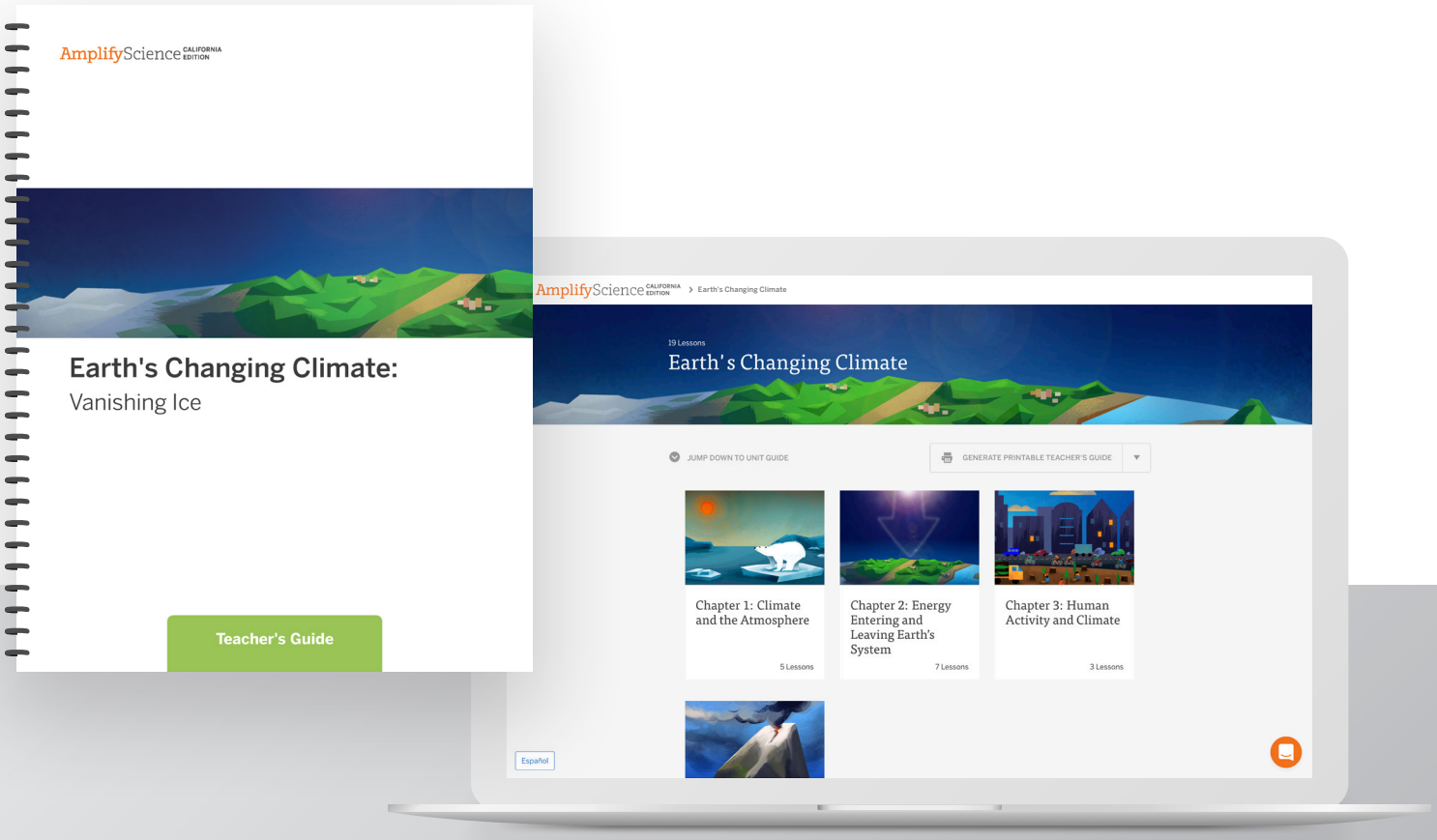
Amplify Science
CALIFORNIA

UNIT GUIDE

Earth's Changing Climate



Amplify.

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

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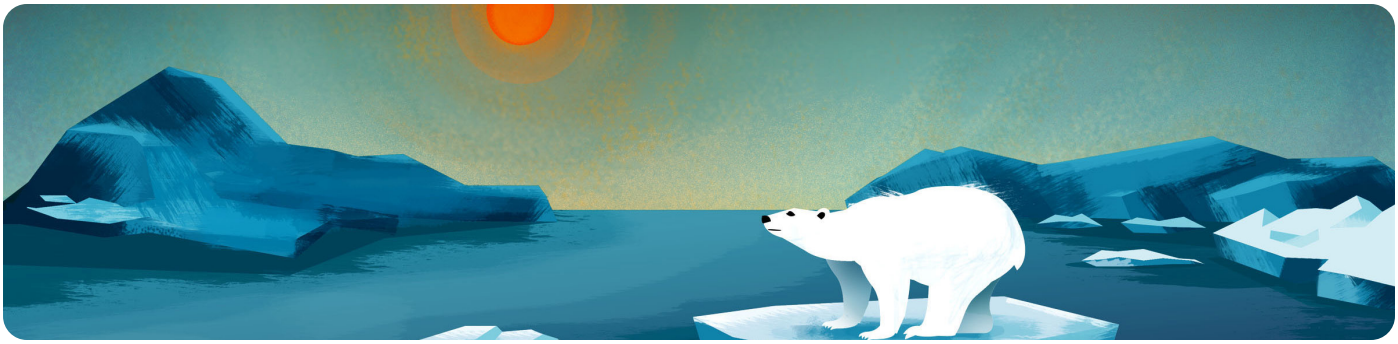


Welcome to Earth's Changing Climate

Most curricula that address the topic of climate change limit learning to the correlation among carbon dioxide, methane, and temperature. In contrast, Amplify Science California invites students to figure out why carbon dioxide and methane lead to higher temperatures. Students do this by investigating and refuting common alternative and inaccurate claims, analyzing sets of data for themselves, and making and testing their own hypotheses.

> Unlike a typical curriculum, Amplify Science California anchors learning by inviting students to take on the role of scientists and engineers.

In this unit, students take on the role of climatologists. Their job is to help the fictional World Climate Institute research causes of ice loss and climate change with the goal of educating the public about their findings. Working together, students learn some of the effects of climate change, and some possible solutions, and they compare our current climate change to other climate changes in Earth's history. The unit concludes with a Science Seminar, in which students use what they have learned to analyze evidence and participate in a discussion about whether large volcanic eruptions have a cooling or warming effect on the climate.

Unit Type: Core

Student Role: Climatologists

Phenomenon: The ice on Earth's surface is melting.

Core Concept: Understanding the causes of climate change

Target Performance Expectations:

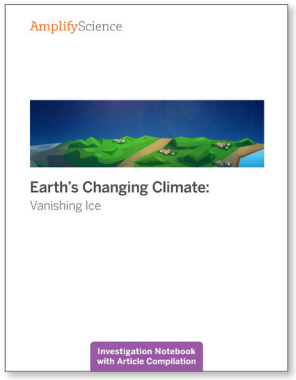
- ESS3-3: Designs to Minimize Impact
- ESS3-5: Factors for Global Temperature

Related Performance Expectations:

- LS2-1: Resources and Populations
- LS2-4: Changes Affect Populations
- ESS3-2: Natural Hazards
- ESS3-4: Human Population

Students figure out the unit phenomenon through the use of a variety of resources.

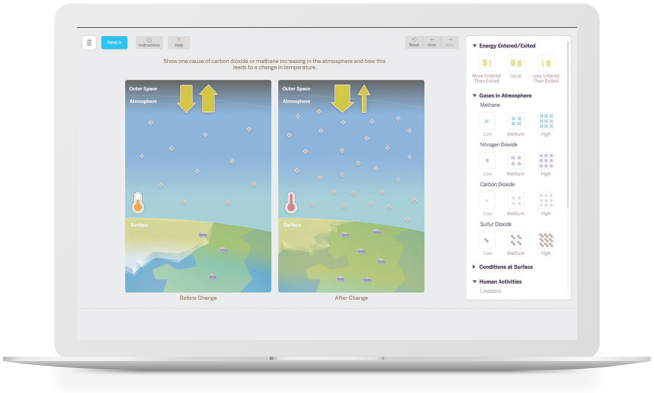
Student Investigation Notebook



Hands-On Kit

Videos

Digital Tools



About technology in this unit:
All Amplify Science California lessons were designed with device sharing in mind, and never assume that every student has a separate device.

In this grade, student-facing technology includes Practice Tools and digital Simulations. When the use of a digital tool is called for in a lesson, teachers have several implementation options:

If limited student devices are available—teachers can have students do activities in pairs or small groups.

If no student devices are available—teachers can project the digital tool to the class and either "drive" the digital tool themself or invite students to "drive" by using their device.

If internet access is unavailable—teachers can "pre-load" the digital tool on their device for use offline.

Chapter 1:
The storyline begins

What students investigate:

Why is the ice on Earth's surface melting?

What they figure out:

The decrease in ice has been caused by an increase in the amount of energy absorbed at Earth's surface (shown by an increase in global average temperature). This increase in temperature correlates with changes to Earth's atmosphere over the same time period. As carbon dioxide and methane have increased in the atmosphere, so has the global average temperature.

How they figure it out:

- Analyzing data about ice cover, temperature, and several gases in the atmosphere
- Testing changes to the amounts of different gases in the atmosphere using the Sim
- Reading about the implications of climate change and common misconceptions in the articles "The Effects of Climate Change" and "A Hole in Earth's Ozone Layer"

KEY


CLASS


HANDS-ON


HOMEWORK


MODELING


READING


SIM


STUDENT-TO-STUDENT DISCUSSION


TEACHER


TEACHER-LED DISCUSSION


WARM-UP


WRITING

DAY 1 | LESSON 1.1

Pre-Unit Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

Pre-Unit Assessment

DAY 2 | LESSON 1.2

Introduction to Climate Change

- Warm-Up (10 min)
- Introduction to the Unit (3 min)
- Introduction to Climatologist Role (7 min)
- Analyzing Climate Data (15 min)
- Trend and Fluctuation in Climate Research (10 min)
- Homework

DAY 3 | LESSON 1.3

Exploring Energy in the Earth System

- Warm-Up (7 min)
- Exploring Earth's Changing Climate Simulation (23 min)
- Debriefing the Sim Missions (15 min)

DAY 4 | LESSON 1.4

Testing Changes to the Atmosphere

- Warm-Up (7 min)
- Introducing the Claims Chart (5 min)
- Testing Changes to the Atmosphere (23 min)
- Using the Word Relationships Routine to Reflect (10 min)
- Homework

On-the-Fly Assessment

DAY 5 | LESSON 1.5

Evidence About Gases in the Atmosphere

- Warm-Up (5 min)
- Analyzing Gas and Temperature Data (20 min)
- Introducing the Modeling Tool (20 min)
- Homework
- Self-Assessment (Optional)

On-the-Fly Assessment
Self-Assessment

Chapter 2:
The storyline builds

What students investigate:

Why do temperatures on Earth increase when the amount of carbon dioxide or methane in the Earth system increases?

What they figure out:

The overall temperature of the Earth system can be stable even as energy is flowing into and out of the system. If this balanced flow is disrupted, there may be changes to the system. Temperature increases if more energy enters than exits, and decreases when less energy enters than exits. An increase in carbon dioxide or methane disrupts the system by causing less energy to exit than enter. This is because carbon dioxide and methane stop energy from leaving by redirecting energy that would have exited the system.

How they figure it out:

- Gathering evidence about stable and changing systems of energy flow from a physical model and from the Sim
- Reading an article about the history of Earth's changing climate
- Demonstrating their ideas using the unit's Modeling Tool
- Writing and sharing explanations

KEY


CLASS


HANDS-ON


HOMEWORK


MODELING


READING


SIM


STUDENT-TO-STUDENT DISCUSSION


TEACHER


TEACHER-LED DISCUSSION


WARM-UP


WRITING

DAY 6 | LESSON 2.1

Introduction to Energy Entering and Leaving

- Warm-Up (5 min)
- Energy Token Physical Model (15 min)
- Flows Entering and Exiting a System (5 min)
- Investigating Energy in the Sim (15 min)
- Reflecting on Energy (5 min)

DAY 7 | LESSON 2.2

"Past Climate Changes on Earth"

- Warm-Up (10 min)
- Reading "Past Climate Changes on Earth" (22 min)
- Discussing Annotations (13 min)
- Homework

On-the-Fly Assessment

DAY 8 | LESSON 2.3

Learning More About Past Climate Changes

- Warm-Up (5 min)
- Rereading "Past Climate Changes on Earth" (20 min)
- Modeling an Increase in Temperature Due to Gases (15 min)
- Revisiting the Anticipation Guide (5 min)

On-the-Fly Assessment

DAY 9 | LESSON 2.4

Critical Juncture Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

Critical Juncture Assessment

DAY 10 | LESSON 2.5

Reviewing Key Ideas in Climate Change

- Warm-Up (5 min)
- Preparing for the Sim Activity (3 min)
- Simulating Climate Change from the Article (17 min)
- Preparing for the Modeling Tool Activity
- Revising or Creating Modeling Tool Diagrams (10 min)
- Sharing Results (10 min)
- Family Homework Experience (Optional)

DAY 11 | LESSON 2.6

Investigating Paths of Energy

- Warm-Up (5 min)
- Investigating Energy Interactions in the Sim (20 min)
- Investigating with the Energy Token Model (20 min)
- Homework

On-the-Fly Assessment

DAY 12 | LESSON 2.7

Explaining Climate Change

- Warm-Up (5 min)
- Explaining Climate Change with the Modeling Tool (15 min)
- Discussing Causes of Climate Change (15 min)
- Writing About Climate Change for the Public (10 min)
- Homework
- Self-Assessment (Optional)

On-the-Fly Assessment
Self-Assessment

Chapter 3:
The storyline goes deeper

What students investigate:

What can be done to stop the carbon dioxide and methane in Earth's atmosphere from increasing?

What they figure out:

The increases in carbon dioxide and methane in the atmosphere are due to human activities. They learn that combustion of fossil fuels releases carbon dioxide, that livestock release methane, and that combustion of fossil fuels and the amount of livestock kept have both been increasing. Students learn that reducing these activities can slow the addition of these gases to the atmosphere and that they can be captured and taken out of the atmosphere by reforestation.

How they figure it out:

- Analyzing data about human activity
- Testing changes to human activities in the Sim
- Reading an article about solutions to climate change
- Demonstrating their understanding with the Modeling Tool
- Writing and sharing explanations

KEY


CLASS


HANDS-ON


HOMEWORK


MODELING


READING


SIM


STUDENT-TO-STUDENT DISCUSSION


TEACHER


TEACHER-LED DISCUSSION


WARM-UP


WRITING

DAY 13 | LESSON 3.1

Investigating Human Activity and the Atmosphere

- Warm-Up (5 min)
- Investigating Human Activities in the Sim (15 min)
- Video About Combustion (5 min)
- Analyzing Human Activities Data (20 min)
- Homework

On-the-Fly Assessment

DAY 14 | LESSON 3.2

"Climate Change Solutions"

- Warm-Up (5 min)
- Reading "Climate Change Solutions" (25 min)
- Discussing Annotations (10 min)
- Revisiting the Anticipation Guide (5 min)
- Homework

Optional Flextension: *Measuring Trees for Carbon Content*

On-the-Fly Assessment

DAY 15 | LESSON 3.3

Explaining Possible Solutions

- Warm-Up (5 min)
- Rereading About One Solution (20 min)
- Modeling One Solution (20 min)
- Stable Temperature in the Sim (Optional)
- Homework
- Self-Assessment (Optional)

On-the-Fly Assessment

Self-Assessment

Chapter 4:
Application to a new storyline

What students investigate:

Even though volcanic eruptions are not the cause of the long-term trend of increasing temperatures that has been occurring since 1880, they do influence the climate in other ways. But how? More specifically, does a large volcanic eruption have a warming or cooling effect on the climate in the five to ten years following the eruption?

What they figure out:

Scientists must communicate how their claims and evidence are supported with reasoning in a convincing scientific argument. In order to convince its reader, a written scientific argument needs to state a claim, describe specific evidence, and explain how the evidence supports the claim. A claim can sometimes be supported more effectively if you consider the combination of several different pieces of evidence.

How they figure it out:

- Analyzing and sorting evidence, mostly from one large volcanic eruption (Pinatubo in 1991)
- Considering the factors that cause warming versus those that cause cooling
- Making claims supported by the evidence
- Engaging in oral argumentation in a student-led discourse routine called a Science Seminar
- Writing final arguments

KEY

- CLASS
- HANDS-ON
- HOMEWORK
- MODELING
- READING
- SIM
- STUDENT-TO-STUDENT DISCUSSION
- TEACHER
- TEACHER-LED DISCUSSION
- WARM-UP
- WRITING

DAY 16 | LESSON 4.1

Investigating Volcanic Eruptions

- Warm-Up (5 min)
- Introducing Volcanic Eruptions (10 min)
- Simulating Effects of Sulfur Dioxide (20 min)
- Evaluating Temperature Evidence (15 min)
- Homework

DAY 17 | LESSON 4.2

Examining Evidence About Volcanic Eruptions

- Warm-Up (5 min)
- Examining Evidence About Volcanic Activity (25 min)
- Discussing Evidence and Claims (15 min)
- Introducing Homework (Optional)
- Homework

On-the-Fly Assessment

DAY 18 | LESSON 4.3

Science Seminar

- Warm-Up (10 min)
- Introducing the Science Seminar (5 min)
- Participating in the Science Seminar (25 min)
- Introducing the Homework (5 min)
- Homework
- Self-Assessment (Optional)

On-the-Fly Assessment
Self-Assessment

DAY 19 | LESSON 4.4

End-of-Unit Assessment

- Multiple-Choice Questions (25 min)
- Written-Response Question #1 (10 min)
- Written-Response Question #2 (10 min)

End-of-Unit Assessment

All students. All standards.

Rather than treating the standards simply as a list of topics to cover, we designed Amplify Science California to allow for truly in-depth and integrated coverage of the disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs). Unlike other programs, however, ours makes the NGSS' vision of "all students, all standards" a reality by creating a unit-specific learning progression for every unit called a Progress Build.

Each Progress Build defines several levels of understanding of the unit's anchoring phenomenon, with each level integrating and building upon the knowledge and skills from lower levels. In this way, each Progress Build provides a clear roadmap for how students' understanding of the phenomenon is expected to deepen and develop with each successive chapter and lesson.

What's more, the program's system of assessments is also tied to these Progress Builds. This carefully crafted integration provides teachers with credible, actionable, and timely diagnostic information about student progress toward the unit's learning goals and grade-level performance expectations. Armed with this powerful data, teachers have the ultimate flexibility to decide when to move on and when to slow down and dive deeper.

Earth's Changing Climate Progress Build

The Progress Build in this unit consists of three levels of understanding. At each level, students add new ideas and integrate them into a progressively deeper understanding about the causes of climate change.

Progress Build Level 1:

Changes in the amount of carbon dioxide and methane in the atmosphere are correlated with changes in the amount of energy absorbed by Earth's surface.

Progress Build Level 2:

Carbon dioxide and methane affect the balance of energy entering and exiting the Earth system.

Progress Build Level 3:

Carbon dioxide and methane redirect outbound energy, which causes less energy to exit.

Examples of differentiation in this unit

In addition to providing unit-specific Progress Builds that break learning goals into smaller, more achievable levels of understanding, Amplify Science California makes learning accessible for all students through a variety of scaffolds, supports, and differentiation strategies for every lesson. **For a complete list of strategies, see the Differentiation section of every Lesson Brief**.

Below are a few examples of strategies embedded in this unit.

For English learners:

Graphic organizers (Example from Lesson 2.3)
Graphic organizers can be a supportive scaffold for some English learners or other students who need to be more deliberative and organized when reading for a purpose. For this activity you may want to use a three-column table. Ask students to write a title, such as "Climate Change during the Eocene." Next have them label each column; for example, one column could be "What Happened to Energy?", another column "Carbon Dioxide," and the third column, "Methane." Have students write notes under the correct column when they find supporting information in the text.

For students needing more support:

Extra teacher modeling when exploring the Simulation (Example from Lesson 1.3)
Students will be working with the Sim many times in this unit. If needed, take time in this lesson to develop students' proficiency by stopping and modeling how to carefully explore the Sim. Ask, "I wonder what happens if I change _____ but keep _____ the same?" Or, "I wonder how this graph relates to what I just observed in live view. What do you think?"

For students ready for a challenge:

Create additional models (Example from Lesson 3.3)
Students who need more challenge should model more than one climate change solution. Modeling additional solutions will require these students to read in detail about multiple solutions, understand the specifics, and create Before Change and After Change panels for each. After modeling multiple solutions, students could compare and contrast the solutions.

3-D Statements

In order to help teachers recognize the three-dimensional structure of every unit, chapter, and lesson, each unit contains a 3-D Statement document that makes the integration clear.

Making the 3-D statement document all the more effective, the three dimensions are color-coded for easy recognition.

Earth's Changing Climate 3-D Coverage

SEPs
Science and Engineering Practices

DCIs
Disciplinary Core Ideas

CCCs
Cross-Cutting Concepts

Unit Level

Students use digital and physical models and analyze global temperature data in order to construct explanations of how changes to the atmosphere affect Earth's temperature by altering the energy flow (energy and matter) into and out of Earth's system (systems and system models), disrupting a dynamic but stable system (stability and change). Students discuss ways that human activities are contributing to climate change as well as discuss evidence-based strategies for mitigating climate change.

Chapter Level

Chapter 1: Climate and the Atmosphere

Students learn to distinguish between trends and fluctuations in data in order to determine evidence of stability or change in Earth's global average temperature and ice cover (stability and change). They use a digital model to gather evidence about how various changes to the atmosphere affect Earth's temperature.

Chapter 2: Energy Entering and Leaving Earth's System

Students gather evidence from a digital model and a simple physical model and obtain information from a video and an article about the flow of energy both entering and exiting the Earth system (energy and matter, systems and system models). Students construct visual models that explain how carbon dioxide and methane redirect energy toward Earth's surface and how the addition of these gases to the atmosphere disrupts a dynamic but stable system (stability and change) and causes climate change.

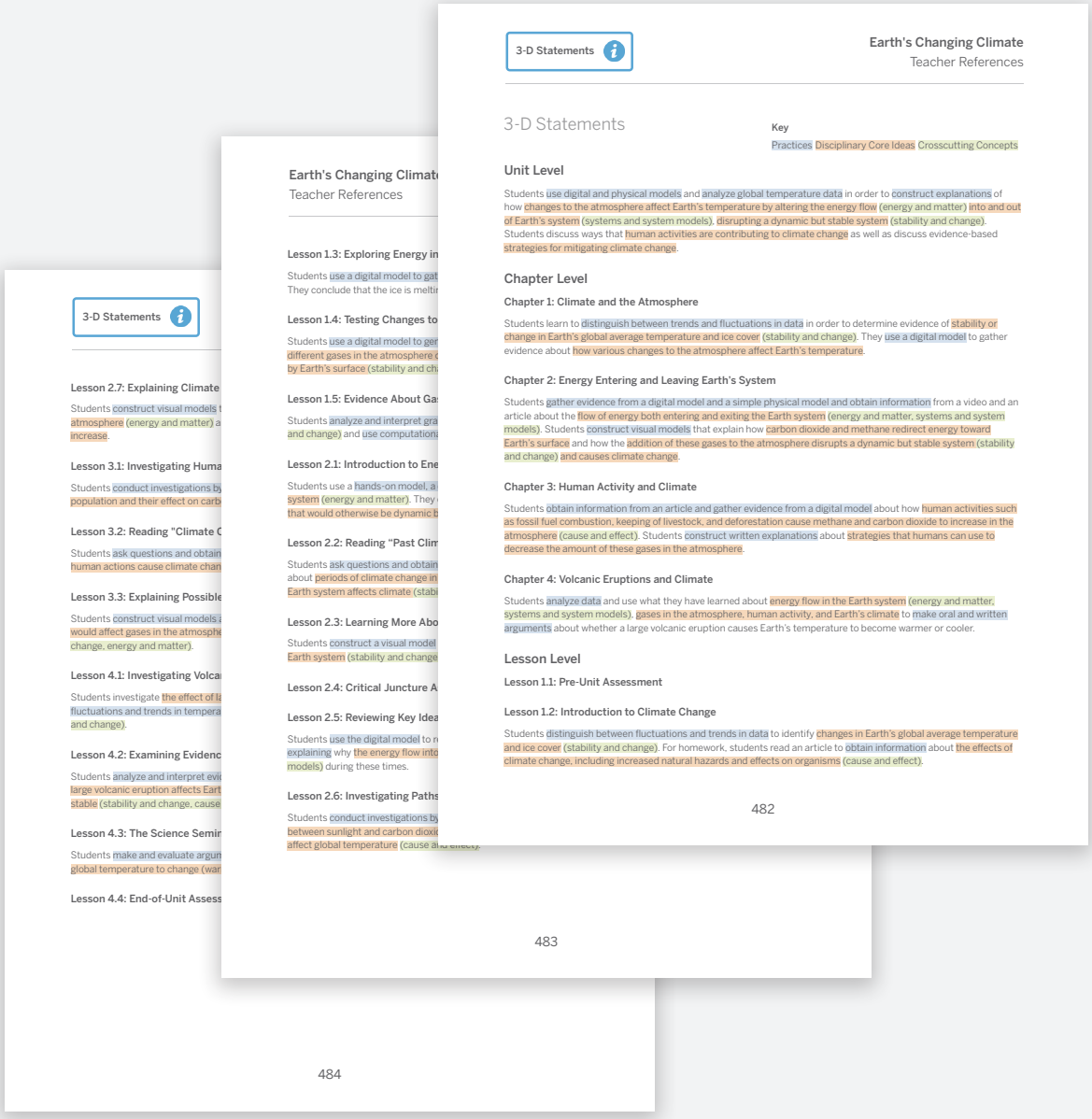
Chapter 3: Human Activity and Climate

Students obtain information from an article and gather evidence from a digital model about how human activities such as fossil fuel combustion, keeping of livestock, and deforestation cause methane and carbon dioxide to increase in the atmosphere (cause and effect). Students construct written explanations about strategies that humans can use to decrease the amount of these gases in the atmosphere.

Chapter 4: Volcanic Eruptions and Climate

Students analyze data and use what they have learned about energy flow in the Earth system (energy and matter, systems and system models), gases in the atmosphere, human activity, and Earth's climate to make oral and written arguments about whether a large volcanic eruption causes Earth's temperature to become warmer or cooler.

To review the 3-D Statements at the lesson level, see the Lesson Brief section of every lesson.



3-D Statements

Earth's Changing Climate
Teacher References

3-D Statements

Key
Practices Disciplinary Core Ideas Crosscutting Concepts

Unit Level

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Lesson Level

Lesson 1.1: Pre-Unit Assessment

Lesson 1.2: Introduction to Climate Change

Students distinguish between fluctuations and trends in data to identify changes in Earth's global average temperature and ice cover (stability and change). For homework, students read an article to obtain information about the effects of climate change, including increased natural hazards and effects on organisms (cause and effect).

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Earth's Changing Climate
Teacher References

Lesson 1.3: Exploring Energy in

Students use a digital model to gat
They conclude that the ice is melti

Lesson 1.4: Testing Changes to

Students use a digital model to ger
different gases in the atmosphere
by Earth's surface (stability and ch

Lesson 1.5: Evidence About Ga

Students analyze and interpret gra
and change) and use computationa

Lesson 2.1: Introduction to Ene

Students use a hands-on model, a
system (energy and matter). They
that would otherwise be dynamic b

Lesson 2.2: Reading "Past Clim

Students ask questions and obtain
about periods of climate change in
Earth system affects climate (stabi

Lesson 2.3: Learning More Abo

Students construct a visual model
Earth system (stability and change

Lesson 2.4: Critical Juncture A

Lesson 2.5: Reviewing Key Idea

Students use the digital model to r
explaining why the energy flow into
models) during these times.

Lesson 2.6: Investigating Paths

Students conduct investigations by
between sunlight and carbon dioxi
affect global temperature (cause and effect).

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3-D Statements

Lesson 2.7: Explaining Climate

Students construct visual models t
atmosphere (energy and matter) a
increase.

Lesson 3.1: Investigating Huma

Students conduct investigations by
population and their effect on carb

Lesson 3.2: Reading "Climate C

Students ask questions and obtain
human actions cause climate chan

Lesson 3.3: Explaining Possible

Students construct visual models a
would affect gases in the atmosphe
change, energy and matter).

Lesson 4.1: Investigating Volca

Students investigate the effect of la
fluctuations and trends in tempera
and change).

Lesson 4.2: Examining Evidenc

Students analyze and interpret evi
large volcanic eruption affects Eart
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Lesson 4.3: The Science Semin

Students make and evaluate argun
global temperature to change (war

Lesson 4.4: End-of-Unit Assess

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Notes

Notes

For more information on Amplify Science, visit **amplify.com/science/california**.

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