Question 1 Rubric

Rubric Measures: Students explain what causes patterns of weather movement in the tropics and midlatitudes and support their explanations using ideas about the Coriolis effect.

Performance Expectation	Alignment to NGSS Dimensions	Performance Outcomes	Alignment to Prompt/Criteria in Performance Assessment
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.~~	*SEP – Constructing Explanations:* **Apply scientific ideas**, principles and/or evidence **to construct**, revise, and/or use **an explanation for real-world phenomena**, examples, or events. *DCI – ESS2.D:* **Weather** ~~and climate~~ is **influenced by the interactions involving sunlight**, the ocean, and **the atmosphere**, ~~ice, landforms, and living things~~. **These interactions vary with latitude**, altitude, and local and regional geography, all of **which can affect** ~~oceanic~~ **atmospheric flow patterns**. *CCC – Cause and Effect:* **Phenomena may have more than one cause**, and some cause and effect relationships in systems can only be described using probability.	Develop an explanation for how the Coriolis effect causes patterns of air mass movement in the tropics and midlatitudes.	Weather forecasters know there is a direction weather usually follows as air masses move in the midlatitudes and tropics. Answer the next two questions to explain why forecasters often predict that weather will move in the direction of the arrows shown on the globe below. 1. Why is the arrow showing wind direction curving to the east at point A? Why is the arrow curving to the west at point B?

Correct Answer

Air that would be moving south toward the equator is curved to the west, and air that would be moving north toward the pole is curved to the east because of the Coriolis effect. The wind is curved because of Earth's rotation.

Question 1 Rubric

Rubric Measures: Students explain what causes patterns of weather movement in the tropics and midlatitudes and support their explanations using ideas about the Coriolis effect.

	Emerging[1] -1	Developing-2	Proficient-3
PERFORMANCE	Explanation uses **irrelevant or minimal** science ideas about the Coriolis effect as a cause of air mass movement AND reasoning connecting the cause/s to the phenomenon is **irrelevant or missing**.	Explanation **uses partially accurate and relevant** science ideas about the Coriolis effect as a cause of air mass movement BUT reasoning connecting the cause/s to the phenomenon is **irrelevant or missing**.	Explanation uses **accurate and relevant** science ideas about the Coriolis effect as a cause of air mass movement AND reasoning connecting the cause/s to the phenomenon is **present**.
LOOK FOR	• Describes some aspects related to the Coriolis effect. • No reasoning or reasoning is irrelevant.	• Mentions the Coriolis effect but not what it means. • No reasoning or reasoning does not link how the cause leads to observed east-west patterns in air mass movement. Mentions keywords (Coriolis effect) but with no real explanation.	• Describes the Coriolis effect. • Describes Earth's rotation as the cause of observed patterns in air mass movement. • Does not necessarily need to use the vocabulary "Coriolis effect" if the description includes a discussion of Earth's rotation.
SAMPLE RESPONSE	*The earth moves this way because clouds move this way.*	*Weather moves this way because of the Coriolis effect.*	*Weather usually moves from west to east or east to west because of the rotation of the Earth.* *In the tropics, the weather moves to the west, and in the mid-latitudes, weather moves to the east. This happens because the earth is spinning, which causes air to curve east to west or west to east.* (Note: Students may mention that this west-east movement happens in the Northern Hemisphere.)

[1] If the student provides no assessable evidence (e.g., "I don't know" or leaves the answer blank), then that student response cannot be evaluated using the rubric.

[2] NGSS assessment boundary for this PE states: "Assessment does not include the dynamics of the Coriolis effect". A level 3 response on this rubric, therefore, does not expect students to reason further about the Coriolis effect than it is due to Earth's rotation.

Question 2 Rubric

Rubric Measures: Students explain what causes patterns of weather movement in the tropics and midlatitudes and support their explanation using ideas about global convection.

Performance Expectation	Alignment to NGSS Dimensions	Performance Outcomes	Alignment to Prompt/Criteria in Performance Assessment
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~~.	*SEP – Constructing Explanations:* **Apply scientific ideas**, principles and/or evidence **to construct**, revise, and/or use **an explanation for real-world phenomena**, examples, or events. *DCI – ESS2.D:* **Weather** ~~and climate~~ is **influenced by the interactions involving sunlight**, the ocean, and **the atmosphere**. ~~ice, landforms, and living things~~. **These interactions vary with latitude**, altitude, and local and regional geography, all of **which can affect** ~~oceanic~~ **atmospheric flow patterns**. *CCC:* **Cause and effect relationships may be used to predict phenomena in natural** or designed **systems.**	Develop an explanation for how global convection causes patterns of air mass movement in the tropics and midlatitudes.	2. If the Earth didn't spin, what direction would the air in the region of A move? What direction would the air in the region of B move?

Correct Answer

If the Earth didn't spin, then the Coriolis effect would not curve global winds. Air at point A would move north, and air at point B would move south because of global convection. Global convection happens because the planet is heated more at the equator than anywhere else, so warm air rises there.

Question 2 Rubric

Rubric Measures: Students explain what causes patterns of weather movement in the tropics and midlatitudes and support their explanation using ideas about global convection.

	Emerging[3] -1	Developing-2	Approaching Proficiency-3	Excelling-4
PERFORMANCE	Explanation uses **irrelevant or minimal** science ideas about global convection as a cause of air mass movement AND reasoning connecting the cause/s to the phenomenon is **irrelevant or missing**.	Explanation **uses partially accurate and relevant** science ideas about global convection as a cause of air mass movement BUT reasoning connecting the cause/s to the phenomenon is **irrelevant or missing.**	Explanation uses **accurate and relevant** science ideas about global convection as a cause of air mass movement BUT reasoning connecting the cause/s to the phenomenon is **vague or general** and **doesn't describe how the cause** explains patterns of air mass movement.	Explanation uses **accurate and relevant** science ideas about global convection as a cause of air mass movement AND reasoning connecting the cause to the phenomenon **describes how the cause** explains patterns of air mass movement.
LOOK FOR	• Describes some aspects related to convection. • No reasoning or reasoning is irrelevant.	• Describes aspects of convection (air circulation, areas of high and low pressure, warm temp at equator and cool temp at 30°N). • No reasoning or reasoning does not link how the cause leads to observed north-south patterns in air mass movement (i.e., mentions keywords such as convection, high/low pressure, uneven heating but offers no explanation).	• Describes aspects of convection (air circulation, areas of high and low pressure, warm temp at equator and cool temp at 30°N). • Vague, but present, reasoning linking how convection leads to observed north-south patterns in air mass movement.	• Describes convection (air circulation, areas of high and low pressure, warm temp at equator and cool temp at 30°N). • Reasoning explains how or why convection results in observed north-south patterns in air mass movement.
SAMPLE RESPONSE	*If the Earth didn't spin, then the clouds wouldn't move the way that they do.*	*If the Earth didn't spin, then weather would move because of the differences in low and high pressure.* *Because of the sunlight directly hitting the equator and indirectly hitting the midlatitudes.*	*If the Earth didn't spin, then warm air would rise from the equator, cool air from the pole moves downward to take the warm air's place.*	*If the Earth didn't spin, then the Coriolis effect would not curve global winds. Air at point A would move north, and air at point B would move south because of global convection. Global convection happens because the planet is heated more at the equator than anywhere else.*

[3] If the student provides no assessable evidence (e.g., "I don't know" or leaves the answer blank), then that student response cannot be evaluated using the rubric.

Question 3 Rubric

Rubric Measures: Students analyze and interpret the pattern in air pressure data for air masses at a front to determine upward and downward movement.

Performance Expectation	Alignment to NGSS Dimensions	Performance Outcomes	Alignment to Prompt/Criteria in Performance Assessment
MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.	*SEP:* **Use graphical displays** (e.g., **maps**, charts, graphs, and/or tables) **of large data sets to identify** temporal and **spatial relationships**. *DCI:* 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. Sudden changes in weather can result when different air masses collide. *CCC:* **Students use** graphs and **charts to identify patterns in data.**	Analyze and interpret pattern in air pressure data to explain why air moves vertically in areas of high and low pressure.	A school in Nebraska is planning a graduation party for a day in May. One day before the party, weather forecasters warned: *Even though it is warm and sunny now, a cold front will soon move into Nebraska. Tomorrow the weather will become cool and rainy.* The weather forecasters used air pressure data (measured in millibars; shown on the map below) to predict more precisely how the front will move. 3. Use the air pressure data and cold front shown in the map to describe how air is moving at location A. Explain why it moves this way. Now describe how the air is moving at location B. Explain why it is moving this way.

Correct Answer

Location A has lower air pressure than other areas on the map, and it's located at the cold front, so air will be rising. Low pressure air rises because it is warmer and less dense than the air around it. Location B on the map shows higher air pressure, and it's between the area with the highest pressure (to the west) and the cold front with lower pressure (to the east), so the air will be moving from west to east. Also, because it's higher pressure, air will be sinking because the air is cooler and more dense than the air around it.

Question 3 Rubric

Rubric Measures: Students analyze and interpret the pattern in air pressure data for air masses at a front to determine upward and downward movement.

	Emerging -1	Developing-2	Approaching Proficiency-3	Excelling-4
PERFORMANCE	**Does not interpret** the significance of the pattern, or makes **inaccurate inferences** about air moving up and down in areas of high and low pressure AND **does not support inferences**.	Interpretation makes **some accurate and inaccurate inferences** about air moving up and down in areas of high and low pressure BUT supports them with **inaccurate or irrelevant** information **or does not support** inferences.	Interpretation makes **accurate** inferences about air moving up and down in areas of high and low pressure AND **vaguely** supports interpretation with reasoning about why air moves this way in those locations.	Interpretation makes **accurate** inferences about air moving up and down in areas of high and low pressure AND **explicitly** supports interpretation with reasoning about why air moves this way in those locations.
LOOK FOR	• Air moves down at location A. • Air moves up at location B. • Does not explain the upward or downward movement. • No reasoning provided or reasoning is irrelevant.	• Correctly identifies that air moves up and down because of pressure, but does not clearly connect up and down to high or low pressure. • Correctly identifies up at location A and down at location B, but applies no reasoning or reasoning uses inaccurate information.	• Identifies that high pressure air (location B) is associated with sinking air, and low pressure air (location A) is associated with rising air. • Provides very little explanation of how they know this.	• Identifies that high pressure (location B) is associated with sinking air and low pressure (location A) is associated with rising air. • Reasoning explains something about the space between air molecules, density of air, or movement of molecules (e.g., high-pressure molecules are closer together, moving less, and sinking; low-pressure air molecules are spread apart, moving more, and rising) Note: Reasoning does not need to include references to air molecules to be excelling.
SAMPLE RESPONSE	*Air would be blowing a lot in location A.* *Location A would have air pushing down on it.*	*Air rises in areas of low pressure, so that's why it's windy.*	*In areas with high pressure, air flows from the atmosphere to the surface (down), and areas of low pressure have rising air.*	*Areas of high pressure are usually colder and particles are closer together and sinking. Areas of low pressure usually have more rising air and particles are spread apart.*

Question 4 Rubric

Rubric Measures: Student uses analysis of pressure data to explain the direction of movement of air masses (across the surface).

Performance Expectation	Alignment to NGSS Dimensions 	Performance Outcomes	Alignment to Prompt/Criteria in Performance Assessment
MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.	*SEP:* **Use graphical displays** (e.g., **maps**, charts, graphs, and/or tables) **of large data sets to identify** temporal and **spatial relationships**. *DCI:* **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. Sudden changes in weather can result when different air masses collide. *CCC:* **Cause and effect relationships may be used to predict phenomena in natural** or designed **systems.**	Use air pressure data to explain why air masses move across the surface from high to low pressure.	4. Use the air pressure data and your knowledge about how air is moving at locations A and B to explain why weather forecasters predict that the front will likely move to Nebraska.

Correct Answer

Students indicate that air masses move from areas of high pressure to low pressure. Air pushes away from higher pressure areas at the ground surface and moves toward areas of lower pressure. That is why the overall movement of the cold front is going from high to low pressure (west to east). Students need to use the vertical movement of air (Question 3) to help them explain the movement from west to east (horizontal movement) across the surface. Students do not need to explain clockwise or counterclockwise rotation (Coriolis effect) or prevailing winds as part of their explanation.

Question 4 Rubric

Rubric Measures: Student uses analysis of pressure data to explain the direction of movement of air masses (across the surface).

	Emerging[4] -1	Developing-2	Approaching Proficiency-3	Excelling-4
PERFORMANCE	Uses **irrelevant or inaccurate** information to predict direction of motion and supports explanation with **inaccurate or irrelevan**t information **or does not support** explanation.	Explanation is **partially** supported with an **accurate** interpretation of data but provides either an **inaccurate or irrelevant** explanation about how air masses of different pressure interact or no explanation at all.	Explanation is supported with an **accurate** interpretation of the data BUT an **incomplete or vague** explanation about how masses of different pressure interact.	Explanation is fully supported using an **accurate** interpretation of the data and a **complete explanation** about how air masses of different pressure interact.
LOOK FOR	• Does not identify high pressure sinking and low pressure rising. • Does not identify high pressure push and low pressure pulling or rising.	• Description of higher pressure pushing the lower pressure mass east (toward Nebraska) with no explanation. • Description of prevailing winds as the mechanism of movement, not pressure differences. • Description of up and down movement of air but not connected to the east-west movement.	• Description of a higher pressure air mass moving east toward a lower pressure air mass with vague reference to high pressure pushing down or out and low pressure rising up or away.	• Description of a higher pressure air mass moving east toward a lower pressure air mass. • Explanation includes a mechanism for motion, such as when two air masses interact the higher pressure air moves below the lower pressure air, causing lower pressure air to move upward and causing higher pressure air to move in the direction of the lower pressure air.
SAMPLE RESPONSE	*The front will probably move to Nebraska because wind blows west to east.*	*Higher pressure will move to lower pressure, which makes it move to Nebraska.*	*High pressure air moves downward and spreads outward, and low pressure air moves upward, so nearby air rushes to fill the space.*	*High pressure air pushes into low pressure air that is rising and pushes low pressure air upward. The high pressure air is spreading out pushing toward low pressure. That is why the air masses move to low pressure.*

[4] If the student provides no assessable evidence (e.g., "I don't know" or leaves the answer blank), then that student response cannot be evaluated using the rubric.

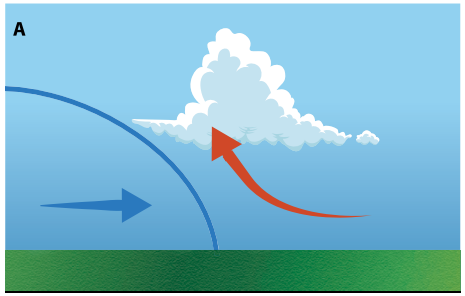
Question 5 Rubric

Rubric Measures: Students develop a model to show how the cold air causes the warmer air to move upward when two air masses interact at a cold front.

Performance Expectation	Alignment to NGSS Dimensions	Performance Outcomes	Alignment to Prompt/Criteria in Performance Assessment
MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.	*SEP:* **Develop** and/or use **models to describe** and/or predict **phenomena.** *DCI:* **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. Sudden changes in weather can result when different air masses collide.**	Develop a model to show how warm and cold air masses interact along a cold front.	5. Think about the temperature of the air masses that make up a cold front and the air pressure data from the map on the previous page. When the cold front arrives in Nebraska, what will happen to the warm air that is there now? Draw and label a cross-sectional model in the box below to show how the air masses will interact. Your model should show: • the warm air mass • the cold air mass • the location of the cold front • the direction that the cold front is moving • what causes the cold front to move this way

Correct Answer

- Students accurately place a cold front between a warm air mass and a cold air mass.
- Students indicate (with an arrow or some other symbol) the cold air is pushing into the warm air.
- Students indicate (with an arrow or some other symbol) an upward lift of the warm air mass as the cold air pushes under the warmer air.
- Students indicate that the front is moving from west to east, toward Nebraska.
- Students may label the "cause" or mechanism for why the air masses move this way (e.g., density differences, pressure differences).



Question 5 Rubric

Rubric Measures: Students develop a model to show how the cold air causes the warmer air to move upward when two air masses interact at a cold front.

	Emerging[5] -1	Developing-2	Approaching Proficiency-3	Excelling-4
PERFORMANCE	Model shows an **inaccurate or irrelevant** prediction about where the warm air mass will move AND how the air masses interact OR an accurate prediction of direction without any explanation or interaction.	Model shows a **partially accurate** prediction about where the warm air mass will move AND how the air masses interact.	Model shows an **accurate** prediction of where the warm air mass will move and **generally** describes how the air masses interact.	Model shows an **accurate and clear** prediction of where the warm air mass will move AND how it interacts with the cold air mass.
LOOK FOR	• Incorrectly describes the direction of the movement of both air masses or does not describe the movement of either. • Gets the direction correct, but does not include and accurate mechanism to describe the movement.	• Incorrectly describes the direction of the movement of one air mass or does not describe the movement of both air masses. • Does not include an accurate mechanism for movement of warm air or the mechanism is really vague.	• Model shows the two air masses and upward movement of warm air. • Either the model or the description doesn't clearly include a mechanism (e.g., very limited ideas that cold air is pushing the warm air upward).	• Shows the cold air pushing into the warm air as it moves east. • Includes a mechanism (e.g., the warm air moves upward over the cold air).
SAMPLE RESPONSE	*My model shows the cold front colliding with the warm air and the directions they are going.* (Model does not show any consistency in air flow or cold air rising.)	*My model shows that when cold and warm air meet at a cold front, the cold front pushes the warm air away.* (Model does not show the warm air going over the cold air.)	*My model shows that when cold and warm air meet at a cold front, the cold air goes under the warm air and pushes it up.*	*My model shows two air masses; one being cool and the other being warm. The warm air will rise because it is low pressure, and the cool air will sink because it is high pressure.*

[5] If the student provides no assessable evidence (e.g., "I don't know" or leaves the answer blank), then that student response cannot be evaluated using the rubric.

Question 6 Rubric

Rubric Measures: Students explain the upward lift of warm air with respect to pressure or density differences between interacting air masses.

Performance Expectation	Alignment to NGSS Dimensions	Performance Outcomes	Alignment to Prompt/Criteria in Performance Assessment
MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.	*SEP:* **Develop** and/or use **models to describe** and/or predict **phenomena.** *DCI:* **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. Sudden changes in weather can result when different air masses collide.** *CCC:* **Cause and effect relationships may be used to predict phenomena in natural** or designed **systems.**	Use a model to explain why warm air rises over cold air along a cold front.	6. Explain why the warm air and cold air will move the way you showed in your model.

Correct Answer

- Students explain the upward lift as the cold air pushes under the warmer air. Students may explain this in terms of air pressure or air density depending on what you emphasized in your instruction.
- Students should indicate the cold air has higher pressure or is more dense than warm air and is pushing into the warm air with lower pressure. They should also say that the warm air is less dense, with lower pressure, and is rising away from the surface.

Question 6 Rubric

Rubric Measures: Students explain the upward lift of warm air with respect to pressure or density differences between interacting air masses.

	Emerging[6] -1	Developing-2	Approaching Proficiency-3	Excelling-4
PERFORMANCE	Explanation uses **irrelevant, minimal, or inaccurate** science ideas about the upward lift of warm air AND reasoning connecting the cause/s to the phenomenon is **irrelevant or missing.**	Explanation **uses partially accurate and relevant** science ideas about the upward lift of warm air OR pressure differences between two air masses BUT reasoning connecting the cause/s to the phenomenon is **irrelevant or missing**.	Explanation **uses accurate and relevant** science ideas about the upward lift of warm air OR pressure differences between two air masses. Reasoning connecting the cause/s to the phenomenon is **vague or general** in explaining patterns in how warm and cold air move when they interact due to temperature or pressure differences.	Explanation **uses accurate and relevant** science ideas about the upward lift of warm air OR pressure differences between two air masses AND **reasoning** connects the cause/s to the phenomenon in a **clear and explicit** way.
LOOK FOR	• Cold air rising, warm air sinking OR movement from low to high pressure. • Focusing on precipitation, or the location, such as Nebraska.	• General reference to warm air rising and cold air sinking with no explanation about why this pattern happens.	• Explanation is present, but it is not clear. • May reference pressure, density, or molecular movement in the explanation, but the description of the mechanism is limited.	• Explanation is present, clear, and accurate. • References pressure or density to describe the motion. Note: May reference molecular movement in the explanation.
SAMPLE RESPONSE	*Because of humidity and how the wind moves by the precipitation.* *It goes that way because warm air pushes the cold air.* *The air will mix to make a tornado.*	*Because warm air rises and cold air sinks.* *Because warm air rises and cold air pushes warm air up.*	*The warm air goes above because the pressure pushes it.*	*Warm air is less dense, and it will rise above cold air.* *The air will move this way because cold air has higher pressure and it sinks, while warm air moves up because of the low pressure.*

[6] If the student provides no assessable evidence (e.g., "I don't know" or leaves the answer blank), then that student response cannot be evaluated using the rubric.

Question 7 Rubric

Rubric Measures: Students explain the upward lift of relatively more humid air into cooler altitudes forming clouds and storms.

Performance Expectation	Alignment to NGSS Dimensions 	Performance Outcomes	Alignment to Prompt/Criteria in Performance Assessment
MS-ESS2-5: Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.	*SEP:* Develop and/or **use models to describe a**nd/or predict **phenomena.** *DCI:* **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. Sudden changes in weather can result when different air masses collide.** *CCC:* **Cause and effect relationships may be used to predict phenomena in natural** or designed **systems.**	Use a model to explain why a cold front (where warm and cold air masses interact) often causes rain.	7. Before the cold front moved into Nebraska, students noticed it felt very muggy or humid. Use your model to explain why it will probably rain in Nebraska during the graduation party.

Correct Answer

Students accurately describe the warm air as more humid and the upward lift of this air into cooler temperatures at higher altitudes, resulting in condensation and then precipitation, which forms near/at the front where the warm, moist air is lifted.

Question 7 Rubric

Rubric Measures: Students explain the upward lift of relatively more humid air into cooler altitudes forming clouds and storms.

	Emerging[7] -1	Developing-2	Approaching Proficiency-3	Excelling-4
PERFORMANCE	Explanation uses **irrelevant, minimal, or inaccurate** science ideas about the upward lift of warm, moist air AND reasoning connecting the cause/s to the phenomenon (rain event) is **irrelevant or missing**.	Explanation **uses partially accurate and relevant** science ideas about the upward lift of warm, moist air BUT reasoning connecting the cause/s to the phenomenon is **irrelevant or missing**.	Explanation **uses accurate and relevant** science ideas about the upward lift of warm, moist air. Reasoning connecting the cause/s to the phenomenon is **vague or general** (e.g., a general description of water cycling).	Explanation **uses accurate and relevant** science ideas about the upward lift of warm, moist air AND **reasoning connects** the cause/s to the phenomenon, explaining the cool temperature at higher altitudes resulting in condensation of water.
LOOK FOR	• Applies incorrect science ideas like cold air moving up, warm air staying low. • East-west movement and not the vertical lift of warm air. • Cold air bringing moisture with it. • Collision of air, tornados.	• General connection of warm, rising air to clouds or storms. • Mix of correct and incorrect ideas (e.g., warm air going up causing evaporation).	• Describes an accurate water cycle story, but it's not necessarily connected to the frontal phenomena. • Provides little to no connection to cooler temperatures higher in the atmosphere.	• Clearly links upward movement of moisture condensing with cooler temperatures higher in the atmosphere. • Reasoning is clear and detailed and connects the upward movement of warm, moist air to the phenomenon of rain at a frontal boundary.
SAMPLE RESPONSE	*Since the front is going over Nebraska, it will most likely rain. It will also be cold because the warm air will bring the warm air with it to fuel the storm.* *When a cold front arrives, it usually brings rain with it.*	*Well, if it's hot there, before the cold front gets there, the sun will make the water evaporate. When the cold front gets there, it'll drop all the water.* *It will probably rain because the cold air will push the warm air up, causing evaporation and condensation. Then it will rain.*	*Water droplets evaporate and rise into the air then mix with the warm air to make clouds (condensation). The droplets then merge with dust particles and become heavier so the clouds have to release them as rain, (or snow, sleet, or hail) in precipitation.*	*In my model, the warm air is being pushed up. Since it is colder at higher altitudes, the water vapor in the warm air mass would condense and form a cloud. If there is too much moisture, it will precipitate.*

[7] If the student provides no assessable evidence (e.g., "I don't know" or leaves the answer blank), then that student response cannot be evaluated using the rubric.

Question 8 Rubric

Rubric Measures: Students identify that surface temperatures are warmer than the air temperatures above the surface, and they explain this concept using ideas about heating of the surface by the Sun, followed by heating the air above the surface.

Performance Expectation	Alignment to NGSS Dimensions	Performance Outcomes	Alignment to Prompt/Criteria in Performance Assessment
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.~~	*SEP:* **Construct**, analyze, and/or interpret **graphical displays of data** and/or large data sets **to identify** linear and non-linear **relationships**. *DCI:* ~~Global~~ Movement of water and its changes in form are propelled by sunlight. ~~and gravity.~~ *CCC:* **Patterns in rates of change and other numerical relationships can provide information about natural** and human-designed **systems.**	Use knowledge of daily patterns in surface temperature and their relationship to air temperature to draw a graph of changes in surface temperature over a day.	8. A school in Des Moines, Iowa has a similar problem. On graduation day there was a thunderstorm around 4:00 p.m. that stopped after about an hour. Use the air temperature and humidity data in the graphs below to analyze the storm. 8a. Think about how air temperature and surface temperature are different. Scientists reported that ground surface temperature at 7:00 am was 23°C. Draw a new line on the air temperature graph above to show how the surface temperature changes during the day. 8b. Explain why ground surface temperature would follow the line that you drew.

Correct Answer

- Students correctly draw the surface temperature data mirroring (at least mostly) the air temperature data, with surface temperature warmer than air temperature. Note: This could vary at different times of year in different locations. Students could present a reasonable explanation for the surface being colder than the air above early in the morning.
- Students explain that the ground is warmed by the Sun, which then warms the air above it.

Question 8 Rubric

Rubric Measures: Students identify that surface temperatures are warmer than the air temperatures above the surface, and they explain this concept using ideas about heating of the surface by the Sun, followed by heating the air above the surface.

	Emerging[8] -1	Developing-2	Approaching Proficiency-3	Excelling-4
PERFORMANCE	Graph shows an **inaccurate or irrelevant** prediction for surface temperature **and** reasoning using inaccurate, irrelevant, or ambiguous science ideas to support it.	Graph shows a **partially accurate** prediction for surface temperature **and** reasoning using partially accurate science ideas or incomplete science ideas.	Graph shows an **accurate** prediction for surface temperature **and generally** describes mechanisms that result in this pattern.	Graph shows an **accurate and clear** prediction of surface temperature and accurate **and** clear reasoning about the mechanisms resulting in the pattern.
LOOK FOR	• A line below air temperature or no line at all. • Reasoning about air being warmer than the surface. • Focuses on times of day but does not explain heating.	• A line that starts below and then goes above the air temperature line. • A mix of accurate and incorrect ideas or vague reference to the Sun.	• A line drawn above the air temperature graph. • Accurate, but vague, reasoning about the Sun heating the surface and mixing up light and heat, but with a mostly accurate idea.	• A line drawn above air temperature graph. • A clear statement about sun causing heating of the surface first, which heats air above it.
SAMPLE RESPONSE	*[Student draws a line that does not follow the trend of the air temperature.]* *I expect it to get warmer because by 7:00 p.m., they have humidity of 90%, but from11:30 a.m. to 4:30 p.m., I expect it to get cooler.*	*[Student draws a line that follows the trend of the air temperature and is warmer than the air.]* *It heats and cools throughout the day. The surface would be warmer because it's a solid.* *The Sun is going to rise and the ground will get hotter.*	*Correct graph and responses.* *The ground is always warmer than the air, OR the ground heats the air above it.* *The surface absorbs the heat, so it's always hotter on the surface than the air.* *Since the solid objects cool and heat up faster than the surrounding air, they absorb more heat than air, so the surface is hotter than air.*	*Correct graph and responses.* *The ground surface is always more directly hit by sunlight and usually heats up faster (than the surrounding air).* *I drew the surface temperature higher than the air temperature because the surface is absorbing more direct sunlight than it is reflecting into the atmosphere.*

[8] If the student provides no assessable evidence (e.g., "I don't know" or leaves the answer blank), then that student response cannot be evaluated using the rubric.

Question 9 Rubric

Rubric Measures: Students identify a sudden drop in temperature and rise in humidity as conditions for a precipitation event.

Performance Expectation	Alignment to NGSS Dimensions	Performance Outcomes	Alignment to Prompt/Criteria in Performance Assessment
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.~~	*SEP:* **Analyze and interpret data to provide evidence for phenomena.** *DCI:* Water continually cycles among land and ~~ocean, and~~ atmosphere via ~~transpiration~~, evaporation, condensation, crystallization, and precipitation. ~~as well as downhill flows on land.~~ ~~Global~~ Movement of water and its changes in form are propelled by sunlight. ~~and gravity.~~ *CCC:* **Patterns in rates of change and other numerical relationships can provide information about natural** and human-designed **systems.**	Analyze and interpret patterns in temperature and humidity data to explain why a storm occurred.	9. Use the temperature and humidity data in the graphs above to explain why it rained in the afternoon.

Correct Answer

- Students describe how sunlight warms Earth's surface, causing air above it to warm up as well as water to evaporate. This leads to moist, rising air.
- Students explain that there was a decrease in temperature and an increase in humidity, which are necessary ingredients for a storm.
- Students explain that the decrease in temperature causes moisture in the sky to condense and precipitate.
- Students explain that humidity needs to be high for a storm to form, so a quick increase in humidity indicates clouds or storms forming.

Question 9 Rubric

Rubric Measures: Students identify a sudden drop in temperature and rise in humidity as conditions for a precipitation event.

	Emerging[9] -1	Developing-2	Approaching Proficiency-3	Excelling-4
PERFORMANCE	Explanation uses **irrelevant, minimal, or inaccurate** science ideas about changes to **both temperature and humidity** as they relate to the afternoon storm **and** reasoning connecting the cause/s to the phenomenon is **irrelevant, missing, or ambiguous.**	Explanation **uses partially accurate and relevant** science ideas about **one or both temperature and humidity as** factors influencing the storm formation. Reasoning connecting the cause/s to the phenomenon is **irrelevant, missing, or ambiguous.**	A. Explanation uses **accurate and relevant science** ideas about one or **both temperature and humidity as** factors influencing the storm formation. Reasoning connecting the cause/s to the phenomenon is **vague or general** and **doesn't explain how the two work together** to explain storm formation. OR B. Explanation **uses accurate and relevant** science ideas about **either temperature or humidity** as the factor relates to storm formation **and fully connects to the cause** of the afternoon storm, but it *does not* connect the second factor to the afternoon storm.	Explanation uses **accurate and relevant** science ideas about **both temperature and humidity** AND reasoning connects the cause/s to the afternoon storm and explains **how the two work together** to result in the storm forming.
LOOK FOR	**Incorrect pattern:** • Air temperature decreases (it actually increases and only decreases right at the storm). • Humidity decreases (this happens at first, but humidity has to be high for the storm). • Using a cold front in their explanation.	**Mostly correct pattern for part of the day:** • Rising or warm temperatures are needed. • Rising or increasing humidity is needed.	**Correct pattern throughout the day:** • Air temperature increases and only drops around the time of the storm. • Humidity initially decreases, then increases right before the storm.	**Correct pattern throughout the day:** • Air temperature increases and only drops around the time of the storm. • Humidity initially decreases, then increases right before the storm. • Reasoning that explains: • How time and warm temperature lead to moist rising air. • How a drop in temperature leads to condensation. • How high humidity is needed for storm formation.
SAMPLE RESPONSE	*As the area was colder, the temperature was just right to make the storm.* *Because there was less humidity and higher air temperature.* *Because it cannot hold water so it rains.*	*The temperature goes down quickly and leads to humidity and clouds rising.* *The weather changes caused the thunderstorms because based on temperature there are different reactions to how hot or cold it is and how high or low the air pressure is.* *Humidity went up and air temperature went down.*	*When the temperature drops all of a sudden, it's not able to hold the cloud, so the cloud must precipitate, causing the thunderstorm.* *Since air temperature was cooling at the time and humidity was increasing, the conditions made it perfect for a storm to form. A storm needs cooler surface/air temps and high humidity as a basic.*	*Sunlight warms the ground, causing air above it to warm and water to evaporate. This leads to moist, rising air.* *There was a decrease in temperature and an increase in humidity, which are needed for a storm. The cooler temperature causes water vapor in the sky to condense, forming clouds and precipitation. There needs to be high humidity for a storm to form, so a quick increase in humidity indicates clouds or storms forming.*

[8] If the student provides no assessable evidence (e.g., "I don't know" or leaves the answer blank), then that student response cannot be evaluated using the rubric.