Title of Unit	The Changing Climate	Grade Level	Grade 9
Subject	Earth Science	Time Frame	Approximately 7-9 days

Stage 1 - Identify Desired Results
NGSS 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. HS-ESS2.A.1Earth Materials and Systems: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. HS-ESS2.D.1 Weather and Climate: The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. SEP Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reasonable scientific claims or determine an optimal design solution. CCC Feedback (negative or positive) can stabilize or destabilize a system.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and Interpreting Data Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution	ESS2.A: Earth Materials and Systems ESS2.A.1 Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. ESS2.D: Weather and Climate ESS2.D.1 The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re- radiation into space.	Stability and Change Feedback (negative or positive) can stabilize or destabilize a system. --- Connections to Engineering, Technology, and Applications of Science Influence of Engineering, Technology, and Science on Society and the Natural World New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Essential Questions

Unit EQs: What are the cause-and-effect events and the feedback responses associated with them?

Stage 2 – Assessment Evidence

Performance Task at the end of the TOPIC

Elements of the Performance Task

G – Goal What should students accomplish by completing this task?	Goal: Students will use their knowledge and understanding of Earth's Feedback Systems, Energy and Climate, and Impact of Climate Change to create an infographic of the impact of climate change for their local region.

R – Role What role (perspective) will your students be taking?	Role: Students are being researchers to identify local changes in climate using data. They will be presented with the following information as well: Here's what we know: • Events can trigger an effect that can have a positive or negative feedback on Earth's systems. • Earth's climate can be impacted by natural events, as well as by human activities. • Data can be presented in many ways, and can be used to make predictions for the future
A – Audience Who is the relevant audience?	Audience: Your community
S – Situation The context or challenge provided to the student.	Situation: Anchoring Phenomena Since the Industrial Revolution, human activities have had a major impact on the climate conditions of the planet, including global warming. Scientists have connected major weather events like hurricanes, sea-ice decline, and sea-level rise, to changes in Earth's global climate. Although blame can be assigned on a global scale, the regional community response must happen quickly. Mission Briefing You are a part of an organization called Clean Earth Advocates. Your organization wants to educate community members and the local government about climate change, in order to illustrate the importance of change in everyday activities. Your mission will be to create an infographic to inform your community of ways in which climate change has impacted, and will continue to impact, the region in which you live. Your infographic should include the following topics: • What are the cause-and-effect events and the feedback responses associated with them? • Explain the ways in which Earth's climate is impacted by natural events. • How can data be presented in different ways and used to make predictions?
P-Product	Product: The product will be two-fold: 1. Infographic of local climate change impacts 2. Presentation to share infographic with community
S – Standards & Criteria for Success	See answer key and rubrics for SEP and CCC

Other Evidence Through what other evidence (work samples, observations, quizzes, tests, journals or other means) will students demonstrate achievement of the desired results? Formative and summative assessments used throughout the unit to arrive at the outcomes.	Student Self-Assessment How will students reflect upon or self-assess their learning?
CER Answers to activity questions Group discussion Public Service Announcement	Graphic organizer completion at the end of each activity Students will be asked to self-assess the CER before submitting it using the rubric

Stage 3 – Learning Plan

What teaching and learning experiences will you use to:

How will you engage students at the beginning of the unit? (motivational set)

See prior knowledge and hook activities below

What events will help students experience and explore the enduring understandings and essential questions in the unit? How will you equip them with needed skills and knowledge?

#	Lesson Title and Day Allocation for a 90 Minute Block Class	Lesson Activities Unit EQ: What are the cause-and-effect events and the feedback responses associated with them?	NGSS Standards	Resources

1	Approx 1 day	Guiding Question: What are the cause-and-effect events and the feedback responses associated with them? Assessing Prior Knowledge Students are asked to agree or disagree with five statements. Teacher should read aloud each statement. 1. Earth's surface has remained more or less the same for most of its history. 2. Earth's crust moves because of heat in the mantle beneath it. 3. The most important layer of Earth is its core. 4. The surface of Earth is primarily shaped by events that occur deep inside its core. 5. Earth's climate and weather conditions are a result of events occurring beneath Earth's crust. Allow students a few minutes to analyze all five statements and indicate their level of agreement or disagreement. After given time, divide the room into an "agree" side and a "disagree" side, one question at a time. Have students move to the side of the room based on their response. Have a few students in each group share why they chose to agree or disagree with each statement. Hook – 30 minutes  Demonstration: Show students each can (see above final set up). Explain that each represents a part of Earth's surface. Ask students for their thoughts on what part of Earth's surface each can represents (the white	HS-ESS1.A.1 See SEP above	Surface Color and Temperature handout (per pair) 2 Heat lamps 1 Soda can painted matte white 1 Soda can painted matte black 2 Thermometers 1 Timer 1 Can koozie Water Glacier video

		can represents ice, while the black can represents open ocean). On the whiteboard, write the initial temperatures of both cans in the data table. Have three students observe the thermometers in cans, while three more students record temperatures on the whiteboard. Have a fifth student be the official timer. Turn on both lights, and have the student start the timer. Every minute have the students record the temperatures of the cans on a surface that all students can see. After the temperature has risen an appreciable amount (it can be 10 minutes or less, it varies), turn off the heat lamps. Place one black can into a can koozie. Again, have students record the temperatures of the cans on the whiteboard every minute for 10 minutes. Ask students to discuss in think-pair-share groups the results from the demonstration and answer the questions on their handout. Discuss: a. What did the different color cans represent? Different areas of Earth's surface. b. What did the heat lamps represent? The Sun. c. What did you observe happening as the cans were exposed to the heat lamps? The temperature was rising. d. What is your analysis of the different can temperatures and their colors? The lighter color did not get as warm as the darker color. e. What is this demonstration attempting to model? The effect of sunlight on Earth's surface. f. How did the koozie effect the temperature? The temperature did not decrease as quickly in the can with the koozie. g. Is this demonstration a good model? Why or why not? It models how color can impact temperature change well but did not use different types of materials like Earth's surface has.		

		Introducing the Phenomena Show students the video that shows a glacier that is melting into a lake. Introduce students to the sample Phenomena question. The melting of global ice has many implications, including an increase in surface temperature. How are they related? Allow students time to generate possible answers to the question. The teacher can record the student responses so that they can be referred to throughout the unit. Allow students time to generate their own questions about the phenomena. Tell students that as they move through the scope they will be doing many activities to learn the information needed to describe the events happening in the Phenomena. The content they learn during the scope can be on the graphic organizer. Each time students learn something new, discuss how the information relates to the Phenomena question and record their ideas in the organizer and class Phenomena organizer.		

2	Impacting Earth's Systems Approx. 2 days	Guiding Question: What are the cause-and-effect events and the feedback responses associated with them? Lesson Description; Students will conduct research on an environmental scenario that has a cause-and-effect relationship. Students will collect quantifiable data to illustrate this scenario. Using this data, students will create a public service announcement. Lesson Activity: Distribute impacting Earth's Systems. Students should be in groups of 3-4. Students should begin reading the introduction to themselves. As students are reading, instruct them to write down any questions that they may have about the introduction paragraph. Introduction Paragraph Since the arrival of man, the landscape of Earth has been altered significantly. Accordingly, the dynamic interactions taking place between Earth's systems have been altered away from their original homeostatic conditions. Scientists have continually sought out data that could qualify and quantify the impact that these changes have had on the planet. In so doing, scientists are attempting to predict future outcomes and provide solutions to the driving factors of these changes. When all students have finished reading the introduction paragraph, answer any questions the students may have about the assignment. When all questions have been answered and groups are ready to continue, review the procedures for Part I. Part I: Research Teacher should provide students with a randomly selected topic from the following list: How has usage of fossil fuel increased atmospheric carbon dioxide? How has industrial-production runoff contaminated groundwater? How has agricultural farming increased soil degradation?	HS-ESS1.A.1 See SEP and CCC above	Technology Impacting Earth's Systems handout (per group) Rubric for PSA

		How has deforestation increased soil erosion? How has urbanization created heat islands within cities? How have landfills increased atmospheric methane? How has overpopulation decreased the availability of freshwater supplies? How has hydraulic fracking caused earthquakes? How have forest fires increased black-carbon emission? How has the building of dams decreased sediment deposition? Students will use computers, iPads, phones, etc. to research the environmental scenario. Collect data that illustrates a causal trend over the past 25 years. Use the data to produce a model of the causal trend over the past 25 years. The teacher should assist students in ideas for a visual model. Look for answers to following questions: a. What are some specific examples of how this scenario is occurring? Answers will vary by group. b. What location on Earth is responsible for the highest rate of occurrence for this scenario? Answers will vary by group. c. How has the rate of this scenario changed over the past 25 years? Answers will vary by group. d. If left uncorrected, how will this scenario likely develop in the next 25 years? Answers will vary by group. 6. What other data would you research to find out more information? Answers will vary by group. Part II: Public Service Announcement Directions Create a public service announcement that illustrates the need for		

		awareness of your specific scenario. This can be done in any of the several formats listed below or in a presentation format of your choosing. All presentation formats must be approved by the teacher and should address answers to the questions researched in Part I. This information will be presented to the class by each group. • Poster • Video • Radio advertisement • Website • Digital presentation (i.e., PowerPoint, Google Slides, Prezi) • Brochure • Model • Song • Skit Students should be given approximately 4 minutes to present their product and 1 minute to answer any questions from the audience. Review positive and negative feedback and debrief with the question below. Say to students: Consider the different forms of feedback that you have described in Part I and Part II. The effect of this feedback is described as either positive or negative. With positive feedback, the results perpetuate the stimulus, therefore getting more of the same results. In positive feedback, the change to the system is increasing and causing destabilization of the system. With negative feedback, the results decrease the changes, allowing the system to stabilize. With positive feedback, the cause and effect continue to feed each other, creating a runaway effect, moving the system away from equilibrium. With negative feedback, the cause-and-effect relationship moves the system back to equilibrium after the initial change. Ask: What type of feedback results from the scenarios that have been		

		presented? Introduce or review the vocabulary terms feedback ○ feedback effects ○ constructive forces ○ destructive forces Closure: Have students fill in appropriate information on the Phenomena Graphic Organizer share out to place on class organizer.		
3	Connecting Earth's Feedback Systems Approx. 6 days	Guiding Question: What are the cause-and-effect events and the feedback responses associated with them? Lesson Description: Students will present data on a topic that is connected to a cause-and-effect relationship in or among Earth's systems. After hearing all the data, students will determine what topic is connected to their topic and gather additional data to seek a connection and identify the relationship between the two. The information will be presented as a public service announcement. Lesson Activity: Students should be placed in groups of three. Distribute copies of the handout or have it ready loaded on devices. Students should read the introductory paragraph. Introduction Paragraph All Earth's systems, including the biosphere, cryosphere, atmosphere, geosphere, and hydrosphere, are connected through a series of biogeochemical processes. As the surface of Earth is changed by these natural processes as well as human activities, a series of feedback systems is created. Geoscience data has provided scientists with a clear view of exactly what degree of impact these feedback systems are having on Earth. For example, an increased level of greenhouse gases has caused a	HS-ESS1.A.1 HS-ESS2.D.1 See SEP and CCC above	Technology Connecting Earth's Feedback Systems handout (per student)

		rise in global temperatures. These high temperatures have melted glacial ice, which has reduced the amount of sunlight that has been reflected from Earth's surface. The resulting increased temperature on Earth's surface further reduces the amount of glacial ice. Have students reflect on how many different examples of feedback are given based on one event. Review Part I of the activity with students. Part I: What's the Connection? Directions Your group will be given an environmental scenario. This scenario illustrates a cause-and-effect relationship. • Assign each group a topic from the following list: o Fossil-fuel usage o Industrial-production runoff o Agricultural farming o Deforestation o Urbanization o Landfills o Overpopulation o Hydraulic fracking o Forest fires o Building of dams o Atmospheric carbon dioxide o Groundwater contamination o Soil degradation o Soil erosion o Heat islands in cities o Atmospheric methane o Freshwater supplies o Earthquakes		

		○ Black-carbon emission ○ Sediment deposition Give students the following directions: • Research the topic to determine what system the process occurs in (hydrosphere, cryosphere, atmosphere, biosphere, or geosphere). • Identify data that shows any changes that have occurred with that topic over time. • Organize the data and present their findings to the class in such a way that other students could use the data to determine a possible relationship with their topic. • Include the source where they found their data so others could access it if needed. • After all data has been presented, students should determine what other topic their system could be associated with. • Identify the relationship and determine how a change in one system is related to a change in the other. • Identify and describe possible feedbacks the two topics would have that are related to each other. Also identify at least one possible feedback to the climate. • You'll then analyze the data to determine how human activity, technology, or both have influenced the effect. • Describe the mechanism for feedbacks between the two systems and identify whether the feedback is positive (increasing the change, resulting in destabilization) or negative (decreasing the change, resulting in stabilization). • Determine if there was an unintentional effect related to increased technology and describe the connection. • Describe any uncertainties with the data. (This could include limitations, accuracy, bias, scale, or collection process. Part II: Where Is the Quantitative Evidence?		

		• Instruct students to seek quantitative data that comes from a reliable source, such as a website that ends in .gov or .edu • Recommend to the students a model such as a data table or graph. • When student groups have finished creating their models and are ready to move forward, read/review the directions for Part III. Part III: What Type of Feedback Is Being Described? Clarify the difference between positive feedback and negative feedback. When students have completed Part III, debrief the activity using the following questions: Which of the following scenarios has the greatest impact on the environment? • How has fossil fuel usage increased atmospheric carbon dioxide? • How has industrial-production runoff contaminated groundwater? • How has agricultural farming increased soil degradation? • How has deforestation increased soil erosion? • How has urbanization created heat islands within cities? • How have landfills increased atmospheric methane? • How has overpopulation decreased the availability of freshwater supplies? • How has hydraulic fracking caused earthquakes? • How have forest fires increased black-carbon emission? • How has the building of dams decreased sediment deposition? Ask: Are Earth's feedback systems affected more heavily by natural activities or human activities? What evidence do you have? Introduce or review the vocabulary terms: land systems, electromagnetic radiation, Closure: Have students fill in appropriate information on the Phenomena Graphic Organizer share out to place on class organizer.		

4	Earth's Feedback Systems Approx. 2 days	Guiding Question; What are the cause-and-effect events and the feedback responses associated with them? Lesson Description: Students will use a data set on ocean and land temperatures to conclude what relationship this feedback has with the use of modern technology. Students will complete a CER in which they will claim this feedback as being positive or negative. Lesson Activity: Distribute The Effect of Modern Technology. Students should read the introduction paragraph and look for words or concepts that they do not understand. Introduction Paragraph The data set, "Sea and Land Temperature Change," shows estimated mean annual temperature (shown as "Anomalies") over land and over oceans, based on data from satellites, land stations, and estimates from models. A temperature anomaly refers to how different the temperature that year was from the long-term average. The data set is produced by the NASA Goddard Space Flight Center's Surface Temperature Analysis Program (GISTEMP). Review the directions and have students begin manipulating their TUVA data that was embedded called "Sea and Land Temperature Change" onto devices. Directions Refer to the data set "Sea and Land Temperature Change." 1. Drag and drop the attribute "Year" onto the x-axis.	HS-ESS2.A.1 HS-ESS2.D.1 See SEP and CCC above	Technology device The Effect of Modern Technology (per student)

		2. Drag and drop the attribute "Mean Land Temp Anomaly (°C)" onto the y-axis. 3. Drag and drop the attribute "Mean Ocean Temp Anomaly (°C) onto the y-axis. Drop the attribute over the "+" to add another attribute. 4. Hover over the drop-down menu for "Graph." 5. Move your cursor to "Line" and click "Line Graph." 6. Answer the following questions. When students have successfully produced the graph, instruct them to begin answering the questions that follow. 1. How has the mean temperature anomaly on land changed since 1880? 2. How has the mean temperature anomaly in the ocean changed since 1880? 3. How has the advancement and use of technology changed the mean land and air temperatures since 1880? 4. What additional types of feedback could result from a rise in average temperature? Discuss answers to the questions with the students. Review the prompt and rubric for the CER. Give students time to complete their written CER Prompt: Does the advancement and use of modern technology produce positive or negative feedbacks within Earth's systems? Write a scientific explanation that determines which type of feedback exists between technology and Earth's systems. Claim The advancement and use of modern technology produces positive feedback with Earth's systems.		

		Evidence Since 1840, the type and use of technology have advanced significantly. Meanwhile, the temperature of the ocean and the land has increased. Reasoning A positive feedback is represented by a congruent increase or decrease between the cause and effect. Assuming the relationship between technology and surface temperatures is causal, it would be accurate to describe this feedback as positive. As technology and its use have increased, the temperatures on Earth have also increased. Rebuttal Advancements in green technology have significantly reduced the negative impacts that technology has had recently. The data set includes no data showing how temperatures have changed in relation to this green technology. It is entirely possible that there is negative feedback occurring. Engage the class discussion in a that allows the students to state their claim, evidence, and reasoning. Closure: Have students fill in appropriate information on the Phenomena Graphic Organizer share out to place on class organizer. Distribute the performance take mission log. Have students answer the questions that correspond to the completed unit on Earth's Feedbakc Systems. (this process will be repeated after each unit in this topic). Students will work on the action plan once all three units are completed.		
5	Debate: Plate Tectonic Theory Optional extension lesson	Divide students into six groups, one for each of the following debate assignments: fossil distributions; surface landforms and rock-type evidence; magnetic pole reversal; paleomagnetism; surface landforms in ocean basins and seafloor spreading; age dating of material on either side of ridges and rifts; and locations and depths recorded for earthquake foci.		

	Approx. 2 days	Give students this debate topic: What scientific evidence or discovery is most important or crucial to the support of the theory of plate tectonics? Each debate team should research the following and use their findings to create a debate planner (statements with supporting facts or details): 1. Explanation of the evidence or discovery 2. Details and supporting facts of the evidence or discovery 3. How this information supports the theory of plate tectonics: how and why plates have moved throughout Earth's history, how and why mountains form, how and why volcanos occur, and how and why earthquakes occur At the conclusion of all debates, have students analyze, evaluate, and critique all presentations in a short group discussion. Wrap up the debates by asking all students to summarize their opinions about which piece of evidence or discovery is the most important or crucial to the support of the plate tectonic theory based on the information presented in the debates. Emphasize that the individually written student summaries should include objective, fact-based information that they have gained while watching the debates. (Use the state argument rubric 9-10 to score summaries)		

Considerations	Comments
Purposeful adjustments to the curriculum content (not outcomes), instructional practices, and/or the learning environment to meet the learning needs and diversities of all students?	Possible accommodations during this unit: Give students time to practice their presentation in front of a smaller group before presenting to the whole class. Give students specific ideas to speak about ahead of time. Have students use note cards to outline major talking points and to refer to during their presentation. Allow students to modify how they would like to express themselves during an oral presentation. This may include presenting in front of a small group or in front

	of just you rather than the entire class. Assess students on the content rather than the speech quality or clarity. Have students work in pairs to develop their CER. After completing the CER, students should read another student's reasoning and ask questions to make sure they understand what was written. Then have students write a rebuttal or reflection based on the other student's CER responses. Allow students to complete the sentence stems before the discussion portion. Example sentence stems: "My claim is _____. My evidence is __. My reasoning is __. I heard you say __, and I hadn't thought about that before. However, I think _____." Give students small sections of writing at a time. Ensure that the first section has been completed successfully before moving on to the next.
Instructional Approaches: Use of a variety of teacher directed and student-centered instructional approaches?	Activities in this unit include discussions, which would be introduced by the teacher, then the students will be given the opportunity to lead and participate as structured by the teacher. Teachers are encouraged to plan collaborative engagement structures that promote full student participation and engagement in class and small group activities and discussion. These may include think or write – pair share, rally coach, rally robin, stand up-hand up – pair up, and quiz-quiz-trade

Lesson 1

Earth's Feedback Systems

Graphic Organizer

Name: _____ Date: _____

Global ice melting has many implications, including an increase in surface temperature. How are these implications related?

How do scientists determine if a relationship between Earth systems is a cause-and-effect relationship and not just coincidence?	When is a cause-and-effect relationship considered a positive or negative feedback?	Why is it important to understand if relationships between Earth's systems or human impacts on Earth's systems are positive or negative feedbacks?

Hook

Name: _____ Date: _____

Surface Color and Temperature

Respond to the following after observing the demonstration:

1. What did you observe happening as the cans were exposed to the heat lamps?

2. What is your analysis of the different can temperatures and their colors?

3. What is this demonstration attempting to model?

4. How did the koozie effect the temperature?

5. Is this demonstration a good model? Why or why not?

Explore

Name: _____ Date: _____

Impacting Earth's Systems

Introduction

Since the arrival of man, the landscape of Earth has been altered significantly. Accordingly, the dynamic interactions taking place between Earth's systems have been altered away from their original homeostatic conditions. Scientists have continually sought out data that could qualify and quantify the impact these changes have had on the planet. In doing so, scientists are attempting to predict future outcomes and provide solutions to the driving factors of these changes.

Part I: Research

Procedure

1. Receive from your teacher an environmental cause-and-effect scenario.
2. Use your internet-ready device to research the environmental scenario.
3. Collect data that illustrates a causal trend over the past 25 years.
4. Use the data to produce a model of the causal trend over the past 25 years.
5. Look for answers to following questions:
    a. What are some specific examples of how this scenario is occurring?

    b. What location on Earth is responsible for the highest rate of occurrence for this scenario?

    c. How has the rate of this scenario changed over the past 25 years?

    d. If left uncorrected, how will this scenario likely develop in the next 25 years?

Explore

6. What other data would you research to find out more information?

Organize

Use this space to organize the information you gathered.

Explore

Part II: Public Service Announcement

Directions

Create a public service announcement that illustrates the need for awareness of your specific scenario. This can be done in any of the several formats listed below or in a presentation format of your choosing. All presentation formats must be approved by the teacher and should address answers to the questions researched in Part I. This information will be presented to the class by your group.

- Poster
- Video
- Radio advertisement
- Website
- Digital presentation (i.e., PowerPoint, Google Slides, Prezi)
- Brochure
- Model
- Song
- Skit

Explore

Rubric

Points Awarded	3	2	1	0
Information	The information is accurate, relevant to the topic or questions, and clear.	The information is somewhat accurate, relevant, and clear.	The information is unclear.	The information is completely inaccurate, not given, or plagiarized.
21st Century Skill: Communication	Effectively uses communication to inform others, using both verbal and nonverbal communication.	Uses communication to inform others, using verbal communication.	Attempts to inform others with verbal communication.	No attempt is made to communicate with others.
Presentation	Presentation was organized and clear.	Presentation was somewhat organized and partially clear.	Presentation was unorganized or unclear.	No presentation was conducted.

Explore

Name: _____ Date: _____

Connecting Earth's Feedback Systems

Introduction

All Earth's systems, including the biosphere, cryosphere, atmosphere, geosphere, and hydrosphere, are connected through a series of biogeochemical processes. As the surface of Earth is changed by these natural processes as well as human activities, a series of feedback systems is created. Geoscience data has provided scientists with a clear view of exactly what degree of impact these feedback systems are having on Earth. For example, an increased level of greenhouse gases has caused a rise in global temperatures. These high temperatures have melted glacial ice, which has reduced the amount of sunlight that has been reflected from Earth's surface. The resulting increased temperature on Earth's surface further reduces the amount of glacial ice.

Part I: What's the Connection?

Directions
Your group will be given an environmental scenario. This scenario illustrates a cause-and-effect relationship.

1. Briefly describe the process that is taking place in your assigned scenario. Include at least one specific example of how and where this process is taking place.

2. Consider additional feedback that can result between your scenario and Earth's systems. Provide at least two additional forms of feedback that your scenario can cause within Earth's systems. Use the introduction paragraph as a reference for this process. Research can be done using your internet-ready device.

Explore

Part II: Where Is the Quantitative Evidence?

Directions

In Part I, you described additional forms of feedback that your scenario can have with the environment. In the space below, develop a quantitative model that illustrates how your scenario correlates with the additional forms of feedback you provided. Use your internet-ready devices to find data.

Explore

Part III: What Type of Feedback Is Being Described?

Consider the different forms of feedback that you have described in Part I and Part II. This feedback can be either positive or negative. With positive feedback, the cause and effect continue to feed each other, creating a runaway effect, moving the system away from equilibrium. With negative feedback, the cause-and-effect relationship moves the system back to equilibrium after the initial change.

What type of feedback results from the scenario that you were provided? In the space below, describe the feedback that results from your scenario as either positive or negative. Provide evidence to support your claim.

Explore

Name: _____ Date: _____

The Effect of Modern Technology

Introduction

The data set, "Sea and Land Temperature Change," shows estimated mean annual temperature (shown as "Anomalies") over land and over oceans, based on data from satellites, land stations, and estimates from models. A *temperature anomaly* refers to how different the temperature that year was from the long-term average. The data set is produced by the NASA Goddard Space Flight Center's Surface Temperature Analysis Program (GISTEMP).

Directions

Directions

Refer to the data set "Sea and Land Temperature Change."

1. Drag and drop the attribute "Year" onto the x-axis.
2. Drag and drop the attribute "Mean Land Temp Anomaly (°C)" onto the y-axis.
3. Drag and drop the attribute "Mean Ocean Temp Anomaly (°C) onto the y-axis. Drop the attribute over the "+" to add another attribute.
4. Hover over the drop-down menu for "Graph."
5. Move your cursor to "Line" and click "Line Graph."
6. Answer the following questions.

1. How has the mean temperature anomaly on land changed since 1880?

2. How has the mean temperature anomaly in the ocean changed since 1880?

3. How has the advancement and use of technology changed the mean land and air temperatures since 1880?

4. What additional types of feedback could result from a rise in average temperature?

Explore

Does the advancement and use of modern technology produce positive or negative feedbacks within Earth's systems? Write a scientific explanation that determines which type of feedback exists between technology and Earth's systems.

Claim

Evidence

Reasoning

Rebuttal

Explore

Rubric for Writing a Scientific Explanation

Points Awarded	2	1	0
Claim	Answers the question and is accurate based on data.	Answers the question, but is inaccurate based on data.	No claim, or does not answer the question.
Evidence	Cites data and patterns within the data and uses labels accurately.	Cites data from the data source, but not within the context of the prompt.	No evidence, or cites changes, but does not use data from the data source.
Reasoning	Cites the scientifically accurate reason, using correct vocabulary, and connects this to the claim. Shows accurate understanding of the concept.	Cites a reason, but it is inaccurate or does not support the claim. Reasoning does not use scientific terminology or uses it inaccurately.	No reasoning, or restates the claim but offers no reasoning.
Rebuttal	Rebuttal provides reasons for different data or outliers in the data. Can also provide relevance to the real world or other uses for the findings.	Rebuttal is not connected to the data or is not accurate.	Does not offer a rebuttal.

Earth's Feedback Systems

Earth's Feedback Systems

1

Earth's Feedback Systems

Engage - APK

1. Earth's surface has remained more or less the same for most of its history.
2. Earth's crust moves because of heat in the mantle beneath it.
3. The most important layer of Earth is its core.
4. The surface of Earth is primarily shaped by events that occur deep inside its core.
5. Earth's climate and weather conditions are a result of events occurring beneath Earth's crust.

4

Earth's Feedback Systems

Investigative Phenomenon

Global ice melting has many implications, including an increase in surface temperature. How are they related?

2

Earth's Feedback Systems

Engage - Hook

Surface Color and Temperature

1. What did you observe happening as the cans were exposed to the heat lamps?
2. What is your analysis of the different can temperatures and their colors?
3. What is this demonstration attempting to model?
4. How did the koozie effect the temperature?
5. Is this demonstration a good model? Why or why not?

5

Earth's Feedback Systems

Graphic Organizer

Global ice melting has many implications, including an increase in surface temperature. How are these implications related?

How do scientists determine if a relationship between Earth systems is a cause-and-effect relationship and not just coincidence?

When is a cause-and-effect relationship considered a positive or negative feedback?

Why is it important to understand if relationships between Earth's systems or human impacts on Earth's systems are positive or negative feedbacks?

3

Earth's Feedback Systems

Explore

Explore 1 Impacting Earth's Systems

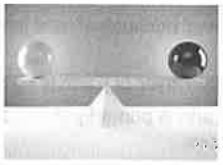
- How has usage of fossil fuel increased atmospheric carbon dioxide?
- How has industrial-production runoff contaminated groundwater?
- How has agricultural farming increased soil degradation?
- How has deforestation increased soil erosion?
- How has urbanization created heat islands within cities?
- How have landfills increased atmospheric methane?
- How has overpopulation decreased the availability of freshwater supplies?
- How has hydraulic fracking caused earthquakes?
- How have forest fires increased black-carbon emission?
- How has the building of dams decreased sediment deposition?

6

Earth's Feedback Systems

Explain - Picture Vocabulary

Feedback



A response within a system that affects the productivity of that system by amplifying or diminishing its end product.

7

Earth's Feedback Systems

Explain - Picture Vocabulary

Feedback Effects

When the result of a process amplifies or diminishes the same process as it proceeds.

8

Earth's Feedback Systems

Explain - Picture Vocabulary

Constructive Forces

Any process that helps build up the Earth.

9

Earth's Feedback Systems

Explore

Explore 1
Impacting Earth's Systems

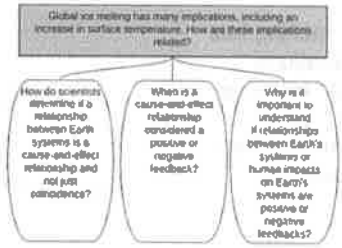
Wrap Up - CER

- What type of feedback results from the scenarios that have been presented?

10

Earth's Feedback Systems

Graphic Organizer



11

Earth's Feedback Systems

Explore

Explore 2
Connecting Earth's Feedback Systems

- Examine the topic and data you are given.
- Analyze and organize the data so you can present it to the class.
- When the presentations are made, determine what additional data is related to your topic.

12

Explain - Picture Vocabulary

Land Systems

Regions with recurring patterns across their landscape.

13

Explain - Picture Vocabulary

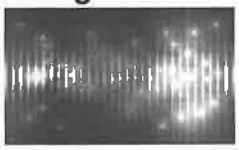
Ocean

The entire body of saltwater that covers about 69% of Earth.

14

Explain - Picture Vocabulary

Electromagnetic Radiation



Energy in the form of oscillating electric and magnetic fields that is released electromagnetic processes; characterized based on the frequency and wavelength of the oscillations as radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays.

15

Explore

Explore 2
Connecting Earth's Feedback Systems

Wrap Up

Which of the following scenarios has the greatest impact on the environment?

a. How has fossil fuel usage increased atmospheric carbon dioxide?
b. How has industrial-production runoff contaminated groundwater?
c. How has agricultural farming increased soil degradation?

16

Explore

Explore 2
Connecting Earth's Feedback Systems

Wrap Up (continued)

d. How has deforestation increased soil erosion?
e. How has urbanization created heat islands within cities?
f. How have landfills increased atmospheric methane?
g. How has overpopulation decreased the availability of freshwater supplies?

17

Explore

Explore 2
Connecting Earth's Feedback Systems

Wrap Up (continued)

h. How has hydraulic fracking caused earthquakes?
i. How have forest fires increased black-carbon emission?
j. How has the building of dams decreased sediment deposition?

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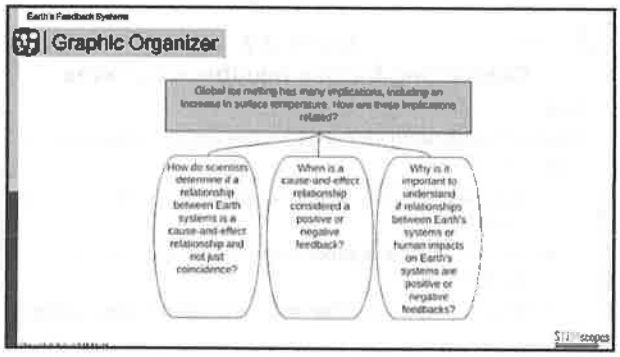

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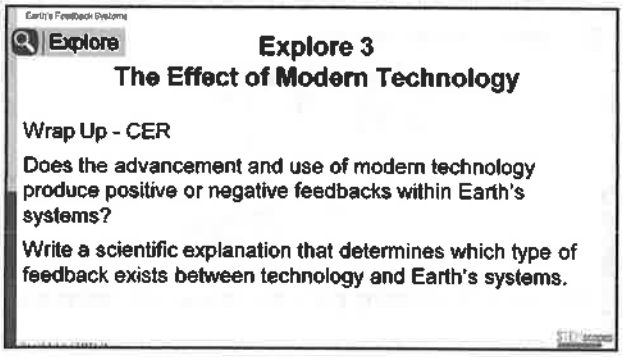

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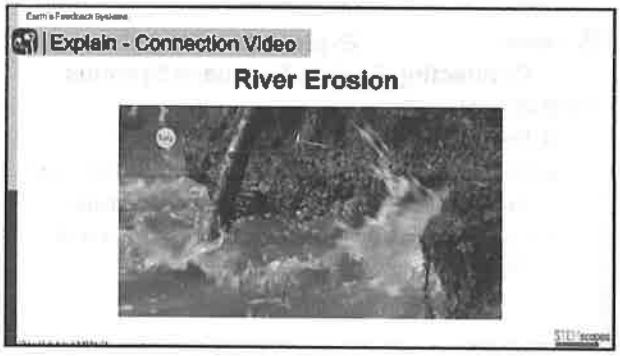

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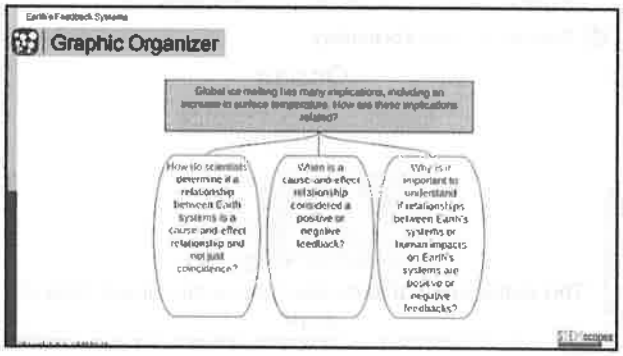

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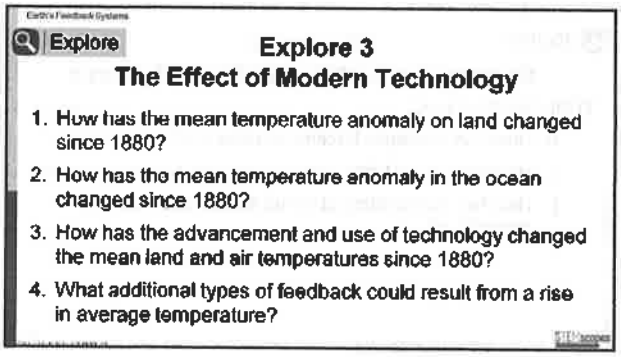

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Earth's Feedback Systems

Explain - STEMscopedia

KWL Chart

Using the KWL Chart, fill in what you already know in the K column and what questions you want answered in the W column. Read the text, then fill in what you learned in the L column.

K What I Know	W What I Want to Know	L What I Learned

25

Earth's Feedback Systems

Evaluate - OER

1. How do interdependent factors - such as climate and lack of resources - impact the carrying capacity of an ecosystem?
2. Explain how predation can be a positive benefit to a population of prey organisms.

28

Earth's Feedback Systems

Explain - Communicate Science

How should we prepare for Earth's rising sea levels?

PSA Goals

- The PSA should be informative so that people living in the area at that time would be able to make decisions about how the changes in sea level might impact them.
- The PSA should include all the following:
  - A scientifically accurate description of content
  - Details that accurately describe the evidence of sea levels rising due to other events
  - Possible solutions for citizens in the area that could mitigate the impacts of the rising sea

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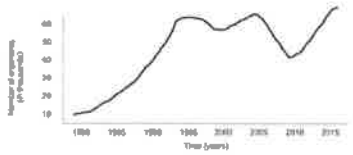
Earth's Feedback Systems

Evaluate - OER

3. Describe the graph below in terms of carrying capacity and hypothesize what caused the change in population in 2010.



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Earth's Feedback Systems

Evaluate - CER

Prompt

Could a wildfire impact Earth's systems in the long term?

27

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Mission Log

Name: _____ Date: _____

Mission Briefing

Anchoring Phenomena

Since the Industrial Revolution, human activities have had a major impact on the climate conditions of the planet, including global warming. Scientists have connected major weather events like hurricanes, sea-ice decline, and sea-level rise, to changes in Earth's global climate. Although blame can be assigned on a global scale, the regional community response must happen quickly.

Mission Briefing

You are a part of an organization called *Clean Earth Advocates*. Your organization wants to educate community members and the local government about climate change, in order to illustrate the importance of change in everyday activities. Your mission will be to create an infographic to inform your community of ways in which climate change has impacted, and will continue to impact, the region in which you live. Your infographic should include the following topics:

- What are the cause-and-effect events and the feedback responses associated with them?
- Explain the ways in which Earth's climate is impacted by natural events.
- How can data be presented in different ways and used to make predictions?

Information Gained

Earth's Feedback Systems

What are some examples of cause-and-effect relationships presented by your classmates?

Explain how an event can create a positive or negative feedback response.

How has technology impacted Earth's systems?

Connection to Mission

Earth's Feedback Systems

What are some examples of cause-and-effect relationships in your region that the community should be made aware of?

What are examples of positive and negative feedback responses in your community?

Information Gained

Energy and Climate

How is climate impacted by Earth's orbit?

What are some naturally occurring phenomena that have impacted Earth's climate?

Connection to Mission

Energy and Climate

How does Earth's orbit impact climate in our region?

What are some naturally occurring events in our region that could be attributing to climate change?

Information Gained

Impact of Climate Change

Why is the presentation of climate change data important, when drawing conclusions?

What data has been gathered to show how different systems are impacted by climate change?

How is data used to make predictions on climate change?

Connection to Mission

Impact of Climate Change

How will you present data in your infographic, and in your proposal?

Which data would you need to gather for your region, in order to show the impact that climate change has had on different systems?

Which data would be valuable to use as a predictor for the future climate in your area?

Action Plan

Name:_____ Date: _____

Create an infographic to inform your community of ways in which climate change has impacted, and will continue to impact, the region in which you live.

You will research how climate has changed locally, attempt to identify the causes of that change (both natural and human induced), present data on how Earth's systems have responded to those events, and predict how the events might impact the community 50–100 years from now, if no change is made.

Here's what we know:

- Events can trigger an effect that can have a positive or negative feedback on Earth's systems.
- Earth's climate can be impacted by natural events, as well as by human activities.
- Data can be presented in many ways, and can be used to make predictions for the future.

Take Action

In the space below, list all the impacts of climate change that concern you in your area. Give a brief description of each.

Take Action

In the space below, draw and color your infographic of local climate change impacts. Be sure to include data.

Mission Log

Name: _____ Date: _____

Mission Briefing

Anchoring Phenomena

Since the Industrial Revolution, human activities have had a major impact on the climate conditions of the planet, including global warming. Scientists have connected major weather events like hurricanes, sea-ice decline, and sea-level rise, to changes in Earth's global climate. Although blame can be assigned on a global scale, the regional community response must happen quickly.

Mission Briefing

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- Explain the ways in which Earth's climate is impacted by natural events.
- How can data be presented in different ways and used to make predictions?

Information Gained

Earth's Feedback Systems

What are some examples of cause-and-effect relationships presented by your classmates?
Answers will vary but should reflect the PSAs presented to the class.

Explain how an event can create a positive or negative feedback response.
A positive feedback is any change in the environment that leads to additional and enhanced changes in that system. A negative feedback is any change that provides stability by reducing change, or stopping further change.

How has technology impacted Earth's systems?
The use of technology has produced a positive feedback as temperatures have risen, causing other systems to respond resulting in an additional increase of temperature.

Connection to Mission

Earth's Feedback Systems

What are some examples of cause-and-effect relationships in your region that the community should be made aware of?
Answers will vary based on regions.

What are examples of positive and negative feedback responses in your community?
Answers will vary based on regions

Information Gained

Energy and Climate

How is climate impacted by Earth's orbit?
A change in the shape of Earth's orbit, from near circular to oval, causes a difference in the intensity of light that strikes Earth. There is a greater intensity when Earth is positioned closer to the Sun, and less intensity when Earth is farther away, regardless of the current season for the hemisphere.

What are some naturally occurring phenomena that have impacted Earth's climate?

- Variations in the Sun's energy output
- Tectonic events
- Changes in ocean circulation
- Volcanic activity
- Glaciers
- Changes in vegetation

Connection to Mission

Energy and Climate

How does Earth's orbit impact climate in our region?
Answers will vary based on regions.

What are some naturally occurring events in our region that could be attributing to climate change?
Answers will vary based on regions.

Information Gained

Impact of Climate Change

Why is the presentation of climate change data important, when drawing conclusions?
The scale and comparisons must be appropriate for the data to show a relationship.

What data has been gathered to show how different systems are impacted by climate change?
Answers will vary based on what the group discovered. Answers could include sea level, changes in temperature, SO_2 emissions, CO_2 concentrations.

How is data used to make predictions on climate change?
By looking at overall trends, scientists can see how different systems lead to different feedback responses, which ultimately leads to a prediction of what the future may look like.

Connection to Mission

Impact of Climate Change

How will you present data in your infographic, and in your proposal?
Answers will vary.

Which data would you need to gather for your region, in order to show the impact that climate change has had on different systems?
Answers will vary based on regions.

Which data would be valuable to use as a predictor for the future climate in your area?
Answers will vary based on regions.

Science & Engineering Practices - Scoring Rubric

High School: Earth & Space Science - *Bundle 3: The Changing Climate*

Scope: Energy and Climate

2) Developing & Using Models

Use a model to provide mechanistic accounts of phenomena.

Artifact

Evaluate the student's response to the following prompt.

"What did the model show about how a change in the tilt of Earth's axis can affect the distribution and intensity of solar radiation on Earth?" (Explore 1)

N–E–P Novice

Novice: A student at the novice level can neither describe how the model behaved nor what this shows about the actual phenomenon.

Representative Novice Responses:

- *I don't know.*
- *The light and shadows were different.*

N–E–P Emergent

Emergent: A student at the emergent level can describe the model ***but can't*** relate it to the real-world phenomenon.

Representative Emergent Responses:

- *When the globe was not tilted the light and shadows were always the same. When the globe was tilted the distribution of light and shadows changed as we moved the globe around the light.*

N–E–P Proficient

Proficient: A student is proficient if they can describe the model ***and also*** relate it to the real-world phenomenon.

Representative Proficient Responses:

- *When the globe was not tilted the light and shadows were always the same. When the globe was tilted the distribution of light and shadows changed as we moved the globe around the light. So on a planet that is not tilted, the climate would be the same throughout the year, no matter where you were. On a tilted planet, like Earth, you would expect cold winters and warm summers.*

Crosscutting Concepts - Scoring Rubric

High School: Earth & Space Science - *Bundle 3: The Changing Climate*

Scope: Energy and Climate

2) Cause & Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Artifact

Evaluate the student's response to the following prompt.

"What phenomenon did your group research? How does that phenomenon cause changes to Earth's climate? What evidence supports this claim of a cause and effect relationship?"

(Explore 2)

N–E–P Novice

Novice: A student at the novice level can only describe the phenomenon researched.

Representative Novice Responses:

- *Student provides a description of the phenomenon but can neither explain its effect on climate change nor provide any evidence to support any claim.*

N–E–P Emergent

Emergent: A student at the emergent level can describe the phenomenon they researched AND its effect on the climate, BUT CANNOT provide any evidence to support their claim.

Representative Emergent Responses:

- *Student provides a description of the phenomenon AND explains its effect on climate change BUt does not provide any evidence to support their claim.*

N–E–P Proficient

Proficient: A student is proficient if they can describe the phenomenon they researched AND its effect on the climate, AND ALSO provide any evidence to support their claim.

Representative Emergent Responses:

- *Student provides a description of the phenomenon AND explains its effect on climate change AND provides evidence to support claim.*