UCAR CENTER FOR SCIENCE EDUCATION

TEACHER ANSWER KEY

CULMINATING TASK

CULMINATING TASK: **Challenge 1** — California Storm

CULMINATING TASK: **Challenge 2** — Where's the Snow?

CULMINATING TASK: **Challenge 3** — We're Warning You

BSCS SCIENCE LEARNING

NASA

THE GLOBE PROGRAM

Name Period Date

CULMINATING TASK: **Challenge 1**

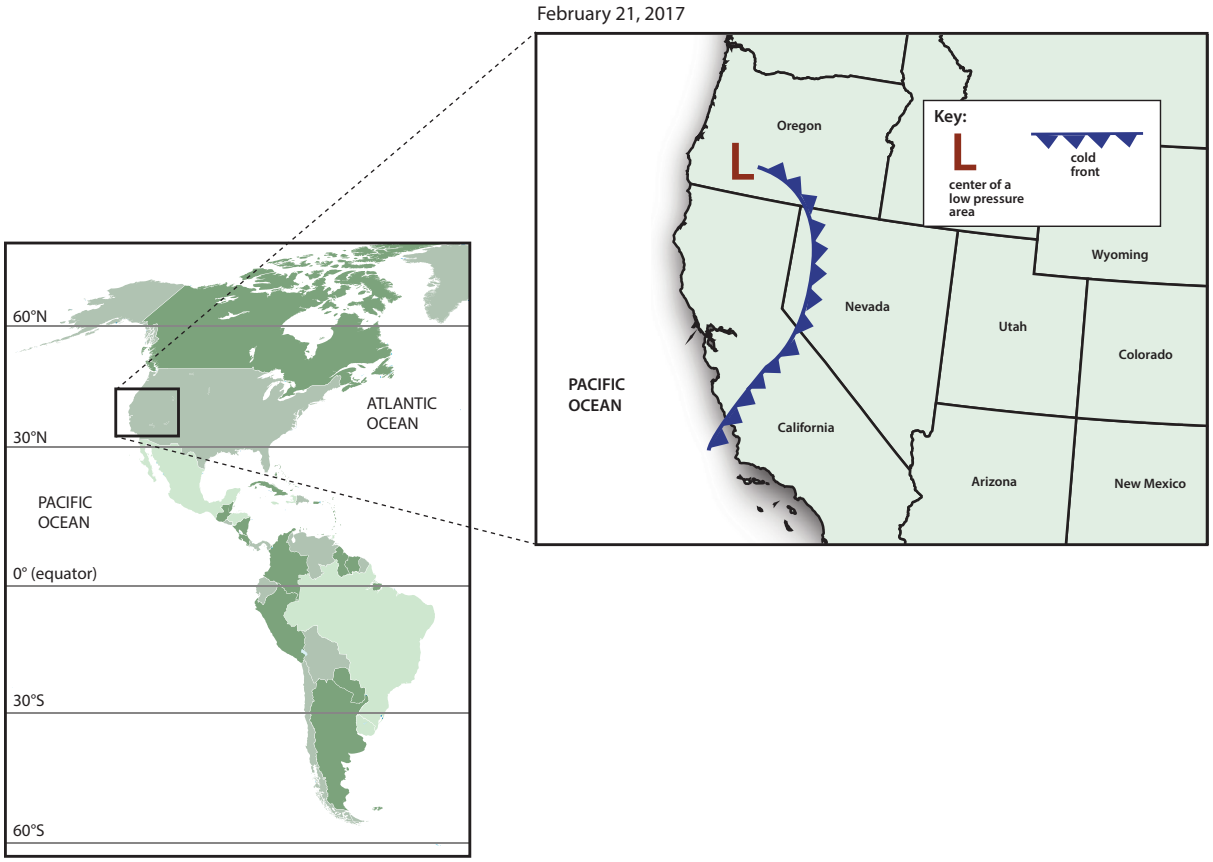
Why did the storm cause rain in some places and snow in other places in California?

On February 20, 2017, a storm passed through California on the West Coast of the United States. The storm brought extreme rainfall which caused flooding and mudslides in some places. The storm brought deep snow to mountainous areas of California.

USA TODAY:

Battered Northern California blasted by new storm

"The National Weather Service was calling for up to eight inches of rain over parts of the region Monday and Tuesday. Wind gusts in some areas could reach 65 mph. Flood warnings for a handful of rivers could last until week's end — this for a state that two months ago was mired in severe drought. Heavy snow was forecast to pound the Sierra Nevada Mountains, where totals will be measured in feet, not inches."



CULMINATING TASK: **Challenge 1**

Why did the storm cause rain in some places and snow in other places in California?

STEP 1: Analyzing the California storm.

Use the maps on the previous page and what you have learned about storms to answer the questions below.

1. Based on what you learned about global winds, where do you think the cold front was located before it passed over California?

   The front likely came from over the Pacific, moving east towards California. We learned in Lesson 12: Step 1 that storms in North America typically move from west to east.

2. For a storm to cause rain and snow, there must be moisture in the air (humidity). Where do you think the moisture in this storm came from before it was in the atmosphere? Consider what you know about the water cycle as you answer.

   Moisture came from the Pacific Ocean. Solar radiation caused evaporation over the ocean. That moisture rose and then condensed into clouds as air temperature cooled at higher altitudes. When the air became saturated with moisture, precipitation (rain and snow) fell to the ground.

3. Based on what you learned about cold fronts and the symbols on the weather map on the previous page, where do you think the storm will go next? How do you know?

   The cold front should move east, towards Nevada. The triangle symbols on the front line point in the direction that the storm is moving. In this example, the triangles are pointed towards the east.

Why did the storm cause rain in some places and snow in other places in California?

STEP 2: More details about the California storm: On February 21, 2017, the town of South Lake Tahoe, California, had 6.1 cm (2.4 inches) of rain. Meanwhile, the nearby summit of Heavenly Mountain had 61 cm (24 inches) of snow.

1. What information would you need to decide whether rain or snow will fall during a storm? Explain your answer.

   Temperature data would be needed. Air temperature below freezing would result in snow. We know that air temperature decreases with elevation, so we could expect that at a higher elevation, there would be a greater chance of snow.

2. Look below at the cross section showing the town of South Lake Tahoe and Heavenly Mountain. Use what you know about the atmosphere to explain why it snowed on Heavenly Mountain, but rained in the town of South Lake Tahoe.

   Heavenly Mountain is at a higher elevation than South Lake Tahoe. At higher elevations, there are lower temperatures. At higher elevations, precipitation will happen in the form of snow rather than rain if the temperature is below freezing.

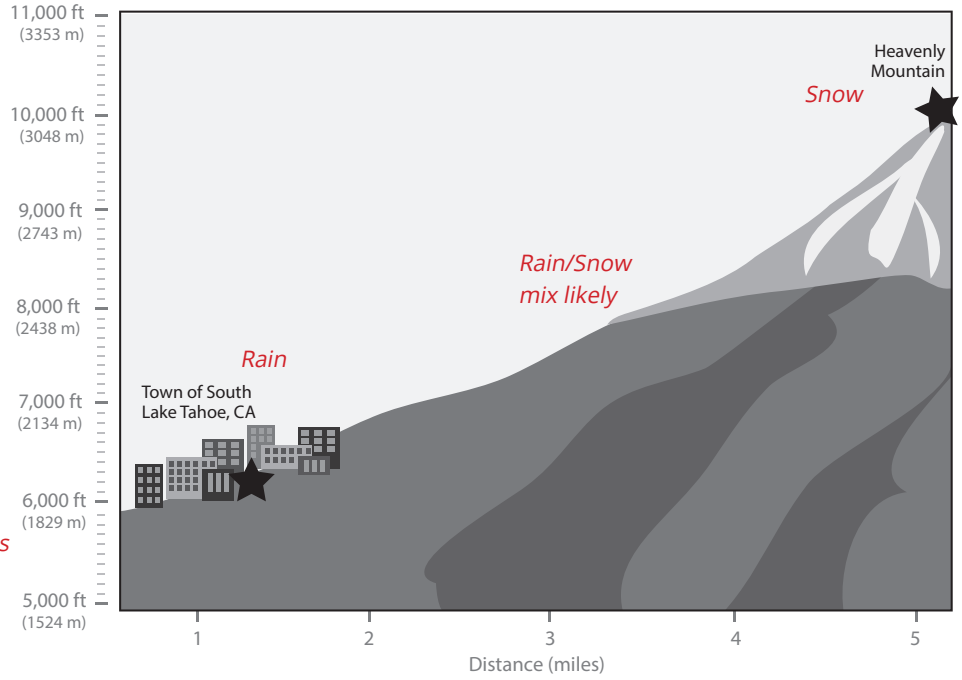
3. **Draw on the cross section below.**

   a. Indicate where the atmosphere is colder and where the atmosphere is warmer.

   b. Indicate the location where it rained and the location where it snowed. Also indicate where along the ground you think a rain/snow mix may have fallen.

   c. Indicate if there are places where you would like more information to know whether rain, snow, or a rain/snow mixture fell.

The atmosphere is colder at higher altitudes.



The atmosphere is warmer at lower altitudes.

**In order to know precisely where precipitation changed from rain to snow, or where there was a rain/snow mix, we would need to know the air temperature at different locations.*

Name Period Date

CULMINATING TASK: **Challenge 2**

As the storm moved east, why did it snow in some areas but not others?

Over a few days, the cold front and the low pressure center moved. From February 20 to 22, the storm moved gradually from California to Nevada. Then, on February 23, the storm moved more quickly to the east and south. In the middle of the country, temperatures were cold enough for snow.

CULMINATING TASK: **Challenge 2**

As the storm moved east, why did it snow in some areas but not others?

STEP 1: Map the snowfall data.

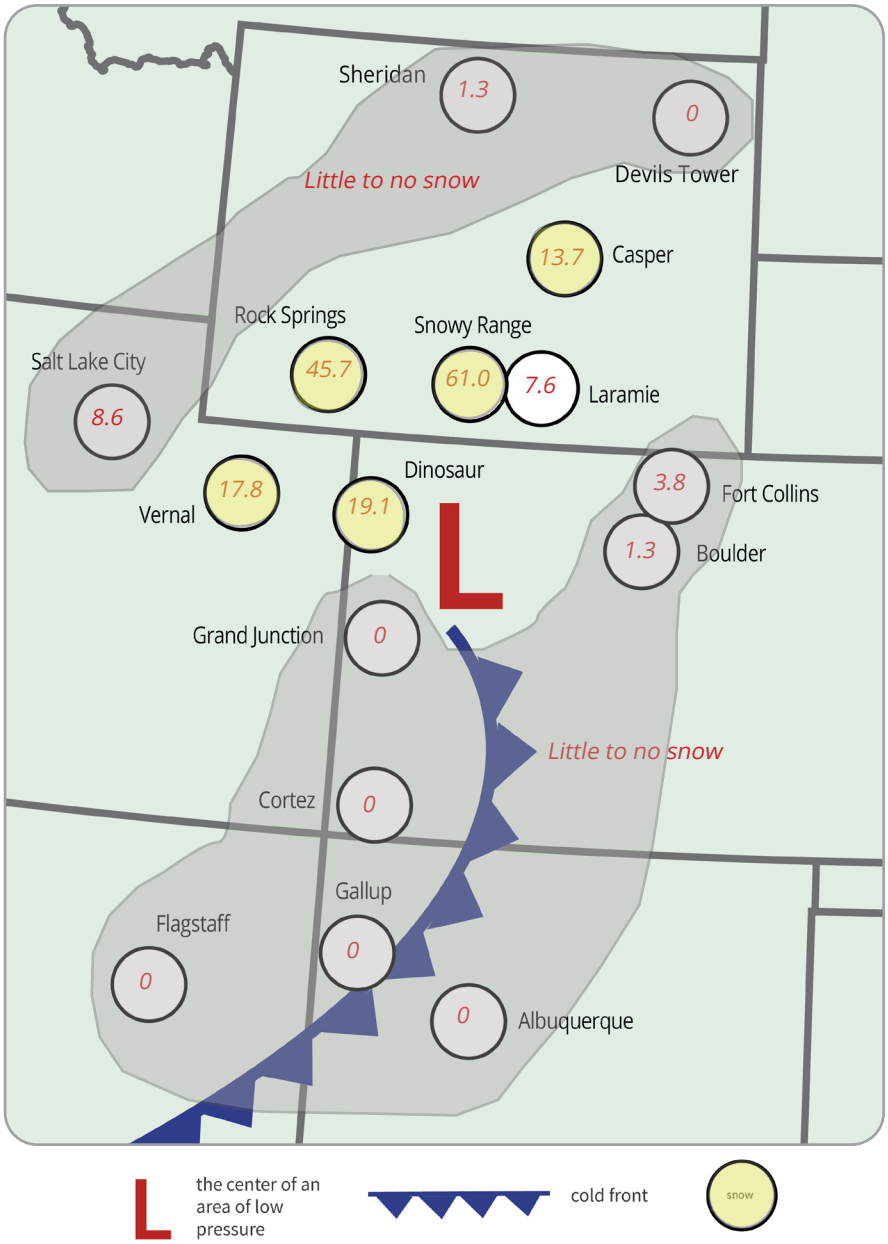
Below is the snowfall report for the communities shown on the map.

1. Locate the communities on the map and **write the snowfall** in the circles.

**Areas shown in gray on the snowfall map below refer to Step 4 on the following page. These are locations with little or no snowfall.*

LOCATION	SNOW (cm)
Rock Springs, WY	45.7
Laramie, WY	7.6
Snowy Range, WY	61.0
Sheridan, WY	1.3
Devils Tower, WY	0
Casper, WY	13.7
Dinosaur, CO	19.1
Grand Junction, CO	0
Fort Collins, CO	3.8
Boulder, CO	1.3
Cortez, CO	0
Flagstaff, AZ	0
Salt Lake City, UT	8.6
Vernal, UT	17.8
Gallup, NM	0
Albuquerque, NM	0

SNOWFALL: FEBRUARY 23, 2017



STEP 2: Where might schools close?

Schools may close if there is heavy snowfall.

Locate where you think schools closed because of snow. **Color these locations with a bright color** on the map so you can easily see where the most snow occurred.

Note: Students' answers about where schools may have closed will vary depending on what they think qualifies as "heavy" snowfall. Look for reasonable selections, and perhaps ask students to justify their choices.

As the storm moved east, why did it snow in some areas but not others?

STEP 3: Look for a trend in the snowfall.

Refer to the map of snowfall on the previous page to answer the questions below.

1. What do you notice about the location of communities with the most snowfall? Where did the most snow fall with respect to the front and area of low pressure?

   The areas with the most snowfall (Rock Springs, Snowy Range, Casper, Dinosaur, and Vernal) are all located to the north of the front and near the low pressure area.

2. Why do you think this area received more snow?

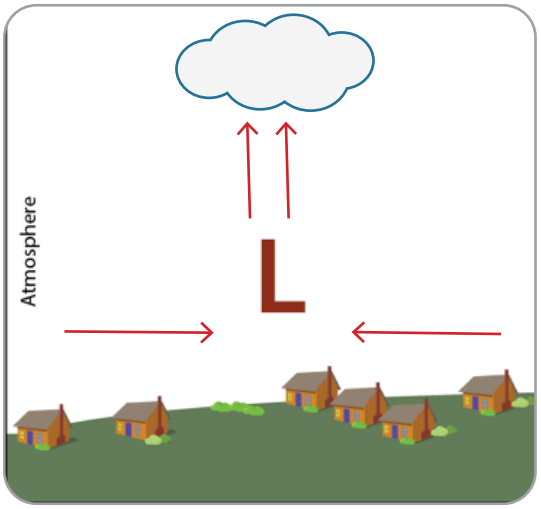
   At a low pressure area, warmer air is rising. Warmer air can have higher humidity, so that might be why there was more precipitation.

STEP 4: Why didn't it snow everywhere?

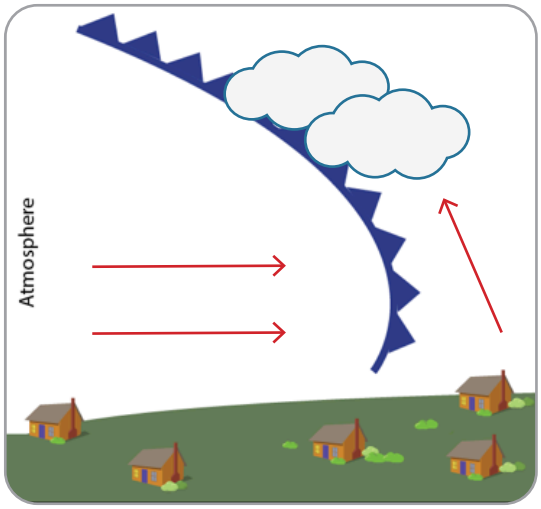
There are two things that a storm needs to cause precipitation:

1. Air that is rising and cooling and
2. Enough moisture in the air to create clouds and precipitation.

1. **Draw a cross section** that shows how air is moving and where clouds are forming at an area of low pressure and at a cold front using models you developed as a class.



How air is moving and where clouds are forming **at an area of low pressure**



How air is moving and where clouds are forming **at a cold front**

2. Notice where there is low pressure and where the front is on the snowfall map. Remember that the storm came from the west, so it moved over the areas on the west side of the map before it got to this location.
   - **Circle locations on the snowfall map** where there was little or no snow. **shown in gray on the snowfall map*
   - Why do you think these locations didn't get much/any snow?

     They are too far away from the area of low pressure.
3. **Name the locations** that you think are too far from the storm to get much snow.

   Flagstaff, Gallup, Alberquerque, Cortex, Grand Junction, Boulder, Fort Collins, Sheridan, and Devil's Tower

Moisture: When it was on the West Coast, this storm was full of moisture, which is what caused so much rain and snow. Is it still full of moisture? The amount of moisture in the air is measured as humidity. On the following page is the average humidity data for the communities shown on the map.

CULMINATING TASK: **Challenge 2**

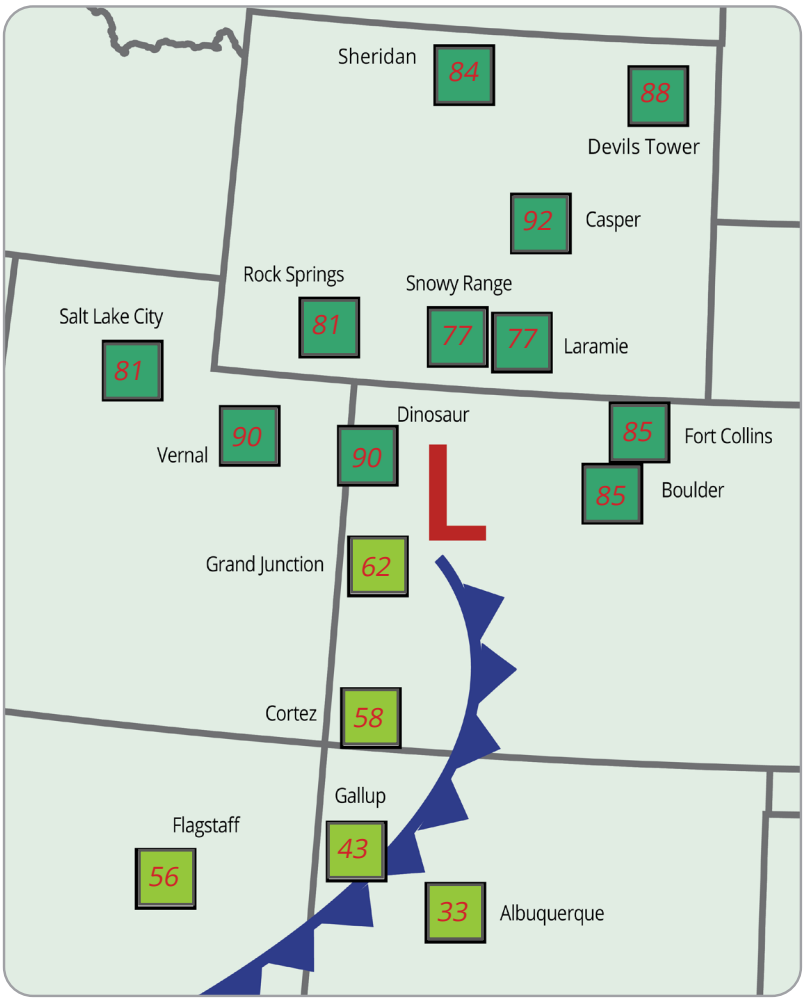
As the storm moved east, why did it snow in some areas but not others?

Use these directions below to create the humidity map.

1. The humidity measurements in the table are from near the ground, not up in the clouds, but they can help us estimate how much moisture is in the air. Locate the communities on the map and **write the humidity** in the squares using a different color than the snowfall measurements.
2. **Color code** the locations that had an average humidity under 70%. These locations are less likely to get precipitation. **Choose another color** for the locations with humidity over 70%. These locations are more likely to get precipitation.
3. Name the locations that you think didn't get much precipitation because the air didn't have enough moisture.
   Flagstaff, Gallup, Alburquerque, Cortez, Grand Junction

LOCATION	AVERAGE HUMIDITY (%)
Rock Springs, WY	81
Laramie, WY	77
Snowy Range, WY	77
Sheridan, WY	84
Devils Tower, WY	88
Casper, WY	92
Dinosaur, CO	90
Grand Junction, CO	62
Fort Collins, CO	85
Boulder, CO	85
Cortez, CO	58
Flagstaff, AZ	56
Salt Lake City, UT	81
Vernal, UT	90
Gallup, NM	43
Albuquerque, NM	33

HUMIDITY: FEBRUARY 23, 2017



KEY:

L — the center of an area of low pressure

cold front

humidity

humidity under 70% *(choose a color)*

humidity over 70% *(choose a color)*

Discuss with your class.

How does the humidity data help you understand why it snowed in some places and not others?

Where the humidity is less than 70%, there is less or no snow. There is more snow in places where the humidity is higher than 70%, and they are near the area of low pressure.

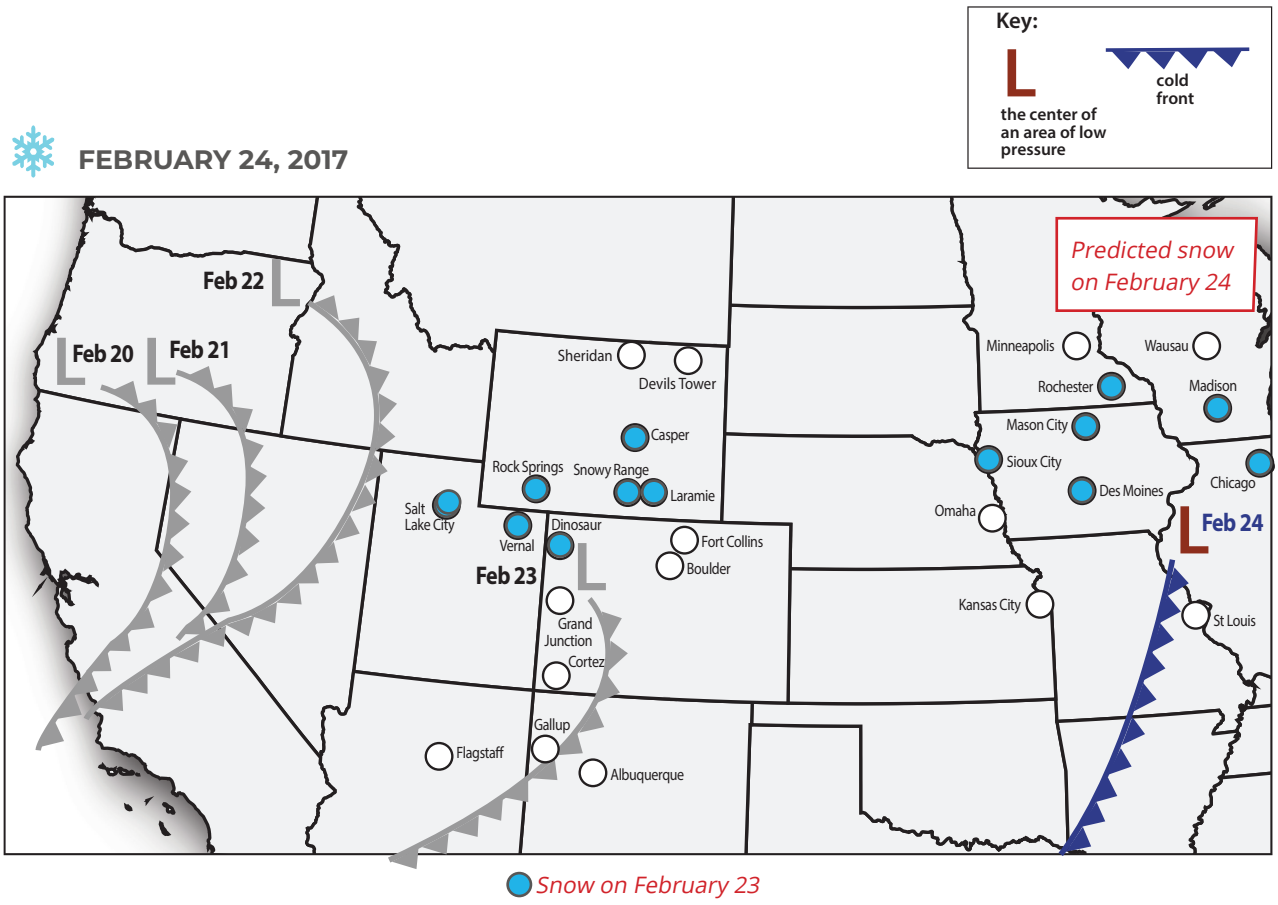
Name Period Date

CULMINATING TASK: **Challenge 3**

Where will schools have a snow day on February 24?

STEP 1: Consider where it snowed on February 23.
To predict the weather, meteorologists take into account what the weather was like the day before. In this case, you are the meteorologist. To predict where snow is likely to fall on February 24, you must take into account where this storm caused snow the day before (February 23).

Choose a color and fill in the circles where it snowed more than 5 cm on February 23 using the snowfall map from Challenge 2: Step 1. Leave circles without a color where little snow (5 cm or less) or no snow fell on February 23.



Where will schools have a snow day on February 24?

STEP 2: Where's the snow compared to the cold front and low pressure area?

Over North America, it's common for an area of low pressure to be located at the north end of a cold front. Looking at the map on the previous page, what do you notice about the location of the snow on February 23?

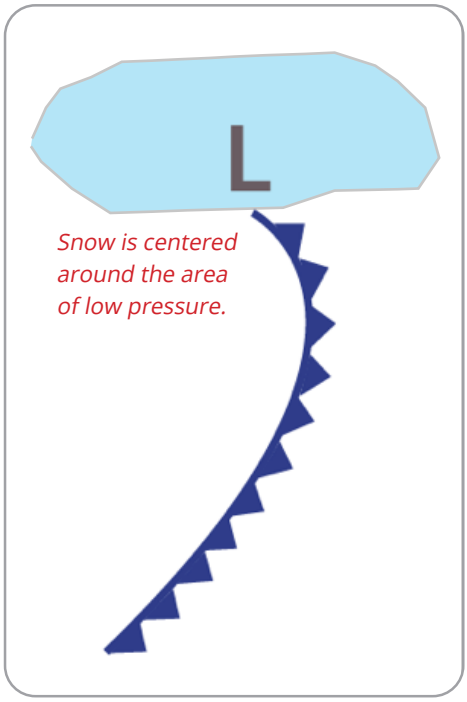
Draw the approximate location of snow in relationship to the location of the cold front and the area of low pressure on the diagram on the right.

1. How is the winter storm in this example similar to the cold front model that you developed? How is it different?

Similar: The winter storm is caused by a cold front, so it has cold air pushing warm, moist air up into the atmosphere with a low pressure system to the north of the front, just like in the cold front model.

Different: Unlike the cold front model we developed, the precipitation in the windier storm is centered around the low pressure area and not along the front. Also, lower temperatures mean that the storm is bringing snow instead of rain.

WHERE SNOW IS LIKELY:



STEP 3: Make a prediction for where it will snow on February 24.

Based on where the snow fell during this storm on February 23, where do you think snow will fall on February 24?

1. **Color in the circles** for towns on the February 24th weather map where you think it will snow more than 5 cm.
2. **Write the names** of the locations below and explain why the locations would receive precipitation.
   Predict snow on February 24th in Sioux City, Mason City, Rochester, Madison, and Chicago.

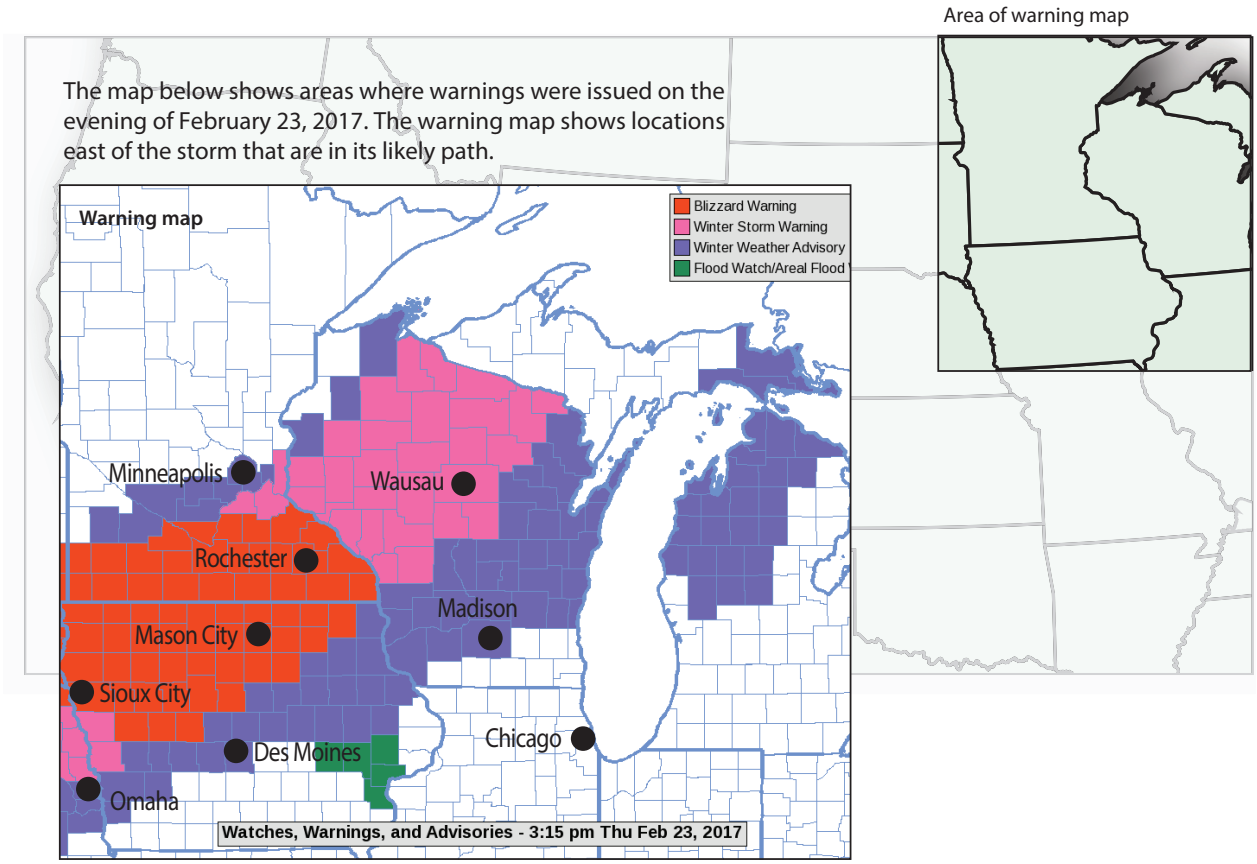
   Places that are just north of the low pressure area and near the cold front will have snow, based on snowfall from the previous day.

Where will schools have a snow day on February 24?

STEP 4: Warning Map.

The map below shows areas where warnings were issued on the evening of February 23, 2017. The warning map shows locations east of the storm that are in its likely path.

- **A Blizzard Warning** is issued for winter storms with winds of 35 mph or higher and heavy, blowing snow.
- **A Winter Storm Warning** is issued when a winter storm is expected within 36 hours with at least 4 inches (10 cm) of snow or at least 3 inches (7.6 cm) of snow and large amounts of ice.
- **A Winter Weather Advisory** is issued when a low pressure system produces a combination of winter weather (snow, freezing rain, or sleet) that presents a hazard.
- **A Flood Watch** is issued when conditions are favorable for flooding.



Where will schools have a snow day on February 24?

Is it a snow day?

Depending on where you live, you might have felt the excitement when snow is in the forecast. Sure, snow is fun no matter when it happens, but when it happens on a school day and school is canceled, that's particularly exciting.

School officials must decide if they're going to cancel school or delay classes. Their job is to keep people safe. How do they make that decision?

In places where snow is rare, like the southeast U.S., a weather forecast that includes any snow and ice might be enough to cause schools to close. These places often don't have snow plows or trucks that add salt or sand to the roads to melt ice. This means that it doesn't take much to make the roads and sidewalks unsafe.

In places where snowy weather is common, towns and cities usually have plans for dealing with it. Schools often do not close for snow if the roads and sidewalks can be cleared. However, schools do close for extreme cold temperatures so that students are not waiting for the bus or walking to school when the temperature is below freezing. Schools might also close if snow is blowing, which reduces visibility.

Many types of weather information are important for school officials to decide whether to cancel school including the timing of the storm, the temperature, the amount of snow, and the amount of wind. School officials take into account whether the National Weather Service has issued weather watches, warnings, or advisories.

1. What locations should cancel school based on the reading above and your predictions of snowfall from Step 3?

   Schools in Sioux City, Mason City, Rochester, and Wausau should cancel.

   These places are within the Blizzard Warning or the Winter Storm Warning, and also are located just north of the cold front and within the low pressure area. Students might also suggest that places within the Winter Weather Advisory (purple) could also be at risk for lots of snow.

STEP 5: Discuss with the class.

Talk with your classmates. Does everyone have the same hypothesis about where it will snow on February 24? Look at where the most snow (more than 15 cm) fell on February 23 and decide which locations might close schools and workplaces on February 24. Take the warning map into account.

School cancellations could also be possible in Madison, Des Moines, and Omaha. Students should support their choices by comparing the amount of snowfall on previous days to the location of cities relative to the storm front and low pressure area.