Florida Coastal Hazards Come in Waves

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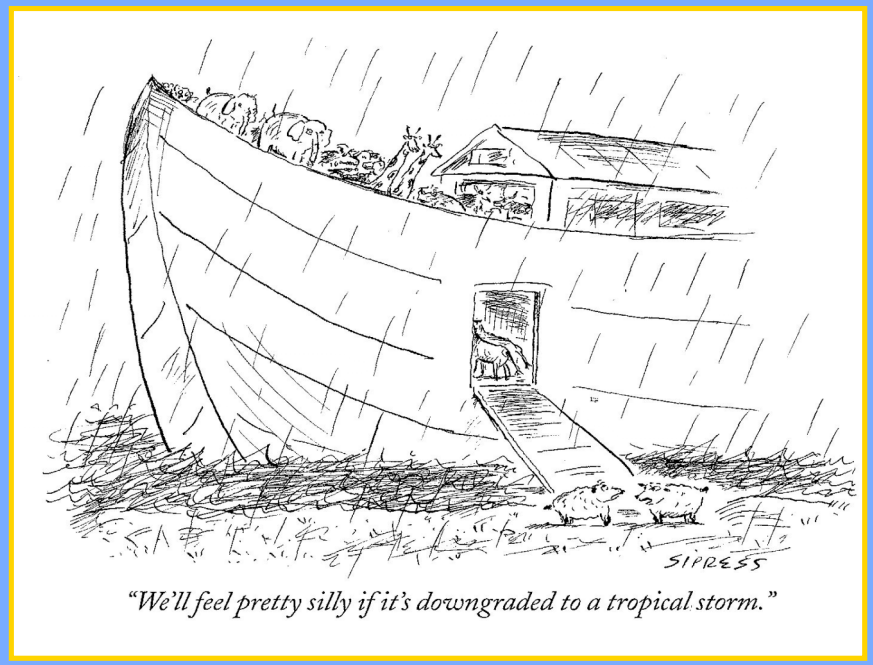
Outline of the Talk

- Sea Level
  - Ups and downs
- Tsunami
  - The Atlantic risk
- Storm Surge
  - The case of Wilma
- …everything [else] you always wanted to know…but were afraid to ask
- Summary
- Questions?



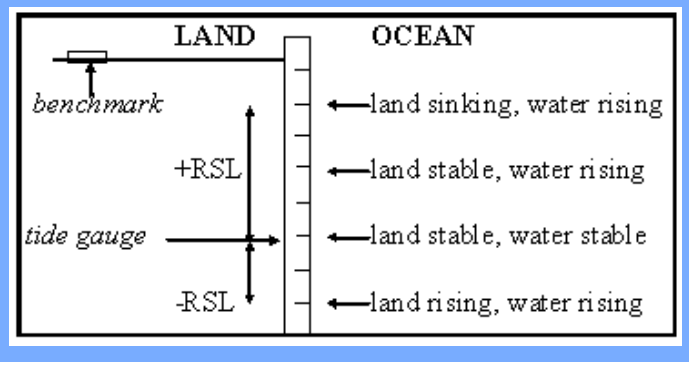
"We'll feel pretty silly if it's downgraded to a tropical storm."

Sea Level

- Earth's sea-level changes on time-scales of the twice-daily tides to thousands of years.
- Relative sea-level is the relationship between the water and the land.
- If the land is sinking, relative sea-level (RSL) is rising, and if the land is rising, sea-level appears to be falling.

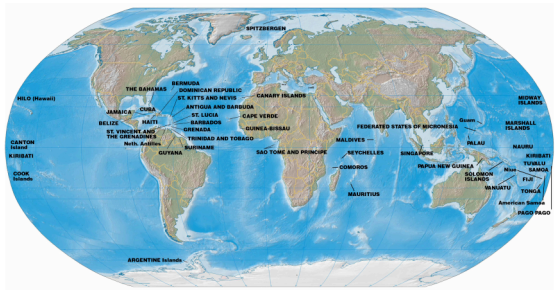
Tide gauge

RSL

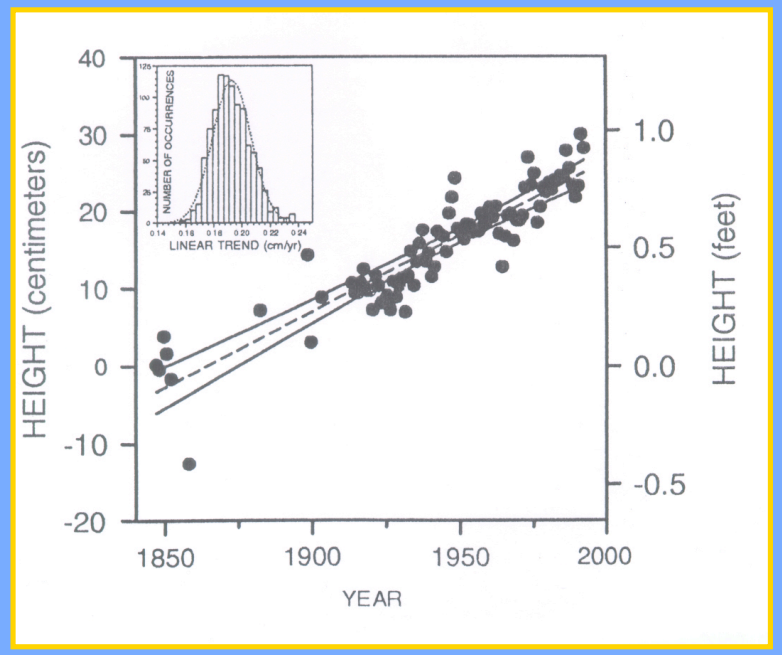


Factors Affecting Relative Sea Level (RSL) Change

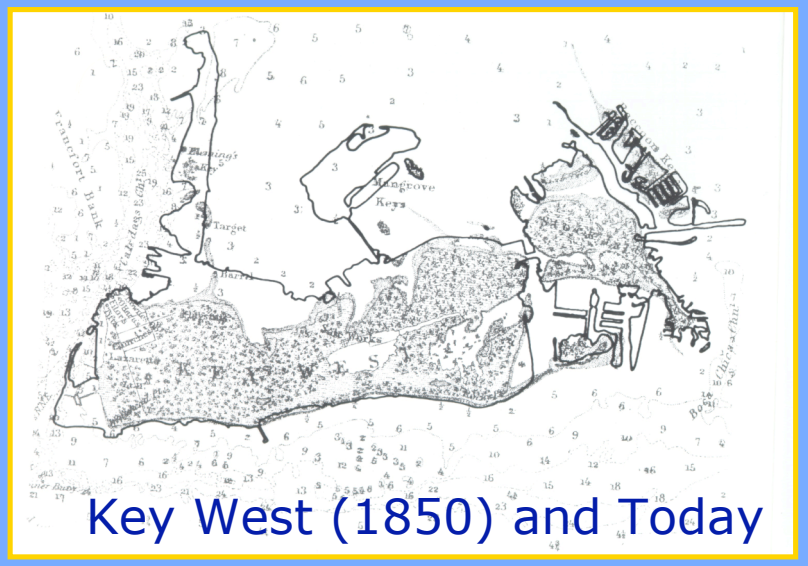
$$
\begin{aligned}
RSL = & \text{ Height}_{\text{thermal expansion}} \\
& + \text{ Height}_{\text{land motion}} \\
& + \text{ Height}_{\text{glacial melt}} \\
& + \text{ Height}_{\text{ocean circulation}} \\
& + \text{ Height}_{\text{winds}} \\
& + \text{ Height}_{\text{barometric pressure}} \\
& + \text{ Height}_{\text{tides}} \\
& + \text{ Residual}
\end{aligned}
$$



Key West Sea Level
America's Longest Record

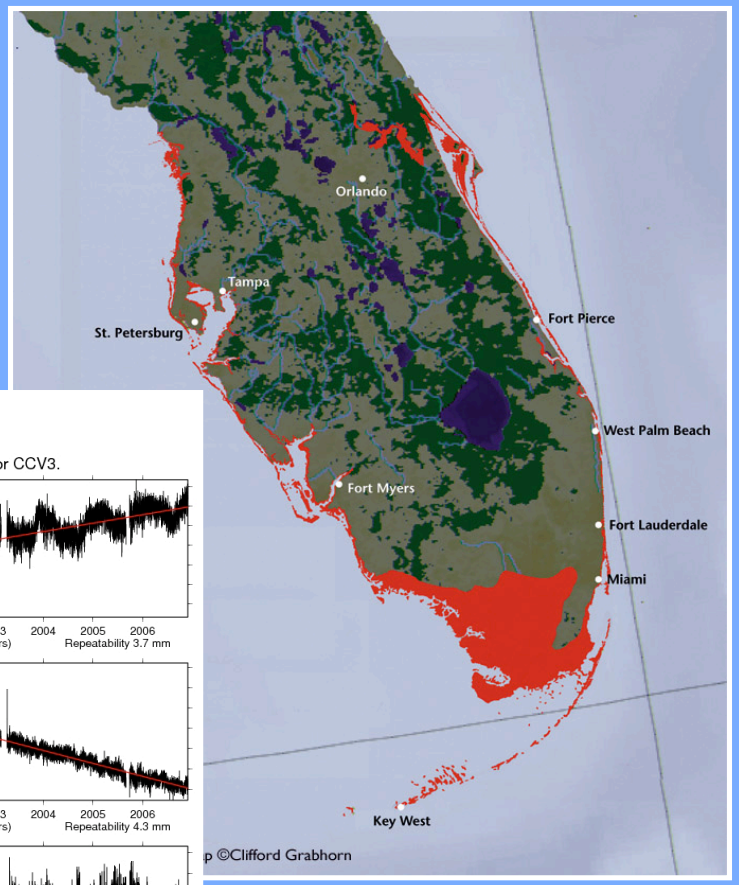


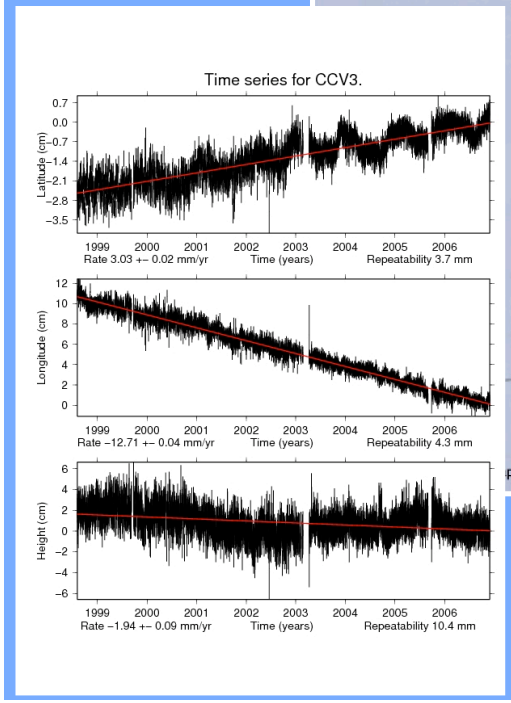
Station	***RSL***	***Uncertainty***
Cedar Key	19 cm/century	± 1 cm
Fernandina Beach	22 cm/century	± 1 cm
Key West	22 cm/century	± 4 cm
Mayport	24 cm/century	± 2 cm
Miami Beach	24 cm/century	± 2 cm
Pensacola	22 cm/century	± 2 cm
St. Petersburg	25 cm/century	± 2 cm



Key West (1850) and Today

Projected effect of sea level rise on Florida





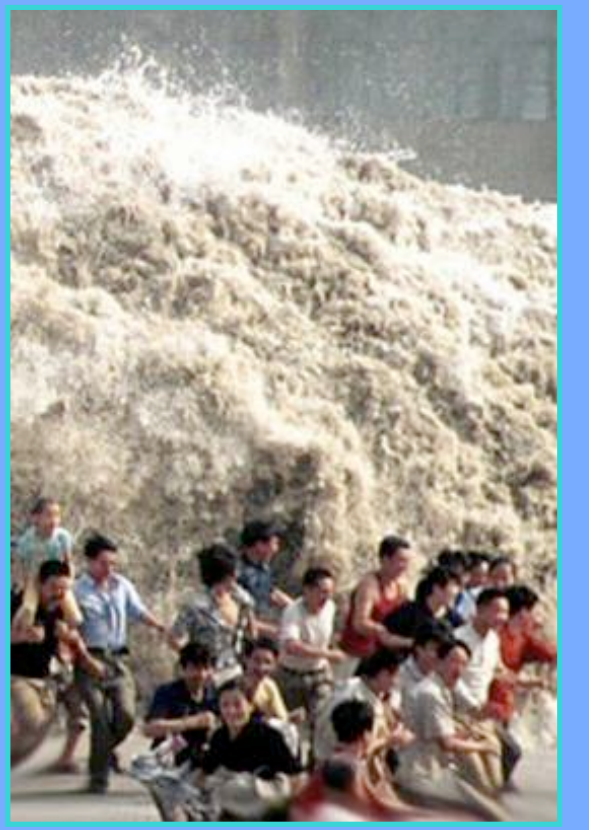
At the current rate of Florida sea level rise of 2.3 mm per year, this will take >400 years.

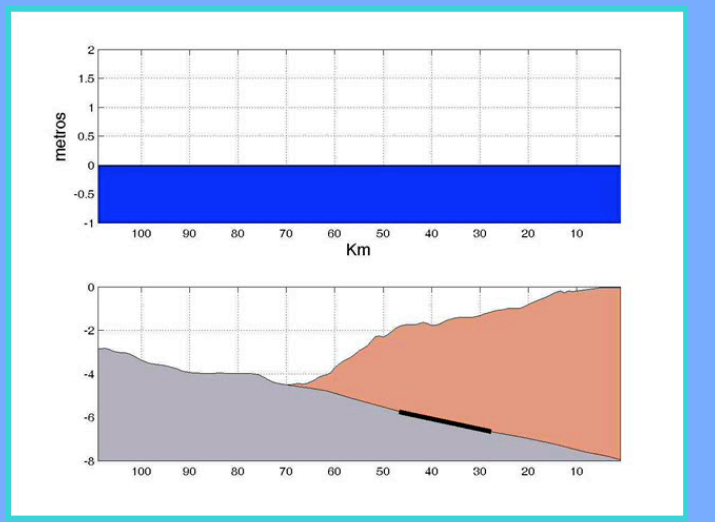
Cape Canaveral CORS data

Tsunami

- Tsunamis are sea waves usually of seismic origin from an undersea earthquake.
- They travel across the sea at a speed depending on the water-depth with typical values of 400 mph.
- As they enter shallow water, their height increases and they have been known to grow to hundreds of feet high.

Record tsunami height = 1700 feet





Percentage Distribution of Tsunamis in the World's Oceans

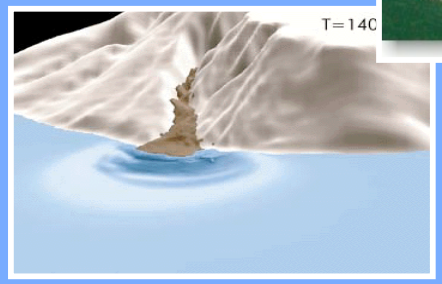
Location	%
Atlantic East Coast	1.6
Atlantic West Coast	0.4
Mediterranean	10.1
Caribbean	13.8
Bay of Bengal	0.8
East Indies	20.3
Oceania	25.4
Japan-Russia	18.6
Pacific East Coast	8.9

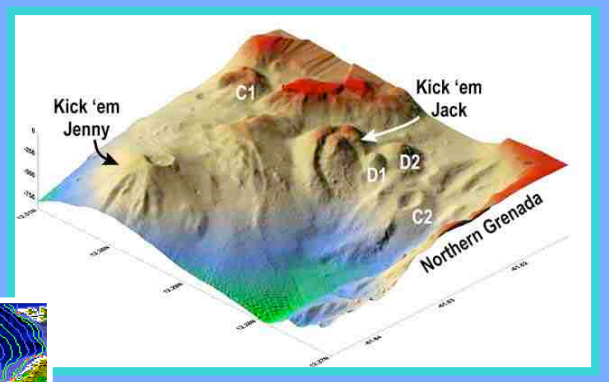
There are three kinds of lies: lies, damned lies, and statistics.

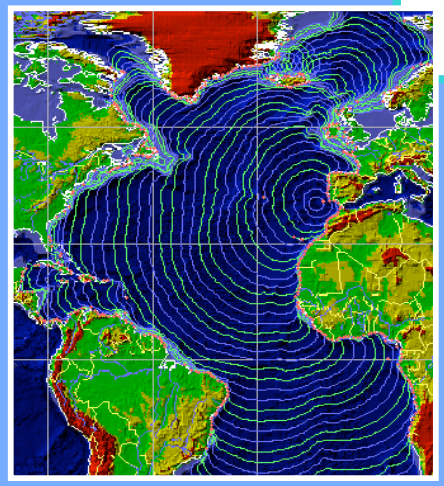
40 East Coast USA Tsunami or Tsunami-like Events Since 1600

Atlantic Tsunami Risk

- Close Earthquake
- Landslide
- Submarine Volcano
- Tele-tsunami

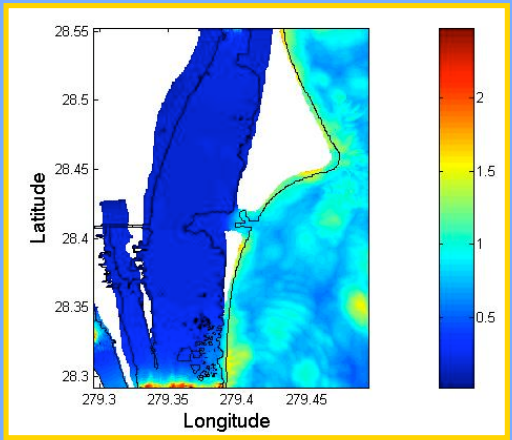




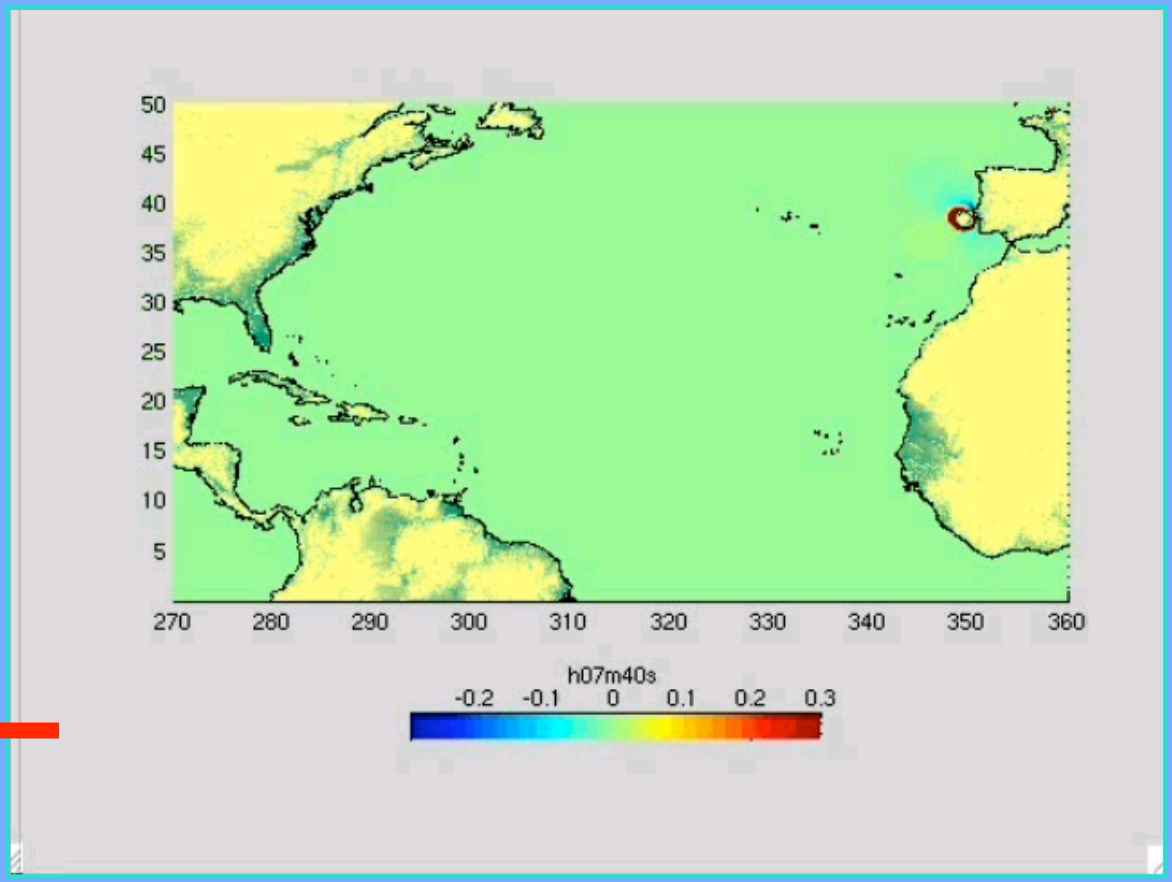


It is tough to make predictions, especially about the future.

Tsunami: Is Florida At Risk?



~1.5 meter high, 30 minute period waves off Cape Canaveral



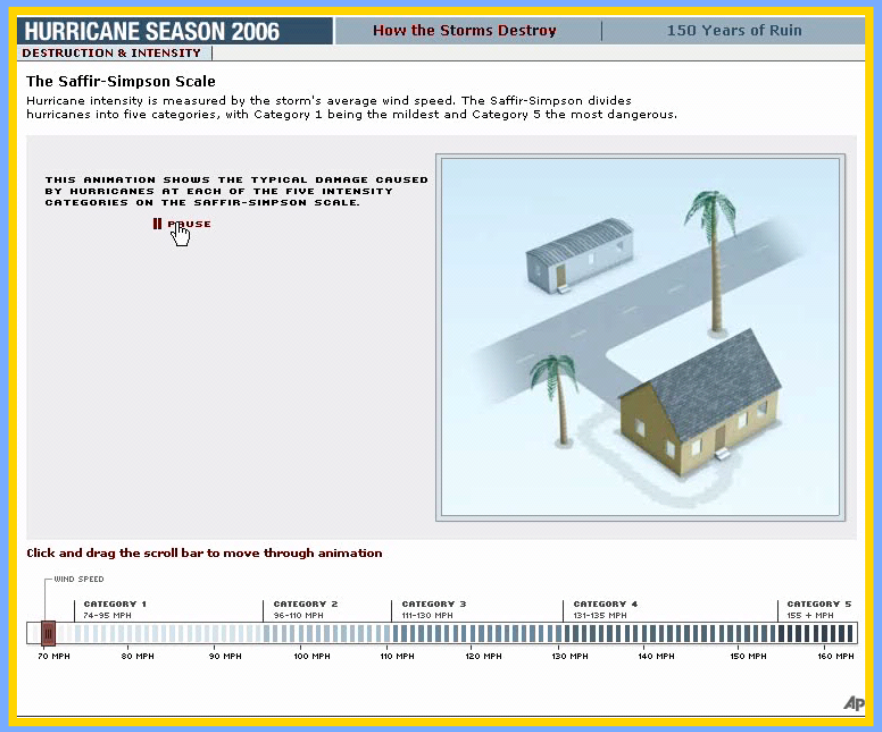
1755 Lisbon Tsunami Simulation

Storm Surge

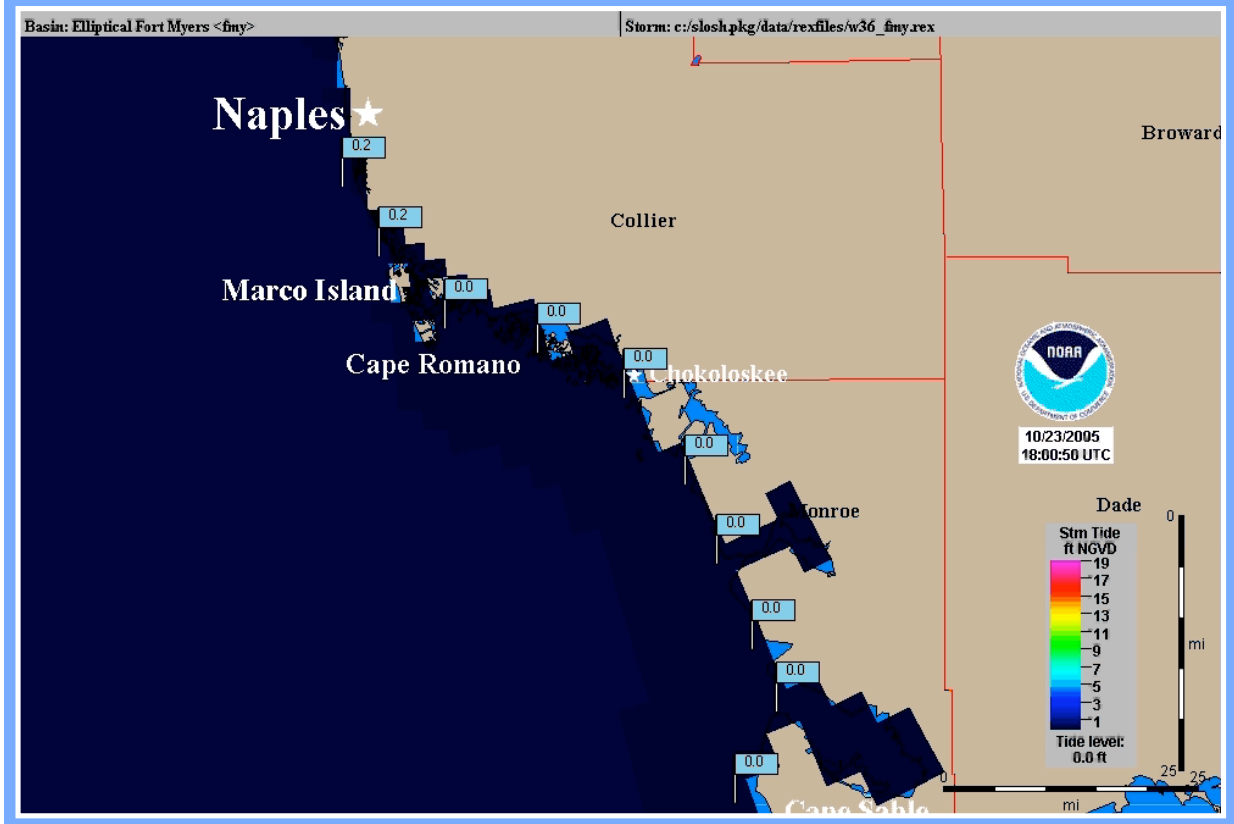
- Winds blowing over the water cause the sea surface to slope uphill and this mound of water grows higher as the water gets more shallow.
- The low pressure in the storm also causes the water to rise in what is called the inverted barometer effect.
- The combination, depending on the stage of the tide, can add tens of feet of water level rise – on top of which are the wind waves!

Saffir-Simpson Hurricane Scale and related Storm Surge

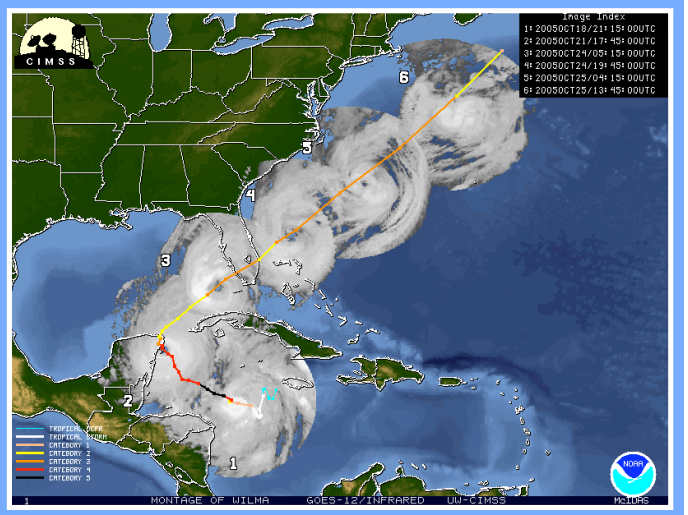
Category	Maximum Sustained Wind Speed mph (m/s)	Minimum Surface Pressure mb	Storm Surge m (ft)
1	74-96 (33-42)	> 980	1.0-1.7 (3-5)
2	97-111 (43-49)	979-965	1.8-2.6 (6-8)
3	112-131 (50-58)	964-945	2.7-3.8 (9-12)
4	132-155 (59-69)	944-920	3.9-5.6 (13-18)
5	156+ (70+)	< 920	5.7+ (19+)



Hurricane Wilma Storm Surge



Southwest Florida Coast



Wilma Path

Storm surge effect: Hurricane Camille, 1969

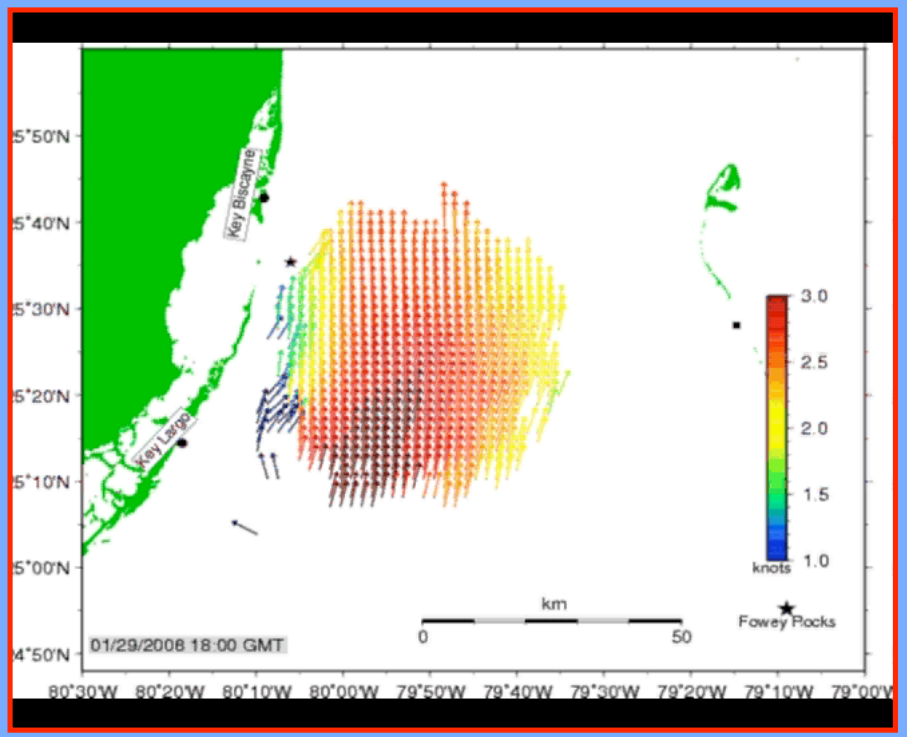
Storm surge records: Florida Keys (1935) = 30 feet, Camille (1969) = 24 feet, Hugo (1989) = 19.8 feet, Carla (1961) = 18.5 feet.

Coastal Hazards and COOS

(Coastal Ocean Observing System)

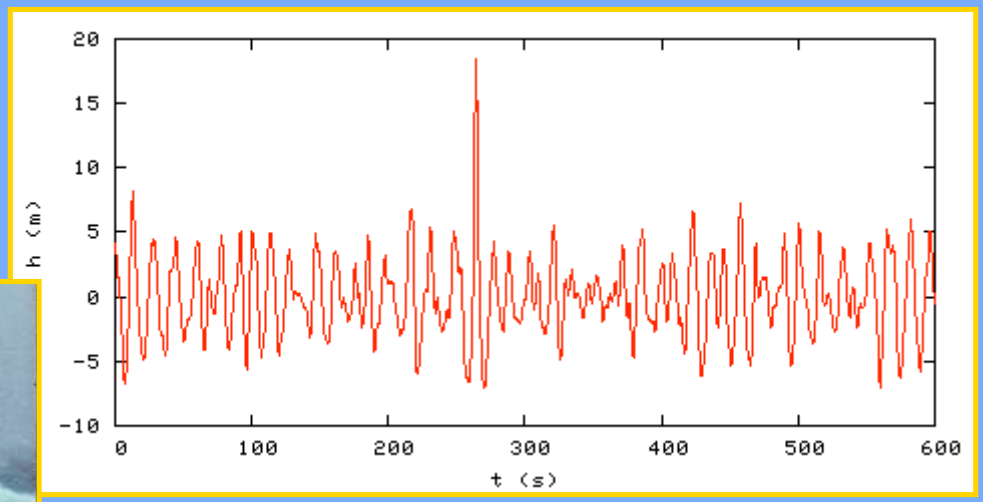
…and then there are rogue waves, current meanders, harmful algae blooms, rip currents, extreme tides, high surf, undertow, littoral drift, coastal floods…

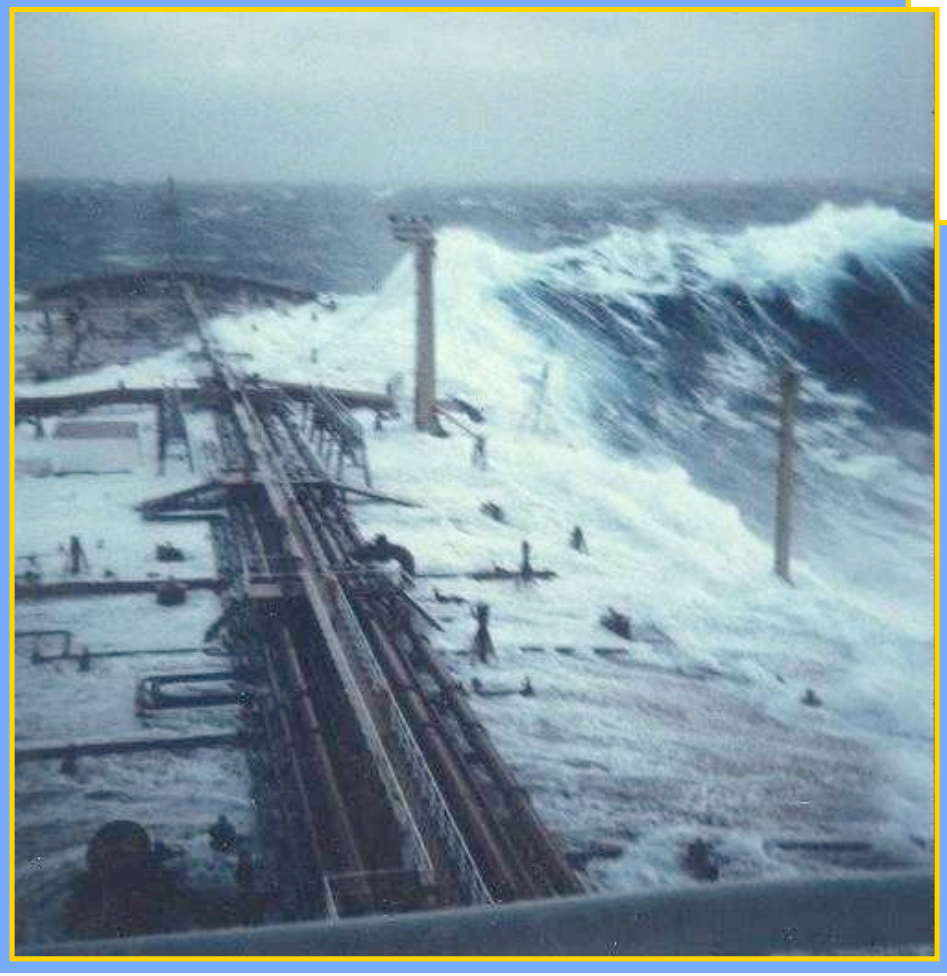
Let's look at a few!



Coastal Radar measures eddies off Miami

Rogue Waves

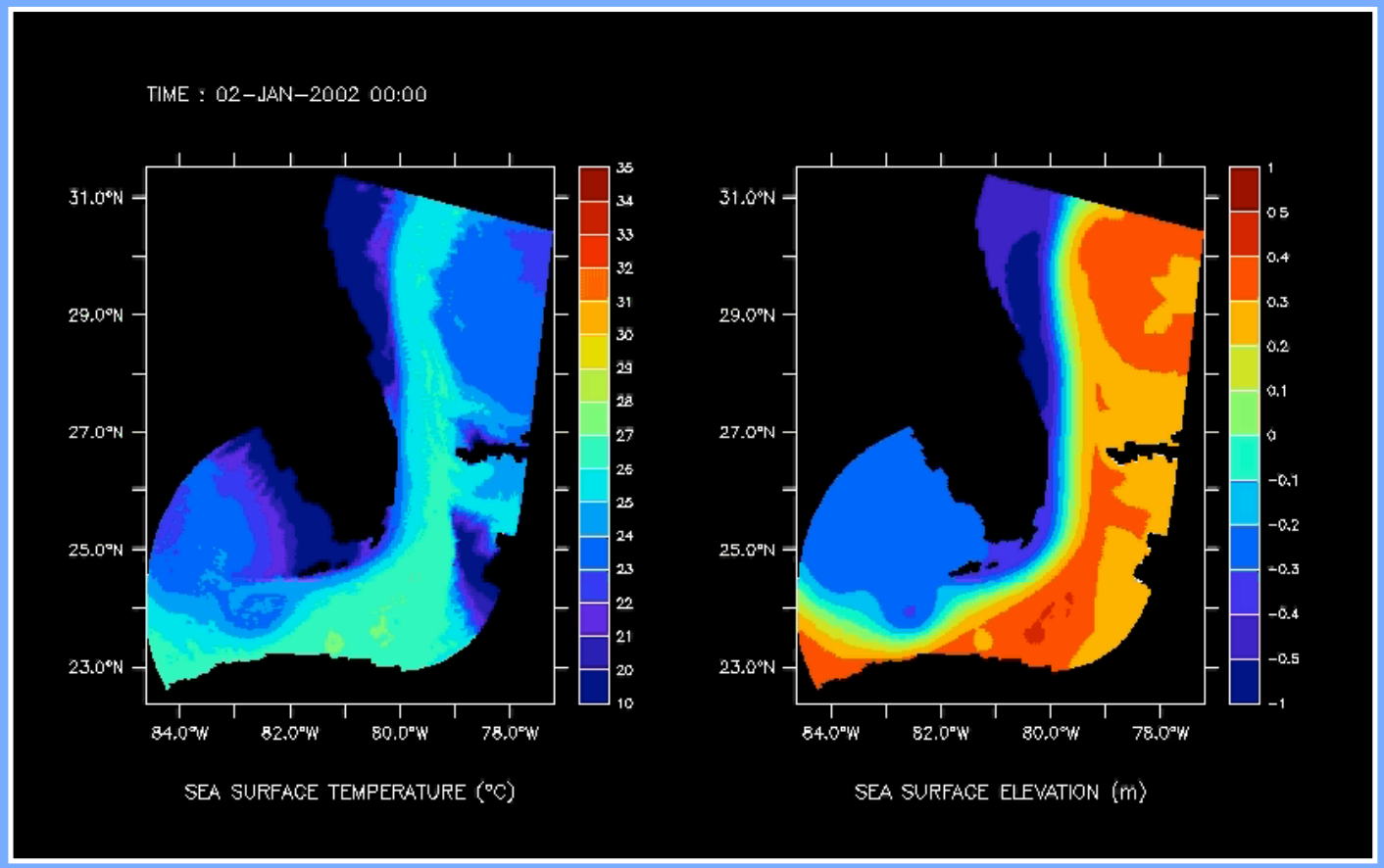




Non-linear interaction between storm-generated ocean waves gives rise to more than 2+2!

3 July 1992 Daytona Beach event was most likely a rogue wave

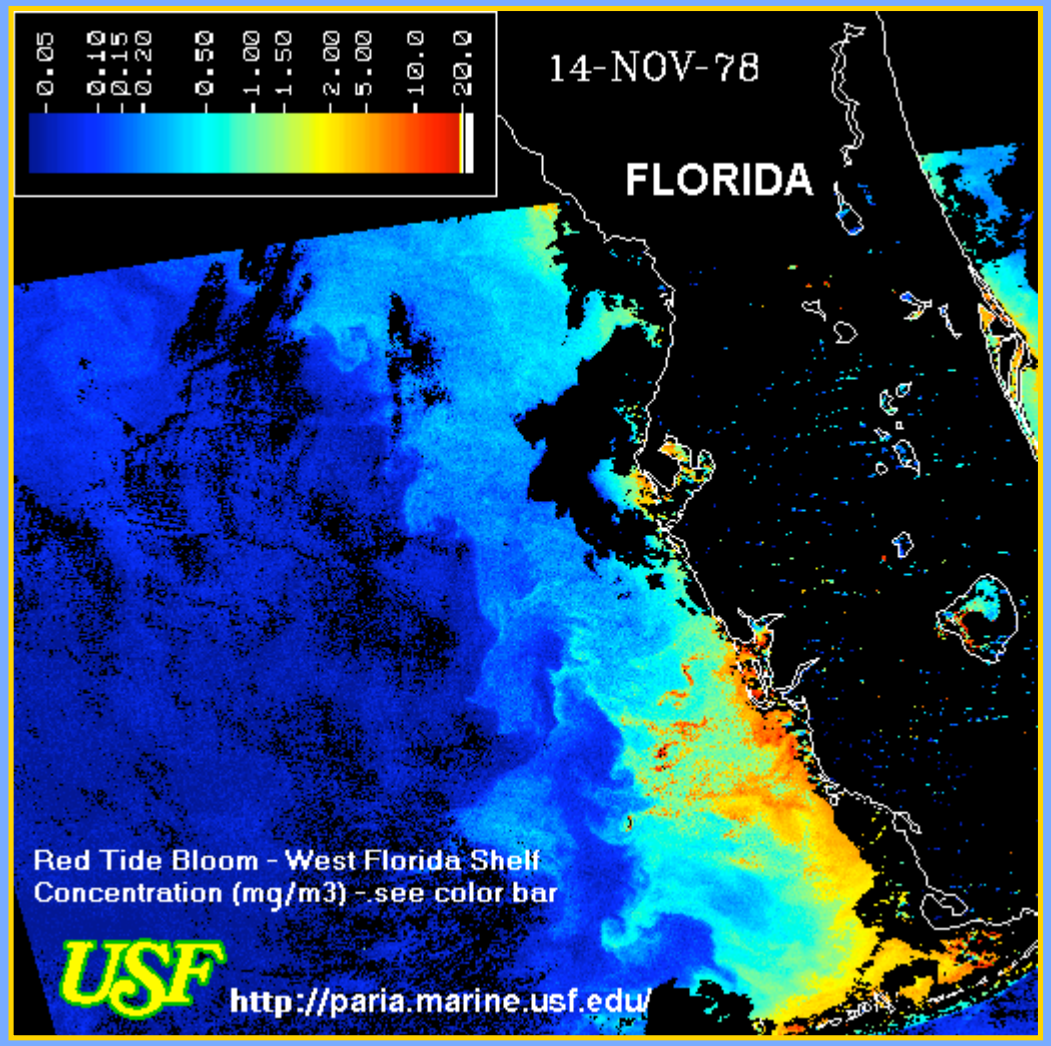
Horizontal Waves in Currents



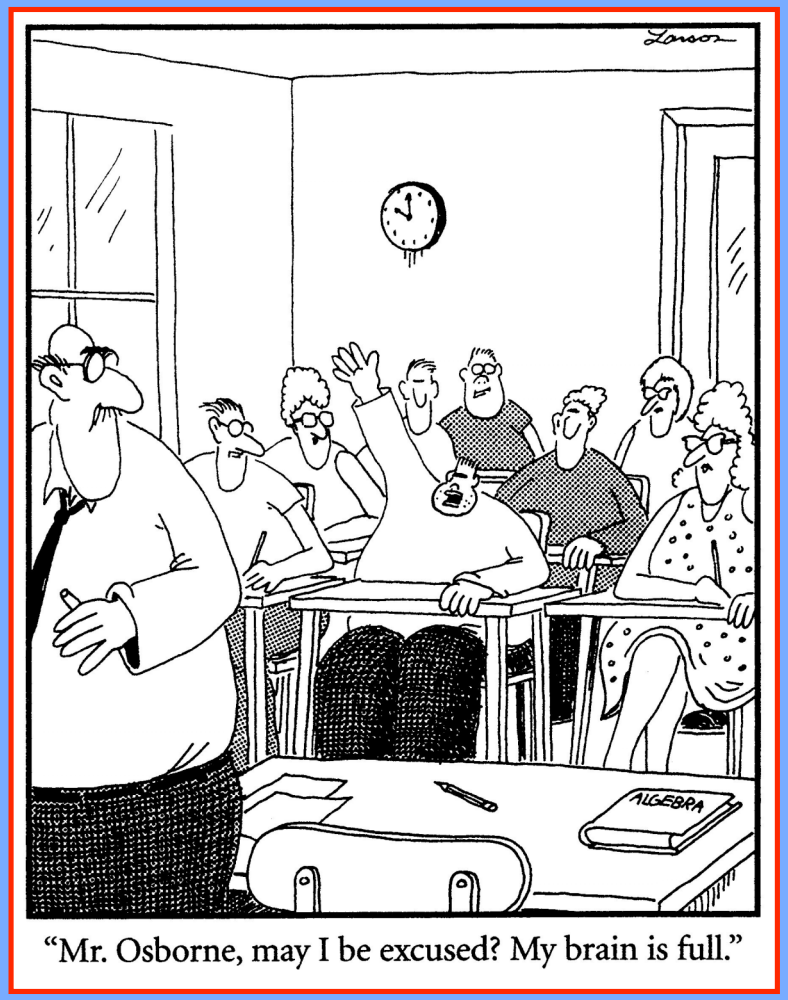
Florida Current Numerical Simulation

Harmful Algal Blooms

Karenia brevis



Coastal Hazards and COOS



"Mr. Osborne, may I be excused? My brain is full."

...not to mention extreme tides, high surf, littoral drift, rip currents, coastal floods...

Phew!

Florida Coastal Ocean Observing System (COOS) Consortium

University of Miami

NSU Nova Southeastern University

USF University of South Florida

Florida State University 1851

Mote Marine Laboratory

Florida Institute of Technology

State of Florida Institute of Oceanography FIO

Harbor Branch Oceanographic

UF University of Florida

Florida Gulf Coast University

UNF University of North Florida

FIU Florida International University

MCS Maritime Communication Services

Harris

WeatherFlow

University of West Florida

University of Central Florida

A fully developed Coastal Ocean Observing System (COOS) will eventually provide real-time access to data, to monitor and forecast coastal ocean waters biophysically, which would assist in the management of this environment, and that is the underlying purpose of the Florida ***Clean Ocean Act***.

SUMMARY

- Sea level change is very localized, but for Florida it has been about 9” (23 cm) per century.
- Atlantic tsunami deaths in last ~150 years (1853, 1867, 1907, 1918, 1929, 1946, 1991): at least 2,500 persons.
- Hurricane storm surge can exceed 25’ in a category 5 hurricane, on top of which are tides and waves.
- North Atlantic coastal population to increase ~40 million persons from 2000-2025; Florida’s by 9 million!
- Need integrated warning system.
- Not a matter of if but when!

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Japan Tsunami, 1993