Frost Depth Measurements

Levels V-VI

Grades 9-12

Overview:

Vegetation can be an indicator of soil underlain with permafrost. In this lesson, students explore the active layer above permafrost, examine satellite images to predict permafrost location, and begin a long-term investigation of frost depth. (NOTE: This lesson requires a frost tube in your community. If one has not already been installed, a frost tube can be installed at your school by following the steps on the TEACHER INFORMATION SHEET: "Frost Tube Installation," included in this lesson.)

Objectives:

The student will:

- make accurate measurements; and
- measure and record frost depth.

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.

Whole Picture:

The depth to which soil is frozen into permafrost varies based on local climate, soil and vegetation conditions. Frost tubes are important in the study of permafrost, allowing scientists to measure the extent of frost penetration and the thickness of the active layer, and to determine how the soil responds to seasonal variations in temperature and snowpack.

Frost tubes are a fairly recent development, previously, scientists had to undertake full-scale destructive excavations to study permafrost zones. The frost tube design is quite simple: a hollow plastic tube driven into a hole drilled in the soil past the line of permafrost. A thin plastic bag is placed in the tube and filled with water, and the line at which the water freezes is the level at which the ground is frozen. A coloring agent is often added to the water to make the freeze line clearly visible.

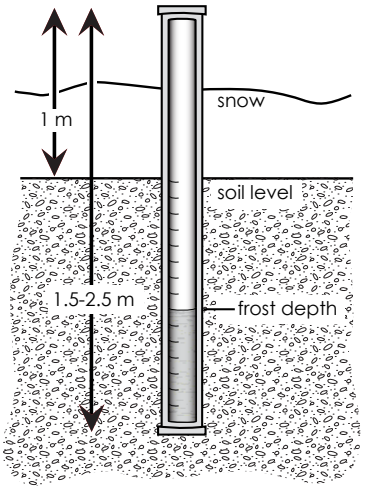
A frost tube measurement is accurate to within about a half-inch, and while it doesn't provide detailed information on temperature ranges, the tubes can be combined with temperature sensors that provide a temperature timeline for each location. The ease of frost tube fabrication, installation, and maintenance has allowed researchers to expand permafrost measurements across Alaska.

The equipment and materials needed to install a frost tube can easily be transported by snowmachine or light aircraft, giving scientists the ability to acquire new data on permafrost in remote locations.

Materials:

- Blank transparency film (one per student)
- Markers (red, blue, and black)
- OVERHEAD: "Satellite Imagery"
- OVERHEAD: "Permafrost Distribution"

- TEACHER INFORMATION SHEET: “Frost Tube Installation”
- STUDENT WORKSHEET: “Vegetation and Permafrost”



Activity Procedure:

1. Remind students the top layer of ground above permafrost is called the active layer. The active layer thaws during the summer and freezes during the winter, as opposed to the permafrost, which stays frozen all year.
2. Explain scientists put tubes of water in the ground to determine how far down the ground is frozen. Just as water will freeze if it is put in a freezer, water will freeze if it’s surrounded by frozen soil.
3. Explain the frost tube is generally 2 meters or about 6½ feet deep (each site may vary). If the ground is frozen from the surface all the way down to 2 meters, then the water in the frost tube will be completely frozen. If the water in the frost tube is only frozen to 10 centimeters, the ground is only frozen down to 10 centimeters.
4. Take the class outside and demonstrate how to measure the frost depth by recording the depth of frozen water in the frost tube at your local school.
5. Frost depth should be measured on the same day at the same time each week, ideally within one hour of solar noon. To measure, remove the cap on the outer pipe and raise the flexible inner tube.
6. Ask for a student volunteer to note the depth where the water is frozen (frozen water in inner tubing is clear; unfrozen water will have the color of whatever food coloring you added in the frost tube), and count the number of centimeters down from the soil surface the freezing extends.
7. Return the inner tube to the outer pipe and record the measurement. Return to the classroom. Explain to students that they will take a frost depth measurement each week for a year to explore how the active layer changes over time.
8. As a class, navigate to the Student Network for Observing Weather (http://www.ArcticClimateModeling.org/son/index.html). Click on **Enter Data**. Select **School Location** from the drop-down menu, and enter the password for your school site. In the section marked **Frost Depth**, click on the drop-down menu and then on the number of centimeters for that day’s frost depth. Explain the class will transfer their data to the Student Network for Observing Weather, so students in other classes can examine the data.
9. Ask students if they know how scientists determine where to put a frost tube; how do scientists predict where permafrost is located?
10. Explain there are many indicators on the land surface to indicate the presence of permafrost. Show the OVERHEAD: “Satellite Imagery.” Explain the overhead presents two satellite images. The first one is a typical satellite image. The second one is the same image, but colorized. Colors have been added to the image to help show the different features. The purple areas are black spruce trees on a north-facing slope. The green areas are birch and aspen trees on a south-facing slope.
11. Ask students which areas they think have permafrost. Ask students to explain their reasoning; discuss as a class. Show OVERHEAD: “Permafrost Distribution.” Explain the overhead shows a map of permafrost distribution for the area in the satellite image. From this image, note permafrost is present in areas of black spruce. Make sure students understand that black spruce tends to grow in areas of permafrost. Birch and aspen trees cannot thrive in those areas, and so they tend to grow on areas of non-frozen ground.

Critical Thinking Question: Think-Pair-Share Method. Divide students into pairs. Ask pairs to discuss why they think it is important to determine where permafrost exists in the community. Provide students 5-10 minutes to discuss in pairs; then discuss as a class.

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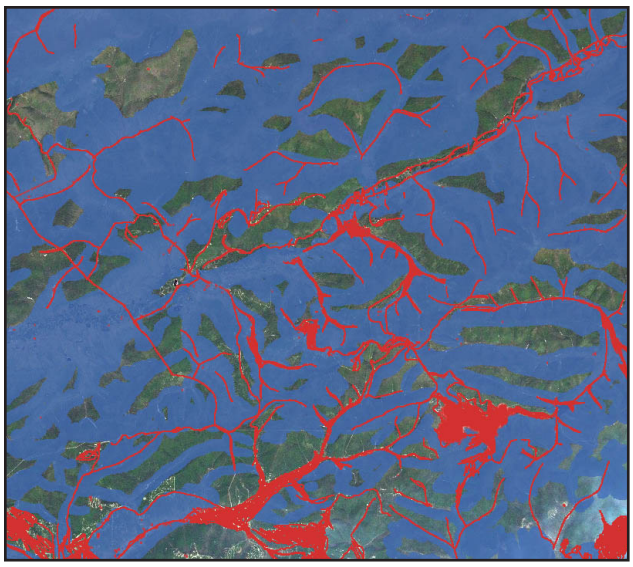
12. Distribute the STUDENT WORKSHEET: “Vegetation and Permafrost” and instruct students to complete the worksheet in small groups.

Answers:



red = streams and lakes

blue = locations of permafrost

Name:_____

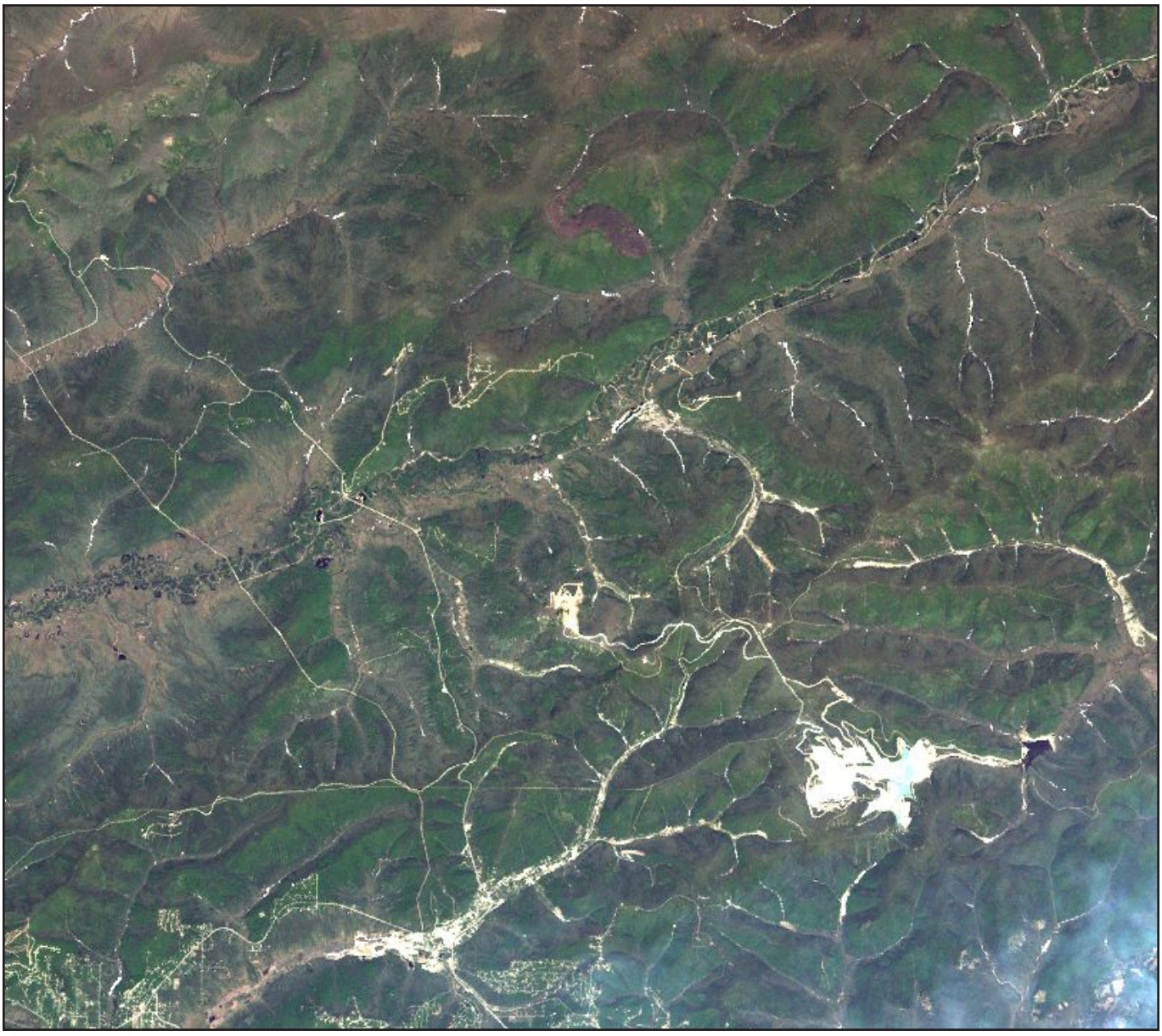
Levels V-VI

Vegetation and Permafrost

Student Worksheet

Directions: Overlay a sheet of transparency film on top of the image below. Trace the border of the image. In red pen, draw all streams and lakes. In blue, mark the locations of permafrost.

Background Information: Vegetation, or lack of it is a good indicator of permafrost locations. In Interior Alaska, black spruce trees and areas of little to no vegetation (brown and purple on image) are indicators of soil underlain with permafrost; whereas birch and aspen trees (green on image) are indicators of non-permafrost soil.



Frost Tube Installation

Materials:

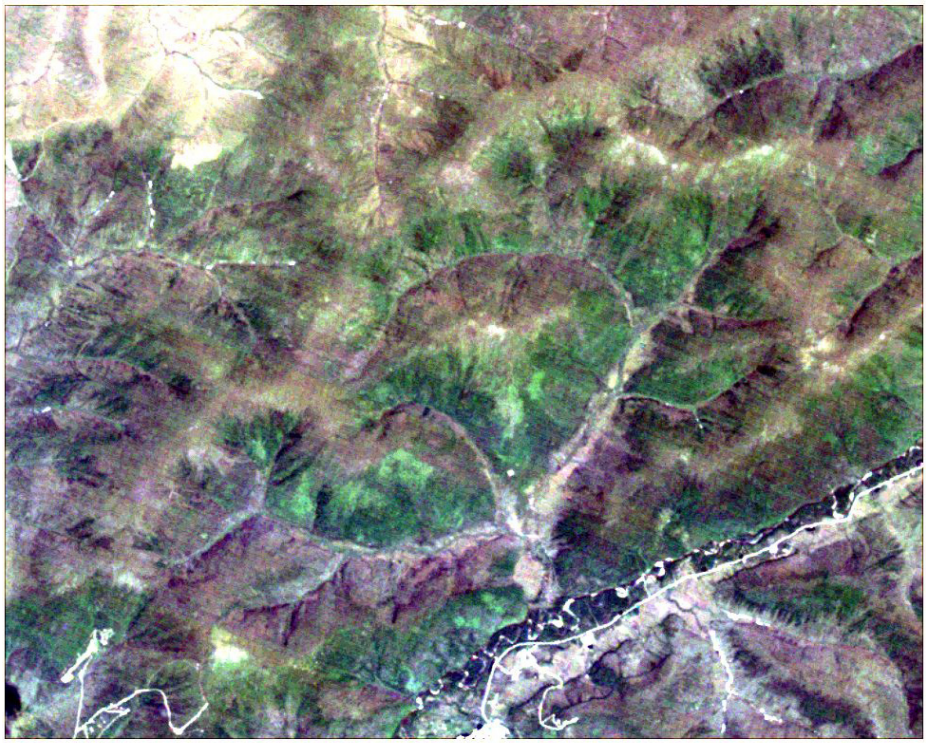
- Soil auger or post digger (12 millimeter diameter)
- 12 millimeter CPVC Pipe (up to 4 meters*)
- 10 millimeter O.D. tubing (up to 4 meters*)
- Ground cover, cap, or other material to keep water and cold air out
- Food coloring
- Funnel
- Black waterproof marker
- Meter stick with centimeter markings
- CPVC pipe glue
- Lighter

* See Activity Procedure step 2.

Activity Procedure:

1. Find a location that is undisturbed and contains loose soil. Check with the appropriate authority to verify it is safe to dig at the selected site. If possible, obtain a GPS reading of the location for future reference.
2. If possible, measure the depth of the active layer by using a steel stick to probe the ground at the end of summer. The length of the outer pipe/tube and flexible inner tubing should be this length with an additional 1 meter (above the surface).
3. Attach the CPVC cap to the bottom end of the CPVC pipe using the CPVC glue.
4. Seal one end of the flexible inner tubing, using a lighter to melt the plastic. Use caution and do this in a well-ventilated area. Do not touch the hot plastic. Allow the melted end to dry fully to form a seal.
5. Using a funnel, fill the flexible tube with water and food coloring until the water is 15 centimeters from the top.
6. Seal the top end of the tube in the same manner as in step 4.
7. Place the tubing into the CPVC tube so that it extends to the bottom.
8. Use a soil auger or post digger to dig the hole into which the frost tube will be placed. Save the removed soil for step 10.
9. Place the frost tube (flexible inner tubing and outside tube) into the hole.
10. Mix the removed soil with a little water and then use this paste to fill in any gap between the frost tube and the surrounding soil. If possible, try to place the different kinds of soil back into the gap in the order in which they were removed. Gently work the soil into the gap with a stick, trying to eliminate any air pockets.
11. Note how far the ground level is from the top of the CPVC outer tube. Raise the flexible inner tube and mark that place with a permanent marker on the outside of the tube. Using the meter stick as a guide, continue to mark each centimeter below that line until you get to the bottom. Indicate every 10 centimeters with consecutive numbers next to each mark (10, 20, 30, etc.). Return the flexible tube to the installed CPVC tube and leave until measurement day.
12. Cover the top of the outside tube with a CPVC cap (do not glue) to minimize the chance of cold air or water getting down into the space between the flexible tube and the CPVC tube.

Permafrost Distribution
Overhead



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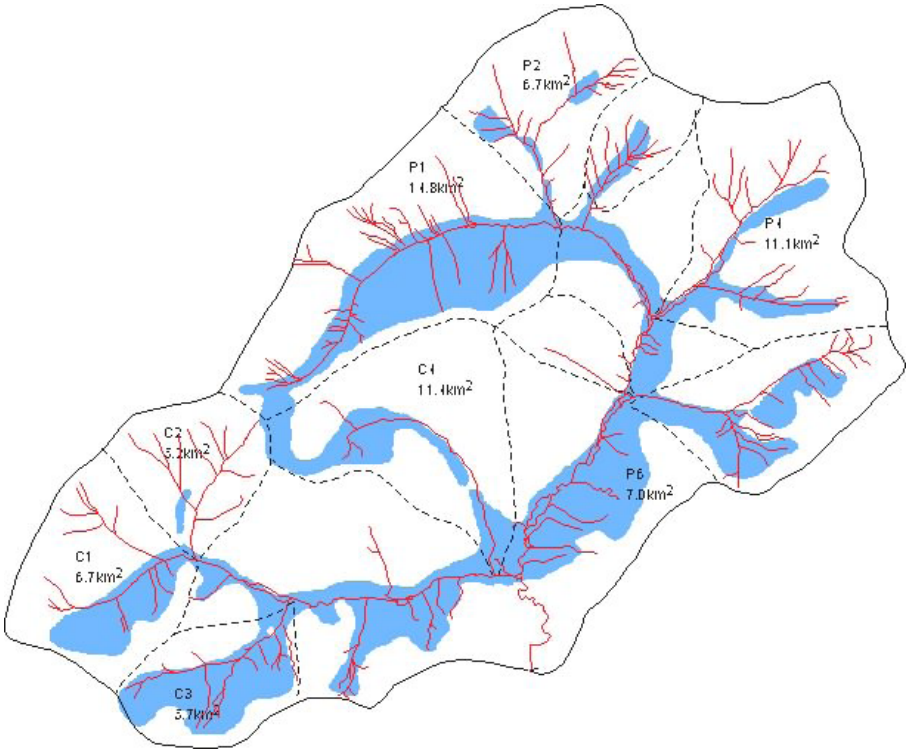

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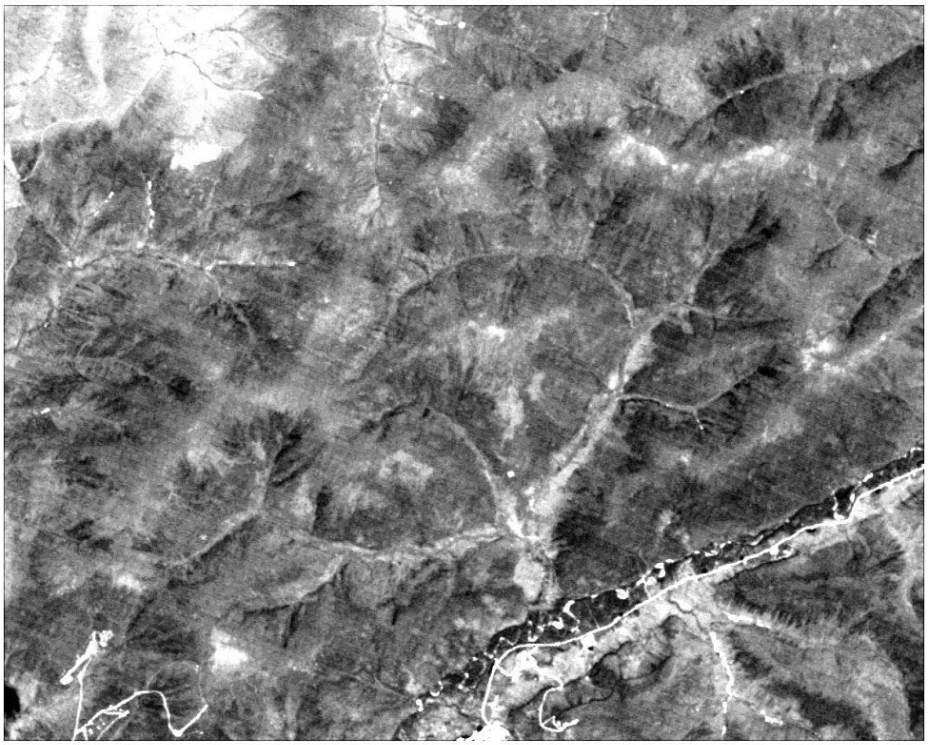
Satellite Imagery
Overhead



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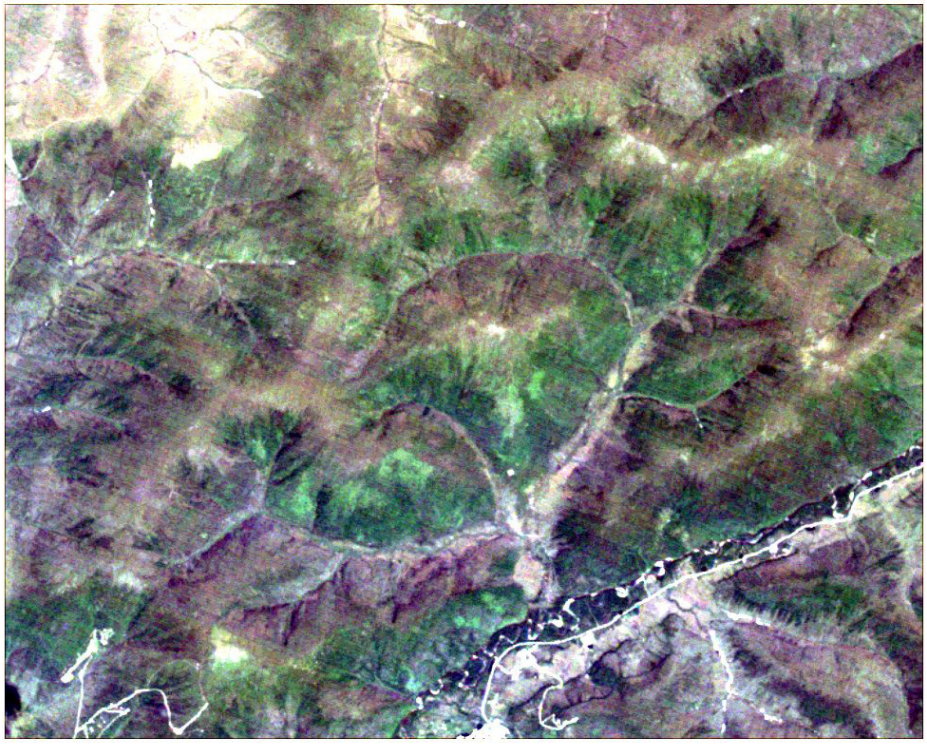

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