

Lesson Plan: Teach the Earth's Climate System Through Simulations (Earth-Like)

As a **Middle or High School Earth Sciences, Environmental Sciences, or Geography** teacher, you can use this lesson plan to teach the Earth's climate system and help your students understand different aspects of Earth's climate using simulations. This lesson plan is based on the web-based tool 'Earth-Like' developed at the Earth- Life Science Institute, Japan.

This lesson plan **introduces Earth's climate system**, an overview of the Earth-Like simulator, and provides a guided exercise that uses the simulator to help your students understand what are the main factors that determine the climate of planet Earth.

There are several **factors that impact the surface temperature and the climate of the planet**. These include the role of the sun and solar flux incident on the planet, the roles of the atmosphere and its greenhouse effect, the hydrosphere, the lithosphere, the biosphere, the cryosphere, the anthroposphere, and their interactions on a variety of spatial and temporal scales. This lesson plan demonstrates the use of the Earth-Like simulation to explain select aspects of the Earth's climate system.

Thus, the use of this lesson plan allows you to teach Climate Science and Climate Change in your **Earth Sciences, Environmental Sciences, and Geography** classrooms. This lesson plan is particularly effective to use in a flipped classroom and as a blended learning educational resource.

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

1. What would Earth's average surface temperature be if the sun was a Red Dwarf (0.002 L) like Proxima Centauri? If it was a Yellow-White Dwarf (5 L)?
2. What role does the incoming solar flux play in determining the average surface temperature of planet Earth?
3. What do you expect the average surface temperature of the Earth to be if the rate of volcanism increases?
4. What would Earth's climate be like if it was much closer to the Sun?

About the Lesson Plan

Grade Level: High School, Middle School

Discipline: Earth Sciences, Environmental Sciences, Geography

Topic(s) in Discipline: Earth's Climate System, Climate Change

Climate Topic: Planetary Climate

Location: Global

Access: Online

Language(s): English

Approximate Time Required: 50 min

1 Contents

1. Video Lecture (15 min)

A video micro-lecture produced by the University of British Columbia that explains the Earth's climate system and what determines the climate of planet Earth.

This can be accessed at:

<https://www.youtube.com/watch?v=nW-s8KXKlzQ>

2. Introduction to Simulator Earth-Like (10 min)

The Earth-Like simulator developed at the Earth- Life Science Institute, Japan to understand Earth's climate system

This can be accessed at:

<http://earthlike.world/>

3. Classroom/Laboratory Activity (25 min)

A classroom/ laboratory activity that uses the Earth-Like simulator to guide learning about Earth's climate system and the role that different factors play in determining Earth's climate and changes to it.

4. Suggested questions/assignments for learning evaluation

- What would Earth's average surface temperature be if the sun was a Red Dwarf (0.002 L) like Proxima Centauri? If it was a Yellow-White Dwarf (5 L)?
- What role does the incoming solar flux play in determining the average surface temperature of planet Earth?

- What do you expect the average surface temperature of the Earth to be if the rate of volcanism increases?
- What would Earth's climate be like if it was much closer to the Sun?

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. Introduction to the Earth's Climate System

Introduce the Earth's climate system to your students through the video lecture 'Earth's Climate System' developed by the University of British Columbia as part of the course titled 'Climate Literacy: Navigating Climate Change Conversations'.

Emphasize the following topics from the video lecture: What determines the climate of planet Earth, specifically the significant role of the sun and the solar energy flux received on the planet, and the roles of the atmosphere, biosphere, geosphere, hydrosphere, and cryosphere.

This resource can be accessed at:

https://www.youtube.com/watch?v=zQs6YuVry_k

2. Classroom/Laboratory Activity

Introduce your students to the Earth-Like simulator developed at the Earth-Life Science Institute, Japan. This simulator was developed as a project from the ELSI Origins Network Planetary Diversity Workshop.

The Earth-Like simulator can be accessed at:

<http://earthlike.world/>

The Earth-Like is a simulator allows you to render new planets and examine the average surface temperature and the climate of the planet by varying the most significant contributors to the Earth's climate system. The simulator has two options: A classic toolkit and an advanced toolkit. The simulator includes the following:

Classic Toolkit

1. Fraction of the planet's surface covered by land
2. The rate of volcanism
3. Position within Habitable zone

Advanced Toolkit

1. Fraction of the planet's surface covered by land
2. The rate of volcanism
3. The type of sun
4. The distance from the sun

Your students can choose either toolkit to evaluate the roles of each of the factors listed above in determining the climate of the planet. The simulator can be used by changing values of these factors and rendering a new planet. The results are given in terms of the average surface of temperature of the new planet and is compared with that of our current day Earth.

The Earth-Like website also includes a brief description of climate science and specifically the role of land fraction cover with an emphasis on the weathering reaction, rate of volcanic degassing, solar insolation levels, the planetary thermostat and the carbon cycle. A description of the model and the mathematics behind it is also provided.

Give your students an assignment and ask them to answer the following questions. At the end of each question, emphasize to your students how varying each factor changes the average surface temperature of the planet. This will allow them to better understand the role of these factors in determining planet Earth's climate. The solutions to the assignment are provided as a separate downloadable document.

Q 1. What would Earth's average surface temperature be if the sun was a Red Dwarf (0.002 L) like Proxima Centauri? If it was a Yellow-White Dwarf (5 L)?

Q 2. How does change in the land cover fraction affect the average surface temperature of planet Earth?

Q 3. What do you expect the average surface temperature of the Earth to be if the rate of volcanism increases?

Q 4. What would Earth's climate be like if it was much closer to the Sun? What would the average surface temperature be if the planet were much farther from the Sun?

3 Learning Outcomes

The tools in this lesson plan will enable students to:

- learn about what determines the climate of planet Earth
- understand the role of the sun and distance from the sun in determining the average surface temperature
- understand the role of volcanic degassing, weathering, and land surface fraction in Earth's climate system
- use simulators to understand the Earth's climate system and climate change

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 Lecture; 'Earth's Climate System'

Developed by the [University of British Columbia](#) as part of the course titled '[Climate Literacy: Navigating Climate Change Conversations](#)'.

2. Simulator; 'Earth-Like'

Developed at the [Earth-Life Science Institute](#), Japan.