Lake Ice and Energy Transfer

Levels V-VI

Grades 9-12

Overview:

Students use lab data collected in a previous lesson to determine snow temperature gradient.

Objectives:

The student will:

- convert centimeters to meters; and
- use data to determine snow temperature gradient.

Materials:

- STUDENT WORKSHEET: “The Science of Snow” (completed in an earlier lesson)
- STUDENT WORKSHEET: “Lake Ice and Energy Transfer”

GLEs Addressed:

Science

- [9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.
- [10-11] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.

Math

- [8] MEA-1 The student demonstrates understanding of measurable attributes by converting measurements within the same system (English or metric) (M2.3.2)

Activity Procedure:

1. This lesson will refer to the data collected during a previous lesson entitled: “The Science of Snow.” Students will need their lab results from that activity to complete the STUDENT WORKSHEET: “Lake Ice and Energy Transfer.” This lesson is designed to support the ALISON curriculum developed by University of Alaska Fairbanks scientist Martin Jeffries. For further information on his project, visit the Web site at **www.gi.alaska.edu/alison/ALISON_contact.html**.
2. Ask students to imagine a hot day in the summer. A cool lake is warmed by the air moving over it (thermal energy is transferred from the air to the lake). In the fall the air temperature cools, and the lake is warmer than the air. As winter moves in, frigid air temperatures cause ice to form on the lake, but water under the ice is above freezing. This water contains a large reservoir of ***heat***. This stored heat is the lakes thermal heat capacity.
3. Ask students to define ***thermal conductivity*** *(the ability to conduct heat)*, and ***conductive heat transfer*** (the direct movement of heat between two surfaces that are touching).
4. Ice and snow reduce the transfer of heat from the water to the atmosphere, and prevent it from freezing clear to the bottom. As temperatures continue to drop ***conductive heat transfer*** occurs, causing the ice to thicken. Because snow is much less dense than ice, snow cover on top of ice acts as a better insulation layer than ice alone. Lake ice without any snow cover will continue to thicken in very cold weather. When snow falls on the ice it helps reduce the transfer of heat from the water below the ice, and the ice does not grow as fast or as thick as it does without snow.
5. Ask students what this means in terms of traveling across lake ice? (*Very cold temperatures com-*

bined with little snow will cause the ice to thicken, while deep snow means thinner ice.)

6. In order to study global climate change, scientists try to understand how heat is stored, for how long, and where it goes. Understanding how much heat escapes from a lake covered by ice and snow may help scientists predict how glaciers melt and whether the climate will become drier or wetter as Earth's temperature rises in response to carbon dioxide levels.
7. One way to measure the movement of latent heat is to determine the ***Snow Temperature Gradient***. Snow Temperature Gradient describes the difference in the temperature measured on top of the snow and the temperature under the snow, divided by snow depth.

$$\text{Snow Temperature Gradient} = \frac{(\text{surface temperature in } ^\circ\text{C}) - (\text{bottom temperature in } ^\circ\text{C})}{\text{snow depth in meters}}$$

For example, a thermometer placed on top of the snow on Puvragik Lake in Wales on a cold January day in 2003 read -21 ˚C, while the thermometer reading from under the snow (on the ice) was -12 ˚C. The depth of snow was 0.114 meters.

$$\text{The Snow Temperature Gradient therefore is: } \frac{(-21\ ^\circ\text{C}) - (-12\ ^\circ\text{C})}{0.114\ \text{m}} = \frac{-9\ ^\circ\text{C}}{0.114\ \text{m}} = -78.94\ ^\circ\text{C/M}$$

(Note that snow depth is measured in meters, while data in "The Science of Snow" was measured in centimeters. Make sure that students convert centimeters to meters by dividing by 100.)

Critical Thinking Concept: Discussion Method. When students have completed the worksheet, ask them to pair up to compare their answers and discuss how they came up with their answers.

Hand out the STUDENT WORKSHEET: "Lake Ice and Energy Transfer" and their results from "The Science of Snow" activity to complete the worksheet.

Answers:

1. Answers will vary
2. Answers will vary
3. Answer to #1 - #2
4. Answers will vary
5. Answers will vary
6. Answers will vary
7. d
8. Snow cover reduces the transfer of warmer temperatures from the lake to the atmosphere (or from the atmosphere to the lake if the air temperature is warmer).
9. Answers will vary but may include: ice forming later in the fall, and melting earlier in the spring, thinner ice, less safe for travel.

Name:_____

Lake Ice and Energy Transfer

Student Worksheet (page 1 of 2)

Levels V-VI

Snow Temperature Gradient affects the movement of heat, which affects the thickness of ice on lakes and oceans. It is calculated by taking the difference in the temperature measured on top of the snow and the temperature under the snow and dividing the result by the snow depth.

$$\text{Snow Temperature Gradient} = \frac{(\text{surface temperature in } ^\circ\text{C}) - (\text{bottom temperature in } ^\circ\text{C})}{\text{snow depth in meters}}$$

In "The Science of Snow" activity, measurements of snow temperature, depth and mass (weight) were taken, and snow density was determined. Use the data collected for snow temperature at that time to answer the following questions:

1. What was the surface temperature of the snow? _____

2. What was the bottom temperature of the snow? _____

3. What is the difference between the temperature at the bottom and the temperature at the top?

   _____

4. What was the average snow depth? _____

Average snow depth was measured in centimeters. For this formula average snow depth must be converted to meters.

5. To convert centimeters to meters, multiply the number of centimeters by .01 meters:

   _____ cm x .01 meters = _____ meters

6. Refer to the equation at the top of this page to determine Snow Temperature Gradient:

   $$\text{Snow temperature gradient: } \frac{(\_\_\_\_\_\ ^\circ\text{C}) - (\_\_\_\_\_\ ^\circ\text{C})}{(\ \_\_\_\_\_\ \text{meters})} = \_\_\_\_\_$$

Name:_____

Lake Ice and Energy Transfer

Student Worksheet (page 2 of 2)

7. What interaction between the air and the lake ice is reduced by a layer of snow?
   a. global warming
   b. thermal conductivity
   c. snow water equivalent
   d. conductive heat transfer

8. Explain why the temperature under the snow is different from the temperature on top of the snow.

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9. Explain how an increase in Earth's temperature due to climate change might affect lake ice and sea ice.

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