3-ESS2 Earth's Systems

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Students who demonstrate understanding can:

3-ESS2-a. Organize simple weather data sets to record local weather data and identify day-to-day variations, as well as long-term patterns of weather. [Assessment Boundary: Weather data is limited to temperature, precipitation, and wind direction.]

3-ESS2-b. Display simple data sets in tables and graphs to describe typical weather conditions expected during a particular season and identify variations over years. [Clarification Statement: Data at this grade level could include average temperature or precipitation.] [Assessment Boundary: Climate change not to be assessed.]

3-ESS2-c. Obtain and communicate information about the similarities and differences between weather and climate.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data
Analyzing data in 3–5 builds on K–2 and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations.

- Display data in tables and graphs, using digital tools when feasible, to reveal patterns that indicate relationships. (3-ESS2-b)

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 3–5 level builds on K–2 and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to compare alternative design solutions.

- Organize simple data sets to reveal patterns that suggest relationships. (3-ESS2-a)
- Describe, measure, estimate, and graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems. (3-ESS2-a)

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 3–5 builds on K–2 and progresses to evaluating the merit and accuracy of ideas and methods.

- Compare and/or combine across complex texts and/or other reliable media to acquire appropriate scientific and/or technical information. (3-ESS2-c)
- Combine information in written text with that contained in corresponding tables, diagrams, and/or charts. (3-ESS2-c)
- Use multiple sources to generate and communicate scientific and/or technical information orally and/or in written formats, including various forms of media and may include tables, diagrams, and charts. (3-ESS2-c)

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- Weather is the minute-by-minute to day-by-day variation of the atmosphere's condition on a local scale. Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-a),(3-ESS2-b),(3-ESS2-c),*(secondary to 3-ESS3-b)*

Crosscutting Concepts

Patterns

- Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena and designed products. (3-ESS2-a),(3-ESS2-b),(3-ESS2-c)

Connections to other DCIs in this grade-level: will be added in future version.

Articulation of DCIs across grade-levels: will be added in future version.

Common Core State Standards Connections:

ELA/Literacy –

RI.3.9 Compare and contrast the most important points and key details presented in two texts on the same topic. (3-ESS2-b)

RI.3.10 By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 2–3 text. (3-ESS2-c)

W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (3-ESS2-c)

SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. (3-ESS2-c)

Mathematics –

3.MD.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. (3-ESS2-a)

3.MD.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in bar graphs. (3-ESS2-a),(3-ESS2-b)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice, Disciplinary Core Idea, or Crosscutting Concept.

Dress for the Weather

Students learn how climate differs from weather as they explore local and national data sets to give travelers advice.

By Nicole J. Glen and Lara K. Smetana

It was a cold spring day in Massachusetts—a mixture of rain and wet snow falling outside the classroom windows—the perfect day to begin a science unit about weather and climate with fifth-grade students. We asked students the following question: *If someone were traveling to our area for the first time during this time of year, what would you tell them to bring to wear? Why?*

Combined with our question, we used the following 5E learning cycle lesson (Engage, Explore, Explain, Elaborate, and Evaluate; BSCS 1992) to debunk the difference between weather and climate.

Engage With a Question

We used our question to engage students with the guided-inquiry unit. We allowed them to brainstorm by writing a list in their science notebooks. They came up with items of clothing like winter jackets, winter hats, scarves, gloves, boots, shoes, socks, sweaters, long-sleeved shirts, and pants. Their reasons for writing down those items included, "because I looked out the window," "that's what I have on today," and "we live here so we know what it's like." These lists and reasons were a good preassessment, showing that students based their claims on the current weather rather than the climate.

Explore With Weather Data

We began by asking students where they could get information to support their list besides their personal experiences. Students pointed out that they could watch the weather on the news or look it up on the internet. Although this is true, we wondered aloud how that would tell them what the weather was typically like at that time of year. Students thought that information from previous years would be a better resource.

We then introduced students to charts obtained from the National Weather Service website (see Internet Resources for this one and others). We gave students weather data for two weeks from the previous two years, including a key to help them understand the columns with relevant information (Figure 1). After we discussed what each column represents, we came up with questions as a class that helped students become more familiar with working with the data. The questions included:

- What does the temperature seem to be like during the day? (usually the maximum)
- What does the temperature seem to be like at night? (usually the minimum)
- How much precipitation fell (rain or snow)?
- How windy was it?
- How cloudy or sunny was it?

Working with partners, students tackled these questions by recording answers in their science notebooks. We encouraged students to answer them generally (e.g., snow rarely fell during the two weeks). Mathematics was also integrated by teaching students about mean (the average). Thus, the mean maximum temperature was 9°C and the mean minimum temperature was 1.5°C for 2008.

What to Wear?

Once students answered the guiding questions, we had them go back to their original list of clothing and cross items off and/or add items. At this point, however, students needed to provide evidence for their choices. Several student pairs decided that the visitor should bring long-sleeved shirts; their evidence pertained to the mean maximum temperatures they calculated. The student pairs then made a list of their clothing items on a large piece of paper and posted it in the room. We used these posters to generate a class discussion about the similarities and differences among the lists, leading students to realize that scientists can come to different claims with the same evidence based on personal experiences. Students also wrote in their science notebooks about why they made changes or kept things the same in their lists. The posters, class discussion, and science notebook were all forms of formative assessment to see how well students were able to use the data to revise their lists and support their revisions with evidence.

The most common items that students deleted from their original clothing lists included winter gear (jackets, boots, scarves, gloves, hats) because they noticed that it was not usually cold or snowy enough for them. The most common additions included lighter jackets or rain jackets and umbrellas because it rained at least a little on more days than not.

Explain With Definitions

We told students that their lists were no longer based on the weather but on something else—climate. We asked students to describe what we meant by *climate*, knowing that it lent support for their clothing lists. The class was able to come up with their own definition using knowledge gained from previous investigation: "*Climate* is what it's usually like in an area during a certain time of year." Along with definitions, we also wanted students to understand how climate is different from weather. We asked students to explain this, and they created a general rule: "Weather can change based on the day or hour, but climate changes based on the time of year."

Figure 1.

Data compiled from the National Weather Service.

Boston, MA 2008

DY	MAX	MIN	AVG	WTR	AVG SNW	SPD	S-S
March							
25	3	-2	0	T	T	22	5
26	14	3	8	T	0	28	5
27	12	2	7	T	0	15	8
28	6	1	3	0.71	T	16	10
29	2	−2	0	T	T	23	4
30	5	−3	1	0.00	0	15	0
31	11	−1	5	0.48	0	18	8
April							
1	17	11	14	0.43	0	36	7
2	12	2	7	0.00	0	33	2
3	11	0	6	0.00	0	20	2
4	6	2	5	1.85	0	14	10
5	12	3	8	0.15	0	9	9
6	5	3	5	0.03	0	25	10
7	6	2	4	0.00	0	24	7

DY = Day; MAX = high temperature (°C); MIN = low temperature (°C); AVG = average daily temperature (°C); WTR = total precipitation (cm); SNW = total snow (cm); T = trace; AVG SPD = average wind speed (kmp/h); S-S = average sky cover (0 = no clouds; 10 = entire sky filled with clouds)

Now that students had some experience reading weather data and using it to answer a scientific question, it was time for a guided inquiry activity to help them understand more about how location affects weather and climate. Guided inquiries involve students investigating a teacher-presented question using student-selected procedures (Bell, Smetana, and Binns 2005).

Elaborate With Location

We had students look at a U.S. map to describe how they thought the climate between two locations varied. For example, we discussed how Boston, Massachusetts, and Miami, Florida, compared. Many students were familiar with the variations in climate between north and south locations along the East Coast. Next, we asked students about the differences they predicted between two locations of similar latitude: Boston, Massachusetts, and Omaha, Nebraska. This time, students were not as sure. It was time for another exploration!

To further investigate how the climate of locations of similar latitude compared, we helped students consult the map and identify pairs of U.S. cities to collect and analyze average annual temperature data. They focused on pairs of cities that were of similar latitude and elevation; one landlocked and one coastal location. We used Boston and Omaha as models to guide students through their inquiry. We challenged students to investigate regions of greatest interest to them that spanned the entire United States. To review what students previously learned about the difference between weather and climate, we asked them to explain why it is important to look at average monthly data, rather than just that day's data. We also drew their attention to how many years the data on the website is based on. For example, the website we used, Weatherbase (see Internet Resources), has data that is typically based on more than 30 years.

Next, we led the class in creating a data collection table to record cities' average monthly high and low temperatures. It is important to have students leave space for calculations of the temperature range as well. We reviewed with students how a line graph can be used to illustrate the temperature changes over the course of the year and instructed them to create a line graph to plot their data.

Student pairs then went to work consulting charts obtained from Weatherbase and making calculations for their selected cities. Once all the data was collected, students plotted their results and posted their graphs around the room. Students circulated the room, reviewed the graphs, identified patterns, and drew evidence-based claims in their science notebooks. We created the following questions to guide students:

1. For each pair of cities, which has the higher summer temperature? Which has the lower winter temperature?
2. What patterns do you notice between a city's location and its climate?
3. Which cities had greater ranges in temperature?

Evaluate With Discussion

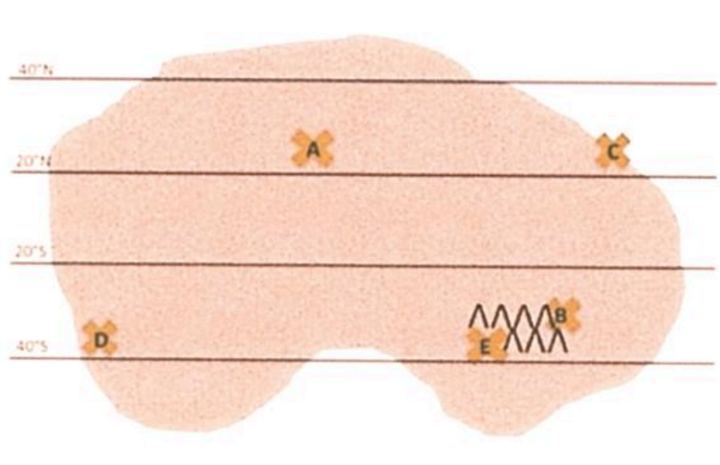
A whole-class discussion ensued about the patterns that appeared and the modifying effect that oceans have on weather and climate. We asked questions such as, "What evidence do you have to support the claim that bodies of water act like an air conditioner in the summer and a heater in the winter?" "Based on the evidence you collected, which do you think warms up more quickly in the summer, water or land?" and "Which do you think cools more quickly in the winter, water or land?" This discussion allowed for more formative assessment about the features of location that affect a city's climate (adding to the formative assessment done with student's weather and climate definitions and the posters, class discussion, and science notebooks).

At this point we conducted a demonstration to show how water and earth (in the form of sand) heat up at different rates. We filled two containers—one with water and one with sand. We filled them to the same level and attached a heat lamp to the side of each so that the bulb was facing the material. For safety, this was conducted as a demonstration only, we did not allow students to touch the heat lamps because they can get extremely hot, and we did not leave the heat lamps on for more than two minutes—plenty of time to show a difference. We placed a digital thermometer

CAUTION

Figure 2.

Imaginary landmass for summative assessment.



just under the surface of the water and sand. We recorded the intial temperature of each material (they should both be at about room temperature) and then turned both heat lamps on at the same time. After two minutes elapsed, we recorded the final temperature of each material. For example, the temperature of the water increased by about 3.5°C, whereas the temperature of the sand increased by about 12.5°C.

We then asked students questions to connect this demonstration to their data for landlocked and coastal cities. Using Boston and Omaha as an example, we asked the following questions: (1) Which container represents each city? Why? *Boston is represented with the water because it is near an ocean.* (2) Our graphs for Boston and Omaha show that Boston has cooler summer temperatures. Using our demonstration, why do you think that is the case? *Our demonstration showed that water doesn't heat up as much as sand, so if Boston is near the ocean the summertime Sun won't heat it up as fast either.* (3) In Boston, we often get a breeze off the ocean in the summer. Why does this affect Boston's summer temperatures? *Water stays cooler than land even when the Sun is shining on it, so the breeze will be cooler than the breeze in Omaha, which blows across the hot land.* Students then used the demonstration to write a description for their own cities about why the summer temperatures of their two cities were different. Through their data collection, examination of graphs, the demonstration, and a class dicsussion about cities' proximity to water, students began to articulate that because water heats at a different rate than land, a city's proximity to water will affect its average summer and winter temperatures.

Using personally meaningful investigations to answer a variety of scientific questions related to weather and climate, students deepened their understanding of weather and climate and the factors affecting both. For a summative assessment, we gave them a map of an imaginary landmass with locations marked in a variety of landscapes (Figure 2). They had to describe the conditions that they would predict for each location that would affect its climate and explain their reasoning. You might also consider asking them to explain why a location's weather might differ from its predicted climate.

Extend With More Questions!

By the end of this guided-inquiry unit, students gained a considerable amount of new knowledge about weather and climate. But, many new questions were also raised in their minds! Why does 90°F feel unbearable in Charlottesville, Virginia, but not in Las Vegas, Nevada? Or, why does a cold day seem more extreme in Cleveland, Ohio, than in Denver, Colorado? Why is the ocean still cold in June, even on days when the sand is too hot to walk on? And then, why is that same water still warm in October, when the air feels chilly? Why does the western (windward) side of the mountains receive more rain and snow than the eastern (leeward) side?

Students can be encouraged to further investigate other factors that affect climate, including elevation, orographic effect (the effect of hills or mountains), and ocean currents. After all, they are now prepared to do much more than recommend the appropriate clothing to a visitor traveling to their area!

Involving students in such explorations promotes active learning, connections to real-world situations, and the develoment of scientific-process skills and habits of mind. ■

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References

Bell, R., L. Smetana, and I. Binns. 2005. Simplifying inquiry instruction. *The Science Teacher* 72 (7): 30–34.

Biological Science Curriculum Study (BSCS). 1992. *Science for life and living.* Dubuque, IA: Kendall Hunt.

Internet Resources

National Climatic Data Center
www.ncdc.noaa.gov/oa/climate/stationlocator.html

National Weather Service
www.weather.gov/climate/index.php?wfo=box

Weatherbase
www.weatherbase.com

Weather Underground
www.wunderground.com

NSTA Connection

Access free Science Objects on the ocean's effect on weather and climate at *http://learningcenter.nsta.org.* Search "weather" or click on "See all FREE Resources."

Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996):

Content Standards

Grades 5–8

Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Standard D: Earth and Space Science
- Structure of the Earth system

National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academies Press.

#2019. Climate in Our Back Yard (Pennsylvania)

Science, level: Elementary
Posted Sun Nov 19 10:07:18 PST 2000 by Trent Kissinger (brth@grove.iup.edu).
Indiana University of Pennsylvania, Indiana, USA
Materials Required: globe, map of PA, clothing, misc. items, cardboard boxes, poster board, markers
Activity Time: 45 Minutes
Concepts Taught: Weather

Lesson 4: Climate In Our Back Yard

RATIONALE AND BACKGROUND

The purpose of this lesson is to make the students aware of the climate they are presently living in and how it affects them every day to fulfill the national teaching standard which states that 3rd grade students will be able to describe specific weather patterns and phenomena. Because of this, the lesson is specific to Pennsylvania. In this lesson the four seasons will be discussed; along with weather phenomena and outdoor activities associated with each season.

Students have sufficient background knowledge of specific weather events such as snow and rain. The students also have basic map reading skills. Finally, the students have knowledge of poster making.

LESSON OBJECTIVES

TLW describe major characteristics of the climate and seasons of Pennsylvania and explain its significance to their everyday lives. (UO #5; cognitive and affective)

PI: After a class discussion on the climate of Pennsylvania, students will construct an "A Year in Pennsylvania" poster on which they will creatively describe at least three examples of how the climate they live in shapes their lives during every season of the year. (Individual assessment)

RESOURCES/MATERIALS

- Globe
- Map of Pennsylvania
- Various articles of clothing including mittens, sunglasses, scarf, heavy coat, and a pair of shorts.
- Miscellaneous items including a football, sunscreen, ice skates, umbrella, and a packet of flower seeds.
- Four large cardboard boxes, each clearly marked with either spring, summer, autumn, or winter.
- Roll of wrapping paper
- Poster board cut into halves (enough for each student in class to have one piece)

- Markers, crayons, colored pencils
- A poster which says "A Year in Pennsylvania" on it. Hang it on an empty wall.

CONCEPTS

Climate: The long-term pattern of weather in a particular region, including temperatures, rain, snow, and other factors. Day-by-day variations are weather, while climate is the general trend, based on statistical data over a long period of time.

Pennsylvania has four seasons (spring, summer, autumn, and winter) each with specific characteristics that affect our everyday lives due to climate conditions caused by weather.

PROCEDURES

A. Introduction and Motivation

Before the lesson, place all the clothing and miscellaneous objects on a table in front of the classroom or somewhere else where they are easily seen by everyone. Place the four cardboard boxes at different corners of the room.

Start the lesson by pointing out the items on the table and the boxes found in each of the corners of the room. Invite a student to come up to the table, pick up an object or article of clothing and place it in the correct box which says the season we would most likely see the object being used. Guide the students through the activity until all the objects are in boxes. Ask four volunteers to bring the boxes to the front of the room. Review what was put in each one of the boxes. Why did we put the sunglasses in the summer box? What are these ice skates doing here in this winter box…why can't we put them in the summer box? Acknowledge all answers.

Remove all the boxes from the table EXCEPT the winter box and lay the roll of wrapping paper on top of it. My cousin who lives in Florida is having a birthday and I believe I will wrap up this box and send it to him! Do you think he will like these birthday presents? Respond to all answers. You don't think he will like them, Tyler? But I've had a lot of fun skating on the frozen pond by my house with these skates…Don't you think my cousin in Florida would like to do that too? Acknowledge answers. I think sending this package to my cousin who lives in Florida wouldn't be such a good idea; he would have no use for this heavy coat because it does not get really cold all the way in Florida! Although there are a few places of similar climate, in Pennsylvania, we have weather that is different from many other places in the world. Today we are going to talk about weather we see right here where we live and how it effects us every day.

B. Lesson Body

For the past couple of weeks we have discussed several aspects of climate. Like I said earlier, today, we are just going to focus on climate conditions that we see here in Pennsylvania. First, lets review where we are found in the world. Show the globe and point out North America and then Pennsylvania. Show the map of Pennsylvania and then point out the area where you are found. It is important to remember that not every place in the world has the same climate. For example: The weather we see throughout the year here in Pennsylvania is definitely different than here in the deserts of Arizona. Point to Arizona on the globe. Also, the climate in Antarctica is different from ours', too. Point to Antarctica on the globe. Because climate differs from place to place, people in different places must adapt to their specific climate to live a comfortable life.

Break the class into four groups and assign each group a specific season of the year. Groups, now that you all have a different season, try to write down as many things that would describe that season here in Pennsylvania. Remember to include weather, temperature, seasonal activities, etc. Try to be specific: instead of just writing "In Winter it is cold." write "In winter it can get so cold that ponds can freeze. Any questions? Ok, start!

When you believe sufficient time has been given, ask for attention and continue with the lesson. With chalk, divide the blackboard into four equal sections and write one season in each section. As the students read off what characteristics they came up with, write them in the appropriate section of the board. As you discuss each of the seasons, be sure to add the following information:

Spring:

Rainy

Many plants begin to grow

Summer:

Temperatures range from 68 to > 90 degrees

Thunderstorms are likely (30 – 35 a year average)

Tornadoes (5 –6 annually)

Autumn:

Warm days (66 – 75 degrees) cool nights (lows in 40's and 50's)

Winter

Temperatures range from 21 – 48 degrees in January

Snowfall amounts vary dynamically from year to year, ranging from 20 – 90 inches annually depending on where you are in the state.

Distribute the poster board and art supplies to the class. To wrap up our discussion on climate here in Pennsylvania, we are going to make an "A Year in Pennsylvania" poster. First, divided your paper into four squares by drawing two lines which cross in the middle. In each of the boxes, write a different season. When I tell you to, fill in your boxes with words, sentences, and drawings that describe that specific season. Try to make this reflect what you like to do during that time of year. For example: in the summer time I like to go swimming; so, I may decide to draw a picture of me swimming in the summer box on my poster. Try to fill each box up with as many things as you can. When you are done, bring you poster over to this wall and we will hang them up under this heading that says "A Year in Pennsylvania".

EVALUATION

Student Assessment

Students' understanding of the climate of Pennsylvania and how it effects their everyday lives will be assessed through the "A Year in Pennsylvania" poster which each student will individually make and the level of participation in classroom discussion. Each student must give at lease three examples for each of the four seasons of the year.