Session 5: Three Dimensional Instruction of Energy and Matter

Overview

In this session, participants examine their understanding of how the ocean and atmosphere are interconnected. They write their initial ideas, and are then presented with a puzzling weather phenomenon. As they apply their understanding of science concepts about ocean and air currents, participants explain the phenomenon. As an optional activity, participants move from observing a local weather pattern to looking for patterns in global atmospheric and oceanic phenomena, and construct explanations using the patterns and the questions they have about these phenomena. Participants then complete an assessment about the science ideas covered in the sessions so far, and are provided with the tools designed to support students with this task. They use a scoring guide to examine how the assessment measures conceptual understanding, and discuss how different forms of assessments can be used to inform instruction. Participants also take a close look at what middle school students are expected to know and be able to do in the content areas covered in the course so far. They dissect the three dimensions in each of the NGSS middle school performance expectations and discuss how the experiences they were provided supported them to meet these expectations, and what supports are still needed. Finally, participants consider how use of phenomena can provide authentic contexts for students to explore and deepen their understanding of science concepts, and generate examples of possible phenomena to support science concepts about the carbon cycle that will be addressed in the next session and future sessions including lessons from OSS Unit 2.

Session Goals

Theme	Goals
Climate Science Ideas	Deepen understanding of the ocean-atmosphere connection and consider the water cycle through the lens of energy and matter. Understand: ● Evaporation and condensation move heat energy around Earth (OSS 1.10). ● Winds caused by differences in air density move heat energy (inside water

	vapor molecules) around the world (OSS 1.10). ● The water cycle, winds, and ocean currents distribute heat energy around Earth, and that keeps temperatures more uniform (OSS 1.11).
Using Data	Build on skills covered in previous sessions and explore ways to: ● Compare and contrast the use of raw data vs. simulated data.
Teaching & Learning	● Experience an embedded assessment, use a scoring guide, and discuss affordances and limitations of different types of assessments ● Discuss the use of phenomena to support student engagement with science concepts
Framework/ NGSS	● Use NGSS (or other state standards) to determine what middle school students should be able to do to demonstrate their understanding regarding science concepts, practices and crosscutting concepts. Also become familiar with NGSS Performance Expectations. ● Consider how use of phenomena can provide authentic contexts for students to explore and deepen their understanding of science concepts.

Materials Needed

For the class

- Powerpoint presentation
- Digital Projector
- Whiteboard or flipchart and markers
- Big Chart of Data Skills (Created in Session 4)
- Big Chart of Science and Engineering Practices
- Big Chart of Crosscutting Concepts

For every participant

- 1 copy of Revised Ideas, Part 2
- 1 copy of Revised Ideas Student Tool
- 1 copy of Unit 1 Scoring Guide
- 1 copy of Science Background_Unit 1

- 1 copy of SEP (Science and Engineering Practices) Chart
- 1 copy of Crosscutting Concepts Chart
- 1 copy of NGSS MS Life Science
- 1 copy of Matrix of K–12 Progressions SEP
- 1 copy of Matrix of K–12 Progressions Crosscutting Concepts
- Climate Science Ideas sheet (introduced in Session 1)

For every pair of participants

- One set of molecule cards (introduced in Session 1)
- 1 copy of NGSS MS Earth Systems

For C. Activity: *The puzzling case of the daily rains (OSS 1.10)*

- 1 tall plastic container (1 gallon)
- 1 ice cube tray and cooler or ice chest
- 1 pie tin
- Electric kettle or hot tap water
- 2 matches

For Climate Science Content Activity: *Global Winds and Surface currents (OSS 1.11)*

- Global Winds Animation: http://www.geography.hunter.cuny.edu/tbw/wc.notes/7.circ.atm/animations/GlobalWind.html

Preparation of Materials

1. **Create the Big Chart to record information on Crosscutting Concepts.** On a piece of chart paper, copy the format below to fill the page.

	Teacher	Learner
Patterns		

Cause & Effect		

Make 3 more sheets to record the remaining crosscutting concepts: Scale, Proportion, & Quantity; Systems & System Models; Energy & Matter; Structure & Function; Stability & Change.

2. **Create the Big Chart to record information on Science and Engineering Practices.** On a piece of chart paper, copy the format below to fill the page.

	Teacher	Learner
Asking questions (for science) and defining problems (for engineering)		
Developing and Using Models		

Make 3 more sheets to record the remaining Science and Engineering Practices: Planning and Carrying out Investigations; Analyzing and Interpreting Data; Using mathematics and computational thinking; Constructing explanations (for science) and designing solutions (for engineering); Engaging in argument from evidence; Obtaining, evaluating, and communicating information.

3. **Duplicate handouts.** Make enough copies of the following handouts for
1 per participant:
    - 1 copy of Revised Ideas, Part 2
    - 1 copy of Revised Ideas Student Tool
    - 1 copy of Unit 1 Scoring Guide

- 1 copy of Science Background_Unit 1
- 1 copy of SEP (Science and Engineering Practices) Chart
- 1 copy of Crosscutting Concepts Chart
- 1 copy of NGSS MS Life Science
- 1 copy of Matrix of K–12 Progressions SEP
- 1 copy of Matrix of K–12 Progressions Crosscutting Concepts

For every pair of participants

- 1 copy of NGSS MS Earth Systems

Before the day of the session:

1. **Decide if you will use the optional OSS 1.11 activity (Section C).** This activity is optional because it is fairly straightforward. If you decide not to use it, read the instructor's note in that section for ideas on how to share the information with participants without doing the activity or by doing a very abbreviated version of the activity

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2. **Preview the Global Winds animation (for Section C).** Use the version on the OSS website or http://www.geography.hunter.cuny.edu/tbw/wc.notes/7.circ.atm/animations/GlobalWind.html

3. **Obtain or make ice.** Obtain about one tray of ice cubes for use with the Cloud in a Jar Model.

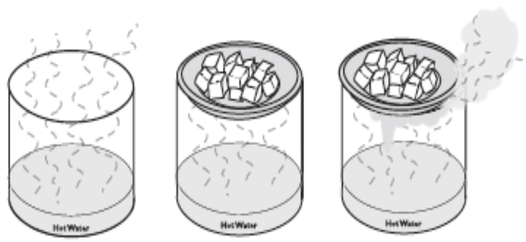
4. **Cloud in a Jar model - do as demo or small-group activity?** The session is written for the Cloud Model to be done as an instructor demonstration. If you can spend a bit more time, it may be effective for participants to do it themselves in small groups. See page 115 of Unit 1 Teacher's Guide, Providing More Experience, for materials needed for the "cloud-in-a-cup" activity.

5. **Remind students to bring:** Their personal copies of the Climate Science Ideas sheet and the Big Charts for Data.

6. **Make copies.** Remake molecule cards if necessary (see Session 1).

Immediately before the session:

1. **Prepare Cloud model setup.** Have ready the tall container, pie tin, and matches. If you do not have hot tap water available, heat about 2 quarts of water in an electric kettle and unplug before



class begins. Just before the demonstration, put the ice cubes into the pie tin and have the pie tin ready to set on top of the container. If participants will do the cloud model in small groups, add materials as necessary.

Session at a Glance

Task	Description	Time (minutes)
A. Introduction: *share session goals*	Session goals are shared.	5
B. Turn and Talk: *three dimensional teaching*	Participants consider what it means to teach in a three-dimensional way, using homework reading and experiences to inform the discussion.	15
C. Activity: *The puzzling case of the daily rains (OSS 1.10)*	Participants are introduced to a weather pattern phenomenon in Costa Rica. They write and discuss their first ideas regarding ocean–atmosphere connections, then use a model and group discussions about understanding of molecules and heat energy to explain the phenomenon.	30
D. Reflection: *Create Big Charts*	Participants reflect on how the three dimensions support learning by charting selected Science and Engineering Practices and Crosscutting Concepts they have engaged in to support their understanding of content. These reflections are compiled on class	25

	Big charts.	
E. Activity and Discussion: *Assessments*	Participants consider how three dimensional teaching and learning might be assessed. They use an assessment to analyze how it measures their own understanding of concepts, and discuss how they might assess their future students' data skills. The section concludes with more information about types of assessments.	40
F. Reflection Activity: *What should middle school students understand about ocean-atmosphere connections?*	Participants examine Middle School NGSS Performance Expectations related to the content introduced so far. They discuss how the experiences they have been provided support understanding of the related science ideas, crosscutting concepts, and science and engineering practices.	30
G. Discussion: *Phenomena-driven Learning*	Participants consider how phenomena can provide authentic contexts for students to explore and deepen their understanding of science concepts. They generate examples of possible phenomena to support the science concepts explored in upcoming sessions, tied to related DCIs in NGSS.	20
H. Homework	**1. Supporting teacher content knowledge:** **Read:** Science Background Unit 1 handout. **Journal:** Select a concept that you don't fully understand. Find information that builds your understanding of this concept and be prepared to share where and how you found the information. **2. Frame Carbon Cycle content with a Crosscutting Concept:** **Read:** *Framework for K–12 Science Education*, (LS1.C, pp. 147-148 and LS2.B 152-154) http://www.nap.edu/read/13165/chapter/10#147 **Journal:** Describe how the crosscutting concept of Energy and Matter might support students as they build their understanding of the Carbon Cycle.	5
	Total: 2 hrs 50 min	**170**

Optional / Additional Resources

Climate Science Content Activity: *Global Winds and Surface currents (OSS 1.11)* (to insert between Sections C and D)	In this optional activity, participants add to their understanding of how the ocean and atmosphere are interconnected, by engaging in an activity about how global winds set ocean surface currents in motion.	20 minutes

Session Details

A. Introduction: *Share session goals*

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

- **Climate science ideas:** Deepen understanding of the ocean-atmosphere connection and consider the water cycle through the lens of energy and matter.
- **Using Data:** Use models, compare and contrast using raw and simulated data, and work to relate what you have learned from the data to a bigger science concept. Authentic contexts for students to explore and deepen their understanding of science concepts.
- **Teaching and Learning:** Consider the affordances and limitations of different types of assessments and discuss the use of phenomena to support student engagement with science concepts.
- **Framework/ NGSS:** Use NGSS (or other state standards) to determine what middle school students should be able to do to demonstrate their understanding regarding science concepts, practices and crosscutting concepts. Become familiar with NGSS Performance Expectations. Consider how use of phenomena can provide authentic contexts for students to engage with science concepts.

B. Turn and Talk: *Three dimensional teaching*

Turn and Talk

1. **Participants discuss three dimensional teaching.** Tell participants to turn and talk to a neighbor about the prompts:
    - What does it mean to teach science in a three-dimensional way?
    - How might this be different from how science has been taught and assessed traditionally?
    - How will assessment capture three-dimensional teaching and learning?

    Give them about 5 minutes to discuss.

2. **Facilitate a whole group discussion about the turn and talk prompts.** This discussion builds on participants' partner conversations with the goal of sharing their understanding of three-dimensional instruction, a major shift from the traditionally siloed approach of teaching content and science practices separately, and the lack of explicit instruction around big ideas or crosscutting concepts as frameworks. Facilitate and encourage participation by utilizing some of the following strategies and questions:
    - Listen to their responses
    - Ask participants to provide explanations, evidence, or clarifications to elaborate on their thinking. Suggested probing questions:
        - What makes you think that?
        - Please give an example from your experience.
        - What do you mean?
    - Remember to stay neutral in your reaction to participants' comments.
    - Invite others to react and respond to the ideas shared. Suggested probing questions:
        - Can anyone add something to that comment?
        - Who would like to share an alternative opinion?
        - Does anyone disagree with that comment?
    - Reference and cross-reference their comments as you facilitate the discussion to encourage participants to think about and respond to one another's ideas.

3. **Summarize the discussion.** At the conclusion of the discussion, summarize participant thinking. If the following ideas have not been discussed, make sure to share:
    - Teachers have traditionally taught science using a more siloed approach. Content is one focus, and science practices are a separate focus (if taught at all).
    - Crosscutting concepts have never been a traditional focus in science classrooms.
    - Three-dimensional instruction calls on teachers to teach science in a way that mirrors how science is practiced. Students use science practices and crosscutting concepts to help them understand science content more deeply. For example, during the Ocean as a heat reservoir activities in a previous session, we used the crosscutting concept of energy and matter and the scientific practices of developing and using models (the simulation we observed) and Constructing Explanations and Designing Solutions to make sense of water's ability to act as a heat reservoir.
    - To assess the three dimensions, students must demonstrate their understanding of

disciplinary core ideas and crosscutting concepts by doing something.

C. Activity: *The puzzling case of the daily rains (OSS 1.10)*

Present the Phenomenon

1. **Introduce the phenomenon.** Display the 'Puzzling case of the daily rains' slide, and tell participants that they will be explaining a mystery called the 'Puzzling Case of the Daily Rains.' Explain that the phenomenon occurs in Costa Rica, Central America, near the equator and it may help them make further connections between the ocean and atmosphere.

How are the ocean and atmosphere connected? Part 1

1. **Recall *Ocean Currents* activity from Session 2.** Remind the participants that in Session 2 they were learning about ocean currents and atmospheric currents. Ask them to turn to a partner and discuss the following prompts for about 3 minutes:
   - What similarities do you think there are in how water and air move around Earth? Why do you think this is so?
   - How does adding heat energy affect air? water?
   - What kind of data could you look at to give you more evidence?"

2. **Quick Write.** Tell participants to reflect on and then write about their ideas to this prompt, "How are the ocean and atmosphere connected?" After 2 minutes, ask the participants to share some of their ideas.

Explore the phenomenon

1. **Project five slides.** Show the series of five slides and tell participants that this is what happens in Costa Rica on many days every year. (Participants will see a weather pattern: morning is clear, afternoon is cloudy, late afternoon is rainy, it begins to clear in the evening, and night is clear.) Go through the weather slides again, and explain that this pattern repeats itself, day after day in Costa Rica and other tropical ocean places.

2. **Turn and Talk: Discuss the mystery using Molecule Cards.** Ask, "**In places near the ocean and equator, why might this weather pattern repeat itself over and over again?**" Tell participants that they know some things about water molecules that could help them explain this

phenomenon. Distribute a set of Molecule Cards to each pair of participants so they can refer to them as they discuss the mystery, and remind them to think about the crosscutting concept of Energy and Matter. Give participants a few minutes to try to explain what's going on in the Puzzling Case of the Daily Rains.

3. **Allow participants to grapple with the mystery.** Refrain, for now, from offering information or answering questions. If participants have prior knowledge about the water cycle, encourage them to share it with one another, but don't correct their ideas or add information yet.

4. **Debrief participants' ideas about the mystery.** Allow several participants to share their ideas about what causes the pattern of weather in Costa Rica. Listen to their ideas, asking others if they have any additional information to add or if they have alternative ideas. If participants use a word such as evaporate, ask them to explain what it means in terms of heat energy and matter, and to use the molecule cards in their explanation.

Cloud in a Jar

1. **Introduce and set up the Cloud Model.** Say that a model might help explain the ideas that have been discussed. Ask the participants what variables should be included in the model. Be accepting of all answers and record what the participants say on the board. After the conversation slows down, fill the jar with hot water, then pour out most of it, leaving only about two inches of hot water in the bottom. Set the pie pan containing ice cubes on top of the jar. Tell participants that this model represents the ocean water and atmosphere near Costa Rica. In the model, the ice cools the air higher up in the jar and represents the colder air that is higher up in the atmosphere.

2. **Add smoke.** Tell participants that there are particles of dust in Earth's atmosphere. Water vapor in Earth's atmosphere condenses around these dust particles to form liquid water. In this model, dust will be represented by smoke. Light a match, blow it out, and hold the smoking match in the jar for a few seconds. Replace the pie pan to re-cover the jar.

3. **Observe model.** Ask participants to describe what they see. Ask them to explain why swirling clouds form in the jar. Don't correct their ideas at this point, but encourage discussion and the exchange of different ideas. Also encourage the participants to reference their original list of variables for the model and think if there are any variables in the actual model that they had missed in their original brainstorm.

4. **Summarize by drawing water cycle.** Bring together the participants' observations from the Cloud Model and the idea of precipitation by drawing a simple water cycle on the board, or asking volunteers to help you sketch.

5. **Project Key Concepts slides.** Project the three key concepts slides and have participants read the key concepts. Also, have them record the key concepts on their Climate Science Ideas Chart.
   - If enough heat energy is:
     - Added to liquid water, some of the water molecules at the surface evaporate into the air as water vapor.
     - Taken away from water vapor, some of the water molecules condense into liquid water.
   - Evaporation and condensation move heat energy around Earth. Without this, Earth would be much hotter in some places and much colder in others.
   - The water cycle, winds, and ocean currents distribute heat energy around Earth, and that keeps temperatures more uniform.

6. **Participants discuss the mystery.** Tell participants they will now think about how they would explain the daily rains. Pass out the Puzzling Case of the Daily Rains handout. Ask for volunteers to share their ideas to explain why clouds form every afternoon in Costa Rica. Ask them why the sky is clear in the morning and at night. Challenge them to use evidence and the following terms in their explanations:
   - molecules
   - density
   - daily wind and temperature patterns near the ocean
   - evaporation, and condensation

   If participants express confusion about water cycle terms, help them without providing an answer to the mystery. Allow them to struggle with applying the concepts to the mystery.

7. **Quickly review explanations of mystery.** Share some of the possible answers for the Puzzling Case of the Daily Rains from the list below.
   - Morning: *Clear. The ocean water is still cool, so there isn't much evaporation, so there are no clouds.*

- Afternoon: *Clouds. The Sun's heat energy makes some water molecules evaporate into the air as water vapor. The water vapor rises, then cools as it meets colder air higher up in the atmosphere. The molecules slow down, move less far apart, and become denser; eventually the water vapor condenses into liquid water.*
- Late Afternoon: *Rain. The liquid water falls as rain.*
- Evening: *Clearing. Dust particles are washed away by the rain, and cooler air currents flow in. No new clouds form because it is cooler in the evening.*
- Night: Clear. *There are no clouds because it isn't warm enough for much evaporation to happen.*

How are the ocean and atmosphere connected? Part 2.

1. **Add to Quick Write.** Ask participants to return to their Quick Writes about the interconnections between the ocean and atmosphere that they started earlier. Explain that they have an opportunity to revisit these ideas and add any new ideas the mystery and cloud model may have helped them to understand. [*Key points may include:*
    - *When water evaporates, heat energy moves from the ocean into the atmosphere in water vapor molecules.*
    - *When water vapor cools and condenses, heat energy that was originally in the ocean is released into the atmosphere.*
    - *Winds caused by differences in air density move heat energy (held by water vapor molecules) around the world.*]

2. **Extend thinking.** Ask participants to turn to a partner and discuss the following prompts:
    - Where in the world do you think the most clouds form? What is the cause? Why do you think that? What is your evidence?
    - Knowing what you know about the water cycle, where would most of the evaporation on Earth take place? What is the cause? Why do you think that? What is your evidence?

Climate Science Ideas Chart

1. **Connecting climate science ideas to climate change.** Tell participants to turn to a partner and discuss one last prompt: How do you think the key concepts from this session might connect to climate change? *Key concepts:*
    - *If enough heat energy is added to liquid water, some of the water molecules at the surface evaporate into the air as water vapor.*

- *If enough heat energy is taken away from water vapor, some of the water molecules condense into liquid water.*
- *Evaporation and condensation move heat energy around Earth. Without this, Earth would be much hotter in some places and much colder in others.*

2. **Connections to climate change are recorded.** Ask participants to share out their responses to the last question and add responses to the class Climate Science Ideas Chart and have them complete their own Climate Science Ideas charts. [*Participants may mention that warming climate may lead to increased evaporation and storms in places further north and south of the equator.*]

D. Reflection: *Create Big Charts*

Introduce Big Charts

1. **Introduce the Science and Engineering Practices Big Chart.** Draw participant attention to the Big Chart of Science and Engineering Practices. Distribute a copy of *Matrix of K–12 Progressions SEP* to each participant to use as a resource. Have participants share examples of ways the instructor and they used some of the Science and Engineering Practices as they learned science content in previous sessions, using notes they made for homework. Add the examples to the Science and Engineering Practices Big Chart.
[*Potential responses include:*
    - ***Developing and Using Models*** *- used various models to predict and/or describe phenomena of ocean currents and ocean as a heat reservoir, and to generate data to test ideas about phenomena in natural or designed systems; use molecule cards as a model to support explanations of unobservable mechanisms; identifying model limitations with Great Ocean Conveyor Belt model, discuss variables and assumptions made to create the conveyor belt model; used the Cloud in a Jar model to identify variables in the water cycle*
    - ***Constructing Explanations and Developing Solutions*** *- used evidence from activities to build explanations - spoken, written and drawn; considered strengths and weaknesses of explanations; instructor shared an example of a high quality explanation, and pointed out qualities of what makes a good explanation, applied scientific reasoning to show why the data or evidence is adequate for the explanation; constructed explanations that*

included qualitative or quantitative relationships between variables that describe phenomena.]

2. **Add to other Practices on the Big Chart.** If time allows and participants have observations to add, ask participants to share examples of engaging in other Practices of Science and Engineering. Suggestions might include:
   - **Analyzing and interpreting data** - *constructed, analyzed and/or interpreted graphical displays of data to identify linear relationships; analyzed and interpreted data to provide evidence for phenomena; analyzed and interpreted data to determine similarities and differences in findings.*
   - **Engaging in Argument from Evidence** - *compared claims to find the best explanation, looking at evidence and reasoning.*

3. **Introduce the Crosscutting Concepts Big Chart**. Draw participant attention to the Big Chart of Crosscutting Concepts. Distribute a copy of *Matrix of K–12 Progressions Crosscutting Concepts* to each participant to use as a resource. Have participants share examples of ways the instructor and they used some of the Crosscutting Concepts in previous sessions, using notes they made for homework. Add the examples to the Crosscutting Concepts Big Chart.
   [*Potential responses are:*
   - ***Energy and Matter*** *- answered prompts that specifically called attention to the movement of heat energy and how it affects air and water molecules.*
   - ***Systems and System Models*** *- Considered the ocean as a system, the atmosphere as a system, and system interactions.*

4. **Update the Data Chart.** Draw participant attention to the Data Skills Big Chart. Have participants share examples of ways the instructor and they engaged with data thus far, using their personal packets completed for homework. Add the examples to the Big Chart.
   [See completed Data Skills Big Chart to match each of the activities described below to the correct SEPs, Teaching with Data Category, and Data Skills. *Potential responses could be: In Session 4, through the nonsense data activity, reflection on what helps us make sense of data, and levels of engagement with data, they attended to the details and context of the data and recognized the basic components of data visualizations (e.g., title, labels, legends) that are needed to start reading the visualization and read different types of data visualizations.*]

E. Activity and Discussion: *Assessments*

[Note to Instructor: *this section is not intended to be all of the instruction participants get concerning assessment. We focus here on formative and embedded assessments because of the important role they play in the learning experience.]*

Participant Assessment

1. **Revised Ideas and Student Tool.** Tell participants they will now examine their own understanding of the science concepts covered in the course so far as they complete an embedded assessment task. Distribute the *Revised Ideas, Part 2* handout to each participant. Explain that the OSS curriculum also provides supporting documents for middle school students to use with this assessment, *Revised Ideas Student Tool*, which they can also try out. Tell them they now have ten minutes to complete three or more of the prompts on the *Revised Ideas, Part 2* pages, referring to the supporting documents as desired.

2. **Review Scoring Guide.** After participants have worked on the embedded assessment task for about 10 minutes, distribute the *Scoring Guide* to each participant. Have them use the *Scoring Guide* to assess their own understanding of the science ideas as compared to the different levels of understanding described on the *Scoring Guide*. Explain that they should look at different sections of the *Scoring Guide*, depending on which assessment tasks they completed as follows: *for Item 1, see B1, B3, B4, and B6; for Item 2, see C; for Items 3 and 4, see B1–B5; for Item 5, see A; for Item 6, see B1, B3, and B4.*

3. **Think-Pair-Share about assessment and using data.** Have participants refer to their completed embedded assessment and think back to the work they have done with data so far in the course as they engage in a think-pair-share. Have them share their ideas about one of the following prompts with a partner. You may decide to assign different prompts to each table group to ensure that all the prompts are addressed.
    a. What did you learn about your own understanding of the concepts addressed in the previous sessions about how the ocean and atmosphere interact? Did you find that there were some concepts that you felt less sure about? Which ones? Why do you think you had a less deep understanding of those concepts? What might a teacher do with the information gained from this assessment?

b. Did you find the scoring guide useful? In what ways? What might you be able to tell about student understanding of the concepts with this assessment? What are the challenges of using an assessment like this? How might you use information gleaned from this student assessment?
c. Did you find the tools for writing and the graphic organizer useful for your own writing? Why or why not? How might they be useful to your future students?
d. What are your personal feelings about this kind of assessment compared to a multiple choice test? What can you learn from each kind of assessment? How might you use both types of assessments in a formative way? (Formative assessments are given when the teacher still has time to do something about the results.)
e. Did you find that working with data (i.e. raw or simulated) helped you to gain a greater understanding of or become more engaged with the concepts presented in earlier sessions? If so, how? If not, why not? Which types of data did you find most helpful? Least helpful? Why?
f. How might you assess your students understanding of a data visualization or what level of engagement (i.e. orientation, interpretation, or synthesis) they were at? What questions would you include in an assessment to find out?

4. **Whole group discussion.** Encourage participants responding to different prompts to share their ideas and challenges. Accept all reasonable answers without correcting or confirming them. Remember to use the discussion map to engage all participants in the discussion.

Kinds of Assessments

1. **Share information about assessments.** Depending on what your participants share and their experience with assessment, you might want to include some of the following information:
    a. **Assessment Definitions.** Briefly provide a few definitions of kinds of assessments, including:
        i. Formative: provides information about student learning during the course of instruction;
        ii. Summative: measures students' progress at the end of the unit of instruction;
        iii. Embedded: curriculum embedded tasks assess what students understand about the specific topic being studied in class.

iv. Benchmark: evaluates students' knowledge and skills relative to an explicit set of longer-term learning goals of the school and/or district curriculum. Administered periodically throughout the school year, at specified times, the results can be aggregated at the classroom, grade, school, and district levels to decision-makers, as well as to teachers.

v. Large scale: measures student progress at the local, state or national level to describe the educational status of students, make decisions about individual students, and develop or revise existing local, state, and national policies. Results are usually used to compare groups of students in districts, states, and nationally. (e.g., GRE, SAT)

(**Note to instructor:** *OSS also includes a pre/post summative assessment built on performance variables if you are interested in sharing information about performance variables with your participants. Information about the pre/post summative assessment is available on the handout 'OSS_Assessments_Final.pdf or at:* http://mare.lawrencehallofscience.org/sites/mare.lawrencehallofscience.org/files/images/OSS_Assessments_Final.pdf)

b. **More about formative assessments.** Formative assessments are an incredible, yet often underutilized resource. Even typical multiple choice tests can be used in a formative way if students are provided with the opportunity to discuss their answers with others after first attempting to answer the questions on their own. Some teachers score the tests, but don't allow the students to see if they were right or wrong. Instead, they return the tests and put students in groups to discuss their ideas and allow them to change their answers if they hear an explanation that seems more correct. Students are asked to support their answers with evidence and explanations.

F. Reflection Activity: *What should middle school students understand about ocean-atmosphere connections?*

1. **Introduce performance expectations.** The Framework and NGSS describe specific goals for science learning in the form of *performance expectations,* statements about what students should know and be able to do at each grade level. These assessment tasks should allow students to engage in science practices in the context of disciplinary core ideas and crosscutting concepts.

Each performance expectation incorporates all three dimensions of NGSS, and the importance of the connections among scientific concepts, practices and crosscutting concepts is emphasized.

2. **Middle School Earth Science Performance Expectations.** Explain to participants that they will review a particular set of NGSS Earth Sciences standards for middle school related to what we have been covering in class about ocean-atmosphere connections. They will start by looking at the Performance Expectations (PEs) that focus on what middle school students will be expected to do in order to demonstrate their understanding of the disciplinary core ideas, crosscutting concepts, and science and engineering practices we have been focusing on in this course.

3. **Display Performance Expectations.** Display a page of NGSS showing PE's and foundation boxes, and explain that each PE represents the product of what a student should know and be able to do in order to demonstrate their understanding of content of the foundation boxes. (Note: Depending on the experience of your participants, determine if you need to give an example of how the 3-dimensions are represented in each PE.)

4. **Examine the related NGSS Performance Expectations.** Distribute NGSS Earth Systems Standards packets to each pair in a table group of six participants. Explain that this packet contains the Performance Expectations (PE) and the supporting Disciplinary Core Ideas (DCI), Science and Engineering Practices (SEP) and Crosscutting Concepts (CC) for some of the PE's relevant to what we have been studying. These PE's include MS-ESS2-4, ESS2-5, and ESS2-6. Ask each pair to read through the PE's and to select just one of the three PE's to focus on, making sure that all the pairs at the table have selected a different PE.

5. **Explain the Clarification Statements and Assessment Boundaries**. Tell the participants that as they examine the components of their PE they should also pay close attention to any 'Clarification Statements' and 'Assessment Boundaries'. Explain that these statements provide examples that clarify the level of rigor expected and connect concepts with applications.

6. **Pairs identify the three dimensions in a selected PE.** Ask participants to read through their performance expectation and find the SEP, CC and DCIs, then to carefully read about each of these particular dimensions in the foundation boxes below. When they have a clearer understanding of the NGSS expectation of what students should know and be able to do, they should work with their partner to:

- Identify what experiences they have had that would support them being able to meet the performance expectation.
- Identify the skills and understanding they still need in order to meet the performance expectation.

Give the participants 5 - 10 minutes to complete this task.

7. **Pairs share their findings and ideas with their table group.** Tell the participants that each pair will now share with their table group what they have discussed about the Performance Expectation they selected. When all the pairs have shared about the different PEs, the table group should discuss and be ready to share with the whole group:
   - One thing they found surprising or interesting from their examinations of the selected performance expectations and the ocean-atmosphere connections instructional sequence they have experienced.
   - Questions they have about the performance expectations.

8. **Whole group share.** Lead a whole group discussion as representatives from each table group share their ideas and questions. Emphasize to the participants that performance expectations are not curriculum, they are not meant to define the instructional sequence or the instructional strategies that the teacher utilizes to achieve the outcome.

G. Discussion: *Phenomena-driven Learning*

1. **Introduce phenomena-driven learning.** Tell participants that until now you have discussed how NGSS shifts the focus of science from students learning about science ideas to where students explore, examine, and use science ideas to explain how and why phenomena occur. Levels of explanation progress K-12.
   a. In grades K-2 students focus on phenomena they can directly experience and investigate.
   b. In grades 3-5 they focus on invisible, but still primarily macroscopic entities, such as what is inside the body or Earth--they don't focus so much on the actual size of microscopic entities, but do learn that they are too small to see

directly, instead using pictures, physical models, and simulations to represent the entities and relate them to phenomena that the students can investigate and interpret.

c. In grades 6-8, students move to atomic-level explanations of physical phenomena and cellular-level explanations of life processes and biological structures, but without detail on the inner workings of an atom or a cell.

d. In 9-12, students shift to subatomic and subcellular explanations of phenomena.

Based on what we know about how people learn (Five Foundational Ideas about How People Learn), we know that students learn best when they are able to cognitively engage with material in an authentic context. Phenomena provide this context.

2. **Define Phenomena, project image.** Project image of the dead and decaying rabbit. Explain that a phenomena is really any real world event that provides a student-driven question and explanation. It does not have to be phenomenal. A phenomena builds on everyday, familiar experience for all students and requires students to build an understanding of science ideas while engaging in science and engineering practices and using big ideas (crosscutting concepts), as thinking tools. A phenomena can be an intriguing or unusual observation or case to investigate (a decaying body) or something that is puzzling (where does the rabbit body go?) or a wonderment (why isn't Earth covered in dead bodies?).
[Note to instructor: *Remind participants of the video they watched for homework for Session 1:* *http://www.nextgenscience.org/resources/ngss-equip-rubric-using-phenomena*]

3. **Turn and talk - recall phenomena introduced so far.** Ask participants to recall and discuss with a partner examples of phenomena that have driven their learning about how the ocean and atmosphere are interconnected. [*Possible responses: the balloon demo, the differences in temperatures in places at the same latitude, the mystery of the floating balloons, puzzling case of the daily rains*].

4. **Introduce 'How does carbon flow through the ocean, land, and atmosphere?' (OSS Unit 2).** Tell participants that now you're going to look for some interesting phenomena to help middle

school students engage with ideas about "How does carbon flow through the ocean, land, and atmosphere?" — the second OSS unit. Ask, **"Which processes do you think students might explore to answer this question?"** Give participants a minute to turn and talk then share out some ideas. [*Participants may mention: photosynthesis, respiration, decomposition, combustion, or the rock cycle. But it's also possible they may not have thought about carbon flow before*].

5. **Individuals explore ideas from the Middle School NGSS Life Science handout.** Tell participants that some of the ideas covered in the next unit come from Disciplinary Core Ideas in the handout you are about to share. Pass out the Middle School NGSS Life Science handout. Tell participants to read DCIs LS1.C, LS2.B, and PS3.D. While they are reading they should make notes in the margins about possible phenomena that could be presented to students to engage with the content in the DCI. These phenomena should provide opportunities for students to engage in a way that will require them to gain a deeper understanding of the concept in order to explain it. Give participants about 5 minutes for this step.

6. **Partners discuss phenomena to support NGSS DCIs.** Have participants partner up to discuss one phenomenon they have considered. As part of the discussion, partners should think about the science ideas and supporting experiences that would be needed for students to be able to explain the phenomenon. Tell each pair to be prepared to share out highlights from their discussion with the class.

7. **Whole class share out.** After a few minutes, ask for a couple of volunteers to share their example of a phenomenon that is relevant to the DCIs they have read. Accept all responses. Wrap up the discussion by telling participants that they will start to explore some of these phenomena, and others, in the next several sessions.

H. Homework

Show slide of Homework Assignments. Describe tasks as follows:

1. **Supporting teacher content knowledge.**

    Read:

- OSS Introduction, Science Background handout.
    - Select a concept that you don't fully understand. Find information that builds your understanding of this concept and be prepared to share where and how you found the information.

2. **Frame content on Carbon Cycle with a crosscutting concept.**
    - *Framework for K–12 Science Education*, (LS1.C, pp. 147-148 and LS2.B 152-154) http://www.nap.edu/read/13165/chapter/10#147
        - Describe how the crosscutting concept of Matter and Energy might support students as they build their understanding of the Carbon Cycle.

Optional / Additional Resources

Climate Science Content Activity: *Ocean Currents and Global Winds (OSS 1.11)*

Note to Instructor: *Generally, adults don't struggle with the concept that winds drive surface currents as long as they see the direction of the wind patterns and note that land blocks water from continuing to move in a particular direction. If you wish to do an abbreviated version of the activity to give participants an opportunity to look for patterns and make further connections between the atmosphere and ocean, you can do steps 1-3 and then skip to step 6, followed by steps 10-13. Alternatively, you can assign this section for homework by sharing the animation and currents slides accompanied by any discussion prompts in steps 1 and 8-10. Also, make sure to share the key concept introduced in step 13.*

1. **Project and discuss Global Winds animation.** Explain to participants that they will now watch an animated model of the global atmospheric system, and with their partner they will look for noticeable patterns. Orient the participants to the animation by discussing that there are Hs and Ls shown on the animation—H stands for high pressure (high density = denser air) and L stands for low pressure (low density = less-dense air). Encourage participants to talk to a partner about what patterns they observe and any questions they have.

2. **Participants share observed patterns.** Ask for volunteers to share out some of their observations and questions. If participants don't mention them, key patterns to point out are:

- *Direction trade winds are blowing. Trade winds create surface currents that move westward along the equator.*
- *Notice how the air is flowing from denser (H) to less dense (L).*
- *Clouds that form along the equator, and relate them to daily rain pattern in Costa Rica.*

3. **Project the Crosscutting Concept Patterns slide**. Project the Crosscutting Concept Patterns slide, 'Noticing patterns is often a first step to organizing phenomena and asking scientific questions about why and how the patterns occur.' (*Framework, pp.85).*

4. **Partners discuss explanations for patterns in The Great Ocean Conveyor Belt.** Remind participants that they are familiar with the animated model of the global oceanic system, and that they have learned how differences in density of ocean water cause large, global currents to flow throughout the ocean. Project The Great Ocean Conveyor Belt slide, and ask participants to discuss with their partner patterns they observe, and to try to use what they know about ocean currents to explain the patterns and answer any questions they have.

5. **Participants share observed patterns.** Ask for volunteers to share out some of the patterns they observed and the questions and explanations they led to. Summarize the observations by emphasizing:
    - The Great Ocean Conveyor Belt currents are driven by differences in the density of ocean water; the density differences are created because of changes in temperature and salinity; cold, dense water travels along the bottom of the ocean.
    - The Great Ocean Conveyor Belt is a global current that connects the atmosphere and deep ocean circulation systems, transporting oxygen and nutrients, as well as heat energy, around the planet.

6. **Introduce surface currents.** Remind participants that they are continuing to look for ways that the ocean system and atmospheric system interacts. Tell participants that while the deep ocean currents are caused by differences in density, most surface currents are caused by wind blowing over the water.

7. **Review what causes wind to blow.** Ask participants, "what causes wind to blow?" Have participants share their ideas.

8. **Project Slide, Ocean Surface Currents; share observations.** Project the Ocean Surface Currents slide and ask participants to share some of their observations about the patterns they notice on the map of average surface currents. If they don't mention it, point out the warm currents shown in red and the cold currents in blue. Also point out the large circular currents flowing on either side of the equator. Tell the participants that these large circular currents are called gyres.

9. **Discuss Gyres.** Lead a brief discussion about gyres using some or all of the following prompts:
   - What direction are the gyres in the Northern and Southern Hemispheres flowing? [*Clockwise in Northern Hemisphere and counterclockwise in Southern Hemisphere.*]
   - What direction do you think the prevailing winds would have to be pushing the water in order to set these currents in motion in the actual ocean? [*Westward across the equator.*]
   - How do you think the landmasses affect the currents? [*When the current encounters land masses, they are deflected polewards - either towards the north or south polar regions.*]
   - What current pattern do you think would form if prevailing winds were blowing the water westward along the equator, but there were no continents? [*Likely one large current flowing westward around the entire planet.*]

10. **Project slide, Trade Winds and Ocean Currents.** Ask participants to discuss with their partner what patterns they notice about this global phenomena. Remind them to try to make explanations of the phenomena using the patterns they have noticed, and to record the questions they have. If necessary, help participants by saying that the large orange arrows show the direction of major global winds, these winds are called the trade winds, and to notice the direction they are blowing in both the Pacific and Atlantic.

11. **Partners share their ideas.** Have the partners join with another pair or form a table group and ask them to share their explanations of the Trade winds and Ocean Currents image, and the questions they have.

12. **Whole group discussion.** Have table groups share their discussions and explanations about the Trade Winds and Ocean Currents image, and any questions that emerged. Remember to use the discussion map to encourage alternative ideas and to build on each other's responses. Record the group's questions on a wall chart. Ask participants which questions were answered in the group discussion and which still remain unanswered.

13. **Project key concept slide; small group discussion**. Project the slide with the key concept, 'Winds are the main cause of ocean surface currents. Wind sets these currents in motion, but land masses, Earth's rotation, and friction direct the movement of currents from the equator toward the poles'. Have the table groups discuss the key concept in terms of the explanations they discussed previously, including how the key concepts are similar, different, or add to their understanding. Ask participants if there are still some unanswered questions, and if so, lead a discussion about how they might go about finding out the answers.