

Lesson #2: Altimetry

Introduction/Rationale

Many students are aware that there are satellites orbiting around the Earth. They probably can cite some applications of them that tie into their daily lives, namely satellite radio, satellite television, and meteorological reports on television. The purpose of this lesson is to introduce the use of satellites as a tool for studying the Earth. Students will learn how satellites help scientists monitor sea surface height.

Lesson Concepts and Skills

Radar - Acronym for "radio detection and ranging." Method of detecting the distance of an object by reflecting radio waves off a surface.

Materials

Six to eight different types of balls, there should be a mixture of bouncing and non-bouncing ones (e.g. Styrofoam, tennis, ping pong, hacky sack)

"Radar signal" sign for each group

10 meter length of rope with markings every 10cm for each group

Stopwatch for each group

Nine traffic cones per group (for use in the Radar Run setup)

Electronic tape measure per group (if possible)

Standard tape measure per group (if possible)

Pair of cymbals (contact music teacher)

Computer lab access or computer projector

Copies of "Satellite Altimetry Facts" for each student

Large copy of "Ocean Floor" image

Teaching Strategies Employed

Multi-sensory (kinesthetic approach)

Cooperative learning

Direct instruction

Demonstration

Time Frame

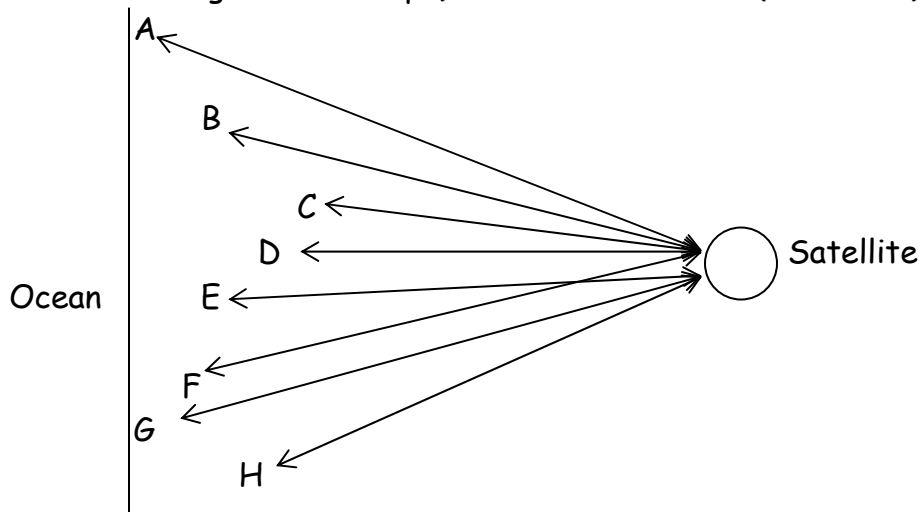
One class period

Target Audience

Grade five

Teacher Preparation

- Select an open area where the students have room to run safely, such as the gymnasium or the playground.
- Label one traffic cone "Satellite" for each group, label the remaining eight with a letter A-H.
- Arrange the cones so that they are varying distances (not exceeding the length of the rope) from the satellite. (see below)



National Science Content Standard

As a result of activities in grades 5-8, all students should develop understandings about scientific inquiry.

- Mathematics is important in all aspects of scientific inquiry.
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

As a result of activities in grades 5-8, all students should develop understandings about transfer of energy.

- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.

Behavioral Objectives

Students will accurately measure the distance to eight points on an uneven surface by conducting a simulation of satellite altimetry.

Students will create a two-dimensional model of the simulated ocean surface by graphing data from the Radar Run activity.

Engagement

Write the word "yes" on the board on one half of the room and "no" on the other half. Select six to eight student volunteers (depending on the number of balls available for the demonstration) and give each one a ball. Be sure to place the students with balls that bounce on the "yes" side and those without bouncing balls on the "no" side. Instruct the class that they will observe a demonstration and then need to determine how the yes and no groups were categorized.

Have the volunteers drop the balls, and then ask the rest of the class what made some of the balls a yes and others a no. (Their ability to bounce.)

Tell students that all the balls in the yes group have something in common with satellites, and that in today's lesson they will find out what that commonality is.

Exploration

Inform students that they will participate in a simulation of a satellite sensing the height of the ocean's surface. Distribute the "Radar Run" paper to all students. Review the directions as a class.

Point out that it is impossible to move through the air in the same direction as a radar signal, therefore our simulation is turned on its side. Divide students into groups of six. Lead them to the area set aside for the Radar Run.

Distribute materials. Circulate among the groups. Once the simulations are complete, return to the classroom. (If possible, keep one set of traffic cones in place until the "Extension" part of the lesson.)

Explanation

Tell students that light is not instantaneous, it takes a brief time to travel from one place to another. The speed of light is measurable. In fact, light's speed is 300,000 km/sec (186,000 mi/sec.), as is ultraviolet radiation's and infrared's. If people could travel that fast, we could circle Earth seven

times in one second and it would only take 0.1 sec. to travel from the U.S. to Great Britain!

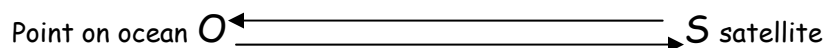
If time and space permit, illustrate the fact that light (and radio waves) travel faster than sound. Lead the class outside to a wide-open area. Choose one student to stand at a pre-selected location, approximately 100 m away from the rest of the class. Give that student a pair of cymbals. When he/she stands at the predetermined spot, using large arm movements, he/she must crash the cymbals once. The rest of the class should be able to visually detect the cymbals crashing before hearing their sound. Sound travels much, much slower than light at 343 m/sec at sea level at 1 atm. (This is why you can determine the location of a thunderstorm by counting the number of seconds between the lightning and the thunder. Thunder travels one kilometer every three seconds, or one mile every five seconds.)

Instruct students that light and radar signals travel at the same speed [300,000 km/sec (186,000 mi/sec.)]. Because it does take time (albeit very little) for radar signals to travel from point A to point B, scientists use this knowledge to help measure the time it takes for the radar signals to make a round trip from the satellite.

Distribute "Satellite Altimetry Facts" paper to all students. Read it as a class.

Ask students to identify what the bouncing balls from earlier in the lesson had to do with satellites. (The balls reflect off a surface just like radar signals.) State that the students who were the radar signal left the satellite, *bounced* off the ocean surface, then returned to the satellite.

Make a drawing on the chalkboard similar to the one below.



Use this simple example to teach students about radar calculations. Tell students that a radar signal took 6 seconds to return to a satellite. Ask how many seconds it took to travel just one direction, from the satellite to the ocean. (Three seconds.) Tell students that since we know the distance radio

waves and light travel in a second, we can calculate that the satellite must be 900,000 km away because $300,000 \text{ km/sec} \times 3 \text{ sec} = 900,000 \text{ km}$.

Stress to students that in real life, the travel time is in fractions of a second and the calculations are more complicated. Additionally, scientists also have to take into account changes in the radio waves as they travel (Doppler shift).

Project the image from the website

http://www.jason.oceanobs.com/html/alti/principe_uk.html to better illustrate the mechanics of satellite altimetry.

Evaluation

Have students complete the "Evaluation" part of the Radar Run packet to create a diagram of the "ocean surface" using measurements from the activity.

Hold a class discussion to review responses to evaluation questions.

Extension

In the computer lab or on the teacher's computer projector, go to <http://electronics.howstuffworks.com/radar.htm>. Discuss additional uses for radar besides satellite altimetry.

Return to the area where the ocean and satellite model is. Using an electronic tape measure such as the Strait Line Laser, measure the distances from the satellite cone to the ocean cones. (It might be necessary to have a student stand in place of the cone for a larger target.)

Explain to students that the tape measure sends out waves and can calculate distance based on the amount of time it takes for the waves to bounce back. In the case of this tool, sound waves are sent out rather than radar.

If possible, provide each group with an electronic tape measure and standard tape measure. Give them 10 minutes to experiment with each tool. Reassemble the class and hold a discussion about the pros and cons of each tool. Ask students to guess what would happen if the electronic tape measure were used from a higher in the atmosphere. (Changes in air

pressure would affect the travel time of the sound waves and the measurements' accuracy would be affected.) If you only have one electronic tape measure and one standard one, pull a single group at a time to experiment with them. Meanwhile, the rest of the class could be working on the evaluation questions.

Bibliography

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Name _____
Date _____



Radar Run activity

Materials

Radar Signal sign

Rope

Stopwatch

Procedure

1. Select one person in your group to be the “Radar Signal.” He/she must wear the “Radar Signal” sign. Another person should be the timer and a third, the rope holder.
2. All students must stand at the “satellite” area designated by the traffic cone.
3. Tie one end of the rope around Radar Signal person’s wrist. The rope holder person should hold the rope so that there is little to no slack. Both the Radar Signal person and rope holder must stand next to the “satellite” cone.
4. The person with the stopwatch will signal when to start the radar run so that timing may begin.
5. The radar signal person must run as fast as she/he can, touch cone A with the hand attached to rope, and continue running straight back to the satellite, at which point timing should stop. As the radar signal is running, the rope holder should lightly hold the rope as it is pulled away. Once the rope has stopped moving, it should be grasped until the radar signal returns and it can be measured.
6. Count the number of marks on the rope from the rope holder to the radar signal person’s hand. Remember that every mark is 10cm, or 1dm. Record in the Radar Run Data table below.

7. Complete next column by converting decimeters to meters, which is accomplished by multiplying the number by ten. Finally, record the time it took the radar signal to return back to the satellite.

8. Repeats steps 4-7 for cones B-H.

RADAR RUN DATA

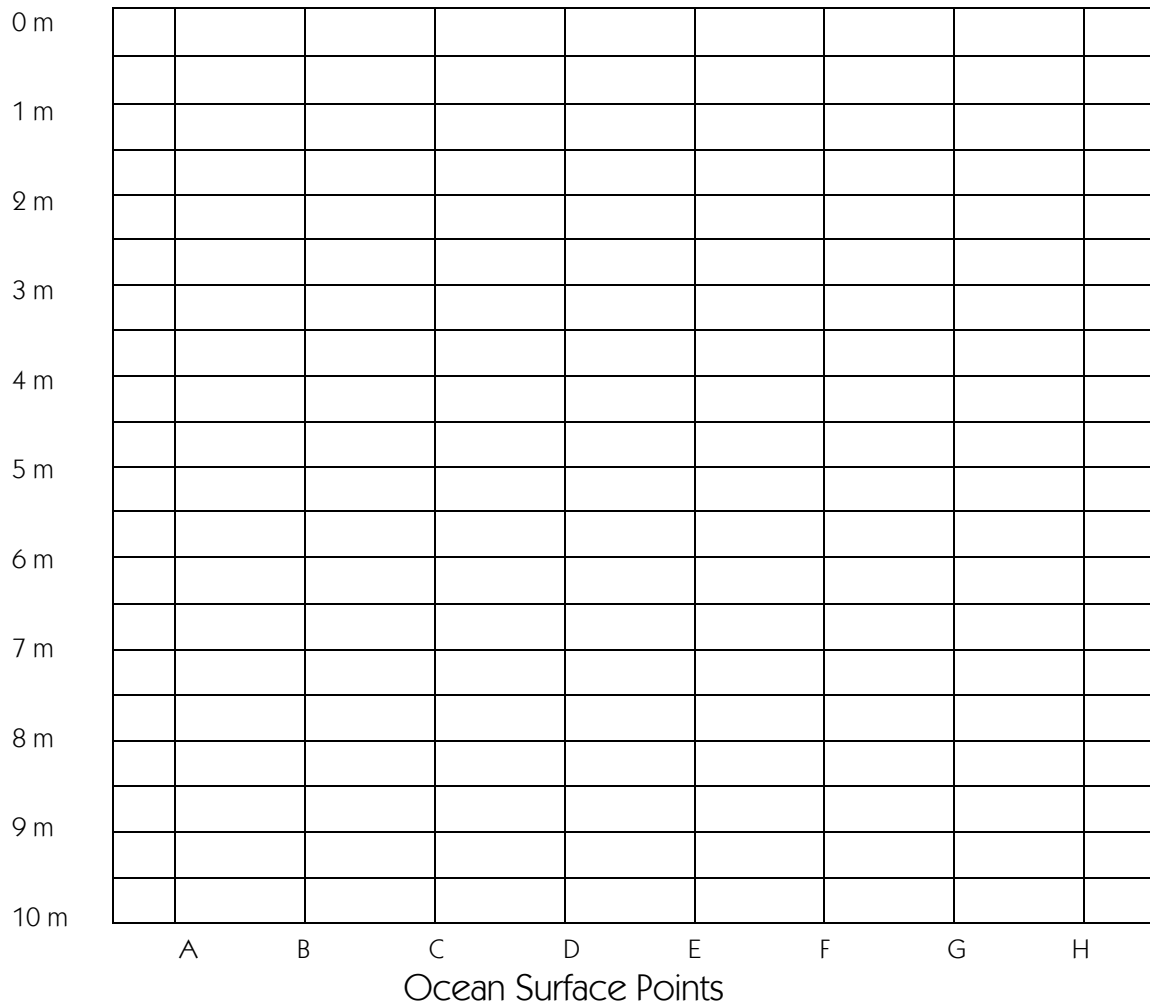
Ocean Surface Point	Distance between ocean and satellite in decimeters (number of marks on rope)	Multiply decimeters by 10 to change to METERS	Round trip running time of radar signal
A			
B			
C			
D			
E			
F			
G			
H			

EVALUATION: A MAP OF THE OCEAN SURFACE

Use data from the table above, in meters, to plot the ocean surface height from the radar run. Then use a ruler to connect the points with a straight line.

N.B. Distances were measured *from* the satellite to the ocean, so the scale is upside down here.

Distances between Ocean Surface and Satellite in Meters



EVALUATION QUESTIONS

1. Compare the graph you drew of the ocean surface with the actual model from the Radar Run activity. Do they appear to be similar or are there large differences? Explain.

2. What did the Radar Run activity teach you about satellite altimetry?

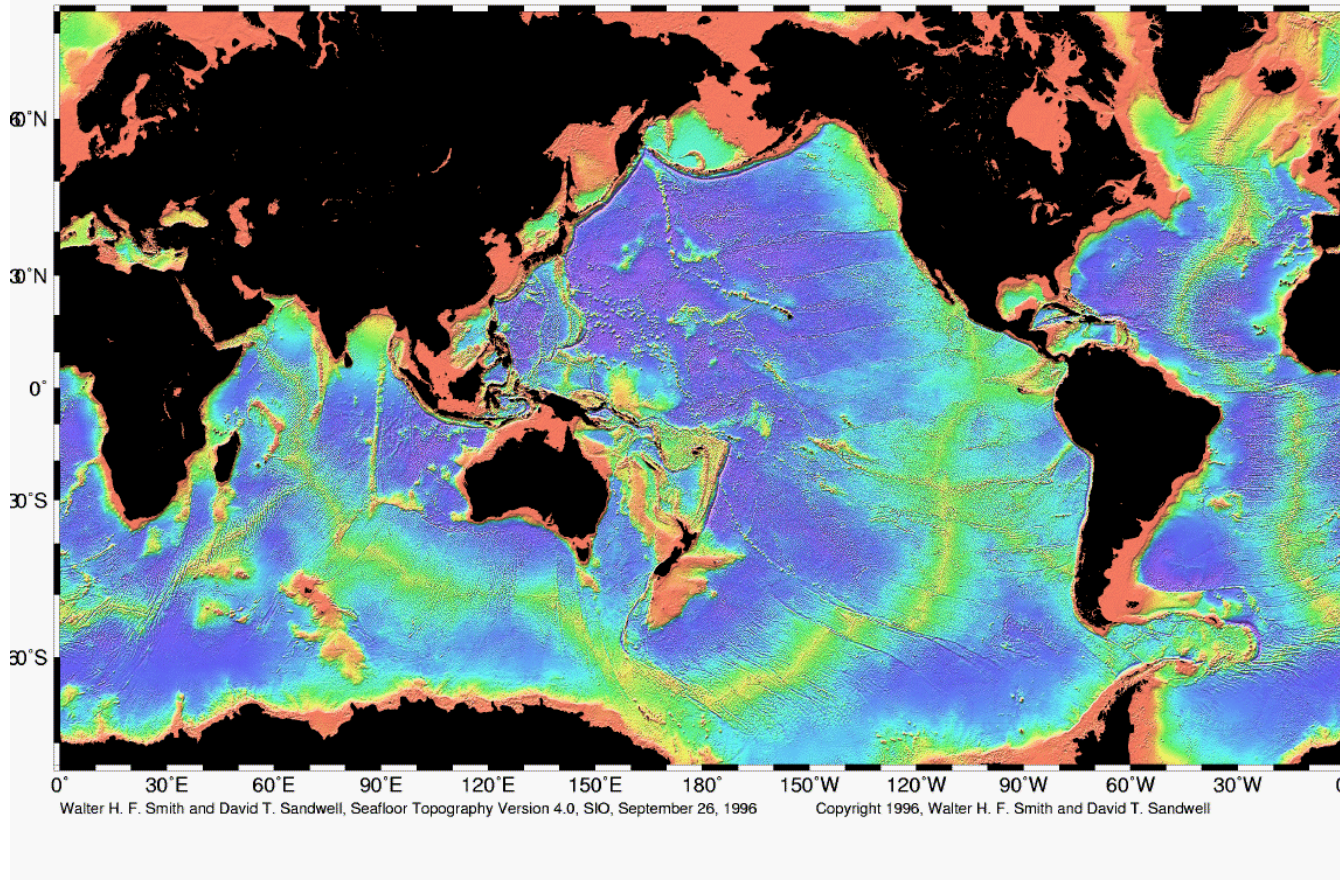
3. Why is the height of the ocean important to scientists? (How do they use this information?)

4. Using what you've read and experienced during this lesson, explain some limitations (negative points) of satellite altimetry. (For instance, does the data from the radar run really tell you the height of the ocean?)

Satellite Altimetry Facts

- Satellite altimetry - using radar pulses from a satellite to measure the height of the ocean
- Radar pulses travel at the speed of light, 300,000 km/sec (186,000 mi/sec.).
- The ocean is not level. Its surface is full of hills and valleys that form from an unevenness in gravity's pull and the depth of the ocean. Scientists use the height of the ocean to help map what its floor looks like. (See image below.)
 - An area of the Indian Ocean dips down 100 m because of this strong pull of gravity.
- Scientists use measurements from satellites to find out the speed and direction of ocean currents. This helps them:
 - Study the climate and make predictions
 - Monitor the habits of fish and other ocean creatures, such as sea turtles
 - Track oil spills
 - Study drifting of debris (garbage)
- Sea level/ocean level is rising little by little each year (approximately 2 mm per year, or the thickness of a nickel). Because of the information gathered from satellites, scientists believe that the rising is caused by melted ice from the continents and glaciers.
 - Since the Ice Age, sea level has risen 100 m because ice from Canada and Northern Europe melted over time.
 - If all of Greenland's ice melted, there would be a 70 m rise in sea level. If Antarctica's ice melted, the rise would be greater than 100 m.
- Finally, satellite altimetry data are used in the measurements of ocean wave height and wind speed.

Ocean Floor



Scientists used satellite data to create this image of the ocean floor. The colors show how deep the different parts of the ocean are. The orange areas are the "continental shelf," which measure about 100 m below the surface. The yellow areas show where tectonic plates meet ("plate boundaries") and are approximately 1000 m below the surface. The dark blue areas are around 3-5 km deep and show the "abyssal" zones of the oceans.