6 Changes All Around

In small groups, students examine the climate of countries in different environments. Students then predict what might happen to the climate of a particular country as the earth continues to warm.

Adapted from "Regional Effects of Global Warming" by Elizabeth K. Andre, Will Steger Foundation

Inquiry/Critical Thinking Questions

- How does climate differ in regions around the world?
- What are some common impacts of climate change?
- How might the climate in a particular country change as the earth warms?
- What are some ways that we can reverse, limit, and/or prevent damaging impacts of climate change on different environments?

Objectives

Students will:

- Examine the climate of countries in different world regions
- Consider the common manifestations of climate change
- Predict how a rise in average global temperature might impact countries in particular regions
- Explore how humans will be impacted by changes in their own environment and by changes in foreign environments
- Identify ways to prevent or mitigate the effects of climate change on different environment

Time Required

50 minutes (plus another 50 minutes for research, optional)

Key Concepts

- Regional climate features and variations
- Global impacts of climate change
- Climate predictions
- Interconnections

Subject Areas

- Social Studies (Geography, Global Studies, Contemporary World Problems)
- Science (Earth, Environmental, Life, Physical)

National Standards Alignment

National Science Education Standards (NSES)

- Standard A: Science as Inquiry
- Standard C: Life Science
- Standard D: Earth and Space Science
- Standard F: Science in Personal and Social Perspectives

National Council for the Social Studies (NCSS)

- Strand 3: People, Places, and Environments
- Strand 7: Production, Distribution, and Consumption
- Strand 9: Global Connections

Materials/Preparation

- Climate Impact Projections, 1 set per group of 2-4 students
- Regional Climate Summary, 1 per student group
- Climate Prediction Sheet, 1 per student group

Activity

Introduction

1. Ask students if they think climate change is different than global warming. Have them explain why or why not.
2. Have students review/brainstorm some common elements of climate change worldwide (e.g., changes in precipitation, rising sea levels).
3. Tell students that they are going to be making more specific predictions about climate change impacts for countries in different environments.

Steps

1. Divide students into groups of 2-4.
2. Hand out 1 Regional Climate Summary to each group. If students do not know the location of the region on their card, help them find it on a world map.

   Lesson Variation: Instead of using the Regional Climate Summaries, have students research information about specific countries using the CIA World Factbook (**http://www.cia.gov/cia/publications/factbook/index.html**), the United Nations Statistics Division (**http://unstats.un.org/unsd/cdb/cdb_list_countries.asp**), and World Climate (**http://www.worldclimate.com**). Students can find information about population, GDP, economic sectors, geographic features, climate trends, and signs of climate change, to help them predict climate impacts for their assigned country.

3. Give each group a Climate Impact Projections handout.
4. Give the groups 10-20 minutes to predict how the climate in their assigned region may change as the earth continues to warm. Have the group members read each of the Climate Impact Projections and then discuss how the general trend described might affect their region, using information from the Regional Climate Summary.
5. Have each group write their predictions on the Climate Prediction Sheet, and tell them to be prepared to share their predictions with the rest of the class.
6. Ask each group to give the class a short description of their region and its climate, as well as the group's predictions and how they reached these predictions.
7. When listening to the other groups, encourage students to think about how the impacts other students are predicting might affect the climate in their assigned environment.
8. Continue with the following reflection questions.

Reflection

1. Was it difficult to make predictions, even with the information and knowledge you had? Why or why not? What additional information or tools would be helpful in making more accurate climate change predictions?
2. How important do you think it is to make accurate projections about climate change in order to take steps to reverse, mitigate, or prevent climate change?
3. What kinds of connections did you discover between climate change impacts in your country and other countries? How might humans in your environment be impacted by climate change in other environments?
4. Are any environments impacted more (i.e., more sensitive or vulnerable to climate change) than others? What characteristics of these environments make them especially sensitive to climate change?
5. What are some variables that are likely to affect the rate of future climate change? (E.g., population growth, economic development, global equity, type, and efficiency of energy use.)
6. What actions do we take that contribute to the impacts of climate change on other environments? What can we do to mitigate the impacts of climate change on other environments?

Technology Extension

Have students examine computerized climate models from the Hadley Centre for Climate Prediction and Research: **http://www.metoffice.gov.uk/research/hadleycentre/models/modeldata.html**. One of the animated models shows predicted global temperature changes from 1870-2100. The other shows predicted sea ice coverage for the same time period.

Based on what they have learned about climate change predictions in this lesson, ask students to identify some of the uncertain variables that must have gone into these models (population growth, economic growth, measures to reduce greenhouse gas emissions, etc.). Have students imagine how these models would be altered by a change in these variables. Students can create drawings of these new "models" for specific time periods.

Action Project

Interview a climate witness. Collect oral histories from older relatives or community members. Ask them to explain how climate (temperatures, rainfall, long-term weather patterns) has changed during their lifetime. Document climate change in your community by combining these oral histories in a book to share with other community members. For more information, including a sample interview form, see the World Wildlife Fund's Climate Witness project, available at http://www.panda.org/climatewitness.

Additional Resources

Film

Rising Waters: Global Warming and the Fate of the Pacific Islands, directed by Andrea Torrice, 2000, 57 minutes, http://www.bullfrogfilms.com/catalog/rw.html. Through personal stories of Pacific Islanders in Kiribati, the Samoas, Hawaii, and the atolls of Micronesia, as well as researchers in the continental United States, this documentary film puts a human face on the international climate change debate.

Websites

- **http://www.panda.org/climatewitness**—Climate Witness is a World Wildlife Fund (WWF) initiative to document the direct experiences of people who are witnessing the impacts of climate change on their local environment. WWF works with scientists around the world who provide scientific background information to the climate witness testimonies.

- **http://www.npr.org/news/specials/climate/interactive**—On the Climate Connections: A Global Journey website, students can click on an interactive world map to read and hear stories from National Public Radio (NPR) related to climate change around the world.
- **http://green.nationalgeographic.com/environment/global-warming/gw-impacts-interactive.html**—National Geographic provides an interactive map with expected impacts of climate change in various regions. Students can click on specific locations on the map to learn about these impacts.

> Just as climate change does not affect all places in the same way, it does not affect all people in the same way, either.

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Climate Impact Projections

Increasing temperatures

THE GLOBAL AVERAGE TEMPERATURE IS projected to rise between 2.5 and 10.4°F (1.4 and 5.8°C) over the period 1990-2100. Temperatures will not rise equally everywhere, however. The centers of continents will warm more rapidly than land near the oceans. Landmasses in higher latitudes are also predicted to warm more than in lower latitudes (tropics). For example, the Arctic is projected to warm an additional 7.2-12.6°F (4 to 7°C), while tropical areas are projected to warm much less.

Consequences of higher temperatures may include the following:

- more heat-related deaths, especially in urban areas and among poor people
- fewer cold-related deaths in cooler climates
- decreased use of energy for heat (in cooler climates) and increased use of energy for air conditioning
- melting glaciers and permafrost (permanently frozen ground)
- later frosts, earlier spring plantings, and longer growing seasons in cooler climates
- reduced growing season and increased heat damage to crops in warmer and drier climates
- changes in ecosystems due to poleward shift of plant and animal species
- earlier spring migrations of birds and fish
- increased heat stress to wildlife and livestock
- increased risk of drought and forest wildfires
- increased susceptibility of trees and crops to pests
- shifts in tourist destinations

Changes in precipitation

WARMER TEMPERATURES ARE EXPECTED TO lead to changes in the water cycle, and global mean precipitation is expected to increase. However, it is difficult to predict how much the amount of precipitation will change in any given area. Certain regions will get more precipitation and others less. In general, areas in higher latitudes (closer to the poles) and closer to oceans may get more precipitation, while areas in lower latitudes (closer to the equator) and farther inland may get less. Areas in which there are already water shortages may have even less available water. While the frequency of precipitation may not increase, the intensity of precipitation (or amount of precipitation per event) is expected to increase. As a result, precipitation in many areas may come in extreme events, causing flooding and erosion.

Consequences of changes in precipitation may include increased stress on flood insurance systems and government disaster relief systems, increased damage to plants and crops, increased risk of forest fires, and recharged floodplain aquifers (natural underground water storage areas).

Increasing evaporation

EVEN THOUGH CLIMATE CHANGE MAY increase the total amount of precipitation that an area receives, increased heat will cause increased evaporation. If the rain comes during the winter or wet season and the heat comes in the summer or dry season, the land may dry out.

This may cause increased desertification and drying-up of lakes and rivers, decreased crop yields, decreased water resource quantity and quality, and increased risk of forest fires.

Warmer oceans

GLOBAL OCEAN HEAT CONTENT IS expected to continue to increase. Most of the increase will happen near the surface of the ocean.

The temperature differences between the oceans, the atmosphere, and land creates winds and atmospheric circulation patterns such as the jet stream. Because oceans do not warm up as quickly as air and land (due to the capacity of water to absorb heat), the difference in temperature between sea and land is expected to increase, causing a higher likelihood of strong winds, storms, and unpredictable weather events. Hurricanes get their energy from energy stored in the ocean in the form of heat. As more energy in the form of heat accumulates in the oceans, hurricanes can get more intense.

Warming oceans are likely to cause bleaching of coral reefs, as a result of the algae living in the reef dying. Coastal communities that rely on fish and other marine animals living around these coral reefs will be affected. Communities that rely on aquaculture (the raising of fish in enclosures floating in the ocean) may have difficulty if waters become too warm for the type of fish they are raising, or if the warmer water makes diseases and toxic algal blooms more common. The warming of the oceans is also a major cause of rising sea levels.

Shorter and milder winters

IN AREAS WITH TRADITIONALLY COLD winters, the hard frosts kill off insect pests, and the accumulated snow melts slowly during the spring to recharge groundwater and feed streams. Often these areas rely on snow and ice to draw winter tourists for activities like skiing, snowmobiling, dogsledding, and ice climbing.

Warmer winters would enable more insect pests to survive. This could threaten local communities of living things. Also, less snowpack that melts earlier means that less water might be available in the spring and summer, when plants need it most. Areas with winter tourism would also suffer from reduced ice and snowpack.

Spreading disease vectors

AS THE CLIMATE WARMS, DISEASE vectors (things that carry disease) like mosquitoes and ticks will be able to extend their ranges. At the same time, climate change may increase waterborne pathogens (microorganisms that cause disease), decrease water and air quality, and decrease the amount and quality of available food in some regions. These effects will be most severe in developing countries and among the poor.

Rising sea levels

SEA LEVEL WILL CONTINUE TO rise as a result of global warming. Part of this rise is due to thermal expansion of the oceans (as water gets warmer, it becomes less dense and takes up more space), and part is due to melting glaciers and icecaps. Scientists have so far been unable to predict precisely how much and how quickly the oceans will rise because there are so many variables, including how much glaciers will melt, how much sea water will expand, and how ocean circulation patterns will change. Projections for sea level rise by the year 2100 range from 4 inches (10 centimeters) to as high as several yards/meters (if ice sheets begin to disintegrate). Rising sea levels will make low-lying coastal areas, deltas, and small islands at risk for flooding and erosion. Some very low-lying islands and other areas may need to be evacuated.

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Regional Climate Summaries

Region #1: Maldives

THIS ISLAND NATION, LOCATED IN the Indian Ocean about 435 miles (700 kilometers) southwest of Sri Lanka, is smaller than one-tenth of the U.S. state of Rhode Island and is home to almost 300,000 people. The Maldives holds the record for being the flattest and lowest nation. Its highest natural elevation is 7.5 feet (2.3 meters) above sea level, although in certain areas the land has been constructed to be somewhat higher. The Maldives is composed of twenty-six atolls, which are low-lying coral islands, and 1,192 islets (200 of which are inhabited by people). Islets are mounds of broken coral and other reef detritus (waste) that stick out of the water in shallow lagoons.

The December 2004 Tsunami almost completely flooded the Maldives with waves of up to 5 feet (1.5 meters) high. The tsunami killed at least seventy-five people and the devastation from the waves left many people homeless. After the tsunami, the shape of the islands had changed and maps of the country had to be redrawn.

The two major industries of the Maldives are tourism and fisheries. Each year, around half a million tourists visit the Maldives. Fisheries employ about one-third of the country's citizens. Other industries such as shipping, banking, and manufacturing are growing.

The Maldives has the highest per capita GDP (gross domestic product, which is one way that economists measure wealth) of all the nations in South Asia. The Maldives GDP is about US$4000 per person per year.

Region #2: Norway

THE SCANDINAVIAN NATION OF NORWAY is approximately the size of the U.S. state of New Mexico and is home to 4.6 million people. Norway is a long and thin country with a very long coastline bordering five bodies of water (North Atlantic Ocean, Barents Sea, Arctic Ocean, North Sea, and Norwegian Sea). The northern part of Norway is north of the Arctic Circle. More than two-thirds of Norway is covered in rugged mountains. Several major glaciers occupy the central mountain plateau.

The moderating influence of the oceans and the Gulf Stream make the climate in coastal Norway quite temperate, considering how far north it is. Temperatures in the capital, Oslo, average 61 degrees Fahrenheit (16.4 degrees Celsius) in the summer and 24 degrees Fahrenheit (-4.3 degrees Celsius) in the winter. The climate farther inland and to the north can be more severe.

In recent decades, however, Norway has been experiencing warmer temperatures. The average temperature in Norway over the last fifteen years has been 1.8-4.5 degrees Fahrenheit (1-2.5 degrees Celsius) warmer in January and 0.9-1.8 degrees Fahrenheit (0.5-1 degree Celsius) warmer in July.

The economy of Norway is based on petroleum and natural gas exports, forestry, fishing, mining, and hydroelectric power. Less than 3% of the land in Norway is arable (able to be cultivated with crops).

Region #3: Iowa

THE U.S. STATE OF IOWA is located in the upper Midwest and home to almost 3 million people. The upper Midwest has a continental climate, which means that it is far away from the temperature-moderating influence of the oceans. Winters are cold, with daytime temperatures as low as 0 degrees Fahrenheit (-18 degrees Celsius). Summers can get very hot, with daytime temperatures over 100 degrees Fahrenheit (38 degrees Celsius).

Iowa's main industries are agriculture, manufacturing, and insurance. About 90% of the land area in Iowa is used for farming. Iowa leads the nation in the production of pork, corn, soybeans, and eggs. Iowa is also the country's largest producer of corn-derived ethanol (a fuel). Iowa also produces beef, dairy, sheep, and honey.

Iowa receives an average of about 33 inches (84 centimeters) of precipitation per year. The months of April through October receive the most rain. This relatively regular rainfall, especially during the growing season, means that it has traditionally been possible to grow crops in Iowa without irrigation, although some farmers do irrigate.

The Mississippi River forms the eastern border of Iowa, and the Missouri River forms the western border. From May through September of 1993, heavy rains caused record flooding on the Mississippi, Missouri, and numerous other major rivers in the upper Midwest. The flood caused billions of dollars in damages in what was one of the worst natural disasters in United States history.

Region #4: Southern California

THE SOUTHERN QUARTER OF THE U.S. state of California is home to around 24 million people and includes the second largest metropolitan area in the United States (encompassing Los Angeles, San Diego, and neighboring cities) as well as the surrounding desert. Coastal areas in southern California are home to unique ecosystems.

Southern California has a diversified economy that includes the service industry, entertainment, tourism, technology, construction, manufacturing, finance, insurance, real estate, and trade, as well as agriculture and fishing. Southern California leads the nation in production of fruit and vegetables such as broccoli, carrots, onions, tomatoes, lettuce, almonds, strawberries, oranges, and flowers. These crops depend on irrigation (the agricultural Imperial Valley averages less than 3 inches (7.6 centimeters) of rain per year and the San Joaquin Valley averages less than six inches (15.2 centimeters) of rain per year, making them both deserts. With irrigation, however, the land can produce two crops a year and is a major source of the nation's fresh produce during the winter.

Securing and distributing enough water to the large human population in southern California is a challenge for this region.

Parts of southern California are moist enough to allow trees to grow but are still dry enough that forest fires are a common occurrence. With frequent winds fueling the flames, wildfires in southern California can be intense. Wildfires can destroy the vegetation that previously prevented erosion. When intense rains come after wildfires, they can sometimes trigger landslides and flash floods.

Region #5: The Republic of Chad

CHAD IS A LAND-LOCKED nation in Central Africa and larger than the U.S. states of Texas and California combined. It is home to about 9.7 million people, 80% of whom rely on subsistence farming and raising livestock. Chad's main exports have, until recently, been cotton, cattle, and chewing gum. Beginning in 2003, Chad began to export petroleum, and its petroleum exports have been growing rapidly since then, doubling the country's GDP (gross domestic product, one way that economists measure wealth) to about US$1000 per person per year. Chad is one of the poorer countries in the world.

Chad is far from the ocean and gets little precipitation. Only 3% of the land in Chad is arable (able to be cultivated with crops). Chad has frequent droughts, persistent hot and dry winds, and frequent locust plagues (insects that destroy crops).

Lake Chad, which is on the border of Chad and neighboring Cameroon, was once the second largest lake in Africa. In the past several decades, however, Lake Chad has shrunk by 90%. Lake Chad doubles in size during the rainy season.

The only two important rivers in Chad are in the southwest of the country and flow into Lake Chad. The low-lying plains in the Lake Chad Basin get enough rainfall during the rainy season to allow agriculture without irrigation. Daytime temperatures in this region range from around 80 degrees Fahrenheit (27 degrees Celsius) to around 104 degrees Fahrenheit (40 degrees Celsius).

The center of the country is arid plains inhabited by mostly nomadic people (people who, instead of living in permanent housing, move frequently to follow livestock or desirable weather conditions).

The northern part of Chad is desert and receives only trace amounts of rain. Daytime temperatures in the northern desert range from around 90 degrees Fahrenheit (32 degrees Celsius) in the coolest months to around 113 degrees Fahrenheit (45 degrees Celsius) in the hottest months.

Region #6: The Amazon River Basin

THE AMAZON RIVER BASIN COVERS about 2.7 million square miles (7 million square kilometers) in eight different South American countries. The climate is warm and humid with an average daily temperature of almost 80 degrees Fahrenheit (26.6 degrees Celsius) and an average annual rainfall of around 80 inches (203 centimeters). There is little seasonal temperature variation in the Amazon basin.

There is typically no dry season in the Amazon River Basin. The basin often floods between June and October. This wet climate supports the Amazon rainforest, the largest rainforest in the world.

The main channel of the Amazon River is usually between one and six miles wide and navigable by large steamers as far as 900 miles (1450 kilometers) upstream of its mouth. This river is an important means of transportation for people along its length.

Beginning in 2005 and continuing through 2006, however, the Amazon experienced an extreme drought. The river dried to a trickle in many places, stranding boats and stressing ecosystems.

Climate Prediction Sheet

GROUP MEMBERS _____

COUNTRY NAME _____

INSTRUCTIONS: Based on the information you have about the climate in your country and the Climate Impact Projections reading, answer the questions below to predict how global climate change might affect your country.

Remember that these are just your predictions, and not right/wrong answers!

1. At what time of year might precipitation come? In what form? How much?

2. Might part of your region be affected by droughts? Floods?

3. Might the area be affected by storms? What kinds of storms, and where?

4. Would shorter and milder winters affect the area? If so, how?

5. Might the area be affected by rising sea levels? If so, how?

6. How would the production of food or other crops be affected?

7. What concerns might the area have related to diseases? Agricultural pests?