

## Chapter 35 – Antarctica: Researching Climate Change at the Coldest Place on Earth



### 1. Introduction

Antarctica is the coldest continent on Earth. The average temperature at the South Pole is  $-74^{\circ}\text{F}$ , a temperature at which spilled coffee can turn to ice before it hits the ground. No one lives year-round on this cold continent. Each summer, though, Antarctica warms up a bit, and during these few warmer months researchers from throughout the world travel to Antarctica to work.

Researchers come to Antarctica to study many things. One of the most important areas of research, however, is **global warming**, a term referring to a slow increase in the temperature of Earth's surface. **Climate** records for the past 25 years have shown a worldwide surface temperature increase of about  $0.4^{\circ}\text{F}$ . However, this warming has not occurred uniformly throughout the world. Some places are warmer, while others are cooler.

Many scientists believe that this warming relates to the **greenhouse effect**, a process that occurs when gases in the **atmosphere** prevent heat from Earth's surface from escaping into space. The trapped heat, the scientists believe, makes Earth warmer. Studies of ice bubbles trapped in polar ice show that amounts of **greenhouse gases** in the atmosphere are increasing, but not all scientists think that this increase explains Earth's warming. In fact, some aren't sure whether the planet is warming at all.

In this chapter, you will consider ideas about global warming and how it may be affecting Antarctica. You will also look at possible effects of global warming on the rest of the world.

### Essential Question

**How might global warming affect the environment in the world's coldest places?**

These two researchers are debating the theory of global warming. One believes that her research in Antarctica supports the theory. The other has doubts based on his research. Think about this debate as you try to answer the Essential Question.

### Graphic Organizer



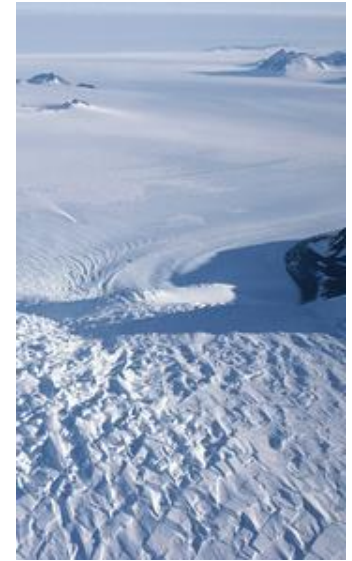
### 2. The Geographic Setting

Antarctica surrounds the South Pole, which is the southernmost point on Earth. This icy continent is larger than Australia or Europe. Almost all its land is buried beneath **glaciers**, and most of the Earth's fresh water is frozen here as ice.

**The Coldest Place on Earth** Antarctica can be unimaginably cold. On July 21, 1983, instruments in Antarctica registered a temperature of  $-129^{\circ}\text{F}$ , which is the coldest temperature ever recorded on Earth.

Why does Antarctica get so bitterly cold? As the most distant continent from the equator, it receives less sunshine than other parts of the world. On some winter days, the sun never even rises above the horizon. The small amount of **solar energy** that Antarctica does receive is mostly reflected by the vast expanses of ice back into space.

Antarctica also has the distinction of being the world's driest continent, receiving only about two inches of **precipitation** per year. Few living things can survive in such a cold, dry **biome**, or large **ecosystem**. Only two species of flowering plants grow on Antarctica, and no trees or shrubs. However, a variety of animals thrive in the waters surrounding the continent, including seals and whales, as well as penguins and many other kinds of birds.



Glaciers cover approximately 98 percent of Antarctica, with much of this ice measuring well over a mile thick. Moving flows of ice called **ice streams** slide across the surface of this **ice cap**, carrying ice from the center of the continent to the sea. Upon reaching the coast, an ice stream flows outward into the ocean. There it forms an **ice shelf**, or floating sheet of ice, that remains attached to the continent. The largest of these ice shelves, the Ross Ice Shelf, is roughly the size of France. In some places, the Ross Ice Shelf is up to 3,000 feet thick.

### ► Geoterms

**biome** a very large ecosystem such as a desert, forest, wetland, or grassland. Each biome is home to its own community of plants and animals.

**global warming** the gradual increase in the temperature of Earth's surface over time. This warming may be the result of natural causes. It may also be caused by human activity.

**greenhouse effect** the process by which gases in the atmosphere trap heat from the sun and keep it close to Earth's surface. This trapped heat may contribute to global warming.

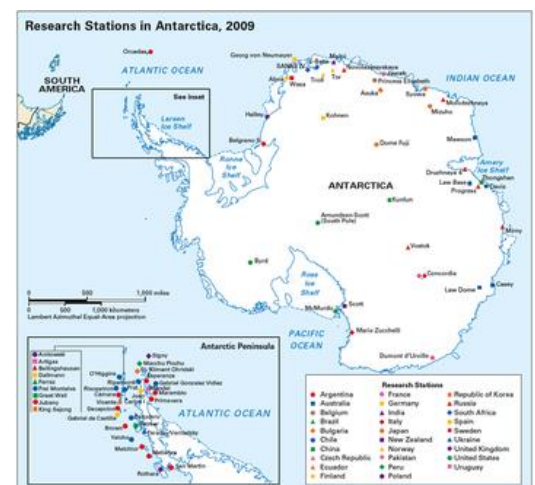
**ice shelf** a large, floating sheet of ice that is attached to the coast. Ice shelves can extend out to sea for hundreds of miles.

### A Continent Reserved for International Research

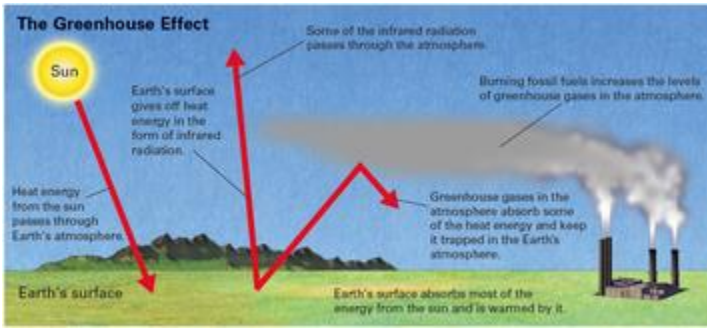
In 1978, a woman boarded a plane in Argentina and flew to a research station in Antarctica. While there, she gave birth to a baby boy. He was the first human being to be born on the continent, yet he could not be considered a citizen of Antarctica. That is because Antarctica has no country and no government.

In the past, seven countries have claimed various parts of Antarctica. In 1959, those countries joined with others to sign the Antarctic Treaty, in which the seven countries agreed to set aside any claims to the continent. The treaty stated that Antarctica, in order to promote international cooperation, should be reserved for peaceful activities such as scientific investigation.

More than 4,000 people travel to Antarctica every year to participate in scientific studies. Scientists find Antarctica a good place to do research for many reasons, one of which is that it is the least populated continent on Earth. This helps researchers see how Earth has changed over time without the influence of human activity.



Also, Antarctica's glaciers serve as historic records of climate change. Researchers drill deep into the thick ice and pull up samples called **ice cores**, which can be studied to learn what the climate was like as far back as 420,000 years ago. Researchers use this information to help understand the warming and cooling of Earth over time.



### 3. The Theory of Global Warming

In the past, Earth's climate has had both warm and cool periods. Changes from one period to another were caused by natural events. The last cool period ended about 12,500 years ago. Since then, Earth has been in a warm period. During the past 200 years, however, temperatures seem to have risen faster than usual. The theory of global warming tries to explain why the climate is heating up.

#### Three Key Ideas About Global Warming

The theory of global warming is based on three key ideas. The first is that Earth's climate is getting warmer. The second is that this trend, or change over time, is mainly caused by human activity, not natural causes. The third key idea is that global warming is harmful to people and many biomes. Because of this, many people believe it should be slowed or even stopped.

#### The Greenhouse Effect Keeps Earth Warm

Earth is kept warm by a natural process called the *greenhouse effect*. This process traps energy from the sun in our atmosphere. The atmosphere then acts like a giant greenhouse surrounding Earth. This “greenhouse” keeps Earth's average surface temperature at a warm 59°F. Without it, the temperature could drop to 0°F, or well below freezing.

The greenhouse effect works because of gases in the atmosphere. The most common greenhouse gases are carbon dioxide, methane, and water vapor. They trap heat from the sun in the atmosphere. Otherwise, this heat would escape into space.

Since around 1800, levels of greenhouse gases in the atmosphere have been rising. This increase is due mainly to people burning **fossil fuels** such as coal, oil, and natural gas. When these fuels are burned, they give off carbon dioxide. Many scientists believe that the increase in carbon dioxide and other greenhouse gases is causing Earth to warm. Others are not so sure.

#### 4. Support for the Global Warming Theory

Scientists who support the theory of global warming point to three kinds of evidence. The first is climate records. These records show rising surface temperatures in many places. The second is glacier records. They show that glaciers around the world are melting as temperatures rise. The third type of evidence is rising levels of greenhouse gases in the atmosphere. Studies of air bubbles trapped in polar ice show that greenhouse gas levels are the highest they've been in 420,000 years.

Supporters of the global warming theory trace these changes back to the start of the **Industrial Revolution**. During this time, many new machines were invented. Many were powered by the burning of fossil fuels.

Today we use coal, oil, and natural gas to heat our homes, run our cars, and power our factories. Because of this activity, we add more than 4 billion tons of carbon dioxide to the air every year. This gas will stay in our atmosphere for at least the next 100 years.

The results of global warming, these scientists warn, could have terrible consequences. Some biomes may lose plants and animals that are unable to adapt to warmer conditions. Crop failures may become common, leading to widespread hunger. Ocean levels may rise as polar ice melts. Higher seas may flood low-lying islands and coastal cities.

The best way to prevent these disasters, these scientists say, is to reduce activities that create greenhouse gases. This could mean difficult changes in the way many people today live.



## 5. Doubts About the Global Warming Theory

Not all scientists agree with the global warming theory. Some doubt that Earth's temperature is, in fact, rising at all.

Like supporters, the doubters support their views with evidence. They point out that temperature records of the upper atmosphere show little sign of warming. Most surface temperature records, they argue, come from urban areas. City buildings and pavement absorb more heat from the sun than green spaces. As a result, urban areas get warmer as they grow. What looks like global warming may just be city warming.

The doubters also note that not all glaciers are shrinking. Some are growing.

Some doubters accept evidence that Earth is warming. But they believe this is due to natural causes. Changes in the sun's energy or in ocean currents are far more likely to cause climate change, they believe, than human activity.

Finally, some doubters question whether rising temperatures will be so disastrous. People living in cold climates, they point out, might welcome warmer winters. Areas that are now too cold for crops might become productive farmland. Also, more carbon dioxide in the air may boost plant growth. The result could be faster growing crops and forests. This might be good, not bad, for many biomes.

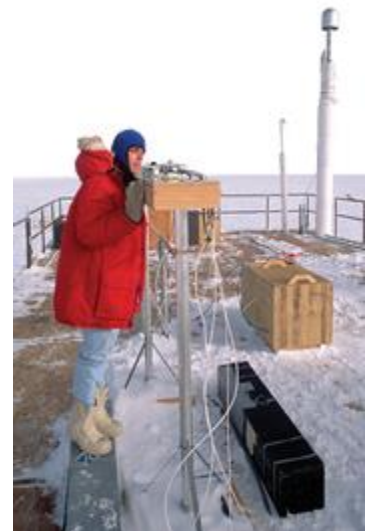
## 6. Studying Temperatures in Antarctica

The impact of global warming on Antarctica could be dramatic because warmer temperatures could cause glaciers and ice shelves to melt. If the area of the continent that is covered by ice shrinks, less energy from the sun would be reflected into space. As a consequence, temperatures would rise even more.

To find out whether such temperature changes are probable, scientists have been gathering data on air temperatures in many parts of Antarctica. They compare those data with records from recent years to identify any trends.

Researchers are also collecting information about Antarctica's climate from thousands of years ago. The snow that falls in Antarctica each year doesn't melt. Instead, it piles up in layers, which are thicker in wet years and thinner in dry years.

Researchers drill deep into glaciers to take out cores of ice, each of which looks like a very long pole with thin cross stripes. Each stripe, or layer, represents a year's snowfall. By examining these ice cores, researchers can learn what the climate was like when each layer of snow fell. They can determine how much precipitation fell and what temperatures were like for that year. The deeper they drill, the farther back in time they can explore.





## 7. Studying Ice Shelves in Antarctica

As you have read, ice shelves are floating sheets of ice that have remained attached to the continent. Ice shelves form approximately half of the coastline of Antarctica and more than a tenth of its surface area. Every summer, the edges of some Antarctic ice shelves break off to form [icebergs](#), which are large masses of ice that float around in the ocean.

Researchers in Antarctica study ice shelves to determine whether they are growing or melting. They also watch for large chunks of ice that break off and

float away. One way in which they monitor ice shelves is by placing cameras on satellites that orbit, or circle, Earth. These satellite cameras produce images of ice shelves as they form and break apart.

Researchers also spend time at observation posts on or near the ice shelves. From there, they can examine how seasonal temperature changes affect the ice shelves.

## 8. Studying Penguins in Antarctica

The Adelie is the most common penguin in this polar biome, with nearly 5 million Adelie penguins calling Antarctica home. Each summer, these penguins raise their young on the few areas of coastline that are not covered with ice.

Global warming could be harmful for Adelines. Warmer air can hold more moisture, which could lead to increased snowfall in Antarctica. If snow covers the few bare spots that Adelie penguins require for nesting, they might stop breeding.

Researchers are studying how many Adelie penguins return to their nesting grounds each year. They do this by taking a simple [census](#), which means counting the number of penguins that return to each nesting site. Researchers also try to track the birds' movements over the year by gluing transmitters on the penguins' feathers and using satellites to track the signals given off.

## Summary - Beginning to Think Globally

In this chapter, you learned that Antarctica is a very cold, remote place. Researchers visit Antarctica to study global warming by gathering information on air temperatures, ice shelves, and penguins.

Researchers don't always agree on the significance of their findings. For example, air temperatures are rising in some areas of Antarctica. This may be due to the greenhouse effect, but temperatures are falling in other areas. The significance of these temperature variations is unclear.

In recent years, researchers have observed enormous chunks of ice shelves break off to form icebergs. However, scientists aren't sure what is triggering the breakups or what impact the breakups will have on the polar biome.

Researchers have also observed changes in the penguin populations. There are far fewer Adelines in some areas than in the past, but other penguin species are increasing their numbers. Neither of these changes may be the result of global warming.

Most scientists connect global warming to increasing levels of greenhouse gases within the atmosphere. They argue that this rise is a consequence of human activity, especially the burning of fossil fuels. However, the use of fossil fuels varies significantly from country to country. Think about this as you examine the maps in the next section.

## Global Connections

The cartogram on the opposite page shows the total amount of greenhouse gases produced by countries throughout the world in 2004. Notice the size of the United States. The maps across the bottom show how global warming could impact three parts of the world. The maps show coastlines in each of these places as they appear today and how those coastlines would change if the polar ice caps were to melt.

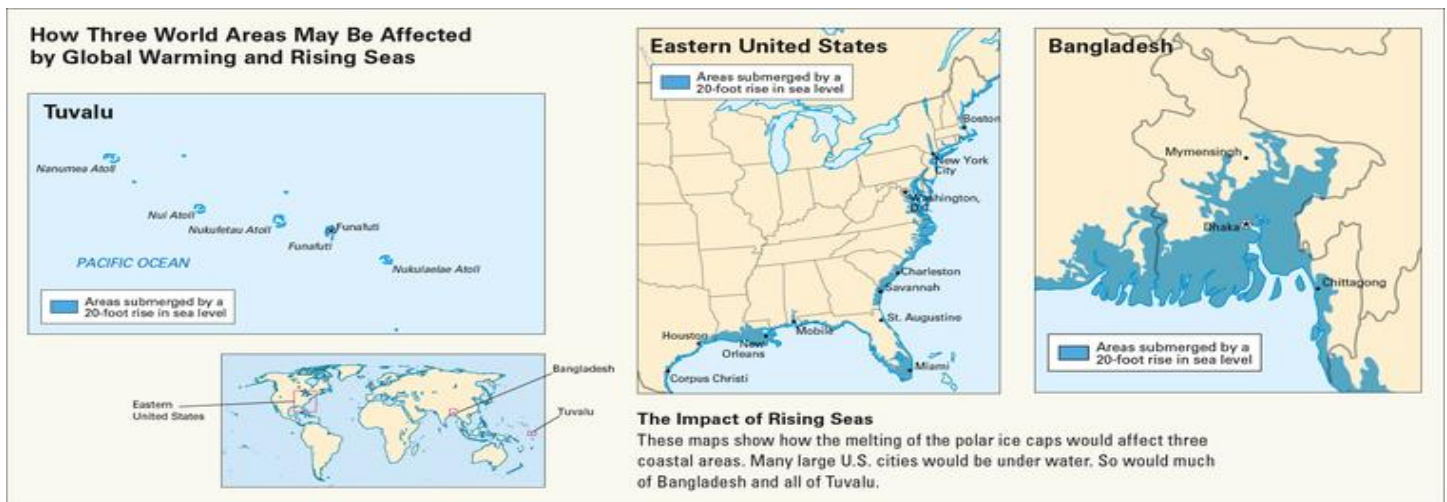


### How might rising sea levels be connected to greenhouse gases?

Greenhouse gases may cause surface temperatures to rise. As Earth warms, glaciers and ice shelves will melt, resulting in a dramatic rise in sea levels around the world.

### Are the countries that produce the most greenhouse gases the ones that will be most affected by rising sea levels?

The major producers of greenhouse gases are the developed countries, such as the United States and Canada. Such countries operate their factories and cars on fossil fuels. Poor developing countries such as Bangladesh and Tuvalu have little industry, but because they are at low elevations and relatively flat, they could be severely affected by rising sea levels.



### What can people do to reduce the greenhouse gases they add to the environment?

People can reduce their production of greenhouse gases by using less energy from fossil fuels. One way to do this is to drive cars that get more miles per gallon of gas. Another step is to use energy-saving fluorescent lights. Still another is to turn lights and televisions off when they are not being used. Each of these steps may seem small, but together they can add up to considerable greenhouse gas savings.