

Earth's Changing Atmosphere

Developed by Mark Goldner – Brookline, MA – 7th Grade Science (2023-2024)

Guiding Questions

- In what ways is Global Warming affecting temperatures in different parts of the globe?
- Is Global Warming affecting different parts of the globe in the same way?
- What is the connection between air temperature and ocean temperature?

Placement in Curriculum

I use this to introduce a unit on climate change called “Earth’s Changing Atmosphere”. This helps ground the students in the human impacts of climate change even as we dive into the science. No prior background on climate science is required.

Learning Objectives

- **Earth’s Changing Atmosphere:** Life on Earth relies on a fragile atmosphere, which is being altered by human-induced greenhouse gasses, resulting in global climate changes.
 - Students will explain the connection between greenhouse gas emissions from modern processes (industrial, transportation, agricultural, etc.) and our current climate crisis.
 - Students will interpret global data sets which show specific examples of global climate change, will make connections between different data sets and offer hypotheses about why these connections may exist.
- **Human Impacts of Climate Change:** Climate change impacts human societies by altering weather patterns, increasing natural disasters, and affecting resources, requiring adaptation and mitigation strategies for sustainable living.
 - Students will describe examples of how the global climate crisis is affecting human societies now and in the future.
 - Students will present specific examples of how humans may mitigate the future effects of climate change.

Standards Alignment

Performance Expectations:

- *MS-ESS3-5*: Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
- *MS-ESS3-4*: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Disciplinary Core Ideas:

- *ESS2.A*: Earth’s Materials and Systems
- *ESS3.D*: Global Climate Change
- *ESS3.C*: Human Impacts on Earth Systems

Science and Engineering Practices (SEP):

- Developing and Using Models
- Engaging in Argument from Evidence

Crosscutting Concepts (CCC):

- Patterns
- Scale, Proportion, and Quantity
- Cause and Effect
- Stability and Change

Advice for Educators

Doing observation and discussion with students is an incredibly powerful way to get students to share in a collaborative way. I am always surprised at how students display flexible thinking during the process - there’s always a student or two who is adamant about what they think they are seeing, but then after listening to others they quickly change their thinking. Some groups where students feel more inhibited can show a reluctance to participate in the discussions at first. Giving students a chance to write first makes a big difference.

One of the important parts of this unit is the fenceposts activity, in which students get a chance to practice the process of thinking through what design tools might work best for a particular survey question. Although it can be somewhat time consuming to have students vote on which design tool to use, I think it was quite powerful to go through that exercise, because students really had to defend their choice of a particular tool. Then, after the activity, they can evaluate their choices. But giving students choice and voice in this process was important - not only did they buy into the activity, but it forced them to think more deeply about the design choices.

When doing the Data Sketches activity, don’t worry about students’ lack of background knowledge in terms of the connections they come up with. The purpose of this activity is not to get them to develop sophisticated claims, but rather to look at data and ask questions about what possible correlations might be possible. The questions they raise are more important than the answers they come up with.

Materials

- Computer and LCD Projector to display artwork and dataset
- [Slide with Norms for Observation and Discussion](#)
- Optional: [Climate Data Art Project Extension Activity](#)
- Featured Artwork: [Helicopter Hands](#)
- Featured Data: [Sea Surface Temperature Anomaly for July](#)
- Sticky notes/easel/dry erase boards for recording questions
- Long strips of cardstock paper approximately 10 inches long by 2 inches across so you can have 6 squares of 2 in. x 2 in. ([Template](#)). Dimensions and shape can be changed based on your circumstances/resources/space.
- String and clothespins or tape
- Scissors, markers, colored pencils, erasers
- Rulers
- Paper clips
- Scratch paper
- 11" x 17" vellum tracing paper
- [Base Map Template](#)
- Handouts:
 - [Fenceposts Survey Questions](#)
 - [Design Tools Guide](#)
 - Additional Mapped Datasets
 - [Nighttime Lights](#)
 - [Hurricane Tracks](#)
 - [Sea Surface Temperature Anomaly](#)
 - [Data Sketches Student Worksheets](#)
 - [Data Sketches Reflection Worksheet](#)
 - [Data Sketches Reflection CER](#)
 - Assessment (Optional):
 - [Observation & Discussion Data Reflection](#)
 - [Data Visualization Choices Worksheet](#)
 - [Post-Fenceposts Reflection Worksheet](#)
 - [Post-Data Sketches Group CER Worksheet](#)

STEP 1 – Observation and Discussion

Part 1 – Art

1. Students start a new page in their notebooks titled “Observation with Art #1”.
2. Use the **Slide with Norms for Observation and Discussion** to share norms for the discussion and briefly introduce the process to the students.
3. Project the **Featured Artwork** so that it’s visible to the entire class.
4. Invite students to observe the image silently for 1-2 min.
5. Have students journal or write down initial ideas during this time.
6. Tell students: “*Let’s take a moment to look at this picture together.*”
7. Invite as many students as possible to share their ideas about what the image shows, using the following prompts/facilitation sequence (10-15 minutes)
 - a. Invite Student Ideas: *What’s going on in this image?*
 - b. Gesture: As each student is speaking, use your hand, mouse, or pointer to gesture to parts of the image that they are referencing so that the whole class can see.
 - c. Paraphrase: Repeat the student’s observations using different language, taking advantage of opportunities to introduce appropriate vocabulary and without validating/invalidating their ideas.
 - d. Ask for Evidence: *What do you see that makes you say _____ ?*
 - e. Invite More Ideas: *What more can we find?*
8. Thank the class for participating in the experience and for sharing their observations.
9. (Optional) Have students share in pairs any additional thoughts or observations (5 minutes): “*Now that we have all looked together, I know there are still more ideas. Turn to a person sitting next to you and share more or share something you didn’t share with the larger group.*”

Part 2 – Data

1. Tell students that now you are going to use the same approach and observe a mapped dataset. **It is important you do these observation sessions back-to-back. The observation and discussion with the art image may be more accessible to many students and encourages those that do not usually speak up or that are uncomfortable with science/data to participate. The art image may be more engaging and personally relevant, getting the students primed in the approach of observing and talking.*
2. Project the **Featured Data** WITHOUT the legend. Ask for 1 minute of silent observation time and 2-3 minutes of journaling time. Use the map: **Temperature Anomaly for July 2023 – WITHOUT Legend**.
3. (If this happens on the next day) Review the norms for discussion again using the **Slide with Norms for Observation and Discussion**.

4. Invite as many students as possible to share their ideas about the visual patterns they see in the data visualization, using the following facilitation sequence and prompts (~5 minutes)
 - a. Invite Student Ideas: *What’s going on in this image?*
 - b. Gesture: As each student is speaking, use your hand, mouse, or pointer to gesture to parts of the visualization that they are referencing so that the whole class can see.
 - c. Paraphrase: Repeat the student’s observations using different language, taking advantage of opportunities to introduce appropriate vocabulary related to the phenomenon, visualization, and/or data (e.g., scale, hemisphere, latitude/longitude, trend, variability) and without validating/invalidating their ideas.
 - d. Ask for Evidence: *What do you see that makes you say _____ ?*
 - e. Invite More Ideas: *What more can we find?*
5. Project the **Featured Data** WITH the legend now, so that it’s visible to the entire class.
6. Invite students to look again at the data visualization that now includes a legend, providing ~1 minute to silently and independently observe.
7. Invite as many students as possible to share their ideas about the visual patterns they see in the data visualization, using the following facilitation sequence and prompts (~5 minutes)
 - a. Invite Student Ideas: *Now that you see this addition, how has your thinking changed?*
 - b. Gesture: As each student is speaking, use your hand, mouse, or pointer to gesture to parts of the visualization that they are referencing so that the whole class can see.
 - c. Paraphrase: Repeat the student’s observations using different language, taking advantage of opportunities to introduce appropriate vocabulary related to the phenomenon, visualization, and/or data (e.g., scale, hemisphere, latitude/longitude, trend, variability) and without validating/invalidating their ideas.
 - d. Ask for Evidence: *What do you see that makes you say _____ ?*
 - e. Probe for more: *What do you think [visual feature you observed] might mean?*
 - f. Invite More Ideas: *What more can we find?*
 - g. If students are having difficulty providing new observations, try asking:
 - i. *What do you wonder?*
 - ii. *What jumps out at you? What do you see first?*
 - iii. *Does anything in this visualization seem unusual or unexpected to you?*
 - iv. *What’s interesting to you? What is familiar to you?*
 - v. *If you could talk to the scientists who made this, is there anything you’d want to ask them?*
8. Thank the class for participating in the experience and for sharing their observations.

9. (Optional) Have students share in pairs any additional thoughts or observations. Ask them to think about additional questions they have which you will record in the next section (~5 minutes)
10. Tell students: *“Now that we have all looked together I know there are still more ideas. Turn to a person sitting next to you and share more or share something you didn’t share with the larger group. Think about additional questions you might have. We will discuss these questions next as a class.”*
11. Develop a list of questions that were generated and ask for more questions. Teachers should interject questions that would facilitate the investigation/learning of content if the students have not yet brought it up. Ask: *What are you curious about? What questions do we have? I’m curious why the patterns are...?*
12. Create a digital (e.g., Google Docs) parking lot with a question list or use sticky notes and tell students you will revisit these questions later in the program. Another option is for the teacher to aggregate the questions into 5-10 questions for a Driving Question Board that can be displayed in the classroom during this unit.
13. Optional Extension or Homework Assignment: Students can use the **Observation with Data Reflection Worksheet** to reflect on the observation and discussion with data. This can also be used as a formative assessment.

STEP 2 – Bridging Approach: Fencepost Activity

1. Begin by having students fill out the **Fencepost Survey Questions** about their experiences with severe weather. Give students time to fill out the survey questions on their own on paper.
2. Give each student the **Design Tools Guide** handout.
3. Tell students: *“Data like we just saw in the Mapped Data exercise comes from a variety of sources – individuals can collect data at a local level or one point in time and then combine those observations/data to show data over time or over a larger spatial area. We can also collect data with satellites which provide large areas of remotely sensed observations and can even provide global pictures of data/science phenomena. People use symbols to convey information in a simple and effective way. Symbols are an important part of maps and can represent a range of different types of data. Symbols are described in a legend – a box or other place on the map where there is a key that says what each color of symbol means. Let’s look at different ways we can represent data.”*
4. Review the **Design Tools Guide** with students - ask the students to reflect on the previous activity comparing maps about which design tools were used/chosen and why.
5. Break the class into small groups. For each question on the survey, have each group consider which design tool would be best, and then determine which color, symbol, shading, etc. would work for that question. Tell the students that they can’t use each design tool more than once in the survey.
6. For each question, have each group share their idea for the design tool and symbol, and then have the class vote. ****Note:** This can be a little time-consuming, but it’s a great way to give students a chance to think carefully about design tools, and to take ownership over the data.**
7. Give each student a strip of paper that is divided into 6 numbered squares (You can use the **Template** provided). Then, give students some time to fill out the fence post strip using markers or colored pencils as needed.
8. After all students have finished their responses, line all the students’ work side by side as a “fence post” (tape them on a wall or attach to a string) so that you can see trends across the class. Alternatively, you can spread them out onto a table so the strips can be moved around.
9. Optional homework: Photograph the Fencepost data and make it available to the students. Have the students fill out the **Fencepost Activity Reflection Worksheet**. This can be a useful way to assess students’ understanding of the data and of the process of coming up with data visualization tools.
10. Optional Exit Ticket: Give students an index card.
On a scale of 1-10, rate your *climate anxiety*. In addition, add any comments or questions you want to share.
11. Optional Classwork or Homework: Give students the **Data Visualization Choices Worksheet** to do in class or for homework.

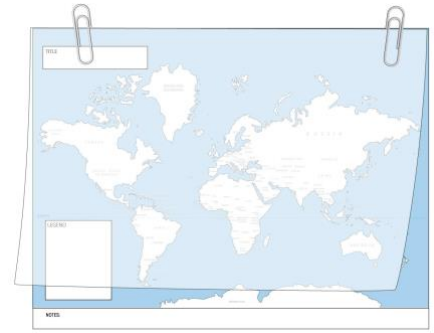
STEP 3 – Data Sketches: Making Data Visual

Have students sit in groups of three or four.

Part 1 – Plan & Sketch

1. Give each student a printed copy of the original mapped data (with legend) from the Observation and Discussion with Data session along with the **Design Tools Guide** handout.
Note: By now the students should be familiar with both the original map and the design tools. It is important to keep referring to the design tools so students become familiar with using them.
2. Explain: “Remember how we looked at the different mapped data representations and how we used the Design Tools to come up with our own symbols to answer the questions in the Fencepost Activity? Today we are going to discuss mapped data further and practice using these tools ourselves by creating our very own map legends with symbols, colors, marks...”
3. First, let’s remind ourselves about our map from earlier in this lesson. Invite discussion about the following questions regarding the printed map you have handed out (10 minutes):
 - What design tools were used to draw the data on this map?
 - What is included in the legend?
 - Why do you think they chose this particular design tool for this set of data?
 - While some tools are better for representing sets of data, there is no right or wrong tool. Are there different design tools we could use to represent this data? *Look through the handout and discuss what some good choices might be for this topic.*
4. Give each group 2-3 **Additional Mapped Datasets** related to the topic so that each student has a different map to work with. You can have students choose or you can assign datasets to different students based on ability or interest. If your groups are smaller than 4, not every group will have every map represented, which is fine. Just make sure that someone from each group is assigned to the original **Featured Data**.
5. Invite students to silently observe their maps for a few minutes and have them spend a little time making sure they understand what the data is trying to show. (5 min.)
6. Ask the students to decide within their group how they might represent the data in each of the three maps in a different way than it is currently while using three distinct design tools (i.e., color, symbols, scale) from their **Design Tools Guide** for the three maps. Have students work on developing new legends for each map using scrap paper, pencils, and markers (10 minutes)
7. Ask each student to choose one of the maps. Hand out the **Data Sketches Student Worksheet 1** and the **Base Map Template**.

8. Have students paperclip a sheet of tracing paper over the map template and follow the prompts on worksheet 1 (*please show an example of what they are being asked to do*). This worksheet will guide them through beginning their map. *The map template provided to be used as a guide under the tracing paper is important because it forces each student to create a map that is on the same scale as the others so that these maps can be easily layered together in the second part of this exercise. The order of steps on the worksheet is important to follow because it allows the student to create the legend prior to getting involved in the task of drawing. You, as the teacher, can walk through each step one at a time, if needed, or have the students follow the instructions independently. (10 minutes)*



9. “Sketch” - the final task of this worksheet asks for the student to use their new legend as a guide to sketching out their mapped data in a new way. Students are also asked to note important features. *Students may begin by tracing the outline of the countries and, although it is not necessary and sometimes time-consuming, it is a way that they can begin to process the map spatially. For that reason, the timing of this component is variable and left up to the teacher. Students should have a minimum of 20 minutes to respond or the teacher may choose to break here and allow the students to complete their mapped “work of art” at home overnight and wrap up the next day with Part 2. (20 minutes – 2 hours)*



Part 2 – Analyze & Discuss

1. Looking at the maps they have sketched, ask students to write a one or two sentence summary of what their sketched data represents and then complete the **Data Sketches Reflection Worksheet**.
2. Have the students share their answers with their group. (5 min.)
3. Group work Round 1 - Patterns, Correlations, Hypotheses: The group works together to layer two maps at a time and look carefully at the paired maps, noting any patterns and correlations they can find and hypothesizing about what the correlations mean and giving each other feedback.

Give students a dry erase board to write down their ideas for patterns, correlations and hypotheses they come up with. (15 minutes)

Suggested sentence starters:

- *We notice that there is a correlation between ____ and ____ ...*
- *There seems to be a pattern in...*
- *One possible hypothesis that could explain this correlation / pattern is... This makes sense because...*
- *This could tell us about... by...*

4. Have students report out as a group to the rest of the class about possible patterns, correlations, hypotheses. (10 minutes)

Wrap Up/Synthesis

1. Group work Round 2 - Evaluating Design Choices. Students discuss the design tools they used and evaluate how well those choices worked in terms of helping their analysis of the data.

Suggested sentence starters:

- *One design tool we used was... It helped us notice...*
- *When we used.... as a design tool, it made it more difficult to notice...*
- *Using as a design tool was interesting because...*
- *If we could do it again, we would do... differently. This is because...*

Have students use a dry erase board to write down their ideas for evaluating their design choices. (10 minutes)

2. Have students report out as a group to the rest of the class about their design choices. (5 minutes)

Optional Extensions

Claim, Evidence, Reasoning (CER)

Have each group write a short CER about the data they analyzed using the **Post-Data Sketches Group CER Worksheet**.

Climate Data Art Project

Have students complete the **Climate Data Art Project Extension Activity**.

STEP 4 – Guided Discussion

1. Revisit the questions generated (parking lot/sticky notes) in Step 1.
2. Review if the answers were found during the rest of the activities or if more sleuthing and research needs to be done. This can also be a great jumping off point for other related lessons and activities related to your content.
3. Discuss with the class the following questions:
 - a. What questions did we answer?
 - b. What questions remain?
 - c. How can we find the answers to the remaining questions?
 - d. What skills/tools have we learned that can help us answer them?
 - e. What research can we do? What additional data do we need?

Assessment

Use the provided worksheets to assess students throughout the unit:

- **Observation & Discussion Data Reflection**
- **Data Visualization Choices Worksheet**
- **Post-Fenceposts Reflection Worksheet**
- **Post-Data Sketches Group CER Worksheet**

Assessment can also be individualized based on your classroom/students. You can use these general questions for ideas.

- Did student complete all activities?
- Did student participate actively in discussion?
- Did student show understanding of content?
- Did student show critical thinking?