

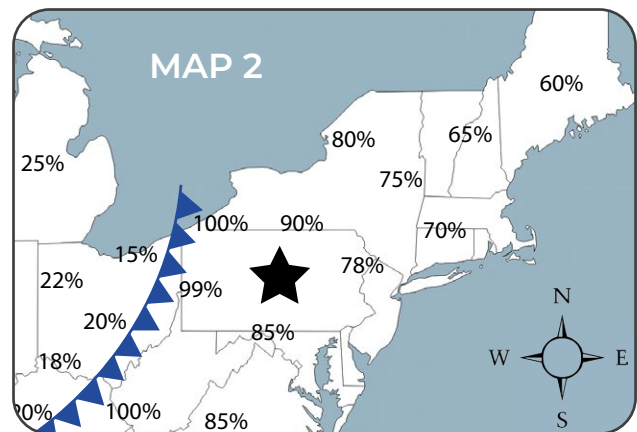
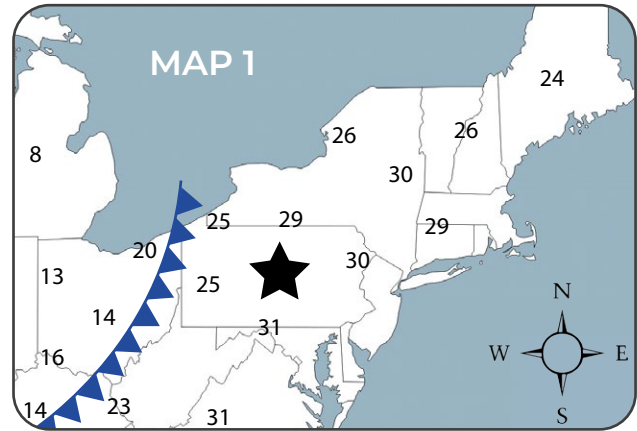
## Learning Sequence 2 Assessment: A Front Headed Your Way

Map 1, to the right, shows maximum air temperatures (°C) across the northeastern United States on June 28, and Map 2 shows humidity (%).

Weather forecasts **for the next day** (June 29) in central Pennsylvania (shown on the maps with a star ★) predict the following:

▶ Temperatures will drop to 15–20°C, and storms are likely by the afternoon.

Answer the following questions to explain how weather forecasters used the data in these maps to decide that a storm is coming to central Pennsylvania.



- The line with the triangles on each map shows the location of a cold front. Describe the temperature and humidity of the air on both sides of the front.

East of the front (to the right of the front on the map):

West of the front (to the left of the front on the map):

**Performance Outcome:** Use temperature and humidity data to describe the characteristics of air masses at a cold front.

**Indicators of progress**

- Students use the temperature and humidity data from the maps to identify that there is warm, moist air east of the front and cooler air with lower humidity west of the front.

**Incomplete or inaccurate ideas**

- Students focus on temperature differences only and do not recognize the importance of humidity in characterizing air masses.

**Suggestions:** If students do not perform well on this item, have them apply the color-coding strategies they used in Learning Sequence 2 to make sense of mapped data. For example, have students color warmer temperatures red and colder temperatures blue. They could also color-code the humidity map for humidity that is high and low.

- Using what you know about the air on both sides of the front, describe how air is moving at the front.

**Performance Outcome:** Analyze temperature and humidity data to describe the interaction of air masses at a cold front.

**Indicators of progress**

- Students mention that warmer air on the right (east) side is pushed up by cooler air behind (to the west of) the cold front.

**Incomplete or inaccurate ideas**

- Students focus on wind and storms and the horizontal movement of air but do not recognize the vertical movement of air along the front where air masses interact.

**Suggestions:** Revisit the Warm Meets Cold demonstration (Lesson 9) with the density tank. Ask your students what is happening to the air right where the two air masses in the model meet.

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3. Draw an **L** to show where you would expect to find the lowest air pressure on a map on the previous page and an **H** to show where you would expect to find the highest air pressure. Explain why you put the H and the L where you put them.

**Performance Outcome:** Analyze and interpret temperature and humidity data to identify regions of high and low pressure.

**Indicators of progress**

- Students place the L on the front symbol or at the northern end of the front. They place an H behind the front in the cooler air mass.
- Students explain that the area of low pressure is where air rises and the area of high pressure is located where air is relatively cooler and sinking.

**Incomplete or inaccurate ideas**

- Students may connect the low pressure only with storms and the high pressure only with blue skies and may not make the connection to rising or sinking air. This is not inaccurate but is incomplete.
- Students place the area of low pressure ahead of the front. Students may associate the colors used for the symbols with temperature and therefore draw a L with the warmer temperatures and a H with the cooler temperatures.

**Suggestions:** Reread about low and high pressure in Lesson 10. Also, revisit the Freedom High School air pressure data in Lesson 10 where students identified the lowest air pressure happening right at the front and the highest air pressure after the front.

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4. Describe how you'd expect air pressure to change in central Pennsylvania (shown with a star ★ on the maps on the previous page) from June 28 to June 29 as the cold front moves through. Explain your reasoning.

**Performance Outcome:** Analyze and interpret temperature and humidity data to predict how air pressure would change over time.

**Indicators of progress**

- Students identify that pressure will decrease from June 28 to June 29 as the front arrives.

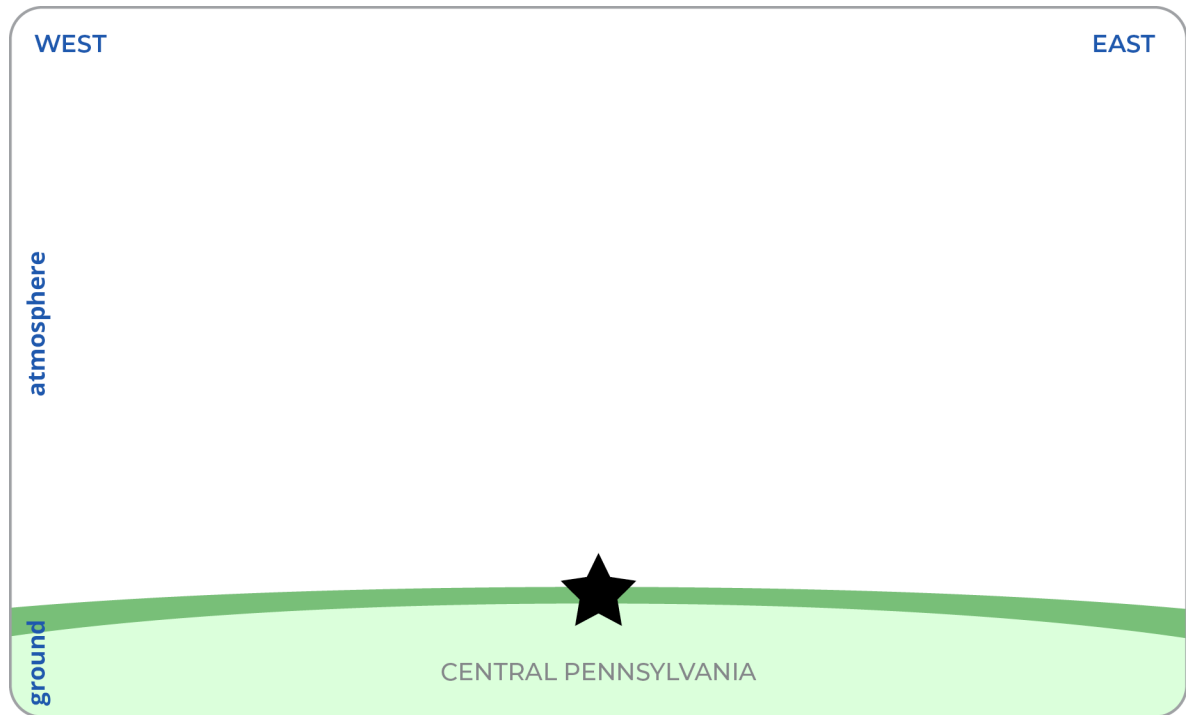
**Incomplete or inaccurate ideas**

- Students may believe that pressure is already low on June 28 and will get higher on June 29. Remind students that June 28 is before the front and June 29 is during the front.

**Suggestions:** Reread about low and high pressure in Lesson 10. Also, revisit the Freedom High School air pressure data in Lesson 10 where students identified the lowest air pressure happening right at the front and the highest air pressure after the front.

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5. Draw a cross-sectional model below to show how the air masses will interact along the cold front as it moves through central Pennsylvania (shown with a star ★) on June 29. Your model should:
- show the location of the cold front.
  - show the location of air masses (and note the temperature, humidity, and air pressure).
  - use arrows to show how air is moving.
  - indicate where a storm is likely to form.



6. How can the movement of the air shown in your cross-sectional model cause a storm? Explain your reasoning.

**Performance Outcome for 5 & 6:** Develop and use a model of a cold front to describe how cold air pushes warm air higher in the atmosphere, where it cools and water vapor condenses forming clouds.

**Indicators of progress**

- Students accurately place a cold front between a warm air mass and a cold air mass.
- Students identify the warm air mass as having higher humidity.
- Students identify the cold air mass as having lower humidity.

Students indicate upward movement of warm air as the cold air pushes under the warmer air, which results in clouds and precipitation forming at or near the front.

**Incomplete or inaccurate ideas**

- Students focus on temperature differences only and do not recognize the importance of humidity in characterizing air masses ahead of and behind the front.
- Students focus on wind and the horizontal movement of air but do not recognize the vertical movement of air as the warm air is lifted and the cold air pushes underneath.
- Students place the storms in the warmer air mass and not along the front.

**Suggestions:** Revisit the Warm Meets Cold demonstration (Lesson 9) with the density tank. Ask your students what is happening to the air right where the two air masses in the model meet.

7. Add an **H** to your cross-sectional model to show where air pressure would be highest and an **L** where air pressure would be lowest. How do these differences in air pressure cause the air to move?

**Performance Outcome:** Develop and use a model to describe how differences in air pressure based on air temperature cause higher pressure air to move toward and push lower pressure air.

**Indicators of progress**

- Students identify an area of high pressure behind the front with the cooler air mass.
- Students identify low pressure near the front where warm air is lifted and also near the surface.

- Students include in their model how air is moving from high pressure to low pressure. Students may indicate this using arrows or words.

**Incomplete or inaccurate ideas**

- Students indicate that the low pressure is ahead of the front and not along the front, which shows they associate low air pressure with the air mass.
- Students do not include a description or symbols depicting how air pressure influences the movement of air. Students may not understand the horizontal movement of air from high to low pressure.
- Students do not connect cooler temperature with sinking air or the flow of air away from areas of high pressure.

**Suggestions:** Reread about low and high pressure in Lesson 10. Also, revisit the Freedom High School air pressure data in Lesson 10 where students identified the lowest air pressure happening right at the front and the highest air pressure after the front.

8. Use your model and the temperature and humidity data on the maps to explain why it will likely rain in central Pennsylvania (star ★).

**Performance Outcome:** Analyze and interpret temperature and humidity data to support a claim about a cold front causing rain.

**Indicators of progress**

- Students use the temperature and humidity data from the maps to identify that there is warm, moist air on one side of the front, which is pushed up by cooler air behind the front. When the warm, rising air cools higher in the upper atmosphere, the water condenses to form clouds and storms. .

**Incomplete or inaccurate ideas**

- Students describe the cold front as being stormy without explanation of the upward lift of warm, moist air.
- Students associate the air behind the front with storms but not necessarily as contributing to the lift of the warm, moist air.
- Students do not mention that the rising, warm air eventually cools and water condenses from the air in the cooler temperatures higher in the atmosphere.

**Suggestions:** Revisit the Model Idea Tracker and the class Consensus Model from Learning Sequence 2. Discuss what is happening to the moisture where the two air masses interact. Discuss what would increase chances for more rain (higher humidity in the warm air mass) and what could decrease chances for rain (less humidity in the warm air mass).

9. In the table below, describe two similarities and two differences in how isolated storms and cold front storms form.

SIMILARITIES		DIFFERENCES	
1			
2			

**Performance Outcome:** Use knowledge about storms caused by cold fronts and isolated storms to make comparisons about their similarities and differences.

**Indicators of progress**

- Students identify similarities including the key role of warm, rising air and high humidity in storm formation.

- *Students identify differences including the length of time (hours for isolated storms versus days for cold front storms), the spatial scale (isolated storms occur in a single location while cold front storms occur along a regional front), and that cold fronts involve interacting air masses, while isolated storms happen within an air mass.*

***Incomplete or inaccurate ideas***

- *Any of the incomplete or inaccurate ideas previously mentioned could be included here.*
- *Students focus on temperature differences only and do not recognize the key role of humidity in storm formation*

***Suggestions:*** Compare the class consensus models from Learning Sequences 1 and 2. Discuss which model ideas from the Model Idea Tracker pertain to both kinds of storms and which are exclusive to one or the other kind of storm.

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10. What are some reasons that could explain why one air mass would have a higher temperature than another air mass? Explain each reason.
11. Think about what you know about air temperature around the Earth. Some areas are usually warmer than others. What causes some areas to be warmer than others?

***Performance Outcome for 10 & 11 (working toward):*** Use knowledge of the relationship between sunlight and air temperature and that different places can have different amounts of sunlight and that air masses move from place to place to explain differences in temperature between two air masses.

***Look for the following:***

- *Students mention that the geographic location of the air mass matters.*
- *Students mention connections to sunlight and heating of Earth.*
- *Students mention latitude (warm places near the equator, cold places near the poles).*
- *Students mention that the season or time of year could be related.*

***Suggestions:*** Use student ideas shared for questions 7 and 8 to inform your instruction during Learning Sequence 3.

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