Sea Level Slopes and Surface Currents

Introduction

The ocean surface is not level, but has broad, gradual hills and valleys created by surface winds and density differences. Surface currents flow around the sides of these hills and valleys. Measuring this sea surface topography is a challenging task. One measuring device is the TOPEX/Poseidon radar altimeter mounted on an Earth-orbiting satellite. This device sends radar beams down to the sea surface, where they are reflected back to the satellite. The round-trip travel times for the beams allow scientists to measure the satellite to sea surface distance to within a few centimeters. The satellite-derived sea surface elevations are then compared to those that the sea surface would have if the oceans was still (no currents, waves, etc.). Specifically, the elevations of the imaginary still ocean are subtracted from those calculated from the satellite's data. The height differences show where the ocean's hills and valleys are and the slope of the surface between them.

The following activity uses some of these sea height differences, calculated from TOPEX/Poseidon data to investigate the relationship between sea surface topography and ocean surface currents.

Objectives

After completing this study, you should be able to:

- Describe the use of a radar altimeter to measure sea surface height.
- Describe the relationship between the slope of the sea surface and the direction and speed of ocean surface currents.

Investigations

1. Examine the accompanying map of the North Atlantic Ocean [Fig. 1] which shows part of the ground track of one orbit of the satellite carrying the TOPEX/Poseidon altimeter. The part of the ground track of interest for this activity is between 38° and 40° N latitude. Mark with an "X" each end of the ground track segment directly on the map.
2. Turn to the table of sea surface height differences [Table 1]. The positive height differences show where the sea surface was higher than the surface of the imaginary still ocean would have been. The negative heights show the opposite. The heights are listed at regular intervals measured along the ground track of the altimeter. In the table, the total difference between the highest and lowest sea surface heights is about (0.3) (0.6) (0.9) meter.
3. On the sea surface height difference diagram [Fig. 2], plot the data given in the table. Connect adjacent plotted points with solid straight lines.
4. The surface of the real ocean is constantly changing as winds and density differences cause gentle hills and valleys to form. Although these slopes are very small when compared to those on land, surface water responds to these changes in topography as it would on land, by starting to move (uphill) (downhill).
5. On Earth, surface water set in motion is deflected about 90° to the right of its initial direction in the Northern Hemisphere and to the left in the Southern Hemisphere. This deflection is due to Earth's rotation. To model the current that results from this deflection, place your pencil along

the satellite track with its point facing down hill. The pencil points in the direction that water will start to flow. Now rotate the pencil 90° to the right because this is the direction of deflection in the Northern Hemisphere. Thus, from the sea surface slope, you can determine that at this location, the Gulf Stream flows towards the (northeast) (southwest).

6. Surface currents are strongest on the steepest slopes and weakest on the gentlest slopes. The Gulf Stream is one of the strongest surface currents so it occurs on one of the (steepest) (gentlest) slopes.
7. Surface currents flow in such a direction that the hills of water are on the right of the current in the Northern Hemisphere. For the Gulf Stream, the hill of water would be on the (right) (left).
8. Because of the relationship between sea surface slope and surface currents, observations of currents can be used to estimate where the sea level is higher and where it is lower. For example, observations show that in the Southern Hemisphere, the Peru Current flows northward along the coasts of Chile and Peru. Thus, we would expect sea level to be (higher) (lower) to the left (or west) of the current than it is to the right (or east).

Source

The Maury Project, American Meteorological Society

Figure 1. North Atlantic Map.

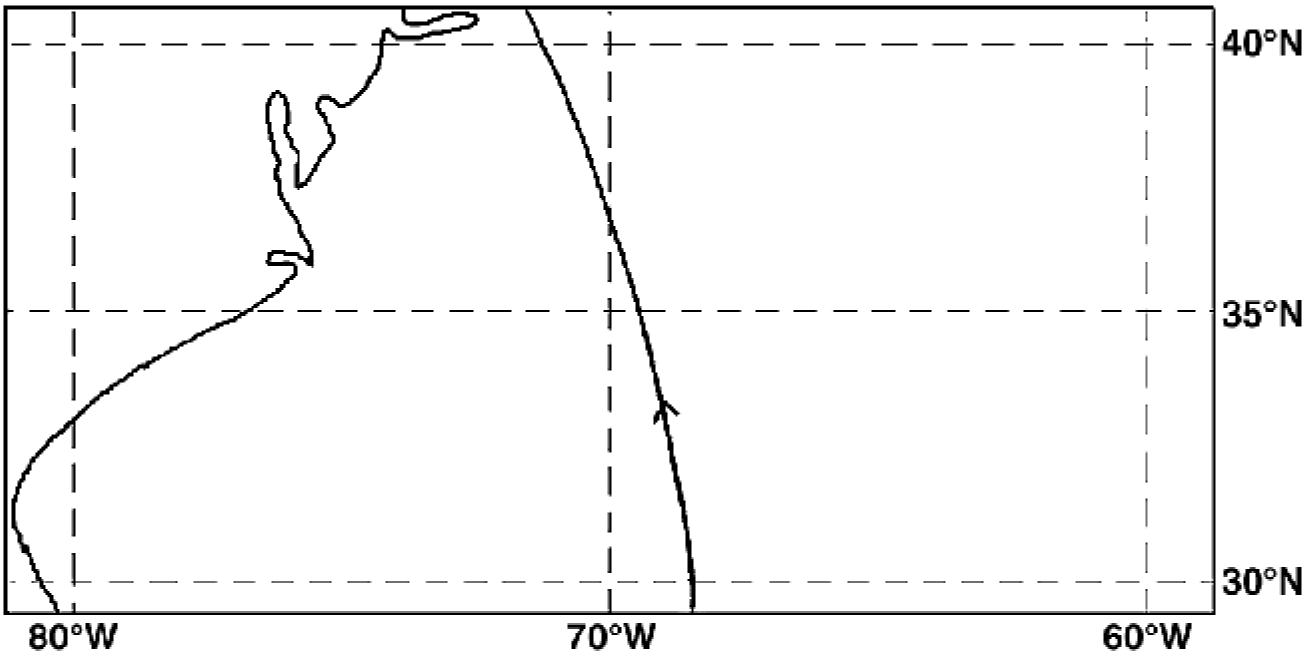

Table 1. Sea Surface Height Differences

Latitude (∞N)	38.6	38.8	39.0	39.2	39.4
Height (m)	+0.15	+0.11	+0.10	-0.09	-0.46

Figure 2. Sea Surface Height Difference Diagram