

EAPS 10000 Y01 *Planet Earth* online course
Homework #5 (40 points; revised March, 2014)
HURRICANES HUGO and KATRINA

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Objective:

Study the development of Hurricane Hugo through time by analysis of Hugo's location, wind speed, and atmospheric pressure at twelve-hour intervals from September 11-22, 1989. One excellent reason for detailed study of the time history of a hurricane such as Hugo, is to provide information that can be used to predict the behavior, motion, intensity, and characteristics of future hurricanes. This predictive information may then be used to reduce the hazard of hurricane damage from a storm as it develops in the Atlantic and travels across the ocean toward North America. Studies of many hurricanes like Hugo provide us with reasonably reliable forecast statistics for Atlantic hurricanes.

This assignment illustrates the detailed study of Atlantic hurricane development for a particularly significant hurricane, Hugo, which caused substantial damage in Puerto Rico and the South Carolina area. The assignment also provides practice with data plotting (maps and graphs) and analysis. In addition, we review the track of Hurricane Katrina (2005) using an available online database.

Part 1

Procedure:

1. Using the Table (page 4) of Hurricane Hugo's location (in latitude and longitude), maximum sustained wind speed (in km/hr), and minimum atmospheric pressure (in millibars, or hPa), and the attached map (page 6) of the north Atlantic Ocean, plot the location of Hurricane Hugo at twelve-hour intervals (locations are given at 10:00 and 22:00 hours [24 hour UTC or GMT time] for each date) from September 11 to 22. Using the dashed latitude and longitude lines on the north Atlantic Ocean map, for each location in the table (for example, for 22:00 hours on September 11, the location is 12.8°N latitude and 30.5°W longitude), put a dot on the map at that location. For the locations at 22:00 hours of each day, write the date (11, 12, etc.) next to the dot. As an example and to get you started, the first three data points are already plotted on the map for you. Note that you need to interpolate (estimate) the locations between the dashed latitude and longitude grid (5 by 5 degree "squares") lines. Connect the dots with lines to show the track of the hurricane over time.
2. On the attached graph (page 5), plot the wind speed and atmospheric pressure data as a function of time. Use triangles (▲) for the wind speed data and dots (●) for the pressure data. As an example, the first two data points from the Table are already plotted on the graph. Connect the points with smooth lines to show the wind speed and pressure variation with time for Hurricane Hugo. (If you wish to plot by computer, you can obtain the data at: <http://web.ics.purdue.edu/~braile/EAS100online/HurricaneHugoDataTable.xls>. You can produce an Excel plot, or use other software, to paste into your Hw 5 submission. If you plot by computer, please be sure to make the graph look similar to that shown on page 5.)

Questions:

1. Examine the track of Hurricane Hugo on the North Atlantic Ocean map. What is the approximate direction (note that the North direction on the map, page 6, is parallel to lines of longitude [and not always toward the top of the page as is the common convention] and changes depending on the location on the map) that Hugo traveled during the following periods (circle the correct direction)?



← You can copy, paste and drag to circle the directions.

Time Period**Direction of travel of Hugo****September 11-15**N NE E SE S SW **W** NW**September 17-21**N NE E SE S SW W **NW**

2. Using the track of Hugo plotted on the North Atlantic Ocean map and the kilometer scale provided on the map, what is the approximate speed that the hurricane was moving across the Atlantic during the time period of September 11-15 (4 days or 96 hours)?

31.25 km/hr

Note that the hurricane's motion across the ocean slows down somewhat from September 16-19, and then speeds up again after September 19.

3. Examine the satellite photo (20:31 hours UTC or GMT, September 21, 1989) of Hurricane Hugo (see <http://web.ics.purdue.edu/~braile/eas100/hwk4SatelliteImage.pdf>). Place an asterisk (*) on your north Atlantic Ocean map along the track of Hugo at the location (and therefore time) of Hugo corresponding to this time. Using the satellite photo and the scale, what is the approximate width (diameter) of Hurricane Hugo (measure through the eye of the storm in an approximately SW to NE direction)?

107.43 km

4. Examine the graph showing wind speed and pressure versus time for Hurricane Hugo. In general, the variations of wind speed and pressure for Hugo from September 11-22 can be described by (multiple choice, circle the correct response):



← You can copy, paste and drag to circle the correct answer.

a. The two curves (time series of wind speed and pressure) appear to be un-related to each other.



b. The two curves are nearly inversely correlated, when the pressure decreases the wind speed increases and when the pressure increases, the wind speed decreases.

c. The two curves are nearly correlated implying that high pressure produced high wind speed.

5. During what time period does the hurricane intensify, attaining the lowest pressures and highest wind speeds (multiple choice, circle the correct response)?



← You can copy, paste and drag to circle the correct answer.

a. September 11-13

b. September 15-18

c. September 19-20

d. September 22-23

6. Where is Hugo near the end of this time of greatest intensity (about September 17-18) and how fast is it moving (multiple choice, circle the correct answer)?

← You can copy, paste and drag to circle the correct answer.

- a. In the central Atlantic, moving across the ocean with a speed of about 40 km/hr.
- b. Just off the coast of South Carolina, moving across the ocean with a speed of about 20 km/hr.
- ☒ c. In the eastern Caribbean (near the Greater Antilles and Puerto Rico), moving across the ocean with a speed of about 20 km/hr.

7. Hugo builds slowly from September 11-15 (winds increasing and pressure decreasing), but weakens rapidly after September 21. This rapid weakening is most likely caused by (multiple choice, circle the correct response):

← You can copy, paste and drag to circle the correct answer.

- a. The "age" of the hurricane; most tropical storms and hurricanes cannot sustain high winds for more than a few days.
- b. The change of direction to the northwest after September 17.
- ☒ c. The fact that the hurricane encounters land after September 21, thus removing the significant energy source of warm ocean waters and producing increased "friction" on air movements (wind) because of the rougher land surface.

8. At the most intense periods of the hurricane (September 16-18 and September 21), Hugo was what "category" storm on the Saffir-Simpson scale (see below from Table 14.2 in Lutgens and Tarbuck, 2014; Table 14.3 in Lutgens and Tarbuck, 2011; Lutgens and Tarbuck, 2008) as indicated by wind speed (multiple choice, circle the correct response):

← You can copy, paste and drag to circle the correct answer.

- a. Category 1 b. Category 2 c. Category 3 ☒ d. Category 4 e. Category 5

Note the graph of the storm surge (labeled maximum storm tide) along the South Carolina coastline. What category does the observed maximum storm surge height (about 30 km north of Charleston, South Carolina) indicate for Hugo?

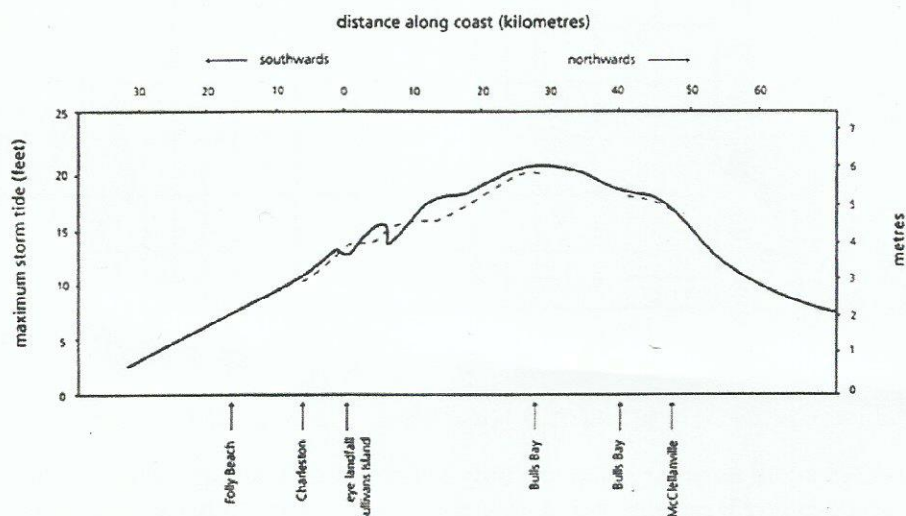
← You can copy, paste and drag to circle the correct answer.

- a. Category 1 b. Category 2 c. Category 3 d. Category 4 ☒ e. Category 5

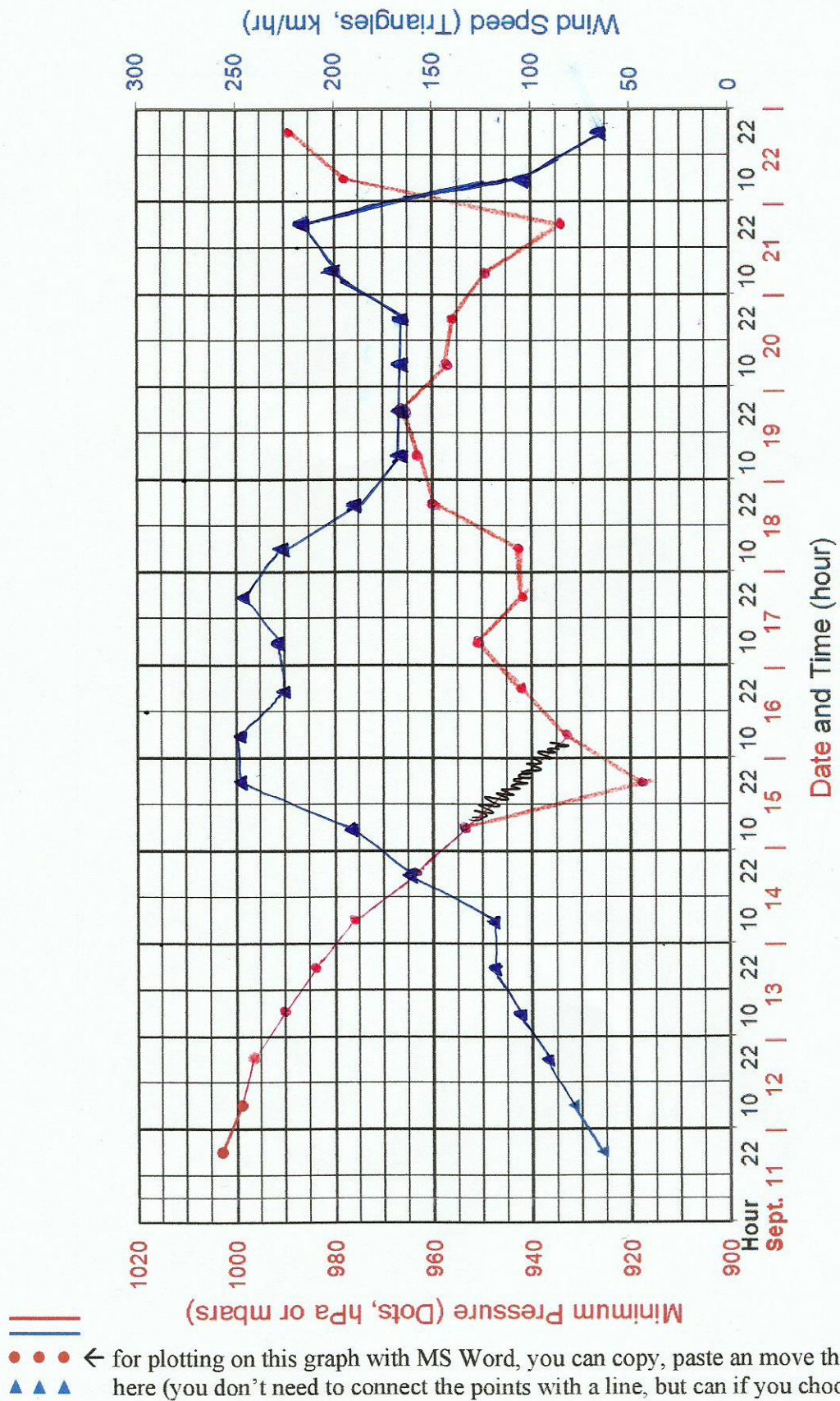
Table 14.2 Saffir-Simpson Hurricane Scale

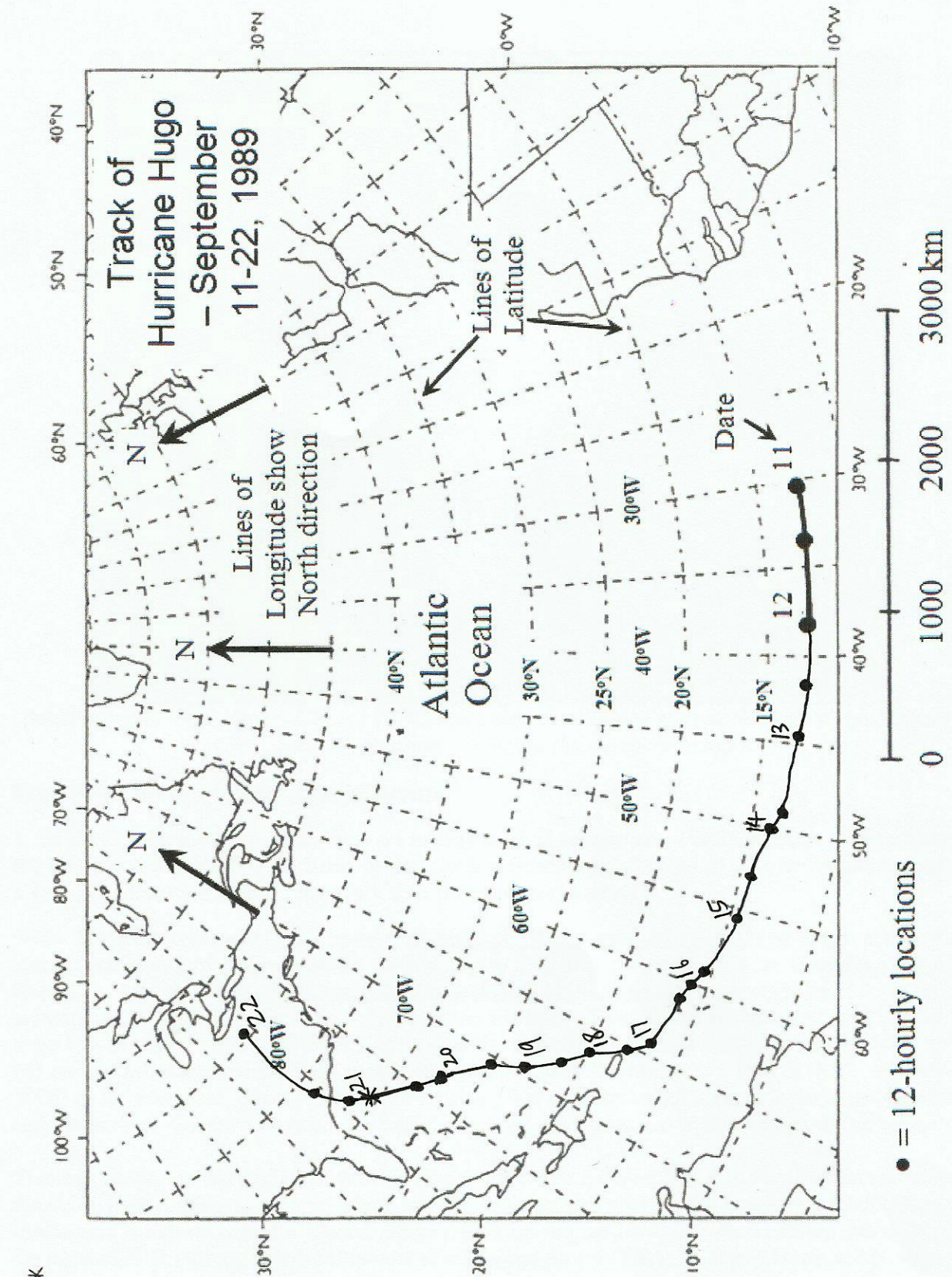
Scale Number (category)	Central Pressure (millibars)	Winds (km/hr)	Storm Surge (meters)	Damage
1	≥980	119–153	1.2–1.5	Minimal
2	965–979	154–177	1.6–2.4	Moderate
3	945–964	178–209	2.5–3.6	Extensive
4	920–944	210–250	3.7–5.4	Extreme
5	<920	>250	>5.4	Catastrophic

Hurricane Hugo (1989) Data					
Time	Date	Location	Location	Wind	Min. Sea Level
UTC/GMT	Sept.	Latitude	Longitude	Velocity	Pressure
(hr)		(Deg. N)	(Deg. W)	(km/hr)	(hPa or mbars)
2200	11	12.8	30.5	65	1003
1000	12	12.5	33.7	80	999
2200	12	12.9	38.0	89	996
1000	13	12.7	42.0	105	990
2200	13	12.9	44.5	120	984
1000	14	13.0	48.0	120	976
2200	14	13.7	49.9	161	964
1000	15	14.1	52.8	192	954
2200	15	14.8	55.5	241	918
1000	16	15.3	58.3	241	933
2200	16	16.0	60.0	226	942
1000	17	16.4	61.7	231	951
2200	17	17.1	64.1	244	942
1000	18	17.9	65.1	226	943
2200	18	19.5	67.0	185	960
1000	19	21.2	67.7	168	963
2200	19	23.3	68.9	168	966
1000	20	24.9	70.5	168	957
2200	20	27.0	73.0	168	956
1000	21	28.2	75.0	200	949
2200	21	31.7	78.6	218	934
1000	22	33.7	80.3	107	978
2200	22	40.5	81.0	65	989

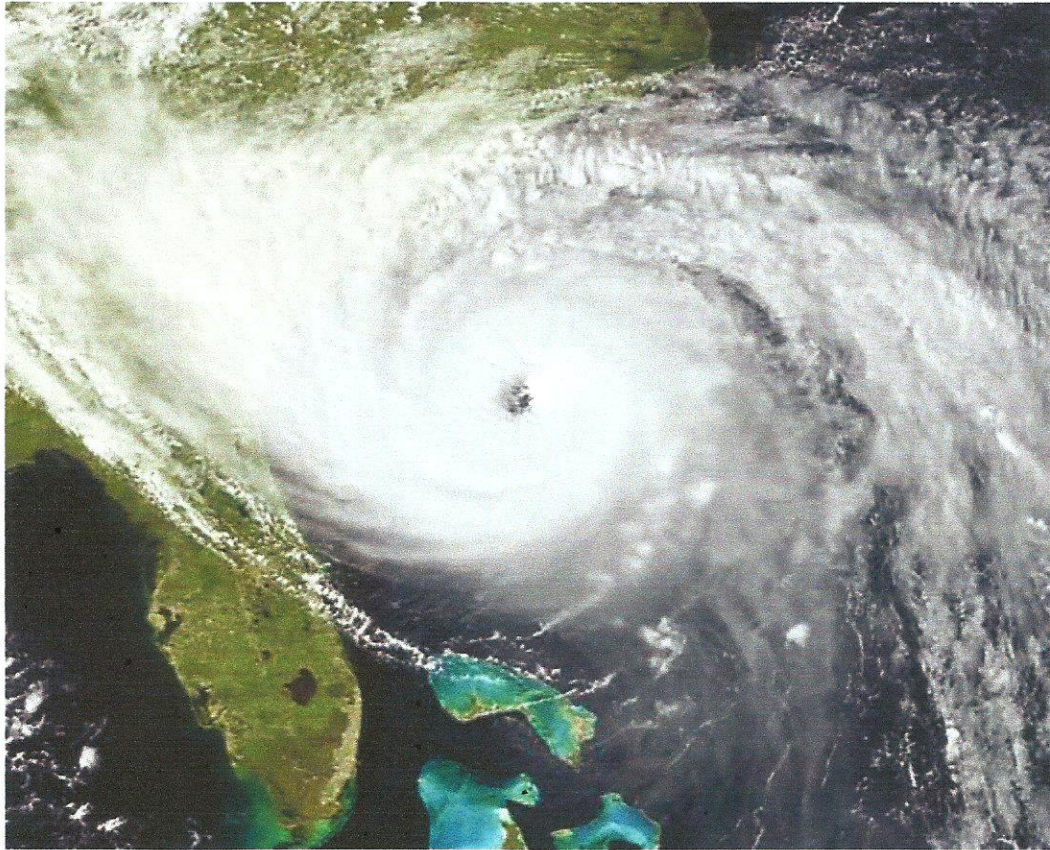


Maximum storm surge data for Hurricane Hugo (meter scale on right – 0 to 7 m).





← for plotting on this graph with MS Word, you can copy, paste and move the symbols shown here (you don't need to connect the points with a line, but can if you choose)



Satellite image (20:31 hours UTC or GMT, September 21, 1989) of Hurricane Hugo (Cape Hatteras, NC is on the coastline just below the top of the image).

Part 2 – Tracking Hurricane Katrina

1. In the last decade or so, hurricanes are usually tracked on computers and the tracks are available on the Internet so that plotting, by hand, as done in this exercise, is not required. A good example (and for a very significant hurricane) is the track data for Hurricane Katrina.

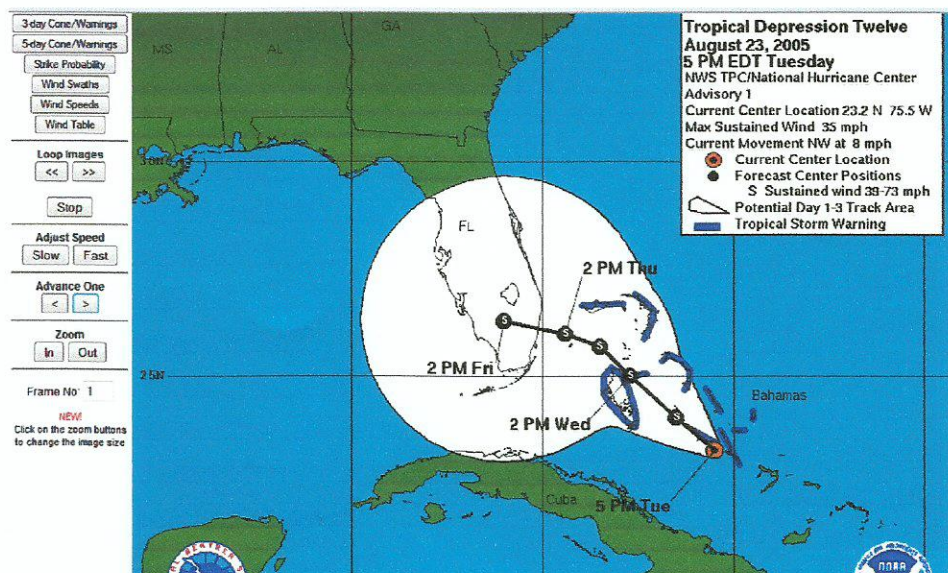
Note: The stormpulse site (<http://www.stormpulse.com/hurricane-katrina-2005>) no longer supports the Katrina tracking information without subscribing to their site, so we will use an alternative site from NOAA. **Go to:** http://www.nhc.noaa.gov/archive/2005/KATRINA_graphics.shtml. Stop the animation (click **Stop** on the menu of options on the left). Then **Zoom In** once and scroll down the page so you can see the location of Katrina and the Gulf of Mexico area. Then click the back arrow (<) on the **Advance** option in the menu until you get back to **Advisory 1** (5 p.m. EDT, August 23, 2005) in the text dialog box. Scroll up or down so that the location of Katrina (orange dot) is visible on your screen. We are now ready to scroll through the advisories and answer the questions below.

The map shows the track of Hurricane Katrina and includes a dialog box that shows information about the storm (**Advisories**) over time. There are 31 advisories that provide information on the location and intensity of the storm over time from 5:00 p.m. EDT on August 23, 2005 (when Katrina was a Tropical Depression, T.D.) through its development as a Tropical Storm (T.S.) and then a Hurricane (Categories 1 through 5 on the Saffir-Simpson scale), and then weakening back to T.D. strength at 10:00 a.m. CDT on August 30, 2005. **Note: the wind speed in these figures is given in miles per hour (mph).**

A simplified Saffir-Simpson scale for classifying hurricanes by wind speed (using miles per hour [mph]) is given below.

Hurricane Category	1	2	3	4	5
Max Sustained Wind	74-95 mph	96-110 mph	111-129 mph	130-156 mph	>156 mph

Additional Classifications: **Tropical Depression <39 mph; Tropical Storm 39-73 mph.**



Partial screen image http://www.nhc.noaa.gov/archive/2005/KATRINA_graphics.shtml after zooming.

2. Track through the advisories using the **right arrow key** (Advance menu) on the left side of the map. Note the track of the storm through time and the geographic areas affected by the storm. When did Katrina first become a Hurricane (use the Saffir-Simpson scale in the Table above to classify the storm category (intensity)?

Frame No. 9 August 25, 2005 5pm EDT write date and time or advisory number

3. What was the maximum Saffir-Simpson Category for Katrina and when did that first occur?

Category? 1 When? (write date and time or advisory number) advisory 9

4. At 5:00 a.m. EDT on August 27, Katrina was a (strengthening!) Category 3 (major) Hurricane and most likely headed for somewhere near New Orleans, LA (note the projected path in Advisory 16). This should have provided significant warning time for preparations and evacuations as long as the predicted location was reasonably accurate and officials and local people took the advisories seriously. How many hours lead time is this advisory (Number 16) from the time that the eye of the storm reached the coastline (with hurricane force winds and a strong storm surge in New Orleans)?

47 hours based on it reaches ~~east~~ coastline in advisory 26.

4AM Monday
5AM Saturday

References/additional information and images:

National Hurricane Center Katrina Report - http://www.nhc.noaa.gov/pdf/TCR-AL122005_Katrina.pdf.

Additional images of Katrina including illustrations of flooded areas of New Orleans - http://www.nasa.gov/vision/earth/lookingatearth/h2005_katrina.html.