The Albedo Effect & The Warming of the Arctic

Summary

Students will explain how color affects the ability of a material to reflect light and absorb heat. They will explain how less sea ice (and more dark ocean water) in the Arctic could raise Arctic and global temperatures.

Materials

For each student team:

- desk light with 150 watt bulb
- 2 pieces of construction paper, one black and one white
- 2 thermometers or digital temperature probes
- stapler
- 2 photographs of sea ice in the Arctic

Vocabulary

- albedo
- solar radiation
- sublimation
- sea ice
- glaciers
- ice caps
- ice sheets
- feedback

Background for Teachers

The Arctic and Antarctic function as natural air conditioners for the Earth. Warm ocean currents carry heat from the tropics to the poles where the waters are then cooled. Following changes in temperature, density, and salinity, the waters continue along a complex conveyor belt system of ocean currents aided by the wind and deflected in direction by the Coriolis effect -- the influence of the Earth's rotation on moving bodies of air and water. These major ocean currents impact our weather and climate in ways scientists are still trying to fully understand.

One reason the polar regions remain cold is because much of the sunlight shining on an ice- or snow-covered surface is reflected back into the atmosphere, resulting in less heat being absorbed by the underlying land or water. Ice reflects 30-40% of any solar radiation it receives, and fresh snow can reflect as much as 75-95%. Water, which is darker, typically reflects only 2-10% and absorbs the rest as heat. The amount of light reflected by a surface is expressed as a percentage and is called the "albedo". Some clouds have an albedo as high as 90% which makes Earth appear bright when observed from space.

Much has been reported about a recent decrease in sea ice in the Arctic. Sea ice forms directly over water in contrast to glaciers, ice caps, or ice sheets that form over land. A large body of water covered with lots of sea ice will reflect much of the sunlight striking it and absorb far less solar radiation than ice-free waters. Sea ice helps maintain the cold temperatures of the underlying water and can serve as a platform from which certain Arctic animals can hunt for food. The ocean bottom can support entire ecosystems of marine organisms. Data collected by satellites show that the area of the Arctic's summer sea ice has shrunk about 15-20% since the late 1970's. Radar has been used to measure its thickness and shows a thinning of almost 40% in certain regions. A continued loss of sea ice could result in warmer Arctic waters which could impact global ocean currents. Changes in the currents could impact weather and climate in ways scientists might not be able to predict. It could also

significantly impact Arctic food webs. On the other hand, there are those who believe there could be positive economic benefits, at least for some. An Arctic Ocean free of summer sea ice would open shipping lanes, resulting in shorter travel time and distance and possibly encourage more Arctic tourism.

Because of the thickness of the East Antarctic ice sheet, and the fact that it sits atop a true continent rather than an ocean, scientists are currently somewhat less concerned about a warming of this region. The West Antarctic ice sheet, however, has many areas which are grounded *below* sea level. If processes similar to those occurring in Greenland resulted in the loss of the West Antarctica ice sheet, sea level rise becomes a huge problem that would affect coastal regions globally. Researchers continue to monitor Antarctica from space and through surface observations, in some of the most challenging and important science campaigns of the present IPY.

Instructional Procedures

Show the students a dark T-shirt and a white T-shirt. Ask them which they would prefer to wear on a hot, sunny day. Which one would help them stay cooler and why?
Introduce the concept of "albedo." On winter days when large areas are covered with a blanket of snow, the albedo of the snow can cause it to persist. Snow reflects away solar radiation so less heat is available to cause it melt or "sublime" (a phase change from solid directly to gas without first becoming a liquid.) Air temperature near the ground is lower if the ground is covered with snow.
How does the albedo of sea ice help maintain cold Arctic Ocean temperatures? What impacts would a loss of sea ice have on ocean temperature? What impact might this also have on Arctic Ocean currents?
Download NASA's albedo animation.
Procedure

- Cut each piece of construction paper in half and fold into pockets
- Staple three sides of each paper pocket making one black paper pocket and one white paper pocket
- Place the bulb end of a thermometer or digital temperature probe into each pocket
- Place both paper pockets approximately 12 inches under the desk lamp
- Ask the students to develop a hypothesis as to whether the white pocket or black pocket will get warmer when exposed to the direct light
- Turn on the lamp and record the temperature on each thermometer or probe every 60 seconds for 10 minutes
- Graph the data and compare the results
- Show the students two photographs of sea ice in the Arctic Ocean
- Tape the thermometer or probe under a light colored area on one photograph and under a dark colored area on the other
- Repeat the steps of the previous demonstration

Extensions

- Research what has happened to sea ice in the Arctic over the past five years. Suggested website: Sea Ice Yearly Minimum 1979-2007
- Based on your observations during the demonstrations, what changes might you expect in Arctic temperatures if a loss of sea ice continues? Why?
- Using a light meter measure the amount of light reflected off the surfaces of various colors and brightness. If you live in a region which gets snow, measure the amount of sunlight reflected off snow and compare it to spots on the ground that are not covered by snow.

Bibliography

Adapted from:

"Forces of Change, Arctic: A Friend Acting Strangely, Smithsonian"
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