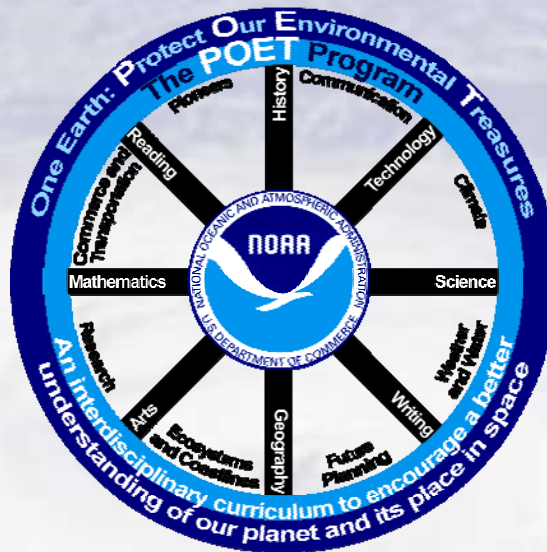# Hurricanes: Environmental Satellites (1 of 3)

Category

Technology, Art, Science

Materials

Satellite Diagrams (Included)

Real World Connection

Weather, Research, Future Planning

Problem Question – Part 1

How does a geostationary satellite system collect data?

Prior Knowledge What I Know	Conclusion What I Learned
Based on your prior knowledge, answer the problem question to the best of your ability.	*Answer the problem question after completing the activity.*

Background – Part 1

Cloud images and other data that are seen on daily weather forecasts come from satellites that orbit the Earth continuously. Originally built as a warning for severe weather, these geostationary (geo = Earth / stationary = does not move) satellites now provide data for a variety of uses.

Procedure – Part 1

Carefully examine the diagrams in Figure 6-1 that follow on this page and the next. Summarize your observations by completing the table "NOAA GOES Satellite". Use the "two column notes" method: Fill-in the right-hand column with information that describes the topic in the left-hand column. Include historical information, dates, uses, and a brief description on how the GOES system works.

Use of geostationary satellites for weather observations and space research began in the 1970's. Now, similar environmental satellites collect data used in weather forecasts, climate research and prediction, volcano monitoring, forest fire detection, and search and rescue operations.

Geostationary satellites circle the Earth in a "geosynchronous" (synchronous = same time) orbit. In other words, when a satellite revolves around Earth at the same speed that the Earth spins on its axis, the satellite always appears to be at the same location to an observer on Earth.

GOES is an acronym used for a series of U.S. weather satellites that stands for "**G**eostationary **O**perational **E**nvironmental **S**atellite".

- *Geostationary* means that the satellite is always above the same location on the Earth.
- *Operational* means that these satellites are used on a daily basis for a large variety of applications, such as weather forecasting.
- *Environmental* because this satellite measures a variety of environmental properties, including temperature and moisture.
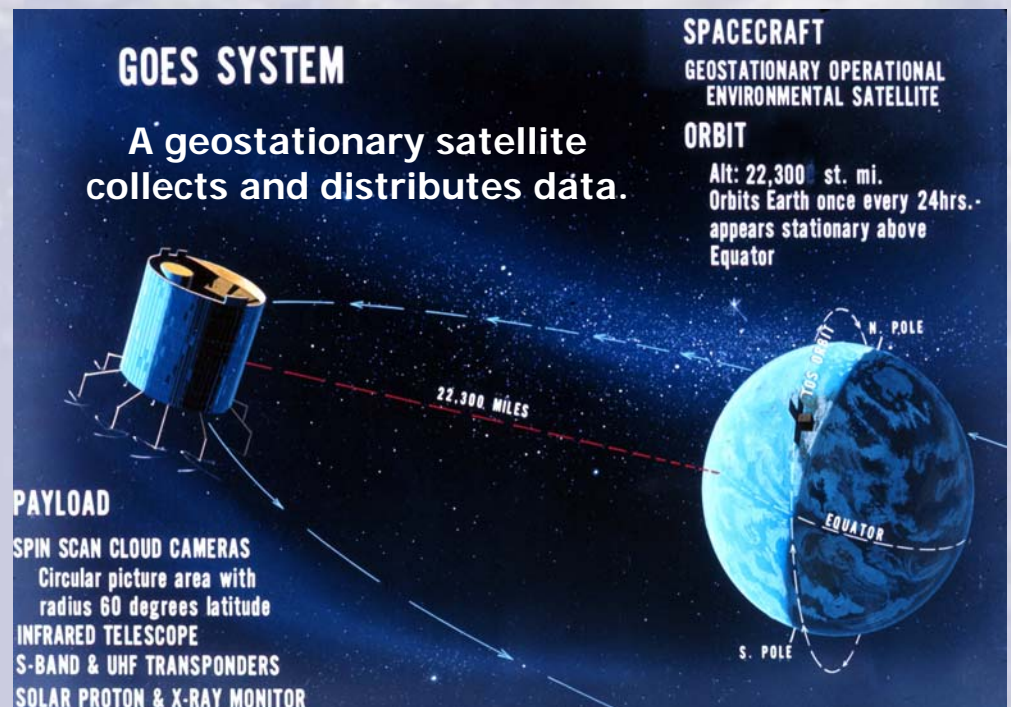- *Satellite* because it is, in fact, a satellite; it orbits the Earth.

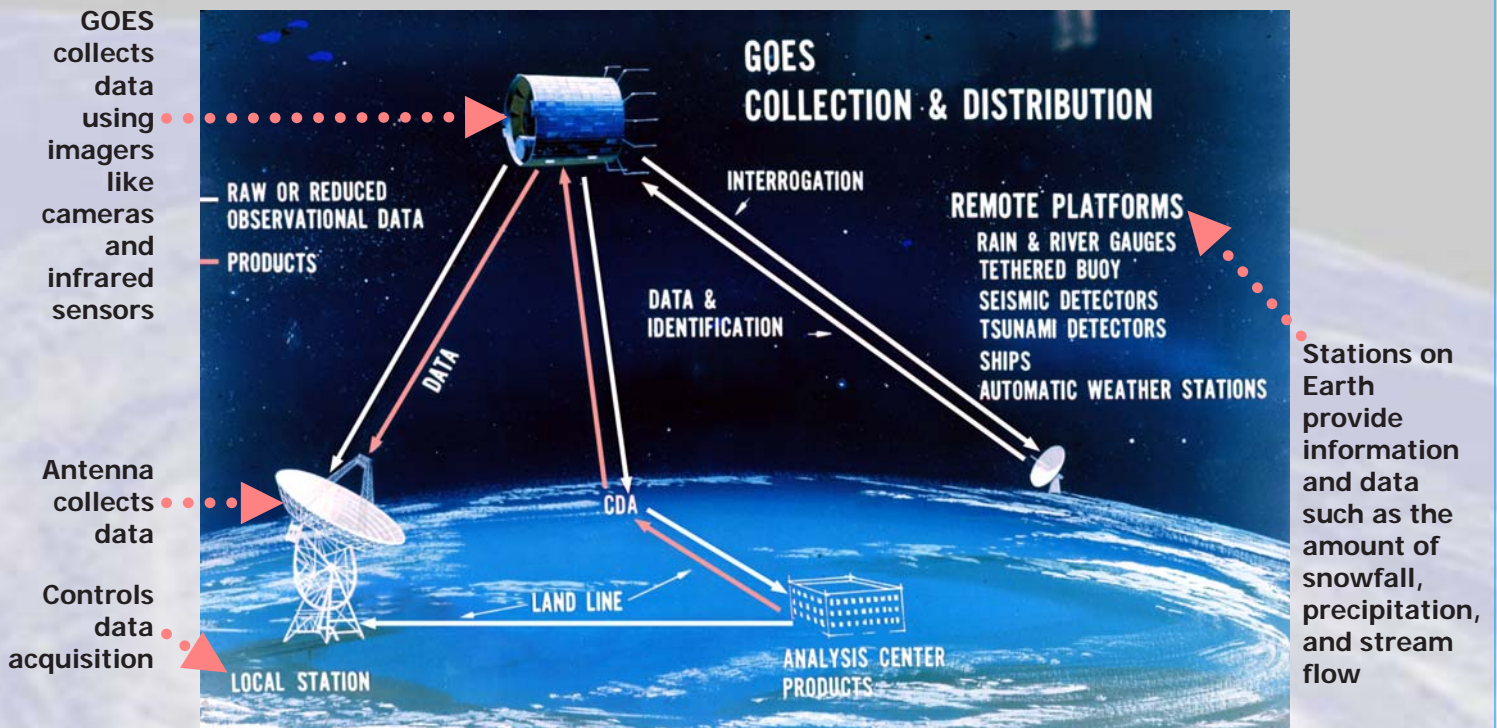*Figure 6-1. Compendium of geostationary satellite images and informational text.*

GOES collects data using imagers like cameras and infrared sensors

Antenna collects data

Controls data acquisition

GOES COLLECTION & DISTRIBUTION

RAW OR REDUCED OBSERVATIONAL DATA
PRODUCTS

INTERROGATION

DATA & IDENTIFICATION

DATA

REMOTE PLATFORMS
RAIN & RIVER GAUGES
TETHERED BUOY
SEISMIC DETECTORS
TSUNAMI DETECTORS
SHIPS
AUTOMATIC WEATHER STATIONS

CDA

LAND LINE

LOCAL STATION

ANALYSIS CENTER PRODUCTS

Stations on Earth provide information and data such as the amount of snowfall, precipitation, and stream flow

Figure 6-1 - Continued. Compendium of geostationary satellite images and informational text.

NOAA – GOES Satellite

Fill-in the right-hand side with "bullets" of information for each topic or question that is listed on the left-hand side

1. Background: Include the meaning of the acronym GOES, original uses and dates, and a list of the equipment that is part of the GOES System	
2. Current Uses	
3. How GOES Works	
4. Importance of learning about satellites and satellite images	

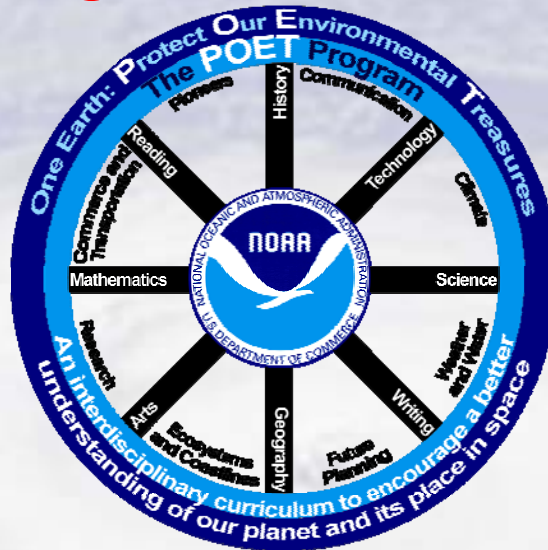# Hurricanes: Creating a Satellite Image Using Pixels (2 of 3)

Category

Technology, Art, Mathematics, Science, History, Geography

Real World Connection

Weather, Research, Future Planning

Materials

Colored Pencils

Infrared Color Table and Coloring Figure (Included)

Problem Questions – Part 2

What does the satellite image of a hurricane look like when its pixel size is enlarged?

What can we observe and infer about a hurricane from a satellite pixel image?

Prior Knowledge What I Know	Conclusion What I Learned
Based on your prior knowledge, answer the problem questions to the best of your ability.	*Answer the problem questions after completing the activity.*
1. 2.	1. 2.

Background – Part 2

Imagine! A satellite focused upon a ferocious, swirling mass of clouds, spewing danger for anything in its path. Aboard the satellite, sensors scan the Earth in small blocks, called pixels, to detect infrared (heat) radiation in the form of numerical data (temperature). Once the information is collected, computers convert the numbers into an image. Thus, the building block of a satellite picture is also called a pixel. Although the infrared detectors can only "see" the tops of clouds – not into or through the cloud, these sensors provide important information about the amount of rain in the cloud. Since cloud temperature is coldest at the top, the highest and thickest clouds probably contain the heaviest rain. In a hurricane, this area is called the "eyewall". Knowing the location of the hurricane and amount of rainfall, allows people to prepare for hurricanes in advance.

Procedure – Part 2

Using Figure 6-2, color each square on the graph according to Table 6-1, the infrared color table. The graph represents a satellite infrared image of Hurricane Georges – the "eye" and main central area – September 25, 1998. Each square represents one pixel of the satellite infrared image.

1	1	1	1	1	2	3	1	1	3	5	4	4	5	4	5	4	6	4	1	1	1	1	1	1
1	1	1	1	2	2	4	2	3	3	3	5	6	5	5	4	3	6	6	3	1	1	1	1	1
1	1	1	1	1	2	2	3	3	4	6	6	6	6	5	5	5	4	3	4	2	2	1	1	1
1	1	2	1	2	2	3	4	5	6	7	7	7	7	7	6	6	4	4	4	3	3	1	1	1
1	1	1	2	2	3	3	4	6	7	7	7	7	7	7	7	7	6	5	7	4	2	1	1	1
2	1	2	2	3	3	4	6	7	8	8	7	7	8	7	7	7	6	5	7	4	2	1	1	1
1	1	2	2	3	4	6	7	7	8	8	8	8	8	8	7	7	7	7	6	5	4	2	2	2
1	2	2	2	4	4	6	7	8	8	8	8	8	8	8	7	7	7	6	7	6	4	2	1	1
1	2	2	2	4	4	6	7	7	8	7	7	7	7	8	8	7	7	7	5	6	6	4	2	1
1	2	2	3	4	4	6	7	7	8	7	7	7	7	8	8	7	7	7	6	5	6	5	2	1
1	2	2	3	4	4	5	7	7	7	7	3	7	7	8	8	7	7	7	6	6	6	6	3	4
1	2	2	3	4	5	5	6	6	7	6	6	7	8	8	7	7	7	7	5	6	6	4	4	6
1	2	3	3	4	4	5	5	7	7	7	8	8	8	8	7	7	6	6	4	5	7	5	5	2
1	3	3	3	6	4	4	5	6	6	8	8	8	8	8	8	7	6	5	4	5	6	5	4	2
2	3	4	2	6	6	5	6	6	7	8	8	8	8	8	7	6	6	5	5	5	5	4	4	2
2	5	6	6	6	5	5	4	6	8	8	8	8	8	7	7	6	6	6	6	5	4	4	2	2
4	3	6	5	6	5	5	5	7	7	7	7	8	8	7	6	6	5	6	7	4	5	5	2	1
4	4	5	5	4	5	4	6	7	7	7	8	8	7	7	5	6	4	5	4	4	5	5	1	1
3	2	4	5	5	6	6	7	7	7	7	6	7	6	5	5	4	4	7	4	4	4	3	2	1
1	2	3	4	4	5	6	6	6	6	7	7	6	5	5	5	4	3	6	4	2	4	2	2	1
1	1	4	3	4	5	6	6	6	6	5	5	5	5	4	4	6	5	6	4	4	3	4	1	3
1	1	1	3	4	5	6	5	6	4	5	6	5	3	3	4	4	4	2	3	4	2	2	3	2
1	1	1	2	2	3	3	2	1	3	4	4	4	4	6	4	2	2	3	2	2	2	1	6	7
1	2	4	5	5	4	2	4	4	4	4	5	5	6	4	3	2	2	3	2	4	1	4	6	7
1	1	1	3	2	2	4	4	4	4	5	5	5	2	2	2	2	2	2	2	4	1	6	6	1

Figure 6-2. Satellite Image of Hurricane Georges – Eye and Main Central Area – September 25, 1998 – Each Numbered Square is One Pixel.

Black - 1 ■ White - 3 □ Yellow - 5 ■ **Red - 7** ■
Gray - 2 ■ **Blue - 4** ■ Orange - 6 ■ Purple - 8 ■

Table 6-1. Satellite Infrared Color Table.

Questions – Part 2

1. Define "Infrared".

2. How would you describe the shape of the hurricane from the top looking down?

3. If each pixel represents 32 kilometers, then what is the approximate length and width of the hurricane through the eye?

4. What is the approximate diameter in kilometers of the hurricane's "eye" (the center of the hurricane)?

   In a hurricane, the highest winds and heaviest rainfall occur in the area next to the "eye" – called the "eyewall".

5. What two colors represent the area with the heaviest rainfall and highest wind speed? Hint: Notice the colors surrounding the eyewall where the cloud tops are coldest and therefore highest.
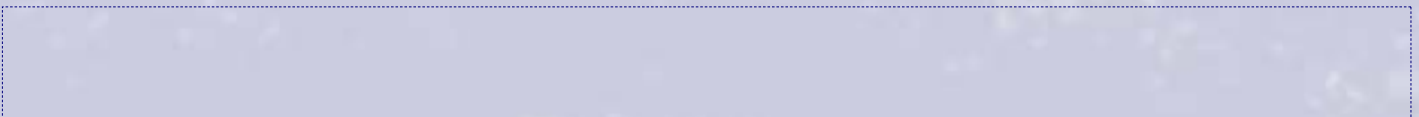
6. What two colors represent the area with little or no rainfall and wind?

Questions – Part 2 (Continued)

7. The two images in Figure 6-3 are actual GOES-8 satellite pictures of Hurricane Georges as it crossed the Caribbean through the Dominican Republic, Haiti, Cuba, and South Florida during late September 1998. Carefully observe, then compare and contrast these two images. Use the space below to record your observations.
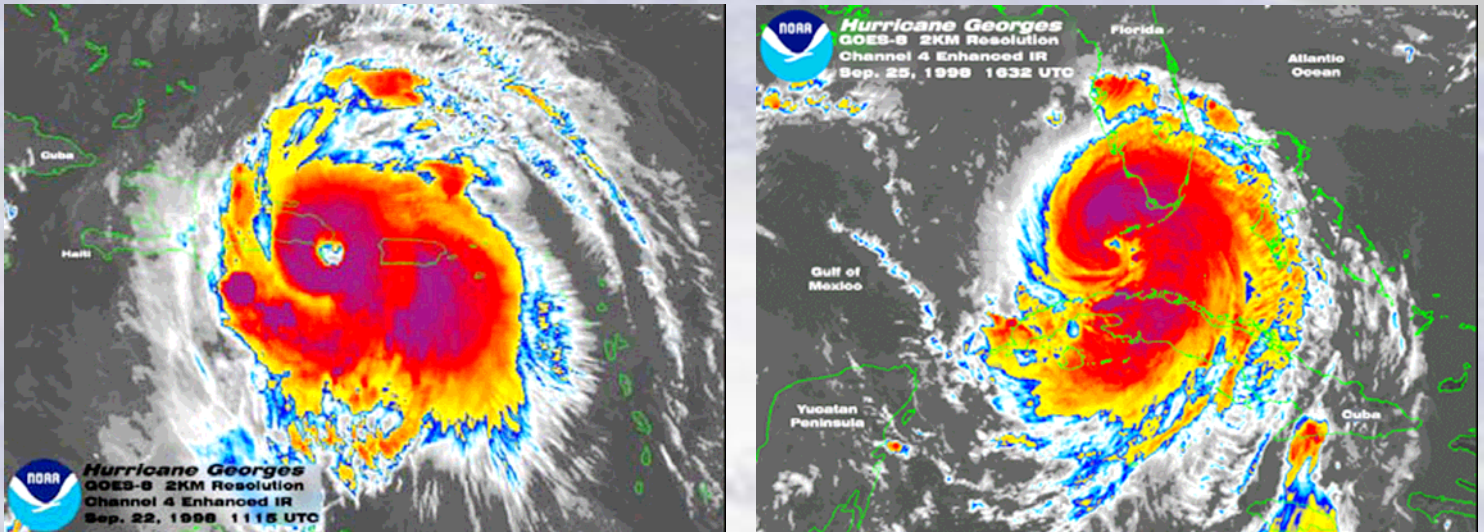
Figure 6-3. GOES-8 satellite pictures of Hurricane Georges as it crossed the Caribbean through the Dominican Republic, Haiti, Cuba, and South Florida during late September 1998.

List the similarities and differences that you observe between the September 22 and September 25 satellite pictures for Hurricane Georges	
<u>*Similarities*</u>	<u>*Differences*</u>

8. What information can we observe/infer from a satellite image with colored pixels like the image that you created?

Hurricanes: A Cross-Section Through the "Eye" of a Hurricane (3 of 3)

Category

Technology, Mathematics, Science

Real World Connection

Weather, Research, Future Planning
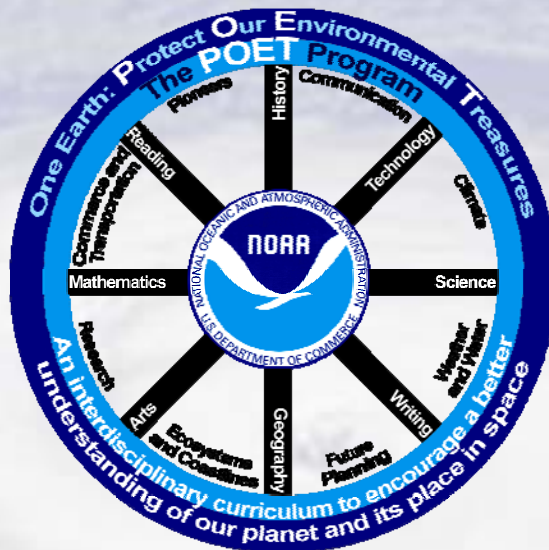
Materials

Colored Pencils,

Infrared Satellite Temperature and Altitude Data for a Hurricane, Graph Paper (Both Included)

Problem Question – Part 3

What does the cross-sectional view through the "eye" of a hurricane look like when its cloud height is plotted on a graph?

Prior Knowledge What I Know	Conclusion What I Learned
Based on your prior knowledge, answer the problem question to the best of your ability.	*Answer the problem question after completing the activity.*

Background – Part 3

(Refer to Figures 6-4, 6-5, and 6-6)

Hurricanes can sometimes be **800 km wide**, but most are about 500 km wide (Figures 6-4, 6-5, and 6-6). Meteorologists have given names to the different parts of a hurricane.

The **eye** of a hurricane is pretty much empty. The winds of the hurricane spin so fast that the clouds are thrown to the edges of the eye. The edges of the eye are made up of this swirling clouds that spin around the eye. Those edges are called the **eyewall** because they are made up of a wall of clouds (Figures 6-4, 6-5, and 6-6).

Other clouds circle the eye, but are farther away from the eye. They are called **rain bands** because they move in a circular pattern around the storm and bring the rain in bands of clouds (Figures 6-4, 6-5, and 6-6).

The eye of a hurricane is usually from **32 – 64 km across**. It is pretty calm and partially clear with very weak winds blowing inside the eye (Figures 6-4, 6-5, and 6-6).

The winds of a hurricane are **strongest in the eyewall**. Also, dangerous **thunderstorms and tornadoes are inside the eye wall** (Figures 6-4, 6-5, and 6-6).

Hurricane Georges (Figure 6-6) - Notice the definite **counterclockwise rotation**. Hurricanes spin around a very low pressure system. In the southern hemisphere, storms spin in a clockwise direction.
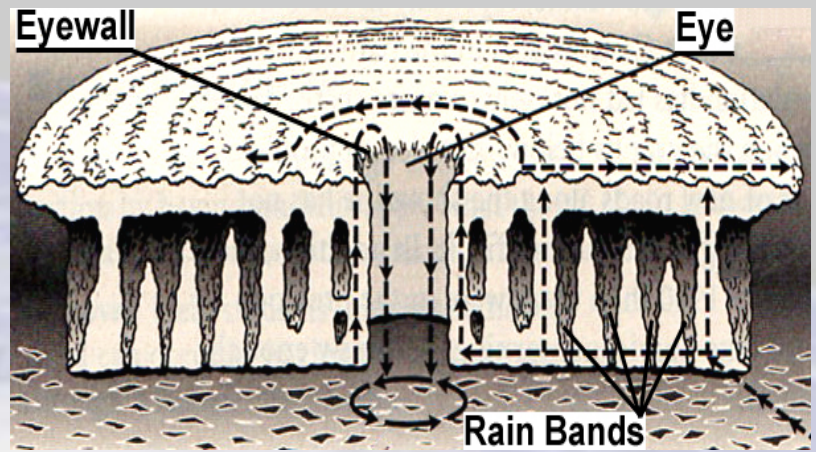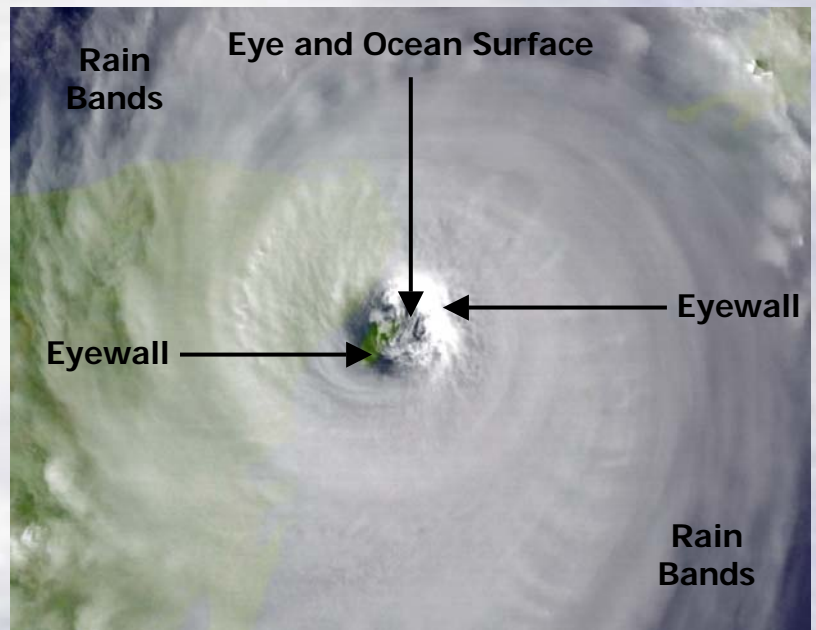

Figure 6-4. Hurricane Diagram.
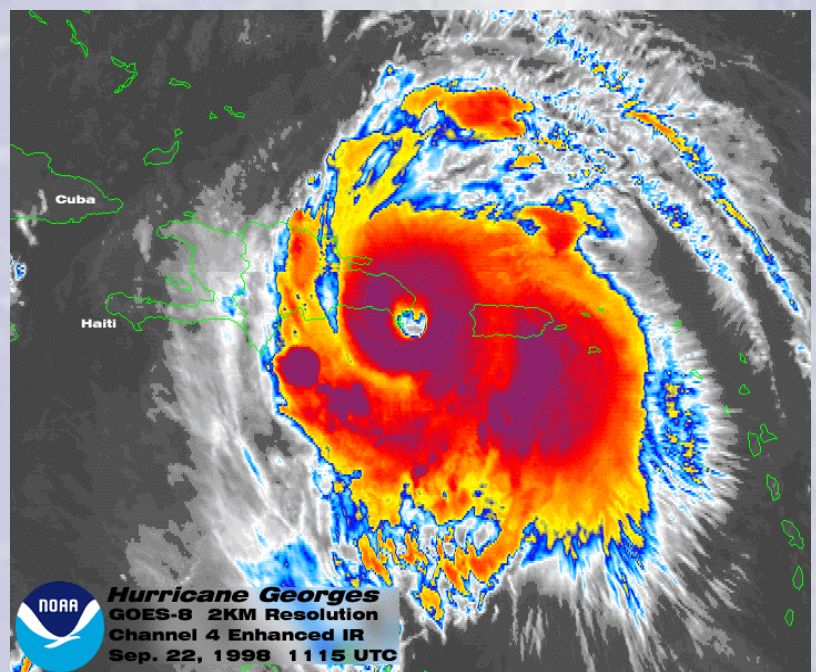

Figure 6-5. Visible Satellite Image of a Hurricane.

Figure 6-6. Hurricane Georges.

Procedure – Part 3

Use Figure 6-7 and Table 6-2 and these following steps to plot a line graph that shows what the cross-section through a hurricane looks like.

1. Along the x-axis (horizontal) at the bottom of Figure 6-7, number from zero to 800, counting by 32s. The first four are done for you so you can see the pattern. Label the x axis "West - East Distance Through the Eye of a Hurricane (kilometers)".

2. Along the y-axis (vertical) at the left-hand side of Figure 6-7, number from zero to 20,000 by 1000s. Label the y-axis "Cloud Height (meters)".

3. From the figure that has your colored image of a hurricane's eye and central area from the "Hurricanes: Creating a Satellite Image Using Pixels" Activity, locate the horizontal line of pixels from west to east (left to right) on your colored image that runs directly through the "eye" of the hurricane. Notice that the first pixel is black (or very dark gray).

4. Use Table 6-2, "Satellite Color, Temperature, and Cloud Top Height Table", to find the approximate cloud height represented by the color black.

5. At "32 kilometers", plot the cloud height.

6. Continue the same procedure for the next pixel in the line (very light gray), that is, find its cloud height in Table 6-2 and plot it at the next kilometer value (64).

7. Continue this procedure for each successive pixel. Color across the entire line. Connect the points as you go.

8. Draw another y-axis on the right-hand side of the graph. Label this y-axis "Approximate Temperature (degrees Celcius)".

9. Now write the temperature or temperature range, listed in Table 6-2, on the right-hand side, opposite its corresponding height in meters on the left-hand side. For example, write "-30 to -39" opposite 5000 meters.

10. Write a title for your graph.

Color Number	Color Name	Approximate Temperature (degrees C)	Approximate Height (meters)
1	Black	+15	100
2	Gray	-10 to -19	1,500
3	White	-20 to -29	3,000
4	Blue	-30 to -39	5,000
5	Yellow	-40 to -45	9,000
6	Orange	-46 to -51	12,000
7	Red	-52 to -57	14,000
8	Purple	-58 to -68	16,000

Table 6-2. Satellite Color, Temperature, and Cloud Top Height Table.

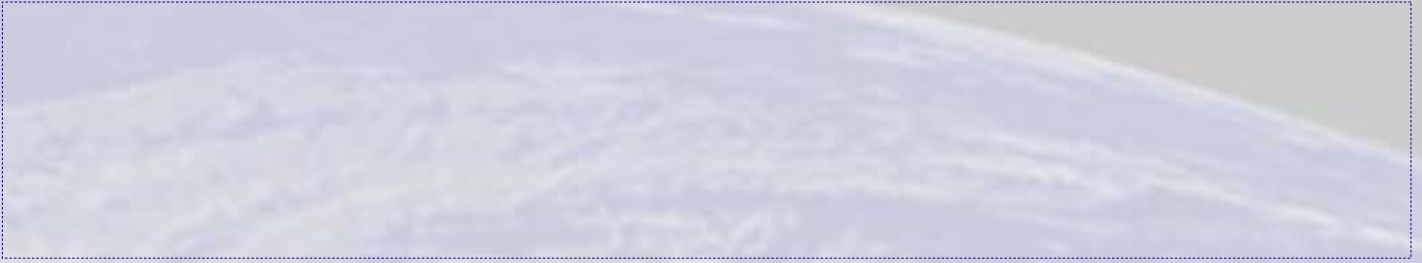**Y-Axis Label:**_____

Title:_____

0 32 64 96
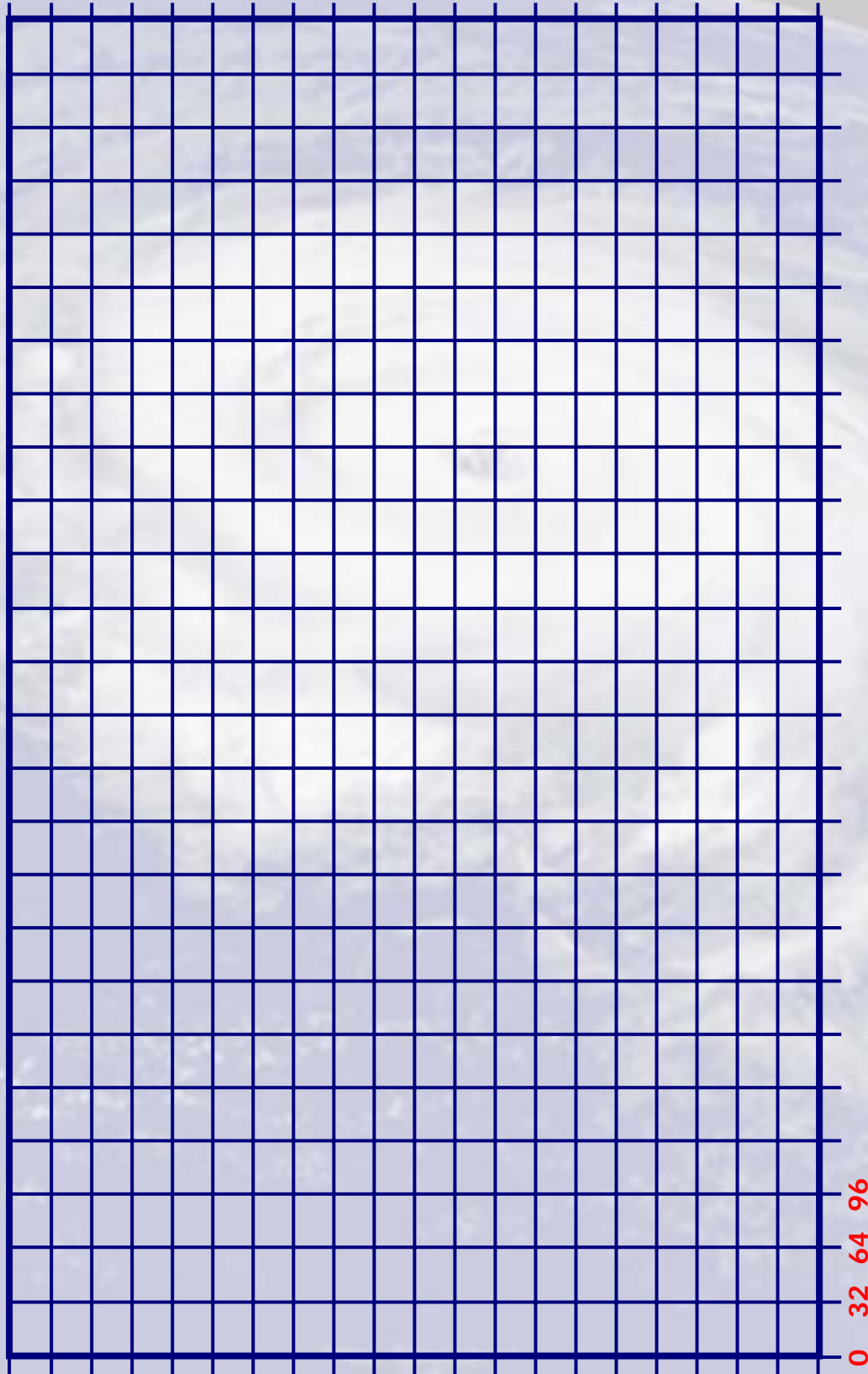
X-Axis Label:

Figure 6-7. Graph for Plotting Hurricane Georges Height and Temperature Cross-Section

Y-Axis Label:_____

Questions – Part 3

1. Define the "eye" of a hurricane.
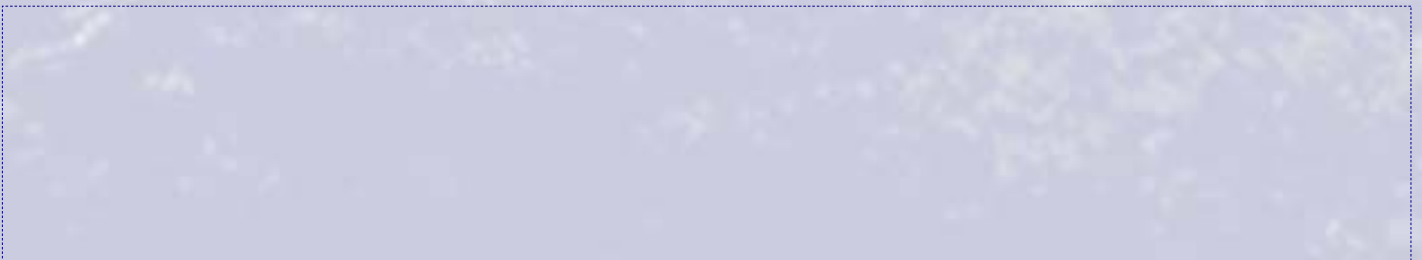
2. Describe the shape of your graph.

3. Where is the "eye" of the hurricane located on your graph? How do you know?

4. On your graph, where would the thicker colder clouds be located? How do you know?

5. On your graph, where is the heaviest rainfall and highest winds located? How do you know?

6. **OPTIONAL CHALLENGE** - Draw seven arrows on Figure 6-6 that show the wind direction in different parts of the hurricane near the Earth's surface.

→ → → → → → →