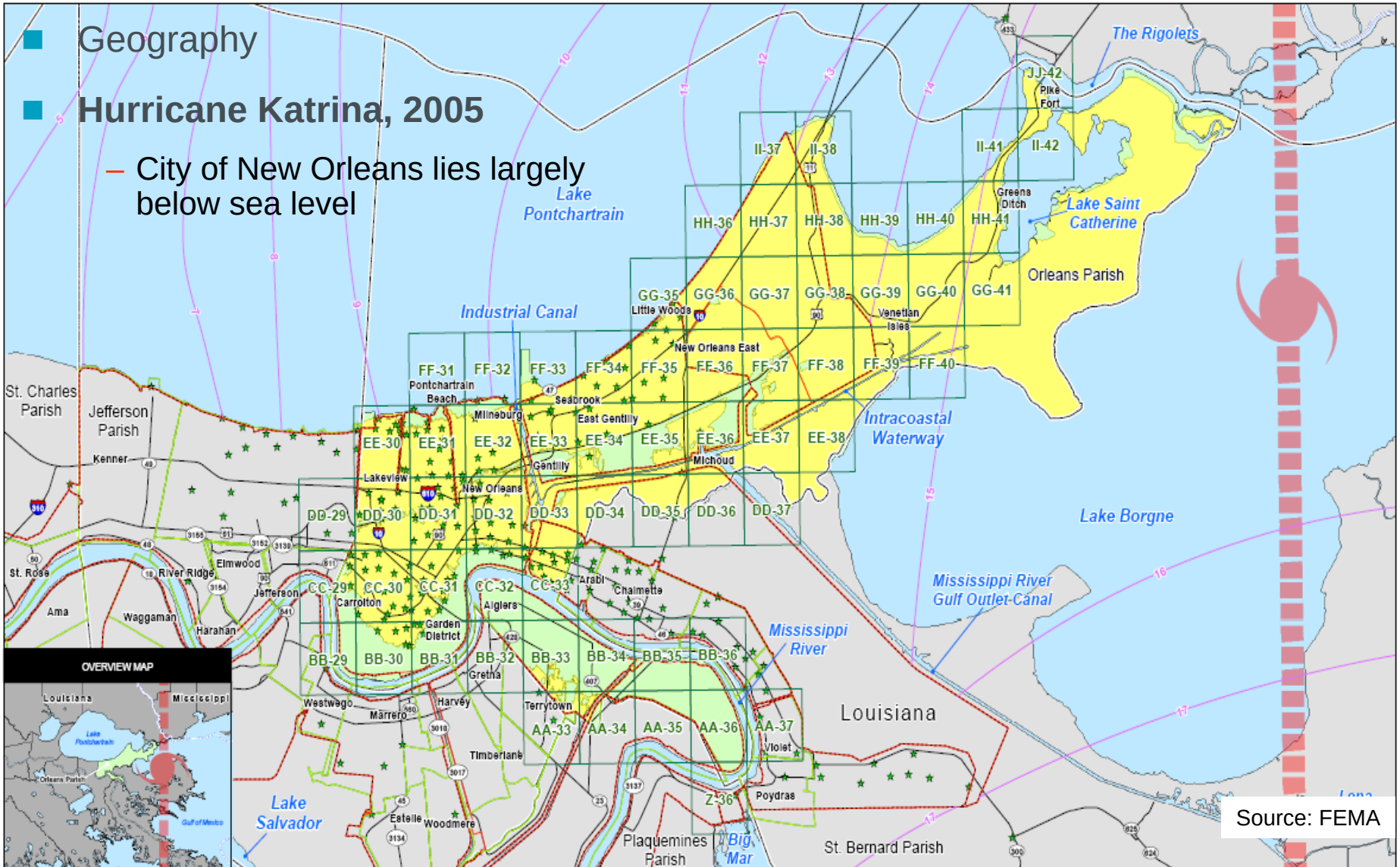
Physical aspects of vulnerability

- Geography
- **Hurricane Katrina, 2005**
  - City of New Orleans lies largely below sea level



Source: FEMA

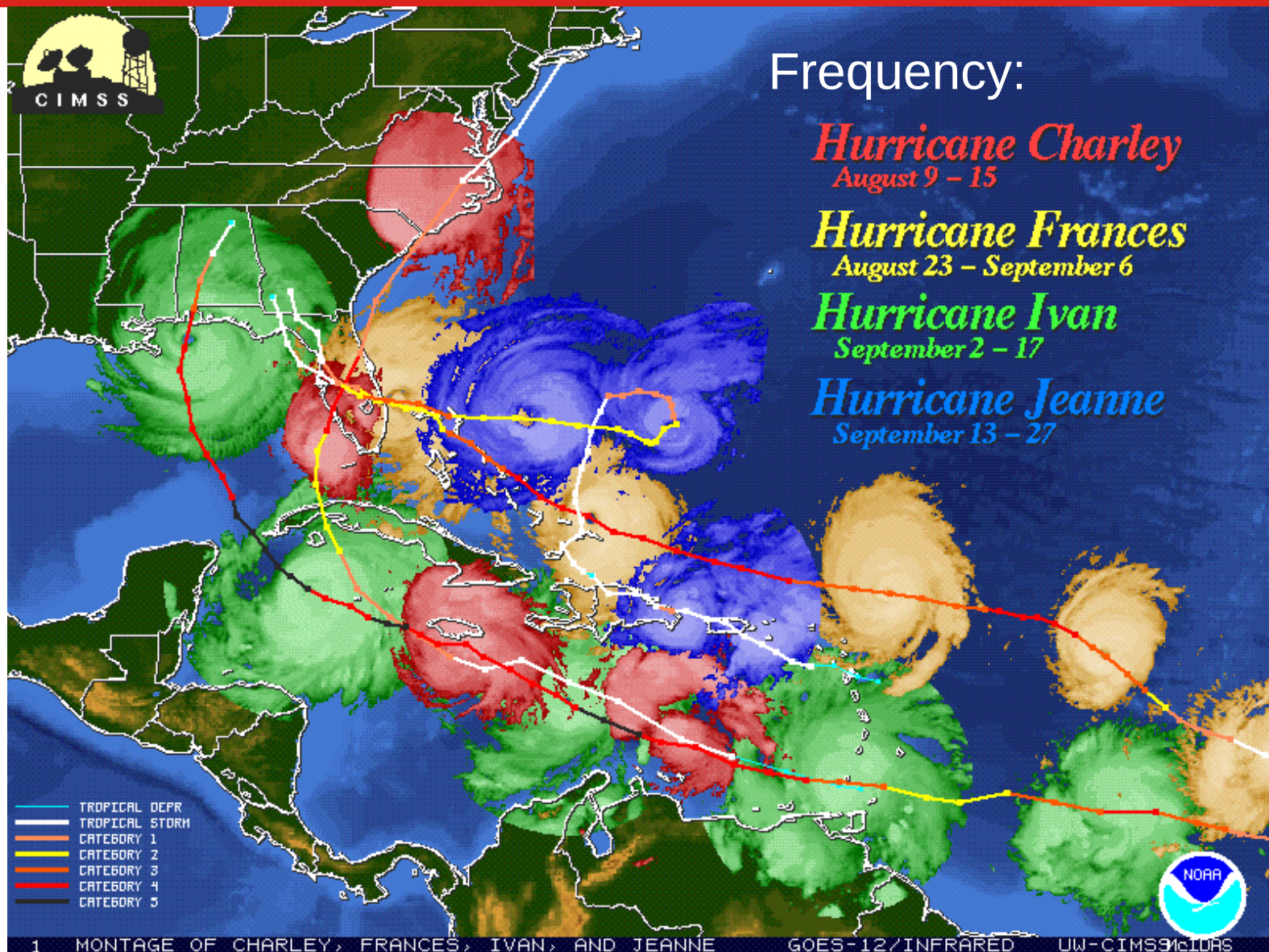
Events themselves drive vulnerability

Intensity:

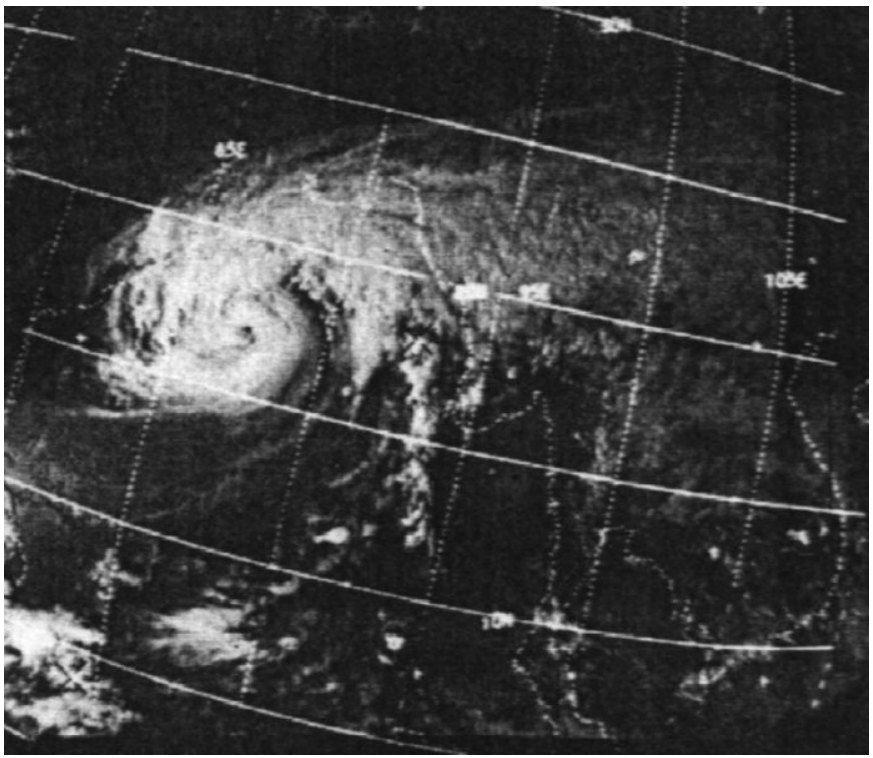
Andrew
1992

Mitch
1998

Fabian
2003



Combinations of factors can maximize vulnerability



- **1970 Bhola Cyclone:** Deadliest known tropical cyclone of all time
  - A powerful cyclone that hit Bangladesh on November 13, 1970 killed 500,000 people from storm surge, high winds, and flooding.
- **2005 Hurricane Katrina**
- **Factors:**
  - Lack of Awareness &/or Preparedness
  - Geography
  - Population
  - Intensity

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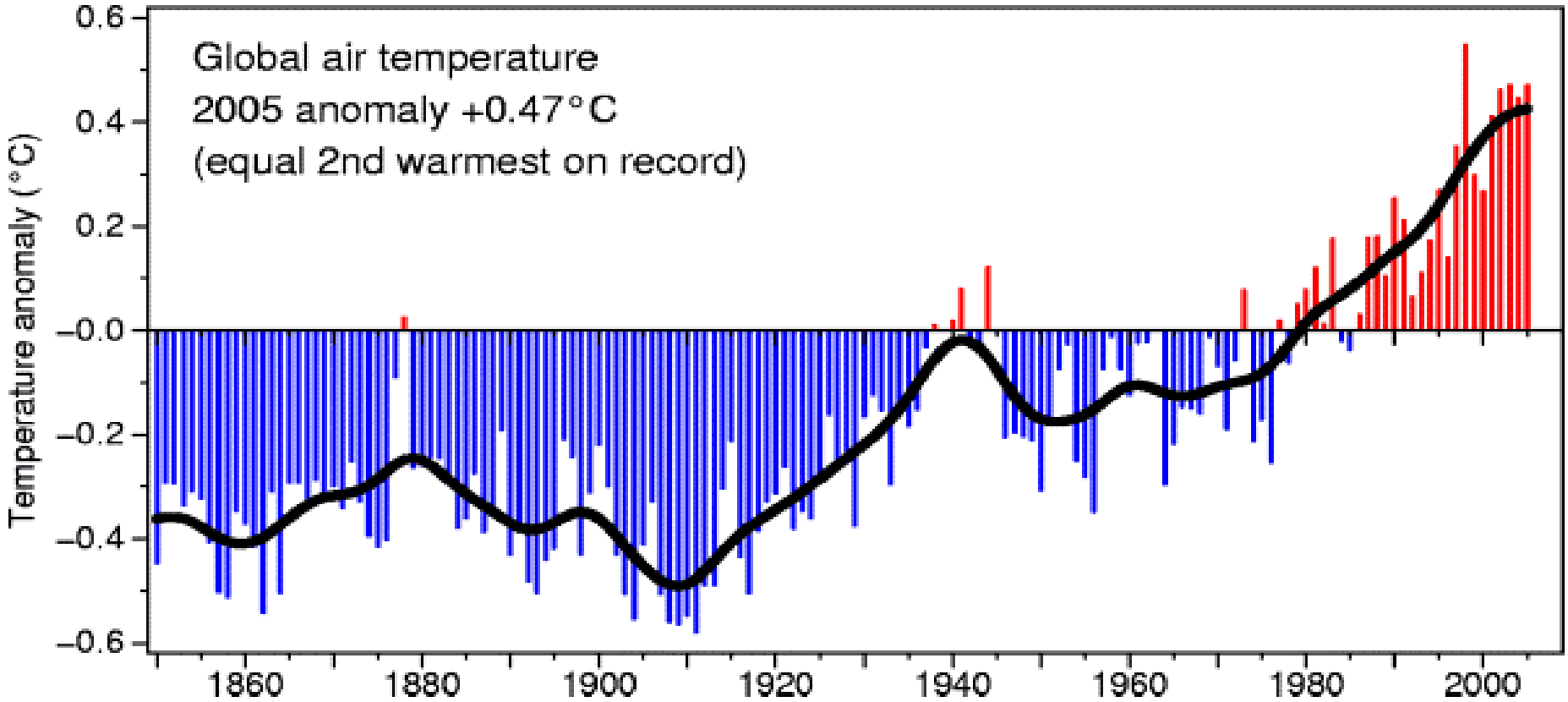
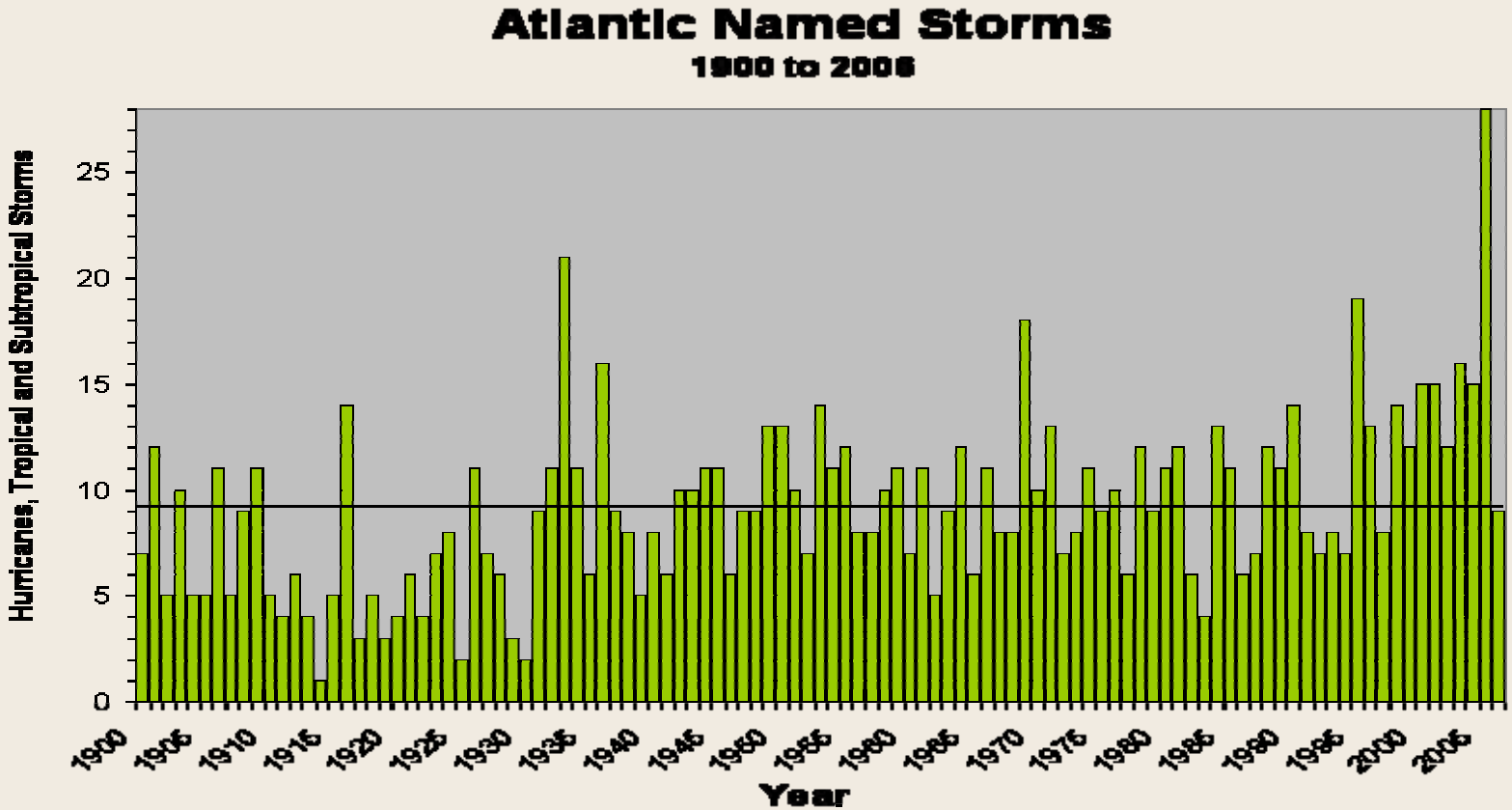
3) Global Warming and Hurricanes



Source: UEA

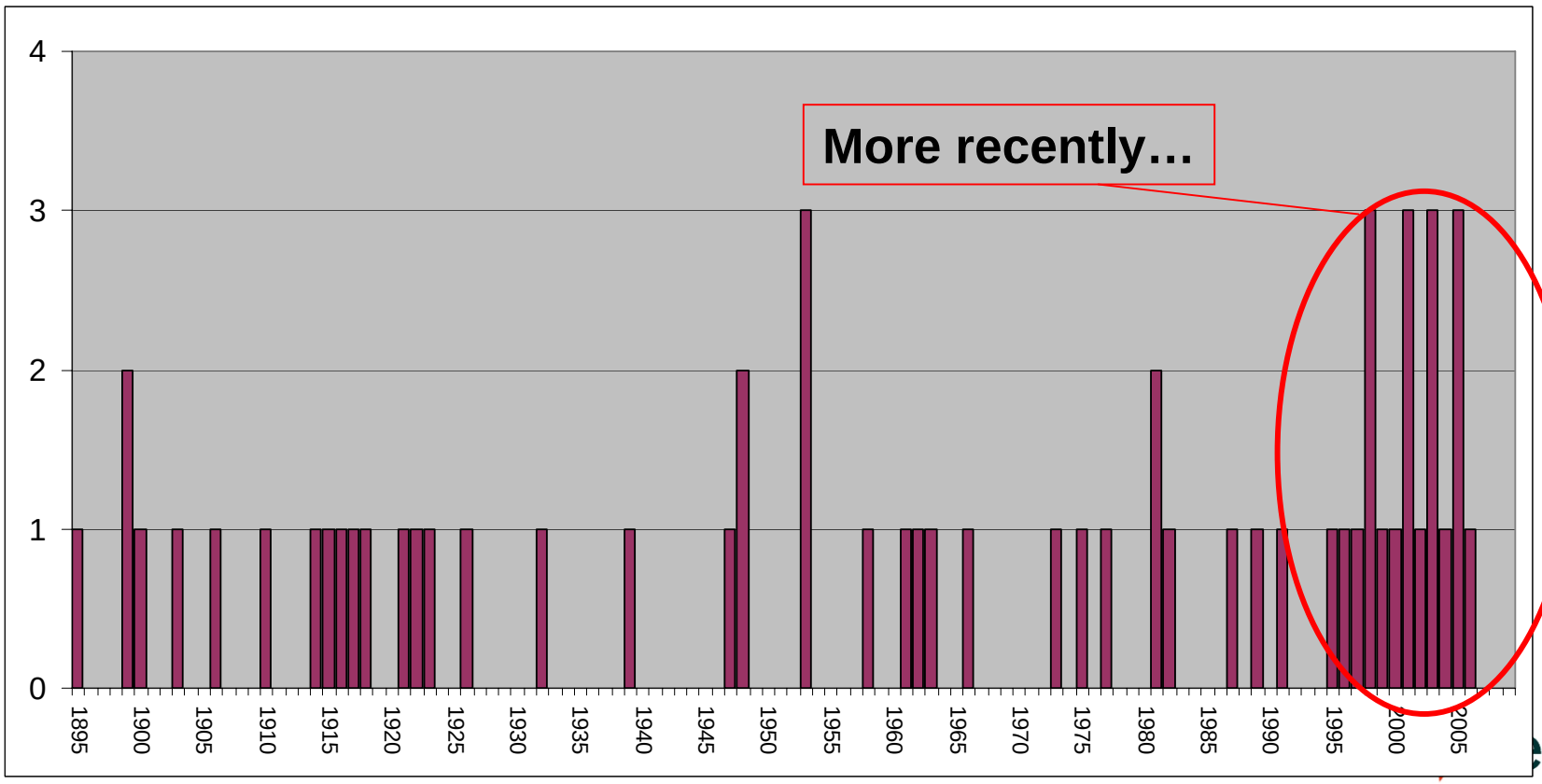
NHC Best Track Storm Database



Source: Landsea, 2006

Bermuda Best Track Storms

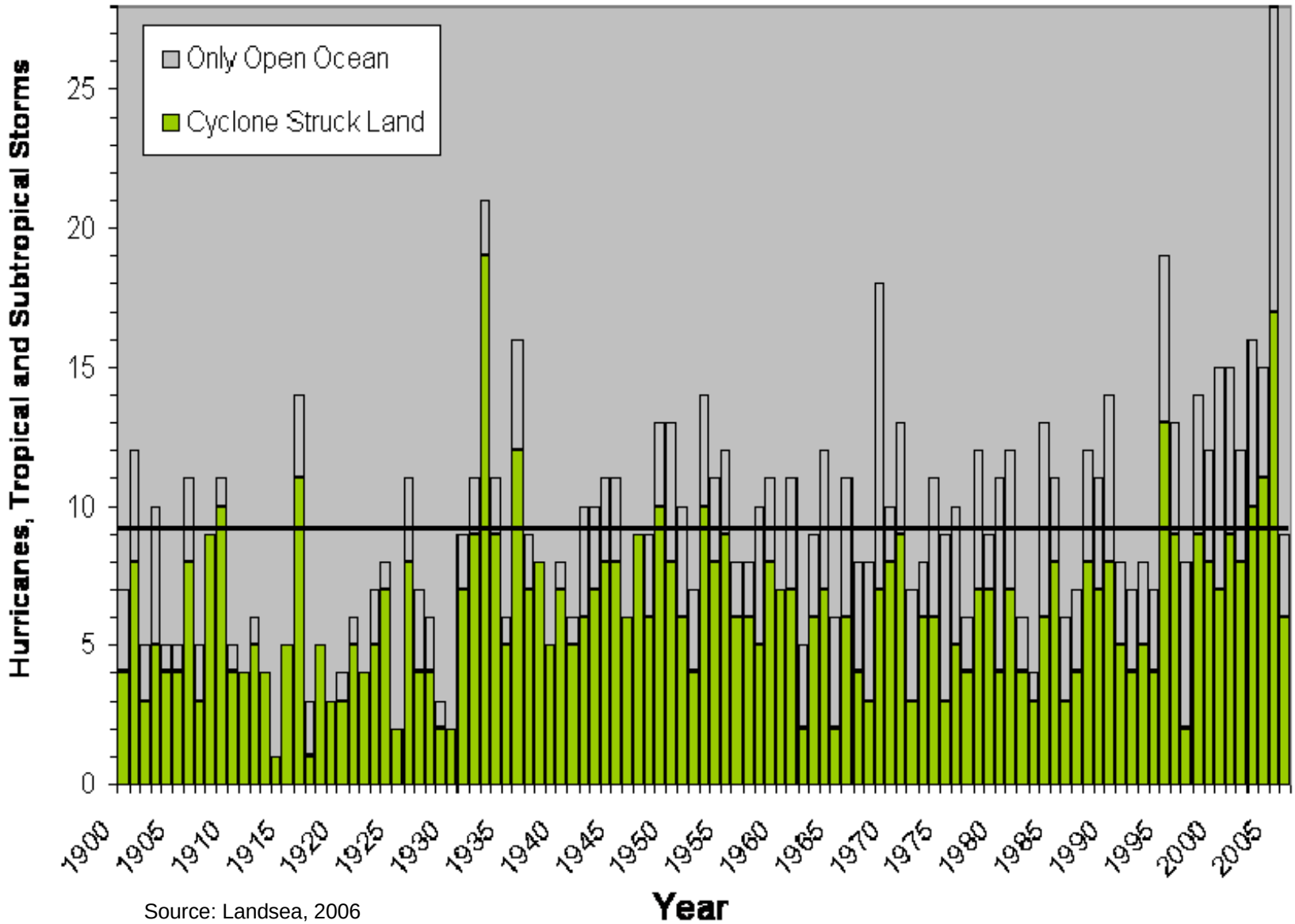
- Historically Bermuda is ***affected*** on average ~1 every 2 years (not necessarily direct hits)



Source: BWS

Atlantic Named Storms

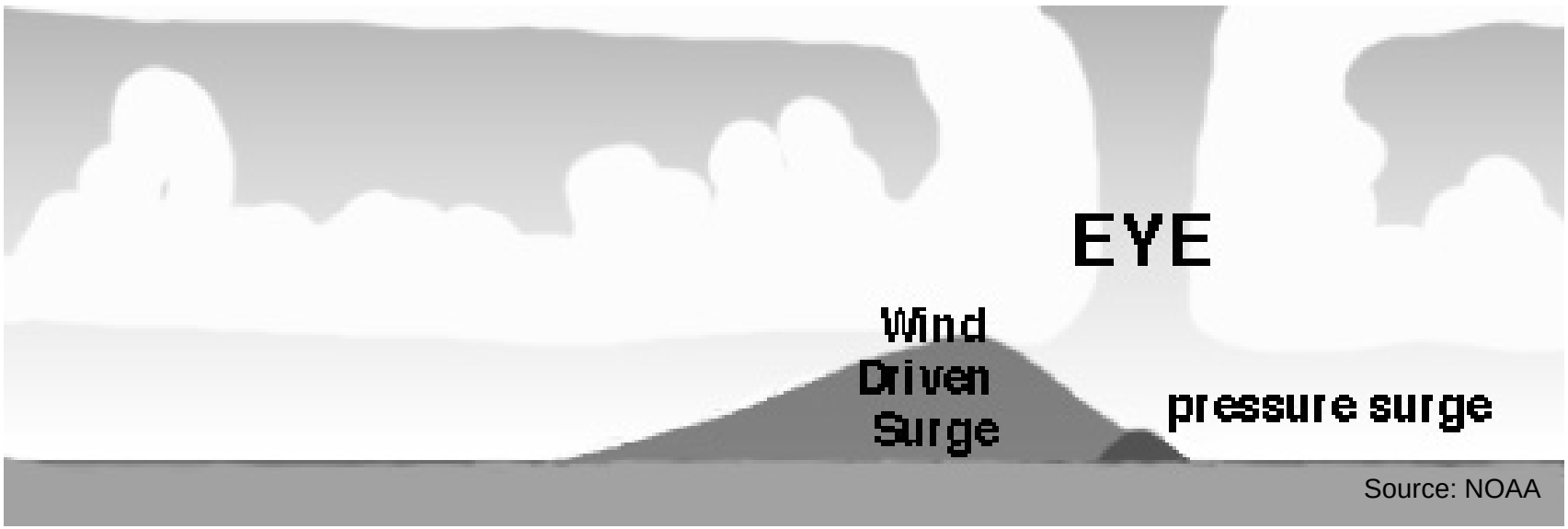
1900 to 2006



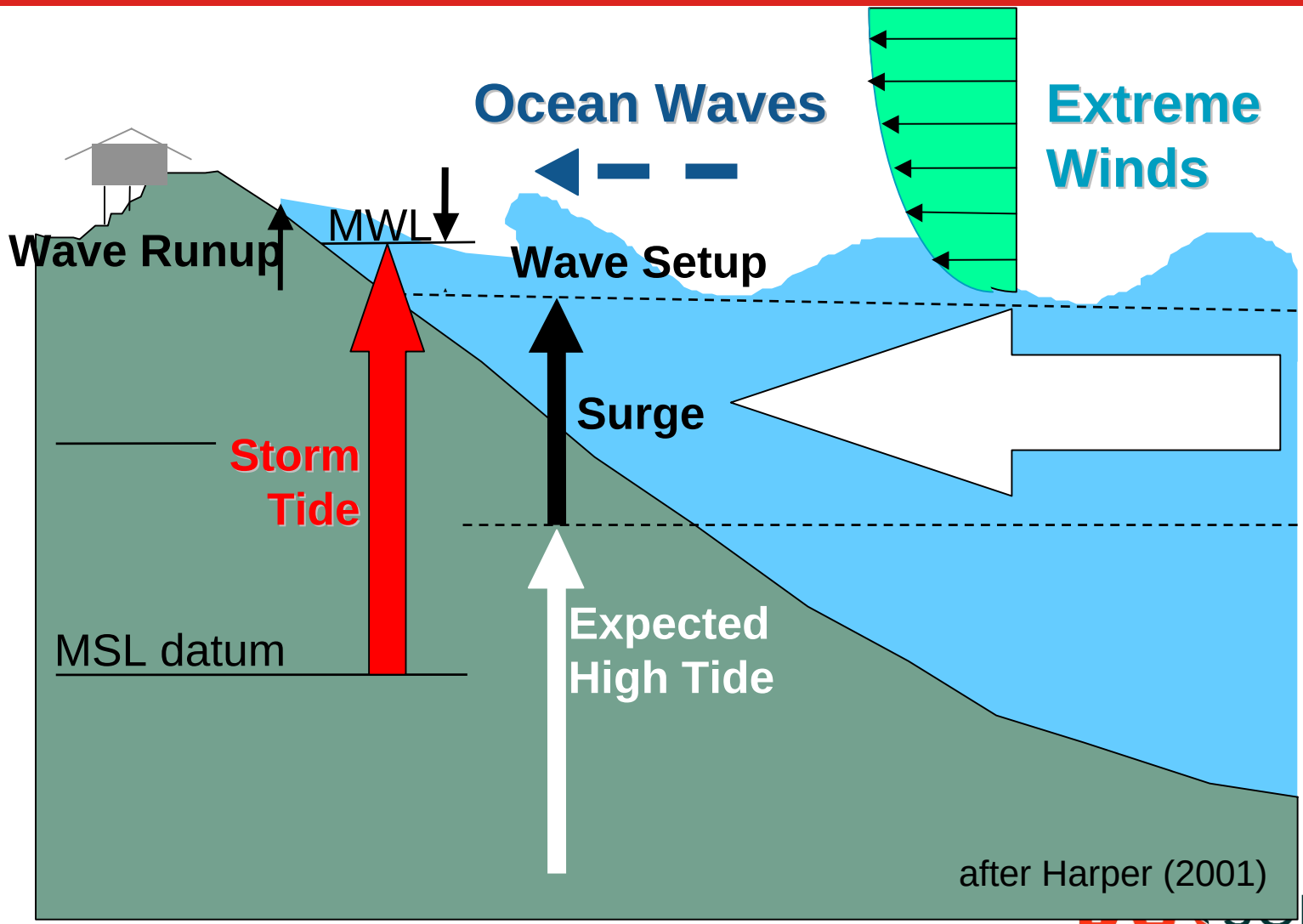
Source: Landsea, 2006

4) Water is the biggest killer, not wind

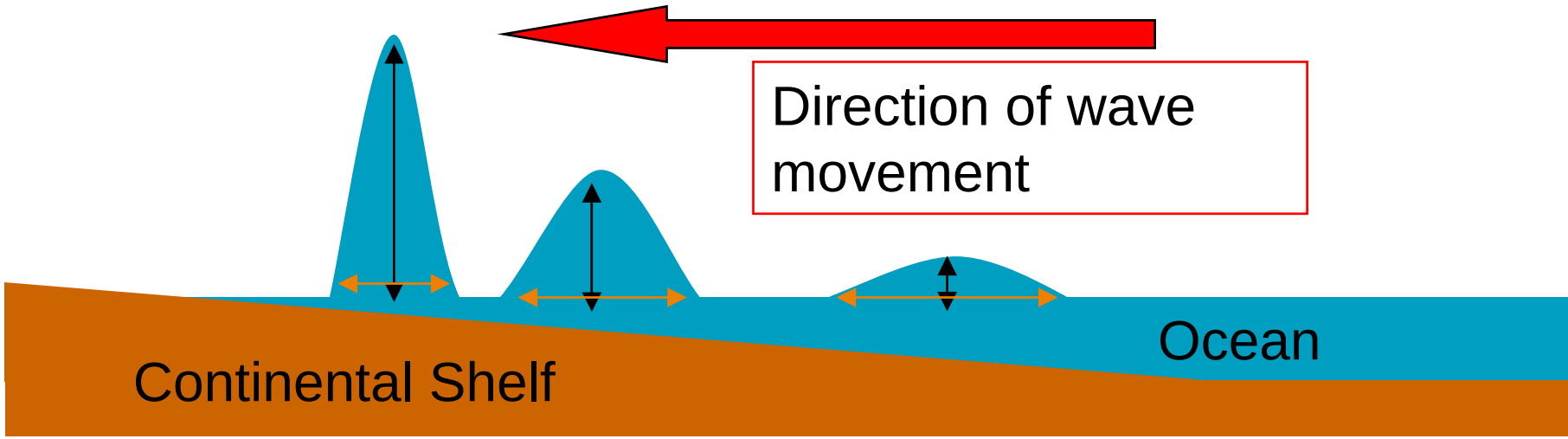
- "If the projected rise in sea level due to global warming occurs, then the vulnerability to tropical cyclone storm surge flooding would increase."
- Storm Surge is a dome of water driven by the persistent strong winds in a tropical system (not by the low central pressure!)



Storm Tide

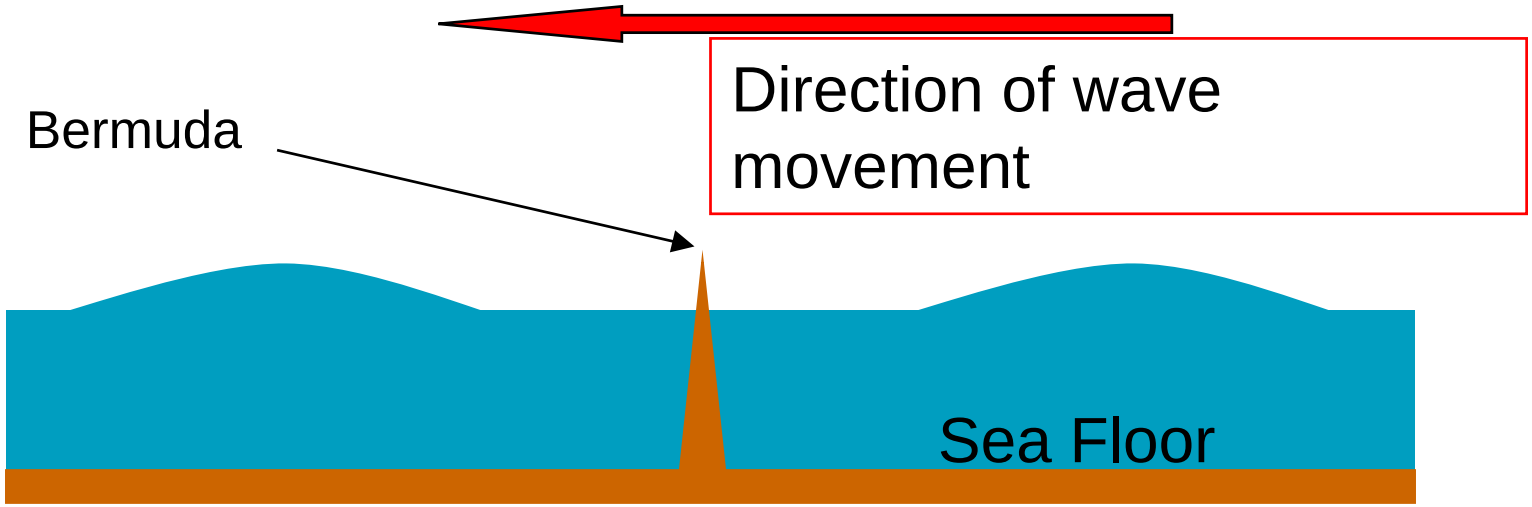

Ocean Waves
Extreme Winds
MWL
Wave Runup
Wave Setup
Surge
Storm Tide
MSL datum
Expected High Tide
after Harper (2001)

Storm Surge - Continental Effects



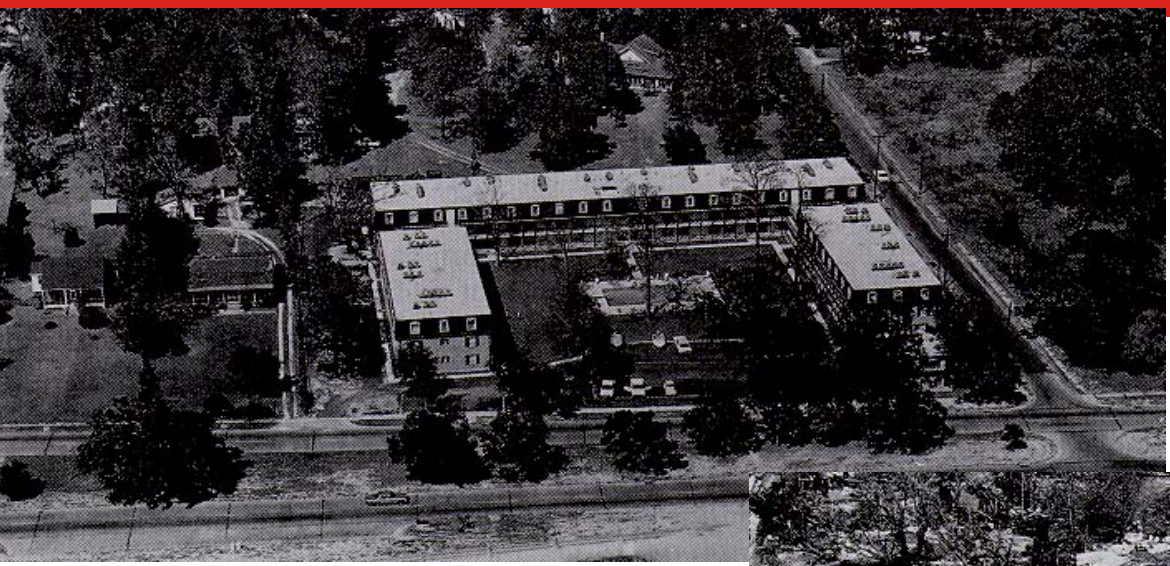
- As waves move into a shallower environment, their amplitudes increase and wavelengths decrease.

Waves - Island effects



- On a small, isolated island such as Bermuda, this effect is small; Large waves are deflected around the sea mount, in the surrounding deep water.
- Amplitudes and wavelengths stay fairly constant.
- However, sea states can still be quite significant in tropical systems...

Before and After the Hurricane



Source: NOAA

Richelieu Apartments
Pass Christian, MS
Hurricane Camille
17 Aug 1969

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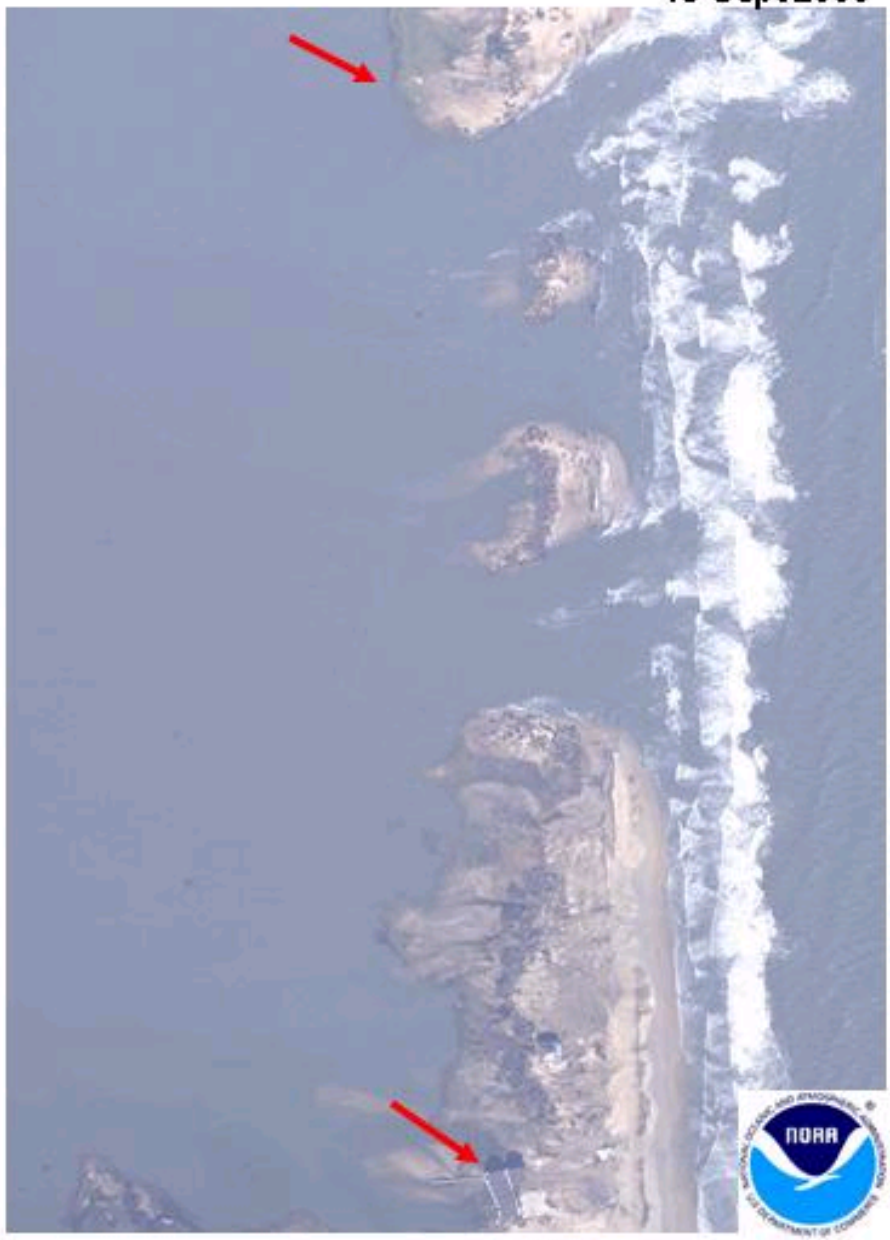
Hurricane Isabel Damage Assessment

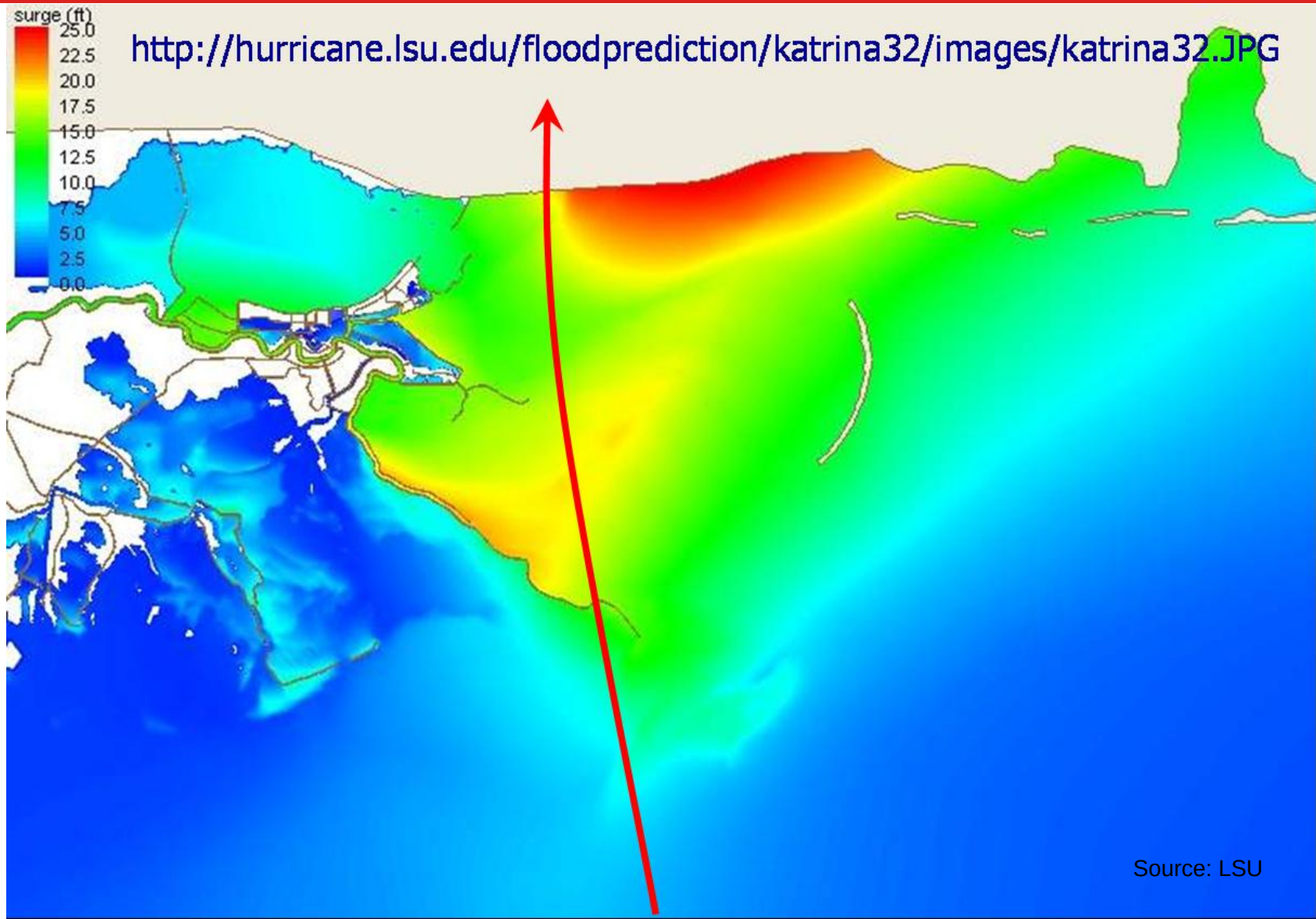
1998

19 Sept 2003

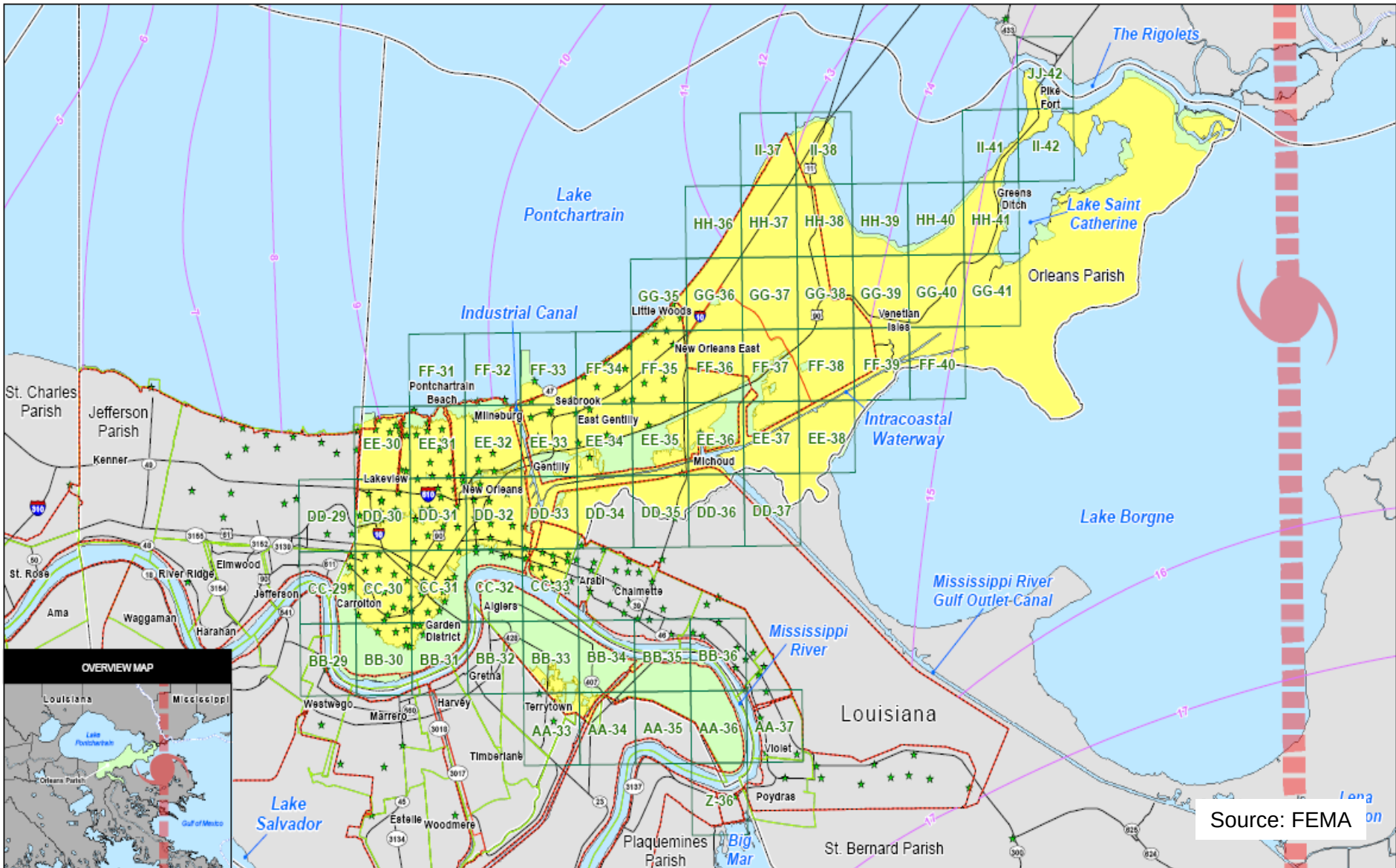


Cape Hatteras National Seashore, North of Hatteras Village, NC.

Katrina Storm Surge Model

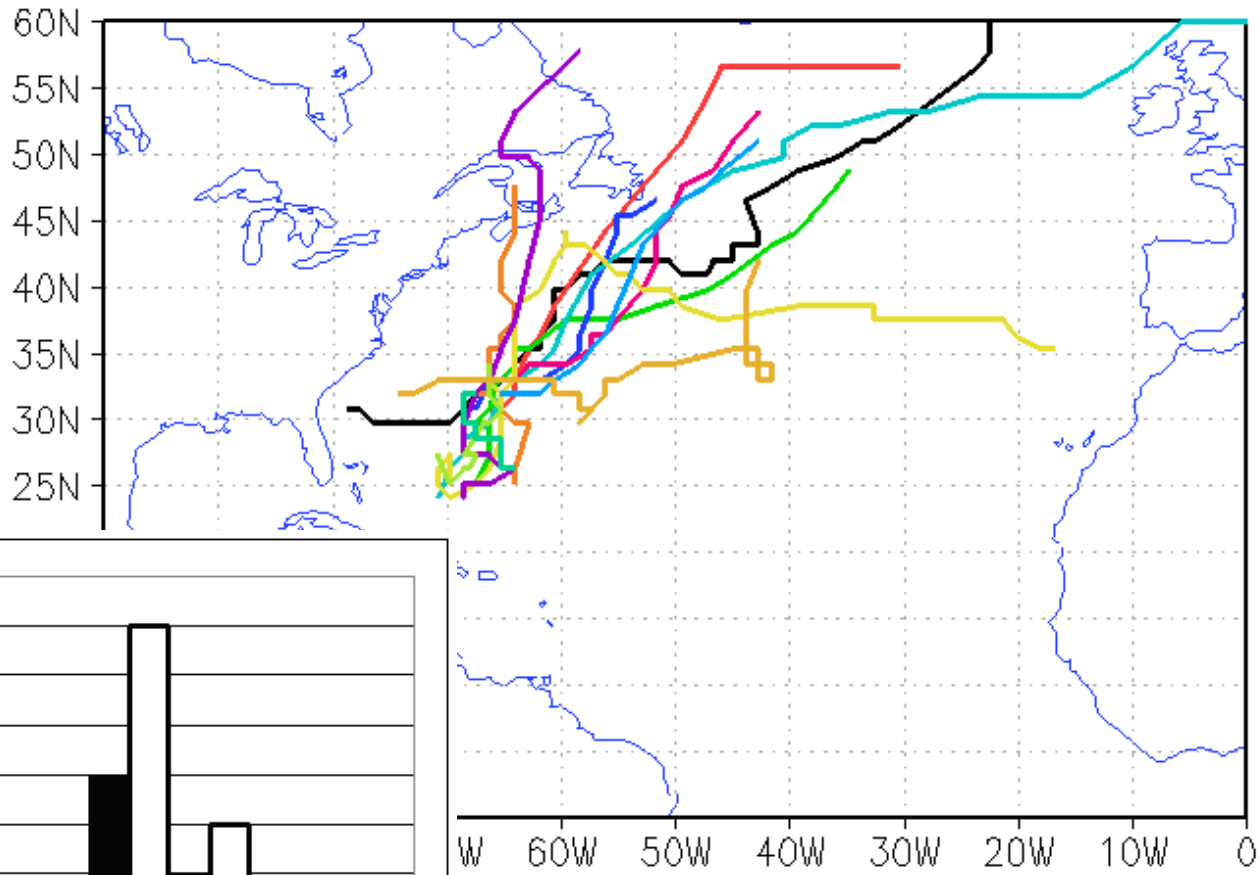


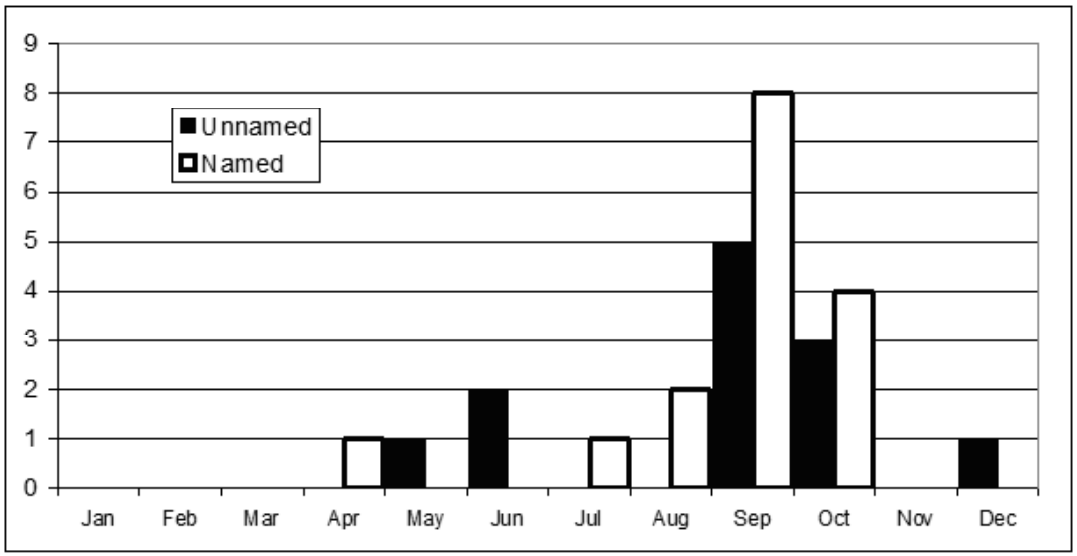
Katrina Storm Surge Map



5) A Hurricane is not always a Hurricane…

- Subtropical storms – about half of the storms we get in hurricane season are not even named by NHC





Source: Guishard, 2007

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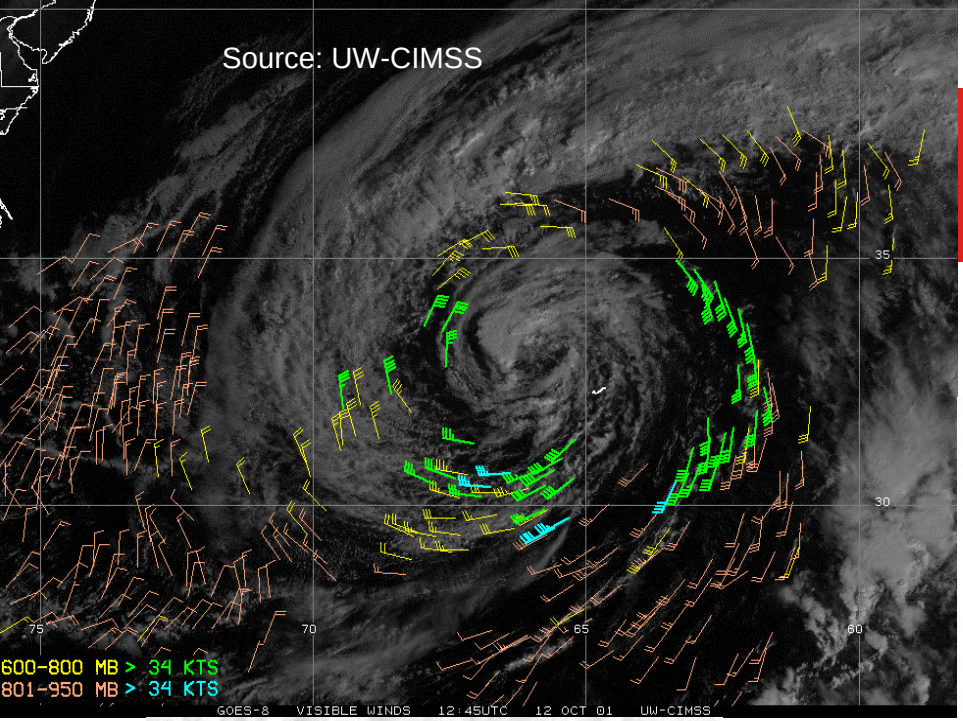
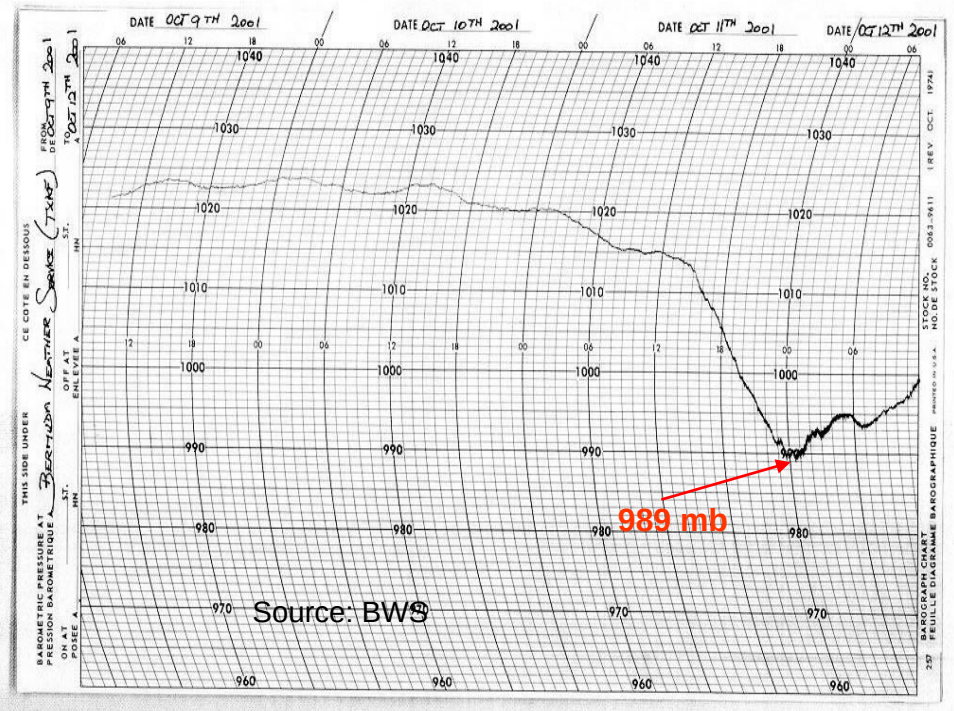
October 2001: Subtropical Storm ⇒ Hurricane Karen





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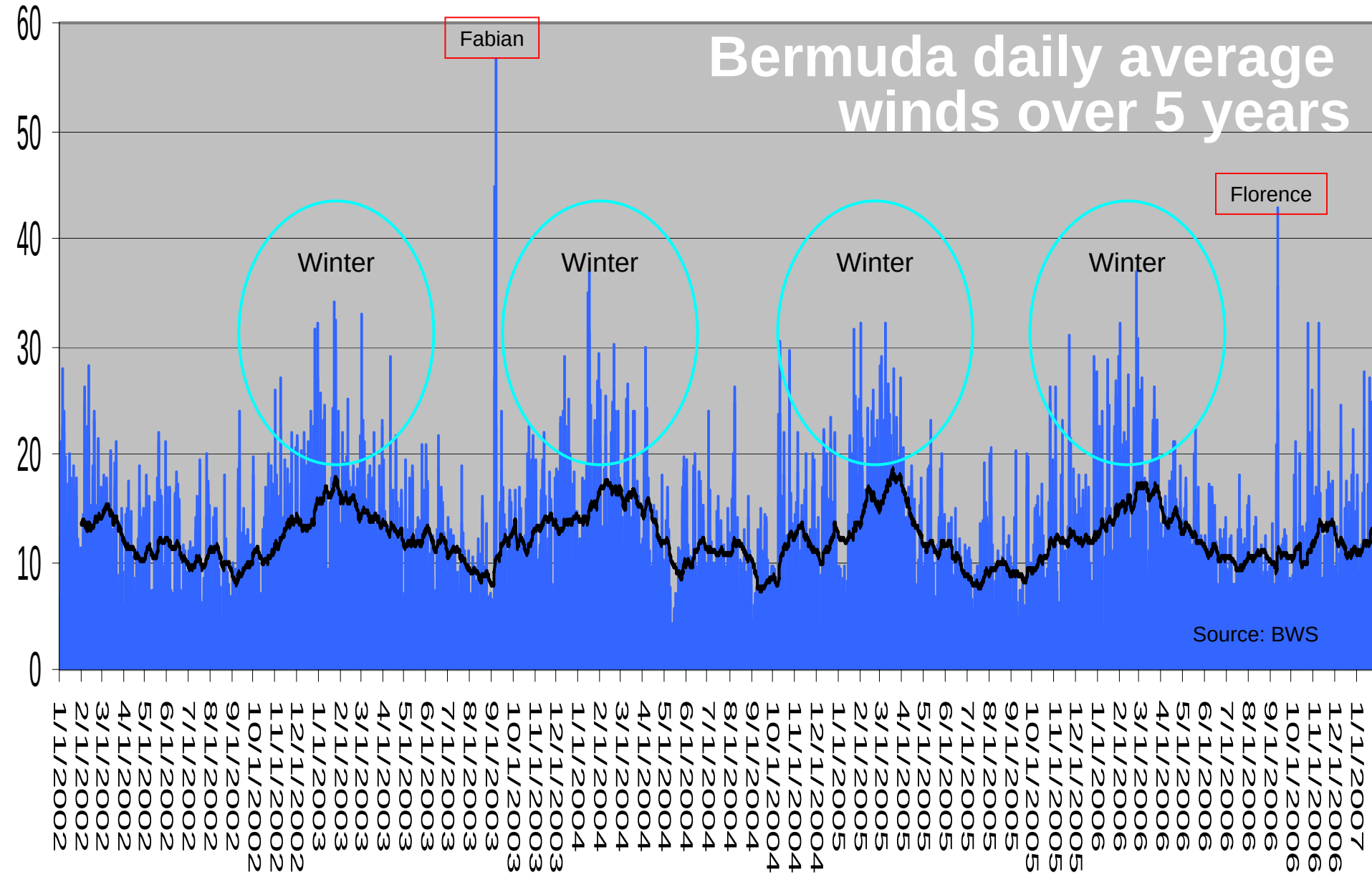
Bermuda daily average winds over 5 years
Fabian
Florence
Winter
Winter
Winter
Winter
Source: BWS
60
50
40
30
20
10
0
1/1/2002
2/1/2002
3/1/2002
4/1/2002
5/1/2002
6/1/2002
7/1/2002
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6/1/2006
7/1/2006
8/1/2006
9/1/2006
10/1/2006
11/1/2006
12/1/2006
1/1/2007

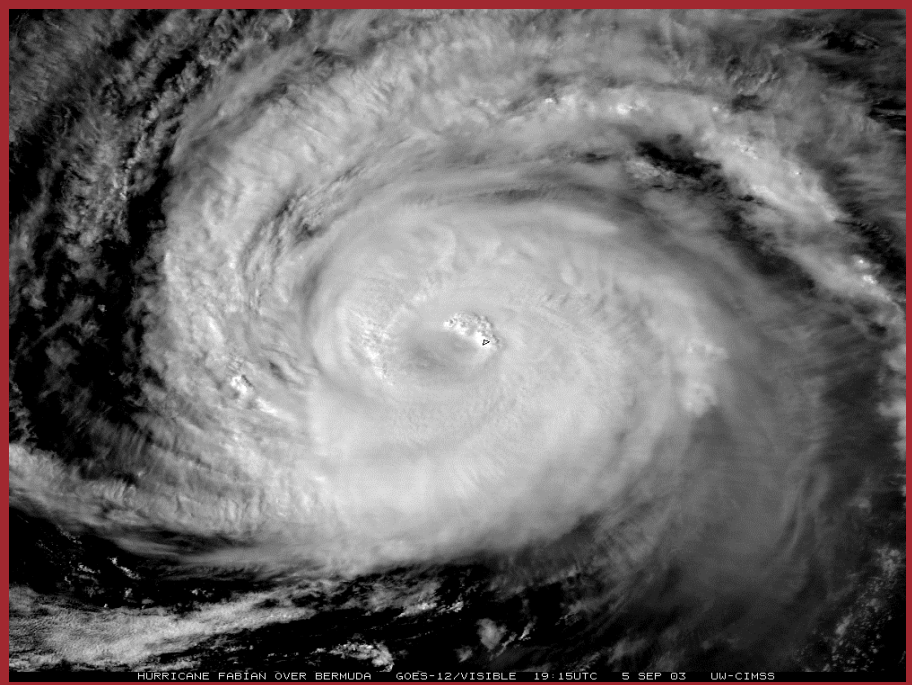
Recap

- El Niño
  - Natural climate pattern
  - Reduces hurricane formation in the Atlantic…
  - …by changing the shear pattern in the main development region.
- Vulnerability to Hurricanes is compounded by social and physical aspects like
  - Geography,
  - Population and
  - Awareness,
  - in addition to the frequency and intensity of the events themselves.

Recap

- The effects of global warming on hurricanes in the Atlantic are not as clear as they might appear at first. Unreliable database before:
  - Satellites and Radar
  - Aircraft reconnaissance
  - Weather Balloons
- Water is the biggest cause of fatalities in hurricanes, not direct wind strength.
- Hurricane force winds don't always come from what we classically think of as hurricanes.

Any Questions?



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