OCE-3014L
Lab 8 –Oceanography from Space & Remote Sensing

Name_____ Date_____

Objectives:

- To understand the various uses of remote sensing systems
- To map sea-surface temperatures and the extent of warm and cold water masses
- To map the important areas of phytoplankton productivity

Remote sensing may be defined as the collection of information or data about objects without actually being in physical contact with them. In 1858, just 32 years after the invention of photography, the first aerial photograph was taken from a tethered balloon. The first photograph from a rocket was taken in about 1906, and Wilbur Wright took the first photograph from an airplane in 1909. The first artificial satellite to orbit the Earth was Sputnik I, launched by the Soviet Union in 1957. Four years later, the United States launched a weather satellite, Tiros 1. Tiros is an acronym for Television and Infrared Observation Satellite. Almost all subsequent earth-orbiting satellites were named following this convention; for instance, the Earth Observation Satellite is known as EOS. In 1965 there were 3,000 detectable earth-orbiting objects, sometimes called "space junk," and in 1998 this number had tripled to 9,000 objects. Many of these objects are weather, earth-monitoring, or communication devices.

Sensing the Earth

The sun bathes the Earth with light and invisible forms of radiant energy. Some of this energy fuel the biosphere, some is reflected, and some is absorbed by rocks, soil, atmosphere, and oceans (Figure 2). Much of this absorbed energy is then radiated back into space in the infrared (IR) part of the spectrum. Figure 3 illustrates quantitatively how the hot sun and the cool Earth radiate energy at wavelengths important to remote sensing. Note that all of the Earth's absorbed solar energy is emitted in the infrared region. Also note that the amount of solar energy reaching the Earth from the sun must equal the amount emitted by the Earth, or global warming or cooling will result. When less heat is lost to space than is received from the sun, then global warming is the

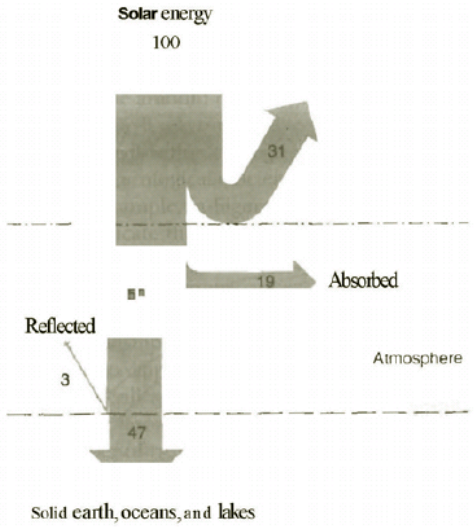

Figure 2: The amount of solar energy reaching the surface of the Earth on a day with average cloud cover. About half the solar energy that encounters the Earth's upper atmosphere reaches the surface of the Earth; the rest is reflected or absorbed by the atmosphere.

consequence. The slightly higher solar energy input (sun at Earth curve) in Figure 3 reflects photosynthesis and storage of solar energy by plants. Long-term storage is in the form of coal and oil, which have a plant origin.

It is estimated that the oceans lose 40% of the solar energy they receive. Because they back-radiate in the long-wavelength portion of the spectrum, sensors that detect IR radiation are very useful in obtaining remote images of the oceans (Table 1).

An important measure for the quality of visible-light remote images of Earth is albedo, the percentage of visible radiation that is reflected away from an opaque (solid Earth) or translucent (atmosphere and ocean) surface. Seen from space, bright objects, such as clouds and snow, have high albedos, and low-reflectivity objects, such as the oceans, some forests, lakes, have low albedos (Table 2). Remote sensing techniques that depend upon visible light use film or video cameras.

Most satellites (spy satellites excluded) are meteorological ones. These satellites tell us a great deal about the movement and temperature of the atmosphere and oceans, and aid greatly in weather forecasting. The information gleaned is invaluable in planning, particularly for air sea transportation. A satellite's sensors are called radiometers, and they are designed to measure radiation brightness in very narrow wavelength ranges known as channels. An important sensor for measuring surface temperature (SST) is the Advanced Very High Resolution Radiometer (AVHRR, Color Plates 1 and 2). It measures IR radiation from the Earth at five wavelengths (channels) that are able to penetrate the atmosphere. The visible (VIS) channel on the AVHRR measures the amount of solar radiation that is reflected away from the Earth. Since Earth features tend to have different albedos, interpreters with experience are able to distinguish between cloud types, water, ice, rocks, and soil.

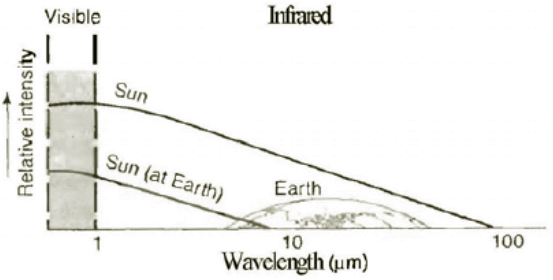

Figure 3: The sun's and Earth's relative emissions of electromagnetic radiation at wavelengths of interest for remote sensing. Note that all the Earth's emissions are in the infrared region of the spectrum.

Table 1
The spectral distribution of the sun's energy and the earth's backradiation energy

Type of radiation	Percentage of total energy
Sun	
Infrared and heat rays	50.0
Visible light rays	40.5
X-rays and gamma rays	9.0
Ultraviolet rays	0.5
Earth	
Infrared and heat rays	100.0

Table 2

Feature	Albedo
Clouds	30–92
Fresh snow	75–90
Week-old snow	40–70
Sand dunes, dry	35–45
Concrete	17–20
Blacktop roadway	5–10
Oceans and lakes	7–9
Sunglint on Gulf of Mexico	17
Desert	25–35
Tundra	15–20
Sorest, deciduous	10–20
Forest, coniferous	5–15

For over 100 years marine biologists have studied and tried to understand factors controlling the distribution, growth, and fate of phytoplankton. Because these microscopic floating plants are the base of the marine food chain, their growth and distribution (productivity) are important in a

growing world partially dependent upon the sea for food. Adequate phytoplankton sampling of the vast ocean is not possible using ships alone. The Coastal Zone Color Scanner (CZCS), first launched on Nimbus-7 in 1978, takes advantage of the fact that phytoplankton contain chlorophyll and other pigments that capture sunlight (Color Plates 3 and 4). As phytoplankton increase in number, their associated chlorophyll pigments absorb blue light, and water color changes from blue to green. The change in the ratio of blue to green enables us to compute chlorophyll content.

1. The sea-surface temperature (SST) image in Color Plate 2 represents the average SST taken over a 12-year period.

a. Explain the wedge-shaped mass of cool water along the equator off the west coast of South America. The tiny dots in the mass are the Galapagos Islands, which lie at 0º latitude. Provide two straightforward reasons for the colder water at the equator.

i._____
_____
ii_____
_____

b. What is the average SST off San Diego, California, on the west coast of North America? _____ºC
What is the average SST of Savannah, Georgia off the east coast of North America? _____ºC
These North American cities are at approximately the same latitude. Explain the reason there is this difference in SST.

_____
_____
_____
_____

2. Color Plate 3 shows upwelling on the west coast of the U.S. (California and Oregon).

a. From which direction(s) must the wind blow to produce the upwelling and cool water seen in Color Plate 4b? Circle the best answer below, keeping in mind currents and Ekman transport.

north to south east to west south to north west to east

b. Explain the plume of warm water off San Francisco Bay._____
_____

c. In Color Plate 3a, note how the distribution of high chlorophyll (phytoplankton) concentrations at (8) matches the areas of intense upwelling in Color Plate 3b. Briefly explain why this match is predictable.

_____
_____
_____
_____

3. Color Plate 4 shows chlorophyll concentrations in the western North Atlantic Ocean.
Note the formation of rings (1, 2, and 3) which pinch off from meanders in the main flow. A recently formed warm-core ring with Sargasso Sea water in the center can be seen east of Delaware Bay (1).
What can be said of the fishing possibilities in the Sargasso Sea?

a. _____

b. What can be said of the commercial fishing potential of Nantucket Shoal (4) and Georges Bank (5)?

_____
_____
_____

c. The chlorophyll-rich banks at (6) are known as _____. How may one explain the high productivity of this shallow warm water limestone plateau? Hint: See item e below.

_____
_____

d. Does the image suggest that the Great Lakes are highly productive?_____

e. What is the general correlation between water temperature and marine productivity depicted in this plate?

_____
_____

f. What is the Tongue of the Ocean (TOTO)?

_____
_____
_____

Hint- You may wish to *Google* Tongue of the Ocean.

4. The Gulf of Mexico's Loop Current –see Figure 5 in Color Plate Packet.

The Loop Current is the hot clear water from the Caribbean Sea flowing into and out of the cooler Gulf of Mexico. It circles the Gulf of Mexico in a clockwise looping behavior. It flows in from the south and leaves to the southeast through the Florida Straits (where the Florida Current begins; the Florida Current is the southernmost reach of the Gulf Stream Current).

Other inflow ports to the Gulf of Mexico are the rivers (cool water), with most river inflow occurring along the northern boundary of the Gulf.

Bathymetry channeling the Loop Current includes the wide shelves found along the Florida and Campeche coasts and narrower ones surrounding the western basin. A very narrow shelf is found between Pensacola and Apalachicola, Florida where the De Soto Canyon penetrates almost to the shoreline.

Figure 5. shows the subtropical convergence in the middle of a subtropical gyre produced by the Loop Current. In other words, the sea level in the center of the Gulf of Mexico is higher as water literally piles up in the middle of the basin. This sea level anomaly, tidal in nature, has also been correlated to the SST (sea surface temperature) of the Loop Current. The SST of the loop current increases with the dynamic height shown in altimetry imagery

a. In Figure 5, over the 12 year period what is the greatest height of the sea surface above mean sea level in the Gulf of Mexico? _____cm.

b. The seafloor depth beneath the gyre is greater than_____ _____meters

c. Where along coastal Florida is the sea surface anomaly most elevated? _____

By how much? _____cm

d. On the sketch map below of the Sargasso Sea provide a dashed line where you would estimate seawater to mound to the greatest height above mean sea level creating an anomaly like that depicted in Figure 5.

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The Sargasso Sea is a subtropical gyre located in the northwest Atlantic Ocean within the northern "Horse Latitudes," a region of relatively calm seas. It contains great masses of floating sargassum, a species of seaweed. The Gulf Stream Current flows between the Sargasso Sea and the U.S. Much of the legendary Bermuda Triangle is located within these quiet waters.

5. See Plates 6 and 7. Be able to locate and/or describe the following for the final quiz. In all likelihood you will see Plate 6 again, or something similar.

The Gulf Stream Current
A Warm Core Ring
A Cold Core Ring
The Sargasso Sea
Area of downwelling in the Labrador Sea
The Tongue of the Ocean
The Florida Straits
Waters of high productivity
Waters fishermen would be wise to avoid
Longitude 80 degrees west
Latitude 25 degrees north
The Loop Current
Florida Current
Polar waters
Cape Hatteras ~ 35 degrees north latitude
The Bahama Islands and Blake's Plateau
A subtropical, clockwise circulating gyre in the North Atlantic
Greenland
The Gulf of Mexico