Document 2 (Last D2L Document)

This document is mostly NSF InTeGrate materials. There are minor contributions by Mark Abolins. A small amount of content is from the publisher (Pearson).

InTeGrate: http://serc.carleton.edu/integrate/index.html

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SCHEDULE FOR GEOL 1030-1 AFTER SPRING BREAK

PRE-CLASS ASSIGNMENT. COMPLETE *PRIOR* TO CLASS ON INDICATED DAY.	IN CLASS	OPTIONAL READING (TLT, 14th ed.)
None.	1. M 3/13. Earthquakes E2 (Doc 1)	
W 3/15. Complete MasteringGeology assignment(s).	2. W 3/15. Weathering and Water	Bowen's Reaction Series p. 69-70; p. 150.
None.	3. F 3/17. Field trip	
None.	4. M 3/20. Field trip	
None.	5. W 3/22. Discussion of field trip	
None.	6. F 3/24. M5 Mining Impacts and Water (Doc 1)	
None.	7. M 3/27. M4.2 Water and Mineral Resources – Mining Sand (Doc 1)	
W 3/29. Mock proposal or watershed brochure due.	8. W 3/29. M4.3 Water and Mineral Resources – Mining Salt (Doc 1)	
F 3/31. Homework – Exam 3 Prep.	9. F 3/31. In-class review.	
None.	10. Sun. 4/2. Facebook review 7p-8p.	
	11. M 4/3. Exam 3	

Continued on next page.

PRE-CLASS ASSIGNMENT. COMPLETE *PRIOR* TO CLASS ON INDICATED DAY.	IN CLASS	OPTIONAL READING (TLT, 14th ed.)
W 4/5. Complete MasteringGeology Assignment(s).	12. Astrosaur 2017! Space and Dinosaurs Day!	
F 4/7. Complete MasteringGeology Assignment(s).	13. F 4/7. Hurricanes	p. 595-601.
None.	14. M 4/10. Hurricanes	
W 4/12. Complete MasteringGeology Assignment(s).	15. W 4/12. Hurricanes	
None.	16. F 4/14. Hurricanes	
M 4/17. Complete MasteringGeology Assignment(s).	17. M 4/17. Hurricanes	
None.	18. W 4/19 Hurricanes	
F 4/21. Complete MasteringGeology Assignment(s).	19. F 4/21. Climate	p. 566-570; p. 623-633.
M 4/24	20. M 4/24. Climate	
W 4/26	21. W 4/26. In-class review	
M 5/1	22. Facebook review M 5/1, 7p-8p.	
None.	**23. W 5/3 Final Exam** 10a-noon in 100 DSB.	

.**Weathering, soils, and mass wasting**

Takeaways

1. Soil is important because of agriculture and because most buildings and roads are built on soil.
2. Soil horizons form over hundreds or even thousands of years. Consequently, conserving them is important.
3. Deleted.
4. Deleted
5. Although only isolated areas are susceptible to mass wasting (landslides and similar) within Middle Tennessee, the eastern part of the state is part of a huge belt of landslide hazard roughly coincident with parts of the Appalachians, Valley and Ridge, and Cumberland Plateau geomorphic provinces.

A (somewhat over-) simple version of Bowen's Reaction Series

Temperature	**Minerals**	**Rock (volcanic/plutonic)**
High	Pyroxene, Ca-rich plagioclase, maybe some olivine	Basalt/gabbro
Intermediate	Amphibole, intermediate plagioclase	Andesite/diorite
Low (for liquid rock)	Orthoclase, Na-rich plagioclase, quartz, a little biotite	Rhyolite/granite

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Water

Takeaways

1. Although Earth is the "blue marble," only 3% of the water is fresh.
2. Of what little water is fresh, most is in ice sheets and glaciers (mostly the Antarctic and Greenland ice sheets).
3. Groundwater exploration involves the search for a saturated zone within an aquifer.

4. Karst develops on limestone and a few other kinds of rocks. Karst areas are characterized by caves, sinkholes, and disappearing streams. They are also characterized by poor drainage and groundwater pollution problems.

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Glaciers and Deserts

Takeaways

Glaciers

1. Glaciers are on land and show evidence of past or present flow (among other things).
2. Even when a glacier is retreating, almost all of the ice in the glacier is still flowing downhill.
3. Globally, approximately 90% of glaciers are retreating today.
4. Deleted.

Deserts and wind

5. Deserts cover approximately 30% of the Earth today.
6. Most erosion in a desert is caused by running water(!)

Atmosphere – Chapters 16-20

1. *Weather* involves present atmospheric conditions or atmospheric conditions over a short time interval. *Climate* involves atmospheric conditions over a long expanse of time and is in many ways inherently statistical.
2. Air is mostly nitrogen, and, to a lesser extent, oxygen. Carbon dioxide makes up a very small amount of the atmosphere, but, for precisely that reason, human activity has resulted in a large percentage increase in the amount of carbon dioxide.
3. Deleted.
4. Clouds form and precipitation happens when air rises, expands, and cools, and relative humidity reaches (or exceeds) 100% (saturation).
5. Much of Middle Tennessee's stormy weather involves middle latitude cyclones. Cyclones form around lows in pressure, develop warm, cold, and occluded fronts, and generally move west to east within the Westerlies wind belt.
6. Middle Tennessee is in or adjacent to Dixie Alley, a region of elevated tornado hazard.
7. During the last 150 years, atmospheric carbon dioxide and global temperatures have both increased. Almost all climate scientists (the people with Ph.D.'s who actually work on climate) believe that the increase in global temperature is largely a consequence of rising carbon dioxide levels. Carbon dioxide levels have increased in large part because of the burning of fossil fuels (oil, coal, and natural gas).

Stones River Watershed

Water quality circa 2000. Visit http://tdeconline.tn.gov/Stones/ for updates.

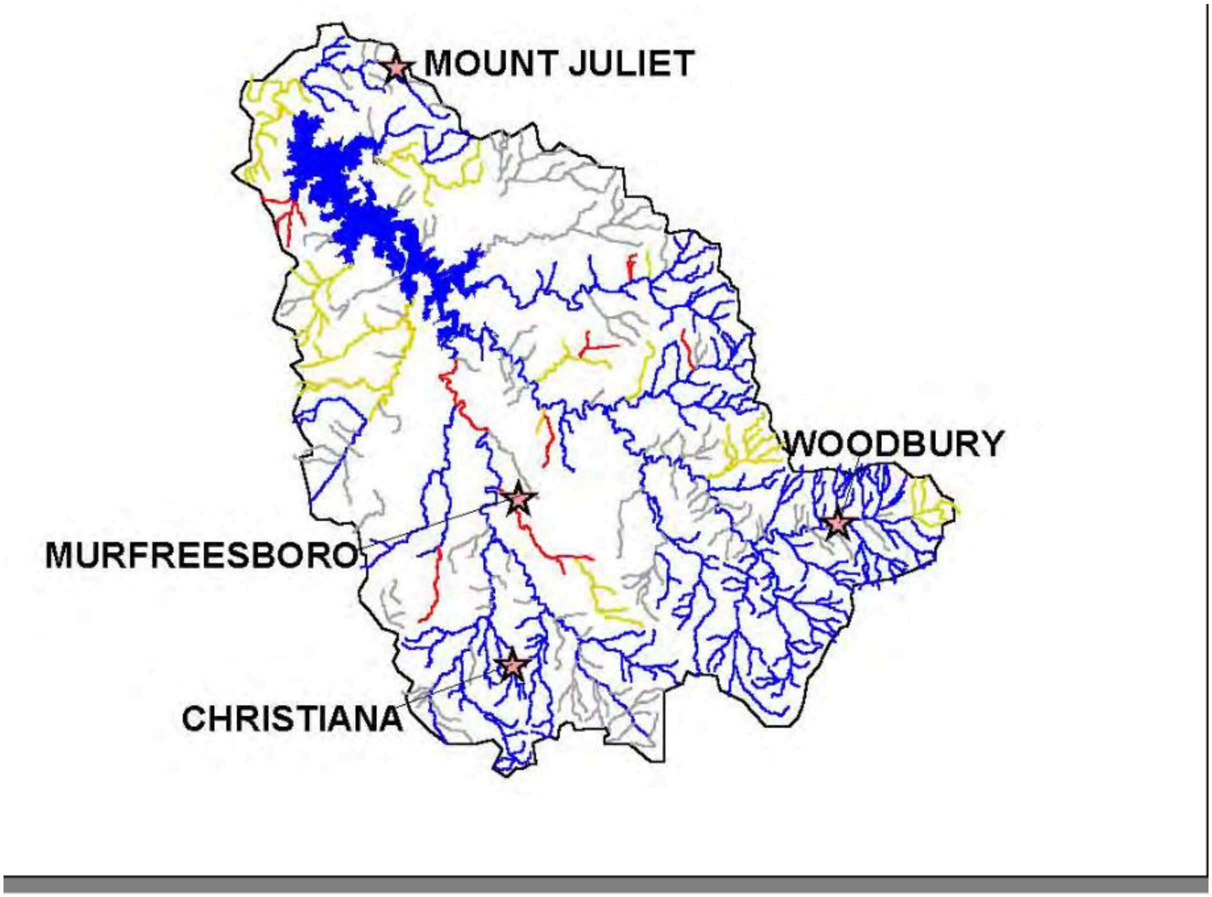
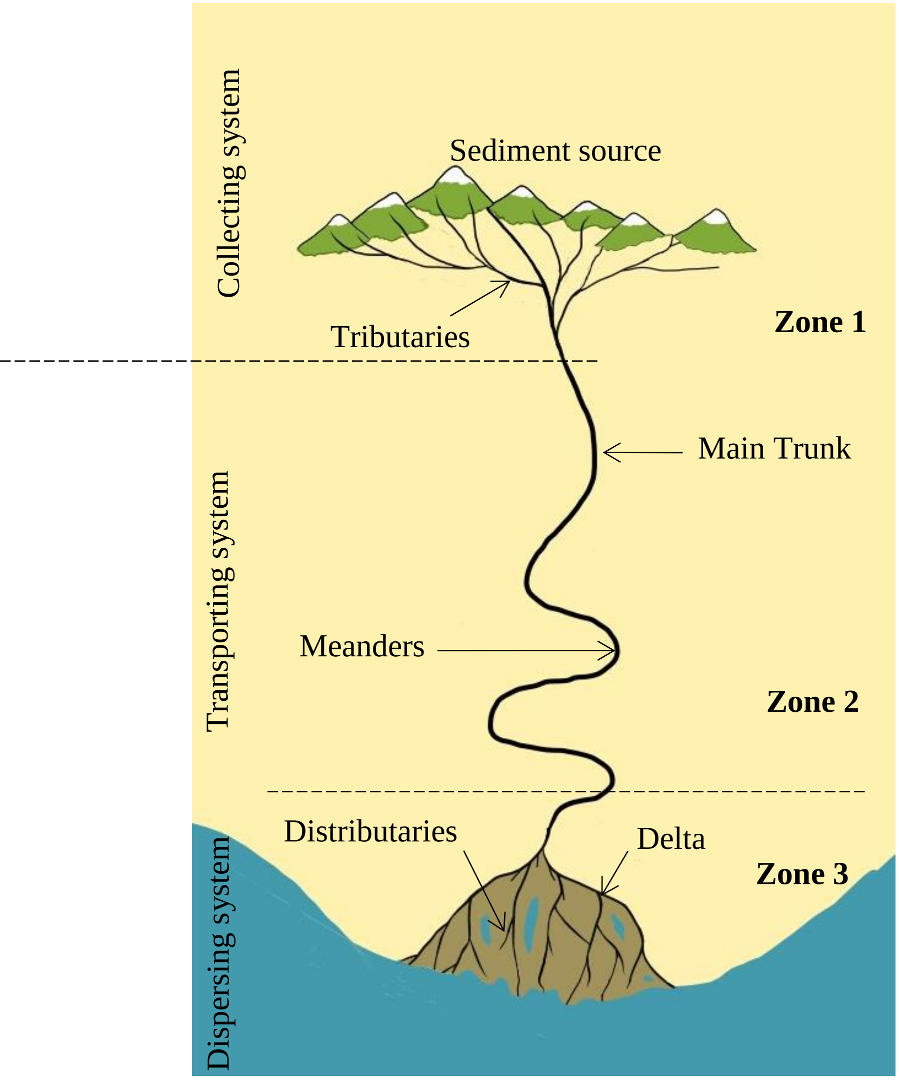


Figure 3-8a. Overall Use Support Attainment in the Stones River Watershed. *Assessment data are based on the 2000 Water Quality Assessment. Blue, Fully Supports Designated Use; Yellow, Partially Supports Designated Use; Red, Does Not Support Designated Use; Gray, Not Assessed. Water Quality Standards are described at http://www.state.tn.us/sos/rules/1200/1200-04/1200-04.htm. Christiana, Mount Juliet, Murfreesboro, and Woodbury are shown for reference. More information is provided in Stones-Appendix III.*



Unit 2: Rivers

Part 1: Characteristics of a River System

Background

Fluvial systems are the main factors in shaping the surface of the continents as they drain the water on the continents and move weathered material (gravel, sand, silt, mud) to the ocean basins. The appearance of rivers and streams is strongly influenced by the climate, geology, and the topography of the region. Although the appearance of rivers may differ from one to the next, all rivers have three subsystems (or zones) that define the entire river system: 1) collecting system, 2) transporting system, and 3) dispersing system.

The diagram to the left is a sketch of a prototypical river system with a dashed line between zones. Although there is typically only a gradual gradation between the subsystems, when you view them at a regional scale, you can recognize patterns characteristic of each subsystem.

Directions: To answer questions 1-1 through 1-3 you will need to examine the map of the Stones River watershed. With the instructor's help, add the Cumberland River to the map, label Percy Priest Reservoir, and circle or highlight the West and East Forks of the Stones River.

Collecting system (Zone 1)

The collecting system is where the headwaters are located in the region where the river begins. The collecting system is typically a mountainous region containing a network of small tributaries that are created as water and sediment is funneled toward the main stream.

1-1. What is the name of the town, county, or area where the river begins?

___

Transporting system (Zone 2)

This part of the river system consists of the main channel (trunk) and the major tributaries. The transporting system is where water and sediment that has collected in the headwaters is transported downstream to a lake or ocean. This section of the river system will often contain meanders. These are formed by the combination of erosion and deposition of sediment. As the slope (gradient) of the stream channel decreases, so does the velocity.

1-2. What are the names of towns or cities located along the transporting system?

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Dispersing system (zone 3)

This part of the river system is at the end of the river where the elevation of the river is nearing sea level. Here you can observe a network of distributaries that redistribute the water and sediments into the ocean. The fine-grained sediments (clay, mud) remain suspended in the water and continue to be transported and finally deposited into the bay or ocean. The coarser material is deposited at the shoreline and forms a delta.

1-3. What body of water does the river empty into at the **end** of the dispersing system?

1-4. In what ways is the "protoypical river" graphic a good representation of the Stones River watershed and in what ways is it not a good representation?

1-5. With the instructor's help, modify the "prototypical river" graphic to reflect the realities (both natural and human) of the Stones River watershed.

A Growing Concern: Sustaining Soil Resources through Local Decision Making

100 200 300 400
Intro Level
2-3 Weeks
6 Units

Sarah Fortner (Wittenberg University)
Martha Murphy (Santa Rosa Junior College)
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Unit 3: Natural and Agricultural Erosion Rates

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Author Profiles

▸ **This material was developed and reviewed through the InTeGrate curricular materials development process.**

By the end of the unit, students will be able to:

- Interpret data from geospatial figures and analyze erosion rates.
- Discuss the influence of agricultural erosion on soil sustainability.
- Confront preconceived ideas, reframe these ideas given new data, and reflect on that process.

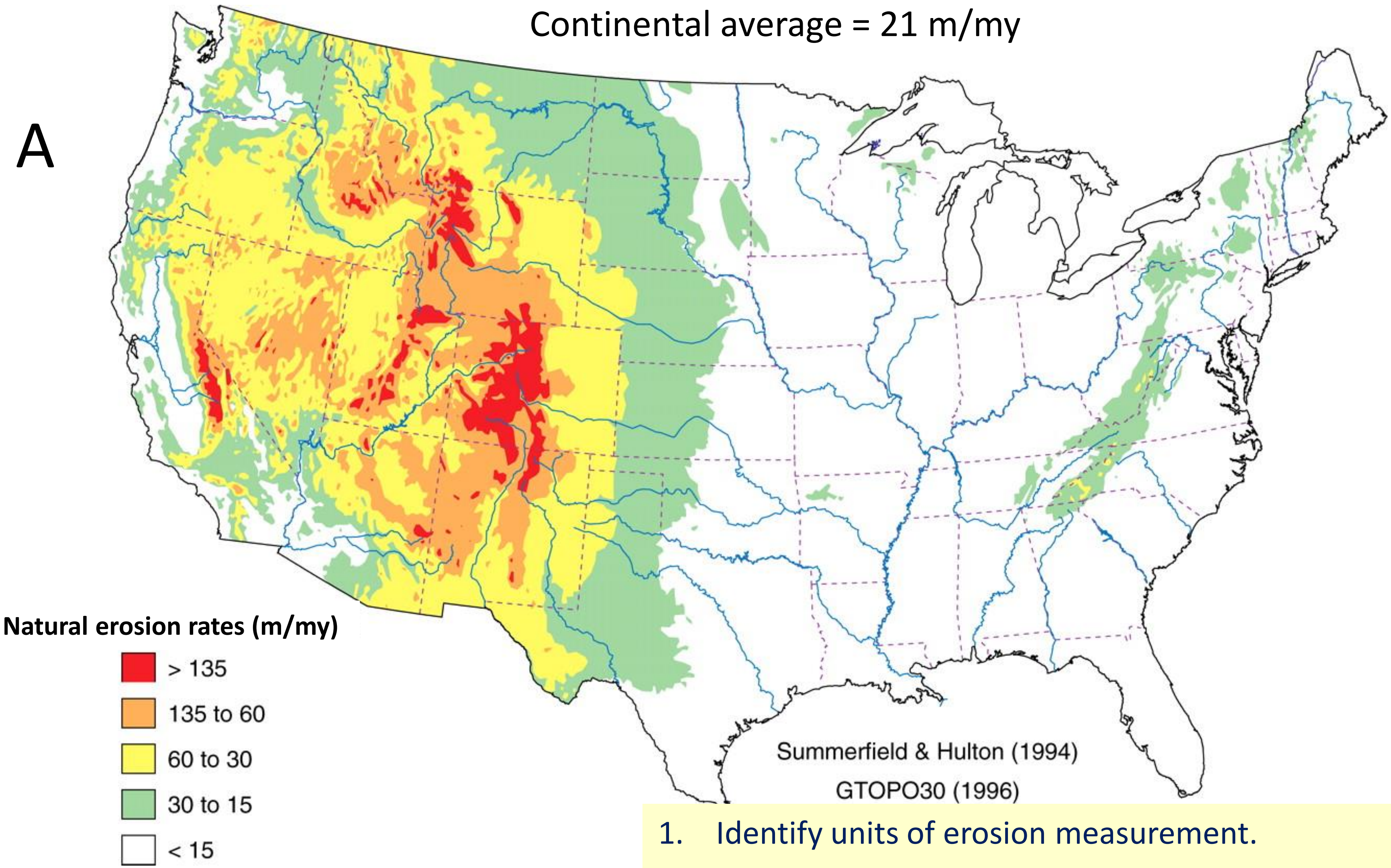
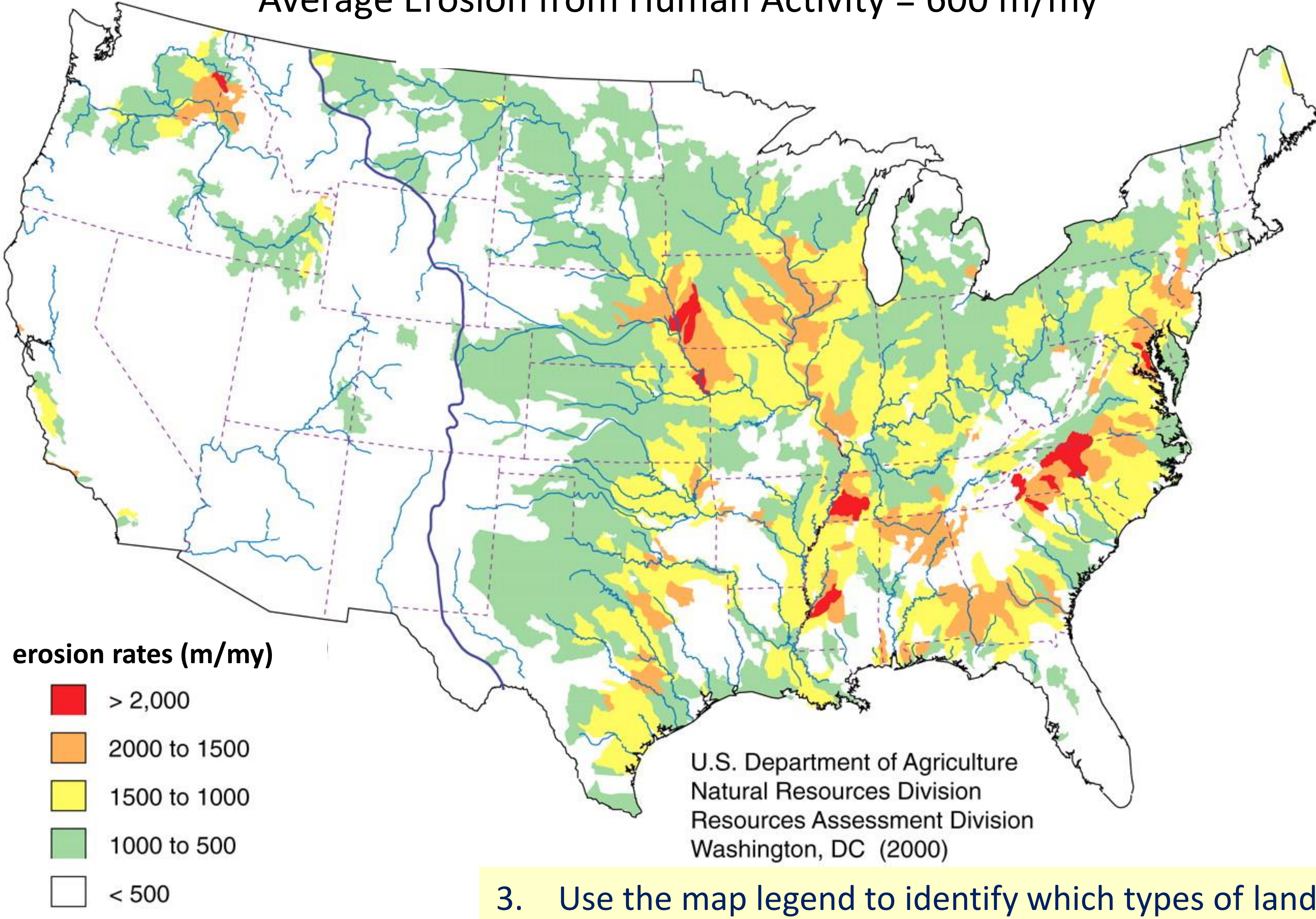


Figure 6. Estimates of average natural erosion (denudation) rates inferred from GTOPO30 area-elevation data and global fluvial erosion-elevations relations from [Summerfield and Hulton (1994)](). Mean rate of denudation for the entire area of the contiguous United States is ~21 m/m.y. (Wilkinson and McElroy, 2007, *GSA Bulletin January/February, 2007 vol. 119 no. 1-2 140-156*)

1. Identify units of erosion measurement.
2. What is the average natural erosion rate in millimeters per year (1 meter = 1000 millimeters)?
3. Use the map legend to identify which types of landscapes have the highest natural (not impacted by humans) erosion rates and predict why these locations have the highest rates.

Average Erosion from Human Activity = 600 m/my

B



(Wilkinson and McElroy, 2007, *GSA Bulletin January/February, 2007 vol. 119 no. 1-2 140-156*)

3. Use the map legend to identify which types of landscapes or environments have the greatest erosion from human activity.
4. How does that average rate compare to the average natural rate of erosion?
5. Predict the potential source of human erosion in Figure B.

Mountains

Maximum erosion rates = >135 m/my

Average rate of cropland erosion = 6 mm/decade.
Average rate of soil formation = 0.36 mm/decade.
An average soil thickness = ~15 cm (150 mm).

At these rates, how much soil would be lost in the remainder of your lifetime (~60 years)?

At current rates, how long would it take to completely remove 15 cm of soil?

Follow-Up Assignment

1) Based on your work today, how does agriculture threaten the sustainability of soil? (2 pts)

A correct answer will consider how the balance of available fertile soil relates to soil erosion and soil production. (1 pt) It should also consider the spatial extent of erosion (1 pt).

2) Does what you learned today through exploring the figures of natural and cropland erosion support or conflict with your initial perceptions of erosion? (1 pt)

(Your answer should refer to your initial impressions of erosion as we looked at the pictures of agricultural and mountain erosion. Did you think mountains or croplands were more erosive? Is this consistent with what you learned by looking at the figures?)

3) Reflecting on your comparison between the two erosion figures, what question(s) do you still have?

1 question required, more allowed (1 pt).

Hazard or risk?

Goal: Understanding the difference between **hazard** and **risk** is critical for understanding the relationship between natural phenomena and human interactions with those phenomena.

Assignment: Study the cartoon and answer the questions below.

1. In this cartoon, what are the hazards?

2. How could the parachutist minimize her risk from these hazards?

Calculating Hurricane Risk: Natural Hazards and Risks Module
Student Sheet

Goals

In this activity, you will calculate your own personal risk from hurricanes. Quantifying risk is an important way to understand and compare the significance of natural hazards from a societal perspective.

Introduction

How do we define risk? Insurance companies use a simple formula to decide how much to charge us. After doing this activity, students will be able to use this formula to make simple comparisons of risks from different hazards in their own location.

The formula

Risk = Likelihood x Cost

This equation is fundamental to assessing risk. The terms are defined as follows:

> **Likelihood.** For our purposes, likelihood refers to the percent chance of a hazard happening in a specific place over a certain amount of time. Likelihood is an estimate, based on past events.
>
> > Example 1: California has had 8 major (magnitude>7) earthquakes in the last 100 years. That is about 12 years between major hurricanes, on average (also called the return period). So the likelihood of a major earthquake somewhere in the state is 8% each year.
> >
> > Example 2: The return period of landslides on Smith Lane is 5 years. The likelihood of a landslide on Smith Lane this year is 20%.
>
> **Cost**. Cost refers to the impact of a particular hazard. Cost is both a dollar amount in terms of damages to property and infrastructure, but can also be more difficult to quantify in terms of time/productivity lost, or injuries and deaths.
>
> **Risk**. Simply stated, risk is likelihood times cost. If the cost is very small or the frequency is very low, the risk will likely be low.

Assignment

Determine your own personal risk from hurricanes. Use the figure below to locate the frequency of hurricanes in your area. If your house and belongings all together are worth $200,000, what is the risk to your house being hit by a hurricane this year?

Implications

A hurricane insurance policy on your house (if such a thing were available to you) might reasonably cost about this amount per year. Knowing your risk can also help you make decisions about where to live and work.

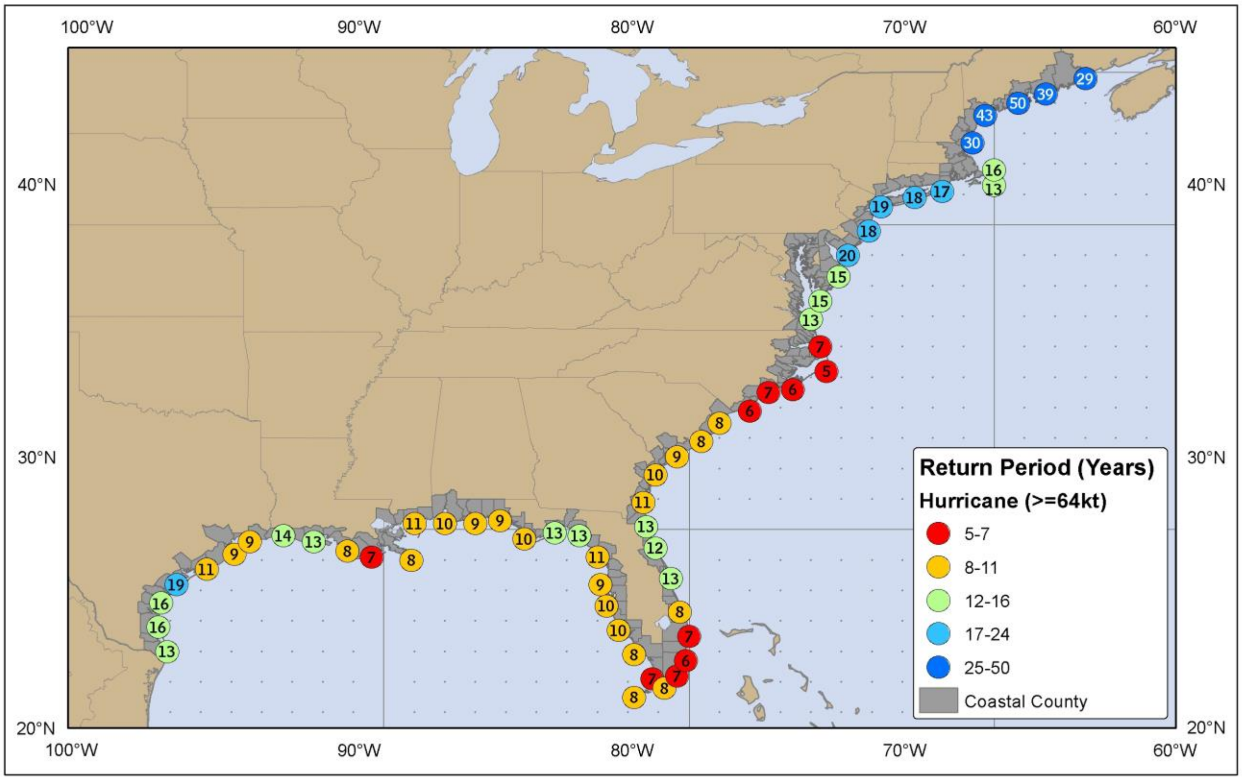


Figure. Hurricane return period of hurricanes passing within 50 nautical miles of various locations on the U.S. Coast, from the National Weather Service. http://www.nhc.noaa.gov/climo/

Avoiding a Hurricane: Stay in Port or Continue as Planned?
Student Activity Sheet

Goal: Use data to predict hurricane track and make recommendations for a ship in the potential path of a hurricane at sea.

Background: Hurricanes in the North Atlantic can be tracked after they form, and often follow similar routes (Figure 1). Generally, a hurricane will travel from east to west and then north. North of about 30N, a hurricane will often turn to the northeast, following warmer waters of the Gulf Stream. Predictions for a hurricane's position are made for three to five days into the future, with the hurricane's likely path represented by a cone (Figure 2). The cone is larger further from the present location of a hurricane because uncertainty increases with forecast time. The entire track of the hurricane is within the cone 60-70% of the time.

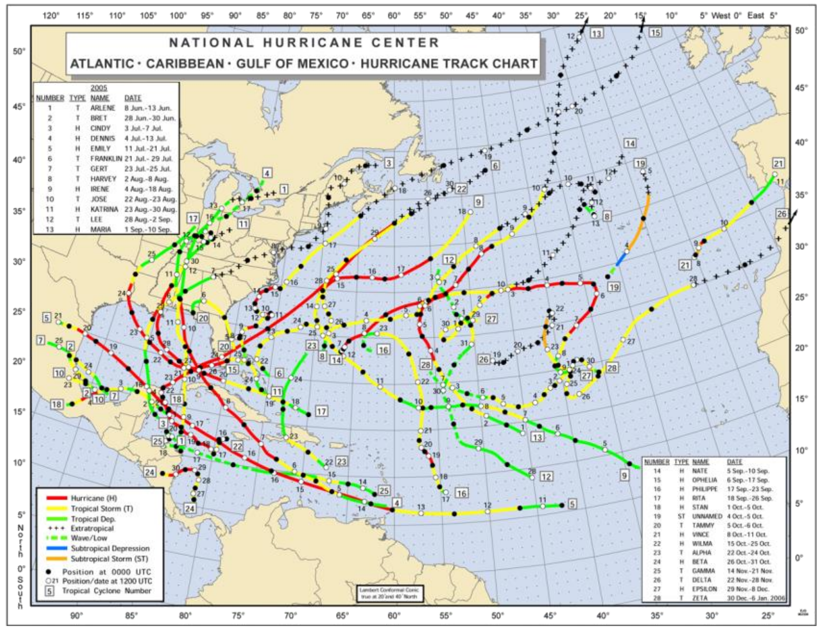


Figure 1. North Atlantic hurricane paths from 2005. (http://www.nhc.noaa.gov/tracks/2005atl.gif)

Scenario: It is Friday morning and your container ship in Miami is scheduled to sail for Galveston, Texas, this afternoon. It is normally a three-day trip, but a hurricane is predicted to be near Miami by Sunday night (Figure 2). What do you do? Explain the relative risks of staying in port or heading to Galveston on schedule.

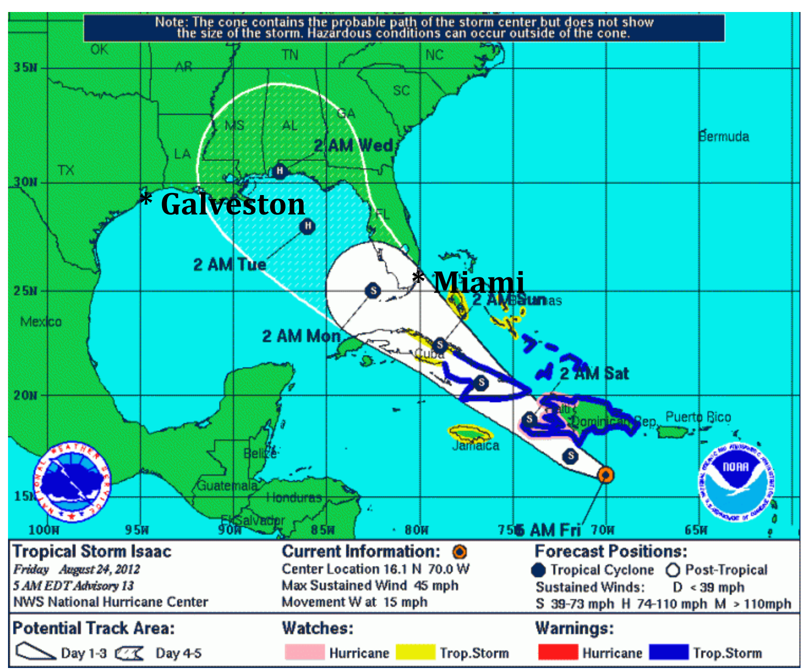
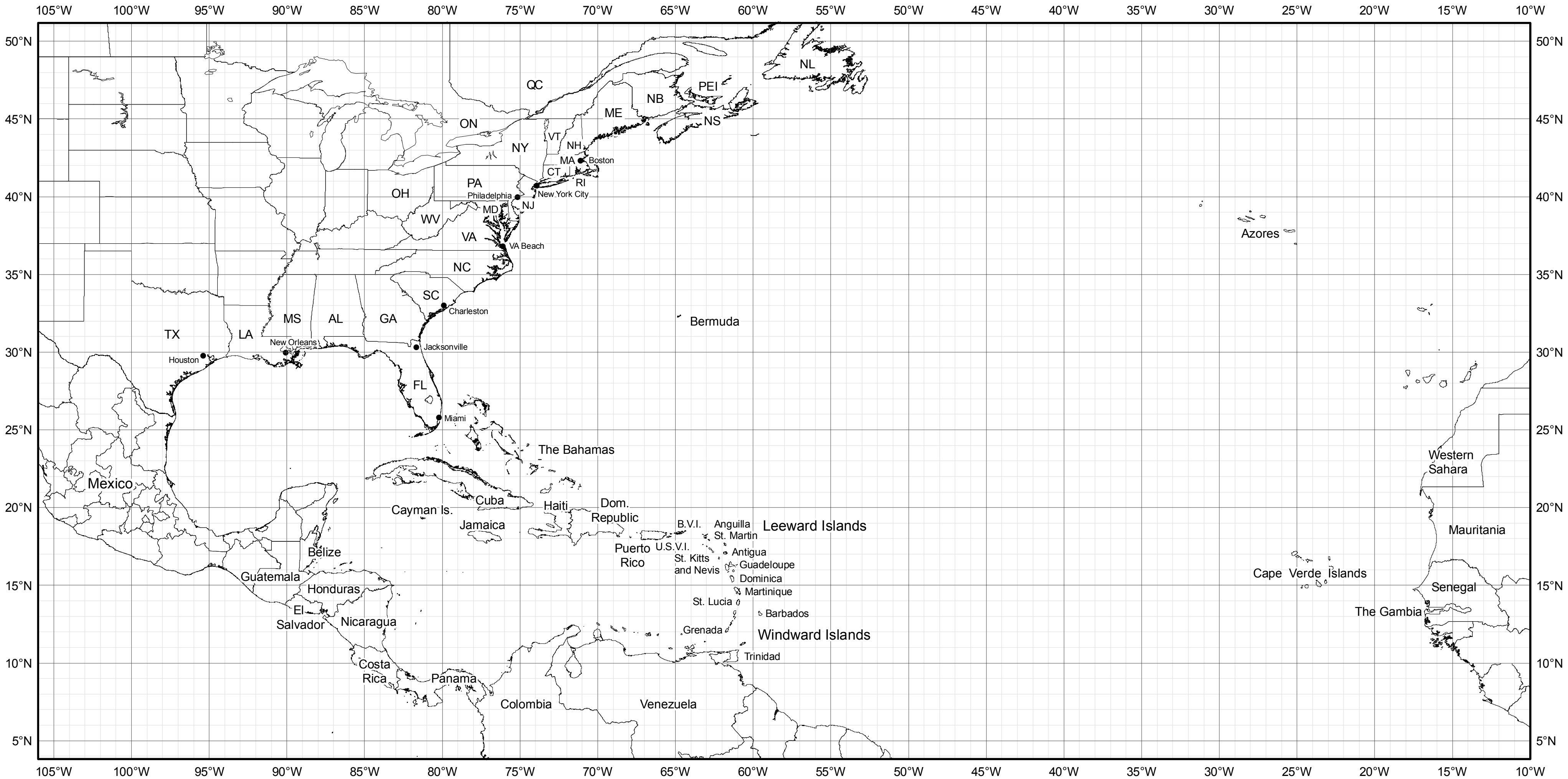


Figure 2. Hypothetical hurricane track. (http://www.nhc.noaa.gov)

Atlantic Basin Hurricane Tracking Chart

National Hurricane Center, Miami, Florida



Hurricane Irene Track Data

Date	Time (Z*)	Latitude (N)	Longitude (W)	Maximum sustained (1 minute) surface (10m) windspeed in knots*	Pressure (Central surface pressure of storm in mb (if available).
8/21/11	0:00	15.0	59.0	45	1006
8/21/11	6:00	16.0	60.6	45	1006
8/21/11	12:00	16.8	62.2	45	1005
8/21/11	18:00	17.5	63.7	50	999
8/22/11	0:00	17.9	65.0	60	993
8/22/11	6:00	18.2	65.9	65	990
8/22/11	12:00	18.9	67.0	70	989
8/22/11	18:00	19.3	68.0	75	988
8/23/11	0:00	19.7	68.8	80	981
8/23/11	6:00	20.1	69.7	80	978
8/23/11	12:00	20.4	70.6	80	978
8/23/11	18:00	20.7	71.2	80	977
8/24/11	0:00	21.0	71.9	80	969
8/24/11	6:00	21.3	72.5	95	965
8/24/11	12:00	21.9	73.3	105	957
8/24/11	18:00	22.7	74.3	100	954
8/25/11	0:00	23.5	75.1	95	952
8/25/11	6:00	24.1	75.9	95	950
8/25/11	12:00	25.4	76.6	90	950
8/25/11	18:00	26.5	77.2	90	950
8/26/11	0:00	27.7	77.3	90	946
8/26/11	6:00	28.8	77.3	90	942
8/26/11	12:00	30.0	77.4	85	947
8/26/11	18:00	31.1	77.5	80	950
8/27/11	0:00	32.1	77.1	75	952
8/27/11	6:00	33.4	76.8	75	952
8/27/11	12:00	34.7	76.6	75	952
8/27/11	18:00	35.5	76.3	65	950
8/28/11	0:00	36.7	75.7	65	951
8/28/11	6:00	38.1	75.0	65	958
8/28/11	12:00	40.3	74.1	55	963
8/28/11	18:00	42.5	73.1	50	970
8/29/11	0:00	44.2	72.1	45	979
8/29/11	6:00	46.5	69.5	40	983
8/29/11	12:00	49.1	66.7	40	985
8/29/11	18:00	51.3	63.8	40	987
8/30/11	0:00	53.0	60.0	40	991
8/30/11	6:00	NA	NA	NA	NA
8/30/11	12:00	NA	NA	NA	NA
8/30/11	18:00	NA	NA	NA	NA

Saffir–Simpson Hurricane Scale

Category	Wind speed mph (km/h) (kn)
Five	≥ 157 (≥ 252) (≥ 137)
Four	130–156 (209–251) (113–136)
Three	111–129 (178–208) (96–112)
Two	96–110 (154–177) (83–95)
One	74–95 (119–153) (64–82)
Additional classifications	
Tropical storm	39–73 (63–118) (35–63)
Tropical depression	0–38 (0–62) (0–34)

S-S scale from wikipedia, accessed 07-06-12
[http://en.wikipedia.org/wiki/Tropical_cyclone_scales]

These data come from the "Best Hurricane Track Data (HURDAT)"

http://www.nhc.noaa.gov/pastall.shtml#hurdat (accessed June 17, 2012)
(for Irene, Students can check their work here: http://www.nhc.noaa.gov/tracks/2011atl.jpg)

*Notes: "Z" is short for Zulu time and is the same as Greenwich mean time (GMT).

A knot is 1 nautical mile per hour. The conversion from knots to mph is ~ 1 knot = 1.15 mph and the conversion fro knots to kilometers per hour is approximately 1 knot =1.85 km/hr

Comparing Hurricanes and Hurricane Seasons

Seasonal Outlooks (predictions)

Each year in May, August, and October, NOAA issues a seasonal outlook for the Atlantic Ocean. Among the parameters predicted by NOAA are the number of named storms, the number of hurricanes, the number of major hurricanes, and the Accumulated Cyclone Energy (ACE) index. These parameters are explained below.

Hurricane Classification

Hurricanes are classified by their maximum sustained wind speed, using the Saffir-Simpson Hurricane Scale:

Category	Maximum Sustained Wind Speed (knots)
Hurricane Category 5	≥ 157
Hurricane Category 4	130–156
Hurricane Category 3	111–129
Hurricane Category 2	96–110
Hurricane Category 1	74–95
Tropical Storm	39–73
Tropical Depression	0–38

Hurricanes that are Category 3 or higher (greater than 111 knots sustained winds) are called Major Hurricanes. In the North Atlantic, a “near-normal” hurricane season (June 1 to November 30) has 12 storms that are classified as Tropical Storms or higher, 6 that are Hurricanes, 2 of which are considered Major Hurricanes.

Summary data for the 1981-2010 seasons:

Season Type	Average # of Tropical Storms	Range # of Tropical Storms	Average # of Hurricanes	Range # of Hurricanes	Mean # of Major Hurricanes	Range # of Major Hurricanes
Above-Normal	15.8	11 to 28	9.1	5 to 15	4.4	2 to 7
Near-Normal	11.8	7 to 14	5.8	4 to 8	1.9	1 to 3
Below-Normal	7.0	4 to 9	3.2	2 to 4	1.0	0 to 2
All Seasons (1981–2010)	12.1	4 to 28	6.4	2 to 15	2.7	0 to 7

(Table modified from the Climate Prediction Center of the National Weather Service, http://www.cpc.ncep.noaa.gov/products/outlooks/background_information.shtml)

Accumulated Cyclone Energy (ACE) Index

The Accumulated Cyclone Energy (ACE) index is a measure of the intensity and duration of hurricanes and large tropical storms.

Every six hours, the maximum surface sustained wind speed is measured in knots. To calculate the ACE index of an individual hurricane, add the sum of the squares of the maximum wind speed for every six hours that the storm is at least tropical storm strength. Then, divide by 10^4 kt^2.

For example, the wind speeds for Hurricane Irene were:

Date	Time (Z)	Maximum sustained winds (knots)
8/21/11	0:00	45
8/21/11	6:00	45
8/21/11	12:00	45
8/21/11	18:00	50
8/22/11	0:00	60
8/22/11	6:00	65
8/22/11	12:00	70
8/22/11	18:00	75
8/23/11	0:00	80
8/23/11	6:00	80
8/23/11	18:00	80
8/24/11	0:00	80
8/24/11	6:00	95
8/24/11	12:00	105
8/24/11	18:00	100
8/25/11	0:00	95
8/25/11	6:00	95
8/25/11	12:00	90
8/25/11	18:00	90
8/26/11	0:00	90
8/26/11	6:00	90
8/26/11	12:00	85
8/26/11	18:00	80
8/27/11	0:00	75
8/27/11	6:00	75
8/27/11	12:00	75
8/27/11	18:00	65
8/28/11	0:00	65
8/28/11	6:00	65
8/28/11	12:00	55
8/28/11	18:00	50
8/29/11	0:00	45
8/29/11	6:00	40
8/29/11	12:00	40
8/29/11	18:00	40

Thus, the ACE of Irene is $45^2 + 45^2 + 45^2 + 50^2$... (add up all the numbers) = 196550 kt^2 or, about $2.0 \times 10^5\ kt^2/10^4\ kt^2 = 20$.

ACE by storm, 2011 season:

25	Katia	2	Emily
20	Irene	2	Gert
18	Ophelia	2	Lee
15	Philippe	2	Arlene
9	Rina	2	Don
9	Maria	2	Harvey
4	Nate	1	Unnamed
3	Sean	1	Jose
2	Bret	<1	Franklin
2	Cindy		

Total: 121

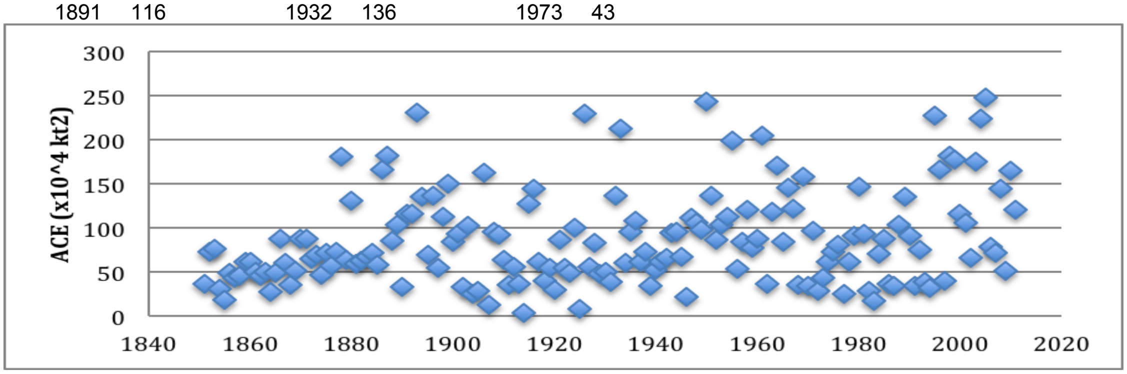
An above-normal season is one with a total ACE >150.
A near-normal year is one with a total ACE 100–150.
A below-normal year is one with a total ACE <100.

Was 2011 above average, normal, or below average?___________

For next class (3 questions): Use the data from 1850–2011 to determine:

1. Which years were above normal? Circle them.
2. Which years were below normal? Underline them.

year	ACE	year	ACE	year	ACE	year	ACE
1851	36	1892	116	1933	213	1974	61
1852	73	1893	231	1934	60	1975	73
1853	76	1894	135	1935	95	1976	81
1854	31	1895	69	1936	108	1977	25
1855	18	1896	136	1937	61	1978	62
1856	49	1897	55	1938	73	1979	91
1857	43	1898	113	1939	34	1980	147
1858	45	1899	150	1940	52	1981	93
1859	61	1900	84	1941	61	1982	29
1860	62	1901	93	1942	66	1983	17
1861	50	1902	33	1943	94	1984	71
1862	46	1903	102	1944	96	1985	88
1863	50	1904	25	1945	67	1986	36
1864	27	1905	28	1946	22	1987	34
1865	49	1906	163	1947	112	1988	103
1866	88	1907	13	1948	106	1989	135
1867	60	1908	95	1949	98	1990	91
1868	35	1909	92	1950	243	1991	34
1869	51	1910	64	1951	137	1992	75
1870	88	1911	35	1952	87	1993	39
1871	88	1912	56	1953	104	1994	32
1872	65	1913	36	1954	113	1995	227
1873	69	1914	3	1955	199	1996	166
1874	47	1915	127	1956	54	1997	40
1875	72	1916	144	1957	84	1998	182
1876	57	1917	61	1958	121	1999	177
1877	73	1918	40	1959	77	2000	116
1878	181	1919	55	1960	88	2001	106
1879	64	1920	30	1961	205	2002	66
1880	131	1921	87	1962	36	2003	175
1881	59	1922	55	1963	118	2004	224
1882	63	1923	49	1964	170	2005	248
1883	67	1924	100	1965	84	2006	78
1884	72	1925	8	1966	145	2007	72
1885	58	1926	230	1967	122	2008	144
1886	166	1927	56	1968	35	2009	51
1887	182	1928	83	1969	158	2010	165
1888	85	1929	48	1970	34	2011	121
1889	104	1930	50	1971	97		
1890	33	1931	39	1972	28		
1891	116	1932	136	1973	43		



3. If there is a 25-year cycle of above- and below-normal phases, which phase are we in now? When did this phase start and when will it likely end? Explain.

STUDENT'S SHEET

Name: _________________________ Date: _____________

Activity 5.1: Hurricane risks
Time: 30 minutes

Summary: Describe how risks have changed over time from coastal development and changes in storm frequency.

Cost of preparing for an approaching hurricane: To get ready for an approaching hurricane, there are preparations and evacuations along vast stretches of the coast that need to be made. Preparations include storing food and water supplies, writing and enacting emergency plans, securing houses (boarding up windows, removing potential flying debris, etc.), and acquiring the needed supplies in case of severe damage. These activities cost large amounts of money and must be taken into account when determining the costs of hurricanes. The average warning is extended for 350 miles of coastline at a cost of $0.75 million ($750,000) per mile of warning, and is typically done three times per hurricane season. Data from: http://www.aoml.noaa.gov/hrd/hrd_sub/cost_benefits.html

1. What is the average annual cost of hurricane preparation?

Human costs: From 1970–2000, an average of slightly more than 19 people were killed annually by hurricanes. While it may seem morbid to place a value on human life (the impact of a person's death is far larger than a dollar amount), public policy places the average cost of a human death at an average of $7.5 million.

2. What is the average annual cost in human deaths?

Changes in hazards and risks over time
We will examine whether hurricane hazards and hurricane risks have changed over time. Briefly review the difference between hazards and risk from Activity 1a and Activity 1b.

3. What is the difference between hazards and risks? Which one does human activity, such as coastal development, change? Which one is presented by a natural process such as a hurricane?

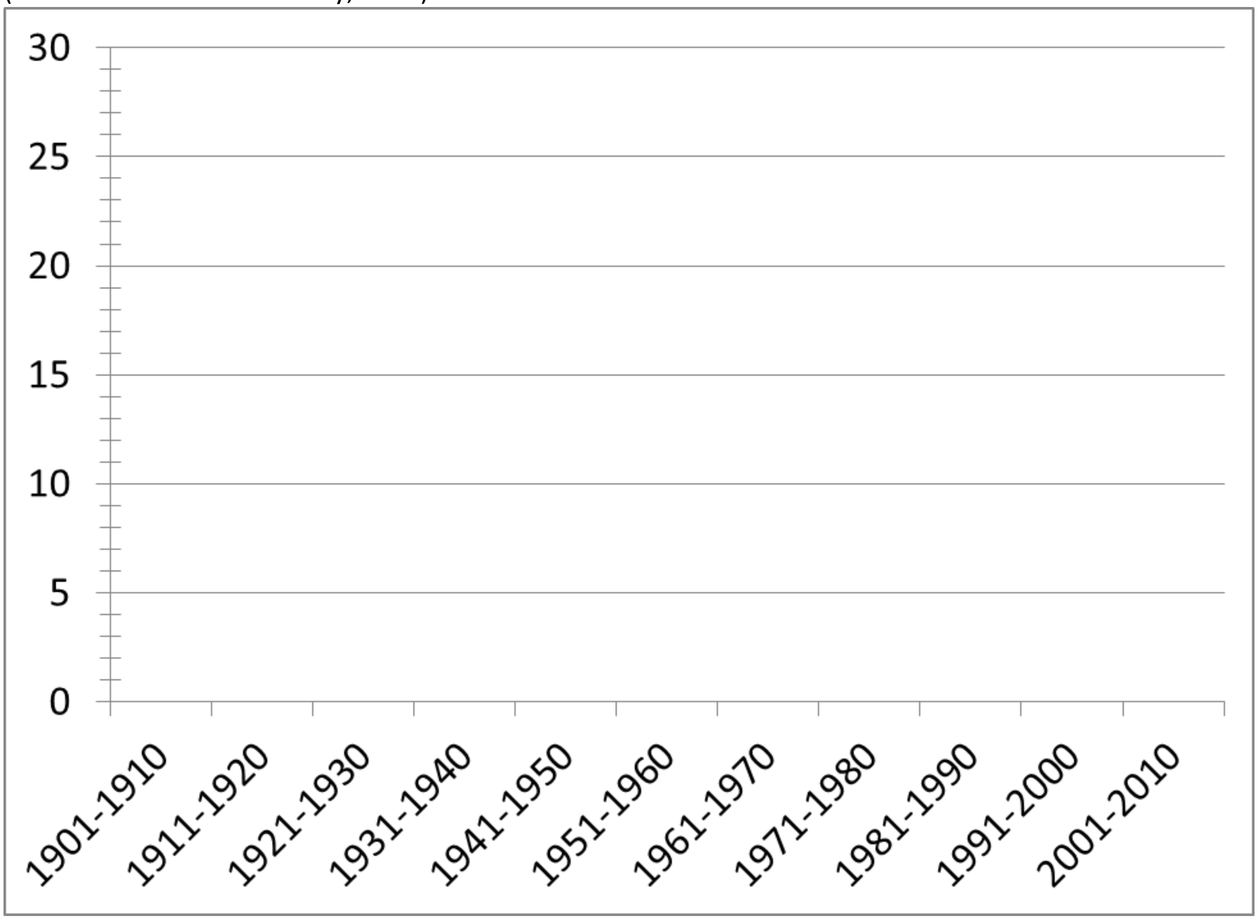
To see if there have been significant changes in hurricane risks and hazards over time, plot the number of major storms, deaths, and costs per decade.

3. Plot the following data per decade on 1) the total number of hurricanes to strike the mainland United States, 2) the deaths, and 3) the cost of hurricanes per decade adjusted for inflation to 2010 dollars (Data from Blake and Gibney, 2011).

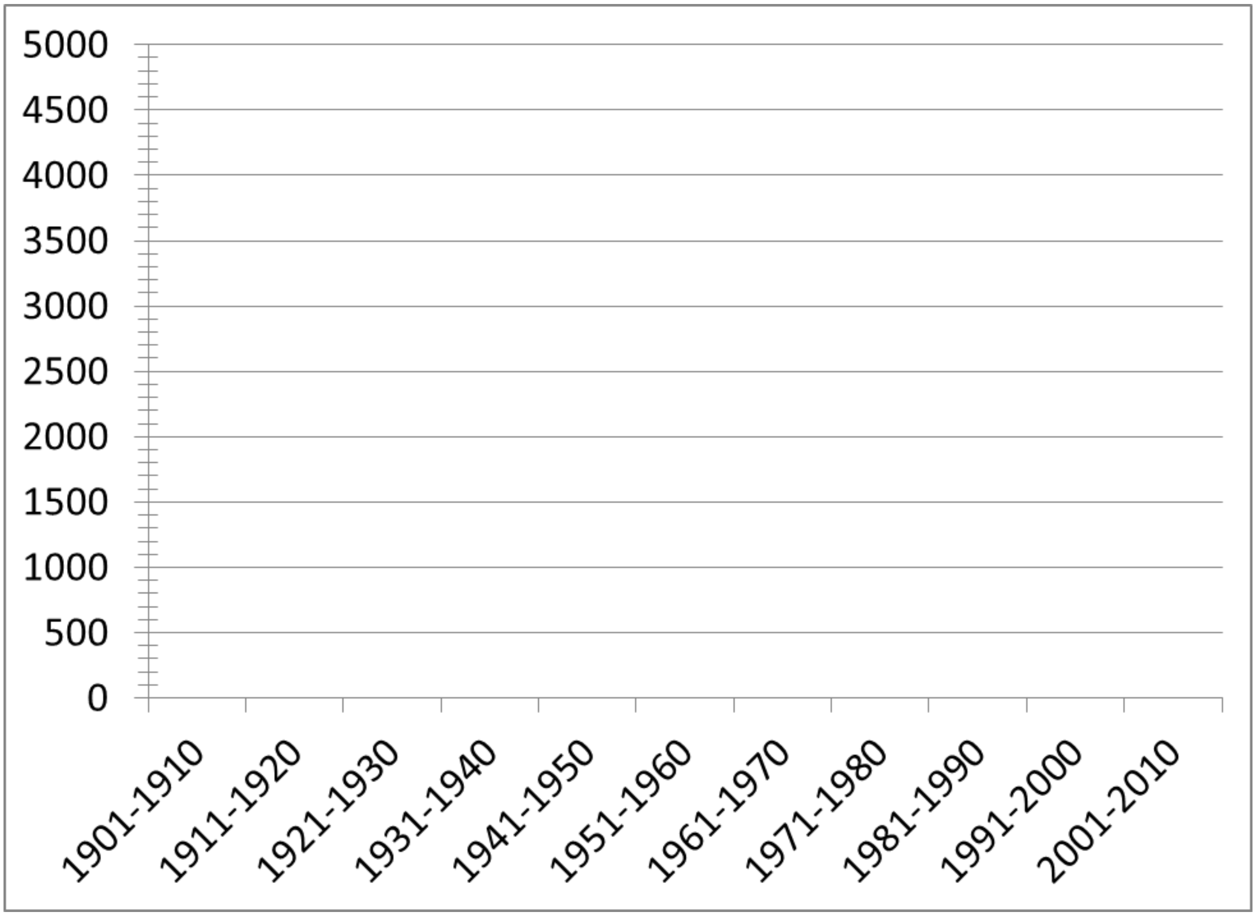
Decade	**Total hurricanes**	**Deaths**	**Adjusted cost (2010 dollars)**
1901-1910	18	764	691
1911-1920	20	1,008	4,705
1921-1930	15	2,925	2,913
1931-1940	19	1,197	8,181
1941-1950	24	184	7,619
1951-1960	18	952	20,761
1961-1970	14	531	36,038
1971-1980	12	226	25,904
1981-1990	15	140	27,842
1991-2000	14	242	82,130
2001-2010	19	1,431	249,164

Table 1. Decadal data on the total number of hurricanes, deaths, and costs (adjusted for inflation to 2010 dollars) for hurricanes that have struck the lower 48 United States.

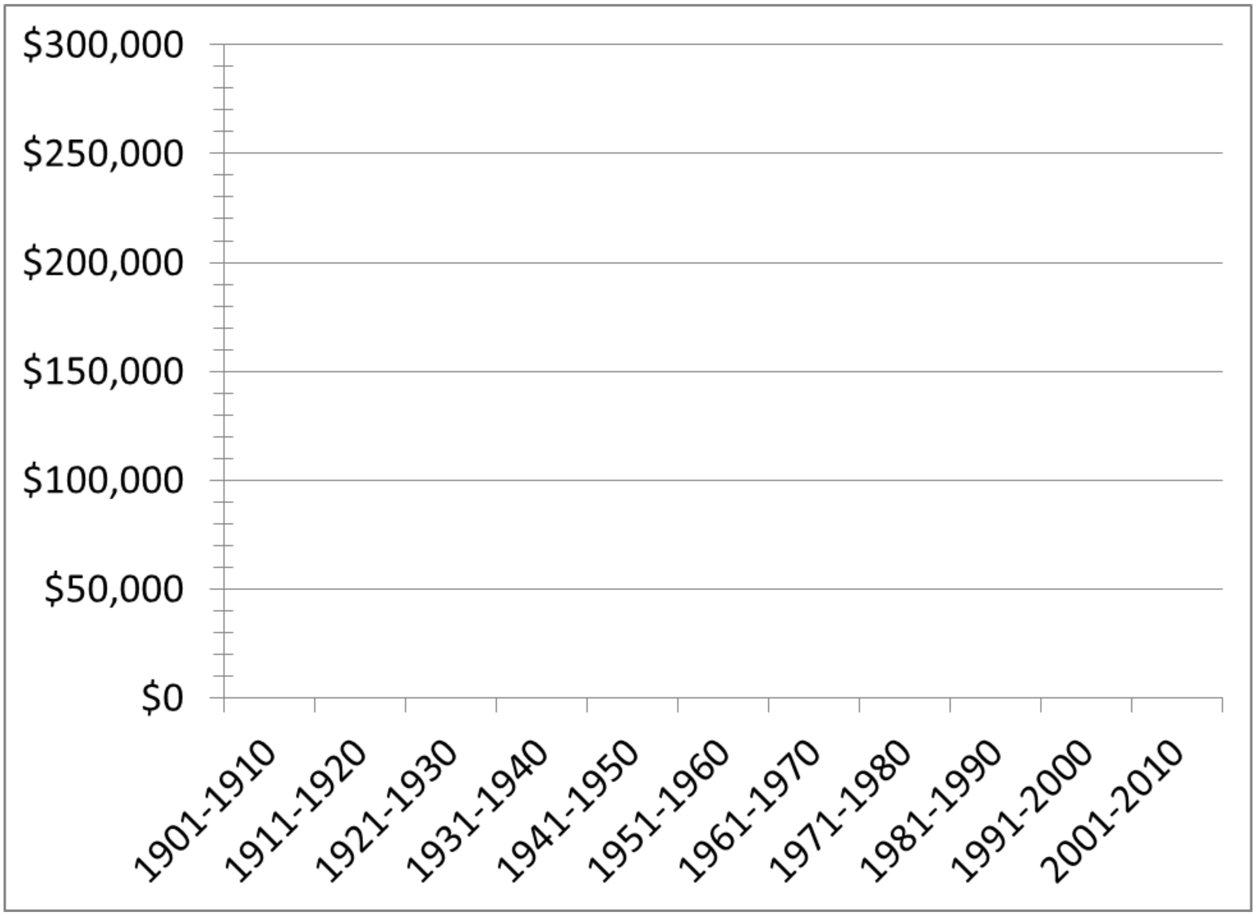
4. Plot the number of hurricanes per decade that have hit the lower 48 states, 1901–2010, from Table 1 (Data from Blake and Gibney, 2011).



5. Plot the number of deaths per decade that have occurred in the lower 48 states, 1901–2010, from Table 1 (Data from Blake and Gibney, 2011).



6. Plot the cost of hurricane damage (adjusted to 2010 dollars) per decade that have hit the lower 48 states, 1901–2010, from Table 1 (Data from Blake and Gibney, 2011).



7. What are the patterns (trends) in the total number of hurricanes, deaths, and costs over time?

8. Have the preparations and evacuations been more effective in saving lives or reducing the damages (costs) of hurricanes?

OPTIONAL ESSAY

9. Write a brief (1-2 paragraph) explanation for differences in the trends of number of hurricanes, deaths, and property damage (#8). What actions can be taken to decrease human deaths from a hurricane, and what can be done to reduce property damage? Include both short-term (such as actions taken when a hurricane is days away) and long-term (planning for years or decades into the future) actions in your answer.

Part 4 – Predicting Future Floods

It would be nice if people living along a river had a crystal ball and could predict the maximum discharge for the coming year. Unfortunately, we cannot predict the future and cannot travel into the future to see when the next big flood will occur. Instead, all we can do is use the data from past floods to calculate the probability that a flood of a given size will occur. Small floods happen almost every year, but the really big floods rarely happen. These are the ones that people are most concerned about.

Scientists have defined the term "a 100-year flood" to mean a flood of that has a 1% probability of occurring in any given year. The term "100-year flood" does **NOT** mean that a flood of that size occurs only once in a hundred years, just that the probability of a flood that size is *very* low. In fact, there is a 26% probability that a 100-year flood will occur at least once during a 30-year time period.

The USGS and other organizations monitor the discharge (volume of water in the stream) at gauging stations along many rivers and creeks and use it to determine the frequency of flooding along the stream. Estimates of **flood frequency** are more accurate with a long record (many years) of discharge records. The flood frequency is typically expressed as a **recurrence interval**. This is the *average* number of years expected between floods of a given magnitude, and it is calculated by listing all of the floods that have ever occurred and ranking them from the largest to the smallest.

The USGS has continuously monitored the Cedar River near Cedar Falls, Iowa, since 1941. The following table lists the largest discharges for 27 of the 73 years. The **Great Flood of 2008** is not listed; we will get to that one a bit later. Some of the smaller floods are also not listed so the graph will be easier to read, but a truly accurate recurrence interval would use all 73 values. You need to complete the table by calculating the recurrence interval for five of the floods. The equation for recurrence interval is . . .

Recurrence Interval = (n+1)/Rank

Where n = the number of years on record (in this case 72)* and Rank = the position within that list.

Rank	Date	Discharge (m^3/s)	Recurrence Interval
1	Mar 29, 1961	2171.9	73.0
2	Apr 8, 1965	1968.0	
3	Jul 23, 1999	1962.4	24.3
4	Apr 2, 1993	1928.4	18.3
5	Jun 29, 1969	1659.4	14.6
6	May 25, 2004	1656.5	
7	May 31, 2013	1622.6	10.4
8	Apr 9, 1951	1597.1	9.1
9	Jun 13, 1947	1574.4	8.1
10	Mar 17, 1945	1509.3	7.3
11	Mar 31, 1962	1449.8	6.6
12	Mar 5, 2010	1413.0	6.1
13	Jun 23, 1954	1398.9	

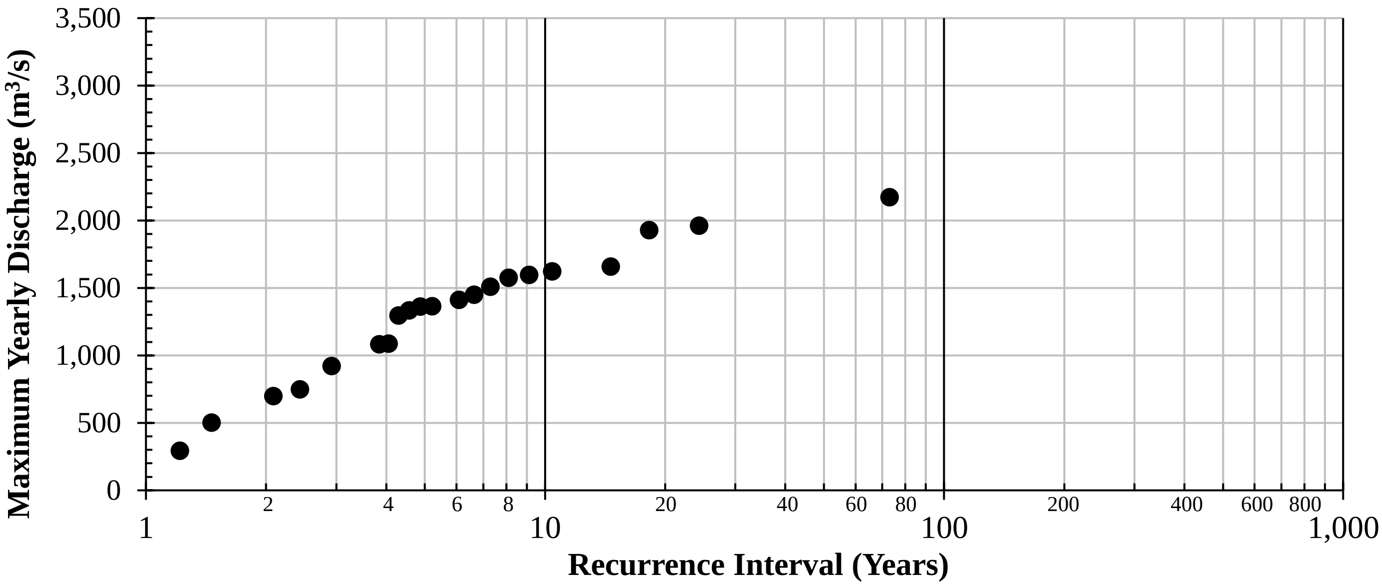
* For now we are not including 2008 in the calculations, so even though there are records from 73 years, use n = 72 when calculating the recurrence interval.

Rank	Date	Discharge (m^3/s)	Recurrence Interval
14	May 21, 1991	1364.9	5.2
15	Mar 31, 1960	1362.0	4.9
16	Jul 30, 1990	1333.7	4.6
17	Apr 15, 2001	1296.9	4.3
18	Mar 8, 1950	1087.4	4.1
19	Mar 1, 1948	1081.7	3.8
20	Apr 18, 1973	1056.2	
25	Aug 25, 1979	920.3	2.9
30	Jun 17, 1944	747.6	2.4
35	Mar 28, 1959	699.4	2.1
40	Jun 30, 1998	659.8	
50	Mar 28, 1943	501.2	1.5
60	Mar 5, 1985	294.5	1.2
70	Jul 17, 1958	122.3	

4-1. Complete the table by calculating the recurrence intervals for six of the floods where the recurrence interval field is empty.

4-2. Once you have calculated the recurrence intervals, you need to plot your answers on the **flood frequency graph** shown below. The vertical lines are not evenly spaced because they are plotted on a logarithm scale rather than a linear scale. Plot the points just like you would on a normal-looking graph except that the lines are not evenly spaced.

Flood Recurrence Intervals For The Cedar River Near Cedar Falls, IA



4-3. After you have the six points plotted, use a ruler or straight edge to draw a **single straight line** that passes through the values that have recurrence intervals of 4 years or greater and extend this line to the right-hand edge of the graph. It is OK if the line does not pass through all of the points. It represents the "**best fit**" of the data. This line shows the average discharge for any given recurrence interval.

By extending the line to the right, you can predict the discharge for extremely large floods that have never occurred.

4-4. Based on your graph, what would be the discharge of a 200-year flood? A 300-year flood? Explain below how you arrived at those answers.

200-year flood = _________________ m^3/s

300-year flood = _________________ m^3/s

____

____

____

____

The recurrence intervals can also be thought of as the **probability** of a flood of that size occurring in any given year. The table below shows how recurrence intervals and the probabilities are related.

4-5. The probability (P) for any given recurrence interval (RI) is **P =100 ÷ the RI**. The table on the right compares recurrence intervals to the probability of that flood occurring. Calculate the missing probabilities.

Recurrence Interval (years)	**Probability of That Flood Occurring in Any Given Year**
1	100%
2	50%
5	
10	10%
50	
100	1%
500	

4-6. On June 11, 2008, the Cedar River had a record discharge of 3171 m^3/s. Use the graph on the previous page to estimate the recurrence interval for that flood and determine the probability that a flood of that size could happen again. Explain below how you arrived at those answers.

Recurrence Interval = ________________ Probability = ________________

4-7. In 2010, a river near you experienced a 500-year flood. Two students are discussing what that term means and whether it is safe to live near the river. Peter says that it is safe to live close to the river but not right on the river because the term 500-year flood means that a flood of that size only comes around once every 500 years. That means that a flood of this size will not happen again until sometime around the year 2500 (500 years from now). Lindsey says that it is not a good idea to live near the river in a place that was flooded in 2008. She claims the term 500-year flood refers to the chances that a flood of that size will happen this summer, and because that chance is not zero, it is possible that the area will experience another 500-year flood next year. Who do you think is right? Explain why.

Coastal Development and Changes in Hurricane Hazards

Time: 25 minutes

Summary: Students will determine how changes in coastal development have altered the risks presented by hurricanes by analyzing historic maps and aerial photographs.

CHANGES IN DEVELOPMENT

Human development can have significant effects on the coastal environments. This development has occurred in many places around the United States and globally, and has been recent enough that we have documented evidence of this from maps and historic aerial photographs. In the following exercise you will compare how development of the coast has changed.

Figure 1. Images comparing part of Fort Lauderdale, Florida. Image on the left is from 1947 (USDA, from ufdc.ufl.edu), and on the right from 2008 (The National Map, USGS, nationalmap.gov). Each image is approximately 1 mile wide.

1. Describe the land uses visble in 1947 and in 2008. How has land use changed from 1947 to 2008?

Figure 2. A historic topographic map from 1900 (top) and a satellite photograph (bottom) from 2008. Rockaway Beach is approximately 5 miles east of New York City. Historic map from a portion of the Brooklyn NY 15' USGS topographic map from the National Map: Historical Topographic Map Collection (http://nationalmap.gov/historical/index.html) and the modern image from the National Map (nationalmap.gov).

2. Describe the land uses visble in 1900 and in 2008. How has land use changed from 1900 to 2008?

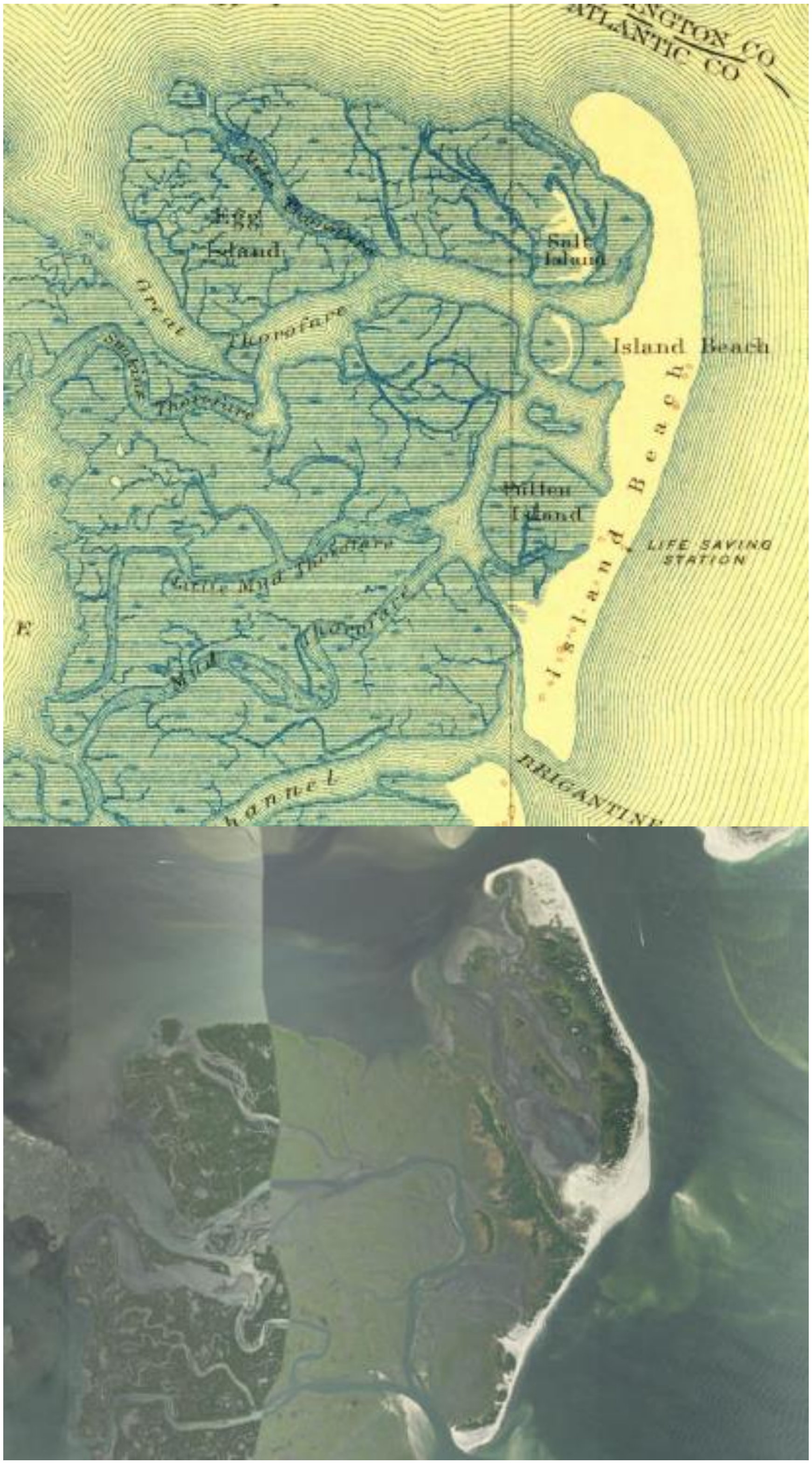


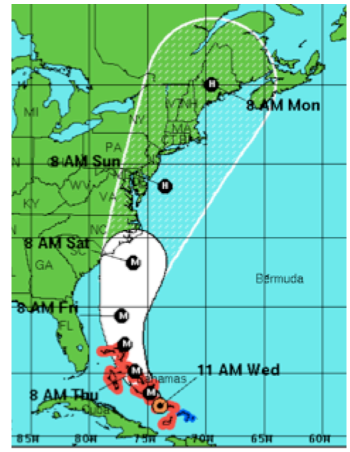
Figure 3. A historic topographic map from 1894 (top) and a satellite photograph (bottom) from 2008 of part of the Little Egg Inlet, New Jersey, approximately 5 miles northeast of Atlantic City. Historic map from a portion of the Atlantic City, NJ 15' USGS topographic map from the National Map: Historical Topographic Map Collection (http://nationalmap.gov/historical/index.html) and the modern image from the National Map (nationalmap.gov).

3. Describe the land uses visble in 1894 and in 2008. How has land use changed from 1894 to 2008?

4. The number of deaths from hurricanes has generally decreased over the last 100 years, but the amount of property damage has increased. How do you explain this given what you have observed in these pairs of images?

References:

United States Department of Agriculture, aerial photographs of Broward County – Flight 2D (1947). http://ufdc.ufl.edu/UF00071731/00019.
Historic Topographic maps obtained from the National Map: Historical Topographic Map Collection (http://nationalmap.gov/historical/index.html
National Map Viewer
http://nationalmap.gov/viewer.html



(NOAA)

Making the difficult decision of whether or not to evacuate our town

The scenario:

- It's Wednesday morning and a Category 2-3 hurricane is predicted to make landfall here Sunday.
- The mayor is hearing statements today.

Please consider:

- Do you think a mandatory evacuation order should be issued? Give both pros and cons.
- Does timing matter? How much time do you reasonably need to prepare for evacuation? How soon is too soon?

Below, draft your Position Statement as ______________________________________:
(stakeholder)

Predicting Patterns

What Does La Niña Look Like?

The El Niño-Southern Oscillation results from changes in the strength of the Pacific trade winds. Normally these easterly winds push the warm equatorial waters away from the west coast of South America, forcing deep, cold, nutrient-rich waters to be drawn up along the coast. This deep water upwelling provides a habitat for the large fish communities that support coastal fishing economies. During El Niño years the trade winds are weakened, and the warm waters of the tropical Pacific flow back toward South America, preventing coastal upwelling. El Niño has many impacts throughout the region, including drought in the west and flooding in the east, along with decimation of the fish trade the upwelling supports.

El Niño itself is only one-third of what we call ENSO, or the Southern Oscillation. The other parts of ENSO are the normal condition and La Niña. El Niño is considered the positive condition and La Niña the negative. (These don't mean “good” and “bad” though! Positive and negative just refer to the pressure states associated with the anomaly.) El Niño has a longer history of study than La Niña, but does not necessarily occur more often.

The change ENSO causes in the distribution of heat energy across the tropical Pacific equals changes in convection too—the location of precipitation in the region follows the hottest water, so strong anomalies mean flooding and drought for areas corresponding higher or lower than normal precipitation. As ENSO originates in the tropical Pacific, the impacts there relate closely to the original phenomena. As we learn more about ENSO, however, its global impacts become more clear. Flood, storm, and drought events around the world arise due to this oscillation in the tropical Pacific.

During this activity you will:

(predict the local effects of La Niña based on the mechanics of El Niño,

(create precipitation intensity maps for the three states of the El Niño-Southern Oscillation,

(predict the regional coastal effects of ENSO based on its mechanics, and

(consider the global effects of ENSO and its potential long-term impacts.

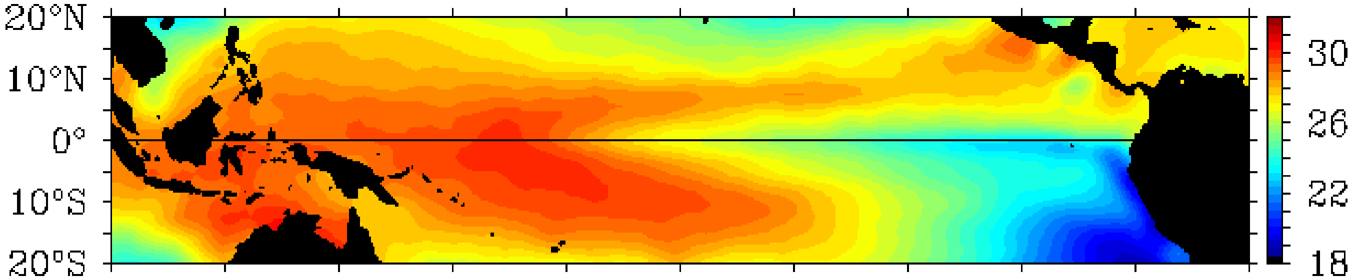
1. On the following page are two maps of southern Pacific Ocean sea surface temperatures (SST) for December 1993 and 1997, respectively. One map represents ocean temperature data from normal conditions, the other from El Niño conditions. Label the maps. Which is El Niño and which is normal? How do you know?

2. During La Niña the Pacific trade winds are stronger than normal (as opposed to El Niño, during which they are weaker). With stronger winds, what do you think will happen to the warm equatorial water of the eastern tropical Pacific?

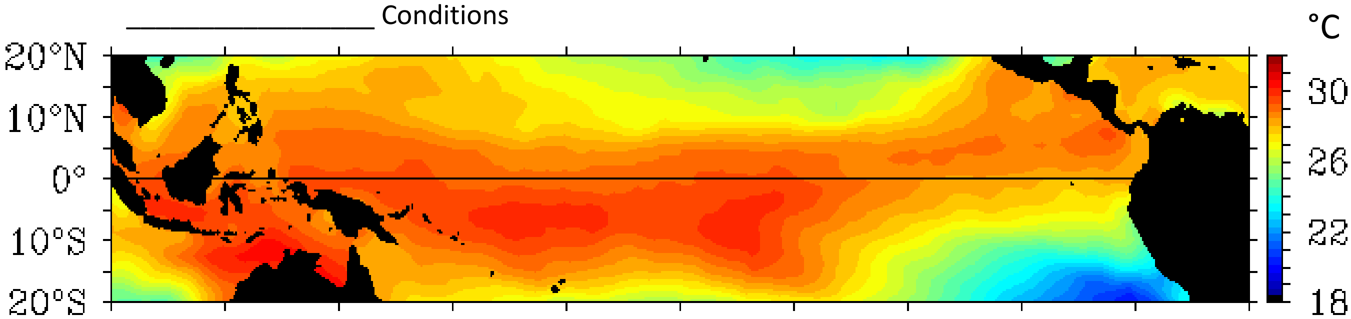
Images on this page are from NOAA.

Maps of the Reynolds Sea Surface Temperature (SST) analysis for 1993 and 1997 from the National Center for Environmental Prediction (NCEP) for the Pacific Ocean (70°N to 70°S), created by Dai McClurg of the TAO Project.

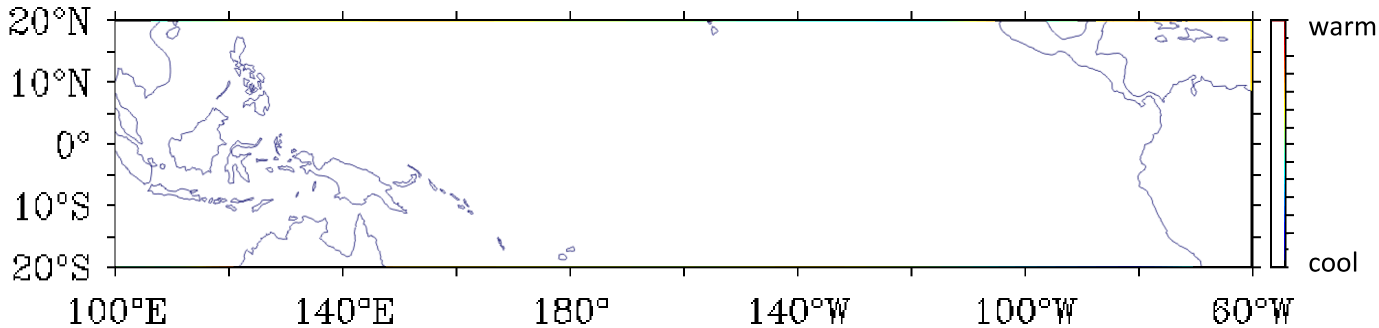
__________________ Conditions



__________________ Conditions

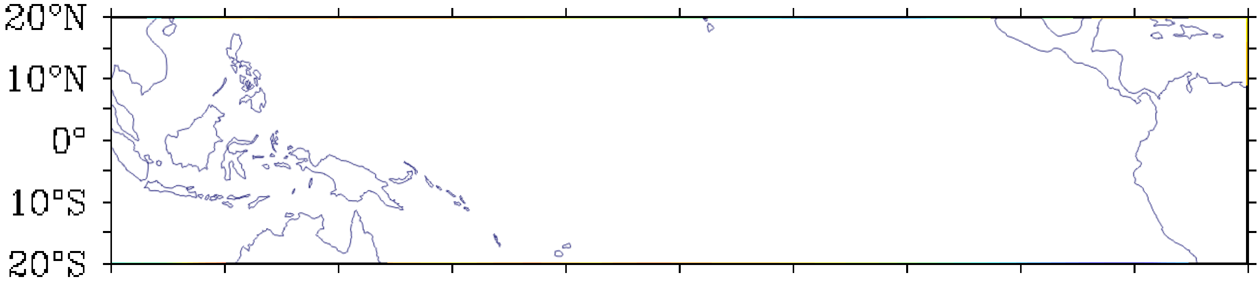


La Niña Conditions

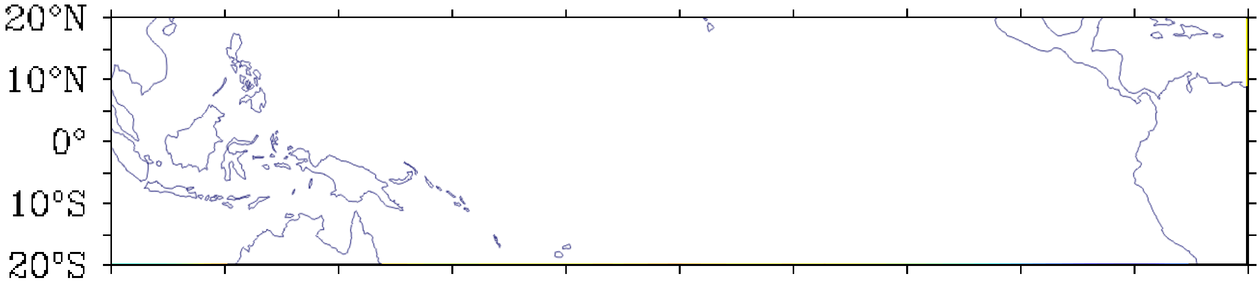


3. Fill in the blank map of La Niña SST conditions above based on your predictions. Use colors or symbols to represent contrasting warm and cool SST. Make sure to amend your map temperature legend.
4. Fish can't live in the waters off the northwestern coast of South America during El Niño years, causing the fish trade and fisher livelihoods to suffer in these areas. Does the same phenomenon occur during La Niña years? Why or why not?
5. One of the immediate effects of changing SST is changing precipitation patterns. As warm equatorial water moves through the tropical Pacific with changes in trade wind strength, so do locations of high precipitation. Why does this correlation exist? How (specifically) does SST relate to the likelihood of precipitation?
6. Based on your SST maps and the relationship you just described, create maps of precipitation intensity for El Niño, ENSO normal, and La Niña conditions on the three blank maps on the following page, using colors or symbols to show contrasting high and low precipitation. Create a legend for your maps.

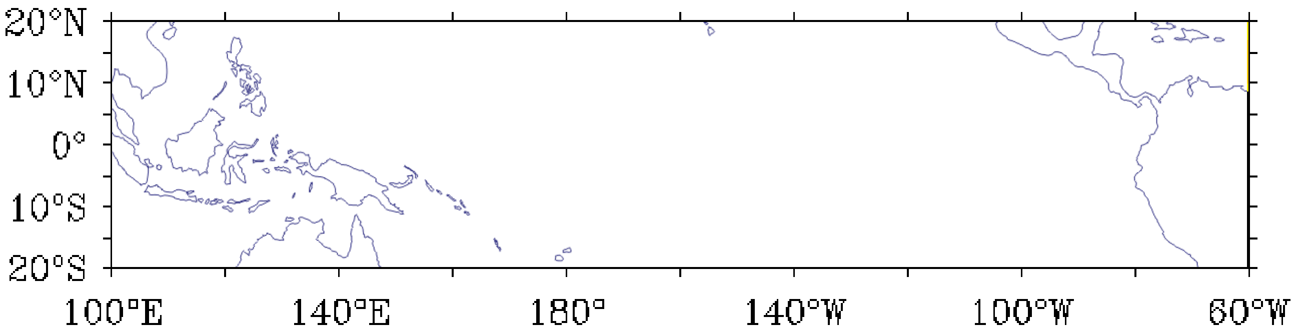
Precipitation Pattern — __________________ Conditions



Precipitation Pattern — __________________ Conditions



Precipitation Pattern — __________________ Conditions



7. Given that coastal ecosystems are relatively equilibrated to normal conditions, ENSO causes instabilities during both El Niño and La Niña years. In locations where it is wetter than normal, floods occur, while in those where it is drier than normal, drought ensues. Based on these general relationships and your precipitation maps above, identify the coastal impacts of El Niño and La Niña in the tropical Pacific. (Circle the appropriate options.) (HINT: Consider the definition of *anomaly*.)

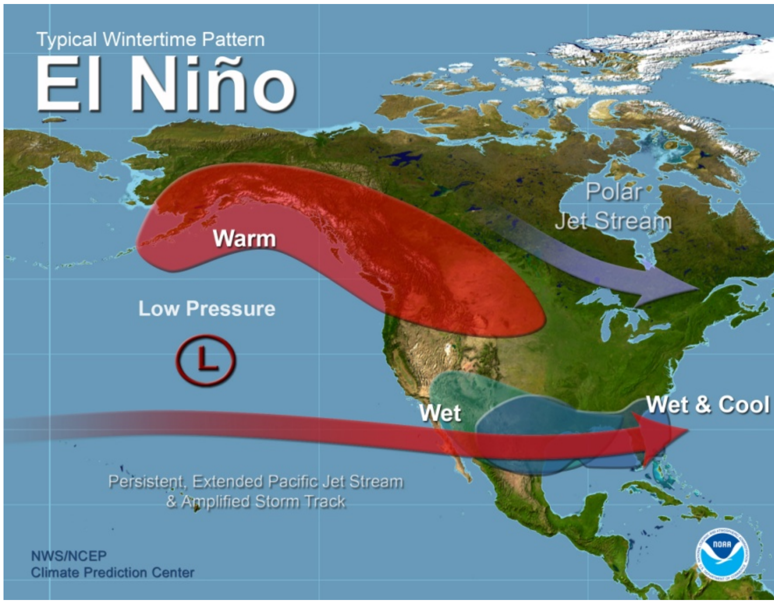
Region	Anomaly	Effect	Impact
western Pacific (Oceana & northern Australia)	El Niño	drier normal wetter	drought flood none
	La Niña	drier normal wetter	drought flood none
eastern Pacific (Central America & western South America)	El Niño	drier normal wetter	drought flood none
	La Niña	drier normal wetter	drought flood none

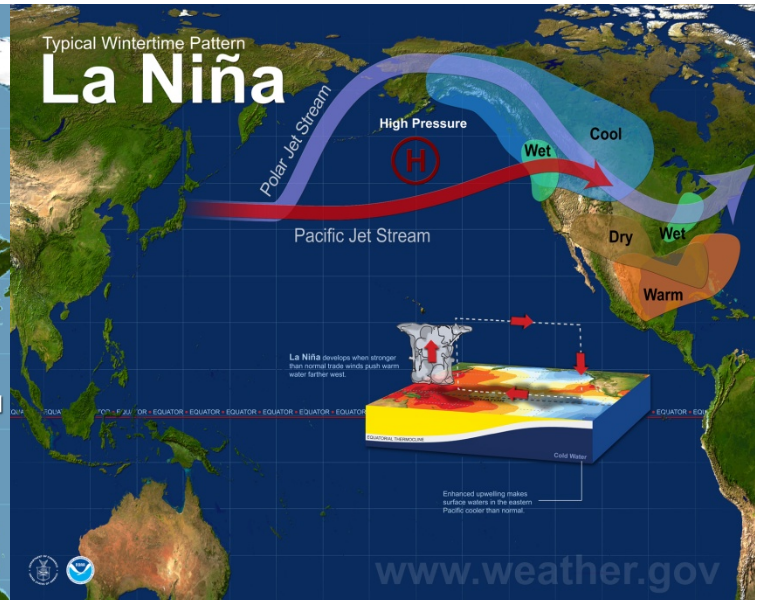
8. Why do you think ENSO has global impacts? How could an ocean surface anomaly in the tropical Pacific incite variations in other parts of the world?

9. If ENSO events became more frequent, what would happen to ecosystems and economies in locations subject to these weather variations, both in the tropical Pacific and around the world?

Name: ______________________________

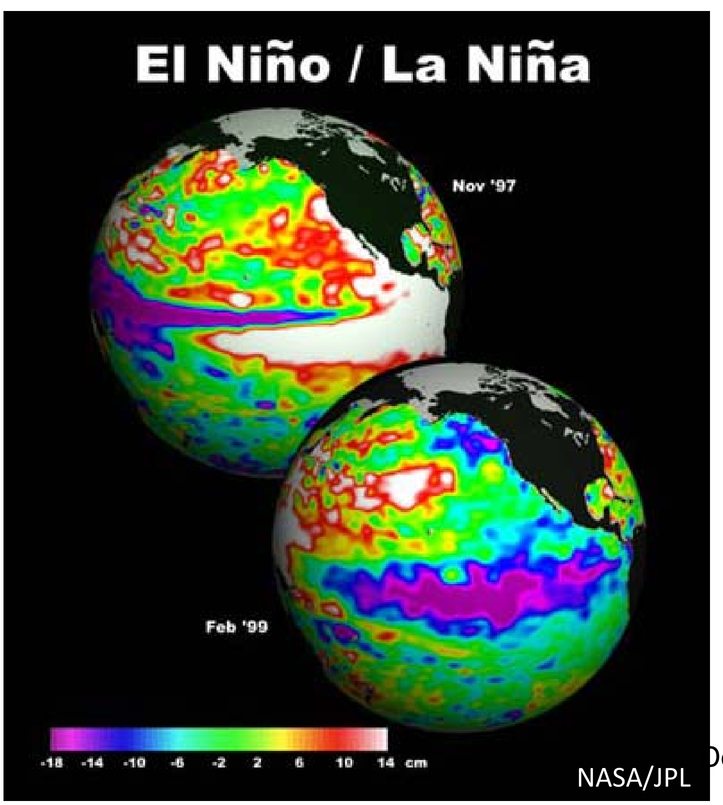
Exploring Patterns: *ENSO on the Global Stage*





Above are depictions of how El Niño (ENSO+) and La Niña (ENSO-) affect conditions in North America. You may have heard about such impacts on the news, which can include things like low water availability and crop yields, or increased glacial melt. Along with ENSO there are other ocean surface anomaly systems, like the North Atlantic Oscillation (NAO) and Pacific Decadal Oscillation (PDO). Additionally, interactions between different ocean surface anomaly systems can cause the weather conditions we actually experience to vary from those we expect of the oscillation. For example, some expressions of NAO can be quite subtle, depending on the state of ENSO and its impact on the jet stream.

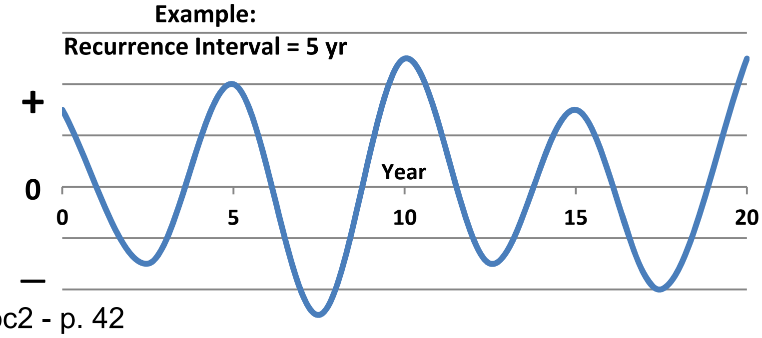
Some oscillations reoccur in a regular time cycle (e.g., every 10 yr or every 25 yr), called a *recurrence interval.* Understanding the recurrence interval of a climate phenomenon can help us to plan for and mitigate its impacts.



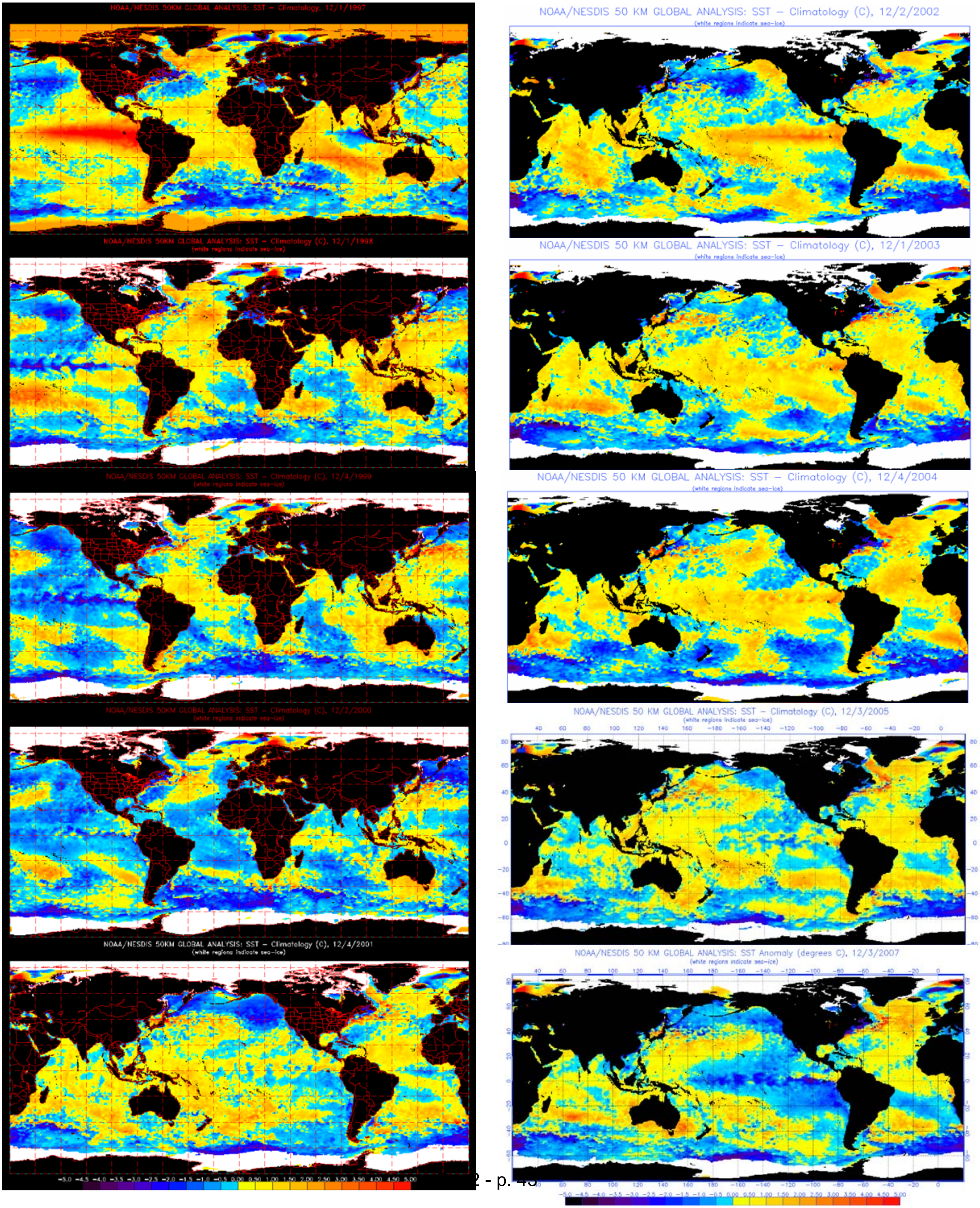
You will explore these concepts by:

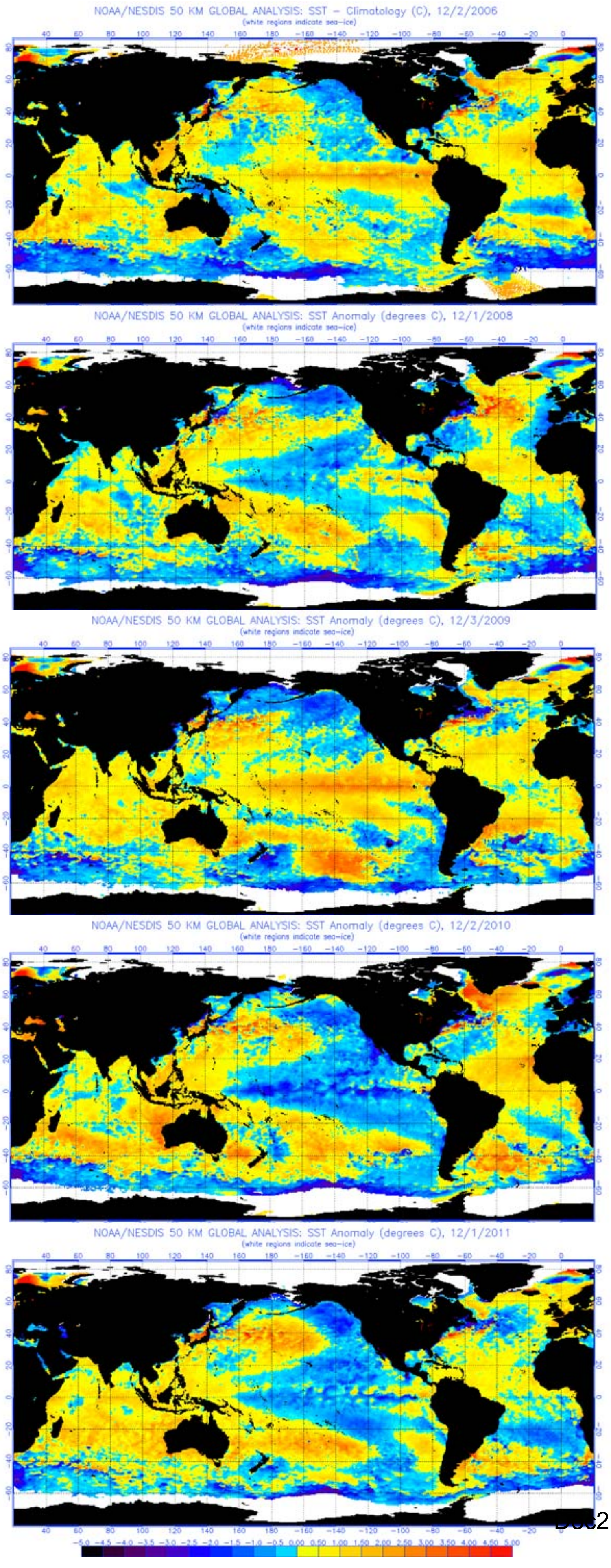
- reading global sea surface temperature (SST) anomaly maps,
- assessing the state of the El Niño Southern Oscillation from SST anomaly maps,
- creating a timeline of changes in ENSO conditions, &
- assessing the recurrence interval of the ENSO system.

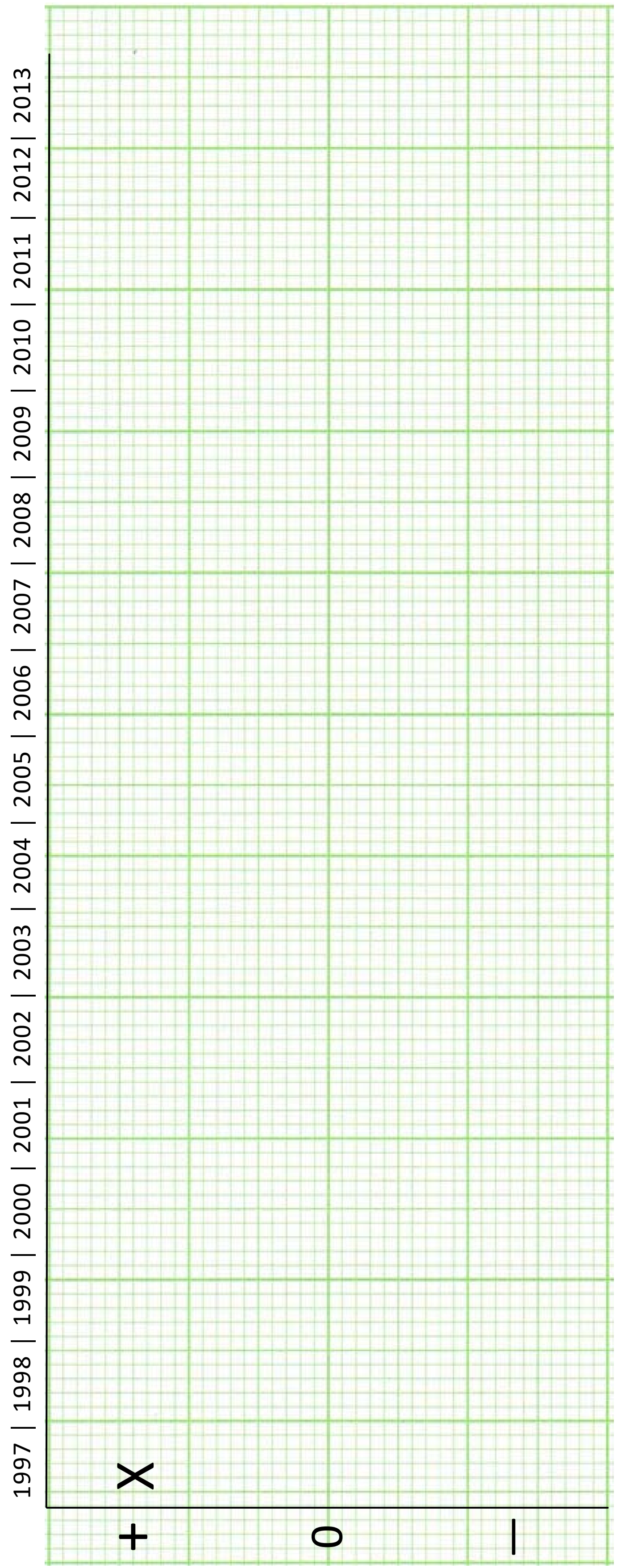
Example:



Maps of the sea surface temperature anomaly in early December from 1997-2011 created by the National Oceanic and Atmospheric Administration's Coral Reef Watch. SST Anomaly is produced by subtracting the long-term mean SST (for that location in that time of year) from the current value. A positive anomaly means that the current sea surface temperature is warmer than average, and *vice versa*.




NOAA/NESDIS 50 KM GLOBAL ANALYSIS: SST − Climatology (C), 12/2/2006
(white regions indicate sea-ice)
NOAA/NESDIS 50 KM GLOBAL ANALYSIS: SST Anomaly (degrees C), 12/1/2008
(white regions indicate sea-ice)
NOAA/NESDIS 50 KM GLOBAL ANALYSIS: SST Anomaly (degrees C), 12/3/2009
(white regions indicate sea-ice)
NOAA/NESDIS 50 KM GLOBAL ANALYSIS: SST Anomaly (degrees C), 12/2/2010
(white regions indicate sea-ice)
NOAA/NESDIS 50 KM GLOBAL ANALYSIS: SST Anomaly (degrees C), 12/1/2011
(white regions indicate sea-ice)


1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013
X
+
0
|

1. Using the SST anomaly map time series and graph provided on the previous pages, create a timeline of ENSO events from 1997-2011. Include El Niño (+), La, Niña (-), and ENSO normal (0) ocean surface conditions. The assessment for 1997 is completed for you.

2. What is the difference between SST and SST anomaly maps? Which type of map is more helpful for recognizing an SST oscillation pattern and why?

3. According to your timeline graph, what is the recurrence interval of each anomalous ocean surface condition?

   ENSO+

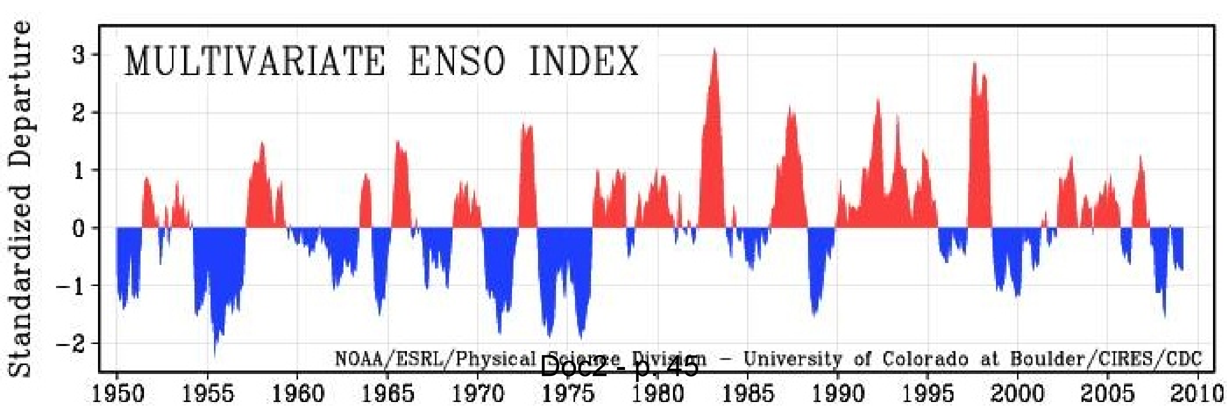
   ENSO-

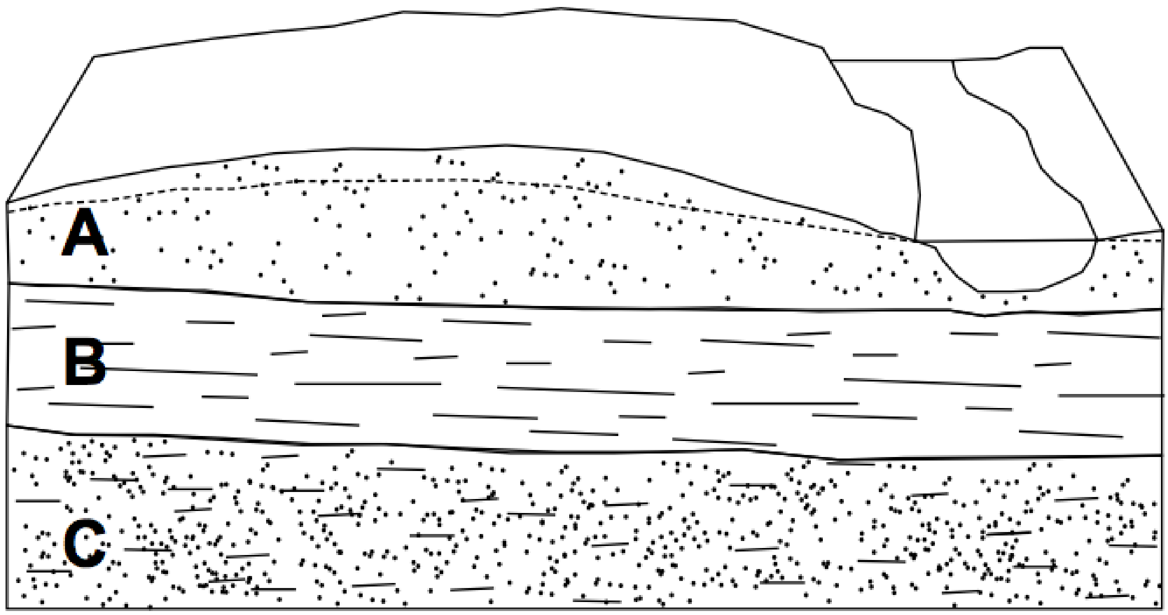
4. Use your time series analysis to predict the ENSO condition in 2012 and 2013. How certain are you of your prediction?

   +1 Extra credit: Perform an internet search for ENSO conditions in 2012 and 2013 to check your prediction. Were you correct or incorrect and why?

5. What other oscillations/patterns of change in the global ocean do you observe? Where do they occur and how do they compare with ENSO?

6. Below is a representation of variation in ENSO from 1950 to 2010. Do you observe a regular recurrence interval here? Does this graph change your interpretations above or confirm them? Explain.



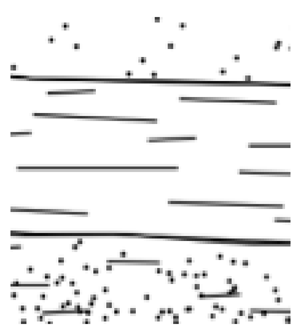


Lithologic symbols:

Sandstone (A)

Shale (B)

Silt (C)



78. Indicate which layer is the confined (closed) aquifer: A B C

79. Indicate which layer is the unconfined (open) aquifer: A B C

80. Indicate which layer is the confining layer (also aquiclude or aquitard): A B C

From EPA website http://www2.epa.gov/aboutepa/love-canal-tragedy

On the first day of August, 1978, the lead paragraph of a front-page story in the New York Times read:

NIAGARA FALLS, N.Y.--Twenty five years after the Hooker Chemical Company stopped using the Love Canal here as an industrial dump, 82 different compounds, 11 of them suspected carcinogens, have been percolating upward through the soil, their drum containers rotting and leaching their contents into the backyards and basements of 100 homes and a public school built on the banks of the canal.

In an article prepared for the February, 1978 *EPA Journal*, I wrote, regarding chemical dumpsites in general, that "even though some of these landfills have been closed down, they may stand like ticking time bombs." Just months later, Love Canal exploded.

The explosion was triggered by a record amount of rainfall. Shortly thereafter, the leaching began.

I visited the canal area at that time. Corroding waste-disposal drums could be seen breaking up through the grounds of backyards. Trees and gardens were turning black and dying. One entire swimming pool had been had been popped up from its foundation, afloat now on a small sea of chemicals. Puddles of noxious substances were pointed out to me by the residents. Some of these puddles were in their yards, some were in their basements, others yet were on the school grounds. Everywhere the air had a faint, choking smell. Children returned from play with burns on their hands and faces.

81) Which of these happened because of the chemicals buried in Love Canal? (bubble one)

a) Steel drums rusted releasing hazardous waste into the soil.
b) Children were developing burns and getting sick.
c) Toxic swamps were created by heavy rains.
d) All of the above.

82) The leader of the justice movement to draw attention to the toxic and hazardous materials at Love Canal was (bubble one)

a) William T. Love
b) Erin Brockovich
c) Lois Gibbs
d) Jimmy Carter

83) An underground clay layer that is relatively flat-lying, when interacting with water will (bubble one)

a) Absorb the water.
b) Expand on contact with the water.
c) Act as a barrier so the water will not infiltrate any further.
d) Become more permeable than a sand layer.

84) This 1980 Congressional act requires that companies safely dispose of hazardous chemicals they generate and pay to clean up the sites they contaminate. (bubble one)

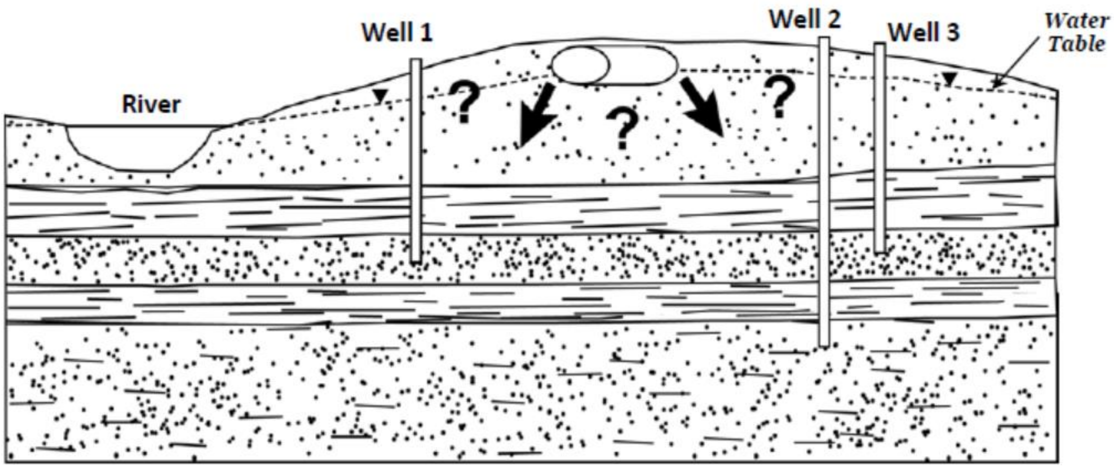
a) North American Free Trade Agreement or NAFTA
b) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or the Superfund Act
c) Resource Conservation and Recovery Act or RCRA
d) Dodd-Frank Act

FOR 85-100, DO **NOT** BUBBLE ANSWERS ON THE SCANTRON. INSTEAD, CIRCLE ANSWERS OR WRITE ANSWERS (AS REQUIRED) ON THE PAGES THAT FOLLOW. NOTE THAT YOU CAN CIRCLE MORE THAN ONE ANSWER FOR SOME MULTIPLE CHOICE QUESTIONS.

85. El Nino involves ____________.
.
a. a warming of the sea surface in the eastern tropical Pacific
b. a cooling of the sea surface in the eastern tropical Pacific
c. a warming of the sea surface in the western Pacific

86. The geologic cross section below shows a leaking underground storage tank. The tank is known to be leaking a toxic liquid but the direction of flow and amount and type of chemical is unknown. Just looking at the geologic context shown in the diagram, which of the labeled features (i.e., River, Well 1, Well 2, and Well 3) would be impacted by the toxic material first, second, third and last.

Answer:
1st ____________ 2nd ____________ 3rd ____________ last ____________



HURRICANES

87. DELETED

88. Select all that apply. What conditions are necessary for hurricane formation?

A. atmospheric instability
B. sea surface temperature > 27 C
C. sea surface temperature < 27 C
D. little or no vertical wind shear
E. significant vertical wind shear
F. within 10 degrees of the equator
G. at least 5 to 10 degrees north or south of the equator

89. Which of these hazards are often associated with hurricanes? Select as many as apply.

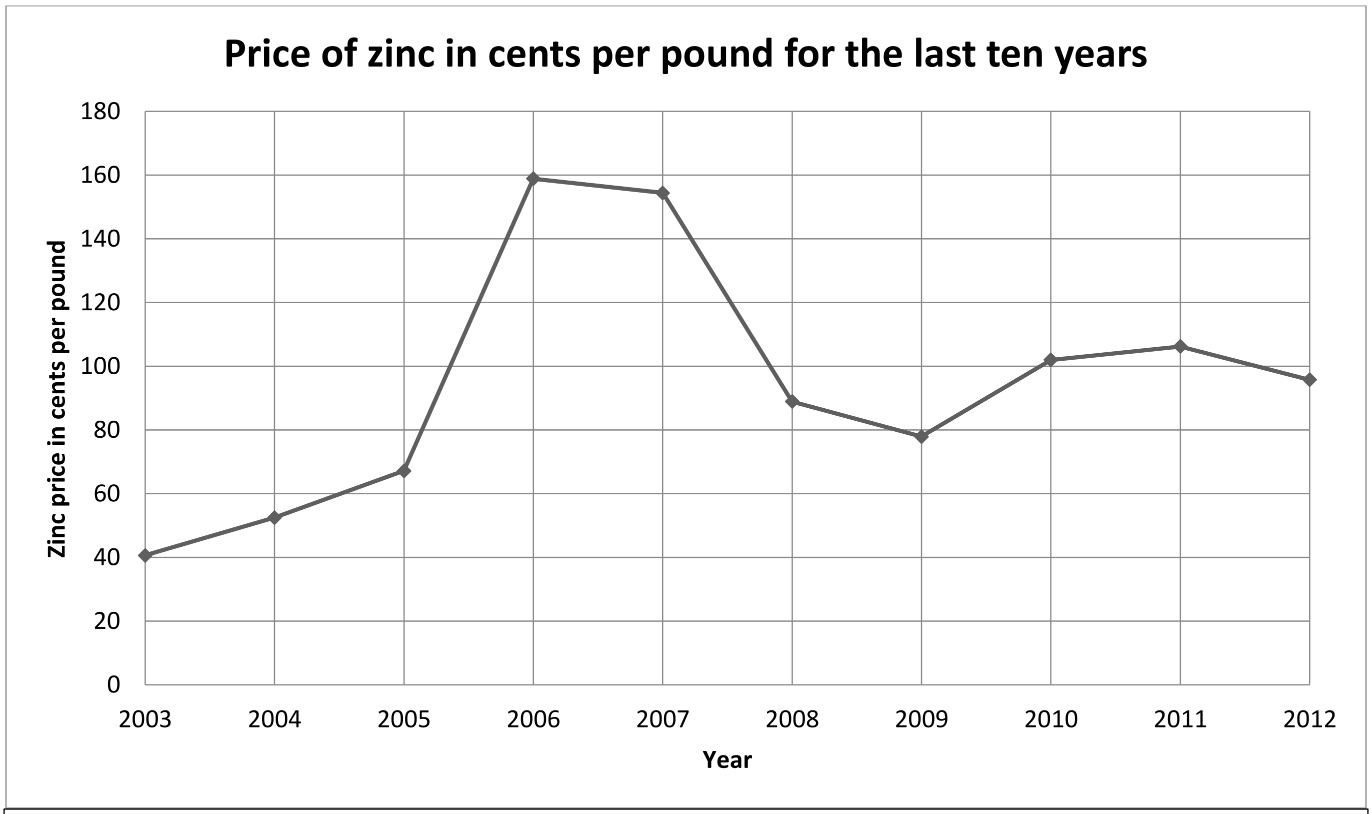
A. high winds
B. heavy rain
C. storm surge
D. coastal land loss
E. thunderstorms
F. snow storms

MINERALS AND ROCKS

Sphalerite is a sulfide mineral (ZnS). Zinc is extracted from sphalerite. Several zinc mines exist in Tennessee. Most of the zinc mines in Tennessee are underground mines as opposed to open pit mines.

90. Imagine you are the project manager of a mining company that might be interested in establishing an underground zinc mine in Tennessee. Describe at least **two geologic, one socioeconomic, and two environmental factors OTHER THAN ACID MINE DRAINAGE** that you need to consider for locating a suitable mine site in Tennessee. Explain why each of those factors is important for establishing the mine.

91. As the project manager, what measure(s) would you take to <u>prevent acid mine drainage from occurring</u>? What measure(s) would you take to mitigate acid mine drainage <u>if it does happen</u> despite your precautions? Explain your answer for both situations.



Graph showing how the price of zinc have changed over the last ten years. Graph by juk Bhattacharyya, University of Wisconsin–Whitewater, based on data from USGS Mineral Information (http://minerals.usgs.gov/minerals/pubs/commodity/zinc/)

92. The above graph shows the price variation for zinc (in cents per pound) over the last ten years. **Assuming all other controlling factors except for price of zinc remained the same**, how might the price change between 2003 and 2007 affect zinc mining? Explain your answer.

93. DELETED.

PLATE TECTONICS

95. Based on your risk assessment of the two schools in this activity, make the case for funding upgrades to buildings at one. Prepare a set of bullet points to be presented to the City of San Francisco that uses data from your analysis to support your recommendations. If additional measures are necessary to mitigate risk at other schools, outline them and support them as well.

SOIL

96. Based on what you have learned, how does agriculture threaten the sustainability of soil?

CLIMATE

97. Give an example of a real-world system and describe its parts.

98. Explain how parts of the system interact. Use systems concepts in your explanation (e.g., positive and negative feedbacks, equilibrium, rates, etc.).

99. DELETED.

100. DELETED.