What's Up in the Atmosphere? Exploring Colors in the Sky

Text by Becca Hatheway and Kerry Zarlengo
Illustrations by Lisa Gardiner

Elementary GLOBE™

What's Up in the Atmosphere?

Exploring Colors in the Sky

Text by Becca Hatheway and Kerry Zarlengo
Illustrations by Lisa S. Gardiner


GUEST
HOME

The gym was bustling with activity. Dennis set up the lights and adjusted the camera, preparing for the student newscast.

Miss Garcia called everyone together. “I think we’re ready to get started! I’m so excited about our first student newscast of the school year. Who can remind us of the theme for this program?” she asked.

Anita jumped up and said, “We’re discussing physical fitness! We wrote stories about the healthy activities we participated in last week, and we’ll be sharing those during the newscast. Can I go first?”

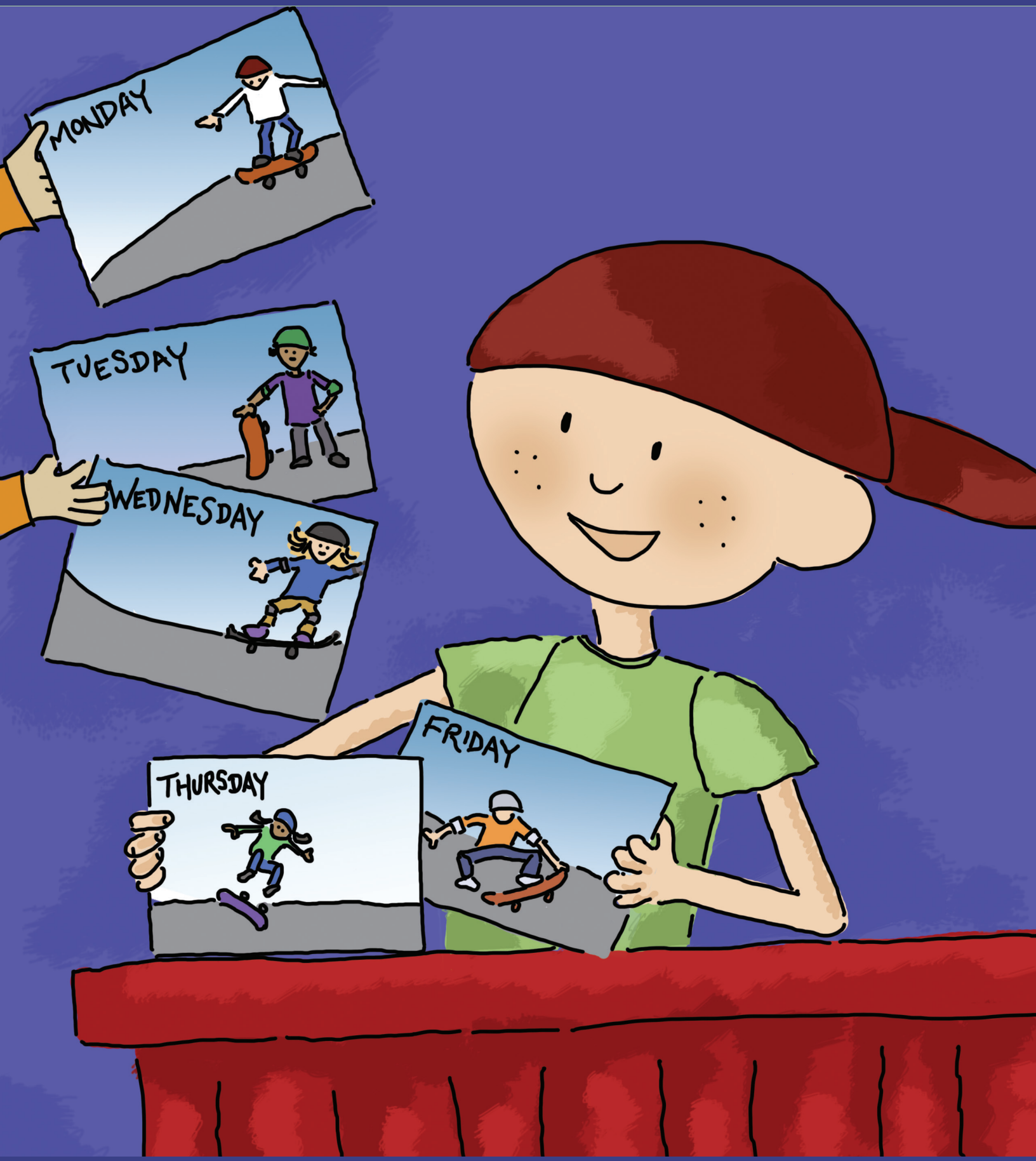
Simon grinned, “Sure, Anita, you seem too excited to wait! The set is ready, so let’s get started.”

The student reporters took their seats at the news desk and they started the program.

"Good afternoon and welcome to our newscast. Today we're reporting on physical fitness in our community," Anita said. "We all know that it's very important to exercise."

She continued, "My group participated in a running club. Some days we ran really fast around the track and on other days it took a few of the kids longer to finish their laps. It was a lot of fun and now I'm planning to sign up for the track team!"

After other students shared their reports about cycling and soccer, Anita added, "Last up is Simon, reporting on his group's project at the skateboard park."


MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY

"Thanks, Anita!" Simon chimed in. "My group spent the week at the new skateboard park. We learned a lot of new tricks and also got a few scrapes. At first we needed to get used to the ramps and half-pipe, but by the end of the week we all could land a kickflip and the frontside noseslide!"

"We documented our activities with a camera, and I labeled each picture with the day of the week," Simon continued. "Here are some of the best shots."

"Anita, the tricks some of our friends can do are amazing! We're all going to have a blast at this new park," Simon wrapped up.

"Great report, Simon. I can't wait to visit the park after hearing your story! And now, turning to the weather, the warm trend will continue for several days and there's a chance of thunderstorms the next few afternoons. Ok, that's it for today. Thanks for tuning in, and we'll see you next time!" Anita said as they ended the newscast.


MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY

Miss Garcia said, “Great show! You gave us some interesting ideas for how to have fun while being active.”

Dennis went over to the news desk to help Anita and Simon take off their microphones. “Simon,” he asked, “Can I take a look at your photos? I want to look more closely at the sky in the background. On some of the days the sky looks so blue, but on Thursday it looked white and there weren’t any clouds. Why did the sky look white?”

“I don’t know,” Simon said, shrugging his shoulders, “I was paying attention to the skateboarders, not the sky!”

“Dennis, you just gave me an idea,” Anita exclaimed. “My records show that on Thursday a few of the kids who have asthma had slower lap times, and I remember that it was harder for them to breathe. Do you think the color of the sky on Thursday had anything to do with their breathing on that day?”

“Maybe you’re onto something! We should look into this. Let’s talk to Ms. Patel when we get back to class,” said Simon.

After the kids sat down in their classroom, Ms. Patel exclaimed, "That was a really informative newscast!"

"Ms. Patel," Anita gushed, "Now we have a scientific question and we need your help!"

The kids spread their journals and photos across the table. Dennis explained, "Here's all of the data the groups collected during their activities last week. Our friends who have asthma said they felt more sluggish and had a harder time breathing on Thursday than on the other days."

Simon added, "We just noticed in my photos of the skateboard park that the sky was really blue on every day except Thursday. On Thursday it was hazy and white, even though there weren't any clouds in the sky. So here's our question: is there a connection between the color of the sky and how our friends felt?"

Anita replied, "I think we've found our next topic to study in science."

"That's a great scientific question," Ms. Patel said, with a smile.

"Now let's figure this out!" the kids exclaimed.

"Ok, class, you noticed that the sky was white last Thursday and blue on the other days," Ms. Patel said. "Was it the exact same shade of blue each day?"

Simon replied, "No, sometimes it was a clear, deep blue, and on other days it was pale like a robin's egg."

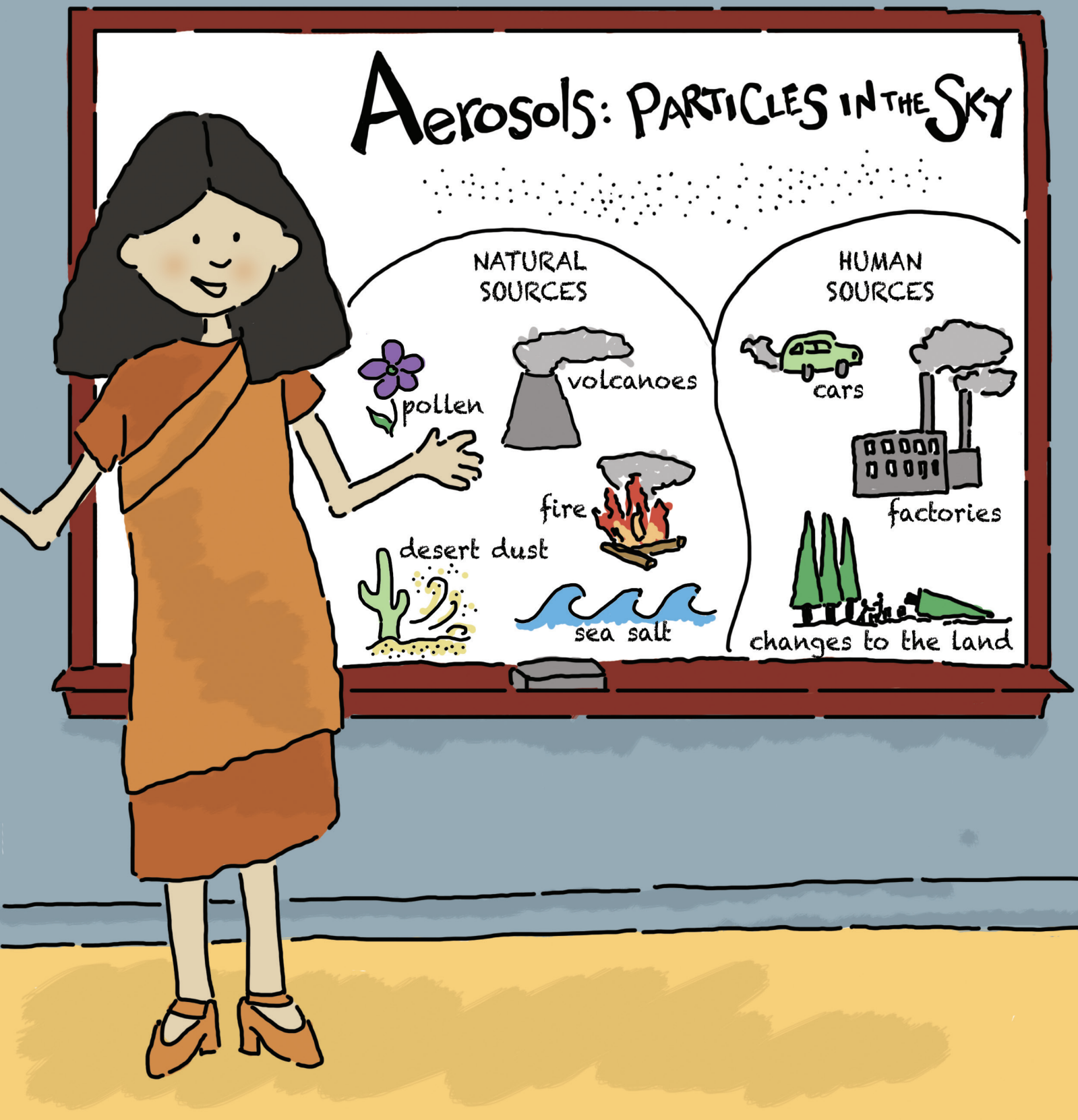
"Can the sky only be white or blue? Have you seen any other colors?" Anita asked.

"I think it can be really colorful at sunset," Dennis said. "I saw a red sunset the other day."

Anita added, "It's colorful at sunrise, too."

"What do these colors have to do with our friends' trouble breathing when the sky looked white last Thursday?" asked Simon.

"Everything in the atmosphere impacts the colors we see in the sky," Ms. Patel said. "As you just noticed, the sky isn't always blue. Today we can see white and different shades of blue. This has to do with solids and liquids in the atmosphere."


Aerosols: Particles in the Sky
NATURAL SOURCES
pollen
volcanoes
fire
desert dust
sea salt
HUMAN SOURCES
cars
factories
changes to the land

"What do you mean?" Simon asked. "I don't think I have seen anything solid in the atmosphere before."

Ms. Patel replied, "There are tiny solid particles in the air that we call aerosols. Some are natural and some come from human activities."

Anita asked, "How tiny are they? As small as a ladybug?"

"They are actually smaller than the spots on a ladybug! Aerosols include pollen, dust, soot from wildfires, or ash from volcanoes. They also come from the exhaust pipes on cars and factory smokestacks," Ms. Patel explained.

"So aerosols make the sky different colors?" Simon asked.

"Aerosols are part of it, but it's more complicated than that," Ms. Patel responded. "The angle of the Sun and the way sunlight is scattered in the atmosphere creates the colors we see in the sky, and aerosols can affect these colors."

She continued, "Aerosols also impact air quality. This is complicated, too, because in addition to aerosols there are also some gases we can't see that impact air quality."

Dennis added, "This does sound complicated! I think we need to make some observations about the colors we see in the sky so we can understand more about the atmosphere!"

"Excellent idea, Dennis! Let's make a plan," Anita said.

Ms. Patel asked, "How do you think you will record these observations?"

"It would be easy for me to take more photos of the sky," Simon said.

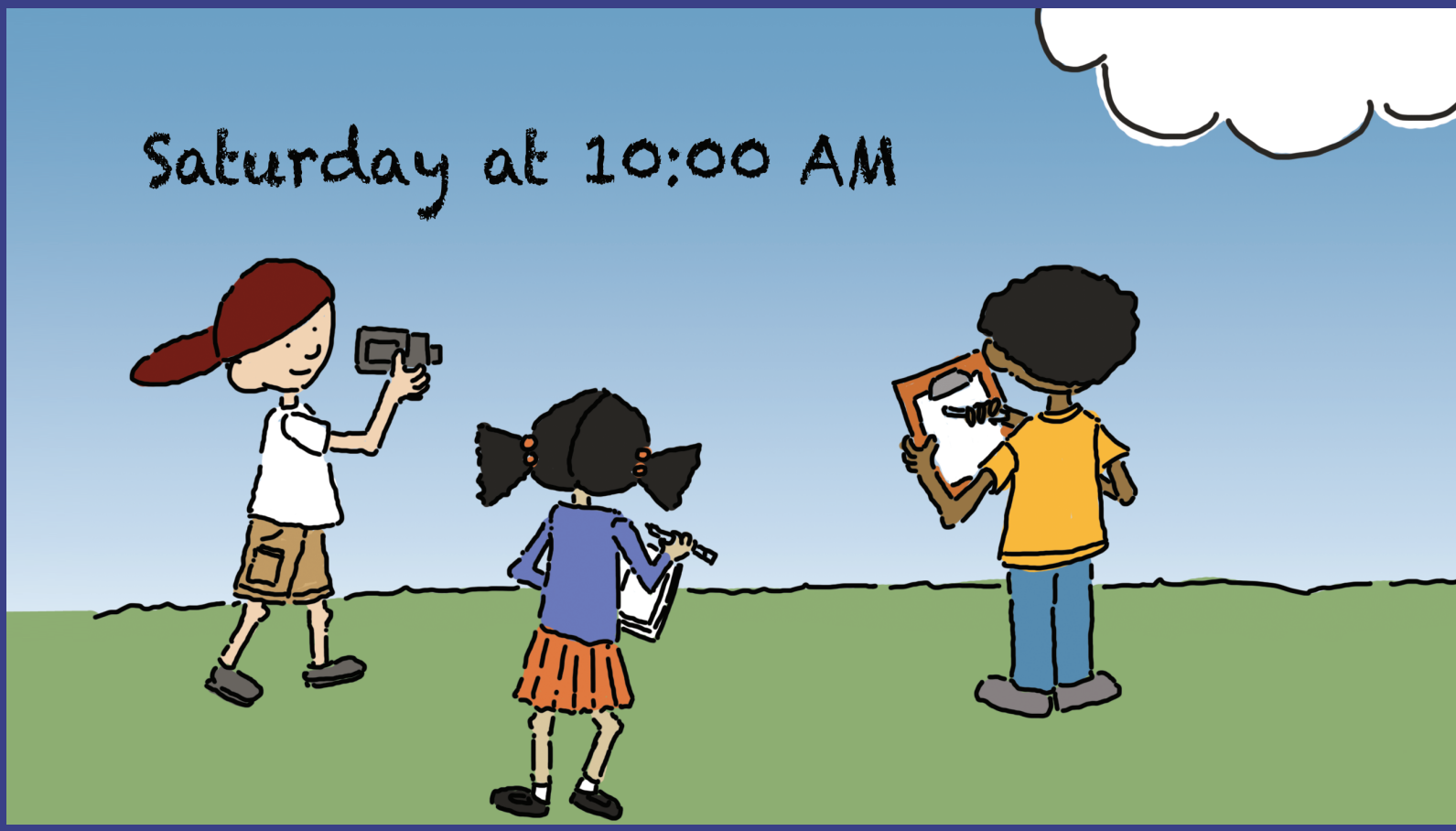
Anita added, "You know me, I always have my science journal in my backpack. For this project I'll use my colored pencils to draw what I see."

"I have an idea for how to record my observations, but I want to work on it before I show it to you," Dennis said.

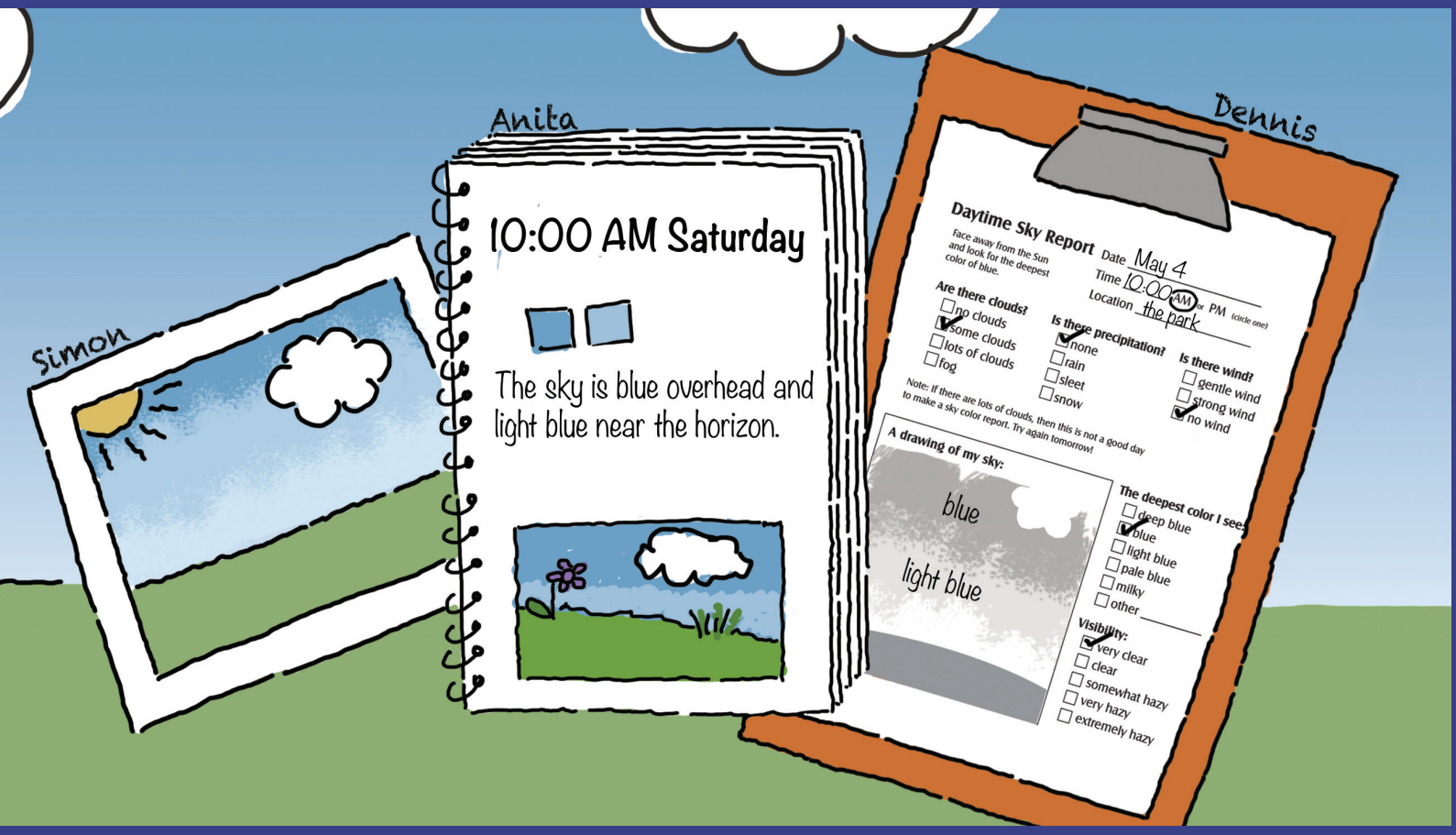
"Have you thought about when you're going to make your observations?" Ms. Patel asked.

"Since the weekend is coming up, we could do mid-morning and evening observations on Saturday and Sunday," Anita said. "Then we can compare our data on Monday!"

"This sounds like a great plan," said Ms. Patel. "This is the same kind of work done by scientists who study aerosols. They make observations just like you described. Remember that we're looking at the color of the sky and not the color of the clouds!"


Saturday at 10:00 AM

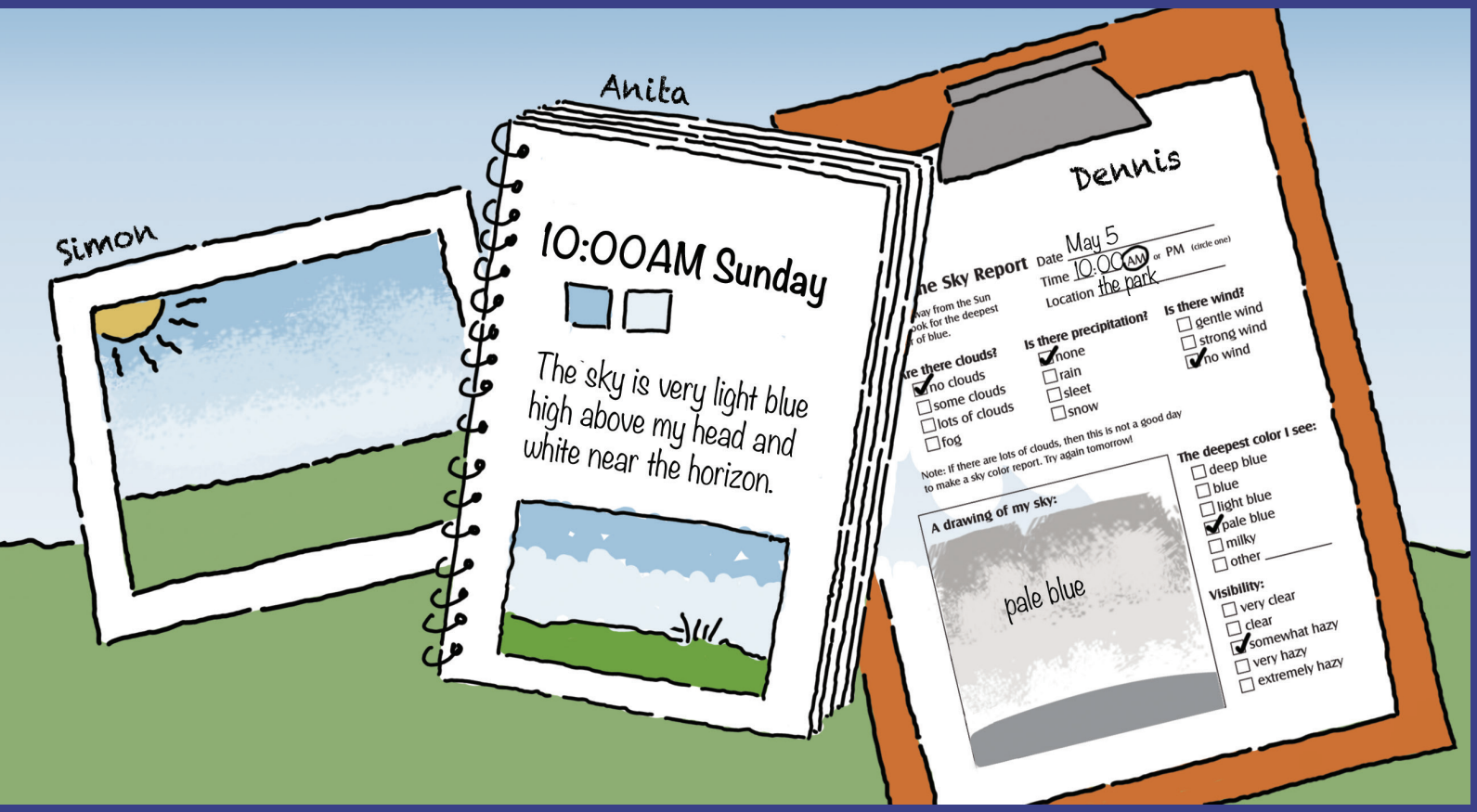

Saturday at 7:30 PM

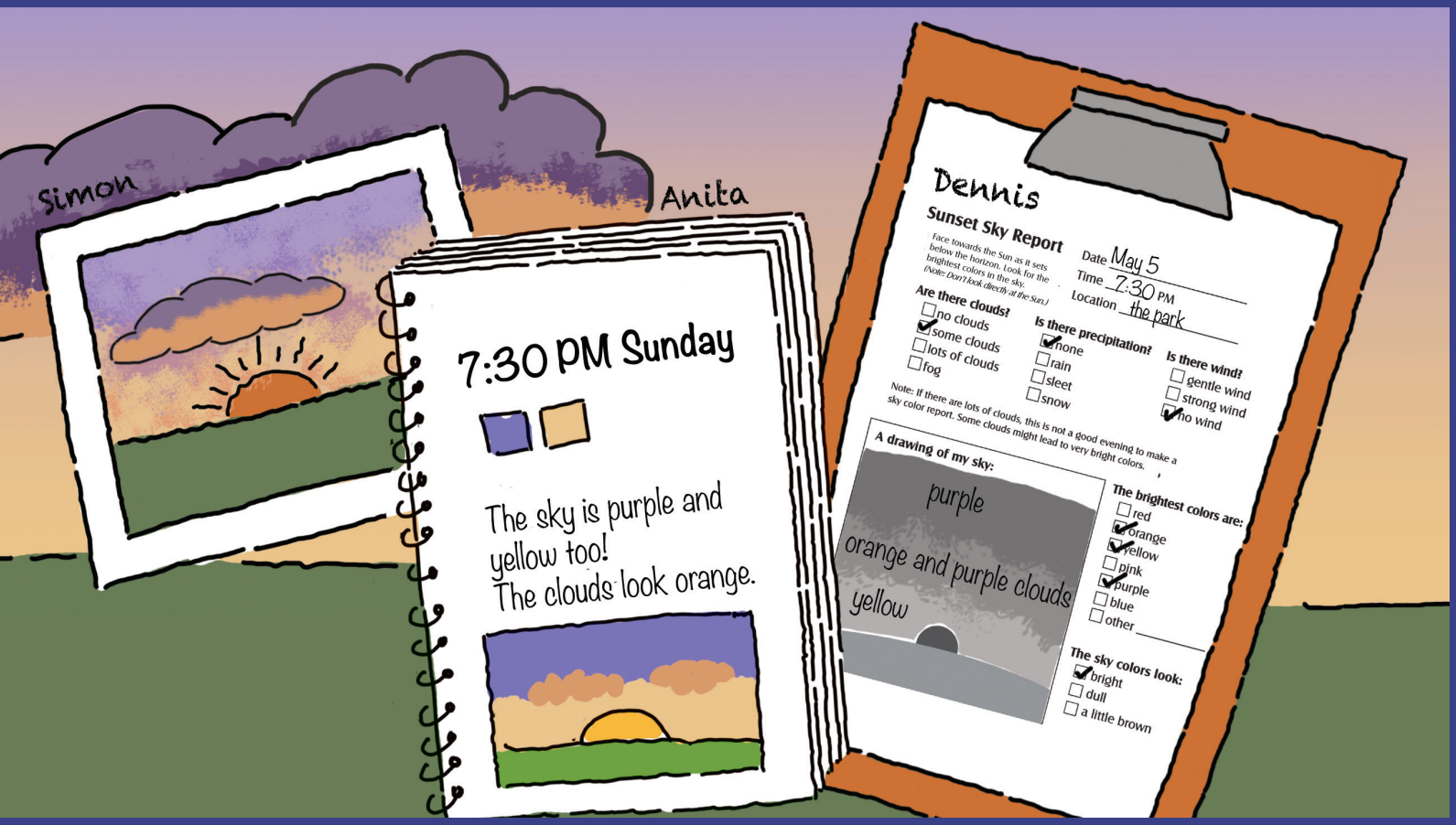

Simon
Anita
10:00 AM Saturday
The sky is blue overhead and light blue near the horizon.
Dennis
Daytime Sky Report
Date May 4
Time 10:00 AM or PM (circle one)
Location the park
Face away from the Sun and look for the deepest color of blue.
Are there clouds?
no clouds
some clouds
lots of clouds
fog
Is there precipitation?
none
rain
sleet
snow
Is there wind?
gentle wind
strong wind
no wind
Note: If there are lots of clouds, then this is not a good day to make a sky color report. Try again tomorrow!
A drawing of my sky:
blue
light blue
The deepest color I see:
deep blue
blue
light blue
pale blue
milky
other
Visibility:
very clear
clear
somewhat hazy
very hazy
extremely hazy


Simon
Anita
7:30 PM Saturday
The sky is lots of colors now. The edges of the clouds have more colors too.
Dennis
Sunset Sky Report
Date May 4
Time 7:30 PM
Location the park
Face towards the Sun as it sets below the horizon. Look for the brightest colors in the sky. (Note: Don't look directly at the Sun.)
there clouds?
no clouds
some clouds
lots of clouds
fog
Is there precipitation?
none
rain
sleet
snow
Is there wind?
gentle wind
strong wind
no wind
Note: If there are lots of clouds, this is not a good evening to make a sky color report. Some clouds might lead to very bright colors.
A drawing of my sky:
blue
purple
orange
The brightest colors are:
red
orange
yellow
pink
purple
blue
other
The sky colors look:
bright
dull
a little brown


Sunday at 10:00 AM


Sunday at 7:30 PM


Simon
Anita
10:00AM Sunday
The sky is very light blue high above my head and white near the horizon.
Dennis
Sky Report
Date May 5
Time 10:00 AM or PM (circle one)
Location the park
Are there clouds?
no clouds
some clouds
lots of clouds
fog
Is there precipitation?
none
rain
sleet
snow
Is there wind?
gentle wind
strong wind
no wind
Note: If there are lots of clouds, then this is not a good day to make a sky color report. Try again tomorrow!
A drawing of my sky:
pale blue
The deepest color I see:
deep blue
blue
light blue
pale blue
milky
other
Visibility:
very clear
clear
somewhat hazy
very hazy
extremely hazy


Simon
Anita
7:30 PM Sunday
The sky is purple and yellow too!
The clouds look orange.
Dennis
Sunset Sky Report
Face towards the Sun as it sets below the horizon. Look for the brightest colors in the sky. (Note: Don't look directly at the Sun.)
Date May 5
Time 7:30 PM
Location the park
Are there clouds?
no clouds
some clouds
lots of clouds
fog
Is there precipitation?
none
rain
sleet
snow
Is there wind?
gentle wind
strong wind
no wind
Note: If there are lots of clouds, this is not a good evening to make a sky color report. Some clouds might lead to very bright colors.
A drawing of my sky:
purple
orange and purple clouds
yellow
The brightest colors are:
red
orange
yellow
pink
purple
blue
other
The sky colors look:
bright
dull
a little brown


WHAT WE NOTICED IN THE SKY:
lots of different colors
SATURDAY
SUNDAY
DAY
blue
light blue
some clouds
light blue
pale blue, white
no clouds
SUNSET
dull orange
purple, blue
some clouds
bright orange
yellow, purple
some clouds
The sky was white on Thursday too.

On Monday during science class, the kids spread out all of their data on a table.

"Wow, you gathered a lot of information this weekend! What do you notice about the data?" Ms. Patel asked.

"It's cool to see that we each recorded some of the same information, even though we did it in different ways," said Anita. "Dennis, your data collection sheet was so organized!"

"Thanks!" Dennis replied. "I created this so I could collect the same types of information each time. I only had a pencil when I made my observations so it doesn't show the colors in the sky. Next time I think it would be good to use colored pencils just like Anita did."

"I like all of the methods you used to record your observations! And I agree with Anita that Dennis' sheet was a good way to organize the information," Ms. Patel said.

"Let's use Dennis' data sheet when we make more observations in the future," Anita suggested.

"Good idea! Since we have so many observations here, let's work together to organize what we observed," Simon suggested. "Then we can record our information in one place on the board."


deep blue
blue
light blue
pale blue
milky
less
AEROSOLS
more
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY

Next the kids began to discuss the questions they had about their data. They wondered if aerosols made the sky different colors.

Ms. Patel said, "You all are making some really good connections. Your big idea that aerosols impact the colors we see in the sky is correct. When there are a lot of aerosols during the day, the sky will look white. And in the evening, both sunlight and aerosols impact the colors we see during sunset."

Anita exclaimed, "Hey, wait a minute! Our friends who have asthma were slower runners on the day that the sky was white. That makes me think that aerosols are bad for your lungs and make it harder to breathe."

Dennis added, "But sometimes they have a hard time breathing when the sky is clear blue. Why is that?"

"That's because of what we call air quality," Ms. Patel replied. "Air quality is impacted by particles we see, those too small to see, and invisible gases. In fact, TV and radio stations provide air quality forecasts that will tell you if it's going to be an unhealthy day."

Simon added, "We should check the air quality forecast before we plan our activities. Let's also add that information to our weather forecast during the next news program!"

Back on the set, Dennis was adjusting the lights and the camera. Anita and Simon took their places at the news desk.

"Good afternoon and welcome to our newscast," Anita began. "We're adding a new feature to this program. Simon is here to tell us all about it."

"Thanks, Anita," Simon said. "We have been studying the colors in the sky and we have learned that there are a lot of reasons why it can be so many different colors. The angle of the Sun, the way light is scattered through the atmosphere, and tiny particles in the sky called aerosols all influence the color of the sky. Aerosols, as well as gases we can't see, also impact how easy it is to breathe. That is what we call air quality."

"So starting today we'll include air quality in our forecast," Simon continued. "The quality of our air can vary each day, and this forecast will help us plan when to do our outside activities."

Then Simon gave the weather and air quality forecast for the next day. After the newscast, Anita said, "Thank you, Simon! I think this information was the perfect addition to our newscast."

Dennis commented, "We've learned so much about aerosols and the colors in the sky. Now everyone at our school will know that it's important to check the air quality. Then we can make informed decisions about when to do outside activities."

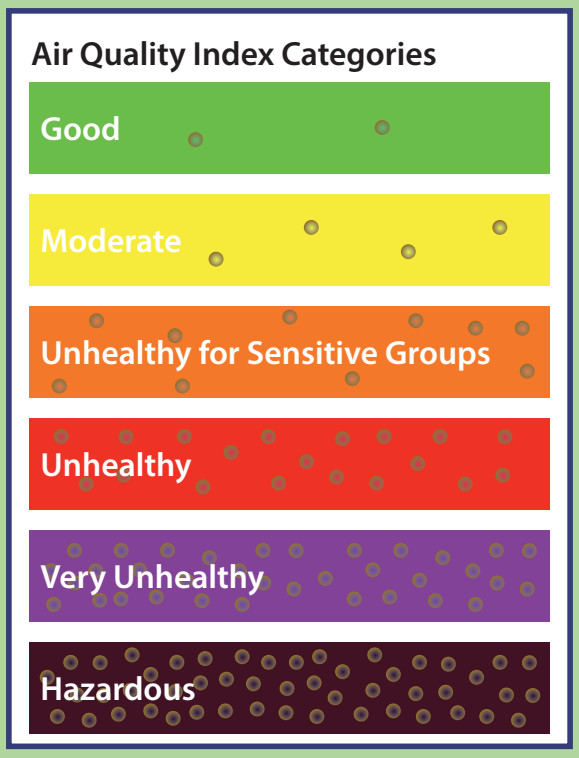
"We work well together as a team! I wonder what we'll investigate next?" Anita asked with a grin.

Teacher's Notes

Air Quality
Air quality is the measurement of the pollutants in the air. Good air quality means that the air is fresh and clean, and this air is easy for people to breathe. Polluted air is harder for people to breathe and can cause problems for some people.

The Air Quality Index (AQI) is like a weather forecast, except the AQI tells us how clean or dirty the air is rather than telling us about the weather. The AQI has six color-coded categories ranging from "Good" to "Hazardous."

Aerosols and Gases Impact Air Quality
Aerosols are tiny particles found in the atmosphere. Natural sources of aerosols include pollen, sea salt, desert dust, ash from volcanic eruptions, and smoke from forest fires. Aerosols that come from human activities include exhaust from burning fossil fuels, manufacturing chemicals from factories, and land use. Aerosols can contribute to air pollution. Note: In the past, aerosol spray cans contained chlorofluorocarbons (CFCs), which contributed to the depletion of the ozone layer. Under U.S. law, aerosol spray cans no longer contain CFCs. This use of the word "aerosol" is different than what this book describes.



Ozone is an invisible gas that is found in two layers of the atmosphere that surrounds the Earth: the stratosphere ("good" ozone) and the troposphere (ground-level or "bad" ozone). Ozone in the stratosphere protects us from the Sun's harmful ultraviolet (UV) rays. Ground-level ozone makes up most of the air pollution we call smog, and it causes

breathing problems for humans and damages some plants. Very little ozone is found naturally at ground-level. It is created by chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOCs.

More about Aerosols

Aerosols are really small! They can be as small as a few nanometers—less than the width of the smallest viruses—to 10,000 nanometers—about the diameter of human hair. For reference, a sheet of paper is 100,000 nanometers thick! (A nanometer is 1 billionth of a meter.) Aerosols usually remain in the atmosphere until they are washed out by rain, which usually takes 5-14 days, depending on the weather.

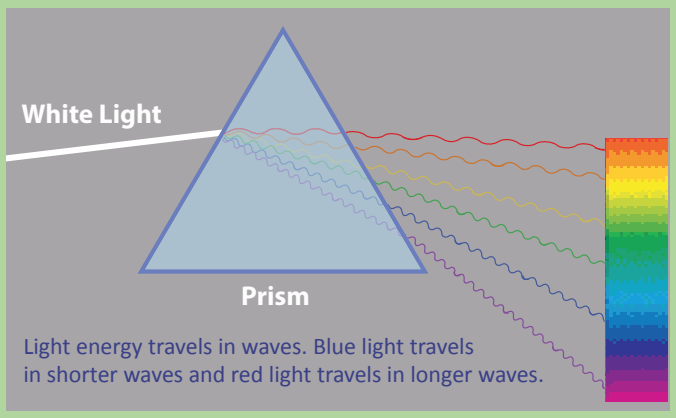
Scientists use a variety of instruments to measure aerosols. Some examples of these instruments include: ground-based sun photometers, particle counters onboard aircraft, and lasers and radiometers onboard satellites.

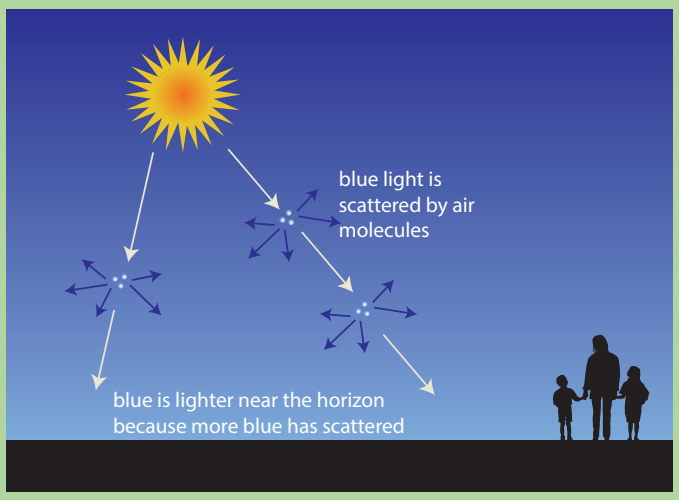
Why is it important to understand aerosols (beyond air quality)?

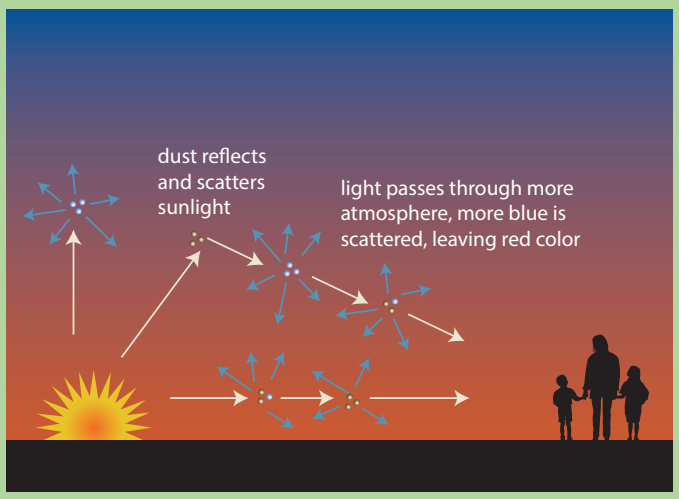
In addition to impacting air quality, aerosols influence other processes in our atmosphere.

- Aerosols contribute to cloud formation by acting as cloud condensation nuclei. In order for clouds to form, water vapor needs some sort of particle, such as dust or pollen, to condense upon. These particles are called condensation nuclei. Eventually, enough water vapor will condense upon condensation nuclei to form a cloud. The water droplets in the cloud may eventually fall down to Earth in the form of rain or snow (or other forms of precipitation).
- Aerosols have an impact on Earth's climate. Some aerosols reflect incoming solar radiation back out into space, and other aerosols absorb solar radiation, depending on what the particle is made of. These processes can have a warming or cooling influence on the atmosphere and contribute to the warming or cooling of our planet.

(The Teacher's Notes are continued on the next page)







Aerosols and Sky Color
Aerosols scatter and absorb sunlight. This scattering of sunlight can create haze and reduce visibility. It also contributes to making sunsets more colorful and red.

When the Sun is high in the sky, the sky looks blue because the sunlight is scattered in all directions by the air molecules in the Earth's atmosphere. These molecules are good at scattering blue and violet light, but not as good at scattering red and orange light. To an observer on the ground, this scattered light fills the entire sky and the sky appears blue.

When there are relatively few aerosols in the atmosphere, the sky appears clear. On a very clear day the sky looks deep blue. As the aerosol concentration increases and light scattering increases, the sky appears less blue. With enough of this scattering the sky looks hazy, pale blue, or white.

At sunrise and sunset, the Sun is low on the horizon and sunlight passes through more of the atmosphere than when the Sun is higher in the sky. This causes the light to scatter and we see shades of red, orange, or yellow, which are the longer wavelengths of light.

Glossary

Aerosols: Tiny particles (solids or liquid droplets) that are suspended in the atmosphere

Air Quality: The condition of the air around us; a description of the air in terms of its pollution levels

Air Quality Index (AQI): A measurement of the pollutants in the air related to healthiness and safety; this is calculated by the Environmental Protection Agency and reported by local weather and news stations

Asthma: A condition often triggered by poor air quality which causes the airways of the lungs to narrow and swell, which can lead to wheezing, coughing, shortness of breath, and tightness in the chest

Atmosphere: A layer of gases surrounding the Earth; the common name for these gases is air

Fossil Fuels: A hydrocarbon deposit, such as petroleum, coal, or natural gas, derived from the accumulated remains of ancient plants and animals and used as fuel

Gas: A state of matter; an air-like substance which expands freely to fill any space available regardless of its quantity

Hazy: An atmospheric occurrence where dust, smoke, and other particles obscure/conceal the clarity of the sky, creating a milky, obscured, and almost white appearance

Liquid: A state of matter; a fluid that conforms to the shape of its container and keeps its volume

Particle: A tiny portion of matter

Solid: A state of matter in which the particles are closely packed together

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, and weather. 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*
Kerry Zarlengo, *Fitzmorris Elementary, Arvada, CO*

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

Project Advisors:
Lin Chambers*
Kristyn Damadeo* *Science Systems and Applications, Inc.*
Jessica Taylor*

Science Advisors:
Rosemary Baize*
Jim Crawford*
Sarah Crecelius* *Science Systems and Applications, Inc.*
Gloria Hernandez*
Preston Lewis* *Science Systems and Applications, Inc.*
Dave Macdonnell*
Ann Martin* *Science Systems and Applications, Inc.*
Richard Moore*
Ali Omar*
Margaret Pippin*
Marilee Roell*
Diane Stanitski *National Oceanic and Atmospheric Administration*
Jason Tackett* *Science Systems and Applications, Inc.*
Larry Thomason*
Christine Wiedinmyer *National Center for Atmospheric Research*
Joe Zawodny*

** NASA Langley Research Center*

Field Test Teachers:

Augustine Frkuska
Crestview Elementary (Grades K-5), Live Oak, TX

Amy Hoskins
Fitzmorris Elementary, Arvada, CO

Stefany Johnson
Altamahaw-Ossipee Elementary, Elon, NC

Angie Kinder
Nichols Elementary, Barboursville, WV

Kathy Sinn
Grover Hill Elementary, Grover Hill, OH

Copyeditor:
Eileen Carpenter, *UCAR Center for Science Education*

Reviewers at the Elementary GLOBE Partners Meeting:
Jennifer Bourgeault, Georgia Cobbs, Nicomas Dollar, Peggy Foletta, Augustine Frkuska, Tina Harte, Mikell Lynne Hedley, Lynne Hehr, Tom Hunt, Michael Jabot, Janelle Johnson, Teresa Kennedy, Anne Lewis, John Moore, Peter Schmidt, Rick Sharpe, Todd Toth, Lynn Vaughan Reeves, Kristin Wegner, Alisa Wickliff

This publication was supported by NASA under the SAGE III on ISS and CALIPSO missions, award #NNX14AL78G.

NASA UCAR

What color is the sky today?

Anita, Simon and Dennis want to know why the sky isn't always blue. They learn that there's a lot more than air in the atmosphere, which can affect the colors we see in the sky.

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, and soils. 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.