Session 4: Introduction to Working with Climate Data

Overview

Participants first refer back to research on learning and are asked to discuss their own experiences as learners in this session. Participants consider the challenges in bringing real and near-real time data into the classroom in authentic ways, and strategies that support data use in the classroom. They also consider and discuss the tremendous value of having students engage with authentic, locally-relevant data as they explore concepts and engage in the process of science. Participants handle real water and air temperature data as they look at patterns formed by ocean and atmospheric air temperatures. Using the data, reasoning and conceptual knowledge, they construct evidence-based explanations and discuss contradictory evidence for claims for climate patterns found in locations across the US. An optional activity enables participants to learn more about the different kinds of data visualizations scientists use depending on the data and question being investigated.

Session Goals

Theme	Goals
Climate Science Ideas	Understand that: ● The ocean warms cold air and cools warm air. The ocean keeps temperatures more even all over the planet. (OSS 1.4)
Using Data	Build on skills covered in previous sessions and explore ways to: ● Find high quality and reliable sources of data online. ● Articulate what the different variables (controls, independent, dependent) are within an investigation or data visualization. ● Engage students at three different levels with data visualizations—orientation, interpretation, and synthesis.
Teaching & Learning	Discuss the importance of using local ecological data as a pedagogical tool to improve the relevancy of concepts, ecological processes, and global change.
Framework/ NGSS	Experience shifts in teaching and learning as described in the Framework for K–12 Science Education and NGSS. Read selected Science and Engineering Practices and Crosscutting Concepts.

Materials Needed

For the class

- PowerPoint presentation
- Digital/data projector
- Whiteboard or flip chart paper and pens
- masking tape
- Big Chart of Data Skills
- Scientific Evidence chart

For every participant

- 1 copy of Value of Local Ecological Knowledge in the Classroom
- 1 copy of Engaging with Data Visualizations - Air Temperatures Activity (each page copied single sided to be passed out in succession)
- 1 copy of Session 4 Mystery Locations handout
- 1 copy of Session 4 Mystery Locations Response Worksheet

Optional copies

- Earth is heated unevenly handout
- Student Data Sheet for NERR Water Temperatures (homework from Session 3)
- Key of Data Visualizations Activity Handout and Answer Key (Optional activity)

Per pair of participants

- 1 copy of Session 4 Mystery Locations Handout_same axis (graphs and map)

  OR
- 1 copy of Session 4 Mystery Locations Handout_different axis (graphs and map)

For each participant (in group 1,2 or 3)

- Nonsense Data Handout A (each of the three different groups should have a different data set)
- Nonsense Data Handout B (each group should have a different data set, but their A & B should match)

For E. Activity: *Making Evidence-Based Explanations and Three Corners activity (OSS 1.4)*

- 4 pieces of 8.5 x 11" paper labeled A, B and C in a letter that fills the page

For groups of 4

- (Optional) NERR Water Temperature Graphs (one for each group, if homework was not completed)

Preparation of Materials

1. **Duplicate handouts.** Make enough copies of the following handouts for

   1 per participant:

   - 1 copy of Value of Local Ecological Knowledge in the Classroom
   - 1 copy of Engaging with Data Visualizations - Air Temperatures Activity (each page copied single sided so it can be passed out in succession)

   Optional copies

   - Earth is heated unevenly handout
   - Student Data Sheet for NERR Water Temperatures (homework from Session 3)
   - Key of Data Visualizations Activity Handout and Answer Key (Optional activity)

   For each participant (in either group 1, 2 or 3)

   - Nonsense Data Handout A (each group should have a different data set, but their A & B should match)
   - Nonsense Data Handout B (each group should have a different data set, but their A & B should match)

2. **Create the Big Chart of Data Skills.** On a sheet of chart paper, copy the format below to fill the page.

	Teacher	Learner	NGSS Science & Engineering Practice
Prior to Having a Data Visualization			

Data Orientation			

Set up another sheet the same way with the remaining two "Teaching with Data Categories": Data Interpretation and Data Synthesis., e.g.

	Teacher	Learner	NGSS Science & Engineering Practice
Data Interpretation			
Data Synthesis			

3. **For E. Activity:** *Making Evidence-Based Explanations and Three Corners activity (OSS 1.4)*
    1. **Create three corners.** Write A on one sheet of 8.5 x 11" paper so that it fills the page. Do the same for B and C. Tape them up in three different corners of the room.
    2. **Duplicate handouts.**
        a. Duplicate the Session 4 Mystery Locations handout (i.e. data graphs and US map) for every pair of participants. (Decide if you would like to use the data graphs plotted on the same axis, or those plotted on different axis. The graph using the same axis are easier to interpret, but you may decide to challenge your participants with the graphs on different axis).
        b. Duplicate the Session 4 Mystery Locations Response Worksheet for every participant.
    3. **Create Scientific Evidence Chart.** On a sheet of chart paper, write:

Scientific Evidence

- *Evidence is a clue that helps answer a question or explain something.*
- *Evidence can come from…*
    - *our own investigations*

- *other people's investigations*

➢ *Evidence includes reasoning about WHY or HOW the data help to answer the question or explain something.*

➢ *Scientific explanations are based on evidence.*

Session at a Glance

Task	Description	Time (minutes)
A. Homework Reflection Think Pair Share: *How People Learn*	Participants do a T-P-S on the different ideas presented in the *Key Ideas from the Literature: How People Learn* Research Discussion readings, and how those ideas compare to their own experiences as learners. Session goals are presented.	15
B. Activity: *Nonsense Data*	Participants explore common struggles students have when looking at data and reading graphs, as they engage in an activity using nonsense data and a reflection about teaching implications.	20
C. Reflection: *What helps us make sense of data?*	Participants engage in discussions and reflections about what is involved in making sense of data through data visualizations. Then are introduced to the Three Levels of Engagement with Data Visualizations.	15
D. Activity: *Engaging with Data Visualizations - Air Temperatures*	Participants explore how the questions used at different levels of the 3 Levels of Engaging with Data Visualizations vary to support learners' understanding of the data through an investigation of Air Temperature data across different locations.	25
E. Activity: *Making Evidence-Based Explanations and Three Corners activity (OSS 1.4)*	Participants consider what makes a good explanation and examine the strengths and weaknesses of five different explanations. They engage in an activity where they consider data collected at different locations across the US. and discuss evidence that supports and refutes matching the data with a claim.	45
F. Homework Discussion: *Online*	Participants engage in a discussion about challenges they faced in finding and plotting the online data for homework and what	20

data	challenges their students may have.	
G. Big Chart of Data Skills	Participants are also introduced to the Big Chart of Data Skills to keep track of skills throughout the session and course.	10
H. Discussion: *Value of local ecological data*	Participants reflect on and discuss the value of using local ecological data as a pedagogical tool to improve the efficacy of learning, relevancy of content to students, and identity with ecological processes and global change.	15
I. Homework	1. **Read using active reading strategy:** Framework for K-12 Science Education Chapter 2. P.23-36 **Journal:** What does it mean to teach in a 3-dimensional way? And, how might this be different from how science has been taught and assessed traditionally? 2. **Read and chart ideas on handout:** Framework for K-12 Science Education Chapter 3. Science and Engineering Practices: Developing and Using Models, and Constructing Explanations and Designing Solutions. **Chart:** How has the instructor and the learner used these Science and Engineering Practices as they learned science content in previous sessions. 3. **Read and chart ideas on handout:** Framework for K-12 Science Education Chapter 4. Crosscutting Concepts:Energy and Matter, and Systems and System Models. **Chart:** How has the instructor and the learner used these Crosscutting Concepts as they learned science content in previous sessions.	5
	TOTAL: 2 hrs 50 mins	**170**

Optional / Additional Resources

Data Activity:	Participants discuss and explore, through developing their own Key	20 minutes

Choosing Data Visualizations to Match Your Question	of Data Visualizations, some of the different data visualizations that can be used depending on what one would like to show in the data (i.e. what your question is). Note: A handout addressing these ideas will be provided in Session 9 for participants to use as they design their own data activity.	
Archived Data Activity: *Analyzing surface water data from different coastal Reserves*	Participants interpret water temperature data from coastal reserves collected for homework. They synthesize concepts from previous sessions and construct explanations for differences between Reserves and patterns they observe. Participants compare two different data parameters collected simultaneously (i.e. air and water temperature) and reflect on what the experience means in terms of exposing their students to authentic data and multiple variables at the same time.	50 minutes

Session Details

A. Homework Reflection Think-Pair-Share: *How People Learn*

1. **Think Pair Share – How People Learn.** Have participants reflect back on their homework assignment reading and responding to *Key Ideas from the Literature: How People Learn*. Remind them of the four prompts and ask them to **think** about what they would like to share about each of them:
    a. Describe what you think are the most important ideas from each section.
    b. How can the ideas about learning described in the reading be useful and relevant to you as a learner?
    c. When you teach, how might you use what you know about how people learn to help your learners ***make sense*** of the science?

2. **Share ideas with small group.** Encourage participants to share their ideas about each of the prompts with their small group. Remind them to challenge their small group to provide examples, details and evidence to support their ideas.

3. **Introduce session goals.** Project the Goals slide and briefly introduce each goal with a description of how they are connected and flow from one to another.

    - **Climate science ideas:** Understand that:
        - The ocean warms cold air and cools warm air. The ocean keeps temperatures more even all over the planet. (OSS 1.4)
    - **Using Data:** Continue to build on skills covered in previous sessions and explore ways to:
        - Find high quality and reliable sources of data online.
        - Articulate what the different variables (controls, independent, dependent) are within an investigation or data visualization.
        - Engage students at three different levels with data visualizations—orientation, interpretation, and synthesis.

- **Teaching & Learning:** Discuss the importance of using local ecological data as a pedagogical tool to improve the relevancy of concepts, ecological processes, and global change.
- **Framework/ NGSS:** Experience shifts in teaching and learning as described in the Framework for K–12 Science Education and NGSS. Read selected Science and Engineering Practices and Crosscutting Concepts.

B. Activity: *Nonsense Data*

1. **Set the context.** Tell participants that similar to how they reviewed ways to think through how to most effectively develop learning experiences through the Learning Cycle, it is important to think through how to most effectively teach using data to build learners' data literacy skills.

2. **Define data visualization**.Tell participants that an important aspect of being comfortable with data is being able to interact with data visualizations. Remind participants that a "data visualization" refers to any format of looking at data.

3. **Introduce activity.** Tell participants that this next activity will give them a better understanding and reminder of what it is like for a novice data user to interact with a data visualization.

[**Note to instructor**: *Expert data users process multiple components of a data visualization at once when orienting to it, interpreting the data, and synthesizing what the data means in relation to other information. However, many novice data users (like our students) struggle with interacting with data visualizations — they often do not know where to start looking, how to make sense of what they see, and how to relate it to other concepts being discussed in class*].

4. **Display Activity Instructions.** Divide the class into three groups - Group 1, 2, and 3. Tell them as they work through the activity which includes two different handouts, they should:
    a) note which skills they are using in order to answer the questions;
    b) think about what they paid attention to;
    c) reflect on how they arrived at their answers; and
    d) think about what they could and could NOT answer.

5. **Distribute Handout A.** Tell participants they have about 2 minutes to complete this handout. Circulate and listen to participant conversations as they work to complete Handout A. Answer clarifying questions pertaining to the activity instructions above, but don't provide any answers to the questions on the handout.

6. **Distribute Handout B.** After the groups have finished with Handout A, provide them with Handout B and give them about 3 minutes to work on it. Again, continue to circulate to make sure the participants understand what they need to do, but do not provide them with any answers to questions on the handout.

7. **Turn and Talk - Debrief activity components.** After the groups have worked on Handout B for about 3 minutes, regain their attention and ask the participants to talk about the following questions with someone next to them:
    a) Were you able to answer the questions on Handout A?
    b) What about the questions on Handout B?
    c) Were the questions difficult or easy?
    d) Where did you find the information you needed?
    e) What skills did you use to answer the questions?
    f) How did you report this information?
    g) What skills or information would you need to be able to answer your unanswered questions?

8. **Turn and Talk - Debrief activity implications.** Have the participants turn and talk with a partner about what aspects of this activity they found surprising and what implications could this activity have on how they teach with data to their future middle school (or other) students.

9. **Whole group debrief.** After a few minutes, regain the attention of the whole group and have volunteers share what they were discussing.
    a. As participants add to the conversation, ask others if they discussed different or other things that they would like to include in the conversation.
    b. Record some of the implications that participants bring up in the conversation.

c. If it doesn't come up, you may want to conclude the discussion by emphasizing how this activity demonstrates that you can easily answer questions about what is on the graph without understanding the data, but it is difficult to answer questions that require you to synthesize the information without understanding the data. Therefore, it is important to think critically about what kinds of questions you are asking, and what leaps in understanding you are asking the students to make.
d. Tell participants that next they will discuss tips for how to make sure to provide those opportunities to students through the remainder of the course.

10. **Concluding the discussion.** Tell participants that this activity was intended to give them a sense of what students will be feeling/doing when teachers introduce data into their classrooms, and insights on what they can do as educators to help their students be more successful. Emphasize that this is not an activity that they should do with their students for the following reasons:
    a. it would lead to frustration, and
    b. potentially send the wrong message that the students should try to answer synthesis level questions, even when they do not have enough information, just to provide an answer for the teacher.

C. Reflection: *What helps us make sense of data?*

1. **Graph Reflection Turn and Talk**. Show the slide "What helps us make sense of data?". Ask participants to turn and talk to their neighbor about what they would need to do as a teacher to help their students interpret the displayed graphs to understand the overall annual pattern of air temperature changes at an unidentified location.

2. **Graph Reflection Debrief**. As the turn and talk progresses, quickly sketch a table with three columns on the board and label them: Orientation, Interpretation, Synthesis. After a few minutes of discussion, regain the attention of the class, and ask for volunteers to share with the whole class some of the points that came up in their discussions. As they share, ask others if they talked about something similar or different and if they want to add anything else to the conversation. As participants share their thoughts, try to capture the essence of their statements on the table, assigning the comments as appropriate to one of the three columns.

3. **Introduction to Three Levels of Engagement with Data Visualizations**. Remind participants that they were provided with a handout in Session 3 (Data Skills used in working and teaching with data) that introduced these terms. Also remind them of the definition of data visualization (any visual form of looking at data – table, graph, figure, chart, image, map, etc.)

4. **Explain the Three Levels of Engagement with Data Visualizations**. Project the "Three Levels of Engagement with Data Visualizations" slides. Explain the different steps necessary for engaging with a data visualization:
    - *Orientation* – This is the stage to ask "what is there on the page?" To answer this question, engage in the following tasks:
        i. Determine what are the units of measurement in the graph.
        ii. Determine where the data were collected.
        iii. Understand the context of the data – i.e what each variable mean.
    - *Interpretation* – Following orientation, ask the question "what does the data on the page show?" To answer this question, engage in the following:
        i. Use pattern recognition to determine what is going on in the data in relation to the axes and other points.
        ii. Determine if there are outliers in the data.
        iii. Decide what the pattern in the data shows with respect to the variables.
    - *Synthesis* – After interpretation of the data patterns on the page, ask the question "what does the data pattern explain regarding what is not on the page?" To answer this question:
        i. Articulate what the data pattern means with respect to things off of the page that you know.
        ii. Discuss whether the data look plausible and if you think they are reliable.
        iii. Think about whether your conclusion would change if you had more data or data from a different variable.

5. **Summarize.** Remind participants that all three of these levels are critical to truly understand and make sense of data, and in fact whenever anyone – novice or expert – looks at a data visualization they need to go through all three levels of engagement to fully understand what is included in the visualization.

- It is critical to provide opportunities to engage in all three levels repeatedly when looking at data, especially data of a new variable or a new visualization of data.
- It is only over lots of time and practice that expert scientists can move quickly through or even skip some of these steps when making sense of data.

Ask participants if they have any clarifying questions about the three levels of engagement with data visualizations.

D. Activity: *Engaging with Data Visualizations - Air Temperatures*

1. **Introduce Activity**. Explain that participants will do a short activity to further explore using the 3 Levels of Engagement in teaching by looking at air temperature from two mystery locations. Participants will work with a partner to complete the activity and answer a series of questions to facilitate their understanding of the data and results.

2. **Hand out procedure and data graphs.** Provide each partner group with a worksheet of the procedure and the data graphs (Page 1 of "*Engaging with Data Visualizations - Air Temperatures from Different Locations Activity*" handout). Have participants read through the procedure and ask if anyone has any clarifying questions.

3. **Display Earth is Heated Unevenly slide (and optional handout).** Briefly explain the slide and tell participants that this information may be a helpful reminder when they are working through the activity (It can also be distributed as a handout - Optional-Earth is heated unevenly).
    - The Sun heats Earth unevenly.
    - Places near Earth's equator are generally warmer than the poles.
    - Places near Earth's equator change less in temperature from winter to summer than places near the poles do.
    - When it's summer north of the equator, it's winter south of the equator. When it's winter in the north, it's summer in the south.

4. **Begin the activity**. After participants have read through the procedure, distribute the *Engaging with Data Visualizations - Air Temperatures Activity Handout A: Orientation* (Page 2). Walk

around while the participants perform the activity (*refer to the* "*Engaging with Data Visualizations - Air Temperatures Activity Answer Key" if desired*).

5. **Data Interpretation Handout**. As the groups finish *Handout A: Orientation*, provide them with *Engaging with Data Visualizations - Air Temperatures Activity Handout B: Interpretation* (Page 3) to complete.

6. **Data Synthesis Handout**. As the groups finish *Handout B: Interpretation*, provide them with *Engaging with Data Visualizations - Air Temperatures Activity Handout C: Synthesis* (Page 4) to complete.

7. **Activity wrap-up; discuss results and conclusions.** After participants complete the last handout, regain the attention of the class to briefly discuss their results and conclusions about the locations of where these air temperature data were collected.

8. **Quick Write reflection**. Tell participants to do a quick write on the following questions to reflect on the activity related to the levels of engagement with data visualizations:
    - What skills did you need as a learner to be successful with each step of the activity – answering the orientation questions, answering the interpretation questions, and then answering the synthesis questions?
    - What did the instructor (or worksheet) do to support you in the learning experience?

9. **Levels of Engagement with Data Visualizations Wrap-up**. After 5 minutes, invite participants to share aspects of their reflections with the class. Remember to ask if anyone:
    - wrote something similar or different, and/or
    - wants to add something else to the conversation.

    Encourage participants to continually think back to these three levels of engagement with data visualizations (orientation, interpretation and synthesis) as they are participating in the rest of the course to think about how they as learners are engaging with the data and how they could assist their students to successfully engage with the data.

E. Activity: *Making Evidence-Based Explanations and Three Corners activity*

(OSS 1.4).

1. **Introduce the activity.** Tell participants that they are about to apply what they have learned so far about the ocean as a heat reservoir, as well as some additional background information, to make predictions about air temperature profiles of the average monthly temperatures in different parts of the US.

2. **Introduce Evaluating Five Explanations.** Tell participants that in a few minutes, they will work in groups to figure out the mystery locations. But first, they'll look at five explanations given by five make-believe students. Participants will discuss whether these explanations are backed up with evidence and if the evidence cited is reliable.

3. **Project slide, example: Mystery Locations.** On the two temperature line graphs orient the participants to the graph by pointing out the *x* axis (months of the year) and the *y* axis (average temperature). Ask the participants the interpretation questions of **"Which graph shows generally warmer average temperatures?"** [Location 2.] **"Which graph shows a bigger change in temperature from winter to summer?"** [Location 1.]

4. **Turn and Talk about Mystery Location example.** Have participants turn and talk about which of the temperatures would match Hawaii and which would match Alaska to begin to synthesize the information from the graphs. Remind them to discuss evidence that supports their ideas. After about two minutes, ask a few pairs to share out. Accept all ideas, probe for evidence, and don't correct participants' ideas at this time.

5. **Review Scientific Evidence chart.** Draw participants' attention to the Scientific Evidence chart and remind them that evidence can come from our or from other people's investigations, and it includes reasoning about why it counts as evidence.

6. **Project five explanation slides, What's wrong with this explanation?** For each slide, lead a brief discussion about what's wrong with each explanation:
    - **Explanation #1.** The explanation provides no evidence, only opinion.
    - **Explanation #2.** The explanation provides no evidence, just saying "the evidence" is not

specific enough.

- **Explanation #3.** No reasons are given for the temperature difference. Some evidence backs up the explanation, but the evidence is based on personal opinion (warm vs. cold instead of actual temperature readings; one person's cold may be another person's warm) and observation during a single point in time. It would be better if there were evidence from careful investigations over time.
- **Explanation #4.** This is a good explanation because it uses evidence and tells where the evidence came from. The evidence fits the explanation and makes sense. However, this isn't a complete explanation because it contains no reasoning.
- **Explanation #5.** This is a complete explanation because it includes reasoning as well as the evidence.

7. **Project slide – What makes a good scientific explanation?** To sum up, emphasize that a good scientific explanation is supported by strong and reliable evidence. Go over three key points: the evidence supports the explanation; the evidence is based on carefully collected data and information, and the evidence is from a reliable source. Point out that a casual observation (such as when the student noticed Hawaii was hot) is not as strong as evidence showing measurements taken over a long time. Leave this slide projected during the next activity.

Three corners mystery locations - NERR sites around the US

1. **Introduce the three corners mystery locations activity.** Tell participants that they will now determine if the climate science ideas they've learned can help them solve a mystery.

2. **Distribute handouts.** Pass out a copy of the Mystery Locations handout_different axis or _same axis (with graphs and map) to each pair of participants. Simultaneously, show a slide with the graphs and map. Remind participants that these are again similar types of line graphs of air temperature that we have looked at previously, but this time they don't show just the monthly averages.

3. **Explain handouts.** Clarify that the three locations share the same approximate altitude (distance above sea level) but that not all share the same latitude. Additionally, if you have chosen the graphs with different axes, help orient the participants to the graphs by drawing their attention to the differences in temperature ranges on the Y-axis of the three graphs. *[***NOTE:** *Remind*

participants that some middle school students may find interpreting data from different graphs challenging when the scale of the y-axis differs. The curriculum provides two versions of the handouts and slides with similar vs. different y-axis scales. Choose accordingly based on the level of your students.]

4. **Identify the three corners.** Point out the three corners of the room with A, B and C posted on them. Tell participants that they will now have one minute to decide which data set represents Jacques Cousteau Reserve (NJ). Once they have selected the data set, they should move to the corresponding corner of the room, with that data set's letter displayed (A, B or C). They should also bring their notebooks and handouts with them.

5. **Participants explain why they are in that corner.** After no more than one minute, make sure that all participants have selected a corner. Ask all participants to turn and talk to the person standing next to them about why they selected that particular corner.
    - What is the evidence that the data set matches the location of Jacques Cousteau Reserve on the map?
    - What is the evidence that the data set does not match the location of Jacques Cousteau Reserve on the map?
    - What is the evidence that this data set does not belong to one of the other locations?

    Make sure that all participants remain in their corner, even if they change their mind at this point.

Collect evidence for and against.

1. **Create an evidence table on the board.** While participants are talking, on the board (or on chart paper), create a large evidence table as shown below. Leave plenty of room in each of the evidence cells.

    Jacques Cousteau Reserve, New Jersey

Data set	Evidence for	Evidence against
A		
B		
C		

2. **Whole group discussion from corners.** Ask a representative from the corner with the most people to share out his/her rationale for selecting that corner, providing:
    - evidence that connects the data set with the map location for Jacques Cousteau Reserve,
    - evidence against the data set matching other locations.

3. **Switching corners.** Tell participants that anyone is welcome to change their corner at any time. However, they will have to state their reasons for moving before changing spots, including:
    - What was convincing about what someone else said?
    - Why they no longer agree with their original decision?
    - What evidence convinced them that their original selection was incorrect?

4. **Record evidence on the chart.** As participants share their evidence for and against each data set, record their evidence for and against on the table.

5. **Why record evidence for and against?** Tell participants that you are recording evidence for and against the different claims because:
    - It is just as important to understand why the claim supported by less evidence is a less likely conclusion as it is to understand why the claim supported by stronger evidence is a more likely conclusion—this leads to deeper understanding of concepts.
    - It also supports student understanding of how science works. In science, ideas are accepted or refuted based on the quality and strength of evidence. Scientists change their thinking when more convincing evidence points to acceptance of a different claim. This is what is meant by scientific debate, which is different from the colloquial use of debate focused on changing people's opinions.

[**Note to instructor**: *it is better to avoid terms like accurate and inaccurate as that can fuel the perception that science has a correct or proven answer; rather than when there is a large amount of evidence for something it is the most likely explanation. It may be good to review this with participants as a concrete way to reinforce in their teaching how important it is to present science as a probabilistic endeavor rather than a deterministic field.*]

6. **Call on a second corner to share out (optional).** If more information may come out, call on a participant from a different corner to share their thinking. Continue asking the questions

suggested above, allowing participants to change corners, and recording evidence.

7. **Wrap up the discussion.** When all, or nearly all, of the participants have gravitated toward corner B, have one person summarize the discussion by reviewing the evidence for data set B on the table as well as the evidence against data sets A and C. Leave the evidence table displayed.

8. **Leading this activity with students.** Tell participants that if you had done this activity with middle school students, you would have begun the activity in partners and given students more than one minute to select a corner. You might also have given them graphs with consistent temperature ranges on the y-axis to reduce the challenge of interpretation.

Recording evidence for and evidence against.

1. **Prepare participants to write about their claims.** Have participants return to their seats with their Mystery Locations handout_different axis or _same axis (depending on which one you used). Distribute the Mystery Locations Response Worksheet handout. Leave the evidence table, graphs and map visible.

2. **Participants write about their claims.** Have participants record their scientific explanation regarding Jacques Cousteau Reserve being the location connected to Data Set B in the correct location on the Mystery Locations Response handout. Ask participants to refer back to the evidence table to support their claim with as much evidence as they can.

3. **Record evidence against other locations.** Once they are done with the evidence for Jacques Cousteau, have them complete the response worksheet with their evidence for why each data set is (or is not) matched to the locations A and C.

4. **Describe how students complete this activity.** Tell them that their students would be ready to tackle the other two examples in pairs or on their own at this point, and they could use their explanations for how they matched the other two locations as an embedded assessment.

F. Homework Discussion: *Online Data*

1. **Quick Write - Challenges of accessing online data.** Have the participants reflect on their homework in writing. Post the following questions:
    - What challenges did you encounter doing the homework of finding and plotting data through the NERRS online data portal?
    - Think about what challenges your students may face doing a similar task.

2. **Discuss quick write reflections.** After 3 minutes, ask several participants to share their quick write reflections.

3. **First of multiple encounters with NERRS online data portal.** Explain to the participants that this was the first of multiple encounters that they will have with the NERRS online data portal throughout the course. Through each activity they should be continually thinking about what challenges they face and what challenges their students might face when they interact with an online data portal.

G. Big Chart of Data Skills

1. **Introduce the class Big Chart of Data Skills.** Tell participants that they will create a chart for all the data skills that we practice and develop throughout the course. Because data skills are also integral to effectively implementing the Science & Engineering Practices in NGSS, the Science & Engineering Practice addressed by each data skill will also be recorded, but not at this time.

2. **Add to the Big Chart of Data Skills**. Have participants think about which data skills they have engaged in during the course to date, using the Data Skills Used in Working & Teaching with Data handout (first introduced in Session 3) as a reference. Encourage them to include what they were asked to do as learners and things that their instructors did to facilitate their learning. After a couple of minutes of individual work, have them turn and talk to a partner to share ideas, and then for those skills that they agree upon, write them on a sticky note and add them to the poster. Some data skills and practices they might suggest include:

	Teacher	***Learner***	***NGSS Science & Engineering Practices***

Prior to Having a Data Visualization	*- Discussed benefits and limitations of using simulated data (Session 2.B, 2.C, 3.G)* *- Differentiated between types of data (Session 3.G)*	*- Used simulations (Session 1.D, 2.B, 2.C, 3.C)* *- Discussed benefits and limitations of using simulated data (Session 2.B, 2.C, 3.G)*	
Data Orientation	*- Pointed out basic components of graphs (Session 1.D)* *- Attended to details and context of data (Session 2.C, 4.B, 4.D)*	*- Articulated basic components of graphs (Session 2.B, 2.C, 3.C, 4.B, 4.D)* *- Attended to details and context of data (Session 2.C, 4.B, 4.D)*	
Data Interpretation	*- Looked into conclusions from raw and averaged data (Session 1.D)*	*- Used raw and averaged data for conclusions (Session 3.Optional)* *- Compared different data sets (Session 3.C, 4.D)*	
Data Synthesis	*- Used patterns in data to explain what data indicates (Session 1.D, 2.B, 2.C, 4.B, 4.D)* *- Related data pattern to larger science concept (Session 2.B, 4.D)* *- Compared predictions to data patterns (Session 1.D, 2.B, 2.C, 3.C)*	*- Used patterns in data to explain what data indicates (Session 1.D, 2.B, 2.C, 4.B, 4.D)* *- Related data pattern to larger science concept (Session 2.B, 4.D)* *- Compared predictions to data patterns (Session 1.D, 2.B, 2.C, 3.C)*	

H. Think-Pair-Share: *Local Ecological Knowledge*

1. **THINK: Connecting NERRS data with local ecological knowledge.** Ask participants to think about any previous experiences they have had using data or observations that were collected in

local places or natural ecosystems with which they were familiar. Provide each participant with a Value of Local Ecological Knowledge in the Classroom handout and ask them to write down ways in which local ecological data or knowledge improved the quality of their learning experience.

2. **PAIR: Discuss with a partner.** After two minutes, tell participants to pair up with their neighbor to explain and discuss their written responses. After approx. 2-3 minutes (and if class size allows), ask each pair of students to join a neighboring pair. Ask each group of four to share their reflections, then discuss the following prompt:
    - In what ways could using locally-collected data improve the ability to teach science to middle school students?

   Remind participants to record their responses and be prepared to share out with the whole group.

3. **SHARE: Whole group discussion.** Prompt participants to share their group's discussion with the rest of the class, and record their ideas on chart paper. Facilitate the discussion and reporting out so as to build a working list of the value of using local data and generating local ecological knowledge. If participants don't address these ideas during the discussion regarding the pedagogical value of using local environmental data, both through learner-generated data and also especially through authentic real time data sources, point out that:
    - Students make personal connections to their local natural environment and the patterns that are there through the data.
    - Helps make abstract concepts more relevant and accessible because they are happening in the students' "backyard."
    - Ecological processes and global change become more relevant when it is evident that they are impacting local waters and/or ecosystems.
    - It is a portal (i.e. invitation) for engaging students in classroom activities when the data are relevant to activities of interest (e.g. sailing, surfing, outdoor sports) outside of school.
    - Allows local, place-based investigations of nearby ecosystems without having to go in the field (for online real time data).
    - Additional ideas related more generally to the value of working with authentic data include:
        - Allows students to formulate and test hypotheses using "real data."

- Allows student to interact with data the way that scientists do.
- Students can investigate the ocean without having to go to the ocean.

4. **Wrap-up**. Display the charted ideas and slide, and ask the participants to add any ideas from the lists that they missed to their handout. Suggest that they continue to add to this list as they grow in their own learning and skillsets for working with data.

I. Homework

Show slide of Homework Assignments. Describe Tasks as follows:

1. **Read & use active reading strategy:**
   Framework for K-12 Science Education Chapter 2 Guiding Assumptions and Organization of the Framework pp.23-38 (Links to an external site.)

   Journal: What does it mean to teach in a 3-dimensional way? And, how might this be different from how science has been taught and assessed traditionally?

2. **Read and record ideas about Science and Engineering Practices.** Provide participants with the individual copy of the Big Chart of Science and Engineering Practices. Instruct them to:

   Read: Framework for K-12 Science Education Chapter 3. Science and Engineering Practices: Developing and Using Models, and Constructing Explanations and Designing Solutions

   Framework for K-12 Science Education Chapter 3. Science and Engineering Practices: Practice 2. Developing and Using Models P.56-59

   Framework for K-12 Science Education Chapter 3. Science and Engineering Practices: Practice 6. Constructing Explanations and Designing Solutions P67-71.

   Chart: How have the instructor and the learner engaged in these Science and Engineering Practices as science content was learned in previous sessions?

3. **Read and record ideas about Crosscutting Concepts.** Provide participants with the individual copy of the Big Chart of Science and Engineering Practices. Instruct them to:

   Read: Framework for K-12 Science Education Chapter 4. Crosscutting Concepts: Energy and Matter, and Systems and System Models.

   Framework for K-12 Science Education Chapter 4. Crosscutting Concepts: Systems and

Systems Models. P.91-94.

Framework for K-12 Science Education Chapter 4. Crosscutting Concepts: Energy and Matter: Flows,Cycles, and Conservation. P.94-96.

Chart: How has the instructor and the learner used these Crosscutting Concepts as they learned science content in previous sessions?

Optional / Additional Resources

Data Skill Activity: *Choosing Data Visualizations to Match Your Question*

[**Note to instructor**: *The kind of data visualization that you use is largely determined by what your question is and what kind of data you have, however we rarely teach people the basics of how to choose an appropriate data visualization. This activity provides a way for participants to gain better skills and understanding of when to use a variety of common data visualizations.*]

1. **Introduce Variety of Data Visualizations.** Talk with participants about how there are multiple things that you can be interested in showing through a data visualization (using a slide that has lots of different examples of different data visualizations). The first step in deciding what type of graph/figure/plot/map etc. to use is to understand what kind of data you have and what you are trying to show. For instance, you may want to show:
    - A comparison of values between variables,
    - Or, the distribution of a variable across a range of possible values,
    - Or, the composition of the components of the variables.

    Each of these different ways of showing data have their own data visualization that should be used. It is important to choose the correct data visualization for the data that you have, and the question you are asking of the data. One way to think about this is that the relationship among data visualizations and the kinds of data are like different sports and their particular equipment to use in each sport; data visualizations are specific to the kind of data that you have. You would not be a very good tennis player if all you had were soccer cleats and shin guards. Similarly, it would be difficult to interpret the distribution of a variable if it were plotted only as a comparison of the average value.

2. **Introduce activity; show handout slide**. Tell participants they will work in small groups to come up with their own Key of Data Visualizations using the provided Data Visualization Handout and Charts. Demonstrate how they will work together to arrange the different chart options onto the handout to line up the different types of charts into the open boxes. Tell them that they have the exact number of charts for the boxes. Once the group has completed the organization of the charts onto the handout, have them write a description on the back of the handout explaining why they organized the charts the way that they did. Ask if there are any clarifying questions.

3. **Small groups do activity.** Have participants form groups of 3-4 and distribute supplies for each group. As the participants are putting their charts on the open boxes in the handout, walk around the room and answer questions about the types of charts and/or the ways that data visualizations can show aspects of the data. (Note: do not answer questions about whether the participants have the charts in the correct locations.) If the participants are really struggling to understand what the types of chart are showing, have them use resources like: The Data Visualization Catalogue (http://www.datavizcatalogue.com/), Introduction to Data Visualizations: Visualization Types (http://guides.library.duke.edu/datavis/vis_types), or the Data Visualization: Examples of Diagrams used for Data Visualization (https://en.wikipedia.org/wiki/Data_visualization).

4. **Groups compare and contrast their charts.** After the groups have completed organizing the charts and writing down their explanations of why they organized the charts the way that they did, have neighboring small groups join together and swap handouts. First let each group read through the completed handout of the other group. Then have the groups discuss amongst themselves:
    - What aspects of the organization were similar or different between the two groups?
    - What aspects of the reasoning varied between the two groups?
    - What additional questions do you have about how to choose a data visualization for your data?

    As the participants are talking, walk around and listen to their conversations. Then when you think it is appropriate, pass out the Answer Key to each participant so that they can compare their answers with the answer key and so that they can have a completed correct Key of Data Visualizations to keep for their reference later.

5. **Review words associated with graphs.** As the conversation slows down, review with the participants that a great way to think about what kind of chart to use is to think of what words you are using to describe your data. For instance,
    a. If you are using words like "before/after, categories, compare, contrast, over time, peaks, rank, trend, types, valleys" then you are making a Comparison and will probably want to use a Bar Chart or Line Chart.
    b. If you are using words like "cluster, distributed, from/to, plotted, points, spread, spread over, relative to, transfer" then you are looking at Distributions and will probably want to use a Histogram, Bubble Chart, Scatter Chart, or Box Plot.
    c. Finally, if you are using words like "components, divided up, group, makes up, of the whole, parts, percentages, pieces, portion, proportion, slices, subsections, total" then you are looking at Compositions and will probably want to use a Pie Chart or Stacked Area Chart.

    It is important to note that these are in no way all of the possible charts that exist, for example we have not included any maps, but they do cover many of the common data visualizations that you will use with your students in your teaching with data.

6. **Whole group debrief.** Once the group discussions begin to slow down, regain the attention of the whole class and ask the participants to share any thoughts or opinions they have about learning which data visualization goes with the different ways you want to show data, and/or any additional questions they have about choosing the appropriate data visualization.

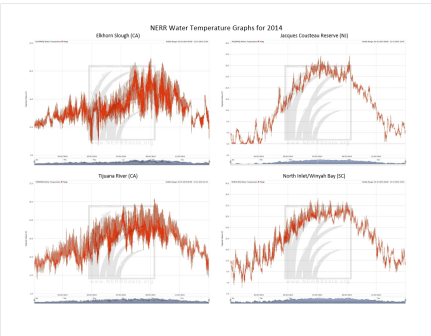
Archived Data Activity: *Investigating Surface Water Temperature at NERR Reserves*

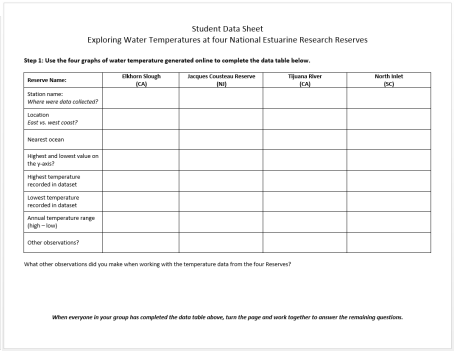
[**Note to instructor**: *There is a benefit to looking at a range of variables when making a conclusion about the environment. This activity provides participants an opportunity to look at water temperature data from the same Mystery Locations that they looked at air temperature previously. Another key benefit of this activity is that it demonstrates how you can scaffold and support conceptual understanding using professionally-collected data.*]

1. **Introduction and concept review**. Have participants reflect back to the Mystery Locations activity from Session 4 where they discussed factors influencing air temperature data from three

different locations (i.e. Jacques Cousteau Reserve (NJ), North Inlet/Winyah Bay (SC) and Urbana (IL)). In this optional activity, participants will extend this exploration of authentic environmental data to include water temperature at four different National Estuarine Research Reserves, located on the east and west coasts of the United States.

2. **Data assignments.** Have participants convene in their groups of four and share their NERR water temperature graphs created for homework prior to class. Make sure each group has all four reserves represented (i.e. Tijuana River (CA), Winyah Bay (SC), Elkhorn Slough (CA), Jacques Cousteau Reserve (NJ)). If participants do not have data printouts from homework they can be printed using the "NERR Water Temperature Graphs" file.




Student Data Sheet
Exploring Water Temperatures at four National Estuarine Research Reserves

Step 1: Use the four graphs of water temperature generated online to complete the data table below.

Reserve Name:	Elkhorn Slough (CA)	Jacques Cousteau Reserve (NJ)	Tijuana River (CA)	North Inlet (SC)
Station name: *Where were data collected?*				
Location *East vs. west coast?*				
Nearest ocean				
Highest and lowest value on the y-axis?				
Highest temperature recorded in dataset				
Lowest temperature recorded in dataset				
Annual temperature range (high – low)				
Other observations?				

What other observations did you make when working with the temperature data from the four Reserves?

When everyone in your group has completed the data table above, turn the page and work together to answer the remaining questions.

3. **Working with the data to answer the questions.** Once each group has all four graphs, hand out copies of the "Student Data Sheet - Exploring Water Temperatures at four National Estuarine Research Reserves" and have participants work together to complete the data table by collecting data from their water temperature homework graphs. The worksheet also has questions which they will work together to answer, including

Data Orientation Questions:

a. What kind of graph is being used to display the data? What type of data are represented by the x- and y-axis of the figures? [*line chart or scatter chart*; *x-axis is time, y-axis is water temperature (C)*]

b. How do you think water temperature data were measured and recorded? [*Answers will vary. Water temperatures are collected using a submerged sensor deployed at each site and transmitted via remote cellular connection to the database server.*]

Data Interpretation Question:

c. Did the timing of periods of warm and cold water differ among the four reserves? Explain. [*Answers will vary. Confirm that claims and interpretations are based on evidence from the data in the graphs. Temperatures are generally warmer/colder in summer/winter months.*]

Data Synthesis Questions:

d. Warming of surface waters occurs later in Oregon than the other east coast reserves. What do you think might explain this pattern? [*Answers will vary and depend on prior knowledge. The earlier warming of east coast waters is associated with the influence of the warm Gulf Stream current, as well as shallow waters across the continental shelf that warm more quickly during spring and summer. Coastal Oregon is influenced by cold, deep Pacific ocean water that takes longer to warm as the summer progresses.*].

e. Compare the different temperature scales (i.e. y-axis) on the four graphs. How did this influence your interpretation of patterns and making comparisons among the Reserves? What challenges this present to middle school students trying to make these comparisons? How would you address this challenge? [*Answers will vary*].

Example of entries for the Data Table

Reserve Name	***Jacques Cousteau Reserve***	***Winyah Bay/North Inlet***
Station:	*Lower Bank*	*Oyster Landing*
Location	*East Coast (New Jersey)*	*East coast (South Carolina)*
Nearest ocean	*Atlantic Ocean*	*Atlantic Ocean*
Highest temperature recorded	*31.4 ℃*	*34 ℃*
Lowest temperature recorded	*0 ℃*	*2 ℃*
Annual temperature range (high – low)	*31.4 ℃*	*32 ℃*
Other observations?	*Looks like the water froze in January and there was a spike in water temp in September*	*Similar to Jacques Cousteau reserve, but water never got to freezing*

4. **Making explanations, more data synthesis:** Participants will further explore the patterns in their graphs. (*Note to instructor: this is considered 'synthesis' as the students are thinking about what could be drivers and explanations of what is happening based on information they already know.*) Provide students with the following prompt "**How do you think the following factors might explain differences in annual water temperatures at the four reserves?**" Have them discuss two factors from the list below and encourage them to use evidence in their explanations

whenever possible.

a. Location on the east vs. west coast
b. Latitude of the reserve
c. Season
d. Surface or deep ocean currents

5. **Comparing air and water temperature data, more data synthesis**: Have participants return to their explanations from the "Three Corners Mystery Locations Activity" (Session 4E) where they identified the location of three air temperature datasets. Have them discuss the following prompt: "**Does the water temperature data from Jacques Cousteau Reserve and North Inlet Winyah Bay provide additional evidence in support of your claims regarding the location where air temperature data from Location A and Location B were collected?"**

6. **Turn and Talk about data activity.** After participants have completed the data activity, have them turn and talk to a neighbor about the following prompts. Depending on the time available, you may want to have participants choose two to discuss and then share out with the rest of the class.

   - What skills did you use to compare the air and water temperature data to look for relationships? [*recognize components of graph to read it, attention to scale of variables, attention to how data collected, comparing maximum and minimum values, looking at and comparing patterns from two graphs, using patterns in data to support explanations, relate patterns to prior knowledge and broader concepts, add a new data source in to make further sense of the data*].

   - Based on your experience with this data activity, what are some of the opportunities and challenges that come to mind when you consider using authentic online data resources with your students?

     [*Pros: Students can explore and work with data like scientists do; online datasets can support student-led inquiry when the students are able to choose what aspects of the data to use; students who are computer savvy who enjoy working online bring this skillset to the group investigation; students have great empowerment or ownership of the data if they access it themselves.*

     Challenges: Many students may find it difficult to navigate data portals as they are often

built for scientists rather than general users; the large datasets can be overwhelming; there can be lots of natural variability in authentic data as the data has not been "cleaned" to remove the natural variability, making interpretation of patterns potentially difficult if you are not used to look at variation in data; the context of the data and how it were collected can sometimes be difficult to find an/or understand.]

- Did these comparisons provide further evidence for the importance of the ocean in regulating air temperature? Explain.[*Answers will vary. One explanation is that the similarity in maximum and minimum temperatures - as well as the total temperature range - are similar when air and water data are compared for any given reserve. This suggests ocean temperature is regulating air temperature*].
- What additional information about these two reserves did you learn from looking at the air temperature data for a second time (e.g., what did you see/understand this time that you didn't last time)? [*Answers will vary*].

7. **Whole group sharing.** After 5 minutes, ask participants to share their ideas with the whole group about any of the three prompts above. Encourage other participants to engage with their classmates and actively participate in the conversation. As the discussion slows down highlight for the participants that working with data and developing confidence in working with data is something that takes a lot of practice and repetition for all levels of learners.