Introduction:

The Teacher Guide is designed to support teachers in teaching with the new Mystery Science Anchor Layer. This is a new feature, and we plan to revise and improve the Anchor Layer based on your feedback! Thank you!

What is the Anchor Layer?

In NGSS instruction, there is a distinction between *anchor* phenomena and *investigative* phenomena. Anchor phenomena are complex phenomena that students need an entire unit, and multiple scientific ideas, to explain. Investigative phenomena are specific, lesson-level phenomena that help students understand smaller conceptual pieces of a larger idea. As students investigate specific phenomena, they can use those learnings to make sense of the anchor phenomenon that guides the unit.

We think of our traditional lessons as investigative phenomena. This new Anchor Layer adds an anchor phenomenon to open and frame the unit. After each lesson, students return to the anchor phenomenon and apply what they've learned to develop increasingly sophisticated models, arguments, explanations or design solutions that help them make sense of the anchor phenomenon.

We've designed the Anchor Layer to be optional for teachers. Teachers can teach our lessons with or without the Anchor Layer.

Storylines:

Storylines provide a coherent overview of how the Anchor Layer unfolds, what students are figuring out at each step, and questions that lead to the next investigation. **View Anchor Layer Storylines**

Before Lessons

I. Anchor Phenomenon
Observe puzzling, complex real-world events explained through scientific evidence

II. Student Inquiry
Make observations and ask questions

III. Initial Student Ideas
Develop initial Conceptual Model, Argument, Explanation, or Design Solution

During Lessons

IV. Investigative Phenomena
Investigate specific real-world events that provide conceptual pieces to a larger idea

V. Student Revision
Revise Conceptual Model, Argument, Explanation, or Design Solution

After Lessons

VI. Performance Task
Demonstrate conceptual understanding in a new scenario

Stormy Skies Anchor Layer

Teacher Guide

TEACHER RESOURCE

Unit Overview

Key Concepts Overview:

- **Water** can exist in the **liquid, solid,** or **gas** state.
- **Clouds** are made of small drops of water and different types of clouds are present during different types of weather.
- **Evaporation** is the process of liquid turning to gas. This happens more quickly when the liquid is warm.
- Different regions on Earth have different large-scale and long-term weather patterns called **climates**.
- Weather and climate conditions on the ground can be very different than the conditions high in the air.
- Engineers can design solutions to weather-related hazards.

3-Dimensional Alignment	
Crosscutting Concepts	Cause and Effect Patterns
Science and Engineering Practices	Analyzing and Interpreting Data Constructing Explanations Designing Solutions Engaging in Argument from Evidence Developing and Using Models Obtain and Communicate Information
Disciplinary Core Ideas	**ESS2.D:** Weather and Climate **ESS3.B:** Natural Hazards
Performance Expectations	**3-ESS2-1.** Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. **3-ESS2-2.** Obtain and combine information to describe climates in different regions of the world. **3-ESS3-1.** Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.

Unit Pacing Guide			
Anchor Phenomenon	1 hour	**Lesson 4**	1.5 hours
Lesson 1	1.5 hours	**Lesson 5**	1.5 hours
Lesson 2	1.5 hours	**Performance Task**	1.5 hours
Lesson 3	1.5 hours		
Note: Using Extensions for lesson 1-4 can extend each lesson up to an additional 2 hours.			

TEACHER BACKGROUND INFORMATION

Anchor Phenomenon Explanation

How can an ice storm happen during hot summer weather?

We live on the ground at the bottom of the atmosphere. The main idea at the center of this Anchor Layer is that the weather and climate conditions at the bottom of the atmosphere (where we live) can be very, very different than the conditions higher up. We wouldn't expect there to be huge amounts of extremely cold air and icy water high above us when we're on the warm ground, but that's exactly what leads to hailstorms!

Imagine it's the end of winter, after months of cold. The atmosphere is likely to be cold from the ground all the way up. When spring begins, the increasing intensity of sunlight causes the ground to warm up. The warming ground warms the air at the bottom of the atmosphere, but the air just a bit higher is still cold. This leads to the formation of warm, humid air at ground level with cold air immediately above it. The warmer air will tend to rise and carry water vapor along with it.

As warm, humid air rises higher in the sky, it will cool down. The water vapor being carried upward will condense and form clouds and eventually large water droplets. If those water droplets cool even further, they will freeze and form hailstones!

Over time, the flow of warm air from the bottom of the atmosphere to the top will slowly warm the upper atmosphere, which decreases the likelihood of forming icy hailstones in late summer and fall. As temperatures begin to drop again at the beginning of winter, the entire atmosphere cools off from bottom to top. This makes it more likely for water vapor to freeze directly from a gas into a solid, which is how snowflakes are formed.

Stormy Skies Anchor Layer

Teacher Guide

BEFORE LESSON 1

Anchor Phenomenon

I. Anchor Phenomenon

Puzzling, complex real-world events explained through scientific evidence

1. Prepare your classroom for the Anchor Phenomenon lesson:
   a. Create a class See-Think-Wonder chart
   b. Print one copy per student of the Summer Ice Storm worksheet
2. Begin the Anchor Phenomenon lesson. The lesson includes visuals and text describing the hailstorm that occurred in Guadalajara, Mexico, on June 29, 2019.

Tip: *The unit anchor phenomenon is a real-world occurrence that motivates students to ask questions and learn more about scientific concepts. Encourage them to investigate throughout the unit.*

II. Student Inquiry

Students make observations and ask questions

1. Pass out See-Think-Wonder charts to students.
2. Students complete the first column *(I see…)* for the images displayed. We recommend using the Think-Pair-Share strategy for this activity.
3. Discuss class responses and write them in your class See-Think-Wonder chart.
4. Repeat Steps 2-3 for the second *(I think…)* and third *(I wonder…) columns*.

Tip: *The chart on the next page provides possible student responses. Use this resource to help you further the See-Think-Wonder discussion with your students.*

BEFORE LESSON 1

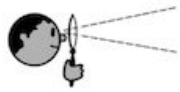
Anchor Phenomenon

II. Student Inquiry (continued)

Students make observations and ask questions

Sample student See-Think-Wonder responses

See-Think-Wonder Chart

See What did you observe? 	Think How can you explain what is happening? 	Wonder What questions do you have? 
• *Lots of hail on the ground* • *People walking on the hail* • *People dressed in clothes for warm weather* • *Sunshine* • *Cars buried in hail*	• *Hail could be just like snow or frozen rain* • *Maybe it wasn't actually hot everywhere...it could be cold nearby*	• *How can hail fall when it is hot out?* • *Why did hail fall?* • *Why didn't this happen in winter?* • *Can this happen where I live?*

III. Initial Student Ideas
Develop initial Conceptual Model, Argument, Explanation, or Design Solution

Students follow the step-by-step directions in the lesson to create an initial description of what happened and an attempt at drawing a model that explains how it happened. Their model should try to explain what could have been going on both at ground level and up in the air that would have led to an ice storm in the summer.

Throughout the unit, students learn new concepts and conduct investigations to help them understand that the conditions at ground level can be very different than the conditions up in the air.

1. When instructed to do so in the Anchor Phenomenon lesson slides, pass out the Summer Ice Storm worksheet.
2. Have students write their initial description of what conditions were like at ground level before the summer ice storm.
3. Small Group Discussion: Students discuss what might have been happening high in the sky.
4. Students then draw their initial thoughts about what conditions may have been like in the sky before the summer ice storm.

Crosscutting Concepts: Cause and Effect, Systems

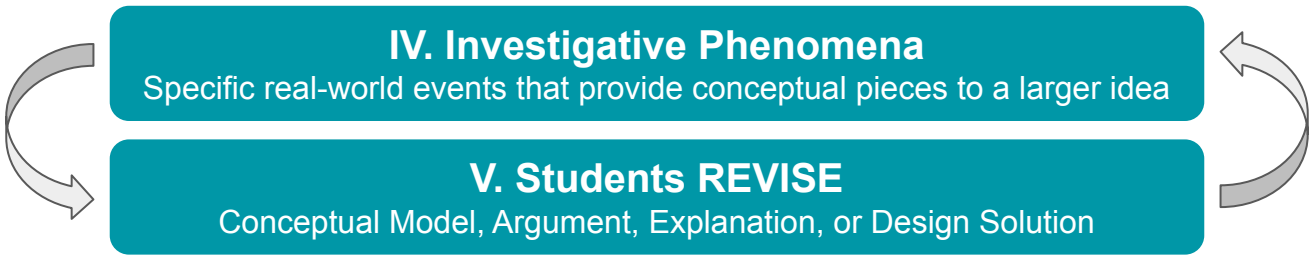
- This is a great opportunity to reinforce the crosscutting concepts of **cause and effect** and **systems**.
- A **system** is a group of related parts that interact with one another.
- When the parts of a system interact with one another, those interactions **cause** certain **effects** to occur.
- Students describe the parts and conditions of a summer weather system that can lead to icy hail.

Matrix of Crosscutting Concepts in NGSS

Stormy Skies Anchor Layer

Teacher Guide

DURING LESSONS



1. Teach the lesson (Investigative Phenomenon).
2. **Anchor Connection (after Activity):**
    a. After the Activity of each lesson, continue advancing through the slides to the Anchor Connection.
    b. Discuss the **Anchor Phenomenon Connection** questions.
    c. Revise the Summer Ice Storm sheet to include new information learned in each lesson.

Lesson *(Investigative Phenomenon)*	**During the Anchor Phenomenon Connection slides, guide students toward these ideas:**	**If they haven't already, students can update their explanations and/or drawings by:**
Lesson 1: Where do clouds come from? *(Foundational for 3-ESS2-1)*	Warm water evaporates more readily than cold water does. If there is hot weather somewhere that has water at ground level, that water will be more likely to evaporate. That water vapor can then form clouds and a wide range of types of precipitation. The amount of water at ground level can be very different than the amount of water in the sky.	• Adding that water on the ground evaporates and becomes water gas in the air • Adding that clouds are made of water
Lesson 2: How can we predict when it's going to storm? *(3-ESS2-2)*	The temperature at ground level can be hot or cold, but as you go higher and higher in the sky it becomes colder and colder. If you've ever seen bits of frost on the window of an airplane, you've seen this effect. The temperature on the ground can be very different than the temperature in the sky.	• Adding details about the temperature difference between the ground and high in the sky • Drawing and labeling the clouds as cumulonimbus

DURING LESSONS

Continued from page 8

Lesson *(Investigative Phenomenon)*	**During the Anchor Phenomenon Connection slides, guide students toward these ideas:**	**If they haven't already, students can update their explanations and/or drawings by:**
Lesson 3: Where's the best place to build a snow fort? *(3-ESS2-1)*	The fact that water freezes when it falls below 32° Fahrenheit, and melts when it is above 32° Fahrenheit allows us to predict whether we will get liquid water or frozen ice.	• Adding that water freezes below 32° Fahrenheit and melts above that temperature

Lesson 4: Why are some places always hot?
 	
(3-ESS2-1, 3-ESS2-2)
	The climate map for the top of the tallest clouds is almost the opposite of the climate map on the ground. The tops of the tallest clouds are **coldest** over the equator, and **hottest** over the poles. This is the opposite of the pattern that is present at ground level.
	
	The climate on the ground is very different than the climate in the sky.
		Note: Give students a copy of the final sheet so they can neatly record everything they've learned.
		
		• Coloring in the "Sky Climate Map" on their sheet.
		• Neatly showing the key information from the earlier lessons about:
		  ○ Water evaporating from the ground and eventually forming clouds in the sky
		  ○ The temperature on the ground and in the sky
		  ○ The name and appearance of the type of clouds that cause these storms

Lesson 5: How can you keep a house from blowing away in a windstorm? *(3-ESS3-1, 3-5-ETS1-1, 3-5-ETS1-2, 3-5-ETS1-3)*	Another aspect of understanding weather is learning how to reduce the negative impact of harmful weather, such as droughts, floods, hurricanes, tornadoes, and hail storms. Hailstorms cause nearly $10 billion in damage each year in the United States alone, and nearly $1 billion of that damage is to cars and trucks.	*Students will not update the Summer Ice Storm sheets that they had been updating up to this point. Instead, they will record their design plan for a device that will protect cars and trucks from hail damage. This design will be referenced in the Performance Task at the end of the unit.*

AFTER LESSONS

Performance Task Lesson

VI. Performance Task

Students demonstrate conceptual understanding

The performance task is an opportunity for students to apply their conceptual understanding to a new scenario. In this performance task, students will use real weather data to make predictions about future hailstorms.

Crosscutting Concepts:
Cause and Effect

- This is a great opportunity to reinforce the crosscutting concept of **cause and effect**.
- Cause and effect relationships are used to explain surprising phenomena such as a summer hailstorm.
- Hailstorms are a result of multiple causes, such as a huge temperature difference from the bottom to the top of the atmosphere.

Matrix of Crosscutting Concepts in NGSS

Crosscutting Concepts:
Systems and System Models

- This is a great opportunity to reinforce the crosscutting concept of **systems and system models**.
- A system is a group of related parts that interact with one another.
- All weather systems involve varying interactions between the air, water, and/or land. Many of the processes are driven by differences of temperature.

Matrix of Crosscutting Concepts in NGSS

1. Begin Performance Task Lesson, which includes a review of the:
   a. Anchor phenomenon
   b. Unit key concepts (*page 3 of Teacher Guide*)

2. Begin Activity Step-by-Step
   a. Have students get into groups of 2-4.
   b. Each student needs one Past Hailstorm Patterns worksheet.
   c. Each group needs one Hailstorm Data packet.
   d. Students work independently and use data from one season to complete the top of the Past Hailstorm Patterns worksheet.
   e. Students work with their group to complete the rest of that sheet.
   f. Discuss the hailstorm patterns as a class.
   g. Pass out the Future Hailstorm Prediction sheet and have students use their data to complete it.