

## Lesson Plan: Permafrost and Climate Change

Teacher-contributed lesson plan by Dr. Vandna Luthra, Gargi College (University of Delhi), India

As a **high school** or **undergraduate Geography, Environmental Sciences** or **Earth Sciences** teacher, you can use this set of computer-based tools to teach about **permafrost**, the **nature and distribution of permafrost** in the Earth's cryosphere, **thawing of permafrost** due to global warming which in turn, results in the **release of a potent greenhouse gas methane**; and therefore, the **possible impacts of permafrost thawing on climate**.

This lesson plan introduces the topic of permafrost and the observed thawing of permafrost in recent times due to rising global temperatures. A computer-based activity/model helps in exploring the possible impacts of permafrost thawing on the Earth's climate. Thus, the use of this lesson plan allows you to integrate the teaching of a climate science topic with a core topic in Geography, Environmental Sciences or Earth Sciences.

Use this lesson plan to help your students find answers to:

1. What is permafrost? Where is it found?
2. What changes have been observed in permafrost characteristics in recent times?
3. What is the active layer of the soil? How is it affected when permafrost thaws?
4. Why is methane, a greenhouse gas, released into the atmosphere when permafrost thaws?
5. What are the possible impacts of permafrost thawing on the Earth's climate?

## About the Lesson Plan

**Grade Level:** High School, Undergraduate

**Discipline:** Geography, Environmental Sciences, Earth Sciences

**Topic(s) in Discipline:** Permafrost, Methane, Thawing of Permafrost, Global Warming, Methanogens, Greenhouse Gases, Emissions, Active Layer of Soil

**Climate Topic:** Climate and the Cryosphere, The Greenhouse Effect

**Location:** Global

**Access:** Online

**Language(s):** English

**Approximate Time Required:** 50-60 min

# 1 Contents

## 1. Video (~7 min)

A video that introduces permafrost and its distribution on Earth. The video also describes the changing nature of permafrost across several regions due to higher surface temperatures and the possible impact of permafrost thawing on Earth's climate owing to the release of methane, a greenhouse gas.

This video can be accessed at

<http://www.nbclearn.com/portal/site/learn/cuecard/52627>

## 2. Classroom/Laboratory activity

### a. For high school students (30-45 min per activity):

A set of hands-on classroom and computer-based activities to learn about permafrost and to explore various web-based scientific data portals to investigate permafrost distribution, characteristics of permafrost, and the effects of thawing permafrost on the atmosphere and the environment.

Note: The plan includes 3-4 activities; one or more of these activities can be conducted. The time required for each activity is specified in the summary table of the laboratory plan.

This can be accessed at

[https://www.windows2universe.org/?page=/teacher\\_resources/permafrost\\_gas\\_leak.html](https://www.windows2universe.org/?page=/teacher_resources/permafrost_gas_leak.html)

### b. For undergraduates (45 min):

A computer-based model/ simulation to observe and compare the changes in the concentration of methane in the global atmosphere when compared with normal trends (resulting from natural and anthropogenic emissions), when a sudden increase in methane (as an

effect of thawing of permafrost) is introduced. The model/ simulation also enables students to observe the radiative forcing of methane when compared with that of carbon dioxide under similar conditions.

This can be accessed at

<http://climatemodels.uchicago.edu/methane/>

### 3. Suggested questions/assignments for learning evaluation

1. What is permafrost? Where is it found?
2. What changes have been observed in permafrost characteristics in recent times?
3. What is the active layer of the soil? How is it affected when permafrost thaws?
4. Why is methane, a greenhouse gas, released into the atmosphere when permafrost thaws?
5. What are the possible impacts of permafrost thawing on the Earth's climate?

## 2 Step-by-step User Guide

Here is a step-by-step guide to using this lesson plan in the classroom/laboratory. We have suggested these steps as a possible plan of action. You may customize the lesson plan according to your preferences and requirements.

### 1. Introduce the topic by playing a video and facilitating a discussion

Play the video "[Thawing Permafrost](#)" by NBC Learn to introduce the topic of permafrost. Use the video to describe the characteristics of permafrost and its distribution across the globe. Then, discuss how permafrost is used to study soil conditions for periods dating back to several thousands of years by drilling boreholes and extracting ice cores for analyses. Discuss how higher surface temperatures cause changes in permafrost conditions, leading to the thawing of permafrost in many regions. Further, describe how this thawing has led to local environmental

perturbations such as sinkholes, landslides, increased vegetation, and an enhanced active-layer bacterial activity. Finally, discuss how permafrost thawing can lead to the release of greenhouse gases such as methane to the atmosphere which can in turn, impact the Earth's climate.

This video is available at <http://www.nbclearn.com/portal/site/learn/cuecard/52627>

## 2. Conduct a classroom/laboratory activity

a. For high school students:

Use the laboratory plan “[Changing Planet: Permafrost Gas Leak](#)”, developed by Missy Holzer, Jennifer Bergman, and Roberta Johnson, Windows to the Universe team members from the National Earth Science Teachers Association (NESTA), to enable students to

- investigate permafrost characteristics
- understand borehole data and identify the trends in the data observed
- find a correlation between atmospheric methane data and permafrost thawing data

The laboratory plan is available at [https://www.windows2universe.org/?page=/teacher\\_resources/permafrost\\_gas\\_leak.html](https://www.windows2universe.org/?page=/teacher_resources/permafrost_gas_leak.html).

Follow the instructions provided in the plan to complete these laboratory activities. Each activity can be conducted separately. The relevant reading material and links for datasets and worksheets are given in the main text or in the table (under the “Materials” section).

b. For undergraduate students:

Use the model/simulation “[METHANE in the Atmosphere](#)” by Prof. David Archer, University of Chicago, to observe the methane concentration in the atmosphere under different hypothetical conditions and timescales.

The model/simulation is available at <http://climatemodels.uchicago.edu/methane/>.

Large-scale thawing of the Earth's permafrost can lead to a sudden release of the greenhouse gas methane into the atmosphere. Go to <http://climatemodels.uchicago.edu/methane/methane.doc.html>. Then, click the “Overview” tab to read about the model. Next, play the “Video Introduction” to understand how the model can be used to simulate sudden methane perturbations in the atmosphere. Observe the subsequent impact on its atmospheric concentration.

Now, run the model to

- note changes in atmospheric methane concentration **or**

- track the atmospheric methane budget (source versus sink) **or**
- observe atmospheric methane persistence over time **or**
- compare the radiative forcing of atmospheric methane and carbon dioxide

when different amounts of methane are released into the atmosphere over varying time scales. Use the data points generated to draw graphs representing different scenarios of methane perturbations. Use these representations to discuss the implications of methane release in the atmosphere due to the large-scale thawing of permafrost.

### 3. Questions/Assignments

Use the tools and the concepts learned so far to discuss and determine answers to the following questions:

1. What is permafrost? Where is it found?
2. What changes have been observed in permafrost characteristics in recent times?
3. What is the active layer of the soil? How is it affected when permafrost thaws?
4. Why is methane, a greenhouse gas, released into the atmosphere when permafrost thaws?
5. What are the possible impacts of permafrost thawing on the Earth's climate?

## 3 Learning Outcomes

The tools in this lesson plan will enable students to:

- describe permafrost and its characteristics
- discuss the changing nature and distribution of permafrost on Earth
- explain the possible effects of thawing of permafrost on Earth's climate
- interpret, analyze, and predict trends in data from permafrost-related datasets

## 4 Additional Resources

If you or your students would like to explore the topic further, these additional resources will be useful.

### 1. Teaching Module (60-90 min) (High School)

A laboratory module “Part B: Permafrost, a Frozen Soil starting to Thaw” from the Science Education Research Centre (SERC), Carleton College, to introduce the topic of permafrost and engage the students in discussions about thawing of permafrost and its impact on “Soil and the Carbon Cycle”.

<https://serc.carleton.edu/eslabs/carbon/5b.html>

### 2. Video (~12 min)

An animated video, “Permafrost- what is it?” by Lars Grübner, Alfred Wegener Institute, Norway, that explains permafrost and the effects of permafrost thawing on the Earth’s climate and environment.

<https://www.youtube.com/watch?v=lxixy1u8GjY>

## 5 Credits/Copyrights

All the teaching tools in our collated list are owned by the corresponding creators/authors/organizations as listed on their websites. Please view the individual copyright and ownership details for each tool by following the individual links provided. We have selected and analyzed the tools that align with the overall objective of our project and have provided the corresponding links. We do not claim ownership of or responsibility/liability for any of the listed tools.

### 1. Video, “Thawing Permafrost”

Created by [NBC Learn](#) as part of the “Changing Planet” series, in partnership with the National Science Foundation (NSF)

### 2. a. Laboratory plan, “Changing Planet: Permafrost Gas Leak”

Presented by Missy Holzer, Jennifer Bergman, and Roberta Johnson of the [“Windows to the Universe”](#) team of the National Earth Science Teachers Association (NESTA)

### b. Model/ Simulation, “Methane in the atmosphere”

[Prof. David Archer](#), University of Chicago

### 3. Additional Resources

“Part B: Permafrost, a Frozen Soil starting to Thaw”: [Science Education Research Centre \(SERC\)](#), Carleton College

“Permafrost- what is it?”: Lars Grübner, [Alfred Wegener Institute](#), Norway