Sea Surface Topography

Overview

Students will interpret a *sea surface topography* image from TOPEX/Poseidon and make a three dimensional map of the oceans' topographic *contours* using layers of cardboard and cardstock.

Concepts

- *Sea surface topography* is the height of sea level after variations due to gravity and tides have been removed.
- Scientists can use sea surface topography to calculate the speed and direction of *ocean currents* almost everywhere in the ocean.
- Variations in ocean currents can lead to variations in ocean and atmospheric heat transport and to changes in weather patterns.

Materials

- Satellite image of sea surface topography from TOPEX/Poseidon with corresponding height scale (included, see Preparation section below)
- Color printer (preferred)
- Tracing paper
- Pencil
- Thin cardboard
- Card stock
- Scissors
- Glue
- Paint (optional)

Preparation

Figure 1 is an image derived from TOPEX/Poseidon satellite and other altimeter data. It shows sea surface topography for the Gulf of Mexico. You can use this figure for the activity, or alternatively, you may access http://www-ccar.colorado.edu/research/gom/html/gom_nrt.html and click on "Latest sea surface height map." You can use this site to view maps of Gulf of Mexico sea surface topography, recent and archived (click on "Archive of sea surface height maps," choose folder with the month and year of interest, then pick date of interest). You may also wish to see animations of how sea surface height changes over time by choosing "Animation of the sea surface height maps to date for current month" or "Monthly animations of the sea surface height." Different groups can all build contour maps of the same time, or each group could do a different date, month, or year.

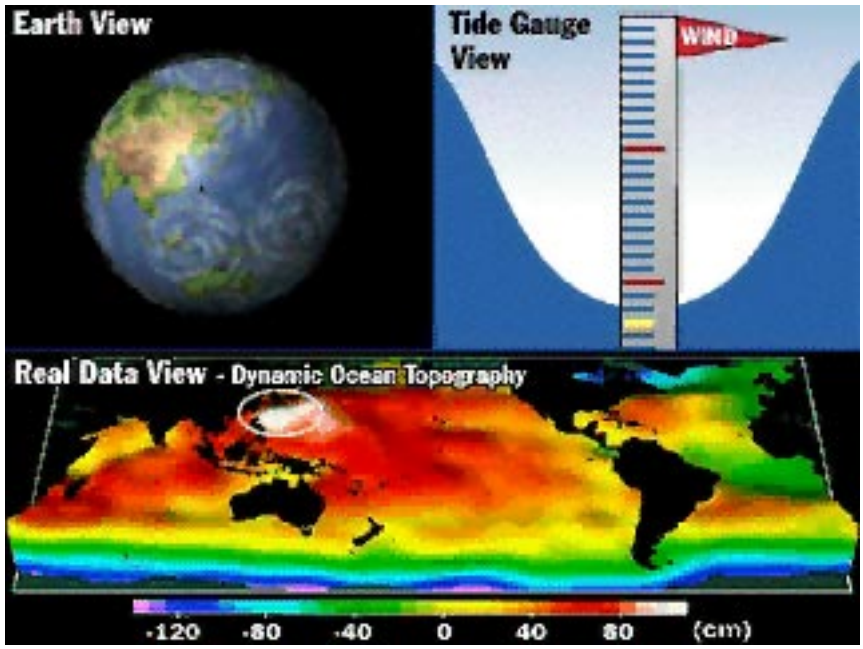
Ideally, each group should have a color print of Figure 1 or its equivalent. You *may* be able to use black-and-white prints if each group is given a chance to study the color version either on a monitor or in hardcopy format. This will help to make sure they know which color corresponds to each contour interval. The usefulness of a black-and-white print will depend on the image and your printer. Try it first. Students may also be able to trace contours by placing tracing paper over the monitor screen.

You might wish to make a model for the students to see before they begin this activity.

PROCEDURE

Engagement

What is the shape of the ocean surface? It is amazing to think that, just as land has variations in its shape, so does the ocean surface. However, ocean "hills" and "valleys" are much smaller than those on land. One of the largest factors that affects sea surface height is Earth's *gravity,* which can raise or lower sea level by tens of meters. *Tides* also affect height in the open ocean but usually less than one meter [Movie 1]. In your study images, the effects of gravity and tides have been removed because this allows scientists to calculate the flow of surface ocean currents. You will make a model of sea surface topography based on a TOPEX/Poseidon satellite image using layers of cardboard and card stock. Stacked one on top of another, they will show the shape of the ocean surface as measured by the TOPEX/Poseidon satellite.



Movie 1. There are many factors that influence sea level on Earth. Relatively stable factors include density differences deep within our planet and ocean bottom topography. shorter-term changes in sea level are caused by tides, wind patterns, and the rotation of Earth

Activity

1. Use the color TOPEX/Poseidon image of Gulf of Mexico sea surface topography provided [Fig. 1]. Alternatively, you may access the Internet site (previously mentioned) to get a time series of sea surface height maps. Then individual groups can compare and contrast their data with those of the other groups.
2. Place the tracing paper on top of the map. Trace the contours of the surface by outlining the different colors shown on the image. Use the provided scale to determine the height of each color on the map. To lessen the tracing and cutting, you may want to combine colors into 10-centimeter intervals rather than the given 5-centimeter groupings (for example, use bright green for sea surface height from +5 to -5 centimeters, yellow-orange for +5 to +15 centimeters, dark orange for +15 to +25 centimeters, and red for 25 centimeters and higher, etc.)
3. Trace the line of each contour onto a separate sheet of card stock, then cut out each contour outline. The card stock cutouts will represent the shape and size of each contour. Optionally, use different color card stock for each contour level either by purchasing or painting different colors.
4. Cut small pieces of cardboard to place between each layer. The cardboard will provide a means of indicating the relative height of each contour.
5. Position cardstock and cardboard on the tracing paper, glue the cardstock cutouts one on top of the other to build the model of the sea surface.

6. Compare your contour model to how the ocean currents were flowing at that time (shown as black arrows on Fig. 1). Do you see a tie between the "hills" on your model and how the currents were flowing? What about the "valleys"? Can you guess how sea surface topography and currents are related?

Explanation

Sea surface topography is the height of sea level relative to Earth's *geoid* (equal gravity surface) after variations due to tides have been subtracted. While patterns of the ocean's currents have been charted by sailors for hundreds of years, TOPEX/Poseidon is the first satellite mission that allows scientists to view changes in the world's ocean currents every few days. Sea surface topography data are used to calculate the speed and direction of ocean currents in much the same way meteorologists use maps of atmospheric pressure to calculate the speed and direction of winds.

Extension

With maps of sea surface topography, scientists can observe detailed motion of currents in the world's oceans. Because Earth rotates ocean currents flow clockwise around surface "hills" and counterclockwise around "valleys" in the northern hemisphere; this process is reversed in the southern hemisphere. These "hills" and "valleys" are oceanic counterparts of circulation systems in our atmosphere.

Have the students access the Internet address previously listed. Generate two Gulf of Mexico sea surface topography maps from a date in April 1997 and a date in October 1997 (within "Archive of Sea Surface Maps"). With these data, analyze seasonal changes in the current flow in the Gulf of Mexico. They can verify their conclusions about current flow direction on these dates by accessing the "Gulf of Mexico Near Real-Time Altimeter Data *Geostrophic* Velocity Viewer" website at http://www-ccar.colorado.edu/~realtime/gom-real-time_vel/. Enter the chosen date from April 1997 by using the "pull-down" menus under "Analysis Date." Scroll to the bottom of the page and hit "Send Values." (If you get a "warning message" hit "OK.") After a few moments an image of the TOPEX/Poseidon satellite will appear. Click on the image. Next you will see a map that shows both sea surface height and the current flow direction for the date you entered. Repeat the process for the chosen date in October 1997.

The students can also compare contour maps of sea surface topography and land topography. What is the elevation difference between contours on each of the maps?

Links to Related CD Activities, Images, and Movies

Movie of *Factors that influence ocean levels*

Activity *Fathometer in a Box*

Vocabulary

contours	*geoid*	*geostrophic*
gravity	*ocean currents*	*sea surface topography*
tide	*upwelling*	

Source

Orange County Marine Institute / San Juan Institute Activity Series.

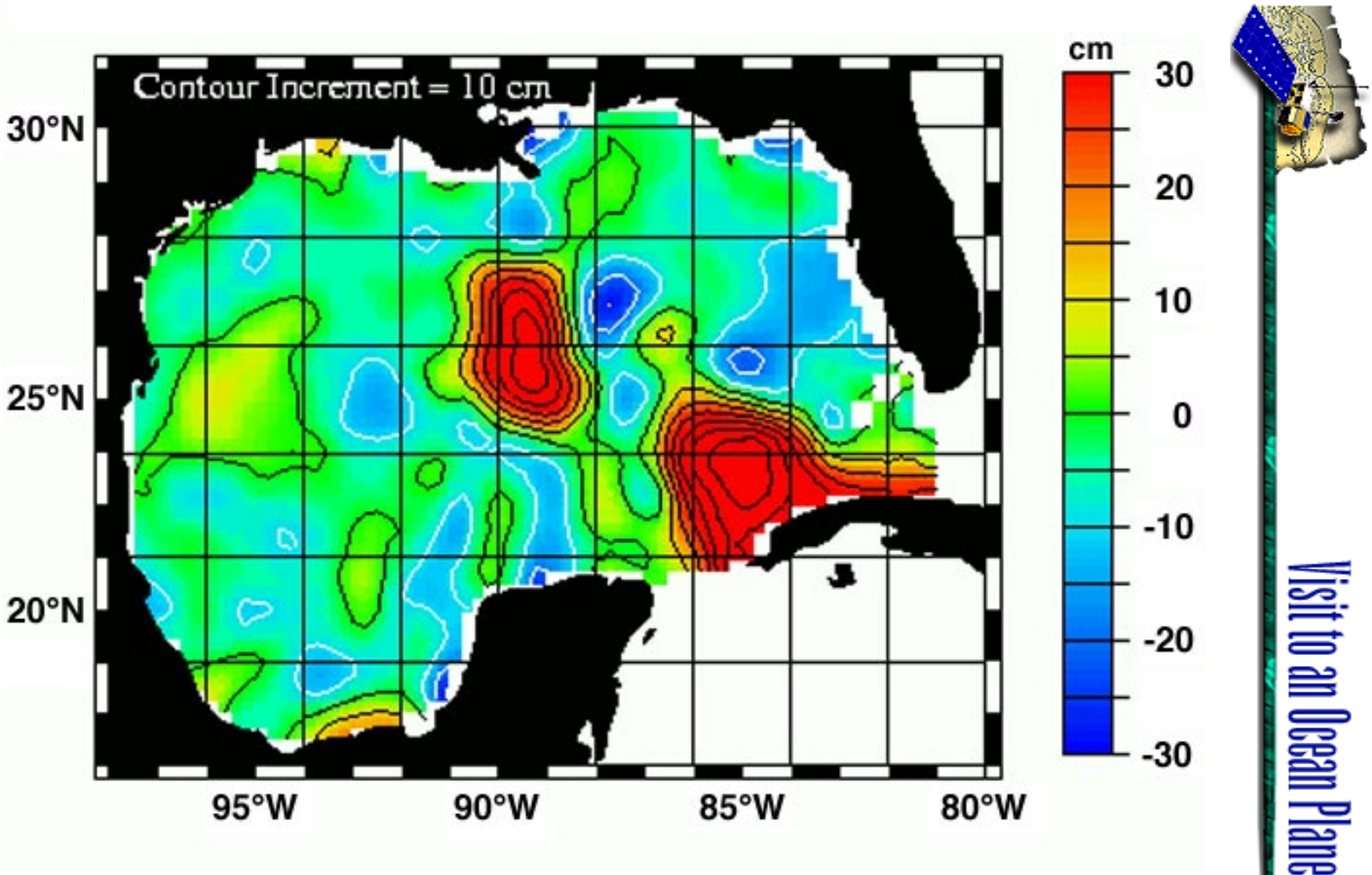


Figure 1. **TOPEX/Poseidon derived sea surface topography of the Gulf of Mexico.**. This map shows the Loop Current and associated eddies sweeping through the Gulf of Mexico. These features can raise sea surface height above average (shown as red and yellow). Dark blue areas of lowered sea height often correlate with *upwelling*.