

Altimeter in a Box

Overview:

Students will explore how satellite altimeters work by constructing and mapping “ocean topography” in a closed box. Altimeters, such as those used in the Jason series, use radar instruments to bounce signals off the sea surface and record the time that it takes for the signals to return to the satellite. Resulting data are used to create maps of sea surface height.

Concepts:

- Jason satellites use radar to measure the height of the satellite above the sea surface. Echoes from “hills” on the sea surface return more quickly than echoes from ocean “valleys.”
- Data from altimeters are used to determine sea surface topography.

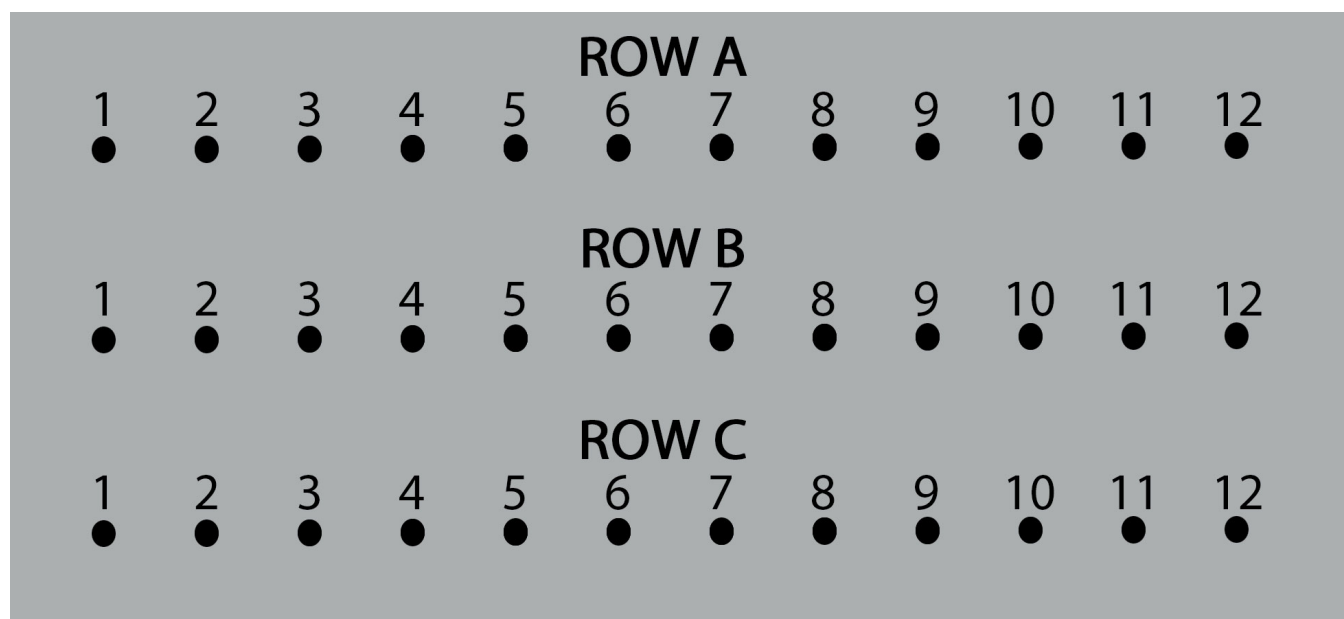
Materials (per group):

- Shoe box with lid
- Stiff wire or 1/4” wooden dowels
- *Scale for Echo Return Time Measurements* (6 rulers provided on the last page)
- Newspaper, clay, or plaster (or you can use wood scraps of varying thickness and shapes and glue them to the bottom of the box)
- 2 sheets of graph paper
- Ice pick (or other tool to punch holes in the top of a shoe box)

Preparation:

Set up one work station for each group. Use an ice pick to punch holes in the top of the shoebox every inch or so, spanning the box’s long dimension. Label holes from one end of the box to the other as 1, 2, 3, etc. If you have more than one row, make sure that the holes are spaced consistently between rows and label each row “A”, “B”, etc. This will establish two coordinates for each hole (e.g., “A1”, “A2”, etc. and “B1”, “B2”, etc.) and allow you to use the same horizontal axis for graphing data from multiple rows. For a more elaborate project, use paper maché to form sea surface topography.

An example of how the shoebox lid might be labeled is presented below.



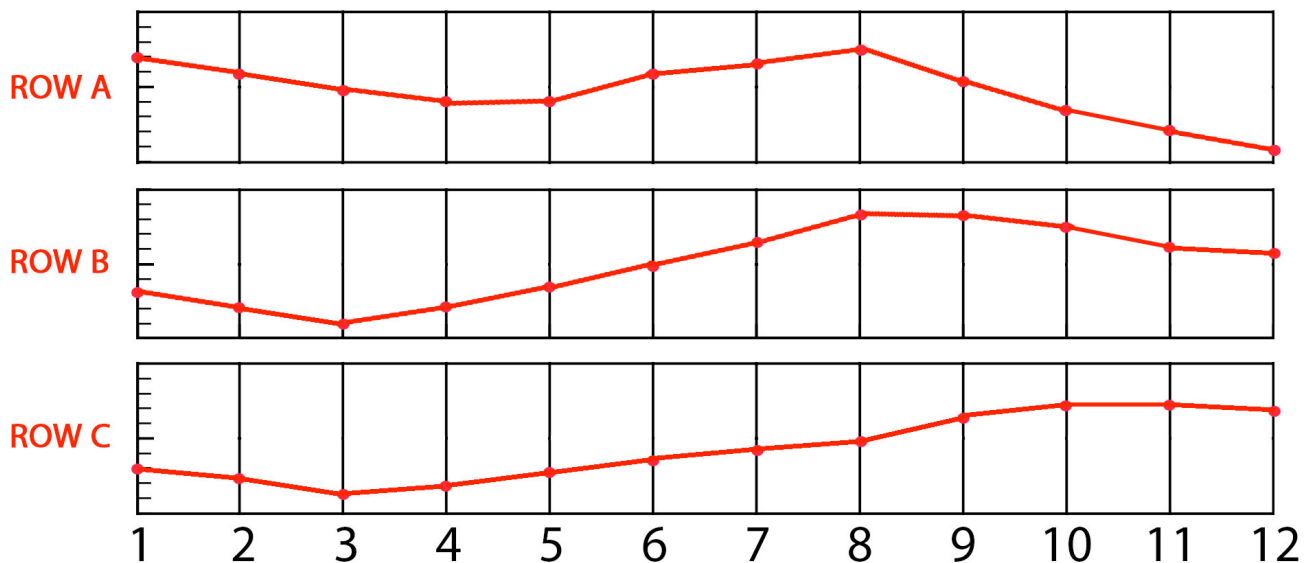
Altimeter in a Box - Procedure

Engagement:

How is sea surface height measured? What instruments do we use? In this activity you will see how an altimeter uses radar to measure sea surface height, which can be used to map ocean surface topography. The hills and valleys on the ocean surface tell us about ocean circulation patterns. In addition, decades of measuring sea surface height with satellite altimeters gives conclusive evidence that global sea level is rising.

Activity:

1. Gather materials to create a model of the ocean surface. Open the shoe box and use the materials provided to shape the ocean surface in the box. Make sure that there are at least two different major topographic features (hills, valleys) in your design.
2. The teacher will collect and redistribute all of the boxes. Each group should get a box other than the one that they built.
3. The wire or wooden dowel represents the radar pulse that is bounced off the ocean surface. Slide the wire or wooden dowel vertically into each hole in the box. Keep track of the length that fits into the box with either a pencil mark or your fingers. For each hole, use the *Scale for Echo Return Time Measurements* (provided) to measure how long the radar signal took to travel from the satellite to the ocean surface and back.
4. On graph paper, plot travel time versus location for each row. The graph should be a fairly accurate representation of the sea surface features found in the shoebox. If you have more than one row of holes, then graph each row's data using the same horizontal axis (i.e., hole number). Make sure to place the rows in sequential order (e.g., Row A at top, Row B below, etc.). Below is an example of what the graph might look like.



5. Compare results with the class.
6. You may want to repeat the procedure after redistributing the boxes again.

Explanation:

The primary instrument for measuring ocean topography is the radar altimeter. It bounces microwave pulses off the sea surface and a timer records the duration from transmission to reception. By recording how long the signals take to travel from the satellite to the sea surface and back, the altimeter determines the distance between the satellite and the sea surface.

Water vapor in the atmosphere slows down the return of the microwave signal. So an instrument called a radiometer is used to adjust for the influence of water in the atmosphere.

Altimeter and radiometer data, combined with precise knowledge of the satellite's position, are used to obtain a detailed map of sea surface topography. From this, scientists calculate ocean current patterns and speeds.

Radar altimeters have also been used to determine the topography of Venus, most notably from the Magellan spacecraft. Its radio waves were able to penetrate Venus' thick cloud cover.

Extension:

Have the students research methods and uses of altimeters on Earth and other planets. If you were planning a mission to Mars or Pluto, would you explore using an altimeter? Why or why not? What types of scientific studies are aided by topography data?

SCALE FOR ECHO RETURN TIME MEASUREMENTS



Time needed to travel from satellite to ocean surface and back (seconds)

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