UCAR CENTER FOR SCIENCE EDUCATION

TEACHER GUIDE

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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

Snow Day?

How can we apply what we've learned about weather to a winter storm?

Students apply models and ideas they figured out from Learning Sequences 1, 2, and 3 to explain what is happening with a new phenomenon: a winter storm that crossed the United States in February 2017. Students should make connections between the dynamics of the atmosphere that they learned about in Learning Sequence 1 (how the atmosphere cools with altitude, how humidity is needed for precipitation, and how rising air cools and moisture condenses), the characteristics of a cold front that they learned about in Learning Sequence 2 (how a cold air mass pushes into a warmer air mass, causing it to rise higher in the atmosphere and how areas with low pressure are prone to have precipitation), and global-scale processes that they learned about in Learning Sequence 3 (such as prevailing winds in the midlatitudes moving from west to east).

The storm presented in the Culminating Task is intentionally different from the storms in the learning sequences, giving students the opportunity to apply what they have learned in a new context. This storm is another example of how weather can impact people's lives. Students work in groups to understand what's happening in the storm using what they've learned in GLOBE Weather and applying it to answer questions about this storm. Looking at the history of snowfall from the storm over several days, the path of the storm, and warning information, students make a decision about where schools and businesses will likely close due to snow and ice.

SCIENCE IDEAS

Weather in a given area is based on geographic location (i.e., latitude, altitude, and geographic features) and changing atmospheric conditions (i.e., air temperature, humidity, air masses, fronts, atmospheric pressure, prevailing winds, and global atmospheric circulation). Weather impacts people's lives and the communities in which they live in different ways. Winter storms affect transportation, safety, economics, and recreational activities.

CULMINATING TASK: **Challenge 1**

CALIFORNIA STORM

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

AT A GLANCE

ACTIVITY DESCRIPTION	MATERIALS
(50 minutes)	
Introduction to the Winter Storm Students view a video of a new phenomenon, winter storm Quid, and observe the storm.	**Challenge 1: Student Activity Sheet** CULMINATING TASK: **Challenge 1** Winter storm Quid video: scied.ucar.edu/winter-storm-quid
Challenge 1: California Storm Students explain what caused this storm to bring precipitation in California and why precipitation is different at South Lake Tahoe and Heavenly Mountain, drawing on ideas from Learning Sequences 1, 2, and 3. Students work in small groups to develop explanations. They then share their ideas with the class and come to consensus.	Model Idea Tracker, Consensus Models

NGSS Sensemaking

In Challenge 1, students use models developed in Learning Sequences 1, 2, and 3 to explain where the moisture in this winter storm came from, how the storm is moving and why, and why precipitation is snow in one location and rain in another.

NGSS DIMENSIONS (GRADES 6-8)

- **Apply scientific ideas to construct an explanation for real-world phenomena or events.**
- **Weather is influenced by interactions involving sunlight, the ocean, and the atmosphere. These interactions vary with latitude, altitude, and regional geography, all of which can affect atmospheric flow patterns.**

Teacher Procedures

Introduction to the Winter Storm

1. **Introduce students to the winter storm.** Tell students that they will be investigating a winter storm and that they should draw on ideas from Learning Sequences 1, 2, and 3 to predict the storm's path. Once we know the storm's path, we can warn people who will be affected. Show students a video, which forecasts how this winter storm could affect the Midwest.

WINTER STORM QUID WEATHER FORECAST
https://scied.ucar.edu/winter-storm-quid
(Credit: the Weather Channel)
This short video from the Weather Channel gives a sense of what the storm was shaping up to be as it crossed the United States in February 2017. (Note: The Weather Channel names winter storms. This one was named Quid.)

2. **Introduce the three challenges that are part of the Culminating Task.** Explain to students that they will work in groups of two or three to understand this winter storm as it moved from California to the Rockies to then predict how it will affect the Midwest.

Their tasks are:

1. Understand factors that increase the chances of precipitation.
2. Predict which communities in the storm's path in the Midwest should prepare for heavy snow and take safety precautions.

Challenge 1: California Storm

1. **Motivate a purpose for Challenge 1.** Tell students that when the storm was in California, heavy rain fell in some areas and heavy snow fell in other areas. Explain that students will need to figure out why that happened and also where the storm came from and where it is going.

CT Challenge 1 STEP 1

2. **Introduce Challenge 1.** Pass out the *Challenge 1: Student Activity Sheet* and orient students to the map, which shows a zoomed-out box of the area where the storm hit (the symbols on the map should be familiar to students at this point, review as needed). Together, read the introduction addressing where it rained along the West Coast on February 20, 2017.

3. **Prepare students to work on Challenge 1.** Arrange students in partners or groups of three (students will work in the same groups throughout all three challenges of the Culminating Task). Display the class Consensus Models developed during Learning Sequences 1, 2, and 3 as well as the Model Idea Tracker. Tell students they can use these ideas and models to help them with the challenge.

4. **Work on Challenge 1 in small groups.** Give students time to answer the questions in *Challenge 1: Step 1* about the California storm. As students work, circulate the groups and prompt students to draw on previous models and Model Ideas.

- *What is the direction of prevailing winds across North America?*
- *How can you use the symbol for a cold front to figure out the front's direction?*

Storyline Link
Remind students of the destruction they saw with the Colorado storm and that understanding how storms form and where they move can help us prepare communities in their paths.

Developing & Using Models
Student models from Learning Sequences 1, 2 and 3 should help students develop explanations for where the storm came from and where it's heading.

CT Challenge 1 STEP 2

5. **Draw student attention to *Challenge 1: Step 2*, which provides more detail about the California storm.** The new information details South Lake Tahoe experiencing rain while Heavenly Mountain experiences snow. Give students time to answer the *Step 2* questions with their group. Encourage students to sketch on the cross section what is happening in the air at South Lake Tahoe compared with Heavenly Mountain. Introduce the idea that as the weather transitions from rain to snow there will likely be an area that experiences a rain-snow mixture. Student answers about where the rain-snow mixture might have happened will vary. There is not enough data for them to pinpoint exactly where that happens, but they should understand that it will happen somewhere between the town and the mountaintop.

    - *What do we know about temperatures at lower and higher altitude?*
    - *How might air temperature at the Heavenly summit be different from air temperature at South Lake Tahoe?*

6. **Share initial ideas with another group.** Have students share their ideas about *Steps 1 and 2* in Challenge 1 with another small group. Give students time to edit and add to their explanations as they share and discuss similarities and differences between their initial responses to the questions.

7. **Discuss Challenge 1 questions as a whole class.** Focus on coming to consensus about each question and recording the consensus explanation for the class. Students can continue to edit their ideas if they hear something new or different they'd like to add. Have students share their images of what is happening on a document camera to support their explanations.

SUGGESTED PROMPTS	SAMPLE STUDENT RESPONSES
Where do you think the cold front was located before it passed over California?	• It's moving from west to east, according to global circulation, which means it was over the Pacific Ocean.
Where do you think the moisture that's in this storm came from before it was in the atmosphere?	• It evaporated from the Pacific Ocean. (Some water evaporated from Lake Tahoe, but it was a small amount compared with the amount that evaporated from the ocean.)
Where do you think the storm will go next?	• Surface winds blow west to east at the midlatitudes, so this storm should move east due to these winds. • The cold front symbol has the triangles pointing toward the east, so that is the direction the storm is moving.

Developing & Using Models
Student explorations of the Virtual Ballooning interactive in Learning Sequence 1 will help them with the question of rain versus snow. Students may need help connecting what they learned about temperature and altitude with formation of snowflakes (i.e., that the temperature needs to be below freezing for snowflakes to form).

Assessment
Listen to student responses to the Challenge question and/or read their explanations on the Exit Tickets to give you clues about how students are leveraging science ideas from the previous lessons.

SUGGESTED PROMPTS	SAMPLE STUDENT RESPONSES
Why did it snow at Heavenly Mountain and rain in South Lake Tahoe?	• The air temperature is cooler higher in the troposphere. We know that from the Virtual Ballooning investigation. So, it should be colder at Heavenly, which is a higher altitude than South Lake Tahoe. This means it would snow at Heavenly if the temperature is freezing. • Both locations are at high altitude, but Heavenly is much higher, and it must be below freezing.
If you were to decide whether rain or snow will fall during a storm, what information would you look at and why?	• You would look at air temperature because if it is a certain temperature, the water will freeze to snow.

8. **Return to the Challenge 1 question.** Revisit the question: *"Why did the storm cause rain in some places and snow in other places in California?"* Have students discuss an explanation to this question in groups and/or write a response on an Exit Ticket before the end of the lesson.

CULMINATING TASK: **Challenge 2**

WHERE'S THE SNOW?

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

AT A GLANCE

ACTIVITY DESCRIPTION	MATERIALS
(50 minutes)	
Challenge 2: Where's the Snow? Students examine data as the winter storm moves east across the western interior. They explain why this storm brought precipitation to some locations but not others, drawing on ideas from previous lessons. Students work in small groups to develop explanations. They then share their ideas with the class and come to consensus.	**Challenge 2: Student Activity Sheet** CULMINATING TASK: **Challenge 2** Colored pencils

NGSS Sensemaking

In Challenge 2, students use models developed in Learning Sequences 1, 2, and 3 to explain why some areas in the Rockies got a lot of snow and others did not. Students identify that heavy precipitation is located near an area of low pressure where moist air rises and becomes available for precipitation.

NGSS DIMENSIONS (GRADES 6-8)

- 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.
- Weather is influenced by interactions involving sunlight, the ocean, and the atmosphere. These interactions vary with latitude, altitude, and regional geography, all of which can affect atmospheric flow patterns.
- Apply scientific ideas to construct an explanation for real-world phenomena or events.
- Charts can be used to identify patterns in data.

Teacher Procedures

Challenge 2: Where's the Snow?

1. **Navigate from the previous lesson.** Review what students learned about winter storm Quid in Challenge 1 and revisit the two questions that ended the previous challenge:
   - *What information would you need to decide whether rain or snow will fall during a storm?*
   - *Where is the storm heading next and how do you know?*

   Listen for the following responses:
   - You need to look at temperature. If it's colder in the atmosphere, it will snow.
   - This winter storm will move east because of prevailing surface winds in the midlatitudes.

2. **Discuss where the winter storm is heading.** Project the class map for Challenge 2 and explain that in Challenge 2 students will analyze precipitation data for the winter storm three days after it was in California. The storm is now located in the Rocky Mountains. Their goal is to identify places with heavy precipitation and decide what is causing precipitation in this area.

CT Challenge 2
STEP 1-4

3. **Prepare to complete Challenge 2.** Pass out the *Challenge 2: Student Activity Sheet.* Read the instructions together for Challenge 2 and outline the four steps students will complete. Orient students to what is shown on the map over the four days of the storm. Have students return to their groups/partners from the previous day. Remind students to use their class Consensus Models and Model Idea Tracker to help them decide what is happening to cause heavy precipitation.

4. **Work on Challenge 2 in small groups.** Give students 20 minutes to work on *Challenge 2: Steps 1-4*. In *Step 1*, students will write the snowfall totals from the data table on their map and identify the communities that had significant snow. In *Step 2,* students use the snowfall map to predict where schools might close. For *Step 3,* students consider patterns in snowfall and why some areas had more snow than others. *Step 4* reminds students of the two things needed for precipitation (rising, cooling air and humidity). Students draw air movement and cloud formation in the cross sections showing low pressure and the front and relate distance from the storm to the amount of snowfall received. *Step 4* continues with students completing the humidity map and determining which locations didn't have enough moisture to result in a storm.

   As students work, circulate the groups and prompt students to draw on previous models and Model Ideas.
   - *Think about how precipitation forms around a front. What's happening to the air along the front?*
   - *What happens to air in a low-pressure area?*
   - *Even though a cold front is passing through all these towns, why might some not get any precipitation? What's an important ingredient that could be missing?*

5. **Discuss Challenge 2 questions as a whole class.** Project the map for Challenge 2 and discuss the following question prompts. Focus on coming to consensus about each question and recording the consensus explanation for the class. Students can continue to edit their answers from *Steps 1-4* if they hear something new or different they'd like to add. Have students share their images of what is happening on a document camera to support their explanations.

Storyline Link
In the previous challenge, students explained that temperature was important for determining precipitation and the storm was heading east.

Developing & Using Models
Student models from Learning Sequences 1 and 2 should help students develop explanations for why it snowed in some places but not others.

Patterns in Data
Students identify patterns in the data tables, looking for relationships between places with heavy snow and average humidity.

SUGGESTED PROMPTS	SAMPLE STUDENT RESPONSES
Where were the communities with heavy snowfall located in relation to the storm?	• These locations are near or just behind the area of low pressure at the northern end of the cold front.
Explain why places like Cortez, Gallup, and Albuquerque didn't get any snowfall at all.	• They are not close enough to the low pressure area, which is necessary for warmer, moist air to rise up into the atmosphere.
Did it always snow in areas that had high humidity? Explain why or why not. Give examples.	• Devils Tower is the only location that had high humidity but absolutely no snow. Since it is the farthest from the low-pressure system, there was no mechanism for the moisture to rise up into the atmosphere. In general, areas with high snowfall did indeed also have high humidity.
Compare the two areas with the highest snowfall to the two areas with the highest humidity.	• The areas with the highest snowfall did indeed have high humidity, but the areas with the highest humidity didn't happen to have all that much snow due to the large distance between them and the storm.
Why do some communities have more snowfall than others? What is happening to air in these areas?	• Areas of low pressure have warm, rising air with moisture. This means there is more moisture rising in this area, so there is a higher potential for more precipitation. (Students' Step 4 drawings may vary but should indicate that an area of low pressure is where warm air, or relatively warm air, with moisture is rising and then cooling to create storms and precipitation.)
Why didn't it snow everywhere?	• Some of the places where it didn't snow were too far from the storm. • Some of the places where it didn't snow had low humidity. That means they didn't have enough moisture in the air for it to snow.
Where might schools close?	• Students' answers may vary but should include all locations with significant snow (Rock Springs, WY; Dinosaur, CO; Vernal, UT). Students may include locations with less snow depending on their experience with snowstorms and school cancelations. (Students will learn more about safety and cancelations in Challenge 3.)

6. **Return to the Challenge 2 question.** Revisit the question: *"As the storm moved east, why did it snow in some areas but not others?"* Have students discuss an explanation to this question in groups and/or write a response on an Exit Ticket before the end of the lesson.

Assessment
Listen to student responses to the Challenge question and/or read their explanation on the Exit Tickets. See if students identify rising, moist air in the area of low pressure as a key factor in the heavy snow.

CULMINATING TASK: **Challenge 3**

WE'RE WARNING YOU

Where will schools have a snow day on February 24th?

AT A GLANCE

ACTIVITY DESCRIPTION	MATERIALS
(50 minutes)	
Challenge 3: We're Warning You Students draw on ideas from Challenges 1 and 2 as well as their class Consensus Models to predict where snow will fall next as Quid moves toward the Midwest. Students work in small groups to develop predictions for the location of heavy snowfall. They share their predictions with the class. They review storm warning information and read a text about storm warning systems. Using this information, students revise their predictions. Students consider how what they've learned in the unit can prepare them for severe weather in their area.	**Challenge 3: Student Activity Sheet** CULMINATING TASK: **Challenge 3** Color copies of the warning map (or access to the map on a computer/tablet) Model Idea Tracker, Consensus Models Driving Question Board

NGSS Sensemaking

In Challenge 3, students use models developed in Learning Sequences 1, 2, and 3 to predict what areas in the Midwest can expect a lot of snow. Students reflect on the questions they asked at the start of the unit and what they know now. Students then construct an explanation about a specific precipitation event in their community demonstrating what they've learned about the unit driving question.

NGSS DIMENSIONS (GRADES 6-8)

- 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.
- Weather is influenced by interactions involving sunlight and the atmosphere. These interactions vary with latitude, altitude, and regional geography, all of which can affect atmospheric flow patterns. Because these patterns are so complex, weather can only be predicted probabilistically.
- Use a model to predict phenomena.

NGSS DIMENSIONS (GRADES 3-5)(REINFORCING)

- Patterns of change can be used to make predictions.

Teacher Procedures

Challenge 3: We're Warning You

1. **Navigate from the previous lesson.** Review what students learned about this winter storm in Challenge 2. Focus the review discussion on the questions that ended the previous challenge:
   - *How do we know where it will snow? What's happening to the air in this area?*
   - *Where is the storm heading next, and how do you know?*

   Listen for the following responses:
   - It will snow in places near the front that have sufficient moisture. Most of these places are near the area of low pressure because there is more rising moisture here.
   - This winter storm will move east because of prevailing surface winds in the midlatitudes.

2. **Introduce Challenge 3.** Project the class map for Challenge 3 and explain that students will take what they know about this winter storm on February 23, 2017 and make a prediction about which locations will be in the path of the storm on February 24, 2017. Explain that weather predictions are often made to help keep people safe. Introduce how winter storms can prove hazardous (e.g., blowing snow can reduce visibility on the roads, ice can cause people to slip while walking and have auto accidents). Challenge students to identify which communities need to consider closing schools and businesses to stay safe. (Note: As you introduce the class map, students may notice that the front and low-pressure areas are moving at different rates than they were a few days before. It's not uncommon for a storm system's rate of movement to change.)

3. **Prepare to complete Challenge 3.** Pass out the *Challenge 3: Student Activity Sheet*. Have students return to their groups/partners from the previous day. Have students take out the class Consensus Models and their Model Idea Tracker. Tell students they can draw on these ideas and models to help them with the challenge.

CT Challenge 3
STEP 1-3

4. **Work on Challenge 3 in small groups.** Give students 20 minutes to work on *Steps 1-3* in Challenge 3. Have students make predictions about where it will snow on February 24, 2017 based on characteristics of the storm on February 23, 2017. As students work, circulate the groups and prompt students to draw on previous models and Model Ideas.
   - *In Challenge 2, what was the air pressure like in places where heavy amounts of snow fell? [low]*
   - *What was happening to the air in this area?[it was rising]*
   - *What side(s) of the low-pressure area did the snow fall in Challenge 2? [on the north and west sides]*

5. **Discuss Challenge 3 questions as a whole class.** Project the map for Challenge 3 and discuss question prompts from *Steps 1, 2, and 3*. Students do not need to come to consensus on their predictions yet.

Storyline Link
In this lesson, students draw on observations from Challenge 2 and their models to predict where snow will fall as the storm moves east.

Developing & Using Models
Student compare similarities and differences with this winter storm to the model they developed in Learning Sequence 2 to explain precipitation along a cold front.

SUGGESTED PROMPTS	SAMPLE STUDENT RESPONSES
Where did it snow on February 23, 2017? Compare the locations with snow to the location of the front and low-pressure area.	• It snowed in places just behind the area of low pressure and at the northern end of the cold front.
Where do you think will it snow on February 24, 2017 and why?	• It will likely snow in places like Des Moines, IA and Madison, WI that are behind the low pressure area and to the north of it.

CT Challenge 3 STEP 4

6. **Read the warning map and snow day text in *Step 4*.** Explain that these are the areas where warnings were issued as places that may be vulnerable to severe weather on February 24, 2017. Have students read the warning map and text: Is it a snow day? Students answer the question at the end of the text on their own.

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

    NOTE: Students need to view the warning map in color. Consider making a class set of color print outs for repeated use or plan to have students use a computer or tablet to view the map in color. The warning map is also included in the slide set.

CT Challenge 3 STEP 5

7. **Discuss and revise predictions with the class in *Step 5*.** Tell students that scientists, including meteorologists, revise their predictions once they have more information. Have students revise their predictions for February 24, 2017 to take into account the warning information and text. Discuss and revise predictions about where it will snow on February 24, 2017.

SUGGESTED PROMPTS	SAMPLE STUDENT RESPONSES
Where will it snow on February 24, 2017 and why?	• It will snow in places like Des Moines, IA and Madison, WI that are behind the low-pressure area and to the north of it.

8. **Conclude the discussion and focus on preparing for severe weather in your area.**

SUGGESTED PROMPTS	SAMPLE STUDENT RESPONSES
What types of weather hazards do we face that can close schools, businesses, or roads in our area? *How could what we learned in this unit help us prepare for severe weather in our area?*	• Answers will vary (e.g., flooding, tornadoes, ice on the roads). • Answers will vary (e.g., it helps us know what's causing the heavy precipitation; it helps us know why some places get more precipitation than others).

Construct an Explanation
Ask students to use their models to help them construct an explanation about a specific kind of precipitation event in their community. This activity can be used as an assessment of learning.

9. **Return to the unit driving question: "What do we know about storms?"** Ask students to think of one type of precipitation event in their local area. It can be an isolated storm, a front, or a different precipitation pattern. Ask students to explain as much as they can about why they think this storm happened. This activity can occur as a class discussion and/or an individual writing task, followed by small group sharing of ideas.

10. **Return to the Driving Question Board to answer any lingering questions.** Ask students to revisit the Driving Question Board to answer any questions. There may be several questions remaining on the board that were not answered in the course of the unit. Consider having students take responsibility for researching one question from the board and reporting what they learned back to the class.

11. **Wrap up the *GLOBE Weather* unit.** Have students brainstorm answers to the question: "How can we use what we've learned about weather?" There are many correct answers to this question, so encourage students to be creative. Student answers may be individual (e.g., "Now we know what the meteorologist on TV is talking about.") or larger and more involved (e.g., "Now we can collect our own weather data or research what types of storms happen where we live.").