Lab 8 OCE-3014L - Hurricane Storm Surge and El Niño/La Niña


A. Hurricane Storm Surge – The number 1 cause for lives lost in hurricanes.

Storm surge is simply water pushed toward the shore by the force of the winds swirling around the storm. This advancing surge combines with the normal tides to create the hurricane storm tide, which can increase the mean water level 18 feet or more. In addition, wind driven waves are superimposed on the storm tide. This rise in water level can cause severe flooding in coastal areas, particularly when the storm surge coincides with high tide. Much of the densely populated Atlantic and Gulf Coast coastlines lie less than 10 feet above mean sea level; the danger from storm tides is tremendous.

The level of surge in a particular area is also determined by the slope of the continental shelf. A shallow slope off the coast will allow a greater surge to inundate coastal communities. Storm tides in confined harbors severely damage ships.

1. Go to the website below that predicts high and low tide levels; scroll down about 80% to find locations in Miami-Dade County; click on each of the three locations tabulated below in Table 1. Record consecutive high and low tide levels (low and high tide, as the case may be) after moonrise. Be sure to record the high-low (low-high) sequence after moonrise to keep data comparable between the three locations. Then complete the rest of the table computing tidal range and averages.

http://tbone.biol.sc.edu/tide/sites_useastlower.html

Table 1

Miami-Dade County Location	HIGH TIDE feet above mean sea level	LOW TIDE feet below mean sea level	Tidal Range (ft.) (Difference between low and high tides)
Haulover Pier, North Miami, FL			
Miami Beach (City Pier) FL			
Bear Cut, Virginia Key			
Average High Tide for three locations cited above:			(ft)
Average Low Tide for three locations cited above:			(ft)
Average Tidal Range for three locations cited above:			(ft)

2. Now go to
http://tidesonline.nos.noaa.gov/plotcomp.shtml?station_info=8723214+Virginia+Key%2C+FL

This NOAA station plots the observed tide levels with the predicted levels.

- Note the time of the most recent observation____________________.
- For the past 24 hours did the high tide exceed or fall short of predicted level? ________________
- Note the wind speed and wind direction at the time of observation.________________________
- In your estimation, did wind speed/direction appear to have any effect on the observed high tide level vs. the predicted level? **Yes** **No**

3a. Use the values from Table 1 for average high and low tides together with the storm surge level data tabulated in the Saffir-Simpson hurricane scale (below) to estimate storm tide for a hurricane making landfall along the Miami coast during 1) low tide; 2) high tide. Use the highest storm surge value for each hurricane category to approximate worst-case scenario. Storm Tide = Storm Surge + Astronomical Tide referenced to mean sea level.

Table 2

Hurricane Category	Maximum Storm Tide at high tide (feet)	Minimum Storm Tide at low tide (feet)
1		
2		
3		
4		
5		

The Saffir-Simpson hurricane scale

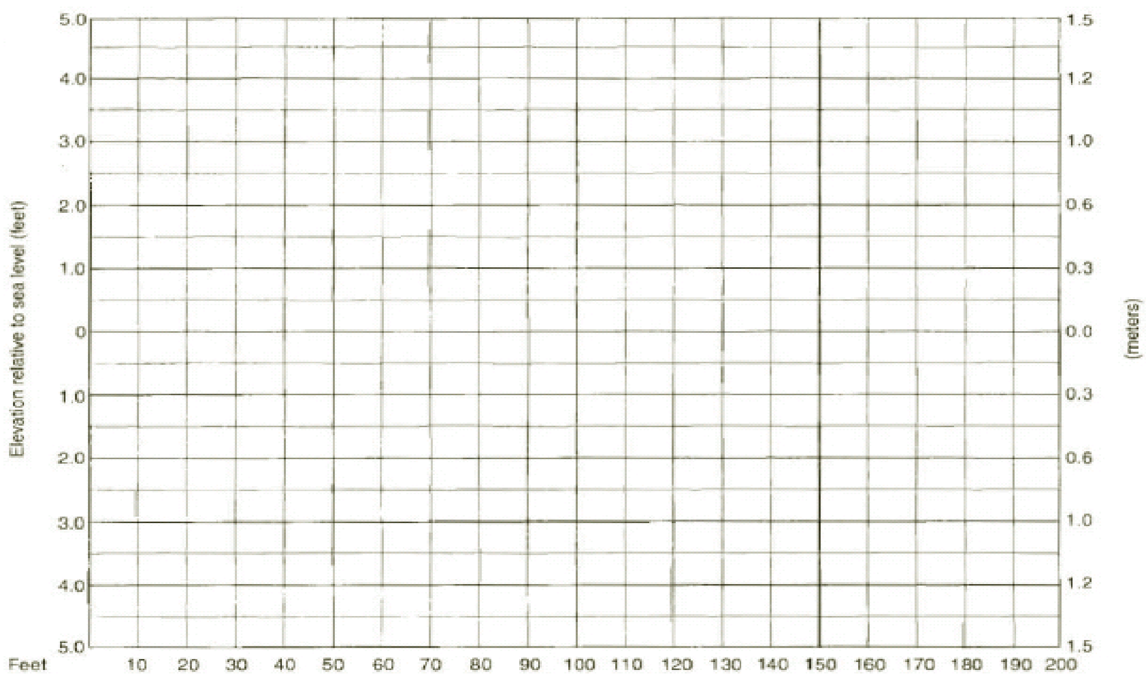
Hurricane category	*Maximum sustained wind speed* kilometers/hour	miles/hour	Storm surge (feet)	Minimum Surface pressure (mbar)	Damage
1	119–153	74–96	4–5	>980	Minimal
2	154–178	97–111	6–8	979–965	Moderate
3	179–210	112–131	9–12	964–945	Extensive
4	211–250	132–155	13–18	944–920	Extreme
5	>250	156+	18+	<920	Catastrophic

3b. 16.9 feet was the highest storm tide from Category 5 Hurricane Andrew (August 1992), measured on the western shoreline of Biscayne Bay in South Dade. It was high tide when Andrew struck. Estimating astronomical high tide and using the storm surge range, does this storm tide fall within the range of a Category 5 Hurricane?

YES **NO**

4. The shoreline of Noname Beach was altered after a Category 2 Hurricane made landfall. All elevations are relative to a benchmark pounded into a beach parking lot, originally 135 feet inland from mean sea level. Calculate the post hurricane net loss/gain in elevation for each distance seaward of the benchmark. Plot these data, using a different color for before-hurricane and after-hurricane beach profiles.

	Shoreline Survey Relative to Benchmark on Noname Beach before and after Hurricane Zeke					
	Shoreline before hurricane			Shoreline after hurricane		
	Distance seaward from benchmark (ft)	Elevation Relative to benchmark (ft.)		Distance seaward from benchmark (ft)	Elevation Relative to benchmark (ft.)	Net beach loss (-) or gain (+) (ft)
← Distance seaward from benchmark (feet)	0	5.0		0	4.8	
	15	4.6		15	5.0	
	35	4.1		35	2.5	
	50	4.4		50	1.5	
	75	4.9		75	0.7	
	90	3.2		90	0.3	
	100	2.2		100	0.0	
	125	0.5		125	-1.0	
	135	0.0		135	-1.9	
	150	-1.9		150	-1.2	
	175	-3.4		175	-1.5	
	200	-3.6		200	-2.0	



Distance from benchmark on shore → seaward (feet)

- In the above graph, Is the post hurricane benchmark in the parking lot closer to the sea, farther away, or the same?________________________

- What effect did the hurricane have on the position of the shoreline and the profile of the beach? Is the beach leveler? steeper? What about the area offshore?

  Change in beach profile____

  Change in offshore profile____

- From where was sand eroded and to where was the eroded sand deposited?

  ____

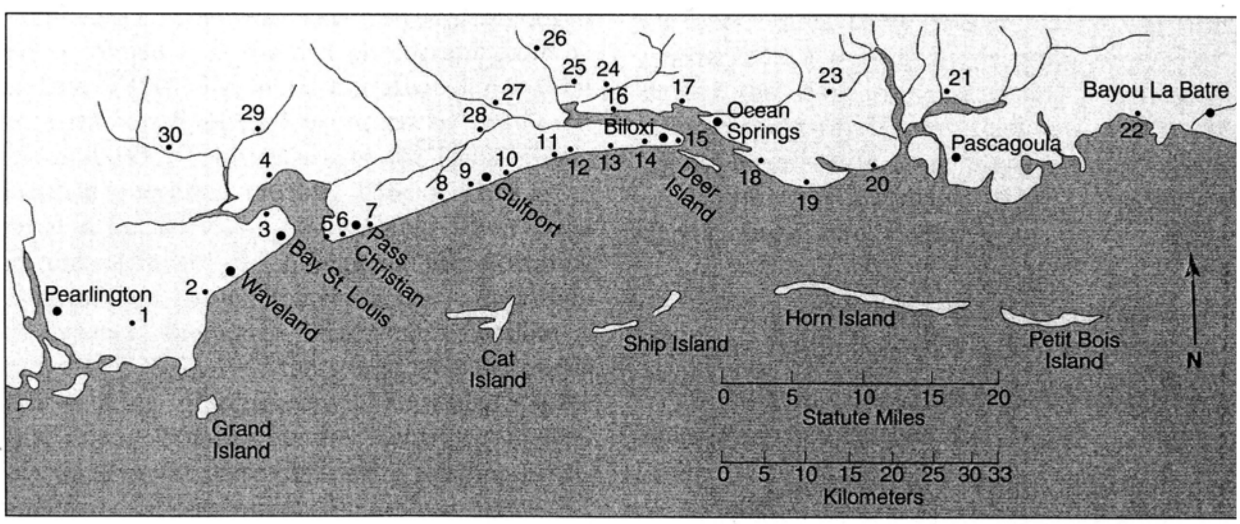
  ____

5a. In the figure below, which barrier island off the Mississippi Gulf coast was directly in the path of Category 5 Hurricane Camille (August 17, 1969) when storm surge was measured at 25 feet in Pass Christian, leveling the community.

[Pass Christian was rebuilt after Camille only to be leveled by the estimated 30-32 foot storm surge from Hurricane Katrina (August 29, 2005). The very gently sloping, shallow coastal bathymetry extending a great distance into the Gulf of Mexico intensifies storm surge in this area.]

Hint: To find the barrier island directly in the path of Camille, look at accompanying photographs, page 5.

____



Barrier Island before hurricane

Barrier Islands after hurricane

b. What natural force altered the topography of this barrier island?____________________________________

B. El Niño

This oceanographic phenomenon in the Pacific Ocean was originally noticed by fishermen along the Pacific coast of Peru and Ecuador, when periodic appearances of warm, nutrient-poor waters led to decreases in the local fishing industry. In 1892, fishermen in the Peruvian port of Paita called an invasion of warm water off the coast around Christmas time "Corriente del Niño" (current of the Christ Child). In 1958, the term El Niño was proposed for the oceanographic and meteorological events that occurred across the Pacific Ocean during December of that year, and persisted for several months before restoration of "normal" ocean currents and surface-water temperatures. In 1972, oceanographers and meteorologists used the term El Niño-Southern Oscillation (ENSO), broadening the definition of these events to include periodic climate-related shifts in weather patterns in the equatorial Pacific and Indian oceans. To complicate matters, during the 1990's, the news media began to refer to times when anomalously cold surface-water masses appeared in the eastern equatorial Pacific Ocean as La Niña events.

Strong trade winds and upwelling of cold nutrient rich waters along its eastern margin are normal features of the Pacific Ocean circulation. When El Nino occurs, winds slacken, and downwelling occurs on the eastern margin instead of upwelling (and upwelling instead of downwelling occurs along the western margin). Warmer waters produce a moister climate along the west coasts of South America and North America; however, Australia and Indonesia become drier and subject to forest fires. Climates alter on a global scale.

El Niño events affect the Atlantic Ocean as the subtropical jet stream (the Pineapple Express which is usually over Hawaii) shifts northward allowing warmer moister air to flow over California, Oregon, and Washington State and over the Gulf of Mexico and into the Caribbean Sea. The added warm moist air from the Pacific slows down the development of tropical storms and hurricanes in the Atlantic basin acting in conjunction with Atlantic's interplay of low and high pressure cells.

La Niña events are an extreme case of strong trade winds and cold upwelling along the eastern side of the Pacific. La Niña events can signal an increased number of tropical storms and hurricanes in the Atlantic. The dynamics of La Niña are less understood than those of El Niño.

ENSO events are periodic, with a return interval of 3-7 years. NOAA attempts tracking and predicting the onset of El Niño events by maintaining an array of 70 buoys moored in the central Pacific between
5 °N and 5 °S, termed the Niño-4 Region. NOAA buoys measure temperature, winds, and currents.

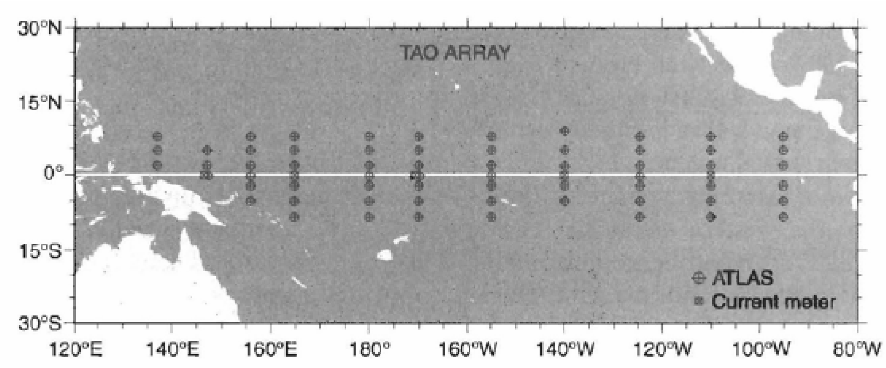
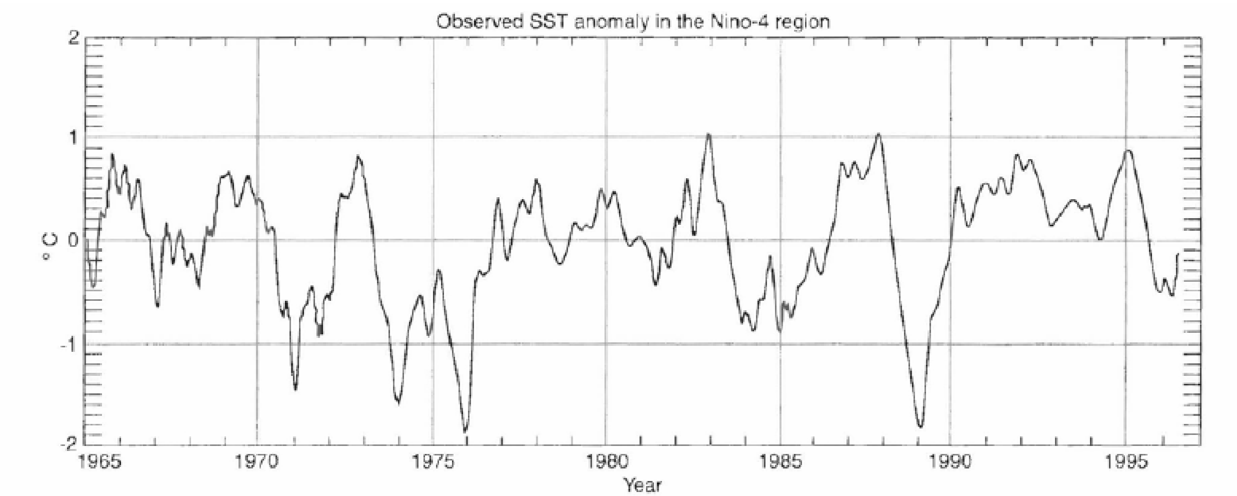


Figure 6: The Tropical Atmospheric Ocean Array (TAO) of oceanographic sensor buoys and moored current meters in the Niño-4 region of central Pacific Ocean (between 160°E and 150°W and from 5°S to 5°N). Data obtained from these sensors is used by NOAA to monitor oceanic conditions that might mark the onset of El Niño events.



6. Use the information above of observed sea surface **temperature anomalies** (0° C meaning no temperature deviation above or below normal.) in the equatorial Pacific to determine the number of El Niño events between 1965 and 1995. One event may last more than a year. You may wish to color enhance temperatures above normal. _________________.

b. How many La Niña (cooler than normal conditions) events occurred during the same 30 years? ___________

c. Is the periodicity of El Niño Events the same as for La Niña events? Look at the average time elapsed between events and the average duration of events_____________________________________

____

d. Go to http://www.osdpd.noaa.gov/PSB/EPS/SST/climo.html Click on today's/yesterday's date to enlarge the global SST's.

Are this month's SST (sea surface temperatures) in the Gulf Stream normal or is there an anomaly? If an anomaly, is the SST cooler or warmer?

____

Are this month's SST (sea surface temperatures) off the coast of Peru/Ecuador normal or is there a temperature anomaly?

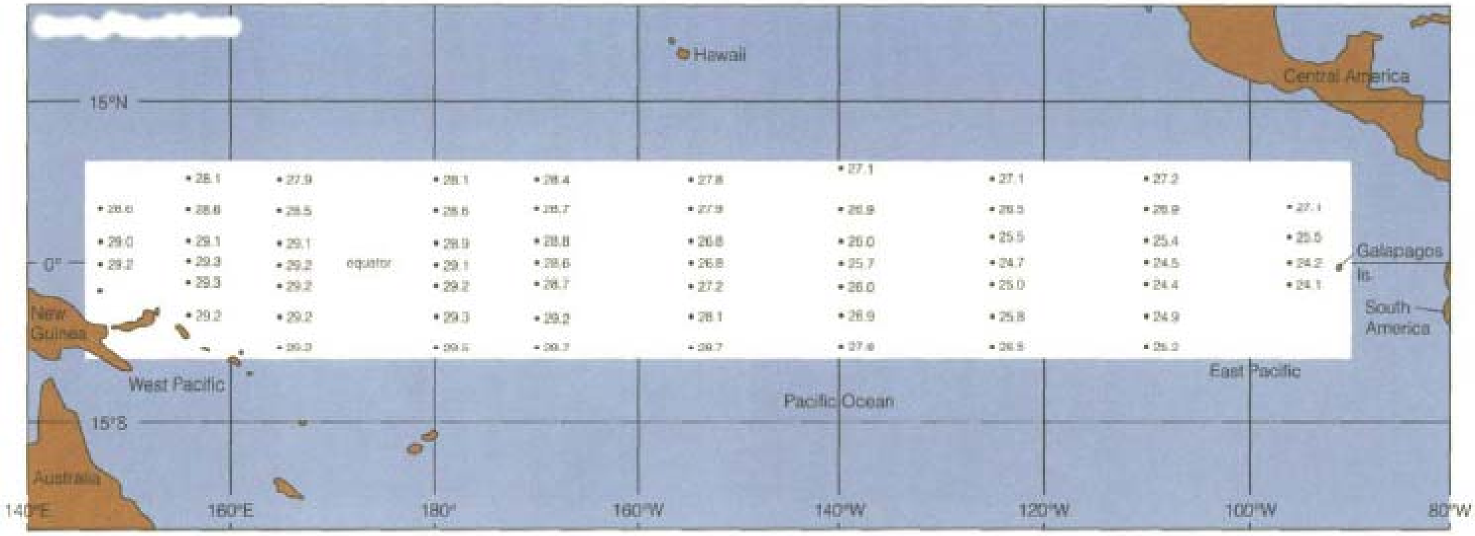
____

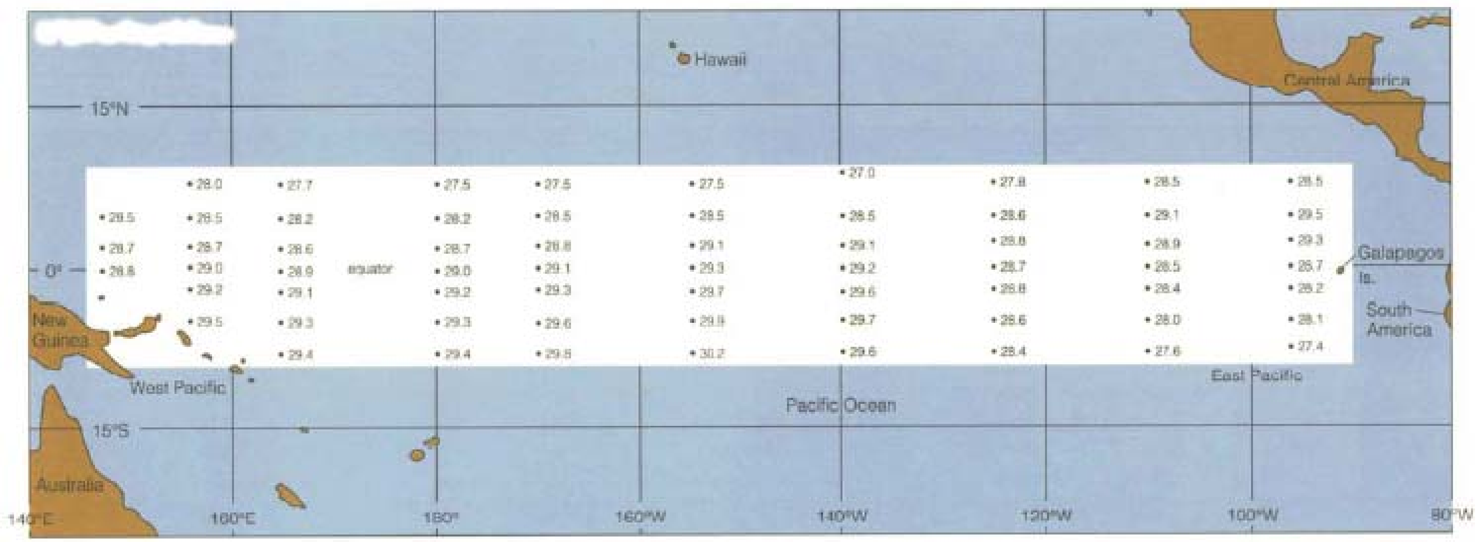
Off the coast of Peru, are conditions currently Normal El Niño La Niña

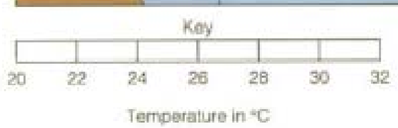
e. It is now well accepted that El Nino conditions reduce hurricane activity in the North Atlantic whereas La Nina years see increased hurricane activity. What kind of hurricane season might we anticipated based on current conditions?

____

6. The following 2 figures show locations of oceanographic buoys from the NOAA-TAO array in the equatorial Pacific, with mean sea-surface temperature (SST) anomaly data indicated for each buoy. Use a pencil to draw temperature contours using a 1°C contour interval. Select six gradational colors from cool colors (blues/greens) to warm colors (yellows/oranges) to represent water temperatures for every 2°C from 20°C to 32°C, filling in contours using your selected color scheme. Enter color code in color key.


Hawaii
Central America
15°N
0°
equator
Galapagos Is.
New Guinea
South America
West Pacific
East Pacific
Pacific Ocean
15°S
Australia
140°E
160°E
180°
160°W
140°W
120°W
100°W
80°W


Hawaii
Central America
15°N
0°
equator
Galapagos Is.
New Guinea
South America
West Pacific
East Pacific
Pacific Ocean
15°S
Australia
140°E
160°E
180°
160°W
140°W
120°W
100°W
80°W


Key
20
22
24
26
28
30
32
Temperature in °C

6b. The two figures above represent an El Niño event and a normal event.
Label the figures with the condition represented.

6c Complete the table below.

Condition	Western Equatorial Pacific Australia & Indonesia			Eastern Equatorial Pacific West Coast of South America and Central America		
	Water Temperature (warm, cool, cold)	Atmospheric Pressure (high or low)	Rainfall (heavy, normal, drought)	Water Temperature (warm, cool, cold)	Atmospheric Pressure (high or low)	Rainfall (heavy, normal, drought)
Normal						
El Niño						
La Niña						