OCEAN SEASONS

OVERVIEW

Students will observe and identify distinctive features in TOPEX/Poseidon-derived maps of *sea surface height* for each season. They will use their observations to recognize seasonal variations in sea surface height in the mid-*latitudes* (20°-50°). This exercise will help students understand how sea level change is largely controlled by heating (which causes higher sea levels due to thermal expansion of the water) and cooling of the upper oceans.

CONCEPTS

- *Sea level* varies regionally with the seasons.
- In the mid-latitudes, seasonal sea level change is primarily controlled by heating and cooling in the upper oceans.
- TOPEX/Poseidon measures global sea-level changes with high accuracy. This allows oceanographers to observe seasonal changes in the world's ocean surface. This has lead to an improved understanding of the oceans' role in climate change.
- Water has a high *heat capacity*. This means that it takes a lot of energy to heat or cool it (change its temperature). Thus, the oceans heat and cool more slowly than the land or the atmosphere.

MATERIALS

- Color version (on monitor or color print out or color transparency) of Figure 1.
- World map with latitude information

PREPARATION

The purpose of this activity is to stimulate a discussion about sea surface height and the high heat capacity of water. It can be completed in one of several ways. The way you choose to present the images may depend upon the equipment available. You can use a computer screen to display the color images (students can work in groups or individually at the computer), or the images can be presented to the entire class on a large monitor. Alternatively, you can print color versions for students to work with, or print a color transparency to use on an overhead projector.

Students should be familiar with seasons and their cause before the activity, or these topics can be covered or reviewed during the Engagement section.

PROCEDURE

Engagement

Earth's *obliquity*--the tilt of its *rotational axis* relative to its *orbit*--causes us to experience four seasons each year: summer, fall, winter, and spring. Timing of the seasons in the northern and southern hemispheres are reversed. For example, summer in the *northern hemisphere* occurs at the same time as winter in the *southern hemisphere*.

Figure 1 shows how *sea surface height* varies from its annual average from season to season. In this activity you will analyze four satellite data maps and match them to the season they represent. The images are derived from sea level measurements made by Earth-orbiting TOPEX/Poseidon satellite from September 1992 to August 1993.

A clue for interpreting the images is that water has a very high heat capacity, meaning that it takes a lot of energy transfer to change its temperature, i.e., heat it up or cool it down. Thus, the ocean heats and cools

more slowly than land. You will use this concept and your knowledge of the amount of solar heating that occurs in each season, to determine which map is from fall, winter, spring, and summer.

Activity

1. Observe all four images together. First, locate the land masses on each image. You will need a map with latitude markings for reference. Use this map to roughly sketch the *equator* and relevant lines of *latitude* on each of the four images in Fig.1. For this discussion, focus on the mid-latitudes in the northern hemisphere (20°N - 50°N).
2. Make sure that you are familiar with the color-coded sea surface height scale for the images. In which image do you find the highest sea surface heights? In which image do you find the lowest sea surface heights? Explain your answers.
3. Use your sea surface height observations to determine which of the four images represents the sea levels from fall in the northern hemisphere (spring in the southern hemisphere). Why did you choose that image? How might the timing of the seasonal sea level variations relate to the heat capacity of water?

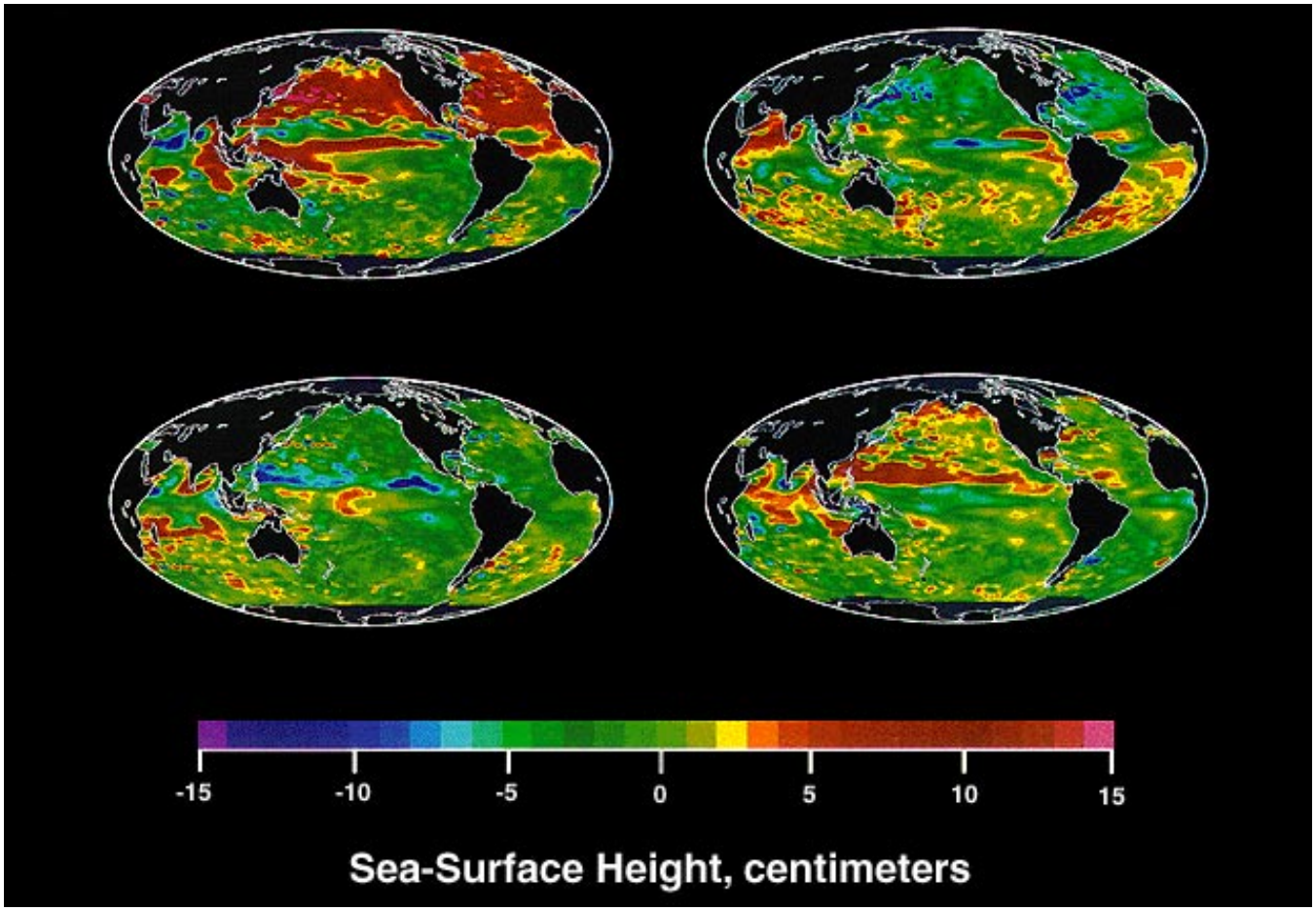

Figure 1. **Ocean seasons as measured by TOPEX/Poseidon.** The maps show variations in sea level relative to the ocean's annual average height. Each image corresponds to a different season. Effects of tides and gravity variations have been removed. The sea surface height scale is provided on the image.

4. Once you have determined which image represents the fall in the northern hemisphere, try to find the image that represents summer. Why did you choose that image? How does sea surface height compare between summer and fall? Finally, try to identify the maps of northern hemisphere winter and spring. Explain your answers.
5. Compare sea level responses in mid-latitudes in the northern hemisphere with those in the southern hemisphere. Do they vary in the same way? Which hemisphere has larger variations in sea surface height? Can you guess why?

Explanation

Regional sea levels vary with the seasons. At mid-latitudes, 20° to 50° north and south, sea level change is controlled by heating (which causes higher sea levels due to thermal expansion of the water) and cooling in the upper ocean. In the northern hemisphere fall, the temperature of the upper ocean layer and sea level are high after being warmed throughout the summer. The lowest sea levels occur in the northern hemisphere's spring.

The southern hemisphere also experiences seasonal changes, but to a lesser extent. One reason for this is that there is less land in the southern hemisphere. This limits the extent of cold winter air that blows out from continents to cool the oceans. Moreover, the southern hemisphere has a greater proportion of ocean to land, which results in a more moderate climate with less seasonal change.

Extension

In the tropics (from about 20°N - 20°S latitude), sea level is primarily controlled by wind. Bands of high and low sea level across the Pacific and Atlantic Oceans correspond to changes in equatorial currents. These equatorial currents shift in response to seasonal cycles of the *trade winds*. The El Niño phenomenon, which is triggered by an unusual "breakdown" of trade winds in the western Pacific, affects ocean heat storage patterns. Discuss the relationship between equatorial trade winds, sea level, heat storage, and weather patterns during El Niño events. (See activity *Ocean Variations During an El Niño*.)

In the longer term, the oceans play an important role in determining global climate. Discuss how data such as these can help scientists to better understand patterns and changes in global climate.

Links to Related CD Activities, Images, and Movies

Animation of *Earth in its orbit and the relationship to seasons*

Activity *Properties of Fresh Water and Sea Water*

Activity *Expansion of Water*

Activity *Coastal versus Inland Temperatures*

Vocabulary

equator	*heat capacity*	*latitude*
northern hemisphere	*obliquity*	*orbit*
rotational axis	*sea level*	*sea surface height*
southern hemisphere	*trade winds*	

Source

San Juan Institute / Orange County Marine Institute Activity Series.