Name Period Date

LESSON 9

What causes precipitation along a cold front?

STEP 1: How does the air change as a front moves through a place?

Illustrate the weather conditions (temperature, humidity, and wind) you might see a day before the front, during the front, and a day after the front arrived at Freedom High School, South Riding, Virginia. Use color and symbols to show changes in temperature, humidity, and wind.

BEFORE	DURING	AFTER

CREATE A KEY:

◯ Warm air ◯ Cool air ◯ ◯

(choose a color) *(choose symbols to show changes in humidity and wind)*

STEP 2: Make observations of what happens to the warm and cool fluids in the tank.

Record your observations of the water tank in the space below. The tank is a model that uses warm and cool water to simulate warm and cool air in the atmosphere. With it, we can see what happens when warm air and cool air meet.

Make a cross section that shows what the tank looks like **BEFORE** the partition is removed.

Make a cross section that shows what the tank looks like right **AFTER** the partition is removed.

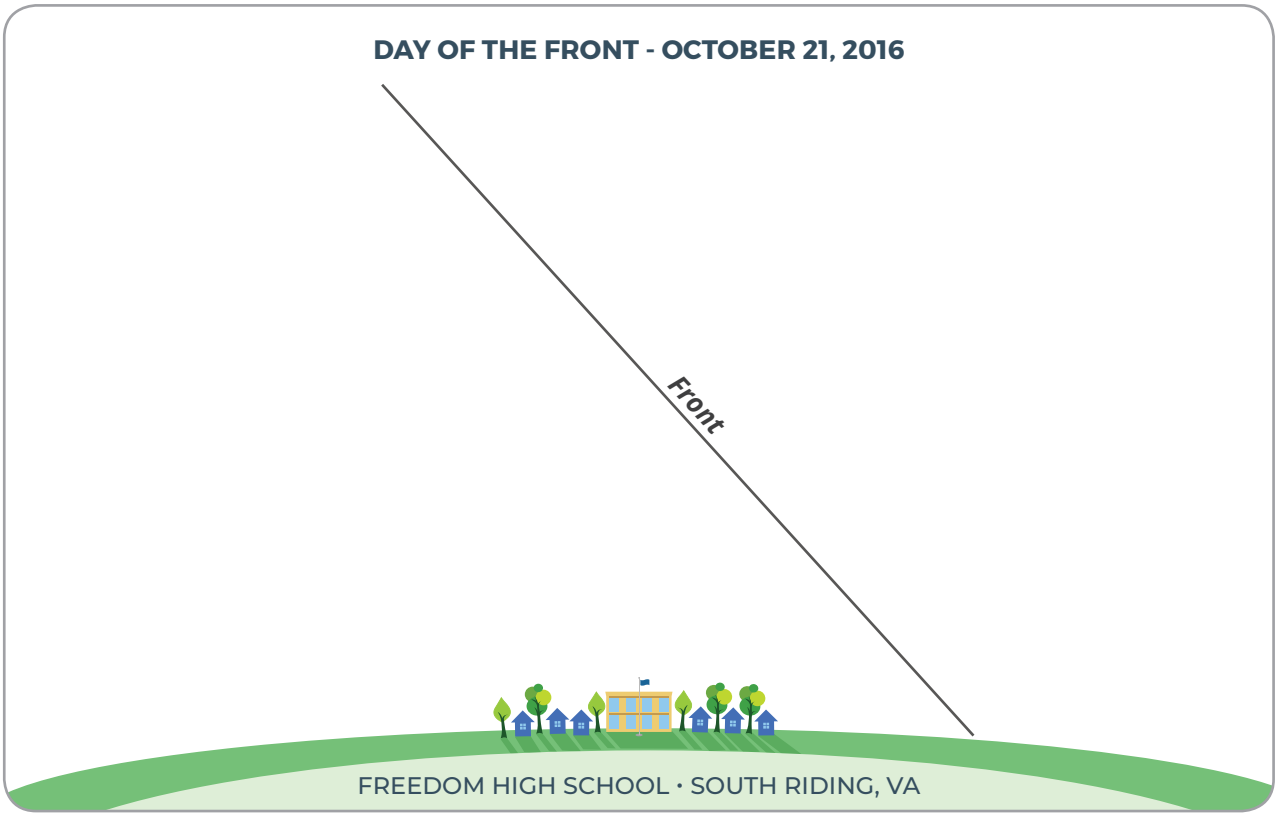
DISCUSS AS A CLASS:

What happened when the cold and warm fluids met?

What causes precipitation along a cold front?

STEP 3: Develop a model for explaining precipitation during the cold front.
This model is a cross section of the atmosphere, just like the water tank that showed a cold front. Draw on the model to explain:

1. The location of the cold air mass.
2. The location of the warm air mass.
3. The direction that each air mass is moving.
4. Where you'd expect clouds to form.



EXPLANATION: Write a caption for your model to explain why Freedom High School had precipitation on October 21, 2016.

What causes precipitation along a cold front?

STEP 4: Investigate air masses and fronts.

Over large areas, air can have similar temperature and moisture. Air with similar characteristics is called an **air mass**. For example, air over northern North America can form a cold, dry air mass. It is cold because it forms at high latitude, near the Arctic. It is dry because it forms over land, and there is little moisture evaporating from the land as compared with the ocean. Air over the Gulf of Mexico and the southern United States can form a warm, moist air mass. It is warm because it forms at a lower latitude, closer to the equator. Water evaporating from the Gulf of Mexico makes the air mass moist. The two kinds of air masses often "bump" into each other as they move, forming fronts.

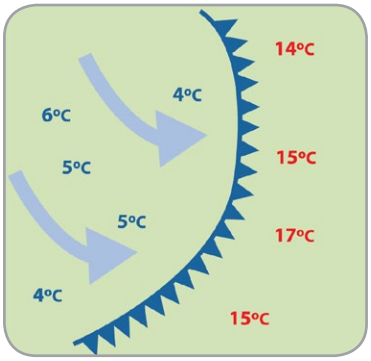
STOP AND THINK

What type of air mass was over Freedom High School before the front moved through the area?

What type of air mass was over Freedom High School after the front moved through the area?

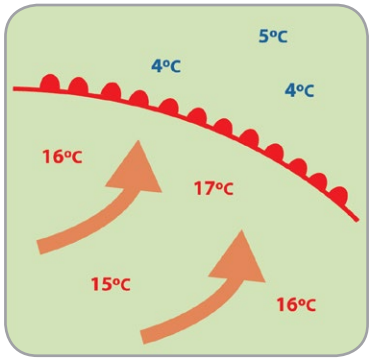
There are several different types of fronts. The type of front depends on how the air masses interact. The pictures below show how different types of fronts are shown on weather maps using symbols.

COLD FRONT



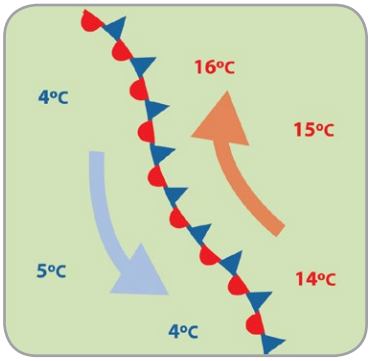
At a cold front, a colder air mass moves into a warmer air mass. A cold front is shown on a weather map as a blue line with triangles in the direction of movement.

WARM FRONT



At a warm front, a warmer air mass moves into a colder air mass. A warm front is shown on a weather map as a red line and half circles in the direction of movement.

STATIONARY FRONT



At a stationary front, a cold air mass and warm air mass are side by side. Both might be moving, but neither has enough force to move into the other's space. A stationary front is shown on a weather map with both red half circles and blue triangles.

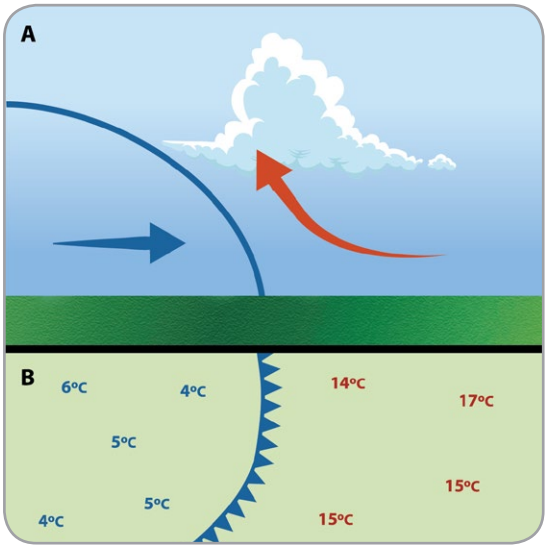
What causes precipitation along a cold front?

In this investigation, we are focusing on cold fronts.

Cold fronts can produce dramatic storms. Winds become gusty, and there is a sudden drop in temperature. There can be heavy rain, hail, thunder, and lightning. As warm air is pushed up at a cold front, cumulus clouds form just as they did in the isolated storms you learned about before – as the air moves upward it cools, and water vapor becomes liquid water droplets that make up clouds. The clouds may grow into cumulonimbus clouds and cause rain, or snow if the temperature is below freezing. After a cold front moves through, you may notice that the temperature cools down, the rain stops, and clear skies or other types of clouds replace the cumulus clouds.

STOP AND THINK

What happened as the cold air mass moved into the warm air mass at Freedom High School?



(A) The upper part of this image shows a cross section of a cold front. This is where a cold air mass is pushing into a warm air mass. The warm air is pushed upward where it cools, and water vapor condenses into clouds.

(B) The lower part of this image shows a weather map view of a cold front. The cold air mass is on the left side, pushing into a warm air mass. The blue line with triangles along it indicates the location where cool and warm air meet.

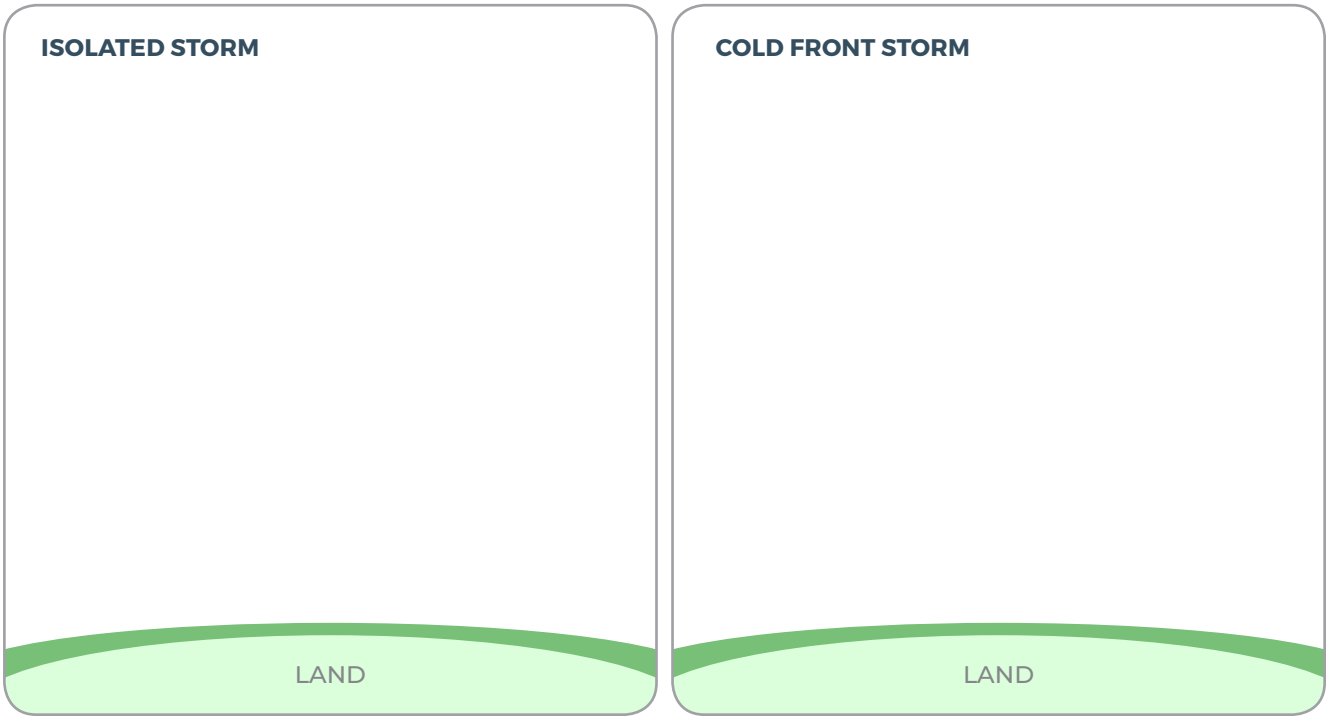
A cold front (and the cold air mass that moves in) may not be cold. During the summer, temperatures might be quite warm, but we can still have cold fronts. A cold front in the summer typically brings cooler weather compared with the previous days.

What causes precipitation along a cold front?

STEP 5: Let's compare our two types of storms: isolated storms and storms that form along a cold front.

Draw cross section models to explain how precipitation could happen in each kind of storm.

- Use the other models you've made and the reading in this lesson to help you decide what to draw.
- Indicate where air is warmer and where it is cooler.
- Use arrows to show how air moves.
- Show where clouds form in both types of storms.



1. How are isolated storms and cold front storms similar?

2. How are they different?

What causes precipitation along a cold front?

STEP 6: Focus on the big picture using our cold front model.

Your teacher will assign you to a group. Each member of your group will map weather data for one day over a four-day time period on the map on the following page. Then you'll look at all four maps together to see what happened as a cold front moved through this area, the Midwest, and Northeast.

1. **Choose a day.** Each member in your group will choose one day of data to map. On the next page, circle your day on the Maximum Temperature and Precipitation Tables and write the date on your map.

2. **Color and label your map.**
   a. Color locations where the temperature is greater than 30°C RED.
   b. Color locations where the temperature is equal to, or less than, 30°C BLUE.
   c. Draw slanted rain lines near the location if it had precipitation.
   d. Add the red and blue colors to the key.

3. **Compare maps.** When your group completes all four maps, line them up in order beginning September 8 and ending with September 11.

4. **Determine where the cold front is located.** Draw the front on each map using the blue line/blue triangle symbol.

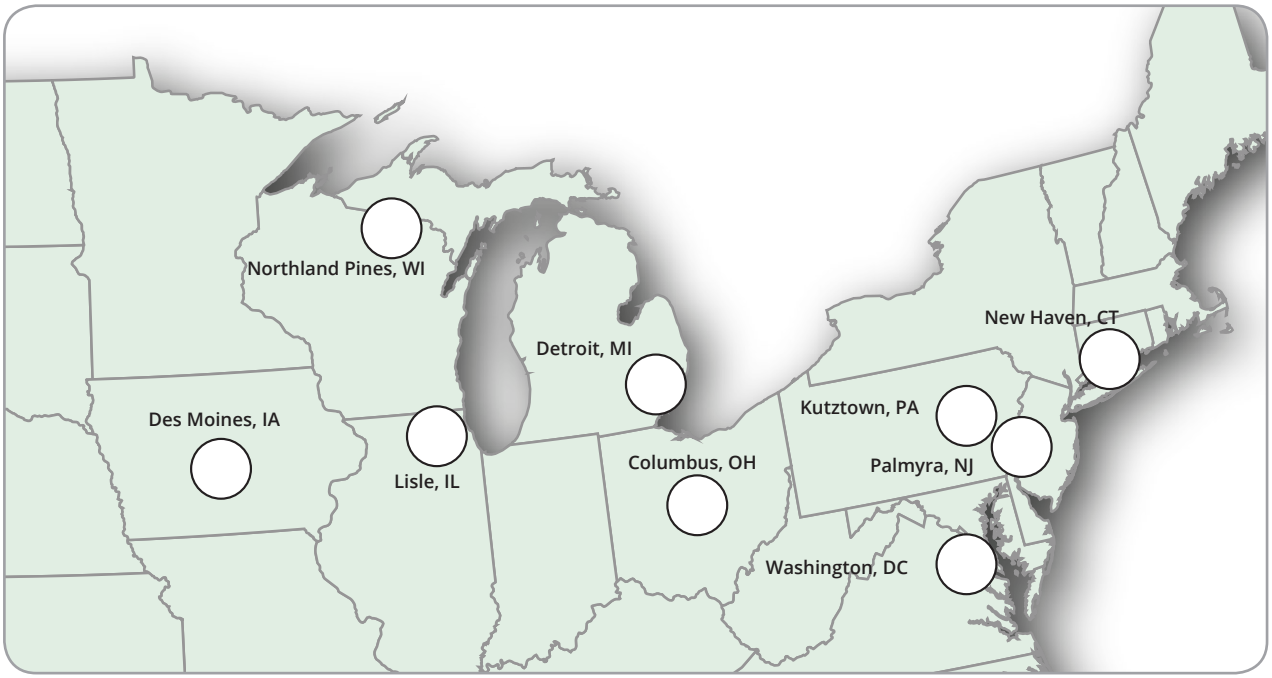
5. **Determine where the cold air mass is located.** Shade the cold air mass BLUE on each map.

6. **Determine where the warm air mass is located.** Shade the warm air mass RED on each map.

7. **Make observations of how the front and air masses move over time.** Be prepared to discuss your ideas.

LESSON 9

What causes precipitation along a cold front?



DATE:

- Max temperature above 30°C
- Max temperature equal to or less than 30°C
- Precipitation

MAXIMUM TEMPERATURE (°C)

	9/8/15	9/9/15	9/10/15	9/11/15
Des Moines, IA	27.8	27.8	28.9	21.1
Northland Pines, WI	25.4	22.7	19.6	16.9
Lisle, IL	31.7	23.3	25.6	19.6
Detroit, MI	31.2	30.1	24.7	25.8
Columbus, OH	32.7	30.9	26.1	28.2
Washington, DC	33.3	34.4	28.9	30.5
Palmyra, NJ	32.2	32.7	33.9	26
Kutztown, PA	31.2	32.5	32.7	22
New Haven, CT	32.8	30	25	26.7

PRECIPITATION (cm)

	9/8/15	9/9/15	9/10/15	9/11/15
Des Moines, IA	0.3	0	0	0
Northland Pines, WI	0.5	0.1	0	0.1
Lisle, IL	2.2	0	0.9	1.5
Detroit, MI	0	0.1	0	0.6
Columbus, OH	0	0	0	1.6
Washington, DC	0	0	0.3	0
Palmyra, NJ	0	0	3.6	0.1
Kutztown, PA	0	0.6	3.6	0
New Haven, CT	0	0	0	0