Unit Summary
What factors interact and influence weather and climate?   This unit is broken down into three sub-ideas: Earth's large-scale systems interactions, the roles of water in Earth's surface processes, and weather and climate. Students make sense of how Earth's geosystems operate by modeling the flow of energy and cycling of matter within and among different systems. A systems approach is also important here, examining the feedbacks between systems as energy from the Sun is transferred between systems and circulates though the ocean and atmosphere. The crosscutting concepts of *cause and effect*, *systems and system models*, and *energy and matter* are called out as frameworks for understanding the disciplinary core ideas. In this unit, students are expected to demonstrate proficiency in *developing and using models* and *planning and carrying out investigations* as they make sense of the disciplinary core ideas. Students are also expected to use these practices to demonstrate understanding of the core ideas.   This unit is based on MS-ESS2-4, MS-ESS2-5, and MS-ESS2-6.
Student Learning Objectives
Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. *[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]* **(MS-ESS2-4)**
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. *[Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.]* **(MS-ESS2-5)**
Explain how variations in density result from variations in temperature and salinity drive a global pattern of interconnected ocean currents. *[Note: This SLO is based on a disciplinary core idea found in the Framework. It is included as a scaffold to the following SLO.]* (ESS2.C)
Use a model to explain the mechanisms that cause varying daily temperature ranges in a coastal community and in a community located in the interior of the country. *[Note: This SLO is based disciplinary core ideas found in the Framework. It is included as a scaffold to the following SLO.]* (ESS2.C; ESS2.D)
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. *[Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.]* **(MS-ESS2-6)**

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Unit Sequence	
Part A: *What are the processes involved in the cycling of water through Earth's systems?*	
Concepts	**Formative Assessment**
• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. • Global movements of water and its changes in form are propelled by sunlight and gravity. • The cycling of water through Earth's systems is driven by energy from the sun and the force of gravity. • Within Earth's systems, the transfer of energy drives the motion and/or cycling of water.	*Students who understand the concepts are able to:* • Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. • Model the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle.

Unit Sequence	
Part B: *What is the relationship between the complex interactions of air masses and changes in weather conditions?*	
Concepts	**Formative Assessment**
• The motions and complex interactions of air masses result in changes in weather conditions. • The complex patterns of the changes in and movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. • Examples of data that can be used to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions include weather maps, diagrams, and visualizations; other examples can be obtained through laboratory experiments.	*Students who understand the concepts are able to:* • Collect data to serve as the basis for evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

• Air masses flow from regions of high pressure to regions of low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time. • Because patterns of the changes and the movement of water in the atmosphere are so complex, weather can only be predicted probabilistically. • Sudden changes in weather can result when different air masses collide. • Weather can be predicted within probabilistic ranges. • Cause-and effect-relationships may be used to predict changes in weather.	

Unit Sequence	
Part C: *What are the major factors that determine regional climates?*	
Concepts	**Formative Assessment**
• Unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. • Patterns of atmospheric and oceanic circulation that determine regional climates vary by latitude, altitude, and geographic land distribution. • Atmospheric circulation that, in part, determines regional climates is the result of sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds. • Ocean circulation that, in part, determines regional climates is the result of the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. • Models that can be used to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates can be diagrams, maps and globes, or digital representations.	*Students who understand the concepts are able to:* • 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.

What it Looks Like in the Classroom

During this unit, students will answer the question "What factors interact and influence weather and climate?" beginning with the cycling of water in Earth's systems. Models will be created and emphasis will be on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Students will model the continuous movement of water from land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation. Students will focus on the global movement of water and its changes in form that are driven by sunlight as it heats the Earth's surface water.

The motions and complex interactions of air masses result in changes in weather conditions. The 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. Students will collect data from weather maps, diagrams, visualizations, and laboratory experiments to explain how the movements of air masses from regions of high pressure to regions of low pressure cause weather at a fixed location. For example, students can observe the movement of colored water that simulates the movement of hot and cold air masses. Students can observe the cooler water flowing in the direction of the warmer area and equate this with wind being created from the uneven heating of the Earth. Students will compare data collected from sources such as simulations, video, or experiments to identify the patterns of change in the movement of water in the atmosphere that are used to make weather predictions, understanding that any predictions are reported within probability ranges. Students will also make predictions about the conditions that result in sudden changes in weather.

Students will use models, diagrams, maps, and globes to understand atmospheric and ocean circulation patterns. Since 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, the ocean will be studied as a system with interactions such as inputs, outputs, processes, energy, and matter. Students will model how the unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. They will describe how the unequal heating of the global ocean produces convection currents. By examining maps, globes and digital representations of the movement of ocean currents, students will model the patterns by latitude, altitude, and geographic distribution. They will show that these patterns vary as a result of sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing wines.

Digital models like NOAA videos can be used to help students visualize how variations in density due to temperature and salinity drive a global pattern of interconnected ocean currents. This can be demonstrated in the classroom using models in which colored water with different temperatures or water with different densities is added to clear tubs of water. Students can observe that the warmer water is pushed upwards by the colder water. This same demonstration can be used with water that has different salinities. Using a turntable and drawing a straight line from the middle to the edge can model the Coriolis effect. If a turntable is not available, a Lazy Susan is a great substitute. The turntable or Lazy Susan can be painted with chalk paint, and the students can draw the line using chalk. Using chalk paint and chalk will enable the teacher to use them over and over. After the turntable is stopped, students will see that the motion of the turntable resulted in a curved line, and they will then be able to correlate how the rotation of Earth results in the movement of air.

Connecting English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

- Support the analysis of science and technical texts by citing specific textual evidence for how the motions and complex interactions of air masses result in changes in weather conditions.
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with information that is gained from reading text about how the complex patterns of the changes and movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents are major determinants of local weather patterns.
- Gather relevant information from multiple print and digital sources about how the complex patterns of the changes and movement of water in the atmosphere,

determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.

- Include multimedia components and visual displays in presentations to clarify information about how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Mathematics

- Reason abstractly and quantitatively by using data such as weather maps, diagrams, and visualizations or obtained through laboratory experiments to predict weather within probabilities ranges.
- Understand that positive and negative numbers are used together to describe quantities having opposite directions or values. Use positive and negative numbers to represent changes in atmospheric and oceanic temperatures, explaining the meaning of 0 in each situation.

Modifications

(Note: Teachers identify the modifications that they will use in the unit. See NGSS Appendix D: All Standards, All Students/Case Studies for vignettes and explanations of the modifications.)

- Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.
- Structure the learning around explaining or solving a social or community-based issue.
- Provide ELL students with multiple literacy strategies.
- Collaborate with after-school programs or clubs to extend learning opportunities.
- Restructure lesson using UDL principals (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)

Research on Student Learning

Students of all ages (including college students and adults) have difficulty understanding what causes the seasons. Students may not be able to understand explanations of the seasons before they reasonably understand the relative size, motion, and distance of the sun and the earth. Many students before and after instruction in earth science think that winter is colder than summer because the earth is further from the sun in winter. This idea is often related to the belief that the earth orbits the sun in an elongated elliptical path. Other students, especially after instruction, think that the distance between the northern hemisphere and the sun changes because the earth leans toward the sun in the summer and away from the sun in winter. Students' ideas about how light travels and about the earth-sun relationship, including the shape of the earth's orbit, the period of the earth's revolution around the sun, and the period of the earth's rotation around its axis, may interfere with students' understanding of the seasons. For example, some students believe that the side of the sun not facing the earth experiences winter, indicating confusion between the daily rotation of the earth and its yearly revolution around the sun.

Although upper elementary students may identify air as existing even in static situations and recognize that it takes space, recognizing that air has weight may be challenging even for high-school students. Students of all ages (including college students) may believe that air exerts force or pressure only when it is moving and only downwards. Only a few middle-school students use the idea of pressure differences between regions of the atmosphere to account for wind; instead they may account for winds in terms of visible moving objects or the movement of the earth.

Before students understand that water is converted to an invisible form, they may initially believe that when water evaporates it ceases to exist, or that it changes location but remains a liquid, or that it is transformed into some other perceptible form (fog, steam, droplets, etc.). With special instruction, some students in 5th grade may be able to identify the air as the final location of evaporating water Students must accept air as a permanent substance before they can identify the air as the final location of evaporating water. For many students, difficulty understanding the existence of water vapor in the atmosphere persists in middle school years. Students can understand rainfall in terms of gravity once they attribute weight to little drops of water (typically in upper elementary grades), but the mechanism through which condensation occurs may not be understood until high school.

Students of all ages may confuse the ozone layer with the greenhouse effect, and may have a tendency to imagine that all environmentally friendly actions help to solve all environmental problems (for example, that the use of unleaded petrol reduces the risk of global warming). Students have difficulty linking relevant elements of knowledge when explaining the greenhouse effect and may confuse the natural greenhouse effect with the enhancement of that effect (NSDL, 2015).

Prior Learning

By the end of Grade 5, students understand that:

- Most of the Earth's water is in the ocean, and much of the Earth's fresh water is in glaciers or underground.
- Climate describes patterns of typical weather conditions over different scales and variations.
- Historical weather patterns can be analyzed.

Future Learning

Physical science

- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.
- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.
- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

Earth and space science

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.
- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.
- The complex patterns of the changes and movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

- Global movements of water and its changes in form are propelled by sunlight and gravity. Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.
- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations.
- 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.
- Because these patterns are so complex, weather can only be predicted probabilistically.
- 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.
- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.
- This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.

Connections to Other Units

Grade 6 Unit 1: Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).

Grade 6 Unit 2: Interactions of Matter

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- 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.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.

Grade 6 Unit 4: Forces and Motion

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.

Grade 6 Unit 5: Types of Interactions

- Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun.
- Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively)

Grade 8 Unit 5: Relationships among Forms of Energy

- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- A system of objects may also contain stored (potential) energy, depending on their relative positions.
- When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

Grade 8 Unit 6: Thermal Energy

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones.
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

Grade 8 Unit 7: The Electromagnetic Spectrum

- 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.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.

- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Sample of Open Education Resources

Air Masses of a set of Level 1 activities designed by the Science Center for Teaching, Outreach, and Research on Meteorology (STORM) Project. The authors suggest that previous activities in the unit be completed before Activity 12: Air Masses, including those that address pressure systems and dew point temperature. In Activity 12, the students learn about the four main types of air masses that affect weather in the United States, their characteristic temperatures, and humidity levels as it relates to dew point temperatures. The lesson plan follows the 5E format. Initially, students discuss local weather and then examine surface temperature and dew point data on maps to determine patterns and possible locations of air masses. They learn about the source regions of air masses and compare their maps to a forecast weather map with fronts and pressure systems drawn in. During the Extension phase, students access current maps with surface and dew point temperatures at http://www.uni.edu/storm/activities/level1 and try to identify locations of air masses. They sketch in fronts and compare their results to the fronts map. Evaluation consists of collection of student papers.

Ocean Currents and Sea Surface Temperature allows students to gather data using My NASA Data microsets to investigate how differential heating of Earth results in circulation patterns in the oceans and the atmosphere that globally distribute the heat. They examine the relationship between the rotation of Earth and the circular motions of ocean currents and air. Students also make predictions based on the data to concerns about global climate change. They begin by examining the temperature of ocean's surface currents and ocean surface winds. These currents, driven by the wind, mark the movement of surface heating as monitored by satellites. Students explore the link between 1) ocean temperatures and currents, 2) uneven heating and rotation of Earth, 3) resulting climate and weather patterns, and 4) projected impacts of climate change (global warming). Using the Live Access Server, students can select data sets for various elements for different regions of the globe, at different times of the year, and for multiple years. The information is provided in maps or graphs which can be saved for future reference. Some of the data sets accessed for this lesson include Sea Surface Temperature, Cloud Coverage, and Sea Level Height for this lesson. The lesson provides directions for accessing the data as well as questions to guide discussion and learning. The estimated time for completing the activity is 50 minutes. Inclusion of the Extension activities could broaden the scope of the lesson to several days in length. Links to informative maps and text such as the deep ocean conveyor belt, upwelling, and coastal fog as needed to answer questions in the extension activities are included.

Adopt a Drifter: Do Ocean Surface Currents Influence Climate? Students construct climographs showing both precipitation and temperature for 3 coastal cities and describe how ocean surface currents affect climate on nearby land. They are provided with the research question, "Do ocean currents influence climate?" and are asked to construct a hypothesis. The students are asked to read an introductory paragraph explaining the relationship between the temperature of the ocean current and temperature and precipitation on adjacent land and examine a map of major ocean currents. They construct 3 climographs using data provided. The labels on the graphs are not directly on the lines, so the teacher would need to instruct students on the placement of their data points. Conclusion and analysis questions are provided asking students to examine the direction of flow of ocean currents, temperature of the water, source regions of the current, and impact on both temperature and precipitation on coastal regions. Extension activities include researching additional information on vegetation, culture and physical geography of the 3 cities studied, plus comparing data for 2 additional cities. The activity should take 2 class periods.

Appendix A: NGSS and Foundations for the Unit

Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. *[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]* **(MS-ESS2-4)**
Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. *[Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] [Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.]* **(MS-ESS2-5)**
Explain how variations in density result from variations in temperature and salinity drive a global pattern of interconnected ocean currents. (ESS2.C)
Use a model to explain the mechanisms that cause varying daily temperature ranges in a coastal community and in a community located in the interior of the country. (ESS2.C; ESS2.D)
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. *[Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.]* **(MS-ESS2-6)**
Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. *[Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]* **(MS-ESS2-4)**

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop and use a model to describe phenomena. (MS-ESS2-6) • Develop a model to describe unobservable mechanisms. (MS-ESS2-4) **Planning and Carrying Out Investigations** • Collect data to produce data to serve as the	**ESS2.C: The Roles of Water in Earth's Surface Processes** • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4) • The complex patterns of the changes and the	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5) **Systems and System Models** • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information

basis for evidence to answer scientific questions or test design solutions under a range of conditions. (MS-ESS2-5)	movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (MS-ESS2-5) • Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4) • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. (MS-ESS2-6) **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. (MS-ESS2-6) • Because these patterns are so complex, weather can only be predicted probabilistically. (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. (MS-ESS2-6)	flows within systems. (MS-ESS2-6) **Energy and Matter** • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)

English Language Arts	Mathematics
Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS2-5),(MS-ESS3-5) **RST.6-8.1** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-5) **RST.6-8.9** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote	Reason abstractly and quantitatively. (MS-ESS2-5),(MS-ESS3-5) **MP.2** 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/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-ESS2-5) **6.NS.C.5** Use variables to represent numbers and write expressions when solving a real-

or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-ESS2-5) **WHST.6-8.8** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-ESS2-6) **SL.8.5**	world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. (MS-ESS3-5) **6.EE.B.6**