Climate Change - I'm Supposed To Know What That Is?

Light Up Your World

Adapted from Reflecting on Reflectivity, http://www.climatechangenorth.ca

Overview:
Students often confuse global warming and the depletion of atmospheric ozone. They believe that the hole in the ozone layer allows more solar radiation to come through (which in effect is true), which heats up the planet (which is not). This activity focuses on how changing the albedo of a surface changes how solar radiation works on the planet and how it may effect surface temperatures.

Objectives:
1. TSW investigate the effects of albedo on a variety of different surfaces.
2. TSW analyze the relationship between the albedo of a surface and how much heat is absorbs an releases.
3. TSW assess how changes in a surface's albedo may have a significance to climate change.

Background: (from "Reflecting on Reflectivity", http://www.climatechangenorth.ca)

Planetary albedo is the ratio between incoming and reflected radiation at the top of the atmosphere. This includes effects of reflection from the atmosphere, mainly clouds, and surface albedo. On average 24% of incoming radiation is reflected by low altitude clouds and water vapor, and ozone in the stratosphere. Low clouds reflect most sunlight and have little effect on the energy reflected by the earth, helping to cool the current climate. In other words, low clouds do not trap energy that is headed for space. While higher temperatures are the result of high clouds that reflect less radiation and trap more emitted energy. **Changes in the atmosphere can alter climate by changing the amount of solar radiation that reaches the Earth's surface.**

Cloud Overcast	% of incoming radiation reflected
Cumuliform	70–90 %
Stratus (500–1,000' thick)	59–84%
Altostratus	39–59 %
Cirrostratus	44–50 %

Surface albedo is the ratio of incoming radiation to reflected radiation where the atmosphere comes in contact with Earth's surfaces (the boundary between earth surface and the atmosphere). Reflectivity is the capacity of an object to reflect solar radiation. It depends o radiation wavelength and the physical composition of the object. Soil reflectivity varies because of variations of moisture content, particle size, organic matter content, surface roughness, and mineral composition. Vegetation reflectivity varies with how much of the ground it covers, leaf size and area and plant growth stage. Snow reflectivity varies with crystal size, compaction, age, and liquid water content. Water reflectivity is affected by turbidity, depth, and concentrations of small aquatic plants called phytoplankton. Water albedo is lowest when the sun is near zenith and increases to near 100% when the sun is near the horizon. Here are samples of some of Earth's surface albedos in percentages.

Water Surfaces

Winter:	
0° latitude	6
30° latitude	9
60° latitude	21
Summer:	
0° latitude	6
30° latitude	6
60° latitude	7

Bare Areas & Soils

Snow, fresh-fallen	75–95
Snow, several days old	40–70
Ice, sea	30–40
Sand dune, dry	35–45
Sand dune, wet	20–30
Soil, dark	5–15
Soil, moist gray	10–20
Soil, dry clay or gray	20–35
Soil, dry light sand	25–45
Concrete, dry	17 –27
Road, black top	5–10

Natural Surfaces

Desert	25–30
Savanna dry season	25–30
Savanna wet season	15–20
Meadows green	10–20
Forest deciduous	10–20
Forest coniferous	5–15
Tundra	15–20
Crops	15–25

Albedo varies with geographic region and time of year since snow and ice are generally highly reflective. The temperature difference between the Tropics and the Poles is the driving force behind the circulation of the Earth's atmosphere and oceans, thus creating winds and ocean currents that carry excess heat and moisture.

When the moisture encounters cooler temperatures as it moves to the poles, clouds form and reduce the emission of energy to space. Any change in surface albedo will alter climate by drastically changing the amount of solar energy absorbed by the planet.

When the angle of the sun to the surface is low (closer to the horizon), solar energy is less intense since it is spread out over a larger area. Changes in this angle are one of the controlling factors that that make latitude one of the strongest influences on climate. The other controlling factor is the length of day. For latitudes of 66.5* and above, the length ranges from zero during winter solstice to 24 hours during summer solstice. The Equator has a constant 12-hour day all year long. The seasonal range of temperature therefore decreases from high latitudes to the tropics.

Human Effects On Earth's Albedo

Suggestions have been made that human modifications of the Earth's surface may be altering the planet's albedo. It has been said that overgrazing in desert regions can increase surface albedo as much as 20%. It has also been estimated that such changes may suppress rainfall, which can enhance the process of desertification. And again it's possible for extensive deforestation in tropical rain forests to increase surface albedo and result in a major climatic change.

Materials:

Small boxes
Black construction paper
Adhesives (tape, glue, etc)
Scissors
Data loggers that can measure light (and temperature) Recommend HOBO Data logger from Onset Corp. (http://www.iScienceProject.com)
Thermometers to measure temperature (if not included with data loggers)

Concepts:

albedo
reflectivity
absorption
solar radiation
feedback loops

Lesson Sequence:

Engagement:

Present your students with a question about the nature of global climate change. If the world is heating up, where is all of this extra heat coming from? One of the answers that is often given by students is that the extra radiation is the result of the hole in the ozone layer. Explain that in this activity students will be gathering data on the how much light different surfaces reflect or absorb as we try to understand where this extra heat is coming from.

Exploration:

Building the Instrument

Pose the student with the problem of designing an instrument which will accurately measure the reflectivity and temperature of different surfaces given the materials available (cardboard boxes, construction paper, adhesives, scissors, thermometers, etc). The students should take into account the variables which may affect the ability of the data logger to accurately measure the reflectivity of the surface and should plan accordingly. If you have not used the data loggers previously in the classroom, take time to explain how the data logger collects information. Divide the students into groups of three. Have each group create a design and then approach the teacher for approval before beginning construction.

Measuring Reflectivity

With their reflectivity measuring instruments, have the student groups decide how they will record the measure of reflectivity of different surfaces (i.e. How long will they measure the reflectivity? How will they move from one location to the next so they know which is which? etc.). Have the as a classroom decide on what surfaces they should measure reflectivity. What about the temperature of the surfaces? Have the students create a log sheet and then begin their data collection outdoors.

When the students have finished their data collection outdoors, have them bring their data loggers back to the classroom and download the data to computers for analysis. Students should use their log sheets to record the differences in reflectivity of the different surfaces, determine the average lumen rate for the surface and the temperature recorded at that surface. This data should be graphed and used when the class comes back together.

Explanation:

When all of the students have completed the analysis of their data, have the class come back together and have the students share their results. They should have found that lighter surfaces have a much higher reflectivity than do darker surfaces. However, temperature readings may vary on the surfaces, especially on the plant covered surfaces. Ask the students why this might be?

Launch an explanation of the albedo effect, the reflectivity of the earth's surface, and different types of solar radiation (See background information). This will allow you to introduce the idea that the hole in the ozone layer has nothing to do with climate warming. Have the students discuss what the reflectivity of different surfaces on the planet might be like (Arctic Ice, Sahara Desert, tropical rain forest, city, etc). How might the reflectivity of these different surfaces effect the surface temperatures of the planet? What if some of these conditions changed (for instance the gradual melting of the Arctic ice cap is of great concern, as is the loss of tropical rain forest)? How does the data that they collected relate to this?

Evaluation:

Using what they now understand about solar radiation, have the students design an experiment which would test the differences in temperature between two surfaces which have a similar albedo. However, one of the surfaces should be covered with living materials, while the other is covered with non-living material. Have the students design an apparatus which would measure the albedo and temperature in those two environments over a period of time (for instance, using cut off two-liter pop bottles turned upside down over the area). After a 24-hour time period have them download their data, analyze it, and create a report on how the albedo effect plays out in that area and the influence of plants on the amount of solar radiation being absorbed or reflected by the surface. The report should make reference as to how this might have an effect on climate.

Evaluation:
Use the reports generated by the first exploration and the reports generated by the elaboration to check for understanding of the key concepts and if the students grasp the relationship between albedo, solar radiation, feedback loops and climate.