THAWING THERMOKARST

Overview:
In this lesson, students use multimedia to identify and explore changes resulting from thawing permafrost in thermokarst terrain.

Objectives:
The student will:
• define thermokarst;
• identify ecosystem changes resulting from thawing permafrost in thermokarst terrain; and
• relate thermokarst terrain to global climate change.

Targeted Alaska Grade Level Expectations:

Science
[9] SA2.1 The student demonstrates an understanding of the attitudes and approaches to scientific inquiry by formulating conclusions that are logical and supported by evidence
[9] SB3.2 The student demonstrates an understanding of the interactions between matter and energy and the effects of these interactions on systems by explaining that chemical and nuclear reactions, energy (e.g. heat, light, mechanical, and electrical) is transferred into and out of a system
[10] SC3.2 The student demonstrates an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy by exploring ecological relationships (e.g competition, niche, feeding relationships, symbiosis)
[9-10] SD2.1 The student demonstrates an understanding of the forces that shape Earth by recognizing the dynamic interaction of erosion and deposition including human causes
[10] SD3.1 The student demonstrates and understanding of cycles influenced by energy from the sun and by Earth's position and motion in our solar system by describing causes, effects, preventions, and mitigations of human impact on climate

Whole Picture:
Permafrost is the foundation of the Arctic landscape. It has shaped conceptions about the land for the indigenous people who have lived in the Arctic for thousands of years. Thawing permafrost could result in fundamental changes to this landscape as well as to modern and traditional infrastructure.

Karst is a geologic term used to refer to a landscape underlain by limestone that has eroded leaving ridges, sinkholes and fissures. Thermokarst is a similar landscape, but thawing ice-rich permafrost causes it. The resulting soil collapse creates an irregular landscape of domes, depressions and bands of broken tundra. Thermokarst dominates large parts of the Arctic landscape.

Thermokarst landscapes contribute to a positive feedback loop by releasing CO2 and methane that is trapped in permafrost. Carbon dioxide and methane are greenhouse gases that enhance global warming conditions, resulting in the thawing of more permafrost, the subsequent release of more greenhouse gases, and so on.

Vocabulary:
thermokarst—a landscape feature formed as ice-rich permafrost thaws; it is characterized by irregular topography due to degradation of massive ice and is more abundant in warming climatic conditions

Materials:
• MULTIMEDIA: “Horn Lake Thermokarst” available at www.uniteusforclimate.org (running time 2:36)
• VISUAL AID: “Thermokarst Terrain”
• VISUAL AID: “Thermokarst Aerial View”
• STUDENT WORKSHEET: “Horn Lake Thermokarst”
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Activity Procedure:

1. Write the word “thermokarst” on the white board. Ask students if and where they have heard this word and what they think it means. Show VISUAL AID: “Thermokarst Terrain” and ask students to describe thermokarst and to guess how and why it forms. Invite students to share their own experiences with thermokarst terrain.

2. Pass out STUDENT WORKSHEET: “Horn Lake Thermokarst” and review directions if necessary. Explain students will view a short video (running time 2:36). The video is a compilation of photographs that were taken every hour for one month (July 25-August 25). Show VISUAL AID: “Thermokarst Aerial View.” Explain this is an aerial view of the landscape they are about to see on the video. Allow time for students to complete the worksheet. Periodically remind students to look at the “big picture” (the aerial view). When all students have completed the worksheet, review answers. As you discuss the impact on water clarity and substrate, explain in 2003 this particular thermokarst poured so much sediment into the lake that visibility was reduced from 14 meters to just one meter!

Ideas for Filming:

NOTE: Students will create a short film about permafrost for the final project associated with this UNITE US unit. Each lesson leading to the final project contains ideas about what students might film as they compile clips. Students are not limited to the list and are encouraged to use their imagination and creativity when filming.

In MULTIMEDIA: “Horn Lake Thermokarst” students watch a video of slumping thermokarst. One student could film the video as another student narrates for the camera. If possible, students should find an area in their community where they can see and film thermokarst terrain, and discuss its properties.

Answers:

1. Answers will vary. Examples of things student may report include: the large volume of mud washing into the lake, the clumps of grasses slumping down and the grass growing up in front of the camera. Observant students may notice that as the summer progresses darkness becomes more evident and temperatures begin to drop. Lower temperatures decrease the thawing and thus the volume of material slumping into the lake. Very observant students may even notice the researchers appear in the frame on 8/16/10 at 10 a.m.!

2. Water clarity: The substrate washing into the lake will decrease water clarity. This can impact the infiltration of sunlight, which affects photosynthesis of aquatic plants. Excessive sediment can also clog the gills of fish and invertebrates.

   Lake Substrate (bottom): Sediment can cover the bottom of the lake, burying fish eggs, spawning areas and aquatic macroinvertebrates.

3. Students should report that as the images move further into August, temperatures decrease and it begins to get dark. This combination significantly decreases the amount of thaw and subsequent slumping of material into the lake. Students should conclude that temperature is related to the amount of thaw, and thus the amount of slumping. Students may conclude global warming will increase thawing and slumping of thermokarst terrain (affecting large parts of the arctic landscape).
Thermokarst Terrain northwest of Toolik Field Station on the North Slope of Alaska. Photo by Ben Abbot, UAF.
Thermokarst aerial view north of Toolik Field Station on the North Slope of Alaska. Photo by Ben Abbot, UAF.
Directions: Access the MULTIMEDIA: “Horn Lake Thermokarst” at www.uniteusforclimate.org. Answer the questions below.

1. Watch the video all the way through. Imagine you are a field biologist collecting qualitative data at Horn Lake. Report what you see happening.

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2. Look at the aerial photograph of Horn Lake. Describe how you think the thawing permafrost and slumping landscape will affect the lake ecosystem in each of the following ways:

   A. water clarity: ________________________________________________________________

   B. lake substrate (bottom): ______________________________________________________

3. What did you notice about the temperature data at the start of the video (in July and early August) compared to the end of the video (at the end of August). Do you notice any corresponding change in the amount of slumping? What does this tell you about the cause of the slumping? What do you predict for the future?

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