Wind Chill!!!!

Overview

In this activity students use a variety of windchill charts to determine how cold the temperature "feels" versus how cold it really is. Students experiment with cooling due to evaporation versus cooling due to evaporation enhanced by wind. Students tie their knowledge of wind chill to understanding the impact of cold and wind in the polar environment and prevention of dangerous conditions

Rationale

The temperature of the air is not always a good indicator of how cold you might feel when you are outdoors. The amount of sunshine, the humidity and the wind all have an affect on how cold you might feel. In 1939, the term "wind chill" was coined by Paul Siple to describe the degree of discomfort caused by a combination of wind and temperature. Siple refined his experiments at Little America, Antarctica to develop the current formula used for the determination of wind chill. The wind chill index is based on a skin temperature of 33 C (91.4 F) and represents how cold the air feels to the skin. The wind chill index only applies to human skin, not other materials.

In the experiments at Little America, Siple and Charles Passel did not use human skin but rather measured how long it would take to freeze a known mass of water at different combinations of wind and temperature.

Grade Level/Discipline

8-12, Earth Science, Meteorology

Objectives

Students will:

- predict the relationship between wind, the actual temperature and the "apparent temperature" felt by living things
- conduct an experiment designed to explore the relationship between these variables
- graph and present their findings
- predict and explore how this phenomenon impacts living in polar regions; suggest measures that can curtail the impact

Teacher Preparation for Activity

Before class, set up a "cooling station." On a side table, set up the fan.

Fold the cardboard into three sections (u-shaped) and stand the cardboard in front of the fan so that it blocks half of the fan flow. Secure the cardboard shield to the table with the masking tape. Attach one thermometer to the inside of the cardboard "U" (the side away from the fan flow) so that it can be read easily by the students.

With the masking tape, attach the second thermometer to the side of the cardboard facing the fan such that the fan flow is blowing over the thermometer.

Place the wet towel in the pan or bucket near the "cooling station." Keep the wet towel away from the electrical outlet and appliances. Caution the students to not touch the appliances with wet hands.

Materials
For the class:

- standard house fan in stationary mode
- wet towel
- pan or bucket to hold the towel
- two standard thermometers
- masking tape to secure thermometers
- cardboard shield (approximately 3' x 3')

For each student or group of students:

- sheet of paper for recording observations at fan station
- two temperature probes
- squares of filter paper
- small rubber bands
- beaker of water at room temperature
- Computer-Based Laboratory (CBL) (optional)
- string
- ringstand
- indexcard
- stopwatch
- graph paper
- colored pencils
- wind chill charts

Time Frame
1 class period

Teaching Sequence

Engagement and Exploration (Student Inquiry Activity)
The students will work in groups of 4 or 5. Ask each group to assign the data recording to one individual.

Have each group separately approach the "cooling station." Ask the students to observe the temperature registered on the thermometer near the fan and the thermometer on the inside of the cardboard shield. The recorder should note the temperatures.

Have each student wet both hands with the wet towel. Each student should, simultaneously, hold one hand in front of the fan and one hand in front of the cardboard shield that blocks the circulation of the fan.

What do the students observe? Which hand "feels" colder? The group recorder should tally the responses.

Explanation (Discussing)
As a class, discuss the results of the experiment. Which hand felt colder, the wet hand in front of the fan or the wet hand in front of the cardboard shield? Most of the students will state that the hand in front of the fan felt colder.

Was there a temperature difference? Ask the recorders to share their data. The temperatures should be the same for the fan and for the barrier region. What do the students think is happening?

The effect the students experienced is called "wind chill." Wind chill makes you **feel** colder on windy days than on calm days of the same temperature. Wind cools because it blows away a thin layer of warm air that normally surrounds our bodies. The wind also draws away heat by quickly evaporating any moisture that forms on our skin. Often "wind chill" is presented as a more accurate measurement of outdoor temperature than the actual temperature. The wind chill index describes the equivalent temperature for which the heat loss from exposed skin would be the same if the wind were near calm. Inanimate objects, such as cars, do not "feel" wind chill. Water will not freeze until the temperature reaches freezing - no matter how hard the wind is blowing.

What factors, other than temperature, determine how "chilly" you feel?

Ask the student groups to use the wind chill charts to find the wind chill equivalent temperature for each of the following:

A. On a cold day on your way to school, the air temperature is -7 C (20 F) and the wind speed is 15 mph

B. The air temperature is -20 C (-5 F) and the wind speed is 20 mph

C. The air temperature is 2 C (35 F) and the wind speed is 25 mph

Elaboration (Polar Applications)
Hypothesize:
What happens to water temperature as the water evaporates in a windy situation? In a "wind-free" environment?

1. What will the temperature curve will look like when water evaporates with no wind? Make a predictive graph.

2. What the temperature curve look like when water evaporates with a large wind? Make a predictive graph.

Procedure:
1. Wrap two temperature probes (or two thermometers) with square pieces of filter paper secured by small rubber bands. Roll the filter paper around the probe tip in the shape of a cylinder. Hint: First slip the rubber band up on the probe, wrap the paper around the probe, and then finally slip the rubber band over the wrapped paper. The paper should be even with the probe end.

2. Use the CBL to set up a time graph to measure the cooling rate of the two probes as the water evaporates. If using thermometers, use string to secure the two thermometers to a ring stand, monitor the temperature and time with a stopwatch and graph your results.

3. Start data collection with the two probes in a beaker of water, then remove them from the beaker and hold one probe stationary and swing the other gently in the air.

4. If using thermometers, use string to secure the two thermometers to a ring stand, monitor the temperature and time with a stopwatch and graph your results. Fan one thermometer with an index card, while the other thermometer has no wind.

5. Compare the two graphs.

Exchange (Students Draw Conclusions)
What did the graphs look like? What was the effect of the wind on the temperature?

Why do polar researchers take the temperature and wind chill so seriously? What causes frostbite and hypothermia? How might wind chill influence the onset of these conditions? What precautions might prevent these conditions?

Evaluation (Assessing Student Performance)

Authors

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Background

How cold is it outside? Simply knowing the temperature doesn't tell you enough about the conditions to enable you to dress sensibly for all winter weather. Other factors including wind speed, relative humidity and sunshine play important roles in determining how cold you feel outside. A description of the character of weather known as "coldness" was proposed about 1940 by scientists working in the Antarctic. The "wind chill index" as developed to describe the relative discomfort/danger resulting from the combination of wind and temperature.

The wind chill index describes an equivalent temperature at which the heat loss from exposed flesh would be the same if the wind were near calm. For example, a wind chill index of -5 indicates that the affects of wind and temperature on exposed flesh are the same as if the air temperature were 5 degrees below zero even though the actual temperature is much higher.

The importance of the wind chill index is as an indicator of how to dress properly for winter weather. (Wind chill does not affect your car's antifreeze protection, freezing of water pipes, etc.) In dressing for cold weather an important factor to remember is that entrapped insulating air warmed by body heat is the best protection against the cold. Consequently, wear loose-fitting, lightweight, warm clothing in several layers. Outer garments should be tightly- woven, water-repellant and hooded. Mittens snug at the wrist are better protection than fingered gloves.

The formula the National Weather Service uses to compute wind chill is:

T(wc) = 0.0817(3.71V**0.5 + 5.81 -0.25V)(T - 91.4) + 91.4

T(wc) is the wind chill
V is in the wind speed in statute miles per hour
T is the temperature in degrees Fahrenheit

The formula to calculate a Celsius wind chill using V as the wind speed in kilometers per hour and T in degrees Celsius is:

T(wc) = 0.045(5.27V**0.5 + 10.45 - 0.28V) (T - 33) + 33

Excerpted from: Weather, Road Conditions, and Travel Advisories, http://www.cvfn.org/weather/windchill.html, 26 December, 1997

Gene's Measurements and Weather Page: Wind chill Factors: A much overused and misused measurement, http://ourworld.compuserve.com/homepages/Gene_Nygaard/windchil.htm, 26 December, 1997.

Resources

For a neat, interactive program that calculates temperature based on wind chill, go to: http://leav-www.army.mil/weather/Windchil.htm