How Do Changes in Earth's System Impact Our Communities and What Can We Do About It?

DEVELOPER: OpenSciEd

GRADE: 7 **|** **DATE OF REVIEW:** January 2022

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Educators Evaluating Quality Instructional Products

NextGen Science
WestEd

How Do Changes in Earth's System Impact Our Communities and What Can We Do About It?

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL RATING: E
TOTAL SCORE: 8

CATEGORY I: NGSS 3D Design Score	CATEGORY II: NGSS Instructional Supports Score	CATEGORY III: Monitoring NGSS Student Progress Score
3	2	3

Click here to see the scoring guidelines.

This review was conducted by the Science Peer Review Panel using the EQuIP Rubric for Science.

CATEGORY I CRITERIA RATINGS			CATEGORY II CRITERIA RATINGS			CATEGORY III CRITERIA RATINGS		
A.	Explaining Phenomena/ Designing Solutions	Extensive	**A.**	Relevance and Authenticity	Extensive	**A.**	Monitoring 3D Student Performances	Adequate
B.	Three Dimensions	Extensive	**B.**	Student Ideas	Extensive	**B.**	Formative	Extensive
C.	Integrating the Three Dimensions	Extensive	**C.**	Building Progressions	Adequate	**C.**	Scoring Guidance	Extensive
D.	Unit Coherence	Extensive	**D.**	Scientific Accuracy	Extensive	**D.**	Unbiased Tasks/Items	Extensive
E.	Multiple Science Domains	Extensive	**E.**	Differentiated Instruction	Extensive	**E.**	Coherence Assessment System	Extensive
F.	Math and ELA	Extensive	**F.**	Teacher Support for Unit Coherence	Extensive	**F.**	Opportunity to Learn	Adequate
			G.	Scaffolded Differentiation Over Time	Inadequate			

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Summary Comments

Thank you for your commitment to students and their science education. NextGenScience is glad to partner with you in this continuous improvement process. It is obvious that this unit was thoughtfully crafted. The unit is strong in several areas, including the following:

- By connecting to local phenomenon, the unit is relevant to students. Suggestions are provided for how to connect the materials to students living in most locations.
- The unit combines many different strategies for teachers to navigate from one lesson to the next, forming a cohesive group of experiences.
- Student questions and ideas are routinely elicited, discussed, and clarified. The unit includes many strategies to support teachers in promoting student ideas and agency.
- The unit incorporates an extensive assessment system including different types of assessments and guidance to teachers for evaluating student responses on formal assessments.

During revisions, the reviewers recommend paying close attention to the following areas:

- **Developing student proficiency in targeted SEP and CCC elements over time:** Students currently have few opportunities to receive support and scaffolding to grow in their use and understanding of the use of targeted SEP and CCC elements throughout the unit. For example, students could be provided with teacher guidance early on that is reduced as the unit continues, allowing students to show their increasing proficiency.

Note that in the feedback below, black text is used for either neutral comments or evidence the criterion was met and purple text is used as evidence that doesn't support a claim that the criterion was met. The purple text in these review reports is written directly related to criteria and is meant to point out details that could be possible areas where there is room for improvement. Not all purple text lowers a score; much of it is too minor to affect the score. For example, even criteria rated as Extensive could have purple text that is meant to be helpful for continuous improvement processes; in these cases, the criterion WAS met; the purple text is simply not part of the argument for that Extensive rating.

CATEGORY I

NGSS 3D DESIGN

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

I.B. THREE DIMENSIONS

I.C. INTEGRATING THE THREE DIMENSIONS

I.D. UNIT COHERENCE

I.E. MULTIPLE SCIENCE DOMAINS

I.F. MATH AND ELA

How Do Changes in Earth's System Impact Our Communities and What Can We Do About It?

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I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS

Making sense of phenomena and/or designing solutions to a problem drive student learning.

i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving.

ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems.

iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.

Rating for Criterion I.A. Explaining Phenomena/Designing Solutions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that learning is driven by students making sense of phenomena or designing solutions to a problem because the materials are organized so students figure out a central phenomenon. Throughout the unit, students add layers of understanding directly related to the unit phenomenon of the increasing frequency of droughts and floods. Figuring out the phenomenon leads to an associated problem of how to change human behavior to solve the climate change problem. Students return to the phenomenon during the lessons, using all three dimensions to develop an explanation of the causes of the increasing flooding events and droughts.

The focus of the unit is to support students in both making sense of phenomena and designing a solution to a problem. For example:

- The anchoring phenomenon is introduced in Lesson 1.
    - The unit is introduced, saying "Set the stage by making a connection to a local water story. Tell students about a local situation related to a change in the amount of precipitation in your area. Here are some possible connections: Share a picture of a local body of water that is or was unusually low. Say something like, I remember that this reservoir was really high in March, and now it is super low. I was thinking maybe we are getting less rain than usual or we are in a drought or something. It got me thinking about what else is out there, so I found some videos of other locations experiencing something like this, too. If you are in an area that has put in measures to address water shortages (e.g., no watering of lawns, etc.), say something like, We have been doing things to address the recent water shortages. It got me thinking about what it's like in other places and what they are doing about things like water shortages. It also made me wonder about places where the opposite is happening. If you are in a place that has experienced floods or the bodies of water are unusually high, say something like, Who

can remember the recent flood we had? It got me thinking—are we the only place experiencing this, and what are other people doing about floods? It also made me wonder about places where the opposite is happening. If you are in a place where neither droughts nor floods seem to be happening with enough frequency or seemingly little direct impact on the people living there, you could connect to other issues related to too much or too little water, such as earlier snowmelt or dry conditions that lead to wildfires" (Teacher Edition, page 29). Students are shown video clips of towns that are experiencing drought and floods (Teacher Edition, page 30).

  - Lesson 1: The phenomenon is extended by analyzing headlines from across the country. "Introduce the headlines. Show slide I. Say, These stories made me wonder what is happening with floods and droughts in other parts of the country, and I found some other locations that seem to be having problems with too little and too much water as well. I gathered some headlines from those locations that might help us learn more about what is happening elsewhere. Explain that the map shows locations that have had droughts and floods in just the past few years. Brown markers represent a location that experienced a drought, while green marks a location of a flood. Say, Let's look at headlines from these locations to see if we can find any patterns to help us explain what's going on. Arrange students in pairs or small groups to examine headlines. Project slide J. Pass out the headline cards or provide a link to the headlines on an electronic whiteboard, such as Jamboard. Assign half of the pairs to the drought headlines and half to the flood headlines. Give students about 8–10 minutes to read and organize the headlines in order to identify patterns" (Teacher Edition, page 31).
  - The observation of this phenomenon of flooding events and droughts increasing motivates students to look at how changes in Earth's systems may affect communities.
- Students explore what could be causing the droughts and floods, or changes to Earth's systems, in Lessons 2–12.
- In Lessons 13–18, students design a solution to the problem of too much carbon dioxide in the atmosphere and are tasked to figure out solutions at different scales.

As the unit progresses, the class returns to the phenomenon and adds new understanding.

- Lesson 1: The phenomenon is introduced and the class develops a consensus model showing students' initial explanations.
- In Lesson 2, students analyze patterns in drought and flood data.
- In Lesson 3, after an investigation, students are asked, "How does what we did here relate to the droughts and floods we're investigating?" and "What new ideas do we have about the flood and drought locations?" (Teacher Edition, page 87)
- In Lesson 4, students are asked, "How is the small rise in temperature affecting more than just droughts and floods?" (Teacher Edition, page 104)
- In Lesson 5, students use model ideas to build a cause-and-effect model to explain droughts and floods.

- At the beginning of Lesson 6, students are asked, "How has your understanding of the problems of droughts and floods changed?" (Teacher Edition, page 123)
- Lesson 7: The lessons return to the phenomenon as they move from a discussion of water to an investigation of the role of atmospheric gases. "Navigation into the lesson. Display slide A. Say, So far we have seen that there have been an increase in droughts or floods in different places. We also saw that in Alaska we have an increase in wildfires and a decrease in multi-year sea ice. We also figured out that all out that all our case sites show increasing air temperatures. Let's think about what we figured out about how these events and data seem to be connected" (Teacher Edition, page 137).
- Lesson 8: After identifying rising temperatures as a possible cause of more droughts and floods, students look at atmospheric data to determine what has changed over time.
- Lesson 10: After identifying carbon dioxide as a molecule that is increasing in the atmosphere, students look at Earth's history to determine what led to the rise in carbon dioxide in the atmosphere.
- Lesson 12: Students have gathered enough information to be able to explain how increased levels of carbon dioxide in our atmosphere can lead to increases in droughts and floods.
- Lesson 14: Students determine their carbon footprint and look at ways carbon dioxide in the atmosphere can be reduced.
- Lesson 16: Students look at community resilience plans from communities experiencing either floods or droughts.

Student questions drive most of the learning throughout the unit. For example:

- Lesson 1: Students generate questions and then organize questions to determine the focus for investigations. "A DQB provides a public representation of the class's joint mission. Students can share their questions and wonderings with one another, and the visual representation offers another modality for students to access science in the classroom. The DQB should be centrally located in the classroom so that it can be referenced and added to throughout the unit" (Teacher Edition, page 40). "Cluster the questions. After all students have shared their questions, you will end up with a DQB that has several different clusters of questions. As a class, decide on 'umbrella' questions or topics for the clusters of questions. After creating the DQB, discuss an overarching driving question. Say, It seems like we have questions about how changes in things like temperature and the amount of precipitation impact us and what we can do about it. Suggest that we add a broader question that our model and DQB are seeking to answer: How do changes in Earth's system impact our communities and what can we do about it?" (Teacher Edition, page 42).
- Lesson 6: Students return to the DQB after the *Alaska Wildfires and Sea Ice* assessment by filling out the "DQB Check-In" handout, working with a partner and then the whole class to determine which questions have been answered, partially answered or not answered. Students then add new questions to the DQB after discussing the assessment they just finished and the term "climate change" (Teacher Edition, pages 129–130).

- Lesson 7: Teachers are asked to say to the students "We see that methane and carbon dioxide are increasing the most. But so what? How could gases that are so small in amount in the atmosphere really matter? And it seems really strange that carbon dioxide, the gas we exhale and that plants use to make food could be related to temperature change anyway? Now that we do know some gases are changing in the atmosphere, this may prompt new questions for you. Look back at any wonderings you had today, or even previously, and let's see if we can get new questions on our DQB that we need to answer now." Teachers are then asked to "facilitate students in adding and categorizing [the new questions they have] on the DQB. Just as with the original DQB, ask students to read their questions one at a time and make connections to other students' questions. Categorize the questions and add labels to the categories" (Teacher Edition, page 141). Although students ask questions, student questions added to the DQB are not leveraged to drive the learning for the rest of this part of the unit (Lessons 7–12). Instead, the main question from the teacher is what drives the focus of the learning.
- Lesson 8: Although the materials for Section 8 claim to use the Driving Question Board (DQB), it is not clear in the teacher instructions that students are reflecting on or adding to the DQB and the teacher ends the lesson by saying "Say, OK, it sounds like we will have to look at that longer term data that you requested to determine if this is normal, or has happened before. Maybe we can determine if this is normal or not in the next class" (Teacher Edition, page 160).
- Lesson 12: Students add their own questions to the DQB on the carbon imbalance. Teachers are prompted to say "It sounds like we have heard of other solutions, and we think the problem is only going to get worse unless we do something about it. For the next class period, let's try to make a list of some different solutions we have heard of and see if those will really help our problem" (Teacher Edition, page 223).
- Lesson 18: Students reflect on the DQB and which questions were fully answered, partially answered, or not answered by the unit (Teacher Edition, page 299).

Suggestions for Improvement

Student questions are currently asked throughout the material, but not consistently leveraged to determine what should be figured out in the next lesson. Consider providing teacher guidance on how to use the student generated questions to drive the learning throughout the unit.

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I.B. THREE DIMENSIONS

Builds understanding of multiple grade-appropriate elements of the science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) that are deliberately selected to aid student sense-making of phenomena and/or designing of solutions.

i. Provides opportunities to *develop and use* specific elements of the SEP(s).

ii. Provides opportunities to *develop and use* specific elements of the DCI(s).

iii. Provides opportunities to *develop and use* specific elements of the CCC(s).

Rating for Criterion I.B. Three Dimensions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions because students are engaged in grade appropriate targeted elements of the SEPs, CCCs, and DCIs.

Science and Engineering Practices (SEPs) | **Rating: Extensive**

The reviewers found extensive evidence that students have the opportunity to use and develop the SEPs in this unit. Targeted elements of the SEP are used and developed in service of making sense of the phenomenon in the unit.

The following SEP have been identified as the targets for this unit.

Asking Questions and Defining Problems

- *Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.*
    - Lesson 1: Students are asked to fill out a notice/wonder chart as they watch a video of both a community that is experiencing drought and one experiencing flooding (Teacher Edition, page 30).
    - Lesson 1: Students ask questions after viewing videos and headlines and after making an individual model and a class consensus model. "Prompt students to take out and review the following resources (in their science notebooks): noticings and wonderings from stories and headlines, your initial model, the initial class model. Discuss types of questions that can help us get to an explanation for our phenomena. Say, We are really

curious about what is causing temperature changes, how temperature changes cause floods and droughts, and how even air temperature could be related to water cycling processes. Let's think about how we can ask our questions to help us get to these explanations. What kinds of questions could help us get at the causes of all this stuff? What kinds of questions could help us answer how all of the things—even things that don't seem related—could be connected?" (Teacher Edition, page 40).

- *Ask questions that require sufficient and appropriate empirical evidence to answer.*
    - Lesson 10: "Ask questions to identify or clarify evidence. Say, We figured out earlier that we are using a lot of fossil fuels for energy and we also know that CO levels in our atmosphere are increasing. These two things are correlated. But we don't know for sure that burning fossil fuels is what is causing the CO levels to go up. We think so, and we may have heard that before—but we do not have evidence to support the claim that burning fossil fuels causes CO levels to rise. What questions can we ask and answer that will help us figure that out? Give students a minute to think of questions they may want to ask and answer." In the process of students posing these questions, the teacher is to look for "students asking for evidence for the products of the combustion of fossil fuels" (Teacher Edition, page 186).
    - Lesson 18: "After students have shared their tweets, ask students to think about the questions that remain unanswered in the unit or across the school year. Display slide F. Pose the question, What questions did we pose this year that we didn't answer, but we want to carry forward into future science learning?" "Ask students to also post ideas for gathering evidence to answer the questions they post by writing their ideas on a new sticky note that they post with their question or by indicating their ideas on the question sticky note " (Teacher Edition, page 301).
- *Ask questions that challenge the premise(s) of an argument or the interpretation of a data set.*
    - Lesson 17: Students ask questions to evaluate the plans of another student. "Say, We are going to evaluate each other's plans not on whether they picked the 'best' solutions, but rather if they took into account the problems in our community and stakeholders at risk, and whether they are bringing helpful science ideas to explain what's happening. Review the goals of evaluating the plans to (1) take the stance of a community member who is skeptical of the need for a plan or the solutions being proposed. With this perspective, they ask questions to challenge the plan, and then (2) take the position of a thought partner to offer suggestions to help the group better meet the class' agreed upon Criteria Checklist. Have students spend 12 minutes reviewing and recording feedback to each other" (Teacher Edition, page 291).

Using Mathematics and Computational Thinking

- *Use mathematical representations to describe and/or support scientific conclusions and design solutions.*

- Lesson 14: Students use their individual data scaled up to the country to generate initial ideas of how the use of carbon can be decreased. "Facilitate a concluding discussion of the scaled numbers. Say, When we did our own calculations, we were only saving 3.7 tons per person, which didn't seem very big. But look how quickly it grows when more people are willing to make changes. Remember we were trying to save about 9 gigatons of carbon per year (which is 1 billion tons). We don't get very close with a few people, but we do start to get larger number when more people are willing to make changes" (Teacher Edition, page 249).

- *Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.*
  - Lesson 7: Students calculate the ratio of different gases in the atmosphere. "Practice representing parts per million as a fraction and percent. Using the data table, have students work in partners to practice moving between parts per million and percent. Ask partners to pick one gas from the table to write as a fraction in their notebook or on scrap paper." Students use a mathematical process to understand the relationship of percent and parts per million (Teacher Edition, page 138).
  - Lesson 7: "Prepare students to determine the rate of percent change. Tell students, Let's say this change occurred over 10 years. Scientists would want to know how much the concentration of these gases changed each year. This gives scientists the rate of change and helps predict future changes in the concentration of gases in the atmosphere. How can we determine the percent change in one year? (We would have to divide the percent change by the number of years). So let's figure it out: Ex: 20/10 = 2% change per year. Students calculate the percent change" (Teacher Edition, page 140).
  - Lesson 11: Students use the mathematical concept of rate to compare carbon given off during various processes. The class discusses these numbers with the purpose "to engage in mathematical thinking about rates and proportions to conclude that combustion is leading to more CO_2 in the atmosphere than can be taken up via photosynthesis" (Teacher Edition, page 204).
  - Lesson 14: Students calculate the class average and range of their "carbon score." Students discuss these numbers and their accuracy. Then, students compare to real data on the American carbon footprint. Students are prompted to discuss, "What do you notice about the range—highs and lows? What do you notice about the overall trends? How does the most recent average compare to our class average?" Students then are prompted to see if they can make more changes that would lower their score and recalculate the class average and range (Teacher Edition, pages 245).

Obtaining, Evaluating, and Communicating Information

- *Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).*

- Lesson 4: Students read about different case studies from different cities. They complete the "Obtaining Information about Other Components" handout which guides them to read critically and obtain scientific information.
- Lesson 8: Students read the text, "Gases that Vibrate" and are instructed, "As you read, think about how these gases relate to temperatures and whether having more of them matters" (Teacher Edition, page 155).
- Lesson 10: Students read "Powering our World" to understand what was happening in the world when CO_2 was rising.
- Lesson 16: Students read about existing community reliance plans and pull out specific information. "Prepare to read and analyze text using a Close Reading strategy. Display slide C. Ask students, Before we begin digging into these texts, what is it that we hope to gain information about? Students might say: more information about these communities, what problems the community has identified more information about solutions" (Teacher Edition, page 272).

- *Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.*
  - Lesson 4: Students use a visual model constructed by the class and read text to clarify how temperature changes are causing problems in different places. "Set the purpose for reading the text. Display slide B. Say, We're pretty certain that this temperature change is causing more problems in different places of our model, but we're not certain how. What could be important to pay attention to as we read more about each component? How can we tell if the information is showing something normal or not normal? Display slide C and pass out 1 copy of Obtaining Information about Other Components to each student. Students have previously engaged in similar reading strategies to obtain information during the Maple Syrup Unit and the Palm Oil Unit. Use the handout to preview the different information students should attend to and record as they read the text" (Teacher Edition, page 100).
  - Lesson 10: Graphical displays of data are used to determine the relationship between atmospheric CO_2 levels and human activity. "This is an opportunity for students to focus on the patterns in three data sets that show a correlation between the rise of CO_2 in the atmosphere with a rise in human population and energy consumption from fossil fuels" (Teacher Edition, page 183).
  - Lesson 16: Students access community resilience plans that contain written text and visual displays of data. "Prepare to read and analyze text using a Close Reading strategy. Display slide C. Ask students, Before we begin digging into these texts, what is it that we hope to gain information about? Students might say: more information about these communities, what problems the community has identified, more information about solutions" (Teacher Edition, page 272).
- *Communicate scientific and/or technical information (e.g., about a proposed object, tool, process, system) in writing and/or through oral presentations.*

- Lesson 5: Students use the class determined models idea list to construct a written explanation. "Consider how to include the model ideas needed to answer this question. Say, How might we take the ideas we have figured out and communicate them in a way so that our audience understands why floods are happening in some places and droughts are happening in other places? Would we need to include every model idea for every case site? Why or why not?" (Teacher Edition, page 113).
- Lesson 17: Although the following is an example of the use of the SEP element, it is not a required part of the lesson for all students. "Extension opportunity: Carrying out communication of the community resilience plan can happen in a number of ways using different platforms, from hanging posters around the school hallways, to presenting to school administrators, to writing letters and sharing plans with city officials and planners. Taking on this extension will deepen students' experience of the project and increase authenticity by sharing the plans with community stakeholders. If you complete this extension, there is an additional LLPE to guide your assessment target and an example rubric, Communicating Our Community Resilience Plans. We encourage you to discuss with your class what would make for a successful communication with the target stakeholders and co-construct the rubric together as a class. Note that this extension opportunity should prompt your students to bring a lens of Systems Thinking to their communication plan. They should consider how individuals, family units, or school units are subsystems that are part of the larger community system. This can help them make a convincing communication plan for how solutions taken at the subsystem level contribute to the larger system's needs and goals" (Teacher Edition, page 293).

The following unclaimed SEPs are also used in the unit:

Developing and Using Models

- *Develop and/or use a model to predict and/or describe phenomena.*
  - Lesson 1: Students are exposed to the phenomenon in multiple ways and then construct an initial model. "Individually develop an initial model. Project slide S. Give students about 8 minutes to develop an initial model to answer the questions, 'How can increased temperatures lead to both droughts AND floods?' and 'What is causing the temperatures to increase?' Keep the slide with the questions and image for the model visible, as well as the list of things to include in their models" (Teacher Edition, page 34).
  - Lesson 2: The class uses prior knowledge to make a model of a water system to help understand the role of precipitation in the phenomenon. "Convene an Initial Ideas Discussion. Display slide C. As a class, develop an initial diagram to represent where water is distributed on Earth. This diagram will become a systems model that will track what is happening to water in the system. Students can already identify some of the places in the system where water is located. Data about the places and processes will be added to in subsequent lessons, so develop it on chart paper and keep it in the public space through Lesson 6. The diagram should include a space for listing locations in the

air, at the ground, and underground. Title this chart 'Earth's Water System Model'" (Teacher Edition, page 51).

- Lesson 12: To further understand how CO_2 affects rainfall, the class works together and then students work in small groups to develop a cause-and-effect model of the relationship between the use of fossil fuels and rising temperatures. "Guide students in completing the model. Next, generate a box that says, 'Carbon dioxide releases energy back to the atmosphere.' Continue by asking students to connect this idea to the model ideas and linking this box to the 'increase in temperatures' box. Once the 'increase in temperatures' box is completed, place the Lesson 5 Cause-and-Effect diagram on the right side of the Fossil Fuels Cause-and-Effect diagram to connect the two processes. Overlap the two boxes that say, 'increase in temperatures.' Continue across the completed model sections to identify what model ideas support the rest of the now-connected causal chain. Students should be able to answer the following questions about each box that will help guide them from box to box as they work across the causes shown in the models: What evidence have we encountered in our lessons that supports this science idea? What model idea numbers support this box?" (Teacher Edition, page 215).

- *Develop or modify a model — based on evidence — to match what happens if a variable or component of a system is changed.*
  - Lesson 3: The class model is updated with new information. "Identify sites and use sticky notes with arrows on the Earth's Water System Model. As students share, stand at the Earth's Water System Model with sticky notes. Write the name of the case site at the bottom of a sticky note. Add arrows to each sticky note to indicate the trend in water resources as either going up, going down, or staying about the same (↑, ↓, or =). For example, the group investigating the Navajo Nation would share that precipitation is decreasing. On the class model, place Navajo Nation and next to the section of the model for precipitation. Add a down arrow to this sticky note to show that the precipitation is decreasing" (Teacher Edition, page 69).
  - Lesson 11: "Modify the model with a partner to include human processes that move carbon. Display slide C. Have students work with a partner to modify the model. Have them pick a new color to represent how humans change the system. They can add more parts, or locations, to the model. Circulate among partners to see if they are focusing on 'combustion' as the main process moving CO_2 into the atmosphere, and drilling and mining as processes that move carbon to the surface. Note: students can use the term 'carbon' to refer to any carbon-containing molecule; they do not need to know specific molecules, other than CO_2" (Teacher Edition, page 201).
- *Develop a model to describe unobservable mechanisms.*
  - Lesson 8: Students develop and use models of molecules and an interactive to compare the movement of different gases found in the atmosphere, which is an unobservable mechanism. "Display slide I and the chart from the previous day about which molecules move the most. Have students turn and talk with a partner about what they noticed

about how the different gases that make up the atmosphere acted when energy was transferred to them. Students should note that H_2O, CO_2, and CH_4 vibrated or wiggled and moved more when energy was transferred to them. From the interactive, those molecules also released that energy in all directions, while the ones that wiggled less let energy go straight through" (Teacher Edition, page 153).

- *Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.*
  - Lesson 5: Students build a cause-and-effect model explaining the ideas they learned about in Lessons 2–4 (Teacher Edition, page 109).

Planning and Carrying Out Investigations

- *Plan an investigation individually or collaboratively, and in the design identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.*
  - Lesson 3: "Use Temperature and Evaporation Investigation Planning to help students develop this practice by identifying the question they are trying to answer, the data they need, and the procedures to collect the data" (Teacher Edition, page 81).
  - Lesson 3: "Focus on the change we are testing and identify variables. Say, Let's use what we know about independent and dependent variables to agree on what change we are trying to test and what we are going to measure to see if there is a difference. Elicit ideas from students for the independent variable, dependent variables, and control variables. Slide F provides prompts for a Turn and Talk before discussing together as a class. Examples include: The one thing we are changing (independent variable) - increased temperature What we are measuring (dependent variables) - humidity or water vapor in air, temperature change in the air, water collecting on sides of bottle Control - Students will be testing the same set up with heated and non-heated, so those two groups will want to sample from the same amount of soil, bottle size, time, etc. The non-heated bottle is the 'control' condition" (Teacher Edition, page 83).
- *Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.*
  - Lesson 10: Students help plan an investigation into burning fossil fuels. "This is a good opportunity for students to practice different aspects of identifying data they will collect, how they will collect it, and how to organize the data to make sense of the investigation" (Teacher Edition, page 187).

Analyzing and Interpreting Data

- *Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.*
  - Lesson 2: Students examine graphs of weather data. Students first list "What I see" statements followed by "What is means" statements to notice changes over time.

"Prepare for the I sensemaking strategy (part 2 of handout). Project slide I to students and remind them how to use the I_2 strategy to analyze and interpret data. Arrange students in groups of three. Use I_2 as a class to complete an example of using the strategy to analyze graphs. It may have been some time since students have used I_2 or this may be their first time. It will be helpful to work through an example of a pair of WIS and WIM statements so students understand how to use the I_2 strategy. Navigate to the NOAA Climate at a Glance time series data website at https://www.ncdc.noaa.gov/cag/county/timeseries and display the local data following the instructions you used from [ER.L2.TREF2] to prepare the graphs. Project the precipitation graph and work through an example of a pair of WIS and WIM statements with your class. Ask students to copy the example onto their graphs so they have a guide for completing the analysis. Use the following dialogue as a guide but use your student responses to write the WIS and WIM statements" (Teacher Edition, page 59).

- Lesson 6: Student groups analyze graphs that show changes over time. "Focus on the temperature graph as a causal mechanism, and ask students if the increase in temperatures would contribute to any of the other changing graphs and how the increase in temperatures would cause those changes to occur" (Teacher Edition, page 127).

- *Analyze and interpret data to provide evidence for phenomena.*
  - Lesson 3: Students view a data visualization, record their observations, and use this information to answer further questions about the phenomenon. "Update the class model. Display slide Q. Focus students' attention to the evaporation section of the model. Ask students, What can we conclude about the effects of an increase in temperature on evaporation? Students should respond that an increased temperature causes increased evaporation, and this increases the overall amounts of water vapor in the atmosphere. Probe students about the causal relationship, listening for whether the data supports that changing temperature causes a change to evaporation" (Teacher Edition, page 91).
  - Lesson 9: Students examine data from ice core samples to determine past levels of CO_2 in the atmosphere and whether the amount of CO_2 is increasing, a key part of understanding the phenomenon. "Say, The ice core data tells us that CO_2 levels in the atmosphere are increasing at a faster rate than normal cycles. What do you think is different now than in the past that is causing more CO_2 to be in the atmosphere? (Teacher Edition, page 173).
- *Analyze and interpret data to determine similarities and differences in findings.*
  - Lesson 2: Data from several sites across the country are examined and compared. Students convene in a Scientist Circle to discuss similarities and differences in the data. "Have each group briefly share information about their case site and their claims based on the data (1–2 minutes each). Students should connect their data analysis with what is going on at their case site and share that with the class. Encourage others to listen closely and use their science notebook to track similarities and differences between

their assigned site and the other sites that are being discussed (Teacher Edition, page 69).

Constructing Explanations and Designing Solutions

- *Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do in the future.*
    - Lesson 5: Students use their understanding of previous investigations to develop an explanation of what is happening in each of the case studies. "Remind students that their role is to use data and their model ideas to create a clear and convincing communication to others to (1) explain how or why something is happening and (2) support the how or why with evidence" (Teacher Edition, page 113).
    - Lesson 6: In the assessment, students construct an explanation of what is happening in an Alaska town and if the changes are related to the incidence of wildfires (Teacher Edition, page 127).
    - Lesson 9: Students analyze data from ice cores to determine whether the level of CO_2 is cyclical in nature and a normal occurrence or is changing at a non-normal rate (Teacher Edition, page 168).
- *Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process, or system.*
    - Lesson 17: Students develop a Community Resilience Plan after coming to consensus on criteria of an effective plan and what changes may most affect their community.

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Engaging in Argument From Evidence

- *Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.*
    - Lesson 15: Students determine criteria and constraints and evaluate systems for reducing carbon. "As students engage in this discussion to evaluate solutions, focus them on how the evidence from their Carbon Solution Cards can be useful for evaluating claims and persuading others about the validity of their ideas. When students are engaged in the work of argumentation, they should explicitly build from evidence, past experiences, and/or shared observations to support their conclusions. Students may not agree on the same rankings, which is OK, but they should develop an evidence-based rationale for which solutions they want to continue to support as promising ones" (Teacher Edition, page 260).
    - Lesson 16: After developing a system, students evaluate different solutions. "Pass out Evaluating Community Solutions and have groups work together to sort and organize the different solutions into three options: solutions that reduce carbon emissions; solutions that take carbon out of the atmosphere; and solutions that help the community adapt to changes already happening. Have students work together, using the handouts, to sort each solution and provide a brief rationale for how the solutions

works to share with the whole class. They will need to information to help map the solutions onto the carbon system model" (Teacher Edition, page 272).

- *Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.*
  - Lesson 5: Students write a water story, participate in peer feedback of their writing and then revise their explanations. "Students will provide and receive critiques on their water story explanations. This is a good opportunity for students to practice giving clear and constructive feedback to peers. It is also an opportunity for them to prioritize which feedback they can respond to (or not) and why they might do so. If students have been giving and receiving feedback already during the school year, consider fading the scaffolds provided in Peer Feedback Guidelines to allow students to independently practice this element of arguing from evidence" (Teacher Edition, page 115).
- *Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.*
  - Lesson 12: Students are asked to refute a social media post that tries to explain the effects of climate change. Students are given a graphic organizer to break down the claims made in the explanation. Students are then asked to clarify and revise the claims based on evidence they have collected so far throughout the unit to be scientifically accurate. In the "Our clarification of the claims" section of the graphic organizer, students are asked to craft statements to reason the science ideas in the claims (Teacher Edition, pages 216–218).
  - Lesson 17: In the individual assessment, students complete a written argument about the best solution for the community (Assessment, Lesson 17).

Disciplinary Core Ideas (DCIs) | **Rating: Extensive**

The reviewers found extensive evidence that students have the opportunity to use or develop the DCIs in this unit. Most of the time, students use some identified core ideas in service of making sense of a phenomenon or designing a solution to a problem.

The charts on pages 14 and 15 provided teachers with specific information about which DCI elements or parts of elements are used in the unit. Because this is the final unit in a year-long sequence, information is also given about how this unit builds and uses science ideas developed in earlier units (Teacher Edition, page 15). More specific information appears on page 18 to show how the DCIs developed in this unit have been previously used.

ESS3.A Natural Resources

- *Humans depend on Earth's land, ~~ocean~~, atmosphere, and ~~biosphere~~ for many different resources. Minerals, fresh water, and ~~biosphere resources~~ are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.*

- Lesson 1: The phenomena of both too much water and not enough water is introduced with videos.
- Lesson 2: "Convene an Initial Ideas Discussion. Display slide C. As a class, develop an initial diagram to represent where water is distributed on Earth. This diagram will become a systems model that will track what is happening to water in the system. Students can already identify some of the places in the system where water is located. Data about the places and processes will be added to in subsequent lessons, so develop it on chart paper and keep it in the public space through Lesson 6. The diagram should include a space for listing locations in the air, at the ground, and underground. Title this chart 'Earth's Water System Model'" (Teacher Edition, page 51).
- Lesson 4: The reading selections for this lesson include information about human use of the water resource. An example from the selection on groundwater, "People get groundwater by drilling wells and pumping the water to the surface. Groundwater is an important backup water source when precipitation is lower than normal or when there is not a water supply at the surface. When there is not enough water at the surface, people pump groundwater to meet their needs. Farmers depend a lot on groundwater when precipitation is not enough or not happening at the right time for their crops" (Student Handout "Groundwater").
- Lesson 10: The video "Global CO_2 Emissions" addressed the uneven distribution of carbon. The "Extension Opportunity: Uneven Distribution of Fossil Fuel Resources" was the only location found that discusses the uneven distribution of fossil fuels, however this is an optional activity (Teacher Edition, page 178).
- Lesson 12: Students create a causal chain that explains how increased use of fossil fuels has changed community water resources. This lesson does not discuss how humans depend on Earth's land and biosphere for different resources. The materials also do not discuss minerals and biosphere resources or nonrenewable and renewable resources and how they are distributed unevenly (Teacher Edition, page 216).
- Minerals are not addressed in the unit.

ESS3.C Human Impacts of Earth Systems

- *Human activities have significantly altered the biosphere, ~~sometimes damaging or destroying natural habitats and causing the extinction of other species.~~ But changes to Earth's environments can have different impacts (negative a~~nd positive)~~ for different living things.*
    - In the unit, students examine how changes in human behavior have affected atmospheric temperatures and amounts of precipitation.
        - Lesson 1: Students consider why droughts and floods are occurring more often.
        - Lesson 2: The class determines what is normal rainfall for certain places and is precipitation really changing.
        - Lesson 3: The linkage between increased temperature and evaporation and how that may affect precipitation is explored.

        - Lessons 7 and 8: The specific molecules present in the atmosphere that lead to rising temperatures is determined.
        - Lessons 10 and 11: The source of rising CO_2 levels is related to human activities.
- *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.*
    - Lesson 12: Students develop a causal chain model to connect fossil fuel use and temperature change (Teacher Edition, page 216).
    - Lesson 12: Students are prompted to consider: "We have had some time to work in our groups and determine how fossil fuel use and changing water resources are linked. Our big question we were trying to answer was, How are changes in Earth's system impacting our communities?" (Teacher Edition, page 213). "After constructing the model, take a moment to reflect as a class on the chain of events that can lead to changes in water resources. Re-read each box and ask students if they agree with the chain of events. Say, We have done an excellent job mapping how the action of adding carbon dioxide to our atmosphere can have a large effect on our resources. We thought about each part and how that has an effect on the next part of our model. Each item has a ripple effect across our model. Now that we are able to explain how increased levels of carbon dioxide in our atmosphere can lead to changing water resources, we can start thinking about using the information to inform others" (Teacher Edition, page 216).
    - Lesson 14: Students understand the role of humans in releasing carbon by calculating their personal carbon footprint and then using that data to determine more large-scale measurements of carbon use (Teacher Edition, page 244).
    - Lesson 15: Students examine possible solutions to the carbon imbalance problem (Teacher Edition, page 256).

ESS3.D Global Climate Change

- *Human 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 the level of climate change and 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 human behavior and applying that knowledge wisely in decisions and activities.*
    - Lesson 7: Students investigate the composition of gases in the atmosphere. "Yes, we need to see if the amounts of these gases are changing and, if so, by how much. We have some data for a few gases in the atmosphere" (Teacher Edition, page 129).
    - Lesson 8: Students use an interactive to determine the relationship between greenhouse gases and a warming atmosphere. "Students use evidence gathered through multiple means to figure out that GHG molecules absorb, vibrate, and release energy. It is important to emphasize this mechanism as what causes the atmosphere to warm. Understanding that GHGs are the cause is an important part of understanding

the problem of global warming and climate change, as well as understanding and developing solutions to mitigate these problems" (Teacher Edition, page 153).

- Lesson 11: Students develop models of the relationship between carbon in the atmosphere released by humans and changes to Earth's water system.
- Lesson 12: Students crate a cause-and-effect chain of events to show the relationship between increased CO_2 and rising temperatures. "Go over the Fossil Fuel base diagram as a class. Display the Fossil Fuel Use Cause-and-Effect diagram. Explain to students that our last diagram had a starting box that says, 'increase in temperatures.' Since we have already constructed a model to show how an increase in temperatures has led to the increase in droughts and floods, we will now work to trace fossil fuel use to this cause (Teacher Edition, page 216).
- Lesson 13: Students connect human actions to increased levels of CO_2. "Discuss potential solutions to the carbon imbalance problem. Project slide E. Say, So one way to get back in balance is to cut the carbon emissions, but how can we do that? What are some solutions you have heard your family or friends are doing or have tried to do to reduce carbon emissions?" (Teacher Edition, page 236).
- Lesson 14: Students calculate their individual carbon footprint and then extend this to their school, their community, and the country (Teacher Edition, page 248).
- Lesson 11: The reviewers found evidence of students being required to apply ideas from a high school grade band DCI: *Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes* (**LS2.B Cycles of Matter and Energy Transfer in Ecosystems**). This unit focuses on the student understanding of part of this **LS2.B** HS element, which is fundamental for students to understand Earth's carbon system and therefore the phenomenon of the changing temperature and precipitation in communities.
  This life science expectation that all students to go beyond the middle school level in Lesson 11 is explicitly noted in the teacher guide, along with a rationale for the inclusion of part of the high school DCI element:
  "In prior units from the 7th grade OpenSciEd Scope and Sequence, students will have learned a great deal about chemical reactions, tracing carbon atoms through reactions, and applying those ideas to explain processes in living systems (e.g., the Bath Bombs Unit, Inside Our Bodies Unit, and Maple Syrup Unit). In the Bath Bombs Unit students learned that the atoms that make up the molecules of the substances can break apart and rearrange to form new molecules made from the same atoms, only in different arrangements. In the Homemade Heater Unit they added to their understanding that these reactions can release or absorb energy from the surroundings. Students applied these ideas to metabolic reactions in animals in the Inside Our Bodies Unit and likened cellular respiration to combustion in that unit. They also developed a deeper understanding of cellular respiration and photosynthesis, and how these processes move carbon atoms through food webs at an ecosystem level during the Maple Syrup

Unit. In the previous lesson in this unit, students also developed an atomic-molecular scale understanding of combustion to identify a cause-and-effect relationship between burning fossil fuels and CO in the atmosphere. All of this previously developed understanding will be activated in this one day lesson. Therefore, you can connect to the following DCIs, which are not focal in this unit, but activated in this new context:

> **PS1.B**: Chemical Reactions: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
>
> **LS1.C**: Organization for Matter and Energy Flow in Organisms: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen.
>
> **PS3.D**: Energy in Chemical Processes and Everyday Life: The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from the sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.
>
> "This lesson will extend student understanding by asking students to (1) compare these processes in the context of a large-scale system, and (2) compare rates of photosynthesis, cellular respiration, and combustion in terms of putting carbon dioxide into the atmosphere or taking it out. This is a stepping stone toward a more sophisticated global carbon cycling and quantitative pool and flux carbon model that students will develop in high school (see HS-LS2-5, HS-ESS2-6). We acknowledge that a large-scale model for photosynthesis, cellular respiration, and combustion is more complex than might be expected for students to explore in the middle school grade band, but we felt strongly that students needed a concrete amount of carbon dioxide from human activities that is out of balance with natural processes. With this new understanding, students can then have a way to evaluate how impactful different kinds of solutions are toward rebalancing carbon. We provided extra scaffolding to support students in reflecting on the carbon-transforming processes they have already learned about at organismal and ecosystem scale, now in the context of a large-scale representation of them……"
>
> "This lesson does not include a full carbon system model that includes oceans. Likewise it is very limited in scope in terms of fluxes between carbon reservoirs, or pools. The 'pools' in this model are represented with macroscale icons that

are familiar to students. The lesson only focuses on three processes students have prior knowledge about, leaving out a lot of carbon cycling processes that students will learn about later in their schooling. Students will develop a more complete global carbon cycle model and pool and flux model in high school. The focus on three processes now helps students to calculate a target for carbon imbalance that they need going forward. Avoid complicating this model further as students will develop a more complete, complex, and quantitative model in high school" (Teacher Edition, page 198).

ETS1.B Developing Possible Solutions

- *There are systemic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.*
    - Lesson 15: "Define the problem and criteria for analyzing solutions. Say, It sounds like we have a lot of potential larger scale solutions we would like to explore that might help with our carbon imbalance problem. Remind students that we have documented our problem on our Defining the Problem chart, but we have not yet figured out what our solutions would need to do to be successful. Display slide B. Tell students that as they shared information from their exit tickets, you noticed that some solutions to the problem they suggested will reduce emissions, like planting trees, and some might help with rebalancing the amount of CO in the atmosphere. Before we learn more about some possible larger-scale solutions, we first need to decide on criteria for analyzing them" (Teacher Edition, page 255).
    - Lesson 15: "Brainstorm constraints in small groups. Say, Talk with your table groups for a few minutes to think about what some constraints or limitations would be on implementing these different solutions. Be ready to share with the class. Give students a few minutes to talk with their group. Record constraints. Bring the class back together and come to agreement on what constraints we should consider. Tell students that, as ideas for constraints are shared, the ones that the class comes to agreement on we will add to Carbon Reduction Solution Matrix at the top in the columns labeled 'constraints,' but students should not fill these in until the class has agreed" (Teacher Edition, page 259).
    - Lesson 17: Students consider criteria and constraints when developing a checklist about what the community resilience plan needs to do.

Crosscutting Concepts (CCCs) | **Rating: Extensive**

The reviewers found extensive evidence that students have the opportunity to use or develop the CCCs in this unit. Through the unit, students develop competence in using the CCCs. Students also use grade appropriate elements of the CCCs to make sense of the phenomena.

The following CCCs are identified as a focus in the unit:

Cause and Effect

- *Cause and effect relationships may be used to predict phenomena in natural or designed system.*
    - Lesson 3: Students express their understanding of the relationship of temperature and evaporation when they revise the class consensus model. "Students should respond that an increased temperature causes increased evaporation, and this increases the overall amounts of water vapor in the atmosphere. Probe students about the causal relationship, listening for whether the data supports that changing temperature causes a change to evaporation" (Teacher Edition, page 91).
    - Lesson 5: The class begins developing a cause-and-effect chain of events linking a rise in air temperatures to the phenomenon of droughts and floods (Teacher Edition, page 109).
    - Lesson 8: After an interactive using several atmospheric gases, teachers are guided to "have students turn and talk with a partner about what they noticed about how the different gases that make up the atmosphere acted when energy is transferred to them. Students should note that H_2O, CO_2, and CH_4 vibrated or wiggled and moved more when heat was transferred to them. From the interactive, those molecules also released that heat in all directions, while the ones that wiggled less let heat go straight through." Then, in the call out box, Supporting Students in **Developing and Using Cause and Effect**, teachers are guided with "Students use evidence gathered through multiple means to figure out that GHG molecules absorb, vibrate, and release energy. It is important to emphasize this mechanism as what causes the atmosphere to warm. Understanding that GHGs are the cause is an important part of understanding the problem of global warming and climate change, as well as understanding and developing solutions to mitigate these problems" (Teacher Edition, page 153).
    - Lesson 8: Students develop ideas about the relationship between greenhouse gases and temperature. "What to look/listen for: As a formative assessment opportunity, listen for the key ideas listed below to assess the class's understanding of the important ideas they have figured out through using molecular models, working with the interactive, and the reading. Key ideas: The amount of GHGs in the atmosphere causes temperature changes in the atmosphere. Increasing GHGs cause atmospheric temperatures to increase. Decreasing GHGs cause atmospheric temperatures to decrease" (Teacher Edition, page 158).
- *Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.*
    - Lesson 1: "Individually develop an initial model. Project slide S. Give students about 8 minutes to develop an initial model to answer the questions, 'How can increased temperatures lead to both droughts AND floods?' and 'What is causing the temperatures to increase?'" (Teacher Edition, page 34).
    - Lesson 3: Students express their prior knowledge of evaporation and make predictions that warmer temperatures can cause more evaporation. "When students bring up this connection, use probing questions to motivate needing evidence to support this causal

relationship: What evidence do we have right now that warmer temperatures could cause more evaporation? What science ideas are you using (from previous learning] to draw these conclusions? How could we be more certain of this causal relationship between temperature change and evaporation?" (Teacher Edition, page 80).

- Lesson 5: "Students have used cause-and-effect diagrams in previous OpenSciEd units, such as the Everest Unit and Tsunami Unit. If students struggle with ideas for how to show cause-and-effect relationships, prompt them with: Remember when we did that in Everest Unit and the Tsunami Unit? How did we represent the cause-and-effect relationship? Or use prompts such as: In Lesson 3, what did we figure out about what happens to evaporation when temperatures go up? (let students respond) Then say, So an increase in temperature causes an increase in evaporation?" (Teacher Edition, page 111).
- Lesson 7: "Say, We are wondering if gases that are rising are related to the temperatures going up? Right now we only see that they could be related (correlated), but we'd need more information to understand if carbon dioxide and methane are causing a temperature change" (Teacher Edition, page 142).
- Lesson 8: "If students struggle to understand the causal mechanism for temperature change, facilitate a deeper discussion to explain the relationship between GHGs in the atmosphere and atmospheric air temperature. Write 'Amount of GHGs in the air' and 'Air temperature' on the board, drawing a box around each one. Have the class share ways to represent the connection between the two boxes. For example, if they simply draw a line between the two, what does this communicate about how the two are related? If they use an arrow, what are the ways they can draw the arrow, and if they draw the arrow in this direction, what would that mean? Ask students to use their evidence from their investigations to decide the best way to represent the relationship between the two, indicated with an orange checkmark in the example image" (Teacher Edition, page 158).
- Lesson 10: Students first examine data to find a correlation between a rise in human population and energy consumption from fossil fuels. "Say, We are wondering if gases that are rising are related to the temperatures going up? Right now we only see that they could be related (correlated), but we'd need more information to understand if carbon dioxide and methane are causing a temperature change" (Teacher Edition, page 183).

Scale, Proportion, and Quantity

- *The observed function of natural and designed systems may change with scale.*
  - Lesson 16: The reviewers did not find evidence that this element is used in this lesson.
- *Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.*
  - Lesson 3: Students use a small-scale system to understand changes in the larger scale water system. "Generate ideas about what the bottles helped us see. Display slide K.

Point out to students that they just used these small scale models to start drawing conclusions about what is happening in the different case study locations. Guide students through a brief reflection on the benefits and limitations of the bottles using the prompts on the slide" (Teacher Edition, page 87).

- *Proportional relationships (e.g,. speed as the ratio of distance traveled to time taken) among different type of quantities provide information about the magnitude of properties and processes.*
  - Lesson 7: "Use this opportunity to emphasize the vastly different quantities of gases in the atmosphere, in particular, carbon dioxide making up very little of the overall mixture of gases. You can help students scale their understanding of the immensity of the atmosphere by connecting this concept to everyday processes they know change the molecules found in the air. For example, every living thing gives off carbon dioxide into the atmosphere, yet carbon dioxide remains a small overall amount of the total gases" (Teacher Edition, pages 138–139).
  - Lesson 8: "Emphasize the proportional relationship between GHGs and temperature when adding model ideas. Take a moment to write this sentence in your notebooks: As GHGs in the atmosphere go _______, temperature goes __________. Have students individually complete this sentence to show their understanding of the proportional relationship between GHGs and temperature" (Teacher Edition, page 157).
  - Lesson 10: "This is an additional opportunity to develop another crosscutting concept by developing a conceptual equation for population growth and per capita consumption resulting in a greater magnitude of CO_2 emissions. This relationship thinking supports the development of Scale, Proportion, and Quantity, and in particular, using the element of: Proportional relationships among different types of quantities provides information about the magnitude of properties and processes. In this example, the proportional relationship between the number of people and the average energy needs per person can help to explain the magnitude of CO_2 rise on the graph" (Teacher Edition, page 183).
  - Lesson 14: "Calculate the carbon savings for the class. Display slide F. Have students calculate how much the class saved per person by making the change (simple subtraction). Scale the per person savings to larger populations. Engage students in calculations and a deeper discussion of scaling the changes to more people. Allow students to choose different populations that they could scale their changes to, such as the school, community, family, church community, everyone in the city, their zip code, their sports team, etc. Be prepared with some of these population numbers on hand or have students estimate the population number. Students should multiply the per person savings by the new larger population" (Teacher Edition, page 248).

Stability and Change

- *Small changes in one part of a system might cause large changes in another part.*
  - Lesson 1: While students are constructing their initial models, one of the questions they need to consider involves small changes in temperature. "How did your partner explain

how a small change in temperature leads to large changes in other parts of the system?" (Teacher Edition, page 34).

- Lesson 4: Students read and examine graphs to determine how small changes in temperature affect the water system on Earth. (Teacher Edition, page 100).
- Lesson 5: "It might be helpful to explicitly introduce Stability and Change here by saying something like, It surprised us that a small rise in temperature was related to all of these big changes in precipitation and Earth's whole water system. The audience may find this surprising, too. Why don't we add, 'How could a small change in one part of the system have a big impact on the community's water?' to our list. Explaining this may help the audience understand the problem better. When students cite evidence from their case site locations, encourage them to include ideas about how as one part of the 'normal,' or stable, system changes, it impacts other parts of the system" (Teacher Edition, page 112).
- Lesson 7: Students analyze graphs showing changes in atmospheric gases over time. Students determine that some gases have increased at an unusual rate over time, while others have remained mostly stable. Additional advice is given to the teacher in a call-out box. "When students begin their analyses of the data and calculate percent change, encourage students to use the crosscutting concept of Stability and Change as a lens for explaining what is happening to gases over time. Students should know that fluctuations within a normal range can be considered stable (Lesson 2) but that an overall trend in one direction could indicate a change in the normal pattern. Prompt students to think about whether the data supports a stable pattern or a changing pattern" (Teacher Edition, page 139). "Say, We see that methane and carbon dioxide are increasing the most. But so what? How could gases that are so small in amount in the atmosphere really matter?" (Teacher Edition, page 141). However, this doesn't quite address the intent of the CCC element since although CO_2 is overall a small fraction of the atmospheric gases, the lesson makes the case that there is a very large change in the CO_2 concentration.
- Lesson 14: "Facilitate a Building Understandings Discussion about everyday changes and compounding effects. This discussion has two parts. First, to develop an understanding that even small everyday actions add up to reduce CO_2 emissions and that actions may be different for people in different situations. Second, to scale the average carbon reduction to larger populations of people" (Teacher Edition, page 247).
- Lesson 15: Students analyze solutions to the problem of increasing levels of carbon dioxide in the environment. During a consensus discussion students argue that "some small solutions would be easy for everyone to implement, and if everyone did, it would make a difference in the CO_2 in the air" (Teacher Edition, page 263).

- *Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.*
  - Lesson 7: Students analyze the composition of gases in the air. Teachers are prompted to say: "Students should notice that the labels of the axes are parts per million (y-axis)

and years (x-axis). They should also notice that the scales on both axes are different for each graph because their concentrations differ and the time period differs slightly. For example, data for oxygen is only given from 1980 until 2020" (Teacher Edition, page 139).

- Lesson 9: Students examine graphs of data from ice core samples to see levels of carbon dioxide long ago. "When students are working with their partner to analyze the data, listen for them to notice that there have been normal, or cyclical, increases and decreases in the amount of carbon dioxide in the atmosphere over time, but the increase that is happening right now is not normal. Students should also notice that the first graph does show an increase in carbon dioxide since the 1950s, but the amount of increase that is represented since then in the second graph is much steeper when it is compared to 800,000 years ago. They should argue that this is another piece of data that shows this increase is not normal" (Teacher Edition, page 172).
- Lesson 17: The materials claim that this element is used in Lesson 17. The activity cited, the development of the community resilience plan, does not reflect the use or development of this CCC element.

- *Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.*
  - Lesson 13: A simulation is used to determine the stability of the system. "Students can change variables of the amount of carbon dioxide and amount of yearly warming to see the effects on future temperatures. Discuss findings from the simulation. Display slide D. Lead a class discussion using the prompts on the slide to identify the changes to emissions needed to reduce, stabilize, or decrease global temperatures by the reduction of emission rates. Introduce the idea of 'equilibrium' in the context of keeping CO_2 concentrations in the atmosphere stable by balancing the amount of CO_2 that enters the atmosphere with that amount of CO_2 taken out of the atmosphere. Identify that a slight change in cutting emissions will not be enough to decrease temperatures before reaching the recommended temperature limit by 2100" (Teacher Edition, page 233).

The reviewers also found evidence of the use of the following unclaimed CCCs:

Patterns

- *Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems.*
  - Lesson 2: "To press students to consider the rate of change and the numerical relationships in the data, ask students questions like: Has there been a steady change over time, or has most of the change occurred in a specific time period? Can you point to evidence from the data? Have there always been storms like this or has the rate (or frequency) of storms increased or decreased for a place? What is the evidence from the data? Does any data indicate a change in how long or how often something (e.g., drought, floods) are happening in a place?" (Teacher Edition, page 69).
- *Patterns can be used to identify cause and effect relationships.*

- Lesson 3: "Look for patterns in humidity data. Project slide I with the class data for their investigation. Give students 2 minutes to turn and talk about the following question: Compare the average temperature and humidity level change in the unheated bottles with the average temperature and humidity level change in the heated bottles. What patterns do you notice? Bring students back together for a whole group discussion. Use this opportunity to check-in on what conclusions students are drawing from the data. Students should identify the following ideas: All conditions saw an increase in humidity, even the dry soil conditions. Wet soil conditions had a greater humidity increase than dry soil conditions. Heated conditions had a greater humidity increase than non-heated conditions" (Teacher Edition, page 86).

- *Graphs, charts, and images can be used to identify patterns in data.*
  - Lesson 1: "Let's return to our observations to see if we can find any patterns to help us explain what's going on. Return to the class T-chart and the sticky notes that students added. Discuss differences and similarities. Connect back to the stories the class added by posing the question, 'Do any of these headlines have a similar story to what we/our community/our families have experienced?'" (Teacher Edition, page 33).
  - Lesson 2: "Turn and talk about interpretations of patterns in the data. Project slide O. Facilitate a Building Understandings Discussion during which students share their interpretations of the long-term precipitation, temperature, and drought data for their local community" (Teacher Edition, page 63).
  - Lesson 6: In preparation for an assessment, students analyze graphs to determine patterns. "What to look for/listen for: Increasing wildfires can be partially attributed to the decrease in precipitation. The increase in temperatures contributes to the increase in wildfires, changes in precipitation, and decreases in sea ice age and amount. The drier than normal conditions in Alaska contribute to wildfires increasing and can be explained by decreasing precipitation" (Teacher Edition, page 126).

Systems and System Models

- *Models can be used to represent systems and their interactions — such as inputs, processes, and outputs — and energy, matter, and information flows within the system.*
  - Lesson 2: The class makes an initial model of the different parts of Earth's water system. "Convene an Initial Ideas Discussion. Display slide C. As a class, develop an initial diagram to represent where water is distributed on Earth. This diagram will become a systems model that will track what is happening to water in the system. Students can already identify some of the places in the system where water is located. Data about the places and processes will be added to in subsequent lessons, so develop it on chart paper and keep it in the public space through Lesson 6. The diagram should include a space for listing locations in the air, at the ground, and underground. Title this chart 'Earth's Water System Model'" (Teacher Edition, page 52).
  - Lesson 11: Students modify their model of the carbon system to include the impact of human use of fossil fuels. "Modify the model with a partner to include human processes

that move carbon. Display slide C. Have students work with a partner to modify the model" (Teacher Edition, page 201).

Matter and Energy

- *Within a natural or designed system, the transfer of energy derives the motion and/or cycling of matter.*
  - Lesson 3: "Consider adding prompts to activate students in using energy as they share initial ideas: When we learned about energy and particles before, what did we decide happens when energy is transferred to a particle? How can we use energy to explain what happens to particles when they evaporate? If the air temperatures are warmer, what does that tell us about the energy of those air particles?" (Teacher Edition, page 80).
- *The transfer of energy can be tracked as energy flows through a designed or natural system.*
  - Lesson 8: "Listen for students to recall: When molecules move more they have more energy which can be transferred to other molecules. The surface of Earth is warmed by the sun. The air is then warmed by conduction and convection. When air molecules start moving more, the air has a warmer temperature. Discuss and diagram students' knowledge about how air molecules could be related to temperatures. Say, I heard in your conversations that the Sun warms Earth and that the ground warms the air. Let's represent our thinking in a model to see what we already know about temperature and warming up. Start a diagram like the one shown to the right. Document your students' existing knowledge in a diagram on chart paper or the white board. Introduce a different way for energy to transfer. Say, You learned in previous units that energy transfers by conduction and convection. Those ways both require matter to carry the energy—like in the air or water. Do you think energy from the sun can transfer or move without matter?" (Teacher Edition, page 148).
- *Matter is conserved because atoms are conserved in physical and chemical processes.*
  - Lesson 10: "The Examine Fuel and Food Molecules activity reinforces the big idea and crosscutting concept that matter is conserved because atoms are conserved in chemical processes. As students wonder about the atoms in the reactants and want to use that information to help them either predict or confirm the atoms in the products of the reaction, they are demonstrating that they have internalized and are truly using this crosscutting concept to figure out new science ideas. Knowing that the reactants in the reaction (hydrocarbons and oxygen) contain hydrogen, carbon, and oxygen and then reasoning that those atoms and only those atoms must make up the products of the reaction, is a fundamental step in using the crosscutting concept of conservation as an intellectual tool that will help them understand core science ideas" (Teacher Edition, page 191).

Suggestions for Improvement

Science and Engineering Practice

None

Disciplinary Core Ideas

- For focal DCI components, consider ensuring that students have opportunities to develop and build the full ideas over the course of the materials.
- Consider either striking through "minerals" in the DCI element for **ESS3.A** on page 14 or providing students opportunities to develop related understanding during the unit.

Crosscutting Concepts

Consider including more guidance to teachers about the development and use of the identified CCCs or including more opportunities for students to develop and use elements of these CCCs throughout the material.

I.C. INTEGRATING THE THREE DIMENSIONS

Student sense-making of phenomena and/or designing of solutions requires student performances that integrate elements of the SEPs, CCCs, and DCIs.

Rating for Criterion I.C. Integrating the Three Dimensions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that student performances integrate elements of the three dimensions in service of figuring out phenomena or designing solutions to problems because there are numerous events that require students to use all three dimensions for the purpose of figuring something out. At the beginning of each lesson, one or more Lesson Level Performance Expectations (LLPE) are stated and each LLPE shows the three dimensions students use in the lesson.

Related evidence includes:

- Lesson 2: Students analyze and interpret data (SEP) to discover important temporal patterns (CCC) in how Earth's temperature and precipitation data (DCI) are changing over time.
- Lesson 4: "As students read, annotate, and record notes from the texts, they should engage in all three dimensions. The Obtaining Information about Other Components handout will guide students to consider how to obtain and evaluate technical information from the text (SEP). The handout also focuses students on the question of how a small change in temperature could be affecting a component of the water system (CCC). As students engage in the practice of obtaining and evaluating information and use the lens of stability and change, they work toward an understanding that water cycling components and processes are changing as a result of temperature rise (DCI)" (Teacher Edition, page 100).

- Lesson 14: Students calculate their own carbon footprint and then calculate the average of the class. Students recalculate their carbon footprint if they were to make changes and then determine how many more people would need to make changes to make a difference. The lesson objective is "Apply mathematical concepts to calculate an average carbon impact (SEP) and possible carbon reduction solutions (DCI) and scale those reductions to see what would happen if more people were to change their behaviors (CCC)" (Teacher Edition, page 239).

Suggestions for Improvement

None

I.D. UNIT COHERENCE

Lessons fit together to target a set of performance expectations.

i. Each lesson builds on prior lessons by addressing questions raised in those lessons, cultivating new questions that build on what students figured out, or cultivating new questions from related phenomena, problems, and prior student experiences.

ii. The lessons help students develop toward proficiency in a targeted set of performance expectations.

Rating for Criterion I.D. Unit Coherence	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that lessons fit together coherently to target a set of performance expectations because numerous high-leverage strategies are used throughout this unit to create a coherent sequence of learning. The lessons fit together in a way that clearly builds upon prior lessons and leads towards proficiency in the targeted performance expectations.

In the Teacher Handbook (pages 16–17) the Navigation routine is described: "The Navigation routine enables students to experience the unit as a coherent storyline in which each activity has a purpose and is connected to what has gone before and what is coming. It also provides a valuable opportunity for students to reflect on their learning over time."

The DQB is developed in Lesson 1 and used to brainstorm investigations and sources of data that could help figure out the phenomenon. Students return to the DQB in Lessons 3, 6, 7, 12, 16, 17, and 18 to add questions or to determine which questions have been answered. This routine links the lessons from the perspective of the student. Related evidence includes:

- Lesson 1: Students ask questions about the phenomenon and categorize the questions on the DQB. They begin recording what information and data might be needed to answer some of their questions.
- Lesson 6: "Complete a DQB check-in. Distribute a copy of the DQB Check-In to students with student questions added. Instruct students to work with a partner to determine which questions they have fully answered, partially answered, and not answered yet by placing a checkmark in the appropriate column. Give students roughly 7 minutes to complete this activity. Discuss answered questions with students. Bring students back together around the Driving Question Board. Ask students to share what questions they believe we have made progress on or have answered. As students share, confirm that the rest of the class agrees that progress has been made. If the class agrees, add a small checkmark to the bottom corner of the sticky note or move the sticky note to an area of the board that can be designated for 'answered questions'" (Teacher Edition, page 128).
- Lesson 10: "The next two activities may be done in either order depending on which makes the most sense based on the questions and ideas that your students share in the navigation. If your students want to know what the atoms are in the molecules that make up fossil fuels when they are asked about the products of burning them, this is great! It indicates that students truly understand the law of conservation and know that the atoms in the products must come from atoms that are reacting. If your class wants to see the molecules first, do the EXAMINE FUEL AND FOOD MOLECULES activity first and do the BURNING FUEL DEMONSTRATION LAB after students have had a chance to look at the molecules. On the other hand, if students want to burn the fuels and use a detector or indicator to find out the products of burning fossil fuels, then continue in the order it is written here" (Teacher Edition, page 186).

Coherence across the lessons in the unit from the student point of view is strengthened when students record their understanding in the Progress Tracker. The Progress Tracker is used throughout the unit to help students record their thoughts, ideas, and progress. This tracker is updated in Lessons 1, 2, 4, 8, 10, 15, and 18. In Lesson 6, students are encouraged to use it on an assessment and in Lesson 9, students are asked to review their Progress Tracker. For example:

- Lesson 2: "The individual Progress Tracker is a space for students to be creative and to synthesize earning in their own words and drawings at the end of a lesson. It is not supposed to follow a prescriptive plan or structure and should be a low-stakes opportunity for students to make sense of what they are learning without the worry and anxiety that comes with knowing their work will be graded. Students have already engaged in discussion about this question, so the Progress Tracker provides an additional modality for students to express their understanding and reasoning in their own way. Encourage students to express what they have learned using a mode that makes sense for them" (Teacher Edition, page 69).

Learning goals for each lesson, in all three dimensions, are expressed in the Lesson Level Performance Expectations (LLPEs). A chart is included, showing LLPEs and support for teachers to determine the level of student proficiency. The lessons in this unit are designed to build toward the following Performance Expectations:

- **MS-ESS3-1.** Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
- **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- **MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
- **MS-ESS3-5.** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
- **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Suggestions for Improvement

None

I.E. MULTIPLE SCIENCE DOMAINS

When appropriate, links are made across the science domains of life science, physical science and Earth and space science.

i. Disciplinary core ideas from different disciplines are used together to explain phenomena.

ii. The usefulness of crosscutting concepts to make sense of phenomena or design solutions to problems across science domains is highlighted.

Rating for Criterion I.E. Multiple Science Domains	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that links are made across the science domains when appropriate because students use multiple science domains to make sense of the unit phenomenon and problem. Although the focus of the unit is four Earth and Space Science PEs, a thorough understanding of the phenomenon requires students to integrate information about both life science and physical science topics.

Multiple science domains are used in the unit. For example:

- Lesson 8: A cause and effect relationship (CCC) is used to explain how greenhouse gas molecules respond to energy transfer from Earth into the atmosphere, connecting physical sciences to Earth and space sciences. This connection is made explicit to students.

- Lesson 10: Students determine that there is a correlation between human activities and the amount of CO_2 put into the atmosphere, connecting life sciences to Earth and space sciences.
- Lesson 11: Students consider the proportions of the rate that CO_2 enters the atmosphere through burning fossil fuels and the rate of photosynthesis taking CO_2 out of the atmosphere, connecting life, physical, and Earth sciences.

Students are expected to use knowledge they have from previous units on **Chemical Reactions (PS1.B)**, **Organization for Matter and Energy Flow in Organisms (LS1.C)** and the **Definitions of Energy (PS3.A)**. For example:

- Students use **PS1.B** to understand how fossil fuels going through combustion release water vapor and carbon dioxide in Lesson 3.
- Students use **LS1.C** in Lesson 11 when they build a model of where carbon occurs in the Earth system.
- Students should use their understanding of the term "heat" and energy transfer in Lesson 8 as they figure out how the changes in the molecules in the atmosphere have changed the air temperature.

Crosscutting concepts are explicitly used to show the connections between the domains. For example:

- Lesson 7: Students investigate and compare the amounts of gases in the atmosphere. They use the CCC of **Stability and Change** to connect physical science, life science and Earth science topics. "Use this opportunity to emphasize the vastly different quantities of gases in the atmosphere, in particular, carbon dioxide making up very little of the overall mixture of gases. You can help students scale their understanding of the immensity of the atmosphere by connecting this concept to everyday processes they know change the molecules found in the air. For example, every living thing gives off carbon dioxide into the atmosphere, yet carbon dioxide remains a small overall amount of the total gases" (Teacher Edition, pages 138).
- Lesson 8: Students use computer simulations to determine what happens when atmospheric gas molecules react when energy is transferred to them, using the CCC of **Cause and Effect** to connect physical science and Earth science. "Students use evidence gathered through multiple means to figure out that GHG molecules absorb, vibrate, and release energy. It is important to emphasize this mechanism as what causes the atmosphere to warm. Understanding that GHGs are the cause is an important part of understanding the problem of global warming and climate change, as well as understanding and developing solutions to mitigate these problems" (Teacher Edition, page 153).

Suggestions for Improvement

None

I.F. MATH AND ELA	
Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.	
Rating for Criterion I.F. Math and ELA	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials provide grade-appropriate connections to the Common Core State Standards (CCSS) in mathematics, English language arts (ELA), history, social studies, or technical standards because the teacher materials explicitly state mathematics and ELA standards that are used in the unit and provide support in the materials for students to see connections between content areas. Additionally, students regularly use speaking and listening skills in a variety of formats and writing skills to communicate their understanding of the drought and flood phenomenon.

Throughout the unit, a variety of specific opportunities for students to engage in CCSS are explicitly called out. Some examples are below:

Mathematics:

- An overview of the mathematics used in the unit is provided. "What mathematics is required to fully access the unit's learning experiences? Throughout the unit, students will engage in mathematical thinking, rate and ratio reasoning, and encounter many histograms, line graphs, and/or scatterplots that they will need to interpret. In particular, Lessons 7, 8, 9, 10, 13, and 14 utilize a number of math concepts in the context of explaining phenomena and solving problems. Prerequisite math concepts that will be helpful include: CCSS.Math.Content.6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. CCSS.Math.Content.6.RP.A.2 Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. CCSS.Math.Content.6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. CCSS.Math.Content.6.RP.A.3.c Find a percent of a quantity as a rate per 100. CCSS.Math.Content.6.RP.A.3.d Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities. CCSS.Math.Content.6.NS.B.3 Fluently add, subtract, multiply, and divide multi-digit decimals using the standard algorithm for each operation. CCSS.Math.Content.6.SP.B.5.c Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern, with reference to the context in which the data were gathered. In Lesson 8, and revisited in Lesson 13 and 14, students start to develop an understanding of the proportional relationship between greenhouse gas concentrations and air temperature. Proportional relationships are a focus of math learning in 7th grade. Because this unit falls at the end of the 7th-grade school year, it is likely that your students have learned about proportional relationships. However, talk with your math colleagues to confirm so that you can better anticipate what students will understand or not understand as they work to establish this relationship. CCSS.Math.Content.7.RP.A.2 Recognize and represent proportional relationships between quantities. In Lesson 10 students encounter graphs that show exponential growth. Focus on the overall trends upward and avoid discussing the shape of the curve and the exponential function, which is a high-school math concept" (Teacher Edition, page 21).

- At the end of lessons that contain tasks requiring mathematics, a statement of the appropriate CCSS standard is given along with a summary of how that standard was used in the lesson. For example:
    - Lesson 7: *"CCSS.Math.Content.6.RP.A.2: Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship.* Through discussion and calculations, students apply grade-appropriate mathematical concepts of unit rate and ratio reasoning to describe and explain measurement of and change in atmospheric gases. For example, students parse descriptions of quantities that use rate language (like 'parts per million') and practice converting parts per million to fractions and percentage. To better understand change in gas concentration, students calculate a 'percent change' over a time period of 100 years, then determine the rate of 'percent change' per year. In each case, the ratio reasoning supports students in making sense of how amount and change over time can communicate very different things about what is happening to gases in the atmosphere. For example, looking at the amount alone may mislead someone to conclude that carbon dioxide is insignificant, while calculating percent change would lead to a different conclusion. If students need extra support with ratio reasoning or representations, consider offering math support, like targeted questioning or anchor charts on ratio language or graphing on the coordinate plane, so that students can demonstrate their understanding of key science concepts through mathematical language and representations. Support may focus on helping students to identify ratio language like 'per' or two quantities separated by the word 'to' and translating these ratios to make sense of how one quantity is compared to another (for example, making sense of 'carbon dioxide molecules per million gas molecules' to mean how many carbon dioxide can be found in a sample of one million particles). To further support students' understanding of unit rate, provide familiar examples of unit rates such as speed or heart rate" (Teacher Edition, page 142).
    - Lesson 8: "CCSS.Math.Content.7.RP.A.2: Recognize and represent proportional relationships between quantities. In this lesson students will engage in developing a conceptual understanding of proportional relationships between greenhouse gases (GHGs) and atmospheric air temperature….they will be coming to consensus on the

foundational ideas that GHGs are proportionally related to temperature and that the relationship is causal. This will support students in making sense of solutions that involve cutting carbon dioxide emissions, and how cuts to emissions impact the concentration of CO in the atmosphere and, in turn, air temperature" (Teacher Edition, page 161).
  - Similar information is given at the end of all lessons that include connections to mathematics.

ELA/Literacy

- Lessons describe CCSS used. For example:
  - Lesson 1: "CCSS.ELA-LITERACY.RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts. On days 1 and 2, students analyze text in the form of headlines to find patterns in what is happening with floods and droughts in different locations and what might be causing them" (Teacher Edition, page 43).
  - Lesson 1: "CCSS.ELA-Literacy.SL.6.1.c: Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion. When the class is building the Driving Question Board, if a student forgets to explain why or how their question is linked to someone else's question, press that student to try to talk through their own thinking. This is a key way to emphasize the importance of listening to and building off of one another's ideas and to help scaffold student thinking" (Teacher Edition, page 43).
  - Lesson 2: "CCSS.ELA-LITERACY.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). Students integrate quantitative and technical information across text, video, histograms, and line graphs to develop a claim for how the data supports a change in temperature and/or precipitation for a community" (Teacher Edition, page 73).
  - Similar information at the end of the lesson shows connections with the appropriate CCSS.
- Discussion with peers is a major component of the unit with students having multiple opportunities to engage in discussion with peers. For example:
  - The Teacher Handbook provides descriptions of several types of the class discussions used throughout the materials. This includes purpose, when the discussion type may be used, and useful strategies (Teacher Edition, pages 38–45).
  - Lesson 2: After viewing the phenomenon and recording observations and questions about the phenomenon, students express ideas to explain what is happening. "Convene an Initial Ideas Discussion" (Teacher Edition, page 51).
  - Lesson 8: "Lead a Building Understandings Discussion and update model. You may want to project the interactive and have the molecular models available so that you or the students can demonstrate throughout this discussion. Say, We have figured out several things about these gases. Let's make a list of ideas that we have figured out. Can

someone offer an idea that you have figured out about gas molecules in our atmosphere?" (Teacher Edition, page 153).
    - Lesson 9 "Brainstorm with a partner: Where could you go on Earth today to find snow or ice that lasts from one year to the next?" (Teacher Edition, page 168).
    - Lesson 10 "Handout Population Growth and CO_2 Emissions Graphs and ask students to also have their annotated version of Graph of Energy Sources Over Time available. Display slide F. Give students a few minutes to look across the three graphs and jot down some noticings onto each one. Then have students share their noticings with a partner before sharing as a whole class" (Teacher Edition, page 183).
- Students also have an opportunity to engage in a variety of reading formats for the purpose of learning new material. For example:
    - Lesson 2: Each Case Study document contains writing, pictures, graphs, and other infographics to support students in understanding the situation in each community.
    - Lesson 4: A strategy for reading text is used to guide students as they read. The reading selections vary in their reading levels and include lower levels as well as beyond grade level.
    - Lesson 7: After reading *Gases that Vibrate*, students summarize important ideas from the reading.
- Students write throughout the unit. They write responses in the Student Handbook pages, in the Progress Tracker, and on formative and summative assessments. For example, in Lesson 5, students have options for expressing their ideas. "Establish options for how to communicate with the audience. Display slide C. Provide students with options they can choose for communicating their explanations. These options are: Write a headline for the site and give a news story that includes a scientific explanation of what's happening. Create an infographic that communicates how and why water is changing in the community. Allow students to suggest additional options and a rationale for why that format is helpful" (Teacher Edition, page 113).

Suggestions for Improvement

None

OVERALL CATEGORY I SCORE: 3	
Unit Scoring Guide – Category I	
Criteria A-F	
3	At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C
2	At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C
1	Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C
0	Inadequate (or no) evidence to meet any criteria in Category I (A–F)

CATEGORY II

NGSS INSTRUCTIONAL SUPPORTS

II.A. RELEVANCE AND AUTHENTICITY

II.B. STUDENT IDEAS

II.C. BUILDING PROGRESSIONS

II.D. SCIENTIFIC ACCURACY

II.E. DIFFERENTIATED INSTRUCTION

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

II.A. RELEVANCE AND AUTHENTICITY

Engages students in authentic and meaningful scenarios that reflect the practice of science and engineering as experienced in the real world.

i. Students experience phenomena or design problems as directly as possible (firsthand or through media representations).

ii. Includes suggestions for how to connect instruction to the students' home, neighborhood, community and/or culture as appropriate.

iii. Provides opportunities for students to connect their explanation of a phenomenon and/or their design solution to a problem to questions from their own experience.

Rating for Criterion II.A. Relevance and Authenticity	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world. The phenomenon is likely to be engaging to students and serves as a basis for student sense-making. Students have opportunities to connect the phenomenon to experiences in their own lives. Various supports are provided to teachers to help elicit these connections.

Students are provided with the opportunity to experience the anchor phenomenon through media representations to make as close a connection as possible to the plight of those experiencing drought and floods. Students are provided an opportunity to connect the anchoring phenomenon of changes in Earth's water system with changes in their local water systems. For example:

- A description of how the unit could be changed to concentrate on the local community is provided. "The unit includes support for you to integrate drought or flood events from your community in the anchor lesson and to use local precipitation and temperature data for your community in Lesson 2. There is an option to explain changes to precipitation in your community in the first Putting the Pieces Together lesson (Lesson 5). The public release version of the unit includes additional support for local solutions to changing water resources due to precipitation change (and per-capita consumption in some communities). In Lesson Set 3, students consider both carbon and water solutions that are relevant to their families and communities and presents an opportunity to create a community plan" (Teacher Edition, page 13).
- Lesson 1: "Set the stage by making a connection to a local water story. Tell students about a local situation related to a change in the amount of precipitation in your area. Here are some possible connections: Share a picture of a local body of water that is or was unusually low. Say something like, I remember that this reservoir was really high in March, and now it is super low.

I was thinking maybe we are getting less rain than usual or we are in a drought or something. It got me thinking about what else is out there, so I found some videos of other locations experiencing something like this, too. If you are in an area that has put in measures to address water shortages (e.g., no watering of lawns, etc.), say something like, We have been doing things to address the recent water shortages. It got me thinking about what it's like in other places and what they are doing about things like water shortages. It also made me wonder about places where the opposite is happening. If you are in a place that has experienced floods or the bodies of water are unusually high, say something like, Who can remember the recent flood we had? It got me thinking—are we the only place experiencing this, and what are other people doing about floods? It also made me wonder about places where the opposite is happening. If you are in a place where neither droughts nor floods seem to be happening with enough frequency or seemingly little direct impact on the people living there, you could connect to other issues related to too much or too little water, such as earlier snowmelt or dry conditions that lead to wildfires" (Teacher Edition, page 29).

- Lesson 1: A home learning assignment involves students asking their parents about experiences with drought or flood. "Explain the home learning. Say, Next class period we are going to share some of what we noticed about these headlines and floods and droughts in other communities. However, in the meantime, you and your families may have experienced or heard about situations that are similar to those we have heard about today. Display slide L. Explain that students should talk to members of their families or communities and bring back any stories to share on day 2" (Teacher Edition, page 32).
- Lesson 2: "Introduce the idea of distribution of water for communities. Get students' initial ideas for how communities are connected to this Earth's Water System Model, starting with Porterville and Vicksburg and broadening from there to think about other communities, including your own" (Teacher Edition, page 49). "It's OK if students do not know any or all of the sources of their community's water. This move is mainly to help students get a better understanding of their own community's water resources, in anticipation of brainstorming the data we need to support what is changing in the model. If students do not know, tell students something like, Well, I had to look up where our community gets water because mostly I just turn on the tap, so I didn't really know. We get our water from ____ and ____. So, what part of the system is that?" (Teacher Edition, page 53).
- Lesson 2: Another connection to the community is made when students are asked to think about their own local water source. "Determine what is normal for the local community. Ask students if they see any similarities between their Lesson 1 water stories and the stories of Portersville and Vicksburg. As they share, ask if they think that their water stories are unusual for this area. The goal is to have students ask the question, 'Is this normal for our area?' or start to wonder if the events in their stories are normal or not. Once the idea of normal has come up, have a discussion similar to the following example using conditions from your community and the water stories students told in the previous lesson" (Teacher Edition, page 55).
- Lesson 2: Local historical weather data is used as a basis for analysis. "Introduce the data and the data source. Tell students that the National Oceanic and Atmospheric Administration

(NOAA) and its partners (such as the National Weather Service) have weather monitoring stations all over the country. The stations collect data, up to every 15 minutes, and when combined over days and years, we have a historical data set that gives us a view of precipitation and temperature in any place in the US. We can choose how long we want our data to span" (Teacher Edition, page 58).

Students are provided an opportunity to connect the problem of climate change to their own lives. For example:

- Lesson 10: Students consider the use of fossil fuels in their everyday life.
- Lesson 13: Students conduct a home carbon audit. "So for home learning tonight, use Home Carbon Audit as a guide to collect some information about these activities/actions that you and your family do and bring this information back to our next class so that we can use it to figure out more about which solutions to implement and how" (Teacher Edition, page 236).
- Lesson 14: "Have students return to their footprint calculator to make 2–4 changes to try to lower their score. Ask students to record their changes by either (1) starring them on their Home Carbon Audit handout or (2) recording them in their science notebook" (Teacher Edition, page 246).
- Lesson 15: "Students are asked to consider the authentic needs of the community and relevant ways in which to engage their stakeholders. Placing the carbon solutions project in a local context provides relevance for both students and stakeholders. Assessing the needs of the stakeholders identifies additional value to the community and creates an authentic project that can be utilized both inside and outside of the classroom" (Teacher Edition, page 289).
- Lesson 15: "Your community may also have solutions that are more locally relevant that would be meaningful for students to investigate and utilize. Consider telling students that these additional solutions can be explored also. To do this, add these solutions to the Carbon Solution Cards by using the template Information for Carbon Solution Cards" (Teacher Edition, page 256).
- Lesson 16: "Say, Now that we've seen other community plans, do we have one of our own for our community we could evaluate? How might we do that? Or, could we develop a new plan with some of these solutions and others we identified in earlier lessons?" (Teacher Edition, page 275).
- Lesson 17: Students create a checklist for what a resilience plan for the school and local community should include.

Support is provided to teachers to anticipate any emotions or uneasiness students may have when discussing topics in this unit. Some examples are below:

- Lesson 1: "A unit on floods and droughts is likely to elicit emotional stress from some students, either in terms of the empathy they feel for those affected, or from experiencing the natural hazard directly or through the experiences of family and friends. Emotional stress from these events can often be great in students who feel they do not understand the situation or that they have no control over the situation. While droughts and floods often bring impacts that students cannot control, the aim of this unit is to help students understand what is happening to cause these events and to feel as though they can understand them, and use their knowledge to understand a community's response to them (e.g., water restrictions, flood warnings). If you have students who have traumatic experiences from a drought or flood event, a recommended source to read is located at the CDC Children in Disasters: Teachers and Childcare website at https://www.cdc.gov/childrenindisasters/schools.html" (Teacher Edition, page 29).

- Lesson 14: "An important thing you can do, particularly in this lesson, is to create a safe space for students. To do this, you need to minimize threats in the learning environment. Calculating a personal carbon footprint and sharing results can potentially create a situation in which students feel threatened and, therefore, may disengage. To reduce threat, have students post their carbon footprint numbers anonymously and avoid asking students to make comparisons to each other. Rather, have students make comparisons to themselves in terms of before and after they've made changes to their carbon footprint" (Teacher Edition, page 243).
- Lesson 14: "Climate change can be an upsetting topic for many students. Some students may feel that not enough is being done, and others may feel that it is a hopeless problem. The purpose of looking at the real-time data is to emphasize to students that what the United States has been doing in recent years (shown as 2007–2016 on graph) has resulted in a downward trend in CO_2 emissions. Use this data to encourage your students that we are trending in the right direction, and there are things that everyday citizens can do to support and participate in this trend" (Teacher Edition, page 234.
- Lesson 17: "Students may feel like they do not have any power or hope to change or feel constrained in terms of what is possible in the context of their school or community. This is a normal reaction to a very large, complex problem. This lesson is designed to help students focus on the future, imagine new possibilities, and to be thoughtful about what steps could be taken to benefit them and their community" (Teacher Edition, page 282).

Suggestions for Improvement

None

II.B. STUDENT IDEAS

Provides opportunities for students to express, clarify, justify, interpret, and represent their ideas and respond to peer and teacher feedback orally and/or in written form as appropriate.

Rating for Criterion II.B. Student Ideas	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials provide students with opportunities to both share their ideas and thinking and respond to feedback on their ideas because teachers are guided on how to elicit ideas, help students clarify their thinking, and provide opportunities for peer interactions. Students express their ideas in a variety of ways throughout the unit.

Students have multiple opportunities to clarify, justify, interpret, and represent their ideas in small group and whole class discussions. Students also represent their ideas in writing and in a variety of forms on the final project. For example:

- The Teacher Handbook has general descriptions of the types of class discussion, including the purpose, when this type of discussion is useful, and strategies for implementing the discussion (Teacher Handbook, pages 38–45).
- There are many examples where students do a "turn and talk" with a partner to share their ideas. These opportunities for partner talk occur in every lesson.
- Students set up their notebook in the beginning of Lesson 1 and use it throughout the unit. "Remind students that the notebook is their tool for recording their observations, evidence, and ideas to share with the classroom community. They should see it as a space to brainstorm and record their thinking, as well as a place to show how their thinking changes as they learn more" (Teacher Edition, page 29).
- Students gather in Scientists Circles, which allow for whole group discussion. Scientists Circles are included in Lessons 1, 2, 3, 5, 7, 9, 15, 17, and 18. Some examples of teacher guidance is provided below:
    - Lesson 2: "Have students bring their handouts and reference materials and gather in a Scientists Circle. Have each group briefly share information about their case site and their claims based on the data (1–2 minutes each). Students should connect their data analysis with what is going on at their case site and share that with the class. Encourage others to listen closely and use their science notebook to track similarities and differences between their assigned site and the other sites that are being discussed" (Teacher Edition, page 69).
    - Lesson 5: "Say, We've figured out quite a bit about what is happening at these places that are having droughts and floods. How do we feel about these questions? How are rising temperatures changing water stories in these communities? Have your ideas about droughts and floods changed or stayed the same since the beginning of the unit? Why or why not?" (Teacher Edition, page 111).
    - Lesson 12: "Take a step back with the class and ask students, Before we start to work on our consensus diagram, how would you say that our thinking about this question has changed since Lesson 1?" (Teacher Edition, page 214).
- The DQB is set up to represent student questions. After initially starting the DQB in Lesson 1, students are asked to go back to the DQB and add more questions in multiple lessons.
- The Progress Tracker is found in the students' notebooks. Students record what they have figured out in each lesson and use this new information to build their understanding of the phenomenon.

- Lesson 3: A discussion with the purpose of brainstorming a link between temperature and evaporation is described. Prompts for the teacher include initial questions that students discuss in small groups and a list of key ideas that should emerge from the whole class discussion. "Give students 1–2 minutes to turn and talk about the questions on the slide. What do you think causes evaporation? What is happening at a particle scale when water evaporates? What causes the particles to do what they do during evaporation? Using these ideas, what do you predict will happen with evaporation in warmer temperatures? Why? Facilitate a brief whole group sharing of their ideas. You may want to represent ideas on the class whiteboard" (Teacher Edition, page 80).
- The teacher frequently facilitates a "Building Understandings Discussion." Students typically share their ideas, revise their ideas, and make claims with reasoning during these discussions. A "Building Understandings Discussion" is facilitated in Lessons 2, 3, 7, 10, 11, 14 and 16. Some examples of the directions for the discussions are below.
    - Lesson 2: "Facilitate a Building Understandings Discussion during which students share their interpretations of the long-term precipitation, temperature, and drought data for their local community. Ask each group to try to make connections between their WIS and WIM statements across the data sets" (Teacher Edition, page 63).
    - Lesson 7: After an investigation, student ideas about what gases change over time emerge in a "Building Understanding Discussion." Guidance to the teacher includes an idea about organizing student thinking in a chart and a list of key ideas to look for in students' discussion. "Discuss and categorize the gases by how much they have changed. Gather in a Scientists Circle with the DQB visible. Display slide G. Work as a class to categorize the gases by which ones are changing the most and which are changing the least based on the percent change" (Teacher Edition, page 140).
    - Lesson 16: "Once all communities have been shared and solutions mapped to the model using sticky notes, facilitate a building understanding discussion about the different approaches communities are using to rebalance carbon in our atmosphere and also adapt to changes they are experiencing now. Update the community resilience word wall card to include images that represent what students learned about community resilience" (Teacher Edition, page 273).

The unit provides opportunities for students to receive and respond to peer and teacher feedback. For example:

- The Teacher Handbook contains a section on how to facilitate peer feedback. This section provides classroom strategies as well as ideas for helping students give and receive peer feedback (Teacher Handbook, pages 64–65).
- Lesson 1: "If your students struggle with identifying important parts (components) and processes for the cycling of water, you may need to spend additional time reviewing those key processes before they develop their individual models. If students don't explain how the change in temperature is causing the changes to the processes and components that the class identified, use prompts to solicit those connections (e.g., I see you are showing that

evaporation is changing, can you add some words to explain how that is connected to the increased temperatures?" (Teacher Edition, page 35).

- Lesson 5: In Section 6, students are given "Peer Feedback Guidelines" and the class discusses how to give productive feedback to their partners. Students give feedback to their peers on their explanations of the different case sites (Teacher Edition, page 115).
- Lesson 5: As part of a formative assessment, teachers are guided on what to look and listen for in student responses. "Look for evidence that students have revised their explanation, based on peer feedback, by comparing the first draft and the revised explanation and reviewing their reflections on what feedback they used and didn't use" (Teacher Edition, page 116).
- Lesson 5: Students are provided the "Explaining Water Stories" Handout as a scaffold to revise their explanation based on the feedback provided. Students must reflect on "Things they want to add based on feedback" and "Things I am not going to add and why" (Explaining Water Stories Handout).
- Lesson 6: The teacher provides individual feedback to student work before the students complete the assessment. "Collect handouts. At the end of class, collect Alaska Graph Notes, What Causes Wildfires?, and Alaska Graphs from students. Review Alaska Graph Notes before the next class period to check student understanding. Provide individualized feedback for students on Alaska Graph Notes prior to beginning the assessment on Day 2" (Teacher Edition, page 126).
- Lesson 8: Ideas about providing feedback and support for individual students are provided. "Provide quiet time for students to work individually on their Progress Trackers. Monitor their work, and, if students are struggling with representing important ideas in their models, call attention to the model ideas and sketches you did with the class during the discussion. They can use these as a starting point for their models. Collect student notebooks or Progress Trackers before they attach them to their notebooks so you can review them" (Teacher Edition, page 159).
- Lesson 12: As students work in small groups to refine their models, teachers are given specific ideas on how to give feedback. "Help with model idea connections: Point out the specific box that students have not completed or need help with. Ask how the model idea supports the box in question, or what model ideas connect to the science ideas in the box. Ask what model ideas would have an impact on how the box would function in their causal chain of events" (Teacher Edition, page 213).
- Lesson 17: Students exchange their group's plan with the plan from another group. They review the plans and offer feedback (Teacher Edition, page 291).

Suggestions for Improvement

None

II.C. BUILDING PROGRESSIONS

Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers:

i. Explicitly identifying prior student learning expected for all three dimensions

ii. Clearly explaining how the prior learning will be built upon.

Rating for Criterion II.C. Building Progressions	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials identify and build on students' prior learning in all three dimensions. Prior learning is documented in the Front Matter and throughout the unit. The materials show a progression from prior learning to integration of new science ideas. Targeted elements of all three dimensions are included, but very few of the claimed CCC and SEP element learning progressions are explicitly stated.

The materials list the expected prior learning both in the Front Matter (pages 13–17) and more specifically, at important parts of the unit. The materials discuss some common ideas that students may have at the start of the unit. Lessons build on prior knowledge in aspects of all three dimensions. Prior learning in the DCIs is evident in several places in the unit. Prior learning for the SEPs and CCCs is mainly found in the callouts.

Prior learning and learning progressions in the DCIs

- In the "What additional ideas will my students have or know from earlier grades or OpenSciEd units?" section, the teacher is provided with the following information:
    - "This unit is designed to leverage science ideas from previous units and grades, including ideas about:
        - temperature, precipitation, and water cycling developed in Storms Unit and in 5th grade. In particular, students will use what they have learned about the normal cycling of water to help identify and explain why precipitation patterns are changing in communities as air temperatures rise.
        - chemical reactions and conservation of matter developed in Bath Bombs Unit and Homemade Heater Unit. In particular, in Lesson 10, students trace carbon dioxide as a product of a combustion reaction between fossil fuels and oxygen.

    - matter (carbon) cycling developed in Maple Syrup Unit. Across Lesson Set 2, students identify the matter in the system (i.e., Earth's atmosphere), how the composition of the matter in the system is changing, and the causes for the change in the system from adding a carbon source to the atmosphere from burning fossil fuels.
    - human impact on ecosystems and designing solutions to reduce these impacts developed in Palm Oil Unit. Students build on their previous knowledge to add additional ideas for how.
    - human energy use is changing the atmosphere, which then has numerous climate and ecosystem impacts on communities. Students then focus on investigating and evaluating design solutions to reduce the impact from human activities.
    - defining problems, defining criteria and constraints, and evaluating solutions using systematic processes, previously developed in the Cup Design Unit, the Tsunami Unit, and the Homemade Heater Unit. Students apply systematic processes, including identifying criteria and constraints, and identifying stakeholders and their needs, in order to better understand which solutions might work and why for some communities versus other communities" (Teacher Edition, page 19).
- Each lesson begins with a section called "Where we are going" and "Where we are not going." Expected learning in prior grades and in prior units is discussed as part of this section. "Where We Are Going: Students will have partially explored the relationship between temperature and precipitation during Lesson 2, and have developed conceptual understanding of the water cycle in Storms Unit that they will apply to their emerging understanding of Earth's water system. This lesson offers a deeper dive into temperature to better understand how it affects other components of Earth's water system over time around the world and not just at single case sites. It also gives students opportunities to reinforce ESS2.C learned in previous units, including that (1) most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere (5th grade) and (2) that water continually cycles among land, ocean, and atmosphere via evaporation and precipitation, as well as downhill flows on land (6th grade in Storms Unit). The lesson also offers a moment to reinforce parts of ESS3.A that humans depend on Earth for many different resources, including freshwater, and that these resources are distributed unevenly around. In order to build new understanding about changes in the water system, students will obtain more information through reading scientific technical texts coupled with visual displays of data. In particular, they will consider the claims made by scientists and evaluate the data provided to support those claims. Furthermore, students will use the lens of stability and change coupled with systems models throughout the lesson, which is demonstrated by the focus question they take up at the start, and during their analysis of data: Are rising temperatures affecting anything else in Earth's water system? As students discuss what they have investigated, you can help to facilitate students' use of these CCCs by guiding students to consider how a small change in temperature has led to large changes in the

water system. The focus of this discussion is to help students build the element: 'small changes in one part of a system might cause large changes in another part.'" "Where We Are NOT Going: Students will not yet provide a full explanation for changes to Earth's water system, though, they will gather the last piece of that understanding in this lesson that they can use to develop a full explanation in the next lesson. Students will not explore the specifics of how data was gathered and calculated across both satellite and ground observations to produce the findings shared in each reading. This topic would make for an excellent extension opportunity for any student with high interest in how scientists use satellite data to make surface measurements. NASA offers ample resources should a student want to learn more" (Teacher Edition, page 98).

- Lesson 1: "Relevant ideas from this previous work include:
    - Air particles near the ground get warmed up by the sun, and this energy is transferred from the particles in the ground to the air through conduction.
    - As heat is added, water molecules from a water source and moist soil also heat up.
    - As more energy is added, some water molecules turn into a gas and become water vapor (evaporation).
    - As water vapor rises in the atmosphere, it cools and will turn back into liquid. It condenses on dust particles or other things in the air and begins to form clouds and eventually falls as precipitation.
    - The role of wind in moving parcels of air around.
    - Weather is the minute-by-minute or day-by-day variation in the condition of the atmosphere, while climate is longer term (years to centuries)" (Teacher Edition, page 28).
- Lesson 2: The Additional Guidance section includes background knowledge the lesson builds upon. "Students should have some background knowledge from earlier grades about where our water comes from on Earth. Water is found in oceans, rivers, lakes, and ponds. Water exists as solid ice and in liquid form (2-ESS2-3). Nearly all of Earth's available water is in the oceans. Most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere (5-ESS2-2)" (Teacher Edition, page 52).
- Lesson 4: The section called "Where We Are Going" tells how the lesson will build on previous learning. "Students will have partially explored the relationship between temperature and precipitation during Lesson 2, and have developed conceptual understanding of the water cycle in Storms Unit that they will apply to their emerging understanding of Earth's water system. This lesson offers a deeper dive into temperature to better understand how it affects other components of Earth's water system over time around the world and not just at single case sites. It also gives students opportunities to reinforce ESS2.C learned in previous units, including that (1) most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere (5th grade) and (2) that water continually cycles among land, ocean, and atmosphere via evaporation and precipitation, as well as downhill flows on land (6th grade in Storms Unit). The lesson also offers a moment to reinforce parts of ESS3.A that humans depend on Earth for many different resources, including freshwater, and that these resources are distributed unevenly around" (Teacher Edition, page 98).

- Lesson 7: Specific content from previous units is referenced. "Ask the students to recall the gases that are found in the air. Students should recall ideas from the following units: Storms Unit, Bath Bombs Unit, and Maple Syrup Unit" (Teacher Edition, page 137).

Prior learning in SEPs and CCCs

The SEP and CCC elements that are used in each lesson are documented on the "Elements of SEP/CCC" document found in the teacher resources on the website. Although these give the elements of focus for each lesson and describe how the students engage with them, there is not a specific description of how individual elements are developed (i.e., how new understanding is learned or formed), with two exceptions (listed below), both only in the case of students not having the expected level of prior knowledge. If an element is used multiple times in the unit, there is no guidance on how the prior use within the unit can be leveraged in later lessons. Related evidence includes:

- Lesson 3: The Where We Are Going description talks about the how the DCI element is being built upon as well as describing multiple CCCs that could be leveraged in the lesson. "This lesson reinforces disciplinary core ideas previously built as part of Storms Unit with the bundle of ESS2.C The Roles of Water in Earth's Surface Processes provides an opportunity for students to use these ideas in a new context to answer a new question about how increased temperatures affect evaporation" "Several crosscutting concepts will be advantageous to leverage in this lesson: Patterns, Cause and Effect; Scale, Proportion, and Quantity; and Matter and Energy" (Teacher Edition, page 79).
- Lesson 3: "A crosscutting concept you'll want to attend to specifically is Cause and Effect since students will focus on articulating the causal relationship between temperature and evaporation by the end of this lesson. In Grades 3–5 students learned that events occurring together may or may not indicate causation. New in middle school is that students are expected to more clearly differentiate between causal relationships versus correlation (which are explicitly taught in the Everest Unit and the Tsunami Unit). If you've been working on causation versus correlation this school year, elicit from students what they have done in the past to decide if the relationship is causal or not. Use their prior knowledge of causation as a way to set-up, test, and evaluate the relationship between temperature and evaporation. If your students are new to causation versus correlation, use this lab to call their attention to the purpose of collecting evidence to more fully understand if a causal relationship is supported by the data" (Teacher Edition, page 79). This teacher guidance describes some potential CCC progression information, but only if students do not have the expected level of prior knowledge.
- Lesson 6: The Where We Are Going description describes the SEP and CCC categories that will be used but is not specific to the elemental level. "Throughout this lesson, students will engage with mathematical reasoning about the phenomena. Students calculate and use percent to understand gas concentrations and their change over time. Two crosscutting concepts—Scale, Proportion, Quantity and Stability and Change—should be used by students to support their reasoning" (Teacher Edition, page 136).

- Lesson 10: "Students have worked closely with correlation and causation in the Everest Unit and Tsunami Unit. This unit will continue to build on these ideas by looking across multiple data sets to establish correlation; they will then plan and carry out an investigation to gather evidence for causation" (Teacher Edition, page 179).
- Lesson 13: "Students have previously used simulations to test theories and generate data, most notably in the previous unit, OpenSciEd Unit 7.5: How does changing an ecosystem affect what lives there? (Palm Oil Unit). The design of this lesson assumes that students have developed this aspect of the practice; add or remove scaffolds around the simulation to fit your students' development of this practice" (Teacher Edition, page 228). This teacher guidance describes some potential SEP progression information, but only if students do not have the expected level of prior knowledge.

Support is given to teachers for use if the unit is taught out of sequence of the OpenSciEd curriculum. For example:

- In the "How will I need to modify this unit if taught out of sequence?" section of the front matter, teachers are given an overview of the science ideas that are referenced from earlier OpenSciEd materials (Teacher Edition, page 20).
- Within the unit, each lesson begins with a "Where We Are Going" and "Where We Are NOT Going" section. For example, in Lesson 7, "In this lesson, students will investigate that greenhouse gas molecules behave differently than other atmospheric gas molecules when energy is transferred to them. In previous units they have learned that (1) a group of particles with a higher average kinetic energy are at a higher in temperature; (2) particles with more kinetic energy can transfer energy when they collide with particles with less kinetic energy; (3) this transfer of energy from between objects or materials of different temperatures is heat; and (4) when the sun warms Earth's surface particles, there is a transfer of energy from the surface particles to the air particles above them through conduction, and that warmer air rises (convection), which is part of the reason the atmosphere is heated. Thus, prior to this lesson students will have familiarity with energy transfer in the atmosphere by two mechanisms - conduction and convection" (Teacher Edition, page 146). These sections also make it clear where the lesson is not going, either to keep the lesson in the correct grade band or to clarify the direction of the DCIs to explore.

Support is provided to teachers to uncover and clarify potential alternative conceptions students may have. For example:

- In the "What are Some Common Ideas Students May Have?" section in the Teacher Guide, it states, "Students may confuse climate as simply long-term weather and, therefore, unpredictable. In reality there are important differences in the ways scientists study and measure both weather and climate."
- Lesson 7: "However, it is possible that students may believe that the Sun is getting warmer or closer to Earth or that the ozone hole is related to warming temperature."

Suggestions for Improvement

Consider providing support for teachers in understanding the plan for SEP and CCC element development in the unit, both from prior grade-bands and prior OpenSciEd units by detailing how the SEPs and CCCs that are focused on in each lesson are being built upon. This could be limited to the unit's described "focal" SEP and CCC elements.

II.D. SCIENTIFIC ACCURACY

Uses scientifically accurate and grade-appropriate scientific information, phenomena, and representations to support students' three-dimensional learning.

Rating for Criterion II.D. Scientific Accuracy	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials use scientifically accurate and grade appropriate scientific information in the unit. Most ideas and representations are accurate and the materials allow for and address student expression of scientifically inaccurate information.

Related evidence includes:

- A "What are some common ideas students might have?" section is included in the Teacher Background Knowledge. It includes common ideas students have about "Climate versus Weather," "Temperature and Water Cycling," "Causes of Global Warming and Climate Change," and "Pollution versus Greenhouse Gases" (Teacher Edition, page 19).
- Several real data sources are used throughout the unit, for example, NOAA Climate Data in Lesson 2, a NASA Visualization based on real data in Lesson 3, and the UCAR Simple Climate Model in Lesson 13.

Suggestions for Improvement

None

II.E. DIFFERENTIATED INSTRUCTION

Provides guidance for teachers to support differentiated instruction by including:

i. Supportive ways to access instruction, including appropriate linguistic, visual, and kinesthetic engagement opportunities that are essential for effective science and engineering learning and particularly beneficial for multilingual learners and students with disabilities.

ii. Extra support (e.g., phenomena, representations, tasks) for students who are struggling to meet the targeted expectations.

iii. Extensions for students with high interest or who have already met the performance expectations to develop deeper understanding of the practices, disciplinary core ideas, and crosscutting concepts.

Rating for Criterion II.E. Differentiated Instruction	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials provide guidance for teachers to support differentiated instruction because the needs of all students are addressed in ways that make the materials accessible for them by providing ample strategies for teachers to use throughout the unit.

Language guidance is provided that could support multilingual learners. For example:

- The Teacher Handbook provides a general discussion of working with Emergent Multilingual Learners (Teacher Handbook, pages 46–48).
- "Guidance for Developing Your Word Wall" supports teachers in the use of academic vocabulary throughout the material. Words are sorted into "Words we earn," "Words we encounter," and "Words we reinforce or apply from previous units." The guidance states that "It is best for students if you wait and create cards for the Word Wall in the moment, using definitions and pictorial representations that the class develops together as they discuss their experiences in the lesson. When they co-create the posted meaning of the word, students 'own' the word—it honors their use of language and connects their specific experiences to the vocabulary of science beyond their classroom. It is especially important for emergent multilingual students to have a reference for this important vocabulary, which includes an accessible definition and visual support" (Teacher Edition, pages 21–22).

- "Attending to Equity" call-out boxes are scattered throughout the unit, often giving advice to teachers for "Supporting Emerging Multilingual Students." These call-out boxes can be found in Lessons 2, 5, 8, 16, and 17. An example of the guidance provided is below:
    - Lesson 1: The Attending to Equity sidebar "Supporting Emergent Multilingual Students: Asking questions in everyday language allows students to share their thinking or experiences, even if they do not have the appropriate scientific vocabulary yet. This is helpful for emergent multilingual students because, by not requiring scientific words at the onset, you do not limit their participation in classroom discourse" (Teacher Edition, page 41).
    - Lesson 2: "Supporting Emergent Multilingual Students: When developing new vocabulary, strategies that may benefit emergent multilingual learners are to use student-friendly definitions, make connections to cognate words when possible, and include a visual representation of the word. Variability is variabilidad and trend is la tendencia in Spanish. Using cognate stems like 'vary' or words like 'trends' show where the data 'tends' to head… might be able to help emergent multilingual students. Include a drawing as well for a visual clue to distinguish the two words. Use these strategies throughout the unit for both 'words we earn' and 'words we encounter'" (Teacher Edition, pages 63–64).
    - In Lesson 16, "Using cognates, teachers can support emerging multilingual students in making connections between new science vocabulary and their native language(s). This can reduce the vocabulary overload that they may experience in science" (Teacher Edition, page 271).

Guidance is provided for struggling students. For example:

- Lesson 1: Guidance is provided related to students who are struggling with their initial Earth water system model: "Ask students to leave their notebooks in the classroom for you to assess their work. If your students struggle with identifying important components and processes for the cycling of water, you may need to spend additional time reviewing those key processes before they develop their individual models. If students don't explain how the change in temperature is causing the changes to the processes and components that the class identified, use prompts to solicit those connections (e.g., I see you are showing that evaporation is changing, can you add some words to explain how that is connected to the increased temperatures?)" (Teacher Edition, page 35).
- Lesson 2: "Students may struggle with some of the precipitation patterns. It might be helpful to use the Earth's Water System Model to help students understand that, even if one part of the water system for a place seems normal, another part of the system might not be" (Teacher Edition, page 72).
- Lesson 4: "If students struggle with interpreting the data in their reading with the information in the text, prompt them to brainstorm strategies they have used in the past to help them analyze data" (Teacher Edition, page 101).

- Lesson 4: "If you notice students are struggling, suggest that they focus on what 'negative' or 'positive' numbers mean" (Teacher Edition, page 100).
- Lesson 5: Students who are struggling with their revised explanation of the case site "If students struggle to include model ideas, cue students to reference the class's Earth's Water System Model and their Progress Trackers. If students struggle to include all of the interactions among parts of the system, encourage them to review the blue and orange parts of the system model. If students struggle to include evidence from investigations, direct them to their science notebooks to remember the evidence that they gathered from Lessons 2, 3, and 4" (Teacher Edition, page 116).
- Lesson 7: "If students struggle to draw conclusions, do the following. Draw a two-column chart. Label the left column 'Abundance in the atmosphere' and the right column 'Percent change over time.' In the left column, have students list the gases from most to least abundant (i.e., nitrogen, oxygen, water vapor, carbon dioxide, and methane). In the right column, have students list the gases from greatest to least change over time (i.e., methane, carbon dioxide, water vapor, oxygen, and nitrogen)" (Teacher Edition, page 141).
- Lesson 8: "If students struggle to understand the causal mechanism for temperature change, facilitate a deeper discussion to explain the relationship between GHGs in the atmosphere and atmospheric air temperature" (Teacher Edition, page 158).
- Lesson 8: "Monitor their work, and, if students are struggling with representing important ideas in their models, call attention to the model ideas and sketches you did with the class during the discussion. They can use these as a starting point for their models" (Teacher Edition, page 159).

Guidance is provided for students who read below grade level. For example:

- Lesson 4: "Take care to assign students to the text that will be most accessible at their reading level. Consider partner reading with heterogeneous grouping as needed. The texts are slightly leveled to be accessible to below and on grade level readers. One text is designed to challenge above grade level readers."
- Lesson 8: "This is informational text. For some students, such as Emerging Multilingual Learners or students who need reading support, creating an audio recording as an alternate representation of this text that these students can listen to as they follow along on the reading can help students access the text."
- Lesson 16: "While students read the texts, encourage students to use colored pencils, highlighters, or pens to mark-up the text and note words they are curious about or questions they have. This is a useful strategy to help readers access language & symbols contained in text and comprehend the information from the text."

There are opportunities for students who have high interest or who have already met the performance expectations. However, most of these materials do not provide supports for students to develop deeper understanding in all three dimensions. Related evidence includes:

- There is a section that says "To extend or enhance the unit, consider the following:" in the beginning of the unit (Teacher Edition, page 20). What follows is a list of lessons and ways to change the task to make it more challenging.
- Lesson 1: "To promote student engagement you may choose to differentiate the degree of difficulty or complexity of the task by giving some groups both sets of headlines" (Teacher Edition, page 31).
- Lesson 4: In the Where We Are NOT Going Section "Students will not explore the specifics of how data was gathered and calculated across both satellite and ground observations to produce the findings shared in each reading. This topic would make for an excellent extension opportunity for any student with high interest in how scientists use satellite data to make surface measurements. NASA offers ample resources should a student want to learn more" (Teacher Edition, page 98).
- Lesson 7: In the Where We Are Not Going section "Oxygen: Scientists have measured that atmospheric oxygen is declining over time. For the purposes of this lesson, oxygen is treated as a relatively 'stable' gas because it has changed less than 1% over time. The science to explain this change is still tentative as scientists make sense of complex natural and human-generated causes for the decline. The change in oxygen concentration over time would make for an interesting extension opportunity for high interest learners should they express more curiosity about the decline" (Teacher Edition, page 136).
- Lesson 8: "Extension Opportunity: Students who have clearly mastered the content and do not need the reading to solidify the science ideas in the article, may benefit from this extension opportunity. For these students, direct them to the original Phet simulation at: https://phet.colorado.edu/sims/html/molecules-and-light/latest/molecules-and-light_en.html . This version of the interactive has additional information that accelerated students will enjoy exploring" (Teacher Edition, page 155).
- Lesson 9: "Extension Opportunity: Rather than viewing the CO graphs included in version 1 of the StoryMap, students can practice developing and interpreting these graphs using the Tuva platform embedded into version 2 of the StoryMap. This extension activity can provide students with the opportunity to develop deeper aspects of the practices of 4. Analyzing and Interpreting Data and 5. Mathematics and Computational Thinking. Specifically: 4.2: Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. 5.1: Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. Use Extension Opportunity with Tuva for extra guidance on using Tuva. The StoryMap and interactive data set can be accessed at https://arcg.is/08y4by" (Teacher Edition, page 171).
- Lesson 10: "Extension Opportunity: The graph provided in this lesson has all fuel sources already graphed. For students who may need a challenge or have high interest, this is an opportunity for them to make the graph themselves before interpreting the patterns" (Teacher Edition, page 181).

- Lesson 12: "Version 2: Social Media Post Assessment is meant for students who could benefit from an additional challenge" (Teacher Edition, page 209).

Strategies are provided to support Universal Design for Learning, supporting all students to meet the expectations of the unit. For example:

- Lesson 1: "You may use color coding to foreground parts of the model. Although color coding is a useful way to quickly reference the parts of the model, letter or number coding helps ensure accessibility for any student who may be color-blind" (Teacher Edition, page 36).
- Lesson 2: "The StoryMaps and student handouts illustrate each case site with multiple forms of media, including video, audio, pictures, maps, line graphs, histograms, and text. The information in the text is also written explicitly to help students make links across these multiple forms of media" (Teacher Edition, page 67).
- Lesson 3: "Some students may benefit from a change in data representation by condensing the chart to show only the average differences in humidity and temperature change. By removing the unnecessary data, some students are better able to see patterns in a smaller dataset" (Teacher Edition, page 84).
- Lesson 4: "Assigning students to the different texts based on the considerations below should support accessibility and engagement with the text. There are three considerations to account for when assigning students to the texts: (1) student interest and questions, (2) reading level, and (3) assigned case study in Lesson 2" (Teacher Edition, page 100).
- Lesson 5: "Offer students a choice of modalities for communicating their explanations, such as written or oral news stories. Students can also choose to represent their ideas in written or pictorial form" (Teacher Edition, page 113).

Suggestions for Improvement

None

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

Supports teachers in facilitating coherent student learning experiences over time by:

i. Providing strategies for linking student engagement across lessons (e.g. cultivating new student questions at the end of a lesson in a way that leads to future lessons, helping students connect related problems and phenomena across lessons, etc.).

ii. Providing strategies for ensuring student sense-making and/or problem-solving is linked to learning in all three dimensions.

How Do Changes in Earth's System Impact Our Communities and What Can We Do About It?

EQuIP RUBRIC FOR SCIENCE EVALUATION

Rating for Criterion II.F. Teacher Support for Unit Coherence	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials support teachers in facilitating coherent student learning experiences over time because teachers are given guidance about linking student engagement across lessons with student questions and ensuring that students see their progress in explaining the phenomenon.

There is guidance to teachers to support generating student questions. For example:

- Lesson 1: "It may be helpful to ask students to generate questions in rounds. For example, they could first generate a question about the floods and droughts and then generate questions about changing temperatures. This will encourage a range of questions across the model ideas" (Teacher Edition, page 41).
- Lesson 1: "Brainstorm ideas for data and information we need. Project slide Y. Now that the class has created a DQB, tell students that it is time to really dig into the hard work of figuring out what is going on! Ask students, What kinds of information or data do we need to figure out the answers to our questions?" (Teacher Edition, page 42).
- Lesson 1: "Have students turn and talk about their ideas before sharing out with the whole group. Assign each small group a category of questions to focus on. Have small groups share out their ideas with the whole group. Make sure that all groups get to share at least a few ideas. Make a class record of the ideas for future investigations and data we need. You may want to prompt students to keep a record of our proposed investigations in their science notebooks" (Teacher Edition, page 43).
- Lesson 6: "Say, It seems like we have several ideas about what is causing these air temperatures to increase and cause our climate to change. What new questions do we have about any of these possible causes or what is happening for the air temperatures to increase? Add any new questions to the DQB. Project slide L. Give students a moment to consider any new questions that they have. Give the student a sticky note and allow them to add those questions to our DQB. After new questions have been added to the DQB, ask students, Do we have any ideas for investigation or data sources that might help us figure out the answers to our new questions?" (Teacher Edition, page 130).
- Lesson 10: "Students who are skeptical about results are demonstrating that they are beginning to act and think like scientists. This is a good place to encourage that skepticism and to encourage students to ask questions of your and of their peers to clarify evidence for the products of these reactions." This guidance points to a specific place in the lesson where students may have questions (Teacher Edition, page 187).

The unit materials use a navigation routine to recognize what students have figured out and what questions still need to be investigated. Related evidence includes:

- The Unit Storyline document provides a "Navigation to Next Lesson" statement at the end of each Lesson.
- Teacher Handbook: The Navigation Routine discusses the typical elements used in the unit (pages 16–17). For example:
    - Element 1: Look Back: How did we get here?
      Lesson 10: Element 1, which involves looking back at what is currently understood, is employed: "Reconsider the CO graph and update Progress Trackers. Display slide A. Say, Let's think back to what we figured out last time. What did we see last class when we looked at CO over a long time and what were we curious about? Take a moment to update your Progress Tracker with what we figured out about CO in the atmosphere over time" (Teacher Edition, page 180).
    - Element 2: Take Stock: Where are we now?
        - Lesson 2: "Say, We have figured out some data from our community, but it doesn't necessarily explain Porterville, Vicksburg, and other places? Continue by asking, What do we need to help us use what we figured out about our community to explain what is going on in these other places?" (Teacher Edition, page 66).
        - Lesson 5: "Say, Wow, we have figured out a lot already about what is going on in our cases that we've been working with. How might we use our model to explain what is happening in each case site? Give a few students an opportunity to share how they might use the model to explain one site" (Teacher Edition, page 112).
        - Lesson 8: "Say, It seems we have figured out that the molecules in the atmosphere can move in different ways when energy reaches them. Then what? Where does the energy go and does the wiggling seem to matter?" (Teacher Edition, page 151).
    - Element 3: Looking forward: Where are we going?
        - Lesson 6: Element 3 of the navigation routine involves looking forward. In this end of lesson activity, students complete a DQB check-in. "Distribute a copy of the DQB Check-in to students with student questions added. Instruct students to work with a partner to determine which questions they have fully answered, partially answered, and not answered yet by placing a checkmark in the appropriate column" (Teacher Edition, page 128). The class then reviews the questions that have been answered and students have an opportunity to add new questions to the DQB.

Progress Trackers are used throughout the unit. "The individual Progress Tracker is a space for students to be creative and to synthesize learning in their own words and drawings at the end of a lesson. It is not supposed to follow a prescriptive plan or structure and should be a low-stakes opportunity for students to make sense of what they are learning without the worry and anxiety that comes with knowing their work will be graded" (Teacher Edition, page 69).

Students are periodically reminded about how their learning in each dimension assists in their sense-making. Related evidence includes:

- The CCC category of **Cause and Effect** is explicitly referenced in the unit and becomes a tool for students to use to make sense of the phenomenon. For example, in Lesson 12, students independently complete a cause-and-effect diagram where they connect the cause (fossil fuel use) with the effect (influences on the community water resources) using concepts learned in the lesson (Teacher Edition, page 216).
- The SEP category of **Developing and Using Models** is used throughout the unit and students base much of their understanding of the phenomenon through making models and revising those models when new information becomes available. For example:
  - Lesson 1: Students use the SEP of modeling throughout the unit to better understand the phenomenon. An initial model is created by individual students in the first lesson of the unit. "Purpose of this discussion: Develop an initial class consensus model to capture the ideas we agree and disagree on or are more uncertain about to explain how increasing temperatures could be causing an increase in floods and droughts and what could be causing the increasing temperatures" (Teacher Edition, page 36).
  - Lesson 2: Students' ideas about a component of the system (Earth's water) is developed and displayed in a model (Teacher Edition, page 52). After an investigation in Lesson 3, this model is revised to explain how a change in atmospheric temperature affects evaporation in Earth's water system with input from students (Teacher Edition, page 82).

Suggestions for Improvement

None

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

Provides supports to help students engage in the practices as needed and gradually adjusts supports over time so that students are increasingly responsible for making sense of phenomena and/or designing solutions to problems.

Rating for Criterion II.G. Scaffolded Differentiation Over Time	Inadequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found inadequate evidence that the materials support teachers in helping students engage in the practices as needed and gradually adjusting supports over time because students do not have the opportunity to engage in the practices at progressively more sophisticated or independent levels with teacher support gradually changing over time. There are very few elements that are developed or used multiple times over the course of the unit. When the elements are used multiple times in instruction, there are not directions for teachers on how to build upon or leverage what all students already worked on earlier in the unit.

There is limited evidence that teacher-provided supports for students to engage in specific SEP elements over the course of the unit are gradually released or lessened. For example:

- The focal SEP for this unit is **Asking Questions and Defining Problems**. Students are expected to use elements in this SEP independently in most of the material. Then in Lesson 10 (after students have already been using the SEP independently), there are two "Supporting students in engaging in asking questions and defining problems" call out boxes to support teachers with students engaging in this SEP:
    - "By middle school, students should be asking questions to clarify or identify evidence. In this case, students need evidence that burning fossil fuels produces carbon dioxide and is what is causing the amount of carbon dioxide in the air to increase. There will be several opportunities in this lesson for students to use this practice to clarify or identify evidence related to the combustion of fossil fuels" (Teacher Edition, page 185).
    - "Asking questions to identify and/or clarify evidence is one of the practices to focus on during this activity. Students who are skeptical about results are demonstrating that they are beginning to act and think like scientists. This is a good place to encourage that skepticism and to encourage students to ask questions of you and of their peers to clarify evidence for the products of these reactions" (Teacher Edition, pages 187).
- The materials identify **Using Mathematics and Computational Thinking** as a developed SEP, however the support for teachers is the same throughout the materials. In Lessons 7, 11, and 14: the element *Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems* is used:
    - Lesson 7: Students practice representing parts per million as a fraction and as a percent. Then as a class, students are given a sample equation to find the percent change over time. Students are also given a sample equation to calculate the rate of percent change, as a whole class. Next students work with a group or partner to calculate a new percent change.
    - Lesson 11: After playing the dice game, students are given rates of photosynthesis, cellular respiration, and combustion. They calculate the imbalance (basic operations). "Prompt students to discuss the new information about rates and the imbalance of 8.5 GtC/yr, combined with what they noticed from the Carbon Dice Game" (Teacher Edition, page 203).
    - Lesson 14: "Arrange students in small groups or partners. Provide each group with a calculator. Display slide B. Ask groups to discuss what they notice about the footprint numbers across the class. Have them work together to find the class range and to calculate the average." After students make changes to their carbon footprint, "Ask a

few students in class to calculate the new class average and post this to the Carbon Scoreboard using a large sticky note" (Teacher Edition, page 244).
  - Specific guidance is not provided to reduce the amount of scaffolding over the course of the unit. No progression of learning or independence was seen in the claimed element.
- According to the **Developing and Using Science and Engineering Practices** (by Lesson), the following element is developed and used in Lessons 4, 10, and 16. *Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.* However, a progression of learning was not found specific to this SEP element. For example:
  - Lesson 4: Students use a graphic organizer to collect information from a brief reading with accompanying graphs and photograph. Guidance is provided to the teacher, "The numerical units and data displays used in the readings are different from those students are used to interpreting. If you notice students are struggling, suggest that they focus on what 'negative' or 'positive' numbers mean. If students are reading about aquifers, you can ask what a 'negative trend' would indicate (water is decreasing)" (Teacher Edition, page 100).
  - Lesson 10: Students watch a video, read text, and analyze graphs to determine a connection between energy use and population. Guidance is provided to the teacher, "Use this moment to help students integrate words, graphs, and pictures from the text onto the graph of energy consumption" (Teacher Edition, page 181).
  - Lesson 16: Students work in groups to examine a community resilience plan which contains text, maps, photos, and charts. Guidance is provided to the teacher, "Support students with prompts such as: What is the solution and how does it work? What part of the community is involved in implementing this solution? Who is involved - individuals, government, business? How does reading through these plans help us understand what we've been working on these last few classes?" (Teacher Edition, page 272).
  - Specific guidance is not provided to reduce the amount of scaffolding over the course of the unit. No progression was seen in the claimed element.
- A single partial example of moving from supported student work to independent student work in an element from the SEP of **Analyzing and Interpreting Data,** *Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships* is presented in Lessons 2 and 6. However, this SEP element is not one of the SEPs targeted by the materials as a learning goal. Related evidence includes:
  - Lesson 2: Students interpret graphs using the I^2 strategy.
  - Lesson 6: In preparation for an assessment, students individually analyze graphs.

Suggestions for Improvement

- Although this unit engages students in using many SEP elements, there are limited times each element is used more than once. For elements identified as being built upon, there would ideally be multiple opportunities for students to develop the element and receive feedback.

Consider explicitly describing how the teacher scaffolds for the SEP elements identified as being built in the unit could be reduced over the course of the unit to allow students more independence in using the SEP.

- Consider using the call-out boxes or links to online teacher resources to provide suggestions for how teachers could reduce the amount of scaffolding in elements of an SEP over the course of the unit.
- Consider providing support for teachers in leveraging and building upon elements of all three dimensions throughout the material, especially the SEP and CCC elements that appear multiple times within the unit. This could look like in the "Supporting Students…" sidebars including suggestions or links to suggestions for the teachers on moving students towards independent use of the element over the course of the unit.

OVERALL CATEGORY II SCORE: **2**	
Unit Scoring Guide – Category II	
Criteria A-G	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

CATEGORY III

MONITORING NGSS STUDENT PROGRESS

III.A. MONITORING 3D STUDENT PERFORMANCES

III.B. FORMATIVE

III.C. SCORING GUIDANCE

III.D. UNBIASED TASK/ITEMS

III.E. COHERENT ASSESSMENT SYSTEM

III.F. OPPORTUNITY TO LEARN

How Do Changes in Earth's System Impact Our Communities and What Can We Do About It?

EQuIP RUBRIC FOR SCIENCE EVALUATION

III.A. MONITORING 3D STUDENT PERFORMANCES

Elicits direct, observable evidence of three-dimensional learning; students are using practices with core ideas and crosscutting concepts to make sense of phenomena and/or to design solutions.

Rating for Criterion III.A. Monitoring 3D Student Performances	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials elicit direct, observable evidence of students using practices with core ideas and crosscutting concepts to make sense of phenomena or design solutions. Important tasks are three dimensional and show evidence of using targeted, grade appropriate DCIs, SEPs, and CCCs. However, although each lesson includes Lesson-Level Performance Expectations (LLPEs), which are described as potential assessment opportunities to evaluate students learning in all three dimensions, some of the artifacts identified by these LLPEs are group work and would not provide observable evidence of individual student understanding. Not enough individual student artifacts would be produced for teachers to be able to monitor students' learning for key assessment targets.

There are multiple documents that provide support for monitoring student performances. These include:

- The Teacher Edition and the Assessment Overview Document include a comprehensive Assessment System Overview, which explains what the assessment is, the type of assessment (formative or summative), and what to look for.
- The Assessment System Overview also includes a section called the Lesson-by-Lesson Assessment Opportunities, which list the three-dimensional, lesson-level performance expectations, the targeted SEP(s) and CCC(s), and the DCI understandings students should be able to demonstrate.

The materials provide opportunities for students to show sense-making using grade-appropriate elements of all three dimensions most of the time in class activities and formal tasks. For example:

- Assessment Opportunities occur throughout the unit. Each of these contains a three-dimensional learning target that includes information about some of the specific elements used. For example:
    - Lesson 2: "Building towards: 2.C Analyze and interpret data about patterns in rates of change and numerical relationships to determine similarities and differences between drought and flood sites" (Teacher Edition, page 72). In this example, the SEP and CCC elements are evident, but it is unclear what DCI element is targeted.

  - Lesson 11: "Building towards: 11.A Apply mathematical concepts to identify that the rate of combustion putting CO into the atmosphere is not proportional to the rate for photosynthesis taking CO out of the atmosphere leading to an imbalance in Earth's Carbon System" (Teacher Edition, page 205). The specific SEP element is evident, but the CCC element and the DCI element targeted are not clear.
  - Lesson 5: "Building towards: 5.A Construct a scientific explanation based on valid and reliable evidence that small changes in temperature can have big impacts on the water sources available for communities" (Teacher Edition, page 116). In this example, the SEP and CCC elements are evident, but it is unclear what DCI element is targeted.
- Lesson 5: In this formal formative assessment task, individual students construct an explanation using both data from investigations and a class model that has been generated through the unit. The explanation is designed "To create a clear and convincing explanation to others to (1) explain how or why water is changing in one community and (2) support the how or why with evidence." This requires a grade-appropriate element from the SEP of **Constructing Explanations and Designing Solutions.** The explanation requires students to use the CCC of **Stability and Change** and the DCI of **ESS2.C: The Roles of Water in Earth's Surface Processes.** This aligns to the lesson-level performance expectation of "Construct a scientific explanation based on valid and reliable evidence that small changes in temperature can have big impacts on the water sources available for communities."
- Lesson 6: In this formal summative assessment task students use graphs, readings, and their previous work on Explaining Water Stories in an assessment where they explain how the increasing wildfires and the decreasing sea ice might be related. This assessment requires the use of the CCC of **Patterns**, the SEP of **Analyzing and Interpreting Data** to explain an important concept contained in the DCI of **ESS3.C Human Impacts on Earth's Systems.** This aligns to the lesson-level performance expectation "Compare graphs and charts from multiple claims to identify patterns in the similarities and differences to determine that changes in the environments are caused by increasing temperatures".

The LLPEs are described as potential formative assessment opportunities to evaluate students learning in all three dimensions. However, not all LLPEs have direct, observable evidence that students integrate multiple dimensions because they are group activities where students work as a whole class to create a class product. For example, in Lesson 2 students create a class model of Earth's water system. The LLPE is "Develop and use a model to describe the components, interactions, and processes of water distribution and movement on Earth." This is an example of students working as a group to use **Developing and Using Models, System and System Models,** and **ESS2.C.** Because students create this model as a whole class, there is no opportunity for teachers to collect artifacts of individual students' understanding of the three dimensions (Teacher Edition, page 51).

Formal tasks incorporate phenomena that are real world and require students to connect their understanding to a new scenario. For example:

- Lesson 6: The formal assessment is based on a real-world scenario and uses real world data. Students use their learning from the first four lessons to analyze a new situation.
- Lesson 12: First the class analyzes a social media post by identifying claims, using evidence to determine which claims are supported by science, and selecting claims that needs additional science ideas to explain or clarify the claim. They complete an individual assessment using a new social media post and using the strategies acquired in the whole class activity.

Suggestions for Improvement

- If the materials intend that the LLPEs be used as a formative assessment opportunity for three-dimensional learning, it would be helpful for there to be a way for teachers to collect individual student responses to show three-dimensional understanding.
- Consider amending the assessment in Lesson 11 such that students could address phenomena or problems with grade-level appropriate DCI elements.

III.B. FORMATIVE

Embeds formative assessment processes throughout that evaluate student learning to inform instruction.

Rating for Criterion III.B. Formative	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials embed formative assessment processes throughout that evaluate student learning and inform instruction because the materials include frequent and varied supports to the teacher for formative assessments. The assessments are part of instruction and are found in various formats. Teachers are provided with support to modify instruction based on the results of formative assessments. Formative assessments occur in all lessons in the unit. The formative assessment opportunities allow students to show their thinking across all three dimensions. Formative assessment also attends to student equity and access, and the supports are based both on class responses as well as individual student responses.

Related examples include:

- Assessment System Overview: A summary of opportunities for formative assessments is provided for each lesson. Teachers are given guidance about when to use the assessment and what to look for in student responses (Teacher Edition, pages 304–307).
- Each lesson provides at least one formative assessment opportunity where guidance is provided on what to look for and what to do for struggling students. Supports are provided for teachers in

call out boxes for additional support to attend to equity for all students. For example, Lesson 1: "Building towards: 1.C Ask questions that arise from initial observations of stories and headlines about rising temperatures, floods, and droughts to clarify whether increasing temperatures are related to or causing both floods and droughts. What to look for: Look for questions that are open (how/why) and testable versus closed (yes/no) in the classroom. Also listen for questions that address both parts of our model. What do to: Since students will put their initials on the backs of these sticky notes, you will have a few opportunities to take stock of the kinds of questions students ask in this initial lesson after they are posted on the DQB, as well as when they are writing them. When students share these questions for the DQB, they will likely only have time to share one. Collect the remaining questions that don't get posted after the development of the DQB is complete. If your students are asking mostly closed questions, you can provide a copy of a photo of the questions on the Driving Question Board and ask them to work on refining three or more of these questions so that they become 'how' and 'why' questions that can help answer the original question posted, as well the original yes/no question. This could be an in-class or home-learning assignment" (Teacher Edition, page 41).

- Lesson 3: Students modify their model of Earth's water system based on evidence from an investigation. Teachers are directed to modify instruction if students are having difficulty using the CCC of **Cause and Effect**. "If students do not immediately agree on the causal relationship between an increase in temperature and an increase in evaporation, transition to thought experiments around other explanations. For example: Allow students to suggest other causes that would explain why there was more evaporation in the heated conditions. Use the prompt, If an increase in temperature is not causing more evaporation, what other variables or factors can we identify in our bottles that would explain why the heated conditions had more evaporation? Be prepared to test these new ideas. Have students track evidence from the bottle setups, visualizations, prior science learning, and out of school experiences that support that increased temperature causes increased evaporation. Chart evidence that supports or does not support this explanation" (Teacher Edition, page 94).
- Lesson 8: Students update their Progress Tracker to include new information. "Provide quiet time for students to work individually on their Progress Trackers. Monitor their work, and, if students are struggling with representing important ideas in their models, call attention to the model ideas and sketches you did with the class during the discussion. They can use these as a starting point for their models. Collect student notebooks or Progress Trackers before they attach them to their notebooks so you can review them" (Teacher Edition, page 159). Note that the direction to adjust instruction if students are struggling seems to be a general suggestion about what to do if the whole class is struggling rather than a specific piece of feedback for individual students.
- In Lesson 13, "**Building towards: 13.A** Use the carbon dioxide model simulation to generate data and test ideas about different emissions rates scenarios to determine how to reach carbon dioxide equilibrium in the atmosphere. **What to look for/listen for**: Listen for students to determine that, even by cutting emissions in half, the global temperature will still increase. Students should identify that a cut of 9 GtC/yr will need to be made to emissions to reach CO_2

equilibrium in the atmosphere. **What to do**: If students do not recognize that the rate needs to be cut by 9 GtC/yr, ask students if anyone was able to cut emissions to a point where the temperatures remained steady. Students should identify that this rate is at 1.6 GtC/yr. Ask students what the difference is between the starting rate and the cut rate. Students should identify that it is roughly 9 GtC/yr. If students argue that the rate is at 8.9 GtC/yr, remind students that this simulation is using 2015 data, and emissions have since increased. By using the rounded-up 9 GtC/yr estimate, we can have a number that more closely reflects the actual imbalance and amount needed to reach CO_2 equilibrium in the carbon system" (Teacher Edition, page 234).

- Students record their individual understanding in a progress tracker. For example:
  - "The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena and figuring out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment. We strongly suggest that it is not collected for a summative 'grade' other than for completion. The Progress Tracker is already included in Lessons 2, 4, 7, and 9, but can be added to the other lessons or as a home learning reflection assignment" (Teacher Edition, page 306).

- During class discussions, the teacher has an opportunity to assess student thinking and modify the lesson or go back and review. For example, in Lesson 11, a consensus discussion allows the teacher to determine how well students are understanding important mathematical concepts and how they are used to make sense of differing rates of carbon entering and exiting the atmosphere. If students are not making the connection, teachers are advised: "Have students complete a third round of the dice game but with increased fossil fuels use so that, when they roll the dice, there is more opportunity to leave the fossil fuel reservoir. Have them complete a round with reduced fossil fuel use where there is only one opportunity (rolling a 6) to leave the fossil fuel reservoir. The additional rounds may help students see that the rate of use of fossil fuels can greatly affect buildup of carbon in the atmosphere" (Teacher Edition, page 205).

Suggestions for Improvement

None

How Do Changes in Earth's System Impact Our Communities and What Can We Do About It?

EQuIP RUBRIC FOR SCIENCE EVALUATION

III.C. SCORING GUIDANCE

Includes aligned rubrics and scoring guidelines that provide guidance for interpreting student performance along the three dimensions to support teachers in (a) planning instruction and (b) providing ongoing feedback to students.

Rating for Criterion III.C. Scoring Guidance	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials include aligned rubrics and scoring guidelines that help the teacher interpret student performance for all three dimensions. Assessment targets are clearly stated in the form of an LLPE at the beginning of each lesson, although targeted elements of each dimension in the LLPEs, especially the DCI elements, are not always clear. Teachers are guided on how to evaluate student performances by the use "What to Look/Listen For" lists, scoring rubrics, keys, and ideas for modification of the lesson if necessary. All formative assessments include three-dimensional learning goals, key ideas that should surface, and how to interpret student responses and modify instruction.

Related evidence includes:

- LLPEs do not always clarify the targeted three dimensions. See examples under Criterion III.A.
- Exemplar student responses are provided for all classroom discourse/teacher oral questioning. For example:
    - In Lesson 1, in response to the question, "What other ideas did you have for increased floods?" the teacher is provided with multiple possible responses. "Sample Student Responses: I said that there is more evaporation when it is warmer, so then there is more water in the air that turns into clouds. If there is more water around, then there is more to condense and cause more rain. I added that there is more water because of the ice melting" (Teacher Edition, page 38).
    - In Lesson 2, "If we are talking about 'weather,' what kind of data might we be looking at? Sample student responses might include: The temperature outside right now. Whether it is sunny or cloudy outside right now. What the forecast might be for the week. It is even shorter term than the 10 years we looked at—it is more like a day or a few days" (Teacher Edition, page 65).
- Students track their own progress toward learning goals through the use of a Progress Tracker. Lesson 2 explains how the Progress Tracker is used (Teacher Edition, page 61). "The individual Progress Tracker is a space for students to be creative and to synthesize learning in their own words and drawings at the end of a lesson. It is not supposed to follow a prescriptive plan or structure and should be a low-stakes opportunity for students to make sense of what they are

learning without the worry and anxiety that comes with knowing their work will be graded. Students have already engaged in discussion about this question, so the Progress Tracker provides an additional modality for students to express their understanding and reasoning in their own way. Encourage students to express what they have learned using a mode that makes sense for them" (Teacher Edition, page 69).

- Students have enough information to track their own progress toward learning goals throughout the unit. For example, students use a Model Ideas List to track their learning. This list is compiled by the whole class, but students provide input on what should be on the list and students can see their own progress in learning. Students use this for both Earth's water system and carbon system.

All summative tasks have detailed scoring guidance.

- Answer keys and scoring guidance (including a range of student responses) are provided for the Alaska Wildfires assessment (Teacher Edition, pages 329–332) and the Tweet Claims assessment (Teacher Edition, pages 373–379). Each has a chart showing the targeted elements. They also include expected student claims along with data that is used to support the claim.
- A scoring rubric are provided for Case Site Explanations (Teacher Edition, pages 329–332). The scoring guide has a detailed chart showing the SEP, CCC, and DCI elements targeted and a rubric with three levels of proficiency. The materials also include samples of student work that represent a range of student ideas.

Suggestions for Improvement

None

III.D. UNBIASED TASK/ITEMS

Assesses student proficiency using methods, vocabulary, representations, and examples that are accessible and unbiased for all students.

Rating for Criterion III.D. Unbiased Task/Items	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials assess student proficiency using accessible and unbiased methods, vocabulary, representations, and examples because a variety of materials is used to allow students to access tasks in a meaningful way, and students have some choice of modality.

Guidance is provided for teachers to create and use a word wall to increase retention of grade-level appropriate scientific vocabulary. For example:

- "After students have developed a deep understanding of a science idea through these experiences, and sometimes because they are looking for a more efficient way to express that idea, they have 'earned' that word and can add the specific term to the class Word Wall. These 'words we earn' should be recorded on the Word Wall using the students' own definition whenever possible" (Teacher Edition, page 22).
- "The words we earn and words we encounter in this unit are listed in this document and in each lesson to help prepare and also to avoid introducing a word before students have earned it. They are not intended as a vocabulary list for students to study before a lesson, as that would undermine the authentic and lasting connection students can make with these words when they are allowed to experience them first as ideas that they're trying to figure out" (Teacher Edition, page 22).

The amount and level of texts are varied and grade-level appropriate and include Lexile range and Flesch-Kincaid Grade Level. For example, in Lesson 4, "The texts are slightly leveled to be accessible to below and on grade level readers. One text is designed to challenge above grade level readers. While all texts fall within a 810L–1000L Lexile range, the Flesch-Kincaid score shows the slight differences in reading level. Additional modifications can be made to the texts to make them more accessible or more challenging depending on your students' needs" (Teacher Edition, page 97).

A variety of modalities are utilized sometimes throughout the unit. For example:

- Lesson 2: "The StoryMaps and student handouts illustrate each case site with multiple forms of media, including video, audio, pictures, maps, line graphs, histograms, and text. The information in the text is also written explicitly to help students make links across these multiple forms of media" (Teacher Edition, page 647).
- Lesson 9: "Students engage with data and information in this lesson using multiple forms of media. Students begin with a simple line graph then use a time-lapse animated video to begin to identify when changes in CO_2 were happening. This is followed by a reading with text and images to understand what was happening in the world when carbon dioxide was rising. Finally, they use other graphs to connect energy use and population growth. Providing multiple forms of media to represent the information provides more access for the diverse learners in your classroom" (Teacher Edition, page 180).

The materials provide some opportunities for student choice of activities and modalities. Some examples include:

- Lesson 5: "Offer students a choice of modalities for communicating their explanations, such as written or oral news stories. Students can also choose to represent their ideas in written or pictorial form" (Teacher Edition, page 113).

- Lesson 12: "Providing students the opportunity to choose the level of perceived challenge by selecting a tweet of their choice can support student engagement and help develop self-determination, pride in accomplishment, and increase the degree to which they feel connected to their learning" (Teacher Edition, page 222).
- Lesson 15: "Students should have the opportunity to read at least 1 solution of their choice and up to 3 solutions" (Teacher Edition, page 256).
- Lesson 17: The Project Choice and Platform Information document suggests choices that can be offered to students as well as different platforms they can use to create their presentation. Students can choose the type of project they will use to communicate their Community Resilience Plan.

Suggestions for Improvement

None

III.E. COHERENT ASSESSMENT SYSTEM

Includes pre-, formative, summative, and self-assessment measures that assess three-dimensional learning.

Rating for Criterion III.E. Coherent Assessment System	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials include pre-, formative, summative, and self-assessment measures that assess three-dimensional learning because a comprehensive assessment system overview is provided. Teachers are provided with a purpose and rationale for how, when, and why student learning is measured across the materials. Rationale for these assessments is provided in the "Assessment System Overview."

Multiple key assessment tasks are found in every lesson and are called out in the "Assessment Opportunity" boxes. All of these "Assessment Opportunity" tasks assess student learning in three dimensions and are used by students in either making sense of the phenomenon or in creating a community resilience plan (problem solving). The unit contains pre-, formative, summative, and self-assessment tasks.

Pre-Assessment

- From the "Assessment System Overview":

- "The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn more about the ideas that your students bring to this unit" (Teacher Edition, page 304).
- "The Driving Question Board is another opportunity for pre-assessment" (Teacher Edition, page 304).

Formative Assessment

- From the "Assessment System Overview":
  - Lesson 5: "This explanation provides formative information and practice before students transfer their understanding to a new case in Lesson 6. If your students have not developed a written scientific explanation, there is a Building Prerequisite Understanding option for you to model and co-construct an explanation together before they write their own individually" (Teacher Edition, page 305).
- In the "Lesson-by-Lesson Assessment Opportunities":
  - "The table below summarizes opportunities in each lesson for assessing every lesson-level performance expectation (LLPE). Examples of these opportunities include student handouts, home learning assignments, progress trackers, or student discussions. Most LLPEs are recommended as potential formative assessments" (Teacher Edition, page 307).
- Lesson 2: "This is an early formative assessment moment to figure out how much students are bringing from earlier grades and OpenSciEd units" (Teacher Edition, page 54).
- Lesson 6: "This handout is meant as a formative assessment before Alaska Wildfires and Sea Ice" (Teacher Edition, page 127).
- Lesson 8: "As a formative assessment opportunity, listen for the key ideas listed below to assess the class's understanding of the important ideas they have figured out through using molecular models, working with the interactive, and the reading" (Teacher Edition, page 158).

Summative Assessment

- Lesson 6: Alaska Wildfire and Sea Ice Transfer Task
- Lesson 12: Social Media Post Assessment
- Lesson 17: Community Resilience Plan: Project Planning Sheet
- Lesson 17: Argue for the Best Solution to Solve a Problem in Your Community
- Lesson 17: Arguing for an Important Solution for your Community

Self-Assessment

- Lesson 17 Self-Assessment: Giving Feedback and Self-Assessment: Receiving Feedback.
- Students can also use the Progress Tracker and the "Self- Assessment Discussion Rubric" after in-class discussions to self-assess.

Suggestions for Improvement

None

III.F. OPPORTUNITY TO LEARN

Provides multiple opportunities for students to demonstrate performance of practices connected with their understanding of disciplinary core ideas and crosscutting concepts and receive feedback.

Rating for Criterion III.F. Opportunity to Learn	Adequate *(None, Inadequate, Adequate, Extensive)*

The reviewers found adequate evidence that the materials provide multiple opportunities for students to demonstrate performance of practices connected with their understanding of core ideas and crosscutting concepts. There are limited student performances that provide students with opportunities to demonstrate growth in all three dimensions, especially the SEPs, throughout the unit. Most feedback from the teacher is oral and written feedback by the teacher is limited, related to only a small number of the targeted student learning goals.

The focal SEPs listed are **Asking Questions and Defining Problems, Using Mathematics and Computational Thinking** and **Obtaining, Communicating, and Evaluating Information.** These are addressed more at the category level (e.g., "Asking Questions" rather than a specific middle school level element), with little student opportunity to increase proficiency in individual elements of these SEPs over the course of the material. For example:

- **Asking Questions and Defining Problems**
  - *Ask questions that require sufficient and appropriate empirical evidence to answer.*
    - Lesson 10: The assessment opportunity is looking for students asking for evidence for the products of the combustion of fossil fuels and students recognizing and asking questions about energy as a product of the combustion reactions, as well as matter that comes from the reactants. (Ask questions to clarify whether the CO_2 in the atmosphere can come from burning fossil fuels for energy.)
    - Lesson 18: The assessment opportunity is looking for students asking new questions that arise from investigations, or some existing questions may remain unanswered or need additional evidence to answer. (Communicate scientific information orally about the patterns of class questions that have been explained with sufficient evidence about the impact of a changing climate and

community solutions, and ask additional questions that require appropriate and sufficient evidence to answer.)

- *Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.*
    - This element is only used in one lesson (Lesson 1) and would therefore not provide students with multiple opportunities to learn and improve.
- *Ask questions that challenge the premise(s) of an argument or the interpretation of a data set.*
    - This element is only used in one lesson (Lesson 17) and would therefore not provide students with multiple opportunities to learn and improve.

- **Using Mathematics and Computational Thinking**: The element *Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems* is used in multiple lessons, however in each lesson students focus on a different process and do not have repeated opportunities to demonstrate proficiency in one process. For example:
    - *Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions or problems.*
        - Lesson 7: The assessment opportunity asks for students to identify that nitrogen and oxygen are mostly stable and not changing over time, to identify that carbon dioxide and methane are increasing by a high percentage, to classify water vapor as "changing a little," and to conclude that, while carbon dioxide and methane make up a small quantity of gas in the atmosphere, the change over time for both types of gas is unusually high. (*Apply mathematical concepts of percent to understand the proportion and quantity of and stability and/or change in the concentration of gases in the atmosphere over time*.)
        - Lesson 11: The Assessment Opportunity is looking for students to apply the rates to make sense of the imbalance that occurs when comparing the rate of CO_2 entering the atmosphere from combustion versus the rate of CO_2 taken out of the atmosphere from photosynthesis, to use the rates to explain that a net of 8.5 GtC/yr is going into the atmosphere without an offsetting process to take it out, to explain that the processes are not balanced, and to explain that when humans started to burn fossil fuels we created a change to the system. (*Apply mathematical concepts to identify that the rate of combustion putting CO_2 into the atmosphere is not proportional to the rate for photosynthesis taking CO_2 out of the atmosphere leading to an imbalance in Earth's Carbon System.*)
        - Lesson 14: The Assessment Opportunity is looking for students to calculate the carbon savings from their behavior changes, multiply the savings by different population sizes, understand why they are multiplying, recognize that their calculations are based on getting 100% of people to make changes, to recalculate a more realistic percentage, and to understand that the numbers reflect an average carbon savings based on different actions people may be

willing to take. (*Apply mathematical concepts to calculate the class's average carbon impact and possible carbon reductions and scale those reductions if more people change their behaviors*.)

- *Use mathematical representations to describe and/or support scientific conclusions and design solutions.*
    - Lesson 14: The class develops a carbon scoreboard.
    - This element is only used in one lesson and would therefore not provide students with multiple opportunities to learn and improve.
- Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
    - Lesson 10: Students analyze a large data set.
    - This element is only used in one lesson and would therefore not provide students with multiple opportunities to learn and improve.

- **Obtaining, Evaluating, and Communicating Information**
    - *Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.*
        - Lesson 4: The Assessment Opportunity is looking for students to produce conclusions that are generally similar to the claims made by the scientists but in students' own words, describing how the component is changing (e.g., increasing, decreasing, etc.), describing how temperature is related to the change in the component (e.g., melting ice, changing precipitation from rain to snow, causing a process to happen earlier, etc.), and how the conclusions are supported by the data included with the text. (*Integrate scientific information with media and graphical displays of data to clarify how a small change in temperature affects components of Earth's water system*.)
        - Lesson 10: The Assessment Opportunity is looking for student ideas about the pattern in each individual graph, student ideas about a correlation in the patterns across the three graphs, and student ideas about how a growing population that consumes large amounts of mineral resources is correlated with the rapid increases in CO_2 in Earth's atmosphere. (*Integrate qualitative and quantitative scientific information in written text with visual displays of atmospheric CO_2 levels, energy consumption, and human population levels to determine a correlation between human activities and CO_2 emissions*.)
        - Lesson 16: The element is claimed to be assessed in this lesson, but there is not an Assessment Opportunity for this element.
    - *Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).*
        - Lesson 16: Students use information from Community resilience plans to understand how communities ae planning for climate change.

- This element is only used in one lesson and would therefore not provide students with multiple opportunities to learn and improve.

Students receive feedback from the teacher and peers to grow in their ability to use a couple of elements of the CCC of **Stability and Change** and some targeted DCIs over the course of the unit. For example:

- *Small changes in one part of a system might cause large changes in another part.*
  - Lesson 4: Students read a case study and analyze the information through the lens of **Stability and Change** (Teacher Edition, page 96).
  - Lesson 5: The teacher introduces terms to the students to focus their thinking. "It might be helpful to explicitly introduce Stability and Change here by saying something like, It surprised us that a small rise in temperature was related to all of these big changes in precipitation and Earth's whole water system. The audience may find this surprising, too. Why don't we add, 'How could a small change in one part of the system have a big impact on the community's water?' to our list. Explaining this may help the audience understand the problem better. When students cite evidence from their case site locations, encourage them to include ideas about how as one part of the 'normal,' or stable, system changes, it impacts other parts of the system" (Teacher Edition, page 113).
- *Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.*
  - Lesson 7: Teacher feedback helps students to use the idea of **Stability and Change**. "When students begin their analyses of the data and calculate percent change, encourage students to use the crosscutting concept of Stability and Change as a lens for explaining what is happening to gases over time. Students should know that fluctuations within a normal range can be considered stable (Lesson 2) but that an overall trend in one direction could indicate a change in the normal pattern. Prompt students to think about whether the data supports a stable pattern or a changing pattern" (Teacher Edition, page 139).
  - Lesson 8: As students analyze ice samples, they come to conclusions about the levels of CO_2 over time by focusing on whether the level shows a cycle of increases and decreases. Students draw on their previous experiences with using the lens of change in a system. Teacher feedback helps students conclude that recent changes in the level of CO_2 are not in the normal range. "Students should also notice that the first graph does show an increase in carbon dioxide since the 1950s, but the amount of increase that is represented since then in the second graph is much steeper when it is compared to 800,000 years ago. They should argue that this is another piece of data that shows this increase is not normal" (Teacher Edition, page 172).

Students have multiple opportunities to demonstrate their understanding over the course of the unit, receive feedback, and apply that feedback to deepen their understanding. For example:

- Lesson 5: Students develop an explanation of a specific location and receive peer feedback on their explanation for how they use science ideas to support their explanation how/why this is happening and evidence they are using to support their science ideas (Peer Feedback Instructions Handout). Students are supported in how they provide feedback and how they respond to feedback in the "Peer Feedback Guidelines" handout.
- Lesson 6: Students are given the transfer task "Alaska Wildfires and Sea Ice," which is different than the case study task they just completed but looks at whether or not they understand the same concepts.
- Lesson 12: The class co-constructs an argument to a Twitter post, listing claims made in the post. Students then discuss claims that need clarification or that are inaccurate. They talk with peers about how they would change the claims to match their current understanding. A class discussion, with feedback from the teacher, is used to gather ideas from all students. After this formative assessment, students complete an individual assessment where they use the strategies learned in the whole class activity to analyze the claims in a different tweet.

Suggestions for Improvement

There are currently few opportunities for students to improve their performance in targeted CCC and SEP elements in the unit, and to receive feedback on their performance of those targeted elements along the way. Consider refocusing the scope of the material so that students have the opportunity to iteratively develop all targeted SEP and CCC elements during the unit.

OVERALL CATEGORY III SCORE: 3	
Unit Scoring Guide – Category III	
Criteria A-F	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

How Do Changes in Earth's System Impact Our Communities and What Can We Do About It?

EQuIP RUBRIC FOR SCIENCE EVALUATION

SCORING GUIDES

SCORING GUIDES FOR EACH CATEGORY

UNIT SCORING GUIDE – CATEGORY I (CRITERIA A-F)

UNIT SCORING GUIDE – CATEGORY II (CRITERIA A-G)

UNIT SCORING GUIDE – CATEGORY III (CRITERIA A-F)

OVERALL SCORING GUIDE

Scoring Guides for Each Category

Unit Scoring Guide – Category I (Criteria A-F)	
3	At least adequate evidence for all of the unit criteria in the category; extensive evidence for criteria A–C
2	At least some evidence for all unit criteria in Category I (A–F); adequate evidence for criteria A–C
1	Adequate evidence for some criteria in Category I, but inadequate/no evidence for at least one criterion A–C
0	Inadequate (or no) evidence to meet any criteria in Category I (A–F)

Unit Scoring Guide – Category II (Criteria A-G)	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least two criteria
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

Unit Scoring Guide – Category III (Criteria A-F)	
3	At least adequate evidence for all criteria in the category; extensive evidence for at least one criterion
2	Some evidence for all criteria in the category and adequate evidence for at least five criteria, including A
1	Adequate evidence for at least three criteria in the category
0	Adequate evidence for no more than two criteria in the category

How Do Changes in Earth's System Impact Our Communities and What Can We Do About It?

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL SCORING GUIDE	
E	**Example of high quality NGSS design—**High quality design for the NGSS across all three categories of the rubric; a lesson or unit with this rating will still need adjustments for a specific classroom, but the support is there to make this possible; exemplifies most criteria across Categories I, II, & III of the rubric. (total score ~8–9)
E/I	**Example of high quality NGSS design if Improved—**Adequate design for the NGSS, but would benefit from some improvement in one or more categories; most criteria have at least adequate evidence (total score ~6–7)
R	**Revision needed—**Partially designed for the NGSS, but needs significant revision in one or more categories (total ~3–5)
N	**Not ready to review**—Not designed for the NGSS; does not meet criteria (total 0–2)