What in the World Is Happening to Our Climate?

Text by Becca Hatheway and Diane Stanitski

Illustrations by Lisa Gardiner

Elementary GLOBE™

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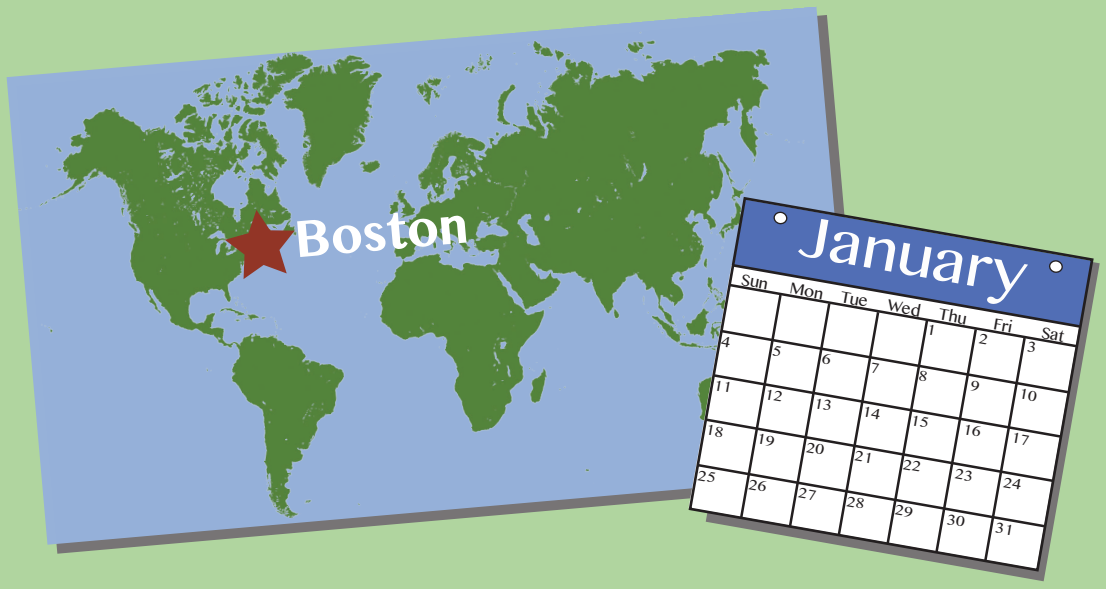
“That hill was awesome! Thanks for sharing your favorite sledding spot, Dennis,” said Simon.

“I’m glad you came sledding with me,” Dennis replied. “I can’t believe this is our fourth snow day in a row, and the snow keeps piling up! The way it’s going we’ll be making up school days until the middle of summer.”

“I know. This is the biggest snow storm we’ve had all winter!” Anita exclaimed. “I’ve been measuring the snowfall over the last four days. My dad showed me how to do it, and you’re supposed to take the measurement every day. Do you want to come back to my house to see how it’s done?”

“Sure, let’s go!” Simon and Dennis said.



When they arrived at Anita's house, her dad handed them big mugs of hot chocolate. "Wow, look at the three of you! You're covered in snow! Did you have fun out there?" asked Dr. Sanchez.

"It was great! We flew down the hill so many times and then we started to get wet and cold," Anita explained. "After we warm up, Dennis and Simon want me to show them how we measure snow using a scientific snowboard."

Later on, they went to the middle of the backyard where Anita and her dad had been measuring snowfall all winter.

Dennis looked at the ruler and said, "It looks like it has snowed 14 inches. That's strange! It seemed like there was a lot more snow on the sledding hill. The snow was up to my waist!"

"You're right, but we cleared the snowboard after each measurement was recorded. So, it has snowed 14 inches, or almost 36 centimeters, since yesterday and a lot more since the beginning of the storm." Anita showed them how she was recording the snowfall amounts in her journal.

"Last night on the news the meteorologist predicted that we'd break a record today for the greatest snowfall in January. It looks like we've done it!" exclaimed Dennis.

Simon shoveled the snow off the board and said, "That's so weird. This isn't anything like the snowboard I use on the ski slopes!"

"You're right, it's a wooden board that's flat so the snow piles up evenly on it. I wonder how much we'll measure tomorrow," Anita said. "Brrr, it's cold! Let's go back inside."

yearly snow depth

Once inside, Anita pulled up a website on her tablet that showed the history of snowfall for their town. “This really IS a lot of snow,” she said. “Look, the snowfall amounts have been different from year to year, but clearly we’ve had the most this year.”

“We’ve been talking about global warming in school, so how can it be warming if we’re getting all this snow?” asked Dennis.

Dr. Sanchez explained, “I like to call it climate change, because we’re seeing many different types of changes in our climate, not just warming. A phrase we use is: ‘climate is what you expect, and weather is what you get.’ We know it will be cold here due to our winter climate, but the storms and temperatures we’ve seen this month are examples of our daily weather.”

Dennis asked, “Are big weather events like these happening because of climate change?”

“No, one day of extreme rain or snow doesn’t mean the climate is changing, but many record-breaking storms begin to show changes in climate over time. The changes we’re seeing in temperature are examples of this, too,” Dr. Sanchez replied. “We need to keep a record of this information, like Anita and I have been doing.”

“I think I understand that now, but why are these changes happening?” asked Simon.

Arctic
Greenland
Boston
Maldives
Tropics
The Greenhouse Effect
CO_2
CO_2
carbon dioxide CO_2
KEY
energy from Sun
energy from Earth

Dr. Sanchez answered, "Good question, Simon. The atmosphere is warming more from all the carbon dioxide and other gases released into the air when people drive cars, use electricity, and make things in factories. These gases trap heat in the atmosphere and cause its temperature to increase, a process called the greenhouse effect."

"So, is carbon dioxide a bad thing?" Dennis asked.

Dr. Sanchez replied, "Actually, carbon dioxide and other greenhouse gases help make our planet livable by keeping it warm enough for life, but there can be too much of a good thing. With too much carbon dioxide, the Earth warms even more, affecting plants, animals, and people, as well as weather and climate."

"How do we know this is happening?" Anita asked. "It seems like climate would be a complicated thing to study."

"Many scientists work together, using a variety of tools, to understand Earth's climate," Dr. Sanchez said. "Like me! This summer I'm traveling to two places to study the impacts of climate change."

Dr. Sanchez told them that he would be visiting both Greenland and the Maldives on his research trip. He explained that the Arctic is changing faster than anywhere else on Earth, and that people living on tropical islands have had to adapt to keep up with the changes where they live.

"Would you like to be a part of my research team?" Dr. Sanchez asked. "I enjoy working with student scientists. You'll need to pack clothing for both warm and cold temperatures."

"Can we really go with you? That would be so awesome," the kids exclaimed.

A few months later, Dr. Sanchez and the kids began their research trip in Greenland. Soon after they arrived, they went out on a boat to take temperature measurements and check out this new environment.

"We're really lucky to be able to learn about the Arctic this way. I feel so tiny compared to that huge wall of ice!" Anita exclaimed. "Dad, this is so cool!"

"It's not just cool, it's cold!" joked Simon and the group laughed.

"That huge section of ice that sits on top of the land is called the Greenland Ice Sheet. It is made up of glaciers," Dr. Sanchez explained. "Rivers of glacial ice melt and flow from the land into the ocean."

As the kids were watching the edge of the glacier in front of them, a huge chunk of ice suddenly broke off the front and fell into the water.

Dennis called out to the others. "Whoa, look at that!"

Simon added, "That was loud!"

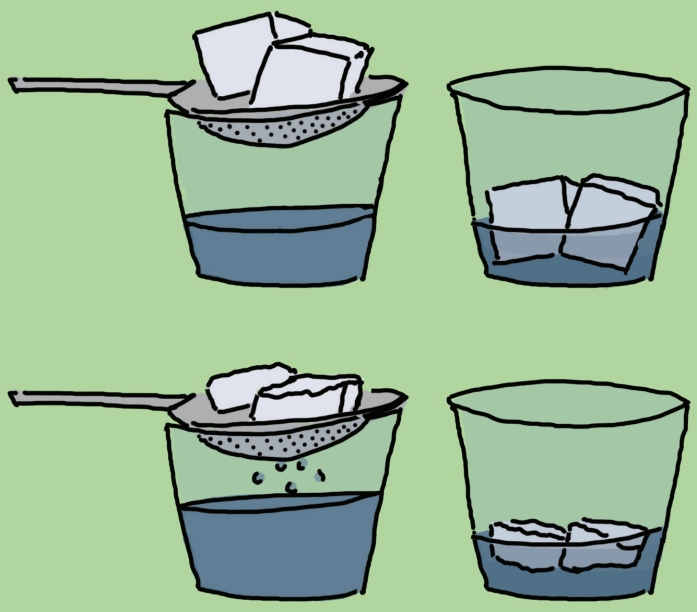
Dr. Sanchez said, "Those sounds you heard were the glacial ice breaking off and plunging into the water due to warming temperatures. This is part of what my team is studying here."

"Dad, why do you come all the way from Boston to study ice in Greenland?" asked Anita.

He replied, "Do you remember when we talked about carbon dioxide trapping heat in the atmosphere and causing the Earth to warm? When the air temperature increases, glaciers speed up and more ice flows into the sea, making the level of the ocean go up. My team is studying this important topic because sea level rise affects people living in coastal areas all over the world, including Boston."

"What about the ice that we see further out in the sea? When that melts, will it cause sea level to rise, too?" Simon asked.

"That is actually sea ice that's floating in the water, which doesn't raise the level of the ocean." Dr. Sanchez said. "It's different than what we just talked about - when ice on the land melts and flows into the ocean, it adds water to the sea."



"That's just like the experiment we did in school!" Dennis exclaimed. "It showed how melting ice cubes floating in a cup of water don't change the level of the water, but ice cubes melting above the cup make the water level go up."

Dr. Sanchez replied, "Perfect example, Dennis. When we leave Greenland in a few days, we're going to the tropics to learn why this matters to people there, too. Hold that thought and we'll get back to it soon! For now, I need you to help me collect some data."

"Awesome! We're ready to get started!" exclaimed Anita.

RESEARCH STATION

After returning to shore, they stopped by the research station where Dr. Sanchez showed them his instruments.

"Look at all this equipment! What can we use?" asked Simon.

Dr. Sanchez pulled out his thermometers and explained how to take air and surface temperature measurements. "It's important to take hourly readings and record them in a field journal. Take a look at this special thermometer. It's an infrared thermometer, which we also call an IRT."

"Cool! How does it work?" Dennis asked, wide-eyed.

Dr. Sanchez said, "When we point it at different objects, it displays each object's temperature."

"Let's give it a try," Anita called out. "Hey look, the IRT shows that the soil is much warmer than the snow!"

"Good observation, Anita," Dr. Sanchez commented. "Darker surfaces like land and water absorb more heat from the Sun than the lighter-colored snow and ice. That's why Anita's light-colored boots would be cooler than Simon's dark boots."

"Oh, I get it! As the ice and snow melt on land, the warmer land makes the ice around it melt even more. And then even more water flows into the ocean, which causes it to rise," Simon remarked. "I really hope we can do something about this before all the ice melts and our favorite beaches are under water."

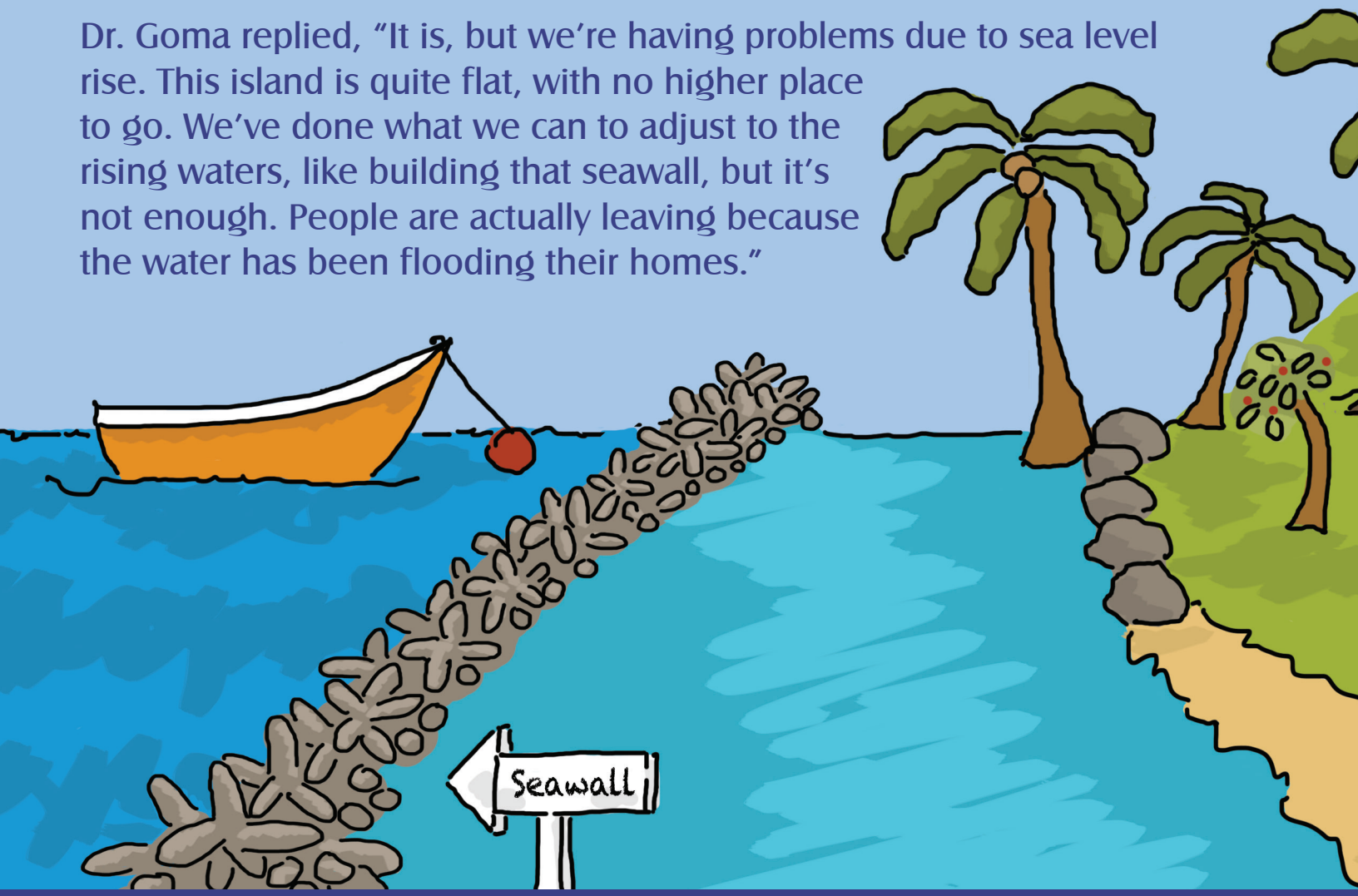
Dr. Sanchez replied, "Nice job putting all the pieces of the puzzle together. Now, let's get back to work. When we get to the Maldives in a few days we'll see how rising sea levels are impacting people there."

A few days later, Dr. Sanchez and the kids flew to the Maldives where they met with a local scientist. Dr. Sanchez said, "Kids, I'd like for you to meet Dr. Goma, a friend I've been working with for years. Over time she has shared climate data with me, as well as pictures of what these tropical islands looked like when she was a young girl."

"Welcome to the Maldives!" Dr. Goma said. "I heard that you're spending the summer learning about some effects of climate change around the globe. You've come to the right place to learn how tropical islands are changing. Let's go for a walk along the beach so I can show you some of the impacts."

Once they arrived at the beach, Dennis said, "This seems like a really nice place to live."

Dr. Goma replied, "It is, but we're having problems due to sea level rise. This island is quite flat, with no higher place to go. We've done what we can to adjust to the rising waters, like building that seawall, but it's not enough. People are actually leaving because the water has been flooding their homes."



"Wow!" Anita exclaimed. "This is what you were talking about in Greenland, Dad! I wouldn't want to be forced to move because the climate is changing my environment."

"It's not just the people on land who are coping with change," Dr. Goma explained. "The water is getting warmer here and animals and other life in the ocean are also being affected. Would you like to go snorkeling so you can see what I'm talking about?"

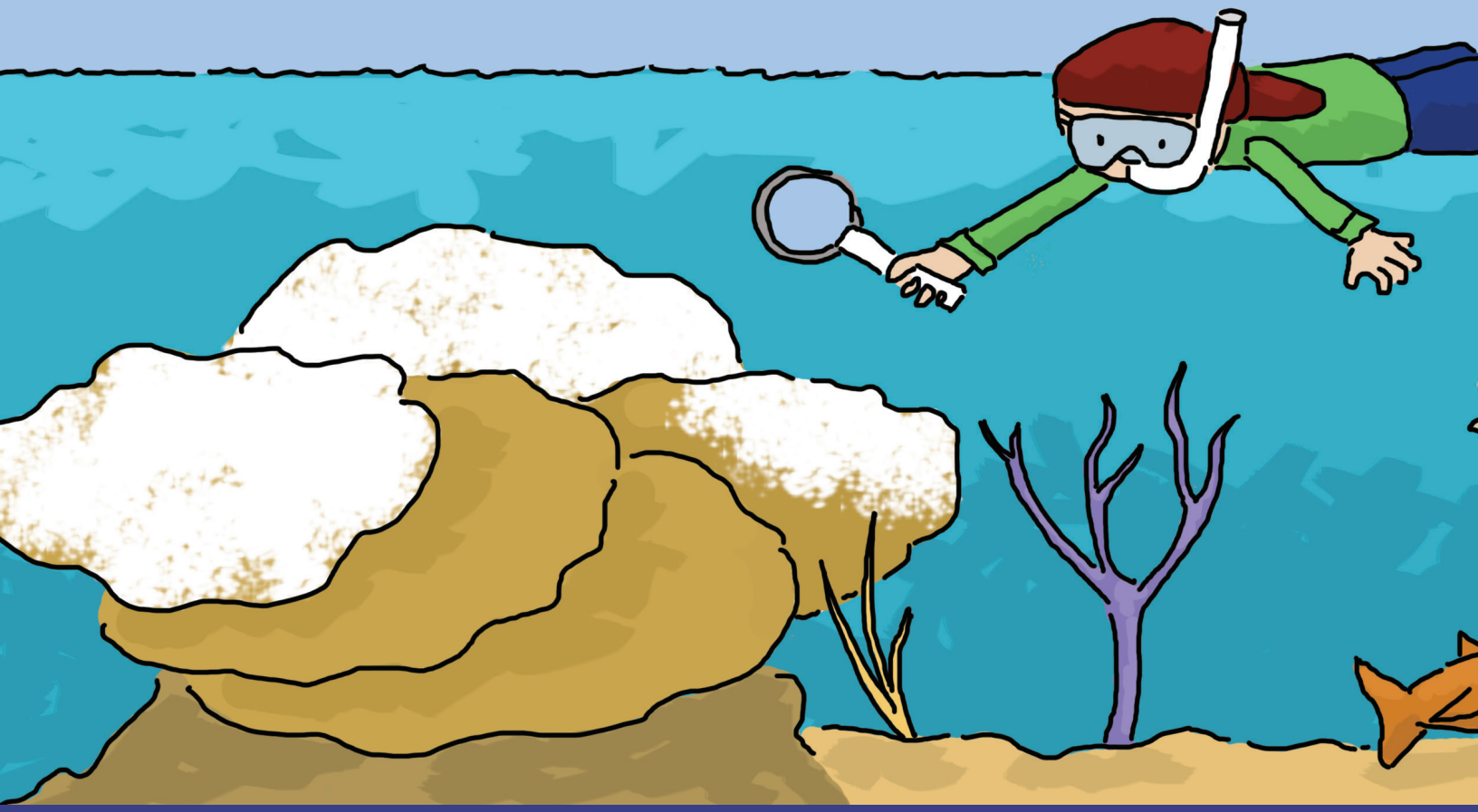
"Yes, let's go!" the kids exclaimed.

"Dad, I've never been swimming in water this warm," Anita bubbled through her snorkel. "This feels like bath water. Dennis, what's the water temperature?"

"87 degrees Fahrenheit," Dennis called out. "That's 55 degrees warmer than the water temperature in Greenland!"

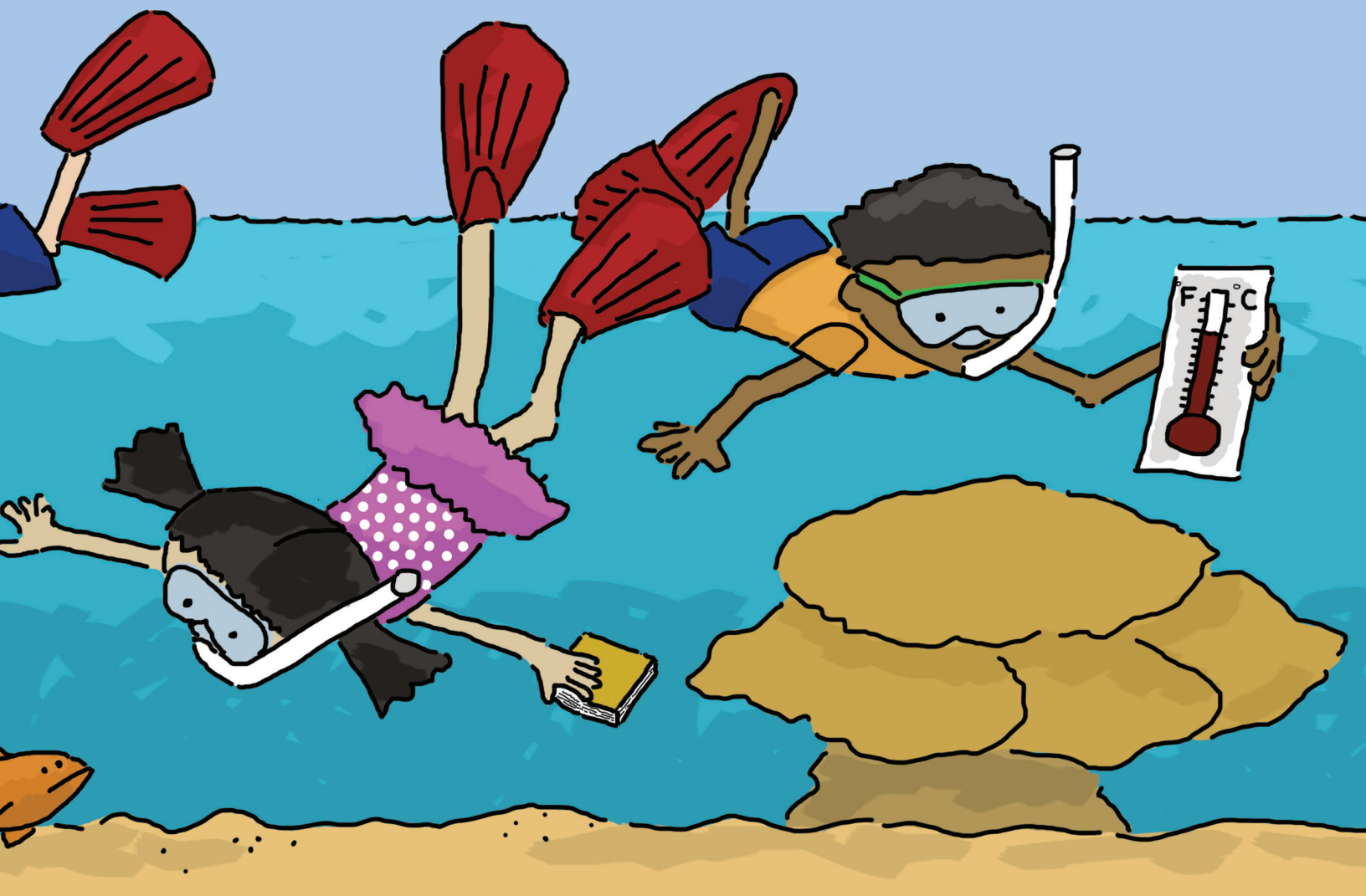
Simon pointed and said, "This coral doesn't look like the pictures I've seen in books. It's white!"

Later that day, Dr. Sanchez described what they saw in the water. "You made a good observation today, Simon. I'm sorry to say that what you noticed are the signs of coral bleaching, something that happens when the water temperature warms."



He added, “Corals need to live in warm water, but when the water gets above 86 degrees Fahrenheit, they get stressed and force the colorful algae that live within them to leave. This causes corals to weaken and often kills them. Corals are actually very small animals, not colorful rocks like some people think, so they are affected by changes in the ocean.”

Dr. Goma said, “Now you’ve seen some of the challenges we’re facing in the Maldives. We’re struggling to find solutions to these problems.”



As they sat on the beach that afternoon, Dennis, Simon, and Anita reviewed what they had learned about climate during their summer adventure.

Dennis said to Dr. Goma, "We've seen that Earth's climate is changing, and it's causing problems in different parts of the world."

Dr. Goma replied, "Yes, each place has its own type of climate, and people living in those places can experience different impacts over time."

"That's true! We've learned about changes in snowfall, sea level rise, and ocean temperature that have happened over many years. These are all related to climate, and people affect the climate. What can we do to help?" Anita replied.

Simon said, "Let's do something back at home to reduce the greenhouse gases we produce!"

"We should work on this at school, too. Let's collect data to study our climate. We can also look at past data and that will help us understand how our climate is changing," Anita suggested.

Dr. Sanchez said, "I know that your teacher will be excited to help you."

"That's a great idea." Simon replied. "Let's ask Ms. Patel!"

Virtual
Science Fair
WIND ENERGY
BUILDING KIT

On the first day of the new school year, Anita, Simon, and Dennis told the class about their climate adventure. The kids were really excited to begin taking measurements of their local weather and to work on some solutions to the problems they saw on their travels.

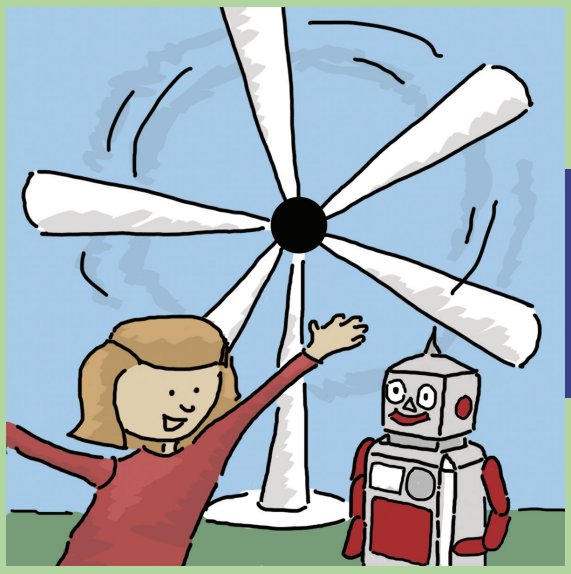
Later in the day, while they were investigating what they could do to help address climate change, Ms. Patel announced, "I just learned that we've been invited to the GLOBE International Virtual Science Fair! During this online event, students from all around the world share the data they've collected and discuss solutions they're trying out in their communities."

"That's so great!" Anita said. "I really want to see and hear what other kids are doing to help solve climate problems. I know we'll learn so much."

"Yes, and afterwards we can continue to collect our own data and work together to try out some solutions we heard about from the other kids!" Simon exclaimed.

A few months later, the time had come for the kids to participate in the GLOBE International Virtual Science Fair. Each group at the conference was doing something in their community to either reduce greenhouse gas emissions or collect data to address impacts of climate change.

The students from Nigeria baked cookies in a solar oven, showing one option for making food using renewable energy.



The German students built a small wind turbine that produced enough electricity to power their robot.

Kids from India counted mosquito larvae and designed a new water container that keeps disease-spreading mosquitoes from laying their eggs on the inside of the container or in the water.

The American kids started a Student Rain Gauge Campaign to increase the number of schools reporting rainfall data in areas experiencing drought, helping farmers decide how much to irrigate their crops.

After participating in the conference, Anita, Simon, and Dennis sat down to share what they learned with their classmates. "There were a lot of cool projects!" Simon exclaimed.

"I learned that the number of mosquitoes around the world has increased due to a warming climate, so more people are getting diseases like dengue," Dennis said.

Anita added, "I thought it was awesome that a robot could be powered by the wind."

The kids talked about the connection between the climate change impacts they saw on their summer trip with the ideas for data collection and solutions they learned about at the science fair.

"We're so lucky to have had this opportunity, and now we can try out some of these ideas at our school and in our community," Anita said.

OUR SCHOOL GARDEN FARM STAND

Over the next several months, the kids worked together to collect data and carry out many different solutions. Their parents and neighbors got involved by helping with these hands-on community projects.

At the end of the school year, the class met to celebrate the progress they made on their climate projects. Ms. Patel congratulated her students on taking the information they learned and turning it into actions.

"You've done a fantastic job! Over the past year, we learned that human activities like driving cars and using electricity add greenhouse gases to the atmosphere, which is causing our climate to change. We also learned how that impacts people and places all over the world," said Ms. Patel. "I'm very proud of all that you have accomplished!"

"Also, collecting data helps us understand how our climate is changing. And we're trying out solutions to help deal with those changes!" Simon exclaimed.

"Climate change is an issue that affects the whole Earth," Dennis added, "and it feels great to get involved!"

Anita agreed, "Kids like us really can make a difference, and we're all part of the solution!"

Teacher's Notes

The Difference Between Weather and Climate

The primary difference between weather and climate is the length of time over which one is looking. Weather describes the conditions in the atmosphere over a short period of time. Weather varies day-to-day and even minute-to-minute. It is described with words like sunny, cloudy, rainy, windy. Climate is the typical weather of a place — if it is usually hot and sunny in July, for example. To determine what the climate of a place is like, scientists average 30 years of weather data (or more). With many years of data averaged together, unusual events, such as a cold day in the summer, don't stand out as much as the typical weather.

Some people use the phrase, "Climate is what you expect; weather is what you get." Others note that the clothes we buy reflect the climate where we live, but what we choose to wear each day depends on the weather.

Regional and Global Climate

The climate where you live is called regional climate. It is the average weather in a place over more than 30 years. To describe the regional climate of a place, people often discuss what the temperatures are like over the seasons, how windy it is, and how much rain or snow falls. This depends on many factors, including the amount of sunlight it receives, its elevation above sea level, the shape of the land, and how close it is to oceans. Since the equator receives more sunlight than the poles, a region's climate varies depending on its distance from the equator.

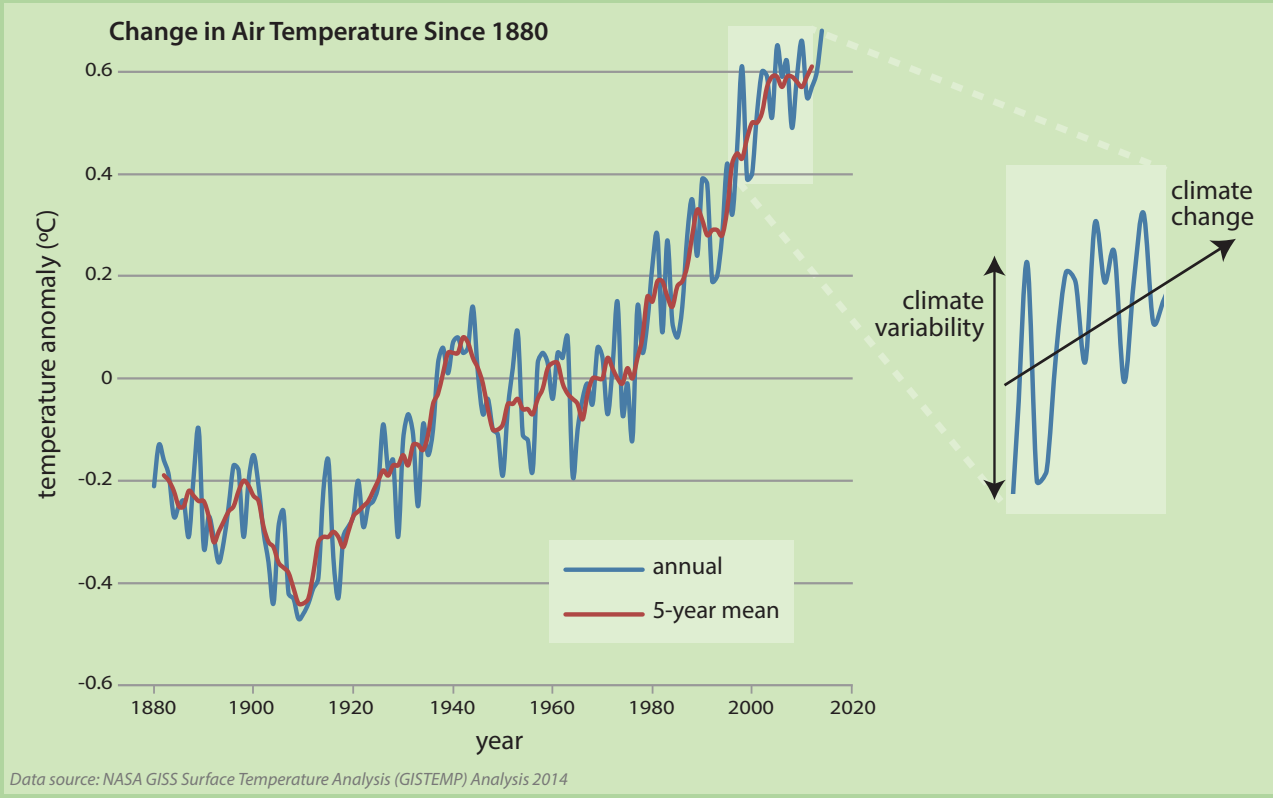
Global climate is a description of the climate of a planet as a whole, with all the regional differences averaged. Overall, global climate depends on the amount of energy received by the Sun minus the amount that escapes back to space, resulting in energy that is trapped in the Earth system.

Climate Change

Natural and human influences cause two different types of variations in climate:

- ***Climate variability*** is how different factors (like temperature and precipitation) depart from some average state, either above or below the average, every few years or decades.
- ***Climate change*** is a trend where one or more factors have a fairly smooth continuous increase or decrease during the period of record (at least 30 years) for a location.

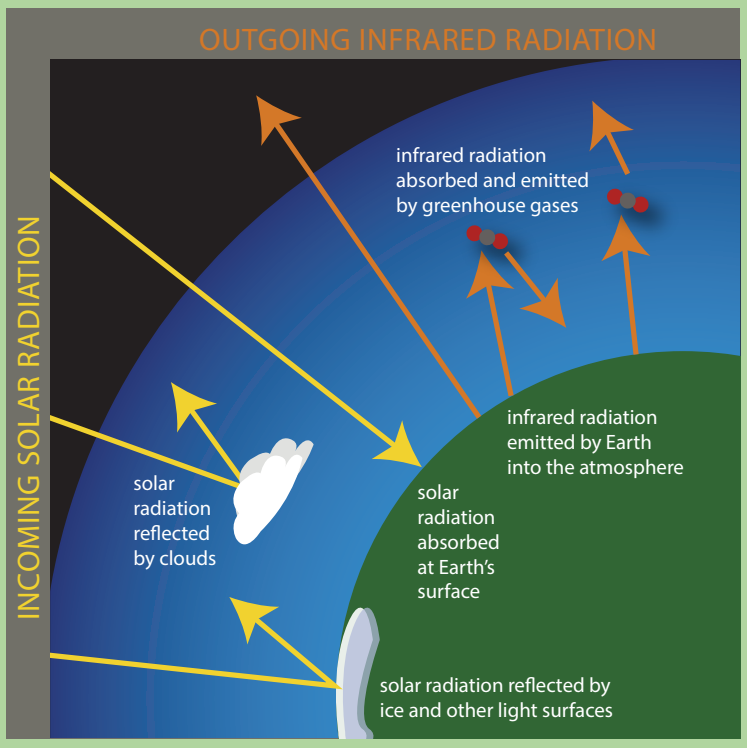
Climate variability occurs due to natural and sometimes periodic changes in the circulation of the air and ocean, volcanic eruptions, and other factors.



Today, climate change is occurring because the amount of greenhouse gases in the air is increasing. Excess greenhouse gases are released into the air as people drive cars, use electricity, and make things in factories that burn coal, natural gas, and oil. Changes in the way we use land contribute to climate change when trees, which take carbon dioxide out of the air as they photosynthesize, are cut down.

Greenhouse Effect

The greenhouse effect refers to the trapping of the Earth's energy in the lower atmosphere. Earth's surface absorbs some of the Sun's energy and heats up. The Earth cools down by giving off infrared energy, but before all of this energy can escape to space, greenhouse gases in the atmosphere absorb some of it, making the atmosphere warmer.

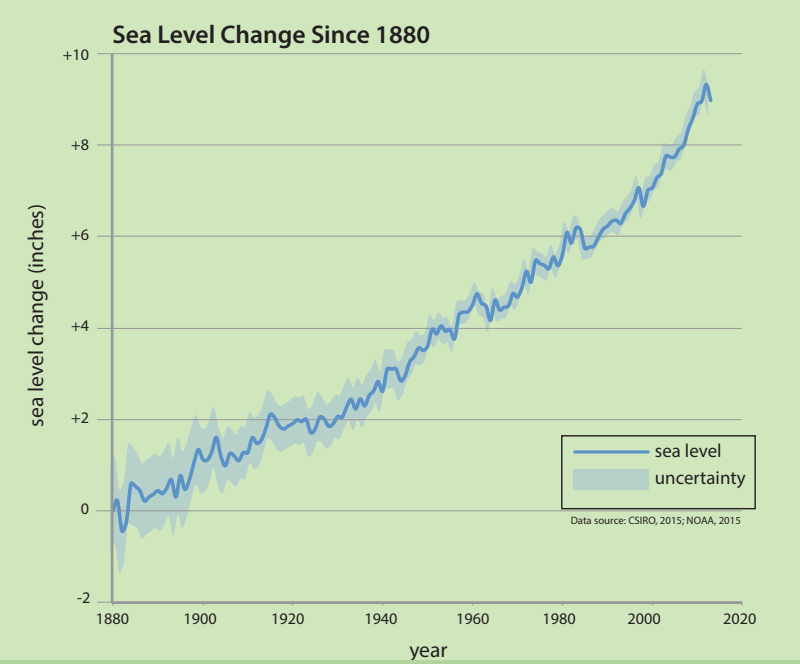


(Teacher's Notes continue on the next page.)

Teacher's notes (continued)

Sea Level Rise

Almost 40% of people in the U.S. live in high population coastal areas. Rising sea levels in the U.S. and around the world affect flooding, shoreline erosion, and coastal inundation during storms. Eight of the world's ten largest cities are near a coast. This makes people highly vulnerable to sea level rise, which affects infrastructure, homes, livelihoods, recreation, creates stress on coastal ecosystems, and affects habitat for fish and wildlife.



Today, sea level is rising on average 0.13 inches/year (3.3 mm/year). There are two main reasons for this - and both are due to climate change:

- Melting glaciers and ice sheets (like those in Greenland and Antarctica) add water to the ocean so the increased water impacts coasts everywhere, especially small island nations like the Maldives.
- Warming of ocean water causes the water to expand, contributing to sea level rise.

Solutions

While humans add greenhouse gases to the atmosphere as a result of going about our daily lives, we can make choices in some aspects of our lives that reduce these emissions. The choices we make in our homes, our travel, the food we eat, and what we buy and throw away all contribute to the greenhouse gas emissions we produce, and reducing those emissions can help ensure a stable climate for future generations. People can help this situation in small ways through lifestyle choices they make in their homes and communities. In addition, larger municipalities and governments can implement larger-scale solutions such as changing energy sources, mass transit options, and recycling and composting services.

To learn more, visit the following web sites:

- NOAA's Climate.gov (https://www.climate.gov/)
- Climate Kids: NASA's Eyes on the Earth (http://climatekids.nasa.gov/)
- The UCAR Center for Science Education (https://scied.ucar.edu/)
- GlobalChange.gov (http://www.globalchange.gov)

Glossary

Carbon dioxide (CO_2): Carbon dioxide is a greenhouse gas that traps the Sun's heat in the Earth's atmosphere, producing the greenhouse effect. CO_2 is produced by respiration from animals and from the burning of fossil fuels.

Coral bleaching: Coral bleaching is a common result of corals that are stressed by their environment (e.g., water too hot, too cold, or too dirty), causing them to expel their colorful symbiotic algae living within their tissues, and making the corals turn white.

Dengue (DENG-gey): Dengue is a viral disease transmitted by mosquitoes that often live in close proximity with humans in tropical urban areas. Mosquitoes lay their eggs in containers filled with water that are usually found in or around houses.

Glacier: A glacier is a slowly moving mass or river of ice formed by the accumulation and compaction of snow on mountains or near the poles.

Greenhouse gases: Greenhouse gases trap heat in the atmosphere, which makes the Earth warmer. The following are the major greenhouse gases: water vapor, carbon dioxide, methane, and nitrous oxide.

Greenland Ice Sheet: An ice sheet is a mass of glacial land ice extending more than 50,000 square kilometers (20,000 square miles). The Greenland Ice Sheet extends about 1.7 million square kilometers (656,000 square miles), covering most of the island of Greenland, three times the size of Texas.

Infrared thermometer (IRT): An IRT is a device that measures the surface temperature of an object by detecting its emitted infrared radiation.

Maldives (MALL-deevz): The Maldives is a country made up of islands in the Indian Ocean southwest of Sri Lanka.

Meteorologist/Climatologist: Meteorologists study the atmosphere and produce forecasts that are intended to predict weather conditions over the short term, often a horizon no longer than 7 to 10 days. Climatologists research historical weather patterns and trends to analyze and forecast long-term weather patterns or climate changes.

Renewable energy: Renewable energy is clean energy collected from resources which are naturally replenished on a human timescale and do not produce greenhouse gases. Examples of this include energy from the Sun, wind, and water.

Sea level rise: Sea level rise is the sea's increasing surface height due to the influx of fresh water or the warming of ocean water over time.

Snowboard - A scientific snowboard is a thin, flat surface that sits on the ground and is used to measure solid precipitation. New snow that falls on top of it can be measured with a meter stick.

The GLOBE Program is a hands-on international education and science program that joins students, educators, and scientists from around the world in studying Earth system science (ESS). The core objectives of GLOBE are to improve science education, enhance environmental awareness, and increase understanding of Earth as a system. For more information, please visit www.globe.gov.

Elementary GLOBE is designed to introduce K-4 students to the study of Earth system science (ESS). Elementary GLOBE forms an instructional unit that comprises multiple modules that address ESS and interrelated subjects including aerosols, seasons, soils, water, weather, and climate. Each Elementary GLOBE module contains a science-based storybook, classroom learning activities that complement the science content covered in each book, and teacher's notes. The storybooks explore a component of the Earth system and the associated classroom learning activities provide students with a meaningful introduction to technology, a basic understanding of the methods of inquiry, and connections to mathematics and literacy skills. For more information, please visit www.globe.gov/elementaryglobe.

Storybook and Resource Reviewers and Contributors

Written by:
Becca Hatheway, *UCAR Center for Science Education*
Diane Stanitski, *National Oceanic and Atmospheric Administration*

Illustrated by:
Lisa Gardiner, *UCAR Center for Science Education*

Project Advisors:
Jessica Taylor, *NASA Langley Research Center*
Kerry Zarlengo, *Educational Consultant*

Science Advisors:
Science Directorate at NASA Langley Research Center
John Adler, *University of Colorado at Boulder*
Mary Hayden, *National Center for Atmospheric Research*
Marika Holland, *National Center for Atmospheric Research*
Krisanadej Jaroensutasinee, *Walailak University, Thailand*
Mullica Jaroensutasinee, *Walailak University, Thailand*
Frank Niepold, *National Oceanic and Atmospheric Administration*
Ann Reiser, *National Oceanic and Atmospheric Administration*
Nan Rosenbloom, *National Center for Atmospheric Research*
Pieter Tans, *National Oceanic and Atmospheric Administration*

Educational Reviewers:
Collin Adler, *Wake County School District*
Tim Barnes, *UCAR Center for Science Education*
Louise Belnay, *National Oceanic and Atmospheric Administration*
Eileen Carpenter, *UCAR Center for Science Education*
Julie Malmberg, *GLOBE Implementation Office*
Paulo Maurin, *National Oceanic and Atmospheric Administration*
Marc Mueller, *UCAR Center for Science Education*
Tony Murphy, *GLOBE Implementation Office*
John Ristvey, *UCAR Center for Science Education*
Kristin Wegner, *GLOBE Implementation Office*

Field Test Teachers:
Audra Davis
Public School 11 - The Highbridge School, Bronx, NY
Augustine Frkuska
Crestview Elementary, Live Oak, TX
Stefany Johnson
Altamahaw-Ossipee Elementary, Elon, NC
Erin Koenig
Boulder Community School for Integrated Studies, Boulder, CO

Copy Editors:
Kris Woodall, *GLOBE Implementation Office*
Sharon Clark, *UCAR Center for Science Education*

Reviewers at the GLOBE North American Regional Meeting:
Sam Aceil, Laila Ali, Bruce Anderson, Jennifer Bourgeault, Jonathan Boxerman, Dixon Butler, David Bydlowski, Haluk Cetin, Kevin Czajkowski, Svetlana Darche, Don DeRosa, Stephen Edberg, Peter Falcon, Peter Garik, Michael Griffith, Jodi Haney, Evangeline Stefanakis, Tina Harte, Lynne Hehr, Sherry Herron, Michael Jabot, David Jakim, Dorian Janney, Janelle Johnson, Magaly Koch, Preston Lewis, Veshell Lewis, Anne Lewis, Glenn Lipscomb, Angela Lodge, Sarah McCrea, Sara Mierzwiak, John Moore, Ramona Nelson, Michael Odell, Tracy Ostrom, David Overoye, David Padgett, Diane Ripley, Kim Sadler, Peter Schmidt, Jill Senn, Steven Smith, Janet Struble, Mark Templin, and Todd Toth

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It's time for a global field trip!

Anita, Simon, and Dennis take a science adventure with Anita's dad and learn that climate change affects the whole wide world. With the help of Ms. Patel, they find ways to solve the problem.

Elementary GLOBE™

This storybook is one of several books in the Elementary GLOBE unit. Elementary GLOBE is designed to introduce K-4 students to the study of Earth system science (ESS). The books form an instructional unit that addresses ESS and related subjects including aerosols, weather, water, seasons, soils, and climate. The science content provided in the books serves as a springboard to GLOBE's scientific protocols, and also provides students with a meaningful introduction to technology, a basic understanding of the methods of inquiry, and connections to mathematics and literacy skills. Each book has associated hands-on Learning Activities to support learning exploration. For more information, please visit www.globe.gov/elementaryglobe.

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