14 Climate Change

Content Area: **Science**
Course(s): **AP Physics C**
Time Period: **Semester 2**
Length: **5 weeks**
Status: **Published**

Standards

HS-ESS2-2	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
	Analyzing and Interpreting Data
ESS2.A	Earth Materials and Systems
	Stability and Change
	Developing and Using Models
	Cause and Effect
HS-ESS2-6	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
	Energy and Matter
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.
	Constructing Explanations and Designing Solutions
ESS3.C	Human Impacts on Earth Systems
ETS1.B	Developing Possible Solutions
HS-ESS3-5	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
ESS3.D	Global Climate Change
HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change).
	Using Mathematics and Computational Thinking
ESS2.D	Weather and Climate
	Systems and System Models
HS-ETS1-1	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
	Asking Questions and Defining Problems
HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
ETS1.C	Optimizing the Design Solution
HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Enduring Understandings

Local and regional human activities can have impacts at the global level.

The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.

Essential Questions

To what extent are human activities damaging the Earth's atmosphere, climate, and biosphere, and how can we reverse this trend?

Knowledge and Skills

Knowledge:

- The principal greenhouse gases are carbon dioxide, methane, water vapor, nitrous oxide, and chlorofluorocarbons (CFCs).
- While water vapor is a greenhouse gas, it doesn't contribute significantly to global climate change because it has a short residence time in the atmosphere.
- The greenhouse effect results in the surface temperature necessary for life on Earth to exist.
- Carbon dioxide, which has a global warming potential (GWP) of 1, is used as a reference point for the comparison of different greenhouse gases and their impacts on global climate change. Chlorofluorocarbons (CFCs) have the highest GWP, followed by nitrous oxide, then methane.
- Global climate change, caused by excess greenhouse gases in the atmosphere, can lead to a variety of environmental problems including rising sea levels resulting from melting ice sheets and ocean water expansion, and disease vectors spreading from the tropics toward the poles. These problems can lead to changes in population dynamics and population movements in response.
- The Earth has undergone climate change throughout geologic time, with major shifts in global temperatures causing periods of warming and cooling as recorded with CO2 data and ice cores.
- Effects of climate change include rising temperatures, melting permafrost and sea ice, rising sea levels, and displacement of coastal populations.
- Marine ecosystems are affected by changes in sea level, some positively, such as in newly created habitats on now-flooded continental shelves, and some negatively, such as deeper communities that may no longer be in the photic zone of seawater.
- Winds generated by atmospheric circulation help transport heat throughout the Earth. Climate change may change circulation patterns, as temperature changes may impact Hadley cells and the jet stream
- Oceanic currents, or the ocean conveyor belt, carry heat throughout the world. When these currents change, it can have a big impact on global climate, especially in coastal regions.
- Climate change can affect soil through changes in temperature and rainfall, which can impact soil's viability and potentially increase erosion.
- Earth's polar regions are showing faster response times to global climate change because ice and snow in these regions reflect the most energy back out to space, leading to a positive feedback loop.
- As the Earth warms, this ice and snow melts, meaning less solar energy is radiated back into space and instead is absorbed by the Earth's surface. This in turn causes more warming of the polar regions.

- Global climate change response time in the Arctic is due to positive feedback loops involving melting sea ice and thawing tundra, and the subsequent release of greenhouse gases like methane.
- One consequence of the loss of ice and snow in polar regions is the effect on species that depend on the ice for habitat and food.
- Ocean warming is caused by the increase in greenhouse gases in the atmosphere.
- Ocean warming can affect marine species in a variety of ways, including loss of habitat, and metabolic and reproductive changes.
- Ocean warming is causing coral bleaching, which occurs when the loss of algae within corals cause the corals to bleach white. Some corals recover and some die.
- Ocean acidification is the decrease in pH of the oceans, primarily due to increased CO2 concentrations in the atmosphere, and can be expressed as chemical equations.
- As more CO2 is released into the atmosphere, the oceans, which absorb a large part of that CO2, become more acidic.
- Anthropogenic activities that contribute to ocean acidification are those that lead to increased CO2 concentrations in the atmosphere: burning of fossil fuels, vehicle emissions, and deforestation.
- Ocean acidification damages coral because acidification makes it difficult for them to form shells, due to the loss of calcium carbonate.

Learning Objectives and Skills:

- The student will be able to describe the difference between weather and climate.
- The student will be able to describe the difference between global warming and climate change.
- The student will be able to describe the greenhouse effect and how it traps heat in the atmosphere.
- The student will be able to identify the causes of anthropogenic climate change.
- The student will be able to describe the potential impacts of climate change.
- The student will be able to interpret and explain sources of evidence of climate change.
- The student will be able to identify the most important greenhouse gases and describe their properties as they relate to climate change.
- The student will be able to explain how greenhouse gases absorb and emit infrared radiation.
- The student will be able to describe the relationship between the concentration of greenhouse gases in the atmosphere and global warming.
- The student will be able to describe the relationship between surface albedo and infrared radiation.
- The student will be able to compare the absorption and emission of radiation by land and ocean surfaces.
- The student will be able to compare the absorption and emission of greenhouse gases by land and ocean surfaces.
- The student will be able to evaluate the effect of greenhouse gas concentrations on the absorption and reflection of sunlight and infrared radiation.
- The student will be able to explain the effect of greenhouse gas emissions on atmospheric temperature.
- The student will be able to analyze data of various greenhouse gas concentrations from the Ice Age to present day and the corresponding global average surface temperatures.
- The student will be able to analyze the effect of atmospheric layers on the greenhouse effect.
- The student will be able to synthesize evidence and physical principles to predict the effect of continuing increases in greenhouse gas emissions on surface temperature.
- The student will be able to describe and explain the current and projected impacts of climate change on different climate regions around the world.
- The student will be able to describe and explain the current and projected impacts of climate change on the environment, human health, and the economy.
- The student will be able to evaluate potential geopolitical impacts of climate change.
- The student will be able to evaluate the efforts of the state of New Jersey to combat climate change,

decrease greenhouse gas emissions, build a climate resilient economy, and enact adaptations to climate change.
- The student will be able to apply physical principles and data analysis to evaluate and disprove false claims regarding climate change.

Transfer Goals

This unit is designed to give students the opportunity to explore and investigate the science of climate change, research local and global efforts to combat climate change, and disprove misinformation and myths about climate change with scientific evidence. Prior knowledge of climate change or physics is not needed for this unit. Students will need to draw on content learned in previous science courses. It is expected that students have had exposure to the electromagnetic spectrum, the nature of light, thermodynamics, photosynthesis, combustion reactions, and the water cycle. Completion of introductory Biology and Chemistry courses is sufficient preparation.

Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit?usp=sharing