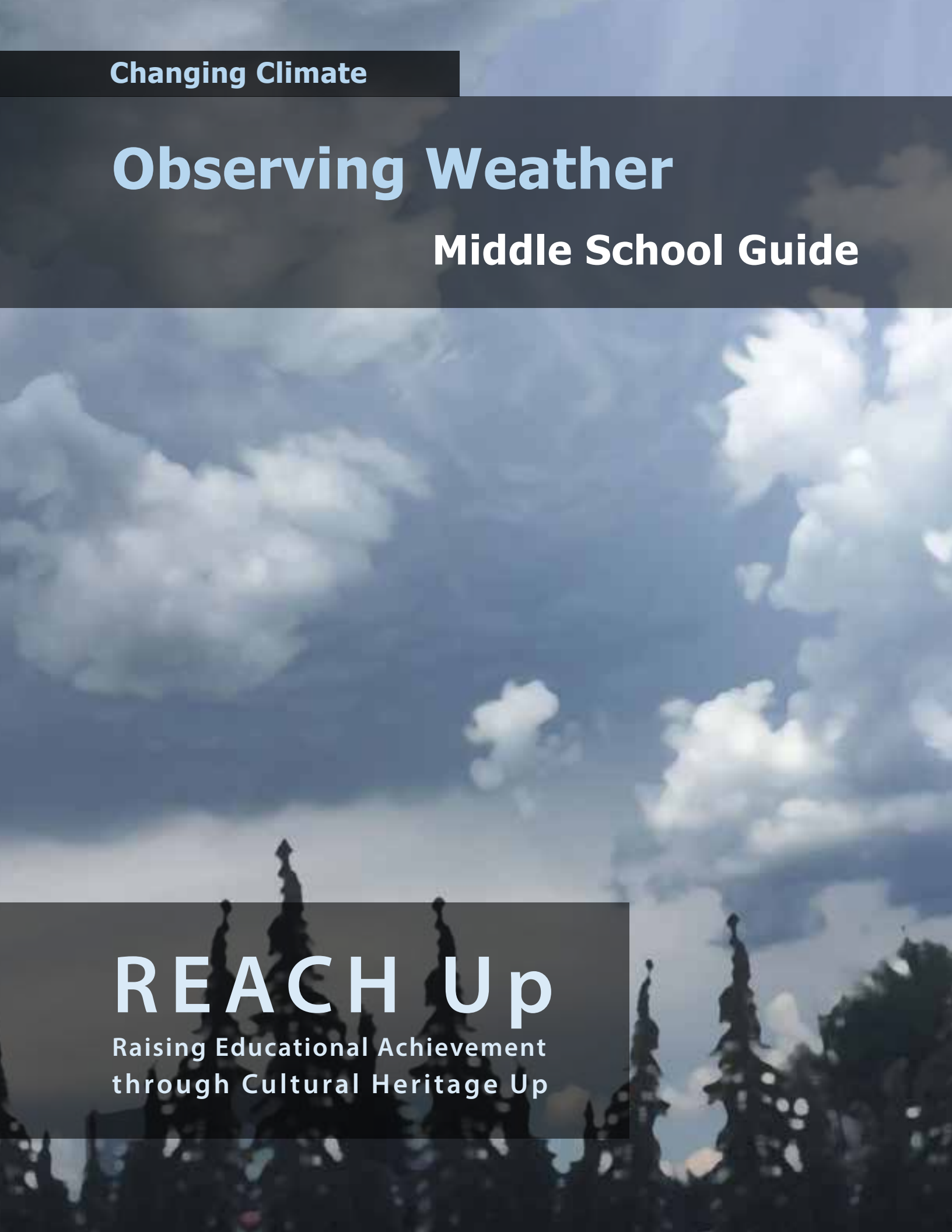


Changing Climate

Observing Weather

Middle School Guide

REACH Up

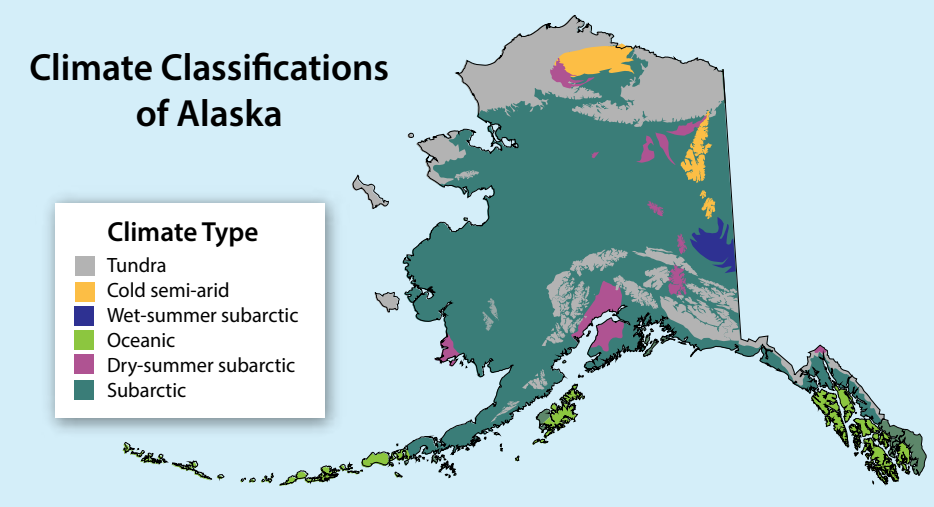
Raising Educational Achievement
through Cultural Heritage Up

Changing Climate

What is Climate?

Climate is the long-term average of weather conditions that occur in a particular region. The Bering Strait region of Alaska includes subarctic and tundra climates. Subarctic climates are characterized as having their coldest months average below 0°C (32°F) and at least one month that averages above 10°C (50°F). Much of Alaska has a subarctic climate in which there is no significant difference in the amount of precipitation between seasons. Some areas get most of their precipitation in winter (dry summer subarctic), while other areas get most of their precipitation in summer (wet summer subarctic.) The tundra climate is characterized by temperatures that average below 10°C (50°F) in the warmest months. The tundra climate is a subcategory of polar and alpine climates; the other subcategory of polar climate is an ice cap climate, where all twelve months of the year average below 0°C (32°F). Which climate classification describes your community?

Residents across the Bering Strait region report changes to the local climate. Scientists, both local and distant, are working to understand the changes. The changes have been so extensive and persistent that a New Arctic is emerging. The New Arctic is warmer, with less sea ice and shorter winters. In the New Arctic, permafrost is thawing and glaciers are shrinking.



Map based on Wikimedia map "Köppen Climate Types of Alaska."
Source: WorldClim.org.

Measuring and understanding climate change requires collecting data about the weather and environmental conditions in the area over a long period of time. Both qualitative data (the use of words to describe what is observed) and quantitative data (the use of numbers to describe what is observed) are used in climate science. Qualitative data might include descriptions of visual environmental observations, oral histories of extreme weather events, and photographs of sea ice conditions. Quantitative data about weather, such as temperature, wind speed, and snow depth can be gathered using instruments. What qualitative and quantitative environmental observations do you make? When and why do you observe weather?

What is Weather?

Weather is the condition of the atmosphere at a particular place and time. Weather includes characteristics such as wind, cloudiness, **precipitation**, temperature, **humidity** and atmospheric pressure. How would you describe the weather in your community today?

What types of weather data are collected in your community? Why? Who collects the data? What methods do they use? Who do they share the data with?

Children enjoy a winter day on the playground in Shaktoolik. *Photo: Yuri Bult-Ito, REACH Up.*

Ask an Expert

1. Watch the video *Observing Weather* available at *www.k12reach.org/videos.php.*

2. Discuss local weather observation with an elder or other community member. Some questions you may want to ask:
    - What sort of weather can we expect during each season?
    - What observation strategies, methods, tools or resources do you use to monitor the weather?
    - Why is it important to pay attention to the weather?
    - Have you noticed any changes in the typical weather during your lifetime? If so, what has changed and how?
    - If there have been changes, how have the changes impacted your lifestyle or the lifestyles of others in our community?

3. If the person you interview speaks an Alaska Native language, ask them what language and dialects they are familiar with. Ask them to please translate the following words:

    - atmosphere
    - cloud
    - measure
    - observe
    - rain
    - snow
    - sun
    - weather
    - wind

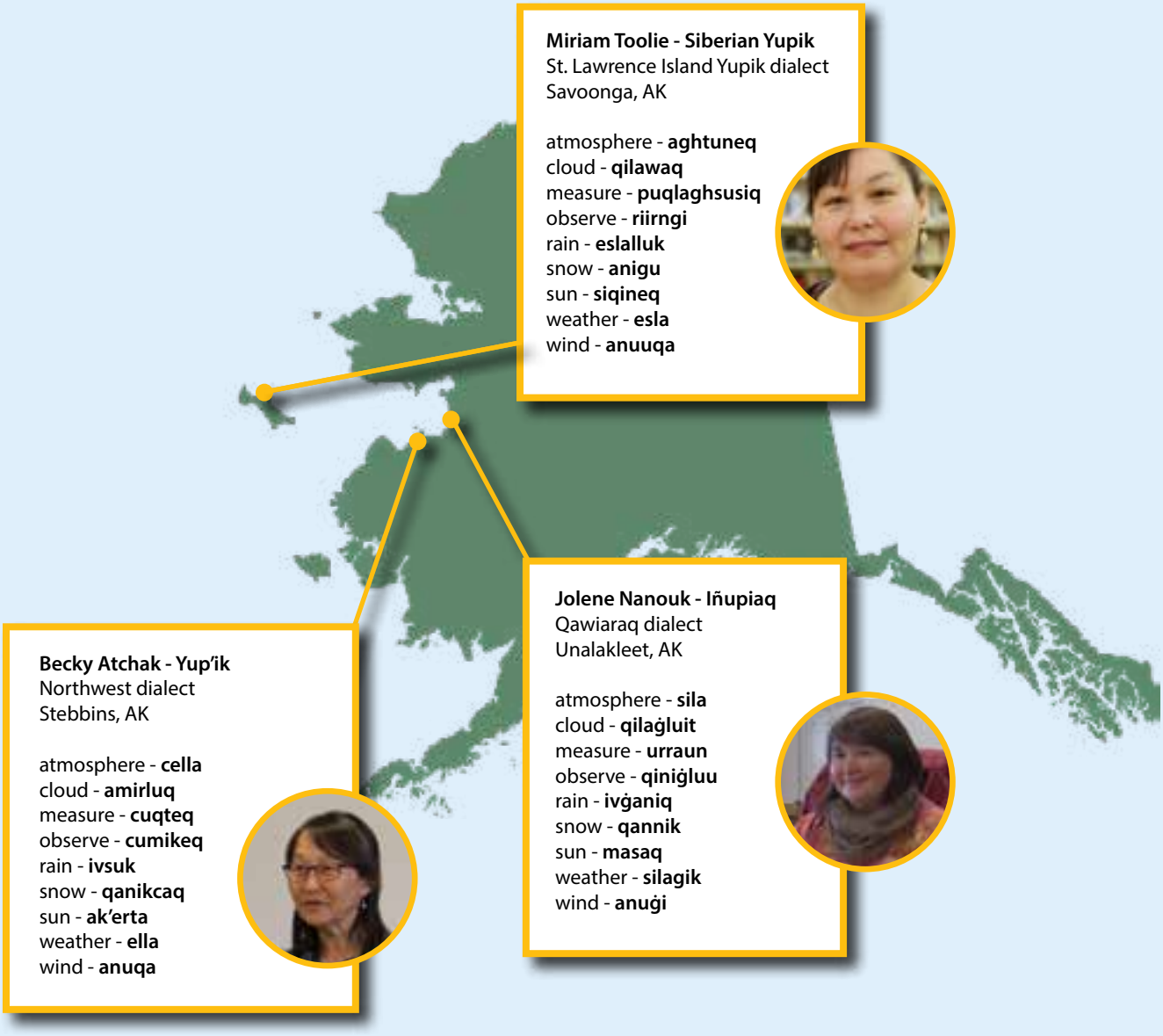
Abigail Takak, Shaktoolik discusses changes to weather in her community.
Photo: Kelsey Skonberg, REACH Up.

Compare your words with the translations on the Observing Weather Vocabulary page of this student guide. Are any of the terms the same or similar?

Observing Weather Vocabulary

Would you like to know Alaska Native language terms related to observing weather?

Work with a classmate or your teacher to practice weather vocabulary words in English and the indigenous language of your community. Your teacher will give you vocabulary cards with the English word and an illustration on one side. Write the corresponding Indigenous term on the blank line on the back of each card. Use the words that you learned from a local Elder or cultural knowledge bearer, or choose the translation below that is closest to your community.



Miriam Toolie - Siberian Yupik
St. Lawrence Island Yupik dialect
Savoonga, AK

atmosphere - **aghtuneq**
cloud - **qilawaq**
measure - **puqlaghsusiq**
observe - **riirngi**
rain - **eslalluk**
snow - **anigu**
sun - **siqineq**
weather - **esla**
wind - **anuuqa**

Jolene Nanouk - Iñupiaq
Qawiaraq dialect
Unalakleet, AK

atmosphere - **sila**
cloud - **qilaġluit**
measure - **urraun**
observe - **qiniġluu**
rain - **ivġaniq**
snow - **qannik**
sun - **masaq**
weather - **silagik**
wind - **anuġi**

Becky Atchak - Yup'ik
Northwest dialect
Stebbins, AK

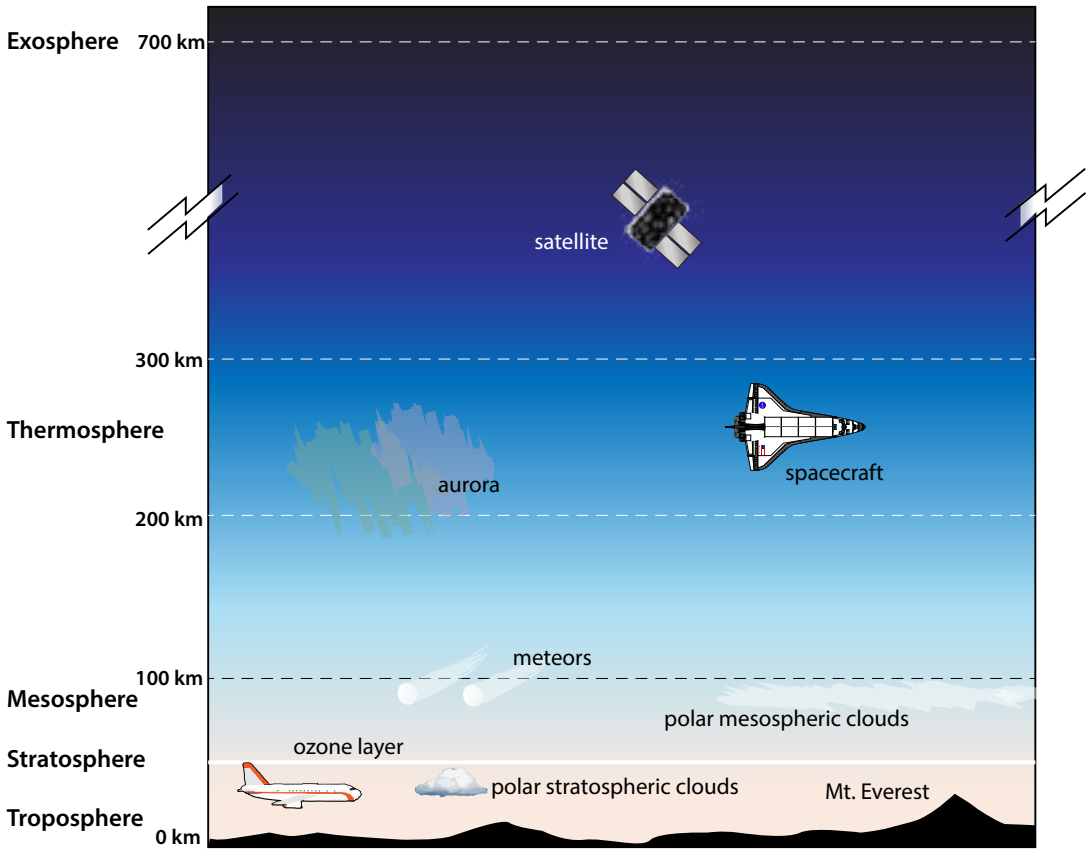
atmosphere - **cella**
cloud - **amirluq**
measure - **cuqteq**
observe - **cumikeq**
rain - **ivsuk**
snow - **qanikcaq**
sun - **ak'erta**
weather - **ella**
wind - **anuqa**

What is the Atmosphere?

The **atmosphere** is a blanket of gases that surrounds Earth. During the day, solar radiation travels through the atmosphere, heating Earth's surface. As the surface warms, it conducts the heat further into the ground beneath it. At night, the surface cools, radiating the heat energy back into the atmosphere. Much of this energy escapes into space, but greenhouse gases in the atmosphere reflect some of the energy back to Earth. This keeps Earth warmer at night than it otherwise would be, and reduces the temperature difference between day and night.

The atmosphere is made up of layers. The layer of the atmosphere closest to Earth's surface is the troposphere. It contains most of the atmosphere's water vapor, and it is where most weather occurs. The troposphere is thickest near Earth's equator and thinner near the poles. People, land animals and plants live in Earth's troposphere. Above Alaska, the troposphere stretches from Earth's surface to about 7 km (4 miles) above Earth.

Take a deep breath and wave your hand quickly from side to side. The air you feel filling your lungs and pressing against your hand is part of the troposphere. The troposphere is part of the atmosphere.



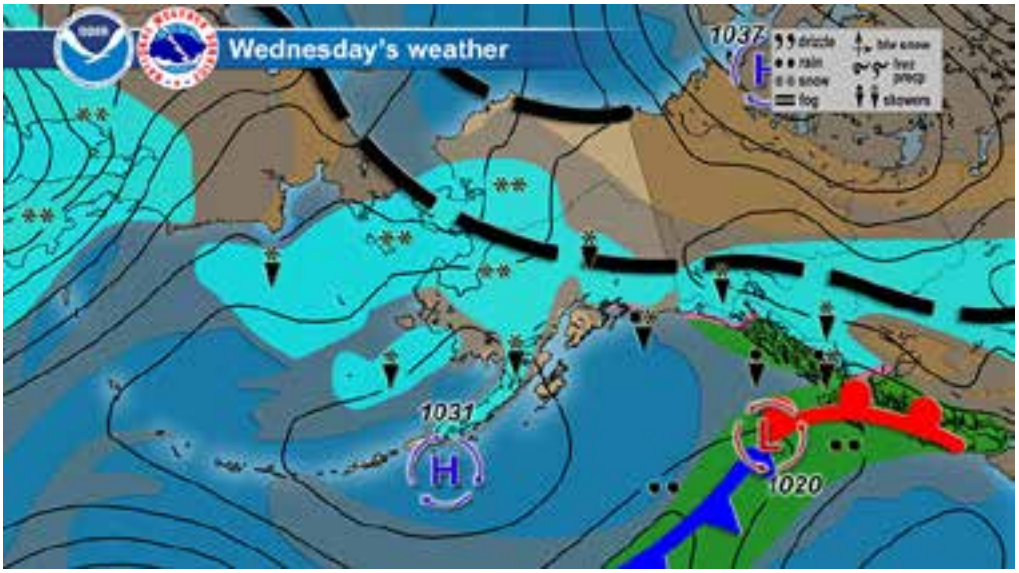
How do High Pressure Systems and Low Pressure Systems Differ?

The air (gas) that makes up Earth's atmosphere has mass, and gravity pulls it toward Earth. The pressure of that air against everything around it is known as atmospheric pressure. Atmospheric pressure is greater at sea level than it is on a mountaintop because the mountaintop has less atmosphere above it than the ocean does. The change in atmospheric pressure due to altitude is why your ears pop when you fly up in an airplane.

Atmospheric pressure also changes with temperature. Warm air is less dense than cold air. In weather terms, a body of warm air is known as a **low pressure system**. The leading edge of a low pressure system is known as a warm front. A body of cold air is known as a **high pressure system**. The leading edge of a high pressure system is known as a cold front.

When a high pressure system and a low pressure system meet, the warm air within the low pressure system rises and begins to cool. It is replaced near Earth's surface by cooler air. This transfer of energy is known as convection. As the rising air cools, water vapor within the air condenses into clouds and precipitation can form. This is why you may have heard a weather forecaster say "expect rain or snow as a low pressure system moves into the area." When a high pressure system is over an area, you can expect clear weather.

Wind is the movement of air. It is driven by atmospheric pressure systems. Wind moves toward areas of low pressure. The rotation of Earth also affects the direction that wind moves.



Weather forecasters use maps like this one to show high (H) and low (L) pressure systems as well as other weather characteristics. *Source: NWS NOAA.*

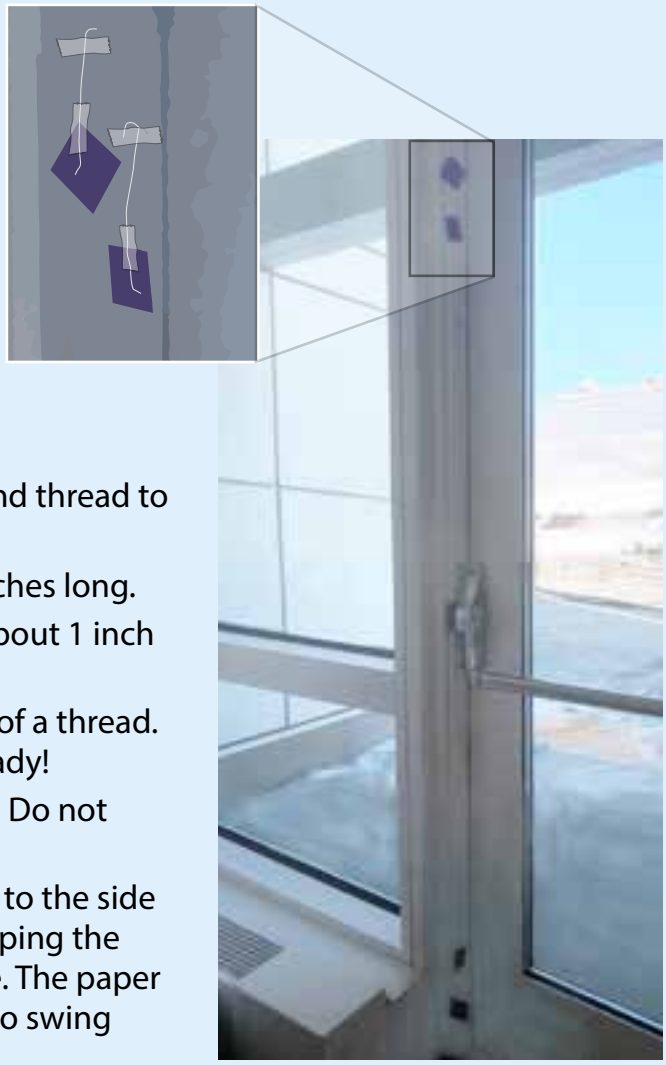
Modeling Pressure Systems

What happens when a low pressure system and a high pressure system meet?

On school days in Alaska, it is usually much colder outside than it is inside. If today is one of those days, then you have a model at your fingertips! The warm air inside your school is a low pressure system compared to the cold air outside of your school. Observe what happens when the warm front of a low pressure system meets the cold front of a high pressure system by following the steps below.

Materials

- Thread
- Scissors
- Paper
- Tape
- Student Worksheet: *Modeling Pressure Systems*



Preparation

Air can be difficult to observe. Use paper and thread to create air movement detectors.

1. Cut four pieces of thread about 6 inches long.
2. Cut four small squares of paper to about 1 inch on each side.
3. Tape each paper square to one end of a thread. Your air movement detectors are ready!
4. Find an exterior door in your school. Do not open it yet!
5. Secure two air movement detectors to the side of the doorframe near the top, by taping the loose end of the thread to the frame. The paper end of the detector should be able to swing freely, like a pendulum.
6. Tape the other two air movement detectors to the side of the doorframe near the bottom of the door.

Predict

- What do you think will happen when you open the door?
- Will the air movement detectors move? If so, which direction will they move? Why?
- Will the detectors at the top of the door move differently than those at the bottom of the door?

Model it

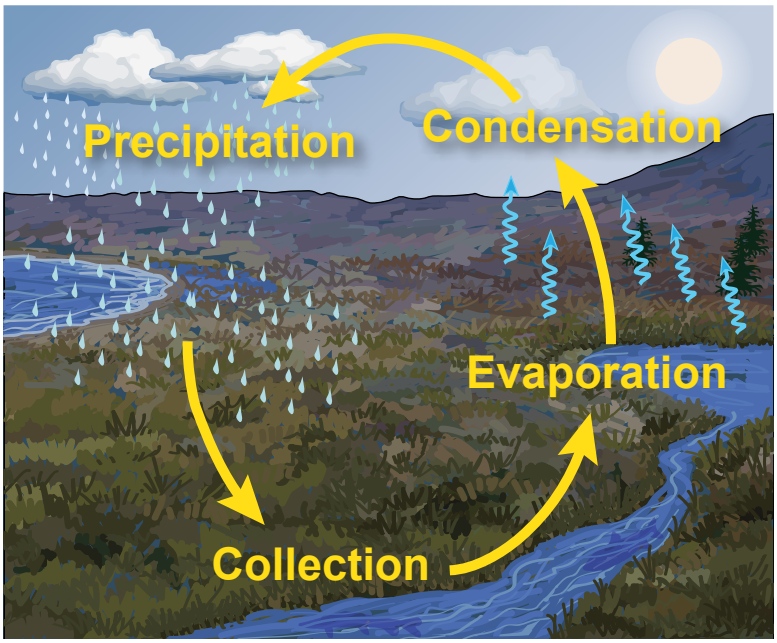
Open the door and hold it open for a few minutes. What happened?

Discuss

1. What happened when the warm front of your school's low pressure system met the cold front of the high pressure system outside?
2. How did the two bodies of air move relative to each other? How do you know?

How Does the Water Cycle Relate to Weather?

Several weather characteristics are directly tied to the water cycle. The water cycle describes the continuous movement of water between the atmosphere, Earth's surface and subsurface. Water changes phases as it moves through the cycle.



Clouds form when water vapor condenses on dust particles floating in the air. Clouds reduce the amount of solar radiation that reaches Earth's surface by reflecting it back into space. Clouds also insulate Earth by reflecting heat escaping from the surface back toward Earth.

In the Bering Strait region, cloud cover frequently impacts air travel, as low visibility can prevent planes from taking off or landing. Dark clouds can indicate that stormy weather or precipitation is on the way. How do clouds impact your daily life?

Humidity is the amount of water vapor in the air. Communities near the ocean, such as those in the Bering Strait, tend to be more humid than interior parts of the state. This is because water evaporates from the ocean into the atmosphere.

Precipitation is water, in liquid or solid form, that falls from the atmosphere. Snow, rain, hail and sleet are forms of precipitation found in Western Alaska and elsewhere. Rain forms when condensed water droplets within clouds merge with other water droplets, become too heavy and fall to the ground. Snow forms when the air in a cloud is well below freezing. Ice crystals, rather than water droplets, condense out of the cloud. Each crystal tumbles about within the cloud and grows as more and more water condenses and freezes to it. Eventually the snowflake falls to the ground.

How is Temperature Data Collected?

Weather data is collected to help people prepare for outdoor conditions, to inform with weather forecasts, and to help understand the climate in an area.

Temperature

Temperature data is collected using a variety of instruments. Across most of Alaska, surface air temperatures are increasing at twice the rate that temperatures are increasing globally. **Surface temperature** describes how hot or cold the air is near Earth's surface.

In the United States, the most common scale used to discuss temperature is Fahrenheit. There are several temperature scales. Scales allow us to precisely measure and describe temperature. Scientists and most of the rest of the world use the Celsius scale. Look at the temperature measured by the thermometer below. What is the temperature according to the Fahrenheit scale? What is the temperature according to the Celsius scale? It is important to specify what scale you are using when recording temperature.

The shield around this temperature sensor protects it from the sun, keeps it dry and provides ventilation. *Photo: Yuri Bult-Ito, REACH Up.*

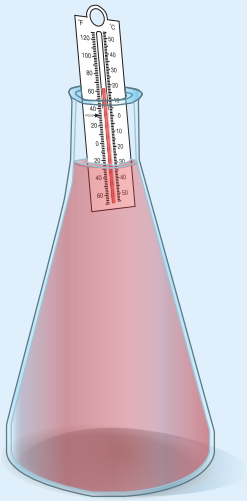
The level of the liquid inside the tube of a thermometer can gauge temperature. *Photo: Yuri Bult-Ito, REACH Up.*

Build a Thermometer

How do thermometers work?

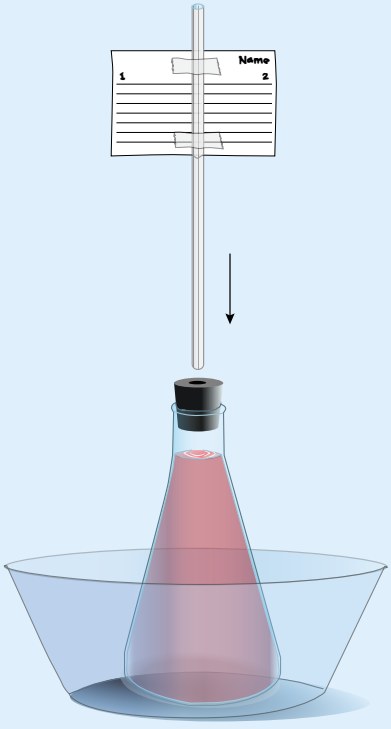
Liquid bulb thermometers work due to thermal expansion of the liquid. As the liquid warms, the particles in the liquid move about more quickly and spread apart. As the particles spread apart, the volume of the liquid increases (i.e. it takes up more space). As the volume increases, the liquid moves up the tube. Because the liquid will always expand the same amount at a given temperature, the level of the liquid can be used to measure temperature. Build your own liquid bulb thermometer by following the instructions below.

Materials



- Glass flask
- Hard plastic tubing, about 12 inches long
- Rubber stoppers with holes sized to fit tubing
- Water (room temperature and warm water)
- Bowl
- Red food coloring
- Transparent tape
- Thermometer (or temperature sensor and data logger)
- Lined index card
- Student Worksheet: *Thermometer*

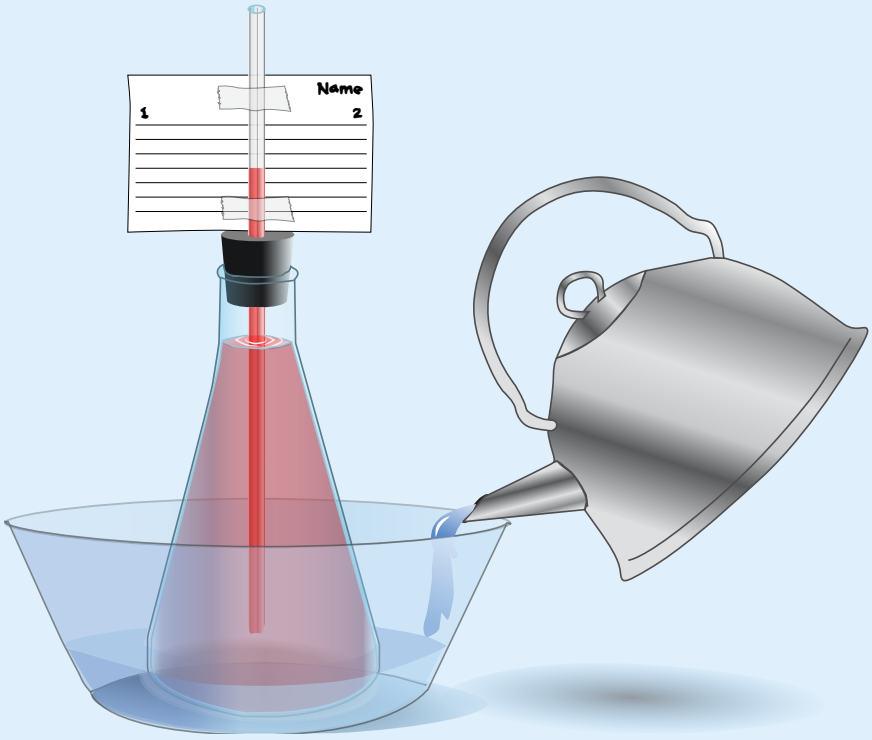
Part 1: Make a Thermometer



1. Fill the flask with room temperature water. Put 5-10 drops of food coloring in the water and swish it around until the water is reddish pink.
2. Set the flask in the empty bowl.
3. Use a thermometer to measure the temperature of the water. Record the temperature on your worksheet.
4. Push the plastic tube through the stopper so that when the stopper is inserted in the flask, the tubing will reach at least half way into the flask.
5. Insert the stopper quickly and firmly into the flask. Press on the stopper until the water level in the tube rises above the stopper.
6. Tape the index card to the tubing so that it is resting on the stopper.

Part 2: Calibrate your Thermometer

1. The current level of the water in the tube represents the temperature of the water just before you closed the flask. Use a pencil to mark the water level on the index card. Write the temperature next to the mark.
2. Pour warm water into the bowl that your flask-thermometer is sitting in. Watch the liquid in the tube. It should go up. When it **stops moving** or begins to drop, place the end of the calibrated thermometer (or temperature sensor) in the bowl of water to find the new temperature that your thermometer is indicating.
3. Make another mark on the index card to indicate the new water level and write the temperature beside it. Be sure to use the same temperature scale for both of the temperatures on your card.



Discuss

1. What happened to the water in the tube when you poured warm water into the bowl? Why?
2. What do you think would happen to the water in the tube if you poured ice water into the bowl instead of warm water?
3. How might you determine the temperature of the water in the bowl as it cools, using only the thermometer you built?
4. Would your thermometer work at temperatures below freezing? Why or why not?

How is Weather Data Collected?

Clouds

Visual observations of clouds can be made in person or by using satellite images. Quantitative data about cloudiness is collected by observing sky conditions and then estimating what fraction of the sky (in eighths) is covered in cloud. The unit of measurement used is an okta. A measurement of 0 oktas means that the sky is clear, 3 oktas means that 3/8 of the sky is covered in clouds, while 8 oktas means that the sky is completely covered by clouds.

Clouds also can be categorized according to their shape and altitude. This is a qualitative way to describe clouds. There are many types of cloud, but the four basic kinds include:

- **Cirrus**: These clouds look like wispy white streamers and are located high in the sky. Cirrus clouds are made of ice crystals.

Cirrus clouds. *Photo: Yuri Bult-Ito, REACH Up.*

- **Cumulonimbus**: These thunderstorm clouds grow vertically and often develop an anvil-like shape. Cumulonimbus clouds bring heavy rain, snow, hail and lightning.

Cumulonimbus cloud. *Photo: University Corporation for Atmospheric Research (UCAR).*

Cumulus clouds. *Photo: Rick Thoman, NWS Alaska Region.*

- **Cumulus**: Cumulus clouds are fluffy white clouds with a flat base. They can bring precipitation.

Stratus clouds. *Photo: Yuri Bult-Ito, REACH Up.*

- **Stratus**: These low, gray clouds cover most or all of the sky. They resemble fog and sometimes bring light precipitation.

What are the cloud conditions in your community today?

Precipitation

In the Bering Strait region, the most common forms of precipitation are rain and snow. Both can be measured using a precipitation gauge. This instrument resembles a funnel or graduated cylinder and is placed outside to collect precipitation as it falls. The amount of precipitation that collects in the gauge is typically measured in inches or centimeters. Snow contains varying amounts of water and air. When snow collects in the gauge, the liquid water equivalent of the snowfall can be determined by bringing the gauge indoors and allowing the snow to melt.

Precipitation gauges do not catch all of the snowfall because of wind. In areas where snow is common, windshields are often set up around the gauge to reduce wind-induced errors in snow measurements.

Humidity

Hot air can hold more humidity than cold air. This is why you can sometimes see your breath. When you exhale on a cold day, the water vapor in your breath immediately condenses into a small cloud because the air is too cold to hold the moisture that you exhale. On warm days, you cannot see your breath, because the air is warm enough to allow the water vapor in your breath to remain a gas.

Relative humidity is the ratio of moisture in the air as compared to the maximum amount of moisture the air can hold. It is expressed as a percentage. A hygrometer is an instrument used to measure humidity.

While outdoors during the winter or cool months, vapor from our breath is visible when we breathe out.

Cold air cannot hold as much moisture as warm air. A cold winter day with 54% humidity is much drier than a warm summer day with 54% humidity.

Wind

Wind is named for the direction from which it blows. A South wind, for example, comes from the South. There are many visual indicators of wind. For instance, you might look at the direction that the shrubs or grasses are leaning to determine the direction the wind is blowing. In winter, snowdrift patterns can indicate predominant wind direction for the area.

There are many different instruments used to measure wind. Anemometers measure wind speed. Wind vanes indicate the direction of the wind. Windsocks measure speed and direction. Have you seen a windsock or other instrument used to measure wind in your community?

Strong winds can create ripples in the snow. *Photo: Nilfanion via Wikimedia Commons.*

This anemometer is attached to a larger weather station on the UAF campus. *Photo: Yuri Bult-Ito, REACH Up.*

A windsock in Gambell, Alaska. *Photo: Yuri Bult-Ito, REACH Up.*

Atmospheric Pressure

A barometer is an instrument used to measure atmospheric pressure. There are many different units of measure. Scientists who study weather most commonly use millibars (mb). Air pressure at sea level at a temperature of 15 degrees Celsius (59 degrees Fahrenheit) is equal to 1013.25 mb.

Changes in atmospheric pressure can indicate that a change in the weather is coming. Gradually rising pressure can indicate clear weather, while decreasing pressure tends to indicate cloudy or stormy weather or precipitation.

Collecting Weather Data

What is the weather in your community today?

Describe today's weather by using your observational skills and one of the weather instruments provided by your teacher. Divide into groups to use the different instruments. Record your group's findings and share them with your class.

Wind Group	Water Group
Materials: • Anemometer • Paper, clipboard and pencil **Measure**: Go outdoors and follow the directions enclosed with the anemometer to measure wind speed and wind chill. Record your findings. **Observe**: Can you feel the wind? Which direction is it coming from? Wind can blow in different directions at different altitudes. If there are clouds today, which way are they moving? This indicates which direction the wind is blowing in that part of the atmosphere. Record your observations to share.	**Materials**: • Hygrometer • Cloud identification sheet • Paper, clipboard and pencil **Measure**: Go outdoors and follow the directions enclosed with the hygrometer to measure relative humidity. Record your findings. **Observe**: Look at the sky. Describe the cloud conditions (clear, partly cloudy, cloudy). If there are clouds, use the cloud identification sheet to determine which types of clouds are visible. Is precipitation falling? If so, what kind? Record your observations to share.
Temperature Group	**Atmospheric Pressure Group**
Materials: • Thermometer • Paper, clipboard and pencil **Measure**: Go outdoors and use the thermometer to measure temperature. Record the temperature in degrees Celsius and degrees Fahrenheit. **Observe**: What indications of cold or warmth do you notice around you? Is there snow on the ground? Do you see green plants, or perhaps plants that are brown? Can you feel the warmth of sunshine on your cheeks? Can you see your breath? Record your observations to share.	**Materials**: • Barometer • Paper, clipboard and pencil **Measure**: Go outdoors and follow the directions enclosed with the barometer to measure atmospheric pressure. Record your findings. **Observe**: Study the sky. Describe the cloud conditions. If there are clouds, where in the sky are they located? Which direction are they moving? Based on sky conditions, is there a high pressure system, or a low pressure system in your area? Are any pressure fronts visible? Record your observations to share.

REACH Up, K-12 Outreach Office
School of Education, University of Alaska Fairbanks
P.O. Box 755400
Fairbanks, AK 99775
www.k12reach.org