Name: _____

Lab 4: Satellite Image Laboratory 80 pts

Introduction

One of the most important advances in oceanography has been the opportunity to study the entire ocean system as a whole. This has come about largely through the use of satellites, which have the unique ability to acquire large amounts of data about the world's oceans repeatedly, over a relatively short period of time. Prior to satellites, oceanographers were much more dependent on the direct observations of ships, buoys, etc. which provided a relatively sparse and unreliable database from which to work.

It is important to understand what quantity is depicted on each image and how it is represented by colors, arrows, etc. Satellite data is not without its own limitations. Data is often acquired over several days, is averaged over large areas and must be heavily processed. Measurement may depend on "proxies", that is, measurement of one thing to arrive at another; for example, sea roughness as a proxy for wind speed.

Procedure

In this exercise, you will have the opportunity to use some of this imagery to reinforce some of the concepts discussed in the lecture part of this course. Refer to the "Oceanography from Space" image set (available in the class time or on reserve in the Library). The following questions refer to the image numbers listed on the front page of the book. Work through each question by making careful, objective observations. Note that many of the images have a description on the back-this information may be useful in answering some of the questions. Finally, treat this data set with care and **DO NOT WRITE ON THE IMAGES!**

IMAGE #1- Sea Surface Topography and Ocean Bathymetry

The upper image of this set is the height of "sea level", as measured from the earth's center. The lower image represents the bathymetry of the sea floor. It is important to note that while the maps of the sea floor seen in the classroom and in textbooks are spectacular, they are an "artist's representation" of the sea floor bathymetry. In contrast, this image represents real data (enhanced by a computer) depicting the shape of the sea floor.

1. What tectonic feature is located at number 1? (**1 pt**)_____

2. What features are at numbers 2 and 3? (**2 pts**)_____

3. Describe the general relationship between sea floor bathymetry and sea level. (**4 pts**)

IMAGE #3 – Global Surface Temperatures

The upper image shows the distribution of global surface temperatures as measured in January; the middle image shows surface temperatures in July of the same year. On both images, brown and red depict warmer temperatures, while dark blue depicts cold temperatures. The lower image indicates the change in temperature between the two time periods, with red/brown indicating the most intense warming, while dark blue indicates the most intense cooling.

4. Which undergoes a more dramatic change in surface temperature? **Land** or **Ocean** (circle one) **(1 pt)**

5. Note that there is more continental land mass in the northern hemisphere than in the southern hemisphere. What effect does this have of seasonal changes in sea surface temperatures? **(3 pts)**

IMAGE #4 – Winds over the Pacific

This image was made from radar scatterometer data, which looks at sea surface roughness in order to establish wind direction and velocity. The vectors (arrows) show the direction of the wind, while their length is proportional to wind velocity. The colors indicate areas of greater and lesser wind speed. Data for this image was acquired over the Pacific Ocean Basin in September 1978. The wind directions shown here correspond roughly but not exactly to the global pattern of surface winds described in lecture.

6. What is the name of the winds indicated at number 4? **(1 pt**)_____

7. What is the name of the winds indicated at number 1? (**1 pt**)_____

8. What is happening at numbers 2 and 3 to disrupt the general pattern of surface winds? **(5 pts)**

IMAGE #5 –Winds over the Atlantic and Indian Ocean

This image displays surface wind information for the Atlantic and Indian Oceans for September in the same manner as IMAGE #4. Notice the symmetry of wind patterns north and south of the equator in the Atlantic Ocean.

9. How does the Indian Ocean wind pattern differ from both the Atlantic and Pacific? **(2 pts)**

10. Locate the narrow band of low wind velocity (indicated by the number 2) in the North Atlantic. This zone represents the boundary between which two surface wind systems? **(2 pts)**

11. What is this boundary called? **(1 pt)**_____

12. What general statement can you make about the pattern of surface winds in the northern hemisphere oceans vs. those in the southern hemisphere oceans? **(5 pts)**

IMAGE #6 – West Coast Upwelling

Because of the phenomenon called "Ekman Transport", a prevailing wind blowing parallel to a shoreline can cause upwelling or downwelling of ocean water along the coast. This pair of images shows an upwelling condition along the west coastline of the U.S. The image on the right depicts warm temperature; blue indicates the cold, upwelling water along the coast, while red represents the warmer waters of the California Current. The image on the left shows ocean color, which is a function of plankton productivity. The areas in red represent high plankton content, while the areas in blue exhibit low biologic activity.

13. What is the relative temperature of water coming from San Francisco Bay? Why? **(5 pts)**

14. What is the relationship between upwelling and productivity? How might commercial fishermen use this information? **(5 pts)**

IMAGE #10 – Gulf Stream Temperature

This striking image shows sea surface temperature. Red to orange colors indicate warm water, yellow and green indicate intermediate temperatures, while blue and purple indicate the coldest water.

15. Study the satellite image carefully. On the map on the right, sketch the boundary between the cold Labrador Current and the Warm Gulf Stream. Use multiple arrows to show the direction of flow of each of these two currents. Also draw in the boundary between the Gulf Stream and the Sargasso Sea. Label the part of the Sargasso Sea that shows on the image. **(5 pts)**

16. What are the features at number 3 and 4? **(2 pts)**

17. How are they different? **(4 pts)**

IMAGE #11 – Phytoplankton and Temperature Patterns

These two images show the distribution of photosynthesizing plankton (top) and ocean temperature (bottom) along the boundary between the Gulf Stream and the Labrador Current. (Note Cape Cod in the middle left of the image.) In the upper image, high abundances of plankton are shown in brown and red, low amounts in blue. In the lower image, warm water is shown in red, while colder water is shown in blue.

18. In general, do Phytoplankton prefer **shallow coastal water** or **deeper ocean waters** (circle one)? **(1 pt)**

19. Do phytoplankton prefer **warm water** or **cold water**? (circle one) **(1 pt)**

IMAGE #12 – Western North Atlantic Color

Note that in this image the true blues and greens of the ocean are "spread out" across the full color spectrum from red to purple. Ocean color is a function of plankton productivity, therefore this image, like #11, reflects the abundance of plankton at the ocean surface. Notice how well the Gulf Stream/Labrador Current boundary is defined by ocean color.

20. What are the features numbered 1 and 2? Why is biologic productivity low there? **(2 pts)**

21. About 3cm below feature 3 is an eddy with high productivity relative to surrounding waters. What will eventually happen to the cold water organisms in this area? **(2 pts)**

IMAGE #22 –Tuna Catch and Ocean Color

This is another image of ocean color taken in September 1981 and covering the coastal area off of San Francisco Bay. Orange indicates water with a high abundance of planktonic organisms, while blue indicates plankton free water.

22. How could this information be used by fishermen to increase the tuna fish catch? **(2 Pts)**

23. Why are most tuna caught at the boundary between high and low productivity areas? **(2 pts)**

IMAGE #23 – Tropical Pacific Time Series

This set of 5 images shows January ocean surface temperatures for the Central Pacific from 1979-1983. Red indicates warm water, blue indicates cold water.

24. How does the January 1983 surface temperature pattern differ from other years? **(4 pts)**

IMAGE #24 – 1982-1983 El Niño

This set of three images also indicate ocean temperatures. The top image was made from data acquired Jan. 20, 1984; the middle image was composed from data acquired on Jan. 20, 1983. Red indicates warm water, green and blue are cold water. The lower image is a plot of the difference in water temperature from 1983-1984; red indicates warming, blue indicates cooling.

25. Does the information here agree with the information from the previous page? **(1 pt)**

Yes or **No** (circle one)

26. Did the central Pacific experience **WARMING** or **COOLING** in 1983 (circle one; **1 pt**)?

This wintertime change in ocean temperature is known as "El Niño" because it is usually first detected around Christmas. It occurs roughly every 7 yrs and is caused by a weakening of the Easterly Tradewinds. The El Niño of 1983 was the worst of this century, and caused millions of dollars of damage in many areas, but especially in western South America. Carefully study the changes caused by El Niño along the northwest coast of South America (Ecuador and Peru). Many people in these areas depend on a healthy anchovy fishery for their livelihood.

27. Based on your knowledge of water temperature vs. plankton productivity vs. fish abundance (see previous questions), what effect might an El Niño have on the economy of these South American countries? Explain your reasoning. **(10 pts)**

IMAGE #25 – California El Niño

These two images indicate ocean temperature (red is warm, blue and green are cold). The image on the left is from January 1982; the image on the right is from January 1983.

28. What (if any) effect could an El Niño have on Southern California? **(5 pts)**