Activity 1.4
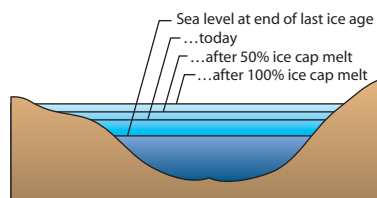
What if the ice caps melted?

Introduction

Global warming—a situation in which the Earth's mean temperature rises over long periods of time—is of great concern today. In this activity, you will examine the potential consequences of an extreme global warming event in which the Antarctica and Greenland ice caps melt.

1. What would happen if the ice caps melted? Speculate on how it would affect our land, economy, and society.

Sea level and melting ice caps

Sea level at end of last ice age
…today
…after 50% ice cap melt
…after 100% ice cap melt

Changes in sea level caused by changes in global ice caps (not to scale).

The change in mean sea level

To estimate the change in sea level that would occur if the continental ice caps melted, you will determine the volume of the ice caps and then calculate how that water would change the depth of the oceans.

2. In **Activity 1.2**, you determined the total volume of water in the ice caps (Table 2, page 9) and the total surface area of the oceans (Table 1, page 7). Write those values below. Include the units.

   a. Volume of water in ice caps =

   b. Surface area of oceans =

If the ice caps were to melt, their water would spread out across the surface of the oceans, raising sea level. The rise in sea level would actually increase the surface area of the oceans as water spread out on to what is presently dry land. To simplify this calculation, however, assume the change in the oceans' surface area is small enough to be ignored.

▸ Calculate the rise in sea level by dividing the volume of water in the ice caps by the total surface area of the ocean. To convert from kilometers to meters, multiply the result by 1000.

3. By how much would sea level rise if the ice caps were to melt?

Calculating sea level rise

Change in sea level =

$$\frac{\text{Volume of ice caps}}{\text{Surface area of oceans}}$$

How big is a meter?

A meter is about 39 inches—slightly more than 1 yard.

Effects of the rising sea level

Now that you have a rough estimate of the change in sea level due to the complete melting of the ice caps, you can examine the effects of a sea level rise on global land masses.

▸ Launch ArcView and locate and open the **gwater.apr** file.
▸ Open the **Melting Ice Caps** view.

This view shows the countries of the world and the boundaries of the ocean projected after a 10-meter, 30-meter, and 60-meter rise in sea level. The boundary for the 60-meter rise includes the 30-meter rise and the 10-meter rise.
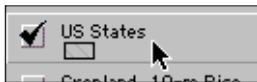
4. On the map below, indicate the two regions that would experience the greatest flooding from a 60-meter rise in sea level.
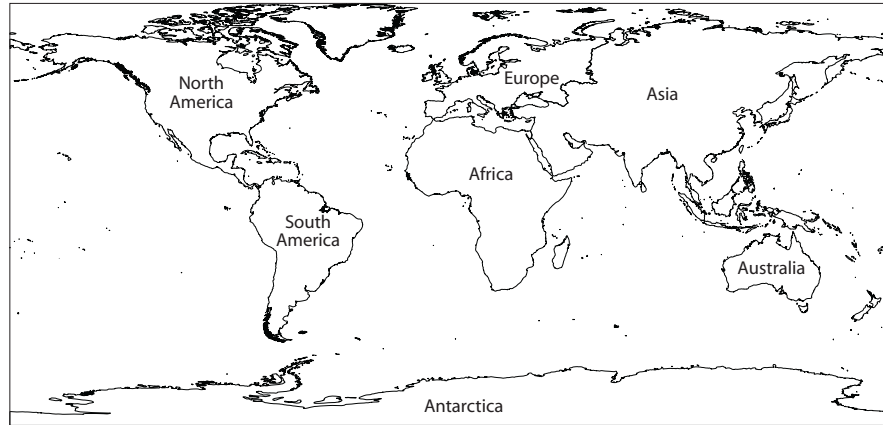
To turn a theme on or off, click its checkbox in the Table of Contents.
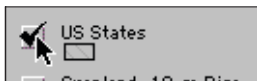
To activate a theme, click on its name in the Table of Contents. Active themes are indicated by a raised border.

Which state is that?

If you need help identifying states, make sure the **US States** theme is active and on. Using the Identify tool , click on a state and read its name in the Identify Results window.

▸ Use the Zoom In tool to zoom in on the contiguous 48 United States (excluding Alaska and Hawaii).

5. Near which U.S. coast (east or west) would you rather be living if the ice caps were to melt? Why?

▸ Turn on and activate the **US States** theme.

6. After a 60-meter sea level rise, which states are completely underwater?

▸ Choose **View ▸ Full Extent** to view the whole world.

▸ Turn off the **10-meter Rise**, **30-meter Rise**, and **60-meter Rise** themes and turn on the **Affected Population** theme.

The **Affected Population** theme shows the global population living within the region affected by a 60-meter increase in sea level. The theme consists of a number of rectangles, each of which is color-coded according to its population. Areas with fewer than 10,000 inhabitants are not shown.

▸ Use the Zoom In tool to explore the population data.

7. On which continents will the most people be affected by a 60-meter rise in sea level? How does this compare to your answer for question 4?

▸ Choose **View ▸ Full Extent** to view the entire map.

Next, you will estimate the total population affected, the total number of cities inundated by floodwaters, and the amount of cropland flooded if sea level were to rise 10, 30, or 60 meters.

Total flooded area

Determine the total area flooded for each rise in sea level, starting with the **10-meter Rise** theme.

▶ Turn on and activate the **10-meter Rise** theme.

▶ Click the Open Theme Table button 🖾 to open the **10-meter Rise** theme table.

▶ Click the **Area (km2)** field heading. The field name will be highlighted gray to show that it is selected.

▶ Choose **Field ▶ Statistics...**.

In the statistics window, the total area flooded is given as the **Sum**.

8. Record the total area in the **Total flooded area (km²)** column of Table 1. Round to the nearest 100,000 km².

Rounding

If you need a refresher on how to round, see the examples on page v.

**Table 1—Impacts of sea level rises of 10, 30, and 60 meters**

Sea level rise	Total flooded area (km²) *to nearest 100,000*	Total population affected *to nearest 100,000,000*	Number of cities flooded	Total cropland flooded (km²) *to nearest 100,000*
10 meters				
30 meters				
60 meters				

▶ Close the **10-meter Rise** theme table.

▶ Repeat the above steps to find the total area flooded by a 30-meter and 60-meter rise in sea level and record your results in Table 1. Be sure to activate the appropriate theme each time.

▶ When you are finished, close all theme table windows.

Affected population

Next, estimate the affected population in each of the flooded areas.

▶ Activate the **Affected Population** theme.

▶ Choose **Theme ▶ Select By Theme...**.

▶ Choose from the pop-up menus to make the dialog box read "Select features of active themes that **Intersect** the selected features of **10-meter Rise** (do *not* select "Cropland, 10-m Rise"), and click the **New Set** button.
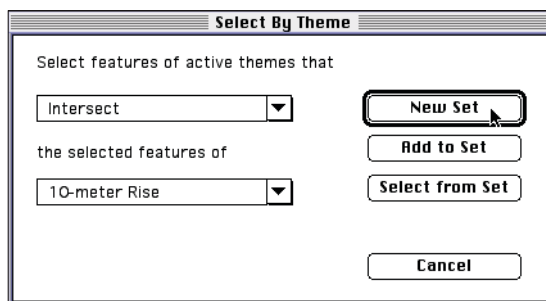
The densely populated areas that would be flooded by a 10-meter rise in sea level will be highlighted in the map.

▶ Click the Open Theme Table button 🖾 to open the **Affected Population** theme table.

▶ Click the **Population** field heading. The field name will be high-lighted gray to show that it is selected.

▶ Choose **Field ▶ Statistics...**.

The total number of people affected by a 10-meter rise in sea level is reported in the statistics window as the **Sum**.

9. Round the total population affected to the nearest 100,000,000 and record it in Table 1.

▶ Repeat these steps to determine the total population that would be affected by a 30-meter and 60-meter rise in sea level and record these totals in Table 1. Be sure to choose the appropriate theme in the lower pop-up menu of the Select By Theme dialog box.

▶ Turn off the **Affected Population** theme and close all theme table windows.

Flooded cities

Next, you will determine the number of cities affected by flooding.

▶ Turn on and activate the **Major Cities** theme.

The **Major Cities** theme includes cities with populations greater than 20,000, capitals, and small but geographically-important towns. The size of the circle represents the size of the city's population. Determining the total number of cities affected is similar to estimating the affected populations.

▶ Choose **Theme ▶ Select By Theme...**

▶ In the dialog box, set the pop-up menus so that the sentence reads "Select features of active themes that **Intersect** the selected features of **10-meter Rise**."

▶ Click the **New Set** button.

▶ Click the Open Theme Table button 🖾 to open the **Major Cities** theme table.

▶ Read the number of flooded cities in the status bar.

read number here

| | of | | selected |

10. Record the number of cities in Table 1.

▶ Repeat these steps to determine the number of cities flooded by a 30-meter and 60-meter rise in sea level. Be sure to choose the appropriate theme in the lower pop-up menu of the Select By Theme dialog box.

11. If sea level rose 10 meters, would a major city in your state be flooded? How might this affect you?

▸ Turn off the **Major Cities** theme.

Flooded croplands

Finally, you will determine the amount of cropland affected by flooding, using a series of themes that show the intersections between the flooding zones and the world's croplands.

▸ Turn on and activate the **Cropland, 10-m Rise** theme.

▸ Click the Open Theme Table button 🖾 to open the **Cropland, 10-m Rise** theme table.

▸ Click the **Area (km2)** field heading. The field name will be highlighted gray to show that it is selected.

▸ Choose **Field ▸ Statistics....**

The total area of cropland flooded by a 10-meter rise in sea level is given as the **Sum**.

12. Record the total area of cropland flooded in Table 1. Round to the nearest $100,000 \text{ km}^2$.

▸ Close the statistics window.

▸ Repeat the above steps to find the total area of cropland flooded by a 30-meter and 60-meter rise in sea level. Be sure to turn on and activate the appropriate cropland theme each time.

By themselves, these figures on area, population, and cropland affected by a rise in sea level are somewhat hard to assess. It is useful to compare the figures to the totals for each category and calculate the percentage of land, population, and cropland affected. These totals are given in Table 2 below.

Table 2—Global statistics

Total land area	$147,000,000 \text{ km}^2$
Total population	6,200,000,000 people
Total major cities	606 cities
Total cropland area	$23,000,000 \text{ km}^2$

Calculating percentages

To calculate percentages for Table 3, divide the value from the corresponding cell in Table 1 by the appropriate total in Table 2, and multiply by 100. For example, for a 10-meter rise in sea level:

% Land area affected =

$$\frac{5,400,000 \text{ km}^2}{147,000,000 \text{ km}^2} \times 100 = 3.67\%$$

Round to nearest 1% = 4%.

13. Use the totals provided in Table 2 to calculate the percentage affected for each category for a 10-, 30-, and 60-meter rise in sea level and complete Table 3. Round all results to the nearest 1%.

Table 3—Effects of rising sea level

Sea level rise	% Area affected	% Population affected	% Major cities affected	% Cropland affected
10 meters				
30 meters				
60 meters				

Plotting your results on graphs will help you interpret them. First, you will examine the relationship between the percentage of affected land area and the percentage of affected population.

14. On Graph 1, plot your results for the percent of population affected (on the vertical axis) versus your results for the percent of land area affected (on the horizontal axis). Connect your points with a smooth curve that passes through the origin of the graph (0% land affected, 0% of the population affected).

Graph 1—Effects of sea level rise on population and cropland
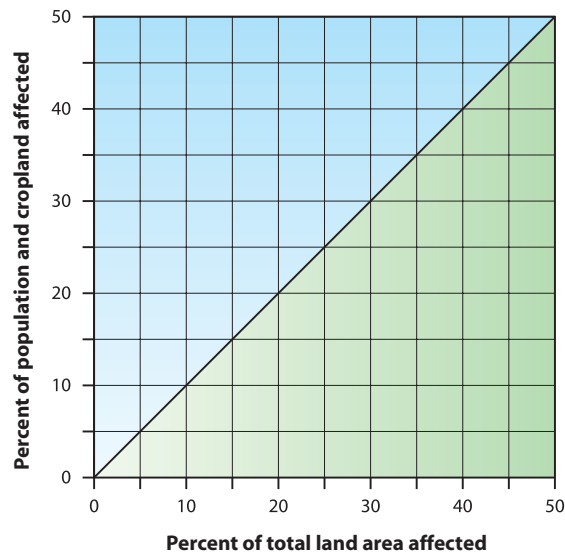
15. Plot the percentage of cropland affected versus the percentage of total land area affected on the same graph, using a dashed line.

The diagonal line divides the graph into two regions that show the relative strength of the effect of a rising sea level. Points plotted above the line (in the blue region) reflect a greater impact on people and cropland. Points plotted below the line (in the green region) reflect a greater impact on total land area.

16. Which is affected more strongly by a rising sea level, population or land area? What does this tell you about where people tend to live—near coastlines or in the interiors of continents? Explain.

Rising water and global population

The scenarios in this activity are extreme. A global rise in sea level of 1 to 2 meters is a more realistic hazard. You can use your data to construct a graph that will help estimate the effects of such a scenario.

17. On Graph 2, plot the percent of the world's total population affected versus the sea level rise. Connect your points with a smooth curve that passes through the origin of the graph.

Graph 2—Percent of population affected versus sea level rise
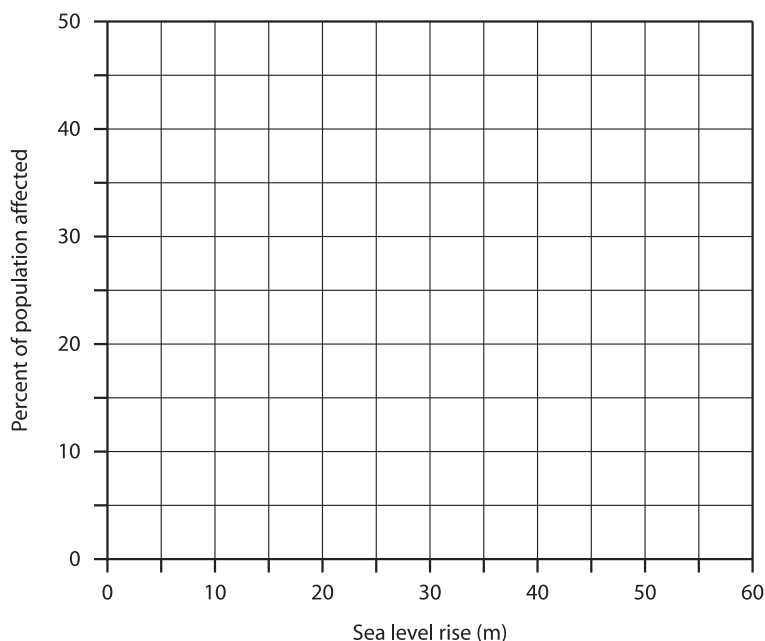
18. What percent of the world's population would be affected by a 2-meter rise in sea level? How about a 5-meter rise?

19. Are these scenarios of flooding a cause for concern? Explain.

Assessing the accuracy of your calculation

At the beginning of this activity, you estimated the rise in sea level due to the melting of the continental ice caps. One of the assumptions you made was that the change in the oceans' surface area was small enough to ignore. Later, however, you saw that the amount of land covered by the rising sea was quite substantial. In fact, in the 60-meter rise scenario, the amount of land covered by floodwaters is about half the size of the Atlantic Ocean. You can use this knowledge to refine your estimate of the rise in sea level.

20. What is the combined area of the oceans and the 60-meter flood-waters? (Refer to question 2b and Table 1 of this activity.)

    a. Surface area of the oceans =

    b. 60-meter flooded area =

    c. Combined area = (a) + (b) =

21. Calculate the rise in sea level that would occur if the continental ice caps melted completely, by dividing the total volume of water in the ice caps (question 2a in this activity) by the combined area (question 20c). Multiply the result by 1000 to convert from kilometers to meters, and round to the nearest meter.

This estimate for the rise in sea level is a lower limit; your original estimate is an upper limit. The actual rise in sea level would be somewhere between the two.