Atmospheric Radiation Measurement
Climate Research Facility
U.S. Department of Energy

# Climate Education Update

NEWS AND INFORMATION ABOUT CLIMATE CHANGE STUDIES FOR TEACHERS AND STUDENTS

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The Department of Energy's Atmospheric Radiation Measurement (ARM) Climate Research Facility supports education and outreach efforts for communities and schools located near its sites. The mission of the Education and Outreach Program is to promote basic science education and community awareness of climate change research by focusing on three goals: student enrichment, teacher support, and community outreach.

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## Global research community gathers for International Polar Year

*by Dr. Hans Verlinde, ARM Scientist*

In the last year, the subject of climate change at the two poles has been in the news more than ever before. Ice cover in the Arctic is decreasing in extent and area; icebergs are breaking off Antarctica because of thinning ice shelves; permafrost is melting in Alaska, causing ground heaving and destroying roads and houses; bird migratory patterns are changing; and polar bears are becoming cannibalistic. Communities in the Arctic are being forced to relocate as a result of increased coastal erosion from unusually strong storms and more open seas. While there is much discussion about climate change observed in the Earth's highly populated mid-latitudes, there are drastic changes taking place in the Polar Regions, almost entirely out of the public's eye. Alaska, Siberia and the Antarctic Peninsula are the regions of the Earth with the fastest observed warming over the last several decades. In the Arctic as a whole, defined as the area north of 60°N, warming has proceeded at a rate about twice that of the global average.

*The sun sets over the Arctic Ocean off the coast of Barrow, Alaska.*

Scientists do not fully understand the enhanced climate sensitivity at the two poles. Global climate models have difficulty reproducing the current

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Arctic climate, and differences between climate projections from various climate models is much larger in the Arctic than other regions of the Earth. For example, the forecasted Arctic summer ice cover ranges from almost no change at all compared to today, to a perennially ice-free Arctic toward the end of this century. Much of this uncertainty is the result of an incomplete understanding of the many physical processes involved. To address these uncertainties, many nations from around the world are making plans to participate in the **International Polar Year (IPY) 2007–2008**, a period of intense, coordinated observations at the two poles.

## Seeing the big picture

Much of the current scientific knowledge of physical processes in the Arctic and Antarctic resulted from previous IPYs (1882–1883 and 1932–1933) and the International Geophysical Year (IGY) in 1957–1958. These observational periods focused mostly on the physics of the polar atmospheres and oceans, and resulted in greater understanding of polar meteorology and oceanography and the role Polar Regions play in Earth's climate. IPY 2007–2008 will have a wider scope of research than the previous IPYs to include biological, ecological and social science elements, and will strongly emphasize interdisciplinary studies. In the spirit of previous IPYs, broad international participation will allow scientists to look beyond national borders, while the interdisciplinary focus transcends traditional disciplinary borders, leading toward a comprehensive polar system analysis.

Why the new interdisciplinary focus? Scientists realize that changes in climate impact all the Earth's systems, resulting in many changes that interact in complicated, sometimes unexpected ways. Climate change forces ecological changes, which forces biological changes, which forces social changes. Some processes can accelerate the changes and others can counteract them. Think about a possible scenario in the Arctic: changes in the Arctic water cycle due to melting surface ice and/or precipitation will impact plant communities. This will change the way Arctic soils preserve carbon dioxide and methane, and the total mass of atmospheric greenhouse gases will be impacted. The resulting global consequences may include the acceleration of melting surface ice.

It is often difficult to think on a global scale, so for right now, concentrate just on the complicated picture unfolding in the Arctic itself. Scientists initially assumed increased melting would be a major implication of warmer temperatures. But ice is highly reflective, so decreases in polar ice cover means an increase in the amount of solar radiation absorbed at the surface of the Earth in a cloudless atmosphere as less solar radiation is reflected back to space. The characteristics of the clouds in the sky also play an important role in the puzzle; clouds offset the increase in absorption by allowing less sunlight to reach the surface. On the other hand, increased cloudiness in winter will lead to greater warming at the surface because the clouds prevent energy radiated from the surface to escape to space, and may slow the rate at which sea ice forms, which will make the sea ice and Greenland ice cap more susceptible to summer melting. More fresh water from melting ice in the Arctic and changing temperature differences between the equator and the poles will have profound impacts on both atmospheric and oceanic circulations, reducing the amount of energy transported from the equator to the Arctic. Could this reduction in energy transport into the Arctic overwhelm the current observed

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*A watchful Iñupiat whale hunter stands at the edge of the sea ice in Barrow, Alaska. Native Alaskans observe that climate change has impacted traditional whale hunting. More information about this can be found in the ARM kiosk at the Iñupiat Heritage Center in Barrow.*

## Teacher's Notes

Scientists who keep a close watch on climate change are concerned about the global impacts of melting polar ice. A significant consequence of melting ice is sea level rise and the possibility of flooding in low-lying coastal communities. However, scientists are less concerned about melting icebergs than melting glaciers. Why? First, the majority of an iceberg is under water, so sea level doesn't rise significantly as icebergs melt. On the other hand, glaciers are on land, so as they melt into the oceans, sea level is increased more significantly. Furthermore, the loss of land ice is more concerning because it changes the way solar energy is reflected and absorbed by the surface of the earth. While heat from the sun is reflected equally by ice on land and ice on water, land tends to retain the heat longer than water. As a result, the loss of ice on land is more significant because sunlight that had previously been reflected by ice will now be absorbed by land. As the planet absorbs more heat, the temperature rises, causing more melting. The end result may be a warmer planet with greater potential for rising sea levels.

To begin this lesson, ensure that students are familiar with the following terms:

**Glacier** – a large body of ice that moves slowly over the land, changing its surface
**Iceberg** – a large ice mass floating in the sea
**Sea level rise** – an occurrence that could take place as a result of rising global temperatures and the melting of glaciers and icebergs

Ask students if they think the consequences of melting land and sea ice are the same or different. Students should write down what they think to be the correct answer along with any information or facts they may know to support their opinion. Then lead the students in the following demonstrations to further their understanding of the differences between melting land and sea ice.

### When Floating Ice Melts in the Sea (demonstration 1)

**Objective**
The objective is to investigate effects on sea level caused by the melting of floating ice as a result of climate change.

**Materials**
Each student or group of students will need the following:

- Container
- Water
- Ice cubes

**Important Points to Understand**
We may think that, with the melting of icebergs, more water will be present the oceans and cause a rise in sea level. However, floating ice in the ocean does not raise the sea level significantly when it melts.

**Procedure**

1. Place the ice cubes in the container.
2. Gently fill the container with water until it is almost overflowing.
3. Watch the water level as the ice melts.

**Questions**

1. Does the water overflow when ice melts?
2. Do you think that melting icebergs will make the sea level rise?
3. Do you have any reason to support your answer in question (2)?

# When Land Ice Melts (demonstration 2)

**Objective**

The objective of this activity is to demonstrate what happens when land ice (glacier) melts and how it is different from the effect of melting icebergs.

**Materials**

- A big rectangular container
- Piece of wood (approximately 5 centimeters x 15 centimeters)
- Ice cubes
- Water

**Important Points to Understand**

- The Arctic and Antarctica are covered with large, heavy sheets of ice. Other islands like New Zealand have ice masses in the form of glaciers on them.
- When land-based ice melts, more water flows into the sea and sea level rises.
- The land on which the ice previously rested also rises when the load is removed.
- Icebergs in the ocean are broken off bits of land ice.

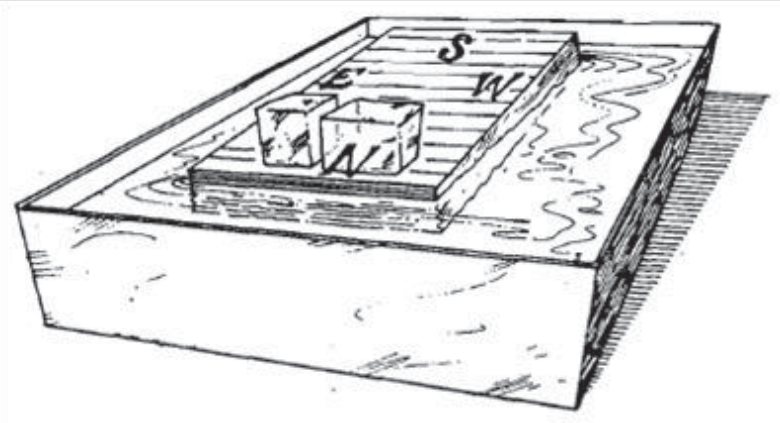
**Preparation**

Try to explain what happens to the continents (land) that are floating on the earth's molten core when they are relieved of their heavy burden of ice load.

An increase in elevation of the land is an isostatic response to the removal of the ice load that had depressed the land.

**Procedure**

1. On the surface of the wood, mark the points of the compass north, south, east, and west.
2. From north to south across the surface, draw lines (east to west) at 1-centimeter intervals.
3. Along the north and south edge, mark lines at 2-millimeter intervals.
4. Fill the container with water and place the wood in the water.
5. Put one or two ice cubes on the north edge of the floating wood.
6. Watch and note the level of water in the container and on the north and south edges.




**Questions**

1. What happens to the water level in the container?
2. What happens to the north and south edges of the block of wood as the ice melts?
3. Do you think melting glaciers and other land-based ice masses will make sea level rise?
4. Will it submerge the continents on which the ice used to be?

warming? Most scientists think the warming will continue, but with lingering uncertainties, the conclusion is not yet concrete.

## ACRF: An "anchor" for the 2007–2008 IPY

The complete plan for the IPY is still in flux as scientists from various nations decide what they will do and how they will cooperate. However, it is clear that research in the Arctic will build around existing monitoring facilities, such as the **A**tmospheric **R**adiation **M**easurement (ARM) **C**limate **R**esearch **F**acility (ACRF) site in Barrow, Alaska. Barrow is located at the northernmost point in the United States, 330 miles north of the Arctic Circle in an area known as the North Slope. This location was chosen for an ACRF site because of the Arctic's particular sensitivity to climate changes, and it will be one of the anchoring points during the IPY. ARM scientists focus their research on how solar radiation is transferred through the atmosphere; a significant component of the research is the role of clouds and other aerosols.

*The ARM Climate Research Facility's "Great White" instrument shelter was installed in Barrow in 1997. The Sky Deck, surrounded by yellow rails, was added to support additional instrumentation. ARM has a second research facility in Alaska located approximately 70 miles south of Barrow in the city of Atqasuk.*

*ARM technicians Jimmy Ivanoff (top) and Walter Brower (bottom) work on radiometric instruments at the ARCF site in Barrow.*

In addition to the ACRF site, Barrow hosts research centers from other agencies, thus making Barrow the premier location for Arctic interdisciplinary research. Data resulting from ARM's research on the North Slope provides critical information to other programs. For example, ARM data of incident solar radiation (the amount of solar radiation striking a surface per unit of time and area) would be useful to scientists studying plant activity. In turn, other programs provide information on the ways various Earth systems influence how the atmosphere interacts with solar radiation. Recent technological developments such as satellites, unmanned aircraft and molecular biology techniques provide new opportunities to obtain Arctic measurements. The detailed knowledge of processes learned at a highly instrumented site such as Barrow will allow scientists to interpret Arctic measurements in terms of processes. The result will be improved global climate models. The upcoming IPY offers new and exciting opportunities for ARM scientists and others from around the world to understand the various changes to the environment and the subsequent consequences. What can be more interesting…and more important? ■

*Dr. Verlinde is an observational atmospheric scientist interested in understanding the physical processes in clouds. He is the ARM Site Scientist for the ACRF sites on the North Slope of Alaska. Dr. Verlinde is working to achieve a better understanding of Arctic cloud processes and how those relate to the rapidly changing Arctic environment.*

## News Notes

Surround by the Pacific Ocean, the Republic of Nauru is a small island inhabited by people who have a keen understanding of the importance of weather and climate. Coastal erosion, drought and rising sea level are only a few concerns Nauruans have related to climate change, and now they have a new forum for expressing those concerns and educating future generations about the delicate balance that exists between the ocean and atmosphere. On November 8, 2006, ARM Education and Outreach staff installed the *Climate Change: Science and Traditional Knowledge* kiosk that was developed specifically for the community of Nauru. More than 30 students, along with their teachers, attended the official launch of the kiosk at the departure lounge of the Nauru Airport.

Beginning in 2003, ARM Education and Outreach interviewed elders and community leaders about their observations of climate change on the island. Several scientists from the ARM Program and Australian Bureau of Meteorology were interviewed to provide scientific information about climate and the research they are doing on Nauru. All this information was compiled into a touch-screen kiosk and translated into Nauruan, the native language of the people of Nauru. The primary purpose of the kiosk is to encourage students to take an interest in learning about weather and climate, and to promote awareness of the research ARM is doing on the island.


*The newly installed kiosk gets a thumbs up from Nauruan students.*

Mr. Baron Waqa, Minister of Education in Nauru, attended the official launch in support of the kiosk. "ARM has had a presence in our schools for many years," Mr. Waqa said, "I hope the working relationship continues." ARM Education and Outreach presented Mr. Waqa with four computers for classroom use.

Elders who attended the opening were presented with certificates of appreciation for their contributions to the kiosk. TWP Site Manager Larry Jones thanked the Nauruan government for its ongoing support of ARM's research on the island.

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