# UNIT OVERVIEW

## Why does a lot of hail, rain, or snow fall at some times and not others?

This unit on weather, climate, and water cycling is broken into four separate lesson sets. In the first two lesson sets, students explain small-scale storms. In the third and fourth lesson sets, students explain mesoscale weather systems and climate-level patterns of precipitation. Each of these two parts of the unit is grounded in a different anchoring phenomenon.

The unit starts out with anchoring students in the exploration of a series of videos of hailstorms from different locations across the country at different times of the year. The videos show that pieces of ice of different sizes (some very large) are falling out of the sky, sometimes accompanied by rain and wind gusts, all on days when the temperature of the air outside remained above freezing for the entire day. These cases spark questions and ideas for investigations, such as investigating how ice can be falling from the sky on a warm day, how clouds form, why some clouds produce storms with large amounts of precipitation and others don't, and how all that water gets into the air in the first place.

In this first half of the unit, students investigate weather data specific to these events and the temperature profile of the atmosphere above the Earth's surface. They conduct investigations into how sunlight affects the temperature of different surfaces and the air above them, and how this contributes to cloud formation and growth. They work with manipulatives, simulations, and labs to figure out how molecules in different phases change states under different conditions and they conduct investigations into why air moves the way it does as it is heated and cooled.

The second half of the unit is anchored in the exploration of a weather report of a winter storm that affected large portions of the midwestern United States. The maps, transcripts, and video that students analyze show them that the storm was forecasted to produce large amounts of snow and ice accumulation in large portions of the northeastern part of the country within the next day. This case sparks questions and ideas for investigations around trying to figure out what could be causing such a large-scale storm and why it would end up affecting a different part of the country a day later.

In the second half of the unit, students also investigate changes in weather conditions over the entire country over multiple days, as well as forecasts of three other storms that are forecasted to affect other parts of the country. They explore how the interactions of air masses, prevailing winds, proximity to the ocean, ocean currents, and surface elevation profiles work together to influence how much precipitation different regions receive. At the end of the second half of the unit, they apply their understandings to develop an explanation for why South America has a tropical rainforest in one part of the continent and temperate rainforest in another part of the continent, despite having some of the driest places on Earth relatively close by both.

**Focal Disciplinary Core Ideas (DCIs):** ESS2.C, ESS2.D, PS1.A, PS3.A
**Focal Science and Engineering Practices (SEPs):** Developing and Using Models; Planning and Carrying Out Investigations; Analyzing and Interpreting Data
**Focal Crosscutting Concepts (CCCs):** Patterns; Cause and Effect; Systems and System Models; Matter and Energy

## Building Toward NGSS Performance Expectations

MS-PS1-4:
Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.

MS-ESS2-4:
Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

MS-ESS2-5:
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.

MS-ESS2-6:
Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

# TEACHER BACKGROUND KNOWLEDGE

## What are the Disciplinary Core Ideas (DCIs) used in the context of the phenomena for this unit?

Disciplinary Core Ideas are reproduced verbatim from *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. DOI: https://doi.org/10.17226/13165. National Research Council; Division of Behavioral and Social Sciences and Education; Board on Science Education; Committee on a Conceptual Framework for New K-12 Science Education Standards. National Academies Press, Washington, DC.

The unit expands students' understanding of weather and climate, and the role of water in Earth's surface processes which include these grades 6-8 elements of the Disciplinary Core Ideas (DCIs). It addresses all but the crossed out sections of the ones shown below. LA specific MS.EVS1A.c (DCI) is not explicitly addressed

**ESS2.C: The Roles of Water in Earth's Surface Processes**

- Global movements of water and its changes in form are propelled by sunlight and gravity. 7-MS-ESS2-4
- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. 7-MS-ESS2-5
- Variations in density due to variations in temperature ~~and salinity~~ drive a global pattern of interconnected ocean currents. 7-MS-ESS2-6
- Water continually cycles among land, ocean, and atmosphere via ~~transpiration,~~ evaporation, condensation and crystallization, and precipitation~~, as well as downhill flows on land~~. 7-MS-ESS2-4

**ESS2.D: Weather and Climate**

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms~~, and living things~~. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. 7-MS-ESS2-6 & 7-MS-ESS2-5
- Because these patterns are so complex, weather can only be predicted ~~probabilistically~~. 7-MS-ESS2-6 & 7-MS-ESS2-5
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. 7-MS-ESS2-6

The OpenSciEd Unit 7.4 (a 7th grade unit) on Matter Cycling will make reference to transpiration in Lesson 4, when students are investigating if water comes out of plants leaves.

*need background knowledge from Thermal Energy

This unit builds on DCI elements that students should have developed in the prior OpenSciEd unit 6.2. These ideas are elicited and are used in new contexts (primarily different because of time and temporal scale). In many cases, the unit helps students extend these DCIs. The plain text beneath each of the DCI elements below describes how the ideas are used and where they are extended.

- **PS1.A: Structure and Properties of Matter:** Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
    - This particle model is reused and extended in Lessons 3-11, 13-14, and 17-18. It is used to model (1) how energy is transferred from the ground to the air (through conduction), (2) why air changes its density (due to changes in the speed of air particles), (3) why density would affect the amount of air pressure detected by a barometer (due to differences in the amount of force applied to the barometer from changes in the weight of a column of air particles overhead), and (4) how the cooling of water vapor in the air can cause the molecules in it to slow down enough that they stick to, rather than bounce off of, neighboring particles in collisions, thereby causing the particles to condense or solidify out of the air. 7-MS-PS1-4
- **PS3.A: Definitions of Thermal Energy:** The temperature of a system is proportional to the average internal kinetic energy and potential energy per molecule (whichever is the appropriate building block for the system's material). When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time.
    - The idea that thermal energy transfer can occur through conduction is used to explain how the air above the ground is heated by it, and how warm rising air cools off as it moves higher up. This idea is reused in Lessons 5-8, 10, 12, 13, 14, 17, 18, 20, and 22. 7-MS-PS1-4
- **PS4.B: Electromagnetic Radiation** When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. - 6th grade
    - The idea that light is absorbed by the ground and converted to thermal energy is an idea that is reused in Lessons 3, 6-8, 10, 14, 17, 18, 20, and 22 in this unit.

6-MS-PS4-2

*possible area for unfinished learning

Core ideas students should know → ★ watch for possible unfinished learning

| This also unit builds on the following DCI elements from the K-2 grade band: | This also unit builds on the following DCI elements from the 3-5 grade band: |
|---|---|
| **ESS2.C: The Roles of Water in Earth's Surface Processes**<br>• Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.<br>**ESS2.D: Weather and Climate**<br>• Sunlight warms Earth's surface.<br>• Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. | **ESS2.C: The Roles of Water in Earth's Surface Processes**<br>• Nearly all of Earth's available water is in the ocean. Most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere.<br>**ESS2.D: Weather and Climate**<br>• Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.<br>• Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over the years |

## What should my students know from earlier grades or units?

While this unit engages students in multiple SEPs across the lesson-level performance expectations for all of the lessons in the unit, there are three focal practices that this unit targets to support students' development of the SEPs for the 6th grade year. These are:

1. Developing and Using Models,
2. Planning and Carrying Out Investigations
3. Analyzing and Interpreting Data

} Focal SEPs

The sections below describe the development of the SEPs leading to and continuing through this unit for each of these practices.

**1) Supporting the practice of Developing and Using Models**

| This unit assumes ~~students have had~~ experience with the following elements of this practice from the 3-5 grade band: | By the end of units 6.1 (Light and Matter (6th grade)) and 6.2 (Thermal), students will have experience with the following middle school elements of this practice: |
|---|---|
| • Identify limitations of models.<br>• Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.<br>• Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.<br>• Develop and/or use models to describe and/or predict phenomena.<br>• Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.<br>• Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system. | • Develop or modify a model— based on evidence—to match what happens if a variable or component of a system is changed.<br>• Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.<br>• Develop and/or use a model to predict and/or describe phenomena.<br>• Develop a model to describe unobservable mechanisms. |

In this unit, students build on their prior experiences with models by engaging in all of the above listed middle school elements again, by using the elements of the SEPs to model systems that are much more complex. The major shift in their engagement in the modeling practice includes:

New to student Science and Engineering Practices {

- **Systems at a much larger spatial scale.** Earlier units had students model systems that were no bigger than a room. Now they will be modeling systems that range in size from miles (in the first half of this unit) to hundreds of miles (in the second half of the unit).
- **Non-visible system boundaries.** Earlier units used boundaries between solids and liquids as the system boundaries that were being modeled. The boundary between the liquid inside the system and the solid that contains the liquid is a simpler modeling situation than those in this unit. This unit introduces invisible boundaries around gases - including air parcels and air masses.
- **Systems over longer time scales.** Phenomena that students modeled in prior units occurred almost instantly (reflections) or within minutes (cooling liquids in a cup). Phenomena that students model in this unit occur over days (mesoscale storms) or many years (climate patterns).
- **Modeling space in three dimensions.** Students develop models from multiple points of view in more than one dimension in this unit. This is the first unit in which students develop both a profile view of the system and a bird's eye view of the system. This occurs in the second half of the unit. This is a major shift towards a three-dimensional visualization

of a system, which sets important groundwork for what students will need to do in the next unit (OpenSciEd unit 6.4). Students will need to model the surface of the Earth and what is below the surface from both of these perspectives in that unit.

**2) Supporting the practice of Planning and Carrying Out Investigations**

| This unit assumes students ~~have had~~ experience with the following elements of this practice from the 3-5 grade band: | By the end of units 6.1 and 6.2, students will have experience with the the following middle school elements of this practice: |
|---|---|
| • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.<br>• Evaluate appropriate methods and/or tools for collecting data.<br>• Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.<br>• Make predictions about what would happen if a variable changes.<br>• Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success. | • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.<br>• Evaluate the accuracy of various methods for collecting data.<br>• Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.<br>• Collect data about the performance of a proposed object, tool, process, or system under a range of conditions. |

In this unit, students build on their prior experiences with planning and carrying out investigations by engaging in these elements again, but also engage in a new element in lesson 8 and 13:

- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation

And they engage in more co-construction of the data collection protocol related to this element in lesson 3, particularly related to how measurements will be gathered and recorded:

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

These lessons mark a shift toward engaging students in more revision, evaluation, and modification of experimental designs than in prior units.

**3) Supporting the practice of Analyzing and Interpreting Data.**

| This unit assumes students ~~have had~~ experience with the following elements of this practice from the 3-5 grade band: | By the end of units 6.1 and 6.2, students will have experience with the following middle school elements of this practice: |
|---|---|
| • Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.<br>• Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.<br>• Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.<br>• Analyze data to refine a problem statement or the design of a proposed object, tool, or process.<br>• Use data to evaluate and refine design solutions. | • Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.<br>• Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).<br>• Analyze and interpret data to provide evidence for phenomena.<br>• Analyze and interpret data to determine similarities and differences in findings.<br>• Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships. |

In this unit, students again engage in two elements listed in the right-hand column of the table above. They consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials), and they analyze and interpret data to provide evidence for phenomena. The last bulleted element in the right-hand column , using graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships,, is one that students engage with in new ways and to much greater depth than they did before. In the prior unit (OpenSciEd 6.2), only one lesson targeted this element in a lesson level expectation (LLPE). In this unit, students engage with data on maps at different scales (e.g. across a few miles vs. hundreds of miles and across a few days vs. years) to identify temporal and spatial relationships in Lessons 2, 7, 13, 14, 15, 17, 18, 19, 20, 21, and 22.

**What are the Focal Crosscutting Concepts (CCCs) for this unit?**

While this unit engages students in multiple CCCs across the lesson level performance expectations for all the lessons in the unit, there are four focal practices that this unit targets to help support students' development of CCCs across the 6th grade year in CCCs. These are:

1. Patterns
2. Cause & Effect
3. Systems and System Models
4. Matter & Energy

The sections below describe the development of these CCCs leading to this unit and through this unit.

**1) Using Patterns:**

| This unit assumes students have had experience with the following elements of this CCC from the 3-5 grade band: | By the end of units 6.1 and unit 6.2, students will have experience with the following middle school elements of this CCC: |
|---|---|
| • Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena and designed products.<br>• Patterns of change can be used to make predictions.<br>• Patterns can be used as evidence to support an explanation. | • Macroscopic patterns are related to the nature of microscopic and atomic-level structure.<br>• Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems.<br>• Patterns can be used to identify cause and effect relationships.<br>• Graphs, charts, and images can be used to identify patterns in data. |

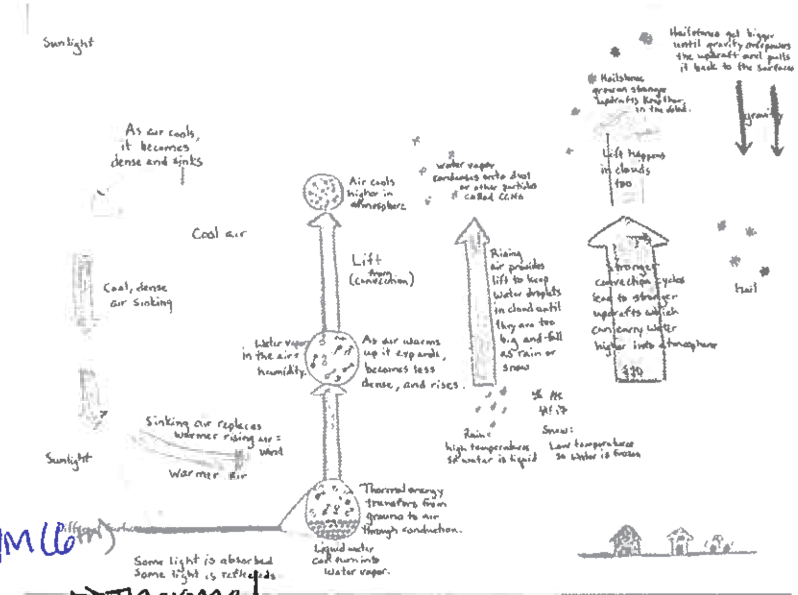
In this unit, students again engage in the middle school level elements listed above. However the last bulleted element, involving use of visualizations to uncover patterns, is one of the focal CCCs in this unit. Students engage in this CCC element to a much greater extent and in new ways than they did previously. In this unit, students work with data represented on maps at multiple scales (e.g., across a few miles vs. hundreds of miles and across a few days vs. years) to identify temporal and spatial relationships in Lessons 2, 6, 13, 14, 15, 17, 18, 19, 20, 21, and 22 of this unit. The structure of this data grows in complexity from Lesson 2 onward. For example, in Lesson 2, students look at hail accumulation maps from multiple cities and in Lesson 6 they look at two parallel sets of global maps (one showing net radiation and one showing land surface temperature) from two different times of year. In Lesson 14, they look at a time series set of national weather maps showing multiple layers of data overlaid on them, including precipitation amounts and types, cloud cover, low pressure air mass centers, and fronts.

Students' engagement in finding and making sense of patterns will generally be more complex in this unit than in prior units. In prior units, students looked for patterns in data tables, but this work was limited to collecting and analyzing light and temperature data from their own in-class investigations. The complexity of those data tables is extended in this unit. In Lesson 2, students work with weather conditions data that were taken across different times of day at different locations and are represented in multiple data tables. They also work with air temperature data from multiple locations and multiple times of year in Lessons 3 and 6, again represented in multiple data tables. These data include negative values for temperature, which is a concept connected to a new 6th grade Common Core math standard (CCSS.MATH.CONTENT.6.NS.C.5). In Lesson 16, students also use graphs to look for patterns in ways they haven't before. They examine the x-values and y-values of two points on a coordinate graph to find differences in the amount of water vapor in the air and differences in air temperature. This also is a connection to a new 6th grade Common Core math standard (CSS.MATH.CONTENT.6.NS.C.8).

**2) Using Cause and Effect:**

| This unit assumes students have had experience with the following elements of this CCC from the 3-5 grade band: | By the end of units 6.1 and 6.2, students will have experience with the following middle school elements of this CCC: |
|---|---|
| • Cause and effect relationships are routinely identified, tested, and used to explain change.<br>• Events that occur together with regularity might or might not be a cause and effect relationship. | • Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.<br>• Cause and effect relationships may be used to predict phenomena in natural or designed systems.<br>• Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. |

In this unit, students again engage in the three middle school level elements listed above in the right-hand column. However, they develop much longer chains of cause and effect than in previous units. Students used a single mechanism to explain phenomena in the previous units (e.g., reflection vs. transmission of light in Unit 6.1, and conduction in Unit 6.2). In contrast, students construct a much longer and more complex chain of cause and effect to explain the anchoring phenomena in this unit. This chain of cause and effect includes (1) light's interaction with matter, (2) conduction, (3) density changes in air, (4) convections, (5) evaporation, (6) condensation, and (7) opposing forces on suspended water particles in the air. The system model students develop in Lesson 13, shown here, reflects this increased complexity in cause and effect thinking.




L/M (6th)
Thermal

### 3) Using Systems and System Models:

| This unit assumes students have had experience with the following elements of this CCC from the 3-5 grade band: | By the end of units 6.1 and unit 6.2, students will have experience with the following middle school elements of this CCC: |
|---|---|
| • A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.<br>• A system can be described in terms of its components and their interactions. | • Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.<br>• Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. |

In this unit, students again engage in the middle school level elements listed in the right-hand column above. As described in the SEP Developing and Using Models section above, they also develop system models for much more complex systems. In this unit, the major shifts in thinking about the nature of this more complex system include:

- **systems at a much larger spatial scale**
- **non-visible system boundaries**
- **systems over longer time scales**
- **modeling space with a three-dimensional perspectives**

Major Shifts!

Student also engage in a new element of this CCC in Lesson 10:

- Models are limited in that they only represent certain aspects of the system under study. ← New ☆

They do this when evaluating the limitations of the thunderstorm simulation, identifying which aspects of the system are represented in the model and which additional aspects could be added to account for thunderstorm develop and then propose modifications to that simulation, to better represent particle level mechanisms and energy flow through the system.

**4) Using Matter & Energy:**

| This unit assumes ~~students have~~ had experience with the following elements of this CCC from the 3-5 grade band: | By the end of units 6.1 and 6.2, students will have experience with the following middle school elements of this CCC: |
|---|---|
| • Matter is made of particles.<br>• Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems.<br>• Energy can be transferred in various ways and between objects. | • Matter is conserved because atoms are conserved in physical and chemical processes.<br>• Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.<br>• Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).<br>• The transfer of energy can be tracked as energy flows through a designed or natural system. |

→ 4M (6th)

In the OpenSciEd unit 6.1, students tracked matter in and out of an open system and argued for mass conservation in closed system processes. In this unit, students track the flow of matter and energy across systems at a scale that is much larger and includes non-visible system boundaries, across longer time scales, and in three dimensional perspectives (see section 3 above). Thus, they use their ideas about matter and energy flow to address a completely new range of phenomena that occur across dramatically different scales of time and space. In addition, they use three different energy transfer processes to do this - radiation, conduction, and convection (see section 2 above).

Four focal CCCs may seem like a lot for a single unit. However, this is an 8-week unit, which is one of two units (out of twenty-four) that are the longest in the entire OpenSciEd middle school scope and sequence. Our more typical 5 to 6 week units tend to have two to three focal CCCs.

In many ways, one can think of this unit as two units in one - where lesson sets 1 and 2 are anchored around a small-scale weather phenomenon, and lessons sets 3 and 4 are anchored around large-scale weather phenomenon and long-term patterns (climate level). Patterns is a focal CCC in the second half of the unit, whereas the Matter & Energy CCC is a focal CCC in the first half. The CCCs of Cause & Effect and Systems & System Models cut across all lesson sets. Analyzing and Interpreting Data is a focal SEP in the second half of the unit, whereas Planning and Carrying out Investigations is a focal SEP in the second half. The chart below summarizes this pattern.

| *X = a focal SEP or CCC in this lesson set.* | *Lesson set 1* | *Lesson set 2* | *Lesson set 3* | *Lesson set 4* |
|---|---|---|---|---|
| SEP: Developing and Using Models – throughout | X | X | X | X |
| SEP: Planning & Carrying Out Investigations – 1st 1/2 focus | X | X | | |
| SEP: Analyzing and Interpreting Data – 2nd 1/2 focus | | | X | X |
| CCC: Patterns – 2nd 1/2 focus | | | X | X |
| CCC: Cause & Effect – throughout | X | X | X | X |
| CCC: System & System Models – throughout | X | X | X | X |
| CCC: Matter and Energy – 1st 1/2 focus | X | X | | |

Lesson sets 1–2: Anchored with small-scale weather phenomenon

Lesson sets 3–4: Anchored with large-scale weather phenomenon and long-term patterns

## What are some common ideas that students might have?

★possible competing ideas

equity builder

It is valuable to think of the *relevant ideas* listed below not as misconceptions that need to be erased but as productive ideas that we can use to build understanding. Not only does this help some students feel more comfortable talking about science and build a scientific identity, it improves science learning across the board. Having a set of competing ideas to compare, evaluate, and resolve is what drives the focus of many of the lesson questions and related investigations of the unit. Students will make incremental progress on revising these ideas over multiple lessons. The list below also indicates where students will first encounter a line of evidence that they can use to start to refute these ideas.

Some *relevant ideas* about **what causes differences in air temperature** that students may come into the unit with include:

- *Air should get warmer higher up because it is closer to the sun.*
    - In lesson 3, students will encounter evidence that this does not happen in the lower atmosphere, when they determine the temperature profile of the air from balloon sounding data. → shows how competing idea can be used to build understanding
- *Light warms the air above the Earth's surface by absorbing the light that reaches it, rather than being mostly heated by indirect heating from conduction between the air and the surface it is in contact with.*
    - In lesson 4, students gather first hand evidence that light from the sun directly heats the earth's surface when it is absorbed by those surfaces.

Some *relevant ideas* about the **composition of air and clouds** that students may come into the unit with include:

- *The humidity of air is the same everywhere on Earth and does not change.*
    - In lesson 7, students will encounter a reading about relative humidity and how it changes. They will also carry out an investigation to directly measure change in the relative humidity of the air.
- *A cloud is all gas, rather than a combination of gas and water droplets or ice crystals.*
- *Water vapor is in the air outside of a cloud but not in the air inside of a cloud.*
- *A cloud is something similar to a sponge - a solid that can absorb only so much water before it becomes saturated and starts overflowing with water, leading to precipitation.*
    - In lesson 9, students' ideas about clouds will be addressed in a reading that describes the composition of clouds.

Some *relevant ideas* about **what causes precipitation** that students may come into the unit with include:

- *Precipitation occurs as a result of clouds running into other clouds.*
- *Precipitation occurs as a result of strong winds blowing into or on clouds.*
    - In lesson 8, students will develop a model that explains how intermolecular attraction in combination with changes in the average speed of molecules can explain why water vapor condenses into a liquid below a certain temperature. In lesson 9 they will determine the role of CCN in initiating this process.
- *Precipitation is independent of temperature changes in the air.*
    - In lesson 16 students will address this idea when they calculate how much water vapor condenses out of the air and how much the relative humidity of the air changes when the temperature of the air drops a certain amount.

Some relevant ideas about **ocean temperatures and ocean currents** that students may come into the unit with include:

- *The temperature of the ocean is much colder than the land.*
- *The temperature of the ocean is the same everywhere.*
    - In lesson 13, students will encounter a transfer task about hurricanes that describes how warm the surface of the ocean gets in parts of the world where hurricanes form during a particular time of year. In lesson 20, students will analyze maps showing the average surface temperature of the oceans across the entire Earth.
- *Ocean currents only occur near the shore.*
    - In lesson 20, students will address this idea when they work with a reading and a map that shows how ocean currents move water great distances and that some ocean currents move warm water away from the equator toward the poles and other ocean currents bring colder water from the poles toward the equator.

## What modifications will I need to make if this unit is taught out of sequence?

★important to look at implementation guides to see where unfinished learning may be

This is the third unit in 6th grade in the OpenSciEd Scope and Sequence. Given this placement, several modifications would need to be made if teaching this unit earlier or later in the middle school curriculum. These include the following adjustments:

- If taught before OpenSciEd Unit 6.2, supplemental teaching of the following would be required:
    - Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.

consider if teaching before thermal

- The temperature of a sample of matter is proportional to the average internal kinetic energy per molecule in that sample.
    - When the kinetic energy of a particle object changes, there is inevitably some other change in energy at the same time; kinetic energy can be transferred from one particle to another through particle collision. This form of energy transfer (conduction) can occur between solid, liquids and gases when they make contact with each other.
    - When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the color of the light. Energy from the light that is absorbed by a sample of matter is converted to increased particle motion energy in that sample of matter.
    - The total kinetic energy of particles in a sample of matter is also referred to as the thermal energy of that matter.
    - Identifying independent and dependent variables and controlling for other variables, can help you conduct fair tests, which is a necessary condition for producing data that can serve as the basis for evidence in supporting or refuting a potential cause and effect relationship in a system.
- If taught before OpenSciEd Unit 6.1 (or at the start of the school year), supplemental teaching of classroom norms, setting up the Driving Question Board, and asking open-ended and testable questions would need to be added. Experience with using light sensors and reading and interpreting their output would need to be added.

→ Light and Matter (6th)

## What are prerequisite math concepts necessary for the unit?

→ Share this with math co-teacher

In this unit, students will need to have prior experiences in working with the ideas in the **bolded** sections of the related Common Core Math Standards listed below.

CCSS.MATH.CONTENT.6.NS.C.5: **Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero,** elevation above/below sea level, credits/deb ts, positive/negative electric charge); **use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.**

CSS.MATH.CONTENT.6.NS.C.8: Solve real-world and mathematical problems by graphing points in all four quadrants of the coordinate plane. Include use of coordinates and absolute value to **find distances between points with the same first coordinate or the same second coordinate.**

CCSS.MATH.CONTENT.6.RP.A.2: **Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0,** and use rate language in the context of a ratio relationship.

CCSS.MATH.CONTENT.6.RP.A.3: **Use ratio and rate reasoning to solve real-world and mathematical problems,** e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

Additionally, when students generate and interpret the tables of data in Lessons 2, 4, and 11, they will draw on what they have learned across a number of Represent and Interpret data standards for grades 1-5, within the domain of Measurement and Data in the Common Core Mathematics Standards.