Bringing Climate Change Into The Classroom

ARM Education Program

North Slope of Alaska

2002

ARM Atmospheric Radiation Measurement Program

What is ARM?

The Atmospheric Radiation Measurement Program (here, “radiation” means sunlight and radiant heat) is the largest global climate change research program supported by the U.S. Department of Energy. The ARM Program has data collecting sites in three very different places in the world: the Tropical Western Pacific (Australia, Papua New Guinea, and Nauru), in the Southern Great Plains of the U.S. (Oklahoma and Kansas), and on the North Slope of Alaska (Barrow and Atqasuk). Scientists gather and use the data from these sites to study the effects of sunlight, radiant heat, and clouds on temperature, weather, and climate.

At each ARM site, data is collected, and this data is then used to evaluate and improve the Global Climate Models – large computer programs that simulate how the entire earth’s atmosphere and oceans behave. By having ARM sites in very different locations from the Tropics to the Arctic, we can learn how to improve the accuracy of the models over the whole surface of the earth.

What is ARM Education?

The ARM Education Program is involved in climate change educational outreach in the communities and regions hosting the ARM Program’s data-gathering field sites. The goal of the education program is to develop basic science awareness and increase critical thinking skills by focusing on environmental science and climate change for K-12 students. In addition, the program supports relationship building between teachers, students, scientists, and the community.

The ARM Education Program complements the ARM Program scientific efforts by supporting ARM Program objectives and using ARM data to enrich students’ science programs. Each site is different, and the education program staff is committed to incorporating the regional culture into the education program materials that are being developed

Planned activities for the program include teacher in-service days, community and teacher workshops, Internet projects, educational kiosks, curriculum development, site tours, and support for teacher enrichment activities.

Bringing Climate Into The Classroom

Key Ideas

Students will:
- Understand the greenhouse effect and how it works.
- Investigate how sea ice affects the atmosphere.
- Understand the concept of “climate change”.
- Understand that people are adaptable.
- Consider the potential effects of climate change in the Arctic.

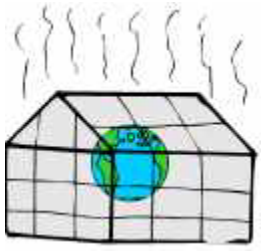
Background Information on Climate Change

What is Climate Change?

The surface temperature of our earth depends on a process called the heat budget. This budget, like any other type of budget, remains balanced if the amount of energy coming in equals the amount going out. If the energy balance is disrupted, then the result would be a change in temperature. Ice ages occur when the energy going out exceeds incoming solar energy; global warming occurs when the incoming solar energy is greater than the energy going out. Clouds play a major role in the heat budget. Clouds act as both a block to solar energy coming in as well as an insulator trapping heat below.

An indication of climate change would be a gradual shift in the earth’s average surface temperature. Locally, annual temperatures might fluctuate due to differences in weather systems from one year to the next. On a global scale, however, those local fluctuations are canceled out and the earth’s average temperature should remain the same. But global average temperature, currently 57^{o} F (14^{o} C), has risen almost 1 degree over the last century. Some scientists predict that temperatures will rise another 2 to 6 degrees over the next century!

The Greenhouse Effect



Greenhouse gases are atmospheric gases (including CO_2, water vapor and aerosols) that trap heat given off by the Earth. As a result they enhance global warming much like a greenhouse gardeners use to shield their plants fomr the outside weather. Greenhouses trap solar energy and keep the inside warmMany of these gases occur naturally on our earth and are essential to life on earth by providing a blanket of warmth for marine and terrestrial organisms. Without them, temperatures on earth would be too cold. However, when the concentrations of these gases become too high, they may make the earth much too hot and contribute to global warming. Many scientists believe that human activities have been changing the concentrations of these gases since the start of the industrial revolution, around 1850.

Causes of Climate Change

Since the start of the industrial revolution, human activities have caused a steady increase in the concentration of some greenhouse gases to unprecedented levels in our Earth's recent history. Human activities release large amounts of carbon dioxide, methane, and nitrous oxide from the burning of fossil fuels (e.g., oil, gas and coal) from industrial activities, landfills, agricultural practices, and many other processes. By adding more greenhouse gases to the atmosphere, we increase the atmosphere's capacity to trap heat, therefore making the whole planet warmer. Human activities that contribute to climate change include disruptions to natural ecosystems, such as deforestation, overuse of water, burning of fossil fuels, and increased pollution.

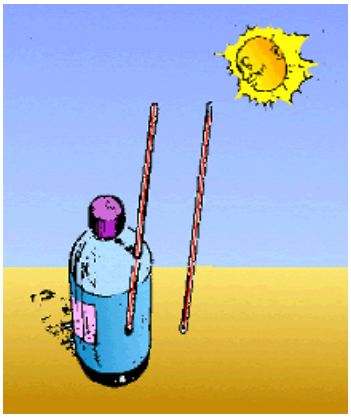
Greenhouse Gases

Greenhouse gases may be described as

Long-lived which means they are stable, and last many years in the atmosphere.
Well-mixed which means they are evenly distributed in the atmosphere.

Most greenhouse gases are both long-lived and well-mixed. They include carbon dioxide, methane gas, oxides of nitrogen, and halocarbons. Ozone is long-lived but is found in higher concentrations in cities, especially in the northern hemisphere. Therefore, it is not well-mixed. Water vapor is actually the most dominant greenhouse gas, but it is neither well-mixed nor long-lived. Because of this, its overall effect on global warming is the least understood. Water vapor is important because it is necessary for the formation of clouds. Water vapor is one of the greenhouse gases we need to learn more about to study its impact on global warming. The ARM Program is designed to gather data from our three field research sites is providing us with some important information about how water vapor affects climate change.

Activity 1: Make Your Own Greenhouse



Objective: The objective is to make your own small greenhouse and to test its effect on temperature.

Materials:
Plastic bottle
Nail
2 thermometers
If sunlight is not available, you will need a heat lamp to simulate the sun.

Important Points to Understand:
In cool climates greenhouses are used to control the environment of plants so that they can grow in a season or in an area where they would not normally grow. Do you know anyone in your community who

uses a greenhouse to grow plants in the summer? Try to visit a greenhouse and see how its environment is different to that outside.

Procedure:

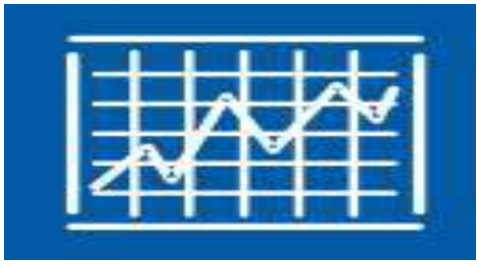
1. Make a hole near the top of the plastic bottle with the nail and insert one thermometer.
2. Place the second thermometer next to the bottle.
3. Make sure that the same amount of sunlight reaches both thermometers.
4. Record the temperature values from both thermometers after 10 minutes or so.
5. Take the temperature records again after another 10 minutes. Repeat a few times.

Questions:

1. Do both thermometers record the same temperature?
2. If the answer is No for the previous question, which one is higher?
3. Can you explain why these two temperature records are not the same?
4. Can you give a similar example to demonstrate the greenhouse effect in our daily life?

Activity 2: Historical Climate Statistics

Objective: The object of this activity is to demonstrate the concept of climate change at a sample locality where the historical temperature records are available.



Materials:
Graph paper
Ruler
Pen and pencil

Important Points to Understand:

- Scientists have evidence that the global climate has changed in the past and is subject to natural changes even before the idea of enhanced greenhouse gases.
- Global temperature is gradually changing according to the long-term temperature records.
- There are no accurate predictions of what will happen to the Earth's climate with an increase in greenhouse gases.

Preparation:
Before the activity, try to explain that the climate system is very complex. Scientists have been using a combination of mathematical models, the geological record of past climates, meteorological records and theories on the global atmospheric and oceanic circulation to provide an estimate for past, current, and future values.

The information in the following table shows the average winter temperature in central England from 900-1900 AD.

Year	**900**	**950**	**1000**	**1050**	**1100**	**1150**	**1200**	**1250**	**1300**	**1350**	**1400**
Temp (º C)	3.45	3.55	3.62	3.69	3.58	3.69	4.12	4.09	4.05	3.81	3.63

Year	**1450**	**1500**	**1550**	**1600**	**1630**	**1700**	**1750**	**1800**	**1850**	**1900**
Temp (º C)	3.46	3.65	3.5	3.21	3.18	3.38	3.55	3.47	3.66	3.97

Procedure:

1. Plot on graph paper, time on the x axis and temperature on the y axis.
2. The period 1550-1700 in Europe is known as the Little Ice Age. Can you see evidence for this?
3. What can you say in general from the whole plot?
4. Can you explain why the temperatures in the plot are much warmer than the temperatures on the North Slope?

Extension for older students:

How far back is there recorded average temperature data for the North Slope of Alaska? A good student research project would be to try to find this out. Have students talk to their community members, the National Weather Service, NOAA, or do research on the web.

Background Information: Impacts of Climate Change in the Arctic

The Arctic is one of the planet's most extreme environments. It has extreme temperatures, limited sunlight and precipitation, and a short growing season. The ecosystems in the Arctic are all quite sensitive to change. Sea ice, snow cover, glaciers, tundra, permafrost, boreal forests, and peatlands all respond to small changes in sunlight, surface temperature, ocean heat transport, air and ocean chemistry, and pollution in the atmosphere.

The ARM Program does climate change research in the Arctic in order to help make global climate models more accurate. These models currently show that climate change in polar regions will most likely result in changes in the extent of sea ice, increased thawing of permafrost, and melting of polar ice masses, which will cause societal impacts around the globe.

Changing Weather and Climate

Alaska is vulnerable to climate change, and Alaska's climate is expected to change as global temperatures rise. Climate trends over the last three decades have shown considerable warming. This has al-

ready led to major impacts on the environment and the economy. Subsistence livelihoods in the Inupiat communities on the North Slope depend on fish, marine mammals and other wildlife, and play a very important social and cultural role. Arctic residents and scientists report many changes in recent decades such as a decrease in the predictability of weather, increases in lightning and thunder, changes in wind, stormis, and other weather variables. The changes in the weather and climate are beginning to impact Arctic ecosystems, and these large-scale changes are bound to greatly affect communities on the North Slope.

Changing Ecosystem

Arctic ecosystems are known to have complex interrelationships between species and their physical environment. As a result, climate-induced changes that affect one part of a species life cycle can have wide-reaching effects on the ecosystem as a whole. First, a warming climate will cause a shift toward the pole of ecosystems and their associated animals. For example, the current northern treeline, shrubs, and associated plants will move north over the tundra. This will have major impacts on biological resources. Warming also causes considerable thawing of permafrost. This will lead to changes in drainage, increased bank slumping, and altered landscapes over large areas. All of these effects will disrupt current vegetation, ecosystems, water balance, and human structures. Warming might increase biological production in the Arctic ecosystem, but this may lead to different species composition on the land and in the sea. In the sea, marine ecosystems will move poleward, and animals dependent on ice may be disadvantaged. The melting sea ice will cause changes in salinity in the Arctic Ocean which will have an impact on marine life and on water circulation. Human communities in the Arctic will be affected by these physical and ecological changes. The effects will be particularly important for indigenous peoples leading traditional lifestyles.

Sea Ice

Sea ice off the Barrow coast.

Sea ice covers a vast area in the Arctic Ocean, about 7.5 to 15.0 million kilometers. This permanent ice pack covers the North Pole and is always moving and decreasing and increasing in area throughout the year. This cover of sea ice over the ocean greatly effects the interaction of energy exchange between the ocean and the atmosphere, absorption and reflection of sunlight, and the ability to support marine life within the Arctic Ocean. Sea ice plays a major role in global heat balance. Higher temperatures in our atmophere may cause the area of ocean covered by sea ice to reduce. In the summer, this would allow increased absorption of solar radiation, or sunlight, at the ocean surface. This will cause a further increase in atmosphere and ocean temperatures, which will then further reduce ice cover. This is known as the “sea ice albedo temperature positive feedback loop.” In the winter, leads and cracks in the sea ice allow heat flow from the relatively warm water to the much colder atmosphere, which also causes a warming of the atmosphere. Since the early 1970’s satellites have observed a steady decline in the Arctic sea ice cover, and scientists

are studying whether global warming is the force that is driving this reduction in sea ice. So, as you can see, small changes in sea ice can cause big changes in the polar climate, which affects the global climate!

Activity 4: Melting Sea Ice

Objective: The goal of this activity is to teach the students about the insulating properties of sea ice and what happens to the atmosphere when the sea ice is gone.

Materials:
Thermal cups, such as styrofoam or coffee mugs
Thermometers (digital thermometers work best)
Boiling water
Lid for one of the cups (You can make a lid out of styrofoam)

Introduction:
Did you know that in high latitudes, such as the Arctic, sea ice keeps the ocean warm and the atmosphere cold? Sea ice acts like an insulating blanket that helps to slow the loss of heat from the relatively warm ocean to the much colder atmosphere. When sea ice melts, or leads and openings occur in the sea ice, ocean heat flows into the atmosphere. This in turn affects regional climate and has the potential to affect long-term climate change! A warmer atmosphere causes more sea ice to melt, which in turn creates a warmer atmosphere.

Leads and openings in the winter sea ice only take up a small percentage of the sea ice area. However, it is estimated that half of the total heat transfer from the ocean to the atmosphere in the winter occurs at these ice openings. Scientists say that the sea ice is the most important factor in heat exchange at high latitudes. Also, studies have shown that older, thicker sea ice is a much better insulator than young ice. Because different types of ice vary in their insulating abilities, it is important to know how much of each type is present.

What happens when sea ice responds to our warming atmosphere by melting? Sea ice is important to the overall energy balance of the Earth because it covers so much of the ocean in winter (it typically covers about 14 to 16 million square kilometers in late winter in the Arctic and 17 to 20 million square kilometers in the Antarctic's Southern Ocean). When enough sea ice melts, this can change our atmosphere's temperatures both locally and globally.

Procedure:

1. Take your two thermal cups and fill them ¾ full with boiling or almost boiling water (Depending on the age of the students, teachers may want to handle the water). The water in these cups represents the ocean in the Arctic.

2. Place a thermometer in each of the cups and make a lid for one of the cups that can fit around the thermometer. Make sure you make a lid out of material that provides insulation, such as Styrofoam. The lid on the cup represents sea ice over the ocean (Note: Make sure your thermometers go up to a high enough temperature so they do not break).

3. Measure the temperature in each of your cups every 10 -15 minutes for one to two hours. Make a data sheet to record your data.

Example data sheet:

Time:	**9:00am**	**9:15am**	**9:30am**	**9:45am**	**10:00am**	**10:15am**
Ocean with sea ice (cup w/ lid)	**(temperature)**					
Ocean with no sea ice (no lid)						

4. Create a graph with this data showing how the temperatures change over time. This is a great way to practice graphing using your own data and comparing numbers visually! See our lesson on "Learn How to Graph" at http://www.arm.gov/docs/education/lessons/gettingstarted/learn2graph.pdf.

Questions:

1. What did you observe happen in each of your cups? Why did this happen?
2. What does the boiling water represent?
3. When heat was transferred out of the "ocean," where did it go?
4. How does sea ice help to make the air cool?

Other Related Classroom Activities:

Students who live along the coast can invite a local elder to speak to the classroom about sea ice. For example, elders can relate stories of traveling over the sea ice, speak of the marine mammals that live on and under the sea ice, and teach about the different types of sea ice.

Activity 4: Adapting to Survive

This lesson is an introduction to Native Alaskans of the past. In order to survive, humans have always had the same basic physical needs such as food, shelter, and companionship. The physical characteristics of the land determine in large part how we satisfy those needs, and as the Earth changes we must adapt to survive.

Objective:

The objects of this lesson are:

1. To increase the student's knowledge of climate differences in the different regions of Alaska.
2. To increase the student's awareness of the relationship between the physical characteristics of the land and the ways in which people adapted in that area.
3. To increase the student's awareness of the importance of traditional knowledge.

Materials:

Map of Alaska

Use of computers with access to the Internet

Books, magazines, textbooks with information on the different regions of Alaska and on Native Alaskan peoples that are from each region.

Introduction:
Climate plays an important role in determining the physical characteristics, ecosystem, and vegetation of a region. People everywhere have to adapt to the physical environment around them in order to survive. This was especially true in the past, before all of the modern conveniences we have today. Think about the skills needed by Native Alaskan people in the past when basic needs such as food, clothing, and shelter were determined by what people found in the natural world around them.

Lesson 1: Climate
Looking at a large map of Alaska, point out the 5 different regions in Alaska, the Southeast, the Aleutian Chain, the Interior, the North Slope, and the Western region of Alaska. Discuss differences in climate, weather, and environment in these regions. Discuss with the class how climate can affect the environment. Have the students tell you what they know about each region.

Suggested Websites:
http://climate.gi.alaska.edu/change/regions.html
http://tqjunior.thinkquest.org/3878/
http://www.wrcc.dri.edu/narratives/ALASKA.htm

Suggested Readings:
The Great Alaska Nature Factbook. Alaskas Geographic Regions, pages 9-15
Alaska Almanac, Regions of Alaska

Teachers: Have the students do research using either textbooks or the Internet. Have them first find out what climate is, and then research and discuss how it affects the different regions in Alaska. What are the ecosystems in these 5 regions like? What are the differences between these 5 regions? Have your students:

1. Write a paragraph on climate. What is climate? What are some basic facts about climate vs. weather?
2. Write either a short paper or give a presentation to the class on the differences in climate in the 5 Alaskan regions (Teachers, as an alternative you can break the class into 5 groups and have students from each group research one of the 5.)

Lesson 2: Traditional Knowledge
How did people who lived in these regions in the past adapt to survive? Every society in the world has evolved useful and fitting adaptations to the surrounding environment. Adaptions are how cultures are created. Discuss ways in which Native Alaskan people took objects they found in the natural world and made things that were necessary for survival such as tools, home building materials, and clothing. Discuss some of the differences of living and surviving that Native Alaskan people used in each of these 5 regions.

Other Related Classroom Activities:
1. Have students write a paragraph about how they would use their natural surroundings to survive. What did people eat? What would they use for shelter? Clothes?
2. Invite an elder from your community into the classroom to talk about some of the traditional knowledge useful for survival in the area.

To find out more about climate change, visit these web sites:

- Atmospheric Radiation Measurement (ARM) Project: **www.arm.gov**
- EPA Global Warming site: **http://www.epa.gov/globalwarming/**
- Institute of Global Environment and Society: **http://grads.iges.org/**
- NSF Polar Reserch: **http://www.nsf.gov/home/polar/start.html**

For climate change teaching resources, visit these websites:

- ARM Education Program's Education Center: **www.arm.gov/docs/education**
- ARM Education Lessons: **http://www.arm.gov/docs/education/tlessons.html**
- Oklahoma Climatological Survey Weather Series Lessons: **http://k12.ocs.ou.edu/teachers/lessons/default.html**
- Atmospheric Visualization Collection lessons: **http://avc.comm.nsdlib.org/cgi-bin/wiki.pl?Atmospheric_Visualization_Collection**

References:

Atmospheric Radiation Program: http://www.arm.gov
National Science Foundation: http://www.nsf.gov/od/lpa/news/publicat/nsf0050/arctic/seaice.htm
Center for Global Change and Arctic System Research: http://www.cgc.uaf.edu/
Arctic Climate System Study: http://acsys.npolar.no/impplan/sea%20ice.htm
National Snow and Ice Data Center: http://nsidc.org/sotc/sea_ice.html