OHSU-E-80-001 C2

Ohio Sea Grant

OEAGLS - Oceanic Education Activities for Great Lakes Schools

THE EFFECT OF LAKE ERIE ON OHIO'S TEMPERATURE

by

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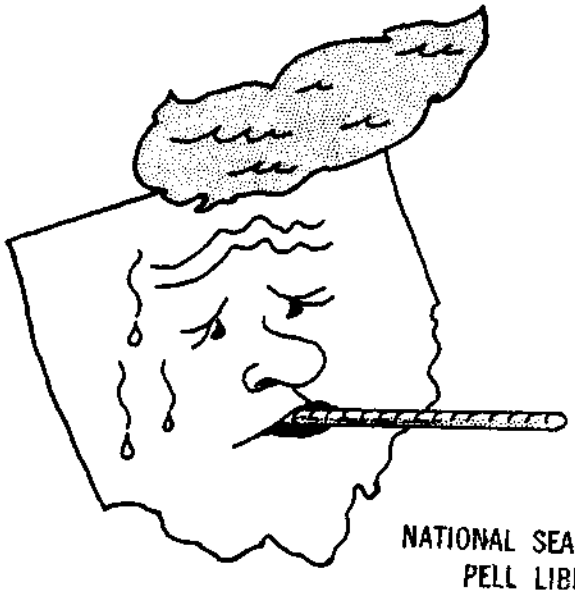

Ohio Sea Grant Program
Charles E. Herdendorf, Program Director
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OEAGLS INVESTIGATION 1

Completed February, 1979
Revised, December, 1979
Revised, August, 1980
Reprinted, January, 1983

This instructional activity was prepared with the support of National Oceanic and Atmospheric Administration Grant Nos. 04-158-44099 and 04-8-M01-170. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the authors, and do not necessarily reflect the views of NOAA.

INVESTIGATION THE EFFECT OF LAKE ERIE ON OHIO'S TEMPERATURE

INTRODUCTION

Even as far back as the "log cabin days," people have known that water absorbs a great deal of heat energy and can in turn release this heat. Pioneers would prevent foods from freezing on cold nights by placing a large container of water in the room. Can you think of why this might work?

In this investigation we will explore how bodies of water can affect the surrounding areas.

OBJECTIVES

When you have completed this investigation, you should be able to:

1. Describe how soil and water differ in their ability to absorb and release heat energy.

2. Describe how this difference in heat absorbed or released affects the atmosphere immediately above the land and immediately above the water.

3. Describe the effects of Lake Erie upon the temperature of Ohio.

ACTIVITY A WHAT ARE HEAT SOURCES AND HEAT SINKS?

In the early spring when the weather is warming, some days are so hot we would like to jump in the lake and take a swim. We would find, however, that even though the air is hot, the water is very cold.

Published by: Ohio Sea Grant
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MATERIALS

Four thermometers, a container of soil and one of water, two 30 cm rulers, masking tape, ringstand, graph paper, pencil, light with reflector.

PROCEDURE

Set up your materials according to the following directions. (See Figure 1.)

A. Place the containers of earth and water about 3 cm apart.

B. Lay one ruler across each container, resting it on the container's rim.

C. Place one thermometer in the soil with the thermometer bulb just barely covered. Attach with masking tape to the ruler.

D. Place another thermometer close to the first one, but about 1 cm above the soil. Attach with masking tape to the ruler.

E. Repeat steps C and D for the container of water.

F. Place the lamp on a ring stand with the reflector pointing down.

G. Position the lamp 30 cm above and centered between the containers.

H. Be certain that the bulb of each thermometer is shielded from the direct rays of the lamp.

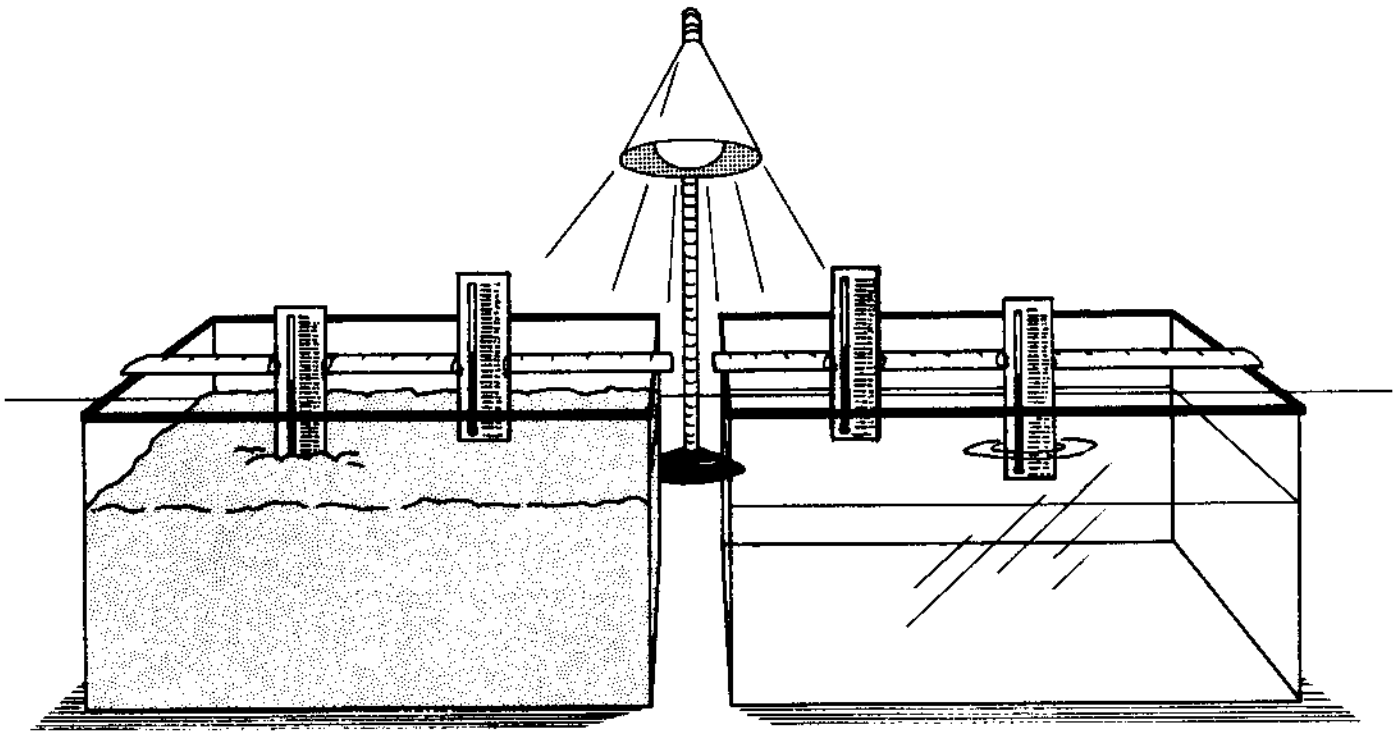


FIGURE 1: Set-up used in Activity A.

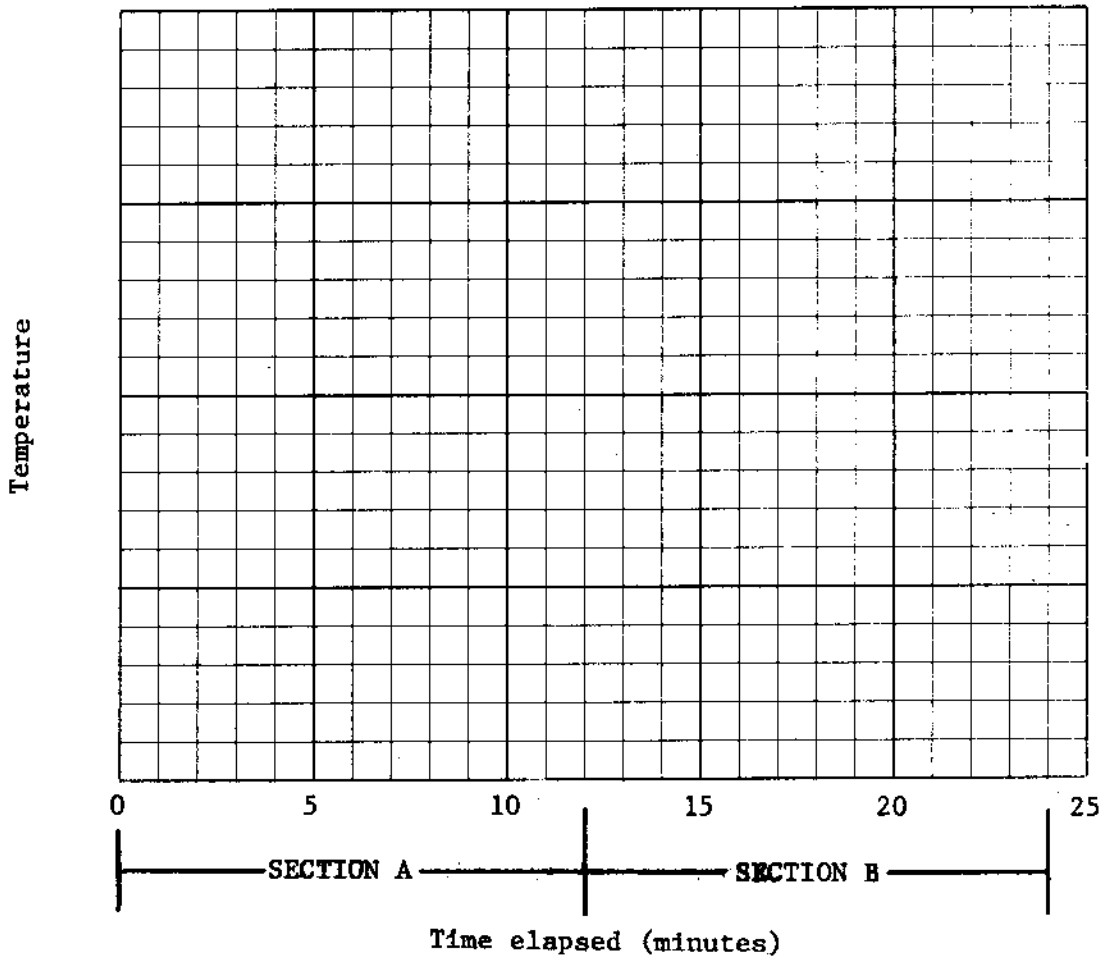
After your teacher has examined your set-up, do the following:

1. Construct a data table according to the instructions of your teacher.

2. Turn the lamp on. At one minute intervals record the temperatures indicated on each of the four thermometers. Continue for 12 minutes.

3. Turn the lamp off. Continue recording temperatures at one-minute intervals for 12 minutes.

4. Plot your data on the time-temperature graph below. Use a different color for the data from each thermometer.



Key to graph lines:
Air over soil-
Air over water-
Soil-
Water-

Answer questions 5-7 using data from the first 12 minute intervals on the data table and time-temperature graph.

5. With the light on, does air heat up faster over the soil or over the water?

_____

6. Which changes more: the temperature of soil or the temperature of the water?

_____

7. Which absorbs more energy, soil or water?

_____

Use the data for the last 12 minute-intervals to answer questions 8-11.

8. With the light off, which changes more: the temperature of soil or the temperature of the water?

_____

9. Which changes most after the light is turned off, the temperature above the soil or the temperature above the water?

_____

10. Which loses heat faster, soil or water?

_____

11. Which keeps heat energy longest, soil or water?

_____

Anything that adds heat energy to the atmosphere is called a heat source. A heat sink takes energy from the atmosphere.

12. Could soil or water be considered a heat sink while the light was on ? Discuss.

_____

_____

13. After the light was turned off, was the soil a heat source? Was the water a heat source? Discuss.

_____

_____

_____

ACTIVITY B

HOW DO LAKE ERIE AND THE OCEANS AFFECT CLIMATE?

In Activity A, you learned that the pan of water was a good heat sink while the lamp was on and a good heat source while the light was off. Soil also acts as a heat sink and source, but its capacity to hold energy is much lower than that of water. Therefore, soil will become a heat source soon after the light is turned on and will quit acting as a heat source not long after the light is turned off.

A body of water such as a lake acts much the same way during the summer. During the day the water is a heat sink, storing up heat from the atmosphere. At night it becomes a heat source, giving up heat throughout the night. If you live near a lake you have experienced land sea breezes which are caused by the lake. Lake water tends to increase in temperature all summer. This indicates that it is storing up extra energy from the atmosphere. It acts as a heat sink throughout the summer. In the winter, however, there is less radiation from the sun. Then lakes become heat sources giving up their energy to the atmosphere.

PROCEDURES

Figures 2 and 3 are maps of Ohio with isotherms drawn on them. An isotherm is a line that connects points of equal temperature. Those on Figure 2 represent the average temperature in Fahrenheit for the month of July. The isotherms in Figure 3 represent average temperatures for the month of January.

1. What happens to the average temperature along line AB in Figure 2 as Lake Erie is approached from the west?

   _____

2. What happens to the average temperature along line CD in Figure 3 as Lake Erie is approached from the west?

   _____

3. Explain the differences in temperature patterns between July and January.

   _____

   _____

4. Is Lake Erie a heat source or sink? Discuss.

   _____

   _____

5. Describe the effects of Lake Erie on the temperature of northern Ohio.

   _____

   _____

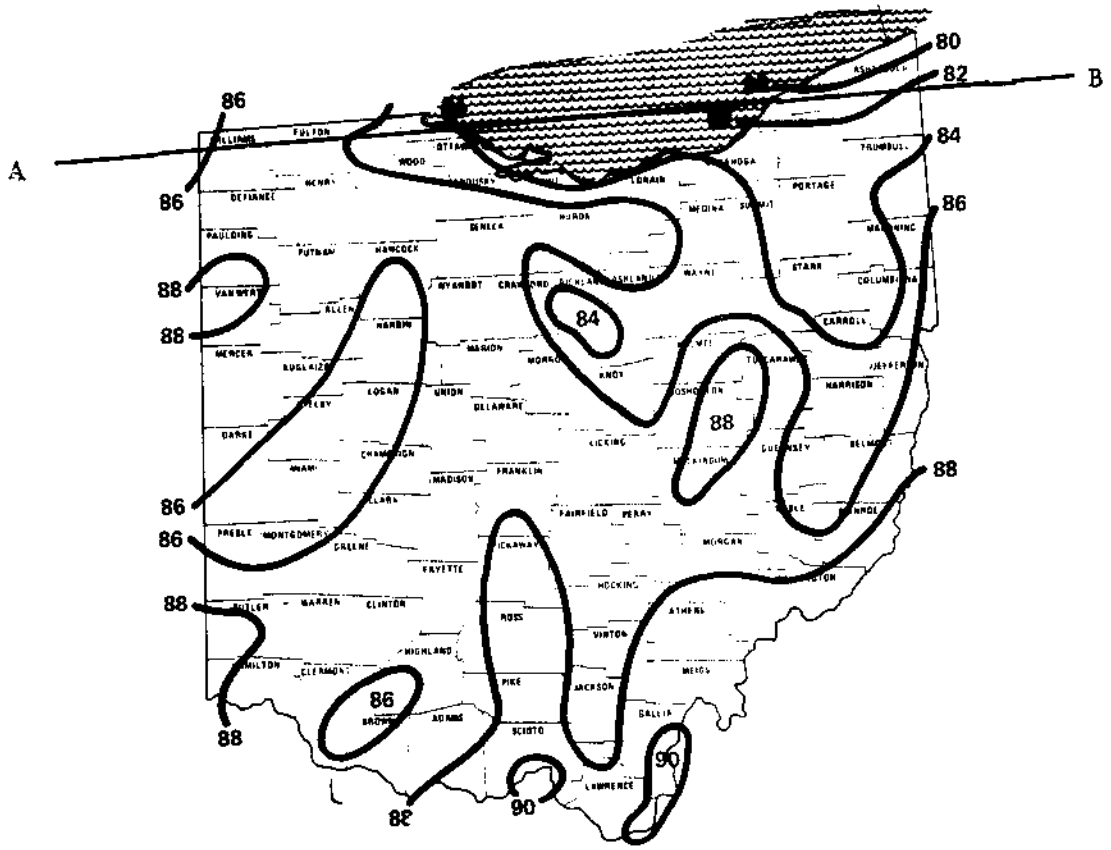


FIGURE 2: MEAN MAXIMUM TEMPERATURE
OF 1931-52 AVERAGE JULY

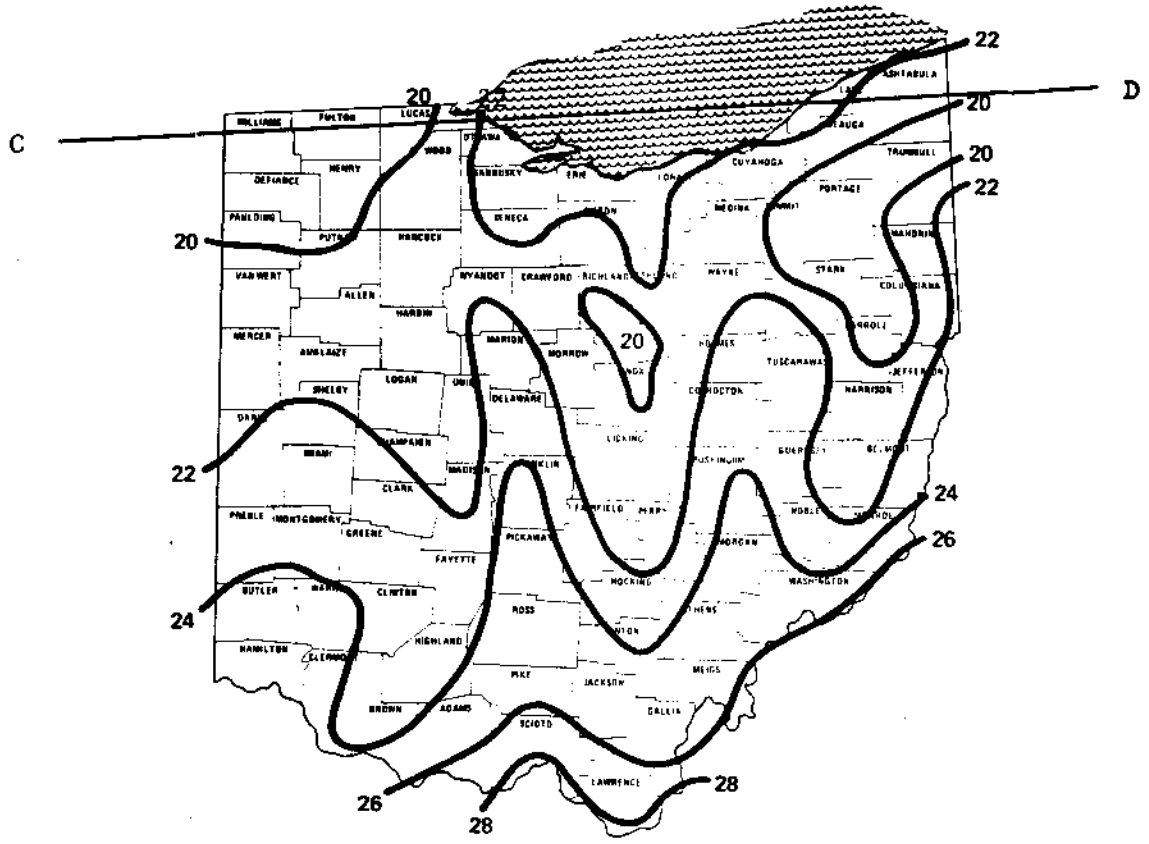


FIGURE 3: MEAN MINIMUM TEMPERATURE
OF 1931-52 AVERAGE JANUARY

Oceans are also large bodies of water. They affect temperature in much the same way as large lakes. Figure 4 is a map of the world on which are drawn isotherms representing the average temperatures in January. Notice that the average temperatures in Figures 4 and 5 are given in degrees celsius. The Ohio temperature maps are in degrees farenheit.

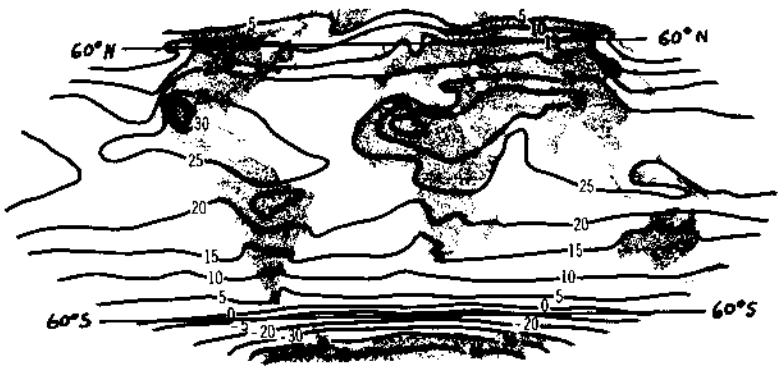


FIGURE 4: World Map of Average Temperatures (C°) in July.

6. Follow parallel 60°N latitude across Figure 4. How is temperature affected by the continents? By the oceans?

_____

_____

_____

_____

7. Do the same for Figure 5. Describe the differences in average temperatures.

_____

_____

_____

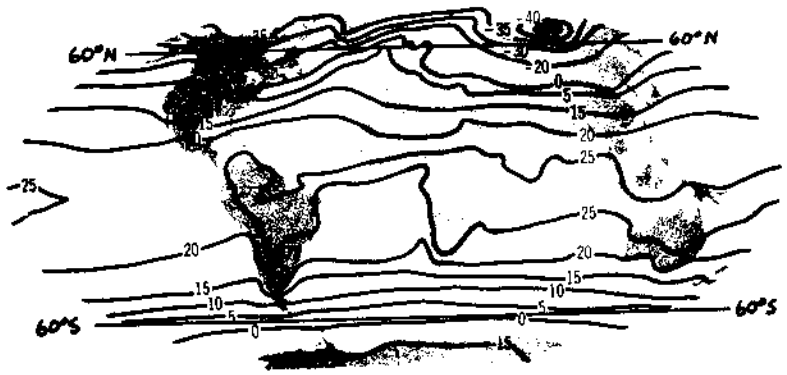


FIGURE 5: World Map of Average Temperatures (C˚) in January.

The oceans affect the temperature of Ohio. When we have warm winter temperatures we are under the influence of air that starts over the oceans. The cold, frigid winter air comes from northern Canada, where the oceans do not have an effect.

8. Do oceans act as heat sources or sinks? How do you know?

_____

_____

_____

_____

9. Do continents ever act as heat sources? Explain.

_____

_____

_____

_____

REVIEW
QUESTIONS

1. What is a heat source? A heat sink?

2. When do large bodies of water, such as Lake Erie, act as heat sources? Heat sinks?

3. How does the temperature of northern Ohio differ from that of central Ohio? What causes this difference?

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TEACHER GUIDE

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Figures 2 and 3: U.S. Dept. of Commerce, Environmental Sciences Services Administration, Climatological Summary.

Figures 4 and 5: American Geological Institute, Investigating the Earth, Boston: Houghton Mifflin Company, 1967.

TEACHER GUIDE

TITLE

THE EFFECT OF LAKE ERIE ON OHIO'S TEMPERATURE

OVERVIEW

When a large container of water is placed in a room with foods, as described in the Introduction to the Investigation, the water will prevent the foods from freezing since water acts as a heat source if it is at a higher temperature than its surroundings. Water adds heat energy to the atmosphere thereby keeping the room warm and the food from freezing.

In Activity A students study the ideas of heat source and heat sink. They conduct an experiment on the effect of solar insolation on soil and water using a lamp as a source of radiation. They collect and analyze data on the temperature differences between soil and water and the air immediately above them.

In Activity B they apply this knowledge of heat sources and sinks to Lake Erie and Ohio, and to the oceans and land masses of the world to study the effect of large bodies of water on climate.

PREREQUISITE STUDENT BACKGROUND

The students should know how to graph data.

MATERIALS

Each lab group should have four thermometers, a container of dark soil and one of water, two 30 cm rulers, masking tape, ringstand, graph paper, and a light with reflector. The light should be at least 150 watts.

OBJECTIVES

When the students have completed these activities, they should be able to:

1. Describe how soil and water differ in their ability to absorb and release heat energy.
2. Describe how this difference in heat absorbed or released affects the atmosphere immediately above the land and immediately above the water.
3. Describe the effects of the Great Lakes upon the temperature of Ohio.

SUGGESTED APPROACH

Activity A could be done in larger groups to help cut down on the amount of equipment needed.

Activity B could be done in these same groups, or done individually.

ACTIVITY A — WHAT ARE HEAT SOURCES AND HEAT SINKS?

The introduction to Activity A is meant to introduce the most widely observed effect of heat sources and heat sinks. What is happening? The spring sunshine has warmed the land's surface rapidly, thus the land was a heat sink for a short period of time. Then the land became a heat source as it re-radiated or gave up its heat to the air above it thus adding more heat to the air. The water, however, acts as a heat sink for a much longer period of time and warms up much slower; this is why water is cooler during the days of spring and early summer than is the surrounding air.

PROCEDURE

Keywords: heat source, heat sink, isotherm

Set out the soil and water a day ahead to allow them to come to room temperature.

Steps A-G describe the experiment set-up shown in Figure 1 of the student guide. Each student set-up should be examined by you before the students turn on the lamp. Check to make sure that the thermometer bulbs are shaded from the direct light. You should point out the importance of taking accurate temperature readings.

1. Explain how to set up their data tables. See Figure TG 1 below.

Time Elapsed	Thermometer 1 (above earth)	Thermometer 2 (in earth)	Thermometer 3 (above water)	Thermometer 4 (in water)
1 min.				
2 min.				
3 min.				

FIGURE TG 1. Sample Data Table

Remind students to turn off the lamp after their 12 minute reading. They should continue to take readings every minute for another 12 minutes.

2-4. To help make the graphs easier to interpret, it is best if all the initial temperature readings for each set-up are the same. If the students' thermometers did not read

the same at the beginning, then the temperature readings should be adjusted so that the initial temperatures are equal. This is done by finding the difference between the thermometer with the lowest reading and each of the others. The difference for each of the other thermometers is then subtracted from each reading given by the thermometer.

5. The air heats up faster over the soil.

6 and 8. While the lamp is on, the soil should be heating up more rapidly than the water since soil has a lower specific heat and it absorbs all radiation close to the surface. Specific heat is the amount of heat (in calories) required to raise the temperature of one gram of a substance by one degree celsius. The specific heat of water is 1. For all other common liquids and solids the specific heat is less than 1.

After the light is turned off, the soil should cool more rapidly than the water because of its lower specific heat. (See Figure TG 2.) Note that the curves for soil and water do show a drop at different rates in Section B of the graph. Most students should be able to notice the difference on this part of their curves.

7 and 9. The water will absorb more energy. It will be very difficult for students to understand this. The clue is in the "air" curves. The air over the soil heats up much more rapidly than that over the water. This is because soil cannot hold on to the heat energy and gives it right back to the atmosphere. The difference in the two curves therefore implies that water has a greater capacity for storing heat energy. This idea is further supported by the ends of the two curves. Note that they cross at about 19 minutes. This is because the water is now giving off more energy than the soil. This is energy that was stored in the water. Note that the curves continue to diverge after 19 minutes. Water is acting as a source of heat energy for the atmosphere.

10. Soil loses heat faster than water.

11. Water keeps its energy the longest. If students place their thermometers too deeply in the soil their temperatures will show a continuing rise in temperature after the light is turned off. This happens because some of the energy from the surface is conducted downward into the soil.

12. Normally soil will function very briefly as a heat sink after the light is turned on. Shortly, however, it will begin radiating energy back to the atmosphere (become a heat source) as indicated by the heating of the air above the soil. Water should remain a heat sink, however, and produce only a minimum rise in temperature of the air above. Figure TG 2 does not show this relationship.

Graph for Activity A

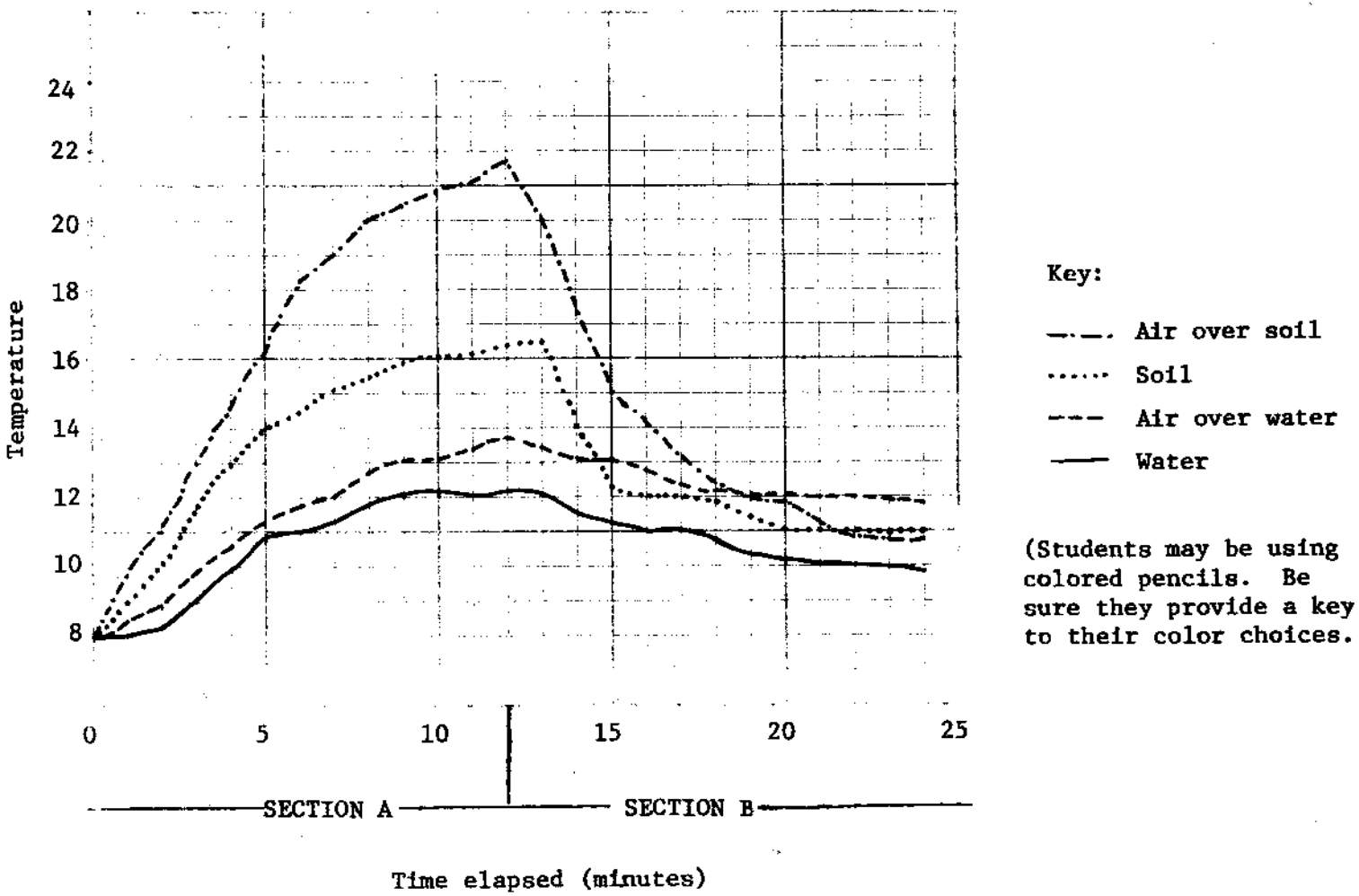


FIGURE TG 2: Sample of Completed Graph

13. After the light is turned off soil functions only briefly as a heat source. Water, however, continues as a source to the end of the recording period. Since the air temperature above the water remains higher than that of the water itself, it will continue to act as a heat source until the surface water is the same temperature as the air over it.

ACTIVITY B

This activity applies the ideas of heat sources and heat sinks to the climate of Ohio and the world.

Keywords: isotherm

PROCEDURE

1. As you approach the lake the temperature decreases.

2. As you approach the lake from the west, the temperature increases.

3. During the summer the lake absorbs energy but the land re-radiates energy to the atmosphere. Therefore, air over land is warmer than that over the water. In the winter the energy absorbed by the lake water is gradually released to the atmosphere, making the air over the water warmer than that over the land.

4. Lake Erie is both a heat source and a heat sink depending on the season. In the lake spring and summer, it is a heat sink, but in the fall and winter it is a heat source.

5. Lake Erie acts as a moderator for northern Ohio's climate. It keeps the air cooler in the early summer and warmer in the rest of the fall and the winter, than other parts of the state.

6. As you follow the 60^{o}N parallel across the map for July the temperature rises over the continents and falls over the oceans.

   If your students are familiar with how to make a topographic profile, they could make a temperature profile here to show this more graphically.

   You might also wish to look at other latitudes such as 30^{o}S for examples of temperature differences.

7. As you follow the 60^{o}N parallel across the map for January, the temperature falls over the continents and rises over the oceans.

8. Oceans act as heat sources in winter and heat sinks in summer, just as Lake Erie does.

9. The continents act as heat sources in summer and heat sinks in winter, just like the land in Ohio does.

REVIEW QUESTIONS

1. A heat source adds heat energy to the atmosphere. A heat sink takes energy from the atmosphere.

2. Large bodies of water such as Lake Erie act as heat sources in the fall and winter when they are giving up heat to the atmosphere. They act as heat sinks in the late spring and summer when they are absorbing heat from the sun and atmosphere.

3. The climate in northern Ohio is more moderate than the climate in central Ohio. The difference is caused by the moderating effect of Lake Erie.

REFERENCE

American Geological Institute, Investigating the Earth, Boston: Houghton Mifflin Company, 1967. Activity A is adapted from an investigation on page 172.

EVALUATION ITEMS

1. A heat sink

   1. has a higher temperature than its surroundings.
   2. "gives off" excess heat.
   *3. absorbs and stores excess heat.
   4. is the Great Lakes in the wintertime.

2. Generally, the average summer air temperature at the shore of a large lake is

   1. warmer than 50 miles inland.
   *2. cooler than 50 miles inland.
   3. the same as 50 miles inland.
   4. dependent upon the direction of the prevailing winds.
   5. usually the same as the average temperature in winter.

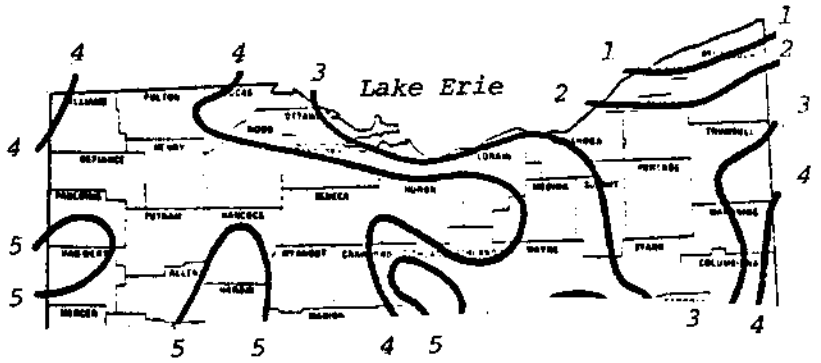
3. If you place a bucket of water and a bucket of soil out in the sun in the morning, what would happen to their temperature?

   1. their temperatures would not change.
   2. both would warm up at the same rate.
   3. water would warm up faster than the soil.
   *4. soil would warm up faster than the water.

4. If you kept those same two buckets outside until after the sun set, what would happen to the temperatures?

   1. both would cool at the same rate.
   *2. soil would cool faster.
   3. water would cool faster.
   4. their temperatures would not change.

5. The isotherms in the map of Northern Ohio below represent the average daily high temperature for a month with one being the lowest and five being the highest average daily temperature.



This map represents

*1. summer temperatures.
2. winter temperatures.
3. early fall temperatures.
4. can't tell.