



Lesson 4: How is human activity contributing to the increase in global temperatures?

HS Climate Change Unit

Previous Lesson....Where we've been: We determined that land surface (albedo) effects temperatures. Low albedo surfaces create greater heating in cities known as the Urban Heat Island Effect and lowering albedo in states would increase temperatures, but not enough to reach current temperatures. We noticed that albedo doesn't help explain why temperatures in the Arctic are increasing.

 This Lesson....What we are doing now: This lesson explores a computer simulation to understand the Greenhouse Effect and then develop a model for how this works.			
Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figure Out (CCCs & DCIs), <i>New Questions and Next Steps</i>
L4: How is human activity contributing to the increase in global temperatures? 2 Periods  <i>Building toward</i> ↓ <u>NGSS</u> <u>PEs:</u> HS-ESS-3-6	Greenhouse Gases Simulation Radiant Energy Simulation	Observe simulations in order to understand how greenhouse gases (emissions) influence temperature Create a model to explain how greenhouse gases (emissions) influence temperature	<p>Last class we realized that human development and land use can't be the only thing that explains warming temperatures.</p> <p>We use an equation to determine that yes, a lower albedo does increase the state's temperature but that there is another variable missing from our understanding. Referring back to the Driving Questions Board we determine this variable to be something to do with the atmosphere/ gases.</p> <p>We decide that we need to investigate what other variables (e.g., gases) can impact temperature besides albedo because we were wondering why our temperature equation that was based off land surface is significantly low.</p> <p>We think it might be something to do with emissions, we know that rural areas have livestock, trees, urban areas have people, factories, and cars so we use a computer simulations to determine how Greenhouse Gases work in the atmosphere.</p> <p>Based on what we learn from the simulation, we create a model to explain this process. We use our model to ask if the Greenhouse Effect is bad and what the Earth would be without it?</p> <p>We figure out more heat is being trapped due to an increase in Greenhouse Gases, and this is the missing variable in our calculations.</p> <p>We find out Greenhouse Gas emissions matter, and there are natural and human-caused sources of these emissions.. We consider the sources of these gases, which are related to human activity.</p> <p><i>We are wondering if this natural process can be harmful or dangerous and why? What happens? Is this normal? How long has this been going on? Is this normal that world temperatures are rising this fast?</i></p> <p>We decide to look at paleoclimate data to see if a trend like this has happened before in Earth's history</p>

Next Lesson....Where we're going: This lesson will explore historical data to determine if the changes in global climate are normal for Earth or unusual.



Getting Ready: Materials Preparation

Materials For Each Group

- Computers with internet connection (see preparation of materials section for strategies how to utilize this material for different school scenarios)
- Poster paper larger than a sheet of paper (1 for each group)
- Markers (for each group)

Preparation of Materials (15 min.)

- Students will need access to computers for these simulations.
- Copies of Student Activity Sheets
- [Slides](#)

Materials For Each Student

- [Student Activity Sheet](#)
- [Instructions for computer simulation](#)

Safety



Getting Ready: Teacher Preparation

Background Knowledge

ESS3.C from the FRAMEWORK:

By the end of grade 8: Human activities have significantly altered the biosphere sometimes damaging or destroying natural habitats and causing the extinction of many other species. However, changes to Earth's environment can have different impacts (negative and positive) for different living things. Typically, as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

ESS3.D from the FRAMEWORK:

By the end of grade 8: Activities such as the release of Greenhouse Gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior, applying that knowledge wisely, decisions, and activities.

ESS3 from the FRAMEWORK: "Thus science and engineering will be essential both to understanding the possible impacts of global climate change and to informing decisions about how to slow its rate and consequences..."

Rate of and region of change matters for understanding climate change. Cities are changing faster because of their characteristics - localized amplification because of things black tops, resulting in heat islands in cities. However, this isn't the entire explanation for climate change. Overall, regionally and globally human activities are increasing CO₂ and Greenhouse Gases, which result in global warming.

Alternative Student Conceptions

Students may have learned about the Greenhouse Effect before or have heard about the process in the news. They may have incorrect ideas about how the process works.

Linking Our Understanding to Scientific Terminology

- Visible energy
- Infrared energy
- Absorb
- Reradiate
- Reflect
- Greenhouse Gases
- Regular/ non-Greenhouse Gases
- Greenhouse Effect



Learning Plan: How is human activity contributing to the increase in global temperatures?

(90min)

1. (5 min) Have students work with a partner to answer the questions for their Do Now section.

Suggested Prompts:

- What did we figure out yesterday about albedo?
- What does it help us explain?
- What are some gaps that albedo doesn't help us explain?

Listen for student responses:

- *We figured out that albedo is the measure of how much light a surface reflects.*
- *Albedo helps us explain urban heat islands where it gets hotter in places with surfaces that absorb heat like pavement.*
- *It doesn't help us explain why the temperatures are increasing more than normal in places like the Arctic which have high albedo.*

2. (15 min) Guide students in an Initial Ideas Discussion^A to emphasize that what we know of albedo is not the entire explanation for increased temperatures using the following prompts.

Suggested Prompts:

- What are we missing from our explanation?
- How can we use our understanding of albedo to understand the increase in a state's temperature?
- Average state temperature trends are also increasing [refer to figure on slide] not just city temperatures, how can we explain this?
- What is the difference between the "spikes" versus the overall trend line on this graph^B?

Listen for student responses:

- *Surfaces of states are changing too:*
 - ◆ *More/ growing cities causing lower albedo and more absorption.*
 - ◆ *Less snow for some reason = lower albedo, more absorption - like the ice albedo feedback we read about?*
- *Estimate the albedo of the state land using our satellite imagery, and use it to calculate temperature.*



Teacher Supports & Notes



Strategies for this Initial Ideas Discussion

A: The goal here is to highlight that albedo doesn't explain the worldwide trend of increasing temperature. Use the graphs in the slides and push students to point out that albedo doesn't explain the increase we are seeing in places like the Arctic. You also want students to come up with the idea that they need to apply what they learned from the last lesson to actual land areas and try to calculate albedo in different locations.

B: This question is very important. Standard: **CCSS.Math.Content.HSS.ID.A.3** would be great if the math was being taught at the same time. Talking about outliers and what they tell you (small-scale changes that don't mean much in the long term etc.) would enhance this study.



Suggested Prompts:

- Reviewing Colorado in Google Earth, we notice there is more rural space than urban spaces (cities) in Colorado, but the color of those surfaces are important too, even if they are not urban.
- What percentage of the land would we categorize as “high albedo?” (ask students to assist in reviewing this terminology, being specific). What we are looking for when categorizing a high versus a low albedo surface?
- How would this percentage translate to the albedo scale we read about yesterday? (The percentage will just be in decimal form, for example, 60% will become 0.6).

3. [14 min] Hand out the Student Activity Sheet and read through the procedure. Break down the equation, going through each number and variable, as the equation may seem daunting to students. Complete calculations^c to determine how changing the albedo of the state of Colorado might affect temperature. Each group/pair will complete a different albedo value to see how changing this value affects temperature, and this should be transcribed in a table on the board for students to copy into notes as calculations are completed (to be done on the Student Activity Sheet).

1. Read equation introduction together (students popcorn read), noting what variables are present in the equation we are using and why they are important.
2. Determine what albedo ratings we want to explore as a class - one group should do the estimated “Colorado State” albedo, and from there students can choose higher and lower albedos to explore.
3. Circulate and support students with their calculations, instruct students to put their answer in Fahrenheit on the board next to their group’s albedo value when completed. Students should copy data from board onto their Student Activity Sheet.

Once students have compiled the class set of albedo data, guide them in a Building Understandings Discussion to summarize what the relationship between albedo and temperature is, and to compare the values we calculated with the average temperature of Colorado. Here students should note that even though albedo explains an increase in temperature, the temperatures we calculated are far below the state average.

Suggested Prompts:

- What is the relationship between albedo value and temperature?
- If albedo was decreasing in Colorado over time, could that result in an increase in temperature?
- Does albedo fully explain the average temperature of Colorado? Why or why not?
 - ◆ Here, students should note that the albedo change in Colorado is far too small for the changes we see.

Listen for student responses:

- *The expected temperatures based on albedo are very low compared to the true temperature average of Colorado and we are wondering why?*

**Additional Guidance**

C: Students may need some support for this mathematical task as the equation can be daunting. Use appropriate grouping strategies or whole class instruction as you see fit with your students.

If groups finish early, those group members can “tutor” other groups and check their work to make sure everyone reaches their goal.



4. (5 mins) Return to the Driving Questions Board to determine the missing variable (Greenhouse Gases). The goal of this section is to get students thinking about the role of gases in the temperature rise- whether in the form of emissions (Greenhouse Gases), or simply drawing on what they know about the carbon cycle with plants.

Suggested Prompts:

- Based on the albedo we estimated for Colorado, the average temperature should be _____ for our state. Does that sound correct for what is actually is? Why is this average low? Is something missing from our equation?
- What from our Driving Questions Board might help us understand another variable that influences temperature?
- What are Greenhouse Gases, how do they affect temperature?
- Are all gases Greenhouse Gases? Which are and which are not?

Listen for student responses:

- *From the Driving Questions Board: photosynthesis, emissions, and Greenhouse Gases should attract student attention. Use these to build toward the goal of this lesson.*
- *Greenhouse Gases trap heat, we don't specifically know how.*
- *Not all gases are Greenhouse Gases, O_2 and N_2 are not, CO_2 and methane are... we don't know about water vapor.*

5. (5 min) Ask student to brainstorm in a whole class discussion or a think pair share, what our next steps should be in our investigation.

Suggested Prompts:

- What could we do to investigate this idea of Greenhouse Gases?
- How could we answer our questions?

Listen for student responses such as:

- *We think both land type (albedo) and emissions (Greenhouse Gases, the atmosphere) have something to do with this so we decided to look at both of these relative contributions.*
- *We need to figure out how Greenhouse Gases trap heat.*
- *We need to determine the sources of Greenhouse Gases and if these sources are changing/increasing.*



6. (5 min) Now that students have determined that it's not just albedo that affects temperature, but also the gases in Earth's atmosphere, have students complete the gases table in their Student Activity Sheets to determine what prior knowledge they have.

Suggested Prompts:

- What gases are in this room right now?
- What gases do living organisms produce?
- What gases are considered "emissions" from our Driving Questions Board?
- What are emissions and what affects them?
- What percentage of our atmosphere are each of these gases?

Ask students to share their ideas and create a class list of things they know about the gases in our atmosphere, organizing these observations on the board.

Listen for and capture student responses, such as:

- *Oxygen, animals use it to respire... byproduct of photosynthesis*
- *CO₂ - people exhale it, plants use it for photosynthesis*
- *CO₂- emissions from cars, factories, burning fossil fuels, which make energy for humans to use (really important to make sure students bring up)*
- *Methane - cows*
- *Water vapor - from evaporation of water, clouds*

7. (25 min) At this point, it should be clear that there is disparity in what students know/understand about Greenhouse Gases and how they work. Use this to motivate the need for some type of activity to help students understand Greenhouse Gases. Then, introduce the "Greenhouse Gas" computer simulations (there are 2) and explain how they will demonstrate how Greenhouse Gases interact with energy from the sun. Instruct students to use their Student Activity Sheets and the Simulation Help Handout to complete the simulation.

8. (15 mins) Have students create models on poster paper (using markers to help illustrate the different types of energy) where they explain how the Greenhouse Effect works on planet earth, following the directions in their Student Activity Sheet. They must have labeled steps on these posters (at least 5 steps), they must use all the vocabulary terms listed, and they must submit the posters for an assessment. Remind students to not focus on artistry, focus on content. Circulate between groups to provide feedback/support/ help them extend their thinking.



9. (15 mins) Once students have had a chance to complete their models, direct them to answer the Making Sense Questions in their Student Activity Sheets and then guide students in a Building Understandings Discussion.

Suggested Prompts:

- Which of the gases that we've explored today are Greenhouse Gases? How do you know?
- Why are they called Greenhouse Gases? Why is this called the Greenhouse Effect?
- Are Greenhouse Gases bad?

Listen for student responses

- *The most important Greenhouse Gases are CO₂, Methane, and water vapor... these molecules seem to have more than one element present... "lopsided polarity" and can trap infrared heat. N₂ and O₂ cannot.*
- *Similar to a greenhouse, which is a glass/plastic structure where visible light can enter through glass, be absorbed and changed to infrared heat, and then trapped in the greenhouse to warm the greenhouse so plants can grow there even in the winter.*
- *Greenhouse Gases are not bad, but too many Greenhouse Gases trapping an excessive amount of heat could be bad.*

Suggested Prompts:

- Are Greenhouse Gases increasing in Colorado? Why?
- What could cause Greenhouse Gas concentrations to change in Colorado?
 - ◆ What are sources of Greenhouse Gases (identify natural versus anthropogenic)
- What evidence might we look for in Colorado to show that the temperature is changing?

Listen for student responses

- *CO₂ has a natural yearly cycle in Colorado; lower when more photosynthesis is taking place. This cycle is in equilibrium.*
- *In Colorado - more forest fires, trees dead from pine beetle, cutting down forests, more people consuming more fossil fuels, bigger cars, larger cities.*
 - ◆ *There are human-caused sources of CO₂ that might be disrupting this balance. We've heard of "fossil fuels" releasing CO₂, we know our cars release emissions, and methane comes from cows.*
 - ◆ *The human population is increasing worldwide, so the amount of Greenhouse Gases being emitted could be increasing too.*
- *Less snowpack, warmer summers, changing ecosystems*

Suggested Prompts:

- *What is the temperature trend for the USA... for the world?*
- *Are all locations in the USA warming at the same rate? What might account for these regional differences?*
- *Is everywhere in the world warming at the same rate? What might account for these regional differences?*



Listen for *student responses*

- Overall trend is the world is getting warmer, and this might relate back to Greenhouse Gases.
- There are regional differences in warming...
 - ◆ oceans/albedo might have a role

10. (5 min) Use the following prompts to guide students in a Consensus Building Discussion.

Suggested Prompts:

- What have we figured out so far?
- What is our reaction to increasing worldwide temperatures?
- What should be the next steps be in our investigation?

Listen for *student responses* such as:

- We figured out how the Greenhouse Effect works and that temperatures are increasing all over the world, including Colorado.
- Has this period of warmer temperature/ higher CO₂ happened before in Earth's history? Is this normal?
- How is increasing global temperatures dangerous, what can happen?
- For how long have temperatures been increasing?

Record and post what we figured out and what we are wondering from this closing discussion.



Alignment With Standards

Building Toward Target NGSS PE

- **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.

Building Toward Common Core Standard(s)

- **MP.4:** Model with mathematics.

