UNDERSTANDING CLIMATE CHANGE

GRADES 7–12

LAURA TUCKER
LOIS SHERWOOD

NSTA press
National Science Teachers Association

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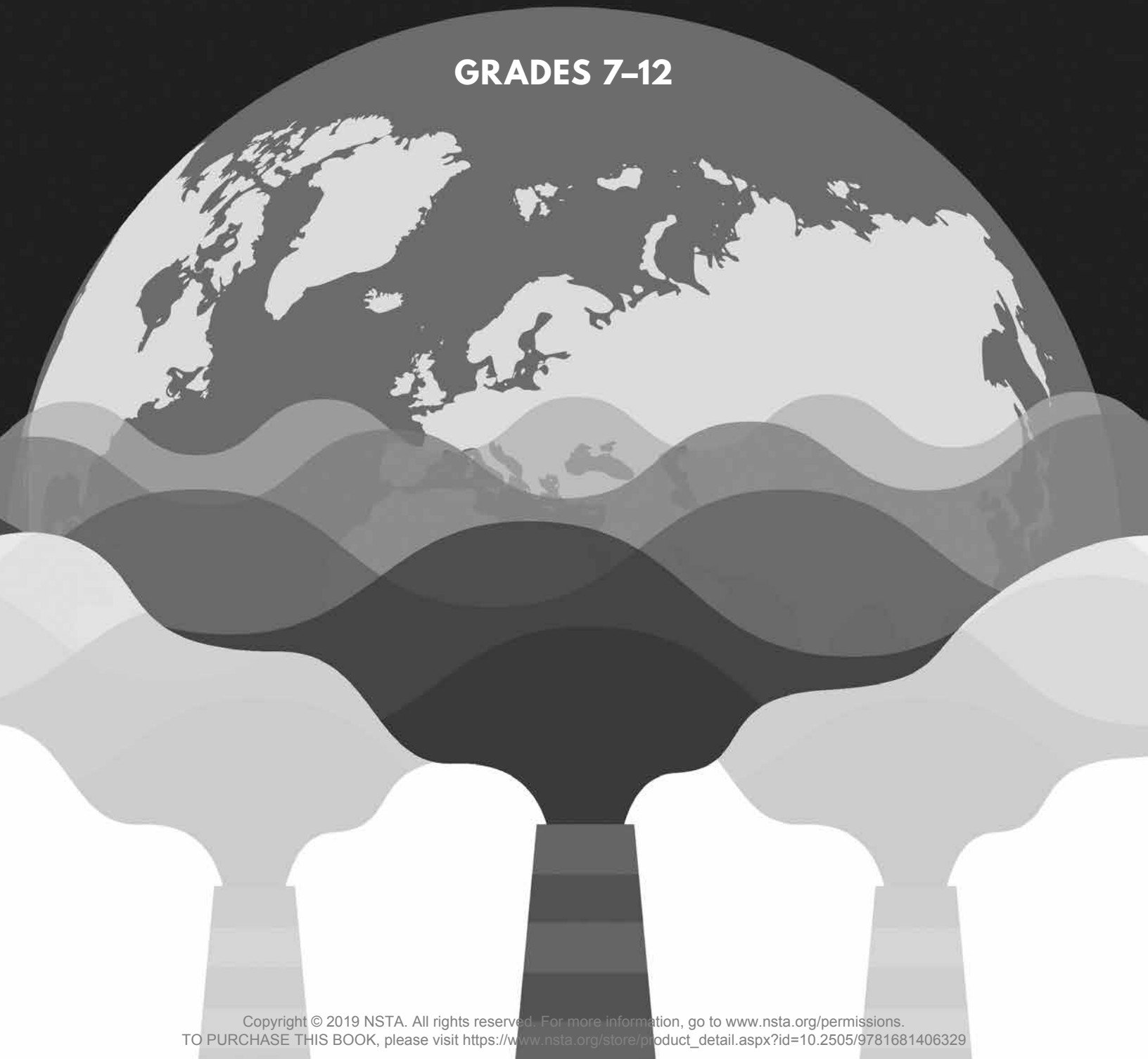

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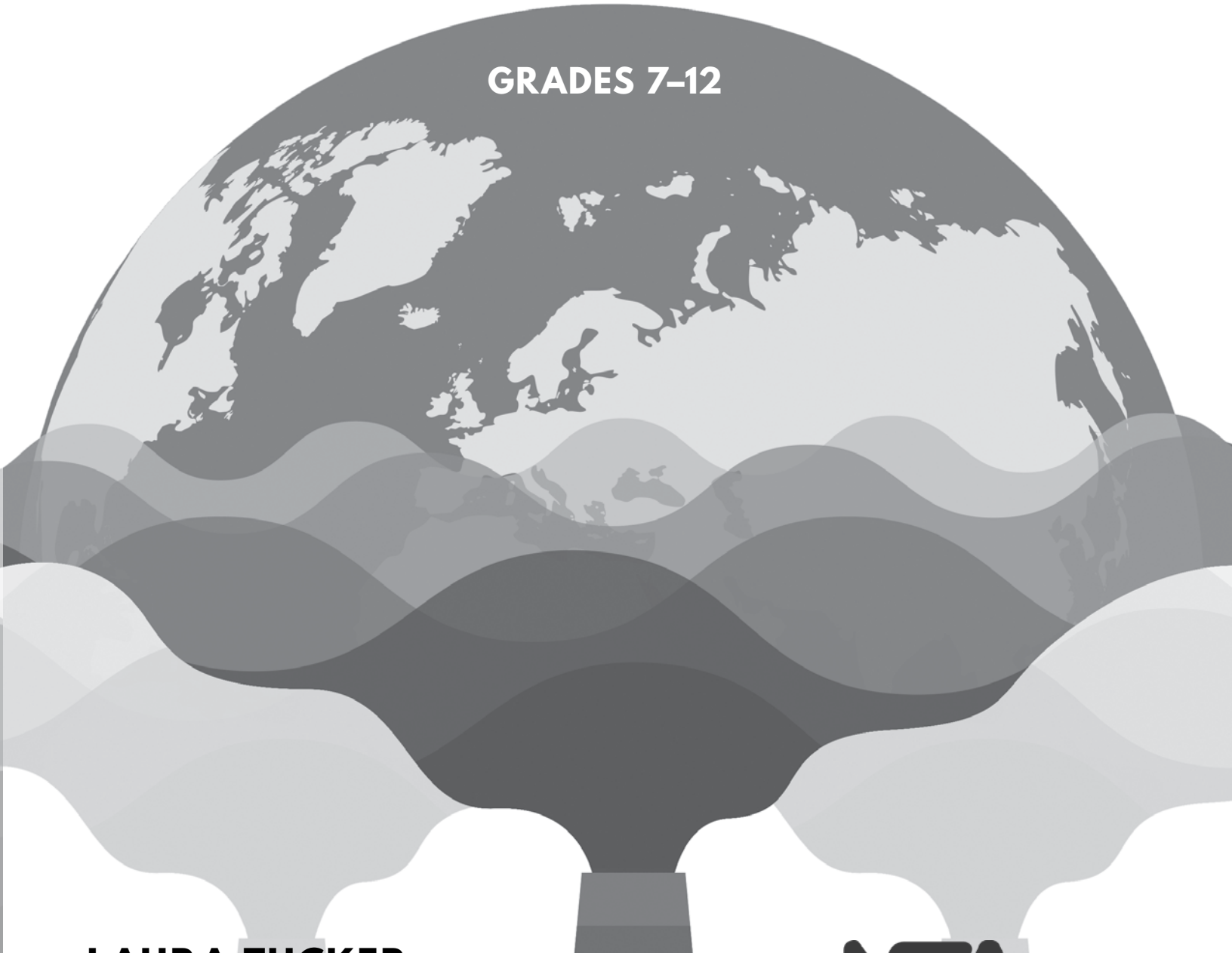

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Foreword

In the autumn of 2018, the National Science Teachers Association (NSTA) published a powerful position statement on its website about teaching climate change. And at the end of the year, *New York Times* writer David Leonhardt wrote, "There were more obvious big news stories than climate change in 2018. But there weren't any more important stories, in my view. That's why it is my choice for the top story of the year. It's the one most likely to affect the lives of future generations." Among all areas of science, climate science may well be the most critical for all citizens to understand. While the science of climate change is well understood by scientists, everyone will be affected by its consequences and everyone has a stake in how we respond.

Beyond its societal importance, climate science has a nearly unique pedagogical position as an inherently multidisciplinary, practical subject. Historical observations of weather and climate take into account everything from the physics of incoming and outgoing radiation balance to the chemistry of gases that absorb infrared radiation to the biology of photosynthesis and respiration applied to the land, ocean, and atmosphere of our planet. What's more, the subject is accessible to all ages: *A Framework for K–12 Science Education* articulates grade band endpoints for students from 2nd through 12th grade (NRC 2012, p. 188).

While many organizations and agencies have published materials to help educators teach about climate science, few books provide assistance for teachers in covering the scope of climate science with special attention to humanity's role. Laura Tucker and Lois Sherwood have set out to do just that with conscious attention to the three-dimensional teaching and learning called for in the *Framework*. Recognizing that many teachers have not had specific training in climate science, the authors provide useful summaries of the underlying science. The sections on the greenhouse effect, scientifically evaluating data, and conducting research on climate change topics are particularly helpful in recognizing the multidisciplinary aspects of climate science.

The response to climate change is not itself a scientific subject. Tucker and Sherwood are very clear that there is no debate about climate science. When considering what actions to take in the face of a changing climate system, we move from the scientific to the social or economic or political, where we need

science to inform our arguments and decisions. The boundary between science as a means of understanding the natural world and the consequences of that understanding is often poorly defined. The NSTA position statement emphasizes the "science side" but recognizes the implications for society, as well. The authors have made a real contribution in this area by providing structured suggestions that encourage students to use the science they have learned in considering the effects of human activity. By making this connection, students have the best chance to use science to positively "affect the lives of future generations."

—David L. Evans, PhD
Executive Director
National Science Teachers Association

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About the Authors

Laura Tucker has been a science educator for more than 40 years. Initially educated as a wildlife biologist, she found her passion teaching students in the outdoors. In 1979, she founded a nonprofit educational organization called Exploring New Horizons. It was designed to provide a comprehensive outdoor environmental science program for K–8 grade students and a summer camp program for children ranging from age 9 to 18. During her tenure at the organization, she helped develop a variety of programs that combined environmental science curricula (redwood, coastal, and Sierra Nevada natural history and ecology, marine biology, botany, zoology, geology, and astronomy) with music, dance, drama, art, and team building. The programs blended the teaching skills and talents of staff naturalists with those of classroom teachers to facilitate the incorporation of the outdoor school experience into the classroom. Approximately 60,000 students attended the programs while Laura was the executive director. Exploring New Horizons continues to this day, serving about 6,000 students per year on three campuses in California's Santa Cruz Mountains.

In 1992, Laura became the professional development coordinator for Great Explorations in Math and Science (GEMS), a nationally acclaimed resource for activity-based science and mathematics at the Lawrence Hall of Science at the University of California, Berkeley. While at GEMS, she worked with a variety of educators, including preservice teachers; classroom teachers; district, regional, and state curriculum coordinators; university faculty; and nonformal educators from museums, zoos, and nature centers. She was a leader in establishing the GEMS Network, which included approximately 72 sites and centers around the United States and 11 international locations. Laura served as a curriculum developer and reviewer for many GEMS publications, including *Aquatic Habitats* (Barrett and Willard 1998), *Dry Ice Investigations* (Barber, Beals, and Bergman 1999), *River Cutters* (Sneider and Barrett 1999), and *Schoolyard Ecology* (Barrett and Willard 2001) teacher guides. She also worked on handbooks that support the implementation of GEMS units and other programs.

Laura has focused a great deal of her energy on climate education. In 2012, she was selected as a Climate Reality Project presenter and joined former vice president Al Gore and 1,000 other educators from 59 countries for three days of intensive training. She is an NOAA Climate Steward as well as a team member

of the Climate Change Environmental Education Project-Based Online Learning Community Alliance in partnership with Cornell University, the North American Alliance for Environmental Education, and the EECapacity Project. She serves as a mentor with Students for Sustainability, a group from Port Townsend High School in Port Townsend, Washington, that is taking action to mitigate climate change at their school, in their community, in their state, and at the national level. Laura also serves on the Jefferson County/City of Port Townsend Climate Action Committee and chairs the L2020 Climate Action Outreach Group. In December 2015, she attended the 21st Conference of the Parties in Paris where she conducted live interviews between young climate scientists and activists and students in her community.

Currently, Laura wears two hats. She is the waste reduction education coordinator for Jefferson County, Washington, teaching the community to reduce, reuse, and recycle. She is also a consultant, providing custom professional development for formal and informal educational programs in standards-based environmental and STEM (science, technology, engineering, and mathematics) education.

When Laura is not working to address the climate crisis, she is recharging her batteries by hiking, swimming, sea kayaking, soaking in hot springs, and enjoying the beauty of our natural world with her husband and their English bulldog, Yogi.

Lois Sherwood originally trained in zoology at Washington State University and worked in the medical profession after graduating. But after a chance visit to a high school classroom, she realized that teaching was her calling.

Lois began her teaching career at the SEA Discovery Center (formerly the Poulsbo Marine Science Center) and then moved to Port Townsend High School. During her career, she has taught health, marine biology, oceanography, physical science, math, biology, and integrated science.

While teaching, she earned a master's degree in science, also through Washington State University. As she deepened her understanding of science, she became interested in constructivist teaching and allowing students to learn through engaging in science practices. She refined this skill through inquiry training with the Exploratorium museum in San Francisco, California. Her training later led to codeveloping inquiry workshops, which she taught for several summers through the Port Townsend Marine Science Center.

Lois also served as a district teacher leader and as a Teacher on Special Assignment (TOSA) with the North Cascade and Olympic Science Partnership, which was a five-year science leadership project sponsored by Western Washington University and funded by a National Science Foundation grant. Along with a cohort of five other TOSAs, she promoted teacher leadership and best teaching practices in a five-county region of northwestern Washington.

With the cohort of TOSAs, she designed and led monthly regional workshops in addition to working with partner teachers in their classrooms.

Lois received National Board Certification in Teaching in 2007 and was recertified in 2017. For her work in the classroom, she received the Amgen Excellence in Science Teaching award in 2011 and was a finalist for the Presidential Award for Excellence in Mathematics and Science Teaching in both 2013 and 2015.

Beyond the classroom, Lois served as a regional representative with the Washington Science Teachers Association (WSTA) from 2007 to 2016. In 2011, she cochaired a joint statewide teachers conference with WSTA and the Environmental Education Association of Washington. In 2016, she was appointed as professional development coordinator for WSTA. In this role, she has facilitated the design and presentation of professional development offerings for the organization.

Connecting science to student involvement motivated Lois to facilitate a variety of student-led environmental clubs over the course of her career. Although the focus of the clubs has evolved based on student interest, the goal has always been to promote environmental and social justice locally, regionally, and nationally.

Lois's passion for science education is driven by a personal passion to understand and experience the natural world. This also fuels her hobbies, which include bird watching, beach exploration, kayaking, hiking, biking, and running.

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My endless appreciation goes out to Lois Sherwood, my exceptional coauthor, who brings her years of high school classroom experience and extensive knowledge of the *Next Generation Science Standards* (*NGSS*) to take this revised edition to a new level of excellence and effectiveness.

I am also grateful to Lois for allowing me to use her four 10th-grade classes to field-test the first edition of this book in 2011. After completing this unit, a number of students formed their own group—Students for Sustainability—and went on to make huge changes in their school and in their community. They even took *public transportation* from Washington state to Washington, D.C., to lobby for climate action—6,000 miles round-trip. They are featured as Climate Change Agents in Session 8.

This book would not have been possible without spending 20 years working with the brilliant and talented curriculum developers and staff of GEMS (Great Explorations in Math and Science) at the University of California, Berkeley's Lawrence Hall of Science. Their years of experience and keen insight into creating effective, teacher-friendly curricula have taught me well. They were on the cutting edge of climate change curricula with the book *Global Warming and the Greenhouse Effect*, written in 1990.

GEMS was the inspiration for *Understanding Climate Change*. Sessions 2 and 3 are adapted and modified from *Global Warming and the Greenhouse Effect*, copyrighted by The Regents of the University of California and used here with permission. Other sessions are partly inspired by the activities in the GEMS guide but are substantially revised, rewritten, and updated by the authors.

The scientific discourse circle in Session 4 is inspired by similar student-group activities in the *Seeds of Science/Roots of Reading* curriculum by GEMS, copyrighted by The Regents of the University of California and used here with permission.

Special thanks to the Climate Reality Project. Their extraordinarily talented staff conducts trainings around the globe and provides support for more than 15,000 Climate Reality Leaders, ranging from 12 to 86 years in age. I was honored to be included in their 2012 training in San Francisco that brought more than 1,000 leaders from 59 countries together for three days of information,

empowerment, and hope. We went out into our corners of the world to share the science of the climate crisis and provide a vision for how we can solve it.

I particularly want to thank all of the wonderful Climate Change Agents who so kindly agreed to be interviewed for this book and give a face to those working on the front lines for climate change solutions:

- James Balog
- Dr. Robert Bindschadler
- Dr. Shallin Busch
- Kate Chadwick
- Eliza Dawson
- Dr. Ziv Hameiri
- Dahr Jamail
- Rayan Krishnan
- Dr. Heidi Roop
- Ewan Shortess

My deepest gratitude goes to the exceptional staff at NSTA Press. To Claire Reinburg, my sincere appreciation for accepting my manuscript and moving it forward. To my phenomenal editors, Rachel Ledbetter and Andrea Silen, I am in awe of your ability to make sense of every word, every page, and every graphic. Thank you for weaving this all together so beautifully.

—Laura Tucker

SESSION 1

What Have You Heard About Climate Change?

Introduction

The goal of this session is to set the stage for student investigations into the complex topics of global warming and climate change. Students first participate in a networking activity to introduce them to the Climate Change Agents whose interviews are found throughout the guide. They then activate their prior knowledge through a brainstorm of what they have heard about climate change. In order to reveal student understanding and misconceptions about climate change, the term *heard* is used rather than the term *know.* This allows students to feel free to share anything they have heard without fear of being wrong while the teacher is able to uncover their misconceptions prior to further instruction. This process sets up thinking and communication practices that prepare the students for *Next Generation Science Standards* (*NGSS*) performance expectations that are developed in the subsequent sessions. After listing ideas they've heard about climate change, students review one another's lists and formulate questions that they have about climate change.

A formative assessment probe from *Uncovering Student Ideas in Earth and Environmental Science* by Page Keeley and Laura Tucker is included to assist teachers in assessing whether their students have a firm understanding of the difference between climate and weather.

Objectives

1. To encourage students to share their own information about what they have heard regarding climate change, which serves as a preassessment of their prior knowledge
2. To establish a base of common information that will be useful both for teaching and for evaluating the information covered in the unit
3. To assess what knowledge and misconceptions students hold about climate change

What You Need

Gather the following materials.

For the class:

- ❑ Package of sentence strips (usually 100 in a package)
- ❑ Roll of masking tape

For each group of four students:

- ❑ Marking pens
- ❑ 5 or more sentence strips from the class package

  Note: *You can make your own sentence strips rather than buying them. Use butcher paper cut into 3 × 36 in. long strips, or if the sentence strips are too cumbersome, choose a shared document platform that students can access from digital devices.*

For each student:

- ❑ Science notebook
- ❑ Networking card from Handout 1.1: Networking
- ❑ Copy of Handout 1.2: Climate Change Agent Interview
- ❑ Copy of assessment probe Are They Talking About Climate or Weather?

  Note: *The handouts and probe are located on the Extras page: www.nsta.org/climatechange.*

Preparation

A Few Days Before the Class

1. Find a space on the wall for four columns of sentence strips.
2. Write the following column headings on four different-colored sentence strips:
   - Questions We Have About Climate Change
   - Accepted as Accurate—Supported by Evidence
   - Accepted as Inaccurate—Supported by Evidence
   - Needs More Information/Evidence/Research

   Table 1.1 provides an example of how the columns should look once you set them up on the wall during class.

Table 1.1: Example of Wall Columns

Questions We Have About Climate Change	Accepted as Accurate—Supported by Evidence	Accepted as Inaccurate—Supported by Evidence	Need More Information/Evidence/Research
• question • question	• statement • statement	• statement • statement	• statement • statement

3. Decide how you will attach the sentence strips to the wall. A recommended method is to attach two long strips of masking tape to the wall for each column of sentence strips, sticky side out. Place the strips about two feet apart from each other. You may also use poster putty instead of tape.
4. Decide how you will manage the sentence strips for each class. You can roll them up after each period or compile them as a group, depending on how many classes you have.

   Note: *It is important that the statements in each category can be moved back and forth as new information is discovered. For example, a statement in the Accepted as Inaccurate column might be moved to the Needs More Information/Evidence/Research section when additional information is revealed. Questions can be removed when they are answered.*

The Day Before the Class

1. Prepare Handout 1.1: Networking for the class. The five-page-long handout includes 10 different networking cards, with 2 cards per page. Each card features a quote from a different Climate Change Agent. Make enough copies so that each student in your class receives a card. So, for example, if you have 30 students in your class, make three copies of the handout. Cut each page in half after printing the copies to separate the cards. (Given that there are only 10 separate cards, some students will likely have the same interview.)
2. Make copies of Handout 1.2: Climate Change Agent Interview.

Begin!

Networking

1. Distribute one networking card to each student. Tell students that they will take on the identity of the person on their card and attend a "networking event" with many other very important people. Let students know that name-dropping is important at networking events.
2. Ask students to walk around the room and gather information from as many different people as possible. As they meet each person, they should exchange names and read the quotes on their cards to each other. Students then record the names and key ideas from each person they meet. If your school policy allows it, students may take pictures of each other's cards with their cell phones.
3. After about five minutes, have students return to their tables. Ask them to work with their table partners to compare their impressions of the people they met at the networking event. Once students have finished discussing their impressions, tell them that they will have an opportunity to read more about each of these people in the upcoming unit.
4. Ask students to discuss the following questions in groups and record their thinking in their notebooks:
   - What is the common thread between all of the people at the networking event?
   - Which person are you most interested in learning more about? Why?
   - What do you think you will be learning in the upcoming unit?
5. Give students an opportunity to share their answers with the class.

Drain Your Brain About Climate Change

1. Tell the class that you want to find out what they have *heard* about climate change.

   Note: *Use the term* heard *rather than* know *as it takes pressure off of students to have correct answers and prompts them to share more freely. This will allow you to be more effective in assessing your students' prior knowledge.*

2. Invite students to think about everything they have heard about climate change from television, the internet, social media, books, newspapers, or word of mouth. Anything they have heard is acceptable.
3. Tell students they each have a few minutes to make a list in their notebooks of everything that comes to mind. Each student should have at least four items in their list. Tell them not to worry about using whole sentences or whether or not they are certain of the information. They don't need to personally agree with what they have heard from a particular source, either. It is good to get all information and misinformation out where the students can discuss it.
4. Ask them if they have questions about what they are going to do, and then begin.
5. If some students run out of things to write, have them write questions they have about climate change.

Thought Swap

1. After a few minutes, or once most students are finished, have them stop writing.
2. Explain that it is time for a Thought Swap. Students will work in groups of three to four. The directions are as follows:

   a. Each student will read their list to the group. No one is allowed to interrupt the speaker or comment on the information that is shared at this time.

   b. After one person finishes sharing, the next person has a turn, stating only those things not covered by the first speaker. This continues until everyone has shared the content of their lists. Students may add information shared by their classmates to their own lists.

   c. After all group members have shared their information, they can ask one another questions and discuss what each person had to say. Any disagreements can be discussed at a later time.

3. While the group discussion is going on, post the following four sentence-strip headings to your wall columns or use a computer to project the categories:
   - Questions We Have About Climate Change
   - Accepted as Accurate—Supported by Evidence
   - Accepted as Inaccurate—Supported by Evidence
   - Needs More Information/Evidence/Research

   If sentence strips are being used, leave room under each heading for 15–20 statements to be posted.
4. Ask if there are any questions before moving on.

Sharing What We've Heard About Climate Change

1. After about 10 minutes (or when most groups are finished), stop the small-group discussions. Ask each group to choose two of the things that they have heard about climate change to share with the whole class. Tell groups that if what they decide to share is presented by another group first, then they will have to pick something else to share. Do not make any comments at this time about the accuracy or inaccuracy of the information.
2. After each group shares, ask if anything that they had heard about climate change seems to be contradictory. Mention that climate change is a complex topic, and misconceptions are very common. Students may find conflicting information as they study the topic further. However, the job of conscientious scientists is to back up any statement with solid evidence, and the students will all be acting like conscientious scientists throughout the unit. You may want to point out that what is accepted in science can change as new information is discovered or revealed, and what we thought to be accurate in the past may no longer be accurate today.
3. Point out the column headings you placed on the wall. Mention that at this point in the unit, students most likely will not have enough information to decide whether the ideas they have heard about climate change can be accepted as accurate or inaccurate, so you will leave those categories empty for the time being. As they go through the unit, students will be conducting investigations, comparing data, and performing their own research to determine the accuracy or inaccuracy of what they have heard about climate change. For now, they will keep all of their ideas written in their notebooks for future reference.

Note: *Students may bring up the ozone hole, acid rain, or other environmental issues that they confuse with climate change. You may choose to ask them to eliminate those statements from their list or leave them in as part of the discussion.*

Examples of What Students May Have Heard About Climate Change

"What I have heard about climate change …"

- If the climate changes, it will cause glaciers to melt, which will eventually raise the sea level.
- It's caused by ozone-layer thickening.
- CO_2 levels are increasing.
- Ocean temperatures are increasing.
- Climate change causes storms to grow larger.
- Climate change makes the world warmer.
- A portion of the United States does not recognize it as a problem.
- The polar ice caps are melting, raising ocean levels.
- Global warming is bad.
- Climate change is caused by greenhouse gases.
- Pollution is depleting the ozone layer.
- It is making our atmosphere thinner.
- It is making the world unstable.
- Burning fossil fuels causes greenhouse gases.
- Natural disasters are getting worse.
- It is thought to be more extreme now than in the past.
- Arctic species are going to be extinct in 20 years.

The Difference Between Weather and Climate

1. It is important that students have a clear understanding of the difference between the terms *weather* and *climate* before continuing with this unit. *Weather* refers to the conditions at one particular time and place. These conditions can change from hour to hour, day to day, and season to season. *Climate,* on the other hand, refers to the long-term average pattern of weather in a location. For example, we might say that the climate of South Florida is warm, moist, and sunny, although the weather on a particular day in this region could be quite different than that. Long-term data are needed to determine changes in climate.

2. To be sure students have a firm grasp of this foundational component of the study of climate change, administer the formative assessment probe Are They Talking About Climate or Weather? The probe can be found on the Extras page (*www.nsta.org/climatechange*). Answers and sample student responses to the open-ended question in the probe can be found in the Resources section (pp. 25–27) at the end of this session.
3. If students do not demonstrate a clear understanding of this fundamental concept, review reteaching suggestions in the Pedagogy section (pp. 24–25) of this session.

What We Don't Know About Climate Change

1. Ask students in each group to review their notes on what they have heard about climate change. From those notes, they will brainstorm questions they have about climate change. They should have at least one question per person in the group.
2. Students will post their questions in one of two ways:
   - Have students in each group write their questions on sentence strips. Then they can bring the strips up to the wall and post them in the Questions We Have About Climate Change column. As the questions are being posted, have students monitor the board so there are no duplicate questions.
   - If using Google Docs or another electronic posting medium, have students in each group post their questions in the document you have created. Be sure to monitor what the students are posting to avoid duplicates and/or inappropriate comments.
3. Once all of the questions are posted, have students take turns reading them aloud to the class.

   Examples of Student Questions

   "Questions that I have about climate change …"

   - Why is it a big deal?
   - Is there a scientific experiment on solving climate change?
   - Will it cause any land to disappear?
   - How can we stop it?
   - How long will it take to get too hot to live?
   - How long has it been going on?
   - Will it cause the world to end?
   - How does the release of animal methane affect the ozone?

- Why have we not fixed it when we have known about this for so long?
- Are our advances in science and technology helping or hurting climate change?
- What are the contributors?
- How do automobiles compare with factories in contributing to climate change?
- Is climate change speeding up or at a steady pace?

4. Ask students to raise their hands if they know the answers to any of the questions currently posted. Have them silently write their answers to these questions in their notebooks without discussion with other students. Explain that they will have a chance to review these questions and answers as the unit progresses.

Climate Change Agent Interview

1. Distribute Handout 1.2 to the class. It features the story of Eliza Dawson, who planned to row from California to Hawaii to draw attention to the issue of climate change. Ask students for their initial impressions of the interview. Take a few responses. Refrain from getting into long discussions at this time. This interview is designed to get students engaged in the topic of climate change and to introduce a young scientist who is so passionate that she and three friends planned to row more than 2,400 miles across the Pacific Ocean to study climate change.
2. Ask students for their impressions of Eliza's major setback in her quest to row to Hawaii and how she handled the setback. Do they agree or disagree with her choices? Again, this first interview is meant to give them a brief introduction to the issue of climate change and whet their appetite for future interviews.

Background for Teachers

Definitions

As you go through the session, you may find the following definitions from the Environmental Protection Agency helpful.

Climate: The average weather conditions in a particular location or region at a particular time of the year. Climate is usually measured over a period of 30 years or more.

Climate Change: A significant change in the Earth's climate. The Earth is currently getting warmer because people are adding heat-trapping greenhouse gases to the atmosphere. The term *global warming* refers to warmer temperatures, whereas *climate change* refers to the broader set of changes that go along with warmer temperatures, including changes in weather patterns, the oceans, ice and snow, and ecosystems around the world.

Global Warming: An increase in temperature near the surface of the Earth. Global warming has occurred in the distant past as the result of natural causes. However, the term is most often used to refer to recent and ongoing warming caused by people's activities. Global warming leads to a bigger set of changes referred to as *global climate change*.

Weather: The condition of the atmosphere at a particular place and time. Some familiar characteristics of the weather include wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. Weather can change from hour to hour, day to day, and season to season.

Pedagogy

What Students Have Heard Versus What They Know

Teachers have often observed that students will remember inaccurate statements as true when they see them posted for the whole class to see. This is why students are instructed to put what they have *heard* in their notebooks and not where the whole class can read the statements. This helps individual students reflect on their own ideas and misconceptions and correct them as the unit goes on. Once a statement has been determined as accurate or inaccurate by the class based on evidence they have discovered, then the statement can be placed where it can be seen by the class. Teachers can monitor a specific student's conceptual path by reading their science notebook.

Addressing Misconceptions in Climate Versus Weather

The upcoming sessions will direct students to dig deeply into the data associated with climate change, research the lines of evidence supporting climate change, and engage in scholarly discourse. For this to have meaning, students need to have a sound understanding of the difference between climate and weather. Many students can recite the catchphrase that climate determines the clothes in your closet, and weather determines the clothes that you select to wear today. However, when asked to apply their understanding to real-world situations, students (and adults, too!) often lack deep understanding. To evaluate this, ask students to complete the formative assessment probe Are They Talking About Climate or Weather? Answers and sample student responses to the open-ended question in the probe appear at the end of the Resources section (pp. 26–27). As you review students' results, you may find that you need to do some reteaching.

Select the resources that you want to use for reteaching. You may select readings from the students' textbook or appropriate video shorts to share with your class. (Two short videos are included in the Resources section.) Alternatively you may give students an opportunity to research weather and climate online.

After showing a video or giving students time for personal research, ask them to record their own definitions of weather and climate in their notebooks.

Once they have recorded their own thinking, ask students to share their definitions with others in their group. When everyone has shared, each group will create one definition for the term *weather* and one definition for the term *climate.*

Have students share their group definitions with the class. Ask students to make any additions or corrections to their group definition, then create a class definition for the terms *climate* and *weather.* You may use the definitions provided in the Background for Teachers section (pp. 23–24) to guide student thinking.

Hand back students' formative assessment and allow them to make corrections to their original responses. Review responses with the class quickly. If you come to a response where there is disagreement, allow students to make the case for their selections. Using the class definitions, come to consensus for each item. This is a great place to give students an opportunity to engage in argumentation, which is both a science and engineering practice in the *NGSS* and a *Common Core State Standard* for both English language arts and math.

Resources

1. These videos help students understand the difference between weather and climate.
   - This video may be more appropriate for middle school students: *www.youtube.com/watch?v=YbAWny7FV3w.*
   - This video may be more appropriate for high school students: *www.youtube.com/watch?v=VHgyOa70Q7Y.*
2. The following skit by Deep Rogue Ram shows a weather reporter gone rogue when she is confronted by her coanchor, who is rather clueless on the issue of climate change: *www.youtube.com/watch?v=TmfcJP_0eMc&t=6s.*
3. Skeptical Science (*www.skepticalscience.com*) is an excellent resource with commonly accepted misconceptions about global warming and climate change along with corresponding scientific explanations. You can choose different levels of scientific explanations, from basic to

intermediate to advanced. DO NOT SHARE this information with students at this time. Students will explore common misconceptions in Session 4. This resource is listed to help you understand some of the common misconceptions your students will have heard.

4. National Oceanic and Atmospheric Administration (NOAA) offers a climate literacy guide called *Climate Literacy: The Essential Principles of Climate Sciences*. The guide presents a vision of a climate-literate society. Many scientists and educators collaborated to produce this guide, building on efforts to define climate literacy and identify the principles and concepts of climate science that should be included in K–12 curricula. You can find the guide here: *https://oceanservice.noaa.gov/education/literacy.html.*

5. The Yale Program on Climate Change Communication has been conducting some of the most comprehensive research on public opinion and behavior concerning climate change. In their studies, they found that 63% of Americans believe that global warming is happening, but many do not understand why. Only 8% of Americans would receive a letter grade of an A or B for their knowledge of global warming, 40% would receive a C or D, and 52% would get an F. The studies also found important gaps in knowledge and common misconceptions about climate change and the Earth system. These misconceptions lead some people to doubt that global warming is happening or that human activities are a major contributor, to misunderstand the causes and the solutions, and to be unaware of the risks. For more information, go here: *http://climatecommunication.yale.edu/publications/americans-knowledge-of-climate-change.*

6. For the Are They Talking About Climate or Weather? assessment probe, the best answer is that B, E, and H are statements related to climate. Answer choices A, C, D, and G are statements related to weather. Students have effectively argued that answer choice F can relate to both climate and weather. Sample responses to the open-ended question in the probe are listed here:
   - What had to do with clothing was W and the rest was C, but that did not work for some.
   - I chose climate for the time of year and weather for anything that had to do with weather.
   - If the weather was not usual, then I put C, and if it was, I put W.
   - I think climate hasn't happened; it might happen. Weather already happened, like it is raining.

- I put weather for the ones that state rain, drought. Climate is what makes the weather happen.
- It's climate if it's a change, and it's a W if it's something to do with how the outdoors affects your day.
- Rain is something that happens outside. That is climate. Weather is something you might have to change your clothes for.
- I think climate when I hear rain, because global warming melts icebergs, which means more water, and water evaporates quicker with more rain.
- My reasoning is that weather is what happens every day and is mostly unpredictable, and climate is more predictable and is what happens over a number of years.
- Weather is rain, snow, hail, sunshine, and wind, and climate is density. Density is like humidity or moisture in the air.
- Weather is random. Climate change is big news and at a certain place.
- Weather is the conditions such as raining, snowing, sunny, etc. Climate is conditions of the air, such as humid, muggy, dry, and others.
- If the sentence referred to a specific weather condition such as snow, rain, or temperature, I counted it as weather. If the sentence referred to natural disasters or did not mention a specific weather condition, I counted it as climate.

References

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Note: Page references in **boldface** indicate information contained in figures or tables.

UNDERSTANDING CLIMATE CHANGE

GRADES 7–12

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